99th ACS Colloids & Surface Science Symposium

&

18th IACIS Conference

University of Alberta

Edmonton, Alberta, Canada

June 22-26, 2025

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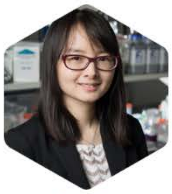

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99th ACS June 22-26, 2025
Colloids & Surface Science Symposium
&
18th IACIS Conference
University of Alberta

Welcome to the Joint 99th ACS Colloid and Surface Science Symposium and the 18th IACIS Conference! Please review the information below to ensure a safe and enjoyable experience. If you have any questions, please send a query on the conference website.

Venue

The conference will take place at the University of Alberta North Campus in the following buildings (see attached maps, Address: 9120 116 St NW, Edmonton, AB T6G 1T6):

- ETLC: Engineering Teaching & Learning Complex
- ECERF: Electrical and Computer Engineering Research Facility
- NREF: Natural Resources Engineering Facility
- ICE: Donadeo Innovation Centre for Engineering

The conference banquet (June 25, 18:00 – 22:30) will be held at the Edmonton Convention Centre.
Address: 9797 Jasper Ave, Edmonton, AB T5J 1N9
Tickets are required for admission and may be found inside the badge holder given at check-in.

Conference Check-in

Conference check-in will be in ETLC on Sunday and ECERF lobby Monday-Thursday.

- June 22: 15:30-19:30
- June 23-25 (daily): 8:30-15:30
- June 26: 8:30-11:30

Transportation

Public Transit: A complimentary Arc Card is included in your conference package for free ride on Edmonton Transit Service (ETS) buses and light rail transit (LRT) services for the period of the conference.

Ride-hailing services such as Uber, Lyft, or CO-OP Taxi are available. Edmonton has electric scooter/bike sharing available in select areas. Bird Scooters or Lime Scooters are available for rent through their respective apps.

Parking: Self-paid parking is available near ETLC at Windsor Car Park and Stadium Car Park.

Accessibility

The ETLC-East entrance and ECERF-West entrance are ADA compliant, and they will be open during:

- June 22: 15:00 – 20:00
- June 23-26 (daily): 07:00 – 19:30

Meals

At the ETLC Solarium:

- A welcome reception will be held on June 22, 17:30 – 19:30.
- Breakfast will be provided daily, 7:30 – 8:30.
- Lunches will be catered daily 12 – 13:20.
- There will be coffee, refreshments and snacks between technical sessions.

On the 8th floor of the ICE building:

- Refreshments will be provided at the Poster sessions, June 23 and 24, 17:30-18:30.

Program

The full program can be found on the conference website, along with instructions for Oral and Poster presenters.

Poster boards are located on the 8th floor of ICE building. Each poster is assigned a number (see full program). Please install your poster on the poster board with the designated number. Push pins will be provided.

Posters should be installed before 12:00 on June 23 and removed by 12:00 on June 26. Presenters should attend both poster sessions (June 23 and 24). The Poster Hall remains open throughout the conference.

Internet Access

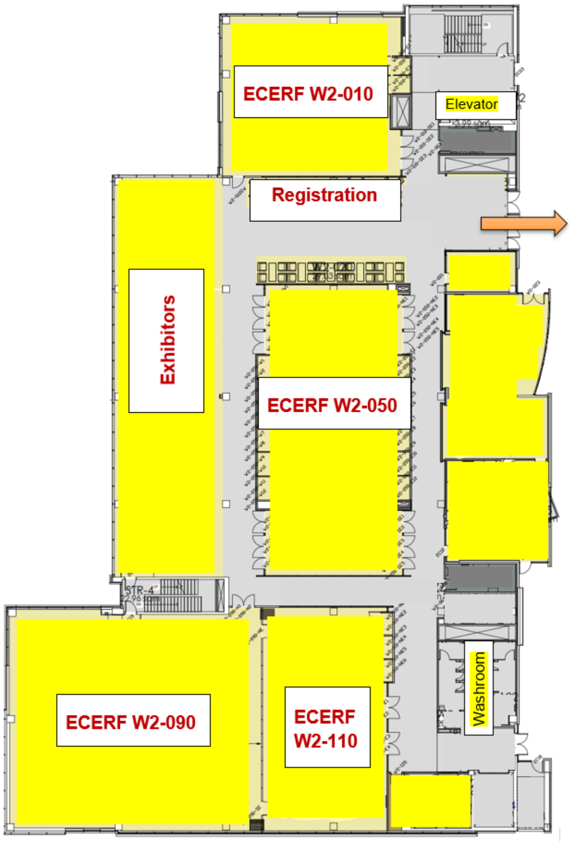
On the University of Alberta campus, you can get easily connected with eduroam, the world-wide roaming access service for faculty, staff and students in the international research and education community. Alternatively, Guest@UA is a free wireless connection. To connect to Guest@UA:

1. Click the wireless connection icon near the clock. Scroll down the list and select Guest@UA.
2. Your computer will launch a web browser to the University of Alberta Guest wireless service webpage. After you accept the terms of the Acceptable Use Policy, you will be asked to enter your email address.
3. An email message will be sent from uofaguest@ualberta.ca to the email address you provided. You may need to look in your SPAM folder. Press the Activate Access button within the 5 minute time limit to log into the Guest@UA wireless network. Your web browser will automatically be redirected to the University of Alberta homepage.
4. If you fail to press the Activate Access button within the allotted time you will need to reconnect to the Guest@UA wireless network and start the process all over again.
5. For more information, see the instructions.

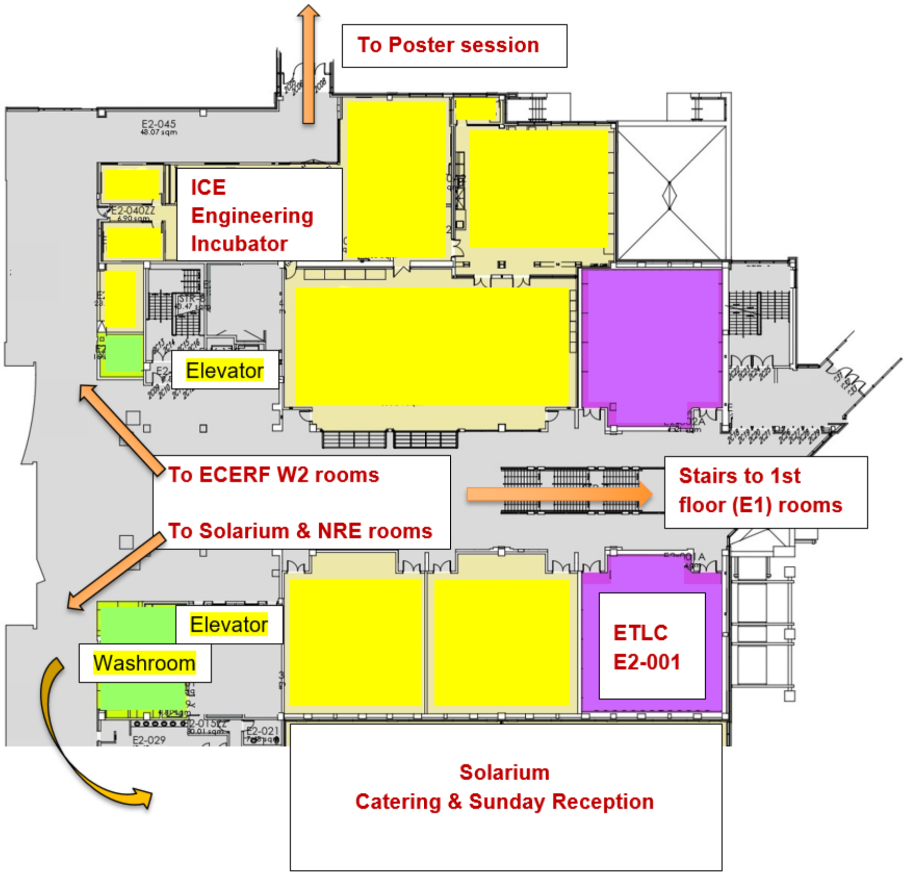
UNIVERSITY OF ALBERTA

Highlighted:
Conference venue, parking, and walkways from Lister Centre, Campus Tower Hotel and LRT University Station.

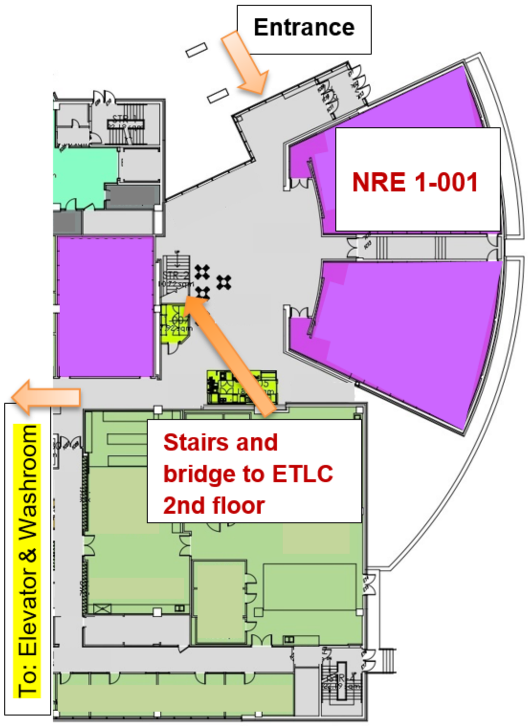
NORTH CAMPUS



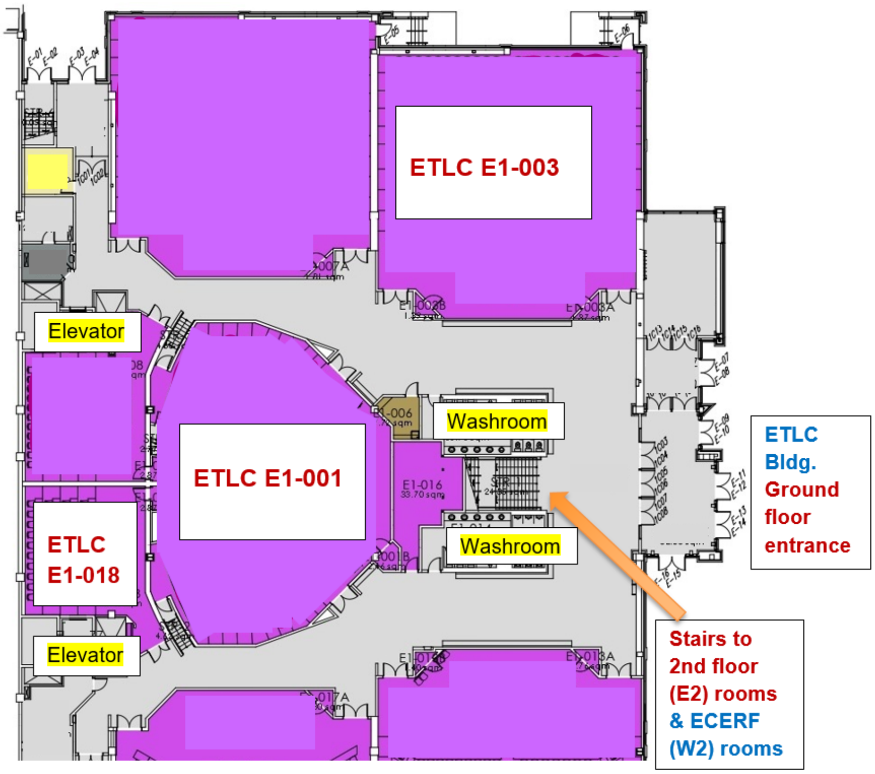
ECERF Second Floor



ETLC Second Floor



NREF First Floor



ETLC First Floor

EXPLORE
EDMONTON

LOW CARBON TRAVEL IN EDMONTON

Edmonton is on a regenerative and sustainable tourism journey. You can support the city's environmental goals by choosing low-emission transportation options during your visit.

GETTING AROUND WITH EDMONTON TRANSIT

- **ELECTRIC & HYDROGEN BUSES:** Edmonton Transit Service (ETS) operates 60 electric buses and 2 hydrogen fuel cell buses. These zero-emission buses are part of the city's commitment to reducing greenhouse gas emissions and improving air quality.
- **LIGHT RAIL TRANSIT (LRT):** The LRT is a key part of Edmonton's mass transit network and continues to grow, providing efficient and eco-friendly travel across the city.

SOFT TRAVEL OPTIONS

For short-distance travel, Edmonton offers several low- to no-fuel transportation choices:

- **WALK OR BIKE:** Explore over 160 km of walking and biking trails, including the scenic River Valley Trail, which connects more than 30 parks and offers stunning views of the North Saskatchewan River.
- **E-BIKES & E-SCOOTERS:** Three shared micromobility providers in the city—Bird Canada, Lime, and Neuron—each providing easy to use mobile applications with maps, unit locations, and payment options.
- **DISCOVER YEG MAP:** an interactive and mobile friendly map to discover bike routes, nearby transportation options and more.

STAY CLOSE, TRAVEL LIGHT

Several hotels are located within a one-kilometer radius of the Edmonton Convention Centre and other downtown hotel venues, allowing to enjoy a scenic walk while minimizing the carbon footprint.

Downtown also has an extensive system of pedestrian walkways (above and below-ground) connecting most major downtown buildings.

SCAN TO DISCOVER DOWNTOWN PEDWAYS:

23rd Jun 2025

07:30 - 08:30	**Breakfast** ETLC Solarium							
08:30 - 09:30	**Plenary Talk - David A. Weitz (Harvard University)** ETLC E1-001 Chair: Tian Tang							
09:30 - 10:00	**Coffee Break** ETLC Solarium							
10:00 - 12:00	**AI Methods in Surface Sciences - 1** ICE Incubator Chair: Vida Jamali	**Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 1** NRE 1-001 Chair: Mohtada Sadrzadeh	**Colloidal systems for Food: Production, Processing and Sustainability - 1** ETLC E1-018 Chair: Julia Maldonado-Valderrama	**General Aspects of Colloid and Interface Science - 1** ECERF W2-010 Chair: Piotr Warszynski	**Rheology and Tribology of Complex Fluids - 1** ECERF W2-110 Chair: Volfango Bertola	**Molecules and Particles at Fluid Interfaces - 1** ETLC E2-001 Chair: Man Hin Kwok	**Wetting and Adhesion - 1** ETLC E1-003 Chair: Hans-Jürgen Butt	**Soft Matter - 1** ECERF W2-050 Chair: Ignaas Jimidar
12:00 - 13:20	**Lunch - Mentor & Mentee Introduction**							
13:20 - 15:00	**AI Methods in Surface Sciences - 2** ICE Incubator Chair: Alidad Amirfazli	**Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 2** NRE 1-001 Chair: Norman Wagner	**Colloidal systems for Food: Production, Processing and Sustainability - 2** ETLC E1-018 Chair: John Frostad	**Colloids for Sustainability and Energy - 1** ECERF W2-010 Chair: Siddhartha Das	**Rheology and Tribology of Complex Fluids - 2** ECERF W2-110 Chair: Nezia De Rosso	**Molecules and Particles at Fluid Interfaces - 2** ETLC E2-001 Chair: Man Hin Kwok	**Wetting and Adhesion - 2** ETLC E1-003 Chair: Carlo Antonini	**Soft Matter - 2** ECERF W2-050 Chair: Robert Macfarlane
15:00 - 15:20	**Coffee Break** ETLC Solarium							
15:20 - 15:30	**ACS Victor K LaMer Award Lecture - Elastic Turbulence in 3D Porous Media** ETLC E1-001 Chair: Cari Dutcher							
15:30 - 16:20								
16:20 - 16:30	**Break**							
16:30 - 17:30	**Invited Talk: The science of sustained and sustainable career success: what to know and do** ETLC E1-003 Chair: Cuiying Jian							
17:30 - 18:30	**Poster Session** ICE 8th Floor lobby							

24th Jun 2025

07:30 - 08:30	**Breakfast** ETLC Solarium							
08:30 - 09:30	**Plenary Talk - Marie Pierre Krafft (University of Strasbourg)** ETLC E1-001 Chair: Hans-Jürgen Butt							
09:30 - 10:00	**Coffee Break** ETLC Solarium							
10:00 - 11:40	**Fabrication Methods & Colloidal Metamaterials - 1** ICE Incubator Chair: Cuiying Jian	**Rheology and Tribology of Complex Fluids - 3** ETLC E2-001 Chair: Volfango Bertola	**Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 3** NRE 1-001 Chair: Mehrasa Yassari	**Colloids for Sustainability and Energy - 2** ECERF W2-110 Chair: Karthik Shankar	**Colloidal systems for Food: Production, Processing and Sustainability - 3** ETLC E1-018 Chair: Eleni Kalogianni	**General Aspects of Colloid and Interface Science - 2** ECERF W2-010 Chair: Mark Vis	**Self and Directed Assembly - 1** ECERF W2-050 Chair: Wuge Briscoe	**Soft Matter - 3** ETLC E1-003 Chair: Greg Warr
11:40 - 13:20	**Lunch** ETLC Solarium							
13:20 - 15:00	**Fabrication Methods & Colloidal Metamaterials - 2** ICE Incubator Chair: Alidad Amirfazli	**AI Methods in Surface Sciences - 3** ETLC E2-001 Chair: Cuiying Jian	**Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 4** NRE 1-001 Chair: Valeria Milam	**Colloids for Sustainability and Energy - 3** ECERF W2-110 Chair: Karthik Shankar	**Colloidal systems for Food: Production, Processing and Sustainability - 4** ETLC E1-018 Chair: Julia Maldonado-Valderrama	**General Aspects of Colloid and Interface Science - 3** ECERF W2-010 Chair: Vida Jamali	**Self and Directed Assembly - 2** ECERF W2-050 Chair: Wuge Briscoe	**Wetting and Adhesion - 3** ETLC E1-003 Chair: Kevin Golovin
15:00 - 15:20	**Coffee Break** ETLC Solarium							
15:20 - 15:30	**Panel Discussion - From Research to Publication: Editors' Advice** ETLC E1-003 Chair: Wylie Stroberg							
15:30 - 16:20								
16:20 - 16:30	**Break**							
16:30 - 17:30	**Panel Discussion - Colloids & Surfaces at the Forefront: Addressing Global Challenges** ETLC E1-003 Chair: Janet Elliott							
17:30 - 18:30	**Poster Session** ICE 8th Floor lobby							

25th Jun 2025

07:30 - 08:30	**Breakfast** ETLC Solarium							
08:30 - 09:30	**Plenary Talk (IACIS Lifetime Achievement Award) - Dominique Langevin (Université Paris-Saclay)** ETLC E1-001 Chair: Greg Warr							
09:30 - 10:00	**Coffee Break** ETLC Solarium							
10:00 - 12:00	**Surfactants and Colloidal systems in Resource Extraction - 1** ICE Incubator Chair: Zhenghe Xu	**Surfactants and Emulsions - 1** ETLC E1-018 Chair: Lukas Zeininger	**Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 5** NRE 1-001 Chair: Nikolai Denkov	**Colloids for Sustainability and Energy - 4** ECERF W2-110 Chair: Sathish Ponnurangam	**Industrial Applications of Colloid and Surface Systems - 1** ECERF W2-010 Chair: Noemi Nagy	**Molecules and Particles at Fluid Interfaces - 3** ETLC E2-001 Chair: Alberto MARTIN-MOLINA	**Wetting and Adhesion - 4** ETLC E1-003 Chair: Tatiana Gambaryan Roisman	**Self and Directed Assembly - 3** ECERF W2-050 Chair: Saskia Lindhoud
12:00 - 13:20	**Lunch** ETLC Solarium							
13:20 - 15:00	**Surfactants and Colloidal systems in Resource Extraction - 2** ICE Incubator Chair: Edgar Acosta	**Surfactants and Emulsions - 2** ETLC E1-018 Chair: Joachim Venzmer	**Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 6** NRE 1-001 Chair: Alexandra Komrakova	**Colloids for Sustainability and Energy - 5** ECERF W2-110 Chair: Sathish Ponnurangam	**Industrial Applications of Colloid and Surface Systems - 2** ECERF W2-010 Chair: Noemi Nagy	**Molecules and Particles at Fluid Interfaces - 4** ETLC E2-001 Chair: Julianne Gibbs	**Wetting and Adhesion - 5** ETLC E1-003 Chair: Sami Khan	**Self and Directed Assembly - 4** ECERF W2-050 Chair: Ignaas Jimidar
15:00 - 15:20	**Coffee Break** ETLC Solarium							
15:20 - 15:30	**Surfactants and Colloidal systems in Resource Extraction - 3** ICE Incubator Chair: Edgar Acosta	**Surfactants and Emulsions - 3** ETLC E1-018 Chair: Joachim Venzmer	**General Aspects of Colloid and Interface Science - 4** ECERF W2-010 Chair: Remco Tuinier	**Colloids for Sustainability and Energy - 6** ECERF W2-110 Chair: Karthik Shankar	**Industrial Applications of Colloid and Surface Systems - 3** NRE 1-001 Chair: Seyed Seyed Mehdi	**Molecules and Particles at Fluid Interfaces - 5** ETLC E2-001 Chair: Julianne Gibbs	**Wetting and Adhesion - 6** ETLC E1-003 Chair: Francisco Javier Montes ruiz-Cabello	**Self and Directed Assembly - 5** ECERF W2-050 Chair: Xuehua Zhang
15:30 - 17:00								
17:00 - 18:00	**Free Time**							
18:00 - 22:30	**Gala Dinner & Entertainment - Award Presentations** **Edmonton Convention Centre (9797 Jasper Ave, Edmonton)**							

26th Jun 2025

07:30 - 08:30	**Breakfast** ETLC Solarium							
08:30 - 09:30	**Plenary Talk - Himanshu Mishra (KAUST)** ETLC E1-001 Chair: Alidad Amirfazli							
09:30 - 10:00	**Coffee Break** ETLC Solarium							
10:00 - 11:30	**Capillary Phenomenon and Field Effects - 1** ICE Incubator Chair: Janet Elliott	**Surfactants and Emulsions - 4** ECERF W2-110 Chair: Alidad Amirfazli	**General Aspects of Colloid and Interface Science - 5** ECERF W2-010 Chair: Remco Tuinier	**Microfluidics and Nano/Biosensing Devices - 1** ECERF W2-050 Chair: Chun Yang			**Wetting and Adhesion - 7** ETLC E1-003 Chair: Carlo Antonini	
11:30 - 12:00								
12:00 - 13:20	**Lunch** ETLC Solarium							
13:20 - 15:00	**Capillary Phenomenon and Field Effects - 2** ICE Incubator Chair: Janet Elliott	**Surfactants and Emulsions - 5** ECERF W2-110 Chair: Lukas Zeininger	**General Aspects of Colloid and Interface Science - 6** ECERF W2-010 Chair: Mehrasa Yassari	**Microfluidics and Nano/Biosensing Devices - 2** ECERF W2-050 Chair: Sara Hashemi				
15:00 - 15:05	**Conference Closing** ETLC E1-001							

Plenary Presentations

“Asymmetric Vesicles Structures with Unusual Properties Produced with Micorfluidic Systems for Drug Delivery Applications” By

David A. Weitz

Harvard University

Weitz worked for nearly two decades at Exxon Research and Engineering on interfacial phenomena and complex fluids area before moving to academia, first, at the University of Pennsylvania, and then in 1999 when he moved to Harvard University where he is currently the Mallinckrodt Professor of Physics and of Applied Physics. In 2016, Weitz was elected a member of the National Academy of Engineering for “discoveries of complex fluids, colloids, and emulsions”, which have resulted in new products and companies. Weitz is also an elected member of the National Academy of Science and the American Academy of Arts & Sciences. His current focus is on three areas of: (i) growth and dynamics of colloidal crystals, glasses and gels; (ii) use of multiphase fluid flow to create, control and use emulsions with microfluidic devices; and (iii) biophysics with a focus on the mechanical properties of cells, and developing new methods to probe these properties with emphasis on biopolymer networks, and the study of rheological properties of such systems.

“Thermodynamically Stable Oil-in-Oil Microemulsionson” By

Marie Pierre Krafft

University of Strasbourg

Marie Pierre Krafft is Research Director at the Institut Charles Sadron (CNRS), University of Strasbourg (France). Her research focusses on the design, engineering and investigation of fluorocarbon-promoted molecular self-assemblies, colloids and interfaces, including nano- and microemulsions, microbubbles, micelles and vesicles, life-mimicking active droplets, and fluorocarbon-based therapeutics. She is also concerned with PFAS-related environmental remediation issues. She published over 200 papers, holds 12 patents, delivered over 100 invited lectures in International Meetings, is Co-Editor-in-Chief for *Current Opinion in Colloid Interface Science*. She has received Awards from the French Académie des Sciences, Chemical Society of Japan, Fluorous Technology Committee, is a Member of the European Academy of Sciences and Chevalier de la Légion d’honneur.

“On the Role of Surfactants in Emulsions and Foams” By

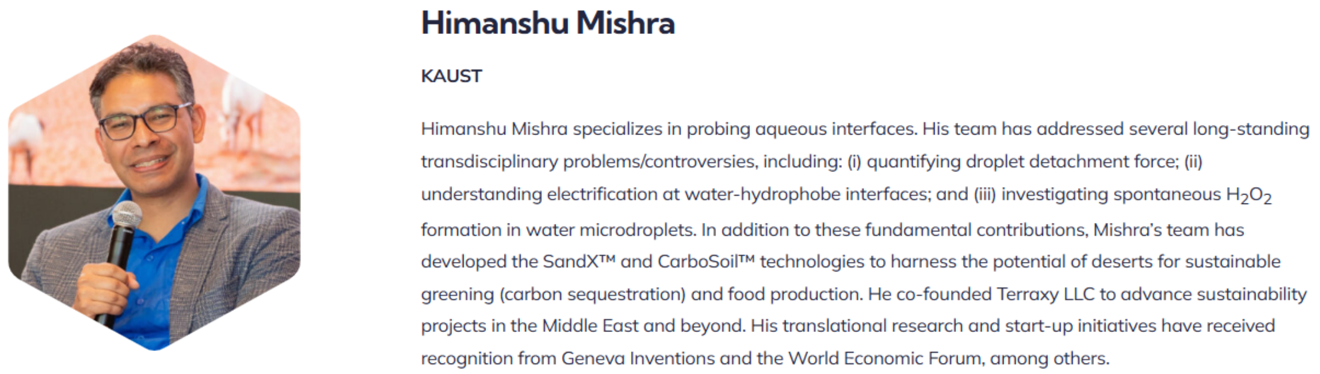
Dominique Langevin

Université Paris-Saclay

Dominique LANGEVIN studied at Ecole Normale Supérieure Paris and became afterwards CNRS research scientist, being presently directeur de recherche emeritus. She began her research at the Physics laboratory of Ecole Normale Supérieure. She directed later the Centre de Recherche Paul Pascal, Bordeaux. She works presently at the Physique des Solides laboratory, University Paris-Saclay. She is member of Academia Europea and received various awards among which the L’Oreal-Unesco Women in Science award, and the Overbeek Gold Medal. Her research topics focus on studies of the dynamic behavior of interfaces between complex fluids (surfactants, polymers, liquid crystals, nanoparticles) with various techniques, mainly optical, such as light scattering. She is specialist of interfacial rheology and its relation with foam, emulsion and microemulsion properties. She wrote a book on these topics in 2020.

Dr. Dominique Langevin is the recipient of the IACIS Lifetime Achievement Award.

“Water–Hydrophobe Interfaces: Facts, Artifacts, and Global Food–Water–Climate Security” By



Himanshu Mishra

KAUST

Himanshu Mishra specializes in probing aqueous interfaces. His team has addressed several long-standing transdisciplinary problems/controversies, including: (i) quantifying droplet detachment force; (ii) understanding electrification at water-hydrophobe interfaces; and (iii) investigating spontaneous H_2O_2 formation in water microdroplets. In addition to these fundamental contributions, Mishra’s team has developed the SandX™ and CarboSoil™ technologies to harness the potential of deserts for sustainable greening (carbon sequestration) and food production. He co-founded Terraxy LLC to advance sustainability projects in the Middle East and beyond. His translational research and start-up initiatives have received recognition from Geneva Inventions and the World Economic Forum, among others.

Keynote Presentations

“Protein Colloid Assembly and Its Applications in Healthy Foods and Biomaterials”
By Lingyun Chen, University of Alberta

“Interactions between Nanoparticles and Soft-Matter-Liquid Interfaces: Towards Developing Generic Nanocomposites, Conductive Inks with Low Sintering Temperatures, and Droplet-Based Cargo Transfer Mechanisms”
By Siddhartha Das, University of Maryland

“Multi-Dimensional Manipulation of Solid-Liquid Interaction”
By Xu Deng, University of Electronic Science and Technology of China

“Precision Agriculture with Colloids”
By Jordan Dinglasan, Vive Crop Protection

“Exploring Colloidal and Interfacial Systems: Data-Driven Insights into Partial Molar “Volumes and Water-in-Oil Droplet Coalescence”
By Cuiying Jian, York University

“Biomolecular Induced Chiral Assembly of Plasmonic Nanoparticles”
By Kun Liu, Jilin University

“Nanocomposite Synthesis via Brush-Grafted Colloids”
By Rob Macfarlane, MIT

“Self-Assembled Nanopolysaccharide Gels for Multifunctional Lightweight Materials”
By Orlando Rojas, University of British Columbia

“Plant Protein Particles: from Bulk to Surface Properties”
By Anwesha Sarkar, University of Leeds

“Colloidal Drug Aggregates: from Lemons to Lemonade”
By Molly Shoichet, University of Toronto

“Dynamic Nature of Static: Charge Separation and Transfer at all Interfaces of Matter”
By Siow Ling Soh, National University of Singapore

“Surface Interactions of Non-Newtonian Droplets”
By Outi Tammisola, KTH Royal Institute of Technology Stockholm

“Colloidal Science in Heavy Oil Extraction from Canadian Oil Sands”
By Zhenghe Xu, Southern University of Science and Technology

“Self-regulating Complex Droplets as Nano-to-macro Messenger Colloids”
By Lukas Zeininger, Max Planck Institute of Colloids & Interfaces

ACS Division of Colloid and Surface Chemistry
Victor K. LaMer Award Lecture

“Elastic Turbulence in 3D Porous Media” By

Christopher A. Browne

University of Pennsylvania

Dr. Brown is currently a postdoctoral fellow at the University of Pennsylvania’s Center for Soft and Living Matter. His work focuses on studying soft matter and fluids in complex settings. He obtained his B.S. in Chemical Engineering from Purdue University, conducting research on the surface adhesion of explosive binders with Prof. Stephen Beaudoin. He received his Ph.D. in Chemical Engineering from Princeton University studying viscoelastic flow instabilities, porous media flows, and percolation dynamics with Prof. Sujit Datta. His postdoctoral work with Prof. Chinedum Osuji at the University of Pennsylvania studies emergent activity that arises during the phase separation of liquid crystal mixtures. He will join the University of Michigan in Spring 2026 as an Assistant Professor of chemical engineering.

ACS Unilever Award

Recipient

Alexandra Bayles

University of Delaware

IACIS Emerging Investigator Award Finalists

Dr. Rose Cersonsky
University of Wisconsin Madison

Dr. Diana Cholakova
Sofia University

Dr. Tianyi Han
Tsinghua University

Dr. Ignaas Jimidar
Vrije Universiteit Brussel

Dr. Stefania Ketzetzi
Harvard University

Dr. Shurui Miao
University of Oxford

ACS Langmuir Graduate Student Award Finalists

Camille Brigodiot,
IFP Energies Nouvelles

Lin Chen
University of Helsinki

Wanran Lin
Southern University of Science and Technology

Jonathan Martín González
Friedrich-Alexander-Universität Erlangen-Nürnberg

Ali Mirzaalian Dastjerdi
University of Alberta

Junyong Park
Chung-Ang University

Mohammadamin Rashidi
University of Alberta

Meenal Rathi
University of Minnesota

Leslie Vanessa Sanchez Castillo
University of Alberta

Amirhossein Taghipour
University of Alberta

Qimeng Yang
University of Toronto

Charles Yeh
University of Pennsylvania

Plenary Talk - David A. Weitz (Harvard University)

08:30 - 09:30 Monday, 23rd June, 2025
ETLC E1-001
Tian Tang

Asymmetric vesicles structures with unusual properties produced with micorfluidic systems for drug delivery applications

AI Methods in Surface Sciences - 1

10:00 - 12:00 Monday, 23rd June, 2025
ICE Incubator
AI Methods in Surface and Colloid Sciences
Vida Jamali

10:00 - 10:40

318 Exploring Colloidal and Interfacial Systems: Data-Driven Insights into Partial Molar Volumes and Water-in-Oil Droplet Coalescence

Hasan Imani Parashkooh, Cuiying Jian

York University, Toronto, Canada

Abstract

In recent years, data mining techniques have become indispensable for extracting valuable insights from complex molecular simulations of colloidal and interfacial systems. This research utilized these techniques to probe partial molar volumes (PMVs) and explore water-in-oil droplet coalescence using molecular dynamics (MD) simulations.

Examining PMVs provides important insights into structural analyses and molecular interactions in multicomponent systems. However, traditional methods for calculating PMVs are time-consuming and involve complex procedures. By employing linear regression, a novel PMV calculation method was developed. This method uses systematic data sampling from standard MD trajectories, where compositions remain unchanged throughout the simulation. It achieved deviations as low as 1.18% compared to experimental data. Validation on two systems showed absolute deviations of 6.19 cm^3/mol for mesitylene and 7.80 cm^3/mol for isopropanol. The method

was then applied to investigate systems involving asphaltene, organic solvents, and chemical inhibitors, with violanthrone-79 (VO-79) used as a proxy for asphaltene. It was found that adding chemical inhibitors to systems containing VO-79 and solvent led to a decrease in the PMV value, suggesting a reduced Hildebrand solubility parameter and enhanced solubility with increasing concentrations of chemical inhibitors.

Moreover, data mining revealed the interplay between proxy asphaltene (VO-79) aggregation and water-in-oil droplet coalescence. A nonmonotonic trend in the stacking of VO-79 molecules with increasing droplet size was observed, driven by the competing effects of aggregation and adsorption. An in-house tool was developed to examine the coalescence mode of water droplets. This tool extracts and quantifies water molecular behaviors from the high-dimensional space of MD simulation trajectories. It was found that the growth of water droplets is dominated by the largest droplet acting as the nucleation site.

These findings highlight the effectiveness of data mining techniques in analyzing complex molecular systems. The methods developed can be applied to a variety of interfacial and colloidal systems, enriching our understanding of molecular interactions and collective behaviors.

10:40 - 11:00

300 Automated multi-fidelity workflow for optimized synthesis of inorganic nanostructured materials

Abdul Moeez, Lilo Pozzo

University of Washington, Seattle, USA

Abstract

The functional properties of nanostructures are reliant on their morphological characteristics which in turn are dependent on synthesis conditions. The vast synthesis parameter space is often explored through discrete iterations to achieve the targeted properties. In this work, we demonstrate the design of an automated multi-fidelity platform to scan the parameter space and establish direct correlation of synthesis chemistry, processing conditions, nano-scale structure and optical characteristics. We achieve this by integrating microfluidic synthesis with in-line characterization tools such as UV-Vis/NIR spectroscopy and Small Angle X-Ray Scattering (SAXS) to measure optical properties (bandgap) and morphological characteristics (size and shape of the particles), respectively. We demonstrated the use of this workflow to in situ evaluate the evolution of ZnO nanoparticles' structure and optical properties in relation to changes in synthesis parameters. Moreover, with the addition of an optimization strategy, the system can autonomously tune the synthesis parameter space to achieve the targeted morphology and optical characteristics. Furthermore, this workflow is also capable of capturing intermediate phases leading to the formation of final structure. The workflow can contribute to accelerated optimization for synthesis of targeted nanostructures for diagnostic and optical applications.

11:00 - 11:20

397 Application of AI to Accelerate Research Process: Case of Dropwise Condensation

Joaquin Ramirez-Medina[1], Mohammadmehdi Ataei[2], Alidad Amirfazli[1]

[1]Department of Mechanical Engineering, York University, Toronto, Canada. [2]Autodesk Research, Toronto, Canada

Abstract

Development of novel ideas such as electro-wetting assisted dropwise condensation to create high-tech condensers, requires integration and synthesis of current expansive literature across various areas such as, physical chemistry, heat transfer, droplet adhesion, and electrode design, to name but a few. This is a tedious and time-consuming task, considering the exponential growth of academic publications to review and to conduct subsequent procedural planning. Large Language Models (LLMs) have emerged as powerful AI tools for general-purpose tasks, though they require integration with specialization techniques and additional resources to handle more complex, domain specific tasks, as described above.

To address this need, we have developed the Artificial Research Innovator Assistant (ARIA), a four-agent, multi-LLM framework that integrates data management frameworks and various academic database application programming interfaces. By emulating a team of expert assistants, ARIA systematically replicates the human research workflow to autonomously search, retrieve, and screen thousands of papers. Additionally, ARIA synthesizes identified relevant literature into actionable research procedures. In a case study for the electro-wetting assisted dropwise condensation, we discuss the utility of the ARIA to gather all relevant literature, synthesize the information relevant to the goal of the research, and to present streamlined, actionable research tasks within an hour, rather than months following traditional practice in the research process.

11:20 - 11:40

162 Data-driven approach for rapid reformulation of high internal phase emulsions.

Michal Roguski[1], Sijie Fu[1], Robert Tilton[1], Lynn Walker[2], Newell Washburn[1], Eric Johnson[3]

[1]Carnegie Mellon University, Pittsburgh, USA. [2]University of Minnesota, Minneapolis, USA. [3]Procter and Gamble, Mason, USA

Abstract

High internal phase emulsion stability is a multivariable problem that has been studied for decades and is of interest to many industries. However, the impact of the physical properties of emulsifiers and oil phases on the overall emulsion stability is poorly understood. We present a systematic study of the impact of properties of oil phases and emulsifiers on the stability of emulsions. Machine learning is used to discover patterns in properties of the oil phase of the emulsions and the emulsifiers across a wide range of materials. The emulsions are studied with a high throughput optical method and the data is analyzed with a machine learning model. The model is used to learn relationships between the physical properties of emulsifiers and oil phases and predict the emulsion stability of previously untested formulations with MAE = 0.1235. The key features determining emulsion stability are also identified and include features whose values depend on the properties of both emulsifiers and oils and the key physical properties of emulsifiers.

11:40 - 12:00

304 AI-Driven Automated Workflow for Optimized Synthesis of Stöber Silica Particles

Brenden Pelkie, Chi Yuet Yung, Lilo Pozzo

University of Washington, Seattle, USA

Abstract

Monodisperse silica nanoparticles and colloids are synthesized through the established Stöber sol-gel process involving common precursors and ambient conditions. Research developments over decades have uncovered the necessary synthesis conditions to create both solid spherical and mesoporous nanoparticles with internal porosity with sizes spanning from tens of nanometers to micrometers. Yet, within this accessible synthesis process there is still incredible complexity with inter-relationships in the multi-dimensional parameter space that must be navigated to attain a desired level of morphological control. Particle diameter, polydispersity, and internal structure or 'porosity' are all controlled by many interdependent and often competing factors including precursor identity (surfactants, silanes), concentrations, pH, and temperature amongst others. This large parameter space makes it challenging to achieve retrosynthetic planning for the synthesis of particles with a specific target morphology (e.g. specific size, porosity, and dispersity). Accelerated experimentation via automation and artificial intelligence integration can aid in selecting appropriate synthesis conditions to achieve target particle morphologies for use in applications including catalytic supports and drug delivery, among others. We have developed an automated experimentation platform and workflow for high-throughput synthesis and autonomous closed-loop optimization of silica nanoparticles. This system uses the Jubilee laboratory automation platform to create nanoparticles via sol-gel synthesis processes, and a custom sample loading system to integrate small angle x-ray scattering (SAXS) structural characterization. A shape-based distance metric is used to compare synthesized samples to target particle morphologies, and Bayesian optimization is used to select sample synthesis conditions. This system can be operated in 'high-throughput synthesis' mode, where it has enabled us to extensively explore the relationships between synthesis parameters and morphological outcomes for silica

nanoparticles. It can also operate in 'target optimization' mode, where we are using it to synthesize silica nanoparticles with arbitrarily selected target diameters, dispersity and, potentially, porosities.

Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 1

10:00 - 12:00 Monday, 23rd June, 2025
NRE 1-001
Wetting and Adhesion Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces
Mohtada Sadrzadeh

10:00 - 10:20

308 Artificial Compound Eye for Clear Vision in Harsh Environment

Kehinde Kassim, Qiuyun Lu, Xuehua Zhang

University of Alberta, Edmonton, Canada

Abstract

ABSTRACT

The compound eye (CE) is known for its optical perception system, expansive field of vision, high light sensitivity, and motion tracking capabilities. In this study, we developed a superhydrophobic compound eye using microdroplet polymerization, soft lithography, and surface modification. The fabricated superhydrophobic CE maintains clear vision even underwater and in harsh environments. We demonstrate the exceptional imaging and motion tracking abilities of the CE by capturing the spatial orientation of a crawling spider and a moving thread, achieving a remarkable field of view and detailed information. Our results show that the CE can image alphabetic letters in rainy and foggy conditions. The superhydrophobic CE effectively recovered images that were distorted by rain and exhibited six times the fog resistance compared to a hydrophilic CE, ensuring that projected images remained visible up to three times longer in heavy fog. Additionally, a machine learning algorithm, trained on a dataset of 300,000 CE images of the five vowels in fog, achieved 100% validation accuracy in identifying blurred images. The superhydrophobic CE holds great potential for applications in outdoor visualization, motion detection, and signal identification in adverse weather conditions.

Keywords: Ommatidium, Droplet array, Motion tracking, Machine learning, Optical imaging

https://doi.org/10.1002/adfm.202402466

10:20 - 10:40

177 Bio-inspired Structures: Beyond Self-assembly of Particles

ASHISH KUMAR THOKCHOM

Soft Matter Lab, Department of Chemical Engineering, Shiv Nadar Institution of Eminence Deemed to be University, Greater Noida, India

Abstract

Structuring solution-mediated materials is a fundamental requirement for desired high-performance functions of the materials in various applications. Traditional microscale patterning not only boosted the microelectronics industry but also allowed the emergence of a lab on a chip for low-cost analytical instrumentation in parallel. In particular, nanoscale feature size opened new opportunities by offering many advantageous chemical, optical, electrical, and thermal characteristics derived from their high surface-to-volume ratio. For this reason, it is highly demanding to develop effective methods that are not only simple and low-cost but also are less limited in dimension, complex structure, and even 3-D patterns and/or structures. Several fabrication methods have been developed such as lithography, nanoimprinting, and microcontact printing etc. Compared with the above-mentioned techniques, inkjet printing is a direct depositing technique using liquid-phase materials. By virtue of its cost-effectiveness, ease of handling and speediness, the inkjet printing technique has become a reliable technique for high-quality and well pattern fabrication. The surface morphologies of injected droplets are strongly influenced by many factors such as substrate wettability, ink rheology, printing apparatus and external field. As a result, it is still difficult to obtain desired morphologies by inkjet printing.

The proposed research is to understand the basic underlying mechanism for obtaining monolayer self-assembly of nanoparticles on the substrate and the corresponding photonic nature. Later, the monolayer self-assembly of nanoparticles on the substrate will be used as mold to create for the development of flexible microstructure techniques for various applications such as tunable photonic crystals for anti-counterfeit, chemical sensors, camouflage etc.

10:40 - 11:00

277 Adsorption Dynamics and Interfacial Morphology of Lung Surfactant

Ziwen He[1], Zachary MacAllister[1], Soyoon Yoon[2], Joseph Zasadzinski[1]

[1]University of Minnesota, Minneapolis, USA. [2]Minneapolis, Minneapolis, USA

Abstract

Lung surfactant is essential for proper mammalian breathing, as it prevents lung collapse by lowering surface tension at the alveolar liquid-air interface. While surfactant monolayers are often studied on flat surfaces using a Langmuir trough, alveoli are inherently spherical. Here, we studied the adsorption dynamics and morphological changes of Survanta, a clinical replacement lung surfactant, using a micrometer bubble-based microtensiometer and confocal fluorescence microscopy. We record the evolution of the surface tension during adsorption while simultaneously imaging the interface with high-speed confocal microscopy. We observed coexisting liquid-ordered and liquid-disordered phases which have never been observed before in the absence of cholesterol. We also observe the morphological progression of liquid condensed domains in a liquid expanded matrix. We confirmed a theoretically predicted circle-to-stripe transition of the liquid-condensed (LC) phase domains driven by the curvature of the alveolar sized air bubbles ($R < 100$ µm), driven by an anisotropic bending energy cost. A scaling law was used to describe the average stripe width on curved surfaces as a function of the bubble radius, line tension, and Young's modulus. These findings provide new insights into the physiological effects of Survanta monolayers in treating neonatal respiratory distress syndrome (NRDS) and enhance our understanding of treatment pathways for acute respiratory distress syndrome (ARDS).

11:00 - 11:20

298 Adsorption and competitive adsorption of Monoclonal Antibodies and non-ionic Surfactants at the air-water interface

Benjamin Thompson[1], Kiet Pham[1], Ken Qian[2], Yun Liu[3], Norman Wagner[1]

[1]University of Delaware, Newark, USA. [2]Lilly, Indianapolis, USA. [3]National Institute of Standards and Technology, Gaithersburg, USA

Abstract

Monoclonal antibodies (mAbs) adsorb strongly at the air-water (a/w) interface, which can lead to the formation of visible and sub-visible particles in solution that adversely affect therapeutic efficacy and immunogenicity of protein formulations. Prior work in our group shows that interfacial shear elastic modulus of adsorbed mAbs correlates strongly with the long term (3 year) stability in solution (*J.Phys.Chem.B, 2023).* To mitigate interface-induced instability in formulation and delivery, the biopharmaceutical industry employs excipients, such as non-ionic surfactants, to rapidly adsorb to and protect against mAb adsorption at interfaces. To better elucidate molecular interactions at the a/w interface during mechanical deformation the interfacial pressure and rheology are measured for adsorbed mAb at the a/w and with Poloxamer 188 (P188) along with Brewster angle microscopy (BAM), and neutron reflectometry (NR). mAb adsorbs rapidly to the air-water interface, but the evolution of surface pressure and interfacial shear moduli continues long after the equilibrium surface excess has been reached. NR measurements quantify changes in the molecular layer when undergoing dilatational stresses. Injection of P188 into the subphase below an established mAb interface results in an increase in surface pressure and a decrease in interfacial shear moduli; however, mAb remains at the interface with a greatly modified mesoscale surface topology. Comparisons to adsorption from a pre-mixed mAb-P188 solution highlights the importance of the order of addition in therapeutic formulations and the results link macroscale behavior at the a/w interface to molecular interactions.

11:20 - 11:40

259 Using Diffusion Instabilities to Measure Line Tension in Lipid Monolayers

Zachary McAllister[1], Cain Valtierrez-Gaytan[1], Alexander Smith[1], Joseph Barakat[2], Bjorn Solberg[3], Aidan Dosch[3], Benjamin Stottrup[3], Joseph Zasadzinski[1]

[1]University of Minnesota, Minneapolis, USA. [2]University of California, Santa Barbara, USA. [3]Augsburg University, Minneapolis, USA

Abstract

Lipid monolayers are effective models for studying biological membranes and their corresponding interfacial phenomena. Although many properties of monolayers have been studied extensively—including surface tension and compressibility—the role of line tension at phase boundaries remains underexplored. We employ a new understanding of the Mullins-Sekerka theory in two-dimensions to showcase a technique for measuring the line tension of lipid monolayers requiring no perturbation to the monolayer other than standard confocal microscopy techniques. This first-of-its-kind technique is used to determine and compare the line tension of liquid-condensed-liquid-expanded monolayers with various sterol groups and can be coupled with phase equilibrium theory to determine the dipole density difference.

11:40 - 12:00

445 From active colloids to self-reconfiguring active molecules

Stefania Ketzetzi

Harvard University, Cambridge, USA

Abstract

Synthetic microswimmers in the form of active colloidal particles are prominent candidates for numerous applications, for example in microsurgery or biomedicine, where they could be used as probes for diagnostics or deliver drugs at specific locations within complex environments. Recently, their strong affinity for surfaces (1, 2) was leveraged in experiments that incorporate microprinted structures, causing capture along one-dimensional paths. Along those paths, colloids exhibit a plethora of cooperative behaviors (3) that open the door towards increasing motion efficiency.

Nevertheless, active colloids still lack internal flexibility and self-regulation as well as active response to their surroundings, which limits their applicability. To overcome this, we create self-reconfiguring active colloidal molecules and investigate the emergence of adaptive motility under an electric field (4). In this talk, I will show that upon neighbour encounters, the novel properties of self-steering and avoidance emerge from self-reconfiguration. These properties, highly desirable for "intelligent" synthetic microswimmers, are clearly distinct from those exhibited by traditional mechanically pre-configured active colloids and pave the way towards exploring complex biological behaviors with synthetic particles. We propose that self-reconfiguration can promote novel modes of environment navigation and collective organization.

(1) S. Ketzetzi, J. de Graaf, D. J. Kraft. Phys. Rev. Lett. 125, 238001 (2020).

(2) S. Ketzetzi, J. de Graaf, R. P. Doherty, D. J. Kraft. Phys. Rev. Lett. 124, 048002 (2020).

(3) S. Ketzetzi, M. Rinaldin, P. Dröge, J. de Graaf, D. J. Kraft. Nat. Commun. 13, 1772 (2022).

(4) S. Ketzetzi, L. Caprini, V. Willems, L. Alvarez, H. Löwen, L. Isa. arXiv:2501.00672 (2024).

Colloidal systems for Food: Production, Processing and Sustainability - 1

10:00 - 12:00 Monday, 23rd June, 2025
ETLC E1-018

10:00 - 10:40

70 Plant protein particles: from bulk to surface properties

Prof. Anwesha Sarkar

University of Leeds, Leeds, United Kingdom

Abstract

Dispersions of liquid emulsion droplets or gas bubbles stabilized by colloidal particles (via the Pickering stabilization mechanism) are highly resilient towards coalescence and Ostwald ripening as compared with conventional dispersions stabilized by surfactants or polymers. In the last decade, major advances have occurred in the use of plant-based colloidal particles for the stabilization of emulsions. In this keynote talk, the characteristics of plant protein-based particles with respect to their particle size, degree of aggregation, hydrophobicity and electrical charge will be discussed. Specific effects of processing on bulk rheology will be highlighted. Particularly, a case study on stabilization of emulsions by pea protein microgels and their ability to stabilise interfaces will be discussed. Special emphasis will be directed towards the issue of correctly defining the stabilization mechanism to distinguish those cases where the particles are acting as genuine Pickering stabilizers, through direct adsorption at the liquid–liquid interface, from those cases where the plant-based particles are predominantly behaving as 'rheology modifiers' jamming the droplets without necessarily adsorbing at the interface. Some key concerns of astringency issues of plant proteins during oral processing will be addressed and how microgelation of plant proteins can help to address those tribological issues will be discussed, where experiments are conducted using 3D biomimetic tongue-like surface. Finally, outlook in the field of plant-based particles for food applications will be highlighted.

Acknowledgement: The UK National Alternative Protein Innovation Centre (NAPIC) funded by the Biotechnology and Biological Sciences Research Council (BBSRC) and Innovate UK (Grant No. BB/Z516119/1) is acknowledged.

10:40 - 11:00

214 Enzymatic modification of the oil-water interface – structural changes to understand and control the dispersion of acylglycerols

Eimantas Gladkauskas[1], Jennifer Gilbert[2,3], Ben Humphreys[2,4], Anna Maria Pina Canaveras[2,5], Jenny Lindberg Yilmaz[1,6], Tommy Nylander[2,7,8,9], Patrick Adlercreutz[1], Cecilia Tullberg[1]

[1]Biotechnology, Lund University, Lund, Sweden. [2]Physical Chemistry, Lund University, Lund, Sweden. [3]Chemical Biology, Chalmers University of Technology, Gothenburg, Sweden. [4]Institut Laue-Langevin, Grenoble, France. [5]Biomedicine, University of Barcelona, Barcelona, Spain. [6]Experimental Medical Science, Lund University, Lund, Sweden. [7]NanoLund, Lund University, Lund, Sweden. [8]LINXS Institute of Advanced Neutron and X-ray Science, Lund, Sweden. [9]School of Chemical Engineering and Translational Nanobioscience Research Center, Sungkyunkwan University, Suwon, Sweden

Abstract

The demand from consumers and industry for sustainably produced and healthy ingrediencies for food and pharmaceuticals that also ensures product quality and processability has increased. The modification of edible oils from plant raw materials by using recent advances in enzyme technology offers the possibility to obtain dispersed system on the nanoscale with a minimum of additives. Based on neutron and x-ray data we will show the nature of the oil/water-interphase and how the processes that can occur during lipolysis can change the structure and composition in the interfacial layer. The structural changes are controlled by the pH. We show that when adding lipase to the concentrated oat oil dispersion, the appearance evolves from thick creamy emulsion to a gel-like structure without additives. Small angle x-ray scattering (SAXS) and cryogenic transmission electron microscopy (cryoTEM) allowed us to determine the phase behaviour and structure of the formed dispersions, which could be related to the lipid composition as determined by thin layer chromatography (TLC). The lipid composition changes due to the lipolysis, which lead to a decrease in triglycerides and an increase in mono- and diglycerides as well as fatty acids. The nano-structural change in the dispersion which evolves from a reverse hexagonal phase to produce a Fd3m reverse micellar cubic phase. This transition time could be manipulated by the choice of lipase as well as the processing conditions. Well-defined liquid crystalline nanoparticles could be formed upon dilution. These can be used for formulation of nutrients, drugs and other bio-functional ingredients without adding stabilizers and dispersing agents.

11:00 - 11:20

118 Interfacial tension measurements as means to better comprehend oil separation during enzymatically assisted oil extraction

Eleni P. Kalogianni, Paraskevi Tzika, Despoina Georgiou

International Hellenic University, Thessaloniki, Greece

Abstract

A late trend in oil extraction in the food industry is enzymatically assisted extraction in which the protein and/or polysaccharide rich material adsorbed on the oil/water interface is hydrolyzed with the use of enzymes to liberate the oil droplets and allow them to be separated using physical methods. Such methods can be used for different material including fish by-products the valorization of which is becoming increasingly important considering sustainability, the growth of population as well as their high nutritional value. Fish by-products are a rich source of nutrients such as omega-3 fatty acid lipids, however these lipids are are mechanically entrapped and/or emulsified in a proteinaceous material. Such emulsions are often difficult to break and separate and therefore the nutritive value of these oils is under-valorized and not used for human cosumprion.

In this work we attempt to obtain a better comprehension on the phenomena occurring at the oil/water interface during enzymatic hydrolysis via interfacial tension and interfacial rheology measurements. To our knowledge oil separation from fish by-products has not been addressed previously as a process controlled by interfacial phenomena. In this work, by-products of *Todarodes saggitatus* (European flying squid) are used which are rich in omega-3 fatty acid oils but difficult to extract. In addition, the oil in fish by-product emulsion during enzyme activity is monitored via Confocal Laser Scanning Microscopy (CLSM) and correlated with the oil yield during the separation processes.

11:20 - 11:40

141 Foamability and Interfacial Properties of Plant-based Milks

Shuting Xu, Yuan Xu, Ming Yao Lim, Jason Stokes

University of Queensland, Brisbane, Australia

Abstract

Foam is critical in many food products, such as cappuccino-style beverages, where foamability and stability are usually key factors influencing product quality and consumer perception. Plant-based milks formulated with combinations of plant proteins (e.g., from almonds, soy, or oats), oils, polysaccharides, and fibres, are increasingly used as dairy alternatives, yet achieving desirable foaming properties remains challenging. We studied the foaming properties of several commercial UHT-treated plant-based milks and found that notable differences in foamability, stability, morphology, liquid content, and rheology (Fig.1). The variations were attributed to differences in protein type (solubility and hydrophobicity), protein concentration, and the presence of polysaccharides (including starch), fibres, and insoluble particles such as protein aggregates.

To gain a more fundamental understanding, model plant-based milk systems were created by systematically varying protein types and concentrations, as well as oil, and polysaccharides. Interfacial properties of model milks, such as dynamic surface tension, interfacial viscosity, and viscoelasticity, were studied using tensiometry and interfacial rheometry. The findings indicated that the type of plant protein primarily determines adsorption kinetics and conformational changes at the air-water interface, which substantially differ from dairy systems. These interfacial behaviours, in turn, dictate foamability and the properties of foams in the model systems. These findings provide insights into the relationships between composition, interfacial behaviour, and foaming performance in plant-based milks, offering a basis for optimizing the foaming properties of plant-based food applications.

11:40 - 12:00

405 Interfacial Characterization of Protein Films by Imaging Spectroscopic Ellipsometry (ISE) and Brewster Angle Microscopy (BAM)

Peter H. Thiesen[1], Liesa M. Thiesen[2], Lucas Sales Queiroz[3], Federico Casanova[3]

[1]Park Systems GmbH, Göttingen, Germany. [2]Justus-Liebig-Universität, Gießen, Germany. [3]DTU - Technical University of Denmark, Lyngby, Denmark

Abstract

In the search for sustainable solutions in the food industry, research into alternative protein sources in general and interfacial properties of these candidates in particular is a central question in current food science.

A central parameter is the layer formation of the protein layers that can be thickness, especially directly at the air water interface at the air/water interface

Current example of the characterized the air-water interfacial properties and foaming functionality of Lupine protein-pectin mixtures (Xingfa Ma et al. 2025), refined rapeseed protein (Panayiotis Voudouris, 2025) Lentil protein isolate (Penghui Shen 2025). The layer thickness was determined using an imaging ellipsometer.

The focus of our presentation - In addition to an overview of current research work – will be the characterization of different proteins with high and low tendency towards film formation. Time depending Imaging Spectroscopic Ellipsometry (ISE) as well as Brester Angle Microscopy (BAM) with regard to the dynamic behavior at the air-water interface, the film formation and the drying behavior at the solid gas interface.

Fig. 1. BAM images of the surface of Fish Galantine (a) Beta Lacto Globuline (b) Pea protein (d), the mixture from Pea Protein + Beta Lacto Globuline (c). Additionally an ellipsometric contrast micrograph (ECM) under substrate nulling conditions of the drying residue from 5 µl Beta Lacto Globuline solution (e) and the thickness maps at t= 0 and 3540 s, calculated for the pea protein based microscopic Delta and Psi map and the refractive index calculated from i-VASE measurements of an analog pea protein film.

References:

Xingfa Ma et al. (2025) Food Hydrocolloids 158, Part 1, 110567,

Panayiotis Voudouris et al. (2025) Food Hydrocolloids, 160, Part 1, 110754.

Penghui Shen et al. (2024) Food Hydrocolloids 147, Part A, 109342,

General Aspects of Colloid and Interface Science - 1

10:00 - 12:00 Monday, 23rd June, 2025
ECERF W2-010
General Aspects of Colloid and Interface Science
Piotr Warszynski

10:00 - 10:20

217 Effect of polymer chain stiffness on depletion layers in colloid–polymer mixtures

Max Martens, Stijn van Leuken, Joeri Opdam, Mark Vis, Remco Tuinier

Eindhoven University of Technology, Eindhoven, Netherlands

Abstract

Mixtures of colloidal particles with non-adsorbing polymers are ubiquitous both in science and in industry. The non-adsorbing polymers induce an effective attraction between the colloidal particles, known as the depletion interaction, and as a result colloid–polymer mixtures display rich physics. Theoretical descriptions of such systems historically assumed the polymer chains to be fully flexible coils, while in reality many polymers have a certain degree of chain stiffness. The effect of this stiffness on the depletion interaction and the resulting phase behavior of these mixtures is as of yet poorly understood, even though it is highly relevant for describing realistic systems.

We present a new analytical theory [1,2] that describes the concentration profile and depletion thickness of a solution of non-adsorbing semiflexible polymers next to a flat surface. Our theory covers both the dilute and semidilute regime. For fixed polymer radius of gyration, increasing the chain stiffness leads to a monotonic decrease in the depletion thickness in dilute conditions. However, in the semidilute regime, remarkably there is a maximum in the depletion thickness as a function of the chain stiffness. Furthermore, we present an extension of the theory towards semiflexible polymer solutions around spherical colloids, yielding insights into the phase stability of colloid–polymer mixtures. The analytical expressions are in quantitative agreement with numerical self-consistent field calculations and experiments.

[1] C. M. Martens et al.,*PCCP* **24**, 3618 (2022).

[2] C. M. Martens, *PhD thesis* (2024)

10:20 - 10:40

326 Covalent Functionalization of Two-Dimensional Borophene Nanosheets

Shauvik Bhattacharya, Noor Abdulqader, Mark McDermott

University of Alberta, Edmonton, Canada

Abstract

Borophene, a two-dimensional material composed entirely of boron atoms, has emerged as a material of great scientific interest due to its exceptional electronic, mechanical, and optical properties. Its high surface area, tunable electronic structure, and outstanding conductivity make it suitable for a wide range of applications, including energy storage devices, superconductors, gas sensors, and biosensors. Despite its promising characteristics, pristine borophene is relatively chemically inert, which limits its direct use in many applications. Covalent functionalization provides an effective strategy to overcome this limitation by introducing new functionalities. This approach can enhance borophene's properties, such as opening its bandgap, tuning its electrical conductivity, and improving its solubility and stability.

In this study, the chemical functionalization of borophene nanosheets through aryl diazonium chemistry has been investigated. Both direct covalent and electrochemical functionalization routes were explored to modify the surface properties of borophene nanosheets. The functionalized materials were characterized comprehensively using scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), X-ray photoelectron spectroscopy (XPS), and Raman spectroscopy. These techniques confirmed successful modification and revealed structural and chemical changes in the borophene nanosheets. Furthermore, we demonstrate the application of functionalized borophene as a Surface-Enhanced Raman Scattering (SERS) active substrate for biosensing. This work underscores the transformative potential of chemically functionalized borophene in advancing next-generation biosensing technologies and expanding its applicability across diverse scientific and technological domains.

10:40 - 11:00

73 Crystallization of organic molecules in surface nanodroplets driven by in situ liquid-liquid extraction and droplet dissolution

Jae Bem You

Chungnam National University, Daejeon, Korea, Republic of

Abstract

Droplets have been widely used for studying crystallization reactions which are difficult to control in the bulk. Most crystallization studies, however, rely on the evaporation or dissolution of the droplet liquid to achieve crystal growth and these methods do not enable the control of supersaturation rate. In this talk, surface nanodroplets are used for controlling the supersaturation and crytallization of organic molecules. Crystallization is achieved by the fast liquid-liquid extraction of organic molecules from its aqueous solution into the surface nanodroplets with concurrent dissolution of the droplets by the continuously flowing aqueous stream. The synergy between liquid-liquid extraction and droplet dissolution drives supersaturation inside the surface nanodroplets that ultimately leads to nucleation and crystallization of organic molecules. The influence of molecule concentration and solution flow rate is investigated by tuning these parameters independently. The method shown in this work can potentially be used in the formation of single crystals which is important in many areas including semiconductors, pharmaceuticals, and energy devices.

11:00 - 11:20

93 Adsorption of polydisperse charged polymers on porous cellulose fibers

Abdollah Karami, Robert H. Pelton, Jose Moran-Mirabal

McMaster University, Hamilton, Canada

Abstract

A standard surface treatment technology in pulp and papermaking is the adsorption of cationic water-soluble polymers onto negatively charged pulp fibers. The presence of such polymers is important to enhance paper wet and dry strength. Many of the most important polymers have broad molecular weight distributions, and much of the fiber/water interfaces are in pores that are inaccessible to the highest molecular weight fractions. The polymer adsorption isotherms are rich in details. This contribution presents a new adsorption data analysis for polydisperse cationic polymers adsorbing onto negatively charged porous cellulosic substrates. We developed expressions to estimate the saturation amount of polymer on the fibers' exterior surfaces (Γ_{ex}) and the maximum fraction of added polymer that can access pore (interior) surfaces (f_{max}) using parameters directly extractable from the isotherm. These include the maximum polymer dose that can fully adsorb (Γ_I), which corresponds to the y-axis intercept, the slope of the isotherm at the intercept (S_{max}), and the maximum adsorption capacity (Γ_{max}). We applied this analysis to the adsorption of polyamide-amine epichlorohydrin (PAE), a commercial polydisperse polymer, onto bleached kraft pulp fibers treated with hydrolyzed ploy(ethylene-alt-maleic anhydride), PEMAc, and its derivatives, to give a range of carboxylic acid contents. High molecular weight PEMAc grafting introduced many carboxylic acid groups, increasing PAE adsorption compared to untreated pulp fibers. Finally, PAE adsorption was not stoichiometric. A ratio of 2:1 of carboxylic acid groups to cationic PAE equivalent was determined.

11:20 - 11:40

122 Structuring of Interfacial Water and Specific Ion Effects in Carbon Mineralisation

Shurui Miao, Kieran Agg, Susan Perkin

Physical and Theoretical Chemistry Laboratory, University of Oxford, Oxford, United Kingdom

Abstract

Accelerated carbon mineralisation recently emerged as a promising approach for long-term carbon sequestration. This process involves reacting naturally abundant minerals (e.g. basalt, rich in Ca^{2+} and Mg^{2+}) with aqueous CO_2 solution to form stable carbonate minerals.[1] However, its molecular mechanism remains largely unknown due to the lack of direct experimental data probing structures and forces near the solid-liquid interface.[2] Nonclassical 2-steps crystallisation is now widely recognised as pathways of carbonate mineral formation.[3,4] A common feature to such nonclassical mechanism is the formation of correlated ion clusters prior to crystallisation. The formation of these hydrated clusters and the drainage of solvents are closely related to the ordering of the water near the solid-solution interface. Our work uses surface force balance to measure the force between mineral surfaces across electrolyte solutions with micro-Newton and Angstrom precision. We observed unexpected long-range repulsive forces that cannot be explained by the DLVO theory, and it is insensitive to ionic strength (beyond a threshold concentration) and pH. This work provides key experimental results and insights to understand the specific ion effects at the solid-liquid interface, which is critical to the design and engineering of solution processes and colloidal systems such as carbon mineralisation.

[1] J. M. Matter, et al., Science 352, 1312-1314 (2016)

[2] J. J. De Yoreo, et al., Science 349, aaa6760 (2015)

[3] P. J. M. Smeets, et al., PNAS, 114 (38) E7882-E7890 (2017)

[4] B. Jin., et al. Nat. Mater. 24, 125-132 (2025)

11:40 - 12:00

86 Ion Adsorption and Hydration Superlubricity

Tianyi Han[1], Chenhui Zhang[1], Jianbin Luo[1], Xavier Banquy[2]

[1]Tsinghua University, Beijing, China. [2]Université de Montréal, Montreal, Canada

Abstract

Aqueous lubricants play key roles in many mechanical, technical, medical, physiological, and biological applications, particularly over the past twenty years or so, their role in boundary lubrication has been widely studied. The role of hydrated ions in aqueous superlubricity has long been known. The structure of hydrated ion layers adsorbed on solid surfaces that determine the lubricating properties of aqueous lubricants is thought to be invariable in hydration lubrication. However, we prove that the ion surface coverage dictates the roughness of the hydration layer and its lubricating properties, especially under subnanometer confinement. In this study, we systematically evaluate the adsorption and lubrication properties of monovalent, divalent, and trivalent ions at microscale and macroscale conditions through using a surface force apparatus (SFA) and a universal mechanical tribometer (UMT), respectively. The hydration layer structure is characterized by an atomic force microscope (AFM), streaming current measurements and molecular dynamic (MD) simulations. Our results shed light on the origins of boundary superlubricity, with potential applications both for marine engineering and biolubrication.

Rheology and Tribology of Complex Fluids - 1

10:00 - 12:00 Monday, 23rd June, 2025
ECERF W2-110
Rheology and Tribology of Complex Fluids
Volfango Bertola

10:00 - 10:20

79 Self-Assembly of Amphiphilic Copolymers in the DES Reline to Modify Largely the Flow Behavior

Michael Gradzielski, Tomas Omasta, Arshdeep Singh Bains

Technische Universität Berlin, Berlin, Germany

Abstract

Polymers typically do not dissolve easily in deep eutectic solvents (DES) like reline. However, after comprehensive screening of homopolymer solubility we were able to design block copolymers of poly-N-isopropyl acrylamide (PNiPAM) and polyacrylamide (PAM) with different block lengths that can be dissolved up to higher concentrations in reline. Depending on the block length, very different rheological behaviour can be observed with marked gelation for longer PNiPAM blocks that is little affected by temperature but strongly shear-thinning (see Figure below, always 5 wt% of polymer). In contrast, for shorter blocks no large viscosity enhancement is seen, but here the expected marked reduction of viscosity with increasing temperature is observed. For longer PAM blocks the shear-thinning behavior completely disappears and one observes rather classical Newtonian flow-behavior. The temperature dependence of viscosity is well described by the Vogel-Fulcher-Tammann model.

To our surprise, small-angle neutron scattering (SANS) as a function of concentration and temperature did not show the formation of larger aggregates in solution, but instead formation of networks of different strength and interconnection. This means that these polymers self-assemble in reline but in a different fashion than in water, as we directly compared their behavior in reline to that in water.

This means that we can control the flow behavior (up to gelation) of the DES reline via the architecture of added amphiphilic block copolymers, which self-assemble depending on this architecture. In this way one can functionalize DES, thereby giving them potential for different applications where such rheological modification is asked for.

10:20 - 10:40

302 The Effect of Molecular Architecture at Interfaces: Interfacial Rheology and Structure of Polymers

Damian Renggli[1], Dimitris Vlassopoulos[2,3], Norman J. Wagner[1]

[1]University of Delaware, Newark, DE, USA. [2]FORTH, Heraklion , Crete, Greece. [3]University of Crete, Heraklion , Crete, Greece

Abstract

Polymeric entanglements akin to three-dimensional (bulk) networks are not possible in true two-dimensional mono-molecular configurations as, e.g., at liquid—air interfaces. In the absence of free ends, ring-shaped polymers accommodate topological constraints of their neighbors (entanglements) by adapting a loopy conformation that is described by the lattice animal or fractal loopy globule models. The loops are local double-folded segments that are thought to interdigitate. These ‘entangled’ configurations will strongly influence the properties of said interfaces compared to linear polymers.

We use a novel multimode interfacial rheometer [1,2], that allows the independent measurement of dilatational and shear interfacial rheology with clean kinematics. We carry out the entire rheological and thermodynamic characterization of the interface in one instrument. Furthermore, we complement these measurements with neutron reflectometry and Brewster angle microscopy to confirm the arrangement of these polymers at the interface.

While distinct differences between linear and ring architectures for polyethylene oxide (PEO) appear in the compression isotherms (i.e. thermodynamic properties), polystyrene (PS) exhibits more prominent differences in the interfacial rheological properties. The change in this behavior is likely originating by the strong differences in glass transition temperature between PEO and PS, which has a direct effect on dynamical and structural properties of the interfacial layer. Therefore, we demonstrate the influence of the polymer's architecture on thermodynamic and rheological properties.

This work elucidates the importance of molecular architecture on interfacial entanglements; a concept yet unaccounted for.

[1] J. Rheol. 68(5), 785–799 (2024), https://doi.org/10.1122/8.0000857

[2] Rev. Sci. Instrum. 93, 093903 (2022), https://doi.org/10.1063/5.0090350

10:40 - 11:00

327 Thermophoresis of Colloidal Particles in Non-polar Viscoelastic Solutions: From Theory to Experiment

Amirreza Panahi, Giovanniantonio Natale, Anne Benneker

University of Calgary, Calgary, Canada

Abstract

Thermophoresis is the movement of colloids in a fluid medium to either the hot or cold side when subjected to a temperature gradient with applications in microfluidics, drug delivery, and separation processes. In this work, we examine the effect of polymer molecules on the thermophoretic motion of colloids. Such a system is relevant to developing colloidal assembly solutions and detection of viruses including SARS-CoV-2. Various non-polar systems are chosen here to elucidate the role of Van der Waals interactions in these ternary systems. We tackle this problem theoretically through a statistical thermodynamics approach considering the Van der Waals interactions between solvent, polymer, and colloid. In this framework, we consider the effect of the heterogeneous environment around the moving particle resulting from the non-homogeneous concentration profile of polymer molecules in the applied temperature gradient. Experimentally, hydrophobic silica particles are dispersed in polystyrene (PS) and Poly (methyl methacrylate) (PMMA) solutions to examine the applicability of the developed theory within the relevant range of Van der Waals interactions. In the performed experiments, the effect of mean temperature and polymer concentration on the thermophoretic motion of colloids is examined. Both theoretical and experimental results show that the silica particles move faster towards the hot wall at higher mean temperatures, while the thermophoretic force reaches a maximum in magnitude at moderate concentrations which stems from the antagonistic effects of polymer concentration and viscosity on thermophoretic motion. Our results will guide the design of solutions to achieve controlled motion of particles in targeted drug delivery.

11:00 - 11:20

82 *RHEOLOGICAL PROPERTIES OF XANTHAN GUM, GUARGUM, AND A BLEND OF XANTHAN GUM AND GUAR GUM*

Nezia de Rosso, Fabian Ramos-Maldonado, Isabel Hernández-Montoya, Cezar Negrão

Federal University of Technology – Paraná (UTFPR), Curitiba, Brazil

Abstract

Xanthan gum (XG) and guar gum (GG) are widely used hydrocolloids in various industries due to their rheological and stabilizing properties. This research explores the rheological properties of XG, GG, and 20:80 XG:GG blend in aqueous solution. The results show that XG solution is a yield stress fluid with a storage modulus, G', higher than the loss modulus, G'', for an extensive frequency range (0.1 to 100Hz), indicating a solid-like behavior, while the GG solution is a pseudoplastic fluidwith a G" higher than the G' at low frequencies (0.1 ~ 10Hz) and a G' higher than G'' at high frequencies (10 ~100Hz). Despite the lower XG proportion in the mixture, the XG-GG blend shows a viscoplastic behavior, with yield stress smaller than the XG solution value. Although the mixture presents G' larger than G" for the tested range of frequencies (0.1 to 100Hz), they are closer to each other when compared with the XG solution counterparts. The rheological properties of the mixture deviate from the expected theoretical results based on the mixing rule and indicate some synergy effects. Imagens obtained byscanning electron microscopy (SEM) show how the material structure can be associated with the rheological properties of the solutions.

11:20 - 11:40

439 **Dynamics and mechanics of polymer gelation in flow through microchannels**

Sara Hashmi, Barrett T. Smith

Northeastern University, Boston, USA

Abstract

The rheology of polymers undergoing gelation in bulk is well characterized for a wide variety of chemistries. As polymers and other complex fluids find increasing use in 3D printing technologies and additive manufacturing, understanding the dynamics of polymer gelation in flow through microchannels is needed to avoid pitfalls like clogging and nozzle failure. We mix hydrogel biopolymer alginate with its crosslinker calcium in flow through microfluidic channels to investigate the fundamental fluid dynamics of gelation in flow *in situ*. Despite the chemical simplicity of the fluid composition, allowing these two components to mix in flow creates beautifully complex and interesting dynamics, as well as generating robust hydrogel rods. As the polymer crosslinks to form a gel, the gel deposits, partially blocking flow through the channel. As local velocity increases to maintain constant volume flow through the channel, the viscous shear stress on the gel similarly increases, eventually causing the newly-formed gel to break off the channel wall and elute, exiting the channel. In certain regimes of chemical composition and flow rate, this process can continue nearly indefinitely, or for at least as long as the duration of the flow test. These persistent intermittent dynamics provide a reproducible, single phase, synthetic method to create flexible microgel rods of controllable size, shape, and mechanical properties. The generation of these rods *in flow* causes their structure and composition to differ from bulk gels. Flow vorticity causes fibrils of the forming gel to create chiral, porous rods with controllable bending mechanics, stiffer than expected from bulk rheological characterization.

11:40 - 12:00

330 Rheological and structural effects of cellulosic nanomaterials on lamellar-based surfactant formulations

Carla Manuela Sganzerla Sabino[1], Paulo Ricardo A. F. Garcia[1], Laura L. C. E. Silva[1], Emily D. Cranston[2], Luigi Gentile[3], Guilherme Augusto Ferreira[4], Watson Loh[1]

[1]University of Campinas, Campinas, Brazil. [2]University of British Columbia, Vancouver, Canada. [3]University of Bari, Bari, Italy. [4]Federal University of Bahia, Salvador, Brazil

Abstract

Petroleum-based polymers are widely used as additives to tailor cosmetic formulation properties. However, bio-based, biodegradable alternatives such as polysaccharides, including nanocelluloses, have been proposed as more sustainable options. In this study, negatively charged cellulose nanocrystals (CNC) and cellulose nanofibrils (CNF) were compared with their molecular counterpart, carboxymethylcellulose (CMC), to assess their rheological effects when added to a surfactant lamellar phase. This phase, commonly used in cosmetic applications, is formed by the cationic surfactant dioctadecyldimethylammonium chloride (DODAC). Rheological changes were correlated with the system's internal organization using a multiscale approach, including scattering, calorimetric, and microscopy techniques. Independent of the cellulose type, results showed that the material becomes more rigid and less plastic with increasing cellulose concentration until a maximum concentration is reached. Beyond this point, the mixtures exhibit increased plastic-like behavior and reduced rigidity. This critical concentration depends on the

surfactant concentration and the type of cellulose additive—CNC, CNF, or CMC. Small-angle X-ray Scattering (SAXS) revealed structural changes, including decreased bilayer repeat distance with cellulose addition. Moreover, Small-Angle Neutron Scattering (SANS) combined with the contrast matching technique suggested that cellulose can be confined within the aqueous spaces between bilayers. Cryogenic Transmission Electron Microscopy (Cryo-TEM) and Fourier-Transform Infrared Microscopy (FTIR) confirmed the integration of nanocelluloses into the lamellar matrix, with micro- and nano-scale cellulose aggregates observed. Additionally, tribology measurements showed improved lubrication properties in formulations with CNC and CMC. These findings suggest that cellulose additives can effectively tailor the rheology of cosmetic formulations and serve as sustainable alternatives to petroleum-based polymers.

Molecules and Particles at Fluid Interfaces - 1

10:00 - 12:00 Monday, 23rd June, 2025
ETLC E2-001
Wetting and Adhesion Molecules and Particles at Fluid Interfaces
Man Hin Kwok

10:00 - 10:20

60 The effect of interfacial hydrogen bonding and electrostatic interactions on the adsorption and foaming properties in saponin mixtures

Marcel Krzan[1], Mateusz Jamroży[1], Weronika Kieres[1], Sonia Kudłacik-Kramarczyk[1], Piotr Warszyński[1], Wojtek Płaziński[1], Małgorzata Nattich-Rak[1], Björn Braunschweig[2]

[1]Jerzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences, Kraków, Poland. [2]Institute of Physical Chemistry, Westfälische Wilhelms-Universität Münster, Münster, Germany

Abstract

The work aims to verify the influence of surface hydrogen bonds formed by various solution components between each other and with water molecules on adsorption processes, surface dilatational elasticity, foamability and stability of the obtained foam fractions in saponin-based solutions.

Saponin is a natural anionic biosurfactant widely used in cosmetic, pharmaceutical and food technologies because of its efficiency as a bio-active component and biodegradability. In these fields, there is increasing interest in developing new formulations of biodegradable and biocompatible foams for environmental reasons and in limiting the use of synthetic surfactants in commercial products.

In the current research, we enriched saponin solutions with simple chemical compounds suitable donors or acceptors of hydrogen bonds (urea, glycerol, and choline chloride). Saponin and its mixtures were investigated versus the composition by interfacial tension and dilational rheology measurements. The actual state of the adsorption layer was investigated directly using Sum Frequency Spectroscopy and theoretically using Molecular Dynamics modelling. Finally, the respective foams were analyzed during their formation and evolution.

We have shown that adding choline, urea, or glycerol changed the surface activity, surface dilational elasticity, foaming ability and stability in the tested saponin mixtures. This proves the existence of strong interactions between the saponin and the additives used through hydrogen bonds and/or electrostatic interactions.

Acknowledgements:
Financial support from the National Science Center of Poland research projects (grants no. 2022/45/B/ST8/02058 & 2024/53/B/ST8/03269) is gratefully acknowledged.

10:20 - 10:40

161 Interfacial adsorption and shear rheological properties of pea protein modified by ultrasonication and pH shifting

QAYYUM SHEHZAD[1,2], Catherine Whitby[2]

[1]Riddet Institute, Massey University, Palmerston North, New Zealand. [2]School of Food Technology and Natural Sciences, Massey University, Palmerston North, New Zealand

Abstract

Plant proteins have fetched attentions as natural emulsifiers in the food sector owing to their eco-friendly nature and sustainability. They meet the dietary requirements of vegans and vegetarians and are cost-effective. However, plant proteins have a compact and aggregated structure, which reduces their solubility in aqueous solutions and buries the hydrophobic amino acids within the folded conformation. In addition, less is known about their structure, interactions, and surface rheology of adsorbed layers. Therefore, pea protein was modified in this study, and its physicochemical properties and interfacial shear rheological properties were investigated.

The focus of this work is on the impact of exposing pea protein solutions to highly alkaline conditions and then reducing the solution pH to pH 7 (so called pH shifting). This was found to reduce the average size of protein aggregates in solution. The solubility of the protein increased from ~14 to ~47%. Combining pH shifting with the application of ultrasound increased the protein solubility to ~78%.

The modifications also exposed hidden hydrophobic groups on the protein surface, resulting in increased protein hydrophobicity. Protein adsorption behaviour and viscoelastic properties at the oil-water interface were investigated by measuring the interfacial tension and shear rheology before and after modification. The modified protein adsorbed more slowly at the oil-water interface. Interfacial layers of modified protein showed less viscoelastic behaviour. Future work will focus on exploring other modification approaches, including high-pressure homogenization and heating.

10:40 - 11:00

165 Catanionic surfactants for sustainable fluorine free foams with enhanced stability

Pragnya Chatterjee, Meenal Rathi, Joseph Zasadzinski, Cari Dutcher

University of Minnesota, Minneapolis, USA

Abstract

Aqueous Film Forming Foams (AFFF) are widely used to extinguish Type B fuel fires. These foams contain per- and polyfluoroalkyl substances (PFAS), which provide excellent foam properties and spreading capabilities in both fresh and seawater. However, the environmental persistence of PFAS has led to significant regulatory action, highlighting the urgent need for sustainable alternatives. Developing PFAS-free formulations that either provide the foam properties needed to extinguish a fire or achieve the low surface tensions necessary to create an effective aqueous film between fuel and air remains a critical challenge. Bilayer vesicle-forming catanionic surfactants have emerged as promising candidates due to their synergistic behavior in reducing critical micelle concentration and lowering equilibrium surface tension. This study demonstrates the potential of vesicle-forming catanionic alkyl surfactant mixtures to enhance the rheological properties of the air/aqueous interface, thereby improving foam stability. Foam height measurements in the presence of salt (NaCl) as well as fuel (heptane) provide valuable insights into the performance of these formulations under realistic, challenging conditions.

11:00 - 11:20

172 Understanding surfactant transport of commercial surfactants with fluorine-free firefighting applications

Meenal Rathi, Josesph Zasadzinski, Cari Dutcher

University of Minnesota, Twin Cities, Minneapolis, USA

Abstract

Aqueous film forming foams (AFFF) spread spontaneously over liquid fuels, making them vital for extinguishing fuel fires. However, the recent ban on the use of PFAS based surfactants in AFFF necessitates the development of effective PFAS-free formulations. This study examines the surfactant transport to fluid-fluid interfaces in commercial mixtures, known to suppress fuel fires, using pendant drop (PD) and capillary pressure microstensiometry (CPM) to measure the interface tension. Notably, some surfactant mixtures exhibit a complex stepwise adsorption when held at constant interface area, attributing to their chemical heterogeneity. A novel modeling framework incorporating multiple adsorption states is developed to extract key equilibrium constants and diffusivity for individual surfactant components. Additionally, experiments are conducted across temperatures (23°C and 60°C) with interface curvatures ranging 1.5 mm to 60 µm, revealing their influence on adsorption dynamics. These findings contribute to understanding the chemical composition of essential commercial surfactants, paving the way for optimized formulations of PFAS-free firefighting foam formulations.

11:20 - 11:40

385 Surfactant-Mediated Interfacial Hydrogen Evolution Reaction

Boubakar Sanogo[1], Xuehua Zhang[1,2], Pratibha Dogra[1], Kangkana Kalita[1]

[1]Department of Chemical and Materials Engineering, University of Alberta, Edmonton, Canada.
[2]Physics of Fluids Group and Max Planck Center for Complex Fluid Dynamics, University of Twente, Enschede, Netherlands

Abstract

Liquid organic hydrogen carriers (LOHCs) are promising media for hydrogen storage, transport, and generation. However, their dehydrogenation in water is severely limited by phase immiscibility, resulting in sluggish reaction kinetics. This study investigates the interfacial hydrogen evolution reaction between polymethylhydrosiloxane (PMH), a representative LOHC, and water, focusing on controlling reaction kinetics by modifying interfacial properties with surfactants. The hydrogen production rate at a planer interface between PMH and water catalyzed by sodium hydroxide revealed that surfactants such as Tween 20 and sodium dodecyl sulfate (SDS) can slow down the hydrogen formation by 5 to 20 times, possibly due to an overcrowded interface effect. In contrast, cationic surfactants, such as hexadecyltrimethylammonium bromide (CTAB) and other quaternary ammonium surfactants, act as pseudo phase-transfer catalysts (Figure 1A) and accelerate the hydrogen formation rate up to 3-fold at a concentration of 0.05 times their critical micelle concentration. As the PMH microdroplets were dispersed in the surfactant aqueous solution, the conversion yields of hydrogen with CTAB achieved 40%, a significantly higher yield than with Tween 20 or SDS (Figure 1B). The effects of the surfactant type were further confirmed by following hydrogen bubble growth in a single PMH droplet. Overall, our findings demonstrate that selecting an appropriate surfactant can provide an effective control over the interfacial reaction rate of dehydrogenation of LOHCs. This offers strategies for manipulating liquid-liquid interfaces and controlling in-demand hydrogen production.

11:40 - 12:00

234 Surfactant based composites at interfaces and application

Saule Aidarova[1], Altynay Sharipova[2], Miras Issakhov[1], Fariza Amankeldy[1]

[1]Kazakh-British technical university, Almaty, Kazakhstan. [2]Satbayev university, Almaty, Kazakhstan

Abstract

The interaction between nanoparticles and surfactants plays a key role in structuring the dynamic and static behavior of interfacial layers, which has important implications for a variety of industrial and scientific applications [1-3]. In this study, we investigate the effect of hydrophilic silica nanoparticles on the colloidal chemistry of systems with anionic (SDS), cationic (CTAB), and nonionic (Tween-65) surfactants. This study is motivated by the growing interest in understanding the complex interactions between surfactants and nanoparticles. Using an integrated approach including surface tension measurements, rheological analysis, dynamic and static surface tension studies, and zeta potential measurements, the study aims to better understand the synergistic effects and optimize the conditions for using nanofluids in various technological applications. Surface-active properties, including surface tension, dilatational elasticity, and viscosity of surfactants (anionic, cationic, and nonionic), nanoparticles, and their composites at the water/air interface were investigated. The study aimed to understand how these properties vary depending on the nature of the surfactant. The identified range of surfactant concentrations showed the optimal manifestation of surface-active properties in composites. The bulk properties of surfactants, nanoparticles, and their composites were also investigated, demonstrating distinctive features depending on factors such as salinity, pH, and the different nature of the surfactant. The size and charge of the nanoparticles and their composites were studied taking into account the presence of NaCl and different pH levels, as well as composites with surfactants of different natures (cationic, anionic, and nonionic). It was noted that with an increase in the surfactant concentration, there is a decrease in the size of the composites. The obtained results on the bulk properties correlate with the data on the surface tension and dilatational rheology. The observed changes in surface tension, rheological parameters, and zeta potential values highlight the importance of considering nanoparticle-surfactant interactions when optimizing nanofluid formulations for various technological applications. These results provide a comprehensive understanding of the interactions of anionic, cationic, and nonionic surfactants with nanoparticles, illuminating how their surface and bulk properties are modified by various factors. This understanding is key to optimizing the composition and performance of these composite systems in areas such as materials science and environmental engineering.

References:

1. Ahmadi, A.; Saeedi Dehaghani, A.H.; Saviz, S. Experimental Study of SDS Foam Stability in the Presence of Silica Nanoparticle. J. Chem. Pet. Eng. 2022, 56, 203–213.

Wetting and Adhesion - 1

10:00 - 12:00 Monday, 23rd June, 2025
ETLC E1-003
Wetting and Adhesion
Hans-Juergen Butt

10:00 - 10:20

222 Durable Slippery Coating for Anti-smudge and Anti-icing

Junfei Ou[1], Alidad Amirfazli[2]

[1]Jiangsu University of Technology, Changzhou, China. [2]York University, Toronto, Canada

Abstract

To effectively reduce the adhesion of accumulated ice, a variety of functional coatings have been developed that feature superhydrophobicity, high slipperiness, and low elastic modulus. However, achieving both excellent anti-icing performance and long-lasting durability remains a significant challenge for existing anti-icing coatings. Our goal is to develop advanced coatings using different structures of polydimethylsiloxane (PDMS), including dihydroxy-terminated, monohydroxy-terminated, diamino-terminated, and monoamino-terminated PDMS, as well as PEG-PDMS copolymers, combined with polysilazane (PSZ) as raw materials. The objective is to create coatings that exhibit both superior ice repellency and exceptional durability. By incorporating low modulus PDMS, the surface of high hardness PSZ will induce a "stress localization" effect. The mobility of the methyl end in monofunctional group-terminated PDMS is expected to enable a "solid-state slippage" effect. Additionally, the non-ionic hydrophilic groups (-OCH3 or -OH) in PEG-PDMS copolymers are anticipated to enhance the hydration effect of the coatings, facilitating the formation of a "quasi-liquid layer" on the coating surface at sub-zero temperatures. Through the synergistic effect of these design elements, we aim to achieve a co-optimization of anti-icing performance and durability. The resulting coating is designed to be highly stable under abrasion and UV exposure, making it practical for both anti-icing and anti-smudge applications.

10:20 - 10:40

16 Superhydrophobic surfaces demonstrating low interfacial toughness with ice

Qimeng Yang, Ali Doladabadi, Kevin Golovin
University of Toronto, Toronto, Canada

Abstract

Superhydrophobic surfaces (SHPs) demonstrate superior water repellency and promising surface properties like self-cleaning, anti-fouling, and drag-reducing. However, it remains debatable whether SHPs can effectively lower the adhesion of ice accumulated on a surface, particularly for large-scale interfaces (>1 cm) where the delamination of ice from the surface is controlled by interfacial toughness. In the current study, it was found that the mechanical durability of many commercially available SHP products was insufficient even for collecting reproducible ice adhesion results using the common push-off test. While roughening a piece of hydrophobic surface like Teflon could increase the water repellency to be considered as a SHP, the adhesion of ice on the textured surface was dramatically increased due to the mechanically interlocking. Instead, a SHP surface was designed with both micro- and nanostructures conformally coated by a silica layer as a primer, followed by a perfluoropolyether (PFPE) topcoat. This SHP, due to its durability and robust Cassie Baxter state, demonstrated promising large-scale ice repellency, i.e. a low interfacial toughness (LIT) with ice, under freezing conditions at -20 °C, even after more than 40 repeated icing/de-icing tests. The hierarchical structure in addition to the high grafting density of the PFPE polymer was potentially the reason for this specific SHP surface presenting a competitively low interfacial toughness with ice (<0.5 J/m^2).

10:40 - 11:00

393 Discontinuity-enhanced icephobicity for reduced ice adhesion on surfaces

Carlo Antonini[1], Pablo F. Ibáñez Ibáñez[1,2], Luca Stendardo[1], Anny Catalina Ospina Patiño[1], Rajat Chaudhary[1], Irene Tagliaro[1]

[1]University of Milano-Bicocca, Milano, Italy. [2]University of Granada, Granada, Italy

Abstract

Passive low ice-adhesion surfaces are frequently composed of soft materials; however, soft materials potentially present durability issues, which could be overcome by fabricating composite surfaces with patterned rigid and soft areas. Here we propose the innovative concept of discontinuity-enhanced icephobic surfaces, demonstrating that the stress concentration at the edge between rigid and soft areas facilitates ice detachment.

Complementing experimental tests with numerical simulations, it was found that on a composite surface containing rigid and soft areas, stress is concentrated at the edge between the two, i.e. at the discontinuity line, rather than all over the soft or rigid areas. As a result, ice detachment is promoted: the crack occurs first at the discontinuity line, propagates on rigid and then on soft areas. Moreover, it was demonstrated that an increase in discontinuities promotes crack initiation and leads to a reduction of ice adhesion. Remarkably, an unexpected non-unidirectional crack propagation was observed for the first time and elucidated.

11:00 - 11:20

273 Evaluation of Ice Adhesion Shear Strength: Experimental and Numerical Investigation of Interface Length and Geometry Effects under Centrifugal Loading

Derek Harvey, Caroline Blackburn, Gelareh Momen

Université du Québec à Chicoutimi, Saguenay, Canada

Abstract

Atmospheric icing poses significant risks in aerospace, wind energy, and power transmission lines. Over three decades, researchers have pursued passive protection solutions to reduce ice adhesion. However, measuring ice adhesion strength remains challenging due to the lack of standardized test methods and poor control of failure mechanics during testing. As a result, adhesion strength measurements vary widely, complicating efforts by researchers to advance the field and hindering end users' ability to evaluate and compare protection solutions effectively.

Recent studies in ice adhesion testing emphasize the importance of distinguishing between strength-dominated and toughness-dominated failures, as the experimentally measured average shear stress is reliable only if the failure is strength-dominated. In this study, the effects of interface length and ice specimen geometry effects are investigated using the centrifugal adhesion test (CAT) to identify configurations that promote strength-dominated adhesive failures. An extensive experimental campaign was conducted with molded ice specimens at -10°C. The average shear stress obtained by CAT was calculated and compared across different configurations, with high-speed imaging employed to document the failure.

Additionally, numerical simulations were performed to analyse stress distributions at the interface, estimating maximum and minimum shear stresses at failure. Results demonstrate that optimizing specimen geometry to minimize stress concentrations is essential to test below the critical interface length where failure transitions from strength-dominated to toughness-dominated.

This work marks a significant step toward standardizing ice adhesion testing and reducing variability caused by improper failure modes, thereby improving the reliability of ice adhesion strength measurements.

Soft Matter - 1

10:00 - 12:00 Monday, 23rd June, 2025
ECERF W2-050
Soft Matter
Ignaas Jimidar

10:00 - 10:20

289 High-Throughput Thermal Analysis of Particle-Laden Heat Transfer Fluids

Mohammad Zargartalebi, Amin Kazemi, Maryam Ebrahimiazar, David Sinton

University of Toronto, Toronto, Canada

Abstract

Particulate heat transfer fluids are gaining significant attention in the energy industry due to their enhanced thermal properties. However, traditional methods for analyzing key thermal properties, such as heat capacity and thermal conductivity, are time-consuming and unsuitable for real flow conditions. Conventional approaches are limited by their reliance on heat flux and absolute temperature quantification, posing challenges for the rapid development of these fluids for various applications. In this work, we present high-throughput, flow-based methods for measuring the thermal properties of particulate fluids. These methods leverage the principle of relative conductive and advective temperature/heat bias measurement using reference and sample microchannels. The symmetric design of the measurement system eliminates dependency on absolute heat flux or temperature quantification, enabling efficient, high-throughput screening of thermal properties. Our approach achieves a 100-fold improvement in throughput for heat capacity measurements compared to conventional methods, accurately testing over 20 fluids (~1% error) in an hour—including particle-laden fluids—with a sample volume of less than 1 ml. The system also enables thermal conductivity measurements with a 10-fold increase in throughput, requiring only 10 μL of fluid and maintaining an accuracy of ~1.1%. By performing measurements under flow conditions that mimic real-world applications, our device facilitates real-time screening and development of colloidal mixtures tailored for energy applications. This innovation provides a transformative platform for advancing bespoke heat transfer fluids for sustainable energy systems.

10:20 - 10:40

130 Thermodynamic Investigation of Homogeneous Bubble Nucleation from a Multicomponent Liquid–Gas Solution

Soheil Rezvani, Janet A. W. Elliott
University of Alberta, Edmonton, Canada

Abstract

The stability of vapor–gas bubbles homogeneously nucleated within a liquid–gas solution depends on the temperature, pressure, and concentration of dissolved components. While extensive studies have explored bubble nucleation in single-component systems, research on multicomponent systems has mainly focused on binary liquid–gas solutions. Furthermore, existing studies have predominantly examined bubble size stability, leaving other critical factors underexplored. We propose a methodology to determine potential equilibrium states for a vapor–gas bubble nucleated within a multicomponent liquid–gas solution, containing a subcritical solvent and n–1 gaseous components, under constant temperature and pressure. Stability is assessed by analyzing free energy changes with respect to both bubble size and vapor–gas composition, using rigorous phase equilibrium equations to account for nonideal behavior in both phases. We then apply this to investigate the number and nature of equilibrium states in a ternary system of water–oxygen–nitrogen across various scenarios of oxygen and nitrogen saturation levels in the liquid phase, while also meticulously examining the effects of liquid phase temperature and pressure on the stability of the system. The proposed model can be used to optimize the design of micro-nano bubble technologies for diverse engineering applications, ranging from agriculture to water treatment and biomedicine. This research has been submitted to the *Journal of Physical Chemistry B*.

This research was funded by the Natural Sciences and Engineering Research Council (NSERC) of Canada, Alberta Innovates, and the University of Alberta. Janet A. W. Elliott holds a Canada Research Chair in Thermodynamics.

10:40 - 11:00

168 Response Dynamics of Colorimetric pH-Sensitive Nanocomposite Hydrogels

Ozge Zengin Akca, Fredrick Flores, Umut Zengin, Hyun-Joong Chung

University of Alberta, Edmonton, Canada

Abstract

We present a pH-responsive hydrogel system that incorporates pH-indicative dyes that are covalently incorporated in the polymer matrix. The hydrogel's integrity is further enhanced with fillers such as Laponite and Nanocellulose crystals. These hydrogels sense and display the pH variation of the aqueous environment by color changes that are visible to the naked eye. While the colorimetric response is quantified by variations in hue values along with UV-vis spectra, establishing rapid response time is of utmost interest in most practical applications. The response time, however, is affected by multiple factors that are sensitive to varying pH values, such as conformational changes of polymer chains and interaction between nanoparticles. For example, Laponite, a synthetic clay, displays pH-dependent behavior, aggregating/collapsing in acidic environments and stabilizing in alkaline environments, thus influencing the hydrogel's response time in acidic conditions. In contrast, nanocellulose, whose interparticle interactions are less sensitive to the variation of pH, causes less variation in the pH dependence on the response time. The kinetics of ionic diffusion in the hydrogel matrix provide insights to understand the variations in response time. These findings suggest potential hydrogel applications in environmental real-time monitoring, where rapid detection and robust performance are crucial through strategic filler integration.

11:00 - 11:20

208 Coarse-grained simulations of thermosensitive polymer nanocomposites

Alberto MARTIN-MOLINA[1,2], María del Mar RAMOS-TEJADA[3], Manuel QUESADA-PEREZ[3]

[1]Department of Applied Physics. University of Granada, Granada, Spain. [2]Institute Carlos I for Theoretical and Computational Physics, Granada, Spain. [3]Department of Physics. University of Jaen, Jaen, Spain

Abstract

Polymer nanocomposites (PNCs) are advanced soft materials that incorporate nanoparticles with a polymer matrix to achieve superior performance. For instance, PNCs can greatly enhance a wide range of industrial applications, including coatings, paints, electronics, food packaging, and personal care products [1]. In some cases, the polymer matrix consists of cross-linked polymer chains that form soft nanoparticles termed nanogels. The interest in nanogels has grown rapidly over the past decades because they can undergo a volume phase transition by external stimuli (temperature, pH, electromagnetic radiation, etc.). Therefore, nanogels are used for novel technological applications such as controlled drug delivery, optoelectronic switches or artificial muscles. In the case of nanomedicine, the potential of nanogels is even more promising when they form PNCs consisting of nanogels doped with nanoparticles. These hybrid systems have already been used as novel contrast agents for bioimaging and in controlled antibacterial assays [2].

On the other hand, coarse-grained computer simulations have proven to be a very useful tool for characterising nanogels and also for the resulting PNCs obtained from them. Such simulations have been previously used to study the absorption of nanoparticles into swollen nanogels, where the behaviour of the corresponding PNCs was mainly governed by electrostatic forces [3]. Accordingly, the objective of this work is to extend the study to thermo-shrinking PNCs by using thermoresponsive nanogels to deliver drugs by heating them. In particular, we investigate the conditions at which nanoparticles encapsulated in a nanogel are expelled when the polymeric network shrinks in response to a change in temperature. To this end, the effect of the charge of the polymers as well as the size of the nanoparticles is analysed. Finally, the simulation results are compared with the calculations from a Poisson–Boltzmann cell model.

Acknowledgements

We thank Ministerio de Ciencia e Innovación (PID2023-149387OB-I00) and Consejería de Universidad, Investigación e Innovación and ERDF Andalusia Program 2021-2027 (Grant C-EXP-187-UGR23) for providing financial support.

References

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11:40 - 12:00

320 Optimization of Additively Manufacturable Magnetic Composite Organogel Silicones for Soft Robotic Applications

Rayan Basodan[1,2], Byuoingyoul Park[2], Hyun-Joong Chung[1]

[1]University of Alberta, Edmonton, Canada. [2]NRC, Edmonton, Canada

Abstract

Magnetic composite silicones, soft silicone matrices with magnetic micro particles dispersed within, are highly functional materials used in a variety of applications. The elastomeric composite is a soft actuator material that can be controlled by applied external magnetic fields. 3D printing of these magnetic composite silicones further enhances their functionality as it enables preprogramed actuation through magnetic alignment. 3D printability also enables freeform manufacturing of intricate designs and patterns. To enable the printing of the uncured silicone matrix, fumed silica is often added as a rheological modifier to the precursor solution. However, the amount of fumed silica that is required for printability causes excessive stiffness of the cured magnetic composite silicones, which is detrimental to soft robotic applications. Dispersing magnetic micro particles is beneficial for maximizing the magnetic response of the soft actuators, but increasing their amount also results in the stiffening effect.

We developed additively manufacturable magnetic composite silicones with maximal amounts of magnetic additives compared to similar materials in the literature. This soft composite material system circumvents the limit of magnetic particle amount (~20 vol%) by incorporating low CST oil in the matrix to make a soft organogel, enabling up to (~50 vol%) of the micro magnetic additive. At this high concentration, the small magnetic particles (~5 um) also function as an effective rheological modifier to enable 3D printing before polymerization without the need for fumed silica. Such a low stiffness high magnetization composite can advance magnetic soft actuator applications.

AI Methods in Surface Sciences - 2

13:20 - 15:00 Monday, 23rd June, 2025
ICE Incubator
AI Methods in Surface and Colloid Sciences
Alidad Amirfazli

13:20 - 13:40

204 A Machine Learning Approach to Contact Angle Analysis

Daniel Shaw, Joseph Berry

University of Melbourne, Melbourne, Australia

Abstract

Wetting is a fundamental property of interest when creating novel materials or fluids. Analysing surface wetting properties using sessile drop contact angles is a simple process but can take up to 20 min per sample due to many points of human input and slow drop fitting methods. Contact angle measurements are increasingly used by researchers from a diverse range of fields, however, current techniques require human input which introduces a significant source of variability in measurements. This research presents a new approach to sessile drop contact angle analysis employing machine learning, thereby increasing the speed, accuracy, and autonomy of this important measurement. The model is trained on a large data set of synthetic drop images created by solving the Young-Laplace equation, and outputs a predicted contact angle. Current work shows a Machine Learning approach is more accurate and faster than the current best practice approach to contact angle measurement fitting: the Young-Laplace fit. Further functionality has been incorporated into the approach to allow for completely automated analysis and applicability to dynamic (needle-in) sessile drop measurements. All code open-source and accessible via an app for users with little or no coding experience. This method of contact angle analysis will make efficient and reliable wetting analysis accessible to the wider academic community, allowing for higher quality investigation into surface wetting properties across a wide range of applications.

13:40 - 14:00

173 **Integration of Color Sensor with Machine Learning Regression Models for the Precise Quantification of Biochemical Protein Assays**

Soo Jee Do, Hyunji Chaa, Surjith Kumaran, Euna Oh, Hyo-Jick Choi

University of Alberta, Edmonton, Canada

Abstract

The emergence of novel technologies has significantly increased research efforts focused on non-destructive color sensors, particularly those aimed at enhancing biological assays and quantifying various biological components such as proteins, cells, or pathogens. However, the lack of specificity in selecting the RGB color space during detection and analysis presents a major challenge in developing standardized methods for this field, leading to potential discrepancies. Existing color sensors based on the RGB color space either require a classification algorithm or rely on human observation of the regenerated image to recognize the color. This lack of specificity in detection and analysis further complicates the creation of standardized methods. The rapid quantification of various biological materials and assays using color sensors is critical for efficient healthcare and point-of-care applications. In this study, we integrate common colorimetric protein concentration assays, such as Bicinchoninic acid (BCA) and Bradford assays, with machine learning (ML) techniques. This integration offers an opportunity to enhance data analysis and interpretation, enabling insights discovery, prediction, process automation, and decision-making. By leveraging four regression models, the semiconductor based RGB sensor can effectively interpret and process color data, facilitating precise color detection and analysis. This study highlights the potential of simple, cost-effective colorimetry to improve the quantification of assays, particularly those requiring low volume or paper/spot tests. It offers a wide range of applications in industries such as healthcare, oil and gas, and quantitative water analysis, all without the need for expensive and time-consuming equipment.

14:00 - 14:20

428 Machine learning to predict efficacy of biofilm removal from the biocolloidal properties of bacterial clusters released from disrupted biofilms

Sydney Packard, Randy Paffenroth, Elizabeth Stewart

Worcester Polytechnic Institute, Worcester, MA, USA

Abstract

Bacterial clusters released from disrupted biofilms are found to have distinct clustering characteristics that can be used to predict biofilm removal rates with machine learning. Biofouling of water pipe networks and manufacturing processes with biofilms leads to significant increases in energy consumption, waste, and health risks for humans. Monitoring techniques to assess the success of biofilm removal in hard-to-reach areas, such as within the human body or upstream processes, are prohibitively invasive and expensive. Here we use quantitative image analysis techniques frequently used in colloidal science to measure the size and morphology of bacterial clusters released from biofilms after targeted disruption of matrix polysaccharides, proteins, DNA or solubilization of the extracellular polymeric substances. *K*-means clustering analysis of cell clusters released from biofilms reveals that across all treatments clusters are released in three distinct sizes (small, medium and large) and morphologies (oblate, prolate, spherical). However, the distributions of cluster sizes and morphologies are distinct across the treatments and relate to the extent of biofilm removal after matrix targeted disruption. We evaluate machine learning classifier models (Random Forest, Gaussian Naïve Bayes) for predicting biofilm removal rate based on the biocolloidal properties of bacterial cell clusters released from biofilms. We discuss the significance of these results to applying machine learning methods to small experimental datasets and the design of biofilm removal strategies with data-informed analysis.

14:20 - 14:40

62 DROP IMPACT ON HEATED NANOSTRUCTURED SURFACE: AN EXPERIMENTAL AND MACHINE LEARNING APPROACH

Lap Au-Yeung[1], Lihui Liu[1,2], Guobiao Cai[2], Peichun Tsai[1]

[1]University of Alberta, Edmonton, Canada. [2]Beihang University, Beijing, China

Abstract

Droplet impact on a solid surface plays a crucial role in many industrial applications. Utilizing high-speed imaging, we conduct a series of experiments using water droplets impacting heated surfaces. A phase diagram of various impact outcomes, as a function of Weber numbers (We) and surface temperature (T_s), is established by varying four critical control parameters: impact velocity, nanopillars' packing fraction (ϕ), surface roughness (r), and T_s. The impact outcomes on flat surfaces vary from deposition, spreading, rebound, to splashing as We and T_s increase. However, a significant influence from nanostructures is observed, triggering impact events, such as splashing and central jetting, within a certain parameter range.

To delve deeper into our experimental data, we employ three different data-driven machine learning algorithms, namely artificial neural networks (ANN), random forest, and support vector machine (SVM). With the four experimental control parameters as inputs, we obtain optimal prediction accuracy with ANN in classifying different impact outcomes and constructing a phase diagram. The results show that both the boundaries between impact regimes in the phase diagram and β_{max} at lower We ($\lessapprox 2000$) can be influenced by varying ϕ and r. An increase in ϕ promotes deposition and spreading events, while increasing r results in enhanced heat transfer that promotes rebound and greater disturbances of the liquid lamella triggering splashing. The SVM regressor predicts that $\beta_{\max}$ of a spreading droplet becomes independent of T_s as We increases beyond a critical We, whose value depends on ϕ and r.

14:40 - 15:00

392 A Machine Learning Approach to Understand the Effect of Contact Angle on Droplet Impact Outcomes

Ismail Alkomy, Alidad Amirfazli

York University, Toronto, Canada

Abstract

Accurately predicting the behavior of droplets upon impact with a solid surface is vital across a wide range of natural and technological applications. The diverse impact outcomes, such as deposition, partial or complete recoil, prompt or corona splashing, as well as the maximum spreading, are significantly influenced by surface wettability, as characterized by contact angle. This study harnesses a wealth of existing high-quality experimental data to train our developed machine learning model, enabling precise prediction of impact outcomes and enhancing differentiation between wetting and non-wetting surfaces. By framing the controlling parameters in terms of dimensionless groups such as the Weber, Reynolds, and Ohnesorge numbers, alongside the contact angle, the machine learning model developed effectively generates detailed regime maps that classify impact outcomes across a broad spectrum of impact conditions and surface wettability. Furthermore, regression models demonstrate high accuracy in predicting the maximum spreading, providing valuable insights into the underlying dynamics of droplet impacts using dependency parameters (i.e., SHAP analysis). This approach surpasses traditional methods reliant

on empirical correlations, offering robust generalization to unseen scenarios, both within and beyond the range of training data, and demonstrating significant transformative potential to advance the field of droplet impact studies.

Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 2

13:20 - 15:00 Monday, 23rd June, 2025
NRE 1-001
Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces
Norman Wagner

13:20 - 13:40

281 Processing-Structure-Property Relationships in Silica Hydrogels for Bone Tissue Composite Scaffolds

Marzieh Matinfar, John Nychka

University of Alberta, Edmonton, Canada

Abstract

Silica hydrogels derived from sodium silicate solutions hold significant promise for bio-inspired composite bone scaffolds due to their customizable porosity, biocompatibility, and mechanical and thermal stability. Our previous work explored a composite design combining 45S5 Bioglass® frit with a waterglass binder, using phosphoric acid (PA) and boric acid (BA) as initiators, resulting in formable, in-situ setting bone scaffolds. However, the mechanical properties and microstructural evolution of silica hydrogels are not fully understood.

This study investigates how pH, waterglass concentration, and acid initiators influence the mechanical properties and microstructure of silica hydrogels. Real-time compression tests revealed three stress-strain behaviors: brittle fracture, plastic deformation with a plateau, and continuous strain hardening. Initial compressive strengths ranged from 7.3 to 9.9 MPa, increasing to 16–38 MPa (basic group) and 21–53 MPa (acidic group) after aging. Basic 1:3 (25 wt.% waterglass) and acidic 1:1 (50 wt.% waterglass) formulations showed the highest strengths.

The differences between these gel systems were attributed to the size of their structural units, the primary and secondary colloidal silicate particles, and the density of physical bond formation within the network. These factors influenced the microstructure, pore size, and mechanical properties. Basic gels formed larger structural units and pores, enhancing ductility, while acidic gels formed a denser network with smaller pores, resulting in brittle behavior. These findings offer valuable insights into optimizing the processing-structure-property relationships of silica hydrogels for sustainable bio-inspired materials in medical applications.

13:40 - 14:00

347 Developing Bacteriophage-based Microgels with Electro-Hydrodynamic Processing

Davood Zaeim[1], Maryam Badv[1,2]

[1]Department of Biomedical Engineering, University of Calgary, Calgary, Canada. [2]Libin Cardiovascular Institute, University of Calgary, Calgary, Canada

Abstract

The rise of multidrug-resistant bacteria highlights the urgent need to develop innovative antibacterial platforms. In this study, we report a high-throughput, bio-friendly method for fabricating phage-based microgels. Utilizing M13 bacteriophages as the building blocks, we fabricated biodegradable microstructures using an electro-hydrodynamic atomization (EHDA) method aiming to maintain the bioactivity and antimicrobial efficacy of the phage agents. The operational parameters, including voltage, feed rate, tip-to-collector distance, as well as the physicochemical properties of the phage suspension, were tuned by incorporating NaCl, bovine serum albumin (BSA), and Tween 20 to optimize the electrical conductivity, viscosity, and surface tension of the feed solution, supporting a reproducible EHDA process. The electro-sprayed feed solution was collected in an oil bath to form uniform spherical microdroplets, and 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide (EDC) incorporated in the collector crosslinked the phages and formed microgels. Scanning electron microscopy (SEM) images revealed the spherical shape of the microparticles with a relatively narrow size distribution. The antibacterial properties of the microgels were tested against antibiotic-resistant *Escherichia coli* K12 strains, exhibiting the preservation of their antimicrobial properties during/after the EHDA fabrication process. The hydrated nature of the microgels minimized desiccation-induced phage inactivation, while their spherical geometry enhanced surface phage binding sites for bacterial eradication. The developed phage-based microgels offer as antimicrobial biomaterials for various biomedical applications, addressing critical needs in combating microbial contamination and infection.

14:00 - 14:20

269 Viscoelastic properties of an air-liquid interface exhibiting bacterial turbulence

Jacob John[1], Andrew Geppert[1], Raghavi Poopalarajah[2], Erum Ravzi[3], Lynne Howell[4], Joe Harrison[1], Giovanniantonio Natale[1]
[1]University of Calagry, Calgary, Canada. [2]NYU Abu Dhabi, Abu Dhabi, UAE. [3]Ontario Genomics, Toronto, Canada. [4]The Hospital for Sick Children (SickKids), Toronto, Canada

Abstract

Collective motion of bacterial suspensions at high densities giving rise to chaotic patterns resembling high Reynolds number turbulence is known as bacterial turbulence. While bacterial turbulence is commonly observed in 3D suspensions, we show that a particular strain of the common bacterium *Pseudomonas aeruginosa* can exhibit turbulence at fluid-fluid interfaces. Despite being one of the common habitats of bacterial biofilm formation in nature, the correlation between biological and physical phenomena associated with bacterial cells at fluid-fluid interfaces is not well understood. In this work, we use wild-type *Pseudomonas aeruginosa* PA-14 bacterium, and its isogenic *ΔpelF* mutant strain to uncover the relation between interfacial viscoelasticity and bacterial turbulence at fluid-fluid interfaces. This mutant strain is useful to create a dense system at the interface without the formation of arrested colonies thereby helping the study of bacterial turbulence at interfaces. We use fluorescence microscopy, image analysis, and interfacial rheology to correlate the bacterial turbulence with interfacial viscoelastic properties. In the case of *ΔpelF*, as the population of the cells at the fluid-fluid interface increases, the motility of the cells reduce and large fluctuations in density is observed as chaotic patterns emerge at the interface. At this stage the interface exhibits a two-step yielding viscoelastic behavior, indicating the presence of hierarchical structures. However, in the case of the control wild-type strain, due to the production of exopolysaccharides, bacterial cells aggregate at the interface to form interconnected interface spanning colonies and the freely moving cells exhibit collective motion between them. We further explore the role of motility and chemical communication between the cells with the help of mutant strains of the same bacterium to bring new insights into the bacterial turbulence observed at interfaces for the first time.

14:20 - 14:40

268 Spider Silk-inspired Drug-eluting Nanofiber Yarns as Surgical Sutures

Jiawei Chen, Changhao Fang, Xianyi Xia, Elizjia Conti, Michael Serpe, Tian Tang, Cagri Ayranci

University of Alberta, Edmonton, Canada

Abstract

Surgical site infections present a significant challenge in healthcare, promoting the development of suture materials loaded with antibacterial drugs. Inspired by the encapsulation of water droplets and controlled release properties of spider silk, poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) yarns reinforced with 1 wt% cellulose nanocrystals (CNC) produced via yarn electrospinning has been introduced in this study. Using crystal violet (CV) as a model drug, the yarns demonstrated robust structural integrity through multiple drug loading and release cycles without swelling or erosion. The yarns exhibited pH-responsive drug release behavior with optimal drug release observed at pH 3 and 37°C. The release profile conformed to the Ritger-Peppas model, indicating Fickian diffusion as the dominant mechanism. The yarns loaded with levofloxacin (LVX) exhibited antimicrobial activity and excellent cytocompatibility, highlighting their

potential for antibacterial suture applications. These findings underscore the promise of PVDF-HFP/CNC yarns as an antibacterial drug-eluting suture material with great biocompatibility, paving the way for innovative solutions in wound healing and other potential healthcare applications.

Colloidal systems for Food: Production, Processing and Sustainability - 2

13:20 - 15:00 Monday, 23rd June, 2025
ETLC E1-018
Colloidal Systems for Food: production, processing and sustainability
John Frostad

13:20 - 13:40

128 Swelling of polymer networks: starch gelatinization

John Frostad[1], Botong Li[2], Lanxin Mo[1], Ganesan Narsimhan[3], Vivek Narsimhan[3]

[1]U. British Columbia, Vancouver, Canada. [2]University of Science and Technology Beijing, Beijing, China. [3]Purdue U., West Lafayette, USA

Abstract

Starch is an important functional ingredient in many food products, as well as paper products, textiles, adhesives, and more. Starch is extracted from plants as small particles ranging in size from around one micron to more than one hundred microns and consists of a complex network of polymers (amylose and amylopectin) of varying molecular weight and architecture. In most applications, the functional properties of starch are accessed by first hydrolyzing the polymers by heating the starch particles in water, which is known as “gelatinization”. While much is known about starch from decades (if not centuries) of research, there is still a significant amount of work to be done on developing first-principles, predictive models for describing the gelatinization process and predicting the resultant rheological properties. In this talk, I will present recent on the development of a relatively simple model based on mass transfer and Flory-Rehner theory. The goal is to reproduce a prior experimental observation in which the swelling of starch particles was found to follow a universal curve.

13:40 - 14:00

29 Insights into the dispersion behaviour of insoluble biopolymer particles in non-aqueous media

Megan Holdstock[1], Brent Murray[1], Anwesha Sarkar[1], Michael Rappolt[1], Paraskevi Paximada[1], Isabel Celigueta Torres[2]

[1]University of Leeds, Leeds, United Kingdom. [2]Nestlé PTC, York, United Kingdom

Abstract

Controlling the dispersion of solid particles in low-polarity media, like oils, is challenging, particularly when the particles are amphiphilic in nature. The dispersion behaviour in oil of insoluble *organic* biopolymer particles was studied using rheological techniques and compared to a model colloidal system - *inorganic* silica nanoparticles with different degrees of surface modification (silanization). Both biopolymer and silica particles formed structured aggregates in oil that broke down under shear, whilst the aggregation was also influenced by particle size and surface chemistry. At sufficiently high concentrations, both particle types formed space spanning networks exhibiting elastic properties. Rheological scaling theories revealed a higher intra-floc fractal dimension and a lower network backbone dimension. As the size of the biopolymer particles was decreased (by mechanical treatment), the fractal dimensions approached those of the partially hydrophobic silica particles. Thus the ‘average surface character’ of the biopolymer particles, despite its complexity, seems similar to the partially hydrophobic silica surface, allowing parallels to be drawn with these simpler colloidal systems.

We also examined the effects of both particle types on fat crystallization via X-ray scattering. The crystal structure of the fat polymorphs remained unchanged, implying their exclusion from the crystal lattices. On the other hand, the particles appeared to hinder crystal growth, most likely due to the significantly increased viscosity in the presence of the particles. Dynamic shear rheology provided further evidence for effects on the temporal evolution of crystallization and interactions of the particles with fat crystal networks.

14:00 - 14:20

133 Protein and Alginate-Based Hydrogels for Azotobacter chroococcum Encapsulation: Enhancing Bacterial Viability and Plant Growth Promotion

Lei Zhang[1], Amish Gungah[1], Jonathan Kan[1], Reina Mazloum[1], Ella Chow[1], Jun Liu[2], Michael Fefer[2], Todd Hoare[1]

[1]Department of Chemical Engineering, McMaster University, Hamilton, Canada. [2]Nutrien Ag Solutions (Canada), Calgary, Canada

Abstract

Plant growth-promoting bacteria (PGPBs), particularly *Azotobacter*, offer an eco-friendly alternative to chemical fertilizers by enhancing soil fertility and promoting plant growth. Encapsulation in sodium alginate hydrogels has previously been demonstrated to provide a protective microenvironment that improves bacterial viability while enabling controlled release. While alginate hydrogels are cell-compatible and cost-effective, the incorporation of proteins and biomolecules that can not only serve as a nutrition source for bacteria but also optimize hydrogel properties can further enhance performance. We have developed alginate-based hydrogel microparticles enriched with various proteins, lysine amino acid, and metal ions with optimized mechanical strengths and degradation rates to encapsulate bioactive *Azotobacter chroococcum* using a co-axial air jet method. The formulations consisting of 2% alginate, 1% protein, 0.5% lysine, and 0.5% combinations of metal ions effectively maintained the stiffness of the microenvironment, provided nutrients to the bacteria, and enhanced bacterial survival for over two months. As such, hybrid alginate hydrogel-based microparticles offer improved performance as a sustainable agricultural solution.

14:20 - 14:40

52 Oat protein-polysaccharide self-assembly: Responsiveness to pH

Jennifer McLauchlan[1], Hans Bolinsson[2], Lars Nilsson[2], Arwen I. I. Tyler[1], Caroline Orfila[3], Anwesha Sarkar[1]

[1]Food Colloids and Bioprocessing Group, School of Food Science and Nutrition, School of Food Science and Nutrition, University of Leeds, Leeds, United Kingdom. [2]Department of Food Technology, Engineering and Nutrition, Faculty of Engineering LTH, Lund University, Lund, Sweden. [3]Oatly AB, London, United Kingdom

Abstract

Presently, demand is high for the exploration of new plant protein sources as sustainable alternatives to animal-derived or synthetically sourced materials. Whilst oats are known for their positive health benefits, the fundamental colloidal properties of oat protein have rarely been published.[1] Herein, we characterise a novel, dilute oat protein-polysaccharide self-assembly (OPP) using a facile extraction process. Sodium dodecyl-sulphate polyacrylamide gel electrophoresis (SDS-PAGE) revealed OPP protein composition, containing major fraction oat 12S globulin (65-67 kDa). Asymmetric flow field-flow fractionation (AF4) with in-line multi-angle light scattering, UV, and fluorescence detection confirmed multiple size distributions in OPP including small monomeric proteins, protein hexamers (12S globulin) and oat *β*-glucan. Coelution of protein and *β*-glucan, and their aggregates, support the hypothesis of a protein-polysaccharide self-assembly.

Dynamic light scattering measurements of OPP were conducted at various pH conditions, showing a regular feature (d_H ~100-150 nm), and another peak ($d_H = 22$ nm, oat 12S globulin) becoming more prominent at pH 10. OPP also showed a negative zeta-potential (ζ) at pH 7.0 and an isoelectric point of pH 4.0-4.5 driven by the proteinaceous component. The remarkable pH tunability of OPP is showcased further with confocal laser scanning micrographs showing a transition from a phase separated system at pH 2 to co-localisation of protein and polysaccharide in micrometre-scale clusters at pH 10. Results highlight an ability to control the structure of this self-assembly via modification of pH which will aid in molecular design of sustainable soft matter systems.

1. McLauchlan, J. et. al., *Food Hydrocoll.* **154**, 110139 (2024).

14:40 - 15:00

438 Marine Saponins for Sustainable Food Systems: Characterization and Potential Applications

Vicente Domínguez-Arca[1], Luis T. Antelo[2], Thomas Hellweg[1]

[1]University of Bielefeld, Bielefeld, Germany. [2]IIM-CSIC, Vigo, Spain

Abstract

Marine saponins, a class of thalassochemicals with distinctive amphiphilic and bioactive properties, hold significant potential for sustainable food technologies and nutraceuticals. Their cholesterol-lowering, antimicrobial, and emulsifying properties position them as valuable functional ingredients. However, the complexity of their extraction and structural characterization remains challenging, requiring both experimental and computational approaches to unlock their full potential.

We have identified and characterized multiple marine saponins using mass spectrometry, elucidating their fragmentation patterns and molecular diversity. These structural insights serve as a foundation for further computational studies. We currently employ machine learning-based quantitative structure-activity relationship (QSAR) models to predict their bioactivity, focusing on their unique molecular features and interactions. By integrating graph neural networks (GNNs) and explainable AI techniques, we aim to establish structure-function relationships that could guide their application in nutraceutical formulations. Preliminary findings suggest that specific saponin subclasses exhibit strong bioactive potential, supporting their role in functional food development.

By combining experimental characterization with computational modeling, we contribute to developing next-generation nutraceuticals.

Colloids for Sustainability and Energy - 1

13:20 - 15:00 Monday, 23rd June, 2025
ECERF W2-010
Colloids for Sustainability and Energy
Siddhartha Das

13:20 - 13:40

260 Elucidating the Colloidal Phase Behavior in Ionic Liquids for Energy Storage Applications

Hwigwang Lim[1], Caleb Youngwerth[2], Lisa Je[1], Rose Cersonsky[1]

[1]Department of Chemical and Biological Engineering, University of Wisconsin-Madison, Madison, USA. [2]Department of Physics, University of Wisconsin-Madison, Madison, USA

Abstract

Ionic liquids are promising candidates for charge transport in energy storage devices based on their ionic conductivities, as well as their high thermal and electrochemical stability and low volatility. Still, they remain vulnerable to leakage and dendrite formation that can lead to instability and, ultimately, failure. Colloidal gel matrices are a promising way to improve the stability of the system by enhancing mechanical and interfacial properties without significantly inhibiting ionic conduction. However, the behavior of colloidal particles in these strongly charged systems is still poorly understood. Molecular simulation enables us to analyze collective behaviors and configurations of our colloidal system and identify their phase behavior. To do so, we build off the classical approach of DLVO (Derjaguin, Landau, Verwey, and Overbeek) theory, which superposes van der Waals and electrostatic interactions between nanoparticles. We augment this approach with insight from recent studies showing that the screening length of the electrostatic

interactions deviates from traditional DLVO theory in highly concentrated electrolytes, such as ionic liquids. We then employ Topological Data Analysis to delineate different colloidal phases resulting from molecular dynamics simulation, providing a way to identify quantitative order parameters for higher-order phase transformations. Our approach yields a cohesive simulation framework to model the colloidal phase behavior in ionic liquids such that we can ultimately design more stable battery technologies.

13:40 - 14:00

185 Manipulating ZnO Tetrapod Dispersions to Achieve Tunable Photocatalytic Activity

Navneet Kumar[1], Md Masud Rana[1], Narendra Chaulagain[1], Preeti Gahtori[2], Yogendra Mishra[3], Julianne Gibbs[2], Karthik Shankar[1]

[1]University of Alberta Faculty of Engineering, Edmonton, Canada. [2]University of Alberta Faculty of Science, Edmonton, Canada. [3]University of Southern Denmark, Sønderborg, Denmark

Abstract

ZnO is one of a handful of compounds that combines high performance semiconducting behavior with piezoelectric properties. A ZnO tetrapod is an unusual type of nanocrystal that consists of four arms (each a nanorod) joined to a central core at angles of 105-110 degrees with respect to each other. ZnO tetrapods form stable colloidal dispersions in polar solvents at a range of concentrations. When cast into solid films from such colloidal dispersions, a high porosity is retained in the resulting framework leading to the use of ZnO tetrapods in aerogels. The semiconducting and catalytic properties of ZnO tetrapods are sensitive to the surface charge. For instance, ultraviolet light has been used to create on-demand oxygen vacancies on the surface of ZnO tetrapods and thus achieve switchable hydrophilicity. We sought to manipulate the zeta potential of ZnO tetrapod dispersions using (i) Surfactants (ii) Self-assembled monolayers and (iii) Ultraviolet illumination. Multiple spectroscopic techniques were used to characterize the ZnO tetrapods. Subsequently, the ZnO tetrapod dispersions were used as catalysts for (1) Photocatalytic hydrogen evolution and (2) Photocatalytic deposition of coinage metal nanoparticles. 3 mg of ZnO tetrapods were dispersed in 2 mL of deionized water containing 10% triethanolamine through sonication for 10 minutes. The ZnO tetrapod dispersion was loaded into a sealed stainless photocatalytic reactor and purged with 20 psi of nitrogen. Subsequently, the dispersion was irradiated with a 254 nm UV lamp for 2 hours. Gas chromatographic analysis of the reaction products indicated a hydrogen generation rate of ~81 μmol g^{-1} hr^{-1}. Photodeposition was conducted in methanolic dispersions of ZnO tetrapods containing $HAuCl_4$, $AgNO_3$ or $Cu(acac)_2$.

14:00 - 14:20

325 Colloidal Quantum Dots for Solar Energy Harvesting

Jiangwen Zhang, Lingju Meng, Xinmei Liu, Qiwei Xu, Xihua Wang

University of Alberta, Edmonton, Canada

Abstract

Colloidal quantum dots (CQDs), which can be tailored in size, shape, composition, and surface groups, show great promise for electronics, optoelectronics, and photonics due to their extraordinary properties like tunable band gap, multiexciton generation, solution processability, and narrow emission line width. Electronically coupled CQD solids (e.g., PbS CQD films) have been demonstrated to produce high performance solar cells [1], photodetectors [2], thin-film transistors [3], and light-emitting devices [4].

Doping CQDs has been challenging due to the “self-purification” phenomenon. Surface ligand engineering has emerged as an effective strategy to control free carrier concentrations and doping types in CQD solids. We demonstrated a p-type CQD solar cell using halide surface treatment which was only used to produce n-type PbS CQD solids in previous reports.[5] The p-type behavior originates from a novel surface ligand, the HOH^+ group. The inverted-structure CQD solar cells based on p-type CQDs, achieving a power conversion efficiency of 7.49%.

CQD materials also show promise in luminescent solar concentrator (LSC) technology due to their tunable Stokes-shift, which minimizes light reabsorption. LSCs present a cost-effective alternative to conventional photovoltaics, enhancing solar cell output. Cellulose nanocrystals (CNCs) are a promising candidate as the LSC matrix due to their good mechanical properties, high aspect ratio, low density, low thermal expansion, and eco-friendly properties. We successfully prepared CQD/CNC-based luminescent films by embedding inorganic ligand-capped core-shell CdSeS/ZnS CQDs into surface-functionalized CNC matrix.[6] The functionalization ensured compatibility between CQDs and CNCs in polar organic solvents, resulting in highly fluorescent bio-based composites.

[1] Liu, Mengxia, et al. "Hybrid organic–inorganic inks flatten the energy landscape in colloidal quantum dot solids." *Nature materials* 16.2 (2017): 258-263.
[2] Clifford, Jason P., et al. "Fast, sensitive and spectrally tuneable colloidal-quantum-dot photodetectors." *Nature nanotechnology* 4.1 (2009): 40-44.
[3] Kim, David K., et al. "Flexible and low-voltage integrated circuits constructed from high-performance nanocrystal transistors." *Nature communications* 3.1 (2012): 1216.
[4] Choi, Moon Kee, et al. "Flexible quantum dot light-emitting diodes for next-generation displays." *npj Flexible Electronics* 2.1 (2018): 10.

[5] Meng, Lingju, et al. "Unusual Surface Ligand Doping-Induced p-Type Quantum Dot Solids and Their Application in Solar Cells." *ACS applied materials & interfaces* 12.48 (2020): 53942-53949.
[6] Liu, Xinmei, et al. "Luminescent films employing quantum dot-cellulose nanocrystal hybrid nanomaterials." *Materials Letters* 294 (2021): 129737.

14:20 - 14:40

449 Surfactant peptides at the air-aqueous interface for foam fractionation recovery of rare earth elements

Charles Maldarelli[1], Luis Ortuno Macias[1], Raymond S. Tu[1], Surabh Kt[1], Kathleen J. Stebe[2], Monica Olvera de la Cruz[3]

[1]The City College of New York, New York, USA. [2]University of Pennsylvania, Philadelphia, USA. [3]Univ of Northwestern, Evanston, USA

Abstract

Solvent extraction is widely used for separation of the trivalent rare earth element cations (Ln3+) from an aqueous phase into an organic solvent. This process is energy intensive and environmentally unfriendly. Foam fractionation recovery of these cations is a promising, less energy intensive alternative, in which oppositely charged surfactants complex to the cations in solution, and then adsorb to bubbles sparged through the solution; the bubbles are collected as a foam at the top of the column to complete the recovery. A key challenge is to design surfactants to selectively bind to a particular lanthanide cation so that a selective recovery can be enabled.

Here lanthanide binding tag (LBT) amphiphilic peptides are used to selectively complex Ln3+ cations. The LBT peptides bind through a binding loop of polar residues which coordinate to a specific Ln3+, and also contain hydrophobic residues which provide amphiphilicity. We use LBT13+ which is uncharged upon lanthanide binding to eliminate nonspecific electrostatic complexation. LBT13+ is selective for Tb3+. Surface tension measurements demonstrate that LBT13+ is surface active, and complexation (LBT13+:Tb3+) enhances the activity. X-ray specular reflectivity and x-ray fluorescence near total internal reflection measurements of the adsorbed interfacial layer show a 1:1 ratio of LBT13+ and Tb3+, and molecular dynamics simulations demonstrate the cation remains bound in the loop on adsorption. Experiments on LBT13+ binding to 1:1 mixtures of Tb3+ and lanthanum (La3+) show a selectivity for Tb3+ at the interface. Finally, a demonstration of this selectivity in a foam fractionation column is presented.

14:40 - 15:00

360 Solvent Mediated Assembly of Asphaltenes on Silicon Nanoparticles as High-Performance Anode Materials of Lithium-Ion Batteries

Wanran LIN[1], Wen TAN[1], Feng JIANG[1], Zhouguang LU[1], Fan YANG[2], Zhenghe XU[1]

[1]Shenzhen Key Laboratory of Interfacial Science and Engineering of Materials, Department of Materials Science and Engineering, Southern University of Science and Technology, Shenzhen, China. [2]College of New Materials and New Energies, Shenzhen Technology University, Shenzhen, China

Abstract

With the proposal of the dual-carbon strategy to achieve a global common goal of carbon neutrality, along with the restructuring of the energy framework, industrial upgrading and enhancements in energy efficiency, significant advancements have been made in the optimization of lithium-ion batteries (LIBs) as an effective energy storage strategy. As a core component of LIBs, the anode plays a decisive role in determining their overall performance. Carbon coating on such materials as silicon and silicon oxides (SiOx) of poor electronic conductivity and large volume changes during cycling is one of the most common methods to improve the performance of Li-ion batteries. However, its brittle nature and low elasticity make the conventional carbon coatings crack easily and hence lose the conductive connection with active materials after a few cycles. In this work, we propose a scalable and low-cost synthesis method to deposit a protective carbon layer on silicon nanoparticles by molecular-level controlled association of natural polyaromatic asphaltene molecules in heavy oil. Si/C nanocomposites of a fullerene-like carbon layer coated on silicon nanoparticles hosted in the hierarchical carbon matrix were synthesized by molecular-level controlled association of natural polyaromatic molecules in heavy oil through the control of quality of solvent. The synthesized silicon-carbon composite anode materials exhibited outstanding electrochemical performance. The results demonstrate that asphaltenes in the residue of heavy oil refinery or heavy oil such as bitumen are a viable carbon source for preparation of Si/C nanocomposites through solvent-controlled molecular association on silicon nanoparticles that exhibit excellent electrochemical performance. Such approach shows great potential to meet rapidly growing demands for high-density and heavy-duty power storage systems.

Rheology and Tribology of Complex Fluids - 2

13:20 - 15:00 Monday, 23rd June, 2025
ECERF W2-110
Rheology and Tribology of Complex Fluids
Nezia De Rosso

13:20 - 13:40

18 Boundary lubrication with adsorbed anionic surfactant bilayers in hard water

Aya Toyoda[1], Hikaru Kimura[1], Tadashi Sugahara[1], Atsushi Miyazaki[1], Takaya Sakai[2], Shinji Yamada[1]

[1]Kao Corporation, Wakayama, Japan. [2]Kao Corporation, Tokyo, Japan

Abstract

The adsorption behavior of an anionic surfactant, hydroxy alkane sulfonate with the alkyl chain length of 18 (C18HAS), from its hard water solution onto a mica surface and resulting lubrication properties were investigated. Because of the double chain like chemical structure and aggregation behavior, C18HAS formed vesicles in hard water which adsorbed onto a negatively charged mica surface via cation (Ca^{2+}) bridging and then transformed into a bilayer film. The number of bilayers formed on the surface was evaluated by force curve measurements using atomic force microscope (AFM); the results showed a time dependent increase of the number of adsorbed bilayers. Friction and lubrication properties were evaluated for the confined film of C18HAS hard water solution between mica surfaces using the surface forces apparatus (SFA). When the two surfaces were brought in contact under load and sheared against each other, the lubricating film consisted of two adsorbed C18HAS bilayers whose friction coefficient m of the order of 10^{-3} or below. The detailed analysis of the friction features revealed that the slipping in the boundary film does not occur at the interface between opposed headgroup region of the two adsorbed bilayers, which is the typical mechanism for the low friction of adsorbed phospholipid bilayers extensively studied in literatures. Instead, slipping occurs at the interface between opposed *liquid-like* alkyl chain tails within the adsorbed bilayers; the low friction coefficient comes from the existence of two slip planes in the boundary film.

13:40 - 14:00

454 Capillary breakup of a viscoplastic drop with pressure boundary condition

Volfango Bertola[1], Teodor Burghelea[2]

[1]University of Liverpool, Liverpool, United Kingdom. [2]Univ Nantes, Nantes, France

Abstract

The process of drop formation from a capillary nozzle has been extensively investigated for both Newtonian and non-Newtonian fluids. In these works, pendant drops are generated at a small, constant flow rate, e.g. using a syringe pump. Here, we investigate by means of high-speed imaging combined with micro-PIV the formation and capillary breakup of viscoplastic drops generated by imposing a constant pressure upstream of the dispensing nozzle. Drop formation and capillary breakup are fundamental phenomena in fluid mechanics, with applications in microfluidics, inkjet printing, and emulsions. Understanding these processes is crucial for optimizing industrial and biological applications.

Drops of aqueous Carbopol 980 dispersion were generated at the tip of a blunt hypodermic needle by means of a pressure-based flow controller. To enable velocity measurements, the fluid was seeded with PMMA particles (0.1% v/v), and drops were immersed in an oil bath contained in a transparent rectangular reservoir. The oil level was maintained constant to offset hydrostatic pressure. A high-speed camera (Mikrotron EOSense) was used to capture images of the growth and pinch-off process, while illumination was provided by a 532nm continuous wave laser sheet perpendicular to the optical axis.

The behaviour of pure water drops was compared with that of Carbopol dispersion drops of different concentrations, i.e., with different magnitudes of the yield stress. Results show the drop lifetime, as well as the neck diameter, exhibit distinct scaling behaviours with respect to the applied pressure, which correspond to different patterns of the flow within the drop.

14:00 - 14:20

192 Test of entropy scaling of relaxation dynamics in buckled colloidal monolayers

Xiaoguang Ma

Southern University of Science and Technology, Shenzhen, China

Abstract

Excess entropy scaling is a phenomenological law connecting dynamics with thermodynamics in simple and complex fluids. Here, we investigate the entropy scaling law in colloidal samples that mimic Ising magnets. Our experiment employs colloidal monolayers confined between two parallel walls with a wall-wall separation slightly bigger than the particle size. The out-of-plane displacements of particles are extracted from video microscopy and mapped to an Ising spin model. We collect time series of the Ising spin states from three experiments with different control protocols. In the first and second experiments, we employ laser tweezer arrays to apply in-plane shear and compression to the sample, respectively. In the third experiment, we utilize thermo-responsive surfactant micelles to alter depletion attractions between particles. Using the Ising spin data, we compute the spin relaxation time, τ_α, and the information entropy, S. We find that the two satisfy the scaling law, $\tau_\alpha \sim \exp(c^*S)$, with the coefficient c dependent on the control protocols. This result suggests that entropy can predict dynamics in coupled spin systems.

14:20 - 14:40

334 Stringy Products: film formation in dispensing flows and how to avoid it

Jonathan Mantzouridis, Patrick Spicer

UNSW, Sydney, Australia

Abstract

Many products are designed to form films to coat surfaces or skin, providing adhesion, controlled release of actives, or protective barriers. Film formation during dripping, produces liquid filaments with elastic surface skins that are hard to break or “stringy”. While string formation enables spider-silk production and fibre-spinning, it undermines product performance in high-throughput dispensing processes, creating nozzle-trailing threads that contaminate bottling lines and waste material.

Detection, control and avoidance of stringing during processing or use requires rapid tests, a mechanistic understanding and predictive models for film formation. Existing models explain bulk viscoelasticity in polymer solutions through chain-relaxation but often fail to capture surface-driven processes, like drying or adsorption in non-polymeric and surfactant-based systems. Multi-component systems, especially consumer products, are rarely studied, but often contain high concentrations of thickeners and surfactants, and evaporative and adsorptive effects are frequently overlooked in water-based formulations.

This work investigates film formation in a range of commercial liquid products, using capillary break-up extensional rheometry, shear rheometry, thermo-gravimetric analysis and interfacial tensiometry to probe the characteristic flow and solidification time-scales. We show that product stringiness often arises from interfacial film formation rather than polymer elasticity, when evaporation, adsorption, or reaction time-scales are short relative to flow. This behaviour is common in products with high viscosities >10 Pa·s and flow time-scales >1s, like hand soaps and sugar syrups, and can be identified using a strain-hardening index. Lastly, we demonstrate that rapid adsorption dynamics can be leveraged to design low-viscosity formulations with high-interfacial-elasticity that enable more stable foams.

Molecules and Particles at Fluid Interfaces - 2

13:20 - 15:00 Monday, 23rd June, 2025
ETLC E2-001
Molecules and Particles at Fluid Interfaces
Man Hin Kwok

13:20 - 13:40

35 Modeling ion transfer across liquid–liquid interfaces assisted by phase-transfer catalyst

Ying-Lung Steve Tse, Chung Chi Chio

The Chinese University of Hong Kong, Hong Kong, China

Abstract

We present a systematic approach for developing accurate classical polarizable force fields to study ion transfer across liquid-liquid interfaces. Our method optimizes force field parameters by minimizing relative entropy and root mean squared deviation in atomic forces using ab initio molecular dynamics reference data.

Using chloride ion transfer across water-dichloromethane and water-benzene interfaces as model systems, we demonstrate the efficacy of our parameterization scheme both with and without tetraethylammonium cation (TEA) as a phase-transfer catalyst. The optimized force fields

successfully reproduce bulk properties and hydration shell structures from both ab initio and experimental data.

Through steered molecular dynamics simulations, we obtained free energy profiles showing that TEA reduces the transfer barrier by 2.4 kcal/mol in the water-dichloromethane system and 4.6 kcal/mol in the water-benzene system. Energy decomposition analysis reveals the critical roles of both electronic polarization and charge-charge interactions between chloride and TEA+ in lowering the free energy barrier. Hydration shell analysis indicates that chloride ions retain approximately 4 and 8 water molecules after transfer into dichloromethane and benzene phases, respectively.

Our parameterization scheme enables efficient simulations of larger systems over longer time scales compared to ab initio methods while maintaining accuracy. This approach provides a general framework for modeling various liquid-liquid interfaces, with the potential for further refinement through more flexible force field functional forms to better match atomic forces and reduce relative entropy.

13:40 - 14:00

244 Developing a theory for AFM force measurements in complex liquids using DFT

Simone Riva[1], Regine von Klitzing[2], Ofer Manor[1]

[1]Technion - Israel Institute of Technology, Haifa, Israel. [2]Technische Universität Darmstadt, Darmstadt, Germany

Abstract

We use classical density functional theory (DFT) to model colloidal-probe atomic force microscopy (AFM) force measurements. The AFM probe interacts with the substrate through an aqueous suspension of solid nanoparticles. Nanoparticles, even nonionic, are known from experiments to produce oscillatory structural forces, characterized by an alternation of excluded-volume repulsion and depletion attraction. In the charged nanoparticles suspensions that we use, the structural force is a product of both the nanoparticles' excluded volume and electrostatic repulsion. It further enhances the colloidal suspension's stability beyond the repulsive double-layer (EDL) barrier of an ionic fluid.

EDL and structural forces are both calculated in a DFT scheme by minimizing dedicated functionals. For the former, ions are modeled as charged hard spheres. A functional for the double layer predicts the distribution of the electrolyte and the corresponding electric potential between the probe and the substrate. The functional for the structural force models nanoparticles as hard spheres with an effective size that accounts for their radius and electrostatic repulsive shell. Through this we are able to reproduce the oscillation amplitude and period of the force. The former is related to the particles' size and concentration; the latter only depends on the concentration, to

which it is related through a simple general scaling law. This law is a product of the packing structures that the nanoparticles form next to each confining wall. The theory is able to calculate the two force contributions consistently and is the first one to reproduce measurements while being independent of experiments.

14:00 - 14:20

255 Nanoarchitectonic phenomena in the adsorption of antennary oligoglycines at fluid interfaces

Elena Mileva, Ljubomir Nikolov, Dimitrinka Arabadzhieva

Institute of Physical Chemistry, BAS, Sofia, Bulgaria

Abstract

The research is aimed at acquisition of new knowledge about supramolecular nanostructures, formed in aqueous solutions of two, three and four-antennary oligoglycines. An important asset in formulating the design strategies for these systems is the possibility for characterization of interfacial structure-property relationships for various fluid compositions.

The key nanoarchitectonic phenomenon is linked to the molecular structure of these compounds. They consist of a central connecting element, attached to glycine portions (antennae) of optimal length. Intramolecular ‘click-clack’ interactions are promoted among the antennae in one molecule, and because of their close proximity, modification of the initial conformation is observed. At the second nanoarchitectonic stage these intra-molecular architectures serve as building blocks, which initiate inter-molecular options for consecutive structural reorganizations and the onset of oligoglycine aggregates (tectomers), micelle-like nanostructures, gel-like entities. Both, the single molecules and the tectomers, can enter interfacial regions and adsorb at fluid interfaces, or initiate super-regular coatings.

Mechanisms and kinetics of tectomer formation, morphology of nanostructures, and paths of changing the interfacial properties, are investigated through appropriate experimental techniques. The fine-tuning of structure-property relationships is regulated by changes in pH values, temperature, oligoglycine concentration, addition of low-molecular-mass additives, synthetic and natural amphiphiles.

The obtained peculiarities of the adsorption layers at fluid interfaces and of super-regular coatings allow to extract the specific nanoarchitechtonic tendencies in these complex fluids. The research outcomes verify that antennary oligoglycines have substantial potential for applications in medicine, biotechnologies, drug delivery, environmental protection. Several of the achieved application options are presented and discussed.

Acknowledgements: The study is funded by Bulgarian National Fund for Scientific Research through Project "Design and Characterization of Soft Nanostructured Materials Based on Antennary Oligoglycines", Grant No. КП-06-Н39/5

14:20 - 14:40

341 Bubble Detachment Pathway under the Influence of Surfactant-induced Marangoni Effect

Nhat N. Nguyen, Tuan A. H. Nguyen, Ngoc N. Nguyen, Anh V. Nguyen

The University of Queensland, Brisbane, Australia

Abstract

Bubble formation and detachment are fundamental processes in multiphase systems such as froth flotation and emerging electrochemical processes for the sustainable production of minerals, fuels, and chemicals. Classical models have studied the quasi-static growth and departure of air bubbles under constant chemical potential. However, these models fail to account for experimental observations involving chemical concentration gradients that develop during bubble evolution. Here, we introduce a new experimental approach based on the surfactant-induced Marangoni effect, manipulating surface tension forces while maintaining constant bubble volume and buoyancy. High-speed video microscopy, combined with image analysis, and numerical modelling, enabled accurate quantification of the bubble detachment pathway through a pinch-off neck. Our findings reveal deviations from the Young-Laplace theory in describing the fast kinetic regime, particularly just before detachment. By correcting the Young-Laplace theory with momentum conservation equations, we account for detachment acceleration, showing that larger bubbles experience higher acceleration, leading to an extended detachment process. We identified the significant role of Marangoni flows - arising from surfactant redistribution during detachment - which alter surface tension gradients and change neck pinch-off dynamics. Classical models, which assume uniform surface tension, overlook this effect, leading to inaccurate predictions. This study challenges existing assumptions and provides a more comprehensive framework for understanding bubble detachment physics in surfactant-laden systems.

14:40 - 15:00

371 Transport Phenomena of Highly Concentrated Hydrophobic Particles in Confined Fluid Flow

Ryan Haggerty, Yusong Li, Jae Sung Park, Seyed Mohammad Hosseini
University of Nebraska-Lincoln, Lincoln, NE, USA

Abstract

Highly concentrated hydrophobic particles display non-trivial behavior in confined microfluidic spaces due to slip at the particle-fluid interface. At high concentrations, suspensions of rigid spheres tend to migrate toward the center of a microchannel. Our previous computational studies suggest that slip velocity at the hydrophobic particle interface enhances this migration. Therefore, we hypothesize that increased slip velocity in hydrophobic particles should further amplify this central migration effect. While models and experiments have investigated the behavior of confined particles in the dilute regime, experimental data for highly concentrated hydrophobic suspensions (volume percentage > 0.1) are not available.

In this work, we use fluorescent polyethylene particles to study the transport of highly concentrated particles under varying flow conditions, comparing the effects of slip and non-slip interfaces. We extract and analyze 2-D microfluidic channel images and videos captured using a Nikon Ti-2 microscope to qualitatively compare plume profiles of slippery and non-slippery particles in the transverse direction. Particle velocity fluctuations in the flow are calculated from high-quality video data using particle tracking with FIJI. Our experimental observations align with our computational results, confirming that hydrophobic particles, with slip effects and increased slip velocity, exhibit significantly greater migration toward the channel centerline.

Wetting and Adhesion - 2

13:20 - 15:00 Monday, 23rd June, 2025
ETLC E1-003
Wetting and Adhesion
Carlo Antonini

13:20 - 13:40

25 Unveiling the Interfacial Structure of Ionic Liquids through Dynamic Wetting Measurements

Owen Johnson, Filippo Mangolini
The University of Texas at Austin, Austin, USA

Abstract

Understanding the interfacial structure between ionic liquids (ILs) and solid surfaces is essential for advancing the implementation of ILs in a variety of applications, including as concentrated electrolytes in energy storage devices and lubricants. While established techniques like atomic force microscopy (AFM), the surface force apparatus (SFA), and neutron reflectometry (NR) provide insights into the static structure of IL/solid interfaces, methods for investigating the dynamics of these interfaces remain underdeveloped. Here, we present dynamic wetting as a method to investigate both the static and dynamic interfacial structures of a series of structurally-related ILs, which contain cations with varying chain length, on oxidized silicon in the absence of any spatial nanoconfinement. The dynamic wetting data were modeled using the molecular kinetic theory (MKT). The results suggest that a progressive change in interfacial organization of the ions, in which cations are increasingly oriented more perpendicularly to the substrate surface, occur as the cation alkyl chain length increases. The outcomes of this work, establishing links between the molecular architecture of ILs and their interfacial properties without any spatial confinement, shed new light on the behavior of ILs at solid interfaces.

13:40 - 14:00

37 Superspreading of trisiloxane surfactants - The mystery is solved!?

Joachim Venzmer

Evonik Operations GmbH, Essen, Germany

Abstract

Superspreading is a fascinating feature of dilute solutions of some trisiloxane surfactants on hydrophobic substrates (Figure 1)[1,2]. Even 35 years after the first phys-chem paper discussing the spreading mechanism, this phenomenon continues to attract much attention mainly for two reasons: (i) the practical benefits of the effect in agrochemical applications and (ii) the scientific challenges to explain the mode of action of the surfactants, including why only some trisiloxane surfactants exhibit superspreading, while others of quite similar chemical structure only behave like ordinary surfactants. Surprisingly, even today surface tension gradients and Marangoni flow are still discussed as the most viable mode of action [3], including an area expansion against thermodynamics which is supposed to maintain the surface tension gradient during the spreading process of in total 60 s. This sounds weird even without considering that there is sufficient experimental evidence that surface tension gradients cannot play a role in superspreading [2]. It will be shown that there is nothing unusual concerning trisiloxane surfactants, as their interfacial behavior follows the rules of basic physical chemistry and all phenomena observed can be explained easily by considering thermodynamics and the "normal", well-accepted behavior of surfactants at interfaces [4].

[1] J. Venzmer, *Current Opinion in Colloid & Interface Science* **16** (2011) 335-343.

[2] J. Venzmer, *Advances in Colloid & Interface Science* 288 (2021) 102343.

[3] J. Lee, S. Murad, A. Nikolov, *Langmuir* **40** (2024) 27356-27363.

[4] J. Venzmer, *Current Opinion in Colloid & Interface Science* **72** (2024) 101807.

14:00 - 14:20

84 Revisiting Marangoni Effect Contribution to the Spreading and Contraction of Binary Mixtures Evaporating Drops

Mohammad ABO JABAL[1,2], Ekhlas Homede[1]

[1]Guangdong Technion-Israel Institute of Technology, SHANTOU, China. [2]Shenkar College of Engineering and Design, Tel Aviv, Israel

Abstract

The prevailing hypothesis in droplet wetting dynamics suggests that outward Marangoni flow (OMF) causes spreading, while inward Marangoni flow (IMF) leads to contraction. In this study we critically examine this hypothesis and explore the relationship between Marangoni flow directionality and the spreading dynamics of evaporating binary mixture droplets, isolating solutal Marangoni flow from other mechanisms.

We investigate four binary mixtures: propanol/toluene and propanol/propyl acetate for IMF, and water/ethanol and propanol/iso-propanol for OMF. The spreading area and internal flow dynamics of evaporating droplets are monitored using microscopic particle image velocimetry (μPIV) and high-speed imaging. The experiments are designed to minimize the effects of gravity, thermal gradients, and buoyancy, as verified through dimensional analysis.

Contrary to the prevailing hypothesis, we find that IMF mixtures spread, whereas OMF mixtures do not. The extent of spreading in IMF mixtures varies non-monotonically with composition. PIV measurements reveal complex internal flows: IMF mixtures induce symmetrical inward flow, whereas OMF mixtures exhibit chaotic flow with multiple vortices instead of symmetrical outward flow. We observe an inverse relationship between vorticity and spreading area for IMF mixtures. These findings suggest that solutal Marangoni flow alone cannot explain the spreading behavior. We propose that the excess volume of non-ideal liquid mixtures influences spreading dynamics due to liquid-liquid interactions. Our results challenge existing assumptions and emphasize the need for a nuanced understanding of thermodynamic non-ideality effects on wetting and evaporation processes in binary mixture droplets.

14:20 - 14:40

81 Enhancing Gas Bubble Removal in Electrochemical Reactions: Aerophobic Polymer Coatings for Improved Electrode Wettability

Seunghyun Lee, Yunseok Kang, Misol Bae, Dasom Jeon, Jinwoo Park, Jungki Ryu, Dong Woog Lee

Ulsan National Institute of Science and Technology, Ulsan, Korea, Republic of

Abstract

Gas-evolving electrochemical reactions play a critical role in achieving a sustainable, carbon-neutral society. Key examples include hydrogen evolution reactions (HER) and oxygen evolution reactions (OER), both of which are integral to hydrogen production via water electrolysis. A defining feature of these reactions is the involvement of the solid-liquid-gas triphase interface, which poses significant challenges for practical implementation. For instance, gas bubbles generated during HER and OER often adhere to electrode surfaces, reducing the effective active surface area available for electrochemical reactions and limiting the efficiency of these systems. Addressing this issue requires innovative strategies to enhance gas bubble removal by modifying the wetting properties of electrodes. This presentation will highlight recent advancements in improving electrode wettability through the use of aerophobic polymer coatings.

14:40 - 15:00

246 Understanding the Bubble Detachment Dynamics on Heterogeneous Wettability Surfaces for Enhancing the Coarse and Composite Particle Flotation

Quang Dao, Nhat Nguyen, Ngoc Nguyen, Tuan Nguyen, Anh Nguyen

The University of Queensland, Brisbane, Australia

Abstract

Bubble interaction with chemically and topologically heterogeneous surfaces is a governing factor of the efficient separation of critical minerals, in particular in the flotation of composite and coarse particles. However, most existing studies reported on the static regimes of bubble-particle detachment interactions based primarily on the traditional Young-Laplace model, while the dynamic aspects of this process (especially prior to the detachment event) remain largely unexplored. We studied the dynamic regimes of bubble detachment from a patterned silicon wafer

surface to simulate the heterogeneous surface of composite minerals, using high-speed camera micrography and a home-built MATLAB code for bubble profile analysis. We are particularly interested in the dynamic regime within milliseconds prior to the bubble detachment. We found that in such a dynamic regime, the capillary length showed an unexpectedly steep increase, suggesting the complex balance of dynamic forces. In addition, curvature analyses indicated that the classical Young-Laplace model is insufficient to capture the detachment behaviour of the bubble, calling for the development of new empirical models to describe the dynamic regime of the bubble-particle interaction. Insights established in this work challenge the traditional point of view on bubble-particle detachment interaction and call for further attention to this field to establish a better foundational basis for the emerging technology of coarse and composite particle flotation.

Soft Matter - 2

13:20 - 15:00 Monday, 23rd June, 2025
ECERF W2-050
Soft Matter
Robert Macfarlane

13:20 - 14:00

233 Dynamic Nature of Static: Charge Separation and Transfer at all Interfaces of Matter

Siowling Soh

National University of Singapore, Singapore, Singapore

Abstract

What is static? Static charge is the immobile charged species generated on surfaces by contact electrification. Beyond knowing its existence, the fundamentals and general behaviors of static, including its identity and mechanism of generation, are poorly understood. Static is important in our society, with a vast range of applications (e.g., in energy and sustainability) and influences on our daily activities (e.g., dust adhering onto screens). This severe lack of understanding has greatly hindered the development of technologies.

This presentation first addresses the two most important fundamental questions of solid-solid contact electrification: the chemical identity of static charge and its mechanism of generation. Our molecular-scale analysis using surfaces with self-assembled monolayers of molecules shows the elementary steps of contact electrification: the exact location of heterolytic cleavage of covalent bonds (i.e., Si-C bond), exact charged species generated (i.e., alkyl carbocation), and transfer of molecular fragments. The identity of static charge is thus an ionic molecular fragment.

At the solid-liquid interface, we found that water can charge highly after contacting solid surfaces; thus, energy of rain can be harvested effectively. We further found that charged surfaces readily transfer charge to all types of liquids, including nonpolar liquids. At the solid-gas interface, we found a dynamically reversible solid-gas charge transfer that enables the charge of a flexible material to change with shape. Hence, shape changes the charge states of materials. These findings reveal the dynamic nature of static charge as it separates and transfers actively across all interfaces of matter. Static is dynamic.

14:00 - 14:20

134 Self-Assembly of Surface-Active Ionic Liquids in Neoteric Solvents

Gregory Warr[1], Elise Guerinoni[1], Alexandra Mort[1], Joshua Marlow[1], Kathleen Wood[2], Yunxiao Zhang[3], Jianan Wang[3], Rob Atkin[3]

[1]The University of Sydney, Sydney, Australia. [2]Australian Nuclear Science and Technology Organisation, Lucas Heights, Australia. [3]University of Western Australia, Perth, Australia

Abstract

Many surface-active ionic liquids (SAILs) can be prepared by combining the 2,2'-ethylhexylsulfosuccinate (AOT) anion with various cations.[1] Here we describe how the self-assembled, sponge-like liquid nanostructure of AOT-based SAILs depends on the structure of aprotic[2] and protic ionic liquid (IL) organic cations in the pure state, as well as on the formation of novel solvate SAILs by coordination of alkali metal cations with glymes.[3]

We will also describe the structure evolution, phase behavior, and some surprising miscibility phenomena of AOT-based SAILs when diluted in water and in conventional ionic liquid solvents. These can be understood by considering how the competitive binding of cations influences the curvature of the anion-rich bilayer that forms the structural scaffold in the liquid.

References

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[2] "Phase Behaviour and Aggregate Structures of the Surface-Active Ionic Liquid [BMIm][AOT] in Water" Y. Zhang, J.B. Marlow, K. Wood, J. Wang, G.G. Warr, H. Li, R. Atkin *J. Colloid Interface Sci,* **2023**, *652*, 749-757.

[3] "Bulk nanostructure of the prototypical 'good' and 'poor' solvate ionic liquids [Li(G4)][TFSI] and [Li(G4)][NO_3]" T. Murphy, S. Callear, K. Shimizu, J.N. Canongia-Lopes, Y. Nageshwar, M. Watanabe, T. Darwish, G.G. Warr, R. Atkin, *Phys. Chem. Chem. Phys.* **2016**, *18*, 17224-17236

14:20 - 14:40

200 Towards the assembly of 2D tunable crystal patterns of spherical colloids without using solvents

Kai Sotthewes[1], Andris Sutka[2], Ignaas Jimidar[3]

[1]University of Twente, Enschede, Netherlands. [2]Riga Technical University, Riga, Latvia. [3]VU Brussels, Brussel, Belgium

Abstract

Entering an era of miniaturization prompted scientists to explore assembly strategies to assemble colloidal crystals for numerous applications, including photonic crystals, optical sensors, and new materials. Here, the manual rubbing assembly method is utilized to rapidly (approx. 20 seconds) attain monolayers comprising hexagonal closely packed (HCP) crystals of monodisperse dry powder spherical particles with a diameter ranging from 500 nm to 10 µ on non-elastomeric substrates using a PDMS stamp. It is evident that the tribocharging-induced electrostatic attraction, particularly on relatively stiff substrates, and contact mechanics force between particles and substrate are critical contributors to attaining large-scale HCP structures on conductive and insulating substrates. Furthermore, when PDMS or fluorocarbon are constituents of the system, crystal formation is promoted due to their tribocharging properties. At last, it is shown that the solvent-free assembly of crystal patterns can be tuned with great control on a chemically templated surface. This rubbing method allows for addressing a fundamental knowledge gap in solvent-free assembly of colloidal particles on the one hand, while opening avenues for more sustainable and faster fabrication of ordered monolayers or patterned crystals that can be promising in applications such as triboelectric nanogenerators (TENGs), and microfluidic platforms for performing bioassays and other biosensing application. To prove this, results of a working granular TENG are shown based on our developed rubbing method.

14:40 - 15:00

210 Electrokinetic spectroscopy of ion and charge dynamics near charged surfaces in electrolyte solutions using modulated surface acoustic waves

Ofer Manor, Yifan Li, sudeepthi Aremanda

Technion - Israel Institute of Technology, Haifa, Israel

Abstract

We use MHz-level frequency-modulated surface acoustic waves (SAWs) to study the dynamics of ions in the electrical double layer (EDL), to appear near charged solid surfaces in electrolyte solutions. The SAW travels in the solid; the EDL exists in the electrolyte; both phenomena are entangled through a field effect, a mechanical evanescent wave, which is invoked in the electrolyte by the SAW [1] and vibrates ions in the EDL to result in the leakage of an electrical field off the EDL [2]. This is a spectroscopy of ion dynamics in isolated and unique EDLs. See the figure for the experiment and a physics illustration.

EDLs are nanometer-thick clouds of ions that appear at the charged interface between a substrate and an electrolyte solution and determine its electrical properties. Ions migrate through the EDL within micro- to nano-seconds: These are the EDL relaxation-times for charging and discharging, which are a product of the EDL structure and ion species therein.

Ion relaxation times similar to the SAW periodic time result in an ion electro-mechanical resonance, which maximizes ion vibration and the leakage of electrical fields off the EDL. [3] The leakage identifies the relaxation-time spectrum and presence of ions and the intrinsic rate by which they charge and discharge EDLs.

[1] O. Manor, L. Y. Yeo, J. R. Friend, J. Fluid Mech. 707, 482–495 (2012)

[2] O. Dubrovski and O. Manor. Langmuir 2021, 37, 14679–14687 (2021)

[3] S. Aremanda and O. Manor. J. Phys. Chem. C, 127, 20911–20918 (2023)

ACS Victor K LaMer Award Lecture - Elastic Turbulence in 3D Porous Media

15:20 - 16:20 Monday, 23rd June, 2025
ETLC E1-001
Cari Dutcher
Awardee: **Dr. Christopher A. Browne**

453 Elastic Turbulence in 3D Porous Media

Christopher Brown

University of Pennsylvania, Philadelphia, USA

Abstract

A wide range of environmental, industrial, and energy processes rely on transport in disordered 3D porous media. In many of these settings, transport is limited by strong flow heterogeneities and the steady, laminar flow imposed by geometric confinement (Re«1). Polymer additives have potential as a key engineering tool for modifying these flows to improve transport. However, the flow behavior of these rheologically-complex fluids remains poorly understood in these disordered settings—in large part due to imaging limitations.

My work addresses this gap in knowledge by fabricating transparent 3D porous media and directly imaging the flow in situ. I find that polymer stretching can give rise to an elastic instability that generates turbulent-like fluctuations under conditions prohibitive for traditional turbulence. This is the first demonstration, to our knowledge, that "elastic turbulence" can arise in disordered 3D porous media at flow conditions relevant to industrial applications. Leveraging this new knowledge of the underlying flow, I develop a theoretical model for the macroscopic flow resistance at varying flow rate. This modeling provides the first quantitative link between microscopic fluctuations and macroscopic transport of polymer solutions in porous media, resolving an over-50-year-old puzzle. Understanding of this nonlinear resistance provides us with new engineering control, allowing us to design fluids that reduce flow heterogeneity in stratified porous media. Furthermore, I show how these chaotic fluctuations can enhance pore-scale mixing of solutes, analogous to Batchelor mixing. I show that this dynamic pore-scale mixing works cooperatively with the spatial dispersive effects of porous media, enhancing the macroscopic solute transport by 3–6×. Finally, I demonstrate how this elastic instability can be harnessed to increase the rate of chemical reactions by an order of magnitude, surpassing inherent limitations in packed bed reactors and suggesting new avenues to improve reactivity in environmental and

industrial settings. This work demonstrates how couplings between complex geometries and complex fluid rheology can give rise to intriguing flow behaviors—providing new avenues to understand, control, and engineer transport in confined spaces.

Invited Talk: The science of sustained and sustainable career success: what to know and do

16:30 - 17:30 Monday, 23rd June, 2025
ETLC E1-003
Cuiying Jian

By Alex Clark, author of the acclaimed book "How to Be a Happy Academic"

Poster Session

17:30 - 18:30 Monday, 23rd June, 2025
ICE 8th Floor lobby

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14 Controlling Self-Assembly in Block Copolymeric Micelles for Enhanced Nanocarrier Performance in Drug Delivery Applications

Sadafara Pillai

School of Sciences, P P Savani University, Surat, Gujarat, India, India

Abstract

Over the years, block copolymeric micelles have emerged as versatile nanocarriers for drug delivery, providing controlled encapsulation and targeted release of therapeutic agents. The micellization behavior of these copolymers in aqueous environments, driven by the amphiphilic nature of block copolymers, is crucial to their effectiveness as nanocarriers. By precisely fine-tuning parameters such as copolymer composition, block length, concentration, and environmental factors (like pH, temperature, and ionic strength), the self-assembly process to enhance micelle stability, size, and morphology can be optimized. This precise control leads to improved drug loading, retention, and release profiles, ultimately enhancing bioavailability and reducing toxicity.

The critical micellar concentration (CMC) and micelle stability against dilution are some of the key considerations for practical application. Additionally, functionalizing the surfaces of micelles enables site-specific targeting, which increases the efficiency of drug delivery while minimizing adverse effects. Recent advancements have established that stimuli-responsive block copolymeric micelles, which alter their structure in response to external triggers (e.g., temperature or pH changes), provide additional control for targeted and sustained drug release. This talk will explore

various strategies for manipulating micelle formation and stability, emphasizing how these approaches can maximize therapeutic efficacy and advance the design of block copolymeric micelles as sophisticated nanocarriers for drug delivery.

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76 Bioresponsive and immunotherapeutic nanomaterials to remodel tumor microenvironment for enhanced immune checkpoint blockade

Guojun Chen

McGill University, Montreal, Canada

Abstract

Immune checkpoint blockade (ICB) therapy is a revolutionary approach to treat cancers, but still have limited clinical applications. Accumulating evidence pinpoints the immunosuppressive characteristics of the tumor microenvironment (TME) as one major obstacle. The TME, characterized by acidity, hypoxia and elevated ROS levels, exerts its detrimental effects on infiltrating anti-tumor immune cells. Here, we developed a TME-responsive and immunotherapeutic catalase-loaded calcium carbonate nanoparticles (termed as CAT@$CaCO_3$ NPs) as the simple yet versatile multi-modulator for TME remodeling. $CaCO_3$ NPs can consume protons in the acidic TME to normalize the TME pH. CAT catalyzed the decomposition of ROS and thus generated O_2. The released Ca^{2+} led to Ca^{2+} overload in the tumor cells which then triggered the release of damage-associated molecular patterns (DAMP) signals to initiate anti-tumor immune responses, including tumor antigen presentation by dendritic cells. Meanwhile, CAT@$CaCO_3$ NPs-induced immunosupportive TME also promoted the polarization of the M2 tumor-associated macrophages to the M1 phenotype, further enhancing tumor antigen presentation. Consequently, T cell-mediated anti-tumor responses were activated, the efficacy of which was further boosted by aPD-1 immune checkpoint blockade. Our study demonstrated that local treatment of CAT@$CaCO_3$ NPs and aPD-1 combination can effectively evoke local and systemic anti-tumor immune responses, inhibiting the growth of treated tumors and distant diseases.

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88 Exploring Chelator-Containing Mesoporous Silica Nanoparticles in Mass Cytometry

Seoyeon Lee, Xiaochong Li, Mitch Winnik

University of Toronto, Toronto, Canada

Abstract

Understanding biomarkers and their interactions can unlock a variety of biological research questions. Out of multiple methods, mass cytometry (MC) is a powerful single-cell analysis technique with multiplexing capabilities and minimal background. However, MC is currently limited to identifying ~50 biomarkers simultaneously. Tailoring the MC reagent design can improve MC sensitivity and open more mass channels. Mesoporous silica nanoparticles (MSNs) are materials composed of siloxane bonds, making them highly suitable for various chemical modifications via silane chemistry. Additionally, they have large surface areas and pore volume, which can be utilized for loading a large amount of metal. Therefore, MSNs have demonstrated great potential as MC reagents.

The primary focus of this project is to develop chelator-containing MSNs for MC applications. Chelators such as tetraxetan, diethylenetriamine pentaacetate, and carboxyphenyl porphyrin can further enhance metal uptake, generating stronger signals in MC. With appropriate chelators, hard, soft, or even low-sensitivity metals can be utilized in MC, expanding new mass channels. Furthermore, this design can prevent transchelation experienced with metal-chelating polymers and soft metals, reducing the metal leaching to some extent. By incorporating chelators into MSN design, we aim to create a more versatile and precise MC reagent. These advancements will enable improved biomarker analysis and facilitate the identification of complex biological interactions.

115 Are all biosurfactants really so effective in lowering surface tension ?

Kamil Wojciechowski, Jolanta Mierzejewska, Karolina Borucka

Warsaw University of Technology, Warsaw, Poland

Abstract

Numerous yeasts produce biosurfactants to facilitate colonization of hydrophobic surfaces. These biosurfactants offer an interesting alternative to the currently employed synthetic ones. The study discusses some pitfalls in attempts to determine reliable surface tension values for the culture media and their extracts for two biosurfactant-producing yeast strains. Using an Axisymmetric Drop Shape Analysis tensiometer we observed a systematic shallowing of the dynamic surface tension curves, suggesting loss of their surface activity. The rate of this apparent surface activity loss depended on the sample history, with slower changes observed in the vigorously shaken samples. At the same time, the force-based Wilhelmy plate method provided apparently stable surface tension values of the order of 30 mN/m for the same samples, in accordance with numerous previous literature reports on similar yeast biosurfactants. We show that both observations are in fact biased by the presence of an oil emulsified by the yeast-produced biosurfactants. The odd (apparent) surface tension results are then the measurement artifacts resulting from a slow demulsification and subsequent oil-spreading assisted by the yeast biosurfactants. Eventually, the apparent surface tension reduction is thus caused by the presence of biosurfactants, but its value does not represent a genuine adsorption. Analogously, the often reported in the literature very low

surface tension values for the yeast culture media, of the order of 30±5 mN/m, may also be biased, and should be treated with caution, especially if the emulsion stabilized with the biosurfactant had not been fully destabilized prior to the measurement.

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160 Surface Modification of TaO_2 Nanoparticles and their Applications in Mass Cytometry

Xu Chen, Dialia Ritaine, Tianjia Yang, Mitchell Winnik

University of Toronto, Toronto, Canada

Abstract

Mass cytometry (MC) has emerged as a powerful bioanalytical tool for biomarker detection with single-cell resolution. In this technique, cells are stained with antibodies (Abs) labeled with heavy-atom isotopes and then nebulized into an inductively coupled plasma time-of-flight mass spectrometry (ICP-TOF-MS) instrument. Current metal-chelating polymer reagents carry only 100 to 200 metal atoms/Ab, which restricts the lower threshold of MC measurement to 104 to 106 biomarkers per cell. Nanoparticle (NP) reagents offer the potential for enhancing sensitivity by carrying large numbers of heavy metal isotopes. For example, ^{181}Ta (tantalum) is a stable isotope with a high natural abundance (99.988%) and low biological occurrence. Tantalum oxide nanoparticles (TaO_2 NPs) have a strong potential as an elemental mass tag in MC immunoassays. However, the sensitivity of this mass tag with polyethylene glycol chains grafted to its surface is limited due to high nonspecific binding (NSB) signals observed at higher NP doses. In this work, TaO_2 NPs were modified with other non-ionic and zwitterionic polymers in an attempt to reduce the NSB signal, and their performance in suppressing NSB was assessed.

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171 Enhanced biocidal activities of salt-introduced alcohol spray disinfectant via salt recrystallization mechanism

Soo Jee Do, Euna Oh, Sumin Han, Hyo-Jick Choi

University of Alberta, Edmonton, Canada

Abstract

A bio-contaminated surface poses a significant risk for disease transmission and a serious threat to public health. Alcohol-based disinfectants are extensively utilized for decontaminating high-touch surfaces; however, their limited biocidal efficacy against alcohol-tolerant strains highlights the critical need for the development of enhanced formulations. This study introduces a novel salt-enhanced alcohol disinfectant that combines the antimicrobial properties of alcohol with the physical disruption caused by salt recrystallization, achieving broad-spectrum pathogen inactivation. Time-dependent crystallization of NaCl-containing alcohol solutions and the morphological changes in pathogens were analyzed using X-ray diffraction to evaluate the biocidal activity of salt-only, alcohol-only, and salt-alcohol solutions. Viability was evaluated by quantifying colony-forming units (CFU) over time after applying disinfectants to glass, Petri dishes, and stainless-steel surfaces inoculated with a range of microorganisms, including Gram-positive and Gram-negative bacteria, alcohol-tolerant *Escherichia coli*, bacterial spores, enveloped influenza virus, non-enveloped adenovirus, as well as mold and yeast fungi. Results showed that the alcohol-salt formulations significantly reduced pathogen viability compared to alcohol or salt alone. Importantly, the formulation demonstrated enhanced efficacy against alcohol-tolerant *E. coli*, indicating the synergistic effects of alcohol's antimicrobial action and salt's physical disruption through recrystallization. This study presents a simple yet highly effective approach to enhancing alcohol-based disinfectants, providing broad-spectrum efficacy against diverse pathogens, including alcohol-tolerant and mutant strains. The findings suggest potential applications in improving infection control across various settings.

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196 **Development of Hydrophobic Edible Biopolymer Films from Agri-Food Waste for Sustainable Food Packaging**

Alpamys Babayev[1], Jaroslav Katona[2], Saule Aidarova[1], Altynay Sharipova[3], Kuanysh Musabekov[1]

[1]Kazakh-British technical university, Almaty, Kazakhstan. [2]University of Novi Sad, Novi Sad, Serbia. [3]Satpayev University, Almaty, Kazakhstan

Abstract

The food industry faces an urgent need for sustainable alternatives to traditional petroleum-based packaging materials. A promising direction involves the development of biodegradable and compostable materials derived from renewable resources, particularly agri-food waste. A key challenge in this area is the creation of edible, hydrophobic biopolymer films with desirable moisture barrier properties for food preservation. These films must not only be eco-friendly but also produced using green technologies, ensuring they are both sustainable and safe for direct consumption.

This research aims to leverage soft nanotechnology techniques to design and fabricate hydrophobic, edible barrier films derived from agri-food waste, focusing on the high-value utilization of waste materials without the need for organic solvents. The films are inspired by the natural protective barrier of plant cuticula, a biodegradable polyester that plays a key role in protecting plants from environmental stress. The main structural component of cuticula, cutin, is a non-toxic, waterproof, UV-blocking biopolymer that can serve as an ideal model for developing food packaging materials with enhanced moisture barrier properties.

Through the isolation of cutin with tailored colloidal properties, this study investigates the impact of various isolation parameters—such as grinding methods, drying conditions, and additives—on the physicochemical characteristics of cutin. The research successfully identifies the optimal conditions for producing cutin with the desired colloidal properties and establishes an efficient protocol for its isolation and preparation.

The findings of this study contribute to the development of innovative, environmentally friendly food packaging solutions, promoting the use of renewable resources while advancing the use of biopolymers in food preservation applications.

243 New microcapsulated biostimulants based on natural polymers

Altynay Sharipova[1], Assem Issayeva[2], Saule Aidarova[3]

[1]Satbayev university, Almaty, Kazakhstan. [2]LLP SPE Antigen, Almaty, Kazakhstan. [3]Kazakh-British technical university, Almaty, Kazakhstan

Abstract

The work is aimed at developing an up-to-date interdisciplinary direction in the field of biostimulant application in agro-industry. Most biostimulants are unstable and lose their effectiveness during storage and use. This is due to their chemical structure and the influence of external factors such as temperature, humidity, UV light, and microorganisms. At the same time, studies of the stability and effectiveness of encapsulated biostimulants of humic acid with natural polymers in various conditions are insufficient.

By using natural polymers like chitosan, sodium alginate, and pectin are natural polymers to encapsulate the biostimulants of humic acid, it is possible to protect from external influences. In addition, the controlled release of the biostimulator from microcapsules will allow them to be evenly distributed in the medium and enhance their ability to neutralize heavy metals and pesticides in the soil. The physico-chemical properties used to produce micro- and nanocapsules of a biostimulants, such as surface-active (surface tension, wettability), dilational rheological and bulk (viscosity, pH, etc.) properties were studied. Micro- and nanocapsules of a biostimulatnts based on a natural polymer using Pickering emulsions were obtained.

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368 Bio-inspired magnetically induced self-assembling Janus solar evaporator with antifouling and antiscaling properties

Pan Huang, Charley Huang, Hongbo Zeng

University of Alberta, Edmonton, Canada

Abstract

Engineering solar evaporators with Janus structures is crucial for facilitating water transition and heat localization to enhance water evaporation efficiency. However, the fragile discontinuous bilayer structures and unavoidable surface fouling significantly hinder their application. Herein, inspired by the Janus structure of Black Amanita mushrooms, we designed a robust solar evaporator with an integrated wood-like and Janus structure using directional freeze-casting and magnetically induced self-assembly of polypyrrole-coated $Fe3O4$ particles as a build-in photothermal top layer within a hydrophilic matrix, followed by covering it with an additional hydrophobic fluorine layer to simultaneously regulate surface wettability and antifouling properties. Incorporating the hydrophobic fluorine layer onto the solar evaporator not only enhances its water evaporation efficiency via thermal localization effects, but also prevents fouling, salt, and dust scaling accumulation on its surface, facilitating water transportation, thus achieving a groundbreaking performance with the evaporation rate of 2.13 kg m^{-2} h^{-1} under one sun irradiation. Moreover, the mechanical performance of the as-prepared solar evaporator can be further optimized by precisely modulating supramolecular interactions within its structure, achieving Young's modulus over 4 MPa and maintaining structural integrity after the peel-off tests. The fabricated solar evaporator enables highly efficient water purification from artificial seawater, oil-in-water emulsions, and industrial wastewater, providing a rational strategy for designing high-yield solar evaporation systems for wastewater containing complex contaminants.

394 OPTIMIZING NANOPARTICLE FUNCTION: INVESTIGATING THE ADSORPTION-AGGREGATION TRADE-OFF IN PROTEIN CORONA FORMATION

Justine Saber, Pierre-Luc Latreille, Dikran Mekhjian, Marine Le Goas, Xavier Banquy

Université de Montreal, Montreal, Canada

Abstract

Nanoparticles interact with biological systems primarily through the formation of a protein corona, significantly influencing their behavior and function. Understanding the balance between protein adsorption and aggregation on nanoparticle surfaces is crucial for optimizing biomedical applications. This study aims to disentangle the adsorption-aggregation trade-off in protein corona formation on gold and polystyrene nanoparticles, using a range of advanced characterization techniques.

Differential Dynamic Microscopy (DDM) in fluorescence and phase holographic (PH) modes enabled precise quantification of both adsorption and aggregation processes. Localized Surface Plasmon Resonance (LSPR) was applied to gold nanoparticles to probe protein corona evolution. These techniques provided quantitative insights into protein binding affinity and aggregation states.

The results reveal a complex interplay between protein adsorption and aggregation, influenced by nanoparticle type and concentrations of both proteins and nanoparticles. Gold nanoparticles, with their plasmonic properties, and polystyrene nanoparticles, characterized by hydrophobic surfaces, exhibited distinct affinities and aggregation behaviors depending on particle concentration. Excessive aggregation during adsorption could compromise nanoparticle function, underscoring the need for careful process control.

These findings provide critical insights into protein corona dynamics, highlighting the importance of understanding material-specific interactions to optimize nanoparticle-based drug delivery systems and diagnostic tools

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396 Tuning the Conformation of Surface-bound Fibronectin

Diego Jaramillo Pinto[1], Ummay Honey[1], Syeda Tajin Ahmed[2], Lenka Vitkova[3], Kevin De France[3], Roberto C. Andresen Eguiluz[2,4]

[1]Materials and Biomaterials Science and Engineering Graduate Group, University of California, Merced, Merced, USA. [2]Department of Chemical and Materials Engineering, University of California, Merced, Merced, USA. [3]Department of Chemical Engineering, Queen's University, Kingston, Canada. [4]Health Sciences Research Institute, University of California Merced, Merced, USA

Abstract

The interface between the articular cartilage extracellular matrix (ECM) and synovial fluid (SF) dissipates energy, protecting the articular cartilage surface by forming a protein nanofilm. Fibronectin, a glycoprotein, is abundant at the surface of articular cartilage ECM. In this study, we present a cartilage surface model in which we control the molecular conformation of surface-bound fibronectin. We expose bulk fibronectin to neutral or acidic pH aqueous environments before grafting to gold surfaces functionalized with short (cysteamine hydrochloride) or long (11-amino-1-undecanethiol hydrochloride) self-assembled monolayers. We used a combination of Fourier Transform Infrared (FTIR) and Circular Dichroism (CD) spectroscopies to quantify fibronectin conformations. Additionally, we used Atomic Force Microscopy (AFM) to visualize fibronectin film morphologies and coverage. Preliminary FTIR data shows significant changes in the secondary structure of fibronectin while varying the pH for the long-SAMs case. For long-SAMs, we observed 48% of random coil structure at pH 7, which increased to 53% at pH 4. These results are consistent with CD spectra results. Preliminary AFM measurements show that at pH 7, fibronectin films adsorbed on long-SAMs seem less porous than in short-SAMs. This can be due to the predominance of substrate roughness in the case of short-SAMs. With this platform, we aim to understand how fibronectin mediates SF component adsorption and retention.

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413 Enhancing solubility of hydrophobic peptides in organic and aqueous solution mixtures

Sixin Zhai[1], Syeda Tajin Ahmed[2], Xin Huang[3], Kunle Adewole[4], Andrea Merg[5], Jing Yan[3], Roberto C. Andresen Eguiluz[2,6]

[1]Materials and Biomaterials Science and Engineering Graduate Group, University of California, Merced, USA. [2]Department of Chemical and Materials Engineering, University of California Merced, Merced, USA. [3]Department of Molecular, Cellular & Developmental Biology, Yale University, Merced, USA. [4]Chemistry and Biochemistry Graduate Group, University of California Merced, Merced, USA. [5]Department of Chemistry and Biochemistry, University of California Merced, Merced, USA. [6]Health Sciences Research Institute, University of California Merced, Merced, USA

Abstract

The low solubility of peptides containing a high content of hydrophobic amino acid residues in aqueous buffers is a common problem in supramolecular chemistry-related fields. Often, to solubilize hydrophobic peptides, strategies involve a dissolution step of the peptides in organic solvents followed by a second dissolution in a selected aqueous solvent suitable for the choice of experiments. Large peptides tend to form aggregates due to a synergistic effect of the medium, including peptide concentration, ionic strength, pH value, and temperature. This study presents an optimization strategy to solubilize a peptide with more than 45% hydrophobic content, a 57 amino acids long peptide (WT-57aa), having the same sequence as a native peptide domain found in the adhesin Bap-1 of *Vibrio Cholerae*, in addition to a shuffled sequence (S-57 aa) analog. We used a series of organic-aqueous mixtures and a fast, non-destructive method, Dynamic Light Scattering (DLS), to measure the aggregate size (as a metric of solubility) of WT-57aa and S-57aa peptides. First, in the absence of peptides, we observed a downward trend followed by a slight increase in the hydrodynamic size of dimethyl sulfoxide (DMSO) aggregates in M9 buffer dilutions. With peptides present, we observed that the removal of salts leads to a decrease in the hydrodynamic size of the peptide aggregate, independent of the sequence. Increasing peptide concentrations led to an increase in aggregate size. The results of this work will contribute to understanding the solubility limits of hydrophobic peptides in complex systems for peptide processing and characterization.

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414 Biocompatible interfacial solar evaporator for seawater desalination and mineral recovery

Mojtaba Ebrahimian Mashhadi, Md. Mehadi Hassan, Qingye Lu

University of Calgary, Calgary, Canada

Abstract

Operating with only sunlight as the input energy source, interfacial solar evaporators have drawn significant attention as a green solution for the global water shortage issue. In a typical interfacial solar evaporator, sunlight is absorbed and converted to heat by photothermal materials. The generated heat is then used to vaporize water which further is collected as clean water. In addition to seawater desalination, these solar evaporators have shown the capacity to be multifunctional for electricity generation, wastewater treatment, sterilization, antibacterial activity, and salt collection, among others. To be a sustainable solution, the evaporators with a high degree of biodegradability/biocompatibility are the center of attention. Cellulose as the most abundant biopolymer in the world seems an appealing material choice for the fabrication of interfacial solar evaporators. In this work, an electrospun scaffold was made from cellulose acetate and it was partially coated with an aqueous slurry of carbon black/poly(vinyl alcohol) (CB/PVA) as the photothermal layer. The fabricated evaporator showed an excellent evaporation rate by reducing the enthalpy of vaporization, leading to a high conversion efficiency under one sun illumination. Furthermore, its long-term desalination performance was stable with edge-preferential formation of salt crystals which were shed and collected under the gravity force. This novel interfacial solar evaporator exhibits great potential for seawater desalination and mineral recovery.

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261 Using capillary behavior of modified aligned PHBV fibers for chromatography applications

Javad Esmaeili, Reza Aminabadi

UQAC, Quebec, Canada

Abstract

Fabricating electrospun patches for thin-layer chromatography (TLC) has garnered significant attention in analytical chemistry due to its potential for enhanced separation performance. This study explores the preparation of aligned electrospun PHBV patches modified for TLC applications. We found out that creating straight microchannels within the nanofiber matrix will enable high-quality separation and precise analysis, addressing limitations such as uneven separation and low resolution in conventional TLC.

To achieve this, electrospinning was employed to produce aligned microfibers under an optimization approach, which are modified through three techniques: i) plasma surface modification, ii) chemical treatment, and iii) nano-coating. The patches are characterized using SEM, FTIR, profilometry, EDX, contact angle analysis, and mechanical strength tests. Key performance indices such as microchannel size, nanofiber diameter, hydrophilicity, liquid diffusion rate, and Rf values are evaluated to determine efficacy.

Preliminary results suggest that the modified patches enhance separation efficiency and detection sensitivity, offering significant advantages for applications such as DNA sequencing, protein analysis, and pharmaceutical quality control. This innovative approach could pave the way for

distinct analytical applications across diverse fields, including environmental monitoring and biomedical research.

34 Development of High-Performance Thermally Stable TFC Membranes Using Carbon Nitride Nanosheets

Fatemeh Seyedpour, Mohtada Sadrzadeh, Pooria karami

UofA, Edmonton, Canada

Abstract

The demand for the development of thermally stable thin-film composite (TFC) membranes is increasing, given that there is a notable constraint in currently available commercial membranes, which tend to have limited performance at elevated temperatures. In this study, we developed thermally stable reverse osmosis (RO) thin-film composite (TFC) membranes by incorporating a small amount of carbon nitride nanosheets (CNNs) into the polyamide structure. The resulting thin-film nanocomposite (TFN) membranes demonstrated significantly enhanced water permeability and thermal stability. CNNs were synthesized using a simple, eco-friendly pyrolysis method with sustainable precursors. Featuring heterocyclic triazine rings, CNNs imparted superior thermal stability to the RO process. This functionalization, completed efficiently within an hour, is repeatable and does not compromise separation performance. Comprehensive characterization of the CNN-modified TFN membranes, including FTIR, XPS, SEM, and EDX analyses, confirmed their structural and functional enhancements. Notably, CNN incorporation doubled water permeability and improved salt rejection, showcasing the potential of these membranes for extended high-temperature applications without the need for frequent module replacement.

57 Investigating the Stabilization Mechanisms of CNC-Stabilized Emulsions for CO_2 Sequestration Under High-Pressure and Saline Conditions.

Asma Iram, Muhammad Jahid Hassan, Abelardo Ramírez-Hernández, Esteban E. Ureña-Benavides

University of Texas at San Antonio, San Antonio, USA

Abstract

Cellulose nanocrystals (CNCs) are effective stabilizers for emulsions under extreme conditions, offering significant potential for CO_2 sequestration applications. This study explores the morphology, stability, and interfacial properties of CNC-stabilized emulsions at both ambient and elevated pressures. CNC characterization was conducted using atomic force microscopy (AFM) to determine particle size and morphology. Superficial sulfate groups and surface charge were quantified via conductometric titration and zeta potential measurements. Dynamic light scattering (DLS) and laser diffraction were employed to assess floc size under varying ionic strengths, providing insights into CNC colloidal stability. Optical microscopy was used to examine the morphology of emulsion droplets, and droplet size distribution was analyzed over time to evaluate emulsion stability. Emulsion droplet morphology was also examined using critical point drying and scanning electron microscopy (SEM), revealing the formation of robust CNC crusts at droplet interfaces. To further evaluate interfacial behavior, interfacial tension and interfacial dilatational rheology measurements were performed for CNC concentrations of 0.1 to 1.0 wt% across salinities ranging from deionized water to 1.9 M NaCl. These experiments, using the oscillating drop method, allowed the quantification of interfacial elastic modulus and complex interfacial viscosity at ambient conditions with heptane as the oil phase, and at elevated pressures (2,000 psi) with liquid CO_2. This work provides critical insights into the stabilization mechanisms of CNC-stabilized emulsions, emphasizing their structural integrity and interfacial robustness under extreme conditions. The findings demonstrate CNCs as efficient stabilizers for CO_2-in-water emulsions, advancing the development of stable systems for high-pressure CO_2 sequestration processes.

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193 Wettability and Residual CO2 Trapping: Insights and Advances for Geological Carbon Storage

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Abstract

Residual trapping is a key process for securely storing CO2 in geological formations, and wettability plays a crucial role in how efficiently this mechanism works. This review takes a close look at how wettability affects CO2 trapping, particularly in saline aquifers and hydrocarbon reservoirs. Drawing on experimental studies, theoretical models, and simulations, we explore how factors like temperature, pressure, salinity, and organic contaminants influence wettability and CO2 storage capacity. Water-wet systems consistently show higher CO2 retention compared to CO2-wet systems, particularly in sandstone reservoirs. On the other hand, intermediate and CO2-wet conditions can weaken capillary sealing, increasing the risk of CO2 leakage.

Innovative strategies, such as using nanofluids are also discussed to modify wettability, which show promise in improving CO2 trapping efficiency. By identifying key knowledge gaps, this review offers a roadmap for optimizing wettability conditions to make CO2 storage safer and more reliable. This work brings together insights to advance Carbon Capture and Storage (CCS) technology. It highlights the critical role of managing wettability in boosting the effectiveness of CO2 trapping while ensuring CCS remains a practical and sustainable solution.

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274 Comparison of Various Nanoparticles for CO2 Sequestration in Mimicked Deep Saline Aquifer Conditions.

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Abstract

This study investigates the potential of carbohydrate nanoparticles to stabilize CO_2 foams under deep saline aquifer conditions characterized by high pressure, high temperature, and high salinity. The research compares the performance of cellulose nanocrystals (CNC), modified cellulose nanocrystals, and chitin nanocrystals (ChNC) in stabilizing CO_2 foams and facilitating carbon sequestration, in addition, to investigating the impact of the polyelectrolyte poly(2-acrylamido-2-methyl-1-propanesulfonic acid-co-acrylic acid). Nanoparticles, due to their strong detachment energy and rigidity, improve foam stability compared to traditional surfactants, which only reduce surface tension. Experiments demonstrated that foams stabilized with these nanoparticles maintained their structure for 24 hours, even under challenging reservoir conditions. Subsequent foam transport experiments involved pumping stabile foams through rock cores to assess nanoparticle retention rates and foam transport efficiency. Analytical techniques, including total organic carbon/nitrogen (TOC/TN) measurements, were used to quantify nanoparticle retention and evaluate their effectiveness in trapping CO_2. The findings highlight the importance of nanoparticle transport in maximizing CO_2 sequestration potential. Results suggest that the use of these carbohydrate nanoparticles could significantly enhance CO_2 trapping efficiency, offering a sustainable solution for reducing greenhouse gas emissions. This work provides critical insights into the role of nanoparticle-stabilized foams in advancing carbon capture technologies in deep saline aquifer applications.

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321 Electrospun of sulfonated poly ether ether ketone (sPEEK) crosslinked nanofibrous membranes for selective separation of lithium

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Abstract

High-capacity lithium batteries are the cornerstone of modern world high-density applications and a viable energy storage solution to address the intermittency problem of renewable energy resources. Alberta's formation water contains a significant amount of Li$^+$ (see below) [2]; however, Li$^+$ extraction is faced with obstacles - mainly, the low concentrations (< 70 mg Li$^+$/l), and the presence of 100-fold higher concentrations of other cations sharing similar charge characteristics and ionic radius such as Na$^+$, K$^+$, Ca^{2+}, and Mg^{2+}. In this work, we report a mechanically strong, cost-effective nanofiber (NF) composite for selective extraction of lithium from brines with low concentrations of Li$^+$ (< 75 mg/l). Targeted properties include adsorption capacity ($q_e > 36.83$ mg Li$^+$/g adsorbent), adsorption rate (> 0.01134 g mg^{-1} h^{-1}), regeneration cycles (>50-100 cycles with minimal or no loss of capacity), and high selectivity for Li$^+$ over Na$^+$, K$^+$, Ca^{2+} and Mg^{2+}. Towards this, we report optimization of chemical, physical, and process parameters of our NF composite including sulfonation extent, ratio of polymer to hydrous TiO2 adsorbent, and electrospinning variables. This optimization is aimed at high Li$^+$ removal rate, adsorption capacity and long term use durability. Due to the environmentally friendly constituents, mechanical strength, antifouling capability (from the organic-inorganic hybrid membrane materials), and controlled swelling, our NF composite membrane can be used directly as a Li$^+$ extraction filter from seawater or any other low concentration non-conventional resources.

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410 Operando Imaging Ellipsometry – a microscopic approach to follow the spatial resolved Intercalation of alkaline cations into battery electrode materials.

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Abstract

The Operando characterization of alkaline cations intercalation requires a high sensitive method with microscopic spatial resolution to optimize the rapid mass transport and the homogeneity of storage of ions for rechargeable battery electrode materials.

Operando Imaging ellipsometry [1] is a method for real time imaging the electrode material in a working cell with a lateral resolution down to 1 µm while the cell is charged/discharged or is changed under other external influences. Imaging ellipsometry in more general, combines optical microscopy and ellipsometry for spatially resolved layer-thickness and refractive index measurements of micro-structured thin-films and substrates. It is an all-optical, non-destructive measurement technique, based on the sample's interaction with polarized light. It is highly sensitive to single- and multi-layer ultrathin films, ranging from mono-atomic or monomolecular layers (sub-nm regime) up to thicknesses of several microns. The technique has been used to characterize the optical properties of graphene [2], [3], to localize flakes [4] and for atomic layer resolved Imaging of 2D Materials with microscopic resolution [5].

As an example, the reversible intercalation of sodium ions into Janus graphene as novel anode for sodium ion battery was investigated, and the corresponding Delta and Psi were recorded during three charge/discharge cycles. The motivation for designing these materials is that replacing lithium by sodium in batteries is both a promising and challenging approach. The most critical step is the intercalation of Na ions into graphite. We provided a new idea using artificial graphite nanostructures based on "Janus" graphene to address this issue [1].

Figure 1. Setup of Operando Imaging Ellipsometry as well as results: Microscopic Delta maps of the uncharged Janus-Graphene (a), at different points during intercalation/deintercalation (b-e) and Delta maps referenced to the map representing the uncharged one (f-g).

Acknowledgements: The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation program under GrapheneCore3 881603–Graphene Flagship, FLAG-ERA project PROSPECT, and from the Swedish Research Council under project Janus 2017-04456.

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420 Electrolyte Interphase Engineering for high performance Zn metal anode

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Abstract

Aqueous zinc batteries (AZBs) are an emerging energy storage technology that offers enhanced safety, environmental sustainability, and strong potential for grid-scale applications. However, the inherent thermodynamic instability of the Zn anode in aqueous electrolytes presents significant challenges, including corrosion, hydrogen evolution reaction (HER), and dendrite formation. These issues drastically reduce the cycle life and coulombic efficiency of the zinc anode. To overcome these challenges, the formation of a stable and robust in situ solid electrolyte interphase (SEI) on the anode surface, achieved through the decomposition of electrolyte components, plays a crucial role in suppressing side reactions and improving anode stability and performance. Fluoride-based interphase engineering, incorporating zincophilic and hydrophobic properties through electrolyte modification, offers a simple yet effective approach with promising advantages. Zincophilic materials enhance zinc ion transfer kinetics, while hydrophobic components mitigate water-induced side reactions by reducing water activity near the anode, thereby improving the overall stability of the Zn metal anode. In this study, we utilized an aqueous zinc salt electrolyte with a fluorine-based additive, which promotes the formation of a ZnF_2-rich inorganic inner layer and a fluoride-rich organic outer layer. The synergistic effects of this engineered SEI architecture significantly enhance the cycling stability of the zinc anode, even under high current density.

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83 Dietary fibre coated β-carotene loaded nanoliposomes, bioaccessibility, release mucus micro-viscosity and absorption through intestinal lumen: An ex-vivo study

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Abstract

Recently, the use of biopolymers as coating material to stabilise phospholipid-based nanocarriers has increased. One such class of biopolymers is the dietary fibre beta-glucan (βG), the major health benefit associated with βG is its glycaemic index and cholesterol-lowering effect. Many studies claim that coating with DF like chitosan, alginate, and gums can improve the bioaccessibility of lipophilic compounds. However, their effect on mucus permeability and subsequent absorption of lipophilic active agents in the intestinal lumen is a poorly investigated area of research.

In this study, we developed and characterized beta-carotene (βC) loaded βG coated nanoliposomes (GNLs). To investigate the effect of βG coating on the stability, controlled release, bioaccessibility, diffusion and subsequent absorption of the lipophilic active agent. The size, charge (z-potential), and FTIR spectra were measured to determine the physicochemical stability of GNLs. βG coating reduced the bioaccessibility, provided prolonged release and increased the antioxidant activity of the nanoliposomes. Multiple particle tracking (MPT) data suggested that βC-GNLs were less diffusive in porcine intestinal mucus (PIM). Additionally, the micro-viscosity of the PIM treated with GNLs was observed to be higher (0.04744 ± 0.00865 Pa.s) than the PIM incubated with uncoated NLs (0.015 ± 0.0004 Pa.s). An *Ex-vivo* experiment was performed on mouse jejunum to measure the absorption of beta-carotene from loaded coated (βC-GNLs) and uncoated nanoliposomes (βC-NLs). Data suggested that after 130 minutes, 27.7 ± 1.3 ng/mL of βC encapsulated in GNLs and 61.54 ± 3 ng/mL of the βC encapsulated in uncoated NLs permeated through mouse intestinal mucosa.

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117 Foaming Agents From Simultaneous Extraction-Hydrolysis of Lupine Seeds

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Abstract

The lupine (*Lupinus*) genus belongs to the legume family *Fabacae* and includes about 300 species. Besides the proteins and dietary fibers, lupine seeds are a source of lipids and polyphenols but also of flatulence-causing oligosaccharides of raffinose family. In most experimental protocols described in the literature, a plant seed protein extraction and its enzymatic hydrolysis are separated. In this contribution a simultaneous extraction and hydrolysis process was proposed as a much simpler and less energy-demanding alternative. The enzymatic lupine protein hydrolysates obtained in the simultaneous process were tested for their ability to produce and maintain foams, showing that the proposed process simplification did not compromise foaming properties of the hydrolysates. Two animal-sourced (trypsin and pancreatin) and one plant-sourced proteolytic enzyme (papain) were employed at variable enzyme-to-substrate (E/S) ratios. The enzymatic hydrolysis improved foaming properties of the extracts, both in the subsequent (when the extraction and the hydrolysis were performed in separated steps) and simultaneous (when the

extraction and hydrolysis were taking place simultaneously) modes: foam capacity (FC) increased from ~100 % to ~270 % (for papain) with >50 % initial foam volume retained after 10 min. The obtained hydrolysates could be employed to provide a foaming activity of cosmetic, pharmaceutical or food products; when using the plant-sourced papain - also of the fully vegan ones.

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212 Surface activity of protein extracts from seed oil by-products

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Abstract

Protein concentrates, extracted from the by-products of Hemp (Cannabis sativa), Cardoon (Cynara cardunculus), and Argan (Argania spinosa L.) oilseeds after oil extraction, have been used to produce sustainable and eco-friendly protein-based bioplastics. These compounds and bioplastics show some solubility, which motivated a detailed investigation of the surface activity of protein concentrates used for film formation, which can alter the packaging.The adsorption/desorption kinetics, surface tension and dilatational rheology are reported at two different pH values (10 and 12). The three protein concentrates were surface-active and developed stable adsorbed layers at the air-water interface after 1 h. Cardoon proteins showed similar surface tension values at both pHs, while Argan and Hemp proteins displayed lower values than Cardoon, especially at pH 12, indicative of higher surface activity. Finally, Argan protein adsorbed more irreversibly, followed by Hemp protein, while Cardoon protein provided the largest partial desorption from the surface. These surface properties should be considered in the advanced design of food packaging and coating technology.

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Reference: Mirpoor et al. Surface activity of protein extracts from seed oil by-products and wettability of developed bioplastics. Food Hydrocolloids 145 (2023) 109091. https://doi.org/10.1016/j.foodhyd.2023.109091.

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218 Effect of pH on Grass Pea (Lathyrus Satirus L.) microgel particles: a structural, rheological and tribological characterization

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Abstract

Grass pea (*Lathyrus sativus* L.) is a highly resilient protein crop with impressive adaptability to marginal soils under extreme climatic conditions (drought and heat stress). Despite its nutritional potential, it remains under-valued, making it a promising candidate as an alternative protein source for human consumption. A possible strategy for its valorization may rely on technological functionalities unexplored up to now. This study thus investigated the behavior of thermally induced gels from grass pea protein isolate at different pH values (2, 3, 7 and 9) and their influence on the properties of microgels prepared from these parent gels. Thermal gels were characterized for their viscoelastic properties, while microgels were analyzed for droplet size, zeta potential, microstructure, flow behavior, and tribological properties. The pH was found to significantly influence both parent gel and microgel properties. Gels formed at acidic pH (2 and 3) were harder, while the derived microgels exhibited shear-thinning behavior. In contrast, gels formed at neutral (7) and alkaline (9) pH yielded microgels with Newtonian flow behavior. Tribological analysis revealed a dependence of friction coefficients on pH. Microgels prepared from acidic gels exhibited higher friction, which decreased progressively under neutral and alkaline conditions. Particle size and zeta-potential analyses indicated that microgels formed at acidic pH were larger, probably due to aggregation phenomena. These findings demonstrate the critical role of pH in shaping the structural, rheological, and tribological properties of grass pea protein microgels, providing valuable insights for their potential applications in food systems as sustainable alternative protein ingredient.

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228 Unveiling the impact of high-pressure homogenization on dry-fractionated pea proteins: exploring energy density and valve dynamics in structural and functional modifications

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Abstract

High-pressure homogenization (HPH) is an effective technique for modifying plant proteins, yet its effects on protein structure and functionality remain contradictory in literature, some reporting improved technological properties, while others finding minimal or no enhancement. These discrepancies likely arise from knowledge gaps regarding the impact of pressures, cycles, and energy density applied, as well as the influence of raw material heterogeneity. This study investigated the structural and functional changes in dry-fractionated pea proteins treated with HPH under varying pressure-cycle combinations (15 MPa-6 cycles, 22.5 MPa - 4 cycles and 45 MPa -2 cycles) at equal energy densities (900 MJ m^{-3}). SDS-PAGE analysis under non-reducing conditions and free -SH group quantification showed no significant alterations in the primary structure, though weak interactions or partial reversible unfolding were observed in samples treated at 45 MPa. Tryptophan fluorescence and ANS-based surface hydrophobicity analyses indicated increased hydrophobic group exposure at higher pressures, particularly at 45 MPa, as evidenced by a slope value increase. A FRET-based protocol, optimized to evaluate structural changes, showed higher energy transfer in the 45 MPa treatment, suggesting tertiary or quaternary rearrangements without major structural shifts. Rheological analyses carried out on 6% (w/w) protein gels showed that treated proteins formed weaker gels compared to untreated, suggesting pressure-induced swelling rather than denaturation or enhanced gelation. These findings highlight a pressure-dependent effect on protein structure, potentially enhancing their interaction with other compounds while limiting their gelling ability. Further research is needed to optimize HPH conditions for targeted applications in plant-based formulations.

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292 Comparison of Pasting and Rheological Properties of Rice Flours and Cross-linked Waxy Rice Starches using the Rapid Visco Analyser and Dynamic Rheometer

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Abstract

The pasting and rheological properties of rice flour and starch are critical for assessing functional and structural qualities of food products. This study compared pasting and rheological properties of rice flours from short-, medium-, and long-grain cultivars, with varying amylose content, and native and cross-linked waxy rice starches using a Rapid Visco Analyser (RVA) and an oscillatory rheometer equipped with a parallel plate geometry. In contrast to the RVA, which requires ~3 g of sample and only measures the pasting properties, the oscillatory rheometer allows for the sequential analysis of pasting and rheological properties with smaller sample sizes as low as 25 mg. When 200 mg or 25 mg of flour or starch were used, the oscillatory rheometer obtained similar pasting profiles to the RVA and assessed the viscoelastic behavior of the resulting pastes, which correlated with the amylose content. Using 25 mg of sample, with a 0.4 mm gap, allowed for the differentiation of the storage moduli across varying levels of cross-linking. A smaller gap size

relative to the sample amount, e. g. 100 mg of sample with a 0.5 mm gap, did not distinguish the pasting profiles of rice cultivars with similar amylose contents, possibly due to excessive granule swelling and breakdown. This study highlights the capability of the oscillatory rheometer to characterize starch functionality, offering a robust method for sequentially analyzing pasting and viscoelastic properties of limited samples, such as those from breeding programs.

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425 Influence of Emulsifiers on Whippability and Foam Stability of Non-Dairy Cream

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Abstract

This study investigated the whippability and foam stability of non-dairy oil-in-water emulsions containing hydrogenated palm kernel oil (HPKO) and an emulsifier blend comprising oleic acid citrem (OA-citrem), stearic acid citrem (SA-citrem), and sucrose ester (S170). We hypothesized that emulsifiers would influence fat crystallization behavior and regulate partial coalescence of fat droplets, a process critical for forming a semi-rigid network that supports air incorporation during whipping. Differential scanning calorimetry was employed to analyze the thermal behavior of bulk HPKO with various emulsifiers. Polarized light microscopy was used to observe the influence of different emulsifiers on the morphology of fat crystals in bulk HPKO. The degree of partial coalescence after whipping was measured using the Mastersizer, and the microstructure of the whipped cream was examined by scanning electron microscopy. Results demonstrated that the presence of OA-citrem led to increased partial coalescence thereby significantly improving cream whippability. SA-citrem promoted foam stability by forming solid shells around oil droplets, limiting partial coalescence during storage. Conversely, S170 suppressed partial coalescence by limiting HPKO fat crystal growth and crystal size, leading to reduced whippability. Using binary emulsifier blends allowed precise control over both whippability and foam stability. These differences in emulsifier behavior likely arose from differences in their spatial distribution within the droplet bulk, at the oil-water interface, or in the aqueous phase. These effects governed the extent of fat droplet adsorption at the air interface and contributed to the stabilization of air cells in whipped cream. The findings demonstrate that HPKO and optimized emulsifier blends effectively replicate the foam formation and stabilization of dairy-like cream and provides valuable insights for developing stable, high-performance non-dairy whipped creams.

24 Facile Epitaxial Growth of Nanoscale Ag-MAFs on TFC RO Membranes: Enhancing Performance, Antibacterial Activity, and Biofouling Resistance

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Abstract

The demand for advanced thin-film composite (TFC) membranes is increasing due to the limitations of current commercial membranes, particularly regarding water permeability and biofouling resistance. In this study, we developed TFC reverse osmosis (RO) membranes through in-situ surface functionalization with silver-based metal-azolate frameworks (Ag-MAFs), significantly enhancing water flux, antifouling, and antibacterial properties. The permeate flux increased by 45% without sacrificing salt rejection (97.6%) compared to the neat TFC membrane. Surface functionalization is a rapid and non-destructive process that uses eco-friendly solvents, silver salts, and amino-benzimidazole ligands, allowing for repeatable surface modification without compromising separation efficiency. The successful functionalization of membranes with Ag-MAFs was verified through detailed chemical characterizations, including FTIR, XPS, and EDX. Notably, the strong stability of Ag-MAFs on the TFC membrane was confirmed, with no detachment or leaching observed after 20 days of membrane immersion in water. SEM and confocal microscopy demonstrated that the Ag-MAF nanoparticles imparted potent antibacterial activity, reducing live bacteria by nearly 99%. The fouling results revealed that the Ag-MAF functionalized membranes demonstrated higher fouling resistance and water recovery ratios than neat TFC membranes during a 10-hour filtration. This study highlights a promising and reproducible method for developing advanced anti-biofouling TFC membranes for long-term operation without the need for module disassembly.

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190 A Universal Droplet Strategy for Surface-Mounted Metal Organic Framework Microdomes and Hybrids for Recyclable Photocatalysts and In-Situ Monitoring

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Abstract

Surface-mounted metal–organic frameworks (MOFs) have garnered growing interest due to their tunable morphologies, enhanced robustness, and tailorable interfacial functionalities. In this study, we present a versatile femtoliter droplet-mediated synthesis approach that enables in-situ formation and functionalization of MOF microdomes on substrates within a narrow flow chamber. By using MIL-100 as a prototypical example, we show that dome size, shape, and surface coverage can be controlled by tuning the solution composition for droplet generation. Furthermore, we demonstrate a sequential reaction strategy to form Ag nanoparticle (AgNP)–decorated MOF hybrids via in-situ reduction, producing bifunctional materials capable of efficient photodegradation of organic pollutants and simultaneous real-time monitoring by surface-enhanced Raman scattering (SERS). This droplet-mediated method can be extended to other MOFs, including ZIF-8, MIL-88A, and HKUST-1, offering a robust platform for catalytic conversion, chemical sensing, and environmental remediation.

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307 Investigating Opto-Electrochemical Surface Interfaces and Cell Viability Assays for Antibiotic Susceptibility Testing

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Abstract

Understanding the fundamental mechanisms at material interfaces is crucial for advancing diagnostic technologies. Interfaces between nanostructured materials and biological systems influence the dynamics of signal generation, detection, and interpretation. This study leverages the unique properties of nanostructured electrodes to explore the electrochemical mechanisms underlying the metabolic activity of bacteria. We present an electrochemical platform that integrates nanostructured electrodes with different cell viability assays to investigate the metabolic activity of bacteria under various conditions. The system employs interface-driven phenomena to capture and analyze electrochemical signals with high sensitivity and precision. By combining nanotechnology, surface engineering, and microfluidic innovations, the platform achieves accurate and rapid detection of bacterial metabolism. This work focuses on mechanistic insights into how nanostructured materials influence electron transfer and signal transduction. These findings serve as a basis for designing diagnostic tools that utilize material properties to achieve enhanced performance. By emphasizing the interplay between nanostructured surfaces and electrochemical analysis, this study provides a pathway for developing solutions to challenges in diagnostics, offering a platform that is both robust and versatile.

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311 Multi-layered Microfluidic Systems for Bioassays with Integrated Unit Operations

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Abstract

Integrated microfluidic systems play crucial role miniaturize and automate complex bioassays, thereby enabling the execution of these processes with minimal input from trained personnel. Achieving this requires the incorporation of microfluidic unit operations, including but not limited to *mixing, fluid actuation, fluid metering, incubation, filtration, and valving,* to replicate the intricate functionality of conventional laboratory workflows on the microscale. However, traditional fabrication techniques like soft lithography are not only complex and time-consuming, but also present limitations to incorporating more than a handful of unit operations owing to intricate post-fabrication assembly processes. Here, we propose a Stereolithography (SLA) leveraged muti-layered microfluidic fabrication workflow integration of *five-unit operations* – valving, mixing, incubation, filtration and metering- required for a typical metabolic viability assay.

The design was first modeled on SolidWorks software and then analyzed with computation fluid dynamics (CFD) simulation for ensuring uniform flow and pressure distribution with connect to a syringe pump. We propose a versatile adhesive enhanced assembly, to seamlessly assemble multiple 3D printed open channel fluidic layers. Capillary stop valves enabled storage of metabolic assay reagents. Serpentine mixer enabled mixing of metabolic assay reagents with urine sample. Incubation, and filtration facilitated color change driven metabolic assay. Component-wise unit operations were characterized with *E.Coli* as the model pathogen.

This work demonstrates a novel SLA-leveraged muti-layered microfluidic fabrication workflow for a metabolic viability assay. This setup marks a significant improvement in automation of complex bioassays and making microfluidic fabrication more accessible at the point of need.

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324 Silicone-Encapsulated Cholesteric Liquid Crystals for Colorimetric Temperature Sensor Application

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Abstract

Cholesteric liquid crystals change their color upon the reflection of incident white light by modulating the spacing between their helical structures in response to temperature changes. This physical phenomenon provides a fast response time and low hysteresis, making them highly effective for temperature sensing applications. However, the cholesteric liquid crystals phase that provides the colorimetric response is possible only within a set range of temperatures. In addition, the liquid crystals lose their helical structure at high temperatures, wherein they transition into an isotropic liquid state. When placed in aqueous environments, the transition leads to dissolution. In this study, we developed a two-step fabrication process to encapsulate liquid crystals within a silicone shell. In the first step, liquid crystals were coated with Sylgard 184 base containing Pt catalyst. In the second step, the coated liquid crystals were immersed in a mixture of the base and curing agent to form a silicone shell. The results showed that the amount of Pt catalyst, the ratio

of curing agent, and the reaction time influenced the thickness and physical properties of the shell. At optimized conditions, we produced a stable protection shell wherein the liquid crystal is safely encapsulated. The fabricated samples provided colorimetric temperature sensing ability in aqueous environments without being dissolved into the environment. Upon adequate surface treatment, these encapsulated liquid crystals were embedded in polyacrylamide hydrogels. The temperature sensitivity of the samples within the physiological range for medical and environmental sensing. These findings suggest that the fabricated samples could serve as a robust platform for developing thermo-responsive sensors, particularly in aqueous or hydrogel-based environments.

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333 Universal electrochemical platforms for biosensing applications

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Abstract

Additive manufacturing (AM) and stencil lithography address persistent challenges associated with traditional microfabrication methods. By leveraging these approaches, we developed flexible universal electrochemical biosensing platforms and sample collection cartridges that accommodate various electrode configurations. In addition, signal-on and signal-off aptameric assays were incorporated to detect small-molecule and macromolecular biomarkers. The fabrication process involved designing a 0.5 mm-thick vinyl adhesive stencil featuring electrode and contact patterns, cut by a cutter plotter. This stencil was then applied to flexible substrates such as polystyrene and polymethyl methacrylate, followed by gold deposition via sputtering. Removing the stencil revealed the patterned electrodes and contacts. The resulting electrodes exhibited excellent reproducibility, repeatability, and stability. As a proof of concept, the biosensing capabilities of the fabricated electrodes and a custom-built potentiostat were evaluated using an aptamer-based, signal-off steric hindrance assay for S-protein (SP) detection in saliva and serum. The device achieved rapid (5-minute), multiplex, and selective detection within a dynamic range of 1–10,000 pg/mL in saliva, with a detection limit below 90 fg/mL. Mechanistically, the aptamer/SP complex impedes the flow of a redox probe, reducing electrochemical signals and interfacial electron transfer. Two factors contribute to this hindrance: (1) S-protein binding restricts redox molecule diffusion, and (2) aptamer conformational changes upon target binding impose additional steric interference. The combination of the homemade electrodes, fabricated based on AM and stencil lithography, and the portable potentiostat with different types of aptameric assays can bring about a point-of-care testing approach.

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386 Mathematical Modeling of Glucose Electrooxidation on Nano-architected Electrodes Fabricated by the Glancing Angle Deposition Technique

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Abstract

Recent advancements in nanostructured Ni/NiO electrodes fabricated using glancing angle deposition (GLAD) have demonstrated exceptional sensitivity, selectivity, and consistency in detecting glucose levels in low-concentration environments, such as sweat samples. The GLAD technique allows for the fabrication of precisely designed nano-architectures, enabling exact control over morphological features such as shape, porosity, and film thickness, significantly enhancing sensor efficiency. Currently, determining optimal GLAD parameters is largely an experimental process that relies heavily on trial and error, leading to considerable time and resource consumption. Numerical simulations offer a promising alternative for investigating how the geometric parameters of GLAD electrodes can optimize sensor performance. We aim to develop geometries that closely mimic actual sensor designs, thereby improving the predictive accuracy of sensor modeling and other GLAD applications. We utilize an on-lattice kinetic Monte Carlo (kMC) model to simulate and grow GLAD NiO structures. This methodology enables us to analyze the surface and investigate how deposition angle and morphological features influence mass transport properties. By incorporating thermodynamics, kinetics, and mass transport, we examine the electrooxidation process of glucose through mathematical modeling to compute the associated electrochemical current within GLAD NiO structures. The insights gained from this research can be applied to various electrochemical applications, including glucose electrooxidation, energy generation, and hydrogen production within GLAD configurations.

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362 **Detection of avian influenza virus based on stimuli-responsive microgel poly(*N*-isopropylacrylamide)-*co*-acrylic acid etalon device**

Seerat Saleem, Michael Serpe

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Abstract

An etalon-based detection system was devised utilizing the stimuli-responsive microgel poly(*N*-isopropylacrylamide)-*co*-acrylic acid for the detection of avian influenza virus. The etalon consists of a microgel layer sandwiched between two gold layers, was integrated into a microfluidic chip. The etalon color change in response to a solvent was monitored using a raspberry pi camera. The top surface of the etalon was chemically modified to immobilize an antibody specific to the avian influenza virus membrane protein hemagglutinin using biotin-streptavidin chemistry. Initially, a solvent was introduced to the etalon, resulting in a color change due to its interaction with the microgel. Subsequently, a sample containing the virus was passed over the surface, where the virus particles were captured by the immobilized antibodies, effectively blocking the surface of the etalon. This blocking mechanism hindered the diffusion of the solvent into the etalon, leading to a reduced interaction of solvent with the microgel, which in turn changed the color of etalon. A

software program was used to compare the color images of the etalons on a pixel-by-pixel basis, enabling the analysis of viral content presence. A graph is plotted to illustrate the relationship between the variation in etalon color and viral concentration, revealing a linear correlation between the concentration of viral content and the relative change in etalon color. The system has demonstrated successful detection of different viral strains including H5N2 and H7N3 with detection limits reaching 0.1 x 10^7 viral copies/mL and 1 x 10^6 viral copies/mL respectively.

145 Effect of n-hexane vapors on the behavior of air bubbles in solutions of non-ionic and ionic surfactants

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Abstract

Our study investigates the impact of organic (n-hexane) vapors on the behavior of gas bubbles in solutions containing non-ionic (n-octanol) and cationic (dodecyltrimethylammonium bromide – C12TAB) surfactants. Two experimental techniques were employed: (i) dynamic surface tension of stationary bubbles was measured using profile analysis tensiometry, and (ii) the rising bubble velocity profile was analyzed to monitor dynamic layer formation.

In pure water, a significant reduction in surface tension was observed for hexane-saturated bubbles compared to hexane-free systems. However, the rising bubble velocity profile showed no difference between bubbles containing pure air and those with n-hexane vapors.

In surfactant solutions, the presence of n-hexane had a pronounced effect in both experimental techniques. Similar to pure water systems, the presence of n-hexane caused a decrease in the surface tension of the surfactant solutions. Analysis of the bubble velocity profile revealed that n-hexane in the gaseous phase influenced dynamic layer formation (Figure 1A) and the bubble's terminal velocity (Figure 1B).

Both approaches highlighted a synergistic effect of the co-adsorption of n-hexane and surfactants. These findings were further supported by Molecular Dynamics (MD) Simulations conducted on the corresponding systems

116 Pickering emulsions stabilized by magnetic nanoparticles: toward bioseparation and detection of food and water pathogens.

hana klein

Volcani Institute, Rishon LeZion, Israel

Abstract

Foodborne bacterial pathogens present significant global health risks and economic challenges.[1] Conventional detection methods, while accurate, are impractical for rapid, on-site applications.[1] Magnetic nanoparticles (MNPs), such as Fe_3O_4, show promise for pathogen bioseparation due to their high surface area and magnetic responsiveness. However, their small size limits effective magnetic collection.[2] To address this, this study investigates oil-in-water Pickering emulsions stabilized by Fe_3O_4-APTES nanoparticles, which enhance the magnetic field effect through interfacial self-assembly while preserving a large surface area for efficient separation.[3]

This research includes the synthesis and characterization of Fe_3O_4-APTES nanoparticles using XRD, FTIR, EDX, DLS, zeta potential analysis, TGA, and VSM to confirm the structure, surface modification, and MNPs properties. The stability of the emulsions was demonstrated through confocal microscopy and LUMiSizer analysis, while their magnetic separation was successfully tested under an external magnetic field, demonstrating practical potential.

Ongoing efforts aim to develop these functionalized magnetic emulsions as a dual-function platform for the rapid separation and sensitive detection of pathogens in food and water systems. Future work will focus on biofunctionalization and validating the system with contaminated samples. This approach provides a scalable and innovative solution to current limitations in food safety diagnostics.

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144 Effect of Synthetic Polypeptide–Bio-Surfactant Composition on the Formation and Stability of Foams

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Abstract

In recent decades, numerous studies have focused on finding environmentally friendly substitutes for commonly used petrochemical-based compounds. Our study explores the potential use of poly-L-lysine (PLL)/rhamnolipids (RH) and poly-L-glutamic acid (PGA)/ethyl lauroyl arginate (LAE®) mixtures, for foam formation and stabilization.

Two complementary methods were employed to investigate the synergistic and antagonistic effects of these mixed polyelectrolyte/surfactant systems: (1) foamability tests were conducted using a standard dynamic foam analyzer (DFA) and (2) the thinning and rupture of thin foam films formed under dynamic conditions were monitored using a dynamic fluid-film interferometer (DFI). The results demonstrated that adding a polyelectrolyte to an oppositely charged surfactant primarily induces a synergistic effect, enhancing foaming properties and extending foam lifetime (Figure 1A). Furthermore, interferometric methods confirmed the improved stability and slower drainage of thin foam films formed by a rising bubble colliding with a free surface in systems containing synthetic polypeptides (Figure 1B).

However, at surfactant concentrations exceeding a critical threshold, a second phase emerges, leading to a significant decrease in the foamability of the system. Thus, it should be emphasized that polyelectrolyte/surfactant systems can only be used within a narrow concentration range. Nevertheless, the presented study demonstrated that polyelectrolyte/surfactant systems could be an interesting and promising alternative to standard foaming formulations.

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207 Pickering Emulsions: Microgels as Alternative Surfactants

To Ngai

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Abstract

Microgels stand out as compelling alternatives to traditional emulsifiers in Pickering emulsions, owing to their unique deformability and responsiveness. In this talk, I will provide an overview of recent advancements in microgel synthesis and the stabilization of Pickering emulsions using microgels. Additionally, I will discuss the underlying stabilization mechanisms of microgel-stabilized emulsions, elucidating the influencing factors such as microgel properties, environmental conditions, and interfacial structures that significantly impact emulsion stability. Given these recent achievements, I will highlight the promising applications associated with diverse Pickering emulsion systems stabilized by tailored microgels, including bacterial microencapsulation, growth and separation.

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236 Enhanced foam stability by nanoparticle composites for industrial applications

Miras Issakhov[1], Altynay Sharipova[2], Fariza Amankeldy[1], Reinhard Miller[3], Peyman Pourafshary[4]
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Abstract

The stabilization of surfactant-stabilized foams under challenging conditions, such as high temperature and salinity, remains a critical issue in enhanced oil recovery (EOR) and other industrial applications. Recent advancements suggest that hydrophilic silica (SiO2) nanoparticles hold significant potential as effective foam stabilizers due to their synergistic interaction with surfactants. This study focuses on evaluating the effect of SiO2 nanoparticles on the stability of foams stabilized by sodium dodecyl sulfate (SDS). Foam stability was assessed through half-life measurements, foam size distribution, and zeta potential analysis.

Experimental results demonstrate that the incorporation of SiO2 nanoparticles substantially enhances foam stability compared to foams stabilized solely by SDS. Silica nanoparticles improve foam performance in deionized water at 25 °C by increasing foam stability, particularly at SDS concentrations below the critical micelle concentration (CMC), where the nanoparticles enhance surface tension reduction and foamability. Adsorption of SDS onto SiO2 nanoparticles was observed, further stabilizing the gas-liquid interface. However, maximum foam stability was achieved at SDS concentrations beyond the CMC, reflecting a peak synergistic effect. At excessive SiO2 concentrations, nanoparticle aggregation reduced foam stability.

These findings underline the practical importance of SDS/silica nanoparticle systems, providing deeper insights into their colloid-chemical interactions and opening the way for the development of stable and efficient foams for applications in EOR and other industries. Furthermore, the study emphasizes the broader applicability of silica nanoparticles, which have properties like chemical stability and low adsorption on mineral surfaces, making them attractive for various technological fields.

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406 Electric Field-Induced Coalescence of Particle-Laden Droplets

Yongxiang Sun, Chenyu Qiao, Hongbo Zeng

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Abstract

The assembly of colloidal particles on or near the droplet surface is fundamental to the formation of particle-stabilized emulsions. Here we report that both electrostatic attraction and electrohydrodynamic flow facilitate the movement of nano-sized silica particles to a silicon oil-water interface. Electro-coalescence of particle-laden water droplets in silicon oil is investigated by combining high-speed photography with electric current measurement. The results show that the strength of interfacial film formed by particle adsorption greatly determine the coalescence behavior. At sufficiently high particle concentrations, the interface transitions from a fluid-like to a solid-like state. The interfacial film becomes 'jammed' when two droplet surfaces merge and be constrained to further morphological evolution. Even in cases where particles do not effectively adsorbed onto the oil-water interface, the electric-field-induced convective flow within each droplet can also direct particles from the bulk to the near-interface region. The locally increased particle density ultimately alters coalescence behavior through a spatial obstruction effect. We anticipate that these findings offer new insights into the stability of Pickering emulsion with useful implications for the development of electrical demulsification technologies.

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409 Modified Orange Peel and Rice Starch as Bio-based Stabilizers for Moringa Oil Pickering Emulsions: A Stability Study

Fatemeh Moosavi, Fatemeh Eslami

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Abstract

This study investigates the stabilization of moringa oil-in-water Pickering emulsions using two bio-based stabilizers: modified orange peel (MOP) and modified rice starch particles (MSP). The research systematically evaluates the efficacy of these stabilizers and examines the influence of key formulation parameters on emulsion stability. Fourier-transform infrared (FTIR) spectroscopy confirmed the successful esterification of orange peel, which enhanced its amphiphilic characteristics and resulted in superior stabilization performance compared to MSP. Dynamic light scattering (DLS) measurements revealed uniform particle size distributions and favorable zeta potential values for both stabilizers, suggesting robust electrostatic and steric contributions to emulsion stability. Contact angle studies further demonstrated effective adsorption of particles at the oil-water interface, with MOP exhibiting stronger interfacial affinity. A Box-Behnken experimental design was employed to optimize emulsion formulation, analyzing the effects of oil-to-water ratio, stabilizer ratio (MOP:MSP), and stabilizer concentration on stability. Fifteen distinct formulations were evaluated, with stability monitored over 25 days through pH, droplet size, zeta potential, and a stability index. Results indicated that higher stabilizer concentrations and an increased proportion of MOP significantly improved emulsion stability, attributed to MOP's enhanced amphiphilicity and interfacial activity. Statistical optimization via Minitab

software identified optimal parameters for achieving long-term stability, underscoring the interplay between stabilizer physicochemical properties and formulation design. These findings highlight the potential of agricultural waste-derived stabilizers, particularly functionalized orange peel, in developing sustainable, stable Pickering emulsions for food, cosmetic, or pharmaceutical applications. The study provides critical insights into the role of particle modification, interfacial behavior, and formulation engineering in emulsion stabilization, advancing the design of eco-friendly colloidal systems.

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418 Characterization of particles at the liquid/gas and liquid/liquid interface by imaging ellipsometry - an Overview

Peter H. Thiesen

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Abstract

The behavior or interaction of particles at or with the liquid-gas or liquid-liquid interface is relevant for a wide range of questions, be it for the optimization of Pickering emulsions or, for example, to gain a better understanding of the effect of nanoparticles on lung surfactant films.

Imaging ellipsometry and Brewster angle microscopy are imaging techniques with unique sensitivity for thin films based on their interaction with reflected polarized light. Brewster angle microscopy is a common method for imaging thin films at the air/water interface. Imaging ellipsometry enable additionally more quantitative data like film thickness and optical properties and derived quantities such as the contact angles of nanoparticles at the air/water interface.

By using optical fibers, in situ imaging ellipsometry can be performed at the liquid-liquid interface. Examples are the visualization of polymer particles or magnetic nanoparticles in the presence and absence of a magnetic field.

The presentation will provide an overview of current applications of these techniques and an outlook on future developments.

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441 Non-Destructive Techniques for Hydrocolloid Size, Structure and Rheology Characterization

J. Medinger, G. M. Conley, I. D. Block, A. Vaccaro

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Abstract

Innovative natural materials are increasingly important for applications ranging from food and food ingredient product development to drug delivery system design to meet the growing demands of discerning consumers and evolving regulations. Hydrocolloids are widely used across this application space to provide control over product viscosity, texture, stability and bioavailability. Precise and accurate methods are therefore required to characterize their size, shape, microstructure, rheology and stability.

Diffusing Wave Spectroscopy (DWS), a multiple light scattering-based technique, enables rapid, non-contact quantification of key physicochemical parameters, including gelation kinetics, viscoelastic moduli, colloidal size, mesh size, nanoscale dynamics, and turbidity. Unlike traditional destructive mechanical measurements, DWS avoids interfacial challenges, strain-induced artifacts with sensitive microstructures, and inertia-induced errors with low-viscosity materials. Its sealed, low-volume format allows fast, simple measurements and supports long-term studies and high-throughput automation.

We demonstrate DWS applications in hydrocolloid characterization by capturing gelatin's fluid-to-solid transition across temperatures and monitoring yogurt acidification in real time. Additionally, we explore its use in emulsion binding analysis, detecting subtle structural variations crucial for texture optimization. These findings underscore DWS's capabilities as a powerful tool for advancing hydrocolloid research and the development of innovative food and pharmaceutical products.

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50 Controlling Aggregate Formation in Amide Amine Oxide Surfactant Systems: Role of Protonation and Chemical Structures

Rie Kakehashi, Naoji Tokai, Makoto Nakagawa

Osaka Research Institute of Industrial Science and Technology, Osaka, Japan

Abstract

Amide amine oxide surfactants (AAOs) containing multiple amide groups form aggregates in water through intermolecular hydrogen bonding, leading to thickening and gelation of aqueous solutions. Previous studies have shown that subtle chemical structural variations in AAOs significantly influence their aggregate morphology and the resulting gel viscoelasticity. The amine oxide groups in AAOs serve as additional hydrogen bonding sites, with their behavior dependent on protonation degree.

This study investigates how the protonation degree (β) of amine oxide groups affects the aggregation behavior and thickening properties of AAO aqueous solutions. Through viscometry, transmission electron microscopy, and rheological measurements, we examined the relationship between protonation and aggregate structure. Results revealed that moderate protonation (β=0.5) of amine oxide groups effectively controlled aggregate formation, causing a transition from rod-like (β=0 and 1) to ribbon-like structures (β=0.5). This morphological transition demonstrates that protonation serves dual functions: introducing electrostatic interactions and creating additional hydrogen bonding sites, although these bonds were weaker than those between amide groups. The gelation temperature peaked at β=0.5, correlating with aggregate curvature, while unprotonated systems (β=0) exhibited enhanced viscoelasticity compared to fully protonated ones (β=1) despite their similar rod-like morphologies.

Our findings emphasize the importance of hydrogen bonding location in determining aggregate morphology and subsequent material properties.

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13 Single-Step Film Structuring: Characterization of Stratified Polymer-Particle Mixtures

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Abstract

This investigation explores stratification, a single-step evaporative drying technique, as a more efficient and cost-effective way to create vertically structured multi-component polymer and colloid films. Utilizing microbeam Small-Angle X-ray Scattering (SAXS) and Atomic Force Microscopy (AFM), films comprising poly(acrylic acid) (PAA) and polystyrene (PS) colloids were examined under different compositions and drying conditions. The investigation seeks to clarify the impact of evaporation rates and colloid sizes on stratification dynamics. Under atmospheric drying conditions, particle-on-top stratification was observed, which is consistent with the Peclet number theory. Conversely, in the medium evaporation drying system, increased evaporation rates resulted in non-stratified configurations for certain mixtures. Fast evaporation drying at elevated temperatures induced polymer-on-top stratification, which aligns with theoretical predictions. AFM images complemented these findings, with slow evaporation conditions revealing particle-on-top stratification and fast evaporation conditions validating polymer-on-top stratification. This comprehensive work improves our understanding of polymer-colloidal film stratification by highlighting the importance of drying conditions, Peclet numbers, and colloid size. Overall, this study proposes a more efficient method for creating vertically structured films, with implications for various industries.

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184 Synthesis of Oligothiophene Dendron-Modified Au Nanoparticles and Their Self-Assembled Structure

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Abstract

Au nanoparticles (NPs) exhibit localized surface plasmon resonance (LSPR). Since Au NPs absorb specific visible light by LSPR, energy transfer with other optical materials may occur. Among organic soft materials, oligothiophene dendrons are one of the organic semiconductor molecules containing a π-conjugated moiety which provides wavelength-controllable photoluminescence (PL). Additionally, organic-inorganic hybrid NPs can form long-range ordered structures. In our previous study, liquid crystalline (LC) dendron-modified Au NPs self-assembled in hexagonal phase, and the structure was transitioned into LC cubic phase at 150 °C. In this study, oligothiophene dendron-modified Au NPs were synthesized, and their optical properties and self-assembled structure were investigated.

1-dodecanethiol (DT) modified Au NPs (**A**) and second generation oligothiophene dendron (**T7**) -modified Au NPs (**DA**), in which the ligand preparation ratio of **T7** to DT is 1:1, were synthesized. Transmission electron microscopy images of **A** and **DA** shows that the particle sizes were 4.6 ± 0.5 and 4.4 ± 0.6 nm, respectively. Interparticle distance of **DA** expanded by steric effect of dendric moiety. The optical property of NPs and **T7** in chloroform was investigated by PL measurement. The PL intensity of **DA** was quenched by 91% compared to an equivalent amount of **T7**, suggesting energy transfer from **T7** to Au core. The self-assembled structure of **DA** casted on kapton film was evaluated by small-angle X-ray scattering. **DA** self-assembled into a face-centered cubic structure at 150 °C. The effect of modification ratio of **T7** on the self-assembled structure will be discussed.

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271 Phase Behavior of Colloidal Clusters: Bridging the Gap Between Icosahedral and FCC

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Abstract

In bulk, monodisperse colloidal particles crystallize into close-packed structures. This arrangement maximizes their packing, thus, minimizing the free energy of the system. However, when confined in a finite space, the geometry of the confinement, as well as the discretization of the system, gives rise to complex crystallization behavior and structures that differ from the bulk behavior. Previous studies have shown the appearance of icosahedral clusters composed of a Mackay core and different number of anti-Mackay shells for small clusters. As the number of particles increases, these clusters transition to FCC structures, adopting bulk behavior. However, upon close observation, new crystalline structures start to appear. We observe the appearance of decahedral clusters, as well as a new cluster with a symmetry reminiscent of a football.

Using a combination of experimental characterization and event-driven molecular dynamics simulations, we investigate the mechanisms driving the transition between crystalline structures and the fundamentals behind the rich phase diagram of spherical colloidal clusters. Our research has examined the size evolution of icosahedral clusters, and provided insights into the formation mechanisms of decahedral clusters. Building on this work, we are extending the phase diagram with a newly proposed crystalline cluster, named as "football" cluster, that appears as a link between closed-shell icosahedral and FCC clusters.

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357 Engineering Cellulose Foam-MOF composites for Environmental Remediation

Praven Trichy Kamalanathan, Farhad Ahmadijokani, Tianyu Guo, Tina Raeisi, Orlando Rojas

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Abstract

The incorporation of bioresource-based advanced adsorbents into the water treatment sector is an emerging yet challenging endeavor. While bioresource materials have found widespread applications in areas such as insulation and packaging, their integration into water treatment systems remains hindered by issues such as low stability in aqueous media, limited functionality, and unsuitable shapes for practical applications. To address these challenges, we focused on producing water-stable cellulose foams from Northern Bleached Softwood Kraft (NBSK) pulp produced from trees native to Canada such as pine and fir. Refining and fibrillation of the pulp were conducted to prepare it for subsequent modifications. In order to compensate for the low functionality of the foam substrates, we introduced highly functional fillers favorable for water decontamination. Specifically, water-stable metal-organic frameworks (MOFs), such as ZIF-67 and UiO-66-NH2, were in-situ grown onto the cellulose foams. To enhance the interaction between the MOFs and the cellulose fibers, carboxymethyl cellulose adsorption (CMC) was used to modify the substrate by introducing carboxyl groups, which are among the most effective binding sites for MOFs. This approach showed a highly uniform distribution of the MOF crystals throughout the fibre surface improving assembly of the MOF on fibre surface. Subsequently, the effect of MOF chemistry on the selectivity and the efficacy of the porous substrate towards the adsorption of antibiotics and heavy metals are demonstrated .

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43 pH-responsive acidic nanogel system

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Abstract

The solubility of 6-acrylamido hexanoic acid (AaH) polymers in water depends on pH due to the protonation and deprotonation of pendant carboxy groups in acidic and basic conditions, respectively. Protonated PAaH is hydrophobic, while deprotonated PAaH is hydrophilic. To create pH-responsive nanoparticles, AaH and hydrophilic 2-acrylamido-2-methylpropanesulfonic acid

(AMPS) were polymerized in water at pH 2. The resulting nanoparticle (P(AaH/AMPS10)) was purified by centrifugation. Dynamic light scattering (DLS) measurements showed that the hydrodynamic radius (R_h) of P(AaH/AMPS10) was 119 nm in acidic conditions and 613 nm in basic conditions. Transmission electron microscopy (TEM) observations confirmed a spherical shape regardless of pH, with dry particle sizes of 97 nm and 104 nm in acidic and basic conditions, respectively, suggesting that dry nanoparticles did not exhibit pH responsiveness. The pH-responsive behavior of the nanoparticles was assessed using *N*-phenyl-1-naphthylamine (PNA), a hydrophobic fluorescence probe whose intensity increases in hydrophobic environments. Under acidic conditions, PNA was encapsulated within the nanoparticles due to hydrophobic interactions. In contrast, under basic conditions, PNA was released from the nanoparticles, indicating a shift in nanoparticle hydrophobicity with pH changes.

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103 Phase change behavior and mechanical transformation of eutectic hydrated-salt phase-change gels tuned by water

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Abstract

Hydrated-salt phase-change gels (PCGs), composed of polymer and hydrated-salt phase change materials (PCMs), are dynamic materials with switchable mechanical states mediated by solid-liquid phase change behavior of PCM . Water is an important factor affecting the phase change behavior of salt hydrates and expected to be used in tuning the mechanical performance of PCGs. In this work, eutectic $MgCl_2·6H_2O$-$Mg(NO_3)_2·6H_2O$ PCMs (Mg-PCMs) and their corresponding phase-change gels (Mg-PCGs) were prepared. Using differential scanning calorimetry (DSC) and atomic force microscopy (AFM), effects of water content on the phase change behavior and nanomechanical properties of Mg-PCMs and Mg-PCGs were investigated. Extra water ($n > 6.000$, 41.30%$MgCl_2$-58.70%$Mg(NO_3)_2$-nH_2O) or less water ($n < 6.000$) could lead to changes in phase transition behavior such as the appearance of new characteristic peaks accompanied by the formation of ice or tetrahydrate salt. With increase in water content and the resulting changes in phase change behavior, Young's modulus of solid Mg-PCMs decreases from about 72.52 GPa to 2.02 GPa. In addition, Mg-PCGs could switched from a clear soft solid to a white rigid solid with up to 10^4 times change in modulus (7.79 GPa vs 490 kPa). As the water content changing, upper and lower limits of the switchable modulus can be tuned in the ranges of 13.90-3.32 GPa (rigid) and 0.91-0.48 MPa (soft), respectively. The temperature-responsive PCGs switching between two stable solid states with upper and lower limits of modulus quantified tuned by water content, show great application prospects on bionic and automation fields.

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107 Smaller Shells, Faster CO_2 Emission: A Quantitative Study of Size Effects on CO_2 Emission Rates in Acid-Eggshell Reactions

Yuki Maeda, Jing Liu

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Abstract

Eggshells, a common type of kitchen waste, release CO_2 when exposed to acidic environments, potentially contributing to environmental challenges. This study investigates the influence of crushed eggshell size on the CO_2 emission rate during acid-carbonate reactions, modeled using eggshells and acetic acid to simulate interactions between discarded eggshells and organic acids in the environment.

In the experiments, equal-mass eggshell samples were crushed into five size categories, ranging from 0.025 mm^2 to 100 mm^2, and reacted with acetic acid solutions of fixed concentration. Acetic acid concentrations were measured at intervals over 1 to 9 hours. Results revealed a rapid decrease in acetic acid concentration within the first hour for all shell sizes, signifying a burst of CO_2 emission. Reaction rates declined over time as acetic acid levels decreased, aligning with a first-order kinetic reaction model. A strong dependency on shell size was observed: the smallest particles reacted over twice as fast as the largest shells in the first hour. Minimal differences were noted between the 100 mm^2 and 25 mm^2 sizes, but particles smaller than 4 mm^2 exhibited a dramatic increase in reaction rate—nearly 36 times faster—indicating a shift in reaction kinetics due to the significant surface area increase as particle dimensions approached shell thickness.

Disposing of eggshells in larger pieces could help mitigate rapid CO_2 emissions. These findings also provide broader insights into managing kitchen waste to reduce environmental impacts from rapid CO_2 release.

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263 Ionic conductivity and mechanical performance of solid-foam hydrogels under large-amplitude compression

Amir Sina Nassirian, Jacob Miller, Mohammed Skaik, Reghan J. Hill

McGill University, Montreal, Canada

Abstract

The ionic conductivity and flexibility of hydrogels are important properties in biomedical, energy storage and soft-robotics applications. This study examines the electrical conductivity and viscoelasticity of macro-porous solid-foam hydrogels under large-amplitude compression.

Impedance spectroscopy furnishes new insights on how micro- and macro-scale porosities influence ion transport (conductivity and dielectric permittivity) of micro- and macro-porous hydrogels. Additionally, micro-computed tomography (micro-CT) unveils the macro-scale pore distribution of solid-foams under large-amplitude compression. By integrating electrical and mechanical analyses, this work provides new fundamental insights into the structure-property relationships of these unusually compliant and highly porous materials, highlighting their potential for use in soft electronics, actuators and sensors.

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319 Thermal Degradation and Resulting Corrosive Effects of Crude Vegetable Oils Over Extended Periods

Josh Ness, Jing Liu

University of Alberta, Edmonton, Canada

Abstract

This project seeks to investigate the corrosion potential and thermal stability of crude vegetable oils during their storage and transportation for co-refining applications. In this project, two types of crude vegetable oils (CVOs) will be studied, specifically type 1 crude super-degummed canola oil and crude-degummed grade soybean oil. A series of long-term experiments are designed to immerse steel samples with varying Cr contents in these two CVOs at various elevated temperatures (e.g. 200, 300, and 400 F) for 1, 10, and 100 days. The thermal degradation of these two CVOs will be evaluated by the changes of their thermal stability, chemical degradation, water content, and viscosity using thermogravimetric analysis (TGA), Fourier Transform Infrared Spectroscopy (FTIR), Karl Fischer titration analysis, and rheometry. Weight loss data of steels with varying chromium contents will be recorded for corrosion rate calculation. Surface scanning electron microscope (SEM) will be done on the post-corrosion samples to analyze the corrosion morphology.

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378 Hydrosetting sustainable polymers show spatially regulated microstructures with differential mechano-responsiveness

WENBO CHEN

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Abstract

Given the essential role of plastics in the global economy, a holistic and sustainable strategy to manage their lifetime is required, however, current efforts including upcycling and processing are

passive and still far from their promise. Achieving self-regulated structural characteristics are of challenge to existing plastics, demonstrates an active strategy on extending the sustainable service through their versatility on distinct occasions. While developing green approaches, we reveal sustainable polymers, herein cellulose phenoxyacetate as a typical example, with unusual water-responsive dual-mechanic functionalities via a chronological water training strategy. While a bulk mechano-responsiveness was evident after 3 minutes water exposure, an unprecedented differential mechano-responsiveness due to the formation of spatially distributed mesostructures after 3 hours water training. This endows the materials with multiple recoverable shape-changes during water and air training, and consequently even underlines the switchability between the pre-loaded stable water shapes (> 13 months) and the sequentially fixed air shapes. Our hydrosetting sustainable polymers, which exploits the water training initiated competitive mechanics, promoting a paradigm shift from conventional passive plastics processing into emergent plastics with actively spatially regulated mesostructures afforded by their internal differential mechanical attributes. Insights into the molecular changes represents a considerable fundamental innovation, which can be generally applicable to a wide range of biomass.

290 1D Model for emulsions transport in porous media and its use to interpret the extraction of bitumen using targetted emulsified solvent injection (TESI).

Nga Nguyen, Jahnavi Upreti, Edgar Acosta

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Abstract

In targeted emulsified solvent injection (TESI), a solvent such as cyclohexane is emulsified using a low surfactant concentration that can produce very low interfacial tensions (IFT~0.1 mN/m). This emulsion becomes unstable inside the porous media and deposits the emulsified solvent on the pore surfaces, following a process described by the colloid filtration theory (CFT). The deposited solvent mixes with bitumen, decreasing its viscosity. The shear imparted by the flow, the low interfacial tension imparted by the surfactant, and the low viscosity afforded by the mixing of the bitumen and solvent lead to conditions that are suitable for the capillary displacement (CD) and recovery of the diluted bitumen. The experimental data of Stammitti (http://hdl.handle.net/1807/108103) and others is interpreted in light of a new 1D-CFT+CD model that uses CFT to describe the deposition of the emulsified solvent combined with a CD model for the diluted bitumen detachment (and recovery) from the porous media. The first part of the presentation introduces the model and its validation with literature data, and the second part concentrates on the application of the model to selected TESI extraction cases. The potential implications of this CFT+CD model for other enhanced oil recovery applications are discussed.

329 Probing Structure-Property Relationships in Colloidal Lignin Particles via Fluorescence

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Abstract

As an abundant byproduct of the pulp and paper industry, Kraft lignins are a desirable target for valorization given their phenolic-rich chemical structure and widespread availability. Transforming the complex and heterogeneous lignin polymer into colloidal lignin particles (CLPs) offers potential for diverse, high-value applications. Yet, the relationship between lignin source, structure, and CLP properties is poorly understood. Here, we use fluorescence spectroscopy to study CLPs produced from Kraft lignins of various sources and extraction procedures. We investigate how lignin structure, CLP size, and surface chemistry influence the fluorescence signals. We employ chemometrics techniques to determine correlations between these structural features, fluorescence behaviour, and CLP properties. This work can contribute to the identification of structure-property relationships and can inform strategies for producing CLPs with tailorable properties.

40 Natural surfactant cocamidopropyl betaine can be used as a dispersant for marine crude oil spills

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Abstract

Crude oil spills have many harmful effects on marine life and environment. The pollution caused by oil spills can lead to parks and beaches closing down, seafood becoming unsafe to eat and many more consequences. Chemical dispersants are one of the more effective methods to treat marine oil pollution, it is particularly important to choose an environmentally friendly and biodegradable chemical dispersant in order to not further increase pollution. One dispersant called Cocamidopropyl Betaine is considered a natural surfactant that is biodegradable and environmentally safe. In this study, the dispersing effect of cocamidopropyl betaine on crude oil (light crude oil from Daqing Oilfield, China) was studied. Surfactant Tween20 and commercial dispersant Nokomis3 were selected as controls, the study used simulated seawater to determine the dispersing effect on crude oil through the baffled flask test. The results showed that the commercial dispersant Nokomis3 had the best crude oil dispersing effect, and its dispersing efficiency was close to 100% when the dispersant to oil ratio (DOR) was 1:12.5 (volume). However, when the DOR of Cocamidopropyl Betaine was 1:8.33, its dispersing efficiency was also close to 100%. When the DOR of Tween20 was 1:8.33, its dispersion efficiency was only 60%. This result showed that although Cocamidopropyl Betaine is not as efficient as commercial

dispersant Nokomis3, it could be used as a viable alternative as a biodegradable natural surfactant with little negative impact on the environment.

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68 Shaping Amoeba Morphologies: Heat and Light Responsive Liquid Crystal Emulsions

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Abstract

Liquid crystals are well-established stimuli-responsive materials that exhibit distinct molecular orientations under external perturbations, such as thermal, photonic, magnetic, or electric stimuli. These materials have garnered significant interest due to their ability to transition between different phases and configurations, enabling a wide range of functional applications. This study focuses on a class of α-cyanostilbene derivatives that exhibit dual functionality as liquid crystals and surfactants. These compounds not only stabilize complex emulsions but also display dynamic alignment changes in response to external stimuli, such as temperature or light. These alignment modulations lead to variations in interfacial tension, which drive controlled morphological transformations.

Advanced techniques like polarized optical microscopy (POM) and fluorescence imaging were used to observe molecular alignments and dynamic behaviors. These transformations were shown to be reversible and programmable under different conditions, offering precise control over emulsion properties.

The results demonstrate the potential of these materials in applications like targeted drug delivery and adaptive soft matter systems. Their responsiveness to multiple stimuli makes them ideal for multifunctional and tunable material design, advancing the field of stimuli-responsive emulsion technologies.

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87 Interactions of saponins at the water-air interface with chemical compounds acting as hydrogen bond donors or acceptors and their role in emulsion stabilization

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Abstract

The purpose of our study is to explore the potential for modifying the surface adsorption and emulsifying properties of saponin by introducing compounds capable of interacting with it in solution through hydrogen bonding or electrostatic forces. These compounds include urea, thiourea, glycerol, choline chloride, betaine, and nicotinic acid. The experiments are conducted in an emulsion system where the aqueous phase is paired with oil phase which contains the medium-chain triglyceride oil Miglyol 812N.

The study examined how various additives influence saponin adsorption at water-air interface, as well as the long-term stability of the resulting emulsions. Building upon previous research [1-3], the relationship between the properties of adsorptive layers and the corresponding emulsions was explored, with a particular focus on how selected chemical additives affect the destabilization mechanisms of oil-in-water emulsions. The emulsions were analyzed from their formation through their evolution. Understanding the interfacial properties of saponins and their interactions with additives is essential for developing stable emulsions with desired characteristics

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169 Design of Mesoporous Silica Nanoparticles using Stimuli-Responsive Templates

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Abstract

Mesoporous silica nanoparticles (MSNs) are exciting materials due to their high internal surface area and pore volume, tunable pore size, colloidal stability, and the ability to selectively functionalize the internal or the external particle surface.

MSNs with a dual pore system have two different types of pores that can interact independently with two different cargos simultaneously in a single particle, opening great prospects in areas such as catalysis, anti-corrosion, drug delivery, and biomedicine.

Although some attempts have been made to developed silica nanoparticles with two different pore morphologies, in all cases the templates used to form the mesoporous structures have been removed at the same time. This poses a problem since the templates used to prepare MSNs with dual-pore systems should be selectively removed to allow independent pore functionalization and selective controlled release. An innovative strategy would be the use of a light-responsive smart amphiphilic copolymer that can be selectively removed, before removal of a second template, using standard methods.

In this work we present the first steps towards the preparation of a light-responsive smart amphiphilic copolymer, based on a novel hydrophilic block linked via click chemistry to the hydrophobic block containing the light responsive group. The amphiphilic copolymer should self-assemble into cylindrical micelles, which will be used as template to prepare mesoporous structures. To control this process, blocks with different degrees of polymerization were prepared and characterized using nuclear magnetic resonance spectroscopy.

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242 Fabrication of Vesicular Structures from Pseudotriple-Chain Ion Pair Amphiphiles for Drug Delivery Applications

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Abstract

In this study, charged vesicular structures were fabricated from pseudotriple-chain ion pair amphiphiles for drug delivery applications. Pseudotriple-chain ion pair amphiphiles were prepared from mixed double-chain cationic/single-chain anionic surfactant mixtures, and were used as raw materials to fabricate vesicular structures through a forced formation process. It was found that positively charged vesicular structures with average sizes of 125-130 nm could be successfully fabricated without the addition of additives. The positive charge character might be due to the preferential dissolution of the single-chain anionic surfactant moiety from the vesicular structure surfaces, and could be adjusted by the alkyl chain length of the surfactant moiety. By using a pseudotriple-chain ion pair amphiphile, prepared from a mixed single-chain cationic/double-chain anionic surfactant mixture, as the raw material, negatively charged vesicular structures with an average size of 130 nm and high physical stability could be prepared, and the phase transition temperature of the vesicular bilayer structures was about 38°C Fatty acids, which are environmental friendly and can be obtained from natural sources, were then adopted as additives to control the vesicular bilayer fluidity in order to regulate the phase transition temperature for drug delivery applications. The results indicated that the vesicular bilayer structures became rigid with increasing molar fractions of the fatty acids, which could be further

modulated by the alkyl chain length of the fatty acids, showing potential as thermosensitive drug delivery carriers.

379 Novel Dicephalic and Quadruple Head Cationic Surfactants at the Air/Solution Interface

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Abstract

Contemporary research concerning surfactant science and technology comprises a variety of requirements relating to the design of surfactant structures with widely varying architectures to achieve physicochemical properties and dedicated functionality. Even slight modifications within the surfactant structure, compared to conventional analogues having single hydrophobic and hydrophilic motifs, result in a wide spectrum of unique physicochemical and functional properties, allowing for targeted technological applications e.g., magnetic surfactants, biocidal agents, capping and stabilizing reagents or reactive agents at interfaces. Multicharged structures stand out as the most noteworthy among them. [1]

The aim of the presented studies was to design structures and develop efficient synthetic methods for producing high-purity multifunctional cationic-type surfactants branched on a nitrogen atom: 2,2'-(alkylimino)bis(*N,N,N*-trimethylethanammonium) dibromides (dicephalic-headed, C_n-$D_N NMe_3Br$) and *N,N,N*-bis(2-(*N,N,N*-bis(2-ammoniumethyl)amino)ethyl)alkylamine tetrabromide (quadruple-headed, C_n-$D_N Q_N NMe_3Br$). These surfactants were synthesized *via* multistep processes, including the alkylation of diethanolamine with an appropriate bromoalkene to obtain the corresponding amine-diol, followed by the replacement of hydroxyl groups with bromide moieties. The resulting derivative was quaternized using an excess of trimethylamine to yield the final product, which was then purified through triple crystallization and verified by ^{1}H-NMR, ESI-MS, and elemental analysis. Surface tension isotherms of aqueous solutions of the examined multicharged surfactants were determined with the use of the pendant drop shape analysis method and evaluated with the modified surface quasi-two-dimensional electrolyte (mSTDE) model of ionic surfactant adsorption. [2] It has been proven that the addition of NaBr, HBr and NaOH has a different impact on surface activity due to charge screening and protonation/deprotonation of tertiary amine. The results obtained could be interpreted well by the theoretical mSTDE model.

404 A Comparative Study of Free Energy Minimization and Semi-Empirical HLD Models for Microemulsions

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Abstract

Microemulsions significantly enhance the solubility of hydrophobic substances in aqueous environments, offering transformative potential in biopharmaceutical applications such as drug delivery. However, their intricate phase behavior poses challenges in predicting solubilization capacity. Two prominent modeling frameworks address this: (i) the molecular thermodynamic approach, which rigorously minimizes Gibbs free energy to predict phase equilibria, and (ii) the semi-empirical Hydrophilic-Lipophilic Difference (HLD) model, favored for its simplicity in formulation design. This study systematically compares these two approaches for a specific water-oil-surfactant (SOW) system, aiming to establish a theoretical bridge between the empirical parameters of the HLD model and the fundamental thermodynamic parameters. Free energy minimization at constant temperature, pressure, and overall composition determines equilibrium phase compositions and geometrical characteristics. From these equilibrium properties, the solubilization parameter—a measure of hydrophobic uptake—is calculated and validated against experimental data. Furthermore, the surfactant's standard chemical potential difference between the aqueous and oil phases is determined from the chemical equilibrium equation. This difference corresponds to *theoretical* definition of HLD. Hence, by employing the thermodynamic definition of HLD, rather than the *empirical* correlation for HLD, the predictive performance of HLD-NAC equation of state for microemulsion phase behavior is critically assessed. By substituting the empirical HLD with its thermodynamic counterpart, we critically assess the HLD-NAC model's predictive accuracy. Additionally, the models are linked via the solubilization parameter, offering thermodynamic insights into the semi-empirical model.

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408 Investigating the phase separation dynamics in microemulsion systems with image processing

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Abstract

Surfactant-oil-water (SOW) systems are extensively used in industries such as pharmaceuticals, food, detergent production, and petroleum, where the solubilization capacity of surfactant and the stability of emulsions play a crucial role. In microemulsion systems, the optimal formulation occurs when the hydrophilic-lipophilic difference (HLD) approaches zero, a condition associated with Winsor III phase behavior. However, determining the optimal formulation is challenging, particularly for newly developed materials, and often results in material waste and time inefficiencies. This research introduces a novel, image processing-based method for the rapid identification of optimal formulations in microemulsion systems. The method automates the evaluation of critical parameters such as phase separation rate, interphase formation time, and the volume of separated phases through advanced visual monitoring and rapid computational analysis. In this study, salinity scans were conducted using sodium dodecyl sulfate (SDS) and sodium dodecyl benzenesulfonate (SDBS) as surfactants, with toluene as the oil phase. Experimental results revealed that one of the fastest phase separations of excess phases occurs near HLD = 0, confirming the significance of this data in optimizing optimal formulations. These parameters were quantified using imaging and motion analysis techniques, enabling accurate prediction of system properties while reducing experimental time and trial iterations. Additionally, the study investigated hypotheses regarding the influence of phase separation kinetics and interfacial dynamics on formulation optimization. This research provides a fast, accurate, and efficient solution for formulating SOW systems using image processing tools, which streamlines research and development workflows in various fields**.**

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7 Vibrations as a Tool for Modulating Surface Interaction Forces between supported lipid bilayers

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Abstract

Understanding and controlling surface interactions are essential for numerous biomedical applications, including drug delivery, biosensing, and tissue engineering. In this study, we explore the potential of low amplitude vibrations (< 10nm) as a non-invasive and tunable tool for manipulating surface interaction forces on model-supported lipid bilayers.

Lipid bilayers composed of DSPE-DPPC were deposited onto mica substrates via the Langmuir-Blodgett technique. These bilayer-coated surfaces were subsequently transferred to a Surface Forces Apparatus (SFA) equipped with a vibration module, allowing for precise measurements of the interaction forces between the lipid bilayers under controlled vibrational conditions.

Our results show that vibrations can effectively modulate surface forces, transitioning from adhesive to repulsive behavior with changes in both amplitude and frequency. At lower vibration frequencies and amplitudes, strong adhesion was observed between the surfaces. However, as vibration frequency increased, the adhesive forces weakened, giving rise to repulsive forces. This shift demonstrates vibration's potential as a dynamic tool for regulating lipid bilayer interactions.

These findings introduce vibrations as a novel and non-invasive strategy for fine-tuning surface interactions at the molecular level. This approach holds significant promise for advancing biomedical technologies that require precise control of surface forces, such as enhancing nanoparticle circulation times in drug delivery or improving biosensor designs.

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170 Analyzing the Impact of Salt Coating and Layering on Mask Performance, Contact Transmission, and Biocidal Efficacy

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Abstract

Respiratory diseases have a widespread and multifaceted impact, influencing individuals, healthcare systems, and global economies. Masks and respirators have proven essential in mitigating the spread of respiratory pathogens by effectively reducing transmission. The drawbacks of traditional face masks and respirators, often face challenges, including single-use designs, environmental concerns, and contact-based transmission risks. These limitations have driven advancements in antimicrobial mask technology, which require a thorough understanding of the properties and configurations of mask layers to maximize protective efficacy. This study investigates the performance of individual layers in standard 3-ply masks and layered spunbond (SB) fabrics, both with and without salt (NaCl, KCl, and K_2SO_4) coatings, under dry and wet conditions. Filtration efficiency, pressure drop, and the impact of salt coatings on particle capture and antimicrobial efficacy were assessed. Bare fabrics demonstrated reduced filtration efficiency in wet conditions, while salt-coated fabrics showed enhanced performance, particularly in capturing and neutralizing infectious particles. Stacks of salt-coated SB fabrics were effective as the outermost layer in 3-ply masks and as supplementary coverings for existing masks or N95 respirators. These layers not only filtered contaminants but also prolonged the lifespan of the masks by reducing contamination burdens on the melt-blown filter. This study underscores the potential of salt-coated SB fabrics to improve respiratory protection by enhancing filtration and antimicrobial properties, offering a sustainable solution for reducing disease transmission and extending the usability of masks and respirators. These findings provide a practical framework for integrating salt-coated antimicrobial technology into respiratory protection devices.

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174 Engineering Microstructured Surfaces to Minimize Ice Adhesion: Insights into Wetting States and Interfacial Stress Distributions

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Abstract

Ice adhesion on structured surfaces presents significant challenges in industries such as transportation and energy. This study explores the role of surface microstructures, specifically micropillars, in reducing ice adhesion strength by influencing wetting states. Experimental and numerical investigations were conducted on hydrophobic and superhydrophobic silicon wafer surfaces with varied microstructure geometries. Micro push-off tests revealed that patterning these surfaces minimizes ice adhesion strength by reducing the interfacial contact area. Notably, surfaces with micropillars (D = 10 µm, H = 20 µm, S = 20 µm) achieved the lowest ice adhesion strength at −20°C for a 10 µL frozen droplet. The study further identified two debonding modes—translational and rotational—depending on the wetting state and surface geometry. Finite element simulations provided insights into stress distributions at the interface, elucidating the role of surface topology and droplet shape in ice detachment. These findings offer a deeper understanding of ice adhesion mechanisms, contributing to the development of surfaces with optimized anti-icing properties.

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421 The Stood-up drops to determine receding contact angles and its relation to substrate-coating adhesion performance

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Abstract

The receding contact angle (CA) can provide most relevant information for e.g. coating and bonding processes. However, measurements of the receding CA are typically time-consuming, challenging, and necessitate extensive protocols. In this study, we introduce a novel drop deposition method that enables the rapid measurement of the recently receded CA and is entirely user independent.

The method builds upon the existing "liquid-needle method" used to measure advancing CAs, wherein a thin liquid jet is meticulously controlled to deposit a droplet on the surface without imparting excess kinetic energy. In contrast to this, our novel method for receding CA involves the liquid first spreading radially during dosing, forming a pancake-shaped film, and subsequently retracting to form a spherical cap-droplet shape, as illustrated in the Figure. Consequently, we refer to such droplets as "stood-up drops" (SUD).

We elucidate the crucial dosing parameters necessary to ensure that the contact angle of SUD accurately represents the recently receded contact angle and compares favorably to classically determined receding CA. We provide real life industrial application examples wherein this novel SUD CA measurement could address production problems hitherto unresolvable with classical (advancing) contact angle measurements. In particular, we present a series of studies establishing a strong correlation between recently receded contact angle data, and substrate-coating adhesion performance, as determined per ISO 2409 (cross-cut adhesion/tape test). This correlation was tested on a wide range of substrate types, including metals, polymers, plasma-activated polymers, and base-coated substrates, with different coatings.

131 Wettability of rare earth oxide ceramics from the structural and environmental exposure perspective

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Abstract

Rare earth oxide (REO) ceramics with excellent thermal and chemical robustness are of interest in the wettability community as they were assumed to be hydrophobic (water contact angle WCA > 90°) due to their unique electronic structure. However, other non-wetting mechanisms were proposed as well, namely (i) the adsorption of airborne hydrocarbons and (ii) vacuum treatment requirements to remove excess or loosely adsorbed oxygen on the surface from the fabrication process. To clarify the intrinsic mechanism, we explored the wettability of REOs single crystals with different crystallographic orientations: (001), (110) and (111). We found that freshly prepared REO epitaxial films grown by pulsed laser deposition are hydrophilic and the water contact angle strongly depends on the crystallographic orientation, reflecting the differences in the crystal surface energies. In addition, regardless of the crystallographic orientation, the water contact angle of REOs increased rapidly and converged to about 80° upon exposure to ambient environment, due to the adsorption of airborne hydrocarbons. Furthermore, carefully designed experiments were performed to explore the effect of vacuum storage on the surface chemistry of these surfaces. We found that accumulation of surface absorbates including carbon and fluorine occurred after extended residence in "clean", ultra-high vacuum environment. The results of this study provide important insights on the interpretation of water wettability of rare earth oxides and the applicability of these materials as robust, non-wetting surfaces.

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157 Synergistic effects of UV Radiation and Metal Corrosion on Bio-Oil Aging for Storage Optimization

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Abstract

Fast pyrolysis oils (FPOs) are known for their thermal instability and high corrosivity to common structural steels, factors must be critically considered in the design of storage and transportation systems. However, the impact of UV radiation on the storage stability of FPOs and its interactions with containment metals remains insufficiently understood. This study examines the impact of UV radiation on the stability of methanol-stabilized bio-oil and its interaction with common metals of constructions (MOCs), including CSA36, Cr2Mo, P91, Cr14Mo, and SS 316L at 50 ℃ for 10 weeks. Results reveal that UV radiation significantly accelerates the aging process of FPO, as

evidenced by increased viscosity and chemical changes, while also amplifying corrosion rates of the tested MOCs. Additionally, the leaching of metal ions catalyzes polymerization reactions within the FPO, reinforcing a self-reinforcing loop that exacerbates aging. These findings highlight the critical need to minimize UV exposure in bio-oil storage systems to enhance FPO stability and prolong the lifespan of containment materials. This study offers valuable insights for optimizing industrial bio-oil storage and handling practices.

245 Synthesis of Blue-emission Carbon Quantum Dots with High Quantum Yield for Ciprofloxacin Detection

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Abstract

Highly fluorescent blue-emissive carbon quantum dots (CQDs) were synthesized successfully via a hydrothermal method using Ortho aminophenol and Citric acid as precursors. The CQDs were characterized using high-resolution transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS), and Fourier-transform infrared spectroscopy (FTIR). The results show that the CQDs had a mean diameter of 2.1 nm and were surface functionalized with hydroxyl, amine, and carboxyl groups. These CQDs exhibited an excellent fluorescent property with an outstanding quantum yield of 89.7%, which is among the highest values reported for blue-emissive CQDs in the literature. These CQDs were then applied as a fluorescent probe to detect ciprofloxacin, a widely used fluoroquinolone antibiotic. It demonstrated that the CQD-based fluorescent probe demonstrated a linear response to ciprofloxacin concentrations in the range of 0 – 40 μM, with a remarkable limit of detection as low as 36 nM. The sensing performance was validated through successful quantification of ciprofloxacin in real samples of urine and blood serum, showing its practical applicability with an excellent recovery rate of 98.27% - 105.06%. These results imply that the CQDs are promising candidate for various optoelectronic and analytical applications.

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349 Investigating Overpotentials in CO_2RR Systems: A Focus on Catalyst-Membrane Interfaces

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Abstract

Electrochemical conversion of CO_2 (CO_2RR) offers a promising pathway for producing valuable chemicals using renewable electricity, with significantly lower emissions compared to traditional methods. However, for this technology to become commercially viable, it is essential to achieve

current densities exceeding 200 mA/cm², as determined by techno-economic analysis. Such operating conditions help amortize the capital costs of electrolyzers over their lifetime. While recent advancements have met this reaction rate target for several products, reducing the operating voltage of CO_2 electrolyzers remains a critical barrier to improving energy efficiency and cost-effectiveness.

The economic viability of CO_2 electrolyzers is heavily influenced by their operating voltage, a key performance metric that defines energy efficiency. Despite its importance, detailed information on voltage loss distribution—particularly within membrane electrode assembly (MEA) electrolyzers—is rare due to the challenges in integrating reference electrodes in such configurations. Current research has focused on improving the performance of CO_2 electrolyzers under industrially relevant conditions, but achieving both high current densities and high energy efficiency remains a challenge.

In this study, we developed an analytical zero-gap MEA electrolyzer capable of resolving voltage losses. This system incorporates reference electrodes on each side of the membrane to measure both cathodic and anodic overpotentials. The diagnostic platform is utilized to evaluate the performance of several CO_2 reduction approaches, including conventional neutral CO_2R in MEAs and acidic CO_2R configurations. Once the cell components contributing the most to the voltage drop are identified, the next stage of the study will focus on optimizing these components to effectively reduce the overall cell voltage.

A key area of interest is the membrane/catalyst interface in acidic CO_2RR systems, where significant ohmic losses have been observed. To address this challenge, the study investigates strategies to mitigate high ohmic losses by focusing on optimizing the membrane/catalyst interface. These findings highlight the critical role of the catalyst/membrane interface in determining overall cell voltage and underscore its importance in improving the energy efficiency of CO_2RR systems.

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363 Thermodynamic Modeling of the Droplet Curvature Effect on W/O/W Emulsion Liquid Membranes with Reactions

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Abstract

Emulsion liquid membrane (ELM) is a promising separation technique in the wastewater treatment. The impact of interfacial curvature on separation efficiency of ELM with a chemical reaction has not been investigated. We have developed a thermodynamic model including the effect of interfacial curvature in a water-in-oil-in-water (W/O/W) ELM system. The dissociation of water and weak acid is considered as chemical reactions, occurring both in the external and the

internal aqueous phases. When the water droplets inside the organic phase are submicron, the effect of pressure difference between the internal and the membrane phases cannot be neglected. From the second law of thermodynamic for the composite system at equilibrium, we derived the equilibrium conditions (thermal, mechanical, and chemical equilibrium). The extended Debye-Hückel model was used for the activity coefficients in aqueous phases, while the NRTL model was used for the organic phase. Along with the mass balances, a system of nonlinear equations represents the W/O/W ELM system. Due to the complexity of solving this system of nonlinear equations, the problem was solved, as an optimization problem, by minimizing the objective function using Genetic Algorithm. Our results indicate how the interfacial curvature affects the final compositions in phases and the separation efficiency. When the size of the inner droplet phase is submicron, the separation efficiency improves by up to 20%.

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419 From Macro to Nano – how does the combination of imaging spectroscopic ellipsometry and scanning force microscopic methods enable a deeper understanding of complex surface systems?

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Abstract

Imaging spectroscopic ellipsometry (ISE) is based on the interaction of polarized light with the material surface under reflecting conditions. Atomic Force Microscopy (AFM) allows to measure acting forces on a nanometer scale for example to study mechanical interactions or electrical properties.

Imaging spectroscopic ellipsometry and (AFM) have a similar sensitivity regarding layer thickness but a completely different lateral resolution. Imaging ellipsometry offers a microscopic view and in combination with x,y scanning and stitching even super images of mm to wafer size with a microscopic resolution. However, at the end of the day, the technique is limited to the Abbe diffraction limit and other optical effects. A lateral resolution in the nm range or even atomic resolution images are, however, the strength of AFM.

As mentioned, from the macroscopic point of view, ellipsometric contrast micrographs or microscopic maps of Delta and Psi can be stitched and offer a fast, non-contact, wafer-scale, atomic layer resolved Imaging of 2D Materials on a variety of substrates. Including maps recorded at different wavelength, a specific search for microcrystals with a dedicated number of layers or a predefined thickness pas been reported.

From the nanoscopic point of view, methods like Kelvin probe force microscopy (KPFM) provide information on structure and electrical properties at the same time and the data analysis can illuminate how the surface potential difference and the work function correlate with the thickness, size and shape.

Combining information from both methods like including the topological information from AFM into the optical modelling of an imaging ellipsometer offers a microscopic view on the optical properties of smallest particles as well as the correlation between optical properties and topology or mechanical and electrical information recorded with scanning probe method.

455 Cellulose Nanocrystal Directed MOF Porosity Engineering for High-Performance CO_2 Separation Membranes

Xinyu Wang, Seyed Fatemeh Seyedpour, Sabahudin Hrapovic, Usha D. Hemraz, Mohammad Mozafari, Masoud Soroush, Muhammad Amirul Islam, Arash Mollahosseini, Mohtada Sadrzadeh, Jae-Young Cho

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Abstract

In response to the growing demand for cleaner energy, Alberta is increasingly prioritizing carbon capture, utilization, and storage (CCUS) as a key strategy to reduce its environmental impact while supporting economic growth [1]. While amine-based absorption remains the most established carbon capture method, it is hindered by high costs and chemical waste generation [2]. Membrane-based separation offers a more sustainable alternative, with advantages such as compact design, lower energy demand, tunable selectivity, and waste-free operation. Mixed-matrix membranes (MMMs), enhanced by microporous metal organic frameworks (MOFs), show promise in overcoming the permeability-selectivity trade-off of dense polymer membrane [4. However, challenges remain in achieving uniform MOF dispersion, minimizing agglomeration, and maintaining compatibility between the polymer matrix and inorganic fillers [3].

This study aims to maximize the performance of MOF-incorporated mixed matrix membrane (MMM) systems by developing a two-step solvothermal synthesis to grow ultrasmall (12–30 nm) UiO-66 MOFs on a cellulose nanocrystal (CNC) template, enabling uniform and complete surface decoration to produce a one-dimensional, microporous, CO_2-philic nanofiller [4]. By tuning synthesis parameters, the CNC-guided approach enables precise defect engineering, yielding UiO-66 samples with varying levels of metal site unsaturation and pore structure [5].

The synthesized hybrid was incorporated into a Pebax matrix and fabricated as a thin selective layer on a porous PES support. The positively charged UiO-66 framework enhances CO2 adsorption and transport while improving polymer–filler compatibility, facilitating uniform dispersion and defect-free membrane formation. Additionally, the aligned one-dimensional CNC structure promotes directional gas transport, optimizing CO2 diffusion pathways [6]. By fine-tuning pore size and surface chemistry, the hybrid filler significantly improves separation performance—doubling the CO2/N2 selectivity compared to the neat membrane—while maintaining higher permeability at low nanofiller loadings (0.5–2 wt.%). These findings demonstrate a promising strategy for scalable, high-efficiency membrane-based CO2 capture through rational design of MOF-based hybrid nanofillers.

Reference

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Plenary Talk - Marie Pierre Krafft (University of Strasbourg)

08:30 - 09:30 Tuesday, 24th June, 2025
ETLC E1-001
Hans-Juergen Butt

Thermodynamically Stable Oil-in-Oil Microemulsionson

Fabrication Methods & Colloidal Metamaterials - 1

10:00 - 11:40 Tuesday, 24th June, 2025
ICE Incubator
Fabrication Methods & Colloidal Metamaterials
Cuiying Jian

10:00 - 10:40

432 Nanocomposite Synthesis via Brush-Grafted Colloids

Robert Macfarlane

MIT, Cambridge, USA

Abstract

Polymer nanocomposites consisting of inorganic particles embedded in a polymer matrix are attractive platforms for complex materials design. Combining the vastly different chemical and physical characteristics of these material types allows for mechanical, chemical, electromagnetic, or combinations of these properties not possible with either component alone. While such composites therefore offer a massive parameter space to tailor material performance, the process of designing new, useful nanocomposites is not always as straightforward as simply blending a set of nanoparticle building blocks into a soft macromolecular matrix. There is ample opportunity for next-generation composite designs to both maximize material performance and to introduce new emergent phenomena that occur when nanoparticle organization within the matrix is intentionally programmed.

In this talk, I will highlight the Macfarlane lab's progress in designing nanocomposites via the integration of supramolecular chemistry, polymer synthesis, and materials processing. Our group has established a suite of "brush particles" that are inherently composite architectures containing rigid inorganic particle cores, soft polymer brush coatings, and supramolecular binding groups that dictate interactions between the polymer and nanoparticle components. Key advancements presented will include synthesis methods to achieve macroscopically scalable composites with ~85 wt% inorganic content that remain mechanically robust and readily processible. Additionally, the first self-assembly method capable of scalably fabricating macroscopic, fully 3D composites consisting entirely of nanoparticle superlattice arrays will be discussed. I will outline the advancements that guide our thinking about composite synthesis, underscore key design motifs for brush particle-based nanocomposites, and detail how materials chemistry and processing permit the formation of materials with controlled hierarchical organization across 7 orders of magnitude in length scale simultaneously.

10:40 - 11:00

312 Strongly Coupled Plasmonic Nanoparticle Metamaterials: Fundamental Insights, Efficient Approximate Methods, and Inverse Design Strategies

Zachary Sherman, Rishabh Sanghavi, Kenny Lam, Vera Kotova

University of Washington, Seattle, USA

Abstract

Self-assembly of strongly coupled plasmonic nanoparticles is a scalable and promising route for producing optical metamaterials with emergent photonic properties. These metamaterials can be incorporated into nanophotonic devices to function as energy harvesters, waveguides, optical filters, and photo- and thermocatalysts. Understanding, controlling, and designing the light-matter interactions of these components is crucial to improving their performance. In this talk, I'll discuss two distinct strategies we have developed to dramatically increase the ability of electromagnetic simulations to aid in the design of nanoparticle metamaterials. First, I discuss a new method that approximates the full optical spectra of ensembles of plasmonic nanoparticles using a simulation at a single small frequency. This avoids the cost of traditional optical calculations associated with iterating one-by-one through frequencies over the spectral range of interest. Second, I discuss how we formulate optical materials design as an inverse problem, where we first specify target optical behavior and then use numerical optimization to autonomously discover self-assembled nanoparticle metamaterials possessing the desired features. By combining the rapid electromagnetic simulations of the first strategy with the small number of simulations required of the second strategy, we have an extremely rapid tool for producing metamaterial designs. We use our tool to propose physically realizable metamaterials with optical features tunable over an enormous range. By examining libraries of metamaterials with similar optical features, we can describe the key structure-property relations governing their optical responses. Future work will include incorporating our inverse design methods into an AI controller for automated and high-throughput experimental workflows to synthesize optical metamaterials.

11:00 - 11:20

47 Stabilization of Nonaqueous Foam by Crystal Particles in Photocurable Resins for DLP printing

Wen-Chien Tai, Ying-Chih Liao

Department of Chemical Engineering, National Taiwan University, Taipei, Taiwan

Abstract

Foam-based materials have gained increasing attention as fillers in modern industries due to their ability to reduce material consumption and weight while offering advantages such as thermal insulation, cooling, and noise reduction. However, the inherent complexity of foam structures presents significant challenges in achieving precise control over critical properties such as shape, porosity, and mechanical strength during manufacturing processes. These limitations often hinder their broader application, particularly in fields that demand high-performance, lightweight materials.

To address these challenges, a novel method was developed for stabilizing nonaqueous foams in low-surface-tension photocurable resins. Crystallizable surfactants, specifically a 7:3 mixture of octadecan-1-ol and stearic acid, were utilized as stabilizers at the air-in-oil interface. A dense protective layer was formed by the surfactant crystals around air bubbles, preventing coalescence and significantly enhancing foam stability. Stability tests revealed that the addition of 10 wt% of these crystallized surfactants allowed the foam structure to be maintained for over seven days, confirming its long-term stability. Additionally, 4 wt% Triton X-100 was incorporated as a dispersant to further disperse the crystallized surfactant particles to 5 um, increasing the air content in the resin-based foam to 40 vol%. By enabling precise control over foam morphology and porosity, this approach paves the way for fabricating hierarchical structures tailored to the unique requirements of photocurable 3D printing, with promising applications in lightweight structural components, energy dissipation systems, and advanced thermal insulation solutions.

11:20 - 11:40

46 Optimized ink solvent composition for suppressing the coffee ring effect in inkjet-printed polymer thin films

Ching-Tai Kuo, Ying-Chih Liao

Department of Chemical Engineering, National Taiwan University, Taipei, Taiwan

Abstract

Inkjet printing has become a widely used technique for fabricating various organic semiconductor devices, including organic light-emitting diodes (OLEDs), organic field-effect transistors (OFETs), and organic solar cells (OSCs). However, when fine patterns are printed on a substrate and dried under ambient conditions, solvent evaporation causes a reduction in pattern volume, leading to boundary shrinkage and pattern distortion. Moreover, solute deposition at the pattern edges, driven by convective flow in the drying droplets, known as the coffee ring effect, hinders the formation of uniform thin films. To address these issues, this study proposes an ink formulation method aimed at improving the quality of printed patterns by mitigating the effects of boundary movement and the coffee ring phenomenon during solvent evaporation. A binary solvent system of toluene and o-dichlorobenzene was employed, taking advantage of toluene's rapid evaporation rate to quickly increase the viscosity of the drying droplets, reducing convective flow and suppressing the coffee ring effect. Additionally, boundary movement during droplet drying was closely monitored and controlled to ensure pattern integrity. This ink formulation is anticipated to have practical applications in advancing inkjet printing technology.

Rheology and Tribology of Complex Fluids - 3

10:00 - 11:40 Tuesday, 24th June, 2025
ETLC E2-001
Rheology and Tribology of Complex Fluids
Volfango Bertola

10:00 - 10:40

431 Surface interactions of non-Newtonian droplets

Outi Tammisola

KTH, Stockholm, Sweden

Abstract

Surfaces with superhydrophobic or self-cleaning properties are typically designed to repel water droplets. However, droplets in real life often contain contaminants, such as polymers or surfactants, resulting in non-Newtonian fluid properties (for example, elasticity and shear-thinning). In this talk, we show how non-Newtonian droplets interact with superhydrophobic surfaces during sliding, jumping, and droplet impact. We demonstrate that droplets with small amounts of polymer additives can behave qualitatively differently from water. At high Weber numbers, we find a new impact regime (balloon regime) that arises due to elasticity due to the polymer additives, in combination with the microscopic structure of the surface. This regime results in a complete rebound of the droplet, refuting the common assumption that polymer additives in water suppress the droplet rebound on superhydrophobic surfaces.

10:40 - 11:00

49 UNVEILING POLYMER VISCOELASTICITYTHROUGH BEAD-ROD MODELING

Alan Jeffrey Giacomin
University of Nevada, Reno, Reno, USA

Abstract

One good way to explain the elasticity of a polymeric liquid, is to just consider the orientation distribution of the macromolecules. When exploring how macromolecular architecture affects the elasticity of a polymeric liquid, we find general rigid bead-rod theory to be both versatile and accurate. This theory sculpts macromolecules using beads and rods. Whereas beads represent points of Stokes flow resistances, the rods represent rigid separations. In this way, how the shape of the macromolecule affects its rheological behavior in suspension is determined. Our work shows the recent advances in polymer viscoelasticity using general rigid bead-rod theory, including the discovery of the first new materials functions from general beadrod

theory since the first, the complex viscosity of Hassager (1974). These include the steady shear material functions, large-amplitude oscillatory shear flow material functions, and the steady uniaxial, biaxial, planar extensional viscosities, oscillatory superposed on steady shear (both parallel and orthogonal). We find each of these material functions to depend upon the same molecular feature: the ratio of the macromolecular moment of inertia about the molecular axis to that about the axes transverse to the molecular axis. We then use these new material functions to bridge the Oldroyd 8-constant framework (and thus all of its many special cases) to general beadrod theory.

11:00 - 11:20

195 The mechanisms of yielding: How localized rearrangements drive global failure

Jens Allard[1], M. Paul Lettinga[1,2], Erin Koos[1]

[1]KU Leuven, Leuven, Belgium. [2]Forschungszentrum Jülich, Jülich, Germany

Abstract

Yielding of particle gels is a process of paramount importance in many industries ranging from food, pharmaceutics, construction materials, and printed electronics. In this work, we investigate the yielding of a particle network using a capillary suspension model system which has the unique advantage that bonds between particles are directly visualized using confocal microscopy. These liquid bridges, created by the addition of a small amount of immiscible secondary liquid to the binary suspension, form a sample-spanning network with contacts between particle pairs. We show that the local rigidity is the deterministic precursor of the spatially heterogeneous yielding. Direct visualization of the bridges and the attractive capillary force proves that bond stretching occupies a longer part of the oscillation cycle than bridge retraction. The sequence of physical processes analysis provides rheological fingerprints to identify the boundaries of the different yielding regimes: a reversible region just outside the linear viscoelastic regime with small reorientations of floppy connections, followed by irreversible yielding in the flow direction with bridge stretching and retractions, and finally a catastrophic loss of connectivity between clusters above the crossover point. We believe these findings can be used to understand not just the yielding of capillary suspensions but particulate systems in general.

11:20 - 11:40

427 Three stories on the microrheology of colloidal suspensions

Thomas Waigh

University of Manchester, Manchester, United Kingdom

Abstract

Three stories on the microrheology of colloidal suspensions are considered: the viscoelasticity of *monoclonal antibodies*, *neural networks* for dynamic segmentation of tracks in particle tracking microrheology and *optical coherence tomography velocimetry*.

High concentration *monoclonal antibodies* (mAbs) are important biologics with many applications in modern biotechnology e.g. in immunotherapies to treat cancers. Using high speed particle tracking microrheology, we showed that mAb solutions are viscoelastic with rheology typical of charged stabilized Brownian colloids [Lewis et al, *APL Bioengineering*, 2024]. Furthermore, we investigated the pH induced gelation. We observe a continuous phase transition and cure-time superposition provides universal master curves pre- and post-gelation [Lewis et al, in preparation].

Neural networks have been demonstrated to be more sensitive than conventional mean square displacements for analyzing data from particle tracking microrheology experiments [Han et al, *eLife*, 2020]. Trained on fractional Brownian motion, neural networks can provide an order of magnitude improvement in sensitivity to explore the heterogeneous viscoelasticity of colloidal suspension in both time and space [Moores, et al, *PRE*, 2025]. Examples are given for lamellar gels and mAb gelation.

Optical coherence tomography velocimetry has been explored for in-line processing of colloidal materials [Moores, et al, *ACS Engineering Au*, 2025]. Spatially resolved velocimetry measurements are possible from 3 pL volumes *in situ* in realistic test rigs and factory pipe lines. Spatial variations in the velocity of both opaque and transparent flows of colloidal materials can be measured. Examples are given for lamellar gels, worm-like micelles and biologics.

Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 3

10:00 - 11:40 Tuesday, 24th June, 2025
NRE 1-001
Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces
Mehrasa Yassari

10:00 - 10:40

442 Colloidal Drug Aggregates: from lemons to lemonade

Molly S Shoichet, Kai Slaughter, Mickael Dang, Timothy Cheung

University of Toronto, Toronto, Canada

Abstract

Colloidal drug aggregates have led to both false positives in enzyme-based drug screens and false negatives in cell-based screens. To turns these lemons to lemonade, we wondered if we could harness these very high content drug nanoparticles to achieve enhanced delivery. We started with fulvestrant – a well-known breast cancer drug and a "good" aggregator. Fulvestrant colloids were stabilized with excipients and proteins to enhance cell uptake, and then modified with ionizable groups to enhance endosomal escape. We then wondered if we could use these ionizable fulvestrant molecules instead of the ionizable lipid nanoparticle as a way to deliver both RNA and drug in one formulation. We achieved success and demonstrated both gene knockdown of a non-druggable target with siRNA delivery against cyclin E1 and cytostatic effects of fulvestrant. To further enhance endosomal escape, we incorporated a zwitterionic polymer in the lipid nanoparticle formulation and achieved a 5-fold increase in siRNA in the cytosol.

In parallel studies, we wondered if we could formulate a soluble small molecule drug into a colloidal drug aggregate and thereby achieve sustained release. Timolol – a well-known glaucoma treatment – was modified with hydrophobic tails to enhance colloid formation. One of the formulations, timolol-palmitate showed slow release in vitro over one month and efficacy in vivo in a rodent. Thus, from our initial discovery of colloidal lemons, we demonstrated their potential as colloidal lemonade in two distinct disease areas (breast cancer and glaucoma), and expect broader impact in a diversity of diseases in the future.

10:40 - 11:00

296 Versatile Trimethyl Chitosan Nanoparticles for siRNA Delivery and Mucoadhesive Therapeutics

Leslie Vanessa Sanchez Castillo[1], Fabiola Guareschi[2], Eleni Tsekoura[1], Virginia Patterlini[2], Julie Suman[3], Fabio Sonvico[2], Ravin Narain[1]

[1]University of Alberta, Edmonton, Canada. [2]Università di Parma, Parma, Italy. [3]Aptar Pharma, New York, USA

Abstract

Trimethyl chitosan (TMC) nanoparticles (NPs) were investigated as innovative vectors for small interfering RNA (siRNA) delivery. TMC, a quaternized derivative of chitosan, is widely recognized for its excellent biocompatibility, solubility at neutral and alkaline pH, and strong mucoadhesive properties, which enhance therapeutic delivery across mucus barriers. Additionally, TMC has shown promise in crossing biological barriers, including the blood-brain barrier (BBB), expanding its potential for applications in neurodegenerative diseases and central nervous system (CNS) therapies. This study emphasizes the ability of TMC nanoparticles to achieve efficient siRNA encapsulation, controlled release, and effective transfection while exhibiting robust mucoadhesive and mucopenetrative behavior.

Mucoadhesive carriers like TMC NPs hold significant promise in improving the delivery of therapeutics, including vaccines, biologics, and CNS-targeted therapies, by overcoming both mucus and endothelial barriers. In this work, TMC nanoparticles were formulated using various weight:weight ratios and systematically assessed for siRNA binding efficiency, release, cytocompatibility, and gene silencing. The results demonstrated superior siRNA retention and stability at higher TMC content, with additives such as dextran sulfate (DS), tripolyphosphate (TPP), and hyaluronic acid (HA) enhancing nanoparticle stability and performance. Optimized formulations exhibited high biocompatibility and significant gene expression suppression. Advanced imaging on rabbit nasal mucosa using two-photon microscopy further confirmed the exceptional mucoadhesion and deep tissue penetration of TMC nanoparticles compared to free siRNA.

These findings underscore the potential of TMC nanoparticles as a versatile platform for gene therapy, vaccines, and the treatment of CNS disorders through non-invasive delivery mechanisms.

11:00 - 11:20

256 Spontaneous self-shaping, swimming and division of micrometer oily droplets undergoing phase transitions

Nikolai Denkov, Diana Cholakova, Slavka Tcholakova

Department of Chemical and Pharmaceutical Engineering, Faculty of Chemistry and Pharmacy, Sofia University, 1 James Bourchier Ave., 1164, Sofia, Bulgaria

Abstract

Emulsion droplets typically adopt spherical shapes due to the energy minimization principle. The self-shaping process is a conceptually new approach, enabling micrometer-sized lipid droplets (composed of alkanes, triglycerides, and other compounds) dispersed in appropriate surfactant solutions to transform into complex fluid shapes, including regular polyhedra, hexagonal, tetragonal and triangular platelets, and thin fibers [1,2]. The observed morphogenesis is driven by the formation of intermediate in stability phases (e.g. rotator phases in alkanes or α-polymorphs in triglycerides) near the droplet surface upon cooling. The enthalpy gain from lipid structuring compensates for the increased interfacial area during deformations under positive interfacial tension [2].

Some of these non-spherical particles can eject micrometer or sub-micrometer in diameter fibers, resembling flagella of living cells, thus enabling self-propulsion of the droplets through the solution. This creates a new type of synthetic microswimmers [4]. Additionally, thermal cycling around the lipid phase's melting point can cause micrometer-sized particles to spontaneously burst into nanoparticles without any mechanical energy input [5]. The mechanisms behind these fascinating phenomena and the governing factors will be discussed in detail.

Acknowledgements: Current work is supported by the Bulgarian Ministry of Education and Science, under the National Research Program "VIHREN", project ROTA-Active (no. KP-06-DV-4/2019).

References:

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11:20 - 11:40

424 Spontaneous Formation of Core-Shell Microdroplets During Conventional Coacervate Phase Separation

Chelsea Edwards[1,2], Hongyi Zhang[1], Ginny Wang[1], Matthew Helgeson[1,2]

[1]Department of Chemical Engineering, University of California, Santa Barbara, CA, USA.
[2]Materials Research Lab, University of California, Santa Barbara, CA, USA

Abstract

We report single-step formation and stability of protocell-like, core-shell coacervate droplets comprising a polyelectrolyte-rich shell and a solvent-rich vacuole core from the poly(allylamine hydrochloride) (PAH) and poly(acrylic acid) (PAA) system. These double emulsion (DE) coacervate droplets coexist with single emulsion (SE) droplets, suggesting a kinetic mechanism of formation. We use high-throughput microscopy and machine learning to classify droplet morphologies across various final compositions (polyelectrolyte ratios and salt concentrations) and processing routes (mixing rate and thermodynamic path). We find that DE droplets form preferentially to SE droplets at a wide range of compositions using a slow injection mixing rate. DE droplet formation is enhanced at lower salt (NaCl) levels and near 1:1 charge stoichiometry, showing preference for polycation excess. DE droplets are stable to the micron scale and retain their core-shell structure even after coalescence. Nevertheless, they are metastable; direct observations of the various coarsening phenomena suggest that they are primarily stabilized by the viscoelasticity and high viscosity of the polymer-rich shell. Overall, the scalable, simple mixing process used herein offers a novel mechanism to produce multiphase coacervate droplets that is orthogonal to existing routes, which require either dropwise synthesis or thermodynamic tuning.

Colloids for Sustainability and Energy - 2

10:00 - 11:40 Tuesday, 24th June, 2025
ECERF W2-110
Colloids for Sustainability and Energy
Karthik Shankar

10:00 - 10:20

316 Metal Ion Precipitation and Separation in PEGDA Hydrogels for Critical Material Recovery

Zachery Wylie[1], Abdul Moeez[1], Joelle Scott[1], David Bergsman[1], Elias Nakouzi[2], Lilo Pozzo[1]

[1]University of Washington, Seattle, USA. [2]Pacific Northwest National Lab, Richland, USA

Abstract

The recycling of materials has become exceedingly important as modern reliance on critical metals such as lithium, cobalt, nickel, and rare earth elements continues to increase. Demand for lithium-ion batteries is expected to grow 9000% by 2050 which will be unsustainable without integrating robust recycling technologies into the global supply chain. Currently utilized LIB recycling technologies, however, are energy intensive, costly, limited in ion selectivity, or all of the above. In this work, we study the fundamental phenomena of metal ion precipitation in PEGDA hydrogels loaded with precipitant as a cost-effective and green methodology for the separation of metals from a feedstock. These hydrogels represent a nanoconfined regime which we measure in and ex situ across length scales using USAXS/SAXS/WAXS to unite the effects of concentration, precipitant, gel weight fraction, and gel pore-size. Small angle X-ray scattering allows us to study precipitants that vary in size from a few nanometers to many microns as well as identify them by their lattice structure. We demonstrate that changes in all of these parameters affect the rate of diffusion and spatial segregation of cobalt and nickel species during their precipitation, two species which are normally very costly to separate. This understanding of the complicated relationships behind nanoconfined reaction-diffusion phenomena is of vital importance to controlling and scaling up any precipitation process for use in applied technologies.

10:20 - 10:40

354 Ultra-stable foams for CO2-sequestration and enhanced oil recovery by designing interfacial properties with nanoparticles and surfactants

Keith Johnston[1], Xiongyu Chen[1], Daniel Hatchell[1], Hugh Daigle[1], Jean-Richard Ordonez-Varela[2], Chang Da[1]

[1]University of Texas, Austin, USA. [2]TotalEnergies, Pau, France

Abstract

The ability to design nanoparticle laden viscoelastic interfaces for highly stable emulsions and foams is of fundamental mechanistic interest for a broad range of applications including mobility control in CO_2 sequestration and enhanced oil recovery. At these conditions, the relationships between the interfacial rheology of NP laden gas-brine interfaces and NP adsorption and interparticle interactions are not well understood. Herein, we design binary ligands on the surface of silica NPs whereby the primary ligand provides steric stabilization in bulk brine and at the air-brine interface, whereas a second ligand raises the hydrophobicity to promote NP adsorption. The level of NPs adsorption at steady state is sufficient to produce an interface with a relatively strong elastic dilational modulus.. However, the interface is ductile with a relatively slow change in E' as the interfacial area is varied enabling highly stable nitrogen/water (N_2/brine) foams. The viscoelastic gas-brine interface arrests coarsening (Ostwald ripening) for days. With the addition of a liked-charged surfactant to the NP solution, the foams are also highly stable, but may be formed at a much lower shear rate than in the case of NPs alone. Furthermore, ultra-stable CO2-in-water foams have been generated with switchable Janus nanoparticles *in-situ*.

10:40 - 11:00

249 Enhancing heavy oil recovery by novel magnetic CO2-responsive nanoparticles

Bailin Xiang

Shenzhen Technology University, Shenzhen, China

Abstract

The novel magnetic CO_2-responsive nanoparticles were manufactured by coating a solid SiO_2 layer on Fe_3O_4 nanoparticles and grafting CO_2-switchable functional groups on their surfaces. The resistance to strong acid/mild base environments and its switchable surface activity make this nanoparticle (Fe_3O_4@SiO_2-NN) a potential oil displacement agent and a demulsifier in the enhanced oil recovery process (EOR). Fe_3O_4@SiO_2-NN was characterized by Fourier transform infrared spectrometry and X-ray photoelectron spectroscopy to confirm the successful grafting of amidine. Its magnetization (M(H)) curve was determined to ensure its strong response to the

magnetic field. It was found that $Fe_3O_4@SiO_2$-NN significantly decreased the interfacial tension between crude oil and seawater to enhance the displacement of crude oil from the quartz surfaces. The water flooding test showed that injection of $Fe_3O_4@SiO_2$-NN nanofluid increased the heavy oil recovery to above 70% from the original 45% with seawater. Meanwhile, its switchable surface activity allows easy demulsification by purging CO_2 and applying an external magnetic field to remove the nanoparticles.

11:00 - 11:20

138 Atmospheric Cold Plasma for Degradation of Naphthenic Acids in Oil Sands Process-Affected Water

Engin Deniz, Mohammadamin Rashidi, Qiuyun Lu, Mohamed Gamal El-Din, Nobuo Maeda, Xuehua Zhang

University of Alberta, Edmonton, Canada

Abstract

The effective treatment of oil sands process-affected water (OSPW) is regarded as a demanding environmental challenge due to the presence of persistent and toxic Napthenic acids (NAs). In recent decades, multiple advanced oxidation process, such as photocatalytic degradation, have been explored for the removal of NAs. Cold plasma activation (CPA) technology, compared with those methods, avoids the addition of oxidants and successive separation process, shows great potential in the treatment of NAs-contained OSPW. This work investigated the efficiency of CPA for the degradation of model NAs, including 5-phenylvaleric acid (PVA) and isonipecotic acid (IA), along with NAs in real OSPW. In our configuration, microbubbles formed in a Venturi tube where single or double plasma needles were placed above water flow and enhanced the production and transfer rates of reactive oxygen and nitrogen species (RONS) in the aqueous phase.

By adding a solution drop on a PDMS film decorated with functionalized silver nanoparticles (AgNPs), surface-enhanced Raman spectrum of NAs in the solution can be obtained rapidly from which degradation efficiency of NAs was sensitively monitored without time-consuming solvent extraction of NAs from water. Our results show that MB-CPA achieved near-complete degradation of model NAs within 90 minutes in double plasma needle configurations. When applied to real OSPW, MB-CPA treatment reduced toxicity, enhanced nitrogen species availability, and improved seed germination rates, transforming the treated water into a potential resource for agricultural applications. Notably, the treated OSPW demonstrated a 30 % higher germination rate and increased seedling growth compared to untreated sample.

11:20 - 11:40

22 How physics can prevent upstream bacteria contamination

Zhiwei Peng

University of Alberta, Edmonton, Canada

Abstract

Recent studies have demonstrated that motile bacteria, such as *E. coli*, are capable of swimming against fluid flows. This upstream migration poses significant clinical risks for urinary tract infections, particularly in catheterized patients. In this work, we present the development of a macrotransport theory to characterize the dynamics of active matter within periodic geometries. This theory allows us to characterize the transport and dispersion of active matter in periodic geometries under the influence of fluid flows and/or external fields. Utilizing this theoretical framework, we propose a novel catheter design that leverages geometry-induced rectification and disturbance flows to impede upstream bacterial migration. Experimental validation of this design reveals a reduction in upstream migration by 1–2 orders of magnitude, offering a promising approach to mitigating infection risks in clinical settings.

Colloidal systems for Food: Production, Processing and Sustainability - 3

10:00 - 11:40 Tuesday, 24th June, 2025
ETLC E1-018
Colloidal Systems for Food: production, processing and sustainability
Eleni Kalogianni

10:00 - 10:20

188 Novel functional lipids in vegan/hybrid cheese products: effects on microstructure, rheology, and physical properties

Ming Yao Lim[1], Yuan Xu[1], Isabelle Lacroix[2], Hanh Nguyen[2], Jason Stokes[1]

[1]The University of Queensland, Brisbane, Australia. [2]Nourish Ingredients, Canberra, Australia

Abstract

A novel functional lipid product has been developed to enhance the dairy flavour and creaminess of plant-based dairy alternatives. These lipids are surface active and interact with fats and proteins typically present in vegan/hybrid cheese products. They influence the microstructure and stability of such matrices classed as emulsion gel. This study elucidated how these novel lipids can be utilised in creating desirable physical properties for vegan/hybrid cheeses. We found that the differences in raw material from plant sources and concentration of lipid primarily influence the microstructure, rheology, and texture of vegan/hybrid cheese.

Confocal laser scanning microscopy (CLSM) images have shown that the addition of lipids derived from different plant sources significantly affect the microstructure of cheeses, in particular the fat droplet size, fat-protein interactions and their distribution within the cheese matrices. Through bubble drop tensiometry, we have found that the lipids from different sources with different phospholipid composition influence the competitive adsorption between the lipid and protein, which we hypothesise lead to the differences in microstructure. The competitive adsorption behaviour is also dependent on the concentration of lipids. Above a critical level, the lipids lead to the destabilisation of fat, forming large fat droplets which result in more brittle cheeses which fracture at high stress and low strain. Our study reveals the key drivers that influence the microstructure, rheology, and texture of vegan/hybrid cheeses, and provides potential levers in developing products with desirable properties.

10:20 - 10:40

224 **Impact of Ultra-High Temperature Treatment on Whey Protein Nanogel Particle Dispersions with Nutritionally Relevant Salts using an Active Learning Method for Phase Diagram Creation**

Pernille Koch[1], Rita Moura da Silva Moreira[1], Anni Bygvrå Hougaard[1], Franciscus Winfried J. van der Berg[1], Søren Bang Nielsen[2], Serafim Bakalis[1]

[1]Department of Food Science, University of Copenhagen, Copenhagen, Denmark. [2]Arla Foods Ingredients Innovation Centre, Videbæk, Denmark

Abstract

Protein nanogel particles hold great potential as functional ingredients in food systems. Thermally induced whey protein nanogel particles in dispersion demonstrate enhanced viscosity properties compared to other whey protein aggregates. However, the molecular mechanisms underlying this behavior remain unexplored. Investigating interactions between nanogel particles and other food matrix components such as minerals is critical for future applications. Understanding potential structural changes during heat treatments used in food processing is of particular relevance.

We established phase diagrams for whey protein nanogel particle dispersions subjected to ultra-high temperature treatment, analyzing the effects of protein concentration and various nutritionally relevant salts. To optimize the sequential sampling process and boundary determination in the phase diagrams, an active learning algorithm was developed. Structural changes in dispersions at the boundary region were studied using static light scattering and microscopy.

At low salt concentrations, nanogel particle dispersions remain in a liquid state after ultra-high temperature treatment. As salt concentration increases, a region of particle aggregation emerges, where the dispersion remains liquid but shows signs of interaction. At higher salt concentrations, gelation occurs. The active learning algorithm was extended to multiple dimensions, enabling the generation of phase diagrams that account for combined effects of different matrix components while minimizing the number of required samples.

10:40 - 11:00

54 Plant protein-based microgels: from structure to interfacial performance

Daisy Akgonullu[1], Brent Murray[1], Simon Connell[1], Amin Sadeghpour[1], Peter Fischer[2], Bruce Linter[3], Yuan Fang[4], Anwesha Sarkar[1]

[1]University of Leeds, Leeds, United Kingdom. [2]ETH Zurich, Zurich, Switzerland. [3]PepsiCo UK, Leicester, United Kingdom. [4]PepsiCo, New York, USA

Abstract

This study encapsulates a range of interfacial techniques to compare the behaviour of un-gelled globular protein obtained from potatoes (PoP) with microgels made from the same protein (PoPM). The microgels were formed via thermal crosslinking of PoP solutions, followed by high-shear homogenisation of the resulting bulk PoP gel. The PoPM are thus deformable particles of tuneable viscoelasticity, capable of acting as effective Pickering stabilisers. The bulk gel viscoelasticity was studied via dynamic shear rheology and internal structure of the PoPM biopolymer network was investigated via small angle x-ray scattering (SAXS).

Adsorbed layer viscoelasticity is normally critical in determining emulsion stability by biopolymers, and adsorbed microgels usually give rise to very robust films. Both the PoP and PoPM were surface active but, surprisingly, the interfacial viscoelasticity of adsorbed layers of all PoPM types (from hard to soft microgels) was lower than that of PoP. This is associated with the formation of a clustered and less cohesive interfacial structure which restricts the formation of lateral interactions.

To further our understanding of PoPM behaviour, we studied spread monolayers of PoPM and Langmuir-Blodgett deposition of these monolayers to assess particle conformation, aggregation and deformability via Atomic Force Microscopy. It was discovered that both pH and oil type not only affect the interfacial structure and viscoelasticity, but also the rate of adsorbed film formation. In conclusion, by choosing the appropriate PoPM and solution conditions, these materials offer a new sustainable platform for the development of responsive Pickering emulsions for tackling a range of industrial challenges.

11:00 - 11:20

265 Influence of process control on the texture of pea protein-based yogurt alternatives with the addition of pectin-based microgel particles

Désirée Martin, Ulrike S. van der Schaaf

Institute of Process Engineering in Life Sciences – Chair of Food Process Engineering, Karlsruhe, Germany

Abstract

Yogurt, a fermented milk product, is an essential component of many individuals' daily diets. In recent years, the growing interest in veganism for ethical, moral, and health reasons has highlighted the potential of pea protein as a substitute for dairy. Pea protein offers a complete amino acid profile, is allergen-free, and serves as a promising raw material for the development of vegan yogurt alternatives. Concurrently, consumer demand for high-protein products has increased significantly. However, these products are often criticized for their firm or sandy texture, a challenge that is particularly pronounced in vegan high-protein yogurt alternatives. This textural issue arises due to the unique gelling properties of plant-based proteins. Therefore, understanding how to modulate the texture of fermented pea protein gels is critical to improving product quality. This study will demonstrate how the rheological properties of vegan yogurt alternatives can be modulated through the incorporation of microgel particles and the adjustment of temperature-time profiles. Increasing the temperature during processing leads to a higher yield point, thereby enhancing the gel's firmness. Pectin-based microgel particles act as inactive fillers within the gel network, loosening its structure. Heating the protein dispersion in the presence of these particles amplifies this effect and further influences the texture. These findings underscore the potential of combining temperature modulation and microgel particle addition to modulate the texture of vegan high-protein yogurt alternatives, which could improve consumer acceptance and contribute to the broader adoption of sustainable, plant-based products.

11:20 - 11:40

335 How microbes in colloidal state contribute to a resilient aquaculture environment?

Jianzhong HE, Yifan Zhang

National University of Singapore, Singapore, Singapore

Abstract

To realize a healthy ecosystem for aquaculture development, an energy efficient and cost saving aquaculture wastewater treatment system is required to avoid formation of excess nitrate. Here we discovered an innovative technology that applies a colloidal microbial community comprising

unique denitrifying phosphate accumulating organisms and anammox bacteria to sustain high levels of nutrient removal in low carbon, nitrogen-rich aquaculture wastewater. This culture can remove ammonium, nitrite, and nitrate at rate of 2.85, 1.98, and 2.42 mg-N/L/h, respectively, which can also remove high levels of nitrate present in aquaculture wastewater under limited oxygen and low C/N ratios. Very importantly, the microbial consortia can work efficiently in high salinity (~3% salinity) environment, especially for saline fish farm waters. This microbes in colloidal state leads to the development of a de-nutrient bioreactor that incorporates the anammox reaction to achieve high levels of nutrients (nitrogen and phosphorus) removal without requiring aeration or carbon supplementation for a resilient aquaculture environment.

General Aspects of Colloid and Interface Science - 2

10:00 - 11:40 Tuesday, 24th June, 2025
ECERF W2-010
General Aspects of Colloid and Interface Science
Mark Vis

10:00 - 10:20

163 WATER DISPERSIBLE NANOCOMPOSITES AND NANOPARTICLES FOR IN-SOLUTION SURFACE ENHANCED RAMAN SCATTERING

Casey Rusin, Ahmed Mahmoud, Huijun Mao, Mark McDermott

University of Alberta, Edmonton, Canada

Abstract

Advances in the synthesis and fabrication of metallic nanostructures of various sizes and shapes has opened pathways for sensitive analytical measurements. Analytical applications of surface enhanced Raman scattering (SERS) have certainly benefited from advances in the synthesis of noble metal nanoparticles with anisotropic shapes. While the design and fabrication of nanostructured solid substrates is well established, the development of materials for in solution SERS is less advanced. Dispersed spherical Au nanoparticles do not provide significant in solution SERS intensity unless they are partially aggregated. Reproducible partial aggregation is challenging. Our approach is the attachment of noble metal nanoparticles onto nanoscale substrates that are themselves water dispersible. Results will be presented for Ag nanoparticles on cellulose nanofibers, Au nanoparticles on silica spheres and Au nanoparticles conjugated to the backbone of an aromatic polymer. The goal in the synthesis of these materials is to generate sufficient density of the metal nanoparticles on the substrate and thus the reproducible formation of SERS hot-spots. Electron micrographs showing examples of this for Ag on cellulose and Au on silica are shown in the figure. The synthesis and characterization of the materials will be described. Colloidal stability and shelf-life are important properties for applications. The SERS performance is optimized using

standard probe molecules that are known to tightly bind to Ag and Au and possess reasonable Raman cross-sections. The substrates have been applied to the measurement of pesticide and other aromatic pollutants in aqueous samples. The analytical utility of this approach is verified with these samples.

10:20 - 10:40

331 Why Seawater Is Foamy:Nanoscale Transport during Liquid Film Thinning Inhibits Bubble Coalescing Behavior in Electrolyte Solutions

Bo Liu[1,2], Rogerio Manica[2], Qingxia Liu[2], Zhenghe Xu[2], Evert Klasober[3], Qiang Yang[1]

[1]East China University of Science and Technology, Shanghai, China. [2]University of Alberta, Edmonton, Canada. [3]Institute of High Performance Computing, Singapore, Singapore

Abstract

The long-standing puzzle of why two colliding bubbles in an electrolyte solution do not coalesce immediately upon contact is resolved. The water film between the bubbles needs to be drained out first before its rupture, i.e., coalescence. Experiments reveal clearly that the film thinning exhibits a rather sudden slowdown (around 30–50 nm), which is orders of magnitude smaller than similar experiments involving surfactants. A critical step in explaining this phenomenon is to realize that the solute concentration is different in bulk and at the surface. During thinning, this will generate an electrolyte concentration difference in film solution along the interacting region, which in turn causes a Marangoni stress to resist film thinning. We develop a film drainage model that explains the experimentally observed phenomena well. The underlying physical mechanism, that confused the scientific community for decades, is now finally revealed.

10:40 - 11:00

339 Evaporation-Induced Bubble Expansion when entering a Volatile Liquid from water

Yuxi Liu, Bo Liu, Qiang Yang, Fang Yuan

East China University of Science and Technology, Shang Hai, China

Abstract

Bubbles typically dissolve in liquids due to excessive Laplace pressure. However, we observe a rapid bubble growth phenomenon when bubbles transition from water into volatile liquids such as pentane or hexane. The bubble volume nearly doubles within seconds of crossing the oil-water interface. A theoretical model is proposed to explain this behavior, attributing it to oil evaporation,

with the final bubble size determined by the oil's volatile pressure under constant pressure conditions. This discovery holds potential significance for processes operating at high temperatures where oil volatility is elevated. such as bitumen extraction, oil-water separation, and hydrogenation etc.

11:00 - 11:20

314 Silver-coated gold nanoparticles as in-solution SERS substrates for the rapid screening of pharmaceutical contaminants in wastewater

Ola Mabrouk, Mark McDermott

Department of Chemistry, University of Alberta, Edmonton, Canada

Abstract

Silver-coated gold nanoparticles (Au@AgNPs) have gained significant attention in the field of surface-enhanced Raman spectroscopy (SERS) due to their unique optical, chemical, and electronic properties. They exhibit synergistic effects that enhance localized surface plasmon resonance (LSPR) and improve the electromagnetic field at the surface, making them highly effective for SERS applications. The gold core provides structural stability while the silver shell offers superior plasmonic properties, including strong LSPR and higher electromagnetic field enhancement. The combination of gold and silver allows for tailored plasmonic behavior, offering enhanced sensitivity and tunability of the plasmon resonance over a wide wavelength range. SERS measurement platforms are generally categorized into solid- and solution-based. Although solid SERS is more commonly used, in-solution SERS offers the advantage of low cost, competitive reproducibility, and short analysis times. In this work, colloidal solutions of Au@AgNPs are employed as an active in-solution SERS substrate.

The preparation of core-shelled nanoparticles is straightforward through a seed-mediated growth process. Different reducing agents were tested and compared to reduce silver nitrate into Ag that can steadily grow on the surface of the gold seed. The synthesized bimetallic Au@AgNPs were characterized using UV-Vis spectroscopy, Dynamic light scattering, high magnification transmission electron microscopy (TEM) and energy-dispersive X-ray spectroscopy (EDS). The performance of Au@AgNPs was compared to their monometallic counterparts of AgNPs and AuNPs using Rhodamine 6G (R6G) as a Raman probe. Preliminary results for the surface modification of the synthesized nanoparticles with benzene-1,4-dithiol to determine trace concentrations of pharmaceutical contaminants in real wastewater will be presented.

11:20 - 11:40

323 The Impact of T_g of Model Rubber on the Viscosity of the Rubber-Ice Interface

Michael Stevens, Masashi Mizukami, Kazue Kurihara

Tohoku University, Sendai, Japan

Abstract

At the ice interface, a phenomenon called premelting manifests, stemming from less interactions with neighbouring molecules compared to those in the bulk. This leads to the formation of a premelted layer at the surface which possesses viscoelastic properties that are sensitive to the characteristics of the opposing sliding surface. Resonance shear measurements (RSM), using the low-temperature surface force apparatus (LT-SFA), presents a novel approach to elucidating the viscoelastic behaviour of interfacial liquids (Figure 1). The characteristics can be measured as a function of temperature, sliding velocity, and pressure at small junctions, typically of the order of ~10,000 μm^2, thereby bridging the gap between the nanoscopic and macroscopic. Utilising RSM, we aim to elucidate the temperature dependence (between -20 and 0˚C) of the rubber-ice interface's viscoelastic properties. Prior studies have suggested that cured rubbers have no impact on the effective viscosity of the interfacial layer, however deformation of the interface is dominated by rubber below -5˚C [1]. Here, we investigate uncured poly(styrene-co-butadiene) rubbers (5, 23 and 45 wt% styrene) and gain insights on how glass transition temperature (T_g = -74, -55 and -31˚C respectively) impacts the interface's viscosity. This aims to aid future understanding of the mechanisms of slip at the ice interface, and therefore improve the future rational design of materials for use in ice-bearing conditions.

[1] F. Lecadre, M. Kasuya, S. Hemette, A. Harano, Y. Kanno & K. Kurihara, Ice premelting layer of ice–rubber friction studied using resonance shear measurement, SoftMatter, 2020, **16**, 8677

Self and Directed Assembly - 1

Soft Matter - 3

10:00 - 11:40 Tuesday, 24th June, 2025
ETLC E1-003
Soft Matter
Greg Warr

10:00 - 10:20

31 Coil Dimensions of Macromolecules in the Presence of Crowding Colloids: Impact of Crowder Size

Klaus Huber[1], Max Martens[2], Remco Tuinier[2]

[1]Paderborn University, Paderborn, Germany. [2]Eindhoven University of Technology, Eindhoven, Netherlands

Abstract

Characteristic of the cytoplasm of living cells is the high concentration of biomacromolecules (including proteins, ribosomes and nucleic acids) that they contain (up to 400 g/L). The large volume fraction occupied by these macromolecules influence the organization within cells at various length scales. A question that arises is: how is the coil size of a biopolymer mediated by the presence of proteins? It has been shown that the size of a macromolecule in solution is strongly influenced by the size and concentration of added colloidal particles. Previous experimental and computer simulation studies have shown conflicting results regarding the influence of colloid size on coil compaction.

We present theory that predicts how the colloid size mediates the compaction of macromolecules in crowded environments. The theory suggests the coil size depends on the segment / nanoparticle size ratio. The theoretical approach predicts that the shrinking of a polymer coil upon adding colloidal particles varies with the size of the colloids. We find coil shrinking is weakest when the colloidal particles are approximately the same size as the Kuhn segment length. The extent of coil shrinking passes a minimum at a specific colloid size relative to the Kuhn segment length (see the plot), which is confirmed by self-consistent field (SCF) lattice computations. Comparison with scattering experiments from the literature corroborate the extent of polymer shrinking at a given volume fraction of colloids. Our theoretical approach reproduces the functional dependence of the collapse on the crowder volume fraction.

10:20 - 10:40

59 The Impact of Tween 80 on the Physicochemical Properties of Bilayer Oleogels Stabilized with Ecogel™

Sonia Kudłacik-Kramarczyk, Alicja Przybyłowicz, Weronika Kieres, Piotr Warszyński, Marcel Krzan

erzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences, Krakow, Poland

Abstract

Bilayer oleogels are innovative materials with significant potential in pharmaceutical and cosmetic applications, particularly as carriers for active ingredients. This study focused on the development and characterization of bilayer oleogels stabilized with Ecogel™, incorporating Tween 80, glycerin, and gelatin. The influence of Tween 80 on the physicochemical and rheological properties of the oleogels was investigated, emphasizing structural stability, hydrophobicity, and water-binding capacity. Analytical techniques included FT-IR spectroscopy, microscopy, contact angle measurements, and rheological tests.

The results revealed that Tween 80 enhances the stiffness and structural stability of the oleogels, as evidenced by an increase in the elastic modulus. Additionally, oleogels with higher Tween 80 concentrations displayed significantly larger water contact angles, indicating a more hydrophobic nature. Sorption studies demonstrated that Tween 80 facilitates water release from the oleogel matrix, while samples without this additive retained moisture more effectively.

The findings suggest that oleogels containing Tween 80 exhibit superior stability and interactions with non-polar components, such as skin lipids, making them promising carriers for dermatological applications. These include sensitive skin care, moisturizers, and systems for the controlled delivery of active ingredients. The developed formulations combine lightweight structures with exceptional sensory properties, addressing the growing demand for advanced, multifunctional products in the cosmetic and pharmaceutical sectors.

This work received funding from the National Science Centre of Poland (grant number 2024/08/X/ST8/00054).

10:40 - 11:00

96 Piezoelectric hydrogels structured by self-assembled fatty acids

Erica Pensini, Alejandro Marangoni, Aicheng Chen, Stefano Gregori
University of Guelph, Guelph, Canada

Abstract

Piezoelectric materials generate electricity when subjected to mechanical stress. They are used in different applications, ranging from clean energy production and sensors to dermal patches that enhance healing of the skin.

We produced piezoelectric materials containing over 90% water, unsaturated fatty acids, such as oleic and linoleic acids, and either alkanolamines or amino acids (e.g., arginine and lysine). In the absence of fatty acids, aqueous mixtures of alkanolamines and amino acids are electrically conductive, but not capacitive. Therefore, current vs. voltage curves measured during cyclic voltammetry experiments display negligible hysteresis.

In the absence of water, alkanolamines and fatty acids yield non-conductive materials that are either hard and brittle or highly viscous, depending on the saturation of the fatty acid used. Aqueous mixtures of oleic or linoleic acids and either amino acids or alkanolamines are gels, as shown by shear rheology. Synchrotron small angle X ray scattering (SAXS) reveals that these gels are liquid crystals, ranging from lamellar to columnar hexagonal, depending on the composition. Self-assembled fatty acids arrange themselves into ribbons or other structures, as seen by polarized light microscopy.

Polarized light microscopy further reveals that mechanical stresses develop in the gels when they are subjected to electric fields. Synchrotron SAXS shows that applied electric fields deform the crystalline structure of the gels. This is because gels are piezoelectric, as shown by cyclic voltammetry experiments, and when they are compressed, electric current flows through them.

11:00 - 11:20

159 Soft Matter Templating for Aerogel Design through Interfacial Co-assembly of Nanomaterials/Surfactants

Milad Kamkar

University of Waterloo, Waterloo, Canada

Abstract

Over the past few years, our group has focused on developing novel processes to create new types of soft materials. This has been achieved through innovative techniques such as liquid streaming/templating, droplet templating, and chaotic direct ink writing (ChDIW). The first two

techniques leverage interfacial co-assembly of nanomaterials and surfactants to transform liquid-like suspensions into structured liquids. ChDIW, on the other hand, has been introduced to fabricate gel-like suspensions with micro-ordered structures. These techniques have enabled the development of novel soft materials, including multilayered, gradient, and interpenetrated liquids, and 3D printed hybrid hydrogels. These soft materials can be readily converted into 3D-structured ultralightweight aerogels with unique morphologies, referred to as worm-like, compartmentalized, and welded aerogels. In this presentation, we will discuss and introduce these new manufacturing processes, along with the resulting innovative soft materials and aerogels. These developments open new possibilities in the fields of advanced materials and their applications.

Fabrication Methods & Colloidal Metamaterials - 2

13:20 - 15:00 Tuesday, 24th June, 2025
ICE Incubator
Fabrication Methods & Colloidal Metamaterials
Alidad Amirfazli

13:20 - 13:40

230 Formation of the alternating binary multilayer with alkanethiol-modified Au nanoparticles and CdS quantum dots

Rina Sato[1], Masaki Matsubara[2,3], Megumi Suyama[1], Takehiro Yachi[1], Hideyuki Mitomo[4], Yuto Kajino[5], Kaoru Tamada[5], Atsushi Muramatsu[1,2], Kiyoshi Kanie[1,2]

[1]IMRAM, Tohoku Univ., Miyagi, Japan. [2]SRIS, Tohoku Univ., Miyagi, Japan. [3]NIT, Sendai College, Miyagi, Japan. [4]RIES, Hokkaido Univ., Hokkaido, Japan. [5]IMCE, Kyushu Univ., Fukuoka, Japan

Abstract

Assemblies composed of two types of nanoparticles (NPs), binary NPs superlattices (BNSLs), offer a versatile approach to control their physical properties depending on the interparticle distance or the entire arrangement. In this work, dodecanethiol-modified Au NPs (**A**) and CdS quantum dots (**Q**) were used to form a binary multilayered superlattice through alternating lamination of their monolayers (Fig.). The monolayers were formed by spreading **A** and **Q** in toluene onto a water surface, resulting in highly ordered hexagonal arrays as observed from transmission electron microscopy (shown in Fig.). The respective diameters of **A** and **Q** were 9.4 ± 0.2 nm and 3.1 ± 0.5 nm, with intersurface distances of 1.5 ± 0.2 nm and 2.8 ± 0.1 nm. These monolayers were alternatively laminated several times onto the same substrate to obtain the binary multilayered superlattice, **A**/**Q**. Grazing-incidence small-angle X-ray scattering measurement confirmed the periodicity of the NP arrangement, with **A** forming a face-centered-cubic structure in **A**/**Q**. Furthermore, photoluminescence (PL) intensity of **A**/**Q** was systematically increased or

decreased by the lamination of **Q** or **A** layers. Numerical simulations attributed such PL behavior to the formation of uniform layered structure. These results demonstrate the successful formation of a highly periodic BNSL with a well-defined optical property through proper lamination of the NP monolayers. The multilayering technique will be extended to further applications by varying the types of NPs used as building blocks.

13:40 - 14:00

294 Teaching an Old Dog New Tricks: Advancing Hydrogen Silsesquioxane-Derived Silicon Nanocrystals

Abbie Rubletz, Kevin O'Connor, Katelynn Johnson, Dmitry Vrublevskiy, Mia Dolanjski, Suni Guo, Christina Zafeiridou, Jonathan Veinot

University of Alberta, Edmonton, Canada

Abstract

Semiconductor nanoparticles (e.g., quantum dots) have emerged as important components of modern technologies. Recently, attention has shifted to larger (d > 75 nm) silicon nanoparticles (SiNPs) as optical metamaterials because of their strong interactions with visible light (*ca*. 400 - 800 nm).[2] The solid state, thermally-induced disproportionation of hydrogen silsesquioxane (HSQ), yielding nanocrystalline domains of elemental silicon embedded within an SiO_2-like matrix, is an established robust route to *small, pseudospherical* (d < 10 nm) SiNPs; ethanolic HF etching of oxide composites afforded from this procedure provides freestanding colloidal SiNPs.[3] We have demonstrated the potential for producing larger, faceted architectures more suitable for metamaterial applications.[4] This presentation will describe a systematic investigation of the temperatures immediately bracketing the melting point of bulk Si (1414 °C) and how it provides invaluable insight into the role of thermal mobility on the morphology, crystallinity, and diameter of HSQ-derived SiNPs. A full understanding of these effects is crucial to the expansion of the HSQ approach and the associated materials into this new, underexplored size regime.

References[1]

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(2) De Marco, M. L.; Semlali, S.; Korgel, B. A.; Barois, P.; Drisko, G. L.; Aymonier, C. Silicon-Based Dielectric Metamaterials: Focus on the Current Synthetic Challenges. *ACIE* **2018**, *57*, 4478–4498.

(3) Hessel, C. M.; Henderson, E. J.; Veinot, J. G. C. An Investigation of the Formation and Growth of Oxide-Embedded Silicon Nanocrystals in Hydrogen Silsesquioxane-Derived Nanocomposites. *J. Phys. Chem. C* **2007**, *111*, 6956–6961.

(4) O'Connor, K. M.; Rubletz, A.; Ni, C.; He, Y.; Butler, C.; Veinot, J. G. C. High-Temperature Anomaly in the Synthesis of Large (*d* > 100 nm) Silicon Nanoparticles from Hydrogen Silsesquioxane. *Chem. Mater.* **2023**, *35*, 7967–7973.

14:00 - 14:20

322 Bio-Inspired Metamaterial Surfaces for Enhanced IR Thermal Management: High-Pressure Embossing of Polymethylpentene Using Durable Silicone Rubber Molds

Abolfazl Vaheb, Dan Sameoto

University of Alberta, Edmonton, Canada

Abstract

This work presents an approach to controlling thermal infrared (IR) transmission in polymeric surfaces through metamaterial design and high-pressure embossing of polymethylpentene (TPX™). Inspired by biological surface, we employ fiberglass-reinforced silicone rubber molds to create microstructured features—lenticular lenses and microscale pillars—on TPX™, thereby modulating visible and IR transmission via scattering/absorption and tunable transparency/opacity within the 8–14 µm IR window.

To achieve robust, high-quality replication of microscale patterns, we reinforce silicone rubber molds with thin fiberglass layers (mold thickness ~400-700 µm). This is a requirement to achieve dimensionally stable silicone molds at high temperatures (>240 °C) and pressures (> 1MPa) to form thin IR transparent sheets. TPX™ is highly transparent in visible and thermal IR spectrums and exhibits extremely low surface energy, having advantages over polypropylene, and polyethylene sheets (featured in our previous work). These include greater temperature tolerance, high optical clarity, and solvent compatibility for microfluidics applications. This approach ensures consistent microstructural precision and preserves the designed features required for effective IR manipulation. Our findings so far—validated through grid-pattern replication tests and optical microscope pictures of the PE sheets being molded successfully and uniformly—confirm that reinforced molds significantly reduce feature distortion and mold the thermoplastic effectively compared to non-reinforced counterparts, allowing accurate fabrication of TPX™-based metamaterial surfaces in this work.

Overall, this scalable, cost-effective platform addresses energy efficiency and environmental control. Bio-inspired microstructures and advanced molding techniques demonstrate the synergy among materials science and colloidal research, paving the way for next-generation thermal and optical interfaces.

14:20 - 14:40

155 Investigating a multi-phase (liquid-solid) particle as a candidate to substitute insects in the impact of insect studies.

Pierre Lesbats, Alidad Amirfazli

York University, Toronto, Canada

Abstract

Bug splatter created from insect impacts on vehicles, wind turbines, and aircraft creates residues that affect safety sensors, reduce bikers' visibility, increase skin drag, and lower aerodynamic efficiency. Experiments with live insects to study the effects of coatings, impact velocity, and angle on residue area and height raise ethical concerns, produce inconsistent results, and limit data reliability.

To date, a chemical solution as a hemolymph analog has been used for coating mitigation tests but fails to account for impact velocity, angle, or residue height. To solve this, **we propose a core-shell multi-phase particle** as an insect surrogate. The key challenge, hemolymph coagulation upon air contact, is addressed with Octadecane wax, which transitions from liquid to solid upon impact, and Docosane wax, which remains solid to replicate residue height. These waxes compose the particle core, encapsulated by a calcium alginate shell.

Impact experiments were conducted on aluminum targets for 4 impact angles (90, 67.5, 45, and 30 degrees). The surrogate residue's area, height, and shape were measured and compared to the insect's.

Analyses show a **3% difference** between the insect and the surrogate for the area at a 90-degree impact angle and a **similar trend** through the angles for the evolution of the area and height, showcasing the surrogate's accuracy in replicating the insect residue.

The surrogate residue shape was also compared and **matched the insect's pattern one**, setting the validation of the multi-phase particle as a **good candidate for insect analog**.

14:40 - 15:00

321 Electrospun of sulfonated poly ether ether ketone (sPEEK) crosslinked nanofibrous membranes for selective separation of lithium

Wesam Tork, Edward Roberts, Sathish Ponnurangam

University of Calgary, Calgary, Canada

Abstract

High-capacity lithium batteries are the cornerstone of modern world high-density applications and a viable energy storage solution to address the intermittency problem of renewable energy resources. Alberta's formation water contains a significant amount of Li^+ (see below) [2]; however, Li^+ extraction is faced with obstacles - mainly, the low concentrations (< 70 mg Li^+/l), and the presence of 100-fold higher concentrations of other cations sharing similar charge characteristics and ionic radius such as Na^+, K^+, Ca^{2+}, and Mg^{2+}. In this work, we report a mechanically strong, cost-effective nanofiber (NF) composite for selective extraction of lithium from brines with low concentrations of Li^+ (< 75 mg/l). Targeted properties include adsorption capacity (q_e > 36.83 mg Li^+/g adsorbent), adsorption rate (> 0.01134 g mg^{-1} h^{-1}), regeneration cycles (>50-100 cycles with minimal or no loss of capacity), and high selectivity for Li^+ over Na^+, K^+, Ca^{2+} and Mg^{2+}. Towards this, we report optimization of chemical, physical, and process parameters of our NF composite including sulfonation extent, ratio of polymer to hydrous TiO2 adsorbent, and electrospinning variables. This optimization is aimed at high Li^+ removal rate, adsorption capacity and long term use durability. Due to the environmentally friendly constituents, mechanical strength, antifouling capability (from the organic-inorganic hybrid membrane materials), and controlled swelling, our NF composite membrane can be used directly as a Li^+ extraction filter from seawater or any other low concentration non-conventional resources.

AI Methods in Surface Sciences - 3

13:20 - 15:00 Tuesday, 24th June, 2025
ETLC E2-001
AI Methods in Surface and Colloid Sciences
Cuiying Jian

13:20 - 13:40

375 AI-enabled single particle tracking in liquid-phase transmission electron microscopy

Zain Shabeeb, Risha Goel, Isabel Panicker, Vida Jamali

Georgia Institute of Technology, Atlanta, USA

Abstract

Liquid phase transmission electron microscopy (LPTEM) provides unprecedented spatial and temporal resolution for studying nanoparticle dynamics, enabling nanoparticle tracking in complex liquid environments. However, challenges such as low signal-to-noise ratios and the lack of robust particle tracking frameworks hinder its broader adoption. Addressing these gaps, we developed SAM4EM, an interactive framework leveraging Meta's Segment Anything Model 2 (SAM2) – a foundation model for video and image segmentation – for zero-shot segmentation of noisy LPTEM videos. SAM4EM is an open-source framework that fills a critical gap in LPTEM analysis by providing a standardized, accessible tool for promptable particle tracking and statistical analysis. Achieving nearly 50-fold higher accuracy in segmenting LPTEM videos compared to state-of-the-art methods, SAM4EM enables researchers across disciplines to advance nanoscale dynamics research.

Once high-quality spatiotemporal trajectories are extracted from LPTEM videos via SAM4EM, the next step is to uncover the physical principles governing nanoparticles' motion. To this end, we developed LEONARDO, a transformer-based variational autoencoder with a physics-informed loss function. LEONARDO learns the statistical properties of experimental nanoparticle trajectories, such as non-Gaussian displacement distributions and velocity autocorrelation, shedding light on heterogeneous interfacial dynamics and the viscoelastic properties of the liquid cell environment.

Combining SAM4EM with LEONARDO establishes a transformative approach to single particle tracking using LPTEM, bridging nanoparticles' motion with physics-based insights derived through generative AI. This combined framework not only standardizes single particle tracking but also enables deeper exploration of nanoscale interfacial phenomena, paving the way for advancements in probing biological interfacial dynamics, optimizing catalytic surfaces, and achieving targeted delivery in complex colloidal systems.

13:40 - 14:00

332 Understanding colloidal lignin particle formation with multivariate data analysis

Daniel Barker-Rothschild[1,2], Oliver Musl[3], Julia Azzi[1,2], Tao Zou[1,2], Scott Renneckar[1,2], Antje Potthast[3], Orlando Rojas[1,2]

[1]University of British Columbia, Department of Chemical & Biological Engineering/Wood Science/Chemistry, Vancouver, Canada. [2]University of British Columbia, Bioproducts Institute, Vancouver, Canada. [3]BOKU University, Department of Chemistry, Institute of Chemistry of Renewable Resources, Tulln, Austria

Abstract

Lignin is a class of phenolic macromolecules accounting for roughly 30% of woody biomass. Despite its natural abundance and availability as a co-product of the pulp and paper industry or emerging biorefineries, lignin remains an underutilized resource. This is the result of the natural variability and structural heterogeneity of lignin, that presents significant challenges for upgrading strategies.

Remarkably, through simple solvent exchange approaches lignin can be transformed into spherical colloidal particles (50 nm to 1 μm) with narrow size distributions, that are further stable in water at moderate pH due to the negative surface charge from the weak acid carboxylic hydroxy groups present in its structure. The resulting colloidal particles are highly tunable and exhibit enhanced uniformity relative to the raw material and therefore offer new opportunities for utilization of lignin. However, the high variability of lignin feedstocks in terms of its chemical structure and composition result in challenges with the reliable production of these particles. Further, there are gaps in our understanding of the relative impact of structural and synthesis variables on particle formation and their resulting colloidal properties. A fundamental understanding of colloidal lignin particle formation is critical to ensure control over these important particle properties, i.e., size, shape, and surface charge, especially in colloidal systems where minor differences have major impacts.

This work investigates the formation of colloidal particles from lignin in a multivariate context. Colloidal particles are synthesized from a diverse library of technical lignins and under a range of synthesis conditions. Multivariate models are applied to isolate for key variables that dictate important particle properties. Critical perspectives on the formation of colloidal particles from one of the world's most abundant yet underutilized biopolymers are provided.

14:00 - 14:20

164 Unravelling Protein-Surface Adsorption in Plant-based Proteins Using Numerical and Machine Learning Approaches.

Simha Sridharan[1], Rammile Ettelaie[1], Rik Sarkar[2], Nicholas Watson[1], Anwesha Sarkar[1]

[1]Food Colloids and Bio-Processing Group, School of Food Science, University of Leeds, Leeds, United Kingdom. [2]School of informatics, University of Edinburgh, Edinburgh, United Kingdom

Abstract

Adsorption of proteins to weakly polar surfaces and the subsequent adsorbed protein structure plays a key role in a wide range of processes ranging from bio-chemical reactions in cells to biofouling to oral perception of foods. Nevertheless, primary sequence parameters (*e.g.* hydrophobicity, protein sequence, relative distribution of hydrophobic and hydrophilic amino acids) that individually or collectively drive such protein-surface interaction remain poorly understood. Particularly such knowledge is even more scarce in plant proteins which have garnered significant research attention owing to their importance from sustainability viewpoints. Latest advances in data science approaches can prove to be powerful in bringing insights from a large dataset of plant proteins. To achieve this, we have uniquely combined Self-consistent Field Theory (SCFT) modelling with Machine Learning (ML) to investigate the adsorbed structure of plant proteins. We use protein chain information, obtained from UniProt in SCFT model to numerically simulate surface adsorption and structure of plant protein layers adsorbed onto hydrophobic surfaces. Then SCFT outputs on thickness of adsorbed layers, adsorbed structure (e.g. loop like, chain like) was used to train ML models to classify these structures into clusters of similar adsorbed layer properties. By comparing these structures to well-known functional proteins, we present new insights on importance of primary sequence parameters that dictate the surface adsorption behaviour. Overall, the study provides a new theoretical framework that can be applied to a wide range of proteins to make informed decision in choosing proteins for biomaterials and in food design.

14:20 - 14:40

65 AI-enabled Investigation into Liquid-Phase Exfoliation of Graphitic Carbon Nitride

Ehsan Shahini, Narendra Chaulagain, Karthik Shankar, Tian Tang

University of Alberta, Edmonton, Canada

Abstract

Liquid-phase exfoliation (LPE) of graphitic carbon nitride (g-C_3N_4) is a promising technique to produce high-quality two-dimensional nanosheets for photocatalytic applications, but it requires optimal solvent selection. We combine machine learning (ML) with molecular dynamics (MD) simulations to predict the free energy of exfoliation (ΔG_{exf}) and solvation free energy (ΔG_{sol}) for the nanosheets, key metrics determining LPE performance. Using an Extra Trees Regressor (ETR) model trained on MD-generated data from 48 organic solvents, we correlate ΔG_{exf} and ΔG_{sol} with solvent descriptors such as heat of vaporization, dielectric constant, surface tension, density, and molecular weight. Descriptor selection refines the model, achieving high accuracy and enabling the evaluation of over 150 additional solvents. This approach identifies promising solvents for effective exfoliation without the need for new extensive MD simulations. Extending the methodology to binary solvent mixtures, we apply the ETR model to predict ΔG_{exf} for over 14,000 combinations, uncovering an unexpected result: binary mixtures are often dominated by either their superior or inferior solvent component. This behavior is validated through targeted MD simulations, revealing that a binary mixture's performance can closely mirror that of one constituent. Our AI-enabled framework reduces computational cost and accelerates solvent discovery, providing molecular-level insights that go beyond traditional surface tension criteria. It offers a scalable strategy adaptable to other layered materials and complex fluid systems, emphasizing the transformative potential of AI in surface and colloid sciences.

14:40 - 15:00

443 Representing and interpreting chemical objects in data science and machine learning: beyond the atom

Rose Cersonsky

University of Wisconsin Madison, Madison, USA

Abstract

In recent years, machine learning (ML) methods have transformed computational chemistry and materials research. In ML algorithms, we rely on machine-learning representations to serve as a “mathematical proxy” for our underlying chemistry or particle configuration. In this talk, I will address several key problems and strategies for applying these techniques to colloidal and interfacial problems.

I’ll first start on the idea of thermodynamic fingerprints as order parameters for complex phenomena, contrasting technologies built through the machine-learning potentials community with traditional analyses, as well as extending these ideas into new methods for bottom-up coarse-graining and complex phase transitions. From here, I will focus on how to extract actionable chemical and physical principles from models built on chemical data. This task is traditionally performed through unsupervised analyses such as principal components analysis or t-stochastic neighborhood embeddings, however, these methods only ask, “What makes these data points similar?” not “In what ways does my model see these data points as similar?” The latter question,

particularly in the context of supervised ML models, is more powerful and informative for structure-property relationships. Our results show that this multi-objective framing, with its inherent interpretability, reveals underlying trends across many ML tasks, from materials classification to machine-learning potential building to non-linear regression tasks.

Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 4

13:20 - 15:00 Tuesday, 24th June, 2025
NRE 1-001
Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces
Valeria Milam

13:20 - 13:40

119 Nanocellulose-based bicontinuous emulsion through solvent transfer-induced phase separation

Minke Yang[1,2], Yi Lu[1,3], Guang Gao[4], Orlando Rojas[1,2,5,6]

[1]Bioproducts Institute, The University of British Columbia, Vancouver, Canada. [2]Department of Wood Science, The University of British Columbia, Vancouver, Canada. [3]CAS Key Laboratory of Green Process and Engineering, Institute of Process Engineering, Chinese Academy of Sciences, Beijing, China. [4]Life Sciences Institute, University of British Columbia, Vancouver, Canada. [5]Department of Chemical and Biological Engineering, The University of British Columbia, Vancouver, Canada. [6]Department of Chemistry, The University of British Columbia, Vancouver, Canada

Abstract

Bicontinuous particle-stabilized emulsion gels (bijels) have drawn increased attention in catalysis, bio-engineering, and food applications due to their high interfacial area and tortuous networks between the aqueous and organic phases. Here, we studied the interlocking of bicontinuous morphology during solvent transfer-induced phase separation (STRIPs) *via* a bio-based nanoparticle, cellulose nanocrystal (CNC). Two types of cationic surfactants (hexadecyltrimethylammonium bromide, CTAB and didodecyldimethylammonium bromide, DDAB) were investigated to modify *in-situ* the CNC surface wettability, which dramatically impacted the diffusion and jamming efficiency of nanoparticles, as well as controlled the microstructure and alignment. DDAB modification showcased an obvious and uniform bicontinuous morphology, most likely due to strong adsorption to CNC. The STRIPs method offers new opportunities to alter the surface and internal features of bijel filaments *via* compositional and hydrodynamic changes. In summary, we provide new insights into the bio-nanoparticle based

bicontinuous emulsion through STRIPs method, paving the pathway to further research on the role of bio-particles during the STRIPs process.

13:40 - 14:00

186 Aerotaxis-driven biofabrication of layered nanocellulose for flexible all-in-one supercapacitor

Xin Shu[1,2], Yi Lu[1,3], Xuetong Shi[1,2], Zhangmin Wan[1,2], Orlando J. Rojas[1,2,4,5]

[1]Bioproducts Institute, The University of British Columbia, Vancouver, Canada. [2]Department of Chemical and Biological Engineering, The University of British Columbia, Vancouver, Canada. [3]CAS Key Laboratory of Green Process and Engineering, Institute of Process Engineering, Chinese Academy of Sciences, Beijing, Canada. [4]Department of Wood Science, The University of British Columbia, Vancouver, Canada. [5]Department of Chemistry, The University of British Columbia, Vancouver, Canada

Abstract

Cellulose can be produced by aerobic bacteria (*e.g.*, *Komagataeibacter medellinensis*) at air-liquid interface, known as bacterial nanocellulose (BNC). However, pristine BNC biofilms lack distinct structural features at microscopic and macroscopic scales. This is mainly due to the intrinsic chaotic bacteria locomotion, which limits their capabilities in structuring high-performance materials. Herein, we introduce a 3D biofabrication strategy toward one-step formation of BNC sandwiched biofilms that can act as scaffolds for supercapacitors. The multilayer and spatial distribution of BNC nanofibers is achieved by aerotaxis phenomena according to available oxygen interfaces. A layer of dense, biocompatible, and oxygen-permeable organic phase (*i.e.*, hydrofluoroether) is introduced underneath an aqueous culture medium to promote a vertical gradient for microorganisms to move, which correspondingly leads to differentiated BNC mass density. This integrated sandwich structure enables the development of a versatile and adaptive all-in-one supercapacitor, characterized by exceptional flexibility and mechanical durability as an energy storage device.

14:00 - 14:20

135 Multifunctional nanocellulose-based hybrid hydrogels for 3D Printing applications

Seyed Mohammad Amin Ojagh[1], Milad Kamkar[2], The G.M. van de Ven[1]

[1]McGill University, Montreal, Canada. [2]University of Waterloo, Waterloo, Canada

Abstract

Nanocellulose, derived from renewable resources, has attracted significant interest in 3D printing due to its biocompatibility, sustainability, and favorable mechanical properties. However, a major challenge in using nanocellulose-based hydrogels for 3D printing is balancing printability and structural stability. This study addresses two critical issues in the additive manufacturing of cellulosic hydrogels and cryogels: (i) the inadequate rheological properties of cationic hairy nanocellulose (CHNC) suspensions for 3D printing and (ii) the poor mechanical strength of 3D-printed cellulose nanocrystal (CNC) cryogels. To resolve these challenges, CNC and CHNC were hybridized by optimizing the molar ratio of their functional groups. Fine-tuning the CNC/CHNC molar ratio allowed precise control of the rheological behavior of the hybrid system, enabling high-fidelity 3D printing of hydrogels. Additionally, the mechanical properties of the cryogels obtained by freeze-drying the printed hydrogels were significantly enhanced by adjusting the CNC/CHNC ratio. This study presents new opportunities for the development of sustainable, biocompatible, and lightweight cellulosic scaffolds with tunable properties, offering the potential for a broad range of applications.

14:20 - 14:40

33 Surface functionalization of cellulose nanocrystals with porphyrin-based metal-chelating polymers for drug delivery applications

Richard Fuku, Paolo Giuliana, Balmiki Kumar, Landon Edgar, Mitchell Winnik

University of Toronto, Toronto, Canada

Abstract

Cellulose nanocrystals (CNCs) have emerged as sustainable biomaterials for drug delivery applications due to their high surface area, excellent biocompatibility, and low toxicity. CNCs are rod-like nanoparticles derived from natural cellulose and exhibit an abundance of surface hydroxyl groups that can be readily modified with the targeting ligands, fluorophores, therapeutic agents, and protein-repellent polymers to enable targeted drug delivery. These characteristics make CNCs well-suited for image-guided drug delivery systems. Herein, I proposed a CNC-based theranostic platform with multimodal imaging and targeted radioimmunotherapy for glioblastoma multiforme (GBM). The present work demonstrates the proof-of-concept design for porphyrin-modified CNCs that are conjugated to panitumumab and radiolabelled with ^{64}Cu for targeted cancer therapy using 3D multicellular tumour spheroids (MCTSs) models. Specifically, an azide-terminated porphyrin-containing block copolymer was prepared via the RAFT polymerization. Upon aminolysis, the thiol end group of the RAFT polymer was conjugated to the panitumumab antibody through a bis-maleimide linker, while the azide end group was attached to the DBCO-functionalized CNCs via the copper-free click chemistry. Preliminary investigations have been conducted on the effects of different protein-repellent polymer coatings on the cellular uptake behaviours of CNCs by various immune cells and GBM cell lines. The theranostic activity of ^{64}Cu-labelled porphyrin-CNCs will

be further investigated on both 2D and 3D models of GBM cell lines using confocal microscopy, radioisotopic localization and apoptosis analysis by spectral flow cytometry.

Colloids for Sustainability and Energy - 3

13:20 - 15:00 Tuesday, 24th June, 2025
ECERF W2-110
Colloids for Sustainability and Energy
Karthik Shankar

13:20 - 13:40

213 TiO_2 Nanoparticles-embedded Solid Polymeric Foams with Controlled Porosity for Water Remediation

Jean-Baptiste Boyssou, Zygimantas Gricius, Maria Fernandino, Gisle Øye, Nadia Shardt

Norwegian University of Science and Technology, Trondheim, Norway

Abstract

Most advanced water treatment methods rely on innovative materials for chemical or physical purification. However, existing challenges remain, such as the incomplete removal and recovery of photocatalytic nanoparticles (NPs) or the limited efficiency of non-modified polymeric materials.

To address these issues, we present a novel approach for the preparation of well-defined macroporous polyacrylamide (PAM) foams with embedded titanium oxide (TiO_2) nanoparticles. Synthesis of several foams with different loading of TiO_2 NPs was achieved through photopolymerization of aqueous foams stabilized by nanoparticles. Bubble size and macropore topology are affected by the titania loading, air volume fraction and the photoinitiator concentration. Morphology of the solid polymeric foams was characterized by SEM, while the TiO_2 loading was assessed by calcination and TGA analysis. Pore size can be tailored by varying the NP content, leading to pores as small as 20µm with a narrow polydispersity.

Presence of NPs and polymeric backbone lead to a novel bi-responsive material, namely photocatalytically-active and absorbing. Photocatalytic degradation of model pollutants, namely 4-propylbenzoic acid and methylene blue, is demonstrated with an efficiency comparable to standard NP dispersions prepared from TiO_2.

At the same time, the titania-doped polyacrylamide foams exhibit an enhanced swelling capacity, with the doped materials reaching a swelling ratio as high as 5. Once activated by hydrolysis, the synthesized solid Pickering foams show a high affinity for adsorbing positively charged pollutants.

Coupling absorption activity with photodegradation enables selective pollutant capture while retaining the integrity of the material for reuse in subsequent water remediation cycles.

13:40 - 14:00

353 Determining the pH-Dependent Interfacial Water Structure at the Titania Nanotube/Aqueous Interface

Julianne Gibbs, Mokhtar Rashwan, Ryan Kisslinger, Karthik Shankar

University of Alberta, Edmonton, Canada

Abstract

Titania nanotube assemblies show promise as photoactive materials in photovoltaics and photocatalysis. For applications such as photocatalytic water splitting, the titania is emerged in aqueous media. As such the interfacial structure of water is important to understand the surface reactivity of the titania nanotubes in various applications. Here we use vibrational sum frequency generation, a surface-sensitive technique, to monitor the interfacial structure of water at both planar titania surfaces and those that have been reacted to generate a layer of parallel oriented titania nanotubes. Upon increasing the pH, we observe an increase in the interfacial water structure. This is consistent with deprotonation of titania sites that lead to an increase in the surface static field, which in turn aligns the water. These water structure titrations exhibit a clear shift to higher pH when comparing the planar and nanotube titania interfaces. This observation suggests that confinement influences the acidity of the surface titania sites.

14:00 - 14:20

69 Coalescence-induced late departure of bubbles improves water electrolysis efficiency

Tao Wu, Bo Liu

East China University of Science and Technology, shanghai, China

Abstract

In water electrolysis, bubbles form on the electrode and interact through processes such as collision and coalescence. Achieving the primary optimization goals of water electrolysis, including improving current density (and thus increasing gas production rate) and enhancing electrolysis efficiency, largely depends on mitigating the effects of bubbles. However, the impact of bubble-

bubble interactions, e.g., collision and coalescence, on electrolysis efficiency remains unclear. Here, we set out to unravel this mystery by systematically manipulating the coalescence probability of colliding bubbles in microelectrode experiments. By introducing coalescence inhibition electrolytes, such as $HClO_4$, to a 0.5 M H_2SO_4 solution (where bubbles merge rapidly), we observed a 50% reduction in bubble departure diameter corresponding to a surprising 30% dip in HER (hydrogen evolution reaction) efficiency. The efficiency reduction becomes more pronounced with the increase of electrolysis current density, and varies significantly with the type and concentration of the coalescence inhibition electrolyte. Remarkably, the result suggests that late bubble departure at larger sizes induced by coalescence enhances electrolysis efficiency, challenging the conventional belief that smaller bubble departure diameters favour electrolysis efficiency. These findings should fundamentally alter our understanding and strategies for mitigating the bubble effect in water electrolysis, particularly in originally coalescence-inhibited electrolytes, such as in alkaline water/seawater electrolysis and the chlor-alkali industry.

14:20 - 14:40

358 Molecular origins of enhanced bioproduct properties by pretreatment of agricultural residues with deep eutectic solvents

zhangmin wan[1], Orlando Rojas[1], Simcha Srebnik[2]

[1]The University of British Columbia, Vancouver, Canada. [2]The University of British Columbia, Vancouver city, Canada

Abstract

Pretreatment facilitates cost-effective operations on lignocellulosic biomass ranging from densification to deconstruction and bioproduct development. However, determining molecular-level mechanisms behind pretreatment and their effects has remained elusive. Here, we combine computational simulation and experiment to investigate the effects on wheat straw agricultural residue densification of an emerging pretreatment solvent, namely, a deep eutectic solvent (DES) consisting of choline chloride (ChCl) and oxalic acid (OA). *Ab initio* molecular dynamics indicates that dissociation of lignin from cellulose in lignin–carbohydrate complexes, which does not occur to a significant extent in aqueous solution, is favorable in the DES and occurs *via* cleavage of the guaiacyl : xylose ether bond linkage by OA. The ensuing hemicellulose removal exposes lignin to the DES which, molecular dynamics simulation indicates, leads to lignin expansion. The resulting changes in wheat straw fiber structure, lignin distribution, and functional group modifications upon DES treatment by scanning electron and fluorescence microscopy along with Fourier-transform infrared spectroscopy. The molecular expansion of lignin enhances inter-particle binding in wheat straw, leading to denser structures under pelletization. The resulting high mechanical stability and combustion properties make the wheat straw a suitable precursor of high-quality densified solids (*e.g.*, solid biofuel). Overall, we shed light on the molecular-level mechanisms involved in DES pretreatment for biomass densification, demonstrated here in the development of a solid biofuel.

The approach here illuminates the rational design from first chemical principles of methods to convert lignocellulosic resources into advanced materials.

14:40 - 15:00

366 Mechanistic Insights into Coalescence Inhibition and Agglomeration Initiation Near the Critical Dilution of Asphaltene Precipitation

Evgeniya Hristova[1], Stanislav Stoyanov[1], Plamen Tchoukov[2]

[1]NRCan, CanmetENERGY, Devon, Canada. [2]Bulgarian Academy of Science, Sofia, Bulgaria

Abstract

The critical dilution of bitumen by solvents is defined as the onset of bulk asphaltene precipitation. The commercial steam-assisted gravity drainage (SAGD) is designed to operate below critical dilution Ground operations following SAGD, however, often face disruptions due to the random occurrence of undesirable emulsions due to coalescence inhibition. Here, asphaltene precipitation is investigated with respect to the proximity to critical dilution upon the addition of paraffinic solvent to provide a deeper understanding of the oil-water separation mechanism. Experimental evidence from optical microscopy and thin liquid films shows changes at the oil-water interface, causing the inhibition of the coalescence and the initiation of agglomeration below critical dilution. Unlike the well-known agglomeration driven by bulk asphaltene precipitation above critical dilution, the agglomeration near critical dilution can be attributed to surface asphaltene precipitation. The initial formation of oil gel-like structures in the contact zone between adjacent water droplets helps formulate the progression of this process, , and defines the "surface asphaltenes precipitation". Asphaltene precipitation progression increases gradually rather than abruptly, challenging the current understanding of critical dilution. It is proposed to consider asphaltene precipitation as a progression rather than a single onset point. The initial surface onset, , occurs below critical dilution and is followed by the initial bulk and massive bulk onsets. The newly defined surface precipitation and mechanism challenge the conventional understanding that bulk asphaltene precipitation drives both agglomeration and effective oil-water separation. These findings provide valuable understanding and help formulate directions for addressing recurring issues in bitumen recovery.

Colloidal systems for Food: Production, Processing and Sustainability - 4

13:20 - 15:00 Tuesday, 24th June, 2025
ETLC E1-018
Colloidal Systems for Food: production, processing and sustainability
Julia Maldonado-Valderrama

13:20 - 13:40

283 Yeast Viability and Activity in HLD-NAC Designed Fully Dilutable Lecithin-Linker Microemulsions

Juan Doratt Mendoza, Jingwen Ding, Michelle Acosta Alvarez, Edgar Acosta

University of Toronto, Toronto, Canada

Abstract

Using microemulsions (µEs) as preservation media for cells was pursued in the 1990s; however, the difficulty in formulating bio-compatible µEs and keeping the cells alive for more than three days hindered developments in this area. This work explores the use of fully dilutable self-microemulsifying delivery systems (SMEDS) formulated with lecithin (Le) and polyglycerol-10-caprylate (PG10C) at a ratio of 2/5. This surfactant blend was mixed with ethyl oleate (EOL) at a ratio of 60 surfactant/40 EOL to produce a D60 dilution line. This D60 SMEDS was diluted with 0.9 %w/v NaCl solution to produce lecithin-linker µEs (LLMs). The properties of the resulting LLMs were predicted using the hydrophilic-lipophilic-difference (HLD) and net-average curvature (NAC) model, indicating that LLMs with aqueous content from 5% to 60% are bicontinuous, confirmed via viscosity and conductivity. The largest yeast activity and viability obtained with LLMs were achieved with 30% aqueous content, resulting from the balance between having enough water for the effective transport of metabolites, enough SMEDS to contribute nutrients and lipids and low enough water to limit the partition of PG10C that, when present in the aqueous phase, inhibited yeast activity. For SMEDS, its low water activity ensured that the yeast remained dormant, maintaining them partially viable for at least 10 weeks. Given these findings, the potential use of SMEDS in delivery systems for probiotics is discussed.

13:40 - 14:00

293 Physical Crosslinked Chitosan Microgels for the Delivery of Agrochemicals

Fabian Kolodzy[1,2,3], Andrij Pich[1,2,4]

[1]DWI - Leibniz-Institute for Interactive Materials e.V., 52074 Aachen, Germany. [2]ITMC - RWTH Aachen University, 52074 Aachen, Germany. [3]BioSC - Forschungszentrum Jülich, 52425 Jülich, Germany. [4]AMIBM - Maastricht University, Geleen 6167 RD, Netherlands

Abstract

Controlled delivery systems in agriculture are applied to minimize the use of agrochemicals while ensuring plant health and sufficient crop yield. Crosslinked polymer networks, known as microgels, have gained attention as potential tools for the controlled release of fertilizers and pesticides due to their stimuli-responsive swelling behavior. However, the use of synthetic microgels poses a risk due to persistence of the polymers so that the development of biobased alternatives is required.

This study describes a scalable synthesis of physical crosslinked microgels made from chitosan, a natural cationic polysaccharide. The ionic gelation of vibration-induced droplets with varying phosphate crosslinkers enables the production of polysaccharide microgels without the use of organic solvents. The morphology of the microgels can be varied between a homogeneous and a capsule-like structure by variation of the pH as confirmed by microscopy and IR.

The ability of the microgels for the diffusive uptake as well as the pH- and salt-dependent release of an auxin-based herbicide (low molecular weight) and an RNA-based insecticide (high molecular weight) is verified by UV/Vis. Hereby, the capsule-like microgels achieve a higher loading than homogeneous crosslinked microgels. Finally, we identified a response of the microgels' swelling to the gut lumen of Colorado potato beetles triggering the specific release of RNA-based insecticides inside the insect gut.

Our results confirm the sustainable and scalable synthesis of chitosan microgels with high loading capacities for anionic drugs. The versatile application makes these gels great candidates as controlled delivery agents in agricultural application to enable a circular bioeconomy.

14:00 - 14:20

225 Linking the structural, rheological and tribological properties to sensory perceptions of EVOO and pea proteins-based o/w emulsions by a multivariate statistical approach

Mujahid Hassan Khan, Giampiero Sacchetti, Lilia Neri, Paola Pittia, Carla Di Mattia

University of Teramo Department of Bioscience and Technology for Agriculture, Food and Environment, Teramo, Italy

Abstract

Taste and sensory perception are the main drivers in determining consumers' choice; the understanding of how raw materials (hence formulation) and the structural and physicochemical properties impact the sensory perception of o/w emulsions is thus crucial for food product development. Thus, this work was aimed at investigating how the sensory perception of EVOO based emulsions, stabilized by pea proteins, were related to rheological, tribological and structural properties. EVOO was chosen as lipid phase because of its peculiar properties and its complex composition in terms of minor amphiphilic compounds (mainly polyphenols) which have been proved to actively affect the colloidal properties of emulsified matrices. A central composite design was applied to systematically consider the variation of phase volume and EVOO concentrations by using blends of EVOO and refined olive oil. A multivariate regression analysis (PLS) was applied to analyze the relationships between sensory attributes obtained from a trained panel (bitterness, pungency, smoothness, thickness, fattiness, oiliness, creaminess, astringency, and mouthcoating) and physical properties (dx90, span factor, Zeta potential, rheological properties -consistency index, flow behavior index, and yield stress- and tribological parameters extrapolated from Stribeck curves). Results revealed that the majority of the sensory attributes were significantly linked to flow behavior parameters and droplet size; however, when dealing with specific mouthfeel perception like creaminess, and mouthcoating, lubrication properties were most significant. Such results offered deeper insights into how physical characteristics influence sensory perception and can help in targeting specific sensory outcomes when designing emulsified food products.

This work has been funded by the European Union - NextGenerationEU, Mission 4, Component 1, under the Italian Ministry of University and Research (MUR) National Innovation Ecosystem grant ECS00000041 - VITALITY - CUP: C43C22000380007.

14:20 - 14:40

356 Electrophoretic deposition of electrostatically stabilized plant proteins and formation of novel food structures

Michael Shen, Paul Takhistov
Rutgers, the State University of New Jersey, New Brunswick, USA

Abstract

Electrostatic stabilization is critical in preventing the formation of self-assembled structures of globular plant protein. This study explores the existence of a critical electric field that disrupts this stabilization, facilitating the formation of dense, agglomerated protein materials through the electrophoretic deposition (EPD) process. Focusing on soy protein isolate (SPI) solutions at neutral pH, we demonstrate that applying a DC electric field within a specific threshold induces a two-stage deposition mechanism.

Initially, the system undergoes the formation of a soft deposit as the critical electric field overcomes electrostatic repulsion, promoting the migration and aggregation of protein particles. This soft deposit phase is characterized by loosely packed protein structures with high water content. After a certain time, a second stage of catastrophic densification occurs, leading to the self-assembly of tightly packed protein conglomerates. This densification increases deposit density and mechanical strength, resulting in novel cheese-like structures without thermal or biochemical processing.

We present a simple mathematical model that describes the EPD process, incorporating parameters such as electric field strength, particle charge, and aggregation kinetics. We discuss potential mechanisms driving deposit densification.

Our findings highlight the critical role of preprocessing and electric field strength in controlling protein aggregation and deposit formation. This work advances the understanding of protein colloidal stability and opens avenues for novel food science and materials engineering applications.

14:40 - 15:00

382 Connecting the Structure of Casein Micelles with the Rheology of Skim Milk Concentrate

Cynthia Andriani[1,2], Geoff Willmott[1,2], Derek Knighton[3], Catherine Whitby[1,4], Bill Williams[3]

[1]MacDiarmid Institute for Advanced Materials and Nanotechnology, Wellington, New Zealand. [2]Departments of Physics and Chemistry, University of Auckland, Auckland, New Zealand. [3]Fonterra Research and Development Center, Palmerston North, New Zealand. [4]School of Food Technology and Natural Sciences, Massey University, Palmerston North, New Zealand

Abstract

The rheological properties of dairy-based products such as skim milk concentrate (SMC) are strongly influenced by the properties of casein micelles. However, it is challenging to connect the rheology of SMC with casein micelle micro- and nanostructure, especially because the rheology

of SMC changes with shear rate, solids content, temperature, and time. This presentation will describe efforts to use structural analysis methods to explain a viscosity data set for SMC prepared by vacuum-evaporating reconstituted skim milk powder. Each structural analysis method has characteristic advantages and disadvantages for this investigation; we have trialled dynamic light scattering (DLS), environmental scanning electron microscopy (E-SEM), cryo-SEM, transmission electron microscopy (TEM), cryo-TEM, and rheo-SAXS. Bulk rheology data have been carefully collected using shear rate sweeps (0.1–1000 s^{-1}) at different temperatures (55, 40, 20, 5 °C) and total solids (10 – 68 %w/w). By applying the MPQ model [1] to rheology data, it was found that that the voluminosity decreases at high temperature and solids content. This phenomenon can be related to deformation caused by the decreasing hydration capacity of casein micelles.

[1] Nöbel et al., "Apparent voluminosity of casein micelles in the temperature range 35–70 °C", *Int. Dairy J.* 59, 80-84 (2016).

General Aspects of Colloid and Interface Science - 3

13:20 - 15:00 Tuesday, 24th June, 2025
ECERF W2-010
General Aspects of Colloid and Interface Science
Vida Jamali

13:20 - 13:40

28 Surface interaction mechanics and antifouling properties of polyelectrolyte membranes for water/oil separation

Lu Gong

China University of Petroleum (Beijign), Beijing, China

Abstract

Fouling phenomena have significantly limited the practical applications of polyelectrolyte membranes in water/oil separation, a challenge affecting various industries ranging from chemical engineering to oil and gas. Understanding the surface interaction mechanisms involved in adsorbing and fouling processes on membrane surfaces is crucial for improving membrane performance. In this study, the interactions among zwitterions, water droplets, and polyelectrolyte surfaces were quantitatively examined using atomic force microscopy (AFM)-based surface force measurement techniques. Results revealed that attractive electrostatic interactions between zwitterionic groups were the primary cause of adsorption behavior of charged molecules on polyelectrolyte surfaces, leading to fouling. Moreover, adjusting solution pH to modulate the membrane surface potential and generate a repulsive electric double layer (EDL) force was found to effectively prevent the deposition of charged oil droplets, offering a practical approach to

adaptive antifouling properties for water treatment. Additionally, the presence of different anions in water was found to notably influence the interaction of water droplets with polyelectrolyte surfaces, following the famous Hofmeister series. Theoretical analysis showed that the surface behavior of these anions significantly impacted the dipole-dipole interactions between interfacial water molecules and charged groups, which governed water spreading and self-cleaning performance. This work provides valuable insights into the surface interaction mechanisms of fouling on polyelectrolyte membranes, aiding the development of more efficient antifouling materials and membranes for various applications.

13:40 - 14:00

108 Investigating the unique stability of anionic surfactant bilayers at solid-liquid interface and in air

Taichi Habe[1], Tadashi Sugahara[1], Atsushi Miyazaki[2], Shigeto Inoue[3], Takaya Sakai[2], Motomu Tanaka[4,5]

[1]Kao Corporation, Wakayama, Japan. [2]Kao Corporation, Tokyo, Japan. [3]Kao Corporation, Cincinnati, USA. [4]Kyoto University, Kyoto, Japan. [5]Heidelberg University, Heidelberg, Germany

Abstract

This study investigated the adsorption behavior and unique stability of bio-based C18 hydroxy alkane sulfonate (C18HAS) bilayers at solid-liquid interfaces, with a particular focus on their remarkable persistence upon exposure to air. In the presence of hard water, C18HAS formed vesicles that spontaneously adsorbed onto surfaces and formed a stable solid-supported bilayer. The commonly used double-chain cationic surfactant *N,N*-dioctadecyl-*N,N*-dimethylammonium bromide (DODAB) formed a hydrophobic surface when exposed to air, whereas C18HAS maintained its hydrophilicity when exposed to air, despite both forming a bilayer at the solid-liquid interface. This difference was shown by contact angle measurements, where C18HAS exhibited a water contact angle of 15°, significantly lower than that of 94°observed for DODAB. Spectroscopic analyses using Surface-Enhanced Infrared Absorption Spectroscopy (SEIRAS) and Polarization Modulation Infrared Reflection Absorption Spectroscopy (PM-IRRAS) suggested that the alkyl chains within the C18HAS bilayer remained in a liquid-like state and that the hydrophilic head group may be involved in intramolecular hydrogen bonds and interactions with the Ca2+ ions in hard water. X-ray reflectivity (XRR) analysis further confirmed that C18HAS maintained its bilayer structure under varying humidity conditions. This interesting behavior highlighted the potential of C18HAS as a promising bio-based anionic surfactant for surface modification.

14:00 - 14:20

91 Impact of cap weight on Janus particles' self-propulsion

Christopher Wirth, Muhammad Haroon

Case Western Reserve University, Cleveland, USA

Abstract

Platinum-coated polystyrene Janus particles exhibit deterministic motion in hydrogen peroxide solution, making them promising candidates for applications in microscale cargo transport, drug delivery, and environmental remediation. This study systematically investigated the impact of cap weight and hydrogen peroxide concentration on particle velocity and orientation. Trajectories of Janus particles with cap thicknesses of 5 nm, 10 nm, 20 nm, and 35 nm in 1 wt./vol.% and 3 wt./vol.% hydrogen peroxide near the bottom boundary of a fluid cell were recorded. Mean-square displacement of trajectories was used to measure the influence of cap thickness on propulsion speed. Results indicated that particles move faster in 3% peroxide compared to 1%, with lower cap thicknesses exhibiting higher velocities. Furthermore, gravitational effects influenced particle orientation: in 1% peroxide, particles with 20 nm and 35 nm caps adopted a cap-down orientation, while in 3% peroxide, only 35 nm capped particles exhibited this behavior. For 20 nm cap thickness particles in 1% peroxide, self-propelling force was insufficient to overcome the gravitational force due to cap weight, resulting in cap down orientation of particles. Whereas, in 3% peroxide self-propelling force overcame the gravitational force and propelled the particle along a straight path. These findings demonstrate the interplay between gravitational force due to cap-weight and self-propulsion in determining the dynamics of Janus particles very near a boundary.

14:20 - 14:40

423 The Interaction Radius and Its Implications for Guinier Analysis: Low-Q Asymptotic Behavior of the Effective Structure Factor

Chelsea Edwards[1], Wellington Leite[2], Yun Liu[1]

[1]NIST Center for Neutron Research, National Institute of Standards and Technology, Gaithersburg, MD, USA. [2]Neutron Scattering Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA

Abstract

Guinier analysis has been extensively used in academic and industrial research settings since the 1940s to obtain the model-independent size of a polymer, protein, or colloid in solution from small-angle scattering data. Using the Guinier model, the radius of gyration (R_g) is extracted from the form factor at low Q. Here, we develop an analogous approach for analyzing the effective structure factor data at low Q to extract a model-independent radius of interaction potential (R_i). Whereas

R_g^2 describes how spread out the scattering length density distribution of typical particles is from their center of mass, R_i^2 is an effective mean-squared distance that quantifies how far a typical particle is displaced from its ideal gas configuration due to interactions. We demonstrate this novel analysis method by applying it to experimental small-angle neutron scattering data on lysozyme protein solutions, and discuss its broader implications for Guinier analysis and data analysis of small-angle X-ray and neutron scattering data more generally.

14:40 - 15:00

254 Friction force between water droplets and micro-overhang structures

Yue Li, Alexander Saal, Miguel Navarro-Cia, Ludwig Schneider, Nan Gao

University of Birmingham, Birmingham, United Kingdom

Abstract

The study of droplet motion on solid surfaces is fundamental to improve a variety of industrial applications. Understanding how the friction builds up and dissipates at the solid-liquid interface is critical for capturing the motion pattern, thereby enabling the prediction or modification of the motion behaviour. In this work, we have measured the fiction forces of droplets moving on micro-structured surfaces using a custom-made setup that allows us to test a range of velocities. The micro-structured surfaces are characterised by pillars with re-entrant, doubly re-entrant and funnel overhangs (doubly re-entrant with hollow centre), respectively. The data suggest that it is the contact line, rather than the contact area that dominates the friction force. The doubly re-entrant surface generates less friction force due to its high contact angles and small contact angle hysteresis compared to the re-entrant surface. Nevertheless, it is noteworthy that, although the hollow space of the funnel overhang pillar introduces the air cushion, the friction force experienced by the droplet does not significantly decrease compared to that of doubly re-entrant pillars. We also compared the normalised friction force down to single pillar level considering the contact area difference due to the structural design, which yields the same result. The result of this work will be beneficial to understand the influence of the micro air pocket on the motion of the droplet at the solid-liquid interface.

Self and Directed Assembly - 2

13:20 - 15:00 Tuesday, 24th June, 2025
ECERF W2-050
Self and Directed Assembly
Wuge Briscoe

13:20 - 14:00

436 Biomolecular Induced Chiral Assembly of Plasmonic Nanoparticles

Kun Liu
Jilin University, Jilin, China

Abstract

Irregular changes in chiral structures of biomolecules are closely related to many major diseases. However, the detection of irregular changes of biomolecules is highly challenging due to their weak chiroptical signals. The transfer and amplification of the chiroptical signals of biomolecules by using surface plasmonic nanoparticles hold great promise for the early diagnosis of major diseases. Our research has focused on bio-macromolecular mediated chiral assembly of plasmonic nanoparticles. In the present talk, I would like to share with you how we have derived a more universal equation to correlate the order of nanostructures with the asymmetric factor (g-factor), which was used to guide the chiral assembly nanostructures with long-range order and with giant g-factors (up to 0.12) We have also developed a series of new synthetic methods for chiral shaped nanoparticle enantiomers, of which the chiral assembly lead to a further increase of g-factors to 0.24. In addition, we have discovered the chiral morphology dependent of chiral cellular uptake for the chiral enantiomers. These works paved new paths for the transfer and amplification of the chiral signal of bio-molecules.

14:00 - 14:20

150 Self-Assembly of Two-Antennary Oligoglycines: From Concept to Application

Eduarda Encheva[1], Dimitrinka Arabadzhieva[1], Ivan Minkov[1,2], Stoyan Iliev[3], Anela Ivanova[3], Elena Mileva[1], Plamen Tchoukov[1]

[1]Institute of Physical Chemistry, Bulgarian Academy of Sciences, Sofia, Bulgaria. [2]Faculty of Medicine, Sofia University, Sofia, Bulgaria. [3]Faculty of Chemistry and Pharmacy, Sofia University, Sofia, Bulgaria

Abstract

Two-antennary oligoglycines are biocompatible compounds with a bola-amphiphilic structure, consisting of a central hydrophobic core attached to two hydrophilic oligoglycine chains of equal length. These molecules spontaneously self-assemble in aqueous media, forming stable

supramolecular structures known as tectomers [1]. The size and shape of these tectomers can be controlled by adjusting experimental parameters such as pH, ionic strength (I), and oligoglycine concentration (C) [2]. Due to their specific structure and properties, two-antennary oligoglycines find applications in various fields (nanotechnology, pharmaceutics, and medicine). However, the lack of a comprehensive theoretical investigation limits the full understanding of the available experimental results.

In the present study, the bulk self-assembly of a member of the two-antennary oligoglycines is investigated, using a combination of experimental and molecular dynamics (MD) approaches. Dynamic light scattering (DLS) experiments reveal the impact of pH, ionic strength, and concentration, on the size distribution and morphology of the self-assembled structures. Based on experimental findings, atomistic MD simulations are performed to obtain insights into the structure of the tectomers and the mechanisms and kinetics of the self-assembly process. Furthermore, proof-of-concept experiments demonstrate the ability of oligoglycine tectomers to capture hydrophobic substances. This study advances our understanding of the self-assembly of oligoglycines and highlights their potential for designing novel nanomaterials with practical applications.

[1] D. Arabadzhieva et al., ChemSusChem, 2019, 12, 672–683.

[2] D. Arabadzhieva et al., Colloids Surf., 2021, 630, 127591.

Acknowledgement: The present investigation is funded by the European Union-NextGenerationEU, project BG-RRP-2.012-0005-C01.

14:20 - 14:40

10 Distribution of polyelectrolytes and counterions upon polyelectrolyte complexation

Giulia Allegri, Ricardo Martinho, Saskia Lindhoud

University of Twente, Enschede, Netherlands

Abstract

When aqueous solutions of oppositely charged polyelectrolytes are mixed, the system phase separates in a dense polyelectrolyte complex phase, rich in polyelectrolytes and, a dilute phase. This process is entropically driven, upon polyelectrolyte complexation the counterions are released. Although polyelectrolyte complexation is extensively studied, so far, no methodology has been proposed and used to determine the compositions of the dense and dilute phase, i.e., the concentrations of the polyanions, polycations and their counterions.

In this talk I will show that NMR can be used to determine these concentrations. The focus will be on complexes of the weak polyelectrolytes polyacrylic acid (PAA) and polyallylamine (PAH)

complexes with Na^+ and Cl^- as counterions, prepared at pH 6.5 with no salt added. Five different mixing ratios were studied, and stoichiometric and off-stoichiometric systems will be compared. Our results allow us to make a detailed sketch of PAA/PAH polyelectrolyte complexes. In addition, mixed weak and strong polyelectrolyte complexes and complexes consisting of oppositely charged strong polyelectrolytes will be discussed as well as the effect of added salt.

We envision that our methodology can be used to study polyelectrolyte complexation in detail and help to develop theory on polyelectrolyte complexation. In addition, we expect that it will contribute to study the Hoffmeister series and will help to characterize ion exchange materials and processes.

14:40 - 15:00

42 Programmable two-dimensional biopolymer-van der Waals heterogeneous interfaces

Shuai Zhang[1,2], Chenyang Shi[1], Wenhao Zhou[2], Chunlong Chen[1,2], Jim De Yoreo[1,2]

[1]Pacific Northwest National Laboratory, Richland, USA. [2]University of Washington, Seattle, USA

Abstract

Biopolymer assembly has emerged as a cornerstone in developing biohybrid materials for diverse applications, including bioelectronics such as sensors, memristors, and force generators. However, designing programmable two-dimensional (2D) heterogeneous interfaces using biopolymers and van der Waals (vdW) materials remains challenging due to the limited understanding of hierarchical assembly mechanisms and the principles for achieving programmable electronic properties.

Our recent work focuses on engineering biopolymers, particularly peptides and peptoids, for hierarchical assembly on vdW surfaces like graphene and MoS_2. We observed various assembly phases on MoS_2 by programming peptoid sequences, including highly crystalline monolayer hybrid films, vesicles, lamellae, and multi-layer ribbons. These assemblies and their transitions are governed by the interplay between peptoids, solvents, and MoS_2, strongly influenced by environmental factors such as pH.

In related research, we demonstrated the epitaxial growth of highly ordered 2D silk fibroin (SF) films on graphite. We used advanced spectroscopic and imaging techniques to show that these films comprise lamellae retaining the native silk nanocrystallite structure. SF multilayer formation occurs via direct assembly or a two-step process involving initial disordered monolayer formation followed by crystallization, depending on concentration. The SF films modulated the surface potential of graphite.

Our findings provide key insights into programming hierarchical biomolecular architectures on vdW materials. In addition, these programmed 2D biopolymer films significantly modulate the surface potential of vdW substrates, offering a robust platform for energy transfer, microelectronics, and quantum information processing applications.

Wetting and Adhesion - 3

13:20 - 15:00 Tuesday, 24th June, 2025
ETLC E1-003
Wetting and Adhesion
Kevin Golovin

13:20 - 13:40

377 Formation and relaxation of soft ridges during condensation of water drops on lubricant-infused surfaces

Till Pfeiffer, Dennis Geier, Peter Stephan, Tatiana Gambaryan-Roisman

Technical University of Darmstadt, Darmstadt, Germany

Abstract

Dropwise condensation is characterized by significantly higher heat and mass transfer rates in comparison to filmwise condensation. Lubricant-infused surfaces are promising for promotion of dropwise condensation of water and increasing of condensation efficiency, since the mobility of drops on such surfaces is increased due to low contact angle hysteresis. In this work, we investigate the microscale mechanisms of dropwise condensation of water from a humid air on lubricant-infused surfaces (LIS). These surfaces are fabricated by coating of glass substrates with a covalently bound solid PDMS layer and a subsequent spin coating with a low viscosity silicone oil film.

In the condensation experiments, the water drops are condensed from the humid air on vertically oriented subcooled substrates. As a drop grows during condensation and coalesces with its neighboring drops, it slides off or rolls over the surface and leaves a soft ridge along its former three phase contact line. We observe the surface tension-driven relaxation of the ridge and use interferometry to determine the height and the width of the ridge as a function of time. The experimental results are compared with the model predictions. We observe that the distribution of newly nucleated drops on the area previously occupied by a large drop crucially depends on the size and a shape of the ridge. Therefore, the dynamics of formation and relaxation of the soft ridge has a major effect on the condensation efficiency.

13:40 - 14:00

338 Hierarchical microtextured surfaces enhance reversible phase transition and wettability of salt hydrates

Ken Chisholm, Kamran Hassani, Sami Khan

Simon Fraser University, Surrey, Canada

Abstract

Salt hydrates, which are inorganic salts with water molecules incorporated within their crystal lattice, are effective energy storage materials due to the latent heat released during their phase transitions. Upon heating, the water of crystallization is ejected from the hydrate to form a concentrated aqueous solution of the salt, which recrystallizes upon cooling to regenerate the original hydrate. A major challenge in this process is subcooling, a detrimental phenomenon where the salt hydrate remains liquified even below its solidification temperature. Random, spontaneous nucleation occurs in subcooled salt hydrates which prolongs the phase change process and affects its long-term consistency and reversibility. In this research, we develop hierarchical microtextured surfaces covered with nanoscale features using laser ablation to enhance the phase change performance of lithium nitrate trihydrate salt. Using environmental scanning electron microscopy (ESEM), we observe that nanotextures promote preferential and predictable nucleation of crystals, while the microtextures enhance the wettability of the aqueous salt solution and suppress subcooling. Through a systematic design of experiments, we identify optimal microtexture criteria such as shapes and spacings that maximize wettability and reversibility of the phase transition even after multiple thermal cycles. Additionally, we find that pre-wetting these hierarchical textures further reduces subcooling and promotes consistent phase change. These findings suggest that highly wettable hierarchical surfaces significantly enhance thermal performance, providing a promising approach for improving the efficiency and reliability of salt hydrate-based energy storage systems.

14:00 - 14:20

147 Dew water collection by functionalized surfaces: The role of surface energy, roughness and surface micro-structure

Francisco Javier Montes Ruiz-Cabello, Sergio Parra-Vicente, Guillermo Lorite-Méndez, Miguel Ángel Rodríguez-Valverde

University of Granada, Granada, Spain

Abstract

Dew water collection mediated by radiative cooling is a promising strategy for passive water harvesting in rain-scarce cold environments. Dew is deposited overnight on surfaces when they are cooled down by a radiative cooling process. When the surface temperature is lower than the dew point, which mainly occurs during the cold seasons, the water vapor starts to condensate on them. Depending on the surface wettability properties, this condensation may be film-wise or drop-wise. The ability of a surface to capture the humidity of the environment is powered by their radiative properties, their thermal conductivity and their ability to drain the liquid water that has been already formed on it (wetting properties). Some natural surfaces such as certain plant leaves or petals are adapted to capture the environmental humidity (dew or fog). Their wetting properties in terms of water contact angle and drop adhesion seem to play a key role. In most cases, the natural surfaces use a combination of different wetting regimes intercalating film-wise or drop wise condensation using chemical patches with different adhesion properties and liquid mobility.

In this work, we studied the water collection of metal substrates with homogeneous and heterogeneous surfaces. As homogeneous surfaces, we fabricated superhydrophilic, hydrophilic hydrophobic petal-like surfaces (parahydrophobic) and superhydrophobic surfaces. As heterogenous surfaces we fabricated directional slippery surfaces inspired on the rice leaf. These surfaces contain grooves or hydrophilic bands that serve as drainers, which promotes faster water renovation. It enhances the rate of condensed and captured water. The water collection was analyzed inside a climate chamber that reproduces and controls the condensation conditions. The surfaces used in study are metal surfaces which roughness was modified by a combination of different surface treatments such as mechanization, laser patterning and acid etching. The surface energy of these surfaces was modified by several hydrophobization processes such as fluoropolymer deposition or silanization.

The aim of the study is to understand and control the key factors that influence the performance of the surfaces as passive water harvesters.

14:20 - 14:40

89 Dew water harvesting on surfaces by conductive cooling: understanding the condensation process

Sergio Parra-Vicente, Miguel Cabrerizo-Vílchez, Francisco Javier Montes Ruiz-Cabello, Miguel Ángel Rodríguez-Valverde

University of Granada, Granada, Spain

Abstract

Climate change, population growth, and future hydrologic uncertainties demand increased water conservation and alternative sources. Atmospheric Water Harvesting (AWH) has emerged as a viable solution, particularly in arid and semi-arid regions, by reducing reliance on centralized water systems and enabling household-level implementation.

Inspired by nature, where organisms have evolved specialized structures to collect water in adverse conditions, bioinspired surfaces with tailored wettability enhance condensation-based water collection. Petal-like surfaces (parahydrophobicity) are especially effective due to their ability to promote pearl-shaped droplet growth and exhibit high droplet retention influenced by volume.

Radiative cooling-based dew water harvesting is a promising passive approach for water collection in open-air environments. This strategy leverages thermodynamic principles, wherein condensation results from a temperature gradient between a surface and its surroundings. However, the liquid layer formed during condensation creates a thermal barrier, limiting further vapor condensation. Efficient removal and renewal of this layer are critical to enhancing the process. The Heat Transfer Coefficient (HTC) plays a key role in determining heat transfer effectiveness during condensation.

This work explores fundamental parameters influencing HTC to optimize water collection. Using a climate chamber to replicate condensation under conductive cooling, factors such as surface temperature, water collection rate, edge effects, and surface durability (aging) were analyzed. Surfaces with varying wettability were evaluated to understand their theoretical and practical contributions. The ultimate goal is to advance open-air radiative cooling for water harvesting applications.

Keywords: Bioinspiration, Dew AWH, Condensation, HTC

Acknowlegments: Financial support was provided by projects PID2020.116082GB.I00 and PID2023.147135OB.I00 (MCIN/AEI/10.13039/501100011033 and FEDER, UE).

14:40 - 15:00

342 Aerophilic micropyramidal surfaces enhance CO2 dissolution in aqueous absorbents

Omar Nemir, Rawad Refai, Ralph Rodrigues, Natasia Fisher, Campbell Tiffin, Sami Khan

Simon Fraser University, Surrey, Canada

Abstract

Despite advancements in clean energy technologies, global carbon dioxide (CO2) concentrations are projected to increase by over 10% in the next three decades, highlighting the urgent need for more efficient CO2 capture methods. In this research, we develop aerophilic micropyramidal surfaces that enhance the dissolution of CO2 in aqueous absorbents. This approach leverages the plastron effect to increase the saturated CO2 concentration at the gas-liquid interface. Aerophilic surfaces with interpyramidal spacings varying between 40.0 µm and 80.0 µm were fabricated using laser ablation followed by vapour deposition of a fluorosilane hydrophobic coating. Their aerophilicity was validated by water contact angle measurements measuring between 152^o and 158^o. The CO2 absorptivity of these surfaces was evaluated and compared with a reference case where CO2 was bubbled into the absorbent under the same flow conditions. We observed a remarkable enhancement in CO2 absorptivity by over 400% using aerophilic surfaces, compared to a maximum absorptivity of 66% using the reference method at absorbent pH as low as 7.5. Using bromothymol blue as a pH indicator, we visualized the development of the CO2 concentration boundary layer and experimental results were further corroborated by a theoretical model predicting enhanced CO2 concentrations near the micropyramidal surfaces. These findings demonstrate the potential aerophilic micropyramidal surfaces to significantly enhance gas-liquid contact efficiency in CO2 capture technologies.

Panel Discussion - From Research to Publication: Editors' Advice

15:20 - 16:20 Tuesday, 24th June, 2025
ETLC E1-003
Wylie Stroberg

Panelists

- Erin Koos, Langmuir
- Marie Krafft, Current Opinion in Colloid and Interface Science
- Hongbo Zeng, Advances in Colloid and Interface Science
- Xuehua Zhang, Soft Matter

15:20 - 16:20

453 Elastic Turbulence in 3D Porous Media

Christopher Brown

University of Pennsylvania, Philadelphia, USA

Abstract

A wide range of environmental, industrial, and energy processes rely on transport in disordered 3D porous media. In many of these settings, transport is limited by strong flow heterogeneities and the steady, laminar flow imposed by geometric confinement (Re«1). Polymer additives have potential as a key engineering tool for modifying these flows to improve transport. However, the flow behavior of these rheologically-complex fluids remains poorly understood in these disordered settings—in large part due to imaging limitations.

My work addresses this gap in knowledge by fabricating transparent 3D porous media and directly imaging the flow in situ. I find that polymer stretching can give rise to an elastic instability that generates turbulent-like fluctuations under conditions prohibitive for traditional turbulence. This is the first demonstration, to our knowledge, that "elastic turbulence" can arise in disordered 3D porous media at flow conditions relevant to industrial applications. Leveraging this new knowledge of the underlying flow, I develop a theoretical model for the macroscopic flow resistance at varying flow rate. This modeling provides the first quantitative link between microscopic fluctuations and macroscopic transport of polymer solutions in porous media, resolving an over-50-year-old puzzle. Understanding of this nonlinear resistance provides us with new engineering control, allowing us to design fluids that reduce flow heterogeneity in stratified porous media. Furthermore, I show how these chaotic fluctuations can enhance pore-scale mixing of solutes, analogous to Batchelor mixing. I show that this dynamic pore-scale mixing works cooperatively with the spatial dispersive effects of porous media, enhancing the macroscopic solute transport by 3–6×. Finally, I demonstrate how this elastic instability can be harnessed to increase the rate of chemical reactions by an order of magnitude, surpassing inherent limitations in packed bed reactors and suggesting new avenues to improve reactivity in environmental and industrial settings. This work demonstrates how couplings between complex geometries and complex fluid rheology can give rise to intriguing flow behaviors—providing new avenues to understand, control, and engineer transport in confined spaces.

Panel Discussion - Colloids & Surfaces at the Forefront: Addressing Global Challenges

16:30 - 17:30 Tuesday, 24th June, 2025
ETLC E1-003
Janet Elliott

Panelists
- Sibani Lisa Biswal, Rice University
- Hans-Jürgen Butt, Max Planck Institute for Polymer Research
- Keith Johnston, University of Texas, Austin

25th June, 2025

Plenary Talk (IACIS Lifetime Achievement Award) - Dominique Langevin (Université Paris-Saclay)

08:30 - 09:30 Wednesday, 25th June, 2025
ETLC E1-001
Greg Warr

On the Role of Surfactants in Emulsions and Foams

Surfactants and Colloidal systems in Resource Extraction - 1

10:00 - 12:00 Wednesday, 25th June, 2025
ICE Incubator
Surfactants and Colloidal systems in Resource Extraction
Zhenghe Xu

10:00 - 10:20

74 Converting soluble pollutants into colloids for intensified wastewater treatments

Kun-Lin Yang, Jianzhong He

National University of Singapore, Singapore, Singapore

Abstract

In high-strength industrial wastewater treatment, Advanced Oxidation Processes (AOPs) are often employed to oxidize pollutants into smaller molecules, ultimately converting them to carbon dioxide (CO_2). However, these methods often prove impractical due to the excessive generation of waste sludge. The addition of chemicals such as acids, caustic soda, catalysts, coagulants, and flocculants contributes to the formation of heavy sludge, which must be treated as hazardous waste and incinerated.

To address the problem, we developed a green process to convert soluble pollutants into colloids, which can be precipitated through coagulation or fluctuation. The transformation can be accomplished either through oxidative oligomerization or atom transfer radical polymerization (ATRP) in aqueous solutions. Both reactions are highly specific and the reaction rates can be accelerated by using a metal-complex catalyst. Specifically, aromatic pollutants such as phenol and aniline form oligomers during oxidative oligomerization with H_2O_2 as an oxidant. When the molecular mass of the oligomers becomes large enough, the oligomerized pollutants started to form colloids, which can be precipitated from the wastewater by using gravity without using any flocculant such as polyaluminum chloride (PAC). The process only requires a minute amount of catalyst and hydrogen peroxide, which decomposes into water and oxygen in the process. The waste sludge is only generated from the pollutant itself. It can be fully recovered and treated in an anaerobic digester to release methane and carbon dioxide. Hence, the process is green and more environmentally friendly compared to traditional advanced oxidation processes (AOPs).

10:20 - 10:40

102 Experimental Analysis of CO_2 Foam Structure and Displacement Dynamics in a Hele-Shaw Cell

Nikoo Moradpour[1], Reza Azadi[1,2], Peichun Amy Tsai[1]

[1]University of Alberta, Edmonton, Canada. [2]The University of Sydney, Sydney, Australia

Abstract

CO_2 foam injection, an alternative to traditional CO_2 gas for enhanced oil recovery (EOR), addresses the challenges of early breakthrough and low sweep efficiency caused by the high viscosity contrast between the gas and oil phases. Our study utilizes a Hele-Shaw visual cell to systematically characterize the foam structure and examine the foam-oil interactions. The foam is generated by simultaneous injection of CO_2 and a surfactant solution, with variations in total injection rates (Q_t) of 2–10 cc/min, gas ratios (R_g) of 0.50-0.90, and surfactant types, including commercial (SDS + SiO_2 nanoparticles) and green (Saponin + cellulose nanofibers). Foam's apparent viscosity is determined using pressure drop measurements and particle image velocimetry

The results show that the mean bubble size increases sixfold by enhancing the R_g from 0.50 (wet foam) to 0.90 (dry foam) at $Q_t = 2$ cc/min. However, this increase in bubble size is less pronounced at higher Q_t of 10 cc/min. The apparent viscosity for commercial foams peaks at 0.77 Pa.s at Rg = 0.85, beyond which instability causes a reduction in viscosity. In addition, the foam viscosity decreases at higher Q_t values of 4 and 10 cc/min. Importantly, when using viscous CO_2 foam at $R_g = 0.85$ for oil displacement, the viscosity contrast is reduced to as low as 0.53, effectively mitigating viscous fingering and delaying breakthrough time. Furthermore, green surfactants demonstrate a foam viscosity increase up to 3.4 times and improve foam stability in contact with oil.

10:40 - 11:00

291 High-Throughput Self-Driving Platform for Optimizing Nanofluids in Geothermal Heat Extraction Applications

Maryam Ebrahimiazar, Mahyar Rajabi, Mohammad Zargartalebi, Mohamad Moosavi, David Sinton

University of Toronto, Toronto, Canada

Abstract

The roles of colloidal systems are increasingly significant in advancing resource extraction processes, including geothermal energy applications. However, scaling such fluids for industrial use requires a comprehensive analysis of their flow and thermal properties under reservoir conditions. This work introduces a high-throughput automated platform designed to measure the thermophysical properties of nanofluids, specifically targeting their use in geothermal heat extraction. Accurately characterizing the thermophysical properties of geothermal fluids is essential for optimizing heat transfer, as these properties directly influence geothermal performance. The platform combines high-pressure, high-temperature microfluidics with automation to precisely characterize viscosity, density, heat capacity, and thermal conductivity at bespoke reservoir conditions, achieving speeds 100 times faster than traditional methods with <1 ml per measurement. Leveraging a Bayesian optimization framework, the platform intelligently guides experiments to efficiently explore the vast formulation space of nanoparticle concentrations and compositions. The platform was validated against over 50 fluid samples, achieving property measurement errors below 5%, and demonstrates the capability to operate autonomously with minimal human intervention. By streamlining the testing and optimization process, this work provides a powerful tool for advancing the development of high-performance nanofluids tailored for sustainable and efficient geothermal energy applications.

11:00 - 11:20

451 Interfacial Hydrophobic Theory and Its DLVO Pro Based on Statistical Thermodynamics

Hongliang Li

Taiyuan University of Technology, Taiyuan, China

Abstract

This paper develops a theory of interfacial hydrophobicity based on statistical thermodynamics and unifies it with the DLVO theory. By considering ligands and spontaneous dipole energy, the weakening of hydrogen bonding at the interface is derived. Through this approach, the enthalpic change in hydrogen bonding is used as the primary factor to derive associated changes in entropy, chemical potential, and density potential. This leads to the construction of the energy transition law for hydrophobic interfaces, as well as the boundary conditions on both sides of the interface, yielding the hydrophobic energy of a single condensed-phase interface and the local densification of the gas-liquid interface. The paper also explores the formation of interfacial microbubbles based on the structure of interfacial water and their relationship with vapor pressure, encompassing the hydrophobic microbubble phenomena. Additionally, changes in hydrogen bonding are used to determine the interfacial dielectric constant, refractive index, and hydrogen bond vibration frequencies.To unify the theory of interfacial hydrophobicity with the DLVO theory, we begin by deriving the hydrophobic-induced ion activity and induced potential from the chemical potential of the hydrophobic interface. Next, we examine the impact of induced ion pairs on surface potential and the adsorption of the electrical double layer (EDL), as well as the feedback of total ion activity

at the interface on the hydrophobic effect. This leads to the formulation of a unified interfacial hydrophobic-DLVO theory, addressing scenarios such as depletion layers, vapor bridges, and gas-liquid interfaces.

11:20 - 11:40

415 Dynamic interfacial behavior and partitioning of naphthenic acids (NAs) and sodium naphthenates (NaNs)

Hassan Ghasemi Vincheh, Rafael Perez Franco, Edgar Acosta

University of Toronto, Toronto, Canada

Abstract

Studies have shown that naphthenic acids (NAs) and sodium naphthenates (NaNs) dominate the interfacial activity of bitumen and the formation of bitumen emulsions. NAs are naturally occurring mixtures of carboxylic acids in bitumen. Unlike other fatty acids, the neutralization of NAs in surfactant-oil-water (SOW) systems does not lead to ultralow interfacial tensions (IFT<0.1 mN/m), which is beneficial for reducing the activation energy of coalescence. Equilibrium partition studies (obtained via HPLC) suggest that a large fraction of NaNs formed at the interface after the neutralization of NAs in alkaline solutions move back into the bulk oil phase. When pre-neutralized NaNs are first dissolved in water and introduced in the SOW system, they produce transient ultralow IFTs. This presentation explores the role of NaN transport at the oil-water interface on this dynamic IFT behavior, assessed via the dynamic partition of naphthenic (NAs, NaNs) species between aqueous phases and model solvents (heptane + toluene mixtures), characterized via HPLC and LC-MS techniques. The implication of this dynamic partition phenomenon on the extraction and processing of bitumen is discussed.

Surfactants and Emulsions - 1

10:00 - 12:00 Wednesday, 25th June, 2025
ETLC E1-018
Surfactants and Emulsions
Lukas Zeininger

10:00 - 10:20

231 Deep-Sea-Inspired Process for Nanoemulsification of Alkyl Ester in Water

Takuya Okamura[1], Takaak Masuda[1], Tsuyoshi Koga[2], Shigeru Deguchi[3]

[1]Pola Chemical Industries, Inc.,, Yokohama, Japan. [2]Kyoto University, Kyoto, Japan. [3]JAMSTEC, Yokosuka, Japan

Abstract

The emulsification of water and oil is vital across diverse industries. Emulsions are thermodynamically unstable, inevitably separating into water and oil phases over time. Thus, even with identical compositions of water, oil, and emulsifiers, emulsions can vary significantly depending on the emulsification method. Developing innovative processes is therefore essential for creating novel emulsion types and expanding their applications.

The Monodisperse Nanodroplet Generation in Quenched Hydrothermal Solution (MAGIQ) process utilizes the unique properties of water under high-temperature and high-pressure conditions to produce nanoemulsions. Near its critical point (T_c = 374 °C, P_c = 22.1 MPa), water becomes miscible with various oils. In the MAGIQ process, a homogeneous oil-supercritical water solution is rapidly quenched by mixing with cold, surfactant-containing water, inducing phase separation. This results in the self-assembly of oil molecules into nano-sized droplets. Unlike conventional techniques, MAGIQ operates as a single-pass process in a flow reactor, enabling the continuous production of alkane-in-water nanoemulsions.

Alkyl esters, a crucial class of oils in practical applications, present a unique challenge for the MAGIQ process due to their susceptibility to hydrolysis and pyrolysis in extreme aqueous conditions. In this talk, we report the nanoemulsification of alkyl esters in water using MAGIQ. Remarkably, the nanoemulsions exhibited negligible degradation of the alkyl esters. Potential mechanisms underlying this suppression of degradation and its implications for expanding the utility of the MAGIQ process will be discussed.

10:20 - 10:40

252 Temperature-induced dynamics of triglyceride droplets: From fragmentation to double w/o/w emulsion formation

Diana Cholakova, Slavka Tcholakova, Nikolai Denkov

Department of Chemical and Pharmaceutical Engineering, Faculty of Chemistry and Pharmacy, Sofia University, 1 James Bourchier Ave., 1164, Sofia, Bulgaria

Abstract

Triglycerides (TAGs) exhibit several polymorphic forms upon crystallization [1]. Recent studies revealed that polymorphic phase transitions in solidified TAG particles create a nanoporous network throughout the lipid structure. These nanopores are spontaneously flooded with the surrounding aqueous medium. For single-component TAGs (e.g. trilaurin, tristearin), this phenomenon results in either spontaneous fragmentation of micrometer-sized particles into nanoparticles as small as 20 nm or the formation of double water-in-oil-in-water (w/o/w) emulsions upon heating [2]. The outcome is governed by the wetting properties of the aqueous surfactant solution.

In practical applications, natural triglycerides, consisting of molecules with mixed fatty acid residues, are used rather than pure TAGs. The melting process of these mixtures occurs over a broad temperature range, enabling co-existence of molten and frozen domains. This complexity offers additional control over lipid melting dynamics. By adjusting melting kinetics, we observed either spontaneous fragmentation or w/o/w emulsion formation for the same surfactant/lipid system [3]. We also identify critical factors enabling nanoparticle production with natural TAG oils, achieved solely through controlled cooling and heating of coarse emulsions, offering scalable methods for producing nanometer-sized particles [4].

Acknowledgements: Current work is supported by the Bulgarian Ministry of Education and Science, National Research Program "VIHREN", project ROTA-Active (no. KP-06-DV-4/2019).

References:

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[2] D. Cholakova et al. *ACS Nano*, **2020**, 14, 8594.

[3] D. Cholakova et al. *Colloids Surf. A*, **2023**, 668, 131439.

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10:40 - 11:00

297 Use of the Double Langmuir-Szyszkowski Isotherm to assess the critical microemulsion concentration (CμC) for single surfactants and surfactant mixtures.

Hassan Ghasemi, Edgar Acosta

University of Toronto, Toronto, Canada

Abstract

The critical microemulsion (μE) concentration (CμC) is the minimal surfactant concentration required to form a middle phase μE or to achieve plateau ultralow interfacial tension (IFT) for surfactant-oil-water (SOW) systems formulated at the surfactant phase inversion point (PIP). Compared to the well-known Critical Micelle Concentration (CMC), little is known about the origins of the CμC, and much less how the surfactant and oil molecular structure affect the CμC value. Knowing the value of CμC is of great industrial relevance because it means being capable of developing ultralow IFTs (lower than 0.1 mN/m) at relatively low surfactant concentrations (often in the order of 0.1 wt%), which is important for applications such as oil demulsification, enhanced oil recovery, and potentially, liquid-liquid extraction. This presentation shows how curves of IFT vs. surfactant concentration (at PIP conditions) lead to a two-step decrease, the first described by the well-known Langmuir-Szyszkowski (L-S) isotherm that follows from surfactant-free systems to system where the surfactant concentration reaches the CMC. The second step is here also described using L-S, where the IFT reduces from its value at CMC (often ~ 1 mN/m) to the IFT at the CμC (~0.01 to 0.001 mN/m). This work reviews literature data, and our experimental data with single surfactants and with surfactant mixtures. The results from applying this double L-S model suggest that after the CMC, surfactant assemblies segregate to the macroscopic oil-water interface. The potential applications and challenges of this approach are discussed.

11:00 - 11:20

85 Indications for rhamnolipid/alkyl ethoxylate segregation in amphiphilic films stabilizing microemulsions

Janine Birnbach[1,2], Francois Ribot[3], Sylvain Prevost[4], Thomas Bizien[5], Tanya K. Todorova[6], Andreas Bick[6], Xenophon Krokidis[6], Thomas Sottmann[7], Niki Baccile[8], Peter Schmiedel[1], Matthias Karg[2]

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Chemie, University of Stuttgart, Stuttgart, Germany. [8]Sorbonne Université, CNRS, Laboratoire de Chimie de la Matière Condensée de Paris, Paris, Germany

Abstract

Many technical applications involve the mixing of oil and water. Specific combinations of surfactants can achieve thermodynamically stable mixing of oil and water, a state known as microemulsion [1]. Many studies have been conducted on microemulsion stabilized by alkyl ethoxylates [2]. Considering the increasing demand for green surfactant systems, we studied the impact of the biosurfactant rhamnolipid (RL) on the structure of the microemulsion $C_{12}E_4$/n-decane/water [3]. By combining a series of complementary techniques, including pulsed gradient spin echo nuclear magnetic resonance, small- and wide-angle x-ray scattering, contrast matching small-angle neutron scattering and coarse-grained molecular dynamic simulations, it was observed, that the RL exerts only negligible influence on the domain size of the microemulsion $C_{12}E_4$/n-decane/water. Interestingly, indications for a nanoscopic phase separation within the mixed amphiphilic film have been found, suggesting that RL and $C_{12}E_4$ prefer homo- rather than hetero-interactions. These new findings on the compatibility of biosurfactants and conventional nonionic surfactants thus provide an important contribution to paving the way for the development of more environmentally friendly formulations for applications such as cleansing.

[1] Tartaro et al. *Nanomaterials* 10.9 (2020): 1657.
[2] Sottmann & Strey. *Fundamentals of interface and colloid science* (2005): 1-96.
[3] Birnbach, et al., *Current Opinion in Colloid & Interface Science* (2023): 101765.

11:20 - 12:00

216 Effect of Oil Species on the Viscoelastic Behavior of Span 65 Film Formed at Oil/Water Interface

Hideki Sakai[1], Hiroki Kuwabara[1,2], Koji Tsuchiya[1], Kyosuke Arakawa[1], Yoshifumi Yamagata[3], Kenichi Sakai[1]

[1]Tokyo University of Science, Noda, Japan. [2]Ikeda Mohando Corporation., Ltd., Toyama, Japan. [3]Anton Paar Japan K. K., Tokyo, Japan

Abstract

Clarifying the viscoelastic properties of oil/water interfacial films is important for evaluating the resistance of emulsions to coalescence. In recent years, strain-controlled rheometers with a bi-cone geometry have become gathered significant attentions for measuring the viscoelasticity of liquid/liquid interfaces1). In the present study, we sought to clarify the effect of oil species on the viscoelastic behavior of the oil/water interfacial film formed by a nonionic surfactant (Span 65) and correlate it with the emulsion stability.

A series of interfacial rheological measurements on saturated hydrocarbons with varying alkyl chain lengths as the oil phase showed that the elasticity of the oil/water interfacial film increased as the difference between the alkyl chain length of the oil phase and that of Span 65 increased. The stability of the water in oil (W/O) emulsions prepared using each oil phase also improved with increasing alkyl chain length difference. These results demonstrated that viscoelastic parameters evaluated using this interfacial rheology are promising indicators for predicting the emulsions stability. From the perspective of differences in the orientations of Span 65 and the oil phase at the interface, we also discussed the mechanism by which the viscoelastic behavior of the interfacial film differs depending on the alkyl chain length of the oil phase.

References: 1) S. Demand, et. al., *J. Surf. Deterg.*, **2019**, *22*, 597-611.

Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 5

10:00 - 12:00 Wednesday, 25th June, 2025
NRE 1-001
Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces
Nikolai Denkov

10:00 - 10:20

120 Dynamic and orientationally ordered cell matrices

Yimin Luo[1], Junrou Huang[1], Yuxin Luo[1], Juan Chen[2], Mengyang Gu[3]

[1]Yale University, New Haven, USA. [2]University of Pennsylvania, Philadelphia, USA. [3]University of California, Santa Barbara, Santa Barbara, USA

Abstract

Cells collectively exert directional forces that drive programmed folding and growth of the layers, forming tissues and organs. This process is often guided by spatiotemporal cues embedded in the extracellular matrix, which regulate cell alignment, collective force generation, and tissue organization. Next-generation tissue scaffolds call for dynamic matrices that are not just passive support for cells, but also actively mediators of cellular behaviors. We envision creating time-varying, ordered, cell-laden matrices, by leveraging concepts and techniques in soft materials. In the first part of the talk, we achieve free-standing, self-organizing matrices by using liquid crystal-templated hydrogel fibers to control cell orientation over centimeter scale in three dimensions. For uniformly aligned cell matrices, oriented cells exert traction forces that can induce anisotropic contraction of the matrix. Simultaneously, the matrix densifies and develops directionality via cell remodeling. This approach can be extended to create cell arrangements with arbitrary in-plane patterns, allowing for coordinated cell forces and pre-programmed, macroscopic shape changes. In the second part of this talk, we investigate how the dynamics of network formation can influence

cell morphologies. We adopt an active learning approach to improve gelation time prediction for a two-component, polyethylene glycol-based hydrogel at varying temperatures, concentrations, and pH conditions. We show that gelation time reliably predicts the aspect ratio of encapsulated cells in double networks. Our work reveals fundamentally new modalities for controlled force generation and the dynamic control of cell shapes.

10:20 - 10:40

71 Confounding Experimental Variables in Measuring Cell Volume Osmotic Responses Relevant to Cryopreservation

Faranak Yadegari, Janet A. W. Elliott

University of Alberta, Edmonton, Canada

Abstract

Cryopreservation is the process of stabilizing biological matter such as cells and tissues at extremely low temperatures (e.g., −196 °C). During cryopreservation, cells are susceptible to various injuries that can be mitigated by controlling the cooling and warming rates and adding cryoprotectants. The presence of cryoprotectants, and cooling and warming in the presence of extracellular ice, cause osmotic changes in cell volume that in themselves can be harmful. Mathematical models of the osmotic transport of water and solutes across cell membranes are used in understanding cryobiological processes and developing optimal cryopreservation procedures. There is a debate in the literature about whether or not there are non-osmotic mechanisms controlling the cell volume that take place during cryopreservation. In this work, we examine the role of confounding variables in interpreting experimental cell volume responses to changes in osmolality. We show that for human umbilical vein endothelial cells (HUVECs) experimental artefacts can be incorrectly interpreted as non-osmotic responses. This highlights the need for precise experimental procedures and mathematical modelling of cell osmotics when analyzing experimental data to investigate the potential role of non-osmotic mechanisms.

10:40 - 11:00

285 Phase behavior of a potentially cryoprotectant plant membrane lipid in Langmuir monolayers.

Joshua Boyd[1], Elena Sánchez-Brenes[2], Zachery Shomo[3], Rebecca Roston[3], Elizabeth Mann[1], Edgar Kooijman[2]

[1]Kent State University Department of Physics, Kent, USA. [2]Kent State University Department of Biological Sciences, Kent, USA. [3]University of Nebraska-Lincoln Department of Biochemistry, Lincoln, USA

Abstract

Freezing tolerance in plants is a complex trait influenced by multiple factors, including membrane lipid composition. During severe cold, the chloroplast membrane accumulates distinctive oligogalactolipids, specifically trigalactosyldiacylglycerol (TGDG) and the enzyme synthesizing it is essential for freezing tolerance. The specific role of this lipid in conferring membrane tolerance to cold remains poorly understood. Here, we compare the behavior of this lipid with related lipid systems, in a model membrane system, the Langmuir monolayer. The other two lipids studied are MGDG (Monogalactosyldiacylglycerol) and DGDG (Digalactosyldiacylglycerol), from which TGDG is formed. The Langmuir isotherms, together with Brewster Angle Microscopy images, show that MGDG and DGDG formed homogeneous monolayers at most surface pressures, while TGDG exhibited domain formation at all pressures. These data show that MGDG, DGDG, and TGDG have significantly different behavior at the air-aqueous surface, which may form the starting point for new insights into the mechanisms allowing membranes to tolerate both low temperature and low hydration.

11:00 - 11:20

80 Intracellular Ice Detection by Freeze Substitution and Automated Image Analysis

MingHan Yu, Leah Marquez-Curtis, Janet Elliott

University of Alberta, Edmonton, Canada

Abstract

Controlling the formation of ice within cells is an integral aspect of developing successful cryopreservation protocols for cells and tissues. For simple tissue constructs such as cell monolayers, cryopreservation parameters including cryoprotective agents, adhesion substrates, and cooling profile have all been hypothesized to influence intracellular ice formation. However, current assessment of the influence of these parameters on intracellular ice formation is either done without direct quantification of ice formation, or completely visually through manual counting of

the number of cells exhibiting ice formation in only a few select images. Here, we report our development of a freeze substitution protocol to visualize intracellular ice formation in cell monolayers, and the design of an associated automated ice detection algorithm for high-throughput image analysis. Together, these protocols provide a data-driven method to quantify ice formation in cell monolayers subjected to various cryopreservation parameters, with the automated algorithm producing comparable accuracy in ice detection to the manual visual counting method while allowing for rapid processing of large numbers of images. This new tool enables direct, quantitative assessment of intracellular ice in cryopreservation or tissue-freezing experiments. Furthermore, it provides an additional assay to evaluate the cryoprotective effects of various cryopreservation parameters and can help inform decision-making when designing future cryopreservation procedures.

This research was funded by the Canadian Institutes for Health Research (CIHR PS 166125). J. A. W. Elliott holds a Canada Research Chair in Thermodynamics.

11:20 - 11:40

75 Impact of lignin nanoparticles on oil spill bioremediation by oil-degrading bacteria

Amber Pete[1], Michael Benton[2], Bhuvnesh Bharti[2]

[1]Missouri University of Science and Technology, Rolla, USA. [2]Louisiana State University, Baton Rouge, USA

Abstract

Effective and timely remediation of marine oil spills is crucial. Bioremediation is a technique employed to manage oil spills, in which naturally occurring microbial species metabolize hydrocarbons, thereby removing oil from the environment. However, complete biodegradation can take decades, prompting ongoing research into methods to enhance this process. Recent studies have explored the use of nanoparticles to accelerate biodegradation rates, as these nanoparticles can serve as emulsifiers that increase the bioavailability of oil. This study investigates the effects of lignin nanoparticles on the hydrocarbon-degrading capabilities of the marine bacterium *Alcanivorax borkumensis*. We examine how the surface charge of the nanoparticles influences their adsorption onto the bacterial surface and the subsequent binding of the bacteria-nanoparticle composite at the oil-water interface. The surface charge of the nanoparticles was modified by selectively coating them with the positively charged polyelectrolyte chitosan. Notably, we observed nearly a 50% increase in the number of bacteria adhering to hexadecane when chitosan-coated lignin nanoparticles were present, compared to cells cultivated without nanoparticles. We correlate the observed growth rates of the bacteria in the presence of nanoparticles with interfacial tension measurements, suggesting that chitosan-coated lignin nanoparticles enhance the proliferation *of A. borkumensi*s and likely promote an increase in biosurfactant production by the bacterium. These findings highlight the potential of naturally derived nanoparticles to improve the bioremediation of spilled oil, offering a sustainable alternative for large-scale oil spill remediation.

11:40 - 12:00

272 Probing the Mechanism of Liquid-to-Solid Transitions in Peptide-Based Polyelectrolyte Complexes

Tahoora Ateeq[1], Christian Reinhardt[2], Akash Rajaram[1], Pritha Sarkar[1], Kausik Mukhopadhyay[1], Lorraine Leon[1]

[1]University of Central Florida, Orlando, USA. [2]University of Michigan, Ann Arbor, USA

Abstract

Membraneless organelles (MLOs) perform essential functions in the body such as cellular organization and biomolecule compartmentalization and are formed via liquid-liquid phase separation. Notably, MLOs have been observed to undergo a transition from phase-separated liquid droplets to solid aggregates in diseases such as amyotrophic lateral sclerosis, Alzheimer's disease and various cancers. Similarly, polyelectrolyte complexes (PECs), formed upon counterion release between a polycation and polyanion, can form liquid droplets as well as solid aggregates. To study potential factors driving pathogenic liquid-to-solid transitions in MLOs, we have used a peptide-based PEC system which allows for control over properties such as charge density and aromaticity, which are also present in MLOs. By chiral patterning of our peptides based on previous studies, we have been able to develop a library of solid-forming and liquid-forming PECs. Upon mixing solid PECs into our liquid PEC system, liquid-to-solid transitions of complexes were observed via optical microscopy and fluorescence microscopy with Thioflavin-T. The change in secondary structure was quantified using FT-IR. Results illustrated that chain length and hydrophobicity play a role in the ability of a solid complex to transition a liquid PEC, whereas percent beta-sheet secondary structure of the solid complex as well as type of beta-sheet secondary structure may not play a role. Turbidimetric studies of critical salt concentration and increasing charge ratio of additional complexes have shown that pairing of the cationic solid-forming peptide and anionic liquid forming peptide may be driving the liquid to solid transitions.

Colloids for Sustainability and Energy - 4

10:00 - 12:00 Wednesday, 25th June, 2025
ECERF W2-110
Colloids for Sustainability and Energy
Sathish Ponnurangam

10:00 - 10:40

100 Interactions between Nanoparticles and Soft-Matter-Liquid Interfaces: Towards Developing Generic Nanocomposites, Conductive Inks with Low Sintering Temperatures, and Droplet-Based Cargo Transfer Mechanisms

Siddhartha Das

University of Maryland, College Park, USA

Abstract

In this talk, I shall discuss three recent studies from my group, where interactions between nanoparticles and soft-matter-liquid interfaces have been leveraged to unravel interesting effects that have deep implications towards a variety of different applications in the area of colloidal science.

First, I shall discuss a molecular dynamics (MD) simulation study that shows the possibility of establishing stable contacts between a nanoparticle (NP) and a layer of solvated grafted polymer layer phobic to the NPs, by harnessing appropriate wetting and steric interactions. Such an accomplishment opens up avenues for applications involving a much larger array of NP and polymer combinations transcending the barriers dictated by the limited interaction strengths between the NP and the polymer.

Second, I shall discuss our investigation highlighting the true cause that dictates the failure of the sintered 3D-printable metallic nanoparticle-based conductive inks to match the conductivity of the bulk metals. Using experiments and simulations, we establish that under standard sintering conditions there remains a residual polymer layer on NP surfaces, preventing direct NP-NP contacts, causing the reduced conductivity. This finding motivates designing conductive inks with low sintering temperatures.

Finally, I shall discuss my group's recent findings, where we enforce magnetic NPs (present inside a drop) to aggregate and interact with drop-PDMS interface enabling their complete de-encapsulation (in the presence of a magnetic field) from the drop interior. We further utilize this mechanism for (1) de-encapsulation-based particle deposition and printing; (2) nanoparticle cargo transfer and exchange between drops; (3) drop-encapsulate interaction driven drop-drop coalescence.

10:40 - 11:00

278 Electrophoretic deposition solves the carbon nitride leaching problem in g-C_3N_4 coated TiO_2 nanotube array photoanodes

Navneet Kumar, Narendra Chaulagain, Biya Saji, Kazi Alam, Karthik Shankar

University of Alberta Faculty of Engineering, Edmonton, Canada

Abstract

Graphitic carbon nitride (g-C_3N_4) has gained significant attention due to its favorable optoelectronic properties for photo/electrocatalysis, and its remarkable thermomechanical and chemical resilience. g-C_3N_4 is a metal-free polymeric organic semiconductor that has a 2D-layered structure and absorbs visible light. Due to its ability to form efficient heterojunctions with various semiconductors, it has been researched extensively in hydrogen evolution via photoelectrochemical water splitting. However, an inherent issue with carbon nitride is the leaching of its film in strong alkaline and acidic media, thus raising doubts on the durability of g-C_3N_4-based heterojunction photoanodes. Here we report an electrophoretically deposited (EPD) carbon nitride film on transparent TiO_2 nanotube arrays (TNTAs) that shows excellent adhesion to the TiO_2 layer beneath. The deposition was carried out by preparing a colloidal solution of carbon nitride nanoparticles (CNNP) in dimethyl sulfoxide (DMSO) and applying a voltage bias to the substrate to be deposited (TNTAs in this case) for a few minutes. When the EPD-mediated g-C_3N_4/TNTA heterojunction photoanode was tested in sunlight-driven photoelectrochemical water splitting under AM1.5G one sun irradiation in an aqueous electrolyte of 1 M KOH, it generated a photocurrent density of 3.3 $mAcm^{-2}$, more than 4 times the photocurrent density generated by a bare TiO_2 nanotube array photoanode. It was observed that the g-C_3N_4/TNTA photoanode sample retained the g-C_3N_4 layer even after 1 hour of exposure in the solar-illuminated electrolyte pointing to its superior photostability and durability. Our work demonstrates a way forward to deposit leaching-free g-C_3N_4 films on various technologically important substrates.

11:00 - 11:20

381 Room-temperature Flow-synthesis of Pd–Ru Solid-solution Alloy Nanoparticles Using a Microreactor and Catalytic Performance of Carbon Monoxide Oxidation

Shotaro Danjo, Shotaro Hiraide, Satoshi Watanabe
Kyoto University, Kyoto, Japan

Abstract

Solid-solution alloy nanoparticles (ANPs) can fine-tune their electronic states by tuning their size and composition, thereby enabling properties often unattainable with single-component metals and driving diverse catalytic and optical innovations. Although the crystal phases of bulk alloys are typically designed via thermodynamic phase diagrams, nanoscale systems can exhibit non-typical solid solutions in the bulk state. However, synthesizing ANPs from immiscible elements often requires high temperature, high pressure, or organic solvents. Here, we introduced a simple method

to synthesize palladium–ruthenium (Pd–Ru) ANPs in aqueous solution at room temperature using a microreactor with excellent mixing performance (Figure). By minimizing inhomogeneous mixing and instantly introducing a strong reducing agent, Pd^{2+} and Ru^{3+} ions were simultaneously and rapidly reduced, and uniform alloy nuclei were formed. Synchrotron X-ray diffraction, electron microscopy, and energy-dispersive X-ray spectroscopy confirmed that the resulting nanoparticles exhibited substitutional solid-solution phases even at room temperature. The unique local distortions arising from room-temperature synthesis enhanced catalytic performance in CO oxidation, surpassing monometallic Pd or Ru. Notably, Ru-rich ANPs showed the highest activity at lower temperatures. These findings underscore the critical role of process intensification and microfluidic platforms in producing immiscible alloy systems under mild and green conditions. This microreactor-based approach paves the way for efficient, scalable production of advanced colloidal catalysts in energy and environmental applications. Eliminating high-temperature or high-pressure steps also mitigates safety hazards, offering more sustainable routes to alloy-based technologies. Overall, these results highlight the significance of microreactor-based approaches in colloidal interface science.

11:20 - 11:40

154 Phytoglycogen: Soft Nanoparticles with Tunable Properties

John Dutcher, Michael Grossutti, Benjamin Baylis, John Simmons, Hurmiz Shamana, Nicholas van Heijst, Carley Miki, Benjamin Morling

University of Guelph, Guelph, Canada

Abstract

Phytoglycogen (PG) is a glucose-based polymer with a tree-like or dendritic architecture that is produced as rather monodisperse, dense, compact nanoparticles in the kernels of sweet corn. Our measurements of their structure, morphology, hydration and stiffness using a wide range of microscopy (Figure 1), spectroscopy and scattering techniques have revealed that the particles are soft, porous, hydrated and hairy. These physical properties, combined with their non-toxicity and digestibility, make PG ideal for a broad range of applications in personal care, nutrition and biomedicine, and offer opportunities to probe fundamental issues such as the soft colloidal glass transition and the structuring of nanoconfined water. The properties of PG can also be tuned through controlled digestion using dilute acids or enzymes, or through covalent attachment of chemical groups that can impart different functionalities such as charge and hydrophobicity. These simple modifications have produced significant and sometimes dramatic changes to the physical properties of the particles, opening up new applications of this sustainable nanotechnology.

Figure 1: Atomic force microscopy (AFM) force spectroscopy images of a single PG nanoparticle measured in Milli-Q water, consisting of 9604 force-distance curves [Baylis et al., Biomacromolecules 2021, 22, 2985−2995]. (A) height image corresponding to the contact point

between the AFM tip and the particle; (B) height image collected with an applied force of 2 nN; (C) Young's modulus image of the particle.

11:40 - 12:00

232 High-yield and scalable preparation of lignin nanoparticles with size-independent surface properties for stable Pickering emulsions

Lin Chen[1], Patrícia Figueiredo[1], Maarit Lahtinen[1], Kirsi Mikkonen[1,2]

[1]Department of Food and Nutrition, Faculty of Agriculture and Forestry, University of Helsinki, Helsinki, Finland. [2]Helsinki Institute of Sustainability Science (HELSUS), University of Helsinki, Helsinki, Finland

Abstract

Lignin, a sustainable and abundant biopolymer, holds immense potential for advanced material applications. Lignin nanoparticles offer enhanced functionality and tunable properties compared to bulk lignin, generating increasing interest in research and industry. This study presents a green, scalable method for preparing lignin nanoparticles via antisolvent precipitation, with a focus on high yield and robust performance. The process is environmentally friendly, as organic solvents are fully recyclable. The resulting particles can be easily redispersed in aqueous media by sonication.

The effects of lignin concentration on particle size, zeta potential, yield, and surface properties were systematically investigated. Particle size and yield increased with concentration at moderate levels, stabilizing when a balance between nucleation and growth was reached. Lignin nanoparticles demonstrated excellent surface activity, effectively adsorbing at oil-water interfaces and reducing interfacial tension. Remarkably, the surface properties, including contact angle and dynamic interfacial tension remained size-independent across the experimental range (hydrodynamic diameter 100–370 nm), ensuring consistent functional performance. The lignin nanoparticles were further employed as stabilizers for Pickering emulsions, which demonstrated uniform droplet sizes and excellent stability, irrespective of particle size.

This work highlights the scalability and sustainability of lignin nanoparticles production with minimal impact on their performance, offering a promising pathway for developing eco-friendly emulsions and advanced biobased materials. The findings underscore the potential of lignin nanoparticles as versatile, high yield, and surface property stable agents for green material applications.

Industrial Applications of Colloid and Surface Systems -1

10:00 - 12:00 Wednesday, 25th June, 2025
ECERF W2-010
Industrial Applications of Colloid and Surface Systems
Noemi Nagy

10:00 - 10:20

209 Colloidal Particles and Pickering Emulsions: A Journey of Innovation and Application

To Ngai, Liangdong Liu, Tong Zhang

The Chinese University of Hong Kong, Hong Kong, China

Abstract

The application of colloidal particles at fluid interfaces has gained considerable interest in recent years, especially regarding Pickering emulsions, which utilize these particles instead of conventional surfactants for stabilization. This method not only improves emulsion stability but also facilitates the development of advanced materials with customized properties. In this talk, I will first outline the behavior of colloidal particles at fluid-fluid interfaces, highlighting the essential connection between single-particle interactions and the overall properties of the emulsions produced. Then, I will demonstrate the use of these Pickering emulsions as templates for creating hollow spheres, which offers exciting possibilities for applications in UV-blocking and functional materials. By harnessing the structural and functional adaptability of colloidal systems, we can create innovative materials that fulfill the needs of various sectors, from personal care to advanced coatings.

10:20 - 10:40

143 Detection of PFAS by diblock copolymer PS-*b*-P4VP in complex emulsions at ppb levels.

Narani Rakesh[1], Meng-Fu Hsieh[1], Cathy cathy[2], Huang Hang[1], Dr. Hsiung Tu Lin[2], Dr. Che-Jen Lin[1]

[1]National Dong Hwa University, Hualien, Taiwan. [2]Academia Sinica, Taipei, Taiwan

Abstract

This study explores the use of polystyrene-block-poly(4-vinylpyridine) **(PS-*b*-P4VP)** diblock copolymers as effective stabilizers for complex triple emulsions, particularly for the detection of per- and polyfluoroalkyl substances **(PFAS)** in aqueous environments. The amphiphilic nature of

PS-*b*-P4VP enables it to significantly manipulate interfacial tension and stabilize liquid-liquid interfaces, facilitating the encapsulation of water layers within hydrocarbon and fluorocarbon phases. We synthesized **PS-*b*-P4VP** with varying monomer ratios and employed a vortex method to prepare complex emulsions, observing notable morphological transformations upon the introduction of **PFAS**.

The interaction between the **P4VP** segment of the copolymer and **PFOA** leads to alterations in droplet morphology, which can be quantitatively assessed through **MWFC** (multi-well flow chips) changes in morphological properties at low detection levels. Our results demonstrate that these emulsions can serve as responsive platforms for **PFOA** detection, showcasing their potential application in environmental monitoring. This work highlights the versatility of **BCPs** in emulsion stabilization and their critical role in developing advanced sensing mechanisms for hazardous substances.

10:40 - 11:00

364 Electrochemical TEMPO-mediated oxidation to tailor industrially-produced cellulose nanocrystals (CNCs)

Alexandra Rousseau, David P. Wilkinson, Emily D. Cranston

University of British Columbia, Vancouver, Canada

Abstract

A typical method to carboxylate nanocelluloses uses (2,2,6,6-tetramethylpiperidin-1-yl)oxyl (TEMPO)-mediated oxidation. TEMPO – a stable radical catalyst – oxidizes primary alcohols to carboxylic acids. These -COOH groups are deprotonated over a wide pH range, making carboxylated nanocelluloses, such as cellulose nanocrystals (CNCs), charged and colloidally stable in many aqueous environments.

We previously demonstrated the use of an electrochemical approach to replace oxidizing agents in TEMPO-mediated CNC oxidation. Conventional TEMPO-mediated oxidation uses strong oxidizing agents, such as bleach, to convert TEMPO to its reactive form TEMPO$^+$. TEMPO$^+$ then reacts with the alcohols on the cellulose surface to impart charged groups. We successfully replaced the use of bleach with an electrochemical potential, and while optimizing the reaction for this new approach, we found that mildly alkaline conditions (pH 8.5) and a divided electrochemical cell were necessary for high product yield. With this new knowledge, we have scaled the reaction and improved conditions to create the best possible product and determine its economic feasibility.

In this work, we applied our electrochemical modification method to industrially-produced CNCs to "boost" to carboxyl content. For the starting material, we used low-charge carboxylated CNCs (140 mmol COOH/kg CNC) and sulfated CNCs (250 mmol OSO_3H/kg CNC). We demonstrate

the use of our novel reaction as a follow-up modification to tailor industrially-produced CNCs for specialized applications. The electrochemically-modified CNCs were characterized by surface charge titration, atomic force microscopy size, powder X-ray diffraction crystallinity, and colloidal stability.

11:00 - 11:20

48 Stimuli-Responsive Colloidal Gates for Tunable Liquid and Molecular Transport

Gideon Onuh, Oz M. Gazit, Ofer Manor

Technion - Israel Institute of Technology, Haifa, Israel

Abstract

We developed stimuli-responsive particle systems with tailored interfacial properties to enable the controlled transport of liquids and molecules. Drawing inspiration from the natural swelling and shrinking behavior of clay particles in response to changes in pH, we have designed sub-micron silica colloids densely grafted with pH-sensitive polyelectrolyte brushes. These "colloidal gates" exhibit reversible volume transitions upon variation of the solution pH, effectively modulating the transport of liquids and molecules through a fixed-bed column packed with the particles. At higher pH values, the polyelectrolyte brushes undergo deprotonation, leading to particle dispersion and increased permeability of the column. Conversely, at lower pH, the protonated brushes promote particle coagulation and reduced transport. We have systematically investigated the coagulation and dispersion behaviors of the pH-responsive particles as a function of ionic strength and pH, and correlated these interfacial properties with the observed transport phenomena. Our results demonstrate the key role of surface forces and interparticle interactions in governing the permeability of the colloidal system [1]. This work showcases the potential of stimuli-responsive colloidal gates as a versatile platform for the development of smart separation and filtration technologies, with applications ranging from water purification to drug delivery.

Reference

[1] G. Onuh, R. Bar-On, and O. Manor, “Particle Network Self-Assembly of Similar Size Sub-Micron Calcium Alginate and Polystyrene Particles Atop Glass,” Macromolecular Bioscience, p. 2300219, Aug. 2023. [Online]. Available: https://onlinelibrary.wiley.com/doi/10.1002/mabi.202300219

11:20 - 11:40

129 Applications of Functionalized Cellulose Nanocrystals (CNCs) in Organic Optoelectronics and Photocatalysis

Kazi Alam, Narendra Chaulagain, John Garcia, Navneet Kumar, Karthik Shankar

University of Alberta Faculty of Engineering, Edmonton, Canada

Abstract

CNCs are crystalline building blocks of cellulose, which is a naturally occurring carbohydrate polymer. CNCs are essentially nanorods with widths of 5-50 nm and lengths of 100-2000 nm exhibiting insulating properties and a high strength-to-weight ratio. CNCs have a high surface density of hydroxyl (-OH) groups which renders them dispersible in water. Due to CNCs' electrically inert nature and incompatibility with organic solvents, the electronic applications of CNCs have been mostly ignored. However, the one-dimensional needle-like morphology of CNCs coupled with the ability to graft π-conjugated organic moieties on the surface of CNCs through esterification protocols has opened up intriguing possibilities to improve the optoelectronic properties of thin films of both small molecule organic semiconductors (SM-OSCs) and conjugated polymers (CPs). Electronically active aggregates of crystalline SM-OSCs suffer from a planarity restriction which limits their use in three-dimensional devices such as bulk heterojunction organic photovoltaics. This restriction can be relaxed or overcome by grafting crystalline SM-OSC aggregates on the surface of rod-like CNCs. We conjugated zinc phthalocyanine (ZnPc) to CNCs. The resulting ZnPc-CNC core-shell nanorods were brightly fluorescent and enabled the construction of bistable all-organic memory devices. CNCs conjugated to cobalt phthalocyanine exhibited long-lived charge separation and visible light-driven photocatalytic activity. While CPs can be easily cast into three-dimensional, semiconducting thin films and blends, one encounters non-ideal chain conformations due to the chains becoming twisted and/or tangled. Polymer-grafted CNCs exhibited an improved, lamellar chain morphology when blended with poly(3-hexylthiophene) which dramatically improved the optoelectronic properties of the blended films.

11:40 - 12:00

389 DNA Delivery to Intact Plant Cells by Casein Nanoparticles with Confirmed Gene Expression

Avital Ben-Haim[1,2], Guy Mechrez[3]

[1]Department of Food Sciences Institute of Postharvest and Food Sciences Agricultural Research Organization (ARO) Volcani institute, 68 HaMaccabim Road, Rishon Letzion 7505101, Israel. [2]The Robert H. Smith Faculty of Agriculture Food and Environment The Hebrew University of Jerusalem, POB 12, Rehovot 7610001, Israel. [3]Department of Food Sciences Institute of

Postharvest and Food Sciences Agricultural Research Organization (ARO) Volcani institute, POB 12, Rehovot 7610001, Israel

Abstract

This research presents gene expression after DNA delivery into intact

plant cells by protein nanoparticles. The DNA delivery is carried out by casein nanoparticles (CNPs). A plasmid harboring the red fluorescent protein DsRed sequence is absorbed to the CNPs surface by electrostatic interaction and served as a model DNA in this study, and its expression is monitored by the fluorescence of the DsRed protein. The zeta potential of the CNPs is tuned by altering the pH to obtain sufficient electrostatic interaction between the CNPs and the DsRed plasmid for successful DNA delivery into the cells of the model plant ***Nicotiana benthamiana***. The CNPs are covalently modified with the green fluorescent dye 6-Aminofluorescein (6-AF) to determine their location in the plant. To assess the ability of the CNPs to deliver DNA into the cells, CNP/6- AF/DsRed plasmid electrostatic conjugates are infiltrated into ***N. benthamiana*** leaves. Confocal fluorescence microscopy results showed successful intracellular and nucleus uptake of the conjugates at pH 4.5 and a concentration of 2 mg mL^{-1} at CNPs: DsRed plasmid ratio of 1:0.01. The successful gene expression is confirmed by RT-PCR and qRT-PCR. The first appearance of the emitted red signal of the DsRed protein is observed 24 h post-infiltration.

Molecules and Particles at Fluid Interfaces - 3

10:00 - 12:00 Wednesday, 25th June, 2025
ETLC E2-001
Molecules and Particles at Fluid Interfaces
Alberto MARTIN-MOLINA

10:00 - 10:20

30 Investigating the effect of temperature on in situ cyclodextrin inclusion complex interfacial films

Oisin Owens[1], Olivier Cayre[1], David Harbottle[1], Benjamin Lobel[2], Ian Harrison[3]

[1]University of Leeds, Leeds, United Kingdom. [2]Murdoch University, Perth, Australia. [3]Givaudan, Paris, France

Abstract

Cyclodextrin (CD) inclusion complexes (ICs) are effective oil-water emulsion stabilisers, offering several advantages such as encapsulation of a variety of guest molecules, non-spherical emulsion droplet formation, the self-assembly of dense, resilient films at liquid-liquid interfaces. Additionally, their biocompatibility makes them a sustainable alternative to petroleum-based surfactants in various applications. Dissolved in the emulsion aqueous phase, CDs IC compatibility with oil molecules provides a host of interesting well-defined structures upon self-assembly. Such emulsions appear to stabilise the interface as Pickering particles and thus tend to benefit from high stability when kept in the same initial conditions. However, shifts in the host-guest complexation equilibrium (such as upon dilution) drastically influence IC-loaded films, which is generally poorly understood along with the role of guest structure. Indeed, unlike conventional Pickering particles, CD ICs appear to respond to shifts in their environment and desorb from the interface, influencing the properties of the corresponding emulsion.

This work investigates the response of the IC laden interfacial film upon temperature rises for a series of oils with increasing alkane chain length and complexity. The solid CD-oil IC networks ability to retain its elastic film integrity under environmental shifts is examined by measuring the changes in film elastic and loss modulus when subjected to interfacial shear stress in a double wall ring interfacial rheometer with temperature control unit. Additionally, we provide visual representation of the influence of oil type and temperature on the interfacial aggregates that populate the IC film by imaging the emulsion droplets optically and in Cryo-SEM.

10:20 - 10:40

114 New class of Pickering emulsion stabilized by ultra soft microgels: Pac-man emulsions

Man Hin Kwok, Eliana Yi Yan Chan, To Ngai

The Chinese University of Hong Kong, Hong Kong, Hong Kong

Abstract

Conventional Pickering emulsions are formed by self-assembly of interfacially active colloids at the oil-water interfaces. Each emulsion droplet is expected to be surrounded and stabilized by numerous adsorbed colloids, protecting them from coalescence and phase separation. Soft nanoparticles such as microgel also exhibit remarkable interfacial activity and considered to be effective Pickering stabilizers. The deformability of these soft colloids is found to play an important role in the emulsification process. Recently, the deformability of poly(*N*-isopropylacrylamide-*co*-methacrylic acid) (pNIPAM-MAA) microgels has once again been pushed to the limit by a carefully designed temperature-programmed synthesis. The resulting microgels are capable of achieving a staggering 2.6-fold pH-responsive swelling from 2.4 µm to 6.3 µm. These ultra soft (pNIPAM-MAA) microgels are extremely deformable while their interfacial activity is maintained. Therefore, they can bend dramatically and surround oil droplets, forming a new class of Pickering emulsions: Pac-man emulsions. One oil droplet is stabilized by one highly deformed microgel particle and the shape of them resembles the classic arcade game Pac-man. Pac-man emulsions also display interesting rheological properties that are different from their conventional counterparts.

10:40 - 11:00

166 Understanding the stability of Pickering emulsions using on-chip microfluidics

Xuefeng Shen, Siddharth Deshpande, Jasper van der Gucht

Wageningen University & Research, Wageningen, Netherlands

Abstract

Particle-stabilized emulsions, commonly referred to as Pickering emulsions, offer superior stability, and functional versatility, compared to conventional surfactant-stabilized emulsions. While the majority of the work in this field has focused on densely covered Pickering emulsions, such emulsions are known to retain their exceptional stability even when the interfaces are sparsely covered with particles. In this talk, I will present our latest findings regarding the formation, dynamics, and stability of poorly covered model Pickering emulsions using a microfluidic

platform, enabling precise design, production, and systematic analysis. I will show that the formed Pickering emulsions remain highly stable, over at least 12 hours, even with a surface area coverage below 3%. By directly visualizing the droplet interface at various stages, the exceptional stability is attributed to the highly spatially heterogeneous distribution of the adsorbed particles which exclusively form particle bridges at the contact point between the droplets. Remarkably, these bridges are assembled in the form of crowns between the droplet interfaces, as visualized by confocal microscopy. Lastly, I will discuss the different forces present during emulsification and how the assembly behavior of the adsorbed particles is dominated by hydrodynamic forces leading to a non-uniform particle distribution, corroborated by numerical simulations. In conclusion, our work provides an easy-to-access, controlled lab-on-a-chip platform to study Pickering emulsions, and gives important insights about the production and dynamics of Pickering emulsions via preferential interfacial localization of particles.

Reference: X. Shen et al., Understanding the stability of poorly covered Pickering emulsions using on-chip microfluidics, Advanced Science (in press)

11:00 - 11:20

175 PHOTO-RESPONSIVE RECONFIGURABLE PICKERING EMULSIONS

Shivangi Chourasia, Catherine P Whitby

Massey University, Palmerston North, New Zealand

Abstract

Reconfigurable emulsion systems have gained interest in colloidal science for their ability to reversibly change configurations in response to external stimuli. While advances have been made in designing surfactant-stabilised, photo-responsive emulsions, using particles to stabilise reconfigurable photo-responsive emulsions remains unexplored.

This study investigates the development of light-responsive oil-in-oil-in-water double emulsions stabilised by both surfactants and particles. Hydrocarbon and fluorocarbon oils were used, with the oil-water interface stabilised by a 1:1 ratio of fluorocarbon (Capstone FS30) and photo-responsive (PhRes) surfactants. PhRes contained an azobenzene moiety that underwent photo-isomerization between cis and trans form on UV and Blue irradiation. This ratio resulted in a Janus configuration, with both oils exposed to the aqueous phase. Before UV irradiation, the hydrocarbon tail of the PhRes surfactant effectively stabilised the hydrocarbon-water interface, leading to configurations where fluorocarbon oil was less exposed to the aqueous phase. Upon UV irradiation, PhRes became less effective, allowing Capstone to dominate, leading to increased exposure of fluorocarbon oil to the aqueous phase. Blue light restored the *trans* form of PhRes, reversing these changes.

To extend the functionality of these systems, future work will incorporate particles (hydrophobic silica particles modified with fluorophilic group) at the oil-oil interface. By introducing particles, we aim to stabilise droplet morphologies and explore their influence on reconfiguration. Variations in particle concentration and surfactant ratios may enable transitions between Janus and droplet-in-droplet configurations and may even facilitate phase inversions under light stimuli. This approach will fill a gap in particle-stabilised reconfigurable emulsions, opening new possibilities for industrial applications.

11:20 - 11:40

422 Ultrasound aided preparation of Pogostemon cablin (Patchouli) essential oil-based nano emulsion

Ajmal Koya Pulikkal, Irom Ragish Singh

National Institute of Technology Mizoram, Aizawl, India

Abstract

Patchouli essential oil (PEO) obtained from *Pogostemon cablin*, acclaimed for its therapeutic properties and aroma, has gained an increased attention for its potential applications that embody food, pharmaceuticals, and cosmeceutical industries. However, the application of PEO is of modest extent due to its hydrophobicity, poor solubility in aqueous media, and high volatility. Nano emulsions (NEs) rides to the rescue of these inconsistencies with its proficiency to encapsulate PEO as nano sized droplets and thus provide a new dimension to the modern-day drug delivery of PEO. The present work reports preparation of patchouli essential oil-based nano emulsions (PNEs) by ultrasonication using Tween 80 as emulsifier, and water as the continuous medium. Twelve PNEs were prepared with 1:1, 1:2, and 1:3 oil to surfactant ratios (OSRs) and sonication times of 5 min, 10 min, 15 min, and 20 min. Increase in sonication time and decrease in OSR reduced average droplet diameter (Z_{avg}) of the PNEs. PNE with 1:3 OSR and 20 min sonication was optimized for biological studies as it displayed the minimum Z_{avg} (~ 14 nm), maximum stability upon centrifugation (5000 rpm), thermal treatment (30, 60, and 90 °C), and storage (4 weeks) where it showed a slowest Ostwald ripening rate (ω) of ~ 6.7×10^{-6} nm^3 s^{-1}.

Wetting and Adhesion - 4

10:00 - 12:00 Wednesday, 25th June, 2025
ETLC E1-003
Wetting and Adhesion
Tatiana Gambaryan Roisman

10:00 - 10:20

111 **Surfactants screen slide electrification**

Xiaomei Li[1,2], Zhongyuan Ni[1], Xiaoteng Zhou[1], Lisa Bauer[3], Diego Diaz[1], Gabriele Schaefer[1], Hans-Juergen Butt[1]

[1]Max Planck Institute for Polymer Research, Mainz, Germany. [2]ETH Zuerich, Department of Chemistry and Applied Biosciences, Institute for Chemical and Bioengineering, Zuerich, Switzerland. [3]Institute for Nano- and Microfluidics, TU Darmstadt, Darmstadt, Germany

Abstract

Water drops accumulated charges spontaneously when moving on dielectric hydrophobic surfaces by slide or contact electrification. Slide electrification generates electricity with possible applications on tiny devices. On the other hand, the potential up to 1 KV generated by slide electrification might damage the surfaces. Thus, it is crucial to know the factors affecting slide electrification. With the fact that water is naturally contaminated and many contaminants act as surfactants enrich at the water interface, however, how sensitively charge generation depends on clean water or possible contamination remains unknown. Here, we demonstrate that the charge of moving water drops on hydrophobic surfaces is reduced by addition of surfactant. We attributed the reduction of charge to the adsorption of surfactant on the solid surfaces during wetting and the desorption of pre-absorbed surfactants during dewetting. The reduction of charge by surfactant might help to get rid of possible surface corrosion with the vanish of high potential formed by slide electrification.

10:20 - 10:40

136 Electro-adhesion between Acrylamide / Sodium Alginate Double Network Hydrogels and Hard Conductive Surfaces

Shima Jalali, Hyun-Joong Chung, Dan Sameoto

University of Alberta, Edmonton, Canada

Abstract

Hydrogels, with their high-water content, flexibility, and biocompatibility, mimic biological tissues, interact seamlessly with them and adapt to complex geometries. These properties are crucial for medical devices and soft robotics, where controlled, reversible adhesion to hard surfaces is essential. electro-adhesion (EA), which offers reversible and tunable adhesion between hard-metallic surface and double-network hydrogel, is an emerging technique reported recently by Xu et al. [1] Our research reports strategies to improve EA by optimizing polymeric materials, fabrication techniques, and electrochemical reaction parameters. Underlying chemical mechanisms governing adhesion and cohesion at the interface is explored to enhance reversibility and increase the durability of the system over multiple cycles onto various hard surfaces.

Acrylamide, a biocompatible polymer, initially showed good electrically triggered adhesion with metals like copper but lacked mechanical strength; adding sodium alginate as secondary network to the acrylamide enhanced toughness and stretch-ability while maintaining EA mechanism. We incorporated electrochemical principles into our experiments to systematically study and control adhesion at the hydrogel-metal interface. This approach allowed us to study factors such as ion concentration, charge distribution, and conductivity, which directly influence adhesion strength. Applying a low voltage (<5V), achieved strong adhesion at the interface, and polarity reversal detached the hydrogel, demonstrating effective, reversible adhesion.

This research highlights the potential of double-network hydrogels to improve mechanical toughness while maintaining reversible EA using electrochemical framework. Although cohesive strength failure remains limitation, these findings highlight potential for further improvements through hydrogel toughening strategies.

[1] Xu et al., ACS Central Science, 10(3), 2024, 695-707.

10:40 - 11:00

202 Energy dissipation from depinning of droplets causes irreversible charge transfer

Shuaijia Chen[1], Ronald Leon[1], Rahmat Qambari[1], Yan Yan[1], Menghan Chen[1], Peter Sherrell[2], Amanda Ellis[1], Joseph Berry[1]

[1]University of Melbourne, Melbourne, Australia. [2]RMIT, Melbourne, Australia

Abstract

Liquids flowing over solids occur everywhere in life, from droplets down a windscreen to fuels flowing through pipes. While it has been observed that surface charging (electrification) can occur from this solid-liquid motion, the role of interfacial forces acting on the electrification of the solid-liquid interface remains poorly understood. In this study, the sessile drop method, combined with charge measurements is introduced to investigate electrification within the solid-liquid interface and determine the contribution of interfacial energy dissipated from contact line motion to the solid-liquid electrification. For the first time, it has been observed that interfacial energy dissipation during the stick-slip motion of a liquid drop on a non-conductive polymer substrate causes an increase in electrical charge that is independent of the interfacial velocity. This observation is analogous to solid-solid frictional electrification within the solid-solid interface. Understanding this electrification mechanism will reinforce the design of energy harvesters with improved efficiency and aid development of risk mitigation strategies for eliminating electrostatic accumulation across real-world industrial applications.

11:00 - 11:20

361 Biopolymer-Enhanced TFC Membranes: Effect of Lignin on Hydrophilicity and Surface Charge

Amirhossein Taghipour, Pooria Karami, Elham Jashni, Mohtada Sadrzadeh

University of Alberta, Edmonton, Canada

Abstract

Fouling remains as one of the primary challenges in membrane-based water treatment technologies, significantly reducing efficiency and increasing operational costs. In this study, we investigated the use of lignin, an abundant and sustainable biopolymer, to enhance the hydrophilicity and surface charge of thin-film composite (TFC) membranes. Lignin was incorporated into the polymer matrix at various concentrations, and its impact on membrane properties was evaluated using standard characterization techniques. The results demonstrated that lignin integration effectively improved the hydrophilicity and surface charge of the membranes, leading to enhanced antifouling performance. Our findings showed that lignin-modified TFC

membranes represent a promising approach to mitigating fouling and improving the overall performance of water treatment systems.

11:20 - 11:40

240 Spontaneous charging from sliding water drops determines the interfacial deposition of charged solutes

Xiaoteng Zhou[1,2], Yuwen Ji[2], Zhongyuan Ni[2], Javier Garcia Lopez[3], Kalina Peneva[3], Shan Jiang[4], Kaloian Koynov[2], Hans-Jürgen Butt[2]

[1]Massachusetts Institute of Technology, Cambridge, USA. [2]Max Planck Institute for Polymer Research, Mainz, Germany. [3]Institute of Organic Chemistry and Macromolecular Chemistry, Friedrich Schiller University Jena, Jena, Germany. [4]Department of Materials Science and Engineering, Iowa State University of Science and Technology, ames, USA

Abstract

It has been discovered during the last decade when water drops slide on hydrophobic surfaces, they spontaneously leave negative charges along the drop path. The drops become positively charged with a potential of 1 kV. This process, called *slide electrification*, influences drop motion and alters contact angles. Here, we demonstrate a third effect of slide electrification: the preferential deposition of dissolved solutes with positive charges. To illustrate this, we let water drops containing dissolved charged fluorophore ions slide down a tilted hydrophobic surface, and then image their track. We applied two perylene derivatives as fluorophores, one chromophore carrying positive charges, PDI^+, and one carrying negative charges, PDI^-. PDI^+ was deposited at a concentration as low as 0.5 µM. In contrast, PDI^- was only deposited above 10 µM. Experiments using grounded drops or a hydrophobic coating on a conducting substrate indicate that the electric field generated from the negative surface charges behind the drop causes a preferential deposition of the dissolved ions near the interface. As an example of complex biomolecules, we demonstrate single-stranded DNAs in sliding drops are spontaneously deposited when a positively charged end-group is attached. These findings contribute to a better understanding of mass transfer processes at interfaces.

11:40 - 12:00

181 Ultra-Low Friction and Rapid Coefficient Switching via Vapor-Controlled Mechanisms

Chenxu Liu[1], Yu Tian[2], Hongbo Zeng[1]

[1]University of Alberta, Edmonton, Canada. [2]Tsinghua University, Beijing, China

Abstract

Unsteady friction phenomena arising from the evaporation of lubricating fluids are prevalent in everyday applications and extreme operating conditions, such windshield wiper operation and vacuum environments, where lubricant evaporation significantly impacts friction systems. While it is generally accepted that the friction coefficient (COF) increases as the lubricating fluid evaporates, we discovered an intriguing ultralow friction state that precedes the transition to dry friction. Specifically, a COF as low as 0.01-0.03 was observed for approximately 10 seconds in the system of a polymer plate and a ceramic ball lubricated by ethanol. This ultralow friction is attributed to a nanoscale boundary film, rather than a thicker liquid film or liquid bridge. Introducing water vapor extended the ultralow friction state to over 4000 seconds, whereas replacing water vapor with liquid water caused the COF to increase drastically to above 1.7. By dynamically controlling the alternation between dry friction and vapor lubrication, rapid switching of the COF between 2-3 and 0.02 was achieved within seconds. These findings reveal new mechanisms of vapor-controlled friction and hold significant potential for applications in friction state monitoring and friction control.

Self and Directed Assembly - 3

10:00 - 12:00 Wednesday, 25th June, 2025
ECERF W2-050
Self and Directed Assembly
Saskia Lindhoud

10:00 - 10:20

270 "Centipede" statistical polymer under nano-confinement: *Surface forces, superlubricity, and transient interfacial gels*

Wuge Briscoe

University of Bristol, Bristol, United Kingdom

Abstract

Understanding polymer-mediated surface forces and friction is critically important to colloidal stability, biological processes, and industrial applications. Such interactions depend sensitively on the polymer conformation at the interface, which in turn depends intimately on the polymer molecular architecture.

Here we report surprising interfacial behavior, through direct measurement of surface forces and friction mediated by a functionalized statistical copolymer (FOCP) in *n*-dodecane using the surface force apparatus (SFA). The bespoke-architecture of FOCP (M_n = 59,004 g mol^{-1}) has an olefin backbone decorated with a statistical distribution of ~6 wt% polar-aromatic (N-(4-aminophenyl)aniline) groups, with a structure that we term as "*centipede*" (Fig.1A inset). The polymer is anchored on the mica surface in SFA through either physisorption or using the classic Langmuir-Blodgett (LB) method.

As the LB-polymer layers are brought into nano-confinement in the SFA, the surface forces (F_n) observed can be described by the classic Alexander–de Gennes theory (solids lines, Fig.1A), with the onset surface separation for the surface force far exceeding the thickness of an LB-polymer-monolayer. This is confirmed by complementary synchrotron X-ray reflectivity measurements, indicating a *multilayer* structure. Compared to adsorbed polymer layers, the LB polymer layers can mediate *superlubricity* (with a friction coefficient as low as 0.0002, comparable to that found in uman articular joints). We propose a new mechanism in which molecular arrangement leads to the multilayer nanofilm with a structure akin to an *interfacial gel*, with the *transient crosslinking* facilitated by the intra- and inter-molecular interactions between the functional groups (Fig.1B).

10:20 - 10:40

303 Colloidal Crystallization of Binary Crystals in Spherical Confinement into Supraparticles

Alfons van Blaaderen, Ruizhi Yang, Linglan Li, Alptuğ Ulugöl, Laura Filion

University, Utrecht, Netherlands

Abstract

Drying emulsion droplets of particles is a powerful methodology to create structured nanomaterials, supraparticles (SPs) by self-assembly (SA) as also the final structures can still be in the colloidal domain and thus take part in further/additional SA. Interestingly, we have shown that both for single sized and binary dispersions of colloids interacting with a hard interaction potential SA inside a spherical boundary results in equilibrium phases with *icosahedral* symmetry and are thus different from bulk phases up until SPs composed of >100.000 particles! Deviations from a spherical shape can be used to induce directional attachment of the particles inside the SPs. Next to many possible applications in fields like catalysis, sensing, lighting, structural colors, including possibly a full photonic bandgap for visible light, (nano)photonics (including lasing [8]), quantum matter and sustainability research in general, supraparticles are leading to new insights into fundamental questions in condensed matter science as well. Here we will discuss our latest unpublished results on how the spherical confinement affects the binary crystallization of systems that in bulk grow into AlB_2, NaCl and LS_6 type crystals with quantitative analysis on the single particle level using STED (stimulated emission depletion) confocal microscopy and FIB (focused ion beam) SEM (scanning electron microscopy).

10:40 - 11:00

275 Stoichiometric off-neutrality catanionic tubules

Valerio La Gambina[1], Alessandra Del Giudice[1], Maria Chiara di Gregorio[1], Simona Sennato[2], Karin Schillèn[3], Luciano Galantini[1]

[1]Department of Chemistry, Sapienza University of Rome, Rome, Italy. [2]Institute of Complex Systems, National Research Council, Rome, Italy. [3]Division of Physical Chemistry, Department of Chemistry, Lund University, Lund, Sweden

Abstract

Aggregation in ionic solutions is mainly promoted by electrostatic interactions and generally provides separation of neutral aggregates. Stoichiometric associations of oppositely charged ions occur when saturation is reached in mixtures of inorganic salts, resulting in the separation of uncharged crystals. Although a more complex behavior is expected due to the contribution of

hydrophobic interactions, the equimolar charge composition is generally identified as the most favorable association condition also for mixtures of anionic and cationic conventional surfactants with similar chain lengths, where precipitation of the catanionic surfactant is commonly observed at 1:1 charge ratio of the two amphiphiles. Specific aggregation out of the equimolar charge composition can be observed for these systems, with the formation for example of stable vesicles not too far from the 1:1 charge stoichiometry. Here we report on the behavior of mixtures formed by the conventional cationic surfactant cetyltrimethylammonium bromide (CTAB) and an anionic bile salt derivative (BSD)[1], which assemble into nanotubes (Figure 1) with a specific off-neutrality stoichiometry of 9 BSD per CTAB molecules. UV, circular dichroism, SAXS and microscopy data suggest a molecular packing where the BSD creates the scaffold of the tubule's bilayer, whereas CTAB promote the assembly by screening the charged heads. Self-assembly catanionic nanotubes are an odd architecture with relevant applicative interests. Their formation is very rare and there is currently no clear understanding of their physical chemistry. The reported data highlight a novel case within the narrow umbrella of catanionic nanotubes and encourage further exploration on catanionic mixtures of amphiphiles.

11:00 - 11:20

27 Synthesis and Characterisations of Novel Core-Shell Polymeric Surfactants

Wafaa Al-Shatty[1], Donald Hill[2], Sarah Rogers[3], Shirin Alexander[2]

[1]University of Bath, Bath, United Kingdom. [2]Swansea University, Swansea, United Kingdom. [3]STFC, Didcot, United Kingdom

Abstract

The synthesis, characterisation and applications of two new families of amphiphilic graft polymers (AGCs) are reported. The graft polymers were synthesised using various molecular weights of polyethylene glycol (PEG) (as hydrophilic graft chains) and two different hydrophobic backbones (with a varied quantity of functional groups) using a "graft onto" technique. NMR data shows that a higher molecular weight of the grafted PEG, and a higher number of functional groups in the backbone, lead to a higher grafting number and, therefore, an increase of the hydrophilic to hydrophobic ratio, establishing a correlation between the chain length of the grafted PEGs and the wettability of the polymer films. Consequently, both hydrophobic backbones wettability (~ 90 - 110 °) altered upon grafting onto synthesis and the contact angle data showed that the higher molecular weight of grafted chains led to higher hydrophilicity of grafted polymers (~11 - 65°). The critical micelle concentrations and surface activity of AGCs in water were determined by the surface tension technique, and it revealed that these polymers can act as polymeric surfactants with CMC of around 2-3 wt.%. Small-angle neutron (SANS) was used to examine the conformation of the AGCS in aqueous solutions which displayed the formation of ellipsoidal core-shell micelles. This research provides a fundamental understanding of potentially important polymeric materials with a variety of applications from emulsifiers to drug carriers to enhance oil recovery additives.

11:20 - 11:40

44 Capillary-Assisted Printing of Droplets at a Solid-like Liquid-Liquid Interface

Anshu Thapa[1], Robert Malinowski[1], Matthew Blunt[1], Giorgio Volpe[1], Joe Forth[2]
[1]University College London, London, United Kingdom. [2]University of Liverpool, Liverpool, United Kingdom

Abstract

We discuss a self-building material assembled from aqueous droplets printed at the oil-water interface. We first develop a system of cellulose nanocrystal surfactants that assemble at the oil-water interface into solid-like monolayers. These assemblies exhibit massive mechanical anisotropy; their surface shear modulus is largely constant (approx. 1 N m^{-1}), while their bending modulus can be tuned from sub-k_BT to 10^6 k_BT by varying system composition. Aqueous droplets can be placed at these solid-like oil-water interfaces without coalescing with the underlying aqueous sub-phase for extended periods of time. The droplets then attract each other over millimetric scales because of interactions mediated by the solid-like liquid-liquid interface. We observe a scaling behaviour for this attractive motion that differs from theoretical predictions for pristine interfaces and develop a theoretical model based on capillary interactions that captures system dynamics. Applying printing methods allows us to finely control initial droplet positions, from which they self-assemble into cellular materials. Finally, by embedding gold nanoparticles in the solid-like liquid-liquid interface, we use plasmon-assisted optofluidics to manipulate these droplet-based materials at the interface with temperature gradients. Our results provide a new approach to build complex, droplet-based materials of highly controllable structure and composition.

[1] Forth *et al*, "The Buckling Spectra of Nanoparticle Surfactant Assemblies", *Nano Letters* (**2021**), **21**, 7116-7122. [2] Thapa *et al*, "Capillary-Assisted Printing of Droplets at a Solid-Like Liquid-Liquid Interface", *arXiv* (**2024**)

11:40 - 12:00

266 Entropic Trapping in Icosahedral Colloidal Clusters

Jonathan Martín-González, Nicolas Vogel

Institute of Particle Technology, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany

Abstract

Entropy-driven self-assembly has been fundamental for the exploration and application of colloidal self-assembly into defined structures. A particularly interesting system appears when colloidal particles are constrained under spherical confinement, where the curvature alters the self-

assembly process. For clusters ranging from 10^2 to 10^4 particles, icosahedral colloidal cluster appear as the thermodynamically stable structures. Icosahedral clusters have lower packing fraction than that of the typical bulk crystalline structure with fcc symmetry, but are entropically preferred as they are able to conform better to the curved interface. This is because they are composed of multiple distorted grains. However, the distortion level varies across grains, with the highest at the vertices of the icosahedral structure. These different packing densities induce a preference for defect particles to accumulate in the vertex regions. In crystalline regions, defect particles would impose a high entropic penalty. However, in the less packed vertex regions, they would minimize the free energy of the system.

Event-driven molecular dynamics simulations using hard spheres demonstrate the entropic nature of the trapping of impurity large particles at the vertex of icosahedral clusters. Expanding on these findings, we design an experimental system where icosahedral colloidal clusters are assembled from a large population of small particles, and a few large particles. We explore the phase diagram of this system for different cluster sizes and particle size ratios. We find that under the right size ratios, large impurity particles can be efficiently directed to the vertex sides, thus experimentally realizing the entropic trapping mechanism.

Surfactants and Colloidal systems in Resource Extraction - 2

13:20 - 15:00 Wednesday, 25th June, 2025
ICE Incubator
Surfactants and Colloidal systems in Resource Extraction
Edgar Acosta

13:20 - 13:40

97 Polymer Degradation and Gel-Breaking Properties of Novel SiO_2/Enzyme Nanocomposite

Jun Yang[1,2], Maen M Husein[2], Reza Lashkari[3]

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Abstract

Oil and gas sweep efficiency is vastly influenced by polymer adsorption and retention in heterogeneous reservoirs. Incomplete polymer degradation contributes to reservoir blockage. In this work, a novel SiO_2/enzyme nanocomposite is assessed as a targeted gel-breaker for polymers retained in reservoirs. Analytical techniques, including X-ray diffraction (XRD), transmission electron microscopy (TEM), energy-dispersive X-ray spectroscopy (EDS), Fourier transform infrared spectroscopy (FT-IR), and N_2 adsorption-desorption confirmed the formation of a

nanocomposite material consisting of α-amylase-encapsulated nano-SiO_2 aggregates. The degradation of commonly applied starch-based polymers (CMS, HPS, CLS) by the nanocomposite revealed > 95% degradation efficiency. The rate of gel-breaking increased with temperature, while decreased with higher nano-SiO_2 content and pH.

13:40 - 14:00

67 External Electric Field Effects on Asphaltene Adsorption on Kaolinite -Water Interface: A Molecular Dynamics Study

Wenyuan Sun

China University of Petroleum, Beijing, Beijing, China

Abstract

Applying electric fields to promote water/oil recovery efficiency is gaining increasing attention in downstream of heavy oil development. In this work, molecular dynamics simulations were performed to study the motion of N-(1-Hexylheptyl)-N'-(5-carboxylicpentyl) perylene-3,4,9,10-tetracarboxylic bisimide (C5Pe) between kaolinite surfaces mediated by external electric field in water under different pH. In acidic solutions, C5Pe carried zero charge, and yet its distribution was affected by the electric field. The electric fields mediated the wettability of the two kaolinite surfaces differently, and C5Pe preferred to adsorb on the more hydrated surface. The mediation of the electric fields on the wettability of surfaces was achieved in two stages. In the first stage, when the electric field of a low strength was applied, diffusion of water enhanced. The hydration of both surfaces became increased as water molecules formed more hydrogen bonds with the surfaces. As the electric field strength became sufficiently high, diffusion showed no further enhancement, and the re-orientation of water dipoles started dominating the hydrogen bonding with the surfaces. Carrying opposite charges, the hydrogen bond donors and acceptors of water were differently regulated by the electric field. The hydrogen bonding between water and the two Kaol surfaces (placed on two sides of the simulated box under the electric field) varied with their positions. Due to the structural hindrance of the hydroxyl groups on the surface, the surface could provide more hydrogen bonding donors formed more hydrogen bonds with water, and thus became more hydrophilic and had stronger attraction to C5Pe.

14:00 - 14:20

124 An in-situ study of the interaction mechanism between xanthate (ROCSS–) and sphalerite (ZnS) surface

YE CHEN

Guangxi University, Nanning, China

Abstract

The mechanism of surface hydration and xanthate ($ROCSS^-$) adsorption in the flotation of unactivated/Cu-activated sphalerite (ZnS) is still controversial. Therefore, a study combining in-situ measurement and quantum simulation is employed to investigate the interaction mechanism of ethyl xanthate ($C_2H_5OCSS^-$, EX) and butyl xanthate ($C_4H_9OCSS^-$, BX) on the fully hydrated, unactivated/Cu-activated sphalerite surfaces at solid-liquid interfaces. Density functional based on tight-binding (DFTB+) and molecular dynamics (MD) results suggest that the Cu-activated surface is hydrophobic with the first layer of water being distributed more disorderly on it. This is due to the difficulty of the lone pair electrons of water to interact with Cu. On the unactivated surface, water adsorption is more favorable than xanthates, hence, water molecules are physically adsorbed on it. Whereas the interaction of EX/BX with the hydrated, activated surface is chemisorption. The higher reactivity of Cu^+ d orbitals to form π-backbonds with xanthate and the orbital symmetry matching of the Cu d_{yz} orbitals and xanthate p_z orbitals contribute to these results. Microcalorimetric results also demonstrate that copper activation enhances the exothermic heat and reaction rate, facilitating the interaction of EX/BX with sphalerite. These are consistent with the flotation and quartz crystal microbalance with dissipation (QCM-D) results.

14:20 - 14:40

407 Unraveling Nanoscale Mechanisms of Asphaltene Subfraction Adsorption on Silica Surfaces

Hongtao Ma

University of Alberta, Edmonton, Canada

Abstract

Asphaltene adsorption and precipitation on solid surfaces present significant challenges in the oil industry. Previous studies have demonstrated that interfacially-active asphaltenes (IAA) have a strong ability to adsorb at the oil/water interface; it was hypothesized in this study that IAA asphaltenes can also actively associate with solid particles. Herein, quartz crystal microbalance with dissipation (QCM-D), surface forces apparatus (SFA), and atomic force microscopy (AFM) were applied to quantify the adsorption amount, kinetics, and surface forces of asphaltene subfractions on silica surfaces. The results showed that IAA asphaltenes possess exceptional adsorption abilities on silica surfaces reaching an adsorption capacity of ~ 150 mg/m^2, which is much higher than interfacially non-active asphaltenes (INAA) and previously reported values in literature. After an adsorption time of 90 minutes, the thickness of adsorbed IAA layers on mica surfaces (mimicking silica surfaces) reaches approximately 67 nm, which is considerably higher than the thickness of INAA asphaltenes (~4.1 nm). Significant adhesion forces were measured for IAA-silica interactions, whereas negligible adhesion was observed for INAA-silica and INAA-INAA interactions. Notably, IAA-silica and IAA-IAA interaction show an evident increment in adhesion with increasing maximum loading forces, most likely due to the short-range and time-dependent hydrogen bonding interaction. The strong ability of IAA asphaltenes to interact with silica surfaces and undergo self-association lead to multilayer adsorption. This work provides useful molecular insights into asphaltene adsorption behavior on silica surfaces, which can be further applied to explain many asphaltene-related interfacial phenomena such as asphaltene aggregation, oil fouling, and asphaltene-stabilized W/O emulsion.

14:40 - 15:00

373 Experimental investigation on flushing phenomenon of settled solids inside hydrotransport lines

Sadman Shahriar, Shubham Sharma, Xuehua Zhang

University of Alberta, Edmonton, Canada

Abstract

The transport of slurry from oil extraction unit to the tailing pond is always a crucial part of any hydrotransport technology in mineral processing. The presence of solids in large quantities makes the slurry concentrated, which makes it difficult to transport. Thus, during conveyance, the denser particles tend to settle over the inverted section of the pipe due to the effect of gravity. The continuous deposition of particles inside pipeline leads to operational inadequacy, such as the reduction in transportation efficiency with huge pressure change. Thus, flushing the settled solids is a necessary condition for industries. This study investigates the flushing dynamics of solid deposits by supplying clean water. The key experimental parameters flow velocity, solid concentration and particle size are considered in the range of 0.71 m/s to 1.06 m/s, 45 µm - 425 µm, and 11.8 % to 49.6 % by volume, respectively. Moreover, a bubble-assisted novel approach is also explored to enhance solid removal efficiency. The velocity study reveals that on moving from low to high range of velocity, the removal efficiency is found to increase, however, the increasing rate is reduced on moving from 0.91 m./s to 1.06 m/s velocity. Further, the study of particle size revealed that finer particles completely flushed out in less than 2/3 rd of the time needed for larger particles. This emphasizes the dominance of particle inertia over flow turbulence. Furthermore, the bubble-assisted study is performed by the inception of various size maco, micro and nano bubbles. The introduction of bubbles as a secondary phase shows a decrease in flushing time by at least 12%, compared to no bubble operating condition. However, smaller particles demonstrated greater sensitivity to bubble-infused carrier fluid, which might be due to a higher surface to volume ratio. This study presents a novel and efficient methodology to improve the flushing performance of any hydrotransport line through changes in flow parameters and the introduction of bubbles, which can be explored for industrial applications.

Surfactants and Emulsions - 2

13:20 - 15:00 Wednesday, 25th June, 2025
ETLC E1-018
Surfactants and Emulsions
Joachim Venzmer

13:20 - 13:40

158 Impact of Homogenisation on the Surface Adsorption of Milk Fat Globules and Oleosomes

Amin Aliyari[1], Vincenzo di Bari[1], Liam Ratcliffe[2], David Gray[1]

[1]University of Nottingham, Nottingham, United Kingdom. [2]Unilever Research & Development, Bedford, United Kingdom

Abstract

This study investigates the impact of high-pressure homogenization (using a microfluidizer) on the interfacial behavior of milk fat globules (MFG) and oleosomes (also called as oil bodies or lipid bodies) at the air-water interface. The interfacial properties of these systems were characterized by particle size distribution, surface charge, interfacial protein profile, and adsorption behavior at the air-water interface followed by advanced microscopy techniques to monitor droplets' stability upon adsorption. Homogenization significantly reduced droplet size, with the degree of reduction correlating with the applied pressure and the number of passes. The size reduction and the resultant increase in the surface area of the newly formed droplets led to significant changes in their adsorption behavior at the air-water interface. Additionally, the colloidal stability of the droplets upon adsorption was enhanced after homogenization. These findings were corroborated by analyzing the phospholipid and protein profiles of the membranes of the newly formed droplets. This study provides valuable insights into the adsorption mechanisms of milk fat globules, a key ingredient in dairy products (e.g., ice cream), and explores the potential of oleosomes as replacements for MFGs in the formulation of plant-based products.

13:40 - 14:00

167 Surfactant and drop size effects on coalescence-induced wetting on a solid substrate

Sepehr Hoomani Rad, Arun Ramachandran, Edgar Acosta

University of Toronto, Toronto, Canada

Abstract

The wetting of substrates by emulsion drops is pivotal in various industrial applications, yet traditional theories often fall short when considering the finite solubility of the drop fluid. This research delves into coalescence-induced wetting, a novel mechanism where solubility within the continuous phase leads to the formation of secondary droplets or "islands" that facilitate wetting. The study specifically investigates the role of non-ionic surfactants, focusing on Span80 at concentrations below the critical micelle concentration (CMC), and their impact on the nucleation and growth of these islands. Furthermore, the impact of emulsion drop size on coalescence-induced wetting is studied.

We conducted experiments using water emulsion drops in a castor oil medium with freshly cleaved mica and glass as substrates to determine the surfactant's effect on wetting dynamics. Reflection Interference Contrast Microscopy (RICM) was employed to visualize the hydrodynamic drainage, island formation, and emulsion drop movement, key processes in the coalescence-induced wetting mechanism.

Results indicate that Span80 significantly influences the formation and growth of islands by reducing interfacial tension, thereby enhancing the nucleation rate. These effects precipitate faster and more efficient wetting processes, underscoring the pivotal role of surfactant concentration in modifying wetting behaviors. Quantitative measurements reveal that an increase in surfactant concentration from 3% to 20% relative to CMC elevates the island growth rate by a factor of three to four. Additionally, graphs quantifying island size distribution over time provide a deeper understanding of the dewetting process. These diagrams allow us to differentiate and analyze distinct stages of island formation, growth, and coalescence on the film surface. Furthermore, the study examines drop size as a crucial variable in wetting dynamics. It was found that larger drops achieve wetting at greater critical heights, primarily due to the formation of a dimple that decelerates the parent drop's approach towards the substrate. This delay permits more extensive island development. Additionally, larger drops provide a more substantial water source for island formation, resulting in a higher proportion of the substrate being covered by islands at the time of bridge formation.

The profound implications of these findings suggest potential optimization of emulsion formulations for industrial applications such as pesticide delivery and oil recovery, where precise control over wetting properties is essential. It also lays the groundwork for future research aimed at optimizing formulations for specific industrial uses, contributing to a deeper understanding of the interactions at the three-phase boundary.

14:00 - 14:20

206 Analysis of lyotropic phase changes of alpha olefin sulfonate in a drying droplet

Robin Winder[1], Sepideh Khodaparast[1], Andrew Bayly[1], Ian McRobbie[2], Michael Rappolt[1], David Harbottle[1]

[1]University of Leeds, Leeds, United Kingdom. [2]Innospec, Ellesmere Port, United Kingdom

Abstract

Alpha Olefin Sulfonate (AOS) is a complex mixture of alkene sulfonates and hydroxyalkane sulfonates. It can be found in many formulated products such as toothpaste. Despite its use as a commercial surfactant, little is understood about the relationship between the surfactant drying process and the resultant performance of the final product. The lyotropic phase changes as a function of concentration and temperature were first examined in bulk. Cross-polarized microscopy was used to identify the concentration ranges of different phases forming, which were then analysed in greater detail by small-angle X-ray scattering (SAXS). Five different concentration-dependent lyotropic phases were observed, displaying a normal micellar, a normal hexagonal, a ribbon-like, 3D-hexagonal and a lamellar nanostructure. Accordingly, a temperature-concentration phase diagram was constructed. Secondly, the phase behaviour was studied within a drying droplet in an acoustic levitator equipped with a bespoke heating unit. This allowed in-situ SAXS analysis of the droplet during the drying process. The resulting phase evolution during the droplet drying at ambient temperature is shown in Fig.1, starting with a normal micellar phase. Further experiments at elevated temperatures and concentrations with different initial phases have been conducted to map the phase evolution at conditions better resembling process conditions. The study has generated a unique view of the drying process of the AOS system, providing critical insights between process conditions and product performance, with the latter being dependent on the final solid-state structure.

14:20 - 14:40

369 Evaporation Induced Destablization of Oil-in-Water Emulsion

Sanket Kumar, Deniz Gunes, Erin Koos

KU Leuven, Leuven, Belgium

Abstract

Emulsions are widely used in commercial products such as cosmetics, paints, and adhesives. These products are often used as coating layers where drying of the volatile component is inevitable, often leading to coalescence and deformation of the oil droplets. In this work, we present the evaporation-induced destabilization of a single oil-in-water emulsion droplet. The contraction of the air-water interface due to the evaporation of water leads to the vertical compression of the oil droplets. In response to the compression, the droplet flattens in the direction of the compression and expands laterally, ultimately leading to bursting. The area expansion of the oil droplet under compression shows a non-linear behavior and is independent of the initial droplet size. The droplet flattening, however, increases with increasing droplet size. A morphological investigation of the particulate film at the droplet surface revealed the nucleation of cracks in the lateral surface as the droplet area expands beyond a critical threshold. The cracks propagate towards the top and bottom surface of the droplet under compression as the expansion increases. When the area fraction of the cracks surpasses a critical value, the particulate film ruptures, resulting in the bursting of the oil droplet. Further, the crack area fraction, a critical areal expansion for the crack nucleation, the evolution of the crack area, and the number with the areal expansion are quantified. In addition, the bursting behavior of a droplet in the presence of the nearest neighbor is also discussed in detail.

14:40 - 15:00

267 Freeze-Thawing of Oilseed Rape Oleosome Emulsions

Filippo Bramante[1], Vincenzo di Bari[1], Gary Adams[1], Frederic Beaudoin[2], Gustav Waschatko[3], Ralf Jakobi[3], Nils Billecke[3], David Gray[1]

[1]University of Nottingham, Nottingham, United Kingdom. [2]Rothamsted Research, Harpenden, United Kingdom. [3]Cargill R&D Centre Europe BV, Vilvoorde, Belgium

Abstract

This work investigated natural oleosome emulsions stability on freeze-thawing. Oleosomes were recovered from oilseed rape seeds following an aqueous extraction process with sodium bicarbonate (0.1 M). The emulsions were prepared at pH 9, 6 and 3, resulting in a surface charge of -50.3±1.6, -20.0±2.4, and 37.5±0.5 mV, respectively. Emulsions with 0.28±0.02 lipid mass fraction were cooled to -20°C for up to 24 h and thawed at 20°C for 18 h, and their freeze-thaw destabilisation quantified as released oil amount (oil yield). Oleosome emulsions destabilisation at pH 9 and 6 increased with isothermal holding time at -20°C, whereas the emulsion at pH 3 destabilised more rapidly. Differential scanning calorimetry analysis of emulsions cooled from 20°C to -20°C at -10°C/min, and held at -20°C for 8 h, revealed rapid continuous phase crystallisation on cooling, whereas lipid crystallisation started after 2 h at -20°C and continued for the following 3 h. Oil yield data combined with differential scanning calorimetry curves suggested that emulsions at pH 9 and 6 destabilised by partial coalescence during lipid phase crystallisation, as also suggested by further work in our group. In contrast, emulsions at pH 3 destabilised during continuous phase crystallisation, possibly due to weakened electrostatic interactions at the interface between phospholipids and oleosins, the main oleosome interface components.

Increasing the continuous phase mass fraction to 0.50 and 0.70 in the emulsions seemed to reduce the extent of destabilisation. Increasing the number of freeze-thaw cycles from one to three did not significantly raise the oil yield.

Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces - 6

13:20 - 15:00 Wednesday, 25th June, 2025
NRE 1-001
Biological, Bio-Inspired, and Biomimetic Colloids and Interfaces
Alexandra Komrakova

13:20 - 13:40

395 Detecting changes in the order and dynamics of lipid molecules in plasma membranes via nonlinear optical microscopy

Noritaka Kato

Meiji University, Kawasaki, Japan

Abstract

When the cells are stained with fluorescent, amphiphilic, polar dye molecules, they predominantly intercalate in the outer leaf of their plasma membranes. This nonsymmetric alignment of the dye molecules results in a detectable second harmonic generation (SHG) from the membranes. The fluorescence nature of the dye molecule also enables simultaneous 3D imaging of SHG and two-photon excited fluorescence (TPF) using laser scanning nonlinear optical microscopy. The SHG intensity depends on the order and alignment of the dipole moment of the dye molecule. Because the dye molecules intercalate into the membranes by hydrophobic interaction, their order and alignment reflect those of lipid molecules in the membranes. Thus, the SHG intensity decreases when the alignment of the lipids in the membranes perturbs, or their dynamics (flip-flop, trans-bilayer diffusion of lipids) is enhanced. Contrary the TPF intensity does not depend on the lipid ordering or dynamics. The technique based on the combination of these features revealed how polycations affect the ordered structure of the membrane, even at low concentrations where the conventional enzyme release assay cannot detect membrane damage [1,2]. It was also found that the lipid molecules in the bleb membrane of the wounded cell enhance flip-flop [2]. Furthermore, the restoration of the ordering of the lipids in the membranes after being affected by polycation-based transfection agents will be discussed.

[1] N. Kato, Biophys. Rev. 11, 2019, 399-408.

[2] E. Aiyama, N. Kato, J. Phys. Chem. B 128, 2024, 1680-1688.

13:40 - 14:00

280 Finding DNA aptamers for mCherry protein using structurally diverse screening libraries

Steven Ochoa, Valeria Milam

Georgia Institute of Technology, Atlanta, USA

Abstract

DNA aptamers represent exciting possibilities as bio-inspired, macromolecular capture agents for particular targets such as biological molecules or colloids. Many challenges remain, however, in designing effective screening libraries; selecting aptamers with high target specificity during the screening process; and finally in identifying the primary structures of all aptamer “hits” or winners. To tackle each challenge, we are undertaking a multi-faceted approach to finding DNA aptamers for a model biological colloid-specifically a fluorescent protein called mCherry. First, we have prepared a rich library consisting of the following three sequence subpopulations: random DNA sequences (subpopulation #1) as a control and two structurally diverse DNA sequence libraries with patterned nucleotide compositions to promote G-quadruplexes (subpopulation 2) and hairpins (subpopulation 3). Theoretical and experimental data show three distinct ranges of self-melting temperatures for these three subpopulations of sequences. In our ongoing work, we are employing both traditional SELEX (Systematic Evolution of Ligands by EXponential enrichment) and a non-evolutionary screening approach called CompELS (Competition-Enhanced Ligand Screening) to drive competition-based selection of aptamer candidates against the mCherry target. We hypothesize that the simplicity and competition-driven approach of the CompELS platform will enable faster selection of equivalent, if not superior, aptamers compared with SELEX. Finally, following a separate pilot project in 2024, we are adapting our characterization approach which involves a genomic sequencing tool called Next Generation Sequencing to maximize the quality and quantity of the resulting nongenomic sequence data analyzed from both the starting screening library (prior to screening) and the target-bound sequence winners.

14:00 - 14:20

355 Colloidal Behavior of Monoclonal Antibodies at High Concentration and Polymersomes for Photoacoustic Cancer Imaging

Keith Johnston, William Kimball, Mohammed Kawelah, Jongyeong Jeon, Alex Marras, Thomas Truskett

University of Texas, Austin, USA

Abstract

Fundamental colloid and interface science plays a key role in designing mAbs for stability and subcutaneous delivery at high concentration and for design of polymersomes with indocyanine green for photoacoustic imaging (PAI) and theranostics. For processing and subcutaneous delivery of monoclonal antibodies (~10 nm colloidal particles) it is challenging to achieve low viscosities and high stabilities at high concentrations from 100 to 300 mg/ml. Advancements in this field are being guided by a deeper understanding of protein-protein interactions and morphology with small angle X-ray scattering (SAXS) rheological studies. In the field of bionanotechnology, clinical translation of photoacoustic imaging (PAI) and image guided therapy/surgery of cancer has been limited by the lack of sensitive near infrared (NIR) contrast agents with low toxicity. To address this challenge, we have formed nanocomposite materials with exceptionally high payloads by tuning the interfacial interactions. In particular, 50 nm "J aggregates" of FDA approved indocyanine green (ICG) with strong NIR absorbance and PAI contrast are encapsulated at high loadings within small polymer vesicles (polymersomes) composed of poly(lactide-co-glycolide-b-polyethylene glycol) (PLGA-*b*-PEG) bilayers. The small polymersome hydrodynamic diameter is advantageous to improve transport through the extracellular matrix of tumors and for uptake into cancel cells. Directional conjugation with EGFR targeting cetuximab antibodies renders molecular specificity.

14:20 - 14:40

17 Cancer Treatment with Asphaltenes-based Photoactive Agents

Ozioma Akakuru, Steven Bryant, Milana Trifkovic

University of Calgary, Calgary, Canada

Abstract

Cancer photothermal therapy utilizes photothermal agents to convert light into heat, effectively ablating cancer cells through localized necrosis. Despite their promise, conventional photothermal agents such as gold nanoparticles, copper sulfide, palladium, mesoporous silica nanoparticles, and indocyanine green dye often face limitations like scalability issues or photobleaching under prolonged irradiation, hindering their practical application. To address these challenges, asphaltenes-derived carbon dots (ACDs, ~5 nm) have been developed as a low-cost, photostable photothermal agent with minimal in vivo cytotoxicity. The ACDs feature abundant water-solvating functional groups on their surface, providing superior water re-dispersibility compared to many commercial nanomaterials. Mechanistically, their photothermal therapeutic efficacy stems from non-radiative transitions of excited electrons at 808 nm via internal conversion and vibrational relaxation. Remarkably, a single near-infrared irradiation session with ACDs enabled effective cancer photothermal therapy in mice within 15 days post-treatment. This pioneering work represents the first application of asphaltenes-based materials in cancer therapy, paving the way for their broader use in cancer theranostics.

14:40 - 15:00

282 Self-assembled Recombinant Protein Nanocolloids as Viral Inhibitors and Ultrasound Contrast Agents

Rajarshi Chattaraj

New Jersey Institute of Technology, Newark, USA

Abstract

Colloids made from recombinant proteins (RPs) – instead of traditional lipid/polymer-based surfactants – have enormous promise for developing theranostics. RPs can be engineered precisely, do not need post formulation modification/washing steps, and sparingly soluble motifs can be genetically appended to soluble protein backbones to increase product yield. We use oleosin for developing recombinant nanocolloids (NCs). Oleosin is a stabilizer for fat bodies in plant seeds. It is a rare protein that can act as a free-chain triblock surfactant and can be engineered to assemble into micelles and vesicles. Here, we show oleosin NCs that bind and inactivate the SARS-CoV-2 virus. We can readily incorporate functional peptide motifs into oleosin recombinantly. Additionally, unlike free peptide inhibitors, NCs can be multifunctional, provide a steric barrier to virus-cell interactions, and have longer *in vivo* half-life. We demonstrate multifunctional oleosin NCs can individually and synergistically inhibit viral infection *in vitro*, with significantly improved performance over free peptides.

Secondly, we will discuss how oleosin – instead of phospholipids – can be used as a surfactant to stabilize droplets and bubbles which function as ultrasound contrast agents. Proteins like albumin have previously been used – however, such proteins must be heated to high temperatures for unfolding and assembling around a bubble or droplet, forming a non-uniform membrane with limited functionalization capacity. We show for the first time that an RP can be used to stabilize microbubbles and nanodroplets, that when exposed to acoustic pressure, generate signal detectable by a clinical ultrasound scanner, paving the way for highly tunable contrast agents.

Colloids for Sustainability and Energy - 5

13:20 - 15:00 Wednesday, 25th June, 2025
ECERF W2-110
Colloids for Sustainability and Energy
Sathish Ponnurangam

13:20 - 13:40

95 Exploring Surfaces of Inorganic Colloidal Nanocrystals Using Solid-state and DNP NMR

Vladimir Michaelis

University of Alberta, Edmonton, Canada

Abstract

Inorganic colloidal nanocrystals (NCs) are increasingly gaining attention for their excellent optoelectronic applications in displays, lasers, photovoltaics, sensors, biomaterials, and photodetectors. The selection of inorganic elements and organic ligands that surround these nano-sized semiconductors can significantly shape their surface structure, thus affecting their customizable optical and electronic characteristics. It is well-established that the configuration of these nanomaterials influences their optical, chemical, and physical properties; consequently, grasping their atomic-level structure is crucial for their engineering and optimization across various applications. A common obstacle in nanomaterial research is identifying effective analytical characterization methods to determine the distinct structural attributes, including the core, surface, and corresponding interface, that define the properties of these materials.

Effective surface characterization methods in inorganic colloidal semiconductors, ranging from micron to nanoscale, utilizing solid-state and dynamic nuclear polarization (DNP) NMR spectroscopy, will be discussed. Recent findings will be showcased using one- and two-dimensional NMR techniques, revealing structural insight unattainable from traditional diffraction methods. This includes heteronuclear dipolar coupling techniques, which can provide valuable information about the relationship between organic capping agents and the metal surfaces of the nanocrystals. The delicate nature of magnetic shielding will be highlighted as a responsive tool to differentiate between the crystalline core and disordered surfaces and assess crystallite size and the related optical bandgap in semiconducting nanocrystals. Solid-state NMR spectroscopy continues to advance our scientific comprehension of these hybrid nanomaterials.

13:40 - 14:00

203 Multifunctional Luminescent Amino Acid Surfactants: Insights from NMR Relaxation and Applications in Sustainable Energy

Ettiene Wiese

North West University, Potchefstroom, South Africa

Abstract

Amino acid surfactants with dual functionality—unique relaxation properties and non-traditional intrinsic luminescence (NTIL)—offer promising advancements in colloidal science for energy and sustainability. This study investigates the NMR relaxation behavior of eight amino acid surfactants and their novel luminescent properties. T_1 and T_2 relaxation rates, along with T_2/T_1 (Tr) values, were analyzed across a broad concentration range to explore aggregate formation, structural dynamics, and the influence of surfactant chain length and headgroup symmetry.

Simultaneously, these surfactants were identified as a new class of NTIL materials, challenging conventional paradigms by exhibiting luminescence without aromatic or π-conjugated systems. Their luminescence intensity and color are tunable by modifying the amino acid headgroup, enabling potential applications in optical technologies, such as solar panel coatings. These surfactants act as UV downconverters and surface homogenizers, reducing light scattering and potentially enhancing photoconversion efficiency.

A correlation between NMR relaxation data and luminescence behavior was observed, suggesting that aggregate dynamics influence quantum yield and photophysical properties. This dual characterization provides critical insights into the design of multifunctional colloids for sustainable energy applications, including solar energy harvesting, biodegradable composites, and optical materials. By combining advanced characterization techniques and innovative material design, this work highlights the potential of luminescent amino acid surfactants to address energy and environmental challenges.

14:00 - 14:20

132 Can stable narrow bandwidth photo- and electro-luminescence be realized from silicon quantum dots emitters?

Jonathan Veinot

University of Alberta, Edmonton, Canada

Abstract

Silicon quantum dots (SiQDs) are attractive nanoparticles for a variety of applications in part because they exhibit tunable luminescence, are non-toxic, and based upon the second most abundant element in the earth's crust. Despite these appealing attributes, and that effective methods have been established for their preparation, challenges associated with optimizing SiQD optical properties persist. The broad luminescence bandwidth of SiQDs, that results from inherent material properties is particularly troublesome, requires alternative solutions because methods such as size selection used for other quantum dots has met with only limited success. This presentation will outline the regulation of SiQD emission using Fabry-Pérot (FP) optical cavities and show that optically driven FP resonators based upon SiQD-polymer hybrids provide tunable luminescence with narrow photoluminescence (PL). Building on this foundation, discussion will then turn to electrically driven SiQD-based cavity light-emitting diodes (SiQD-cLEDs).

14:20 - 14:40

109 Enhancement of Photocatalytic Activity in Carbon Nitride Wrapped Cadmium Sulfide Nanowires

Kazi Alam, Narendra Chaulagain, Karthik Shankar

University of Alberta Faculty of Engineering, Edmonton, Canada

Abstract

CdS is a high mobility inorganic semiconductor vulnerable to photocorrosion due to the difficulty in extracting photogenerated holes from CdS. We formed colloidal suspensions of CdS nanowires and wrapped them with two different types of exfoliated carbon nitrides to form core-shell nanowires. The zeta potential of bare colloidal CdS nanowires was negative while that of exfoliated carbon nitride nanosheets was positive. One type of carbon nitride shell was the narrow bandgap polymer C_3N_5, which was found to be an excellent passivating agent to heal surface traps in CdS nanowires. The other type of carbon nitride used as a shell was the exfoliated nanosheet form of tris-s-triazine (C_6N_7) linked pyromellitic dianhydride polydiimide (CN:PDI). CN:PDI has a deep lying highest occupied molecular orbital (HOMO) which enabled it to improve the photooxidation ability of CdS@CN:PDI core-shell nanowires. The wrapping process occurred

spontaneously through electrostatic interactions when colloidal suspensions of CdS and exfoliated C_3N_5 or CN:PDI were mixed in methanol and subjected to prolonged stirring. Bare CdS nanowires performed the photocatalytic degradation of rhodamine B (RhB) dye through the chromophore cleavage pathway while CdS@C_3N_5 core-shell nanowires photodegraded RhB through the N-deethylation pathway. CdS@CN:PDI core-shell nanowires photo-oxidized benzyl alcohol to benzaldehyde with 90% yield under AM1.5G one sun illumination. On the other hand, the bare CdS and bare CN:PDI exhibited negligible photocatalytic activity for the same oxidation reaction. The reaction was confirmed to be photon-driven since no reaction product was obtained under dark conditions.

14:40 - 15:00

226 Novel sustainable polyphenolic polyphosphazene colloids for bio-based flame retardants on cellulose matrices

Laura Hetjens[1,2], Kevin Sabel[2], Regina Palkovits[2], Andrij Pich[1,2]

[1]DWI-Leibniz Institut for Interactive Materials, Aachen, Germany. [2]ITMC- Institut for Technical and Macromoleculare Chemistry, RWTH Aachen, Aachen, Germany

Abstract

Bio-based and interactive colloids are a promising area of innovation driven by the need for new sustainable and environmentally friendly materials. In particular, in the research field of flame retardants (FR), the development of new halogen-free polymeric phosphorus-based colloids, without harmful substances and no risks to human health and environment, could offer a safe option and at the same time effective flame retardancy.
A new approach could be the polyphenol polyphosphazene colloids, in particular phosphornitrilic chloride trimer (HCCP) in combination with polyphenolic building blocks such as isocraugsodine, which show great promise as FR finishes. This is due to their high phosphorus and nitrogen content, high cross-linking density and adaptability to different surfaces. Their high phosphorus content contributes to high char formation on the coated material surface during combustion. This char layer acts as a protective barrier, limiting oxygen access to the surface and reducing the ignition process. These bio-based polyphosphazene colloids are biocompatible and biodegradable due to the P-N rich cyclomatrix structure and the combination of functional aromatic polyphenols. The addition of polyphenolic building blocks such as isocraugsodine could improve their performance as flame retardants, but also ensure that they are biodegradable and non-toxic, enhancing their use as environmentally friendly flame retardants. The successful synthesis of tannic acid/HCCP colloids via precipitation polycondensation has already been confirmed by the Pich group, and such halogen-free cyclomatrix polyphosphazene materials have shown suitable properties in thermal analyses, allowing FR applications on various cellulose surfaces. These novel polyphenolic polyphosphazene colloids on cotton could be a new promising candidate for construction or textile industry.

Industrial Applications of Colloid and Surface Systems - 2

13:20 - 15:00 Wednesday, 25th June, 2025
ECERF W2-010
Industrial Applications of Colloid and Surface Systems
Noemi Nagy

13:20 - 14:00

437 Precision Agriculture with Colloids

Jordan Dinglasan

Vive Crop Protection, Mississauga, Canada

Abstract

The effective use of colloidal and interfacial interactions in agricultural formulations can enhance the targeting and performance of pesticidal active ingredients, creating new ways to utilize already trusted products. At Vive Crop Protection, we use polymer particles to control surface interactions of active ingredients with their surrounding environment - in the jug, in the tank, and in the field. By manipulating polymer particle interactions, we can improve product shelf-life, product compatibility as well as performance on the soil and on the leaf. Our unique approach to product development not only ensures that the active ingredients are more stable and effective but also reduces the environmental impact by minimizing the amount of pesticide needed. This leads to more sustainable agricultural practices and better crop yields. In this talk, we will delve into the science behind our technology, share case studies demonstrating its effectiveness, and discuss future directions for research and development in this field.

14:00 - 14:20

20 The Utility of Low-Field NMR Solvent Relaxation Measurements to Characterize High-Performance Particulate Dispersions

Heather Clarke[1], David Fairhurst[2], Ravi Sharma[3]

[1]Cabot Corporation, Billerica, USA. [2]Colloid Consultants Ltd., Spartanburg, USA. [3]Mageleka Inc., Naples, USA

Abstract

Many consumables such as inks, paints, cosmetics, and pharmaceuticals are formulated as concentrated particulate dispersions. Their preparation often relies on controlling particle

interactions in solvents to enhance product performance and reliability. In addition, a major concern for formulators, e.g., in the coatings industry, is the frequently encountered difficulty in reproducing performance in a product when an equivalent material ingredient from a different source is substituted. Many materials are marketed/sold as "equivalent" but are demonstrably not because they alter product performance. Making formulation adjustments to solve the materials equivalency problem is economically costly and time-consuming.

Low-field NMR (LF-NMR) solvent relaxation has been used to characterize particle slurries and determine material equivalency to great advantage as it is rapid and can be used as a tool during formulation to enhance product consistency and reduce manufacturing costs.

Here we present studies highlighting the use of a small benchtop LF-NMR spectrometer to characterize a range of colored materials and dispersions: (i) as a rapid QC screen for incoming raw material lots, (ii) to determine the Hansen Solubility Parameters of materials, (iii) to determine the particle *wetted* surface area during dispersion processing, (iv) to determine the sedimentation behavior of (concentrated, non-transparent) particulate dispersions, and (v) to determine material equivalency for replacement/substitution purposes.

14:20 - 14:40

450 Understanding Rare Earth Minerals Flotation from Norwegian Carbonatite through Automated Mineralogy

Pshem Kowalczuk, Ezgi Akyildiz, Camilo M. Silva, Kornel Tobiczyk

Norwegian University of Science and Technology, Trondheim, Norway

Abstract

This study investigates the flotation behaviour of rare earth minerals (REM)—parisite, monazite, and bastnäsite—from a Norwegian carbonatite deposit, using bench-scale flotation combined with scanning electron microscopy-based automated mineralogy (SEM-AM). The flotation process included a rougher stage followed by two cleaner stages. The final concentrate achieved 72% total REM (TREM) recovery with a 45 wt.% rare earth oxide (REO) grade. More than 70% of each targeted mineral was recovered, including 74% of parisite, 77% of bastnäsite, and 73% of monazite. The SEM-AM analysis was used to assess liberation, mineral associations, and surface exposure. Parisite was often associated with related subgroups, while monazite and bastnäsite occurred as inclusions within gangue phases, presenting challenges for efficient separation. Despite this, sufficient surface exposure was observed for all target minerals, enabling effective flotation and recovery. These results provide mineralogical insight into the flotation response of REM in carbonatite systems. The study highlights the value of automated mineralogy in understanding the textural and surface characteristics that influence flotation performance.

14:40 - 15:00

286 Multiscale Modeling of Dispersants and Detergents: Mechanisms and Effects on Deposit Control

Anil Agiral[1], David Growney[2], Erhan Ozdemir[3], Erol Yildirim[3]

[1]Lubrizol Corporation, Wickliffe, USA. [2]Lubrizol Corporation, Sheffield, United Kingdom. [3]Middle East Technical University, Ankara, Turkey

Abstract

Protecting material surfaces from deposits, soot, and sludge particles extends engine life and reduces waste. Lubricant detergents and dispersants in engine oils are crucial additives that prevent deposit formation in internal combustion engines. This study uses multiscale modeling methods to understand how these additives work.

We first examine the self-aggregation behavior of soot and sludge particles, then explore the effects of different groups in detergents and dispersants on deposit formation using various computational techniques, including quantum mechanical calculations, DFT, Monte Carlo algorithms, all-atom molecular dynamics, and coarse-grained simulations.

Our results show that soot and sludge models can be created with a relatively polar surface and diverse functional groups using experimental data. Solubility parameters indicate that polar groups interact with the polar surface of nanoparticles, while non-polar tails extend into the base oil. Positive solvation free energy and hydrogen bonds are primary reasons for colloidal aggregation. Dispersants and detergents prevent aggregation by intercalating between nanoparticles and forming hydrogen bonds, with their long alkyl tails extending into the base oil to create a repulsive layer.

Coarse-grained simulations reveal that without dispersants and detergents, nanoparticle aggregation is inevitable. However, their addition mitigates aggregation, with a critical molecular ratio required for effective dispersion. Our study concludes that dispersants and detergents do not completely disperse nanoparticle clusters but prevent the formation of larger aggregates.

Molecules and Particles at Fluid Interfaces - 4

13:20 - 15:00 Wednesday, 25th June, 2025
ETLC E2-001
Molecules and Particles at Fluid Interfaces
Julianne Gibbs

13:20 - 13:40

125 How Microgel Stiffness Controls Fast Interfacial Deformations: Insights from Droplet Bouncing and Jetting Dynamics

Atieh Razavi, Regine von Klitzing, Amin Rahimzadeh, Hayden Robertson

Technical University of Darmstadt, Darmstadt, Germany

Abstract

PNIPAM microgels, as cross-linked polymer networks, are known to adsorb at the air-water interface, reducing surface tension. The kinetics of their adsorption, and thus the dynamic surface tension, depend on their cross-linking density, which determines the stiffness of individual microgels. Softer microgels with lower cross-linking density deform more at the interface, covering a larger area per microgel and reducing surface tension faster. Under interfacial perturbations such as dilation, softer microgels restore surface tension more rapidly, creating interfaces with higher surface elastic moduli, as shown by interfacial rheology studies using profile analysis tensiometry (1–10 s timescales) [1].

However, the behavior of microgels under very rapid interfacial deformations (milliseconds) remains unclear. We address this question through experiments involving droplet bouncing and jetting, processes relevant to applications such as inkjet printing and needle-free drug delivery. Our results demonstrate that microgels rapidly respond to fast interfacial deformations, with softer microgels restoring surface tension more efficiently. This quicker response allows greater interfacial extension in the presence of softer microgels. Molecular dynamics simulations corroborate our experimental findings, providing further insight into the mechanisms at play.

This study highlights the critical role of microgel stiffness in determining their interfacial dynamics across a wide range of timescales and deformation rates.

References

[1] Tatry et al. Interfacial Rheology of Model Water–Air Microgels Laden Interfaces: Effect of Cross-Linking. *J. Colloid Interface Sci.* **2023**, *629*, 288–299.

13:40 - 14:00

152 Dilatational rheology unravels the interfacial structure of stimuli-responsive microgels

Carmen Cara-Galdeano[1], Garbiñe Aguirre[2], Laurent Billon[2], Teresa Del Castillo Santaella[1], Alberto Martín-Molina[1], Julia Maldonado-Valderrama[1]

[1]University of Granada, Granada, Spain. [2]University of Pau and Pays de l'Adour, Pau, France

Abstract

Microgels have lately received considerable attention as one of the most promising materials for developing new delivery systems owing to their soft structure and stimuli responsiveness. In particular, the use of microgels as emulsion and foam stabilizers has motivated much interest in understading their interfacial activity. The microgel adsorbed layers share some similarities with the protein, polymeric, or head/tail surfactant layers but cannot be categorized in any of those groups. Here, we report recent findings on the interfacial properties of thermoresponsive/pH-responsive microgels and how they are reflected at the interface. We demonstrate that our microgels adsorb irreversibly and stretch as much as possible, forming a single interfacial layer. In addition, the dilatational rheology provides a single maximum indicative of a single conformational regime, which approaches the Gibbs elasticity obtained for spread monolayers. The analysis of dynamics and nonlinear deformation provides additional information on the swelling state of microgels, which can be useful for the fine application of microgels as stabilisers in stimuli responsive foams and emulsions.

Funding: Ministerio de Ciencia e Innovación (PID2023-149387OB-I00) and Consejería de Universidad, Investigación e Innovación and ERDF Andalusia Program 2021-2027 (Grant C-EXP-187-UGR23)

Reference: Fernandez-Rodriguez et al. Microgels at interfaces, from mickering emulsions to flat interfaces and back. Advances Colloid Interface Sci. 288 (2021) 102350.

14:00 - 14:20

205 Unravelling the vertical and lateral structure of adsorbed polymer microgels: Insights from X-ray reflectivity and atomic force microscopy

Hayden Robertson, Joanne Zimmer, Regine von Klitzing, Olaf Soltwedel
Technical University of Darmstadt, Darmstadt, Germany

Abstract

Polymer microgel particles are cross-linked polymer networks and readily self-assemble at interfaces. Microgel particles are particularly advantageous as their elasticity and rigidity can be tuned by tailoring the cross-linker density, enabling distinct modifications to interfacial properties.

Upon adsorption to the air-water interface, these core-shell particles flatten and adopt a core-corona (i.e., fried-egg) structure, showing significant deformation relative to their bulk counterpart.

The novel surface characterisation approaches presented here highlight, for the first time, the use of both specular and off-specular X-ray reflectivity (XRR) to probe the vertical and lateral structure of adsorbed polymer microgel particles at various interfaces, offering in-situ, non-invasive insights without doping or transfer-induced artefacts. In particular, we demonstrate the complementarity of two readily accessible laboratory techniques for characterising the structure of adsorbed microgels: atomic force microscopy (AFM) and XRR. Initial ex-situ AFM of Langmuir-Blodgett deposited microgels at the solid interface revealed strong lateral 2D hexagonal ordering across a broad range of surface pressures. However, for the first time, these results are confirmed by off-specular XRR, demonstrating the existence of hexagonal long-range ordering at low and intermediate surface pressures for in-situ conditions at the air-water interface. Upon uniaxial compression of the interface, the microgel lattice constants decrease monotonically, indicating tighter packing. At higher surface pressures, AFM and off-specular XRR reveal the formation of microgel domains; hexagonal short-range ordering is maintained whereas long-range ordering diminishes. Importantly, transfer effects during the Langmuir-Blodgett deposition were confirmed by comparing lateral structures across in-situ and ex-situ measurements.[2]

[1] doi.org/10.1515/zpch-2014-0568

[2] doi.org/10.1039/D2SM01125E

14:20 - 14:40

238 Sequential adsorption of dual microgels at emulsion interface

Hang Jiang[1], To Ngai[2]

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Abstract

The use of two or more types of particles to regulate emulsions introduces a new dimension compared to emulsions stabilized by a single type of particle. However, research on the stabilization of Pickering emulsions using multiple particles remains relatively sparse, and the exploration of design concepts, stabilization mechanisms, and application scenarios is still in its nascent stages. Most studies reported thus far have focused on the properties and applications of emulsions stabilized by two types of particles undergoing the emulsification process simultaneously. In contrast, few investigations have addressed the sequential participation of two types of particles in the emulsification process and the dynamic regulation of emulsion properties achieved through this method. This study employs microgels as particulate stabilizers, utilizing two types of microgel particles that participate sequentially in the emulsification process. The first type of particle stabilizes the water-oil interface through emulsification, while the second microgel diffuses and self-adsorbs onto the established water-oil interface, allowing for dynamic control over the properties of the emulsion. Notably, this research is the first to use super-resolution confocal microscopy to observe the dynamic interfacial adsorption process of microgels, leading to an in-depth understanding of the stability effects and regulatory mechanisms of microgel-stabilized emulsions and particle interactions, significantly enriching the comprehension of soft particles in the co-stabilization of Pickering emulsions.

14:40 - 15:00

387 Influence of a pH-responsive polymer on mineral dewetting

Anna Nikitina, David Beattie, Marta Krasowska

University of South Australia, Adelaide, Australia

Abstract

Carboxymethyl cellulose (CMC) is a well-known pH-responsive polymer. CMC's carboxyl groups respond to pH changes by taking or releasing protons. In acidic conditions, the CMC becomes water-insoluble, causing the hydrogel to limit water penetration. In neutral or alkaline (pH9) conditions, the polymer chains expand, allowing more water to penetrate the hydrogel. Such behavior could be potentially applied in mineral processing, particularly in froth flotation. CMC can be used to prevent the collection of unwanted minerals, such as talc. CMC decreases the hydrophobicity of the talc and prevents the bubble attachment to the surface. Hydrophobicity and bubble-particle attachment are crucial in flotation because they determine mineral separation efficiency.

Our approach to studying the adsorption behavior of CMC onto talc has involved detailed studies of bubble–surface collisions using high-speed video microscopy. This has enabled a comprehensive investigation of wetting film rupture and dynamic dewetting for bare talc for varying protonation states of CMC. Interferometric atomic force microscopy was performed to study the repulsive forces between the bubble and the modified surface upon the bubble approach. The forces increase by a factor of five compared to the bare talc surface.

To further investigate the CMC adsorbed layer properties under the conditions in the bubble-surface collisions, its adsorption was studied onto a model non-polar hydrophobic surface using the quartz crystal microbalance (QCM) (mixed thiol layer, composed of 1-Hexadecanethiol and 16-mercapto-1-hexadecanol, matching the talc advancing contact angle of 94.6±3.1°).

Results demonstrated that the adsorbed CMC layer significantly increased the time of wetting film drainage and enhanced the hydrophilicity of the talc surface. The QCM study revealed thickness

and hydration changes depending on the pH of the background solution. Altered solution conditions control how well the polymer can change the surface properties relevant to flotation.

Wetting and Adhesion - 5

13:20 - 15:00 Wednesday, 25th June, 2025
ETLC E1-003
Wetting and Adhesion
Sami Khan

13:20 - 13:40

151 Surfactant-induced dewetting of liquid oil at the solid-water interface

Ken-ichi Iimura[1], Rin Yamazaki[1], Yuna Kim[1], Satoru Okamura[2], Keita Aono[2]

[1]Utsunomiya University, Utsunomiya, Japan. [2]Kao corporation, Wakayama, Japan

Abstract

Surfactants induce changes in the wettability of oil at the solid-water interface. This phenomenon is one of fundamental issues in interfacial science and has attracted continuous interest due to its significance in both scientific and industrial applications. We have focused on interesting interfacial characteristics of dialkyl sulfosuccinate surfactants, such as bis(2-ethylhexyl) sulfosuccinate sodium salt (AOT), and investigated their functions to interfacial phenomena especially on wetting. In this presentation, I will describe significantly different influences of surfactants on the dewetting behavior of triolein as a liquid oil at the hydrophobic solid-water interface, studied by the inverted sessile drop method. In addition to AOT, the surfactants used include sodium dodecyl sulfate (SDS) and cetyltrimethylammonium bromide (CTAB) as representative anionic and cationic ones, respectively. In an aqueous solution of AOT, the contact angle of the triolein droplet increased with increase of AOT concentration, reaching about 160 deg at a concentration corresponding to 12-times the critical micelle concentration (cmc). In contrast, for SDS, the triolein contact angle increased to approximately 45 deg at 1 cmc but remained nearly constant at higher concentrations. For CTAB, the highest contact angle over 110 deg was observed below 1 cmc, but the angle stabilized at lower values at concentrations above 2 cmc. These results will be discussed in terms of interfacial energies and structural properties of surfactant-adsorbed films at the interfaces.

13:40 - 14:00

194 Fingering instability in dewetting capillary nanosuspensions

Lingyue Liu[1], Mete Abbot[2], Philipp Brockmann[2], Ilia V. Roisman[2], Jeanette Hussong[2], Erin Koos[1]

[1]KU Leuven, Leuven, Belgium. [2]Technical University of Darmstadt, Darmstadt, Germany

Abstract

This study investigates the fingering instability that forms when a capillary nanosuspension liquid bridge is stretched. The dewetting process is observed using a transparent lifted Hele-Shaw cell. The liquid bridge is stretched under constant acceleration, and the resulting instability patterns are recorded using two high-speed cameras. Finger-like structures, characteristic of the Saffman-Taylor instability are observed. The total length of the dendrites and the overlapped number of branches are quantified. We reveal the roles of microparticles, nanoparticles, and the secondary liquid during the fingering instability. Addition of microparticles to pure liquid enhanced finger length due to increased particle interactions and nucleation sites for bubbles. Addition of secondary fluid reduces fingering length by forming a strong interparticle network. Incorporation of Nanoparticles induces an early onset of cavitation and enhanced fingering instability. However, nanoparticles make the capillary suspensions' overall micro-structure more homogeneous, reduce the sample variation in fingering patterns, and promote the even distribution of gel on both slides during splitting. These findings highlight the complex interactions governing dewetting in capillary (nano)suspensions. This knowledge has potential applications in microfluidics, 3D printing, and thin-film coatings, where controlling dewetting is crucial.

14:00 - 14:20

317 Understanding and Mitigating Contamination from Airborne Hydrocarbons

Daniel Preston

Rice University, Houston, TX, USA

Abstract

Contamination from airborne hydrocarbons profoundly affects surface chemical composition by partially or completely passivating surfaces, in turn impacting wettability because the formation and morphology of droplets and bubbles is substantially influenced by surface chemistry. However, contamination remains difficult to manage due to the ubiquitous nature of hydrocarbons and the spontaneity of the adsorption process. We show that contamination even affects fundamental measurements taken during X-ray photoelectron spectroscopy (XPS), within minutes, evidenced with tests conducted in different XPS systems at multiple universities, both with and without pre-cleaning via ion bombardment. To overcome the pervasive issues associated with contamination, we developed a passive clean storage technology that employs a low-cost and scalable high-surface-area ultraclean storage medium as the getter, with its design based on molecular adsorption–desorption competition theory. Experiments show that this strategy maintains a consistent level of surface cleanliness for several weeks—in contrast to commonly used approaches including storage under vacuum and in sealed sample holders—and can even passively clean initially contaminated samples during storage. The proposed strategy represents a promising approach for preservation and transportation of contamination-sensitive samples and will help achieve consistent experimental results for fundamental studies in surface science while also enhancing performance in applications reliant on careful control of wettability in the energy, food, and medical industries.

14:20 - 14:40

262 Substrate engineering for durable omniphobic liquid-like surfaces

Tao Wen[1], Issac Gresham[2], Rafaela Aguiar[1], Patrick Lee[1], Chiara Neto[2], Kevin Golovin[1]

[1]University of Toronto, Toronto, Canada. [2]University of Sydney, Sydney, Australia

Abstract

This study investigates the crucial role of substrates in enhancing the performance of omniphobic liquid-like surfaces (LLSs) for daily-life applications. It is found that a substrate's density of surface silanol groups significantly impacts the wetting behavior of grafted polydimethylsiloxane (PDMS)-based LLSs. A silanol density ≤1.43 nm^{-2} is inadequate for achieving minimal contact angle hysteresis (CAH). Oxygen plasma treatment of silica formed from 1,2-bis(triethoxysilyl)ethane increases the silanol density to 2.28 nm^{-2}, significantly reducing CAH. The mechanical properties of substrates also is found to influence the abrasion resistance of PDMS-LLSs, with three distinct failure modes by abrasion identified via meniscus force mapping. Two failure modes involve the removal or cleavage of PDMS chains, which are unaffected by the substrate material, while a third mode, caused by substrate scratching, led to a rapid loss of liquid-repellency, particularly on softer silica substrates. Moreover, a bilayer silica system formed from two different organosilica precursors is developed as an intermediary layer to smoothen rough substrates while maintaining good abrasion resistance. The findings not only advance the application of PDMS-LLS on a wider range of substrates but also offer insights in engineering substrates for other coating systems.

14:40 - 15:00

336 Role of Solvent-Mediation on the Wettability and Stability of Phase Change Materials

Kamran Hassani, Ken Chisholm, Sami Khan

Simon Fraser University, Surrey, Canada

Abstract

Phase change materials (PCMs) are widely used in thermal energy storage systems due to their high energy density and ability to harness intermittent energy sources such as wind and solar. However, their performance is constrained by chemical and physical degradation during thermal cycles, and poor wettability with the underlying material of construction. Inorganic PCMs such as hydrated and molten salts are especially susceptible to dehydration and crystallite changes, which subsequently affect their thermophysical properties and wettability. In this research, we introduce a solvent-mediated approach to enhance both wetting and stability of PCMs. We use magnesium nitrate hexahydrate as a model inorganic PCM and find that it readily dissolves in isopropanol at room temperature. Using contact angle and tensiometry measurements, we determine optimal composition of the isopropanol-PCM mixture which consistently yields a positive spreading coefficient on substrates with varying surface energies. X-ray diffraction (XRD) analysis confirms the retention of water of crystallization in the PCM even after solvent boil-off. We also find that in the solvent-mediated case, the pristine PCM state persists even after multiple phase change cycles, whereas the PCM without solvent mediation shows loss in water. Differential scanning calorimetry (DSC) is also used to compare PCM thermal stability and performance with and without solvent mediation. This approach holds promise for enabling more reliable and efficient thermal energy storage technologies.

Self and Directed Assembly - 4

13:20 - 15:00 Wednesday, 25th June, 2025
ECERF W2-050
Self and Directed Assembly
Ignaas Jimidar

13:20 - 13:40

32 Magnetic Manipulation of Oil- Nanoparticle Assemblies for Delivery of Therapeutics

oluwafemi ligan, Kathleen STEBE, Hyun Koo, Edward Steager

University of Pennsylvania, philadelphia, USA

Abstract

Iron oxide nanoparticles (IONP) assemblies have a great potential for multiple applications, such as targeted drug delivery and micromanipulation under external magnetic fields. IONP can be aggregated into micro robotic structures that can be controlled using magnetic fields to precisely kill, degrade, and remove biofilms with remarkable efficiency. Here, we extend this ability to form and manipulate functional structures by introducing oil droplets for incorporation into the assembled structures and for delivery as cargo. In our experiments, we exploit 3D-Helmholtz coils that generate a magnetic field designed to set up a 'walking' motion that minimizes drag with bounding surfaces. We focus on oil droplets placed in a suspension of free magnetic particles that are partially wetted by the oil and find a range of structures with distinct motions in this setting. We find that at low volume fraction, IONPs assemble at the poles of the droplets, causing them to spin in the rotating field. At moderate IONP volume fraction, the IONP form stilt-like structures whose length increases with time and IONP volume fraction. The droplets move effectively under rotating fields on these stilts to "walk" at speeds that increase linearly with stilt length. The formation of these diverse structures is rationalized in terms of interacting magnetic dipoles in the field. Current work focuses on exploiting these structures to carry, transport and deliver hydrophobic antibacterial and antifungal essential oils to treat a *Candida albicans* biofilm infection on hard and soft surfaces.

13:40 - 14:00

305 Prediction of Magnetic Multi-Patch Particle Assembly with Differential Evolution

Eric McPherson[1], Kenneth Kroenlein[2], Ilona Kretzschmar[1]

[1]The City College of New York, New York, NY, USA. [2]Citrine Informatics, Redwood City, CA, USA

Abstract

Magnetic Janus particles assemble into a variety of complex structures that can lead to magnetorheological (MR) fluids with interesting macroscopic properties. The structures that form must be characterized to understand the connection between the Janus particle properties and macroscopic characteristics. However, the parameter space that is possible for Janus and patchy particles is difficult to explore because it is large – there can be different particle and cap material properties and geometries, applied external fields, mixtures of particles, etc. – making it difficult to design MR fluids with specific properties. Here, a proof-of-concept simulation method based on differential evolution (DE) is used to explore the directed and self-assembly of laterally- and radially-shifted magnetic Janus particles. Initial two-dimensional DE simulations without out-of-plane rotation quantitatively reproduce published particle orientations and cluster morphologies. However, observations based on cluster reorientation and multi-particle rearrangement are less well reproduced. Here, the DE simulation is expanded to include out-of-plane rotation and multi-patch particles and their impact on cluster structure and aggregation.

14:00 - 14:20

310 Enhanced Transport and Assembly of Paramagnetic Colloids

Ayca Ersoy, Zachary Sherman

University of Washington, Seattle, USA

Abstract

Magnetic nanoparticles (MNPs) are easily controlled and separated remotely using external magnetic fields and this feature makes them extremely effective for cell sorting, targeted drug delivery, and metal ion separations. Understanding the magnetophoretic transport properties of MNPs and developing predictive models is crucial to implementing MNPs for these applications. While simple to understand in the dilute limit, transport in concentrated dispersions of MNPs is complex and extremely sensitive to the magnetic field characteristics, the nanoparticle physical features, and the self-assembled structures that form. In this talk, we investigate the structure and magnetophoretic transport of concentrated MNP suspensions using coarse-grained Brownian dynamics simulations. We describe how two crucial features, hydrodynamic interactions and

dipolar interactions, among MNPs dictate their structure and motion. At large field strengths, particles aggregate in field-aligned chains which reduces their hydrodynamic drag and increases their magnetophoretic mobility. These chains further aggregate laterally into a percolated gel network, which greatly inhibits their mobility. Under appropriate conditions on the magnitude of the magnetic field and the magnitude of the magnetic field gradient, the MNP networks are vulnerable to hydrodynamic shear forces that rupture the gel. After rupture, the mobility of MNP aggregates dramatically increases. We characterize the network break-up times in terms of the competition between cohesive dipolar forces holding the network together and the shear forces ripping the network apart. This fundamental understanding of magnetophoretic transport informs our future investigations of multicomponent MNP mixtures, theranostic function of MNPs, transport in porous media, and mobility of nonspherical magnetic particles.

14:20 - 14:40

23 Prediction of an Active-Passive Colloids Complex Crystallization through Self-Assembly

Nur Syazaliyana Azali, Stephen Ebbens

University of Sheffield, Sheffield, United Kingdom

Abstract

Colloidal crystallization represents the new development of hierarchically ordered materials through self-assembly. Active colloids, or catalytic Janus colloids, are small-scale materials that have the capability of decomposing dissolved fuel to provide rapid motion in fluids. Fabrication of active and passive colloids into complex crystallization is believed to promote new potential to synthesize smart materials and improve current developing technology for active particles.

Here, the formation of complex large active-passive colloids of Ca-6, Polymethyl Methacrylate (PMMA), has been shown to self-organize into close-packed hexagonally ordered monocrystalline. The crystallization formation was set under the influence of fuel concentration for catalytic analysis of active colloids, and their capability to self-organize into crystal arrangements was analyzed through a series of static images. Additionally, catalytic activity and rapid motion are expected to create additional interactions that will allow access to new reconfigurable and responsive structures for material applications that rely on colloidal self-assembly.

However, in this highly sensitive system, the sequence of colloidal interactions plays a vital role during crystal formation. Various factors, including catalytical interaction and shear effects, have mutually significant effects on colloidal crystallization. The presence of active colloids in active-passive complex crystallization has considerable influence on crystal defects.

These findings could indicate the ability of colloidal systems to form crystal arrangements under the influence of a catalytic field with a small doping of active colloids into the system. The study

will consequently motivate a new insight into the crystallization of colloids, thus optimizing the use of colloidal systems for research advancement.

14:40 - 15:00

403 Solvent effects on amphiphile self-assembly in Deep Eutectic Solvents

Karen Edler

Lund University, Lund, Sweden

Abstract

Deep eutectic solvents (DES) are mixtures of hydrogen bond donors and acceptors that form strongly hydrogen-bonded room temperature liquids. These mixtures are straightforward to prepare, using cheap, bioderived components, with lower toxicity than ionic liquids and lower volatility than many organic solvents, so are potential green solvents for applications from extractions to battery electrolytes. Changing the H-bonding components and their ratios can alter the physicochemical properties of DES, leading to changes in solubility of other species in these solvents and also altering the self-organisation of surfactants in these mixtures. We have investigated how component ratios in several different DES impact upon solubility and structuring in surfactant solutions, using small angle X-ray and neutron scattering and rheology. Factors such as polarity, the presence of water, and the intermolecular interactions between both solvent components themselves and with the surfactant headgroups play a role in the size and morphology of the micelles formed. We aim to develop design rules for novel complex solutions with applications in templating, rheology control and encapsulation using these interesting new solvent systems.

Surfactants and Colloidal systems in Resource Extraction - 3

15:20 - 17:00 Wednesday, 25th June, 2025
ICE Incubator
Surfactants and Colloidal systems in Resource Extraction
Edgar Acosta

15:20 - 16:00

365 Colloidal Science in Heavy Oil Extraction from Canadian Oil Sands

Zhenghe Xu[1,2], Jacob Masliyah[1]

[1]University of Alberta, Edmonton, Canada. [2]Southern University of Science and Technology, Shenzhen, China

Abstract

Heavy oil production from Canadian oil sands remains a viable source of petroleum with a daily production rate of crude between 3.1 and 3.2 MMB. Colloidal science plays a critical role in many subprocesses of heavy oil (bitumen extraction) from oil sands, starting from liberation of bitumen from sand grains to bitumen-air attachment in flotation, emulsion breaking in froth treatment and fine particle consolidation in tailings management, all linked to each other. This presentation will illustrate how fundamental understanding of colloidal phenomena helps large scale bitumen production from Canadian oil sands.

A general overview on bitumen extraction process will be presented first, followed by the analysis of microscale processes and challenges involved in bitumen recovery. Our work on molecular and colloidal understanding of poor processing ores using start-of-the-art techniques such as zeta potential distribution measurement and colloidal force measurement using atomic force microscope will be highlighted. Such fundamental understanding on clay surface chemistry and clay-bitumen interactions helped the industry to deal with lower grade and poorer processing ores of high clay contents and high electrolyte concentration for more efficient bitumen recovery and less negative environmental impact.

16:00 - 16:20

36 Surface Nano-mechanics of Ionic Polyether on Water-Oil Emulsion Stability in Oil Production

fengzhi Guo, fan shao, lu gong, yue ma, changtao yue

China University of Petroleum, Beijing, Beijing, China

Abstract

Polyester polymers have been widely applied during oil production for water/oil separation, enhanced oil recovery, oil refining, waste water treatment and so on. Nowadays, the increasing content of heavy oil has significantly inhibited the application and efficiency of various polyester-based materials. It is of emergent and practical importance to develop new polyesters for highly efficient water/oil separation. Investigating the influence of ionic modification of polyesters in their interfacial adsorption behaviors and emulsion stability remains challenging. In this study, different ionic modifications have been conducted including anionic group (i.e., sulfonic group), cationic group (i.e., quaternary ammonium group), and zwitterionic groups (i.e., sulfonic betaine) to endow polyesters with excellent hydrophilicity. The interfacial energy experiments demonstrated that, among the single-ended modifications, the anionic modification exhibited the highest interfacial activity. Besides, both-ended anion-modified polyether had higher interfacial activity than single-ended anion-modified polyether; conversely cation-modified polyether with both-end structures had higher interfacial activity than cation-modified polyether with single-end structures. Finally, the molecular dynamic (MD) simulation results also proved that both-ended modified ionic polyether might have the interesting interfacial self-assembling behavior to form a loop conformation, which could increase the surface coverage area of the polyether molecules at the oil-water interface. Our work has paved the way toward the fundamental investigation of functional interfacial polymers in water/oil separation, as well as the development of polyester-based materials in oil industries.

16:20 - 16:40

257 Design of thermo-stable surfactant formulations for oil recovery

Ben Shiau, Heba Aladwani, Collins Adjei-Ampah, Tchemongo Berte, Mashhad Fahes

The University of Oklahoma, Norman, USA

Abstract

The recovery of residual oil after water flooding phase in oil reservoirs can be improved by using surfactants as part of the chemical enhanced oil recovery phase. Developing such formulations for elevated temperature reservoirs, such as 90°C and plus, requires the use of thermos-stable surfactant candidates, such as Internal olefin sulfonates (IOS). As part of the expansion efforts (toward both conventional and unconventional formations), Petrostep S2, served as IOS candidate, was used to address these challenges and additional opportunities, e.g., shale oil EOR. Phase behavior studies of a system including surfactant, brine, and oil were conducted, starting with Petrostep S2 as single surfactant system and moving to combinations with multiple surfactants, like Alfoterra (alkyl ether carboxylate), SDBS (sodium dodecylbenzene sulfonate), and Calfax 16L-35 (alkyl diphenyl oxide disulfonate). The binary mixtures were first tested at varying concentrations and surfactant ratios of 50:50, 90:10, and 80:20 (primary/secondary components); specifically with salinity (salt) scans ranging from 4 to 25 wt% NaCl to be able to identify Winsor Type III microemulsions. For example, one of the optimal formulations was realized and achieved using a 50:50 (wt %/%) mixture of Petrostep S2 and SDBS close to 17 wt% NaCl at 90^{o}C, which successfully reached ultralow IFT value. The Chun-Huh equation was applied to validate the IFT values from the measurements. This study provides a framework for designing thermostable surfactant formulations with potential for chemical enhanced oil recovery in high temperature reservoirs and/or served as part of the ingredients for tight shale formations.

Surfactants and Emulsions - 3

15:20 - 17:00 Wednesday, 25th June, 2025
ETLC E1-018
Surfactants and Emulsions
Joachim Venzmer

15:20 - 15:40

94 Sulfolane facilitates diisopropylamine dissolution in water, potentially enhancing pollutant transport

Erica Pensini[1], Alejandro Marangoni[1], Sylvain Prevost[2]

[1]University of Guelph, Guelph, Canada. [2]Institut Laue Langevin, Grenoble, France

Abstract

Diisopropylamine (DIPA) and sulfolane are emerging groundwater co-pollutants. They are used in different industrial processes, including carbon capture and sweetening of sour gas. In binary aqueous mixtures, sulfolane is freely miscible in water, with limited sorption onto minerals. In contrast, DIPA yields sub-micron dispersions in water and sorbs onto various minerals. This limits DIPA migration in groundwater. Ternary aqueous mixtures of DIPA and sulfolane have not been studied before. Our study shows that sulfolane enhances DIPA miscibility in water, although sulfolane and DIPA are immiscible without water. This unexpected co-solvency effect inhibits DIPA sorption onto minerals. Small angle neutron scattering experiments reveal composite droplets with a small DIPA core (diameter≈12 Å) surrounded by sulfolane, which disperses DIPA.

Fourier transform infrared spectroscopy and computer simulations show interactions between DIPA and sulfolane in water, which in aid in solubilizing DIPA in water. These findings will aid in predicting and preventing co-pollutant migration in groundwater.

15:40 - 16:00

149 Unlocking Next-Gen Polyolefin Degradation by Heat-Resistant Double Emulsions

Antolin Jesila Jesu Amalraj, Guy Mechrez

Agriculture Research Organization - Volcani Institute., Rishon leTzion, Israel

Abstract

Our project aims to revolutionize spore encapsulation within emulsions as a Hybrid living material (HLMs) to confer exceptional heat resistance, ensuring spore viability amidst plastic hydrolysis. We employ O/W/O emulsions comprising paraffin oil (O) with an aqueous phase (W). Stabilization is achieved through hydrophilic silica (A300 treated with APTES) for single emulsions and hydrophobic silica (R812) for double emulsions. Single emulsion compositions maintain a 5:5 water-to-oil ratio with 2% A300/APTES, while double emulsions integrate single emulsion components, paraffin oil (5:5 ratio), and 4% R812. The oil droplet O1 of O1/W/O2 emulsion was encapsulated with Conidia (simulation) and bacterial (empirical) spores with an outstanding encapsulated efficiency of around 96.5%. Visual confirmation through Confocal 2D/3D, SEM, and Cryo-SEM images showcases fungi`s encapsulation within single and double emulsions. Viability tests underscore our breakthrough, for freshly prepared emulsions and an impressive retention with 250-day-old O/W/O emulsions. Our milestone achievement culminates in the successful extrusion of emulsion-spore blends with LDPE, PP, and PLA, affirming the survival of emulsion droplets and encapsulated spores at an astounding temperature (120-180 °C), with the results providing signs for efficient biodegradation. This resilience is attributed to the remarkable structural stability and viscoelastic properties of the O/W/O emulsion. Therefore, our efforts not only introduce a new way to encase spores but also reveal a groundbreaking method to keep them alive during plastic processing.

16:00 - 16:20

178 New encapsulation platform based on aqueous two-phase systems stabilized by double hydrophilic block copolymer surfactants

Mihee Kim

Los Alamos National Laboratory, Los Alamos, USA

Abstract

Encapsulation technologies have been used for biomedical and pharmaceutical applications such as high-throughput cell screening, stem cell delivery, or 3D cell culture. The widely used methods for achieving stable droplets for encapsulation include water-in-oil emulsions or crosslinking the entire droplets to create microgels. However, hydrophobic components may denature proteins or prohibit the diffusion of metabolic wastes and nutrients. The single size distribution of pores in microgels makes encapsulating cells or particles with vastly different sizes challenging, as smaller components may easily diffuse out of the network when the pores are sized to capture larger particles. In this talk, we will present our current efforts to develop all-aqueous-based strategies to create stable droplets for encapsulating several different sizes of cells or particles. We generate biocompatible emulsion droplets based on aqueous two-phase systems (ATPS) by leveraging the phase separation of incompatible water-soluble polymers. We will present our effort to stabilize emulsion droplets made by ATPS by incorporating double hydrophilic block copolymers into the systems. To gain a fundamental understanding of droplet stabilization, we investigate the phase behavior and self-assembly in systems of polyethylene oxide (PEO), dextran, and PEO-b-dextran double hydrophilic block copolymers. We will conclude by discussing material design strategies for crosslinking the block copolymers at the interfaces between PEO and dextran phases to achieve a nanoporous semi-permeable barrier at the droplet surfaces.

16:20 - 16:40

227 Gas bubble-Encapsulating Microcapsules (GEMs) via osmosis-induced-cavitation

CK Yeh[1], Yijin Huang[2], Luuk Schoenmarkers[3], Daeyeon Lee[1]

[1]University of Pennsylvania, Philadelphia, USA. [2]Tsinghua University, Beijing, China. [3]Utrecht University, Utrecht, Netherlands

Abstract

Microcapsules are widely used as carriers for encapsulating and delivering active materials. Incorporating gas bubbles into these microcapsules introduces unique functionalities not achievable with traditional designs. Although capsules that contain bubbles have been reported, the methods for their fabrication make it difficult to control the size of the bubble and capsule. In this work, we present a method for creating gas bubble-encapsulating microcapsules (GEMs) using osmosis-induced cavitation. The method involves taking microcapsules that have a relatively low concentration of salt inside their core and placing them into a high salt solution, posing a high negative pressure on the water inside the capsule. Under this pressure, the dissolved air can expand into a gas bubble and grow until the inside and outside salt concentration balance. Furthermore, we show that once these bubbles are grown under the high salt concentration, their size can be modulated by placing the GEMs back into lower salt concentrations. As a practical application, we show that buoyancy, enabled by the bubbles, can be used to separate intact microcapsules from defective ones. Osmosis-induced-cavitation presents a versatile and scalable approach to introduce

and modulate bubbles within microcapsules, enabling new functionalities including intact microcapsule separation.

16:40 - 17:00

411 Mechanistic insights into polymer microparticle formation for controlled drug release

Suryavarshini Sundar[1], Eric J. Hukkanen[2], Renato A. Chiarella[2], Arun Ramachandran[1]

[1]University of Toronto, Toronto, Canada. [2]Alkermes Inc., Waltham, USA

Abstract

Polymer microparticles are widely utilized as carriers for active pharmaceutical ingredients in controlled-release drug delivery systems. The morphology and distribution of the drug within the microparticle significantly affect the polymer degradation rates and the drug release kinetics. This study focuses on elucidating the mechanistic dynamics of microparticle formation and the resultant morphology at the level of a single drop. To do this we have used a microfluidic extensional flow device to create and trap polymer solution drops of a desired size and capture the microparticle formation through solvent extraction. We studied the obtained microparticles using brightfield and fluorescence microscopy and observed internal pockets of fluid where the polymer and drug were absent. We attributed these regions of fluid to the presence of dissolved water in the droplet and to test this hypothesis we created polymer solution droplets pre-saturated with water and studied the resulting microparticles. We observed the dynamics of the internal partitioning of water and the consequent formation of double emulsion, core-shell, and Janus-type microparticles with varying degrees of internal particle morphology. We will discuss the mechanisms driving these configurations and their impact on drug release profiles. The results of this work have significant relevance to the literature on the design of polymer microsphere-based delivery systems, potentially leading to more effective and precisely controlled sustained-release formulations.

General Aspects of Colloid and Interface Science - 4

15:20 - 17:00 Wednesday, 25th June, 2025
ECERF W2-010
General Aspects of Colloid and Interface Science
Remco Tuinier

15:20 - 16:00

433 Protein Colloid Assembly and Its Applications in Healthy Foods and Biomaterials

Lingyun Chen

Univ of Alberta, Edmonton, Canada

Abstract

The growing demand for sustainable and health-conscious food products has led to an increased interest in plant proteins as alternatives to animal proteins. However, developing stable and palatable protein-rich foods using plant proteins presents significant challenges. These challenges arise primarily from the structural limitations of plant proteins, which often exhibit lower solubility and functional properties due to their complex quaternary aggregates.

This presentation will explore the assembly of protein-based colloids as an effective strategy to address these challenges. It will focus on the design and development of protein fibrillar and particulate aggregates, as well as protein microgels, utilizing both bottom-up and top-down approaches. The impact of their morphology, size, and chemical characteristics on key functional properties—such as emulsifying, foaming, and gelling—will be discussed. The potential of protein-based colloids to enhance the stability, sensory attributes, and nutritional value of plant protein-based food products will be highlighted. Furthermore, the combination of protein colloid assembly with 3D printing will be explored as a strategy for designing biodegradable materials for biomedical and industrial applications. This approach enables the development of eco-friendly materials from renewable agricultural resources, addressing critical sustainability challenges in materials science.

16:00 - 16:20

92 Colloidal Heterostructures of Bismuth-based 2D Nanomaterials for Photocatalytic Hydrogen Generation

Md Masud Rana[1,2], Kazi Alam[1], Karthik Shankar[1]

[1]University of Alberta Faculty of Engineering, Edmonton, Canada. [2]Jashore University of Science and Technology, Jashore, Bangladesh

Abstract

Two-dimensional (2D) layered materials are exciting candidates for use in energy harvesting applications owing to their unique properties such as high specific surface area, porosity, facile charge transfer and layer-dependent bandgaps. Bi-based 2D materials are non-toxic, earth-abundant, photostable, and possess suitable band positions, which are beneficial for solar-driven photocatalytic hydrogen production. The fundamental steps involved in photocatalytic water splitting are photon absorption from sunlight, electron-hole pair generation, separation of photogenerated charge carriers, transport of the separated carriers to the surface of photocatalysts, and reduction of proton (H^+) to evolve hydrogen. The key challenge for the photocatalytic hydrogen evolution is the efficient separation and transport of photogenerated carriers and preventing rapid recombination of electrons and holes. The design and synthesis of suitable heterostructures have been utilized to enhance the charge separation and thus improve the photocatalytic yield. A variety of synthesis methods have been adopted to synthesize bismuth-based materials including solvothermal, hydrothermal, solid-state reaction, sol-gel, and sonochemical techniques. In the present work, we synthesized a $BiOBr/Bi_2WO_6/Bi_2S_3$ ternary heterostructure by a two-step method which yielded colloids. A colloidal photocatalytic system offers some intriguing advantages such as a short distance for charge transport and exploiting the benefits of quantum confinement effects. We tested our bismuth-based ternary heterostructure for photocatalytic hydrogen evolution under an AM 1.5G class A solar simulator. The evolved gases were analyzed by a Shimadzu gas chromatograph. $BiOBr/Bi_2WO_6/Bi_2S_3$ colloids generated 140.02 $\mu mol\ g^{-1}\ h^{-1}$ of H_2 (solar-to-hydrogen efficiency of 3.26%), much higher than the yields from $BiOBr/Bi_2S_3$ and Bi_2WO_6/Bi_2S_3 binary heterostructures.

16:20 - 16:40

343 Mechanisms of freeze-thaw instability in oil body (oleosomes) emulsions

Vincenzo di Bari, Filippo Bramante, David Gray

University of Nottingham, Nottingham, United Kingdom

Abstract

Oil bodies (OBs) are micron-sized neutral lipid intracellular droplet stored in plant seeds providing energy during germination. OBs can be recovered using an aqueous process yielding natural oil-in-water emulsions. This study investigates for the first time the OB-in-water emulsion (72%, wt%) freeze-thaw behaviour. Emulsions were cooled to three temperatures to control the crystallization of each phase. When cooled to -10°C or -60°C, where the aqueous phase or both lipid and aqueous phase crystallised, respectively, the emulsion remained stable. At -10°C the mechanical pressure applied by ice crystals cannot destabilise OBs. The rapid crystallisation at -60°C preserves emulsions structure, possibly due to the formation of small crystals in both phases. At -20°C, OB destabilisation was observed as phase separated oil. Oil release increased from 41% to 49% with increasing cooling rate from -0.1 to -10°C/min. At -20°C, ice crystals formed rapidly, while OBs crystallised over four-hour, following a sigmoidal phase transition profile characteristic of lipid crystallisation. Crystallisation was recorded at shorter time in OB than in bulk rapeseed oil. We hypothesise interfacial heterogenous nucleation occur in OB with lipid crystals forming near the interface. We propose destabilisation occurs through a mechanism of partial coalescence: OB droplets are forced in close contact by ice crystals and after forming lipid crystals can pierce the interface of neighbouring droplets causing inter-droplet anchoring, structural damage due to crystal penetration, and liquid oil exchange. Upon thawing, the damaged interface cannot hold the oil resulting in phase separation.

16:40 - 17:00

390 Lubricant-Infused Thick Porous Organogels to Shed off Mud/Ice/Slush Contaminants

Zhitong Lin, Gabrielle Anne Bacani, Hyun-Joong Chung

University of Alberta, Edmonton, Canada

Abstract

Winter conditions often cause surface contamination by sticky foulants like ice, mud, and their mixtures, compromising the functionality of cleanliness-sensitive surfaces such as sensors and cameras. Developing a durable, slippery surface coating that can effortlessly repel these contaminants is highly advantageous. While many anti-fouling surfaces have been created using slippery surface designs, their longevity remains a challenge. Here, we present the fabrication of a

thick, porous polydimethylsiloxane (PDMS) film using a humidity-assisted method, followed by silicone oil infusion to create a robust, slippery, anti-fouling surface. The resulting PDMS film exhibited five distinct layers in a stratified manner, with compositions varying based on experimental conditions. Among these, the structure predominantly composed of spherical cellular pores demonstrated to be optimal for lubricant infusion, owing to its high oil absorption rate and enhanced reservoir capacity. The anti-fouling performance of the lubricant-infused porous PDMS surface was demonstrated through ultralow ice adhesion and the rapid sliding of clay-containing droplets on a 10° incline, outperforming both pristine lubricant-infused PDMS and lubricant-containing PDMS fabricated using the one-pot synthesis method. Additionally, a real-world testing confirmed its excellent resistance to winter foulants. The oil-infused porous PDMS surface also exhibited remarkable transparency and abrasion resistance, which broaden its potential applications in various fields.

Colloids for Sustainability and Energy - 6

15:20 - 17:00 Wednesday, 25th June, 2025
ECERF W2-110
Colloids for Sustainability and Energy
Karthik Shankar

15:20 - 16:00

426 Self-Assembled Nanopolysaccharide Gels for Multifunctional Lightweight Materials

Orlando Rojas

University of British Columbia, Vancouver, Canada

Abstract

Nanopolysaccharides, including nanocelluloses and nanochitin, self-assemble in aqueous solutions to form gel networks, supramolecular inclusion complexes, and other hierarchical structures that adsorb at air/water and oil/water interfaces. These properties make them ideal for stabilizing multiphase systems such as Pickering emulgels and foams, where nanopolysaccharides contribute their intrinsic functionalities. Their performance can be further enhanced through surface chemical modification or hybridization with surfactants and polymers, enabling the design of stimuli-responsive, tunable, and functional bio-based materials for diverse applications.

Here, we explore the chemistry, structure, and physicochemical properties of nanocellulose and deacetylated nanochitin for the synthesis of lightweight materials. We demonstrate how anisotropic and chiral nematic arrangements of cellulose nanocrystals enable the formation of aerogels with tunable opto-mechanical properties. Furthermore, we present the development of 3D-structured hybrid aerogels via liquid-liquid sculpting, wherein an elastic film at immiscible

liquid interfaces gives rise to highly porous honeycomb architectures. Upon thermal annealing, these structures become highly conductive and effectively attenuate incident electromagnetic (EM) waves.

Finally, we highlight the exceptional thermal insulation and infrared shielding capabilities of these aerogels, which significantly reduce heat transfer, offering energy-efficient solutions for advanced material applications.

16:00 - 16:20

189 Surfactant-Enabled Dispersion of Stabilized Lithium Metal Particles (SLMP)

Sibani Lisa Biswal

Rice University, Houston, USA

Abstract

Silicon anodes hold great promise for next-generation lithium-ion batteries due to their high theoretical capacity, but their significant volumetric expansion during lithiation poses challenges to electrode stability and cycle life. Prelithiation methods can offset the initial capacity loss and improve the cycling performance of Si anodes, yet scalable approaches suitable for industrial manufacturing remain limited.

Here, we present a novel surfactant-stabilized dispersion of stabilized lithium metal particles (SLMPs) designed for spray-coating onto prefabricated Si composite anodes. This method forms a uniformly distributed and well-adhered SLMP layer, enabling effective in situ prelithiation during cell assembly. The process is compatible with current industrial electrode fabrication workflows, offering a "drop-in" solution for large-scale implementation.

We evaluated the performance of the prelithiated Si anodes in full cells, examining the effects of SLMP loading ratios as a function of loading densities under different cycling regimes. Our findings demonstrate that optimized SLMP loading enhances the capacity retention and cycling stability of Si anodes, paving the way for practical applications in high-energy-density lithium-ion batteries.

16:20 - 16:40

376 Optimization of Lithium Hydroxide Crystallization: Effects of Local Supersaturation in Ethanol Antisolvent Systems

Chentao He, Liuyin Xia

University of Alberta, Edmonton, Canada

Abstract

Lithium hydroxide (LiOH) is a crucial material for lithium-ion battery cathodes, playing a pivotal role in the advancement of energy storage technologies. In the lithium market, LiOH has taken approximately 35% of the total lithium compound demand alongside lithium carbonate (Li_2CO_3). Typically, lithium ions are extracted from primary sources such as brines or hard rocks, and then LiOH solids are produced through energy-intensive thermal evaporation. This study employs ethanol as the antisolvent, explores ethanol-based antisolvent crystallization as a sustainable alternative, which is executed under ambient conditions with less energy-cost. To optimize crystal characteristics such as shape, size distribution, and yield, we performed experiments by varying temperature, crystallization time, and solution-to-antisolvent (O/A) ratios. The highest yield of 72% was achieved at an O/A ratio of 1.2:1. Kinetic analysis using the Avrami model revealed exponents below 1, indicating instantaneous crystallization, and an activation energy of 2 kJ/mol, confirming a diffusion-controlled process. These findings demonstrate that ethanol antisolvent crystallization effectively reduces energy consumption and offers a viable method for LiOH extraction. Understanding the influence of local supersaturation provides critical insights for controlling crystallization outcomes, paving the way for more efficient and environmentally friendly lithium hydroxide production.

16:40 - 17:00

51 Clay minerals as suitable delivery device for polyphosphate fertilizers

Gianluca Utzeri, Marie Skip

Lund University, Lund, Sweden

Abstract

Phosphorus is a fundamental nutrient for plant growth, however the direct application of polyphosphate-based fertilizers led to 10-20% of plant uptake.
How can we improve the availability of phosphorus sources?
Our study investigates the application of clay minerals as delivery device for the transport of polyphosphates (PPs) as sustainable agricultural alternative. We hypothesis that the anisotropic charge distribution of the clay platelets which led to diverse phase behaviour is the key parameter.

The permanently negative charged surface and the pH-dependent positive charges at the edge rule the electrostatic interactions within platelets or ion-ion correlation forces. The electrostatic interactions of PPs with different chain length, namely PO_4^{3-}, $P_2O_7^{4-}$, $P_3O_{10}^{5-}$, $P_{14}O_{43}^{16-}$, $P_{60}O_{181}^{62-}$ and , $P_{130}O_{391}^{132-}$, with the laponite (LAP) and montmorillonite (MMT) platelets, are being analysed. LAP and MMT are a synthetic and natural trioctahedral clay mineral, respectively. It was macroscopically observed that the addition of polyphosphate increases the stability of the dispersion reducing the gelling process as function of time. Considering Na-LAP, the small-angle X-Ray scattering measurements shows how the intra- and inter-particle interactions are affected. The inter-particles interactions are sligthy affected by the three charge ratio between PPs and LAP platelets, considered. A more significative effect is shown by the chain length of polyphosphate, indeed we pass from attractive interparticle interactions in presence of PO_4^{3-}, $P_2O_7^{4-}$, $P_3O_{10}^{5-}$ to repulsive interparticle interactions in presence of $P_{14}O_{43}^{16-}$, $P_{60}O_{181}^{62-}$ and , $P_{130}O_{391}^{132-}$. Complementary analysis are being performed for a deeper understanding of the systems.

Industrial Applications of Colloid and Surface Systems - 3

15:20 - 17:00 Wednesday, 25th June, 2025
NRE 1-001
Industrial Applications of Colloid and Surface Systems
Seyed Seyed Mehdi

15:20 - 15:40

191 Microemulsion remediation of asphaltene deposits

Sibani Lisa Biswal

Rice University, Houston, USA

Abstract

We have generated a microemulsion formulation that can successfully remediate asphaltene deposits. Microemulsions have been considered sound carrier systems that can directly deliver the solvent to an asphaltene deposit and effectively remove it. Additionally, emulsions can effectively lower the interfacial tension between oil and water, leading to better solubilization of the asphaltene deposit. I will describe how d-Limonene (a terpene-based citrus oil) microemulsions can effectively remove asphaltene deposits. The proposed mechanism is that the microemulsion must diffuse to the asphaltene deposit, allow the solvent to infiltrate the deposit, followed by swelling and solubilization of the asphaltene deposits.

15:40 - 16:00

372 Innovative SERS Sensors for Detecting Naphthenic Acids in Oil SandsProcess-Affected Water

Mohammadamin Rashidi, Hongyan Wu, Engin Deniz, Qiuyun Lu, Mohamed Gamal El-Din, Nobuo Maeda, Xuehua Zhang

University of Alberta, Edmonton, Canada

Abstract

Naphthenic acids, commonly found in oil sands process-affected water (OSPW), are highly toxic and contribute to the contamination of water resources, impacting aquatic life and the surrounding ecosystems. Given the hazardous nature of these contaminants, rapid and reliable detection is crucial for minimizing their environmental impact and protecting public health. Traditional detection methods, such as gas chromatography and infrared spectroscopy, often require extensive sample preparation and long processing times. In contrast, surface-enhanced Raman spectroscopy (SERS) offers a promising solution. By enhancing Raman scattering signals through the use of metal nanoparticle substrates, SERS enables the detection of low concentrations of contaminants, such as oil by-products and pesticides, even in complex environmental samples. This makes SERS a highly sensitive and rapid tool for real-time monitoring of pollutants in environmental matrices like produced water and OSPW.

This work demonstrates a new generation of SERS sensors with increased sensitivity and flexibility. The sensors' scalability is increased through the formation of silver nanoparticle (AgNPs) aggregation by using a solvent-exchange method. The AgNPs are grown in situ through surface reactions on a flexible layer. The addition of the AgNPs to the sensors increases the sensitivity of the SERS technique, while the polymer increases their flexibility. Additionally, the sensors' sensitivity will be further increased through a surface coating to serve different fields. This method demonstrates the sensitive detection of isonipecotic acid and 5-phenylvaleric acid in OSPW, with detection limits as low as 0.3 mg/L for both acids. The sensor provides sensitive and fast quantification of NAs.

16:00 - 16:20

248 Investigating Film Formation and Coalescence of UV-Curable, Low Molecular Weight Polyurethane Dispersions using Fluorescence Resonant Energy Transfer.

Owen Chun Ho Kwok[1], Wolfgang Paulus[2], Mitchell A. Winnik[1]

[1]Universtiy of Toronto, Toronto, Canada. [2]BASF SE, Ludwigshafen, Germany

Abstract

Polyurethane dispersions (PUD) designed for radiation cure are an important class of material in the coatings industry. However, the coalescence and film formation of these dispersions have yet been studied at a molecular level. In this work, the film formation and coalescence of PUDs was studied using fluorescence resonance energy transfer (FRET) dye pairs as molecular probes. The high content of 2-hydroxyethyl acrylate (HEA, 20 wt%) in the PUD recipe led to a low M_n (~ 2.5 kDa) and a broad molecular weight distribution. By replacing a small fraction of the HEA with donor or acceptor dyes for FRET experiments we found that the HEA was concentrated in a low molecular weight fraction of the polymer, an unexpected result. Introducing the dyes by pre-reacting them with the hexamethylene diisocyanate (HDI)-trimer component of the formulation led to a more uniform distribution of the dyes in the sample. We prepared components labeled with phenanthrene (Phen) as the fluorescent donor dye or with 1-(4-nitrophenyl)pyrrolidine (NPP) as the non-fluorescent acceptor dye. FRET experiments conducted on samples in the dispersed state showed that a significant extent of nanoparticle-nanoparticle polymer transfer took place through the water phase. Films formed at room temperature showed a significant amount of energy transfer almost immediately upon drying, $\Phi_{\mathrm{ET}} = 69\%$ for HDI-trimer-labeled samples and $\Phi_{\mathrm{ET}} = 75\%$ for samples in which the dyes replaced HEA. These experiments indicate the high mobility of the polyurethane chains and that substantial polymer diffusion occurs very quickly in the film.

16:20 - 16:40

299 At a Glance Detection of Hydrofluoric Acid in Lithium Battery Electrolytes

Alkiviathes Meldrum, Razieh Firoujihaji, Dhwani Arun, Ebrahim Ghadirzadeh, Michael Fleischauer, Jon Veinot

University of Alberta, Edmonton, Canada

Abstract

Lithium-ion batteries are widely used in electric vehicles (EVs) and many other technologies. One major problem is that current lithium batteries contain several dangerous and toxic materials. One

of the worst of these is hydrofluoric acid (HF), which forms when the lithium salt dissolved in the electrolyte comes in contact with water. Thus, the electrolyte must be kept strictly dry – even trace amounts of moisture will react to form HF, which leads to corrosion, reduced performance, and major potential safety issues. HF is a toxic chemical that degrades battery components and can become volatile in the event of a fire. Active reporting of the HF concentration in lithium batteries, especially in electric vehicles (EVs) whose batteries contain tens of Liters of electrolyte solution, is thus important from the point of view of battery safety. Unfortunately, measuring HF in battery electrolytes currently requires the post-operation use of expensive equipment and trained lab personnel. Our research aims to solve these problems by finding all-optical method to report the HF levels in lithium batteries. To do this, we developed a special color-change dye that is highly soluble in organic carbonate electrolyte solutions. Upon exposure to HF, there is a fluorescence color shift from blue through green, yellow and orange, where the observable color correlates to the amount of HF present in the electrolyte. We are using this method to measure the kinetics of HF formation in battery electrolytes under relevant conditions of temperature and humidity.

16:40 - 17:00

337 Superhydrophobic Nano-coatings as an Smart Polymer (Anti-Foaling coating) for Concrete Fish Breeding Ponds

Seyed Seyed-Mehdi

Amirkabir University, Tehran, Iran, Islamic Republic of

Abstract

Superhydrophobic nano-coatings are fabricated from polyurethane and silane served as the low surface energy (LSE) material needed to make smart polymer (anti-fouling coating). Nano-silica is used to provide the desired surface texture needed for superhydrophobicity. It was hypothesized that chemically bonding of LSE material to the surface of nanosilica will improve the durability of the coating. The mixture of nanoparticles and low surface energy polymer was applied on the concrete surface. FTIR spectra confirmed the chemical reaction of nano-silica and silane. The results showed that coatings had contact angles higher than 150°C and contact angle hysteresis (CAH) less than 8°. The coatings indicated good water/UV durability. Superhydrophobic coatings were applied by spray coating method on a fish breeding pond with the 100 square meter surface area. The thickness of coatings on the bottom was 50 µm and on the walls of pond was 150 µm. The pond was filled with water and trout fishes for two months. After this period, some fouls were adhered to walls and the bottom of pond. However, the amount of foul on walls were considerably less than bottom of pond. Also, it was interesting that fouls on the walls of pond were removed much easier from the concrete surfaces compared with the bottom. The result indicated that the thickness of superhydrophobic coatings has an important effect in the anti-fouling property of smart polymer.

Molecules and Particles at Fluid Interfaces - 5

15:20 - 17:00 Wednesday, 25th June, 2025
ETLC E2-001
Molecules and Particles at Fluid Interfaces
Julianne Gibbs

15:20 - 15:40

58 Enhanced Rare Earth Recovery through Foam Fractionation via Electrostatic Adsorption of LBT Peptides onto Nanoparticles

Surabh KT[1], Luis Ortuno Macias[1], Ben Ocko[2], Honghu Zhang[2], Kathleen Stebe[3], Raymond Tu[1], Robert Messinger[1], Charles Maldarelli[1]
[1]The City College of New York, New York, USA. [2]Brookhaven National Lab, New York, USA. [3]University of Pennsylvania, Philadelphia, USA

Abstract

Rare earth elements (REEs) are essential for modern technologies due to their unique properties, but their separation from feedstocks/end products is challenging because of similar physicochemical characteristics. Current methods, such as solvent extraction, are energy-intensive, multi-step processes with significant environmental drawbacks due to the use of organophosphate extractants. Lanthanide binding tag peptides (LBTs), which selectively bind Ln^{3+} cations, offer a bioinspired alternative for REE separation. Their amphiphilic nature allows adsorption to the air-water interface following Ln^{3+} binding, enabling recovery via foam fractionation. However, foam stability and liquid fraction significantly impact separation efficiency.

This work explores the use of positively charged silica nanoparticles to enhance foam stability by electrostatically adsorbing negatively charged LBT:REE complexes. LBT1 (YIDTNNDGWYEGDELLA), engineered for high-affinity binding to Tb^{3+}, was employed. Positively charged nanoparticles adsorb LBT1:REE complexes while preventing nonselective cation adsorption. The effectiveness of nanoparticles in enhancing foam stability was evaluated through surface tension and elasticity measurements. GISAXS experiments revealed that the nanoparticles adsorb to the air water interface and assume a packed structuring. X-ray fluorescence measurements further demonstrated that LBTs retain their REE selectivity

A lab-scale foam fractionation column was designed to separate Tb^{3+} from non-REEs. Foam stability was enhanced in the presence of nanoparticles, producing drier foam. ICP-OES analysis of collected foam confirmed selective REE recovery, with higher Tb^{3+} content over non-REEs.

Overall, this study presents an innovative strategy using nanoparticles to improve REE separation efficiency via enhanced foam stability, offering a sustainable, energy-efficient alternative to traditional methods.

15:40 - 16:00

121 Controlling polymer conformations at particulate interfaces: Implications for particle stability and aggregation

Ryan Poling-Skutvik

University of Rhode Island, Kingston, USA

Abstract

Polymers can be localized at surfaces through covalent bonds or thermodynamic attractions. The surface then modifies the conformation of polymers through two primary mechanisms. First, the surface tether prevents spatial fluctuations of the attached monomers, and second, the surface localization of the chains increases the local monomer concentration. These conformational changes suggest that the thermodynamics of these surface-localized chains are significantly altered from those of free linear chains. Here, we discuss how we can modify these thermodynamics in two stories. First, we use telechelic triblock copolymers to bridge between emulsion droplets. By adding these endblock associating polymers to a suspension of oil droplets, we link them into a cohesive elastic network, the elasticity of which is governed by the propensity of these polymers to adopt bridging conformations. We modify the conformation of the midblock to promote bridging and drive the system to a more elastic state. Second, we discuss how surfaces alter the phase behavior of polymer solutions. By grafting polymers to particulate surfaces, we suppress the Θ-temperature in lower critical solution temperature (LCST) systems and modify the onset and progression of colloidal aggregation. The resulting growth rate is significantly slower than classical models of colloidal aggregation for hard spheres with short-range interactions, demonstrating the important role of polymer-mediated interactions on colloidal stability.

16:00 - 16:20

139 Effect of Anisotropic Colloids on the Shape Transformation of Liquid Droplets Undergoing Interfacial Freezing

Emery Hsu[1], Eli Sloutskin[2], Daeyeon Lee[1]

[1]University of Pennsylvania, Philadelphia, USA. [2]Bar-Ilan University, Ramat Gan, Israel

Abstract

Surfactant molecules stabilizing emulsion droplets can induce interfacial freezing and temperature-controlled shape transformations from spheres to icosahedra. While previous studies have delved into the relationship between particle adsorption and interfacial freezing, the impact of high interfacial particle density on droplet shape transformation has been underexplored. Past research involving spherical particles has demonstrated that adsorbed particles tend to position themselves at the vertices of faceted emulsion droplets at lower interfacial particle densities. At higher interfacial particle densities, sphere-to-icosahedron transition remains robust, and spherical particles at the interface do not disrupt shape transformation. This work probes how a high density of anisotropic particles on oil droplets, co-stabilized by interfacial-freezing-inducing surfactant, influences shape transformation. We examine the impact of rod orientation at the interface and their aspect ratio on this transformation behavior. To observe the phenomena effectively, we trap emulsion droplets in a microwell array and introduce a surfactant that co-crystallizes with the oil through a pressure-driven flow, all under temperature controlled conditions. We show that silica rods oriented perpendicularly to droplet surfaces do not hinder shape transformation. In contrast, rods aligned parallel to the interface can prevent shape transformation. We will discuss the factors contributing to the suppression of shape transformation. This investigation into how the aspect ratio of rigid anisotropic particles at high interfacial particle densities affects self-faceting transition opens new pathways for controlling emulsion interfaces.

16:20 - 16:40

211 Manipulation of Particles at Dynamically Deforming Liquid Interfaces

Keno Ky Studer, Lucio Isa, Federico Paratore

ETH Zurich, Zurich, Switzerland

Abstract

We present a novel platform designed to modulate and monitor the curvature of liquid interfaces to manipulate particles pinned therein. At the core of our platform is a self-aligning micropillar fabricated through two-photon-lithography (Figure 1(a)), which pins to the liquid interface, creating a global interfacial deformation. The micropillar is mounted on a three-axis automated stage connected to a force sensor, allowing for precise control over both the position and extent of liquid deformation, while simultaneously recording forces. The free hinge that connects the micropillar to the sensor allows the former to self-adjust in the position that minimizes interfacial deformation at zero applied force. Integrated with a digital holographic microscope, our platform also enables real-time monitoring of the local interface undulations around pinned particles (Figure 1 (b)) as well as the global interfacial deformation (Figure 1 (c)) generated by the pillar. We demonstrate the use of this platform to quantify the interface undulations surrounding two-photon-lithography-printed microparticles with tailored capillary multipoles (Figure 1 (b)) and determine the capillary force acting on them on a static, curved liquid interface. We then present first results of particle manipulation at liquid interfaces, using their characteristic time response to dynamically changing curvature gradients. We believe that the ability to create and visualize controlled liquid deformations has the potential to enhance our understanding of particle behavior at liquid interfaces, extending beyond static interfaces and opening new avenues for exploring particle dynamics in complex, dynamically evolving liquid topographies.

16:40 - 17:00

229 Functionalities of hemicellulose-modified lignin nanoparticles in emulsion systems

Felix Abik, Danila Morais de Carvalho, Patricia Figueiredo, Maarit Lahtinen, kristiina hilden, Kirsi S. Mikkonen

University of Helsinki, Helsinki, Finland

Abstract

Among the many candidates for future functional materials, lignocellulosic biomass remains as a frontrunner due to its renewability and the possibility of extracting it from various agricultural and forestry side streams. Lignin, particularly, has attracted attention as a natural aromatic polymer. In addition to being utilized directly post-extraction, lignin can also be transformed into nanoparticles (LNPs), the surface of which can be modified to suit a broad range of applications, for example as emulsifiers. However, most LNPs tend to aggregate at low pH, limiting the range of pH where they can be used in emulsion-based products, especially in products that require low pH environments.

In this study, we present the modification of LNPs using wood-derived hemicelluloses in an effort to create a more acid-stable lignin-derived emulsifier. We coated softwood- and hardwood-derived LNPs using galactoglucomannans (GGM) from spruce, analyzing the effect of the GGM coating towards their stability at different pH values and their interfacial properties. We used a combination of different techniques, such as compositional analysis, light scattering, interfacial tensiometry, atomic force microscopy, etc. We also assessed their viability in stabilizing oil-in-water emulsions in acidic and neutral pH values, both as dilute and high internal phase emulsions. Our results demonstrate the versatility and tailorability of lignocellulosic materials as emulsifiers, providing a sustainable alternative to the current industrial emulsifiers. Additionally, our all-wood modification route enables a more complete utilization of wood processing side streams into high-value applications.

Wetting and Adhesion - 6

15:20 - 17:00 Wednesday, 25th June, 2025
ETLC E1-003
Wetting and Adhesion
Francisco Javier Montes ruiz-Cabello

15:20 - 15:40

239 Estimating Hamaker Constants of Solid Materials via Atomic Force Microscopy: Incorporating Steric Repulsion Within the Approach-to-Contact and Pull-Off Methods

Juan Vazquez, Lucas Ellis, David Corti, Stephen Beaudoin

Purdue University, West Lafayette, USA

Abstract

Particle adhesion plays an important role in several industries. While several forces give rise to the phenomenon of adhesion, the attractive van der Waals (vdW) force is of particular interest, whose strength is quantified through the Hamaker constant, A. The atomic force microscope (AFM) proves effective at estimating values of A for solid systems as it can determine particle-surface forces. Recently, an AFM-based method for estimating A with low uncertainty was proposed (*J. Phys. Chem. C* **2023**, 127, 19, 9371–9379), by directly accounting for the surface roughness of the substrate this method can predict the deflections at first contact (d_c) obtained in the approach-to-contact (AtC) portion of an AFM experiment. Although this method yielded accurate estimates of A for various solid materials, it neglected the short-ranged repulsive interactions that must arise between the AFM cantilever tip and the substrate.

We therefore propose a modified AFM-based method that accounts explicitly for both the attractive vdW and steric repulsive forces (*Langmuir* **2024**, 40, 47, 24808–24819). The new method directly predicts the -distribution as well as the distribution of pull-off (PO) deflections, both of which are not typically obtained from the same approach. A comparison of the model predicted and experimentally obtained AtC and PO deflection distributions is used to estimate values of A, along with an estimate of the effective size of the molecules comprising the solid materials. The resulting values of A are found to be in good agreement with those values obtained from the Lifshitz theory.

15:40 - 16:00

328 Adhesion in water: new insights on specific and nonspecific surface forces

Xavier Banquy, Nahid Hassanpour, ChangSheng Wang

universite de montreal, montreal, Canada

Abstract

Adhesion between colloids or surfaces in water is essential in numerous natural and man-made systems. Sedentary crustacean species must produce strong adhesives to survive underwater, much like certain aquatic bacteria (e.g., *Caulobacter*), which secrete robust adhesives to colonize surfaces.

Although the molecular interactions underlying adhesive materials produced by aquatic and marine organisms have been well characterized under controlled lab conditions, they have seldom been investigated under authentic environmental conditions. Our recent work aims to address a straightforward question: **Are the molecular interactions involved in underwater adhesion still present under conditions approximating those of the real world?**

We examined two specific scenarios. The first focuses on cation–π interactions in soft adhesive materials, exploring the role of ions in the adhesive properties of these materials when cation–π interactions serve as a primary adhesion mechanism. The second scenario investigates how nanometric vibrations influence both long- and short-range surface forces, emphasizing electrostatic and van der Waals interactions in water. Using a surface forces apparatus, we evaluated the behavior of these systems under near-realistic underwater conditions, uncovering surprising phenomena that challenge our current understanding of colloidal forces and their broader significance in shaping our world.

16:00 - 16:20

241 Improving Hamaker Constant Estimates of Particle-Solid Systems via a Centrifuge-Based Method

Stephen Beaudoin, Juan Vazquez, Anne Serban, Briana Duran Mieses, Stephen Vaz, David Corti

Purdue University, West Lafayette, USA

Abstract

Understanding particle adhesion is crucial to avoid issues such as contamination, caking, and uneven mixing in a wide range of industries such as microelectronics, pharmaceuticals, and defense. Centrifuge-based methods prove themselves effective at empirically characterizing the adhesive behavior of an entire particle size range on a substrate of interest, however they have notable shortcomings when it comes to determining the Hamaker constant of a solid system. Existing centrifuge approaches tend to neglect surface roughness and/or not yield a unique Hamaker constant, but rather a set of size dependent effective Hamaker constants. We therefore propose a modified centrifuge method that incorporates a recently published van der Waals-steric force model (*Langmuir* **2024**, 40, 47, 24808–24819) that accounts for surface roughness and incorporates the particle size-distribution to predict the drop-off curves observed in centrifuge experiments. Unlike some existing methods, a single estimate of the Hamaker constant is obtained by comparing the model predicted to the experimentally observed drop-off curves. Preliminary results show that this new method can more accurately describe experimentally observed results with Hamaker constant values whose magnitude is in closer agreement with the Lifshitz theory especially when compared to the Derjaguin (Flat plate-sphere) approximation that tends to underestimate Hamaker constants as it neglects the decrease in adhesion due to surface roughness. Unlike the Lifshitz theory, which is hard to implement experimentally, centrifuge-based methods are straightforward to implement with solid systems, as such improving their accuracy is important.

16:20 - 16:40

66 THE MAXIMUM SPREADING OF VISCOUS DROPS IMPACTING ON FLAT SURFACES

LIHUI LIU[1], Guobiao Cai[2], Peichun Amy Tsai[1]

[1]University of Alberta, Edmontonn, Canada. [2]Beihang University, Beijing, China

Abstract

Drop impact on solid surfaces is a fundamental phenomenon with significant implications in both nature and industry. Among the diverse impact outcomes, such as rebound, splashing, and jetting, spreading is the most common outcome and is typically characterized by the maximum spreading factor ($\beta_m = D_m/D_0$), the ratio of the maximum spreading diameter (D_m) to the initial droplet diameter (D_0). In this study, we comprehensively investigate β_m of viscous droplets impacting flat surfaces, where the droplet spreading is predominantly governed by liquid viscosity. We assume that, for low-viscosity droplets, viscous dissipation is confined to a thin boundary layer near the liquid-solid interface. In contrast, dissipation extends throughout the droplet bulk in high-viscosity droplets. By applying energy conservation principles, where the initial kinetic energy of the impacting droplet is completely dissipated by viscosity upon reaching β_m, two theoretical scaling laws are derived: $\beta_m \sim (We/Oh)^{1/6}$ for low-viscosity regimes and $\beta_m \sim Re^{1/5}$ for high-viscosity regimes, where We, Re, and Oh are Weber, Reynolds, and Ohnesorge numbers, respectively. Our experimental data demonstrate that the former scaling law holds for $Oh \lesssim 0.1$, while the latter is applicable for $Oh > 1$. Moreover, to account for finite spreading ($\beta_m \approx 1$) at negligible impact

velocities (i.e., $We = 0$), we propose a semi-empirical scaling law, $\beta_m \sim (A + We/Oh)^{1/6}$, with A = 23.3 being a fitting constant. This semi-empirical law effectively models β_m for a wide experimental range of $10^{-3} \leq Oh \leq 10^0$ and $10^1 \leq We \leq 10^3$, providing a universal framework for predicting viscous droplet spreading.

16:40 - 17:00

179 Molecular origin of slippery behaviour in tethered liquid layers

Isaac Gresham[1,2], Fabio Rasera[3], Antonio Tinti[3,4], Andrew Nelson[5], Kaloian Koynov[6], Alberto Giacomello[3], Chiara Neto[1,2]

[1]University of Sydney, Sydney, Australia. [2]Sydney Nano Institute, Sydney, Australia. [3]Sapienza Università di Roma, Rome, Italy. [4]Institut des Sciences et Ingénierie Chimiques, École Polytechnique Fédérale de Lausanne, Sion, Switzerland. [5]Australian Nuclear Science and Technology Organisation, Sydney, Australia. [6]Max Planck Institute for Polymer Research, Mainz, Germany

Abstract

Slippery covalently attached liquid surfaces (SCALS) are a family of nanothin polymer layers with remarkably low static droplet friction, characterized by a low contact angle hysteresis (CAH, < 5˚), which makes them ideally suited to self-cleaning, water harvesting, and anti-fouling applications. Recently, a Goldilocks zone of lowest CAH has been identified for polydimethylsiloxane (PDMS) SCALS of intermediate thickness (» 4 nm, minimum in Figure) [1,2], yet, molecular-level insights are missing to reveal the underlying physical mechanism of this elusive, slippery optimum.

Here we present a multiscale investigation into the SCALS phenomenon, which connects the physicochemical properties (*σ, N,* see Figure) of grafted PDMS layers to their nanoscale surface topography and, subsequently, their macroscopic properties (namely, CAH). Our study finds that SCALS CAH can be explained by a balance of chemical heterogeneity, polydispersity-induced roughness, and layer deformability. We draw these insights from a combination of contact angle measurements, sophisticated characterisation techniques [3], self-consistent field theory, coarse-grained molecular dynamics [4], and simple wetting models.

[1] Chen, L. et al. Nat. Rev. Chem. 7, 123-137 (2023). 10.1038/s41570-022-00455-w
[2] Gresham, I. J. & Neto, C. Adv. Colloid Interface Sci. 315, 102906 (2023). 10.1016/j.cis.2023.102906
[3] Gresham, I. J. et al. Angew. Chem. Int. Ed. Engl., e202308008 (2023). 10.1002/anie.202308008

[4] Rasera, F. et al., ACS Nano, *in press*. 10.48550/arXiv.2410.00815

Self and Directed Assembly - 5

15:20 - 17:00 Wednesday, 25th June, 2025
ECERF W2-050
Self and Directed Assembly
Xuehua Zhang

15:20 - 15:40

45 Dynamic observation of supported bilayer formation of cationic surfactants on solid surface with high-speed AFM

Shigeto Inoue[1,2], Takaya Sakai[3]

[1]Americas Research Laboratories, Kao USA Inc., Cincinnati, USA. [2]R&D - Analytical Science Research, Kao Corporation, Tokyo, Japan. [3]R&D, Kao Corporation, Tokyo, Japan

Abstract

It is widely recognized that vesicle aggregates of certain surfactants or phospholipids in water spontaneously adsorb onto solid surfaces, forming a solid-supported bilayer. The formation of bilayers on solid substrates through the fusion of unilamellar vesicles in water has gained significant attention in the biological, medical, and industrial fields due to its capability to spontaneously create highly ordered bilayer films. However, the actual dynamic process is so small and rapid that it has not been clearly observed until now. Consequently, the fundamental mechanism remains hypothetical, with various models having been proposed. In this study, we used high-speed atomic force microscopy to successfully observe the bilayer formation of *N,N*-dioctadecyl-*N,N*-dimethylammonium bromide (DODAB) unilamellar vesicles on a mica surface in situ, providing nanoscale three-dimensional information. Additionally, when using another cationic surfactant that is more cohesive in water than DODAB, we observed significant differences in the initial domain formation process on the surface. This study demonstrated that spherical vesicles quickly transitioned from tetralayer to bilayer domains on the substrate, and subsequently, a uniform bilayer membrane was formed through fusion between the domains on the substrate. This observation could be the clear verifications to some hypothesis in “black boxes” of supported bilayer formation process by vesicle fusion.

15:40 - 16:00

253 Gelation mechanisms in nonionic sucrose ester surfactants: Effects of temperature, electrolyte addition and pH

Slavka Tcholakova, Diana Cholakova, Nevena Pagureva

Department of Chemical and Pharmaceutical Engineering, Faculty of Chemistry and Pharmacy, Sofia University, 1 James Bourchier Ave., 1164, Sofia, Bulgaria

Abstract

Sucrose esters (SEs), derived from sucrose and fatty acids, are nonionic, biodegradable surfactants [1]. Aqueous solutions of long-chain SE surfactants exhibit intriguing temperature-dependent behavior, with a viscosity peak around 40-50°C. Our investigations revealed that this phenomenon is driven by the presence of both monoesters and diesters in commercial SEs. Solutions rich in sucrose monoesters behave as typical nonionic surfactants. However, the coexistence of mono- and di-esters leads to the formation of diester particles and a network of fused particles at low temperatures. As the temperature approaches the diesters melting point, wormlike micelles form, causing the viscosity peak, which increases with diester concentration. Further heating induces micelle branching and phase separation [2]

Despite being nonionic, the viscosity of SE dispersions was found to be significantly affected by the addition of electrolytes or pH decrease. At low electrolyte concentrations and pH $\gtrsim 5$, dispersions of 0.5-5 wt. % SE exhibit low viscosities and behaved as freely flowing liquids. However, addition of small amount of electrolyte (e.g. 9 mM NaCl) or decrease of pH below 5 induced gelation [3]. This talk will explore the mechanisms behind these phenomena and provide insights into controlling the system behavior

Acknowledgements: This study was funded by the European Union-Next GenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project No BG-RRP-2.004-0008

References:

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[3] D. Cholakova et al., under review.

16:00 - 16:20

276 Extended Stepwise Co-Assembly in an Amphiphilic Block Copolymer-Surfactant System

Guanqun Du[1], Alessandra Del Giudice[2], Bo Nyström[3], Yilin Wang[4,5], Luciano Galantini[2], Karin Schillén[1]

[1]Division of Physical Chemistry, Department of Chemistry, Lund University, Lund, Sweden. [2]Department of Chemistry, Sapienza University of Rome, Rome, Italy. [3]Department of Chemistry, University of Oslo, Oslo, Norway. [4]Key Laboratory of Colloid and Interface Science, Beijing National Laboratory for Molecular Sciences, Institute of Chemistry, Chinese Academy of Sciences, Beijing, China. [5]Suzhou Institute for Advanced Research, University of Science and Technology of China, Suzhou, China

Abstract

The co-assembly between polyelectrolyte-amphiphilic neutral diblock copolymers and oppositely charged surfactants is governed by not only electrostatic but also hydrophobic interactions. In this study a composition-dependent stepwise co-assembly between the anionic surfactant sodium dodecyl sulfate (SDS) and a cationic poly(*N*-isopropylacrylamide) (PNIPAM)-*block*-poly((3-acrylamidopropyl)trimethylammonium chloride) (PAMPTMA(+)) diblock copolymer in water is revealed. The co-assembly starts with the interaction of the surfactant with the polyelectrolyte block and ends with a well-defined step that involves the hydrophobic interaction of the surfactant with the neutral block. The mixed block copolymer-surfactant solutions were investigated using by isothermal titration calorimetry, cryogenic transmission electron microscopy (cryo-TEM), small angle X-ray scattering (SAXS), differential scanning calorimetry (DSC) and dynamic light scattering in combination with electrophoretic mobility. In the low SDS concentration regime, SDS binds cooperatively to the cationic blocks leading to the formation of small SDS micelles dressed by copolymer chains and larger mixed aggregates. Flat hexagonally shaped mixed complexes with a hexagonal ordered interior consisting of SDS micelles neutralized by the PAMPTMA(+) blocks and with a neutral PNIPAM corona are formed at intermediate SDS concentrations as revealed by cryo-TEM and SAXS. In the last step of the co-assembly process, due to the hydrophobic interaction between SDS and PNIPAM, SDS continues to bind to the corona beyond charge neutralization thus influencing the thermoresponsive behavior of the system as monitored by DSC. This unusual step provides negatively charged thermally stable aggregates with hexagonally ordered core, which could expand the application interest of oppositely charged block copolymer-surfactant mixtures.

16:20 - 16:40

359 Influence of Additives of Surfactants on Temperature Induced Electrical Percolation in AOT Reverse Microemulsions

Ketevan Nanobashvili, Mariam Gabadadze, Irma Tikanadze, Marina Rukhadze
Faculty of Exact and Natural Sciences, Javakhishvili Tbilisi State University, Tbilisi, Georgia

Abstract

The doping of most widely used sodium bis (2-ethylhexyl) sulfosuccinate (AOT) reverse microemulsions interface with surfactants of different nature alters elastic rigidity of the interface and microviscosity of the confined water, also affects percolation of electrical conductance, etc.

The goal of the proposed work was to study the influence of additives of surfactants of both monomeric and polymeric type, ((viz. nonionic polyoxyethylene (4) lauryl ether (Brij-30), tyloxapol, pluronic F-127, triton X 100, anionic sodium cholate (SC) and cationic promethazine (PMZ) and chlorpromazine (CPZ) hydrochlorides)) on the electrical percolation threshold and sizes of water droplets in mixed reverse microemulsions in temperature induced electrical percolation mode with conductivity measurements and dynamic light scattering method.

Electrical percolation in mixed (AOT and Brij-30, AOT and SC) microemulsions with a fixed value of the molar ratio of surfactant to water (W=20) takes place at relatively lower temperature than for reversed microemulsion based on AOT alone. In contrast to this, quenching of percolation is observed in case of additives of cationic surfactant PMZ. Tyloxapol and pluronic F-127 occupy an intermediate positions between the above-mentioned additives according to percolation suppression ability, however, the percolation threshold in the presence of pluronic (Tp=50℃) exceeds that of tyloxapol (Tp=40℃), and in the presence of triton X 100 (a tyloxapol monomer), percolation begins at an even lower temperature (Tp=35℃). The obtained results will be useful to clarify the fine mechanisms of electrical percolation phenomenon in reverse microemulsions and to study membrane conductance of electrical impulses, mass transfer in organisms, etc.

16:40 - 17:00

346 Photoinduced Self-assembly Triggers Liquid-Liquid Phase Separation (LLPS) in Complex Emulsions

Che-Jen Lin

National Dong Hwa University, Hualien, Taiwan

Abstract

Liquid-liquid phase separation (LLPS) is a process in which a homogeneous liquid phase spontaneously segregates into two distinct liquid phases with different compositions. In this study, we successfully induced LLPS under UV irradiation in a complex emulsion containing both hydrocarbon and fluorocarbon oils. The amphiphilic chromophore **CNFCPEG** exhibits greater solubility in the hydrocarbon phase.

In concentrated complex emulsions, UV irradiation triggers molecular self-assembly, as evidenced by excimer emission and the formation of larger aggregates upon solvent removal under vacuum. Notably, the assembled structures show enhanced solubility in the fluorocarbon phase, likely due to micelle formation. This photo-induced self-assembly drives chromophores to preferentially dissolve in fluorocarbon oils, resulting in morphological transitions from F/H/W structures to Janus structures and ultimately to H/F/W structures. Additionally, the formation of solid assemblies may increase the H/F interfacial tension, as supported by the observed reduction in the H/F interfacial surface area.

We directly observed Marangoni flow through excimer emission during liquid-liquid phase separation. This dynamic process encourages the merging of adjacent droplets, resulting in the formation of worm-like structures. Our findings present a novel approach for creating non-spherical complex emulsions through photo-induced self-assembly, offering new insights into tunable emulsification and phase behavior.

Gala Dinner & Entertainment - Award Presentations

18:00 - 22:30 Wednesday, 25th June, 2025
Edmonton Convention Centre - 9797 Jasper Ave, Edmonton

Special short talk on "One Century of Colloid Science" by J. Venzmer

Live Music and entertainment

Award Presentations

26th June, 2025

Plenary Talk - Himanshu Mishra (KAUST)

08:30 - 09:30 Thursday, 26th June, 2025
ETLC E1-001
Alidad Amirfazli

Water–Hydrophobe Interfaces: Facts, Artifacts, and Global Food–Water–Climate Security

Capillary Phenomenon and Field Effects - 1

10:00 - 12:00 Thursday, 26th June, 2025
ICE Incubator
Capillary Phenomenon and Field Effects
Janet Elliott

10:00 - 10:20

9 Foam stabilization in salt solutions: Roles of capillary drainage and Marangoni stresses

Gerald Fuler, Suraj Borkar, Ekta Sharma

Stanford University, Stanford, USA

Abstract

The common observation that foaming is easier in seawater compared to freshwater remains is not well-understood. In this study, we utilize interferometric single-bubble experiments to demonstrate that the theory proposed by G. Marrucci (1969) explains this phenomenon. Electrolyte solutions with varying concentrations of phosphate salts were employed to analyze thin-film formation and drainage by following the thickness using interferometry. In deionized water, bubbles rupture within seconds due to rapid dimple collapse. However, in phosphate salt solutions, bubbles persisted for several minutes and this translates towards remarkable bulk foam stabilization.

Earlier work has suggested that evaporation drives salt concentration gradients, thereby inducing surface tension gradients and Marangoni stresses. However, this cannot explain bulk foam stability, where internal bubbles are insulated from the effects of evaporation. Our results show that despite film thinning being capillary drainage-dominated, Marangoni-driven influx can be

observed. Marrucci’s theory reconciles this by explaining that an increased interfacial area, created as the film thins, leads to increased salt concentration in the film due to Gibbs surface excess. The associated increases in surface tension with salt concentration induces Marangoni stresses, causing flow reversal, increased film thickness, and enhanced foam stability.

We show that Marrucci’s theory has not been properly analyzed, and the predicted critical heights where fluid influx occurs closely match our findings, and other studies using sodium chloride. Additionally, we extend the theory’s applicability to foam films in multicomponent, non aqueous oils, highlighting its broader relevance.

10:20 - 10:40

352 Weak Electrostatic Repulsion: A Key to Monodisperse Poly(acrylic acid) Colloidal Particles Made by Precipitation Polymerization

Kazuo Sakurai

University of Kitakyushu, Kitakyushu, Japan

Abstract

Precipitation polymerization of acrylic acid in the organic solvent with high dielectric constant provides monodisperse spherical poly acrylic acid particles (PAA sphere). In this study, we investigated the growth process of PAA spheres using small-angle X-ray scattering (SAXS). It identified two growth regimes: (1) particle coalescence, where particle size and standard deviation increase, modeled using a modified Smoluchowski coagulation theory considering electrostatic repulsion, and (2) constant particle count with growth through monomer/polymer absorption or smaller nuclei integration, regarded as the collision model. The results highlight the critical role of electrostatic interactions in influencing particle growth and stability. It provides insights into controlling particle sizes and the particle size distribution in polymerization, crucial for designing materials with specific properties.

Figure caption: Time evolution of scattering profiles during the PAA polymerization in acetniril, compareing with the theoretical curves caluculated from solid sphere model. The profile at late stage show 10 th intensity maximum peak, suggesting a very narrow dispersity.

10:40 - 11:00

201 Interaction Forces between Silica Surfaces with Charged and Non-charged Polymers in Concentrated Electrolytes

Naoyuki Ishida[1], Yurika Nakayama[1,2], Kanato Nakasuji[1], Koreyoshi Imamura[2]

[1]Doshisha University, Kyotanabe, Japan. [2]Okayama University, Okayama, Japan

Abstract

In recent years, significant attention has been given to interfacial phenomena in solutions containing very high concentrations of electrolytes. Experimentally, a unique phenomenon has been observed in various systems where substances that aggregate upon the addition of high ion concentrations return to a state similar to that in solutions with lower ion concentrations when even more ions are added. This phenomenon is known as underscreening.

In this study, the interaction between silica surfaces with adsorbed polymers in concentrated electrolyte solutions was investigated using direct atomic force microscopy (AFM) measurements. Polyethylenimine (PEI) was adsorbed onto silica surfaces, and interaction forces between the surfaces were measured in aqueous electrolyte solutions.

In a 1 mM NaCl solution, steric repulsion was observed starting at around 30 nm. At 2 M, the steric repulsion became significantly short-ranged due to screening. However, at 5 M, re-entrant of the repulsive force was detected from around 10 nm, indicating polymer re-stretching driven by underscreening. This phenomenon was observed irrespective of the electrolyte species.

We also measured the forces between silica surfaces with non-charged polyvinyl alcohol (PVA). In this case as well, a re-entrant of the repulsive force, which had become short-ranged in a 2 M NaCl solution, was observed at 5 M. This suggests that the re-stretching of polymers in concentrated electrolytes can occur even for non-charged polymers.

11:00 - 11:20

220 Partitioning of charged colloidal particles in polyelectrolyte complex coacervates.

Maryam S. Ali[1], Robert D. Tilton[1], Lynn M. Walker[2]

[1]Carnegie Mellon University, Pittsburgh, USA. [2]University of Minnesota, Minneapolis, USA

Abstract

Complex coacervation is the liquid-liquid phase separation of oppositely charged species into a concentrated coacervate phase and a dilute phase. This spontaneous phase separation occurs in the presence of salt and is driven by attractive electrostatic interactions between charged groups and the displacement of polyelectrolyte counterions. Progress has been made in understanding coacervation between two polyelectrolytes, but much less is known about coacervation in multicomponent systems. Emerging applications involve formulating coacervating systems to suspend colloids, both to deliver active ingredients to a surface or remove pollutants from wastewater. Designing these systems demands a deeper understanding of how charged colloids interact with coacervate phases. In this study, we experimentally determine the partitioning of negatively charged polystyrene colloids in mixtures of sodium poly(styrene sulfonate) and poly(diallyldimethylammonium chloride) coacervating polyelectrolytes. We observe the impact of the surface charge density and the total ionic strength of the system on the partitioning of the particle between the coacervate and dilute phase. Our findings reveal a clear salt dependence, with the colloidal particles preferential partitioning and uniformly distributing into the coacervate phase at lower salt concentrations and shifting to preferential partitioning in the dilute phase in a flocculated state with increasing salt concentration. Results are being interpreted in terms of the effect of polyelectrolytes on the colloidal interaction forces.

11:20 - 11:40

112 Use of audible sound to change the forces between charged surfaces in aqueous solutions

Cathy McNamee[1], Shinpei Yamamoto[2]

[1]Kyoto University, Kyoto, Japan. [2]Sankei Giken Kogyo Co., Ltd., Isesaki, Japan

Abstract

The forces between charged particles in aqueous solutions determine whether they will disperse or aggregate in aqueous solutions. The ability to control and change these forces can change the properties of those systems and therefore helps determine the success of their applications. Inter-particle forces can be changed, if the electrical double layer (EDL) around the charged surfaces is modified by an external stimuli. Sound waves have been theoretically predicted to periodically polarize the ionic atmospheres around charged particles in aqueous solutions [1], thus causing an EDL change. There are numerous studies investigating the effect of ultrasound on the physical properties of systems. However, studies are lacking on the effect of audible sounds on the EDL, in spite of audible sound being readily available at a low cost.

In this study, we used an Atomic Force Microscope to measure the forces between a negatively charged silica particle and silicon wafer in aqueous solutions in the absence and presence of an applied audible sound. Information on the EDL was obtained from the force curves. Sound decreased the magnitude and range of the repulsive forces, where the decrease became larger as the sound frequency was increased. The decreased force range was explained by a decreased EDL thickness, which was thought to result from the EDL being compressed by the pressure of the sound wave. The decrease in the force magnitude was explained by the increased electrostatic screening that accompanies an EDL thickness decrease. [1] Dukhin S.S. *Adv. Colloid Interface Sci.* **1993**, *44*, 1-134.

Surfactants and Emulsions - 4

10:00 - 12:00 Thursday, 26th June, 2025
ECERF W2-110
Surfactants and Emulsions
Alidad Amirfazli

10:00 - 10:40

448 Self-regulating complex droplets as nano-to-macro messenger colloids

Lukas Zeininger

Max Planck Institute of Colloids and Interfaces, Potsdam, Germany

Abstract

Autonomous chemo-mechanical signal transduction is an inherent feature by which natural systems exert control over complex biological functions. It is therefore essential for the emulation and delineation of complex emergent behaviors in artificial dissipative material systems. Bio-inspired, life-like material platforms focus on the non-equilibrium properties of matter, thereby departing from present-day material design paradigms, which typically emphasize thermodynamic stability to ensure long-term viability in an application context. Emulsions, composed of liquid droplets dispersed in another immiscible fluid phase, have emerged as fascinating chemically minimal materials for studying such non-equilibrium, life-inspired properties. Surfactant stabilized emulsion droplets intrinsically persist in thermodynamic out-of-equilibrium states and are highly dynamic, with molecules constantly being exchanged between the droplets and their environment. Interface-selective sensitization of droplets allows such systems to exhibit programmed up-and down-regulating capabilities and dynamic and reversible interfacial host–guest complexation can trigger morphological reconfigurations of complex droplets, which resembles cell surface environments. Complex droplets can selectively and dynamically present, hide, or expand liquid–liquid interfaces, and thereby serve as messenger colloids to visualize and report force gradients in temperature, chemistry, and concentration with up to femtomolar sensitivity.

In this presentation, I will explore how studying minimalistic chemical droplet systems that exhibit simple emergent collective behaviors can provide physico-chemical design guidelines for the future design of synthetic active and adaptive material systems. More specifically, the presentation will highlight examples of a kinetic trapping of non-equilibrium droplet shapes as a basis for chemo-mechanical signal transduction. Leveraging the droplets' ability to harness various forms of energies and gradients in parallel and competitively allows controlling and regulating multiple independent responsive modalities independently. Such systems can move chemotactically and reversibly in response to interfacial tension differentials, tilt out of gravitational alignment due to multivalent chemical interactions or intra-droplet thermocapillary fluid convections, and exhibit a self-regulated ability to communicate. I will introduce a fundamentally new mechanism for chemo-mechanical signal transduction in purely liquid systems, enabling rapid, multimodal shape

transformations and actuation of emulsion droplets within seconds, generating tactile forces proportional to the minimum interfacial tension in the system and the droplet size, on the micronewton scale in one second. The integration of a spring-like charging and latch-controlled release mechanism provides a level of force amplification far beyond conventional stimuli-responsive surfactant systems, unlocking new possibilities for transient structuring and shape programming of all-liquid matter. Parallel control over the dynamic partitioning of solutes yields adaptive droplet ensembles with self-regulated decision-making skills, with significant implications for future soft robotics and sensing technologies

10:40 - 11:00

345 SAXS-based Hydrophilic-Lipophilic-Difference (HLD) equation obtained via the Net-Average Curvature (NAC) model

Edgar Acosta, Hassan Ghasemi, Rania Sakr, Juan Doratt Mendoza

University of Toronto, Toronto, Canada

Abstract

The HLD is a set of two numerical correlations (for ionic and nonionic surfactants) to obtain the phase inversion point (PIP) of surfactants in surfactant-oil-water (SOW) systems. The advantage of HLD over the packing factor or the hydrophilic-lipophilic balance (HLB) is that HLD considers the entire system conditions, not the surfactant alone, making the HLD a benchmark for industrial and academic groups dedicated to formulating SOW systems. The interpretation of HLD as an expression of the normalized net curvature (Hn) of SOW systems connects the HLD to the dimensions of oil-swollen micelles, water-swollen reverse micelles, and bicontinuous systems. This connection, known as the Net-Average Curvature (NAC) model, combines the HLD values with surfactant geometry (e.g., the surfactant tail length parameter "L", and the surfactant volume to neck area ratio v_s/a_s) to predict SOW dimensions such as the characteristic length (ξ_H), which can be confirmed using Small-Angle X-ray Scattering (SAXS). In this presentation, we reverse this approach and instead use SAXS to determine ξ_H for SOW systems produced at different salinities and with different oils that, when introduced into the NAC model, can produce estimated HLD values. A simple regression analysis of these SAXS-derived HLDs with salinity and the oil's Equivalent Alkane Carbon Number (EACN, an oil hydrophobicity indicator) leads to new SAXS-based HLD equations. The results show that SAXS-based HLD can produce similar HLDs to the conventional approach, all while avoiding the use (and possible bias) of mixtures with reference surfactants.

11:00 - 11:20

123 Effect of Trace Ions on Self-assembly of Ionic Surfactants in Ionic Liquids

Shurui Miao[1], Alexander Albright[1], Tristan Youngs[2], Kun Ma[2], Gregory Warr[3], Rob Atkin[4], Susan Perkin[1]

[1]Physical and Theoretical Chemistry Laboratory, University of Oxford, Oxford, United Kingdom. [2]ISIS Facility, STFC Rutherford Appleton Laboratory, Didcot, United Kingdom. [3]School of Chemistry, University of Sydney, Sydney, Australia. [4]School of Molecular Sciences, The University of Western Australia, Perth, Australia

Abstract

Ionic liquids (ILs) are liquids composed entirely of ions. Constituents are held together via strong electrostatic forces, giving rise to low volatilities and enhanced recyclability.[1] More strikingly, many ILs were reported to support amphiphilic self-assembly and exhibit nanostructure in the bulk.[2] The amphiphilic nanostructure of ionic liquids often consist of interpenetrating and bicontinuous polar and apolar networks, allowing ILs to dissolve a wide range of complex solutes. Nevertheless, the effect of this nanostructure on additive self-assembly is not well understood. In particular, literature highlighted a specific ion effect, whereby the identity of the counterion for a cationic surfactant affects the nature of the micelle formation.[3] The counterion is at least 50 times less abundant relative to ions that constitute the IL, as well as the high ionic strength of the IL (> 10 M) is expected to screen any coulombic effects. Our work uses neutron diffraction to explore the self-assembly properties of dodecyltrimethylammonium surfactants (with nitrate or bromide as counterions), and alkylammonium nitrate ILs. In combination with computational modelling, this provides insight into the specific interactions occurring at the molecular level to understand the molecular origin of specific ion effects in ILs. This will enhance our understanding of ILs as self-assembly media for ionic species, and how specific interactions can be optimised by solvent design.

[1] S. Miao, et al., Green Chem. 24(19), 7281-7304 (2022)

[2] R. Hayes, et al., Chem. Rev. 115(13), 6357-6426 (2015)

[3] A. Dolan, et al., Chem. Sci. 6(11), 6189-6198 (2015)

11:20 - 12:00

284 Enhanced Stability of Non-Aqueous Emulsions for Water-Sensitive Polymerization Applications

Gustavo P. Zago, João B. P. Soares

University of Alberta, Edmonton, Canada

Abstract

Emulsions are mixtures of two immiscible liquids in which droplets of one are dispersed in a continuous phase of the other. Oil-water emulsions are commonly employed in polymerization reactions to achieve polymers with narrow molecular weight distributions and higher molecular weights than conventional methods, but their use is limited in the presence of water-sensitive reactants. We investigated the formation and stability of non-aqueous emulsions made with ethylene glycol as the continuous phase and styrene-ethyl acetate mixtures as the dispersed phase. In this study, we used two different type of block copolymer surfactant at a concentration between 0.5 and $5\%_{w/w}$ and in dispersed phase fractions between 0.30 and 0.40. We evaluated three emulsification methods: ultrasonication, stirring, and high-shear mixing. According to the results, varying the proportions of block copolymers effectively improves emulsion stability. Among the tested methods, ultrasonication produced the most stable emulsions, potentially due to better interfacial adsorption and uniform energy distribution. These findings highlight the potential for custom block copolymer formulations to stabilize oil-in-oil emulsions, providing new possibilities for polymer synthesis by enabling the use of monomers and catalysts that react with water.

11:40 - 12:00

452 Fluids Optimization by Hydrophobically Associating Polyacrylamide /Surfactant Hybrids

Di Yang[1,2], Yufan Guo[1], Chaogang Luo[1], Hao Zhang[1], Xuehua Zhang[2]

[1]Chengdu University of Technology, Chengdu, China. [2]University of Alberta, Edmonton, Canada

Abstract

While the surfactant-enhanced hydrophobic association of polymers is a consensus, optimizing molecular structures for the best effects has been rarely studied. Herein, we investigated the self-assembly behavior between hydrophobically associating polyacrylamide (HAPAM) and surfactants, driven by ternary supramolecular force—hydrogen bonding, ionic bonding, and hydrophobic effects. By employing three distinct hydrophobic monomers in combination with four surfactants, it was considered that the hydrophobic monomer M_{12}, which contains amide groups, quaternary ammonium cations, and long alkyl chains, exhibits the strongest synergistic effect with

sodium dodecylbenzene sulfonate (SDBS). The mixed micelles exhibited a maximum average particle size of 518 nm, significantly larger than individual M_{12} (10.7 nm) and SDBS (3.2 nm) systems. Moreover, the hybrid system behaved accelerated dynamic adsorption at the air-water interface and achieved a lower equilibrium surface tension compared to individual components. The above indicated that the ternary supramolecular forces enabled tighter interfacial molecular arrangement. Benefiting from this mechanism, rheology zero-shear viscosity of 0.2 wt% polymer (containing 0.25 mol% M12 monomer) water solution was enhanced from 615 mPa·s to 7524 mPa·s by introducing SDBS. The microstructure transitioned from linearly oriented arrangements to disordered crosslinked networks. Driven by ternary supramolecular forces, the M_{12}/SDBS hybrid system forms densely packed, large-scale micellar assemblies. This mechanism significantly enhances polymer associative effects, representing an effective strategy to improve the performance of polymer-based fracturing fluids.

General Aspects of Colloid and Interface Science - 5

10:00 - 12:00 Thursday, 26th June, 2025
ECERF W2-010
General Aspects of Colloid and Interface Science
Remco Tuinier

10:00 - 10:20

219 Molecular level computation in understanding complex surfactant adsorption

Piotr Batys[1], Izabella Leszczyńska[1], Gabriela Wojtan[1], Łukasz Lamch[2], Weronika Szczęsna-Górniak[2], Ewelina Jarek[1], Kazimiera A. Wilk[2], Piotr Warszyński[1]

[1]Jerzy Haber Institute of Catalysis and Surface Chemistry PAS, Kraków, Poland. [2]Wrocław University of Science and Technology, Wrocław, Poland

Abstract

Computations at the molecular level by quantum chemistry methods contribute to the description of single molecules or the interactions between them. Moreover, they provide output to the force fields used in molecular dynamics (MD), which can describe systems consisting of millions of atoms. Increasing computational power and software development allowed for the description of multiphase problems, such as surfactant behavior at interfaces. The best method for verification of modeling results is to confront them with experimental data, e.g., by comparing surface tension isotherms.

In this work, we performed MD simulation of the adsorption of various surfactants, i.e., nonionic n-octanol, cationic dodecyldimethylammonium bromide (DTAB) and its dicephalic counterpart, 2-dodecyl-*N,N,N,N',N',N'*-hexamethylpropan-1,3-ammonium dibromide (C_{12}-D_CNMe_3Br) -

comprising exclusively carbon atoms in the hydrophobic part. Standard computational chemistry setup and Gromacs software were used for all-atom MD modelling . The equilibrium surface tension measurements were performed using the pendant drop shape analysis method. For the theoretical description of the surfactant adsorption, we propose the extended model (mSTDE) by using the Helfand–Frisch–Lebowitz isotherm based on the equation of state of 2D hard disk-like particles, adjusted to the description of ionic surfactants.

We found that whereas for nonionic surfactant, n-octanol the MD simulation resulting isotherm underestimated the decrease of the surface tension at a given surfactant surface concentration, the opposite could be observed for cationic surfactants. It is probably due to the overrating of electrostatic interactions, as the degree of charge compensation in the interfacial layer, although in qualitative agreement, seems to be overestimated.

This work was supported by the National Science Center (Poland) (Project No. 2022/45/B/ST4/01184 (OPUS 23)). We gratefully acknowledge Polish high-performance computing infrastructure PLGrid (HPC Center: ACK Cyfronet AGH) for providing computer facilities and support within computational grant no. PLG/2024/017771

10:20 - 10:40

72 A Compressive Studies of Bulk Nanobubbles via Molecular Simulations and Experiments

Fankai Peng, Ahmad Jabbarzadeh

The University of Sydney, Sydney, Australia

Abstract

Nanobubbles have received increasing attention in the scientific community due to their unique properties, which makes them beneficial in several applications. However, the fundamental cause of nanobubbles' super-stability and many of their properties are still puzzling.

Our recent research, conducted via all-atom molecular simulations on bulk nanobubbles in water, has identified some unique properties. A novel charged gas and a TIP4P water molecular model are applied, contributing to a more precise prediction of the behaviour of nanobubbles. A unique cage region (nanobubble-water interface region) has been identified with a charged double layer: a negatively charged outer layer and a positively charged inner layer, mainly due to the water molecules. We then further scrutinised the pressure profile and explained the negative pressure in recent studies. Also, we noticed that super-stability might be attributed to the supersaturated water with gases rather than surface charges because electrostatics stress is relatively small compared to the internal pressure. Furthermore, different diffusion behaviours have been observed in distinct regions, and a unique region that speeds up diffusion has been identified. It should be highlighted that we used two different methods to determine the surface tension of the water-nanobubble interface, which is different from the surface tension of the water-vapour and water-compressed

gas planar interface due to the unique structure of the nanobubble. The rheological properties of the nanobubbles and some of our experimental results will also be presented. This comprehensive approach provides a more complete understanding of nanobubbles and their potential applications.

10:40 - 11:00

221 Interaction between a micro-particle and a flat surface across a nanoparticle dispersion: Theoretical analysis and comparison to AFM force-measurement

Ofer Manor[1], Simone Riva[1], Regine von Klitzing[2]

[1]Technion - Israel Institute of Technology, Haifa, Israel. [2]Technische Universität Darmstadt, Darmstadt, Germany

Abstract

The collisions of micro-particles across a dispersion of nanoparticles confines the latter particles in layers, which yields oscillatory structural forces, a mixture of attractive depletion and repulsive steric effects between the micro-particles. The repulsive steric force supports energy barriers for micro-particle attachment. Moreover, the micro-particles and the nanoparticles may be charged, which leads to a complex, many-body, colloidal interaction. We study this problem using a model for the interaction of a micro-particle and a solid surface.

We use a theory devoid of fitting parameters to simulate atomic force microscopy (AFM) measurement of the interaction force between a 2-micron silica particle and a flat silica substrate submerged in a dispersion of 15 nm silica particles in an aqueous electrolyte. Using density functional theory, we capture entropic and enthalpic contributions from the finite volume nanoparticles and their electrostatic interactions to the interaction energy experienced by the micro-particle as it collides with the flat solid. We capture the total ion population in the dispersion by accounting for added salt and counter-ions of the charged nanoparticle surface. We then capture the electrostatic interaction across the dispersion using the Jellium approximation and convert the nominal nano-particle diameter and their soft electrostatic interaction energy to an effective model of hard sphere interactions.

Quantitative agreement with the experiment highlights the equilibrium packing structure of the confined nanoparticles and the specific contribution of each interaction mechanism to the measured force. We thus differentiate between the stabilizing and destabilizing contributions to charged micro-particles in a dispersion of charged nanoparticles.

11:00 - 11:20

247 Polydisperse Polymer Solutions near a Surface: Insights from Analytical Mean-Field Theory

Anne Floor den Ouden, Remco Tuinier, Mark Vis, Max Martens

Eindhoven University of Technology, Eindhoven, Netherlands

Abstract

Mixtures of colloidal particles and polymers are ubiquitous in food, cosmetics, and paint as well as in biological systems such as the living cell. The adsorption of polymers at a colloidal surface modifies the surfaces of the colloids, mediates colloidal interactions, and therefore influences the colloidal stability. In practice, polymers are often highly polydisperse, which is hardly considered in theoretical accounts of polymer adsorption.

We present an analytical linearized mean-field theory for the adsorption of a polydisperse polymer solution onto colloidal surfaces. Within a weak inhomogeneity expansion we find that a polydisperse collection of polymers in solution can be well described by their number average degree of polymerization, independent of the shape or the variance of their chain length distribution. Analogous to the case of strong adsorption in polydisperse polymer solutions, theory predicts that the longer chain length fraction of the polymers in solution preferentially adsorbs at the surface. Our results quantitatively match with numerical Scheutjens-Fleer self-consistent field computations and we discuss the comparison of our results with experiments. The analytical expressions are shown to be valid for polymer solutions as well as for polymer melts.

11:20 - 11:40

391 Colloidally Stable Multicharged Cationic Surfactant-Capped Silver Nanoparticles: Experimental Design and Optimization of Synthetic Process

Sebastian Balicki, Kazimiera A. Wilk

Wrocław University of Science and Technology, Wrocław, Poland

Abstract

Cationic surfactants as capping agents of colloidal silver nanoparticles (AgNPs) have many advantages. Their positively charged head group leads to a stronger interaction with the nanoparticles. The hydrophobic chain length forms a steric hinderance around the nanoparticles and, hence, can protect them from aggregation and act as a better stabilizer. Due to high hydrophobicity and morphology control, for example dicephalic surfactants have been considered as one of the best shapes directing agents over classical single tail head cationic surfactants.

Therefore, the capping agents (plant extracts, gums, cationic surfactants and polymers) play an important role in the synthesis of AgNPs, eliminating agglomeration – due to their high surface energy – of the colloidal particles surrounding the AgNPs [1,2].

Novel cationic surfactants containing two and four hydrophilic groups and having a dicephalic architecture, in comparison to n-alkyl trimethylammonium bromides' standards with dodecyl, tetradecyl, and hexadecyl hydrophobic chains (respectively, DTABr, TTABr, and CTABr), have been used as an efficient capping agent to synthesize AgNPs that are colloidally stable over a long period of time.

The systematic design of experiments (DoE) is the most successful method for developing solutions, since it enhances understanding of the cause-and-effect relationships inside processes. It is best for identifying the most effective techniques to produce outstanding commercial items from a variety of materials. Response surface methodology (RSM) facilitates the straightforward construction of models for optimizing independent parameters in production or formulation development, utilizing effective theoretical, statistical, and numerical techniques. RSM seeks to provide sequential methodologies for conducting tests and verifying the congruence of experimental data with constructed models [3]. Various adaptations of RSM methodologies, grounded in diverse computational and statistical frameworks, have been employed to ascertain a broad spectrum of optimal solutions to the examined issue.

The authors acknowledge funding from National Science Centre, Poland within the OPUS 23 program (2022/45/B/ST4/01184).

[1] R. Ahmady, P. Hosseninzadeh, A. Solouk, S. Akbari, A.M. Szulc, B.E. Brycki, Adv. Colloid Interface Sci., 2022, 299, 102581.
[2] Ł. Lamch, W. Szczęsna, S.J. Balicki, M. Bartman, L. Szyk-Warszyńska, P. Warszyński, Wilk, K.A., Molecules, 2023, 28, 5806.
[3] M. Bartman, S. Balicki, L. Hołysz, K.A. Wilk, Colloid Surf. A-Physicochem. Eng. Asp. 2023, 659, 130792.

11:40 - 12:00

53 A Multiscale Framework for the Analysis of Nanobubbles in Supersaturated Liquids

Ali Ghamartale[1], Ehsan Shahini[1], Aditya Jain[2], Rogerio Manica[3], Peter Berg[4], Tian Tang[1]

[1]Department of Mechanical Engineering, University of Alberta, Edmonton, Canada. [2]Department of Mechanical Engineering, Delhi Technological University, Delhi, India. [3]Department of Chemical and Materials Engineering, University of Alberta, Edmonton, Canada. [4]Department of Physics, Brock University, St. Catharines, Canada

Abstract

Nano-sized gas bubbles are gaining attention in electro-chemical applications due to their exceptional stability and impact on reaction kinetics. Accurately predicting nanobubble stability and their size is critical for advancing technologies such as electrolysis and fuel cell systems. This study presents a multiscale framework combining molecular dynamics (MD) simulations and macroscale thermodynamic modeling to determine nanobubble stability and size under isothermal-isobaric condition. Assuming the nanobubble consists of a van der Waals (vdW) gas, constants in the vdW equation are extracted from MD simulations of pure gas systems. Combining the vdW equation with the assumption of chemical and mechanical equilibrium, a thermodynamic model is developed that establishes a predictive relationship between nanobubble size and gas concentration. MD simulations are performed for hydrogen in water under supersaturation, and the results are compared with theoretical predictions. Our findings confirm the validity of the Young-Laplace equation for bubbles above a critical radius, with surface tension aligning with bulk values. Deviations for smaller bubbles can be accounted for using size-dependent (e.g., Tolman) surface tension models. Analytical predictions of bubble sizes closely match MD results, affirming the framework's accuracy and scalability. This work bridges nanoscale and macroscale understandings of nanobubble behavior, paving the way for innovations in multiple applications.

Microfluidics and Nano/Biosensing Devices - 1

10:00 - 12:00 Thursday, 26th June, 2025
ECERF W2-050
Microfluidics and Nano/Biosensing Devices
Chun Yang

10:00 - 10:20

77 Colorimetric and Fluorometric Polydiacetylene Vesicle Sensors

John Miller[1], Tonya Kuhl[2]

[1]UC Davis, Davis, USA. [2]UC Davis, CA, USA

Abstract

Polydiacetylenes (PDA's) are conjugated polymers that are non-fluorescent and visually blue when polymerized. When some stimulus is applied (heat, light, mechanical stresses) they transform into a visibly red phase that is highly fluorescent. These colorimetric and fluorometric properties make PDA's particularly powerful for sensing applications. Surfactant-based diacetylenes can self-assemble into vesicles through a solvent injection approach and are available with carbon tails between 17 and 29 carbon units with the diacetylene motif typically at the 10 and 12 carbon positions. To make specific sensors, the carboxylic acid headgroup can be readily functionalized using peptide coupling schemes. In this work we investigate the effects changing the structure of the surfactant has on changing the polymerization properties and sensitivity of the self-assembled vesicles to thermal stimuli towards designing optimized sensors. We particularly focus on how the length of the hydrocarbon tail and structure of the headgroup change the sensitivity of the PDA vesicle sensors. We also investigated select PDA systems for both colorimetric and fluorometric sensing of arginine. Three samples (10,12 pentacosadiynoic acid-PCDA, 10,12 nonacosadiynoic acid-NCDA, and ethanolamine functionalized PCDA-Et-PCDA) were chosen to screen for arginine in solution. PCDA was the most sensitive in both colorimetric and fluorometric response. NCDA only partially transformed due to its increased van der Waals interactions along the side chains. Et-PCDA did not transformation when exposed to arginine due to screening of the negatively charged amino acid by the ethanolamine headgroup. These findings can aid in designing improved PDA based surfactant sensors.

10:20 - 10:40

127 Microfluidic systems with SMART PEG hydrogels for study of microbe-microbe and microbe-material interactions

Ryan Hansen

Kansas State University, Manhattan, USA

Abstract

Microfluidic devices can be combined with stimulus-responsive hydrogel interfaces to enable novel microbiological studies. In this presentation, the integration of photodegradable polyethylene glycol (PEG) based hydrogel materials into microdevices for the study of microbial interactions will be covered. First, a microwell device designed for high-throughput screening and discovery of ecologically important microbe-microbe interactions will be discussed. Diverse communities of microbes are washed from soil or plant root and then seeded and trapped within microwells using photodegradable hydrogels, where each individual microwell serves as a co-culture chamber with a unique combination of cells. Cell growth is tracked to identify co-cultures with unique growth phenotypes, then micropatterned 365 nm light is used to degrade the hydrogel over an individual well to selectively recover cells of interest for sequencing and further application. This device has been used to rapidly screen plant root microbiomes and discover novel plant growth promoting bacteria for biofertilizer and biocontrol applications. Second, to understand cellular transport through these hydrogels, they were deposited within microfluidic channels and then exposed to controlled doses of patterned 365 nm light. Chemical gradients were then generated across them, enabling a highly systematic approach for observing bacteria chemotaxis through hydrogels with controlled levels of degradation. Bacteria were found to transition from run-and-tumble motility to trapping-and-hopping motility as hydrogel degradation levels decreased, and average cell speed and directionality within the hydrogel were controlled by tuning degradation. These findings will advance degradable hydrogel materials for the controlled transport of bacteria in emerging living material and biotherapeutic applications.

10:40 - 11:00

140 Colorimetric Dye-Grafted Hydrogels: A Versatile Platform for Chemical Sensing

Hyun-Joong Chung, Ozge Zengin Akca, Monojit Batabyal, Rayan Basodan

University of Alberta, Edmonton, Canada

Abstract

Hydrogels contain water that often incorporates various solutes; unless hydrogels are encapsulated by a barrier, the solutes in the hydrogels reach an equilibrium with the environment. The most attractive feature of hydrogels is that the aqueous environment becomes a substantial part of the material itself, while the hydrogels maintain their mechanical consistency with a physical boundary. For these reasons, hydrogel is an ideal sensor platform in aqueous media. Colorimetric assays deliver information intuitively; keeping chromophores free from leaching has been a challenge in aqueous media. Direct ink writing is a versatile freeform manufacturing method for hydrogels; a generalizable formula to enable 3D printability can be impactful.

In this study, dual network hydrogels of polyacrylamide and alginate with acrylated chromophores are printed by incorporating Laponite® as a universal rheological modifier. Here, a co-polymerization of the acrylated chromophores with polyacrylamide enables colorimetric response to various chemical analytes. Our 3D printed colorimetric pH sensing hydrogels combine sensitivity, intuitive data interpretation, mechanical strength, and structural integrity to operate in various aqueous environments while having arbitrary shapes to address various needs in environmental, underwater, and healthcare applications with a robust and versatile platform to incorporate multifunctional sensitivity.

11:00 - 11:20

295 A microfluidic device for isothermal plasmonically accelerated nucleic acid-based bacterial identification

Tamer AbdElFatah[1], Mahsa Jalali[1], Sripadh Guptha Yedire[1], Imman I. Hosseini[1], Carolina del Real Mata[1], Haleema Khan[1], Seyed Vahid Hamidi[1], Roozbeh Siavash Moakhar[1], Geoffrey McKay[2], Dao Nguyen[2], Sara Mahshid[1]

[1]McGill University, Montreal, Canada. [2]McGill University Health Center (MUHC), Montreal, Canada

Abstract

Polymerase chain reaction (PCR) is the standard molecular pathogen identification assay. It offers high sensitivity and specificity yet it is challenging to deploy in low-resource environments as it

requires lengthy protocols, specialized equipment, and highly trained operators. Thus a need arises for pathogen identification in low-resource settings for deciding suitable medical interventions and interpreting AMR profiles.

Here, we introduce a microfluidic chip integrating Loop-mediated isothermal amplification (LAMP) assays and plasmonic nanostructures for bacterial identification in under 20 minutes. Upon illumination, the integrated nanostructures catalyze the amplification reaction by injecting hot-electrons into the assay accelerating the polymerization rate and phenol red color change from fuchsia to yellow. The chip sample-to-answer time of 20 minutes constitutes 5 minutes of thermal lysis and 15 minutes of amplification at 65 .

To validate the efficacy of 65 lysis, *E coli mm294* was cultured overnight and diluted to 10^5 CFU/mL. Subsequently, aliquots were subjected to standard 3 min lysis at 95 and 5 mins at 65 The aliquots and negative controls (*pseudomonas aeruginosa -PA-* DNA and water) were subjected to *E coli* LAMP amplification assay. Using gel electrophoreses, we confirmed the successful *E. coli* amplification for the positive conditions. Next, we used LAMP assays for *PA* and *E coli* identification in LB media and urine. The chip showed selective and quantifiable signals for *PA* and *E. coli* concentrations from 1 to 10^5 and 1 to 10^7 CFU/mL respectively. Overall, we present a microfluidic chip with a simple design for bacterial identification in 20 minutes.

11:20 - 11:40

380 Microfluidic device coupled with Raman Spectroscopy readout enables cancerous extracellular vesicles profiling at a single level.

Carolina del Real Mata[1], Erdem Cakmak[1], Yao Lu[1], Imman I. Hosseini[2], Tamer Abdelwahab[1], Sripadh Guptha Yedire[1], Mahsa Jalali[3], Sara Mahshid[1]

[1]McGill University, Montreal, Canada. [2]Johns Hopkins Medical School, Baltimore, USA. [3]Research Institute of McGill University Health Center, Montreal, Canada

Abstract

Optical sensors based on surface-enhanced Raman spectroscopy (SERS) can generate molecular composition fingerprints of sample such as extracellular vesicles (EVs). EVs are nanosized vesicles shed by cells, including cancerous ones, carrying molecular signatures from their cell of origin, making them ideal biomarkers for non-invasive techniques like liquid biopsy. Novel diagnostic devices capable of combining automation with patient samples are desired to increase the turnout in data gathering and sample throughput. We introduce a microfluidic system capable of trapping EVs derived from blood-plasma samples in a SERS-active sensor, that enables EV profiling at single-vesicle resolution. This system uses size exclusion chromatography (SEC) columns to separate EVs by size, passively guiding them sequentially into detection chambers hosting a nanostructured plasmonic array sensor. The experiments on blood-plasma samples demonstrated comparable size distribution of extracellular vesicles in-device from the collection

zones with their respective fraction counterparts of only SEC column separation. This EV separation system is a versatile tool that enables patient sample profiling at the single-EV resolution. The use of microfluidic devices has immense potential to overcome challenges posed by accessibility, rapidity, and sample throughput, which could be pivotal in advancing personalized medicine technologies.

11:40 - 12:00

440 **Fluidic sensing of soft micromaterials: subtleties of microgel and capsule fabrication in flow**

Sara Hashmi, Sabrina Marnoto

Northeastern University, boston, USA

Abstract

Fluidic droplet generation technology is increasingly used in the fabrication of soft polymeric materials for encapsulation, both for biomedical research purposes and to develop consumer products from pharmaceuticals to cosmetics. While the size, shape, and frequency of generation of soft materials in flow is readily measured using microscopy, optimization of their mechanical properties can be cumbersome. Traditional assays to measure and then optimize mechanical properties require removal of the material in flow, and are often destructive and time-consuming. We use in-line, on-chip fluidic platforms to investigate both the structural ‘zoology’ and the mechanical response of fluidic-fabricated micromaterials flowing through constrictions. Our case studies include investigations of both microgel particles and capsules. One commonly used polymer for particle formation is the blank slate hydrogel polyethylene glycol diacrylate (PEGDA), which can be polymerized and crosslinked using UV light. Typically, formation of UV-crosslinked PEGDA microgel particles in fluidics is accomplished by over-illumination of the polymer to ensure complete gelation. We find that adjusting UV illumination not only controls the transition from PEGDA-filled droplets to fully gelled particles, but also reveals the emergence of interesting structures and morphologies of fluidic-generated soft materials through the gelation transition. Fluidic techniques reveal similarly interesting behavior in materials that form capsules in flow, whether due to gelation of a polymer shell or the formation or removal of an oxide layer around a liquid metal droplet. We couple our fluidic techniques with macroscopic techniques like pendant drop and bulk rheology to better elucidate the impact of flow on the properties of fluidic-generated materials.

Wetting and Adhesion - 7

10:00 - 12:00 Thursday, 26th June, 2025
ETLC E1-003
Wetting and Adhesion
Carlo Antonini

10:00 - 10:20

55 Nanoscale properties of grafted polydimethylsiloxane chains

Kevin Golovin

University of Toronto, Toronto, Canada

Abstract

Linear polydimethylsiloxane (PDMS) chains, when covalently grafted onto a surface, exhibit many novel interfacial properties not observed in other grafted polymer systems, especially in terms of friction, wettability, and adhesion. This anomalous behaviour arises from their unique architecture at the nanoscale. In this talk I will outline some of the most exciting interfacial properties of grafted PDMS chains, along with the molecular origin of these properties. This includes both physical and chemical characteristics, and highlights the complex interplay between molecular weight, grafting density, polymer chain termination, and interfacial phenomenon. I will also discuss our recent discovery of autophobicity in grafted PDMS systems, i.e., the dewetting of chemically identical chains from one another due to their interfacial arrangement on surfaces. Perhaps surprisingly, the surface's resistance to mechanical abrasion is substantially improved in the presence of autophobic dewetted nanoclusters of grafted PDMS chains, and we propose that such clusters can be sheared, undergo chain scission, and then re-attach to the grafted PDMS layer in a self-healing manner. Evidence for this self-healing mechanism is provided in terms of chain termination, as grafted PDMS chains with trimethylsilyl end functionality–which show superior properties in terms of liquid repellency–counter-intuitively exhibit worse durability because they are unable to self-heal after mechanical wear.

10:20 - 10:40

315 Mechanical Properties of Polymer Hydrogel Surface Using a Resonance Shear Measurement

Masashi Mizukami[1], Masao Gen[1], Kazuaki Kato[2], Kazue Kurihara[1]

[1]Tohoku University, Sendai, Japan. [2]The University of Tokyo, Tokyo, Japan

Abstract

Polymer hydrogel is known to have excellent lubrication property, biodegradability, and biocompatibility. Such properties of polymer hydrogels have been drawing great attention for future application as lubricating materials and cell culture, etc. For the application of the gels above mentioned, the understanding of the mechanical properties of the gel is becoming essential.

In this study, we investigated the surface elasticity of a so-called "slide ring (SR) gels"[1] by RSM, and compared it with that of a typical chemical gel, pullulan gel (Fig). The SR gels have polymer chains are topologically interlocked by figure-of-eight cross-linkers (connected two cyclodextrin rings), which can move freely along the polymer chains. The elastic moduli of the gel surfaces (E_{surface}) were evaluated based on the method previously we reported.[2] The E_{surface} value of the PG gels were 3 to 4 times larger than their Young's moduli. This indicated that the reduction of the tension among the polymer chains was not effective at the gel surfaces compared with those inside of the gel. On the other hand, the E_{surface} values of the SR gels were smaller or slightly larger than their Young's moduli. This indicated that the slide ring effects worked to reduce the tension of the polymer chain network near the surface as well as the inside of the gel.

1. Y. Okumura and K. Ito, Adv. Mater., 2001, 13, 485-487.

2. M. Mizukami, H.-Y. Ren, H. Furukawa and K. Kurihara, J. Chem. Phys., 2018, 149, 163327.

10:40 - 11:00

26 Superhydrophobic and lubricant-infused surfaces with inherent antibacterial properties

Jitao Zhang[1], Georgia Williams[1], Diana Vinchira-Villarraga[1], Thanaphun Jitniyom[1], Navdeep Singh[1], Alexander Saal[1], Lily Riordan[2], Madeline Berrow[2], James Churm[1], Mojgan Rabiey[3], Manuel Banzhaf[4], Felicity De Cogan[2], Nan Gao[1]

[1]University of Birmingham, Birmingham, United Kingdom. [2]University of Nottingham, Nottingham, United Kingdom. [3]University of Warwick, Conventry, United Kingdom. [4]Newcastle University, Newcastle, United Kingdom

Abstract

Bacterial adhesion and related infections have caused great concern to the medical and healthcare sectors over the past decades. Herein, we report on superhydrophobic and lubricant-infused surfaces based on nanopillar structures of zinc oxide. Low-adhesion properties have been observed of the surfaces during dynamic testing, where the contact angle hysteresis of water droplets are within 2°. Further, these surfaces exhibit inherent antibacterial activity and effective reduction of bacterial attachment against various bacteria, respectively, including *Escherichia coli* (*E. coli*), *Staphylococcus aureus* (*S. aureus*) and *Pseudomonas syringae pv. syringae* (*Pss*), which have different biofilm formation modes. Microscopic studies indicate that bacteria can be killed after incubation on the surfaces. This is attributed to the photocatalytic activity that the underlying ZnO nanopillars of the superhydrophobic and lubricant-infused surfaces possess. Such attributes make these superhydrophobic and lubricant-infused surfaces a potential candidate for use in healthcare industries to resist bacterial adhesion and tackle biofouling.

11:00 - 11:20

309 Ultrathin polydimethylsiloxane brushes: advanced protein-repellent coatings for healthcare applications

Mehdi Sadeghi[1], Kevin Golovin[1], Bahareh Raisi[2], Nektaria Markoglou[2]

[1]Department of Mechanical & Industrial Engineering, University of Toronto, Toronto, Canada.
[2]Meltech Innovation Canada Inc., St-Eustache, Canada

Abstract

Healthcare-associated infections (HAIs) are a global issue that increase healthcare costs and reduce the quality of life. Many patients, including 7.9% of Canadian hospital patients, suffer from HAIs. This escalates to 30% for special care patients who contact medical equipment and intrusive catheters for longer periods.

Two important sources of HAIs are airborne pathogen transmission, which spreads infections such as COVID-19, and prolonged contact with medical devices, which results in various bacterial infections. Protein adsorption is an important factor that increases the risk of HAIs. As an example, 5-10% of residents in Canadian long-term care institutions suffer from urinary tract infections caused by catheterization. This infection starts with the adsorption of proteins from the host's body onto the catheter surface, forming a scaffold to which bacteria bind. Many HAI prevention studies involve actively killing pathogens. These methods can be limited to specific species or lead to antibiotic resistance. Therefore, coatings which passively prevent HAIs by reducing protein adsorption are needed.

As demonstrated in this study, an ultrathin layer of surface-grafted Polydimethylsiloxane (PDMS) chains, referred to as PDMS brushes, can be utilized as a passive protein-repellent coating. In the presented work, we compared contamination caused by drying protein droplets on a smooth glass surface before and after being coated with PDMS brushes. It was observed that PDMS brushes not only reduce the size of the dried residue by up to ~60% compared to the initial droplet, but also that the dried protein residue can spontaneously delaminate, leaving the surface completely clean.

11:20 - 11:40

401 pH dependent interfacial adhesion of Hydroxypyridinone based surface primers as wet adhesives

Syeda Tajin Ahmed[1], George Degen[2], Parker Stow[3], Melanie Susman[3], Alison Butler[3], ROBERTO ANDRESEN EGUILUZ[1,4]

[1]Department of Materials Science and Engineering, University of California, Merced, USA.
[2]Department of Chemical Engineering, University of California, Santa Barbara, USA.
[3]Department of Chemistry and Biochemistry, University of California, Santa Barbara, USA.
[4]Health Sciences Research Institute, University of California, Merced, USA

Abstract

Wet adhesives inspired by mussel foot proteins provide excellent alternatives to existing medical adhesives, many of which are either cytotoxic or ineffective. These materials have catecholic (3,4-dihydroxyphenylalanine), or DOPA, and cationic lysine residues which synergistically drive the adhesion process. However, DOPA is oxidized at neutral pH, thus limiting its application where adhesion at an extensive range of pH values is desirable. To address this limitation, we studied hydroxypyridinone (HOPO) compounds, namely Tren(Lys-1,2-HOPO)$_3$ and Tren(Lys-3,4-HOPO)$_3$ hypothesized to be more resistant to oxidation than catechols, as a candidate for multifunctional wet adhesives. We compared the pH dependence on adhesion of Tren(Lys-1,2-HOPO)$_3$ compound against previously reported catechol-based molecules that mediate strong wet adhesion at acidic pHs, namely- Tren(Lys 2,3-dihydroxybenzoyl group)$_3$, using a Surface Force Apparatus. The results suggest that the adhesion force of Tren(Lys-1,2-HOPO)$_3$ between two atomically smooth mica surfaces at pH 10 falls to ~30% of the peak adhesion force of ~ - 40 mN/m (or adhesion energy of –8.5 mJ/m^2), similar to catecholic compounds with dihydroxybenzoyl groups. More interestingly, after switching back to acidic pH of 3, the 1,2-HOPO compound retains ~75% of the peak adhesion force, unlike the catecholic TLCs that do not recover adhesion. Tren(Lys-3,4-HOPO)$_3$ compound shows a similar trend. With the absence of lysine, the adhesion of Tren(1,2-HOPO)$_3$ is completely abolished. Also, only the tren-core or Tris(2-aminoethyl amine) does not participate in the adhesion mechanism. The results of this work should guide the design of a new generation of smart adhesives for binding to charged surfaces in saline environments.

11:40 - 12:00

187 Advancing Surface Characterization: A Numerical Approach for Force-Based Analysis of Chemically and Topographically Heterogeneous Surfaces

Pawan Kumar, Joe Berry

The University of Melbourne, Melbourne, Australia

Abstract

Chemically heterogeneous surfaces, comprising regions with distinct surface chemistries, are critical to various applications, including directional wetting, Lab-on-a-Chip devices, water harvesting, printing technology, droplet sorting, and liquid patterning. The functionality of such surfaces depends on the precise design of local surface chemistry and geometry, such as the shape and size of heterogeneous patches. Over time, surface degradation can adversely affect performance, necessitating reliable methods for surface characterization. Although widely employed due to its simplicity, contact angle measurement is unsuitable for extreme contact angles (<40° or >150°) and prone to significant inaccuracies. While offering an alternative, direct force measurement techniques fail to quantify the local distribution of surface chemistry or contact angles, limiting their utility.

We present a numerical model based on free energy minimization to calculate forces exerted when a droplet is compressed between a cantilever and a chemically heterogeneous surface. The model is validated through experimental force measurements on a checkerboard surface with alternating wettability patches using atomic force microscopy (AFM). The results demonstrate that the squashing force is influenced by both the local surface chemistry and its spatial distribution. Additionally, the force curves reveal discrete instances of contact line jumps, observable as abrupt drops in the measured force. Comparison of numerical and experimental results enables accurate prediction of surface chemical heterogeneity. The model is further extended to evaluate adhesion forces on superhydrophobic pillared surfaces, allowing the characterization of parameters such as pillar area fraction, spatial distribution, and local advancing/receding contact angles. This robust approach bridges the limitations of conventional methods, offering comprehensive surface characterization capabilities for chemically and topographically heterogeneous surfaces.

Capillary Phenomenon and Field Effects - 2

13:20 - 15:00 Thursday, 26th June, 2025
ICE Incubator
Capillary Phenomenon and Field Effects
Janet Elliott

13:20 - 13:40

64 3D EMULSION FLOWS IN A RECTANGULAR MICROFLUIDIC CHANNEL

Santhosh Virappane[1], Reza Azadi[1,2], Neelarun Mukherjee[3], Peichun Amy Tsai[1]

[1]University of Alberta, Edmonton, Canada. [2]University of Sydney, Sydney, Australia. [3]University of Texas, Texas, USA

Abstract

A fundamental understanding of segmented Taylor flow of emulsions in a microchannel is recognized as essential due to its relevance in enhancing heat and mass transfer across various technological applications, such as chemical reactors and carbon capture and sequestration technologies. Numerical simulations were conducted to elucidate the flow fields of low-Capillary number (Ca ~ $O(10^{-3})$) Taylor flow emulsions, where immiscible CO_2 is carried by water in a microfluidic T-junction of small depth. High-resolution two- and three-dimensional (2D, 3D) numerical simulations were performed with a finite volume approach and volume of fluid (VOF) method. These simulations were initially validated against experimental data.

The necessity for 3D simulations to accurately capture the dynamics of liquid and supercritical CO_2 emulsions is revealed by our numerical results. Vortex patterns at multiple vertical planes within the emulsions, specifically in the third dimension, were uncovered by examining these 3D simulations. Located near the sidewalls, the intense vortices are characterized by high magnitude vorticity. From Q-criterion analysis, it was determined that the strongest vortices occur across the microchannel in the third dimension, offering improved exchange mechanisms. Intense vortex patterns for gaseous CO_2 were found near the interfacial area of the emulsion body and the cap region, influenced by the surrounding flow. At higher Capillary numbers, liquid and supercritical CO2 emulsions exhibit prominent vortex patterns occurring in the upstream cap regions. These findings pinpoint specific areas within the emulsions that should be prioritized to enhance the stabilization or exchange mechanisms in low-Capillary, Taylor-flow emulsions.

13:40 - 14:00

340 Efficient Mass Transfer Optimization via Rising Bubbles in an Electrochemical System with Confined Plate Spacing

Wanyi Zhang, Bo Liu, Fang Yuan, Qiang Yang

East China University of Science and Technology, Shanghai, China

Abstract

Electrochemical energy conversion devices, such as hydrogen production systems and liquid flow batteries, critically depend on efficient mass transfer to achieve optimal performance. This study demonstrates that rising millimeter-sized bubbles can significantly enhance mass transfer in an electrochemical system with parallel plates spaced just 5 mm apart—a typical configuration in such devices. The introduction of ~90 mL/min of gas bubbles increases the mass transport limiting current by over 10 times compared to static conditions. Remarkably, achieving comparable performance through liquid circulation alone requires a substantially higher volumetric flow rate of approximately 2000 mL/min. Through theoretical analysis and numerical simulations, we reveal that this enhancement is driven by turbulent tail vortices generated by bubbles rising at velocities exceeding 20 cm/s, even within the confined plate spacing. These findings present a highly efficient and practical strategy for optimizing mass transfer, offering transformative potential for the design and operation of advanced electrochemical systems.

14:00 - 14:20

105 Droplet evaporation and particle deposition on stretched soft substrates

Binyu Zhao[1], Günter Auernhammer[2]

[1]Qinghai Institute of Salt Lakes, Chinese Academy of Sciences, Xining, China. [2]Leibniz Institute of Polymer Research, Dresden, Germany

Abstract

Droplet evaporation on solid substrates is a ubiquitous phenomenon and relevant in many natural and industrial processes. We systematically investigate the contact line dynamics of droplets evaporating on crosslinked polydimethylsiloxane substrates with different stiffness and stretching ratios and the structures of evaporative deposition patterns of nanoparticles. We show that the shapes of droplets and their contact line dynamics are strongly affected by uniaxially stretching the substrates. The droplet evaporates with an elongated non-circular contact line and switches the elongation direction during evaporation. The contact line recedes earlier and faster in the direction parallel to the stretching than in the perpendicular direction. This is rationalized by a direct visualization of the evolution of the surface deformation, the so-called wetting ridge underneath

the contact line. The anisotropic contact line receding only occurs on stretched substrates that are sufficiently soft. This anisotropic contact line motion enables us to prepare anisotropic non-circular patterns, which are beyond the well-known coffee-ring, by evaporating colloidal suspension droplets on stretched soft substrates. By further combining inclination and rotation of the stretched substrate, a variety of complex deposition patterns can be prepared. These findings broaden our fundamental understanding of droplet wetting dynamics and evaporative particle deposition on soft and anisotropic substrates, and the approach for anisotropic patterning offers original opportunities in applications involving micro- and nano-fabrication and printing.

Surfactants and Emulsions - 5

13:20 - 15:00 Thursday, 26th June, 2025
ECERF W2-110
Surfactants and Emulsions
Lukas Zeininger

13:20 - 13:40

21 Nonionic surfactants at the oil/water interface: short-time dynamic behavior observed with a microfluidic tensiometer

Camille Brigodiot[1], Boxin Deng[2], Marie Marsiglia[1], Christine Dalmazzone[1], Annie Colin[3], Karin Schroën[2,4]

[1]IFP Energies nouvelles, Rueil-Malmaison, France. [2]Wageningen University and Research, Wageningen, Netherlands. [3]ESPCI, Paris, France. [4]University of Twente, Enschede, Netherlands

Abstract

The understanding surfactant behavior at very short time scales should be crucial in the design of processes in which interfaces are created. In reality, classical tensiometry methods are used, but they generate insights at time scales that are orders of magnitude longer than those occurring in processes. Maybe even more importantly, these measurements revolve around diffusion, while in practice two mechanisms are at work: diffusion from the bulk to the interface followed by adsorption onto the interface. This study combines both aspects to thus elucidate interfacial dynamics. Microfluidic devices provide insights at short time scales from the millisecond, crucial for adsorption phenomenon while classical tensiometers allow us to unravel surfactant mass transport at larger time and length scales.

We have performed dynamic interfacial tension measurements with the EDGE tensiometer (Deng et al., LabOnChip, 2022) for different surfactants of the CiEj family at the water/n-hexadecane interface, at time scales ranging from 10 ms to 10 s. At short times, the results have been compared with theoretical models (Langmuir, reorientation model) and have been found to be driven by

adsorption. Combining equilibrium studies (rising drop method) and theoretical adsorption models, kinetic parameters were successfully determined. For micellar solutions, the mass transport kinetics is likely to shift from adsorption limited to a mixed-diffusion process.

In conclusion, adsorption and diffusion were successfully deconvoluted, and parameters were determined for specific systems. The results obtained with microfluidics are instrumental in unraveling surfactant mass transport and adsorption at time and length scales relevant for industrial processes.

13:40 - 14:00

148 Lecithin Stabilized Water-in-Oil Emulsions: Thin Liquid Films and Interfacial Rheology Study

Plamen Tchoukov, Hristina Petkova, Dimitrinka Arabadzhieva, Nikolay Panchev, Khristo Khristov

Institute of Physical Chemistry, Bulgarian Academy of Sciences, Sofia, Bulgaria

Abstract

Lecithin is a mixture of amphiphilic phospholipids that can be derived from sustainable natural sources like soybeans. Its eco-friendly nature and cost-effectiveness, make it a versatile ingredient in a wide range of applications. While lecithin effectively stabilizes both water-in-oil (W/O) and oil-in-water (O/W) emulsions, its adoption as a sustainable alternative to synthetic emulsifiers requires optimizing its performance, particularly in the less studied and understood W/O system. This study focuses on the mechanisms of stability in soybean-lecithin (SBL) stabilized W/O emulsions, employing the thin liquid film (TLF) technique along with profile analysis tensiometry (PAT-1). Thin film parameters, including lifetime, the probability of stable film formation, equilibrium film thickness, and disjoining pressure isotherms were measured to characterize the emulsion films of toluene and edible oils stabilized with SBL. Additionally, a modified TLF cell was used to apply electric field, enabling the determination of the critical DC voltage of film rupture. These results allowed to define the minimum SBL concentrations required for film stabilization and the associated steric stabilizing surface forces. Furthermore, the thin film results were compared with the dilatational rheology of lecithin adsorption layers. Stable films were formed at concentrations beyond the observed maximum in the dilatational elasticity. The results of this study outline the favorable conditions (SBL concentration, pH, and electrolyte) for the formation of W/O emulsion and provide insights into the underlying stabilization mechanisms, and the role of adsorption layer rheological properties.

Acknowledgement: The investigation is partly funded by the European Union-NextGenerationEU, project BG-RRP-2.015-0009-C01.

14:00 - 14:20

288 Microfluidic measurements for stabilizing water-in-oil emulsions with salt and surfactant mixtures

Rana Rana Bachnak, Cari Dutcher

University of Minnesota, Minneapolis, USA

Abstract

Emulsions and foams are ubiquitous in both natural and industrial settings, where their stability can be either advantageous or undesirable. For instance, shipboard bilgewater, containing oil droplets, salts, and surfactants, must be treated before being discharged into the ocean. The presence of surfactants in these emulsions stabilizes the interface and hinders separation. Conversely, applications such as firefighting foams rely on surfactants to enhance stability for effective fire suppression. This presentation highlights the effect of salt and surfactants on the stability of water-in-oil emulsions containing sub-millimeter sized droplets. The first factor studied is the presence of salt, where emulsion stability is assessed by measuring interfacial tension (IFT), at both bulk and microscale levels, and through microfluidic coalescence. Results show that IFT relaxation occurs orders of magnitude faster at the microscale compared to bulk measurements. Additionally, in the presence of oil phase SPAN80 surfactant, adding NaCl to the aqueous phase lowers IFT and extends film drainage times. The second factor studied is the effect of surfactants and their combinations. A microfluidic device is designed to analyze coalescence behavior by measuring droplet coalescence frequency. The performance of various surfactants is evaluated, using formulations informed by new per- and polyfluoroalkyl substances (PFAS)-free fire-fighting foams. Notably, a synergistic combination of a siloxane-polyoxyethylene surfactant and an alkyl polyglycoside surfactant results in a reduction in both IFT and coalescence frequency. The findings align with the established understanding of the mixture's enhanced fire suppression capability, when used in foams, suggesting that formulations addressing environmental concerns can also improve emulsion stability.

14:20 - 14:40

370 Dilational Rheology of saponin at b-pinene/water interface

Feng Lin

Natural Resources Canada, Devon, Canada

Abstract

Understanding interfacial properties of surface-active agents at interfaces is important to produce stable emulsions and foams. In this study, interfacial viscoelasticity of b-pinene droplet in saponin aqueous solution was evaluated using dilational rheology measurement. Both saponin and b-pinene are biocompatible and abundant in plants, trees and agricultural wastes. For comparison, saponin at air-water interface was also studied. Results show that dilational moduli of saponin at b-pinene/water interface increased with increasing oscillating frequency, but less significant frequency dependence than their counterparts at air/water interface. Interestingly, dilational moduli of saponin at b-pinene/water interface passed through a minimum with increasing saponin bulk concentration, while air/water interface exhibited a strikingly different trend in term of concentration dependence and a higher magnitude of dilational moduli. However, compared to those using petroleum-based surfactants and oils, saponin at b-pinene/water interface shows relatively larger dilational elasticity and viscosity. The dilational properties of saponin at the two interfaces are also discussed with its corresponding adsorption behaviours. The finding in this study is informative to develop new bio-based and eco-friendly emulsion and foam products.

General Aspects of Colloid and Interface Science - 6

13:20 - 15:00 Thursday, 26th June, 2025
ECERF W2-010
General Aspects of Colloid and Interface Science
Mehrasa Yassari

13:20 - 13:40

183 Bioinspired Capillary Force-Driven Super-Adhesive Aerosol Filter

Junyong Park[1], Chan Sik Moon[1], Ji Min Lee[1], Sazzadul A. Rahat[2], Sang Moon Kim[3], Jonathan T. Pham[2], Michael Kappl[4], Hans-Jürgen Butt[4], Sanghyuk Wooh[1]

[1]Chung-Ang University, Seoul, Korea, Republic of. [2]University of Cincinnati, Cincinnati, USA. [3]Incheon National University, Incheon, Korea, Republic of. [4]Max Planck Institute for Polymer Research, Mainz, Germany

Abstract

Capturing particles with low, nanonewton scale adhesion is an ongoing challenge for conventional air filters. Inspired by the natural filtration capabilities of mucus-coated nasal hairs, we introduce an efficient biomimetic filter that exploits a thin liquid coating. Here, a stable thin liquid layer is formed on a variety of filter media that generates enhanced particulate adhesion, driven by micro- to sub-micronewton capillary forces. The enhanced particle adhesion results in outstanding filtration of airborne particulates while maintaining air permeability, providing longer filter lifetime and increased energy savings. Moreover, strong adhesion of the captured particles enables effective filtration under high-speed airflow as well as suppression of particle redispersion. We anticipate that these filters with thin liquid layers affords a new way to innovate PM filtering systems.

13:40 - 14:00

15 Nucleation of ice and gas hydrates

Nobuo Maeda, Yu Wei, Xin Zhang, Ying Zhou

University of Alberta, Edmonton, Canada

Abstract

Nucleation is an activation process at an initial stage of a first-order phase transition. Nucleation of ice has been studied over many years but many outstanding issues still remain, like (1) What is

the most important factor that influence the efficacy of additives, (2) Why some substances are efficient in facilitating heterogeneous nucleation, (3) How to design an efficient heterogeneous nucleator.

We have been experimentally investigating the heterogeneous nucleation of ice and that of gas hydrates concurrently, in the hope that insights obtained in one may help the understanding of the other. In this presentation, we will report recent developments in our findings.

14:00 - 14:20

98 Molecular Insights into Lignin Aggregation in Singular and Binary Solvents

Ali Mirzaalian Dasjerdi, Jing Liu, Tian Tang

University of Alberta, Edmonton, Canada

Abstract

Fast pyrolysis bio-oils (FPBOs) offer a sustainable alternative to fossil fuels due to their renewability, carbon neutrality, and low sulfur content. However, their complex composition, particularly the presence of lignin oligomers, acids, and other oxygenated compounds, leads to phase instability, limiting practical applications. This study uses molecular dynamics simulations to investigate the solubility and aggregation of lignin monomers in various solvents relevant to FPBO processing. Organic solvents (OS) including acetic acid (AA), phenol (PH), methanol (ME), hydroxy acetone (HA), and furfural (FU) were analyzed individually and in their binary mixtures with water. Solvation free energy for one lignin monomer showed minimal differences among the OS. However, solvent-accessible surface areas for lignin mixed with OS (25:75 wt%) followed the order of ME > AA ~ PH > HA > FU, while adding water (lignin: OS: water = 25:50:25 wt%) shifted the ranking to PH > AA > ME > HA > FU due to intricate OS-lignin and OS-water interactions. ME, AA, and HA solubilized lignin via hydrogen bonding. This ability was compromised by water, unlike the case of PH, where lignin maintained high solubility through π-π interactions. Consequently, compared to the other OS, lignin aggregation is lower in PH when water is added. Contrarily, ME's greater polarity compatibility with water compared to lignin results in decreased solubility. Furfural exhibited limited interactions with both lignin and water. The findings highlight the critical role of solvent structure and intermolecular interaction in lignin solubility and aggregation, laying a foundation to improve the stability of FPBOs.

14:20 - 14:40

301 Colloidal aspects of geopolymer formation by rheology, stopped flow SAXS, and SANS for terrestrial and lunar applications.

Norman Wagner[1], Thaddeus Egnacyzyk[2], Ryan Murphy[2], Quent Hartt[1]

[1]University of Delaware, Newark, USA. [2]University of Delaware, newark, USA

Abstract

Geopolymers are a sustainable construction material with greatly reduced CO2 emissions as compared to cement as well as candidates for insitu resource utilization (ISRU) for lunar construction. Temporal measurements of the nanostructure and mechanical properties during gelation for sodium aluminosilicate hydrate (N-A-S-H) fractal gels provide insight into the complex polycondensation reactions of alkali-activated materials. A stopped-flow SAXS sample environment deployed at CHESS and ESRF captures the nucleation, growth, and aggregation of aluminosilicate particles that form the binder. Reaction kinetics are described empirically by the Avrami kinetic equation for N-A-S-H gel compositions spanning Si/Al ratios of 2 to 6, and a master curve for both a rheological extent of reaction and extent of volume occupied by fractal aggregates is developed. Colloidal gelation describes the evolution of the gel from the strong-link Shih scaling close to the gel point, followed by a transition to weak-link scaling at later times. This fundamental advance in understanding the gelation mechanism in this model aluminosilicate system is shown to be industrially relevant to the design and processing of sustainable alkali-activated binder construction materials, including for additive manufacturing. Results for a current experiment exposing geopolymers made from lunar regolith simulants to the low earth orbit environment aboard the MISSE test station on the ISS will be presented.

14:40 - 15:00

367 Rheological Properties of Crude Oils Treated with a Natural Product-based Organogelator for Improved Oil Spill Response

Evgeniya Hristova, Stanislav Stoyanov, Lindsay Hounjet, Hosnay Mobarok

NRCan, CanmetENERGY, Devon, Canada

Abstract

Phase-selective organogelators are spill-treating agents that self-assemble within oil slicks on water to render the oil a semi-solid, which can facilitate its containment and recovery from the environment. We have synthesized the organogelator N-acetyl-*L*-isoleucine-N’-*n*-octylamide (Ac-Ile-C8) and applied it to diluted bitumen (DB) and conventional crude (CC) oils spilled onto river water. The scoopability of solidified oils is an important criterion describing how easily spilled oil

can be removed from the water surface. While only visually observed in previous demonstration, scoopability can be quantified based on rheology changes upon solidification. To employ this method, the non-Newtonian behaviors of gelated oils are investigated at varied shear rates. The viscosity profile of DB represents a Newtonian fluid. The initial viscosity of the gelated DB is ~3.5 orders of magnitude higher than that of the pure oil and gradually decreases as the applied shear rate is increased. The gelated CC exhibits initial viscosity comparable with that of gelated DB, even as the viscosity of pure CC is substantially lower than that of pure DB. The dynamic rheological properties of frequency and strain sweep of the gelated DB and CC are also investigated to determine the storage modules and viscoelastic properties of the solidified oils. It was demonstrated that the gelated oils exhibit yield stress, viscosity, and shear properties representative of non-Newtonian behavior, which contrast the Newtonian behavior of the non-gelated oils, suggesting a method to quantify scoopability. The measured viscoelastic properties provide valuable information for the engineering adaptation of spill response equipment.

Microfluidics and Nano/Biosensing Devices - 2

13:20 - 15:00 Thursday, 26th June, 2025
ECERF W2-050
Microfluidics and Nano/Biosensing Devices
Sara Hashemi

13:20 - 13:40

39 Universal Microchamber for On-Demand Fabrication of Flexible Plasmonic Films with Near-Single-Molecule Surface-Enhanced Raman Spectroscopy Sensitivity for Trace-Level Detection in Agriculture and Healthcare

Chiranjeevi Kanike[1,2], Hongyan Wu[1], Qiuyun Lu[1], Arnab Atta[2], Xuehua Zhang[1]

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Abstract

Rapid detection of agrochemical residues and uremic toxins is crucial for advancing agricultural intelligence and improving healthcare, as both pose significant risks to the environment and human health, requiring precise, affordable, simple, and noninvasive solutions. Surface-enhanced Raman spectroscopy (SERS) offers a sensitive, fast, and clinical-grade approach for real-time monitoring of plant health and uremic toxins, enabling effective agrochemical residue monitoring and timely diagnosis of human health conditions. This study introduces a versatile 3D-printed microfluidic device capable of fabricating flexible plasmonic films for on-site detection of agrochemical residues and uremic toxins via SERS. The device enables scalable, cost-effective synthesis of plain polydimethylsiloxane (PDMS) and micro-well-structured PDMS films functionalized with silver nanoparticles via controlled droplet reactions, achieving near single-molecule sensitivity. The films are optically transparent, flexible, and conform to non-planar surfaces, acting as wearable sensors that support dual sensitivity and multiplexed detection in complex matrices. These films provide highly sensitive and reproducible SERS measurements for trace-level detection, with detection limits ranging from 10^{-16} to 10^{-13} M for micro-well structured films. For plain plasmonic films, ultralow detection limits of 10^{-11} M for rhodamine 6G, 10^{-7} M for adenine, and 10^{-6} M for pharmaceutical drugs were achieved, demonstrating their suitability for on-field, non-invasive monitoring of pesticide residues on fruit surfaces. Additionally, 13 biological toxins, including neurotransmitters and urea cycle metabolites, were detected at concentrations below permissible levels. This compact, scalable device integrates fabrication and detection, offering a cost-effective solution for real-time diagnostics in environmental and healthcare applications, including personalized health monitoring and point-of-care diagnostics.

13:40 - 14:00

61 Microfluidic Mixing Mediated by Acoustic Streaming around Microscale Obstacles

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Abstract

Microscale mixing is an important chemical process that facilitates reactions for biomedical diagnostics and drug development. In this work, we present the application of a microfluidic platform that utilizes acoustic streaming as a mechanism for fluid mixing. The platform features a Y-channel configuration with circular obstacles embedded within the channel. A piezoelectric transducer, driven at a frequency of 5.6 kHz and varying voltage levels (15 V – 70 V), is used to generate streaming about the circular obstacles that induce mixing within the channel. Fluorescent polystyrene particles are used to visualize the mixing process and evaluate the local flow field via microscopic particle image velocimetry (uPIV). The polystyrene particles are also used to assess the quality of the mixing process for flow rates ranging from 100 uL/hr to 400 uL/hr. The mixing process mediated by the acoustic streaming about the circular obstacles is compared to the case where the obstacles are triangular in structure. Although the triangular obstacles generate stronger vortices in comparison to the circular obstacles, we find that the circular obstacles are more efficient at mixing the fluid due to localized trapping at the triangle corners. Lastly, we introduced a polymer solution consisting of Methoxy poly(ethylene glycol)-block-poly(ε-caprolactone), a block polymer to test if the mixing process will result in flash precipitation. When an organic stream of block polymer is mixed with water under acoustic conditions, ~200 nm diameter polymer nanoparticles are created. Thus, ultimately demonstrating the applicability of this platform as a microfluidic reactor.

14:00 - 14:20

63 Microfluidic Investigations on Supercritical CO_2 Mass Transfer

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Abstract

Motivated by carbon capture and sequestration (CCS) in deep saline aquifers, we investigate the mass transfer dynamics of CO_2 in reservoir fluids under reservoir-like conditions using microfluidic systems. Our study experimentally examines CO_2 dissolution in water and brine at high pressures (up to 9.5 MPa) and temperatures (up to 50°C), utilizing microfluidics to generate CO_2 bubbles near a T-junction and track their shrinkage within the aqueous phase. Volumetric mass transfer coefficients (kLa) are derived from a unit cell model to characterize convective mass transfer. Dissolution in water is studied across a range of pressures (0.1–9.5 MPa) and temperatures (24–35°C), with CO_2 in gas, liquid, and supercritical states. Compared with liquid and gas states, supercritical CO_2 demonstrates the highest k_La (~100 s−1). Compared to millimeter-scale systems, microfluidics (hydraulic diameter ≅ 50 µm) yields k_La values that are 2–3 orders of magnitude higher.

We also extend to supercritical CO_2 dissolution in brine, assessing salinity (0–1 M) and flow rates (15–60 µL/min) at 8 MPa and 50°C. Results show k_La values of 50.3–144.0 s^{-1}, increasing with flow rate, while salinity has a minimal effect. Supercritical CO2 in brine exhibits significantly higher k_La than gas or liquid CO_2 in water, which is attributed to enhanced molecular diffusion at elevated temperatures. A theoretical analysis highlights the dominant role of liquid film mass transfer, emphasizing the potential for enhanced CO_2 solubility trapping in saline aquifers through fluid recirculation and large surface areas.

14:20 - 14:40

429 Enhanced Microfluidic Electroporation for Bacteria Inactivation

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Abstract

The process of reversible electroporation allows to transport genes and other molecules into the cells via mass diffusion, electroosmosis or/and electrophoresis. However, it requires applying high

voltages for achieving irreversible electroporation-based cell inactivation operation. To overcome this drawback, we propose a new method to enhance irreversible electroporation for bacterial inaction via non-uniform electric field induced non-linear dielectrophoresis. From the physical viewpoints, two phenomena occur for bacterial cells: One is that non-uniform electric field is generated locally with higher field strength formed near the pillar regions, and it interacts with the dielectric cells to induce a non-linear electrokinetic phenomenon - positive dielectrophoresis that attracts the cells to the neighborhood of each pillar. The other is that the cells undergo electroporation near each pillar such that *multiple electroporation zones* are created. We investigate the bacteria inactivation performance of two different microfluidic electroporation devices with rhombus and circular micropillars used for generating locally enhanced electric field strength, showing significant reduction in required electric voltages. Experiments are carried out to characterize the inactivation performance with *Escherichia coli* and *Enterococcus faecalis*. We find that under the same applied electric field, the device with rhombus micropillars performs better than the device with circular micropillars for both *E. coli* and *E. faecalis*. Numerical simulations show that due to the corner induced singularity effect, the maximum electric field enhancement is higher in the device with rhombus micropillars than that in the device with circular micropillars. We also study the effects of DC and AC electric fields and flowrate.