

COLLOID AND INTERFACE SYMPOSIUM 2019

COINS 2019 HK



Abstract Booklet

June 13-14, 2019

9:00 - 18:00

Lecture Theatre A, Chow Yei Ching Building

The University of Hong Kong

For registration and more details:

<https://coins2019.weebly.com/>



Organized by
HKU Mechanical Engineering
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AMORE PACIFIC
Division of Colloid and Molecular Assembly
Polymer Society of Korea

Welcome

The Organizing Committee cordially invites you to participate in the 2019 Colloid and Interface Symposium to be held on June 13 ~ June 14, 2019, at the University of Hong Kong (HKU), Hong Kong, China. The main objectives of the symposium are to share the latest research results, to exchange ideas and to boost the cooperative relations among colloids, interfaces and related fields. The scope of the symposium will cover all aspects of colloidal researches on synthesis, characterization, assembly, active colloids, nano-processing and device applications.

Organizing Committee

Prof. Anderson Shum

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Symposium Topics

New Frontiers in Colloid and Interface Science

Colloids are small enough that thermal energy drives their dynamics and ensures equilibration with the suspending fluid; they are also large enough that their positions and motions can be measured precisely using optical methods, such as light scattering and laser-scanning confocal fluorescence microscopy. Colloidal particles with controlled internal architectures have attracted recent interest because of their promising properties for drug delivery, molecular imaging and self-assembly. Many interesting phenomena, such as surface plasmon coupling, exciton coupling, plasmon-exciton interactions and magnetic coupling, originate from the colloidal particles assembly, in which particles organize in purposeful ways and interact with one another. A variety of interesting and efficient particle strategies have been investigated spanning from polymeric, organic, to inorganic and metallic materials.

Previous COINS events

COINS 2018 Sungkyukwan University, Suwon, Korea

COINS 2017 Sungkyukwan University, Suwon, Korea

Venue

Lecture Theatre A
Chow Yei Ching Building
The University of Hong Kong
Pokfulam Road
Hong Kong





Symposium Schedule

June 13th (Thursday): Registration and Symposium Day 1

June 14th (Friday): Symposium Day 2 and Closing remark

Registration

On-site registration free of charge.

Symposium Programs [June 13-14, 2019]

June 13 (Thursday)

9:00 - 9:20	Registration
9:20 - 9:30	Welcome address

Session I. (Chair: Anderson Shum)

9:30 - 10:00	David Pine	[A-1] Probing local heterogeneous glassy dynamics at the microscale
10:00 - 10:30	Ping Sheng	[A-2] Non-Stokes drag in single particle electrophoresis: New insights on a classic problem
10:30 - 11:00	Stefano Sacanna	[A-3] Mix-and-Melt Colloidal Engineering
11:00 - 11:30	Yilong Han	[A-4] Surface wetting and premelting of colloidal crystals
12:00 - 13:30	Lunch	

Session II. (Chair: Yufeng Wang)

13:30 - 14:00	Vinothan Manoharan	[B-1] Watching RNA viruses self-assemble
14:00 - 14:30	Jinyao Tang	[B-2] Light powered microswimmer- optical manipulation from multiple dimensions
14:30 - 15:00	Alfonso Ngan	[B-3] Nano-Chemomechanics at Play - Novel Nickel-Hydroxide Thin-Film Actuating Materials for Micro-Robotics Applications
15:00 - 15:30	Shin-Hyun Kim	[B-4] Photonic Capsule Sensors for In-Situ Monitoring of Microenvironment
15:30 - 16:30	Coffee Break & Poster Session	

Session III. (Chair: Etienne Ducrot)

16:30 - 17:00	Qian Chen	[C-1] Crystallization pathways at the nanoscale
17:00 - 17:30	Pil J. Yoo	[C-2] Plesiohedral Cellular Network of Graphene Bubbles for Ultralight, Strong, and Superelastic Materials
17:30 - 18:00	Dong June Ahn	[C-3] Organic Semiconductors Assembled with DNAs
18:30 - 20:00	Banquet	

June 14 (Friday)

Session IV. (Chair: Stefano Sacanna)		
9:00 - 9:30	Orlin Velev	[D-1] Microscale engineering of flexible, reconfigurable, and self-propelling particle structures driven by magnetic fields
9:30 - 10:00	Miriam Unterlass	[D-2] Fully crystalline polymers, liquid crystals, and shape-anisotropic particles from a prototypical rigid-rod polymer
10:00 - 10:30	Ho Seok Park	[D-3] Ultracapacitive Energy Storage Using 2D Nanomaterials Under Extreme Conditions
10:30 - 11:00	Coffee Break	

Session V. (Chair: Ji Tae Kim)		
11:00 - 11:30	Daeyeon Lee	[E-1] Infiltration of Polymers into Disordered Nanoparticle Packings: Polymers under Extreme Nanoconfinement
11:30 - 12:00	Govind Kaigala	[E-2] Tunable flow confinements for microscale molecular analysis on surfaces
12:00 - 13:30	Lunch	

Session VI. (Chair: Daeyeon Lee)		
13:30 - 14:00	Armin Knoll	[F-1] Nanofluidic Rocking Brownian Motors
14:00 - 14:30	Penger Tong	[F-2] Colloidal diffusion over complex potential landscapes: From passive to active particles
14:30 - 15:00	Lei Xu	[F-3] Diffusion-dominated pinch-off of ultralow surface tension fluids
15:00 - 15:30	Gi-Ra Yi	[F-4] Angle-independent structural colors from colloidal glasses
15:30 - 16:30	Coffee Break & Poster session	

Session VII. (Chair: Gi-Ra Yi)		
16:30 - 17:00	Jin Woong Kim	[G-1] Smart Nanoemulsion Films via Controlled Spinodal Decomposition
17:00 - 17:30	Etienne Ducrot	[G-2] Light controlled crystallization of DNA coated particles
17:30 - 18:00	Jeremie Palacci	[G-3] Carving non-equilibrium pathways to control self-assembly
18:30 - 20:00	Dinner	

[Invited Talks]

[A-1] Probing local heterogeneous glassy dynamics at the microscale

David Pine

Department of Physics, New York University, New York, NY, the USA

Department of Chemical & Biological Engineering, New York University, Brooklyn, NY, USA

Abstract

Colloidal suspensions have received wide interest as a model system to study the glassy dynamics of amorphous systems. They are valued as model systems because of their simplicity and because of the relatively large size of the particles, which allows access to the microscopic dynamics at an individual particle level.

However, there are problems with colloidal systems that have been used to study colloidal glasses, including gradual particle charging and swelling, which can result in problematic dynamics, as well as difficulties in synthesizing and maintaining a robust stabilization coating. We introduce a new system based on crosslinked 3-(trimethoxysilyl) propyl methacrylate (TPM) colloidal particles that is stable, easy to handle, and simple to synthesize. The dynamical properties of the suspension are characterized and the structural relaxation in the glassy regime is studied by dynamic light scattering.

We also describe a new method to characterize the local glassy dynamics by measuring the rotational diffusion of elliptical tracer particles. Using tracers of various aspect ratios as passive micro-probes, the response of the microstructure to different strains can be measured. A new and unique design of the tracers enhances their optical anisotropy, which enables us to follow the 3-dimensional rotation of probes with small geometric aspect ratio. As the volume fraction of the glassy suspension increases over some volume fraction, the rotational diffusion of the ellipsoids slows down dramatically and becomes more heterogeneous. The rise of the heterogeneous dynamics is found to be related to rotational cage breaking, which reflects the dynamical heterogeneity in microscale of glassy materials.

[A-2] Non-Stokes drag in single particle electrophoresis: New insights on a classic problem *

Ping Sheng

Department of Physics, HKUST, Clear Water Bay, Kowloon, Hong Kong

Abstract

When immersed in an electrolyte solution, a charged colloidal particle would be enveloped in an ionic cloud of screening counter-ions, denoted the Debye layer. Application of an external electric field to a suspension of such charged particles can result in the steady motion of the solid particulates. The physical picture underlying this phenomenon, known as the electrophoresis effect, can be dated back to Smoluchowski in which the crucial element is the electroosmotic fluid flow in the Debye layer. Through clever mathematical manipulations, Smoluchowski has shown rigorously that the electrophoretic mobility of the charged particle, μ_E , is directly proportional to the zeta potential ζ (which is directly related to the surface charge density) on the surface of the solid particle, i.e., $v_\infty = \mu_E E_\infty$, where E_∞ is the applied electric field, v_∞ is the electrophoretic velocity, and $\mu_E = -(\varepsilon / \eta)\zeta$, with η , ε being the solution viscosity and dielectric constant, respectively. The Smoluchowski relation is accurate in the limit of $a \gg \lambda_D$, where λ_D is the Debye length and a the particle radius. In spite of this success one century ago, there has been little progress on either the experimental measurement or the theoretical derivation of the drag coefficient γ_E associated with the electrophoresis phenomenon, defined as $F = \gamma_E v_\infty$, where F is the drag force. In this talk, I report on both the theory and the experimental results on the electrophoretic drag coefficient. By numerically solving the Poisson-Nernst-Planck equations coupled with the Navier-Stokes equation, we find the flow field to be divided into two regions. The outer flow field reproduces well the Smoluchowski flow field in the asymptotic limit, whereas the inner flow field region is governed by highly nonlinear partial differential equations, owing to the strong local electric field arising from the net charges in the Debye layer. The two flow regions are sharply separated by a slip surface; and the drag coefficient calculated on the slip surface agrees very well with the experimentally measured result. The electrophoretic drag coefficient is generally larger than the Stokes drag coefficient γ_S , with the peak ratio $\gamma_E / \gamma_S > 2$. The slip surface is generally at a distance of several Debye lengths from the liquid-solid interface. These results and their related physical picture represent a new discovery on a classical phenomenon.

*Work done in collaboration with *Maijia Liao, Ming-Tzo Wei, Shixin Xu, and H. Daniel Ou-Yang*

[A-3] Mix-and-Melt Colloidal Engineering

Stefano Sacanna

Department of Chemistry, New York University, New York, NY, USA

Abstract

Traditionally, a chemist's task has been to characterize and manipulate atomic and molecular building blocks. On the micron scale, however, we have the opportunity to design altogether new, colloidal, building blocks from the bottom up. This vast synthetic freedom translates into a world of assembly possibilities because while there are a set few atomic units, the colloidal periodic table is seemingly infinite. An enormous research effort is currently taking place to develop heuristics for generating three-dimensional architecture from "soups" of intelligently designed colloids so that future materials can be imbued with intricate microscale detail.

In this talk, I will present new methods for shaping, programming, and assembling matter at the nano- and micron-scale. A particular emphasis will be given to colloidal fluids of patchy, shape-changing, and active particles.

[A-4] Surface wetting and premelting of colloidal crystals

Yilong Han

Department of Physics, Hong Kong University of Science and Technology, Hong Kong

Abstract

Crystal surfaces typically premelt into a thin liquid layer slightly below the melting point. Here, we employed colloidal spheres with tunable attractions to form equilibrium crystal-vapor interfaces and studied their surface premelting using video microscopy. Monolayer crystals underwent a bulk isostructural solid-solid transition that triggered the surface premelting. The premelting was incomplete because of the interruption of a mechanical-instability-induced homogeneous bulk melting, even under the presence of free surfaces. By contrast, multi-layer crystals exhibit complete premelting with divergent surface-liquid thickness. We further observed a novel phenomenon that the surface of a triangular lattice can develop a wetting layer of square lattice instead of a premelted wetting layer of liquid. These interplays between surface and bulk transitions cast new light to both of them.

[B-1] Watching RNA viruses self-assemble

Vinothan Manoharan

Harvard John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, USA

Abstract

Nearly 60 years ago, Caspar and Klug coined the term "self-assembly" to describe the formation of a virus from its constituent parts (Cold Spring Harbor Symposia on Quantitative Biology 1962). But we still don't understand how this process occurs even in the simplest viruses, positive-sense RNA viruses. Such viruses consists of proteins that form a highly-ordered protective shell (called a capsid) around the viral RNA. Viral particles can self-assemble spontaneously in a mixture of RNA and coat protein in a buffer, in the absence of any host factors. The yield and fidelity of the assembly is particularly remarkable in viruses with a triangulation number of 3 or higher, in which case some of the proteins must find their way to 5-fold coordinated sites and others to 6-fold coordinated sites on the same shell. To understand how such systems assemble, we have developed an interferometric technique that allows us to measure the scattering of individual assembling viral particles (MS2 bacteriophage) on time scales ranging from 1 ms to 1000 s. By comparing the scattered intensity to that of the wild-type virus, we infer the mass of proteins that have attached to the central RNA as a function of time. We find that individual particles grow to nearly full size in a short time following a much longer delay period. The distribution of delay times suggests that the assembly follows a nucleation-and-growth pathway. I will discuss how such a pathway might allow the virus to assemble so robustly -- and what we might learn about colloidal self-assembly from such systems.

[B-2] Light powered microswimmer-optical manipulation from multiple dimensions

Jinyao Tang

Department of Chemistry, The University of Hong Kong, Pokfulam, Hong Kong, China

Abstract

It has attracted much interest to design a self-powered artificial nanorobotic system which mimics the behavior of the motile bacteria due to both scientific merits as well as its potential applications. Previously, it has been demonstrated that the asymmetric chemical reaction on microparticle surface can induce surface flow which provide the necessary propulsion for nano/microswimmers. One goal for the development of these microswimmers is the biological and biomedical applications such as the targeted drug delivery and non-invasive surgery. In order to achieve this, several key scientific challenges have to be overcome including highly versatile controllability and high biocompatibility which enables a programmable and controllable migration of microswimmers in in-vivo environment.

Recently, new approach of harness the energy from absorbed photons by photoelectrochemical (PEC) reaction for directed self-propulsion in microswimmer system has been proposed and shows several advantages. In this approach, light not only provide energy for migration but also can be used as a control signal for microswimmer manipulation. As a versatile external stimulus, light offers more flexibilities than other existing method, such as different frequencies of light can be applied spontaneously which enables multi-channel controllability over the microswimmers.

In this presentation, we will discuss several new approaches towards the better controllability and better biocompatibility for artificial microswimmers. Particularly, we will discuss about how to engineer the light spectral response of artificial microswimmers for multi-channel controllability and how to prepare artificial microswimmer system which can adapt to intercellular environment.

[B-3] Nano-Chemomechanics at Play - Novel Nickel-Hydroxide Thin-Film Actuating Materials for Micro-Robotics Applications

Alfonso Ngan^{*}, Runni Wu

Department of Mechanical Engineering, University of Hong Kong, Hong Kong

Abstract

In this talk, we report a novel actuating material – nickel hydroxide-oxyhydroxide – that exhibits enormous actuation due to a volume change stimulated either electrochemically, or by illumination of visible light of low intensities. For electrochemical actuation, Ni(OH)₂/NiOOH is capable of undergoing fast, reversible, and large actuation in alkaline electrolytes under potentials of less than 1 V, due to a redox reaction involving volume changes. On the other hand, the light actuation of Ni(OH)₂/NiOOH is due to its turbostratic crystal structure which is capable of intercalating water molecules. It is shown that the intercalated water can be rapidly and reversibly desorbed into the environment under visible light of intensities lower than 1 sun, resulting in fast actuation driven wirelessly by light.

By electroplating the actuating material on passive substrates, we have fabricated film-actuators capable of undergoing reversible bending and curling with an intrinsic actuating stress of tens of megapascals at response rates in the order of tens to hundreds of degrees per second, which are comparable to mammalian skeletal muscles. Also, by intentionally electroplating the nickel hydroxide-oxyhydroxide on selected areas of the substrate, we have also fabricated actuation devices of various shapes and functions, e.g. a hinged actuator that can lift objects ~100 times of the weight of the actuating material is achieved, and other examples showing the potential use in robotic devices. The light-induced actuation mechanism reported here has the potential for realizing wirelessly powered micro-robotic devices.

[B-4] Photonic Capsule Sensors for In-Situ Monitoring of Microenvironment

Shin-Hyun Kim

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Abstract

Sensor technology based on electronic circuits has led the current IoT world. However, the conventional sensor platform is inadequate for analysis of microenvironment. Here, we design photonic-crystal-laden microcapsules to make a new sensor platform. The microcapsules are produced to have a hollow core and solid shell using w/o/w double-emulsion drops as a template. In the core, stimuli-responsive colloids are assembled to have hexagonal close-packed (hcp) lattice through depletion attraction. In the close-packed array, the volume change of individual colloids fully influences the change of lattice constant, leading to a wide stopband shift. The fragile colloidal crystals in the core are completely isolated from surrounding by a solid shell, providing high stability against external mechanical stress. The photonic capsule sensors are injectable, suspendable, and implantable, which renders them promising for in-situ monitoring of microenvironment condition and its distribution

Reference

- [1] Tae Min Choi, Kwanghwi Je, Jin-Gyu Park, Gun Ho Lee, and Shin-Hyun Kim, "Photonic Capsule Sensors with Built-in Colloidal Crystallites", *Advanced Materials*, 30, 1803387 (2018).
- [2] Jin-Gyu Park, W. Benjamin Rogers, Sofia Magkiriadou, Tom Kodger, Shin-Hyun Kim, Young-Seok Kim, and Vinothan Manoharan, "Photonic-Crystal Hydrogels with a Rapidly Tunable Stop Band and High Reflectivity across the Visible", *Optical Express Materials*, 7, 253-263 (2017).

[C-1] Crystallization pathways at the nanoscale

Qian Chen

*Department of Materials Science and Engineering, Department of Chemistry,
Materials Research Laboratory, University of Illinois, Urbana, Illinois, USA*

Abstract

I will discuss my group's recent work using liquid-phase TEM to directly image the otherwise elusive crystallization pathways of nanosized colloids into superlattices. There are similarities to micron-sized colloids, such as a non-classical two-step crystallization pathway with amorphous intermediates, and a quantitative agreement of interfacial fluctuation with capillary wave theory. But there are also differences, in particular a potentially universal layer-by-layer growth mode that we observe for the first time and repeatedly in nano-sized colloids of different shapes (e.g., nanospheres, nanorods, nanocubes). The layer-by-layer growth has been the hallmark of atomic crystallization but barely observed in micron-sized colloids. Single particle tracking, statistical mechanics based analysis and simulations together unravel the crucial energetic and kinetic details which render this crystal growth mode possible and even universal at the unexplored nanoscale.

[C-2] Plesiohedral Cellular Network of Graphene Bubbles for Ultralight, Strong, and Superelastic Materials

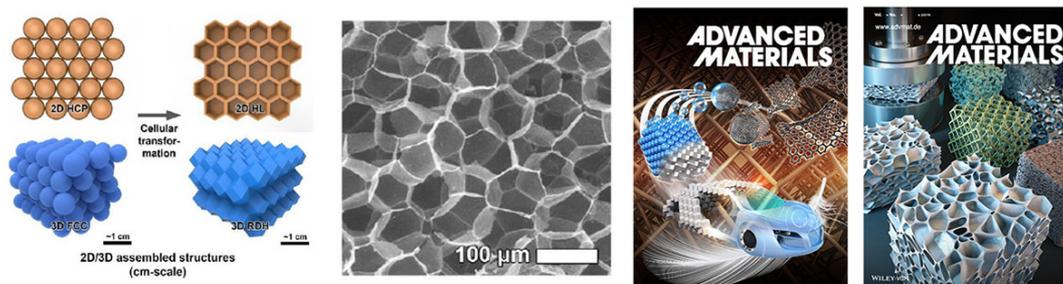
Pil Jin YOO

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Abstract

Advanced materials with low density and high strength have transformative impacts in construction, aerospace and automobile industries. These materials are realized with integrating well-designed modular building units into interconnected structures. Here, we present a hierarchical design strategy to demonstrate a new class of carbon-based closed-cellular structures (CCS). The building units are prepared by a multi-scale approach starting from functionalized graphene oxide nanosheets, leading to the microfluidic synthesis of solid-shelled bubbles with shape diversity at the micro-scale, followed by the assembly into meso-scale 3D structures. Subsequently, these are transformed into self-interconnected and structurally-reinforced CCS, resulting in graphene lattices with rhombic dodecahedral honeycomb structures at the centimeter-scale. The 3D suprastructure simultaneously exhibits the Young's modulus above 300 kPa while retaining a light density of 7.7 mg/cm^3 and the elasticity against up to 80% of the compressive strain. The fabricated 3D CCS opens a new pathway for designing lightweight, strong, and superelastic materials.



<Figure> Formation of complete-space-filling 3D structures using micro-solid bubble assembly

Reference

1. S. J. Yeo, M. J. Oh, and P. J. Yoo* et al., "Plesiohedral Cellular Network of Graphene Bubbles for Ultralight, Strong, and Superelastic Materials", *Advanced Materials*, 30, 1802997, 2018.
2. S. J. Yeo, M. J. Oh and P. J. Yoo*, "Structurally Controlled Cellular Architectures for High Performance Ultra-Lightweight Materials", *Advanced Materials*, 1803670, 2018.

[C-3] Organic Semiconductors Assembled with DNAs

Dong June AHN

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Abstract

Organic small molecules and macromolecules having π -moieties have been extensively investigated since they express attractive optical and electrical functions that offer rosy pictures in applications of modern electronics and energy-related devices. Nature, in the meantime, works with abundant biomolecules such as DNAs, RNAs, proteins, etc. making themselves distinct from other materials in a sense that they can recognize through specific bindings to target species. Therefore, as we attempt successful conjugation of such biomolecules with functional π -molecules and/or macromolecules, new fields of applications face us especially in technology convergent realms related to medicine and biology. There have been various research outcomes by eminent scientists and engineers contributing to this goal. We have investigated conjugated chemicals-based sensing materials [1] and bio-functionalized OLED particles [2]. In the present talk, we will introduce our recent efforts in advancing organic semiconductor micro- and nanoparticles to deliver bio-functional interfaces by means of nucleic acids.

Reference

- [1] Ahn et al., J. Am. Chem. Soc. (2003, 2005), Small (2016, 2018), Macromolecules (2017, 2017), Nat. Commun. (2018), Nanoscale (2019).
[2] Ahn et al., Nat. Commun. (2016), Nanoscale (2018), and unpublished results.

[D-1] Microscale engineering of flexible, reconfigurable, and self-propelling particle structures driven by magnetic fields

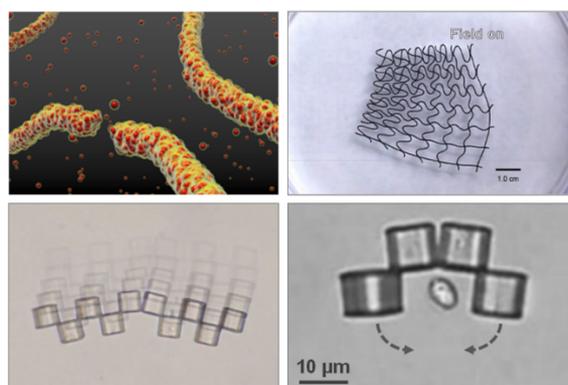
Orlin D. Velev

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Abstract

We will discuss advances in the microscale engineering of novel classes of flexible and dynamically reconfigurable assemblies from colloidal particles. Examples of such assemblies include magnetically reconfigurable gel networks, shape-changing microbots, and inks for 3D printing. The key to making such structures is the engineering of directional interactions and of flexible inter-particle bonds. In the first part of the talk, we will discuss how complex magnetic polarization patterns on metallo-dielectric microcubes lead to multidirectional interactions and assembly of reconfigurable microclusters. These sequence-encoded clusters can be reversibly actuated and spatially transported by magnetic fields and can be designed to be self-motile in non-Newtonian media. In the second part of the talk we will describe new types of multiphasic capillary gels from particles bound by liquid bridges. The first gel system is made of filaments from magnetically responsive iron oxide nanoparticles suspended in water-oil systems. The nanocapillary binding results in ultra-high filament flexibility. The second multiphasic system that we introduced is a new class of 3D printing inks consisting of PDMS microbeads, liquid PDMS and water. Owing to the capillary binding, such Homocomposite Thixotropic Pastes (HTPs) can be extruded and shaped on a 3D printer. The curing of the liquid bridges in the HTPs results in remarkably elastic and flexible porous silicone material. The HTP 3D printing method makes possible the fabrication of soft architectures that reconfigure in magnetic fields and could find a broad range of applications, such as making of 2D auxetic materials, soft actuators, and microtools for interfacial studies.



[D-2] Fully crystalline polymers, liquid crystals, and shape-anisotropic particles from a prototypical rigid-rod polymer

Miriam M. Unterlass^{1,2,3,*}

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²*Technische Universität Wien, Institute of Applied Synthetic Chemistry, TU Wien, Vienna, 1060, Austria*

³*CeMM- Research Center for Molecular Medicine of the Austrian Academy of Sciences, Vienna, 1090, Austria*

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Abstract

Rigid-rod polymers are macromolecules that comprise entirely stiff polymer backbones. The most prototypical rigid-rod polymer is poly(*p*-phenylene pyromellitimide), PPPI, which is composed of exclusively benzene rings and 5-membered imide rings. This backbone is most intriguing from a fundamental point of view: PPPI is so rigid that it imparts most striking physicochemical properties: its Young's modulus (in chain direction) is predicted to be 500 GPa (which is in the range of pure metals), and its glass transition temperature (T_g) and melting temperature (T_m) are predicted to be at 700 °C and 1030 °C, respectively.^[1,2] However, PPPI's T_g and T_m could never be measured as it decomposes prior to reaching these temperatures, and likewise its E-modulus along the chain axis was never experimentally determined, as PPPI – lacking any softening or solubility – could to this day not be processed into fibers, or even intact films.

With this contribution, I show how we can transform PPPI in different types of materials using non-classical synthesis, and give an outlook on how these materials can be transferred to actual applications. First, using geomimetic polymerizations, i.e. procedures that mimic natural mineral formation, we can generate fully crystalline PPPI of tunable morphologies.^[3,4] Second, employing solid-state polymerization (SSP) of monomer single crystal, shape-anisotropic particles can be generated.^[5] Third, through molecular design and again using SSP variants thermotropic liquid-crystalline PPPI derivatives can be generated.

References

- [1] K. Tashiro, *Prog. Polym. Sci.* **1993**, *18*, 377–435.
- [2] R. Giesa, U. Keller, P. Eiselt, & H.-W. Schmidt, *J. Polym. Sci. Part A: Polym. Chem.* **1993**, *31(1)*, 141–151.
- [3] B. Baumgartner, M. J. Bojdys, & M. M. Unterlass, *Polym. Chem.* **2014**, *5*, 3771–3776.
- [4] M. J. Taublaender, M. Reiter & M. M. Unterlass, *Macromol. Chem. Phys.* **2018**, *219*, 1700397–170407.
- [5] K. Kriechbaum, D. A. Cerrón-Infantes, B. Stöger & M. M. Unterlass, *Macromolecules* **2015**, *48*, 8773–8780.

[D-3] Ultracapacitive Energy Storage Using 2D Nanomaterials Under Extreme Conditions

Ho Seok Park*

School of Chemical Engineering, Samsung Advanced Institute for Health Science & Technology (SAIHST) & SKKU Advanced Institute of Nano Technology (SAINT), Sungkyunkwan University (SKKU), Suwon 440-746, Republic of Korea

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Abstract

With increasing demand for high performance energy storage devices, the feasibility of reliable and functional energy storage devices that well operates under extreme conditions is of prime importance for expanding applicative fields as well as for understanding materials' intrinsic and extrinsic properties and device physics.¹⁻⁴ In this talk, I will introduce the control in the physical structure and chemical composition of 2D nanomaterials for ultracapacitive energy storage devices under limited circumstances, where conditions are classified into thermodynamic (e.g. pressure, volume and temperature) and kinetic (e.g. high rate and frequency) variables.¹⁻¹⁰ In addition, a fundamental foundation via in-situ spectroscopic techniques will be presented to understand charge storage phenomenon of new materials and devices occurring on a nanoscale under various circumstances.⁸⁻¹⁰

Reference

- [1] Ho Seok Park*, et al. *Adv. Energy Mater.*, 2015, 1500959. Cover
- [2] Ho Seok Park*, et al. *ACS Nano.*, 2015, 9, 8569-8577.
- [3] Ho Seok Park*, et al. *Adv. Funct. Mater.*, 2015, 25, 1053-1062. Cover
- [4] Ho Seok Park*, et al. *ACS Nano*, 2011, 5, 5167-5174.
- [5] Ho Seok Park*, et al. *Nano Lett.*, 2015, 15 (4), 2269-2277.
- [6] Ho Seok Park*, et al. *Adv. Energy Mater.*, 2016, 6, 1501115. Cover
- [7] Ho Seok Park*, et al. *Adv. Energy Mater.*, 2018, 8, 1702930.
- [8] Ho Seok Park*, et al. *ACS Energy Lett.*, 2018, 3, 724.
- [9] Ho Seok Park*, et al. *Joule*, 2019, 3, 1-13. Cover
- [10] Ho Seok Park*, et al. *Nat. Mater.*, 2019, 18, 156-162.

[E-1] Infiltration of Polymers into Disordered Nanoparticle Packings: Polymers under Extreme Nanoconfinement

Daeyeon Lee

Department of Chemical and Biomolecular Engineering, University of Pennsylvania

Abstract

Capillary rise infiltration (CaRI) is a new method of fabricating polymer nanocomposites with extremely high fractions of nanoparticles (> 50 vol%). In CaRI, highly filled composites are formed by thermally annealing a bilayer of polymer and nanoparticle, which induces imbibition of polymer into the interstices of the nanoparticle packing. The chain dimension of the polymer, which depends on its molecular weight, can be comparable to or greater than the average pore size of the nanoparticle packing; thus this system provides a powerful platform to study the effects of extreme nanoconfinement on the transport and thermomechanical properties of polymers. I will share our current understanding of the transport phenomena and glass transition of polymers under such nanoconfinement using a combination of experimental and computational approaches.

[E-2] Tunable flow confinements for microscale molecular analysis on surfaces

Dr. Govind V. Kaigala

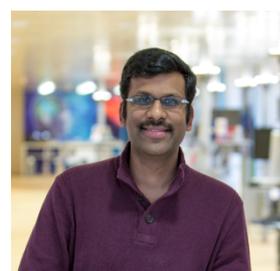
IBM Research Laboratory – Zurich, Switzerland

Abstract

Traditionally, compartments are formed with hydrogels, multi-phase systems (droplets), or inkjets. In contrast, we are developing ‘flow confinements’ which comprise compartments formed on a surface by the flow of a shaping liquid around a processing liquid. We termed these implementations collectively as tunable flow confinements (TFC). In contrast to standard microfluidics, which are typically closed, we are developing scanning, non-contact microfluidic technology that can shape liquids in the "open space" over surfaces. TFCs are implemented using a liquid scanning probe called the microfluidic probe and function on standard biological substrates such as Petri dishes, slides, and tissue sections when the substrate is kept wet. In this talk, I will show how this family of liquid scanning probe devices is evolving as a versatile bioanalytical tool to alter the physics and chemistry of biological interfaces at the micrometer to centimeter-length scales. I will also propose concepts pertaining to tissue microprocessing encompassing local phenotyping and molecular profiling, which may contribute to the multi-modal analysis of critical biopsy samples.

Biography

Dr. Govind Kaigala is a Research Staff Member at the Laboratory of IBM in Zurich. He is currently leading activities on liquid-based non-contact scanning probe technologies – microfluidic probe – and is championing concepts on “open space” microfluidics and “tissue microprocessing”. These research activities are driven by specific needs in the fields of pathology and personalized medicine. He is passionate about translational clinical/medical research and strives to bring in quantitation in biology.



Previously, he was an NSERC postdoctoral fellow at the microfluidics laboratory in Mechanical Engineering and Urology at Stanford University, USA. Dr. Kaigala received his Ph.D (Electrical Engineering and Oncology) and M.Eng from the University of Alberta, Canada. Dr. Kaigala has authored and co-authored 53 scientific publications, 90 conference papers/abstracts, 1 book, and 35 patent families. In addition to IBM and other industrial entities, his work is supported by the European Research Council (ERC), the European Union and Swiss National Science Foundation. He is the recipient of several IBM recognitions, Research Division Accomplishment Award in 2014 & 2017, named as IBM “master inventor” in 2018, the Horizon Alumni Award from the University of Alberta, and he is a Senior Member of IEEE.

[F-1] Nanofluidic Rocking Brownian Motors

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Abstract

Mimicking molecular motors known from biology, rocked Brownian motors are artificial Brownian motors that use an asymmetric potential landscape and a zero mean external force to transport particles in a programmed direction without net fluid flow. Already in the theoretical description of the 90s it was shown that the transport exhibits an Arrhenius type onset as a function of the particle size, an ideal prerequisite for particle separation [1, 2].

We implemented a first nanofluidic version of such a motor for nanoparticles [3]. The asymmetric potential landscape is induced by patterning one of the confining walls of the nanochannel with a 3D topography that modulates the gap distance locally. Particles in tighter confinement experience an exponentially increased free energy due to the electrostatic repulsion of the like charged particles and walls. The device is operated by applying a square wave voltage of less than 5 V, resulting in transport speeds of up to 50 microns/s for 60 nm gold nano spheres. Using interferometric scattering detection, we observe the particle motion with up to 4000 frames per second. Therefore, we have access to the particle distribution probability with 10 nm resolution and were able to elucidate the origin of a current reversal at high frequencies [4]. All relevant parameters of the system can be measured in-situ, allowing for a direct and fit-parameter free comparison with theory.

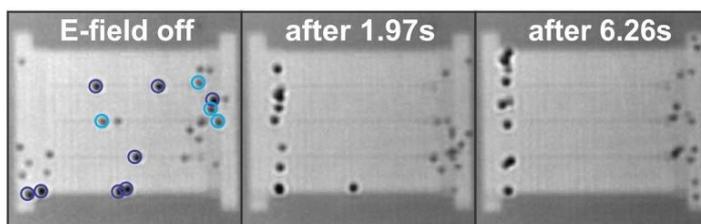


Figure 1. Optical images of the sorting process in a Brownian motor device. 60 and 100 nm diameter gold spheres are separated in a few seconds to opposite borders of the device. The device is $\sim 10 \mu\text{m}$ wide.

By combining two motors pointing in opposite directions with one of them being more selective for bigger particles, we could demonstrate complete separation of 60 and 100 nm gold spheres within seconds in a very small footprint device of only $10 \times 10 \mu\text{m}^2$, see Fig. 1. Modelling

revealed that separation of particles with merely 1 nm radial difference is possible at similar speeds. Naturally, several devices may be stacked into a continuous operation, multi-channel separation device. Moreover, the method is predicted to work with smaller particles, vesicles, or biomolecules. Transport occurs without net fluid flow, which opens up additional possibilities for concentration and detection of ultra-dilute particle populations.

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[F-2] Colloidal diffusion over complex potential landscapes: From passive to active particles

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Abstract

Energy landscape is an important concept in science, which has been widely used in many areas of physics, chemistry, biology and materials science. For many practical applications, however, one often encounters complex energy landscapes. There are few experimental systems in which one can actually visualize the energy landscape, and thus much of the work done so far is through computer simulations. A physical model system, in which one can directly measure the energy landscape and track individual particle trajectories, would be extremely valuable in testing different theoretical ideas. In this talk we will present our recent efforts in developing a two-layer colloidal system to study colloidal transport and dynamics over complex potential landscapes [1-4]. This work opens up a whole new realm of investigation at the single-particle level for a range of interesting problems associated with the diffusive and forced barrier-crossing dynamics over complex energy landscapes. Examples of applications of this system will be discussed.

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This work was done in collaboration with Yun Su, Xiao-Guang Ma, Wei He, Pik-Yin Lai, Bruce J. Ackerson, Yilong Han, and was supported by the Research Grants Council of Hong Kong SAR.

[F-3] Diffusion-dominated pinch-off of ultralow surface tension fluids

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Abstract

We study the breakup of a liquid thread inside another liquid at different surface tensions. In general, the pinch-off of a liquid thread is governed by the dynamics of fluid flow. However, when the interfacial tension is ultralow (2 to 3 orders lower than normal liquids), we find that the pinch-off dynamics can be governed by bulk diffusion. By studying the velocity and the profile of the pinch-off, we explain why the diffusion-dominated pinch-off takes over the conventional breakup at ultralow surface tensions.

[F-4] Angle-independent structural colors from colloidal glasses

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Abstract

Colloidal glasses of monodisperse particles may show the angle-independent structural color of which wavelength corresponds to the average distance between particles. Multiple scattering which may arise in disordered materials can be suppressed by adding a small fraction of broadband absorber such as carbon black. A major fabrication challenge is producing colloidal glasses with an angle-independent structural red color. Theoretical work has shown that such a color can be produced by fabricating inverse photonic glasses with monodisperse, nontouching voids in a silica matrix. Here, we demonstrate a route toward such materials and show that they have an angle-independent red color. We first synthesize monodisperse hollow silica particles with precisely controlled shell thickness and then make glassy colloidal structures by mixing two types of hollow particles with the same core size and different shell thicknesses. We then infiltrate the interstices with index-matched polymers, producing disordered porous materials with uniform, nontouching air voids. This procedure allows us to control the light-scattering form factor and structure factor of these porous materials independently, which is not possible to do in photonic glasses consisting of packed solid particles. The structure factor can be controlled by the shell thickness, which sets the distance between pores, whereas the pore size determines the peak wave vector of the form factor, which can be set below the visible range to keep the main structural color pure. By using a binary mixture of 246 and 268 nm hollow silica particles with 180 nm cores in an index-matched polymer matrix, we achieve the angle-independent red color that can be tuned by controlling the shell thickness. Importantly, the width of the reflection peak can be kept constant, even for larger interparticle distances.

Reference

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[G-1] Smart Nanoemulsion Films *via* Controlled Spinodal Decomposition

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Abstract

We report a new spinodal decomposition-based smart film system. For this, we fabricated nanoemulsion films (NEFs) by alternate layering of nanoscale emulsion drops with polyelectrolytes through the layer-by-layer deposition. The NEFs exhibited an extraordinary spinodal decomposition behavior. When heat is applied to the NEFs, the nanoemulsion drops uniformly immobilized in the polyelectrolyte film network readily inter-diffused to form oil domains in the micrometer scale. Taking advantage of this, we showed that the NEF system could provide an efficient route not only for development of a patch-type drug delivery system, but also for the fabrication of a temperature-responsive smart adhesive film.

Keywords: spinodal decomposition, nanoemulsion films, drug delivery, smart adhesive

[G-2] Light controlled crystallization of DNA coated particles

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Abstract

DNA coatings have been proposed and successfully applied as a versatile tool for programming the self-assembly of micrometer size particles. Recent developments have led to the assembly of a large variety of materials into numerous crystalline structures. The DNA-mediated interaction is highly temperature dependent, for given buffer conditions, a set of complementary DNA-coated particles present a melting temperature T_{melt} that marks the transition between aggregated and melted states. Without a change of environment, one has no further control over T_{melt} and a local control of the interaction is challenging.

Here we present a strategy that uses the combination of DNA coatings and an azobenzene photo-switch to access fine control of the interaction between particles, independently from temperature. Azobenzenes reversibly switch between *trans* and *cis* conformations, an exposure to UV or blue light shifts the population towards the *cis* or *trans* respectively. Once attached to the backbone of a DNA sticky-end, the flat *trans* form can intercalate in the double helix and stabilize the duplex. On the contrary the kinked *cis* azobenzene disrupts the hybridization. We harvest this molecular behavior to modulate the melting temperature of DNA-coated particles, pattern their melting or aggregation, correct defects on the crystals and switch between crystal structures.

[G-3] Carving non-equilibrium pathways to control self-assembly

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Abstract

"Active particles are microscopic particles, which can inject energy locally and made available by recent progress in colloidal science. They are ideal "pump-probes" to explore the emergent properties in non-equilibrium soft systems and control the behavior of soft matter and self-assembly at the microscale.

In this talk, I will demonstrate how we can use dissipative building blocks to control self-assembly and show the robust formation of dynamical superstructures using active particles that consume fuel to carve non-equilibrium pathways. Using tailored particles, we will build self-spinning microgears and demonstrate that non-equilibrium phenomena can be harnessed to shape interactions and form hierarchical structures ^[1]. Next, I will show how we can active particles added to a material to regulates its activity internally and boost the annealing of a colloidal monolayer ^[2]. It opens a broad range of novel opportunities to thermal treatments, where the properties of matter are not controlled macroscopically but microscopically and in real time by active dopants.

Reference

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[Posters]

P-01

Polarized 2D Conjugated Polymer Nanosheets Responding to Strain Orientations

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Abstract

There are fascinating interface phenomena and applications in designing and manufacturing of two-dimensional (2D) geometries in the scientific and engineering fields. Substances created of 2D structure show unusual properties that are different from conventional mechanical, electrical, and optical characteristics. A fabricated 2D conjugated polymer nanosheets (NSs) in this study have a special feature which is optical polarizability using organic compound of diacetylenes. These 2D-NSs of polymerized phase show colorimetric transition from blue to red and fluorescent expression characterization. We demonstrate that the 2D polymer nanosheets respond distinctive to the orientation of mechanical strain.

P-02

FRET-Nanomaterials for One-Step Sensing of Cellular Cholesterol

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Abstract

Cholesterol is an important component of animal cell membranes and the main precursor for synthesis of different biomolecules such as bile acids, steroid hormones and vitamin D. Various analytical methods have been developed for cholesterol detection in serum, but it's not in real cell membrane. Thus, development of sensing method for detection of cholesterol in cell membrane is highly desirable. Turn-on sensing mechanism based on FRET(Energy transfer between two light-sensitive molecules) is suitable for targeting a low concentration of cholesterol in cell membrane because of its high sensitivity. We developed one-step fluorescence turn-on sensing materials with combination of commonly used nanomaterials (AuNPs, Au Nanocube, GO) and chem-bio ligand interfacing. It can be observable to detection of cholesterol in cell membrane.

P-03

Biomolecular Binding Dynamics on CdSe Nanoparticles Moving in Flow Fields

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Abstract

Protein immunohistochemistry has been widely used in medical science and technology. Integration of the probe and target biomolecules generally results from one or more non-covalent interactions: hydrophobic/hydrophilic interactions, ionic bond, positive/negative charge, aromatic π - π stacking and other van der Waals forces. Therein nonspecific binding with similar interaction performance as specific binding in protein immunohistochemistry can produce high background noises, resulting in inconclusive target elucidation that hinders interpretation. Due to nano-fabrication, a shape hybrid of CdSe with good performance was designed and used by our group as biomolecules substrates. Results showed that the magnetic field influenced interactions between biomolecules. By changing the magnetic field, we are able to control the ratio of specifically-bonded biomolecules to non-specifically-bonded biomolecules. In addition, as the non-covalent interactions can be influenced by environmental conditions, we also studied the influence of block agent (ex. BSA), temperature, pH, salt conditions and binding time. Interestingly, higher Accuracy appeared at the high magnetic field, where stronger magnetic field caused higher vortex speed of reaction solution, which means nonspecific binding can be largely replaced by specific binding due to molecular physical interactions.

P-04

“Turn-On” Detection of Human Epithelial Cell Using Aptamer/Graphene Oxide

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Abstract

Aptamers are biopolymers, self-assemble ssDNA or RNA, which can bind to specific target. As well as antigen-antibody binding, aptamer has high affinity and specificity but also stability. Therefore, aptamer has a great potential to be used in many field, biosensor/chip, medical and science, etc. In this research, we developed one-step “turn-on” detectable biosensor based on aptamer/graphene oxide that can easily detect human epithelial cell. We selected Epithelial Growth Factor Receptor (EGFR) aptamer that could bind to the EGFR protein in the cell membrane. Graphene oxide acts as a sensing platform with high fluorescence quenching efficiency and realize real-time target monitoring in living cells. By utilizing the advantages of the above material, we amplified the efficiency to detect only the target material.

P-05

DNA Functionalization of Colloidal Particles via Physisorption of Azido Amphiphilic Block Copolymers

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Abstract

DNA-coated inorganic particles can be prepared by simple physical adsorption of azide-functionalized diblock copolymers (polystyrene-*b*-poly(ethylene oxide)-azide, PS-*b*-PEO-N₃) onto hydrophobically-modified inorganic particles, followed by strain-promoted azide-alkyne cycloaddition (SPAAC, a copper-free click chemistry). This approach can be applied for organosilica, silica and titania particles, which are crystallized into colloidal superstructures under thermal annealing process by DNA-mediated assembly.

Keywords DNA self-assembly, Inorganic microspheres, block-copolymer

P-06

Solution-Processable Photonic Paints of Hollow Carbon-Silica Nanospheres

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Abstract

We make hollow carbon-silica nanospheres that exhibit angle-independent structural color with high saturation and minimal absorption. Through scattering calculations, we show that the structural color arises from Mie resonances that are tuned precisely by varying the thickness of the shells. Since the color does not depend on the spatial arrangement of the particles, the coloration is angle independent and vibrant in powders and liquid suspensions. These properties make hollow carbon-silica nanospheres ideal for applications, and we explore their potential in making flexible, angle-independent films and 3D printed films.

Keywords : Photonic glass, Hollow carbon silica, Self-assembly, Mie scattering

P-07

Dielectrophoretic behavior and separation of Janus particles

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Abstract

Dielectrophoresis (DEP) is a transport phenomenon of dielectric particles under non-uniform electric field. Based on the DEP principle, colloidal particles can be directed, concentrated, assembled, or separated by tuning the DEP parameters, including the dielectric constant and conductivity of particles and medium, and the frequency of applied AC field. DEP has been adopted in various fields, such as biosensors, microchips, and microfluidics. Janus particles are the particles with two physicochemical properties. A few interesting studies on the DEP behavior of Janus particles in terms of frequency and electric field intensity has been done; however, the separation of Janus particles from normal ones by DEP has not been well studied, yet. Here, we present the experimental result of DEP-driven transport of Janus particles. Polystyrene (PS) particles half-coated with gold was used as model Janus particles. The effect of voltage, AC frequency, types of media (water vs. NaCl solution) on the DEP behavior of normal PS particles and Janus particles is discussed. Based on the results, we demonstrate the assembly and separation of Janus particles via DEP.

P-08

Cytotoxicity of Gallium-Indium Liquid Metal in Aqueous Environment

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Abstract

Eutectic gallium–indium alloy (EGaIn) liquid metal has attracted significant attention for many applications, ranging from stretchable electronics to drug delivery, because EGaIn is highly conductive, moldable, and extremely deformable. Even though it is generally known that EGaIn liquid metal has low toxicity, the toxicity of the metal, rather than a salt form of Ga or In, has not been systematically studied yet. Here, we discuss, in an aqueous environment, the time-dependent concentration of the ions released from EGaIn liquid metal and their cytotoxicity to human cells. Without mechanical agitation, only the Ga ion is dominantly released from EGaIn. On the other hand, the concentration of the In ion drastically increases with sonication. Our cytotoxicity study reveals that all human cells tested are viable in the growth media with naturally released Ga and In ions from EGaIn, but the cytotoxicity becomes significant with sonication-induced EGaIn releasates. On the basis of the comparative study with other representative toxic elements, Hg and Cd, it could be concluded that EGaIn is relatively safe to use in an aqueous environment; however, it should be cautiously handled when it is exposed to external agitation.

P-09

Shear Stress-Responsive Biocellulose Nanofluids with Controlled Reversible Sol-Gel Transition

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Abstract

Biocellulose nanofibrils (BCNFs), the most abundant natural polymer on earth, have exceptional properties including high surface area and mechanical strength, as well as availability and biodegradability. In this study, we propose a new approach to program the rheological properties of BCNF-based smart nanofluids. For this, we conducted TEMPO-mediated oxidation in the aqueous solution. Then, we controlled aspect ratio of BCNFs through a mechanical fibrillation process. To give additional interaction-driven chain association, we utilized the host-guest interaction that enables the shear stress-dependent reversible sol-gel transition. To provide the BCNFs with reaction sites, 1-ethyl-3-(3-dimethyl aminopropyl) carbodiimide and N-hydroxysuccinimide were reacted respectively with the BCNFs. Then, the octadecylamine and carboxymethyl-cyclodextrin (each of α , β , and γ types) served as host and guest moieties were grafted onto BCNFs, respectively. We observed that the β -cyclodextrin-conjugated BCNFs exhibited most effective host-guest attraction with with the alkyl chain on the other BCNFs. The BCNF gel network displays strong viscosity enhancement as well as controlled reversible sol-gel transition in response to the applied shear stress. These results highlighted that our attractive BCNF nanofluid system is expected to enable the development of new intelligent formulations in cosmetics, food and pharmaceutical industries.

Keywords: biocellulose nanofibrils, sol-gel transition, host-guest interaction, smart nanofluids.

Polymer chain conformation-driven interdrop association of condensed attractive nanoemulsions

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Abstract

This study introduces a temperature-responsive attractive nanoemulsion (ANE) system, which is characterized by the polymer chain conformation-driven dipolar interaction across different oil droplets in an aqueous medium. For this, highly stable ANEs were produced by co-assembly of amphiphilic triblock copolymers (ATCs), poly(ethylene oxide)-*b*-poly(ϵ -caprolactone)-*b*-poly(ethylene oxide) (PEO-*b*-PCL-*b*-PEO), with lecithin at the oil-water interface. The dipolar attraction of the methoxy terminated-PEO (mPEO) of ATCs on one drop surface with the lecithin head located on the other drop surface led to the drop-to-drop association. We showed that the efficiency of this interdrop association was dominantly influenced by the chain conformation of mPEO blocks. From the dense suspension rheology studies, we demonstrated that the ANEs formed a gel-like phase below the lower critical solution temperature (LCST) of the mPEO, but transforms to a liquid-like phase above the LCST, which occurred reversibly, thus enabling development of temperature-responsive emulsion fluids. Base on this ANE system, we also examined how the chain conformation of mPEO blocks affected the interdrop association in the presence of attractive polymeric micelles (APMs). The results obtained in this study highlight that our ANE system is capable of developing an intelligent flow control technology as well as structurally stable nanoscale emulsions.

Keywords: attractive nanoemulsions, polymer chain conformation, interdrop association, dense suspension rheology.

Multi stimuli-responsive tubular hydrogels by microfluidic system with various geometries and functionalities

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Abstract

In this study, we prepared stimuli responsive tubular hydrogels of different geometries by using microfluidic system together with alginate templating method. Temperature and pH responsive property was obtained through the incorporation of monomers such as *N*-isopropylacrylamide, sodium acrylate, and allyl amine. For the geometry control, simple modifications were applied to the microfluidic system, such as flow control and capillaries diameter adjustment to obtain the desired hydrogels diameter. To get a more advanced modifications such as hollow and double-walled microtubes, it can be achieved by the exchange of precursor solutions position and capillary addition in the microfluidic system. This method is extremely flexible and can be developed for further studies, such as artificial human blood vessel and wearable sensor fibers.

Keywords: tubular hydrogels, responsive hydrogels, microfluidic system

Development of indefective and facile coating on the surface of metal oxide nano-particulates with polymerizable chelating monomer and its cosmetic application

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Abstract

Dispersion of metal oxide nanoparticles in various matrix without aggregation is crucial to the performance of sensors, catalysts, conducting ink and composites and it also largely depends on their physicochemical surface property. Commonly, surface of nanoparticles is modified and stabilized through the physical adsorption of dispersant molecules or binding functional groups chemically. The thickness of adsorption layer affect to the excluded volume around nanoparticles and the coverage ratio decreases electrostatic interaction force between them.

However, applicability of nanoparticles stabilized by physical adsorption of dispersants is limited by the volume fraction of nanoparticles and the high coverage ratio is hard to achieve with conventional sol-gel coating method. Although chemical vapor deposition and atom-transfer radical polymerization can be quite effective way for high coverage coating, these are time-consuming and high expenditure.

Therefore, in this study, we introduced cost-effective and facile novel fabrication method for uniform organic coating layer onto the metal-oxide nanoparticles using 2-(acetoacetoxy) ethyl methacrylate (AAEMA) as polymerizable chelating agent. Diketone group of AAEMA monomers instantly form coordination complex with a surface of titanium dioxide (TiO₂) nanoparticles in organic solvent and easily polymerized with batch process. The thickness of adlayer could be varied along with the feed ratio of monomer and we considered that this layer can cover nearly whole surface area of nanoparticles effectively and it could prevent aggregation even in high concentration conditions.

More interestingly, not only dispersion stability of nanoparticles, according to coating layer thickness, the color of TiO₂ nanoparticles was also affected and it showed absorption increase of 380~500nm wavelength region in that, it can be developed for UV and blue-light screening agents.

Key words: nanoparticles, titanium dioxide, coating, polymerizable chelating monomer

P-13

Fabrication of stratum corneum lipids giant liposome and its internal layer structure modulation

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Abstract

Stratum corneum is the outermost barrier of our body and it prevents the invasion of foreign molecules and modulate the evaporation of water molecules. Its barrier function integrity is due to its composition and sophisticated structure. It consists with keratinocytes which are dead, flat cells filled with keratin bundles and intracellular lipids. Keratinocytes are also adhered strongly each other via numbers of junction points of corneodesmosome and intercellular lipids align their polar heads and non-polar tails, which make repeating bilayer structure.

However, these protections are easily deteriorated by surfactants, organic solvents and mechanical impacts or even sun light, humidity, temperature. As such, maintaining homeostasis of stratum corneum and restoring contents, composition and structure of lipid lamellae is a significant for our healthy life.

Normally, if the barrier function of stratum corneum lipids is damaged, repair sequence is initiated as soon as possible, but according to the individual skin disease, aging and nutritive condition, restoration process would be retarded, in that, direct replenishment of lipids can be effective. Stratum corneum lipid liposomes (SCLs) has been studied for delivering drug molecules through the skin barrier, owing to its lipid composition and stability, it can be applied as an external replenishment of stratum corneum lipids.

However, conventional fabrication methods hard to applied for SCLs due to diverse and low solubility of stratum corneum lipids in that, in this study, we successfully fabricated large-sized SCLs using gel-assisted fabrication method which was developed for giant unilamellar vesicles (GUV). This fabrication method can allow the usage of various kinds of lipids and easy to find out formation and internal structure of liposomes.

Moreover, due to the lipids content of giant unilamellar stratum corneum lipid liposomes (GUSCLs) is very limited, we also converted their uni-lamellar structure to multi-lamellar (GMSCLs). This reconstituted lipid lamellar body can lower the total epidermal water loss (TEWL) level significantly comparing with control group.

Key words: skin barrier, stratum corneum, lipids, giant liposome

P-14

Size control of silver nanowires via seed-mediated growth

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Abstract

Seed-mediated growth has been widely studied for control of size or morphology of nanoparticles. Size control has been a significant objective of seed-mediated growth for amorphous nanoparticles such as silica nanoparticles. On the other hand, for crystalline nanoparticles such as metal nanoparticles, control of morphology has been primarily conducted by seed-mediated growth to study morphology-property relationship such as a field enhancement from plasmonic nanostructures. However, in the number of applications, size control of metal nanomaterials is necessary as well, but it has been relatively unexplored than the morphology control. In this presentation, we introduce seed-mediated growth of silver nanowires as a model system and show how to control the size of silver nanowires.

Colloidal III-V/II-VI Heterovalent Semiconductor Interface for Highly Luminescent Nanocrystals

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Abstract

We demonstrate systematic study on core/shell heterostructure nanocrystals based on III-V/II-VI semiconductor with InP/ZnSe/ZnS geometry that show high photoluminescence quantum yield (>80%) with narrow emission linewidth (~45 nm). We utilized simple and in-situ interface treatment before the ZnSe shell growth to produce chemically mixed cation geometry at the interface between InP and ZnSe. The comparative studies based on spectroscopic analysis and surface characterization by X-ray photoemission spectroscopy and elemental analysis reveals that non-radiative traps in the InP nanocrystals are effectively suppressed by interface treatment. Chemically mixed geometry at the interface of InP/ZnSe nanocrystal suppresses the formation of non-radiative traps and additional surface treatment by halide ions can effectively eliminate the surface defect and successfully confine the electron and hole wavefunction into the InP nanocrystals. Consequently, the III-V/II-VI heterovalent heterostructure allows high PL QY of InP based core/shell heterostructures. For the best of my knowledge, this study is the first propose of the intentionally controlled heterovalent interface in colloidal NCs.

Bright, color-pure and robust InP/ZnSexS1-x quantum dots

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Abstract

We provide a design protocol for bright, color-pure and robust InP based quantum dots (QDs) and their applications to light-emitting diodes. Specifically, we propose a InP emissive core/ZnSexS1-x inner shell/ZnS outermost shell heterostructure that consists of less toxic elements and conduct comprehensive study across synthesis, spectroscopy and quantum mechanical calculation. The systematic study unveils the role of the composition and geometry of InP/ZnSexS1-x/ZnS heterostructures on the optical bandgap, emission linewidth and photoluminescence quantum yield (PL QY). In addition, we conduct the stability test under thermal stress, oxidation and high energy photon exposure. We highlights the realization of green and red-emitting InP based QDs showing peak PL emission wavelength at 525 and 620 nm with narrow spectral linewidth (full width at half maximum (FWHM) below 40 nm), PL QY(90 %) and photochemical stability. Finally, we fabricate QD based light-emitting diodes (QLEDs) that exhibit color-pure green and red emission (CIE(x, y) = (0.24, 0.72) and (0.70, 0.30)) and peak external quantum efficiency as high as 3.78 % and 3.92 %, respectively.

P-17

Surface charge control of polymer microspheres in isoparaffinic fluid for full color electrophoretic reflective display

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Abstract

The increasing demands for display devices with low power consumption and outdoor readability have stimulated comprehensive research into reflective displays that employ tunable photonic crystal technologies. Recently, color tuning of electrophoretic crystalline colloidal array (CCA) has been demonstrated as a promising candidate for full color reflective display. To overcome problematic features of water in electric field, non-aqueous liquid medium is required. Herein, CCA formed from core-shell PMMA/poly(t-butyl methacrylate) microspheres was fabricated, which was stabilized by the inverse micelles of sodium di-2-ethylhexyl-sulfosuccinate in an isoparaffinic fluid. A highly charged organic CCA was found to exhibit full-color tunability with a thousand-fold reduction in the operating current under a voltage bias in comparison with the current in an aqueous system.

Revisiting Cassie equation: Contact angle measurements of chemically heterogeneous smooth surface

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Abstract

Cassie equations have been used in the field of wetting for many decades, but the limitations of the Cassie equation are being investigated through a variety of experimental and theoretical studies. In this study, the water contact angle of flat and chemically heterogeneous surfaces are investigated in detail. The chemically heterogeneous surface was fabricated by photolithography, containing hexagonal arrays of circular patches of trichloro-(1H,1H,2H,2H-perfluorooctyl) silane layers. Patterns with different patch sizes and spacings were utilized to investigate changes in static contact angle due to chemical heterogeneity. The results show that with increasing patch diameter, the deviation between the measured and predicted contact angle (from Cassie equation) was increased, showing a significant difference when the patch size to the base diameter of the droplet was higher than ~ 0.17 . Moreover, the water droplet could not retain its hemispherical shape when the droplet base diameter was comparable to the patch size. These experimental results were further verified by simulation results using a Coarse-grained model.

Tuning hydrophobic force of the lignin nanofilms by ion adsorption

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Abstract

Lignin has been spotlighted as an abundant biorenewable resource in the field of material science and technology. Recent studies on the molecular binding mechanism of lignin became essential to develop optimal design of lignin into higher-value products. In this study, we investigated nanoscale interactions between lignin films in aqueous solution with various electrolyte concentrations revealing the molecular origin of lignin adhesion. The adhesion force was measured using a surface force apparatus (SFA) which has distance and force resolutions of 0.1 nm and 10 nN, respectively. Moreover, the adhesion force of lignin to methyl-terminated self-assembled monolayer (SAM) was measured to investigate the intensity of hydrophobic interaction. The obtained results were analyzed using Derjaguin-Landau-Verwey-Overbeek (DLVO) and hydrophobic theories. Realizing the lignin has a strong hydrophobic adhesion as well as water-soluble property, alkaline lignin was examined as a reinforcing filler of composites with activated carbon, showing a potential to be used as eco-friendly polymeric binders.

Adsorption Ordering and Film Formation of Anisotropic Nanoparticles at Air/Water Interface

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Abstract

Pickering emulsions stabilized using colloidal particles including Janus particles are of practical interest in many fields ranging from biomedicine to cosmetics. Janus particles with two sides of different chemistry or/and polarity have two or more novel different chemical or physical properties among nano-/micro-particles in solution and at interface. These anisotropy nanoparticles have led to interesting aggregation behavior on different length scales and readily attach to fluid interfaces like molecular surfactants which are able to have function as stabilizers for emulsion and foams.

Here we describe our recent experimental results on characterizing the surface adsorption and film formation of two different polystyrene dumbbell nanoparticles with identical morphology at air-water interface, comparing to polystyrene nano-spheres by using isothermal surface force measurements and electron microscopy.

Keywords: Adsorption ordering, Anisotropy nanoparticles, Surface adsorption, Film formation, Isothermal force measurement, Electron microscopy

Self-Assembled Structures for Superhydrophobic and Icephobic Surface

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Abstract

Icephobic surfaces are an area of great interest because of their significant role in decreasing the energy consumption of the refrigerator or in improving safety issues by preventing the formation of ice on the surfaces. Superhydrophobic surfaces incorporating micro- or nanoscale roughness and hydrophobic functional group have been shown to prevent ice accumulation. In this work, we are demonstrating the simple, low-cost and solution-based one-step process for the production of a superhydrophobic surface with a 3-dimensional (3-D) self-assembled multi-dimensional SiO₂ structures. The controlled hydrolysis and polycondensation of n-octadecyl(trichloro)silane produced a highly uniform superhydrophobic surface on versatile surfaces such as glass, metal or polymer surface in a large area without the limitation of surface curvature structures. The as-prepared 3D self-assembled surface exhibited a very high contact angle of 179.9° and a low contact hysteresis of 2.5°. The formation of self-assembled structure is strongly dependent on the types of solvent, water content, and hydrophobic chain length. The microscopic analysis was enabled to find novel SiO₂ square plate nanostructure during the hydrolysis reactions. Water drop impact experiments on the 3D self-assembled glass substrate showed that the as-prepared glass possess a high-impalement threshold resulting in icephobic surface. All these results indicate that the solution-based method suggested in current work is a useful way to produce superhydrophobic and icephobic surface regardless of surface structures and surface properties.

X-ray-Powered Micromotors

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Abstract

Light-powered wireless manipulation of small objects in fluids has been of interest for biomedical and environmental applications. Although many techniques employing UV-Vis-NIR light sources have been devised, new methods that hold greater penetrating power deep into medium are still in demand. Here, we develop a method to exploit X-rays to propel half-metal coated Janus microparticles in aqueous solution: The Janus particles are simultaneously propelled and visualized in real-time by using a full-field transmission X-ray microscopy. Our real-time observation discovers that the propulsive motion follows the bubble growth enhanced by water radiolysis near the particle surface under X-ray irradiation. We also show the propulsion speed is remotely controlled by varying the radiation dose. We expect this work to open opportunities to employ light-powered micro/nanomotors in opaque environments, potentially by combining with medical imaging or non-destructive testing.

Keywords: micromotors; light-driven actuators; X-rays; water radiolysis; microbubbles

Meniscus-on-Demand Parallel 3D Nanoprinting

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Abstract

Exploiting a femtoliter liquid meniscus formed on a nanopipette is a powerful approach to spatially control mass transfer or chemical reaction at the nanoscale. However, the insufficient reliability of techniques for the meniscus formation still restricts its practical use. We report on a noncontact, programmable method to produce a femtoliter liquid meniscus that is utilized for parallel three-dimensional (3D) nanoprinting. The method based on electrohydrodynamic dispensing enables one to create an ink meniscus at a pipette-substrate gap without physical contact and positional feedback. By guiding the meniscus under rapid evaporation of solvent in air, we successfully fabricate freestanding polymer 3D nanostructures. After a quantitative characterization of the experimental conditions, we show that we can use a multi-barrel pipette to achieve parallel fabrication process of clustered nanowires with precise placement. We expect this technique to open an avenue to advance productivity in nanoscale 3D printing.

Keywords: 3D printing, meniscus-guided fabrication, multi-barrel nanopipette, polymers, freestanding nanowires, electrohydrodynamic dispensing.

ZIF-8-laden omniphobic hydrogel membrane by microfluidic templating method for wound healing

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Abstract

Bacterial adhesion and proliferation on wounds are troublesome in chronic wound healing processes^[1]. Current dressings are typically hydrophilic in order to effectively release antibacterial agents into wound exudate^{[2],[3]}. However, hydrophilic dressings cannot inhibit biofilm formation nor prevent excessive blood absorption, leading to bacterial overgrowth, unbalanced moist environment of wound or even serious delay to wound healing process^{[4],[5]}. Herein, we fabricated an omniphobic hydrogel membranes encapsulated with Zinc Imidazolate Framework 8 (ZIF-8) by a microfluidic emulsion templating method. The re-entrant architecture enabled the hanging of blood and body fluid on the porous membrane, even though it was made from hydrophilic polymers. This unique combination not only prevented biofilm formation, but also anti-bacterial ingredients could still release to wounded sits from hydrophilic polymer networks. Thus, we found that the gradual release of zinc ions from ZIF-8-laden omniphobic hydrogel membrane provided 99% antibacterial activity. Moreover, the cell viability of membranes in vitro could reach up to 80%. Further in vivo tests confirmed that the rapid wound closure rates made membranes suitable for healing of infected wounds. Thus, these ZIF-8-based omniphobic hydrogel wound dressings with low bacterial attachment percentage and superb antibacterial activity have enormous potential to be a next-generation dressing for healing wounds clinically.

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