

PP001

Revealing Contact Formation Characteristics of Bacteria: A Single Cell AFM Study in Combination with MC Simulations

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Single cell AFM force spectroscopy (see sketch) has proven to be useful to quantify the acting forces if combined with a clever choice of substrates. On hydrophobic surfaces, the hydrophobic interaction plays the main role for the adhesion of bacteria [1] and the contact formation process is dominated by the longest cell wall macromolecules. In our AFM study, we revealed the initial contact formation by observing the snap-in process in detail [2]. Monte Carlo simulations with a simple model for a bacterium strikingly matching results, corroborating the interpretation that the contact formation of *S. aureus* relies



on thermally fluctuating cell wall proteins that tether to a substratum and subsequently pull the bacterium to the surface. That way, e.g. *S. aureus* is able to attach to surfaces over distances far beyond the range of classic surface forces! Our results therefore suggest that the bacterial adhesion process in general can be described by solely taking into account the tethered macromolecules between a bacterium and a surface. Moreover, force/distance curves of single cell bacterial probes [3] reveal striking differences between bacterial adhesion to hydrophilic and hydrophobic surfaces and enable also to infer the contact area of bacterial adhesion.

[1] Thewes, N. et al., *Beilstein J. Nanotechnol.* **2014**, 5, 1501. [2] Thewes, N. et al., *Soft Matter* **2015**, 11, 8913. [3] Thewes, N. et al., *Eur. Phys. J. E* **2016**, 38, 140.

PP002

The role of supra-molecular assemblies on the interaction of dietary components with intestinal mucin

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The adherent mucus layer is a vital component of the body's mucosal surfaces. Mucus assembly is characterised by the presence of multiple levels of mucin structuring at different length scales. Large molecular weight glycoproteins, known as mucins, constitute the major functional component and give mucus its unique rheological and barrier properties. In this work, we examined the interaction of the intestinal (MUC2) mucin with dietary fibre in solution as well as on the surface of cell wall particles. The plant materials and corresponding fibre were chosen to represent the major classes of health-promoting dietary fibre, and designed to mimic consumption of whole foods. A biochemically well characterised porcine intestinal mucin preparation was utilised as a model for human mucus to characterise the effect of pH and Ca²⁺ on viscoelasticity, structure and dynamics of concentrated mucin solutions and its complexes with dietary fibre. The colloidal interactions that mediate the integrity of the mucin network were investigated using reducing (dithiothreitol), chaotropic (guanidinium chloride) and chelating (ethylenediaminetetraacetic acid) agents. The rheological and structural characteristics of mucin and mucin-fibre complexes were investigated using a combination of particle tracking microrheology, small amplitude oscillatory shear, narrow gap high shear rheometry, and confocal microscopy. We found that the complex rheological properties of the gelling mucus preparation were in a striking contrast with that of extensively purified mucin. The role and importance of non-mucin components of mucus were elaborated, and their contribution to such interactions as hydrogen bonding, Ca²⁺-mediated links, and disulfide bonds evaluated. We also show the ability of soluble dietary fibers and plant cell wall particles to alter the rheological and diffusion properties of gelling mucus preparations. These new insights into how plant polysaccharides can change the barrier properties of mucus provide a fresh perspective on possible mechanisms underpinning health-promoting benefits of dietary fibre.

PP003

Specific-ion effects on Hydrophobic Interactions

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Ions specifically influence bulk and interfacial properties of solvents—a class of phenomena known as specific-ion effects—and play crucial role in self-assembly and function of macromolecules¹. Herein, we report on specific-ion effects due to common ions, including Cl⁻, I⁻, F⁻, ClO₄⁻, and PF₆⁻, on the hydrophobic interaction via a combined experimental and theoretical approach. Our experiments employing a surface forces apparatus² revealed that the hydrophobic interaction between two extended perfluorodecyltrichlorosilane coated mica surfaces was dramatically influenced by large monovalent ions, such as I⁻ (220 pm), ClO₄⁻ (240 pm), and PF₆⁻ (380 pm) dramatically reduce hydrophobic attraction, whereas smaller monovalent ions, such as F⁻ (133 pm) and Cl⁻ (181 pm), have a minimal effect.³ We rationalized these observations on the basis of anion-fractionation at water-hydrophobic interfaces, which is known to correlate with the size of anions⁴. For deeper insights into our experiments, classical molecular dynamics simulations are underway to understand how ions influence hydrogen-bonding networks and their specific adsorption onto water-hydrophobic interfaces decrease the hydrophobic interaction. Both experimental and theoretical results will be presented at the meeting.

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3. Marcus, Y., Ions in Water and Biophysical Implications. Springer **2012** ISBN 978-94-007-4646.
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PP004

Surface forces: Probing for Contributions Emanating from Substrates underneath Ultrathin Polymeric Coatings

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Surface forces play a key role in determining interfacial interactions between materials and their environment, for example protein adsorption, cell attachment, self-assembly, and dewetting.[1] Thin polymeric coatings are attractive for modifying materials to obtain desirable surface performance, for example control of fouling for applications in biosensing, tissue engineering, ultrafiltration device, etc.[2]

But for ultrathin coatings, will the surface forces contain contributions from the substrate “shining through” the coating? Very little is known about substrate effects, but recently it has been found that long-range forces originating from subsurface materials can be significant.[3] In this work we are studying substrate contributions by using the AFM colloid probe method and plasma polymer overlayer films of various thicknesses. Van der Waals and electrostatic forces are extracted and interpreted based on DLVO theory.

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[2] Siow, K. S.; Britcher, L.; Kumar, S.; Griesser, H. J., Plasma methods for the generation of chemically reactive surfaces for biomolecule immobilization and cell colonization - A review. *Plasma Processes and Polymers* 2006, 3 (6-7), 392-418.

[3] Loskill, P.; Hahl, H.; Thewes, N.; Kreis, C. T.; Bischoff, M.; Herrmann, M.; Jacobs, K., Influence of the subsurface composition of a material on the adhesion of staphylococci. *Langmuir* 2012, 28 (18), 7242-7248.

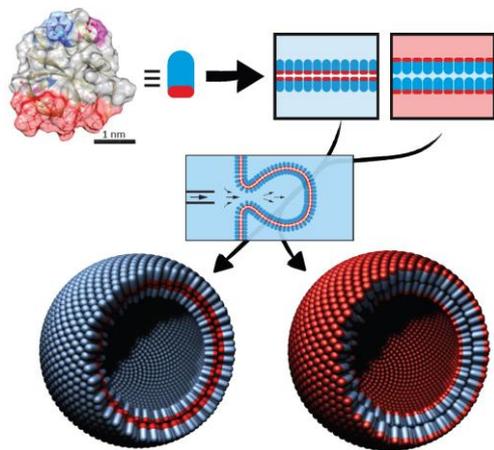
PP005

Pure protein bilayers and vesicles from native fungal hydrophobins: Perfect self-assembly at (bio)interfaces for encapsulation or drug carriage

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In biology, bilayers enable a compartmentalization within one phase, e.g. lipid bilayers separating two aqueous surroundings, allowing for the buildup of organelles. Typically, phospholipids are the building blocks of these membranes, whereby their amphiphilic character is a necessary precondition for the bilayer formation. In this study, we achieved stable bilayers consisting of hydrophobins, which are amphiphilic proteins naturally occurring in fungi and are therefore biocompatible. We demonstrate that hydrophobins form membranes between any type of fluid compartments, be it gas, water or oil. This renders hydrophobins even more versatile than lipids. We show the formation of hydrophobin vesicles as a superior platform for encapsulation in synthetic biology or drug delivery.



[1] H. Hähl, J.N. Vargas, A. Griffo, P. Laaksonen, G. Szilvay, M. Lienemann, K. Jacobs, R. Seemann, and J.-B. Fleury, *Advanced Materials* (in press).

PP006

Liquid-Liquid Dewetting: Morphologies and Rates

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The transient morphologies of liquid polystyrene (PS) dewetting from liquid polymethylmethacrylate (PMMA) towards equilibrium are considered experimentally and theoretically. Both polymers are glassy at room temperature and can be considered as Newtonian liquids with equal viscosities at dewetting temperatures. For various initial layers thickness ratios we determine the evolution of the PS-air, the PMMA-air and the PS-PMMA interfaces. The polymer-air interfaces are imaged *in situ* by scanning force microscopy during dewetting, whereas the liquid-liquid interface is imaged after solidifying the sample and removing the dewetting polystyrene with a selective solvent. Depending on film thickness ratio we observe a characteristic rim profile, both for the polymer-air and the PS-PMMA interface. The dewetting rates, however, do not obey any well-defined scaling behavior and are close to linear. Using the relevant experimental parameters, the experimentally obtained rime evolutions are in excellent agreement with the theoretical prediction from thin-film models, which describe the evolution of a multiphase system of viscous liquids that are purely driven by interfacial tensions. Based on this agreement, we use the numerical simulations to predict local flow fields and the energy dissipation that otherwise would be inaccessible to experiments.

PP008

Marine Antifouling Surfaces Based on Structured Siloxanes

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Biofouling is a problem in aquaculture, as fouling occurs on any unprotected marine surface. Fouling is often initiated by bacteria or diatoms, which are joined by other micro, then macro, organisms. One particularly invasive species for aquaculture is *Ciona Intestinalis* (sea squirt).

Antifouling surfaces can rely on topography which decreases attachment, on surface properties which decrease attachment strength (fouling release), or on release of a biocide.

A variety of such surfaces have been made and tested.

For example, dental elastomeric impression materials based on polyvinylsiloxane, with calcium silicate and silicon dioxide as fillers, and with the surface hydrophilicity modified by the presence of nonylphenol ethoxylates, were unfavorable for growth of both bacteria and diatoms. The nonylphenol ethoxylate also leached out and inhibited the attachment and development of *C. intestinalis* larvae*. Alternate ethoxylates were also investigated.

*Fouling release and chemical activity effects of a siloxane-based material on tunicates N. Filip, A. Pustam, V. Ells, K.M.T. Grosicki, J. Yang, I. Oguejiofor, C.D. Bishop, M.E. DeMont, T. Smith-Palmer and R. Wyeth, Mar.Env.Res.116, 41-50 (2016)

PP009

Tuning the Catalytic Activity of Silver Nanoparticles

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The use of silver nanoparticles in consumer related products has significantly increased over the last decade, especially due to their antimicrobial properties. Today they are used in a variety of products, which range from textiles to dietary supplements. Thus, investigations on nanoscale silver become increasingly important in many fields like biomedicine or catalysis. Unfortunately, the results of these studies are extremely diverse and do not lead to a consistent evaluation of the toxicity of silver nanoparticles. The main problem is the use of nonuniform and poorly characterized particles with broad size distributions. To overcome this problem we modified the known polyol process to synthesize ultra-small core-shell silver nanoparticles in a large scale. The particles are highly stable and show no aggregation for more than six months. Small-angle X-ray scattering analysis reveals a narrow size distribution of the silver cores with a mean radius of 3 nm and a distribution width of 0.6 nm. Dynamic light scattering provides a hydrodynamic radius of 10.0 nm and a PDI of 0.09. The stabilizing ligand PAA can be easily exchanged by biomolecules to modify the surface functionality. Replacements of PAA with glutathione and bovine serum albumin have been successfully performed. To demonstrate the broad applicability of our particles we performed catalysis experiments with the reduction of 4-nitrophenol as model reaction. The PAA-stabilized particles show a catalytic activity of $(436 \pm 24) \text{ L g}^{-1} \text{ s}^{-1}$, which is the highest reported in literature for silver nanoparticles. In contrast, GSH and BSA passivate the surface substantially resulting in lower catalytic activities.

PP010

Silica Nanoparticles Functionalised with Zwitterionic Sulfobetaine Siloxane for Application as a Versatile Antifouling Coating System

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¹University of Wollongong, Wollongong, Australia, ²Bluescope Steel, Wollongong, Australia

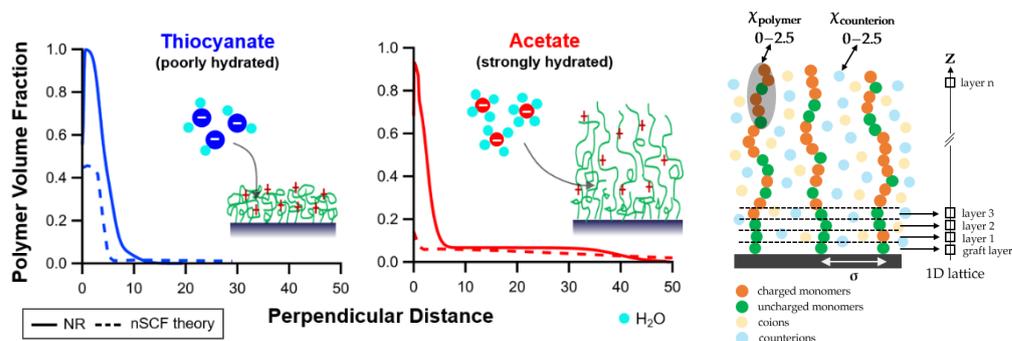
The growing need to develop surfaces able to effectively resist biological fouling has resulted in the widespread investigation of nanomaterials with potential antifouling properties. Here, we report the functionalisation of silica nanoparticles with a zwitterionic silinated sulfobetaine monomer for the preparation of hydrophilic low fouling coatings. Quartz crystal microgravimetry with dissipation monitoring (QCM-D) is presented as a new method through which to optimise the reaction conditions for sulfobetaine functionalisation of silica nanoparticles deposited as thin films, as a model towards solution based nanoparticle functionalisation. Functionalisation of nanoparticle films was rapid and could be achieved over a wide pH range and at low zwitterion concentrations. Similarly, functionalisation of silica nanoparticle suspensions could be achieved under aqueous conditions with moderate grafting densities. Zwitterated particles were used to prepare hydrophilic coatings via a simple spin-coating process. All functionalised particle surfaces presented a high degree of wettability and resulted in large reductions in adsorption of bovine serum albumin (BSA) protein. Prepared particle surfaces also showed a reduction in adhesion of fungal spores (*Epicoccum nigrum*) by up to 87%. These results indicate the potential for functionalised nanosilicas to be further developed as versatile fouling resistant coatings for widespread coating applications.

Anion Hydration can account for the Specific Ion Response of a Hydrophobic Weak Polyelectrolyte Brush

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The pH and ionic strength response of weak, polybasic brushes is significantly influenced by the identity of the counterion and the relative polymer hydrophobicity [1]. Recently, we have extended these analyses using a combination of numerical self-consistent field (nSCF) calculations and neutron reflectometry. At low ionic strength, the hydrophobic poly(2-diisopropylamino) ethyl methacrylate (PDPA) brush formed a collapsed conformation independent of salt identity while at higher ionic strengths (up to 500 mM) the brush formed an extended conformation in potassium acetate solutions, but remained collapsed in potassium thiocyanate solutions. The nSCF calculations revealed that the inclusion of a single Flory-Huggins interaction parameter (χ) analogous to the hydrophilicity of the counterion is sufficient to replicate the observed brush behaviour.



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PP012

Nanostructured Surface Coatings for the Separation of Water-Soluble Oils from Water

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The synthesis of thin-film materials with micro-/nano-meter thickness is a hot research field since it offers various solutions to critical challenges in the globe. One of the challenges facing an environmentally sustainable future is the processing of renewable biomass-derived chemicals, and in particular the separation of water-soluble oils from water. Two main approaches have been introduced for the oil/water separation processes, one using superhydrophobic/superoleophilic coated meshes [1], and the other approach using superhydrophilic/superoleophobic (or underwater superoleophobic) coated meshes [2]. The former approach suffers fouling by oils, however it is efficient in heavy-oils separation, while the latter approach is more robust to contamination by oils. Other challenges face the fabrication process of coated meshes, for example, durability, robustness, and fabrication costs. In our work we fabricated a new polymer hybrid coating material and assembled it over a microporous mesh for successful oil/water separation.

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PP013

Measuring Hydrodynamic Forces on Structured Surfaces via Colloidal Probe AFM.

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Superhydrophobic surfaces, inspired by the lotus leaf [1], and liquid-infused surfaces, inspired by the pitcher plant [2], are promising candidates as structured surfaces with anti-drag properties. These materials utilise micro- and nano-scale topography which traps air, or houses a lubricant, respectively, and both layers reduce the interfacial drag compared to bare solid surfaces. We have produced the required topography for these surfaces via simple methods [3], however, understanding how liquid interacts with these interfaces on the nano-scale is yet to be fully understood. Using colloid probe atomic force microscopy, we are measuring the flow of simple viscous liquids over these structured surfaces, with the aim to quantify interfacial slip [4]. Comparing the interfacial slip on superhydrophobic and liquid-infused surfaces will provide insight regarding liquid flow in confined geometries, and on effective ways to minimise hydrodynamic drag.

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[3] (a) Scarratt, L. R. J.; Hoatson, B. S.; Wood, E. S.; Hawkett, B. S.; Neto, C. *ACS Appl. Mater. Interfaces* **2016**, *8* (10), 6743-6750. (b) Schaffel, D.; Koynov, K.; Vollmer, D.; Butt, H. J.; Schonecker, C. *Phys. Rev. Lett.* **2016**, *116* (13), 5.

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PP014

Liquid-Infused Surfaces via Spontaneous Wrinkling of Polymer Films.

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Lotus leaf inspired superhydrophobic surfaces have received much attention over the past decade for their self-cleaning and anti-fouling properties, possessing many potential commercial applications. Recently, the pitcher plant (Figure 1(a)), is showing promising advantages over superhydrophobic surfaces. These surfaces utilise similar micro- and nano- structures, characteristic of superhydrophobic surfaces (Figure 1(b)), to trap lubricants via capillary forces, forming a smooth customisable interface. Using the spontaneous wrinkling of polymer films [1], we have produced Teflon AF nano-wrinkled surfaces for the infusion of different lubricants (Figure 1(c)). These surfaces are inexpensive, easy to fabricate, and show potential for robust self-cleaning surfaces with regenerative properties.

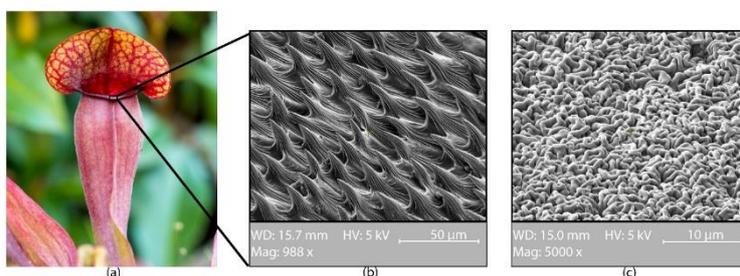


Figure 1. (a) Trumpet pitcher plant (b) SEM image of pitcher plant micro-structure (c) SEM of 1190 nm Teflon wrinkled surface.

[1] Scarratt, L. R. J.; Hoatson, B. S.; Wood, E. S.; Hawkett, B. S.; Neto, C. *ACS Appl. Mater. Interfaces* **2016**, *8* (10), 6743-6750.

The effect of adsorbed citric acid on the surface forces between HfO₂ surfaces fabricated by atomic layer deposition.

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The adsorption of small molecules such as citrate, oxalate and phosphates is used to modify surfaces in a wide range of industries. These effects have in the past been obtained from analysis of the surface forces by AFM. However, the roughness of the surfaces influences the measurement. To resolve this problem, we fabricated smooth surfaces using Atomic Layer Deposition (ALD). In this presentation, we will report the relation between the concentration of citric acid in solution and the measured force between hafnia surfaces produced by ALD. The amount of citrate ion adsorbed onto hafnia surfaces was monitored by Optical Reflectometry (OR). The expected van der Waals forces between the high refractive index hafnia surfaces was not evident in the surface force measurements in the presence of citric acid.

Rather, at all concentrations (10⁻³ M to 10⁻¹ M) of citric acid, the force operating between surfaces was always repulsive at small separations. These results imply that at short-range a steric barrier was present and at long-range the electrostatic repulsion dominated.

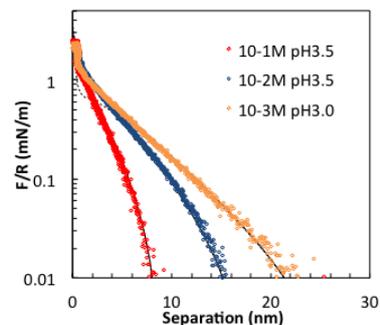


Figure 1 Surface force worked between hafnia in the presence of citric acid around pH 3. The citric acid concentrations were 10⁻³ (yellow), 10⁻² (blue) and 10⁻¹ (red) M. The fitting parameters were the following: (10⁻¹ M) $\kappa^{-1} = 2.1$ nm, $\Psi_0 = -70$ mV; (10⁻² M) $\kappa^{-1} = 4.8$ nm, $\Psi_0 = -68$ mV; (10⁻³ M) $\kappa^{-1} = 5.0$ nm, $\Psi_0 = -47$ mV

PP016

Motion of Droplets on Superhydrophobic Surfaces

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The surfaces of many plant leaves are superhydrophobic, a property that may have evolved to help keep the leaves clean by encouraging the beading and rolling of water droplets. In this paper, molecular dynamics simulations are used to investigate the roles of droplet size and surface geometry on the subsequent equilibrium velocity of droplets travelling down super-hydrophobic surfaces. The results are examined using an extension of previous theoretical descriptions of droplet motion on surfaces, where an effective slip condition is applied at the liquid-surface interface. This approach yields three limiting cases for the steady-state velocity of the droplets, where energy losses are dominated by viscous dissipation, surface friction or contact line friction respectively. We find that, while the motion of the droplet is generally governed by surface friction for small droplets and viscous dissipation within large droplets, the rolling motion of the droplet is significantly enhanced for small droplets with contact areas that match the periodicity of the surface pattern. In such cases, contact line friction plays a significant role.

PP017

Formation of Proline Calix[4]arene Hydrogel Imaged by *In Situ* Atomic Force Microscopy

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Gels are used in many industries and have been studied for centuries. It is still difficult to make gelator molecules in a targeted manner due to the poor understanding of the gelation process. Our understanding of gel formation is currently severely limited by the analysis methods available. Electron microscopy may be used to image the structure of a gel however, the gel must be prepared by either drying it or freezing it beforehand as the analysis must be conducted under high vacuum. It is not known how this preparation affects the gel network morphology. While atomic force microscopy has been used for decades to image gels, it has only been used *in situ* to image gels since 2014. The first study published which allowed for the *in situ* imaging of a gel could not show the change occurring.¹

In 2015 we showed that a gel can be imaged during the assembly and disassembly process by PeakForce tapping AFM.² The assembly process of the proline calix[4]arene gelator with added MgCl₂ was initiated by lowering the temperature of the sample stage. The individual fibre diameter was shown to remain constant throughout the temperature changes while it was shown that bundling of individual fibres increased at lower temperatures as more fibres were formed. Here we report the formation of these gels upon addition of different salts and the effect of inhibitors.

1. L. Schefer *et al.*, *Angewante Chemie*, **2014**, 53(21), 5376-5379.
2. E.C. Barker *et al.*, *Chemical Science*, **2015**, 6, 6133-6138.

PP018

Stimuli Responsive Phospholipid-based Nanomaterials for On-demand Drug Delivery

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Considerable interest has been directed towards designing a drug delivery system that is capable of providing on-demand drug release. Many diseases are in urgent need of such systems as it could enhance therapeutic efficiency, minimize toxic side effects, reduce the frequency of administration and can selectively deliver drug to the target site. This research focuses specifically on age-related macular degeneration, which is the leading cause for irreversible vision impairment and blindness in Australia. Currently, the only effective treatment is highly invasive and frequent monthly injections directly into the eye. Self-assembled phospholipid-based liquid crystalline (LC) mesophases can be manipulated to induce a slow to fast drug release profile, which has potential to reduce the frequency of injection. In hope to relieve the burden of the current treatment, this study aims to design a photo-responsive phospholipid-based LC system that will release drug 'on-demand' in response to near-infrared (NIR) light. Light sensitive gold nanorods (GNR) are incorporated into the LC system and upon NIR irradiation, a phase change and subsequent release of drug will occur due to photothermal heating of the light-sensitive GNR. Light activation will release a unit dose of drug in a repeated pulsatile fashion, mimicking the repeat injections. Hence, the frequency of injections will be reduced by replacing the repeated injections with a non-invasive pulsatile release strategy. The results from this study proves that phase transition can be triggered using NIR laser and such system will have potential to become a less invasive and long-lasting drug delivery system.

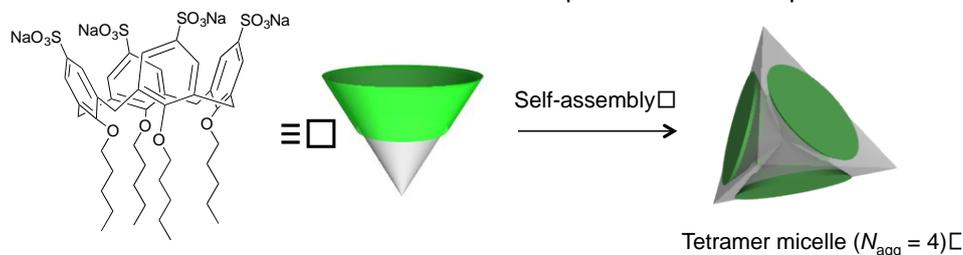
PP019

Unknown aggregation behavior of sulfonatocalixarene lipids: the formation of monodisperse tetramer micelles and salt concentration effects on the micellar structures.

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We have found that some calixarene-based lipids form monodisperse micelles whose



aggregation numbers agree with the face number of Platonic solids, thus we named them “Platonic micelles”¹⁾. Sulfonatocalixarene-based lipids are well known as a general calixarene-based lipid. In this study, we have characterized the morphologies of sulfonatocalixarene-based micelles using small angle X-ray scattering (SAXS) and field flow fractionation coupled with multi angle light scattering (FFF-MALS) measurements. The SAXS and FFF-MALS results show the formation of monodisperse tetramer micelle. Although many salt ions bind to the micellar shell at high NaCl concentration ($C_{NaCl} < 300$ mM), the aggregation number does not change at all until the formation of hexagonal packed cylinders at $C_{NaCl} = 300$ mM. This is because that the sulfonic acid groups attached to benzene of the calixarene unit without any flexible spacer. The lipid headgroup cannot tune the volume balance between hydrophilic and hydrophobic moieties, resulting in unchangeable aggregation number by salt concentration.

PP020

Ionic Liquids Induce Surfactant-free Self-assembly

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As molten salts, ionic liquids (ILs) have huge potential in material and colloid science for their tuneable properties with different cation-anion combinations. While ILs share with water the rare ability to promote surfactant self-assembly, the fundamental yet remarkable difference is the amphiphilic character of neat ILs. Unlike water and other molecular solvents, ILs encourage weak amphiphiles, such as alcohols, to self-assemble into a two-component microemulsion.

Our current study expands the scope of self-assembly. We utilise the amphiphilicity of ILs to induce liquid nanostructure without the presence of a surfactant, such as the water-IL-oil system. We combine three scattering techniques to study the liquid structure, with each providing structural information at a different length scale. Using small/wide-angle X-ray scattering for preliminary screening, we examine the effect of composition and different types of ILs. Detailed nanoscale information is elucidated by small-angle neutron scattering, where we observe a distribution of species into polar and apolar nano-domains. At the atomic resolution, neutron diffraction combined with simulation identifies key interactions that are responsible for nanoscale segregations. A combination of theory and experiment ensures an accurate description of liquid structure. Our research establishes a new matrix of IL-induced microemulsions with predictable structural behaviour to target any specific application.

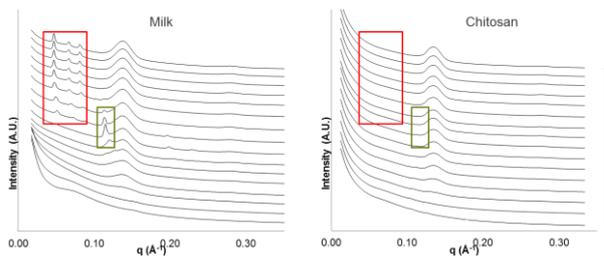
PP021

The interaction of food additives with the lipid digestion process

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The increase in obesity has caused a rise in products available on the market claiming to reduce the amount of fat absorbed from food, but there is little scientific evidence to support these claims. It is hypothesised that these weight loss products impact on the digestion of fat and the subsequent absorption of fatty acids. Milk was selected in the current study as a model food, as it naturally contains high amounts of fat and forms different mesophases during digestion. By using time-resolved synchrotron small angle X-ray scattering (SAXS) coupled to an *in vitro* digestion model the structures that are formed during digestion can be observed and the phase transitions monitored.



When chitosan, present in the commercial product FatMagnet[®], was added to an *in vitro* digestion of milk, the characteristic phase transitions were not observed, as seen in the above figure. It can be hypothesised that the chitosan was interacting with either the bile acids or fatty acids and interfering with the lipid digestion process.

PP022

Sugars bearing calix[4]arene-based micelles: the effects of sugar chain length on the micellar structures

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We have synthesized an calix[4]arene-based lipids with saccharides as the hydrophilic group. Monosaccharides bearing calix[4]arene-based lipids form vesicles in an aqueous solution, whereas the disaccharides bearing lipids form spherical micelles. The morphological difference between the micelles is explained with packing parameter theory. Furthermore, the spherical micelles demonstrates monodispersity in the aggregation number ($N_{agg}=20$) which is one of the Archimedes solids showing a stable structure consisting of some regular polygons.

PP023

Understanding the Link Between Composition, Structure, and Absorption of Milk During Digestion

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Milk is a source of nutrients that is essential for mammalian survival. It is a complex, naturally occurring emulsion comprising of lipids, proteins, lipid soluble vitamins, salts, and carbohydrates. These nutrients are key to the development of the brain, tissue, cellular material, and growth at the beginning of an infant's life, as well as providing a source of calcium, proteins and dietary lipids for bone health and energy supply in adults. Although the composition and physical properties of milk have been studied extensively, little is known about the disposition of lipids in milk during digestion. Recent studies have reported the formation of semi-ordered nanostructures arising from *in situ* digestions and small angle x-ray scattering (SAXS), which suggest that these structures may play a role in the absorption of nutrients i.e. triglycerides, from the small intestine. To gain a further understanding, analytical techniques were used to determine which type of lipids and how much are present in bovine milk during digestion. In addition, *ex vivo* studies with excised rat small intestines following consumption of bovine milk will be observed using SAXS, as well as pharmacokinetic studies to check *in vivo* - *in vitro* translatability, as *in vitro* digestion processes are conducted in a closed system where liberated fatty acids remain within the digestion vessel, while biological processes typically involve the rapid absorption of fatty acids during digestion. A correlation between composition, structure, and absorption of triglycerides during milk digestion could ultimately lead to designing improved, more effective infant formulas.

PP025

Structural Studies of Pluronic Polymers Absorbed at Oil/Water Interfaces

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Pluronic triblock copolymers are amphiphilic molecules that are widely used to enhance stability of colloidal systems. For optimal use in emulsions, understanding their conformations and supramolecular structures at the liquid/liquid interface is essential. However, studying structures at the buried oil/water interface is challenging.

We have developed two new model oil/water interfaces that provide an “anchored” oil film with which traditional surface characterisation experimental approaches can be used. We have created lightly cross-linked PDMS films and also covalently anchored PDMS brushes, both of which act as immobilised oil layers to create large contact surface areas for study. Prepared on large silicon blocks, the films are suitable for neutron reflection or, alternatively, the films can be prepared on quartz crystal microbalance (QCM) discs.

The structures of two Pluronic polymers at the oil/water interface will be described as a function of polymer concentration and ionic strength. Using the combination of neutron reflectivity and QCM, it will be shown that the adsorption behaviour of these non-ionic polymers is surprisingly sensitive to the ionic strength. The practical outcomes for emulsion stabilisation will be discussed.

PP026

**Structural analysis of micelles composed of calix[4]arene based lipids bearing PEG:
Formation of regular polyhedral structures**

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Micelles generally have dispersity in the structure including the size and the aggregation number. Interestingly, we have recently found that calix[4]arene-based lipids form monodisperse micelles in the aggregation number (N_{agg}). The N_{agg} agrees with the face number of Platonic solids. We call these micelles Platonic micelles (PMs). Calix[4]arene-based lipids form into cone-shape with the large headgroup, which endow the ability to form the PMs. In addition, for the formation of the monodisperse micelles, the balance of hydrophilic and hydrophobic moieties should be a very important parameter. However, the relationship between the micellar structure and the hydrophilic group volume of the lipid is not clear enough. In this study, we synthesized polyethylene glycol (PEG) bearing calix[4]arene lipids (PEG_mCaL5, m is molar mass of PEG) to investigate the effect of the headgroup volume on the micellar structure including the monodispersity.

PP029

Engineering Nanocellulose Gels for Biomedical Applications

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Hydrogels are fascinating soft materials possessing polymeric networks which entrap substantial amounts of water. Cellulose has emerged as a promising material to produce biodegradable, biocompatible, and easily functionalised hydrogels that can be used for various food and biomedical applications.

Herein, TEMPO-oxidised cellulose nanofibres are used to produce hydrogels. A combination of techniques – rheology and dynamic light scattering (DLS) – were employed to characterise the structure and understand the mechanism of hydrogel formation. The objective is to develop cellulose nanofibre gels for two specific biomedical applications: blood typing and cell culture medium. Rheology was used to characterize the viscous and the elastic moduli of the gels, while DLS served to identify the onset of gelation. We have found that the hydrogel properties are dependent on fibre concentration, temperature, pH, and ionic strength. With this knowledge we intend to produce modified hydrogels to suit applications by optimising fibre content, and additives.

PP030

Novel Adsorbent-cellulose Fibre Composites for Liquid Filtration

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Liquid filtration is widely used in food and beverage applications. Depth type composite filter mediums, which are porous materials heavily loaded with adsorbents, find a range of applications. These adsorbent filled filter products remove contaminants from liquids by both mechanical entrapment and adsorption. Even though existing products are commercially available, there is still a need of development for high performance filter products with selective adsorption.

In this study, adsorbents were fabricated by embedding zeolite particles into cellulose fibre matrix, where composites were structured into flat sheet configuration by papermaking technique. A retention mechanism for the zeolite particles was developed to achieve composites with high loading of adsorbents. Characterization on mechanical properties and structure was performed. The effect of polyelectrolyte addition on wet strength was quantified. Furthermore, adsorption and filtration characteristics were quantified by using a laboratory benchmark system on removal of suspended particles and solute molecules from aqueous solution.

PP031

Asymmetries in Drop Impacts on Micropillar Arrays

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The study of drop impacts on to solid surfaces is intrinsically appealing due to the aesthetics of the process, and its widespread importance - inkjet printers, agricultural sprays, and water harvesting provide just three examples. As a result, drop impacts have been widely studied [1], and it is known that close control of the physical structure and chemical nature of the surface are important for determining the outcomes of an impact. Studying this phenomenon therefore adds to our fundamental understanding of dynamic contact line motion over a surface.

This presentation will describe high-speed photography experiments in which drops land on regular polymer micropillar arrays. Such arrays provide several advantages, such as the ability to systematically study the effects of surface structure (and therefore roughness), and the possibility of observing the Cassie-Baxter state that is characteristic of superhydrophobicity. Asymmetries that align with the micropillar pattern are of particular interest. Observed asymmetries can be divided into those determined by the surface energy local to a liquid-gas interface, and those dependent on the width of corridors through the microstructure through which air escapes during impact [2].

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PP032

Progress with Slip-Induced Dynamics of Nanospheres

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If a micro- or nanosphere has a slip boundary condition on its surface, we should be able to observe interesting dynamics when the particle is placed in a simple Newtonian flow [1]. These predicted dynamics have recently been supported by the results of a molecular dynamics study [2]. This work raises the possibility of testing (and using) violation of the conventional non-slip boundary condition in new ways. Here, we will describe our progress on this topic.

For experiments, we have made spheres with surfaces that could be expected to produce slip boundary conditions, including silanized silica and decanethiol-functionalized gold. In the latter case, the particles can be Janus spheres, in which one hemisphere has different properties to the other, so that rotational dynamics can be studied. We are now attempting to study the dynamics of these spheres using precise force measurements in an optical tweezers setup.

Although our work so far is focussed on individual particles, there is opportunity to study the collective and emergent behaviour of Janus particles. For example, the slip-induced dynamics may produce particle collections with similarities to active matter, and are likely to significantly affect large-scale phases formed by particle assemblies [3].

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PP033

A Low Temperature, Water-Based Synthesis of Non-Toxic, Single Crystal CZTS Nanoparticles for Photovoltaics

Cameron Ritchie^{1,2}, Anthony Chesman³, Jacek Jasieniak², Paul Mulvaney¹

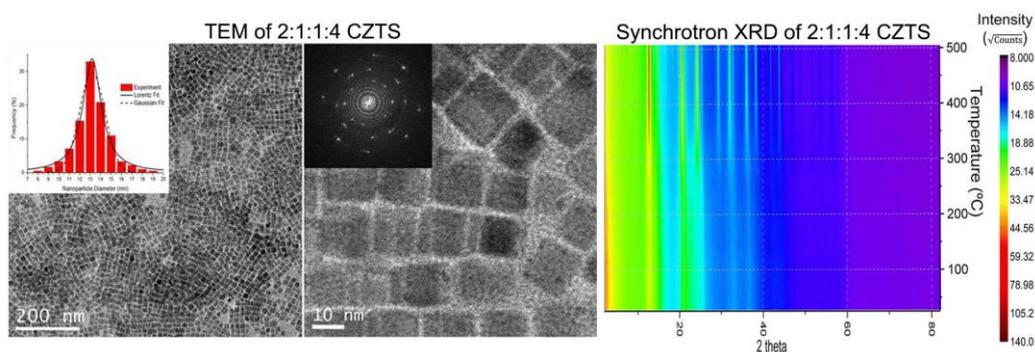
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Solar energy provides the most abundant form of renewable energy. However, there is an ongoing need to cut the cost of current silicon based photovoltaic systems. Silicon based cells are expensive and have a large embodied energy, resulting in long payback times. Economies can be obtained by using cheaper solar energy absorbers and by reducing the processing costs of producing the photovoltaic cells. Copper-Zinc-Tin-Sulfide (CZTS) nanoparticles have the potential to be the ideal absorbing layer for thin film solar cells due to their elemental availability, tuneable bandgap in the ideal region, and low toxicity (1).

We have developed a scalable, non-toxic, low temperature, water-based synthesis of high quality CZTS nanoparticles from cheap & abundant precursors. The resultant nanoparticles are identified by TEM to be nanocubes of ≈ 13 nm which are synthesized with controllable elemental stoichiometric ratios as measured by ICP-MS and negligible secondary crystal phases as determined by synchrotron XRD and Raman spectroscopy.

Our goal is to create nanocrystal based photovoltaic systems; progress on cell fabrication will be reported and results on printing of nanocrystal inks onto various substrates.



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PP034

Synthesis and optical properties of Cs-perovskite and AgI-nanoparticles

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Metal halide based semiconducting nanoparticles have emerged as a class of optoelectronic materials, which combine ease of preparation with excellent optical qualities. To control the growth and shape of CsPbX₃ (X=Br,I) perovskite nanoparticles we used tailored low-molecular weight and functionalized polymeric ligands and studied their effect on colloidal stability and their absorption and luminescence properties. We also investigated the synthesis and the optical properties of AgI-nanoparticles with variation of the precursor system. Reproducible and size-controlled preparation of uniform AgI nanoparticles in organic solvent could be achieved. The growth kinetics and structural evolution nanoparticles can be easily followed *in situ* by small-angle and wide-angle X-ray scattering (SAXS, WAXS) as well as UV-vis-spectroscopy. The shape evolution in presence of different ligands in organic solution has been studied using transmission electron microscopy (TEM).

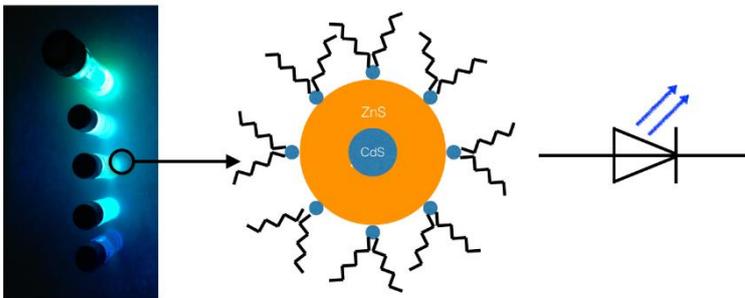
PP035

Can nanoparticles be the new efficient light emitting material for blue ?

Christian Blauth^{1,2}, Paul Mulvaney¹, Tadahiko Hirai²

¹University of Melbourne, Parkville, VIC, Australia, ²CSIRO, Clayton, VIC, Australia

Colloidal Quantum Dots (CQDs) form a novel class of semiconductors with the unique potential to revolutionise the world of electronic and optoelectronic devices. By tailoring the size of the nanoparticles, their band structure, as well as their electronic band gap are tunable. Small particles with a proportionally large band gap, resulting in blue luminescence, are particularly challenging, both in synthesis and in their incorporation in light emitting diodes (LEDs). The long term stability of light emitting diodes remains also a challenge - in particular for blue. Compared to organic LEDs emitting in the blue, CdS/ZnS core/shell nanoparticle based devices show better performance (1). Our particles' emission is highly efficient, near unit quantum yield, however, the lifetime needs to be further addressed (2). We are investigating how to improve the device performance and to identify possible degradation factors.



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- (2)- Bae, Wan Ki, et al. "Gram-Scale One-Pot Synthesis of Highly Luminescent Blue Emitting Cd_{1-x}Zn_xS/ZnS Nanocrystals." *Chemistry of Materials* 2016 (2008).

PP036

THE EFFECTS OF CONTROLLED LATERAL CONFINEMENT WIDTH AND SURFACE CHEMISTRY ON SURFACTANT ADSORPTION ONTO SILICA

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The effects of lateral confinement on an adsorbed surfactant layer are the subject explored here. The pattern used to induce confinement comprises nano-trenches with silica at the bottom, and walls of either pure polymethyl methacrylate (PMMA) or a copolymer of PMMA and methacrylic acid (MAA) to vary hydrophobicity. Atomic force microscopy was used to measure the thickness of the adsorbed surfactant aggregates within the trench structures and compared to the images and thicknesses of aggregates with no confinement. Pillar type structures have also been fabricated which will allow for confinement induced through a lack of surface area. The ultimate goal of this research is to compare the results found using these nano-structures with molecular dynamics simulations performed using similar geometric confinement.

PP037

Encapsulation of therapeutic peptides and proteins into bulk and Cubosomes lipid cubic phase

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RMIT University, Melbourne, Vic, Australia

Therapeutic peptides and proteins represent the fastest growing class of new drugs with application as therapeutics, diagnostics and in vaccines. These complex, fragile macromolecules are, however, associated with significant drawbacks including long-term stability and degradation by the human immune system. In addition, many of these therapeutics have significant hydrophobic character, which makes encapsulation and storage an issue. Encapsulation of these therapeutics in a carrier particle can both protect the protein against degradation, deliver the protein to the desired site of action, and offer controlled release properties. Lipid based particles, in particular, offer a range of advantages including potentially retaining the protein activity, and controlled release. Cubosomes are sub-micron sized (approx. 100-200nm) dispersed lipid cubic phase particles that have been shown to successfully encapsulate hydrophobic proteins and peptides in the lipid bilayer. Uptake of Cubosomes into a cellular environment has been found to be a slow process, with diffusion of therapeutic drugs across the cellular membrane over a prolonged timescale. We have formulated Cubosomes based on a mix of lipids to more successfully mimic the complexity of the native cell membrane. Peptide and protein uptake into these nanoparticles was shown to depend on the lipid composition, the cubic nanostructure, and the geometrical and charge characteristics of the encapsulated proteins. Uptake of these protein-loaded Cubosomes into a range of cell-lines was monitored using confocal microscopy.

PP038

Encapsulating Probiotics for Increased Growth of Farmed Abalone

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Probiotics have been used widely to confer health benefits to farmed aquatic animals. However, conventional methods have not been efficient to deliver probiotics in high viability, enough dosages and to specific target sites. This study aims to develop a novel method to encapsulate probiotics for aquaculture application and to develop a probiotic supplemented feed in order to stimulate the growth and survival of farmed abalone (*Haliotis iris*). Pre-formulation studies were performed to assess biochemical characteristics of host-associated probiotics contributing to feed digestion. Potential probiotics were encapsulated using emulsion technique. Several formulations were developed and compared in order to find an optimum formulation for encapsulating probiotics. Encapsulation efficiency and characterisation of microcapsules were investigated.

Exiguobacterium demonstrated biochemical characteristics for starch, and casein hydrolysis. However, *Vibrio* and *Enterococcus* showed a high ability for alginate hydrolysis and acid production respectively. The results confirmed the capabilities of the abalone-derived probiotic bacteria to enhance feed digestion in this species. Multi-strain encapsulates were formulated in order to improve delivery of the probiotics to farmed abalone. The microencapsulation results indicated promising protection of probiotics during storage and delivery. This strategy would offer various advantages to the current aquaculture practice that utilise formulated feeds, especially the abalone farming industry by shortening the cultivation period required to obtain market-sized animals.

PP039

Immunity control by crosslinked-nanogel consist of CpG-ODN and beta-glucan carrier

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CpG oligonucleotides (CpG-ODN) one of the oligonucleotides medicine are known to be strong immune activator as a adjuvant, based on bacteria genes. CpG-ODN is a recognized toll like receptor 9 (TLR9) in endosome and induces immune responses after it is taken up in antigen presenting cells (APCs). However, CpG-ODN is easy degraded by enzyme in biological fluids. To solve this issue, the development of carrier to deliver CpG-ODN into APCs has been studied. β -glucan schizophyllan (SPG) and some oligonucleotides can form a complex (denoted by ODN/SPG), which is efficient nano size carrier for oligonucleotides medicine delivery.(1-3) ODN/SPG prevents degradation by biological enzymes. We have reported that the complex comprising of SPG and CpG-ODN (CpG-/SPG) can drastically induce high immune-responses owing to a combination of Immunocyte-targeting delivery due to SPG.(4) However the immune-responses remains not enough.

According to recent studies, there was a particular range in size for molecular recognition or cellular uptake. Therefore the preparation of larger or smaller particles with CpG/SPG would enhance the present immune responses. We crosslinked CpG/SPG by mixing cCpG/SPG to obtain larger particles (denoted by cCpG/SPG) than CpG/SPG by using CpG-cCpG hybridization, where cCpG-ODN denotes the complementary sequence of CpG-ODN. The CL-CpG showed higher immune response than CpG/SPG.(5) Moreover, we have made an attempt to model cancer using ovalbumin protein with the CL-CpG. The CL-CpG indicated to be very efficient adjuvant for cancer immune therapy.

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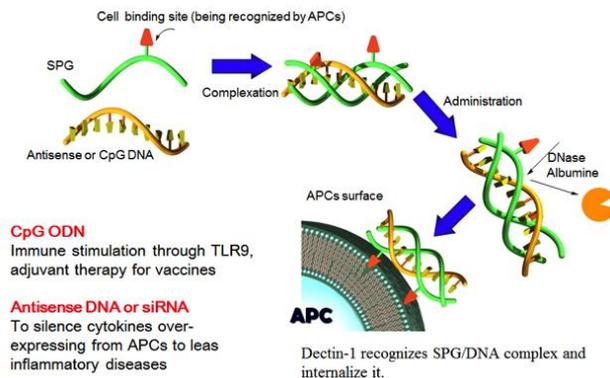
PP040

A Novel Polysaccharide Carrier for Functional Oligonucleotides: APS Targeting DDS with Dectin-1

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Oligonucleotides (ODNs) are easily decomposed in biological fluids, which makes it difficult to administrate antisense DNA or CpG motif in naked state. Cationic compounds have been used as a carrier for ODNs; however, they have drawbacks in cytotoxicity and selectivity in cellular or organ targeting. Schizophyllan (SPG) is a natural β -(1 \rightarrow 3)-D-glucan existing as a triple helix in water and as a single chain in alkaline solutions, respectively. When homo-polynucleotides such as poly(dA) are added to SPG alkaline solution and subsequently pH is adjusted to be neutral, the single chain of SPG forms a stoichiometric complex with the polynucleotide. The complex can protect the bound DNA against nuclease-mediated hydrolysis or non-specific binding to serum proteins. Furthermore, recent immunology revealed that activated antigen presenting cells (APCs) including dendritic immune cells express a receptor called Dectin-1. We have demonstrated that Dectin-1 recognizes SPG/ODN complexes, and the complex is eventually ingested by APCs. This finding suggests that SPG/ODN complex can be specifically ingested by activated APCs and the bound ODN can exert its effect after ingestion. The present talk will show our recent in-vivo and vitro studies to prove this idea and provide a new strategy to specifically transport functional ODNs including antisense-DNA, CpG-DNA, and siRNA to APCs to cure the diseases due to disorientation of immune.



PP041

Controlled release of encapsulated lactoferrin in simulated gastrointestinal conditions

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Lactoferrin (Lf) belongs to a family of iron-binding proteins and has been reported to have helped increase the bioavailability of iron and has bacteriostatic, antioxidant, anti-inflammatory and immunomodulatory properties¹. However, Lf degrades rapidly in the highly acidic environment of the stomach and may therefore not reach the intended site of action in the gastrointestinal (GI) regions. The protection against chemical degradation by gastric pH and targeted release in the small and large intestine is crucial in the efficacious food products. One approach towards targeted release can be achieved through the use of multi-layered soft shells for encapsulation². The advantages of this multi-layering technique include the protection of bioactive material from adverse conditions, flexibility of different release triggers and targeted surface adsorption of bioactives. Here, we demonstrate the development of layer-by-layer (LBL) shells of bovine serum albumin (BSA) and tannic acid (TA) for Lf encapsulation and the kinetics of their degradation under stimulated gastrointestinal conditions. Given the unique advantages of BSA-TA multi-shell design, this is a potential candidate for the targeted delivery of bioactives.

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Pulsed vapor deposition of ligand supported, chemically-synthesised clusters onto defect rich TiO₂

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Chemically synthesised, atomically precise metal clusters have been shown to be able to catalyse industrially relevant reactions under economically favourable conditions [1]. These catalytic properties have been found to be linked to the loss of bulk-like properties as these nanoclusters pass a size-threshold [2] and exhibit molecule-like structural arrangements and quantised valence Density Of States (DOS) that are unique to specific cluster sizes and quantifiable through Metastable induced Electron Spectroscopy (MIES) [3]. These clusters have shown particular promise as one part of a homogenous catalytic system along with a photosensitive semi-conductor species such as TiO₂ for the photocatalytic production of CH₄ as well as water splitting.

Chemically synthesised Au clusters are capped by PPh₃ ligands. These capping ligands ensure stability but are often a hindrance to optimal surface-cluster bond formation and catalytic species adsorption, requiring at least partial removal in order to optimise catalytic performance[4]. This process however can lead to agglomeration of the clusters and subsequent loss in activity, increasing the difficulty of surface characterisation.

Clusters, especially Au clusters are known to bind strongly to defects in titania surfaces and so deposition on a defect rich surface such as TiO₂ Nanoparticles from sol-gel synthetic methods. PPh₃ ligands are also known to remove readily on exposure to vacuum. Coupling these two pieces of information into a cluster deposition system, based on CVD methods promises a new method of affixing cluster species to substrates with minimal contamination. By preparing a sputtered or sol-gel dip coated substrate under vacuum with either calcination or ion sputtering to induce defects, clusters in solvent can be vaporised through injection into the vacuum chamber and affixed to treated surface without exposure to contaminating atmosphere or carbon species.

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PP043

Electrostatic Particle Immobilization in Gold Nanomeshes

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Capillary assembly and convective assembly techniques have been extensively studied to promote a controlled trapping of colloidal particles in patterned substrates. For an effective particle immobilization by capillary forces, the depth of the particle-traps is critical and has to be in the range of the particle radius or greater. In this contribution we focus on the controlled assembly of colloidal particles into chemically modified nanomeshes without capillary or convective forces. We demonstrate the highly defined and dense self-assembly of polystyrene particles into shallow gold nanohole arrays, purely based on electrostatic interaction forces. The glass surface within the holes is selectively functionalized with an aminosilane to obtain positively charged holes in acidic and neutral pH, thus attracting negatively charged polystyrene particles. In contrast, the Au-mesh is treated with OH-terminated thiol, which introduces a repulsive potential. Using AFM force spectroscopy with a polystyrene colloidal probe, the interaction forces were directly determined and correlated with macroscopic particle deposition experiments. In addition, we studied the impact of particle size on the occupation rate of the holes by SEM and in situ by confocal laser scanning microscopy. Tailoring the diameter of the particles relative to the geometric parameter of the nanohole array enables one to switch between multiple particle deposition and highly defined single particle adsorption. Furthermore, we found that the average number of particles in one hole can be controlled by ionic strength maintaining a good selectivity.

PP044

Gas Aggregation at Sub-microscale Investigated by Synchrotron Radiation Technique

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Interfacial gas bubbles at nanoscale are drawing more and more attention due to its superstability and potential applications such as surface cleaning, mineral flotation and protein folding, etc. However, what is inside nanobubbles to explain their long lifetime is still lacking and other techniques except atomic force microscopy to study the property of nanobubbles are not sufficient. Here, we reported that the existence and behavior of interfacial gas nanobubbles confined between two silicon nitride windows are investigated by a synchrotron-based Scanning Transmission X-ray Microscopy (STXM) with nanometer resolution. More importantly, the chemical information of nanobubbles is also explored. Also, X-ray Fluorescence technique was used to investigate the absorption of Krypton on porous materials or surfactant containing solution. Our study showed that synchrotron radiation techniques were promising techniques to study the aggregation of gases near the solid/water interfaces at the nanometer scale.

PP046

Testing the Epstein-Plesset theory: stability of surface nanobubbles in undersaturated aqueous environments on silanised silicon wafer surfaces

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Surface nanobubbles are nanoscopic gas domains on hydrophobic surfaces. The most-cited Epstein-Plesset theory predicts that the lifetime of a bubble with a radius of curvature of 1 micron or less should not exceed 1/100 sec. However long-lived surface nanobubbles have been reported using techniques such as AFM. The EP theory assumes the supersaturation of the bulk solution whilst experimental conditions have been reported to be non-supersaturated. We test the hypothesis that supersaturation in the bulk is required for the stability of nanobubbles by 1) creating nanobubbles on silanised silicon wafer surfaces in aqueous environments, 2) confirming that they are nanobubbles not nanodroplets and 3) subjecting the nanobubbles to undersaturated aqueous solutions. AFM images show the nanobubbles remain in undersaturated aqueous solutions over several hours. This result directly challenges the assumptions behind the EP theory and explanations for the stability of surface nanobubbles built on this theory such as pinning of the three phase line.

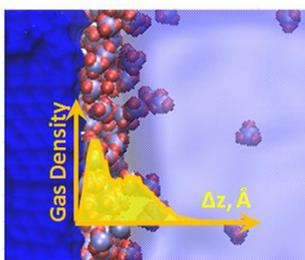
PP047

The Interfacial Gas Enrichment in Promoting Gas Hydrate Formation by Solid Particles

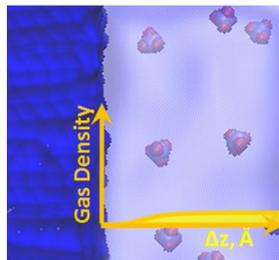
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The interfacial gas enrichment (IGE) at the water-solid interface is an interesting phenomenon and can be important for many processes such as nano-bubble formation, gas hydrate formation and flotation. In this work, we have employed molecular dynamics simulation (MD) and experiments to study the effect of surface hydrophobicity on the formability of IGE. We show that a strong IGE layer of either CH₄ or CO₂ is observed at a hydrophobized solid surface whereas a gas depletion layer exists at a hydrophilized solid surface. It is also found that while CH₄ can completely expel water molecules to form a dense gas layer at the hydrophobized surface, CO₂ coexists with water in a mixture. The MD and experiments show that the hydrophobicity of gas and solid surfaces is a determining factor for the formation of IGE. The outcome of this study enhances our knowledge about the influence of hydrophobicity of solid surfaces on gas hydrate formation, bubble formation and bubble-particle contact.



Hydrophobic surface



Hydrophilic surface

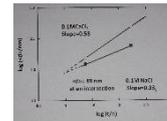
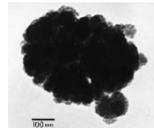
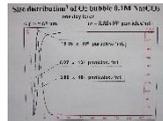
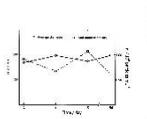
PP048

Universal DLCA kinetics of O₂ and CO₂ gases-filled nanobubbles in 0.1 M CaCl₂

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We have studied the kinetics of O₂ and CO₂ nanobubble cluster aggregations in 0.1M CaCl₂ at late stages with NanoSight Nanoparticle Tracking Analysis(NTA). We show the universality of diffusion limited cluster-cluster irreversible aggregation (DLCA) regime using the nanobubble cluster aggregation. The DLCA kinetics exhibits a power law with the growth exponent of $(1-g)/d_f$, average diameter $\langle d \rangle \sim t^{(1-g)/d_f}$, $g = 0$, Fractal dimension $d_f = 1.75$, $(1-g)/d_f = 0.57$, t : time [1, 2]. We obtained growth exponents of 0.58 and 0.60 for O₂ and CO₂ in 0.1 M CaCl₂. The values of growth exponents are very close to that of the growth exponent in DLCA regime. This suggests that Brownian nanobubble aggregation can be described by DLCA kinetics. O₂ and CO₂ nanobubble solutions were produced with a commercially available bubble generator, operating a 20min's circulation at 34 °C. The number average hydrodynamic diameter and the zeta potential of O₂ nanobubbles were 84nm and -42mV. We measured the time dependence of the average diameter, $\langle d \rangle$ and total number density, n_t of O₂ nanobubbles in pure water. We find a fluctuation appeared in the dependence. We also observed CaCO₃ precipitates from O₂ bubble 0.1M Ca(NO₃)₂ and O₂ bubble 0.1M Na₂CO₃ with TEM. A hollow CaCO₃ particle TEM image reveals 7nm diameter voids and 2.7 nm void - void surface distance. We conjecture the existence of nanobubble clusters composed of ~7nm diameter bubbles from NTA and TEM results. O₂ nanobubble 0.1M CaCl₂ solution was prepared with CaCl₂ powders and O₂ nanobubble water. DLCA kinetics requires large interbubble attraction such as hydrophobic interaction[3]



[1] M. Lin, H. Linsay, D. Weitz, R. Ball, R. Klein, P. Meakin; Nature, 339, 360(1989)

[2]

P. G. I. Van Dongen, M. H. Ernst; PRL, 54, 1396(1985)

[3] Rico F. Tabor et al, J. Phys. Chem. Lett. 4, 3872(2013)

PP049

Oxygen Nanobubbles Prepared by Microwave

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A new method for generating nanobubbles by microwave irradiation was verified and quantified. AFM measurement showed that nanobubbles with diameters ranging from 200 to 600 nm were generated at a water-HOPG surface by applying microwave radiation to aqueous solutions with 9.0–30.0 mg/L dissolved oxygen. The generation of bulk nanobubbles in the pure water solution was measured by nanosight NTA method. The thermal and nonthermal effects of microwave radiation made contributions to decreasing the gas solubility, thus facilitating nanobubble nucleation. The generation of nanobubbles could be well controlled by adjusting the gas concentration, microwave power, or irradiation time. The microwave method may be valuable in preparing nanobubbles quickly and conveniently for various applications, such as catalysis, hypoxia/anoxia remediation, and templates for preparing nanoscale materials.

