10:00  Arrival and registration

10:40  Welcome  
Stuart Prescott  
Complex Fluids Group, UNSW Chemical Engineering

10:45  Mobility of nanocarriers through complex networks for targeted drug delivery  
Firoozeh Babayekhorasani, Patrick Spicer  
Complex Fluids Group, UNSW Chemical Engineering

11:00  Surface Plasmon Resonance (SPR) technology to ‘epitope bin’ antibodies targeting perlecan; a multi-domain proteoglycan  
Zehra Elgundi, P Bean, John Whitelock, Megan Lord  
UNSW Biomedical Engineering, CSIRO

11:15  Using SPR to study the effect of a solid-binding peptide on a fusion protein  
Rachit Bansal, A Care, Zehra Elgundi, Megan Lord, A Sunna  
Macquarie University, UNSW Biomedical Engineering

11:30  Using neutrons to thoroughly interrogate a NIPAM brush layer  
Ben Humphreys, Edwin Johnson, Grant Webber, Erica Wanless, Stuart Prescott, Andrew Nelson, Elliot Gilbert  
University of Newcastle, UNSW Chemical Engineering, ANSTO

11:45  The effect of humidity and temperature on an unsolvated, thermo-responsive polymer brush  
Isaac Gresham, Ben Humphreys, Edwin Johnson, Grant Webber, Erica Wanless, Andrew Nelson, Patrick Spicer, Stuart Prescott  
UNSW Chemical Engineering, University of Newcastle, ANSTO
12:00 Specific ion effects on the thermoresponse of POEGMA polymer brushes in mixed ion environments
Edwin Johnson, Timothy Murdoch, Isaac Gresham, Ben Humphreys, Stuart Prescott, Andrew Nelson, Grant Webber, Erica Wanless
University of Newcastle

12:15 “Elevator pitches” for posters

12:30 Lunch and posters
Sponsored by UNSW Chemical Engineering

13:30 Quantification of long-range forces for underwater superoleophobic surfaces
Ahmed Owais, Truis Smith-Palmer, Angus Gentle, Chiara Neto
University of Sydney, University of Technology Sydney, St Francis Xavier University

13:45 Confining steric stabilisers at the oil/water interface: specific ion effects and complexation with surfactants
Zengyi Wei, Andrew Nelson, Patrick Spicer, Stuart Prescott
Complex Fluids Group, UNSW Chemical Engineering, ANSTO

14:00 Synthesis of graphene-based polymeric nanocomposite materials via Pickering miniemulsion polymerization using graphene oxide as surfactant
Yasemin Fadil, Florent Jasinski, Stuart Thickett, Hideto Minami, Per Zetterlund
Centre for Advanced Macromolecular Design, UNSW Chemical Engineering, University of Tasmania, Kobe University

14:15 Liquid phase effects on electrostatically formed liquid marbles
Casey Thomas, S Fujii, Peter Ireland, Grant Webber, Erica Wanless
University of Newcastle, Osaka Institute of Technology

14:30 Development and characterisation of smart chitosan-based hydrogel for direct nose-to-brain drug delivery
Hanieh Gholizadeh, Michele Pozzoli, Daniela Traini, Paul Young, Agisilaos Kourmatzis, Shaokoon Cheng, Hui Xin Ong
Woolcock Institute, Macquarie University, University of Sydney
14:45  Afternoon tea

15:15  Bioinspired nanomaterials for sensing and drug delivery  
*Plenary lecture*  
Rona Chandrawati  
UNSW Chemical Engineering

16:00  Characterisation of industrial adhesives with spectroscopy and microscopy  
Kash Bhullar, J Thevarajah, A Rebmann, S Cheevers, R Wuhrer, Patrice Castignolles, Marianne Gaborieau  
Western Sydney University

16:15  Bioengineered growth factor binding molecules for vascular tissue repair  
Ha Na Kim, John Whitelock, Megan Lord  
UNSW Biomedical Engineering

16:30  The effects of heparin conjugated cerium oxide nanoparticles on angiogenesis  
Lu Fu, John Whitelock, Megan Lord  
UNSW Biomedical Engineering

16:45  Particle-scale studies of ultrasound and temperature effects on cubosome and hexasome formation  
Haiqiao Wang, Vincent Poulichet, Patrick Spicer  
Complex Fluids Group, UNSW Chemical Engineering

17:00  Close
Mobility of nanocarriers through complex networks for targeted drug delivery

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This work aims to advance our fundamental understanding of how nanocarriers interact with different biological environments, using natural mimic structures as model systems. The underlying dynamics of particle transport through biological networks, like cellular cytoplasm and biofilms, provides significant insights into engineering nanocarriers for optimal targeted drug delivery and cancer treatment. Confinement by rigid hard obstacles, and compliant soft matrices, alters the transport of nanoscale particles in complex media. Within biological cells, nanoscale cargos diffuse through the crowded cytoplasm and a network of rigid microtubules and/or semi-flexible actin filaments.[1,2] Similarly, delivering drugs, diagnostics, or therapeutic agents to targeted human tissues requires transport through a rigid extracellular matrix and the extracellular fluid volume,[3,4] or through the highly selective blood–brain barrier.[5] In these media, diffusive and transport mobility of nanoparticles is hindered by crowding and by confinement, conditions in which their dynamics are still largely unknown.

In this study, we will utilize optical microscopy techniques, along with image analysis and single particle tracking, to investigate mobility of nanocarriers moving through different complex media, to understand their environmental interactions. Diffusive mobility of nanoparticles, characterized by time dependent mean squared displacement, shows slowed and sub-diffusive dynamics as particles are hindered by the media. Mobility of nanoparticles confined by rigid geometrical structures, and by dynamic or semi-dynamic networks, is not only controlled by hydrodynamic interactions, but also by depletion interactions. The distribution of particle displacements is non-Gaussian, consistent with the spatial heterogeneity of the geometrical confinement imposed by the surrounding media. Such insights enable more accurate prediction of targeted delivery based on knowledge of local tissue microenvironments.

Surface Plasmon Resonance (SPR) technology to ‘epitope bin’ antibodies targeting perlecan; a multi-domain proteoglycan

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Perlecan is a major heparan sulfate proteoglycan of basement membranes, a specialised form of the extracellular matrix. The core protein is comprised of five domains with each domain involved in modulating diverse cellular processes through interactions with molecules such as growth factors and cytokines [1]. With an integral role in regulating cell adhesion and migration in angiogenesis, the role of perlecan is being studied in tumorigenesis as well as its application as a novel therapeutic target.

We have generated a panel of monoclonal antibodies that specifically target human perlecan to study its role in the tumour microenvironment. We have employed surface plasmon resonance (SPR) technology using a Biacore™ system to perform a binning campaign by organising the antibodies into distinct bins based on their binding profile to recombinantly expressed perlecan domains. SPR is an optical method that measures in real-time and without labelling, changes in mass and density as molecules interact and complexes form on a gold surface.

A classical sandwich approach was taken to classify antibodies in terms of their ability to block or sandwich pair with one another to identify antibodies that exhibit unique epitopes. These antibodies will be screened in a series of cell-based assays to correlate functional activity to binding epitopes. These studies will provide insight into the function of the individual domains and their interactions with other molecules as well as elucidate the role of perlecan in healthy and pathological conditions.

Using SPR to study the effect of a solid-binding peptide on a fusion protein

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Solid-binding peptides (SBPs) are short amino acid sequences that display binding affinity towards the surfaces of solid materials e.g. metals, metal oxides, carbon materials, polymers, and minerals [1]. Unlike conventional bioconjugation methods (e.g. adsorption and covalent cross-linking), SBPs are able to direct the immobilisation and orientation of proteins onto solid supports without impeding their functionality.

We have developed and applied an innovative bioconjugation platform based on a genetically-engineered fusion protein, Linker-Protein G (L-PG). L-PG comprises two functionally distinct regions; (a) an SBP sequence (referred to as the ‘Linker’), which binds silica-based materials, (b) and Streptococcus Protein G’, which binds antibodies [2]. L-PG acts as an anchor for the immobilisation of antibodies onto silica surfaces without the need for any complex chemical reactions. Using L-PG as a model, this project aims to better understand the mechanisms of the interaction between the Linker and silica surfaces, and any influence it has on the immobilisation and functionality of its fusion partner.

To determine if Linker fusion had any effect on the antibody-binding function of PG, we measured the binding kinetics between PG (with and without the Linker) and antibodies using Biacore. This instrument is based on surface plasmon resonance (SPR) and enables label-free, real-time quantitative studies of protein-protein interactions. When compared to PG (K_D=6.3 nM), L-PG (K_D=7.8 nM) displayed only a marginally lower binding affinity towards antibodies but faster association and dissociation rates. In real time, while the half-life (t_1/2) of the PG-antibody complex is 130.20 min, it is almost half for L-PG (72.63 min). Furthermore, the Linker alone showed no measurable affinity towards antibodies, indicating that only the PG region of L-PG is responsible for the specific binding of antibodies. These results show that the linker has minimal influence on its fusion partner, and therefore can be used as a platform technology for the functional immobilisation of proteins (including antibodies).

Using Neutrons to Thoroughly Interrogate a NIPAM Brush Layer

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The internal structure of a thermoresponsive poly(N-isopropylacrylamide) (PNIPAM) brush coating has been investigated via neutron reflectometry for planar substrates and small angle neutron scattering (SANS) for colloidal particle substrates.¹ The polymer chains were synthesised following the activators continuously regenerated by electron transfer atom transfer radical polymerisation (ARGET ATRP) method from covalently bound sites on the substrate; a ‘grafted from’ approach enabling polymer chains to be end tethered at a grafting density high enough to be influenced by neighbouring chains (the polymer brush regime).

PNIPAM is a thermoresponsive polymer with an entropically driven lower critical solution temperature (LCST). For aqueous solutions, below the LCST (~32 °C), the polymer will hydrogen bond with water molecules solubilising the chains. Above the LCST, the entropic penalty from solubilising the hydrophobic regions of the polymer becomes too great, and PNIPAM becomes insoluble. When tethered to a surface in the polymer brush regime, the brush layer is swollen at low temperatures and collapsed above the LCST. Furthermore, this abrupt LCST broadens into a temperature transition range spanning 10-20 °C.²

We have examined the influence of molecular weight, ionic strength and salt identity on the temperature induced swelling/collapse transition of PNIPAM brushes using ellipsometry, quartz crystal microbalance with dissipation, atomic force microscopy, contact angle measurements and dynamic light scattering.¹-² These techniques provided a detailed understanding of bulk and surface properties of the PNIPAM systems investigated. The use of neutrons to interrogate these systems, however, has enabled subtle variation in the brush volume fraction profile normal to the substrate to be elucidated (Fig. 1). This highlights any variations related to surface curvature, brush thickness, surface confinement, ionic strength and salt identity.

![Figure 1](image.png)

**Figure 1.** Fitted volume fraction profiles for a PNIPAM brush on a planar substrate as a function of (a) temperature, (b) ionic strength and salt identity at 32.5 °C and (c) fitted volume fraction profiles for PNIPAM brush on a curved substrate as a function of temperature.


The effect of humidity and temperature on an unsolvated, thermoresponsive polymer brush

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Surfaces decorated with densely-tethered polymer chains – referred to as polymer brushes – have been shown to possess desirable anti-biofouling, lubricating and optical properties that are directly dependent on their structure.\textsuperscript{1} These surfaces can be engineered to exhibit a structural response to stimuli such as pH, temperature, and the presence of specific ions and molecules, resulting in surfaces with controllable properties. One such system is a Poly(N-isopropylacrylamide) (PNIPAM) brush, which (when solvated) forms a diffuse thermoresponsive layer that exhibits a lower-critical solution temperature (LCST) type behaviour, undergoing an entropy-driven collapse as temperature is increased. Whilst the stimulus response of this polymer brush (and many others) are well characterised for a range of solvated polymer brush systems, little is known of the response exhibited by unsolvated polymer brushes (i.e. exposed to atmosphere). Previous work in this area has examined the use of these systems in sensing devices\textsuperscript{2,3} and their response to relative humidity.\textsuperscript{4}

Here we present a neutron reflectometry study of the effects of both water partial pressure (a better descriptor of brush behaviour than relative humidity) and temperature on the water content and thickness of a PNIPAM polymer brush. We are able to observe significant changes in solvent content with both temperature and humidity, as well as capture some of the dynamics of the temperature and pressure response. Furthermore, we report the formation of voids within the brush upon a sudden change in water partial pressure. These findings have implications for the characterisation of dry polymer brush systems, as well as for the development of polymer brush sensing surfaces. The experimental methodology and mapping of the temperature-humidity response presented here will enable further study of unsolvated polymer brush response.

Figure 1: a) Volume fraction of water within the polymer brush layer, plotted as a function of partial pressure for different temperatures, illustrating the significant response of the PNIPAM brush to both humidity and temperature. b) Scattering length density and c) reflectivity profiles for a PNIPAM brush at 40°C with increasing water pressures.

Specific ion effects on the thermoresponse of POEGMA polymer brushes in mixed ion environments

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The poly(polyethylene glycol methacrylates) (POEGMAs) are a family of thermoresponsive polymers which undergo temperature induced conformational changes.[¹] A switch in hydrophobicity of these polymers occurs at the lower critical solution temperature (LCST). For polymers in the brush regime, this behaviour manifests principally as changes in brush thickness. The temperature induced swelling/collapse transition of POEGMA brushes has been shown to be influenced by the concentration and identity of ions present in the system.[²] Single salt studies on POEGMA brushes show that the transition is shifted to higher temperatures in the presence of chaotropic (salting-in) ions, such as thiocyanate, or to lower temperatures in the presence of kosmotropic (salting-out) ions such as acetate.

Despite a wide range of investigations into specific ion effects for single electrolyte systems, limited work exists for systems of salt mixtures as would commonly be found in application environments.[³] Recently an investigation on the behaviour of a POEGMA brush in mixed salt environments of potassium acetate and thiocyanate has been undertaken using neutron reflectometry (NR), and quartz crystal microbalance with dissipation (QCM-D). NR shows that the thiocyanate ions have a dominant effect in influencing the overall thickness of the polymer with the brush increasing in swelling ratio in all mixed salt conditions. Conversely, QCM-D indicates that the acetate has a greater effect on the stiffness of the polymer chains.

![Figure 1: Volume fraction profiles of a 13 nm POEGMA brush in D₂O (purple), 125 mM KSCN (green), 125 mM KSCN + 125 mM KCH₃COO (red), and 125 mM KSCN + 250 mM KCH₃COO (red) as determined by NR.](image_url)

Quantification of long-range forces for underwater superoleophobic surfaces

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Lubricant-infused surfaces that have slippery and anti-fouling properties have attracted great attention due to their promising impact on many medical, environmental, and industrial applications.1 However, as their function relies on a lubricant layer being trapped in the surface roughness, it is crucial to reach a thorough understanding of the factors that determine the lubricant layer stability. In this work, the long-range van der Waals interactions that are responsible for the stability of thin lubricant films were quantified and the conclusions qualitatively tested against experimental results. Here, the system studied was a structured surface that has underwater superoleophobic properties: a wrinkled layer of hydrophilic poly(4-vinylpyridine) (P4VP), prepared on a shrinkable substrate2. Lifshitz theory3 was used to estimate the Hamaker constant for the system, as a function of P4VP layer thickness. In addition, the capillary effect of trapping water in the specific surface micro- and nanostructure developed through the spontaneous wrinkling of the P4VP surface was estimated. Wrinkled P4VP surfaces with micro-scale wrinkles showed low adhesion to different oils with water droplet roll-off angle of 6° ± 1°, however the theoretical calculations showed that the P4VP is not an ideal polymer for such an application. Other polymers are being identified, for which adhesion of oil can be decreased by minimizing the contact area between the oil and the surface, and by stabilizing the infused water layer.

Underwater roll-off angle of a paraffin oil droplet on (A) wrinkled P4VP film with wrinkle width 1300 nm, and (B) wrinkled P4VP film with wrinkle width 90 nm.

References

Emulsion-based industrial formulations require the addition of amphiphilic molecules at the interface to prevent flocculation, creaming, coalescence, thereby improving colloidal stability and hence achieving desired end-product properties. The addition of stabilisers results in a complex colloidal system consisting of oil, water, surfactants, polymers, electrolytes and many other additives. For instance, a typical hair conditioner contains polydimethylsiloxane (PDMS) stabilised by Pluronic polymers in a buffer solution. Understanding the complex interactions between the components and the conformation of stabilisers at the oil/water interface is key to designing an industrial formulation.

We have employed an end-attached PDMS brush layer as a model oil system for studying interfacial structures of Pluronic polymers in a salty environment and evaluating the efficiency of mixed stabilisers for PDMS emulsions. In this study we will rationalise the efficiency of mixed stabilisers against coalescence and describe the response of Pluronic polymers to salts and confined geometries (when two oil droplets are forced in close proximity). Neutron reflection shows that Pluronic F127 forms a loosely packed layer at the PDMS/water interface. Addition of low concentration SDS swells the PEO segments whilst increasing SDS concentration results in the desorption of F127. Similar competitive adsorption behavior was seen for CTAB/F127 mixtures. With 1 bar of confinement, both SDS/F127 and CTAB/F127 mixtures form a thick mixed polymer/surfactant layer of 10 nm. There is a diffuse layer of mixed surfactants on top of the dehydrated thick layer. Increasing the confinement pressure, we see further dehydration of the polymer/surfactant complex layer.

The effect of salt on the adsorption behaviour was also investigated by neutron reflection. Addition of different sodium halide salts leads to the collapse of the adsorbed F127 layer and the effect is larger for more kosmotropic anions. In confined geometries, F127 alone is difficult to dehydrate and collapse. Salt is seen to have little effect on the collapse of the Pluronic layer in the confined geometry. Little change was observed in reflectivity profiles across 3 confinement strengths. This is in agreement with our previous measurements of F127 in water solution that 7 bar is required to fully dehydrate the adsorbed layer.

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Figure 1: SDS/F127 complex at the PDMS/water interface.

Figure 2: CTAB/F127 complex at the PDMS/water interface.
Synthesis of graphene-based polymeric nanocomposite materials via Pickering miniemulsion polymerization using graphene oxide as surfactant

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ABSTRACT

Graphene is a remarkable organic material due to its unique mechanical, thermal and electrical properties, and has great potential as filler in polymer composites to improve the properties for specific applications such as electronics, adhesives, and coatings. We have developed a convenient and industrially scalable method for synthesis of homogeneous nanocomposite films comprising poly(styrene-stat-butyl acrylate) and nanodimensional graphene oxide (GO) or reduced GO (rGO). The method involves synthesis of an aqueous nanocomposite latex via miniemulsion copolymerization using GO nanosheets as sole surfactant, followed by ambient temperature film formation. Similar latexes prepared by physical mixing of a polymer latex with an aqueous GO dispersion result in phase separation, demonstrating that the miniemulsion approach is key to obtaining homogeneous nanocomposite films. The GO sheets can be easily reduced to rGO by heat treatment of the film to restore the properties of graphene. Miniemulsion polymerization of styrene, as related to the above, can be conducted successfully using GO as sole surfactant, but the polymerization rate is very low. However, introduction of SDS in the system results in a substantial rate enhancement as a result of alternative nucleation pathways in addition to monomer droplet nucleation in the form of nucleation of monomer droplets stabilized by both GO and SDS, nucleation involving free GO sheets as “seeds” as well as homogeneous nucleation. These results represent a substantial step forward in terms of our understanding of the fundamental polymerization mechanism of these Pickering miniemulsion systems, which will aid in preparation of advanced nanocomposite materials based on polymer and graphene (oxide).
Liquid phase effects on electrostatically formed liquid marbles

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Small liquid droplets stabilised by hydrophobic particles, known as liquid marbles, are applied in a number of areas including gas sensing, cosmetics and microfluidics.¹² Both research and commercial interest have increased significantly recently in order to diversify the gas or liquid phase to improve the formation process and stability. Typically, liquid marbles are formed by rolling a liquid droplet on top of a bed of particles, resulting in particle attachment at the gas-liquid interface. An alternate, non-contact method of liquid marble production, using electrostatics to transport particles to a suspended liquid droplet, over a separation distance, has been developed within our group (Figure 1).³ Removing the contact requirement for liquid marble formation has allowed for the investigation of a large particle range, including particles with lower contact angles, such as polymer latexes, which also construct non-spherical shaped aggregates.⁴

![Figure 1: Transport of polypyrrole coated polystyrene to a suspended liquid droplet over a separation distance using electrostatics.](image)

This study examines the impact of altering liquid phase characteristics, such as surface tension, conductivity and viscosity on the formation and stability of polystyrene latex particle coated droplets. Particular applied potentials allow for the electrostatic transfer of particles to the droplet interface, studied via changing bed-drop separation. Modifying the latex particles, through the addition of a conductive polymer shell, can be used to assess the impact of the liquid to the transfer of hydrophobic, spherical monodisperse particles in the presence of an electric field.

Development and characterization of smart chitosan-based hydrogel for direct nose-to-brain drug delivery

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Intranasal administration of neurotherapeutic agents is an exciting potential alternative to conventional systemic drug delivery methods as it offers direct access to the brain bypassing the blood brain barrier that restricts the transfer of drugs into the central nervous system. However, the main physiological barrier that limits brain targeted nasal drug transport is the rapid nasal mucociliary clearance system, which decreases the nasal residential time of drugs. Amongst the strategies to improve the bioavailability of therapeutic agents in the brain, the development and application of smart polymeric systems responding to physiological stimuli has recently generated great interest due to their capability to release drugs at the target site of action for prolonged period of time. Chitosan (Chit) is one such polymer that is widely used in polymeric drug delivery systems that possesses characteristics of biocompatibility, biodegradability, controlled release, transient tight junction modulator, low cost and non-toxicity.\textsuperscript{1,2} In the present work, a smart drug delivery system combining Chit biopolymer with β-glycero phosphate (β-GP) as the gelling agent has been developed for direct nose-to-brain delivery of ibuprofen, a model drug chosen for the treatment of Alzheimer’s Disease (AD). The efficacy of ibuprofen and other nonsteroidal anti-inflammatory drugs have been shown to decrease the risk of AD development via their anti-inflammatory effects on the aggregation of β-amyloid in brain tissue.\textsuperscript{3}

The prepared Chit-β-GP hydrogel is liquid at room temperature, offering ease of nasal spray administration, while it undergoes a phase transition and forms a viscous gel as the temperature reaches physiological temperature of 37 °C. The in-situ formed gel is promising to increase the nasal drug residential time by overcoming the mucociliary clearance. The gelation time of the thermoresponsive Chit-β-GP was optimized by evaluating the influence of Chit and β-GP concentrations. Solutions of Chit and β-GP were prepared with varying concentrations (1-2 %w/v and 50-70 %w/v, respectively) and mixed at different volumetric ratios (4:1, 4:2, and 4:2:5).

A rapid 4 min gelation was observed for the Chit-β-GP containing Chit 1.2 %w/v and β-GP 26.9 %w/v in the final mixture. Hence, formation of the mucoadhesive gel occurring at a much faster rate compared to the rate of mucociliary clearance (approximately 20 min) would have significant advantage in drug retention in the nasal cavity.\textsuperscript{4} Additionally, the phase transition process was characterized in terms of the increase in the storage modulus, viscosity (G') by increase in temperature (20-40 °C). Accordingly, the sol-gel transition temperature, was found to be 33 °C. This feature makes the proposed Chit-β-GP system suitable for gelation at the nasal cavity temperature (34 °C), which could provide a sustained residence of drug that is essential for improving brain uptake of the drug. The solubility of ibuprofen in Chit-β-GP was also measured 1271.64 μg/mL, which 60 times higher than the standard solubility (21 μg/mL). Further studies on the biological properties of the prepared smart polymeric system for in-vitro drug testing is underway in our laboratory.

Bioinspired Nanomaterials for Sensing and Drug Delivery
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Biological systems have the most remarkable features, with living cells being able to sense and discriminate biomolecules in complex media with high specificity and sensitivity while controlling 100,000 chemical reactions in each second to carry out specific metabolic activities. This talk will provide an overview of our research in mimicking biological cell architecture and biological processes leading to the design of advanced materials for sensing and drug delivery.

The detection of target chemical and biological molecules in a specific and sensitive manner is critical for the development of disease diagnostic devices. Membrane fusion is a key biological event that involves a highly selective recognition mechanism for molecular trafficking, facilitating communication between and within cells. The highly evolved fusion process can occur on a sub-millisecond timescale. The rapid response, specificity, and sensitivity make membrane fusion an attractive mechanism for sensing. In this work, we report an assay using liposomes to mimic lipid membrane fusion mechanism for the detection of cancer protein biomarkers (matrix metalloproteinases) and miRNA influenza biomarkers at subnanomolar concentrations. By tuning the recognition elements, this platform may be used for sensing other chemical and biological targets, including proteins, drugs, and cells.

Next, we developed a bottom-up approach to assemble synthetic and biological building blocks into cell-like entities. We extracted organelles (biological building blocks) from cells and fabricated enzyme-loaded liposomes (synthetic building blocks), and we encapsulated both components into alginate beads to mimic biological cell architecture. We demonstrated multiple parallel reactions within the cell mimics and showed that the functional activity of the organelles was preserved. This system offers opportunities in drug delivery applications for replenishing missing or deficient cellular activity.

Characterisation of industrial adhesives with spectroscopy and microscopy

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Adhesives are an important class of industrial polymers with applications ranging from adhesive tape and sticky notes through to resins used in mines. This presentation will showcase the development of a new hot-melt adhesive to repair conveyor belts in mines.

Conveyor belts commonly used in the mining industry to haul ore can breakdown due to wear or failure. Any downtime in the production process is very costly. A repair tool of choice is in this case a hot-melt adhesive: it can be applied quickly, and once applied it does not require a long curing time until it has the desired properties that the process demands. Since there are many possible sources of physical and chemical stress in a mining process, the adhesive needs not only to be strong in its adhesive properties and its flexibility, but also very stable against mechanical stress, heat, UV radiation, acids, bases and other aggressive chemicals, mostly hydrocarbons.

The base resin thus needs to be strengthened by the right combination of additives. ATR FT-IR, and solid-state NMR spectroscopies were assessed for their potential to reveal the composition and homogeneity of the final product. Furthermore, tensile tests were investigated under the scanning electron microscopy. The results were used to evaluate the final product, RubbaFIX® (www.rubbafix.com.au) and how the material deforms under stress.¹

Figure 1: Importance of reliable characterisation methods for the elucidation of the relationship between the synthesis (or formulation) and the functional properties of industrial adhesives.

Bioengineered growth factor binding molecules for vascular tissue repair

Ha Na Kim, John Whitelock and Megan Lord

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Molecules that naturally bind and signal growth factors in tissue development and repair are proteoglycans that are composed of a protein decorated with sulfated glycosaminoglycan chains. These molecules are present in low abundance from natural sources, so their application in tissue engineering requires the development of bioengineered variants. This project has a focus on serglycin, an intracellular proteoglycan that can be decorated with all glycosaminoglycan chain sub-types including chondroitin, dermatan and heparan sulphate and heparin and known to bind a variety of growth factors and cytokines involved in vascular tissue repair (Figure 1). The aims of this study are to (1) express serglycin in mammalian cells as a proteoglycan and (2) explore its structure and biological activity in terms of vascular growth factor binding and signalling.

Bioengineered serglycin was expressed in human embryonic kidney cells as a proteoglycan decorated with chondroitin, dermatan and heparan sulphate and heparin as determined by ELISA and Western blotting. The bioengineered serglycin was found to bind and signal fibroblast growth factor 2 (FGF2), a mitogenic growth factor, through its heparin/heparan sulphate chains as determined in the BaF32 cell assay [1]. Similarly, binding of vascular endothelial growth factor 165 (VEGF165), an angiogenic growth factor, to bioengineered serglycin was observed by surface plasmon resonance and involved the different glycosaminoglycan chains decorating the bioengineered serglycin.

Overall, these data demonstrate that bioengineered serglycin possesses vascular growth factor binding and signalling properties through its glycosaminoglycan chains. The next phase of the project will explore the incorporation of the bioengineered serglycin into biomaterials for delivery of growth factors for vascular repair applications.

Figure 1 Schematic of bioengineered serglycin with its glycosaminoglycan chains possessing vascular growth factor binding properties that in the future will be incorporated into biomaterials for growth factor delivery tissue repair applications

The effects of heparin conjugated cerium oxide nanoparticles on angiogenesis

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Angiogenesis is a vital process required to support the oxygen, nutrient and waste exchange for most tissues. Many tissue engineering constructs to lack the ability to support angiogenesis, thus strategies that support angiogenesis are needed for advances in tissue engineering. Angiogenesis is also essential for cancer development and metastasis and has become a very promising target for inhibiting cancer. Heparin is a linear negatively charged polysaccharide that, in addition to its anticoagulant action, can influence angiogenesis. The unique structural diversity and the high amount of negative charges allow heparin to interact with several proteins through heparin-binding domains and to regulate many cell functions. Cerium oxide nanoparticles (CNPs), due to their reactive oxygen species (ROS) scavenging activity, have been explored for a wide variety of applications including modulating cancer progression. The project aims to develop CNPs with different heparin coated surfaces with a focus on understanding the mechanisms of interaction between heparin coated CNPs and the vasculature as either pro- or anti-angiogenic therapeutics.

We have developed three different types of heparin conjugated CNPs by covalently conjugating different amounts of unfractionated heparin (UFH) and low molecular weight heparin (LMWH) to the surface of the CNPs. These heparin functionalised CNPs are roughly 12 nm in size and have face-centred cubic phase structure in morphology as determined by high-resolution transmission electron microscopy (HRTEM) and X-ray diffraction (XRD) respectively. The successful functionalization of CNPs with heparin was qualitatively verified by attenuated total reflectance-fourier transform infra-red spectroscopy (ATR-FTIR) and X-Ray Photoelectron Spectroscopy (XPS). Additionally, thermogravimetric analysis (TGA) demonstrated the conjugation of heparin on the surface of CNPs with approximately 1.5μmol UFH, and either 1.2μmol or 5.7μmol LMWH conjugated per gram of CNPs. Besides, exposure of the particles to human umbilical vein endothelial cells (HUVECs) showed that none of the CNP or heparin functionalised CNP preparations were cytotoxic to these cells at concentrations up to 1.5 μg/mL, while higher concentrations up to 7.5 μg/mL were cytotoxic. The heparin functionalised CNPs were selectively localised in lysosomes and correlated to their limited ROS scavenging activity as well as their activation of fibroblast growth factor signalling pathways. These data demonstrate the potential of heparin-functionalised CNPs to dose-dependently modulate key processes in angiogenesis.
Particle-scale studies of ultrasound and temperature effects on cubosome and hexasome formation

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Soft particles of cubic and hexagonal liquid crystalline phase, cubosomes and hexasomes, form different shapes based on phase symmetry but are also affected by processes used to make them. Liquid crystalline particles with nanometer length scales are made by a top-down method like sonication.¹ Particles show a lot of variations in shape, even though they are the same phase. For example hexasomes shaped like spheres, flat hexagonal prisms, and three-dimensional bicones can all be found in systems with the same composition if made by different processes.² Simulation and experimental studies of bulk hexagonal phases indicates structural alignment is possible above characteristic flow and deformation rates but controlled studies have not been carried out for cubosomes and hexasomes.³,⁴

In this work, a systematic study of hexasome shape variation is carried out by using an ultrasonic sample cell mounted on a microscope slide⁵, allowing high-speed imaging of the formation of hexasomes and cubosomes in situ (Figure 1a). Ultrasound-generated bubbles oscillate and create micro-streaming flows that break down the bulk phase and form nano and microparticles, as shown in Figure 2b. In this process, the bulk phase is liquefied before being broken down, and particles form and deform under the shear generated by the oscillating bubbles. Particles that have ordered shapes appear not to be fragments of bulk phase, but rather recrystallised particles of liquefied droplets of the yielded bulk phase, Figure 1c. Particle shapes depend on the intensity of processing and rheological properties of the bulk phase. Phases with a lower elastic modulus can more easily yield and deform in a high-intensity field, forming ordered shapes more easily. This study gives a new, particle-level perspective on a much-used technique for creating liquid crystalline particles and controlling their shapes.

Figure 1. (a) Device schematic; (b) hexasomes via sonication; (c) recrystallised hexasome from droplet.

Poster session and lunch

Supported by UNSW Chemical Engineering

**Specific Ion Effects: A Quantum Chemical Investigation**
Kasimir Gregory, Erica Wanless, Grant Webber, Alister Page
*University of Newcastle*

**Electrostatic Formation of Liquid Marbles & Aggregates: Consumer and Complex Marbles**
Benjamin Lobel, Peter Ireland, Grant Webber, Syuji Fujii, Erica Wanless
*University of Newcastle*

**Modifying biofilm materials properties by media rheology**
Goldina Kwandou, Patrick Spicer
*UNSW Complex Fluids Group*

**Optimised biomimetic surfaces toward novel bioengineered vascular grafts**
Shouyuan Jiang, John Whitelock, Jelena Rnjak-Kovacina, Megan Lord
*UNSW Biomedical Engineering*

**Surface functionalisation of silk biomaterials using plasma immersion ion implantation to covalently bind molecules in their bioactive state for vascular applications**
Kieran Lau, Fengying Tang, Megan Lord, John Whitelock, Marcela Bilek, Jelena Rnjak-Kovacina
*UNSW Biomedical Engineering*

**Can microstructures and molecular dynamics help predict digestibility of rice?**
Matthew Van Leeuwen, Giovanni Barbosa, Rachelle Ward, Elliot Gilbert, Jitendra Mata, Patrice Castignolles, Marion Gaborieau
*Western Sydney University*

**Improving separation of glucans in capillary electrophoresis for monitoring in-vitro digestion of starch online**
James Lee, James Oliver, Daniel Waters, Chris Blanchard, Marianne Gaborieau, Patrice Castignolles
*Western Sydney University*

**Controlling droplet deposition on super-hydrophobic surfaces with microfibrous cellulose**
Wenjia Tang, Patrick Spicer
*UNSW Complex Fluids Group*

**Adsorption of Proteins onto Silica Surface during Characterisation using Capillary Electrophoresis**
Mar-dean Du Plessis, Aidan Grosas, Joel Thevarajah, Marion Gaborieau, Patrice Castignolles
*Western Sydney University*

**Non-spherical Droplets Production: Interfacial Crystallization and Microfluidic Approaches**
Haoda Zhao, Patrick Spicer
*UNSW Complex Fluids Group*

**Synthesis of perdeuterated and selectively deuterated phospholipids and lipids for neutron applications**
Nageshwar Rao Yepuri, Tamim Darwish, Anwen Krause-Heuer, Marina Cagnes, Peter Holden
*ANSTO*

**Monitoring the chemical degradation of polyamides used in the mining industry by CE and NMR**
Pierre Blin, John Whitelock, Jelena Rnjak-Kovacina, Megan Lord
*Western Sydney University*

**Branching in poly(acrylic acid) obtained by conventional or controlled radical polymerisation**
Alison Maniego, Adam Sutton, Yohann Guillaumeuf, Catherine Lefay, Mathias Destarac, Christopher Fellows, Patrice Castignolles, Marion Gaborieau
*Western Sydney University*