

30TH AUSTRALIAN COLLOID AND SURFACE
SCIENCE STUDENT CONFERENCE

CONFERENCE HANDBOOK



30TH ACS SSC

Kioloa Coastal Campus, Kioloa NSW
February 1 – 4, 2016

<https://colloid-oz.org.au/30acsssc/>

The 30th Australian Colloid and Surface Science Student Conference is held under the Auspices of the Australasian Colloid and Interfaces Society (ACIS) <https://colloid-oz.org.au/>.



The 30th ACSSSC is proudly hosted by



THE UNIVERSITY OF
SYDNEY



Australian
National
University

Local organising committee:

Chiara Neto, *The University of Sydney*

Liam Scarratt, *The University of Sydney*

Gregory Warr, *The University of Sydney*

Saffron Bryant, *The University of Sydney*

Vince Craig, *The Australian National University*

Virginia Mazzini, *The Australian National University*

30th Australian Colloid and Surface Science Student Conference: *Conference Handbook*, 30th ACSSSC, February 1 – 4, 2016.

WEBSITE: <https://colloid-oz.org.au/30acsssc/>

Titlepage photo: aerial view of the Kioloa Coastal Campus. Downloaded from <http://kioloa.anu.edu.au/>

The ACSSSC logo, printed on the titlepage, represents an AFM cantilever tip scanning an Australia-shaped self-assembled bilayer.

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PREFACE

Welcome to the 30th Australian Colloid and Surface Science Student Conference! Welcome to the 70 students and 20 staff who have travelled to beautiful Kioloa from all over Australia, and from many parts of the world (Canada, France, Ireland, UK, Sweden, Switzerland), to share the wonderfully collegial and friendly atmosphere that is the characteristic of the Australian student conferences.

Being hosted by the University of Sydney and the Australian National University, the 2016 student conference is the last in a long tradition of meetings, established almost 50 years ago as a forum for students in the colloids and interface science area to present their work in a supportive environment. Many student attendees over the years have established at the student conference new friendships and collaborations that have lasted a lifetime. We hope you will too.

For the second time, the student conference is being run under the auspices of the Australasian Colloids and Interface Society (ACIS), an inclusive organisation that brings together everyone in Australia and New Zealand (and beyond) who is interested in colloid and interfacial science, engineering and technology. As attendees of the conference, you are all now members of ACIS. This student conference should be an opportunity for students to get to know ACIS well, and to get involved directly with organising and expanding its initiatives. For this purpose, everyone, especially students, should attend the yearly ACIS Annual General Meeting (AGM), which will be held on Wednesday afternoon.

We have a full schedule of talks (the most important rule of the student conference is: you must attend every talk!), an intense social program and a special initiative to look forward to this year: the career advice session, with a panel of experts in career building for postgraduate students. There are three awards up for grabs: the ECIS / ACIS award for best oral-presentation which supports attendance to the September 2016 meeting of the European Colloid & Interface Society (ECIS) in Rome; the Hunter-Healy award also for best oral presentation; and the best poster prize. So please give these your best shot, and do stand next to your posters during the poster session!

We hope that you enjoy the 30th Australian Colloid and Surface Science Student Conference and the many attractions of the Kioloa beach and bush at your doorstep. Get involved in all the activities, enjoy the science, and have a great time!

Chiara Neto and Liam Scarratt – Conference Chairs, ACSSSC 2016

ORIGINS OF THE ACSSSC



In 1967 Bob Hunter and Tom Healy started the tradition of the Australian Colloid and Surface Science Student Conference.

These conferences have provided postgraduate students of colloid and surface science with an opportunity to present and discuss their research in an informal, supportive and friendly atmosphere.

PREVIOUS CONFERENCES

no.	date	location	state	delegates	presentations
30	Feb 2016	Kioloa	NSW	89	66
29	Feb 2014	Ballarat	VIC	98	65
28	Feb 2012	Newcastle	NSW	100	62
27	Feb 2010	Adelaide	SA	133	64
26	Feb 2008	Warrnambool	VIC	137	70
25	Feb 2006	Beechworth	VIC	131	79
24	Feb 2004	Sunset Cove	QLD	116	74
23	Sep 2002	Lake Hume	NSW	114	66
22	Feb 2001	Bendigo	VIC	110	64
21	Sep 1999	Morpeth	NSW	143	78
20	Feb 1998	Hahndorf	SA	141	84
19	Sep 1996	Murramarang	NSW	118	74
18	Feb 1995	Fairy Meadow	NSW	185	86
17	Feb 1993	Geelong	VIC	144	72
16	Sep 1991	Roseworthy	SA	118	66
15	Jan 1990	Camden	NSW	87	45
14	Aug 1988	Albury	NSW	107	48
13	Feb 1987	Kioloa	NSW	55	36
12	Feb 1985	Roseworthy	SA	49	28
11	May 1983	Yarrowood	VIC	51	30
10	Feb 1982	Mt. Eliza	VIC	70	32
9	May 1980	Kioloa	NSW	45	25
8	Nov 1978	Yarrowood	VIC	53	27
7	Sep 1977	Melbourne/ Blackwood	VIC/SA	34	18
6	May 1976	Canberra	ACT	33	20
5	Nov 1974	Sydney/ Woy Woy	NSW	39	21
4	May 1973	Melbourne/ Blackwood	VIC/SA	30	—
3	Feb 1972	Sydney	NSW	—	10
2	Aug 1970	Melbourne	VIC	14	12
1	May 1968	Sydney	NSW	—	—
0	May 1967	Melbourne	VIC		(informal meeting)

INFORMATION ON YOUR STAY AT KCC

Please be considerate of the environment and of other people during your stay at the Kioloa Coastal Campus (KCC).

Please limit noise and movement late at night and early in the morning.

Housekeeping

Phone reception is poor on the Coastal Campus — wi-fi is freely available. The use of *cottage kitchens* (where available) is NOT included in your registration fee. If you do use them, this will incur an extra fee.

Drinking water is the rain water collected from the roofs.

Sewage and waste: all the field station waste is processed by a worm farm.

Please don't use toxic or antiseptic soaps, and don't flush any toxic or foreign materials down the toilets.

Firewood — take firewood only from the wood heaps supplied.

Fires may only be lit in the designated fireplaces, provided no Total Fire Ban is in force, by the Campus Manager.

WI-FI ACCESS

connect to 'ANU-Access';

open web browser;

insert credentials:

USERNAME KILOLA

PASSWORD Ki0l0@

'0' is zero

'l' lowercase L

Beach and water safety

Alcohol is not permitted on the beach.

No fires are permitted on beaches at any time.

The beach at Kioloa is NOT patrolled by lifeguards: be very cautious even if you are a strong swimmer and never swim alone. If you are not a strong swimmer, we advise entering the water only up to your knees.

Don't swim under the influence of alcohol or drugs.

Make sure you understand what *rip currents* are and spend some time checking for their presence before entering the water.

If you get caught in a rip, DON'T PANIC: do not swim against the rip as you will tire quickly. Either swim to the side, or let it take you out to the back of the surf and signal for help.

Shorebird conservation: please follow the instructions given by signs on the beaches to help preserve native endangered shorebirds.

RIP CURRENTS
are dangerous if
you are
unprepared.

Information [here](#) and
[here](#).

Smoking

Smoking is prohibited in all shared places and within 10 metres of any building. In all other circumstances smokers should consider the rights and comfort of non-smoking companions.

Smokers should take all due care to prevent starting a fire.

Check-out — to be completed on Thursday before talk session starts

Please remove all of your items from your room and bathroom.

If you hired a linen pack, please leave the bed made as you slept in and put the towels in the baskets provided.

Please *sweep out your room* and leave it in a reasonable state of cleanliness.

Dispose of all the litter, shut all windows and doors, turn off all lights.

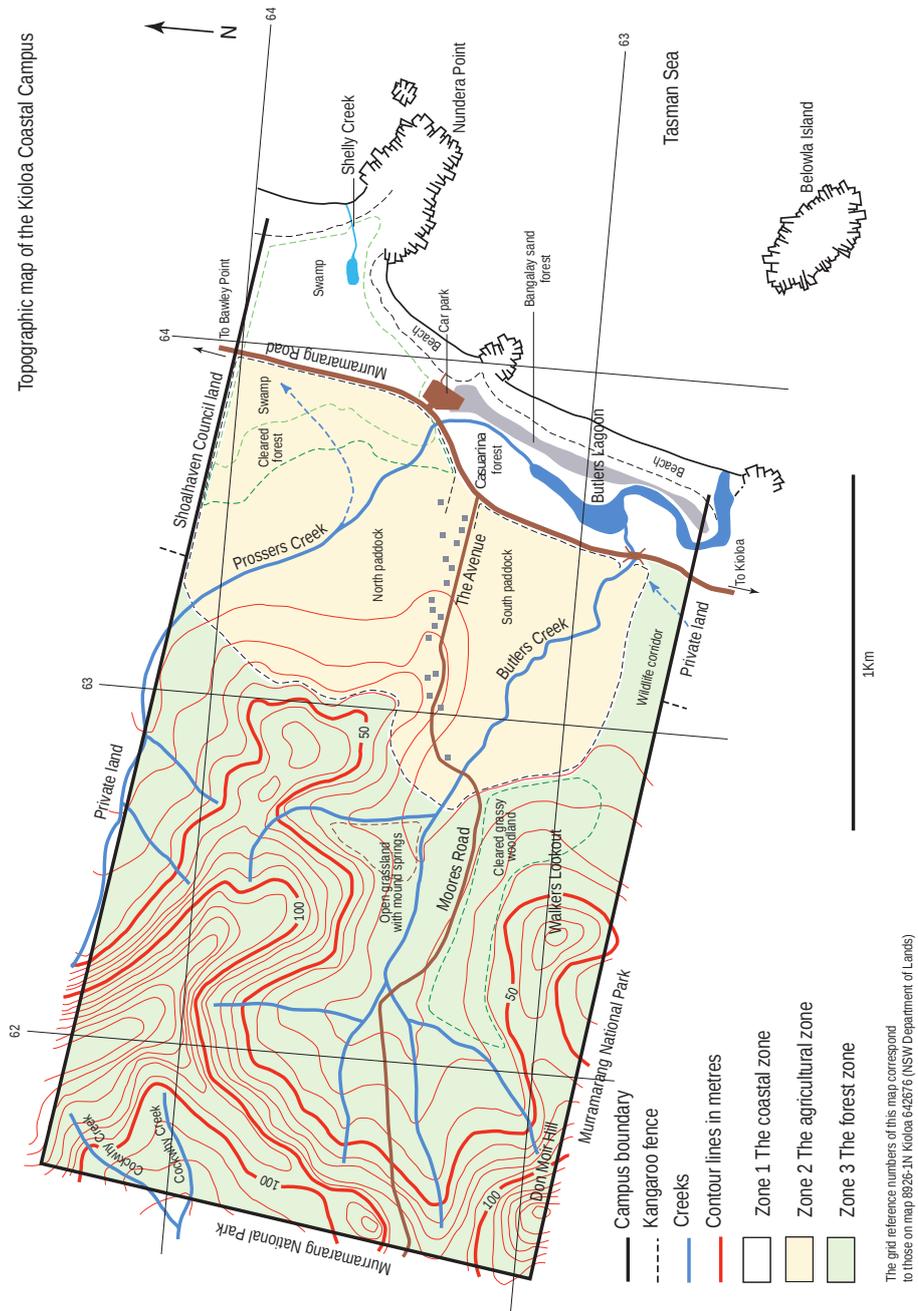
If unreported damage is found or extra cleaning is required after you leave, all of the room occupants will be charged for the additional fees incurred by the Conference Organisation.

Take your luggage
to the London
Shed, where it will
be stored until
departure.

MAPS

KIOLOA COASTAL CAMPUS TOPOGRAPHY

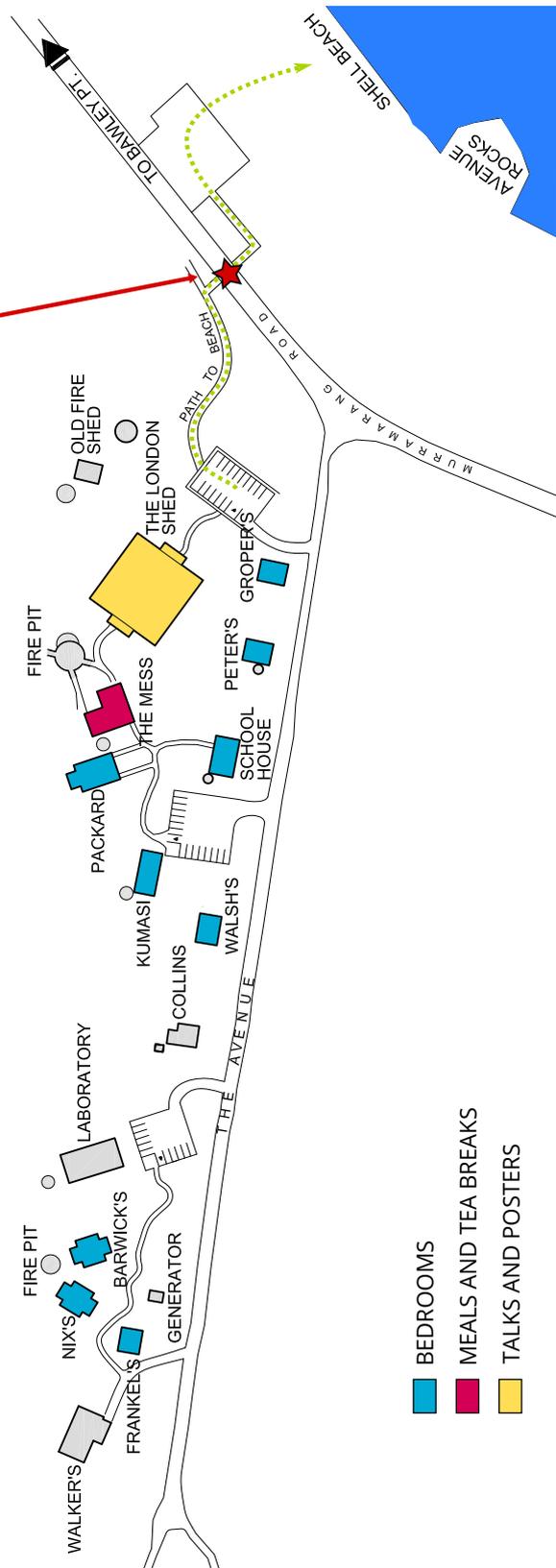
http://kioloa.anu.edu.au/_documents/topographic-map.pdf



VENUE MAP adapted from

http://kioloa.anu.edu.au/_documents/accommodation/2013-mud-map-kioloa.pdf

**This road is speed limited at 80 km/h and can be busy at times.
CARE SHOULD BE TAKEN AT ALL TIMES WHEN CROSSING!**



CONFERENCE AWARDS

HUNTER-HEALY AWARD

The Healy-Hunter Award honours the founders of the Australian Colloid and Surface Science Student Conference; Professor Tom Healy (The University of Melbourne) and Professor Bob Hunter (University of Sydney), who first organised such a conference in 1967. The conferences have been held regularly since this time.

The Award, which highlights and recognises the most outstanding student oral presentation at the conference, consists of a commemorative medal and a contribution towards the travel costs of attending an international conference. In 1998, a Royal Australian Chemical Institute Award Trust was formed as a result of the generous financial support of many Australian surface and colloid science researchers and research groups. Students enrolled at an Australian university are eligible candidates for this Award.

Guidelines

All staff attending the student conference are eligible to vote. Supervisors may vote for their own PhD students if so desired. In judging the Award, staff consider the quality of science, oral/visual skills, and construction and flow of the presentation. In the event of a tie in the voting, the Chair of the RACI Division of Colloid and Surface Science (or nominee) will have the casting vote. The Award can be won only once by any individual.

Previous winners of the Award:

2014	Michael Neeson	The University of Melbourne
2012	Ashish Kumar	University of Melbourne
2010	Robert Hayes	University of Newcastle
2008	Luke Parkinson	IWRI, University of South Australia
2006	Jacqui McRae	Swinburne University of Technology
2004	Drew Evans	The Australian National University
2002	Nicola Richards	IWRI, University of South Australia
2001	Rod Harris	LaTrobe University
1999	Wuge Briscoe	IWRI, University of South Australia
1998	Janine Burns	University of Newcastle

ECIS/ACIS AWARD

The ACIS/ECIS Award recognises the most outstanding student oral presentation at the student conference, by a student typically in their second or third year of PhD.

The Award consists of a contribution towards costs for attending the European Colloids and Interface Society (ECIS) Conference in the same year as the student conference, with the (reciprocal) agreement that the ECIS conference registration will be waived by our European colleagues.

The Award was established in 2013 as a result of the links between the Board of Australasian Colloids and Interface Society (ACIS) and the Board of ECIS, and aims to strengthen and expand the scientific connections between the two Societies.

Guidelines

A number of staff attending the student conference will be chosen to be on the selection panel, and will nominate a winner and two runners-up. In judging the Award, staff consider the quality of science, communication skills, presentation style and ability to answer questions.

Eligibility

Students enrolled at an Australian university for less than 36 months at the time of the student conference are eligible candidates for this Award.

Students must be available to attend the ECIS conference in the same year as the student conference, and must be able to cover the additional costs for travel and accommodation not covered by the Award.

The Awardee cannot be the Awardee of the Hunter-Healy Award in the same year. The Award will be transferred to the chosen candidate, after attendance of the ECIS conference, as reimbursement upon presentation of receipts.

If the first chosen candidate is not available to attend the ECIS conference that year, they should notify ACIS as soon as possible, and the funds will be used to support attendance of the runner-up. The Award for Australian students is administered by the Awards Committee of ACIS.

Previous winner of the Award:

2014 Catherine Fung University of South Australia

POSTER PRIZE

A prize for best poster presentation and a runner up prize will be selected by a panel of 4 - 6 staff members.

PLENARY LECTURE

sponsored by



Australian Government



Multifunctional Materials for Electronics and Photonics

Federico Rosei

UNESCO Chair in Materials and Technologies for Energy Conversion, Saving and Storage
Centre for Energy, Materials and Telecommunications, INRS,
1650 Boul. Lionel Boulet, J3X 1S2 Varennes (QC), Canada

The bottom-up approach is considered a potential alternative for low cost manufacturing of nanostructured materials.¹ It is based on the concept of self-assembly of nanostructures on a substrate, and is emerging as an alternative paradigm for traditional top down fabrication used in the semiconductor industry. We demonstrate various strategies to control nanostructure assembly (both organic and inorganic) at the nanoscale. We study, in particular, multifunctional materials, namely materials that exhibit more than one functionality, and structure/property relationships in such systems, including for example: (i) control of size and luminescence properties of semiconductor nanostructures, synthesized by reactive laser ablation;² (ii) we developed new experimental tools and comparison with simulations are presented to gain atomic scale insight into the surface processes that govern nucleation, growth and assembly;³ (iii) we devised new strategies for synthesizing multifunctional nanoscale materials to be used for electronics and photovoltaics.⁴

BIOGRAPHICAL DETAILS

Federico Rosei has held the Canada Research Chair in Nanostructured Organic and Inorganic Materials since 2003. He is Professor and Director of Institut National de la Recherche Scientifique, Énergie, Matériaux et Télécommunications, Université du Québec, Varennes (QC) Canada. Since January 2014 he holds the UNESCO Chair in Materials and echnologies for Energy Conversion, Saving and Storage. He received MSc and PhD degrees from the University of Rome 'La Sapienza' in 1996 and 2001, respectively.

Dr. Rosei's research interests focus on the properties of nanostructured materials, and on how to control their properties when grown on suitable substrates. He has extensive experience in fabricating, processing and characterizing inorganic, organic and biocompatible nanomaterials. He has published over 200 articles in prestigious international journals, has received several awards and honours, has been invited to speak at international conferences, seminars, colloquia and public lectures in 42 countries on all inhabited continents.



- 1 Rosei, F. J. *Phys.: Condens. Matter* **2004**, *16*, S1373–S1436, DOI: [10.1088/0953-8984/16/17/001](https://doi.org/10.1088/0953-8984/16/17/001).
- 2 Riabinina, D. et al. *Phys. Rev. B* **2006**, *74*, 075334, DOI: [10.1103/physrevb.74.075334](https://doi.org/10.1103/physrevb.74.075334).
- 3 Dunn et al., **2009**, DOI: [10.1103/physrevb.80.035330](https://doi.org/10.1103/physrevb.80.035330); Ratto et al., **2006**, DOI: [10.1002/sml.200500345](https://doi.org/10.1002/sml.200500345); Ratto et al., **2006**, DOI: [10.1103/PhysRevLett.96.096103](https://doi.org/10.1103/PhysRevLett.96.096103); Ratto et al., **2008**, DOI: [10.1088/0957-4484/19/26/265703](https://doi.org/10.1088/0957-4484/19/26/265703); Ratto et al., **2008**, DOI: [10.1016/j.susc.2007.10.025](https://doi.org/10.1016/j.susc.2007.10.025).
- 4 Yan et al., **2010**, DOI: [10.1002/adma.200903589](https://doi.org/10.1002/adma.200903589); Yan et al., **2010**, DOI: [10.1021/ja103743t](https://doi.org/10.1021/ja103743t); Nechache et al., **2011**, DOI: [10.1002/adma.201004405](https://doi.org/10.1002/adma.201004405); Nechache et al., **2011**, DOI: [10.1063/1.3590270](https://doi.org/10.1063/1.3590270); Chen et al., **2012**, DOI: [10.1039/c2cc33396a](https://doi.org/10.1039/c2cc33396a); Chen et al., **2012**, DOI: [10.1002/adfm.201200900](https://doi.org/10.1002/adfm.201200900); Nechache et al., **2012**, DOI: [10.1039/c2nr31429k](https://doi.org/10.1039/c2nr31429k); Toster et al., **2013**, DOI: [10.1039/c2nr32716c](https://doi.org/10.1039/c2nr32716c); Dembele et al., **2013**, DOI: [10.1016/j.jpowsour.2013.01.075](https://doi.org/10.1016/j.jpowsour.2013.01.075); Li et al., **2013**, DOI: [10.1039/c3cc40363g](https://doi.org/10.1039/c3cc40363g); Dembele et al., **2013**, DOI: [10.1021/jp403553t](https://doi.org/10.1021/jp403553t); Nechache et al., **2014**, DOI: [10.1038/nphoton.2014.255](https://doi.org/10.1038/nphoton.2014.255).

CAREER SESSION

sponsored by



A panel of scientists from academic and industrial backgrounds will provide their insights in the Career Session for Higher Degree Research Students and Early Career Researchers.

Confirmed members of the panel are Prof Federico Rosei, Dr Alice Williamson and Mr Mark Ovens.

Federico Rosei is Professor and Director of INRS, Université du Québec, Canada. See page [xiii](#) for a short biography.

Federico is also the author of the book 'Survival Skills for Scientists', Imperial College Press, 2006.

The central theme of the book is that succeeding in science requires skills (often referred to as 'soft professional skills') beyond basic scientific ones.

Dr Alice Williamson is a research chemist, lecturer and science communicator based at The University of Sydney. Originally from the North West of England, Alice completed her PhD at The University of Cambridge, where she worked with colleagues to develop two new reactions.

Alice moved to Australia to take up a position as the lead synthetic chemist for the Open Source Malaria (OSM) consortium. OSM are the world's only open source drug discovery project and are trying to prove that science is better and more efficient when all data and results are shared. Alice makes new medicines in the lab, helps to coordinate the international team and tries to encourage people to join the project. She has also set up some unusual collaborations with high school students and undergraduates who have made new drugs designed to kill the malaria parasite.

In addition to her research, Alice has been lecturing chemistry for the past two years and developing skills as a science communicator. In February 2015, she was named as one of ABC RN and UNSW's 'Top 5 Under 40' in recognition of her passion for sharing science stories. She has been an active participant in science outreach events across Sydney and in June 2015, Alice took up a weekly science slot on FBi Radio's breakfast show.

Mr Mark Ovens is in Business Development for AMSI (the Australian Mathematical Sciences Institute) Intern servicing AMSI's partnership with a cluster of universities in Sydney under the co-investment program. Mark's role is focused on driving internships in NSW, initially with University of Sydney and UTS. With this experience, he brings a clear understanding of what's required of students seeking internships in industry — and what industry is looking for.

Before joining AMSI, Mark worked in professional services organisations with human resources activities for over 15 years. Mark has led and directed many of private industries change management programs, including personally coaching and mentoring staff in all aspects of career management. This included significant recruitment and career development activities in the private sector with Adecco, Lee Hecht Harrison and Morgan & Banks.

Prior to this, Mark held Senior Human Resources roles in Bayer & Allergan and has in-depth understanding of management practices, industry challenges, research and development and he brings a commercial edge and extensive industry network.

Mark holds a BSc in Psychology.



LIST OF PARTICIPANTS

The University of Sydney

Adamson, William
Al-Khayat, Omar
Bryant, Saffron
Duong, Hien
Facchin, Manuela
Jiang, Haihui Joy
Lam, Thu
Neto, Chiara
O'Toole, Patrick
Scarratt, Liam
Shou, Keyun
Warr, Greg

The Australian National University

Alheshibri, Muidh
Craig, Vincent
Eom, Namsoon
Mazzini, Virginia

The University of Melbourne

Bai, Tianyi (Alisa)
Berry, Joseph
Biviano, Matthew
Bolton, Christopher
Brisson, Emma
Chellappan, Sriharini
Crust, Adam
Dagastine, Raymond
de Godois Baroni, Érico
Höfgen, Eric
Kusuma, Tiara
Law, Samuel
Mettu, Srinivas
Ng, Wei Sung
Pinches, Samuel
Scales, Peter

Monash University

Ali, Muthana
Bisset, Nicole
Boyd, Ben
Du, Joanne
Garusinghe, Uthpala
Hong, Linda
Huang, Ziwei
Khan, Jamal
May, Kellie
McCoy, Thomas
Meagher, Laurence
Mendoza, Llyza Ellena
Moore, Jackson
Onur, Aysu
Pottage, Matthew
Prathapan, Ragesh
Raj, Praveena
Tabor, Rico
Thapa, Rajiv
Tripathi, Sumit
Turpin, Loughlin
Yeow, Natasha

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Dahiya, Prerna
Kwandou, Goldina
Martin, Corey
Prescott, Stuart
Song, Jie
Spicer, Patrick
Wang, Haiqiao
Wei, Zengyi

The University of Queensland

Meldrum, Oliver
Tasker, Alison

**Queensland University of
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Rathnayake, Suramya

University of South Australia

Abaka-Wood, George

Kaur, Simarprett

**Royal Melbourne Institute of
Technology (RMIT)**

Sarkar, Sampa

Varun Prasath, Babu Reddiar

Yu, Haitao

Zhang, Xuehua

The University of Newcastle

Humphreys, Ben

McDonald, Samila

Murdoch, Timothy

Stefanovic, Ryan

Wanless, Erica

Webber, Grant

Willott, Joshua

University of Wollongong

Higgins, Michael

Puckert, Christina

Zheng, Tian

**Australian Mathematical Sciences
Institute (AMSI), Melbourne**

Ovens, Mark

**Australian Nuclear Science and
Technology Organisation (ANSTO)**

Mata, Jitendra

University of Geneva, Switzerland

Oncsik, Tamas

University of Sheffield, UK

Cunningham, Victoria

University College Cork, Ireland

Zychowski, Lisa

Stockholm University, Sweden

Gordeyeva, Korneliya

**Institut National des Sciences
Appliquées de Lyon, France**

Sallet, Pauline

**INRS-EMT, Université du Québec,
Canada**

Rosei, Federico

SCIENTIFIC & SOCIAL PROGRAM

MONDAY	TUESDAY	WEDNESDAY	THURSDAY
8:00	7:30 BREAKFAST	BREAKFAST	BREAKFAST
BREAKFAST	9:00		ROOM CLEAN-UP AND CHECKOUT
	FREE TIME	FREE TIME	CHAIR: O. AL-KHAYAT (B.BOYD)
9:30	CHAIR: V.MAZZINI (V.CRAIG)	J.KHAN (R.TABOR)	9:20 O35 — Garusinghe
FREE TIME	10:00 O8 — Martin	O22 — Rathnayake	9:40 O36 — Crust
	10:10 O9 — Mata		10:00 O37 — Du
10:30 MEP SPONSORED MORNING TEA	10:20 O10 — Eom	O23 — Gordeyeva	10:20 O38 — Huang
	10:40 O11 — Oncsik	O24 — Zychowski	10:40 O39 — Yeow
11:00	11:00 O12 — McDonald	O25 — Dahiya	11:00 O40 — Bisset
REGISTRATION	11:20 O13 — Adamson	O26 — Tripathi	11:20 O41 — Yu
	11:40 O14 — Law	O27 — Kusuma	11:40 O42 — Duong
	12:00 O15 — Puckert	O28 — Bolton	12:00 CLOSING REMARKS
	12:30 LUNCH	LUNCH	LUNCH
13:00 LUNCH available until 15:00	CHAIR: S.BRYANT (G.WARR)	T.ZHENG (E.WANLESS)	
	13:30 O16 — Cunningham	O29 — Al-Khayat	DEPART BY 14:00
	13:50 O17 — Willott	O30 — Chellappan	
14:00 REGISTRATION	14:10 O18 — Raj	O31 — Ng	
	14:30 O19 — Zheng	O32 — Brisson	
15:00 OPENING REMARKS	14:50 O20 — Lam	O33 — Murdoch	
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16:00 AFTERNOON TEA	16:00		
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16:50 O2 — Thapa			
17:10 O3 — Bryant			
17:30 O4 — Khan		17:30 ACIS ANNUAL GENERAL MEETING	
17:50 O5 — Sallet			
18:10 O6 — Pinches	18:00		
18:30 O7 — Sarkar	DISCUSSION/ FREE TIME		
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Life in Hydrocarbons: Membranes and Vesicles in Non-Aqueous Systems

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Speculations on the existence of life forms outside Earth include exotic metabolic chemistry in Titan's liquid hydrocarbon lakes. If one considers the possibility of life in hydrocarbons and if one accepts the basic requirements for life, then one can envisage two different types of mechanism for organism formation in the methane lakes of Titan. The first kind includes Earth-like organisms: for example, some propose that compartmentalization — a key requirement for life — might be achieved in liquid methane by self-assembly of conventional surfactant molecules (e.g. phosphatidylcholine) to form reverse liposomes in a hydrocarbon medium.¹ The second alternative implies completely reversing the paradigm of life-as-we-know-it-on-Earth in order to adapt it to the hydrocarbon solvent. This second option is at the basis, for example, of simulated membrane structures dubbed “azotosomes”, based on nitrogen containing molecules that were calculated to be stable and elastic at the cryogenic temperatures of liquid methane.²

With the aim of determining the viability of the latter “reverse paradigm” experimentally, we synthesized two different “reverse” surfactants — i.e. bearing a hydrophilic tail and a lipophilic head — and we attempted to observe whether they would form molecular assemblies in hydrocarbon solvents. Our experimental structural data based on SAXS do in fact show the formation of organized molecular aggregates! In particular, for one of the surfactants we observed typical micellar structures with a 20 Å radius having presumably the lipophilic heads of the surfactant facing outwards towards the hydrocarbon solvent and the hydrophilic tail condensed in the nucleus. We were able to calculate its critical micelle concentration in hexane. The second surfactant, with a larger critical packing parameter, showed the formation of other types of structured aggregates, currently being investigated.

We think we have demonstrated experimentally that it is possible to form self-assembled typical micelles of reverse surfactants in a hydrocarbon solvent. This observation implies that there may be a “reverse option” when searching for alien life. In particular, it is possible to envisage different reverse surfactants able to form bilayers and vesicles that would provide the foundation for membrane mimics in hydrocarbons.

¹ Norman, L. H. *Astron. Geophys.* **2011**, *52*, 1–39, DOI: [10.1111/j.1468-4004.2011.52139.x](https://doi.org/10.1111/j.1468-4004.2011.52139.x).

² Stevenson, J. et al. *Sci. Adv.* **2015**, *1*, e1400067, DOI: [10.1126/sciadv.1400067](https://doi.org/10.1126/sciadv.1400067).

Interactions of Carbon Nanomaterials with Biomimetic Membranes

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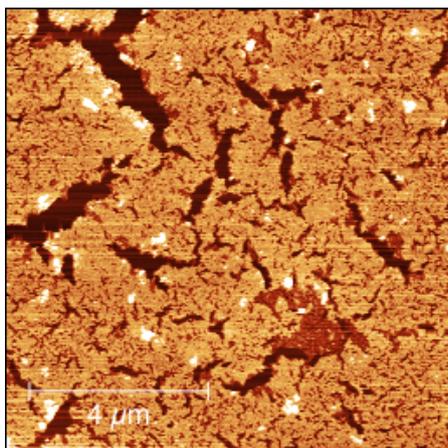


Figure 1: AFM image of lipid (DOPC) bilayer

Carbon nanomaterials (CNMs) are being widely studied for their potential applications in biomedical and biological fields, including as scaffolds, in drug delivery, biosensing, etc. However, the interaction of carbon nanomaterials with biological molecules including proteins and biomembranes needs to be addressed before any of these applications can be achieved. Little is known about the specific interaction of CNMs with cell membranes. We are working to address some of these fundamental questions regarding the interaction of carbon nanomaterials — graphene oxide (GO), reduced graphene oxide (rGO) and carbon nanotubes (CNTs) with biomimetic membranes using AFM imaging and force spectroscopy measurements. Our goal is to find the relationship between solution conditions and the CNM-membrane interaction, understand to the changes in mechanical properties of both the carbon nanomaterial and the lipid layer. We are also looking into how the changes in conformation and surface chemistry of the carbon nanomaterial affect the interaction with the lipid membrane, as the first step toward designing biologically compatible analogues.

Vesicles Formation in Protic Ionic Liquids and Deep Eutectic Solvents

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The discovery of water on Mars has renewed interest in the search for alien life. However, the search for extra-terrestrial life should not be constrained by terrestrial limitations i.e. the presence of liquid water. Compartmentalization is a key feature to prebiotic life and can be excellently modeled by vesicles. Self-assembly of vesicles in non-aqueous environments such as ionic liquids and deep eutectic solvents provides evidence that life could exist without water.

Polarising optical microscopy has demonstrated that vesicles and other lamellar structures can spontaneously self-assemble in non-aqueous solvents. This confirms that water is not unique as a self-assembly solvent, and also that hydrogen bonding is not required for self-assembly to occur.

Small angle neutron scattering and differential scanning calorimetry were used to characterize these vesicles and demonstrated that phospholipid tail length influenced vesicle properties (e.g. bilayer thickness and chain melting temperature) in the same way in ionic liquids as it does in water, further confirming that the same processes can occur without water.

This research demonstrates the very real possibility of water-free, synthetic, life-forms, and also significantly broadens the 'goldilocks zone'. That is, the range of planetary orbits that could potentially support life based on their environmental conditions (e.g. temperature).

Colloid-Forming Lipids and Pharmaceutical Milkshakes

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An important aspect of digestion is the enzymatic breakdown of lipids, which enables the effective absorption of hydrophobic fatty components. When broken down in the small intestine the lipids form self-assembled colloidal structures with the aid of endogenous amphiphilic molecules, effectively solubilising and enabling the transport of other hydrophobic molecules towards sites of absorption. Although it has been known for some time that lipid self-assembly occurs upon digestion, the formation and evolution of the colloidal structures has been characterised only in the last few years using powerful real-time synchrotron scattering techniques. Bovine and human breast milk are two lipid containing systems of interest that could facilitate a further understanding of lipid self-assembly processes during digestion, as both systems have been shown to form colloidal structures upon digestion.¹ In the case of milk it is proposed that the formation of these colloids is integral to the effective delivery of key nutrients, such as lipophilic vitamins. In light of these recent findings there is potential to utilise the colloidal structure formation inherent in milk for the administration of poorly water-soluble drugs in the form of a pharmaceutical milkshake. Synchrotron small-angle x-ray scattering experiments can reveal the effectiveness of such pharmaceutical systems based on milk, by following the formation and evolution of colloidal structures and linking them to the fate of drug upon digestion, for instance determining which colloidal phase in particular is responsible for improved drug solubilisation, and which colloidal phase might more readily lead to drug precipitation during digestion. Thus, an effective and novel drug delivery technique for administering poorly water-soluble compounds can be developed through gaining a detailed understanding of the link between colloidal structure formation and drug disposition during the digestion of milk-based pharmaceutical systems.

¹ Salentinig, S. et al. *ACS Nano* **2013**, *7*, 10904–10911, DOI: [10.1021/nn405123j](https://doi.org/10.1021/nn405123j).

Surface Identification of Secondary Amines on Colloids and Chemical Modification in Aqueous Medium

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Colloidal suspensions are of paramount significance in industrial applications. They are employed in various domains like paintings, inks, pigments,¹ pharmacology,² cosmetics, food, textile, composite materials³ or waste water treatment. Properties of colloids strongly depend on parameters such as the chemical composition, dimensions or morphology. To confer additional features to the colloids, i.e. stability, compatibilization, targeting, stealth properties and so on, it is also crucial to tailor their surface functionalization.

In this work, we intend to develop a methodology allowing for tuning the surface properties of highly cross-linked colloids. To do so, the first objective of this work is to identify functionalities at the surface (of the colloids) amenable to post-modifications. Based on this crucial insight, suitable surface chemistries are further explored to impart new properties to the colloids. Thus the presence of amine functions is highlighted by ninhydrine tests and then exploited to incorporate new functionalities at the surface of colloids.

Incorporation of fluorescent tags (such as Rhodamine Isothiocyanate, RITC), intermediate linkers (such as propargyl acrylate) or polymer chains (α,ω -epoxy functionalized polyethylene glycol) are performed in aqueous conditions and after reaction, colloids are subjected to purification through washing/filtration steps using relevant solvents (aqueous or organic conditions). Depending on the nature of the moieties to be grafted, the resulting colloids are subsequently characterized by Confocal Laser Scanning Microscopy (CLSM), FTIR, XPS, and RAMAN Spectroscopy.

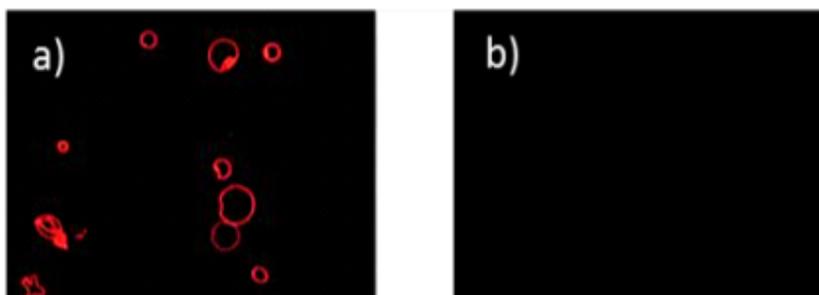


Figure 1: CLSM pictures of RITC-grafted colloids (a) and of blank experiment (b)

¹ Hakeim, O. et al. *Pigm. Resin Technol.* **2010**, *39*, 3–8, DOI: [10.1108/03699421011009537](https://doi.org/10.1108/03699421011009537).

² Lee, D.; Weitz, D. A. *Adv. Mater.* **2008**, *20*, 3498–3503, DOI: [10.1002/adma.200800918](https://doi.org/10.1002/adma.200800918).

³ Zeng, Z. et al. *J. Polym. Sci. A Polym. Chem.* **2004**, *42*, 2253–2262, DOI: [10.1002/pola.20059](https://doi.org/10.1002/pola.20059).

The Influence of Freezing Rate on Microstructure Evolution within Freeze-Cast Ceramics

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The production of dense ceramic parts with complex shapes is currently hindered by an absence of shaping processes suitable for producing parts with high-performance properties; present shaping processes require compromises, either in the complexity of the part, or in the final material properties due to additive loading or defect introduction. Freeze-casting is a colloidal, near net-shaping process, where the shape of the piece is formed in a single step, requiring minimal additional finishing steps. A suspension is injected into a mould, which is subsequently cooled, causing the carrier liquid phase to freeze. This solidification enables the desired shape to be maintained, whilst the part is removed from the mould. Subsequent treatment in a freeze-dryer removes the frozen solvent by sublimation, and this green body can then be sintered to yield the final ceramic piece.

Both the colloidal composition and the freezing conditions have been shown to influence the segregation of colloidal particles in front of the freezing front leaving a network of pores in the green body. It is believed that the freezing front velocity (related to the local freezing rate) influences the pore morphology and final size.¹ This in turn affects the microstructure that evolves in the final ceramic component after solvent removal and sintering stages. In this work, the microstructure formed over a range of experimental freezing conditions were observed. In-situ freeze casting temperature measurements, were conducted to validate a simple theoretical model of the heat transfer within the mould and suspension. The model results are useful to understand relationships between the freezing conditions and microstructure evolution. The simple model produced may be useful in the future to assist with optimising both the freeze-casting process conditions for microstructure control, and future mould designs.

¹ Lasalle, A. et al. *J. Am. Ceram. Soc.* **2011**, 95, ed. by Kim, H.-E., 799–804, doi: [10.1111/j.1551-2916.2011.04993.x](https://doi.org/10.1111/j.1551-2916.2011.04993.x).

Model Biomimetic Lipid Membranes Based on Quaternary Lipid-Water Systems for Protein Encapsulation

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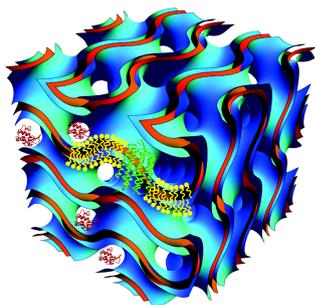


Figure 1: Schematic of a representative soluble protein (lysozyme) and an integral membrane protein (bacteriorhodopsin) contained within a cubic phase

The cell membrane environment, which is ubiquitous in biological systems, provides an exceptional model to devise ‘smart nanostructures’ based on the molecular self-assembly of biological macromolecules such as carbohydrates, lipids, nucleic acids, and proteins. Amphiphilic biomolecules such as lipids can self-assemble into nanostructures of well-defined geometry.¹ The most common of these nanostructures is the lamellar phase which is analogous to the lipid bilayer structure of the cell membrane. Other, more complex architectures may also self-assemble including the lipidic cubic phase, which retains the fundamental lipid bilayer structure (Figure 1).² The lipidic cubic phase can provide an ideal environment for protein encapsulation, Figure 1.

Proteins, especially membrane proteins and peptides, are very fragile when removed from their native cell membrane environment. An appropriate biomimetic environment is required for long-term storage, as well as for various applications of protein-based systems including in meso crystallization,³ delivery of therapeutic proteins and peptides,⁴ biosensors,⁵ cosmetics.⁶

Many of the lipid nanostructures formulated to date consist of a single lipid, or a combination of two lipids in water. Such systems lack the complexity of real cell membrane, which is composed of hundreds of different lipids. In this work we investigate the phase behaviour of quaternary lipid-water systems consisting of three different lipids and water. All lipid systems are based on the lipid Monoolein, which is known to form the lipidic cubic phase. Lipid additives investigated are mainly endogenous and include cholesterol, DOPE, DPPE, DSPE, DLPE, DOPC, DPPC, DSPC, DLPC, DOPS, DSPS and essential fatty acids.

A systematic variation of lipid composition has allowed us to extract the effect of different physiologically relevant lipids on bilayer properties.

- 1 Girard-Egrot, A. P.; Blum, L. J. In *Nanobiotechnology of Biomimetic Membranes*; Springer Science + Business Media, pp 23–74, DOI: [10.1007/0-387-37740-9_2](https://doi.org/10.1007/0-387-37740-9_2).
- 2 Conn, C. E.; Drummond, C. J. *Soft Matter* **2013**, *9*, 3449–3464, DOI: [10.1039/c3sm27743g](https://doi.org/10.1039/c3sm27743g).
- 3 Landau, E. M.; Rosenbusch, J. P. *Proc. Natl. Acad. Sci. USA* **1996**, *93*, 14532–14535, DOI: [10.1073/pnas.93.25.14532](https://doi.org/10.1073/pnas.93.25.14532).
- 4 Leader, B. et al. *Nat. Rev. Drug Discovery* **2008**, *7*, 21–39, DOI: [10.1038/nrd2399](https://doi.org/10.1038/nrd2399).
- 5 Nazaruk, E. et al. *Anal. Bioanal. Chem.* **2008**, *391*, 1569–1578, DOI: [10.1007/s00216-008-2149-y](https://doi.org/10.1007/s00216-008-2149-y).
- 6 Alam, M. et al. *Arab. J. Chem.* **2014**, *7*, 469–479, DOI: [10.1016/j.arabjc.2013.12.023](https://doi.org/10.1016/j.arabjc.2013.12.023).

High Speed Imaging Principles and Techniques

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As scientists and researchers, we use images everyday to help us better understand both man-made and natural phenomenon as well as to communicate our ideas and discoveries to others.

You may have also heard the phrase that ‘a single picture is worth a thousand words’, if this is true then how much more information can be gleaned from one thousand or even one million pictures?

With the recent development of high-speed digital video cameras with higher frame rates and improved image quality, we are now able to visualise previously unseen events with more detail and information than ever before.

This seminar will explain what is high-speed imaging as well as highlight the key principles and techniques that you can use in your own research.



Figure 1: Filming the bursting of a water-filled balloon in high-speed.

Adermann, D. et al. *Fragblast* **2015**, *11*, 471.

Banks, S. P., *Signal processing, image processing and pattern recognition*; Prentice Hall PTR: 1990.
Handbook of Machine Vision; Hornberg, A., Ed.; WILEY-VCH Verlag GmbH & Co. KGaA: 2006,

DOI: [10.1002/9783527610136](https://doi.org/10.1002/9783527610136).

Small Angle X-ray and Neutron Scattering: Nanoscale Structural Characterisation Techniques for Soft Matter Science

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Small angle X-ray and neutron scattering (SAXS, SANS) are versatile techniques for investigating the nanoscale structure of soft materials such as food, surfactants, polymers, colloids, minerals processing fluids, and emulsions. These techniques have been exceptionally useful for studying complex materials of industrial importance in recent years. The use of small angle scattering (SAS) in combination with traditional techniques offers a unique insight into the structure, size, shape and morphology of the materials. Different processes like aggregation, structural transitions, crystallization and phase separation can be studied using SAS techniques in various conditions. SAS are well-established characterization techniques for the nano and microstructure (from 1 nm to 1000 nm) investigations in various materials. These techniques are mostly nondestructive, and particularly useful to study systems in complex sample environment, in-situ, and at different kinetic stages. The use of deuterated molecules and partial deuteration has enhanced the applicability of these methods for soft materials (particularly for SANS technique). We discuss the advantages and limitations of these techniques, and provide examples of recent applications in mineral processing, food technology and colloid science in this talk.

Australia is the home of state of the art reactor based SANS instrument known as Quokka (at the Bragg Institute, ANSTO). Combining Quokka with onsite lab based SAXS instrument or with the Australian Synchrotron based SAXS-WAXS instrument provide versatile techniques to study complex soft matter systems. Bragg institute is known for its high class neutron scattering based science, outstanding deuteration facility, and exceptional sample environment options to couple with various neutron scattering techniques. A general overview of the institute and techniques available will also be provided.

Surface Force Measurements between Atomic Layer Deposition Prepared Mineral Oxide Surfaces

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Direct measurement of surface forces between materials requires that the surfaces are prepared in a suitable geometry with minimal surface roughness. For this reason, very few direct surface force investigations of mineral oxide surfaces have been reported as they generally cannot be prepared in a suitable form. Recently, Atomic Layer Deposition (ALD), a process whereby a film of material is grown in a layer by layer fashion onto a substrate has been successfully employed in surface force measurement. We have produced extremely smooth ALD hafnium oxide films with properties representative of bulk phases. Once these surfaces were characterized by numerous techniques the Atomic Force Microscope (AFM) was used to measure the surface force which had not been previously investigated. At pH values away from the IEP, it was found that the forces remained repulsive up until contact and no van der Waals attraction was present.¹ This result disagrees with the DLVO theory which predicts that the van der Waals attraction should be observed at small separation at all values of the pH studied in this project. This absence of an attraction was also previously observed in the surface force between titanium oxide surfaces and it cannot be explained by the DLVO theory or by the presence of hydration forces. A recently developed method² of incorporating surface roughness into DLVO theory has successfully explained the repulsive forces measured at small separations.

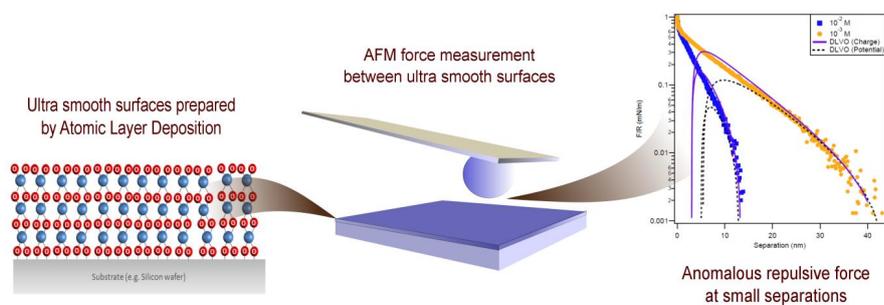


Figure 1: A schematic drawing of the measurement of surface forces between the Atomic Layer Deposition (ALD) prepared surfaces.

¹ Eom, N. et al. *Procedia Eng.* **2015**, *102*, 24–34, DOI: [10.1016/j.proeng.2015.01.103](https://doi.org/10.1016/j.proeng.2015.01.103).

² Parsons, D. F. et al. *J. Chem. Phys.* **2014**, *140*, 164701, DOI: [10.1063/1.4871412](https://doi.org/10.1063/1.4871412).

Tuning the Charging and Aggregation of Colloidal Particles by Aqueous Solutions of Ionic Liquids: Towards an Extended Hofmeister Series

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Ionic liquids (ILs) are excellent candidates for many applications in different areas such as electrochemistry, catalysis as well as synthesis of nanoparticles.¹ In the latter case the interaction between the nanoparticle surface and the IL constituents is crucial.² In the present study, charging and aggregation of two differently functionalized polystyrene latex particles were investigated in aqueous solutions of ILs and simple electrolytes.

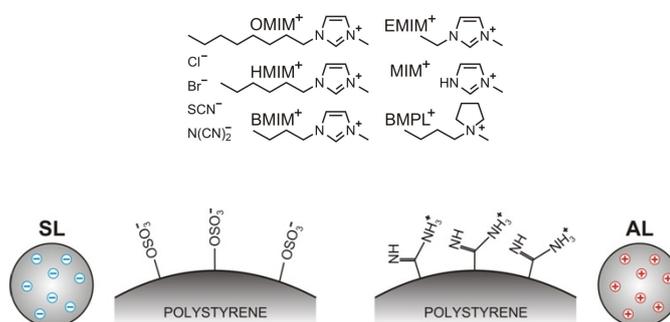


Figure 1: The structure of the IL constituents and the functionalized polystyrene latices used in this study.

Aggregation rates were determined by simultaneous static and dynamic light scattering measurements to describe the aggregation processes and to calculate the corresponding critical coagulation concentrations (CCCs) of the systems. Chloride, bromide, dicyanamide and thiocyanate salts of Na⁺, BMIM⁺ and BMPL⁺ cations were compared with both particles in order to investigate possible counter- and coion dependences.³ For the sulfate-modified particles the influence of alkyl chain length of imidazolium-based IL cations was also investigated. At lower chain lengths (MIM⁺, EMIM⁺, BMIM⁺) the suspensions can be destabilized by screening and charge neutralization. In systems containing HMIM-Cl and OMIM-Cl at intermediate IL concentrations, the dispersions are restabilized due to sufficient overcharging. At higher concentrations the charge-reversed particles are destabilized again due to screening by the IL constituent anions. In general, increasing the hydrophobic character of the IL cation, the coagulating power is increasing due to the more enhanced adsorption onto the particle surface. Despite the substantial differences in the CCCs, the absolute fast aggregation rate does not depend on the type of electrolytes. Based on our particle aggregation study an extended Hofmeister series is suggested.

¹ Hayes, R. et al. *Chem. Rev.* **2015**, *115*, 6357–6426, DOI: [10.1021/cr500411q](https://doi.org/10.1021/cr500411q).

² Szilagyi, I. et al. *Phys. Chem. Chem. Phys.* **2014**, *16*, 9515–9524, DOI: [10.1039/c4cp00804a](https://doi.org/10.1039/c4cp00804a).

³ Oncsik, T. et al. *Langmuir* **2015**, *31*, 3799–3807, DOI: [10.1021/acs.langmuir.5b00225](https://doi.org/10.1021/acs.langmuir.5b00225).

Metal Ion Adsorption at the Ionic Liquid-Mica Interface

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Mica has been employed in many studies of ionic liquid (IL) interfaces on account of its atomic smoothness and well defined surface properties. However, until now it has been unclear whether ions dissolved in ILs can compete with the IL cation and adsorb to mica charge sites. In this work amplitude modulated atomic force microscopy (AM-AFM) has been used to probe metal ion adsorption at the interface of mica with propylammonium nitrate (PAN), a room temperature IL. Lithium, sodium, potassium, magnesium and calcium nitrate salts were added to PAN at a concentration of $\approx 60 \text{ mmol/dm}^3$. Aluminum nitrate was also investigated, but at only 5 mmol/dm^3 because its solubility in PAN is much lower. The AM-AFM images obtained when the metal ions were present are strikingly different to that of pure PAN, indicating that the ions compete effectively with the propylammonium cation and adsorb to negatively charged sites on the mica surface despite their much lower concentration (Figure 1). This is a consequence of electrostatic attractions between the mica charge sites and the metal ions being significantly stronger than for the propylammonium cation; compared to the metal ions the propylammonium charged group is relatively constrained sterically. A distinct honeycomb pattern is noted for the PAN+ Al³⁺ system, less obviously for the divalent ions and not at all for monovalent ions. This difference is attributed to the strength of electrostatic interactions between metal ions and mica charge sites increasing with the ion charge, which means that divalent and (particularly) trivalent ions are located more precisely above the charged sites of the mica lattice. The images obtained allow important distinctions between metal ion adsorption at mica – water and mica – PAN interfaces to be made.

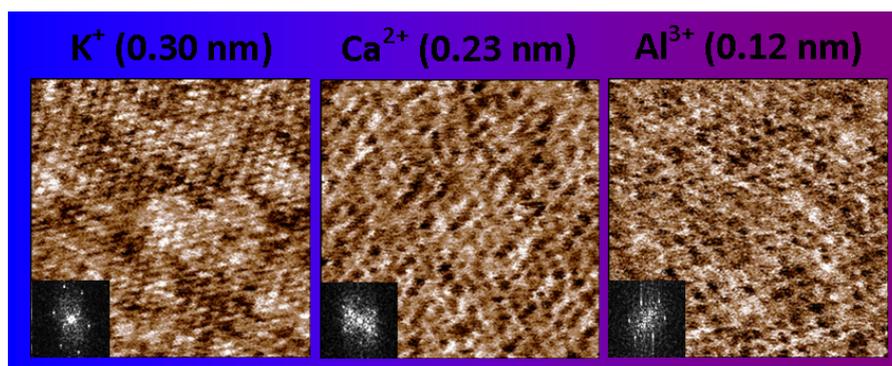


Figure 1: 10 nm × 10 nm AM-AFM phase images of a mica interface with solutions of (left) KNO₃ in PAN, (middle) Ca(NO₃)₂ in PAN and (right) Al(NO₃)₃ in PAN

Critical Micelle Concentrations in Ionic Liquid-Water Mixtures

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The cationic surfactant dodecyltrimethylammonium bromide (DTAB) was shown to aggregate into micelles in the ionic liquids (ILs), ethylammonium nitrate (EAN) and propylammonium nitrate (PAN) at much higher concentrations than in water. Their critical micelle concentrations (cmc) in EAN/water mixtures first decrease, and then increase with increasing ionic liquid content. Cmc's obtained from titration calorimetry (iTC), conductivity, pyrene fluorescence probing and small-angle x-ray scattering are found to be similar over their respective solvent composition ranges, and the suitability of each technique will be compared. Conductivity was used to measure the cmc's at low IL content in water, and showed that the ionic liquid behaves like a simple electrolyte at low concentrations, but at co-surfactants at higher IL concentrations. Conductivity is not applicable in IL-rich mixtures where the cmc is significantly higher, due to the solvent conductance. Here iTC results are compromised by the decreasing enthalpy of micellization (ΔH_m°) which is near zero in pure EAN.

Hexane Recovery from Ruptured Concentrated Microalgae Slurry via Centrifugation

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Microalgae are a promising bioenergy feedstock due to their advantages over other crop-based biofuel feedstock including high productivity and the avoidance of the use of arable land and fresh water. However, a major challenge in microalgal biofuel production is avoiding an energy-intensive and expensive process of thermal drying upstream of lipid extraction.¹ The solution is to utilize a concentrated wet microalgae slurry, typically 15% to 35% dry biomass (mass fraction), as a feedstock in the downstream processes.

To access the algal lipids for biofuel conversion, the concentrated microalgae cells in the slurry must be ruptured before application of a solvent extraction step, typically with hexane.² However, a problem arises when hexane is added to the ruptured concentrated microalgae slurry. The intracellular constituents and cell wall fragments are natural emulsifiers that promote and stabilize the formation of hexane-water emulsion.³ In addition, these release of these components result in a highly viscous material. The formation of this viscous emulsion retains the hexane in the biomass slurry and thus a solid-liquid separation step is required to recover the hexane.

Centrifugation is a common industrial process for solid-liquid separation and industrial-sized centrifugation equipment is readily available. Thus, centrifugation is a promising technique for recovering hexane from the microalgal emulsion. However, this process can be relatively energy and capital intensive and thus it is important to minimise the centrifugation time and force and by increasing the separation rate (kinetics).

In this project, the physical properties and centrifugation behaviour of hexane-mixed ruptured microalgae slurry was investigated in order to study the interaction of various parameters affecting centrifugation efficiency. By understanding the influence of these parameters, it is only then possible to develop an optimal strategy for recovering the hexane with minimal energy requirement.

¹ Xu, L. et al. *Bioresour. Technol.* **2011**, *102*, 5113–5122, DOI: [10.1016/j.biortech.2011.01.066](https://doi.org/10.1016/j.biortech.2011.01.066).

² Olmstead, I. L. et al. *Bioresour. Technol.* **2013**, *148*, 615–619, DOI: [10.1016/j.biortech.2013.09.022](https://doi.org/10.1016/j.biortech.2013.09.022).

³ Heeres, A. S. et al. *Trends Biotechnol.* **2014**, *32*, 221–229, DOI: [10.1016/j.tibtech.2014.02.002](https://doi.org/10.1016/j.tibtech.2014.02.002).

Quantifying Nanomechanical Properties of GelMA in Liquid under Electrical Stimulation Using AFM

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Hydrogels are gaining an increasing focus, as they have similar properties to human tissue, and currently applied for drug release or wound healing applications. However, the replacement of human tissue with hydrogels is still challenging due to the fact that the native cell environment is a very complex structure and not-well understood. In particular, a greater understanding of the nanomechanical properties of hydrogels in liquid and their behaviour in ionic gradients and electrical fields, all of which are influences present in the native tissue environment, is important for the future development of these materials. Here, we quantify the molecular level properties of the hydrogel, Gelatin Methacrylate (GelMA), as a function of electrical stimulation using in-situ Electrochemical-Atomic Force Microscopy (EC-AFM). Later on, the interactions of GelMA with neural stem cells will be quantified as function of electrical stimulation using Electrochemical-Single Cell Force Spectroscopy (EC-SCFS). Methacrylate Gelatin (GelMA) is an inexpensive and rich in collagen hydrogel that is photo-crosslinkable and provides several parameters for varying the nanomechanical properties such as Young's modulus. The project initially explores the nanomechanical properties of the GelMA, followed by EC-SCFS to give novel insights of neural stem cell adhesion to GelMA at the molecular level (i.e. at the level of single cell receptors).

Copolymer Nanoparticles via RAFT Emulsion Polymerisation: Synthesis, Characterisation and Interfacial Activity

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A poly(glycerol monomethacrylate) (PGMA) macromolecular chain transfer agent has been utilised to polymerise benzyl methacrylate (BzMA) via reversible addition-fragmentation chain transfer (RAFT)-mediated aqueous emulsion polymerization. This formulation leads to the efficient formation of spherical diblock copolymer nanoparticles at up to 50% solids. The degree of polymerisation (DP) of the core-forming PBzMA block has been systematically varied to control the mean particle diameter from 20 nm to 193 nm. Conversions of more than 99% were achieved for PGMA₅₁-PBzMA₂₅₀ within 6 h at 70 °C using macro-CTA/initiator molar ratios ranging from 3.0 to 10.0. DMF GPC analyses confirmed that relatively low polydispersities ($M_w/M_n < 1.30$) and high blocking efficiencies could be achieved. These spherical nanoparticles are stable to both freeze-thaw cycles and the presence of added salt (up to 0.25 mol/dm³ MgSO₄). Three sets of PGMA₅₁-PBzMA_x spherical nanoparticles have been used to prepare stable Pickering emulsions at various copolymer concentrations in four model oils: sunflower oil, *n*-dodecane, *n*-hexane and isopropyl myristate. A reduction in mean droplet diameter was observed via laser diffraction on increasing the nanoparticle concentration. Finally, the cis diol functionality on the PGMA stabilizer chains has been exploited to demonstrate the selective adsorption of PGMA₅₁-PBzMA₁₀₀ nanoparticles onto a micro-patterned phenylboronic acid-functionalized planar surface. Formation of a cyclic boronate ester at pH 10 causes strong *selective* binding of the nanoparticles via the cis-diol groups in the PGMA stabiliser chains, as judged by AFM studies. Control experiments confirmed that minimal selective nanoparticle binding occurred at pH 4, or if the PGMA₅₁ stabilizer block was replaced with a PEG₁₁₃ stabilizer block.

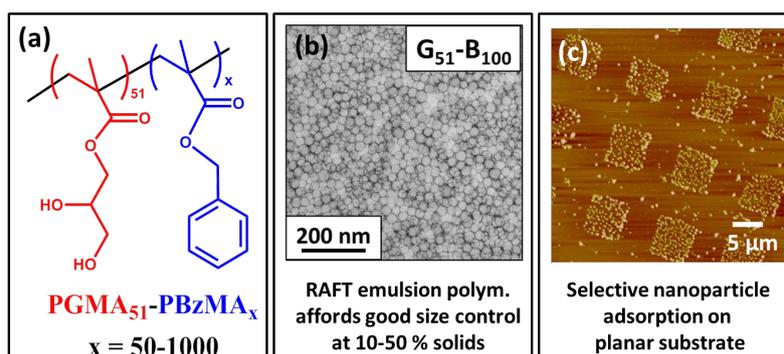


Figure 1: (a) Structure of PGMA₅₁-PBzMA_x diblock copolymers, (b) TEM image showing spherical nanoparticles and (c) AFM image showing selective adsorption of PGMA₅₁-PBzMA₁₀₀ nanoparticles onto phenylboronic acid-functionalised surfaces at pH 10.

Hofmeister Effects within the Behaviour of a Weak Polybasic Brush

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We have studied the influence of ionic strength and specific anion identity on three weakly basic polymer brushes in the presence of aqueous solutions of potassium nitrate, acetate and thiocyanate.¹ Poly(2-diisopropylamino)ethyl methacrylate (PDPA) is the most hydrophobic of the brushes. At low concentrations of KNO_3 the brush is collapsed. With additional KNO_3 the brush swells as it becomes more charged and at high KNO_3 the brush collapses again as screening effects become dominant. Interestingly, the response is different depending on the salt type (Hofmeister effects). Strongly hydrated acetate anions (a kosmotropic anion) display low affinity for the hydrophobic brush and consequently it remains highly swollen towards high ionic strengths. Weakly hydrated thiocyanate anions (a chaotropic anion) are known to partition towards hydrophobic surfaces,² causing the brush to be collapsed.

More recently, we have used atomic force microscopy (AFM) to determine brush molecular weight and hence grafting density by analysing the retraction force curves measured for the interaction of a sharp Si_3N_4 tip with a swollen brush.³ Colloidal probe measurements (see Figure 1) have been performed at the same electrolyte conditions as our earlier work.¹ At very low ionic strength, electrostatic interactions dominate the force profiles with adhesive forces upon probe retraction for nitrate, acetate and thiocyanate. At higher salt concentrations, electrostatics are screened and the approach curves are purely steric in origin. In thiocyanate solutions the retraction curves were always adhesive, consistent with a poorly solvated brush. Towards higher concentrations of nitrate and acetate, the forces on retraction become repulsive due to the high osmotic forces associated with the now swollen brush.

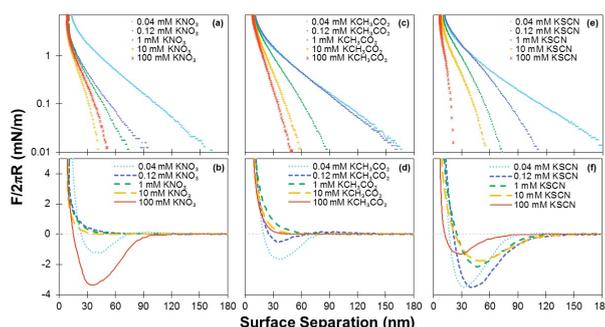


Figure 1: Approach (top, log-normal axes) and retraction (bottom) curves for a DPA brush in the presence of 0.04, 0.12, 1, 10 and 100 m.mol/d.m^3 KNO_3 (a & b), KCH_3CO_2 (c & d), KSCN (e & f).

¹ Willott, J. D. et al. *Langmuir* **2015**, *31*, 3707–3717, DOI: [10.1021/acs.langmuir.5b00116](https://doi.org/10.1021/acs.langmuir.5b00116).

² Rembert, K. B. et al. *J. Am. Chem. Soc.* **2012**, *134*, 10039–10046, DOI: [10.1021/ja301297g](https://doi.org/10.1021/ja301297g).

³ Willott, J. D. et al. XXXX, Submitted to *Macromolecules*.

Effect of Polyelectrolyte Morphology and Adsorption on Nanocellulose Flocculation

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The commercialisation of nanocellulose films is limited to the critical issue of long drainage time. Nanocellulose films are being actively developed as a new class of material for applications in packaging, diagnostics, optically transparent electronic displays and hydrogels. Addition of polyelectrolytes to nanocellulose fibres have been proven to reduce the drainage time significantly bringing the large scale production of these films into reality.¹ In this study, the effect of adding two types of polyelectrolytes with different morphology, on nanocellulose flocculation is investigated. Linear high molecular weight Cationic Polyacrylamide (CPAM) of varying charge density and branched polyethylenimine (PEI) dendrimers of varying molecular weight and charge densities were used. Adsorption isotherm of each polyelectrolyte on MFC was analysed as a function of polyelectrolyte charge, molecular weight and addition level. The maximum polyelectrolyte coverage obtained for the 80 % charged 4 MDa CPAM and 50 % charged 13 MDa CPAM was 0.25 and 0.14 respectively. PEIs of 7.5 MDa and 2 kDa had maximum polyelectrolyte coverage of 0.2 and 0.17, on MFC respectively. The gel point which is the lowest solids concentration at which all the solids are interconnected and form a self- supporting network, was investigated as a function of polyelectrolyte properties. Adding polyelectrolytes reduces the gel point, leading to a more open MFC floc structure, hence reducing the drainage time significantly. The drainage time of nanocellulose suspension into a film was successfully reduced by 2/3 with addition of 2 mg/g 50 % charged 13 MDa CPAM or 1 mg/g 7.5 MDa PEI. The combination of analysing zeta potential, adsorption isotherm and gel point curves also allowed the understanding of interaction mechanisms between each type of polyelectrolyte and MFC. This allowed the quantification of mechanisms by which polyelectrolytes adsorb onto and flocculate nanocellulose fibres in order to facilitate their drainage into continuous films.

¹ Raj, P. et al. *Journal of Colloid and Interface Science* **2015**, *447*, 113–119, DOI: [10.1016/j.jcis.2015.01.019](https://doi.org/10.1016/j.jcis.2015.01.019).

Probing Localized Magnetolectric Effects of PVDF/Fe₃O₄ Nanofibers by Piezoresponse Force Microscopy

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The coupling of magnetic and electric properties in polymer based multi-ferroic (MF) opens door to multifunctional devices. Bulk magnetolectric (ME) effect is well confirmed both theoretically and experimentally, however, it is still an issue whether this effect is maintained in nanoscale. The scale-down mechanism is critical to applying multiferroics in future miniature sensors or even implantable devices in human body. In this paper, PVDF/Fe₃O₄ composite nanofibers were fabricated by conventional electrospinning technique, which is a well-established approach to electroactive phase of polymers. The promotion of β phase formation was confirmed by X-ray diffraction and FT-IR spectra. Then, local ME effect was measured by monitoring the deformation of the composite nanofibers under different in-plane magnetic fields. For the first time, our results confirmed the nanoscale manipulation of piezoresponse by applying external magnetic field in the composite consisting of piezoelectric PVDF and magnetostrictive Fe₃O₄ nanoparticles, induced by strain coupling through the interfaces. The combination of Piezoresponse Force Microscopy and Viable Field Module offers an easy approach to estimating the ME effect of a single nanofiber locally. This could be a guideline to further study on nanoscale applications by MF materials based on flexible piezoelectric polymers.

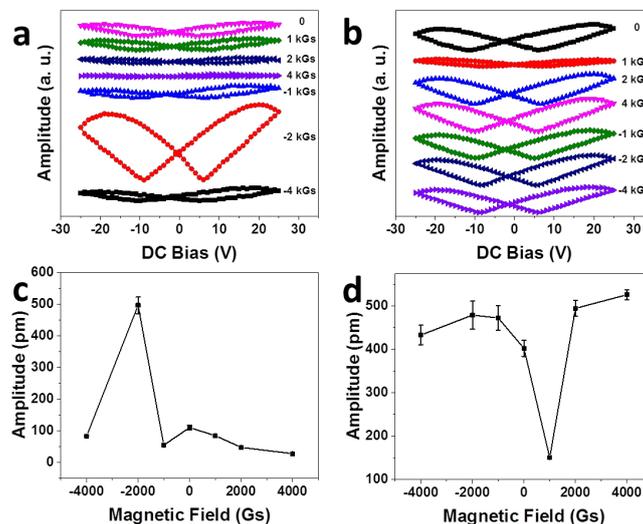


Figure 1: PFM amplitude butterfly loops (a, b) and displacement (c, d) dependence on magnetic field strength of the PVDF-Fe₃O₄ nanofibers obtained in the first (a, c) and second (b, d) trials.

Jia, Y. et al. *Adv. Mater.* **2008**, *20*, 4776–4779, DOI: [10.1002/adma.200800565](https://doi.org/10.1002/adma.200800565).

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Martins, P. et al. *Prog. Polym. Sci.* **2014**, *39*, 683–706, DOI: [10.1016/j.progpolymsci.2013.07.006](https://doi.org/10.1016/j.progpolymsci.2013.07.006).

Self-Assembly of Short Amphiphilic Block Copolymers in Aqueous Solution

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Amphiphilic block copolymers have been used as surfactants, drug delivery agents, stabilisers and dispersants. Amphiphilic co-oligomers comprising a hydrophilic block (5 to 10 units of acrylic acid) and a hydrophobic block (5 to 10 units of *n*-butyl acrylate, *t*-butyl acrylate or ethyl acrylate) were synthesized by reversible addition-fragmentation chain transfer (RAFT) free radical polymerization.¹ Self-assembly of these amphiphiles into micelles and liquid crystals in aqueous solution was investigated by using small angle neutron scattering (SANS), polarising optical microscopy and small angle x-ray scattering (SAXS). Self-assembled structure and lyotropic phase stability in these systems depends on the degree of ionization of hydrophilic (acrylic acid block) and block composition. Liquid isotropic, hexagonal phase and lamellar phase were shown in phase diagrams of these co-oligomers. As compared to a previous system,² hexagonal nanostructure was observed via microscopy and SAXS.

¹ Moad, G. et al. *Aust. J. Chem.* **2009**, *62*, 1402–1472, DOI: [10.1071/ch09311](https://doi.org/10.1071/ch09311).

² Heinen, J. M. et al. *J. Phys. Chem. B* **2013**, *117*, 3005–3018, DOI: [10.1021/jp307875z](https://doi.org/10.1021/jp307875z).

Is the Hofmeister Series Specific to Water? Specific-Ion Effects in Non Aqueous Solvents

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Many properties of electrolyte solutions are ion specific, as they depend on the particular cations and anions present. The influence of different ions on the characteristics of their solutions usually orders according to the Hofmeister series.

Although substantial progress has been made recently, the available theories cannot yet predict how a specific ion will perturb the properties of its solution.

The achievement of a comprehensive theory of specific ion effects is of primary importance, as electrolyte solutions are ubiquitous in everyday phenomena, like the physiology of animals and plants, and in applications such as surfactants self-assembly, lipids phase behaviour and colloids flocculation.

A full understanding of salt solutions would allow us to abandon the largely empirical approach we currently employ in many scientific and technological fields, from medical science to food formulations, mineral processing and water treatment.

Our work investigates the ion-solvent interactions, and focuses on the role played by the solvent.

In order to deduce how the solvent affects the manifestation of ion specificity, we are conducting experiments in a range of polar non aqueous liquids.

Our aim is to provide data and insights to test and expand the current theories. Here we report the results of several studies in this area.

In addition to observing how the electrostriction caused by different electrolytes changes in non aqueous solvents with respect to water, we have conducted Size Exclusion Chromatography (SEC) of several salts in non aqueous solvents, and we have studied the influence of electrolytes on the swelling of polymeric brushes by Quartz Crystal Microbalance (QCM).

Our results contribute to the present understanding and provide significant proving ground for theories of specific ion effects.

Environmental Applications of Inorganic-Organic Clays: Removal of a Recalcitrant Organic Pollutant

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Inorganic-organic clays (IOC) were synthesised by intercalating organic cation such as cationic surfactant (octadecyltrimethylammonium bromide, ODTMA) and inorganic cation such as metal hydroxy polycations (hydroxy aluminium, Al_{13}) into Ca-montmorillonite (Ca-Mt). Three intercalation methods and different ODTMA concentrations were used.¹ IOCs have the properties of both organic and pillared clays hence the ability to remove both inorganic and organic contaminants from water.² Adsorption characteristics of the resultant IOCs towards bisphenol-A (BPA) were investigated through a series of batch experiments. The effect of surfactant loading amount in IOCs, amount of IOCs, agitation time and initial BPA concentration on BPA adsorption into IOCs were investigated and results were compared with ODTMA modified clays (organoclays). Results show that BPA adsorption increased with increasing ODTMA loading. The surfactant in the interlayers and on the external surface of the clay layers contributed to the BPA adsorption via partition and van der Waals interactions, respectively.³ Pseudo second order kinetics model is the best fit suggesting that BPA adsorption into IOCs occurred via chemisorption. Freundlich and Langmuir adsorption isotherms are the best fit for IOCs and organoclay indicating heterogeneous adsorption and monolayer adsorption, respectively.⁴ In conclusion, IOCs are effective adsorbents for BPA with high maximum adsorption capacities (113 mg/g) in removal of hydrophobic organic contaminants such as BPA from water (Figure 1).

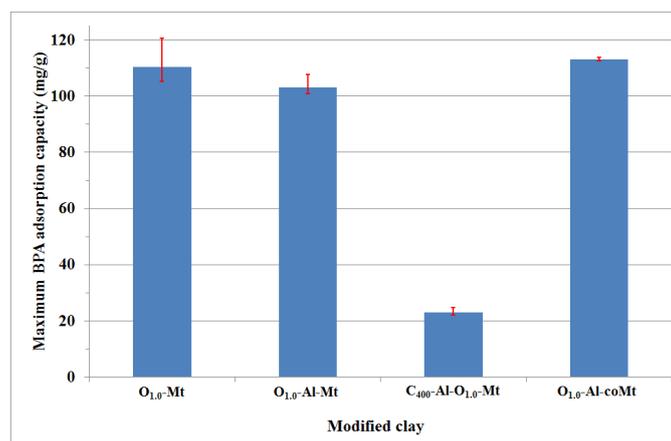


Figure 1: Maximum BPA adsorption capacity of IOCs

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Formation and Characterization of Nanocellulose-Based Foams with Improved Mechanical and Fire Retardant Properties

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Solid foams are widely used as thermal insulation in buildings, as a core in sandwich panels in space vehicles and yachts, for packaging and as flotation devices. Unfortunately, the majority of the utilized products are produced from polystyrene, polyethylene and polyurethane and there is a desire to develop more sustainable solutions based on renewable wood-based materials such as cellulose.

In the present work we will show how wet foams with relatively homogeneous bubbles size distribution, good foamability and long-term stability can be prepared from mixtures of TEMPO-mediated cellulose nanofibrils (CNF) and a non-ionic surfactant. The mechanical rigidity of the wet foams has been improved by delayed Ca-induced aggregation, allowing solid foams with closed pores and well preserved shape to be produced by a simple drying process. Based on results of Scanning Electron Microscopy and X-ray tomography we will describe the microstructure of the dry foams. We will discuss why the stiffness of the dry foams is higher than certain thermo-insulating polyurethane foams and strongly increased in comparison to pure cellulose foams. We will highlight that presence of undissolved CaCO₃ particles also improves the fire retardancy of the cellulose-based foams.

Structuring Emulsion Interfaces to Control Phytosterol Crystallization in Dispersed Systems

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Phytosterols are a naturally occurring plant compounds found within plant cell wall membranes. When consumed by humans, they can lower low-density lipoprotein (LDL) cholesterol levels in the blood and have been shown to possess anti-carcinogenic and anti-inflammatory properties.¹ Like many other bioactive compounds, their bioavailability is dependent upon the solubility of the phytosterol within their carrier matrix. Successful incorporation of these compounds within food matrices is challenging due to their high melting point, low solubility and lipophilic nature.² Previous results have shown that, when dispersed into an emulsion system, plant sterols can reduce interfacial tension and crystallize onto the oil/water interface. Thus, the aim of this study was to investigate the effect of various surfactants on the crystallization of phytosterols in oil-in-water emulsion droplets. Whey protein isolate, phospholipids, and distilled monoglycerides were utilized at two concentrations of phytosterol addition. The presence of phytosterol crystals was studied through the use of small- and wide-angle X-ray scattering (SAXS/WAXS) and Differential Scanning Calorimetry. Results demonstrated that both phospholipid and distilled monoglyceride addition can decrease phytosterol crystallization. This knowledge can lead to a deeper understanding of the impact of surfactant variation on plant sterol crystallization, and aid the functional food and pharmaceutical industry in creating matrices for human consumption.

¹ Smet, E. D. et al. *Mol. Nutr. Food Res.* **2012**, *56*, 1058–1072, DOI: [10.1002/mnfr.201100722](https://doi.org/10.1002/mnfr.201100722).

² *Food Colloids*; Dickinson, E., Leser, M. E., Eds., 465–476; Royal Society of Chemistry (RSC): 2007, DOI: [10.1039/9781847557698](https://doi.org/10.1039/9781847557698).

Arrested Coalescence of Viscoelastic Polydisperse Droplets: Connectivity and Restructuring

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Microstructured viscoelastic droplets in oil-in-water emulsions acquire various resulting shapes depending on the size, concentration and connectivity they have. Arrested coalescence provides versatility in achieving a stable emulsion by forming anisotropic shapes. For instance, it can help by providing firmness, yield stress and viscosity to various food, cosmetics, paints and pharmaceutical products. The recent work contributes to the network formation of the polydisperse viscoelastic binary and multidroplet network to see its effect on droplet deformation and microstructure. It aims to understand the mechanisms of arrested coalescence in complex emulsions and to explain how those mechanisms affect the system.

The idea from binary arrest of monodisperse droplets is used to extend the work further, for which recent model of balancing interfacial and elastic energy is used to get the arrest of droplets. The deep understanding of effects of droplet sizes through this work has shown some significant findings which might be really constructive for designing droplets microstructure. However, the behaviour of droplets in a food system is more complex and is challenging to understand as it consists of various ingredients interacting with them. The connectivity and restructuring of polydisperse droplets is a route to design the anisotropic microstructure and predict the overall quality of formulations. For example, restructuring generates more compact structure by reducing the interfacial area, which occurs when there is curvature difference between droplets' inside and outside (which probably acts as driving force).

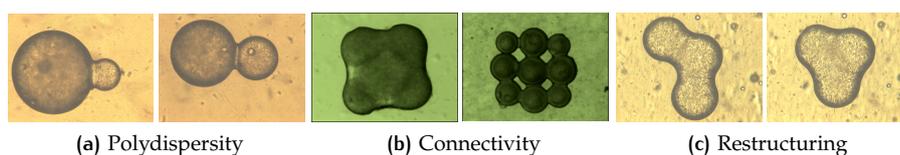


Figure 1: Example of polydisperse doublets, connections and restructuring.

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Lubricated Transport of Heavy Fuel-Oil as Core-Annular Flow through a Horizontal Pipe

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Among all the flow regimes in which two immiscible fluids in pipe may flow, the water-lubricated core annular flow (CAF) has been found to be the most effective way to transport heavy oils. In CAF, the wall shear is close to that of shear observed in pure water only, making it a low energy option to transport highly viscous fluids. In this work, experimental studies are reported in which heavy fuel-oil is transported as a water-lubricated CAF in a horizontal pipe. It is observed that the pumping pressure can be reduced close to 97% using a CAF when compared to pumping oil alone — limiting to pure water flow. The interfacial wave characteristics are captured using a high-speed camera for different flow-rate combinations, and it is observed that the CAF tends toward an axisymmetric flow at higher oil/water ratio. A theoretical approach, showing the effects of viscosities in a perfect core annular flow (PCAF), is also discussed.

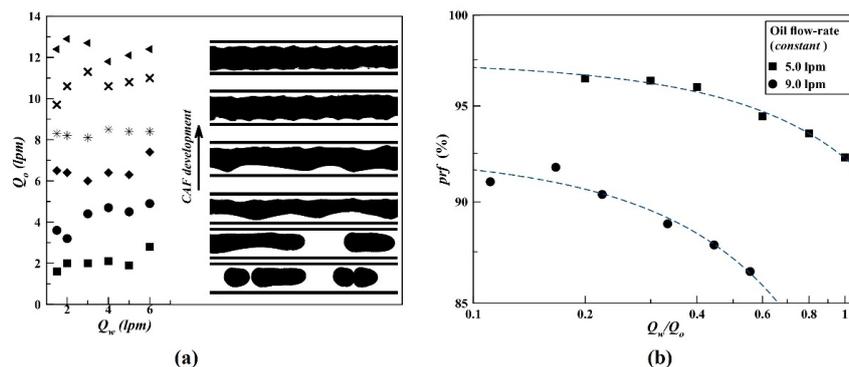


Figure 1: (a) Development of core-annular flow, (b) Pressure reduction factor (*prf*) with water-oil flow-rate ratio (the dashed lines are for fitting only)

Probing the Frictional Behavior between Micro-Particles in Particulate Suspensions

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Correlating the micro-mechanical behavior between particles to the macroscopic yielding of particulate suspensions is an ongoing research area. Many studies focus on correlating the shear rheology of suspensions to the particle interactions using computational models. Whether friction contributes to the non-linear viscoelasticity and shear thickening behavior of suspension is still under debate.^{1,2} However, the contribution of friction force to the rheology of suspensions requires a physical measurement of the friction coefficient between particles. In this work, the friction force between two microspheres was measured using an Atomic Force Microscope (AFM) as a function of different solution conditions and particle type.

A novel experimental method was developed to measure friction force between two particles. A silica microsphere was attached to the AFM cantilever and another sphere was attached to a glass substrate. The normal and lateral deflection signals of the cantilever were recorded when particle probe was slid over the other particle immobilized on the substrate. The deflection signals were converted to forces with independently measured calibration constants. Then, the axial force and friction force were calculated using mathematical expressions derived from an equilibrium balance of forces and moments at the contact point. The measurements were initially performed in NaNO₃ at pH 6 and a range of concentrations. Then, in a background electrolyte of 10 mmol/dm³ NaNO₃, the effects of two different surfactants, sodium dodecyl sulphate (SDS) and cetyl trimethylammonium chloride (CTAC), were examined. The concentration of the surfactants was also varied ranging from low concentration to above the critical micelle concentration (CMC). The subsequent analysis and determination of the friction coefficient as a function of solution conditions will also be discussed. References

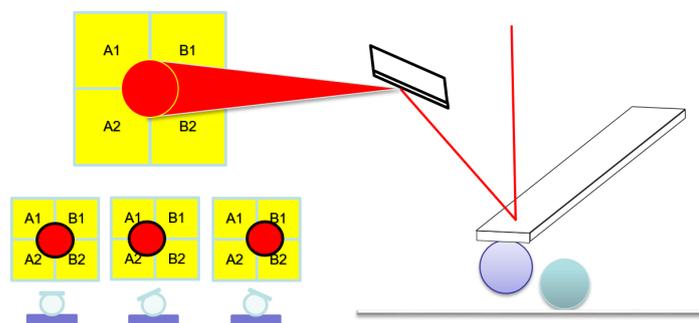


Figure 1: Diagram of friction force measurement using AFM

¹ Jamali, S. et al. *J. Rheol.* **2015**, *59*, 1377–1395, DOI: [10.1122/1.4931655](https://doi.org/10.1122/1.4931655).

² Morris, J. F. *Rheol. Acta* **2009**, *48*, 909–923, DOI: [10.1007/s00397-009-0352-1](https://doi.org/10.1007/s00397-009-0352-1).

Experimental Implications of Near-Field Optical Coupling

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Total internal reflection microscopy (TIRM) is a direct force measurement technique that relies on evanescent light scattering to provide order- $k_B T$ interaction potentials for particles levitated above a plate. The theoretical basis of TIRM for measuring surface forces in systems of isolated spherical particles is well established; in such cases, light scattering is adequately described in the observed far-field by analytic Lorenz Mie theory. In this work we have constructed finite-element models to quantify scattering for TIRM and other near-field measurements in confined systems where particles are no longer strictly isolated, for example in microfluidic channels or multi-particle systems. Specifically, we demonstrate that disregarding near-field optical coupling between adjacent scattering particles may result in the interpretation of spurious forces during a TIRM experiment. We outline limiting cases for TIRM experiments in which this ‘crosstalk’ effect is appreciable, and describe practical implications for other experimental techniques including near-field scanning optical and fluorescence microscopy. We describe complementary experimental uses for this finite-element model, including the topological characterisation and spatiotemporal observation of anisotropic mesoparticles undergoing Brownian motion.

Polymer Film Dewetting: our Route towards Water Harvesting Surface Coatings

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Polymer film dewetting provides a simple, scalable and reliable route towards mimicking the water harvesting adaptation of the stenocara beetle. Here, we present the route taken to produce a surface coating that is a close representation of the structure observed on the elytra of the beetle. We also assess the water collection behaviour and efficiency of our biomimetic surface and present these results.

Dewetting polymer films by solvent vapour annealing, while the focus of many experimental and theoretical works, is a poorly understood phenomenon. Our first aim was to better understand the role of solvent vapour molecules in leading polymer melts to dewet from a metastable state, creating surface coatings with our desired architecture. From this work we concluded that dewetting is primarily affected and occurs most rapidly by the release of elastic potential energy of polymer chains transitioning to a globule equilibrium conformation in the presence of a poor solvent (Figure 1(a)).

Our second aim was to optimise the solvent vapour parameters to dewet a film of poly4vinylpyridine (P4VP) from an underlying polystyrene (PS) film. Where thermal annealing of this system above the T_g of the polymers has previously been shown to lead to layer inversion,¹ we have shown that an appropriate choice of solvents can eliminate this behaviour (Figure 1(c)). It is also possible to select solvent combinations that will lead to successive dewetting of both films leading to the topographies shown in Figure 1(b).

Finally, we tested the efficiency of these biomimetic coatings for water collection from humid environments against the traditionally endorsed hydrophobic coating. Testing of the coatings, including the hydrophobic coating was conducted in a custom-made condensation set up (Figure 1(d)).

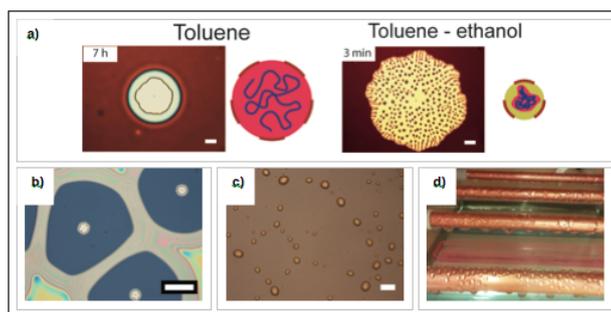


Figure 1: (a) Schematic representation of the elastic stress induced in polymer chains in the presence of poor solvent molecules leading to different dewetting morphologies. (b) Dewetting of a P4VP top layer and PS bottom layer by ethanol-toluene vapour mixture. (c) P4VP droplets on a PS sub layer after annealing in ethanol-acetone-water vapour mixture. (d) Water condensation on copper tubes with different surface coatings. Scale bars = 100 μm .

¹ Thickett, S. C. et al. *Langmuir* 2010, 26, 15989–15999, DOI: [10.1021/la103078k](https://doi.org/10.1021/la103078k).

Cracking the Shits

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Cracking phenomena are of great significance in the drying of colloidal suspensions such as paints, concrete, mud, ceramics, clay etc. Cracking occurs at a point when the capillary pressure of the suspension–air interface exceeds the compressive strength of the drying body such that it would prefer to desaturate rather than consolidate.¹

This study investigates the evaporation of thick film colloidal suspensions like wastewater treatment sludge and the effect of cracking on sludge drying. During sludge evaporation in drying pans, mechanical agitation is used to break the partially desaturated crust that forms at the top of the sludge and mix it with the saturated sludge underneath. Laboratory tray drying experiments were conducted to identify the key stages during sludge drying (shown in Figure 1), in particular to determine the concentration at which the sludge cracks. The crack length, width and shape during different stages of drying were also determined. Overall, this work provides insights for optimising sludge drying practices.

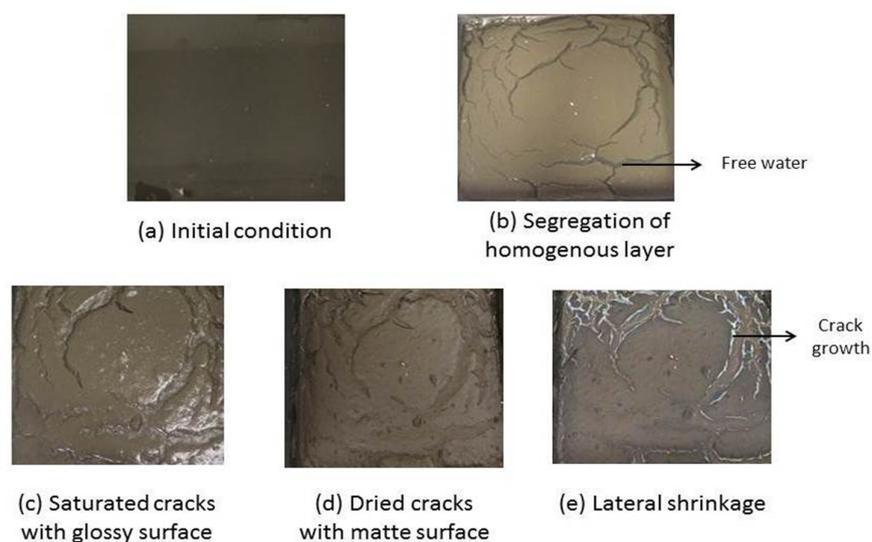


Figure 1: Different stages during wastewater sludge drying

¹ Brown, L. A. et al. *AIChE J.* **2002**, *48*, 492–502, DOI: [10.1002/aic.690480308](https://doi.org/10.1002/aic.690480308).

Surface-Selective Temperature-Responsive Polymers for Mining Applications

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Stimuli-responsive polymers are fascinating materials that can display contrasting behaviours under a change in external conditions, such as temperature, pH, oxidative conditions or even the presence of light.¹ One of the most well-studied examples is poly(*N*-isopropyl acrylamide) (PNIPAM), which undergoes a rapid and reversible hydrophilic-hydrophobic transition when heated above a lower critical solution temperature (LCST) of 32 °C.² PNIPAM is often copolymerised with other functional moieties to incorporate desirable properties such as biocompatibility, surface selectivity, catalytic activity, and responsiveness to multiple stimuli, for use in a host of potential applications in drug delivery systems and wastewater treatment.³ The focus of our study is the application of temperature-responsive polymers in minerals processing, with the aim of improving the recovery of valuable minerals while reducing operating costs. The inherent challenge is the design and conception of a suitable functionality for selective attachment onto the surface of the desired mineral.⁴ Towards this end, we have synthesised and characterised a set of novel PNIPAM copolymers that possess a high degree of affinity towards particular metal interfaces. The transition behaviour and adsorption properties of the copolymers will be discussed, along with the performance of the materials in lab-scale mineral recovery studies. These findings demonstrate the potential for functionalised temperature-responsive polymers to offer a significant improvement to the performance of current mineral treatment techniques.

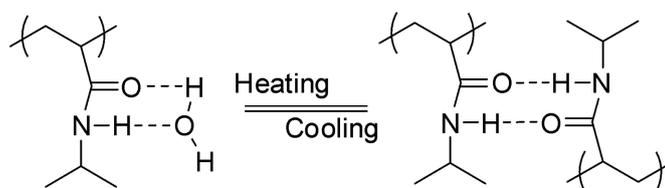


Figure 1: Temperature-responsive hydrophilic-hydrophobic transition of poly(*N*-isopropyl acrylamide).

¹ Koetting, M. C. et al. *Mater. Sci. Eng. R-Rep.* **2015**, *93*, 1–49, DOI: [10.1016/j.mser.2015.04.001](https://doi.org/10.1016/j.mser.2015.04.001).

² Schild, H. G. *Prog. Polym. Sci.* **1992**, *17*, 163–249, DOI: [10.1016/0079-6700\(92\)90023-r](https://doi.org/10.1016/0079-6700(92)90023-r).

³ Liu, R. et al. *Colloid Polym. Sci.* **2009**, *287*, 627–643, DOI: [10.1007/s00396-009-2028-x](https://doi.org/10.1007/s00396-009-2028-x).

⁴ Ng, W. S. et al. *Miner. Eng.* **2015**, *77*, 64–71, DOI: [10.1016/j.mineng.2015.02.013](https://doi.org/10.1016/j.mineng.2015.02.013).

Amino Acid Functional, Thermo-Responsive Polymers: their Synthesis, Responses and Behaviors

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Amino acid functional, temperature responsive polymers have been synthesized using simple and effective chemistry, leading to new polymers that show promise as synthetic mimics of complex biological materials. Copolymers of N-isopropylacrylamide and a benzaldehyde methacrylate have been synthesized using controlled RAFT polymerization. These copolymers have been functionalized with amino acids post polymerization using reductive amination, a chemistry that has been demonstrated to be tolerant to diverse functional groups, and does not require protective group chemistry (Figure 1). This provides an effective and tuneable means to synthesize these materials in an economical fashion. The resulting materials exhibit dual responsiveness to temperature and pH. The highly functional polymers presented exhibit cationic, zwitterionic and anionic behaviour over the full pH range. These temperature and pH responsive amino acid functional materials show promise as biomaterials due to their natural moieties and zwitterionic nature. They may also be useful in chelating certain metal cations from solution and selectively adsorb to certain mineral surfaces. Their response to temperature and pH will be presented.

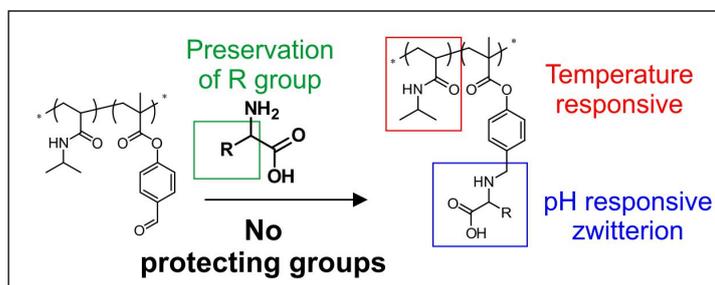


Figure 1: The synthesis of amino acid functional polymers using reductive amination lends itself to facile, protecting group free chemistry of highly functional, dual responsive materials.

Neutron Reflectivity as a Tool for Studying the Structural Response of Polymer Brushes

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Polymer brushes are films formed of end-grafted polymers that modify the interfacial properties of the grafting substrate. Incorporation of appropriate monomers allows these interfacial properties to be varied in response to external stimuli. In previous work we have investigated the swelling of weak polybasic poly(2-dialkylamino)-ethyl methacrylate brushes in response to pH and electrolyte.^{1,2} Using bench-top techniques such as ellipsometry and QCM-D we demonstrated that the brushes were swollen at low pH and intermediate electrolyte concentrations. The magnitude of swelling and collapse at a particular pH and electrolyte concentration was also found to be dependent on the relative hydrophobicity of the monomer and the identity of the counterion used. However, the techniques used cannot determine the structural origins of the variations in swelling state. Elucidating these is important for understanding how different stimuli affect the brush. For example, how is the collapsed brush exposed to high concentrations of chaotropic counterions different from the hydrophobic collapse induced by high pH? Neutron reflectivity is the most suitable technique available for determining the structure of a polymer brush perpendicular to the grafting interface. We have used this technique to determine the structural response brushes to pH (Figure 1), electrolyte, temperature and mechanical confinement.

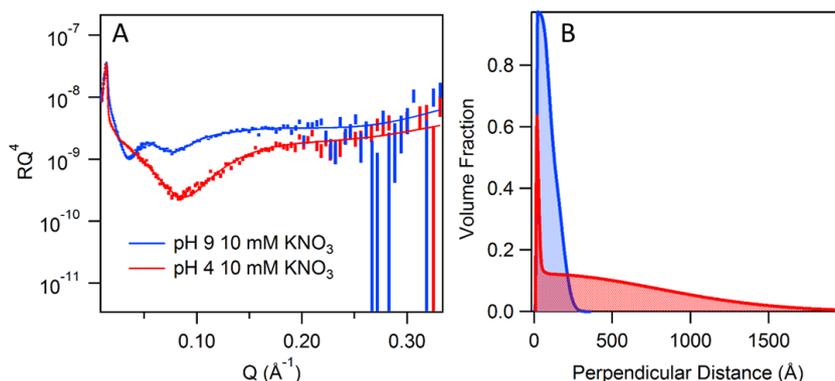


Figure 1: A — Reflectivity curves and B — corresponding fitted volume fraction profiles of a poly(2-diisopropylamino)ethyl methacrylate brush in response to pH.

¹ Willott et al., Anion-specific effects on the behavior of pH-sensitive polybasic brushes., see n. 1.

² Willott, J. D. et al. *Phys. Chem. Chem. Phys.* **2015**, *17*, 3880–3890, DOI: [10.1039/c4cp05292g](https://doi.org/10.1039/c4cp05292g).

Microfluidics Approaches to Understanding the Kinetics of the Transformation of Liquid Crystalline Nanoparticles

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Liquid crystalline nanoparticles (LCNPs) which comprise of lipids have demonstrated great potential in drug delivery systems, but commercial drug products for non-lamellar systems such as cubosomes and hexosomes have been limited due to production and stability constraints. Microfluidics is a tool which can be used to efficiently mix fluids in minute volumes, and has been used to analyse and manipulate biomolecules.¹ To a lesser extent, the analyses of cubic and lamellar phases have also been explored² but in fixed, closed systems. The mechanism by which these particular structures are formed or transformed is still not well understood. Hence the ability to analyse each individual particle via the use of microfluidics and small angle X-ray scattering (SAXS) may elucidate the kinetics of structure formation, and provide a means to efficiently improve current drug delivery systems.

The microfluidic device was placed in line with the SAXS beam at the Australian Synchrotron. Time-resolved analysis was attained by acquiring at various positions along the channels in the microfluidic apparatus, which correlated to a proportional time point in the transformation of the LCNP. Lipid precursor systems containing a modifying agent that renders the lipid stimuli responsive, such as with enzyme-induced transformations,³ were combined with another stream of the stimulus agent within the microfluidic device. The flow rates of each respective fluid were controlled in their separate channels, varying the proportions of each material. By altering the flow rate, the systems were equilibrated to different extents and various intermediate structures were observed. Different compositions and concentrations also resulted in different nanostructures.

Combining microfluidics with scattering techniques such as SAXS can allow the evolution of the liquid crystalline nanostructure to be monitored closely and finely controlled.

¹ Pfohl, T. et al. *ChemPhysChem* **2003**, *4*, 1291–1298, DOI: [10.1002/cphc.200300847](https://doi.org/10.1002/cphc.200300847).

² Khvostichenko, D. S. et al. *Analyst* **2013**, *138*, 5384–5395, DOI: [10.1039/c3an01174g](https://doi.org/10.1039/c3an01174g).

³ Fong, W. K. et al. *Langmuir* **2014**, *30*, 5373–5377, DOI: [10.1021/la5003447](https://doi.org/10.1021/la5003447).

Recyclable Nanofibre Composites as an Excellent Barrier in Packaging Applications

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Cellulose nanofibres are an exciting low-cost renewable new nanomaterials. Cellulose nanofibre sheets have exciting future prospects as barriers. The most important barrier properties of cellulose nanofibre sheets are water vapour permeability (WVP) and oxygen permeability (OP). Due to smaller diameter and small pore size, cellulose nanofibre sheets have low OP, however the WVP is high due to hydrophilic nature of cellulose. Many commercially available packaging materials are associated with wax, aluminium and plastic materials, which has low WVP, but such materials are not recyclable and biodegradable. Therefore, keeping low OP while reducing WVP is a key challenge to the utilisation of cellulose nanofibres as recyclable barrier material today. One way of addressing this issue is to do surface modifications to increase the hydrophobicity of cellulose nanofibres by coating nanofibres with suitable low WVP materials. Another way to address this issue is to increase the tortuosity of the nanofibre sheet thereby water vapours find it difficult to travel across the membrane. This paper explores the latter by preparing nanocellulose hybrids.

Composites were prepared through filtration process by addition of nanocellulose and layered silicates (nanoclays). The nanoclay composition varied between 5 % to 70 % mass fraction. The effect of fibre fibrillation on the WVP of the sheet and the effect of nanoclay addition on WVP of the composite sheet were determined. Effect of nanoclay addition on strength and porosity of the composite was determined as well. The WVP values obtained for composites showed an improved results when compared with the performance of other cellulose sheets reported in literature.

Shear Induced Dewatering in Networked Suspensions

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Many industries utilise thickeners to dewater solid-liquid suspensions to reduce waste volume and recover process liquor. The ability to accurately predict thickener performance in terms of solids throughput and underflow concentration is the ultimate goal for design and operation. A number of researchers^{1,2,3,4} have developed thickener models to predict performance, however resulting in an under estimation of thickener solids flux.⁵

Investigating this discrepancy shows that shear induced change in structure causes a significant increase in the potential extent and rate of dewatering. Shear induced dewatering enhancement has thickener designers asking the question, 'Within a thickener, where and how should the suspension be sheared to achieve optimum performance?' This work investigates the optimum location in a thickener to shear a suspension in order to exploit this phenomenon.

The hindered settling and consolidation regions are two practical locations to impart shear within a thicker. Aggregates are distinct within the hindered settling region and shear induced dewatering is caused via aggregate densification, whereby the aggregate diameter is reduced. In the consolidation region, the solids concentration is high enough that the aggregates form a networked structure. Here the aggregates are no longer distinct and the concept of a change in aggregate diameter can no longer be used. Instead, shearing causes stretching and rearrangement and in turn provides dewatering enhancement.

Previous work has investigated dewatering enhancement due to shearing within the hindered settling region. This work investigates shear during consolidation and in particular the effect of network stress. The results indicate a positive relationship between network stress and the extent of dewatering. An order of magnitude increase in the rate of dewatering is observed when comparing to raking during hindered settling.

Application of this work will allow for the design and operation of more efficient thickeners in which shear induced dewatering will be exploited.

¹ Usher, S. P.; Scales, P. J. *Chem. Eng. J.* **2005**, *111*, 253–261, DOI: [10.1016/j.cej.2005.02.015](https://doi.org/10.1016/j.cej.2005.02.015).

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³ Grassia, P. et al. *Chem. Eng. Sci.* **2014**, *111*, 56–72, DOI: [10.1016/j.ces.2014.02.013](https://doi.org/10.1016/j.ces.2014.02.013).

⁴ Zhang, Y. et al. *Chem. Eng. Sci.* **2013**, *99*, 103–112, DOI: [10.1016/j.ces.2013.05.046](https://doi.org/10.1016/j.ces.2013.05.046).

⁵ Usher, S. Suspension dewatering: characterisation and optimisation., Chemical and Biomolecular Engineering, Ph.D. Thesis, The University of Melbourne: Melbourne, Australia., 2002.

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.¹ 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 (see Figure 1). 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. This 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.

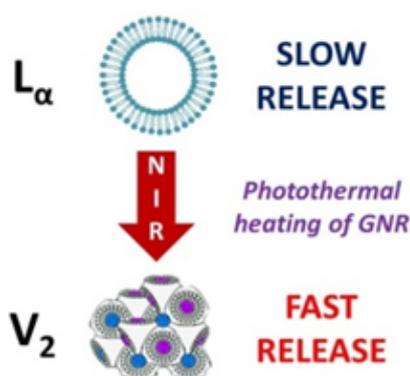


Figure 1: Schematic of the 'desired' LC system with a phase transition from lamellar phase (L_{α}) to bicontinuous cubic phase (V_2) controlled using NIR laser and GNR.

¹ Du, J. D. et al. *Physical Chemistry Chemical Physics* **2015**, *17*, 14021–14027, DOI: [10.1039/c5cp01229e](https://doi.org/10.1039/c5cp01229e).

BSA Stabilizes and Prolongs Antibody Bioactivity on Paper

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As we have identified that the chemical property of the substrate surface plays an important role in antibody bioactivity loss on paper, it is possible to alter this property and increase antibody longevity on paper. Bovine serum albumin (BSA) is commonly used in manufacturing antibody products in liquid form for its ability to prevent adherence between the antibodies and the glass bottles. To perform that function, BSA, as a very adherent chemical, can form a layer on glass surface. In a similar manner, BSA can also cover the chemical groups on paper surface which cause the antibody bioactivity loss over storage. We performed a systemic antibody longevity study on paper towel covered with BSA. The paper samples were stored under two conditions, ambient relative humidity environment as a common storage condition and 100% relative humidity environment as an accelerated aging condition. Our results showed a significant increase in antibody longevity under both environments. BSA can prolong antibody bioactivity to 63 days under both environments, while without BSA protection, antibodies lost their bioactivity on 7 days under ambient condition and 3 days under 100% relative humidity environment. Furthermore, BSA was able to significantly stabilize the antibody performance under ambient environment. We further conduct an XPS analysis for studying the surface chemical property. The result also showed a change in the amount of hydroxyl groups on paper surface after applying BSA on. All those results support our theory that hydroxyl groups are the cause of antibody bioactivity loss. In addition, by altering the surface chemical property, it is possible to significantly optimizing the performance of the paper-based devices. These results are the essential knowledge for optimising the substrate of paper-based blood grouping devices. It would benefit a range of paper-based bio-analysing devices involving antibodies on.

Atomic Force Microscopy for Immunohaematology

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The Atomic Force Microscope (AFM) is a powerful tool for biological imaging, as it produces insightful 3-D images from 1 nm to 10 μm, requires minimal sample pre-treatment, is able to image samples in physiological conditions and has the ability to measure interaction forces.¹ Multiple AFM studies have investigated red blood cells (RBCs) in pathological contexts. However, applications of AFM for blood banking have been poorly explored. The objective of our study is to address this gap in knowledge while exploring the use of chemically functionalized AFM cantilever tips for RBC functional mapping.

Our study focuses on the principle of the Indirect Antiglobulin Test which is widely used to identify the binding of IgG antibodies on the RBC surface with a secondary antibody (typically the anti-IgG antibody).² This experiment involves the use of AFM cantilever tips functionalized with anti-IgG antibodies which specifically identify the non-antigen binding site of human IgG antibodies to quantify the interaction forces between the antibodies on the cantilever tip and those bound to the RBC surface antigen. The Young's Modulus of normal healthy RBC and of RBCs that are incubated with specific corresponding antibodies is also explored.

These studies will not only benefit the optimization of different blood typing assays but also expand the potential of AFM as a biosensor for blood banking.

¹ Muller, D. J. *Biochemistry* **2008**, *47*, 7986–7998, DOI: [10.1021/bi800753x](https://doi.org/10.1021/bi800753x).

² Daniels, G.; Bromilow, I., *Essential Guide to Blood Groups*; Wiley-Blackwell: 2010, DOI: [10.1002/9781444325188](https://doi.org/10.1002/9781444325188).

Nanostructured Liquid Crystalline Nanoparticles as Agricultural Chemical Adjuvant Systems

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Polar amphiphilic lipids, such as phytantriol, can self-assemble in excess water to form liquid crystalline phases such as the inverse bicontinuous cubic phase (V_2) and inverse hexagonal phase (H_2).¹ Liquid crystalline systems have previously been utilised for drug delivery to the skin.² The function of the skin is analogous to that of a leaf,³ it has therefore been proposed that liquid crystalline nanoparticles can be used in the delivery of agrochemicals as novel adjuvant systems. Previous studies on biorelevant surfaces, indicated enhanced adsorption in particular with the cubic phase as well as presenting less phytotoxicity and less disruption to epicuticular waxes when compared to commercial surfactants.^{4,5}

There is a need to understand the nature of colloidal interactions between the adjuvant nanoparticles and the agrochemical products, which are often emulsions. The interparticle transfer of lipids between liquid crystalline nanoparticles and other dispersed lipids in emulsions have been reported.⁶ However, there have been no studies into the kinetic mixing behaviour of liquid crystalline systems with agrochemicals as would occur 'in-tank' when in use by the farmers. It is also not known whether particles retain their structure on a leaf surface, or mix with lipid structures constituting the leaf itself.

Small angle X-ray scattering at the Australian Synchrotron has been used to study the interactions upon mixing agrochemical emulsions with the liquid crystalline systems. Figure 1, shows a phase change from cubosomes (dispersed cubic phase particles) through hexosomes to inverse micellar particles, over time, indicating transfer of components into the liquid crystalline system.

To probe the interaction of cubosomes with leaf surfaces, leaf samples with and without treatment of cubosomes were studied using transmission SAXS. The impact of applying nanoparticle dispersions on harvested Eucalyptus leaves was investigated by placing the untreated and treated leaves directly in the X-ray path. The study showed that the application of the nanoparticle dispersion induced changes in the scattering profiles of the leaf. This is promising for future selection of liquid crystalline nanoparticles as novel adjuvant systems.

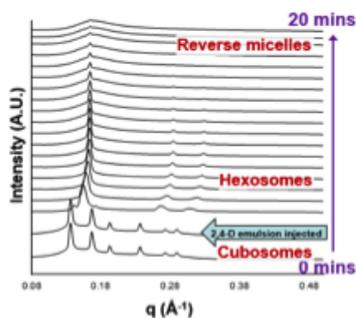


Figure 1: Dynamic mixing of phytantriol cubosomes with 2,4-dichlorophenoxyacetic ethylhexyl ester (2,4-D) emulsion at 7 : 3 (vol/vol) ratio

1 Boyd, B. J. et al. *J. Liposome Res.* **2009**, *19*, 12–28, DOI: [10.1080/08982100802691983](https://doi.org/10.1080/08982100802691983).

2 Bender, J. et al. *J. Controlled Release* **2005**, *106*, 350–360, DOI: [10.1016/j.jconrel.2005.05.010](https://doi.org/10.1016/j.jconrel.2005.05.010).

3 Bender et al., see n. 2.

4 Dong, Y.-D. et al. *ACS Appl. Mater. Interfaces* **2011**, *3*, 1771–1780, DOI: [10.1021/am2003069](https://doi.org/10.1021/am2003069).

5 Nadiminti, P. P. et al. *ACS Appl. Mater. Interfaces* **2013**, *5*, 1818–1826, DOI: [10.1021/am303208t](https://doi.org/10.1021/am303208t).

6 Tilley, A. et al. *Phys. Chem. Chem. Phys.* **2011**, *13*, 3026–3032, DOI: [10.1039/c0cp01724h](https://doi.org/10.1039/c0cp01724h).

Gravitational Effect on the Formation of Surface Nanodroplets

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Nanoscale droplets at a solid-liquid interface are of high relevance for many fundamental phenomena and applied processes. The solvent exchange process is a simple approach to produce e.g. oil nanodroplets over a large surface area on a substrate, by exchange oil-saturated ethanol by oil-saturated water, which has a lower oil solubility than ethanol. In this process, the size of the nanodroplets is closely related to the flow conditions. To achieve control of the droplet size, it is essential to fully understand the nucleation and growth of nanodroplets under different flow conditions. In this work, we investigate the gravitational effect on the droplet formation by the solvent exchange. We compared the droplet size as the substrate was placed on the upper or lower wall in a horizontal fluid channel or on the sides of a vertical channel with an upward or downward flow. We found significant difference in the droplet size for the three substrate positions in a wide channel with height $h = 0.21$ mm. The difference of droplet size was eliminated in a narrow channel with height $h = 0.07$ mm. The relevant dimensional control parameter for the occurrence of the gravitational effects is the Archimedes number Ar and these two heights correspond to $Ar = 10$ and $Ar = 0.35$, respectively. The gravitational effects lead to a non-symmetric parabolic profile of the mixing front, with the velocity maximum being off-center and thus with different distances $\alpha(Ar)h$ and $(1 - \alpha(Ar))h$ to the lower and upper wall, respectively. The ratio of the total droplet volume on the lower and upper wall is theoretically found to be $(\alpha(Ar)/(1 - \alpha(Ar)))^3$. This study thus improves our understanding of the mechanism of the solvent exchange process, providing guidelines for tailoring the volume of surface nanodroplets.

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Lohse, D.; Zhang, X. *Rev. Mod. Phys.* **2015**, *87*, 981–1035, DOI: [10.1103/revmodphys.87.981](https://doi.org/10.1103/revmodphys.87.981).

Co-Delivery of Nitric Oxide and Antibiotic Using Polymeric Nanoparticles

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The rise of hospital-acquired infections, also known as nosocomial infections, is a growing concern in intensive healthcare, causing the death of hundreds of thousands patients and costing billions of dollars worldwide every year. In addition, a decrease in the effectiveness of antibiotics caused by the emergence of drug resistance in pathogens living in biofilm communities poses a significant threat to our health system. The development of new therapeutic agents is urgently needed to overcome this challenge. We have developed new dual action polymeric nanoparticles capable of storing nitric oxide, which can provoke dispersal of biofilms into an antibiotic susceptible planktonic form, together with the aminoglycoside gentamicin, capable of killing the bacteria. The novelty of this work lies in the attachment of NO-releasing moiety to an existing clinically used drug, gentamicin. The nanoparticles were found to release both agents simultaneously and demonstrated synergistic effects, reducing the viability of *Pseudomonas aeruginosa* biofilm and planktonic cultures by more than 90% and 95%, respectively, while treatments with antibiotic or nitric oxide alone resulted in less than 20% decrease in biofilm viability.

Charge Control of Graphene Oxide in Colloidal Systems

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Monolayer sheets of graphene oxide (GO) are known to exist as highly stable aqueous dispersions, with stability to coagulation primarily occurring through electrostatic repulsions between sheets. Hence, it is possible to control the dispersion behaviour of GO by altering its surface charge through the manipulation of system pH. Our poster presents recent advances in the understanding and controlling of aqueous GO dispersions for the purposes of emulsification and water treatment. For the former, GO is used to stabilise oil-in-water emulsions, with emulsion stability being greatly enhanced at highly acidic values of pH, where repulsive forces between sheets are minimised.¹ The basis for this phenomenon is measured directly using atomic force microscopy. In basic conditions however, emulsification of the oil does not occur, hence changing the pH of the GO solution can be used to reversibly control capture and release of the oil. These findings may have potential applications in the recovery and recycling of waste oils from industrial processing.

In addition, a similar concept is used to facilitate the removal of GO sheets from water via magnetic separation.² In this study, magnetic particles of various size scales are employed to form noncovalent, charge-based assemblies with GO, allowing for the easy and efficient separation of the GO from solution. This effect again is shown to be dependent on system pH, with acidic conditions favouring mutual attraction by both the GO and magnetic particles via opposing surface charges, and basic conditions resulting in mutual like-charge repulsions such that the GO cannot be separated magnetically. This method is also shown to be reversible, with the GO being interchangeably captured and released by changes in system pH. This development has obvious potential for the viable use of GO as an adsorbent for the treatment and decontamination of wastewater.

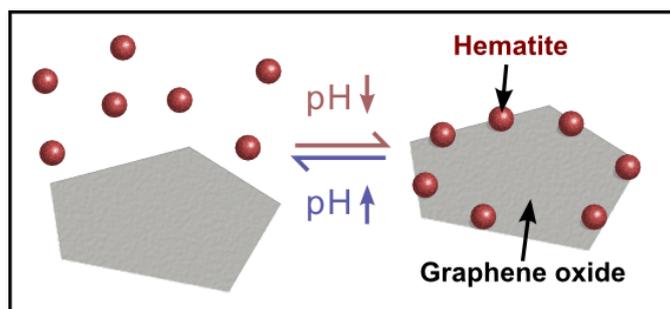


Figure 1: Schematic showing the reversible adsorption and desorption of iron oxide particles onto graphene oxide sheets in response to varying pH conditions.

¹ McCoy, T. M. et al. *J. Phys. Chem. C* **2014**, *118*, 4529–4535, DOI: [10.1021/jp500072a](https://doi.org/10.1021/jp500072a).

² McCoy, T. M. et al. *ACS Appl. Mater. Interfaces* **2015**, *7*, 2124–2133, DOI: [10.1021/am508565d](https://doi.org/10.1021/am508565d).

Engineering the Zeta Potential of Cellulose Nanocrystal Suspensions Using Salts and Surfactants

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The zeta potential of cellulose nanocrystal (CNC) aqueous dispersions was studied as a function of solution conditions, including changing pH and different electrolyte identities and concentrations. A range of electrolytes that spans typical Hofmeister/hydrophobic effects was explored, along with both cationic and anionic surfactants. A subtle interplay of electrostatic and hydrophobic effects in ion adsorption was uncovered, including evidence of charge reversal and supercharging when hydrophobic surfactants are added to aqueous CNC dispersions. The apparent effects of zeta potential on dispersion stability were explored by using atomic force microscopy (AFM) to determine the roughness of resulting CNC films. The root mean square roughness (RMS) of these cellulose films scaled inversely and non-linearly with the zeta potential of the CNC suspension, indicating a facile method for the control of cellulose film roughness.

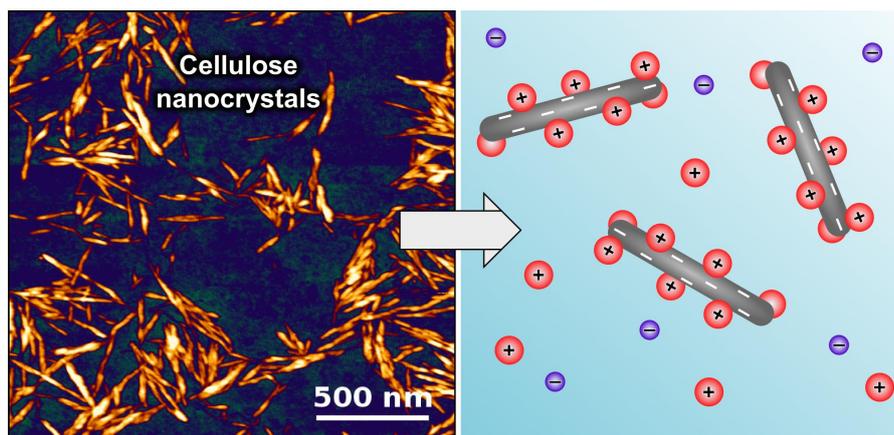


Figure 1: Left side shows the Atomic Force Microscopy (AFM) of cellulose nanocrystals and the right side shows a schematic diagram of how the charges from salts interact within cellulose nanocrystals

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Capturing Heavy Metal Ions Using Non-Covalent, Reversibly Magnetic Graphene Oxide

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The sorption capacity of zinc on both virgin graphene oxide (GO) and non-covalently-bonded magnetic graphene oxide, comprising of GO and magnetic iron oxide nanoparticles (mGO) was investigated using flame atomic absorption spectroscopy. Extending the isotherm to higher zinc concentrations than previous experiments, at pH 4, we demonstrate an unprecedented zinc sorption capacity of approx 900 mg Zn/g of GO for virgin graphene oxide (GO). The sorption capacity of mGO was shown to be lower, at approx 300 mg Zn/g of GO, which is still much higher than the sorption capacities for other commercial or experimental adsorption materials such as activated carbon or zeolites. We establish that at pH 4, a 1 : 2 ratio of magnetite nanoparticles to GO allows for optimal flocculation of the GO. This material shows great potential in future industrial wastewater treatment applications, as it was also shown to be flocculated through controlling the pH of solution, including through the novel, 'reagent-free' method of sparging with carbon dioxide gas to lower the pH to 5.0. At this pH, the magnetite nanoparticles are positively charged, whereas the GO is negatively charged, allowing adsorption and capture through electrostatic attraction and application of an external magnet.

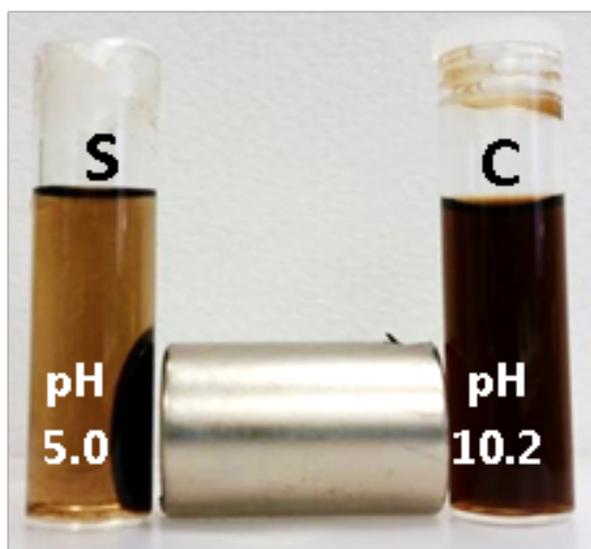


Figure 1: Photograph of GO + iron oxide nanoparticles, demonstrating that the CO₂ sparged sample (S) experienced a large drop in pH after being bubbled with CO₂ for 15 min. After sparging, the sample showed a strong and immediate magnetic response when a strong NdFeB magnet was placed next to both samples, which was not observed in the control sample (C)

McCoy et al., 'Noncovalent Magnetic Control and Reversible Recovery of Graphene Oxide Using Iron Oxide and Magnetic Surfactants'.

Ionic Liquids Induce Surfactant-Free Self-Assembly

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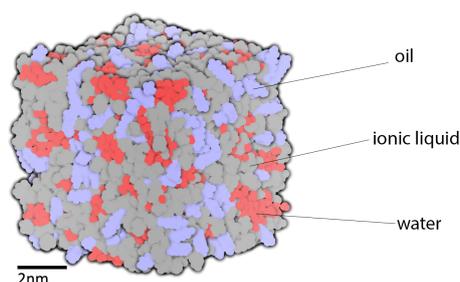
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As molten salts, ionic liquids (ILs) have huge potential in material and colloid science for their tunable properties with different combinations of cations and anions. To date, almost all studies on IL-containing microemulsions involve a surfactant, which itself can form micellar structures in water. 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.^{1,2} Different from water and other molecular solvents, ILs encourage weak amphiphiles, such as alcohols, to self-assemble into a two-component microemulsion.^{3,4} An insight into the amphiphilicity of ILs will open up many opportunities, including tailored liquid nanostructure and highly functional materials.

Our current study expands the scope of amphiphilic self-assembly. We utilise ILs to induce liquid nanostructure without the presence of a surfactant. Using small-angle X-ray scattering, we examine the liquid nanostructure of IL-containing mixtures at various compositions. Depending on the concentration, ILs can act as either ionic additives or self-assembly media. Our systems are simple yet novel. All components are liquids at room temperature, thermally stable, easy to handle, non-halogenated and have low-toxicity. Two model protic ionic liquids (PILs) were chosen: propylammonium nitrate (PAN) as an amphiphilic PIL, and ethanolammonium nitrate (EtAN) as a non-amphiphilic PIL. Using phase diagrams and X-ray scattering we demonstrate the ability of PILs to create nanostructure, starting from binary mixtures. We further illustrate a systematic change in nanostructure by introducing a third component, and we establish a new matrix of PIL-containing microemulsions with predictable structural behaviour.



¹ Atkin, R. et al. *J. Phys. Chem. B* **2010**, *114*, 1350–1360, DOI: [10.1021/jp910649a](https://doi.org/10.1021/jp910649a).

² Hayes, R. et al. *Phys. Chem. Chem. Phys.* **2011**, *13*, 3237–3247, DOI: [10.1039/c0cp01137a](https://doi.org/10.1039/c0cp01137a).

³ Jiang, H. J. et al. *J. Phys. Chem. B* **2014**, *118*, 9983–9990, DOI: [10.1021/jp504998t](https://doi.org/10.1021/jp504998t).

⁴ Murphy, T. et al. **2015**, manuscript in preparation.

Characterising the Biophysical and Dewatering Properties of Microalgae

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Microalgae are ubiquitous organisms that are currently considered promising sources of natural products of industrial interest, such as lipids for biodiesel production, natural pigments for the food industry, and a wide variety of bioactive compounds. However, for the economically competitive use of these organisms as biorefinery feedstocks, several technical and economical obstacles have to be overcome. On an industrial scale, microalgae are usually grown in diluted conditions (≈ 0.1 g/l to 1.0 g/l) requiring extensive and efficient concentration. The cells are small, typically less than 10 μm , at a density close to that of the growth medium, and have a net negative surface charge that provides stability to the algal suspension. These facts pose technical challenges to concentration and dewatering, which represent up to 30% of the total production cost. Traditional solid-liquid separation methods are hindered by these characteristics presenting shortcomings of being energy-intensive (drying and centrifugation), undergoing clogging with low solids concentration in the final product (filtration), or presenting high capital and operating costs (flotation). In order to compare different separation methods on industrial scale this project aims to characterize the fundamental dewatering properties of microalgae suspensions across a diverse range of species. Standardized jar-tests, LUMiFuge[®] and pressure filtration experiments will be used to define the suspensions' compressibility, permeability, and solids diffusivity. These principles will be correlated with changes in physicochemical intrinsic characteristics such as density, morphology, and physiological state during each species' life cycle. Density gradient centrifugation, image analysis, and Nile red staining and Bligh and Dyer extraction routines will be respectively applied. This understanding will be applied to novel strategies including the use of natural low-cost flocculants and ultrasound harvesting to target reductions in operational costs and improved dewatering efficiency.

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The Puzzle of Bulk Nanobubbles' Existence

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The existence of bulk nanobubbles is controversial, given that small bubbles have high internal pressure. From the Young-Laplace equation, the internal pressure for a small bubble with a 100 nm radius in pure water, is $P = P_{\text{atm}} + \frac{2\gamma}{r} \approx 1.45 \text{ MPa}$. Thus, they should dissolve on a timescale of 1 μs to 100 μs , calculated through the use of a widely accepted theory of bubble dissolution.^{1,2} However, surface nanobubbles have been widely studied in the last 10 years. Their acceptance as nanoscopic gaseous bubbles is widespread, even though their stability is not fully understood.

Bulk nanobubbles are the topic of fewer reports in the literature than is the case with surface nanobubbles; in fact, their existence is not widely accepted. The goal of this work is to investigate the presence of bulk nanobubbles, with the ultimate aim of understanding their stability. In this study, water was electrolyzed to generate nanobubbles, and we developed an approach to measure the presence of those bulk nanobubbles and characterize them in terms of size and concentration. The existence of bulk nanobubbles has previously been investigated through the use of dynamic light scattering and nanoparticles tracking analysis techniques, to observe their stability over a number of days. However as yet no definitive proof has been provided to show that they are gas filled. Here we adopt a number of novel approaches to investigate this, such as the removal of oxygen, the reduction of surface tension, and the measurement of dissolved oxygen. Although, bulk nanobubbles represent a relatively new field, surprisingly, they already have applications in various areas, including surface cleaning, wastewater treatment, and froth flotation.³ It is expected that the fundamental science outcomes from this study will enhance our understanding of nanobubbles.

¹ Epstein, P. S.; Plesset, M. S. *J. Chem. Phys.* **1950**, *18*, 1505, DOI: [10.1063/1.1747520](https://doi.org/10.1063/1.1747520).

² Ljunggren, S.; Eriksson, J. C. *Colloids Surf., A* **1997**, *129-130*, 151-155, DOI: [10.1016/S0927-7757\(97\)00033-2](https://doi.org/10.1016/S0927-7757(97)00033-2).

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Superposition of Compression and Shear in Filtration

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In times of ever increasing energy costs and environmental consciousness the optimisation of filtration processes for more efficient operation and for reuse of material streams is of high importance. The filtration of suspensions aims to increase the solids concentration. A particulate network forms at a material specific concentration, called the gel point. At concentrations greater than the gel point, suspensions exhibit a strength against deformation. In shear this resistance is called the shear yield stress τ_v and in compression it is the compressive yield stress P_v , as depicted in Figure (a) and Figure (b). For further dewatering of a suspension, an applied force has to be greater than the apparent network strength. In many industrial processes, a superposition of shear and compression is applied to the suspension due to machine design and/or operation. Thereby, the effect of combining shear and compression (see Figure (c)) in filtration is of great interest. However, the interrelated influence of shear and compression is still unclear and needs further investigation. A novel dewatering device, called High Pressure Dewatering Rolls (HPDR), has been developed at the University of Melbourne that combines shear and compression. The operating principle of the HPDR is depicted in Figure 2. With this device, the extent of shear and compression can be adjusted and thus superposition of the two can be investigated. In this presentation, compressional rheology and models used in soil mechanics and granular materials will be outlined, followed by an overview of the HPDR and preliminary results.

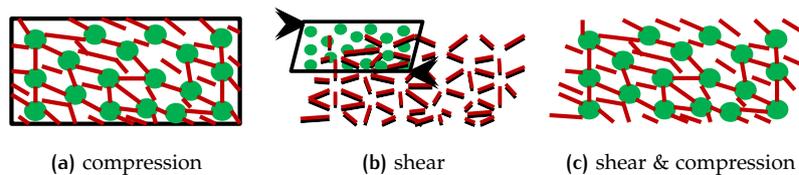


Figure 1: Modes of load application onto a particulate network.

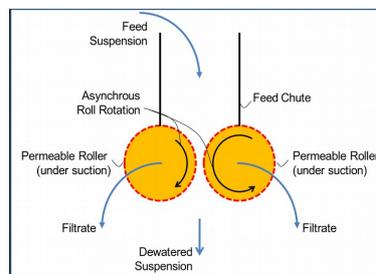


Figure 2: Operating principle of the High Pressure Dewatering Rolls.

Specific Ion Effects within the Thermoresponse of pNIPAM Brushes

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We have investigated the solvation and conformational changes of poly(*N*-isopropylacrylamide) (pNIPAM) brushes in response to aqueous salt solutions; with particular attention to the influence of specific anions at either end of the Hofmeister series. The brushes were synthesised via activators regenerated by electron transfer atom transfer radical polymerisation (ARGET ATRP) from covalently bound initiator sites on oxidised-silicon wafers and silica-coated quartz crystal microbalance with dissipation (QCM-D) sensors. The brush thermoresponse was subsequently analysed via in situ ellipsometry, QCM-D and static contact angle measurements.¹ The temperature response of a pNIPAM brush is dictated by the balance of the entropic interactions between polymer chains and the surrounding solvent molecules.² In aqueous solutions, below the LCST, the amide groups within pNIPAM are capable of forming hydrogen bonds with water molecules thus solubilising the polymer chains and causing the brush to swell (i.e. polymer-solute interactions dominate). At temperatures above the LCST, the entropic penalty associated with the formation of hydration sheaths around the hydrophobic isopropyl groups and the polymer backbone becomes significant causing the polymer chains to become insoluble and the brush collapses (i.e. polymer-polymer interactions dominate). The bulk phase transition for a pNIPAM brush in aqueous solution (ellipsometry and QCM-D measurements) was shown to span a broad temperature range ($\approx 15^\circ\text{C}$) whereas the surface transition of the brush (static contact angle measurements) was significantly less ($\approx 2^\circ\text{C}$) and occurred at a temperature where the brush was still predominantly collapsed. The strongly hydrated acetate anions increasingly shifted the brush response to lower temperatures as a function of concentration. Conversely, the opposite trend was observed for the weakly hydrated thiocyanate anions which are hypothesised to specifically bind within the brush.

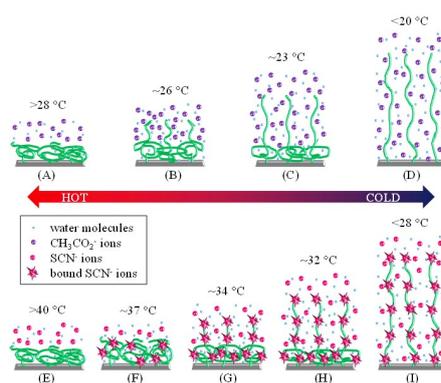


Figure 1: Schematic representation of the proposed equilibrium interactions between a pNIPAM brush and (A-D) 250 mmol/dm^3 acetate ions and (E-I) 250 mmol/dm^3 thiocyanate ions as a function of temperature.

¹ Humphreys, B., Honours Thesis, University of Newcastle, 2015.

² Schild, see n. 2.

Molecular Insights into Amyloid Toxicity Using Model Lipid Membranes

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Celine Valery¹, Nick Reynolds² and Calum Drummond¹

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We aim to understand the interactions between model amyloid-forming peptides and cell membranes. Specifically, we are investigating how the lipid bilayer environment of the cell membrane affects fibrillisation, and conversely, how amyloid fibrils and intermediate oligomeric species affect the structure of the lipid bilayer. We will be focusing on how the mechanism of action of irreversible (toxic) fibrillogenesis e.g. in 'Alzheimer's Disease' differs from that of reversible (functional) fibrillogenesis which is observed for many hormones. Model amyloid peptides will be supplied by Dr. Nick Reynolds (irreversible), a research scientist at Swinburne University and Dr. Celine Valery from the School of Medical Sciences at RMIT University (reversible). Due to the delicate and heterogeneous nature of the cell membrane, we concentrated on lipidic cubic phase as a model lipid bilayer system to simulate few of the properties of the biological systems.¹ Three experimentally detected cubic phases are the Schwarz diamond (Q_{II}^D), the primitive (Q_{II}^P), and the Schoen gyroid cubic phase (Q_{II}^G) and possess crystallographic groups $Pn3m$, $Im3m$ and $Ia3d$ correspondingly. Other frequently observed mesophases are fluid lamellar (L_α) and inverse hexagonal (H_{II}) mesophases.^{2,3}

The aim is to investigate the mechanism of interactions of a sequence of model amyloid peptides with model lipid bilayers mainly focusing on the cubic phases to achieve insight into how these interactions affect fibril assembly kinetics and membrane phase behaviour. In particular we will focus on the effects of charge and lipid composition, as these aspects can strongly disturb membrane interactions in a series of amyloid disease models.⁴ Synchrotron SAXS will be the main technique used to analyse the structure of the lipidic cubic phase in the presence of oligomers and fibrils of each of the amyloid peptides.

¹ Conn and Drummond, see n. 2.

² Van 't Hag, L. et al. *Cryst. Growth Des.* **2014**, *14*, 1771–1781, DOI: [10.1021/cg4018954](https://doi.org/10.1021/cg4018954).

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⁴ Reynolds, N. P. et al. *J. Am. Chem. Soc.* **2011**, *133*, 19366–19375, DOI: [10.1021/ja2029848](https://doi.org/10.1021/ja2029848).

Computational Investigation into the Structure of Deep Eutectic Solvents

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Deep Eutectic Solvents (DES) are a class of ionic solvents formed from mixtures of ionic and molecular components. At a specific mixture composition (known as the eutectic point) the melting point undergoes a temperature depression compared to the pure components. One of the most significant temperature depressions observed is between choline chloride and urea which, at a 1 : 2 mole ratio, has a melting temperature of 22 °C, compared to 302 °C and 133 °C for choline chloride and urea respectively.¹ This temperature depression give DESs properties analogous to Ionic Liquids (ILs) e.g non-flammability and wide electrochemical window, while being relatively cheap, environmentally friendly, and simple to produce.² It is known that the temperature depression is due to reduced lattice energy caused by the frustration of crystal structure from each of the components. Some evidence suggests that it is due to the separation of ions by complexation with molecular components, however very little work has been undertaken to determine the physical structure of these liquids at the nanoscale.

Our group has been working to elucidate the physical structure of choline chloride based DESs employing different HBD molecular species through both experimental and theoretical means. Atomic Force Microscopy (AFM) has been employed to study DES structure at an interface, while quantum mechanical molecular dynamics calculations (QM/MD) has been used to determine bulk structure effects. Molecular species have been chosen based on differences in physical size, polarity, type and number of hydrogen bond donor/acceptor moieties as to generate a deeper understanding of the effect each of these have on the bonding within the DES, and to better understand this temperature depression phenomena.

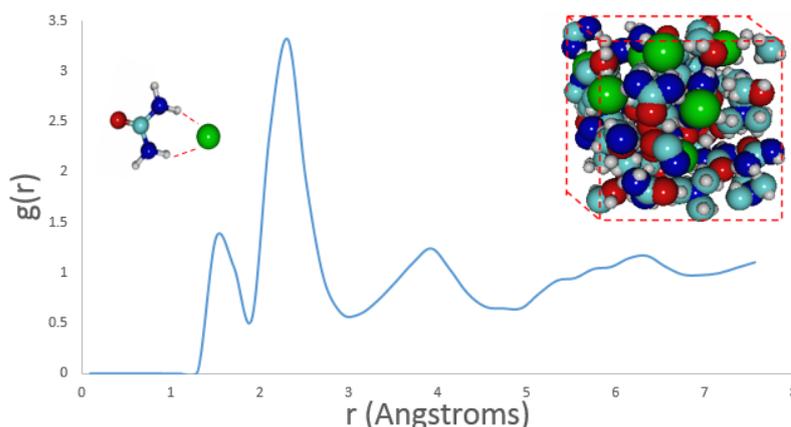


Figure 1: QM/MD Simulation box for choline chloride-urea DES (top right) with Radial Distribution Function of urea-chloride interaction. H = White, O = Red, N = Blue, C = Cyan, Cl = Green

¹ Abbott, A. P. et al. *Chem. Commun.* **2002**, 70–71, DOI: [10.1039/b210714g](https://doi.org/10.1039/b210714g).

² Smith, E. L. et al. *Chem. Rev.* **2014**, *114*, 11060–11082, DOI: [10.1021/cr300162p](https://doi.org/10.1021/cr300162p).

New Carbohydrate-Based Surfactants for Consumer Products

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Abstract: Carbohydrate-based surfactants (CBS) are a class of amphiphile that have found widespread use as emulsifiers, detergents, foaming agents, and wetting agents, particularly in cosmetic products and for agricultural applications. Carbohydrates are ideal polar head groups for surfactant design as they are generally cheap, abundant, and biocompatible. In particular, glucose is ideal for selective derivatisation and is readily functionalised to provide diverse control opportunities for the formulation of new colloidal systems with targeted applications. The design and synthesis of novel CBS from purely renewable sources is extremely promising, especially as safe and effective alternatives to petrochemical-based surfactants utilised in industrial and consumer products.

Alkyl glucosides are among the most commonly used CBS in industry due to their efficacy and simple synthesis. This talk will focus on alkyl glucosides containing a triethylene glycol (TEG) linker between the glucose headgroup and alkyl tailgroup. The inclusion of the TEG linker has resulted in some interesting interfacial and aggregation properties in different media. This is due to a 'softening' of the spatial separation between the hydrophobic and hydrophilic portions — creating an interesting balance of interactions. The aggregation and phase behaviour properties have been studied to provide insight into the effect of the TEG linker. The knowledge gained will direct future use of these materials and will inform whether they represent promising alternatives to those derived from petrochemicals.

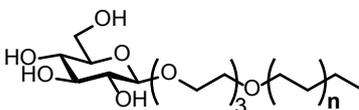


Figure 1: Example of an alkyl glucoside containing a triethylene glycol linker.

Dynamic Nanocellulose Hydrogels

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Hydrogels are 3D structures composed of polymeric networks which entrap large amounts of water. Although these materials can be produced using a plethora of polymers, naturally occurring polymers such as cellulose are of special interest. Cellulose, found commonly as a component of plant matter, is the most abundant biopolymer present in nature. Its hydrophilic nature can be exploited to produce biodegradable and sustainable cellulose-based hydrogels. Due to the innate biocompatibility of cellulose, it is currently being studied and has emerged as a potential candidate for food and biomedical applications.

In the current study, modified nanocellulose is used to produce hydrogels. Stepwise characterisation and modification of these hydrogels is required in order to suit their intended applications. Preliminary work on the rheological and chemical characterisation of these materials will be reported. In addition, some possible methods of enhancing these hydrogel systems will be highlighted. For instance, these hydrogels can be developed to include simple degradation patterns and responsiveness to basic triggers such as pH and temperature. Moreover, the feasibility of incorporating dynamic properties such as controlled degradation, mimicking biophysical cues, spatial heterogeneity, or responsiveness to biochemical triggers will also be discussed.¹

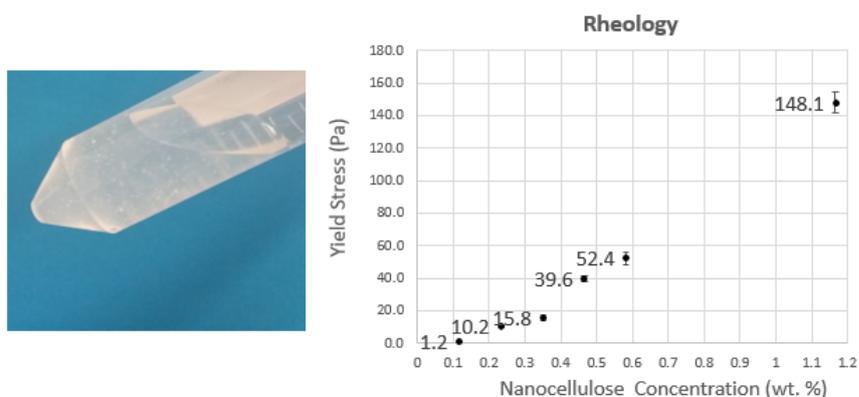


Figure 1: Nanocellulose hydrogel (Left), Yield stress as a function of nanocellulose concentration in hydrogels (Right)

¹ Burdick, J. A.; Murphy, W. L. *Nat. Commun.* **2012**, *3*, 1269, DOI: [10.1038/ncomms2271](https://doi.org/10.1038/ncomms2271).

Pluronic Surfactant Structure under Confinement/ Pluronic Surfactants Interaction with Crosslinked PDMS

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Polymeric materials have a variety of applications including coatings, paintings, biomedical implants and colloidal stability. To fully utilize their properties, understanding their structure in the actual working conditions is essential. Recent studies have shown that under confinement, materials change structures and consequently properties change with structures.^{1,2,3} These studies illustrate that confinement restricts molecular motion and restrain the shape of molecules which are under confinement, leading to new properties. We have developed a new confinement cell and are working towards theoretical models to help reveal confined structural information of polymeric surfactants and hence tuning and predicting of their performance.

We have used neutron reflectometry coupled with a confinement cell to probe the structure of polymeric surfactants in confined geometries. In conjunction with the neutron reflection confinement experiment, we have studied the interaction of F127 with various crosslinked PDMS films using contact angle measurement and QCM. We are able to control the F127 adsorption and migration within crosslinked PDMS by varying its crosslink density. This provides us with an insight in the stability and penetration of polymeric surfactant in PDMS colloidal systems.

¹ Abbott, S. B. et al. *Macromolecules* **2015**, *48*, 2224–2234, DOI: [10.1021/ma502246r](https://doi.org/10.1021/ma502246r).

² Abbott, S. B. et al. *Macromolecules* **2014**, *47*, 3263–3273, DOI: [10.1021/ma500557m](https://doi.org/10.1021/ma500557m).

³ De Vos, W. M. et al. *Macromolecules* **2013**, *46*, 1027–1034, DOI: [10.1021/ma3021773](https://doi.org/10.1021/ma3021773).

Novel Zeolite-(Nano)cellulose Fiber Composites for Liquid Purification by Filtration/adsorption

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Zeolites are being used in vast range of applications as ion exchanger, molecular sieves, adsorbents and catalysts. Due to their channels and pores in the structure, zeolites have high internal surface area which makes them appropriate adsorbents for adsorption.¹ They are currently being used in the forms of pellets and beads for adsorption processes.² Since these current adsorbent structures have some drawbacks such as high pressure drop, limited mass transfer, powdering of zeolites and repacking difficulties, novel non-particulate adsorbent structures are needed. Papermaking technique has been considered to create thin and high density non-particulate adsorbent sheets to overcome these problems.

In our study, we engineer zeolite structured adsorbent sheets using papermaking technique to produce lightweight materials of high surface area and controllable porosity. These composites are transformed into honeycomb structures and tested in filtration and adsorption for food applications such as caffeine removal. The effect of type of zeolites and composite composition are characterized in terms of structure and mechanical properties as well as adsorption and filtration efficiency.

¹ Breck, D. W., *Zeolite Molecular Sieves: Structure, Chemistry, and Use*; John Wiley & Sons: 1974, DOI: [10.1093/chromsci/13.4.18a-c](https://doi.org/10.1093/chromsci/13.4.18a-c).

² Dyer, A., *An Introduction to Zeolite Molecular Sieves*. John Wiley & Sons: 1988, DOI: [10.1017/s001675680006683](https://doi.org/10.1017/s001675680006683).

Counterion Effects in Fluorinated Surfactants

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The effects of counterion size and hydrophobicity on surfactant aggregation have been analysed using the anionic perfluorooctanoate surfactant. Using alkyl-substituted ammonium counterions, both the degree of substitution and the number of carbons on the alkyl chains were modified to provide a comprehensive matrix of different sizes and geometries. Small-angle neutron scattering (SANS) and polarising light microscopy (PLM) were utilised to analyse the changes in surfactant aggregation with different counterions. The phase behaviour of the surfactant with substituted ammonium counterions is dominated by lamellar structures, even at very low concentrations ($\approx 2\%$ mass fraction), however at low concentrations the SANS data shows very diffuse bilayers without a well-defined spacing. At higher temperatures, some species appear to show two different lamellar phases, with an unusual lamellar to lamellar phase transition. This is identified as a microscopic phase transition to a two-phase lamellar/micellar system that remains kinetically trapped. While the difference between the ammonium counterion and the substituted derivatives was substantial, the variation between the different substituted species was surprisingly minimal. As fluorocarbon chains are well known to favour low curvature interfaces in aggregates, the lack of significant variation in aggregates across a variety of counterion size and geometries is rationalised as a result of increased charge screening of the head groups, allowing for packing into structures geometrically favoured by the surfactant tail. We conclude that absolute hydrophobicity is a poor property when considering counterion effects, as diffuseness of charge and charge screening, while often linked to hydrophobicity, are better suited to fully explain the differences in behaviour.

Formation of Cubosomes Driven by Solvent Evaporation

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Amphiphilic lipids possess rich aqueous phase behavior and form various self-assembled phases and structures depending on their geometry. Of these, cubic phase is of interest in drug delivery due to the phase's bicontinuous internal structure. As hydrophilic and hydrophobic regions coexist, polar and non-polar drugs can both be solubilized in cubic phase with relatively high drug loading capacity.¹ However, the bulk cubic phase is a very viscous and solid-like material, which limits its application. When dispersed in excess water, the bulk cubic phase breaks down to small particles, cubosomes. Cubosomes have a microstructure identical to bulk cubic phase but their dispersions have a much lower viscosity.² There are three commonly used methods of preparing cubosomes: top-down, bottom-up³ and sideways.⁴ But high energy input, other hydrotropes or complicated operations are needed in these processes. Because the cubosome sizes obtained in these works range from tens to hundreds of nanometers, their size distribution can not be obtained from TEM images as the number of particles is limited.

One of the most used lipids for preparing cubic phase is monoolein (glyceryl monooleate, GMO), which is non-toxic, biocompatible and biodegradable, making it a good choice for drug delivery system design.⁵ Herein, cubosomes form in the evaporation process of GMO solution in the mixed solvent of H₂O and ethanol.⁶ Initially, phase separation occurs, circular droplets transform to cubosomes on length scales above tens of microns, and then cubes grow and continue to evolve. Cubosome formation is controlled by the concentration of the original solution and the evaporation of solvent. This process can be explained using a ternary phase diagram of GMO/H₂O/ethanol,⁷ and will be optimized to increase cubosome yield.

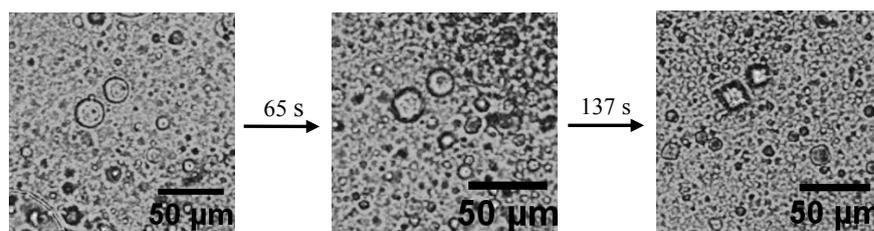


Figure 1: Transformation of circular droplets to cubosomes in GMO/H₂O/ethanol solution with time.

- 1 Mulet, X. et al. *J. Colloid Interface Sci.* **2013**, *393*, 1–20, DOI: [10.1016/j.jcis.2012.10.014](https://doi.org/10.1016/j.jcis.2012.10.014).
- 2 Spicer, P. T. et al. *Langmuir* **2001**, *17*, 5748–5756, DOI: [10.1021/la010161w](https://doi.org/10.1021/la010161w).
- 3 Spicer, P. *Chem. Eng. Res. Des.* **2005**, *83*, 1283–1286, DOI: [10.1205/cherd.05087](https://doi.org/10.1205/cherd.05087).
- 4 Fong et al., Generation of Geometrically Ordered Lipid-Based Liquid-Crystalline Nanoparticles Using Biologically Relevant Enzymatic Processing., see n. 3.
- 5 Fong, C. et al. *Chem. Soc. Rev.* **2012**, *41*, 1297–1322, DOI: [10.1039/c1cs15148g](https://doi.org/10.1039/c1cs15148g).
- 6 Spicer et al., see n. 2.
- 7 Spicer et al., see n. 2.

Physicochemical Characterisation of Monazite, Hematite and Quartz for Flotation

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Monazite is the principal rare earth (RE) mineral from which, among others, cerium, lanthanum and thorium are obtained. Froth flotation, which exploits the difference in the physicochemical properties of minerals has proven to be effective in RE mineral beneficiation. Monazite can be floated using fatty acids and alkyl sulphates. We have characterised the physicochemical properties of monazite and two common gangue minerals (hematite and quartz) in terms of zeta potential, contact angle and floatability. Sodium oleate, sodium dodecyl sulphate and alkyl hydroxamate were used as collectors and sodium silicate as a depressant. Electroacoustic zeta potential measurements were used to identify likely interactions between monazite, hematite and quartz, and the selected collectors, as a function of pH. The capillary rise method was used to determine the contact angle of the three minerals. It is shown that contact angles of the minerals is dependent on the collector type used, while quartz was unaffected. The isoelectric point (IEP) of monazite, hematite and quartz occurred at a pH of 6.5, 7 and 2 respectively, and change with collector adsorption. Single and mixed mineral flotation results demonstrated that monazite and hematite can be floated by the selected collectors, with low or no quartz flotation recovery. Sodium oleate, was shown to be the most selective in floating monazite, against hematite and quartz. Results from electrokinetic and contact angle measurements are consistent with that of single mineral flotation of monazite, quartz and hematite. Monazite can be separated from hematite and quartz using froth flotation, as long as a hematite depressant, such as sodium silicate, is used. Alternatively, magnetic separation can be used to separate hematite before flotation to improve monazite recovery.

The Formation of Self-Assembled Monolayers on Silicon through Halogen Bonding

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Self-assembled monolayers (SAMs) are compact, monomolecular layers formed when molecules spontaneously adsorb onto a solid substrate from solution. Common SAMs utilise strong covalent bonds when undergoing adsorption, prominent examples including the gold-alkanethiol monolayers or silanes on silicon. This work details the discovery of a new system of compact, stable monolayers that utilise the adsorption of both iodo- and brominated perfluorinated alkanes onto silicon through the non-covalent interaction known as halogen bonding. Unlike gold-thiol monolayers, these monolayers are stable for up to 8 weeks in laboratory conditions and are thermally stable up to 150 °C. As the SAMs formed are compact, they impart a hydrophobic wettability on silicon, possessing low surface energies analogous to Teflon (15 mN/m to 20 mN/m). The quality of the monolayer has been quantified through the determination of layer thickness, chemical composition and wettability. Several different surface analysis techniques, including: contact angle measurements, atomic force microscopy (AFM), quartz crystal microbalance (QCM) and X-ray reflectometry (XRR). The properties of these monolayers indicate that they may have applications in electronic systems.

Microscale Yielding of Colloidal Gels of Fiber Networks

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Complex fluids with non-Newtonian rheology are studied and developed throughout most sectors of industry and medicine and a common way to modify fluid rheology is with a colloidal gel. Colloidal gels are suspensions of particles with attractive interactions, resulting in the formation of a bulk network of particles that can impart a yield stress to a fluid. Large aspect ratio cellulose nanofibers are able to form poroelastic gels at very low volume fractions.¹ These systems have a low yield stress but a better ability to suspend particles than non-interacting higher volume fraction systems.² Yielding can thus differ greatly as a result of fluid microstructure.³ A new microrheology technique is developed and applied to study deformation and yielding of fiber gels at small length scales. The new technique indicates that gel yield stress can be a function of the deformation rate because of complex restructuring and response of the fluid, as observed by confocal imaging. The importance of length-scale dependent microstructural deformation indicates the need for a new constitutive model of yielding. Understanding this mechanism, and relating microstructure changes to bulk rheology,⁴ will enhance our ability to formulate and design complex fluids with novel performance.

¹ Emady, H. et al. *J. Rheol.* **2013**, *57*, 1761, DOI: [10.1122/1.4824471](https://doi.org/10.1122/1.4824471).

² Solomon, M. J.; Spicer, P. T. *Soft Matter* **2010**, *6*, 1391, DOI: [10.1039/b918281k](https://doi.org/10.1039/b918281k).

³ Joshi, Y. M. *Annu. Rev. Chem. Biomol.* **2014**, *5*, 181–202, DOI: [10.1146/annurev-chembioeng-060713-040230](https://doi.org/10.1146/annurev-chembioeng-060713-040230).

⁴ Hsiao, L. C. et al. *Proc. Natl. Acad. Sci. USA* **2012**, *109*, 16029–16034, DOI: [10.1073/pnas.1206742109](https://doi.org/10.1073/pnas.1206742109).

Copper Scavenging Nano-Coatings of Glutaraldehyde-Crosslinked Polyethyleneimine: on the Adsorption of Marine Polysaccharides and its Impact on Copper Binding Performance

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Marine biofouling is billion dollar problem for marine industries. Currently it is mainly managed by copper releasing coatings that kill organisms at the coating-water interface. Unfortunately, the release and accumulation of copper in harbours and marinas have detrimental effects on marine life and a ban on the coatings that leach copper is being discussed. The marine biofouling group at University of South Australia is researching a green anti-biofouling technology that utilize copper already present in the sea. By cycles of copper binding and release a biocidal effect will be achieved at the coating-water interface, without any net release of copper to the environment (Figure 1). Recently we showed that nanometre thin glutaraldehyde crosslinked polyethyleneimine (GA-PEI) had potential for solving the first step towards such a technology, the uptake. The coatings effectively accumulated large quantities of copper from both artificial and natural seawater.^{1,2}

Any surface upon submersion in seawater is rapidly covered with organic molecules, such as polysaccharides. Therefore understanding the impact of polysaccharide adsorption on copper binding performance is critical for further development of the GA-PEI coatings for marine applications. The effect of polysaccharide adsorption was investigated in artificial seawater system using three seawater-relevant polysaccharides; sodium alginate, carrageenan and agarose. Adsorption and stability of the formed polysaccharide-layer were determined through quartz crystal microbalance with dissipation monitoring (QCM-D). Dry layer thickness was measured using ellipsometry. X-Ray Photoelectron Spectroscopy (XPS) was used to quantify the atom% copper in the coatings and revealed that adsorbed polysaccharides had insignificant impact on the equilibrium copper uptake and only slight impact on the uptake kinetics. Analysis of copper distribution within the coatings was performed by Time-Of-Flight Secondary Ion Mass Spectroscopy (TOF-SIMS). The results strongly suggest that polysaccharides adsorption will not be a limiting factor for further development of the GA-PEI coatings towards advanced marine applications.

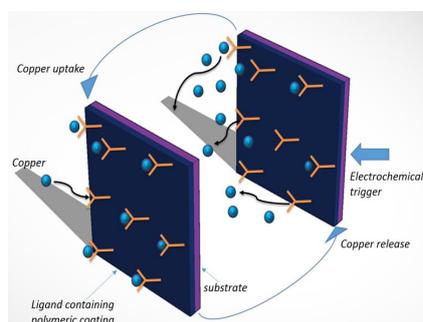


Figure 1: Functional GA-PEI coating that upon a suitable applied potential cyclically switches between a copper uptake state and copper release state to achieve antibiofouling.

¹ Lindén, J. B. et al. *RSC Adv.* **2014**, *4*, 25063–25066, DOI: [10.1039/c4ra02223h](https://doi.org/10.1039/c4ra02223h).

² Lindén, J. B. et al. *RSC Adv.* **2015**, *5*, 51883–51890, DOI: [10.1039/c5ra08029k](https://doi.org/10.1039/c5ra08029k).

The Degradation of Model Fluid under Ultrasound

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Many of biological fluids are highly heterogeneous in terms of their structure, as all of their components might not interact in the same way when that structure is created. Understanding structural heterogeneity is important, as this will affect the overall rheology of the fluids. Degradation of fluids by treatments might change the structure, thus the extent of heterogeneity. Generally, treatments will degrade the heterogeneous structure to become homogeneous structure,¹ however it is possible that more heterogeneity will be created, which eventually will affect the efficacy of those treatments. Thus, understanding this properly will help to improve the efficacy of the treatments.

In this study, the behaviour of a model of biological fluids made of Gellan, a bacterial polysaccharide that has been used previously to mimic biofilms mechanics² under the treatment of ultrasound was studied. The microstructure of Gellan has been shown before to be modified using shear that can create microstructural heterogeneity,³ which actually can make the model become more like the biological fluids. The effect of ultrasound on this Gellan sample was also mapped in terms of their microstructure, the microstructural heterogeneity and eventually the effect on the rheology in both macro and microscale.

¹ Stewart, E. J. et al. *Langmuir* **2013**, *29*, 7017–7024, DOI: [10.1021/la401322k](https://doi.org/10.1021/la401322k).

² Hellriegel, J. et al. *J. Biomater. Nanobiotechnol.* **2014**, *05*, 83–97, DOI: [10.4236/jbnb.2014.52011](https://doi.org/10.4236/jbnb.2014.52011).

³ Caggioni, M. et al. *J. Rheol.* **2007**, *51*, 851–865, DOI: [10.1122/1.2751385](https://doi.org/10.1122/1.2751385).

Examining the Effect of Mesoporous Silica Particles on Lipid Digestion

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Coadministering mesoporous silica particles with fatty meals has been reported to successfully reduce the weight of obese mice.¹ However, only one silica particle, 'S11R' with specific pore size and morphology, enabled the weight reduction, indicating some selectivity in interaction between the fat or carbohydrate components of the food, the digestion products, or interaction with the lipase itself. Recently, studies have shown silica particles can alter the digestion kinetics by the lipase or the lipids molecules adsorbing to the silica surface, offering a possible mechanism of why the weight loss occurred.²

This study aimed to investigate the mechanisms behind the observed weight loss. Using an in vitro digestion model coupled to synchrotron SAXS, the impact of the presence of silica particles on lipid digestion kinetics and structures formed during digestion was studied. The direct adsorption of the individual digested lipid components, monoglyceride, fatty acids bile salt, and carbohydrates to the silica particles was also studied analytically using radiolabeled components.

The silica particles did not produce a significant effect on the lipolysis profiles, however pre-adsorbing the lipase to the rod shaped silica particles resulted in the reduction of enzymatic activity, indicating one possible mechanism explaining the weight loss. The isolated digestion components did not substantially adsorb directly onto the silica particles when mixed at a similar ratio used in the mouse study, however when a larger quantity of silica was used, adsorption of the lipid molecules greatly increased.

In conclusion this study indicates one possible mechanisms to explain the weight reduction, the adsorption of lipase to silica particles. Further studies can be conducted with various ratios of silica particles to investigate the ideal amount for optimal adsorption, which would dictate a likely optimal in vivo dose of silica for treatment of obesity.

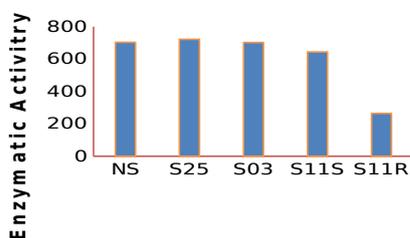


Figure 1: The effect of pre-adsorbing the lipase to the silica particles to the enzymatic activity

¹ Kupferschmidt, N. et al. *Nanomedicine* **2014**, *9*, 1353–1362, DOI: [10.2217/nnm.13.138](https://doi.org/10.2217/nnm.13.138).

² Joyce, P. et al. *Langmuir* **2014**, *30*, 2779–2788, DOI: [10.1021/la500094b](https://doi.org/10.1021/la500094b).

Robust Superhydrophobic Surfaces through Spontaneous Wrinkling

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Mimicking nature's ability to produce superhydrophobic surfaces has been a subject of great interest since 1997, when the lotus leaf's surface topography and chemical properties were revealed.¹ Despite many different approaches to fabricate superhydrophobic surfaces, the development of simple and cost effective methods, which lead to thermodynamically and mechanically robust surfaces, is still a scientific and technological challenge.²

In this project, we use a novel approach to fabricate superhydrophobic surfaces, based on the spontaneous wrinkling of rigid layers deposited on thermally shrinkable plastic substrates. The special wrinkled topography was achieved on a Teflon film shrunk on polystyrene and polyolefin substrates. Both surfaces exhibit superhydrophobic properties, with single- and dual-scale roughness produced by compression forces during annealing. The most effective surface, possessing advancing contact angles of 175°, and contact angle hysteresis of 3°, was obtained on the polyolefin substrate. Water upon contact with these surfaces easily rolled off at tilt angles < 5°. To determine the potential for industrial application, the Teflon wrinkled surfaces were put through an array of mechanical robustness tests, including nano-scratching, nano-indentation and cavitation damage. Through performing these measurements, it was shown that these surfaces have film hardness similar to that of aluminium coatings, and wettability did not degrade after extensive cavitation damage over a two hour period. Typical mechanical robustness characterisation techniques are not suitable for rough surfaces, resulting in large errors across data points. The excellent superhydrophobic properties, combined with the extreme ease of fabrication and the potential for up-scaling, make these wrinkled surfaces promising candidates for self-cleaning and non-stick coatings.

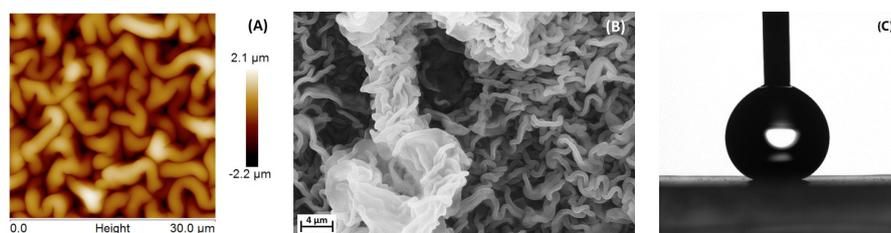


Figure 1: (a) AFM topography of wrinkled Teflon coating on shrinkable polystyrene substrate after thermal annealing. (b) SEM micrograph of wrinkled Teflon coating on shrinkable polyolefin substrate after thermal annealing. (c) Contact angle of a 10 µl water drop on the wrinkled teflon surface.

BIO:

Liam Scarratt completed his Bachelor of Science majoring in Chemistry and Physics at The University of Sydney (2013). In this time, he spent a year working as an Industrial Chemist at NICNAS as part of the Year In Industry Program provided by the School of Chemistry. He commenced his PhD candidature with A/Prof Chiara Neto in 2015, and is working on superhydrophobic surface fabrication for industrial up-scalability.

¹ Neinhuis, C.; Barthlott, W. *Ann. Bot.* **1997**, *79*, 667–677, DOI: [10.1006/anbo.1997.0400](https://doi.org/10.1006/anbo.1997.0400).

² Neto, C. et al. *Phys. Chem. Chem. Phys.* **2009**, *11*, 9537–9544, DOI: [10.1039/b909899b](https://doi.org/10.1039/b909899b); Joseph, K. R.; Neto, C. *Aust. J. Chem.* **2010**, *63*, 525, DOI: [10.1071/ch09292](https://doi.org/10.1071/ch09292); Telford, A. M. et al. *Chem. Mater.* **2013**, *25*, 3472–3479, DOI: [10.1021/cm4016386](https://doi.org/10.1021/cm4016386).

Interaction of Gastrointestinal Mucin with Dietary Polysaccharides

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The adherent mucus layer is a vital component of the body's epithelial surfaces. Upon secretion, it forms a complex viscoelastic fluid lining the internal surfaces of the gastrointestinal (GIT), respiratory, and urogenital tracts. This extracellular barrier is predominantly composed of water (95%), secreted proteins as well as the large molecular weight (>1 MDa) mucin glycoproteins. Mucins are capable of polymerising to form the structural basis of a polymer network that is principally responsible for the barrier properties of mucus. The viscoelastic properties of mucus are very important to the healthy function of the body that is finely tuned to the site of secretion to clear pathogens in the respiratory tract¹ or protect the GIT from microbes and ingested food particles. In the GIT, it serves as the first line of defense against microbial, toxin and enzymatic damage and secondly as a porous selective diffusion barrier to permit the rapid uptake of selected nutrients in the small intestine. However, relatively little is known about the types of interactions that regulate the selective binding of certain nutrients, and the influence of components such as dietary fiber and dietary lipids which could alter nutrient diffusion to the underlying epithelium. Here, we report the characterisation of high purity mucin from pig intestinal mucus that has been demonstrated to gel as expected for native mucus. Additionally, we examine the interaction of soluble dietary fiber and plant cell walls with purified intestinal mucin and their effects on the mucins rheological and diffusion properties. Studying the organisation of the mucus layer after interaction with food components, specifically plant cell walls and soluble dietary fiber, aims to provide new insights into the possible mechanisms by which these nutritional components may be able to affect the barrier properties of mucus, providing a possible underpinning mechanism for their health promoting properties.

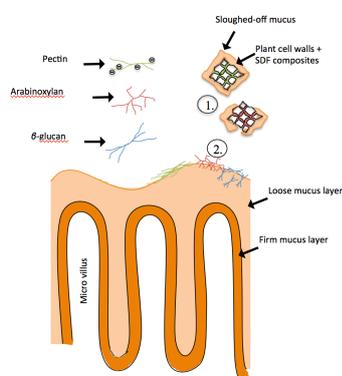


Figure 1:

- 1.) Influence of soluble dietary fiber (pectin, β -glucan, arabinoxylan) and plant cell wall fragments containing soluble dietary fiber (SDF) composites to interact with sloughed-off mucin into the GI lumen
- 2.) Interaction between soluble dietary fiber in mucin to elucidate the effect of SDF on mucins' viscoelastic and gel-forming properties.