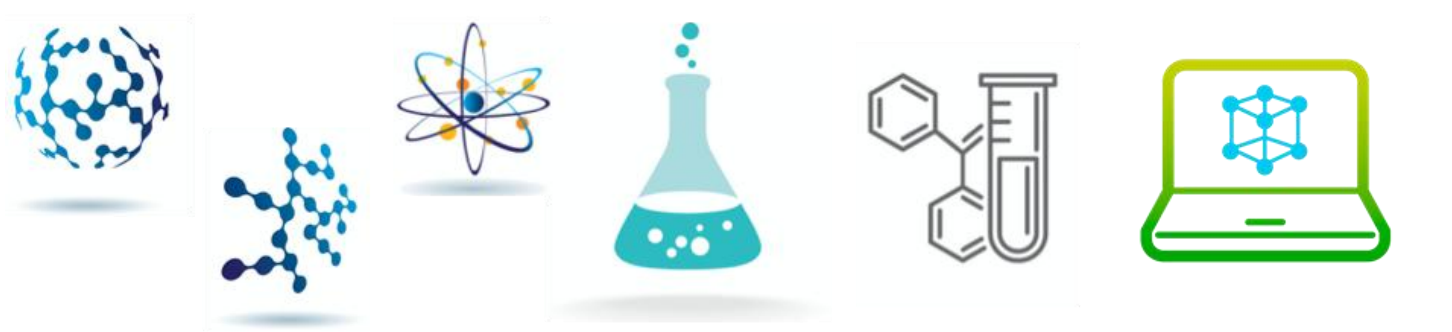
THE UNIVERSITY OF NEWCASTLE AUSTRALIA

DISCIPLINE OF CHEMISTRY

HONOURS AND UNDERGRADUATE RESEARCH PROJECTS

2026



Undergraduate Research in the Discipline of Chemistry

School of Science

There are a number of strong research themes in the discipline of chemistry in areas such as:

- Functional materials for health, environment and energy
- Medicinal Chemistry
- Computational chemistry
- Molecular organic synthesis
- Colloids, interfaces and soft matter

We encourage undergraduates to get involved in research throughout their degree. By doing so you will learn and develop skills in searching, selecting and retrieving information from scientific sources, skills in project management, experimental research skills as well as skills in presenting scientific information in a clear and concise manner, both orally and in writing. These will provide you with a strong foundation for your future career, whether it be in the industrial, commercial or academic sector.

There are three main ways to get involved in research:

a) ***Summer research project:*** Short paid undergraduate research projects over summer. Please contact the relevant project academics directly if you are interested.

b) ***SCIE3500 and SCIE3002:*** Complete a research project under the supervision of an academic staff member as an elective 10 credit point subject. The course is open to third year students who have successfully completed at least 140 units and have a cumulative GPA of at least 5.0 and is offered in both semesters. Course outline links: SCIE3500: Research Integrated Learning; SCIE3002: WIL for the Sciences.

c) ***Honours research project:*** A full-year research project after completion of the Bachelor of Science or another cognate degree. A minimum GPA of 5.0 is required for entry into honours. Program handbook link here.

This booklet contains a list of undergraduate research projects currently available in the discipline. In all cases you should discuss potential projects with prospective supervisors before trying to enrol or apply.

Dr Robert Chapman

Polymer therapeutics and protein mimics

My group uses ***high throughput polymerisation techniques*** to design polymers that will fold like proteins do to make better therapeutics, and to design polymers that will bind to and stabilise proteins and antibodies

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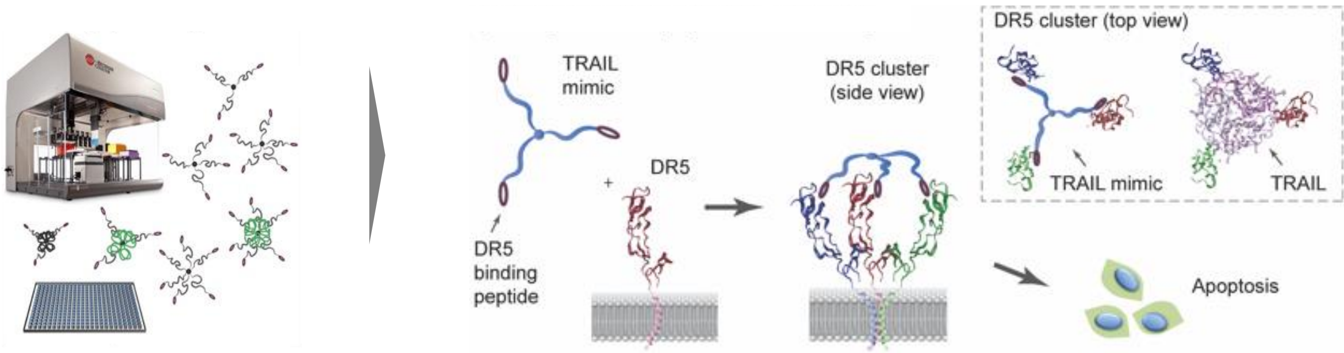
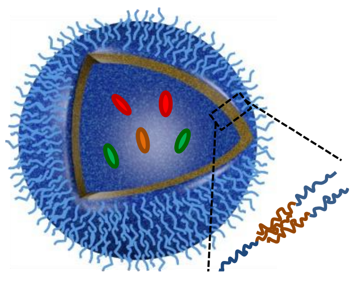
My group's research centres on our ability to polymerise complex polymers in high throughput using a robot, which allows us to screen how the polymer's structure affects its function.

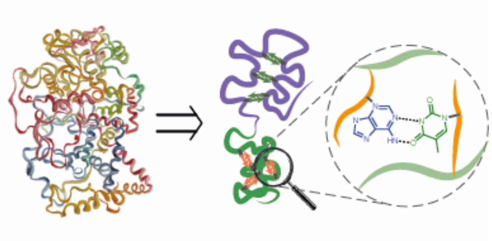
a) Macromolecular therapeutics by high throughput synthesis *(with Dr Thomas Fallon).* Since its discovery in the late 1990s, the TRAIL protein (tumour necrosis factor related apoptosis inducing ligand; also known as Apo2L), has been widely pursued as a highly selective and potent chemotherapeutic across a wide variety of cancers. Yet, despite a massive research investment from both academia and industry, all variants of the TRAIL protein have failed to show efficacy in the clinic to date due to the protein's poor stability and bioavailability. We are using a high throughput polymerisation method established in our lab to make synthetic mimics of TRAIL that can replicate it's biological activity but which have vastly improved pharmacokinetics (circulation times of up to 50 h).[1-2] The project involves a mixture of synthetic organic chemistry, polymer chemistry, and *in-vitro* cell assays.

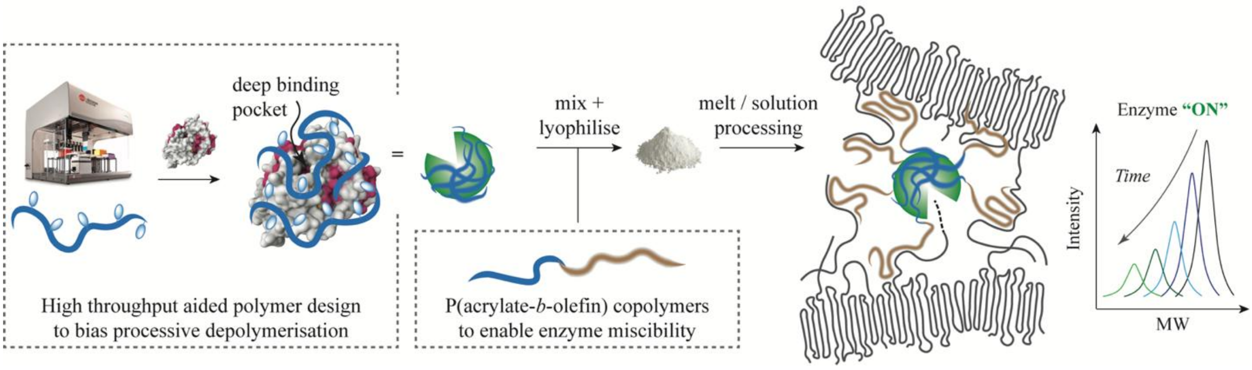


b) Protecting the nitrogenase enzyme to make a nitrogen battery *(with CSIRO Canberra).* We are interested in using a natural enzyme called *nitrogenase* for the electrochemical conversion nitrogen to ammonia, for energy storage applications. *Nitrogenase* is extremely efficient at driving this reaction, but its use is hampered by its sensitive to oxygen. This project will focus on developing methods to stabilise the enzyme by co-encapsulating it in a polymersome with another enzyme called *glucose oxidase*, which is able to consume oxygen. This should stabilise nitrogenase, and enable it to be used in regular oxygenated solutions. The project forms part of a larger project with CSIRO Canberra. Our collaborators have developed excellent and robust techniques for preparing and isolating the enzyme from bacterial cultures, and will supply the enzyme for our work.



c) Depolymerisation of plastic waste using polymer-coated enzymes *(with Prof Erica Wanless & Prof Dominik Konkowlewicz).* This project aims to design polymer coatings for enzymes that will enable them to be embedded into polyethylene, and later activated to in a compost heap to decompose the plastic to small molecules. Enzymes are normally very difficult to disperse in polyethylene, but we have recently developed a range of chemistries to prepare polyacrylate-polyethylene block copolymers that should enable this. By using high throughput polymer synthesis and screening techniques that we have already developed,[3] this project will design polyacrylates that bind strongly to a polyethylene active enzyme called *manganese peroxidase*, and then synthesise polyacrylate-polyethylene block copolymers from these to enable encapsulation of the enzyme in a bulk matrix of polyethylene.





d) Sequence defined oligomers by decarboylative click reactions *(with Dr Thomas Fallon).* Most large biological molecules (proteins, RNA, DNA) are sequence defined polymers – the exact ordering of monomer units is specifically defined. There are relatively few ways to replicate this synthetically. We can make relatively long peptides by sequential amide bond formation but this must be done on a solid support to enable efficient removal of the protecting groups between each coupling reaction. A solution phase synthesis, that doesn't result in any byproducts would enable synthesis of complex oligomers at scale. By extensive screening we have discovered reaction conditions for the azide-alkyne click reaction at which the certain alkyne protecting groups (such as -CO_2H) are stable. The protecting group can then be removed with either heat or light. This project will develop these protocols into an efficient solution phase synthesis of sequence defined polymers.

Selected References:

1. Li, Z.; Kosuri, S.; Foster, H.; Cohen, J.; Jumeaux, C.; Stevens, M.; Chapman, R.; Gormley, A.; ***J. Am. Chem. Soc.*** 2019, 141 (50), 19823–19830.
2. Li, Z; Han, Z.; Stenzel, MH; Chapman R.; ***Nano Lett.*** 2022, *22*, 2660–2666.
3. Mustafa, A. Z.; Kent, B.; Chapman, R.; Stenzel, MH; ***Polym. Chem.*** 2022, 13 (43), 6108–6113.

Dr Sam (Xianjue) Chen

Materials Chemistry, Carbon Materials

My research group are working on '**artificial materials**', particularly new carbon-based materials, through developing new synthesis strategies and applications of materials.

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a) Diamane. Single-layer diamond structure ('diamane') has emerged as a new 2D form of carbon which was first predicted theoretically followed by recent experimental realisation. In collaboration with Prof Marc Dubois (UCA), my team reported the experimental preparation of fluorinated diamane ('F-diamane') from graphite flakes (Carbon, 2021, 175, 124; Appl. Surf. Sci., 2022, 152534). These are the first reports in which diamane-like materials are prepared using a 'top-down' chemical route.

b) Graphene. We have worked with Prof Rodney Ruoff's group (UNIST, CMCM) on the growth, transfer, and folding/stacking of graphene films, including (i) growth of centimetre-wide, AB-stacked bi-layer and ABA-stacked tri-layer graphene films (Nature Nanotechnol. 2020, 15, 289); (ii) non-destructive delamination for transferring CVD graphene (Chem. Mater. 2017, 29, 4546); (iii) folding of single-crystal graphene with defined stacking orders (Nano Lett. 2017, 17, 1467); (iv) layer-by-layer assembly of graphene into macroscopic films (Adv. Mater. 2019, 31, 1909039).

c) Fullerene. Fullerenes, particularly C_{60}, are the only forms of carbon nanomaterials to date that can be made with precisely controlled molecular structures. Our latest research efforts include using fullerenes as molecular building blocks to construct new 'artificial' carbon materials, such as C_{60}-graphene hybrid structures, self-standing C_{60} networks, etc.

d) Chemistry in confined space. Graphene and carbon nanotubes can be used as 2D and 1D 'nano-reactors' for chemical reactions. Such dimensional confinement can lead to new reactions and phenomena that are less explored in the field of chemistry.

These projects are based on experiments in chemistry laboratory, which require the use of advanced microscopic and spectroscopic techniques at the Central Analytical Facilities for material analysis, including transmission electron microscopy (TEM), scanning electron microscopy (SEM), atomic force microscopy (AFM), X-ray diffraction (XRD), Raman spectroscopy, X-ray photoelectron spectroscopy (XPS). Depending on the nature of research project, the candidate will be supported for training and accessing these instruments.

I'm open to other project ideas. Please feel free to send me an email (sam.chen@newcastle.edu.au) or simply drop by my office in C216 Chemistry Building, Callaghan Campus.

Prof Scott Donne

Electrochemistry and energy storage materials

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My main research interests lie in the general area of electrochemistry, particularly on energy storage materials such as batteries, supercapacitors and fuel cells. In this area we focus on the preparation of new materials, and then evaluate their behaviour and performance under a variety of conditions. While this represents research in only a relatively focussed part of electrochemistry, I do also have significant experience in electrodeposition, the application of various electroanalytical methods, as well as in the study of corrosion. At present I also have a number of ongoing projects dealing with industrial chemistry.

a) Advanced Supercapacitors: Modern electronic devices (e.g., consumer electronics and electric/hybrid vehicles) place considerable demands on their respective power sources, to the point where device efficiency is compromised. The inclusion of a supercapacitor has the potential to improve the specific power density and also cycle efficiency of all types of power source. We have recently made considerable advances in improving supercapacitor performance (e.g., 800 F/g for existing systems compared to >2000 F/g in our advanced materials). Projects in this area will be focus on both understanding the origin of this improved performance, as well as implementing these materials into prototype supercapacitors. This work is funded by CSIRO Division of Energy Technology and CAP-XX, and is also in collaboration with the Ecole Polytechnique de la Universitie de Nantes and National Taiwan University.

b) Catalysts for Fuel Cells: Energy can be stored in many chemical forms, and hence used in many different ways. One way is in a fuel cell, of which there are numerous varieties. The cathodic reaction in all though involves reduction of O_2 to H_2O on the surface of a suitable catalyst. This is currently the limiting performance feature of all fuel cell technologies because of its slow reaction kinetics. This focus of projects in this area is to examine the factors that cause slow O_2 reduction kinetics, and to then address these limitations with novel solutions. One particularly important aspect is to examine the role that adsorption plays in determining O_2 reduction kinetics. This work is in collaboration with the Massachusetts Institute of Technology.

c) Corrosion Phenomena in Electrode Materials: Corrosion is an electrochemical phenomenon that can have a devastating effect on all forms of infrastructure if it is not properly monitored and controlled. Projects in this area are focussed on understanding the corrosion phenomena that metals such as titanium and copper undergo, and then developing strategies to minimize their corrosion. Titanium, for example is used as the anode substrate in many modern high volume electrolysis processes, yet it is subject to corrosion and passivation which effectively destroys its performance. Similarly, copper is used as an earthing electrode in modern power infrastructure, in which case its corrosion and failure lessens the safety of such a network. Support for these projects comes from Energy Australia.

d) High Performance Battery Systems: The backbone of energy storage in modern society is the battery. Of course many systems are commercially available, each having been developed to power a specific type of electronic device. The importance and extent of efficient energy storage will increase in the future due to the required move away from fossil fuel powered energy. Projects in this area will focus on the development of advanced materials, and improving our fundamental understanding of the charge storage mechanisms various materials possess. Funding in this area comes from the CSIRO Division of Energy Technology (Li-ion systems), Duracell (advanced MnO_2), Pure Energy Battery Systems (rechargeable MnO_2), and Litronik Batterietechnologie (battery systems for implantable pacemakers).

e) Hydrogen Production: Hydrogen has been variously described as the perfect fuel. It is abundant, chemically non- toxic, and it burns to produce non-toxic species. However, its main limitation to commercial uptake is its synthesis, since it requires more energy to produce hydrogen than what is returned upon its combustion. Projects in this area revolve around the use of the Hybrid Sulfur (HyS) Cycle for the large scale production of hydrogen. Using renewable energy inputs water can be split into its components through the use of a sulphur-based intermediate. Part of the HyS cycle involves an electrolysis step (SO_2 oxidation to H_2SO_4), the efficiency of which is a significant limitation to the overall process. Therefore, our focus will be on developing an understanding of the oxidation mechanism, and developing new catalysts to facilitate its improvement. This work is in collaboration with the CSIRO Division of Energy technology.

Prof Adam McCluskey

Medicinal organic chemistry

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My primary area of research is in the medicinal chemistry / chemical biology space where my main focus is in the development of tool compounds, and drugs, targeting endocytosis. The potential outcomes of our research include (but are not limited to) the development of new synthetic methodologies; the development of new drugs & the development of new tools for dissecting signal transduction pathways.

a) Flow Chemistry / Medicinal Chemistry / Organic Chemistry: Traditional organic synthesis is conducted in a batch manner, i.e. small quantities of materials are mixed and heated for a standard period of time, and the product extracted and purified. Recent advances in flow technologies allow continuous production of novel materials. This technology has been introduced to the medicinal chemistry group at the University; it is currently the best-equipped flow chemistry laboratory in Australia. Reactions are conducted at higher temperatures and pressures, which has the effect of increasing reaction yield and compound purity, largely removing the more tedious aspects of compound purification. Students working in this area will develop new approaches to drugs spanning three research programs: anti-epileptic, anti-cancer and anti-parasitic drugs. This new technology requires subtle optimisation and students will be exposed to cutting edge equipment and ultimately be responsible for the development of new drugs and biological tools to a considerable number of our national and international collaborators.

b) Medicinal Chemistry / Drug Design: Today 1% of the worlds' population suffer from epilepsy, of these 30% fail to respond to existing anti-epileptic drugs. Current anti-epileptic drugs were discovered in the 1960s. We have identified a protein called dynamin as a new ant-epileptic drug target and have advanced compounds that only target epilepsy at seizure onset, a significant advance on existing treatments. This is a major collaborative drug discovery and development effort drawing medicinal chemistry experience at the University of Newcastle (McCluskey), neurobiology and neurochemistry at the Children's Medical Research Institute Westmead Hospital (Prof Phillip Robinson), epilepsy (medical aspects) at the Royal Melbourne Hospital / Melbourne University (Prof Terry O'Brien), and the National Institute of Health (USA). Students working in this area will experience the full drug development cycle through synthesis and biological evaluation of new drugs. You will advance these drugs to the next stage of evaluation and potentially to animal studies in both Melbourne and USA. During the course of your studies you will be trained in the latest technologies associated with drug design and chemical synthesis (see Flow Chemistry above).

Prof Alister Page

Computational & materials chemistry

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The computational materials chemistry group performs fundamental and applied research into self-assembly, complex systems and the structure and properties of material systems, using quantum chemical and molecular dynamics techniques.

a) How do Nanotubes Grow? A carbon nanotube is a sheet of carbon atoms in a chicken wire pattern, rolled up into a cylinder. Although they are only ~1 nanometer in diameter, they can be several millimeters in length, are ~100 times stronger than Kevlar, and can transport ~1000 times as much electricity as copper wires. They can also be both electrically conducting and semiconducting, depending on how the carbon atoms in their structure are arranged. Development of future carbon nanotube-based technologies is currently prevented by our inability to synthesise particular carbon nanotubes selectively. This project will determine how selective carbon nanotube "growth" can be achieved, and will pave the way for the future development of carbon nanotube-based devices.

b) One-Dimensional van der Waals Heterostructures: Atomically-thin 2D materials (graphene, boron nitride, etc.) are the building-blocks of a new and exciting class of functional materials – 2D van der Waals (vdW) heterostructures. 2D vdW heterostructures are formed by 'stacking' multiple atomically-thin 2D materials. Each layer in the stack is held in place via interlayer vdW interactions with its neighbouring layers. 2D vdW heterostructures are the foundation of a new generation of nanoelectronics devices and applications. This project aims to translate the concept of a 2D vdW heterostructure to a single dimension, by understanding the structure and properties *1D vdW heterostructures* - heterostructures composed of inorganic nanotubes held in place via radial vdW interactions – like a nanoscale coaxial cable. The project may also consider how such 1D heterostructures might be formed during chemical vapour deposition synthesis.

c) Origins of Hofmeister Effects: In the late 1800s, Franz Hofmeister discovered that, while some salts would decrease the solubility of egg whites in water, others increased their solubility. This phenomenon is known as the Hofmeister effect. Despite its apparent simplicity, consensus over the origins of the Hofmeister effect still has not been reached. In the century since Hofmeister's discovery, the Hofmeister effect has been observed in a wide range of other dissolved solutes, from DNA, enzymes, surfactants and colloidal suspensions. This project will use molecular simulations to understand the origins of the Hofmeister effect and how dissolved salts influence the solvent structure and properties.

d) Machine Learning for Sustainable Rare Earth Collectors. Rare earth elements are the backbone of modern electronics, magnets, and batteries. The unique chemistry of the rare earths also makes separation and purification of individual elements highly challenging. The recent discovery of selective lanthanide binding proteins, such as Lanmodulin (LanM), has inspired the development of bio-inspired strategies for lanthanide recovery and extraction This project will use machine learning to develop novel peptide materials that mimic

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and improve natural lanthanide binding proteins, for efficient and targeted capture of these metal ions in widely-used solvent extraction (SX) processes.

e) Underscreening in concentrated electrolytes. "Underscreening" is a recently-discovered phenomenon whereby, at sufficiently high salt concentrations, the electrostatic forces in a salt solution become orders of magnitude longer than those predicted by century-old classical theories, such as Debye-Hückel theory. Our group have recently revealed the origins of this phenomenon, and also shown that these long-range forces are themselves concentration and salt-specific. This project will examine the nature of underscreening in molten salts, such as ionic liquids, and complex electrolytes, such as deep eutectic solvents, using molecular dynamics simulations and quantum chemistry.

Dr Qianqian Shi

Plasmonic nanoparticles and their self-assembly

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Metallic nanocrystals are important building blocks in the contemporary nanoscience and nanotechnology, which have demonstrated profound implications in the materials chemistry discipline. In particular, gold and silver nanoparticles attract significant attention due to their unique size- and shape-dependent localized surface-plasmon resonances. These nanoparticles, also referred to as 'artificial atoms,' are nanoscale elements that contribute to the creation of an 'artificial periodic table.' They can be used to construct diverse nanoassemblies for novel applications in electronics, photonics, photovoltaics, medical diagnostics, and therapeutics.[1] My primary research focuses on the design and assembly of novel plasmonic nanocrystals with specific functions in photocatalysis, plasmonics and sensing applications. By engineering the materials design including building blocks synthesis, surface functionalization, and bottom-up self-assembly, my group aims to harness the programmable plasmonic properties and soft conductive properties of plasmonic nanocrystals for broad applications in the design of artificial leaves, flexible plasmonic sensors and flexible plasmonic electronics.

a) Flexible plasmonic artificial leaves: This project aims to design and fabricate soft, ultrathin, and large-area 2D plasmonic photocatalysts with natural leaf-like attributes for solar-to-chemical energy conversions. Traditional photocatalysts are colloidal based or supported on rigid and thick substrates. It is challenging to integrate them into soft leave-like devices and achieve leaf-like structure/functions due to their intrinsic mechanical mismatch in Young's moduli. This project directly addresses this challenge by using self-assembly fabrication technologies to fabricate 2D plasmonic nanoassemblies and further constructing soft artificial leaves for a continuous solar-to-chemical conversion.

b) Flexible plasmonic bio-chemical sensing: Plasmonic nanomaterials have been widely used as surface enhanced Raman scattering (SERS) substrate for bio-chemical sensing because of their ultrahigh detection sensitivity and high specificity. However, traditional SERS substrates are typically rigid and it is challenge to provide a seamless contact with the soft and elastic biointerfaces such as epidermis for bio-chemical sensing. This project can bridges this gap by design a flexible composite made from ultrathin and soft 2D SERS-active plasmonic metasurface and a flexible porous polymer. By extracting analytes such as sweat from the body using the porous polymer, the wearable plasmonic biosensor will provide fingerprint detection of trace-amounts drugs inside the body under different deformation states.

c) Flexible plasmonic stimuli responsive sensors: This project aims to design and fabricate soft and ultrathin 2D plasmonic assemblies with high sensitivity towards environmental stimuli. Plasmonic nanomaterials have also been used as stimuli responsive sensors for detecting the humidity, temperature, laser due to their unique localized plasmonic properties. However, traditional stimuli response plasmonic sensors are normally colloidal based, which make them hard to integrate with functional devices for real-world applications. This project can directly tackle this challenge by designing and fabricating 2D soft responsive plasmonic sensors through self-assembly of plasmonic nanoparticles that functionalized by stimuli responsive polymers.

d) Flexible plasmonic electronics: This project aims to develop soft and flexible plasmonic electronic devices for electronic skin and bio energy devices. Traditional wearable electronics and biofuel cells are constructed with thick and rigid electrodes, which are not suitable for electronic skin and powering wearable electronics due to their poor mechanical compliance to curvilinear human body. This project can directly address this challenge by developing soft, thin yet stretchable conductor as gauge sensor or bioelectrodes via programming nanocrystal self-assembly.

e) Programmable binary plasmonic nanoassemblies (with Dr Robert Chapman): The collective properties of nanoassemblies can differ from individual building blocks or disordered assemblies due to the strong interactions between nanoparticles. While self-assembly of plasmonic nanocrystals into 2D nanoassemblies has shown semiconductor n/p-doping-like properties through controlled doping concentration,[2] the challenge lies in controlling the packing of the binary system with precise arrangement of different building blocks. In this project, we will integrate bottom-up self-assembly with stoichiometric reactions of complementary reactive polymers and/or DNA ligands to achieve programmable structural engineering of 2D binary plasmonic nanoassemblies. New polymers and DNA ligands will be synthesized in collaboration with Dr. Robert Chapman's group. We will synthesize plasmonic nanocrystals, functionalize them with the new polymers and DNA, and assemble them into highly ordered binary structures. Subsequently, we will characterize the plasmonic and structural morphology of these new assemblies using UV-VIS-NIR spectrophotometry, scanning electron microscopy, and transmission electron microscopy to investigate the relationship between their structure and properties.

Selected references:

1. D. Dong, R. Fu, Q. Shi, W. Cheng. Self-assembly and Characterization of 2D Plasmene Nanosheets. Nature Protocols, 2019. 14, 2691–2706.
2. Q. Shi†, D. Sikdar†, R. Fu, K. J. Si, D. Dong, Y. Liu, M. Premaratne, W. Cheng. Two-dimensional Binary Plasmonic Nanoassemblies with Semiconductor n/p-Doping-Like Properties. Adv. Mater., 2018, 30, 1801118.

Prof Erica Wanless

Polymers and Colloids at Interfaces

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Colloid chemistry is a form of materials science particularly concentrating on mixtures, where particles of one or more insoluble material are suspended within a dispersion medium. Surface chemistry is closely linked to colloid chemistry due to a focus on how the surfaces of these particles affect the physical and chemical interactions between the particles and the medium in which they are dispersed. The science of surfaces and particles is essential to food technology, the formulation of personal care and cleaning products, as well as the enhancement of mineral separation, biomedical and other industrial technologies. Erica and her team are expert in designing and testing surface modifications to particles and surfaces, as well as measuring the behaviours of particles at the phase boundary in new and existing colloidal materials.

a) Smart polymeric coatings: Polymer films can radically change the surface of a material while leaving the bulk properties of the material intact. The polymer surface coating controls the interaction with other objects through nanoscale forces. We will fabricate polymer films that contain an inbuilt molecular-scale switch from attractive to repulsive interactions, offering a means for dictating macroscopic character such as the wettability, adhesion or friction of a surface. Academic and industrial interest in these coatings is increasing rapidly, for potential application as low-friction coatings for confined parts or rheology modifiers. This project can have either a polymer synthesis, state-of-the-art physical chemistry characterisation (atomic force microscopy, ellipsometry etc), or materials engineering focus. This project is a collaboration with Ed Johnson.

b) Unravelling specific ion effects: Specific-ion effects (those that depend on ion identity rather than simply salt concentration) are ubiquitous in industrial and natural processes, from next-generation lithium-polymer batteries to the chemical pathways that facilitate energy transfer in our cells and underpin life itself. Much can be gained by improving our fundamental knowledge of ion specificity and in particular, how surfaces and solvents interact with ions to impact the properties of soft matter and colloidal systems. The aim of this project is to conduct surface chemical investigations into how the properties of surfaces and solvents influence specific-ion effects and build our knowledge to ultimately predict and harness these curious effects. You will join the group experimental effort which is being complemented by Alister Page's simulations aimed at understanding the origins of these fascinating phenomena.

c) Electrostatics strike back!: It has recently come to light that the hundred year old theory of colloidal stability which was never designed to be applied in concentrated electrolytes really shouldn't be as these solutions are much more interesting that you would think. Given their importance in high salt applications like batteries, desalination, and critical mineral extraction we need to better understand the role of having limited solvent has on system performance in the presence of lots of salt. In collaboration with Alister Page we have cracked some of the mystery of these previously poorly understood systems. You will join the group experimental effort which is being complemented by Alister Page's simulations aimed at understanding their origins.

d) Depolymerisation of plastic waste using polymer-coated enzymes embedded in films: This project aims to design polymer films containing encapsulated enzymes that will be embedded into polyethylene, and later activated in a compost heap to decompose the plastic to small molecule fragments. This project thus targets microplastic waste and is being conducted in collaboration with Robert Chapman.

Three additional projects are available every year as part of the **ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals** led by the University of Newcastle. This Centre has a mission to reduce water usage and power consumption via smarter, more efficient mineral separation technologies including reprocessing of tailing stockpiles. Erica's role in this Centre lies in improving and optimising the adsorption of molecular and particulate components at the various interfaces that are the key to these technologies. You will join the greater team effort dedicated to more sustainable metal extraction for those 60+ metals in your smartphone!

e) Electrostatic formation of liquid marbles: Liquid marbles are unique liquid-particle aggregates consisting of non-wetting particles coating and thus stabilising a liquid droplet core. These novel materials have inspired a variety of proposed applications, including pollution and gas sensors, actuators and microreactors. Until now, however, liquid marbles have been prepared one by one thus limiting their production and application. This project will study the formation of well-defined particle-stabilised liquid marbles using a novel electrostatic process. The expected outcome is a robust, repeatable process that can in future be scaled up to bulk production.

f) Development of bespoke polymer collectors for selective separation of critical minerals: This project seeks to design and develop novel polymeric reagents as collectors or flocculants for selective separation of critical minerals. New polymers will be synthesised with Ed Johnson or by collaborators at Monash University or the University of Sheffield. At Newcastle we will characterise and quantify the adsorption of these new polymers at the phase boundary between various mineral surfaces with air and water in order to demonstrate selective and effective valuable minerals recovery.

g) Selective mineral separation using responsive polymers through reversible switching from hydrophilic to hydrophobic confirmations: In this project, which is being conducted with colleagues at Adelaide and Melbourne Universities, we will investigate the potential to improve the dewatering process in mineral tailings using conformational changes in added polymers adsorbed to particles to reversibly induce hydrophilicity or hydrophobicity as required. In this way we will facilitate the recovery of process water, which results in the reduction of the impact of mineral processing on the environment and significantly reduces the risks in tailings dam failures. At Newcastle, our experiments will focus on characterising polymer adsorption on gangue minerals and the contact angle that results.

Dr Edwin Johnson

Biologically inspired polymeric materials and soft-matter interactions

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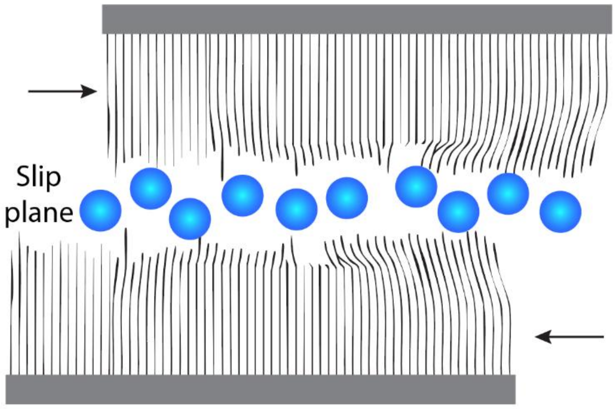
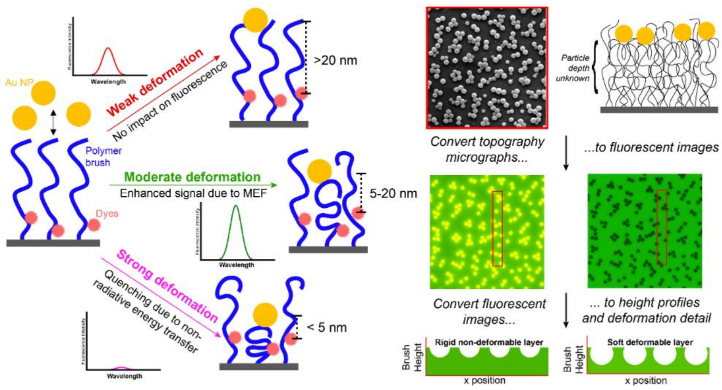
My research explores how we can design soft, polymer-based materials that mimic nature to solve real-world problems. These materials can control how surfaces interact, reduce friction, preventing fouling, or act as sensors for environmental triggers. I'm especially interested in how these polymers assemble and behave at complex interfaces, where chemistry meets physics and biology. By combining ideas from these disciplines, I aim to uncover how natural systems work and use that knowledge to design smarter materials.

a) From Cartilage to Coatings: Understanding the Chemistry of Biological Lubrication: Joints such as our knees and hips achieve remarkably low friction through hydrated, brush-like structures that coat cartilage surfaces. These "hairy" interfacial layers trap water, creating slippery, hydrated boundaries in a process known as *hydration lubrication*. Mimicking this mechanism with charged nanoscale polymer coatings offers exciting opportunities for artificial and biocompatible layers, recently recognised by IUPAC as a Top Ten Emerging Technology in Chemistry (2024). Students will design and characterise hydrated polymer interfaces using atomic force microscopy (AFM), quartz crystal microscopy (QCM), and neutron reflectometry to understand how structure and environment govern lubrication performance.



b) From touch to light: transducing nanoscale mechanical events into photonic signals: Soft, nanostructured polymer interfaces play key roles in technologies such as biomedical implants, sensors, and device coatings due to their ability to regulate interactions with their environment. However, how these soft coatings deform and reorganize upon nanoparticle adsorption remains poorly understood, as such nanoscale processes are difficult to directly visualize. These deformations govern key properties like adhesion, transport, and stability. This project will develop *self-reporting polymer interfaces* that optically signal their own nanoscale deformation using dye-labelled polymer brushes. These model systems will enable real-time optical tracking of



nanoparticle adsorption and deformation, providing insights for designing next-generation soft and biointegrated materials.

d) Can physical chemistry explain biophysics: Physical chemistry provides the foundation for understanding how soft and flexible molecules behave in living systems. The structure and function of biomolecules (such as peptides, proteins, and lipids) arise from a delicate balance of chemical interactions within complex environments. However, predicting their behaviour remains challenging due to the combinatorial complexity of natural systems.In this project, students will explore how soft, responsive polymers behave in complex, biologically relevant environments. You'll design and synthesise polymeric materials and study their structural response in the presence of additives such as sugars, salts, and surfactants. Using techniques such as acoustic-surface characterisation and high-throughput solution measurements, you'll uncover how environmental conditions shape the structure and function of soft materials. The insights gained will not only deepen our understanding of how chemistry drives biological organisation but also help guide the design of smart materials such as responsive coatings and sensors to drug delivery systems that adapt to their environment.

b) Electrically responsive polymers: Polyelectrolyte polymer brushes are soft, charged materials whose structure and properties can be tuned by an applied electric field. Understanding how these molecular layers reorganise and respond to electrical and mechanical forces provides fundamental insight into charge distribution, ion transport, and interfacial dynamics in soft matter systems. In this project, you will design and synthesise polyelectrolyte polymer coatings and develop new experimental approaches to study their behaviour under applied potentials. Using techniques such as ellipsometry**,** atomic force microscopy (AFM)**,** and neutron reflectometry**,** you will probe how their structure and material properties evolve in response to electrical stimuli. The findings will deepen our understanding of how electric fields couple to molecular organisation at soft interfaces laying the groundwork for future electric field-responsive devices and sensors.