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SCIENCE

SCHOOL OF CHEMISTRY

HONOURS PROJECTS

2024

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# INTRODUCTION - Honours 2024

This booklet is intended to provide an overview of the research activities within the School of Chemistry and to give you an indication of the Honours projects that will be offered in 2024. You are encouraged to study these and to speak with the research supervisors. This research project makes up 75% of the final mark for the Honours year, with the other 25% from the coursework component which runs in first semester.

Current third year students are eligible to do Chemistry Honours (Clayton) in 2024 provided that they fulfil the entry requirements and that a supervisor is available.

Students will be allocated to supervisors and projects on the basis of their third year results and their preferred projects. Great care is taken to ensure that all students are treated equitably and where possible that they are allocated to the area and supervisor of their choice.

All Honours candidates must discuss prospective projects with at least four supervisors before choosing their preferred project. They should then select at least three potential supervisors and projects in order of preference. The application forms – one for Honours entry which is an on-line link from the Faculty of Science, the other is the project nomination form which is from the School of Chemistry – are both available on the School of Chemistry Honours web page.

Please note that the project descriptions are quite short, and more comprehensive details can be obtained when speaking to supervisors.

We look forward to seeing you in the Honours course next year. Please contact me if you have any questions about the Honours year!

**Assoc. Prof Mike Grace**

Honours Coordinator

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## Professor Phil Andrews

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This document gives you an idea of the type of research we are undertaking within my group. If you have any further queries, please do not hesitate to contact me (details above).

More information on my research can be seen at:  
<http://monash.edu/science/about/schools/chemistry/staff/Andrews.html>

### 1. Combating multi-drug resistant bacteria with metal complexes (Bi vs Fe vs Ga)

*In tackling the continued growth in multi-resistant bacteria and the increasing rate of antibiotic resistance, this project focuses on the development of bismuth(III) and gallium(III) compounds which show high activities against common and resistant strains of bacteria (eg MRSA, VRE). **Read more:** Chem. Eur. J., 2020, doi.org/10.1002/chem.202000562*

### 2. Development of new bismuth and gallium based anti-Leishmanial drugs

*(with Dr Lukasz Kedzierski, Peter Doherty Institute, University of Melbourne)*

*Leishmaniasis is a parasitic infection prevalent in the developing world. Current frontline drugs are based on Sb(V) compounds which show severe side-effects and for which resistance has begun to appear. This project focuses on developing and testing new bismuth and gallium compounds as more active and less toxic alternatives. **Read more:** Eur. J. Med. Chem., 2020, doi.org/10.1016/j.ejmech.2019.111895*

### 3. Developing new antimicrobial materials and coatings

*(with Dr. Warren Batchelor, Chemical Engineering; Prof. Laurence Meagher, Monash Institute of Medical Engineering)*

*This project investigates the formation of novel bismuth(III) complexes which have high antimicrobial activity and their incorporation into natural and synthetic polymers and materials. The antimicrobial activities of the new materials and their potential as 'clean surfaces' will be assessed. **Read more:** Chem. Eur. J., 2018, **24**, 1 – 13. DOI: 10.1002/chem.201801803*

### 4. Targeting Novel Chiral Heterobimetallic Main Group Complexes

*(with Dr. Victoria Blair)*

*This project involves the design, synthesis and full characterization of novel chiral hetero-di-anionic and hetero-bimetallic complexes of alkali metal, and d or p-block elements (eg. Zn, Cu, Al, Ga, In, Sn, Sb), and subsequent examination of their reactivity and selectivity in asymmetric synthesis and in the formation of unusually substituted heterocycles. Requires inert atmosphere handling techniques. **Read more:** Organometallics, 2018, **37**, 1225–1228. DOI: 10.1021/acs.organomet.8b00047*

### 5. Heterobimetallic Compounds, Cages and Nanoparticles for Radiation Sensitisation

*(with Dr. Kristof Zarschler, Radionuclide Theranostics, Helmholtz Zentrum Dresden-Rossendorf)*

*Radiation therapy (RT) is a common form of cancer treatment, however the resistance of tumour cells to RT is a serious concern. One way to enhance damage to tumour cells is to employ radio-sensitisers. These are molecules, cages or nanoparticles which can increase the radio-sensitivity of tumour cells and therefore the effectiveness of the treatment. This project will explore the design and development of mixed heavy metal compounds and an assessment of their potential as radio-sensitisers for tumour cell depletion. **Background reading:** Trends in Pharmacological Sciences, 2018, **39**, 24-48.*

## Professor Stuart Batten

Room No. 121C, Tel: 9905 4606, email: [stuart.batten@monash.edu](mailto:stuart.batten@monash.edu)

This document will give you an idea of the type of research we are undertaking within my group. If you have any further queries, please do not hesitate to contact me (details above).

More information on my research can be seen at: <http://stuartbatten.net>

### Coordination Polymers and Supramolecules

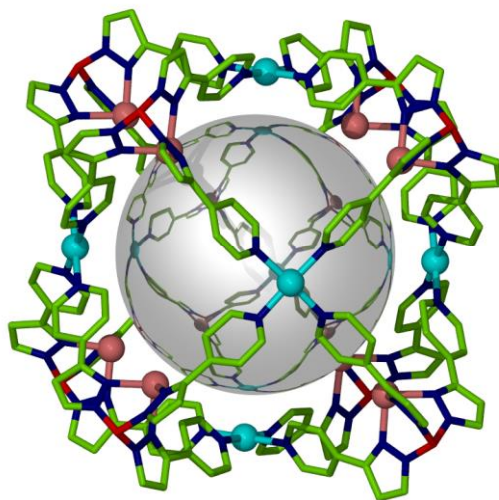
We are designing and making coordination polymers (sometimes also known as metal-organic frameworks, or MOFs) and supramolecular species for a variety of interesting applications, including adsorption of gases such as hydrogen (for hydrogen fuelled cars) and carbon dioxide (greenhouse gas capture), long or short range magnetic ordering, molecular switching (for information storage or molecular sensing), and as new materials for molecular separations. We are pursuing a number of approaches to this, including:

- New classes of bridging ligands in which the bridging length can be controlled by the presence or nature of e.g. group I or II metals (*Chem. Commun.*, 2009, 5579).

- Large (3 nm in diameter) spherical supramolecules (or ‘nanoballs’) (*Angew. Chem. Int. Ed.* 2009, **48**, 2549 & 8919; *ChemPlusChem* 2012, **77**, 616) which show a large variety of properties. For example, they can switch between two magnetic spin states. The change may be induced by change in temperature or irradiation of light. The molecular packing also creates cavities within the solid state, and thus the crystals will readily absorb solvent vapours, hydrogen, and CO<sub>2</sub>. Finally, the nanoballs also show catalytic activity.

- Incorporation of amine groups into porous MOFs in order to increase the selectivity of CO<sub>2</sub> sorption over other gases, such as N<sub>2</sub>. These amine groups also provide sites for further reactivity after assembly of the MOF to tailor the material for specific molecular capture and separation processes.

- Porous MOFs for the chromatographic separation of molecules based on size, chirality or other chemical features. Surprisingly little work has been done in this field, and we are currently exploring this potential in depth (*Chem. Commun.* 2014, **50**, 3735).



### Chemistry of Small Cyano Anions

We have been investigating the chemistry of small cyano anions (*Chem. Commun.* 2011, **47**, 10189). They have shown some remarkable chemistry, including the synthesis of a large range of transition metal and/or lanthanoid clusters which may have applications as single molecule magnets, interesting new coordination polymers and discrete complexes showing unusual packing motifs and ligand binding modes, new hydrogen bonding solid state networks, nucleophilic addition of alcohols and amines across the nitrile groups to give new anion families, and the production of ionic liquids containing either the free anions or even metal complexes of the anions. The versatility and range of applications of these simple anions is unprecedented.

## Associate Professor Toby Bell

*School of Chemistry, Clayton campus*

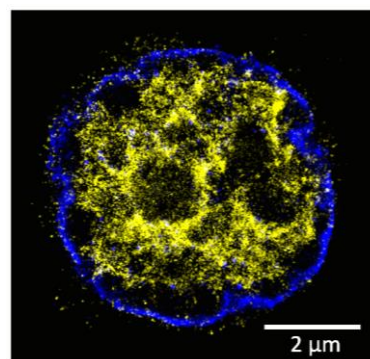
Room G32C / Building 23S, 17 Rainforest Walk. Tel: 69905 4566, email: [toby.bell@monash.edu](mailto:toby.bell@monash.edu)

In the Bell Fluorescence Lab, we develop and apply advanced fluorescence techniques to address major research questions in multidisciplinary contexts. We operate at the ultimate level of single (bio)molecules, to perform super-resolution microscopy and see inside the diffraction limit of light. This enables us to make discoveries from within the sub-cellular milieu. All of our projects make use of our bespoke, home-built instruments and we collaborate widely across Monash, especially with the Monash Biomedicine Discovery Institute. Find out more at:

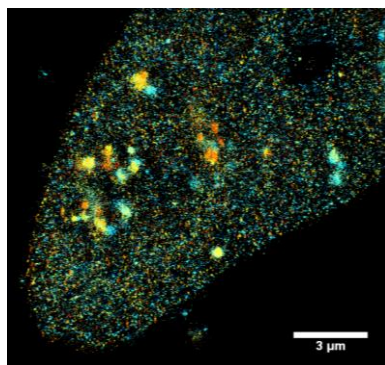
[www.super-resolution.org.au](http://www.super-resolution.org.au) Instagram: Bell\_Fluorescence

### Ultra-resolution microscopy of epi-genetic modifications in the cell nucleus:

Epi-genetic modifications to chromatin play a critical role in gene regulation and expression and are central to cell differentiation and immunological memory. We have developed new tools – ultra-resolution microscopy – capable of mapping individual histone modifications throughout an entire cell nucleus. Projects in this area will involve mapping histone modifications of known function (e.g. repressive/active with respect to gene expression) to investigate the role of spatial distribution, and visualising and characterising higher order chromatin conformations and clusters or regions with dense epi-genetic modifications. A range of cell lines can be studied including pluripotent cells and T cells. Image is of the nuclear envelope (blue) and the active histone mark H3K4me3 (yellow) in a T cell.



### Visualising the host-virus interface:



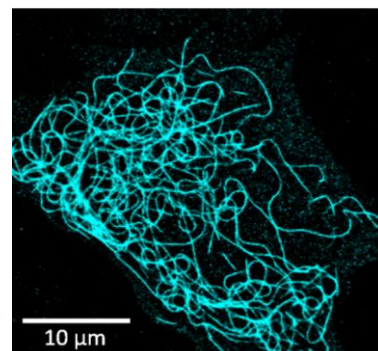
Viruses have developed sophisticated means for hijacking cellular systems for their own needs, in particular the cellular replication machinery for the production of viral proteins. A critical and not well understood aspect at the host-virus interface is how viruses suppress the cellular innate immune response. Current projects in this area focus on rabies and Hendra viruses and include: how rabies virus P proteins remodel the microtubule network by 'bundling' microtubules, how this leads to interferon antagonism, investigating the role of P protein interaction with centrioles, determining where within the nucleolus Hendra M protein localises to, how M protein suppresses ribosomal RNA synthesis, and how M protein interacts with the cell's DNA

damage response mechanism. Image is of a single cell nucleus with M protein 'puncta' located within nucleoli.

### Discovering sub-cellular effects of anti-cancer drugs:

Many current chemotherapeutic drugs have been in use for some decades with good effect. However, off-target side effects can occur leading to sub-optimal outcomes and the mechanisms causing these are not fully understood. Super and ultra-resolution imaging methods can now shed light on what effects drug molecules have at the sub-cellular level. Projects include effects of drugs such as colcemid, paclitaxel, and nocodazole, on various organelles and structures including microtubules, mitochondria and the microtubule network. The image shows aberrant curvature of microtubules in human cancer cells treated with sub-clinical levels of colcemid, a derivative of the anti-mitotic drug colchicine.

Ultimately, this research could lead to improved treatment regimens and outcomes.



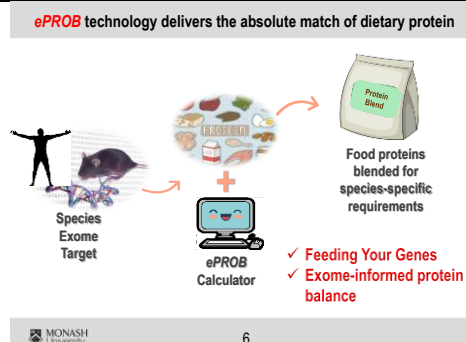
## Professor Louise Bennett

Room No. 318, Green Chemical Futures Bld86 (Rainforest Walk 13), Tel: 99056136; email: [louise.bennett1@monash.edu](mailto:louise.bennett1@monash.edu)

Research in the Food Chemistry group at Monash spans broad applications of physical, analytical and physiological properties of food components, with applications in human health and food technology. The following Honours project topics are available in 2024, so please contact me if you are interested or have any questions.

### Exome-informed Protein Balancing (ePROB)

**ePROB** is a new approach to defining the absolute nutritional quality of dietary protein for any species. This approach can be applied to solve the supply of specific biologically functional proteins for applications in ag tech and filling the 'evolution gap' in amino acid availability in the biosphere and in the food supply. The project focus has some flexibility depending on your sphere of interest.



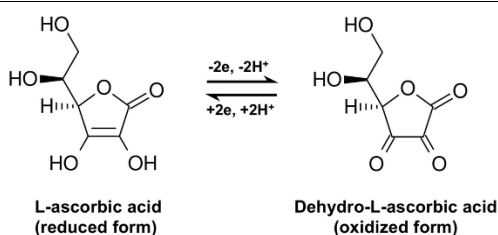
### Food chemistry of almonds

The proximate food chemistry of almonds is reasonably well correlated with cocoa beans. That means it should be possible to make an almond analogue of 'chocolate'. Almondolate? There are many steps to optimize and understand the food chemistry before its ready to eat!



### Essential oils of plants

Hydroxyl-rich polyphenolics as susceptible to chemical and enzymatic oxidation into condensed structures that contribute to the flavours of foods. For example, the oxidation of tea polyphenolics forms a wide range of different styles and flavor profiles of tea. Lets see what happens to structures and aromas when we oxidise hydroxyl-containing essential oils into larger molecular structures. Can we make a 'black tea' analogue of lavender? This project will utilize electronic nose analysis to assess effects of oxidation on aromas.



### Redox chemistry of ascorbic acid and essential oils

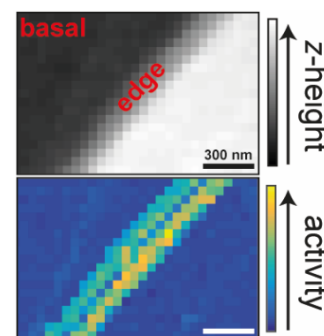
Ascorbic acid or Vitamin C is the most effective water-soluble anti-oxidant but its chemical properties remain to be exploited ex vivo. Lets see if we can get AA to drive the reduction of atmospheric CO<sub>2</sub> into water-soluble forms and help to remove the personal carbon 'breathprint' of human respiration gasses.

## Dr Cameron Bentley

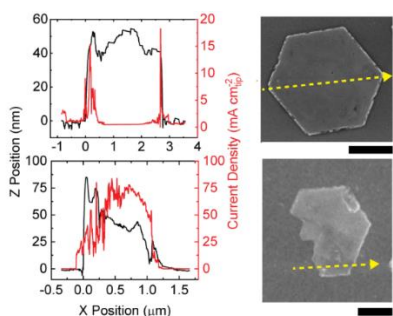
Room No. G24, Bldg 19; Tel: 99059705; email: [cameron.bentley@monash.edu](mailto:cameron.bentley@monash.edu)

[My research](#) centres on the use of glass nanopipettes to “see” the nanoscale active sites of electrodes during operation, through high-resolution *electrochemical microscopy*. Relating electrochemical activity on this scale to the underlying electrode surface structure guides the design/synthesis of the “next-generation” of materials with higher activity, improved stability, longer cycle life etc.

**(1) Nanoscale Reaction Imaging of Water-Splitting Electrodes.** Electrochemical water-splitting is recognised to be one of the most promising approaches to store renewable energy in the form of hydrogen fuel. Commercially feasible water electrolysis requires the use of highly stable and active electrodes, known as electrocatalysts, to overcome the high energy barrier(s) associated with water-splitting. Electrode structure and composition strongly dictate the kinetics and mechanisms of electrocatalytic processes, and thus there is a great need for techniques that can probe electrochemical activity at the scale of surface heterogeneities. In this project, the *Honours Candidate* will probe the nanoscale electrochemistry of promising water-splitting electrocatalysts, in order to reveal catalytic active sites *directly* and *unambiguously*.



**(2) Single Nanoparticle Electrochemistry.** Over the past three decades, the whole of science has been impacted massively by the revolution in nanoscience. For example, nanoparticles (NPs) have found many applications in electrochemistry, such as the noble metal (e.g., Pt) electrocatalysts used in fuel cells or electrolyzers. With the widespread uptake of NPs in electrochemistry and beyond, there is a great demand for techniques that can answer the fundamental question: what is the relationship between structure and/or composition, and electrochemical activity at the *single particle* level? In this project, the *Honours Candidate* will address this important question by probing the structure–activity of individual NPs supported on electrode support surfaces.



**(3) Probing nanoscale electropolymerisation dynamics on flexible substrates.** Chemiresistors are very attractive compared to other electrochemical sensors due to their relative ease of fabrication and ability to be miniaturised. Chemiresistive devices employ a sensing layer in between two electrodes on an insulating substrate and changes in the resistance between the electrodes caused by the analyte’s interaction with the sensing layer is monitored as a function of analyte concentration. Conducting polymers (CPs) have recently come to the fore as ideal sensing layers since they can be fabricated *in situ* by electrochemical polymerisation and allow operation at room temperature. Currently there are no proper characterisation tools to understand the electrochemical growth of the CP from the electrodes to bridge the gaps on insulating substrates. In this project, the *Honours Candidate* will probe the nanoscale formation of CPs on insulating flexible substrates in an attempt to optimise the electrochemical growth to develop highly selective/sensitive sensors. This project will be carried out in collaboration with Dr Krishnan Murugappan ([Krishnan.murugappan@csiro.au](mailto:Krishnan.murugappan@csiro.au)) in CSIRO Minerals, Clayton.

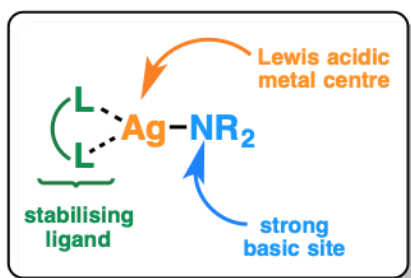
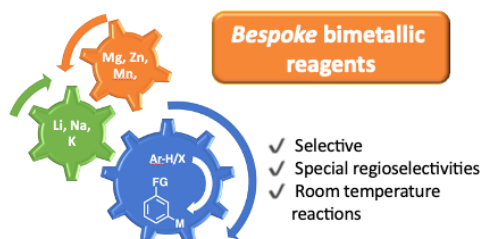
**(4) Electrochemical separation of high value metal species from cathode materials of EoL LIBs.** Li-ion batteries (LIBs) are indispensable in modern society, being the predominant power source used in portable electronics (e.g., mobile phones, laptops etc.) and increasingly, electric vehicles. Once these batteries have reached their end of service life (EoL), effective, economic and sustainable strategies have to be in place to not only deal with the emerging waste streams but, importantly, to recover valuable metal resources inherent in the battery composition. Electrochemical separation is potentially a powerful approach, but a major problem to address is the very narrow potential gap ( $\Delta E$ ) between the reduction potentials of  $\text{Co}^{2+}$  and  $\text{Ni}^{2+}$  (i.e., derived from the LIB cathode) in aqueous solution. If it is possible to widen  $\Delta E$ , an opportunity opens up to achieve separation of the two metal species conveniently by applying electrochemical methodology. The approach we want to take in widening the  $\Delta E$  is rooted in coordination chemistry where certain ligands when associated with a metal species (complexes) can impart individually different behaviour in solution, including their redox potentials. In this project, the *Honours Candidate* will electrochemically screen promising ligands in aqueous solutions of  $\text{Co}^{2+}$  and  $\text{Ni}^{2+}$  to create a library of possible candidates, which will be later tested on LIB waste streams. This project will be carried out in collaboration with Dr Thomas Ruether ([thomas.ruether@csiro.au](mailto:thomas.ruether@csiro.au)) in CSIRO Energy, Clayton.

## Dr Victoria Blair

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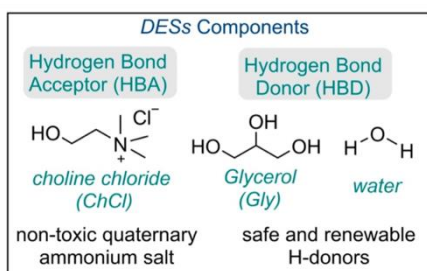
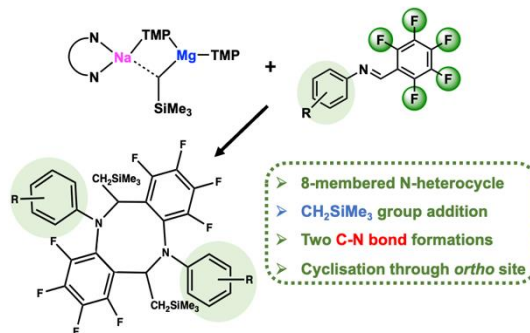
This document will give you an idea of the type of research we are undertaking within my group. If you have any further queries, please do not hesitate to contact me (details above).

**Bespoke Bimetallics:** By combining the reactivity of two metal components within the one system we can make a range of bespoke bimetallic bases that have better reactivity, regioselectivity and atom economy than either of the individual mono-metallic components alone. The unique chemical cooperativity that exists allows the direct C-Mg bond formation, of various aromatic substrates offering new pathways for building molecular scaffolds applicable to the pharmaceutical, material and agrochemical industries.



**Active Metal Catalyst Design:** Of the Group 13 coinage metals studied as potential metal-catalyst systems silver is often overlooked due to its relatively moderate Lewis acidity, ease of reduction and photosensitivity. In our group we have been designing light stable Silver(I)amido pre-catalysts that are active in a range of hydrofunctionalisation reactions. By tailoring both the amido and stabilising ligands attached to the silver metal centre a diverse range of Ag(I) amide complexes can be synthesised which offer unique reactivity profiles yet to be explored. *see Chem. Euro. J.*, **2020**, 26, 4947

**Bimetallics in hydrodefluorination:** 20% of pharmaceuticals and 30% of agrochemicals synthesised today contain at least one C-F bond. Both building and removing them from molecules is a synthetic challenge – partly due to the relative chemically inert C-F bond. Our group are researching the use of bimetallic reagents (Mg/Na) to effectively remove F via C-F activation of a range of fluorinated substrates, creating new C-C, C-N or C-P bonds in their place. This methodology has uncovered some interesting and unexpected organic cyclic products!



**Deep Eutectic Solvents (DES) in Organometallics:** Advancing polar organometallic chemistry away from traditional volatile organic compounds (VOCs) and into more sustainable, environmentally friendly alternative reaction media is central to the green chemistry ethos of 'benign by design'. DESs are room temperature liquids composed of a salt and a hydrogen bond donor molecule. They are cheap, non-toxic, biodegradable and can be fine-tuned for specific applications. Extending DESs to polar organometallic chemistry, in particular, traditionally air and

moisture sensitive metal-mediated reactions will establish a qualitative shift in the way organometallic chemistry is designed and conducted.

## Professor ALAN CHAFFEE

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My group undertakes applied chemistry research on topics that are, in some way, related to biomass and fossil resource utilization. For example, new approaches to the preparation of industrial chemicals, specialty liquid fuels (eg, jet fuel), road bitumen, coke for steel making, and specialist high surface area active carbons are being developed so as to minimize energy losses and CO<sub>2</sub> emissions. We also investigate the capture of CO<sub>2</sub> emissions by adsorption and, once captured, its transformation back into useful products by heterogeneous catalysis. In doing so, innovative new materials such as mesoporous silicas, metal organic frameworks (MOFs) and ionic liquids (ILs) are employed as adsorbents, catalysts and/or solvents. These novel materials are often sourced from other research groups within the School. Molecular modeling tools are also frequently applied in these studies, so that experiment and theory inform each other. More information on my research can be found at:

<http://monash.edu/science/about/schools/chemistry/staff/CHAFFEE.html>

### Turning Carbon Dioxide into Fuel

Waste CO<sub>2</sub>, when combined with 'renewable H<sub>2</sub>' (eg, from photovoltaic water splitting) over appropriate catalysts, leads to hydrocarbon products (methane and higher hydrocarbons, formaldehyde, methanol) which can be directly used as fuel or chemical feedstocks. We are thermally transforming metal organic framework (MOF) precursors to produce nanoparticulate catalysts of varying metal cluster size, supported on carbonaceous ribbons that seek to provide exceptionally high reaction rates and selectivity to these products.



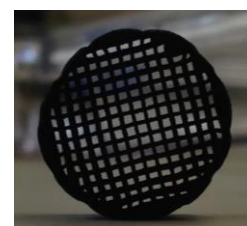
### Capturing Carbon Dioxide from Air

Prior work in the group has identified amine-based adsorbents that have the ability to reversibly capture and release CO<sub>2</sub> at concentrations (~15 wt%) and temperatures typical of the flue gas from power stations. Another approach to controlling CO<sub>2</sub> in the atmosphere could be to adsorb it directly from air at atmospheric concentration (~400 ppm). This project will prepare and evaluate new adsorbent formulations for this purpose involving high surface area mesoporous silica (such as SBA-15) as a support material.



### Environmental Applications of Active Carbon Monoliths

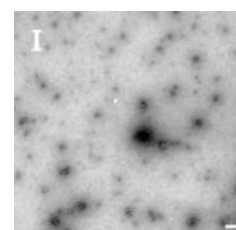
The group has recently developed a new form of monolithic carbon, derived from brown coal, that provides for efficient gas and liquid contact with low pressure drop. These materials have exceptional surface areas and, therefore, multiple potential applications as adsorbents, catalysts, electrodes, etc. Their inherent electrically conductive means that they can, in principal, be very efficiently regenerated by ohmic heating. Projects are available that investigate their performance for the removal of pollutants from gas phase (e.g., NO<sub>x</sub>) or from liquid phase (e.g., heavy metal) streams, their regenerability, as well as optimization of fabrication methods.



Active Carbon Monolith

### Quantum Dot Medicine (Collaboration with Assoc Prof Lisa Martin)

In recent work we have demonstrated that carbon quantum dots (CQDs), prepared from brown coal, can mitigate against the types of protein aggregation that are associated with Alzheimer's disease and Type 2 diabetes. This project will prepare a series of CQDs with varied surface functionality with a view to determining how varied chemical composition effects aggregation rates.



CQDs prevention of fibrilisation

## Professor Philip Chan

Room No. 243A, Building 23, Tel: 9905 1337, email: [phil.chan@monash.edu](mailto:phil.chan@monash.edu)

We are an organic chemistry group focused on the discovery and understanding of new and sustainable reactions through the power of homogeneous catalysis and their application to the synthesis of bioactive natural products and functional materials. More information can be obtained from Philip ([phil.chan@monash.edu](mailto:phil.chan@monash.edu)) and at: <https://research.monash.edu/en/persons/philip-wai-hong-chan>.

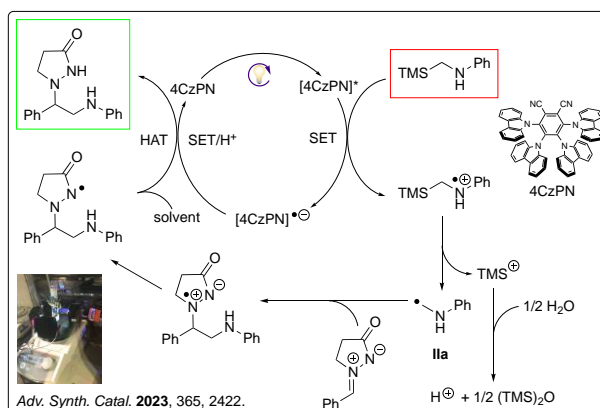
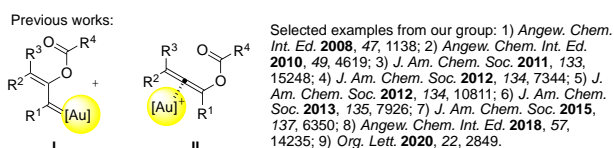
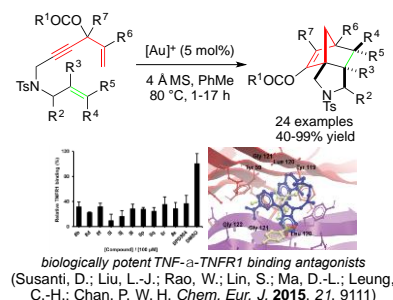
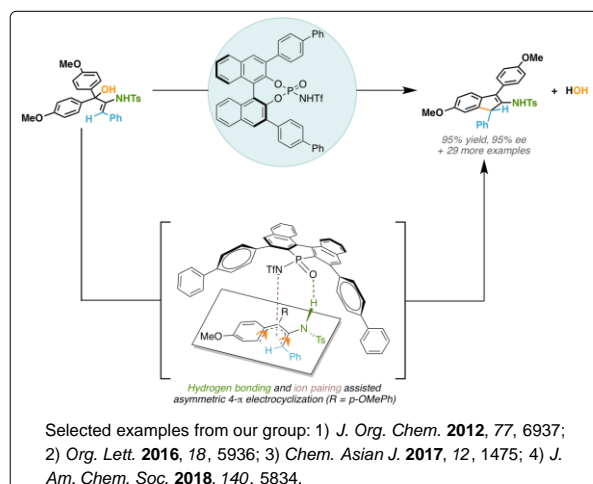
### Homogeneous transition metal catalysis, photoredox catalysis and organocatalysis: new strategies for natural products synthesis and drug discovery

Research in our group is focused on three main areas. The first is homogeneous transition metal catalysis, one of the most powerful and stereoselective synthetic tools in the chemist's armory for the assembly of complex molecules from readily accessible precursors in a single step. In this field of catalysis, we will explore the novel reactivities of the vinyl gold carbenoid species **I** as well as those of the allenylgold intermediate **II** developed by our group in chemical synthesis.

A second area of catalysis research we will focus on is the recent new discoveries from our lab in photoredox catalysis driven by either a metal or organic dye photocatalyst in the presence of a light source, which is currently a hot topic in research. The goal will be to realise new reactivities, develop new catalysts along the way and provide mechanistic insights into these novel synthetic technologies. Several Honours projects that explore this new area of catalysis are available, such as the 4-CzPN-mediated  $\alpha$ -aminoalkylation of azomethine imines by  $\alpha$ -silyl amines under blue LED light.

**Key references:** see references in the Figure and our recent review: León Rojas, A. F.; Kyne, S. H.; Chan, P. W. H. *Acc. Chem. Res.* **2023**, 56, 1406.

The third area of catalysis pursued in the group and one of the most powerful catalytic methods to emerge over the last two decades to rapidly achieve molecular complexity in an enantioselective manner from readily accessible precursors is organocatalysis. Our interest in the organocatalytic reaction chemistry of  $\pi$ -rich alcohols is driven by the ease of substrate preparation providing the possibility to introduce a wide variety of substituents. Added to this is the potential formation of water as the only byproduct that makes it a highly attractive environmentally sustainable and atom-economical approach. A recent example of this strategy is a seminal work by us revealing the first chiral Brønsted acid catalysed dehydrative Nazarov-type dehydrative electrocyclisation of aryl- and 2-thiophenyl- $\beta$ -amino-2-en-1-ols to 1*H*-indenes and 4*H*-cyclopenta[*b*]thiophenes. A number of Honours projects that explore this new area of catalysis are available.



**Key references:** see references in the Figure and our review: Ayers, B. J.; Chan, P. W. H. *Synlett* **2015**, 1305.

## Professor Perran Cook

Room No. 19/G25a, Tel: 9905 54091, email: [perran.cook@monash.edu](mailto:perran.cook@monash.edu)

More information on my research can be seen at:

<http://monash.edu/science/about/schools/chemistry/staff/cook/>

Sand sediments dominate our coastline, yet we have little understanding of how this environment emits greenhouse gases.

Methane production in permeable sediments driven by plant metabolites

Methane is a potent greenhouse gas that is rapidly increasing the atmosphere. To manage methane emissions, we need to better understand sources and sinks of this gas. Typically, methane production in marine sediments is thought to be negligible due to methanogens being outcompeted by sulfate reducing bacteria. However, our recent work has shown high emissions of methane in Port Phillip Bay, and that plant metabolites such as dimethyl sulfide, choline and methyl amines may be important sources. This is potentially very important, because it has been proposed that seaweed farming could be used to absorb CO<sub>2</sub>, yet little is known about its methane production potential. This project will investigate the role that plant metabolites play in methane production in coastal sediments, including the effect of species and growth conditions on this.

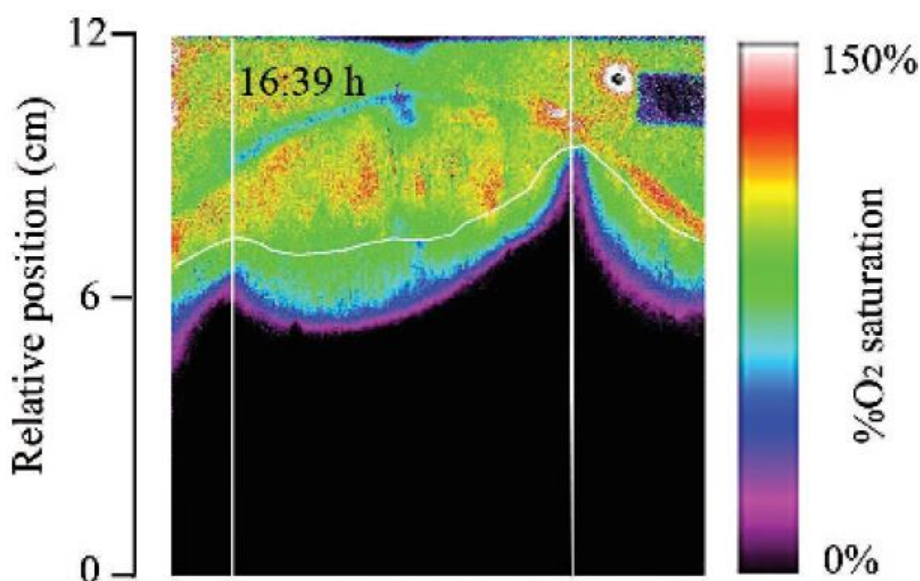


Figure shows oxygen distribution within a sand ripple. Organisms within this environment must cope with rapid shifts in oxygen concentrations. Surprisingly, this environment has the potential to produce large amounts of methane

### Denitrification pathways

Denitrification is a key reaction in the environment because it removes excess bioavailable nitrogen. Nitrous oxide is a key intermediate in the process and is a powerful greenhouse gas.



There are a number of pathways and organisms that can mediate denitrification including bacteria, fungi and chemical processes. By analysing the stable isotopes of N and O in N<sub>2</sub>O we can gain insights into the processes driving denitrification. Our recent research has discovered that chemo denitrification may be a more important denitrification pathway in coastal systems. This project will examine isotope ratios in N<sub>2</sub>O to better understand denitrification pathways taking place in coastal systems and nitrogen rich groundwater.

## Professor Glen Deacon

Room No. 136C, Building 19 Tel: 9905 4568, email: [glen.deacon@monash.edu](mailto:glen.deacon@monash.edu)

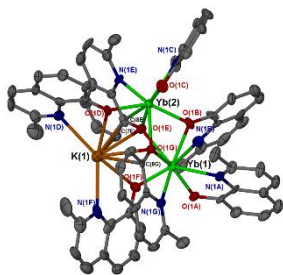
For more information, see: [www.chem.monash.edu.au/staff/deacon.html](http://www.chem.monash.edu.au/staff/deacon.html)

### Rare earth elements (Group 3-Sc, Y, La and the lanthanoids Ce - Lu)

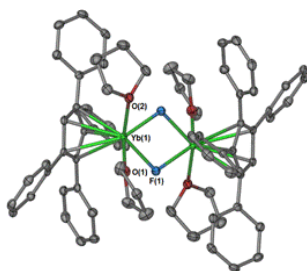
Rare earths are currently seen as the strategic materials of the 21<sup>st</sup> century with considerable international concern over the Chinese domination of the supply of separated elements. Our group provides fundamental knowledge to underpin industrial developments in the area. **Australia has abundant rare earth resources which have been mainly neglected** despite their widespread uses, e.g. ceramic supports for exhaust emission catalysts, alloy magnets in all car engines, and catalysts for artificial rubber production. Potential applications include green corrosion inhibitors (below). Their metal-organic chemistry is a major new frontier and is generating great excitement, for example in the discovery of new oxidation states. We are particularly interested in high reactivity rare earth organometallics (Ln-C), organoamides (Ln-NR<sub>2</sub>) and aryloxides (Ln-OAr), and have developed unique synthetic methods to obtain them. Features of these compounds include low coordination numbers and extraordinary reactivity including C-F bond activation, the most resistant carbon-element bond. To prepare and structurally characterize the compounds represents a major challenge. **The program involves extensive international collaboration. Some specific projects follow:**

1. **New Approaches to Metal-Based Syntheses** (with Prof. Peter Junk (JCU) and Dr Victoria Blair)
2. **Carbon-fluorine activation with reactive rare earth complexes** (with Dr Victoria Blair and Prof Peter Junk)
3. **Heterobimetallic complexes and pseudo solid state synthesis** (with Prof. Peter Junk (JCU) and Dr David Turner)
4. **Green Corrosion Inhibitors** (with Prof. Peter Junk (JCU), Dr David Turner and Prof. Maria Forsyth (Deakin University))
5. **New Materials Derived from Small Cyano Anions** (with Prof. Stuart Batten)

### Novel recent structures



Project 1



Project 2

### Techniques

Inert Atmosphere handling; X-ray crystallography including Synchrotron use. X-ray powder diffraction; IR, UV-Vis, NMR spectroscopy, Mass spectrometry Pseudo solid state synthesis, solvothermal synthesis

### Some recent papers

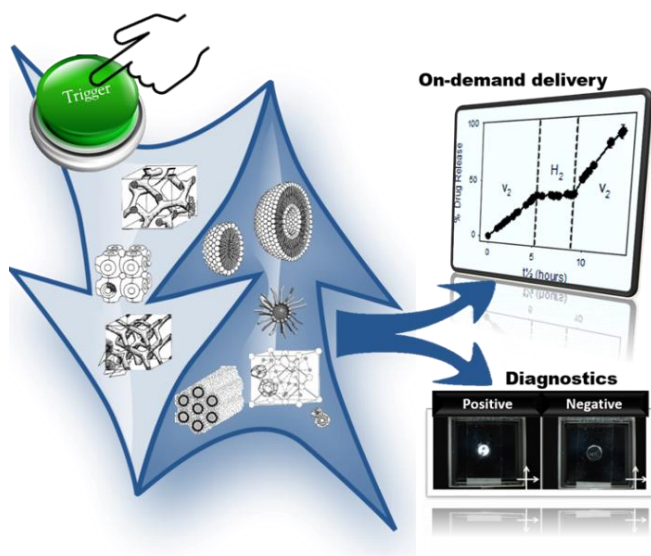
*Angew. Chem. Int. Ed.*, 2009, **48**, 1117-1121; *Chem. Eur. J.*, 2009, **15**, 5503-5519; *Chem. Commun.*, 2010, **46**, 5076-5078; *Chem. Comm.*, 2012, **48**, 124-126; *J. Inorg. Biochem.*, 2012, **115**, 226-239; *Chem. Eur. J.*, 2013, **19**, 1410-1420; *Organometallics*, 2013, **32**, 1370-1378; *Chem. Eur. J.*, 2014, **20**, 4426-4438; *Inorg. Chem.*, 2014, **53**, 2528-2534; *Chem. Commun.*, 2014, **50**, 10655-10657; *Eur. J. Inorg. Chem.*, 2015, 1484-1489; *Chem. Eur. J.* 2016, **22**, 160-173; *Chem. Eur. J.*, 2017, **23**, 2084-2102; *Angew. Chem. Int. Ed.*, 2017, **56**, 8486-8489; *Coord. Chem. Rev.* 2020, **415**, 213232, 1-23; *Dalton Trans.* 2020, **49**, 7701-7707; *Chem. Eur. J.*, 2022, **28**, e202103865 (1 - 11); *Chem. Commun.* 2022, **58**, 4344-4347.

## Dr Khay Fong

Room No. 119, Tel: 9905 0424, email: [khay.fong@monash.edu](mailto:khay.fong@monash.edu)

Our research group **manipulates the dynamic spontaneous assembly of lipids** for use as on-demand drug delivery systems and diagnostic materials, and **quantifies environmental microplastics** to contribute to the global conversation about this generation's pollution problem.

Below is a snapshot of our ongoing projects if you see anything of interest, we can discuss your potential honours project on one of these topics further – please don't hesitate to contact me on the details above!



### Directing self-assembly

Lipids self-assemble into a variety of mesophases when exposed to aqueous conditions. These materials have unique optical and diffusion properties based on their nanostructure. We look at how we can deliberately manipulate their assembly for biopharmaceutical and environmental applications.

Projects in this theme involve formulation, synthesis, colloidal and nanoscale characterisation and the utilisation of scattering techniques at large national facilities such as the Australian Synchrotron and the Australian Nuclear Science and Technology Organisation (NSW).

We're currently looking at:

1. How our native biomacromolecules and our microbiome effect their use **as drug delivery systems**.
2. The **formulation and delivery** of poorly water-soluble drugs.
3. Incorporation of colorimetric molecules for the detection of environmental pollutants.

### Environmental microplastics

Plastic. It's become a dirty word. The pervasive pollution we find in the environment now were once useful materials. The problem stems from the fact that they were built to last so they do not naturally degrade, but weather and fragment into increasingly smaller sizes.

Our group partners with international NGOs such as the [Sail and Explore Association](#) and [AUSMAP](#) to co-organising citizen science expeditions in the marine environment. We subsequently bring the samples back to the lab for analysis with FTIR and machine learning algorithms. This information is then used to inform discourse with the communities involved and contribute to the conversation about how to end plastic pollution.

Projects in this space involve analytical chemistry, science communication and behavioural science.



## Dr Alison Funston

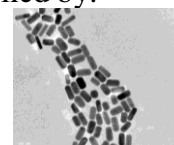
Room No. G32B, Tel: 9905 6292, email: [alison.funston@monash.edu](mailto:alison.funston@monash.edu)  
<https://funstongroup.monash.edu/>

### Research Area – Nanoscience

#### Towards functional super-nanostructures (nanoparticle ‘machines’)!

When matter is divided into tiny particles, that is, into crystals of nanometer sizes ( $1\text{ nm} = 1 \times 10^{-9}\text{ m}$ ), its properties change. Very tiny spheres containing 1000 gold atoms are red. The colour of tiny spheres of semiconductor materials only a few nanometers in diameter can be tuned across the visible region by changing their size. This effect is due to quantum confinement and the spheres are called quantum dots (QDs). The colours of nanoparticles can be controlled by:

- Changing the size or shape of the crystal
- Changing the environment of the crystal
- Bringing two or more nanocrystals into close proximity



The nanocrystals have potential applications in energy harvesting for solar energy, nanoscale energy transfer, sensing, and medicine (drug delivery, cancer therapies).

We research ways to manipulate the way light energy is absorbed, transported and transformed in advanced nanoscale materials for:

- Nanoparticle machines/functional nanostructures
- Solar energy conversion
- Energy-efficient lighting and displays
- Security labelling and optical sensor platforms



Our research involves synthesis, DNA-based self-assembly and investigation of the optical properties of nanocrystal systems. We investigate the mechanism of growth of nanocrystals, making use of electron microscopy (TEM and SEM). We use advanced spectroscopy and microscopy techniques to measure the optical properties of *single nanoparticles* and *single nanoparticle superstructures*.

#### Potential honours projects include:

##### Capturing Light and Manipulating Transport through Nanoscale Structures:

This is important for solar cells and solar energy harvesting. Projects include energy or electron transfer between nanocrystals, across interfaces and in self-assembled films.

##### Changing the Colour of Nanoparticles - Nanoparticle Coupling:

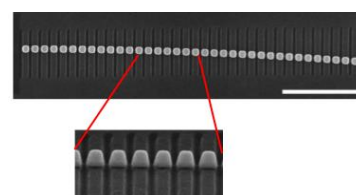
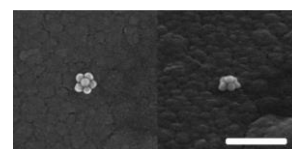
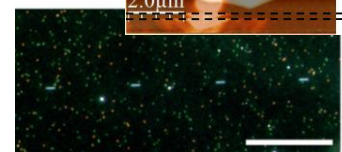
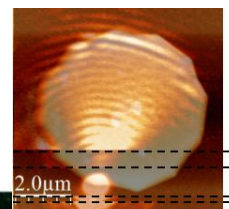
Assemblies of nanocrystals have optimal characteristics for many applications. This project aims to make, understand and use these.

##### Perovskite Particles – Halide Diffusion:

Perovskites are a new class of materials which have shown great promise in solar cells and as sensors. These applications are affected by the halide composition of the crystal. This project aims to understand halide diffusion at the interface of perovskite micro- and nanocrystals.

Nanoparticles and Nanowires as Nanoscale Optical Fibres: Nanowires are able to transport energy below the diffraction limit of light. This project will investigate how the three-dimensional shape of the nanowire changes the efficiency of the energy transport.

Synthesis of Nanoparticles: Silicon nanoparticles are a low-cost, low-toxicity potential alternative to traditional nanoparticle materials which utilize heavy atoms such as cadmium. This project aims to synthesise silicon quantum dots, which emit blue light, and larger particles.



## Associate Professor Mike Grace

Room No. G25c (Water Studies), Tel: 9905 4078, email: [michael.grace@monash.edu](mailto:michael.grace@monash.edu)

*These projects can be modified to suit the interests of the student – from physical, analytical and/or environmental chemistry and biogeochemistry through to aquatic and microbial ecology.*

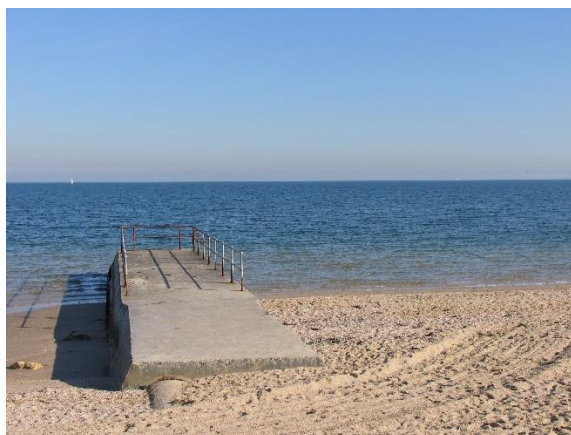
### 1/ Are pharmaceuticals threatening key aquatic ecosystem processes?



Awareness of the effects of common pharmaceuticals on organisms (insects, fish) living in streams and lakes has slowly but definitively emerged over the last decade. Despite their prevalence in urban waterways, there has been almost no published research on how these pharmaceuticals can affect rates of fundamental ecosystem processes. Work in our group has shown that some of these chemicals can have dramatic effects. This project will use novel pharmaceutical diffusing substrates and bioassay techniques to investigate effects of common drugs like antibiotics, mood modifiers, painkillers and antihistamines on a range of fundamental ecosystem processes including photosynthesis, respiration, biomass accrual and denitrification in urban waterways.

### 2/ Emerging Organic Contaminant effects in porous sediments e.g. Port Phillip Bay

Pharmaceuticals, personal care products (including Triclosan) and other organic chemicals including herbicides and pesticides are constantly being discharged into Port Phillip Bay from the Western Treatment plant and tributaries such as the Yarra River and Mordialloc Creek. This project will examine the impacts of such chemicals on near shore, sandy environments from the bay. The focus will be on assessing how environmentally relevant concentrations of some of these chemicals alter rates of organic carbon decomposition (respiration) and nutrient cycling. LC-MS/MS will be used to measure the concentrations of the target organics in the tributaries and flow-through reactors (pictured) will be used as experimental mesocosms.



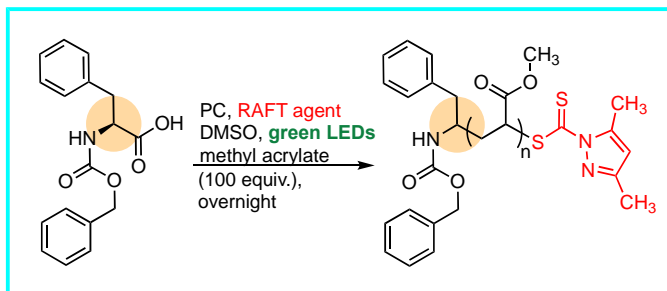
### 3/ A biogeochemistry project based on your interests

I'm very happy to co-design an Honours project with you based on any specific interests (e.g. sites, pharmaceuticals/other contaminants, types of studies etc) you have.

Our group is focused on the development of novel catalytic reactions, and their application to the synthesis of small molecules and materials.

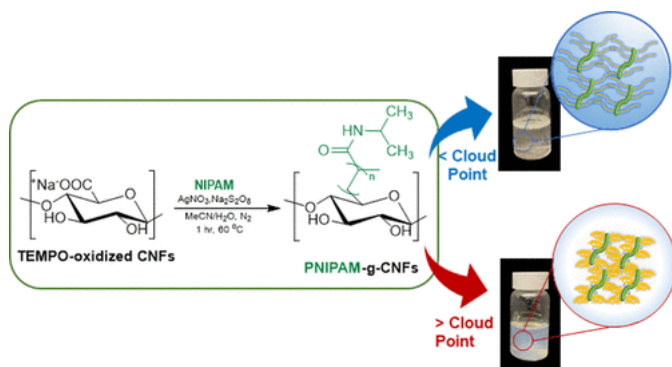
## Radical decarboxylation for polymer synthesis and materials science

The radical decarboxylation of carboxylic acids is a powerful method to generate carbon-centred radicals. We are applying this approach to the synthesis of highly functionalised RAFT polymers, thermoresponsive cellulose materials and functionalised graphene materials.



## Sustainable chemistry for cellulose materials

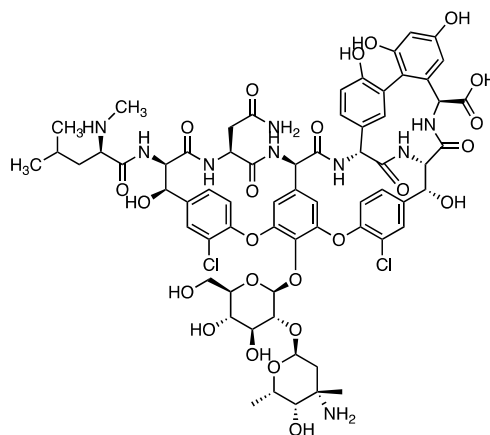
Cellulose is the most abundant polymer on earth, and an invaluable material for sustainable materials and chemical production. We are developing green catalytic processes to convert cellulose into functional and commercially valuable materials for the biotechnology, mining and materials industries. And we aim to do it all in water.



This project is in collaboration with Prof Gil Garnier in Chemical Engineering and the BioPRIA research instate.

## Unnatural amino acids in peptide-based antibiotics

Ribosomally synthesised and post-translationally modified peptides (RiPPs) are a class of peptide-based natural products that have a wide range of biological functions, including antimicrobial activity. We are interested in the synthesis of unnatural amino acids as substrates for enzymatic post-translational modification. This involves the synthesis of novel compounds and their isotopically labelled analogues, and testing in collaboration with Prof Max Cryle in Monash Biochemistry.



**Representative publications:** Hayne, Hooper, Henderson *Chem. Commun.*, **2023**, 9860; Mendoza, Garnier, Hooper *Macromolecules*, **2023**, 56, 3497; Ayuruni, Hooper, *JACS Au*, **2022**, 2, 169.

## Professor Cameron Jones

Room No. 1.10, Tel: 9902 0391, email: [cameron.jones@monash.edu](mailto:cameron.jones@monash.edu)

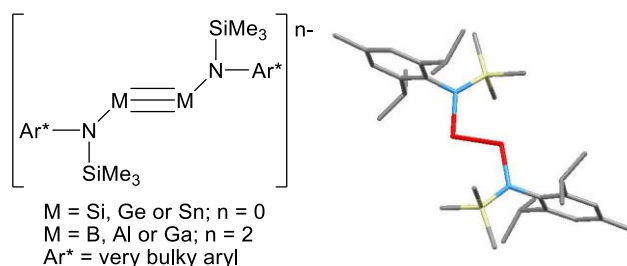
Group website: [www.monash.edu/science/research-groups/chemistry/jonesgroup](http://www.monash.edu/science/research-groups/chemistry/jonesgroup)

### Modern Main Group Chemistry

In the past 10 years remarkable progress has been made in the chemistry of very low oxidation state and low coordination number s- and p-block compounds. It is now possible to prepare and investigate the fascinating reactivity of compounds that were thought incapable of existence until a few years ago. The fundamental and applied aspects of this area are rapidly expanding in the Jones group (see group website for further details). Representative examples of the many potential Honours projects that are available within this exciting area are as follows:

#### (i) Low oxidation state Main Group systems: replacements for transition metal catalysts.

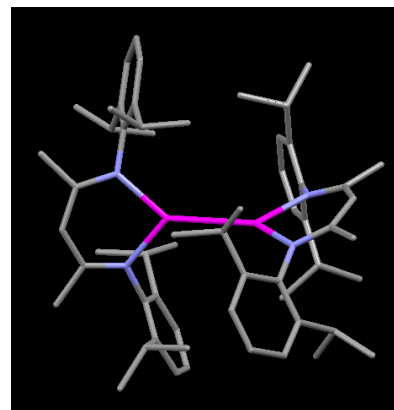
In recent years "trans-bent" compounds containing multiple bonds between two p-block metal(I) centres have been stabilised by ligation with extremely bulky alkyl or aryl substituents (R). These include the remarkable heavier group 14 analogues of alkynes, viz.  $RE\equiv ER$  (E = Si, Ge, Sn or Pb). In this project you will prepare examples of related bulky amido substituted "metalkynes" (see picture), and related compounds, and explore their use for the reversible reductive activation of  $H_2$ ,  $CO_2$ ,  $NH_3$ , ethylene etc. If this can be achieved, the exciting possibility exists to use such compounds as replacements for expensive and toxic transition metal catalysts in numerous industrial processes; and for the conversion of the Greenhouse gas,  $CO_2$ , to useful chemical products such as methanol.



see: (i) *J. Am. Chem. Soc.*, 2014, **136**, 5283; (ii) *J. Am. Chem. Soc.*, 2012, **134**, 6500; (iii) *J. Am. Chem. Soc.*, 2011, **133**, 10074; (iv) *Nature*, 2010, **463**, 171.

#### (ii) Stabilisation and application of complexes of Group 2 metals in the +1 oxidation state.

It has previously been only possible to prepare compounds containing the Group 2 metals (Be, Mg or Ca) with the metal in the +2 oxidation state. Recently, we have reversed this situation with the landmark preparation of the first thermally stable compounds to contain Mg-Mg bonds (e.g. see picture). The formal oxidation state of the magnesium centres in these compounds is, therefore, +1. As a result, these species are highly reducing, a situation which has lent them to use, in our laboratory, as specialist reagents in organic and organometallic synthetic methodologies. You will further explore this potential, in addition to examining the possibility of preparing the first dimeric calcium(I) compounds. Furthermore, you will examine the use of such systems as soluble models to study the reversible addition of dihydrogen to magnesium metal (yielding  $MgH_2$ ). This poorly understood process is of great importance for future hydrogen storage technologies which will be essential for viable zero emission vehicles powered by fuel cells. The activation of other gaseous small molecules (e.g.  $CO_2$ ,  $N_2$ ,  $NH_3$  etc.) will be investigated at high pressure (ca. 200 atm.) with the aid of high pressure sapphire NMR tube technology developed in the Ohlin group at Monash.



see (i) *Science*, 2007, **318**, 1754; (ii) *J. Am. Chem. Soc.*, 2015, **137**, 8944; (iii) *Chem. Sci.*, 2013, **4**, 4383; (iv) *Nature Chem.*, 2010, **2**, 865; (v) *J. Am. Chem. Soc.*, 2014, **136**, 5283;

## Dr Kamila Kochan

Room No. 1.10, Tel: 9905 1407, email: [kamila.kochan@monash.edu](mailto:kamila.kochan@monash.edu)

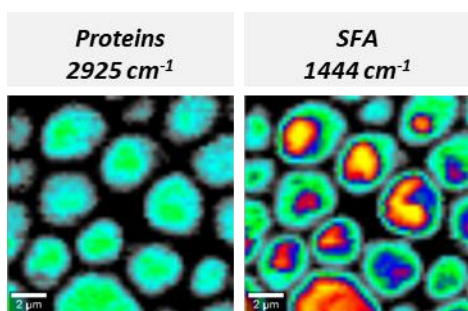
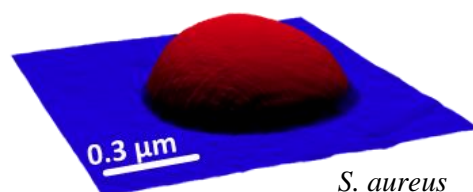
Group website: <https://www.monash.edu/science/cfb>

The following information will give you an idea of the type of research I am undertaking within my group. If you have any further queries, please do not hesitate to contact me (details above).

**Vibrational spectroscopy (IR, Raman, AFM-IR imaging):** My research uses novel, nanoscale vibrational spectroscopy techniques and focuses on their application towards biological materials (tissues, cells, bacteria, single virions, etc.), in the context of solving medical and clinical challenges. The techniques used in my group range from classic Infrared Spectroscopy (IR) in single spectrum and imaging modalities, through more advanced Raman imaging modalities, to novel, state-of-art techniques such as Atomic Force Microscopy Infrared Spectroscopy (AFM-IR). The spectroscopy is accompanied with the use of advanced, AI-driven chemometric data analysis.

Below you can find examples of biomedical and clinical projects that I am currently undertaking and accepting Honours students. Your specific Honours Project can be modified to suit your interest.

**Antimicrobial Resistance (AMR):** AMR is a critical global health issue. Over the past decade, we've witnessed rapid resistance development and global spread of resistant strains. Bleak predictions suggest AMR could become the leading cause of death by 2050. Excessive, inappropriate antibiotic use, in humans, animals, and agriculture, has fuelled this problem, resulting in an 'arms race' with pathogens. Understanding the molecular changes driving resistance - the 'chemistry behind resistance' - is vital for developing effective antimicrobials. However, there's a substantial research gap in accessing these changes in resistant bacteria, leading to knowledge gaps across multiple pathogens, e.g. in the context of resistance towards quinolones (e.g. ciprofloxacin), glycopeptide (e.g. vancomycin) and  $\beta$ -lactam antibiotics. In addition to the complexities surrounding our comprehension of the mechanisms behind AMR, another significant hurdle lies in the realm of its diagnostics. Current diagnostic tests for AMR often suffer from extended turnaround times, failing to provide results quickly enough to guide timely treatment decisions. Advanced vibrational spectroscopy, coupled with AI-driven analysis, opens new possibilities in tackling the AMR crisis. Micro- and nanoscale techniques like Raman and AFM-IR offer detailed insights into chemical composition changes and resistance mechanisms, while rapid, portable methods like ATR FTIR may serve as diagnostic alternatives



**Chronic Kidney Disease (CKD) and Diabetic Kidney Disease (DKD):** CKD and DKD pose significant health challenges, particularly due to the lack of rapid diagnostic tools and the limited means to detect novel biomarkers. CKD is a global health issue characterized by the gradual loss of kidney function, often progressing silently until reaching advanced stages. DKD, a common complication of diabetes, exacerbates CKD risks. The absence of quick diagnostic methods hampers early intervention and effective management, leading to a higher burden on healthcare

systems. Furthermore, as researchers continuously explore new biomarkers specific to CKD and DKD, there is a growing need for innovative tools to detect them efficiently. These novel biomarkers hold the potential to enhance early detection, risk stratification, and treatment monitoring. In this project, we aim to apply vibrational spectroscopy to address these challenges comprehensively. Our objectives include the development of rapid diagnostic tools for CKD and DKD, the creation of a biomarker detection tool, and shedding light on the pathogenesis and changes that occur during the progression of these diseases. This multifaceted approach holds the potential to transform the management and prognosis of CKD and DKD, ultimately improving patient outcomes and reducing healthcare c

## Professor Tanja Junkers

Room No. 220A, Building 23, Tel: 03 9905 4524, email: [tanja.junkers@monash.edu](mailto:tanja.junkers@monash.edu)

Group website: [www.polymatter.net](http://www.polymatter.net)

The **Polymer Reaction Design** group strives for the development of new materials via state-of-the-art polymer synthesis methods and the use of digital chemistry.

*Projects in our research group are always tailored towards the student, and a proposal is developed in consultation. The general possibilities are outlined below.*



### From traditional chemistry to digital synthetic chemistry

In our group we offer many different projects, ranging from traditional synthetic chemistry over polymer engineering to kinetic and mechanistic studies of polymerization. We are mainly interested in:

- ***Bridging synthetic and natural polymers***

We use methods of controlled polymerization to synthesise so called sequence-controlled oligomers. These oligomers resemble classical polymers in their backbone structure, but carry the same depth of information in sequence information as a peptide. The aim is to synthesise such oligomers and test them towards their efficiency in a biomedical context, e.g. as antimicrobial materials, or for cell scaffolds.

**Suitable for:** Students with strong interest in synthetic chemistry and advanced modern polymer chemistry

- ***Automation of polymerization***

Automation is the future of chemical synthesis, we strongly believe in this. To automate our processes, we use continuous flow chemistry methods combined with online monitoring. Robotics play a role here, too. With these high-throughput tools we can rapidly screen reactions with our benchtop NMR, HPLC, FTIR or DLS monitors. The aim is to optimize reactions, and to provide high quality materials for testing. In this way we can screen reactions in few days that conventionally would take months to carry out. This includes synthesis of bioderived and biodegradable polymers.

**Suitable for:** Students with strong interest in modern polymer chemistry and who like to play with technical setups, robotics and instrumentation. Some interest in programming is advantageous, but not strictly required

- ***Developing tools for digital synthetic chemistry***

After automation comes data processing. Based on data acquisition, data mining, and cloud collaboration with other laboratories, we want to transform chemistry into a domain that produces 'big data'. We work with data scientists to use machine learning on every possible level in the synthesis process. A central part in these activities is building databases and using existing ones. This isn't computational chemistry. It directly links to the lab. Think of a reactor that has access to all previous data via the internet from other laboratories, and that then can independently optimise the reaction you want to carry out by itself. This is where we want to get to.

**Suitable for:** Students with strong interest to combine data science with synthetic chemistry. Basic knowledge of how to use Python is required



## Professor David W. Lupton

Catalysis and Synthesis

Room No. 238 Bld. 23 South; Tel: 9902 0327, email: [david.lupton@monash.edu](mailto:david.lupton@monash.edu)



website



@LuptonChemistry

Our group is interesting in the science of:

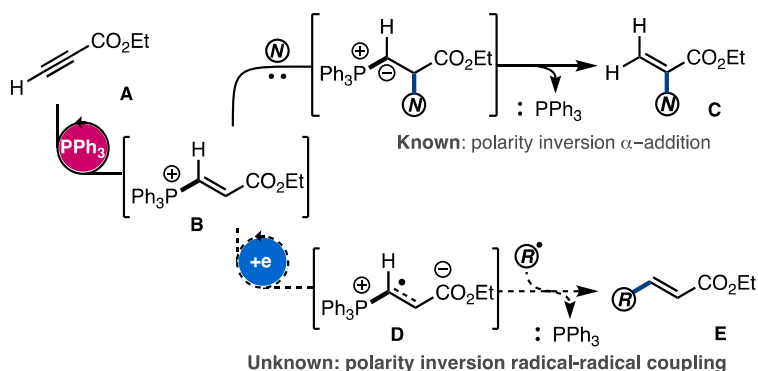
- **The Discovery of New Chemical Reactions** (see Project A)
- **The Development of New Synthetic Strategies** (see Project B) and
- **The Synthesis of Complex Molecules designed for Function** (see Project C)

For more details about our projects arrange a chat with David, or view our website

<http://users.monash.edu.au/~dwlupton/index.html>

### Project A: Can polarity changes allow radical reactions?

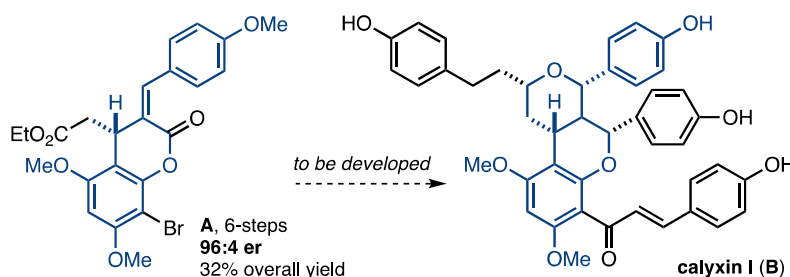
Organocatalysis with alkynes (A) and triphenyl phosphine gives the polarity inverted species B which can couple



with nucleophiles to give product **C**. Recently we commenced studies examining the single electron reduction of **B** to give **D**. These studies have enabled a novel radical addition to give **E**. *Studies in this project are focused on learning just how general this new reactivity pattern is.*

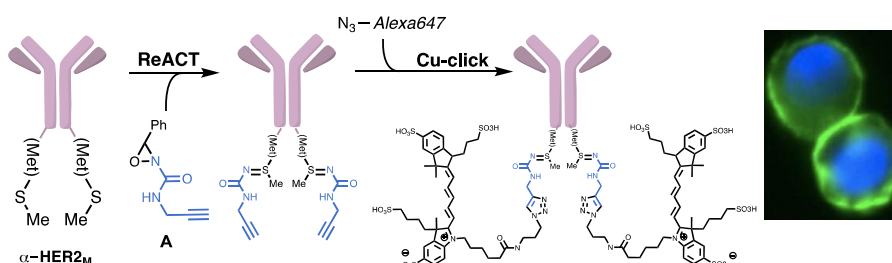
### Project B: Enantioselective synthesis to calyxin I

Earlier studies in our group have developed a simple route to lactone **A**. In this project we will develop a synthetic strategy to convert this material through to calyxin I (**B**). This molecule has undeveloped bioactivity and is yet to be made by chemical synthesis.



### Project C: Bioconjugation at methionine

Chemical probes that allow bioconjugation are useful in chemical biology. Recently we prepared the methionine labelling **A** and developed an antibody tagged



fluorophore selective for cancer cells. *Studies this year are focused on developing a new generation of such probes that are easier to make, more robust and more flexible.*

The following information will give you some ideas about the types of research I am undertaking with my research partners. If you have any further queries, please do not hesitate to contact me.

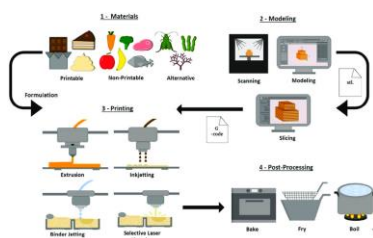
### Food Science, Process, Chemistry



#### Food 3D Printing



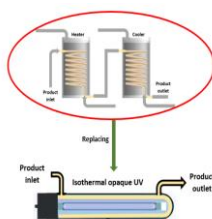
The personalising food request is growing dramatically. It has stimulated a period of innovation and investigation by developing techniques to customise functional foods' texture, flavour and nutritional contents. In this situation, three-dimensional (3D) printing technology is developing quickly to create complex edible shapes, simultaneously enabling alteration of food texture and nutritional content required by specific diets and covering wide nutrition requests.



### UV Applications in Food and Beverage

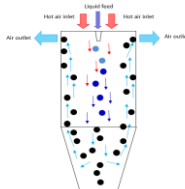
UV technology has been successfully used in various food and beverage industries to treat incoming water, syrups, clean-in-place water, filter systems, wastewater, and surface packaging. However, the direct application in beverages, juices, and milk is still under research.

In this project, we will apply Ultra-fast isothermal pasteurisation of opaque beverages using microcapillary membranes irradiated with UV light to replace the heating process for juices.



### Spray Drying Process

The spray Drying technique is one of the best pharmaceutical and food product drying processes, preferred methods for the production of powders from aqueous (and/or organic-aqueous) solutions or

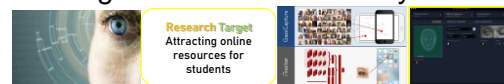


### Educational Research



#### Eyes-Tracker Device and using Gaze-Capture by Eye Movements on Developing Virtual Education

This research aims to show how eye-tracking technology can be employed to develop online teaching resources and enhance classroom engagement skills by collecting data from wearable eye-tracker.



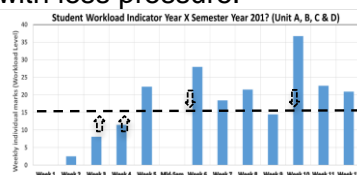
The target is focused on investigating text density through slides by aiming to look at included spacing, text size, and use of images by designing the platform in advance.

#### "Give me a pause, please!" Student Weekly Workload Evaluation



Assessment tasks contribute to students' workload. Many students report that they are overloaded. Some students report that they cannot finish all assessments on time, especially in particular weeks across the semester.

- Has the workload balanced across the semester?
- Can we predict student workload?
- Can we help students to have less overload?
- Can we have a better understanding of the assignments due?
- Providing better assignment timelines will engage students to perform better with less pressure.



## Professor Philip Marriott

Room No. G04 Bldg 23, Tel: 99059630, email: [Philip.Marriott@monash.edu](mailto:Philip.Marriott@monash.edu)

**General area of project interests.** We specialise in Separation Science / Chromatography / Mass Spectrometry (MS) & method development in GC, multidimensional GC (GC×GC, MDGC). We study ultrahigh resolution separations, unusual processes, and chromatography analysis of complex samples **such as pesticides, pollutants, flavours/fragrances, essential oils, foods/fatty acids/triglycerides**. We have a range of GC and MS systems, QQQMS, QTOFMS, GC–MS/FTIR, and portable GC–MS. Our MDGC research is world's-best-practice.

See <http://www.monash.edu/science/schools/chemistry/our-people/staff/marriott>

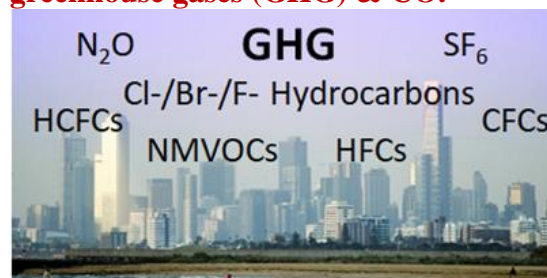
### Example Project Areas

#### [A] Target & Untargeted MS/MS methods for food fraud and allergens.



MS/MS provides both target and untargeted analysis of components depending on the implementation procedure; <sup>3</sup>MS can be a qMS or TOFMS system. We have developed methods for components in pharmaceuticals and foods, e.g. detection of Viagra in nutrient tonics, and allergens. Food fraud has been of concern for more than a century. We will investigate MS/MS methods, focusing on emerging problems in food production.

#### [B] Selective technologies for monitoring greenhouse gases (GHG) & CO.



Projects on GHG and CO monitoring will be offered. With CSIRO Oceans and Atmosphere we will develop new approaches to quantify GHG analysis. Pulsed discharge He ionisation PDHID allows excellent halogen selectivity, so will be applied here. For trace CO, a major problem is isobaric N<sub>2</sub> interference. Using MDGC we aim to introduce a new International protocol to monitor trace CO from the large N<sub>2</sub> background signal.

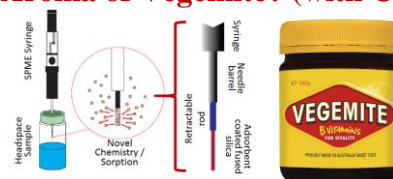
#### [C] Rapid screening tool for trace-level environmental analysis. (with CSIRO)



- Rapid sampling procedures;
- Maximum throughput – minimum sample handling;
- New high-resolution mass spectrometry analysis.

>> Here, we will use very high resolution mass spectrometry and minimised analysis times using a new concept in sample separation. This will be contrasted with classical analytical approaches with, for example, MS/MS and GC×GC procedures. This will suit a keen interest in mass- and separation-based chemical specificity, and an understanding of the potential suppression of electrospray analysis based on our recent reviews on “Expectation beyond Design”.

#### [D] Love it or Loathe it – What Produces the Aroma of Vegemite? (with CSIRO)



- New Sampling Procedure;
  - New Analytical Separations;
  - New Chemical Identification
- >> The project will develop a new approach to the selective extraction and concentration of volatile S compounds in the headspace. It will apply our innovative high-resolution separation domain trace profiling comprehensive two-dimensional gas chromatography – mass spectrometry technique to extracted VOC. It will compare the above analytical identification tool with the super-high resolution mass spectrometry domain GC-orbitrap technique. Sensory analysis for the interpretation of the individual compounds will be conducted.

## Assoc. Professor Lisa Martin

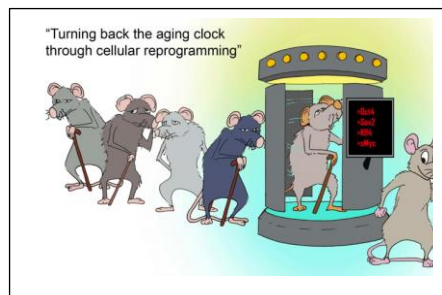
Room No. 157 / 17 Rainforest Walk, P: 9905 4514, email: [Lisa.Martin@monash.edu](mailto:Lisa.Martin@monash.edu)

This page will give you an idea of some of the research projects in my group, so if you are interested or want more details, email me and we can arrange a time to discuss these project areas.

**Bioinspired Chemistry:** Many of the global challenges facing us are in biomedical science; however, these problems need an understanding and knowledge of basic molecular and electronic properties. The Martin group draws on these tools for projects in medicine, biology and materials. Some projects are ...

### 1. Redox balance and aging (with Dr Sasha Simonov)

Oxygen is essential to life and is highly regulated in the body to subcellular levels. As we age, these mechanisms appear to be less able to control the leakage of reactive oxygen species (ROS) and these increasingly accelerate cellular damage. This project uses mitochondrial samples obtained from porcine placenta at defined timelines after piglets are born, to explore the redox state of mitochondria. This will be done using Fourier Transform ac voltammetry and involves both experimental and simulation methods. Mitochondria will be provided from collaborators and can be stored. The outcomes of this work include predictive strategies to provide data on the aging process and approaches to reduce the effects of mitochondrial decay.

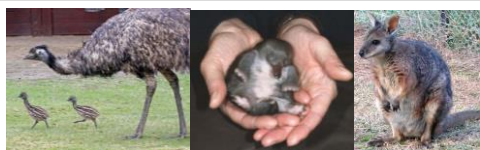


### 2. Synthesis of new semi-conductors by solid-solid redox reactions (with Alan Bond)

Novel semiconductors can be prepared from combinations of redox cations and anions with accessible redox states, e.g. tetrathiafulvalene (TTF) and 7,7,8,8-tetracyanoquinodimethane (TCNQ). Using electrosynthesis to make these materials using metal and non-metal cations, eg we have prepared the first amino acid TCNQ biomaterial, a sophisticated 3-D H-bonding structure and a semi-conductor. This project offers the chance to explore other novel cations with TCNQ using solid-solid transformation. This project offers enormous scope to develop skills in electroanalysis, microscopy and X-ray crystallography.

### 3. The evolution of steroid hormones (with Dr Paul O'Leary)

Steroid hormones are essential for the regulation of water and salt (mineralocorticoids), metabolism (glucocorticoids) and reproduction (androgens and oestrogens). The evolution of steroid hormones offers some fascinating stories, yet to be told. We have several projects involving unique Australian species. The enzyme **aromatase** synthesises *oestrogen*, responsible for female characteristics, thus evolution of all species. Aromatase is the last enzyme to have evolve in the steroid synthesis pathway. In mammals, all but one species has *one gene* hence *one aromatase enzyme*, but did the ancestors of mammals also have only one enzyme? By studying aromatase across species we can examine how the environment influenced the evolution of aromatase.

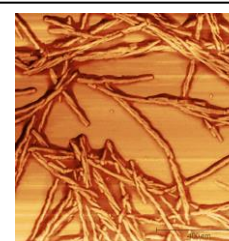


Some Aussie species; Emu, Platypus, Wallaby

Honours projects will include aspects of the steroid analysis, modelling of enzyme structure. These species are selected to transition from reptiles (including birds), to egg laying mammals (monotremes) to pouched (marsupials) and extrapolated to higher mammals such as humans.

### 4. Is Alzheimers Disease linked to an aberrant antimicrobial peptide ?

A number of neurological diseases are linked to protein/peptide aggregation eg Alzheimer's Disease (AD). We are studying *Uperin* which is an antimicrobial peptide from a small frog and which aggregates to form amyloid, similar to AD. This project aims to provide the fundamental molecular knowledge needed to regulate and control peptide aggregation. Also, with **Prof. Alan Chaffee** we are looking at using carbon quantum dots (CQD) that prevent amyloid formation. This collaboration provides new opportunities for recycling brown coal for medicinal chemistry applications!



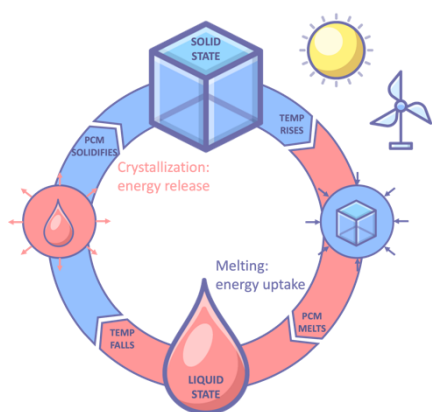
*Uperin*: antimicrobial - aggregating peptide.

## Dr Karolina Matuszek

Room No. 331, Bld 86 13 Rainforest Walk, Tel: 9902 4619, email: [karolina.matuszek@monash.edu](mailto:karolina.matuszek@monash.edu)

My research interests revolve around materials discovery and design for various energy storage applications. My primary objective is to develop a cost-effective technology capable of storing large quantities of renewable energy reliably and durably. If you are interested in materials design and physical chemistry - I am offering Honours projects in three different areas:

### The Carnot Battery – the Future of Renewables (with Prof. D. MacFarlane or A/Prof. R. Tabor)

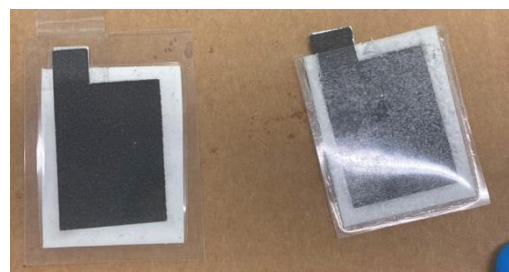


Intermittency of renewable energy sources can be overcome with efficient energy storage technologies, where thermal energy storage (TES) is one of the options. TES can be achieved in many ways, such as using phase change materials (PCMs). PCMs are classified as materials in which heat is absorbed when the material undergoes a phase transition, usually melting, and the heat can be released upon crystallization or solidification. The amount of energy needed to melt the material, the heat of fusion ( $\Delta H_f$ ), is one of the primary properties of PCMs, while its melting point determines the application temperature range (have a look at my recent paper in [Chem.Rev 2023](#) for more detail). If you chose this project, you will be working on the design and synthesis of new intermediate temperature range PCMs ( $T_m$ : 100-220 °C) that can be applied in the Carnot Battery technology. This “battery” allows storage of electricity in

the form of heat and then regeneration of the electricity. This project includes also study of the materials using differential scanning calorimetry (DSC), single crystal X-Ray and/or XRD (potentially synchrotron, Monash X-Ray platform and ANSTO), Raman, IR etc. [RSC Sus. 2023](#), [Mat. Adv. 2023](#).

### Aluminium batteries for global energy storage solutions (with Dr. B. Roy)

Around 15 million Li-ion batteries are required to transition the global transport sector to renewable energy. Simultaneously, approximately 60 million batteries are needed for electricity generation and grid storage via renewable sources. However, there are insufficient resources to meet this demand for lithium batteries. On the other hand, aluminium, which is significantly cheaper (2.8 AU\$/kg) compared to lithium (~40 AU\$/kg) and more abundant, presents an interesting and worthwhile alternative to consider. Currently, aluminium battery technology is in its infancy but is growing rapidly. This project aims to develop a feasible proof-of-concept Al-ion battery pack, which can demonstrate its grid storage application. Our work in this space includes the design and characterisation of new electrolytes including ionic liquids, liquid coordination complexes, deep eutectic solvents etc.



### Green materials for CO<sub>2</sub> capture (with Dr. M. Alivand from Chem. End. Dep.)

CO<sub>2</sub> capture technology, along with renewable energy storage, can play a vital role in the sustainable global energy economy. The existing technology that utilizes alkanolamines is highly energy-consuming and costly. Current research is focused on the development of new absorbents with high CO<sub>2</sub> absorption capacity that do not require high temperatures for regeneration. In collaboration with Dr. M. Alivand, we aim to design and develop new materials, such as ionic liquids, eutectics and deep eutectic solvents. This project will involve materials synthesis, characterization, and CO<sub>2</sub> capture measurements.

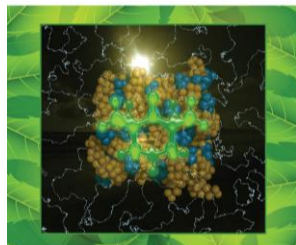
## Professor Katya Pas

Room No. 126, Bld 86 13 Rainforest Walk, Tel: 9905 8639, email: [katya.pas@monash.edu](mailto:katya.pas@monash.edu)

This document will give you an idea of the type of research we are undertaking within my group, Monash Research Computational Chemistry Group. In our research, we apply computational chemistry methods to a range of chemical problems. If you have any further queries, please do not hesitate to contact me (details above). More information on my research & other potential projects can be seen at: <https://mccg.erc.monash.edu/>



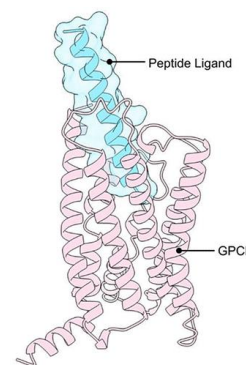
### Projects on Organic redox flow batteries (with Prof. K. Oyaizu (Waseda) and Prof. M. Yoshizawa-Fujita (Sophia), Japan)



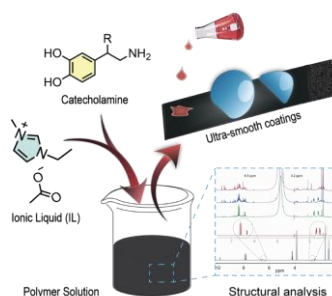
Recently we have discovered significantly increased stability of nitroxide radicals in select ionic liquids, allowing us to control their redox chemistry. Through a careful tailoring of ionic liquids to each nitroxide radical we have managed to successfully test a radical redox flow battery that can now compete with Li-ion batteries. In this project, the student will design ionic liquids based on nitroxide radicals and predict their redox potentials.

### Projects on Binding Affinity (with Prof. Ralf Hoffmann, Leipzig University)

G-protein coupled receptors (GPCRs) represent a very diverse group of receptors responsible for an array of common disorders from anxiety to diabetes. Due to the multitude of GPCRs, the development of highly potent drugs for a specific receptor is challenging. Coupled with the average cost associated with bringing a successful drug to the market, the recent trend in the drug design area is to repurpose the already approved drugs for other disorders. Since the drugs were already deemed as safe for human consumption, repurposing leads to significant cost savings. Prof. Hoffmann in Leipzig has developed a series of proline-rich peptides consisting of a dozen of amino acids that are effective against Gram-negative bacteria. Using the available crystal structures of GPCRs we will use the recently developed GPU-based code called EXESS to predict interaction strength of such peptides to GPCRs.



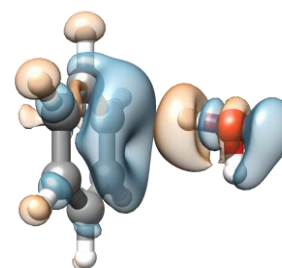
### Experimental and Theoretical Projects on studying properties of polydopamine and analogous polymers (with Prof. Benny Freeman, University of Texas at Austin)



Polydopamine is one of the most intriguing polymers known to man. Its structure had been unknown for decades until our group discovered a designer solvent that can easily solvate pDA that is not otherwise soluble in any known medium. Mussels use a similar polymer to adhere to rocks. Recently we managed to polymerise monomers of the catecholamine family (dopamine, L-DOPA, adrenaline) to create ultrasmooth and ultrathin coatings that ensure their robustness against harsh conditions. The student will study electrochemical and/or antibacterial properties of co-polymers of catecholamines using experimental and/or theoretical techniques.

### Machine Learning Projects (with Prof. Michelle Coote, Flinders University)

There are several projects on offer in one of the fastest growing fields, Machine Learning (ML). In our group we develop new quantum chemical descriptors to predict intermolecular interactions in biochemical systems and biomacromolecules. We have also been successful in using ML to improve the performance of Density Functional Theory (DFT) for the prediction of reaction kinetics and thermodynamics. We are interested in developing accurate and cost-effective DFT functionals that can be fine-tuned on the fly depending on the nature of a chemical reaction. We are also interested in applying our current ML models to study many-body effects in biochemical systems and condensed systems.

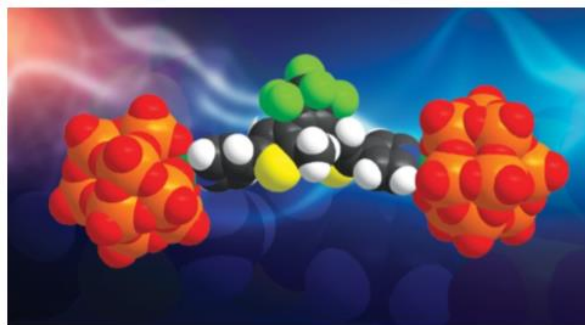


## Dr Chris Ritchie

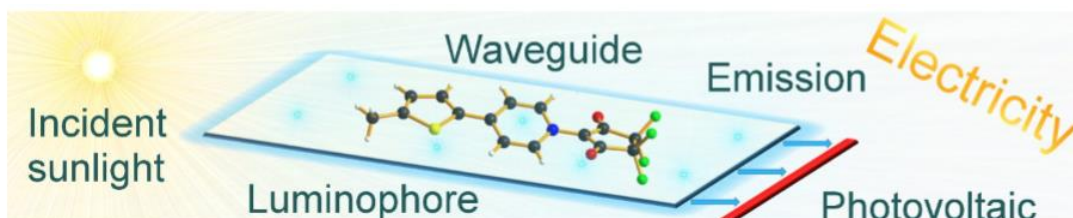
Room 253, Building 23S, I2, Tel: 990 29916, email: [Chris.Ritchie@monash.edu](mailto:Chris.Ritchie@monash.edu)

### Project 1 - Molecular Componentry for Photochromic, Photocatalytic and Electrochromic Materials

The design and synthesis of novel organically functionalised molecular metal oxides will be the core component of this project. In unpublished work, we have revealed that the combination of polyoxometalates and diarylethenes using coordination chemistry results in molecular assemblies with significantly altered photochemical properties. A suitable candidate will have an interest in both inorganic and organic synthetic chemistry (benchtop and inert atmosphere), photochemistry and materials science. This project will involve collaborations with colleagues in Germany and Australia.



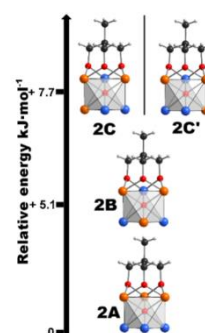
### Project 2 – Highly Fluorescent Pyridinium Betaines for Luminescent Solar Concentrators and Sensors



Recently, we discovered that a selection of pyridinium betaines that display near unity photoluminescent quantum yields and significant emission Stokes shifts. These properties in combination with their thermal stability and minimal aggregation induced luminescence quenching make them suitable candidates for utility in Luminescent Solar Concentrators. Expansion of the compound library has resulted in our identification of structural modifications that result in the activation of sensing capabilities. A suitable candidate will prefer organic synthesis, materials chemistry and the potential for interactions with industry partners. See (J. Xu, B. Zhang, M. Jansen, L. Goerigk, W. W. H. Wong, C. Ritchie, *Angew. Chem. Int. Ed.* 2017, 56, 13882 ) for more details.

### Project 3 – Microwave-assisted Synthesis of Heteropolyoxometallates and Nanoparticle Self-assembly

Over the course of the last four years we have developed microwave-assisted methodologies for the preparation of heteropolyoxometallates. Throughout this study we noted that the substitution patterns of the metal ions within molybdovanadates could be rationalized. We have since expanded upon this fundamental synthetic study to include the preparation of atom transfer radical polymerisation macroinitiators from which we can assemble pH responsive nanoparticles. A suitable candidate will have an interest in inorganic and organic synthetic chemistry, spectroscopy and materials science. See (S. Spillane, R. Sharma, A. Zavras, R. Mulder, C. A. Ohlin, L. Goerigk, R. A. J. O'Hair, C. Ritchie, *Angew. Chem. Int. Ed.* 2017, 56, 8568) for further details.



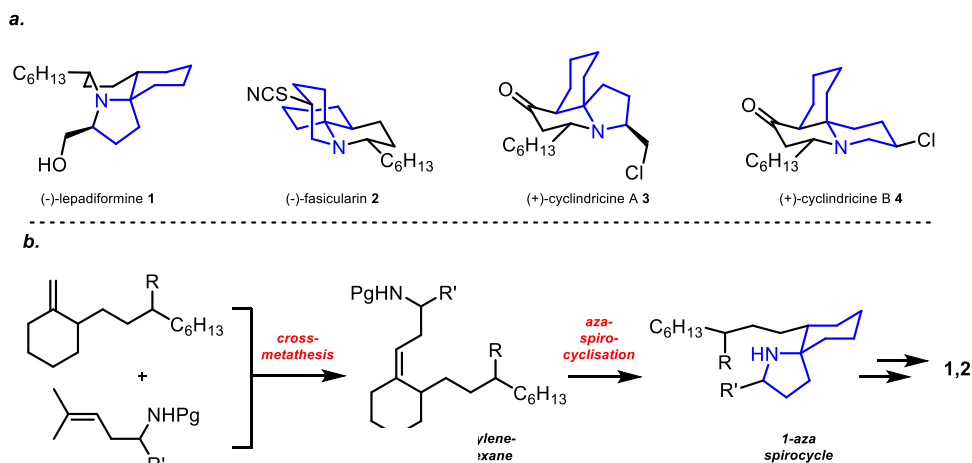
## Professor Andrea Robinson

Room No. 114C, Tel: 9905 4553, email: [andrea.robinson@monash.edu](mailto:andrea.robinson@monash.edu), <http://andrearobinsongroup.com>

This document will give you an idea of the type of research we are undertaking within my group. If you have any further queries, please do not hesitate to contact me (details above).

### Catalysis

Our group has a long standing interest in catalysis, particularly when it is applied to asymmetric synthesis, natural products and peptidomimetics. We are currently interested in the synthesis of new ligands and catalysts, developing efficient tandem catalytic processes for organic transformations and industrial feedstocks, solid supported catalysts and the application of catalysis to bioactive targets and natural products. The development of new catalysts to perform catalysis in water are of particular interest. Recent targets are shown below (a) with associated synthetic strategy (b).



### Cyclic peptides

Nature uses cyclisation to protect peptide backbones from proteolytic cleavage. Unstable cystine bridges can be replaced with non-proteinaceous dicarba linkages. Using tandem catalytic sequences and specially designed non-proteinaceous amino acids, we have developed a way to control the formation of multiple dicarba-bridges. We have several projects examining the preparation of carbocyclic derivatives of naturally occurring cystine containing molecules, including biologically active peptide neurotoxins, cyclotides and somatostatin derivatives. Additionally we have an interest in the design of new peptides for use in radiopharmaceutical applications. Structural characterisation of new peptidomimetics is performed in collaboration with research teams across Australia.

### Insulin superfamily

One important class of disulfide containing peptides is the insulin super family, which includes, insulin, relaxin and a number of insulin-like growth factors (IGFs). These peptides are involved in important biological functions such as glucose metabolism and parturition where several disulfide bonds are formed but whose specific function in the resultant biological function remains unknown. Recently we have made significant progress in understanding insulin's mode of action at its receptor but there is still a lot to uncover! This is important for the design of non-peptidic analogues for the treatment of diabetes.

### Analgesic conotoxins

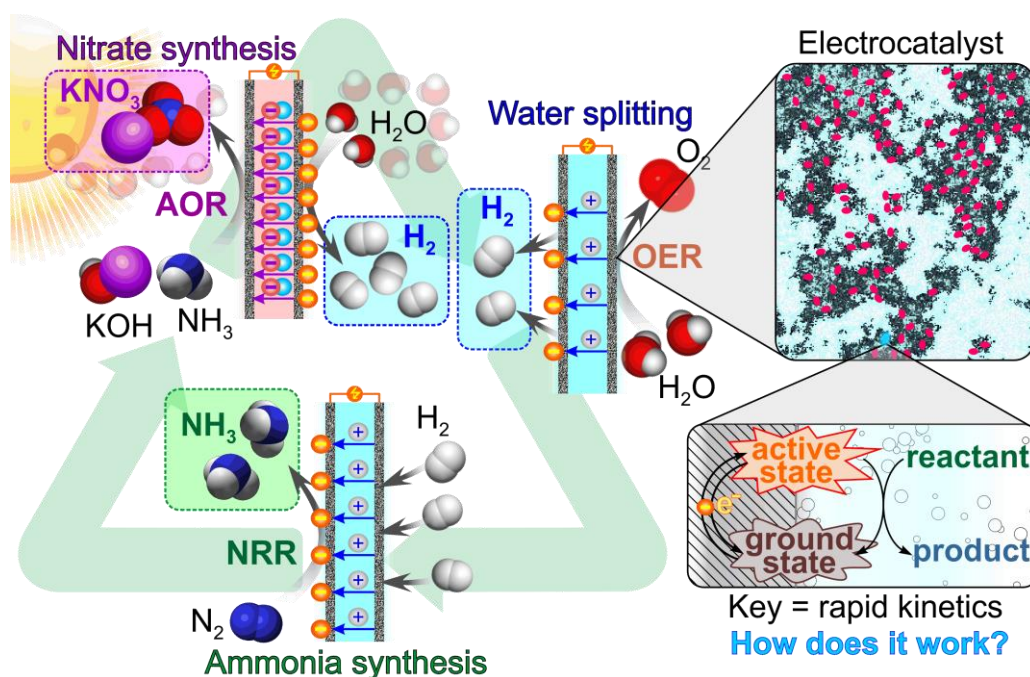
We are also examining the preparation of carbocyclic derivatives of marine derived conotoxin molecules. These natural products exhibit potent analgesic activity yet their mode of action is currently unknown. Projects in the area aim to identify potent and selective analogues for the treatment of chronic pain and uncover their mode of action.

## Associate Professor Alexandr (Sasha) N. Simonov

*Solar fuels and chemicals*

Room 329, Green Chemical Futures Building (Rainforest Walk 13), e-mail: [alexandr.simonov@monash.edu](mailto:alexandr.simonov@monash.edu)

We discover and design new materials and devices that harvest and convert renewable energy into green chemicals and fuels, and investigate their mechanisms of operation using a broad arsenal of cutting-edge techniques. Our perfectly equipped laboratories are located in Green Chemical Futures building. Our researchers and students have access to the state-of-the-art infrastructure and specialised equipment for the fabrication and characterisation of materials, including Monash X-ray platform, Monash Centre for Electron Microscopy, Melbourne Centre for Nanofabrication, Australian Synchrotron and Australian Centre for Neutron Scattering. We actively engage with the Australian and German energy companies, and broadly collaborate with other academic groups globally. In 2021, we have established a **spin-out company Jupiter Ionics Pty Ltd.** to commercialise the green ammonia synthesis technology developed in our laboratory.



Honour projects available in the group will suit candidates interested in physical chemistry, materials science and renewable energy technologies – fields that underpin the new Australian energy and sustainable fabrication sectors. At the heart of the technologies we develop are the renewable-powered electrochemical reactions that enable sustainable production of energy carriers and important commodity chemicals, like hydrogen, ammonia and fertilisers. Over the past decade, we have been highly successful in the design of such electrosynthesis processes and in understanding how they operate. Honours projects will focus on the development and detailed investigation of new types of catalysts, electrodes and/or devices for the processes of applied significance, and will aim to establish the key parameters determining their performance and stable operation.

**Literature:** [Nature 2022](#); [Science 2021](#); [Joule 2020](#); [Advanced Materials 2020](#); [Nature Catalysis 2019](#).

## Assoc. Prof. Rico Tabor

Room No. G24b, Tel: 9905 4558, email: [rico.tabor@monash.edu](mailto:rico.tabor@monash.edu)

This document will give you an idea of the type of research we are undertaking within my group. If you have any further queries, please do not hesitate to contact me (details above).

More information on my research and recent publications can be seen at: [www.ricotabor.com](http://www.ricotabor.com)

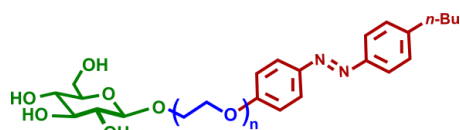
### The chemistry of sustainable, functional colloids, surfactants, and nanomaterials

We are researching a range of topics in fundamental and applied colloid chemistry, including:

- New surfactants and emulsifiers for use in agriculture, formulation and personal care.
- Responsive colloids and nanomaterials that change their properties due to an internal or external stimulus such as pH, light or magnetic/electric fields.
- Nanomaterial design for functional colloidal systems – controlled surface chemistry, sensing substrates, capsules, liquid crystals, *etc.*

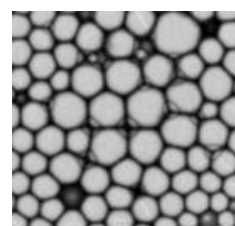
*Some examples of possible projects are provided below. Projects can involve synthesis, analysis, visits to large-scale facilities, e.g. the Australian Synchrotron and OPAL reactor, Lucas Heights, NSW. Much of our research involves working with industry partners.*

**Metal-capturing surfactants and emulsions (with Prof. Kellie Tuck)** – The interaction between metals and surfactants is crucial to solvent extraction (one of the main processes used to capture valuable metals from ores), but also emerging fields of environmental remediation and ion flotation. Using sustainable resources, your project will design and make new surfactants capable of gathering metal ions for recycling electronic waste.



**Controlling liquids with light** – Controlling liquid interfaces is central in designing tailored emulsions, foams and coating systems for fluid handling in printing, diagnostics and nanotechnology. Using a range of recently synthesised light-sensitive surfactants (and potentially new molecules that you design and synthesise), you will create new droplet and bubble systems that can be manipulated using light.

**Encapsulating actives for beauty (with Varden Process Pty Ltd)** – Capsules on the micron scale offer a unique way to protect and transport chemicals. By filling these tiny environments with actives for skincare + beauty, more effective formulations with greater shelf life and lower waste can be developed. Develop the next generation of formulations with truly biodegradable capsules that produce zero microplastics.



**Better barriers for compostable packaging (with Varden Process Pty Ltd)** – Single-use plastic is a cancer on modern society, choking the oceans and turning unsustainable fossil fuel into toxic waste. Current compostable alternatives are designed to sneak past regulations rather than authentically biodegrading at the end of their life. Help to produce the next generation of *truly* compostable packaging that protects products, leaves no toxic traces, and permanently removes single-use plastic from our trolleys.

**Design your own project!** If you have an interest in colloids, nanomaterials or physical forces, then talk to us about what you'd like to study. From biodegradable detergents to the best way to formulate sunscreen, we research all things soft, squishy and self-assembling.

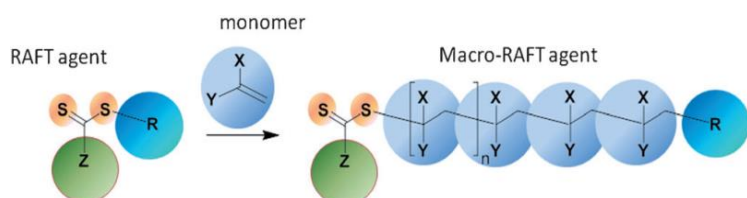
## Professor San Thang AC

Room No. 252, 17 Rainforest Walk, Building 23, Tel: 9905 1351 email: [san.thang@monash.edu](mailto:san.thang@monash.edu)

More information can be obtained by contacting me (details above) or through my web page <http://monash.edu/science/about/schools/chemistry/staff/thang/>

Our group's research interests is to advance the **Reversible Addition-Fragmentation Chain Transfer (RAFT)** polymerization, a process discovered in 1998 by *Moad, Rizzardo and Thang*. The RAFT process has the potential to become the method *par excellence* with its versatility, effectiveness and industrial friendliness for the production of a wide range of specialty polymers of well-defined architectures.

### Reversible Addition-Fragmentation Chain Transfer (RAFT) Process

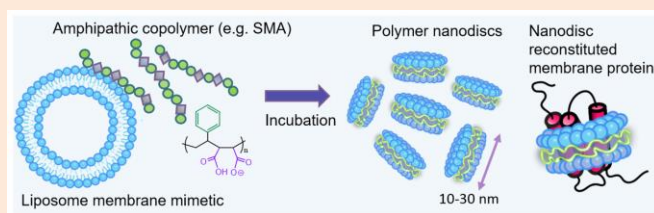


*Macromolecules*, **1998**, 31, 5559-5562. *Aust. J. Chem.*, **2005**, 58, 379-410. *Aust. J. Chem.*, **2006**, 59, 669-692. *Aust. J. Chem.*, **2009**, 62, 1402-1472. *Aust. J. Chem.*, **2012**, 65, 985-1076.

We offer the following projects to students to undertake in our laboratories.

### Fluorescent polymer nanodiscs: synthesis, characterisation and its membrane proteins extraction efficiency

(Joint project supervision with A/Prof Lisa Martin)

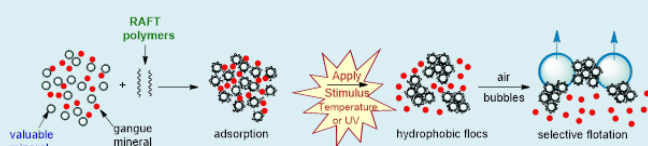


Membrane proteins (MPs) reside within the protective layers encasing and compartmentalising biological cells, otherwise known as phospholipid bilayers. Although MPs are critical to biological processes making them predominant targets for drugs, their structures are underrepresented in the protein database due to inherent difficulties involved in their biophysical characterisation while at the same time retaining their structural integrity. This project will involve the synthesis of fluorescent polymer nanodisc materials by RAFT to harness membrane proteins, and using fluorescence to assess fundamental physical polymer nanodisc properties and functional MPs extraction efficiency.

Ref: *Chemistry – A European Journal* **2021**, 27, 12922-12939

### Smart RAFT polymers design and synthesis for beneficiation of minerals

(Supported by the ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals)

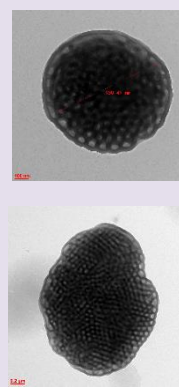
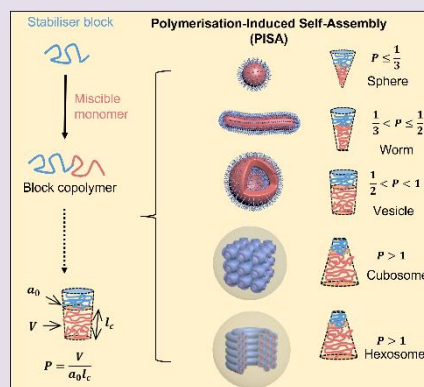


To address the increasing complexity of mineralogy, new reagents for minerals processing are highly sought after, hence the need to develop materials (small molecules and RAFT polymers) for improving its selectivity and functionality with some additional new tricks would be desirable. We welcome a highly motivated research student to join our group to undertake this ARC CoE project on the design and synthesis of smart materials by RAFT for improving selectivity, specificity and stimuli-responsive properties so that valuable minerals (e.g., Cu, Au, Pt, rare earth elements) can be efficiently recovered and gangue minerals can be easily dewatered and removed.

### Polymer Cubosomes and Hexasomes – A New Generation of Triggered Degradable Mesoporous Colloidal Particles

Our recent published work on the RAFT polymerisation-induced self-assembly (RAFT PISA) system has led to the realisation of a new generation of triggered degradable mesoporous colloidal particles (polymer cubosomes and/or hexasomes) with great potentials as smart templating scaffold, platform delivery vehicles for drugs and proteins. This is an exceptional research opportunity to be part of our team to further develop this fascination work on the aspects of its synthesis, optimisation and mechanism study.

Ref: *ACS Nano* **2021**, 15, 4688-4698; *Chem. Sci.*, **2022**, 13, 4192-4224



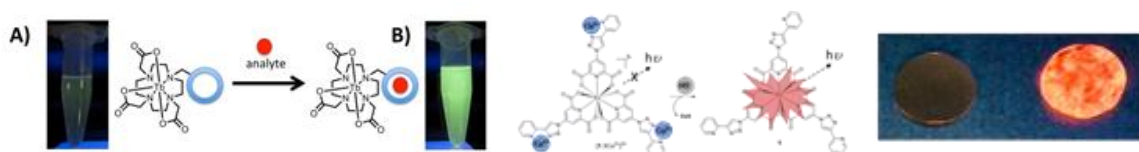
This document will give you an idea of the type of research we are undertaking within my group. If you have any further queries, please do not hesitate to contact me (details above).

For more information on my research see: <https://research.monash.edu/en/persons/kellie-tuck>

## MOLECULAR SENSING TECHNOLOGIES

### Luminescence-based systems for environmental monitoring and toxic chemicals

Chemosensors are molecules that produce a measurable response on binding or sensing the analyte of interest (Fig. 1). We are currently interested in their use for the detection of environmental pollutants and toxic chemicals. We have a number of projects in this area.



**Figure 1.** Example of the luminescent output of a chemosensor in the A) absence of analyte. B) presence of analyte. C) Lanthanide-based sensor for the detection of hydrogen sulfide.

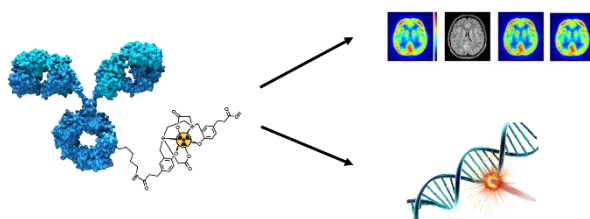
Project collaborations with A/Prof. David Turner (Monash Chem.), Dr Victor Cadarso (Monash Eng.), Prof. Mike Ward (UWarwick), Prof. Bert Kersting (ULeipzig), DSTG.

Recent publication: Mini, P., Springer, M. A., Grace, M. R., Dennison, G. H. & Tuck, K. L., *Chemical Communications*, **2020**, 56, 5605.

### Theranostic nanomedicine (project with Dr Maggie Aulsebrook (Monash Biomedical Imaging))

Theranostic agents enable the diagnosis of a disease with a radiolabeled drug, and subsequent treatment with another radiolabeled drug, both within the same molecule. They are commonly used for the treatment of cancers. This project will involve the synthesis and design of ligands for the radionuclide, binding studies with the non-radioactive isotope, and if time permits radiolabeling experiments at MBI.

Recent publication: Kubeil, M., Martínez, I. I. S., Bachmann, M., Kopka, K., Tuck, K. L. & Stephan, H., *Pharmaceuticals*, **2022**, 15, 27.



**Figure 2.** Example of a radiolabeled agent, that has the potential to be used for imaging and treatment.

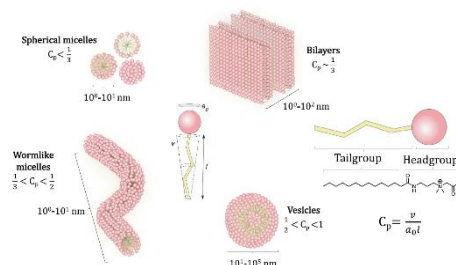
## NOVEL SURFACTANTS

### The synthesis and analysis of surfactants from renewable plant-based feedstocks (project with A/Prof. Rico Tabor (Monash Chem.))

Surfactants are amphiphilic molecules that have commonplace in personal care, formulation and agriculture. Understanding their various micellar geometries is key to their controlling their self-assembly properties (Fig. 3). Many surfactants are derived from petroleum-based feedstocks, we are investigating the use of plant-based feedstocks as they are a sustainable and renewable resource. This project is a collaborative project between the Tabor and Tuck group.

Recent publications: Butler, C. S. G., Giles, L. W., Sokolova, A.

De Campo, L., Tabor, R. F. & Tuck, K. L., *Langmuir*, **2022**, 38, 7522, Kelleppan, V. T., King, J. P., Butler, C. S. G., Williams, A. P., Tuck, K. L. & Tabor, R. F., *Advances in Colloid and Interface Science*, **2021**, 297, 102528.



**Figure 3.** Diagram showing the various micellar geometries of surfactants.

This document will give you an idea of the type of research we are undertaking within my group. If you have any further queries, please do not hesitate to contact me (details above).

More information on my research can be seen at:

<http://monash.edu/science/about/schools/chemistry/staff/turner.html> (follow link to personal site)

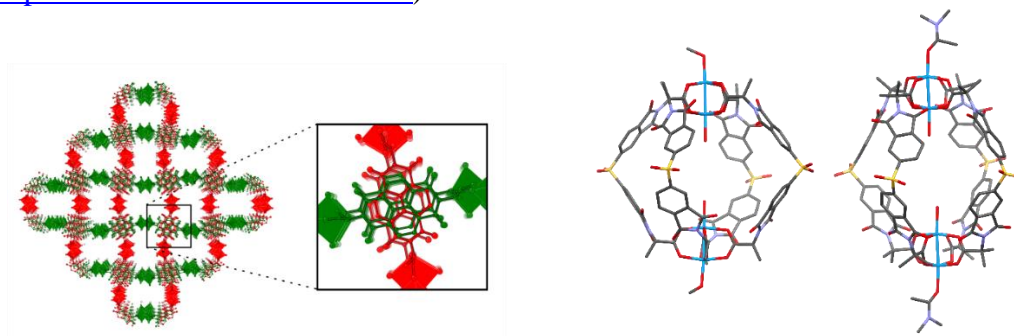
### Description of Project Area(s)

All research projects in my group are concerned with aspects of coordination chemistry and supramolecular chemistry. Our research primarily aims to design coordination compounds that contain holes or pores. These are either polymeric, crystalline materials that resemble nano-scale scaffolding, or soluble coordination cages. In both cases, we aim to make compounds that will be able to selectively store, sense or separate small molecules. All projects involve (i) the synthesis of organic ligands that will be able to bridge between metal atoms to construct the framework and which will possess additional sites for supramolecular interactions, (ii) synthesis of coordination polymers and/or coordination cages, (iii) structural characterization by X-ray crystallography (typically involving the Australian Synchrotron) and (iv) analysis of the physical properties of the materials for separation/storage/sensing where appropriate. The focus of the project is very flexible to your preferred aspects (from lots of synthesis to dozens of crystal structures).

Current project areas include (but are not limited to):

- **Chiral coordination cages.** Discrete cages are broadly studied for their catalytic behavior and ability to trap guests in their internal space. We are also exploring fundamental aspects of these cages, including their ability to swap ligands in solution (including to non-statistical mixtures), how their stability relates to the ligands that are used, whether we can incorporate multiple functionalities around the exterior of the cage, and how to incorporate fluorescent groups into the ligands.
- **Chiral coordination polymers for separation.** Using quite simple bis- or tris-amino acid ligands, we have been able to construct several coordination polymers that are able to provide resolution of racemic mixtures in small-scale liquid chromatographic experiments.
- **Crystal engineering.** We are always interested in exactly how molecules interact within crystals and have a number of projects that are primarily crystallographic, exploring unusual interactions and motifs.

Links to recent papers and more information about recent projects and results can be found on my website (<http://users.monash.edu/~dturner>).

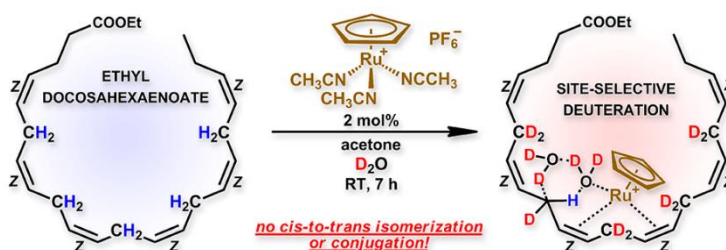


Left: A chiral coordination polymer used for resolution of racemates (Boer et al., *Chem. Eur. J.*, 2014). Right: Cage-type complexes typical of those that we study (Walker et al., unpublished).

Catalysis is the main research theme in our group. We are developing green and sustainable catalysts that are capable of performing a variety of organic transformations.

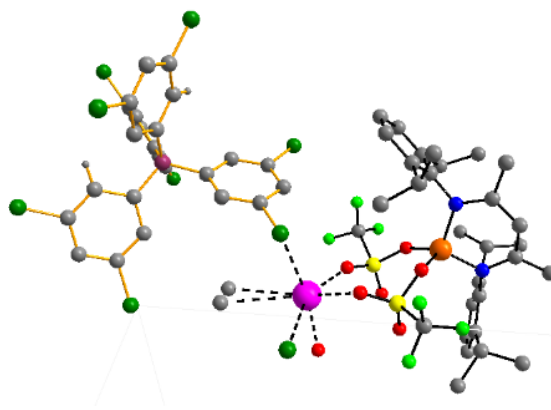
### Project 1. Catalytic deuteration of polyunsaturated fatty acids

This project is performed in collaboration with a pharmaceutical company Retrotope (<https://www.retrotope.com/>) that is developing treatments for various neurodegenerative illnesses including Alzheimer's, Parkinson's, atherosclerosis and various retinal diseases. The overall treatment is based on deuterated polyunsaturated fatty acids (PUFAs) that contain deuterium ( $^2\text{H}$  or D) instead of hydrogen atoms only at specific positions (bis-allylic positions) along the fatty acid chain. Recently we have developed (*J. Org. Chem.* DOI: 10.1021/acs.joc.7b02169) a quite elegant approach to perform the target H/D exchange (deuteration) under exceptional kinetic control. Nevertheless, the simplest PUFA (i.e. linoleic acids) could not be site-specifically deuterated. Therefore, we aim to prepare a bis-metallic complex that could be used for this purpose. Furthermore, we are interested in heterogenization of the existing catalysts which will aid in separating the catalyst from the PUFAs.



### Project 2. Lewis acid catalysis using well-defined aluminium-based complexes

Recent literature has suggested that the field of Lewis acid catalysis is plagued with the presence and consequent activity of hidden Brønsted acids. Beside proper synthesis, identification and use of Lewis acids, the use of various control experiments is crucial for exploring the catalytic activity of these electron deficient species. We believe that majority of the published research is lacking proper steps in minimizing if not eliminating the influence of Brønsted acids. Our Lewis acids are well-defined and well-characterized complexes based on aluminium as it is the most abundant metal in the Earth's crust. We have prepared several aluminium-based complexes that showed remarkable catalytic activity regarding a variety of Diels-Alder cycloadditions (*Dalton Trans.* **2017**, 46, 753. *Chem. Eur. J.* **2015**, 21, 11344). In fact, we have recently discovered that one of our catalytic systems is capable of polymerizing cyclic dienophiles which could be considered as functionalized polyolefins. The preparation of functionalized polyolefins, in general, is very difficult as ill-defined and low-molecular weight materials are normally prepared, while our procedure offers to drastically change that. Therefore, the aims of this project include further exploration of our catalytic systems with respect to several other organic transformations such as borylations, Michael additions, transfer hydrogenations etc. Also, we would like to further explore the synthesis of functional polyolefins in order to determine all their properties.



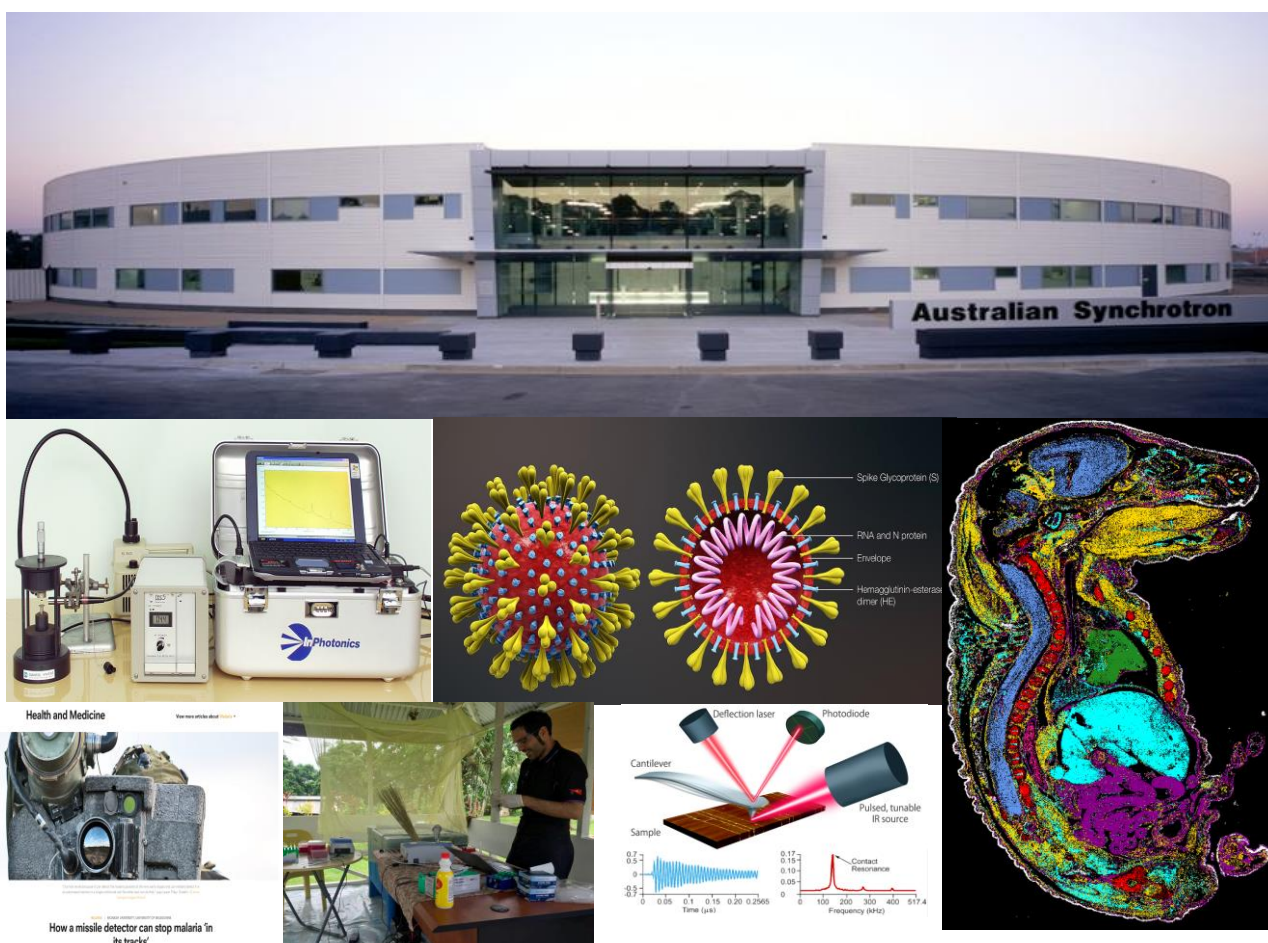
## Professor Bayden Wood

Room No. G24A, Tel: 9905 5721, email: [bayden.wood@monash.edu](mailto:bayden.wood@monash.edu)

Biospectroscopy, an emerging field within the spectroscopic examination of living tissue or body fluids, combines information from physical sciences with advanced computational analysis in order to shed new light on biological processes. This field is at the cutting edge of chemistry and biology research, continually developing knowledge about the structure and activity of biological molecules. Crucially biospectroscopy has the potential to revolutionise clinical diagnostic processes, fulfilling the constant demand for new technologies that can identify diseases to a high level of objectivity, sensitivity and specificity.

Operating in this context, the Centre for Bioepetroscopy, located in the School of Chemistry, has flourished over the course of the past decade. With its broad range of state-of-the-art equipment, strong roster of multidiscipline staff and robust collaborations with other researchers, the world class Centre is driving the development of biophysics and biotechnology.

The Centre of Biospectroscopy, is dedicated to solving biomedical problems using vibrational spectroscopic techniques including FTIR and Raman imaging spectroscopy, Attenuated Total Reflection spectroscopy, portable hand held Raman and FTIR spectrometers and near-field techniques including Tip Enhanced Raman Spectroscopy, nano-FTIR and regularly performs measurements at the Australian Synchrotron. We have a number of different research themes that broadly fall under the banner of vibrational diagnostics and monitoring. Specific research areas include COVID-19 diagnosis and research, malaria diagnosis and treatment, diabetes disease, cancer diagnosis, sepsis diagnosis, HIV, HBV, HCV, IVF, stem cell research, heart disease, liver disease and fundamental studies of how light interacts with matter. If you are interested in any of these research themes please feel to contact me to discuss the specifics of the various projects. More information on my research can be seen at: <http://monash.edu/science/about/schools/chemistry/staff/wood/>



## Associate Professor Jie Zhang

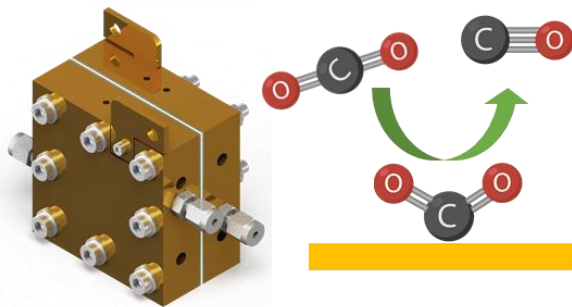
Room No. 145, Tel: 99056289, email: [jie.zhang@monash.edu](mailto:jie.zhang@monash.edu)

### Electrochemistry for energy and sensing

The focus of our research is to (1) develop advanced electrocatalysts for energy and sensing applications and (2) apply artificial intelligence in dynamic electrochemistry. Currently, we have two projects available in these areas:

#### **Project 1:** Electrochemical reduction of carbon dioxide

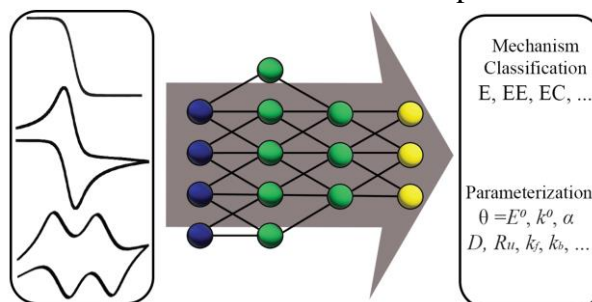
The ultimate aim of this project is to develop electrolyzers for high rate and low-cost carbon dioxide ( $\text{CO}_2$ ) utilisation to generate value added chemicals, such as CO, formate, ethanol and ethylene, using renewable electricity. Through this project, you will learn gas diffusion electrode fabrication, catalyst synthesis and characterisation, and product analysis. The basic principles and practice of electrochemical  $\text{CO}_2$  reduction and some examples of our recent studies can be found in References 1-4.



#### **Project 2:** Development of Bayesian inference and machine learning techniques for data analysis

This project will synergise machine learning and Bayesian supported data analysis frameworks with established state-of-the-art hardware and software infrastructure available within the Monash Electrochemistry Group, so that theoretical and experimental voltammetric data from complex reactions can be compared intelligently to obtain statistically meaningful information. Further information about the applications of artificial intelligence in dynamic electrochemistry and some examples of our recent studies can be found in References 5-9.

If you are interested in these projects and would like to know more details, please feel free to talk to me directly. More information on my research can be found at



<https://research.monash.edu/en/persons/jie-zhang>

<https://scholar.google.com.au/citations?user=W3sW9IAAAAJ&hl=en>

### References:

[1] Li, L. et al., Hydrophobicity Graded Gas Diffusion Layer for Stable Electrochemical Reduction of  $\text{CO}_2$ . *Angew. Chem. Int. Ed.* 2022. [2] Guo, S.-X. et al., Advanced Spatiotemporal Voltammetric Techniques for Kinetic Analysis and Active Site Determination in the Electrochemical Reduction of  $\text{CO}_2$ . *Acc. Chem. Res.* 2022, 55, 241-251. [3] Xiao, C. & Zhang, J., Architectural design for enhanced  $\text{C}_2$  product selectivity in electrochemical  $\text{CO}_2$  reduction using Cu-based catalysts: a review. *ACS Nano* 2021, 15, 7975-8000. [4] Zhang, X. et al., Electrocatalytic carbon dioxide reduction: From fundamental principles to catalyst design. *Materials Today Advances* 2020, 7, 100074. [5] Gundry, L. et al., Inclusion of multiple cycling of potential in the deep neural network classification of voltammetric reaction mechanisms. *Faraday Discuss.* 2022, 233, 44-57. [6] Bond, A. M. et al., Opportunities and Challenges in Applying Machine Learning to Voltammetric Mechanistic Studies. *Curr. Opin. Electrochem.* 2022, 101009. [7] Gundry, L. et al., Establishing zone regions in cyclic voltammetry using unsupervised machine learning. *J. Electroanal. Chem.* 2023, 942, 117551. [8] Gundry, L. et al., Recent advances and future perspectives for automated parameterisation, Bayesian inference and machine learning in voltammetry. *Chem. Commun.* 2021, 57, 1855-1870. [9] Kennedy, G. F. et al., Automatically identifying electrode reaction mechanisms using deep neural networks. *Anal. Chem.* 2019, 91, 12220-12227.

# CSIRO Project

## Assessing and validating low cost greenhouse gas sensor technology

Low cost sensor technology for the measurement of atmospheric composition is a rapidly developing science that has the potential to expand the spatial coverage of air quality monitoring in Australia as well as providing quick response to major air pollution events or emerging air pollution issues. These sensors have the potential to complement existing high precision air quality monitoring methodologies with flexible, affordable, portable and autonomous monitoring solutions. Networks of sensors have the potential to deliver higher spatial and temporal resolution observations, and provide data which will enable the localised validation of models and the forecasting and improved estimates of human exposure.

CSIRO have a strong track record in the application and development of high precision greenhouse gas (GHG) measurement techniques and are looking to expand this capability to include low cost GHG sensors. This project would lay the ground work for this expansion in relation to CO<sub>2</sub> and CH<sub>4</sub>.

### Project outline:

- Identify available sensor technologies for key GHGs, CO<sub>2</sub> and CH<sub>4</sub>, with sufficient data quality for specified applications.
- Procure suitable sensors.
- Using a suite of established analytical reference methods at the CSIRO Oceans and Atmosphere Aspendale laboratories develop a 'test bed' for the validation of sensor technologies.
- Validate and test sensors against established reference methods and under likely field conditions for proposed applications.
- Assessment of the error characteristics of sensors, and their value in regional inversions to estimate emissions.

Please note: lab work will be based at Aspendale campus of CSIRO.

For more information please contact:

Dr. Ann Stavert

Project Scientist  
Climate Science Centre  
CSIRO Oceans & Atmosphere

Email: [Ann.Stavert@csiro.au](mailto:Ann.Stavert@csiro.au)