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ON GREEN AND SUSTAINABLE
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ABSTRACT BOOK

PLENARY PRESENTATIONS

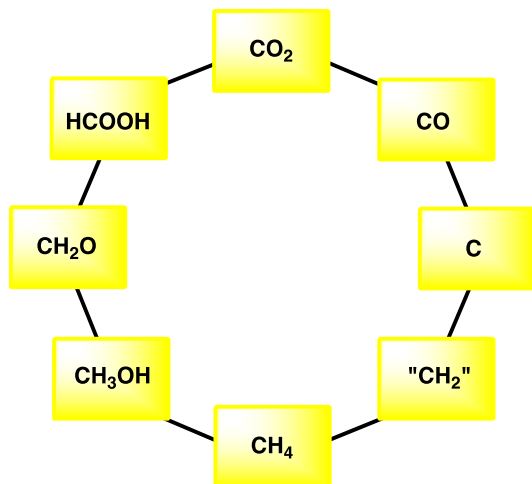
SUSTAINABLE CONVERSIONS OF BIOMASS-DERIVED CARBON SOURCES TO VALUE-ADDED CHEMICALS

George Britovsek, ^{1*}

¹ Department of Chemistry, Imperial College London, MSRH, 82 Wood lane, White City, London W12 0BZ, UK

*Email: g.britovsek@imperial.ac.uk

The finite nature of carbon sources derived from fossil fuels has generated a need for sustainable methods to convert alternative renewable carbon sources to important chemical feedstocks. The oxidised nature of biomass and CO₂ compared to fossil fuels requires novel catalytic technologies with reducing agents such as hydrogen and carbon monoxide in order to obtain suitable platform chemicals for further synthesis. Here we present our progress on catalytic carbonylation, hydrogenation and hydroformylation reactions of biomass-derived substrates and our vision towards a future biorefinery and sustainable carbon management.



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If Green and Sustainable Chemistry and Engineering is to innovate and 'save the planet', what would it entail?

Edward Buckingham

Monash Business School

Masters in Business Innovation Director, Monash University Indonesia

**Email:* edward.buckingham@monash.edu

Climate change and litigation risk play much larger roles in strategic investment decisions in the chemical industry than they did even a decade ago. The media and the public scrutinises the timing and resourcing of chemical technologies far more critically than before. These issues and their associated costs are changing the landscape for chemists in exciting new ways. Enabled and informed by information technology, a new generation of scientists is propelling chemistry and its applications into new territory. A 'scientific revolution' is underway but what do they need to do to 'save the planet?'.

In this presentation I share some frameworks to explore the socio-economic side of the innovation equation and specifically developments relating to Green Chemistry.

For a technology to be innovative it needs a business model, one that generates sufficient returns to: accelerate the accumulation of new capabilities within the community; renovate value chains; and foster industrial clusters. In essence, to innovate means to manage, channel and cultivate resources. The costs and payoffs associated with developing these capabilities are shaped by our values.

Just as values shape what we deem good to eat, they shape what we think important or acceptable in the chemical industry. To a large extent tradition and past practice dominate our values. However, 'Tradition is nothing but an innovation that was once successful' according to one school of thought. For the chemical industry to internalise green chemistry processes some chemical traditions must be set aside. I will show how institutional factors and business models are shaping the rules for chemistry and how associated costs are in practice as important as the science itself.

Perovskite and Heterojunction Photocatalysts

Xuying Li,¹ Sandani Ekanayake,¹ Haoxin Mai,¹ Tu C. Le,² Dehong Chen,¹ Rachel A. Caruso^{1*}

¹ *Applied Chemistry and Environmental Science, School of Science, RMIT University, Melbourne Vic. 3000, Australia*

² *School of Engineering, RMIT University, Melbourne Vic. 3000, Australia*

*Email: rachel.caruso@rmit.edu.au

Photocatalytic reactions, which are initiated by the absorption of light, can be used to produce fuels or break down pollutants. The perovskite structure is one that allows for compositional variation that alters the physicochemical properties and therefore the structure can be tuned for optimal photocatalytic properties. Computational approaches have been used to direct the choice of perovskites to be synthesized and tested, giving good correlation between predicted and experimentally observed results.[2-4] Perovskite/graphitic carbon nitride heterojunction materials have also been synthesised and investigated for photocatalytic activity. Doping of the perovskite extends its light absorbance to 650 nm, increasing visible light utilization, and the formation of the heterojunction decreases charge recombination resulting in increased photocatalytic toluene oxidation. Other carbon-based/TiO₂ materials have also been studied, including multiwalled carbon nanotubes and carbon quantum dots. This presentation will give an overview of their application in the photodegradation of dyes and pharmaceuticals.

This work was supported by Australian Research Council Discovery Projects (DP180103815 and DP220100945).

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Carbon-based metal-free electrocatalysts for clean energy and green chemistry

Liming Dai

*Australian Carbon Materials Centre, School of Chemical Engineering,
University of New South Wales, Sydney, Australia*

Email: l.dai@unsw.edu.au; <https://www.acmc.unsw.edu.au/>

Since our discovery of the first carbon-based metal-free electrocatalyst (C-MFEC, i.e., N-doped carbon nanotube) for oxygen reduction in fuel cells in 2009 [1], the field of C-MFEC has grown enormously. C-MFECs, as alternatives to noble metal-based electrocatalysts, have been widely demonstrated for efficient oxygen reduction, oxygen evolution, hydrogen evolution, carbon dioxide reduction, nitrogen reduction, and many other electrocatalytic reactions [2, 3]. Recent worldwide research effort has shown great potential for applications of C-MFECs in fuel cells for clean energy conversion, metal-air batteries for energy storage, water splitting for hydrogen fuel generation, and electrocatalysis for clean production of value-added chemicals [5,6]. Further research and development of C-MFECs can significantly advance clean energy and green chemical technologies. In this talk, I will summarize some of our work on the development of C-MFECs for clean energy and green chemical processes, along with an overview on recent advances, current challenges, and future perspectives in this exciting field.

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Sodium batteries as a more sustainable energy storage technology

**M. Forsyth, P.C. Howlett, J. Sun, F. Makhlooghi, N. Byrne, A. Kumar, H. Sarma and
L. O'Dell**

*ARC Industry Transformation Training Centre for Future Energy Technologies,
Institute for Frontier Materials (IFM), Deakin University, Burwood, Victoria 3125, Australia.
Email: maria.forsyth@deakin.edu.au*

Lithium ion batteries are ubiquitous in our society with uses extending from personal electronics to EVs and stationary storage. However, due to the environmental and ethical issues of raw materials (i.e., lithium, high purity graphite and cobalt) and increasing demands for lower cost and high safety, emerging battery technologies such as those based on sodium chemistries are becoming more attractive. Sodium metal anodes provide the opportunity for higher energy density devices while the possibility of carbonising waste biomass to produce hard carbons for Na ion batteries offers a more sustainable energy solution. Ionic liquid electrolytes have been investigated for over two decades as a safe alternative to traditional organic solvents, in particular for higher energy density, metal anodes. IL electrolytes are also considered to be stable and likely to be easier to recycle. These IL based electrolytes are shown to offer increased cycling performance through the control of the solid electrolyte interphase (SEI) that is created on the electrode during electrochemical cycling. Furthermore, this SEI can be tuned through choice of electrolyte composition and formation protocols, with the IL offering the additional benefit of fast formation which has positive implications on the cost of battery manufacturing.

In this presentation we will discuss the properties of a range of novel Na battery electrolytes, including polymerizable ILs for use in solid state devices, in terms of their physicochemical properties, electrochemical behavior and performance in devices.

A greener future: top cell routes for silicon based tandem cells

Xiaojing Hao ¹*

¹ School of Photovoltaic and Renewable Energy Engineering, University of New South Wales

**Email: xj.hao@unsw.edu.au*

The development of high-efficiency silicon-based tandem cells is a promising solution for further LCOE reduction. To achieve a lower LCOE than Si cells, while with improved efficiency, the requirement for low degradation rate of Si tandems is critical (i.e. <2% degradation after the 1st year of operation and 0.5%/year afterwards). Additionally, to achieve terawatt-level PV deployment, the use of abundant and non-critical elements for the active layer, contacts, and other key components are needed. There is no confirmed ideal top cell solution yet, meeting all the requirements of stability, cost-effectiveness, non-toxicity, and high-efficiency. Increasing the diversity of viable top cell materials is critical to allow greater adaptability as the technology continues to expand and develop not only for further increasing the efficiency but also fulfill various application areas for everywhere PV. This talk will focus on the promise and recent progress on the top cell options and strategies to make top cell greener.

Micro Elastofluidics: Elasticity and Flexibility for Efficient Microscale Liquid Handling

Nam-Trung Nguyen^{1*}

¹ *Queensland Micro- and Nanotechnology Centre, Griffith University*

*Email: nam-trung.nguyen@griffith.edu.au

Although progress has been made in materials development and flexible electronics, microfluidics in wearable and implantable systems remains an almost unexplored area. There are practical and fundamental reasons for the slow progress in this area: (i) current lab-on-a-chip and organ-on-a-chip devices require bulky lab equipment such as syringe pumps and microscopes to operate, and are not practical for wearable devices; (ii) most wearable systems are continuous-measurement tools that require a different design approach than conventional single-measurement lab-on-a-chip devices; (iii) storage of samples in vials and syringes, as well as their continuous delivery using pumps, makes them too bulky and not practical for wearable systems; (iv) the flexible and conformal nature of wearable/implantable systems does not allow for the implementation of established methods in conventional rigid microfluidics [1]; and most importantly, (v) the fundamentals of fluid–structure interactions, and the effect of structural flexibility and elasticity on storage, mixing, separation and delivery of liquids in molecular scale and macroscale, are not understood well enough to enable suitable engineering solutions. This talk presents our recent promising results in the field of micro elastofluidics, utilising flexibility and elasticity from molecular scale to device scale. Typical examples are enhanced mixing and separation with viscoelastic fluids, liquid storage and handling with liquid beads and tuneable microfluidic devices for separation and handling of biological particles.

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Nam-Trung Nguyen is a professor and the director of Queensland Micro- and Nanotechnology Centre at Griffith University, Australia. He received his Dipl-Ing, Dr Ing, and Dr Ing Habil degrees from Chemnitz University of Technology, Germany, in 1993, 1997, and 2004, respectively. He is a Fellow of ASME and a Senior Member of IEEE. His research is focused on microfluidics, nanofluidics, micro/nano machining technologies, micro/nanoscale science, and instrumentation for biomedical applications.

Green hydrogen generation at ultrahigh current density from untreated water based on a novel semi-steam electrolysis technology

Zongping Shao,^{*1} Jiayi Tang,¹ Moses Tade,¹

¹ WASM-Minerals, Energy and Chemical Engineering, Curtin University, WA, Australia

^{*}Email: zongping.shao@curtin.edu.au

Green hydrogen from widely available water resource like seawater based on electrolysis is of highly attractive, but a big challenge .^[1] In this presentation, we report our recent advances in the generation of green hydrogen from untreated water with a wide range of resources, from seawater, salient water, river water, lake water, tap water and rain water at ultrahigh current density (up to 4.5A cm⁻²) at device level with zero-gap polymer exchange membrane and a semi-steam electrolysis concept, with low cost, easy scale up, high energy efficiency, and size flexibility. The key is that we use water vapor as feed for the anode while liquid water for the cathode, and the water vapor is created through bubble enhanced vaporization. We further adopt a much cheaper RuO₂ as the OER catalyst to replace IrO₂ (which is ten time higher in price than RuO₂) at low loading (0.5 mg cm⁻²). The instability of RuO₂ due to dissolution in liquid water is intrinsically eliminated by the new technology, while the transfer from two-phase reaction to one phase gaseous reaction significantly enhances the reaction kinetics. We further propose a mass and thermal coupling between the water evaporation and cell electrolysis processes, resulting in high energy efficiency and cost effectiveness. As a result, the water electrolysis is successfully operated at hundreds of hours at high current density (1A cm⁻²) without failure and obvious performance degradation, it provides a new technology for hydrogen generation with great practical application potential.

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Advanced oxidation processes for waste degradation and recycle

Shaobin Wang

¹ *School of Chemical Engineering, The University of Adelaide, SA 5005, Australia*

**Email: Shaobin.wang@adelaide.edu.au*

Water pollution has been an important issue globally. Removal of toxic organic pollutants by advanced oxidation processes has been an emerging technique for wastewater treatment. Nanostructured metal- and carbon-based materials have many advantages as catalysts in different reactions. Their design and modification for environmental applications have been widely reported.

However, metal materials can generate secondary pollution as they can release toxic metal ions. Metal-free carbocatalysts, featuring low costs, environmental friendliness, long-term durability, tunable structure and facile regulation of surface chemistry, have been widely exploited in heterogeneous catalytic reactions and exhibit remarkable activities.

In the past years, we have been focusing on metal-free carbon materials, such as graphene, carbon nanotubes, nanodiamonds, or mesoporous carbons as excellent alternatives to metal-based catalysts, for activation of peroxydisulfate (PDS) to produce reactive radicals and induce nonradical reaction. The produced sulfate radicals can show appealing characteristics over hydroxyl radicals, e.g., a flexible pH range, a higher oxidation ability and the free of sludge, for degradation of organic pollutants in water. Meanwhile, nonradical reaction will be more selective in transformation of organics. We found the active sites to be (i) sp^2 carbon framework, (ii) defective sites and edges, and (iii) oxygen functional groups. Delicate material design and comprehensive experiments as well as computational studies were carried out to prove the three proposed active sites. The work offers more insights to intrinsic properties and mechanism of effective carbocatalysts in catalytic applications. In addition, we employed PDS-based oxidation processes to achieve oxidative transformation of organic for chemical synthesis. The findings are critical for understanding the insights of carbon materials as alternatives to metal-based materials for environmental catalysis, leading to the development of novel, metal-free remediation technologies.

Inventing a Sustainable Future with the Principles of Green Chemistry

John C. Warner ^{1*}

¹ Monash University

*Email: john.warner@monash.edu

The materials economy can be thought of as a pendulum with the field of chemistry at its apex. In one direction, the human-built world manifests through manufacturing and recycling. In the other direction, the natural world is a combination of extraction and degradation. The overlap between these two termini of the pendulum is a useful assessment of sustainability. This presentation will describe the 5 embedded cycles of use/reuse, assembly/disassembly, materials metabolism, regeneration and stable ecosystems. Examples of the use of the 12 principles of green chemistry from the human-built world will be presented to illustrate the issues and opportunities for green chemistry to design a sustainable future.

Brief Bio:

John is one of the cofounders of the field of green chemistry, coauthoring the defining text [“Green Chemistry: Theory and Practice”](#) and articulating the [12 principles of green chemistry](#) with Paul Anastas. He is a chemistry inventor who works to design and create commercial technologies inspired by nature consistent with the principles of green chemistry. With over 300 patents, he has invented solutions for dozens of multinational corporations. His inventions have also served as the basis for several new companies (ALS therapy, hair color restoration, asphalt warm mix rejuvenators and low light indoor photovoltaics). He has over 100 publications providing foundational work in the fields of noncovalent derivatization, polymer photochemistry, metal oxide semiconductors and synthetic organic chemistry. John has received prestigious awards as an academic ([Presidential Award for Excellence in Science Mentoring](#) – President G. W. Bush & NSF, 2004) and the [August Wilhelm von Hofmann Medal](#) from the German Chemical Society, (2022), industrial chemist ([Perkin Medal](#) – Society of Chemical Industry, 2014), inventor ([Lemelson Ambassadorship](#) – Lemelson Foundation & AAAS) and for governmental chemicals policy ([Reinventing Government](#) National Performance Review – Vice President A. Gore & EPA, 1997).



Development of Eco-Friendly Nanoparticles for Efficient Gene Delivery to Plant Cells

Zhi Ping (Gordon) Xu,¹ Jiayi Yong,¹ Run Zhang,¹ Bernard Carroll²

1 Australian Institute for Bioengineering and Nanotechnology, The University of Queensland, Brisbane, QLD 4072, Australia

2 School of Chemistry and Molecular Biosciences, The University of Queensland, Brisbane, QLD 4072, Australia.

Email: gordonxu@uq.edu.au

Plant biotechnology, such as delivering nucleic acids to plant cells to manipulate metabolic properties and confer desirable traits in crop plants will play an increasingly important role in addressing the world food shortage. The delivery to plant cells is normally achieved using biolistic bombardment or agrobacteria-mediated gene transfer. However, biolistic bombardment suffers from a low transfection efficiency and causes severe cell damage, while agrobacteria-mediated gene delivery is limited to only certain plant species. It is therefore necessary to develop more benign and universal platforms for the cost-effective delivery of exogenous genes into intact plant cells of crop species.

Nanoparticle-mediated delivery of functional genes appears as an option, but the plant cell wall is a challenging barrier and nanoparticles have so far not been well designed to achieve active delivery to plant cells. Fortunately, our developed layered double hydroxide (LDH) nanoparticles have demonstrated the effective delivery of various genetic forms into plants. In our recent research, LDH nanoparticles less than 50 nm in diameter were readily internalized by bicellular pollen, a simple plant cell model, and effectively delivered dsRNA to pollen to knockdown the target gene expression. We have also shown that 40 nm LDH nanoparticles were rapidly taken up by intact leaf cells and chloroplasts after leaf infiltration. In such a way, 40 nm LDH nanoparticles greatly enhanced the delivery of siRNA to leaf cells and down-regulated the targeted transgene by >70%. Furthermore, small LDH nanoparticles were observed to deliver mRNA and plasmid DNA into the root cells of several plant species to express the target proteins via simple culture of roots. These research data have collectively shown that small LDH nanoparticles appear as a general non-viral vector to overcome the cell wall barrier and deliver functional nucleic acids to plant cells.

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Dr Zhi Ping Xu received his Ph.D. from the National University of Singapore in 2001 after his Bachelor and MSc degrees from University of Science and Technology of China. He then did his postdoctoral research at the University of North Texas from 2001 to 2003, followed by a research fellow position at the University of Queensland (UQ) from 2003 to 2007. He further progressed at UQ as a Senior Research Fellow, Associate Professor and Professor. Currently, he is a Senior Group Leader at the Australian Institute for Bioengineering and Nanotechnology, UQ, and a Principal Investigator at the Institute of Biomedical Health Technology and Engineering, and Institute of Systems and Physical Biology, [Shenzhen Bay Laboratory](#). His research focuses on rational design and controlled preparation of layered double hydroxide nanomaterials, and their applications in biomedicine and agricultural biotechnology. He has published over 350 papers, with over 20,000 citations and H-index of 77. His research has been supported by funds over A\$30 million.

KEYNOTE PRESENTATIONS

Combining conducting paints and electrochemistry as an active antifouling coating for preventing marine growth

Mats R. Andersson ^{1*}

¹ *Flinders Institute for Nanoscale Science and Technology, Flinders University, Sturt Road, Bedford Park, SA 5042, Australia*

**Email: mats.andersson@flinders.edu.au*

Fouling, the growth of marine organisms onto ships hulls or other surfaces in marine environments, is a serious problem that dramatically increases fuel consumption and spreading of invasive species. To overcome the fouling problem current methods mainly use antifouling paints that release harmful biocides, for example copper compounds. These coatings are nowadays under regulatory pressure due to increased copper levels in protected waters and harbours. The alternative, foul-release coatings, are expensive and ineffective under stationary conditions.

In our study we have developed a new active antifouling technique that relies on electrochemical activity of conducting coatings. Our conducting coatings consist of paints mixed with graphite powder. In the project we have shown that micro- and macro-scale fouling can be significantly reduced on coupons that are coated with our conducting paint and subjected to electrochemical stress. Coatings under different applied potentials as well as different duty cycles at set potentials have been evaluated under laboratory conditions. Significant differences between the control and active coatings have been seen with up to 99 % reduction in attachment of diatoms. The lab results were reproduced under real marine growth conditions in Port River Basin, Adelaide, for more than 50 days immersion experiments, using 11 x 9.5 cm test surfaces.[1] The growth of macro-fouling was completely eliminated for all electrochemical conditions that were tested. Our active coatings proved to be highly efficient against marine growth under stationary conditions.

References:

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Biography:



Mats Andersson performed a joint PhD-work at the Departments of Organic Chemistry and Polymer Technology, Chalmers University of Technology, Gothenburg, Sweden, and he received his PhD degree in Organic Chemistry in 1995. He was appointed Professor in Polymer Chemistry in 2004 and he held a chair in Polymer Chemistry 2007-2015. In 2012 he was elected as a member of the Royal Swedish Academy of Engineering Sciences, IVA. In 2013 he was awarded a South Australian Chair in Energy and in 2014 Mats moved to Adelaide, Australia, to join University of South Australia as a Research Professor. In 2017 he moved to Flinders University, Adelaide, as a Matthew Flinders Professor and he is currently director of Flinders Institute for Nanoscale Science and Technology.

Are we there yet? The Water Utility of the future.....

David J Bergmann, ^{1*}

¹ South East Water, 101 Wells St, Frankston

*Email: david.bergmann@sew.com.au

The modern water utility is in a face-off against population growth, urbanization, climate change, ageing assets and escalating customer expectations.

From traditionally focusing on ‘getting-the-basics-right’ of water treatment, supply, sewerage disposal, and a quarterly bill for the service - the future utility is shifting its thinking to ‘healthy-water-for-life’ and can make significant impacts inside and beyond its traditional boundaries. Most Australians are serviced by a water utility in some form, providing an incredible customer channel and relationship for change in our communities. With the right partners and ecosystem, transformational outcomes become possible such as zero waste, resource recovery, negative emissions, food security, cooler cities, and healthier communities.

The solutions that are arising in the industry focus on areas such as IoT, digitalization, real-time monitoring and control, the circular economy, diversity of water sources, live condition assessment, and customer and community engagement. The science and engineering behind developing and delivering these solutions requires new research, new perspectives, new skill sets, multi-disciplinary partnerships, systems thinking, boldness, innovation, and the willingness to learn and advance.

This presentation will show the progress the Australian water industry is making towards these transformational goals, and continue the discussions on the opportunities for green chemistry and engineering to be a key partner in accelerating these outcomes.

References:

NA

Biography:

David is the Research, Development & Innovation Manager at South East Water, and has been in that role since 2015. Creating value from waste, making passive systems smart, use of alternative waters, urban cooling, and smart devices and sensors are areas of particular interest. With a PhD in Chemistry, David has worked in R&D roles in chemicals, detergents, food, manufacturing, and now water and wastewater.

David is also a qualified Company Director and experienced Board Member. He is currently serving on the Board of Water Research Australia and Chairs their Human Resources Subcommittee. David also has various leadership roles in the water industry including Chairing the Training Committee of the ARC Industrial Transformation Training Centre ‘Transforming Biosolids’.

David brings a diverse range of experience from a broad range of industries, from multinational corporations to regional utilities and not-for-profit organizations. He is passionate about positive change, innovation, and the delivery of solutions with impact.



Electrolytes and their Ionic Conductivity: Accounting for Ion-Coupling and Pathway Constriction

Buddhi Siyath Gunatunga,¹ Tanika Duivenvoorden,¹ Mingchao Wang,¹ Stephen Sanderson,¹ and Debra J. Searles (Bernhardt)^{1,2*}

¹ *Australian Institute for Bioengineering and Nanotechnology, The University of Queensland, Brisbane, QLD 4072, Australia*

² *School of Chemistry and Molecular Biosciences, The University of Queensland, Brisbane, QLD 4072, Australia*

**Email: d.bernhardt@uq.edu.au*

To produce effective, green sustainable energy storage systems, new electrolytes that are efficient, safe and stable are required. There are many options such as solid-state electrolytes that include crystalline, amorphous or structural polymer electrolytes and multivalent electrolytes. The optimal choice depends on the details and requirements of the energy storage system. Molecular simulations are often used to determine the ionic conductivity of these systems. One of the reasons that this is important is that it is easy to control the composition, making structure-property relationships more accessible. In addition, it is possible to determine conduction mechanisms and pathways, and propose ways to maximize the conductivity of a particular system. However, approximations are often required for many systems including those involving ion-coupling, restricted pathways for flow, or if the conductivity of one or more species is low. This reduces the accuracy and/or precision of the ionic conductivities obtained. Recently, approaches have been developed to improve the calculations. Here we will present some recent results using new approaches that have been developed in our group and reveal insights that have been obtained. We will compare different approaches that are commonly used and highlight their advantages and disadvantages.

Biography



Debra Bernhardt is an ARC Australian Laureate Fellow in the Australian Institute for Bioengineering and Nanotechnology (AIBN) and School of Chemistry and Molecular Biosciences (SCMB) at The University of Queensland. Her research program focuses on theoretical and computational approaches to develop a fundamental understanding of the behaviour of matter. She applies these approaches to a wide range of problems, particularly transport in nanoscale systems, nonequilibrium flow, design of materials, energy storage and conversion. She is a Fellow of the Royal Australian Chemical Institute and Fellow of the Australian

Academy of Sciences. Debra publishes as Debra J. Searles.

Thermoelectric materials and devices for sustainable energy and refrigeration

Zhi-Gang Chen

¹School of Chemistry and Physics, Queensland University of Technology, Brisbane, Queensland 40000, Australia

*Email: Zhigang.chen@qut.edu.au

Owing to their capabilities of solid-state conversion between heat and electricity, zero emission, and high flexibility, flexible thermoelectric devices (F-TEDs) have exhibited great application potential for power generation and localized refrigeration. However, with the rapid development of TE science and technology, there is still lack of comprehensive review on rational design of F-TEDs from the fundamentals to structures, which critically determines the performance and conformality of F-TEDs. To address this issue, here, we timely overview the latest progress on the up-to-the-date F-TEDs with their unique designs. In this work, we carefully summarize the structure-related principles and factors that determine the performance of F-TEDs and propose strategies for improving their utilities. Besides, we focus on the timeliest designs for inorganic-based devices, organic-based devices, and hybrid-based devices targeting for both power generation and refrigeration. In the end, we point out the current challenges, controversies, and prospects of F-TEDs.

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Bio-inspired Moisture Electric Generator: A Green Energy Harvesting Technology

**Tao Wan, Mengyao Li, Peiyuan Guan,
Ziheng Feng, Chao Liu, Dewei Chu***

*School of Materials Science and Engineering,
UNSW Sydney*

**Email: d.chu@unsw.edu.au*

Harvesting energy from ubiquitous moisture is attracting growing interest for wearable electronics. However, it is still challenging to fabricate high-performing moisture-electric generators (MEGs) with high and stable electric output. Herein, we report a facile strategy to modify the oxygen-based groups of graphene oxide using acid treatment, which boosts the electric output based on the device structure of graphene oxide/polyvinyl alcohol (GO/PVA) MEGs. The resulting MEG enables a stable voltage of 0.85 V and a continuous current density of $92.8 \mu\text{A}\cdot\text{cm}^{-2}$, which are among the highest values reported so far. Protein and hydrogel based MEGs have also been developed to overcome the materials issues. Furthermore, the electrode configuration has been optimized to enhance the power output. This work may open a new era of advance for a new energy conversion technology able to directly power wearable electronic devices.

Metal-organic Framework Catalysts for Sustainable Chemistry

Christian Doonan, ^{1*}

¹ *Department of Chemistry, The University of Adelaide, Adelaide 5005*

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*Email: christian.doonan@adelaide.edu.au

Carbon dioxide hydrogenation and methanation are promising reactions for industrial conversion of CO₂ to C1 building blocks (methanol and methane).¹ Supported metal-nanoparticle catalysts are the most active materials for this chemistry; however, improvements in conversion and selectivity are desired to enhance economic viability of these processes.^{1,2}

Due to their exceptionally high surface areas, highly connected porous structures, and chemically mutable structures, Metal-organic Frameworks (MOFs) represent a novel class of support materials for such catalysts.^{1,3} Zirconium-based MOFs have been investigated as supports for metal-nanoparticles as they are highly stable, and, furthermore, ZrO₂ is a known promoter for Cu/ZnO methanol synthesis catalysts.¹ This contribution will present our recent efforts to examine the influence of the structure metrics and composition of different zirconium-based MOFs as supports for metal nanoparticles that are active towards CO₂ conversion to C1 products.

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Piezo- and tribo-electricity from 3D printed fluoropolymers as energy sources

Amanda V. Ellis

School of Chemical and Biomedical, The University of Melbourne

**Email: amanda.ellis@unimelb.edu.au*

This talk highlights work on the 3D printing of fluoropolymers for applications as piezoelectric and triboelectric energy harvesters. Using 3D printing with induced shear, allows for the cheap, efficient production of poled piezoelectric polymers. Here, pseudo one-dimensional (1D) carbon nanotubes as well as two-dimensional (2D) $\text{Ti}_3\text{C}_2\text{T}_x$ MXene nanosheets are individually combined with poly(vinylidene fluoride-co-trifluoroethylene) (PVDF-TrFE) and 3D printed, leading to unprecedented fluoropolymer charge output without any electrical poling [1]. Electromechanically responsive electrospun laminates were prepared from a variety of polymers, with a stable electromechanical response over 24 h of continuous operation [3]. The relationship of smooth and rough surfaces of various polymers to energy outputs is also discussed [4]. Lastly, our new work on the use of the frequency domain analysis technique – the fast Fourier transform (FFT) is presented, showing decoupling of the energy contributions of piezoelectric and triboelectric nanogenerators (TENG) by comparing a polyvinylidene difluoride (PVDF) PENG against a non-PE polyimide (PI) NG [5].

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Title: Machine Vision beyond Human Performance for Smart Farming

Smart farming studies new knowledge, technologies and devices for automation in agriculture and aquaculture, early detection of pest and plant disease, automatic species identification, plant phenomics, better water resource management, land environment monitoring, coastal environment monitoring, marine life surveillance, etc. In this talk, he will introduce some of their work on automation in agriculture and aquaculture, faster grading and packing, species and cultivar identification, pest and disease recognition at ARC Industrial Transformation Research Hub for Driving Farming Productivity and Disease Prevention and Environmental Informatics@Griffith, including new advancement of visual classification from species to cultivar.

Bio:



Professor Yongsheng Gao is the Director of Australian Research Council (ARC) Research Hub for Driving Farming Productivity and Disease Prevention, and the Director of Institute for Integrated and Intelligent Systems at Griffith University, Australia. He was a member of College of Experts, Australian Research Council. As a Chief Investigator, he has been working on projects in Australia, Singapore, Germany, and China in the areas of smart farming, environmental informatics, biosecurity, face recognition, biometrics, image retrieval, computer vision, pattern recognition, and medical imaging. He was also employed as a consultant by Panasonic Singapore Laboratories Pte Ltd working on the face recognition standard in MPEG-7. His research are reported in the media in Australia and Singapore, including *The Australian*, *The Courier Mail*, *The Sydney Morning Herald*, and *The Straits Times* (Singapore).

Developing sustainable plastics sector: Case study on developing high performance bioplastics

Peter HALLEY, ^{1*}, Emilie GAUTHIER¹, Nick MCCAFFREY², Bronwyn LAYCOCK¹

¹ ARCITTC CBB, School of Chemical Engineering, UQ QLD 4072

² Plantic Technologies Ltd 40 Burns Road, Altona VIC 3018

*Email: p.halley@uq.edu.au

Plastics waste presents a clear and present environmental danger, in part due to the usefulness and popularity of plastics packaging and products. Over 390 tonnes of plastics was used globally in 2021 [1], and of this amount only around 9% was recycled successfully. The solution to using plastics sustainably is a complex issues, and will be solved by a holistic approach of product design, sustainable processing, management of waste collection, recycling and chemical recycling, and use of more sustainable plastics options.

This paper will firstly examine all the options for reduction of plastics waste to develop a more sustainable plastics industry, then as a case study we will summarise the research and development of high value bio-based polymers products. This will include initial work on starch biopolymers through to a range of biopolymer blends and biomaterials. The paper will examine major improvements in material and performance properties that led to wider applications for starch and other biopolymer materials via materials chemistry, polymer blending, tailored processing and cradle to cradle analyses. Application areas include food packaging, agricultural films, injection molded products and high functionality products.

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Biography:



Peter is a professor in polymer engineering in the school of chemical engineering at the university of Queensland. He works on the underlying research for the translation to new sustainable polymer products and processes. He is involved in research projects on biopolymers, rheology and processing of plastics and biomaterials, and sustainable polymer processes.

Cold Plasma for N-Fertilisers Made At-Farm: from Hydrodynamics to Sustainability and ESG

Volker Hessel^{1,2*}

¹ School of Chemical Engineering, The University of Adelaide, Australia

² School of Engineering, University of Warwick, United Kingdom

*Email: volker.hessel@adelaide.edu.au

Cold plasma has promises for chemical nitrogen (N) fixation, which is used to make fertilisers [1,2]. Both ammonia and nitrates (through NO_x) can be formed dependent on the plasma process [2]. When adding an aqueous solution to form a gas-liquid plasma, both fertilizing species can be formed directly in solution, which makes it ready to be immediately pumped to the farm field. This “plasma-activated water” (PAW) has potential to eliminate transportation and mechanical distribution that is needed for solid fertilisers. The plasma can be generated with (locally available) renewable energy, as it is able to work with intermittent energy supply and therefore fluctuating productivity over time [2]. Air can be used for the plasma-based nitrogen synthesis and clean hydrogen for the ammonia synthesis. Therefore, plasma processes can operate along the principles of Green Chemistry and Green Engineering - it allows to process abundantly available resources and renewable energy, promoting new supply chain models with resilience and locally-adaptable productivity and product mixture.

To deploy the full potential of plasma processing, process improvement by deciphering fundamentals is needed. This starts with increasing energy efficiency and plasma catalysis [3], yet also proper engineering of mass and heat transport, as per optimizing hydrodynamics, taps still unreleased potential; especially when done at a micro-scale (micro-plasma). Techno-economic analyses show to which scale (distribution of production) a commercial plasma-ammonia plant can be reduced [4]; yet with the conventional process (Haber-Bosch) still setting the cost-optimal standard. But, this is not necessarily the case anymore when environmental costs and covalorisation are internalised [5] Life cycle assessment can quantify the environmental benefit with regard to reduced carbon footprint, majorly also by reducing or eliminating transportation [6,7]. Largely unexplored is another “green” innovation that plasma processing might provide, which is its impact on Environmental, Society, and Governance (ESG) – plasma’s societal effect.

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Biography:

Prof. Volker Hessel obtained his PhD in chemistry at Mainz University, Germany in 1993. In 1994 he entered the Institut für Mikrotechnik Mainz (IMM). In 2007, he rose to be the Director R&D at IMM. Volker is the Director of Adelaide’s Andy Thomas Centre of Space Resources. Prof. Hessel’s research focuses on new continuous-flow and plasma-catalytic process concepts as well

as application thereof in health, chemistry, energy, space, and agrifood. He has published 606 peer-reviewed papers (h-index: 86). He received many awards including an IUPAC ThalesNano Prize.

Sustainable insect pest and resistance management practices for stored product commodities ensuring food biosecurity and market access.

Rajeswaran Jagadeesan,^{1,2*}, Manoj Nayak¹, Paul Ebert², Greg Daglish¹ and Phil Burrill¹

¹*Crop and Food Science, Queensland Department of Agriculture and Fisheries, Ecosciences Precinct (ESP), 41 Boggo Road, Dutton Park, Queensland 4102, Australia*

² *School of Biological Sciences, The University of Queensland, 4072, Australia*

*Email: raj.jagadeesan@daf.qld.gov.au

Abstract

Protecting stored commodities is essential for alleviating global hunger and facilitating domestic and international trade. A major threat to the safe storage of harvested commodities is spoilage and destruction by insect pests, particularly in subtropical countries like Australia, where harvested commodities are stored under hot and humid conditions that favour the growth of insect populations. Globally, the industry is relying heavily on chemical insecticides for controlling insect pests during storage however, continuous, and indiscriminate usage of them has triggered genetic resistance in field insect populations, threatening global food biosecurity, and market access. There is an additional necessity for Australia, as the country adheres to “Zero tolerance” for live insects in exporting premium quality grains. Therefore, there is a need for establishing and implementing sustainable pest and resistance management strategies for the industry. To address this, we perform comprehensive research in postharvest commodity protection and establish ecologically sound pest and resistance management strategies for commodities such as cereals, pulses, and processed products. The program starts with implementing intensive regional sample surveys (**grain sampling**), followed by screening the samples for live insects and resistance (**diagnostics**) and investigating pest susceptibility to chemical treatments (**monitoring**). While these components set the foundation and provide insights into the severity of the problems, the second aspect of our research focuses on developing and implementing commodity-based **non-chemical and chemical control** strategies. The non-chemical control emphasizes the importance of installing the correct storage structures followed by the timely implementation of appropriate eco-friendly practices such as storage hygiene, aeration, grain cooling, and mass insect trapping. For chemical control, judicious application of various selective insecticides (structural treatments, grain protectants, and fumigants) is recommended for industry, primarily augmenting non-chemical approaches, and reducing overall pest pressure in a storage environment. This integrated approach not only reduces the usage of chemical insecticides in postharvest pest control but also paves the way for achieving food sustainability and market access.

Keywords: insect pests, chemical control, resistance, sustainability, and grain storage

Biography



Dr. Rajeswaran Jagadeesan (Raj) is a Senior Research Scientist in the postharvest grain protection team at the Queensland Department of Agriculture and Fisheries (QDAF), Australia. He has a strong background in agricultural science and specialized in entomology and toxicology (pesticide efficacy, residues, resistance genetics, and integrated pest and resistance management). He has received his BSc (Agriculture) and MSc (Agricultural Entomology) degrees from Tamil Nadu Agricultural University (TNAU), India, and a Ph.D. (Molecular and Applied Entomology) from the University of Queensland (UQ), Australia. Since joining QDAF in 2011, Raj has gained significant research experience in fumigant toxicology, especially in managing genetic resistance to fumigant insecticides. Raj has identified the first phosphine (a fumigant) resistance gene, *dihydrolipoamide dehydrogenase (dld)* in a key grain insect pest, the red flour beetle, *Tribolium castaneum*, that has revealed significant insights into the management of resistance. He has also successfully translated these insights into developing advanced diagnostic tools and practical management protocols in the laboratory and evaluating them in the field. Currently, Raj is exploring an innovative research area: co-fumigation that aims to minimize the environmental impacts and shorten the fumigation time. Raj is also heavily involved in outreaching key findings to the industry and creating visible impacts in practice change. Raj has reaped many prestigious awards, and research grants, and published more than twenty research papers in high-profile international journals including *Science*, *Heredity*, *Journal of Stored Product Research*, *Journal of Economic Entomology*, and *Pest Management Science*. Raj is also an adjunct research fellow at the UQ and collaborates regularly with the School of Biological Sciences.

Minimising environmental impacts of mining

Yonggang Jin*

CSIRO Mineral Resources, Pullenvale QLD 4069 Australia

**Email: yonggang.jin@csiro.au*

Reducing negative impacts of mining on environment forms a critical aspect towards sustainable mining. The Environment and Sustainability (ES) Research Team within CSIRO Mineral Resources focuses on the R&D in decarbonisation, water remediation, mine waste utilisation, and mine/mineral dust. These research efforts are closely aligned with minimising environmental impacts of mining and improving mining sustainability. This presentation will give an overview on the ES team's R&D activities in methane emissions abatement, mine tailings carbonation, mine-impact water treatment, respirable dust monitoring and diesel particulate matter control.



Dr Yonggang Jin is a Principal Research Scientist and Research Team Leader with CSIRO Mineral Resources. He establishes and leads the Environment and Sustainability Research Team in the Sustainable Mining Technologies Research Program. Yonggang completed his PhD in Chemical Engineering at University of Queensland in 2008. Prior to joining CSIRO in 2009, he spent about 1.5 years at the ARC Centre of Excellence for Functional Nanomaterials on his postdoctoral research. He has over 15 years research experience in developing functional materials and innovative processes for PEM fuel cells, methane emissions abatement, carbon capture & utilisation, dust monitoring & analysis, and diesel particulate matter control. He has been involved in various industry/government funded projects for prototype development, site trials and demonstration. He is an author of over 50 peer-reviewed papers in high-impact journals, with more than 5,800 citations and an h-index 27.

Improving our understanding of occurrence, toxicity and risk of contaminants of emerging concern in water

Frederic D.L. Leusch

Australian Rivers Institute, Griffith University, Southport, Qld 4222, Australia

Email: f.leusch@griffith.edu.au

A contaminant of emerging concern (CEC) is broadly defined as “a chemical for which there are increasing concerns regarding its potential risks to humans and ecological systems”. CEC include both naturally occurring chemicals (e.g., algal toxins) and manufactured chemicals, as well as chemicals formed during treatment processes or via natural processes in the environment. The widespread presence of CEC in water is an ongoing issue for the water industry. By their nature, CEC pose unique challenges: assessing their environmental occurrence is challenging because of a lack of suitable analytical methods; characterizing their toxicity is difficult because of limited certified reference material and poor understanding of environmentally relevant concentrations; and the absence of regulatory guidance and limited data make it difficult to manage and assess the risk posed by individual CEC. Understanding CEC therefore requires new techniques.

Effect-based methods (EBM) are high-throughput *in vitro* bioassays and well plate-based *in vivo* assays that can be used to complement chemical analysis as they can detect all chemicals in a sample that are active in the applied bioassay, including known and unknown chemicals. EBM can also account for the mixture effects of the many chemicals present in a water sample. In addition, EBM are risk-scaled, with more potent chemicals eliciting a stronger response than less potent chemicals when present at similar concentrations. EBM have been applied to a range of water types, including drinking water, surface water, recycled water, wastewater and stormwater. Effect-directed analysis (EDA), which combines sample fractionation with EBM testing and chemical analysis, allows identification of novel toxic CEC. Predictive models can also be used to prioritise CEC based on their persistence, bioaccumulative and toxic properties, as well as resistance to water treatment, to develop a risk-based priority list of CEC for further action. Tools like the online Emerging CHemIcals Database for National Awareness (ECHIDNA) can provide valuable information for better decision-making surrounding CEC management.

Biography:



Dr Frederic Leusch is Deputy Director of the Australian Rivers Institute at Griffith University (Australia). Fred has published close to 150 peer-reviewed scientific papers, and his current research focuses on assessing the impact of environmental contaminants on humans and aquatic ecosystems. He is Associate Editor for the journal *Environmental Science & Technology* and serves on various national and international committees on issues related trace organic pollutants and drinking and recycled water quality.

Electrifying Electrolyte-Infused Graphene Membranes: Insights for Future Ionotronics

Dan Li

Department of Chemical Engineering, The University of Melbourne, Melbourne, VIC 3010, Australia

Email: dan.li1@unimelb.edu.au

Ionotronics, an emerging field examining the intertwined interactions between electronic and ionic charge carriers within materials, has already facilitated numerous applications, including energy storage and conversion, energy-efficient separation, sensing, actuation, and neuromorphic computation. Nevertheless, this area still holds many fundamental and technological challenges yet to be addressed. In this presentation, I will discuss our recent research on ion transport within graphene-based membranes, illustrating how 2D nanomaterial membranes can serve as an effective platform for harnessing the immense potential of ionotronics for a sustainable world.

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Professor Dan Li is an Australian Laureate Fellow at the University of Melbourne who is dedicated to developing innovative materials and ionotronic systems to tackle global challenges related to energy, healthcare, and the environment. He is widely recognized for his pioneering research in graphene-based soft materials, 2D nanoionics, and ionotronics, which have led to several prestigious awards, including the Australian Research Council (ARC) Queen Elizabeth II Fellowship, Scopus Young Researcher of the Year Award, ARC Future Fellowship, and Australian Laureate Fellowship. He has also been named a Highly Cited Researcher by Clarivate Analytics.

Multifunctional Carbon-based Materials for Energy Conversion and Storage

Ji Liang

*Key Laboratory for Advanced Ceramics and Machining Technology of Ministry of Education,
School of Materials Science and Engineering, Tianjin University, Tianjin 300350, China*

**Email: liangji@tju.edu.cn*

A series of carbon-based noble-metal-free catalysts for oxygen reduction reaction (ORR) has been designed and constructed, with the purpose of developing highly efficient but low-cost catalysts for fuel cell or metal-air battery applications. Their behaviors have been evaluated from both compositional and structural point of view. These new catalysts show very good ORR performance, which is comparable with commercial Pt/C in many aspects. The principles in designing these advanced carbon materials is also applicable to other critical energy storage and conversion processes, including electrochemical hydrogen peroxide fabrication, nitrogen reduction, and metal ion batteries.

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Fabrication of Food Waste-derived Biodegradable Medical Textiles via Electrospinning and Electrospaying for Healthcare Apparel and Personal Protective Equipment

Johnny Sik Chun Lo¹, Walid Daoud², Chi Yan Tsoi¹, Irum Firdous², Bhaskar Jyoti Dekas³, Carol Sze Ki Lin^{1,*}

¹ School of Energy and Environment, City University of Hong Kong, Hong Kong

² Department of Mechanical Engineering, City University of Hong Kong, Hong Kong

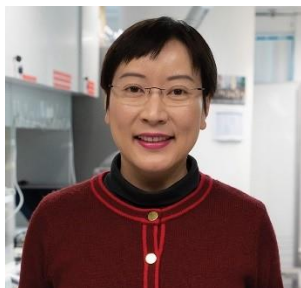
³ Department of Hydrology, Indian Institute of Technology Roorkee, Roorkee 247667, India

**Email: carollin@cityu.edu.hk*

Personal protective equipment (PPE) and healthcare apparel are instrumental in the reduction of risk of viral transmission and infection of COVID-19. Since most PPE are single use items, the demand for research on the production of PPE from bio-based and biodegradable resources is high. Food waste can be valorized into value-added raw materials through a biorefinery process and converted into biodegradable polymers Polylactic acid (PLA) and Poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV). This paper will demonstrate fabrication of medical textile from food waste derived PLA/PHBV via electrospinning and electrospaying process to achieve levels of filtration, breathability and fluid resistance, which is suitable to use as new material in a highly aggressive medical environment.

PLA/PHBV solution with a known concentration and different blend ratios were prepared for electrospinning. Process parameters, e.g., voltage, feed rate, needle tip to collector distance were optimized to obtain uniform nanofibers with optimized properties such as porosity, fibre diameter and thickness. Different concentrations of aerogel incorporated in polydimethylsiloxane (PDMS), polyvinylidene fluoride (PVDF) were electrospayed over a supporting scaffold layer of electrospun PLA/PHBV membrane. The dual-layer membrane is optimized for enhanced hydrophobicity and surface roughness. Multi-spinneret electrospinner was used to carry out the electrospinning and electrospaying processes. Nanofiber and nanosphere were characterized by scanning electron microscopy (SEM). Porosity and pore size were characterized by porometer. Hydrophobicity and surface roughness were characterized by water contact angle and atomic force microscope, respectively.

Biography



Dr. Carol Lin's research group focuses on technological advancement and development of circular waste-based biorefinery for sustainable production of chemicals, materials and fuels, that contributes to reduction of environmental burden of waste disposal and enhancement of resource efficiency. Focusing on these topics, she has secured more than HK\$26 million research funding from various sources. She has been involved in over 20 research projects as Principal Investigator, which mainly focus on development of integrated biorefinery strategies includes valorization of agricultural residues, food, beverage, plastic and textile wastes. She has been involved as an active member of various national and international commissions and committees.

Photocatalytic degradation for remediating PFAS-contaminated water

Yun Liu

Research School of Chemistry, the Australian National University, ACT2601, Australia

Photocatalysts with the appropriate band structure, less charge recombination centres and abundant interfacial sites present promising photocatalytic performance. Research in this field has generally been focusing on incorporating dissimilar materials to prepare heterojunctions. In this talk, I will present two materials design strategies to either build defect clusters to reducing the charge recombination centres or construct intergrown heterojunctions that structurally, the interfacial region is narrowed down to atomic scale, facilitating charge carrier transferring and minimizing potentially unfavoured band bending. Such effectively modified catalysts would greatly enhance photocatalytic effect for highly efficient decomposition of perfluorooctanoic acid with strong C-F bonds.

Integrated bioenergy systems for closed loop organic waste management

Bernadette K. McCabe

Centre for Agricultural Engineering, University of Southern Queensland, Toowoomba

Email: Bernadette.McCabe@usq.edu.au

An integrated, closed loop approach can help agricultural industries make optimal use of their organic waste to produce energy and nutrients in a synergistic cycle of profit-making processes where the by-product of each process becomes the feedstock for another [1]. However, there are some impediments to the full implementation of closed loop technologies, which provides a rich source of research opportunities to improve profitability for the agro-industrial sector [2]. This has been the key challenge to increasing the adoption of biogas plants, with the sale of fertiliser a key missing element needed to make biogas projects economically feasible. This talk will provide an overview and present findings of two areas of closed loop approaches. The first is a summary of our findings in assessing biogas recovery by anaerobic digestion of Australian agro-industrial waste [3] and the development of an innovative online Anaerobic Digestion Assessment Tool which aims to provide a quick, economic feasibility assessment for industry partners interested in anaerobic digestion, as well as identifying co-digestion opportunities in the area [4]. Our aim is to use these outcomes to identify opportunities and minimise uncertainties to facilitate the uptake of biogas technology in Australian agricultural industries. Secondly, to improve the circularity and economics of biogas facilities we are investigating the production of a granulated biofertiliser which is chemically balanced and able to be applied on land [5]. We have conducted a series of interconnected glasshouse and field studies to assess the agronomic performance of the product. Our trials have shown biofertilisers improved soil-nutrient status and has produced higher crop yields compared to urea [6]. The work will improve understanding of the fertiliser replacement value of organic waste and is being applied to other industries such as waste water treatment plants to assess the agronomic value of biosolids-derived biochar.

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Colloid and surface chemistry of clay minerals in the dewatering of fine coal tailings: the paradigm shifts from tailings dams and critical roles of coagulation, flocculation, and reagents

Anh V. Nguyen ¹*

¹School of Chemical Engineering and UQ Node of the ARC Centre of Excellence for Enabling Eco-efficient Beneficiation of Minerals, The University of Queensland, Brisbane, QLD 4072

**Email: a.nguyen@uq.edu.au*

Abstract

Clay minerals interbedded with coal seams and iron-ore surface deposits are often mined and processed together with valuable components during the mining operations and normally ended up in the tailings dams. Since the employed unit operations are water-based, these minerals (particularly smectite or illite clays) tend to swell and breakdown in the process streams to form plastic masses of extremely fine colloidal particles: they have adverse effects on virtually all the operations, critically the stability and operations of fine tailings dams, causing many well-known accidents due to the dam failures. This presentation focuses on the significant aspects of colloid and surface chemistry of clay minerals and relates them with developing important processing routes for the coal processing industry to follow compliance and regulations and optimise the unit operations. The outcomes of our projects, ranging from fundamental studies using atomic force microscopy to reveal the significant properties of clay faces and edges and the ion-specific effects of saline process waters to coagulation, flocculation, and pilot-scale dewatering experiments using solid bowl centrifuges and filter presses will be presented. The paradigm shifts from tailing dams to co-disposals of fine tailings and coarse rejects to dry stacking options will be outlined to demonstrate the efforts of the industry to move into a sustainable future. Developing functionalised reagents to resolve the issues of fine clay minerals in the unit operations and fine coal tailings can help the industry to meet emission targets, increase product quality, and maintain productivity and profitability.

Email abstracts as an attachment to gasc.oz.2022@gmail.com before the abstract deadline **31 March 2023**.

Biography:

Anh Nguyen is a full professor in the School of Chemical Engineering, The University of Queensland, where he held the BMA (BHP Billiton Mitsubishi Alliance) Chair from 2007 till 2017. He was an ARC QEII Fellow and then an associate professor at the University of Newcastle and has held many adjunct and visiting positions overseas, including those at the University of Utah (USA) and Kyushu University (Japan). His research is concerned with applied colloid and surface chemistry in chemical engineering. He is a chief investigator of the ARC Centre of Excellence for Enabling Eco-efficient Beneficiation of Minerals. He published one book on the colloidal science of flotation and over 350 peer-reviewed journal papers and book chapters. He has editorial role on *Advances in Colloid and Interface Science*, and *International Journal of Mineral Processing*.

Green chemistry and practices: the journey from research to delivering sustainable industry impact

Michael O'Shea *

¹ Queensland Alliance for Agriculture and Food Innovation, University of Queensland

**Email: michael.oshea@uq.edu.au*

Originally a research endeavour grounded in theoretical questions, the field of green chemistry is now poised to make the leap towards becoming a long term plank for sustainable practices and impact. In order to achieve this, questions of industry adoption, bottom line economic benefits and the potential impacts (both positive and negative) on industry productivity and sustainability must be addressed.

This presentation will briefly explore agricultural issues from multiple perspectives. It will consider some examples of green chemistry and sustainable applications, but from the varying viewpoints of researchers, collaborations, funders and industry adopters. While the questions posed may be many, the future focus needs to be on the benefits of various applications and how they can be driven from research ideas and eventually translated to demonstrated impact.

Biography:

Dr Michael O'Shea is the Director of Institute Operations at the Queensland Alliance for Agriculture and Food Innovation (QAAFI) at The University of Queensland (UQ). This role oversees QAAFI strategy and operational areas and encompasses business development, grants and partnering, marketing and communications, health and safety, infrastructure and general administrative support.

Prior to joining UQ just over 2 years ago, Michael had a long career within the Australian sugar industry. Across his time at the Bureau of Sugar Experiment Stations and subsequently at Sugar Research Australia (SRA), Michael gained over two decades' experience across varied roles as an industry researcher, program leader, research investment manager, operations manager and Executive Team member.

Michael built and managed SRA's Research Funding Unit which delivered the Rural Research and Development Corporation (RDC) component of SRA's remit. Australia has 15 RDCs which are charged with driving agricultural innovation and impact within their various industries. Michael's team were responsible for developing and driving the sugar industry research investment process and ultimately, the successful delivery of research projects, programs, partnerships, outcomes and impact to the industry.

Most of Michael's career has revolved around driving scientific and operational collaboration to deliver realized value and impact. However, Michael remains a chemist and scientist at heart with a background expertise grounded in diverse areas such as plant chemistry and biochemistry, chemical methods of analysis including NIR spectroscopic methods, diversification opportunities and biomass and sugar quality/processing.

Plasma-nano-electrified clean processes for zero-carbon world

Kostya (Ken) Ostrikov^{1*}, Volker Brueser², Jan Bendikt³, Andriy Styervoyedov⁴, Qin Li⁵

¹ *Queensland University of Technology (QUT), Brisbane, Australia*

² *Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany*

³ *University of Kiel, Germany*

⁴ *Max Planck Institute of Microstructure Physics, Halle, Germany*

⁵ *Griffith University, Brisbane, Australia*

**E-mail: kostya.ostrikov@qut.edu.au*

Opportunities for plasma nanotechnology to contribute to the development of clean and sustainable solutions for the zero-carbon-emissions world are discussed. The highlight is on using plasma-electrified, plasma-catalytic, and hybrid (synergistic) processes for sustainable processing of carbon-rich precursors. The need for these processes is stated by the UN Sustainability Goals and the 2021 Climate Change Conference. The case studies include desalination and recovery of resources from seawater, synthesis of high-performance catalysts, electrodes, and membranes, generation and storage of sustainable energy, capture and conversion of CO₂ to valuable fuels and chemicals, etc. The demands of industry decarbonization necessitate the development of decentralized clean energy production and sustainable resource recovery. The role of plasma processing in the development of low-carbon-emissions technologies, of interest to carbon emissions-heavy industries is emphasized. Decarbonization demands radically new approaches, e. g. electrification (using renewable power P) of the production of materials, chemicals, and fuels (X). We discuss the applications of plasma-power (plasma-P-to-X) to process renewable feedstocks (e.g., industrial and agricultural waste, plastic, carbon emissions, environmental pollutants, biomass, etc.) to produce advanced functional materials, targeting applications in clean and renewable energy conversion and storage, industrial catalysis, chemical products, etc. Support from the Alexander von Humboldt Foundation (Humboldt Award), Federal Ministry of Education and Research in Germany through the Germany-Ukraine PLASMA-SPINergy Core of Excellence, the Australian Research Council, Centre for Materials Science, Centre for Clean Energy Technologies and Practices, and Centre for Waste-free-World is kindly appreciated.



Prof. Ostrikov has gained worldwide recognition across plasma science, nanoscience, materials science, and plasma applications. He is a pioneer and leader in the field of *Plasma Nanoscience* and has led the development of the international collaborative research community. His publications attracted over 37,000 citations and H-index of 89 (GS). His international standing and impact are further evidenced by over 150 plenary, keynote and other invited talks, multiple prestigious awards, honors, fellowships, and professorships in 6 countries, including the Humboldt Prize/Award and Foreign Fellow of the European Academy of Sciences and the Academy of Europe.

New approaches to reducing enteric methane from ruminant livestock.

Ouwerkerk, D.^{1,2*}

¹Agri-Science Queensland, Department of Agriculture and Fisheries (DAF), QLD 4102 Australia.

²QAAFI, The University of Queensland, QLD 4068 Australia

*Email: diane.ouwerkerk@daf.qld.gov.au

The Queensland government has committed to achieving net zero emissions by 2050, with an interim target to reduce emissions by 30% to below 2005 levels by 2030. With agriculture contributing 14.8% of Queensland's 2021 net greenhouse gas (GHG) emissions [1], it has an important role in achieving these targets. The Department of Agriculture and Fisheries has developed a Low Emissions Roadmap providing a framework to achieve lower emissions across five focus pathways including livestock emissions [2]. Ruminant livestock are an important source of anthropogenic methane, produced as by-product from the enteric fermentation of plant biomass in the ruminant digestive system. Decreasing ruminant enteric methane emissions is crucial to achieving emission reduction targets with Queensland having 10.7 million head of cattle, representing 44% of the national herd. There has been over 50 years of research into ruminant methanogenesis, with the enteric methane mitigation research area growing rapidly over the last two decades. Various strategies are being investigated including dietary manipulation, rumen manipulation and breeding selection for low methane-producing animals [3]. The search for ruminant methane-suppressing compounds has resulted in the development of synthetic compounds as highly specific inhibitors of enzymes involved in methanogenesis. The synthetic compound 3-nitrooxypropanol (3-NOP) inactivates the nickel enzyme methyl-coenzyme M reductase [4]. 3-NOP has been shown to be effective in reducing methane emissions in feedlot cattle by up to 90% from day 21 to day 112 [5] and determined to be safe for use in ruminants [6]. *In silico* modelling of interactions of compounds with enzymes in the methane-forming pathway is enabling the identification of potential new inhibitory compounds. Any new methane-suppressing compounds being developed, need to result in lower methane emissions and be shown to have no have toxic effects for animals, humans and the environment.

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- Diane Ouwerkerk Bio document

I am a microbiologist and molecular biologist within the Department of Agriculture and Fisheries, leading the Microbial Ecology Group based at the EcoSciences Precinct in Brisbane. I have a keen interest in using innovative science to better understand the complex role the microbiome (microorganisms, bacteriophage (viruses), and micro-eukaryotes) plays in livestock production systems. I am currently involved in delivering research outcomes through funded projects and developing strategies, research ideas and proposals. My overarching research goal is to achieve real and tangible impacts that improve the productivity, sustainability, and profitability of Queensland's red meat (beef, sheep, goat), dairy and aquaculture industries.

Portable ion chromatography based platform for robust in-field water and soil monitoring of nitrite and nitrate

Yonglin Mai¹, Kurt Debruille¹, Ibraam Mikhail¹, Alireza Ghiasvand¹, Estrella Sanz Rodriguez¹, Vipul Gupta¹, Eoin Murray², Brett Paull^{1*}

¹Australian Centre for Research on Separation Science (ACROSS), University of Tasmania, Hobart, Tasmania, 7001, Australia

²T.E. Laboratories Ltd. (TelLab), Tullow, Carlow, Ireland

*Email: Brett.paull@utas.edu.au

Ion chromatography represents one of many so-called 'gold standard' laboratory technique for environmental monitoring, particularly for common nutrient anions. Currently, grab sampling and lab-based analysis is the typical analytical approach used by the majority of agencies and governing bodies when carrying out such studies. Over the years, several so-called 'portable' ion chromatographs have been developed in various forms, but unfortunately to-date have seen only limited use in real-world applications outside of the laboratory, despite some obvious advantages to be had in doing so. For example, in the area of anionic nutrient monitoring, in both freshwater and saline/estuarine waters, the rapid transformation and loss of anion nutrient species post-sampling is well known, and current methods of catchment assessment are thus prone to vagaries of sample transport and storage, often resulting in completely erroneous results. This issue is highly significant when attempting to evaluate and model large water catchment systems using these traditional 'grab (store) and lab' approaches. Furthermore, study of nutrient mobility and environmental transport requires quantitation of nutrient species in matrices other than natural waters, including for example, spoils and sediments. Thus, the development of field-portable extraction methods is also necessary if the in-field analysis of soils/sediments is of interest. In this presentation, we report upon the development and applications of a totally green, robust and fully portable/field-deployable ion chromatography-based platform, namely the 'Aquamonitrix' nutrient analyser [1-3]. We will outline the analytical performance and capability of the system and demonstrate its versatility in a series of real-world field studies, carried out to evaluate system performance and robustness in challenging locations and environments, including the mobile application of the system on river sampling cruises for a large scale 'whole of catchment' nutrient monitoring, and in the analysis of nitrite and nitrate in soils samples, in the field (literally!). Significantly we will demonstrate the significant quantitative advantages to be had from in-situ real-time analysis, and the issue of significant under-reporting which can arise from current 'grab and lab' approaches to environmental monitoring.

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Bio-based Self-healing Polymers as Sustainable Materials

Kei Saito*

*Graduate School of Advanced Integrated Studies in Human Survivability
Kyoto University*

Higashi-Ichijo-Kan, Yoshida-nakaadachicho 1, Sakyo-ku, Kyoto, 606-8306, Japan

**Email: saito.kei.1y@kyoto-u.ac.jp*

Traditionally, polymers have been designed to possess irreversible covalent bonds between the repeating monomer units. However more recently, significant interest has been directed toward the synthesis of dynamic polymers that are held together by dynamic (reversible) covalent or non-covalent bonds which can reuse and recycle. Within their structures dynamic polymers contain a reversible bond that can be formed from the monomer units and cleaved back to the monomer units by heat or light. $2\pi+2\pi$ cycloaddition reactions are the dynamic reactions which can be formed and cleaved. A select few molecules are known to possess the ability to undergo this type of reaction such as cinnamine, stilbene, thymine, coumarin and styrylpyrene. The first part of this study focused on the full validation of the potential of these unique reversible reactions, topochemically controlled monomer to polymer transformation techniques using $2\pi+2\pi$ cycloaddition reactions are study to create new materials – such as photo-degradable and photo-reusable polymers and self-healing polymers.

Lignin is the second most abundant biopolymer just after cellulose. Its structure is a complex 3D network of phenol compounds linked by C-C (carbon-carbon) or C-O-C (carbon-oxygen-carbon) bonds, thus representing a promising source of aromatic compounds. The second part of this study focused on the production of the novel self-healing materials from lignin. Glycerol-derived polyfunctional monomers having cinnamate groups were produced using a sustainable process from vanillin and syringaldehyde, two compounds readily obtained from the oxidation of lignin to synthesize bio-based photo-crosslinkable/decrosslinkable self-healing polymers. Through a Structure-Activity Relationship (SAR) study, the structural design of these bio-based monomers was optimized with regards to the crosslinking/decrosslinking extent and the self-healing capacity of the corresponding polymer material. Computational density-functional theory (DFT) and time-dependent DFT calculations were further used for the verification of the SAR study in terms of dimerization energy of the synthesized monomers.

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Biography:

Prof. Kei Saito is currently a Professor, GSAIS, Kyoto University, Japan. Before joining Kyoto University in Oct 2020, he was an Associate Professor (2019-2020), Senior Lecturer (2016-2018), and Lecturer (2007-2015) at School of Chemistry, Monash University, Australia.

Solvent-free synthesis of polyphosphoramides as efficient fire retardants for polylactide

Pingan Song,^{1*} Jiabing Feng,² Hao Wang¹

¹ Centre for Future Materials, University of Southern Queensland, Springfield QLD 4300, Australia

² China-Australia Institute for Advanced Materials and Manufacturing, Jiaxing University, Jiaxing 314001, China

*Email: Pingan.song@usq.edu.au

Phosphoramides have shown desired flame retardancy in polymers, particularly in PLA. However, their existing synthesis methods often involve the use of a large number of toxic solvents (e.g., chloroform, triethylamine, and acetonitrile) that do harm to the environment and to human health. To overcome this challenge, we develop a solvent-free synthetic strategy for polyphosphoramides by an amine ester exchange reaction between dimethyl methylphosphonate (DMMP) and diamines (see Figure 1). The results show 1) addition of 2 wt% DM-H makes PLA achieve a desired UL-94 V-0 rating and a high limiting oxygen index (LOI) of 29.7%, primarily owing to its modes of action in the gas phase concerning the effect of radicals quenching and inert gases dilution. In addition, the mechanical properties of the PLA fire-retardant composite are well preserved, such as only a ca. 4% reduction in tensile strength. 2) with only 1.0 wt% of DM-Si, the resultant PLA material exhibits desirable fire retardancy, e.g., a UL-94 V-0 rating and an LOI of 27.9%. This good fire-retardant efficiency is attributed to the P/N/Si cooperative work concerning quenching free radicals and diluting fuels in the gas phase, as well as carbonization with a barrier effect in the condensed phase. Moreover, both tensile strength and transparency of PLA are well-preserved, and the toughness increases by 68%. Our work provides an eco-benign yet facile strategy for the synthesis of phosphoramides flame retardants for creating fire-retardant PLA materials, which hold great promise as sustainable materials for many industrial applications.

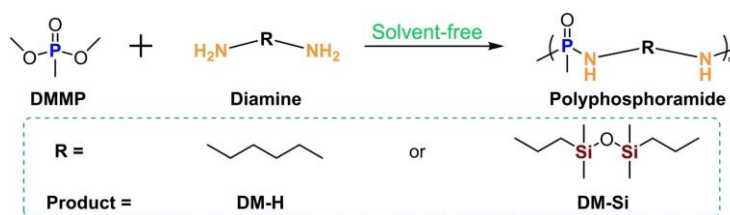


Figure 1. A solvent-free synthetic route of polyphosphoramides

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Techno-economic assessment (TEA) of hydrogen and methane conversion from Victorian agricultural straw biomass

Ross Swinbourn^a, Chao'en Li^b, Feng Wang^{a,*}

^a*Department of Chemistry and Biotechnology, School of Science, Computing and Engineering Technologies, Swinburne University of Technology, Melbourne, Victoria 3122, Australia.*

^b*CSIRO Energy, 71 Normanby Road, Clayton North, Victoria 3169, Australia.*

**Email: fwang@swin.edu.au*

As the most common substance in the universe, hydrogen can be produced from many energy sources with environment benefit. On the other hand, global methane concentrations soar to nearly triple preindustrial levels, researchers fear that global warming itself is behind the rapid rise [1]. Data released recently by the US National Oceanic and Atmospheric Administration show that atmospheric methane has raced past 1,900 parts per billion (ppb). The growth of methane emissions began a rapid and mysterious uptick around 2007. The spike has caused many researchers to worry that global warming is creating a feedback mechanism that will cause ever more methane to be released, making it even harder to rein in rising temperatures. The grim milestone underscores the importance of a pledge made at the 2021 COP26 climate summit to curb emissions of the greenhouse gas, which is at least 28 times as potent as CO₂ [2].

Studies discover that most increase of methane building up in the atmosphere is from biological origin, and landfill and agricultural waste is the 4th largest emission source after wetlands, fossil-fuel extraction, and livestock [2]. Gasification is one of the conventional and mature thermo-chemical conversion processes that enables partial oxidation of biomass at a high temperature in the range of 800–1000 °C, resulting in the conversion of biomass into a flammable gas mixture. The annual global production of agricultural biomass residues is around 140 Gt, predominantly stalks, leaves, roots, fruit peels, hulls, and shells, are normally discarded or burned. Only in the financial year of 2019-2020, Australia produced 17.55 Mt of wheat and approximately 22.82 Mt of wheat straw [3]. The current utilization of agricultural crop residues and wastes presents significant environmental and management issues [4]; however, they are potential feedstocks for a variety of products ranging from the production of fuels to new materials. The present project utilizes techno-economic assessment (TEA) tools to explore the economic feasibility for productions of hydrogen and methane from Australian wheat straw biomass based in Victoria, via the comparison of costs in construction, operation, and taxes, etc. to fulfill the requirements of clean and renewable energy. Preliminary results will be presented.

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Bio: Dr Feng Wang is Professor of Chemistry at Swinburne University Technology. Her expertise covers Molecular Spectroscopy, Computational Chemistry, Materials Simulation and Molecular Physics. Recent years her research concentrates on rational drug design and energy storage materials design. The latter includes organic dye sensitized solar cells (DSSC), liquid organic hydrogen carriers (LOHC) and sustainable aviation fuel (SAF) as well as techno-economic assessment (TEA) for energy material lifecycle. Feng has published over 200 peer review articles. She is Fellow of Royal Australian Chemical Institute (RACI) and Fellow of Australian Institute of Physics (AIP). Feng is the ARC College of Experts (CoE) and Chair of the National Computational Merit Allocation Committee (NCMAS).

High Loading Electrodes for Quasi-Solid Batteries

Da-Wei Wang,^{1*}, Jiaxing Liang¹

¹ School of Chemical Engineering, The University of New South Wales, Sydney, NSW 2052, Australia

*Email: da-wei.wang@unsw.edu.au

Porous electrodes with extraordinary mass transport efficiency in liquid electrolytes are oftentimes incompetent when gel or solid electrolytes are applied because of the escalating ion diffusion limitations brought by the difficulties of infilling the pores of electrode with viscous or rigid electrolytes in the forms of crosslinked networks or solid particles. As a result, the integration of none-liquid electrolytes with electrode active materials through rational design to achieve high utilization ratio becomes an issue, where new electrode architecture could be found valuable.

Learning from the swift ion transport in solvated conductive polymers, we applied the solvated conductive polymers that are also electrically conductive as a mixed-conductive additive to electrodes in solid state batteries where gel or ice electrolytes are used. We noticed that the solvated structures show strong confinement of the solvents (either aqueous or non-aqueous), which are responsible for the fast ion transport kinetics in the absence of flooded electrolytes on electrodes. By using this mixed-conductive additive, it seems promising to eliminate or minimize the use of normal solid electrolytes on electrodes. On the other side, the softness of polymers enables the electrode condensation possible and results in the largely increased electrode density along with the reduced relative porosity. These features are important in allowing well penetrating ion networks for high loading electrodes for quasi-solid batteries working at or below room-temperatures.

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Engineering of Plasmonic Nanomaterials for Surface-enhanced Raman Scattering-based in vitro Cancer Diagnosis

Yuling Wang,^{1*}

¹*School of Natural Sciences, Faculty of Science and Engineering, Macquarie University, 2109, Australia*

**Email: yuling.wang@mq.edu.au*

Abstract: Cancer is a heterogeneous disease, which manifests as different molecular subtypes due to the complex nature of tumor initiation, progression, and metastasis [1]. Therefore, non-invasive and in vitro analysis of circulating biomarkers have the benefit of rapid, low-cost, and little inconvenience to the patients. However, the achievement of liquid biopsy is challenging due to the rare amount of cancer-relevant target biomolecules against an abundant background of non-biotargets. To overcome this technical hurdle in liquid biopsy, we have proposed and utilized surface-enhanced Raman scattering (SERS) spectroscopy as a new analytical tool for in vitro cancer diagnosis, owing to the ultra-sensitivity and multiplexing capability of SERS [2-3]. In this contribution, I will present our recent results [4-7] in this evolving field—from the synthesis of cutting-edge plasmonic nanomaterials [4-5] to the design of biosensor platform [6-7], towards the comprehensive clinical evaluation of SERS strategies in cancer diagnosis [3, 5-7]. By taking advantage of the sensor platform (e.g. microfluidic device) in fast sample preparation and the unique properties of plasmonic nanomaterials, we target simultaneously and selectively detecting a broad panel of cancer biomarkers for cancer diagnosis.

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Brief Biography: Professor Yuling Wang is an Australian Research Council (ARC) Future Fellow and a member of ARC College of Experts (2022-2024) in the School of Natural Sciences at Macquarie University, Sydney, Australia. Yuling completed her PhD at the Chinese Academy of Sciences in 2009. She was then awarded an Alexander von Humboldt (AvH) fellowship (2010) and a German Research Foundation (DFG) Fellowship (2012), working at the University of Duisburg-Essen, Germany. In 2014, she received the ARC DECRA fellowship and worked at the University of Queensland. Since joining Macquarie University in 2017, she has established her group with 5 postdoctoral research fellows, 7 PhD and 2 Master by research students. Her research focuses on platform technologies that use rationally designed nanomaterials and advanced spectroscopic tools for biomarker sensing and cancer molecular profiling, with the aim to enhance in vitro diagnostics and personalized medicine. She has edited 1 book, contributed to 5 book chapters and 128 peer-reviewed journal articles, with over 7500 citations and has an H-index of 51.

Liquids interfacial catalysis and photocatalysis: from the perspective of sustainable chemistry

Jingsan Xu

School of Chemistry and Physics, Queensland University of Technology

Email: jingsan.xu@qut.edu.au

Abstract: Catalysis plays a critical role in molecular transformation and chemical processing. (1) We have developed catalytic processes at the liquid-liquid interfaces in emulsion system to restrain the reaction paths, demonstrating higher atomic efficiency and better selectivity compared to conventional heterogeneous/homogeneous counterparts. (2) Solar energy is considered sustainable than any other energy source. We have used photocatalysis technique for hydrogenation reactions with water as the proton source, instead of using hydrogen gas or organic molecules.

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Short bio:



Prof Jingsan Xu is leading a research group focusing on materials science and energy conversion techniques at Queensland University of Technology. Before commencing at QUT in 2016 as a DECRA fellow, he has conducted research work at the University of California, Berkeley and Max Planck Institute of Colloids and Interfaces. His current research interests include supramolecular chemistry, interfacial catalysis and photochemistry.

High performance anode for direct methane solid oxide fuel cells

Zhonghua (John) Zhu

School of Chemical Engineering, The University of Queensland, Brisbane 4072, Australia

Email: z.zhu@uq.edu.au

Solid oxide fuel cells (SOFCs) have attracted consideration attentions because of their high power output and energy conversion efficiency¹. As the SOFCs usually operate at high temperatures, hydrocarbons such as methane can be directly used as the fuel.² However, for the normally used Ni-based anodes, carbon deposition over the Ni surface significantly hinders the progressing of direct methane SOFCs. Herein, we present our studies on high performance anodes for direct methane solid oxide fuel cells, which have both higher activity and improved stability compared with conventional anode.

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Biography



Prof Zhu's research interests exist in advanced catalysis, gas/liquid adsorption and separation, solid oxide fuel cells and solid oxide electrolysis cells. His publications include one edited book, 8 book chapters, and over 300 journal papers. He holds 8 patents, 5 patents have been licensed to the industrial sponsor. He has raised a total research funding from government and industries in excess of \$30 million. He is the recipient of a number of awards, including RK Murphy Medal 2013, Freehills Award IChemE 2011, 2nd place Innovator of the Year Award Global IChemE 2011, the University of Queensland (UQ) Foundation Research Excellence Award in 2007.

INVITED PRESENTATIONS

Alteration of the cellulose nanocrystal surface chemistry for guided formation of polymer brushes

Nasim Amiralian,^{1*}, Lauren Geurds²

^{1,2} *Australian Institute for Bioengineering and Nanotechnology (AIBN), The University of Queensland*

**Email: n.amiralian@uq.edu.au*

Conductive hydrogels combine the electrical properties of conductive materials such as metallic nanoparticles, conductive polymers, or carbon-based materials with hydrogels' biomimetic features such as high water content and tuneable physical and chemical properties have become promising candidates for developing printable inks for biomedical and electronics industries. Nanocellulose (NC) is the primary building block of plants that gained significant attention as an additive in inks. NC displays time-dependent shear-thinning behaviour, assisting the extrusion process and ink deposition, essential for developing intricate patterns and structures with micrometre precision. In addition, the versatile surface chemistry of NC enables the stabilisation and synthesis of conductive materials such as metallic nanoparticles, supporting the ink formulation[1].

We demonstrate an optimised approach for the esterification while controlling the degree of substitution of the initiator grafted on the surface, maintaining the rod-like morphology, cellulose I structure and minimal loss of the degree of crystallinity. These surface-modified nanocrystals enable the grafting of polymer brush systems with controllable lengths and densities. NC morphology was not compromised after grafting and metal nanorods synthesising[2]. Understanding how reaction variables control and impact the characteristic properties of NC and the degree of substitution guides the tailoring of the surface modification and, as a result, tuning the NC-metal brush systems properties for advanced high-tech applications in different industries including flexible electronics and biomedical.

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Bio:



Dr Nasim Amiralian is the Leader of the Bio-inspired Materials research group at The University of Queensland. Her research focuses on exploring the design and synthesis of tailor-made and precision-engineered biomaterials using agricultural waste to create environmentally friendly products as a replacement for petroleum-based plastics.

The outcome of her work has resulted in the establishment of Australia's first nanocellulose pilot production plant. In recognition of her contribution to the field of nanomaterials engineering and research excellence, she has received several awards including The Eight Australian Women Who Are Shaking up the World of Science (Marie Claire, 2020), one of Australia's Top 5 Scientists (2018), Queensland Women in STEM Prize- judges choice award (2017) and Women in Technology Life Sciences and/or Infotech Rising Star Award (2016). Nasim also is a strong advocate for cultural diversity and equity and supports staff and students to grow as more effective leaders and create social good.

Nanobubble cleaning

Hongjie An, ^{1*} Helena Hansen¹, Lingxi Ouyang¹

QMNC, Griffith University

*Email: hongjie.an@griffith.edu.au

Nanobubbles are tiny gas pockets that can be suspended in bulk or attached to an immersed surface. In recent years, nanobubbles have gained attention due to their various applications in industry, spanning from aquaculture, hydroponics, sanitation, fuel energy, to surface cleaning. In this talk, we will focus on the use of nanobubbles for effectively removing proteins and oil from surfaces, and particles from pores. We conducted experiments to test the cleaning effect of nanobubbles on proteins and oil drops that were deposited on a substrate in a fluid cell. The results showed that nanobubbles can efficiently remove the adsorbed proteins and inhibit their adsorption when premix bubble with proteins. We also evaluated the ability of bubbles to clean particles from pores. In this talk, we will discuss the possible mechanisms of nanobubble cleaning and its potential applications in protein, oil, and particle removal. We will highlight current state-of-the-art research in nanobubble cleaning and the challenges that must be addressed to enable widespread adoption. The potential uses of nanobubble cleaning may extend to a variety of industries, including lake cleaning, mining, food processing, and oil and gas. The work we present in this talk demonstrates the exciting possibilities of using nanobubbles for effective surface cleaning and deep cleaning.

molybdenum-Promoted Surface Reconstruction in Polymorphic Cobalt for Initiating Rapid Oxygen Evolution

Juan Bai^{1,2}, Ziqi Sun^{1,2*}

¹ Centre for Materials Science, Queensland University of Technology, 2 George Street, Brisbane, QLD 4000, Australia

² School of Chemistry and Physics, Queensland University of Technology, 2 George Street, Brisbane, QLD 4000, Australia

*Email: ziqi.sun@qut.edu.au

It is well known that the surface reconstruction of electrocatalysts in the form of phase transition, defect migration, and valence adjustment at the initial stage plays a crucial role in generating truly surface-active catalytic centers and achieving stable surface reactions.^[1] A low activation energy barrier for initiating surface reconstruction is also expected to be crucial for fast and stable electrochemical catalysis.^[2] Despite this, the kinetics of surface reconstruction and its impact on catalytic reactions have been rarely studied. Here, real-time X-ray photoelectron spectroscopy (XPS) structural monitoring of surface chemical state evolution during catalytic reactions is performed using a phase-modulated polymorphic Co-based catalyst with customizable nitrogen-metal bonds via a cationic molybdenum substitution strategy to track Kinetics of initial surface reconstruction during the alkaline oxygen evolution reaction (OER). It is concluded that molybdenum-modulated cobalt-based nanocatalysts can be tuned through good initial surface reconstruction and stable active centers to achieve optimized OER catalysis, accompanied by a low onset overpotential of only 210 mV and 10 mA cm⁻² has a favorable overpotential of 290 mV, which is better than that of commercial noble metal RuO₂ catalysts. Thus, this study provides new conceptual insights into the rational tuning of the initial surface remodeling kinetics for high-performance electrocatalytic reactions.

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Probing the high selectivity of CO₂ toward C₂₊ products using Molecular Modelling

Xiaowan Bai,^{1*}, Yan Jiao¹

¹ School of Chemical Engineering, The University of Adelaide, South Australia 5005, Australia

*Email: xiaowan.bai@adelaide.edu.au

As frontier technology in the field of energy utilisation and carbon neutrality, electrochemical reduction of CO₂ has been regarded as a promising pathway due to its potential for storing intermittent renewable electricity and simultaneously helping to mitigate the currently pressing CO₂ emission concerns.¹⁻² Among various electrocatalysts for CO₂RR, copper (Cu) and Cu-based materials are unique candidates as they can directly reduce CO₂ into high-value multi-carbon (C₂₊) products due to the moderate adsorption of *CO intermediate.³⁻⁴ Despite extensive efforts devoted to CO₂RR, the industrialisation of CO₂RR is still inhibited by its unsatisfactory activity, selectivity, and durability, particularly for value-added ethylene and ethanol products.⁴⁻⁵ Therefore, it is necessary to develop highly active, stable and selective electrocatalysts. Molecular modeling methodologies were used – including Density Functional Theory calculation and Molecular Dynamics simulation – in two directions of exploration to explore promising high selectivity of C₂₊ products: (1) design of efficient electrocatalysts for improving the selectivity of CO₂ reduction to C₂₊ products, including the introduction of Cu clusters or functionalized ligands to promote ethanol selectivity; and (2) probing the dynamic evolution mechanism of catalyst structures under realistic reaction conditions. Taking Cu single-atom catalysts as an example, it was found experimentally that Cu single atoms and Cu small clusters can undergo dynamic transformation under CO₂ reduction conditions and act as active sites to promote the reduction of CO₂ to ethanol.⁶⁻⁷ When the reaction is over or the applied potential is turned off, the Cu clusters can return to the initial atomic dispersion state. However, the origin of the reversible transformation of the catalyst structure could not be observed experimentally. Therefore, molecular modeling is needed to reveal the microscopic reaction mechanism.

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Biography:

Her research interests are focused on the design of electrocatalytic materials for energy conversion and storage and the exploration of microscopic reaction mechanisms. She received her Ph.D. in physics from Southeast University (SEU, China) in September 2021. After graduation, she joined the University of Adelaide as a postdoctoral fellow in the School of Chemical Engineering. She has published 40 papers in journals such as Nat. Common., JACS, Energy Environ. Sci., Adv. Mater., JACS Au, Small, Sci. Bull., Nano-Micro Lett., Carbon, Energy Environ. Mater. She is an early-career researcher and will continue to work hard in her future research career.

UV Wear: Photoswitches and 3D Printing for Rewearable Dosimeters for Sun Protection

Sandra Wiedbrauk^{1,2}, Heather McKinnon³, Levi Swann³, Nathan R. B. Boase^{1,2*}

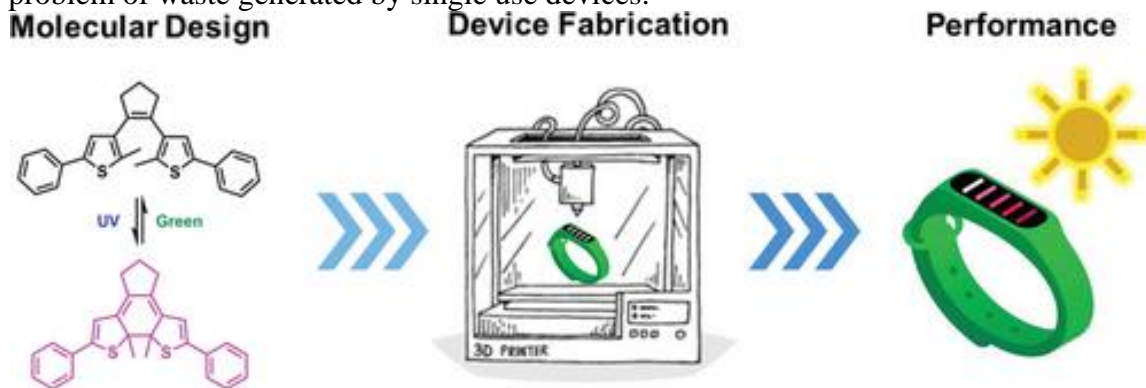
¹ Centre for Materials Science, Queensland University of Technology, Brisbane, QLD 4000,

² School of Chemistry and Physics, Queensland University of Technology, Brisbane, QLD 4000,

³ School of Design, Queensland University of Technology, Brisbane, QLD 4000, Australia.

*Email: nathan.boase@qut.edu.au

Despite the extensive education campaigns linking sun overexposure and skin cancer, mortality and morbidity continue to increase in many parts of the world.^[1] The risk of skin cancer is strongly correlated to overexposure to ultraviolet (UV) light in sunlight, and so can be simply prevented by avoiding sun exposure.^[2] While sun protection can be achieved using sunscreen, clothing and sunglasses, wearers must be made aware of their risk to sun exposure, to facilitate behavior change. In this work we present a new strategy for rewearable and reusable UV sensors, hence overcoming the single use and waste limitations of single use devices. These sun sensor devices are fabricated using photoswitchable diarylethene molecules, that develop a deep colored appearance upon exposure to UV light.^[3] These materials can be reset to colorless within 10 min by exposure to low powered green light, to provide an efficient and reusable system. 3D stereolithographic printing has been used to develop a range of 3D printed sensors, with complex geometries and appealing aesthetics, that can be worn by users in their everyday life. The simple colorimetric response allows for direct visual feedback to the user, allowing for dosimetry of UV exposure over time. A pilot user study has been completed, and early indications on human interaction and perception of the devices will be discussed, in the context of their potential to change behaviour. These new reusable sensors aim to help to reduce people's exposure to sunlight and UV radiation, while not adding to the problem of waste generated by single use devices.



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Biography: Nathan Boase is a senior lecturer at the Queensland University of Technology and a member of the Centre for Materials Science. He completed his Ph.D. at the University of

Queensland in 2015, under the supervision of Prof. Kristofer Thurecht. In 2019 he was recognized as a CAS Future Leader in chemistry. His current research explores controlled synthetic strategies to design materials that can respond to their environment. These materials are applied to solve significant challenges in healthcare, such as antibiotic coatings, nanomedicine, and antivirals.

Ligand Mediated Surface Engineering of Environmentally Friendly Quantum Dots

Dechao Chen^a, Qin Li^{a,b}

^a Queensland Micro- and Nanotechnology Centre, Griffith University, Brisbane, QLD 4111, Australia;

^b School of Engineering and Built Environment, Griffith University, Brisbane, QLD 4111, Australia.

Email: Dechao.chen@griffith.edu.au

Ligand mediated surface engineering is a powerful approach to manifest the physical and chemical properties of quantum dots. [1,2] We present a general top-down and bottom-up method to attract and assemble high-quality carbon dots and zinc-based quantum dots through a colloidal synthesis strategy. The colloidal synthesis improved the quality of quantum dots in its size control and uniformity. The colloidal quantum dots showed an improved emission profile and interesting photophysical properties. The results revealed the surface ligand function and interactions. Benefitting from the outstanding optical and colloidal stability, the colloidal quantum dots demonstrated excellent potential in photo energy conversion applications.

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Tuning of electron configurations in transition metal oxides for higher OER

Zhenxiang Cheng

Institute for Superconducting and Electronic Materials, Innovation Campus, University of Wollongong, North Wollongong, NSW 2500, Australia

E-mail: cheng@uow.edu.au

Electrocatalytic water splitting holds great promise for the future energy conversion devices, but the kinetics of the sluggish oxygen evolution reaction (OER, $4\text{OH}^- = \text{O}_2 + \text{H}_2\text{O} + 4\text{e}^-$) is the rate-determining step and deserves to be studied extensively. The oxygen evolution reaction process not only requires four sequential proton-coupled electron transfers, but also includes a transition in the spin states. Such a spin state transition needs to be promoted by additional energy to occur, enough voltage together with spin orbital coupling.

Considering the scarcity and high cost of commercial OER catalysts, such as Pt and magnetic $\text{RuO}_2/\text{IrO}_2$, a great deal of effort has been expended on possible alternatives. Transition metal-based perovskite is one of the most excellent candidates, owing to its abundance, relatively good stability, and benign electrocatalytic active. In 2011, a volcano-shaped curve of OER efficiency against the number of eg electrons of surface transition metal cations has been proposed by Yang Shao-Horn et al. Following this rule, the fastest OER is observed on $\text{Ba}_{0.5}\text{Sr}_{0.5}\text{Co}_{0.8}\text{Fe}_{0.2}\text{O}_{3-\delta}$ (BSCF), of which the magnetic ions are in the intermediate spin state, that is, the number of eg electrons is around 1.2. Since then, this principle has become an effective guideline to improve the efficiency of perovskite oxide OER catalysts.

Since then the eg electron rule has fully demonstrated its power in OER process. Interestingly, the electron configuration of transition metals also decides the magnetic property of the compounds and finally the electron transfer in the catalytic process. In this talk, using a few examples of transition metal based OER catalysts I will demonstrate how the electron configuration of transition metal decides catalytic behaviour, the spin state transition during OER process and the possible approaches to facilitate the transition.

Biography:



Zhenxiang Cheng earned his B.S. in Physics in 1995 and Ph.D. in Materials Science in 2001 from Shandong University, China. He served as a JSPS fellow (Japanese Society for Promotion of Science) at the National Institute for Materials Science, Japan from 2003 to 2005. Subsequently, he worked as a research fellow at the University of Wollongong from 2005 to 2009. In recognition of his contributions, he received a Future Fellowship from the Australian Research Council from 2009 to 2013. Currently, he holds the position of professor at the University of Wollongong. Dr. Cheng's primary focus lies in the field of ferroic materials, which encompass magnetic, ferroelectric, and

multiferroic materials. His research explores the physics and applications of these materials, with a particular emphasis on energy-related applications such as electrocatalytic water splitting. His extensive publication record includes over 500 papers in reputable journals such as Science, Nature Materials, Nature Communications, Physical Review Letters, Journal of the American Chemical Society (JACS), and Advanced Materials. Dr. Cheng's research efforts have garnered significant

attention and acclaim, accumulating approximately 16,000 citations and yielding an impressive H-index of 63.

Biomass: Waste or an Opportunity?

Deepak Dubal*

Centre for Materials Science, School of Chemistry and Physics, Queensland University of Technology (QUT), 2 George Street, Brisbane 4000, Australia

*Email: deepak.dubal@qut.edu.au

Biomass is an attractive alternative to produce carbon materials, particularly graphenated carbon and hard carbons. Several million tons of agricultural waste is generated in Australia each year, where it is either (a) left in the field, (b) disposed of directly into landfill or (c) combusted to co-generate power or heat for other processes. In landfill, this waste can decompose under anaerobic conditions into methane gas, a potential source of greenhouse gas emissions. Hence, utilising such waste biomass as a precursor for production of carbon products will not only reduce Australia's carbon footprint but also has definite potential for Australian primary producers to value-add and sell into the future high growth energy market. The major challenge in producing carbon products from biomass is efficient and rapid pyrolysis methods. In traditional heating methods, the thermal energy is transferred from the heating element of a heating instrument to carbon precursors via thermal radiation, convection, or conduction through various mediums, leading to waste of heating. We have been developing new rapid heating method to prepare carbon products including graphenated and hard carbons using agricultural waste feedstock. Due to rapid and efficient heating, the carbon products can be prepared in short period of time with high purity and high yield. The resulting carbon materials have applications in clean energy conversion and storage devices.

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Overview on Sugarcane and the industry roadmap SugarPlus

Jason Eglinton,*

¹ *Sugar Research Australia*

*Email: jeglinton@sugarresearch.com.au



Biography:

Dr Eglinton has over 20 years' experience in applied R&D, variety development and commercialisation. He was previously Professor of Plant Breeding at the University of Adelaide leading the development and marketing of malting and feed barley varieties. Dr Eglinton has held a range of leadership roles serving on Boards and committees ranging from academic to commercial and agribusiness settings.

Dr Eglinton joined Sugar Research Australia in 2017, is the Executive Manager for Variety Development, and is the President of the Australian Society of Sugar Cane Technologists.

Drug delivery technologies enabled by metal-organic framework

Zi (Sophia) Gu

School of Chemical Engineering, University of New South Wales, Sydney, NSW 2052, Australia

Email: zi.gu@unsw.edu.au

Metal–organic framework (MOF) nanomaterials have attracted wide attention for biomedical applications and stood out among various nanomaterials due to their unique coordination chemistry, chemical structure, and bio-nano interface characteristics. MOFs are hybrid crystals composed of metal ions or clusters connected by multidentate organic ligands. MOFs possess a metal-organic array structure with high porosity and tunable chemical composition that enable simultaneous delivery of functional metal ions and therapeutic drugs for drug delivery, bioimaging, and multifunctional biomedical applications. In this talk, I will present our recent work on developing smart drug delivery technologies by using zeolitic imidazolate framework-8 (ZIF-8), a typical MOF structure with high hydrolytic stability and sensitive pH responsibility, to deliver therapeutic and diagnostic payloads for targeted delivery, drug repurposing, and cascade catalytic nanomedicine.

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Biography:

Zi (Sophia) Gu is an Associate Professor at the School of Chemical Engineering, University of New South Wales (UNSW Sydney). She leads a NanoBiotechnology Research Group at UNSW, and is a principal investigator in Australian Centre for NanoMedicine and UNSW RNA Institute. After obtaining PhD at the University of Queensland, she secured a NHMRC Fellowship and joined UNSW in 2016. Her research focuses on developing advanced nanomaterials and delivery strategies to address critical issues in pharmaceuticals and health. To date, she has published over 80 journal papers in the areas of nanomaterials and nanomedicine.

Surface modification to enhanced performance in pristine and reclaimed carbon fibres

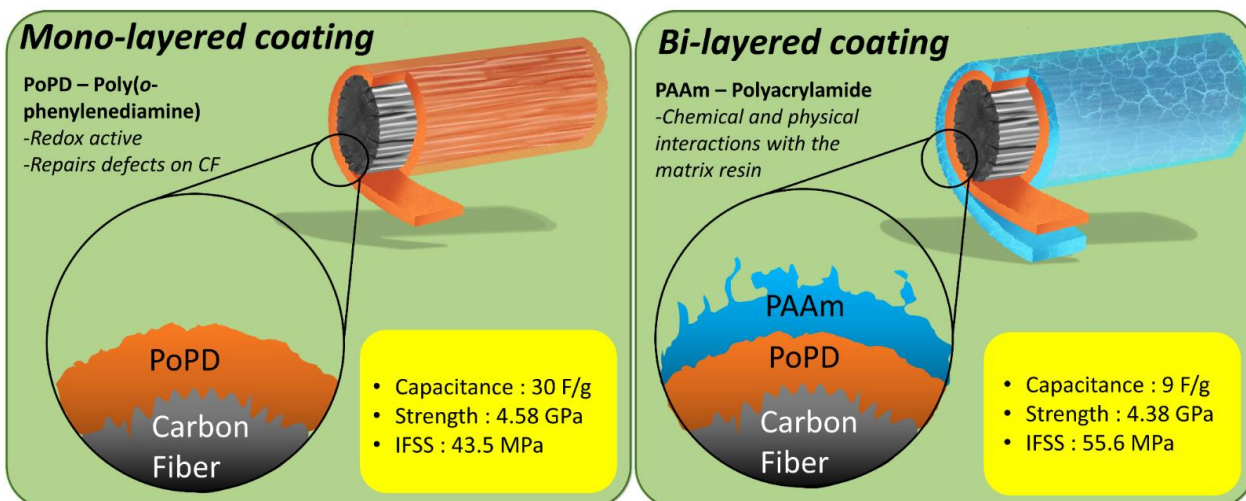
Luke C Henderson,^{1*} Bhagya Dharmasiri,¹ Ben Newman,¹ David J. Hayne,¹ Joselito Razal.¹

¹ Institute for Frontier Materials, Deakin University, Geelong, Victoria, Australia, 3216

*Email: luke.henderson@deakin.edu.au

The application of carbon fibres for energy applications is well established due to their similarity to existing carbonaceous electrode materials. Unfortunately, carbon fibres inherent low surface area is a major limitation in this application. The typical means of ‘surface activation’ involve the subjection of these materials to harsh oxidative conditions that can undermine the physical properties of carbon fibres, thereby devaluing them.

This talk will cover some of our recent efforts to install multifunctionality into carbon fibre composites using a surface modification approach. Specific applications in energy, such as supercapacitors, and environmental remediation will be presented. We have applied this strategy of surface modification and the valorization of waste materials to both pristine and reclaimed carbon fibres. The amount of carbon fibre reclamation is currently only ~2% of the volume produced per year, with the perception being that reclaimed carbon fibre is of little to no value. Therefore, our goal is to demonstrate the value of this currently untapped resource, for high value and possibly unconventional applications (i.e. non-structural).



Biography: Luke completed his PhD in 2007 from Griffith University. He then undertook a postdoctoral role with Prof. Michael Willis at Oxford University, then came back to Australia as an Alfred Deakin Fellow, at Deakin University. He was promoted to Professor in 2020 and his research focusses on the manipulation of surface chemistry and the design of dissimilar material interfaces.

Environmentally friendly methylammonium carboxylate ionic liquids for synthesis of metal halide perovskites

Minh Tam Hoang^{*1,2}, Hongxia Wang^{1,2}

¹ School of Chemistry and Physics, Faculty of Science, Queensland University of Technology, Brisbane, QLD 4001, Australia

² Centre for Materials Science, Queensland University of Technology, Brisbane, QLD 4001, Australia

*Email: m2.hoang@qut.edu.au

The use of metal halide perovskites (MHPs) in photovoltaics has gained significant attention due to their high-power conversion efficiency and low cost. However, the current synthesis methods for MHPs often rely on toxic solvents, which pose significant health and environmental risks. Ionic liquids (MACILs) based on methylammonium carboxylate as a green solvent have emerged as a promising alternative to toxic solvents in the synthesis of MHPs. MACILs offer several advantages, including the ability to control crystal morphology, reduce defects, and improve film uniformity. In this research, I will present our study on the effect of different anions in the MACILs on the growth and morphology of methylammonium lead bromide (MAPbBr₃). Subsequently, we demonstrated a benign method to synthesize green emissive MAPbBr₃ PeNCs by using environmentally friendly MACILs. MAPbBr₃ NCs with controllable sizes and shapes (nanocubes and nanorods) and subsequently with high photoluminescence have been obtained by controlling the alkyl chain length of the carboxylate group and reaction time. Compared to other synthesis methods of PeNCs, the ionic liquid-based synthesis approach has the advantages of facile processing and low environmental impact. It offers a promising solution to the issue of hazardous solvents used in current solution processing of metal halide perovskite materials, paving the way for the development of sustainable fabrication of MHPs based technologies.

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Graphene oxide membranes for purification and separation

Rakesh Joshi*, Xinyue Wen, Dali Ji, Xiaoheng Jin, Tobias Foller

*School of Materials Science and Engineering
University of New South Wales (UNSW) Sydney, NSW Australia*

**Email: r.josh@unsw.edu.au*

We report graphene oxide (GO) based membranes with proper control of structure and morphology for water purification, selective gas separation and moisture adsorption. In collaborative projects with industries, we have successfully employed our GO membrane to remove natural organic matter and other species from water while maintaining high water flux. We have investigated the water transport of cation-intercalated graphene oxide membranes. The cations act as water-attracting impurities on the channel walls. Via controlled water transport experiments, we show that the slip length of the nanochannels decays exponentially with the hydrated diameter of the intercalated cations. We will present our recent findings on the transition metal-incorporated graphene oxide and introduce our straightforward electrochemical method utilizing the angstrom-confinement of laminar reduced graphene oxide nanochannels to obtain a centimetre-scale network of atomically thin 2-dimensional transition metal oxides.

The results discussed here have been (partially/entirely) submitted/presented at other conferences and published in different journals. Everyone contributing to this research is highly acknowledged. Rakesh Joshi will present on behalf of all the researchers/co-authors of the articles published.

In-situ deoxygenation of biomass and polyethylene mixture by trifunctional catalysts

Muxina Konarova,^{1*}, Mohamed Ahmed¹

¹ School of Chemical Engineering

The University of Queensland

*Email: m.konarova@uq.edu.au

Securing sustainable energy sources is essential for combating global warming, a significant challenge confronted by all nations. To attain zero carbon emissions, it is necessary to maximise the use of all existing green resources and reduce waste and pollution. MSW is typically disposed of in landfills despite its high energy density. MSW can be converted into crude bio-oil that has the potential to be refined into liquid fuels through valorisation processes such as fast pyrolysis. For its upgrading, the complex chemical structure of bio-oil derived from municipal solid waste pyrolysis presents challenges and high costs. High-temperature thermal decomposition of polymeric materials is known as pyrolysis. This process can occur concurrently with catalytic upgrading in the same reactor, conserving energy and substantially improving the bio-oil's quality. A multifunctional catalyst can promote multiple reactions during pyrolysis by utilising the synergy between biomass and plastic waste found in municipal solid waste (MSW)[1-3]. Despite extensive studies, difficulties arise in synthesising catalysts that incorporate zeolite, alkaline metals, and transition metals, as well as in preventing coke formation and overcoming diffusion constraints. In this talk, catalytic properties of a trifunctional catalyst containing magnesium, an alkaline metal, and nickel (a transition or noble metal) within a ZSM-5 will be presented. To overcome diffusion limitations, a novel synthesis method involving the growth of a silica shell encasing ZSM-5 crystals containing metals was utilised. During pyrolysis, these multifunctional catalysts allowed for increased carbon recovery and the production of high-quality oil from plastic and biomass mixtures.

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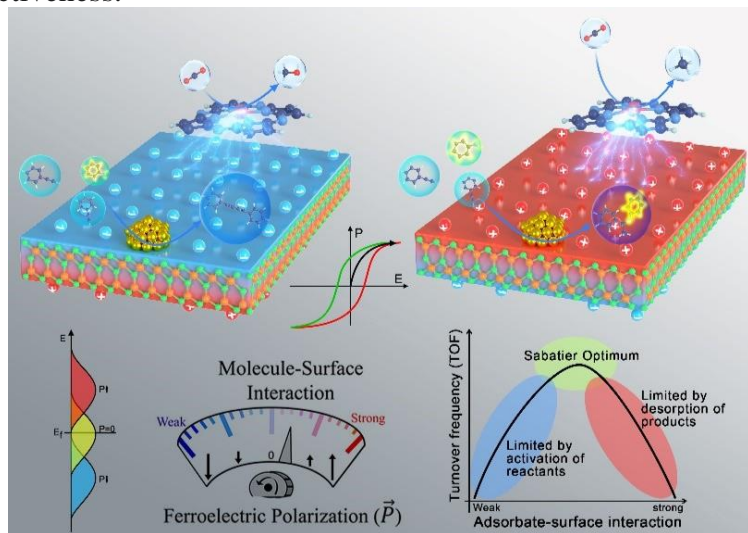
Ferroelectric and Topological Catalysis: Novel Chemical Reactions driven by Physics

A/Prof. Liangzhi Kou

School of Mechanical, Medical and Process Engineering, Queensland university of Technology
Liangzhi.kou@qut.edu.au

Interdisciplinary research is a powerful tool for expanding the boundaries of current research by integrating traditional physical concepts, such as topological states and ferroelectricity, into chemical and energy conversion research. In this talk, we will introduce our recent works in the field of physically boosted chemical reactions, on ferroelectric-controlled chemical reactions and the impact of topological surface states on hydrogen evolution reaction. Specifically, our studies about the effects of reversible polarization on photocatalytic water splitting, gas adsorption, and CO₂ reduction will be comprehensively discussed. In addition, we have clarified the linear relationship between topological surface states and hydrogen evolution reaction, and proposed the density of surface states as an effective descriptor for topological catalysis.

These findings represent a significant contribution to the field of physical chemistry and open a new era of research in the area of physically boosted chemical reactions. The integration of physical concepts into chemical and energy conversion research will allow us to expand our understanding of these important processes and develop new technologies with increased efficiency and effectiveness.



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A/Prof. Liangzhi Kou received his Ph.D. in 2011 from Nanjing University of Aeronautics and Astronautics. He was an Alexander von Humboldt Fellow at the Bremen Center of Computational Materials Sciences (BCCMS) in Germany during 2012–2014, a Research Associate at UNSW Australia in 2014, and ARC-DECRA fellow during 2015-2018. He has been a Lecturer at Queensland University of Technology since 2015 and promoted to senior lecturer in 2018 and Associate Professor in 2021. His research mainly focuses on computational discovery and design of novel 2D materials for energy applications and electronics devices. Until now, he has published over 166 papers with h-index of 51, including Nature Communications, JACS, Nano Letters, ACS Nano, Adv. Sci, Adv. Func. Mater., which have been cited over 9300 times.

Biomimetic 2D layered double hydroxide nanocomposites for hyperthermia-facilitated homologous targeting cancer photo-chemotherapy

Jingjing Wang, Zhi Ping Xu, Li Li*

Australian Institute for Bioengineering and Nanotechnology, The University of Queensland,
Brisbane, QLD 4072, Australia

**Email: l.li2@uq.edu.au*

Nanomedicine with multi-modal therapy has attracted great interest in cancer treatment as it provides enhanced effectiveness and potential stimulation of the immune community. However, off-targeting, insufficient tumour accumulation and systemic side effects of nanomedicine in cancer therapy are still challenging.

Recently, phototherapy, including photothermal (PTT) and photodynamic therapy (PDT), has been intensively exploited to suppress tumor growth by inducing hypothermia and reactive oxygen species (ROS) in the tumors using photosensitizers such as indocyanine green (ICG) under near-infrared (NIR) irradiation. On the other hand, the cancer cell membrane, an active targeting motif and effective biomimetic material, has been coated on the nanoparticle surface for anti-tumor drug delivery to enhance therapeutic efficiency and minimize adverse effects. Herein, we constructed a cancer cell membrane-coated nanomedicine using layered double hydroxide nanoparticles as carriers to specifically deliver therapeutic drugs to the tumours and remarkably reduce immune clearance, significantly improving the accumulation of the therapeutic agents at the tumour sites and their bioavailability. On the other hand, this personalised nanomedicine combined chemotherapy with phototherapy to develop multimodal cancer therapy in one, achieving better performance on tumour inhibitions. This biomimetic layered double hydroxide nanocomposite with cancer cell membrane coating can serve as a potential platform for combination cancer therapy.

Metal-organic framework nanobiohybrids for sustainable engineering applications

Kang Liang^{1,2*}

¹ School of Chemical Engineering, The University of New South Wales, Sydney NSW 2052

² Graduate School of Biomedical Engineering, The University of New South Wales, Sydney NSW 2052

*Email: kang.liang@unsw.edu.au

Nanobiohybrids, synthesized by integrating functional nanomaterials with living systems, have emerged as an exciting branch of research at the interface of materials engineering and biological science. Nanobiohybrids use synthetic nanomaterials to impart organisms with emergent properties outside their scope of evolution. Consequently, they endow new or augmented properties that are either innate or exogenous, such as enhanced tolerance against stress, programmed metabolism and proliferation, artificial photosynthesis, or conductivity.^[1]

In this talk, I will highlight some of my group's recent efforts in the design and engineering of metal-organic framework (MOF) based nanobiohybrids for sustainable engineering applications, to address emerging challenges in biomedicine, energy, and the environment.^[2-15]

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Low dimensional nanomaterials and their hybrids in Sustainable energy application

Ting Liao^{1*}

¹ School of Mechanical, Medical and Process Engineering, Faculty of Engineering, Queensland University of Technology

**Email: t3.liao@qut.edu.au*

Low dimensional nanomaterials have attracted an increasing attention for their unique properties which cannot be obtained from the corresponding bulk forms, such as super-high chemically reactive surfaces, rapid “in-plane” charge transport, significant quantum-confinement effect, etc. In this presentation, low dimensional nanomaterials and their hybrids supported on 2D nanosheet has been studied by DFT-based theoretical calculations, with the aim of understanding the nature and mechanisms of their interfacial electronic coupling, charge transfer, resultant optical response, and catalytic activity in hydrogen evolution reactions (HER), oxygen evolution reactions (OER), and dissociative adsorption reaction of small molecules. Low dimensional nanomaterials and their hybrids, which promote interfacial coupling and efficient charge separation arise from the effects of adsorbent nature, quantum size engineering, and defect assistance, are therefore boost their promising energy correlated applications.

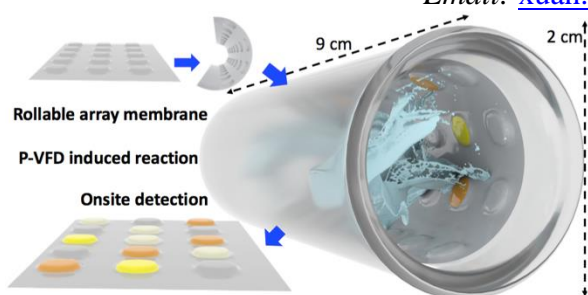
PRINTABLE HYDROGEL ARRAYS FOR PORTABLE AND HIGH-THROUGHPUT SHEAR-MEDIATED ASSAYS

Xuan Luo,^{1*}...Gregory Weiss,² Colin Raston¹

¹ *Flinders Institute for Nanoscale Science and Technology, College of Science and Engineering, Flinders University, Adelaide, SA 5042, Australia.*

² *Department of Chemistry, University of California Irvine, Irvine, California 92697-2025, United States*

*Email: xuan.luo@flinders.edu.au



Hydrogels have been widely used to entrap biomolecules for various biocatalytic reactions. However, solute diffusion in these matrices to initiate such reactions can be very slow. Mixing has been demonstrated to break the diffusion limit and facilitate such reactions, but intense mixing can also lead to irreversible distortions or dislocation of the matrix or even leaking of the entrapped biomolecules. In this case, a target-oriented mixing platform and a tough hydrogel matrix are both needed to completely tackle the issue.^{1,2} Solutions to these challenges will not only have significant implications towards developing simpler and more robust hydrogel/surface binding chemistry, but also establishing various hydrogel associated applications such as shear-mediated hydrogel arrays.

To overcome the diffusion-limit, a shear-stress mediated platform named portable vortex-fluidic device (P-VFD) is developed. P-VFD is a portable platform which consists of two main components, (i) a plasma oxazoline coated polyvinyl chloride (POx-PVC) film with polyacrylamide and alginate (PAAm/Alg-Ca²⁺) tough hydrogel covalently bonded to its surface and (ii) a reactor tube (L x D: 90 mm x 20 mm) where the aforementioned POx-PVC film could be readily inserted for reactions. Through a spotting machine, PAAm/Alg-Ca²⁺ hydrogel can be readily printed on POx-PVC film in an array pattern and up to 25.4 J/m² adhesion energy can be achieved. The hydrogel arrays on the film not only offer a strong matrix for entrapping biomolecules such as streptavidin-horseradish peroxidase (SAV-HRP), but are also shear stress-tolerant in the reactor tube which is also consistent with the shear stress modelling of the device. Through using the tough hydrogel and its stably bonded substrate, the platform enables a >6-fold increase in the reaction rate of HRP and TMB assay, relative to the incubation. It effectively overcomes the diffusion-limit in the hydrogel matrix, without causing appreciable array deformation or dislocation on the substrate film.

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Biography:

Dr Xuan Luo has biotechnology and nanotechnology background. She received her PhD from Flinders University-2019. For her thesis on fabrication of biomedical nano-materials using Vortex Fluidic Devices (VFD) she was awarded the Flinders University PhD award. She then worked as a postdoctoral researcher on vortex-fluidic-mediated biosensor array development. Since 2019, her research has resulted in a number of awards and funding, including the award of Overseas Travel Fellowship from Australian Nanotechnology Network, Flinders University Research Investment Fund and Emerging Research Leader Early Career Researcher Award. Her current research program encompasses multiple projects focused on developing portable device platforms for the immunoassay diagnostic industries.

Metal Halide Perovskites and Derivatives: Addressing Toxicity and Applications Beyond Photovoltaics

Miaoqiang Lyu,^{1, 2*}, Lianzhou Wang^{1, 2}

¹ *Nanomaterials Centre, Australian Institute for Bioengineering and Nanotechnology, The University of Queensland*

² *School of Chemical Engineering*

Faculty of Engineering, Architecture and Information Technology, The University of Queensland

**Email: m.lyu@uq.edu.au*

Metal halide perovskites have attracted tremendous research attention in the past decades due to their rapid progress and breakthroughs as one of the most promising photovoltaic technologies. This family of materials have superior properties, such as solution-processability, easy fabrication with high crystallinity, highly tunable optical bandgaps, high defect tolerance, high light-absorption coefficient and large carrier lifetime, which enable them as very promising candidate for the next-generation of low-cost and high-performance electronic/optoelectronic applications [1-5]. However, serious concerns on the use of toxic lead as well as the instability of these perovskites in humid conditions have triggered efforts towards developing non-toxic and stable organic-inorganic alternatives, which is critically important for their market acceptance in future commercialization [6]. In addition, applications beyond photovoltaics have very attractive opportunities, yet these new research directions are still well under-explored. To this end, we have developed a series of new lead-free metal halide perovskites and perovskite derivatives. We also extend the potential applications of halide perovskites beyond photovoltaics, such as electronic memory, artificial synapse and photocatalysts for solar hydrogen generation. We reported the first halide perovskite-based resistive random access memory in this research field, which has now become a niche research direction in metal halide perovskite. The mixed photonic, electronic and ionic features in the metal halide perovskite and perovskite derivatives endow them with very attractive merits for many applications beyond photovoltaics.

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Silicon carbide electronics for greener bioimplantable applications

Tuan-Khoa Nguyen,¹ Nam-Trung Nguyen,¹

¹ *Queensland Micro and Nanotechnology Centre, Griffith University, Qld, Australia*

*Email: k.nguyentuan@griffith.edu.au

Long-term implantable electronics are of great interest owing to their capability for real-time and continuous cellular-electrical-activity recording. This reduces surgical procedures to replace implants periodically, hence minimizing clinical wastes. Since such systems involve direct interfaces with surrounding biofluidic environments, maintaining their long-term sustainable operation, without leakage currents or corrosion, is a daunting challenge.¹ We introduces an innovative concept for bio-integrated electronics systems using cubic silicon carbide nanomembranes grown on silicon wafers, released and then physically transferred to a flexible substrate.² Our preliminary findings demonstrate that flexible platforms based on nanomembranes of SiC offer several attractive features such as chemical stability in biofluids, outstanding water barrier characteristics and extremely low permeability to ions, suitable for stable operation with projected lifetimes of many decades in biological environments.³ The fabrication approach to release and transfer nanomembranes SiC onto flexible polymer substrates such as polyimide establishes a highly feasible route towards well-suited systems for integration with soft tissues, enabling the development of unusual wide-band-gap semiconducting devices with bendable, foldable and flexible formats and advanced functional modes. We also demonstrated the multiple functionalities in SiC such as transparent electrodes for radio frequency, and irreversible thermal therapy, as well as impedance sensors, and temperature sensors for in situ RF ablation monitoring.⁴ Flexible SiC electrodes also showed their efficiency and potential for effective stimulations of neural system to regain body functions (e.g. for patients with spinal cord injury) through a set of experimental studies on animal models (i.e. mouse model).⁵ The robustness of the SiC bio-interface along with its interesting physical properties including thermoresistive, piezoresistive effects suggest a promising path toward greener and environmental friendly implantable electronics for chronic treatments.

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Manipulating Solution Crystallization for Critical Metals Processing and Utilization

Hong Peng, ^{1*}, James Vaughan ¹

¹ Hydrometallurgy Group, School of Chemical Engineering, The University of Queensland (UQ),

Brisbane, Australia

*Email: h.peng2@uq.edu.au

Abstract: Crystal nucleation from inorganic salt solutions is an important physio-chemical phenomenon which is at the centre of a wide range of industry processes, for producing soda ash and fertilizers (NaCl and KCl) and for precursor materials used in critical metal products (eg Li and Ni salts for batteries). Australia is a major exporter of critical minerals, obtained by dissolution and crystallization. Despite a long history of investigations regarding nucleation and crystal growth, the slow precipitation rate and associated difficulty in process control remain a significant predominantly challenge for the industry. This work will cover some research highlights on utilizing both experimental validation and molecular dynamics simulation to better identify the mechanism of ionic cluster dehydration leading to nucleation and crystallization process, at the atomic level in Hydrometallurgy group, The university of Queensland.

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Biography:



Dr Hong (Marco) Peng is now Amplify Senior Lecturer at School of Chemical Engineering, the University of Queensland (UQ). He gained a bachelor's degree in Minerals Engineering and a Master's degree in Microbiology at Central South University, China followed by a PhD degree in Chemical Engineering at UQ. Before joining UQ, he had industry experience as a chemical engineer at Olympic Dam site and Newcastle Technology Centre, BHP Billiton. His research focuses on fundamental aspects of chemical engineering processes, with a specialization in unlocking nucleation and crystallization phenomena via both experimental and molecular simulation approaches. He applies these understandings with projects on utilization of waste resource as functional materials for water and carbon capture. <https://researchers.uq.edu.au/researcher/8382>

Multiscale modelling of reacting flows and applications: hydrogen production, storage tank and use in steel industry

Yansong Shen

School of Chemical Engineering, University of New South Wales, Sydney, NSW 2052, Australia

Email: ys.shen@unsw.edu.au

Process design and control play a significant role in modern industries. Most processes and reactors are very complex, as they usually involve not only multiphase flows but also heat and mass transfers related to chemical reactions and their interactions and vary intensively in real-time. The operation and reactors must be optimized in order to be competitive and sustainable, particularly under more and more demanding economic and environmental conditions. This will need continuous innovative research and development. Computer simulation and modelling, supported by online data and experiments, have emerged as an indispensable adjunct to the traditional modes of investigation for the design, control and optimization of processes, reactors, and devices. In this presentation, Prof. Shen will report his core research on process modelling of reacting flows and its applications to a range of complex processes and reactors in conventional and emerging industries. Several examples of hydrogen production, storage and use in the steel industry are used for demonstration. The modelling works are indeed helpful in understanding fundamentals and optimising & develop new, cleaner and more efficient technologies with measurable industrial outcomes.

Unveil the Working Principle of the Moisture Electric Generators

Dawei Su*

*School of Mathematical and Physical Sciences, Faculty of Science, The University of Technology
Sydney, Sydney, NSW, 2007, Australia*

**E-mail: Dawei.Su@uts.edu.au*

Abstract: Evaporation-driven electricity generators have recently been proposed to generate electricity by water interacting with nanostructured materials. However, several proposed mechanisms, such as the intrinsic gradient of polar functional groups principle and electrokinetic effect perspective, are in wide discrepancy. Here, through the combination of theoretical calculations involving the time dimension on the electrode's moisturizing process and the experimental analyses, it is revealed the working principle through the water molecule critical triple roles in driving the moisture electric generators (MEG): 1) intrinsic H₂O absorption on the surface of electrode materials and splitting into the hydroxy group and proton due to the polarizability of the electrode surface process determined by the static electric potential of the electrode materials. This process induces the electrochemical potential difference of electrode materials via the workfunction changes, which is the source for the output voltage of MEG; 2) freely diffused proton derived from the H₂O splitting through the interaction with the electrode materials work as the ions charge carriers; 3) via the hydrogen bond of the water molecules to drive ion charge carriers diffuse between the opposite electrode, maintaining the internal circuit current flow. It is successfully unveiled that the anatase TiO₂ based electrode materials for MEG voltage output changes correlated to the domains' workfunction's difference, tuning by the surface adsorption species (H, Cl, OH) and anisotropic exposed crystal facets of the electrode. This work unveils MEG's general working principle and provides the venue for designing the appropriate electrode materials for MEG.

Liquid metal-derived crystals for energy conversion electrocatalysis

Jianbo Tang*

School of Chemical Engineering, University of New South Wales (UNSW), Sydney, New South Wales, Australia

*Email: jianbo.tang@unsw.edu.au

Metal-based catalysts are essential for next-generation electrocatalysis, but their precise design, scalable and sustainable synthesis remain challenging. Solvent-based synthesis is one of the most practiced routes for creating metal-based catalysts, in which metal compounds (such as metal salts) and other reactant(s) are dissolved in an aqueous or organic solvent to form fine metallic structures *via* single or multi-step chemical reactions. Distinct to conventional non-metallic solvents, liquid metals provide high-purity yet strongly interacting environments for thermodynamics-governed (non-chemical) metal crystal growth. Liquid metal-grown crystals reveal unique compositional (e.g., single- or multi-metallic phases) and structural (e.g., facet and grain) characteristics that can be highly desirable in catalysts engineering. In this talk, the unique features of a number of liquid metal synthesis systems will be presented, focusing on two growth modes, namely, surface crystal growth [1,2] and interior crystal growth [3]. The strategies for transforming liquid metal-grown crystals into application-ready catalytic architectures will be further demonstrated along with preliminary results. The potential of using liquid metal-derived crystal structures for energy conversion electrocatalysis will be briefly discussed.

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Engineering Conducting Polymers for Energy Applications

Caiyun Wang*

Intelligent Polymer Research Institute, AIIM Facility, University of Wollongong, NSW2500,
Australia

*Email: caiyun@uow.edu.au

Conducting polymers possess the electronic properties of metals or metal oxides and the mechanical properties of polymers. They are composed of a positively charged polymer backbone with negatively charged dopants. Their “soft” nature allows molecular-level tuning of their properties. They can be used as electrodes alone in the forms of free-standing films and hydrogels. For example, the hydrogel combines suitable mechanical properties for electrode-cellular interactions and appropriate electrochemical properties for a battery.^[1] The single component asymmetric conducting polymer membrane provides ability to capture energy arising from a salinity gradient.^[2] They can also form composites with different types of materials to endow new properties. The integration with a biopolymer silk endows it a biodegradability expanding the application for transient energy storage device.^[3] The incorporation with catalytic Au centers facilitates highly efficient catalytic activity for carbon dioxide electroreduction.^[4]

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Biography:

Dr. Wang completed her BSc at Shandong Normal University, MSc at Nankai University, and PhD at the University of Wollongong. She is currently an Associate Professor at the Intelligent Polymer Research Institute, University of Wollongong. Her research interests include synthesis and application of conducting polymers and 2D materials for wearable/implantable energy storage devices, nanostructured catalysts for electrochemical reduction of CO₂, and asymmetric membranes for osmotic power generation. She has published 2 book chapters and 143 journal articles, which attracts over 7,859 citations generating an h-index of 52 (Scopus).

Coordination-engineered single-atom cocatalyst for high-purity hydrogen production from methanol

Mu Xiao,* Lianzhou Wang

The University of Queensland

St Lucia, QLD, 4072

**Email: m.xiao@uq.edu.au*

Hydrogen as a green energy carrier promises a zero-emission and sustainable future for human society. However, the low density and high explosiveness of hydrogen gas make it challenging to store and transport safely and cost-effectively in large commercial quantities. Methanol has been recommended as one of the most promising liquid hydrogen carriers because of its low cost, easy production from a wide range of sources, liquid phase at ambient conditions, and existed manufacturing and transporting foundations. Solar-driven photocatalytic methanol dehydrogenation holds great promise to release hydrogen from methanol. This approach can achieve the conversion of methanol to hydrogen using renewable solar energy and enable instant hydrogen generation and frequent on-off operating cycles for on-demand hydrogen production using a very simple photocatalytic system. Nevertheless, the purity of produced hydrogen is a concern for various applications, due to the formation of CO, CO₂ and CH₄ by-products. For example, a hydrogen purity of $\geq 99.97\%$ is generally required for fuel cell vehicles to avoid the poison of catalysts. Therefore, the delicate design of photocatalysts is highly desirable to suppress the formation of gaseous carbon by-products for photocatalytic methanol dehydrogenation. In this work, we rationally engineered single-atom cocatalysts and explored their performance for photocatalytic methanol dehydrogenation. X-ray absorption spectroscopy (XAS) and X-ray photoelectron spectroscopy (XPS) analysis identify the specific coordination and electronic state of the single-atom cocatalyst, which can suppress the carbon emission during the photocatalytic methanol dehydrogenation as revealed by the density functional theory (DFT) calculation, resulting in the production of high-purity ($>99.99\%$) hydrogen.

Hierarchical Polymer Design on Hydrogel Surfaces for Biomimetic Electronic Skin

Mengnan Zhang,¹ Shu Gong,² Karen Hakobyan,¹ Kaiqi Pan,¹ Zeyu Shao,¹ Edgar H. Wong,¹ Kang Liang,¹ Wenlong Cheng^{2,*} and Jiangtao Xu^{1,*}

¹ School of Chemical Engineering, UNSW Sydney, NSW 2052, Australia.

² Department of Chemical & Biological Engineering, Monash University, Clayton, Victoria 3800, Australia

*Email: j.xu@unsw.edu.au; wenlong.cheng@monash.edu

Human skin is well known to be an advanced tactile sensing system that comprises complicated structures and multifunctional properties.^[1] To fully imitate the structure and functions remains a great challenge. In this abstract, we report a hierarchical polymer platform to design an integrated electronic skin (e-skin) for skin mimicry in structure and functions (see Figure 1). Unique multifunctional porous polymer films are prepared on the surfaces of diverse hydrogel substrates, yielding unusually durable interfaces which exhibited epidermis-like characteristics.^[2] For instance, the polymer films possess a thickness of 20 to 330 μm and comprise of interconnected nanoparticles tightly bonded to hydrogel surfaces, which structurally resemble the layer of interlocked corneocytes in the epidermis. The hydrogel layer resembles the dermis of skin. Due to these unique structural features, the polymer film exhibits an excellent permeability towards small molecules in the first instance but can then be tailored towards effective protection from excess water loss and for enhanced electrical resistivity. Most significantly, a highly sensitive vertically gold nanowire (v-AuNW) sensor^[3] has been integrated into this hierarchical polymer platform to produce a soft pressure and temperature sensor for the mimicry of sensing function of skin.

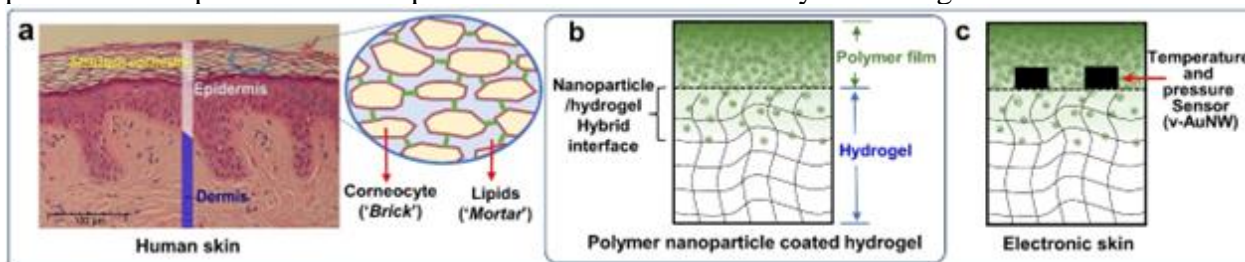


Figure 1. Comparison of human skin anatomy with the skin-like structure of polymer nanoparticle coated hydrogels and integration of electronics into hydrogel. a) Micrograph of human skin indicating the two key layers. b) Schematic structure of polymer nanoparticle coated hydrogel with a comparable bilayer structure to epidermis-dermis, porous polymer film (vs epidermis) and hydrogel (vs dermis) layers. A seamless polymer nanoparticle/hydrogel hybrid interface is present on the top of hydrogel layer to serve the binder between two layers similar to epidermal-dermal junction. c) Integration of a gold nanowire sensor on hydrogel surface using porous polymer films.

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Defective Carbon-based Materials for High-Performance Electrocatalysis

Xuecheng Yan*

*Queensland Micro- and Nanotechnology Centre, Griffith University, Nathan, 4111, QLD,
Australia*

E-mail address: x.yan@griffith.edu.au

The effective production and utilization of clean energy such as green hydrogen is crucial to the sustainable development of mankind, which could relief the greenhouse gas effect caused by the excessive use of fossil fuels. In recent years, hydrogen energy-related technologies such as hydrogen fuel cells and water splitting devices are intensively studied. However, one of the biggest challenges to accelerate their broad application is to reduce the production cost. This is because the expensive noble metal-based materials such as Pt, Ru and Ir, are still the most efficient catalysts for the electrode reactions. In order to replace the precious-metal-based electrocatalysts, both carbon-based metal-free catalysts and non-noble metal-based materials have been widely studied. Particularly, the robust development of the defect engineering provides a feasible strategy to improve the catalytic activity of electrocatalysts. Herein, we developed a series of defective electrocatalysts for different electrochemical reactions by employing the defect engineering. For example, defective porous carbons for the oxygen reduction reaction (ORR), defective graphene for the trifunctional electrocatalysis of ORR, oxygen evolution reaction (OER) and hydrogen evolution reaction (HER). The joint effect of defects and heteroatoms in promoting the electrochemical reactions was investigated as well. In addition, the use of cost-effective highly porous defective carbons as the support could effectively avoid the aggregation of metal species. This could increase the density of the active sites and accordingly improve the catalytic performance of the obtained electrocatalysts. Related work on defects stabilized metal species for high-performance catalysis will also be introduced.

Production of Furfural and Other Bio-Based Chemicals from Catalytic Flash Pyrolysis of Lignocellulosic Biomass

Lian Zhang,^{1*}, Shelly Zhou,¹ Nauman Ahmad,¹ Leo Zhang^{1,2}

¹ Department of Chemical & Biological Engineering, Monash University, Wellington Road, Clayton, Victoria

² Advanced Fuel Innovations, 19 College Walk, Clayton, Victoria

*Email: lian.zhang@monash.edu

Flash pyrolysis of lignocellulose for the production of bio-oil is a promising and feasible route for the generation of sustainable liquid fuel and chemicals. For the resultant primary bio-oil, a further upgrading via hydrotreatment or catalytic cracking is essential to reduce its oxygen content significantly [1]. With regard to the catalytic cracking of bio-oil, the zeolitic catalysts have been employed extensively, due to their established use in the existing fluid catalytic cracking (FCC) units in the refineries. Nevertheless, the other materials such as pyrolytic char have been becoming an emerging alternative to zeolites, due to their abundance, cost-effectiveness and environmental friendliness.

In this presentation for the summary of our studies [2-4], we aim to demonstrate a unique char derived from the pyrolysis of scrap tyre that can efficiently deoxygenate the bio-oil vapour into value-added furfural and phenols, and to elucidate the mechanisms underpinning the catalytic performance and synergy of the inherent zinc (Zn) and sulphur (S) upon their *in-situ* contact with bio-vapours. A micro-reactor namely Pyro-Probe coupled with GC-TCD/FID/MS was used for catalyst screening, which is followed by a large-scale fixed-bed reactor for further validation. Additionally, the catalysts were subjected to a variety of advanced characterisations including synchrotron X-ray adsorption spectroscopy (XAS), X-ray photoelectron spectroscopy (XPS), scanning electron microscope (SEM), transmission electron microscopy (TEM) coupled with small area electron diffraction (SAED), pyridine-Fourier-transform infrared spectroscopy (Pyridine-FTIR), and ammonia-temperature programmed desorption (NH₃-TPD). Finally, based on the composition of scrap tyre char, we further synthesised a nano-sized, Zn-bearing catalyst that can greatly improve the yield and selectivity for furfural [5]. Apart from the extensive testing and advanced characterisation, density functional theory (DFT) calculation and techno-economic analysis (TEA) were also conducted to explore the catalysis mechanism and economic viability, respectively.

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Biography:

Prof Lian Zhang is an academic primarily working on clean energy and fuels in the Department of Chemical and Biological Engineering, Monash University. He has been working on numerous

projects from clean coal technologies to low-emission combustion and waste upcycling. He is also a frequent visitor to Australian Synchrotron beamlines for advanced catalyst and materials characterization. Lian loves to work cross-disciplinarily as well as to work closely with any collaborators who can find a common interest on research.

ORAL PRESENTATIONS

ThermoChemical Dehydrogenation of Liquid Organic Hydrogen Carriers using Innovative Catalyst Technology

Deepali Arora^{1*}, Matt Richards¹, Julia Krstina¹, Xingdong Wang¹, Zongli Xie¹, Stuart Littler¹, Ivan Martinez-Botella¹, John Chiefari¹, and Christian Hornung¹

1 FloWorks Facility, CSIRO Manufacturing, Bag 10, Clayton South, Victoria 3169, Australia.

**Email: deepali.arora@csiro.au*

Liquid Organic Hydrogen Carriers or LOHCs offer an excellent pathway to bind hydrogen for safer storage and transportation, and for clean fuel generation. The Methylcyclohexane (MCH)/Toluene LOHC system is one of the earliest LOHC system explored for hydrogen reforming and has received significant interest in development of alternate technologies for process optimization.¹ CSIRO has developed a new structured catalyst platform that can be used for hydrogen generation from LOHCs in a robust and efficient manner. These 3D-printed catalytic scaffolds or Catalytic Static Mixers (CSMs) offer several advantages of over conventional catalyst packed bed systems (PBS) in that they offer negligible pressure drop, predictable and tunable flow field, the metallic scaffold offers efficient heating and improved catalyst performance. Thus, these CSMs act as great technological alternative to conventional catalyst systems for hydrogen reforming at high temperature/pressure.² A novel 3D scaffold, coated with platinum-based catalysts, is used for the thermochemical dehydrogenation of MCH. The experiments are performed inside a tubular flow reactor, under high temperature/pressure conditions. Sample analysis is performed using ¹H-NMR technology to identify toluene formation. This work will involve investigating the influence of process parameters on reaction kinetics and comparison of CSM dimensions for optimal process efficiencies. Initial experiments show promising toluene generation in the system as high as 25%. Thus, the CSM technology holds significant potential in hydrogen reforming. Through further design and process optimization, it can serve as a strong candidate for on-site hydrogen generation as a compact and robust alternative to conventional catalyst systems.

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Biography:

Deepali Arora is working as a Postdoc (Chemical Engineer) at CSIRO's Manufacturing BU (Clayton, Victoria). Her work on Hydrogen Generation using Catalytic Static Mixers is a crucial project under CSIRO's Hydrogen Mission. She has a Masters in Nanotechnology from India which she complemented with a Doctor of Philosophy in Chemical Engineering from Curtin University (Perth). Her research focus includes flow chemistry, hydrogen, microreactor technology, catalysis, and high temperature/pressure gas processes.

Droplet-based nanoreactor for catalysis and nanostructure fabrications

Lei Bao^{1*}, Haitao Yu¹, Brendan Dyett², Miaosi Li¹

1 School of Engineering, RMIT University, Melbourne, VIC 3000, Australia

2 School of Science, RMIT University, Melbourne, VIC 3000, Australia

**Email: lei.bao@rmit.edu.au*

Surface nanodroplets are referred to small droplets with attoliter to femtoliter in volume and immobilised on substrates in contact with an immiscible liquid phase. The unique microenvironment of surface nanodroplets renders advanced features for miniaturising process and reactions with high efficiency.[1,2] The liquid-liquid interface between nanodroplets and the surrounding phase allows for extended droplet lifetime as well as for reagents imparting from one phase to the other. Within droplets, reactions are compartmentalised and accelerated due to the high surface area-to-volume ratio of nanodroplets.[3]

In this work, we show in situ formation and assembly of gold-thiolate nanostructures in surface nanodroplets. Each droplet served as a nanocompartment to confine the nucleation and growth of the gold nanomaterials. The as-formed gold-functionalised droplets can facilitate a catalytic reaction, leading to a fast fluorescent quench of Nile Red accumulated in droplets.

Moreover, we show that after exposure to air, the shrink of these gold-thiolate decorated droplets led to assembled gold-thiolate nanostructures on the surface. The composition of droplets and the substrate wettability are both key elements to alter these assemblies. The obtained gold-thiolate complex with active gold atoms can serve as scaffolds to enable the selective growth of gold spikes on the top, which have been regarded as favourable structures for surface-enhanced Raman scattering (SERS) substrates. [4] Our results herein highlight the potentials of surface nanodroplets as novel miniaturisation platforms for nanomaterial synthesis, nanostructure fabrication, and catalytic reaction in nanoscale.

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Improved and scaled up green biofuel production

Safira Barros^{1,2*}, Colin Raston¹

1 Flinders Institute for Nanoscale Science and Technology, College of Science and Engineering, Flinders University, Adelaide 5042, Australia

2ARC Industrial Transformation Training Centre for Green Chemistry in Manufacturing

**Email: safira.barros@flinders.edu.au*

The continuous population growth contributes to an increasing pressure to non-renewable sources consumption worldwide, such as fossil fuels, which leads to climate change and air pollution. The demand for renewable fuels led by consumers, supported by changing and encouraging Government policies, and required to deliver reductions in CO₂ emissions to meet commitments made to Intergovernmental Panel on Climate Change (IPCC) is accelerating. In this work, the sustainable biofuel production in the Vortex Fluidic Device (VFD) was exploited, due to its potential to reduce greenhouse gas emissions. The VFD is a high velocity rotating tube, that produces a thin film, increasing mass and heat transfer, promoting micro mixing and reduces processing time and energy consumption. The green reaction was performed in VFD with canola oil, mustard seed oil and waste cooking oil (WCO) as feedstocks. At room temperature and atmospheric pressure, the operational conditions were adjusted for optimization. The biodiesel yields were, respectively, 91%, 90% and 70% with the same optimized variables, without any pretreatment for the WCO. In addition, renewable diesel was achieved in this platform satisfactory.



In industry, to achieve those yields it is necessary to overload the process with solvent and catalyst, due to high Free Fatty Acid (FFA) content in the feedstock. The sustainability of this process is achieved when using less materials and energy, besides renewable sources, to obtain the final product. Biodiesel and Renewable Diesel are clean technologies, and their production is an expanding field, as a low-carbon emission alternative. Finally, due to the use of the VFD, a new sustainable platform, the green biofuel production was improved and scale up for industry application

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Biography:

Ms. Safira Moura Barros has an undergraduate degree in Bachelor of Chemical Engineering at UFBA, Brazil, 2016. During this period, she was an exchange research student for one year at University of Strathclyde, Glasgow, UK in 2014. There, she was able to continue her previously two years of research scholarship about potential industrial applications of protic ionic liquids, aiming greener chemical process, and achieving some international publications. In her final years as an undergraduate student, she worked as an intern with the process and quality engineering team at Xerox Corporation for one semester.

Following on from this, Safira worked in the private sector on Process Safety Management (PSM) with chemical industries, and then Business Innovation, promoting improvements on small local companies. Currently, Safira is undertaking her PhD under the supervision of Professor Colin Raston and Youhong Tang in Flinders University, Australia. With a passion for sustainability in chemicals and energy process, the project's field is organic/inorganic chemical reaction and catalysis under high shear stress for the biofuel industry. The aim of the project is to apply green solutions to the chemical process, with real industry applications. In addition to being supervised by experts in the field at Flinders University, Safira is receiving mentoring and experience from her industry partner: BioWorksTM. They are an independent private company in Australia, with specialist expertise in producing bio-oils. Safira's expectation with this project is to deliver a better understanding and knowledge in the field required for a less costly, green, and sustainable process.



Machine Vision Systems in Agriculture and Aquaculture

Andrew Busch¹

¹ *Institute of Integrated and Intelligent Systems, Griffith University*

**Email: a.busch@griffith.edu.au*

Agriculture and aquaculture are key industries for Australia, contributing more than 2.5% of the GDP, and over 11% of total exports. Despite the importance of these industries, farming methods have been relatively slow to change, with the majority of farmers relying largely on the same techniques and knowledge for the last five decades. This has had significant implications in terms of relative yield, water use, pesticide and herbicide use, and transportation costs. The cost and access to labour is also a pressing issue, with crops often left to rot in fields due to the unavailability of adequate staff to pick them.

Technical innovation in agriculture and aquaculture has the potential to address these issues, increasing yield, reducing resource usage, and reducing the reliance on seasonal labour. One such technology that has seen increasing application within agricultural industries is machine vision, which is used both to provide guidance for robotic operations, and also for quality assurance and crop management. In this work we will provide an overview of the use of machine vision in agriculture and aquaculture, together with current research results and applications in the field.

Strawberry farming is one example of an effective use of machine vision. Accurate recognition and classification of strawberries allows for both robotic harvesting, and automated quality assurance. While there are significant operational challenges to the deployment of this technology, the move towards protected cropping for high-value crops such as strawberries presents an excellent opportunity to take full advantage of vision systems. For broad acre cropping, sugar is another important industry, with Australia being the second largest exporter of sugar worldwide. Vision systems are now seeing increasing use in this industry, with intelligent camera systems monitoring planting, harvesting, and milling operations. Results from current research show that these systems have the potential to accurately identify and classify individual cane billets, giving their size, quality, and planting suitability. By properly utilizing this data, cane farmers can decrease costs by reducing planting tonnage, increase yield by reducing planting gaps, and provide real-time feedback to farmers during planting and harvesting to allow for optimization of these operations.

Bio:

Andrew Busch is an Associate Professor within the School of Engineering and Built Environment at Griffith University, and a member of the Institute for Integrated and Intelligent Systems and the ARC Industry Transformation Hub for Farming Productivity and Disease Prevention. His research interests include image processing, machine vision systems, artificial intelligence and agricultural engineering.

Electrochemical polymerized cobalt phthalocyanine polymer for heterogeneous electrochemical reduction of carbon dioxide

Permsak Chairat^{1,2*}, Supawadee Namuangrak³, Yijiao Jiang,² Patchanita Thamyongkit¹

¹ Department of Chemistry, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand

² School of Engineering, Macquarie University, Sydney, NSW 2109, Australia

³ Nanoscale Simulation Research Team
National Science and Technology Development Agency, Pathum Thani 12120, Thailand

*Email: permsak.chairat@mq.edu.au

Cobalt phthalocyanine (CoPc) was reported as an efficient electrocatalyst for CO₂-to-CO conversion with high faradaic efficiency of CO [1]. However, its large π -conjugation system with planar structure induced the aggregation phenomena resulting in lower catalytic activity and conductivity [2]. To resolve this issue, the CoPc catalyst was deposited onto the supports like carbon nanotubes (CNTs) and chemically polymerized on the electrode [2,3]. In this work, we use electrochemical polymerization of CoPc bearing 4-amino phenoxy substituents on β -position (**CoPc-1**) on conductive substrates including an indium tin oxide-coated glass (ITO-coated glass) and a carbon fiber paper (CFP) to prepare the catalyst. The CoPc presence in the polymer films was confirmed by comparing the absorption feature and reduction peak with its monomer using ultraviolet-visible (UV-vis) spectrophotometry and square wave voltammetry (SWV), respectively. The formation of phenazine linkages in the **CoPc-1** framework was identified using Raman and Fourier transform infrared (FTIR) spectroscopy. The heterogeneous electrochemical reduction (ECR) of carbon dioxide (CO₂) with **pCoPc-1**/CFP electrodes was conducted in 0.5 M KHCO₃ aqueous solution with a continuous flow of CO₂ at 5 mL·min⁻¹. In a controlled potential electrolysis (CPE) experiment at an optimal potential of -1.19 V vs. normal hydrogen electrode (NHE) for 1 h, **CoPc-1** polymer catalyzed the conversion of CO₂ to CO as a major product with current density, Faradaic efficiency (FE) and turnover frequency (TOF) of 4.6 mA·cm⁻², 93.0 % and 8.3 s⁻¹, respectively. Moreover, this polymer provided a stable CO₂-to-CO conversion with FE_{CO} of >90% in a 16-h experiment. This research demonstrates the use of the electropolymerization process to produce the Co(II) polymers as efficient electrocatalysts for CO₂-to-CO conversion.

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Stage-1 C₆₀ Intercalated Graphene Films

Sam Chen

School of Environmental and Life Sciences

The University of Newcastle, Callaghan, New South Wales, Australia 2308

**Email: sam.chen@newcastle.edu.au*

Multi-dimensional “nano-carbon” allotropes can be used as building blocks for constructing unconventional nanostructures. To date, the most extensively studied members of this family are fullerenes, carbon nanotubes and graphene. Despite the challenge of precise control over the self-assembly process, a range of novel hybrid materials based on those existing forms of carbon have been developed, including “peapods” and “nanobuds”, C₆₀-graphene “sandwich” films, composites made by physical mixing, and covalent hybrids involving stronger intermolecular interactions. In this talk, I will introduce our latest efforts on the experimental realization of stage-1 C₆₀-intercalated graphene films, including analysis on their structural and chemical features.¹ Such a novel form of carbon nanostructures could open many new research avenues in carbon science and applications towards clean technologies.

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Production of hydrocarbons Via catalytic pyrolysis of microalgae using CeO₂/ZSM-5

Tewodros Kassa Dada*, Elsa Antunes

College of Science and Engineering, James Cook University, Townsville, QLD 4811, Australia

**Email: tewodroskassa.dada@jcu.edu.au*

Abstract

In this work, Py-GCMS technique was employed to investigate the catalytic pyrolysis of microalgae with and without a catalyst in this study. The study examined the impact of temperature (450, 550, and 650°C) and catalyst to microalgae ratio (1:1, 1:2, and 1:4) on the aromatic content. The catalyst was analyzed using various techniques such as scanning electron microscopy, X-ray photoelectron spectroscopy, N₂ adsorption-desorption, and Fourier-transform infrared spectroscopy. The Py-GCMS outcomes showed that yielded the most substantial aromatic output of 60% at a temperature of 550°C and a catalyst to feedstock ratio of 1:1. As the CCP temperature increased from 450°C to 650°C, the formation of radicals and a hydrocarbon pool promoted the conversion of phenols into poly-aromatics, resulting in an increase in the aromatic yield to 70%. CeO₂/ZSM-5 displayed the greatest selectivity for higher aromatic yield. Furthermore, based on the relative content of BTEX, the effect of temperature, the mechanism for the formation of major aromatic compounds, and the carbon number during catalytic pyrolysis of microalgae were discussed.

Carbon neutral methane production via CO₂ hydrogenation over ZrO₂ catalysts

Venkata D. B. C. Dasireddy,^{1*} Karen Wilson¹ and Adam F. Lee²

1Centre for Advanced Materials & Industrial Chemistry (CAMIC), RMIT University, Melbourne VIC 3000, Australia

2Centre for Catalysis and Clean Energy, School of Environment and Science, Griffith University, Gold Coast Campus QLD 4222, Australia

**Email: venkata.dasireddy@rmit.edu.au*

Fossil fuel combustion is a major contributor to atmospheric greenhouse gas emissions (as CO₂) and attendant anthropomorphic climate change. Methane, as natural gas, remains a major global energy vector via combustion, and hence carbon neutral routes to its production will underpin the ongoing transition to renewable energy resources such as solar, wind and hydroelectric. Liquefaction and transport of methane is cheaper and technologically simpler than hydrogen. [1] An attractive route to low carbon methane is the hydrogenation of CO₂ from flue gas or direct air capture. CO₂ methanation (the Sabatier reaction) is exothermic ($\Delta G_{298K} = 131 \text{ kJ.mol}^{-1}$) with water as the by-product, however the design of active and selective catalysts able to operate at a low temperature, and resistance to sintering and coking, remains a challenge.[2] Ruthenium is one of the most promising metals for catalysing methanation,[3] however it is widely accepted that the reaction proceeds via a bifunctional mechanism in which metal oxide supports influence CO₂ activation and the spillover of carbon species and atomic hydrogen to/from metal sites.

Here we describe a systematic study of CO₂ hydrogenation over a family of Ru/ZrO₂ catalysts in a packed-bed, continuous flow microreactor, and parallel operando diffuse reflectance Fourier Transform infrared (DRIFTS) measurements to develop structure-reactivity relationships.[4] Catalyst pre-reduction strongly influenced light-off temperature, with high CO₂ conversion (~85 %) and CH₄ selectivity (>98 %) achievable at 300 °C. Higher reaction temperature suppressed CO₂ conversion, possibly due to methane partial oxidation to CO and the concomitant water gas shift reaction ($\text{CO} + \text{H}_2\text{O} \rightleftharpoons \text{CO}_2 + \text{H}_2$). Operando DRIFTS identifies co-existing (bi)carbonate, formate and reactive intermediates, whose surface speciation depends on the Ru particle size, support acid and redox properties, and reaction environment. High CO surface coverages suppress CH₄ formation.

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Approach for Green and efficient extraction of Platinum Group Metals

Alex Duan,^{1*} Yeong Ni H'Ng,² Ines Gameiro De Sa Almeida,² Rob Lamb,² Spas Kolev²

¹ Melbourne TrACEES Platform, University of Melbourne, Victoria, 3010

² School of Chemistry, Faculty of Science, University of Melbourne, Victoria, 3010

**Email: duanx@unimelb.edu.au*

Platinum group metals (PGMs), including platinum, palladium, and rhodium, have very unique properties that demonstrate crucial for various industrial applications. However, their low concentrations in the Earth's crust (<0.001%) and limited availability in specific areas make their recycling and reuse imperative for sustainable development and circular economy. In particular, a spent catalytic converter in automobile industry may contain as high as 0.5%. While many studies have investigated the extraction process of PGMs, there has been a lack of comparative studies to determine the optimal extraction efficiency in the hydrometallurgical process. This study investigated the roles of extractants and extraction methods with a focus on green chemistry. The results of this study will provide valuable insights into the recovery of PGMs from spent automotive catalysts and contribute towards their sustainable use with a greener extraction process.

Infrared spectroscopy: Alternative method for assessment of trace elements and mineral composition in soil

U.G. Mihiri Ekanayake , ^{1*}, Brianna Ganly², Nina Welti¹

¹ *CSIRO, Agriculture & food BU, Waite Rd, Urrbrae SA 5064*

² *CSIRO, Mineral resources, Waite Rd, Urrbrae SA 5064*

**Email: uda006@csiro.au*

Agricultural product provenance is emerging as a major concern globally for consumers, the food industries, and regulatory bodies due to product safety issues, fraudulent relabelling of products, and a desire by consumers to know the origin of the products. Australia, having reputation as a provider of high-quality products such as beef, wool, wheat, cotton, dairy, wine etc. being able to verify the product geographic origin is a key requirement for protecting the high-quality brands of Australia. Product provenance has been studied using various analytical techniques including DNA traceability, stable isotope analysis, and trace element analysis. However, the common methods that are used to analyse the isotopes and trace elements, which are isotope ratio mass spectrometry (IR-MS) and X-ray fluorescence spectroscopy (XRF) are cost intensive, required special sample preparation, and require special training in the sample analysis. The main objective of our work is to develop an easy, low cost, user friendly, robust, and efficient method to analyse the composition of agricultural products and identify their product origin. As the initial step, we used the short and mid infrared spectra to identify the trace elements in a sample, which has the potential to become a key technique underpinning food origin and traceability.

How small is the big problem? Small microplastics <300 µm abundant in marine surface waters of the Great Barrier Reef Marine Park

Khay Fong^{1,2*} Maddison Carbery¹, Frithjof Herb¹, Julien Reynes^{3,4}, Christopher K. Pham⁵, Roman Lehner⁶

¹*School of Environmental and Life Sciences, University of Newcastle, Callaghan 2308, NSW*

²*School of Chemistry, Monash University, Clayton, VIC 3800, Australia*

³*Institute of Geological Sciences, University of Bern, CH-3012 Bern, Switzerland*

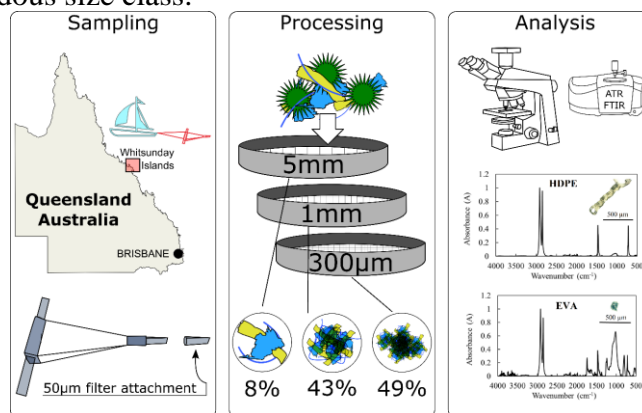
⁴*Institute of Earth Sciences, University of Lausanne, G'éopolis, Quartier Mouline, 1015 Lausanne, Switzerland*

⁵*Instituto de Investigaç~ao em Ci^encias do Mar – IMAR/OKEANOS, Universidade dos Açores, 9900-138 Horta, Portugal*

⁶*Sail and Explore Association, Kramgasse 18, 3011 Bern, Switzerland*

*Email: khay.fong@monash.edu

Particle size plays an important role in determining the behaviour, fate and effects of microplastics (MPs), yet little is known about MPs <300 µm in aquatic environments. Therefore, we performed the first assessment of MPs in marine surface waters around the Whitsunday Islands region of the Great Barrier Reef Marine Park, Australia, to test for the presence of small MPs (50–300 µm) in-situ [1]. Using a modified manta net, we demonstrate that MPs were present in all marine surface water samples, with a mean sea surface concentration of 0.23 ± 0.03 particles m⁻³. Microplastics were mainly blue, clear and black fibres and fragments, consisting of polyethylene terephthalate, high-density polyethylene and polypropylene plastic polymers. Tourism and marine recreation were considered the major contributing sources of MPs to surface waters around the Whitsunday Islands. Between 10 and 124 times the number of MPs exist in the 50 µm–300 µm size class, compared with the 1 mm–5 mm size range. This finding indicates that the global abundance of small MPs in marine surface waters is grossly underestimated and warrants further investigation. Research into the occurrence, characteristics and environmental fate of MPs <300 µm is needed to improve our understanding of the cumulative threats facing valuable ecosystems due to this smaller, potentially more hazardous size class.



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Earth's magnetic field effects on fluid flow dimensions in the VFD: Applications for Green Chemistry

Zoe Gardner,^{1*} Colin Raston¹

¹Flinders University

*Email: zoe.gardner@flinders.edu.au

The Vortex Fluidic Device (VFD) has emerged as a powerful tool for a range of green chemistry processing applications including chemical and nano-material synthesis.^[1] Optimizing fluid flow is critical for achieving desirable results as the enabling precise control over fluid behavior effects the reaction conditions. Over the last few years inroads into understanding the complex fluid behaviors has enabled key insights into the nature of the fluid flow in monophasic^[2] and biphasic^[3] conditions. Recently it has emerged that the earth's magnetic field itself can alter processing outcomes. Presented is evidence for the earth's magnetic field impacting the fluid flow in the VFD through systematic analysis of 'molecular drilling' into thin films of polymer, coupled with study of chiral nanomaterials. Understanding the outcome boosts the arsenal for improving chemical transformations for all applications in the microfluidic platform, however the potential influence of this effect goes beyond the VFD and is relevant to all chemical processing.

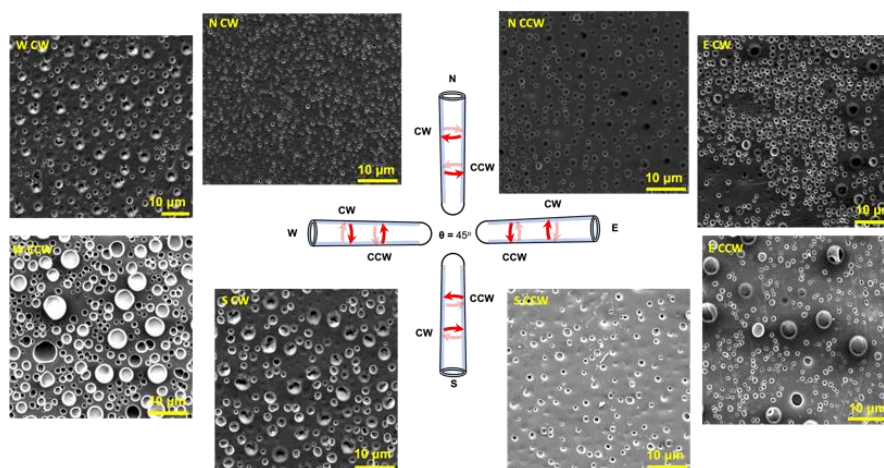


Figure 1: Comparison of the effect of the Earth's magnetic field on the diameter of the holes drilled by the fluid flow at 7750 rpm onto a thin film of polysulfone, layered against the inner wall of a 20 mm quartz tube; CW is clockwise rotation and CCW is counterclockwise rotation.

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Biography:

Zoe Gardner is a PhD student at Flinders university specialising in green chemistry applications for the Vortex Fluidic Device (VFD) under the supervision of Professor Colin Raston AO. Zoe completed her a Bachelor of Science (Clean Technology) (Honours I) at Flinders University in 2020, during which she received a New Columbo Plan scholarship. This year she was awarded a Fulbright scholarship to undertake 6 months research the UCI with Professor Greg Weiss.

Vertical graphene structure for energy applications

Zhaojun Han^{1,2,*}

¹ *CSIRO Manufacturing, Lindfield, NSW 2070*

² *School of Chemical Engineering, The University of New South Wales, Kensington, NSW 2052*

*Email: zhaojun.han@csiro.au

Energy conversion using renewable electricity is critical for a sustainable energy future, yet its widespread application is hampered by the high cost and scarcity of noble metal-based electrocatalysts. Here we report a range of hybrid electrocatalysts based on vertical graphene as the support for both hydrogen production and CO₂ reduction reactions (CO₂RR) [1-6]. Our results show that the group of vertically aligned hybrid catalysts could open new opportunities for low-cost and high-efficiency energy conversions.

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Biography:

Dr. Zhaojun Han is currently a Future Fellow at UNSW and Senior Research Scientist at CSIRO. His research focuses on developing low-dimensional functional materials to tackle the challenges in materials, energy and environmental science. He has published ~150 peer-reviewed papers in journals with a total citation of ~7000 and H-index of 46. He is the key inventor of two graphene-based technologies, the GraphAir technology and the vertical branched graphene technology. He is the recipient of awards such as ARC Future Fellowship, 40 under 40 Most Influential Asian-Australian, CSIRO Corporate Citizen Award, Australia-China Young Scientists Exchange Program Award, ATSE Priming Grant Award, Julius Career Award, and ARC Discovery Early-Career Researcher Award (DECRA).

Upsized Vortex Fluidic Device Enhancement of Mechanical Properties and the Microstructure of Biomass-Based Biodegradable Films

Shan He, ^{1,2*}, Colin L. Raston ^{2*}

¹ School of Chemistry and Chemical Engineering, Guangzhou University, Guangzhou City, China

² Flinders Institute for Nanoscale and Technology, College of Science and Engineering, Flinders University, Bedford Park, SA, Australia

*Email: he0091@gmail.com

A process for fabricating biodegradable polymer films from renewable feedstocks, namely, agar, alginate, and glycerol, with enhanced mechanical properties has been developed. A critical step in the process involves use of high shear stress and micromixing in a liquid thin film in an energy-efficient upsized vortex fluidic device (VFD) operating under confined-mode conditions¹. The upsized VFD having a 50 mm-OD diameter tube tilted at 45° requires a fraction of the processing time and energy consumption relative to the standard VFD having a 20 mmOD diameter tube tilted at the same critical angle, Figure 1. It also overcomes difficulties of jet feed blockage and excessive gelling close to the base of the rapidly rotating tube for the high-viscosity liquid mixture when it is processed in the standard VFD operating under continuous flow for throughput competitive comparison. The enhanced mechanical properties of the polymer films (e.g., 0.14 strain) relates to the formation of a uniform solid inner microstructure and a smoother surface devoid of porosity. This is in contrast to using conventional autoclave processing, which affords films with weaker mechanical properties (e.g., 0.04 strain) having an inner microstructure with cracks and a rougher surface. In addition, the biodegradability of the polymer film produced using the upsized VFD (6 days) was not compromised relative to that produced using conventional autoclave processing. The overall facile scalable processing in generating a polymer with stronger mechanical properties is devoid of auxiliary substances and is high in green chemistry metrics.

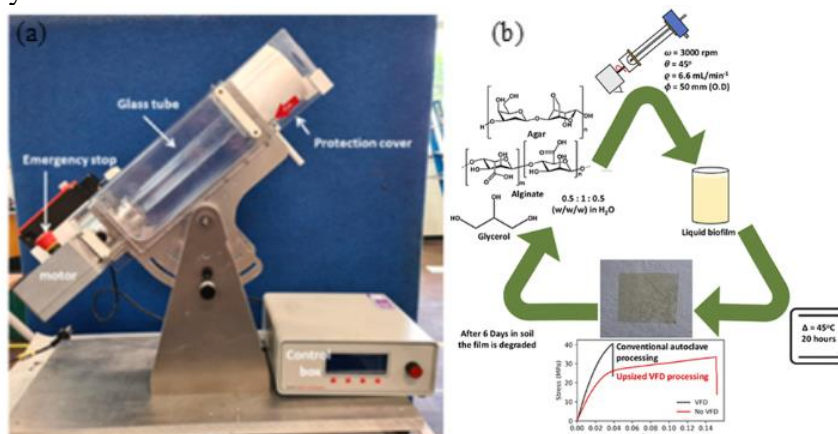


Figure 1. (a). Photograph of the upsized VFD, highlighting its salient features including the central 50 mm-OD quartz tube. (b). Cartoon of the processing and biofilm product produced by upsized VFD

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Transfer and Polymerization of Fullerene Films

Jack Hogan,^{1,*} Sam Chen ¹

¹ *School of Environmental and Life Sciences*

The University of Newcastle, Callaghan, New South Wales, Australia 2308

**Email: JackHogan88@outlook.com*

Carbon allotropes have been the focus of much attention over the past few decades. One such allotrope, fullerenes ('buckyballs'), has received much of the attention due to its unique molecular structure and properties. The structure of 'buckyballs' have been well studied in chemistry and material science.¹ However, their potential to act as building blocks to produce macroscale materials with controlled structures has not been fully explored. Our work has been largely focused around working fullerenes, specifically C₆₀, into novel carbon nanomaterials. Fullerene films have been prepared and transferred onto different substrates. Preliminary attempts at polymerization of fullerene films have been made, the development of which can result in novel substrates for developing new carbon materials. I will discuss the evolution of the methods for fullerene film transfer and its potential applications for future research.

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Develop Functional Thermoelectric Materials by Enhancing Phonon Scatterings

Min Hong*

*Center for Future Materials, University of Southern Queensland, 37 Sinnathamby Blvd,
Springfield Central, Queensland 4300, Australia*

**Email: min.hong@usq.edu.au*

Thermoelectric technology provides sustainable solutions to power generation, waste heat recovery, and refrigeration. Enhancing figure-of-merit (zT) is the priority to realize mass-market applications. Differing from those thermoelectric properties coupled via electron transport, lattice thermal conductivity (k_l) is independently governed by phonon transport. Reducing k_l can lead to a net increase in zT . In our research, new mechanisms have been developed to reinforce phonon scattering for decreasing k_l . (i) The concept of tuning phonon dispersion to enhance the inherent phonon-phonon scatterings was developed in Sb alloyed GeTe.¹⁻² (ii) In polycrystalline thermoelectric materials, the commonly existing point defects and grain boundaries only scatter high- and low-frequency phonons, respectively. To enhance the mid-frequency phonon scattering, we introduced high-density dislocations in the Bi₂Te₃ material by the mechanical plastic deformation and stacking faults in AgSbTe₂ by adjusting the synthesis method.³⁻⁴ (iii) High-density planar vacancies and superlattice precipitates were introduced in GeTe-based materials.⁵ Electron microscopy characterizations and DFT calculations were employed to understand the underlying link between the structural/lattice imperfections and low k_l . Benefiting from the dramatically reduced k_l , high zT was achieved in wide materials. The rationally established strategies can provide alternative routes to tailor thermoelectric performance in broad materials.

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Influence of Grinding Chemistry on Flotation

Alex Horry^{1,2*}, Boris Albijanic^{1,2}, Chris Aldrich^{1,2}

¹Curtin University, Western Australian School of Mines

²ARC Industrial Transformation Training Centre for Green Chemistry in Manufacturing

*Email: alexander.horry@postgrad.curtin.edu.au

During the grinding stage in the mineral processing circuit, selecting the most appropriate grinding balls (media) has been widely demonstrated to improve flotation recoveries [1]. Gas atmospheres such as nitrogen or oxygen can also be introduced to alter the chemistry of the slurry by changing dissolved oxygen levels, a critical species in the galvanic corrosion process, which occurs between the media and mineral couple. For example, in sulfide mineral ores, it has been known that complex iron oxide-hydroxide products coat mineral surfaces when forged steel media is employed, exhibiting lower downstream flotation recoveries [2]. In contrast, a higher recovery has been shown in the same media selection by pre-treating the slurry with copper sulfate, which acts as an activator in reducing conditions to aid hydrophobic-inducing collector adsorption [3]: a critical step in the mechanism of flotation recovery. It is evident, then, that multi-variable chemical processes work together to influence the final flotation recovery by changing a few key unit operation variables. If an industrial-size ball mill can be manufactured to allow for different gas atmospheres, an ideal combination of media and gas atmosphere for a given ore type can be adopted so that the best downstream flotation recoveries of target minerals can be achieved. Process intensification of this kind is not widely available, perhaps due to scarce literature information. Operations would benefit from these technologies since better overall recoveries make grinding more cost-efficient and lead to less reagent waste and gangue; moreover, gas supplies originate from renewable feedstocks, which all aid towards a greener Australian mining industry.

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Opportunities for chemistry in reducing greenhouse gas emissions in agriculture.

Natasha L. Hungerford,^{1*} Mary T. Fletcher.¹

¹ *Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Health and Food Sciences Precinct, Coopers Plains, QLD 4108.*

**Email: n.hungerford@uq.edu.au*

Anthropogenic greenhouse gases (GHG) are threatening ecosystem sustainability on earth. In 2022, Australia joined the global methane pledge to cut methane emissions by 30% by 2030, joining the world's other key agricultural product exporters, such as the USA, Brazil and Indonesia, with the government pledging A\$3bn to fund low emissions technologies, component manufacturing and methane reductions in agriculture. Agricultural emissions contribute 14% to Australia's national GHG emissions. These agricultural emissions include 19% nitrous oxide emissions (crop residue burning/fertiliser use), 4% carbon dioxide (lime/urea use), with 77% due to livestock methane production through enteric fermentation [1]. Challenges exist due to current use of chemical-based fertilisers for increased crop yields and herbicides and pesticides for reducing pests and weeds. Chemical innovation is required to achieve emissions reduction targets, grow market access and increase productivity to meet a growing world population. Chemists will create advanced catalysts for fertiliser production, better understand soil quality, and create feed additives for reduction in enteric methane from ruminant livestock. Fermentation of feed materials in the rumen liberates CO₂ and H₂ which methanogenic archaea (methanogens) utilise as substrates, leading to reductive methane production. There is the potential to design, formulate and assess new molecules with the ability to inhibit methane production in the rumen. Current anti-methanogens added to feed require regular dosing to maintain effect. Different formulations will be needed in dairy/feedlot cattle compared to those on extensive grazing systems for sustained release rates between musters [2]. Residue chemists will be required to assess for residues/metabolites in animal products, including meat and milk as a result of the use of feed additives. Anti-methanogens need also to have negligible negative effects on forage digestibility. Biologically active secondary metabolites could be key to the reduction of enteric methane, aims also being no unforeseen environmental impacts or contribution to ozone depletion.

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Biography:

Dr Natasha Hungerford is a Senior Research Fellow at the Queensland Alliance for Agriculture and Food Innovation (QAAFI), at The University of Queensland (UQ). Dr. Hungerford achieved her PhD in 1998, through the UQ School of Chemistry and Molecular Biosciences, and subsequently conducted postdoctoral research in natural products chemistry and in synthetic organic chemistry. She joined the QAAFI Centre for Animal Science in 2016 as part of the Natural Toxins Group. Her work focuses on the identification and analysis of toxins and bioactives in various plants and agricultural products using liquid chromatography-tandem mass spectrometry (LC-MS/MS). Dr Hungerford applies her chemical skills to agricultural related problems, including addressing the Pimelea poisoning of cattle, determining pyrrolizidine alkaloids in honey, identifying the unusual beneficial sugar trehalulose in stingless bee honey and applying slow-release devices for the release of bioactives to control enteric methane production in rangeland cattle. The latter MLA funded project involves an interdisciplinary team of researchers from UQ and the Queensland Department of Agriculture and Fisheries (QDAF).

Gold Nanoparticles-Modified Carbon Foam for a Yeast-Based Microbial Fuel Cell

Tribidasari A. Ivandini,* and Aliyah Aliyah

Department of Chemistry, Faculty of Mathematics and Natural Science (FMIPA), Universitas Indonesia; Depok 16424, Indonesia

**Email: ivandini.tri@sci.ui.ac.id*

Through comparison against other types of fuel cells, microbial fuel cell (MFC) is regarded as economically and relatively non-harmful source of renewable energy. The applications of MFC have been reported to produce energy from waste, including industrial wastewater, biomass, and urine. The performance of MFC is affected by several factors, including the types of microbials and the fuel substrates as well as the types of the separating membranes and electrodes. Carbon-based materials are generally applied for electrodes in MFCs due to its high conductivity, high surface area and biocompatibility, chemically stable and economical factor. In this research carbon foam was modified with gold nanoparticles (AuNPs) to improve its affinity against microorganism through the hydrothermal method. TEM and SEM characterization of the synthesized nanoparticles indicated the formation of polydisperse spherical AuNPs in the size about 17 nm. However, the nanoparticles attached on the carbon foam surface were agglomerated to be around 1.5 μm in size. The study in electrochemical with cyclic voltammetry procedure confirmed the electroactive properties of the modified carbon foam electrodes toward glucose. The electrode study for a MFC with *Candida fukuyamaensis* yeast as the microorganisms revealed that modified carbon foam generated nearly three times higher current and power density in comparison toward the MCF without modification. This outcome indicates the validity of the modified carbon foam for improving the MFC performance.

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Biography:

Prof. Dr. Ivandini Tribidasari Anggraningrum is a member of the teaching and research staff at the Department of Chemistry, Faculty of Mathematics and Science, Universitas Indonesia, since 1997. In 2003 she accomplished her doctoral degree at The University of Tokyo, Japan. From 2003 to 2007 she finalized her post-doctoral research at the Department of Chemistry, Keio University, Tokyo, Japan with JSPS fellowship during 2004-2006. Her research interest is electrochemistry of solid materials with specific applications in sensors and biosensors as well as electrocatalysts, for renewable energy, energy storages, and CO₂ electroreduction.



Development of a novel plumbojarosite treatment method for reducing childhood lead exposure

Farzana Kastury^{1*}, Wayne Tang¹, Carina Herde², Matt R. Noerpel³, Kirk G. Scheckel³,
Albert L. Juhasz¹

¹*Future Industries Institute, STEM, University of South Australia, SA, Australia*

²*South Australian Health and Medical Research Institute, Adelaide, SA, Australia*

³*United States Environmental Protection Agency, Center for Environmental Solutions and
Emergency Response, Land Remediation and Technology Division, Cincinnati,
Ohio, USA*

*Email: farzana.kastury@unisa.edu.au

Lead (Pb) exposure is a significant global concern that negatively impacts childhood neurological and cognitive development. However, due to the widespread nature of Pb contamination, traditional remediation options, such as, soil removal and replacement, is deemed to be neither cost-effective nor sustainable. This research aimed to develop a Pb immobilization strategy for contaminated soil by promoting the formation of plumbojarosite in soil, thereby reducing Pb bioavailability. During method optimization, a range of treatment times, solid to solution ratios, and $\text{Fe}_2(\text{SO}_4)_3/\text{H}_2\text{SO}_4$ concentrations were assessed using a mining/smelting impacted soil (BHK2, Pb: 3031 mg/kg), followed by treatment of additional Pb contaminated soils (PP, Pb: 1506 mg/kg, G10, Pb: 2454 mg/kg and SoFC-1, Pb: 6340 mg/kg) using the optimized method. Bioaccessibility (Pb dissolution in simulated gastric solution) was assessed using USEPA Method 1340. Speciation of Pb in pre and post treated soil was determined by X-ray Absorption (XAS) spectroscopy at the Materials Research Collaborative Access Team (MRCAT) beamline, Advanced Photon Source, Argonne National Laboratory, USA. Treatment efficacy was also validated using an in vivo mouse assay, where Pb accumulation in femur, kidney and liver was assessed to confirm in vitro bioaccessibility outcomes. Results showed that Pb bioaccessibility was reduced by 77.4-97.0% following treatment of soil with $\text{Fe}_2(\text{SO}_4)_3$ (0.4-1.0 M) and H_2SO_4 (0.05 M) at 150°C for 60 minutes in a closed microwave system. Results of bioavailability assessment demonstrated that bioavailability was reduced between 73% and 93%. Formation of plumbojarosite in treated soils was confirmed by XAS analysis. The method developed during this study will allow treatment to be scaled up and applied to large quantities of soil in the shortest amount of time, using the smallest volume of water, significantly improving the cost-effectiveness of Pb contaminated soil remediation approach.

Biography

I am a passionate advocate for developing sustainable solutions to environmental pollution by assessing exposure to emerging/legacy contaminants and formulating remediation strategies. As UCL Santos Research Fellow, my current research includes developing plumbojarosite formation technique that can be applied to Australian mining and smelting impacted communities, assessing bioavailability of PFAS and arsenic exposure in the legacy Victorian goldfields. My expertise spans across quantifying contaminant concentration using in vivo and in vitro assays, as well as investigating elemental speciation in soil and tissue samples using X-ray Absorption Spectroscopy.

I have been awarded Fulbright Future Scholarship from the Australian American Fulbright Commission in 2020, Early Career Researcher Grant by Australian Institute of Nuclear Science and Engineering (AINSE) in 2021 and AMP Tomorrow Maker award by the AMP Foundation in 2021.

I am also keen to collaborate on projects focusing on preserving Australian biodiversity. Within this scope, I currently collaborate with University of Tasmania investigating exposure to elements and organic pollutants in seabirds and the role of microplastics as a potential vector.

Harnessing Green Nanosilver Supported on Reduced Graphene Oxide for Photocatalytic Degradation of Methylparaben

Sadaf Aiman Khan^{1,2,3,*}, Marut Jain^{1,2,3}, Kamal Kishore Pant², Zyta Maria Ziora³, Mark A. T. Blaskovich³

¹ *The University of Queensland - Indian Institute of Technology Delhi Academy of Research (UQIDAR)*

² *Department of Chemical Engineering, IIT Delhi, India*

³ *Centre for Superbug Solutions, Institute for Molecular Bioscience, The University of Queensland, St Lucia QLD 4072 Australia*

*Email: sadaf.khan@uqconnect.edu.au

ABSTRACT

Methylparaben (MeP) is a hazardous water pollutant found in the effluent from cosmetic industries. It has been reported to cause disruption in various organisms' endocrine or hormonal systems, and its extensive use has led to its increased discharge into water bodies, posing a significant threat to the environment and human health. Therefore, there is a pressing need to develop effective techniques to remove MeP from contaminated water sources.

Plasmonic nanoparticles have emerged as a promising pathway for the removal of pollutants from water treatment processes due to their ability to perform direct visible-light-driven photocatalysis. In this study, a hybrid catalyst of silver nanoparticles on reduced graphene oxide (rGO/AgNPs) was fabricated using a biobased in-situ reduction process and employed as a visible light photocatalyst to treat MeP. The use of green reducing agents during the synthesis process reduces the overall cost and environmental impact of the process. The synthesized catalyst demonstrated significantly enhanced adsorption and photocatalytic degradation of MeP than rGO or AgNPs, individually. The conditions that influence the kinetics of the photocatalytic degradation by rGO/AgNPs were comprehensively studied using response surface methodology (RSM), including solution pH, catalyst dose, persulfate concentration, MeP initial concentration, and time. The catalyst showed good stability and reusability and could induce up to 97.6% MeP degradation efficiency.

Furthermore, the mechanism of the photocatalytic reaction was investigated by scavenger tests and density functional theory (DFT) study. The results indicated that hydroxyl radicals ($\bullet\text{OH}$) played a crucial role in the photocatalytic degradation of MeP. Additionally, the DFT calculations revealed that the adsorption and electron transfer mechanism of MeP on the rGO/AgNPs surface was more favorable than that on the individual components. This study provides a novel approach for the development of low-cost photocatalysts for cosmetic wastewater treatment utilizing visible light irradiation. The biobased synthesis of rGO/AgNPs and the insights into the photocatalytic mechanism could pave the way for the future development of eco-friendly and effective catalysts for the removal of MeP from contaminated water sources.

KEY WORDS

DFT (density functional theory); green synthesis; photocatalytic; reduced graphene oxide; silver nanoparticles.

BIOGRAPHY

Sadaf is currently a joint phd scholar at the Institute for Molecular Biosciences at the University of Queensland, Australia and Department of Chemical engineering at the Indian Institute of Technology Delhi, India. Her research focus on the development of biobased silver nanocomposites for water treatment applications. She holds a masters and bachelors degree in biotechnology. Her interests are in bioprocess, green chemistry, environmental biotechnology and molecular biology. She has published research articles in various reputed journals.



Carbon sequestration and magnesium brine remediation of alkaline excess water streams from Bayer Process refining

Felicia Lee Kiely,^{1*} Kate Leekong¹ and Tayla Hall¹

¹ *Alcoa of Australia Limited*

*Email: felicia.lee@alcoa.com

The Bayer Process involves the processing of bauxite to alumina through a series of steps including digestion in sodium hydroxide solution to extract the aluminium for further processing to alumina and clarification to separate undigested material known as bauxite residue. At the end of the clarifying process the bauxite residue is predominately stored in secured impoundments known as residue storage areas (RSA). Water that infiltrates or runs off the RSA has varying levels of alkalinity and impurities and is managed according to the refinery water balance. Where water cannot be recycled back to the refinery or removed via evaporation, it can be treated to meet water quality standards for re-use or release. Treatment typically involves several steps - with the initial step focused primarily on reducing alkalinity. Carbon sequestration through the injection of CO₂ was found to successfully reduce water alkalinity and trace metal impurities. The reaction was highly dependent on the source water alkalinity and aluminium concentration and the rate of CO₂ injection. pH reduction from 13-6.8 was observed with the formation of amorphous aluminium hydroxide providing adsorption sites for the further removal of other trace metals. With aging, the amorphous aluminium hydroxide was found to transform to dawsonite. Comparative studies with mineral acids such as sulfuric acid showed amorphous aluminium hydroxide/sulfate species were dominant, however with aging and exposure to atmospheric CO₂, dawsonite was formed. When neutralisation was coupled with the use of magnesium brines such as MgCl₂ and MgSO₄ the predominant solid phases generated were amorphous aluminium hydroxide, dawsonite and hydrotalcite. Where the Mg:Al ratio of the reacting solutions were >3 hydrotalcite was the dominant mineral phase. CO₂ and brine neutralisation methods of treatment were applied successfully to water from refineries in Australia, Brazil and Europe. The results have enabled better understanding and optimisation for the full-scale implementation of CO₂ injection and brine addition to excess water streams from Bayer Process refining using CO₂ sequestered from stack gas and magnesium from seawater.

Biography:

Felicia Lee Kiely is an industrial research chemist with more than 10 years' experience in the Bayer refining industry specialising in solid-liquid separation, residue water management and sustainable material development from mining waste streams. She led the deployment of water management strategies across Alcoa's global refining operations including the development of novel treatment solutions. Her research has also generated potential commercial applications for the valorisation of excess mining water and solid residues. Felicia is currently part of Alcoa's Refinery of the Future team to design a refinery that has a zero-carbon footprint, significantly reduces freshwater use and ultimately eliminates bauxite residue.



Employing Bio-inspired Materials for Anode-free Lithium Metal Batteries

Dong Jun Kim, ¹*

¹ School of Chemistry, The University of New South Wales, Sydney, New South Wales, 2052, Australia

*Email: dongjun.kim@unsw.edu.au

Anode-free lithium metal batteries have been proposed as a promising solution for low-cost, high-energy density energy storage systems. AFLMBs eliminate the need for a conventional graphite anode and excess lithium supply, making them more cost-effective. However, anode-free lithium metal batteries have a few drawbacks such as inferior stability of the solid electrolyte interphase layer and inhomogeneous deposition of lithium during charge/discharge processes, which result in rapid capacity degradation. In this talk, I will present bio-inspired coating techniques that can be an effective approach to aid uniform lithium deposition over the current collector, resulting in densely packed lithium deposition. In-situ optical microscopy and Raman mapping results indicate that the coating leads to uniform deposition of lithium across the current collector, resulting in a densely packed lithium layer that significantly enhances its stability during cycles. Our study demonstrates that a simple bio-inspired coating can be an effective method for improving the energy density of anode-free configuration. The findings present a step toward the practical design and realisation of anode-free lithium metal batteries.

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Zn-MOF Derived Carbon Composite as Antibacterial Adsorbent for Indoor Air Purifier

Yuni Krisyuningsih Krisnandi^{1*}, Erlan Arlin¹, Conny Riani Tjampakasari²

¹*Inorganic Framework Laboratory, Department of Chemistry, Faculty of Mathematics and Natural Science, Universitas Indonesia; Depok 16424, Indonesia*

²*Department of Microbiology, Faculty of Medicine, Universitas Indonesia; Depok 1624, Indonesia*

*Corresponding author: yuni.krisnandi@sci.ui.ac.id

Metal-organic framework (MOF) is a carbon rich structure, and the metal species is embedded in the structure. It was converted into Zn-MOF derived carbon (ZnO-MOFC) modified with Chitosan-Ag nanocomposite and used as adsorbent materials in air purifier. The Zn-MOF was synthesized from zinc cations and 1,4-benzenedicarboxylic acid (H₂BDC) linkers through solvothermal procedure, then was converted ZnO-MOFC through carbonization treatment under Argon flow. Afterward, it was composited with 13X zeolite and modified with chitosan/Ag nanoparticles (ZnO-MOFC/13X/Chi-AgNP) to develop antibacterial property. The characterizations using XRD, FTIR, TGA, SEM, TEM, and BET N₂ sorption analysis provide the physicochemical properties of each component and their interaction in the composite. The antibacterial properties were carried out by agar diffusion method on *S. aureus* and *E. coli* bacteria. The composite exhibited outstanding antibacterial activity based on the average diameter of the inhibition zone of 14.5 mm and 11.5 mm on both *S. aureus* and *E. coli* bacteria, respectively. The results are comparable to Erythromycin and Vancomycin as antibiotics for *E. coli* and *S. aureus* giving the inhibition zone of 11.06 mm and 11.93 mm, respectively. Furthermore, when the composite was tested as adsorbent materials inside indoor air purifier materials in controlled 80cm x 60 cm x 60 cm containers, it has significant effectiveness rate of 88.86% \pm 6% in >2 h for reducing microorganism, which exceed the effectiveness rate given by commercial activated carbon, 51.30 \pm 6%.

keywords: Metal organic framework – MOF, antibacterial, indoor air purifier, AgNP

Biography:

Dr. Yuni K. Krisnandi did her master's degree (MSc, UNSW, 2001) and doctoral degree (PhD, University of Aberdeen, 2005) on the photoreactivity of microporous ETS-10 titanosilicates under supervision of Professor Russell Howe. In 2007-2009 she had an opportunity to carry out postdoc at Leibniz Institute for Catalysis (LIKAT) in Berlin, Germany, working on glycerol etherification on zeolite catalysts. She has worked as a lecturer and researcher since 1998, at the Department of Chemistry, Universitas Indonesia. Since 2013 she has set up Solid Inorganic Framework Research Group and focused on Materials Chemistry for Energy and the Environment, especially in heterogeneous catalysts for biomass valorisation and porous materials as adsorbent for pollutant in gas and aqueous media. She has received research grants from internal UI, government, and international research funding such as TWAS and Newton Fund. At this moment, she supervises 5 PhD students, and 9 honours students.



Regulation of the plant ethylene-forming enzyme and ethylene biosynthesis

Francis Kuang ^{1*}, Dona M Gunawardana ² Davide Mercadante², Michael J Haydon³,
Ivanhoe KH Leung^{1,2}

¹ School of Chemistry and the Bio21 Molecular Science & Biotechnology Institute, The University of Melbourne

² School of Chemical Sciences, The University of Auckland

³ School of BioSciences, The University of Melbourne

*Email: francis.kuang@student.unimelb.edu.au

Climate change and extreme weather events are putting increasing stress to plants. This is a significant threat to both the environment (e.g., reduced plant diversity) and agriculture (e.g., decreased crop yields). Ethylene is a vital phytohormone that plays a significant role in plant stress responses. It is also involved in regulating plant growth, development, and senescence. Hence, understanding the precise molecular mechanism that regulates plant ethylene biosynthesis is important as it will allow us to understand how plants response to the changing climate. The biosynthesis of ethylene is mediated by two critical enzymes, 1-aminocyclopropane-1-carboxylic acid (ACC) synthase (ACS), and ACC oxidase (ACO). ACO is the rate-limiting enzyme under developmental and stress conditions. In this study, we aim to uncover the regulatory mechanism of ACO and its potential implications for ethylene biosynthesis. We first employed a combined biochemical, biophysical and computational approach to investigate potential protein modifications that relate to ACO activity and function. We then applied plant molecular biology techniques to reproduce such modifications *in planta* and examined the effects of the modifications to ethylene biosynthesis. Finally, we conducted plant biology experiments to study the impact of different abiotic stress to ACO activity and ethylene biosynthesis. Our results suggest that ACO undergoes redox-mediated modifications that alter its function and activity both *in vitro* and *in planta*. These modifications have significant implications for ethylene biosynthesis and plant growth and stress responses. Hence, our study provides important new insights into the protein-level regulation of ACO and its implications for ethylene biosynthesis. This study has significant implications for sustainable crop production and may inspire the development of new strategies for plant stress tolerance.

Biography:

Francis Kuang is a second-year PhD student at the University of Melbourne, Australia, focusing on plant enzymology and physiology, with a particular emphasis on the regulatory mechanisms of the ethylene-forming enzyme. Working under the supervision of Drs. Ivanhoe Leung and Mike Haydon, Francis is able to combine protein chemistry and plant biology to delve into the intricate processes governed by the ethylene-forming enzyme. Francis has also spent time in visiting Dr. Davide Mercadante's research group to further uncover crucial structural insights of the ethylene-forming enzyme by utilizing protein docking and molecular dynamics simulations. Francis's research is made possible by the Melbourne Research Scholarship and the Dr. Jim Desmarchelier Scholarships.

Investigation of the biological activity of spinach-type *Atriplex hortensis* var. *rubra* plant extracts and isolated betalain pigments

Agnieszka Kumorkiewicz-Jamro^{1,2,3*}, Renata Górską¹, Małgorzata Krok-Borkowicz⁴, Sławomir Wybraniec¹

¹ Faculty of Chemical Engineering and Technology, Cracow University of Technology, Warszawska 24, 31-155 Cracow, Poland

² South Australian Health and Medical Research Institute, Adelaide, 5000 SA, Australia

³ Faculty of Health and Medical Sciences, University of Adelaide, 5005 SA, Australia

⁴ Faculty of Materials Science and Ceramics, AGH University of Science and Technology, Al. Mickiewicza 30, 30-059 Cracow, Poland

*agnieszka.kumorkiewicz-jamro@adelaide.edu.au

According to the State of Food Security and Nutrition in the World 2022 report, between 702 and 828 million people were affected by hunger in 2021 [1]. Currently, searching for novel plant cultivars especially resistant to harsh environmental and growing conditions is high on the agenda. A promising novel source of nutrients is a spinach-type *Atriplex hortensis* var. *rubra* plant rich in acylated betalain pigments [2].

In this research, the dominant betalains present in leaves and seeds of *A. hortensis* “*rubra*” (amaranthin, and celosianin) were isolated and purified using weak anion exchange (WAX) and subsequent preparative HPLC. The target compounds present in the tested extracts and collected fractions were identified by LC-DAD-ESI-MS/MS. The molecular masses and the fragmentation patterns of obtained pigments were confirmed by high-resolution LC-Q-Orbitrap-MS. The antioxidant activities of single pigments and extracts were evaluated by a cellular antioxidant assay (CAA), and chemical assays such as ABTS, FRAP, and ORAC. Individual pigments had the highest CCA and IC₅₀ values among all tested samples. Resazurin assay and fluorescent live/dead staining show that all extracts, as well as amaranthin and celosianin, do not induce cytotoxicity in a wide concentration range (up to 100 µg/ml for extracts and 1 mg/ml for pigments) in rat cardiomyocytes (H9c2). All tested samples increased glutathione levels in H9c2 and protected cells from H₂O₂-induced cell death, and prevented apoptosis induced by Paclitaxel in a concentration range from 0.1 to 10 µg/ml. Taking into consideration easy accessibility, low price, and high resistance to unfavorable growing conditions, *A. hortensis* “*rubra*” plant is an intriguing candidate for a new food source. It may diversify the daily diet of the constantly growing world population, as well as contribute to world food security, especially in developing countries [3].

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Understanding the biodegradation of biopolymers in the natural environment

Bronwyn Laycock, ^{1*}, Paul Lant ¹, Steven Pratt ¹, Tracey Read ¹

¹ ARC Industrial Transformation and Training Centre on Bioplastics and Biocomposites, School of Chemical Engineering, The University of Queensland, Brisbane, Australia \

*Email: b.laycock@uq.edu.au

The factors driving the biodegradation of biopolymers in the natural environment are complex and, to a large extent, poorly understood. While the fundamental chemistry is typically driven by a combination of abiotic and biotic hydrolysis, with some oxidative chemistry contributing to some degree under exposed conditions, the effects of factors such as type of processing, effects of additives, polymer form, and so on have not been well studied [1]. This paper will review some of our research from both laboratory and field trial investigations into biopolymer biodegradation over recent years and highlight some of the key findings in that time.

PLASTIC STATE	LIFETIME		
	PE	PLA	PHAs
 Macro- and mesoplastic	Months to years	Months to years	Weeks to months * $r_D \approx r_B > r_F$
 Micro- and nanoplastic	Hundreds of years * r_D very slow	Years * $r_F > > r_D$	Days to weeks
 Soluble products	Weeks to months	Weeks to months	Hours

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Multi-LED portable analytical devices for a real-time monitoring of value-added products obtained in a pyrolysis process of biobased waste materials

Leo Lebanov^{1*}, Philip Hortin², John Parry², Desmond E Richardson³, Brett Paull¹

¹ *Australian Centre for Research on Separation Science (ACROSS), School of Natural Sciences, University of Tasmania, Private Bag 75, Hobart 7001, Australia*

² *Central Science laboratory, University of Tasmania, Private Bag 74, Hobart 7001, Australia*

³ *Norske Skog Paper Mill, Boyer Road 1279, Boyer 7140, Australia*

**Email: leo.lebanov@utas.edu.au*

The development of value-added renewable products from biobased waste materials using the pyrolysis process presents a promising future for the sustainable chemical industry. The control and operation of such a complex process require the application of small footprint, portable devices that can be connected to the process, operate for long periods of time, and provide real-time characterisation of complex samples. Therefore, flow-based spectroscopic devices are perfectly suited for such task. Due to their low power consumption, short warm-up times, and more stable long-term light output with five to ten times longer lifetimes compared to conventional spectroscopic light sources, light emitting diodes (LEDs) are perfectly suited for on-line flow-based monitoring devices. However, due to their narrow spectral bandwidth, they are underutilized in the direct analysis of complex industrial samples. Here, we present innovative, state-of-the-art multi-LEDs platforms for the direct analysis of complex samples coming from the pyrolysis industrial process. For the first time advanced statistical techniques based on interval PLS are utilized in the LED selection procedure. Four LEDs, coupled with CCD spectrometer, were selected for the characterization of the analytes within the pyrolysis process. By applying a PLS prediction model to the recorded signals, the developed analytical device showed great accuracy during on-site testing, with the predicted values, for all analytes, following the trend of the values obtained using the reference GC-FID method. Using LED and photodiode technologies, another portable analytical device for purity monitoring of the final pyrolysis product was developed. Applying advanced statistical data manipulation enabled producing highly accurate results, within 0.15%, allowing real-time decision making for the operators of the process.

Dr. Lebanov completed his undergraduate and master's studies in Biochemistry at the University of Novi Sad, Serbia. He then successfully completed the Erasmus Mundus master's program, which focused on quality control in analytical laboratories, analytical chemistry techniques, and advanced statistical approaches. Dr. Lebanov's strong interest in advanced statistical techniques motivated him to pursue further research in analytical chemistry. He commenced his PhD studies in 2017 and successfully obtained his PhD in 2021. His expertise lies in the application of advanced statistical techniques, specifically in identifying patterns in metabolomic research, optimizing experiments, and their application in developing LED-based portable devices. In addition to his academic achievements, Dr. Lebanov has been employed at Norske Skog Paper Mills in Tasmania since 2021. As a Scientist, he focuses on green and sustainable chemistry. Working at the intersection of industry and academia has allowed him to develop skills related to translating academic research into an industrial setting.



The use of laccases and polyphenol oxidases to degrade environmental pollutants

Nabangshu Sharma,¹ Yu Li,¹ Jinpeng Zhou,^{2,3} Ivanhoe K. H. Leung^{1,2,3*}

¹ School of Chemical Sciences, The University of Auckland, New Zealand

² School of Chemistry, The University of Melbourne, Australia

³ Bio21 Molecular Science & Biotechnology Institute, The University of Melbourne, Australia

*Email: ivanhoe.leung@unimelb.edu.au

Laccases and polyphenol oxidases (PPOs) are multi-copper oxidase enzymes that carry enormous potential in sustainable industrial applications. They have been successfully employed for a range of processes including biosynthesis and biosensing. Our group is interested in the use of laccases and PPOs to degrade organic pollutants in aqueous environments. In this talk, we will report our work on laccases and PPOs, including assay development, novel enzyme characterization, and emerging environmental pollutant degradation. We will highlight the challenges and discuss the potential of using multi-copper oxidases for bioremediation.

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Biography:

Dr Ivanhoe Leung is a Senior Lecturer in Biological Chemistry at the University of Melbourne. He attained his undergraduate and doctorate degrees in Chemistry and received postdoctoral training at the University of Oxford. In 2014, he joined the University of Auckland as a Lecturer in Chemical Biology. He was promoted to Senior Lecturer in 2017, and to Senior Lecturer (over the bar) in 2019. Dr Leung was recruited to the University of Melbourne through the Driving Research Momentum scheme in 2021. His current interests include (1) mechanistic enzymology, in particular the understanding of the complex relationships between protein structure, function, and modulation, (2) enzyme technology, especially the use of enzymes as biocatalysts for bioremediation, and (3) inhibitor discovery.



Thermostable 1T MoS₂ nanosheets achieved by spontaneous intercalation of Cu single atoms at room temperature and their enhanced HER performance

Mengyao Li^{1,*}

¹*School of Materials Science and Engineering, University of New South Wales, Sydney, NSW 2052, Australia*

Email: mengyao.li1@unsw.edu.au

We report a simple strategy to fabricate Cu single atoms (SAs) layer-intercalated MoS₂ only by stirring Cu metals with MoS₂ nanosheets solution at room temperature. An ultra-high concentration (Cu: Mo=98 at%) of Cu SAs has been achieved due to the higher chemical bonding energy of Cu-S compared to Cu-Cu, and the intercalated Cu atoms strongly enhance the stability of the thermodynamically unstable 1T-phase MoS₂. Notably, the 1T-metallic phase after Cu intercalation could be maintained even at 800 °C, breaking the record to the best of our knowledge. Besides, the as-prepared MoS₂/SAs exhibit outstanding catalytic performance owing to the improved electrical conductivity and the highly-active unsaturated Cu SAs, and in-situ EXAFS is applied to clarify the catalytic mechanism. This strategy is confirmed as a universal method for producing SAs using other transition or post-transition metals such as Ti, Fe, Ni, and Zn, etc. This work has provided a simple route for synthesizing a high concentration of SAs, which may open a new approach toward the fabrication of low cost catalysts for a variety of applications including energy devices (*i.e.* battery and supercapacitors, fuel cells), sensors, microwave absorption, and single atom based ferromagnetism etc. Moreover, the high stability of 1T-MoS₂ may make it suitable catalyst applied at high temperature, such as ammonia synthesis and CO₂ conversion. [1]

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Transforming textile waste into novel nanostructured porous carbon fibre for energy and environmental applications

Quanxiang Li^{1*}, Minoo Naebe^{1*}

¹ Carbon Nexus, Institute for Frontier Materials, Deakin University, Waurn Ponds Campus, Locked Bag, 20000, Victoria, 3220, Australia

*Email: quanxiang.li@deakin.edu.au; minoo.naebe@deakin.edu.au

The exponential growth of textile waste has led to an environmental crisis that requires urgent attention. Current estimates suggest that 250,000 tons of clothing, worth approximately \$70M, are discarded globally each day, with only 12% of textile material being recycled. In this context, the scientific community has been investigating innovative techniques for converting textile waste into high-value products to promote textile circularity. Recent research has focused on thermochemical conversion processes for producing biochar and activated carbon from clothing waste. However, these approaches have limitations as they can only generate carbon materials with simple compositions of micropores and inferior porosity. To address this issue, this project proposes an innovative catalytic activation strategy for converting textile waste into hierarchically porous carbon fibres (PCF) with a series of novel nanostructures. The research findings suggest that carbon–alkali metal (C–M) complex construction is the key step for catalytic activation of the carbon matrix. Cotton textile waste is converted into CF containing C–M carbide. Subsequent controlled supply of active gases stimulates the continuous mutual conversion among activation reaction, phase evolution of C–M/C–O–M, local severe heat release, and carbon gasification, ensuring catalytic reaction going and diverse novel structures development. For the first time, a series of novel nanostructured PCFs are synthesized using cotton textile wastes as the precursor, including interconnected porous structure, graphene-like tubular structure and wrinkled graphene-covering structure. The potential applications of the developed PCFs are evaluated in water purification, CO₂ reduction and energy storage/conversion. The hierarchically porous carbon fibres with substantial micro-meso-macro pores are expected to have exceptional characteristics for advanced energy and environmental applications. This work presents a significant contribution to the field of textile waste valorisation, highlighting the potential for state-of-the-art catalytic activation strategies for transforming textile waste into multifunctional porous carbon fibres.

Biography:

Dr Quanxiang Li is currently an ARC DECRA Fellow specializing in textile waste-derived porous carbon fibre. Dr Li completed his PhD degree at Deakin University in 2016 and was awarded the prestigious Alfred Deakin Postdoctoral Research Fellowship in 2019. He has more than 12 years of research experience and expertise in carbon fibre and composite science. His primary research focuses on the manufacturing process and surface treatment of advanced carbon fibre, as well as the synthesis of porous carbon fibre materials with tailored structures and functionalities for the environment and energy-related applications. Dr Li has published over 60 peer-reviewed papers in high-tier international journals, such as Adv. Sci., ACS Nano, Energy Stor. Mater., J. Mater. Chem. A, Carbon, and Compos. B. Eng., with 2400+ citations and 28 H-index. As a lead chief investigator, he has successfully secured several collaborative projects with international industry partners in the areas of carbon fibre manufacturing, medical aids, and water/gas purification.

Hydrogen Production from Air – No Need to Electrolyse Sea Water

Jining Guo¹, Ali Zavabeti¹, Guoping Hu¹, Xiaolei Fan², Gang Kevin Li^{1*},

¹ Department of Chemical Engineering, the University of Melbourne, Parkville, Victoria 3010, Australia.

² Department of Chemical Engineering, School of Engineering, The University of Manchester, Manchester, M13 9PL, United Kingdom

*Email: li.g@unimelb.edu.au

Presenting author: Gang Kevin Li

Hydrogen is the ultimate clean energy. Despite being the most abundant element in the universe, hydrogen exists on the earth mainly in compounds like water. H₂ produced by water electrolysis using renewable energy, namely, the green hydrogen, represents the most promising energy carrier of the low-carbon economy ^[1]. H₂ can also be used as a medium of energy storage for intermittent energies such as solar, wind, and tidal ^[2-4]. The deployment of water electrolyser is geographically constrained by the availability of freshwater, which, however, can be a scarce commodity. More than one-third of the earth's land surface is arid or semi-arid, supporting 20% of the world's population, where freshwater is extremely difficult to access for daily life, let alone electrolysis ^[5]. On the other hand, areas rich in renewable energies are commonly short in water supply ^[6] and far from major industrial activities.

In this talk, we demonstrate how high purity green hydrogen can be produced from air through a so-called direct air electrolysis (DAE) process where moisture is directly absorbed by the hygroscopic electrolyte and split in situ into H₂ and O₂. Such DAE unit can work under low humidity conditions comparable to that in a desert and reach a Faradaic efficiency of around 95% and for 12 consecutive days ^[7]. We also show how this technology is being scaled up to 1 m² and 10 m² at higher TRLs with support from venture capitals.

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Sustainable production of jet-fuel range hydrocarbons and carbonaceous materials from biowaste catalytic co-pyrolysis

Fanghua Li^{1,*}, Tong Zhao¹, Kena Zhao², Qiaoqiao Zhou³, Chi-Hwa Wang²

¹State Key Laboratory of Urban Water Resources and Environment, Harbin Institute of Technology, Harbin 150040, PR China

²Department of Industrial Systems Engineering and Management, National University of Singapore, Singapore 117576, Singapore

³Department of Chemical & Biological Engineering, Monash University, Wellington Road, Clayton, Victoria, Australia

*Email: fanghuahope99@outlook.com

Abstract: This study addressed the production of high-quality bio-oil and carbonaceous materials from in-situ co-pyrolysis of chicken manure (CM), algal bloom (AB) and woodchip (WC). The effects of biowaste-derived catalyst and AB-based NH₃ on improving the quality of bio-oil, tar and carbonaceous materials were investigated, respectively. The major presence of Ca-Mg-P in CM resulted in a higher quality of bio-oil with a cetane number of 40 and HHVs of 38.62 MJ/kg. The loading of Ni₂P further enhanced the catalytic performance of CM-derived catalyst and contributed to the produced bio-oil with a cetane number of 50 and HHVs of 40.85 MJ/kg. The major presence of K-Cl-Fe in AB and AB-based NH₃ activation contributed to a larger specific surface area of carbonaceous materials as high as 567 m²/g. Furthermore, the catalytic activity, electrochemical activity and potential market value of biowaste-derived carbonaceous materials were explored in this study. To facilitate the investment decision-making in industrial applications, techno-economic analysis was conducted for the deployment of co-pyrolysis system in a hen layer farm for its daily treatment of 20-ton CM. The technological approach and techno-economic analysis can be generalized to the other types of bioresources. This work provides a novel and effective approach to convert and manage biowaste resources for environmental sustainability and carbon neutrality.

Keywords: Biowaste; Co-pyrolysis; Bio-oil; Carbonaceous materials; Techno-economic analysis

Fanghua Li

Harbin Institute of Technology

Associate Professor, PhD Supervisor

Carbon neutrality

Device design

Machine learning

15588750282

lfhhope

fanghuahope99@outlook.com

<http://homepage.hit.edu.cn/Flora>



Research Interest: Selective catalytic conversion of biomass and carbon dioxide to new energy and materials, new development and numerical simulation of process technology related to the efficient conversion of multi-biomass, with knowledge from environment, chemical engineering, mathematics and energy.



Biography:

Fanghua Li received her PhD in Chemical Engineering from Monash University, Australia in 2018 and was a Research Fellow at National University of Singapore from 2018 to 2021. Dr. Li has been educated and employed in China, Singapore, Australia, the United States of America and Europe. She joined Harbin Institute of Technology in 2021. Her research interests focus on the new energy and materials for carbon neutrality and environmental sustainability.

Exploration of C–N Coupling for Electrocatalytic Urea Synthesis

Junxian Liu^{1*}, Yuantong Gu¹, and Liangzhi Kou¹

¹ School of Mechanical, Medical and Process Engineering, Queensland University of Technology, Brisbane QLD 4001, Australia.

*Email: junxian.liu@qut.edu.au

Electrocatalytic coupling of N₂ and CO₂ into urea under mild conditions is a promising approach to reducing energy consumption and environmental pollution associated with the conventional Haber-Bosch process. However, the existing method suffers from the extremely low reaction efficiency due to the sluggish C–N coupling and the low selectivity for urea formation. Here, two novel mechanisms for high-efficiency urea production from N₂ and CO are proposed based on density functional theory (DFT) calculations. In the first mechanism, we proposed a potential pathway involving the N–N bond breakage to facilitate the subsequent C–N coupling. Interestingly, the inert N≡N bond of the adsorbed *N₂ can be gradually weakened and eventually broken through two protonation steps, leading to the facile CO adsorption on the dissociated *NH and the effortless C–N coupling to form the urea precursor *NHCONH. The second mechanism suggests a promising route for urea production from N₂ and CO, where C–N coupling can be achieved without breaking the N–N bond. Additionally, a simple descriptor, namely, effective d electron number, which merely consists of intrinsic properties of the catalysts, is constructed to quantitatively describe and predict the electrocatalytic urea activity of dual-atoms catalysts. Our work offers new opportunities to advance the rapid discovery of novel mechanisms and efficient catalysts for electrochemical synthesis of urea.

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High-performance thermoelectrics: from materials to devices

Weidi Liu,^{1,2,*}

¹*Australian Institute of Bioengineering and Nanotechnology, The University of Queensland, St Lucia 4072, Australia*

²*School of Chemistry and Physics, Queensland University of Technology, Garden Point 4000, Australia*

*Email: w.liu@uq.edu.au, weidi.liu@qut.edu.au

Thermoelectric technology, with the capacity of direct and reversible energy conversion between heat and electricity, has attracted extensive research interest. The performance of thermoelectric technology fundamentally dominated by the material dimensionless figure of merit, zT . And higher zT values of composing thermoelectric materials correspond to high energy conversion efficiency. Obtaining high zT values of thermoelectric materials is typically limited by the coupling relationship between sub-parameters of thermoelectric materials, including electrical conductivity, Seebeck coefficient, and thermal conductivity. Here, based on our state-of-art studies focusing on Bi_2Te_3 - and $\text{Bi}_{0.5}\text{Sb}_{1.5}\text{Te}_3$ -based thin films, we proposed the strategies of obtaining high-performance thermoelectric technologies by decoupling these relationships from both material and device design viewpoints. From the material viewpoint, the synergistic carrier concentration optimization under decoupled sub-parameters, can contribute to high zT values in both n-type Bi_2Te_3 -based and p-type $\text{Bi}_{0.5}\text{Sb}_{1.5}\text{Te}_3$ -based thin films. For practical application, high efficiency and power density are of equal significance, where novel thin-film device design can effectively approach this target. Meanwhile, effective application of thermoelectric technology, such as personal thermal management or chip cooling, requires comprehensive system optimization.

Biography:

Wei-Di Liu is currently a Postdoc Research Fellow at the University of Queensland, Australia. He received his Ph.D. from the University of Queensland, Australia, in 2020. His research interest lies in advanced functional materials, and is specially focusing on the understanding and development of novel thermoelectric materials, devices and applications.



Modulation of Monoatomic Sites for Oxygen Reduction Reaction

Porun Liu

*Centre for Catalysis and Clean Energy, School of Environment and Science, Griffith University,
Gold Coast, Queensland, Australia*

**Email: p.liu@griffith.edu.au*

Heterogeneous electrochemical processes at the electrode interfaces has been one of the intense focuses to convert, store and utilize clean energy. Single-atom (SA) electrocatalysts (SAECs) with isolated metal atoms coordinated on solid substrates have recently emerged as a class of high-performance catalysts due to their ultimate mass-catalytic activity, simple active site configuration and readily tuneable electronic structures. Through altering the coordination environments around the anchored SAs, the catalytic activities of SAECs can be readily tuned. In my presentation, design and construction transition metal (TM = Mn, Fe, Co, Ni, Cu, Ru) SAECs anchored two dimensional (2D) substrates for efficient oxygen reduction reaction (ORR) and hydrogen evolution reaction (HER) will be demonstrated. The electronic modulation of the SAs on the 2D matrix facilitate the adsorption of the reaction intermediate thus enhanced the electrocatalytic activities that enable the excellent performance of ORR in zinc air batteries and HER in alkaline media, respectively.

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Ionic liquids and lipidic self-assembly

Livia Salvati Manni,^{1,2*} Caitlin Davies,¹ Kathleen Wood,³ Salvatore Assenza,⁴ Rob Atkin,⁵ Gregory Warr¹

¹ School of Chemistry & University of Sydney Nano Institute, The University of Sydney, Australia

² School of Environmental and Life Sciences, University of Newcastle, Australia

³ Australian Centre for Neutron Scattering, ANSTO, Australia

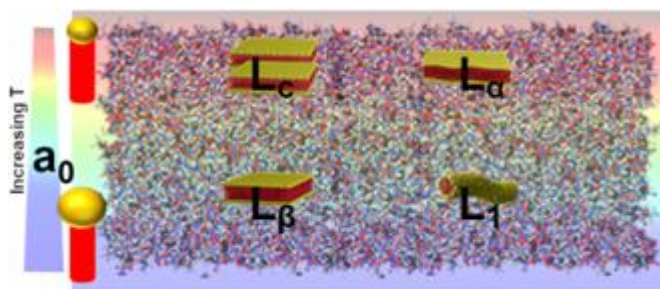
⁴ Departamento de Física Teórica de la Materia Condensada, Condensed Matter Physics Center (IFIMAC), & Instituto Nicolás Cabrera, Universidad Autónoma de Madrid, Madrid, Spain;

⁵ School of Molecular Sciences, The University of Western Australia, Australia

*Email: livia.salvatimanni@sydney.edu.au

Ionic liquids are liquid salts with a melting point below 100 °C and a negligible vapour pressure. Due to their ability to solvate a large range of molecules, they have been employed as solvents in their pure form and in aqueous mixtures, and they have been identified as ‘green’ alternative to molecular solvents.¹

Interestingly they are able to support self-assembly of lipids,² but their effect on lipidic membranes is still unclear. In this work we explored the behaviour of two model phosphatidylcholine-containing phospholipids, DPSC and POPC, mixed with the most common ionic liquid, ethylammonium nitrate (EAN).³ Employing a combination of small- and wide-angle x-ray scattering and small-angle neutron scattering we discovered a complex pattern of phase behaviour. POPC shows a conventional phase sequence at low solvation and an anomalous re-entrant phase behaviour at high solvation, while DPSC shows an unexpected phase sequence with a liquid crystalline lamellar phase at high solvent content and low temperatures (below the chain melting temperature) and a transition to an ordered crystalline phase upon warming. This surprising phase behaviour is attributed to the large size of the EAN ions that solvate the lipid headgroup compared to water changing amphiphile packing. Weaker H-bonding between EAN and lipid headgroups also contributes. These results provide new insight for the design of lipid based nanostructured materials in ionic liquids with atypical properties and in understanding the effect of EAN to lipidic bilayers.



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Extraction of brown seaweed phlorotannins using Natural Deep Eutectic Solvents

Adele Mastroyannis,^{1, 2, 3*} Trung Nguyen^{1, 2*}, Wei Zhang,^{3*} Kirsten Heimann,^{3*} Colin Raston^{1,2,4*}

1 Chemical Sciences, Flinders University, Sturt Rd, Bedford Park SA 5042

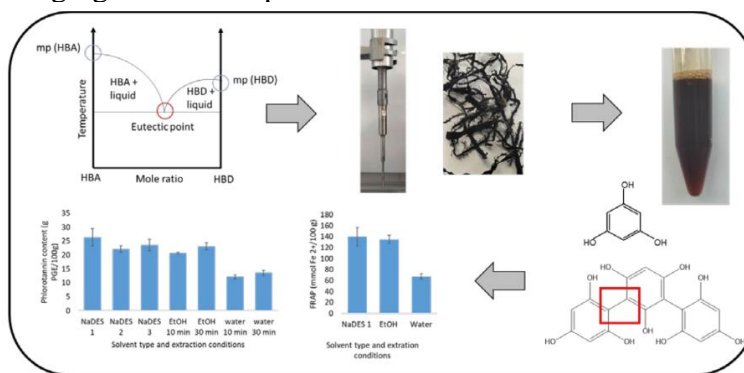
2 ARC Industrial Transformation Training Centre for Green Chemistry in Manufacturing

3 Marine Bioproducts Cooperative Research Centre

4 Institute for Nanoscale Science and Technology, Flinders University, Sturt Rd, Bedford Park SA 5042

**Email: mast0080@flinders.edu.au*

Brown seaweed phlorotannins are unique polyphenols exhibiting a range of bioactivities that include antioxidant, anti-cancer, anti-inflammatory and anti-aging capabilities. Conventional organic solvents are often used as extraction media for solubilising and transferring valuable compounds across the cell membrane. However, organic solvents are highly toxic and in general undesirable when aligning with Green Chemistry principles. Therefore, the need to find alternative extraction media is of paramount importance in reducing the environmental impact, toxicity in human health products and the reduction of chemical usage. Natural deep eutectic solvents (NaDES) could be an alternative ‘green option’ to organic solvent extraction systems. NaDES are a combination of a hydrogen bond acceptor and a hydrogen bond donor, where a solvent is created with a reduced melting point to that of its counterpart. This unique property allows NaDES to be used in a range of applications including extraction of polyphenols from terrestrial plants. However, utilising NaDES as an extraction medium for solubilising brown seaweed phlorotannins has not yet been fully explored, particularly for skin health products. In this study, a range of NaDES made from cosmetic ingredients, were screened for suitable candidates. Results show higher total phenol content than conventional organic solvents, also retaining antioxidant activity suitable for green chemistry-based, anti-aging skin health products.



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5-(Chloromethyl)furfural (CMF) production from agricultural waste: precursors to producing sustainable, valuable products

Loku Mannage N. Lakmini¹, Athukoralalage Don K. Deshan², Hong Duc Pham¹, Darryn Rackemann², Deepak P. Dubal¹, Lalehvash Moghaddam^{1*}

¹ School of Chemistry & Physics, Faculty of Science, Queensland University of Technology, George Street, Brisbane, Queensland, 4000, Australia

² School of Mechanical, Medical & Process Engineering, Faculty of Engineering, Queensland University of Technology, George Street, Brisbane, Queensland, 4000, Australia

*Email: l.moghaddam@qut.edu.au

To mitigate climate change, researchers have developed a range of biomass-derived fuels, energy, and chemical precursors to reduce fossil fuel dependence [1]. Recently, biomass-derived 5-(chloromethyl)furfural (CMF) has attracted significantly more attention than the established platform chemical 5-hydroxymethylfurfural (HMF) due to its higher yields directly from raw biomass under mild conditions. In this study, we converted waste rice, the world's third-largest agricultural crop, into CMF via HCl/chloroform biphasic system at different temperatures (100 °C, 110 °C). The crude oil from this process contained 58%, 56%, 94%, and 89% CMF purities from rice bran (RB), rice hull (RH), broken white rice (BWR), and immature brown rice (IBR), respectively. BWR and IBR display great potential as biomass sources for CMF production with high CMF purities, even in crude oil samples. The main by-product of CMF production was solid residue. The solid residue properties were improved by carbonisation at 800 °C with KOH activating agent. This study focused on the RH solid residue with substantial levels of silica, for potential development into electrodes for lithium-ion batteries (LIB) and symmetric supercapacitors. The untreated RH solid residue demonstrated a high specific capacity of 383 mAh g⁻¹ as an anode material with excellent rate performance and cycling stability. The carbonised RH solid residue, with increased surface area, was utilised as electrode material in a non-aqueous symmetric supercapacitor and demonstrated a high energy density of 273.8 Wh kg⁻¹ at a power density of 127.1 W kg⁻¹ while the device reached an energy density of 57.89 Wh kg⁻¹ at a very high-power density of 12.7 kW kg⁻¹. This study highlights the potential use of rice by-products in a sustainable way to produce CMF and apply the solid residue in lithium-ion energy storage applications. The development of valuable products from waste in this research reveals the opportunities to reduce society's dependence on petroleum feedstock and divert solid waste generated after the extraction of chemicals.

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Biosynthesis of biodegradable polyhydroxyalkanoates (PHAs) from food waste – solving two problems with one solution

Md. Shahruk Nur-A-Tomal^{1,2,*}, Kristian Kempe^{1,3}, Neil Cameron^{1,4}, Leonie van 't Hag^{2,*}

¹ Department of Materials Science and Engineering, Monash University, Clayton, VIC, 3800, Australia

² Department of Chemical and Biological Engineering, Monash University, Clayton, VIC, 3800, Australia

³ Drug Delivery, Disposition and Dynamics, Monash Institute of Pharmaceutical Sciences, Monash University, Parkville, VIC, 3052, Australia

⁴ School of Engineering, University of Warwick, Coventry CV4 7AL, U.K.

* Email: md.nur-a-tomal@monash.edu (MSN), leonie.vanthag@monash.edu (LvH)

Food and agricultural waste (including municipal solid waste) are one of the most significant waste streams generated by human activity [1]. In addition, plastic waste is another issue for waste management programmes. The adverse effect of plastics is well known today. Generally, plastics are not biodegradable and accumulate in the environment for a long time, depending on their chemical nature and the characteristics of the environment where it is disposed of and turn into microplastics as well [2]. Therefore, our current research aims to produce biodegradable polyhydroxyalkanoates (PHAs) to replace synthetic soft plastics in packaging applications. *Pseudomonas putida* generally produces medium-chain-length (mcl) PHAs, which have properties comparable to conventional packaging plastics. In this study, the effect of feeding glucose and fatty acids of a range of chain lengths (C8 – C14) on the production of mcl-PHAs by *Pseudomonas putida* has been studied to explore the possibility of producing mcl-PHAs from food waste and also to tune polymer properties for its applications. Batch-wise shake flask experiments were carried out by varying glucose and fatty acids, where the other parameters were left unchanged, such as temperature, pH and minimal salt media composition. The glucose-dodecanoic acid with a mass ratio of 3:1 was determined to be the most effective in terms of output, that is, dry cell mass. The properties of PHAs were investigated using GC-MS, GPC, TGA, DSC, FTIR and NMR. The results of the characterisations suggest that the carbon feedstocks can be used to tune the chemical structure of PHAs with a range of thermal and mechanical properties suitable for different applications. This can significantly improve the circular economy of food and packaging.

Acknowledgements:

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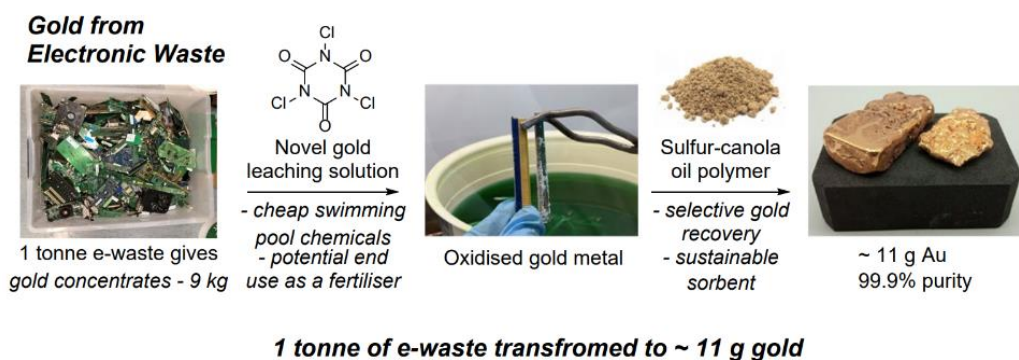
New Chemical Methods to Recover Gold from Electronic Waste

Dr Lynn Lisboa¹, Dr Nicholas Lundquist¹, Dr Maximilian Mann¹, Dr Thomas Nicholls¹, Dr Harshal Patel^{1*}, Prof. Justin Chalker¹

1 Flinders Institute for Nanoscale Science & Technology, Flinders University, Adelaide, SA, Australia

**Email: harshal.patel@flinders.edu.au*

Electronic waste (e-waste) is one of the fastest growing hazardous waste streams globally, with over 53 million metric tonnes (Mt) generated in 2019 alone.¹ Rather than process this waste stream, most countries export it where it disproportionately affects poorer countries. E-waste typically ends up in landfill where it slowly leaches environmental pollutants, or much more rapidly when burnt. E-waste consists of plastics and valuable metals; the concentration of e-waste derived metals (like gold and copper) is substantially higher than in natural deposits, making the “urban mining” of e-waste a huge opportunity, both economically and environmentally.² This research, in partnership with CET and ACE, seeks to apply a new chemical leach solution to e-waste recycling, with an initial focus on gold recovery.³ Our leach solution is comprised of cheap, readily accessible swimming pool chemicals and a catalyst which together, are capable of oxidising gold metal. At the end of its life, the leach solution has the potential to be used as a fertiliser. Selective gold recovery is achieved using a sulfur-canola oil polymer derived from waste and sustainable streams respectively.



Acknowledgements



with Dr Maximilian Mann,
Dr Lynn Lisboa,
Dr. Thomas Nicholls, and
Dr. Nicholas Lundquist

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Electrochemical synthesis of poly(trisulfides)

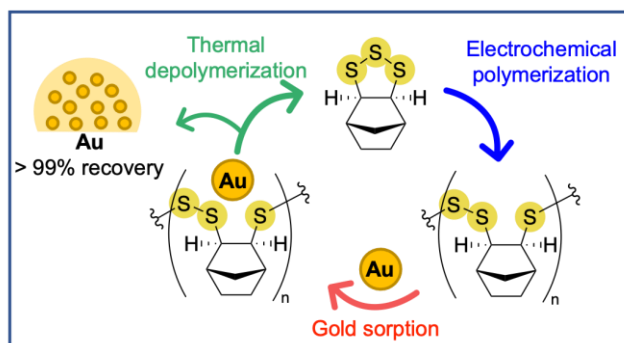
Jasmine M. M. Pople,¹ Thomas P. Nicholls,¹ Le Nhan Pham,¹ Witold M. Bloch,¹ Lynn S. Lisboa,¹ Michael V. Perkins,¹ Christopher T. Gibson,² Michelle L. Coote,^{*1} Zhongfan Jia,^{*1} Justin M. Chalker^{*1}

¹*Institute for Nanoscale Science and Technology, College of Science and Engineering, Flinders University, Bedford Park, South Australia 5042, Australia*

²*Flinders Microscopy and Microanalysis, College of Science and Engineering, Flinders University, Bedford Park, Adelaide, South Australia 5042, Australia*

*Email: popl0006@flinders.edu.au

With increasing interest in high sulfur content polymers, there is a need to develop new methods for their synthesis that feature better safety and control of structure. In this report, electrochemically-initiated ring-opening polymerization of norbornene-based cyclic trisulfide monomers delivered well-defined, linear poly(trisulfides), which were solution processable. Electrochemistry provided a controlled initiation step that obviates the need for hazardous chemical initiators. The high temperatures required for inverse vulcanization are also avoided resulting in an improved safety profile. Density functional theory calculations revealed a reversible ‘self-correcting’ mechanism that ensures trisulfide linkages between monomer units. This control over sulfur rank is a new benchmark for high sulfur content polymers and creates opportunities to better understand the effects of sulfur rank on polymer properties. Thermogravimetric analysis coupled with mass spectrometry revealed the ability to recycle the polymer to the cyclic trisulfide monomer by thermal depolymerization. The featured poly(trisulfide) is an effective gold sorbent, with potential applications in mining and electronic waste recycling. A water-soluble poly(trisulfide) containing a carboxylic acid group was also produced and found to be effective in the binding and recovery of copper from aqueous media.



Polyurethane (PU) phase change material: A promising renewable energy storage solution

Mohammad Mizanur Rahman^{1*}

¹Interdisciplinary Research Center for Advanced Materials, King Fahd University of Petroleum & Minerals

Dhahran 31261, Saudi Arabia

**Email: mohammadmizanur@gmail.com*

Polyurethane (PU) is widely known for its superior properties such as mechanical strength, thermal stability, barrier resistance, adhesion and antibacterial properties. The PU is being widely used in coating, adhesive, biomaterial and foam applications. Recently PU is attracted to renewable energy, particularly as a phase change material (PCM). The PCM can be used in solar energy. The PCM can not only settle the intermittence of energy but also can improve the efficiency (via storing/releasing). One of the main advantages of PU is their tuneable properties by altering the monomers and their contents. The waterborne PU materials which are environmentally friendly further forwarded this material due to an excellent combination of the environmental friendliness with cost effectiveness. PU materials are emerging as a promising material in the clean energy sector. In this study, a series of PU materials were prepared by tuning the polyols and their contents. The phase change enthalpy increased significantly when the polyethyleneoxideglycol (PEG) was used as a main polyol in PU material. The materials can absorb the solar light and light-thermal conversion was achieved with the proper PEG content.

MAX phases and MXenes in heterogeneous catalysis

Shiju N Raveendran, ^{1*}

¹ *Catalysis Engineering Group, Van 't Hoff Institute for Molecular Sciences, University of Amsterdam, Amsterdam, The Netherlands*

**Email: n.r.shiju@uva.nl*

Heterogeneous catalysts enable many chemical transformations of fossil as well as renewable resources into useful products. In Catalysis Engineering group, we try to develop solid catalysts for several types of reactions including CO₂ activation, lower alkane activation and biomass conversion. In this talk, I will give an overview of our recent projects on the development of new types of materials as catalysts for commercially important reactions. Recently we discovered that a MAX phase material, which hitherto had not used in catalysis, efficiently catalyses the oxidation of n-butane to butenes and butadiene. The catalyst, which combines both metallic and ceramic properties, is stable for several hours of reaction. This material has neither lattice oxygen nor noble metals, yet a unique combination of numerous defects and a thin surface mixed oxide layer that is rich in oxygen vacancies makes it an active catalyst. These materials and their 2D derivatives, MXenes, can be used as catalysts and supports in different reactions, which will be described in detail in this talk.

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Plastics-derived carbonaceous nanomaterials catalytic peroxymonosulfate activation and pollutants degradation

Shiying Ren^{1*}

*1 School of Chemical Engineering and Advanced Materials, The University of Adelaide,
Adelaide, SA 5005, Australia*

**Email: Shiying.ren@adelaide.edu.au*

The pollution caused by plastics/microplastics is throwing a big threat to the world. Transforming plastic wastes into value-added carbonaceous functional materials offer a promising strategy to address the challenges in plastic contamination, upgrading, and circulation. Here, we developed a salt template-based carbonization approach to catalytically converting high-density polyethylene (HDPE) into diverse carbon materials, such as core-shell carbon composites, nanosheets and their hybrids. The carbon morphology and proportions of amorphous carbon are controlled by the mass ratio of nickel chloride and HDPE. Carbon nanosheets perform excellent catalytic efficiency for phenol oxidation, due to the high content of amorphous carbons. Amorphous carbons introduced a large number of reactive defects for peroxymonosulfate activation via a nonradical electron-transfer mechanism. We found that radical scavengers (e.g., ethanol) led to a declined phenol removal rate, because of the degressive adsorption of organics rather than the scavenging free radicals, evidenced by deliberate experiment design and kinetics analyses. This work achieves a virtuous closed loop by transforming plastics into treasured carbocatalysts for advanced water purification.

A Continuous Moisture-Driven Electrical Generator Based on Two-Dimensional Lamellar Vermiculite Membrane

Xiaohu Ren,^{1,2*}, Haolan Xu¹

¹ Future Industries Institute, UniSA STEM, University of South Australia, Mawson Lakes Campus, Adelaide, SA, 5095 Australia

² College of Materials Science and Engineering, Xi'an University of Architecture and Technology, Xi'an, Shaanxi, 710055 China

*Email: xiaohu.ren@unisa.edu.au
haolan.xu@unisa.edu.au

Moisture-driven electrical generator (MEG) is highly promising in next generation energy conversion, which has recently attracted intense interest as a facile approach to harvest green energy from absorption moisture in air. However, the practical applications of existing MEG devices are limited due to their low current and voltage outputs, strong dependence on high moisture. Herein, an efficient MEG integrated with high output, low cost and scalable fabrication characteristics based on the rational combination of exfoliated two-dimensional lamellar vermiculite nanosheets and polydiallyl dimethylammonium chloride (PDDA) is developed for the first time. The PDDA layer ionizes Cl^- after absorbing moisture, leaving a positively charged macromolecular chain, while the vermiculite nanosheets surface is negatively charged, hence generating an electrical potential difference along the MEG. Remarkably, the fabricated MEG device can produce a stable voltage output of more than 700 mV and a high current density of $30 \mu\text{A cm}^{-2}$. Even at a low air humidity, the MEG device can provide a high output. Meanwhile, it realizes a sustaining power output for external resistance over long time with good stability. Connecting several devices linearly magnifies voltage up to 100 V. Our results provide an insightful rationale for the design of device structure, which is of great importance to promote the efficient electricity conversion induced by moisture in air.

Magnetic resonance characterisation of interfacial phenomena in porous materials

Neil Robinson^{1*} and Michael L. Johns¹

¹Department of Chemical Engineering, The University of Western Australia, Perth WA

*Email: neil.robinson@uwa.edu.au

While solid–fluid interactions underpin the efficacy of functional porous materials across a diverse array of chemical reaction and separation processes of direct relevance to UN Sustainable Development Goal 7, detailed characterisation of interfacial phenomena within such systems is often hampered by their optically opaque nature. Motivated by the need to bridge this capability gap, this talk will introduce low-field two-dimensional ^1H nuclear spin relaxation measurements as a non-invasive probe of adsorbate identity and interfacial dynamics, taking the relaxation characteristics exhibited by liquid hydrocarbon adsorbates confined to model mesoporous oxides as examples. We will demonstrate the clear capacity of observed $T_1 - T_2$ relaxation time distributions to distinguish functional group-specific relaxation phenomena across a diverse range of alcohols and carboxylic acids employed as solvents, reagents, and liquid hydrogen carriers, wherein distinct relaxation responses may be assigned to the alkyl and hydroxyl moieties of each confined liquid (see Figure 1). Recent advances in utilising these observations to track competitive liquid/liquid displacement processes within such materials will also be discussed; such techniques are anticipated to provide critical information regarding solvent selection in liquid-phase catalytic systems of relevance to green chemical processes.

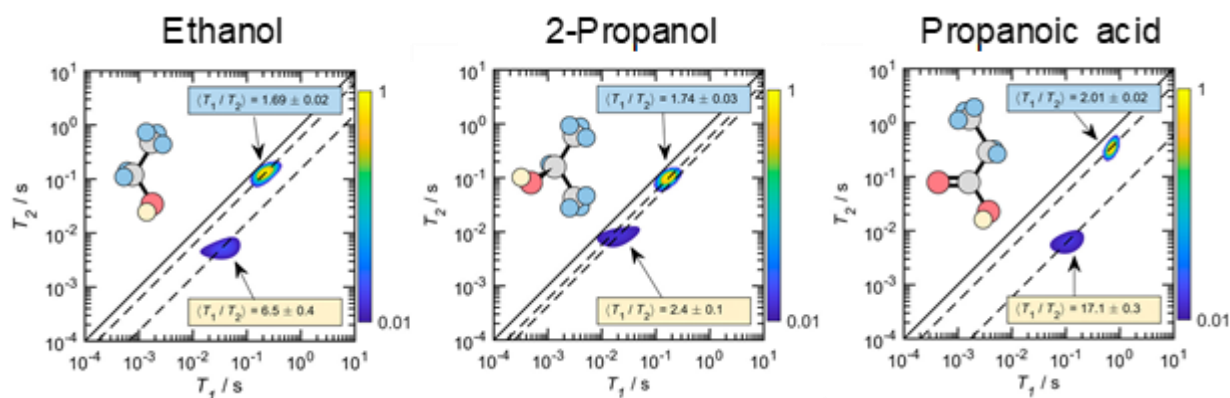


Figure 1. ^1H $T_1 - T_2$ relaxation time distributions obtained from polar hydrocarbon liquids confined within mesoporous silica. Correlation peaks observed at small and large T_1/T_2 ratios are attribution to alkyl and hydroxyl ^1H group relaxation, respectively.

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Quantitation of Boron in Preservative Treated Timber Using Ion Chromatography-Triple Quadrupole Mass Spectrometry

Estrella Sanz Rodriguez^{1*}, Kyra Wood², Brett Paull¹

¹ Australian Centre for Research on Separation Science (ACROSS), School of Natural Sciences (Chemistry), College of Sciences and Engineering, University of Tasmania, Hobart, Tasmania 7001, Australia

² Centre for Sustainable Architecture with Wood, School of Architecture and Design, College of Sciences and Engineering, University of Tasmania, Newnham, Tasmania 7248, Australia

*Email: Estrella.SanzRodriguez@utas.edu.au

Wood preservative treatments are routinely employed to increase the durability and lifespan of various wood products by improving their resistance to wood destroying organisms such as termites and fungi [1]. Historically, many common preservatives applied within the wood-products industry have included hazardous chemicals, which present risks for treatment plant operators and the environment alike. Therefore, there is an ongoing need within the timber industry to find more operator and environment “friendly” preservative systems. Boron-based formulations, which are well known for their preservative properties, exhibit low mammalian toxicity and low volatility, together with high-cost effectiveness [2, 3]. Various formulations are being investigated to treat timbers, both alone, and in conjunction with other chemicals to obtain a synergistic effect, such that the timber is efficiently protected against biodeterioration organisms for extended periods with minimal leaching [2]. In this context, a new, simple, fast and robust method for the determination of boron in aqueous solutions and extracts by suppressed ion chromatography coupled to electrospray ionisation- triple quadrupole mass spectrometry (IC-ESI-QqQ-MS) is presented. The limit of detection (LOD) of the developed method, expressed as boron, was 2.45 µg L⁻¹, the lowest reported in the literature to-date for an IC-based method [4]. The method was validated in a ‘proof of concept’ experiment under laboratory-controlled test conditions by evaluating the retention of boron following dip-treatment of unseasoned boards of Tasmanian Oak in a boron-based solution. Determination of trace amounts of boron is crucial in the analysis of other types of matrices such as nuclear fuels, high -purity quartz, high-purity water or plants and animal tissues [5]. Simple modifications of the new method presented here will allow it to be tailored to suit different applications, being the first analytical method that provides simplicity but also sensitivity for boron quantification in different matrices.

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SnSe-based thermoelectric materials: solvothermal synthetic designs

Xiao-Lei Shi, Zhi-Gang Chen*

*¹School of Chemistry and Physics, Queensland University of Technology
Brisbane, QLD 4000, Australia*

**Email: zhigang.chen@qut.edu.au*

Due to its high cost-effectiveness, low toxicity, and appropriate bandgap, SnSe has shown great potential as a promising thermoelectric material in practical applications. However, the application of SnSe in thermoelectric devices is challenging due to the difficulty in simultaneously optimizing its thermoelectric and mechanical properties. In this work, we carefully summarize the latest strategies for improving the thermoelectric and mechanical properties of bulk SnSe materials based on solvothermal synthesis, developed in our recent research. The progress in synthesis, characterization, thermoelectric performance improvement, and application is also outlined. Finally, we point out the controversies, strategies, and prospects for the future development of tin selenide-based thermoelectric materials and devices for various application scenarios.

Mechanisms of Anaerobic Self-Forming Dynamic Membrane Fouling in Saline Wastewater Treatment

Muhammad Ahmar Siddiqui^{1*}, Guanghao Chen¹, Carol Sze Ki Lin²

¹*Department of Civil and Environmental Engineering, Water Technology Center, Hong Kong.*

¹*Branch of Chinese National Engineering Research Center for Control & Treatment of Heavy Metal Pollution, The Hong Kong University of Science & Technology, Clear Water Bay, Kowloon, Hong Kong, China.*

²*School of Energy and Environment, City University of Hong Kong, Hong Kong.*

*Email: masiddiqui@connect.ust.hk

Abstract:

Conventional Anaerobic membrane bioreactors (AnMBR) based on ultra-filtration (UF) and micro-filtration (MF) membranes have been widely applied and studied in the last 25 years for municipal wastewater treatment (Siddiqui et al., 2021). Its advantages, such as high treatment capacity, small footprint, and good effluent quality make it an attractive technology (Ahmar et al., 2023). However, the high operation and maintenance (O&M) costs arising from extensive gas purging, low permeate flux, high energy consumption, and complicated operation limit their further application to large-scale wastewater treatment (Meng et al., 2017). On the contrary, by utilizing the biological layer, a new kind of AnMBRs called anaerobic self-forming dynamic membrane bioreactors (AnSFDMBRs) has been proposed and tested to tackle membrane fouling (Siddiqui et al., 2020). It reduces 70% cost compared to conventional AnMBR.

Therefore, a side-stream cross-flow anaerobic self-forming dynamic membrane bioreactor (AnSFDMBR) connected with an up-flow anaerobic sludge blanket (UASB) reactor was used to replace the UASB and middle settling tank in sulfate reduction, autotrophic denitrification, and nitrification integrated (SANI) process. To reduce the water and energy consumption for AnSFDMBR backwashing, the optimum condition of trans-membrane pressure (TMP)-based backwashing were investigated under sequential batch operations. Based on the optimum condition, a lab-scale AnSFDMBR was operated continuously for 243 days without a drop in flux, with good effluent quality. In the sequential batch study, AnSFDMBR showed no significant accumulation of total extracellular polymeric substances (EPSs) during 40 days of operation without backwashing. Polysaccharides slightly accumulated in the dynamic layer regardless of the final TMP and operation duration, indicating that TMP-based backwashing is suitable for the studied AnSFDMBR system. In long-term operation with TMP-based backwashing, total EPSs in dynamic layer to sludge ratio dramatically dropped during the fouling phase. According to the evaluation of total organic sulfur (TOS) in dynamic layer and mesh EPSs, it was found that TOS, mainly polysulfur generated in UASB reactor, played a critical role in fouling in saline wastewater treatment. TOS deposited on the mesh over 40% by weight of the total EPS in the fouling phase clearly led to system fouling. Additional sequential batch experiments with different seawater percentages (% V/V) (control, 10%, 20%, 30% and 50%) demonstrated that the TOS accumulation on the mesh increased with time and salinity which also aligned with the long-term operation.

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Formulating MOF inks for the 3D Printing of Monoliths

Marcello B. Solomon,^{1,2,*} Eleanor R. Kearns,^{1,2} Qingbo Xia,² Deanna M. D'Alessandro,^{1,2}

¹*School of Chemical and Biomolecular Engineering, Faculty of Engineering, The University of Sydney, New South Wales, Australia 2006*

²*School of Chemistry, The University of Sydney, New South Wales 2006, Australia.*

*Email: marcello.solomon@sydney.edu.au

The versatility of Metal-Organic Frameworks (MOFs) enables their use in a range of functional applications, including gas capture, storage and electrochemical transformations.¹ Their polycrystallinity, however, can inhibit their processability into useable devices for deployment on the industrial scale.² Generating MOF-composite materials has been increasingly used as a strategy to exploit the benefits of MOFs with the processability of other materials.³ The burgeoning field of 3D printing holds significant potential in the development of functional composite materials.⁴ 3D printing techniques such as Direct Ink Writing may simplify the fabrication of devices and enable the facile generation of optimised monolith geometries at reduced costs.

Herein, we report the blending of TIFSIX-Ni and Ni₃(BTC)₂ into composite inks for the 3D printing of scalable, functional monoliths. The blending of MOFs with conductive carbon, binders and plasticisers created a MOF ink, which could be extruded into a monolith. These monoliths were tested for the capture and release of CO₂ gas using Electric Swing Adsorption under dry and humid conditions, or for the electrochemical sensing of bioanalytes. Formulation of the inks preserved the performance of the pristine MOFs, while cycling experiments showed that the MOFs retained their performances over several hours. We discuss the opportunities and challenges associated with the scale up of monoliths for the deployment into the field, as well as investigate the economics behind deployment into the field.

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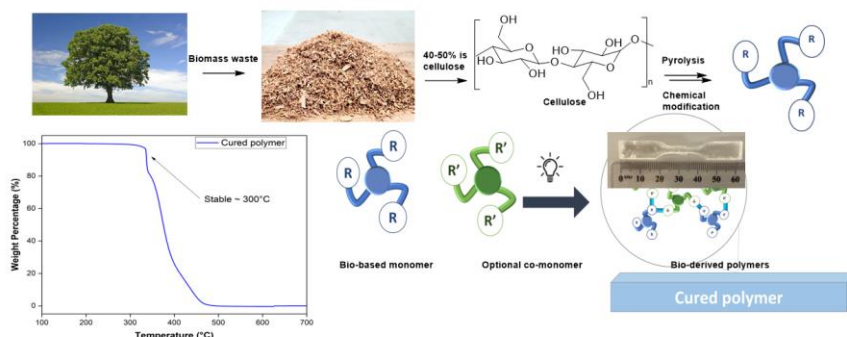
Wood waste to plastic: bio-based polymers as next generation polymer material

Melissa K. Stanfield,^{1*} Jason Smith,¹ Stuart C. Thickett¹

¹ School of Natural Science (Chemistry), University of Tasmania, Sandy Bay, TAS 7001, Australia

*Email: melissa.stanfield@utas.edu.au

More than 90% of today's synthetic polymers are derived from fossil fuels, 87% of these contribute to plastic waste. The largest source of renewable carbon-based energy is biomass waste. Cellulose accounts for up to 40-50 % of biomass waste. Biomass waste is a renewable source of valuable monomer and polymeric material. Chemical modifications of biomass waste products can yield desired scaffold monomers. The polymerised materials are viable alternatives to petrochemical derived polymers. The work herein, attempts to find an alternative to petrochemical derived polymers via the synthesis of monomers and polymers to create biobased plastics. A catalogue of monomer derivatives is readily available at hand, with selective, tailored chemical functionality. The novel plastic materials have been characterised via mechanical analysis, thermalgravimetric analysis (TGA) and the rapid (<60s) cure kinetics have been examined. There are potential applications for the resulting polymers as biobased 3D printing inks or surface coatings.



The thermoset materials are solvent resistant, optically transparent and stable until 350 °C. Moreover, the thermosets demonstrate a higher tensile strength compared to similar literature reported biopolymers.

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Plasmon Nanoparticle-Driven Biomass Conversion Under Illumination: Exploring Efficient and Sustainable Pathways

Haoyue Sun¹, Jun Huang^{1*}

¹ School of Chemical and Biomolecular Engineering, The University of Sydney, New South Wales, 2006, Australia

*Email: hsun5455@uni.sydney.edu.au, jun.huang@sydney.edu.au

Biomass conversion presents an appealing and sustainable approach to chemical production. However, the selective oxidation of aromatic alcohols to carbonyl compounds using traditional methods that require high temperatures has limited the catalytic process's energy efficiency, selectivity, stability, and reusability. To overcome these limitations, a solar-driven nanoreactor based on a porous carbon nanosphere-supported Pd-Au (Pd-Au/MCN) bimetallic nanocatalyst has been proposed in our work. The Pd-Au/MCN nanoreactor demonstrated excellent catalytic activity due to its high specific surface area, ordered porous channels, well-controlled metal location, broad-spectrum utilization, and well-controlled mass transfer and diffusion. This green and sustainable catalytic pathway enables the conversion of aromatic alcohols into other value-added chemicals using solar energy to replace the conventional thermocatalytic biomass reforming on metal nanocatalysts under ambient conditions. This work provides a potential alternative to produce valuable chemicals from biomass in a more energy-efficient, selective, and stable manner while reducing environmental impact.

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A sustainable CO₂ utilization and hydrogen storage cycle by plasmonic photocatalysts

Zhehao Sun, Zongyou Yin*

Research School of Chemistry, The Australian National University. Canberra, Australian Capital Territory, 2601, Australia.

**Email: Zongyou.Yin@anu.edu.au*

Converting solar energy into renewable and storable chemical energy holds immense potential for sustainable human development.¹ Plasmonic catalysts have emerged as ideal candidates for photocatalysis due to their tunable photoresponse range, hot electrons generation and local electric-field (E-field) generation, which induces broad interest.^{2, 3} We here designed two plasmonic photocatalysts for the green energy conversion. First, by integrating noble-free plasmonic bismuth nanoparticles and non-plasmon redox heterojunctions, the reaction path is successfully tailored by the E-field to maximize product selectivity. Bi particles with a BiOCl shell attached to self-assembled TiO₂ nanosheets exhibit high photoactivity in CO₂ reduction and excellent methanol selectivity due to the synergy between plasmonic E-field and complementary light absorption in the hybrid nanostructure. Moreover, zero-emission production of green and self-separating H₂ fuel are achieved through a plasmonic Cu-WC/W catalytic system through solar-driven ultra-wideband plasmonic photoreforming. Results show that the synergistic effect of the one-way flow of charge carriers caused by the local E-field, lattice-misfit strain, and photovoltaic gradient in such plasmon system gives excellent plasmonic photocatalytic activity and selectivity.⁴ The results of our two work provide a unique example of CO₂ > methanol > H₂ + liquid C₂ cycle, where we have successfully designed an efficient and clean hydrogen storage and production cycle, while simultaneously reducing greenhouse gas emissions, providing strong support for the development of green energy conversion.

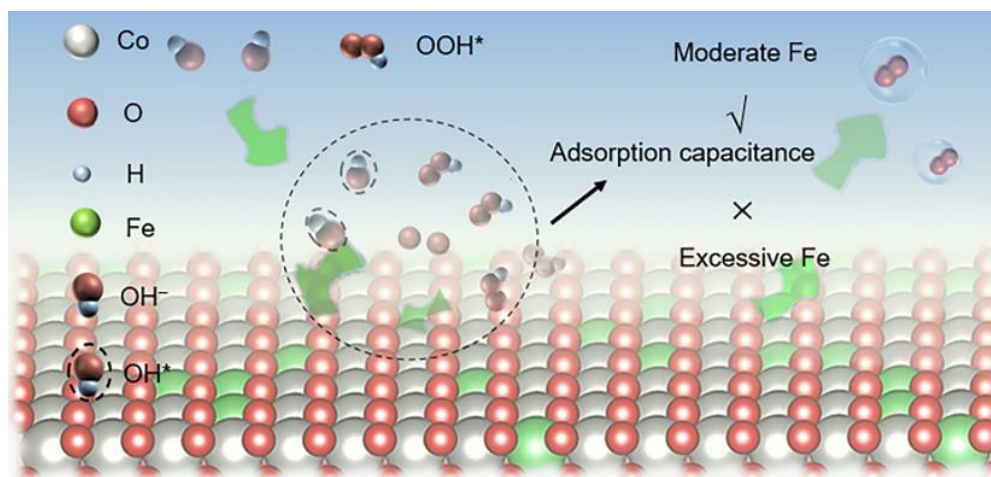
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Electrochemical water splitting catalysis on 2D nanomaterials

Ziqi Sun, Jun Mei, Juan Bai, Ziyang Wu, Ting Liao
School of Chemistry and Physics, Queensland University of Technology
2 George Street, Brisbane, QLD 4001, Australia
Ziqi.sun@qut.edu.au

As one promising green fuel generation technology, electrochemical water splitting is expected to support a sustainable future powered by providing renewable hydrogen. To realize this promising technology, low-cost and high-efficient electrocatalysts that possess favourable kinetics towards two half-reactions, i.e., anodic oxygen evolution reaction (OER) and cathodic hydrogen evolution reaction (HER), are the first priority to reduce the energy consumption and offer an affordable fuel supply. In this presentation, two-dimensional (2D) nanomaterials and 2D/2D heterostructures which maximize the exposure of active sites towards the reactants and provide optimal catalytic kinetics via their low-coordinated surface atoms and the tunable localized electronic properties have been developed for high-performance HER/OER catalysis. Our investigations started from monolithic simple binary 2D metal oxide-based catalysts, then expanded to functionalized 2D metal oxides and complex 2D oxides or hydroxides, and finally 2D/2D heterostructures that combine the merits from different types of 2D materials. Our research tries to shed some lights on the principles in designing advanced electrocatalysts and provide some insights into the understanding of electrochemical catalysis mechanism.



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Synthesis and assessment of 1,2,3-triazoles as nitrification inhibitors in Australian soils to reduce agricultural nitrogen pollution

Bethany I. Taggart^{1*}, Sibel Yildirim^{1,2}, Sneha Gupta², Deli Chen³, Uta Wille¹

¹ School of Chemistry, The University of Melbourne, Parkville, Vic, 3010, Australia

² School of BioSciences, The University of Melbourne, Parkville, Vic, 3010, Australia

³ School of Agriculture and Food, The University of Melbourne, Parkville, Vic, 3010, Australia

*Email: bethany.taggart@unimelb.edu.au

Nitrification inhibitors (NIs) can be co-applied with nitrogen (N) based fertilisers to reduce N losses and subsequent adverse environmental implications of N pollution. Many chemicals with NI activity have been identified, with N-containing heterocycles being among the most potent. The best performing commercial NI to date, 3,4-dimethylpyrazole phosphate (DMPP), has a highly inconsistent performance, with NI effectiveness strongly influenced by soil characteristics and environmental factors, such as soil pH or temperature. There is need for new inhibitors that offer more consistent and predictable performance under Australian field conditions.

After identifying that the 1,2,3-triazole core motif had been largely neglected in the NI literature, a library of these compounds was synthesised before laboratory studies were conducted to assess the compounds' nitrification inhibitory activity in Australian soils. These *in vitro* soil tests were conducted in the presence or absence of plants, alongside assessment of the NI potential in pure bacterial cultures. From these experiments, a number of 1,2,3-triazoles were found to behave as NIs and even outperform DMPP, including promising results under the usually problematic conditions of elevated soil temperature and low soil pH.

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***In vitro* anti-proliferative activity of polysaccharide-enriched fractions of a novel mushroom Hengshan *Astragalus* Shiitake enhanced by Green extraction techniques**

Bunu Tamang^{1,2,3*}, Wei Zhang^{1,2,3}, Qi Liang^{1,2}, Jean Winter^{1,4}

¹*Centre for Marine Bioproducts Development*

²*Medical Biotechnology Discipline, College of Medicine and Public Health, Flinders University, Bedford Park, SA 5042, Australia*

³*ARC Industrial Transformation Training Centre for Green Chemistry in Manufacturing*

⁴*Cancer Research, Flinders Health and Medical Research Institute, College of Medicine and Public Health, Flinders University, Bedford Park, SA 5042, Australia.*

*Email: tama0054@flinders.edu.au

Abstract: Hengshan *Astragalus* Shiitake (HAS) is a novel mushroom developed by our industry partner, Shanxi Yulongxiang Agricultural Development Co. Ltd., China by growing Shiitake mushrooms in the substrate beds supplemented with the roots of *Astragalus membranaceus*. As the biologically active components in mushroom depend on the supplement ingredients we feed them, the new HAS mushrooms have some bioactive components transferred from *Astragalus* that was determined by a global metabolome analysis in our previous study. The major aim of this study was to determine any changes in the yield, chemical composition and anti-proliferative activity of the polysaccharides enriched fractions (PEFs) of the HAS mushrooms with different green extraction techniques and compare them with the control Shiitake. The study investigated solvent-free green extraction techniques to extract the PEFs from the mushrooms, which included microwave, ultrasound and enzyme assisted techniques, alone and in combination. Interestingly, the yield of water-soluble PEFs in HAS mushrooms was significantly higher when compared to control Shiitake regardless of the extraction techniques used (~45% w/w more). The monosaccharide composition analysis revealed a significant change in some monosaccharide composition including, glucuronic acid, mannose and glucose concentration between HAS and Shiitake mushrooms. However, the anti-proliferative activity against human colorectal cancer cells (HCT-116) was highly dependent on the conditions used for extraction. The PEFs obtained from ultrasound-enzyme assisted (UEA) technique showed promising anti-proliferative activity with an IC₅₀ value of 367±44 ug/ml and 659±59 ug/ml for HAS and Shiitake extract, respectively while the previous studies reported a maximum inhibition of only ~71% with 1800 ug/ml of Shiitake polysaccharides. Our findings demonstrate that a green extraction technique such as UEA extraction method can be used for efficient and sustainable extraction of bio-active polysaccharides from mushrooms. Future studies assessing its anti-proliferative activity *in vivo* are warranted to provide pre-clinical evidence of its potent anticancer activity.

Keywords: Shiitake, *Astragalus membranaceus*, Hengshan *Astragalus* Shiitake, Green extraction, Polysaccharide-enriched-fractions, Colorectal carcinoma

Biography:

Ms. Bunu Tamang is one of the PhD candidates at Flinders University, College of Medicine and Public Health, South Australia. Ms. Tamang holds a Bachelor's and Master's degree in Pharmacy (Industrial Pharmacy) from Rajiv Gandhi University, India, and a Master's degree in Medical Biotechnology from Flinders University, Australia. She is currently working under Prof. Wei Zhang, Dr. Jean Winter and Dr. Qi Liang in the project entitled 'Biorefinery Process and Health Product Development of Hengshan *Astragalus* Shiitake'. The project is in collaboration with the industry partner Shanxi Yulongxiang Agricultural Development Co. Ltd., China, Flinders University and ARC ITTC Green Chemistry in Manufacturing, Australia.

Nanostructure–interface engineering of halide perovskite catalysts toward solar-fuel generation

Rui Tang,¹ Jun Huang¹

¹ School of Chemical and Biomolecular Engineering, Sydney Nano Institute, The University of Sydney, Sydney, NSW 2037, Australia

*Email: rui.tang2@sydney.edu.au, jun.huang@sydney.edu.au

The continuous release of greenhouse gases from human activities has led to significant environmental problems, including climate change and pollution. Therefore, developing practical technologies that recycle and reuse emitted carbon is urgently needed. Our research aims to address this need by focusing on the development of efficient halide perovskite photocatalysts and their applications in converting CO₂ into industrially valuable products. Our work establishes the structure-catalytic performance relationship of perovskite-based catalysts, demonstrating that the microstructure can be regulated to tune the optical harvesting behaviour of the catalysts efficiently. Furthermore, by changing the interfacial environment of the catalysts, the reaction active site can be tailored to achieve greatly enhanced reaction activity. Our research presents a new approach to designing novel halide perovskite photocatalysts with tunable catalytic behaviour, which can be further applied in other catalytic applications, such as biomass refining and organic synthesis. This work has significant implications for addressing the challenges of greenhouse gas emissions and achieving a sustainable future.

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Au nanocluster enabled SERS enhancement via charge transfer

Mohammad Tavakkoli Yarak¹, Yuling Wang^{1*}

¹ School of Natural Sciences, Faculty of Science and Engineering, Macquarie University, NSW 2109, Australia

*Presenter's Email: mohammad.tavakkoliyaraki@mq.edu.au

*Corresponding Author's Email: yuling.wang@mq.edu.au

Surface-enhanced Raman scattering (SERS) nanotags made of gold coated with Raman molecules (AuNP@Mol) are being used in many environmental and biomedical applications¹. The enhancement of SERS intensity has been a backburning topic since the discovery of SERS because the higher SERS intensity could result in the higher sensitivity of system^{2, 3}. Here, we report how charge transfer process combined with plasmonic enhancement approach could lead to further SERS amplification. Gold nanoclusters have shown promising optical and electronic properties that could be used as donor in charge transfer process^{2, 4}. In this work, we show how introducing bovine serum albumin (BSA)-templated Au nanoclusters (AuNCs) to Raman molecule-coated Au nanoparticles (AuNP@Mol) could enable SERS enhancement via charge transfer. The charge transfer process was confirmed by excitation wavelength-dependent SERS measurements. The possible SERS amplification mechanism was proposed by density functional theory (DFT) calculations (molecular level) and finite-element method simulations (macro level). The results suggested that AuNCs not only affect the SERS performance of Raman molecule through direct charge transfer process, but also, pump electrons to the surface of AuNPs, leading to increase in the charge density at the surface of AuNP. Combined with plasmon coupling effect, the enhanced electric field around AuNP (in a AuNP@Mol@AuNCs system) was increased compared to AuNP@Mol, leading to higher (up to 2-fold) SERS signal. We believe that the results of this work will communicate with researchers across many fields from material science to biology science and energy, where charge transfer plays important role.

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Processing of phosphogypsum as a way to improve the environmental and resource efficiency of mineral fertilizer production

Maksim Tcikin

Chief Specialist Head of Department, NIUIF JSC

Email: MTsykin@phosagro.ru

One of the promising ways to increase the resource and environmental efficiency of enterprises producing mineral fertilizers, as well as to reduce greenhouse gas emissions, is the creation of combined industries that make it possible to efficiently use raw materials and energy resources, including recycling of waste and secondary raw materials. Large-scale by-products of phosphate fertilizer production are phosphogypsum and acid effluent neutralization station sludge resulting from lime neutralization of wastewater containing fluorosilicic acid (FSA) and phosphoric acid. The main problems are caused by the need to create a phosphogypsum storage (land allotment, creation of a dump and monitoring its condition, collection and return of gypsum waters, etc.) and ensuring the neutralization of acidic effluents (delivery and storage of lime, lime milk production, configuration of an acid effluent neutralization station, storage of sludge from the neutralization station). At the same time, in the nitrogen fertilizers manufacture, when ammonia is produced, a significant amount of carbon dioxide is formed and released into the atmosphere; and it is one of the main sources of greenhouse gas emissions in the chemical industry as a whole. The greatest effect from the introduction of existing and prospective conversion methods can be achieved if nitrogen and phosphorus production facilities are located in sufficient proximity, which simplifies the task of transporting raw materials (phosphogypsum, FSA, ammonia, carbon dioxide) and reduces capital and operating costs. In this case, two types of processes can be implemented: 1) conversion of phosphogypsum with an ammonium carbonate solution (obtained from CO_2 and NH_3) to obtain an ammonium sulfate solution and industrial calcium carbonate; 2) new technique, developed by NIUIF, of co-processing by-products phosphogypsum and FSA with production of ammonium sulphate solution and fluoride containing precipitation - industrial calcium fluoride. This process is based on neutralization of the FSA by ammonia in the presence of phosphogypsum.

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Synergistic Effect between Nanostructured Catalysis and Ultrasound in Biomass Conversion to Specialty Chemicals

Thang Q. Trinh*, Nam-Trung Nguyen

Queensland Micro- and Nanotechnology, Griffith University

*Email: t.thang@griffith.edu.au

There are strong incentives to produce chemicals and fuels from renewable biomass resources to reduce the reliance on diminishing fossil resources [1]. Lignocellulosic biomass is expected to be the most promising renewable feedstock, owing to its wide abundance, high energy content, and sustainability. The polyfunctionality of these substrates can unlock new routes for chemical synthesis and catalysts are the central engines to facilitate those chemical transformations. However, controlling the selective conversion of these polyfunctional substrates remains a grand challenge in chemistry. To address this selectivity challenge, a new concept of assisted catalysis has emerged wherein chemical reactions are driven at room temperature by external triggers like electrical potentials, photons, plasma, and ultrasound. In this study, we report and rationalize a synergistic effect between a non-noble metal oxide catalyst (CuO) and high frequency ultrasound (HFUS) on glucose oxidation. While CuO and HFUS are able to independently oxidize glucose to gluconic acid [2,3], the combination of CuO with HFUS led to a dramatic change of the reaction selectivity, with glucuronic acid being formed as the major product. Using the integrated molecular modelling and experimental approach, we show that, under ultrasonic irradiation of water at 550 kHz, the surface lattice oxygen of a CuO catalyst traps H• radicals stemming from the sonolysis of water, making the ring opening of glucose energetically non-favorable and leaving a high coverage of •OH radical on the CuO surface which selectively oxidize glucose to glucuronic acid [4]. This work also points towards a path to optimize the size of the catalyst particle for an ultrasonic frequency which minimizes the damage to the catalyst, resulting in its successful reuse.

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Biography:

Dr Thang Trinh completed his PhD in Chemical Engineering at the National University of Singapore (NUS) in 2014. After PhD graduation, he worked as a Research Fellow at the Nanyang Technological University, Singapore (NTU) for 7 years. From 2021 to 2023, Dr. Trinh was a Research Scientist at the Institute of High-Performance Computing, Agency for Science, Research and Technology (A*STAR), Singapore. Since 2023, Dr. Trinh is a Research Fellow at the Queensland Micro and Nanotechnology at Griffith University. His research areas focus in using the integrated computational-experimental approach to discover novel catalysts and functional materials for renewable, sustainable, and green chemistry applications.

Influence of cobalt salts on biomass conversion to functional carbon-based catalysts for environmental catalysis

Wenjie Tian,^{*}, Zhihao Tian, Shaobin Wang

^{*}Email: wenjie.tian@adelaide.edu.au

Advanced oxidation processes based on peroxymonosulfate (PMS) activation have emerged as a promising approach to eliminate persistent organic pollutants in water. For effective PMS activation, carbon-based catalysts from abundant and low-cost biomass sources are especially promising and sustainable¹. Pristine carbons usually present low or modest catalytic activity, while the modification by transition metals is often considered an effective way to introduce more favorable active sites. Cobalt-based carbon turns out to be exceptionally efficient², whereas the influences of different cobalt precursors affect the structure and catalytic performance of biomass-converted carbon remains unclear. Herein, four typical cobalt salts are investigated for pyrolytic biomass conversion. The melting point of cobalt salts is found to be a critical factor for carbon structure formation. Co-salts (cobalt nitrate ($\text{Co}(\text{NO}_3)_2$), cobalt acetylacetonate ($\text{Co}(\text{acac})_2$), cobalt acetate ($\text{Co}(\text{Ac})_2$)) with low melting points ($\leq 165^\circ\text{C}$) could be trapped in a biomass flower precursor, promote mesopore formation and catalyze the graphitization process, finally forming mesoporous carbon matrixes with $\text{Co}@$ graphitic-C nanoparticles and trace isolated Co atoms (denoted as $\text{Co}@$ C- NO_3 , -Ac, -acac). By comparison, CoSO_4 having a high melting point (735°C) produces an amorphous carbon/ Co_9S_8 nanoparticle composite (denoted as $\text{Co}_9\text{S}_8@$ C- SO_4). $\text{Co}@$ C- NO_3 and $\text{Co}_9\text{S}_8@$ C- SO_4 demonstrated the best performance in peroxymonosulfate (PMS) activation for bisphenol A degradation with distinct catalytic mechanisms due to different types of active sites. $\text{Co}@$ C- NO_3 /PMS shows multiple nonradical/radical pathways, while $\text{Co}_9\text{S}_8@$ C- SO_4 /PMS demonstrates selective sulfate radical-based reaction pathway. Excellent multiple organic pollutant removal performance in real water and good regeneration properties are observed. This study provided a novel insight into rational design of biomass-derived carbon-based catalyst with desired active sites to meet a different catalytic demand.

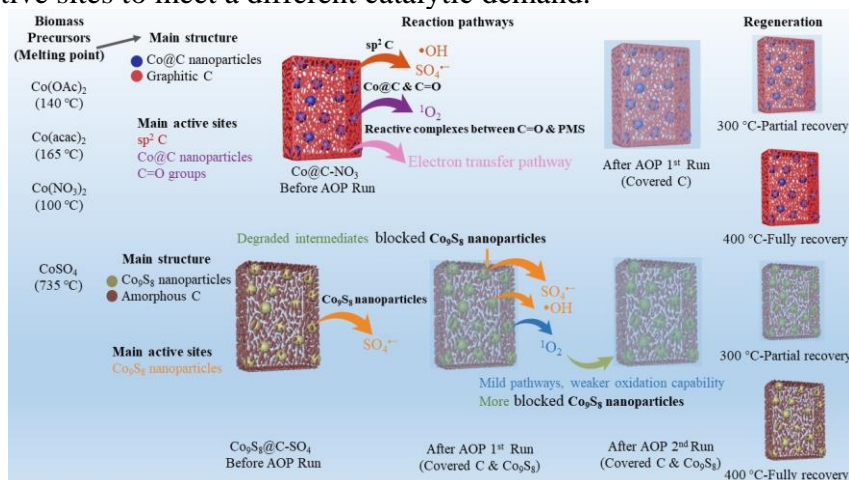


Figure 1 The influences of cobalt precursors on the structures of biomass-derived carbons and their corresponding activity, mechanism, and cyclic performance in PMS activation.

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Interfacially engineered printable graphene inks for energy storage and conversion

Tuan Sang Tran,^{1,2,*} Naba Kumar Dutta,² Namita Roy Choudhury²

¹ School of Chemical Engineering, The University of New South Wales, NSW 2052, Australia.

² School of Engineering, RMIT University, VIC 3000, Australia.

*Email: sang.tran@unsw.edu.au

Currently, 85% of the global energy supply is derived from fossil fuels (i.e. coal, oil and gas). To save the world from ever-increasing energy needs, clean and highly efficient renewable energy sources must be developed. Among various renewable energy technologies, fuel cells are recognized as one of the most promising clean energy sources due to their emission-free nature and high energy conversion efficiency. However, the exorbitant cost and low stability of Platinum-based electrocatalysts prevent fuel cells from becoming commercially viable. Therefore, the development of metal-free electrocatalysts with efficient catalytic performance and long-term stability is highly desired for fuel cells applications. Herein, a novel solution-processable and printable graphene-based electrocatalyst for oxygen reduction reaction (ORR) is developed by interfacing graphene with amphiphilic conductive polymers via exfoliation-assisted noncovalent functionalization. It is found that the strong noncovalent π -stacking interaction between graphene and the hydrophobic rings of conductive polymers disrupts the π - π interactions holding the graphite layers and promotes exfoliation. Such strong π -stacking interactions between graphene basal plane and conductive polymers chains induce the conformational change of the resonant structures to facilitate charge transport, contributing to higher conductivity. The intermolecular electron transfer from graphene to the hydrophobic rings of conductive polymers creates net positively charges at the C atoms of graphene flakes, facilitating its electrical conductivity and electrocatalysis activity. The printable graphene inks were utilized to fabricate metal-free electrocatalyst layers for ORR, which reduces O₂ molecules to OH⁻ ions via the highly efficient four-electron pathway and exhibits superior stability (~97% retention after 10,000 cycles). This printable graphene electrocatalyst provides a breakthrough for the new green chemistry and advanced techniques for fabrication of low-cost and sustainable fuel cells.

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Bio:

Dr. Tuan Sang Tran is currently a Postdoctoral Fellow at School of Chemical Engineering, University of New South Wales (UNSW Sydney). Dr. Tran graduated from RMIT University with a Ph.D. in Chemical Engineering in 2021. After that, he worked as a Postdoctoral Fellow at RMIT from 2021 to 2022, before joining UNSW in early 2023. His current research focuses on designing the interactions between nanomaterials to enable applications in high-performance electronics, renewable energy, and environmental remediation. During his early research career, he featured more than 20 publications, which attracted more than 700 citations. He also holds a patent on advanced manufacturing of high-quality graphene, which is groundbreaking for graphene to take off from the laboratory to practical applications.



Gallium Liquid Metal Nano-toolbox: Green and Sustainable Solution for Fighting Superbugs

Vi Khanh Truong^{1*}

¹ *Biomedical Nanoengineering Laboratory, College of Medicine and Public Health, Flinders University, Bedford Park, SA, Australia*

**Email: vikhanh.truong@flinders.edu.au*

The increasing prevalence of drug resistance in microbial pathogens poses a significant threat to human health, underscoring the need for innovative, sustainable, and eco-friendly treatment strategies [1, 2]. Gallium-based liquid metal nanoparticles have emerged as a promising green alternative. Gallium, a post-transition metal that is liquid at physiological temperatures, is characterized by its unique properties, exceptional antimicrobial efficacy, low toxicity, and minimal environmental impact. Notably, gallium exhibits anti-inflammatory effects on immune cells and can be alloyed with other metals or incorporated into various composites to enhance its properties and functionality. Importantly, the bactericidal mechanism of gallium liquid metal incorporated with other metals may help circumvent the challenge of emerging drug resistance [3-6]. Leveraging these benefits, gallium-based liquid metal nanoparticles offer novel, effective, and environmentally responsible approaches to combat antimicrobial resistance. This presentation will provide an overview of our recent work on gallium liquid metal, focusing on the development of sustainable antimicrobial solutions. Additionally, we will discuss the challenges and opportunities that warrant further research in this rapidly evolving field, emphasizing the importance of sustainability and green technology.

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LEACHING CHARACTERISTICS AND POTENTIAL RISK OF HEAVY METALS FROM DRIP IRRIGATION PIPES AND MULCH SUBSTRATES IN AGRICULTURAL ECOSYSTEMS

Muyesaier (melanie) Tudi

Griffith University

Email: m.tudi@griffith.edu.au

Abstract: Drip irrigation is a valuable method for optimising and motivating water and fertiliser usage. However, the ecological effects of drip irrigation fertilisation have not been sufficiently evaluated, limiting its effective and widespread use. Within this context, we aimed to determine the effects and potential ecological risks of using polyethylene irrigation pipes and mulch substrates under various drip irrigation conditions as well as burning of waste pipes and mulch substrates. Laboratory simulations of field conditions were used to determine the distribution, leaching, and migration patterns of heavy metals (Cd, Cr, Cu, Pb, and Zn) from plastic drip irrigation pipes and agricultural mulch substrates towards various solutions. Maize samples obtained from drip-irrigated fields were analysed to determine the presence of heavy metals and to assess their risk of contamination. Heavy metal leaching from pipes and mulch substrates was high under acidic conditions, while the migration of heavy metals was low from plastic products to alkaline-water soluble fertiliser solutions. After combustion, heavy metal leaching from pipes and mulch residues increased considerably, with the migration capacity of Cd, Cr, and Cu being increased by more than 10-fold. Heavy metals in plastic pipes migrated primarily to the residues (e.g., bottom ash), whereas those from mulch substrates migrated to the fly ash. The migration of heavy metals from plastic pipes and mulch substrates had a negligible effect on the heavy metal content in aqueous environments. Although heavy metal leaching increased, the effect on water quality under actual irrigation conditions was relatively minor (in the order of 10⁻⁹). Thus, the use of plastic irrigation pipes and mulch substrates did not result in significant heavy metal contamination and potential risk to the agriculture ecosystem. Our study findings provide evidence for the effective application and widespread promotion of drip irrigation and fertiliser technology.

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A Controlled Approach to Understanding Microplastics in the Environment

George Vamvounis,^{1,2} Alexandra Gulizia,^{1,2} Bronson Philippa,¹ Cherie Motti^{2, 3}

1 College of Science and Engineering, James Cook University, Queensland, Australia

2 AIMS@JCU, Division of Research and Innovation, James Cook University, Townsville, QLD, Australia

3 Australian Institute of Marine Science (AIMS), Townsville, QLD, Australia

**Email: george.vamvounis@jcu.edu.au*

Plastic pollution, including microplastics, presents a unique threat to aquatic ecosystems and wildlife. Experiments to measure microplastic toxicity often use microplastic particles that are recovered from the environment. In this seminar, I will discuss a controlled approach where microplastics are produced with a known composition. These particles were used to study the chemical digestion parameters often used to isolate microplastic particles. Based on this study, digestion protocols were developed that minimise polymer degradation while harsh enough to digest biological materials (Figure 1a).¹ Furthermore, this controlled approach to produce microplastics with known composition was used to incorporate various additives in polystyrene microplastics. The diffusion of the additives from the microplastics under various conditions (temperature, agitation, salinity, microplastic size) was studied to understand the effect of various environmental factors on the additive leaching (Figure 1b).²

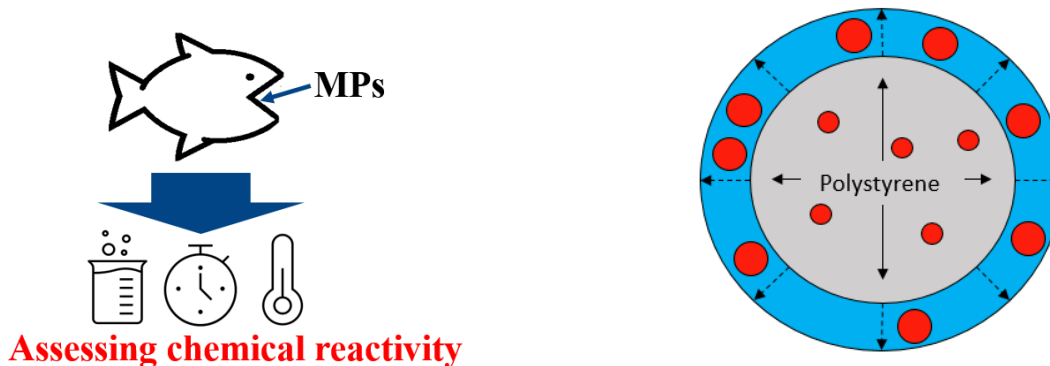


Figure 1. (a) Assessing the chemical processing parameters on the degradation of polystyrene microplastics (b) Understanding the diffusion of additives in polystyrene based microplastics.

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Water Separation through Graphene-Oxide Membranes

Dan Villamanca,^{1*} Karin Ching,² Marc Dubois,³ Sam Chen¹

1. School of Environmental and Life Sciences, The University of Newcastle, Callaghan, New South Wales, 2308, Australia
2. School of Chemistry, University of New South Wales, Sydney, New South Wales, 2052, Australia
3. ICCF, 24 Avenue Blaise Pascal, 63170, Aubière, France
*Email: dan.villamanca@uon.edu.au

Water enriched in less-abundant, naturally occurring isotopes is in high demand due to its crucial roles in many fields of science and technology. Our group has demonstrated that the formation of a novel class of two-dimensional membranes, composed of stacked and/or overlapping layers of graphene oxide, is a promising avenue for a cost-effective and energy-efficient nanofiltration strategy in improving isotopic separation. Pervaporation and dead-end filtration studies demonstrated heavy isotope enrichment for both D and ^{18}O .¹ The effects of interlayer spacing, thickness, intermolecular forces, surface charge and hydrophobicity of graphene-oxide membranes on the water isotopic separation will be discussed in this talk. Additionally, new types of graphene-oxyfluoride membranes with controllable chemical functionalities were made through fluorination of graphene oxide membranes at different temperatures.² These graphene-oxyfluoride membranes exhibited stable morphologies in water whilst maintaining high water vapor permeabilities, which has previously been a limitation of implementing pure graphene-oxide membranes for water separation.

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Robust Flexible Quasi-Solid-State Ag-Zn Batteries with High Areal Capacity and Long Cycle Life

Tao Wan*, Yanzhe Zhu, Dewei Chu

*School of Materials Science and Engineering,
University of New South Wales, Sydney 2052,
Australia*

**Email: tao.wan@unsw.edu.au*

Ag-Zn batteries have been successfully commercialized, but the batteries suffer from inferior cycling performance, low areal capacity, and poor mechanical flexibility, hindering their practical application in next generation electronics. In this work, flexible quasi-solid-state Ag-Zn batteries with high areal capacity and long cycle stability are developed by using mild electrolyte and binder-free electrodes. The electrochemical performance of the batteries has been significantly enhanced through engineering the electrodes and electrolyte. Copper foam is used as current collector to impede the growth of Zn dendrite for high cycle stability, and the structure of Ag cathode is rationally designed to improve the areal capacity and alleviate undesired Ag migration. The novel batteries with dendrite-free anode and stable cathode demonstrate a remarkable capacity retention at high current density. The developed high-performance flexible Ag-Zn batteries can operate in extreme conditions, such as being bent, twisted, cut, put on fire, and sealed in solid ice, and they can power various electronics for practical applications, such as electronic ink display, temperature and humidity sensor, and heart rate sensor. This work provides effective ways to design electrodes and electrolyte towards high-performance flexible Ag-Zn batteries.

Dyson sphere-inspired photothermal evaporator to enhance solar steam generation efficiency by self-created airflow

Deyu Wang, Haolan Xu*

Future Industries Institute, UniSA STEM, University of South Australia, SA 5095

*Email: deyu.wang@mymail.unisa.edu.au; * haolan.xu@unisa.edu.au*

Interfacial solar steam generation (ISSG) provides a cost-effective and sustainable solution for desalination and wastewater treatment. In an ISSG system, the temperature of the solar evaporation surface (SES) is higher than the environment and bulk water, which leads a heat conduction loss from the ISSG system to surrounding air and water. Thus, the high-temperature surface was recognised as a negative factor in the ISSG system, and various strategies were developed to enhance evaporation efficiency by reducing or eliminating the temperature surface area. However, this study indicates that a high-temperature surface can create an airflow to enhance the evaporation rate by activating a larger evaporation surface. Here, a hollow Dyson sphere-inspired ISSG evaporator with inside and outside evaporation surfaces was built. During the ISSG process, solar energy is absorbed by the outside surface and leads to a high surface temperature. Meanwhile, cold evaporation results in a lower temperature of the inside surface than SES. The temperature difference can create an airflow to accelerate the surrounding vapor escape from the evaporator and promote steam generation. In addition, the created airflow can pass through the Dyson sphere-like evaporator and activate the inside cold evaporation surface to further enhance the evaporation rate. Due to the large-scale activated evaporation surface, the evaporation rate of the Dyson sphere-like ISSG evaporator is 3.00 and 8.10 kg m⁻² h⁻¹ under 0 and 4m/s wind speed, respectively.

Developing multifunctional piezocatalysts to enhance hydrogen peroxide production

Kai Wang^{1,2*} Lianzhou Wang², Shaomin Liu¹

¹ *WA School of Mines: Minerals, Energy and Chemical Engineering, Curtin University, Perth, WA 6102 Australia*

² *Nanomaterials Centre, School of Chemical Engineering, The University of Queensland, Brisbane, QLD 4072 Australia*

* Email: kai.wang2@curtin.edu.au; kai.wang@uq.edu.au

Piezocatalysis, a newly developed promising catalysis technology that relies on the piezopotential and piezoelectric properties of the catalysts, is attracting unprecedented research enthusiasm for applications in energy conversion and environmental remediation. The exploration of multifunctional piezocatalysts with desired piezoelectricity and favourable catalytic features plays a key role in the development of piezocatalysis. Herein, the fundamental understanding of piezocatalysis is firstly elucidated to explain the observed piezocatalysis and to provide guidance for the rational design of piezocatalysts. In addition, the state-of-the-art design strategies are also demonstrated to fabricate highly efficient piezocatalysts based on complex oxides for hydrogen peroxide generation. Furthermore, the coupling of piezoelectricity and photocatalytic process is realized via in-situ construction of ultracompact hybrids with the ideal properties from each individual component.

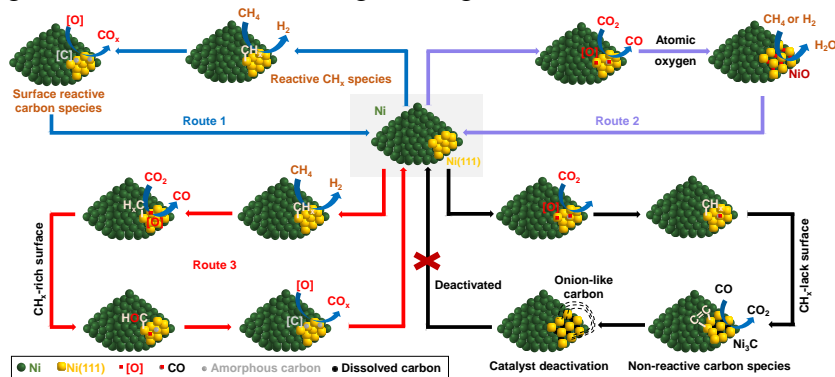
Reveal and Correlate Working Geometry and Surface Chemistry of Ni Nano-catalysts in CO₂ Reforming of Methane

Lizhuo Wang¹, Zichun Wang¹, Wenjie Yang¹, Jun Huang^{1*}

¹ School of Chemical and Biomolecular Engineering, Sydney Nano Institute, The University of Sydney, Sydney, 2037, Australia

*Email: jun.huang@sydney.edu.au

Carbon dioxide (dry) reforming of methane (DRM) is promising for the urgent Net-Zero target since it not only the utilization of two greenhouse gases, but also a sustainable approach to fabricate market-favourite hydrogen (H₂) and carbon monoxide (CO). With minor adjustment, DRM can be applied in industrial scale using the existing steam reforming infrastructure and minimize the carbon dioxide emission in H₂ economy. While Ni-based catalysts with high activity are promising in commercial DRM process, they suffer from quick deactivation due to the lack of knowledge regarding the surface composition and geometry under working conditions. In the present study, we combine *in situ* Cs corrected high resolution environmental transmission electron microscopy (HRETEM) and electron energy-loss spectroscopy (EELS) to identify the structural and chemical change over catalyst surface. The density functional theory (DFT) calculation revealed the carbon deposition mechanism during DRM on Ni. The stepwise transformation of reduced Ni particles from spherical to strongly curved structures correlates with the formation of NiO and Ni₃C upon CO₂ dissociation, while only amorphous carbon and nearly no structural change were observed upon CH₄ decomposition on Ni surface, as confirmed by EELS and DFT calculations. The formation of Ni₃C has been found to inhibit the decomposition of CO₂ and CH₄, and to promote the formation of onion-like carbon to cover/encapsulate the Ni nanoparticles (NPs), leading to the deactivation of the Ni-based catalysts. CO₂-decomposition initiated Ni surface or CO₂-rich reaction environment is not friendly for reforming of CH₄. When advancing CH₄ decomposition over CO₂ activation in DRM, the Ni surface is running without the coke deposition through a Ni oxidation-reduction cycle and the correlated amorphous carbon deposition-consumption cycle. It revealed a potential strategy to develop the coke resistance DRM catalysts by designing the suitable supports or promoters to keep the Ni surface structure under Ni-NiO cycle, which can drive the simultaneously amorphous carbon deposition-consumption cycle and minimise the coke formation. This research focuses on providing insight into the reaction and deactivation mechanisms of Ni catalysts in the DRM, and the uncovered principle is also profound for the investigation of many catalysis challenges both in research and engineering.



Deep Eutectic-Like Solvents with Exceptional Hydrogen Bond Donating Abilities

Cameron C. Weber,^{1,2*} Navneet K. Brar,^{1,2} Roland T. Brown,^{1,2} Kaveh Shahbaz,³
Patricia A. Hunt^{2,4}

¹ School of Chemical Sciences, University of Auckland, Auckland, New Zealand

² MacDiarmid Institute for Advanced Materials and Nanotechnology, Wellington, New Zealand

³ Department of Chemical and Materials Engineering, University of Auckland, Auckland, New Zealand

⁴ School of Chemical and Physical Sciences, Victoria University of Wellington, Wellington, New Zealand

*Email: cameron.weber@auckland.ac.nz

Hydrogen-bonding (H-bonding) interactions strongly influence the behaviour of a solvent in terms of the solubility of solutes, solvent effects on reactivity and the ability of the solvent to selectively extract target analytes.[1] Fluorinated alcohols such as 1, 1, 1, 3, 3, 3-hexafluoroisopropanol (HFIP) fill a unique niche as solvents and catalysts due to their strong H-bond donating ability.[2] However, these alcohols are toxic, volatile and environmentally persistent. Towards identifying viable replacements for fluorinated alcohols, we have investigated the development of deep eutectic-like solvents featuring guanidinium salts, inspired by ionic liquids found to be exceptional H-bond donors.[3] This presentation will describe the preparation of these solvents, their physicochemical properties and the characterisation of their polarity, including the development of an alternative method for assessing H-bond donating strength.[4] Quantum mechanical calculations used to understand the origin of the H-bonding behaviour observed will also be discussed.



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Scalable manufacturing of thermal stable enzymes for industrial applications using spray drying

Yilun Weng, ^{1*}, Chun-Xia Zhao¹

¹ *Australian Institute for Bioengineering and Nanotechnology, The University of Queensland, Australia*

**Email: y.weng@uq.edu.au*

The global demand for animal-sourced food is estimated to rise by 70% in 2050, compared to the year 2000. The livestock sector, which provides greater than one-third of human protein needs is facing a big challenge as a result of the growing demand for meat. Managing the feed cost is important for livestock industry, as it accounts for about 70% of the total livestock production expenses. To reduce animal feed cost, optimize animal performance, and improve process sustainability, exogenous enzymes are frequently utilized in animal feed industry. Phytase is a common enzyme in animal feed industry, due to its well-recognized ability to enhance the digestion and absorption of phosphorus, by catalyzing the hydrolysis of indigestible phytic acid (inositol hexakisphosphate) in animal feed to a highly digestible form. However, the application of phytase in industry has been greatly limited due to its low thermal stability. Animal feeds are pelleted at temperatures up to 105 °C to kill harmful bacteria. During the steam pelleting process, phytase can lose up to 80% of its activity due to moisture and elevated temperatures. Enzyme encapsulation via spray drying has shown great potential for improving enzyme thermal stability, however, limited enzyme loading capacities and bioavailability remains a challenge. In the present work, a scalable enzyme encapsulation method was developed to stabilize enzyme against heat, using alginate as the coating material, and the bioavailability of the encapsulated enzyme was studied in vivo. The thermal stability of the enzyme was improved by 60%, and a high enzyme loading of 48% (w/w) was achieved. The spray dried particles showed a spherical morphology with diameters ranging from 1 to 10 µm. Encapsulated enzymes showed much less conformational structural changes after heat treatment, compared with native enzyme. A rapid and complete release of enzymatic activity was achieved under the simulated poultry gastrointestinal tract (GIT) conditions and excellent bioavailability of the encapsulated enzyme was further confirmed by a chicken trial. This highly scalable spray drying encapsulation technique can be used for stabilization of various bioactive ingredients in the food industry.

Natural coaxial plant tips reaching ultrahigh toughness and sharpness

Binodhya Wijerathne,^{1*}, Ting Liao², Ken Ostrikov¹, Ziqi Sun¹

¹ Centre for Materials Science, Queensland University of Technology, 2 George Street, Brisbane, QLD 4000, Australia

² School of Mechanical, Medical and Process Engineering, Queensland University of Technology, 2 George Street, Brisbane, QLD 4000, Australia

*Email: p.wijerathne@hdr.qut.edu.au

Extraordinary properties beyond the individual constitutional materials and structures have been frequently identified in natural species and have inspired the design of advanced materials with superior performances. In this work, an ultra-tough and sharp top structure of natural *Agave striata* leaves is observed, which features 15-fold higher hardness, 10-fold higher Young's modulus, and approximately 100-fold higher compressive strength than the natural balsa wood. It is very impressive that the mechanical properties of this natural *agave striata* leave-tip are comprehensively outperforming the reported wood and wood-like materials.[1] We reveal that the outstanding compression strength, stiffness, and toughness are originated from the closely packed longitudinal bundle of microfibrils consisting of coaxially stacked alternative hard lignin and viscoelastic bio-polymer layers at a thickness of around 300 nm, by which the lignin layers provide mechanical strength and stiffness, and the filled biopolymer layers accommodate deformation and dissipate damage energy. The combination of stiffness and toughness endorses the natural tip with attractive sharpness, which could inspire the design of easy penetrating and retracting micro-needles. The discovery of the structure-mechanical property relationship of the extraordinary *agave striata* leave-tip provides a new principle in the fabrication of strong and tough fibril composites and ultra-sharp micro-needles and offers a new model for the development of bioinspired advanced materials.

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Strain-induced binary Ru-Sn oxide with optimized Ru-O covalency for effective water oxidation in acidic electrolyte

Yiming Xu

Centre for Catalysis and Clean Energy, School of Environment and Science, Griffith University

**Email: yiming.xu3@griffithuni.edu.au*

The proton exchange membrane water electrolyser (PEMWE) is a promising water electrolysis device due to its larger current densities, lower resistance losses, and less gas crossover.¹ However, the harsh working conditions at the anode (acidic solution, high applied potentials) in PWMWE pose challenges to both the stability and activity of electrocatalysts.² RuO₂ is one of the benchmarks used as the anode electrocatalysts. However, a major challenge posed to RuO₂ is the poor long-term stability due to the participation of lattice oxygen. Utilizing tensile strain to tune the Ru-O covalency can be an effective method to optimize the OER performance of RuO₂.^{9,10} Firstly, tensile strain can optimize the adsorption energy of oxygen intermediates, especially the OOH*, and further accelerate the OER process. Secondly, tensile strain can also prohibit LOM and enhance stability. To inhibit LOM, the gap between the O 2p band and the Fermi level needs to be expanded and the orbital overlap with the metal d band (M-O bond covalency) should be decreased, which improves the formation energy of oxygen vacancy. The covalency change also relates to the bond length. The tensile strain can elongate the M-O bond's length and weaken the M-O covalency. The LOM is thus prohibited, and the stability is improved. Here, we synthesized a binary Ru-Sn oxide by facile pyrolysis and the tensile strain applied to RuO₆ units was evidenced by TEM, XAS and XPS results. The suppressed LOM was proved by in-situ DEMS. The OER performance of Ru-Sn oxide in acid was much better than RuO₂, requiring only 184 mV at 10 mA cm⁻² and exhibiting excellent durability during 150 h chronopotentiometry test. The result demonstrated that our strategy is effective for the design and development of Ru-based electrocatalyst towards OER in acidic media.

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Rational design of oxygen evolution electrocatalysts through leveraging the lattice-oxygen mediated mechanism

Xiaomin Xu^{1*}, Zongping Shao^{1*}

¹ WA School of Mines: Minerals, Energy and Chemical Engineering (WASM-MECE), Curtin University, Perth, WA, 6102 Australia

*Email: xiaomin.xu@curtin.edu.au, zongping.shao@curtin.edu.au

Water electrolysis powered by renewables-generated electricity represents one of the simplest approaches to production of green hydrogen, which, however, is largely impeded by its insufficient efficiency associated with the sluggish kinetics of the half-reactions involved, in particular, the oxygen evolution reaction (OER) on the anode side.^[1] Understanding the reaction mechanisms has proven to be instrumental in developing better OER catalysts.^[2,3] It is recently found that the bulk lattice oxygen of a catalyst could participate in the OER via a so-called lattice oxygen-mediated mechanism (LOM), which can bypass the scaling relationships that are known to constrain the OER activity in the conventional adsorbate evolution mechanism (AEM).^[3,4] Here, we showcase, by designing model catalysts based on perovskite oxide structures, how lattice oxygen can directly participate in the OER and how better catalysts utilising the LOM mechanism can be developed using materials engineering strategies like doping, defect engineering, and compositing.^[5-7] We further show the application of the LOM-based perovskite OER catalysts in practical devices like anion-exchange membrane water electrolyzers which delivered appreciable activity and stability when operated under elevated temperatures.^[8] We expect that these new insights into OER catalysis can facilitate the development of the water electrolysis technology for green hydrogen production.

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Short Biography

Xiaomin Xu obtained his Ph.D. in chemical engineering from Curtin University, Australia. He is currently a research associate at Curtin University. His research interests are mainly focused on the development of functional materials for applications in electrochemical energy storage and conversion including water splitting, Zinc-air batteries, and CO₂ electroreduction.

Regulating water state to lower evaporation enthalpy for improved interfacial solar evaporation

Haolan Xu*

¹ Future Industries Institute, University of South Australia, Mawson Lakes Campus, Adelaide, Australia, SA 5095

*Email: haolan.xu@unisa.edu.au

Interfacial solar evaporation is a green and cost-effective technology for addressing the critical issue of clean water shortages since it only uses solar light as the energy source for seawater desalination.[1] Interfacial solar evaporation involves sunlight absorption, photothermal conversion, heat localization and interfacial water evaporation.[2,3] To improve energy efficiency of interfacial solar steam generation, one of the effective methods is to enhance the light absorption and light-to-heat conversion over the photothermal materials. However, for a 2D evaporator, this method can't break the theoretical limit of light-to-vapor conversion efficiency (i.e., $1.46 \text{ kg m}^{-2} \text{ h}^{-1}$). Energy management such as evaporation enthalpy reduction during solar evaporation is an effective way to significantly improve solar evaporation rates.[4] In this presentation, novel design of photothermal materials which can regulate water state to create more intermediate water to lower evaporation enthalpy will be introduced.[5, 6] Due to the reduced vaporization enthalpy, a solar evaporator can deliver much higher evaporation rates with the same solar energy input, significantly improving the vapor output and clean water production.

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Green Hydrogen Peroxide for Water Disinfection

Xiangkang Zeng* and Xiwang Zhang

UQ DOW Centre, School of Chemical Engineering, The University of Queensland

**Email: x.zeng@uq.edu.au*

Photocatalysis hydrogen peroxide (H_2O_2) production has gained broad research attention since it is a potentially viable route for “green” on-site H_2O_2 manufacturing from just water and oxygen using renewable solar energy ¹. In the past decade, stunning progress has been made. However, efficient photocatalysts are still in need to push the current boundaries of H_2O_2 production in terms of generation rate and product concentration ². Besides, a fit-for-purpose application is in need to demonstrate its practical use. In this presentation, we will talk an example on the rational design of a photocatalyst for improved H_2O_2 production and its application for bacteria disinfection in water. Firstly, we will introduce a facile method to boost the photocatalytic H_2O_2 production by grafting cationic polyethyleneimine (PEI) molecules onto graphitic carbon nitride (C_3N_4) ³. The critical roles of PEI for charge separation and surface reaction in photocatalysis will be elaborated. Moreover, the PEI/ C_3N_4 composite was applied for photocatalytic water disinfection ⁴. With PEI modification, the generation of long-lifespan reactive oxygen species (ROS, $\bullet\text{O}_2^-$ and H_2O_2) in photocatalysis is significantly improved. Additionally, scanning electron microscopy and the atomic force microscopy force spectroscopy characterization reveal that PEI promotes the bacteria-photocatalyst contact via electrostatic adhesion. Due to the synergistic modulation of ROS generation and bacteria-photocatalyst interaction, the photocatalytic bactericidal activity of C_3N_4 is dramatically enhanced after PEI modification.

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Biography:

Dr. Xiangkang Zeng is an ARC DECRA Research Fellow at UQ Dow Centre for Sustainable Engineering Innovation, School of Chemical Engineering, The University of Queensland. He obtained his PhD degree (Chemical Engineering) from Monash University Australia in 2017. He worked at the Hong Kong University of Science and Technology (HKUST) for postdoc research training from 2017 to 2018. He was a Postdoctoral Research Fellow in the Department of Chemical Engineering Monash University Australia from November 2018 to July 2022.

His current research interest mainly focuses on the development of two-dimensional functional catalysts such as graphitic carbon nitride, metal-organic frameworks and covalent-organic frameworks, and their applications in solar-to-chemical energy conversion, water treatment and antibacterial purpose. He has published more than 35 papers in prestigious journals, including *Nature Communications*, *Advanced Functional Materials*, *ACS Catalysis*, *Angewandte Chemie*, *Applied Catalysis B: Environmental*, and *Green Chemistry* etc.

Hydrogen Production from Ammonia Splitting through Single-Atom Catalysis

Huayang Zhang^{1*}, Shaobin Wang¹

¹ School of Chemical Engineering, The University of Adelaide, North Terrace, Adelaide, SA 5005, Australia.

*Email: huayang.zhang@adelaide.edu.au

Hydrogen (H₂) has been regarded as the most promising clean energy. Ammonia (NH₃) is an attractive energy carrier with a high H₂ storage capacity (17.8% by weight) and volumetric density (121 kg H₂ m⁻³ at 10 bar).^[1] Unlike other H₂ storage mediums (e.g., CH₄, CH₃OH), ammonia splitting (NH₃ → 1/2 N₂ + 3/2 H₂) has zero carbon emission.^[2] Importantly, the existing infrastructure for manufacturing, storing, and transporting NH₃ is well-established to support on-site hydrogen production. In 2019, the Ammonia Energy Association Australia's Ammonia = Hydrogen 2.0 Conference took place in Melbourne to explore the prospects of creating a new green ammonia energy system to solve the long-tail problem of hydrogen energy. It is believed that the worldwide energy situation has transitioned into the "ammonia = hydrogen 2.0" era. However, the traditional ammonia cracking process suffered from several limitations,⁶ including high operating temperatures of 600 – 850 °C, low energy efficiency, and severe corrosion originating from NH₃. Herein, we fabricated a series of macroporous carbon nitride-supported single-atom transition metals (TMs-MCN, TMs: Co, Mn, Fe, Ni, Cu) catalyst panels for solar light-driven photocatalytic gaseous NH₃ splitting. Under ambient reaction conditions, the optimized Ni-MCN shows an H₂ production rate of 35.6 μmol g⁻¹ h⁻¹, much superior to that of MCN and other TMs-MCN. The enhanced photoactivity of Ni-MCN originates from the presence of Ni-N₄ sites, which improved the optical properties, accelerated charge carrier separation/transfer, and boosted the NH₃ splitting kinetics of the catalysts. The theoretical calculation revealed that introducing Ni-N₄ sites can modulate the electronic structure of MCN, leading to the optimization of binding strength for NH₃ molecules and other reaction intermediates. Our study can provide valuable guidelines for the rational design of SACs toward energy- and cost-effective photocatalytic NH₃ splitting for H₂ production.

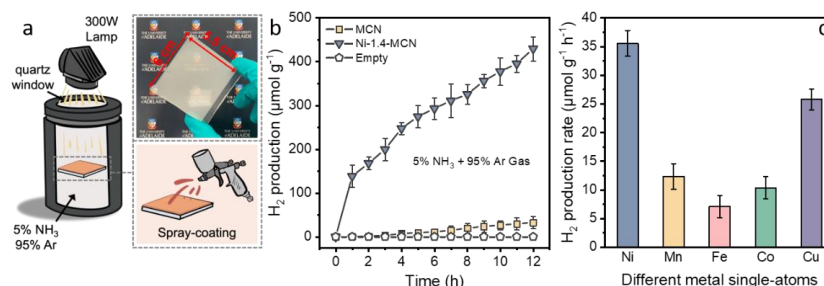


Figure 1 (a) Schematic illustration of the reaction system and photocatalysts-coating panel. (b) and (c) solar-driven H₂ production from NH₃ splitting over TMs-MCN.

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Photothermal catalytic technology for solar fuels production

Jinqiang Zhang^{1*}, Hongqi Sun², Shaobin Wang^{1*}

¹*School of Chemical Engineering, The University of Adelaide, Adelaide, SA 5005, Australia*

²*School of Molecular Sciences, The University of Western Australia, 35 Stirling Highway, Perth, WA 6009, Australia*

*Email: jinqiang.zhang@adelaide.edu.au;
shaobin.wang@adelaide.edu.au

Photothermal catalysis has recently been proposed as a promising alternative to conventional photocatalysis and thermocatalysis in the fields of energy preparation and environmental remediation, attributing to the unprecedented light harvesting efficiency, superior throughputs and moderate reaction conditions. Photothermal catalysis is basically a multiple energy complementary technology integrating solar energy mediated photochemical process and solar light induced thermocatalysis in one unit. Specifically, the photo-excited energetic hot carriers via intraband or interband extinction (also called Landau damping) can directly initiate chemical reactions in much milder conditions. And the hot carriers failing to participate the redox reactions will be converted into heat by thermalisation (also named Ohmic damping). The photo-excited hot carriers can reduce the reaction barrier and improve the reaction selectivity, while the photo-generated internal heat can thermodynamically accelerate reaction rates and ginger up the sluggish hot carriers. Therefore, photothermal catalysis has compensated the disadvantages of photocatalysis and thermocatalysis, and significantly boosted the reaction rates to a level of industrialization by taking advantage of full-spectrum solar light, showing significant potentials on large-scale production of solar fuels. Here, we present our ongoing researches in harnessing the full spectrum solar energy using the photothermal catalytic strategy to drive CO₂ reduction with alkane or hydrogen. Using solar energy to catalytically reduce CO₂ and upgrade conventional fossil fuels has the potential to convert the waste of CO₂ into high value-added chemical fuels and feedstocks in a clean and sustainable manner, allowing the dual opportunity to store the intermittent renewable energy as well as closing the anthropogenic carbon cycle.

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Biography:

Dr. Jinqiang Zhang received is now a Research Fellow under the supervision of Prof. Shaobin Wang at the School of Chemical Engineering, The University of Adelaide. His research interests focus on photo-mediated catalysis, including photocatalysis, photoelectrochemical catalysis and photothermal catalysis, for energy preparation and fossil fuels upgrading.

FeOCl Nanoparticles Loaded onto Oxygen-Enriched Carbon Nanotubes and Nickel-Foam-Based Cathodes for the Electro-Fenton Degradation of Pollutants

Shuang Zhong^{1*}

*1 School of Chemical Engineering and Advanced Materials, The University of Adelaide,
Adelaide, SA 5005, Australia*

**Email: Shuang.zhong@adelaide.edu.au*

Electrochemical advanced oxidation processes (EAOPs) are a class of promising technologies for wastewater remediation. The challenge of EAOPs is the in-situ generation and activation of hydrogen peroxide (H_2O_2) to evolve reactive oxygen species (ROS) simultaneously with low energy consumption and high performances. In this work, we designed an EAOP system, coupling FeOCl nanoparticles on oxygen-enriched carbon nanotubes (O-CNTs) and a nickel foam (FeOCl/O-CNTs/NF) cathode for electro-Fenton (EF) reactions and an IrO_2/Ti anode for anodic oxidation (AO) simultaneously. Specifically, the defects and oxygen functional groups on O-CNTs introduced by a modified Hummers' method could induce the charge redistribution of O-CNTs for outstanding two-electron oxygen-reduction-reaction performances (H_2O_2 selectivity of 73%) and provide more anchoring sites for the loading of active cocatalyst nanoparticles. Thus, abundant FeOCl nanoparticles were successfully loaded onto O-CNTs. Such a FeOCl/O-CNTs/NF cathode exhibited a high H_2O_2 production rate of $95 \text{ mmol g}_{\text{catal}}^{-1}\text{h}^{-1}$ because of the improved exposure of catalytic active sites supported on nickel foam to attain a large specific surface area. $\bullet\text{OH}$ was generated from H_2O_2 via both heterogeneous and homogeneous EF processes induced by the FeOCl/OCNTs/NF cathode and leached ferrous ions accordingly. Sulfamethoxazole (SMX) was completely removed within 30 min at a low specific energy consumption of $0.024 \text{ kWh g}^{-1}\text{SMX}^{-1}$. Thus, the simultaneous FeOCl/O-CNTs/NF-based EF system and AO provide an efficient and cost-effective technology for organic contaminant remediation.

Structure-performance correlation on Ni-Ru bimetallic catalysts for selective CO₂ hydrogenation

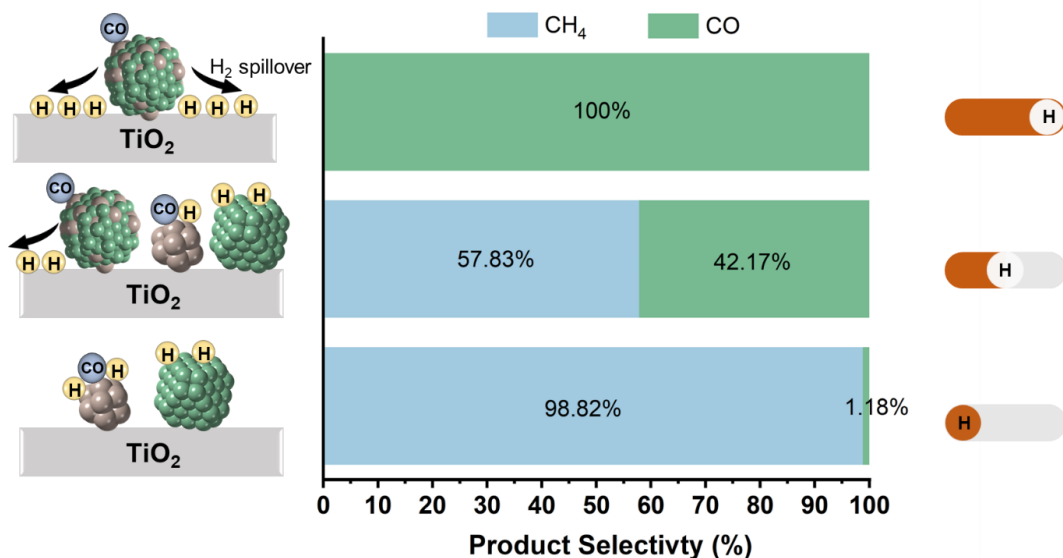
Sibei Zou¹, Jun Huang^{2*}, Xiaozhou Liao^{1*}, Assaad R. Masri^{1*}

¹ School of Aerospace, Mechanical and Mechatronic Engineering, The University of Sydney, New South Wales 2006, Australia

² School of Chemical and Biomolecular Engineering, The University of Sydney, New South Wales, 2006, Australia

*Email: szou4607@uni.sydney.edu.au, jun.huang@sydney.edu.au, xiaozhou.liao@sydney.edu.au, assaad.masri@sydney.edu.au

CO₂ hydrogenation to C1 chemicals has attracted significant interests as a carbon neutral strategy due to the increasing demand of energy and global warming. Continuous efforts in the field of heterogeneous catalysis have revealed that the CO₂ hydrogenation activity and selectivity are structure-sensitive in monometallic catalysts. However, the structure-performance relationship fundamental research in bimetallic catalysts is a big challenge because the well-defined bimetallic structures and the corresponding mechanism are more complex than monometallic ones. Here, with the construction of supported Ni-Ru bimetallic catalysts, evidenced by advanced microscopy and electron energy loss spectroscopy (EELS) characterization methods, the different bimetallic structures have been synthesised for the CO₂ hydrogenation. Assisted by the detailed in-situ DRIFTS experiments, Ni-Ru bimetallic structures act as an ‘H atom-valve’, leading to a switchable product selectivity by controlling the H₂ spill over phenomenon. These findings bring a fundamentally new understanding of the selective hydrogenation on bimetallic nano-catalysis and the structure-performance relationship in controlling the ‘H atom-valve’ for many important chemical processes.



***In situ* Raman Spectroscopic Study towards MXene Single-Atom Electrocatalyst for High-Current Density Alkaline Hydrogen Production**

Yu Zou¹, Huajie Yin², Yun Wang¹, Porun Liu¹, and Huijun Zhao¹

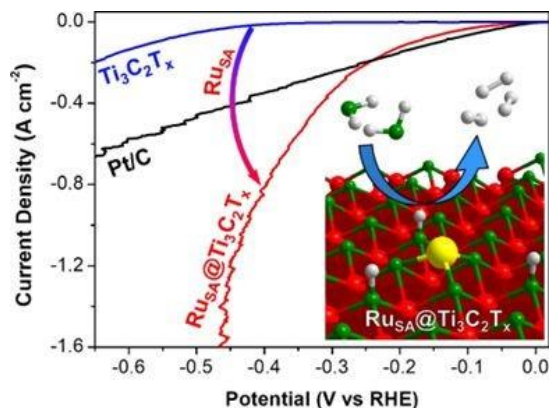
¹ Centre for Catalysis and Clean Energy, Griffith University, Queensland, Australia

² Key Laboratory of Materials Physics, Chinese Academy of Sciences, Hefei, P. R. China

*Email: y.zou@griffith.edu.au

single-atoms (SAs) supported on various substrates have emerged as a new form of electrocatalysts for hydrogen evolution reaction (HER). The exfoliated MXenes possess rich defects/vacancies and surface oxygen groups, can be favorably utilized to anchor SAs. Here, we take advantage of the exfoliated $\text{Ti}_3\text{C}_2\text{T}_x$ to anchor Ru-SAs on $\text{Ti}_3\text{C}_2\text{T}_x$ through a wet-chemistry impregnation process. The obtained $\text{Ru}_{\text{SA}}@\text{Ti}_3\text{C}_2\text{T}_x$ possesses excellent HER activity, especially under high current densities. Remarkably, $\text{Ru}_{\text{SA}}@\text{Ti}_3\text{C}_2\text{T}_x$ can readily attain high current densities of 1 and 1.5 A cm^{-2} at low overpotentials of 425.7 and 464.6 mV, respectively, demonstrating its potential for practical applications.

The reported DFT studies suggested that $\text{Ti}_3\text{C}_2\text{T}_x$ catalyzed HER involves the protonation of O-terminated surface sites into OH-terminated surface, and the HER activity is related to the OH coverage on the surface-terminated O sites.¹ However, the reaction mechanism remains elusive due to the lack of surface O and OH coverage information under the operando HER conditions. Herein, in situ Raman spectroscopic characterizations were applied to provide time-resolved information for mechanistic investigations.² The surface termination groups of $\text{Ti}_3\text{C}_2\text{T}_x$ and $\text{Ru}_{\text{SA}}@\text{Ti}_3\text{C}_2\text{T}_x$ during HER were probed by A1g vibration frequency shift under operando HER conditions. Based on the theoretical and experimental results, we depicted that inducing Ru-SAs to $\text{Ti}_3\text{C}_2\text{T}_x$ enhances water adsorption, promotes water dissociation, and facilitates H_2 formation. The findings of this work provide useful guidance for the design and development of MXene supported single atoms catalysts.



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POSTER PRESENTATIONS

Occurrence, mobility and immobilization of metal mixtures: lessons learned from mine waste sites

Abdul Mehdi Ali, ^{1*}, Jose Cerrato, Isabel Meza, Eliane El Hayek, Johanna Blake, Sumant Avasarala, Carmen Velasco, Cherie DeVore, Taylor Busch, Lucia Rodriguez-Freire, Adrian Brearley, Eric Peterson, Michael Spilde

¹ University of New Mexico

*Email: mehdiali@unm.edu

We investigated the occurrence, mobility, and green chemistry remediation approaches for metal mixtures in uranium (U) mine wastes from sites located in the Southwestern US. Metal release from these mine wastes could pose potential health risks for neighboring communities. Our analyses suggest that U-vanadium (V) and U-organic Matter-rich phases are present in abandoned mine wastes. The dissolution of these phases is relevant to U, As, and V transport. Remediation approaches for mixtures of U and As using naturally occurring calcium (Ca)-bearing minerals is currently being researched for the immobilization of these metal mixtures. Additionally, Ca in carbonate water at circumneutral pH facilitates the transport of U in plant roots, which could be useful for metal uptake and removal from natural water resources. These results are relevant for U transport and remediation in the proximity of mine wastes and mineralized deposits.

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Vortex induced contact electrification in oxygenated water for fabricating metal nanomaterial for the hydrogen evolution reaction

Badriah M. B. Alotaibi,¹ Soraya Rapheima,² Tanglaw Roman^{1,3} Po-Wei Yu,¹ Kasturi Vimalanathan,¹ Xianjue Chen,⁴ Thaar M. D. Alharbi^{1,5} Mats Anderson,¹ Nadim Darwish,² Colin L. Raston^{1*}

¹ Flinders Institute for Nanoscale Science and Technology, College of Science and Engineering, Flinders University, Adelaide, SA 5042, Australia.

² School of Molecular and Life Sciences, Curtin Institute of Functional Molecules and Interfaces, Curtin University, Bentley, WA 6102, Australia.

³ Flinders Microscopy and Microanalysis, College of Science and Engineering, Flinders University, Bedford Park, SA 5042, Australia

⁴ School of Environmental and Life Sciences, The University of Newcastle, Callaghan, New South Wales 2308, Australia

⁵ Physics Department, Faculty of Science, Taibah University, Almadinah Almunawwarrah, Saudi Arabia

Address for correspondence: colin.raston@flinders.edu.au

Abstract:

Structural diversity prevails in foundry gold and rhenium at the nanometre dimensions with their solution-based syntheses typically requiring the use of reducing agents and other auxiliary substances to control their nucleation and growth along with their colloidal stability. We have established the ability to control the size and morphology of gold and rhenium nanoparticles formed in either aqueous auric acid ($\text{H}[\text{AuCl}_4]$) or aqueous potassium hexachlorhenate $\text{K}_2[\text{ReCl}_6]$ in the absence of such additives in thin films of liquid in a vortex fluidic device (VFD) housing a rapidly rotating quartz tube tilted at 45° [1] while irradiated at 254 nm.

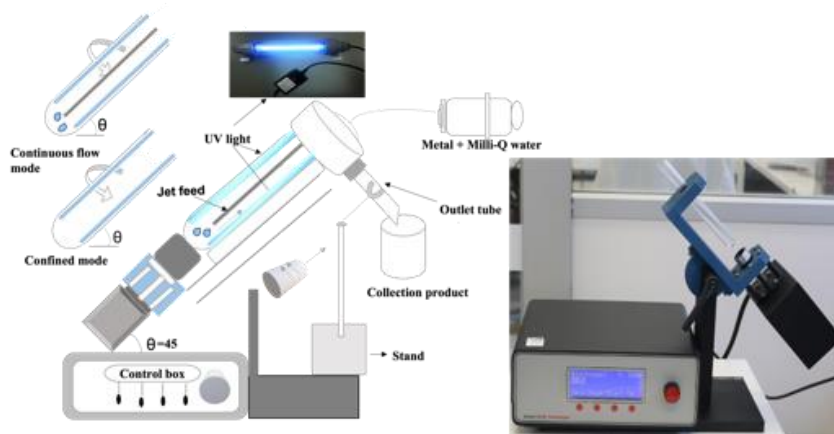


Figure 1: Schematic of the set up for producing metal nanostructures under continuous flow-
Photograph of a Vortex Fluidic Device (VFD)

This photo-thermal induced contact electrification (CE) in the VFD occurs at solid-liquid and liquid-liquid interfaces associated with the different high temperature (high shear) topological fluid flows. For gold, ultra-thin 2D sheets, prisms, hierarchical structures comprised of magnetic nanoparticles embedded within these sheets, and rosette and tubular structures are formed. For Rhenium, 2D sheets are formed. The CE involves the formation hydroxyl radicals, OH^\bullet , which can

smooth the surface of the gold particles. In the presence of oxygen, a competing primary reduction reaction is the formation of superoxide radical anions, $O_2^{\cdot-}$, which also reduces the auric acid with the formation of singlet oxygen, 1O_2 [2-3]. The findings establish a CE paradigm for the VFD which allows access to different nano material beyond what is practical using traditional batch processing strategies, as well the processing having beneficial green chemistry metrics as catalysts in the hydrogen generation reaction.

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Earth's magnetic field impacted shear stress induced crystallisation of fullerene C₆₀

Amjad E. Alotaibi¹, Colin L. Raston^{1*}

¹ Flinders Institute for Nanoscale Science and Technology, College of Science and Engineering, Flinders University, Adelaide, South Australia, Australia

*Email: alot0273@flinders.edu.au
colin.raston@flinders.edu.au

The thin film vortex fluidic device (VFD) is a versatile microfluidic platform with a diversity of applications, including in controlling organic reactions, self-assembly and materials processing in more benign ways.¹ Advances have been made in understanding the fluid flow in the VFD, down to submicron dimensions, which is responsible for the mechano-energy delivered into the thin film in the device. It is in the form of different topological flows.¹ Recently we established the ability to self-assemble fullerene C₆₀ into different shapes, depending on the orientation of the rapidly rotating quartz tube in the device relative to the Earth's magnetic field. Induced 'crystallisation' of fullerene C₆₀ from the toluene solutions of the fullerene, well below the saturation concentration, arises from the shear stress within submicron topological fluid flows in the thin film. These flows are produced by Coriolis forces and eddies associated with Faraday waves, depending on the rotational speed (ω) and the processing time in the 45° tilted tube, and surprisingly now the Earth's magnetic field. Importantly, the formation of nanoparticles of the fullerene is without the need to use surfactants to control the nucleation and growth of the material, in adhering to the tenets of green chemistry. The different structures of the nanoparticles of fullerene C₆₀ were studied using SEM, Figure 1.

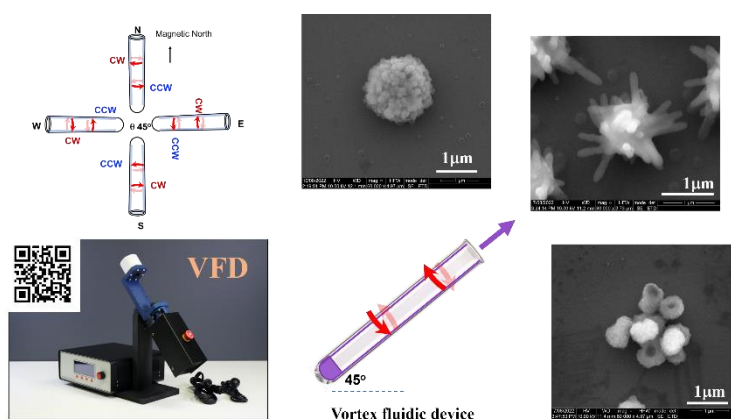


Figure 1: Self-assembly (crystallization) of fullerene C₆₀ into surfactant free particles in the VFD, depending on the orientation of the Earth's magnetic field.

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Vortex fluidic mediated synthesis tellurium nanoparticles from the bulk element

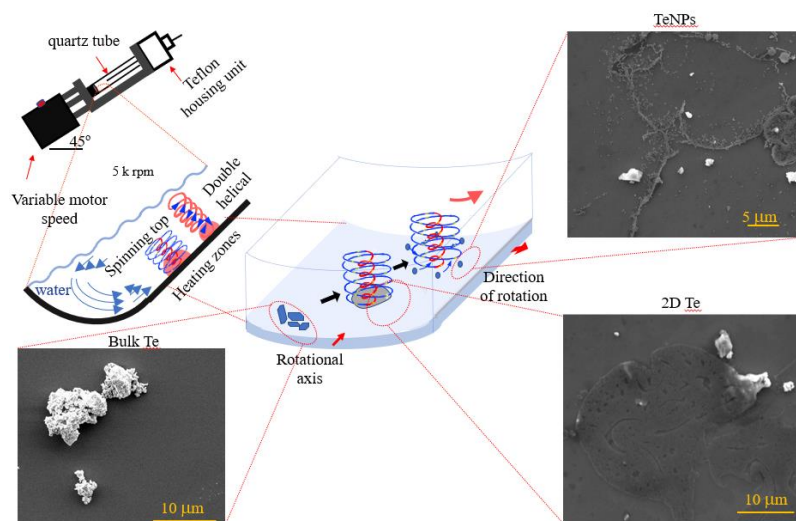
Fayed Alrashaidi, 1,2* Colin L. Raston 1

¹ Flinders Institute for Nanoscale Science and Technology, College of Science and Engineering, Flinders University, Adelaide, SA 5042, Australia

² Department of Chemistry, College of Science, Jouf University, P.O. Box 2014, Sakaka, Saudi Arabia

*Email: alra0139@flinders.edu.au

Tellurium nanoparticles (TeNPs) are becoming important in research because they have attractive properties, such as being biocompatible, antimicrobial, and antioxidant.^[2] A green synthesis has been developed for preparing tellurium nanoparticles (TeNPs) directly from bulk tellurium (Te) dispersions in water (H₂O) at room temperature using the vortex fluidic device (VFD) (Figure 1) without the use of auxiliary substances, including surfactants, and other energy sources as a top-down method. It harnesses the mechanical energy in the VFD in a controlled way which is in the form of high shear topological flows down to submicron dimensions. These are the spinning top (ST) or typhoon like flow which arises from the Coriolis force from the hemispherical base of the tube, and double helical (DH) flow associated with Faraday waves in the dynamic thin film in the device.^[1] The mechanical energy associated with ST flow is sufficient to melt tellurium in water in the VFD, and is the dominant topological flow when the tube in the microfluidic platform is tilted at 45° and spun at 5k rpm. The melting occurs within 45 seconds of processing in the confined mode of operation of the VFD operating at ambient temperature and pressure. Tellurium has a melting point of 449.5 °C and the ST flow creates localised high temperature regimes, sufficient to melt the as received tellurium powder, in forming 2D sheets of tellurium, ‘tellurene’. Changing the rotational speed, results in forming small nanoparticles to Te, 52 nm in diameter. Other 2D



material prepared directly from the element will also be presented, including antimonene.

Figure 1. Schematic diagram of mechanical energy in VFD for synthesis TeNPs from bulk tellurium.

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Vortex mediated transformation of carbon nanotubes

Colin L Raston,¹ Anbarah Azib S Alzahrani^{1*}

¹ Flinders Institute for Nanoscale Science and
Technology, College of Science and
Engineering, Flinders University, Adelaide, SA
5042, Australia

*Email: alza0157@flinders.edu.au

The vortex fluidic device (VFD) is a versatile thin microfluidic platform which has shown promise in fabricating different carbon nano materials. Processing using the VFD has several advantages in it being cleaner and safer technology. Potentially, reducing the waste stream and energy consumption[1]. Carbon nanotubes specifically need to be available in the desired chirality and/or with controlled length for improving their properties for use in energy production[2]. Modifying carbon nanotubes typically requires using surfactant, harsh reagents, catalysts or laser radiation[2]. The VFD provides control in modifying the size and structure in a clean and simple method without the need of using additives. The mechanical energy in the VFD can modify carbon nanotubes and produce nanoparticles that can be used in different applications. We have investigated the change in the morphology of carbon nanotubes in water by processing them in the VFD with the rapidly rotating tube orientated in different directions relative to the Earth's magnetic field. In this work, the confined mode of operation of the VFD was used to process single wall carbon nanotubes (SWCNTs) in a controlled way, for a 1 mg/ml dispersion with the tube rotating at 8000 rpm speed. The results summarized in the figure bellow.

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- SWCNTs as received. SWCNTs after VFD processing

Trapping per- and poly-fluoroalkyl pollutants within coordination cage adsorbents

Caroline V.I. Andersson,^{1*} Witold M. Bloch¹

¹ *College of Science and Engineering, Flinders University, SA, Australia.*
E-mail: caroline.andersson@flinders.edu.au

Environmental contamination by a group of chemicals known as per- and poly-fluoroalkyl substances (PFAS) has become a widespread economic and health burden in Australia and around the world. Current adsorbents utilised for PFAS removal, such as activated carbon and ion-exchange resins, preferentially take up only long-chain PFAS (C [Equation] 8), and capture of other PFAS (e.g., short-chain variants, C [Equation] 7) remains unaddressed. This project aims to fill this gap by developing novel adsorbents that are selective to a broad spectrum of PFAS.

Metal-organic cages (MOCs), with their high degrees of customisability and well defined cavities, are ideal candidates for the capture of target molecules. A water-soluble Pd₆L₄ cage composed of tri-pyridyl ligands has shown promise to capture a range of fluorinated molecules. This type of host offers a combination of hydrophobic and electrostatic interactions which promotes aggregation of these types of fluorinated guests within its cavity. We have found that MOCs of this type also have a strong affinity to capture PFAS, including short and long-chain variants. In order to access different cavity sizes and finetune the selectivity of MOCs for particular types of PFAS, tri-pyridyl ligands of various lengths may be utilised.

Finally, while MOCs have displayed the capacity to capture PFAS on a laboratory scale, their incorporation into materials on a meaningful scale remains elusive. Hence the inclusion of reactive functional groups such as carboxylate groups on the surface of the MOCs opens up the possibility to bind them into porous adsorbents that are suitable for large-scale use.

A Circular economy for biosolids: creating value-added products free of emerging contaminants

Elsa Antunes^{1,*}, Ravinder Kumar¹, , Anna Whelan^{1,2}, Lalji Rathore²

1. College of Science & Engineering, James Cook University, Townsville, QLD 4811, Australia

2. Townsville City Council, Wastewater Operations, Townsville, QLD, 4810, Australia

**Email: elsa.antunes1@jcu.edu.au*

Emerging contaminants (ECs) are a growing concern in biosolids management, as they can have harmful effects on human health and the environment. Pyrolysis of biosolids is a promising technology to degrade these contaminants, as it involves the thermal degradation of organic matter in the absence of oxygen, resulting in the production of biochar. Pyrolysis of biosolids can effectively degrade a wide range of ECs, including per- and polyfluorinated substances (PFAS), pharmaceuticals and personal care products (PPCPs), microplastics (MPs) and some heavy metals (HMs). Besides mitigating the ECs, the final biochar free of emerging contaminants can improve soil quality, increase crop yields, and sequester carbon in the soil, which can contribute to climate change mitigation. Pyrolysis can significantly reduce the volume and weight of biosolids, making them easier and cheaper to transport and dispose of. The energy-rich gases produced from pyrolysis can be used for heat and power generation. The results showed that pyrolysis at 650°C mineralized all PFAS, microplastics and PPCPs compounds since their concentrations in biochar were below the detection limits. In conclusion, pyrolysis is a promising sustainable technology for degrading ECs in biosolids. The process can effectively break down the complex chemical structures of ECs and produce valuable biochar and energy. Pyrolysis is a key process to create a circular economy for biosolids.

Carbon Removal from Gold Ores Using Novel agglomeration

Erica Avelar, ^{1,2*}, Josafat Guintu¹, Teresa McGrath¹

¹ Curtin University, Western Australian School
of Mines: Minerals, Energy and Chemical
Engineering, Perth, Australia

² ARC Centre of Excellence for Enabling Eco-
Efficient Beneficiation of Minerals, Curtin
University Node, Perth, Australia

*Email: erica.avelar@curtin.edu.au

Carbonaceous matter contained in gold-bearing ores inadvertently adsorbs leached gold in the cyanidation process, leading to gold losses because of the preg-robbing effect. Agglomeration using an emulsion binder developed by the University of Newcastle is a proposed solution to selectively separate the preg-robbing material [1, 2]. This study discusses the application of agglomeration to remove carbonaceous matter from gold-bearing ores. Synthetic mineral mixtures, consisting of silica, pyrite and pulverised carbon as the preg-robbing component, were used to simulate a flotation concentrate (15% pyrite), a free milling, and a refractory gold ore containing typical amounts of preg-robbing component (1% to 5%). The testwork program showed satisfactory recovery of the preg-robbing component, over 80% in all mineral mixtures tested using a standard dosage of the binder. The highest preg-robbing recovery was achieved in the agglomeration tests using silica and the preg-robbing. The entrainment of silica to the agglomerate was considered high, at 54 % to 65 %. The tests simulating a refractory gold ore and a flotation concentrate showed that the recovery of the preg-robbing component increased with raise in preg-robbing content in the mixture. However, pyrite has been inadvertently recovered to a significant extent, with over 85% reported to the agglomerate. The gold recovery via cyanidation was tested in the tailings of the agglomeration process to verify whether the unrecovered preg-robbing material presented a deleterious effect on gold recovery. These tests showed that after agglomeration, no gold was lost to the preg-robbing component left. The testwork also showed that the agglomerated preg-robbing material was also blinded by the binder, by saturating it with organics, preventing it to have a preg-robbing effect leading to gold losses.

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Nano “Fairy Bread”: Decoration of C₆₀ on Few-Layer Graphene

Heath Bach*, Sam Chen

School of Environmental and Life Sciences

The University of Newcastle, Callaghan, New South Wales, Australia 2308

**Email: heath.b.bach@gmail.com*

The hybrid material of graphene decorated with fullerenes has been hypothesized to have remarkable semiconducting properties and could be useful for applications in advanced electronics.¹ We have worked towards a solvent-based method to produce few-layer graphene sheets that are non-covalently decorated with fullerenes with a high level of uniformity. The structure, stability, and electrochemical properties of the hybrid material have been studied. The method appears to be also suitable for producing new types of hybrid materials through decorating fullerenes on single-walled carbon nanotubes and other two-dimensional materials including hexagonal boron nitride and MoS₂.

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Bioinspired Topological Design with Unidirectional Water Transfer for Efficient Solar-driven Atmospheric Water Harvesting

Yiming Bu,^{1*} Hongjun Yang,² Jingliang Li¹

¹ Institute of Frontier Materials, Deakin University, VIC 3220, Australia

² Key Laboratory of Green Processing and Functional New Textile Materials of Ministry of Education, Wuhan Textile University, Wuhan 430200, P.R. China

*Email: buyi@deakin.edu.au

Sorption-based atmospheric water harvesting (SAWH) followed by solar-driven water desorption is emerging as a promising cost-effective technique for freshwater production from the air to alleviate the worldwide freshwater scarcity.^[1,2] Developing moisture-absorbing materials with fast sorption-desorption kinetics and low resistance for water transfer remains a challenge. Inspired by the cone-shaped beaks of seabirds that “suck” water based on asymmetric capillary ratchet effects,^[3] we designed a free-standing sodium alginate (SA) based hemispherical SAWH material with radial and centrosymmetric structure to offer distinguished sorption kinetics. This device demonstrates unidirectional water transfer property and high moisture absorption capacity. To enable solar-driven water desorption, the device is engineered with a photothermal layer by chelation of tannic acid (TA) with Fe³⁺ (MPN).^[4] It is the first time to combine well-designed conical channels for unidirectional water transfer and robust MPN layer for high efficiency light-to-heat conversion into an all-in-one system. The device offered a high moisture absorption capacity of 0.90-2.29 g g⁻¹ within a wide range of relative humidity (RH) (40 %-90 %) and solar-powered water desorption rate 1.77 kg m⁻² h⁻¹ under one sun. 82.3 % of the absorbed water could be collected under natural sunlight (average 0.66 kWm⁻²), achieving a daily water collection of 3.72 L m⁻² that can meet the daily drinking water requirement for an adult. The ultra-fast sorption-desorption kinetics of SAWH, along with its scalable atmospheric water harvesting capacity, provides pivotal insights into the development of next-generation SAWH for efficiently harvesting water from the air.

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Vortex fluidics enhancement of organic-based shampoo

Colin Raston^{1,2,4}, Peter Francis³, Xuejiao Cao^{1,2,4*}

1 Chemical Sciences, Flinders University, Sturt Rd, Bedford Park SA 5042

2 ARC Industrial Transformation Training Centre for Green Chemistry in Manufacturing

3 Plantworx Pty Ltd, Glenelg, SA 5045, Australia

*4 Institute for Nanoscale Science and Technology, Flinders University, Sturt Rd, Bedford Park SA 5042 *Email: cao0167@flinders.edu.au*

Natural cosmetic products have attracted significant attention due to their eco-friendliness compared to synthetic products. The development of more benign methods of cosmetic production has allowed for increased functionality and stability of these products, meeting the standards of green chemistry and organic products. One such method uses the Vortex Fluidic Device (VFD), Figure 1, which is an efficient thin film device that utilizes a rapidly rotating tube to implement high shear forces, allowing for intense micro mixing and significant mass transfer, overcoming the mixing and heat transfer limitations of traditional batch processing. In this project, the stability and function of the shampoo is improved by the mechanical energy in the VFD, in the form of topological fluid flows. According to Dynamic Light Scattering data, shampoo processed by VFD showed an increase in zeta potential from 16.8 mV to 24.3 mV, a decrease in PDI from 0.61 to 0.43, and an improvement in both viscosity and storage modulus/loss modulus. Shampoo processed with VFD remained stable even after heating at 50 degrees for 30 days and had less free fatty acid content. In addition, the cleansing function of the shampoo increased, making it easier to remove dirt from hair compared to the non-processed product. Overall, the VFD has enormous potential in preparing and fabricating natural cosmetic products.

HOTO-RECHARGEABLE ZINC-ION BATTERIES USING TERNARY METAL CHALCOGENIDES AS CATHODES

Chesta^{1,2*}, Jegadesan Subbiah², David Jones,² S. Sampath¹

*Department of Inorganic and Physical Chemistry, IISc Bangalore¹
School of Chemistry, University of Melbourne, Victoria, 3010, Australia²
Email: cchesta@student.unimelb.edu.au

Abstract

Solar energy has been considered one of the most effective, promising, and clean renewable energy resources to meet global energy demands. However, solar energy is intermittent in nature and depends on weather conditions and the availability of the sun. Hence, energy storage is required to maintain a balance between energy demand and energy production. Presently, solar panels are integrated with rechargeable batteries for energy storage. These extra electronics introduce energy losses in the system and increase the overall cost. One alternate approach to solve this issue is integrating the photoconversion system and the energy storage within a single device to store excess solar energy efficiently. Photo-rechargeable batteries are a promising alternative to meet energy demands using solar energy, which can be directly charged using sunlight. It involves the use of a photocathode that both harvests and stores energy and hence reduces the extra electronics, device complexity and overall cost. Ternary metal chalcogenides have gained significant attention as 2D layered materials because of their tunable properties. They have the general formula MXY where M is a transition metal, and X, Y are chalcogens (S, Se, Te etc.). These materials possess strong intralayer and weak interlayer forces, which allow easy exfoliation of the material into different layers and hence a tunable band gap. Due to this structural diversity, these materials possess attractive electric and optical properties. Hence, they are promising materials to be studied for their optoelectronic and energy storage application. Aqueous zinc-ion batteries are potential energy storage devices due to their intrinsic safety, cost-effectiveness, high gravimetric energy density and environmental friendliness. In this poster, the performance of photo-rechargeable Zinc-ion batteries using ternary metal chalcogenide as a photocathode material will be discussed.

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One-step solvothermal synthesis of silver nanowires/graphene composite toward flexible transparent conductive electrodes

Jiajun Fan, Peiyuan Guan, Shuhua Peng, Tao Wan, Dewei Chu

*School of Materials Science and Engineering,
University of New South Wales, Sydney 2052,
Australia*

**Email: Jiajun.Fan@student.unsw.edu.au*

Solution-processed silver nanowire (AgNW) networks have been considered as promising candidates for next-generation transparent electrodes. However, they suffer from low mechanical property and poor thermal and electrical stability, hindering their practical applications. In this work, two-dimensional graphene nanosheets are introduced into the AgNWs via a facile one-step solvothermal process. The fabricated AgNW/graphene films exhibit high electrical conductivity as well as good optical transparency. More importantly, the composite films demonstrate excellent mechanical performance, and negligible resistance change is observed even after 10000 repeated bending cycles. Furthermore, the interlocking NW morphology can be maintained under high temperature and applied voltage, leading to enhanced thermal and electrical stability. This work not only provides a low-cost method to realize large-scale synthesis of AgNWs/graphene composite, but also offers guidance to prepare high-performance electrodes for advanced electronics.

Development of a Green Chemistry Outreach Program for Low Socio-economic Schools – Incursion and Teaching Kit.

Adele Mastroyannis^{1*} and Tessa Faulks²

¹ *Flinders University*

² *Monash University*

**Email: tessa.faulks1@monash.edu*

The incorporation of green chemistry into school curriculum plays a pivotal role in educating the youth of Australia and transforming the community mindset towards a sustainable future[1]. While green chemistry has made an emergence into school curriculums for years 11/12 in some areas, there appears to be gaps in the knowledge at the lower years.[2, 3] A program has been developed by PhD researchers, affiliates and post-docs of the ARC Green Chemistry in Manufacturing training center (Monash University, Flinders University, Deakin University and Curtin University). The program will focus on promoting green chemistry to students in lower socio-economic schools. The program hopes to teach students how green chemistry can be applied to daily life while also supporting their science/chemistry learning. Ages 12-15 will be targeted as these years are key in student's understanding of science, prior to their senior school certificate of education subject selection.

The program will consist of two phases, 1. Incursion and 2. Kit experiments. The first phase will involve a lesson taught by members and affiliated if the ARC GCM Outreach center. This lesson and experiment, titled 'Edible Water bottles' hopes to provide students with a basic understanding of polymers and how green chemistry is vital in the development of less toxic alternatives to current plastics. The second phase will consist of supplying a kit containing two experiments with detailed explanations so that the teacher has a quick and engaging lesson for students. The two kit experiments are titled, 'polymer pasta' and 'compost warriors'. All kit ideas and lesson plans have been designed following a constructive learning model that empowers not only teachers, but students in the science classroom (5 Es – Engage, explore, explain, elaborate and evaluate). The lesson plans have also been modified for each year level according to difference in the curriculum and therefore a student's level of understanding.

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Improving nitrogen use efficiency (NUE) through the development of novel methods for coating urea.

Tessa Faulks¹, Terry Turney², Victoria Blair¹, Antonio Patti¹

¹ Monash University

² Sonic Essentials

tessa.faulks1@monash.edu

With the continual increase in world population and decrease in the arable land available for farming, much attention has been drawn to more effective fertiliser use to reduce losses and improve outputs. When fertiliser is applied to the soil, it is not all stored and taken up by plants, but some is lost to the environment [1]. Using urea as an example (most commonly used fertiliser) it is estimated that between 40 – 60% of applied urea is lost to the environment [2]. Urea is produced by the Haber-Bosch process with recent production rates at approximately 180 million metric tonnes per year. In 2015, it was estimated that almost half the world population was being fed by the Haber-Bosch process, demonstrating the dependency on synthetic nitrogen fertilisers – displayed in Figure 1 [3]. Increasing nutrient use efficiency of fertiliser is key in the maintenance of soil and plant health while also meeting global food demands. One of the frequently used methods for improving nutrient delivery and decreasing losses from granular urea is through the use of slow and controlled release granular urea fertilisers[4]. The goal of these fertilisers is to reduce the immediate availability of the nutrient and thus increase the amount available over time in the soil and for plant uptake.

This study will review the current slow and controlled release coated granular urea available for purchase on the global market. Novel methods for coating urea are being investigated by numerous groups. These methods emphasise avoidance of synthetic polymers that may cause adverse effects in the environment, minimising production cost and optimising nitrogen use efficiency.

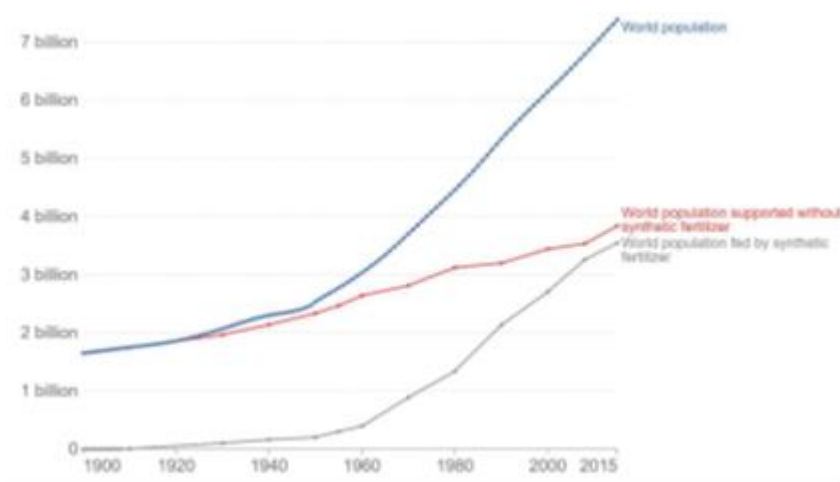


Figure 1: Estimated population reliant on synthetic nitrogen fertiliser produced by the Haber-Bosch process. Adapted from Our World Data [3].

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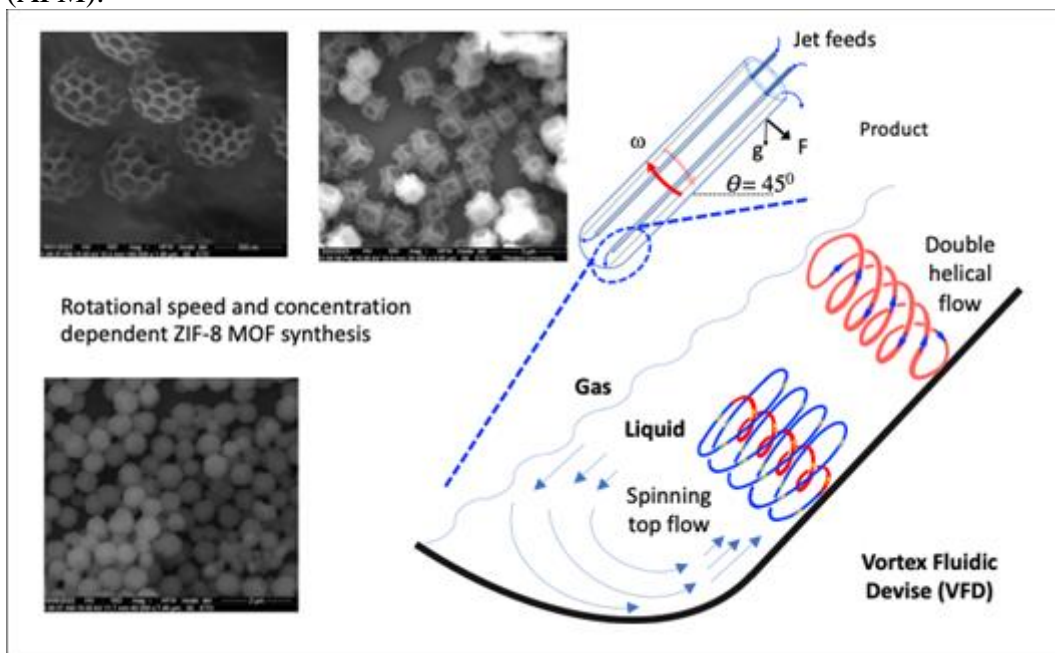
Vortex Fluidic Mediated Synthesis of ZIF-8 MOF

Khamaael Fayyadh^{1*}, Colin L Raston¹

¹ *Flinders Institute for Nanoscale Science and Technology, College of Science and Engineering, Flinders University, Adelaide, Australia*

**Email: colin.raston@flinders.edu.au*

The formation of highly porous zeolitic imidazolate framework-8 (ZIF-8) is accelerated under shear using a vortex fluidic device (VFD). [1-3] ZIF-8 is a type of metal-organic framework (MOF) formed herein via mixing aqueous solutions of imidazole and zinc acetate, using water as the solvent (green chemistry), with the processing in the VFD suitable for entrapping enzymes, bacteria, and cells. Importantly, processing in the VFD thin film microfluidic platform is energy efficient and allows the process to be scaled up using a small processing unit, ie. scalability is incorporated at the start of the project. The VFD imparts mechanical energy in the thin film, which is in the form of high shear topological fluid flow of submicron dimensions, namely double helical and spinning top flows. These topological fluid flows control the size and shape of the particles formed, which are impacted by the rotational speed of the tube, its tilt angle, and concentration of reagents. The fundamentals of green chemistry are embedded in the research, which also include using less hazardous reagents and minimising the generation of waste. The shapes of the ZIF-8 material depend on the operational parameters of the VFD, allowing access to square boxes, sheets, nano-flowers, prisms, rods, and more. Different methods have been used to characterise the material, including Raman spectroscopy, X-ray powder diffraction (XRD), Atomic Force Microscopy (AFM).



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Coating of chitosan on poly D,L-lactic-co glycolic acid thymoquinone nanoparticles enhances the anti-tumor activity

Jingrong Gao^{1,2*}

¹ School of Food and Pharmacy, Zhejiang Ocean University, Zhoushan, China

² College of Science and Engineering, Flinders University, Bedford Park, SA, Australia

*Email: gaojingrong2116@gmail.com

Abstract:

Breast cancer is the second most common cancer around the world. Triple-negative breast cancer (TNBC) is characterized by the absence of three receptors: progesterone, estrogen, and human epidermal growth factor-2 receptor (HER2). Various synthetic chemotherapies have gained attention but they caused unwanted side effects. Therefore, some secondary therapies are now becoming famous against this disease. For instance, natural compounds have been extensively researched against many diseases. However, enzymatic degradation and low solubility remain a major concern. To combat these issues, various nanoparticles have been synthesized and optimized from time to time, which increases its solubility and hence therapeutic potential of a particular drug increases. In this study, we have synthesized Poly D,L-lactic-co-glycolic acid (PLGA) loaded thymoquinone (TQ) nanoparticle (PLGA-TQNPs) and then coated them by chitosan (CS) (PLGA-CS-TQ-NPs), which was characterized by different methods. Size of non-coated NPs was 105 nm with PDI value of 0.3 and the size of coated NPs was 125 nm with PDI value of 0.4. Encapsulation efficiency (EE%) and Drug loading (DL%) was found to be 70.5 ± 2.33 and 3.38 for non-coated and 82.3 ± 3.11 and 2.66 for coated NPs respectively. We have also analysed their cell viability against MDA-MB-231 and SUM-149 TNBC cell lines. The resultant, nanoformulations exhibit anti-cancerous activity in a dose and time-dependent manner for MDA-MB-231 and SUM-149 cell lines with an IC₅₀ value of (10.31 ± 1.15 , 15.60 ± 1.25 , 28.01 ± 1.24) and (23.54 ± 1.24 , 22.37 ± 1.25 , 35 ± 1.27) for TQ free, PLGA-TQ-NPs and PLGA-CS-TQ-NPs respectively. For the first time, we have developed a nanoformulations of PLGA loaded TQ coated with CS NPs (PLGA-CS-TQ-NPs) against TNBC which led to their enhanced anti-cancerous effects.

Australian-seaweed extracts as sustainable and natural aquafeed additives; Oxidative and thermal stability of aquafeed model systems

¹Tharuka Gunathilake, ²Taiwo O. Akanbi, ¹Colin J. Barrow*

¹*School of Life and Environmental Sciences, Deakin University, Geelong, VIC 3216, Australia*

²*School of Environmental and Life Sciences, Faculty of Science, University of Newcastle, Ourimbah, NSW, Australia*

**Email: colin.barrow@deakin.edu.au*

Synthetic additives are one of the integral components of aquafeed formula necessarily to improve their quality and shelf life. However, the prospects for aquaculture sustainability have caused concern due to recent changes to regulatory rules and substantial operational costs associated with synthetic aquafeed additives. Therefore, safe, effective, and non-expensive natural aquafeed additives should be investigated as a matter of urgency. Seaweeds grow rapidly with no requirement of fertilizer, freshwater, and arable lands, making it is a cheaper and more sustainable source of aquafeed additive. However, detailed analysis of Australian seaweed extracts in aquafeed system is scarce in terms of their ability to increase omega-3 oil stability. The present study aims to characterize phenolics from Australian seaweeds and investigates their potential to preserve omega-3 enriched aquafeed model systems. Accordingly, locally grown seaweed species were subjected to conventional solvent extraction followed by determination of extraction yields, total phenolic contents, and *in-vitro* antioxidant properties. Due to the highest extraction yields (10 times) and significantly high antiradical properties, *Ecklonia radiata* has been screened for further analysis while Eckol type phlorotannins has been found as the major phenolic constituent in *E. radiata* extract via LC-ESI-QTOF-MS/MS. Further, selected seaweed extracts have been incorporated into fish oil emulsion and microcapsules subsequently determined the oxidative stability. Further, thermal stability test were conducted on the model systems to better understand the mechanism of this increased stability.

Carbon Nanotubes Encapsulated Transition Metals for Efficient Hydrogen Evolution Reaction: Coupling Effect of 3d Orbital and π -Bond

Yun Han^{1,2*}, Xuecheng Yan¹, Qin Li^{1,2}

¹ *Queensland Micro- and Nanotechnology Centre, Griffith University, Nathan Campus, QLD 4111, Australia.*

² *School of Engineering and Built Environment, Nathan Campus, Queensland, 4111, Australia.*

**Email: yun.han@griffithuni.edu.au*

Carbon materials are widely used in various industrial applications due to their outstanding stability and robustness in diverse structures, yet it remains a revolutionary and challenging task in activating low-cost carbon materials for efficient catalysis. Herein, inspired by the successful experimental synthesis, we for the first-time exploited carbon nanotubes encapsulated transition metal atoms (TM@CNTs) for hydrogen evolution reaction (HER) using density functional theory (DFT) calculations. The Gibbs free energy of H-C bond on pristine CNTs is too positive, which prevents the adsorption of H atoms. However, TM@CNTs (TM = Fe, Co, Ni) have superior HER activity than those widely recognized Pt and MoS₂ catalysts, benefiting from disrupting the π conjugations and activating the stable sp^2 hybridizations among carbon atoms in CNTs. A new set of metal-free catalytic surfaces with strong HER activity have been developed. Meanwhile, the HER activity of graphene nanosheets loaded on the most ubiquitous facet (111) of transition metals (TM@G, TM = Fe, Co, Ni) was also calculated. However, TM@G models show inferior HER activity than that of TM@CNTs, which is attributed to the large curvature of CNTs. These new findings manifest a universal strategy for carbon materials activation that will inspire the rational design of carbon-based electrocatalysts for efficient water splitting reaction.

Biography:



Yun Han received his master's degree from South China University of Technology in 2018. Currently, he is a PhD candidate at Queensland Micro- and Nanotechnology Centre (QMNC) of Griffith University (Australia), under the supervision of Prof. Qin Li and Dr Xuecheng Yan. His research topic focuses on design and study of novel electrocatalysts by first-principle computation.

Understanding Interactions of Nano-cellulose Suspensions with Plant Leaves for Enhancing Topical Delivery of Soluble Bioactive and Particulates

Shang Xu Jiang¹, Zhiping(Gordon) XU^{1,2}, Peng Li¹, Li Li¹

¹ Australian Institute for Bioengineering and Nanotechnology (AIBN), The University of Queensland, St Lucia, QLD 4072, Australia

² Institute of Biomedical Health Technology and Engineering and Institute of Systems and Physical Biology, Shenzhen Bay Laboratory, Shenzhen, P. R. China 518107

**Email: uqsjian7@uq.edu.au*

Efficient topical spray of current agrochemical formulations and newly emerging particle-carried ones is one of the most direct and suitable approaches to sustainably enhancing the crop yield when facing the dramatical growth of the world population. However, the delivery efficiency of these agrochemical formulations is relatively low, resulting in the excessive usage of agrochemicals and subsequent eco-environmental issues. The inefficiency of topical spray of agrochemical formulations is partly attributed to the runoff of spray drops from leaves to soil, which would be mitigated with continuous advances of nanotechnology. Nanotechnology is regarded as one enabling technology for developing sustainable agriculture. Specifically, nano-celluloses appear as an enhancer for topical spray of solutions and suspensions. Cellulose is the most abundant natural biopolymer with high industrial interests due to the low cost, good biodegradability, and no toxicity. The introduction of nano-cellulose suspension is hypothesized to enhance the deposition of droplets on the leaf surfaces through various interactions. In this symposium, I will highlight my group's recent work developing nano-cellulose formulations for enhancing topical spray of soluble and particle-carried agrochemicals. My symposium will focus on two case studies: nano-cellulose suspensions to enhance water adhesion (water retention) on leaves; dried nano-cellulose matrices to capture more moisture for rehydration. This work can be applied using the current spray facilities, and lead to huge economic and environment benefits to Australia and the world.

A Comparative Study of 2D Geometry Dependent Particle-Support Interfaces for Superior Water Splitting Kinetics

Hashara Kandambige^{1*}, Juan Bai¹, Jun Mei¹

¹ School of Chemistry and Physics, Faculty of Science, Queensland University of Technology, Brisbane, QLD 4000, Australia

*Email: hasharakandambige@gmail.com

Electrochemical water splitting is one of the burgeoning ways of producing hydrogen as the clean chemical fuel while bifunctional electrocatalyst is one of the possible ways for improving the overall efficiency of water-splitting. Albeit metal oxides represent a promising electrocatalyst for the hydrogen evolution reaction (HER) in water splitting, its' inefficiency towards the oxygen evolution reaction (OER) is a drawback. Herein, particle-support interaction has been recognised as a driving force for improving catalytic performance. To achieve this unique interaction, the commonly synthetic strategy is to load the active noble-metal particles onto a specific supporter instead of using mere Pt/Ir/Ru based catalysts. Two-dimensional (2D) metal oxides are emerging and promising candidates for metal particles incorporation, owing to unique surface features and sheetlike geometry resulting in the stable interfacial binding and the reduced charge transfer distance. In this study, three different catalysts based on 2D vanadium oxides supporters; 2D-VOH, 1D/2D-VOHN1 and 0D/2D-VOHN3 were synthesized via controllable self-assembly technique. In the synthesis, the use of different solvent systems ended up three different geometries of the vanadium oxide supporters. After the optimum loading of active iridium nanoparticles, the electrocatalytic performance over the hydrogen and oxygen evolution reactions of the three electrocatalysts; Ir@VOH, Ir@VOHN1 and Ir@VOHN3 revealed that the geometry of the supporter is crucial for enhanced catalytic activity. The Ir@VOH catalyst fabricated with the 2D-based vanadium oxide supporter with 2D geometry, exhibits outstanding performance due to its strongest Ir-V-O interactions over particle support interfaces in comparison to the 1D/2D and 0D/2D. This comparative study will provide further modifications to the field of heteroatom doped electrocatalysts for water splitting in alkaline media using various solvents in the synthetic route.

Keywords: Two-dimensional geometry; Vanadium oxides; Iridium; Water splitting; Self-assembly; Particle-support

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Improved stability of the Co-based molecular catalyst in carbon dioxide electroreduction

Alena Kochubei*, Aleksei Marianov, Yijiao Jiang

School of Engineering, Macquarie University, Sydney, NSW 2109, Australia

*Email: alena.kochubei@students.mq.edu.au

Development of durable cost-effective catalyst is crucial for making carbon dioxide electroreduction reaction (CO₂ERR) commercially viable.[1] Molecular catalysts are more cost- and atom-efficient compared to the state-of-the-art noble metal catalysts, such as gold and silver. While they exhibit similar high Faradaic efficiency (FE) above 90 % and comparable activity, the improvement of the stability of molecular catalysts is still needed. Based on the deactivation mechanism reported recently [2], a strategy for the stability enhancement of cobalt(II) phthalocyanine (CoPc) supported on carbon nanotubes (CNTs) was developed. It involves the introduction of bulky and electron-donating methoxy substituents into the outer sphere of the central Co atom which prevents hydrogen evolution reaction (HER) and improves the stability of intermediate states of CO₂ERR. The resulting catalyst **CoPc-(OMe)₈/CNT** was able to maintain a stable turnover frequency (TOF(CO)) of 11.5 s⁻¹ during 100 h electrolysis at -1.10 V vs NHE and reached a specific turnover number (TON(CO)) of around 4.5 million (Figure 1). Almost unchanged TOF(CO) throughout electrolysis indicates that the developed strategy allowed for the synthesis of an organometallic CO₂ERR catalyst with nearly infinite stability. In the future, we plan to perform other modifications of CoPc molecules aimed at improvement of the stability.

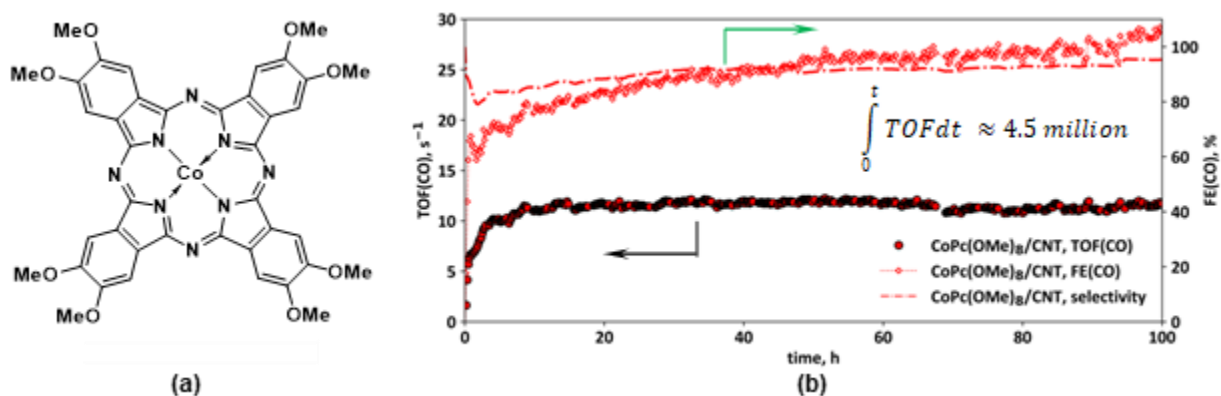


Figure 1. (a) Structure of **CoPc-(OMe)₈**; (b) TOF(CO) and FE(CO) of **CoPc-(OMe)₈/CNT** during 100h long electrolysis. The cumulative TON is given in the inset. Electrolyte: 0.5 M KHCO₃, CO₂ flow rate 5 mL/min.

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Facile Synthesis of Ultralong Copper Nanowires for Flexible Transparent Electrodes and Strain sensors

Yu-Chieh Kuo, Tao Wan, Dewei Chu

*School of Materials Science and Engineering,
University of New South Wales, Sydney 2052,
Australia*

**Email: yu-chieh.kuo@student.unsw.edu.au*

Copper nanowires (CuNWs) have been regarded as a promising alternative material to silver nanowires (AgNWs) and indium tin oxide (ITO) for transparent electronics owing to their low cost, excellent electrical conductivity, and good optical performance. However, alkaline condition and toxic solution (hydrazine, N_2H_4) are generally required for the NW synthesis, seriously limiting the widespread application. In this work, ultralong CuNWs have been successfully synthesized by a one-pot hydrothermal method with non-toxic reducing agent (glucose) and low-toxic oleylamine solution. An efficient purification method is also introduced for CuNW separation. Flexible electrodes with high transparency have been fabricated by vacuum filtration, which can be transferred to various substrates, such as PET and PDMS. Outstanding mechanical durability (bending & stretching) and good thermal stability have been realized by metallic coating through galvanic replacement with Ag^+ ions. The electrodes based on CuNWs are also employed to construct wearable strain sensors for bio-signal detection. This study provides an effective way to design high performance electrodes for flexible electronic applications.

Heterojunction photocatalysts for aqueous phase CO₂ reduction

Thi Kieu Oanh Le,

1* Yunxia Yang, 2 Andrea Merenda, 1 Adam Lee³ and Karen Wilson¹

1Centre for Advanced Materials and Industrial Chemistry (CAMIC), RMIT University,
Melbourne, VIC3000, Australia.

2CSIRO Clayton, 71 Normanby Road, Clayton South, VIC 3168, Australia.

3Centre for Catalysis and Clean Energy, School of Environment and Science, Griffith University,
Gold Coast Campus, Queensland, QLD 4222, Australia.

*Email: s3951435@student.rmit.edu.au

The United Nations Intergovernmental Panel on Climate Change (IPCC) has warned that rising CO₂ atmospheric levels will increase global temperature by 1.7-2.4°C by 2100.[1,2] Chemical conversion of CO₂ presents an enormous opportunity to develop a new sustainable feedstock for into low carbon products and mitigate global warming. Heterojunctions formed between inorganic semiconductors constitute solid photocatalysts with tunable photophysical properties able harness sunlight for the direct activation and reduction of CO₂ to solar fuels and chemicals (Figure 1).[3] Here we describe the synthesis, characterisation and application of heterojunction photocatalysts containing UV (TiO₂) and visible (graphitic carbon nitride, g-C₃N₄) light absorbers, and transition metal co-catalyst for the aqueous phase photoreduction of CO₂ to CO, methane, methanol and formic acid. Mobility and separation of photo-excited charge carriers across the TiO₂/gC₃N₄ interface is probed by photoluminescence and photoelectrochemical measurements to develop structure-reactivity relationships. Photoactivity and product selectivity are a strong function of charge carrier lifetime and valence/conduction band energies.[4] Future opportunities for plasma-assisted photocatalytic reduction of CO₂ will also be reviewed.[5]

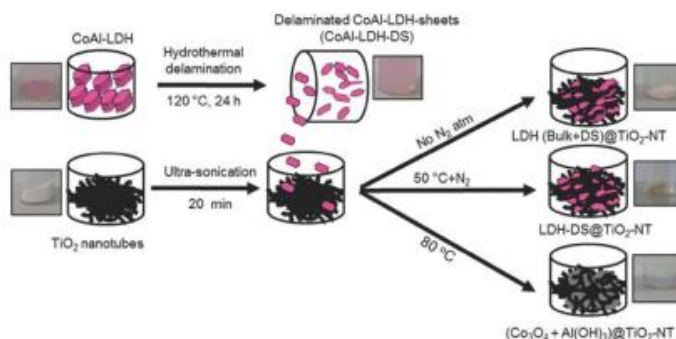


Figure 1. Synthesis of a heterojunction nanocomposite photocatalyst for CO₂ reduction.

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There Is Plenty of Room in Carbon Dots

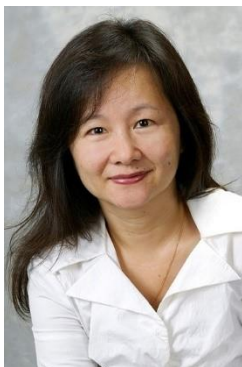
Qin Li

Queensland Micro- and Nanotechnology Centre, School of Engineering and Built Environment,
Griffith University, Nathan QLD 4111, Australia
Email: qin.li@griffith.edu.au

Abstract:

There is no other material like carbon that is as versatile, sitting between the organic and inorganic two worlds. Carbon dots are carbon-based nanoparticles, typically of a size smaller than 50 nm, representing a nanocarbon family that includes graphene quantum dots, amorphous carbon nanoparticles, carbon quantum dots and polymeric ‘carbon’ dots. The common feature of all these carbon-based nanoparticles is their extraordinary optical property – they all fluoresce. However, even on that feature they are different, in their emission profile, absorption characteristics, lifetime etc. Therefore, the relationships in their synthesis method –physiochemical properties- application performance need to be systematically studied. Since carbon dots can be readily made from all kinds of biomass, the variety and complexity of carbon dots has become inexhaustible. Nonetheless, they are not intractable. Rather, they provide inspirations and new opportunities for functionalizing carbon dots. This poster illustrates the outlook of carbon dots research, and their promising applications in energy, water, soil, plant and biomedical research as a green and sustainable contender. There is plenty of room in carbon dots.

Biography



Dr. Qin Li is a Professor of Environmental Engineering at Griffith University. She obtained her PhD in Chemical Engineering from the University of Queensland (2002) and BEng (1994) and MEng degrees (1997) from Zhejiang University. A chemical engineer and nanotech scientist, Prof. Qin Li conducts research on functional materials and applied nanotechnology to provide solutions for energy, water, soil and health management. Prof. Li was a Marie Curie International Incoming Fellow from 2006 – 2008 hosted by the Max Planck Institute for Polymer Research, winner of Curtin Innovation Award 2009, and the finalist of Women in Technology Research Award in 2015 and 2020, respectively. Prof. Li has edited two books and co-authored 6 book chapters, over 120 journal papers and 4 international patents with an h-index of 50 (Google Scholar). Qin Li is named in the Stanford analysis of top 2% of researchers across all disciplines in the world. Prof. Li is the Co-Founding Chair of the Green and Sustainable Chemistry National Group at RACI, and advocates for Innovating Sustainably.

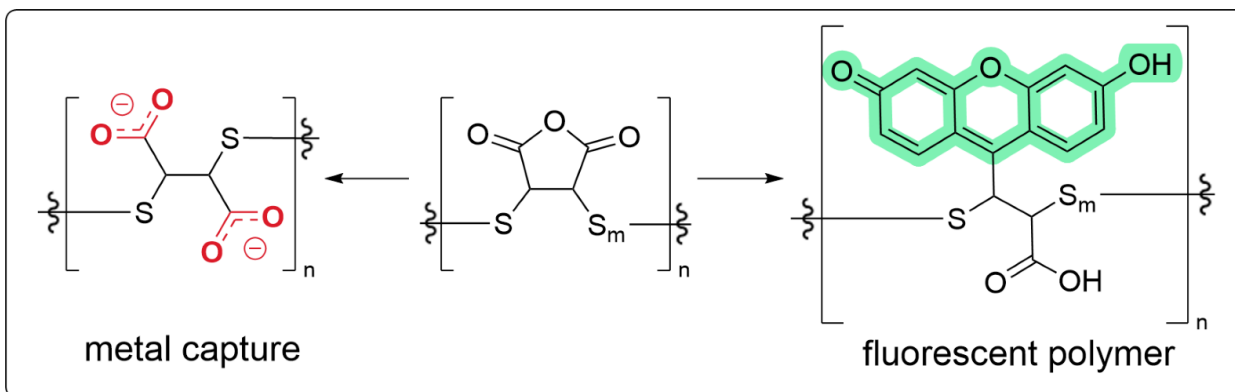
Functionalised sulfur polymers for fine-tuned properties

Lynn S. Lisboa,¹ Jasmine M. M. Pople,¹ Federico G. Muller,¹ Justin M. Chalker^{*1}

¹*Institute for Nanoscale Science and Technology, College of Science and Engineering, Flinders University, Bedford Park, South Australia 5042, Australia*

**Email: lynn.lisboa@flinders.edu.au*

Over recent years, significant interest has been placed on the synthesis of sulfur polymers through the process of inverse vulcanisation. This synthetic strategy crosslinks sulfur chains with organic monomers and in doing so utilises inexpensive sulfur, an industrial waste product. Potential applications for these polymers include their use as dynamic and repairable materials,^[1] infrared lenses for thermal imaging,^[2] oil spill remediation,^[3] and metal sorption.^[4] Although these applications are extremely promising and continually being developed, there remains a gap in the literature for functionalised polymers. We aim to add new functional groups, such as fluorophores and metal coordination sites, to inverse vulcanised polymers in the hopes to develop biological probes and improve metal binding respectively. We have adopted two strategies for the synthesis of these functionalised polymers that are 1) to functionalise the monomer prior to the process of inverse vulcanisation and 2) post-synthetically modify an already synthesised polymer.



Post-synthetic modification of an inverse vulcanised polymer for improved metal capture or fluorescence activity.

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Trace Element Analysis in Seawater Using NexION 2000 ICP-MS and NexION 5000 ICP-MS

Estephany Marillo, ^{1*} Liyan Xing², Chady Stephan²

¹ PerkinElmer Australia

² PerkinElmer Canada

*Email: estephany.marillosialer@perkinelmer.com

The determination of trace elements in seawater is usually considered to be challenging for ICP-MS due to high total dissolved solids (TDS) in this matrix. The high concentrations of matrix components in seawater, such as sodium, magnesium, and chloride ions, may form polyatomic spectral interferences and complicate the determination of elements, such as arsenic, cobalt, vanadium, zinc, copper, and iron. Even for elements like cadmium and lead that are less affected by spectral interferences, the low part-per-trillion (ppt) concentrations in seawater make them difficult to determine with good accuracy and precision.[1]

We report a method to analyze trace elements in coastal and open-ocean seawater using the NexION ICP-MS series instruments [2,3], which meets the specifications to monitor heavy metals in local seawater, as stipulated by ANZECC (Australian and New Zealand Environment and Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand, 2000) water guidelines. Direct analysis of seawater using online dilution was adopted in this work. The dilution was performed using the combination of on-line internal standard addition and on-line gas dilution.

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Response surface methodology and artificial neural network to predict the efficiency of Au (III) removal from aqueous solutions using Iron bark derived biochar

Mahmuda Mele* and Elsa Antunes

College of Science and Engineering, James Cook University

**Email: mahmudaakter.mele@my.jcu.edu.au*

Gold is an expensive metal with many valuable applications such as in jewellery, medical, and electrical industries. Gold is a limited natural resource, therefore its recovery from tailings and wastewater is crucial. Biochar is characterized by high surface area and is a potential low-cost adsorbent, which could be used for gold recovery from aqueous solutions. In this study, we explored the use of iron bark (IB) biochar for gold removal. Several characterization methods showed that the IB biochar successfully adsorbed gold ions from the aqueous solution. The IB biochar prepared by pyrolysis at 500°C with a BET surface area of 423 m²/g showed an adsorption capacity of 475 mg/g, which is one of the highest values reported in literature for biochar. Response surface methodology (RSM) and an artificial neural network combined with the Salp Swarm Algorithm (SSA) were used to analyse the generated findings (ANN-SSA). The RSM prediction model fit was adequate, with a correlation value of 0.990. The correlation coefficient and root mean square error of the ANN-SSA model were 0.995 and 2.712, respectively. RSM experiments were conducted according to the central composite design. However, comparing the statistical criteria revealed that ANN-SSA outperformed RSM in predicting experimental results. Therefore, the ANN model study showed for the first time that IB biochar could be used as a potential green and sustainable adsorbent for gold removal from aqueous solution.

Controlled Expansion of Graphenic Paper

Angus Munday*, Sam Chen

School of Environmental and Life Sciences

The University of Newcastle, Callaghan, New South Wales, Australia 2308

*Email: angus.munday@uon.edu.au

Graphenic paper made of physically stacked layers of graphene with in-plane covalent bonding and weak interlayer bonding have unique material properties distinct from flaky graphite. We previously demonstrated the fabrication of large-area, free-standing films made of stacked/overlapping graphene sheets by (i) chemical oxidation of graphite flakes to graphite oxide followed by exfoliation to graphene oxide, (ii) fabrication of paper-like films by assembling graphene oxide into densely packed films, and (iii) converting to highly crystalline graphene films by high-temperature treatment. [1,2] Recently we find that direct intercalation of centimeter-wide, micrometer-thick graphenic paper can lead to uniform expansion and fine tuning of the distance between the layers in graphenic paper. The expanded graphenic paper can be further treated to produce graphene oxide paper through the Hummers method. The increase in distance between the layers may allow for the ability to insert other substances in between them. This could allow for a range of new composite materials to be produced for a variety of applications.

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Modified cross-linked pectin hydro-films for biomedical applications

Arkasubhro Chatterjee^{1,2,3}, Cresha Gracy Nadar^{1,2,3}, Victoria Haritos⁴, Philip Andrews², Amit Arora^{1,3} and Antonio F. Patti^{2*}

¹IITB – Monash Research Academy, Indian Institute of Technology, Bombay, Powai, Mumbai 400076, India; ²School of Chemistry, Monash University, Clayton, Victoria 3800, Australia ;³Centre for Technology Alternatives for Rural Areas (CTARA), Indian Institute of Technology, Bombay, Powai, Mumbai 400076; ⁴Department of Chemical and Biological Engineering, Monash University, Clayton, Victoria 3800, Australia

Email: tony.patti@monash.edu

Abstract: The global production of fresh fruit for the year 2021 was estimated to be around 870 million metric tons. Approximately 20% of the total fruit produced are wasted due to post harvest losses. Another 25-30% of the total fruits harvested are lost during the processing stage at various industries. At the same time, there is a growing need for versatile, robust polymer-based hydrogels for applications in drug delivery, food preservation, biological implants etc. in the current food and pharmaceutical industry. One possible resolution of the problem is valorisation of fruit wastes and extraction of value-added commodities from the same. Pectin is one such commodity extracted from the peels of fruits such as oranges and apples. Pectin is a polysaccharide present in the cell walls of plant cells that has multiple applications in the food, pharmaceutical and cosmetic industry¹. The current work is aimed at resolving both of these issues by employing green approaches to fabricate biodegradable pectin films derived from renewable fruit waste feedstocks. Here, we report a method for creating insoluble pectin films by crosslinking pectin, extracted from waste fruit peels and pomace, with poly-ethylene glycol diglycidyl ether (PEGDE). Furthermore, in order to improve the physico-chemical characteristics of the films, a physical blend of pectin with a complementary bio-polymer, carboxymethyl cellulose (CMC) was also tested. The crosslinking led to the formation of films that were not only insoluble in water but showed significantly better tensile strength. The films fabricated were then combined with known antimicrobial agents such as Manuka honey in order to test the effectiveness of films in inhibiting microbial growth of known pathogens. This method for creating films with tuneable physical properties from pectin can solve dual problems of waste management and find further high value applications in fields like food preservation, drug delivery and other antimicrobial applications.

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A comparative review on carbon nanomaterials: the scalability of eco-friendly synthesis and impacts on the plant growth

Wei Peng,^{1*}

¹ *Queensland Micro and Nanotechnology Centre*

**Email: w.peng@griffith.edu.au*

Carbon nanomaterials (CNMs) have shown great potential for improving agricultural practices [1]. These nanomaterials have unique physical and chemical properties that make them attractive for a variety of applications in agriculture, including as fertilizers, pesticides, and plant growth regulators [2]. However, the current assessments on the synthesis methods of CNMs have been rarely examined in terms of sustainability and scalability. Besides, CNMs' accumulation, translocation, and plant growth responses in the plant system are poorly understood at the present time, which prevents CNMs from being applied to agricultural practices. This review attempts to provide readers with an update on the status of current CNMs' synthesis methods and systematically summary the effects of CNMs on plant growth with an emphasis on relevant mechanisms. Sections in this paper are devoted to CNMs-plants interaction based on the perspectives of the CNMs' dynamics in plants and CNMs' physicochemical properties. In the final concluding remarks, we suggest future directions of research on the CNMs-plant interactions and important factors that should be considered about the use of CNMs in agriculture.

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Synthesis and study of novel transition-metal-based catalysts

Eve M Poland,^{1*} Meiqiong Tang¹, Curtis C Ho¹, Alex C Bissember¹

1. School of Natural Sciences (Chemistry), University of Tasmania, Tasmania, Australia

*Email: eve.gowen@utas.edu.au

Our research concerns the development of two fundamental classes of transition-metal-based catalysts. The former is a small family of structurally related photoactive metal carbonyl complexes, featuring N-heterocyclic carbene ligands. The physical and structural properties of these catalysts have been investigated and their viability as original photoredox catalysts has been evaluated. The latter catalyst class feature a superbulky phosphangulene ligand, with a distinctive bowl-shaped structure and potential application in CO₂ activation.

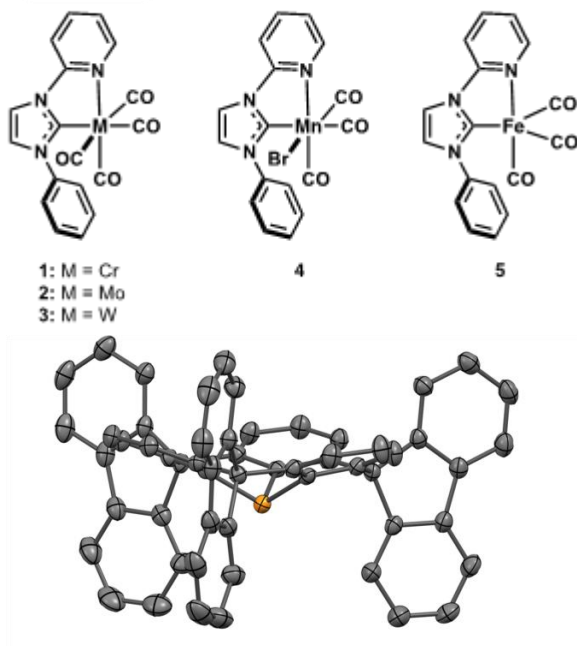


Figure 1: Transition-metal-based catalysts featuring N-heterocyclic carbene ligands (left)¹ and X-ray crystal structure of phosphangulene ligand (right).²

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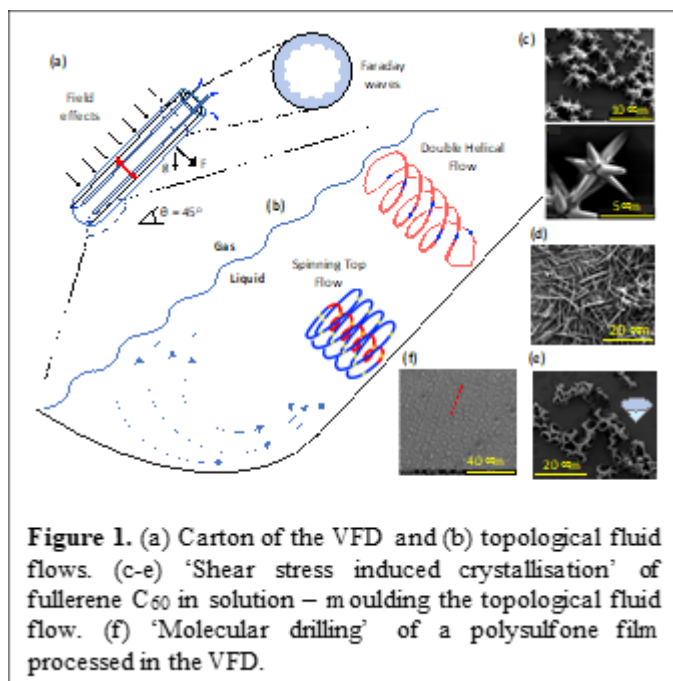
Vortex Fluidic Processing Technology

Colin L Raston AO1*

¹ *Flinders Institute for Nanoscale Science and Technology, College of Science and Engineering, Flinders University, Adelaide, Australia*

*Email: colin.raston@flinders.edu.au

The presentation will highlight the fundamentals and applications of the vortex fluidic device (VFD)[1-4] which imparts mechanical energy in a thin film of liquid in an inclined rapidly rotating tube. The applications are diverse, and we focus on developing processes high in green chemistry metrics. Applications include the ability to slice single, double and multi-walled carbon nanotubes, prepare carbon dots from multi-walled carbon nano-tubes, fold proteins, accelerate enzymatic reactions, control chemical reactivity and selectivity, and self-assembly, purify proteins, exfoliate 2D materials with and without the formation of scrolls, and biomarker detection, and immiscible phase mixing and de-mixing at the nano-meter level.



High shear topological fluid flows down to submicron dimensions are present in the VFD and they can be controlled by varying the operating parameters[2,3]. The fluid flows are the typhoon like spinning top (ST) as a Coriolis force from the curved base of the tube, double helical (DH) flow from Faraday wave eddies twisted by the curved walls of the tube, and a combination of these as spherical or spicular topological fluid flow. They have been established for both homogenous solutions, and mixtures of immiscible liquids. The VFD is designed for incorporating field effects including light sources and lasers, magnetic and electric fields, and plasmas. In addition, real time processing is possible, using UV-vis, fluorescence, Raman spectroscopy, thermal imaging, SANS, as well as studying the fluid behaviour using neutron imaging.

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Prof Colin Raston AO FAA has a Chair in Clean Technology at Flinders University, and is a former President of the Royal Australian Chemical Institute (RACI). He has received the RACI's Green Chemistry, H.G. Smith, Burrows, Leighton Memorial, and Applied Research Awards. In 2015 he shared the Ig Nobel Prize in Chemistry with colleagues at the University of California, Irvine and the University of Western Australia, in 2016 he was Appointed an Officer of the Order of Australia, in 2018 was elected Fellow of the Australian Academy of Science, and in 2020 he was South Australian Scientist of the Year. His current research embraces green chemistry, focusing on the fundamentals of the fluid flow under high shear under continuous flow processing using the vortex fluidic device (VFD), and harnessing the induced mechanical energy in the thin film microfluidic platform for applications where the processing is high in green chemistry metrics. Applications of the VFD include small molecule pharmaceutical synthesis, accelerating enzymatic reactions, refolding proteins, immunoblot assays, separation of proteins, exfoliating 2D material, slicing carbon nanotubes, and food and wine processing.

Hydrogen nuclear spin conversion catalysis

Neil Robinson^{1*} Saif ZS. Al Ghafri¹, Eric F. May¹ and Michael L. Johns¹

¹*Department of Chemical Engineering, The University of Western Australia, Perth WA*

**Email: neil.robinson@uwa.edu.au*

Of the various potential transport vectors, liquefied molecular dihydrogen (LH₂) has emerged as a viable option for the large-scale international export of low-carbon energy. Efficient hydrogen liquefaction processes necessitate the highly exothermic conversion between ortho-H₂ and para-H₂ nuclear spin isomers (see Fig. 1), wherein the two nuclear spin vectors are aligned parallel or antiparallel, respectively. Under ambient conditions so-called normal hydrogen (n-H₂) comprises 75% ortho-H₂ and 25% para-H₂ at equilibrium; upon cooling to 20.3K, however, LH₂ comprises nearly 100% para-H₂ at equilibrium, necessitating significant ortho-to-para conversion upon liquefaction. As the direct interconversion of ortho and para spin isomers is forbidden by quantum mechanical selection rules, ortho-to-para conversion must take place via external stimuli. Such processes are facilitated by the integration of spin conversion catalyst materials into the liquefaction process, which provide both active surfaces to facilitate ortho-to-para transitions, and a heat sink via which to extract the significant (525 kJ/kg) energy released upon conversion. Despite their importance and ubiquity across hydrogen liquefaction processes, detailed knowledge of the surface dynamics and spin conversion mechanisms which take place within these materials remain largely unexplored. Accordingly, this poster will provide a summary of the known spin conversion mechanisms of relevance to hydrogen liquefaction, and detail the analytical tools which may be employed to test emerging materials for such applications.

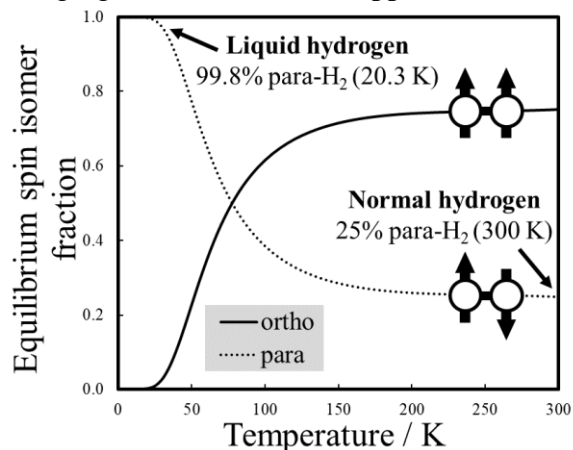


Fig 1. Equilibrium ortho- and para-H₂ spin isomer fractions as a function of temperature.

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Targeted analysis of organic and inorganic acids in sustainable biosolvent production processes by ion chromatography mass spectrometry

Estrella Sanz Rodriguez^{1*}, Leo Lebanov^{1,2}, Noel Davies³, Desmond Eric Richardson², Brett Paull¹

¹*Australian Centre for Research on Separation Science (ACROSS), School of Natural Sciences (Chemistry), College of Sciences and Engineering, University of Tasmania, Hobart, Tasmania 7001, Australia*

²*Norske Skog Boyer, 1279 Boyer Road, Boyer, Tasmania 7140, Australia*

³*Central Science Laboratory, University of Tasmania, Hobart, TAS, Australia*

*Email: Estrella.SanzRodriguez@utas.edu.au

Cyrene™ (dihydrolevoglucosenone) is a green dipolar aprotic solvent produced by the Furacell™ process developed by Circa Group AS. Lignocellulosic biomass is an abundant source of renewable carbon-based energy and provides the feedstock that Furacell™ technology converts into levoglucosenone (LGO) from which the sustainable biosolvent Cyrene™ is derived [1]. Cyrene™ was introduced as a green alternative in 2014 and since then has attracted much attention in different fields [2]. Common to many production processes, the Furacell™ process requires extensive process monitoring and control capabilities to ensure effective and optimal operation. In this context, new, simple, fast and robust analytical methods for monitoring the chemistry of the process and the generation of process by-products are extremely important. Herein, within a collaboration project between Norske Skog Boyer (Tasmania)-Circa Group and the Australian Centre for Research on Separation Science (ACROSS)-University of Tasmania, a new method for process monitoring of acetic, formic, sulfuric, oxalic and phosphoric acids in complex samples from different stages on the manufacture of Cyrene™ is presented. Targeted multi-analyte quantitation was performed using ion chromatography coupled to electrospray ionisation- mass spectrometry (IC-ESI-MS). Optimal chromatographic conditions, providing baseline separation for target acids in under 9 min, were obtained using a Dionex™ IonPac™ AS24 separation column with an electrolytically generated KOH gradient. The high capacity of this column allowed direct injection of large volume of samples highly diluted to minimise a negative effect on the quantitation of targeted compounds by other components present in such complex matrices. Detection was based upon mass spectrometry which permitted sensitive and selective detection even in such highly diluted samples. Nevertheless, a matrix effect was observed within all samples but quantitation by the Standard Addition Method (SAM) was achievable. The results from this study have contributed to a greater understanding of the complex bioprocess manufacturing operations and have directly influenced decisions to expand and to improve capabilities in this new industry.

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Enzymatic Synthesis of Glycolipids and Alkyl Glucosides of Marine Relevance in Natural Deep Eutectic Solvents

Elley Rudebeck^{1*}, Colin Barrow¹, Susan Marshall², Mathew Cumming²

¹Centre for Sustainable Bioproducts, School of Life and Environmental Sciences, Deakin University, Waurn Ponds, VIC

²Plant and Food Research, Nelson, New Zealand

Natural Deep Eutectic Solvents (NaDES) are an emerging class of green solvents in chemical synthesis. These solvents are biodegradable, non-volatile, naturally derived, and inexpensive. Replacement of conventional solvents with NaDES for extraction and enzymatic synthesis has become popular in recent years. In this work, the synthesis of simple glycolipids and alkyl glucosides using fatty acids and alcohols of marine relevance was undertaken, using enzymes as catalysts and NaDES in place of conventional solvents.

Spatially orthogonal nanomaterials for catalytic cascades

Laiba Saleem,^{1*} Karen Wilson¹ and Adam F. Lee²

¹*Centre for Advanced Materials & Industrial Chemistry (CAMIC),
RMIT University, Melbourne VIC 3000, Australia*

²*Centre for Catalysis and Clean Energy, School of Environment and
Science, Griffith University, Gold Coast Campus QLD 4222, Australia*

*Email: s3951825@student.rmit.edu.au

Green and sustainable chemistry is based upon the concept of reshaping the design, synthesis and application of chemical products and processes to minimise the use of raw materials and chemical waste production, and avoid the use of hazardous substances.[1] Use of catalysts is one of the original Green Chemistry principles, and catalysis remains a key enabling technology for chemical synthesis. One strategy to improve the atom- and energy efficiency of chemical transformations to prepare value-added products is to perform one-pot multi-step syntheses, wherein the product of an initial reaction becomes the reactant for a subsequent reaction. Such chemical cascades can be catalysed by heterogeneous (solid) catalysts containing multiple active sites whose spatial location is carefully controlled.[2]

Zeolites are microporous solid acid catalysts with abundant Brønsted acid sites, high surface areas and good thermal stability, and amenable to incorporation into hierarchical porous structures. Here we describe the synthesis of a family of MFI (HZSM-5) zeolites with tunable acid strength and loading, and their encapsulation by mesoporous oxide shells functionalised by organic bases, to produce spatially orthogonal core-shell catalysts for chemical cascades.[3] Independent control over textural and acidic properties of both catalyst components enables optimisation of mass transport and product selectivity in fine chemicals synthesis.[4]

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Carbon Dot Nanomaterials as Sensors For Healthy Water Provision: A Review

Shweta Sareen, *¹ Qin Li¹

¹ School of Engineering and Built Environment, Griffith University, Nathan, QLD 4111

**Email: sareen.shweta@griffithuni.edu.au*

The existence of various pollutants viz., chemical substances, dyes, pesticides and heavy metal ions into the water bodies is a global health crisis which stresses upon the need for developing novel platforms for regular monitoring of concentration of such pollutants entering into water sources, in order to save environment as well as living form of lives from health hazards. Consequently, it becomes imperative to have a low-cost, portable, user-friendly sensor that can detect analytes sensitively and with selectivity in aquatic environment. In this regard, Carbon dots (CDs) have emerged as novel fluorescent nanomaterials for the detection of different analytes in the environment owing to their inherent fluorescent properties, simple synthesis, cost-effectiveness, and high sensitivity. The small size, large specific surface area and high electrical conductivity makes the surface of CDs highly sensitive and reactive to the changes in the temperature and solvent and can significantly improve their performance for the detection of different pollutants in the water bodies. Moreover, the presence of functional groups at their edges act as reaction sites on which varied organic/inorganic moieties and biomolecules (antibody, enzyme, antigen, etc.) could be immobilized. So, a review based on the recent improvements in the sensing applications of CDs with emphasis on different preparation methods, the effect of various synthesis parameters on physical properties and detection mechanisms of CDs for the detection of potential water contaminants will be presented.

Modelling layered double hydroxides using simple ab initio simulations

Gabriel Machado Silva^{1,2*}, Fernando Wypych², Shirley Nakagaki², Karen Wilson¹

1Centre for Advanced Materials and Industrial Chemistry (CAMIC), RMIT University, Melbourne, VIC 3000, Australia

2Universidade Federal do Paraná, Departamento de Química - Centro Politécnico, CP 19032, Jardim das Américas, 81531-980 - Curitiba -PR — Brasil.

**E-mail: quim.gmachado@gmail.com*

Layered Double Hydroxides (LDHs) of general formula $[M_2+(1-x)M_3+x(OH)_2]^{x+}(An^-)_{x/n}.yH_2O$ attract much attention for their potential applications in green and sustainable chemistry. LDHs possess distinct physicochemical properties, related to their intrinsic anisotropy and diverse chemical composition, and find application in many processes, including as catalysts, adsorbents, nanocomposites, energy conversion materials, and for corrosion protection [1,2]. The distinctive characteristics of LDHs, such as their high surface area, tunable pore size and ion-exchange capacity, allow for catalytic sites to be tailored for specific reactions [3], with applications reported including solid base catalysis, oxidation and hydrogenation reactions, and carbon dioxide conversion. LDHs have also been used for energy and environmental applications, including as photocatalysts to convert solar to chemical energy [4], solid bases to produce biodiesel [5], and as sorbents for pollutant removal and waste-water treatment. Whilst LDHs usually comprise positively charged layers with intercalating anions, a few of them also intercalate cations along with anions, such as the shigaite-like minerals [6]. This is a relatively new class of LDH, and the origin of this unique feature and nature of intercalated species requires further investigation. FTIR is a powerful method to characterise intercalated groups in LDH materials. Recently we demonstrated how simple computational chemistry methods and visualisation software for structural models and crystal engineering can assist with FTIR band assignment [7]. Resulting models aid the elucidation of structures, chemical interactions and geometrical properties of the chemical species present in layered materials—especially in the interlayer space—and therefore contributes to the understanding of their chemical behaviour. In this work we present further results on the application of simple ab initio simulations, showing how they can be applied in the FTIR characterisation of complex materials such as LDHs.

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Investigating the Oxidative Degradation of Novel Graphitic Antifouling Coatings and Methods of Improvement

Leilaina Stefaniak,^{1*} Natalie Daou,¹ Mats Andersson¹

¹ *Flinders Institute for Nanoscale Science and Technology,
College of Science and Engineering, Flinders University*

**Email: Leilaina.stefaniak@flinders.edu.au*

Marine biofouling is the unwanted colonisation and growth of biological species on the surface of underwater substrates. It is a global problem that poses several environmental and ecological dangers, from elevated greenhouse emissions to the unwanted spread of invasive marine species. In addition, marine biofouling has presented major ongoing challenges for the maritime industry through increased expenses attributed to maintenance and greater fuel consumption, costing the sector billions of dollars every year. Therefore, the need for technology capable of preventing or removing biofouling (antifouling), is of utmost importance. Recently however, legislations have been enacted against conventional antifouling technology that employed toxic antifouling agents, namely biocides, due to their hazardous accumulation within the environment. As a result, research has been focussed on the development of effective and nontoxic antifouling coatings that are able to combat biofouling and protect marine ecosystems. A promising strategy for biofouling inhibition are conducting fouling-resistant coatings, owing to their highly effective antifouling properties and being deemed environmentally benign.

This research project investigates the stability of a novel conducting antifouling coating developed within our team through a series of experiments that simulate “accelerated ageing” conditions. Since this coating utilises an electrical current to perform electrolysis, high anodic potentials are required for the Oxygen Evolution Reaction (OER), which risks oxidation of the carbon component within the antifouling paint system and consequent oxidative degradation. Therefore, it is crucial to study the coating stability. A range of qualitative and quantitative techniques were used to characterise the level of degradation, such as Auger Electron Spectroscopy and Scotch Tape testing.

The study revealed that our antifouling coating is subject to degradation upon application of continuous electrochemical stresses at anodic potentials. However further investigation is needed to better understand its limits.

The development, design and manufacture of electrochemical cells for the reduction of carbon dioxide to ethylene

Michael Sturman,^{1*} Michael Oelgemöller^{1,2}

¹ James Cook University, College of Science and Engineering, Townsville QLD 4811, Australia

² Hochschule Fresenius gGmbH - University of Applied Sciences, Faculty of Chemistry and Biology, 65510 Idstein, Germany

*Email: michael.sturman@my.jcu.edu.au

The utilization of captured atmospheric carbon dioxide presents an opportunity to create a closed loop carbon cycling system. Upcycling of carbon dioxide to ethylene, one of the most utilized industrial chemicals, can reduce and ultimately eliminate dependence on fossil carbon derived chemicals, including transportation fuels. The versatility of ethylene as a feedstock is that it can be used to synthesize a diverse range of chemical products. Ethylene can be synthesized from carbon dioxide via a green electrochemical process [1]. Carbon dioxide, water and renewable electricity are used as process inputs and via a series of proton and electron addition steps on metallic cathodes, carbon dioxide is sequentially reduced to ethylene. This research focuses on the development, design and manufacture of scalable, environmentally benign electrochemical cells for the direct reduction of carbon dioxide to ethylene.

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Biography:

Michael is a business owner, farmer and Consulting Industrial Chemist. His career spans a diverse range of industries including the production and quality assurance of aviation fuels and lubricants, mineral processing, assay and refining, freeze drying and agriculture. Michael has a strong practical background including skills in fabrication, electronics, TIG welding and mechanics. Many of these skills are frequently used in the operation of his regenerative farm near Yungaburra on the Atherton Tablelands.

Michael is a James Cook University PhD candidate. For his project he is researching and developing a durable electrochemical process and designing scalable cells for converting atmospheric carbon dioxide into ethylene. By design, Michael's electrochemical process uses only environmentally benign inputs and materials. Michael has published a comprehensive review on this subject titled "Process Parameters in the Electrochemical Reduction of Carbon Dioxide to Ethylene". This was awarded as a top downloaded article by Wiley ChemBioEng Reviews. Some of the research outputs to date include inexpensive, non-precious metal oxygen evolution anodes, novel electronic process controls, rapid analytical devices, and an organic solvent-free non-fluorinated ion exchange membrane. Michael was awarded an Eric Booth Memorial Grant in Chemistry (2023).

Oxygen passivated perovskite thin film for highly efficient and stable solar cells

**Selengesuren Suragtkhuu¹, Purevlkham Myagmarsereejid¹,
Munkhjargal Bat-Erdene², Yu Lin Zhong¹, Munkhbayar Batmunkh^{1*}**

¹ *Queensland Micro- and Nanotechnology Centre, School of Environment and Science, Griffith University, Nathan, Queensland 4111, Australia,*

**E-mail: m.batmunkh@griffith.edu.au*

² *Australian Institute for Bioengineering and Nanotechnology, The University of Queensland, Brisbane, Queensland 4072, Australia*

Perovskite solar cells (PSCs) have attracted increasing attention with their high efficiency and low cost; and they promise to be the key system for next generation clean energy technologies. However, PSC's journey toward commercialization is currently hindered by their instability and degradation in ambient environment and other harsh conditions. These stability related issues can be associated with several reasons such as halide vacancies, structural defect, ion migrations and others. In addition, a large density of deep level traps in perovskite film based solar cells is the major factor lowering the device performance. Over the past several years, intensive efforts have been made to enhance the efficiency and stability of PSCs via various strategies including additive engineering, surface passivation and interfacial engineering. Recently, passivating anion vacancies have shown great promise in controlling imperfections, regulating film morphology and pin holes, and thus resulting in enhanced device efficiencies and improved stabilities.

In this work, we passivated halide vacancies of perovskite using oxygen and then systematically investigated the passivation mechanism. In this presentation, I will be sharing the recent finding we made on the effect of this novel passivation using oxygen on the photovoltaic efficiency and stability of PSCs. We anticipate that this work will not only demonstrate the feasibility of passivation using simple oxygen treatment on perovskite thin films, but also provide new knowledge in perovskite research.

Keywords: perovskite, oxygen passivation, halide vacancies, deep level trap

Eucalyptus nitens Biomass: Developing a Chemical Inventory

Rhiannon S. Terry,^{1*} Alex C. Bissember,¹ Fernando A. Maya,¹ Jason A. Smith¹

¹ School of Natural Science - Chemistry, University of Tasmania, Sandy Bay, TAS 7001, Australia

*Email: Rhiannon.Terry@utas.edu.au

Eucalyptus nitens (*E. nitens*) plantations make up approximately 242,000ha in Australia.¹ Approximately 70% of all plantation *E. nitens* are grown in Tasmania on short rotations of 12-20 years to be utilised for pulpwood.² The industry associated with pulpwood production primarily focuses on the timber as a resource, therefore producing mass amounts of waste plant material. Such waste streams include the leaves, bark, and fallout from the heartwood during the chipping process, known as fines.³ Finding applications for these plant materials not only reduces waste streams, but also provides opportunity to both decrease the environmental and increase the economic impacts of this industry.⁴ Additionally, the biomass produced from *E. nitens* plantations and its constituents provide an enormous potential resource which can be may be utilised to develop new industries within Australia.⁵ This research undertakes the preliminary investigation undertaking a chemical inventory of significant isolable compounds and the potential utilization of those compounds in biology or as a high value specialty chemical. Additionally, the non-extractables, including the lignocellulose, provides opportunity to investigate new biomass applications/products via biomass pre-treatment. Overall, this research aims to investigate opportunities for valorisation of industry waste streams.



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3D printed graphene aerogels for clean energy applications

Tuan Sang Tran,^{1,2,*} Naba Kumar Dutta,² Namita Roy Choudhury²

¹ School of Chemical Engineering, The University of New South Wales, NSW 2052, Australia.

² School of Engineering, RMIT University, VIC 3000, Australia.

*Email: sang.tran@unsw.edu.au

Despite significant efforts on graphene-based electrodes for clean energy applications, it remains a major challenge to fabricate 3D-structured graphene with high conductivity and tailored hierarchical porosity for catalysing the electrochemical reactions. Graphene is a novel 2D material with a large surface area and high electrical conductivity, making it a superior electrode material. One of the main drawbacks of the utilisation of graphene is that they tend to restack due to the strong π -stacking, leading to a decrease in performance. Therefore, three-dimensional graphene aerogels have attracted significant interest in clean energy applications due to their high conductivity, extremely low bulk density, high specific surface area, and excellent mechanical strength. Traditional methods for the creation of 3D porous graphene (e.g., self-assembly, sacrificial templates, coating on metallic foams, and crosslinking) are facing significant limitations, such as low scalability, high-cost, complex processes, and poor controllability over the architectures and designs. Therefore, research has driven toward 3D printing for the layer-by-layer fabrication of 2D graphene sheets into functional 3D structures. However, state-of-the-art techniques for 3D printing of graphene aerogels often employ excessive non-conductive additives (e.g., surfactants, dispersants, and binders) to retain its 3D porous structure, which is problematic as the presence of these additives is detrimental to the final electrical properties of graphene. Therefore, the construction of electroactive 3D printable graphene aerogels without non-conductive additives is sought after, especially for green energy applications. Here, we report the development of extrusion 3D printable graphene inks by interfacing graphene with recrystallized nanofibrillar conducting polymers. The formulated inks exhibit excellent rheological properties, which can be 3D printed into multilayer (up to 30 layers) structures via direct ink writing (DIW). The formulated inks were used for fabricating 3D printed electrodes for supercapacitor and electrocatalyst layers for oxygen reduction reaction in fuel cells, with excellent performance and stability.

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Bio:

Dr. Tuan Sang Tran is currently a Postdoctoral Fellow at School of Chemical Engineering, University of New South Wales (UNSW Sydney). Dr. Tran graduated from RMIT University with a Ph.D. in Chemical Engineering in 2021. After that, he worked as a Postdoctoral Fellow at RMIT from 2021 to 2022, before joining UNSW in early 2023. His current research focuses on designing the interactions between nanomaterials to enable applications in high-performance electronics, renewable energy, and environmental remediation. During his early research career, he featured more than 20 publications, which attracted more than 700 citations. He also holds a patent on advanced manufacturing of high-quality graphene, which is groundbreaking for graphene to take off from the laboratory to practical applications.

Biological screening of *Xanthostemon* and *Myrtaceae* essential oils from Oceania and of synthetic triketone analogues

Jayson Wau,^{1*} Nicolas Lebouvier,² Olivia Terceve,² Linda Guentas,² Valérie Medevielle,² David Y. Timi,³ Nicolas Pocquet,⁴ Michael Oelgemöller^{1,5}

¹ James Cook University, College of Science and Engineering, Townsville QLD 4811, Australia

² Université de la Nouvelle Calédonie, Institut des Sciences Exactes et Appliquées, Noumea 98851, New Caledonia

³ Papua New Guinea University of Technology, Department of Applied Sciences, Lae, Papua New Guinea

⁴ Institut Pasteur of New Caledonia, Pasteur Network, Noumea 98845, New Caledonia

⁵ Hochschule Fresenius gGmbH - University of Applied Sciences, Faculty of Chemistry and Biology, 65510 Idstein, Germany

*Email: jayson.wau@my.jcu.edu.au

Essential oils are important renewable materials with a broad range of fragrant, medical, or healthcare properties. According to the UN – FAO, Northeastern Australia, and Melanesia offer rich resources of endemic plant species with potential medical applications.

Xanthostemon, a genus of Myrtaceae has 55 species of which 44 are distributed between Papua New Guinea (4), Australia (14), Indonesia (3), and New Caledonia (23). 50% of *Xanthostemon* species in Australia are endemic, with many containing β -triketone derivatives. Several β -triketones are known for their insecticidal, herbicidal, and antimicrobial properties. For example, *X. chrysanthus* essential oil contains 64-84% of leptospermone and was active against *S. aureus* and *E. coli*. Likewise, acylated β -triketones are the main antimicrobial components of mānuka oil (*Leptospermum scoparium*) with 20-33%. Despite this, no structure-activity relationship study has been conducted on β -triketones to evaluate their antimicrobial potential. The chemical compositions of selected *Xanthostemon* essential oils from Oceania were thus determined and several natural β -triketones were successfully identified. Additional synthetic analogues were likewise prepared and subjected to bioscreening. Several essential oils and synthetic derivatives showed strong biological activities against mosquito larvae and *S. epidermidis*.

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Jayson Wau is a PhD candidate in Organic Chemistry at the College of Science and Engineering at James Cook University in Townsville, Australia. He received his MPhil in Natural Products in 2014 and BSc in Applied Chemistry in 2006 at the Applied Sciences Department at PNG University of Technology. Jayson is currently engaged as a casual academic at JCU and as a tutor in organic chemistry at PNG University of Technology. His current research interest lies in green and sustainable syntheses of fine chemicals, natural products chemistry and bioactivity screening.

Boosting the Acidic OER Performance of Ultra-Thin Defective IrO₂ via Amorphous/Crystalline Heterojunctions

Hongzhe Xu^{1,2*}, Xuecheng Yan¹, Qin Li²

¹ *Queensland Micro- and Nanotechnology Centre, Griffith University, Nathan Campus, QLD 4111, Australia.*

² *School of Engineering and Built Environment, Nathan Campus, Queensland, 4111, Australia.*

*Email: hongzhe.xu@griffithuni.edu.au

Proton exchange membrane water electrolyzers (PEMWEs) for water electrolysis have received tremendous attention due to their advantageous features. Design high-performance, economical and durable electrocatalysts in an acidic environment is still the bottleneck to realize the large-scale commercialization of PEMWEs. Currently, the sluggish kinetics of the oxygen evolution reaction (OER) severely restricts the efficiency of PEMWEs. Iridium-based materials have been considered as promising OER catalysts due to their intrinsic resistance to corrosion under harsh acidic conditions. Amorphous iridium-based catalysts are more active than crystalline structures due to the disorder interconnections. However, the poor stability of the amorphous Ir-based catalysts is a grand challenge needs to be overcome. Herein, we created amorphous/crystalline heterojunctions on defective amorphous iridium oxide (a-IrO₂) to enhance the intrinsic durability, electron transfer ability, and the reaction kinetics. This work realized a balance between the activity and stability of a-IrO₂ through tuning the ratio of amorphous/crystalline and the density of oxygen vacancies. The optimized sample a-IrO₂-350 achieved an excellent OER performance with an overpotential of 223 mV at 10 mA cm⁻² in 0.5 M H₂SO₄. The a-IrO₂-350 also displayed the negligible activity attenuation within 70 h of continuous operation. Moreover, this work revealed the relationship between the amorphous/crystalline ratio and the density of oxygen vacancies. It also uncovered the relationship between the amorphous/crystalline ratio and the activity as well as the stability. It will be beneficial for the design and synthesis of efficient and durable electrocatalysts for practical applications.

Highly active platinum single-atom catalyst grafted onto 3D carbon cloth support for the electrocatalytic hydrogen evolution reaction

Po-Wei Yu,^{1*} Sait Elmas, Tanglaw Roman,¹ Xun Pan,¹ Yanting Yin,¹ Christopher Gibson,¹ Gunther Andersson,¹ Mats Andersson¹

¹ Flinders Institute for Nanoscale Science and Technology,
College of Science and Engineering, Flinders University

*Email: powei.yu@flinders.edu.au

Hydrogen is considered the most promising and competitive green energy carrier due to its extremely clean exhaust: water. However, one of the clean hydrogen production methods, electrolysis of water, requires platinum catalysts to maximize efficiency and lower the onset potential causing the high price of hydrogen fuel which limits the speed of popularizing hydrogen energy. To overcome this issue, the aim of my research is the develop platinum single atom catalysts to minimize the metal usage and maintain its high efficiency at the same time. The single atom catalyst emerged as a powerful technique to bridge the gap between homogeneous and heterogeneous catalysis. Moreover, it has numerous potentials for commercialization by reducing the metal usage, especially the expensive metals.

In this research, we will introduce a straightforward method to produce platinum single atom catalyst on carbon substrate through a single-step electrochemical grafting and aqueous platinum uptake. By attaching selective metal-scavenging ligand, 2,6:2',2''-terpyridine, on carbon cloth substrate through diazonium grafting, each grafted ligand is designed to capture one platinum atom which can be directly activated in hydrogen evolution reaction. This complex material presents high efficiency with an ultra-low platinum loading of $0.26 \pm 0.02 \mu\text{g}/\text{cm}^2$. When comparing with commercially available Pt/C benchmark catalyst in terms of mass activity, this complex material presents up to 82 times higher efficiency at low overpotential of -50 mV (V/RHE) . During the extended operational hours, the terpyridine ligands can also act as effective scavenger for leached platinum from the counter electrode when the surface area of working electrode is much larger than counter electrode. This method to make the Pt single atom catalyst is facile, non-hazardous and versatile without involving any elaborate pre- and post-treatment progresses, and platinum content on terpyridine ligand is only 0.1 US\$ worth per m^2 .

Nanofiber-based colorimetric platform for point-of-care detection of *E. coli*

Jiaqi Zhang ^{1,2}, Gayathri Devi Rajmohan ¹, Dong Wang ^{2*}, Christopher Hurren ^{1*},

¹ Deakin University, Institute for Frontier Materials, Geelong, 3216, Australia

² Key Laboratory of Textile Fiber and Products (Wuhan Textile University) Ministry of Education, Hubei International Scientific and Technological Cooperation Base of Intelligent Textile Materials & Application, Wuhan Textile University, Wuhan 430200, China

*Email: christopher.hurren@deakin.edu.au, wangdon08@126.com

Abstract

Accurate and rapid detection of bacteria in complex environmental samples using simple and portable devices is still a major challenge. This research presents a simple nanofiber-based platform for highly sensitive colorimetric/fluorometric detection of *Escherichia coli* (*E. coli*). Nanofiber membranes (NFM) were loaded with target molecules (fluorescent and chromogenic substrate) via chemical modification to prepare functional NFM (NFM-MUG and NFM-XG). The β -glucuronidase secreted by *E. coli* during the metabolic process triggered the functionalized NFM to produce biological signals and color change. The intensity of bio-signals and color was shown to enable quantitative and qualitative detection of *E. coli*. The nanofiber-based platforms exhibited high stability and a wide detection range (10^2 - 10^7 CFU/mL). The limit of detection (LOD) of NFM-MUG and NFM-XG sensors for *E. coli* were 26 and 69 CFU mL⁻¹, respectively. The sensing time required for NFM-MUG and NFM-XG was 15 mins and 30 mins respectively. The nanofiber-based platforms also exhibited high specificity and low interference from ionic compounds and pH changes. Notably, this assay was easily combined with a smartphone app as a portable device for on-site detection of *E. coli*, showing a great promise in the field of environmental and food safety testing.

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An investigation into the use of laccase to degrade PFAS

Jinpeng Zhou,^{1,2*} Bradley O. Clarke,¹ Ivanhoe K. H. Leung^{1,2}

¹ School of Chemistry, The University of Melbourne, Melbourne, VIC 3010, Australia

² Bio21 Molecular Science & Biotechnology Institute, The University of Melbourne, Melbourne, VIC 3052, Australia

*Email: jinpengz@student.unimelb.edu.au

Per- and polyfluoroalkyl substances (PFAS) are a group of highly stable synthetic fluorinated molecules that are widely used in industry as well as in everyday household products. Due to their widespread use and high stability, PFAS were found to persist in the environment and circulate in the food chain. Recent studies showed that PFAS may bioaccumulate in the human body, and exposure to PFAS are linked to a number of adverse health effects.¹ Hence, it is highly desirable to develop efficient methods to degrade PFAS into less persistent and less toxic molecules. We have recently characterized a novel laccase from *Sulfitobacter indolifex*. We found that the enzyme could mediate the degradation of a range of organic pollutants.² In this poster, we report our recent work investigating the use of laccase to degrade PFAS in water and in wastewater-like environments. This work will provide insights into the degradation of PFAS and pave the way for future development of enzyme technology to breakdown persistent pollutants.

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Biography:

Jinpeng is a final year MSc (Chemistry) student at the University of Melbourne. His MSc research was conducted under the joint-supervision of Drs Ivanhoe Leung and Bradley Clarke, in which he developed and optimized an enzyme-catalyzed method to degrade emerging contaminants including PFAS. He is passionate about pollutant bioremediation and analytical science, particularly in the application and development of new chromatography and mass spectrometry techniques to analyze complex matrices, especially in areas that are connected to environmental sustainability.

A Carbon Dot Toolbox for Managing Biotic and Abiotic Stresses in Plants

Muhammad Zia^{1,2}, Prabhakaran Thanjavur Sambasivam^{3,4}, Dechao Chen^{1,5}, Shamsul Bhuiyan⁶, Rebecca Ford^{3,4}, Qin Li^{1,2,5*}

1. *Queensland Micro- and Nanotechnology Centre, Griffith University, Nathan Campus, QLD 4111, Australia*
2. *School of Engineering and Built Environment, Griffith University, Nathan Campus, QLD 4111, Australia*
3. *Centre for Planetary Health and Food Security, Griffith University, Nathan Campus, QLD 4111, Australia*
4. *School of Natural Science, Griffith University, Gold Coast Campus, QLD 4222, Australia*
5. *Institute for Integrated Intelligent Systems, Griffith University, Nathan Campus, QLD 4111, Australia*
6. *Sugar Research Australia, Woodford, QLD 4514, Australia*

*Corresponding author: qin.li@griffith.edu.au

Erratic weather patterns, increased frequency of natural disasters and reduced water availability because of the climate change, pose significant stress on global food security. Moreover, plant diseases and pests are prevalent, responsible for 20-40% of global crop losses with an estimated value of USD 220 billion. The challenges are beyond what the conventional agrochemicals can offer, and the industry is calling for more environmental-friendly technologies to enable sustainable and productive farming. Nanomaterials have emerged over the last few decades as one of the key contenders in offering such solutions. Carbon dots (C-dots), a new member of the nanocarbon family, are the rising star in offering a versatile toolbox for managing diverse biotic and abiotic stresses faced by the crops. C-dots are carbon-based nanoparticles, typically of a size smaller than 50 nm, exhibiting unique opto- and electro-properties. By tuning the precursors and synthesis method, C-dots can be made as graphene quantum dots, or amorphous carbon nanoparticles, or carbon quantum dots, or even polymeric ‘carbon’ dots. Moreover, their surface functionalities can be easily tuned owing to the versatile carbon chemistry. In this review, the literature in this emerging field of C-dots-enhanced agriculture have been analysed. A focus has been placed on the effects of C-dots on plant stress management. The correlations between the physiochemical properties of C-dots, their application methods on crop plants, and the effects on plants growth and health have been categorized. C-dots have been consistently demonstrated as a promising toolbox for improving plant tolerance to heat, drought, and toxic chemicals, as well as for providing disease resistance to plants.