ANNUAL CONFERENCE 2025
Union House,
University of Adelaide
2nd - 3rd Oct

We acknowledge and pay our respects to the Kaurna people, the traditional custodians whose ancestral lands we gather on. We acknowledge the deep feelings of attachment and relationship of the Kaurna people to country and we respect and value their past, present and ongoing connection to the land and cultural beliefs.

AM2D ARC RESEARCH HUB
THE UNIVERSITY of ADELAIDE
MONASH University
Australian Government
Australian Research Council

Foreword

Directors’ message

Professor Mainak Majumder, Professor Dusan Losic, Professor Namita Choudhury

This conference, the first in-person gathering focussed solely on AM2D participants, is an exciting opportunity to connect our unique research community and to learn about the incredible strides they are making on the 2D-materials landscape.

Research can sometimes feel narrow, technical, or even disconnected from the bigger picture. But in reality, every experiment you run and every dataset you generate is a building block in a much larger scientific effort.

This conference is more than a gathering—it is a chance to step out of the lab and into the flow of ideas that will shape the next stage of our field. Conferences like this are where collaborations are born, where bold ideas meet critical feedback, and where a community of researchers can get to know one another over shared interests and good food.

2D materials remain one of the most exciting frontiers in materials science. We have already seen extraordinary progress—from theoretical predictions, to the discovery of exotic properties, to proof-of-concept devices. Yet, we are still only scratching the surface of what is possible. The challenges we face—scalable synthesis, integration into real-world technologies, and uncovering new phenomena—are precisely where the contributions of AM2D matter most.

Let’s make the most of this opportunity—to learn from one another, to inspire one another, and to continue building a field that could shape the future.

-AM2D Directors

Organisers’ message

Dr Pei Lay Yap, Ammara Waheed, Jo Yee Wong, Niroshan Manoharan, Dr Phillip Sheath

Some of you might know that Adelaide is bi-sected by the Torrens River. The Indigenous people of the Adelaide Plains, the Kaurna people, believed that the reflection of the Milky Way in the river ("Karrawirra Parri" – Red Gum Forest River) was symbolic of the river's connection to the universe. We take this as an apt reminder to the AM2D community to reach for the stars while you're here in Adelaide. Take advantage of the opportunities afforded to you during this time, but also make sure to connect with your peers and other experts, listen, learn and most importantly have fun.

Much of our work involves a lot of emails and virtual meetings. By far the best part of our job is when we get to talk to the incredible researchers and see the incredible outcomes from the activities of the Hub. As such, we are very much looking forward to this event, and we hope you are too.

Conference Schedule

Venue: Union House, University of Adelaide

AM2D ARC RESEARCH HUB | THE UNIVERSITY of ADELAIDE | MONASH University | Australian Government Australian Research Council

DAY 1
2nd October 2025

Start	End	Mins.	Activity
09:30	10:00	30	**Registration**
10:00	10:10	10	**Opening** MC: Phillip Sheath
10:10	10:40	30	**Director's remarks** Prof Mainak Majumder (Monash University) Prof Dusan Losic (University of Adelaide) Prof Namita Choudhury (RMIT)
10:40	11:05	25	Morning Tea
Session 1: Sensors Chair: Joynul Abedin			
11:05	11:20	15	*Engineering of 2D Materials and MOF Hybrids for Room-Temperature Chemoresistive Sensors* Dr Tung Tran (University of Adelaide)
11:20	11:30	10	*Efficient Room-Temperature NH3 Sensing Using Mixed-Phase MoS_2* Md Abdul Jalil (University of Adelaide)
11:30	11:40	10	*Realization and Performance Evaluation of Graphene-Based Chipless RFID Sensor Tag Under Mechanical Deformations* Shadhon Mohonta (Monash University)
11:40	11:55	15	Session Panel (Panel moderator: Prof Rico Tabor)
Posters Facilitator: Dr Phillip Sheath			
11:55	12:25	30	Posters
12:25	13:15	50	Lunch/Posters
Session 2: Energy Chair: Chamalki Liyanage			
13:15	13:25	10	*Investigation into the Role of 1T and 2H MoS2 as a Host in Heterostructuring with CoS2 for Hydrogen Evolution Reaction in Acidic Medium* Francis Prashanth Peter (Monash University)
13:25	13:35	10	*Development of SiO2-biopolymer hybrid microcapsules for thermal energy storage* Jo Yee Wong (Monash University)

Start	End	Mins.	Activity
13:35	13:45	10	*High-performance Electrothermal films based on copper-decorated N-doped thermally reduced graphene: Role of Sheet resistance/electrical conductivity on thermal performance* Olalekan Solomon Oluwole (Monash University)
13:45	13:55	10	*Data-Driven Design of Biomass-Derived Hard Carbons for Sodium-Ion Batteries: A Machine Learning Approach* Niroshan Manoharan (QUT)
13:55	14:10	15	*Volumetrically Efficient Graphene Supercapacitors* Petar Jovanovic (Monash University)
14:10	14:30	20	Session Panel (Panel moderator: Prof Deepak Dubal)
14:30	14:55	25	Afternoon Tea (Group photo)
Session 3: Quality control Chair: Justin Kappen			
14:55	15:05	10	*Comparative Thermal Stability and Oxidative Kinetic Analyses of graphene nanoplatelets and graphite* Siavash Aghili (University of Adelaide)
15:05	15:15	10	*From Quantification to Quality: Defining Epoxide Content in Graphene Oxide* Gimhani Danushika (University of Adelaide)
15:15	15:25	10	*High-throughput optical identification method of graphene and related materials* Lei Chen (Monash University)
15:25	15:45	20	*Harmonizing Characterization and Quality Control for Graphene-Related Materials* Prof Dusan Losic (University of Adelaide)
15:45	16:05	20	Session Panel (Panel moderator: Dr Pei Lay Yap)
16:05	18:30	145	Hotel check-in/Freshen up
18:30	21:30	180	Dinner at Sosta Argentinian Kitchen (291 Rundle St, Adelaide)

DAY 2
3rd October 2025

Start	End	Mins	Activity
9:00	9:25	25	**Guest talk** *Superconducting Quantum Antennas: Toward RF sensing systems* Prof Giuseppe C Tettamanzi (University of Adelaide)
Session 4: Water Chair: Tung Tran			
9:25	9:45	20	*Graphene Membranes: Improved Organic Removal Efficiency Compared to Coagulation in Drinking Water Treatment* Dr Adam Fischmann (Clean TeQ Water / NematiQ)
9:45	10:10	25	Morning Tea
10:10	10:25	15	*The development of practical Graphene Oxide-based membranes in molecular separation* Dr Sally El Meragawi (Monash University)
10:25	10:35	10	*Advancing Hospital Wastewater Treatment via Continuous Adsorption in a Coiled Flow Inverter Reactor* Ammara Waheed (University of Adelaide)
10:35	10:50	15	*Addressing Existing Industry Bottlenecks in Water Purification Technology* Dr Pei Lay Yap (University of Adelaide)
10:50	11:00	10	*Manipulating Intrapore Energy Barriers in Graphene Oxide Nanochannels for Targeted Removal of Short-Chain PFAS* Eubert Mahofa (Monash University)
11:00	11:20	20	Session Panel (Panel moderator: Prof Mainak Majumder)
11:20	12:00	40	Tours
12:00	12:40	40	Lunch
Session 5: Coating and printing Chair: Olalekan Solomon Oluwole			
12:40	12:50	10	*Antibacterial Nanobiocomposites Based on Gallium and Glucose* Masoomeh Asghar Nejad Laskoukalayeh (University of Sydney)
12:50	13:00	10	*Revealing mechanism of graphene enhanced anti-corrosion performance* Kosala Purasinhala (University of Adelaide)
13:00	13:20	20	*Industrial Graphene for Large Scale Applications*

Start	End	Mins	Activity
			Dr Meysam Sharifzadeh (Ionic Industries Ltd)
13:20	13:35	15	*Developing Layered Nanomaterials for Printable Devices* Dr Naimeh Naseri Taheri (Monash University)
13:35	13:55	20	Afternoon Tea
Session 5: Coating and printing (cont.) Chair: Olalekan Solomon Oluwole			
13:55	14:05	10	*Rheological property enhancement of styrenic block copolymers reinforced with 2D nanomaterials for additive manufacturing* Vihanga Kularatne (RMIT)
14:05	14:15	10	*A Green Approach to Functionalizing Graphene for Enhanced Dispersibility and Electrical Conductivity* Chamalki Madhusha (Monash University)
14:15	14:35	20	*Why rheology is crucial for 3D printing?* Namita Choudhury (RMIT)
14:35	15:00	25	Session Panel (Panel moderator: Prof Dusan Losic)
15:00	15:30	30	Prizes and Close

Posters

No.	Presenter	Title
1	Devarani Theenathayalan (Monash University)	Atomic-Thin Hydrophobic Coatings for Stable Zinc Anodes in Aqueous Zn-MnO2 Batteries
2	Kien Tuan Nguyen (Monash University)	Solvation-Modulated Dispersions of Dense-block Graphene towards Binder-Free Conductive Inks
3	Mahnaz Dadkhah Jazi (University of Adelaide)	Enhancement of Electrochromic Properties through the Integration of 2D WO3 for Smart Window Applications
4	Vu-Hoang Nguyen (Monash University)	Influence of metal iodide salts – polymer complexes as soft catalysts on electrochemical performance of lithium–sulfur batteries
5	Rabia Sabir (University of Adelaide)	Engineering of Arsenic Removal from Natural Water Using a Coiled Flow Inverter
6	Jimyl Cruz (University of Adelaide)	Tailoring Iron Oxide Nanoparticles from Biowaste via Physical, Chemical, and Thermal Methods
7	Muhammed Afnas Vilayatteri (Monash University)	Anomalous Ion Transport in 2D Graphene Oxide Membranes enabled by confined Amino Acid Interactions
8	Justin Kappen (RMIT)	2D Nanomaterials for Enhancing the 3D Printability of Thermoplastic Elastomers
9	Olalekan Solomon Oluwole (Monash University)	Low-temperature graphitization by amine-assisted combustion of graphite oxide
10	Vijetha Ponnam (Monash University)	Graphite Flows in Australia: From Mine to Market

Keynote speakers

Superconducting Quantum Antennas: Toward RF sensing systems

Abstract:
RF Antennas and sensors play critical roles in communication to medical and defence applications. With the electromagnetic (EM) spectrum growing increasingly congested, it is becoming more and more difficult to detect EM signals. Superconducting Quantum Antennas (SQAs) represent a new generation of quantum sensors that are highly sensitive, small-scale, and can operate over a wide range of frequencies. In light of the importance of this technology, we are interested in understanding what quantum sensing is from the most fundamental point of view. In our presentation, the links between the geometrical phase, the Berry phase, and the Aharonov-Bohm Effect (sometimes called the Ehrenberg–Siday–Aharonov–Bohm effect) will be briefly discussed. Furthermore, the initial results towards the fabrication of complete RF Sensing systems are discussed in this presentation.

Dr Giuseppe C Tettamanzi (Head of the UoA Jesper Munch Quantum Labs, University of Adelaide) is a world leader in Quantum devices and Quantum materials and leads the UoA Quantum And Nanotechnology Group (QuANTeG). Following his move to UoA, Giuseppe has assembled a strong team of researchers, working on the theory of emergent quantum effects in nano-materials and their potential use in new applications. He has implemented from scratch several novel concept devices, including the smallest existing DC SQUID design and the first implementation of a Single-Atom-Based Single-Electron Source. He has also studied highly complex quantum phenomena in these nano-devices, establishing himself as a leading expert in Solid-State Systems. In 2025, he leads the UoA team as a finalist at the Department of Defence Eureka Prize for Outstanding Science in Safeguarding Australia, the most important of its kind in Australia.

Plenary Sessions (CI & PIs)

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Harmonizing Characterization and Quality Control for Graphene-Related Materials (GRMs)

Dusan Losic, Pei Lay Yap, Gimhani Danushika
School of Chemical Engineering
The University of Adelaide, Adelaide, SA 5000, Australia

The rapid industrial expansion of graphene-related materials (GRMs), coupled with their wide variability in properties and quality, has underscored the urgent need for standardized, scalable, and reliable analytical methods for characterization and quality control. Conventional techniques such as TEM, SEM, AFM, XPS, and Raman spectroscopy are high-cost, localized approaches that fail to capture the bulk properties most relevant for industrial applications. This talk will review harmonized framework for GRM characterization, we developed that integrates complementary, low-cost techniques capable of delivering comprehensive analytical results at the macro, bulk scale. The presentation will review existing ISO-adopted methods and standards and demonstrate how they can be advanced with new complementary approaches to better reveal the structural, compositional, and chemical properties of GRM powders. Novel quality control metrics derived from these methods are developed, illustrating their effectiveness in distinguishing GRMs produced by different processes and raw material sources. By establishing affordable, standardized practices for GRM characterization, this framework will enhance the reliability, reproducibility, and quality of industrial graphene products, ultimately accelerating their adoption across a broad range of technologies and applications.

Graphene Membranes: Improved Organic Removal Efficiency Compared to Coagulation in Drinking Water Treatment

Adam Fischmann, Clean TeQ Water

This study assessed a graphene oxide (GO) nanofiltration membrane for natural organic matter (NOM) removal. Four feed waters contain elevated levels of NOM were tested, from initial bench scale tests with flat sheet and spiral wound membrane to pilot scale. NOM removal improved by 25-40% compared to coagulation using aluminium sulphate.

Adam Fischmann

Adam Fischmann earned a PhD in Inorganic Chemistry from Monash University, following undergraduate studies in chemistry and earth sciences (also at Monash). Adam is currently Principal Chemist – Hydrometallurgy at Clean TeQ Water in Melbourne, and is also Technical Manager at NematiQ (a subsidiary of Clean TeQ Water for commercialisation of graphene oxide membranes). Adam's responsibilities at Clean TeQ Water span R&D in metal recovery by ion exchange, tailings dewatering and graphene oxide nanofiltration. Prior to his current position, Adam worked in the US at Cytec/Solvay (now Syensqo), focusing on the development and application of solvent extraction reagents for metal recovery. Adam also completed a post-doc at the University of British Columbia in Canada on metal leaching. Adam has authored a number of technical papers and patents.

Industrial Graphene for Large Scale Applications

Meysam Sharifzadeh[1]
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Since its discovery, Graphene has been labelled by various titles such as the “wonder material” he “game-changer,” the “material of the future”, and promised to improve almost every application it is introduced to. Now that the hype cycle is behind us and we enter the succeed-or-die era, we’re finally beginning to hear real success stories. These are largely driven by a better understanding of the material, processes, and the development of application-specific specifications for graphene. While in many cases the production of graphene remains costly, we have come to realize that for bulk applications, graphene can be produced at a comparable to other conventional carbon allotropes such as carbon black and activated carbon. As costs fall and expectations become more grounded, both commercial and academic interest is being directed towards more practical, scalable uses, and with that, real progress is on the horizon.

In this talk, I’ll share my personal journey with graphene: the challenges, learnings, and milestones along the way. I’ll also introduce our approach at Ionic to developing graphene-enabled products and touch on how we’ve managed to align innovation with commercial viability in this space.

Meysam Sharifzadeh

As the R&D Manager at Ionic Industries, Meysam specializes in materials science, leveraging over 15 years of experience to pioneer innovative solutions in sensing and energy storage technologies. His expertise lies in developing and commercializing advanced materials, with a particular focus on sensing surfaces, structural health monitoring, and energy storage systems. He has developed multiple technologies that use graphene as the main active component such as sensing element or electrode. His most notable achievement is the development of the world’s most energy-dense supercapacitor electrode, a breakthrough verified by leading independent third parties. He has authored and co-authored over 40 academic publications and patents, including works published in top-tier journals such as Science and Nature.

Why rheology is crucial for 3D printing?

Vihanga Kularatne, Justin Kappen, Naba Kumar Dutta, Namita Roy Choudhury
Chemical and Environmental Engineering
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Australia

Rheology plays a vital role in material processing by governing the flow and deformation behavior of materials, which is critical for process design, optimization, and manufacturing efficiency. In the context of 3D printing, rheological properties directly influence a material's ability to be extruded, maintain its shape after deposition, and support the layering required for complex structures. Key rheological properties such as viscosity, shear-thinning behavior, yield stress, and viscoelasticity must be precisely controlled to optimize printing processes for various materials, from bioprinting of liquid ink and hydrogel forming ink to polymer melt and thermoplastic elastomers. A thorough understanding and optimization of these properties are crucial to achieve high print resolution, structural integrity and desired post-printing performance.
Using several 3D printing case studies aimed at meeting technical challenges, we will explore the critical rheological properties of 2D material inks, hydrogels, polymer melts for various application domains[1-7].
With a view to developing protocols that enable optimisation of parameters, we will also review other additional requirements that viscoelastic materials must meet such as reliable and reproducible rheological tests and data to guide extrudability, printability, shape retention and structural integrity. The careful selection of the key rheological properties is essential for robustly assessing printability and the temporal dimension is critical. The role of viscoelasticity as a function of structure development will be discussed that governs layer adhesion, dimensional accuracy, and surface finish. The findings will highlight the importance of tailoring rheological profiles to achieve consistent extrusion, minimize defects, and enhance mechanical performance of printed parts and enhance manufacturing efficiency.

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Oral presenters Abstracts

Engineering of 2D Materials and MOF Hybrids for Room-Temperature Chemoresistive Sensors

Tung T Tran[1,2*], Trong Tuan Anh Tran[1], Md Abdul Jalil[1], Tetsuya Kida[2], Dusan Losic[1]
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Conventional chemoresistive gas and volatile organic compound (VOC) sensors have traditionally relied on metal oxides as their active materials. While these sensors have seen considerable commercial success, they often suffer from key limitations, including high operating temperatures, limited sensitivity to certain analytes, and poor selectivity. Moreover, tuning sensor performance—typically by employing sensor arrays to distinguish among a broad range of gases and vapors—remains a critical challenge.

Metal–organic frameworks (MOFs) have recently emerged as attractive candidates for sensing applications due to their high porosity and tunable chemical functionality. However, their practical use in chemoresistive sensors has been constrained by poor electrical conductivity and moderate chemical stability. In contrast, two-dimensional (2D) materials such as graphene derivatives and transition metal dichalcogenides (e.g., MoS_2, $MoSe_2$, WS_2) offer excellent electrical properties, rapid response times, and mechanical robustness, yet often lack sufficient selectivity.

This presentation explores the hybridization of 2D materials with MOFs as a synergistic strategy to overcome the individual shortcomings of each material class. By integrating the high conductivity and responsiveness of 2D materials with the molecular selectivity and porosity of MOFs, we demonstrate significant enhancements in both sensitivity and selectivity for room-temperature chemoresistive sensing. This hybrid approach paves the way for the development of the next generation of low-power, high-performance chemical sensors.

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4. T. T. Tung, M A Jalil, Trong T A Tran, D Losic. MoS2-MOF hybrid materials for selective VOC Sensor, 2025 MS preparation.
5. T. T. Tung, M A Jalil, Trong T A Tran, D Losic. WS2 & MoSe2-MOF hybrid materials for high-performance VOC Sensor, 2025 MS preparation

Efficient Room-Temperature NH_3 Sensing Using Mixed-Phase MoS_2

M. A. Jalil [1], Kamrul Hassan [1], Anh Tuan Trong Tran [1], Tran Thanh Tung [1], Manas Ranjan Panda [23], Sally El Meragawi [23], Tetsuya Kida [4], Mainak Majumder [23] and Dusan Losic [*12]

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Molybdenum disulfide (MoS_2) has emerged as a potential sensing material over the past decade due to its unique properties. However, its inherently insulating nature has limited its practical applications as a sensor. So, various strategies have been explored to enhance its sensing capabilities, including doping, surface modification, and the formation of composites with other materials. In this study, we highlight the use of mixed-phase MoS_2 (1T@2H-MoS_2) for superior ammonia (NH_3) sensing performance at room temperature (20 °C). The 1T@2H-MoS_2 was synthesized via a hydrothermal method, and the coexistence of the metallic 1T phase and semiconducting 2H phase was confirmed using transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), and Raman spectroscopy. Field emission scanning electron microscopy (FESEM) and TEM revealed a distinct flower-like morphology. Our findings suggest that the combination of 1T and 2H phases promote the formation of sulfur vacancies, which are believed to play a crucial role in enhancing the material's sensitivity to NH_3. The gas sensing performance evaluation showed that the 1T@2H-MoS_2 sensor exhibited fast and selective detection of ammonia across a broad concentration range (2–100 ppm), with a rapid response time of 7 seconds, quick recovery, and high selectivity at room temperature. Here the enhanced NH_3 sensing performance is attributed to the improved electrical conductivity and the presence of defects in the material, which are believed to result from the formation of the mixed phases. In addition, flower-like morphology is also considered an added advantage, contributing to the material's enhanced sensing performance. This study presents the promise of mixed-phase MoS_2 as a high-performance material for the development of efficient, room-temperature NH_3 gas sensors, with strong potential for practical applications.

Md Abdul Jalil

Md Abdul Jalil is a PhD student at the University of Adelaide's School of Chemical Engineering working on developing 2D materials, and their composites, for sensing applications. He earned his M. Sc in Physics from BUET, Bangladesh. He then studied at CUET, Bangladesh, obtaining his M. Phil. Prior to beginning his PhD, he was a Lecturer in the Department of Physics at CUET. He has expertise in advanced materials synthesis, characterization techniques, and gas sensing. His research aims to develop scalable, cost and energy effective sensors for safety monitoring.

Realization and Performance Evaluation of Graphene-Based Chipless RFID Sensor Tag Under Mechanical Deformations

Shadhon Chandra Mohonta, [*,1,4] **Olalekan Solomon Oluwole,**[2,4] **Petar Jovanović,**[2,4] **Tuan Kien Nguyen,**[2,4] **Phillip Aitchison,**[3] **Fatemeh Babaeian,**[1] **Nemai C. Karmakar,**[1] **and Mainak Majumder**[2,4]

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The inherent flexibility of printed chipless Radio Frequency Identification (RFID) sensors makes them highly suitable for structural health monitoring in complex and dynamic environments. Herein, a complementary U-shaped chipless RFID sensor, based on a frequency-selective surface, is proposed to achieve a high reflected intensity and quality (Q) factor compared to conventional resonator geometries. The sensor is fabricated via blade coating using a synthesized nitrogen-doped thermally reduced graphene oxide (N-TrGO) ink on a low-cost, flexible plastic substrate. In addition, a novel lamination approach is proposed to enhance the sensor's durability against physical and environmental impacts. Comprehensive measurements are conducted to evaluate the electromagnetic performance, reading range, and cyclic mechanical deformations (i.e., bending, torsion, and strain) response of the laminated sensor. The sensor maintains a detectable reflected signal up to 80 cm when the electric field (E-field) of the reader antenna is aligned parallel to the sensor. Under bending and torsion deformations, a linear negative correlation is observed between signal intensity and increasing bending and twisting angles, respectively. In strain sensing, the sensor demonstrates a linear downshift in resonance frequency with applied strain, confirming its capability to detect tensile deformations effectively. Microscopic surface analysis before and after cyclic deformation further confirms the mechanical robustness of the graphene-based chipless RFID sensor tag over conventional metal-based RFID devices. Overall, the sensor addresses reading range limitations and facilitates the quantification of multimodal deformations with high sensitivity, highlighting its potential for robust and qualitative wireless structural health monitoring in demanding industrial environments.

Keywords: Graphene ink, chipless RFID sensor tag, mechanical deformations, bending, torsion, strain.

Investigation into the Role of 1T and 2H MoS_2 as a Host in Heterostructuring with CoS_2 for Hydrogen Evolution Reaction in Acidic Medium

Peter Francis Prashanth[1,2], Naimeh Naseri[1,2], Sally El Meragawi[1,2], Manas Ranjan Panda[3], Muhammed Afnas Villayateri[1,2], Matthew Roland Hill[4], Mainak Majumder[1,2]

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Molybdenum disulphide (MoS_2) and cobalt disulphide (CoS_2) are promising transition metal dichalcogenides (TMDs) for use as heterogeneous catalysts in hydrogen evolution reaction (HER). Studies have shown that combining of these two TMDs in heterostructures can produce catalysts with improved activity for HER. The 1T and 2H phases of MoS_2 possess vastly different activity due to the varying degree of exposure of active sites and the nature of their electronic properties. During the growth of heterostructures, these effects play a crucial role in determining nature of the interface between the two TMDs. In this work, we elucidate the nature of this difference through stability testing using cyclic voltammetry (CV). Techniques like X-ray diffraction (XRD), scanning electron microscopy (SEM), Raman spectroscopy, and high-resolution transmission electron microscopy (HRTEM) were used to assess the transformations occurring in the electrodes after testing in HER conditions.

Our results show that after testing with 4000 CV cycles, an increase in the overpotential of CoS_2/2H MoS_2 (80-100 mV) is observed as opposed to that in CoS_2/1T MoS_2 (5 mV). The loss of activity can be attributed to the leaching of the CoS_2 from 2H MoS_2 into the electrode, which is evidenced by XRD. This was also supported by using ICP-MS to detect higher Co concentrations in the acidic electrolyte for CoS_2 on 2H MoS_2 than that of 1T MoS_2. SEM imaging suggested that CoS_2 nanospheres on 2H MoS_2 underwent a change in the morphology into distorted particles over MoS_2 while that of CoS_2/1T MoS_2 remained as nanospheres on MoS_2 flakes. Overall, the study showed that CoS_2 is more stabilized on 1T MoS_2 than on 2H MoS_2 in acidic environment under HER conditions.

Francis Prashanth

Francis received his bachelor's degree in chemical engineering from Anna University, India in 2016. Prior to joining NSEL, he spent 5 years working as a scientist at the Indian Institute of Technology Madras (India), pursuing research into thermochemical conversion technologies to produce biofuels from waste. He joined the NSEL team at Monash University as a PhD student in April 2023. His research focuses on the use of 2-Dimesional materials for hydrogen storage and production.

Development of SiO_2-GO hybrid microcapsules for thermal energy storage

Jo Yee Wong[1,2], Karolina Matuszek [1], Mainak Majumder[1,2] Rico Tabor [1,2]

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Rapid technological and economic growth due to the evolution of societies stimulates an equally rapid amplification in energy demand. The major anthropogenic generation of energy still originates from burning fossil fuels, however due to its negative impact thermal energy storage (TES) systems act as an alternative (and indeed complementary) solution to this problem. Phase change materials (PCMs), which are also known as latent heat storage materials, have high heats of fusion, which is distinct from traditional sensible heat storage materials that absorb heat by increasing their temperature. Paraffin wax serves as a prevalent choice as a commercially used organic PCM. In this research project, we encapsulate PCMs for thermal energy storage purposes which would result in better heat exchange due to greater total surface area, and solve the leakage problem during solid-liquid phase transition by a scalable, robust and surfactant free method. This method is known as a Pickering emulsion method where graphene oxide would stabilize the oil-droplet, and silica precursor available in the oil droplet would form interfacial sol-gel process on the oil-water interphase resulting a silica graphene oxide hybrid shell making the fabrication of microencapsulated PCMs an inherently flowable from a one-pot synthesis process. The mechanical stability, chemical stability and thermal cyclability was investigated by microscopy, thermal gravimetric analysis (TGA) and differential scanning calorimetry (DSC), indicating that with an increase of silica precursor and post-hydrothermal treatment a more robust and rigid microcapsule is formed. Morphology and shell thickness of the PCMC was determined by atomic force microscopy (AFM), scanning electron microscope (SEM), and focused ion beam SEM (FIB-SEM), where the presence of encapsulated PCMCs was detected by transmission and reflection polarising microscopy. The formation of the silica-GO shell was also confirmed by shrinking-droplet pendant drop, X-ray crystallography (XRD) and X-ray photoelectron spectroscopy (XPS).

Jo Yee Wong

Jo Yee Wong is a PhD candidate from School of Chemistry at Monash University where she is conducting research under the supervision of Prof. Rico Tabor co-supervised by Dr. Karolina Matuszek and Professor Mainak Majumder. Jo Yee's research focuses on microencapsulating phase change materials. Specifically, she is investigating how to encapsulate phase change materials via Pickering emulsions technique with 2D materials- graphene oxide in a one-pot synthesis, with the goal of utilizing the microcapsules for thermal energy storage.

High-performance Electrothermal films based on copper-decorated N-doped thermally reduced graphene: Role of Sheet resistance/electrical conductivity on thermal performance

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Thermally reduced graphene oxide (T-rGO)-based electrothermal films have emerged as promising materials for efficient and flexible heating applications, owing to their tunable electrical and thermal properties. In this study, we systematically investigate the relationship between electrical conductivity (expressed as sheet resistance) and the electrothermal performance of copper-decorated, nitrogen-doped TrGO films under Joule heating using calendered graphene film on a polyimide (PI) substrate. Three categories of films were fabricated with varying conductivity: highly conductive, moderately conductive, and poorly conductive T-rGO. Our results show that the poorly conductive film (sheet resistance > 1000 Ω/sq) required substantially higher operating voltages of 31 V to reach a saturation temperature of ~120 °C, reflecting significant Joule losses and limited electron mobility. In contrast, the highly conductive copper-decorated film (sheet resistance of ~ 1.65 Ω/sq) achieved ~250 °C at a low operating voltage of 4 V with a rapid response time of 15 seconds. However, this performance came at the expense of a high current draw, due to the low resistance pathway within the film, potentially resulting in reduced thermal conversion efficiency, but also opens opportunities for applications requiring high power density and rapid thermal response. The moderately conductive T-rGO film (sheet resistance of ~ 26 Ω/sq) demonstrated a slower response, an optimal balance between voltage and current, reaching a similar temperature at 9 V with a relatively low current draw, presenting an energy-efficient alternative for controlled heating. These findings underscore the critical influence of sheet resistance on the thermal output and power consumption of graphene-based electrothermal systems and provide valuable insights for the design of next-generation energy-efficient heating elements. The practical utility of the copper-decorated films was further demonstrated in real-world applications such as water heating and de-icing.
Keywords: Thermally reduced graphite oxide, copper decorated graphene, amino acids, electrical conductivity, joule heating, electrothermal films.

Data-Driven Design of Biomass-Derived Hard Carbons for Sodium-Ion Batteries: A Machine Learning Approach

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Sodium-ion batteries (SIBs) are gaining momentum as cost-effective and sustainable alternatives to lithium-ion batteries, particularly for grid-scale and stationary energy storage. Biomass-derived hard carbons are among the most promising anode materials due to their structural tunability, abundant feedstock, and environmental compatibility. However, performance variations caused by both material properties and cell fabrication parameters complicate efforts to establish general design principles.

In this study, we propose a 2-layer machine learning (ML)-based framework to predict and understand the electrochemical behaviour of biomass-derived hard carbon anodes by integrating both material characteristics, process and fabrication parameters. A comprehensive dataset of ~500 data points was curated from over 300 peer-reviewed publications. Structural and chemical features such as surface area (SSA), interlayer spacing (d_{002}), I_D/I_G ratio, L_a, L_c, pore volume, and elemental composition were combined with fabrication parameters including salt concentration, electrolyte type, binder type, and cell configuration.Supervised ML models were trained to predict four critical performance indicators: initial coulombic efficiency (ICE), first-cycle capacity, cyclic stability, and high-rate capacity. Cross-validation and feature importance analyses revealed that while interlayer spacing, structural disorder, and current density remain primary predictors, fabrication parameters like salt concentration and electrolyte ratio also significantly influence ICE and long-term capacity retention.

This integrated approach highlights the interplay between material design and cell assembly conditions along with initial process inputs, offering a more realistic and practical prediction framework for sodium-ion battery performance. The results provide not only predictive tools but also actionable insights for researchers to tune both carbon structure and fabrication conditions for optimal performance.

Niroshan Manoharan

Niroshan Manoharan holds a bachelor's degree in Mechatronics Engineering and a Master's in Sustainable Process Engineering. He brings over eight years of industry experience in research and development, with a strong focus on carbon materials. Currently pursuing a PhD, his research explores the conversion of agricultural process waste into value-added products for energy storage and coating applications. His work combines experimental process development with machine learning-based optimization, with core interests in sustainable carbon materials, energy storage systems, and process innovation.

Volumetrically Efficient Graphene Supercapacitors

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Supercapacitors deliver high power but are limited in compact applications by low volumetric energy and power densities. 2D materials like graphene, despite their high packing density, are hindered by poor ion transport kinetics. A rapid thermal annealing step generates uniquely curved turbostratic graphene crystallites, integrated and interwoven within disordered domains in micron-size particles to yield multiscale graphene (M-rGO). Ion insertion into the interlayers enables precise pore-ion matching and partial charge transfer, enabling a remarkable surface area-normalized capacitance of 85 μF/cm2. Here, we show that M-rGO exhibits exceptional ion dynamics within the curved crystallites and disordered domains, and when the high-density electrodes (1.33 g/cm3) are assembled into scaled pouch cell devices, state-of-the-art volumetric energy density (99.5 Wh/L) in ionic liquid electrolytes and record volumetric performance in organic electrolyte (48.2 Wh/L and a power density of 69.2 kW/L at 9.6 Wh/L) are achieved.

Biography

Dr Petar Jovanović finished his PhD from the Mechanical & Aerospace Engineering at Monash University in 2022, where he worked on applying polymer complexes into separator and binder formulations for advanced lithium-sulfur battery applications. Since then, he joined the Nanoscale Science and Engineering Laboratory (NSEL) in 2023 at Monash University as part of the ARC Research Hub for Advanced Manufacturing with 2D Materials. He is working on bridging the gap between academia and industry to advance the Technology Readiness Level (TRL) for various energy storage technologies.

Comparative Thermal Stability and Oxidative Kinetic Analyses of graphene nanoplatelets and graphite

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This study investigates and compares the thermal degradation behaviour and oxidation kinetics of graphite and graphene nanoplatelets (GNPs) under non-isothermal conditions in an airflow atmosphere. To understand their structural and morphological differences, comprehensive characterization was conducted using X-ray diffraction (XRD), Raman spectroscopy, field emission scanning electron microscopy (FESEM) coupled with energy-dispersive X-ray spectroscopy (EDX), and transmission electron microscopy (TEM). Thermal stability was evaluated using simultaneous thermal analysis (STA) at different heating rates. Although both graphite and GNPs displayed similar onset temperatures for oxidation, GNPs exhibited significantly higher thermal parameters. Model-free kinetic methods revealed that graphite has a higher average activation energy than GNPs. Both materials showed decreasing activation energy throughout the oxidation process, suggesting the presence of multiple, overlapping reaction mechanisms. To elucidate these mechanisms, kinetic deconvolution analysis using the Frazer–Suzuki function was applied, identifying two distinct oxidative steps in each material. For graphite, the reaction steps followed F_1 and R_3 kinetic models, with average activation energies of approximately 188 and 151 kJ mol^{-1}, respectively. In contrast, GNPs followed F_1 and A_3 models for the respective steps, with corresponding activation energies of approximately 185 and 84 kJ mol^{-1}. These findings indicate that while graphite and GNPs share a similar initial oxidation pathway, their mechanisms diverge during later stages. This divergence is strongly influenced by differences in structure, geometry, and dimensionality, which significantly affect the thermal behaviour and oxidation kinetics of graphene-based materials.

Key words

Oxidative Mechanisms, Graphene Nanoplatelets, Graphite, Thermal Degradation, Kinetic Deconvolution Analysis, Non-Isothermal Conditions

From Quantification to Quality: Defining Epoxide Content in Graphene Oxide

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Epoxy groups, also referred to as oxirane rings, in graphene oxide (GO) play a key role in enhancing surface reactivity, facilitating covalent bonding with other molecules, and improving compatibility with polymers and composite materials. Despite the common use of Boehm titration to quantify the functional groups contained in GO, such as carboxyl, hydroxyl, carbonyl, and Lactone, it fails to consider epoxides, a crucial component in many of GO's applications. This research presents an approach utilising a catalyst-assisted acid-based aqueous titration technique for the reliable quantification of epoxy groups in GO, which is applicable in different forms, including powder, paste and dispersions. Although this method aligns with green chemistry principles by minimising the use of hazardous reagents, it also offers an environmentally sustainable approach for epoxy group quantification.

The method demonstrated high precision and reproducibility, with epoxy group concentrations ranging from 1.13 ± 0.020 to 1.38 ± 0.056 mmol/g in commercially available GO materials, where the results were further verified using a well-characterised reference GO sample and a commercial epoxy resin of known epoxide content. Complementary analyses using Fourier Transform Infrared Spectroscopy (FTIR) and X-ray Photoelectron Spectroscopy (XPS) reinforced the credibility and robustness of the proposed titration method. Additionally, the study introduces two novel quality control parameters, Epoxide Index (EI) and Equivalent Epoxide Weight (EEW), which provide a standardised framework for evaluating and comparing the epoxide content in GO materials, enhancing their applicability in quality assurance and material classification.

Keywords: Graphene Oxide, Epoxide, Titration, Functional Groups

Gimhani Danushika

She is currently engaged in the development of novel and simplified methods for the characterization and quality control of graphene-related two-dimensional materials (GR2Ms) under the supervision of Professor Dusan Losic and Dr Pei Lay Yap. Her current research focuses on graphene oxide characterization techniques, emphasizing low-cost, accessible analytical methods to support the sustainable development and application of GR2Ms. She has completed a B.Sc. (Special) degree in Environmental Management from the University of Sri Jayewardenepura, Sri Lanka, and earned a M.Sc. (by Research) in Environmental Engineering in 2020 from the Department of Civil Engineering, University of Moratuwa, Sri Lanka.

High-throughput optical identification method of graphene and related materials

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Large-scale commercialization of graphene and graphene oxide (GO) is hampered by expensive, low-throughput characterization workflows that cannot keep pace with industrial production. We report a cost- effective, high-throughput pipeline that couples quantitative polarized optical microscopy (qPOM) with machine-learning (ML) analysis to deliver rapid, microscale quality control of liquid-phase GO dispersions.

A library of qPOM image triplets—bright-field, retardance and colour maps—was acquired from graphite oxide samples prepared by controlled shear-exfoliation and ultrasonication. Images were hierarchically segmented with a convolutional neural network (CNN) trained to separate GO from background and subsequently discriminate exfoliation states (bulk, partially and fully exfoliated) from retardance- derived thickness information.

Building on this validated framework, we outline ongoing integration of atomic-force-microscopy ground truth and density-functional-theory simulations to develop a multi-modal model that links optical signatures to nanoscale morphology, oxidation chemistry and defect density. The ultimate goal is a unified predictor of electrical and thermal performance directly from cost-effective characterization data, enabling in-line monitoring without recourse to SEM, AFM or STEM.

Our preliminary results confirm that qPOM-ML can replace labour-intensive electron or scanning-probe techniques for first-pass screening, cutting per-sample analysis time from hours to seconds and reducing characterization costs by an order of magnitude. The approach provides a scalable route to consistent graphene-based products and offers a transferable template for other two-dimensional materials

Keywords: graphene, graphene oxide, high-throughput characterization, quantitative polarized optical microscopy, machine learning, convolutional neural networks, in-line quality control, multi-modal modelling, nanoscale morphology, two-dimensional material.

The development of practical Graphene Oxide-based membranes in molecular separation

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Membrane-based separation technologies offer significant advantages over conventional methods such as distillation and adsorption, particularly in terms of energy efficiency, cost-effectiveness, and modular scalability. Among emerging membrane materials, atomically thin two-dimensional (2D) materials such as graphene oxide (GO) have shown strong potential to address contemporary challenges in separations, including desalination and emerging organic contaminant removal. GO membranes, with their tuneable interlayer structure and surface chemistry, are promising candidates to overcome the long-standing permeance–selectivity trade-off. However, practical deployment demands more than high intrinsic performance: membranes must also exhibit tuneable selectivity, resistance to chlorine, pH, and solvents, low fouling propensity, long-term stability, and scalable manufacturability.

In recent years, our research group has made substantial progress toward translating the potential of GO membranes into real-world applications. A key element of this development has been the evolution of our design philosophy: we have shifted focus beyond simple steric exclusion and towards the creation of chemically engineered nanochannel environments. These environments can selectively enhance or hinder transport based on tailored interactions, enabling more sophisticated separations. This approach opens a pathway to GO membranes designed not only for performance, but also for precision.

Advancing Hospital Wastewater Treatment via Continuous Adsorption in a Coiled Flow Inverter Reactor

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Hospitals consume large amounts of water, producing wastewater rich in complex organic pollutants like pharmaceuticals and personal care products (PPCPs). These persistent compounds threaten aquatic ecosystems and public health, causing toxicity, fostering antibiotic-resistant bacteria, and contributing to cancer risks, developmental issues in children, immune system disruptions, and reproductive abnormalities in both humans and wildlife.

To improve the efficiency and cost-effectiveness of hospital wastewater (HWW) treatment, this study explores the application of Coiled Flow Inverter (CFI) for HWW treatment using Graphene Oxide (GO) for the adsorptive removal of triamterene (a model PPCP pollutant) from water. Effects of various parameters including flowrates (10 mg/mL and 135 mg/mL), initial pollutant concentration (1-250 ppm), adsorbent dosage (0.2-2 mg/mL) and pH (2-10) were systematically investigated. The results revealed a maximum adsorption capacity of 822 ± 0.07 mg/g, with approximately 99% removal efficiency achieved across all pH regions. The impact of flow rate on removal efficiency was negligible, and the process was ultra-fast, requiring only 40 seconds compared to the conventional batch process, which takes 5 hours to achieve a similar removal efficiency of ~80%. Finally, adsorptive removal of triamterene in real hospital wastewater samples was tested, achieving a removal efficiency of > 90 % in 1 minute. Adsorption, when combined with novel adsorbents and compact systems, improves PPCP removal by enhancing mixing, reducing adsorption time, space, and cost compared to conventional batch/coulmn adsoprtion.

Key outcomes of this study demonstrated significant reduction of treatment time (x450 times faster), minimal space requirement, and improved mixing efficiency compared to conventional batch adsorption approach, paving way for a new sustainable hospital wastewater treatment in a miniaturized reactor.

Key Words:

Hospital wastewater treatment, Adsorption, Coiled Flow Inverter, PPCPs, Sustainability, Graphene Oxide

Ammara Waheed

Ammara Waheed is a research student at University of Adelaide, specializing in wastewater treatment. Her work focuses on removing pharmaceuticals and personal care products (PPCPs) using continuous adsorption and ozonation based techniques in Coiled Flow Inverter (CFI) reactors. Previously, she lectured at Chemical Engineering Department of University of Wah in Pakistan. She has expertise in the synthesis of advanced materials for environmental remediation, including inverse vulcanized copolymers, graphene-based photocatalysts, and biosorption techniques for heavy metal and pollutant removal from wastewater. Her research aims to develop scalable, cost-effective water purification technologies, shaping the future of environmentally sustainable chemical engineering and innovative wastewater treatment solutions.

Addressing Existing Industry Bottlenecks in Water Purification Technology

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The use of graphene in water purification has attracted substantial attention owing to its remarkable properties. Despite its promising potential, limitations including high production cost, challenges in separating graphene from water after purification process and potential environmental concerns due to the migration of graphene in water must be overcome to make it more practically deployable in real-world applications.

To address these limitations, we introduced for the first time a practical 'adsorption-photodegradation hybrid system' developed in collaboration with CGT, where only a minimal amount of active materials- TiO_2 and graphene oxide (GO)- is coated onto sand particles through a unique surface linker to effectively mitigate challenges posed by emerging water pollutants. This approach not only overcomes the major bottlenecks of existing graphene-based adsorbents including poor stability in water, weak interaction between graphene and sand surface, non-uniform distribution of graphene on sand particles, but also the high cost and poor pollutants removal performance.

Results show that TiO_2-GO hybrid sand exhibited promising removal performance for broad class of pollutants including dyes and PPCPs, where rhodamine B (RhB) and triamterene (TA), are used as the modelled water pollutants. TiO_2-GO hybrid sand not only demonstrated remarkable removal efficiency for both tested pollutants, but also outstanding regeneration efficiency with 100% removal of TA for the 1st 10 cycles and up to 99.4% removal of RhB at the 20th cycle in the regeneration study. The developed TiO_2-GO hybrid sand is highly robust over 20 repeated cycles with resistance towards chemicals, photochemical exposure and thermal/mechanical stresses without detectable GO and TiO_2 leaching from the coated sand. Currently, the advancement of this sustainable water purification technology is rated at TRL 4-5, where it is set to undergo pilot-scale production, with plans for licensing, scaling, and eventual market deployment (TRL 6), marking a significant milestone to address emerging water pollutants.

Dr Pei Lay Yap

Dr Pei Lay Yap is a Project Lead funded by the ARC Research Hub for Advanced Manufacturing with 2D Materials at the School of Chemical Engineering, The University of Adelaide, Australia, where she specialises in water purification and carbon capture using graphene-related 2D materials. With a research career spanning over 7 years, Dr. Yap has gained > 2000 citations and published more than 45 peer-reviewed articles and an encyclopaedia chapter in the functional materials, environmental Chemistry and materials metrology disciplines. She received her PhD from the University of Adelaide, and has been honoured with numerous awards, including the recent prestigious 2024 Measurement Achievement Encouragement Award by National Measurement Institute (NMI), Australia, 2023 Catalyst Award and 2021 Cornforth Medal Award by Royal Australian Chemical Institute. Her passion is also devoted on the characterization, quality control and standardisation of graphene materials where she leverages her passion and knowledge on graphene metrology to advance the development of graphene adsorbents for emerging environmental remediation technologies.

Manipulating Intrapore Energy Barriers in Graphene Oxide Nanochannels for Targeted Removal of Short-Chain PFAS

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Removal of per- and poly-fluoroalkyl substances (PFAS) from water has become a research topic of interest in recent times. However, it is very challenging to remove short chain ($< C_8$) PFAS from water sources using traditional means, especially in mixtures. Herein, a beta-cyclodextrin (βCD) modified graphene oxide (GO-βCD) membrane is designed with asymmetrically sized nanochannels that exhibit strong affinitive binding interactions with PFAS. PFAS transport is significantly hindered within the GO-βCD lamella due to interactions with the strategically embedded βCD sites and complementary molecular dynamics simulations reveal that short chain PFAS exhibit ~20 % stronger binding affinity to βCD compared to that of alternative structures of cyclodextrins. The GO-βCD membrane demonstrates remarkable simultaneous retention of over 90% from a mixture of PFBA, PFPeA, PFHxA, and PFOA while achieving a permeance of 21.7 ± 2 L m^{-2} h^{-1} bar^{-1} and up-concentrating the feed by ~300%. The performance of GO-βCD was compared to that of polyamide membranes which exhibit a significant decline in capacity to retain short-chain PFAS (~35 % for PFBA). In combining permeation experiments and molecular dynamics simulations with the transition state theory model, it was demonstrated that the energy barrier for transport of PFAS is greater within the GO-βCD laminar architecture compared to that of GO-αCD and pristine GO. These modified membranes have strategically embedded sites capable of hindering PFAS transport and provides an approach for removing broad spectrum PFAS under realistic conditions, over long-term operation (24h), and at concentrations relevant to drinking and recreational waters.

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Eubert Mahofa

Eubert's background is in Chemical and Process Systems Engineering and he is currently a PhD candidate in Mechanical and Aerospace Engineering at Monash University. His research focuses on the design and development of advanced membranes for the removal of emerging contaminants from water, including per- and polyfluoroalkyl substances (PFAS). His interests span, PFAS remediation from water, membrane design and engineering, and sustainable water treatment.

Antibacterial Nanobiocomposites Based on Gallium and Glucose

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Liquid metals (LMs) are a class of soft, low-melting-point materials with excellent biocompatibility, making them promising candidates for biomedical applications. Gallium, in particular, stands out due to its favorable biological properties and potential use in cancer therapy, tissue engineering, and drug delivery [1,2,3].

While many LM-based studies have explored composites with synthetic polymers, less attention has been given to their interaction with natural biomolecules. In this work, glucose—a biocompatible and biologically relevant molecule—was used to stabilize and coat gallium liquid metal nanoparticles (GaNPs). Glucose–Ga nanocomposites were synthesized by sonicating gallium in aqueous glucose solutions at concentrations of 2, 5, and 8 wt%.

FTIR analysis confirmed hydrogen bonding between glucose and the oxidized surface of GaNPs. When introduced into biological environments, unbonded glucose dissolves, leaving behind GaNPs coated with a thin glucose layer, forming a two-dimensional biocompatible interface.
Antibacterial assays against Escherichia coli revealed strong inhibition with 8 wt% glucose–Ga, while cytocompatibility tests using MEF cells demonstrated significantly higher viability compared to uncoated GaNPs. These results highlight glucose's dual role as a stabilizer and biocompatibility enhancer.

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Masoomeh Asghar Nejad Laskoukalayeh

I'm currently a PhD student in Chemical Engineering. During my master's degree, my research focused on tissue engineering, where I developed a strong foundation in biomaterial and cell-material interactions. For my PhD, I've been working on liquid metals and exploring their potential applications in biomedical fields. My main research interests include biopolymers, biocomposites, and drug delivery systems, especially where material design can offer functional improvements in biological environments.

Performance analysis of graphene derivatives incorporated anti-corrosion coatings

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Graphene and its derivatives have gained significant attention in additive development in protective coatings due to their exceptional properties such as high surface area, superior gas and ionic barrier effect, chemical inertness, and mechanical strength.[1] Once graphene incorporated into polymeric matrices it demonstrates a significant enhancement in corrosion resistance by hindering the penetration of water, oxygen, and other corrosive ions through the coating. However, to realize the real benefits, challenges related to the applicability of graphene materials must be overcome as the challenges to encounter includes galvanic coupling between the graphene and the underlying metal substrate, agglomeration in the polymer matrix, dynamic changes in graphene oxide properties, interaction with polymer matrix etc. [2]

To address these cumbersome, in our study, we explore the corrosion protection mechanisms of graphene and graphene oxide (GO) incorporated coatings via conventional and advanced characterization techniques. Salt spray testing considers as one of the widely used method in industry, which often lacks the sensitivity to detect early-stage corrosion processes. On the other hand, sensitive measurements such as electrochemical techniques includes electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization (Tafel analysis) provides the corrosion mechanism even at molecular level. By corelating these techniques, one another, it provides a better understanding of corrosion process and may leads detect corrosion early as possible. Also, this provides a better understanding of importance of material selection, surface functionalization, proper dispersion methods and suitable dispersing agent in coating formulation and thus to mitigate potential drawback in graphene enhanced coatings.

By knowing the mechanism of corrosion at different conditions it opens a pathways to provide quick, accurate and reliable technique to assess the early-stage corrosion which may be beneficial for the industries and thus provide a bridge between laboratory experiment to real world application.

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Kosala Purasinhala

Kosala Purasinhala is PhD student at the University of Adelaide with a strong background in electrochemistry. He completed his Masters in analytical chemistry at University of Colombo, Sri Lanka. Having a keen interest in materials science, Kosala is currently exploring corrosion protection remedies, specifically on incorporation of nanomaterials such as graphene derivatives into polymer coatings. This project opens a path to combine both conventional and electrochemical testing methods to understand corrosion mechanisms which can provide early detection of corrosion. Through this research his aim is to bridge industrial needs with cutting-edge scientific knowledge to provide rapid and accurate results.

Developing Layered Nanomaterials for Printable Devices

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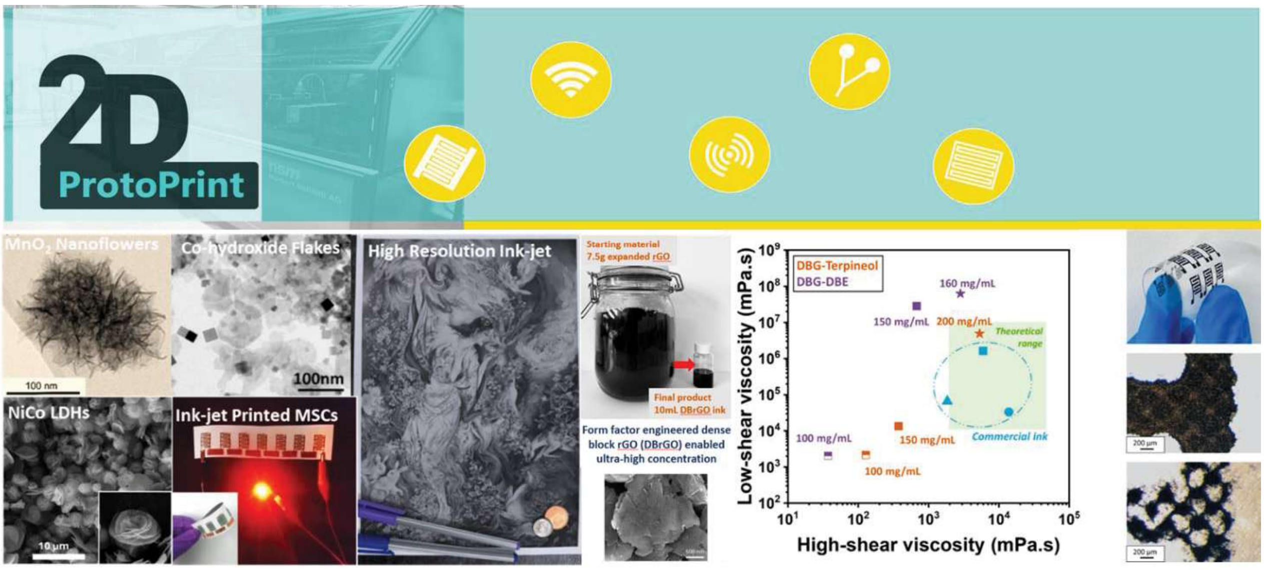
The development of functional materials for printable devices is critical, especially with the growing demands of IoT technologies and digital connectivity. Layered nanomaterials, offering a broad range of tunable physical properties and excellent solution processability, are strong candidates for next-generation printed electronics. However, optimizing their microstructure and rheological behavior to ensure high device performance remains a key challenge. In this presentation, we will explore various forms of layered metal oxides/hydroxides and graphene-based nanostructures that show great potential in this space. We will discuss processing strategies, their influence on rheology, and how these factors are tuned to meet the requirements of high-resolution, high-throughput printing techniques, including inkjet, screen, and flexographic printing. These scalable methods are vital for achieving precise patterning in printed devices.

Introducing the activities of our research initiative, ***2DProtoPrint*** at Monash University, this talk will highlight critical aspects of material design, ink formulation, and process optimization. We will demonstrate how these integrated elements drive the performance and reliability of printed devices for health and energy applications.



Rheological property enhancement of styrenic block copolymers reinforced with 2D nanomaterials for additive manufacturing.

Vihanga Kularatne, Naba Kumar Dutta, Nevena Todorova, Namita Roy Choudhury
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Two-dimensional (2D) nanomaterials such as graphene and its derivatives have attracted significant interest in additive manufacturing due to their exceptional mechanical, thermal, and interfacial properties. Development of strong and tough polymeric materials with high ductility is widely desirable for their industrial applications. However, the current challenge is to integrate high strength and high toughness in polymers without compromising the ductility of the matrix polymers. Extrusion additive manufacturing techniques for soft materials have garnered significant interest, however critical challenges remain due to difficulty in printing soft materials. Therefore, in this study with an aim to address this challenge, we investigate the processability, rheological behaviour and reinforcement mechanisms of thermoplastic elastomer styrene-butadiene-styrene (SBS) nanocomposites filled with graphene nanoplatelets (GNPs), graphene oxide (GO), and reduced graphene oxide (rGO). Due to the unique nature of thermoplastic elastomers, they offer the advantage of being reprocessable and sustainable alternative to conventional thermoset rubbers, which are non-recyclable due to their permanent crosslinked structure. By combining 2D materials, these materials can be engineered to mimic the performance of thermoset rubbers while retaining recyclability. Molecular dynamics (MD) simulations were employed to explore the interfacial interactions and thermodynamic compatibility between the 2D fillers and SBS elastomer at the atomic level. The results revealed strong interactions between poly(butadiene) segments and pristine graphene, promoting pseudo-crystalline ordering. Interestingly, GO showed the highest affinity with poly(styrene) blocks, correlating with enhanced mechanical properties. The melt mixed nanocomposites were characterised using tensile testing, scanning electron microscopy (SEM), atomic force microscopy (AFM), thermogravimetric analysis (TGA), and differential scanning calorimetry (DSC). Among the nanocomposites, GO-reinforced SBS exhibited the most significant improvements in tensile strength, modulus, and elastic recovery. The SEM imaging confirmed the uniform dispersion of GO, while AFM analysis and simulation data showed aggregated SBS chains around GO particles, altering the SBS morphology. Rheological analysis revealed shear-thinning behaviour in all the nanocomposites, with GO-filled composites indicating the highest. This behaviour is critical for the 3D printability of thermoplastics. Despite the lower mechanical improvements observed in rGO composites, they offered lower viscosity at low loadings. This study bridges the gap in understanding nanoscale interfacial interactions between 2D graphene nanomaterials and styrenic block copolymer (SBCs) and their macroscale processability for printing. This offers key insights for developing reprocessable, high-performance elastomer nanocomposites for additive manufacturing.

Vihanga Kularatne

Vihanga Kularatne is a PhD candidate in the Department of Chemical and Environmental Engineering at RMIT University. His research focuses on the development of 2D nanomaterial-based elastomer nanocomposites for 3D printing applications. By combining computational and experimental approaches, he employs molecular dynamics simulations to investigate atomic-scale interactions between 2D materials and thermoplastic elastomers, alongside experimental melt-mixing techniques to fabricate and characterize composites. This integrated approach provides fundamental insights into structure–property relationships while assessing the potential of these materials to replace conventional thermoset elastomers.

A Green Approach to Functionalizing Graphene for Enhanced Dispersibility and Electrical Conductivity

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Graphene's high intrinsic surface energy (~4.7 mJ/m²) results in poor compatibility with most solvents and polymer matrices, leading to weak interfacial interactions and agglomeration rather than uniform dispersion.[1] This severely restricts its integration into functional materials and high-performance composites. Surface functionalization, including oxidation and heteroatom doping, is commonly used to tailor graphene's surface energy and improve dispersibility.[2] However, oxidative treatments often degrade electrical conductivity. In contrast, nitrogen doping introduces polar functional groups that enhance solvent compatibility while improving electronic properties.

Solvent-free mechanochemistry offers a green and scalable strategy for functionalizing graphene, yet most reported methods still require toxic reagents or controlled atmospheres. In this work, we present a sustainable mechanochemical approach to synthesize nitrogen-doped graphene nanoplatelets (N-GNPs) using graphite and glycine; a non-toxic amino acid as the nitrogen precursor. The resulting N-GNPs exhibit a significant enhancement in electrical conductivity and increased surface polarity by resulting in excellent dispersibility. These dual-functional N-GNPs, combining high electrical conductivity with enhanced dispersibility, are well-suited for applications in energy storage, conductive coatings, and polymer nanocomposites. This work demonstrates a green, efficient, and scalable strategy for producing multifunctional graphene materials tailored for next-generation technologies.

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Chamalki Madhusha

Chamalki Madhusha graduated with a Bachelor of Science in Chemistry (2019) and a Master of Philosophy in Chemistry (2022) from the University of Sri Jayewardenepura, Sri Lanka. At the same time, she worked as a graduate research assistant at the University of Sri Jayewardenepura. Chamalki's research interests are nanomaterial synthesis and characterization, food chemistry, drinking water purification, and materials chemistry. She joined NSEL in February of 2023, focusing on functionalization of graphene through green methods and making advanced composites based on functionalized graphene.

Poster Abstracts

Self-Assembled Ultrathin Fatty Acid Coatings for Zinc Anode Protection in Aqueous Zn–MnO_2 Batteries

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Due to the high theoretical capacity of metallic zinc (Zn) anodes and the inherent safety of aqueous electrolytes, aqueous zinc-ion batteries (AZIBs) have emerged as promising alternatives to lithium-ion batteries, offering advantages in terms of cost-effectiveness, safety, and competitive energy density.[1] Recently, AZIB research has attracted significant attention, however, current AZIB technologies still fall short of meeting practical requirements. A primary challenge is the limited Coulombic efficiency (CE) and poor cycling stability of the zinc anode, primarily caused by problematic dendrite formation and side reactions, including corrosion and hydrogen evolution within aqueous electrolytes.[2] To address these critical issues, this study introduces a simple, cost-effective, and environmentally friendly method using naturally extracted saturated fatty acids to construct an artificial protective layer via self-assembly directly on Zn surfaces. The negatively charged carboxyl groups in saturated fatty acid spontaneously bind to Zn, enabling the formation of a stable, metal–organic protective layer. Meanwhile, the hydrophobic alkyl chains in this self-assembled layer effectively repel water, reducing corrosion and hydrogen evolution at the Zn electrolyte interface. This artificial interface significantly improves Zn-ion distribution, prevents dendrite growth, and enhances the overall stability and cycling performance of Zn anodes. The proposed self-assembly approach offers a practical pathway toward safe, durable, and sustainable AZIBs suitable for large-scale energy storage applications.

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Devarani Theenathayalan

Devarani holds a bachelor's degree in chemistry from Lady Doak College (2018) and a master's degree in chemistry from Loyola College (2021), both in India. Prior to joining NSEL in February 2024, she worked as a project associate at the battery research lab of Hindustan Petroleum Green R&D Centre, where she focused on developing high-voltage vanadium-based cathodes for sodium-ion batteries. Currently, her research at centers on improving the performance and stability of aqueous zinc–manganese dioxide (Zn–MnO_2) batteries. Her broader research interests include electrode surface engineering, electrolyte optimization, and sustainable materials for next-generation energy storage systems.

Solvation-Modulated Dispersions of Dense-block Graphene towards Binder-Free Conductive Inks

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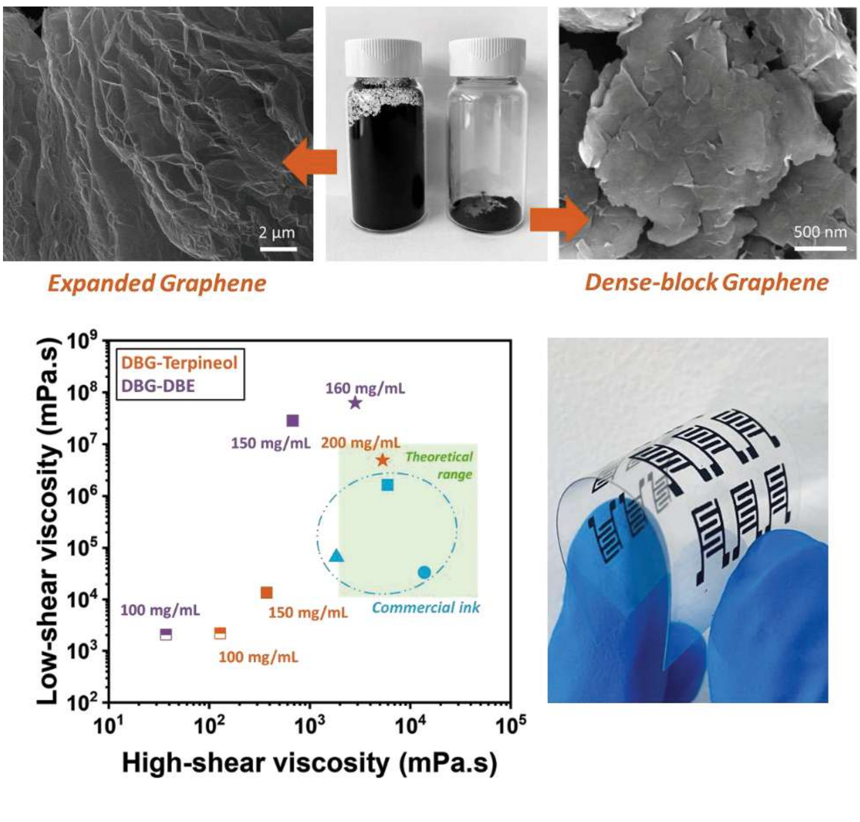
Conductive inks based on bulk graphene materials are essential for translating graphene's potential into real-world applications. High-concentration inks are particularly valuable, enabling fewer deposition steps, reduced drying costs, and improved film uniformity. However, increasing graphene concentration typically leads to a steep rise in viscosity, limiting compatibility with most printing techniques. In this work, we address this challenge by compacting expanded graphene into dense-block graphene, termed DBG, allowing the formulation of stable dispersions at concentrations up to 200 $mg\cdot mL^{-1}$, while maintaining manageable flowability and deformation resistance. We demonstrate that solvation of DBG particles serves as a fundamental strategy to modulate ink viscosity, enabling property tuning at high solids content. The degree of solvation, quantified using polarised light microscopy, correlates well with viscosity predictions based on the Krieger–Dougherty model. Using nitrogen-doped expanded graphene as the starting material, this approach enables single-pass printed films and patterns with conductivities ranging from 5 to 10 $\Omega\cdot\square^{-1}$. Our findings establish general design rules for formulating concentrated, conductive graphene inks with little to no additive, adaptable across various deposition techniques for producing high-resolution, high-fidelity features.



Enhancement of Electrochromic Properties through the Integration of 2D WO3 for Smart Window Applications

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Towards development of highly efficient electrochromic coatings, morphology and size of nanostructures of electrochromic material and their charge insertion capacities play a significant role [1,2]. Herein, we report a study exploring the structure dependent electrochromic coatings based on the use of 2D tungsten trioxide (WO_3) nanostructures. 2D monoclinic WO_3 nanostructure was prepared by a facile and nonhazardous synthesis and used as working electrodes to fabricate electrochromic devices for smart windows applications. Simple, scalable and spray coating was applied on Fluorine-doped Tin Oxide (FTO) substrate to make ~70% transparent working electrodes. The prepared electrochromic cells of WO_3 structures with targeting ~70% transparency was examined to investigate charge insertion capacities, electrochromic active surface area, and coloration efficiency. Results showed that the 2D WO_3 nanoflakes displayed the highest diffusion coefficient for the intercalation of 1.52×10^{-10} cm^2/s with increased electrochromic active surface area of 25.10 mF/cm^2. Furthermore, the 2D WO_3 nanoflakes indicate a large modulation of optical reflectance (42.63%) with 3.79s shorter response time for bleaching. A greater coloration efficiency (CE) value (89.29 cm^2/C) for 2D WO_3 at 700 nm was achieved. The outcome of this study provides a new insight into designing an efficient electrochromic coating by controlling and optimizing the nanostructures of selective electrochromic materials.

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Mahnaz Dadkhah

Mahnaz Dadkhah Jazi is a researcher with expertise in nanomaterials and electrochromic technologies, particularly in the development of materials for smart window applications. She currently is a PhD candidate at the University of Adelaide, School of chemical engineering, focusing on the research of next-generation electrochromic materials and their characterization using techniques such as UV-Vis, SEM, and XRD. Her research also extends to environmental pollutant degradation, contributing significantly to sustainable technology advancements. She has published extensively in high-impact journals, making notable contributions to the fields of nanotechnology, material science, and energy solutions.

Influence of metal iodide salts – polymer complexes as soft catalysts on electrochemical performance of lithium–sulfur batteries.

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Lithium–sulfur batteries (LSBs) are a promising next-generation energy storage system, due to their high theoretical energy density and the rise in global battery demand. Unfortunately, their practical application is hindered by the slow kinetics of sulfur conversions and the shuttle effect of lithium polysulfides. In this research, we investigate the electrochemical impact of various metal iodide salts (LiI, ZnI_2, AlI_3, and BiI_3) complexed with functional polymers, including polyvinylpyrrolidone, carboxymethyl cellulose, and TEMPO-oxidized cellulose nanofibril, when incorporated into sulfur cathode as soft electrocatalysts. Through a combination of physicochemical characterization (UV-Vis, Raman) and electrochemical evaluation (cyclic voltammetry, EIS, and galvanostatic cycling and rate capability), we assess the catalytic activities of these novel catalysis systems on sulfur conversions within LSBs. This study offers a new pathway for designing an advanced catalyst system to expedite the performance of LSBs.

Engineering of Arsenic Removal from Natural Water Using a Coiled Flow Inverter

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Wastewater treatment is a global challenge which requires integration of process optimization, intensification, and automation to reduce cost and improve scalability. For this purpose, developing cost effective compact and sustainable water treatment system tailored for diverse water quality conditions is crucial. Coiled Flow Inverter (CFI) has emerged recently as an ideal candidate for multiphase mixing owing to its enhanced mass transfer rates due to equidistant 90^{o} bends, which addressed the poor mixing, excessive space requirement and prolonged pollutant treatment time in the conventional water pollutants adsorption method.
Arsenic is considered one of the most toxic water pollutants that can result in severe health issues, including skin lesions, developmental disorder, cardiovascular disease, kidney failure and lung cancer. This work leverages the enhanced radial mixing,cost-effectiveness and compact engineering of CFI to advance the adsorption of arsenic from natural water.
A comprehensive evaluation on the effects of various parameters including flowrates (10mL/min, 135 mL/min), initial pollutant concentration (1-200 ppm), adsorbent dosage (0.2- 2 mg/mL) and pH (2-10) were performed. Findings showed that a remarkable 98% adsorption efficiency for As(V) was achieved within a short residence time of 38 seconds at a flow rate of 135 mL/min, initial concentration of As(V) at 10 mg/L and adsorbent dosage of 1.5 mg/mL. To demonstrate its practical application, studies performed on selectivity in the presence of co-ions (Phosphate, Sulphate, Chloride and Carbonate), adsorbent regeneration and effect of water matrix (Torrens River water) confirmed that CFI reactor has good selectivity for As(V), can operate well in repeated cycles after adsorbent regeneration and removes 99%, As(V) from Torrens River water. Benchmarking experiments in Batch and CFI reactor verified that outstanding removal efficiency (98 %) can be attained in 38 seconds at 135 mL/min flow rate in CFI reactor compared to 24 hrs in batch reactor, demonstrating the efficacy of the miniaturized compact device.

KEY WORDS
Coiled flow inverter, Arsenic, Waste-water tretament, Process intensification

Rabia Sabir

Rabia Sabir is a chemical engineer from Pakistan with 8 years of experience in academia as Lecturer, currently pursuing a PhD in Chemical Engineering at the University of Adelaide, Australia. With a strong foundation in chemical engineering, she is focused on developing innovative solutions to address the global challenges of water contamination. Her current research explores advanced methods for efficient water treatment, particularly in the removal of emerging contaminants. Combining engineering expertise with a passion for sustainable environmental solutions, Rabia aims to contribute significantly to the development of more effective and accessible water treatment technologies.

Tailoring Iron Oxide Nanoparticles from Biowaste via Physical, Chemical, and Thermal Methods

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Iron oxide nanoparticles (IONPs) are widely used across various fields due to their magnetic properties, chemical stability, biocompatibility, and ease of surface modification. However, their current production methods based on wet chemistry are very complex, high-cost, and involve hazardous materials. Previous studies showed that IONPs can be produced by very simple and low-cost process using biowaste materials from bacterial biofilms created in the water pipes of SA Water's bore system at River Murray. The utilization of this regularly accumulating biowaste as a sustainable source to produce IONPs presents a promising approach, with added environmental and economic benefits. This study explores the impact of various treatment processes—physical (ball milling, sonication), chemical (reaction with strong acid), thermal (heat treatment at varying temperatures and durations), and the combination thereof— to control the morphology, particle size, crystallinity, and magnetic properties of the final product. Physical methods change the structure of the IONPs from wire-like structure to anisotropic form. In addition, they facilitate particle size reduction, dispersion, and increase in surface area. Chemical treatment purifies the IONPs and increases the roughness of the surface. Heat treatment induces the phase conversion of the amorphous raw biowaste, consisting mainly of hematite, into the strongly magnetic magnetite phase, with increasing magnetization as treatment temperature increases. This work demonstrates techniques capable of tailoring the structural and magnetic properties of iron oxide nanoparticles, making them suitable for a range of applications in biomedicine, environmental remediation, coatings, protective coatings, and related areas.

Keywords: iron oxide nanoparticles, magnetic materials, phase transformation

Jimyl Cruz

She earned both her Bachelor of Science and Master of Science degrees in Chemical Engineering from the University of the Philippines. Currently, she is engaged in research focused on the production, functionalization, and applications of magnetic iron oxide nanoparticles derived from biowaste sources.

Her research interests include material synthesis for nanoparticle-based drug delivery systems, magnetic hyperthermia for cancer treatment, theranostics, and multimodal imaging agents.

Anomalous Ion Transport in 2D Graphene Oxide Membranes enabled by confined Amino Acid Interactions

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Membranes that can selectively discriminate between ions are highly desired for a circular economy and clean energy future. These separations require nanochannels with simultaneous angstrom-scale confinement and ion-selective binding sites. In biological membranes, amino acid residues act as ion-specific binding sites hindering and facilitating the transport of ions into through the cell membrane. Inspired by biological ion channels where ion transport is controlled through a combination of steric effects and affinitive binding sites, we design two-dimensional (2D) ion transport channels based on a graphene oxide (GO) membrane, where ultraviolet (UVC) irradiation enables control over the physical confinement of the transport channels while aspartic acid, an amino acid, interacts with and hinders transport of select ions. Thus, we are able to demonstrate tunable control over the monovalent/divalent ranging from Na^{+}/Ca^{2+} selectivity of ~9.8, to a Ca^{2+}/Na^{+} selectivity of ~4.8. Supported by density functional theory and the transition state theory-based experiments, we reveal that calcium's stronger binding energy with aspartic acid compared to sodium, of ~7.3 kcal/mol for Na^{+} and ~5.4 kcal/mol for Ca^{2+}, plays a crucial role in tuning in selectivity between mono- and di-valent ions. Our findings offer a theoretical basis for controlling ion transport in sub-nanochannels and provide a design strategy for developing membranes with ion-specific binding sites.

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Muhammed Afnas Vilayatteri

I am a PhD student in the NSEL group, which I joined in February 2023. I hold a Masters in Materials Sci and Tech from the National Institute of Technology, Calicut, India. Prior to my PhD, I worked as an Assistant Professor for. My research focuses on developing graphene oxide-based membranes for targeted applications in selective ion separation and water purification, particularly using nanofiltration (NF) and reverse osmosis (RO) technologies. I am broadly interested in membrane science, 2D materials for separation processes, and sustainable approaches such as converting waste into value-added products aligned with the zero-waste concept

2D Nanomaterials for Enhancing the 3D Printability of Thermoplastic Elastomers

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Additive manufacturing offers a new pathway for the sustainable future by minimizing waste and promoting efficient resource utilization. Thermoplastic elastomers (TPEs), with their combination of elasticity and thermoplastic processability, are increasingly considered as alternatives to highly crosslinked thermoset elastomers, which are typically unrecyclable and contribute to landfill accumulation. While TPEs retain many of the advantageous characteristics of thermoset rubbers, their adoption in 3D printing is constrained by challenges such as complex rheological behaviour, limited mechanical strength, and insufficient interlayer adhesion. The incorporation of two-dimensional (2D) nanomaterials such graphene provides promising opportunities to address these limitations through enhanced filler–matrix interactions, rheological tuning, and structural reinforcement. This will open new avenues for developing high-performance, sustainable, and industrially relevant elastomeric materials for additive manufacturing. This study underscores the potential of 2D materials to significantly enhance the 3D printability of TPEs.

Justin Jose Kappen

Justin Jose Kappen is a doctoral researcher in the Department of Chemical and Environmental Engineering at RMIT University, Melbourne, Victoria. His research focuses on the development of 3D printable elastomeric materials, integrating advanced concepts in materials science and additive manufacturing. Justin holds a master's degree in polymer chemistry from Mahatma Gandhi University, Kerala, India, and is passionate about exploring innovative solutions for emerging engineering challenges through interdisciplinary research.

Low-temperature graphitization by amine-assisted combustion of graphite oxide

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The scalable production of bulk graphene-based materials through the deoxygenation and partial graphitization of graphite oxide (GO) remains one of the most practical and industrially viable routes for manufacturing graphene-enhanced products. In this work, we introduce an alternative solid-state combustion strategy, wherein GO acts as both oxidant and carbon source, while amino acids serve as high-energy fuels and reductants. Through controlled thermal processing at relatively moderate temperatures (~900 °C), this method yields combusted reduced graphene oxide (C-rGO) powders enriched with long-range ordered graphene crystallites exceeding 80 nm in length. The resulting material displays strong graphitic (002) XRD reflections, well-defined selected area electron diffraction (SAED) patterns, a high carbon-to-oxygen ratio (>18), and significant nitrogen incorporation (2.93 at.%). Moreover, the C-rGO powders can be readily dispersed to form printable inks, which are compatible with flexible plastic substrates such as PET. By employing roll compression, these inks can be transformed into highly conductive thin films. The practical utility of this approach was further validated through the fabrication of prototype chipless RFID tags operating at a resonant microwave frequency of 3.986 GHz, achieving wireless readout distances of up to 28 mm.

Keywords: reduced graphite oxide, combustion, amino acids, binder-free conductive ink, RFID wireless communication.

Graphite Flows in Australia: From Mine to Market

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Abstract

Graphite is a critical raw material in clean energy technologies, primarily as the dominant anode material in lithium-ion batteries. While geologically possessed of vast reserves, Australia is essentially entirely dependent upon imports of synthetic and natural graphite, primarily from China, to meet local requirements. This study follows graphite flows in Australia (2020–2024), integrating production, trade, reserves, and forecast demand, and benchmarking these trends with global market conditions.

Analysis of past data reveals strong price volatility related to oversupply cycles, geopolitical shocks, and accelerating electric vehicle (EV) expansion. Global demand in 2024 is estimated at ~4.8 Mt where batteries are already absorbing more than 40% of demand and likely to be the most dominant by 2050. Despite China having cost leadership through subsidies and economies of scale, Australian projects have comparatively higher production costs, stricter environmental regulations, and infrastructure constraints, with no current production output despite ~25 Mt of contained graphite resources.

Three main points are presented in the analysis:

1. Exposures of the supply chain – Australia's reliance on imports exposes major sectors to market and geopolitical risk.

2. Opportunities for value addition – HF-free purification investment, spherical graphite production, and recycling can make Australia switch from importer to exporter.

3. Policy and R&D imperative – Government incentives, streamlined approvals, and collaborative R&D (CSIRO, industry, academia) are required to overcome cost differences with China and create ESG-conformant, low-carbon supply chains.

This study provides the first end-to-end mapping of Australian graphite flows and outlines pathways for utilizing national stocks to promote global supply chain resilience. The evidence guides government, industry, and research stakeholders on how Australia can transition from being a net importer to a strategic exporter of battery-grade graphite.