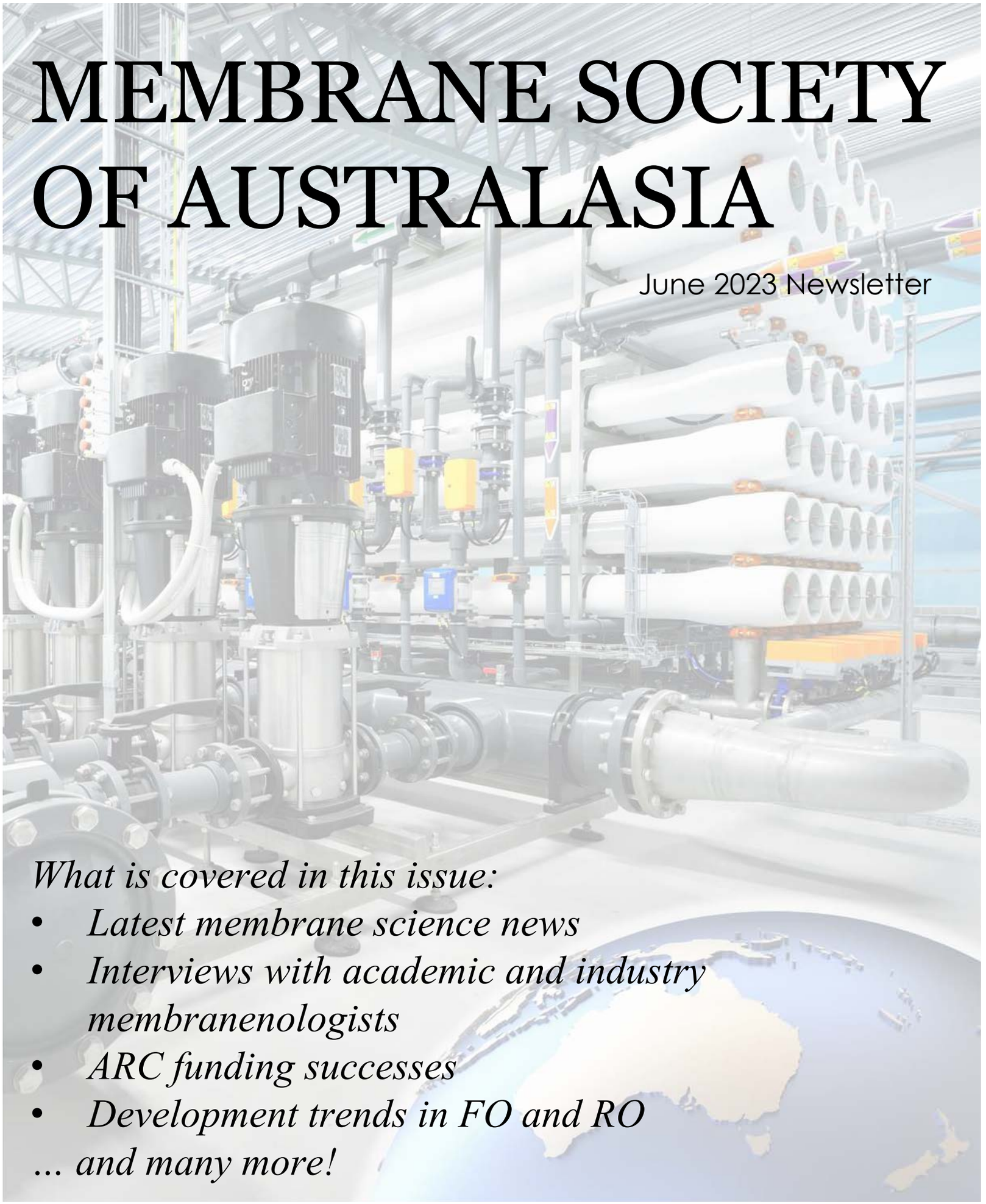
MEMBRANE SOCIETY OF AUSTRALASIA

June 2023 Newsletter



What is covered in this issue:

- *Latest membrane science news*
- *Interviews with academic and industry membranenologists*
- *ARC funding successes*
- *Development trends in FO and RO*

... and many more!

Building a membrane community in Australasia.

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MSA-ISPT 2023

Key Themes

All technical areas of membrane science and separation under three major focus areas:

Circular Design & Engineering Membranes

Sustainable; Circular Economy; Industry Needs

Crossing the Gap with the New Normal

Integration of separation technologies for environmental, energy and more

Carbon Capture and Conversion

Reduce carbon emission through advanced separation technologies

Important Dates

Abstract Submission is Open Now!

Registration is now Open!

Early Bird Registration & abstract submission
Before 31 August 2023

Notification Abstract Acceptance
Sep 2023

Registration
Before 15 Oct 2023

Conference
3 - 6 December 2023

MSA welcomes you to join our 2023 Annual Conference, co-hosted by The International Congress on Separation and Purification Technology. The annual conference will be held in the beautiful city of Perth, Western Australia on 3-6 December 2023. Submit your abstract and register now at https://www.membrane-australasia.org/copy-of-registration.

Chairs:

Dr. Amir Razmjou

Dr. Jingwei Hou

Dr. Shouliang Yi

Organising Committee:

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A.Prof. Huacheng Zhang
A.Prof. Jin Shang
Prof. Jianquan Luo
Dr. Rijia Lin
Dr. Abdellah Shafieian
Dr. Li Gao

Scientific interview

In this new academic engagement section, we interview with Prof. Ho Kyong Shon from the University Technology of Syndney (UTS), who is the director of Australian Research Council (ARC) Research Hub for Nutrients in a Circular Economy (ARC NiCE Hub), Head of Discipline, Environmental and Water Engineering at the UTS and also Editor-in-Chief of Desalination journal.

Interview between Dr. Amir Razmjou and Prof. Ho Kyong Shon from UTS

Left: **Dr Amir Razmjou** Right: **Prof. Ho Kyong Shon**

Amir: We've been talking about this event within our editorial board in MSA Newsletter and really appreciate your time for this interview. So, let's start with your academic journey. Can you please tell us more about it?

Ho Kyong: I studied Chemical Engineering for both my bachelor's and master's degrees in Korea focusing on the biological science. After completing my master's degree in 2000, I started my PhD journey in 2002 at UTS and completed it in late 2005. During my master's degree, I focused on wastewater treatment using biological treatment processes. Although this field posed challenges in terms of time-consuming experimentation and data regeneration, I found it so interesting. However, when I joined my PhD program, my research direction shifted towards physio-chemical water treatment processes, specifically membrane technology and pre-treatment strategies. This change in focus brought about a new level of excitement for me. I worked on microfiltration, nanofiltration, reverse osmosis and forward osmosis membranes for wastewater reuse. This field offered me more opportunities and I thoroughly enjoyed the experience. I would say I had around 15 publications from PhD program.

In my research career, I have co-authored 1 book, 31 book chapters and over 510 refereed journal articles and three patents. Since 2019, I have been leading ARC research hub that focuses on nutrient recovery for a circular economy. This research initiative aligns with the growing trend of resource recovery, and we have garnered support from 20 industry partners and collaboration with seven research universities. With strong backing from ARC and our industry partners, our primary focus lies in addressing nutrient recovery challenges and finding sustainable solutions.

Amir: It was fascinating to know about your academic journey in the field of membranes, starting from the early stages of your PhD all the way to the present. Having had the privilege of being part of your team for the past couple of years, I've always wondered about the pivotal moment that propelled your career forward, as everyone experiences a turning point in your professional career. This turning point led to your subsequent role as the editor-in-chief of Desalination and positioned you among the top five individuals globally active scientists in this field. I am curious to know the specific date and event made this amazing turning point.

Ho Kyong: Well, that's a great question. I could say my turning point in my career was largely influenced by my surrounding environment rather than being solely about myself. When I completed my PhD, job opportunities, research funding, and independent research positions were more readily available, which made it easy for me to get an academic position such as being a lecturer or having chancellor fellowship immediately after PhD graduation. Unlike the current competitive landscape, there were many opportunities for research funding and support 15 years ago. This favourable environment alleviated any concerns about my future prospects, as I consistently secured job positions and received promotions. Comparing the present scenario with my earlier career stages, it is clear that the path to success has become more challenging, not just for me but also for other students pursuing academic careers.

Amir: As the member of the membrane society and having extensive experience in obtaining grants, including government-based grants like the ARC, your insights and advice on this matter would be invaluable for early and mid-career researchers in the field. It is well-known that securing grants, whether from industry or government sources, is a major challenge. We eagerly anticipate receiving tips and guidance from you on how we can enhance our success in acquiring grants, both from ARC-type programs and industry sources?

Ho Kyong: Well, if I am being honest, gaining funding, whether from ARC or industry sources, has become increasingly challenging for researchers, particularly in the membrane field. Reflecting on my experience, securing ARC funding was more favourable during the water crisis in 2008-2009, as water-related topics had a higher chance of success. In the present time, funding is more competitive, and proposals should be more relevant to industry challenges and also have enough scientific quality. Besides, if you want to convince the assessors and panel members specially those who want to confirm your work, you must prepare a well-crafted and competitive proposal, addressing their criteria and ranking well among other submissions. What I am trying to say is that researchers must consider the increasing emphasis on industry-oriented opportunities. The rate of success is getting lower these days, and it requires strong research strengths, dedication, and compelling data. Additionally, building strong relationships and showcasing the broader contribution to Australia's research landscape enhances the chance of securing industry funding. Despite the challenges, obtaining the first ARC grant acts as a significant steppingstone, opening doors to future funding opportunities. Diligence, dedication, and positioning oneself as a leader in the research area are also important for success. Industry funding, on the other hand, requires a different skill set, focusing more on relationships and aligning research with industry strategies. Australia's funding landscape poses additional difficulties, making it crucial to navigate with a tailored approach.

Working closely with local industries and water utilities is highly beneficial in securing funding and building long-term relationships. It is important to align research efforts with the needs and preferences of industry partners, gaining their trust and establishing a solid foundation for collaboration. Industry engagement requires a substantial time investment and a focus on long-term relationships rather than short-term gains. Industry partners are often driven by immediate returns on investment, demanding tangible results within a shorter timeframe. To succeed in industry engagement, researchers must adopt an industry-oriented mindset and position themselves as valuable partners in addressing industry challenges. This requires a different strategic approach compared to securing ARC funding. Researchers need to plan and develop specific industry-focused topics, building strong relationships and understanding the industry's perspective. I believe it requires careful consideration of various angles to effectively navigate both industry engagement and securing the funding. If I want to give one example about those successful proposals, I can say those researchers who have shown the possibility of combining industry collaboration with fundamental research, make a potential case for getting the fund. I mean by fully embracing industry engagement while maintaining a strong focus on fundamental research, researchers can find the best pathway to success in securing the fund with an industry-oriented approach.

Amir: You have expertise in both ARC funding and industry engagement, having developed a strong foundation for obtaining grants and funds from both sources.

As you mentioned, building relationships is a crucial aspect of engagement. When it comes to initiating conversations with industry partners, it requires a strategic approach. Early and mid-career researchers often wonder how to initiate these conversations and establish trust? How do you make that trust that you mentioned?

Ho Kyong: Well, there are multiple options for engaging with industry partners, each with its own approach. One option is to leverage university-industry partnerships and workshops facilitated by the university to create the possible connections. Another option involves collaborating with those who already have industry jobs, working on capstone projects that align with industry needs. I think this will make it easier for them to engage in industrial projects. Besides, it would be so helpful if they prepare themselves to attend different industry conferences, where there is a strong focus on water-related issues. I think this also allows for wider networking and open discussions about industry challenges. Additionally, collaborating with colleagues who have expertise in industry engagement can serve as a valuable entry point. Working together on projects and gradually engaging with industry partners can be an effective strategy.

Amir: Well, that was great, and I think these are the crucial starting points for discussions and establishing connections in industry engagements. Moving on, I would like to inquire about your perspective on the future of membranes. While membranes have evolved significantly over the past few decades, becoming a mature and well-established technology, industry stakeholders express a desire for further optimisation and improvement. In this context, what do you envision as the future of membrane research in the next 5 to 10 years?

Ho Kyong: Although membranes have made significant advancements since their development in the 1960s, there is still room for improvement. Despite the existence of mature membrane technologies, ongoing research and development are focused on enhancing performance through material advancements, grafting techniques, and other innovative approaches. Membranes will continue to evolve in areas such as reverse osmosis, resource recovery, hydrogen production, and high-recovery desalination. I believe the future of membrane research lies in achieving higher rejection rates, permeability, and energy efficiency through atomic-level separations and fabrication methods, ensuring their vital role in various sectors like water, gas, food, and energy.

Amir: You are right. Membrane might be mature in some areas, but there are many more applications such as those you mentioned. I have some few more questions, but something just came into my mind about the artificial intelligence (AI) which is widely using these days. I see that AI is now revolutionising different aspects of academia and research. A clear example is ChatGPT. How do you think AI can contribute into the academic life?

Ho Kyong: Well, I think AI is a transformative force in academia and research, offering boundless possibilities for generating and applying knowledge. It enables us to explore ideas and applications that were previously unimaginable. AI empowers us to leverage its capabilities for membrane technology, such as optimising processes, controlling parameters, and enhancing energy efficiency. By incorporating AI algorithms and machine learning, we can revolutionise membrane design and performance. This intersection of AI and membranes presents an exciting opportunity for researchers to excel and make significant advancements in the field. Embracing AI in our research will undoubtedly give us a chance to move forward and shape the future of academic contributions and publications.

Amir: I really like your comment on the fact that AI can contribute to both membrane processes and development. Moving on, Professor Shon I have a tradition of asking a few rapid questions. If you could choose any city in the world to spend the rest of your life in, which city would you prefer?

Ho Kyong: Well, that is a tricky question. But you know if I am being honest, I would choose Sydney again. I have a strong affection for Sydney due to its vibrant multicultural atmosphere, where people from diverse backgrounds coexist with mutual respect. Over the past 20 years, my career has flourished in this city, making it a significant part of my professional journey.

Amir: Exactly, Sydney is a city that you always like to go there and enjoy. All right, so let's go to the second question. What is your favourite food?

Ho Kyong: Well, you know I love every food. But, if I want to be specific I would say I like fish because I feel I kind of know them and somehow my expertise in water is related to them.

Amir: Very interesting answer. If you had the option to go back and choose another profession, what would it be?

Ho Kyong: Well, you know I am always talking to my boys and imagine what would I do if I were like them in 20 years ago. I would say I choose AI and computer science because you don’t need any infrastructure to learn, and you just need to sit and think and focus. A lot of successful people like Elon Musk and Bill Gates are specialist in computer science.

Amir: Thank you very much Ho Kyong. I'm pretty sure our audience will enjoy this interview and the valuable tips and advice that you shared with us. Thank you very much, and I really appreciate your time.

Ho Kyong: Thank you Amir. It was good to see you here.

CECE 2023 Conference

CECE 2023

The first international conference on the Circular Economy for Climate and Environment (CECE 2023) organised by the University of Technology (UTS) and the ARC Hub for the Nutrient in a Circular Economy (NiCE) Hub will be held in Sydney in 26-27 September 2023. Held over two days, the conference will explore recent advances in technologies and industrial approaches with a focus on Nutrient recovery and reuse for sustainable futures.

Conference Chairs

- Prof Ho Kyong Shon, UTS (Chair)
- Prof Bernadette McCabe, USQ (Co-chair)
- Assoc. Prof Leonard Tijing, UTS (Co-chair)
- Assoc. Prof Dana Cordell, UTS (Co-chair)
- Associate Prof Stefano Freguia, University of Melbourne (Co-chair)

Conference Themes

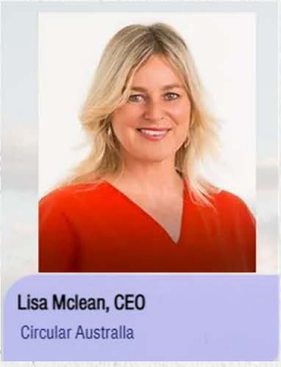
- **Environmental pollution: water, wastewater, air**
- **Environmental technologies**
- **Climate change: impacts, mitigation, adaptation**
- **Waste and resource recovery**
- **Water, energy, and environment**
- **Circular economy**
- **Environmental health and risk**
- **Bioresource**

Key dates

- **Extended abstract submission deadline: 2 July 2023**
- Abstract notification: **July 2023**
- Speaker registration deadline: **30 July 2023**
- Early bird registration deadline: **30 July 2023**
- **CECE Conference Awards nomination: 31 August 2023**

For Abstract Submission/Registration, please visit the website: https://www.nicecece.org/

Plenary Speakers



Contact Us

Conference Email: info@nicecece.org
Prof Hokyong Shon: Hokyong.Shon-1@uts.edu.au
A/Prof Leonard Tijing: leonard.tijing@uts.edu.au
Dr Sherub Phuntsho: Sherub.Phuntsho@uts.edu.au
Dr Ibrahim El Saliby: Ibrahim.ElSaliby@uts.edu.au

The old solution-diffusion model for RO has just been proven wrong!

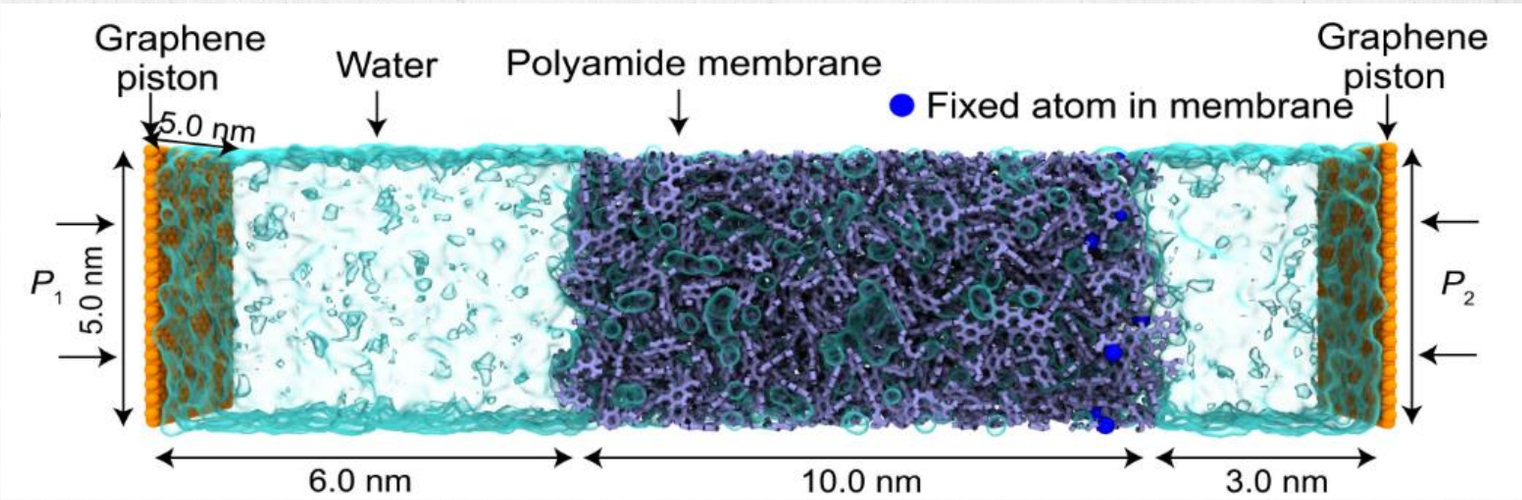
BY Mitra Golgoli

New study reveals that water transport in RO is governed by pore flow

A groundbreaking study led by the lab of Prof. Menachem Elimelech has challenged the conventional understanding of water transport in reverse osmosis (RO) membranes. The widely accepted solution-diffusion (SD) model assumes water molecules diffuse through the RO membranes based on their concentration gradient. However, despite the wide acceptance of the model, recent advancements in electron microscopy have challenged key assumptions of the model. Fully aromatic polyamide RO membranes were found to contain interconnected sub-nanometer cavities and tunnels with water molecules observed to transport through membrane pores, contradicting the model's assumption of dense, nonporous membranes. That calls for a re-evaluation of the models' assumptions. In this study, the researchers examined the transport of water molecules through RO membranes using nonequilibrium molecular dynamics (NEMD) simulations.

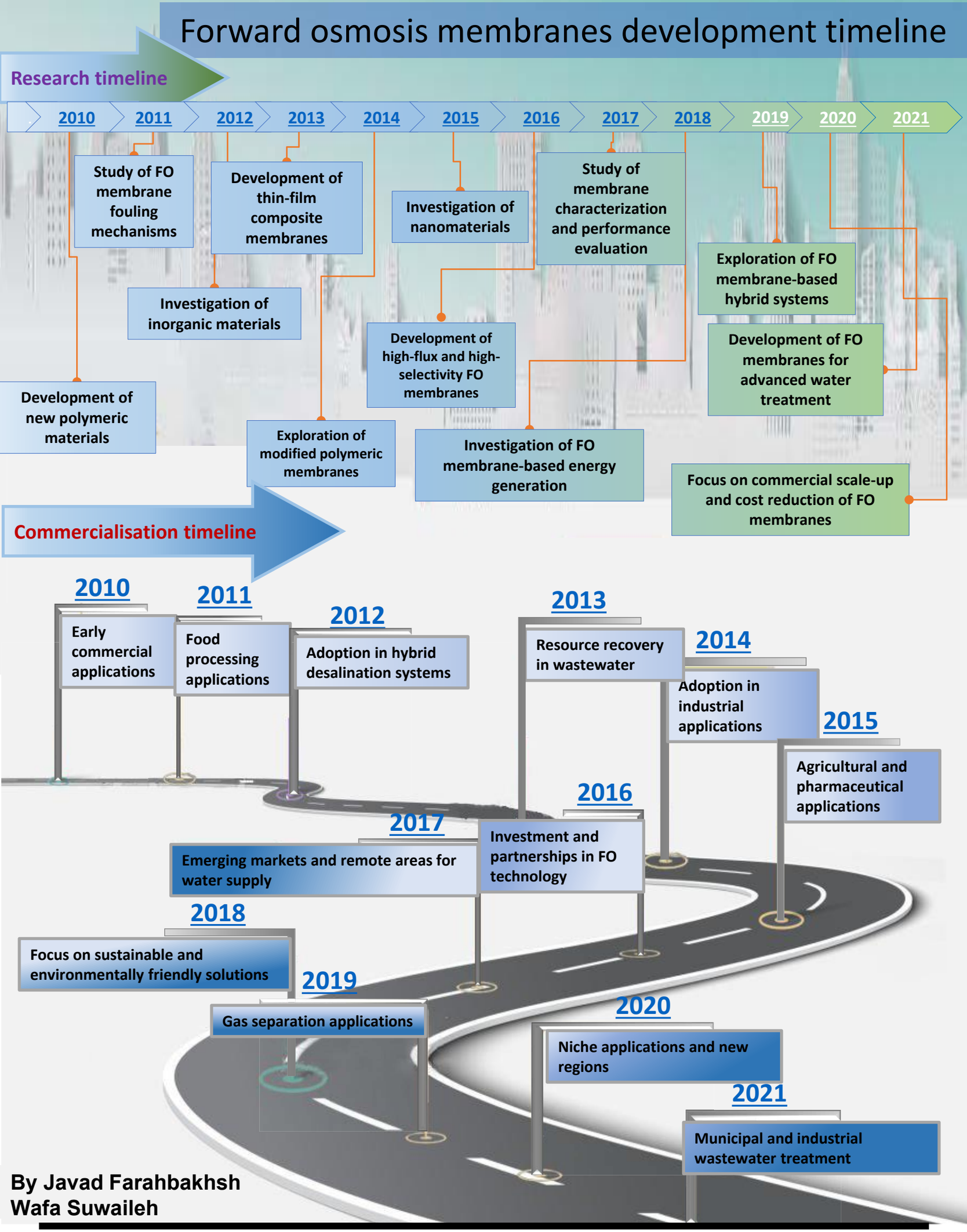
They found that pressure gradients, rather than concentration gradients, play a primary role in driving water transport in RO membranes. Furthermore, the study conducted permeation experiments with water and various solvents on RO membranes. The results indicated that solvent permeance depends on the membrane pore size, kinetic diameter of solvent molecules, and solvent viscosity.

Collectively, this study demonstrates that water transport in RO membranes occurs through a dynamic network of transiently connected pores rather than by diffusion based on concentration gradients. Pressure gradients, solvent size, and membrane structure all influence the permeation process. This finding contradicts the assumptions of the SD model and resulted in a different mechanism named the solution-friction (SF) model. These findings have important implications for our understanding of membrane desalination performance and pave the way for further advancements in RO membrane technology.



Source: Li Wang et al. ,Water transport in reverse osmosis membranes is governed by pore flow, not a solution-diffusion mechanism. Sci. Adv. (2023)

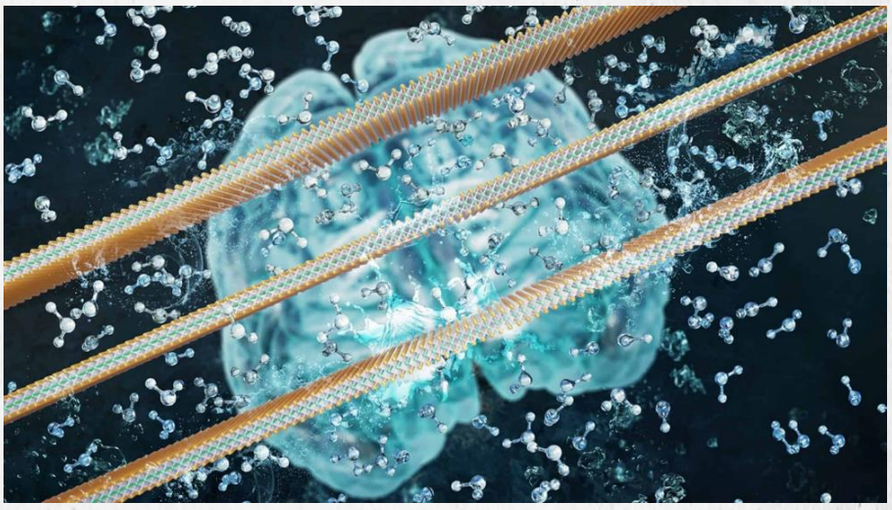
Forward osmosis membranes development timeline



By Javad Farahbakhsh
Wafa Suwaileh

Next-Gen Smart Filters: Membranes with Memories

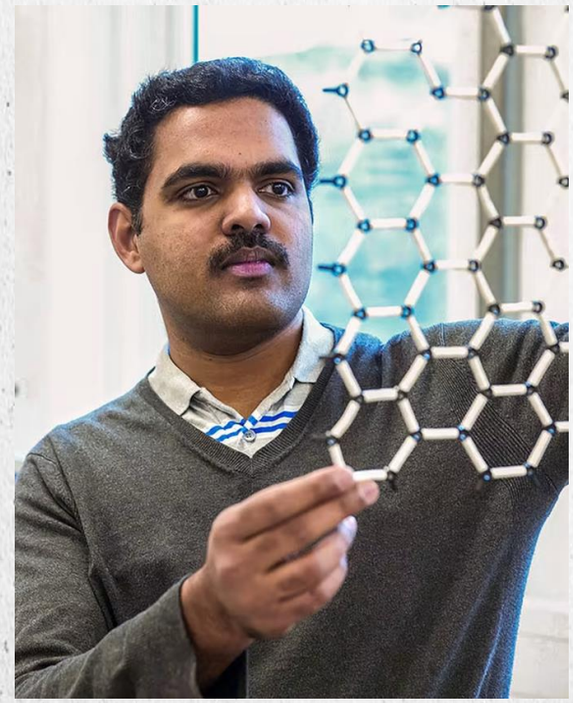
BY Mohadeseh Najafi



Scientists from the National Graphene Institute have made significant strides in the development of "intelligent" membranes that possess adaptive properties and can retain their previous states. This groundbreaking research, published in the prestigious journal Nature, opens up new possibilities for smart separation technology, wound management, drug delivery, sensors, and memory devices.

The research showcases the creation of intelligent membranes that can dynamically alter their properties in response to environmental changes while retaining memory of their permeability. This capacity allows the membranes to adapt to varying conditions in their surroundings and exploit their state retention feature in a multitude of applications.

The team's work demonstrates the memory effects and stimuli-regulated transport of molecules through a phase-changing MoS_2 membrane, with external pH as the controlling factor. The researchers discovered that water and ion permeation through the membrane exhibited pH-dependent hysteresis, causing a significant switch in the permeation rate by several orders of magnitude.



The findings of this study have far-reaching implications, particularly in autonomous wound infection monitoring and pH-dependent nanofiltration. The ability of the intelligent membranes to adjust their properties according to the external pH can revolutionize water purification systems and offer practical solutions to address the global challenge of clean water scarcity.

Led by Professor Rahul Raveendran Nair, Carlsberg/Royal Academy of Engineering Research Chair and team leader of the study, the researchers acknowledge the extensive history of membrane development, which has revolutionized industrial separation processes over the past century. In recent years, efforts have focused on creating membranes that mimic the intelligent characteristics found in biological structures.

The study was published in the scientific journal "Nature", 616, 719–723.

ARC Centre of Excellence

The ARC Centre of Excellence for Green Electrochemical Transformation of Carbon Dioxide aims to advance carbon dioxide electrochemistry innovations to enable the conversion of carbon dioxide into valuable products and transition Australia to a carbon-neutral economy. Prof. Xiwang Zhang, the MSA President, will serve as the centre director and the membrane theme will be led by Dr. Jingwei Hou.

Prof. Xiwang Zhang
MSA President

The University of Queensland

Professor Xiwang Zhang; Professor Rachel Caruso; Professor Zaiping Guo; Dr Ruth Knibbe; Professor Adam Lee; Professor Chuan Zhao; Dr Fengwang Li; Associate Professor Jie Zhang; Associate Professor Thomas Rufford; Professor Yuan Chen; Dr Jingwei Hou; Professor Karen Wilson; Associate Professor Simon Smart; Professor Darren Martin; Professor Christian Doonan; Professor Yansong Shen; Professor Andrew Whittaker; Professor John Zhu; Professor Suresh Bhatia; Professor Alexis Bell; Professor Feng Jiao; Professor Saleem Ali; Professor Graeme Henkelman; Professor Edward Sargent; Professor Dr Aimy Bazylak; Professor John Varcoe; Associate Professor Brian Seger; Dr Benjamin Muir; Dr Elena Corbos; Ms Sylvia Tulloch; Dr Andrew Cornejo; Adjunct Professor James Snow; Mr Wayne Chesher; Dr Michael Groszmann; Adj A/Prof Ashok Kumar Nanjundan; Dr Matthew David

This Centre aims to advance carbon dioxide electrochemistry innovations to enable the conversion of carbon dioxide into valuable products and transition Australia to a carbon-neutral economy. This Centre expects to generate new knowledge using experimental and computational approaches to develop systems-level understanding to furnish industry-ready carbon dioxide utilisation technologies. Expected outcomes include enhanced capacity through collaborations establishing the Centre as an international hub for research, training, technology translation and strategic advice for stakeholders and policymakers. This should accelerate Australia's progress towards net zero emissions targets and grow a sustainable economy and create future jobs.

ARC Industry Fellowship

The inaugural round of the ARC Early Career Industry Fellowships saw several successful recipients working on membrane related projects. One of the recipients is Dr Li Gao, who is also part of the MSA Board of Directors in charge of industry engagement. He will do his fellowship part-timely at Monash University while keeping his current role at South East Water. Congratulations to all the recipients!

Monash University

Dr Li Gao

Ammonium-selective membranes to shift water industry into circular economy. The project aims to develop ammonium-selective membranes which are urgently needed in Australian key industries for sustainable ammonia recovery. The project expects to construct the membranes to achieve desirable pore size and surface functionality for fast and selective ammonia transport. The developed membranes should make ammonia recovery from wastewater more effective and sustainable, leading to the healthy waterway and reduced energy for both ammonia production and removal. Recovered ammonia expects to produce valuable products, supporting agriculture industry and hydrogen economy. The developed membranes should enable water industry's shift into circular economy, providing significant economic and environmental benefits to Australia.

Dr Zhouyou Wang

Advanced separation membrane for sustainable lithium mining and recycling . The project aims to develop and commercialise a novel membrane-based technology based on a newly invented lithium-selective ceramic-polymer membrane for low-cost and environmentally friendly lithium recovery and recycling from various sources. The project expects to generate deep knowledge in the design and scaling up of lithium ion separation membranes, and create a lithium extraction prototype for on-site lithium extraction testing. Expected outcomes of the project include full commercialisation of the lithium separation membrane and new intellectual property for establishing a new membrane manufacturing industry that is critically needed for transforming lithium mining and recycling industries.

Monash University

ARC Industry Fellowship

Griffith University

Dr Ming Zhou

Membrane-based real-time ammonia monitoring system for sewage treatment. This project aims to develop a real-time, calibration-free, low-maintenance ammoniacal nitrogen monitoring system to assist in optimised wastewater treatment control. This project expects to generate new knowledge in the area of sensing technology using a self-developed membrane-based analytical principle, which overcomes the challenge of directly and accurately determining ammonia in a harsh wastewater environment. Expected outcomes include new theories in membrane-based sensing techniques and a market-ready field-based ammonia analytical system. This should provide significant benefits, such as a new technology for optimising wastewater treatment and reducing emissions and a valuable analytical tool to safeguard effluent quality.

Dr Tam Nguyen

Scalable high-performance electrolytic hydrogen generator. The project aims to demonstrate energy-efficient generation of compressed hydrogen by water electrolysis in a high pressure electrolyser test-rig produced by Melbourne company Energys Australia P/L, using high-performance membrane-electrode assemblies. Innovative electrode architectures, membranes, and method for their high through-put lamination will be developed. New knowledge in catalysis, device fabrication and materials science is expected to be generated. The major project outcome is sustainable method for generation of compressed hydrogen at significantly reduced cost as compared to the existing technologies. Benefits include industry-ready processes for electrolyser and hydrogen production that support Australian energy industries.

Monash University

ARC Discovery Projects





University of Technology Sydney

Professor Ho Kyong Shon; Dr Gayathri Naidu; Dr Sherub Phuntsho; Dr Tao He; Professor Enrico Drioli

A novel ion-selective membrane for efficient lithium recovery. This project aims to fabricate a novel membrane that display selective lithium recovery from brine in a renewable energy driven electrochemical membrane technology. The fabrication of lithium selective membranes embedded with nanomaterials and metal organic framework will create new knowledge on the dynamics of ion-size sieving and accelerating lithium transportation. This project will provide significant environmental and economic benefit by establishing a rapid and chemical free method to recover lithium affordably and orders of magnitude more efficiently than hard rock extraction. This project will bring significant commercial benefits to Australian mining industry, desalination and water treatment sectors.

Dr Jingwei Hou; Professor Deanna D'Alessandro; Professor Vicki Chen; Professor Sir Anthony Cheetham

Responsive Metal-organic Framework Glass Membranes for Molecular Sieving. Metal-organic frameworks are an important category of microporous materials, showing extraordinary structural and chemical diversities. The recent discovery of their melting behaviours endows these materials with high processability, enabling the transformation of crystal powders into mechanically durable microporous bulk glasses for device assembly. This project aims to understand the melting and modification mechanism, and to incorporate responsive moieties to the glass. It further aims to realise switchable membrane separation for gas mixtures. This project is expected to enhance the understanding and application of these emerging glass materials and promote Australia's capability in value-added manufacturing of metal minerals.




The University of Queensland


The University of Queensland

Professor Vicki Chen; Dr Ruth Knibbe

Interfacial engineering of multilayered metal organic framework membranes. Metal-organic frameworks are a popular class of microporous materials with tunable structural properties and functionalities. This project aims to investigate the designed synthesis of thin, hierarchically structured films of this material on membranes, which displays extraordinary ion selectivity and ion rectification properties. A better understanding of the interfacial properties will be gained through advanced characterisation, and with proper design and tuning of the film, will ultimately lead to the development of high performing ion-selective membranes that will be applied for energy storage and separation applications. This project is expected to benefit Australia's renewable energy and resource sectors.

ARC Discovery Projects



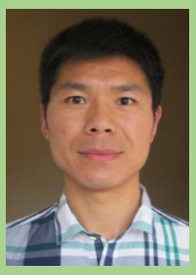

The University of Western Australia

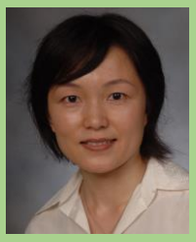
Professor Michael Johns; Dr Einar Fridjonsson; Dr Masoumeh Zargar; Professor Johannes Vrouwenvelder

Monitoring Desalination Membrane Fouling using Sodium Magnetic Resonance. Seawater desalination using membrane modules is critical technology for potable water access, however it faces significant challenges due to fouling. Sodium magnetic resonance techniques will be developed to non-invasively detect and image salt accumulation in these opaque membrane modules due to fouling. These data will first be used to improve our understanding of the unexplored interplay between fouling and detrimental salt accumulation in the modules (known as cake-enhanced concentration polarisation) and thus validate 3D simulations of this phenomenon. The ability to unambiguously detect salt accumulation in membrane modules will then be extrapolated to a non-invasive monitoring tool for membrane fouling in desalination facilities.

Dr Shuaifei Zhao; Professor David Cahill; Professor Qilin Li; Professor Bart Van der Bruggen

Smart foliage: imparting intelligence to synthetic leaves. This project aims to develop an innovative “lab-on-a-leaf” platform technology based on smart membranes with switchable pores to enable hitherto unachievable control of gas and vapour transfer. The innovated membrane based technology can be used as a versatile platform for many important applications, such as desalination and carbon capture. This project expects to advance the knowledge in biomimetic design of synthetic leaves, and bring new membrane technologies to applications, such as desalination, solar energy harvesting, and evaporative cooling. This project should provide significant benefits for Australian manufacturing industry by addressing energy and environmental concerns and boosting national economic growth.






Deakin University

ARC Linkage & LIEF





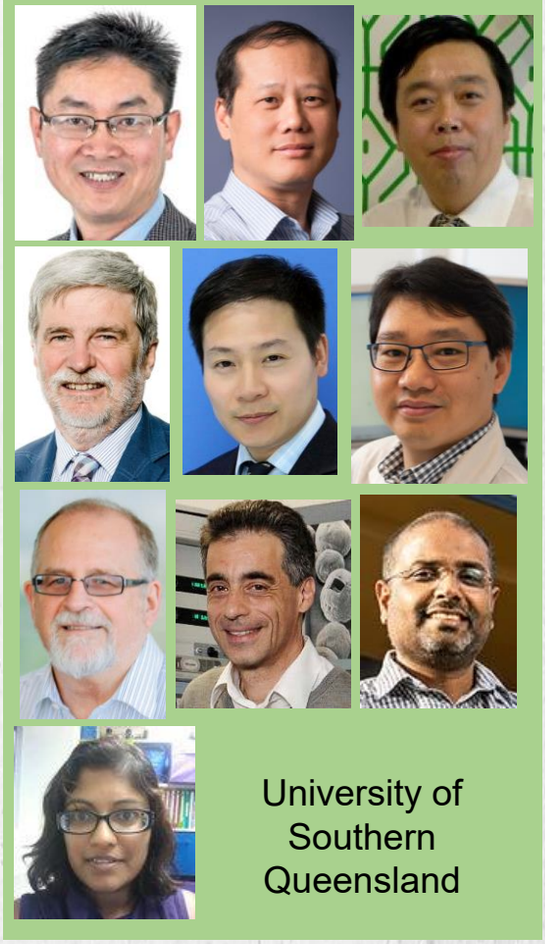
The University of Queensland

Dr Jingwei Hou; Professor Lianzhou Wang; Professor Debra Bernhardt; Dr Zhiliang Wang; Dr Matthew David

Integrated solar to chemical production and membrane concentration system. The efficient conversion of low-cost raw materials to high-value chemicals using solar energy has been a long sought-after goal. This project aims to create an integrated photoreactor and membrane separation system for efficient photocatalytic water splitting. The integrated system will efficiently produce hydrogen and ultrapure hydrogen peroxide, a critical and costly reagent used in the semiconductor and solar panel manufacturing industries. The integrated system addresses current challenges in the production of high-quality hydrogen peroxide and demonstrates a practical solar-to-chemical process with economic benefits. It also advances knowledge in the fields of nanomaterials engineering, photocatalytic devices, and membrane technology.

Professor Hao Wang; Professor Nam-Trung Nguyen; Professor Yuantong Gu; Professor John Bell; Professor Pingan Song; Professor Ziqi Sun; Associate Professor Wayne Hall; Professor Nunzio Motta; Dr Venkata Chevali; Associate Professor Paulomi (Polly) Burey

Environmental Scanning Electron Microscope for High Temperature Analysis. Through the use of a high temperature stage in an environmental SEM, this project intends to develop a comprehensive capability for in situ high temperature scanning electron microscopy. This will enable analysis of material behaviour as a function of elevated temperature. As a result of the project, we expect to discover rare and anomalous microstructural phenomena in several classes of advanced materials. It is expected that this project will address microstructure-property-performance relationships in multiple multifunctional advanced materials, including polymers, semiconductors, membranes, composites, and energy materials, as well as fostering national collaboration and global stewardship of Australian science and technology.



University of Southern Queensland

Industry Engagement

In this edition of the industry engagement series, we interview Bruce Biltoft who was formerly from the Memcor business (acquired by DuPont). He has an incredible 37 years of engineering experience working in Memcor on low pressure membrane systems, and have seen the Memtec/Memcor business going through 6 generations of corporations. We are very grateful to him for sharing his journey in this interview.

If you would like to nominate a person to be featured in this section, please contact our Newsletter Coordinator and Editor or Associate Editor at amir.razmjou@ecu.edu.au / milton.chai@uq.edu.au.

Interview between Dr. Amir Razmjou and Bruce Biltoft

Top: **Bruce Biltoft**
Bottom: **Dr Amir Razmjou**

Amir: Hi Bruce, thanks for your time for this interview. I am sure the MSA society will benefit from this conversation. Let's start off with a bit of background about yourself to help our members to know you better.

Bruce: First of all, I'm a mechanical engineer. I also have an MBA from the Australian Graduate School of Management, but I've basically been an engineer all my working life. I graduated from the Queensland University of Technology with first class honours in 1982 and was awarded the Institute Medal for Engineering that year. I transferred from Brisbane to Sydney in the job I had after graduation, and eventually ended up in Memtec/Memcor based in Sydney ever since. When I joined Memtec in 1985, the membrane world was obviously something very new to me at that time coming from a mechanical services background.

Amir: That's fantastic! Could you tell us more about how you got into membranes and your role at Memtec?

Bruce: My introduction to membranes was sort of an accident. There was an opportunity for me to do real engineering development in an Australian technology company in its infancy, and this was an entry level job in a small company, Memtec. When I joined, Memtec had already been listed on the Australian Stock Exchange, but there were only roughly 10 or 12 employees so it was still very small then. I was the first mechanical engineer to join, working on the machinery to turn membranes into physical products. The business took off pretty quickly and we had to engineer membrane equipment from a minimal knowledge base because both the technology and enterprise itself were in their infancy. I took advice from all the people around me, but also had to scour for engineering guidance in the ultrapure water, food and beverage space, as those were established industries. There were engineering methods you could learn and apply, but it also involved development work to decide how we should go about making it happen.

Amir: I am curious what was the first product out of Memtec?

Bruce: The first commercial sales were already happening in 1985. It was crossflow microfiltration (CMF) using outside-in polypropylene MF membrane with 0.2 micron pore size. The original, incubated idea came from UNSW research based on flat sheet format that was flipped to hollow fibres very quickly. A significant invention from Professor Doug Ford (one of the founders) who came to Memtec from Union Carbide was what we called a gas backwash, which was to push high pressure air through the membrane above its bubble point and use that as the means to clean the membranes. That was the invention we applied for nearly a decade, before we moved into a lower energy approach. Nevertheless, that was the foundation for the original products and it worked pretty well although it had its engineering challenges (handling high pressure air) to make everything robust enough that it would last.

Amir: That's very interesting! How long have you been in Memtec?

Bruce: The Memtec/Memcor business has been through 6 generations of corporations now, and I was in Memcor for 37 years. I left recently in August of 2022.

Amir: Wow, 37 years! I know Memtec has evolved through several generations. Can you quickly go through them?

Bruce: Across those four decades, the first one was essentially developing a product, then growing a market, then maturing and scaling, and now the whole industry has been much more mature in the last decade and a half. You see now that there's some convergence of what products look like because that's generally how technologies evolve. It eventually goes towards what works best and what the market decides it wants. But if I swing back a little bit, the initial application was very broad-brush notwithstanding that there was a vision to establish a business around membrane technology. The reality was that there are not a lot of meat on the bones when you start these enterprises. The early work is really about scouring for opportunities to determine which direction to go to from both the technical and selling viewpoints. That's why we principally did high value products first like fruit juices and wines and even some beer, so it's the customers that you perceived would be able to afford the value of a membrane and industrial applications.

Along the way, one of the obvious features of these membranes is that you can remove bacteria and pathogens from a water source so the idea of treating water made sense, but the economics were not very good.

Municipal treatment was a vision that really materialised with proving that the technology could add value to water treatment and wastewater reclaim, and really seeing that they could take away the large physical scale of existing technologies to make them more compact. The cost was coming down with each year as well. We then swung to a pretty heavy approach to invest in opening up the water and wastewater markets for membrane technology. We succeeded with some small plants in the 1980s when we were doing those industrial applications, together with some smaller scale water treatment that came in the early 1990s, particularly when the US water sector was really starting to look at membranes. They were coming up against some challenges in terms of water quality in surface waters and some shallow ground waters where there's pathogen contamination, in particular chlorine tolerant pathogens, so membranes are a way to add one or two log removal credits of pathogen rejection to an existing treatment train. The beefing up of the surface water treatment rule, together with events like the cryptosporidium outbreak in Milwaukee in 1993, led to the market really starting to crack open for low pressure membranes in water treatment.

One of the milestone projects was in San Jose, California to treat the surface water stream for the Saratoga Water facility and there were many more projects that followed. At the same time, we'd done a bunch of work around wastewater treatment, like tertiary wastewater treatment for reuse and environmental discharge, where there were already leading projects at Water Factory 21 in Orange County, which at that point had not used membranes for their pre-treatment but they were always very open to looking at new technologies. They made the call to move to low pressure membranes to replace their clarification process for pre-treatment and that started to happen more on the wastewater side as well. In the mid-1990s, there was a growth in both the market and volume of product, and with the cost coming down, it just basically feeds on itself. The challenge then, of course, is that the market starts to happen, so people get excited and other people come in to play. You have this brief honeymoon period where everything takes off, but then you have competition. It's been a competitive fight now for multiple decades in membranes.

Amir: In terms of the products, how has it evolved since CMF?

Bruce: The CMF did a little flip. When we did the scale up of the physical product going up by an order of magnitude increase, one of the things we talk about is the cost barrier, but the other thing is energy. If you're going to take membranes into the municipal space, and you want to treat water at cents per kilolitre, you can't do that if you're sweeping the feed flow across the membrane at three metres per second since you're going to burn up a lot of energy. We made the call to flip to using gravity feed and use only backwash as the mechanism to physically clean the membranes. So, we did that in the late 1980s, and CMF went from being called "Crossflow" to "Continuous". It was a little bit of a flip on the acronym. The physical module became what was called the M10 series, and that platform is still embedded in products made today by Memcor. We were using polypropylene (PP) membranes which worked well, and still works well, in fact Orange County runs on PP for the bulk of its plant.

However, it's not chlorine tolerant so the cleaning mechanism for organic fouling is high pH (caustic), and the competition sort of pushed the market towards PVDF. So, we made the call to develop a PVDF line. Although it's a more expensive polymer, it performs significantly better. The fact that it's UF is a bit of a by-product of the switch, but it's also fair to say that a tighter filtration cutoff is more desirable today. That switch to UF PVDF happened in the second half of the 1990s.

Amir: Has there been any discussions on moving towards other membrane processes like NF and RO as well?

Bruce: Memcor is part of DuPont now, so by association we're in the NF/RO business, but Memcor itself would probably not be assigned to develop NF/RO membranes. The key distinction between the low pressure membrane and higher pressure membrane is that we're removing what's insoluble, and once you go into NF and RO, you're starting to remove what's soluble. In low pressure membranes, you would like to have high utility and durability, meaning that you can take a range of feed waters from low to high turbidity and be able to treat them. But if you say I want to do NF as well, you're trying to do too many things because there's a significant change to what's needed around the membrane like limiting concentration polarisation. While there might have been a bit of discussion, the reality is that I don't think we dwelled on that for too long.

Amir: Do you think there are still room for development in MF and UF?

Bruce: This is now a mature technology area, but I think the answer is yes because we know the limitations around low pressure membranes in terms of physical properties, durability, and particularly filtration properties. I'm sure there's some new things that will come to open up opportunities.

The challenge though is that you're bringing those developments into a mature market space where the cost of existing products has already come down quite a way. That's the same with RO.

Amir: In the interest of time, we have a tradition of having some rapid-fire questions before the end of interview. If you had a chance to choose another career, what would be your choice?

Bruce: I would probably go into the design space. I spent a lot of time wondering whether engineering was the right thing to do, but I would say now with hindsight, engineering is a great field. Nevertheless, I always had an interest in design, particularly the combination of form and function. It would have been nice if I had some formal qualifications in that area.

Amir: If you had the chance to have dinner with someone either in the past or present, who would it be?

Bruce: In the past, it would probably be Isambard Kingdom Brunell who was the English engineer that built a lot of the rail network in South of England, a lot of the famous bridges in England and also famously his ship, which was named Brunell, in the mid-1800s. In the present, I would probably say Elon Musk, at least from the science viewpoint.

Yokogawa to Supply Control Systems for Water-Scale Seawater Desalination Plant in Saudi Arabia

Yokogawa Electric Corporation announces that its subsidiary, Yokogawa Saudi Arabia, has received an order from the Saline Water Conversion Corporation to supply control systems and other solutions for the One Million Project, which will introduce seawater reverse osmosis (RO) technology at the Al Jubail desalination plant, a world-scale facility with a water production capacity of 1 million m^3 per day. The construction contractor for this project is a consortium between Saudi Services for Electro Mechanic Works Company and Metito Saudi Arabia.

The Al Jubail plant is located in Jubail, a city on the Persian Gulf coast of Saudi Arabia. This project will replace the existing multi-stage flash distillation (MSF) facilities with RO facilities. Extending the life of the existing plant is seen to be a more environmentally friendly approach than constructing an all-new plant. In the Middle East, the use of fossil fuel-intensive desalination processes was once the mainstream. However, with the advances in membrane filtration techniques that have been achieved in recent years, more and more plants are now turning to the use of the RO technology, which emits less CO_2 and produces water using less energy. This project is part of Saudi Arabia's Net Zero Vision 2060 initiative, which aims to reduce carbon dioxide emissions and achieve net zero emissions by 2060.

For this project, Yokogawa will provide control systems, safety instrumented systems, production management systems, operator training simulators, and cybersecurity solutions. Installation is set to be completed by January 2024, and the new facilities are expected to be fully operational by December 2024. Yokogawa has been involved in over 100 desalination plant projects worldwide, including the supply of control systems for desalination plants in Saudi Arabia, and also monitoring systems for pipelines that transport desalinated water to urban areas.

Source: Smart Water Magazine

A look into reverse osmosis, the dominant desalination technology

The rise and trends of RO for desalination

By Hoda Khoshvaght & Milton Chai

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1940s
- Osmosis and semipermeable membranes explored for salt removal from seawater.

1950s
- Lab-scale demonstration of RO

1960s
- Increasing cellulose acetate RO membrane installation after Coalinga piloting success.

1970s
- Development of high-rejection, high-flux RO membranes, including chlorine-tolerant ones
- Rapid application of RO membranes for ultrapure water production in the semiconductor industry.

1980s
- Optimization of membranes and processes
- Introduction of nanotechnology in RO membrane research and development.

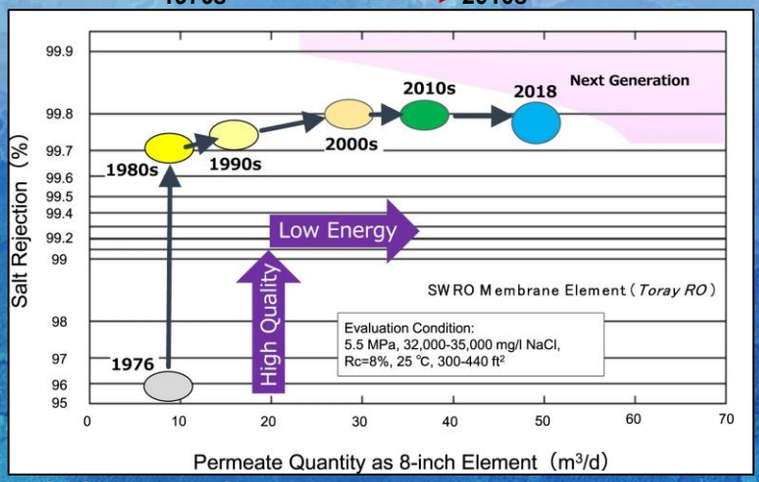
1990s

2000s
- RO accounts for over 70% of desalination water production.
- Extensive investigations on fouling mitigation strategies and significant global growth in desalination plant construction.

2010s

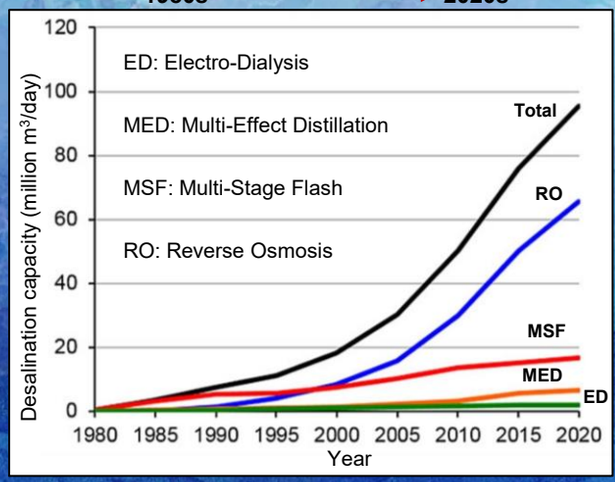
2020s

1970s → 2010s



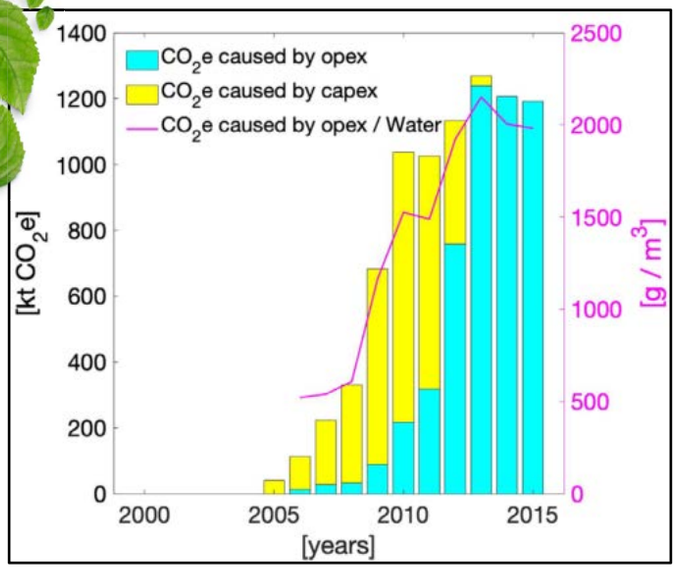
Shift in interest from improving salt rejection quality to producing energy-effective RO membranes[1]

1980s → 2020s



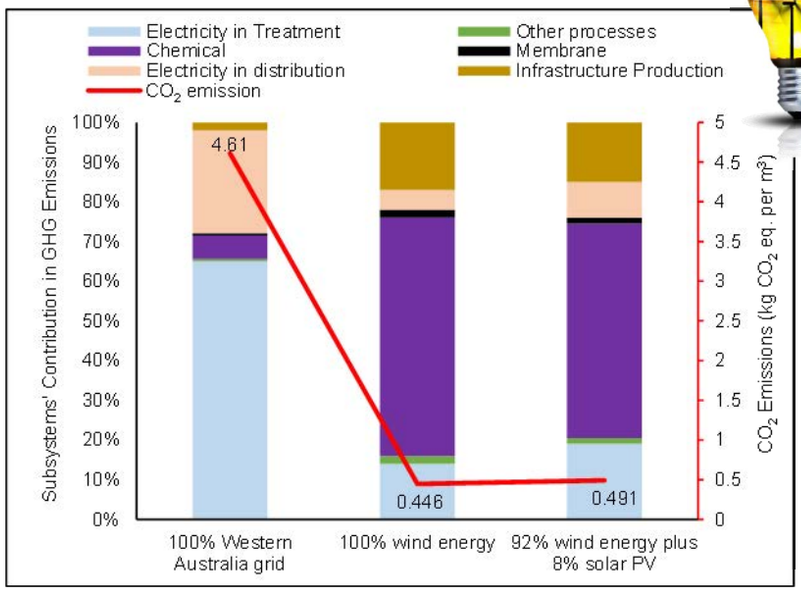
In the 2000s, RO took over as the dominant desalination technology[2]

Carbon footprint of seawater RO desalination in Australia



Carbon emissions from operational RO desalination plants in 2015 was ~1,200 kt CO_2 equivalent. This corresponds to 2000 g of CO_2 emitted per m^3 of water produced.[3]

Integration of renewables with RO



Analysis of a RO desalination plant in Western Australia showed that renewable energy (wind and/or solar) can reduce GHG emissions by around 90%.[4]

Strategic Research Partnership to Develop the Next Generation of Seawater Pretreatment Systems

ACWA Power, a leading developer, investor, and operator of power generation, water desalination, and green hydrogen plants worldwide, has signed a Memorandum of Understanding with Nanostone Water Inc., a global membrane solutions company, to perform R&D and knowledge transfer at the King Abdullah University of Science and Technology (KAUST), the leading innovation hub in Saudi Arabia, to evaluate Nanostone's UF ceramic membranes and process technology in seawater desalination applications.

The collaboration between ACWA Power, Nanostone Water Inc. and KAUST further positions Saudi Arabia as a technological and innovation hub in frontier applications for sustainable power, water desalination and green hydrogen, globally. The new partnership pursues applied industry-oriented research to develop a robust pre-treatment process for seawater desalination applications with superior protection and an extended lifetime for downstream reverse osmosis membranes.

Nanostone's UF technology provides partners and end-users with a robust solution against variations in water quality, including harmful algal blooms, along with reliable delivery of high-quality pre-treated water at a lower total cost of ownership. Both ACWA Power and Nanostone Water aim to capitalise on the outcome of this successful collaboration to jointly promote Nanostone's technology for commercial use in world-scale desalination plants throughout the GCC region. This significant partnership is driven by the Kingdom of Saudi Arabia's unwavering commitment to advancing sustainable and innovative technologies. It is further propelled by the unique environment that KAUST provides to its local and global partners of the highest calibre. In alignment with its ongoing efforts to address critical global challenges in energy, water, environment, food, health, and the digital realm, KAUST leverages the research activities of its outstanding facilities, including research centres and core laboratories.

Source: ACWA Power website

Upcoming Membrane Events

CURRENT EVENTS	DATE OF EVENT	ABSTRACT SUBMISSION
13th International Congress on Membranes and Membrane Processes Makuhari Messe, Chiba, Japan www.icom2023.jp	09 – 14 Jul 2023	**Registration open!** (Abstract deadline past)
The 10th International Water Association (IWA) Membrane Technology Conference & Exhibition for Water and Wastewater Treatment and Reuse Washington University in St. Louis, USA www.sites.wustl.edu/mtc2023	23 – 26 Jul 2023	**Registration open!** (Abstract deadline past)
15th International Conference on Membrane Science and Technology 2023 (MST2023) Duangjitt Resort & Spa in Patong beach, Phuket island, Thailand www.mst2023.com	7 – 8 Sept 2023	**Early Bird Registration by 31 July 2023!** (Abstract deadline past)
International Conference on the Circular Economy for Climate and Environment (CECE 2023) Sydney, Australia https://www.nicecece.org/	26 – 27 Sept 2023	**Early Bird Registration by 30 July 2023!** (Submit abstract by 2 July 2023)
6th International Conference On Desalination Using Membrane Technology (MEMDES 2023) Sitges, Spain www.elsevier.com/MEMDES	19 – 22 Nov 2023	**Early Bird Registration by 8 September 2023!** (Abstract deadline past)
MSA 2023 Annual Conference, co-hosted by The International Congress on Separation and Purification Technology Perth, Australia www.membrane-australasia.org/msa-ispt	3 – 6 Dec 2023	**Early Bird Registration and abstract submission by 31 August 2023!**
The International Conference on Desalination, Environment And Sustainability (IDEAS 2024) Abu Dhabi, UAE https://wp.nyu.edu/abudhabi-ideas2024/	22-23 Jan 2024	**Early Bird Registration by 23 Oct 2023!** (Submit abstract by 1 Sept 2023)

MSA Newsletter Taskforce

Meet our team for this June edition of newsletter!

From left to right:
Vedant A. Joshi, Shiyang Huang, **Dr. Milton Chai (Associate Editor),** **Dr. Amir Razmjou (Newsletter Coordinator and Editor)**, Mitra Golgoli, **Dr. Masoumeh Zargar (Associate Editor)**, Weonjung Sohn, Mohadeseh Najafi, Javad Farahbakhsh

Our Newsletter team is expanding! Please welcome our new assistant editors to the team!

Dr. Wafa Ali

Hoda Khoshvaght

Shiyang Huang