MEMBRANE SOCIETY OF AUSTRALASIA

September 2024 Newsletter

What is covered in this issue:

- MSA Industry Workshop
- Interview with Prof. Faisal Hai
- Latest membrane science and industry news

… and many more!

TABLE OF CONTENTS

MSA Industry Workshop 2024

A huge success for MSA Industry Workshop 2024! More than 50 participants and five keynote speakers from chemical, beverage/wine, water, and food industries shared key insights of membrane application and use in their industries. The thought-provoking presentation and discussion inspired our MSA members. As a bridge between academics and industry, MSA helps our members to transfer their excellent research into real community and industry benefits. Thanks to all speakers and attendees for making this event a success. Special thanks to Dr Li Gao and Dr George Chen for their contributions.

Distinguished Assembly of Speakers

Lee Carty – Founder and MD, PTI Pacific
"Commercial applications for gas, liquid, and alcohol separation in the wine and beverage industry"

George Chen – Lecturer, University of Melbourne
"Assessing Membrane-based Technologies for Food Processing: Insights from Industry Collaborations"

Abozar Akbari – Research & Development Manager, NematiQ
"Industrial Application of Graphene Oxide Membrane Modules"

Alice Makardij – Food and Innovation Strategy Director, GWF
"The Art of Designing Membrane CIP Chemicals"

Guan Jing – Chief Scientist, OriginWater
"Membrane optimisation in the applications of Lithium recovery and biomedicine"

Scientific interview

In this new academic engagement section, we had an interview with Prof. Faisal Hai from the University of Wollongong (UOW). Prof. Hai is the Head of the School of Civil, Mining, Environmental and Architectural Engineering. Prof. Hai's contributions to Membrane Bioreactor Technology for wastewater treatment and reuse have gained international recognition for UOW. He serves as the elected Director of the Membrane Society of Australasia (MSA) and leads the Strategic Water Infrastructure Lab at UOW.

Interview between A/Prof Amir Razmjou and Prof. Faisal Hai

Left: A/Prof Amir Razmjou **Right:** Prof Faisal Hai

Amir: Thank you so much for joining us today. We truly appreciate you taking the time and accepting our invitation. Let's begin with a brief introduction about yourself, and then we'll move on to the questions we have for you.

Faisal: Sure. Thank you, Amir, for this invitation. It is a pleasure to be here today. About myself: I am currently a professor at the University of Wollongong, School of Civil, Mining, Environmental and Architectural Engineering, and I am the research leader of the environmental engineering section of the school.

Amir: Alright, many thanks Faisal. As you know this interview is for membrane society of Australasia (MSA) and we usually ask some questions about membranes. But before that, I want you to tell us more about your background.

Faisal: I was born and raised in Bangladesh, where I completed my undergraduate degree at the Bangladesh University of Engineering and Technology, which is the top university in the country. I graduated in 2001 with a degree in Civil Engineering, specialising in Environmental Engineering.

In 2002, I moved to Japan to pursue my postgraduate studies at the University of Tokyo, where my journey into membrane technology began. The program there starts with a six-month self-research training before moving into the master's program, which I completed in two years. Immediately after, I continued at the University of Tokyo for my PhD.

I had the incredible fortune of working under Professor Kazuo Yamamoto, the inventor of the membrane bioreactor (MBR) technology. It was a remarkable experience to learn about MBR technology directly from the person who pioneered it, and I consider myself very lucky to have been part of his laboratory.

I completed my PhD in October 2007 and then immediately started a postdoctoral fellowship with the Japan Society for the Promotion of Science (JSPS). This fellowship allowed me to continue working on membrane bioreactor technology, but with a new focus on nanofiltration membranes (NF) as NF membrane bioreactors .

Faisal: Unlike the classical approaches that primarily use microfiltration membranes, we were exploring advanced wastewater treatment in a single step, incorporating high retention with the MBR. Although the fellowship was awarded for two years, I shortened it to 20 months, as I secured a position at the University of Wollongong in Australia.

Amir: So in 2009, you joined Wollongong?

Faisal: Yes, Exactly, I moved to Australia in May 2009 and joined the University of Wollongong, I spent about seven years in Japan before making this transition.

Amir: What was your initiative?

Faisal: I started my journey at UOW in a fixed term position. Around 2011, the University launched its first Vice Chancellor's fellowship scheme, and I was fortunate to receive that fellowship. However, around the same time, a lecturer position in Environmental Engineering was advertised. Since arriving in Australia, I have been working hard to position myself well if such an opportunity appears, and I was able to secure that role too. As a result, I had to relinquish my Vice Chancellor's Fellowship to take up the lectureship, officially becoming a continuing lecturer in May 2011.

I received a lot of support at the beginning of my academic career in Australia from professors namely Prof Will Price (UOW), Prof Long Nghiem (then at UOW), Prof Tony Fane (UNSW), Professor Vicki Chen (then at UNSW), Prof Felicity Roddick (RMIT), and eventually was able to work in various schemes/organisation (such as at MSA) with colleagues namely Prof Ho Kyong Shon (UTS), Prof Stuart Khan (USYD), Prof Xiwang Zhang (UQ), Prof Mikel Duke (VU) and many incredibly talented ECR/MCR colleagues like yourself. Over the years, I progressed through various academic ranks and was appointed as a professor in 2020. Looking back, I feel fortunate to have been able to move through these stages fairly smoothly.

Amir: I think I first became familiar with you in 2012 when I finished my PhD at UNSW with Prof. Vicki Chen. I have always respected your exceptional research contributions and know you are well-regarded in the community. Faisal, tell us about when you took on leadership roles. I mean specifically when you became the head of your department. Leadership, especially in academia, is quite different, and I imagine it was particularly challenging transitioning from research, especially since you came from a different cultural environment like Japan. As someone who is excelled in research, how did you manage to balance leadership responsibilities? Was there a particular turning point that led you to step into leadership roles?

Faisal: Thank you. I think my journey into leadership happened gradually. In academia, many of us begin with small research groups, and as those groups grow, we naturally take on leadership roles within them. Over time, as my research group expanded and my collaborations increased, especially across the university and with other institutions, I found myself getting more involved in research governance.

My first substantial leadership role was as the Head of Postgraduate Studies at the University of Wollongong. In this role, I was responsible for overseeing PhD students in the school, facilitating communication between them, their supervisors, and the Central Graduate School. It is a role that allows you to manage more than just research as you become part of the broader academic governance and administration.

So, while research leadership begins with your own group, it eventually expands to include more administrative responsibilities. It is important to be able to balance both aspects as you grow in your career.

Amir: Let's just more focus on this turning point. I mean you began with a small research group, and at some point, you transitioned to an administrative role and became the head of the school. Could you share when you think is the best time for such a transition to happen?

Faisal: I believe the first thing to consider when stepping into a leadership role is asking yourself if you are ready to lead people who may not be directly related to your research or part of your immediate group. For example, as a Head of School, only a portion of the members under the school might be involved in my specific research area. However, the role requires you to go beyond your own interests and look after the research progress of all colleagues within the school, facilitating their growth and supporting their work.
It is essential to ask yourself if you are prepared to cheer for others and contribute to their success, while still maintaining your own research. Personally, I still consider myself a devoted researcher, and I never intended to shift solely to governance. That is why I believe it is crucial to have your own research in a stable position before taking on a leadership role in academic governance.
In Australia, most Heads of School or Executive Deans are also research leaders, rather than purely administrative figures. We have reached this stage through our research, and it is the strength of our research that helps people like us to the next level of leadership. So, before stepping into such roles, it is important to feel comfortable with your own research standing and then ask yourself if you are ready for the next step.

Amir: I am looking to develop a formula based on this. Do you think that for mid-career researchers (MCRs), Level D or E is the ideal time to transition into such roles?

Faisal: Well, it could start from level D. If I recall correctly, I became Head of Postgraduate Studies when I was at Level D, as an Associate Professor. However, even before that, while I was still a Senior Lecturer, I took on the role of Academic Program Director for environmental engineering.
In this position, I was responsible for leading the discipline, which is a significant leadership role in itself. When I was acting as the Academic Program Director, I led the accreditation process for environmental engineering in 2018. Experiences like these are invaluable when transitioning to roles such as Head of School because a Head of School is responsible for ensuring the accreditation of all disciplines under their jurisdiction. If a Head of School does not understand the accreditation requirements and the challenges each discipline faces, it can be difficult to manage effectively.
Leadership roles often begin at Level C, but from my experience, In STEM it is not so common to see someone at that level become a Head of School. I think it may happen more frequently in Level D or E.

Amir: That experience in academic leadership really helps your transition into roles involving more academic governance. But to circle back to membranes, as that is the focus here, you have worked extensively with MBR, ultrafiltration, microfiltration, and NF, which you explored during your fellowship. Many early-career researchers (ECRs) are interested in membranes, but securing a permanent academic position can be challenging, as can balancing the demands of research funding and grant applications. And for those who were sort of lucky enough to get the position, it is very hard to secure funds and Research Grants. What is your advice for ECRs?

Faisal: I believe it is essential for ECRs to recognise that securing academic positions and research funding can be challenging. I can share some insights on what matters in the hiring process. First, it is important to understand that candidates are not always selected based solely on having the highest number of publications or grants.

While selection criteria are significant, the way a candidate presents themselves during the interview also plays a crucial role.

When reviewing achievements, selection committees look for a clear and explainable track record of contributions. It is not just about having your name on numerous publications or grants; it is about demonstrating your actual contributions to these works. If a candidate's name appears on a paper from a different part of the world with no logical connection to their expertise or contribution, it raises questions.

Both quality and quantity of publications are vital in today's academic landscape. ECRs should strive to publish extensively, but they must also ensure that they can articulate their contributions effectively. High-impact research that showcases both quality and the candidate's role in the work will stand out. I think we should also admit that sometimes you have to be lucky and everything has to be in right position for you to secure the fund. Additionally, seeking collaborations with genuine partners is crucial. It is essential to work with collaborators who share the workload and foster mutual growth rather than burdening one another.

Collaboration, both within and beyond the university, is often necessary to secure grants. However, these relationships take time to cultivate. Building trust with collaborators and establishing a shared mindset of growth are essential. While everyone aims for personal advancement, effective collaborators prioritise the growth of their partners as well. People tend to prefer working with sincere and supportive individuals.

Amir: Wow, that was great, many thanks for sharing your valuable feedback on this. Let us now shift our focus to membranes. Given your extensive experience as a membrane specialist working with various types, what do you believe should be prioritised for enhancing membrane technology in the coming years?

Faisal: I tend to focus on the field of wastewater treatment, as that is where I have the most experience with membrane technologies. If I refer to membrane bioreactors, they have made significant progress over the last 20 years. Initially, there were few successful implementations of membrane bioreactor technology, but now we have numerous examples of full-scale applications.

We know that membranes in an MBR can last up to ten years, and the reliability of this technology has been well established. However, challenges continue to arise. For instance, we discuss contaminants like per- and polyfluoroalkyl substances (PFAS) and emerging contaminants such as microplastics, which need to be effectively removed. This highlights that there is still considerable potential for optimising the performance of membrane bioreactors. Another important area of research is pathogen removal during critical periods – with proper operating regimes, MBRs can be an effective barrier to pathogens. While there are various engineering research challenges, there are also practical issues, particularly in Australia. One significant limitation in implementing membrane bioreactor technology in the country is the shortage of trained personnel. We need skilled individuals who can maintain membranes, prevent fouling, and operate systems without causing damage to membranes and this should be prioritised. From an engineering perspective, there is an opportunity to arrange proper training for plant operators. This area presents additional avenues for research and improvement.

Amir: What is your opinion about designing new membranes with latest developed materials? Are you considering the development of new types of membranes as a good option for the future of membrane? Do you believe this field still holds potential for innovation, or do you think it has become saturated, leaving little room for creating membranes with, for example, 99% antifouling properties? What are your thoughts on this?

Faisal: I think it is still a worthwhile topic. You know there was a time that membrane fouling was the number one research topic in MBR, and that research could have been more organised through the lens of practicality. But fouling mitigation is still challenging and using the novel materials to study the antifouling properties of membranes is still a valid topic. As Professor Yamamoto often stated, we must be prepared to live with membrane fouling; complete eradication is unlikely. Instead, we should focus on effectively managing membranes. At the same time, if researchers can develop membranes that are more resilient to fouling, membrane manufacturers will greatly appreciate those contributions. This presents a promising direction for research.

Amir: Thank you, Faisal. I am pretty sure your insights are incredibly valuable to the membrane community. Now, I would like to learn more about the time you joined the MSA. When was the first time you became a member?

Faisal: I became a board member around 2019, but I was aware of the society even before that. My familiarity with the MSA began through my participation in its flagship conference, IMSTEC. My involvement with MSA is meaningful to me, as it aligns closely with my interests. Although I was not directly involved initially, I learned about the society after I moved to Australia around 2010 or 2011, which was shortly after MSA was established. However, it took some time before I became actively engaged.

Amir: We have a tradition of asking some quick questions, so here's the first one: If you could choose any city in the world to live in for the rest of your life, which city would it be?

Faisal: Wollongong.

Amir: Hold on. I was expecting somewhere in Japan and Tokyo.

Faisal: (With a bit of a smile) I wanted to answer it in a very practical way, Amir.

Amir: Yes, I know dear Faisal. Now, let's move on to the second question. Reflecting on your membrane journey since you began in 2002, if you had the chance to choose a different career outside of academia, what profession would you pursue?

Faisal: I would likely have pursued a career as a physician. Although this may not seem directly relevant, I spent much of my life preparing to become a doctor and even gained admission to medical school. Ultimately, I chose to study engineering instead, and I have no regrets about that decision. I truly enjoyed my life in engineering, but if given a second chance, I would probably have chosen to become a medical doctor.

Amir: Thank you very much, Professor Faisal Hai, for your time. It was fantastic to have you here and we highly appreciate your time. I am pretty sure our audience will enjoy this interview.

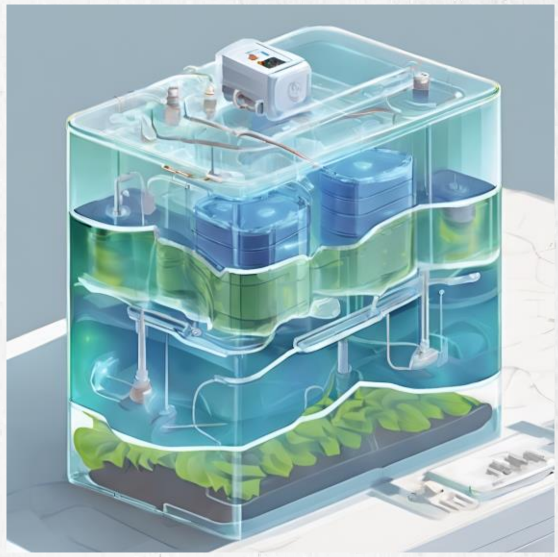
Faisal: Thank you Amir and thank you MSA.

The Promising Potential of Sustainable Salt Batteries with Reverse Electrodialysis

By: Hoseong Han and Mehdi Khiadani

Increasing concerns about atmospheric CO_2 levels caused by fossil fuel reliance have made reducing CO_2 emissions a critical global challenge, driving an urgent need to seek sustainable and green power energy. Salinity gradient power (SGP), commonly known as blue energy, is gaining significant attention as a promising resource within the realm of sustainable energy, alongside other technologies such as wind, solar (photovoltaic), tidal, biomass, and hydropower. In this technology, the electricity is generated by harnessing the salinity difference with a minimum concentration difference of 30–35 g/L, typically between seawater (~ 35 g/L) and river water (~ 0–1 g/L). According to the Reference Case of the International Renewable Energy Agency (IRENA), CO_2 emissions are expected to reach 35 Gt in 2050. However, Kuleszo et al. estimated that SGP could potentially reduce CO_2 emissions by 8 Gt per year.

Reverse Electrodialysis (RED) represents one of the most extensively studied technologies and holds significant global potential. It consists of alternating ion exchange membranes (IEM) (i.e. cation exchange membrane (CEM) and anion exchange membrane (AEM)), which are separated by spacers. Two different salinity solution streams flow alternatively between the ion exchange membranes, and ionic



RED battery by seawater and river water separated by IEMs

current is readily converted into electrical energy through redox reactions at the electrodes.

Since Pattle first proposed the concept of SGP using RED in 1954, RED pilot plants have been successfully tested in both the Netherlands and Italy. Due to the significant advancements in IEMs, spacers, and operating conditions, there has been critical progress toward the practical implementation of RED on a large scale. However, as of now, there are no field-scale RED plants.

Using commercial IEMs, RED achieves power densities ranging from 0.38 to 2.1 W/m^2 under various feed concentrations and room temperature conditions. In contrast, 2D materials and 3D nanoporous structures have demonstrated outstanding performance. For example, Siria et al. (2013) reported a power density of 4,000 W/m^2 using a single boron nitride nanotube at a pH of 11 and a concentration ratio of 1,000. Additionally, Zhang et al. discovered in 2020 that vertically aligned graphene oxide (GO) achieved a power density of 10.6 W/m^2 at a concentration ratio of 500, which is 1000 times higher than that of horizontally stacked GO structures. Zhao et al. integrated metal-organic frameworks (MOF) nanosheets into a polymer matrix of sulfonated poly (ether ether ketone)-sulfonated polysulfone (SPEEK/SPSF) and achieved a power density of up to 6.96 W/m^2 under a 50-fold concentration gradient. This represents a 2.58-fold increase in power density compared to systems without MOF nanosheets. Although newly developed IEMs often surpass commercial benchmarks, their performance often decreases during the scaling-up process from nano/micro-scales. This deterioration is attributed to limitations in the fundamental understanding of IEM fouling and electrochemical reactions on electrodes through IEMs, as well as manufacturing difficulties, which can potentially impair performance at a larger scale.

From an economic aspect, the RED system is estimated to have a lifespan of 25 to 40 years whereas IEMs have a considerably shorter lifespan of 7 to 10 years. Therefore, improving membrane stability is crucial to reduce maintenance costs and extend the overall system's operational efficiency. Future investigations in RED should aim to enhance net power density by employing robust, scalable, and anti-fouling IEMs, while also considering various natural components in feed water streams.

There is no doubt that RED provides significant advantages over unpredictable wind and solar power, particularly in terms of power grid management stability. To compete with the existing energy technologies, however, further technical and economic advancements in membrane development are necessary.

Janus Membrane Technology for Simultaneously Removing Organic Micropollutants and Heavy Metals

By: Amin Sarmadi and Mehdi Khiadani

In recent years, the global concern over drinking water safety has intensified, particularly with the increasing contamination from industrial pollutants. A new study, led by Dr. Huachun Lan, introduces an innovative solution: a low-pressure Janus membrane capable of addressing diverse water pollutants, including organic micropollutants and heavy metals. This groundbreaking work, published in Science Advances "A Janus membrane with electro-induced multi-affinity interfaces for high-efficiency water purification", represents a major leap forward in the field of water purification by simultaneously separating diverse types of organics and heavy metals from wastewaters via single-pass filtration.

Janus, named after the Roman god with two faces — one looking to the past and the other to the future — was first used in materials science by Pierre-Gilles de Gennes in 1991 (Read more). He applied the term to particles with chemically different sides. He primarily referred to these particles as amphiphilic. In his view, the interface of Janus particles exhibits similar properties to surfactants at water/air interfaces. However, in the case of Janus particle interfaces, chemical exchanges between the two sides are facilitated by the interstices between the two grains. He described this phenomenon as "a breathing skin". Since then, materials with asymmetric, dual properties have been called Janus, such as Janus particles, Janus nanosheets, or Janus membranes (Read more).

Traditional water purification membranes face significant challenges in removing both organic pollutants and heavy metals due to their limited permselectivity and efficiency. However, the newly developed Janus membrane, with its 100% regenerability using

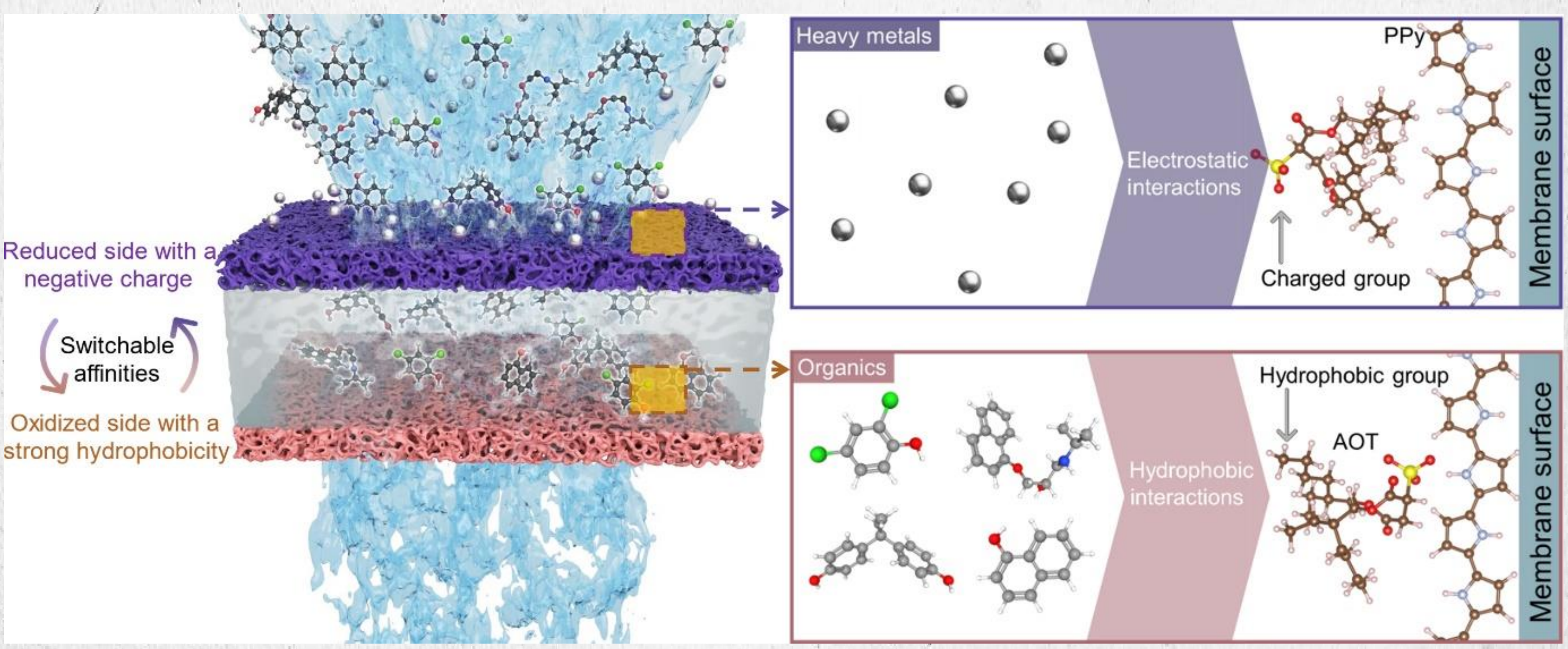


Figure 1. A schematic of the working principle of the electro-responsive Janus membrane (source).

Janus Membrane Technology for Simultaneously Removing Organic Micropollutants and Heavy Metals

electro-induced switching of interfacial affinity, overcomes these limitations. By tapping into hydrophobic and electrostatic interactions, the Janus membrane can simultaneously capture heavy metals, such as Pb^{2+}, and organic pollutants like 1-naphthol (1-NP), offering an efficient, single-pass filtration method.

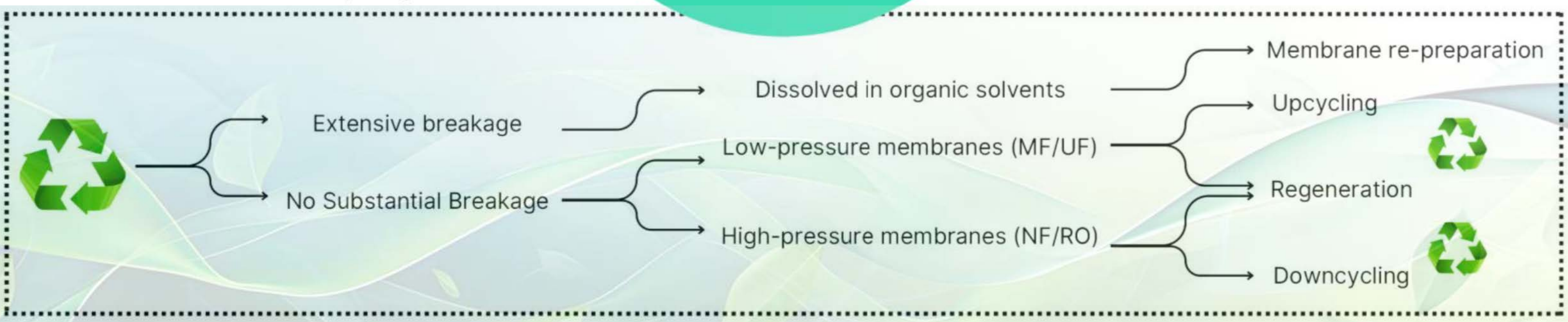
A key feature of the proposed Janus membrane is its multi-adsorptive interface with reversibly switchable affinities for different contaminants, enabled through the reversible redox reactions of polypyrrole. The compromised separation performance can be restored by applying an electrochemical potential of 1.5 V. This means that the Janus membrane can regenerate its performance without the need for chemical additives. A transient electrical stimulation is all that is required to reset the membrane's separation capabilities, allowing it to continue performing efficiently over time. The redox polymers applied on both sides of the Janus membrane resulted in this regenerability. This ability to regenerate can be a leap forward for sustainable water treatment technologies. This membrane showed a high removal efficiency of nearly 100% for both organic micropollutants and heavy metals, alongside a water flux of over 680 L/m²/h. Compared to commercial nanofiltration membranes, the Janus membrane reduces energy consumption by 98%, making it a highly sustainable option for large-scale water treatment. Another important feature of the Janus membrane is its ability to expose hydrophobic alkyl chains or negatively charged sulfonate anions from amphiphilic molecules [dioctylsulfosuccinate (AOT)] when triggered by an electric field. This exposure is crucial for creating hydrophobic surfaces and carries a charge (Figure 1). In membranes without electro-responsive interface, contaminants were not removed due to the lack of these functional surfaces.

To demonstrate the feasibility of this technology on an industrial scale, the researchers constructed a large-area Janus membrane using a continuous casting method. The economic analysis showed that the system not only performed better than current commercial alternatives but did so at a fraction of the energy cost — 0.01 kWh/m³, compared to 0.45 kWh/m³ for traditional NF membranes. As industries continue to release harmful pollutants into water systems, technologies like the Janus membrane offer a glimmer of hope. With further research, investment, and large-scale implementation, such breakthroughs could significantly improve the quality of drinking water and protect communities from unsafe waterborne contaminants.

Circular Economy for Reverse Osmosis Membranes

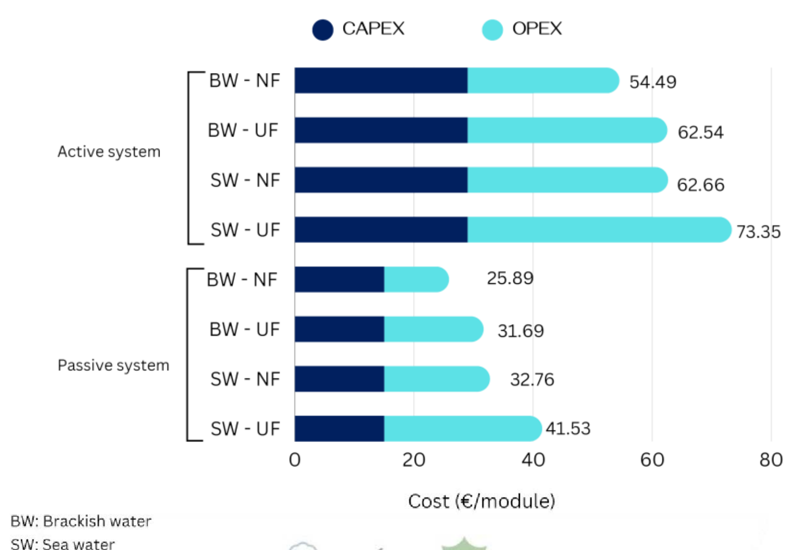
By: Mahsa Golmohammadi, Milton Chai

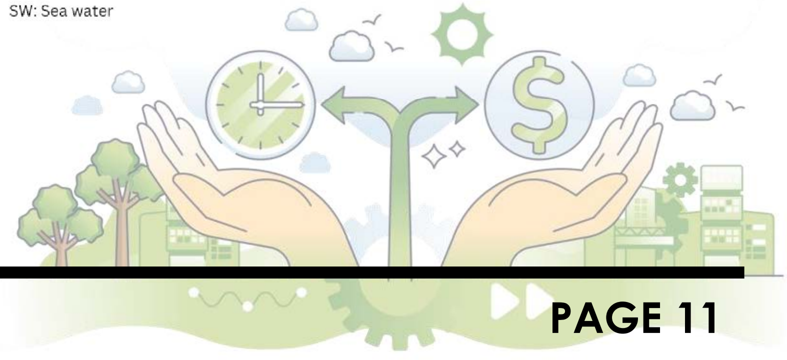
Reverse osmosis (RO) membranes are widely used in desalination technology all over the world. However, their relatively short service life of 5–10 years presents a significant challenge, with approximately 14,000 tonnes of these membranes being discarded as waste and sent to landfills each year. In line with circular economy principles, end-of-life RO membranes should be reused or recycled.



Technological framework for end-of-life membrane recycling (adapted from Tian et al.)

Senán-Salinas et al. conducted a life cycle assessment (LCA) and a cost-effectiveness economic analysis on two pilot designs for recycling end-of-life (EoL) RO membranes. The study considered two factors: the type of EoL RO membrane—either brackish water (BW) or seawater (SW)—and the recycling product, which could be either nanofiltration (NF) or ultrafiltration (UF). The cost-effectiveness analysis, measured in euros per module, was conducted for two pilot systems: active and passive. The key difference between the two systems lies in their internal recirculation. In the active system, internal recirculation is present, and hypochlorite solution is used for membrane cleaning. In contrast, the passive system lacks internal recirculation; instead, six modules are submerged in hypochlorite solution without stirring. The results showed that with a production rate of 300 modules per year, the capital expenditures (CAPEX) and operational expenditures (OPEX) for the passive system (€29.9–41.53 per module) were lower than for the active system (€54.4–73.35 per module). Therefore, the passive system proves to be more cost-effective than the active system.





PVDF and Ceramic Membranes: A Year after the EU PFAS Restrictions – What Does the Future Hold?

Image Ref: https://www.alsys-group.cm

By: Shokat Akbarnezhad and Milton Chai

Dr. Graeme Pearce, a membrane technology specialist with 40 years' experience in the membrane industry and the principal of Membrane Consultancy Associates, discusses the uncertain future of PVDF membranes, which are part of the polyfluoroalkyl substances (PFAS) family, under EU restrictions.

PVDF, widely used in the membrane industry, may not be exempt from these rules, making its continued use doubtful. As the debate continues, it seems likely that PVDF membranes will face challenges, possibly giving ceramic membranes an advantage. The market is indeed shifting towards ceramics. PVDF membranes have long been a leading choice for water treatment, but uncertainty around PVDF due to PFAS regulations is opening doors for ceramics. Some markets, like the UK, had already started moving away from polymeric membranes before the PFAS debate began. For instance, about half of the UK municipal market now uses ceramics, and a major ceramic drinking water plant is set to open near Birmingham soon. Early problems with first-generation polymeric membranes in the UK have led to lasting skepticism among some users.

Despite these issues being resolved, the negative experiences have left a strong impression, pushing decision-makers towards ceramic alternatives.

Comparing ceramics and PVDF membranes in the market has become complex. Early comparisons were straightforward, focusing on flow, rejection, and price for reverse osmosis and just flux and price for ultrafiltration. However, with ceramics offering higher flux but higher costs, the simple comparison of flux and price no longer suffices. Other factors, such as suitability and operational impacts, are now important. This complexity makes it challenging for ceramics to break into markets still considering both options, where sticking with the current choice is often seen as less risky. Ceramics thrive in industrial markets where performance outweighs simple flux and price comparisons, especially in tough conditions. To gain broader market appeal,

PVDF and Ceramic Membranes: A Year after the EU PFAS Restrictions – What Does the Future Hold?

ceramics should emphasize their strengths in areas where polymeric membranes fall short, as a level playing field approach may not fully showcase their advantages.

Ceramics are more effective than PVDF membranes in dealing with challenging feeds, as they can undergo aggressive cleaning to recover functionality. With climate change causing more extreme weather events, leading to issues like turbidity spikes and algal blooms, ceramics are better suited to handle these conditions. Additionally, ceramics take up less space due to higher flux and simpler system design. As environmental and health concerns about PFAS increase, ceramics are likely to become the preferred choice, potentially replacing PVDF in water treatment applications.

Source: www.aquatechtrade.com/news

Literatures-Financial Cost Analysis & Future Prospects

Ceramic membranes are crucial for industrial water treatment due to their superior performance and durability. Companies like Nanostone and Veolia have developed specialized ceramic membranes that, despite being more expensive than polymeric ones, offer better longevity, chemical resistance, and ease of maintenance. Though fouling remains a challenge, their overall durability makes them a preferred choice in harsh environments.

Cost is a significant factor in the industrial application of membranes. Polymeric membranes are much less expensive, ranging from $50 to $400 per square meter, compared to ceramic membranes, which cost between $500 and $2000 per square meter. However, ceramic membranes tend to be more cost-effective in the long run, particularly in harsh conditions, and a 10-year study by Nanostone Water Inc. found that ceramic membranes can reduce system costs by up to 55%. Ceramic membranes also offer greater mechanical, chemical, and thermal stability, ease of cleaning, and durability, making them a better option despite the higher initial cost.

The future of water separation technology will continue to involve both ceramic and polymeric membranes. Ceramic membranes, known for their superior thermal and mechanical strength, will likely maintain an edge over polymeric membranes in terms of durability, permeability, and ease of cleaning at high temperatures. To make ceramic membranes more viable for larger applications, costs must decrease, and improvements in nanomaterials should focus on enhancing antifouling properties, permeability, and chemical stability.

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How do Membranes Play a Role in Green Hydrogen Production?

By: Shiyang Huang and Milton Chai

Australia has one of the world's largest hydrogen project pipelines, with over 100 projects announced since 2019 and an estimated value of over $225 billion. The National Hydrogen Strategy 2024 has stated that Australia will need to actively compete with other nations to be considered a global hydrogen leader, and the economic opportunities include using hydrogen as the energy carrier for export or as a chemical or heat input to the production of green metals, ammonia and low-carbon liquid fuels. So, how can the membrane community support the competition?

It turns out membranes have been an essential part of green hydrogen electrolysers. The two main commercialised green hydrogen production processes - proton exchange membrane (PEM) electrolysis and alkaline water electrolysis (AWE) - rely on an ion-exchange membrane (or a “diaphragm”) to separate the O_2 and H_2 gases on the two sides of the membranes while selectively allowing ions to pass through the membrane to complete the electrolysis process.

Gas crossover through the AWE membranes is a major safety problem. The hydrogen-in-oxygen level should be maintained below 2% for a low explosive risk. Hydrogen Insight has recently reported that the electrolysers at Sinopec’s 260 MW Kuqa facility in China failed to meet the promised operating range of 30 to 100% of its nameplate yield due to the hydrogen crossover issue. The problem occurs when the input electricity coming from renewable energy is less than the nameplate. While the oxygen generation is reduced almost linearly, the hydrogen crossover is affected more mildly and remains relatively high. This means that the proportion of hydrogen to oxygen can rise to dangerous levels, which prompted the plant to change the minimum production to 50% of its maximum output for safety reasons. Some electrolysers will be forced to turn down when the electricity input is low to ensure the others operate at 50% of their nameplate yield. However, turning the stacks on and off more frequently will increase their degradation and result in a shorter lifespan of the electrolysers.

PEM membranes such as Nafion® and Aquivion® are well established. PEM membranes have dense layers and lower cell resistance, which allow them to operate at higher differential pressures and reach higher current densities. The higher current densities make the electrolyser more efficient and safer. However, the main drawback of PEM is the requirement of expensive catalysts such as platinum and iridium, which makes the CAPEX of PEM electrolysis relatively high.

Another factor that may strike the green hydrogen industry in the future is the use of perfluorinated materials for the membranes. PFAS restriction can be catastrophic to the emerging hydrogen sector as there is so far no easy substituents of such membranes for electrolysers.

In addition to above ion-passing membranes, hydrophobic membranes that are typically used for membrane distillation have been added to the electrolyser game recently by a research group in China. Published in Nature in 2022, the research group used a hydrophobic membrane to achieve electrolysis directly from seawater (Fig. 1). Water vapour transporting from the seawater to the "self-dampening electrolyte" is driven by the vapour pressure differential. The benefit of this is to reduce the cost of desalination that produces ultrapure feed water for electrolysis.

According to the report from CGTN, a demonstration system at the Xinghua Bay offshore wind farm was tested and stable for more than 240 hours. Mitigating membrane fouling and improving the productivity may pave the way of this technology to commercialisation.

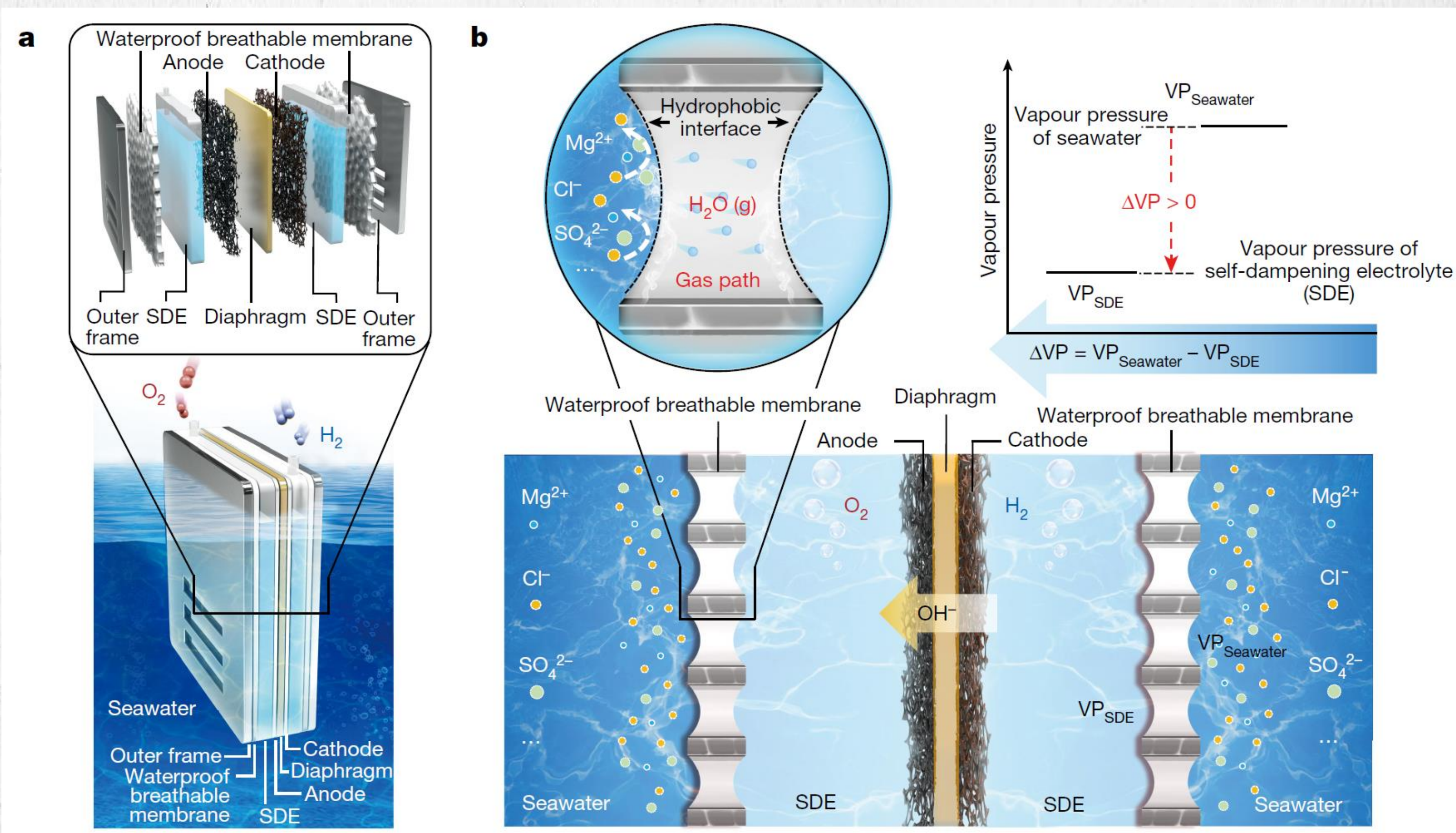

Fig. 1: A membrane-based seawater electrolyser for hydrogen generation (source)

Upcoming Membrane Events

CURRENT EVENTS	DATE OF EVENT	ABSTRACT SUBMISSION
FILTECH 2024 Cologne, Germany filtech.de	12 – 14 November 2024	**Closed**
IDRA World Congress – Addressing Water Scarcity Abu Dhabi, UAE wc.idadesal.org	8 – 12 December 2024	**Closed**
19th Aachener Membran Kolloquium (AMK) 2024 Aachen, Germany conferences.avt.rwth-aachen.de/AMK/	3 – 5 December 2024	**Closed**
MSA Annual Meeting and Conference 2024 Sydney, Australia membrane-australasia.org/msa-amc2024	9 – 11 December 2024	**31 August 2024**
2025 Membrane Technology Conference and Exposition (MTC25) California, USA awwa.org/Events-Education/Membrane-Technology	24 – 27 February 2025	**Closed**
NAMS 2025 Tennessee, USA membranes.org/nams2025/	24 – 28 May 2025	**TBD**

MSA Newsletter Taskforce

Meet our newsletter team for this September edition!

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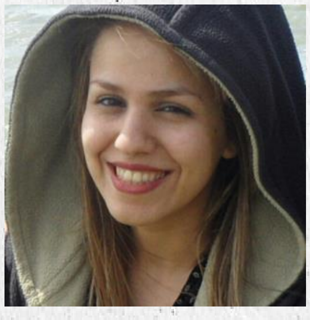

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