Photocatalytic–pervaporation using membranes based on organo-silica for wetland saline water desalination

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Photocatalytic–pervaporation using membranes based on organo-silica for wetland saline water desalination

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This study aims to analyse the morphological structure of organo-silica membranes and investigate their use and performance in a hybrid photocatalytic–pervaporation process for the desalination of wetland saline water. When applied to such raw water sources, this hybrid process – which is shown to have a number of benefits, including excellent water flux and salt rejection, and reduced membrane fouling – has the potential to produce clean water that is often needed in both developing and developed countries worldwide.

Water is essential for life on earth, but searching on a daily basis for sources of clean water can be a challenge.

Wetland saline water potentially could be considered as a usable water source as it is often abundantly available. However, it is essential that its high salt content is removed before it can be used as potable water.

One way of addressing this problem is to use a hybrid process of photocatalytic–pervaporation, based on organo-silica membranes. Researchers at Mangkurat University, South Kalimantan, Indonesia, are studying the morphological structure of organo-silica membranes and investigating their use and performance in a hybrid photocatalytic–pervaporation process for the desalination of wetland saline water, as this article explains.

Hybrid process

In the research carried out, organo-silica membranes were prepared by the sol–gel method, using tetraethyl orthosilicate (TEOS) and a carbon template from banana pectin, at a concentration of 0.5%, which was calcined at 300°C.

The hybrid process of photocatalytic–pervaporation was conducted under vacuum pressure, using an ultraviolet (UV) lamp for illumination and employed titanium dioxide (TiO_2) as a catalyst (at 0.02%, 0.05% and 0.08%) in the feed.

The morphological structures were studied and determined using scanning electron microscopy (SEM) and Brunauer–Emmett–Teller (BET) analysis, whilst the performance of the membrane was examined by evaluating the water flux and salt rejection.

The results show that the organo-silica membrane has a mesoporous structure, with a top layer thickness of ~2 µm.

The photocatalytic process applied to the desalination of wetland saline resulted in excellent water flux – at 2.7 times higher than without the photocatalytic process (organo-silica 0.5% of pectin). Overall, the membrane possessed excellent water flux, at 9.93 $kg.m^{-2}.hr^{-1}$, and extremely good salt rejection, in excess of 99%.

The combination of both photocatalytic and pervaporation, using an organo-silica membrane, is expected to inhibit the occurrence of fouling and enhance membrane performance during the desalination of wetland saline water.

Concerns worldwide

Nowadays, the distribution of clean water is a major concern for both developed and developing countries.

Wetlands can be used as a raw source of water to fufil the need for clean water. However, as the tidal mouth or estuary of a large river meets the sea along the coastline, sea-water intrusion into wetland water makes this resource highly saline (3.5 wt%).[1]

One of the ways in which this water can be used is to treat it by using desalination technology. This membrane-based process has a number of advantages in that it:

- takes place at room temperature;
- can be done continuously and has a varying nature;
- can be adjusted as needed; and
- is environment-friendly.[2–4]

Organo-silica membranes

Organo-silica membranes, which are widely used for desalination, are made from silica and incorporate carbon in order to increase membrane strength.[5–10]

According to Elma,[11–13] the carbon–silica membrane has a large and stable flux for water. Fouling is one of the problems often faced by researchers who are investigating the use of membranes in water treatment. Fouling is caused by the presence of humic or organic material in wetland saline water, which eventually decreases membrane performance.[14–16]

Photocatalysis

Photocatalysis can be used in purification processes. Because it degrades organic compounds,

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such as humic acid in peat water, it can be used in wastewater treatment.[17, 18]

Photocatalysis, using TiO_2 as a catalyst, can degrade organic matter and reduce organic material content in peat water by 89.4%.[19] This indicates the potential of this process in the decomposition of organic materials, found in swamp water, into simpler compounds.

In addition, the use of illumination using UV light can eliminate 99% of pathogenic bacteria and 99% of viruses,[20] which further improves the quality of the results of wetland saline water treatment.

The aim of this research is to further improve results – enhancing water flux and salt rejection – by combining the photocatalytic use of UV light and the TiO_2 catalyst.

Enhancing membrane performance

The application of a photocatalytic process to a membrane-based treatment enhances membrane performance.[21]

In this regard, TiO_2 is often used as a photocatalytic catalyst because it is environment-friendly.[22] Also, using TiO_2 can decrease the activation energy required to accelerate the reaction and can oxidise organic pollutants into carbon dioxide and water.[23]

The appropriate selection of membrane materials is also an important factor in reducing process costs without compromising the membrane's capability.[24] Therefore, this research focuses on the performance of organo-silica membranes, in terms of water flux and salt rejection, in combination with UV radiation using photocatalysis with a variation (at 0.02%, 0.05% and 0.08%) in the amount of TiO_2 catalyst used, in order to treat wetland saline water.

Experimental work

Chemicals and materials

A silica–pectin membrane was prepared according to techniques discussed in previous work by Elma, *et al.*[25]

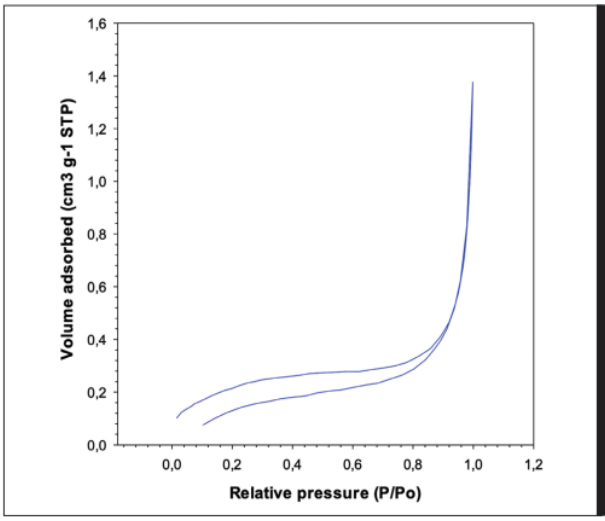

Figure 1. Plot of N_2 sorption isotherms for the calcined xerogels.

A NaCl solution of 3.5 wt% was used as the feed to represent "sea-water" and liquid nitrogen for cooling water vapour, condensing it to a liquid. In addition, an 18 W UV lamp was used in the photocatalytic process.

Photocatalytic–pervaporation

The process of desalination using the method of pervaporation was done with deionised water and wetland saline water.

An initial sample of wetland saline water was characterised by considering total dissolved solids (TDS), UV_{254} absorbance and conductivity. A vaporisation test was then conducted in combination with photocatalysis – the photocatalytic–pervaporation process – using the membrane that had been developed and produced for treating the wetland saline water.

The water flux and salt rejection were measured to determine the photocatalytic effect on the desalination process of the wetland water.

Results and discussion

Wetland saline water characteristics

The water sample was collected during the dry season from the village Muara Halayung, subdistrict Beruntung Baru, Banjar Regency, South Kalimantan, Indonesia.

The pH of the wetland saline water used in this study is relatively neutral, with a pH of 7.82; dissolved organic carbon (DOC) of 16.52 $mg.l^{-1}$; TDS of 7260 $mg.l^{-1}$ and conductivity of 17.42 $mS.cm^{-1}$.

Based on the Indonesia Ministry of Health Regulation No 492 for 2010, setting out the quality requirements of drinking water, the TDS and conductivity should be lower than 700 $mg.l^{-1}$ and 2.5 $mS.cm^{-1}$, respectively. The DOC represents the organic content in the wetland saline water.

Xerogel characterisation and membrane morphology

The physical and textural properties of organo-silica xerogels were studied using nitrogen sorption BET analysis, which provides important qualitative data regarding the microstructure of the resulting molecular sieving membranes. A plot of the N2 sorption isotherms for the calcined xerogels is shown in **Figure 1**.

According to the IUPAC classification, the isotherm belongs to type IV[26] which indicates that the surface structure is mesoporous.[27]

A rapid elevation in the volume of nitrogen adsorbed at high relative pressure and a

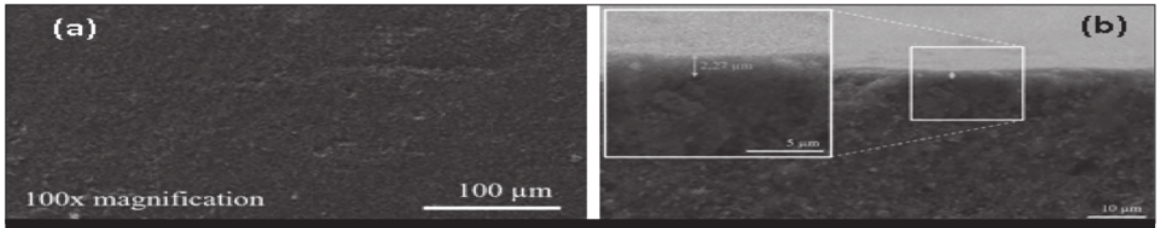

Figure 2. Scanning electron microscope images of the organo-silica membrane, showing the top surface (a); and cross-section, with the inset revealing a close-up view of the respective morphology (b).

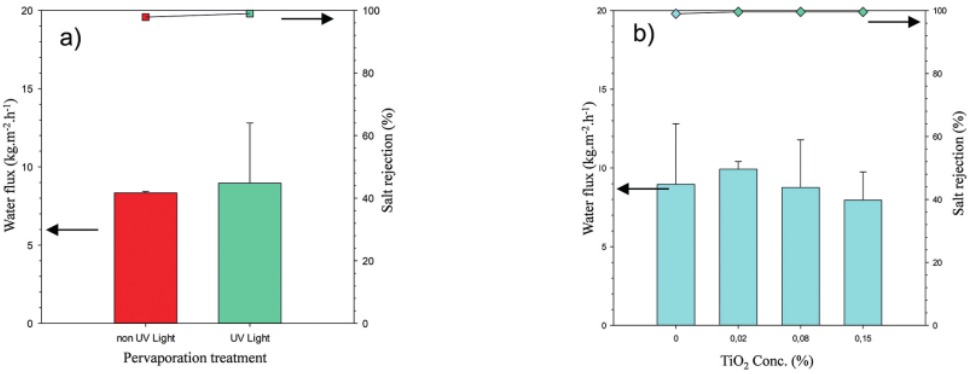

Figure 3. The performance of the organo-silica membrane (0.5% pectin concentration) without the TiO_2 catalyst (a); and photocatalytic–pervaporation membrane performance – with variation in the TiO_2 catalyst – for wetland saline water at 25°C.

hysteresis loop, as found in the present case, are characteristics of mesoporous materials. The prominent characteristic of type-IV isotherms is exhibited with a distinct hysteresis loop of H1 in the P/P_0 range of 0.4–1.0, which implied the presence of relatively large mesopores in the frameworks.[28]

Figures 2a & b show representative scanning electron microscope (SEM) images of a synthesised organo-silica membrane and the underlying alumina substrate.

The top layer and the macroporous substrate layer, between the cross-section of the membrane, shows that there is a lack of clear distinction.

The SEM image in **Figure 2a** indicates that there are no cracks in the membrane surface. These would be caused by pore differences between the top layer and membrane support alumina which has a larger pore size of 100 nm.[29, 30]

Membrane thickness

In addition, differences in both the calcination techniques and temperatures used, affect membrane thickness.

The thickness of the organo-silica membranes can be seen in **Figure 2b**. The SEM image shows an organo-silica membrane (0.5% pectin) calcined at 300°C and ~2 µm thickness.

Compared with the calcination technique that employs conventional thermal processing (CTP), resulting in a thickness in the region of 30–50 nm,[31, 32] the thickness of this membrane, prepared by rapid thermal processing (RTP), is thicker.[2, 3, 29, 33–36]

This is because the application of the RTP technique makes the solvent and water in the silica matrix evaporate completely, whilst they are still trapped in the pores in the CTP calcination process.[37]

Even so, the RTP technique has the advantage of being able to reduce the costs and time associated with membrane fabrication. In addition, the RTP technique can produce larger clusters of siloxane and membrane pores, and potentially increase membrane hydro-stability and the resulting permeate flux.[38–40]

Membrane performance

Water flux and salt rejection measurements are presented in **Figure 3a**.

Referring to Figure 3a, the water flux increases by 6.92%, with the application of UV light and without the addition of the TiO_2 catalyst, compared with the performance of the organo-silica membrane without UV light.

The flux of the non-illuminated membrane, without the reported UV lamp, amounted to 8.96 $kg.m^{-2}.h^{-1}$, compared with flux of 8.34 $kg.m^{-2}.h^{-1}$ achieved in previous studies when a less powerful UV lamp was used.

In addition, in this research, the results show that salt rejection also increased from 97.85% to 98.99%. This increase is caused by the absorption of photon energy through illumination using UV light, which results in an oxidation–reduction reaction. In these cases the radiation results in the process of photodegradation without the addition of the TiO_2 catalyst.[37, 38]

The addition of the TiO_2 catalyst causes a decrease in the TDS in the feed water, which eventually results in better membrane performance compared with when just UV light is used.

This is achieved through a decrease in the TDS content in wetland saline water by 19.28% (with an initial measurement result of 5400 mg/l), which reduces the content of impurities in the water. These impurities affect the membrane greatly as they can reduce the available volume in its pores, which results in a decrease in water flux.[14]

TiO_2 catalyst

Figure 3b shows a comparison between photocatalysis with and without the use of the TiO_2 catalyst. It can be seen that when the catalyst is added there is slight increase and decrease in water flux.

With the addition of TiO_2, at a 0.02% concentration, the water flux increases by 9.77% of the yield without TiO_2 addition, to 8.96 $kg.m^{-2}.hr^{-1}$. This is because the TiO_2 catalyst is "charged" with UV light which occurs with the excitation of electrons and causes the interaction.

Interactions that occur form the hydroxyl radical because of the illumination. Such hydroxyl radicals interact with organic matter in the degradation process.[23]

These radicals will be formed continuously whilst TiO_2 is illuminated with UV light. The radical will "attack" pollutants in the water so that they are degraded.

With the addition of TiO_2, at concentrations of 0.08% and 0.15%, the water flux dropped by a percentage consecutive decrease of 2.23% and 11.16%, respectively.

This is because the catalyst suspension of the solution is too large and blocks the UV light. Consequently, the production of hydroxyl radicals, which are active species in the photodegradation process, will also decrease.

Decreased photodegradation also can be caused by the deactivation of the catalyst's active site as it is covered by other catalytic sites that are in its underlying state (ground state). It also may be because of the sedimentation of catalysts during photodegradation – so that there is a catalyst surface that does not absorb light, or organic compounds in the wetland saline water. In this case the membrane becomes fouled and water flux declines.

In addition, the results show that salt rejection, which is reported in Figure 3, has increased as the concentration of TiO_2 weight increases.

Conclusion

This research has shown that the TiO_2 catalyst has an influence on water flux as well as salt rejection in the photocatalytic–pervaporation process.

The photocatalytic process results in excellent water flux for wetland saline water – at 2.7 times higher than without photocatalytic–pervaporation. The highest photocatalytic membrane performance achieved, with a water flux of 9.93 $kg.m^{-2}.hr^{-1}$ and salt rejection of 99.59%, was for the 0.02% addition of the TiO_2 catalyst.

The photocatalytic process reduces membrane fouling during the pervaporation process and enhances the performance of organo-silica membranes used in the desalination of wetland saline water.

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References

1. M. Elma, N. Riskawati and Marhamah, Silica membranes for wetland saline water desalination: performance and long-term stability, 'IOP Conference Series: Earth and Environmental Science', Vol. 175, No. 1, 012006, IOP Publishing, 2018.
2. M. Elma, Z. L. Assyaifi and Hairullah, Pembuatan silica thin film sebagai pelapis membran dari prekursor TEOS (tetra ethyl ortosilicate), *Quantum: Jurnal Inovasi Pendidikan Sains*, Vol. 8, No. 2, pp. 78–82, 2018.
3. A.E. Pratiwi, M. Elma, M. D. Putra, A. Mirwan, A. Rahma and E. L. A. Rampun, Innovation of carbon from pectin templated in fabrication of interlayer-free silica-pectin membrane, *Jurnal Kimia Sains dan Aplikasi*, Vol. 22, No. 3, pp. 93–98, 2019.
4. M. Elma *et al.*, Development of hybrid and templated silica-p123 membranes for brackish water desalination, *Polymers*, Vol. 12, No. 11, p. 2644, 2020.
5. M. Elma *et al.*, Carbon templated strategies of mesoporous silica applied for water desalination: A review, *Journal of Water Process Engineering*, Vol. 38, 101520, December 2020.
6. A. Rahma, M. Elma, A. E. Pratiwi and E. L. Rampun, Performance of interlayer-free pectin template silica membranes for brackish water desalination, *Membrane Technology*, No. 6, pp. 7–11, 2020.
7. R.A. Lestari *et al.*, Organo silica membranes for wetland saline water desalination: effect of membranes calcination temperatures, E3S Web of Conferences, EDP Sciences, (2020), 07006.
8. A.E. Lestari, M. Elma, S. Rabiah, E.L.A. Rampun, A. Rahma, and A.E. Pratiwi, Performance of mesoporous organo silica membrane for desalination, 'Materials Science Forum', Vol. 1000, pp. 285–292, 2020, Trans Tech Publications Ltd.
9. E.L. Rampun, M. Elma, A. Rahma, and A.E. Pratiwi, Interlayer-free silica–pectin membrane for sea-water desalination, *Membrane Technology*, No. 12, pp. 5–9, 2019.
10. Y. Mawaddah, L.S. Wati, E.L.A. Rampun, A. Sumardi, A.E. Lestari and M. Elma, FTIR studies of the TEOS/TEVS xerogel structure using rapid thermal processing method, *Konversi*, Vol. 9, No. 2, 2020.
11. M. Elma and H. Setyawan, Synthesis of silica xerogels obtained in organic catalyst via sol gel route, 'IOP Conference Series: Earth and Environmental Science', Vol. 175, No. 1, 012008, IOP Publishing, 2018.
12. R.A. Lestari *et al.*, Functionalization of Si–C using TEOS (tetra ethyl ortho silica) as precursor and organic catalyst, E3S Web of Conferences, EDP Science (2020), 07008.
13. M. Elma, A.E. Pratiwi, A. Rahma, E.L.A. Rampun and N. Handayani, The performance of membranes interlayer-free silica-pectin templated for seawater desalination via pervaporation operated at high temperature of feed solution, 'Materials Science Forum', Vol. 981, pp. 349–355, 2020, Trans Tech Publications Ltd.
14. A. Rahma, M. Mahmud and C. Abdi, Pengaruh Pra-Perlakuan Adsorpsi Karbon Aktif terhadap Fouling Membran Ultrafiltrasi Polisulfon (Uf-Psf) pada Penyisihan Bahan Organik Alami (BOA) Air Gambut, Universitas Lambung Mangkurat, 2018.
15. M. Elma, A. Rahma, A.E. Pratiwi, and E.L. Rampun, Coagulation as pretreatment for membrane-based wetland saline water desalination, *Asia–Pacific Journal of Chemical Engineering*, p. e2461, 2020.
16 Mahmud *et al.*, Effect of two stages adsorption as pre-treatment of natural organic matter removal in ultrafiltration process for peat water treatment, 'Materials Science Forum', Vol. 988, pp. 114–121, 2020, Trans Tech Publications Ltd.
17. T. Zhang, M. Elma, F. Xie, J. Motuzas, X. Zhang and D. K. Wang, Rapid thermally processed hierarchical titania-based hollow fibres with tunable physicochemical and photocatalytic properties, *Separation and Purification Technology*, Vol. 206, November 2018, pp. 99–106
18. D.K. Wang *et al.*, Physicochemical and photocatalytic properties of carbonaceous char and titania composite hollow fibers for wastewater treatment, *Carbon*, Vol. 109, pp. 182–191, 1 November 2016.
19. S.F. Jayadi, L. Destiarti and B. Sitorus, Pembuatan Reaktor Fotokatalis dan Aplikasinya untuk Degradasi Bahan Organik Air Gambut menggunakan Katalis TiO_2, *Jurnal Kimia Khatulistiwa*, Vol. 3, No. 3, 2014.
20. M. Abbaszadegan *et al.*, The disinfection efficacy of a point-of-use water treatment system against bacterial, viral and protozoan waterborne pathogens, *Water Research*, Vol. 31, No. 3, pp. 574–582, 1997.
21. D.K. Wang, M. Elma, J. Motuzas, W.-C. Hou, F. Xie and X. Zhang, Rational design and synthesis of molecular-sieving, photocatalytic, hollow fiber membranes for advanced water treatment applications,' *Journal of Membrane Science*, Vol. 524, pp. 163–173, 2017.
22. R. Molinari, P. Argurio, and L. Palmisano, 7 – Photocatalytic membrane reactors for water treatment, in 'Advances in Membrane Technologies for Water Treatment', A. Basile, A. Cassano and N. K. Rastogi (Eds. Oxford), Woodhead Publishing, 2015, pp. 205–238.
23. S.U. Ramadhani, L. Destiarti and I. Syahbanu, Degradasi Bahan Organik pada Air Gambut dengan Fotokatalis TiO_2 Lapis Tipis, *Jurnal Kimia Khatulistiwa*, Vol. 6, No. 1, 2017.
24. M. Elma *et al.*, Fabrication of interlayer-free silica-based membranes – effect of low calcination temperature using an organo-catalyst, *Membrane Technology*, No. 2, pp. 6–10, 2019.
25. M. Elma, F.R. Mustalifah, L. Suryani, E.L.A. Rampun and A. Rahma, Wetland saline water and acid mine drainage desalination by interlayer-free silica pectin membrane from banana peels, *Nusantara Science and Technology Proceedings*, pp. 271–279, 2020.
26. A. Khatoon and R.A.K. Rao, Efficient Cu (II) adsorption from aqueous medium using organic–inorganic nanocomposite

material, *Groundwater for Sustainable Development*, Vol. 9, 100214, 2019.
27. S. Yurdakal, C. Garlisi, L. Özcan, M. Bellardita, and G. Palmisano, Chapter 4 – (Photo)catalyst characterization techniques: adsorption isotherms and BET, SEM, FTIR, UV–Vis, photoluminescence and electrochemical characterizations, 'Heterogeneous Photocatalysis', Elsevier, 2019, pp. 87–152.
28. X. Wang, Y. Pei, M. Lu, X. Lu and X. Du, Highly efficient adsorption of heavy metals from wastewaters by graphene oxide-ordered mesoporous silica materials, *Journal of Materials Science*, Vol. 50, No. 5, pp. 2113–2121, 2015.
29. M. Elma *et al.*, Desalination process via pervaporation of wetland saline water, 'IOP Conference Series: Earth and Environmental Science', Vol. 175, pp. 1–6, IOP Publishing, 2018.
30. M. Elma and G. S. Saputro, Performance of cobalt-silica membranes through pervaporation process with different feed solution concentrations, 'Materials Science Forum', Vol. 981, pp. 342–348, 2020, Trans Tech Publications Ltd.
31. M. Elma, C. Yacou, J. Diniz da Costa and D. Wang, Performance and long term stability of mesoporous silica membranes for desalination, *Membranes*, Vol. 3, No. 3, pp. 136–150, 2013.
32. M. Elma, H. Setyawan, A. Rahma, A. Pratiwi and E.L A. Rampun, Fabrication of interlayer-free P123 carbonised template silica membranes for water desalination: conventional versus rapid thermal processing (CTP vs RTP) techniques, 'IOP Conference Series: Materials Science and Engineering', Vol. 543, No. 1, 012076, IOP Publishing, 2019.
33. M. Elma, R. A. Fitriani, and R. Hidayati, Silica P123 membranes for desalination of wetland saline water in South Kalimantan, 'IOP Conference Series: Earth and Environmental Science', Vol. 175, No. 1, 012007, IOP Publishing, 2018.
34. M. Elma *et al.*, Fabrication of interlayer-free silica-based membranes–effect of low calcination temperature using an organo-catalyst, Membrane Technology, No. 2, pp. 6–10, 2019.
35. Z.L. Assyaifi *et al.*, Membran Silika dari Precursor TEOS (tetra ethyl ortho silicate) untuk Memproduksi Air Bersih yang Terindikasi Garam di Daerah Gambut, ed. Indonesia: Kementerian Riset, Teknologi, dan Pendidikan Tinggi, 2017.
36. E.L.A. Rampun, M. Elma, I. Syauqiah, M.D. Putra, A. Rahma, and A. E. Pratiwi, Interlayer-free Membran Silika Pektin untuk Pervaporasi Air Rawa Asin, *Jurnal Kimia Sains dan Aplikasi*, Vol. 22, No. 3, pp. 99–104, May 2019.
37. A. Rahma, M. Elma, E.L.A. Rampun, A.E. Pratiwi, A. Rakhman and Fitriani, Rapid thermal processing and long term stability of interlayer-free silica-P123 membranes for wetland saline water desalination, *Advanced Research in Fluid Mechanics and Thermal Sciences*, Vol. 71, No. 2, pp. 1–9, July 2020, (art no. 1).
38. S. Wang, High performance ES40-derived silica membranes for desalination, PhD Thesis, School of Chemical Engineering, The University of Queensland, 2016, (https://doi.org/10.14264/uql.2016.532).
39. M. Elma, R. Nur and Marhamah, silica membranes for wetland saline water desalination: performance and long term stability, 'IOP Conference Series: Earth and Environmental Science', Vol. 175, No. 1, 012006, IOP Publishing, 2018.
40. M. Elma *et al.*, Organo-silica membrane for brine water pervaporation, 'IOP Conference Series: Earth and Environmental Science', Vol 473, 012129, IOP Publishing, 2020.

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PATENTS

Cross-flow filtration device

Applicant: **Sartorius Stedim Lab Ltd**

A cross-flow filtration device that is designed to be applied to a pressurised feed liquid forms the subject of this patent. The device comprises a filter membrane and flow channel, for the pressurised feed liquid. The liquid flows in the channel that extends in a path over a retentate surface of the membrane, such that its direction of flow (in the channel) is tangential to the retentate surface, and filtrate derived from the feed liquid passes through the membrane leaving retentate liquid in the flow channel. Also included in this design is a collection chamber for the filtrate. This is formed on an opposite filtrate surface of the membrane. The cross-flow filter further comprises a sealed housing comprising a retentate side and a filtrate side which enclose the flow channel, filter membrane and collection chamber. The device also incorporates flow-channel guide walls that are on an inner surface of the retentate side of the housing. These walls are configured to form a fluid-tight seal with the filter membrane. In doing so, they define the path of the flow channel over the retentate surface of the membrane.

Patent number: WO/2020/173762
Inventors: A. Gilbert, M. Purshouse, M. Bates, C. Biddell, A. Green and T. Davidson
Publication date: 3 September 2020

Pervaporation apparatus for glycerol concentration

Applicant: **Nanjing Weixin Environmental Protection Equipment Technology Research Institute Co Ltd, China**

This invention concerns a hollow-fibre pervaporation membrane-based method for concentrating glycerol. It involves a series of steps. In the first, ultrafiltration (UF) is performed on a glycerol crude liquid with a concentration of 20–50% to filter out total suspended solids (TSS), in order to obtain a filtered clear liquid. This clear liquid is heated, whilst its temperature is controlled between 60°C and 100°C. A hollow-fibre pervaporation membrane is then used to dehydrate and concentrate the filtered clear liquid so as to recover 92–95% of the glycerol. The hollow-fibre pervaporation membrane is sequentially formed – from the inside to outside – of an inner support layer; a selected separation layer; and an outer protective layer. The selected separation layer is arranged between the inner support and outer protective layers. The outer protective layer is hydrophilic. Also discussed is an apparatus based on the hollow-fibre pervaporation membrane, which is used for glycerol concentration.

Patent number: WO/2020/173510
Inventors: Y. Tang, J. Liu and W. Wang
Publication date: 3 September 2020

System for performing RO with integrated pump storage

Applicant: **Fluid Equipment Development Co Llc, USA**

This disclosure relates generally to reverse osmosis (RO) systems, but more specifically to methods and systems for using an elevated reservoir for supplying feed for RO. An RO system is described that includes a first pretreatment unit and a fluid source located below the reservoir. A housing contains an RO membrane, and a first turbocharger includes a first pump and turbine portions. The first pump portion receives feed fluid from the first pre-

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