Zwitterionic poly(arylene ether sulfone) membranes for treatment of Reverse Osmosis brine by pervaporation

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Research Objective

Seawater Reverse Osmosis (SWRO) has been extensively used to purify seawater to obtain potable water. The reject from SWRO, a concentration brine solution can be further purified by techniques like pervaporation to increase water recovery and mitigate harmful environmental effects of brine disposal. This research proposes novel zwitterionic poly(arylene ether sulfone) membranes as membranes for pervaporation desalination of RO brine. The research aligns with Ira A. Fulton Schools of Engineering research theme of sustainability and falls under the research focus on water purification

Introduction

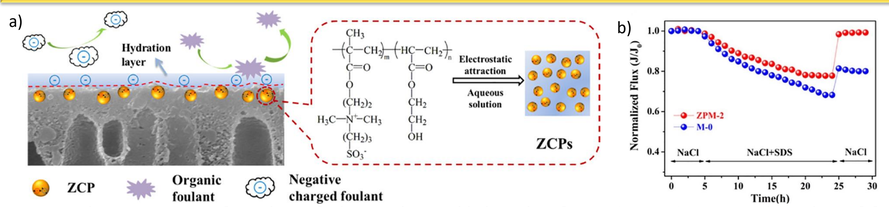

Fig 1: a) Representation of membrane fouling mechanism b) Flux values for a zwitterion-incorporated membrane [1]

- Fouling is the accumulation of particles on the membrane surface [2]
- Decreases flux, selectivity, membrane longevity
- Increases costs of
- Increasing membrane hydrophilicity introduces a hydration layer on the membrane surface [3]
- Increases fouling resistance and water flux

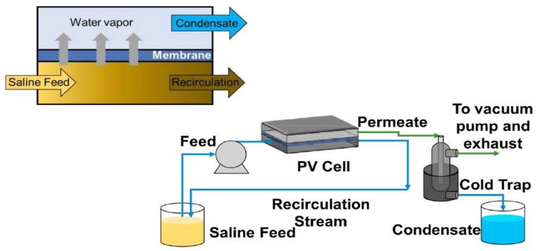

Fig 2: Schematic of pervaporation setup

Pervaporation is a separation process where the separation is based on the difference in partial pressures of the components of the mixture. It is an energy intensive process where the only energy required is the latent heat of evaporation to evaporate the permeate.[4]

Polymer Synthesis

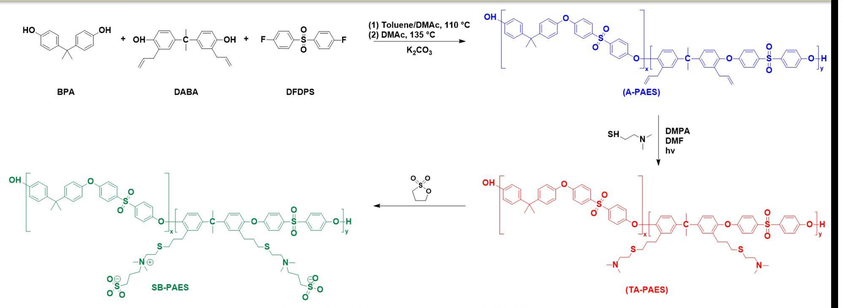

Fig 3: Reaction scheme of SB-PAES

Synthesis of Sulfobetaine modified – poly(arylene ether sulfone) (SB-PAES):

- Synthesis of allyl functionalized-PAES (A-PAES) with 2,2- diallyl bisphenol A (DABA) as one of the monomers.
- Thiol-ene click reaction between A-PAES and 2-dimethyl amino ethanethiol to synthesize tertiary amine modified – PAES (TA-PAES)
- Synthesis of sulfobetaine modified-PAES (SB-PAES) by a reaction between TA-PAES and 1,3-propane sultone.
- Charge content controlled by changing DABA:BPA ratio

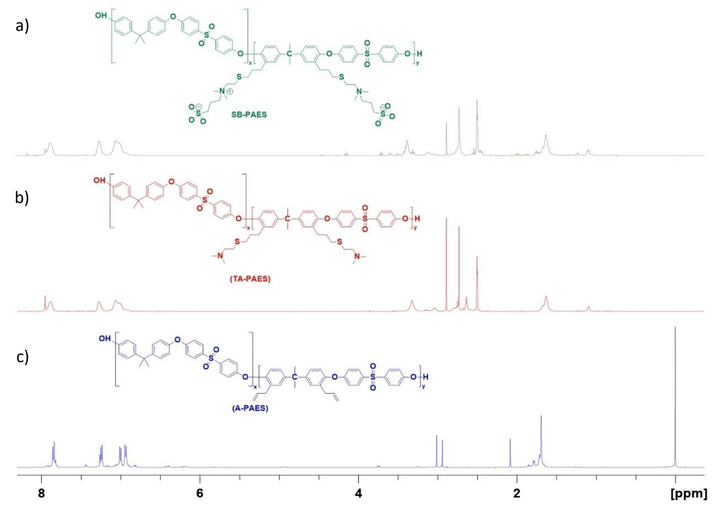

Fig 4: NMR spectrum of a) SB-PAES b)TA-PAES and c) A-PAES [4]

Results And Analysis

- Dense membranes were cast for tests including pervaporation performance and salt rejection.

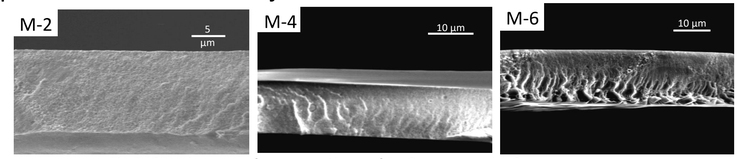

Fig 5: SEM images of cross-sections of M-2, M-4 and M-6 membranes

- **Water Permeation and Flux Recovery :**

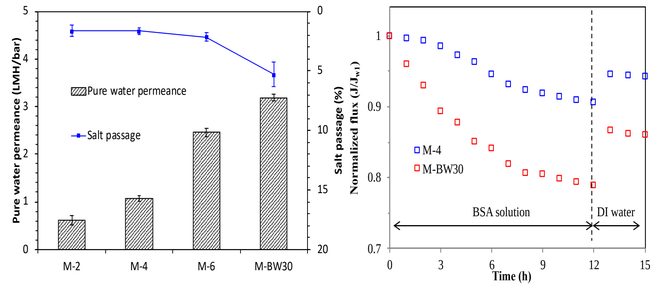

Fig 6: a) Pure water permeance at 8 bar and 25^{O}C with 1 g/L NaCl feed b) Normalized Flux with BSA solution feed and after washing with DI water [6]

- **Pervaporation performance:**

Membrane	Flux (Kg m^{-2} h^{-1})	Water Permeance (Kg m^{-2} h^{-1} bar^{-1})
Pristine PSf	11.43	11.28
SB-PAES (supported)	7.16	286
SB-PAES (unsupported)	17.37	695

- **Future Work:**

Synthesizing membranes of higher charge content and testing their pervaporation performance

[1] Ma. et al., Desalination, 417, 35-44,https://doi.org/10.1016/j.desal.2017.04.016
[2] Weng et al. J. Membr. Sci., 510, 122-130, https://doi.org/10.1016/j.memsci.2016.02.070
[3] Ma et al., Desalination, 381, 100-110, https://doi.org/10.1016/j.desal.2015.11.023
[4] Ong et al., Prog. Polym. Sci., 57, 1-31, https://doi.org/10.1016/j.progpolymsci.2016.02.003
[5] Hatada K, Kitayama T, NMR Spectroscopy of Polymers, Springer Laboratory
[6] Yang et al., J. Membr. Sci., 561, 69-78, https://doi.org/10.1016/j.memsci.2018.05.025

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