Composite membrane structure with asymmetric wetting properties for membrane distillation

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Abstract:

Membrane distillation (MD) via hydrophobic membranes is a highly effective technology for recovering pure water from hypersaline solutions. However, organic fouling and mineral scaling are two prominent challenges faced by membranes when used for practical applications. Commonly, fouling- and scaling-resistance require hydrophilic and superhydrophobic modification of MD membrane, respectively, which seems contradictory to realize both. Therefore, literature rarely report to address both issues to facilitate MD process. Herein, a membrane with an asymmetric superwetting Janus structure, including a thin superhydrophilic coating on a superhydrophobic bulk membrane, was constructed. The coating layer, based on alginate, alleviated fouling and scaling due to the superhydrophilicity and mineral precipitation resistance, while the underlayered polytetrafluoroethylene (PTFE) membrane provided robust hydrophobicity, enabling a successful MD process without the membrane being exposed to water. The coated PTFE membrane with the superwetting Janus structure exhibited much higher and more stable vapor flux than the pristine PTFE membrane in the MD process for the treatment of both oil- and solvent-contaminated seawater. Importantly, the coating imparted a high scaling resistance to the PTFE membrane during long-term MD operation for seawater desalination, thereby producing a water vapor flux six times that of the pristine PTFE membrane. The anti-scaling mechanism of the asymmetric superwetting Janus structure has also been proposed as a hydration effect from the coating layer. This study may provide a promising strategy for the design of fouling- and scaling-resistant membrane materials and structures.

Keywords: Asymmetric wettability; Membrane distillation; Organic fouling; Miner scaling