Evaluating the role of nanomaterials in tuning the performance of hydrophobic membranes for membrane distillation

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Membrane Distillation (MD) is an emerging technology operating at modest temperatures and is useful in seawater desalination and water recovery. In our work, hydrophobic Polyvinylidene fluoride (PVDF) and its copolymers (PVDF-HFP) were used to fabricate microporous membranes using phase inversion and electrospinning techniques. The effect of (i) membrane fabrication conditions, (ii) concentration or molecular weight of pore formers, (iii) post-fabrication treatment such as hot pressing, (iv) surface modification using fluoroalkyl silanes (such as 1H,1H,2H,2H per fluorooctyl triethoxysilane (PFOTES,) 1H,1H,2H,2H perfluorodecyl triethoxysilane, etc.) and (v) nanomaterials- ZIF-8, MCF-5, SBA-15, etc. were investigated in great detail. The performance of the prepared membranes was evaluated in terms of (a) operating parameters – feed/permeate flow rates, temperature gradient, (b) solute concentration, (c) presence of organic foulants- sodium alginate, humic acid, (d) surfactant concentration.

PVDF-HFP phase inversion membranes surface modified using 10 wt./vol % hydrophobic ZIF-8, and PFOTES exhibited a WCA of ~ 122° with an excellent anti-wetting ability for up to 240 minutes when challenged with 0.1mM sodium dodecyl sulfate and proved to be stable for > 10 h for direct seawater desalination in the direct contact membrane distillation mode.

Dual-layered PVDF electrospun nanofibrous membranes containing a modified MCF-5 (top layer) displayed a WCA of ~ 142°, with an average flux of 6 LMH and NaCl rejection >99.98%. These membranes could remove > 95 % of pharmaceutical contaminants present in wastewater and could withstand upto 1.5mM surfactant (CTAB) in the feedwater.

When integrated with pre-treatment techniques such as nanofiltration (NF), electrospun membranes in DCMD showed potential to treat saline oily wastewater with excellent rejection of oil/surfactant emulsion (>98%) and inorganic salts (100%). The reusability of the fouled membrane was also investigated after backwashing.

Keywords: Membrane distillation; desalination; phase inversion; electrospinning; fluoroalkylsilane;