Desalination and Water Treatment
www.deswater.com

doi:10.5004/dwt.2017.21319

100 (2017) 258–267
December

Direct contact membrane distillation: the role of membrane porosity

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Received 4 June 2017; Accepted 10 August 2017

ABSTRACT

Direct contact membrane distillation (DCMD) is pursued as low energy thermally driven process. Its basic configuration consists of two chambers one for the hot brine feed and second for the colder fresh permeate separated by a thin-porous-hydrophobic membrane of low thermal conductivity. The process involves brine evaporation that localized at the hot membrane surface, vapor transport through the thin porous membrane and condensation at the permeate membrane surface side. A sustaining temperature difference across the membrane ensures the driving process pressure. In this work a validated high fidelity model is developed to quantitatively assess the DCMD performance that address the influence of the porosity for homogenous and composite membrane. The flow is governed by the Navier-Stokes of none-isothermal that thermally coupled with the hydrophobic porous membrane consist of a single PVDF layer and a triplet layered membrane in which a stiffer layer SiO_2 is sandwiched in between the PVDF to improve membrane post-treatment. The model was tested and run at fixed salinity value for the brine of 4% and inlet temperate of 75°C under different porosity and membrane composite configurations. Results reveals a pronounced influence of the porosity seen by temperature polarization (TPC), mass and heat flux across the membrane, as well as thermal efficiency metrics. Specifically, an increase or decrease in porosity from the baseline 85% by 5 and 10 points lead to and increase/decrease in the mass flux and the thermal efficiency by 11–12% and 22–25%, respectively. The introduction of a sandwiched silicon oxide layer while preserved the same trend and relative values it, however, drastically reduced the mass flux and efficiency due to over all penalty in the membrane conductivity. This suggests that while inclusion of functional material could improve membrane reliability and post treatment one needs to use these materials at higher porosity than the original membrane to compensate for their added conductivity.

Keywords: Membraneporosity; Composite membrane; Membrane distillation; Thermal efficiency; Temperature polarization (TPC)

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Presented at the Fifth International Conference on Water, Energy and Environment (ICWEE 2017), February 28–March 2, 2017, Sharjah, UAE