FOULING IN DIRECT CONTACT MEMBRANE DISTILLATION DURING TREATMENT OF PRODUCED WATER FROM UNCONVENTIONAL (SHALE) GAS PRODUCTION

Omkar R. Lokare, University of Pittsburgh
orl5@pitt.edu
Sakineh Tavakkoli, University of Pittsburgh
Vikas Khanna, University of Pittsburgh
Radisav D. Vidic, University of Pittsburgh

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Hydraulic fracturing used for natural gas extraction from unconventional onshore resources (i.e., shale plays) generates large quantities of produced water. This water needs to be managed efficiently and economically to ensure further development of this industry. The most common solution for produced water management is disposal by deep well injection. This approach is being scrutinized by public and regulatory agencies due to increasing number of seismic events associated with this practice. The industry is now striving to reuse the produced water for hydraulic fracturing, which is feasible only as long as there are sufficient number of new gas wells being developed. The total dissolved solids (TDS) content of produced water can be in excess of 300,000 mg/l with sodium and chloride being the primary ions, followed by calcium, barium, strontium and magnesium. This water also contains some organics and heavy metals at low concentrations. Most membrane-based technologies employed today for seawater desalination are not feasible in this industry due to extremely high TDS of produced water. Membrane distillation (MD) can achieve complete rejection of ions and non-volatile organics as long as the membrane pores are not wetted. MD may be a cost effective method to treat produced water due to its reasonably high permeate flux and ability to operate using low-quality heat (i.e., it operates at temperatures well below the boiling point of water).

This study focuses on the potential for membrane wetting and/or fouling by inorganic salts present in produced water in the case of direct contact membrane distillation (DCMD) treatment of actual produced water from unconventional gas wells in Pennsylvania. The produced water was concentrated to near halite saturation limit to evaluate potential scaling and its impact on DCMD performance. Initial experiments showed that no membrane wetting occurred as evidenced by extremely low conductivity of the permeate stream. Iron-based scale accumulated on the membrane surface along with embedded islands of barium chloride and sodium chloride. The inorganic scale that formed on PTFE membranes during several hours of operation had negligible effect on MD performance in terms of permeate flux and thermal efficiency. Inspection of these inorganic scales suggests that they are typically very thin (i.e., several microns) and highly porous, which may explain the lack of observable impact on the transport of water vapor in DCMD module.

Initial results suggest that DCMD has great potential for desalination of highly concentrated wastewaters generated by the unconventional gas industry. However, inorganic scale that may form on the feed side could potentially impact the performance of this technology. Further insights into the composition and morphology of inorganic scales that may form under realistic operating conditions will be presented at the conference together with pretreatment options and scale mitigation approaches to minimize the effect of scaling on DCMD performance when treating produced water from the most productive shale plays in the U.S.