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Produced water treatment using forward osmosis membranes: evaluation of extended-time performance and fouling

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Abstract

Forward osmosis (FO) membrane fouling and performance were systematically studied for extended-time during treatment of produced water using cellulose triacetate (CTA) and polyamide thin film composite (TFC) FO membranes. Performance was evaluated with integrity tests that measured water flux, reverse salt flux (RSF), and specific reverse salt flux (SRSF). The CTA membrane reached steady performance after one week and exhibited decreased water flux, RSF, and SRSF. The TFC membrane did not reach steady performance—water flux drastically decreased, and both RSF and SRSF increased. Streaming potential analyses was used to derive membrane zeta potential—the polyamide membrane zeta potential became increasingly negative over three weeks of continuous testing, while the CTA zeta potential was stable. The negative zeta potential reflected foulant deposition on the membrane surface and may have contributed to high RSF through the TFC membrane. The TFC membrane experienced a higher fouling propensity despite smoother, more hydrophilic, and more neutrally charged virgin membrane surfaces. Fouling layers on both membranes consisted of hydrocarbons, iron, and silica. Chemically enhanced osmotic backwashing was performed weekly, which removed calcium, sodium, and chloride from the membrane surface but only marginally improved water flux. Gas chromatography-mass spectroscopy was used to measure hydrocarbon concentrations in the feed and draw solution. The results showed that while both membranes had over 90% rejection of neutral hydrophobic compounds, the TFC membrane exhibited a higher rejection of small organic molecules. Compounds with carbonyl functional groups were not well rejected compared to all other aliphatic and polycyclic aromatic hydrocarbons of the same molecular size, and CTA membrane had lower rejection of these compounds than the TFC membrane.