Title:

Saline wastewater treatment by forward osmosis-nanofiltration hybrid process using continuous draw solute regeneration

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Introduction: This study focuses on forward osmosis-nanofiltration (FO-NF) hybrid technology as an alternative to standalone NF for concentration of metal solutes and enhancing clean water recovery from salty wastewater by minimising energy consumption.

Methods: In this work, the FO-NF process is modeled and experimentally validated at a lab-scale on spiral wound design of both FO and NF modules by simultaneous regeneration of inorganic draw solute.
Feed side: synthetically prepared saline solution and draw side Na_2SO_4 and $MgSO_4$ based aqueous solution
Operating range: flowrates =4-25L/h, Temperature=25ºC and hydraulic pressure across NF (ΔP_{NF})=22-25 bar

Results:
The FO-NF has specific energy consumption (SEC) between 1.89 to 5.42 kWh/m^3. However, by optimising the operating variables, the FO-NF hybrid process saves 30-40% of the SEC. In process operating variables, ΔP_{NF} act as a decisive variable to define minimum process SEC and NF retentate concentration.
Molecular weight of draw solute behaves inversely proportional to specific reverse salt flux (SRSF) across FO membrane. Thus, Na_2SO_4 shows the lowest SRSF values among the draw solutes and also delivers a higher FO permeate flux because of high osmotic pressure.
As compared to a pressure-driven process such as RO/NF FO-NF shows good performance in water recovery, SEC and feed solute rejection. In addition, draw solute cost plays an important role to mitigate the operating cost and SEC of the process. Furthermore, the FO-NF hybrid has low tendency of fouling and also almost reject 99.98% of both monovalent and divalent salts from the feed side.
Therefore, the above results used for designing treatment process by FO-NF hybrid for other industrial saline wastewaters.

Discussion: From the above aforementioned results, the draw solute selection and hydraulic pressure across NF (ΔP_{NF}: process operating variable) is responsible for the FO-NF hybrid system SEC and enhancing in hybrid process recovery. In addition, for future applications, FO-NF hybrid system used for water recovery in space applications.