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Simulation of $CaCO_3$ reverse osmosis membrane scaling at a continuously increasing scaling propensity

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ABSTRACT

The development of calcium carbonate scale on the surface of a reverse osmosis membrane under continuously increasing scaling propensity conditions obtained by recycling the concentrate back to the feed tank in the presence of antiscalants is presented. The work combines experimental results and modeling based on computational fluid dynamics simulation. The model accounts for two distinct flux decline regimes: one due to continuously increasing osmotic pressure, which resulting from permeate withdrawal, and the other due to scale-mass growth. These two regimes are separated by the onset of scaling (OS), indicated by the observed sharp permeate flux decline. The experimental data were well replicated, revealing the water recovery fraction at the OS and the permeate flux profile as a function of the water recovery. The model fit the experimental data well, yielding a pair of adjustable parameters: the deposition rate coefficient and the water recovery fraction at the onset of scaling. With these two adjustable parameters, the model provides concentration profiles of calcium in the bulk solution and on the membrane surface. The model also provides the membrane surface coverage fraction. Overall, the model provides a quantitative approach for simulating scale development and determining the onset of scaling under different desalination conditions.

Keywords: Precipitation; Crystallization; Computational fluid dynamics; Desalination; Scale deposition

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