Incipient crystallization of calcium carbonate on desalination membranes: dead-end filtration with agitation

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ABSTRACT

The development of reliable criteria for determining the onset of scaling on desalination membranes is of high practical value. A novel approach to systematically investigate incipient membrane crystallization and scale-particle evolution was recently reported by this laboratory, involving modeling-relevant phenomena during membrane desalination and experiments, in well-controlled pressure cells operating in dead-end mode with no agitation. However, parallel studies have shown that flow conditions equivalent to those prevailing in real desalination membrane modules are obtained in pressure cells with agitation. Therefore, this work aims to employ the aforementioned approach to the more realistic case of membrane CaCO\textsubscript{3} scaling in dead-end desalination with agitation. Detailed data regarding incipient CaCO\textsubscript{3} scaling of desalination membranes were obtained, by analyzing scanning electron microscopy (SEM) images, for small bulk supersaturation ratios $S = 1$ to 4 and short filtration times (~30–90 min). Mean shear stresses at the membrane surface were similar to those prevailing in desalination modules. The data show that concentration polarization due to salt rejection strongly affects scale-particle growth rate, insignificantly influencing particle-number surface density. There is no evidence of a significant induction period in the nucleation and growth of scale-particles on the membrane surface. The initial CaCO\textsubscript{3} deposit flux, in mg/(m\textsuperscript{2}$\times$min), exhibits a strong dependence on membrane surface supersaturation. Experimental data on the supersaturation-dependent scale evolution appear to significantly differ from predictions based on classical concepts of heterogeneous nucleation and growth, thus indicating that non-conventional nucleation is the dominant mechanism of the membrane-scale development.

Keywords: Incipient CaCO\textsubscript{3} scaling; Brackish water desalination; RO membranes; Particle size distribution; Supersaturation; Nucleation theory

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