Understanding how operating conditions affect biofouling structure in spacer filled membrane filtration channels using optical coherence tomography

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Abstract

The growth of biofilms, causing biofouling on the membrane and feed spacer surface, is an unavoidable phenomenon in reverse osmosis. Biofouling can lead to unacceptable losses in product quality and quantity, and membrane lifetime. Process conditions such as crossflow velocity and nutrient concentration in the feed water strongly affect the development of biofilms. To improve system performance, understanding the relation between process conditions, biofilm development, and system performance is key. Optical coherence tomography (OCT), is increasingly applied to characterize biofilm structure in-situ and non-destructively. In OCT, near-infrared light is used to capture 2D and 3D images from within optical scattering media. In spacer filled channels with representative biodegradable nutrient conditions in the feed, biofilms often develop heterogeneously and dispersed. In such systems, commonly used structural parameters such as average thickness, average roughness, and average porosity may not be reflected in the system performance.

In this study, biofilm structural and spatial parameters are explored with the objective to link biofouling in spacer filled channels to system performance indicators. For this purpose, biofilms are grown in membrane fouling simulators at different nutrient concentrations and flow rates. Biofilm development on the feed spacer and on the membrane and system performance (pressure drop, transmembrane pressure, rejection) are monitored. Understanding the impact of (i) feed water quality and flow rate on biofilm growth and of (ii) biofilm structure and spatial distribution on system performance will lead to the development of more effective strategies for biofouling control.

Keywords

Biofouling; desalination; drinking water production; reverse osmosis; optical coherence tomography; feed spacer; biofilm structure