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Incipient scaling of reverse osmosis desalination membranes in the presence of organic foulants – An experimental study

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Introduction

The effect of organic foulants on incipient membrane scaling is poorly understood, despite its significance particularly in desalination of brackish feed-waters that contain such ever-present foulants. This study aims to shed light on this issue for the common case of gypsum ($CaSO_4 \cdot 2H_2O$) RO-membrane scaling when Sodium Alginate (SA) is present at typical small concentrations (2 and 10mg/L).

Methods

Experiments were performed under realistic once-through flow conditions, with controlled small super-saturation (supersaturation-ratio S = 1.0 to 1.6) at the entry of spacer-filled narrow-channel, thus simulating conditions prevailing at incipient scaling in membrane modules. Synthetic brackish-water was employed with RO membrane (CP2, Hydranautics). After testing/desalination, the membrane-surface condition and morphology of gypsum-scale were examined with scanning electron microscopy (SEM), whereas scale-mass deposition rate ($mg/m^2/min$) was determined through a scale-dissolution technique. For 180min tests, the latter was correlated with supersaturation-ratio at the membrane surface S_w

Results

Figure 1 shows localized membrane fouling/scaling for small (2mg/L) SA-concentration, but complete membrane-coverage by organic gel (with rather large gypsum-crystals growing inside) for high (10mg/L) SA-concentration. Consequently, flux reduction in the former case is significantly smaller than in the latter. Moreover, for the larger SA-concentration, the gypsum-crystals morphology is significantly altered compared to usual needle-shape (Figure 1h,i). The scale-mass deposition rates [$mg/(m^2 min)$], plotted in **Figure 2** versus S_w, are in accord with the above observations, showing very significant enhancement of scale-growth at higher SA-concentration (10mg/L), compared to zero and 2mg/L SA-concentration.

Discussion

At incipient scaling, small SA concentration (2mg/L) seems *to inhibit* scale growth, probably due to adsorption of SA-macromolecules onto gypsum nuclei (mainly in bulk). However, for greater SA-concentration (10mg/L), the polysaccharide-gel layer, rapidly covering the membrane, apparently *enhances* gypsum nucleation and growth. R&D priority should be given to correlate scale deposition-rate with supersaturation-ratio S_w to enable predictions of scaling-onset and evolution in desalination plants.

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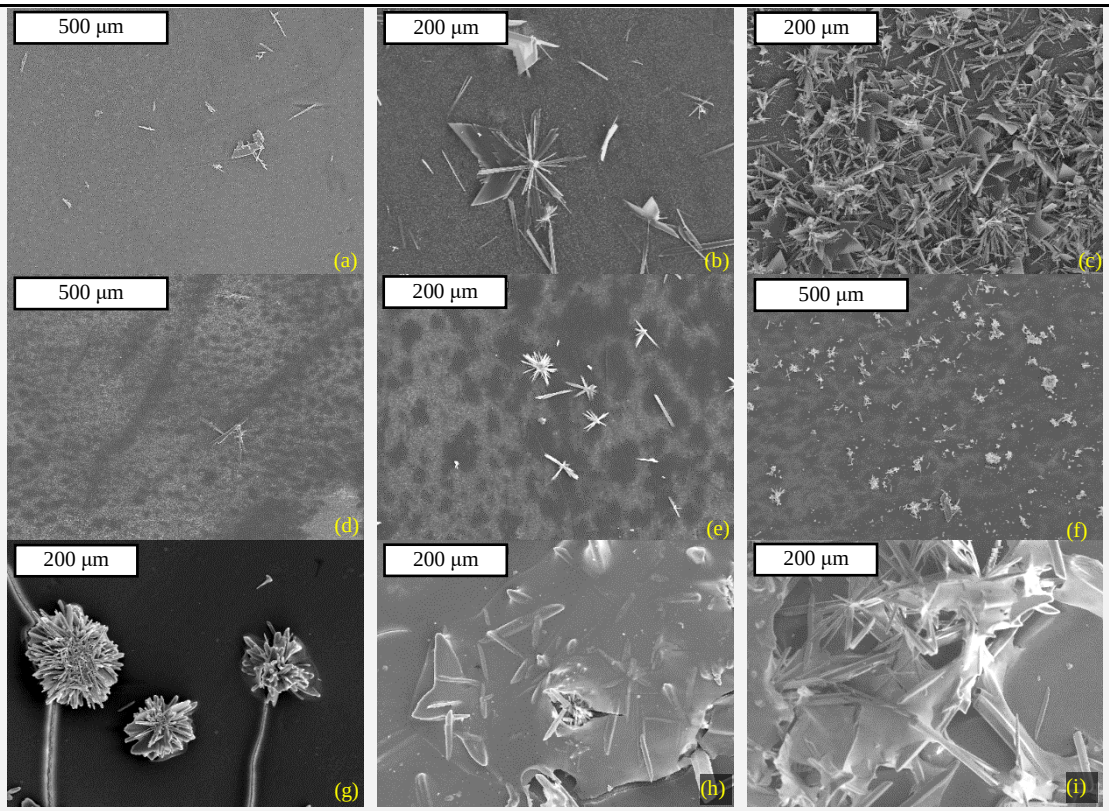

Figure 1 SEM images **of** $CaSO_4$ crystals deposited/developed on the desalination membrane. Scaling tests: a) S_w=1.30; b) S_w=1.45; c) S_w=1.57. Combined fouling/scaling tests: d) S_w=1.20, 2 mg/L SA; e) S_w=1.43, 2 mg/L SA; f) S_w=1.48, 2 mg/L SA; g) S_w=1.19, 10 mg/L SA; h) S_w=1.51, 10 mg/L SA; i) S_w=1.57, 10 mg/L SA

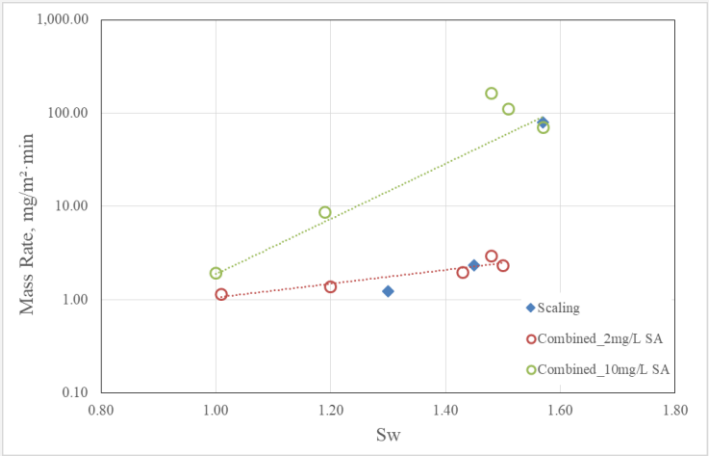

Figure 2. RO membrane scaling by calcium sulfate in the presence of SA; initial scale-mass deposition rate [mg/(m²min)], versus membrane-surface supersaturation ratio S_w.

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