Electrocoagulation Process Considerations during Advanced Pretreatment for Brackish Inland Surface Water Desalination: Nanofilter Fouling Control and Permeate Water Quality

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Introduction. The principal objectives of this research focusing on desalination of brackish surface water are to: (i) optimize electrocoagulation (EC) to maximize natural organic matter (NOM) removal and (ii) evaluate the effectiveness of coupling EC and microfiltration (MF) pretreatment to mitigate nanofilter (NF) fouling. All experiments were performed using water from the Foss Reservoir in West-Central Oklahoma and a commercial membrane (NF270, Dow). NF surfaces were characterized in detail by Fourier Transform Infrared (FTIR) Spectroscopy and X-ray Photoelectron Spectroscopy (XPS) after different pretreatments to identify dominant foulants and fouling mechanisms. Transient NF fouling profiles following pretreatment by EC-MF and MF-only were compared with a synthetic feed water, which was formulated to closely mimic the ionic composition of Foss Reservoir water without any added NOM to operationally establish its role on fouling.

Results and Discussion. During EC, aluminum dissolution for various pH, current densities, and electrolysis durations coalesced into a straight line with respect to total charge passed with a slope 29% higher than Faraday's law. Super-Faradaic dissolution suggests combined electro- and chemical processes with chloride-assisted localized dissolution at the (hydr)oxide-aluminum interface leading to pitting corrosion (Figure 1a – d).

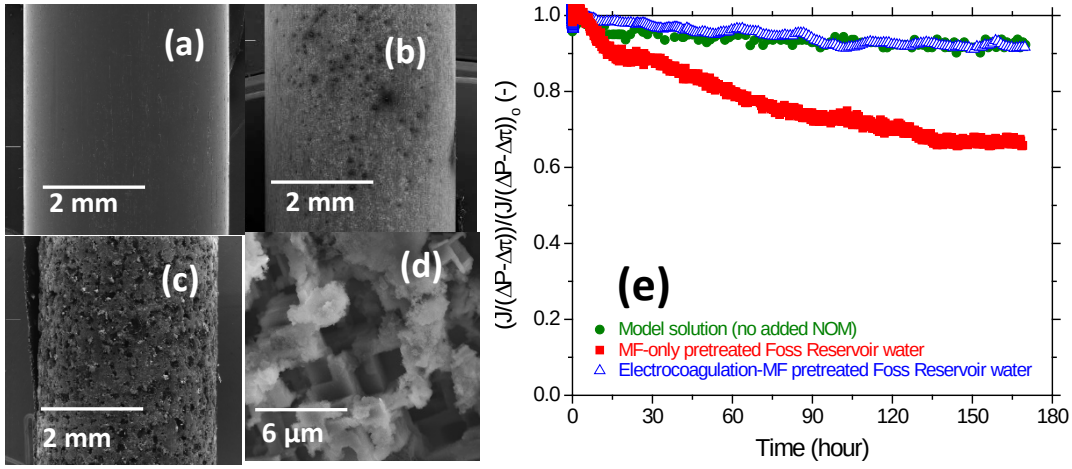


Figure 1. Electron micrographs of a new aluminum rod (a), after electrocoagulating 450 mL water or 1-cycle (b), after electrocoagulating 15 L water or 33-cycles (c). A pit from (c) under higher magnification is shown in (d). NF flux profiles following MF-only pretreatment, EC-MF pretreatment, and for the model solution are shown in (e).

NF specific permeate flux declined by 36% following MF-only pretreatment but only by 8% following EC-MF pretreatment (Figure 1e). Importantly, the flux after EC-MF pretreatment declined in a similar manner as the model solution operationally demonstrating negligible NF organic fouling by integrating EC pretreatment along with MF. Incorporating EC pretreatment to MF preferentially removed hydrophobic and high molecular weight components of NOM as indicated by the lower SUVA values (from 1.18 to 1.02 m-L/mg).

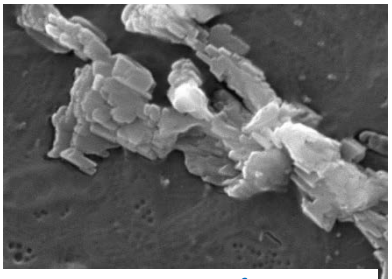


Figure 2. Fragments of $CaCO_3$ crystals visible after NF of EC-MF pretreated Foss Reservoir water. The scale bar represents 4 µm

Polysaccharides and proteins IR peaks on NF surfaces were strongly attenuated following integrated EC-MF pretreatment (compared with MF-only pretreatment) providing direct evidence for excellent hydrophilic NOM removal by EC. However, NOM removal by EC reduced the NOM-calcium interactions causing higher affinity of calcium towards negatively charged nanofilter leading to $CaCO_3$ precipitation, which was also observed for the model solution containing no organics (Figure 2). Importantly, this did not significantly reduce flux under conditions of our experiments. Therefore, both operational data and surface spectra demonstrate that higher NF fluxes were obtained following EC-MF pretreatment because it controlled organic fouling.