Flux decline during nanofiltration of naturally-occurring dissolved organic matter: effects of osmotic pressure, membrane permeability, and cake formation

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Source: JOURNAL OF MEMBRANE SCIENCE **Volume:** 239 **Issue:** 1 **Pages:** 39-53 **Published:** AUG 1 2004

Times Cited: 26 **References:** 67 Citation Map

Abstract: Nanofiltration of naturally-occurring dissolved organic matter (NOM) by an aromatic polyamide membrane was measured in a crossflow bench-scale test cell and modeled using a semi-empirical osmotic pressure/cake formation model. Our objective was to examine flux decline due to NOM fouling while explicitly accounting for flux decline due to osmotic effects and changes in membrane permeability. This approach allowed quantification of the effect of ionic composition on specific NOM cake resistance, and yielded insight into flux decline due to enhanced NaCl rejection by the NOM deposit. In the absence of NOM, increasing NaCl concentration reduced salt rejection and decreased membrane permeability. Flux decline was modeled by accounting for changes in osmotic pressure with time, and by employing an effective permeability. The addition of calcium significantly reduced rejection of sodium and feed conductivity, and thus mitigated flux decline. Increasing pH from 4 (near membrane pI) to 10 increased the effective permeability but also increased NaCl rejection, which resulted in greater flux decline. The presence of NOM caused greater flux decline resulting from a combination of NOM cake resistance and increased rejection of NaCl by negatively charged NOM functional groups. Increasing NaCl concentration had little effect on the mass of NOM deposited, but significantly increased the specific resistance of the NOM cake. The effect of ionic strength on specific resistance correlated with a reduction in NOM size, estimated by separate UF permeation experiments and size exclusion chromatography analysis of UF permeate. Therefore, increased specific cake resistance is consistent with a more compact, less porous cake. Flux decline by NOM solutions showed a maximum at pH 7, where salt rejection was also a maximum. Binding of calcium reduced the ability of NOM to enhance NaCl rejection, and likely increased NOM cake resistance. Flux decline caused by NOM fouling in the presence of calcium was only significantly different than that caused by NOM in a solution of NaCl at the same ionic strength when the calcium concentration corresponded to saturation of NOM

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Document Type: Article

Language: English

Author Keywords: nanofiltration; fouling; natural organic matter; water treatment; concentration polarization

KeyWords Plus: AQUATIC HUMIC SUBSTANCES; ACTIVATED CARBON ADSORPTION; REVERSE-OSMOSIS; PREPARATIVE ISOLATION; MOLECULAR-WEIGHT; AQUEOUS-SOLUTION; IONIC-STRENGTH; DBP CONTROL; ACID; ULTRAFILTRATION

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Publisher: ELSEVIER SCIENCE BV, PO BOX 211, 1000 AE AMSTERDAM, NETHERLANDS

Subject Category: Engineering, Chemical; Polymer Science

IDS Number: 837XL

ISSN: 0376-7388

DOI: 10.1016/j.memsci.2003.12.030

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