Behaviour of Natural organic matter (NOM), Colloidal particle and Solution chemistry on ultra-filtration performance

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Abstract

Mechanistic studies on a charged ultrafiltration (UF) membrane fouled with natural organic matter (NOM) and colloidal particles are systematically investigated to understand the relative role of each NOM fraction and the presence of colloidal particulate to membrane fouling. Humic acid (HA), dextran, and kaolin were employed as surrogate model foulants representing the organic hydrophobic acid NOM, hydrophilic neutral NOM, and inorganic colloidal materials, respectively. The results obtained showed that the organic NOM of hydrophilic surrogate (dextran) plays a primary role in promoting membrane fouling, followed by hydrophobic acids and inorganic kaolin, but to a lesser extent than organic NOM compounds. Significant differences in the extent of fouling between dextran and HA have been observed despite filtering with identical membrane. Greater membrane fluxes and better DOC rejection shown by HA could be seen as evidence demonstrating the electrostatic interactions between HA and the negatively charged membrane surface, in addition to the steric hindrance mechanism, despite possessing relatively greater adsorptive interactions with the hydrophobic PSF membrane. These results suggest that NOM structural variations (aromatic versus aliphatic molecular structure), distribution (apparent molecular weight and size), and charge density are essential factors that determine the fouling potential of each NOM fraction. Feed solution containing all the NOM fractions (HA, dextran, and kaolin) fouled the membrane more readily than the individual organic and colloidal foulants, suggesting that an association of the latter two entities is responsible for the greater extent of membrane fouling. Furthermore, the electrokinetic effects of solution chemistry (ionic strength and Ca2+) was employed to quantify the role of electrostatic interactions in providing principal effect that promotes better permeate flux and NOM rejection, particularly with the charged component such as HA. Moreover, observation of this study is beneficial in elucidating a clearer understanding on the influential factors and responsible mechanisms of UF fouling owing to single NOM solute and multiple NOM solute systems, with respect to membrane filterability and rejection efficiency.

Introduction: Low pressure driven membrane process, namely ultrafiltration (UF), is increasingly employed for removing particulate matter, bacterial cells, and organic solutes from surface water, either as a water treatment process or as a pre-treatment step (Schafer et al., 2000 and Lee et al., 2007).

Methodology: Pure-water flux (Jpwf) was then carried out with membrane being filtered with DI water until permeation reached a steady-state condition, and was determined as given in Equation, where Jpwf is the pure water flux, V is the permeate volume (L), A is the membrane area (m2), and ΔT is the sampling time. The parameters used for the quantification of the efficiency of membrane processes were flux (J)

$$J_{pwf} = \frac{V}{A.\Delta T}$$

(1)

$$J = \frac{Q}{A}$$

(2)

Table 1: Experimental protocol of NOM and inorganic model compounds

Foulant	Concentration (mg/L)	pH
a. Inorganic kaolin colloids	10 mg/L	7.2
b. Organic humic acid (HA)	10 mg DOC[f]/L	7.2
c. Organic dextran	10 mg DOC/L	7.2
d. Combined	(10/10[g]; a+b or a+c)	7.2
e. Combined	(10/10/10[g]; a+b+c)	7.2

Background solutions

NaHCO$_3$ (buffer solution),	0.5 mM[h]	
NaCl (ionic strength controller)	10 mM	
CaCl$_2$ (divalent ion concentration)	0.1 mM	

[f]DOC is dissolved organic carbon

[g] unit is in mg DOC/L

[h] mM is equivalent to 10^{-3} Molar
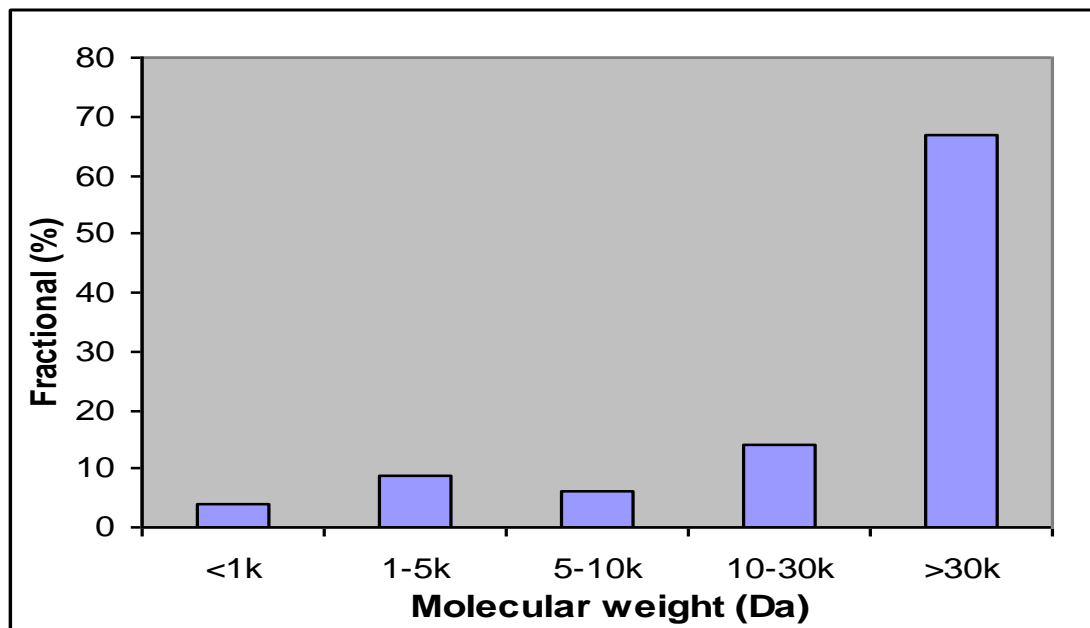
Figure 1. Apparent molecular weight distribution of Aldrich-Sigma humic acids (HA)

References

Schafer, A.I., Fane, A.G., & Waite T.D. (2000). Fouling effect on rejection in the membrane filtration of natural waters. Desalination, *131*, 215-224.

Lee, S. & Lee, C-H. (2007). Effect of membrane properties and pretreatment on flux and NOM rejection in surface water nanofiltration. Separation Purification Technology, *56,* 1-8.