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Modeling Organic Molecule Transport Through Nanofiltration Membranes

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1. Introduction

Nanofiltration (NF) membrane applications in water treatment have grown rapidly from softening to removal of natural organic matter, other organic compounds, and inorganic ions. During organic nanofiltration processes, substances could be rejected according to the mechanisms of steric (size) exclusion and electrostatic interaction (charge exclusion, also called donnan exclusion). However, other solute and membrane physicochemical properties and interactions may also play a role on the separation, such as solute adsorption. To understand these processes, many researches were conducted on organic compounds removal from water using NF membranes.

2. Experiments and Results

In this work, retention of two phenolic compounds (phenol and 2, 4-dinitrophenol, 2, 4-DNP) by three NF membranes (NTR 7450, NF 90, NF 270) was studied. When the membrane surface charge and solution pH was sufficiently high, rejection by charge exclusion was significant. Flux decline was observed in the process, suggesting that the adsorbed compounds blocked membrane pores and increased membrane resistance. Adsorption data measured in batch experiments (Figure 1); Freundlich type isotherms were found. Low pH promoted adsorption, as expected, and under low pH experimental conditions, breakthrough behavior was observed.

Based on a numerical method developed by Skeel and Berzins [1], the breakthrough behavior was modeled using a two-layer non-linear one-dimensional solute transport model, treating the membrane as a porous medium (Figure 2). Hindered diffusive and convective transport was accounted for using available relationships for hindrance factors. The relative contributions of convection, diffusion, and adsorption on solute transport will be discussed.

3. Conclusion

The rejection of phenolic compounds is influenced by pH. Low pH can promote the adsorption of phenolic compounds on membrane. As the model indicated, adsorption also contributes to the break-through behavior.

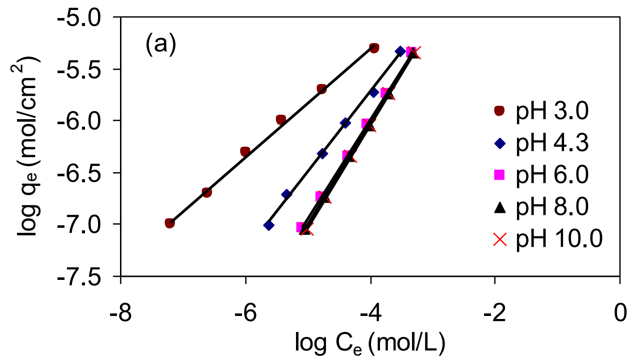

Figure 1: pH effect on 2,4-dinitrophenol adsorption isotherms of NTR 7450 membrane

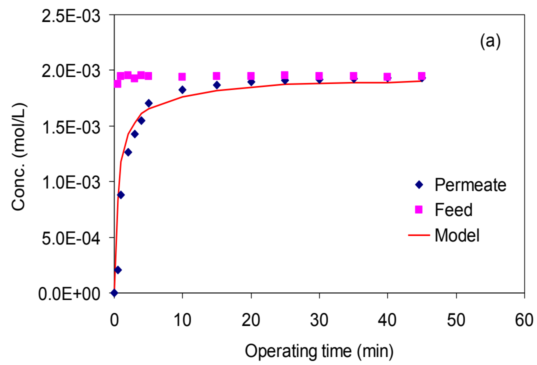

Figure 2: Permeate and feed concentrations of phenol as a function of filtration time for NTR 7450 membrane

References

[1] R.D. Skeel and M. Berzins, SIAM Journal on Scientific and Statistical Computing, 11 (1990), 1–32.