JPUR
JOURNAL OF PURDUE UNDERGRADUATE RESEARCH

ENGINEERING/TECHNOLOGY

The Effect of Molecular Surface Modification on the Selectivity and Permeability of Nanoporous Membranes

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Membrane technology is being researched intensively due to its potential for generating clean water. Surface modifications of nanoporous membranes could be an engineering solution to designing chlorine-tolerant membranes that would last longer in operation and thus reduce the high costs associated with membrane operations. The average pore diameter in a membrane strongly determines its selectivity and permeability. We seek to use molecular surface modification to alter the chemistry of nanoporous membranes with the goal of increasing the membrane selectivity while maintaining high water permeability. Aminosilanes, which are being tested as a model molecule for membrane functionalization, were used to alter the surface chemistry of commercial membranes; the effect of the surface treatment was tested for different membrane materials and initial pore sizes. For a polyacrylonitrile membrane, the flux decreased from 0.0318 ml $s^{-1}psi^{-1}$ to 0.0275 ml $s^{-1}psi^{-1}$ with a standard deviation of 0.002152 ml $s^{-1}psi^{-1}$, while for polysulfone membranes of two different pore diameters (PS10 and PS35), the flux increased from 0.0044 ml $s^{-1}psi^{-1}$ to 0.0957 ml $s^{-1}psi^{-1}$ with a standard deviation of 0.000934 ml $s^{-1}psi^{-1}$ for the PS10, and from 0.0283 ml $s^{-1}psi^{-1}$ to 0.13075 ml $s^{-1}psi^{-1}$ with a standard deviation of 0.040082 ml $s^{-1}psi^{-1}$ for the PS35. Contact angle measurements were performed to determine the interfacial behavior of the modified membranes. The membrane selectivity was measured using a NaCl solution; the salt rejection rate was characterized based on the conductivity of the permeate solution. By changing surface chemistry but minimally altering pore size, we show that water flux and salt rejection are both impacted. The results support the hypothesis that the effect of surface modification is strongly determined by the membrane material and weakly determined by initial pore diameter.

Research advisor John Howarter says, "The design and discovery of new molecular-based surface treatments for nanoporous membranes has the potential to reduce the cost of generating clean water. Suh's work using model silane molecules and commercial membranes successfully builds toward this goal."

Suh, M. (2013). The effect of molecular surface modification on the selectivity and permeability of nanoporous membranes. *Journal of Purdue Undergraduate Research*, 3, 89. http://dx.doi.org/10.5703/1288284315161