298b Evaluation of Nanoporous Lyotropic Liquid Crystal Polymer Membranes for Reverse Osmosis

Parag R. Nemade and Douglas L. Gin

Lyotropic liquid crystal (LLC) assemblies provide an opportunity to make nanoporous polymer membranes with precise control over chemical and structural features on the nanometer scale, which is currently lacking in commercial reverse osmosis (RO) and nanofiltration (NF) membranes available today. These LLC composite membranes are prepared by casting ca. 10 wt% solution of a taper-shaped, sodium carboxylate based LLC monomer over a polysulfone ultrafiltration membrane support. The solvent is evaporated to afford an ordered surfactant assembly composed of hexagonally packed monodisperse cylindrical nanochannels with a diameter of ca. 1.1-1.2 nm. The resulting submicron thick LLC coating is radically photo-cross-linked under Argon. These LLC membranes have been found to completely reject water-soluble solutes greater than 1.2 nm in size. The present work focuses on the evaluation of these supported LLC membranes for rejection of small salt ions from their aqueous solutions for potential RO applications. A pure water flux of 0.026 ± 0.015 L $m^{-2}h^{-1}$ is obtained at a transmembrane pressure of 250 psi with these materials, and the ionic rejection of Na^{+} is 15% and that of Mg^{2+} ions is 35%. These low rejection values are not entirely unexpected considering the LLC nanochannel diameter is ca. 1.2 nm. One of the ways to increase salt rejection is to decrease the effective nanochannel diameter to the sub-nanometer regime. The reduction in channel diameter can be achieved by the use of larger multivalent cations such as Ca^{2+} or Eu^{3+} instead of monovalent Na^{+} as the carboxylate counterion. With Eu^{3+} as the LLC monomer counterion, we have been able to achieve a 15% reduction in the channel diameter to ca. 0.9-1.0 nm. The ionic rejection capabilities of these membranes will be presented. Other methods for increasing the small salt ion rejection capabilities of these LLC membranes and further optimizing their membrane properties will also be presented.