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Development of Nanoporous Ceramic Membranes and Improved Rejection by Control of Surface Chemistry

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Summary

Nanofiltration membranes, which shows intermediate separation performances between reverse osmosis and ultrafiltration membranes, can separate ions according to the electrostatic interaction between ions and the surface charge. In the present study, nanoporous titania membranes, which have excellent chemical and thermal stability, were prepared by sol-gel processing, using titanium isoproxide (TTIP) as Ti source and HNO_3 as acid catalyst. Nanoporous titania membranes with controlled pore sizes in the range of 0.7 - 2.5 nm showed molecular weight cut-offs (MWCO) ranging from 500 - 2,000 with pure water permeability, L_p, of (1 - 15) x 10^{-11} $m^3m^{-2}s^{-1}Pa^{-1}$.

The transport performance of nanoporous TiO_2 membranes was evaluated in the temperature range from 30 to 70°C. Permeate flux increased 2 - 3 times, depending on the pore sizes. The water permeation mechanism was found to be different from the viscous flow. Rejection of neutral solutes such as raffinose decreased with temperature, while that of electrolytes ($MgCl_2$, NaCl) were approximately constant. The transport mechanism of neutral and electrolyte solutes, which are molecular sieving and charge effect, respectively, are found to be responsible for the temperature dependence.

Moreover, phosphorus modified TiO_2 (TiP) sols were prepared by adding phosphorus pentaoxide into TTIP solutions. TiP membranes showed increased rejection toward electrolytes at pH 7, while no rejection was observed for unmodified TiO_2 membranes. Increased rejection confirmed successful control of surface chemistry by phosphorus modified TiO_2.