

Permeation properties of electrolyte solutions through titania and titanium phosphorus oxide membranes

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Summary

Titania (TiO_2) membranes, with molecular weight cut-offs controlled at 250, 400, and 2000, were successfully prepared by the sol-gel process. These porous membranes rejected electrolytes based on Donnan exclusion, and the permeate volume flux, based on the electroviscous effect, was pH-dependent, similar to polymeric porous membranes. Moreover, divalent counterions (Ca^{2+} , Mg^{2+}) which were strongly adsorbed by ion-exchange at alkali pH, drastically reduced volume flux, compared with monovalent cations (Na^+ , K^+); this tendency was pronounced for porous membranes with smaller pore sizes.

Figure 1 shows flux and zeta potentials determined by streaming potential measurements, as a function of the mole fraction of Na^+ in $\text{NaCl}/\text{CaCl}_2$ mixtures, using TiO_2 membranes having different pore sizes, i. e. MWCO of 400 (M-400) and 2,000 (M-2000). The permeate volume flux showed a sharp decrease when a small amount of Ca^{2+} was added, and a gradual decrease in the range of Ca^{2+} mole fraction from 0.2 to 1.0; this tendency is more clearly shown with M-400 than with M-2000. On the other hand, in the case of zeta potential, which reflects the surface charge density, that is, Ca^{2+} adsorption in an ion-exchange manner, no significant differences were observed between M-400 and M-2000.

Therefore, it is strongly suggested that the divalent cation was tightly bound to the inner surface of the titania membranes and neutralized the surface charge, and the adsorbed divalent cation ions, the Stokes size of which is approximately 0.6 nm, caused a reduction in the permeate volume flux through the nanofiltration membranes.

Figure 2 shows rejections and flux as a function of feed concentration through NTR-7450 (Nitto Denko, Japan; negative charge; MWCO=1,000). No dependency of permeate flux of NaCl and CaCl_2 on feed concentration was observed, contrary to the case of titania membranes. The differences in the amount of adsorbed ions was suggested for one of the possible reasons.