Study on Water Transport and Highly Concentrating Sea Water through Ion-exchange Membrane

Akihiko Tanioka
Tokyo Institute of Technology
Department of Organic and Polymeric Materials

Summary

In the salt production process sea water concentration is increased by about 5 times through ion-exchange membrane before evaporation. If the salt should be obtained in the higher efficiency it is necessary to concentrate the sea water by 8 or 9 times. However, we have following problems to be solved before completing this project.

(1) How can we increase the counterion concetration in the membrane.

(2) How can we prevent the water volume flux caused by osmotic pressure difference.

Reducing the water content in the membrane is one of the solutions for this problems. However, it decreases the fixed charge density and the ionic mobility in the membrane. In this study, the effect of ion pairing between fixed charge groups and counterions on the effective charge density and the ionic mobility in the low water content, theoretically and experimentally.

The formal relationship between the ionic activity coefficients in the membrane and the membrane effective charge density is established by comparing the results obtained from a model based on the ideal Donnan equilibrium extended to account for the ion pairing effect with the results obtained from a thermodynamic formalism including ionic activities instead of concentrations. We calculate the membrane effective charge density and the ionic activity coefficients by using a simple model of ion pairing based on the Fuoss approach for contact ion pairs in electrolyte solutions with a correction term for the entropy change of the counterion undergoing ion pairing.

The membrane potential and the permeability coefficients across cation- and anion-exchange membrane was measured for LiCl methanol-water solution. The experimental data were analyzed on the basis of the Donnan equilibrium and the Nernst-Planck equation of ion flux considering the effect of mean activity coefficient of electrolyte in external solution, and the theoretical predictions agreed well with the experimental data. The effective charge density and the mobility of ions in the membrane would decrease with the increase of the weight fraction of methanol. It is postulated that the counter-ions prefer to make ion pairs with the fixed charge groups in the mixed solvent system since the dielectric constant of methanol is smaller than water. Thus the ion pairs between the counter-ions and fixed charge groups will increase with the increase in low water content, and the effective charge density and the mobilities of the counterions will decrease.