DEVELOPMENT OF MULTICOMPONENT TRANSPORT THEORY AND TRANSPORT DATA FOR MEMBRANES IN CONCENTRATED ELECTROLYTES

Electrochemical Technology Corp., 3935 Leary Way, N.W., Seattle, WA 98107 (U.S.A.)

The overall objective of this research is to extend theory and measurement techniques developed for multicomponent transport for cellulose acetate to obtain a fundamental understanding of newer membranes in concentrated electrolytes. In particular, the Nafion 7-1100 membrane is under study in collaboration with D. N. Bennion at Brigham Young University.

The main accomplishments in 1982 were radiotracer measurements of the solubility of sodium and chloride ions, radiotracer measurements of water and sodium and chloride ion transport, and calculations of energy savings by use of membranes in chloralkali cells. The room temperature solubility and transport data are some of the input parameters to D. N. Bennion's concentrated-electrolyte model for membrane transport.

Hittorf cells were used for solubility and transport measurements. Cl^{36} and Na^{22} were used to determine ionic solubility and transport, and tritiated water was used to trace the water transport. The solutions were also titrated for chloride using chloride-specific electrodes. Volume flow across the membrane was also obtained in one of the experiments. Experimental results were as follows. Nafion 7-1100 in 0.13 N NaCl at 20 ± 2 °C gave sodium ion concentrations of 0.936×10^{-3} and 0.915×10^{-3} mol/g of dry Nafion. The corresponding chloride ion concentrations were 4.60×10^{-6} and 6.24×10^{-6} mol/g of dry Nafion. The ion exchange capacity, determined by difference, was therefore 0.920×10^{-3} mol/g of dry Nafion. The sodium self-diffusion permeability coefficient was $P_{Na} = 1.2 \times 10^{-6} <$ cm^2/s, and chloride ion permeability coefficients were in the range 2.0×10^{-7} cm^2/s P_{Cl} - 9.2×10^{-7} cm^2/s P_{Cl}. The water diffusion coefficient was in the range 1.3×10^{-6} cm^2/s $< D_W < 4.6 \times 10^{-6}$ cm^2/s. The average electrical conductivity was 6×10^{-3} ohm^{-1} cm^{-1}. The chloride transference number was 0.08 ± 29 percent. These values are in general agreement with prior work using methods other than radiotracers.

A paper is nearly ready for publication on the technology and economics of membrane cells as compared to conventional diaphragm cells for chloralkali production.

The main thrust planned for 1983 is measurements and interpretation of effects of high current density on the transference number of membranes. A new Hittorf cell designed to operate at a continuous current density of 0.1 A/cm^2, and hopefully above 1 A/cm^2 with pulsed current, is being constructed. Results will be correlated with the concentrated-electrolyte model for transport in membranes.