Ion-Pair Formation in Strontium Chloride and Strontium Hydroxide Solutions at High Temperatures and Pressures

Hugues Arcis [S]
University of Guelph, Department of Chemistry, Guelph, Ontario, Canada

Gregory H. Zimmerman
Bloomsburg University, Department of Chemistry and Biochemistry, Bloomsburg, PA, U.S.A.

Peter R. Tremaine [C]
University of Guelph, Department of Chemistry, Guelph, Ontario, Canada
tremaine@uoguelph.ca

The proposed Generation IV CANDU SCWR nuclear reactor design is a "combined cycle" that would have supercritical water flowing through the reactor core and directly into the turbines. To model the behaviour of fission products in the event of a fuel failure, we are examining the aqueous chemistry of strontium salts in high temperature water. Frequency-dependent electrical conductivities of solutions of aqueous strontium hydroxide and strontium chloride have been measured up to T = 625 K at p = 20 MPa, over a very wide range of concentration, ($3\cdot10^{-5}$ to 0.2 mol·kg^{-1}) using a unique high-precision flow-through AC electrical conductance instrument. Experimental values for the equivalent conductivity of each electrolyte were used to get ionic association constants with the Turq-Blum-Bernard-Kunz ("TBBK") ionic conductivity model. At temperatures above 548 K, association constants derived from the concentration dependent equivalent conductivities were increasingly sensitive to the assumptions used to calculate solution densities. Procedures for minimizing these effects are reported. The TBBK fits to the concentration-dependent equivalent conductivity data for both $Sr(OH)_2$ and $SrCl_2$ required formation constants for the species $Sr(OH)^+$ and $SrCl^+$ at all temperatures, and above 446 K for $Sr(OH)_2^0$ and $SrCl_2^0$. The association constants, K_{A1}, for the charged ion pairs, were found to be greater for the hydroxide than the ones for the chloride. The same observation was made regarding the association constants, K_{A2}, for the neutral ion pairs. Results showed that the neutral species are substantial at concentrations above 10^{-3} mol·kg^{-1} at 350 °C. Consequently the neutral $Sr(OH)_2^0$ may be sufficiently soluble in supercritical steam to be carried to the high pressure turbines. The limiting molar conductivities were found to be a simple exponential function of the solvent viscosity, which can be used to estimate ionic mobilities and diffusion in crevices under supercritical water reactor conditions.