Boric Acid Ionization Constants and Ion-Pair Formation Constants of Sodium and Potassium Borate under Nuclear Reactor Coolant Conditions by AC Conductivity Methods

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Boric acid is used in the primary coolant of pressurized water (PWR) nuclear reactors as a neutron absorber to control the reactor reactivity. Quantitative thermodynamic and transport property databases are needed to model the boron precipitation reactions in fuel deposit crevices, which adversely affect the neutron flux. Here, we report new boric acid ionization constant that have been determined from T = 548 K to T = 623 K at a constant pressure p ~ 20 MPa using a unique high-precision flow-through AC electrical conductance instrument. Frequency-dependent electrical conductivities of aqueous solutions of boric acid, sodium borate and potassium borate have been measured over ionic strengths from 10^{-4} to 10^{-1} mol·kg^{-1}. The concentration-dependent experimental molar conductivities, Λ, were analyzed with the Turq-Blum-Bernard-Kunz ("TBBK") ionic conductivity model to yield values for the ionization constant of boric acid, K_{11}, to an accuracy of ±1 percent at T = 623 K. These compare well with extrapolated values from accurate potentiometric measurements at temperatures up to 573 K and steam saturation pressures [1, 2]. The TBBK fits to molar conductivity data for the borate salts yielded statistically significant ionic association constants for the species $Na[B(OH)_4]^0$ and $K[B(OH)_4]^0$ at T > 573 K. These new data are consistent with extrapolations of potentiometric data obtained below 473 K [3]. Our results also confirmed the validity of the new 2006 IAPWS formulation for the ionization constant of water, pK_w, [4].

References

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