

Experimental Investigations of the Properties of Supercooled Water: Surface Tension And Density at Moderate Pressure

Jan Hrubý^{C, S}, Václav Vinš, Pavel Peukert and Jiří Hykl

Department of Thermodynamics, Institute of Thermomechanics AS CR, v.v.i., Prague 8, Czech Republic

hruby@it.cas.cz

We report on our recently accomplished measurements of the surface tension of supercooled water (J. Phys. Chem. Lett. 5, 2014, 425–428), and the first series of measurements for the density of supercooled water at elevated pressures. The goal of both studies is achieving reference-quality data in the region of supercooled water extending close to the ice homogeneous nucleation limit. This activity is primarily motivated both by the fundamental interest in the properties of supercooled water and by its importance in nature and technology, particularly in atmospheric sciences and aerospace engineering. The research is also inspired by needs of the International Association for the Properties of Water and Steam (IAPWS) which works on extending the accurate analytical formulations of thermophysical properties of water down to the region of supercooled water. The surface tension was measured down to -25°C using a modified capillary rise method. Only a short part of the fused silica capillary was maintained at the temperature of interest, while its rest and the water pool were kept at the ambient temperature. The most interesting result was that the data points represent an almost straight-line extrapolation of the dependence of the surface tension on temperature found in the stable region (positive Celsius temperatures). This is in contrast with the older data by Hacker (NACA TN 2510, 1951) showing an anomalous temperature course characterized by a second inflection point. This claimed anomaly received a partial support by some molecular simulation studies and theoretical models, but most likely it was an experimental artifact. In addition to our published work, we discuss most recent experiments using alternative experimental methods and attempts to extend the temperature range. The goal of the measurements of the density of supercooled water is achieving highly accurate data (0.02% in density or better) for supercooled water in a region limited by the ice homogeneous nucleation temperature at the given pressure and up to 200 MPa. The data should provide a basis for the development of an accurate equation of state (EoS) for cold and supercooled water. The existing data sets either do not cover a sufficient range of temperatures (Sotani et al., High Temp. High Pressures 32, 2000, 433), or show too high uncertainties (Mishima, J. Chem. Phys. 133, 2010, 144503) making them unsuitable for the development of an accurate EoS. Our density measurements are a work in progress. We present the experimental method and preliminary data not yet covering the full pressure and temperature ranges.