Density of Supercooled Waters - Overview of Measurements Using Dual-capillary Dilatometer

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An in-house developed dual-capillary dilatometer, tailored for accurate density measurements of supercooled water and aqueous solutions from ambient pressure to 200 MPa was used for experimental studies of ordinary water, heavy water [1] and IAPSO standard seawater. The dual-capillary method provides relative densities, i.e., the ratios of the density at a temperature of interest to the density at a reference temperature at the same pressure. If reliable densities are available at the reference isotherm (chosen near ambient temperature), relative densities can be easily converted to absolute densities.

After several years of experience and gradual improvements of the dual-capillary method, we present an overview of measurements with different waters. Since the measurements were performed systematically along isobars, the location of the density maxima and their evolution with increasing pressure can be easily evaluated. Thanks to the uniform experimental procedure, several patterns can be observed between the results for ordinary water, heavy water and seawater.

Water at atmospheric pressure exhibits a density maximum close to 277.15 K. With increasing pressure, the maximum moves to lower temperatures, and above about 27 MPa it reaches the supercooled region. For seawater, the density maximum at atmospheric pressure is already located below the freezing point temperature. Inspired by the work of Kanno and Angell [2], it is interesting to compare the results between individual waters in the form of reduced density vs. reduced temperature, where the reducing parameters are the temperature and density of the density maxima for each isobar. The comparison reveals that curves in these coordinates are shifted approximately by a constant pressure between individual waters, suggesting some density scaling possibilities. As an example, simple scaling of ordinary water equation of state for supercooled water of Holten et al. [3] to represent seawater densities is shown.

References

1. A. Blahut, J. Hykl, P. Peukert, V. Vinš, J. Hrubý, *Relative density and isobaric expansivity of cold and supercooled heavy water from 254 to 298 K and up to 100 MPa*, J. Chem. Phys. 151, 034505 (2019)
2. H. Kanno, C. A. Angell, *Volumetric and derived thermal characteristics of liquid D2O at low temperatures and high pressures*, J. Chem. Phys. 73, 1940 (1980)
3. V. Holten, J. V. Sengers, M. A. Anisimov, *Equation of State for Supercooled Water at Pressures up to 400 MPa,* J. Phys. Chem. Ref. Data 43, 043101 (2014)