Rational Representation of Thermodynamic Properties of Liquid CO_2 and Hydrofluorocarbons

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The Tait equation is often used as a thermodynamic equation of state for liquids. It was derived from a simple pressure function of the compressibility of liquid water. Sato confirmed that the simple pressure function is still well represented in the recent precise and accurate experimental data for liquid water, but he derived an equation of state having different functional form from the so-called Tait equation. We call this equation the Sato equation. It can derive thermodynamic properties such as enthalpy and entropy etc. with the aid of specific heat information at a given pressure.

In this study, the Sato equation with an additional temperature-dependent parameter for representing thermodynamic properties in a wider liquid range was applied for liquid carbon dioxide (CO_2). The parameter is a kind of correction for the density value. The revised Sato equation can represent the thermodynamic properties mostly within the experimental uncertainties of available experimental data in the region of temperatures from 216.592 K (triple point) to 273 K and pressures from the saturation pressure to 50 MPa. The maximum deviations of available experimental data are 0.3 % in density, 1.5 % in speed of sound, and 1.5 % in specific heat. Span and Wagner reported a Helmholtz equation of state for CO_2 in 1996 which is the fundamental equation of the IUPAC book. The present revised Sato equation represents the experimental data as accurately as the Span and Wagner equation in the liquid phase.

In the case of refrigerants, thermodynamic properties of liquids at low temperatures are important. Magee and his coworkers measured many specific heat and density values at low temperatures down to 200 K for most hydrofluorocarbons (HFCs). Based on not only Magee's measurements but also on other measurements, the revised Sato equation for liquid refrigerants will be developed and used to assess the thermodynamic consistency among the existing experimental data for liquid refrigerants.