Precise Measurements of Isothermal *PVTx* and Vapor Liquid Equilibrium Properties for Low GWP refrigerant R1123/R1234yf/R32 Ternary Mixtures

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There is an immediate need to replace existing refrigerants that have significant greenhouse effects with next-generation, low-GWP type refrigerants. To decrease flammability and/or toxicity, and increase compatibility with lubricating oils, a variety of three-component and multi-component refrigerants mixed with binary pairs of R1123, R1234yf, and R32 are potential candidates. To predict the thermodynamic properties for mixtures that are more ternary, only parameters for pure and binary mixtures, with no additional parameters for more than ternary mixtures, are adopted. We therefore try to verify the reliability of these predictions, based on comparisons between widely available models, with precise measurements of the thermodynamic properties.

We use two kinds of models. The first are Helmholtz-type models, which are adopted in the most recent REFPROP ver.10.0. We used that version to predict the VLE data of ternary mixtures. The other model is the Peng-Robinson equation-of-state modified by Mathias and Copeman. We determined the required parameters of the pure and binary fluids for the ternary calculations. The data were obtained with a bellows-type isothermal *PVT* and VLE apparatus for the R1123/R1234yf/R32 ternary mixtures. The measurement ranges were 5–55 ℃ and pressures up to 6 MPa. The expanded uncertainties (k=2) in temperature, pressure, density, and component measurements were estimated to be less than 3 mK, 1.4 kPa (p≤6.9 MPa), 0.1%, and 4.1×10-4, respectively. Systematic comparisons between the predicted values and the measurement results for the ternary mixtures will be discussed.