Improved Microwave Re-entrant Cavity Geometries for Dew-Point Measurements and a New Method to Quantify Adsorption and Precondensation Effects

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The accurate description of the thermodynamic behavior of multicomponent gas mixtures is crucial for many industrial applications. While available thermodynamic models, such as multiparameter equations of state, are able to predict the phase behavior of fluid mixtures, the lack of accurate experimental data often leads to large uncertainties in vapor-liquid equilibrium (VLE) calculations. VLE measurements based on microwave re-entrant cavity techniques have proven to deliver reliable and accurate results for phase equilibria and especially dew-point measurements of pure fluids and binary mixtures. Here, phase boundaries are determined based on a change in the system's resonant frequency. In the present work, we describe a microwave re-entrant cavity resonator specifically designed for dew-point measurements. The design process was aided by finite element analysis, addressing potential issues such as sample-mixing inside the cell and the distribution of the electric and magnetic fields necessary for high-quality frequency measurements. Compared to earlier designs, the sample volume has been somewhat reduced, representing a compromise between minimizing the quantity of sample required and the higher microwave frequencies that would accompany smaller cavity dimensions. Hard transitions and sharp edges inside the resonator were softened to achieve better sample mixing. Adsorption and precondensation can have distorting effects on dew-point measurements, but these are rarely discussed in the literature. The simple geometry of the measuring cell allows the minimization of these effects, especially when combined with polished surfaces. We have included the provision of a "cool patch" to localize condensation to a small area. Finally, we are investigating the potential of quantifying adsorption effects through an interchangeable bulb-system, which will utilize bulbs with different surface finishes, e.g., oxidized brass surfaces versus polished and gold-plated surfaces. We present preliminary measurements of binary refrigerant mixtures, with comparisons to dew-point measurements made in a 2-sinker densimeter.