The Four Sinker Densimeter: A Journey Towards Accurate Dew-Point Densities

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A critical step in advancing modeling of vapor-liquid equilibria of fluid mixtures is to provide accurate experimental dew-point density data. Our previous studies [1-2] have shown that to improve the accuracy of such data, the distorting impact of sorption phenomena on solid surfaces must be taken into account. Density measurements of pure fluids were also found to be affected. Even the sophisticated two-sinker density measurement principle does not fully compensate for changes in the composition of mixtures due to sorption phenomena, both in the homogeneous vapor phase and especially in the vicinity of the dew point. Against this background, we designed a novel Four Sinker Densimeter (FSD) [3] that was set up over the past years and recently commissioned [4]. This novel instrument, which applies the two-sinker principle, utilizes four sinkers (two “density sinkers” and two “sorption sinkers”) to investigate gas density and sorption effects simultaneously. The design of the density sinkers allows for increased resolution of the density determination. In contrast, the sorption sinkers are designed to increase the resolution of sorption measurements and to correct for the effect of sorption phenomena on the measured density. In parallel, a new methodology for a more accurate determination of dew-point densities was developed with the aid of Molecular Dynamics Simulation (MDS). MDS can be used to gain more information on the structure of the adsorbate on an atomistic scale [5]. Moreover, it can be used to estimate selective adsorption of the different components of a gas mixture, helping to correct for the subsequent compositional shift. We present the FSD, its commissioning, and a thorough uncertainty analysis. Adsorption and density measurements of pure fluids close to the dew line, used to validate simulations, are shown. Furthermore, the first mixture measurements are reported, and the new methodology to provide accurate dew-point densities will be explained, describing how MDS can supplement experimental measurements.

References

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