Determination of Solubility of Gases in Liquids by the Isochoric Saturation Method

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A new experimental setup for the determination of the solubility of gases in liquids at temperatures from (298.15 to 573.15) K and pressures from (0.1 to 50 MPa) is introduced in the present contribution. The setup relies on the isochoric saturation method, where defined amounts of liquid solvent and gaseous solute are equilibrated in a sample cell with known volume. The mass of the solvent contained in the cell is determined by weighing the mass difference of a syringe before and after the filling procedure. The amount of gas injected into the cell from a volume-calibrated reservoir can be determined by both gravimetry and the application of equations of state. The sample cell is connected to a liquid circulation system consisting of a centrifugal pump, a screw press, and a densimeter. This allows to measure liquid densities for the compressed state as well as for the two-phase region at temperatures up to 473.15 K and pressures up to 40 MPa. In addition, Raman spectra of the liquids with dissolved gases are recorded via two sapphire windows of the cell to calibrate the spectra for solubility measurements in arbitrary systems. After validation with carbon dioxide and 1-hexanol, the new setup was used to study the solubility of hydrogen in a reference liquid organic hydrogen carrier (LOHC) system based on diphenylmethane (DPM). In general, LOHCs allow for the safe chemical storage of hydrogen with considerable loading capacities. Samples based on DPM with varying degrees of hydrogenation were investigated at process-relevant temperatures and pressures up to 480 K and 10 MPa, respectively, where literature data are rare. The solubility of hydrogen in DPM was found to be about 50% smaller than in its fully hydrogenated form.