Gaseous Binary Diffusion Coefficients for Mixtures of Propane with Methane and Carbon Dioxide by Using a Loschmidt Cell Combined with Holographic Interferometry

Pouria Zangi
Institute of Advanced Optical Technologies - Thermophysical Properties (AOT-TP), Friedrich-Alexander-University Erlangen-Nürnberg (FAU), Erlangen, Bavaria, Germany

Ludger Wolff and Thorsten Brands
Chair of Technical Thermodynamics (LTT), RWTH Aachen University, Aachen, North Rhein-Westphalia, Germany

Michael H. Rausch [C]
Institute of Advanced Optical Technologies - Thermophysical Properties (AOT-TP), Friedrich-Alexander-University Erlangen-Nürnberg (FAU), Erlangen, Bavaria, Germany
michael.rausch@fau.de

André Bardow
Chair of Technical Thermodynamics (LTT), RWTH Aachen University, Aachen, North Rhein-Westphalia, Germany

Andreas P. Fröba [S]
Institute of Advanced Optical Technologies - Thermophysical Properties (AOT-TP), Friedrich-Alexander-University Erlangen-Nürnberg (FAU), Erlangen, Bavaria, Germany

As measuring transport properties of all fluids and their mixtures at each thermodynamic state is virtually impossible, reliable experimental data are needed for developing new theoretical approaches to predict the corresponding properties. The present contribution reports on efforts to determine first concentration- and pressure-dependent data for the binary diffusion coefficient D_{12} for the gas mixtures propane/methane and propane/carbon dioxide by using a Loschmidt cell combined with holographic interferometry. These data are of technical interest, but mainly serve as a reference for D_{12} data calculated by molecular dynamics simulations based on new force fields developed from *ab initio* quantum calculations. In detail, these systems were investigated at pressures of (0.1, 0.2, and 0.5) MPa, temperatures of (293.15 and 313.15) K, and propane mole fractions of 1/6, 1/3, 1/2, 2/3, and 5/6. The experiments were performed with various initial propane concentrations in the halves of the Loschmidt cell to obtain the mentioned final mole fractions after the diffusion process. For data evaluation, influences of the optical setup stability, uncertainties in the initial experimental conditions, and the concentration dependency of D_{12} in context with Fick's second law on the results were considered. This new approach was developed in connection with a systematic measurement series for the noble gas system helium/krypton, where several deficiencies of the former data evaluation scheme assuming a constant diffusion coefficient and perfect experimental boundary conditions were identified and solved. While expanded relative uncertainties (k = 2) of the experimental D_{12} data of about 1 % can be reached for helium/krypton with the new evaluation scheme, they are up to 5 % for the propane-based systems because of adsorption effects of the molecular gases. As expected, increasing D_{12} values with increasing temperature and decreasing pressure were found for all investigated systems.