Measurements of the Viscosity of Nitrogen, Methane and Binary Mixtures of Nitrogen and Methane with an Advanced Combined Viscosity-Density Apparatus and a New Apparatus for Viscosities at Low Densities

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There are two important reasons for simultaneous measurements of the viscosity and density. The first reason is that the best description of the viscosity behaviour of fluids over wide ranges of temperature and pressure is gained with correlations depending on temperature and *density*. The second reason is that the density is needed to achieve the highest possible accuracies in viscosity measurements. The density is an essential part of the working equation used to determine the viscosity from the measuring signal, regardless of the type of viscometer. Ideally, one and the same instrument is needed to measure the density together with the viscosity. Nevertheless, in most cases the viscosity is measured together with temperature and pressure instead of a direct density measurement; then the density of the investigated fluid is calculated from an equation of state. Obviously, this procedure limits accurate viscosity measurements and correlations to fluids of which sufficiently accurate equations of state exist. At present time, such equations of state are available only for about 25 pure substances. In the case of mixtures, only a few natural gases and refrigerant mixtures meet this requirement. Consequently, a few years ago, in our group an apparatus was developed for the simultaneous measurements of the viscosity and the density of fluids in the same measuring cell. The main element of the instrument is an electronically controlled magnetic suspension coupling. The density measurement is carried out with a buoyancy-principle based single-sinker densimeter. Here, the magnetic suspension coupling is used for the contactless transfer of the buoyancy forces acting on a sinker in the measuring cell to the microbalance. Besides this, the coupling serves as a frictionless bearing for a slender cylindrical body. The rotation of this freely suspended rotation cylinder is slowed due the viscous drag of the fluid surrounding the cylinder. The viscosity of the fluid can be directly determined from the decay rate of the rotational frequency. The viscometer-densimeter covers a large operational range with respect to pressure and temperature. Very small uncertainties in density and small uncertainties in viscosity measurement have been achieved.

In this project the viscometer-densimeter was advanced and a new, special apparatus for very accurate viscosity measurements at low densities was designed for the same temperature range as the combined apparatus. The low-density apparatus also allows viscosity measurements on fluid mixtures. The apparatus was designed to measure viscosity data near zero-density, which are important for the development of viscosity correlations over wide ranges of temperatures, if these correlations are based on the residual principle. Furthermore, the new apparatus can be used to check the results of the combined viscometer-densimeter. Viscosity and density measurements on nitrogen, methane and three binary mixtures of methane and nitrogen were carried out with the advanced viscometer-densimeter and the new apparatus at low densities. Thus, complete measuring data sets for methane, nitrogen and their binary mixtures over wide ranges of temperature and density with very small uncertainty in density and very small uncertainties in viscosity are provided.