Measurement and Modelling of Density, Viscosity, and Speed of Sound of Methyl Dodecanoate, Ethyl Tetradecanoate and Two Oxymethylethers as Alternative Fuels

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The need for alternative fuels is increasing to fulfill the goal of carbon-free mobility. Methyl dodecanoate (MD), ethyl tetradecanoate (ET), and polyoxymethylene dimethyl ethers (OME), are promising alternatives to fossil fuels. These are synthetic fluids not based on crude oil or natural gas but produced via other sustainable process routes, supporting the shift away from fossil fuels. The MD and ET are already used as a component of diesel to reduce emissions and soot formation [1-3], but they could also replace diesel completely. To improve the combustion and flow of these fluids and fully realize their potential, accurate knowledge of thermophysical and transport properties, such as density, viscosity, and speed of sound, is crucial. For example, while density and viscosity are essential for characterizing flow, spray, and consumption [4], knowing the speed of sound is vital for studying injection efficiency [5]. However, the literature reveals a significant need for more data on these fluids. Here, we present measurements of the density, viscosity, and speed of sound of MD, ET, and two different OME samples over the temperature range from 273 K to 423 K at pressures up to 100 MPa. For the measurements, a commercially available vibrating-tube densimeter, an in-house fabricated vibrating-wire viscometer, and a sound-speed instrument based on the dual-path length pulse-echo technique were employed. Simultaneous density and sound speed measurements were conducted at Chemnitz University of Technology, while density and viscosity were simultaneously measured at Imperial College London. Advanced models for data analysis were applied. The expanded combined uncertainties (k = 2) were estimated to be 1.5 kg/m³ in density for both apparatuses, 0.3 mPa.s in viscosity, and about 1 m/s in speed of sound. The data serve to develop accurate correlation equations for the synthetic fuels, which are presented as well. The data and correlations will form the basis for using the fuels as future test fluids in flow measurements and, thus, for evaluating the measurement performance of flow meters. Ideally, these equations will be incorporated into the flow meter standard in the future.

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