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Measurements and modelling of density and viscosity of methyl dodecanoate and ethyl tetradecanoate

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To reduce the net carbon emissions in maritime and long-distance road transport, biological fuels are feasible options since battery technology is not yet mature enough to ensure, e.g., intercontinental shipping. If these fuels are used, e.g., on ships equipped with the CCS on ships technology, even negative carbon emissions are possible. Biodiesel, a mixture of numerous fatty acid esters (FAE) derived from the transesterification of fatty acids, is already worldwide used with a fraction of up to 10% in blends with fossil diesel in the transportation sector. Pure biodiesel can be used in most common diesel engines, bearing the potential of drastically minimizing carbon emissions. To allow for efficient process design, thermophysical properties of biodiesel such as density, viscosity or heat capacity have to be known at various temperature and pressure conditions since they influence, e.g., flow and pumping behaviour and spray quality. As the composition of biodiesel depends on the composition of the fatty acid feedstock and the alcohol used for transesterification, the thermophysical properties of biodiesel vary. To predict the properties of possible biodiesel compositions, several mixture models exist in the literature, mostly relying on the properties of pure FAE. However, the availability of experimental data for most of the pure FAEs is limited in temperature and often lacking at elevated pressures [1].

Therefore, the density and viscosity behaviour of methyl dodecanoate and ethyl tetradecanoate, typical compounds of biodiesel, were determined in this work, enhancing data availability for both substances. Using a coupled vibrating-wire vibrating-tube viscometer-densimeter, measurements were conducted at pressures from (0.1 to 100) MPa and temperatures from (298 to 423) K. Relative expanded uncertainties of the results were estimated to be within 0.1% for density and 1.2% for viscosity. The new data set was further used to elaborate correlations to predict density and viscosity at arbitrary conditions. For methyl dodecanoate, deviations of the experimental data from the developed Tait equation for density and Tait-Andrade equation for viscosity are exemplarily shown in Figure *1*. With deviations lower than 0.1% for density and lower than 0.8% for viscosity, the correlations represent the new data within their experimental uncertainty. In addition, the correlations agree as well with experimental data available in the literature within their stated measurement uncertainty.

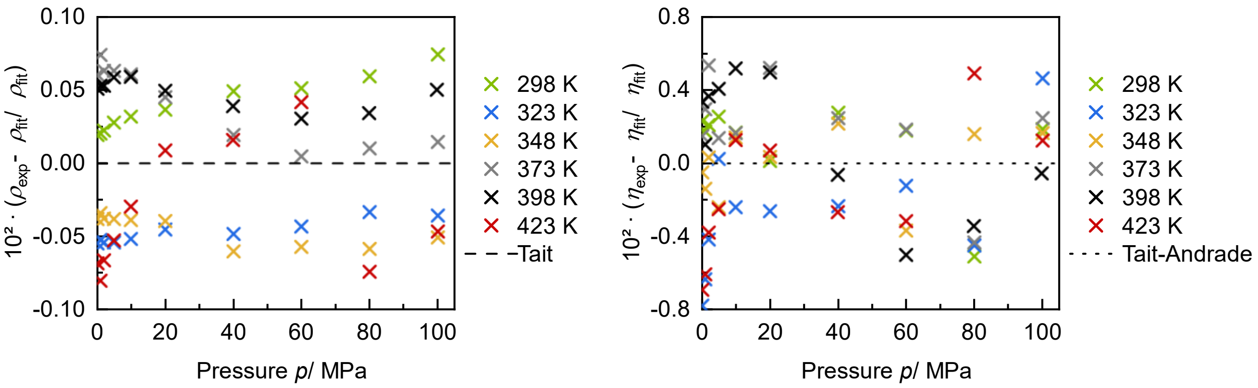

Figure 1. Deviations of the experimental data for methyl dodecanoate for density (left) and viscosity (right) from the developed Tait equation and Tait-Andrade equation, respectively.

Reference

[1] Wedler C, Trusler JPM. Review of density and viscosity data of pure fatty acid methyl ester, ethyl ester and butyl ester. Fuel 2023;339.