

Application and experimental validation of the One-Third rule in determining viscosity and surface tension of crude oil systems

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Thermodynamic and transport properties of hydrocarbon systems are determined, in part, by the van der Waals attractions between molecules. These van der Waals attractions, i.e. London dispersion interactions, are related to the electronic polarizability and molar refractivity of the molecules. Molar refractivity is related to refractive index and molar volume through the Lorentz-Lorenz equation.

We have previously presented a method that relates the refractive index of a hydrocarbon substance with its mass density [1,2]. This is based on the observation that the molar refractivity is approximately proportional to the molecular weight of a hydrocarbon molecule. The proportionality constant is approximately equal to one-third for hydrocarbon and crude oil systems. Although both the refractive index and the mass density are functions of temperature, it has been found that the proportionality constant of this model, called the One-Third rule, is nearly invariable over a wide range of pressures and temperatures. This correlation has been validated with over 200 crude oil samples, in a wide range of densities (10–55°API) and temperatures (10–70°C) as it shown in Figs. 1 and 2.

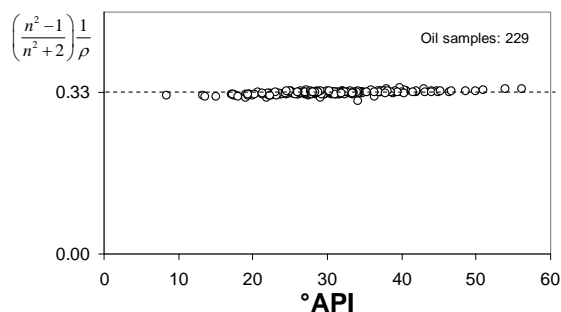


Fig. 1. Consistency test for refractive index and mass density measurements of over 200 crude oil samples [3]. Ratio FRI / ρ is about 1/3 for most of the tested samples

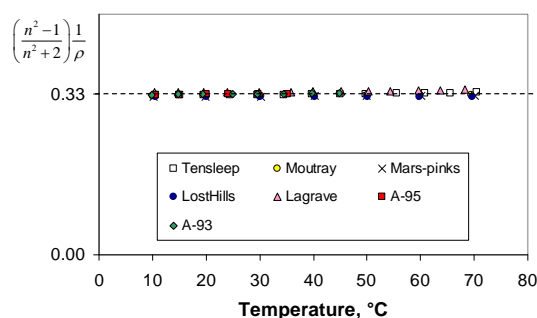


Fig. 2. Validation of the one-third rule in a wide range of temperatures for different crude oils. Experimental data were taken from Wang [3].

In this work the application of the One-Third rule is extended to the calculation of transport properties of crude oil systems. Five crude oil samples from the Middle East are analyzed. Measurements of viscosity and surface tension are obtained experimentally as a function of temperature for the different samples and compared with the values obtained from the model.

Application of the One-Third rule is intended to be used in the determination of transport properties of crude oils based on readily available information such as density, composition and molecular weight.

References

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