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Interfacial Tensions and Viscosities in Multiphase Systems by Surface Light Scattering (SLS)

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Multiphase systems are of interest in many processes of energy engineering such as enhanced oil recovery for the mobilization of residual oil from porous rock structures and the development of high-performance insulating materials. For process and product design in connection with multiphase systems, knowledge on the viscosity of the individual phases and on the interfacial tension between these is needed. Until now, no rigorous theory allows for the modeling of the viscosities and interfacial tensions in multiphase systems. Here, the reliable experimental determination of interfacial tension is challenging due to the often relatively low or even vanishing absolute values. In addition, the necessity of realizing measurements at or very close to equilibrium conditions is often in contradiction to the measuring principles of conventional interfacial tensiometry and viscometers.

The present contribution demonstrates that surface light scattering (SLS) is a suitable method for the simultaneous determination of interfacial tensions and viscosities in multiphase systems at macroscopic thermodynamic equilibrium.[1] This represents a further development of the method which has already been established at AOT-TP in the past two decades as reliable and routine tool for the determination of liquid viscosity and surface tension in vapor-liquid systems.[2] The two model systems investigated in this study consist of *n*-decane and methanol as well as *n*-dodecane and methanol, which form an upper vapor phase, an intermediate *n*-alkane-rich liquid phase, and a lower methanol-rich liquid phase at saturation conditions. Based on the two detected oscillatory signals originating from surface fluctuations at the vapor-liquid and liquid-liquid phase boundaries, it could be proven that the measured dynamics of the surface fluctuations, i.e. their frequency and damping, agrees with the hydrodynamic theory. Absolute data for the viscosities of the two liquid phases as well as the vapor-liquid and liquid-liquid interfacial tensions could be determined for the two model systems at saturation conditions at temperatures between (333 and 358) K with expanded uncertainties ranging from (2.2 to 7.4)% as well as from (1.5 to 6.0)%. The SLS results representing the first experimental data for the studied systems show the expected trends of approaching liquid viscosities and vanishing liquid-liquid interfacial tensions in the vicinity to the upper critical solution temperatures of the systems.

References

[1] T. M. Koller, T. Prucker, J. Cui, T. Klein, and A. P. Fröba, Interfacial Tensions and Viscosities in Multiphase Systems by Surface Light Scattering (SLS), submitted to *J. Colloid Interf. Sci.* (2018)

[2] A. P. Fröba and S. Will, Light Scattering by Surface Waves – Surface Light Scattering. in: M.J. Assael, A.R.H. Goodwin, W.A. Wakeham (Eds.), Experimental Thermodynamics, Volume IX: Advances in Transport Properties of Fluids, Royal Society of Chemistry, Cambridge, United Kingdom, 2014, pp. 22-35.