

**Viscosity and Surface Tension of the Ionic Liquids [EMIM] [EtOSO₃], [EMIM] [NTf₂],
[EMIM] [N(CN)₂], and their Binary Mixtures with Water, Methanol,
and Ethanol by Surface Light Scattering (SLS)**

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In the present work, an analysis of the liquid viscosity and surface tension of the ionic liquids [EMIM] [EtOSO₃] (1-Ethyl-3-methyl-imidazolium ethylsulfate), [EMIM] [NTf₂] (1-Ethyl-3-methyl-imidazolium bis(trifluoromethylsulfonyl)imide), and [EMIM] [N(CN)₂] (1-Ethyl-3-methyl-imidazolium dicyanamide), as well as of their binary mixtures with water, methanol, and ethanol was carried out by surface light scattering (SLS), a technique that is closely related to dynamic light scattering (DLS) in its classical meaning. The difference is that this technique probes, as the name indicates, fluctuations on the surface of a liquid or, in a more general formulation, at phase boundaries. These fluctuations can be understood as thermally excited capillary waves of small amplitude (~ 1-100 nm) with a characteristic wavelength (~ 0.1-1000 µm) and which are quantized in so-called "ripples". Light interacting with such an oscillating surface structure is scattered. The surface fluctuations result in a temporal modulation of the scattered light intensity which contains the information on the dynamics of the surface and thus on the viscoelastic properties of fluids.

For the propagation of capillary waves in the case of small viscosity and/or large surface tension both properties could be determined simultaneously by SLS for [EMIM] [EtOSO₃], [EMIM] [NTf₂], and [EMIM] [N(CN)₂]. For an over-damped behavior of surface fluctuations in the case of large viscosity and/or small surface tension, as it was relevant especially for [EMIM] [EtOSO₃] and [EMIM] [BTA] at low temperatures, the SLS experiment could only deliver information about the ratio of viscosity to surface tension. Here, the viscosity could be derived by a combination of the SLS data with surface tension data obtained by the pendant drop method. In addition, viscosity measurements with a rotational viscometer could serve as verification of the present data. These extend for pure [EMIM] [EtOSO₃], [EMIM] [BTA], and [EMIM] [N(CN)₂] over a wide temperature range from 273 to 433 K. Over a limited temperature range between 283 and 303 K, the present mixture data point up the influence of small amounts of water, methanol, and ethanol on the viscosity and surface tension. The viscosity was found to be reduced dramatically, thus reflecting the non-ideality of the viscosity behavior of binary mixtures of [EMIM] [EtOSO₃] and [EMIM] [BTA] with water, methanol, and ethanol.