Structure of imidazolium-based ionic liquid under shear flow

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" Ionic liquid " (IL) is a generic chemical name for novel ionic compounds which are in liquid states around room temperature. Alkyl-methylimidazolium-based ILs abbreviated to C*n*mimX, where *n* indicates number of carbons in an alkyl-chain and X is an anion, are most intensively studied in terms of physical properties of ILs. Recent researches using x-ray and neutron scattering in C*n*mimX revealed nanoscale structures, which are characteristic of molecular arrangements between polar- and non-polar domains [1-3]. Since the molecular length is some 10 Å, characteristic scattering due to the layer structure appears in small scattering angles. ILs are also considered to be useful as lubricants because they remarkably protect moving elements from wear and reduce friction [4]. Indeed, structural rearrangements and change in the rheological behavior have been observed in confined ILs [5]. As it is suggested in surfactant systems, bicontinuous sponge phase with a short-range layer structure is aligned at the solid surface [6], and it is also shown that shear thinning occurs and the layer structure grows under shear flow [7]. Since the lyotropic surfactant bilayers and the domain structure of ILs are somewhat analogous, it is expected that the sliding of such layers in ILs under shear flow help reducing friction. These backgrounds in mind, we performed structural investigations of ILs under shear flow using SANS in order to pursue understanding the relation between the viscoelastic properties and the mechanism of reducing friction.

Since C8mimCl at liquid state shows relatively high viscosity [8] and the time scales for flow and diffusion motions are likely to be comparable at an available shear rate, we expect to see a structural change. A simultaneous small-angle neutron scattering and rheology experiment was performed on NGB-10m SANS at NIST to access high enough Q values with the rheo-SANS set up. Only radial configuration, which corresponds to a plane of normal and lateral direction to the flow, was measured in the present experiment. A scattering peak due to the nanostructure in the IL is measured. The peak was analyzed using a fit to a Lorenzian function.

Fig. 1. shows the shear rate, $\dot{\gamma}$ dependence of the apparent viscosity, η, the peak position, Q_0, and its width, Γ, at 10°C. Shear-thinning behavior, i.e.; η decreases with shear rate $\dot{\gamma}$, is confirmed. At $\dot{\gamma} \leq 200$ s^{-1}, Q_0 and Γ slightly decreased, suggesting the growth of the ordering of the domain structure with increasing the spacing due to the shear alignment effect. However, Q_0 and Γ increased at higher $\dot{\gamma}$, corresponding to the disordering of the structure.

References

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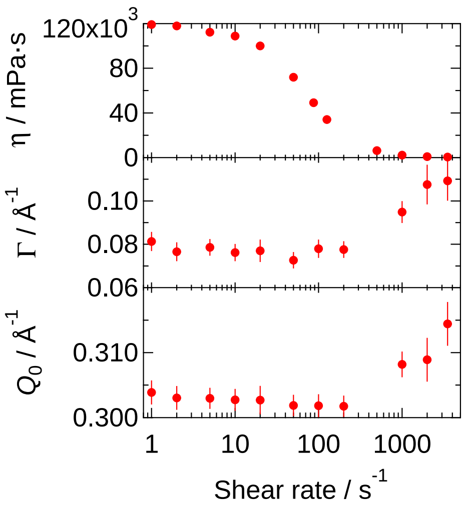

Fig. 1. Shear rate dependence of apparent viscosity η, peak position Q_0 and HWHM of the peak Γ of C8mimCl at 10 °C obtained from the rheo-SANS experiment.