Experimental report

21/02/2021

Proposal: **9-13-835**

Council: 4/2019

Title: Stiffness of Lipid Bilayer Membranes in Ionic Liquids

Research area: Soft condensed matter

This proposal is a resubmission of 8-02-855

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Experimental team: Shurui MIAO

Local contacts: Sylvain PREVOST

Samples: egg lecithin in ethylammonium nitrate
egg lecithin in d-ethylammonium formate
egg lecithin in d-ethanolammonium formate
egg lecithin in mixtures of ILs (above) and D2O

Instrument	Requested days	Allocated days	From	To
D11	1	1	03/09/2019	04/09/2019
IN15	5	5	04/09/2019	09/09/2019

Abstract:

Ionic liquids (ILs) are a novel class of solvents that support amphiphile self-assembly into micelles, vesicles, liquid crystals and microemulsions, but which themselves can also exhibit amphiphilic nanostructure. Here we propose investigating how the flexibility of fluid phospholipid (egg lecithin; POPC) bilayers in ILs differs from that in water, and how it is affected by the nature and extent of solvent nanostructure.

Experimental Report for: Stiffness of Lipid Bilayer Membranes in Ionic Liquids, Exp. No. 9-13-835

Users: Shurui Miao, Gregory Warr, Michael Gradzielski

Local Contact: Ingo Hoffmann

Flexibility of lipid bilayers is of significant interest since they serve as model system for cell membranes. However, almost all existing studies were performed in aqueous environments, neglecting the potential importance of the solvent. With recent advances in our understanding of ionic liquids (ILs), water is no longer the only solvent that supports self-assembly of phospholipids, and ILs have become more biocompatible and relevant with studies of biomolecules. Here, we have investigated the membrane flexibility of egg lecithin vesicles in ionic liquids, namely ethylammonium formate (EAF) and ethanolammonium formate (EtAF) with different water content using the neutron spin echo (NSE) beamline IN15. Due to the relatively high viscosities of ILs, the observed relaxation rates are slow and IN15 is the only instrument worldwide that can reasonably reach the long fourier times required for these samples. Complementary SANS data recorded on the

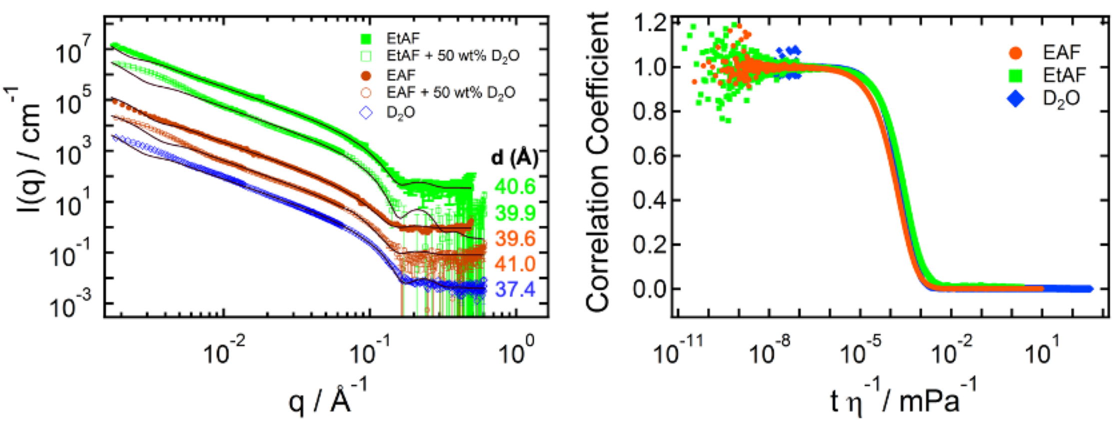

Figure 1: SANS patterns (a) and DLS correlation functions (normalised by solvent viscosity) (b) of 1 wt/v% egg lecithin vesicles in D2O (blue), and the two PILs ethylammonium formate (EAF, red) and ethanolammonium formate (EtAF, green). SANS patterns in filled markers were collected on D11 beamline; hollow markers, including vesicles in IL + 50 wt% D2O, denote spectra collected on the QUOKKA beamline approximately 3 months after the NSE studies were completed. SANS patterns were offset for clarity with fit shown in solid lines. Bilayer thicknesses from Kratky-Porod analysis are shown next to the SANS patterns.

beamlines D11 and QUOKKA (ANSTO, Australia) did not show any significant change in membrane thickness (Figure 1, left), while viscosity scaled DLS data shows that the overall size of the vesicles remains roughly constant (Figure 1, right). Nevertheless, applying the well known Zilman-Granek expression, a significant decrease in membrane rigidity was observed in the NSE data after correcting for solvent viscosity and translational diffusion. The contribution from translational diffusion was fixed in the fits using values obtained from IN15's online DLS. The physical origin of the extremely low bending rigidities in ILs is not yet understood and the subject

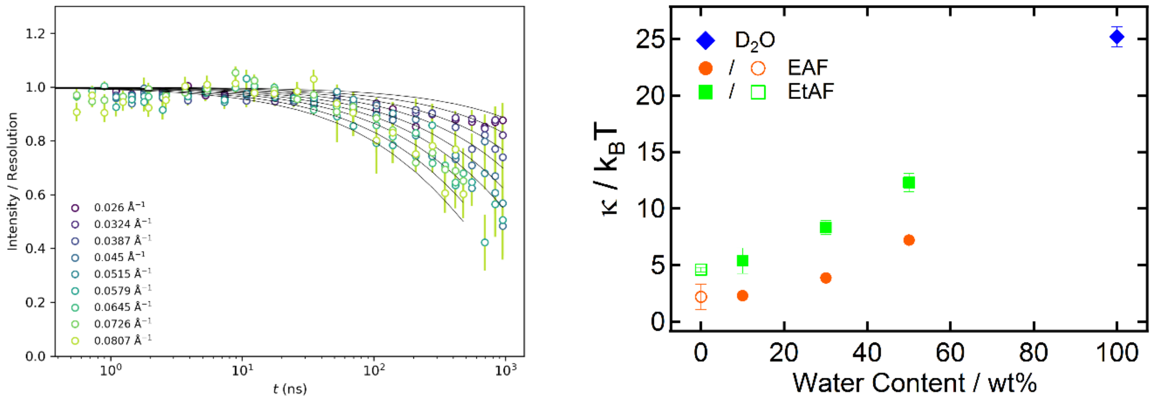

Figure 2: Left: NSE intermediate scattering functions egg lecithin in EAF with 30 wt% D_2O with global fit using the Zilman-Granek model. Right: Bending rigidities obtained from fits. Both ILs drastically reduce the bending rigidity.

of ongoing research. A publication on the data of this experiment is under preparation.