

Experimental report

16/04/2026

Proposal: 9-11-2233

Council: 10/2024

Title: DYNAMICS IN ELECTROACTIVE COMPOSITES OF A BIO-BASED POLYMER AND IONIC LIQUIDS

Research area: Materials

This proposal is a new proposal

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Samples: ionic liquids
PLLA films

Instrument	Requested days	Allocated days	From	To
IN5	2	2	21/05/2025	23/05/2025
IN16B Si 111 BATS	2	2	19/05/2025	21/05/2025

Abstract:

The aim of the proposed experiment is to employ quasielastic neutron scattering (QENS) to study the dynamics of ionic liquids (ILs) in composite materials with a biocompatible and biodegradable polymer poly-L-lactic acid (PLLA). We will vary the chemical structure of the ILs and degree of crystallinity of the PLLA matrix in order to modulate the interaction between the components and resolve the complex IL dynamics, and we plan to investigate the self-H-dynamics of the IL cations. We intend to correlate QENS results with the structural studies and practically important macroscopic properties of the materials. This study is crucial for advancing the applications of polymer/ionic liquid composites in the areas of wearable and implantable sensors/actuators, artificial muscles, etc.

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Aim. The aim of the performed experiment was to investigate the dynamics in composites of an electroactive polymer poly(L-lactic acid) (PLLA) with several ionic liquids (ILs), in order to elucidate the movements of the IL molecules and their interrelations with the practically important macroscopic properties.

Samples. Composite polymer films with ILs were produced by solvent casting method. The study was performed with several organic ionic liquids – [Bmim][SCN], which microphase separates from the polymer and is primarily located in micron sized pores; and [h-Bmim][TFSI] or deuterated [d-Bmim][TFSI] which show a higher compatibility with the polymer. The films were put in coaxial cylindrical aluminium cells, and the total thickness was adjusted to obtain a transmission of ca. 90%.

Measurements. The self-dynamics of protons in the composites was investigated at different q values and at different energy ranges employing IN16B spectrometer (mostly for the inelastic fixed window scans, IFWS) and IN5 spectrometer (for the full QENS analysis). The temperature range was 220-400 K.

Results. The unique energy resolution of IN16B was employed to elucidate the nature of dynamic processes occurring in polymer / IL composites at different temperatures. Below 120K, there is no significant dynamics, consistent with the fact that both IL and polymer are in the glassy state. Above ca. 120 K, an increase of the IFWS intensity is seen, which can be attributed to a “de-freezing” of the methyl group rotation in the ionic liquid. At temperatures higher than 240K, another clear dynamic process is seen, which is most likely due to a “de-freezing” of the polymer segmental motions, couples with the IL molecular motions.

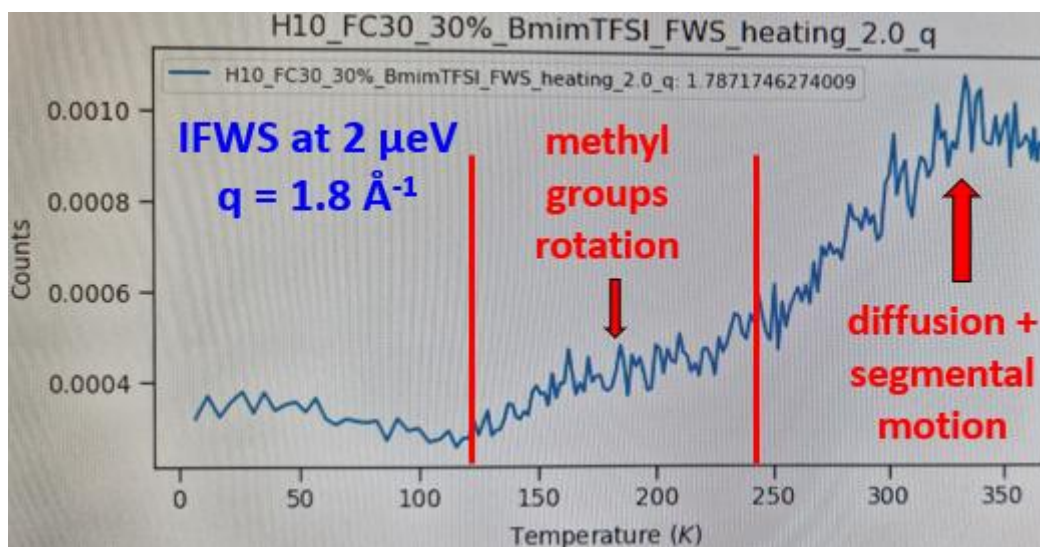


Figure 1. IFWS temperature scan (at the energy of 2 μeV) for the composite containing 30 wt% IL

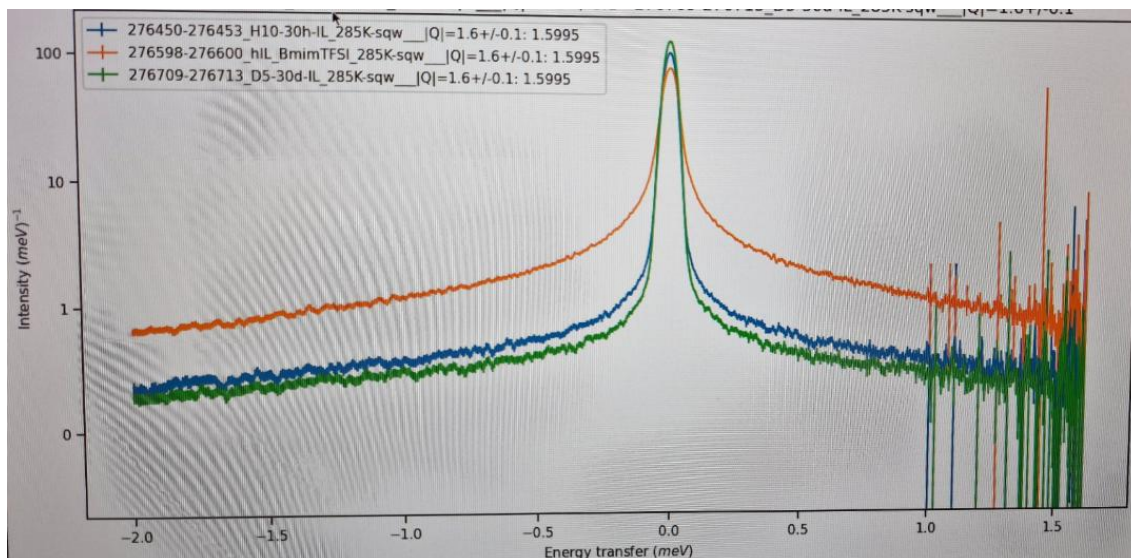


Figure 2. QENS spectra for the bulk h-IL (orange), polymer composite with 30 wt% of hydrogenated ionic liquid (h-IL, blue) and 30 wt% of deuterated ionic liquid (d-IL, blue)

From the IN5 QENS data, it is seen that the IL dynamics is slowed down in the composites as compared to the bulk (Figure 2). Also, the dynamics of the deuterated IL closely resembles the signal of the hydrogenated IL, suggesting that the motions detected by QENS are a result of a cooperative motion of the IL and the polymer segments bound together by electrostatic interactions.