Dynamics study of the slide-ring polymer and clay nanocomposite systems by neutron spin echo

T. Oda[A], H. Endo[B], K. Mayumi[A]

[A]*ISSP-NSL, Univ. of Tokyo,* [B]*IMSS, KEK*

Nanocomposite gels consisting of polymers and clay particles form a network structure and are known to exhibit superior properties such as excellent elongation and recovery properties [1]. Microscopic structural and dynamical analysis are essential for understanding the mechanism of mechanical property of a nanocomposite. To investigate how the polymer interacts with clay particles and how their mobility changes in a mixture of polymer and clay, we planned neutron spin echo (NSE) measurements on the nanocomposite of slide-ring polymer and clay particles. Slide-ring polymers are composed of a chain polymer (e.g. Polyethylene glycol; PEG) and ring molecules (e.g. Cyclodextrin) [2]. The ring molecules penetrate the chain polymer and can move freely on the axial chain, resulting in high strength without stress concentration during stretching.

To start with a simple model, in this beam time, NSE measurements were performed on a solution of PEG (M_w=35,000) 2.5% and clay particle (Laponite XLG (BYK)) 2% at room temperature. To clarify the dynamics of each component in the nanocomposite system, we measured several contrast variations by changing the D_2O ratio (represented by φ) of the D_2O/H_2O solvent. The main power supply of iNSE can output a maximum of 100 A of presession coil current, but in this beamtime, we were only able to adjust it from 1 A up to 60 A, which corresponds to a Fourier time range from 0.16 to 9.6 ns with a neutron wavelength of 7.3 Å. Prior to the NSE measurements, small-angle neutron scattering (SANS) measurements were performed on samples of the same composition. Figure 1 shows the SANS profiles of PEG/Clay solution with contrast φ=1 (100% D_2O solvent) and φ=0.73 (Clay-matching [3]). The yellow shaded region corresponds to the Q-range used in the data reduction of spin echo signal.

Results: Figure 2 shows the intermediate scattering function, I(Q,t) at Q=0.041±0.01 Å^{-1} of PEG/Clay solutions obtained by iNSE. Under the clay matching contrast (φ=0.73), there is almost no scattering from the clay, and the spin echo signal is expected to mainly reflect the motion of the PEG polymer. This result may have observed some indication of the dynamics of the polymer adsorbed on the clay particles.

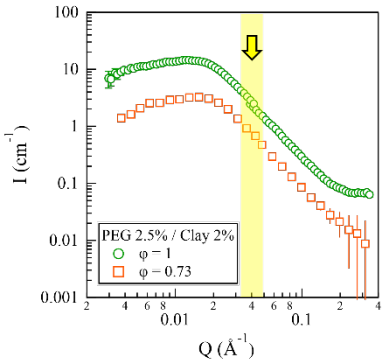

Fig. 1. SANS profiles of PEG/Clay solution at two contrast variations (φ=1 and 0.73) measured at SANS-U, JRR-3. The yellow shade indicates the same Q-range measured by NSE.

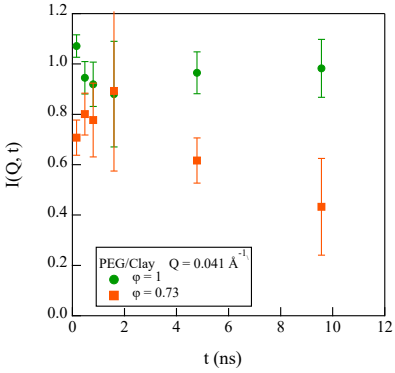

Fig. 2. Intermediate scattering function I(Q,t) of PEG/Clay solution at contrast of φ=1 and 0.73.

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[3] H. Endo, S. Miyazaki, K. Haraguchi, M. Shibayama, Macromolecules, **41**, 5406-5411 (2008).