Structural analysis of tetra-PEG gel containing ionic liquid

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Ionic liquids (ILs) have many unique properties, such as negligible volatility, non-flammability, and high ionic conductivity. Among many applications of ILs, " Ion-gel ", which is a gel with ILs as its solvent, has been getting much attention for the use of high conductive polymer electrolytes. In the case of conventional ion-gels, however, it is necessary to prepare ion-gel with high polymer concentrations to obtain suitable mechanical properties, resulting lower conductivities. To overcome this trade-off problem, we use Tetra-PEG network, which has high mechanical properties even at a low polymer concentration. Thus obtained Tetra-PEG ion-gel showed higher mechanical strength comparing with the conventional ion-gels, however, it is still inferior mechanical properties to the corresponding Tetra-PEG hydrogel. In this experiment, we investigated the structural difference of Tetra-PEG ion-gel formed in Il and water investigated by small-angle neutron scattering (SANS).

SANS experiments were carried out on High-flux Advanced Neutron Application Reactor (HANARO) located at Korea Atomic Energy Research Institute (KAERI), Korea. A monochromated cold neutron beam with an average neutron wavelength 6.00 angstrom was irradiated to the samples. The scattered neutrons were counted with a 2D detector. The sample-to-detector distances were chosen to be 3 and 17.5 m. After necessary corrections for open beam scattering, transmission, and detector inhomogeneities, the corrected scattering intensity functions were normalized to the absolute intensity scale. Tetra-PEG ion gel samples were prepared by mixing two tetra-PEG macromer-IL solutions. These two macromers are tetra-amine-terminated PEG (TAPEG) and tetra-NHS-glutarate-terminated PEG (TNPEG). NHS represents N-hydroxysuccinimide. We use partially deuterated 1-ethyl-3-methylimidazolium bis(trifluorosulfonyl)amide (d_8-EMI^+TFSA^-), as IL. The samples were macromer solutions (before gelation) and the ion-gels as functions of macromer concentration and molecular weight (10k, 20k, and 40k g/mol). Banjo-type and Pinching-type quartz cell with 2 mm thickness were used for the solution samples and the ion-gel samples, respectively.

Figure 1 shows the variation of obtained radius of gyration, R_g and correlation length ξ values against polymer volume fraction,ϕ for (a) IL and (b) aqueous solution of TAPEG. The inset shows the corresponding log-log plots. In the semi-dilute region of IL solutions (20k and 40k g/mol samples) (Figure 1(a)), the ξ values varied as $\xi \sim \phi^{-0.7}$, which was comparable to the relationship of a good solvent system ($\xi \sim \phi^{-3/4}$), where ξ is the blob size. On the other hand, this behavior was different with the case of the hydrogel system (Figure 1(b)). This fact should cause the resulting network structural difference between the ion-gel and hydrogel.

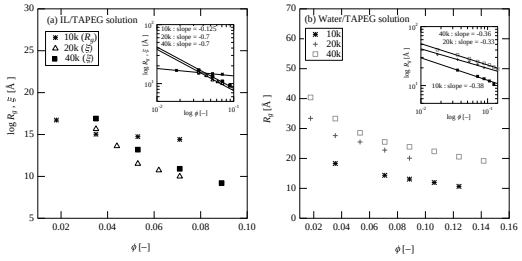

Fig. 1. Variation of Rg and ξ of 10k, 20k, and 40k TAPEG macromers against ϕ. The inset shows the corresponding log-log plots.