

The elucidation of the internal correlation of star poly(ethylene glycol) with small-angle neutron scattering

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Polymer gels are three-dimensional polymer networks swollen with solvents. Polymer gels have been thought to have inherent static heterogeneity for a long time. This concept originated when crosslinking froze the network structure. Indeed, the crosslinking limit the mobility of polymer segments, and they do not diffuse as same as an uncross-linked polymer solution. However, our recent study revealed that crosslinking did not affect the distribution of polymer segments even for a few hundred nanometers in the ideal condition, i.e., the bond percolation condition. The easy way to realize this condition; crosslinking a star-shaped polymer terminated with a functional group in suitable affinity solvent at well high concentration over an overlapping concentration. The homogeneity was confirmed with small-angle X-ray scattering (SAXS) and light scattering. SAXS covers a relatively wider q range, where q is the magnitude of the scattering vector. On the other hand, static light scattering covers the considerably smaller q -range. Thus, the gap range of q between SAXS and light scattering exists. Thus, the structural information of these spatial homogeneous gels at the middle q -range has not been obtained so far.

The feature of small-angle neutron scattering (SANS) is to get broad q -scale information. This fills the gap between SAXS and light scattering and gives us unclear structural information. In this study, we measured the spatial homogeneous gels synthesized with the bond percolation condition. The measurement was conducted on a 2D SANS instrument, SANS-U, at JRR-3 Research Reactor in Tokai, Ibaraki. The sample to detector distance (SDD) was 2 m and 12 m, which covers the q -range about 0.003 - 0.2 \AA^{-1} . The wavelength of the incident neutron was 7 \AA . The acquisition time was determined depending on the contrast of

samples and SDD, and 1-2 h for 2 m SDD and 6-12h for 12 m SDD, respectively.

The obtained 1D scattering profile is shown in Figure 1. Both results obeyed the fitting function like the Ornstein-Zernike (OZ) function, which is typical for polymer solutions. It is well known that scattering profiles of spatial homogeneous gels are reproduced with the OZ function. The position of the shoulder corresponds with the correlation length, and this difference between the two samples originated from the difference in polymer concentration. In a smaller q -region ($\sim 0.03 \text{\AA}^{-1}$), there was no appearance of any upturn of scattering intensity. In general, the heterogeneous spatial gel indicates the upturn of scattering intensity at a small q -region, which is called anomalous scattering. In our case, the scattering profiles connected smoothly for all measured q -region, which meant spatial homogeneity in correspondence spatial regions. This result guaranteed the effectiveness of the bond percolation condition.

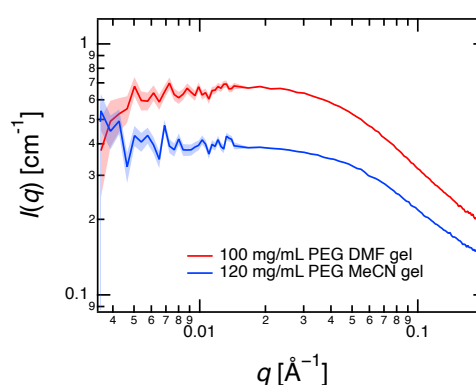


Figure 1. The obtained 1D scattering profile. The subtraction of cell and time, transmittance, and thickness correction were conducted. It should note that solvent was not subtracted due to the data precision of solvent.