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Correlation between transparency and thermal fluctuation of electron density in miscible polymer blends

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Introduction

In these years, transparent polymers have come to be used for optical materials such as optical lenses, optical films, optical fibers, and so on. When the polymers are applied for the optical materials, the optical properties such as transparency, refractive index, and birefringence should be controlled depending on the usage. The properties can be controlled by copolymerizing monomers or blending polymers with given properties. Polymer blending method has advantages such as low-cost, easiness of the processing and controlling the properties by changing the condition of blending. However, most pairs of polymers are immiscible and tend to phase separate to two phases. In such a system, the difference between refractive indices of the phases causes the light scattering loss [1-3]. Moreover, it is believed that the transmittance of even the miscible polymer blend tends to be lower than those of the component neat amorphous polymers. In the case of neat amorphous homopolymer, it is reported that the major factor of lowering transmittance is light scattering loss by the fluctuation of refractive index caused by density fluctuation [4]. On the contrary, in the case of polymer blends, it is thought that the fluctuation of refractive index caused by that of concentration of the component polymers in the blend is a major factor. However, it is considered that the low scattering-loss blend can be realized by optimize the condition to make the blend, because the light scattering loss in the polymer blends must be dependent on the miscibility of the blends to a great extent. In this study, to clarify the relation between the light scattering loss and the fluctuation, electron density fluctuation in a miscible polymer blend is estimated by small angle X-ray scattering (SAXS) measurement.

Experimental

Miscible polymer blend of poly(methyl methacrylate) (PMMA) and poly(styrene-*co*-acrylonitrile) (SAN29 with 29wt% of acrylonitrile), which shows lowest critical solution temperature type phase diagram, was made by casting the THF solution of them.

SAXS measurement was carried out by using BL-10C in the Photon Factory of the High Energy Accelerator Research Organization.

Results and Discussion

Figure 1 shows SAXS profiles of PMMA/SAN29 blends (25/75, 50/50, 75/25) at 50°C. When the SAN29 content in the blend decreased, the scattering intensity increased. Moreover, the correlation length of the electron fluctuation was estimated by the Debye-Bueche analysis:

$$I(q) = \frac{I(0)}{\left(1+\xi^2 q^2\right)^2},$$

where ξ is a correlation length. As the result, the estimated correlation length of the blend increased with decrease of SAN29 content. This tendency agrees with that of scattered intensity.

In the phase diagram of PMMA/SAN29 blend, SAN29 content at the critical composition is less than 25wt%, and then the miscibility of the blend is lower when the SAN29 content is smaller. This suggests that both the intensity and the correlation length become larger where the miscibility of the blend becomes low.

The correlation between the SAXS results and the transparency of the blends for the visible light is not clear yet, and it should be clarified in the future work. In any case, from the results, it is experimentally shown that the electron density fluctuation in the PMMA/SAN29 blend correlates with the miscibility of the blend.

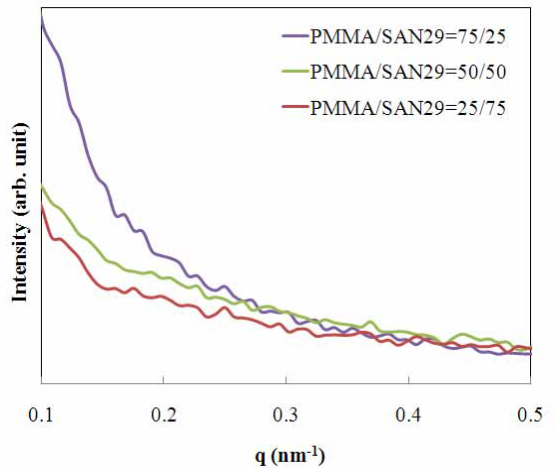

Figure 1. SAXS profiles of PMMA/SAN29 blends.

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