Chain conformation of highly-purified ring polymer in bulk and the blending effect of linaer polymers

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A ring polymer has characteristic structure with no chain ends and it is considered as a model polymer to clarify the topological effect on physical properties such as chain conformations, viscoelastic properties and so on. Recently the molecular weight (Mw) dependence of radius of gyration (Rg) for ring polymers in bulk is of much interest by scientists theoretically and experimentally. The Rg of polymer molecule can be scaled with the Mw in the general form as
Rg ? Mwv
The v value for linear polymers in bulk is 1/2, where the polymer chains can be regarded as an ideal chain. On the other hand, it is considered that the conformations for ring polymers in bulk do not obey the ideal chain statistics because the chain ends are connected. Arrighi et al. reported that the v value for ring polymers in melt is also 0.42 by SANS experiment, though the molecular weights of the ring polymers are fairly low as M<10k, and moreover the amount of linear contamination was not clarified [1]. In this study we have synthesized a series of highly-purified ring polystyrenes with molecular weights ranging 16k<Mw<380k, the radii of gyration were measured in bulk by small-angle neutron scattering (SANS) and molecular weight dependence of Rgs of the ring polymers were investigated.

Synthesis of ring polystyrenes was carried out by the same procedures reported previously [2]. Purified ring polymers were obtained firstly by SEC fractionation and secondly by fractionation using liquid chromatography at the critical condition (LCCC). Four pair of hydrogenated/deutrated highly-purified rings with molecular weights of 16k, 40k, 110k and 380k were prepared. The purities of rings were checked by LCCC and it was confirmed that all ring samples have high purity over 95%. SANS measurements of bulk film samples were performed by using SANS-U spectrometer (ramda=0.70nm) at ISSP, Tokai.

Relationship between Rg and Mw forring polymers are plotted in Figure 1. It was found that Rg of ring polymer can be scaled with Mw as Rg ∝ Mw0.38 in bulk, which were relatively weaker molecular weight dependence than linear ones. This scaling exponent is slightly smaller than the experimental result by Arrighi et al, and located between the predicted value by Cates and Deutsch (v =2/5) [3] and the other one by Suzuki et al. (v =1/3) [4].

References

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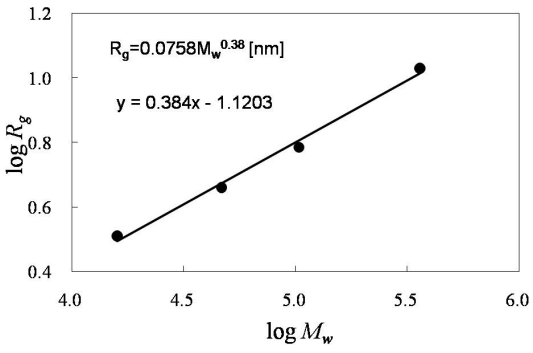

Fig. 1. Figure 1. Relationships between Rg and Mw of ring polystyrenes in bulk.