Molecular Weight Dependence of Domain Spacing in the Double Gyroid Structure of ABC Triblock Copolymers

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Self-consistent field theory (SCFT) predicted that the region in the phase diagram of AB diblock copolymers where the double gyroid structure forms are narrow compared to other structures [1]. Experimental results agree with this prediction [2]. Therefore, confirming the double gyroid structure and the molecular weight dependence of the domain spacing in AB diblock copolymers over a broad molecular weight range is experimentally challenging.

On the other hand, in the phase diagram of a symmetric ABC triblock copolymer, also obtained with SCFT, with an equal block ratio of A and C, a double gyroid structure is predicted to form over a relatively wide range compared to the AB diblock copolymer [3]. Therefore, it is expected that the ABC triblock copolymer will be able to stably form the double gyroid structure even in the high molecular weight region compared to the AB diblock copolymer.

This study investigated the molecular weight dependence of the domain size of the double gyroid structure of poly(isoprene-b-styrene-b-2-vinylpyridine) (ISP) triblock copolymer as the ABC triblock polymer. Five samples of ISP were synthesized by living anionic polymerization, and transmission electron microscopy (TEM) and small-angle X-ray scattering (SAXS) observation were done on these samples, and SCFT simulations[4] were done for the symmetric ABA triblock copolymer with the conditions χ_{AB} = 1.2, 1.8, and chain length N = 25~100.

The molecular weight dependence of the domain spacing is shown in Figure 1. The experimental result showed the relation

$$D = 0.108 M_n^{0.57}.$$

SCFT showed the relation $D \propto M_n^{0.71}$ in both χ_{AB} = 1.2, and 1.8, and the plots are scaled to match the point for N = 25 to Mn=65,300 in Figure 1. From this point, the experimental and SCFT results agree on the region where the molecular weight is about twice as high. However, the experimental result is lower than that of SCFT at higher molecular weights. This discrepancy is expected because the experiment was performed with an ABC structure, whereas SCFT was performed with a symmetric ABA structure. A more detailed comparison will be required in the future.

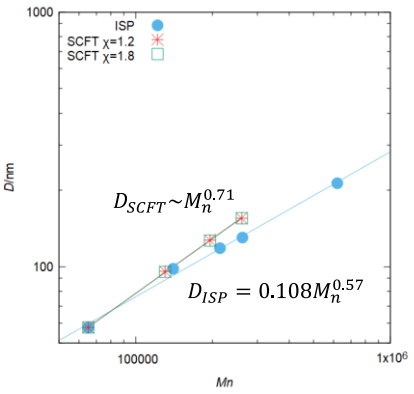

Figure 1 Relationship of *D* vs *Mn*

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