The Bicontinuous GYROID Structure from an AB Type Diblock Copolymer

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AB diblock copolymer consists of two different polmer chains connected by a covalent bond. In the bulk state, the copolymer form two high ordered phases whose periodic length is macromolecular size (10-100nm), if polymer components selected mutually incompatible. The sample used in this study is an anionycally polymerized monodisperse diblock copolymer from two incompatible polymer components at room temperature, polystyrene(S) and poly-2-vinylpyridine(P). The volume fractions of S and P are 0.28 and 0.72, respectively, and the total molecular weight is 8.5×10^4. A film specimen with $0.15mm$ thick for small-angle X-ray scattering (SAXS) measurements was prepared by casting from dilute (5 vol%) tetrahydrofuran (THF) solution of the copolymer, followed by drying at room temperature and annealing for a week at 423K on a tefron plate under vacuum. THF is a good solvent for two block chains. The annealed film was cut into small pieces of $2 \times 5mm$ area for SAXS measurements. The experiments were performed at beam line 15A at Photon Factory. The incided X-ray beam was monochromated and its wavelength λ is $0.1504nm$. A point collimated beam ($0.3 \times 0.7mm$) was placed parallel to the film surface. An imaging plate was used as a detector, camera length was $2327mm$. Figure 1 shows SAXS two-dimensional intensity map on the imaging plate.

SAXS intensities were calculated for *Gyroid structure* (G-structure), whose space group is $Ia3d$. We should begin by evaluating the structure factor $F(\mathbf{q})$ for the unit cell of structure. $F(\mathbf{q})$ is calculated as $F(\mathbf{q}) = \int \rho(\mathbf{r}) \exp(i\mathbf{q} \cdot \mathbf{r}) d\mathbf{r}$, where $\rho(\mathbf{r})$ is the electron density at location $\mathbf{r}$, which actually has two distinct values corresponding to two polymer phases with G-structure. The density distribution of G-structure was determined for two parallel surfaces derived from *Gyroid* surface. Open circles on the intensity map are calculated scattering intensities for G-structure, the sizes of the circles expresses the magnitude of the calculated logarithmic intensities. The agreement between the observed intensities and the calculated ones is satisfactory, except for the scattering peaks on vertical center line. These peaks can be explained by the fact that lamella structure is coexisted with G-structure, which was confirmed by observation of transmission electron microscopy. Thus, it was clarified that SAXS profile for the present diblock copolymer can be explained by the model of *Bicontinuous Gyroid structure*.

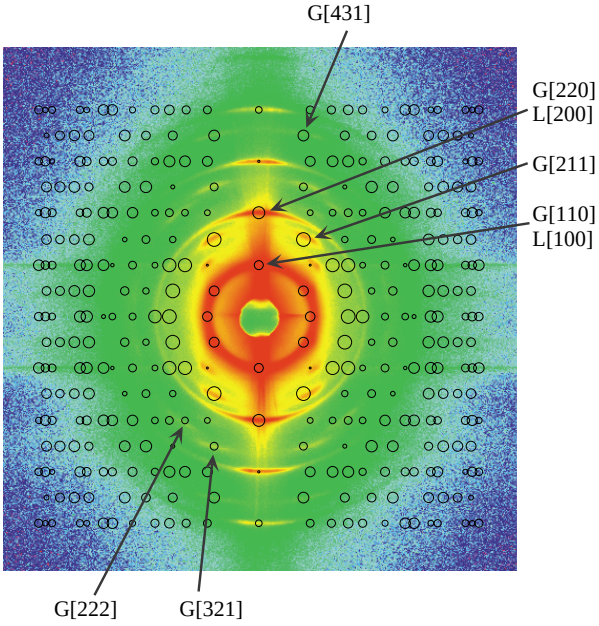

Figure 1 : SAXS intensity map and the calculated intensities for *Gyroid* structure.

References
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