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Dodecagonal Quasicrystals in Binary Mixtures of Block Copolymers and Homopolymers

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1 Introduction

Quasicrystals are structures that have ordered but not periodic tiling. It is well known that a quasicrystal pattern can be arranged completely in a whole space, but does not have translational symmetry.

Recently, it was reported that spherical microdomains could be arrayed in a variety of complicated lattices, such as quasicrystal approximants and quasicrystals. For example, in linear tetrablock copolymer and simple diblock copolymer, both quasicrystal and its approximant were discovered.

Our research group has investigated the phase behavior of a binary mixture of a block copolymer and a homopolymer. Recently, the Frank-Kasper σ phase was observed in polybutadiene-poy(ε-caprolactone) (PB-PCL) diblock copolymer/polybutadiene (PB) blends [1,2]. In this study, the dodecagonal quasicrystal was observed in block copolymer and homopolymer blends.

2 Experiment

Polybutadiene-poly(ε-caprolactone) block copolymer (PB-PCL) and polybutradiene (PB) homopolymer were synthesized by anionic polymerization under a high vacuum. The number -average molecular weight (M_n) and its heterogeneous index (M_w/M_n) of PB-PCL were 6,400 kg/mol and 1.02, respectively. The volume fraction of PCL was 0.27. The M_n of the synthesized PB homopolymer (PB5k) was 4,500, and the M_w/M_n was 1.03. Blend samples were obtained by solvent casting from toluene solution of the blend sample. The weight fraction of added homopolymer was 0.23.

The small angle X-ray scattering (SAXS) measurements were conducted at BL-15A2 in PF. The detector was set at a position of 3.5 m apart from sample position. The energy of X-ray was 5.7 keV.

3 Results and Discussion

Figure 1 shows the SAXS profile of PB-PCL / PB blends obtained at 120 °C. Arrows represent scattering peak positions. Here, the calculated relative *q*-peak positions and the reflection indexes for a dodecagonal quasicrystal are listed in Table 1. It was found that the series of observed scattering peaks are coincident very well with a dodecagonal quasicrystal, indicating that spherical microdomians are arranged into a dodecagonal quasicrystal.

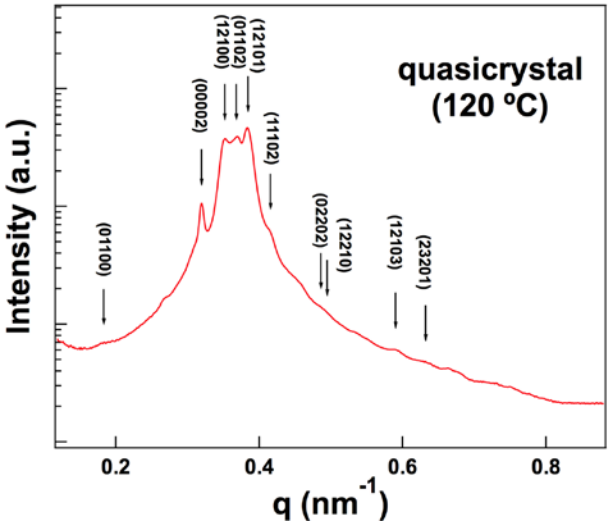

Fig. 1. The SAXS profiles obtained at 120 °C. Thin arrows represent calculated diffraction peaks from a dodecagonal quasicrystal.

Table 1: calculated relative *q*-peak positions and the reflection indexes for a dodecagonal quasicrystal

q_{obs}	q_{calc}	*hkl*
0.181	0.182	01100
0.320	0.352	00002
0.352	0.352	12100
-	0.359	10102
0.369	0.368	01102
0.384	0.387	12101
0.416	0.411	11102
0.454	0.485	02202
0.493	0.498	12210
0.590	0.595	12103

q_{obs}	q_{calc}	*hkl*
-	0.607	22202
-	0.610	23200
0.632	0.631	23201
-	0.639	00004
0.664	0.665	01104
0.682	0.681	13310
-	0.705	24200
0.731	0.730	12104
0.750	0.752	13312

References

[1] H. Takagi, et al., *J. Phys: Condens. Matter* **29**, 204002 (2017).
[2] H. Takagi, et al., *J. Fiber Sci. Technol.* **74**, 10-16 (2018).

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