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Specific Kinetic Pathway from Mesophase to Large Single Crystal of Polymer

Single crystals of polymer, especially large sized ones, have attracted the interest of researchers for many years. We have found a specific kinetic pathway to form giant single crystals of isotactic polypropylene (iPP) via the mesophase, whereas the crystal aggregate, the so-called spherulite, is usually obtained during the conventional crystallization of iPP from the molten state. In order to find such a kinetic pathway, multiple probes, such as wide-angle X-ray diffraction (WAXD), de-polarized light transmission (DPLT) and differential scanning calorimetry (DSC), were used in complementary.

The pre-quenched iPP mesophase was heated to 166°C at a rate of 75°C/min and maintained at this temperature for 24 h. The obtained crystallites exhibited a very high melting temperature, \( T_m \), of 183.7°C, which is ca. 19°C higher than the iPP’s nominal \( T_m \) (~165°C); namely, the observed \( T_m \) is immediately close to the literature value of iPP’s equilibrium melting temperature, \( T_m^0 \) (186.2°C). The crystallites have bamboo leaf-like or needle-like morphology and are ~35 \( \mu \)m in length and ~3.5 \( \mu \)m in width. The thickness of the crystallites was estimated to be 88 nm according to the melting temperature. The number density of the crystallites in a unit volume could be controlled by adjusting the heating rate. As the result, well-isolated single crystals of iPP with the above-mentioned morphology and dimension were obtained.

Small-angle X-ray and Neutron Scattering Analyses of Crosslinked Rubber with Metal Diacrylate

Many industries, including the automobile industry, require lightweight materials with high tensile strengths and high abrasion resistances to improve the manufacturing of commercial products. Therefore, controlling the morphology and structure of functional polymeric materials is indispensable to the development of next-generation materials.

The structure of rubber crosslinked with metal diacylate has been extensively studied because such rubber exhibits so-called “reinforcement effect” without the addition of reinforcing materials such as carbon black, silica or clay. On the other hand, the structure of the matrix rubber in itself, which is a main component in these rubber materials, has not been well studied because of its structural complexity. It is considered that elucidating the structure of the matrix rubber could provide a promising approach to improve the mechanical properties of these rubber materials, we then determined to study the structure of butadiene rubber (BR) crosslinked with metal diacrylate through the complementary use of small-angle X-ray scattering (SAXS) and small angle neutron scattering (SANS).

In addition to the hierarchical structure of metal aggregates we first succeeded to reveal the existence of high crosslink density segment (HC-BR) in the matrix BR. Furthermore it was also found that HC-BR was related to mechanical strength of the present studied butadiene rubber by comparing the results of the tensile measurements with the structural information from both SAXS and SANS measurements.