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学位論文題目	Effect of melt spinning and drawing conditions on the fiber structure development of polyethylene terephthalate (ポリエチレンテレフタレートの繊維構造形成におよぼす溶融紡糸・延伸条件の影響)
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論　文　内　容　の　要　旨

The force-bearing structure of Polyethylene terephthalate (PET) fiber is important because it dominate the fiber properties. In this study, the effects of melt spinning and drawing conditions on the fiber structure development of PET were investigated by using the on-line measurement system. Fibers obtained with spinning speed of 250–2000 m/min and drawing stress of 22 - 188 MPa were used for the measurements. The fibers obtained from laser spinning using a CO_2 laser beam irradiated onto the fiber at the melt spinning line were also analyzed. Changes in the proportion, d-spacing, persistence length, thickness and Hosemann’s disorder parameters (g_{II}) of the fibrillar smectic phase were measured from the smectic (00l′) diffraction peaks. Crystallinity index, crystal orientation factor and tilting angle were measured by wide angle X-ray diffraction (WAXD) images, and long-period and fibrillar structure were observed by small angle X-ray scattering (SAXS) and ultra-small angle X-ray scattering (USAXS) images, respectively. Relationships between these structural parameters and thermomechanical properties of the obtained fibers were discussed.

A strong smectic (001′) diffraction and larger long period, particularly less than 1 ms after necking, were observed for the fibers spun at 500–1500 m/min, while almost no smectic phase was observed at the beginning of crystallization for that spun at 2000 m/min. A higher crystallization rate and clear draw ratio dependence of crystallization rate were also observed for the fiber spun at 2000 m/min. These results suggest the crystallites were mainly developed from the oriented nuclei formed in the spinning process for the fibers spun at 2000 m/min, while they mainly formed by the phase separation of the fibrillar smectic phase for the fibers spun at about 500–1500 m/min.

The proportion, persistence length (50–70 nm) and thickness of fibrillar smectic phase achieved maximum values and its g_{II} reached a minimum value (3.7–4.3%) at 0.3–0.4 ms after necking. The maximum value of the proportion and persistence length and thickness decreased, and the minimum value of g_{II} increased with spinning speed, but they showed little dependence on the drawing stress. The persistence length and Natural draw ratio of the as-spun fiber showed a linear relationship. The d-spacing clearly increased with drawing stress within 0.25 ms after necking. By increasing the d-spacing with a drawing stress, an apparent elastic modulus of approximately 40 GPa was obtained for the oriented molecular bundle. This value suggests that external force concentrates on inter-microfibrillar tie-chains during tensile testing, and orientation of inter-microfibrillar tie-chains increase with drawing stress. On the other hands, four streaks, meridional and equatorial streaks, total reflection and a layer-lined streak, were observed in USAXS images. The intensity of the meridian streak increased with drawing stress, whereas the

intensity of layer-lined scattering decreased with drawing stress. The layer-lined streak can be explained by the periodic bundle of a fibrillar smectic phase.

Although no marked differences of birefringence, crystallinity, and SAXS patterns were observed for the drawn fibers, there were clear differences in their tensile strength and thermal shrinkage behavior. The larger increase in tensile strength and thermal shrinkage stress than that in the Young’s modulus and birefringence with the increase of drawing stress can be explained by the difference in the number and orientation of inter-microfibrillar tie-chains and the uniformity of them.