Microscopic structure of polyethylene/polybutene-1 peel systems

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Blown films of low-density polyethylene/isotactic polybutene-1 (PE-LD/iPB-1) blends are often used as peel systems in packaging, for example in food and household packaging as well as for OI cutlery packages in the medical sector. In practice, two films were sealed by application of heat and/or pressure, building a defined seal area to obtain an applicable peel system. Such peel systems are based on the breakdown of the interface between the matrix (PE-LD) and the dispersed peel component (iPB-1) [1]. The required peel force to open the peel film package depends, among others, on the orientation of the crystalline phase, which, in turn, is controlled by the condition of processing. The orientation of the crystalline phase in blown films is complicated due to variable, sequential transverse and axial loading. This causes re-orientation of crystals during processing before final fixing of the structure by cooling. In extreme cases, molecules in crystals are oriented with their long axis in machine direction (MD), or in transverse direction (TD).

The structure of the PE-LD/iPB-1 blown films with a small relation between axial and transversal elongation during processing and with different content of iPB-1 up to 20 m-% was investigated using wide-angle and small-angle X-ray scattering (WAXS and SAXS), transmission electron microscopy (TEM), and polarizing optical microscopy (POM).

TEM proves formation of a matrix – particle phase structure due to immiscibility of the blend components (figure 1). The iPB-1 particles exhibit plate-like geometry with the longest dimension parallel to the machine direction (MD) and thickness dimension parallel to the film surface. Furthermore, in these particles needle-like crystals are observed, with the c-axis of the hexagonal form I crystal lattice and long axis of the needles oriented parallel or close-to parallel to MD.

The PE-LD matrix shows two populations of crystals. WAXS data indicate that the majority of crystals is oriented with the c-axis of the orthorhombic crystal lattice perpendicular to MD, while SAXS data prove additional presence of stacks of lamellae, oriented parallel to MD. The crystal orientation of the analyzed PE-LD/iPB-1 blends agrees with that obtained on PE-LD in former investigations [2,3]. Quantitative measurement of the birefringence shows that the majority of molecule segments in the specific blown tubular films of the present study is oriented in direction of the circumference of the film, confirming qualitatively the WAXS data. The crystal orientation of the blown films has direct impact on properties which is demonstrated by measurement of the anisotropy of the modulus of elasticity and by measurement of the peel behavior.

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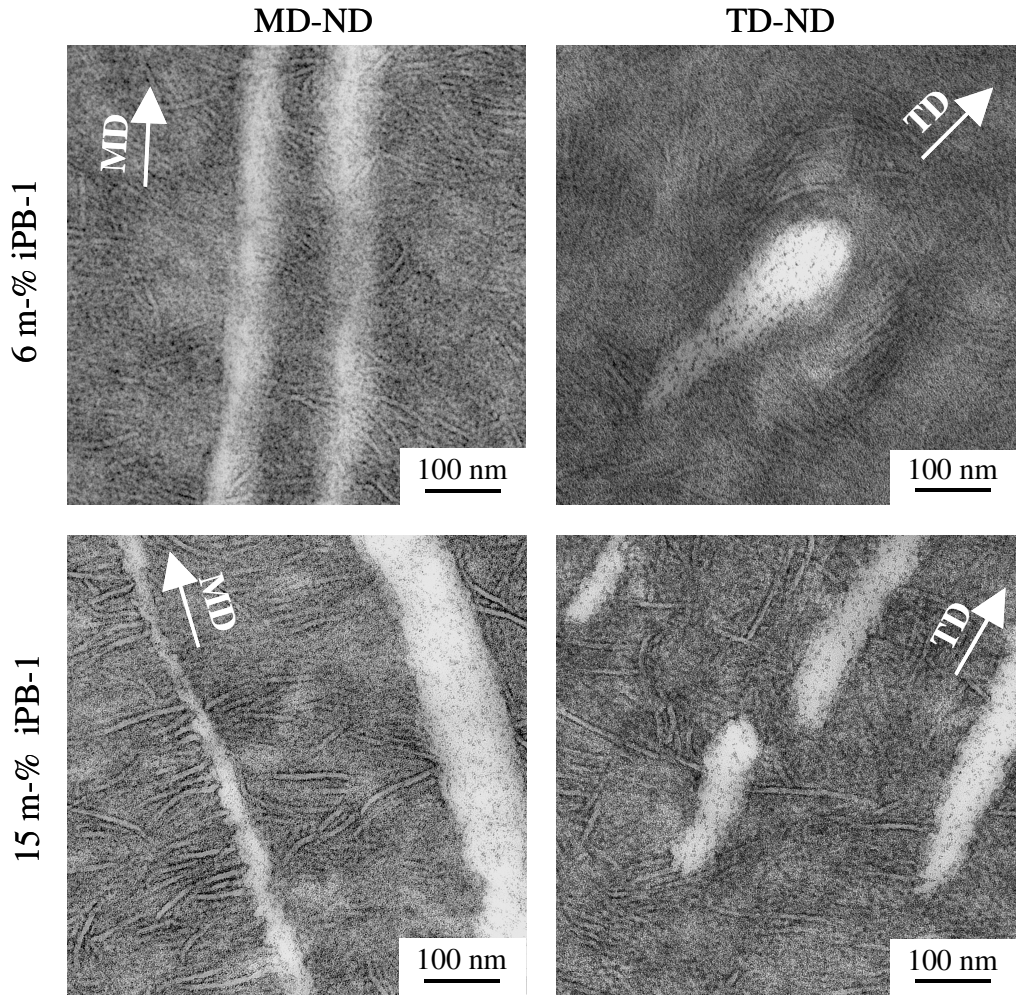

Figure 1. TEM micrographs of PE-LD with 6 m-% iPB-1 (top) and 15 m-% iPB-1 (bottom). Thin sections were taken parallel to the MD-ND plane (left) and parallel to the TD-ND plane (right).

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