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Relation between the supermolecular structure and light scattering behavior in birefringent semicrystalline polymers

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We have investigated isotactic polypropylene with experimental and theoretical techniques in order to establish a relation between the structural properties and the light scattering behavior. The polymer consists of semicrystalline supermolecular units, wherein highly ordered lamellae grown in radial directions in most cases. Within each particle radial birefringence can be attributed to the ordered lamellae with slightly different radial and tangential refractive index.

Model samples with various average crystallite sizes were prepared in the range of 1-200 microns. The samples with different spherulitic structure were prepared using a Mettler FP82 Hot stage in a Zeiss Axioscope at different temperatures. The large spherulites were crystallized at 140 °C and the smaller crystalline units were obtained at proportionally lower temperatures. The growth rate of the spherulites was measured during the isothermal crystallization experiments.

The thin films prepared in the hot stage were measured with dark field microscopy in order to obtain information about the spatial distribution of the origin of the light scattering. Small angle light scattering was used to measure the scattered pattern of individual spherulites. The results of the measurements were compared with anisotropic Mie scattering as well as with the Rayleigh-Gans-Debye approximation. Using these models radial and tangential refractive indices could be calculated. Good agreement was found between the theoretical model and the experimentally recorded scattering map.

Haze and bidirectional scattering distribution function (BSDF) were measured on samples of thickness of 1 mm. The samples were measured with and without index matching liquid in order to divide the light scattering into surface and volume parts. The surface topography of the samples was measured using white light interferometry. A model describing the multiple scattering characteristics of the thick samples was also developed using the information gathered from the microscopic measurements and the single spherulite model. The results indicated clearly that both surface roughness and the polycrystalline structure contribute to the light scattering and consequently to the haze of the sample.