Journal of Macromolecular Science, Part A
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597274

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Online publication date: 28 November 2010

To cite this Article Murárová, A. , Marcincin, A. , Jambrich, M. and Kristofic, M.(1998) 'Evaluation of the Morphological Structure of Polypropylene', Journal of Macromolecular Science, Part A, 35: 7, 1273 — 1278
To link to this Article: DOI: 10.1080/10601329808002117
URL: http://dx.doi.org/10.1080/10601329808002117

J.M.S.—PURE APPL. CHEM., A35(7&8), pp. 1273–1278 (1998)

EVALUATION OF THE MORPHOLOGICAL STRUCTURE OF POLYPROPYLENE

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ABSTRACT

Generally we use the method of small angle laser scattering for evaluation of the morphological structure of polypropylene sheets and fibers. This method enables qualitative and quantitative evaluation of present morphological formations in polypropylene's material. On the bases of the known procedure of preparation of evaluated polypropylenes' sheets and fibers, it is possible to find connections between morphological structure and their properties.

INTRODUCTION

The morphological structure of polypropylene on a certain quantitative and qualitative level expresses a development stage of the preparation of polypropylene material (fibers, sheets) with given physical properties. Polypropylene material on a lower development technological stage of preparation (non-oriented fibers contain structural configurations of crystallites in a polypropylene amorphous phase spherulites). Spherulites are three dimensional morphological configurations with a certain size and periodicity, attaining the dimensions comparable with the wavelength of visible light. They have various sizes and shapes. A non-deformed spherulite is symmetric and it has properties of an isotropic configuration in an isotropic polypropylene. A deformed spherulite demonstrates itself as an isotropic configuration of crystalline grouping in an isotropic environment [1, 2].

The presence of spherulites in polypropylene, their size and shape can be intentionally influenced by various means [3, 4]. One of the intentional structural modifications is reached with various chemical agents. These agents form in the polypropylene heterogeneous centers and influence the crystalline size, or the presence of spherulites [5, 6]. Another method of intentional transition of the polypropylene morphological structure is the physical action, especially the polypropylene deformation at various temperature conditions - spinning. During fiber forming, the morphological structure is markedly changed. The growing mechanism of the morphological configuration passes over from three dimensional growing of spherulites through a two dimensional lamellae growing, and at last to one dimensional growing of fibrils, with a profound orientation in the longitudinal direction of the fiber axis [3, 4, 7]. The knowledge of the qualitative and quantitative level of the morphological structure of the polypropylene material is important from the viewpoint of further processing, stability, and in connection with their physical and mechanical and optical properties.

With regard to the optical dimensions structure of morphological configurations, optical methods are used to evaluate the morphological structure (light polarization microscope, electron microscope, SALS ...). The small angle scattering of the polarized laser beam-SALS suitably supplements the former mentioned methods in the study of the morphological structure of polypropylene. The advantage of the laser light is the coherence and monochromatic character. The laser with incident light on spherulite in polypropylene material is scattered with a small angle and the diffusion is registered in the background. The scattered image renders more information on the morphological structure of the studied material (structural configuration, size, and deformation degree) [8, 9, 10].

EXPERIMENTAL

Sheets of unmodified and modified polypropylene of the type TATREN FF 520 with 20-25 μm thickness were prepared. The size of spherulites was intentionally changed by means of synthetic nucleation agents based on derivatives of sorbitol with the concentration of 0.5% per weight of polypropylene. These nucleation agents having a melting temperature Tm = 110-230°C. Proportional homogenization of nucleation agent in polypropylene has been executed by overmelting. The isotropic morphological spherulites in isotropic material were evaluated.

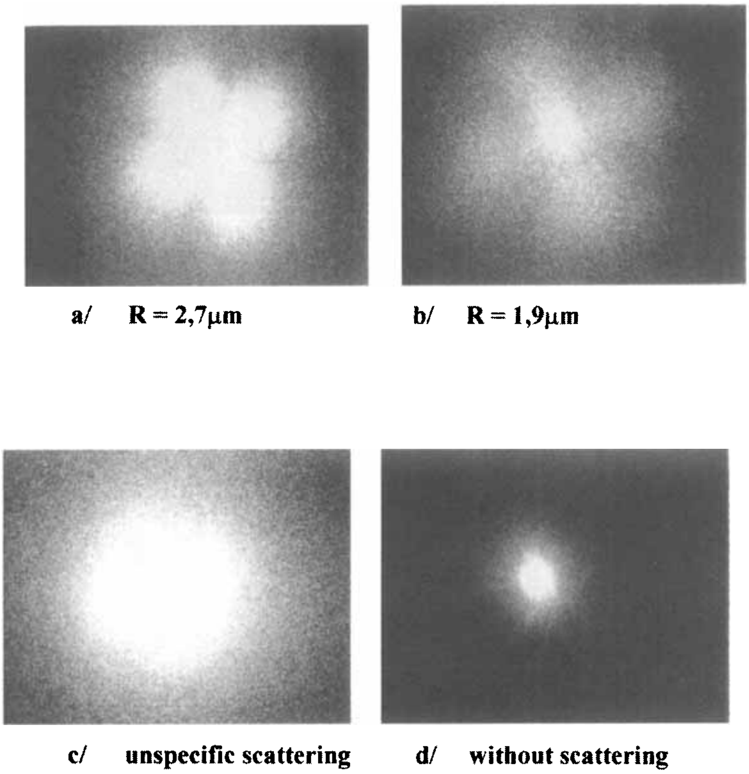


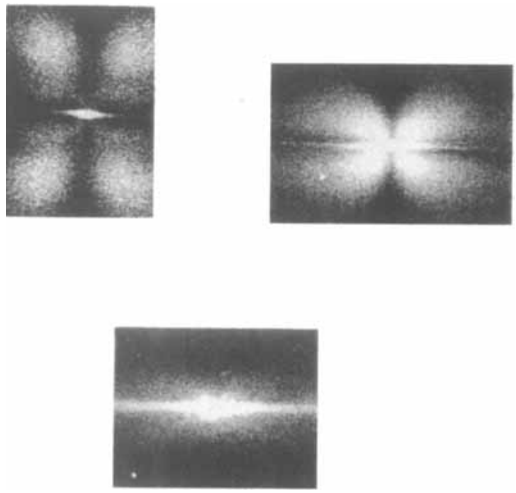
Figure 1. Influence of nucleation agent on the morphological structure of polypropylene in sheets, laser scattering.

Polypropylene fibers were prepared at a spinning rate of Vn = 1800, 2700 and 4000 m/min^{-1}. Anisotropic morphological configurations in isotropic and anisotropic environments were evaluated .

Methods used for evaluation of the morphological structure were SALS. The source of laser light was a semiconductive diode LDD 3.3 with an optical output of 25 mW and λ = 690 nm.

Evaluation of the Morphological Structure and Properties of Polypropylene Material

Figure 1 illustrates morphological configurations in polypropylene sheets obtained by SALS method and a radius of spherulite. For the calculation of radius, the relation is used [1, 2]:



1800 m . min $^{-1}$ **2700 m . min $^{-1}$**

4000 m . min $^{-1}$

Figure 2. Influence of spinning rate on the morphological structure of poly-propylene fibers laser scattering.

$$R = \frac{c \cdot \lambda}{n \cdot \pi \cdot \sin \theta_{max}}$$

c - constant characterizing the shape of the spherulite

λ - laser light wavelength

n - refraction in polypropylene

θ_{max} - angle of scattering located in the place of maximal intensity

Hv - quarterfoil with sharp contours corresponds to developed spherulites (polypropylene without nucleation agents).

Hv - quarterfoil with blunt contours corresponds to less compact spherulite structure.

Hv - scattering without quarterfoil corresponds to configurations with unspecific structure.

Hv - without scattering corresponds to a fine morphological structure (additive in polypropylene with a profound nucleation effect).

Hv - polarizer and analyzer are mutually crossed - dark field.

In Figure 2, the Hv scatterings of laser light on morphological configurations in polypropylene preoriented fibers at spinning rates 1800, 2700, and 4000 m/min^{-1} are recorded. The spherulites in polypropylene fibers have a typical growing mechanism in dependence on the spinning rate.

Hv - quarterfoil with expressive contours corresponds to the presence of developed spherulites in polypropylene fibers, at a spinning rate of Vn = 1800 m/min^{-1}.

Hv - deformed quarterfoil in the main direction of the axis fiber at a spinning rate of Vn = 2700 m/min^{-1}.

Hv - with centric scattering corresponds to a lamellar-fibrilar structure, at a spinning rate of Vn = 4000 m/min^{-1}.

The mentioned records of scattering of laser light on morphological structural configurations in polypropylene fibers give information about preoriented fibers. Drawn fibers with fibril structure do not present scattering of the laser light.

CONCLUSION

The SALS method quickly and responsively determines the presence of large structural configurations in polypropylene material.

The spherulites in polypropylene sheets and fibers have a typical growing mechanism in dependence on the spinning rate.

The information on the development of morphological configurations during the forming of polypropylene material are important from the viewpoint of further processing to a final product .

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