X-ray study on crystalline morphology in iPP/MMT nanocomposite fibers

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Introduction

The structure of fibers formed during spinning is the result of the processes of orientation and crystallization occurring by solidifying the polymer stream. The addition of montmorillonite (MMT) particles into sheared polymer melts complicate the crystallization process and the morphology that subsequently forms. In this study, nanocomposite fibers of isotactic polypropylene (iPP) and an organically modified MMT, were formed from the melt at different take-up velocity. The main goal of investigations is to examine the influence of MMT concentration and processing conditions on its dispersion in the iPP/MMT fibers as well as the effect of nucleating activity of MMT on the crystallization behavior of iPP matrix.

Methods

Investigations were carried out for iPP/MMT filaments formed by means of a laboratory spinning machine. Fibers were extruded from the melt and were spun at take up velocity of 1200, 860, 460 m/min and extrusion velocity 7.5 m/min (gravity spun fibers). The supermolecular structure of iPP/MMT fibers was determined by means of the wide-angle (WAXS) and small-angle (SAXS) X-ray scattering methods. WAXS investigations were carried out with a URD-65 Seifert (Germany) diffractometer. SAXS experiments were performed by means of an MBraun camera, which utilizes conventional Kratky collimation system. In both methods CuKα radiation was used.

Results and discussion

The WAXS patterns of gravity spun fibers extruded without additives reveals several crystalline peaks characteristic for the α-iPP. The crystallinity index of these fibers has the value in the range 0.37-0.55. For the iPP/MMT composite fibers, beside the peaks attributed to the α-iPP, a distinct diffraction peak at 16.1°, assigned to the (300) crystal plane of the β-iPP is observed. The intensity of this peak is the highest when the MMT content is the highest (5 wt.%). For these fibers the crystallinity index slightly increases and takes values from 0.57-0.63. During fiber formation, the process of iPP crystallization proceeds in non-isothermal conditions and under flow field. It is known that flow conditions strongly affect polypropylene crystallization and its influence is reflected in the composite fibers spun at the higher take-up velocity. In such conditions polypropylene crystallization is governed by high orientation. Due to orientation, the segments of polypropylene chains are subject to straightening. Bundles of straightened segments form active row nuclei which are formed regardless of the presence of the additive. The particles of the MMT do not take participation in the nucleation and do not influence on polypropylene crystallization. Therefore, for high speed spun fibers, β-form crystallites are not formed.

Conclusions

The presence of MMT affects the iPP/MMT fibers morphology. Studies reveal β-nucleating ability of MMT in gravity spun fibers. The amount of the β-iPP depends on the additive concentration. In fibers taken at higher velocities crystallization is governed by high orientation and the nucleating effect of the MMT additive loses its importance.