Study of Mechanical Properties and UV Resistance of Polypropylene/ZnO Nanocomposite Fibers

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Abstract

In this thesis, the structure and properties (including photo-degradation resistance) of melt-blended zinc oxide-propylene fibers were investigated. For this purpose, zinc oxide nanoparticles were melt blended with polypropylene using a twin screw extruder. Weight percentage of the nanoparticles was 0, 1 and 2 and the weight ratio of the compatibliser to nanoparticles was 3 to 1. Fibers were produced by a melt spinning apparatus and then were drawn using a drawing machine up to the draw ratio of 3.8. The sample with 1% nanoparticle and 3% compatibiliser was drawn with different draw ratios of 2, 3 and 3.8. Some of the samples were exposed to ultraviolet radiation. The structure and properties of the fibers before and after radiation were investigated using different techniques such as mechanical analysis, birefringence measurements, Wide Angle X-ray Diffraction (WAXD), Fourier Transform Infrared Spectroscopy (FTIR), FESEM and optical observations and thermogravimetry analysis (TGA).

FESEM observations showed that for the samples with no compatibiliser nanoparticles were uniformly distributed within the polypropylene fibers and no accomolation observed even in the sample with 1% nanoparticles. some aggregation were observed In the samples which contained compatibiliser it seems that the accumulation of nanoparticles or groups of maleic anhydride. Aggregation of nanoparticles was increased with increasing Zinc Oxide concentration from 1% to 2%. Zinc Oxide nanoparticles up to 1% concentration had no effect on birefringence of polypropylene fibers.In the sample which contained 2% Zinc Oxide nanoparticle the birefringence of polypropylene fibers was decreased in comparison to the other samples. Birefringence of samples containd 1% nanoparticles and 3% compatibiliser were increased with increasing draw ratio. TGA measurements showed that for compatibiliser contained samples with increasing zinc oxide nanoparticles to 1% have improved thermal stability and a higher temperature of initiation of degredation. Results showed crystallinity, breaking strength and modulus of the samples with 1% nanoparticle which does not contain compatibiliser increased 3.2,5 and 12 percentages, respectively. In the samples which contain compatibiliser, had lower mechanical properties for example the sample with 2% nanoparticles showed 22.6% and 18.1% decline in breaking strength and modulus, respectively. Therefore it is likely that the amount of compatibiliser used were higher than that required. By increasing draw ratio from o to 3.8 in the sample which contained 1% nanoparticles, breaking strength, modulus, birefringence and crystallinity were increased 79.1%, 50.9%, 62.4% and 25.7% respectively.

Results of photo-degradation studies showed that zinc oxide nanoparticles generally improve photo-degradation resistance of polypropylene fibers. The samples that contained nanoparticles showed lower reduction in mechanical properties, lower changes in birefringence, lower surface cracks and carbonyl groups due to the exposure to the ultraviolet radiation. In this regard the difference between the samples contained 0.5 and 1 percent of nanoparticles were not significant. There was also no significant difference in the mentioned properties between samples containing compatibiliser and samples without compatibiliser. The light resistance of the samples containd 1% nanoparticles and 3% compatibiliser were increased with increasing draw ratio.

Key Words

Polypropylene, Zinc oxide, Nanoparticle, Photo-degradation, Nanocomposite.