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Abstract

Products made of polypropylene (PP) are subject to photodegradation under UV-radiation leading to a change in the physical characteristics of the polymer. The addition of UV-filters, like ZnO nanoparticles, contribute to absorb UV-radiation and protect the polymer matrix. In this study ZnO nanopowder with a particle size of 50 nm was modified by 3-aminopropyltriethoxysilane (APTES) and introduced into the PP matrix. The optimal concentration of nanoparticles was determined. PP-films with a thickness of 100 and 200 microns were obtained. Structural and mechanical characteristics before and after irradiation by UV-radiation were studied by means of FTIR-spectroscopy, XRD, DSC, UV-VIS spectrophotometry and tensile tests. It was observed that UV irradiation of PP leads to the break of molecular chains, therefore releasing more molecular segments released. These segments can move and form a new crystal structure in the initial amorphous phase. The oxidation index of PP increased due to the formation of ketones. ZnO nanoparticles modified by APTES acted as nucleation sites and γ-phase was formed in the polymer. Also, the addition of ZnO-APTES nanoparticles in the polymer promoted absorption of UV-radiation in the wavelength range of 200-400 nm, thus protecting the polymer from degradation.

Keywords
Polypropylene; ZnO nanoparticles; UV-radiation; photodegradation; phase transformation

1. Introduction

The degradation of polymer materials is frequently occurring, leading to a modification of the chemical, physical and mechanical properties. There are a lot of factors that cause polymer degradation: the sunlight or other high-energy radiations, thermal effects, chemical or biological effects, and other effects [1]. UV-radiation is the most common source of polymer degradation.

Polypropylene (PP) is one of the most widely used polyolefin [2-9], so degradation of products made of polypropylene under UV-radiation is an actual problem. Significant photodegradation of polypropylene can be caused by irradiation in the wavelength range 310-350 nm [1]. It is well known that the most serious consequence of UV-irradiation is polymer embrittlement and surface alteration. Surface cracks are formed due to compression of the surface layers. This is the main reason for the serious degradation of the mechanical properties of polymer materials (especially plasticity) [10]. One of the most common method of protecting polymer materials from UV radiation is using different absorbing dispersed fillers.

The most effective method is introduction of inorganic UV stabilizers (UV-filters), which remain stable under the radiation. ZnO and TiO_2 powders are widely used as UV stabilizers for polymer products [11-13]. It was reported about addition of such particles in polymethylmethacrylate (PMMA) [14-16], polyethylene terephthalate (PET) [17], polyethylene (PE) [18], polyethylene oxide (PEO) [19] and other polymers. Inorganic UV stabilizer particles are usually added in the polymer in concentration about 7-15% wt. [20-22]. *Shanghua Li et al.* [23] reported about reducing of the UV stabilizer concentration in polymer to 0.1% wt. and less