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Morphology, mechanical, thermal and rheological behavior of microcellular injection molded TPO-clay nanocomposites prepared by kneader ☆

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ABSTRACT

Thermoplastic olefin elastomers (TPO)/montmorillonite (MMT) nanocomposites prepared by kneader was used in this study. The organoclay TPO nanocomposites were then injection molded by conventional and microcellular methods. Nitrogen was used as the blowing agent. The effect of organoclay content on the mechanical/thermal/rheological properties of the TPO-clay nanocomposites was investigated. The results showed that the mechanical properties (tensile, impact, and wear resistance) increased as the clay content increased. Cell size decreased as the clay loading increased. The addition of MMT into TPO also improved the thermal stability of the TPO/clay nanocomposites. The XRD results showed that the nanocomposites having an intercalated layered structure. Rheological results showed the viscosity is clay loading dependent and shear thinning effect takes place at high shear rate.

1. Introduction

Polyethylene is one of the most widely used polyollefins, not only because of its balance of physical and mechanical properties but also because of its recyclability and low cost. It is also well known that the addition of rubber to PE results in a decrease in stiffness. Thus, although successes in improving the impact strength of PE has been achieved by rubber toughening, its application (e.g., in the automotive industry) remains limited because of the opposing trends of stiffness and toughness. Recently, polymer-clay nanocomposites (PCN) have become popular among researchers, and layered materials such as smectite clays (e.g., montmorillonites and MMT) have attracted great interest in preparation of the PCN. After the addition of a small amount of clay to the polymer, the PCN exhibits enhanced physical and mechanical properties, including such aspects as Young's modulus, tensile strength [1], and flame retardancy [2], in comparison to those of neat polymers.

However, PE is a non-polar polymer, and organoclay is a polar material. Thus, PE needs polar compatibilizers, like maleic anhydride (MA) modified PE (PEgMA) [3], to improve the compatibility of PE with clay. These rubber-modified PPs or PEs are often called thermoplastic olefins (TPOs). Eckel et al. [4] studied the organo-clay dispersion of thermoplastic olefin nanocomposites by TEM and X-ray diffraction. They have shown that the sample molded by injection molding has a better clay orientation than that of compression-molded samples resulting in larger intensity in the XRD evaluation. Moreover, TPO nanocomposites with larger d-spacing also have a higher flexural modulus. Mirabella et al. [5] investigated the morphology and mechanical properties of thermoplastic olefin/clay nanocomposites. They have shown that the clay loading increased the ethylene-propylene rubber (EPR) particle breakup and decreased the particle size. The breakup of the EPR particles was probably due to the increased melt viscosity as the clay loading increased. The flexural modulus of the specimen by injection molding increased as the clay loading increased. However, the notched impact strength decreased as the clay loading increased. In Gustin et al.'s study [6], the addition of organoclay improved the stiffness of the nanocomposites. However, the impact strength was lost. Thus, this desirable combination of improved stiffness with no loss of impact strength through the addition of organoclay in TPOs, if achieved, could boost the applications of TPOs in the automotive industry and other industries.

In addition, PCN is also applied during the foaming process where the clay serves as the nucleation agent, leading to a small cell size [7] that is useful in acoustic and thermal insulator applications [8]. Microcellular foaming blends polymer and supercritical fluid, creating millions of microcells whose size is less than 100 μm [9]. However, few papers have reported on the effect of the clay on the rheological behavior. Huang et al. [10] studied the rheological behavior of Nylon 11 and Multi-Walled Carbon nanocomposites (MWCNT) nanocomposites. Their DMA results show that with increasing MWCNT loading,

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