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Effect of material and processing parameters on mechanical properties of Polypropylene/Ethylene–Propylene–Diene–Monomer/clay nanocomposites

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ABSTRACT

Polypropylene/Ethylene–Propylene–Diene–Monomer (PP/EPDM) blends are well known for having a combination of favourable mechanical properties. In this paper, addition of organoclay to PP/EPDM to make PP/EPDM nanocomposites with enhanced mechanical properties is studied. PP/EPDM/organoclay nanocomposites were prepared using a lab scale twin-screw extruder. Maleic anhydride grafted polypropylene (PP-g-MA) was used to enhance the intercalation/exfoliation process and to create good adhesion at the polymer/polymer and polymer/filler interfaces. Taguchi method was employed to deign the experiments and optimize material and processing parameters for optimized mechanical properties. Organoclay (NC) and compatibilizer content were selected as material parameters and the main processing variables were feeding rate and average shear rate (RPM). X-ray diffraction (XRD), Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM) were used to study the microstructure of the nanocomposites samples. It was observed that NC content and shear rate in extruder improved the tensile strength and modulus. Another important result was the insignificant effect of NC content on impact strength while increasing shear rate first increased and then decreased the impact strength.

1. Introduction

Polypropylene (PP)/Ethylene–Propylene–Diene–Monomer (EPDM) blends have gained considerable attention because of having a combination of rubbery and thermoplastic properties and ease of production [1]. Addition of reinforcing fillers, e.g. carbon black and silica to the PP/EPDM blend at high loadings improves the physical properties such as stiffness, heat distortion temperature and dimensional stability significantly but lowers the processability and ductility and introduces a rough surface [2,3].

On the other hand, addition of nanoclay reinforcing fillers such as montmorillonite (MMT) to polymers enhances the mechanical properties at very low loadings [4,5]. High levels of reinforcement in polymers can be obtained by low concentrations of nano layered silicates which makes them attractive for replacement of conventional fillers, e.g., talc or glass fibers, in many applications. In order to enhance the compatibility of layered silicates with non-polar PP chains, it is common to incorporate a compatibilizer, in this case Maleic anhydride grafted polypropylene (PP-g-MA), to achieve a better dispersion of organoclay particles in PP/EPDM matrix and improved stiffness [6]. It is expected that using fillers at nanoscale results in improved stiffness without significant loss of impact strength [7]. Higher stiffness with reasonable impact strength is very attractive for applications such as bumpers in automotive industry.

There are some reports on the study of PP/EPDM/organoclay nanocomposites [1,6–12]. Lee et al. [6] studied the relationship between morphology and mechanical properties of thermoplastic olefin (TPO) materials reinforced with organoclay fillers. They observed that the aspect ratio of the clay particles and the apparent size of elastomer particles decreased with increasing MMT content. They also reported that the tensile modulus and impact strength of the blends increased with the introduction of the clay. Goettler and Lee [8] studied the mechanical properties of PP/EPDM/nanoclay blends prepared without maleic anhydride-modified PP (PPMA) by direct melt mixing. They reported that the tensile modulus (T.M.) of the blends increased with the incorporation of the clay, whereas their tensile strength (T.S.) decreased. Kim et al. [12] examined the effect of maleated polypropylene content on morphology and mechanical properties of TPO-based nanocomposites. They reported that the modulus and yield strength are enhanced by increasing the PP-g-MA/organoclay ratios. Higher toughness of the TPO is obtained when moderate levels of MMT and PP-g-MA are used. Since processing conditions play an important role in determining the final stiffness and toughness of PP/elastomer/nano clay composites, the main objective of this study is to use design of experiments to optimize material and processing conditions in twin screw together, for the compounding of PP/EPDM/organoclay nanocomposites.

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