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Morphological structure, processing and properties of propylene polymer matrix nanocomposites

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Abstract

Nanocomposites are a ratios remarkable form of composite materials, which involve imbedding nano or molecular domain particles into organic polymer or resin matrix materials. It is expected that the theoretically predicted mechanical properties of these morphological structure could make them ideal for an advance of technological application. An intimate transformation of the material mechanical, chemical and morphological structure can be obtained by the proper addition of nanoparticle and the thermal processing during annealing. Composites constituted of thermoplastic resin on the matrix filled with propylene nanoparticles have been synthesized through the latex processing. The reinforced particles of propylene with filler volume fraction ranging from 0% to 30% have been elaborated. Reinforcement of randomly distributed nanoparticle in the polymer matrix is examined on specimens before and after annealing processing at 120 °C. Studies on morphological structure and dynamic rheology of nanocomposites show that particle shape, filler concentration, shear modulus, loss factor, processing technique and filler/matrix interactions are significant factors which will affect the mechanical properties and performance of nanocomposites.

Keywords: Morphological structure; Nanocomposites; Propylene polymer; Dynamic rheology; Filler concentration

1. Introduction

Composites based on nanoscale could offer high strength/density beyond any materials currently available. Nanocomposites are a ratios remarkable form of composite materials, which involve imbedding nano or molecular sized particles into organic polymer, meal or resin matrix materials. With the advance of materials synthesis and device processing capabilities, the importance of developing nanoscale engineering instruments has extremely increased over the past few years. It is perceived that the intimate inclusion of those nanoparticles with high aspect ratio in those matrices can completely change the properties of the materials. In all case, the effective dispersion of anisotropic particle such as short fibers, whiskers and platelets within the polymer matrix, in combination with interfacial adhesion between filler and polymer can substantially improved reinforcement of the polymer matrix [1]. The nanoparticles can serve as matrix reinforcement as well as change the mechanical behavior of these materials. The dispersion of single layers highly depends on the processing techniques, such as solution blending, in situ polymerization and melt compounding [2–7]. Arc evaporation is one of the major experimental techniques in which foreign materials are put in the anode for their incorporation into the CNTs formed from the carbon plasma. Early attempts for filling the nanotubes using arc evaporation have resulted in filled carbon nanoparticles rather than CNTs. The fillers

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include most metallic element and magnetic materials [8–16]. A typical process of CNTs was made by Ajayan and coworkers [17,18] in which CNTs were opened by an oxidation process and foreign materials were drawn into the CNT due to capillary action. Using these arc evaporation method, different types of materials were incorporated into CNTs, such as compounds of metals or their carbides, biological molecules, hydrogen and argon [19–25].

Techniques to obtained homogeneous dispersion and alignment of the nanotubes include application of electric field during polymerization, extrusion functions [26–28]. For the purpose of property enhancement, distinct subject to be resolved include improved dispersion of nanotubes, alignment of nanotubes, functionalization of the nanotubes to increase matrix bonding and the variety-function of the different type of nanotube reinforcements. Most existing nanosize fibres are grown in an appropriate temperature and are made either by extruding polymer followed by heat treatment or by catalyzing hydrocarbon metal catalysts. The given structure will be nearly single crystalline along the axial direction providing the theoretical strength of the covalent carbon bonds as in a single plane of graphite. The discovery of zero-dimensional topologies has played an important role in nanocarbon research. It is found that research in this field has proven the various possibilities for producing a whole new range of carbon structures of various size and shapes. The carbon whiskers or carbon natotubes with high aspect ratio are perfectly straight nanometer-sized tubules with properties similar to that of the ideal graphite fibre. Owing to the advance and understanding of these distinct material, the improved techniques of synthesis and the predict structure related properties have obtained much attention recently. While some techniques have been developed for extrusion or functionalizing of carbon nanotubes, none of these techniques have been entirely successful or particularly practical. Thus getting a proper intimate blend of the nanosized particles into polymer matrix induce a very difficult challenge of research.

The aim of this study is to explain very strong, the structure, properties, the degree of exfoliation and processing of fibers with nanoscale embedded hard particles. The particles may be another polymer, metal, graphite or carbon nanotubes. Therefore a large portion of the nanofiber is effectively interfacial material in which include at least two intimately blended phases. Because a large portion of interfacial phase material is now included in the base of this nanocomposites, the nanoparticles can serve as matrix reinforcement and change the mechanical behavior of these nanomaterials. An intimate transformation of the material's mechanical, chemical and morphological structure can be obtained by the proper addition of nanoparticles. One of the objectives of this work is on the production of Nanocomposite fibers. The ways of intimately blending individual entities of nanofibers, such as carbon nanotubes and SiC whiskers, silica and clay, into polymers with the goal of producing new forms of texile fiber have to be decided. The modulus and strength of existing fiber polymers are expected to be highly enhanced by the addition of nanofiber reinforcement. Nanoparticle reinforced fiber polymers such as nylon, acrylic and polyester are important fiber composites to study as the more traditional choice of fiber producing polymer. If the interaction or adhesion between nanoparticle and polymer matrix is defective, the properties of nanoparticles cannot be fully obtained. The surface modification of carbon nanotubes by carboxylic functionalization can be achieved by using acid treatments and non-covalent wrapping of polyvinyl pyrrolidone molecules on carbon nanotubes. Functionalization can give stronger adhesion and mechanical interlocking between polymeric molecules and molecules attached to carbon nanotubes. In this study, we are investigating two fronts. One is purely scientific and its goal is to produce basic research on nanocomposites structure and properties. The second one is focusing on processing analysis through the production of the evolution of the morphological characteristics and on improved processing and design of nanocomposites with emphasis on controlled nanotube geometric arrangement in order to realize the effect of inclusion of fillers at the nanoscale level in a polymeric matrix.

2. Materials and procedure

The main processes developed of this research are related to the possibility of exploring new combinations of nanofillers and resin in order to meet the requirement for further application. The materials prepared for the test are thermoplastic resin on the matrix while on the reinforcement side; and chemically modified montmorillonite clays, carbon nanotubes and commercial graphite are investigated. Emulsion polymerization process was selected for elaborating the nanocomposites. So as to understand reinforcement mechanisms depending on bonding or aggregation state, materials have been fabricated with different dispersion state. The compounding presented in this report are related to propylene matrix poly obtained from Solvay. Its melt flow index "MFI" is 3.0 dg/min at 200 °C and density 0.95 g/cm^3, and it melting point is 180 °C. It was polymerized using maleic anhydride. Propylene powder and organoclay were premixed in a tumbling mixer. The crosslinking reaction was catalyzed by adding anhydride with respect to the total weight of the mixture. The fillers are first intercalated with the pure epoxy and then the propylene is used for the various concentration of nanoreinforcement.