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Characterization and mechanical properties of high density polyethylene/silane montmorillonite nanocomposites ☆

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ABSTRACT

In order to understand and improve these soft and weak mechanical properties of High Density Polyethylene (HDPE), we add a silane modifier (Nanocor I.31PS) Montmorillonite (MMT) as reinforcement material, then use two kinds of different surfactant: thermoplastic polyolefin elastomers (TPO) or Maleic Anhydride (MA), to join the pieces of HDPE together, making it possess polarization.

After that, use a Plastograph-Mixer by the twin-screw mixed method to obtain standard shaped specimens of Polymer-Clay Nanocomposites (PCN) to prepare HDPE/MMT nanocomposites pellets. By adding the different weight percentages (1, 3, 5 wt.%) of MMT, and 2:1 ratio of MA and MMT, the layer distance of MMT and mechanical property of nanocomposites was investigated.

The chemical structure and polymer morphology of these as-synthesized PCN specimens were characterized by wide-angle powder X-ray diffraction (XRD) and scanning electron microscopy (SEM). In addition, we prepare these experimental specimens in order to probe into its mechanical properties. These tests used are: layer distance of PCN, tensile, impact, shore-hardness, wearing tests, and so on.

In addition, use XRD to accomplish the characterization analysis — comparing it to scatter and layer-distance. It is found that adding the MA into the MMT, layer-distance at 5 wt.% MMT increase from 2.11 nm to 3.55 nm; and add the TPO into the MMT, layer-distance at 5 wt.% MMT increase to the 2.66 nm.

In the mechanical property, it is found that these specimens grafting with the MA have the following results: In the tensile test, the MMT weight percentage 3 wt.% has the best result, increased by 0.26%. In the shore hardness test, the MMT 3 wt.%, strengthened by 0.62%. In the wearing test, the MMT 3 wt.%, strengthened by 2.6%. Moreover, these specimens graft the TPO have the following results: In the impact test, the MMT 5 wt.% has the best result, increased by 16.96%. In the shore hardness test, the MMT 5 wt.% strengthens by 11.11%.

1. Introduction

Recently, layered materials such as smectite clay (*e.g.*, montmorillonite, MMT) have attracted intense research for the preparation of Polymer–Clay Nanocomposite (PCN) materials. PCN materials usually show unique properties superior to traditional composites and conventional materials. In general, PCN materials combine both the characteristics of inorganic nanofillers and organic polymers at the molecular level. Currently, the PCN material is found to be a promising system due to the fact that the clay possesses a high aspect ratio and a platy morphology. It can be employed to boost the physical properties (*e.g.*, thermal stability [1], fire retardant [2], gas barrier [3], and corrosion protection [4]) of bulk polymers. The mechanical property is a particularly significant issue for studying the application and development of PCN materials. Kim and White [5] reported a variety of organic modified MMTs to understand the contribution of the organophilicity of organoclay on the formation of the polymer/clay nanocomposite.

Maleic Acid (MA) is an organic compound that is a dicarboxylic acid (molecule with two carboxyl groups). Other names are malenic acid, maleinic acid and toxilic acid. In industry, MA is derived from maleic anhydride by hydrolysis. Maleic anhydride is produced from benzene or butane in an oxidation process. Maleic acid is soluble in water, has a melting point of 139–140 °C. Both properties of maleic acid can be explained on account of the intramolecular hydrogen bonding [6] that takes place at the expense of intermolecular interactions.

Thermoplastic Polyolefin Elastomers (TPO) is a unique elastomeric product designed to improve impact performance, melt strength, and overall processability for a variety of markets and applications. TPO combine highly desirable elastomeric properties in a pelletized form and are available in a wide range of grades to meet the most demanding processing and performance needs.

HDPE is defined by a density of greater or equal to 0.941 g/cm^3. HDPE has a low degree of branching and thus stronger intermolecular forces and tensile strength. HDPE can be produced by chromium/silica

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