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Short Communication

Properties of polypropylene/polyamide nanocomposites prepared by melt processing with a PP-g-MAH compatibilizer

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ABSTRACT

This article presents the mechanical properties, fire retardancy behavior and the morphology of polypropylene/polyamide66 blends compatibilized with PP-g-MAH and modified with nanoclays. All PP/PA66 formulations modified with untreated and treated nanoclays were prepared by using internal mixer and single screw extruder followed by injection molding. Maleic anhydride polypropylene (MAH-g-PP) was used as the compatibilizer and the nanoclays content was varied between 0 and 8 wt.%. The mechanical and flammability properties of PP/PA66 nanocomposites were examined. Also the structure of PP/PA66 nanocomposites has been characterized by the Scanning electron microscopy (SEM) and the X-ray diffraction (XRD).

The obtained results indicate that the incorporation of nanoclay has a significant effect on the strength of PP/PA66 nanocomposites. Furthermore, it was found that SEM and XRD results revealed the intercalation, exfoliation of nanaclays of nanocomposites and the flame retardancy properties were improved significantly. In addition a good balance of impact strength and flame retardancy was obtained for PP/PA66 nanocomposites in the presence of PP-g-MA compatibilizer.

1. Introduction

Polymer/nanoclays nanocomposites and nanoblends present unique properties that are not observed in conventional composites. The achievement of compatibilization, even by addition a compatibilizer or by in situ chemical reaction between blends components (reactive blending), has played an important role in the development of polymer blends and provides a good solution for needs of industry [1].

Engineering polymers are used in a wide number of applications [2]. The aims of the incorporation of small amounts of nanoclay (<10 wt.%) into polymer matrices may improve dimension stability, mechanical, thermal, optical, electrical, gas barrier properties, and decrease the flammability of polymer–polymer blends [1,3]. It is known that blends of PP and PA66 are immiscible throughout the whole range of composition, and thus exhibit poor properties [4]. Unfavourable interactions at the molecular level lead to high interfacial tension and make the melt mixing of the components difficult. This also leads to unstable morphology and poor interfacial adhesion, which are the main cause's poor mechanical properties of the blends [5]. In order to prevent the incompatibility problem, a suitable compatibilizer is synthesised by grafting maleic anhydride MAH onto PP (PP-g-MAH) because it has anhydride and carboxyl groups that interact with functional groups of the PA66. Numerous researchers described polymer–clay nanocomposites based on single polymer matrix. Polymer-layered silicate nanocomposites are currently prepared in four ways: in situ polymerization, intercalation from a polymer solution, direct intercalation by molten polymer and sol–gel technology. Direct polymer melt intercalation is the most attractive because of its low cost, high productivity and compatibility with current polymer processing techniques [6]. However, thermoplastic nanocomposites based on blends of two or more polymeric materials, i.e. binary or ternary blends; seem to be a new approach in the nanocomposites studies.

Polypropylene and polyamide blending has been attempted to achieve improvement in mechanical properties, paintability and barrier properties, where polyamide contribute mechanical and thermal properties, while PP ensures good processing and insensitivity to moisture. The presented work in this paper focuses on the study of thermoplastic nanocomposites based on blends of PP and PA66 modified by nanoclay (treated and untreated). The aim of this work was to evaluate the effect of nanoclay loading from 2 to 8 wt.% on the rheological, mechanical, morphological and thermal properties of PP-PPgMAH-PA66 nanocomposites.

2. Exprimental work

2.1. Material used

Table 1 summarizes the materials used in this work as well as the specific characteristics and the suppliers.

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Table 1
Materials.

Materials (trade name)	Characteristics	Supplier
Isotactic polypropylene (MOPLEN)	– semi-crystalline polymer – MFI = 28 (g/10 min), (2190 g at 230 °C)	HIMONT company
Polyamide 66 (technyl®A216)	Was used as the dispersed (minor) phase in the blend	Rhone poulenc company
Dicumyl peroxide (DCP)	– Was used for PP degradation as well as for the creation of reactive sites in order to prepare a compatibilizer for the blends – Mw = 324 (g/mole) – Purity greater than 99% – Half life time ($t_{1/2}$) = 1 h at $T°$ = 135−155 °C	Merck company
Stabilizer (irganox 1010)	Was used to stabilize polypropylene against thermal oxidation especially when mixed with polyamide 66	CIBA-GIEGY company
Maleic anhydride (MAH)	Chemical formulae:$C_4H_2O_3$	Fluka chemical company
Untreated nanoclays (DELLITE LVF)	Nanoclay deriving from a naturally occurring especially purified montmorillonite	Laviosa company
Treated nanclays (DELLITE 67G)	Treated with a high content of quaternary ammonium salt (dimethyl dehydrogenated tallow ammonium)	Laviosa company

2.2. Specimen preparation

2.2.1. Polypropylene grafted MAH (PP-g-MAH)

The polypropylene was mixed with dicumyl peroxide DCP and maleic anhydride MAH at 200 °C for 6 min and at a speed of 70 rpm with a Rheocard Haake internal mixer to obtain the PP-g-MA compatibilizer [7,8]. The synthesized PP-g-MA compatibilizer was used to compatibilize the PP/PA66 formulations. The amount of PP-g-MAH was kept constant for all the composites.

2.2.2. PP/PA66 nanocomposite

Melt compounding of the PP/PA66 (70/30) blends and nanocomposites were done by a high shear internal mixer and single screw extruder. The extrusion zone temperature ranged from 220 to 230 °C. Prior to extrusion, PA66 pellets and nanoclay were dehumidified by using a vacuum oven at 80 8C for 8 h. The extrudates were pelletized with the Haake pelletizer. The pellets were injection molded into standard tensile bar using a Battenfeld injection molding machine. Injection molding temperature ranged from 240 to 265 °C. Prior to injection molding, all pellets were dehumidified in vacuum oven (85 °C for 12 h) [6]. The tensile test specimen was molded according to ASTM D 638 standard.[1]

2.3. Testing

2.3.1. Infrared spectroscopic analysis

Fourier-transform infrared spectroscopy (FTIR) was used to obtain some qualitative information about the functional groups and chemical characteristics of the PP-g-MAH as a compatibilizer.

2.3.2. Melt flow index (MFI) and density measurement

Melt flow index and density of various formulations were measured by using Melt Flow Indexer (at 230 °C, load 2.16 kg) and density balance (model METTLER TOLEDO).

2.3.3. Mechanical properties

The impact specimens were prepared according to ASTM D 256 standard[2] using a Battenfeld injection molding machine. PP, as well as, PP-PPgMAH-PA66 nanoblends was injection molded under the same conditions: the nozzle temperature was set to be 265 °C, the injection pressure was fixed at 75 bar while the screw speed is set to 70 rpm.

2.3.4. Morphological characterization

2.3.4.1. X-ray diffraction (XRD) analysis. Wide-angle X-ray spectra were recorded with a D 500 diffractometer (Philips PW 1710, France) in step scan mode using Ni-filtered CuKα radiation (1.5406 Å). Powder samples (clay) were scanned in reflection, whereas the injection-molded compounds were scanned in transmission in the interval 2° and 30°: The interlayer spacing of the nanoclay was derived from the peak position (d_{001}-reflection) in the XRD diffractograms according to the Bragg's equation.

2.3.4.2. Scanning electron microscopy analysis. Notched fractured surfaces of the different nanoblend formulations were examined under a scanning electron microscopy operating at 10–15 KV. Before scanning, a conductive coating layer was spread on the surface of the sample.

2.3.5. The fire retardancy properties

The flammability test (UL94HB) was conducted using the flammability tester 6151/000 that consists of a test chamber, laboratory burner, wire gauge, ring stand and metal support fixture. First the test specimens of 63 mm in width and 3.17 mm in thickness were cut from the impact test specimen. Each specimen was marked at 2 cm from one end then fixed horizontally in the support fixture. After that, the flame of the burner was adjusted to have 6 mm height of its blue portion and the burner was inclined about 45° and moved to reach the specimen edge. Finally the time needed for the flame to spread till the 2 cm mark was recorded. The results were analyzed in terms of the flammability time as a function of the nanoclays content.

3. Results and discussion

3.1. FTIR analysis

Fig. 1 shows FTIR spectra of PP and PP-g-MAH. It illustrates the presence of two new intense overlapping absorption bands at 1785 cm^{-1}, 1712 cm^{-1} and a low absorption bands around 1855 cm^{-1} corresponding respectively to: symmetric, asymmetric stretching and carboxylic acid. This is an indication of the grafting of Maleic anhydride MAH onto PP molecular chain. These results have been reported elsewhere [8].

3.2. Melt flow index (MFI)

3.2.1. PP-g-MAH compatibilizer

It can be shown from Table 2 an important reduction of MFI of modified PP with the constant amounts of DCP and MAH versus

[1] The tensile test specimen was molded according to ASTM D 638 standard.
[2] The impact specimens were prepared according to ASTM D 256 standard.