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Polyamide/Polypropylene/graphene oxide nanocomposites with functional compatibilizers: Morpho-structural and physico-mechanical characterization

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Abstract

Nanofilled polymeric matrices have demonstrated remarkable mechanical, electrical, and thermal properties. Compounding polymers with nanofiller is widely used for the preparation of new materials. Polyamide/polypropylene (PA/PP) composites are interesting because both components are relatively cheap, with advantageous properties, and are processable by melt blending. The compatibilisation of binary polymer compounds can be made by the addition of graft copolymer, segments of which have physical or chemical affinity with two immiscible homopolymers. In this case, polypropylene grafted with maleic anhydride (PP-g-MA) it was used. Polymer nanocomposites containing graphite have been considered as a new generation of composites materials due to their expected unique properties attributed to the high aspect ratio of the inorganic pellets. Combined effects of graphite treatment and compatibilizer polymers (PP-g-MA) on the structure and properties of PA/PP/PP-g-MA/graphene oxide composites were studies. The optimum formulation was used to prepare a series of nanocomposites under different technological conditions. The nanocomposites PA/PP/PP-g-MA/graphene oxide were characterized by scanning electron microscopy (SEM), Fourier transformation infrared spectrum (FT-IR) and physico-mechanical.

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Keywords: nanocomposites; polyamide; graphene oxide

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INTRODUCTION

Unreinforced plastics have a high wear rate and low shock resistance, which leads to unplanned and costly repairs or accidents (Bhattacharya, M., 2016). Polyamide (PA) is a thermoplastic material, widely used in the industry, with varied applications (e.g. fibres, films, textiles, and various casting products) due to its mechanical and thermal properties. However, it has some limitations, such as: humidity absorption, sensitivity to shock, relatively low impact resistance and a weak dimensional stability. As a result, it is necessary to modify PA to improve physical-mechanical properties favourable for the industrial environment (Geim, A.K., Novoselov, K.S., 2007). Composites are compounds whose components are polymers or copolymers in which particles with different properties are evenly dispersed to optimize the initial polymer characteristics, such as: optimal compatibility, possibility of compounding at room temperatures using conventional equipments, abrasion, aggressive chemical agents, temperature and softening resistance, flow index, elasticity modulus, impact, traction and tearing resistance etc. Depending on the compatibility of the constituent polymers and the composite structure, they may be: single-phase systems (solid solutions), generally intermediate to those of the constituents; biphasic systems in which compatibility is limited and architectures are reciprocal dispersions of constituents, the degree of dispersion being the main factor in determining the properties of these systems; systems containing branched polymers obtained by grafting (Chow W. S., and all, 2003; Erdmann E. and all, 2007).

Various types of PA based nano blend composite have been studied by numerous researchers. PA nanocomposites obtained by thermoplastic-thermoplastic blending (both functionalized and un-functionalized): PA6/PP [Chen, B. and all, 2006; Suter, J.L. and all, 2007; Brune, D.A. and Bicerano, J., 2002; Balandin, A.A. and all, 2008), PA6/polyimide/organoclay (Ward, I.M. and all, 2004); PA6/thermotropic liquid crystalline polymer (TLCP)/organoclay (Hu, K. and all, 2014); Nylon 66/Nylon 6/organoclay (Paul, D.R.and all, 2008.); PA6/acrylonitrile- butadiene-styrene (ABS) (Das, P. and all**,** 2013)**;** PA6/low density polyethylene (LDPE)/nanoclay (Biswas, M. and all 2001); PA6/polymethyl methacrylate (PMMA) (Das, P**.** and all 2013)**;** PA6/polystyrene (PS) (Podsiadlo, P. and all 2007**)** PA6/PS/nanosilica (Bitinis, N.and all 2011).

Polyamide/polypropylene (PA/PP) composites are interesting because both components are relatively cheap, with advantageous properties, and are processable by melt blending (Fasolino, A. and all, 2007). The compatibilisation of binary polymer compounds can be made by the addition of graft copolymer, segments of which have physical or chemical affinity with two immiscible homopolymers (Lee, C. and all, 2008). In this case, polypropylene grafted with maleic anhydride (PP-g-MA) it was used.

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers. Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering.

Nanocomposites have been considered as a stimulating route for creating a new type of high performance material that combines the advantages of polymers and nanoparticles (Hyunwoo Kim and 2010). By means of compounding, a series of properties can be changed: temperature and the softening interval, melt flow index, elasticity modulus, shock resistance, tensile and tear strength, etc.

Reinforcing materials of nanometric order are components of composite materials, and have the role of improving the mechanical properties of such materials. They have different shapes and orientations, based on which the following aspects are aimed at: improvement of mechanical characteristics, improvement of thermal resistance, compatibility with the composite matrix, good adaptation to processing, light, and low cost (Lonjon A. and all 2013). Researchers have recently categorized nanoparticles based on their dimension including: 1dimensional (carbon nanotube), 2dimensional (graphite, silicate and spherical or cubic-shaped (fullerene, nano-carbonate calcium) (W. S. Chow and Z. A. Mohd Ishak, 2015). A bulk material should have constant physical properties regardless of its size, but at the nano-scale size-dependent properties are often observed. Thus, the properties of materials change as their size approaches the nanoscale and as the percentage of atoms at the surface of a material becomes significant.

In this paper graphite nanoparticles were selected for PA/PP composites reinforcement. A big challenge in developing polymer/graphite composites with high efficiency is achieving the individual graphene sheets within a polymer matrix in order to have a better dispersion and strong interfacial interactions, in order to decrease percolation threshold in graphene sheets loading and enhancing the graphene-polymer matrix interface. Graphite is a material with high chemical inertia, which leads to low compatibility with many organic or inorganic matrices. To eliminate this disadvantage, graphite nanoparticles are subjected to superficial oxidation, in which case adhesion improves by