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Mechanical Properties of Poly(Propylene)-Based Graphene Nanocomposites

Authors : Luiza Melo De Lima, Tito Trindade, Jose M. Oliveira

Abstract : The development of thermoplastic-based graphene nanocomposites has been of great interest not only to the scientific community but also to different industrial sectors. Due to the possible improvement of performance and weight reduction, thermoplastic nanocomposites are a great promise as a new class of materials. These nanocomposites are of relevance for the automotive industry, namely because the emission limits of CO2 emissions imposed by the European Commission (EC) regulations can be fulfilled without compromising the car's performance but by reducing its weight. Thermoplastic polymers have some advantages over thermosetting polymers such as higher productivity, lower density, and recyclability. In the automotive industry, for example, poly(propylene) (PP) is a common thermoplastic polymer, which represents more than half of the polymeric raw material used in automotive parts. Graphene-based materials (GBM) are potential nanofillers that can improve the properties of polymer matrices at very low loading. In comparison to other composites, such as fiber-based composites, weight reduction can positively affect their processing and future applications. However, the properties and performance of GBM/polymer nanocomposites depend on the type of GBM and polymer matrix, the degree of dispersion, and especially the type of interactions between the fillers and the polymer matrix. In order to take advantage of the superior mechanical strength of GBM, strong interfacial strength between GBM and the polymer matrix is required for efficient stress transfer from GBM to the polymer. Thus, chemical compatibilizers and physicochemical modifications have been reported as important tools during the processing of these nanocomposites. In this study, PP-based nanocomposites were obtained by a simple melt blending technique, using a Brabender type mixer machine. Graphene nanoplatelets (GnPs) were applied as structural reinforcement. Two compatibilizers were used to improve the interaction between PP matrix and GnPs: PP graft maleic anhydride (PPgMA) and PPgMA modified with tertiary amine alcohol (PPgDM). The samples for tensile and Charpy impact tests were obtained by injection molding. The results suggested the GnPs presence can increase the mechanical strength of the polymer. However, it was verified that the GnPs presence can promote a decrease of impact resistance, turning the nanocomposites more fragile than neat PP. The compatibilizers' incorporation increases the impact resistance, suggesting that the compatibilizers can enhance the adhesion between PP and GnPs. Compared to neat PP, Young's modulus of non-compatibilized nanocomposite increase demonstrated that GnPs incorporation can promote a stiffness improvement of the polymer. This trend can be related to the several physical crosslinking points between the PP matrix and the GnPs. Furthermore, the decrease of strain at a yield of PP/GnPs, together with the enhancement of Young's modulus, confirms that the GnPs incorporation led to an increase in stiffness but to a decrease in toughness. Moreover, the results demonstrated that incorporation of compatibilizers did not affect Young's modulus and strain at yield results compared to non-compatibilized nanocomposite. The incorporation of these compatibilizers showed an improvement of nanocomposites' mechanical properties compared both to those the non-compatibilized nanocomposite and to a PP sample used as reference.

Keywords : graphene nanoplatelets, mechanical properties, melt blending processing, poly(propylene)-based nanocomposites
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