CHARACTERIZATION AND PROPERTIES OF POLYAMIDE 12 NANOCOMPOSITES MODIFIED BY A GRAFTED ELASTOMER

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Introduction

There is an increasing interest in the possibility of linking polymer nanocomposite production by clay addition, to blending with a second tough component. This will offer the possibility to overcome the tendency to notch sensitivity and low-notched fracture toughness of nanocomposites by means of rubber modification. In this way, the technique of rubber toughening brittle polymers (that deform by crazing), later extended to ductile polymers (mostly deformed by shear), could also be used for nanocomposites. This would mean that the only major mechanical property that is not enhanced upon organoclay addition, i.e. toughness, could increase with respect to that of the matrix, and that the decrease in stiffness observed upon rubber addition in toughened blends could be counteracted by the presence of the organoclay (OMMT) [1, 2].

Polyamide 12 (PA12) is a semi-crystalline polyamide that offers a good combination of thermal and mechanical properties, which make it suitable for a number of industrial applications. This PA12 is able to form exfoliated PNs with commercially available organically modified clays, but to the best of our knowledge, no work has been published concerning its toughening. This gives us the opportunity to study (i) whether toughening is possible in PA12 PNs (ii) the morphological position of the brittle/tough (B/T) transition by means of the interparticle distance, and (iii) the parameters that influence the position of the B/T transition.

Experimental

The PNs were obtained in two extrusion steps. The PA12/OMMT matrix with 3% OMMT was obtained in a twin screw extruder. Subsequently, a maleinized styrene/ethylene-butylene/styrene copolymer (mSEBS) was added up to 30% in a second extrusion step, before injection molding. The PA12/mSEBS blends were prepared as a reference in one step. The characterization of the nanoestructure was carried out by X-ray diffraction (XRD) and transmission electron microscopy (TEM), the surfaces of cryogenically fractured specimens were observed by scanning electron microscopy (SEM) and the phase structure was analyzed by dynamic mechanical analysis (DMA). The mechanical properties were determined by Izod impact and tensile tests.

Results y discussion

The nanostructure analysis revealed that the clay layers stayed in the PA12 matrix and that the additional processing, required to incorporate the rubber, did not lead to any compaction of the widely exfoliated layers. The morphology of the rubber particles in the PNs was homogeneous, with particle sizes slightly larger than those of the corresponding blends, due to limitations imposed by the OMMT on the compatibilizing effect of the mSEBS. The presence of the exfoliated OMMT and the modification with rubber (25%) led to a polymer nanocomposite in which high toughness (the notched impact strength was 25 times that of the PA12 matrix) (Figure 1) and ductility (the elongation at break was 210%) were produced simultaneously. This indicates that these materials were tough throughout an unusually wide range of strain rates and mode of fracture conditions. The brittle/tough transition of PNs occurred at a τ_c smaller than that of the blends. Taking into account that the extrinsic parameters (testing conditions) that influence τ_c were constant, and that the difference in interfacial adhesion between the PNs and the blends should increase τ_c, the observed behaviour of τ_c must be attributed to the higher modulus of the PNs.

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References

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Figures

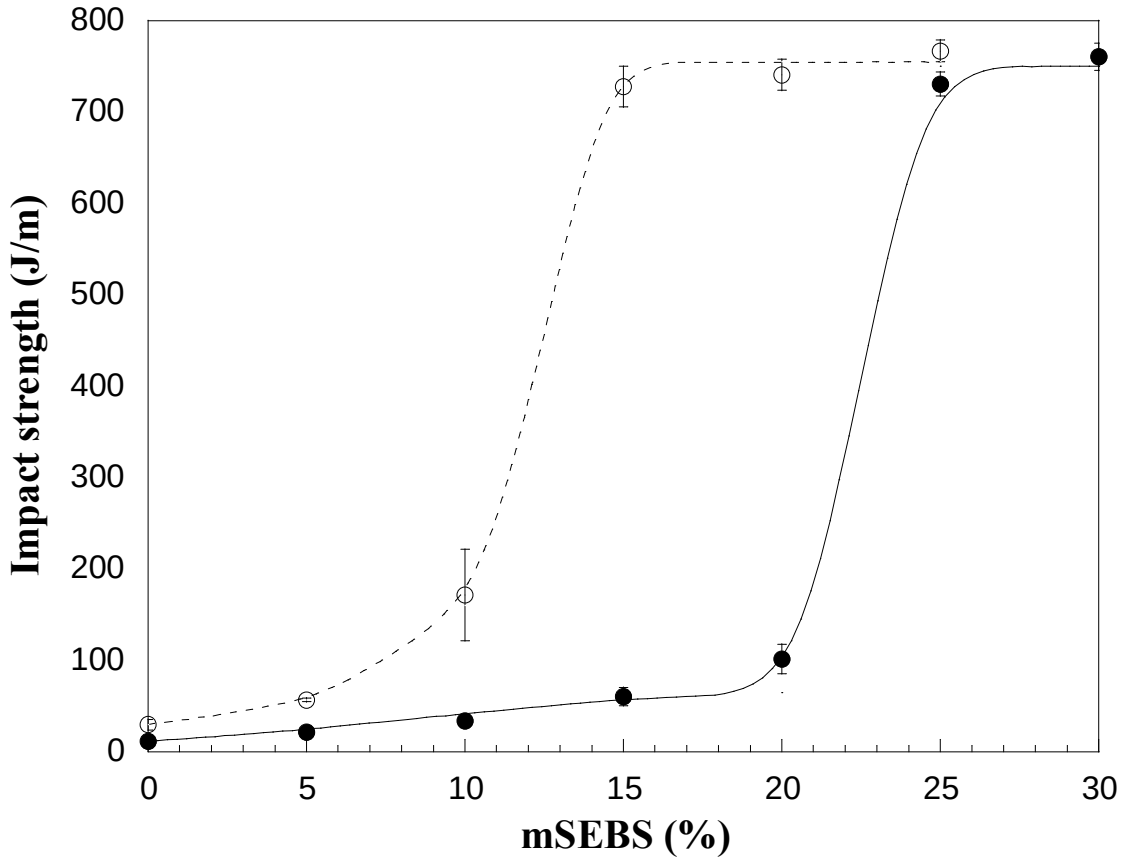

Figure 1. Notched Izod impact strength of the PNs (solid symbols) and reference blends (open symbols) versus mSEBS content.