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TOUGHNESS ASSESSMENT OF THERMOPLASTIC NANOCOMPOSITES BY THE ESSENTIAL WORK OF FRACTURE (EWF) APPROACH

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ABSTRACT

The essential work of fracture (EWF) approach is widely used to determine the plane stress fracture toughness of highly ductile polymers and related systems**.** Though the EWF method is dominantly used for mode-I type loading, it has been successfully adopted for mode-II and mode-III type deformations, too. Moreover, attempts were also made to deduce plane strain toughness values from EWF tests. According to the EWF, the total work of fracture (W_f) can be partitioned into two components: (i) the EWF (W_e) consumed in the inner fracture process zone to create new surface and (ii) the nonessential (or plastic) work (W_p) performed in the outer 'plastic' deformation zone. Nanofiller concentration and surface treatment on the morphology and viscoelastic behaviour of polypropylene (PP)/boehmite alumina (BA) nanocomposites was investigated. Nanocomposite samples were produced by dispersing synthetic BA particles with different surface treatments into the PP matrix through melt mixing and following film blow molding. The effect of nanofiller surface treatment with octylsilane (OS) and by alkylbenzene sulfonic acid (OS2) on the filler dispersion was investigated through scanning and transmission electron microscopies Differential scanning calorimetry and wide-angle X-ray scattering were adopted to detect changes in the crystalline structure of PP.

Results and Discussion

The morphology of the nanocomposites was examined by means of SEM analyses. In particular, SEM micrographs of PP containing the same amount (2.5 wt%) of BA80, BA80-OS and BA80-OS2 nanoparticles, are reported in Figure 1.

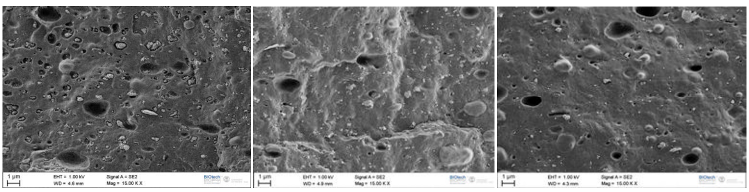

Figure 1 a) BA80, b)BA80-OS and c) BA80-OS2

In fact, nanofiller appeared to be well dispersed in PP/2.5BA80 nanocomposite, although some aggregates and agglomerates are recognizable. The dispersed nanoboehmites are organized in agglomerates with average sizes of 400–500 nm, composed of the much smaller crystallites (Figure 1a)

The XRD diffractogram of BA80 nanopowder, PP, and related nanocomposites are reported in Figure 2. X-ray diffractogram of BA80 nanopowder puts into evidence the presence of two main BA crystals by identification of diffraction reflections (hkl planes) at 2θ=14.7° and 2θ=28.4°, typical of an orthorhombic crystalline structure.

The frequency dependence of the dynamic shear storage modulus (G') and complex viscosity ($|\eta^*|$) at isothermal conditions for neat PP and PP composites filled with 2.5 wt% of untreated and surface treated BA nanoparticles. It is interesting to observe that G' and $|\eta^*|$ values are quite similar when neat PP and nanocomposites filled with surface treated BA nanoparticles are compared

The most relevant parameters from DSC analysis are summarized, It is worthwhile to observe that the addition of BA nanoparticles produced a slight increase in the crystallization peak temperature, irrespective of the boehmite type. The effect became more pronounced at 10 wt% filling

The thermal stability parameters as detected by TGA measurements are reported in Figure 3. A representative thermograph of the unfilled PP, showing the thermogravimetric curve and the first derivative of weight loss curve, is also reported. When considering PP-BA nanocomposites, $T_{d,onset}$ and $T_{d,max}$ increased with increasing filler content.

The nanocomposites have smaller plastic work of fracture, βw_p values when compared to the neat PP material. The increasing filler content also resulted in decreasing βw_p values. However, the w_p terms of the nanocomposites examined, except that of PP/2.5BA80 composite, did not differ significantly (p=0.05), thus the dissipative plastic work was not influenced by the nanofillers.

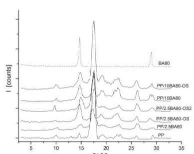

Figure 2 X-ray diffractogram of BA80

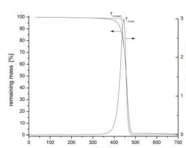

Figure 3 Thermograph of unfilled PP showing weight loss

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