EFFECT OF CLAY REINFORCEMENT ON THE CRYSTALLINE PROPERTIES OF INJECTION MOLDED POLYAMIDE-6 NANOCOMPOSITES

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The mechanical properties of polymers are strongly dependent on crystal properties among other parameters. Layered silicates reinforcing them do affect the crystal properties of these materials as well (Liu et al., 1999; Shen et al., 2004). The orientation of the polymer as much as the lamellae and the clay platelets play an important role in the enhancement of the mechanical properties of the individual components of the nanocomposite. In this work, a study of orientation of the crystalline phases and the lamellar structure of the polymer has been carried out in injection molded samples of polyamide-6 (PA) and smectite reinforced polyamide-6 nanocomposites (NC), to understand the micromechanical behavior of such materials.

The nanocomposite was manufactured by melt intercalation in a double screw extruder and afterwards injection molded (Kraus Maffei KM 250/900B) into plates with 0.5, 0.75, 1 and 2 mm thickness. The results indicate that the crystalline structure of the pure polyamide samples is dependent on the sample thickness. The thermodynamically more stable α structure is prominent in the thinner samples (0.5 mm), decreasing with increasing thickness (0.75 and 1 mm) in favor of the less stable γ, and almost disappearing in the thicker sample (2 mm). This effect is due to different temperature gradients at cooling (smaller in the thinner samples). The surfaces of the platelets of the layered silicates interact with the polyamide macromolecules allowing a good packing of the chains, but at larger distances compared to those required for the H bonds in the α structure. In both PA and NC samples, DSC curves present a small exothermic peak at around 165 ºC - 175 ºC, similar to that reported by Daniel and Ishai (1994) at around 195 ºC in polyamide-6 thin films. This peak was associated with the release of strain energy absorbed during processing, but it may be also due to recrystallization process of small already melted crystals over still not melted bigger ones. The thickness effect is also observed in the crystallinity degree (W_c) calculated from the melting enthalpy, being the thickest samples the most crystalline as well.

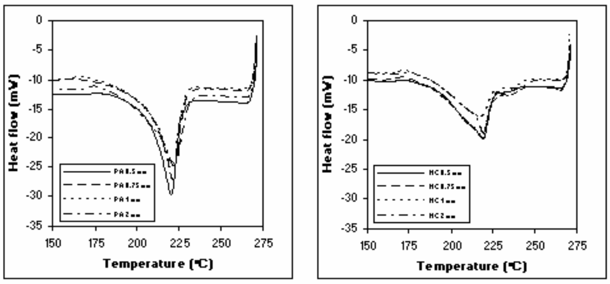

Figure 1.

NC SAXS results display a concentric pattern of a typical non-oriented sample for the core analyses of PA and NC samples. The 0.5 mm and 2 mm skin samples (both PA and NC) rings show a maximum at a certain angle about the reference direction, which demonstrates the occurrence of an organized suprastructure in the samples (lamellae). NC samples present more intensive patterns, coming from a nucleating effect of the clay particles. X-ray pole figures show that NC is more oriented than PA. The skin-core morphology in the thicker samples is a result of the different shear flow across the thickness of the mold during the injection molding process. The shear stress is higher in the skin, and the molecular chains are preferentially oriented in the flow direction. Consequently the samples with a good developed core are poorly oriented, independently on the presence of clay platelets. The uniaxial orientation and the position of the analyzed crystallographic planes suggest a fibrous texture of the crystals aligned with the molding direction.

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