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Preparation of polyamide nanocomposites optimized based on the clay modifier structure and processing conditions

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Abstract – Polyamide/montmorillonite nanocomposites were prepared by melt compounding using polyamide-6 and three commercial montmorillonites. The effect of the organic modifier on the clay dispersion into the matrix was studied. In addition, the effect of varying the processing conditions was evaluated and the preparation procedure optimized. Of the three montmorillonites, it was found that Cloisite-30B dispersed the best in comparison to Cloisite-20A and Cloisite-Na^+. The materials produced using the optimized conditions were characterized by TEM and XRD. Mechanical and permeability properties were determined. It was found that the Young´s modulus increased with increasing clay content while the oxygen and nitrogen permeability decreased.

Polymer-clay nanocomposites clays have attracted a great interest in the last decade, primarily because they exhibit remarkable improvements of physical properties as compared to the neat polymer, due to the nanoscale reinforcement achieved by dispersion of the 1 nm thick layers into the polymer.[1]There is a direct correlation between the improvement in physical properties and the quality of the clay dispersion and delamination. This is principally dependant on the interaction between the clay and the organic matrix, which can be controlled by varying the structure and chemistry of the clay modifiers.[2] An additional parameter which can impact the ultimate properties of the materials are the processing conditions (temperature, mixing velocity and mixing time).[3] In this work, the effect of the organic modifier structure and the processing conditions on the properties of polyamide-6 (PA)-clay nanocomposites are explored. The nanocomposites (containing 1, 3, and 5 wt% clay) were prepared via direct melt compounding using three different commercial montmorillonites: untreated montmorillonite (Cloisite Na^+, CNa^+) and montmorillonites modified with $N^+(CH_2CH_2OH)_2(CH_3)T$, (Cloisite 30B, C30B), and $N^+(HT)_2(CH_3)_2$, (Cloisite 20A, C20A). The process was carried out at screw speeds of between 80 and 110 rpm and at temperatures of 235 and 245 °C

X-Ray diffractograms (XRD) show that nanocomposites prepared using 1 and 3 wt% C30B had delaminated structures, while those prepared with 5 wt% had an intercalated morphology. This is in contrast to the obtained with C20A, in which delamination is only observed in the sample with 1 wt% clay. In case of the CNa^+ it observed that there is no significant increase in the clay interlayer distance. The nanocomposites with C30B and C20A showed an increase in Young´s modulus in proportion to the clay loading and for the composites prepared with CNa^+, no change in the Young´s modulus was observed compared to the PA standard. Since the samples prepared using C30B had shown the greatest increases in physical properties, it was chosen to evaluate the effect of processing conditions. It was found that the diffraction peak d_{001} disappeared upon decreasing the mix velocity from 110 rpm to 80 rpm and increasing the temperature from 235 ºC to 245 ºC. Mixing times longer than 3 min resulted in visible polymer degradation. It was concluded that the best processing conditions to prepare PA/C30B nanocomposites are: 80 rpm, 245 ºC and 3 min. The TEM images of the nanocomposites prepared using these conditions (Figure 1) show that the clay layers are well dispersed in the polymeric matrix at each concentration and are well exfoliated, in agreement with the XRD analysis. The O_2 and N_2 permeability of the nanocomposites were measured using a permeability cell. It was observed that the permeability of the polymer films decreases with increasing clay content resulting in a 24% and 33 % decrease in O_2 and N_2 permeability, respectively with 5 wt% of clay, indicating that the clay layers act as gas diffusion barriers.

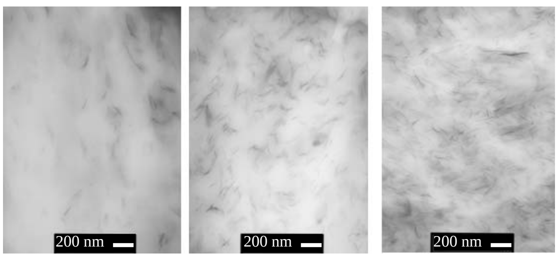

Figure 1: PA/C30B nanocomposites TEM image **a)** 1wt% **b)** 3wt% **c)** 5wt%

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