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MECHANICAL PROPERTIES OF NANOCOMPOSITES BASED ON FUNCTIONALIZED POLYPROPYLENES REINFORCED BY CLAY

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PP/Montmorillonite nanocomposites have become a good tool to prepare composite materials exhibiting excellent thermal, gas barrier, and mechanical properties. However, in order to improve the dispersibility of the silicate layers of montmorillonite in the PP, a compatibilizer agent has to be used¹⁻³. In this article, the effect of three different types of compatibilizers on the mechanical properties of nanocomposites was studied. Each compatibilizer was prepared by melt grafting with three different monomers, such as diethyl maleate, maleic anhydride and a mixture of urea and maleic anhydride. The influence of the amount of compatibilizer used was also investigated.

EXPERIMENTAL

Materials: The materials used for the preparation of the hybrids were sodium montmorillonite from Aldrich, polypropylene J-600 (PP) with a melt flow index of 7 dg/min. from Propilven, octadecylamine from Sigma-Aldrich. Diethylmaleate (DEM), maleic anhydride (MA), urea (U) and dicumyl peroxide (DCP) were employed as the functionalization monomers and initiator, respectively, and used as received. The intercalation method used was described elsewhere¹. The functionalization of the PP with three types of monomers (8 phr) MA, DEM and a mixture of urea and MA, was made in an internal mixer Rheomix (from Haake) at 180°C and 60 rpm. The polymer was fed and melted for 4 min. After that, the initiator was added into the equipment and mixed for four more minutes. FTIR spectra of the grafted materials were obtained in order to verify the grafting of the monomers. These spectra showed a band at 1710-

1790 cm⁻¹ characteristic of the carbonyl groups in the grafted products.

Elaboration of PP-clay nanocomposites: Seven types of hybrids with the intercalated montmorillonite and different compositions of grafted PPs were prepared at 180°C and 60 rpm in the previously mentioned internal mixer. The type of grafted PP and compositions used are shown in Table 1.

Montmorillonite dispersion on PP matrix was evaluated by means of X-ray diffractometry and transmission electron microscopy (TEM). To determine the mechanical properties, specimens were cut from sheets made by compression molding and tensile properties were tested (ASTM-D638).

RESULTS AND DISCUSSION

The tensile properties of the materials are presented in Table 2. As it can be seen, the tensile properties of the grafted PPs (samples 11, 12 and 13) are lower than those of the neat PP. These results are in agreement with the low weight-average molecular weight values obtained by melt flow index measurements, which confirm the PP tendency to undergo β -scission reactions. This in fact leads to difficulties in producing functionalized PP without inducing a significant amount of polymer degradation. Similar results were found for the blends prepared with grafted and neat PP (samples 2, 5 and 8). Concerning the nanocomposites, tensile strength (σ_r) and modulus (E) were remarkably improved in the hybrids when PP-g-MA was used, as reported by other authors¹⁻³. Although, the tensile modulus was increased when PP-g-DEM was used, its lower polar character reduced the improvement. Then, the compatibility between the PP matrix and the modified clay is improved functionalizing with (1) MA, (2) DEM and finally with (3) MA+urea.

TEM micrographs of the three different nanocomposites confirm that the silicate layers were exfoliated (E), intercalated (I) and dispersed uniformly in the PP matrix at the nano level. However, some silicate layers are aggregated in the PP matrix at the micron level (T). From these results, it was found that the type of monomer employed in the functionalization of PP and the degree of

grafting affects the dispersibility of the silicate layers in the PP. The better dispersibility was found when 40 weight % of PP-g-MA was used as compatibilizer in the hybrids due to its higher polar character as it could be seen by FTIR. Similar results were found by other authors when the PP-g-MA was employed as the compatibilizer agent¹⁻³.

CONCLUSIONS

The microstructure of the nanocomposites showed that the clay particles are well dispersed in the PP matrix. Partially exfoliated structures were obtained. Mechanical properties were

improved since, for example, E increased four times for the PP-40%AM-Montmorillonite system in comparison with PP-g-AM or three times in comparison with neat PP.

REFERENCES

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Table 1. Compositions of PP-clay hibrids.

| Sample | Type of compatibilizer | PP (weight %) | Grafted PP (weight %) | Org.Clay (IMt) (weight %) |
|--------|------------------------|---------------|-----------------------|---------------------------|
| 1 | none | 95 | | 5 |
| 2 | PP-g-DEM | 80 | 20 | - |
| 3 | PP-g-DEM | 75 | 20 | 5 |
| 4 | PP-g-DEM | 55 | 40 | 5 |
| 5 | PP-g-UMA | 80 | 20 | - |
| 6 | PP-g-UMA | 75 | 20 | 5 |
| 7 | PP-g-UMA | 55 | 40 | 5 |
| 8 | PP-g-MA | 80 | 20 | - |
| 9 | PP-g-MA | 75 | 20 | 5 |
| 10 | PP-g-MA | 55 | 40 | 5 |

Table 2. Tensile properties of the materials.

| Sample | Material | E (MPa) | σ_r (Mpa) | σ_r (%) |
|--------|----------------------------|------------|------------------|----------------|
| 1 | PP + IMt | 1436 ± 278 | 15 ± 2 | 15 ± 4 |
| 2 | PP + 40 w,% PP-g-DEM | 1061 ± 125 | 20 ± 3 | 445 ± 26 |
| 3 | PP + IMt + 20 w,% PP-g-DEM | 1679 ± 302 | 24 ± 4 | 4 ± 1 |
| 4 | PP + IMt + 40 w,% PP-g-DEM | 2914 ± 354 | 28 ± 3 | 3.7 ± 0.3 |
| 5 | PP + 40 w,% PP-g-UMA | 1096 ± 220 | 22 ± 4 | 501 ± 41 |
| 6 | PP + IMt + 20 w,% PP-g-UMA | 2451 ± 322 | 26 ± 5 | 5 ± 1 |
| 7 | PP + IMt + 40 w,% PP-g-UMA | 3524 ± 412 | 30 ± 4 | 4 ± 1 |
| 8 | PP + 40 w,% PP-g-MA | 1100 ± 157 | 20 ± 3 | 476 ± 62 |
| 9 | PP + IMt + 20 w,% PP-g-MA | 2890 ± 397 | 29 ± 4 | 4 ± 1 |
| 10 | PP + IMt + 40 w,% PP-g-MA | 4048 ± 463 | 34 ± 6 | 4 ± 1 |
| 11 | PP-g-DEM | 943 ± 162 | 13 ± 2 | 5 ± 1 |
| 12 | PP-g-UMA | 996 ± 196 | 16 ± 3 | 5 ± 1 |
| 13 | PP-g-MA | 956 ± 171 | 15 ± 2 | 5 ± 1 |
| 14 | PP | 1347 ± 256 | 22 ± 3 | 563 ± 23 |