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# Influence of lamellar nanoclays in the transport properties of blown films of semi-crystalline polymers

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**Abstract** – In this work, nanocomposites of HDPE and PA6 with organically modified montmorillonite were obtained by twin-screw extrusion and then as blown films using a single screw extruder. The exfoliation level, characterized by wide-angle X-ray diffraction and transmission electron microscopy, showed that the nanoclays' lamellae were intercalated in both HDPE matrices and exfoliated in the PA6 matrix. The water vapor and oxygen permeability rates of the films of nanocomposites of PA6 and HDPE compatibilized with PEMA were lower than the pure blown films. Opposite behavior was observed in HDPE compatibilized with EVA films, because the interface between HDPE and EVA was highly defective.

The blown film process is one of the most important polymer's conformation techniques used in the packaging industry. The use of nanoscale reinforcement agents can result in films with increased mechanical and transport properties [1, 2] if the inorganic phase is well dispersed and there is a good interface between the polymeric matrix and the nanofiller. In this work, the influence of lamellar nanoclays on the water vapor permeability rate (WPTR) and oxygen permeability rate (OTR) of blown films of semi-crystalline polymers (high density polyethylene, HDPE and polyamide 6, PA6) was studied. The nanocomposites were produced in a twin-screw extruder by melt blending and were subsequently blown as films. Three different compatibilizers were used in the HDPE nanocomposites: high density polyethylene grafted with maleic anhydride (PEMA, with 1% of MA groups) and ethylene vinyl-acetate copolymers (EVA, with 19 and 28% of VA groups, named EVA19 and EVA28, respectively). The nanoclays were chosen according to the polymeric matrices and compatibilizers: Cloisite 30B (C30B, montmorillonite modified with polar surfactant), Cloisite 20A (C20A) and Cloisite 15A (C15A), both modified with non-polar surfactants. Wide-angle X-ray diffraction (WAXD) analysis and transmission electron microscopy (TEM) micrographics showed the presence of intercalated structures in all HDPE nanocomposites while exfoliated structures were observed in PA6 nanocomposites with 3 and 5%wt. of nanoclay.

The WPTR and OTR values of all nanocomposites studied are shown in Table 1. The van der Waals volumes of oxygen and water are similar [2, 3]; however, the transport mechanisms of both penetrants in a flexible polymer are different, mainly because of their different polarity (which allows the formation of water clusters, for example). In the HDPE nanocomposites compatibilized with PEMA, it is observed a high decrease of the WPTR and OTR in comparison with the pure HDPE 1 film. The HDPE/PEMA/C20A 1 film had a slightly lower WPTR than the HDPE/PEMA/C20A 2 film; this behavior can be attributed to a higher orientation of the clay's tactoids because the HDPE/PEMA/C20A 1 film was produced at a higher elongational rate. Regarding the HDPE nanocomposites compatibilized with EVA, it was observed an increase of WPTR and OTR in comparison to the pure HDPE 2 film, due to the presence of EVA (a polymer more polar and less crystalline than HDPE) and because the interfaces between HDPE and EVAs were highly defective. The WPTR of the PA6 nanocomposites blown films decreased compared to the pure PA6 blown film. Being the PA6 a polar polymer, its WPTR was higher than the HDPE nanocomposites blown films. Even with the use of nanoclay the PA6 based films were still highly permeable to water vapor. On the other hand, the OTR of the PA6 nanocomposites blown films decreased compared to the pure PA6 blown film. Oxygen, being a non-polar substance, was less permeable in PA6 than in HDPE. In this last case, the use of nanoclay highly improved the OTR of the PA6 based films.

**Table 1:** WPTR and OTR values of the blown films studied.

| Blown Film | WPTR (g water/m$^2$.day/μm) | OTR (mL/m$^2$.day/μm) |
|---|---|---|
| HDPE 1 (thickness ~ 50 μm) | 0.127 ± 0.018 | 67.25 ± 1.5 |
| HDPE/PEMA/C20A 1 (80/15/5) | 0.053 ± 0.005 | 23.92 ± 2.63 |
| HDPE/PEMA/C20A 2 (80/15/5) | 0.072 ± 0.005 | 23.54 ± 2.88 |
| HDPE 2 (thickness ~ 200 μm) | 0.004 ± 0.001 | 1.1 ± 0.1 |
| HDPE/EVA19/C15A (80/15/5) | 0.007 ± 0.001 | 1.8 ± 0.2 |
| HDPE/EVA28/C30B (80/15/5) | 0.012 ± 0.002 | 1.7 ± 0.1 |
| PA6 (thickness ~ 50 μm) | 1.32 ± 0.17 | 0.13 ± 0.01 |
| PA6/C30B (97/3) | 1.05 ± 0.14 | 0.12 ± 0.01 |
| PA6/C30B (95/5) | 0.87 ± 0.11 | 0.09 ± 0.02 |

## References

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