

# EFFECTS OF DRAW RATIO ON THE STRUCTURE AND PROPERTIES OF POLYCARBONATE FILMS REINFORCED BY AN AMORPHOUS POLYAMIDE NANOCOMPOSITE

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## INTRODUCTION

There has been in the recent years an increasing scientific and technological interest in the use of layered clays to improve certain properties of polymeric materials (mainly mechanical, barrier and thermal properties), and it has been established as a very effective route to produce polymer nanocomposites (Nc's) with wide commercial applications.<sup>1</sup> The key to these property improvements is to achieve high levels of dispersion or eventual exfoliation of the clay, so that it is present in the polymeric matrix in the form of platelets with nanometer scale thickness and consequently with high aspect ratios.<sup>1</sup> Recently, the research has been also focused in the use of highly exfoliated Nc's as dispersed phases in different polymer blends to develop ternary systems.<sup>2</sup>

Packaging is one of the application fields for which Nc's are highly attractive, because the property improvements mentioned before could allow such materials to be employed as innovative solutions to satisfy the demanding requirements. The combination of this technology with that of polymer blends could spread out the applications of the base polymers and lead to the development of new materials with enhanced performance.

Polycarbonate (PC) and amorphous polyamides (aPA) are polymers with wide applications in packaging technology. Besides, aPA based Nc's (nano-aPA) have shown wide exfoliation levels due to the good compatibility of aPA with layered silicates.<sup>3</sup> Blends of PC/nano-aPA have been less studied and too little attention has been paid to film extrusion of these blends. The aim of this work is to study the structure and properties of extruded films based on PC/nano-aPA blends and, taking into account the ability of aPA to fibrillate during processing, to establish the effect of the draw ratio (DR) on the fibrillation and the final properties of the films.

## EXPERIMENTAL

In a first step, the Nc based on aPA with 4 wt% of organically modified montmorillonite (Nanomer I30) was obtained in the melt state using a co-rotating twin-screw extruder. The resulting Nc was melt mixed with PC to obtain a 75/25 PC/nano-aPA blend. The reference PC/aPA blend without montmorillonite was also processed at the same conditions. The films were obtained by reextruding the blend pellets in a single extruder equipped with a flat die. A water cooled 3-Roller Calender was used to collect the films, and the take-up velocity was varied from 1.5 to 10.5 m/min. The DR was calculated as the ratio of die gap to the final film thickness. Mechanical properties were measured by means of tensile tests in both machine (MD) and transverse (TD) directions. Thermal properties were determined by means of calorimetric analyses. The orientation was evaluated by means of birefringence and the morphology was observed by scanning electron microscopy (SEM).

## RESULTS AND DISCUSSION

The obtained films exhibited good surface properties. Films prepared from the PC/aPA blend were colourless and transparent, whereas those of the PC/nano-aPA blend had a yellowish colour with less clarity than the pure blend. The phase behavior of the blends, studied by DSC, showed two clear Tg's at the positions of the pure components, indicating the presence of two pure amorphous phases.

Figure 1 shows SEM photomicrographs of the cryogenically fractured surfaces of PC/aPA (Figure 1a) and PC/nano-aPA (Figure 1b) films at low DR. As can be seen, the dispersed phase size was in both cases very small. As can also be seen comparing Figure 1a and Figure 1b, the presence of clay in the dispersed phase did not appear to modify the compatibility between the PC and aPA.

With respect to the mechanical performance, Figure 2 shows the tensile modulus of PC/aPA and PC/nano-aPA films as a function of DR in both the MD and the TD. As can be seen, the modulus in the

MD was around 1.5 GPa higher than in the TD. As the DR increased, the modulus in the MD slightly increased whereas that in the TD remained invariable. This behaviour is consequence of the uniaxial orientation of the polymer chains during stretching. Figure 2 also shows higher modulus in the PC/nano-aPA films in both the MD and the TD, indicating the reinforcing effect of the clay presence in the dispersed phase of the blend. The yield stress was also higher in the PC/nano-aPA blend, due to the contribution of the clay, and increased with the DR.

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## References

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## Figures

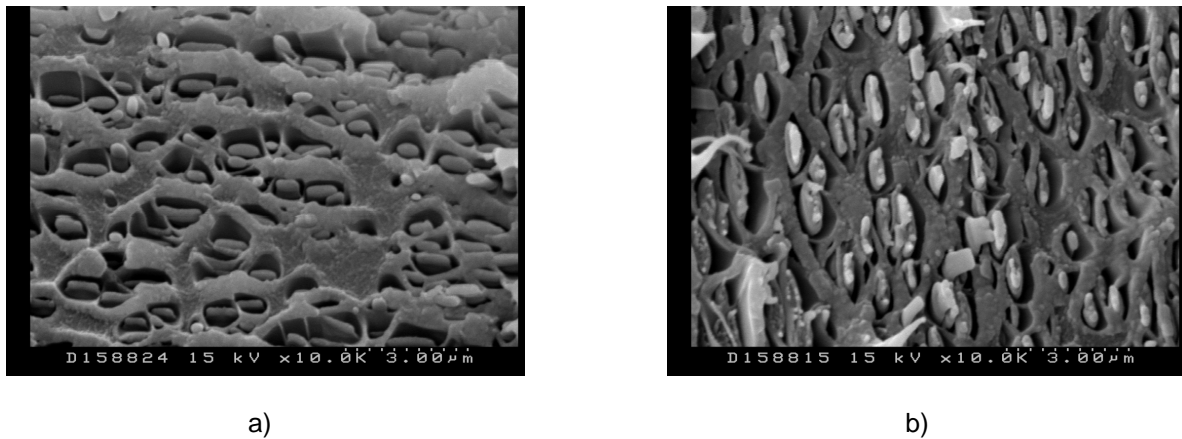


Figure 1. SEM photomicrographs of cryogenically fractured surfaces of PC/aPA (Figure 1a) and PC/nano-aPA (Figure 1b) films at low DR.

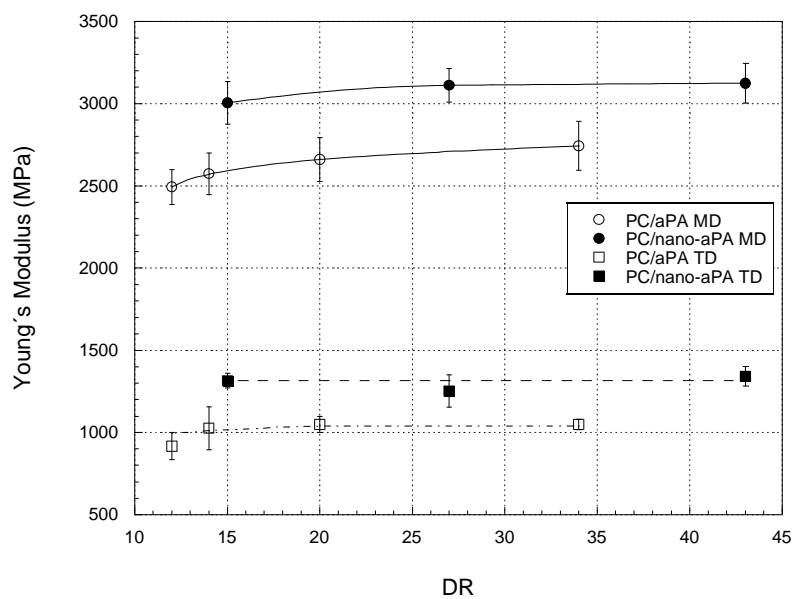


Figure 2. Tensile modulus of the PC/aPA and PC/nano-aPA blends as a function of the DR in both the MD and the TD.