INTRODUCTION

Blends are a mixture of two or more polymers obtained by melting or in solution. Its objective is the preparation of a material that posses the combination of properties of their components, not compassable by separated. The development of a blend with an adequate behavior, especially with respect to their mechanical and physical properties, depends on the interfacial adhesion among the phases. A compatible blend is that in which the dispersed or minority phase is found homogeneously distributed in the matrix or majority phase and in which the adhesion among the same is strong. In this type of blends, a force applied is transmitted among the components of the phases (1).

Polypropylene (PP), a synthetic polymer is an economical material that offers a combination of outstanding physical, mechanical, thermal, chemical properties that are not found in any other thermoplastic polymer (2). The great number of polyolefinic products has caused harmful consequences to the nature due to low degradation rates reached by the traditional polyolefins, e.g. low-density polyethylene (LDPE) and isotactic polypropylene (iPP).

By this way, researchers have studied the incorporation of biodegradable polymers, such as the starch, to the traditional polyolefins, which is justified by the presence of hydrolyzable groups in the natural polymer that are able to induce the biodegradation of the polyolefins (3-5).

Ramos et al. (6) evaluated the biodegradability of iPP/starch blends under simulated soil and observed the materials decomposition under nitrogen and oxygen atmosphere, by different mechanisms of degradation. The biodegradation affected the starch but not the iPP matrix.

When dealing with starch-derivative materials, this last can present a thermoplastic characteristic (commonly called thermoplastic starch or TPS) when incorporating glycerin to it, acting as a plasticizer (7). Moreover, the use of glycerin, as described by Carvalho (7) can increase the fragmentation rate of the material (morphological structure), obtaining through materials with many different characteristics just by varying the amount of glycerin, as described by Carvalho (7) can increase the fragmentation rate of the material (morphological structure), obtaining through materials with many different characteristics just by varying the amount of glycerin on the starch.

In general, it is said that in order to let the polyolefins more susceptible to degradation, some kind of modification is necessary, such as modifications on the crystallinity degree (8), chemical degradation and reduction on the molar mass of polymers to create short molecules that are capable of being absorbed by microorganisms (9).

The inclusion of such materials allows products traditionally produced from non-renewable and environmentally persistent petroleum-based materials, to be produced from materials made from renewable resources which may also provide a degree of degradability to the final product. Starch, in particular, has been used since the 1970s as a filler in plastics (10) and has recently been plasticized and extruded with traditional plastics (11) used as a baked foam for thin walled applications (12), and used as packaging foams (13). Dry granular starch and baked starch, which is pressed and molded, have limited processability and can be used in only a limited range of applications. Plasticized starch, however, is more versatile and can be blended with various polymeric materials for numerous applications.

Starch is an abundant, naturally occurring polysaccharide that is obtained from various plant sources, such as corn, potato, rice, and cassava [14]. Starch is a semi-crystalline polymer comprised of glucose monomer units. Its granular form is comprised of linear amylase or branched amylopectin macromolecules with amylose content of ranging from 20-30% (see Scheme 1). Dry granular starch, by itself, cannot be processed like a plastic; however, it can be heated and blended with several different small polar molecules (water, glycerol) or polar oligomers (polysols), giving a thermoplastic material, generally called (PLS). This process, known as gelatinization, breaks up the granular structure of starch by disrupting hydrogen bonding between adjacent glucose molecules and essentially destroys its crystallinity [15].

2. EXPERIMENTAL PART

2.1 Materials

PP, poly(propylene-co-ethylene); random copolymer (MFR 2,16 kg/230°C); 8.5 g/10 min, PP (MFR 2,16 kg/230°C), poly(propylene-co-ethylene), heterophasic copolymer 12 g/10 min, from PETROQUIM S.A. Glycerine acquired Sigma-Aldrich.

The different types of starches: corn starch (CS) and potato starch (PS) were obtained Sigma-Aldrich.

1.2 Melting Processing

PP / starch and PP / starch blends were obtained in a twin-screw co-rotating extruder (Haake H-25, model Rheomex PTW 16/25, L/D 1:5) operating at 80 rpm. The temperature conditions, 150 and 170°C for preparation and...
processing of blends were chosen to minimize possible degradation of the organic modifier and the matrix.

The PP/starch blends were prepared as described in Table 1, using 7 and 15% wt CS and PS.

Table 1. Experimental conditions of PP/starch blends

<table>
<thead>
<tr>
<th>Experimental conditions</th>
<th>PP 1</th>
<th>PP 2</th>
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<tbody>
<tr>
<td>Mixing temperature (°C)</td>
<td>150</td>
<td>180</td>
</tr>
<tr>
<td>Mixing time (min)</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Mixing speed (rpm)</td>
<td>80</td>
<td>80</td>
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<tr>
<td>Glycerine concentration (% en mass)</td>
<td>2</td>
<td>2</td>
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</table>

From the prepared PP blends, the films were obtained by compression heating the polymer up to 190°C, maintaining for 2 min to obtain the complete melting of the pellets, and a pressure of 6 pounds was applied for 3 min.

1.3 PP/starch characterization

Differential scanning calorimetry (DSC) measurements were made on DSC Q200 TA Instrument. All measurements were carried out under nitrogen atmosphere. The samples were heated from 50 to 200°C at a heating and cooling rate of 5° C/min. The measurements were accomplished during the second heating and cooling cycle.

Thermogravimetric analyses were carried out on a T.A model QA-50 to obtain the inorganic and organic residue, and the clays’ decomposition profile, and PP blends. The samples (10.0 mg in film form) were heated from 25 to 600°C at heating rate of 10°C/min under nitrogen flow.

The morphologies of the PP/starch blends were examined by JEOL-JSM 6380 LV scanning electron microscopy. The fractured surface of blends were coated with a gold film of ca. 50 nm and the images were taken at an accelerating potential of 20 kV.

3. RESULTS AND DISCUSSION

3.1.1. PP 1 blends characterization for DSC

The figure 1 shows the DSC thermograms of neat PP 1 and PP 1/CS blend, and Figure 2 shows pure PP 1 and PP 1/PS blend. The peak around 150°C, corresponds to melting temperature of PP 1, in both thermograms.

The peak between 300-350°C is clearly observed with 7% corn starch (CS) (see figure 1) instead with a 7% potato starch (PS) is not, it is due the content is higher in amyllose corn starch (~29%) compared to potato starch (~21%) (19).

3.1.2. PP 3 blends characterization for DSC

The Figure 3 shows the DSC thermograms of pure PP 3 and PP 3/CS blend, and Figure 4 shows pure PP 3 and PP 3/PS. The peak ~ at 170°C corresponds to melting temperature of PP 3 (see Figures 3 and 4).

The peak above 400°C in pure PP 3 and PP 3/CS (see Figure 1), and PP 3/PS in figure 2 blend is due to the decomposition of PP 3, and PP 3/CS and PP 3/PS blend, respectively. In both figures, the thermograms show the presence of an additional melting peak which occurred at 300-350°C. This peak, which was not present in pure PP 3, is due to the presence of amyllose. The peak intensity between 300-350°C increases with the amyllose content, and increases the miscibility of blend.
The decomposition temperatures decrease with increasing the starch content of the blend. Table 2 shows that the initial decomposition temperature (T_{5\%}) of PP, 334 °C. In the blends PP/7%CS and PP/15%CS initial decomposition temperatures decrease with the increase of corn starch in the blend. This effect is due to amylose content.

The same occurs when T_{95\%} decomposition temperature decreases by increasing the starch content in the blend. The increase of amylose content that produces greater dispersion de CS and PS in PP increases the miscibility (19).

In the case of PP, T_{5\%} and T_{95\%}, the decomposition temperature decreases by less than PP, with increased starch content in the blends. This is probably due to the structure of PP, and PP, PS, poly(propylene-co-ethylene), random copolymer and PP, poly(propylene-co-ethylene), heterophase copolymer.

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3.1.4. PP, blends characterization by SEM.

Figure 6 A, B, C, and d) show the SEM microphotography for PP, PP,7%CS, PP/15%CS. Micron scale phase separation was determined by an examination of blend with SEM. The CS does not undergo complete melting and remain dispersed in the continuous PP.

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4. CONCLUSIONS

From the thermodegradative studies of the PP/CS and PP/PS blends, it can be concluded that the CS and PS content induces a retardant effect on the degradative process of the PP, since it increases the initial decomposition temperature of the blend, acting like an anti-oxidant agent.

The presence of an amylose content as well as corn and potato starches increase in the blend. This increase of amylose content produces a greater dispersion of CS and PS in PP, increases the miscibility. It was corroborated by DSC, TGA, and SEM.

PP/PS blends have lower decomposition temperatures of PP/PS because corn starch has a higher content of amylose than that potato starch.

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