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MECHANICAL AND THERMAL PROPERTIES OF POLYPROPYLENE COMPOSITES WITH CURAUA FIBRE IRRADIATED WITH GAMMA RADIATION

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ABSTRACT

Thermal and mechanical behavior of polypropylene with curaua fibre composites were investigated. The treatment of the curaua fibres was processed in alkaline solution (10% wt NaOH). A coupling agent was used (maleic anhydride) to increase the adhesion of the fibre/matrix interface. This composite was irradiated with gamma source in the doses of 5, 15 and 30 kGy and the adhesion between the fibres and the polymeric matrix was monitored to observe probable changes. The thermal behavior was evaluated using differential scanning calorimetry (DSC) and Thermogravimetry (TGA). The mechanical behavior was evaluated using tensile strength in comparition with non-reinforced polypropylene resin. The morphology of the composite fracture surface was observed using scanning electron microscopy (SEM). There were no significant changes in the thermal properties neither in the adhesion of irradiated fibres at doses of 5, 15 and 30 kGy of gamma radiation.

1. INTRODUCTION

Due to the growth polymer consumption and necessity of materials with improved mechanical properties, synthetic reinforcing agents, such as glass, carbon, and metallic fibres are used by the industry as reinforcing agents. However, these synthetic fibres are expensive, their production consumes a great deal of energy; they are abrasive to the processing equipment and are degradable only in the long term. The necessity to develop and commercialize composite materials based on renewable sources can be help to reduce the dependence on nonrenewable materials derived from fossil sources, especially petroleum. [1-6]

Natural fibres are in general suitable to reinforce plastics (thermosets as well as thermoplastics) since natural fibres are strong, weight, abundant, non-abrasive, non-hazardous and inexpensive.

Another relevant aspect that involves the use natural fibres is the presence of cellulose component that a polar surface associated to the hydroxyl groups (OH). Such feature is responsible for the high hydrophilicity of cellulose, enabling the establishment of strong hydrogen bonding between fibres and the formation of three dimensional fibre-based structures. [2] The application of natural fibres as reinforcements in composite materials requires, just as for synthetic fibre reinforced composites, a strong adhesion between the fibre

and the matrix, in fact mechanical behavior of composite depends to a great extent on the interfacial adhesion between the reinforcing fiber and the polymer matrix. [2-4].

The concern with the environment and use of natural products has strongly contributed in the use of material derived from natural sources. Within this context curaua fibre, originating from the Brazilian Amazon, which have a significant potential, presenting some advantages such as lower density, good mechanical properties, lower cost, as well as being renewable resources and ecologically correct. [5]

The radiation technology is preferred over the other processes due to many advantages when compared with other conventional methods. For initiation processes, radiation differs from chemical initiation. In radiation processing, no catalyst or additives are required to initiate the reaction. Radiation modification is the phenomena by which the properties of the polymers, can be improved. In this process, the fillers are quite effective in radiation process. In short, radiation plays the important role in the polymer processing that is used in composite field. [7]

This work is a research about the development of polypropylene composites with curaua fibres modified by gamma radiation. Its main objective is to present a modification and of the curaua fibre/polypropylene composite by gamma radiation. The characterization consists of tensile test, morphological analysis, and thermogravimetric analysis.

2. MATERIALS AND METHODS

The resin used was the polypropylene EP440L from Quattor Petrochemical, located at Mauá (SP). This is a resin heterophase copolymer of melting index of 6 10 min^{-1} and density of 0.905 g/cm^3.

The curaua fibres were donated by the company Pematec Triangel LTDA of Brazil located in São Bernardo do Campo (SP).

The curaua fibres had an average length of 2.5 to 3.5 mm in length and a diameter of between 0.08 to 0.10 mm. It was used for superficial treatment curaua fibres, a solution of water and sodium hydroxide (NaOH) 10% in weight for a period of 2 hours.

In the mixing stage, it was used Polybond 3150, a coupling agent known as polypropylene grafting (maleic anhydride) and also was used Irganox1010 from Ciba Geigy, which is a mixture of antioxidant and stabilize for both composites.

2.1. Preparation of the mixtures

The quality of the fibre–matrix interface is essencial for the application of natural fibres as reinforcement in plastics. Like fibreglass, natural fibres present poor compatibility with the non-polar polymeric matrix and relatively high moisture sorption; these factors affect the mechanical properties of the composites. In order to improve polymer-fibre adhesion and to reduce water absorption, the surface of the fibre can be modified by physical or chemical

methods. Physical and chemical methods can be used to optimize this interface. These modification methods are of different efficiency for the adhesion between matrix and fibre [2,8].

The curaua fibres were mixed with an phenolic antioxidant, (Irganox with 0.4%), a heat stabilizer (Irgafós 0.8%) and Polybond 3150, an coupling agent, maleic anhydride (MAH), with 2% concentration for all samples of the composite, to improve adherence fibre / matrix and processability. In this work was used a double screw extruder HAAKE Rheomex, for better homogenization of the composite.

It was used a temperature profile of 180 °C and 195ºC of the rotation of screwed up in 60 rpm, to reduce the fibre breaking. A mill knife was used to grind curaua fibres to improve the extrusion and injection.

After the extrusion, the material was cooled in a bathtub with water at room temperature, pelletized in a Borg Mar, packaged and sent to an oven for 2 hours in order to remove the moisture from the cooling processed granulator samples. After dry, the material was flow into a Battenfeld TM 750/210 the temperature of 195ºC and so at 60°C, to reduce tensions in the composite. After flow the samples were irradiated with gamma radiation at 5, 15 and 30 kGy doses.

2.2 Characterization

2.2.1 Thermal Analysis

The analyses in TGA were perfomed in Mettler-Toledo SDTA/851e with heating rate of 10°C min^{-1}, from 35 to 550 °C, under atmosphere of N_2 (10mL min^{-1}).

The analyses in DSC were perfomed Mettler-Toledo DSC822e, using heating rate of 25 to 280 C to 10 °C min^{-1}, remained for five minutes and cooled to 25°C with then reheat of 25 to 280 C to 10°C min^{-1}, under nitrogen atmosphere.

2.2.2 Scanning Electron Microscopy (SEM)

This study was utilized SEM model Phillips and the samples were covered with gold, to better visualization of the surfaces.

3. RESULTS AND DISCUSSION

3.1 Strength Testing

The mechanical characteristics of a fibre-reinforced composite depend not only on the properties of the fibre and the polymer matrix but also on the degree to which an applied load is transmitted to the fibres by the matrix phase. The extent of the load transmittance is controlled by the magnitude of the interfacial bond between the fibre and the matrix phases. [9].

In the Fig. 1(a). the values are indicated of maximum tension at rupture of the PP pristine,

and the composites. It is observed the effect reinforcement of curaua fibres in relation to PP pristine, which values close to those obtained for composites reinforced with fibres. No significant changes in tension rupture with the application of gamma radiation.

In Fig. 1(b). are shown the values of elongation rupture in the samples of the composite of polypropylene with curaua fibres.

With the increase in the fibres content it is observed a decrease of the maximum elongation at rupture, suggesting a rise of rigidity due to increased fibre content. Another important factor that can be considered is the adhesion of fibre in the matrix, lower elongation occurs when increases the adhesion between fibres and matrix.

On other hand, PP pristine modified by gamma radiation, increased in the elongation at rupture, specially at 5 kGy, that can be explained as the crosslink effect of radiation on the polymeric chain

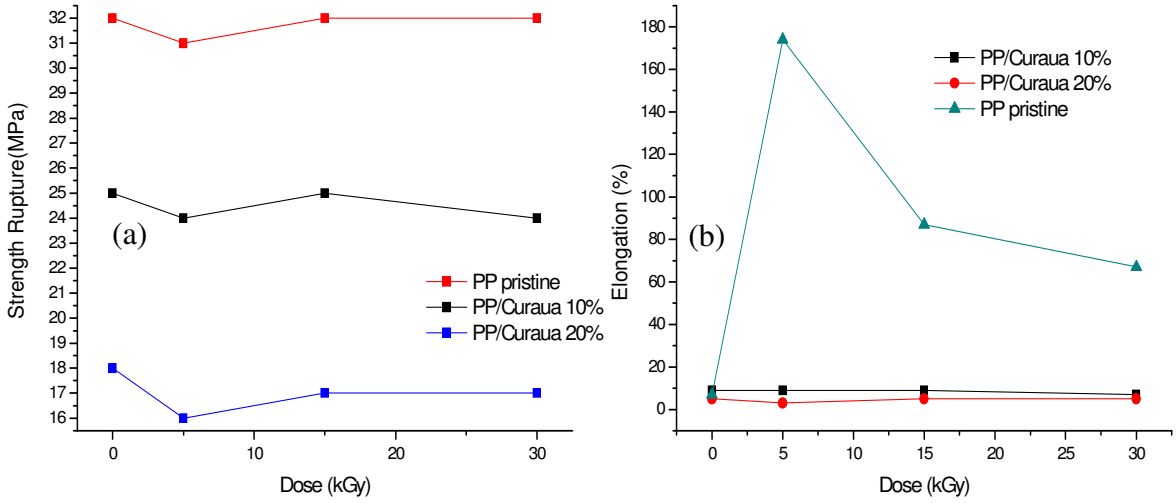

Figure 1. (a) Strength rupture (MPa) for the samples of the composites of polypropylene (0, 5, 15 and 30 kGy), (b) elongation (%) for the samples of the composites of polypropylene (0,5,15 and 30).

3.2 DSC

The DSC melting and cooling thermograms of PP and PP/Curaua composites are shown in Fig. 2 and the values of relevant thermodynamic parameters are summarized in Table 1. It is was noting that in the 2nd heating run the composite samples displaced the typical melting peak of PP (T_m = 167 °C). The occurrence of a slight higher melting peak in the composites suggests the melting of PP crystals with greater stability likely that formed for stress-induced crystallisation in contact with the fibres (oriented nucleation) after the mixing process.

Table 1. Melting temperatures for the composites with curaua, irradiated with gamma radiation compared to PP pristine.

Sample	Melting Temp(ºC)
PP/Curaua 10% 0 kGy	**165**
PP/Curaua 10% 30 kGy	**165**
PP/Curaua 20% 0 kGy	**168**
PP/Curaua 20% 30 kGy	**167**
PPpristine	**167**
PPpristine 30 kGy	**163**

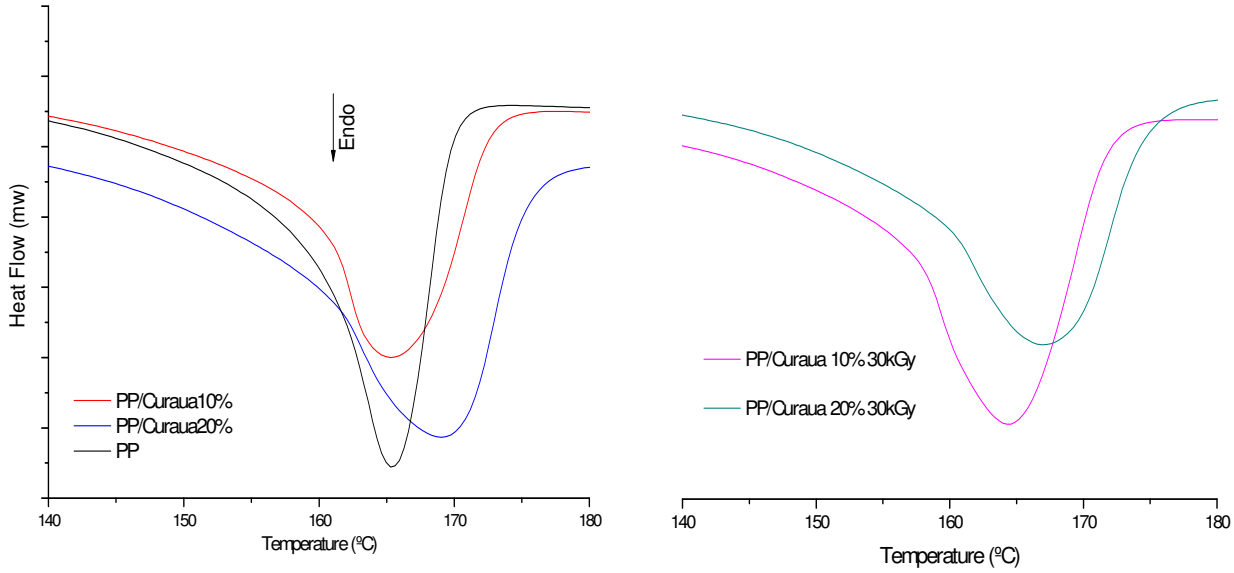

Figure 2. Melting peaks observed after second heating for polypropylene composites with curaua fibres.

3.3 TGA

In the oxidative atmosphere, it is not possible to separate the different degradation processes of the fiber components such as hemicellulose, cellulose and lignin, because the reactions being very complex and they are overlapped in the range of 350 to 520°C.

The Fig.3 shows the decomposition curves of the curaua fibres samples in reactive oxygen atmosphere. The one step decomposition occurred under the oxidative atmosphere of the

samples with curaua fibres have similar profiles, and can be observed that irradiation decreases susceptibility to oxidation in the composites.

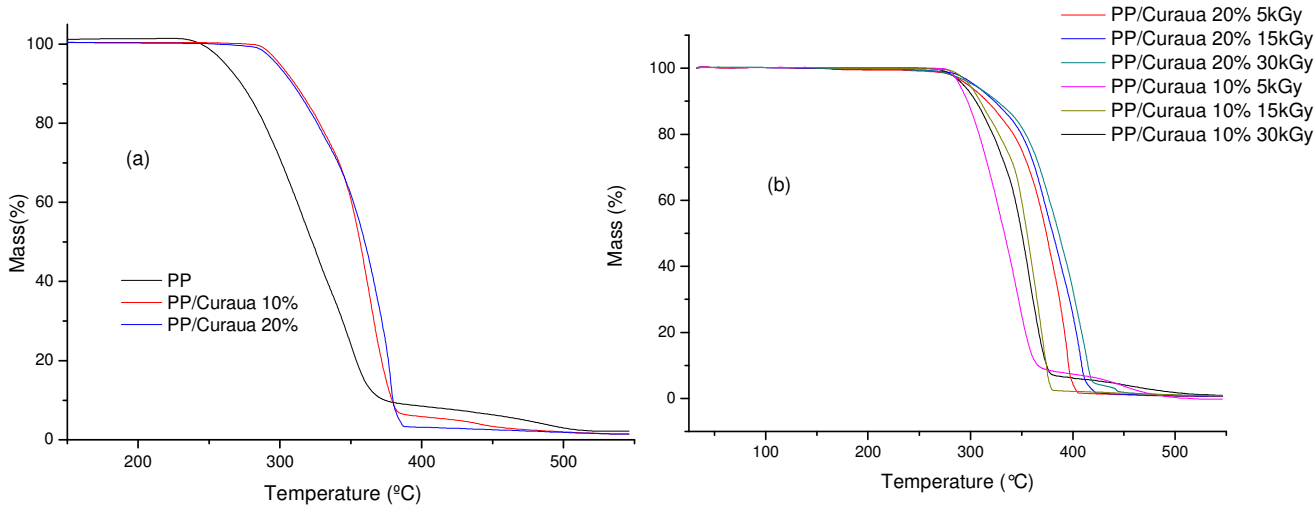

Figure 3. TGA curves in oxidative atmosphere with heating rate of 10 ° C min^{-1}

In irradiated polypropylene composites with 0, 5, 15 and 30 kGy, the final ashes were late by composites with curaua fibres 0, 5, 15 and 30 kGy, the final residue was 2 and 3% (samples with 10 samples and 20%-fibre curaua, respectively).

The rise of thermal stability on the composites indicates that there is an interaction between the thermal degradation mechanisms of the fibers and of the thermoplastic. The thermal stability are increases for all composites curaua fibre/polypropylene, suggest that the hindered phenols present in lignin may act as free radical scavengers, retarding the thermal degradation of the polymer. [1]

3.3 SEM

A morphology study of curaua fibres was carried out using scanning electron microscopy (SEM) to evaluate the fibre surfaces. The changes in morphology are important to predict fibre interaction with the polymer matrix in composites.

Through scanning electron microscopy was possible to evaluate the efficiency of the dispersion of curaua fibres in the polypropylene matrix and the ability of wetting the surface of the fibres with the plastic matrix, as a way to evaluate the efficiency of the agent of coupling used to promote better adherence fibre / matrix. In samples of the composite irradiated with gamma radiation (5,15 and 30 kGy) no changes were observed in the pullot and / or tearing of the curaua fibres Fig. 5 (from a to c) show partial coating of the fibres by polymeric material with no morphological difference concerning the irradiation effects.

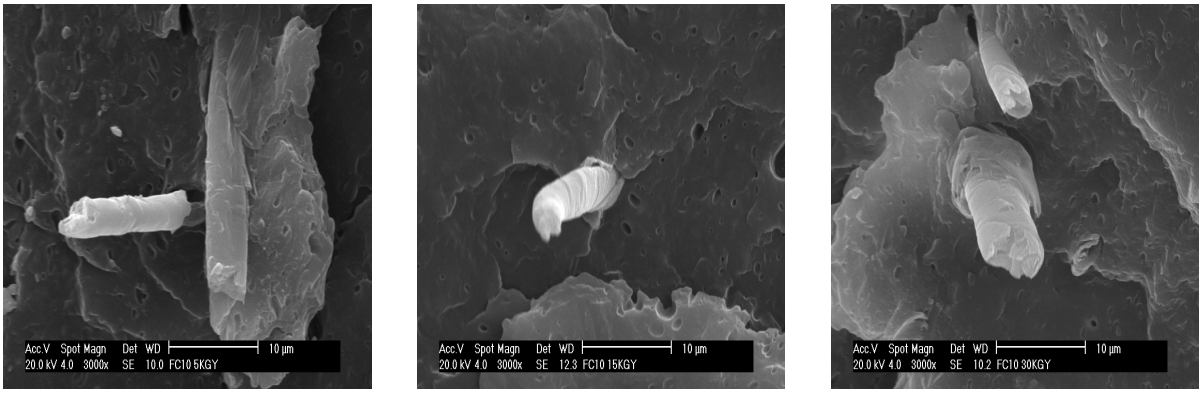

Figure 4. (a) PP/curaua 10% 5 kGy, (b) PP/curaua 10% 15 kGy,(c) PP/curaua 10% 30 kGy.

4. CONCLUSION

Interest in composite manufacture has recently shifted towards the use of natural fibres for reinforcement because of their environmental benefits. Curaua-based polymer composites are receiving increased attention due to material availability and sustainability.

Curaua fibre is a promising reinforcement for use in composites on account of its low cost, low density, high specific strength and modulus, no health risk, easy availability in some countries and renewability. In recent years, there has been an increasing interest in finding new applications for curaua-fibre-reinforced composites that are traditionally used for making ropes, mats, carpets, fancy articles and others.

There were no significant changes in their thermal properties composites and neither in adhesion of the polymer fibres after irradiation, at doses of 5, 15 and 30 kGy. There was a great change in rupture elongation at rupture of in PP pristine irradiated with 5, 15 and 30 kGy in relation to PP and PP composites reinforced with curaua fibres

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