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STUDY OF THE EFFECT OF IONIZING RADIATION ON COMPOSITES OF WOOD FLOUR IN POLYPROPYLENE MATRIX USING BARIUM TITANATE AS COUPLING AGENT

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ABSTRACT

The aim of this work was to study the effects of ionizing radiation on the properties of wood flour composites in polypropylene matrix, using barium titanate as a coupling agent and the reactive monomer tripropylene glycol diacrylate (TPDGA). The investigated compositions consisted of polypropylene/wood flour, polypropylene/wood flour with barium titanate and polypropylene/wood flour with barium titanate and TPDGA, using different wood flour concentrations of 10%, 15% and 20%. Subsequently, the samples were moulded by injection irradiated and submitted to thermal and mechanical tests. The mechanical properties (hardness, impact strength and melt flow index (MFI)), as well as the thermal properties (thermal distortion temperature and Vicat softening temperature) of the composites with and without barium titanate and TPDGA, non irradiated and irradiated were determined. The samples were irradiated in irradiation doses of 10 kGy and 20 kGy in an electron accelerator. Regarding the mechanical properties of non-irradiated samples, the incorporation of wood four to polypropylene, resulted in a decrease of impact strength and melt flow index as well as in an increase in hardness, showing that the wood flour acts like a reinforcement agent. As to the irradiated samples**,** it was observed a decrease in the impact strength, hardness and thermal distortion temperature and an increase Vicat softening temperature.

1. INTRODUCTION

Investments in new polymers synthesis require high financial costs. Thus, the search for new low cost materials, good performance and easily handling ones provides conditions to the investment and the emerging of polymer modification techniques. The addition and reinforcement has the objective of improving the resin properties, constituted of an advantageous alternative compared to other processes such as polymerization or the development of new polymers[1].

The radiation can be used as an alternative in the development of new polymers as well. The ionizing radiation is a process capable to modify the properties of a material, being this, a clean process, since chemical agents are not used[2].

The “Wood-plastic composites” (WPC’s) products are materials that join a thermoplastic polymer or termofixed to an organic reinforcement that can be fiber or wood flour[3]. These composites were known in the market primarily because of the MDF panels ("medium-density-fiberboard") that is constituted of wood with termofixed resin[4].

The utilization of composites with cellulose organic load has been known since the beginning of the 70's, through the automobilist industry, by the so called "Woodstock" which were propylene composites (PP) with wood flour (WF) extruded and layered in plates for the inner covering of car trunks[3].

It is common to use additives in polymeric resins, and they are also used in WPC's. These materials are added in low quantities for the increase of the properties[5]. The coupling agent barium titanate (TiBa) and the additive tripropylene glycol diacrylate (TPDGA) were used in this study.

The coupling agent barium titanate was used to provide better interaction of the wood flour and the polymeric matrix. Its structure allows that chemical joints occur between the two interfaces, load and polymeric matrix improving the adhesion between them; the tiba provides an even better dispersion of the load improving the mechanical properties[1, 6].

The TPDGA is a monomer used as a free radical in polymerization. It was added to the wood flour/polypropylene composite (WF/PP) to help in the interface matrix/load, mainly after the ionizing radiation[7].

It was also in the 70's that, showing positive results, the first publications about ionizing radiation in wood-polymer composites appeared[8]. The main effects caused in polymers by the ionizing radiation are the main chain joint splitting (degradation) and the appearance of chemical joints among polymeric molecules (crosslinking)[9].

In such paper it is indispensable the crosslinking predominance. This process occurs by the recombination among radicals forming three-dimensional nets of the irradiated polymer. In the crossed linkings, the polymeric chains connect themselves through covalent joining generated by chemical joining or by radiation.

During the crosslinking, there is a growth of the molecular weight, mechanical resistance, three-dimensional nets of the system, viscosity and the reduction of the solubility of the irradiated polymer and a change in the temperature of the vitreous transition in amorphous phase of the irradiated polymer. This mechanism also depends on the dose, dose ratio, concentration, irradiation atmosphere among others. However, the polymer sensibility to parameter changes, depends on the type and size of the chains, as well as the polymer morphology[9, 10].

The physical-chemical modifications provided by the radiation complete this study which aims to improve the properties in a composite that uses cellulosic residues as a reinforcement in polypropylene.

2. EXPERIMENTAL

The polypropylene used in this work was sort of SM 6100, made by "Polibrasil S.A. Industria e Comércio". The wood flour was obtained from the sawdust and trituration of wood, specially the "Pinnus eliottis", better known as Pinus. The mesh provided by the "Pinhopó Madeira e Moagem Ltda" was the M-10050. The coupling agent used was the barium titanate type A, provided by the industry “Certronic Ind. e Com. Ltda” and the tripropylene glycol diacrylate was provided by “Bandeirante Chemical Ltda”.

The developed composites were prepared from the load treatment. This phase consisted of a solution of water and ethanol containing the additives TiBa and TPDGA. This homogenized solution is incorporated to the load wood flour in such a way that the quantity of additives becomes around 1%. After drying in the sterilizer, the mixture is added to the PP.

The mixture of the materials occurred in a calandria. This equipment has two warmed rolls that convert the polypropylene into a funded mass, and the load is then added to the polymer at that moment. Afterwards, the samples were shaped by injection and half of each such sample was irradiated. For the irradiation of the samples at different doses an electron accelerator JOB 188 (Dynamitron), energy 1.5 MeV was used. The properties of the samples non-irradiated and irradiated were determined according to the standard ASTM tests.

3. RESULTS AND DISCUSSION

3.1. Melt Flow Index

The rheological characterization of the processed composites was made through melt flow index test. The melt flow index was determined for the following composites: PP (pure); 10% WF/PP, 10% WF+TiBa/PP, 10% WF+TiBa+TPDGA/PP, it was also determined in the concentrations with 15% and 20%WF.

In Figure 1 the melt flow index results are shown.

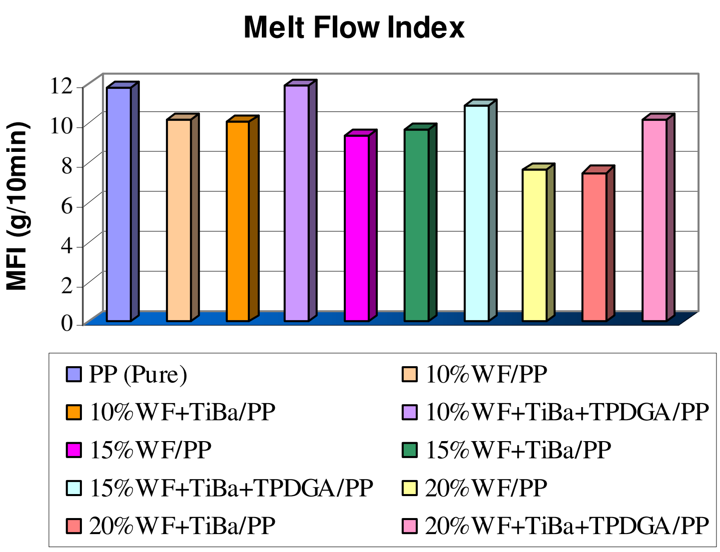

Figure 1. Melt flow index test results for PP pure and different compositions of WF/PP non-irradiated.

The results show that:
- The melt index decrease with the WF concentration;
- The presence of TiBa or TiBa/TPDGA decrease the melt index.

3.2. Impact Strength

The Impact Strength was determined to the following composites: PP (pure); 10% WF/PP, 10% WF+TiBa/PP, 10% WF+TiBa+TPGDA/PP, it was also determined in the concentrations with 15% and 20%WF. The test was done in non-irradiated and irradiated samples with doses of 10 kGy and 20 kGy.

In Figure 2 the results for the property of impact strength are shown.

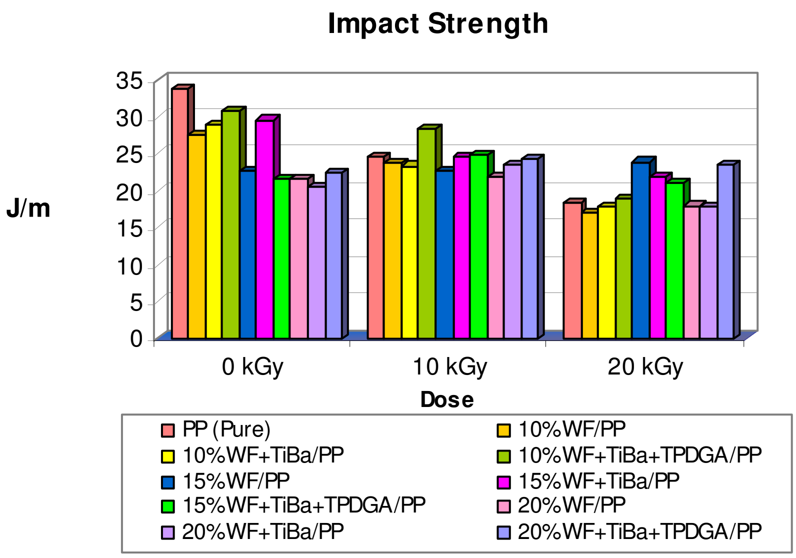

Figure 2. Impact Strength test results for PP pure and different compositions of WF/PP non-irradiated and irradiated.

The results show that:
- The impact strength increase with the WF concentration, probably due to increase of crystallization obtained.

3.3. Hardness Shore D

The hardness test was determined for the following composites: PP (pure); 10% WF/PP, 10% WF+TiBa/PP, 10% WF+TiBa+TPGDA/PP, it was also determined in the concentrations with 15% and 20%WF. The test was carried out in irradiated samples with doses of 10 kGy and 20 kGy and non-irradiated samples.

In Figure 3 the results for the property of hardness are shown.

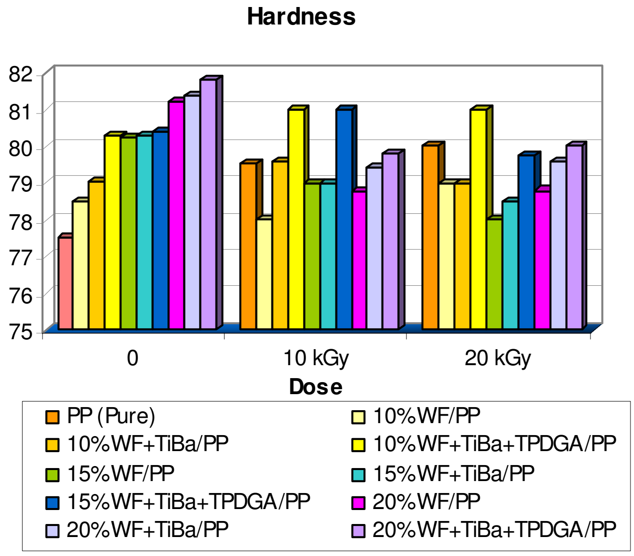

Figure 3. Hardness Shore D test results for PP pure and different compositions of WF/PP non-irradiated and irradiated.

The results show that:
- The hardness increase with the WF concentration;
- The hardness increase in the presence of TiBa or TiBa/TPDGA;
- The hardness increase with the irradiation dose, due to reticulation promote to irradiation.

3.4. Thermal Distortion Temperature (HDT)

The thermal distortion temperature test was determined for the following composites: PP (pure); 10% WF/PP, 10% WF+TiBa/PP, 10% WF+TiBa+TPGDA/PP, it was also determined in the concentrations with 15% and 20%WF. The test was carried out in irradiated samples with doses of 10 kGy and 20 kGy and non-irradiated samples.

In Figure 4 the results for the property of thermal distortion temperature are shown.

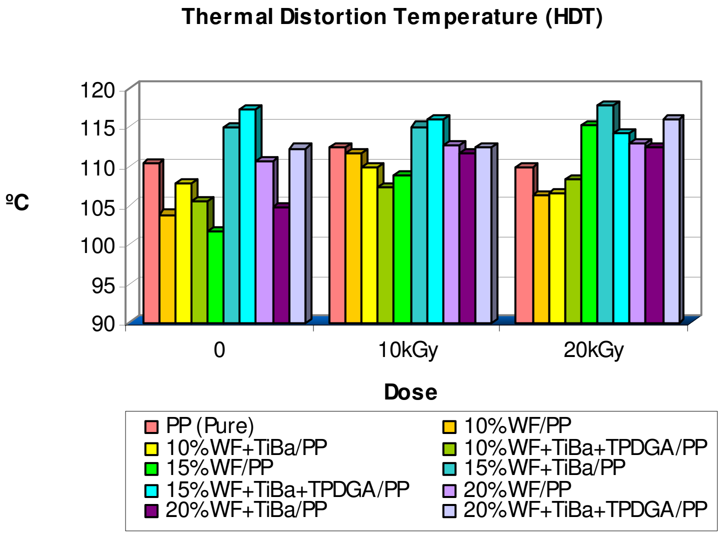

Figure 4. Thermal Distortion Temperature Shore D test results for PP pure and different compositions of WF/PP non-irradiated and irradiated.

The results show that:
- The HDT increase with the WF concentration;
- The hardness increase in the presence of TiBa or TiBa/TPDGA;
- The hardness increase with irradiation dose of 10kGy, to 20kGy dose the hardness decrease.

3.5. Vicat Softening Temperature

The Vicat softening temperature test was determined for the following composites: PP (pure); 10% WF/PP, 10% WF+TiBa/PP, 10% WF+TiBa+TPGDA/PP, it was also determined in the concentrations with 15% and 20%WF. The test was carried out in irradiated samples with doses of 10 kGy and 20 kGy and non-irradiated samples.

In Figure 5 the results for the property of Vicat softening temperature are shown.

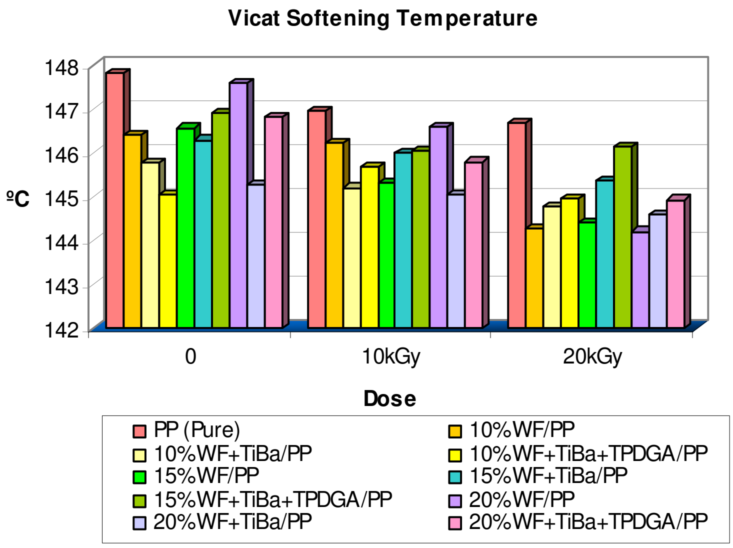

Figure 5. Vicat Softening Temperature test results for PP pure and different compositions of WF/PP non-irradiated and irradiated.

The results show that:
- The addition of WF practically doesn't change the Vicat softening temperature;
- The Vicat softening temperature practically doesn't change with the irradiation dose.

4. CONCLUSIONS

Analyzing the results of the properties evaluated in experimental conditions of this research work we can conclude that:

There was a melt flow index reduction to the composites that contained wood flour, being this reduction most effective in presence of TiBa. This reduction is due to the presence of particles in the matrix that restricts the mobility of macromolecules, difficulting the flow of the melted polymer and in consequence, increasing its viscosity.

There was a decrease in the values of impact strength for the samples with addiction of wood flour in relation to the sample that contained only PP. In the presence of TiBa there was a better reproductively in the values obtained for this property showing that it helps in the homogenization of the fibrous load (wood flour) in PP. We also observed that the sample of 10% WF+TiBa+TPDGA/PP was the one that presented the best result with 10 kGy.

The decrease of the impact strength could have happened because the presence of wood flour reinforcement can act as a tension concentrator and as a consequence to reduce the impact strength, another reason would be the distribution not to have been totally homogeneous. In addition, the load could have contributed to an increase of the cristallinity of the polymer matrix and as a consequence there was a decrease in the impact strength.

There was an increase in the hardness in the composites containing wood flour. The increase in the hardness was meaningful in the composites WF/PP which were not irradiated and this increase happened mainly in the compositions of 20% WF/PP. That is because the greater the load quantity, the greater is the hardness module. In the irradiated samples the hardness increased due to the crosslinking of the wood in the irradiation.

We observed that the samples containing 15%WF+TiBa/PP to 20kGy showed significant values of thermal distortion temperature for all compositions, showing that 15% of the load in the polymeric matrix is the most appropriate for mechanical stress under temperature.

We observed that in some cases the increase in the radiation dose, it did not influence significantly in the variation of the thermal distortion temperature of the composites indicating that there was crosslinking among the molecules promoted by the TPDGA, and an improvement in the adhesion among interfaces promoted by the titanate.

In the Vicat softening temperature test, the presented results were very close to the pure PP. As the results did not show any significant variation, we can consider the composites temperature the same as that of the pure PP.

In the presence of TiBa there was a better interaction between the PP and the WF load, indicating its effective action as a coupling agent between the load and the polymeric matrix. The barium titanate was a coupling agent that favors the compatibility of the PP and the WF. The monomer TPDGA provided a good interaction between the PP and the WF load, but the obtained results did not make it an adequate product to be used together with the TiBa.

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