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Tema: "DESARROLLO Y CARACTERIZACIÓN DE MATERIALES COMPUESTOS BASADOS EN TEJIDO BIDIRECCIONAL DE YUTE"

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Resumen de Tesis.

In the last years, natural fiber composites have attained great academic and commercial interest. This is especially motivated by the low specific gravity, high specific strength and stiffness of the materials that can be obtained. Nowadays, there is a general concern in manufacturing environment-friendly composites. Therefore, the addition of natural fibers to polymer matrices not only reduces the final material costs but are ecological attractive to replace synthetic fibers as well. Both, thermoplastic and thermoset composites are replacing conventional materials in various applications. However, it is still crucial to overcome some deficiencies. The moisture absorption of these fibers, poor wettability, and insufficient interfacial adhesion between polymer matrix and reinforcement lead to debonding. Without an effective wetting, strong interfacial adhesion cannot exist, which promotes the formation of internal flaws in the composite. Therefore, the modification of the fibers or/and the polymeric matrix in order to improve compatibility is a key topic in current research to obtain optimum final composite properties.

This work is focused mainly to the study of the thermal and mechanical behavior of composites made from bidirectional jute fabrics and polypropylene. In order to improve the compatibility between the polar fibers and the non-polar matrix, two alternatives were compared: the addition of coupling agents and the chemical modification

of the fibers. In the first case, two commercial maleated polypropylenes and lignin, a natural polymer, were used. In the second approach, the fibers were esterified using a commercial alkenyl succinic anhydride.

Chapter 1 comprises a general discussion about composites and vegetable fibers as reinforcement of polymers. Then, the previous related publications from other groups are presented and discussed.

The experimental techniques and equipment used to prepare the composites, to carry out the characterization and to measure their final properties are described in Chapter 2.

The characterization of the starting materials is presented in Chapter 3. The different physical and chemical treatments utilized to modify the jute fabric and the matrix are also described. The thermal behavior of the blends PP-compatibilizer is analyzed by differential scanning calorimetry, to confirm that the improvements in the mechanical properties are the result of the improved adhesion between both faces and not due to the changes in the crystallinity of the matrix.

The lignin acts as β nucleation agent for the PP matrix although the amount of β-crystalline phase formed is rather low. It is shown that the area of the β-peak increases as the cooling rate increases, but at very high cooling rates the β-phase formation is suppressed. X-ray diffraction confirms the presence of the β-crystalline phase.

The effect of the jute modifications on the crystallization behavior of the polypropylene matrix is also analyzed in this chapter. Optical microscopy indicates that untreated fibers and washed jute fibers act as heterogeneous nucleating agents for PP and lead to the formation of a transcrystalline layer. On the other hand, samples prepared with alkenyl succinic anhydride treated jute do not exhibit such phenomena. The presence of rather long chains attached to the lignocelullosic surfaces inhibits the heterogeneous nucleation.

The study of the composite mechanical properties is presented in Chapter 4. The final properties are presented as function of reinforcement concentration and chemical modification of the matrix and reinforcement.

For the composites with different jute fabric content, the tensile modulus increases as fiber content increases, although the strain at break decreases due to the restriction imp osed to the deformation of the matrix by the rigid fibers. In spite of the chemical incompatibility between the polar fiber and the PP matrix, the tensile strength increases with jute content because of long woven fibers.

The effect of the coupling agents on the interface properties is inferred from the resulting tensile and impact properties. The out-of plane instrumented falling weight impact (IFWI) tests show that maleated polypropylene compatibilized composites have lower propagation energy than uncompatibilized ones, which is a clear indication that the adhesion between matrix and fibers is better in the former case since fewer mechanisms of energy propagation are activated. These results are in agreement with those provided by tensile tests, inasmuch as the compatibilized with the maleated PP composites exhibit the highest tensile strength. Scanning electron microscopy also reveals that the compatibilized composites exhibit less fiber pullout and smoother fiber surface than the uncompatibilized ones. Nevertheless, no improvement is observed on the composite tensile properties due to the addition of lignin.

Non-destructive techniques are also applied to determine the tensile and fracture mechanical characteristics of the composites. Monitoring the acoustic emission (AE) proves to be a suitable tool to detect changes in the failure mode and the damage development caused by interface modifications. The course of the cumulative AE events and cover curve of the AE amplitude distributions provide useful information on the adhesion between the matrix and jute.

In this chapter, the short term creep-recovery behavior of composites is also studied. The creep deformation could be directly related to the interfacial properties, since it is found that it decreases as the adhesion between fibers and matrix increases. The effect of the coupling agent concentration on the creep behavior is also analyzed. Finally, Bürgers model parameters are calculated from the creep part of the curves, and the recovery part is modeled using these values. A very good agreement between experimental data and theoretical curves are obtained in the creep region, although small discrepancies are detected in the recovery part. The feasibility of the construction of a master curve (using the time-temperature principle) to predict long term creep behavior of the composites is investigated.

In Chapter 5 the behavior of two different matrices with the same reinforcement is studied. A thermosetting polymer (unsaturated polyester) and a biodegradable polymer (Ecoflex) are used in order to obtain composites with bi-directional jute fabric.

For thermoset composites, the effect of the jute treatments on the interface properties is investigated by impact, compression, and tensile tests. The composites

made from as-received jute have the highest impact energy, which is associated with weak interfacial adhesion. Composite samples behave more ductile in compression than in tensile situations due to the brittle characteristics of the resin used as matrix. The effect of the orientation of the fibers with respect to the direction of the applied force in the different mechanical tests is also studied.

On the other hand, the composites based in biopolymer matrix are subjected to in-p lane static and out-plane dynamic loading and the related fracture and failure behavior is studied. Jute fabric proves to be a useful reinforcement for in-plane mechanical tests. The J-integral concept (J-R curve) is adopted to assess the fracture mechanical behavior of the composites. In order to construct the J-R curves the crack propagation is determined in single edge-notched tensile loaded (SEN-T) specimens using the location of the acoustic emission (AE) events. AE serves also as a tool to characterize the failure. Surprisingly, no beneficial effect of the jute fabric is observed in high speed out-of -plain test. This is mostly to characteristics of the jute fiber and fabric hampering the stress redistribution in the composite, at least in high frequency tests.

Palabras claves: materiales compuestos, yute, tejidos bidireccionales, polipropileno, lignina, propiedades mecánicas.