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Mechanical Properties of Laminate of Residual Polyester Resin Reinforced with Recycled Newspaper

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Abstract: In the present project were evaluated the mechanical properties of residual polyester resin laminate reinforced with recycled newspaper, such as tensile, flexural and hardness.The catalyst / resin ratio and the number of layers of recycled newspaper were manipulating in order to establish the effect of these variables on the mechanical properties of the residual resin laminate, and comparing these properties with those obtained from virgin resin laminates. The results show that the average tensile strength of the laminates (0,5%) with residual and virgin resin were 71,8 and 73 MPa, respectively; and it decreases with increasing percentage of catalyst and increases with the addition of layers of recycled newspaper. The flexure strength of residual resin laminates (214,7 MPa) was higher than the virgin resin (210,5 MPa) at 0,5%, and it decreases with increasing percentage of catalyst and the number of layers of recycled newspaper. The number of layers of newspaper does not affect significantly the Shore D hardness of laminates; while, the hardness of laminates increases with increasing the catalytic percentage. On the other hand, hardness of laminates with virgin resin is higher than recycled resin.
Keywords: Residual resin, recycled newspaper, polyester, tensile strength.

1. Introduction

Nowadays, the plastics industry is highly positioned in the global market due to the diversity of uses of these materials. Polyethylene terephthalate (PET) is widely used for its high chemical resistance, transparency, lightness and low costs of production. it is one of the polymers of higher application in the manufacture of beverage bottles; however, the slow degradation PET bottles, has contributed to the accumulation of a large amount of this material, becoming an environmental problem[1]; therefore, the mechanical and chemical recycling are two alternatives to reduce pollution.

POLISUIN S.A. is a multinational company that operates in Colombia, with a plant in the industrial zone of the Cartagena city, dedicated to the recovery of PET by the processes of mechanical and chemical recycling; in these processes waste is generated which has a considerable amount of polyester resin, a concentrated loading of solids and styrene.Environmental normativity not allow these wastes be dumped into effluent or outdoors; therefore, a proper treatment is required. As a temporary solution, POLISUIN S. A., has stored waste in tanks; however, the prolonged storage of this residue can generate difficulty in controlling spills, leaks and emissions of hazardous vapors, which in the case of occur, not only affects people exposed to such waste. Besides, this waste affects the environment in general, causing a deterioration in ecosystems, which can lead to the company serious economic sanctions.

In this investigation was determined the technical feasibility of using this residue in the preparation of laminate of plastic that is reinforced with recycled newspaper. The laminates of composite material was manufactured through molding by direct contact, and evaluating the effect of the catalyst /resin ratio and the effect of the number of layers of recycled newspaper on the mechanical properties of the laminate. At the same time, laminateswere manufactured with virgin resin, to compare their mechanical properties with those obtained with residual resin.

Laminate of plastic reinforced with fiberglass have been developed for different applications: traffic signals[2] and concrete structures[3]. Polyester resin has also been reinforced with fiberof pineapple[4], banana, coconut and aloe[5]. Mechanical and thermal properties were studied forextrusion processof recycled PETresin reinforced with fiberglass[6].The objective of this work is to evaluate the mechanical and physicochemical properties of laminate of recycled PET reinforced with recycled newspaper. Initially, the recycled PET resin will be filtered to remove solid material; subsequently laminates reinforced with recycled newspaper are prepared. Finally, properties such as hardness, functional groups, tensile and flexion are measured.

2. Experimental

2.1. Materials and method

The residual polyester resin was supplied by Polisuin S.A.; and virgin polyester resin supplied by Andercol S.A. The recycled newspaper, containing 84% of fiber from hardwood and 12% of calcium carbonate mineral filler, and 4% of additive. The recycled PET resin was filtered to remove solid material using the 4 mm mesh (Fig. 1). Disintegration of recycled newspaper was carried outby the dry process where the fibers were prepared with a shredder machine of document, obtaining 2 mm wide and 100 mm length paper strips.

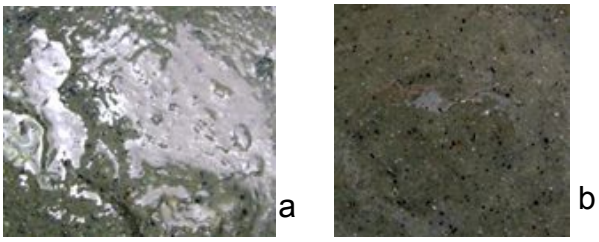

Fig. 1. a) The recycled polyester resin without filter and b) Filtered resin

Laminates of recycled PET reinforced with recycled newspaper were prepared by manual molding.The mold was impregnated with wax to unmold the workpiece. Accelerator of cobalt octoate in 1% was added to the resin and mixture was agitated during two minutes. After, as a catalystwas added Methyl Ethyl Ketone Peroxide in 0.5 and 0.8% to recycled resin. The resin mixture was used to prepare the laminated with two newspaper layers[7].

2.2. Characterization

Assays of tensile, flexural and hardness were conducted to the laminates. The tensile tests were carried out following the standard ASTM D 3039/D3039M-00 using the Universal machine TINIUS OLSEN [38]; the flexural tests were carried out following the standard ASTM D 790–03 using the Universal Machine MARSHALL C.B.R. [39]; The hardness tests were carried out following the standard ASTM D 224 using a DURÓMETRO PCE-D[8].

3. Results and Discussion

The physicochemical properties of a composite material usually depend on the nature of the reinforcement and the polymeric matrix, the dispersion grade of the reinforcement into the matrix, the orientation and quantity of the fibers inside the composite[9-12].Therefore, these properties were carried out and analyzed as indicated below.

3.1. Physicochemical characterization of recycled and virgin resin

Density of recycled resin was 1158,4 kg/m^3 and 1109,2 kg/m^3 for virgin resin. Both resins are the same used in Keren and Viloria[13]; therefore, the FTIR spectra for recycled and virgin resins are the reported in[13]. The spectra havesimilar picks as shown in Fig.2. Both spectra are similar to those found in the literature[14]. The differences of spectra are due to solid material in suspension found in recycled resin.

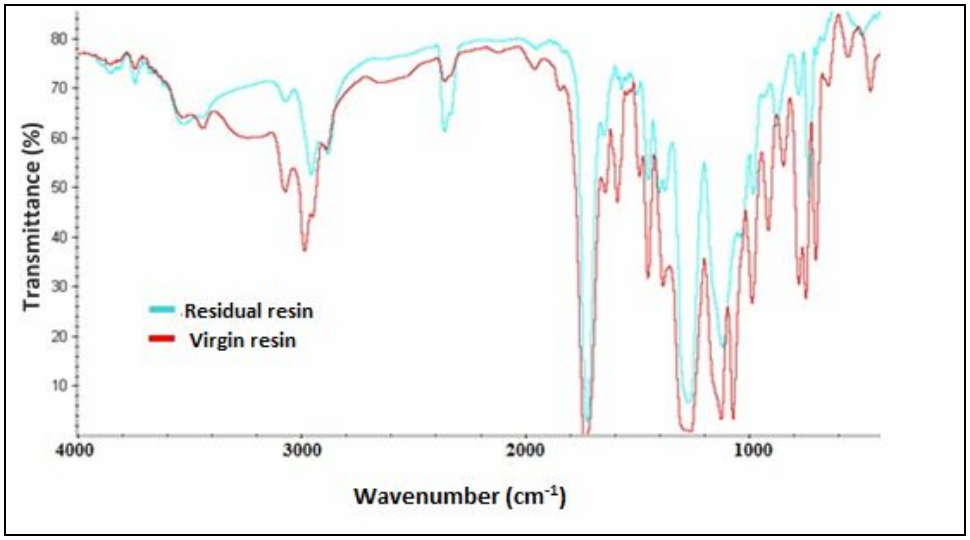

Fig. 2. FT-IR spectra of recycled and virgin polyester resin.

3.2. Effect of catalyst /resin ratio and layer number on the tensile strength

Fig.3 shows that the tensile increases with increasing the layer number of reinforcement of recycled newspaper. On the other hand, the tensile decrease with increasing of catalyst /resin ratiodue to the resin reached high temperature of cured, causing crystallization and weakening the material[15,16]. However, the amount of catalyst/resin ratio must not be too low to avoidlong time of curingreaction and delay the development of the piece.

The values of tensile obtained in this work for residual resin are between values of 64,2 MPa and 75,4 MPa, which are similar to the published in[17].Furthermore, the tensile results of the laminates of both resins, recycled and virgin, aresimilar.

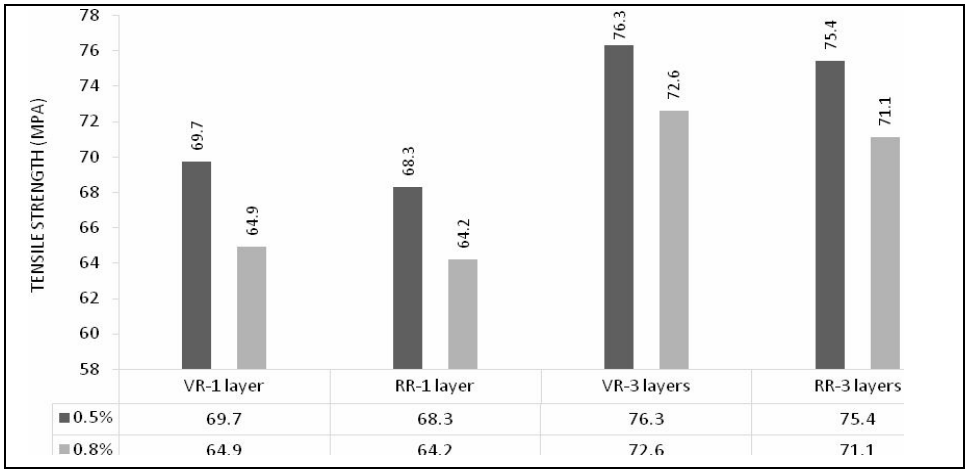

Fig. 3. Effect of catalyst /resin ratio and layer number on the tensile strength

3.3. Effect of catalyst /resin ratio and layer number on the flexure strength

Fig.4 shows the flexure tests of laminates. The flexure decreases with increasing the percentage of catalyst, due to an increase in cross-linking of the chains that hampered the mobility of the same and caused material became more rigid[17]. The flexure of laminates increases with increasing the number of newspaper layers and these values of flexural strength were higher than thoseof the polyester resin without reinforcement as reported by others authors[4,5]. POLISUIN S.A. gives values of flexural strength of 93.4 MPa to 155,1 MPa, for laminates of pre-accelerated polyester resin, and catalyzed with 1% of PMEK and 30% of fiberglass[18]. The flexible of laminates manufactured with recycled resin is higher than laminates manufactured with virgin resin, because of large glycol chain and an increase of space between linkages of polar ester and acid.

3.4. Effect of catalyst /resin ratio and layer number on the laminate hardness

Fig. 5 shows the effect of catalytic percentage and layer number of recycled newspaper on the laminate hardness. The number of layers of newspaper does not affect significantly the Shore D hardness of laminates because of it depends of material surface, while, the hardness of laminates increases with increasing the catalytic percentage, due to an increase in cross-linking of the chains that hampered the mobility of the same and caused material became stiffer, as explained above.

On the other hand, hardness of laminates with virgin resin is higher than recycled resin, because of the recycled resin has impurities, which retarded crosslinking reaction. The hardness of the laminates made with residual resin was about 72 shore D, which is similar to that reported by Valea et al. [19] of 80 Shore D for modacrylic resin laminates.

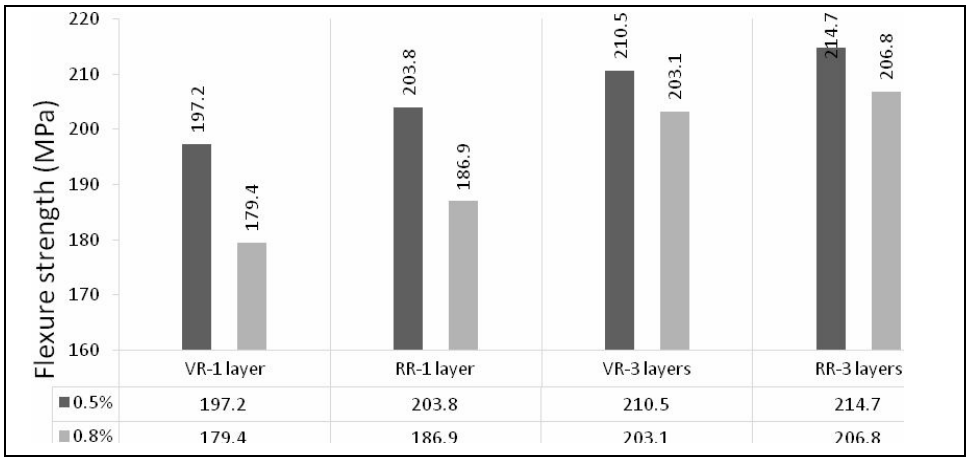

Fig. 4. Effect of catalyst /resin ratio and layer number on the flexure strength

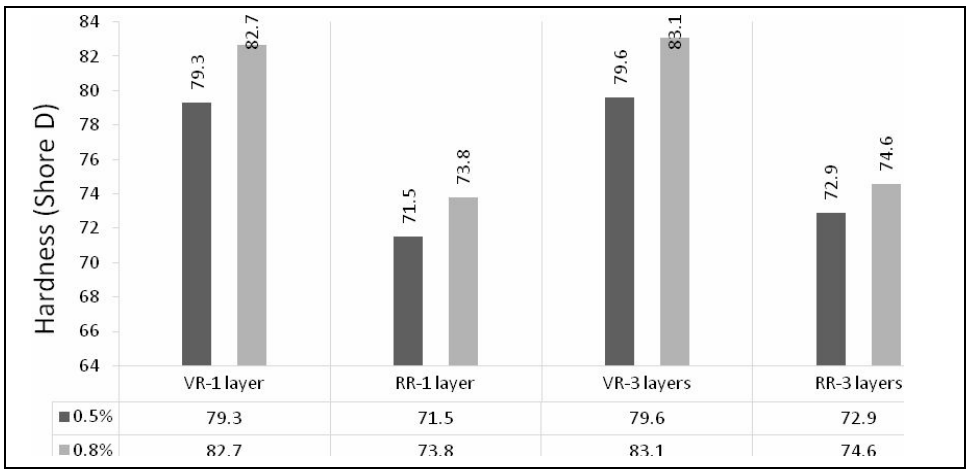

Figure 5. Effect of catalyst /resin ratio and layer number on the laminate hardness

4. Conclusions

Laminates of recycled polyester reinforced with recycled newspaper were manufactured and analyzed. Tensileof laminates increases with increasing the layer number of reinforcement of recycled newspaper. In contrast, the tensile decrease with increasing of catalyst /resin ratio due to the resin reached high temperature of cured. Furthermore, the tensile results of the laminates of both resins, recycled and virgin, are similar.The flexure of recycled resin laminates decreases with increasing the percentage of catalyst andwith increasing the number of newspaper layers. Although, the flexible of laminates manufactured with recycled resin is higher than laminates manufactured with virgin resin. Finally, the layer number of newspaper layers and catalytic percentage do not affect significantly the Shore D hardness of laminates because of it depends of material surface. On the other hand, hardness of laminates with virgin resin is higher than recycled resin.

Acknowledgments

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