



ISSN: 2230-9926

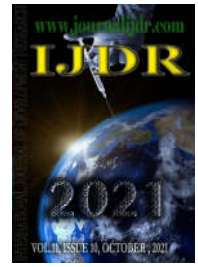
Available online at <http://www.journalijdr.com>

# IJDR

*International Journal of Development Research*

Vol. 11, Issue, 10, pp. 50900-50903, October, 2021

<https://doi.org/10.37118/ijdr.23135.10.2021>



RESEARCH ARTICLE

OPEN ACCESS

## OBTAINING AND CHARACTERIZATION OF POLYMERIC COMPOSITES REINFORCED WITH NATURAL FIBERS

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### ARTICLE INFO

#### Article History:

Received 20<sup>th</sup> August, 2021  
Received in revised form  
14<sup>th</sup> September, 2021  
Accepted 19<sup>th</sup> October, 2021  
Published online 30<sup>th</sup> October, 2021

#### Key Words:

Natural Fibers, High Density Polyethylene, Injection Process, Polymeric Composite, Waste.

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### ABSTRACT

Currently, human activities cause impacts on the environment, and the generation of waste is a major concern. Among different residues will be agro-industrial residues, particularly residues of sugarcane bagasse and green coconut shell. Such chemically treated waste was reused as a polymer matrix reinforcement. In this sense, the present work aims to obtain and characterize polymeric composites reinforced with these natural fibers from green sugarcane bagasse and green coconut shell. The natural fibers were obtained by mercerization process, using sodium hydroxide and acetic acid in the optimized concentrations, washed in distilled water, dried, crushed and classified. By injection process, a polymeric composite made of high density polyethylene and different mass concentrations of natural fibers was obtained in a glass production matrix. The product obtained was characterized by a tensile test, verifying that the maximum tension obtained was 24.5 MPa for the concentrations of 3% and 5% (% wt) of natural fibers. In the compressive strength test, the sugarcane fibers showed greater tensile strength of 792.625 Kgf ± 73.873 at 5 (% wt) of fiber used, while for the higher coconut fibers, the tensile strength of 925,000 Kgf ± 12.832 at 3 (% wt) of fiber.

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Citation: Emília Satoshi Miyamaru Seo, Isabella Tereza Ferro Barbosa, Alessandro Augusto Rogick Athiê and Adriano Camargo de Luca. "Obtaining and characterization of polymeric composites reinforced with natural fibers", *International Journal of Development Research*, 11, (10), 50900-50903.

## INTRODUCTION

Currently, the issue of solid waste generation has been widely discussed, taking into account several management factors that start from generation to final disposal (BRINGHENTI, 2004). Approximately 183.5 thousand tons are collected in Brazil per day, constituting 51.4% of this waste as organic matter (IPEA, 2020). Among this amount of organic waste are those generated by the agribusiness. The agribusiness sector in Brazil generates around 5.9% of the Gross Domestic Product (GDP), it is responsible for transforming raw materials from agriculture and agriculture into products that are sold throughout Brazil and in the world, according to IBGE (IBGE, 2020). Brazil has abundant natural resources due to its favourable climatic conditions and fertile soil and, therefore, a wide variety of natural fibers are produced in the country, such as those from the production of banana, cotton, coconut, sisal,

sugarcane, piassava, pineapple, among others (MATOS, 2005). According to Fernandes (2008), lignocelluloses fibers have been studied for the characteristic of giving reinforcement to components, low cost and, generally, they come from reuse. The mechanical behaviour of lignocelluloses fibers is affected by several factors: proportion of its components (cellulose, hemicellulose and lignin), fiber diameter, molecular orientation (spiral angle between fibrils), proportion of crystalline and non-crystalline regions, morphology (porosity and imperfections), in addition to planting conditions (RAZERA, 2006). Brazil is a major producer of vegetable fibers and a species that stands out for its abundance is sugarcane bagasse. These fibrous lignocelluloses residue comes from the sugarcane stalk of the after crushing and extracting the juice, basically consisting of fibers, water and small portions of insoluble solids, constituting a heterogeneous set of particles of different sizes, which oscillate between 1 mm and 25 mm, presenting an average size of 20 mm (ICPDCA, 1999).

Another vegetable fiber highlighted is the fiber from the coconut (*Cocos nucifera*), which is obtained from the fibrous mesocarp of the coconut, is cultivated predominantly in the hot and humid regions of Brazil. In the Rio de Janeiro, approximately 12000 tons of coconut waste are produced per month (BEDIN, 2014). In view of the considerations presented, this work will emphasize the natural fibers of sugarcane and coconut, as well as the resistance to compression and traction of cups made from composite. In this context, this article aims to obtain and characterize cups based on polymeric composite made of polyethylene and natural fibers from sugarcane bagasse and green coconut mesocarp.

## MATERIALS AND METHODS

Initially, the residues of sugarcane bagasse and green coconut mesocarp were dried in an oven at  $\sim 60^{\circ}\text{C}$  and were submitted to the mercerization process (SILVA; SEO, 2019). In the injection stage, the green high-density polyethylene matrix was mixed with different concentrations of fibers, with 3%, 5% and 7% (wt) either from coconut or sugarcane. The matrix of the injector made of aluminium was used to obtain cups (Figure 1). The mixture of fiber and polyethylene was taken to the injector at a temperature of  $180^{\circ}\text{C}$ , approximately. The matrix was made of high density green polyethylene (HDPE 4950 SGF) supplied by Braskem S / A (Brazil) (BRASKEM, 2013). This input has a specific density of  $0.956\text{ g. cm}^{-3}$  and melt flow index of  $0.34\text{ g} / 10\text{ min}$ . The polymer is 100% made from renewable ethanol from sugarcane. This polyethylene is recyclable, but not biodegradable or compostable. The cups produced were taken for compression and tension tests. The tensile tests were performed in a room with controlled temperature and humidity, using a universal testing machine (Instron 30 kN). The test speed was  $5\text{ mm.min}^{-1}$ .



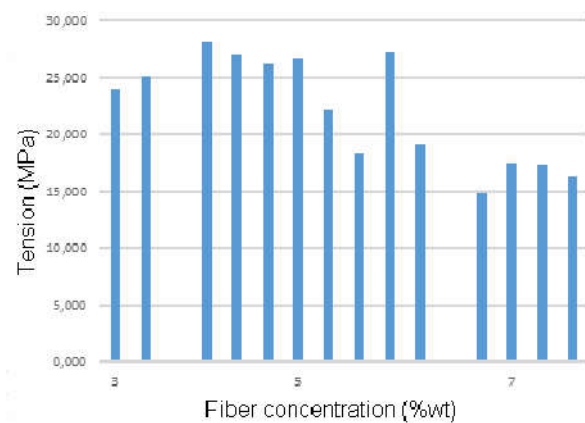
**Figure 1.** Cups produced from bicomposite (polyethylene + natural fibers).



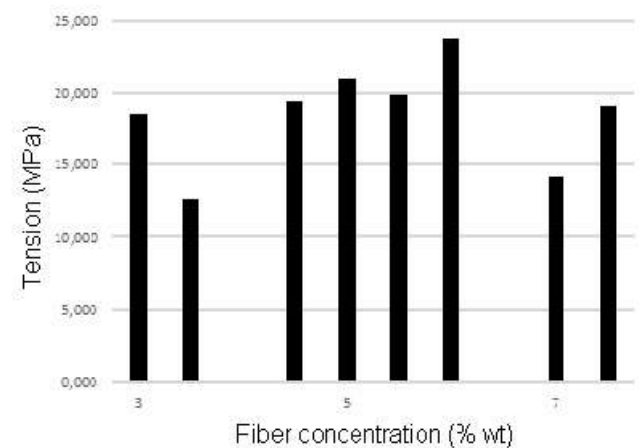
**Figure 2.** Sample for the tensile test



**Figure 3.** Sample for the compression test



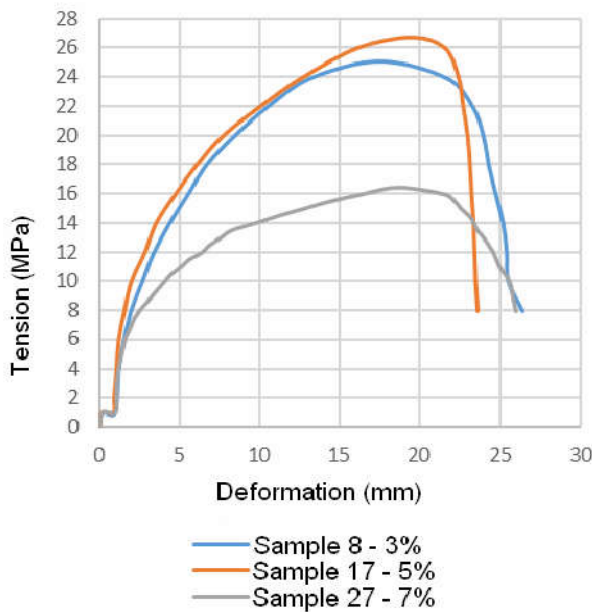
(a)



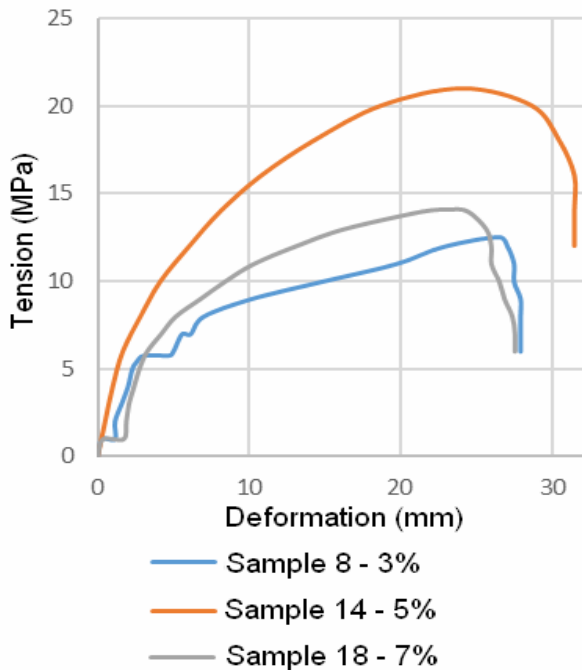
(b)

**Figure 4.** Results of tensile tests on sugarcane fibers (a) and coconut fibers (b)

To start the test, the software was adjusted to the test body according to its size and shape, then the sample was positioned in the device and the claws were adjusted to perform the traction as shown in Figure 2, the machine was activated and after rupture of the material the test was ended. The compression test was carried out in a room with controlled temperature and humidity, using a universal testing machine, with a test speed of  $5\text{ mm} / \text{min}$ . To start the tests, the device was adjusted according to the material, density and shape of the specimen, then the specimen was positioned in the center of the equipment (Figure 3) and the machine was activated, after the first rupture of the material the trial was ended.



a

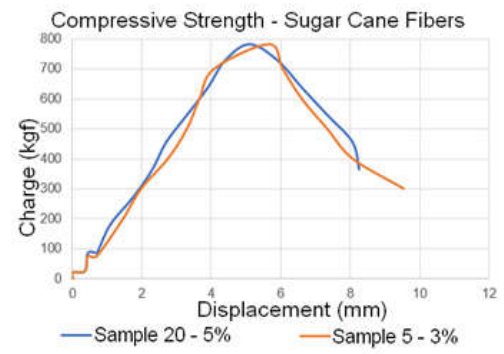


b

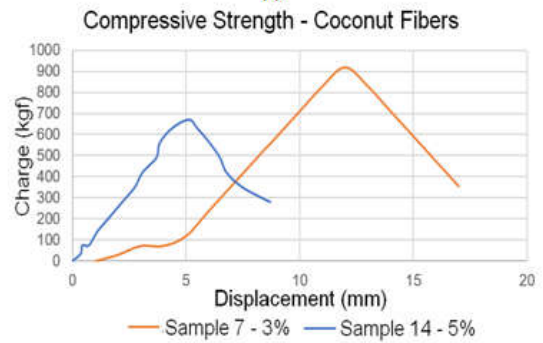
Figure 6: Compressive Strengths of sugarcane composites (a) and coconut composites (b) with different fibers concentrations

## RESULTS AND DISCUSSION

Figures 4a and 4b showed that the concentration of 5 (% wt) vegetable fiber obtained higher values of tensile strength for both studied fibers. Comparing the sugarcane and coconuts fibers to the 5 (%wt), the composite that showed the highest maximum tension was the addition with sugar cane fiber, without weakening the composite. The composition with 7 (% wt) of fibers did not obtain a relevant result, since the increase in the amount of fibers did not offer resistance to the material. Figures 5 (a and b) show the stress and deformation curves, showing that the maximum stress limit is on average 24.5 MPa for concentrations of 3% and 5 (% wt) of vegetable fibers. From the results of the tensile tests, compression tests were carried out on cups containing concentrations of 3 (%wt) and 5 (%wt) of sugarcane and coconut fibers (Table 1).



(a)



(b)

Fibers	Maximum load (Kgf)	
	3 % wt	5 % wt
Sugarcane	781.200±82.116	792.625±73.873
Coconut	925.000±12.832	670.000±00.000

According to the results of Table 1, the glasses with a concentration of 5 % wt) of sugarcane fibers showed greater resistance to rupture while for the glasses of coconut fibers they went to concentrations of 3 (% wt). After the tests it was possible to observe that the addition of sugarcane fibers to the polymer did not bring a great difference in characteristics for the compressive strength, since the values obtained were very close, as shown in Figure 6a and the addition of coconut fibers to the polymer, the best results were with a concentration of 5 (% wt) of coconut fibers (Figure 6b). The composite cups also underwent a water resistance test, where during the period of one month, three cups were emerged in water at a temperature of 35°C, with weekly measurements of their measurements with a caliper. At the end of the experiment, it was found that the composite material did not absorb water during this period, demonstrating water resistance

## CONCLUSION

The injection process for preparing cups was adequate using the fibers obtained from the mercerization process, as they were looser and with favorable conditions for adherence to the polymer, consequently suitable for the injection molding process. The cups obtained by this process showed higher tensile stresses for a concentration of 5% by weight of vegetable fibers from sugar cane and coconut.

The cups made of sugar cane fibers with a concentration of 5% by weight, showed greater resistance to rupture compared to coconut fibers with the same mass concentration. The sugarcane fibers showed greater tensile strength of 792.625 Kgf ± 73.873 at 5 (% wt) of fiber used, while for the higher coconut fibers, the tensile strength of 925,000 Kgf ± 12.832 at 3 (% wt) of fiber. It was found that the composite material did not absorb water. The results shown are promising, leading to the possibility of new technological uses for sugar cane and coconut fibers.

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