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Proposing a Hot Pressing Process in the Mold by Hand to Create a Sample of Polypropylene - Spent Coffee Grounds Composite

Doan Van Nguyen, Long Nhut-Phi Nguyen, Tai Nhat Nguyen, Nam Phan Nguyen, Thiem Van Quach, Quyen Tra-Kim Nguyen

[1]*Faculty of Mechanical Engineering, Ho Chi Minh City University of Technology and Education (HCMUTE), Ho Chi Minh City, Vietnam, 720100*
Corresponding Author: Long Nhut-Phi Nguyen

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ABSTRACT: Currently, the demand for products made from materials using raw materials from post-harvest and processed agriculture (sugarcane bagasse, spent coffee grounds (SCG), rice husks, coconut fiber/powder, etc.) that are easily degradable and environmentally friendly is practical in daily life. This paper proposes creating a composite material sample of polypropylene (PP) - spent coffee grounds (SCG). The sample with PP + 5%wt SCG powder is made by hot pressing in the mold by hand. The results show that, through visual assessment of the surface, the sample has a smooth surface, the tensile strength value achieved is from 12 to 17.85 MPa, and the elongation is from 1.91 to 3.27 mm.

KEYWORDS: polypropylene (PP), spent coffee grounds (SCG), composite material, hot pressing.

I. INTRODUCTION

Nowadays, growing environmental awareness and new regulations are forcing industries to seek more environmentally friendly product materials. Spent coffee grounds (SCG) are one of the valuable resources in the production of biofuel, biochar, biopolymer precursors, composite materials, etc. [1-5]

In the paper [6], the authors developed a material made from a blend of polypropylene and SCG. The paper presents the influence of the binder on the mechanical properties of the polypropylene coffee grounds biocomposite and the degree of degradation of the composite by landfilling in soil. The results show an increase in mechanical properties except for the impact strength of the copolymer blend compared to the homogeneous polymer blend by adding a compactor.

In the study [7], the authors used coffee grounds as a supporting material for PCM. It was found through the FTIR chemical composition of SCBW, SCPW, SCGW, and coffee waste that were effectively vacuum-impregnated into each natural wax. In addition, the DSC results were used to determine the thermal storage performance of each material. Micromorphological analysis with FE-SEM showed whether the impregnation was successful or not. Biocompatible PCM by-products are economical, environmentally friendly, and sufficient to build applications in terms of thermal performance compared to other bio-based composites.

In the article [8], the authors prepared biocomposites by combining polypropylene (PP) with SCG obtained after brewing instant coffee. The samples were prepared by extrusion and injection molding using different SCG contents (0, 5, 10, 15, and 20 wt%) to study the effect of particle loading on thermal, rheological, and mechanical properties. Then, the influence of bleaching treatment and compatibilizer (silane and styrene-ethylene-butene-styrene-graft-maleic anhydride) on the biocomposite properties at 15 wt.% was examined.

The authors in [9] present a study on the processability and properties of thermoplastic polymer composites & spent coffee grounds for

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sustainable applications. SCG powder was characterized by size distribution, moisture content, morphology, and thermal stability. The polymer & SCG composites were prepared by extrusion. Polypropylene (PP) homopolymer and copolymer were used as polymer matrices. After blending by extrusion, the composites were injection molded and characterized for their physical, morphological, and mechanical properties to determine the influence of polymer type and filler content. The morphological characteristics of the composites were studied by optical microscopy and SEM analysis.

The paper [10] presents a green composite prepared with polypropylene matrix and spent coffee grounds (SCG) with 20 wt% for use as wood-plastic composites (WPC). The effect of palmitoyl chloride hydrophobic treatment on SCG powder was compared with a conventional surface treatment based on silanization with (3-Glycidyloxypropyl) trimethoxysilane and the use of a maleized copolymer compatibilizer (polypropylene-grafted-maleic anhydride, PP-g-MA) in terms of mechanical properties, morphology, thermal properties and water absorption. The composites were previously mixed in a twin-screw extruder and then injection molded. The comparative effects of different surface treatments and/or compatibilizers on mechanical performance were investigated by bending, impact, and dynamic mechanical thermal analysis (DMTA-torsion) tests. In addition, the stabilizing effect of SCG was demonstrated by differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA).

In 2002, Tran Vinh Dieu and colleagues studied the fabrication of composites based on PP reinforced with jute fibers [11]. The material was fabricated by stacking layers of PP-MAPP film and jute fibers according to the design and then pressing on a hydraulic press (flat pressing in a closed mold) under a pressure of 7MPa for 50 minutes; the results showed that the MAPP content affected the mechanical properties of the composite.

In 2003, Tran Vinh Dieu and Pham Gia Huan studied the fabrication of polymer-composite materials based on PP reinforced with a hybrid system of bamboo, reed, and glass fiber [12]. The material was fabricated by stacking resin and fiber into the mold layer by layer according to the principle of alternating resin and fiber. The fiber content accounted for 60% and was pressed at a temperature of 190^{o}C, a pressing pressure of 100 kG/cm^{2}, heated for 60 minutes, pressed for 30 minutes, and cooled to 80^{o}C by flat pressing in a mold; the results showed that treating bamboo fiber with NaOH solution increased the cellulose content in the fiber, thereby increasing the adhesion between the fiber and the resin.

The performance of the jute/PP composite material was improved by modifying the original resin (Doan Thi Thu Loan (2010)) [13]. The material was processed through two stages of wood plastic granulation, i.e., twin-screw extruder, and then molded by injection molding (injection molding in a closed mold). The study investigated the effects of PP and MA grafted (MAHgPP) with copolymer compatibilizers on the properties of jute-reinforced PP-based composites.

In 2011, Ha Tien Manh and colleagues studied the effects of the wood powder and polypropylene resin ratio on the properties of wood-plastic composites [14]. The raw materials used were Acacia mangium wood and recycled PP resin and were mixed with wood/plastic ratios in 3 levels (50/50, 60/40; 70/30), mixed well, and granulated on a twin-screw press at 175^{o}C to form wood-plastic granules; Then the product is pressed on a flat press at 170^{o}C under a pressure of 1.5-7.5MPa in a pressing cycle of 40 minutes.

This article proposes a hand-hot pressing process in the mold to create a sample of polypropylene (PP) - spent coffee grounds (SCG) composite material.

II. MATERIAL AND METHODS

The plastic used in this study is polypropylene PP 1100N sourced from Saudi Arabia.

The spent coffee grounds (SCG) are mainly from some stores in the Thu Duc area of Ho Chi Minh City, Vietnam.

The proposed Process was implemented at the Ho Chi Minh City University of Technology and Education (HCMUTE)'s Material Testing Laboratory.

The implementation process includes several basic steps as follows:

Step 1
Dry PP, SCG at about 105^{o}Cand let cool

Step 2
Weigh PP & 5%wt SCG

Step 3
Heat PP in a container and stir

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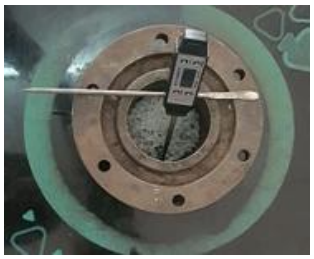
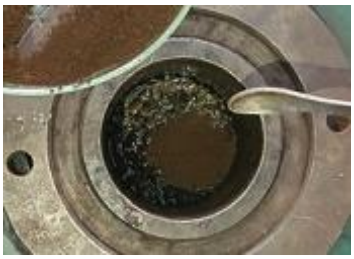


Step 4
Pour in SCG and stir well



Step 5
Pour the mixture into the mold and press it by hand

Step 6
Let it cool, and take out the sample

III. RESULTS AND DISCUSSION

Below are pictures of some tensile test specimens that have been pressed.

Table 1 shows the results of the tensile strength of the PP + 5%wt SCG sample.

Table 1. Tensile strength results

NO.	TENSILE STRENGTH (MPa)	ELONGATION (mm)
1	12.5	1.91
2	14	2.03
3	17.85	3.27

The results showed that the sample's surface is quite smooth after hot pressing by hand. The average tensile strength and elongation values were 14.783 MPa and 2.403 mm, respectively.

IV. CONCLUSION

The article proposed a manual hot-pressing process in a mold to create a composite material sample. Tensile test specimens with polypropylene (PP) + 5 %wt spent coffee grounds (SCG) were pressed. The results show that the obtained samples had smooth surfaces, and tensile strength and elongation reached quite good values. This is also the basis for further research with reduced equipment investment costs.

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