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Evaluation of mechanical and physical properties HDPE/Coffee grounds composites with different filler particles size.

Nadira BELLILI[1,2*]; Badrina DAIRI[1,2]; Nadjia Rabehi[1]; Sara LARKEM[1].

[1]*Department of Process Engineering, Faculty of Technology, Skikda University 20 Aout – 1955 – Algeria*

[2]*Department of Process Engineering, Faculty of Technology, Laboratory of Advanced Polymer Materials (LMPA), Abderrahmane MIRA University, Béjaïa 06000, Algeria*

**Corresponding author email: n.bellili@univ-skikda.dz dina_1961s@yahoo.fr*

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Abstract

Plant-based fiber composites are currently experiencing strong growth due in particular to the growing interest in them from the automotive industry. These fibers present an excellent alternative to glass fibers from an environmental point of view due to their biodegradability and their much more neutral combustibility in terms of the release of harmful gases or solid residues. However, the incorporation of cellulosic materials in the thermoplastic matrix affects a large number of properties. Many factors such as the nature and size of the filler incorporated may influence the properties of composites.

This present work consists, to study the effect of the particle size of a natural waste on the mechanical and physical properties of a polymer matrix. Different formulations based on HDPE/ Coffee grounds flour were prepared with loading rate of 20 % and different sizes of coffee grounds flour particles (125, 180 and 250 µm). They were, characterized by mechanical tests using the tensile and the impact test. The Physical properties of composites are, obtained by the density measurement.

Keywords: *Mechanical properties, natural waste, physical treatment, polymer composites*

I. Introduction

As an alternative to metals and ceramics, polymer materials have the potential to reduce weight and enhance part performance polymer materials possess a wide range of distinctive properties that are beneficial in a diverse range of applications [1]. The dramatic increase in demand for produced products prompts the development of composite materials offering new opportunities for advanced technology [2]. Furthermore, industrial waste as natural fibers can be, used and reduced the fabrication expense of the polymer composites. Therefore, they can play a significant role to enhance their mechanical properties of the latter. Different types of reinforcement are, used with different ratios, and sizes to reveals, the influence of reinforcement on the physical and mechanical properties of polymer matrix composite material. Recently, industrial waste as filler particles with different sizes are widely used in polymer matrix composites and are extensively employed now a, days world, wide are in industrial applications. These industrial wastes used to improve physical, mechanical, thermal and wear resistance properties [3–5]. This present work consists of studying the effect of the particle size of coffee grounds on the mechanical and physical properties of HDPE/coffee grounds composites.

II. Material and methods

The HDPE 5502 type and coffee grounds flour (CGF) are, mixed until the mixture becomes homogeneous. Four formulations were prepared, the pure HDPE (formulations noted F0) and mixtures of 80% HDPE and 20% coffee grounds flour particles size of 250 µm (formulations noted F20/250 µm) , particles size of180 µm (formulations noted F20/180 µm) and particles size of 125 µm (formulations noted F20/125 µm) . The mixtures obtained are, mixed in a two-cylinder mixer (Calendrer). The rotation speed of the two cylinders is around 16 rpm at a temperature of 177°C for a residence time of 15 min. The leaves obtained were, cut into small strips of 2 to 3 cm in length then crushed into small particles. For the preparation of the specimens, the small pieces that have already been cut are put into molds to prepare plates using automatic hydraulic press under a pressure of 100 Kg/cm² at a temperature of 177°C and a time (preheating: 10 min, degassing: 1 min and compression: 7

min). The plates obtained were, cut into the appropriate shapes to characterize them.

The properties of the HDPE/CGF composites developed are then determined by the tensile test, the impact test and by measuring the density.

III. Results and discussion

A. Mechanical properties of HDPE/CGF composites determined by the tensile test

The effect of the particles size of coffee grounds flour (CGF) on the mechanical properties of HDPE/CGF composites was, studied and the results obtained are, illustrated in the figures 1, 2 and 3.

The stiffness of a material and its resistance to elastic deformation are, often represented by the Young's modulus, measured by the slope of the linear part of the stress/strain curve obtained by the tensile test. Figure 1 shows the evolution of the Young's modulus of HDPE/Coffee grounds flour composites at different filler particle sizes.

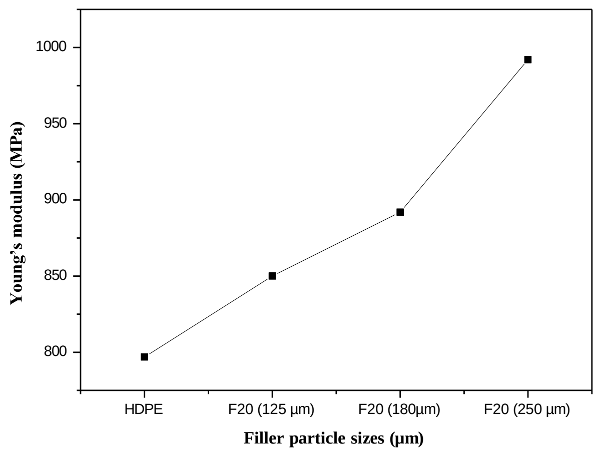

Figure 1. Evolution of the Young's modulus of HDPE/Coffee grounds flour composites at different filler particle sizes

The introduction of the filler into the HDPE matrix increases the rigidity of the material, and reduces their elasticity, which explains the increase in Young's modulus. In addition, the increase in the latter is all the more significant as the size of the CGF particles is high.

The results obtained are similar to those obtained by H. Djidjelli et al., for composites (PVC/olive pomace) and M. Kaci for low-density polyethylene/olive husk flour composites [6, 7].

This result highlights the reinforcing character played by the CGF, this could be, explained by the fact that the particles of the rigid character tend to form a reinforcement inside the composites leading to high resistance.

Figure 2 shows the evolution of the tensile stress at break of HDPE/Coffee grounds flour composites at different filler particle sizes.

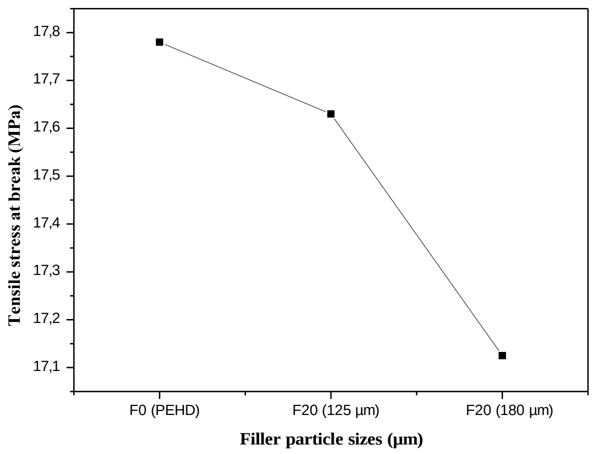

Figure 2. Evolution of the tensile stress at break of HDPE/Coffee grounds flour composites at different filler particle sizes

According to figure 2, one can clearly see a decrease in the breaking stress of the composites after incorporating the filler into the matrix and increasing the particle size of the coffee grounds filler.

This reduction is, attributed to the weak intefaciale adhesion between the filler and the polymer matrix and this is due to the fact that, the CGF particles gradually occupy a larger volume with a tendency to group together and agglomerate generating heterogeneities. They create defects in the polymer matrix consequently these areas of weakness reduce, the cohesion of the material, which is directly, linked to the filler/matrix interfacial adhesion.

Figure 3 shows the evolution of the tensile strain at break of HDPE/Coffee grounds flour composites at different filler particle sizes.

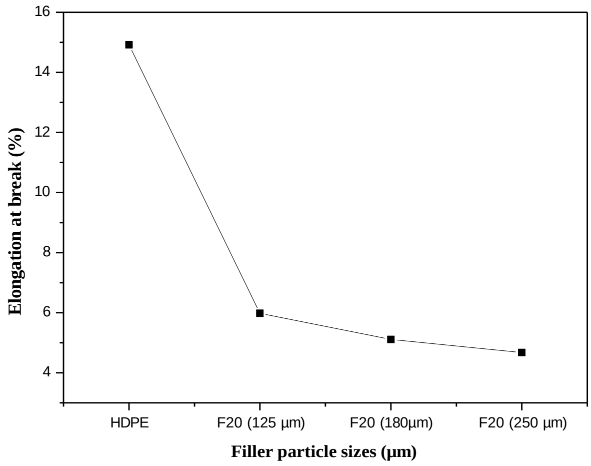

Figure 3. Evolution of the elongation at break of HDPE/Coffee grounds flour composites at different filler particle sizes

The incorporation of rigid coffee grounds filler into the HDPE matrix considerably reduces the mobility of the polymer chains and loses its flexibility, which accelerates the rupture of the specimens at low stresses, and this is, translated by a reduction in elongation at break, due to poor filler/matrix intefacial adhesion. The same observations were, made by Maldas D. et al. [8], Kamdem D. et al. [9] and Mulhaupt R. et al. [10].

B. The mechanical properties of composites obtained by the impact test

The resilience test (impact test) consists of breaking, with a single impact, a notched specimen and measuring the resilience R in (J/m2) absorbed by the break.
The impact resistance results are shown in Figure 4.

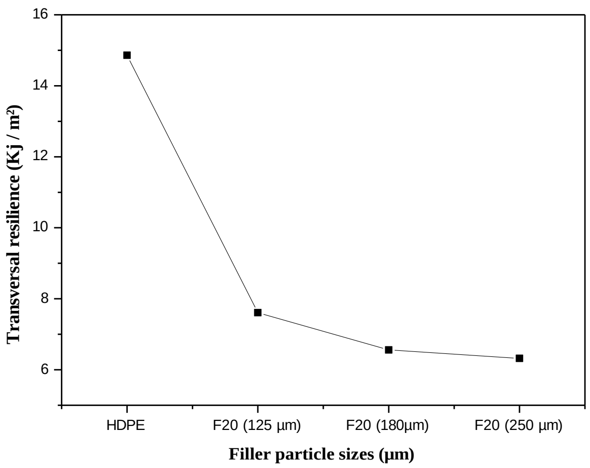

Figure 4. Evolution of the transverse resilience of HDPE/coffee grounds composites as a function of the particles size of the filler.

We find that the impact resilience of HDPE/coffee grounds composites decreases after the addition of the filler and with the increase in the size of the coffee grounds.
Coffee grounds flour, which has a greater rigidity than polyethylene, considerably increases the rigidity of the composite material, which also causes a reduction in impact resistance. This can be, attributed simply to the weak filler/matrix interfacial adhesion. The same observations were, made by Bendgtsson and Osman for composites (PE / Wood flour) [11].

C. Physical properties of composites obtained by the density measurement

The results obtained by measuring the density of the different samples are, summarized in table 1.

Table 1: Variation of HDPE/Coffee grounds flour composites density as a function of filler particle sizes

Samples	HDPE	F20 (125 µm)	F20 (180 µm)	F20 (250 µm)
Density (g/cm^3)	0.9555	>1	>1	>1

The density of composite depends, on CGF content and filler particle sizes. By the presence and increasing the filler particle sizes, the hydrophilicity of the composites will increase. The densities of HDPE and F20 composites at different filler particle sizes were from 0.95 up to greater than 1, respectively (Table I). The obtained data showed comparable results found by A. R. Oromiehie et al. [12].

IV. Conclusions

The objective of this work was to study the effect of the particle size of coffee grounds on the properties of HDPE/ coffee grounds composites. Three particle size classes were, studied: 250, 180 and 125µm. The composites obtained are, characterized by the determination of the mechanical and physical properties.
The analysis of the experimental results allowed us to draw the following main conclusions:

- The mechanical behavior of the HDPE/CGF composites shows that with the incorporation of 20% of CGF and with the increase in the particle size of the filler in the HDPE matrix, the impact resilience, tensile stress and elongation at break decreases, while the modulus of elasticity increases progressively.

- The density of HDPE/CGF composite increased by increasing the particle size of the filler in the HDPE matrix.

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