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Mechanical Properties of Polystyrene / Olive Stone Flour Composites.

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ABSTRACT

This work aims to study the effect of the incorporation of natural fibers on the mechanical properties of materials plastics composite. The use of olive pomace flour (OSF) as a reinforcing filler and polystyrene (PS) as a thermoplastic polymer matrix. The composite material is prepared in the form of films using a single screw extruder. Formulations composite polystyrenes / olive stone flour (PS/OSF) are prepared by with various proportions by weight: 0, 10, 20 and 30 %.
Keywords: Polystyrene, natural fibers, mechanical properties, composites.

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INTRODUCTION

Composites have become an integral part of our day to day life and they can be found everywhere [1]. Composites in the form of wood, teeth, bones, muscle tissue… Composites materials generally consist of a matrix (polymer, ceramic ...) reinforced with either particle or fibers.

Among various polymer matrices, thermoplastics are mostly used in the manufacture of composites [2]. Polystyrene is one of the most important thermoplastic which is in great demand due to its transparency, fluidity and good electrical insulation properties [3, 4].

Nowadays agriculture resources have been exploded in high technology revolution. The interest in using natural fibers as reinforcement in plastic materials has increased dramatically. They have many advantages over the synthetic fiber, due to their biodegradable properties, light weight, less expensive resources, easy processing, high specific modulus and also environmentally friendly [5-7].

The chemical composition of natural fibers varies depending on the type of fibers. The chemical composition and the structure of the plant fibers is rather complicated [8]. Vegetable fibers are composite materials designed by nature. They consist mainly of cellulose, hemicellulose, lignin, waxes, and water-soluble compounds, where the cellulose, hemicelluloses and lignin are the major constituents (they are shown in Figure 1 (a) - (c), respectively) [9].

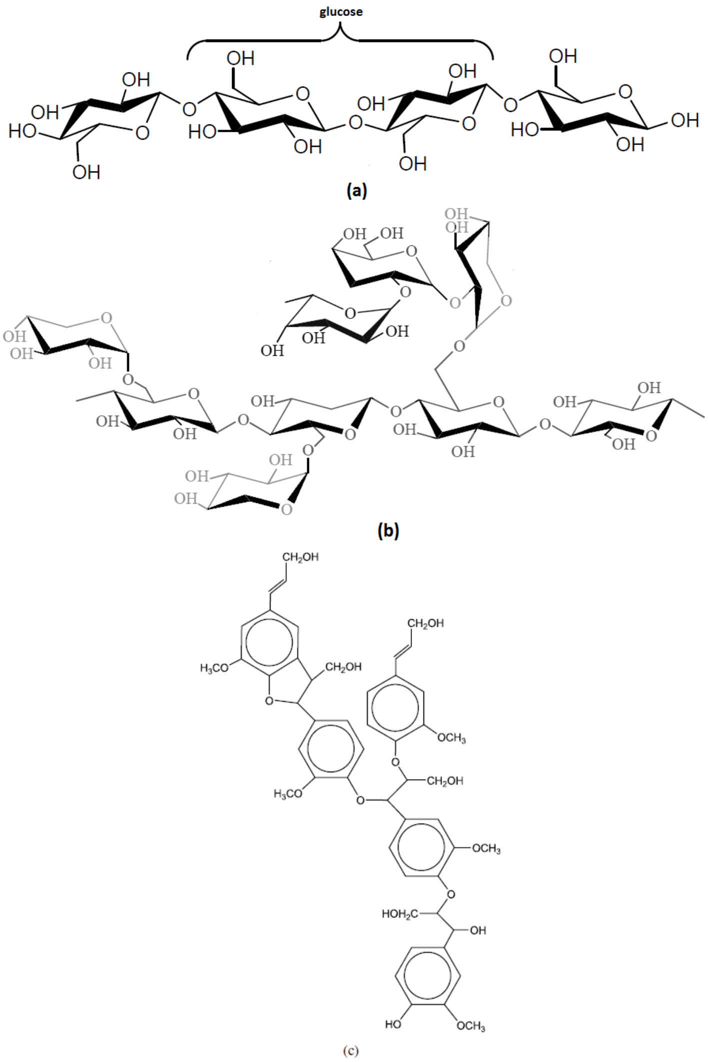

Figure 1: The chemical structure of cellulose (a); hemicellulose (b) and lignin (c).

Olive husk, one of several lignocellulosic materials, is an agricultural industrial residue produced as by-products during the olive milling process in olive-producing countries such as Algeria [10].

The objective of this study was to evaluate the effect of the olive stone flour loading content on the mechanical properties of composites developed with polystyrene (PS).

MATERIALS AND METHODS

Materials

The polystyrene was supplied by Total petrochemicals company, Spain, E-U. The essential physical properties as provided by the supplier with the polymer are listed in Table 1.

Table 1: Properties of the polystyrene polymer

Physical property	Polystyrène
molar mass (g/mol)	104.15
cohesive energy (KJ/mol)	29.6 - 35.4
enthalpy of fusion (KJ/mol)	8.37 - 10
melting entropy (KJ/mol)	0.0153 - 0.0168
transition temperature (K)	373
heat capacity (100K) (KJ/Kmol)	0.04737
thermal conductivity (amorphous, T=473K) (J/smK)	0.13
solubility parameter (MPa)	15.6 - 21.1

The olive husk was obtained from the olive treatment in the region of Biskra located in the south of Algeria. It was firstly air-dried for two weeks and ground into very fine particles of spherical shape.

The additives used in the preparation of the various formulations were Di-Iso-Décyl-Phtalate (DIDP) as a plasticizer produced by ENIP SKIKDA, Algeria, with a viscosity ranging from 120 to 130 mPa.s, a Density of 0.965-0.975 g/cm^3, a thermal stabilizer system based on Ca-Zn type BAROPAN MC 9917 KA. Stearic acid as lubricant.

Preparation of composite samples

Different formulations containing PS/OSF were prepared by two types of processing methods by extrusion and compression molding. The formulations were prepared and noted: F0, F10, F20 and F30 (the number refers to the amount of fiber (OSF) in %). Table 2 shows the compositions by weight of the various formulations of PS / OSF.

Table 2: Composition by weight of different formulations PS/OSF

Mass compositions of the formulations /g				
Contents of blend	F_0 (Virgin PS)	F_{10}	F_{20}	F_{30}
PS resin	100	100	100	100
Plasticizer	30	30	30	30
Stabilize	07	07	07	07
Lubricant	0.5	0.5	0.5	0.5
Olive stone flour	0	10	20	30

The blends of PS/OSF are formed in a mixer type MHS25, the rotational speed and temperature, are respectively (80 rpm/min and 50°C).

The composites were prepared using a single screw extruder Plasti-Corder kind PLE 330. With a mixing speed of 50rpm/min and extruding temperature of 160-190°C. (The extrusion conditions were the same for all samples).

The strips obtained by extrusion are introduced into the mold between two sheets of aluminum and compressed with a hydraulic press type Schwabenthan polystat 300S, with a temperature of 170°C under a pressure of 300bar during 10min. Preheating is performed until an initial melting of the mixture to avoid the presence of air bubbles, a degassing is performed before the application of the final pressure. Sheets of 2mm thick are obtained; they are then cut in the form of dumb-bell and squares to serve in different characterization tests.

Technical characterization

Tensile Test

The mechanical properties (tensile strength, elongation at break) of the composites obtained are measured using traction machine type Zwick / Roell, according to the standard ISO 527. For each type of composite, six samples are tested and used in calculating the average value.

Testing Shore hardness D

The test consists of applying a force tending to push the needle of a durometer Shore D type Zwick/Roell according to ISO 51-123 T, for the plates of the composites.

RESULTS AND DISCUSSION

The evolution of the tensile strength of the composites as a function of pomace olive flour rate is illustrated in Figure 2. It is noted a decrease in the tensile strength of the composite loaded with olive pomace fiber compared to virgin PS. This reduction is estimated at 14.4%, 10.62% and 4.82 for formulations F10, F20 and F30, respectively.

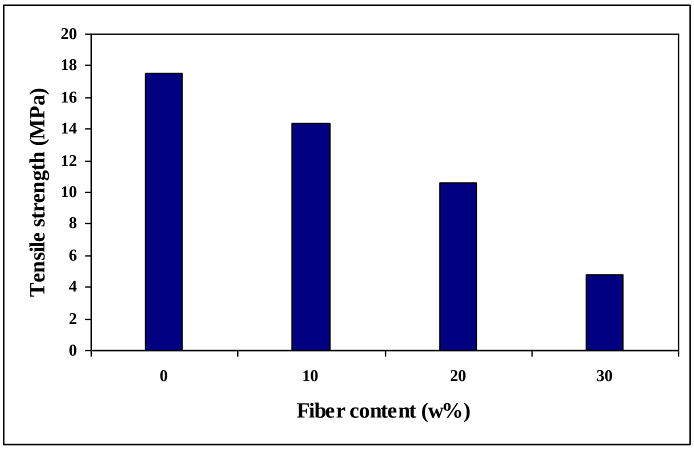

Figure 2: Evolution of the tensile strength of composites PS/OSF according to the rate of the olive husk flour

These results are predictable and are consistent with a lot of work. *Sonia et al* [11], *Demir et al* [12] and *Khalid et al*. [13] *Kaci et al* [14], *Chen Chi Ma et al* [15] *Djidjelli et al* [16], *Hyun-Joong Kim et al* [17] and *Sapuan et al* [18] who attributed this decline to the decrease of the bonding strength between the fiber and the matrix which blocks the propagation of stress. This reduction increases gradually as the meal rate increases, this can be explained by the tendency of the particles of olive pomace flour able to gather in cities forming thus inducing heterogeneities and transfer non stress uniform within the matrix, therefore, it occurs a weakening of the composite material.

The evolution of the elongation at break of the composites based on olive pomace fibers rate is illustrated in Figure 3. Note that the trend of all the formulations based on the rate of olive pomace flour, is characterized by a significant decrease on the elongation at break. For composites prepared with the flour, this decrease may be explained in part by the hydrophilic nature of the fibers that absorb more moisture and causes a swelling in the PS matrix which causes embrittlement of the material and the other part, due to the

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important volume occupied by the filler particles, creating defects in the system and to the interaction cross channels, associated with a ductile-brittle behavior of the variation of material [19].

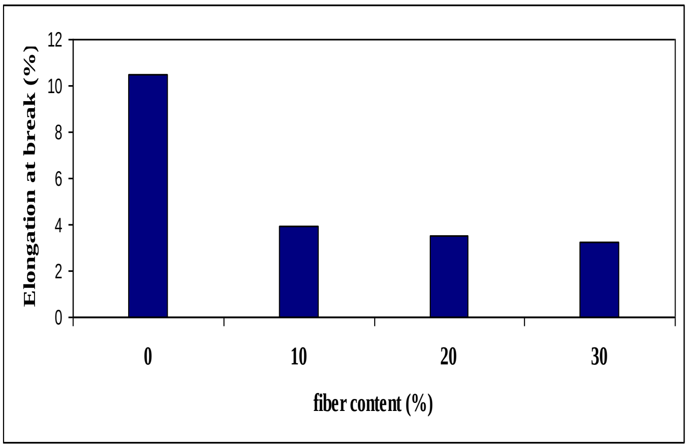

Figure 3: Evolution of the elongation at break of composites PS/OSF according to the rate of the olive husk flour

The evolution of the hardness depending on the rate of olive pomace Flour for composites is shown in Figure 4. The general shape of the curve is characterized by a significant augmentation of hardness with the incorporation of the olive pomace flour. This increase is more important than the rate of the flour is high. These results are predictable in that flour hard nature olive pomace increases the hardness of the PS/OSF composites.

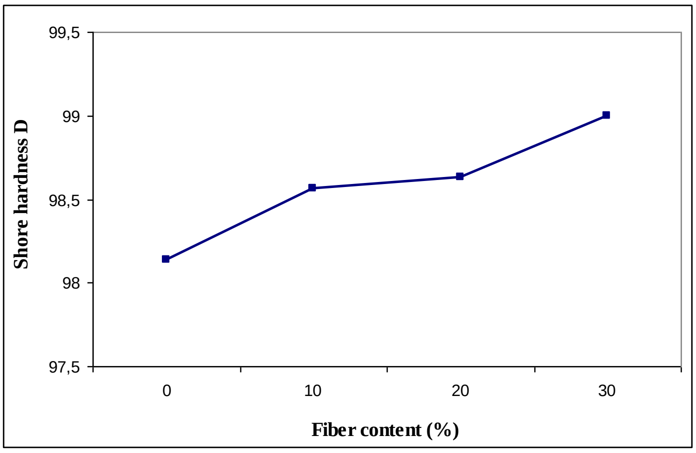

Figure 4: Evolution of the Shore hardness of composites PS/OSF according to the rate of the olive husk flour

CONCLUSION

In this work, we also studied the mechanical behavior of PS/OSF composites. It is obvious to conclude that with the increase in the rate of flour olive pomace, the tensile strength and elongation at break decrease, while the Shore hardness gradually believes this is attributed to poor compatibility of interface between the fiber surface and the polymer, by forming aggregates which lead to a weakened composite material. It can be improved by introducing a surface treatment on the fiber.

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