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Effect of Carbonized Saw Dust on the Mechanical Properties of Polyolefin Plastics

M. N. Akanbi[1*], F. N. Onuoha[1], I. N. Elele[1] and S. C. Nwogu[1]

[1]Department of Polymer and Textile Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Owerri, Imo State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Carbonized particles of saw dust using maleic anhydride as coupling agent have been incorporated into high density polyethylene and polypropylene in the range of 10 – 50 wt % and injection moulded into rectangular sheets. The mechanical properties of the sheets were determined. The results obtained showed that certain properties (mechanical, bending strength as well as bending modulus and flexural) increased significantly in the narrow particle loading of range 0 -10 wt %.

Keywords: Carbonized; high density polyethylene; maleic anhydride; polypropylene; saw dust.

1. INTRODUCTION

Cellulosic wastes in the form of nano or micro particles obtained by high temperature pyrolysis are increasingly used as fillers for polymers.

Several workers have shown interest in cellulose/polymer composite. Mansur M.A. et al. [1] studied bamboo-mesh reinforced cement composites, and found that this reinforcing material could enhance the ductility and toughness of the cement matrix, and increase

**Corresponding author: Email: magdalene910@yahoo.com;*

significantly its tensile, flexural, and impact strengths. A pulp fiber reinforced thermoplastic composite was investigated and the results shown a combination of stiffness increased by a factor of 5.2 and strength increased by a factor of 2.3 relative to the virgin polymer. Maiti S.N. et al. [2] examined the influence of wood flour on the properties of high density polyethylene (HDPE). Tajrdi et al. [3] studied extruded composite made from Reed flour/polypropylene with varying particle sizes. Stark, N.M. et al. [4] showed that the aspect ratio had greater influence on strength and stiffness. Because the physical, chemical and micro structural properties of wood species depend on the type of plant species, the selection of wood specie could have a significant influence on the microstructure of the particles obtained by whatever process, Selle et al. [5].

The interest in these sought of fillers is due to a number of reasons viz abundance, low weight, cheapness, material renewability, low abrasion etc. Susheed et al. [6] these potential fillers also have their draw backs such as poor thermal stability, poor compatibility in hydrophobic polymer matrix, where these are used in hydrophobic polymers such as polyolefins.

The negative properties could be overcome by the use of coupling agents [7,8,9]. It is well known that the interface between the polymer Matrix and the lignocellulosic filler plays a critical role. This role is to ensure that the properties of each component contribute to bulk properties and in developing composite materials without standing physical and mechanical properties, [10].

The influence of different surface modifications of jute on the performance of the biocomposites was studied by Mohanty et al. [11]. In the sturdy, more than a 40% improvement in the tensile strength occurred as a result of reinforcement with alkali treated jute. Jute fiber content also affected the biocomposite performance and about 30% by weight of jute showed optimum properties of the biocomposites.

Myers G.E et al. [12] investigated the effects of the concentration of a maleated polypropylene additive (0 to 5 percent by weight) and of extrusion blending temperature (190°C to 250°C) on the mechanical properties of extruded and injection-molded polypropylene-wood flour composites. The results of mechanical properties obtained shown better strength and modulus. This was presumably as a consequence of increased reinforcement by the filler particles and wood degradation. Also, some dynamic mechanical properties of High Density Polyethylene and Teak wood flour composites were examined by Kamini et al. [13] and they reported that the storage modulus (E") decreased at $\phi f = 0.5$, then increased with ϕf in the HDPE/TWI composites.

2. MATERIALS AND METHODS

2.1 Materials

The polymers (high density polyethylene and polypropylene) used in the present work are products of Indorama Group (a subsidiary of Eleme Petrochemical Company Port Harcourt Nigeria).

The densities and melt flow index of the polymers used are 0.96 g/dm^3, 16 g/10min and o.926 g/cm^3, 2.5-3.5 g/dm^3 for HDPE the polyethylene- g –maleic anhydride was purchased from a chemical store while the sawdust used was obtained from the engineering workshop of the Federal University of Technology Owerri.

2.2 Experimental

2.2.1 Carbonization of saw dust

Some samples of washed dried and mechanically homogenized saw dust were placed in an enclosed steel container and carbornized in the temperature range of 1000ºC – 1150ºC at a heating period of 3 hours.

2.2.2 Injection moulding

The HDPE and PP were respectively compounded with varying amounts of the carbornized saw dust filler and the coupling agent. The samples were injection moulded at a screw speed of 50rpm and injection temperature of 180ºC for HDPE and 220ºC for PP at an Injection pressure of 210 atm.

2.2.3 Mechanical properties

2.2.3.1 Tensile test

Tensile test was carried out using a universal testiometric machine according to ASTM D 638 using rectangular sheets of 4 mm x 5 mm. tests were done at ambient temperatures at a cross

head speed of 50 mm/min giving rise to tensile strength, elongation at break and modulus.

2.2.3.2 Flexural test

The flexural tests were done according to ASTM D2990 using 100mmx50mm test samples. The results of the determination of the bending modulus, bending strength at peak, bending strength at yield and bending strength at break were obtained.

3. RESULTS AND DISCUSSION

3.1 Mechanical Properties

The tensile strength at peak for HDPE and PP are shown in Figs. 1a and 1b. It can be seen that about 10% filler loading in HDPE increased the tensile strength at peak by about 10% while about 12% filler loading increased the tensile strength of PP by almost 50%. These are very significant and clearly show that carbonized saw dust particles can be fruitfully used as filler in polyolefin plastics particularly in applications where strength is required.

3.2 Stress – Strain Properties

The stress – strain curves of the composite Polyolefins are shown in Figs. 2a & 2b. The stress –strain increased for both plastics up to 20% loading of Pyrolysed saw dust. This means that higher stiffness values are obtainable up to 20% loading. The results are in agreement with the work of [14] Debabrata Chowdhury in the study of the mechanical properties of wood dust filled polymer composites and [15-19] other works on wood filled plastics.

3.3 Bending Modulus and Strength

The effect of the filler loading on the bending modulus of the Polyolefins with increase in the filler loading have been assessed by plotting modulus (ratio of stress and strain in the flexural deformation) against percentage filler loading and bending strength against filler loading .As can be seen in Figs. 3a and 3b, the filler loading has a limited effect on the bending modulus in the range 0-10% for HDPE but has a very significant effect on the bending modulus of PP from 0 – 20% of filler. Fig. 4 shows that the bending strength (i.e stiffness) of both plastics are improved for filler compositions of 10% in HDPE and filler loading of up to 20% for PP.

It is seen that the tensile strength of the typical virgin HDPE increased on filler loading of 10% and then started decreasing .The increase in the tensile strength on addition of carbonized saw dust particle at 10% loading is as a result of phase compatibility.

Also from the same graph it is clearly seen that the tensile strength of PP increased on the filler loading of 10%, then started decreasing. The increase in the tensile strength is chiefly due to the good orientation between the PP chain and the carbonized saw dust.

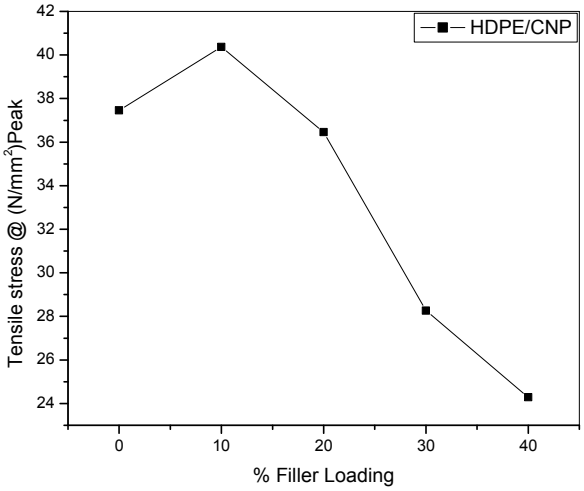

Fig. 1a. Tensile stress at peak vs % filler loading of HDPE/CNP composite

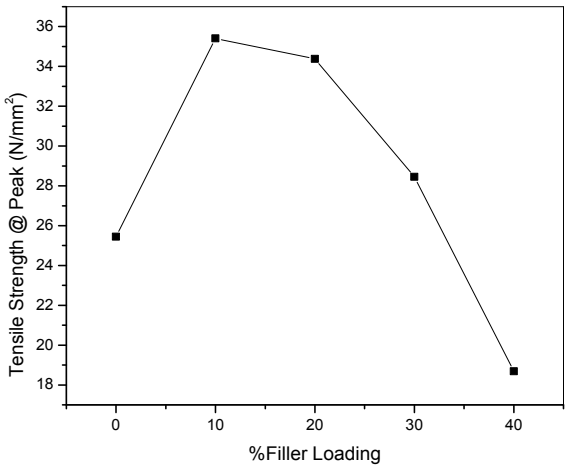

Fig. 1b. Tensile stress at peak Vs % filler loading of PP/CNP composite

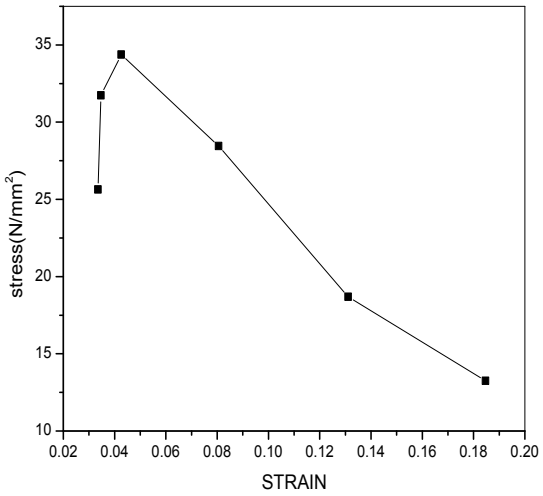

Fig. 2a. Stress /strain graph PP / CNP composite

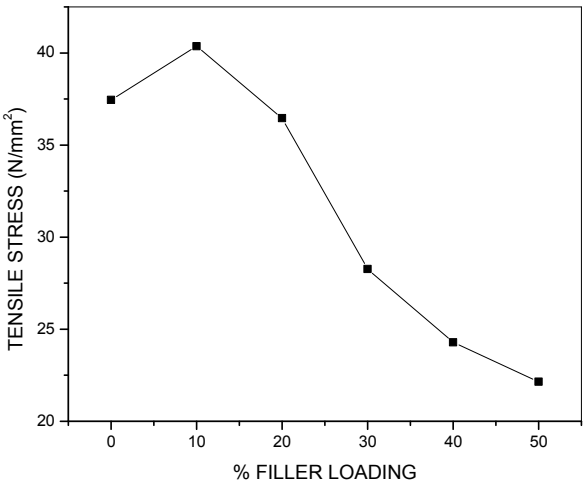

Fig. 2b. Stress /strain graph for HDPE/CNP composite

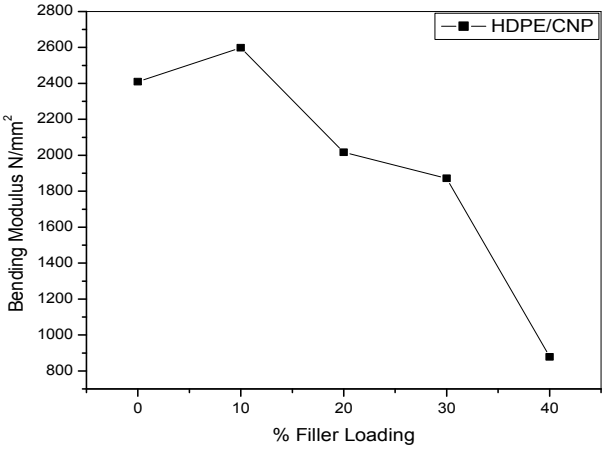

Fig. 3a. Bending modulus vs % filler loading

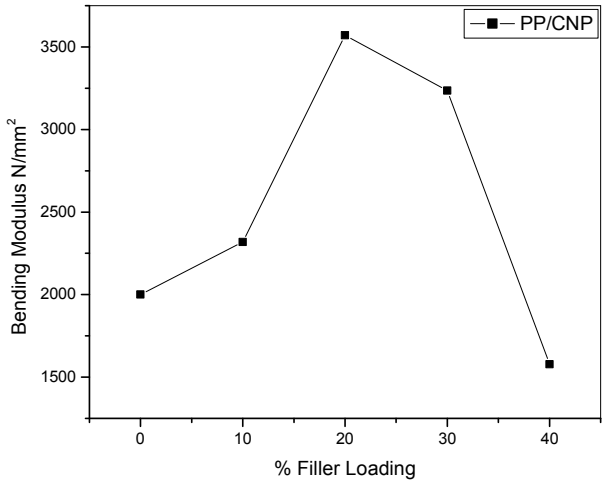

Fig. 3b. Bending modulus vs % filler loading

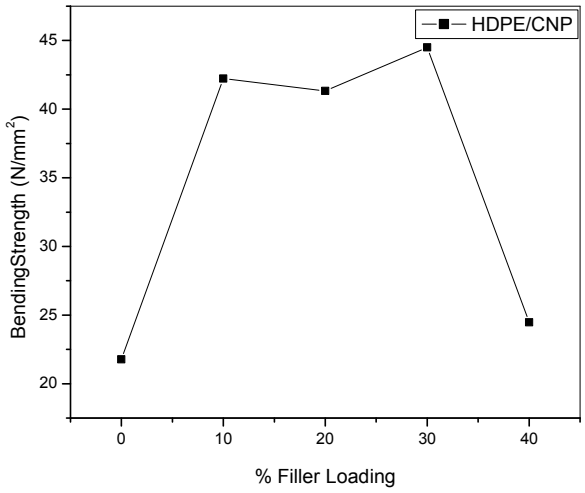

Fig. 4a. Bending strength vs fiber loading (%)

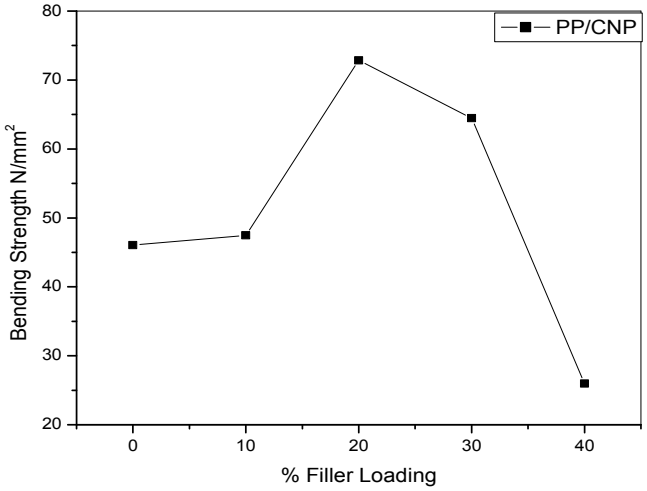

Fig. 4b. Bending strength vs fiber loading (%)

4. CONCLUSION

The investigations on the mechanical properties of both resultant series of polyolefins/saw dust composites have shown that the incorporation of achi wood saw dust into PP matrix enhanced the tensile strength and bending modulus at low filler loadings whilst decreasing this property in a close dependent manner. Also, the HDPE Wood dust composites had higher tensile strength at low filler loadings than the virgin material.

The bending modulus of HDPE/wood dust composite and PP/Wood dust composite improved with increase in filler loading up to 10% for the HDPE/Wood dust and 20% for the PP/Wood dust composite.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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