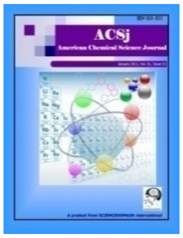

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Mechanical Properties of Cocoa-Pod/Epoxy Composite; Effect of Filler Fraction

P. E. Imoisili[1*], T. C. Ezenwafor[1], B. E. AttahDaniel[1] and S. O. O. Olusunle[1]

[1]Department of Research and Development, Engineering Materials Development Institute P.M.B. 611, Akure, Ondo state, Nigeria.

Authors' contribution

This work was carried out in collaboration of all authors. Author PEI collected and performed all analyses, characterization, and wrote the first draft of the work. Author TCE managed the literature searches. Author BEA designed the study, managed the analyses of the work, Author s SOOO and PEI interpreted the results, corrected, and prepared the final manuscript. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

In this study the mechanical properties of an agricultural waste (cocoa pod) in a polymer matrix (Epoxy resin) was investigated, and the effect of volume fraction of cocoa pod/epoxy resin composite was also investigated, different filler volume fraction (viz. 5 to 30 weight %) were fabricated, tensile and flexural test were performed according to ASTM D638, and ASTM D790, test results reveal that tensile and flexural strength of the composite decrease with filler volume fraction, while tensile modulus, flexural modulus and micro hardness of the composite increase with the increase in filler volume fraction. Morphological studies reveal that there is good dispersion of filler in the polymer matrix.

Keywords: Epoxy resin; filler volume fraction; epoxy composite; flexural strength.

1. INTRODUCTION

Epoxy resins (ER) is an important class of thermosetting polymers which are widely used as matrices for fibre-reinforced composite materials and as structural adhesives [1-2]. Research

**Corresponding author: Email: patrickehis2002@yahoo.com;*

has been carried out in developing composites, using most environmentally friendly agro-wastes as reinforcement and thermosetting polymers as matrixes [3]. A number of natural occurring fillers and fiber in composite have been studied in the past. These include, ash rice husk [4], rice husk [5], Bamboo [6], coconut shell ash [7], oil palm empty fruit bunch [8] etc. These fillers introduce some advantages compared to traditional inorganic fillers, including their renewable nature, low density, nonabrasive properties, reasonable strength, and stiffness [9]. The use of natural materials in reinforce composite offers the following benefit in comparison with mineral filler [9-10] strong and rigid, light weight, environmental friendly, economical, renewable and abundant resource, these fillers also introduce some advantages compared to traditional inorganic fillers, including their renewable nature, low density, nonabrasive properties, reasonable strength, and stiffness [9] However they have the disadvantage of degradation by moisture, poor surface adhesion to hydrophobic polymers, non-uniform filler sizes, not suitable for high temperature application among others [11]. This work is part of an ongoing comprehensive study of the utilization of cocoa-pod with potential application in polymer composite fabrication. The objective of this research therefore, is to study the mechanical properties, micro hardness and morphology of cocoa-pod reinforced epoxy composite.

2. MATERIAL AND METHODS

Cocoa pod Husk was obtained from harvested cocoa during the harvest season in south western Nigeria. The pod was first sun dried for three day, after which the sample was ground into powder and sieved with BS/ISO 3310 into particle size of 38 µm. there after it was oven dried at 80^0C until a constant weight was observed. Epoxy resin 3554A a bisphenol class of epoxy resin, and 3554B an amine class hardener, were supplied by a local supplier in Lagos Nigeria. The weight ratio of resin to hardener used was 2:1**.** After being thoroughly mixed with the filler, the resin was poured onto the cavity of a steel mold, previously coated with a mould releasing agent they were allows to cure, at room temperature for 24hours. Composites with amounts of Coco pod filler (CPF) ranging from 5, 10, 20, and 30 wt. % were manufactured.

2.1 Mechanical Test

Tensile and flexural tests were carried out using a universal Instron testing machine model 3369, in accordance with ASTM Test Method D638 and D790. Micro hardness test was done using a: Leco LM-700AT Micro Hardness Tester in accordance with ASTM Test Method E384, with a dwell time of 10 seconds and a load of 490.3 mN. Surface Morphology was observed, using scanning electron microscope, EVO MA/10 Model.

3. RESULTS AND DISCUSSION

3.1 Tensile Properties

The variation of tensile strength and young's modulus as a function of cocoa pod flour in wt.% is showed in Figure 1. There was over 35% reduction in tensile strength, as filler volume fraction increases, with 30% filler loading showing the lowest strength. The reason might be that the chemical reaction at the interface between the filler particles and the matrix may be too weak to transfer the tensile stress [12].

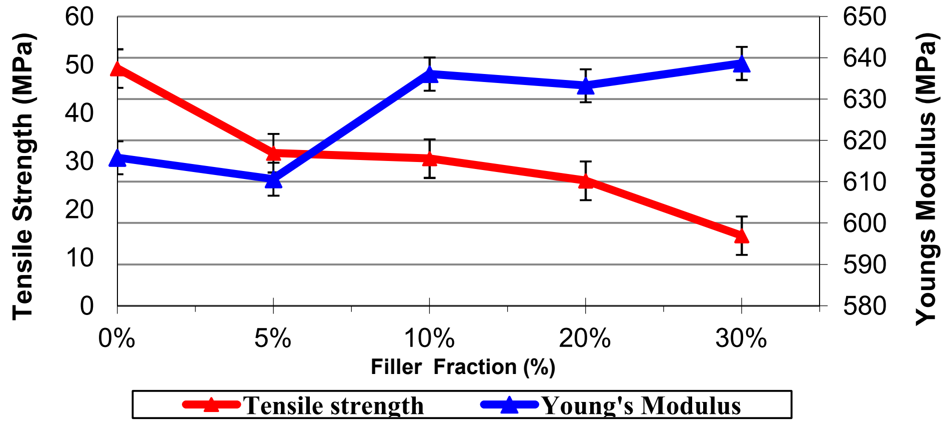

Figure 1. Effect of filler fraction on tensile & young's modulus of cocoa pod /epoxy composite

However, young's modulus shows an initial reduction at 5% filler loading and gradually increases as filler loading increased. The percentage elongation at break also decreases on addition of filler as shown in Figure 2; this is due to the interference of filler in the mobility or deformability of the matrix. This interference is created through the physical interaction and immobilization of the polymer matrix by the presence of mechanical restraints, thereby reducing the elongation at break [13].

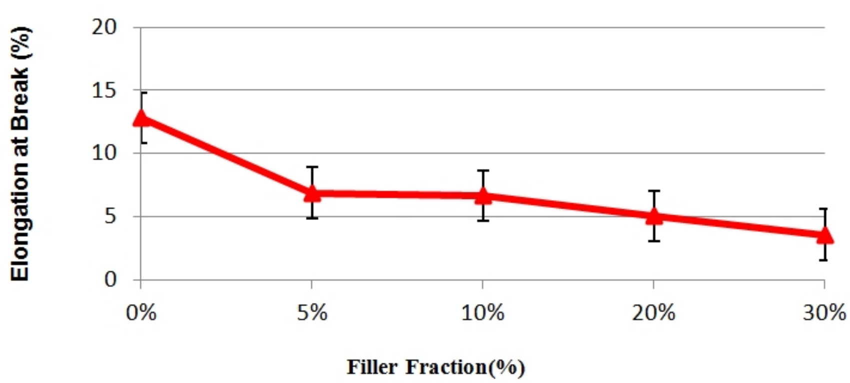

Figure 2. Effects of filler fraction on elongation at break of cocoa pod/epoxy composite

3.1.1 Flexural properties

The variation of flexural strength with filler addition is shown in Figure 3. The flexural strength of composites decreases with increase in filler fraction, 44% decrease in flexural strength was observed, with 20% filler loading showing the best strength. This decreased might be attributed to the increasing worsening interfacial bonding between filler (hydrophilic) and matrix polymer (hydrophobic). However, flexural modulus increases with increase in filler concentration [14].

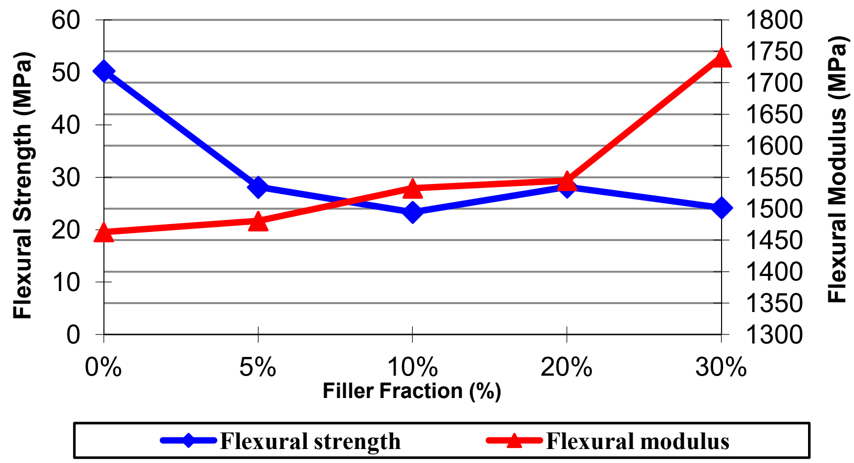

Figure 3. Effect of filler fraction on tensile & young's modulus of cocoa pod /epoxy composite

3.1.1.1 Micro hardness and morphological study

The variation of composite micro-hardness with the weight fraction of cocoa pod flour is shown in Figure 4. Hardness values have been found to have improved for the particulate-filled composites, in this case a compression or pressing stress is in action, so the polymeric matrix phase and the solid filler phase would be pressed together and touches each other more tightly. Thus, the interface can transfer pressure more effectively although the interfacial bond may be poor. This might have resulted in an enhancement of hardness.

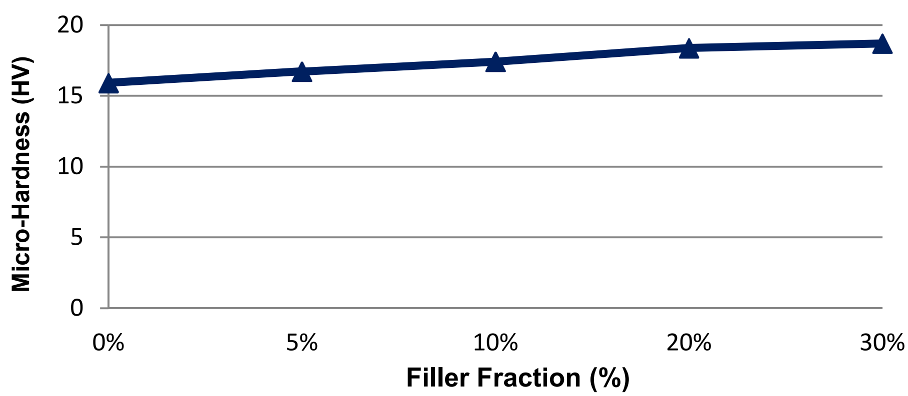

Figure 4. Effect of filler fraction on micro-hardness of cocoa pod /epoxy composite

Figure 5. shows the SEM micrographs of composites with 5-30% loadings of cocoa pod flour, Morphological study shows that there is good dispersion of cocoa pod flour in polymer matrix; however as filler fraction increases above 5%, dispersion of filler in polymer matrix became increasing difficult, thus 5% filler loading shows the best dispersion.

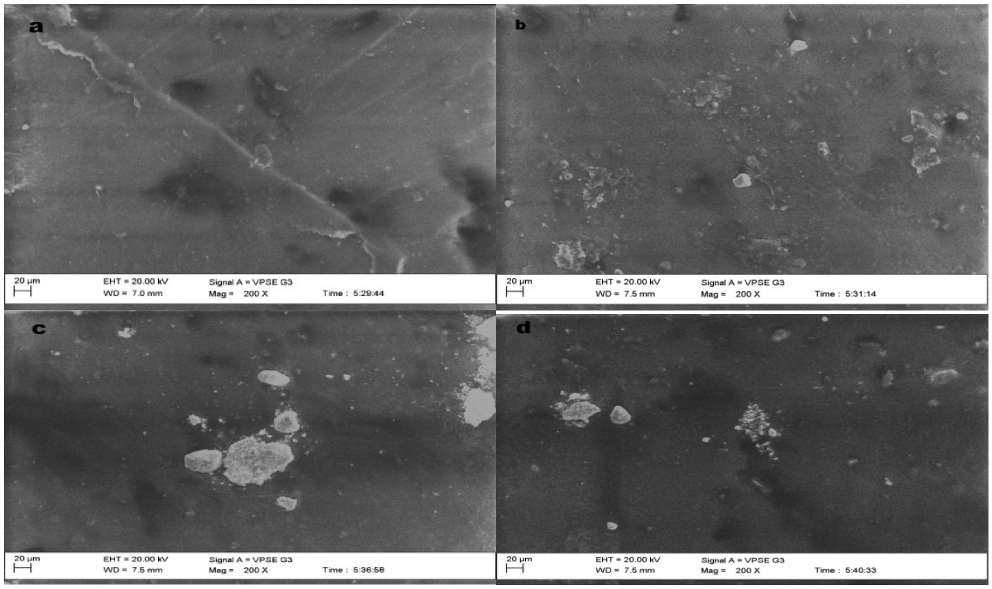

Figure 5. SEM micrographs of composites (a) 5%, (b) 10%, (c) 20%, (d) 30%

4. CONCLUSION

Cocoa pod/epoxy composites have been successfully fabricated; incorporation of these fillers modifies the Mechanical properties of the composite. The micro-hardness of the composites is also greatly influenced by the content of fillers; morphological studies revealed that there is good dispersion of filler in the polymer matrix, hence, while fabricating a composite of specific requirements, there is a need for the choice of appropriate filler material and for optimizing its content in the composite system.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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