IJST EXPLORE International Journal of Science and Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-7318

International Journal of Science and Technology Volume 2 No. 1, January, 2013

Physicochemical Analysis of Cocoa Pod and its Effect as a Filler in Polyester Resin Composite

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ABSTRACT

Nigeria is the fourth largest producer of cocoa pod and harvest season are often accompanied with tones of residues that are of environmental menace and in some cases hazardous. In this paper physicochemical analysis of cocoa pod was carried out and the influence of different volume fraction of the fillers in polyester resin composite was studies. Physicochemical analysis shows Moisture content to be 6.69%, ash 8.91%, lignin 26.51%, cellulose 24.28%, extractive 4.81%. It was also observed that from the tensile test results there was a gradual reduction in both the tensile and specific tensile strength. Percentage Elongation also shows a gradual reduction while modulus and specific modulus of the composite shows increase as filler volume increases. Thus Cocoa pod filler (CPF) can be utilized as a non-reinforcing filler in polyester resin composite.

Keywords: *cocoa pod; polyester resin; composite; volume fraction; tensile strength*

1. INTRODUCTION

Recent investigations of polymer-based composite materials have opened new routes for polymer formulations and have allowed the manufacture of new products with optimal properties for special applications [Karnani*et al* (1997) and George *et al* (2001)].

In most cases, these composites improve the product design and reduce the material and energy consumption. A number of natural occurring fillers and fiber in composite have been studied in the past. These include wood fillers [Gattenholm et al (1993)], ash rice husk [Ismail et al (2001)], rice husk [Imoisili *et al* (2012a), Martí-Ferrer, et al (2006)], coconut shell ash [Imoisili et al (2012b)] , Wood base filler derive from oil palm wood flour [Fuad et al (1998)], e.t.c. These fillers introduce some advantages compared to traditional inorganic fillers, including their renewable nature, low density, nonabrasive properties, reasonable strength, and stiffness [Neus Anglès *et al* (1999)].

Natural filler, in comparison with mineral filler offers the following benefits [Herrara-Franco *et al* (1997) and Maulida *et al* (2000)], strong and rigid, light weight, environmental friendly, economical, renewable and abundant resource. However degradation by moisture, poor surface adhesion to hydrophobic polymers, non-uniform filler sizes, not suitable for high temperature application among others are some of the disadvantages of natural fillers [Belmares *et al* (1983)]

This work is part of a comprehensive study of the utilization of cocoa-pod with potential application in polymer composite fabrication. The objective of this research therefore, involved the physicochemical analysis of cocoa-pod (CP) and investigating its effect as filler on the tensile properties of polyester resin composite

2. MATERIALS AND METHODS

The cocoa pod was obtained from harvested cocoa-pod husk during the harvest season in south west Nigeria. Physicochemical analysis of cocoa pod to determine the ash was carried out as prescribe by ASTM D1102-56, lignin content was determine as prescribe by Tappi T222 om-98, cellulose was determine as prescribe by Kurschner-Hoffer 1931, extractive which refer to the Alcohol-Benzene soluble matter was determine as prescribe by ASTM D1107-56.

3. PREPARATION OF COMPOSITE

Cocoa-pod (CP) was chopped into smaller sizes sun dried for three days, after which they were dried in an oven at 80^0C for 24hr to a constant weight, after which the sample was grinded into powder with the use of an electric blender. The grinded powder was later sieved with BS/ISO 3310 into particle size of 38 µm. This was used for the polyester resin composite

A commercially available Unsaturated Polyester Resin with Cobalt Octoate as Accelerator and Methyl Ethyl Ketone Peroxide (MEKP) as Catalyst was used as matrix for the composites. After the resin and filler has being thoroughly mixed, the mixture was cast onto the cavity of a steel mold, previously coated with a mould releasing agent and left for 24hour cure, after which the samples were de-molded and heat treated in an oven at 80^0C for two hours. Composites with amounts of (CP), ranging from 1, 2.5, 5, 7.5, and 10 wt. % were fabricated.

4. TENSILE TEST

The composite were analyzed using a Universal Instron testing machine model 3369, in accordance with ASTM Test Method D638, with across head speed of 5mm/min.

5. RESULT AND DISCUSSION

The results of physicochemical analysis of cocoa pod are show in table 1 below.

Table 1: Chemical Analysis of Cocoa pod

Moisture (%)	Ash (%)	Lignin (%)	Cellulose (%)	Extractives (%)	Density g/cm^3	PH
6.69	8.91	26.51	24.28	4.81	1.45	7.0

* The extractive here refer to the Alcohol-Benzene Soluble Matter

Figure 1 shows the variation of mean tensile strength with the increase in percentage of volume fraction, it can been seen that there was a gradual decrease in tensile strength as percentage volume fraction increases, there was however a sharp decrease at 10% volume fraction, this shows that there was no bonding between fillers and polymer matrix.

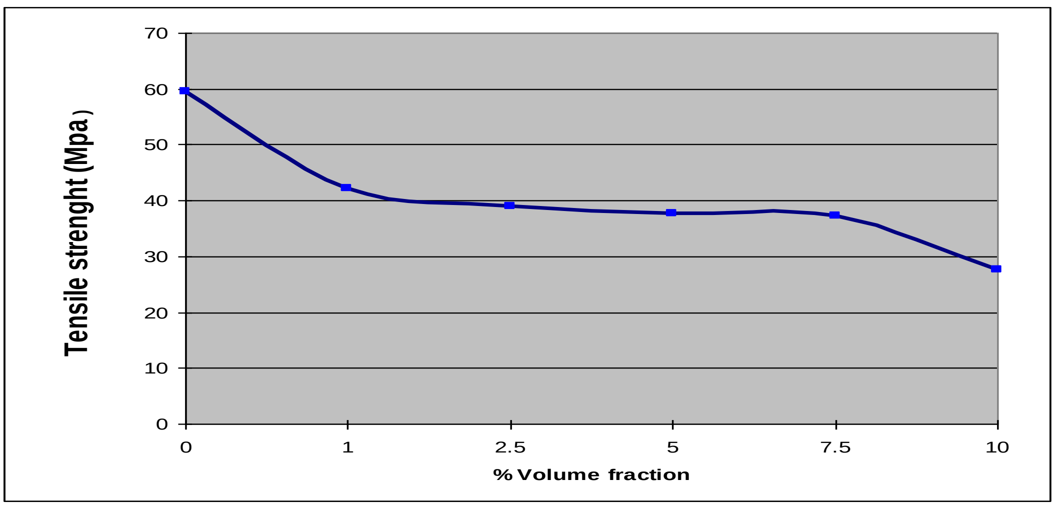

Figure 1: Effect of filler volume fraction on Tensile strength

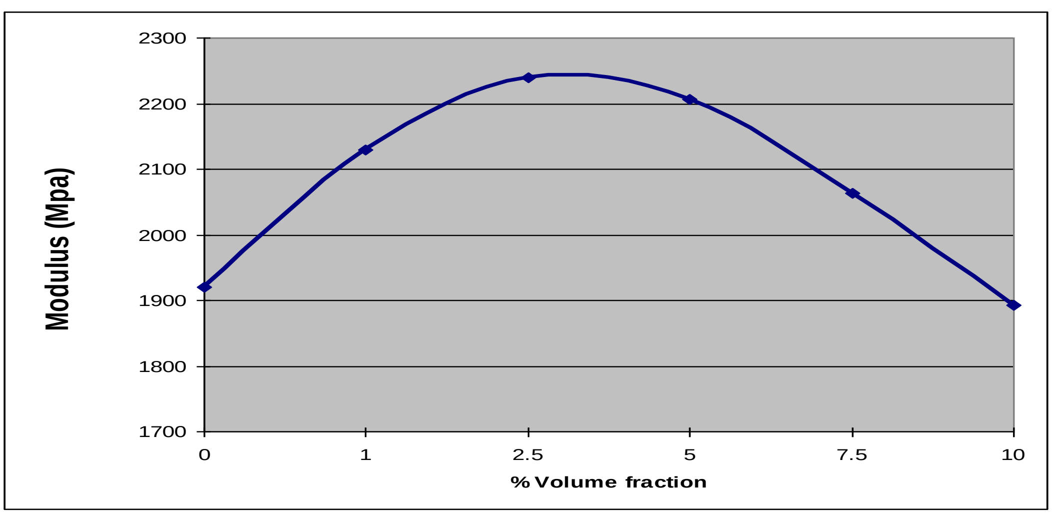

Figure 2: Effect of filler volume fraction on modulus

The modulus of the composite shown in figure 2 reveals an increase of 16.64% as volume fraction increases to 2.5%, and decreases there afterward.

The graph of Specific tensile strength (fig 3), and specific modulus (fig 4) plotted against filler volume fraction shows the same trend in accordance with tensile strength and tensile modulus.

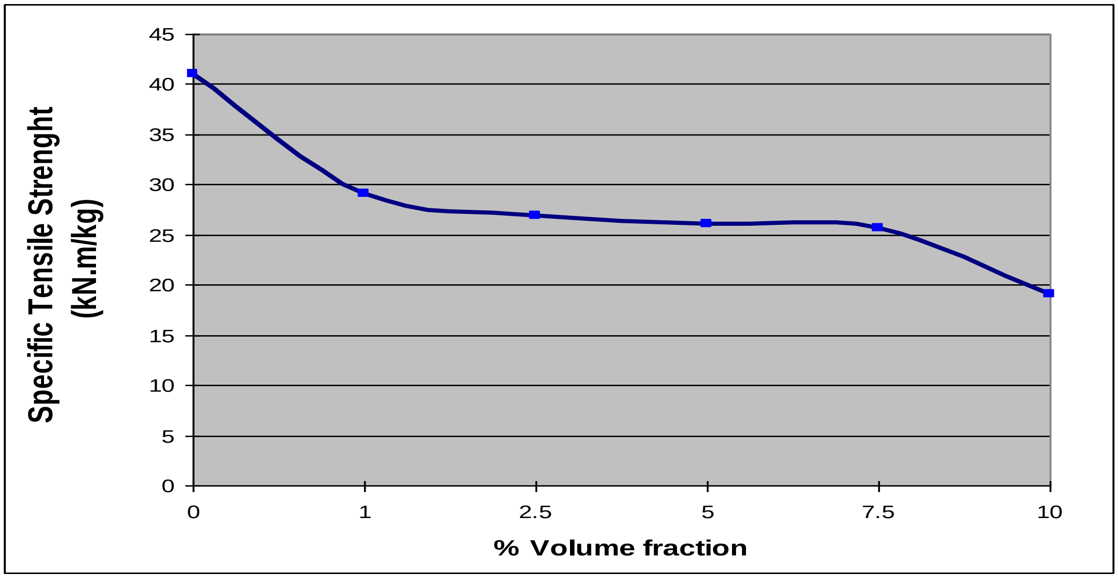

Figure 3: Effect of filler volume fraction on specific Tensile strength

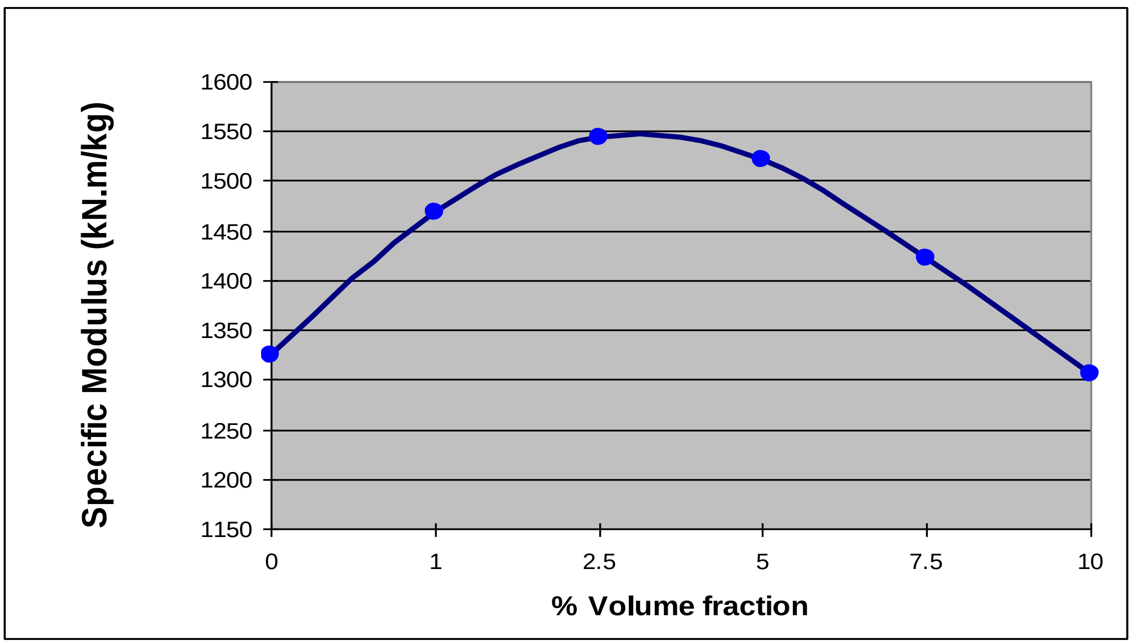

Figure 4: Effect of filler volume fraction on specific modulus

Elongation at break as shown in figure 5, reveals a decrease of 44.34% which shows increased stiffness in the composite.

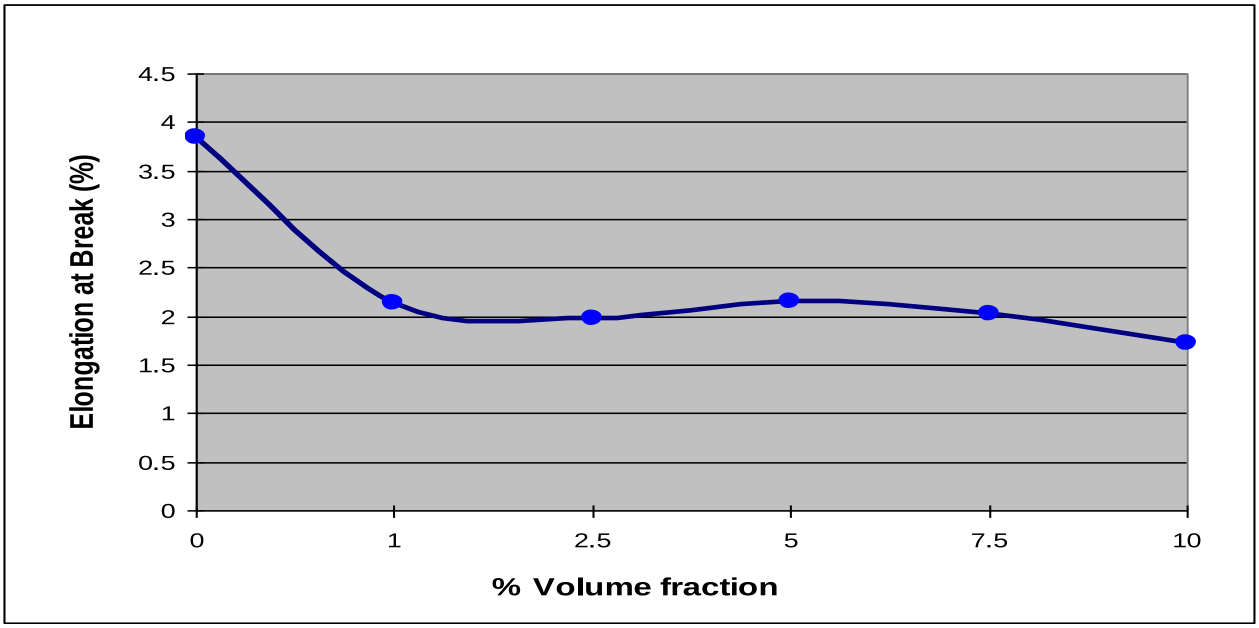

Figure 5: Effect of Elongation at Break against filler volume fraction

6. CONCLUSION

There was reduction in tensile properties of cocoa-pod polyester composite; this may be due to the non bonding of the hydrophilic filler and the highly hydrophobic polymer matrix.

Modulus and specific modulus, show improvement of about 16.64% when compare with virgin resin. Thus Cocoa-pod can be classified as a non reinforcing filler in polyester resin composite

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