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DETERMINATION OF PROPERTIES OF *CANARIUM SCHWEINFURTHII* (BLACKDATE) SEED SHELL REINFORCED COMPOSITE

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ABSTRACT
Crushed particles of canarium schweinfurthii (Blackdate) seed shells were used to reinforce general purpose unsaturated polyester and the properties were studied in this work. Particles of sizes 0.6mm, 1.18mm and 2.36mm with each particle size having a composition weight of 100g, 150g, 180g 200g and 220g respectively were used as reinforcement. The results showed that the composite produced from particles of sizes 0.60mm and composition weight of 100g absorbed the least amount of water with percentage water absorption of 0.89%. The composite from particle size of 1.18mm had the best tensile strength and modulus of rupture of 69.95MN/m^2 and 29.39MN/m^2 at composition weight of 180g and 100g respectively.

Keywords: *Atili (Blackdate) seed shell, particulate materials, composite materials.*

1.0 INTRODUCTION

Composite materials are generally defined as material made by the combination of two or more materials (Mazunder, 2000; Hull and Clyne, 1996). They are compound materials which differ from alloys by the fact that the individual components retain their characteristics, but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings, in order to obtain improved material (Chandramohan and Marimuthu, 2011). These materials consist of matrix and reinforcement which can be metal polymer or ceramics (Mazunder, 2000). The reinforcement comes in different forms and shapes (Tjong, and Meng, 1999; Tjong, et al, 2002; Wan, et al, 2005). Therefore, composite can be classified based on the type of reinforcement, as fiber reinforced where fiber is used and particulate composite where particles are used (Agarwal and Lawrence, 1980). Composite materials have high specific modulus, high specific strength, high resistance to corrosion and this gives them advantage over metals and ceramics (Tjong, et al 2003; Huda, et al 2007; Muhi, et al, 2009).

The need to cope with limitation of polymers in terms of low strength and stiffness and to expand their area of application has led to the use of various kinds of inorganic fillers such as glass, calcium carbonate particles, carbon nanotube and aluminum oxide, etc. (Fu, et al 2008) to form composite. The uses of particles of cow bone, maize hop, rice husk as particulate reinforcement are also reported (Bello, 2002). One of the challenges still faced by material scientists and engineers is availability of renewable source of raw materials productions (Callister, 2007). In recent years, there is high research activities in the use of natural materials as reinforcement in composite materials, because they enhance mechanical properties, they are non-hazardous, cheap and easily biodegradable (Thwe and Liao, 2002).
Canarium Schweinfurthii (Black date) is an exotic tree widely spread in Asia and Africa (Israel, 2009). The fruits are naturally hard which makes it worth studying as particulate reinforcement material. There is need to increase on the data base of renewable and environmentally friendly source of reinforcement material. Therefore, the use of canarium schweinfurthii seed shells as reinforcement in unsaturated polyester resin was studied in this work, with the objective of investigating the effect of particle size and reinforcement loading in the matrix.

2.0 MATERIALS AND METHOD

2.1 Material Preparation

Black date fruits were procured from a market in Jos, Plateau state of Nigeria. The pulps of the fruits and the seed inside the shell were removed to obtain the shell which was the part required for the studies. The seed shells were dried under sun and later transferred to an oven to dry at 60^{o}C for 5hours to remove the moisture. The dried black date seed shell was crushed to particle size of 5-8mm using Tamson 20 Etermer Holland crusher. Further size reduction was done using grinding machine, BBI, Retch Germany to particle size of 0.60mm-2.36mm. The ground samples were sieved into particle sizes of 0.6mm, 1.18mm and 2.36mm using ASTM sieve.

2.2 Production of the Particulate Composite

The composite was produced in a rectangular mild steel mould of size 21 x 16 x4 cm which was cleaned to remove particles and the mould was coated with releasing agent. After the preparation of the mould, polyester mix was prepared by measuring 200ml of polyester in a beaker and 2ml of methyl ethyl ketone catalyst was added to the polyester and mixed using a stirring rod for 5 minutes. 2ml of cobalt accelerator was then added and stirred for another 2 minutes. To this mixture, 100g of the 0.60mm particles of black date was added and mixed. The mixture was poured into the prepared mould and left to cure for 24 hours, after which it was removed and placed in the oven to post cure at 60^{o}C for 3 hours. The same procedure was used to produce other samples using particle weights of 150g, 180g, 200g and 220g for the same particle size. Particle sizes of 1.18mm and 2.36mm were used to also produce composites from 100g, 150g, 180g, 200g and 200g respectively.

2.3 Characterization of composite produced

2.3.1 Mechanical properties

The composites produced were cut into test samples using ASTM standard. The tensile test analysis was conducted with Tensometer, serial no. w3179, using ASTM 638M. The three points loading method was used for the flexural test using universal testing machine Cat Nr. 261; using ASTM D790M.

2.3.2 Physical properties

Water absorption of the reinforced polyester was determined by 24 hours' immersion of samples in water at 25°C, after conditioning the samples according to ASTM method. The water absorption was evaluated using Equation 1 (ASTM D570). The displacement method was used to determine the density of samples with the samples weighed in air and then in water and the density evaluated with Equation 2 (ASTM D792).

$$Waterabsorbed,\% = \frac{wetweight - conditionedweight}{conditionedweight} x100 \cdots 1$$

$$Density = \frac{weightinair}{weightinair - weightinwater} \quad \ldots\ldots 2$$

Weight in air –Weight in water is equivalent to volume of water displaced.

3.0 RESULTS

Figures 1 to 4 presents the effects of composition of blackdate seed shells on physical and mechanical properties of composite materials. Figures 5 to 8 presents the optical micrograph of composites and pure polyester samples at 200X magnification. A1, A11 to A5, A55; B1, B11 to B5, B55 and C1, C11 to C5, C55 of Figures 5 to 8 were used as sample labels to describe the photomicrographs based on particle sizes and weight of blackdate seed shells used. Sample A11 is a repeated sample of A1; and etc.

The photomicrograph of the samples produced which shows the variations of the above properties with composition of Atili seed shell are shown in Figures 5 to 7.

4.0 DISCUSSION OF RESULTS

The density test result obtained for the particulate composite samples produced from particle size of 0.6mm, 1.18mm and 2.36mm are shown in Figure 1 with the respective composition of 100-220g of blackdate seed shells. Particulate composite samples with particle size of 2.36mm had the highest density compared to those produced with particle size of 0.6mm and 1.18mm at composition weight of 220g. This was expected, as the only contributing factor to the weight is the seed shell, therefore the higher the particle size and weight used the heavier the weight of the material produced. However, for the 1.18mm sample, it was not really understood what could have happened, except to speculate that probably, there wasn't proper compaction done between 180g and 220g. Shehu et al (2014) observed that as the particle size increases, the density values also increased for palm kernel shell and compares favourably with the densities of saw dust particle sizes and those of coconut shell. All these particulates mentioned are of the plant origin, similar to the blackdate.

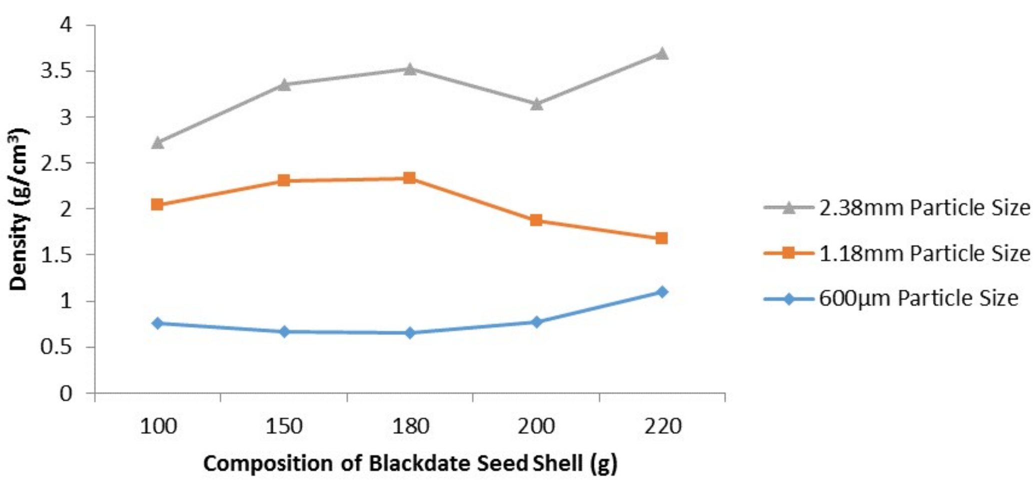

Figure 1: Effect of Composition of Blackdate Seed Shell on Density of Composite material

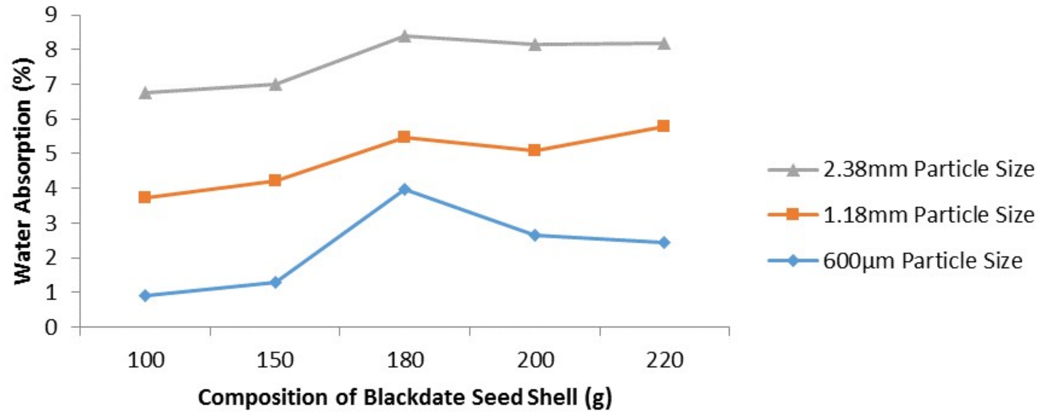

Figure 2: Effect of Composition of Blackdate Seed Shell on Water Absorption of Composite material

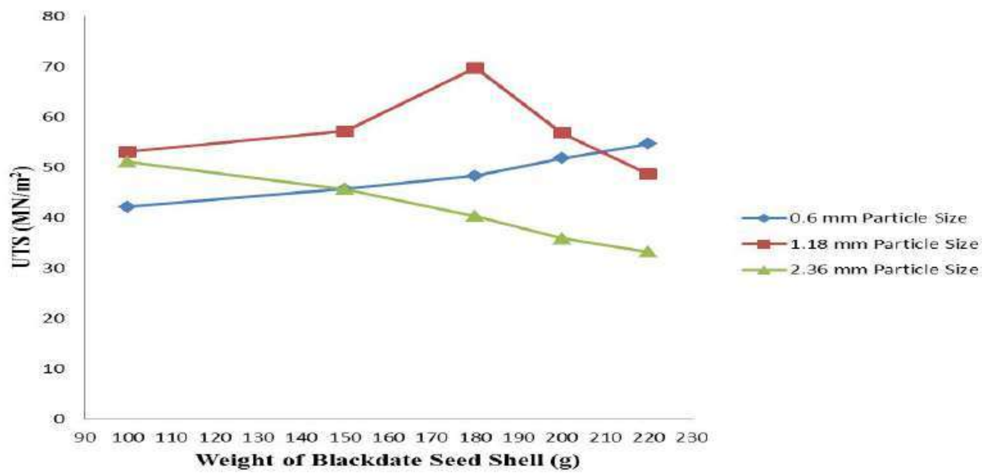

Figure 3: Effect of Composition of Blackdate Seed Shell on Tensile Strength (UTS) of Composite Material

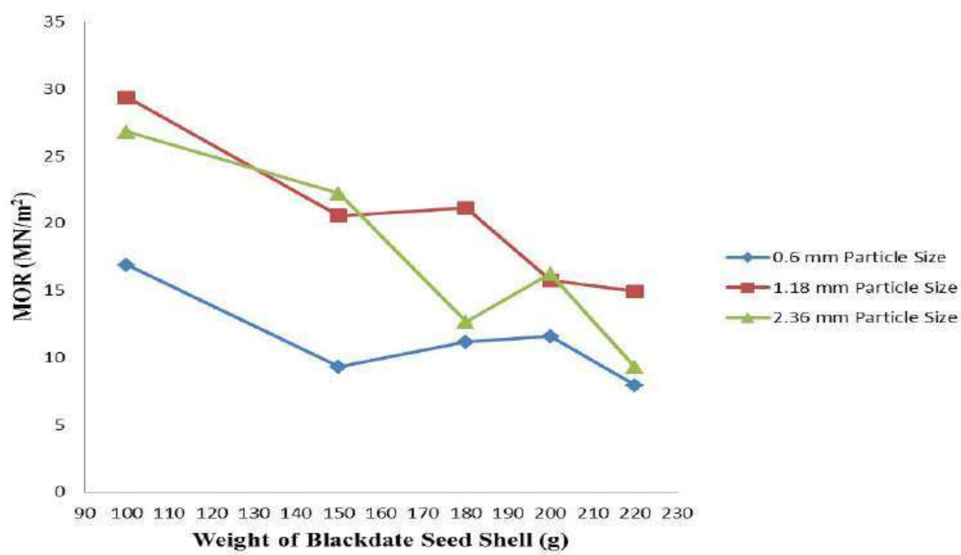

Figure 4: Effect of Composition of Blackdate Seed Shell on Modulus of Rupture (MOR) of Composite Material

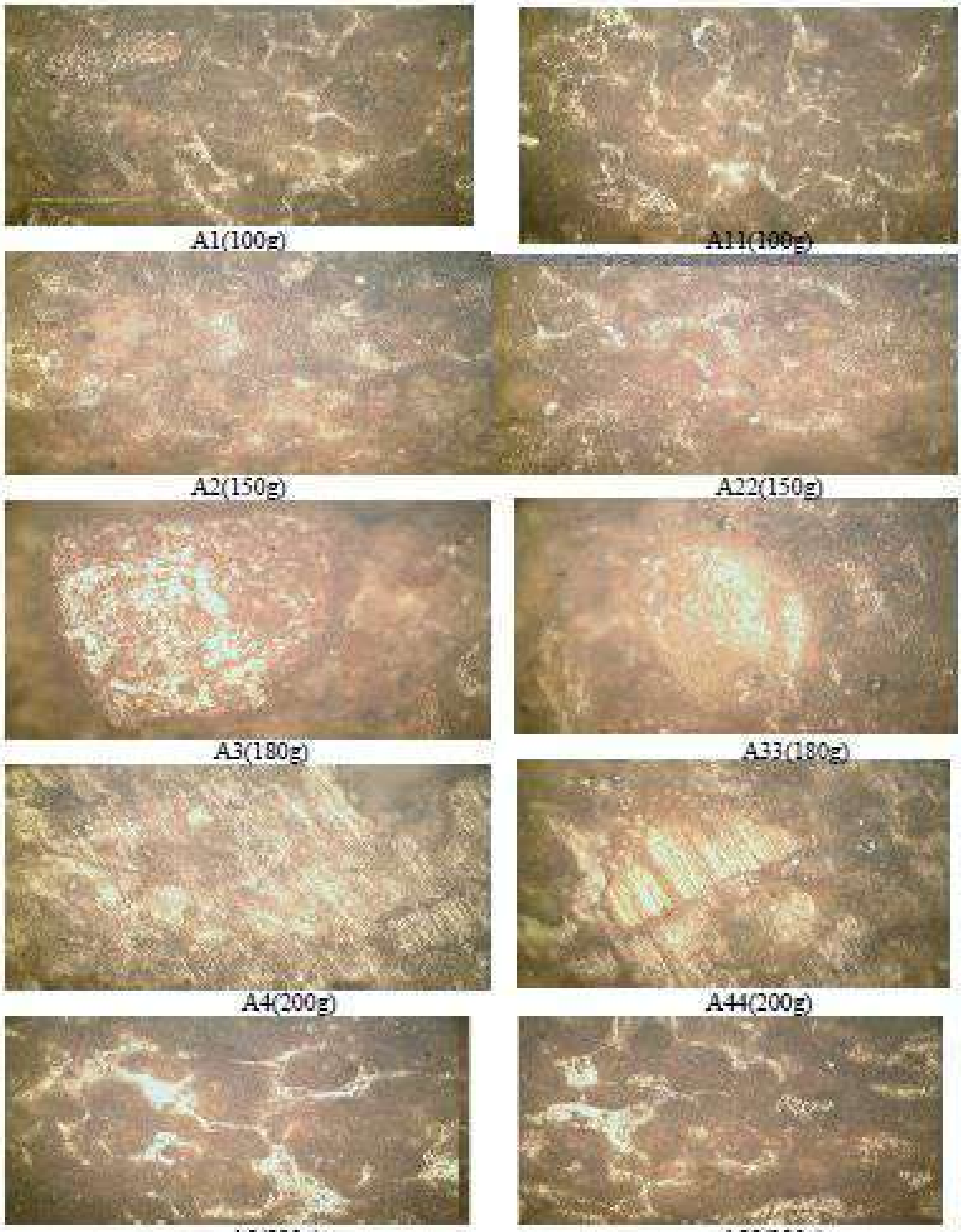

Figure 5: - Photomicrograph for 0.6mm particle size with 200X magnification

Figure 6:- Photomicrograph for 1.18mm particle size with 200X magnification

Figure 7: Photomicrograph for 2.36mm particle size with 200X magnification

Figure 8: Photomicrograph of Pure Polyester Composite Sample with 200X magnification

Figure 2 indicated the water absorption test results obtained for the particulate composite material produced from particle size of 0.6mm, 1.18mm and 2.36mm with the respective composition of 100-220g of Atili (blackdate) seed shells. Particulate composite samples produced with 0.6mm particle size and composition weight of 100g absorbed less water as shown by result in Figure 2. The smaller the particle sizes, the more closely packed and less void; except for the sharp rise at 180g for the 0.6mm particle which looked contrary. Probably error occurred and more voidage opened resulting in more water occupation.

Figure 3 indicated the tensile strength test results (as indicated by its ultimate tensile strength) obtained for the particulate composite material samples produced from Atili (blackdate) seed shells. The particulate composite samples produced from 0.6mm showed lower tensile strength (TS) compared to that of the 1.18mm. Comparing the effect of particle size on the tensile strength, it was observed that the particle size of 0.6 mm had its highest tensile strength of 54.67 MN/m^2 at 220g composition, and the least tensile strength of 42.15 MN/m^2 at 100g composition. The tensile strength of the particulate composite material produced from particle size of 1.18mm was found to increase with increase in filler content with the highest value of 69.95MN/m^2 at 180g composition after which the tensile strength starts to drop. The least tensile strength with a value of 35.92MN/m^2 was recorded at 2.36mm particle size with 200g weight composition. It can be observed that the polyester reduces the filler – filler interaction and thereby increase the tensile strength of the composite materials. Nwanonenyi et al (2013) observed that stiffness of composite is improved on addition of filler and thereby enhances the properties of the matrix. The composition weight ratio of the filler to polymer based matrix is an important factor to be considered in order to ensure the filler actually performs its function of modifying the mechanical properties of the polyester resin.

Figure 4 indicates the Modulus of Rupture (MOR) test results obtained for the particulate composite samples produced from Atili (blackdate) seed shells with respect to composition i.e. 100-200g. Particulate composite samples produced from 1.18mm showed better strength properties compared to those produced from 2.36mm and 0.6mm under the same Atili (blackdate) seed shells composition. This may be attributed to the fact that particles are effective in enhancing the stiffness of the composites but do not offer the potential for much strengthening. It was observed that the MOR of the samples produced in Figure 4 decreased as the composition of Atili (blackdate) seed shell weight increased. The particle size of 1.18mm with composition weight of 100g had the highest MOR value of 29.385MN/m^2, and the least value was recorded at 0.6mm particle size with composition weight of 100g. Here, it can be observed that the MOR value does not follow the trend that says voids between particles are occupied by smaller particle give rise to minimum void volume for maximum packing of polymer – filler in the composite. This deviation may be attributed to the nature of the Atili (blackdate) seed shell.

Figures 5, 6, and 7 shows the photomicrograph for 0.6 mm, 1.18 mm and 2.36 mm particle sizes respectively with 200X magnifications, and also with respect to the compositions. These Figures indicate the deviation in the properties of the particulate composite material samples produced from the pure polyester composite and as seen from the photomicrograph, which shows the structures of the samples and this can be said to attribute to their change in mechanical properties of the particulate composite materials. Those white-spotted portions on the photomicrograph simply represent improper interaction between the particles and poly-ester as a result of improper mixing. Figure 8 show a photomicrograph of pure polyester composite sample with 200X magnification. It can be seen as plain without the Blackdate particles.

Based on the result obtained in this research work, the properties of the polyester resin were modified under the aforementioned conditions as discussed above, though, quantitatively, no comparison could be made to the values obtained from literature as no exact work has been carried out i.e. under the same experimented conditions.

5.0 CONCLUSIONS

Based on the results obtained from the analysis of the samples produced from this research work, the following conclusions can be validly made:

The particulate composite material from 2.36mm had higher density compared to that from 0.6mm and 1.18mm produced under the same set of conditions; hence, for applications requiring high density materials, composite samples produced from 2.36mm is preferable.

The particulate composite material from 0.6mm had better water resisting ability and dimensional stability compared to that from 1.18mm and 2.36mm produced under the same set of conditions, hence, for applications requiring material usage in humid areas, composite samples produced from 0.6mm particle size is preferable.

The particulate composite material from 1.18mm had better strength properties compared to that from 0.6mm and 2.36mm produced under the same set of condition; hence, for applications requiring high stress-withstanding or tough material, composite produced from 1.18mm is preferable.

In addition, better properties were observed for particle size of 0.6mm and 1.18mm; hence, the lower particle size of the samples, the better the particulate composite material produced.

Finally, the properties of the particulate composite materials produced conformed to the properties of embossed particles; hence, they will be suitable for applications such as: door panels, circuit board, architectural paneling, cabinet wainscots, roofing tiles, display unit and various decorative designs.

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