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COMPARATIVE ANALYSIS OF SELECTED PROPERTIES OF SUNDRIED COCONUT HUSK AND SHELL

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ABSTRACT

Coconut shell and husk are farm byproducts from processed seeds of coconut palm trees. They are produced in large quantities with very little usage thereby causing pollution and environmental hazards to the communities. Thus, this research investigated and compared physical and mechanical properties of both coconut shell and husk. The two farm byproducts were collected from different dumping sites, sorted, sundried, grinded, sieved and mixed with epoxy resin and hardener in ratio 2:1. The mixtures were preheated at 120 ^{0}C for 2 minutes, pressed under 5 MPa for 2 minutes and cured at 100 ^{0}C for 3 minutes. Three samples each from the two composites were subjected to various mechanical tests. Coconut husk showed higher moisture content with a value of 45.83% than coconut shell (17.5%). The mechanical properties investigated were; compressive strength with values of 27.87 MPa and 26.8 MPa, hardness (4.58 BHN and 3.51 BHN), impact (7.58 J and 7.59 J) for coconut shell and husk, respectively. Conclusively, coconut shell and husks can be used as reinforcements and fillers whenever the strength ranges obtained from the experiments are required. Moreover, they can be substituted for other materials in the mixture of concrete and polymers especially; pet bottles, polythene bags, plastics and others waste materials, which are capable of standing as matrix in matrix-fibre composites.

KEYWORDS: Coconut shell, Coconut husk, Moisture content, Mechanical properties.

1.0 INTRODUCTION

Coconut husks and shells are natural fibres from the seeds of coconut palm tree; one of the most valuable plants in the world. The trees are cultivated in large quantities at the tropical region where they most flourish. They are known for the production of; coconut water, coconut milk, coconut oil and many other products. The rate of consumption of coconut seeds is very high due to its numerous values which invariably resulted to high generation of waste from the various processes. Coconut shells and husk are mostly abandoned on the farms after harvest (Processed) or fired into the atmosphere without any consideration to their host communities. Their disposal has caused and still causing various degrees of environment hazards and with continuous development of countries and urbanization; the generations of wastes are increasing excessively. They are known biomass wastes which are indiscriminately dumped around the coastal region of most countries with little usage despite their enormous potential as energy source (Qingyue and Jayanto 2018). These wastes are known to be very hazardous and cause air pollution when fired. However, environmental awareness and studies of natural fiber reinforced polymer composite have trigged an enormous interest in utilization of natural fibre as environmental friendly and sustainable materials. In essence, the need for agricultural wastes management has prompted researchers all over the world to focus on ways of utilizing the wastes as a source of raw materials for the industry. These wastes utilization would not only be economical, but may also result to foreign exchange earnings and environmental pollution control. The volume and the number of applications of these agricultural wastes in composite materials have grown steadily, penetrating and conquering new market relentlessly (Dagwa and Ibhadode, 2005).

Moreover, there are many advantages associated with the use of natural fibres which includes; low cost, abundance, low density, high specific properties and lack of residues upon incineration. Composite like coconut shell and husk are increasingly used in place of metals in a wide range of structural application in the aerospace, construction and automotive industries due to their light weight and high specific stiffness and strength (Bledzki and Gassan, 1999). Many investigations have been carried out on different properties of coconut shells and applications which are as described. Harish *et al.* (2009) studied the tensile, flexural properties of coir fiber reinforced epoxy composite and the results revealed that coir fibre can be used for medium load applications. Sapuan *et al.* (2003) investigated the tensile and flexural properties of epoxy-coconut shell filler at different filler contents, viz; 5%, 10% and 15% and the results showed that; tensile, elastic modulus and flexural properties increased with increased in the filler contents. Mustapha (2011) investigated the properties of coconut shell in polyester composite and the result revealed that tensile strength, young modulus and water absorption increased with increased in coconut fibres with reduction in the elongation of breaking. The morphology and mechanical properties of coconut shell reinforced polyethylene composite were also investigated by Olumuyiwa and Talabi, (2012). This was achieved by adding coconut shell with low density polyethylene matrix (5% - 25% volume fraction coconut shell particles) and the mechanical properties of the composites produced were determined. The result shows that the hardness of the composite increased with increase in coconut shell contents though the tensile strength, modulus of elasticity, impact energy and ductility decreased with increased in the particle contents. Vinjayaram (2013) reported that tensile and flexural strength of epoxy coconut filler composite were affected by the filler composition. The results stated that; tensile, flexural and compressive strength increased with increased in the fibre composition. Bhaskar and Sigh (2013) also investigated the water absorption and compressive strength of coconut shell particles with epoxy composite (weight composition of coconut shell in the mixture was varied from 20%, 25%, 30% to 35%). The results showed that; water absorption increased with increased in fibre composition, while composite with 30% coconut shell showed a very good ultimate strength and modulus of elasticity in compressive strength. Invariably, there have been many extensive investigations on coconut shell fibre but little with the husk, thus, the need for investigating the properties of coconut husk cannot be under estimated.

2.0 MATERIALS AND METHOD

2.1 Materials

The materials used for this investigation were; coconut shells, coconut husks and epoxy resin with hardener. The equipment used include; weighing balance, electric sieves shaker, plate milling machine, manual press. moulds, furnace and the testing apparatus.

2.2 Methods

The coconut shells (Figure 2.1 (a and b)) were collected from a dumped site at Sango market in Ibadan, Oyo State while the husks (Figure2.2) were gotten from a coconut farm in Abeokuta, Ogun State. The coconut shells were thoroughly sorted to remove every dirty inclusion and unwanted substances, while the hard covering skins of the coconut husks were carefully removed with a cutlass. The two samples were later chopped into smaller pieces to create more surface exposure to sunrays for drying uniformity. They were weighed individually and spread for days until fixed weight were achieved. The dried coconut shell and husks were grinded with a plate milling machine and sieved into different particle sizes with an electric sievesshaker. Powder metallurgy was employed for the production of the coconut shell and husk composite (Adeyemi *et al.*, 2016; Deepika *et al.*, 2013). At the commencement of the experiment, 60.0 g of 180 µm particle sizes of coconut shells were added to a mixture of epoxy resin and hardener of ratio 2:1 and thoroughly stirred to obtain a homogeneous mixture. Curing was done at specified temperature and time; pre-heating temperature was maintained at 120^{0}C and post-heating at 100 ^{0}C for 2 and 3 minutes, respectively. After the pre-heating, 30.0 g of the mixture was poured into mould, pressed with 5 MPa and allowed to stand under the press for 2 minutes (Plate 2.3). The molded composites were carefully removed and placed in an oven for post-heat treatment at 100 ^{0}C for 3 minutes and allowed to cool in air for several days. The same procedure was repeated with coconut husks.

Plate 2.1(a): Coconut shell.

Plate 2.1(b): Coconut shell particles.

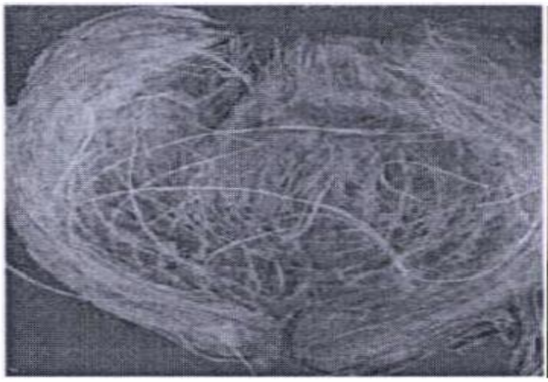

Plate 2.2: Coconut husk.

Plate 2.3: Pressing operation.

2.3 Test analysis

The following experiments were conducted on the samples of the coconut shells and husks composites.

2.3.1 Moisture content

The coconut shells and husks were weighed individually to determine the initial weight before being sun-dried. Sun-drying was repeated for two weeks until a constant weight was achieved. The moisture content of each of the samples was computed using equation 3.1;

$$\%\ \text{moisture content} = \left(\frac{G_2 - G_1}{G_1}\right) \times 100 \quad 3.1$$

Where: G_1= Initial weight of particles

G_2= Final weight after sun drying

2.3.2 Compressive strength

The compressive strength test was carried out in accordance with ASTM D695. Three test specimens (20mm x 20mm x 20mm) were centered flat wise on the lower hardened stainless-steel plate of an INSTRON universal testing machine Model 3369K1781 with a load capacity of 50 kN from a movable cross-head and a test rate of 2 mm/min until failure occurred. The results were analyzed by in-built Blue Hill Protus software.

2.3.3 Hardness

The hardness of each of the composites was carried out in accordance with ASTM E10-18 using Brinell Hardness Tester. Three gauge-sized (20 mm x 20 mm x 20 mm) of each of the samples was used for Hardness test. The Brinell hardness (BHN) is the pressure per unit surface area of the indentation in kg per square meter was then calculated with equation 3.2;

$$BHN = \frac{W}{\frac{\pi D}{2}\left(D - \sqrt{D^2 - d^2}\right)} \quad 3.2$$

Where; W = Load on indenter (kg).

D = Diameter of steel ball (mm).

d = Average measured diameter of indentation (mm).

2.3.4 Impact strength

The impact strength was carried out in accordance with ASTM D 256-06 using Izod Impact (Notched) tester. Three samples (64 mm x 13 mm x 3 mm) specimen of each of the samples were used for this test.

3.0 RESULTS AND DISCUSSION

3.1 Moisture content

The results of the moisture contents of coconut shell and husk are as shown in Table 3.1. The higher moisture content was obtained from coconut husk with a value of 45.83 % while coconut shell has a value of 17.5%.

Table 3.1: Moisture Contents of Coconut Shell and Husk.

S/No	Sample	Initial Weight (kg)	Final Weight (kg)	Weight of Water Lost (kg)	Moisture Content (%)
1	Coconut Shell	4	3.3	0.7	17.5
2	Coconut Husk	2.4	1.3	1.1	45.83333

3.2 Compressive Strength

The results of the compressive strength are as illustrated in figure 3.1 with an average value of 27.87 MPa and 26.8 MPa for coconut shell and husk respectively. Coconut shell is higher in compression than coconut husk with 1.07 MPa difference. However, the two samples can be used in alternative to one another when required for reinforcement or fillers with compressive strength range between 26.8 – 27.87 MPa.

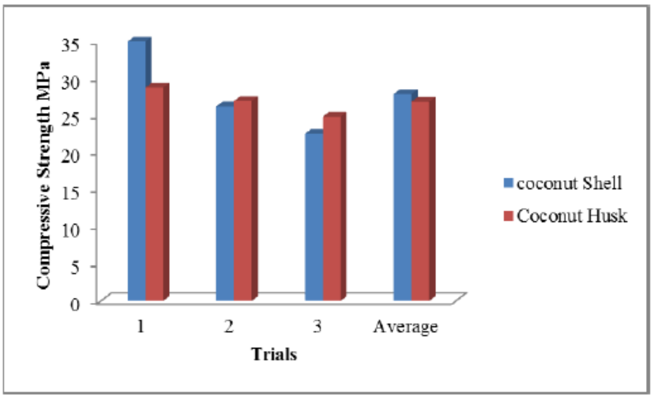

Figure 3.1: Compressive Strength of Coconut Shell and Husk.

3.3 Hardness

The results of the hardness test are as illustrated in figure 3.2. An average value of 3.51 BHN was obtained from coconut husk while 4.58 BHN was obtained from coconut shell. Coconut shell composite is higher in hardness than the coconut husk with 1.07 MPa, however, the husk particles could be used as replacement for the shell when hardness of 3.51 BHN or lower is required.

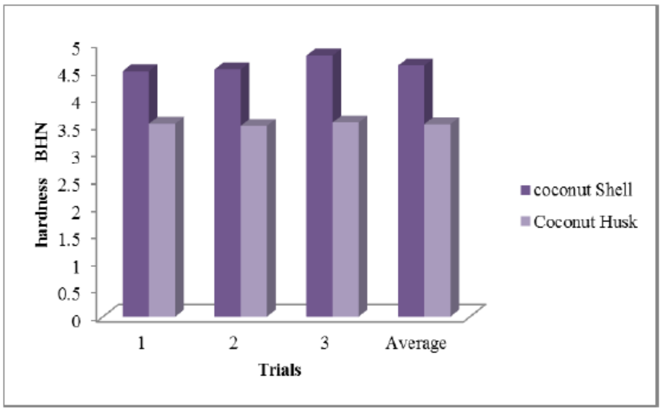

Figure 3.2: Hardness of Coconut Shell and Husk.

3.4 Impact strength

The results of impact energy investigation are illustrated in figure 3.3. An average value of 7.58 J was obtained from coconut husk while 7.59J was obtained from coconut shell. The two samples have almost equal values, although, coconut shell has a greater value with 0.1 J which could be negligible when considering reinforcement with coconut husk particles and impact strength of 7.59 J.

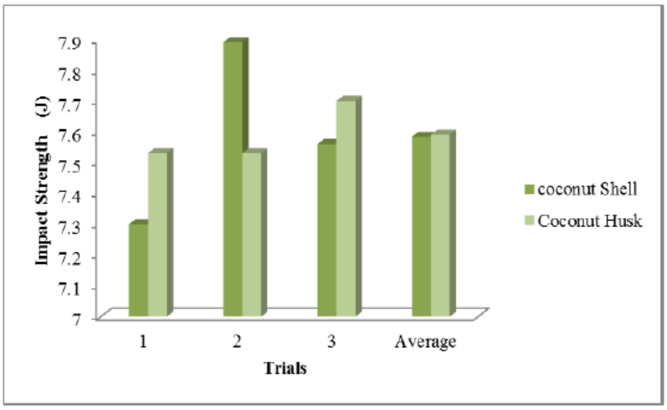

Figure 3.3: The Graph of Impact Energy of Coconut Shell and Husk.

4.0 CONCLUSION

The mechanical properties of both coconut shell and husk competed favorably with one another with little variations but there was a wide variation in their moisture contents. Conversely, coconut shell is better in hardness and compressive strength than the husk; properties which might be required when high strengths are needed. Conclusively, coconut husk can be used in place of the shell for reinforcement and fillers which might require the ranges of the above values. It could also be used for indoors composite structure where humidity and exposure to moist can be controlled but might not be suitable for outdoor purposes. The two materials could also be used for concrete and polymer reinforcements where pet bottles and polythene wastes can be melted to serve as matrix in a matrix-fillers composite.

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