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Development of Epoxy Resin Composite Reinforced With Cow Horn and Cassava Particles for Car Dashboard

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A B S T R A C T

The development of composites from agro-based products is increasingly becoming popular in the field of materials processing. This has a number of benefits including improved economy, wealth creation from agro-wastes, and lighter weight of the developed composites. This work aims at developing cow horn - cassava peel particles reinforced epoxy resin composites using varying compositions of the reinforced particles. The basic production method employed is powder metallurgy process. This involved the preparation of the particles, mixing of the constituents in different ratio for particles compaction, and casting of the mixture. The microstructure of the developed composite was examined using optical microscopy. Thereafter, the hardness, tensile and flexural properties of the developed composites were investigated using Indenter digital hardness testing machine, and Instron universal testing machine. The result shows that the hardness increased as the amount of the cow horn particle increased giving a maximum of 55.2 HV at a composition of 4% cow horn: 6% cassava peel: 90% epoxy resin of the composites. The tensile strength increased as the amount of the cow horn particle increased giving a maximum of 26.7 MPa at a composition of 4% cow horn: 6% cassava peel: 90% epoxy resin of the composites. The flexural increased as the amount of the cow horn particle increased giving a maximum of 122 MPa at a composition of 4% cow horn: 6% cassava peel: 90% epoxy resin of the composites. The two size ranges of the reinforced particles used in this work has a negligible effect on the hardness, tensile and flexural properties of the composites. The mechanical properties of the composite are in the range of values suitable for the making of car dashboard.

1. Introduction

The use of composites materials in the automotive and aerospace industries is increasingly gaining more attention. Some of the major reasons for their selections are the high strength to weight ratio, design flexibility and cheaper cost which provide the manufacturers in these industries edges in the keenly competitive market (Abilash and Sivapragash, 2013). For example, composites have been established as the second most common class of automotive materials after ferrous metals and alloys (Szeteiova, 2010).

Composites comprise of one or more discontinuous phase (i.e. reinforcement) embedded in a continuous phase (i.e. matrix) whose combination produces aggregate properties different from those of the constituents. The matrix is softer and is usually metals, alloys and plastic.

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The reinforcement which provides the strength exists in form of particle, fibre, flake and laminar. Plastic composites reinforced with fibre and particles have been extensively applied in the industries including aerospace and automobile. For example, fractured and heeled rice husks fibre reinforced polypropylene composites has been developed for car door component (Odhong et al., 2016). According to Holbery and Houston (2006), automobile parts including car dashboard, seat backs and door panels are now being made with polymer composites reinforced with natural occurring fibres such as kenaf, hemp, flax, jute, and sisal. It was further reported that the tensile and impact strength and surface finish of the composites are key to the suitability of the composites for the target applications. However, the use of fibre as the reinforcement has more applications because of its extremely lighter weight compared with the particles.

Plastic composites reinforced with particles including glass, carbides, sand, etc. are believed to be cheaper and have increased strength compared with the fibre (Birman et al., 2013).

Due to these reasons, more attention is increasingly being shifted to the particle-reinforced plastic composites. Development of bone ash and bone particulate reinforced polyester composites for biomedical applications has been researched by Oladele (2013). The results show that the materials are compatible and the composites shows improved tensile and flexural strength. The mechanical properties of basalt particle-flilled sheet moulding compound (SMC) composites have been a subject of investigation by Cavdar and Bingol (2016). It was found that the basalt composite compared with the CaCO3 fillers reinforced SMC composite gave 15% increase in tensile strength and 8% increase in flexural strength. However, the development of composites for automotive applications using agro-product as the particle reinforcement has not been well researched.

In this work, cow horn and cassava peel particles reinforced epoxy resin composites was developed. The composites were prepared via casting method at varying compositions of the reinforced particles. The hardness, tensile and flexural properties of the developed composites at varying compositions was investigated.

\2. Materials and Method

2.1 *Materials*

The materials used for this research include cow horn particles, cassava peels particles, and epoxy resin. The cow horns and cassava peels were obtained from Oyigbo market abattoir in Lagos and Federal Institute of Industrial Research, Oshodi, Lagos, respectively. The materials were chemically analysed and the compositions for cow horn and cassava peel are given in Table 1. The two materials were thoroughly washed and cleaned with soapy water so as to remove all surface dirt. The materials were sun-dried for 7 days. Thereafter, the cow horns were further dried in an industrial oven operating at ~100°C temperature before crushing and milling. Fig.1a and 1b show the pictures of the cow horns and cassava peels after drying. The epoxy resin which served as the binder was purchased from Goddy Chemical Venture Nigeria Limited, Lagos, Nigeria.

2.2 *Reinforcement particles preparation*

The dried materials were crushed and milled into particles one after the other. Thereafter, the particles were sieved using an automatic sieve shaker machine. The size of the mesh is < 150 μm indicating that the size range of both the cassava peel and cow horn particles are < 150 μm. Fig. 1c and 1d shows the pictures of the reinforced particles.

2.3 *Composite processing*

The epoxy resin, cassava peel particles and cow horn particles were weighed using an electronic weighing machine. The three materials were thoroughly mixed and prepared in varying compositions as given in Table 2. The percentage compositions of the reinforced particles were varied while that of the binder (including the hardener) was maintained at 90%. Six different compositions giving six samples were prepared.

Immediately after mixing, the mixed composite samples were cast into different shapes, as shown in Fig. 2.

Table 1: Chemical analysis showing the level of detection (%) of various constituents present in the cow horn and cassava peel powder

S/N	Parameter	Level of Detection (%)	
		cassava peel	cow horn
1	SiO_2	31.85	42.6
2	Al_2O_3	5.72	2.34
3	Fe_2O_3	1.96	0.27
4	CaO	6.88	18.54
5	MgO	2.46	4.12
6	Na_2O	0.97	0.43
7	K_2O	15.92	1.51
8	SO_3	0.89	0.42
9	Moisture(%)	0.006	0.01
10	L.O.I(%)	1.52	0.12

Fig 1: Pictures show the (a) dried cow horn, (b) dried cassava peels, (c) crushed particles of dried cow horns and (d) crushed particles of dried cassava peels

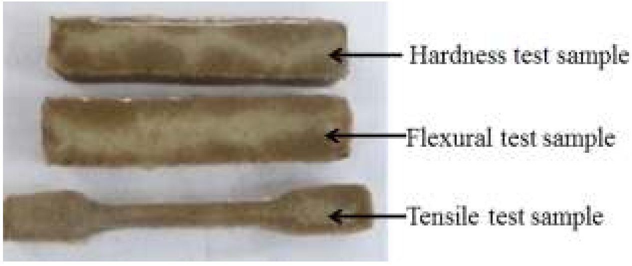

Fig. 2: Cast composite samples

Fig. 3: Samples of the developed cow horn and cassava peel particles reinforced epoxy resin composites

Table 2: The varying compositions of the prepared composite samples (in gram)

S/N	INGREDIENT	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F
1	Cow Horn	10	8	6	4	2	0
2	Cassava Peel	0	2	4	6	8	10
3	Epoxy Resin	90	90	90	90	90	90

2.4 *Microstructural examination*

The cast composite samples were cross-sectioned, ground and viewed using Nikon Eclipse ME600 optical microscopy. This was done so as to examine the microstructural structure of the cast specimens at various compositions.

2.5 *Hardness test*

Macro-hardness tests were conducted on the ground and polished surface of the composite samples using an Indentec digital hardness testing machine with a load of 20 Kg applied for 15 seconds. This was carried following the ASTM D785 procedures. The indentations were made randomly on the surface of each sample. The measurements (at least 5) were adequately spaced from each other in order to avoid any influence between them due to the cold-work hardened area. The test was carried out in the Materials and Metallurgical laboratory of Federal University of Technology, Akure (FUTA), Ondo State, Nigeria.

2.6 *Tensile test*

The tensile testing was carried out at Engineering Materials Development Institute (EMDI), Akure using an Instron universal testing machine operating at a cross head speed of 10 mm/min. The tensile test specimen preparation and testing procedures were conducted using the ASTM D3039 standard as recommended for the polymer matrix composites. Each tensile specimen was positioned in the Instron universal tester and then subjected to increasing tensile loads until the specimen fractured. Graphs of tensile stress versus tensile strain were plotted automatically by the tester for all the tested samples.

2.7 *Flexural test*

The flexural test specimen and test was done following the ASTM D7264 procedures. Similar equipment used for the tensile test was utilised. Each flexural specimen was positioned in the Instron universal tester and then subjected to flexural load until fracture occurred. Graphs of flexural stress versus flexural strain was plotted automatically by the tester and various property of the specimen determined.

3. Results and Discussion

3.1 *Quality of the cast composites*

Fig. 3 shows some of the cow horn and cassava peel particles reinforced epoxy resin composites developed at varying compositions of the particles. The visual observation revealed that the composites are of good surface roughness and dimensional accuracy. The composites are well bonded therefore showing some reasonable strength and hardness. There is no visible crack and pore on the surface of the developed (i.e. cast) composites. This is an indication that the reinforced particles and the epoxy resin were strongly compacted during casting.

3.2 *The microstructure of the composite*

Fig. 4 shows the optical micrographs taking along the cross sections of the developed composites. The particles are dispersed randomly within the epoxy resin which acts as the matrix. The microstructure is to look at the grain size in the material and how it form. The study of the samples revealed a uniform distribution of the cow horn, cassava peel particle and the resin. Distributions of the particles are also influenced by good bonding of the resin and the cow horn – cassava peel particles which resulted in good interfacial bonding.

3.3 *Hardness of the composite*

The macro-hardness of the composites was obtained by making indentations on their respective surfaces. The results presented in the Fig. 5 are averages of 5 indentations made randomly on the surface of each composite.

The result presented in Fig 5 shows that cow horn particles has a more significant effect on the hardness of the developed composite compared with cassava peels particles. This can be attributed to the hardness and rigidity of the cow horn particles.

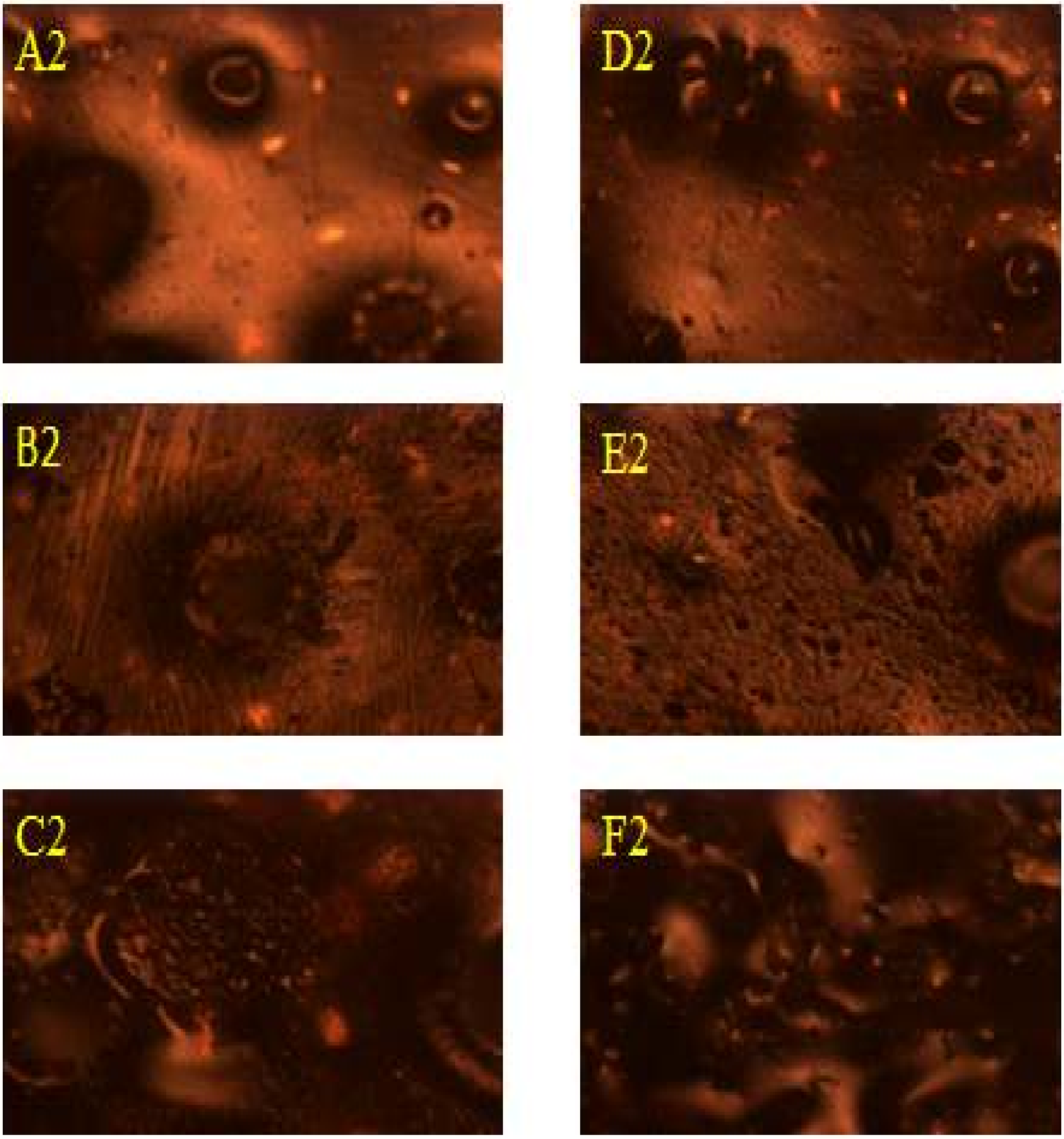

Fig . 4 : Optical micrographs of the cross - sectional area of the cow horn and cassava peel particles reinforced epoxy resin composites at varying particles compositions

3.4 Tensile strength of the composites

The tensile strength of the composite was obtained by carrying out tensile test on the specimens. The results presented in the Fig. 6 shows the averages of 3 results for each specimen. It is evident that the maximum tensile strength (26.4 ± 2.4 MPa) was obtained when the composition of cow horn particles and the cassava peel particles are 6% and 4%. The lowest range of values were obtained when the reinforced particles is 10% cow horn particles and 0% cassava peel particles (11.5 ± 0.6 MPa), and when it is 0% cow horn particles and 10% cassava peel (6.8 ± 1.3 Mpa).

The result, as presented in Fig. 6, indicates that an almost equal composition of the cow horn particles and the cassava peel particles gives the optimal reinforcement to the developed composite. According to Sapuan et al. (2011), naturally occurring Kenaf fibre reinforced polymer composites with varying compositions of reinforcement exhibited tensile properties ranging between 25 -110 MPa and was proved suitable for making car dashboard. The result obtained in this work shows that the optimum tensile property is within the range therefore, making it suitable for the making of car dashboard.

3.5 Flexural strength of the composites

The flexural strength of the composite was obtained by carrying out flexural test on the specimens. The results presented in the Fig. 7 shows the averages of 3 results for each specimen. A maximum flexural strength of 120.67 MPa was obtained when the composition of cow horn particles and the cassava peel particles are 4% and 6% respectively. Similar to the tensile strength result, nearly equal proportions of the cow horn and cassava peel particles are required to obtain the optimal value for the flexural strength of the composite.

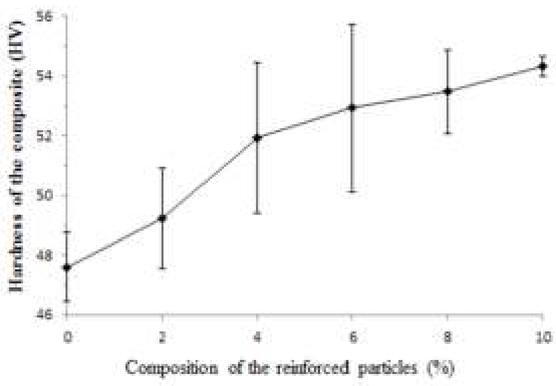

Fig. 5 The variation of the hardness with the compositions of particles reinforced composite

4. Conclusion

The cow horn–cassava peel particles reinforced composites have been developed. The following conclusion can be drawn.

(i) The varying composition of the reinforced particles (i.e cow horn and cassava peel particles) has significant effect on the hardness, tensile strength and flexural strength of the composites.

(ii) The optimal hardness (55.2HV) was obtained when the cow horn / cassava peel / epoxy resin composition is in the ratio 10%:0%:90%. The lowest value (46.1HV) was obtained when the cow horn / cassava peel / epoxy resin composition is in the ratio 0%:10%:90%.

(iii) The maximum tensile strength occurred at the composition of 4%:6%:90% (26.4MPa). The lowest value (6.7MPa) was obtained when the cow horn / cassava peel / epoxy resin composition is in the ratio 0%:10%:90%.

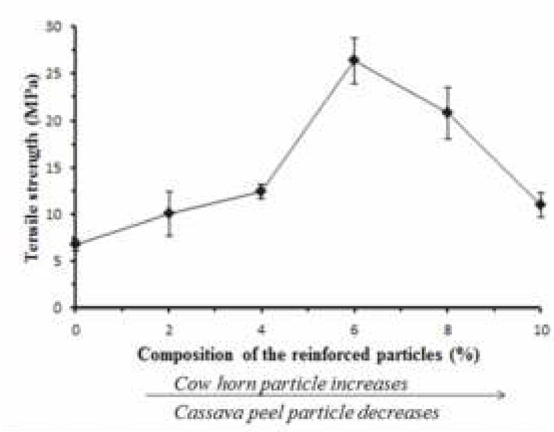

Fig. 6: The tensile strengths of the cow horn–cassava peel particles reinforced composite at varying compositions of the reinforced particles

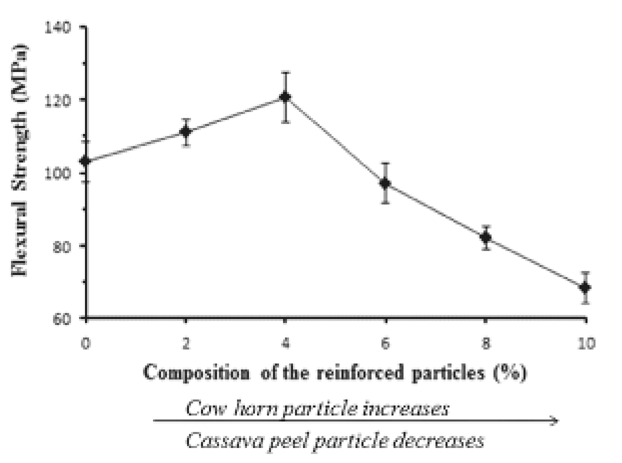

Fig. 7 The flexural strengths of the cow horn–cassava peel particles reinforced composite at varying compositions of the reinforced particles

(iv) The highest value of the flexural strength occurred at (120.7 MPa) when the cow horn / cassava peel / epoxy resin composition is in the ratio 4%:6%:90%. Nearly equal proportions of the two reinforced particles are needed for optimal flexural strength.

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