Property Evaluation of Sea shell Filler Reinforced Unsaturated Polyester Composite

Abiodun Ademola Odusanya, Babatunde Bolasodun, Chioma Ifeyinwa Madueke

Abstract - The objective of this study is to determine the mechanical properties as well as water absorption characteristics of unsaturated polyester composite reinforced with varying weight fractions of sea shell with an aim of finding the composite with optimum mechanical properties. Ground sea shell of particle size 250 microns was introduced at different percentages into the unsaturated polyester resin. Mechanical tests which include: tensile, flexural, impact, hardness tests were carried out on the prepared composite samples. Water absorption test was also carried out on the samples. The tensile test specimen preparation and testing procedures were conducted in accordance with the ASTM. The results showed the flexural strength of the composite with 10wt% seashell particulate reinforcement to be largely improved also the hardness and impact properties were greatly improved at10wt% sea shell filler loading. This composite could therefore be considered for applications where flexural properties, impact and hardness properties are of utmost concern.

Index terms: Composite, flexural, reinforcement, seashell, tensile, specimen, unsaturated polyester.

Introduction:

Nowadays, polymer composites play an important role in polymer industries and engineers always keep on searching for the best material which will be cost effective that will suit certain design and product requirement. One of the key factors which make plastics attractive for engineering applications is the possibility of property enhancement through fibre reinforcement [1]. Also, since the environmental awareness is growing significantly, one of the important factors to be considered in recent development of high performance materials is ecologically friendliness, that is materials with minimum effect on environment and this can be achieved by using renewable, recyclable, and biodegradable resources. Consequently in recent years, researchers have been investigating on these types of materials as potential fillers (reinforcing or non-reinforcing) in a polymer composite system. Although many studies have been carried out on composites, ranging from metal matrix composites, ceramic matrix composites and polymer matrix composites in developed countries , but only few work has been done on polymeric composites reinforced with natural fibres or fillers here in Nigeria. In the development of polyester/eggshell particulate composites, results showed that the density and hardness values of the composite increased steadily with increasing eggshell addition [2]. In using fibreglass wastes as reinforcement of polyester matrix composites, incorporation of the wastes in the composites enhanced considerably the mechanical properties such as tensile modulus and impact strength [3]. In the study of the tensile behaviour and hardness of coconut fibre-ortho unsaturated polyester composites, the results showed that the tensile properties at 10wt% fibre loading were greatly enhanced [4]. Unsaturated polyesters have good freeze-thaw resistance and can be designed for use in many low to moderate temperature applications ranging from refrigerated enclosures to hot water geysers [5]. In the study of the effect of kaolin powder into unsaturated polyester matrix to prepare particulate composite, results showed that kaolin improved the compression strength, improved the flexural modulus, increased the flexural strength, and improved the impact strength and also the hardness of unsaturated polyester [6]. In the study of the effect of recycled copper in the electrical, mechanical and thermal stability properties of the polyester composites results revealed that the hardness of composites increased with increasing amount of filler. It was also observed that increasing the amount of

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recycled copper has led to a decrease in flexural strength and a corresponding increase in flexural modulus [7]. The characteristics of unsaturated polyester resin proved extremely appealing to such markets as automotive, marine, corrosion-resistant structures, building, electrical applications, and consumer goods such as luggage, fishing poles and cases and housings of every type and description [8].The main function of the reinforcement is to enhance or improve the mechanical properties of the matrix. In most cases the reinforcement is harder, stronger, and stiffer than the matrix [9]. It is known that the mechanical properties of fibre reinforced composites among others, depends to a large extent in the fibre content variations [10, 11]

Polyester fibres have high tenacity and E-modulus as well as low water absorption and minimal shrinkage in comparison with other industrial fibres [12]. It is therefore necessary to embark on this research which will help the materials engineer develop better polymeric composites that will replace some of the materials used in the above mentioned sectors of the industry. Hence, there are needs on the study of polymer composites by incorporation of various types of fillers, especially natural fillers in the development of high performance polymer composites. This project is aimed at discovering filled polyester with desirable and superior properties using natural occurring particulate (seashell), this will also help in the recycling of agro wastes giving the environment a hygienic disposal of waste.

2. Materials and Methods

2.1 Materials

The sea shells were obtained from Kuramo beach in Lagos. Unsaturated Polyester resin (matrix), Methyl Ethyl Ketone Peroxide (catalyst) and Cobalt Naphthanate (accelerator) were bought from Chemical Market in Kosofe, Lagos.

2.2 sample preparation

(a)Preparation of seashell filler

The sea shells were well cleaned. They were dried under the sun for four days to eliminate moisture. The shells were ground and finally sieved with a hand sieve of 250 microns in the laboratory.

The ground seashell was weighed using an electronic weighing machine based on the weight percentage of the particulate to be added to the polyester resin. A petridish was placed on the electronic weighing machine and the particulate added gradually into the petridish until the desired weight of particulate necessary for a particular formulation was achieved. The process was repeated for other weight fractions of particulate needed.

(b) Preparation of polyester composite:

The materials required were carefully weighed out using electronic weighing machine. In synthesizing the reinforced polyester composites, the mass of the polyester was varied with that of the reinforcement to give a total of 100grams (i.e. for every 100gram of composite, there will be 95 grams of polyester and 5grams of reinforcement) this was done for particulate composition of (5, 10, 15, 20, 25, 30) wt% and stirred manually with a glass rod for three minutes and this was intimately mixed at room temperature until a uniform mixture was obtained. Thereafter, 1g of catalyst was added and stirred for three minutes, after which 0.5g of accelerator was added and stirred for another three minutes until a consistent mixture was achieved.

vi. Casting of the mixture;

The mixture was poured into a mould already coated with paper tape and allowed to cure for three hours. This procedure was repeated for all samples produced with changes in the particulate percentage. After curing the samples were stripped from the mould.

Formulation of seashell filler/polyester composite

Table 1. Formulation of sea shell filler/polyester composite

Specimen	Composition (g)			
	Particulate sea shell	Unsaturated polyester	Methyl ethyl ketone peroxide (catalyst)	Cobalt naphthanate (accelerator)
A	5.0	95.0	1.0	0.5
B	10.0	90.0	1.0	0.5
C	15.0	85.0	1.0	0.5
D	20.0	80.0	1.0	0.5
E	25.0	75.0	1.0	0.5
F	30.0	70.0	1.0	0.5
Control	0.0	100.0	1.0	0.5

Fig: 1 seashell used

Characterization of the samples

Hardness test

The hardness test was carried out in Obafemi Awolowo University, Ife. Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied [13].The hardness test was carried out on the polymeric material composite at different filler content (0, 5, 10, 15, 20, 25 and 30) wt% of filler content.

(ii)Impact test

This test was carried out at the Obafemi Awolowo University, Ife, Nigeria. Stiffer materials have less impact resistance while resilient materials have better impact resistance[14] An arm held at a specific height (constant potential energy) was released. The arm hit the sample and broke it. From the energy absorbed by the sample, its impact energy was determined. A notched sample is generally used to determine impact energy and notch sensitivity.

(iii)Tensile test

The tensile testing was performed using an Instron Universal Testing Machine operated at a cross head speed of 10mm/min. The tensile test specimen preparation and testing procedures were conducted in accordance with ASTM, using dumbbell test piece. Each tensile specimen was positioned in the instron universal tester and then subjected to tensile load, as the specimen stretches the computer generates graph as well as all the desired parameters until the specimen fractures. A graph of load versus extension was plotted automatically by the tester and various property of the specimen determined are; tensile strength, tensile strain, modulus, tensile strain at break e.t.c

(jv) Flexural test

Three point flexural testing were conducted using testometric testing machine with serial number 25257 and capacity M500-25KN at Federal institute of Industrial Research, Oshodi (FIIRO) Lagos.

Fig 2 Testometric machine used for the test

The flexural test was carried according to ASTM D 7264 at a cross-head speed of 20mm/min, maintaining a span of 100mm. This test was conducted at room temperature. The flexural test specimens were of 120 X 50 X 10 mm.

The testometric machine was used to carry out the three point bending flexural test on the polymeric material composite at different filler content at 0, 5, 10, 15, 20, 25 and 30 wt% of filler content.

(v) Water absorption test

The samples were cut in dimension, their initial weights were taken with the aid of an electronic weighing scale. Each of the samples was immersed in a beaker containing water for 168 hours. On removal from water, the surfaces of the specimens were cleaned dry and weighed immediately, and the new weights of the samples were recorded.

Water absorption is a measure of material ability to absorb moisture (water) . The increase in weight was recorded as percentage gained and is expressed by;

$$\frac{final\ weight - initial\ weight}{initial\ weight} \times 100\%$$

3. Results and discussions

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The results of the mechanical tests carried out are shown in table 2

Table 2: Results of mechanical tests on the seashell samples with various percentages of reinforcement (0, 5,10,15,20,25,30)wt%.

Seashell reinforcement (wt%)	Bending strength at peak(MPa)	Bending modulus (MPa)	Impact strength (Joules)	Brinell hardness (BHN)	Ultimate tensile strength (MPa)	Tensile strain (mm/mm)	
0	30.85	927.28	3.81	24.87	262.05	0.0395	[illegible]
5	27.67	814.28	4.35	22.55	101.20	0.0194	[illegible]
10	35.65	1435.20	5.17	25.92	90.70	0.0147	[illegible]
15	24.88	1492.90	4.76	20.65	169.38	0.0283	0.908
20	26.38	1295.40	4.42	21.33	81.74	0.0081	0.950
25	27.17	1365.00	4.08	20.21	160.94	0.0136	0.829
30	20.77	1077.10	3.54	20.10	112.56	0.0131	1.211

3.1 Bending strength

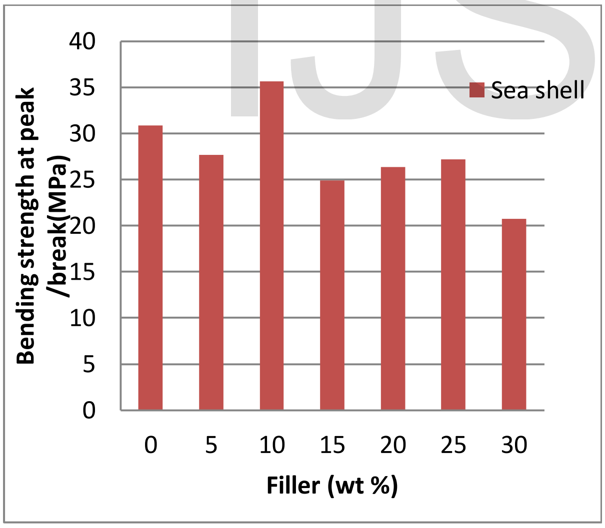

Fig 3 Chart of bending strength against filler concentration

From figure 3 above, the composite at 10wt% sea shell filler loading shows the highest bending strength after which the value continually undulates.

3.2Bending Modulus

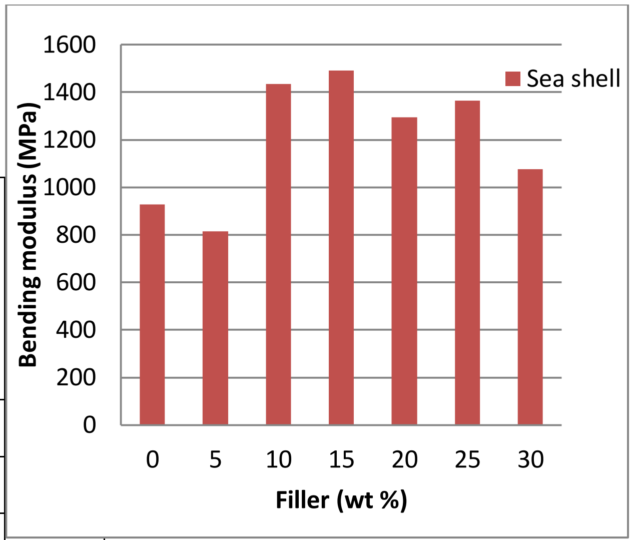

Fig 4 Chart of bending modulus against filler concentration

Figure 4 above shows that the composite at 15wt% filler loading has the highest bending modulus.

3.3 Impact test

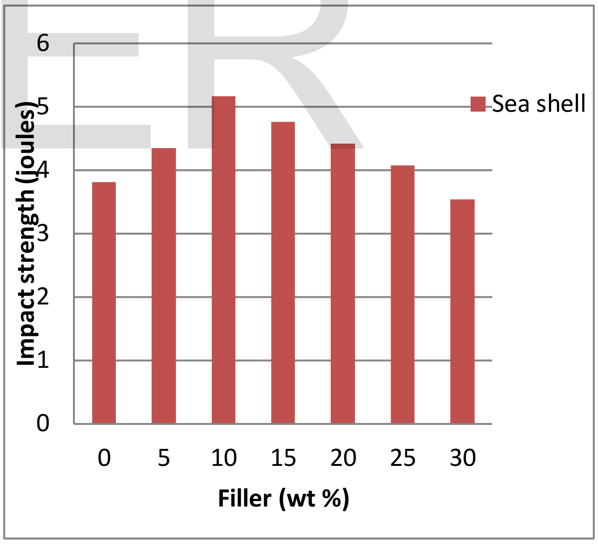

Fig5 Chart of Impact strength against filler concentration

Figure 5 shows the amount of energy the samples can absorb prior to fracture. It was observed that the sea shell samples can only absorb maximum energy at 10wt% filler concentration. The impact strength decreases as the filler content increases.

This is mainly due to the reduction of elasticity of the material due to filler addition.

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3.4 Hardness test

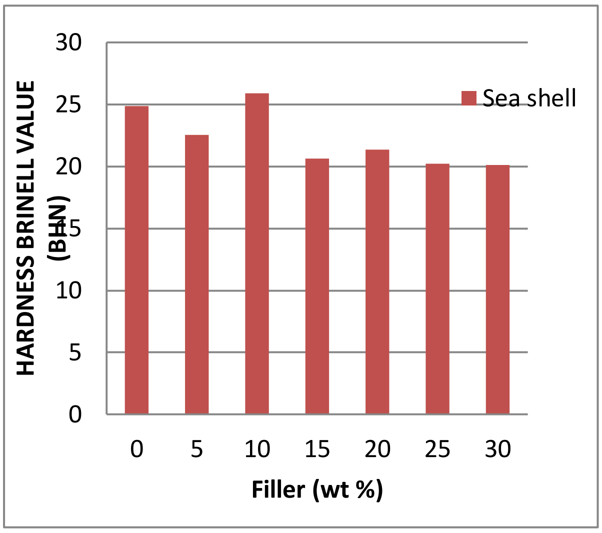

Fig 6 Chart of Brinell hardness against filler concentration

From figure 6, the highest hardness was at 10wt% filler concentration. The unpredictable pattern of the hardness may be probed to be caused by the poor interfacial bonding or surface adhesion of the fillers and polyester resin.

3.5 Ultimate Tensile Strength (UTS)

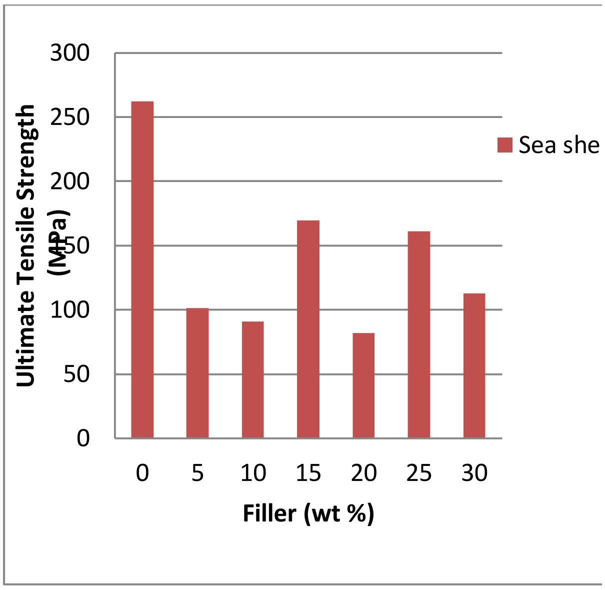

Fig 7 Chart of ultimate tensile strength against filler concentration

Figure 7 above shows the graph of ultimate tensile strength of composite samples against their corresponding percentage reinforcement. The composite's maximum UTS is lower than that of the control sample. The ultimate strength of a composite depends on the weakest fracture path throughout the material. Hard particles affect the strength in two ways. One is the weakening effect due to the stress concentration they cause, and another is the reinforcing effect since they may serve as barriers to crack growth [15] the weakening effect is predominant and thus the composite strength is lower than the matrix; and in other cases, the reinforcing effect is more significant and then the composites will have strengths higher than the matrix.

Prediction of the strength of composites is difficult. The difficulty arises because the strength of composites is determined by the fracture behaviour which are associated with the extreme values of such parameters as interface adhesion, stress concentration and defect size/spatial distributions.

3.6 Tensile Strain at maximum load

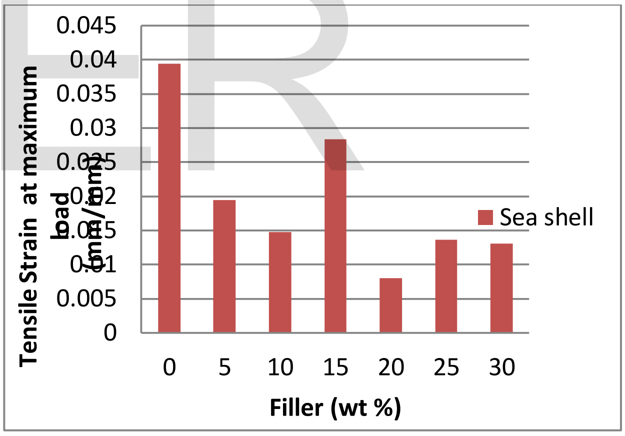

Fig 8 Chart of tensile strain against filler concentration

Again in figure 8 above, the tensile strain at maximum load seems to follow a similar trend as that of the UTS because stress and strain are proportional. The sea shell showed its maximum strain at 15wt% filler concentration. This graph shows that additional filler concentration to the 15wt% sea shell reinforcement will not bring about any improvement on the strain.

3.7 Water Absorption Test

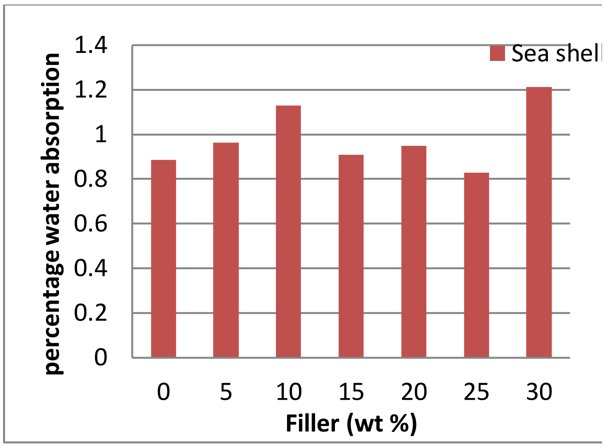

Fig 9 Chart of percentage water absorption against filler concentration

The percentage of water absorption for all the composites is shown in figure 9 above. It can be seen that increasing the filler content, the water absorption becomes quite unpredictable. Though the sea shell filler at 30wt% has the highest value of water absorption.

4. Conclusion

The mechanical tests carried out on the composite samples which include flexural test, hardness test, tensile test, and water absorption test, showed that the mechanical properties of polyester can be immensely improved by sea shell reinforcements.

From figure 3, it can be seen that the sea shell sample of 10wt% reinforcement displayed the highest resistance before fracture. This implies that seashell reinforcement of 10wt% can be used instead of pure polyester in applications requiring great flexibility.

From figure 5, seashell sample of 10wt% reinforcement showed to absorb the highest amount of energy before shattering. Therefore, the seashell of 10wt% can be used in place of pure polyester where impact strength is a major concern.

From figure 6, it can be seen that the composite has the highest hardness at 10wt% filler loading. This goes to tell that seashell reinforcement of 10wt% can be used in place of pure polyester for applications where hardness is a major factor.

From figures 7 and 8, it can be seen that the performance of all the varying weight of the seashell reinforced composite samples were very poor when subjected to tensile loading, the tensile strength and strain of the pure polyester reduced when it was reinforced. Therefore these composites should not be considered in applications that would subject them to tensile loading.

Generally, seashell reinforced unsaturated polyester composite can be used in place of pure polyester depending on the filler content and also the application which it was intended for but definitely should not be considered where tensile strength is of utmost importance.

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