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Research Article

Effect of chemical modification on mechanical properties of Luffa Gourd, Dum Palm and Baobab fibre reinforced composites

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Abstract

Dum palm, Luffa gourd and Baobab plant fibres were extracted from the different plants; it was done with aid of pointed metal object after retting them for 7days in water. Breaking load and extension of the bundle fibres was determined using Instron universal testing machine. Fibres were treated with 5% NaOH. Composites are made from the untreated fibres and 5% NaOH treated fibres. Mechanical Properties of the composites were studied. The properties tested include tensile strength, impact strength, bending strength and hardness. Result shows that Dum palm fibre has the highest strength and it is expected to be more crystalline followed by Luffa gourd fibres and finally Baobab fibre which is less crystalline in nature. On the analysis of composite, it was found that chemical treatment generally improves the mechanical properties of the composites.

Keywords: Dum palm, Luffa gourd, Baobab, Composite

INTRODUCTION

Within the years, composites have become the preferred materials mainly used in high technology industries. The reasons composite materials are favoured over conventional materials is mostly due to their superior mechanical and chemical properties as well as their ability to be tailored specifically for the object at hand. That is, properties of composite structures being a function of its composing materials, their distribution, the interaction in between, etc. enables the designer to select individual materials; combine them together with a specific alignment and therefore manufacture a product with definite properties. Polymer matrix composites are highly favoured materials in the wide variety of composites because they are relatively easy of manufacture and are lower in weight. In addition, mostly fibre reinforced composites are preferred for high technology applications due to their superior mechanical properties. A fibrous reinforcement is determined by their high aspect ratio. Fibre reinforced polymer matrix (FRP) composites have a wide application range due to their orthotropic nature that is; their mechanical properties are different in different directions. This properties results in much flexible designs that cannot be obtained with conventional isotropic materials or particle reinforced composites.

MATERIALS AND METHODS

The tested fibres were extracted from Luffa gourd, Dum palm and Baobab plants. The fibres were extracted after retting in water for 7 days. The extraction was done by mechanical process using a special metal comb designed which is having a pointed edge.

Breaking load and extension of the three fibres was determined using Instron universal testing machine. The fibres were treated with 5% sodium hydroxide. Composites were fabricated with unmodified and 5% sodium hydroxide modified fibres.

Mould fabrication

Mould was fabricated using dumbbell shape. Composites were made of untreated fibres and 5%NaOH treated fibres. Properties of the composites are tested; the properties tested are tensile strength, impact strength and bending modulus.

Tensile properties

The test procedure was carried out in accordance with ASTM D638 of 2003.The tested composites were attached and gripped to the clamp at the upper and lower part of the universal testing machine. The test length of the composite was 85mm and load cell of 5000N force was applied on the specimen at a speed of 60mm/min until a failure occurred. Elongation and breaking load and tensile strength was recorded for the Dum palm fibre composites.

Impact strength

The Izod impact strength tests were carried out in accordance with ASTM D256 2003, to measure the impact strength. The specimen dimension of 10 x4cm were tested using the machine Resil Impactor model P/N6957.000MN1.A hammer size of one Joule (1 J) was used at an angle of 150^0 to the sample axis to obtain a consistent starter crack. The samples were fractured in Resil Impactor Machine and the impact energies were recorded. The process was repeated 3times for each sample.

Bending modulus

The test was performed in accordance with the standard ASTM D790 M. Three bend point test was performed to measure the flexural properties at a speed of 50mm/min using the universal testing machine. Bending stress and elongation were recorded.

Hardness test

The hardness test of the composite was performed using Muver Durometer model 53505 EN ISO 88.The test was carried out according to the standard ASTM D2240.

RESULT AND DISCUSSION

Table 1a. Breaking load and extension of Baobab fibres

Test	Breaking Load (N/g)	Extension at Break (%)
1	43.81	2.29
2	43.25	1.90
3	43.50	2.19
Mean	43.45	2.12
SD	0.2921	0.2027

Table 1b. Breaking load and extension of Dum fibres

Test	Breaking Load (N/g)	Extension at Break (%)
1	93.06	2.13
2	113.29	2.87
3	105.37	2. 65
Mean	103.90	2. 55
SD	7.751	0.380

Table 1c. Breaking load and extension of Luffa fibres

Test	Breaking Load (N/g)	Extension at Break (%)
1	63.35	3.50
2	71.24	2.87
3	72.28	3.22
Mean	68.96	**3.20**
SD	**4.883**	**0.3157**

Determination of the strength of fibres by the universal testing machine as shown in Table 1a-c reveal the breaking load of the different fibres. Dum palm fibres have the highest value of (105.90N/g) followed by Luffa gourd fibres (68.96N/g) and lastly Baobab fibre (43.45N/g). The extension at break shows Luffa gourd fibre to have 3.20% then Dum palm fibres 2.55% and finally Baobab fibres 2.12%.The results indicate that Dum palm fibre has the highest strength and it is expected to be more crystalline followed by Luffa gourd fibres and finally Baobab fibre which is less crystalline in nature.
The Breaking load, Tensile strength and Extension at break of the composites are as shown in tables' 2a and 2b

Table 2a. Tensile Properties of Untreated Composites

S.No	Control (UP without fibres)N/m^2	Baobab		Luffa		Dum palm	
		Tensile Strength (MPa)	%Extension	Tensile Strength(MPa)	%Extension	Tensile Strength(MPa)	%Extension
1	4956000	10491667	1.03	8147222	1.98	13194444	0.94
2	5000000	9952778	0.98	8497222	1.68	8583333	0.84
3	5002780	11030556	1.28	15741667	1.27	9583333	0.98
Mean	4967593	10491667	1.07	10795370	1.60	10453704	0.93
SD		538888.9	0.160728	4287191	0.356417	2425643	0.072111

Table 2b. Tensile Properties of Treated Composites

S.No	Baobab		Luffa		Dumpalm	
	Tensile Strength (MPa)	**%Extension**	**Tensile Strength (MPa)**	**%Extension**	**Tensile Strength (MPa)**	**%Extension**
1	13833333	3.35	12111111	2.43	13277778	1. 63
2	11105556	2.82	11597222	3.06	9016667	2.75
3	13000000	3.32	10527778	3.0	9611111	2.54
Mean	12646296	3.2	11412037	2.8	10635185	2.3
SD	1397864	0.297714	807747.7	0.347707	2307772	0.148492

The results of tensile strength analysis of the composites in Tables 2a and 2b show the composites made with modified fibres have higher tensile strength in the following order : Baobab fibre composites (126.46 MPa), Luffa gourd fibre composites (114.12 MPa) and Dum palm fibre composites (106.35 MPa) these can be compared with the composites made with the unmodified fibres as follows : composites Baobab fibre composites (110.30 MPa), Luffa gourd fibre composites (107.95 MPa) and Dum palm fibre composites (95.83 MPa). Composite without reinforcement that is made of resin only have a tensile strength of (49.95 MPa). The breaking extension of modified fibre composites is higher than the unmodified fibre composites. Baobab composites is has the highest value (3.2%) followed by Luffa gourd fibre composites (2.8%) and then Dum palm fibre composites (2.3%). The results of tensile properties of composites were strongly influenced by the adhesion between the fibre and matrix due to the presence of hydroxyl group in the natural fibres. Therefore composites produced have better strength. Modification of the fibre surface by chemicals usually makes the fibre more hydrophobic (Vilay et al., 2008). On the other hand untreated fibre composites have lower tensile strength which is due to the weak compatibility between fibre and matrix. This is in agreement with the case of tensile properties of rubber reinforced Isora fibre composites. The properties of the composites filled with the treated fibres were higher than those filled untreated fibres at similar loading. To obtain good fibres reinforcement in the rubber composites, the adhesion between the rubber and the fibre was very important. From these results, it was clear that the aqueous alkali treated Isora fibre improved the fibre adhesion to rubber matrix (Lovely and Rani, 2006). The surface of the fibre could be modified by aqueous alkali treated at elevated temperatures and this improves the adhesion properties significantly. According to (flodin and zadorecki, 1985) fibre treatments can be used to prevent debonding at the fibre interface because covalent bonding can be formed between the rubber matrix and fibre.

Table 3a. Impact strength of unmodified fibre composites

Test	Control(J/m^2)	Baobab (J/m^2)	Luffa gourd (J/m^2)	Dum palm (J/m^2)
1	4167	22500	7638.889	5000
2	3888	19888.89	7500	7361.111
3	4167	16888.89	7555.556	5416.667
Mean	4074	19759.26	7564.815	5925.926
SD	45.000	2807.801	69.90587	1260.246

Table 3b. Impact Strength of Treated Composites

Test	Baobab (J/m^2)	Luffa gourd (J/m^2)	Dum palm (J/m^2)
1	27805.56	13333.33	11194.44
2	22277.78	17472.22	9861.111
3	21833.33	12194.44	8527.778
Mean	23972.22	14333.33	9861.111
SD	3327.193	2777.361	1333.333

The result of impact strength in Tables 3a and 3b show that the modified fibre composites have higher impact energies, Baobab fibre composites (23972,22J), Luffa gourd fibre composites (14333.33J) and Dum palm fibre composites (9861.1J), the unmodified composites Baobab fibre composites (19759.26J), Luffa gourd fibre composites (7564.82J) and Dum palm fibre composites (5925.93J). The impact strength of the resin without reinforcement was found to be (4074J).Baobab fibre composites has the highest impact energy followed by Luffa gourd and then Dum palm fibre composites. The impact strength of composites is influenced by many factors, which include the toughness properties and the nature of the interfacial region. This interfacial region is the most important and is directly related to the toughness of the composites. These aforementioned results show that treatment gave improved adhesion. The fibre/matrix adhesion determines the strength of the composites. Improved adhesion after treatment can lead to perfect bonding and thus composites will posses at relatively high impact strength. Composites having better interfacial bonding need absorbing capacity when the crack propagation occur along the fibre/matrix interface and this leads to an increase in impact strength

Table 4a. Bending modulus of untreated fibre composites

Composite	Bending stress (Mpa)	Elongation (%)
Baobab	73.35	11.15
Luffa	45.77	12.02
Dum	64.15	8.29
Control	14.02	10.56

Table 4b. Bending modulus of 5% NaOH fibre treated composite

Composite	Bending stress (Mpa)	Elongation (%)
Baobab	109.92	14.10
Luffa	137.3	12.59
Dum	45.77	12. 62

From the results, it is observed that 5% sodium hydroxide treated Baobab and Luffa gourd fibre treated composites have higher bending strength and higher percentage elongation than the untreated fibre composites. In the case of Dum palm fibre composites, untreated fibre composites have higher bending strength than the treated fibre composites. This signifies that treatment in that fibres did not improve the adhesion, bonding, transfer stress and wetttability between the fibre and the matrix. (Prasan and Thomas, 1995).

Table 5a Hardness property of untreated composite

Test	Baobab(shore D)	Luffa gourd (shore D)	Dum palm(shore D)	UPR
1	59	53	6 0	42
2	6 0	50	50	43
3	6 0	57	58	43
Mean	6 0	53	56	43
SD	**0.50**	**3.55**	**5.29**	**0.005**

Table 5b. Hardness property of 5% NaOH treated composites

Test	**Baobab**(shore D)	Luffa gourd (shore D)	Dum palm (shore D)
1	58	62	57
2	48	62	60
3	53	64	61
Mean	53	63	59
SD	**5.0**	**1.22**	**2.12**

In the assessment of hardness of the composites as shown in Tables 4a and 4b the treatment improves the hardness property of the composites and this indicate that it improves the durability of the composites and also increase adhesion and strength at the fibre matrix interface.

CONCLUSION

It is concluded that Dum palm is highly crystalline, because crystallinity is an indication of strength, followed by Luffa gourd and Baobab fibres are less crystalline in nature. The trend in the extension percent varied, with Luffa gourd fibres 3.20% as the highest followed by Dum palm fibres 2. 55% and Baobab fibres 2.12% with the least value. Treatment generally improves the tensile property of composite. Baobab fibre composite respond better to chemical treatment followed by Luffa gourd and Dum palm fibre composite.

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