Influence Of Alumina Fillers On Mechanical Behaviour Of Royal Palm – Glass/Epoxy Hybrid Composites

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ABSTRACT:

Natural fibre composites are the most promising combination for extensive research during last decade. They exhibit an excellent mechanical property which was proved by engineers and researchers with various natural fibres. The present work investigates the effect of addition of alumina fillers on mechanical behaviour of royal palm – glass/epoxy hybrid composites. The composites were fabricated by reinforcing royal palm fibres with glass - epoxy matrix by varying the wt% of alumina by traditional hand layup method. Results reveal that, there is a significant improvement in mechanical properties of hybrid composites with 5% alumina compared to neat epoxy and hybrid composites with 10% alumina.

KEYWORDS:

Royal palm fibres; alumina fillers; glass fibres; natural fibre composites

1. Introduction

Today polymer composites are used for wide range of applications ranging from kitchen ware item to space exploration. But these polymer composites easily do not undergo biodegradation resulting in generation of solid waste. This causes environmental pollution. To meet this challenge researchers are focusing their attention to produce biodegradable composites with natural fibers/fabrics. Such composites are termed as green composites. Different researchers already developed several biodegradable composites with various natural fibers. As the focus is being shifted towards environment - friendly products, renewable and bio - degradable natural fibers are occupying a prominent place. Several other advantages associated with natural fiber based composites when compared to synthetic fibers like carbon, aramid and glass based composites are light weight, low cost, high specific strength, high specific modulus, reduced tool wear and safe manufacturing process. Carbon dioxide neutrality of natural fibers is particularly attractive. Burning of substances derived from fossil products (e.g. Petroleum) releases enormous amounts of carbon dioxide into the atmosphere which is believed to be the root cause of the greenhouse effect. Hence over the last decade, composites of polymers reinforced with natural fibres have received ever increasing attention, both from the academic world and from various industries. Hemp, jute, rice straw, wood, etc. are also being considered as potential reinforcement in polymer composites. Now they are creating a new range of technological applications beyond traditional usage as ropes, carpets, mats, baskets, fancy items, paint brush, sofa cushion etc. Construction, packaging, furniture and automotive fields are already taking the advantages of natural fiber composites. Most of the interiors of the automobiles like door panels, trunk liners, seal backs, packages, speaker trays, engine and transmission covers are being made with natural fiber composites.

In the proposed study royal palm fibers are being used as reinforcement. The extraction of fibers from royal palm tree is very easy due to the low density and easy dissolve of the gums present in the sheath. The cost involved for this process is very less. Ripened foliage of royal palm that falls on ground naturally are the fibre source. Royal palm trees can be found in California, Texas, Florida, Caribbean, South and Central America. Due to their grace and beauty they are very popular as decorative trees.

Particulate filled composites have been used extensively in various applications owing to their low production costs and the ease of fabrication. Besides, they are isotropic. Generally fillers are used in polymers for a variety of reasons such as cost reduction, improved processing, improved strength density control, optical effects, thermal conductivity, electrical properties, magnetic properties, flame retardancy, improved hardness and wear resistance. Hard particulate fillers consisting of ceramic or metal particles and fiber-fillers made of glass are being used these days to improve the performance of polymer composites to a great extent.

The proposed research work arrives at investigating the mechanical properties of royal palm/glass-epoxy composites with and without addition of alumina (Al_2O_3) as fillers.

2. Materials and Methods

2.1 Specimen Fabrication

The fibre of Royal palm was extracted from Royal palm tree that are available locally. To prepare the hybrid composite, royal palm is reinforced with glass fibre procured from the local supplier. Atul Limited, Gujarat, India supplied the epoxy resin (Lapox-12) and hardener K-6 which was used a matrix material.

To get Royal palm fibre, the sheath obtained from royal palm tree is separated from the leaf stem and leaves. The sheath is placed under the shade for three days. Later the sheath was immersed in water tank for about 25 to 30 days after which the sheath was rubbed by hand and rinsed with water to dissolve the greasy material and fine fibre was extracted. Finally to remove the surplus waste, the extracted fibre was washed again thoroughly in plenty of clean water. This followed by fibre drying for one week under the sun. For composite preparation, an average diameter of 0.25mm Royal palm fibre was used. To remove surface moisture, both glass fibres and Royal palm were dried at 80º C in an oven for 24 h. The mould box was prepared with the dimensions of 300 (L) × 300 (W) × 3·0 (T) mm. Both types of short fibres were intimately mixed. Matrix was prepared by mixing the hardener to epoxy. The epoxy and hardener ratio was maintained at 10:1. Mould box was loaded with appropriate quantities of matrix and fibres in random orientation and ceramic fillers uniformly in the mould wherever necessary; finally the compression pressure was applied evenly to achieve a uniform thickness of 3 mm and cured for 24 h at room temperature. Three different types of samples are prepared. In table 1, the sample designation and the content details are listed. The resultant material was randomly oriented Royal palm/glass fibre reinforced epoxy hybrid composite plate with dimensions 300×300×3 mm^3.

2.2 Tensile Testing

Tensile testing was done with the help of Universal Testing Machine. The test was conducted as per ASTM D 3039-76 at a cross head speed of 10 mm/min. The specimen dimensions were 150 × 15 × 3 mm3. In each case, five samples were tested and the average values were reported.

Table 1: Composition and designation of composites.

Sample Designation	Composition Details			
	Epoxy (Wt %)	Roystonea Regia Fiber (Wt%)	Glass Fiber (Wt%)	Alumina (Wt%)
E100	100	0	0	0
E80+R20	80	20	0	0
E80+G20	80	0	20	0
E80+R10+G10	80	10	10	0
E80+R5+G15	80	5	15	0
E80+R15+G5	80	15	5	0
E80+R5+G10+A5	80	5	10	5
E80+R5+G5+A10	80	5	5	10

2.3 Hardness Testing (Shore D)

Hardness test was conducted on Shore D hardness tester as per ASTM-2240 standards. In each type, five samples were tested and the average values were reported.

2.4 Flexural Test

Flexural Test was done as per ASTM D 5943-96 standards at a cross head speed of 10 mm/min. The specimen dimensions were 100 × 15 × 3 mm3. In each case, five samples were tested and the average values were reported.

3. Results and Discussion

The various mechanical and physical properties of royal palm and glass fibres were shown in Table 2.

Table 2: Mechanical and Physical properties of Royal palm and glass fibres.

Properties	Royal palm	Glass
Density (g/cm3)	0·825	2·14
Diameter (µm)	200–300	5–25
Tensile strength (MPa)	263	2500
Young's modulus (GPa)	21	55
% Elongation	4·012	4·5

3.1 Hardness (Shore D)

Table 3: Variation of hardness values with wt% of Royal palm, glass fibres and Alumina.

Specimen	Hardness (Shore D)
E100	70
E80+R20	77
E80+G20	83
E80+R10+G10	76

E80+R5+G15	81
E80+R15+G5	72
E80+R5+G10+A5	71.5
E80+R5+G5+A10	72.8

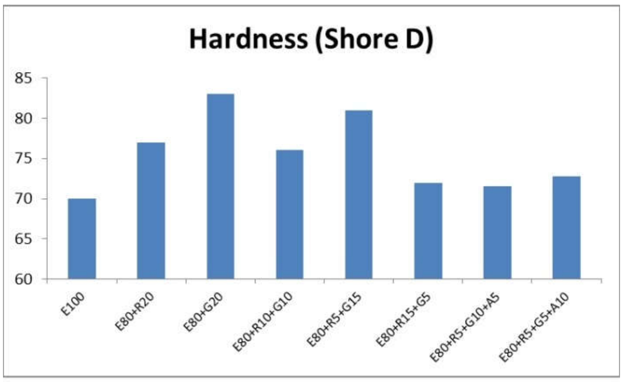

Fig 1: Variation of hardness values with wt% of Royal palm, glass fibres and Alumina

Comparatively all combinations of composites have shown increased hardness, when compared to neat epoxy. The increase in glass fibre content increased the hardness values that are tabulated in table – 3. The density of glass fibre is much higher than the density of Royal palm fibre. The hardness is density dependent and will increase with increase in density. Hence epoxy with glass fibre influences the hardness of the hybrid composite.

3.2 Tensile Properties

Table 4: Variation of tensile properties with wt% of Royal palm, glass fibres and Alumina.

Specimen	% Elongation	Tensile Strength (MPa)
E100	1.2	28
E80+R20	1.2	29
E80+G20	2.4	36
E80+R10+G10	1.7	34
Specimen	**% Elongation**	**Tensile Strength (MPa)**
E80+R5+G15	2.2	35
E80+R15+G5	1.3	32
E80+R5+G10+A5	1.8	21.4
E80+R5+G5+A10	1.4	15.5

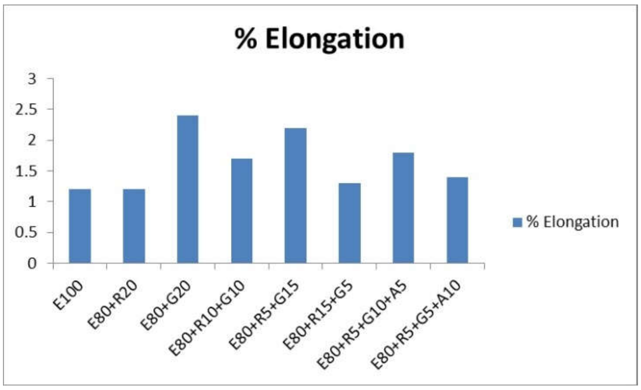

Fig 2: Variation of % elongation with wt% of Royal palm, glass fibres and Alumina.

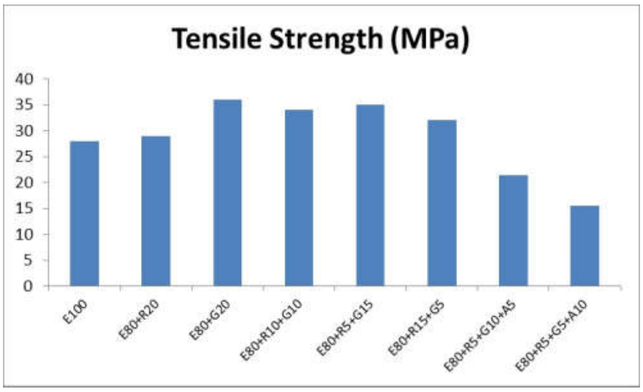

Fig 3: Variation of tensile strength with wt% of Royal palm and glass fibres.

Table-4 shows the variation of tensile strength and % elongation at break with glass fibre loading and alumina in hybrid composites. Figure – 2 is the evident that shows the elongation of specimen. It reveals that the addition of glass fibre i.e., specimen C shows high % elongation compared other specimens. As we know that the strength and modulus of glass fibre is much higher than the strength and modulus of natural fibre. Hence the increase in % elongation at break and tensile strength is due to the increase in glass fibre loading in hybrid composites. In a hybrid composite, properties of the composite depend on the Strength and % elongation at break of the individual reinforcing fibres. The addition of alumina decreased the tensile strength.

3.3 Flexural Properties

Table 5: Variation of Flexural Strength with wt% of Royal palm, glass fibres and Alumina.

Specimen	Flexural Strength (MPa)
E100	40
E80+R20	41

3

E80+G20	52
E80+R10+G10	46
E80+R5+G15	48
E80+R15+G5	40
E80+R5+G10+A5	42
E80+R5+G5+A10	32

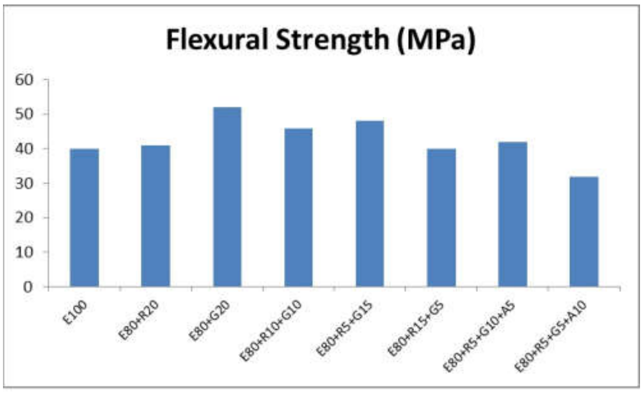

Fig 4: Variation of Flexural Strength with wt% of Royal palm, glass fibres and Alumina.

The increase in glass fibre weight percentage increases the flexural strength and flexural modulus of hybrid composites that are tabulated in table 5. This will enhance the flexural properties. Flexural strength was decreased with addition of alumina fillers when compared with epoxy and glass fibres. With the addition of glass fibre shear resistance of the hybrid composite will increase which will minimize shear failure.

4. Conclusions

From this investigation it is clear that, royal palm fibre reinforced with glass fibre leads to a considerable increase in tensile, flexural and hardness properties. The addition of alumina shows lesser results when compared with all other combination composites in case of hardness, tensile and flexural strength. The probable reason is weak adhesion between alumina powder and matrix. The composite with glass fibres shown better results compared to neat epoxy and with alumina. The presence of glass fibre enhanced the properties when compared with other specimens

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