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MOISTURE ABSORPTION PROPERTIES AND CHEMICAL RESISTANCE OF BANANA, SISAL, LUFFACYLINDRICA, E-GLASS AND THEIR REINFORCED EPOXY COMPOSITES

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Abstract:

Natural fibers are considered as a suitable alternative to glass fiber, due to advantages, which include low cost, high strength-to-weight ratio, and recyclability. On combination of glass fibers with natural fiber can decreases the usage of glass fiber. Glass fiber is serious alternative for natural fibers used as reinforcements in composite materials. There advantages are low density, high strength-to-weight ratio, and resistance to breakage during processing of recyclability and low energy content. Properties of natural-fiber-based composites can be modified or affected by a some factors such as fiber volume fraction, method of processing, fiber combinations, ratio of aspect and water absorption, etc. By the combination of different fiber-matrix can also vary in their process parameters and also influence the final properties. To study environmental conditions effects the performance of Luffacylindrica fiber, banana fiber and sisal fiber epoxy composite, the composite sample were subjected to various environments. Thickness swelling tests, moisture absorption test and chemical resistance test are conducted as per standards with ASTM D570-98. Five specimens for different layers (Single, Double and Triple layers) were cut with dimensions of 140 x 10 mm (length x width) and the experiment was performed using test samples.

Key Words: Waterabsorptiontest, Moisture Absorption, Moisture Absorptionof Luffa, Banana, Sisal and Glass, Chemicaltest of Luffa, Sisal & Banana and Glass

This investigation presents the measured values of the mechanical properties of fibers like luffacylindrica, banana, sisal and glass fiber reinforced epoxy composites laminated with five different combinations. These results are compared with all the five samples of natural fiber reinforced composites. The relative effects of all these samples of composite materials on various tests which can undergone chemical resistance results properties and moisture absorption test results have been discussed.

Density Test:

The composites under this investigation consists of two components of matrix and fiber. The theoretical density of composites (Table 4.1) in terms of weight fraction can easily be obtained as per the following Equation (1). The fiber volume fraction was determined by

$$V_f = \frac{w_f / \rho_f}{(W_f/\rho_f) + (W_m/\rho_m)} \quad (1)$$

W_f = weight fraction of fiber

W_m = weight fraction of matrix and is equal to $(1-w_f)$

ρ_f = fiber density

ρ_m = matrix density

The density of fibers reinforced epoxy composites were measured (Fig. 1 and Fig. 2) using the Equation (2)

$$\rho_c = \frac{1}{(W_f/\rho_f) + (W_m/\rho_m)} \quad (2)$$

Where ρc = density of composite materials

Table 1: Density test result

Composite material	Mass (m) (g)	Volume (v) (cm^3)	Density (ρ)
Banana (B)	9.568	9	1.063
Luffa (L)	7.428	9	0.825
Sisal (S)	9.893	9	1.099
E-glass (G)	14.568	9	1.618
BLS	8.962	9	0.995
GBLS	10.463	9	1.162
GBLSG	11.205	9	1.245
GLBG	11.533	9	1.281
GSLG	11.614	9	1.29

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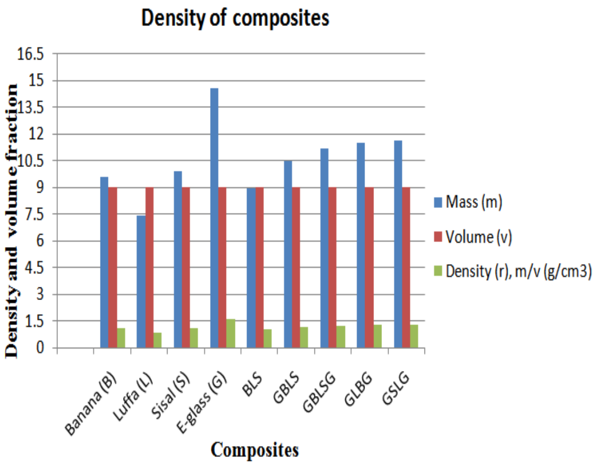

Figure 1: Density of Composites

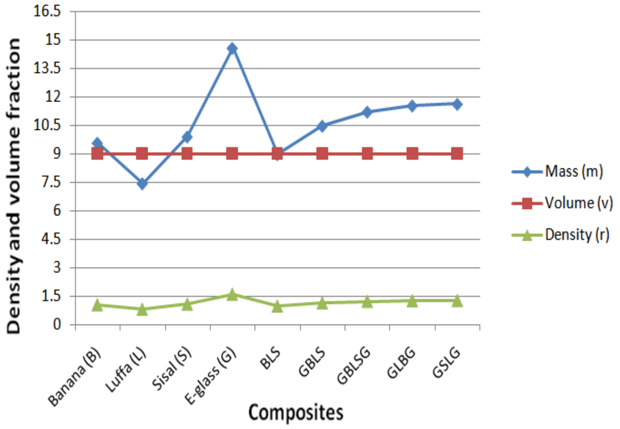

Figure 2: Graphical Representation of Density of Composites

Absorption of Moisture Test:

The absorption of moisture by natural fibers because of the cell wall polymers contains certain hydroxyl and other oxygenated groups that attract the moisture during bonding of hydrogen. The hemicelluloses is responsible to natural fiber for the absorption of moisture. The comparison of the absorption of water treated and raw samples were done. The natural fibers were dried in room temperature testing before 72 hours. At every time intervals of 15 minutes the increase in weight of the fiber was measured. To study environmental conditions effects on performance of Luffacylindrica fiber, banana fiber and sisal fiber epoxy composite, the composite sample were subjected to various environments. These tests were conducted as per the standards with ASTM D570-98. Four specimens for different layers (Single, Double and Triple layers) were cut with dimensions of 140 x 10 mm (length x width) and the experiment was performed using test samples. The testing specimens prior were dried at a Temperature of 800 ^{0}C and then it again made to cool to room temperature and kept in desiccators. The weight of the samples were taken before subjected to steam, saline water and distil water environments. After expose for 12 hr, the specimens were removed out from the moist environment and remove the moisture with a clean dry cloth or tissue paper present at all surfaces. The specimens were weighted again to the nearest 0.001 mg within 1 min of removing them from the environment chamber. The specimens were weighed with a gap of 12 hrs of exposure regularly from 12-156 hrs. After that the moisture absorption was calculated by the weight difference between each gap. The percentage weight of samples gain was measured at different time intervals by using below Equation (3).

$$\%M_t = \frac{(W_t - W_0) \times 100}{W_0} \qquad (3)$$

Where, W_0= the oven-dry weigh and
W_t = weight after time respectively.

Moisture content of EMC of the sample is change when the periodic weight change of the sample was less than 0.1% and thus the equilibrium state was taken as reached. The thickness swelling (TS) was taken by using the below Equation (4).

$$TS\ (t) = \frac{(Ht - H_0) \text{ X } 10}{H_0} \qquad (4)$$

Where, 'H_t' and 'H_0' are the composite thickness after and before the water immersion respectively.

Moisture Absorption Properties at Room Temperature (29^{0}C):

The moisture absorption % of banana, sisal, luffacylindrica, E-glass and their fiber reinforced epoxy composites was evaluated as the difference b/w the dry weight and wet weight of the fibers and specimens. Fig. 3 and Fig.4 show the percentage of gain weight is observed when the fibers are immersed in the bowl of distilled water at 30 minutes interval at room temperature of 29^{0}C. It is observed the composites have gained its moisture absorption weight is approximately up to 2% of weight. The absorption rates of luffacylindrica and E-glass have less moisture content compared with other fibers in Table 2.

Table 2: Absorption of Moisture at Room Temperature (29^{O}C)

Composite Material	Before Moisture Test (G)	After Moisture Test (G)	(%) of Moisture
Banana (B)	9.568	9.579	0.115
Luffa (L)	7.428	7.429	0.013
Sisal (S)	9.893	9.912	0.192
E-glass (G)	14.568	14.57	0.014
BLS	8.962	8.992	0.334
GBLS	10.463	10.501	0.363
GBLSG	11.205	11.238	0.294
GLBG	11.533	11.545	0.104
GSLG	11.614	11.621	0.061

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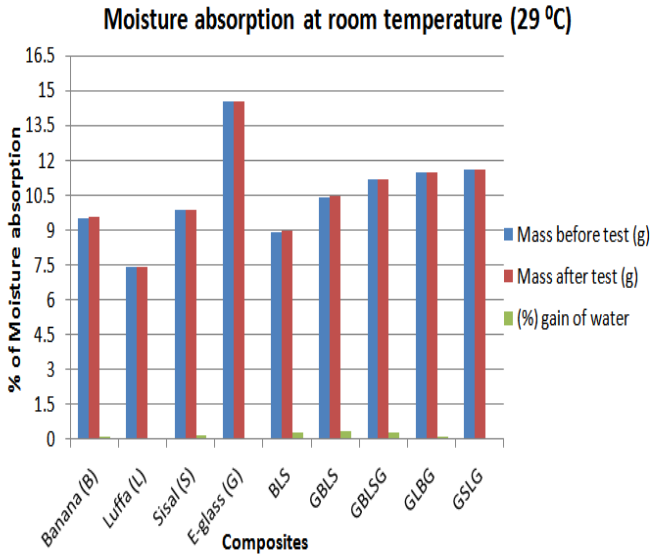

Figure 3: Absorption of Moisture at Room Temperature (29^{0}c)

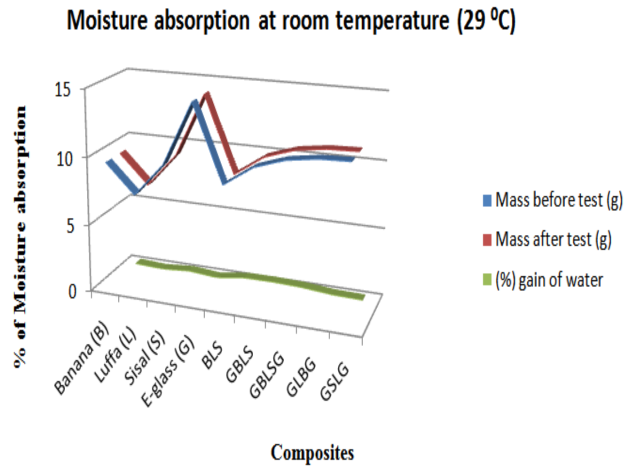

Figure 4: Graphical Representation of Absorption of Moisture at Room Temperature (29^{0}c)

Table 3: Moisture Absorption at 100^{0}c with Boiling Water for 30 Minutes

Composite Material	Before Moisture Test (g)	After Moisture Test (g)	(%) Gain of Moisture
Banana (B)	9.568	10.67	0.118
Luffa (L)	7.428	7.524	0.013
Sisal (S)	9.893	11.841	0.197
E-glass (G)	14.568	14.771	0.014
BLS	8.962	12.044	0.344
GBLS	10.463	14.261	0.363
GBLSG	11.205	14.588	0.302
GLBG	11.533	12.767	0.107
GSLG	11.614	12.343	0.0628

Figure 5: Moisture Absorption At Boiling Water (100^{0}c)

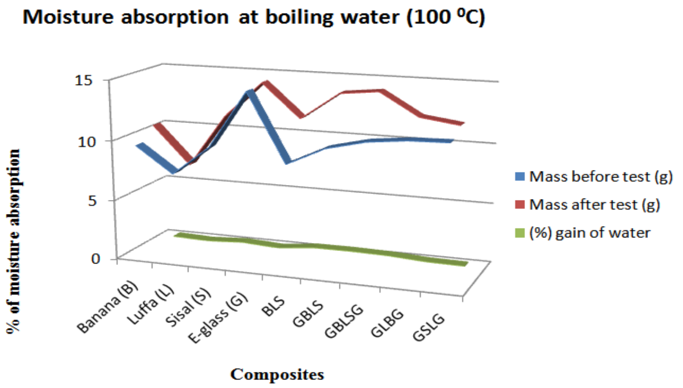

Figure 6: Graphical Representation of Moisture Absorption at Boiling Water (100^{0}c)

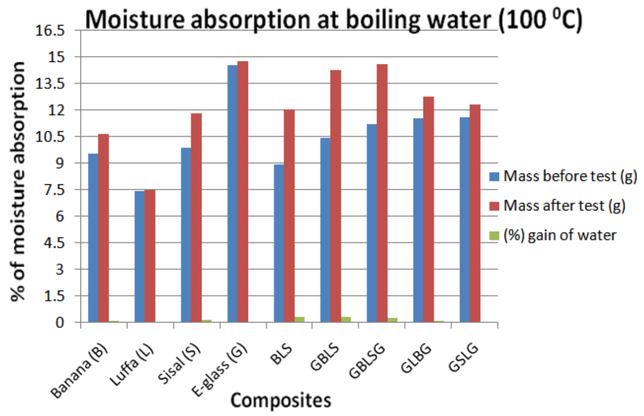

Figure 7: Moisture absorption properties at boiling temperature (100^{0}C)

The moisture absorption % of banana, sisal, luffacylindrica, E-glass and their fiber reinforced epoxy composites was evaluated as the difference between the dry weight and wet weight of the fiber and specimens. Table 3 shows the percentage of gain weight is observed when the fibers are immersed in the bowl of boiling water at 30 minutes interval at room temperature of 100 ^{0}C and it can be inferred that water absorption is more at boiling temperature than at room temperature. The results of moisture absorption of the samples in boiling water (100 ^{0}C) and room temperature (29 ^{0}C) at 30- 60 minutes duration are observed in Fig. 5. When the immersion temperature was increased then the moisture saturation time was significantly shortened. This shows that absorption of water at room temperature took fairly a long period to reach equilibrium than absorption at boiling temperature. For samples the weight gain at moisture saturation point in boiling temperature (100 ^{0}C) was approximately 4% more than that of room temperature (29 ^{0}C) for 30-60 minutes immersion as shown in the Figure 6. The composites of natural fibers observed more water than the glass fiber composites due to more in gain weight. The interlocked of water molecules in the composites are more. Due to more in water molecules it gets chances to attack the interface and finally resulting in the bonding of

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the fiber and the matrix internally in the composite.

Chemical Resistance Test:

To study the chemical resistivity of the plain matrix and the composites, the chemical test method is employed for testing of the composite materials resistivity including banana, sisal, luffacylindrica and E-glass fiber reinforced epoxy composites to chemical reagents. In this test method there is a provision of reporting changes in weight, dimensions, appearance and strength properties. Reagents in the standards are specified to establish results in comparable basis. In this particular work, testing of chemical resistivity is conducted on banana, sisal, luffacylindrica and E-glass fiber reinforced epoxy composites. In the present work three acids, three based and solvents are selected. Nitric acid, Glacial acetic acid, ammonium hydroxide, hydrochloric acid, aqueous sodium carbonate, aqueous sodium hydroxide, carbon tetra chloride, benzene, toluene and water are used after purification. In this each case of samples are pre-weighted in a particular precision electrical balance and immerse in the respective chemical reagents for 24 hours. Then they are removed and washed in pure water and dried by pressing them on both side with a filter paper at room temperature. The treated samples are then re-weighted and the percentage loss/gain is determined by using the below Equation (5).

$$\%\text{ weight loss (-) or gain (+) of the sample} = \frac{\text{Original weight} - \text{Final weight}}{\text{Original weight}} \times 100 \qquad (5)$$

Table 4: Resistance of Banana/Sisal/Luffacylindrica/E-Glass Fiber Reinforced Epoxy Composites to Chemical Regents

Chemicals	Matrix	Composite
40 % nitric acid	0.2233	0.6126
10% Hydrochloric acid	0.9367	0.1217
8% Acetic acid	0.2212	0.0566
10% sodium hydroxide	0.3133	0.3124
20% sodium carbonate	-0.3052	-0.5765
10% Ammonium Hydroxide	-0.0201	-1.0519
Benzene	-0.7778	-0.9936
Toluene	-0.4111	-0.4281
Carbon tetrachloride	-0.3277	-0.8988
Water	0.0479	1.3343

The effect of some acids alkalis, solvents on the matrix & composite under study is presented in Table 4.4. From this table, it is clearly says that for matrix, composite of gain weight is observed after immersion. By this it can be understandable that the matrix is cross linked and as a result formation of gel takes place instead of dissolution. On both the matrix and composite it is also observed that the effect of sodium carbonate, benzene, toluene, carbon tetrachloride is negligible. The chemical resistivity of hybrid composites with banana/ sisal/ luffa/ E-glass fibers is found better for the chemicals mentioned above. The above observations are indicated clearly that the banana/sisal/luffa/E-glass composites possess good acid resistance. As the matrix itself was cross linked, its resistance to chemicals was observed to be higher. Further the absorption of water by the composites is found to be negligible. Basing on the chemical resistance and by water absorption of composites can be used as acid, water storage tanks.

Conclusion:

The hybrid composites of banana, sisal, luffa and glass reinforced epoxy composites are successfully tested. comparative study between the hybrid composites effect in mechanical properties and physical property (Density) of intimately mixed Banana, Luffa, sisal, Glass hybrid fiber reinforced BLS, GBLS, GBLSG, GLBG and GSLG composites was carried out. The following conclusions are derived from this research work.

- ✓ Density test shows that density of composites increasing in order of BLS, GBLS, GBLSG, GLBG and GSLG.
- ✓ The moisture absorption % of banana, sisal, luffacylindrica, E-glass and their reinforced epoxy composites was evaluated as the difference of dry weight and wet weight of the fibers and specimens. Moisture observed in decreasing trend as follows BLS, GBLS, GBLSG, GLBG and GSLG at room temperature. Moisture absorption at 100 0C with boiling water for 30-60 minutes results observed in decreasing trend as follows BLS, GBLS, GBLSG, GLBG and GSLG. Water absorption experiments results shows that water uptake was mainly dependant on the properties of the fibers.
- ✓ The composites of natural fiber observed heavier water than the glass fiber composites due to gain weight is more.
- ✓ The study of effect in some acids likes alkalis and solvents on the matrix and composite are clearly evident and the gain weight is observed by immersion. It is clearly indicated that the glass / sisal /luffa / glass composites possess good acid resistance.
- ✓ The scope of future scholars is very wide to explore this area of research. This study of work is extended to other tribological aspects of abrasion, wear, hardness nature of this composite. The study of authors for the other aspects of such composites same as other potential fillers for development of hybrid composites and evaluation of their behavior of mechanical, erosion and the resulting experimental findings can be similarly analyzed.

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