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Effect of Coconut Fillers on Hybrid Coconut Kevlar Fiber Reinforced Epoxy Composites

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Abstract: This project focuses on the conversion of naturally available coconut fibers and shells into a useful composite. In addition to it, some mechanical properties of the resultant composite is determined and also the effect of coconut shell fillers on the composite is also investigated. The few portion of the composite is incorporated with synthetic Kevlar fiber, thus the coconut fiber is hybridized to enhance the mechanical properties of coconut. In this work two types of composite is fabricate, kevelarcoconutfibre (kc) composite and kevelarcoconutfibre coconut shell filler (kccsf) composite. Coconut fibers have low weight and considerable properties among the natural fibers, while coconut fillers have a good ductile and impact property. The natural fibers and fillers are treated with Na-OH to make it free of organic impurities. Epoxy resin is used as the polymer matrix. Two composite are produced one with fillers and the other without the fillers using compression molding method. Mechanical properties like tensile strength, flexural strength and water absorption tests are done with ASTM standard. It is observed that that the addition of filler materials improves the adhesiveness of the fibers leading to the increase in the above mentioned properties. The density of the composite is also low hence the strength to weight ratio is very high. The water absorption test also showed that the resultant composite had a small adhesion to water and absorption of water.

Keywords: Coconut fibre, coconut shell filler, kevelar fibre, NaOH treatment.

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1 Introduction: Composite material is a material consisting of two or more physically and (or) chemically distinct phase, suitably arranged or distributed. A composite material usually has characteristics that are not depicted by any of its components in isolation. Using this definition, it can be determined that a wide range of engineering materials fall into this category. For example, concrete is a composite because it is a mixture of Portland cement and aggregate [1]. The result performed in fabrication of kenaffiber composites and Their hybrids with glass fibers, the large amount of reinforcement appears quite effective on these fiber laminates and the effect of architecture not yield comparable results in kenaffiber laminates and due to insufficient impregnation and not very effective control of fiber orientation, which affect the flexural and indentation performance of the laminates [2]. The PALF/glass and sisal/glass hybrid fiber reinforcements in polyester resin resulted in composites having encouraging mechanical properties like tensile, flexural and impact due to the surface modification of sisal fibers such as alkali treatment, while cyanoethylation resulted in the maximum increase in flexural strength of the hybrid composite[3]. Study on Roystonearegia and glass fibers, Replacing the Roystonearegia with glass fibre through hybridization leads to increase the mechanical properties like tensile, impact, flexural properties, but the glass fiber add with Roystonearegia including electrical properties like electrical conductivity and dielectric constant decreased due to the presence of glass fiber polar groups [4]. Nowadays, the research and amount invested in the development of alternate materials which can substitute for metals is on the increase. One such material which is now used is composites. Among that, the major type is the fiber reinforced composites. It is one of the most economic but at the same the most important type in terms of application [5]. Among the composites a branch which is making a huge contribution is the Fiber Reinforced Polymer composites. They have a very good strength to weight ratio, non-corrosive and are easy to produce also. They have a very good life and are easy to machine and does not damage the tools also. Usually there are two types of fibers namely natural and synthetic fiber. Hybrid composites can be formed combining any two of the fibers or even both. It was experimentally proved this hybrid composites had better mechanical properties like tensile and flexural strength when compared to the individual fiber composites [6, 7]. The common natural fibers used are jute, flax, coir and hemp. Each fiber has its own distinct physical and mechanical properties. Hence it is suitable for a variety of applications from automobile parts to aerospace [8 - 10]. Fiber Reinforced Composites (FRP) is now used in the field of bio-medicine in addition to its application in the field of engineering and construction, a new area where most of the advanced researches are going on. They are used even in bone grafting replacing the conventional titanium alloys. The superior properties that make them suitable for bio-medical applications are low cost, high resistance to corrosion, low anode-cathode reactions and also growth of tissues. Coconut commonly called as coir is one of the most abundant and cheapest fibers available. Coir had the least density of all the natural fibers but had a high percentage of water absorption characteristics. Coconut coir fibers reinforced in any polymer matrix had a good tensile strength, flexural strength and hardness [11, 12]. Coconut fibers and all natural fibers contain some organic water soluble substances like cellulose, hemicelluloses, lignin, pectin and waxes. It should be treated chemically with some strong base solutions. The most economic treatment is the alkaline treatment [8 - 12].

Table (1): The chemical composition of few natural fibers

Type of fiber	Cellulose (%)	Lignin (%)	Hemicellulose (or Pentosan) (%)	*Pectin (%)*	Ash (%)
Fiber flax	71	2.2	18.6-20.6	*2.3*	-
Kenaf	31-57	15-19	21.5-23	-	2-5
Jute	45-71.5	12-16	13.6-21	*.2*	.5-2
Hemp	57-77	3.7-13	14-22.4	*.9*	-
Sisal	47-78	7-11	10-24	*10*	.6-1
Abaca	56-63	7-9	15-17	-	3
Coir	37	42	11	*7*	3

2 Materials and Method

Materials: Coconut fibers (coir) are collected from the coastal region near kanyakumari while Kevlar fibers are obtained from local market in Madurai. Coconuts shells are collected from the daily household wastes. Epoxy (LY 556) and Araldite (HY 951) are purchased from the local dealers and are used as the polymer matrix for the composites.

Preparation of Coconut Fibers: The coconut fibers are collected and washed in running water to remove the dirt and sand particles. It is then dried in sunlight to remove the water content from the fibers. These fibers are referred as untreated fibers and are subjected to alkali treatment. The untreated fibers are now soaked in 5% NaOH solution for about 24 hours in room temperature. It is then taken out and dried in sunlight for about 48 hours. This removes the organic impurities from the fibers.

Preparation of Coconut Fillers: The coconut fillers also have some initial processes before being used. First process involves the preparation of the fillers from the coconut shells by a crushing machine. It is then filtered to a CSP size of 300-425 microns. Alkali treatment is again done to the filler materials. The untreated fillers are now kept in 5% NaOH solution for 24 hours in room temperature. It is then taken out and kept in sunlight for about 48 hours. It is then heat treated by keeping it in a furnace at 110°c for 3 hours and kept for slow cooling in the furnace itself.

Figure (1): Coconut Shell Filler.

Figure (2): Heat Treatment.

Fabrication of Composites: The treated coconut fibers and coconut fillers are initially prepared in the workplace and woven Kevlar mats are taken for the composite preparation. The two composites are prepared with one having fillers and the other without the fillers. The plate is prepared by reinforcing alternate layers of Kevlar and Coconut in the Epoxy and filler matrix. The number of Kevlar to Coconut mats are in the ratio 3:2. The coconut fibers were arranged in a unidirectional pattern. Fillers are mixed in epoxy for composite fabrication. The matrix contains epoxy mixed with 10:1 of Araldite (hardener). This process is done in jayplastnagercoil. The weight percentage of the two composite plates is given in the table below.

Table (2): The weight percentage of the two composite plates

Composites	Kevlar (%)	Coconut (%)	Epoxy (%)	Filler (%)
Without filler	15	40	45	-
WithFiller	15	40	40	5

When these layers are placed in the required order, a large compressive force is provided by means of a compression moulding machine at a load of 35 psi. The load is applied for 3 hours till proper curing of resin is achieved.

Tensile Test: The tendency of a material to stretch without breaking is known as tensile strength. The tensile strength was performed according to ASIM D3039 standards using UTM, the cross head speed was 0.5 mm/min. The ends of the specimen were clamped between the jaws. The movement of the jaws offer tensile force on the specimen. All the results were taken as the average value of five samples.

Flexural Test: Three-point bending tests, according to ASTM D-790 standard, were performed using a universal testing machine by Instron with cross head speed of 0.5 mm/min. All the results were taken as the average value of five samples.

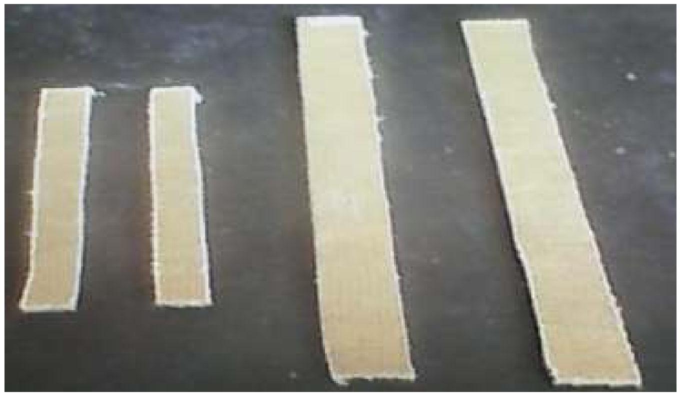

Figure (3): Flexural and Tensile test Specimen.

Water Absorption Test: The water absorption property of the composite samples was determined by using specimen of ASTM D 5229 standards. The experiment was conducted at room temperature for seven days; the weight of the specimen has been observed and tabulated for every 24 hrs. For the calculation the amount of moisture absorbed the samples have the dried in sunlight and immersed in water for the above mentioned days. This test will help determine the extent at which the composites can absorb water. The percentage water absorption [W%] for test samples was calculated using the equ (1).

Figure (4): Water absorption test.

$$\% \text{ of water absorption} = \frac{W_2 - W_1}{W_1} \times 100 \qquad \text{---------- (1)}$$

Where

W1- weight of dry specimen (gm)

W2- corresponding weights of specimen per day (gm)

Density: The density of each specimen is calculated by equ (2). The dimensions of the specimen are measured using verniercaliper. The mass of the specimen is calculated by weighing machine of accuracy 1×10^{-3}Kg.

$$\rho = \frac{mass}{volume} \qquad \text{---------- (2)}$$

Table (3): Physical and mechanical properties of Coconut, Kevlar and Epoxy resin

Properties	Coconut	Kevlar	Epoxy
Density (g/cm3)	1.2	1.47	1.25
Tensile strength (MPa)	175-220	3400	10-25
Young's modulus (GPa)	4-6	186	.75
Elongation at break (%)	15-30	2	2

3 Results and Discussion

Tensile Strength: The important physical and mechanical properties of Coconut fiber, Kevlar fiber and Epoxy are given in Table 3. Figure (5) and Figure (6) show the variation of tensile strength and tensile load of the two composite plate one with filler and the other without filler. The weight % of the fibers is kept constant and only the filler concentration is varied. The Figure clearly explains that the addition of a small percentage of filler materials to the fibers had a significant effect on the final properties of the composites. The addition of 5% fillers significantly improved the properties by some 1.22 times without it.

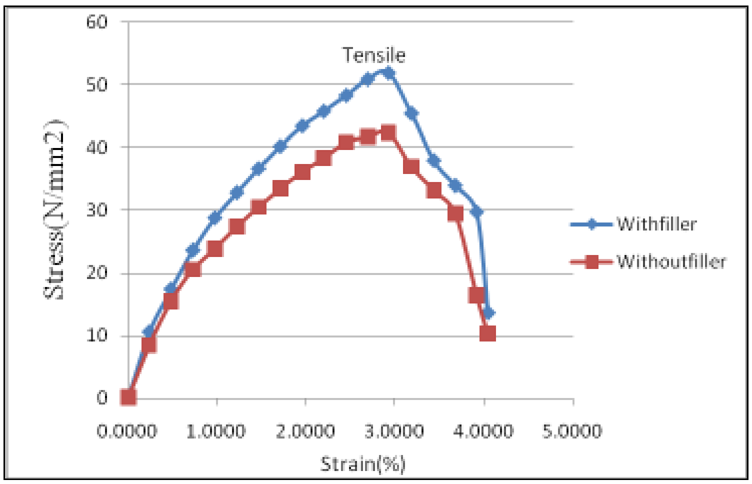

Figure (5): Variation of Tensile Stress with Strain for Composite with Fillers and Without Fillers.

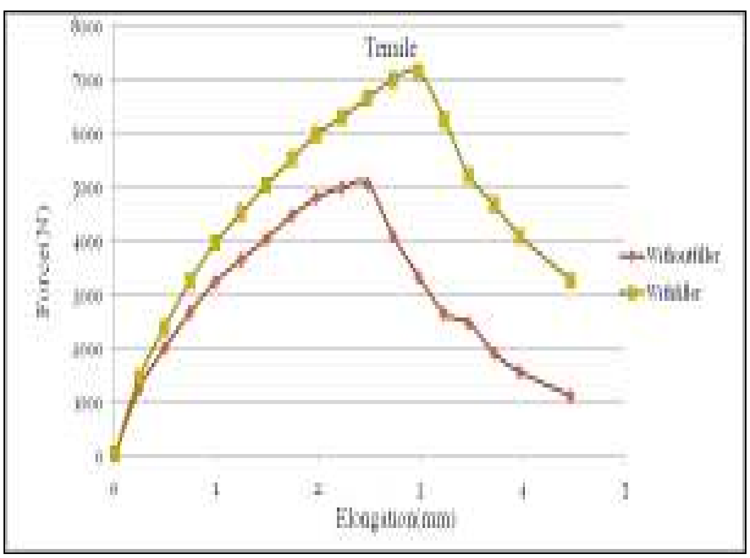

Figure (6): Variation of Displacement with Load for Composite with Fillers and Without Fillers.

Addition of Kevlar fibers even in a small % by weight has a very significant effect on the composites. In a hybrid Composite, the properties of the composite are mainly dependent on the modulus and percentage elongation at the time of failure of the individual reinforcing fibers. The modulus of Kevlar fiber is comparatively higher than that of the coconut fiber, whereas the extensibility of Kevlar is low compared to the coconut fiber. This results in early Kevlar fiber failure which transfers high stress to the less strong coconut fibers and this leads to the failure of the fiber resulting in the failure of the composite. The improvement in tensile strengths of the composites at low wt. % of Kevlar fiber loadings will be due to the fact that at these particular compositions, the coconut fiber can effectively transfer the load from the Kevlar fiber. Hence, comparatively less weight percentage of Kevlar fibers along with the coconut fiber reinforcement results in composites of a more enhanced performance than the 100% coconut fiber reinforced composites.

Also another important factor is the alkaline treatment of both the fillers and also the fibers. Alkali treatment improves the surface roughness and also the adhesive properties of the fibers. This makes the fibers more subjected to large stress and load. This even distribution of the load makes the composites more strong against tensile loading. This makes the 5% fillers to make a considerable change in the properties. The composite with fillers had a maximum of 72 MPa tensile strength and 1.57 GPa modulus which is about 1.5 times higher than that of the composites without fillers.

Flexural Strength: Three point bending test is done by Universal Testing machine (UTM) and the observed values are charted in Figure (7) & (8). The graph in Figure (7) shows addition of fillers has better influence in the bending properties. It's observed that there is a moderate increase in the bending load withstanding capacity of the hybrid composite. Similarly the Figure (8) indicates the addition of fillers has effect on the bending stress absorbed by the composite. Due to the addition of the fillers, the composite withstands up to 116 MPa rather when compared to the composite without filler which doesn't withstand above 80 MPa.

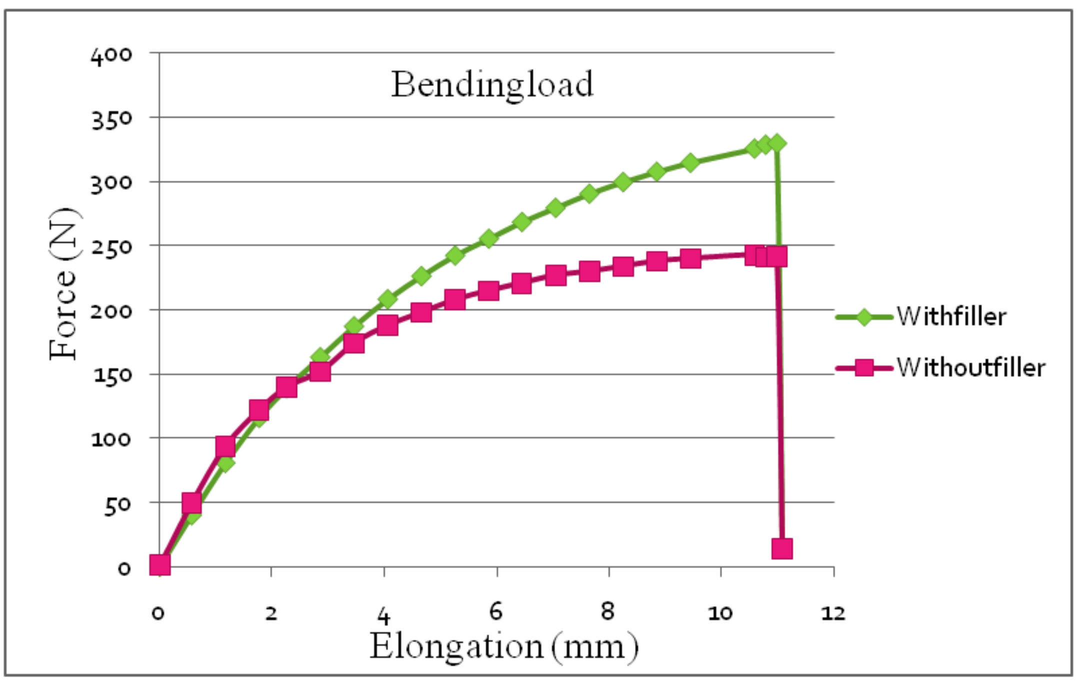

Figure (7): Variation of Flexural Load with Displacement for the Composites with and Without Fillers.

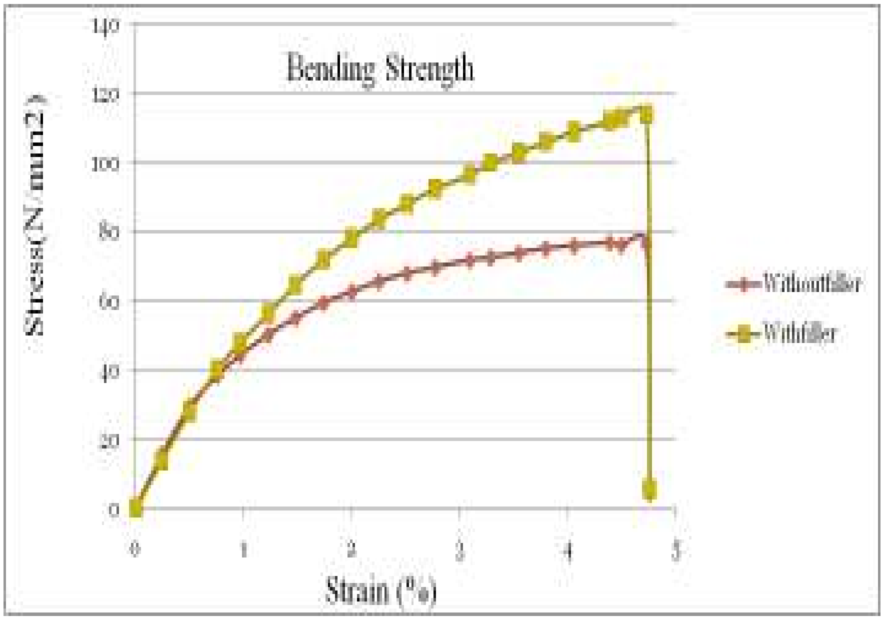

Figure (8): Variation of flexural stress with strain for composites with and without fillers.

Water Absorption Test: The variation in water absorption of various composites is shown in Figure (9), clearly shows a large variation in the water absorption with the addition of fillers. The addition of filler has increased the water absorption property. This is because of both the natural fibers and fillers. Though both are treated with an alkali, the continuous contact with water definitely alters the water absorbing property. At the end of 7 days the composite without fillers had a weight % of 2 while the composite with fillers had a weight % of 2.4. While comparing with other composites the addition of a strong amide group like Kevlar has a huge effect in the amount of water absorbed.

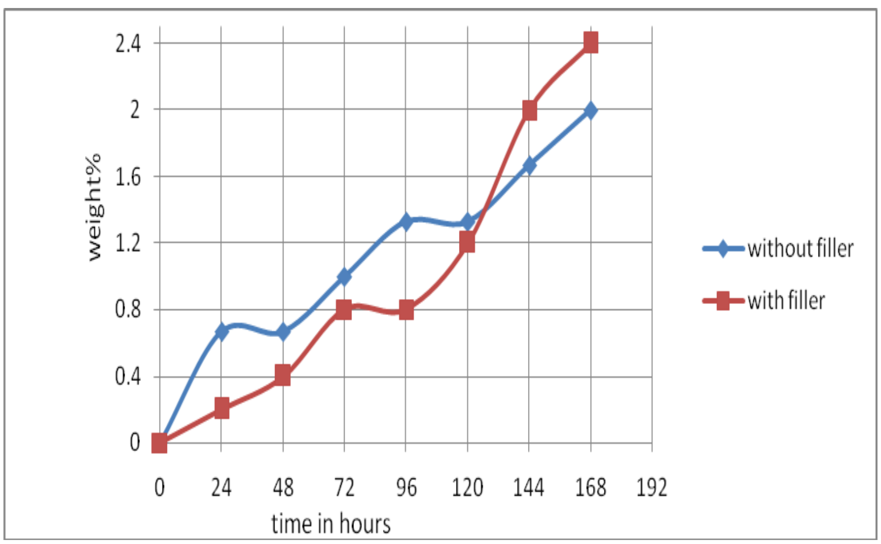

Figure (9): Variation of Water Absorption of the Composites With Respect To Time.

Density: The density of the specimen was calculated by equ (2). The maximum density is pure Kevlar fiber and the minimum density is KC composite. The density chart enlightens us that the composite has low density when compared to the pure Kevlar fiber and coconut fiber. In this result shows KCCSF composite is low density so this material is used to manufacturing in automotive and homemade application.

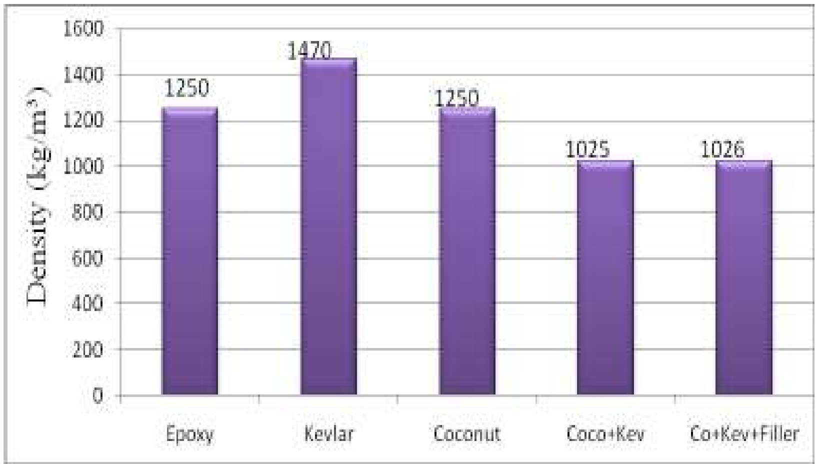

Figure (10): Variation of Density of Various Fibers and Composites.

4 Conclusions: In this paper, mechanical properties of, Coconut fiber/ Kevlar fiber and Coconut fiber/ Kevlar fiber/ coconut shell filler reinforced epoxy composites have been described. The tensile and flexural properties of Coconut fiber/ Kevlar fiber reinforced epoxy composites are observed to have improved by the incorporation of small amount of coconut shell filler in these composites, showing positive hybrid effect. Under the present experimental conditions adopted. Coconut fiber/ Kevlar fiber/ coconut shell filler hybrid epoxy composites of different chemically modified Coconut fiber and coconut shell filler are fabricated and tested. Among the different chemical modifications of the Coconut fiber and coconut shell filler, 5% alkali treatment produced optimum tensile strengths while cyanoethylation resulted in the maximum increase in flexural strength in the hybrid composites. It is also observed that water absorption tendency of composites decreases by the process of hybridization and surface treatments of bio-fibres. The density study was indicated is very low density value made by Coconut fiber/ Kevlar fiber. Thus Coconut fiber/ Kevlar fiber and Coconut fiber/ Kevlar fiber/ coconut shell filler hybrid fibre reinforcements in epoxy resin resulted in composites having encouraging mechanical properties, which may expand the applicability of these composites in automotive and building products industries.

References:

[1] I. A. Al-Mosawi, M. H. Al-Maamori, "Mechanical Properties Of Composite Material Reinforcing By Natural-Synthetic Fibers", 3/3 ISSN-L: 2223-9553 ISSN: 2223-9944.

[2] H. M. Akil, I. M. De Rosa, C. Santulli, "Flexural behaviour of pultruded jute/glass and kenaf/glass hybrid composites monitored using acoustic emission", Materials Science and Engineering A 527 (2010) 2942–2950.

[3] S. Mishraa, A. K. Mohantyb, L. T. Drzalb, M. Misra, "Studies on mechanical performance of biofibre/glass reinforced polyester hybrid composites", Composites Science and Technology 63 (2003) 1377–1385.

[4] G. Goud, R. N. Rao, "Mechanical and electrical performance of Roystonearegia / glass fibre reinforced epoxy hybrid composites", Bull. Mater. Sci. 35/4 (2012) 595–599.

[5] K. Joseph, R. D. TolêdoFilho, B. James, "A Review On Sisal Fiber Reinforced Polymer Composites Revista Brasileira de Engenharia Agrícola e Ambiental", 3/3 (1999) 367-379 Campina Grande, PB, DEAg/UFPB.

[6] H. M. Akil, I. M. De Rosa, "Carlo Santulli Flexural behaviour of pultruded jute/glass and kenaf/glass hybrid composites monitored using acoustic emission", Materials Science and Engineering A 527 (2010) 2942–2950.

[7] A. I. Al-Mosawi, M. H. Al-Maamori, "Mechanical Properties of Composite Material Reinforcing By Natural-Synthetic Fibers", 3/3 ISSN-L: 2223-9553 ISSN: 2223-9944.

[8] S. Mishraa, A. K. Mohanty, L. T. Drzal, Composites Science and Technology 63 (2003) 1377–1385.

[9] A. S. Singha, V. K. Thakur, "Mechanical properties of natural fibre reinforced polymer composites", Bull. Mater. Sci. 31/5 (2008) 791–799.

[10] Z. N. Azwa, B. F. Yousif, "Thermal Degradation Study Of Kenaf Fibre/Epoxy Composites Using Thermo Gravimetric Analysis", MPC 16 (2013) 256-264.

[11] V. K. Singh, P. C. Gope, S. Chauhan, "Mechanical Behavior of Banana Fiber Based Hybrid Bio Composites", J. Mater. Environ. Sci. 3/1 (2012) 185-194 ISSN : 2028-2508CODEN: JMESCN.

[12] J. O. Agunsoy, T. S. Isaac, S. O. Samuel, "Study of Mechanical Behaviour of Coconut Shell Reinforced Polymer Matrix Composite", Journal of Minerals and Materials Characterization and Engineering 11 (2012) 774-779.

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