A STUDY ON THE EFFECT OF SIC ON MECHANICAL PROPERTIES OF CARBON/BANANA PEDUNCLE FIBER REINFORCED EPOXY COMPOSITES

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Abstract. *Nowadays the position of natural fibers in the world fiber is stable, growing in the area of their application, not only in textiles but also in more eco-friendly composites. This work is focused on study of the effect of SiC as filler material on the banana peduncle/Carbon fibers reinforced hybrid composites. Four different laminates are fabricated by varying the matrix composition (BP, BP+SiC, carbon+BP, Carbon+BP+SiC). The alkaline treatment with 6% NaOH of the BP fibers improves the specific strength and binding properties. The filler added composites laminates shows higher mechanical properties. From the results it is seen that mechanical properties like Tensile, Flexural, ILSS, Impact and hardness are improved by 89, 75, 99, 68 and 64% by the addition of the SiC to the banana peduncle/Carbon fiber composite laminate.*
Keywords: *banana fiber, carbon fiber, hand layup, mechanical properties*

1. Introduction

Natural fiber polymer composites (NFPC) are a composite material consisting of a polymer matrix embedded with high-strength natural fibers, like jute, oil palm, sisal, kenaf, and flax. Most of the time, Natural fibers compared to synthetic fibers are inferior in properties such as tensile strength, Flexural strength etc. One possible solution to this is to use the synthetic fiber with the natural fibers resulting in a polymer hybrid composites (Sanjay et al., 2018; Sanjay et al., 2016; Sanjay et al., 2015; Sanjay et al., 2017; Madhu et al., 2018; Sanjay et al., 2018). Synthetic fibers are man-made fibers with chemical synthesis unlike the natural fibers that can be obtained from living organisms with little or no chemical process. Generally, notice that the rise in fiber content causes improving in the tensile properties of the composites. Another vital factor that considerably impacts the properties and surface characteristics of the composites is the process parameters utilized. For that reason, appropriate process techniques and parameters should be rigorously chosen in order to get the best characteristics of producing composite (Jothibasu et al., 2018; Athith et al., 2018; Sanjay et al., 2018; Yashas et al, 2018; Ganesan et al., 2018; Sanjay et al., 2018; Ahmed et al., 2018).

The mechanical property of the hybrid composite laminate is directly proportional to the percentage of synthetic fiber content in the hybrid. Hybridization improves the

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water absorption and mechanical behavior of the carbon/banana hybrid fiber composite (Ramesh et al., 2014). Hybridization improves properties of the natural fiber composites. Sisal fiber with GFRP has better tensile properties and jute fiber with GFRP has better flexural properties (Ramesh et al., 2013). Hybridization increases the mechanical properties of the composites, increases the thermal stability of polypropylene, causes no change in the viscosity, and decreases the water absorption of the composite (Srisuwan et al., 2018).

Fillers are one of the most inexpensive materials used in the fabrication of composites, but they frequently help in improving the performance of composite which might not be achieved with the use of the reinforcement and resin ingredients alone. These fillers are also referred to as extenders. These fillers by reducing the organic contents in the composite laminate can improve mechanical properties including fire and smoke resistance. These fillers also help in minimizing the shrinkage of the composite thereby improving the dimensional accuracy of molded parts. Addition of fillers decreases the voids, improves the physical properties and also improvement in the flexural property (Abishek et al., 2018; Sanjay et al., 2016; Arpitha et al., 2017; Sanjay et al., 2016).

2. Materials and Methods

Extraction Of Banana-Peduncle Fiber

Figure 1. Banana peduncle, peduncle skin cleaning, peduncles under the retting process and extracted fibers

The initial stage was the collection of Banana Peduncles. The peduncles were of a length of half meter each and were suitably cut down to sizes of 30-40cms. With the help of a knife, the outer skin of the Peduncle was removed and cleaned off impurities and dust with the help of purified water. Figure 1 shows the extraction of the banana peduncle fibers from the banana peduncle. The peduncles were firmly tied together in order to prevent loss of cellulose, a key factor that serves as a natural binder. The bundles were collectively immersed into 6% concentrated Sodium Hydroxide (NaOH) solution of water at room temperature. The fibers were also washed many times in demineralized water to remove unwanted ingredients from the skin of the fiber. The setup was allowed to contain for a period of 5 days post which the fibers were removed, washed again, and allowed to be dried under the sun for a few hours. The dried fibers were then separated into thin strands by hand and used in the composite.

Fabrication Method

Hand lay-up is the most common and least expensive open-molding method because it requires the least amount of equipment. Fiber reinforcements are placed by hand in a mold and resin is applied with a brush or roller. Table 1 represents the different types of laminates fabricated in this research.

Table 1. Schematic representation of the fabricated laminates

Laminate	L1	L3	L2	L4
Schematic representation	Banana peduncle fiber *pure BP fiber	Banana peduncle fiber *BP+Filler	Carbon fiber Banana peduncle fiber Carbon Fiber *C+BP+C	Carbon fiber Banana peduncle fiber Carbon fiber *P+BC+P+Filler
Silicon carbide filler	0%	4%	0%	4%

Reinforcement Material

Carbon fiber mats and the banana peduncle fibers were used as a reinforcement material. Carbon fibers are made up of carbon atoms and their diameter varies from 5-10 micrometer. Due to their superior property carbon fiber find its application in many fields like automobiles, aerospace, military, sports products and in civil engineering. Thousands of carbon fibers are bundled together to form a tow, which are then woven into a fabric. Some of the important properties of carbon fiber are High Strength to weight ratio, Rigidity, Corrosion resistance etc. The properties are listed in Table 2.

Table 2. Properties of the banana peduncle fiber and carbon fiber

Property	Carbon fiber	Banana peduncle fiber
Density (gm/cc)	1.8	4.4
Tensile strength (MPa)	3500	550
Youngs modulus(GPa)	230	12-14

Matrix Material

K-6 hardener is mixed with the Lapox (L-12) resin in the ratio of 1:10 thoroughly for 3-4min and then the mixture is used for the laminates fabrication. Fillers in required amounts are added to the matrix, when it is in liquid form for the fabrication of composite laminates with the fillers.

Tensile Test

Tensile testing, also known as tension testing, in this test a sample is subjected to a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young‘s modulus, Poisson's ratio, yield strength, and strain-hardening characteristics. During the test a uniaxial load is applied through both the ends of the specimen. The dimensions of the specimen were according to ASTM D638–03 standards.

Flexural Test

Flexural testing is used to determine the flex or bending properties of a material. Sometimes referred to as a transverse beam test, it involves placing a sample between two points or supports and initiating a load using a third point which is called as 3-Point Bending test.Maximum stress and strain are calculated on the incremental load applied. This test was conducted as per ASTM D790-07standards, using UTM Unitek 9450.

Inter-Laminar Shear Test

The interlaminar shear strength of laminates with a brittle matrix, for example, those made of epoxy resin, is typically determined using a short beam shear test.). ILSS was conducted in the same UTM used for 3-point bending test. ILSS test was conducted according to ASTM D2344. The specimen was loaded at a rate of 1.5 mm/min under three-point bending test by providing two supports and a span length of 40 mm

Impact Test

The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductilebrittle transitions. The specimens were cut and impact test was conducted according to ASTM D256-06.

Hardness test

The micro-hardness of the composite laminate specimens was measured by using a Mitutoyo digital micro-hardness tester (model: HM-122). The test was carried out as per ASTM E384 standard. The loading rate of this machine is 60 µm/sec, and loading duration, loading, unloading was automatically controlled.

3. Results and Discussion

Tensile Properties

The stress in the material just before the failure under tensile load is called tensile strength of the material, the unidirectional banana peduncle fiber reinforced composites have tensile strength of about 43.5MPa, by the addition of the fillers the property is increased by 12.5%, if we hybridized with the synthetic fiber the strength is improved by 173.5%. By the addition of fillers to hybrid composite laminate the tensile strength is improved by 112%, which is lower than the hybrid composite without the filler (L3), by the addition of SiC to matrix the composites tensile strength decreases which in turn increases the brittleness in the composite laminates. Figure 2 shows the comparison plot for the different fabricated composite laminates. The hybridization of the banana with carbon fiber has higher tensile strength compared to the hybridization with the glass fiber (Sanjay et al, 2016).

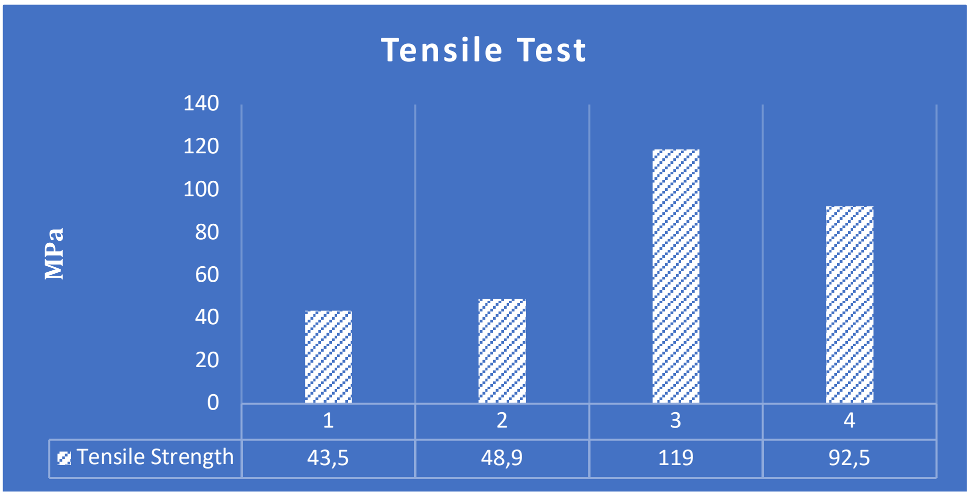

Figure 2. Tensile test comparison plot

Flexural/Bending Test

The flexural test was carried out using a three-point bending test; the specimens were subjected under the combined effect of tensile and compression load. The results of the flexural load are shown in Table 3.The flexural property of the laminates is doubled by hybridizing with the carbon fibers. By the use of SiC the property is enhanced a little bit. Figure 3 shows the flexural properties of the laminates. Laminates L3 and L4 have their flexural strengths higher than those of pure GFRPs and their hybridization with the banana fiber (M R Sanjay et al. 2016).

Table 3. Three-point bending test results.

Laminate	Max. load in N	Max. disp in mm	Flexural strength (MPa)
L1	280	1.620	131.25
L2	380	1.22	178.125
L3	320	2.57	266.67
L4	375	3.99	312.5

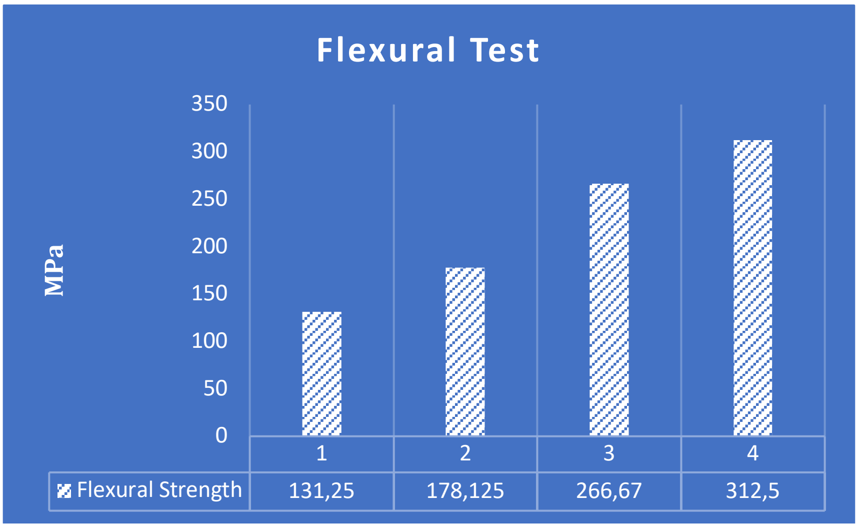

Figure 3. Flexural test comparison plot

Inter-Laminar Shear Strength

ILSS test was conducted in the same UTM which is used for the Bending test, table 4 are the results of the ILSS test. Pure banana peduncle fiber reinforced composite and hybrid composite with SiC have the minimum and maximum ILSS value of about 168.75 and 429.167 MPa respectively. For pure BP fiber reinforced composites, the ILSS value is increased by 27 and 13.6 % due to the addition of fillers, and the hybridization with the carbon fiber.

Table 4. ILSS test results

Laminates	Max. force in N	Max. disp in mm	ILSS in MPa
L1	360	1.65	168.75
L2	460	1.130	215.625
L3	230	2.04	191.7
L4	515	2.780	429.167

Impact Test

The Charpy impact test is conducted to determine the impact strength of all composite laminates. The results of the impact test are indicated in Figure 4. Laminate L4 has the highest impact strength compared to all other laminates, but its impact energy is lower compared to that of the pure glass fiber composites (M R Sanjay et al. 2017). By the addition of the fillers, and by hybridization, the impact strength of the composites laminates is increased by about 25 and 90% respectively (L2 and L3) with respect to the pure banana peduncle fiber reinforced composite.

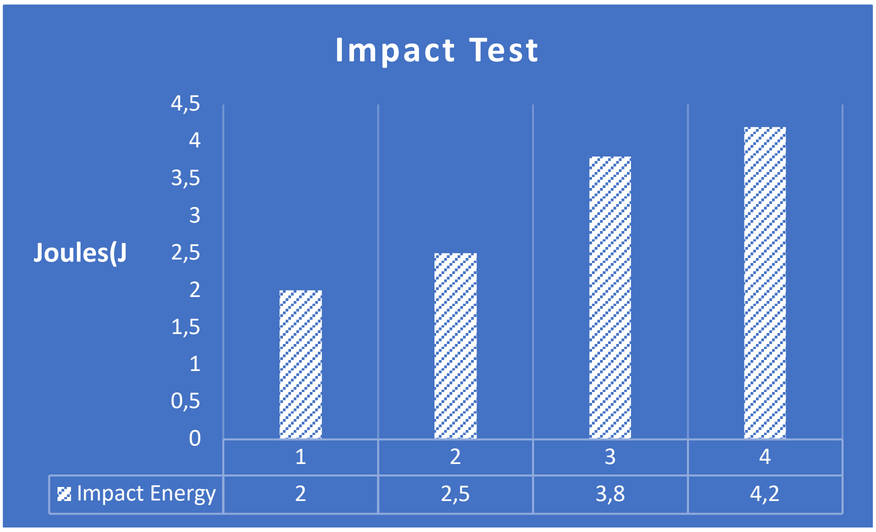

Figure 4. Impact test comparison plot

Micro-Hardness Test

Micro-hardness test results of composite laminates are shown in table 5. The hardness value of the Banana peduncle fiber + Carbon Fiber + SiC is superior to the all other composite laminates. The composite laminates of Banana peduncle fiber + SiC and Banana peduncle fiber + Carbon Fiber show a significant increase in hardness value over the pure Banana peduncle fiber composite. Among these laminate, Banana peduncle fiber + Carbon Fiber + SiC composite laminate again exhibits higher hardness value of 43.41 HV and pure Banana peduncle fiber composite laminate exhibit lower hardness value of 21.18 HV. It shows that having high strength Banana peduncle fibers and Carbon fiber also improves the hardness of the composite laminates.

Table 5. Micro hardness test results

Laminate	Micro-Hardness Number (HV)
L1	21.18
L2	26.37
L3	38.29
L4	43.41

4. Conclusions

Banana peduncle fiber/Carbon fiber-reinforced hybrid epoxy composite laminates were prepared by Hand lay-up method and also an attempt to was made to investigate the effect of SiC as filler on mechanical properties such as tensile strength, flexural strength, ILSS, hardness and impact strength of four fabricated composite laminates.

- It is noticed that the hybridization improves the mechanical property of the laminates.
- The tensile properties of the pure Banana peduncle fiber-reinforced composite are not found to be as good as those with the filler.By the use of SiC as filler the tensile strength is increased by 12.5% for the pure banana peduncle fiber composites.
- The tensile strength is increased by about 173% due to hybridization with the carbon fiber.
- The combination of the tensile and the compressive strength of the laminates i.e. the flexural property is doubled by hybridizing with carbon fibers and with the use of SiC the property is enhanced a little bit
- For pure BP fiber reinforced composites, the ILSS value is increased by the addition of fillers and the hybridization with the carbon fiber by 27 and 13.6 % respectively (L2 and L3).
- By the addition of the fillers and by hybridization the impact strength of the composites laminate are increased by about 25 and 90% respectively(L2 and L3) with respect to pure banana peduncle fiber reinforced composite.
- The hardness value is caused due to the difference in hardness between matrix and fibers. The hybrid laminate with the filler has a higher hardness compared other composite laminates, because of the presence of SiC and due to hybridization.

From this research work it has established that these hybrid composites can be used when cost reduction is the prime consideration and can effectively replace the conventional and relatively expensive materials. Their biodegradability is an additional advantage. Their use may be recommended for building and construction applications like roofing sheets, bricks, door panels, furniture panels, interior paneling, airplane tray tables, car bumpers etc. They may also be suited in other applications such as bath units, chairs, lampshades, partitions, roof, suitcases, trays, tables, and manufacturing of car doors, car interiors, dashboards, headliners, decking, parcel shelves, pallets, spare-wheel pan, seat backs, etc.

References

Ahmed, M. J., Balaji, M. S., Saravanakumar, S. S., Sanjay, M. R., &Senthamaraikannan, P. (2018). Characterization of Arevajavanica Fiber–A Possible Replacement for Synthetic Acrylic Fiber in the Disc Brake Pad. *Journal of Industrial Textiles*, 1528083718779446.

Arpitha, G. R., Sanjay, M. R., Senthamaraikannan, P., Barile, C., &Yogesha, B. (2017). Hybridization Effect of Sisal/Glass/Epoxy/Filler Based Woven Fabric Reinforced Composites. *Experimental Techniques*. 41(6), 577-584.

Athith, D., Sanjay, M. R., Yashas Gowda, T. G., Madhu, P., Arpitha, G. R., Yogesha, B., & Omri, M. A. (2018). Effect of Tungsten Carbide on Mechanical and Tribological Properties of Jute/Sisal/E-Glass Fabrics Reinforced Natural Rubber/Epoxy Composites. *Journal of Industrial Textiles*. 48 (4), 713-737.

Jothibasu, S., Mohanamurugan, S., Vijay, R., Lenin Singaravelu, D., Vinod, A., & Sanjay, M. R. (2018). Investigation on the Mechanical Behavior of Areca Sheath Fibers/Jute Fibers/Glass Fabrics Reinforced Hybrid Composite for Light Weight Applications. *Journal of Industrial Textiles*, 1528083718804207.

Ganesan, K., Kailasanathan, C., Sanjay, M. R., Senthamaraikannan, P., &Saravanakumar, S. S. (2018). A New Assessment on Mechanical Properties of Jute Fiber Mat With Egg Shell Powder/Nanoclay-Reinforced Polyester Matrix Composites. *Journal of Natural Fibers.* 1-9.

Madhu, P., Sanjay, M. R., Senthamaraikannan, P., Pradeep, S., Saravanakumar, S. S., &Yogesha, B. (2018). A Review on Synthesis and Characterization of Commercially Available Natural Fibers: Part-I. *Journal of Natural Fibers*. 1-13.

Ramesh, M., Palanikumar, K., & Reddy, K. H. (2013). Mechanical Property Evaluation of Sisal–Jute–Glass Fiber Reinforced Polyester Composites. *Composites Part B: Engineering*. *48*, 1-9.

Ramesh, M., Atreya, T. S. A., Aswin, U. S., Eashwar, H., &Deepa, C. (2014). Processing and Mechanical Property Evaluation of Banana Fiber Reinforced Polymer Composites. *Procedia Engineering*. *97*, 563-572.

Sanjay, M. R., Arpitha, G. R., &Yogesha, B. (2015). Study on Mechanical Properties of Natural-Glass Fiber Reinforced Polymer Hybrid Composites: A Review. *Materials today: proceedings*. 2(4-5), 2959-2967.

Sanjay, M. R., Arpitha, G. R., Naik, L. L., Gopalakrishna, K., &Yogesha, B. (2016). Applications of Natural Fibers and Its Composites: An overview. *Natural Resources*. 7(03), 108.

Sanjay, M. A., &Yogesha, B. (2016). Studies on Mechanical Properties of Jute/E-Glass Fiber Reinforced Epoxy Hybrid Composites. *Journal of Minerals and materials characterization and engineering*. 4(01), 15.

Sanjay, M. R., &Yogesha, B. (2016). Study on Water Absorption Behaviour of Jute and Kenaf Fabric Reinforced Epoxy Composites: Hybridization Effect of E-Glass Fabric. *International Journal of Composite Materials.* 6(2), 55-62.

Sanjay, M. R., &Yogesha, B. (2017). Studies on Natural/Glass Fiber Reinforced Polymer Hybrid Composites: An evolution. *Materials Today: Proceedings.* 4(2), 2739-2747.

Sanjay, M. R., Arpitha, G. R., Senthamaraikannan, P., Kathiresan, M., Saibalaji, M. A., &Yogesha, B. (2018). The Hybrid Effect of Jute/Kenaf/E-Glass Woven Fabric Epoxy Composites for Medium Load Applications: Impact, Inter-Laminar Strength, and Failure Surface Characterization. *Journal of Natural Fibers*. 1-13.

Sanjay, M. R., Madhu, P., Jawaid, M., Senthamaraikannan, P., Senthil, S., & Pradeep, S. (2018). Characterization and Properties of Natural Fiber Polymer Composites: A Comprehensive Review. *Journal of Cleaner Production*. 172, 566-581.

Sanjay, M. R., Siengchin, S., Parameswaranpillai, J., Jawaid, M., Pruncu, C. I., & Khan, A. (2018). A Comprehensive Review of Techniques for Natural Fibers as Reinforcement in Composites: Preparation, Processing and Characterization. *Carbohydrate polymers*. 207, 108-121

Sanjay, M. R., &Yogesha, B. (2018). Studies on Hybridization Effect of Jute/Kenaf/E-Glass Woven Fabric Epoxy Composites for Potential Applications: Effect of Laminate Stacking Sequences. *Journal of Industrial Textiles.* 47(7), 1830-1848.

Srisuwan, L., Jarukumjorn, K., &Suppakarn, N. (2018). Effect of Silane Treatment Methods on Physical Properties of Rice Husk Flour/Natural Rubber Composites. *Advances in Materials Science and Engineering*, 2018.

Yashas Gowda, T. G., Sanjay, M. R., Subrahmanya Bhat, K., Madhu, P., Senthamaraikannan, P., & Yogesha, B. (2018). Polymer Matrix-Natural Fiber Composites: An Overview. *Cogent Engineering*. 5(1), 1446667.