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Experimental Impact on Mechanical Characteristics of Banana Fiber Reinforced, Groundnut Shell Powder Filled Epoxy Resin Matrix Bio Composites

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Abstract: The outcome of adding together naturally available reinforcement material to the natural fiber epoxy composite was examined experimentally. Composites mates were manufactured with the help of a conventional hand-layup method. All composites are prepared with constant weight fraction (30%) of banana fiber with dissimilar weight fraction of (0, 2, 4, 6%) groundnut shell powder is added to the epoxy composite. As per the ASTM standards, test specimens were cut away from the composite mate using the water jet machining process. Tension, compression, hardness, impact, flexural and water absorption tests were conducted according to ASTM standards, to discover the mechanical behavior of the composites. Experimental results represent that mechanical properties are considerably enhanced by means of the adding up of groundnut shell powder to the epoxy-based banana fiber composite.

Keywords: Epoxy resin, banana fiber, groundnut shell powder, bio-composites, mechanical characteristics.

I. INTRODUCTION

At present, there is a demand in ecological friendly materials and the price of the traditional fibers like carbon, glass, and aramid reinforced polymer-based composites are also so high. These problems were defeated by developing an innovative bio-based composite [1]. A high percentage of urbanization requires the use of low-weight single-use materials which dramatically improves the effective use of products on the basis of plastics for different applications. As a result, ecofriendly materials with better performance characteristics are developed by scientists. Petroleum-based products cause danger to the environment. These were overcome by developing an innovative bio-composite. Recently many researchers are focused to develop ecological friendly bio composite [2]. Natural fibers display improved mechanical characteristics like resiliency, rigidity and modulus in comparison to glass fibers [3]. An embodiment of natural fibers with glass fiber enhances the bending strength and UTS and these composite materials may be utilized for moderate strength applications [4]. Currently, the most significant farming waste is a banana fiber which is cultivated from a banana tree. So that these can be attained easily at no extra cost for industrial use [5]. DMA i.e, dynamic mechanical analysis of banana fiber reinforced polyester composites were examined and discovered that the volume fraction of the fiber has a major impact on the mechanical characteristics of the composite materials [6]. Hybridization of sisal fiber with banana/epoxy composite materials up to 50 wt% improves mechanical characteristics and also reduces the water absorption characteristics. An aggregate bending and tensile characteristics of natural fiber reinforced polymer hybrid composite materials rely heavily on aspect ratio, the tendency of moisture absorption, morphology and size stability of the utilized fibers [7]. Till now, a lot of work has been performed in the field of banana fiber polymer composite materials. The paper showed the structural, mechanical and physical characteristics of banana fiber composite. Additionally, it also encloses a performed work on banana fiber reinforced with epoxy resin [8]. Banana fiber encompasses 62-64 percentage of cellulose, 19 percentages of hemicelluloses and 5percentage of lignin which is a significant component. Plant fibers that are fitted with the higher cellulose content Possessing higher mechanical performance [9]. NFC's performance may be enhanced by hybridization by the addition of the fillers or fibers. Adding the filler material mechanical behavior of the composite was improved. The addition of filler material helps to improve the agglutination between the polymer and fiber [10]. PMC's agglutination between the polymer and fiber is a very important factor for procurement healthier mechanical performance. At the compound of the composite shear stress is transferred to the fibers by the matrix. With the higher agglutination higher performances are achieved, the lifetime of the material also convalesces.

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Mechanical properties not only depend on the fiber-matrix interaction they will depend on the matrix and fiber [11]. The addition of filler material helps to improve the agglutination between the polymer and fiber.

The rate of water absorption also reduces by adding a filler material to the composites [12-14]. It is suggested that the composites which are developed from the coconut shell powder granule and epoxy resin be capable of a substitute for wooden material due to reasonable mechanical properties [15]. In this research work, the researches have been carried out for forecasting the effect of natural filler material on mechanical characteristics of banana fiber reinforced epoxy resin matrix composites.

II. MATERIALS

The matrix materials i.e., MNP Liquid General-Purpose Resin and hardener (HY951) were procured from Covai Seenu and Company, Coimbatore, Tamilnadu, India. Well dried and good quality groundnut shells are obtained from Golden Oil Mills, Dharapuram, Tamilnadu, India. The procured Groundnut shells were dried at atmospheric temperature for one day. Long banana fibers were obtained from Jothi Banana Fibre Unit, Thiruvedagam, Tamilnadu, India. The different materials which are used to make the bio-composite mates are shown in figure.1. The four bio composite mats (250×250×5 mm^3) are manufactured by a normal hand-lay-up technique. Banana fibers are oriented in bidirectional (0°and 90°) and epoxy resin is mixed with a hardener in the ratio of 15:1. The well-dried groundnut shell powders are mixed with the epoxy resin with the help of manual stirrer. Four composites of fixed 30 wt% of banana fibers with different groundnut shell powders weight fraction of (0, 2, 4 and 6 wt %) are prepared. As per ASTM standards, the specimens for the mechanical test were made. Specimens are revealed in Figure 2 and the experimental arrangements were demonstrated in Figure 3. Different mechanical properties of the bio-composites are obtained by standard test methods. In Computerized Universal Testing Machine (CUTM), UTS is performed at a spindle velocity of 2 mm/min as per ASTM D3039 with a dimension of 250 x 25 x 3 mm. In the Impact testing machine, the Impact Izod test was conducted as per standards of ASTM D256 with a dimension of 65 x 13 x 3 mm. In Computerized Universal Testing Machine (CUTM), a compression test was conducted according to ASTM D695 standards with a dimension of 50 x 10 x 4mm. In Computerized Universal Testing Machine (CUTM) flexural test was conducted according to ASTM D7264 standards with a dimension of 165 x 13 x 4mm. A hardness test was conducted on a Rockwell hardness testing machine. The ¼ inch ball indenter is forced on the specimen's surface under a load of 60 kgf.

Figure 1 Materials used for making bio-composites.

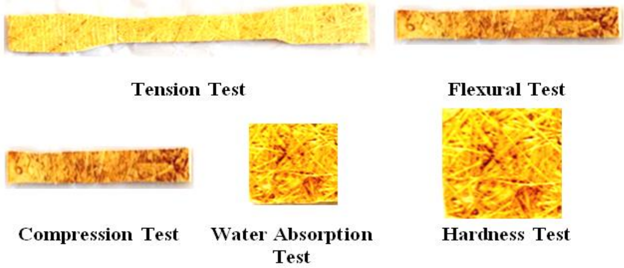

Figure 2 Test Specimens as per ASTM Standards for Mechanical Characteristics and Water absorption test.

Figure 3 Experimental Setup for Mechanical Characteristics and Water absorption test.

III. RESULTS AND DISCUSSIONS

The ultimate tensile, compressive and flexural strength of the four different EBGNSP natural composites is demonstrated in figure.4. It is observed that epoxy with banana fiber-reinforced composite (S1) has the ultimate tensile strength of 13.832 MPa. The epoxy-based banana fiber with 2% wt. filler material composite (S2) obtain the ultimate tensile strength of 20.14 MPa. Similarly, the ultimate tensile strength of for epoxy-based banana fiber with 4% wt. filler material composite (S3) and epoxy-based banana fiber with 6% wt. filler material composite (S4) is 16.255 MPa and 18.119 MPa respectively. It is noticed that the highest UTS of 20.14 MPa was found at epoxy-based banana fiber with 2% wt. filler material composite (S2). It shows that the increasing weight % of filler material with epoxy-based banana fiber composites are considerably enhanced the ultimate tensile strength during the tensile test. This can be achieved due to the enhanced interfacial bonding between the matrix, reinforcement and filler material and a more even distribution of GNSP. Further increase in the weight % of filler material with epoxy-based banana fiber composites decreases the UTS of the composites compared with (S2) composite. The molecular attraction between the epoxy, banana fiber and groundnut shell powder was good for a specific weight percentage of the filler material after that definite percentage it is unable to confer the better tensile strength for the EBGNS natural composites. It is shown that the filler content is helping to improve the strength of the composite. Further, improvements in the filler material UTS of the EBGNSP is decreases, also observed that filler content (groundnut shell powder) with 4 & 6 wt% also gives the greatest values compared to the unfilled composite. Results exhibit that agglutination between the banana fiber and epoxy augment with the addition of the filler material. The interaction between the groundnut shell powder and the banana fiber, the matrix is good for a certain weight percentage after that percentage it will not give better results for the composite.

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The maximum compressive strength for EBGNSP composites is depicted in figure.4.

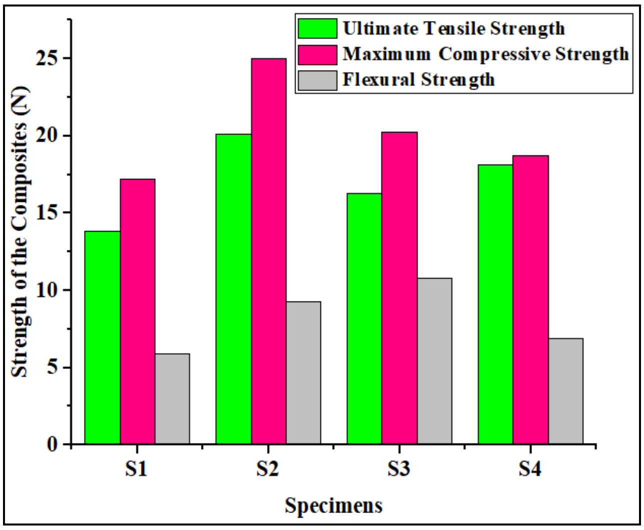

Figure 4 Maximum compressive strength for EBGNSP composites.

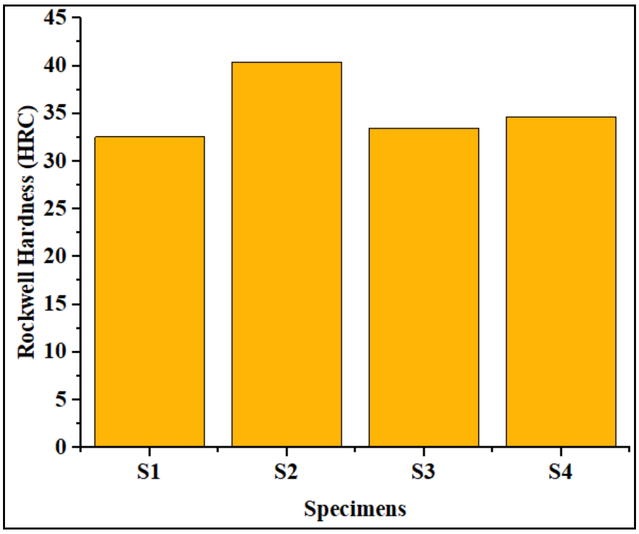

Figure 5 Variation in the Rockwell hardness (HRC) for EBGNSP composites.

It is noted that epoxy with banana fiber-reinforced composite (S1) has the maximum compressive strength of 17.23 MPa. The epoxy-based banana fiber with 2% wt. filler material composite (S2) obtain the maximum compressive strength of 25 MPa. Similarly, the maximum compressive strength for epoxy-based banana fiber with 4% wt. filler material composite (S3) and epoxy-based banana fiber with 6% wt. filler material composite (S4) is 20.27 MPa and 18.73 MPa respectively. It is noticed that the highest compressive strength of 25 MPa was found at epoxy-based banana fiber with 2% wt. filler material composite (S2). The flexural strength for EBGNSP composites is represented in figure.4. It is noted that epoxy with banana fiber-reinforced composite (S1) has a flexural strength of 5.902 MPa.

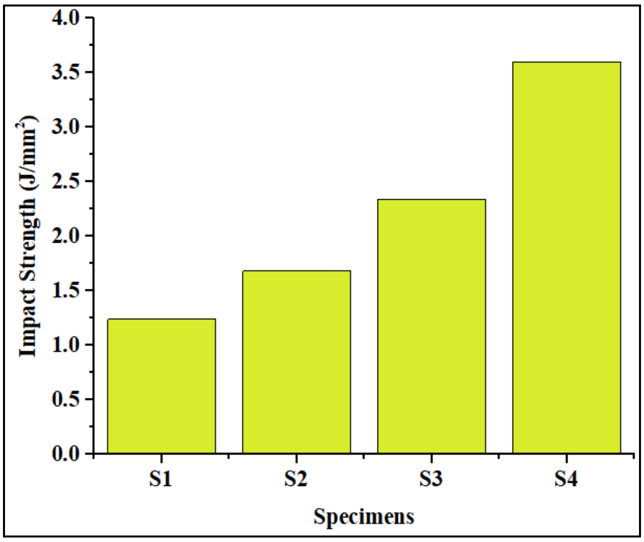

Figure 6 Variation in the impact strength of EBGNSP natural composites.

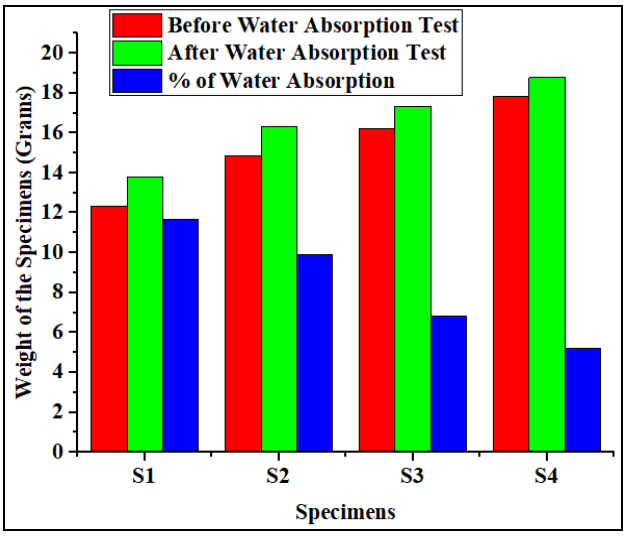

Figure 7 Water absorption test results of EBGNSP composites.

The epoxy-based banana fiber with 2% wt. filler material composite (S2) obtain the flexural strength of 9.245 MPa. Similarly, the maximum flexural strength for epoxy-based banana fiber with 4% wt. filler material composite (S3) and epoxy-based banana fiber with 6% wt. filler material composite (S4) is 10.799 MPa and 6.912 MPa respectively. It is noticed that the better bending strength of 10.799 MPa was found at epoxy-based banana fiber with 4% wt. filler material composite (S3). Variation in the Rockwell hardness (HRC) for EBGNSP natural composites are shown in figure.5. It is observed that the 2 wt% groundnut shell filled composite (S2) has a higher hardness compared to the other composites. It also shows that hardness number slightly decreases with the addition of 4% of filler material, further addition of the filler content decreases the hardness of the composites. Variation in the impact strength of EBGNSP natural composites is demonstrated in Figure 6. The impact strength of EBGNSP composites was depending on the wt% of the filler material.

The increase of filler material considerably increases the impact strength of EBGNSP composites. It was found out that EBGNSP composite (S4) has a higher impact strength. The results which are obtained from the water absorption test of EBGNSP composites are shown in figure.7. It is observed that the 6 wt% groundnut shell powder filled composite (S4) has the smallest possible percentage of water absorption in comparison to the other composites. It also shows that the percentage of water absorption is gradually reduced with improving the addition of filler material; further addition of the filler content decreases the water absorption of the composites (S3 & S4) respectively.

IV. CONCLUSION

Epoxy-Based banana fiber and groundnut shell powder bio-composites were geared up by conventional hand lay-up techniques. It is revealed that the inclusion of groundnut shell powder into the epoxy-based banana fiber gives the superior bonding between the matrix and reinforcement material. Adding up the groundnut shell powder to the epoxy/banana fiber enhances some mechanical properties of composites. Among all composites, the S2 composite had enhanced mechanical behavior apart from the impact and flexural strength. Interfacial bonding and stress concentration are the major parameters for a composite that are influencing the mechanical properties. The fiber pull-out and degree of adhesion are the parameters influencing impact strength of the composite, by this reason composite C4 had a better impact strength than other composites. The addition of groundnut shell powders with increased weight percentage to the epoxy/banana composites tends to reduce the water absorption property of the composites significantly.

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