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Mechanical and microscopic study on Tinospora cordifolia and Tectona grandis composites

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ABSTRACT

The use of natural fibers in various forms for over the 3000 years in India, today the use of plastic is increasing day by day; increasing usage of plastics affects the environment heavily. To reduce and control the usage of plastic can be possible only finding the new fiber-based material usages for the various purposes. The natural fibers are ecofriendly, decomposed naturally and it is economical also. In this research article made an ideological implantations to find a new fiber based composite material for the application interiors of the automobile body. In this investigation has been carried out to make use of Tinospora cordifolia, Tectona grandis, a natural fiber available in India, which is light-weight and strong but also cheaper than other natural fibers. The Tinospora cordifolia, Tectona grandis fibers are already used for some medical purposes, but not used for the composite material fabrication. The fiber, which serves as a reinforcement with epoxy and bisphenol resins and the mechanical properties were characterized.

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1. Introduction

The use of natural fibers as reinforcements for the composites is attracting more interest in fibber industries; the reinforced polymer composites have many applications as the class of structural materials because of their ease of fabrication, relatively low cost and superior mechanical properties compared to polymer resins. Natural fibers have different origins such as wood, pulp, cotton, bark, bagasse, bamboo, cereal straw, and vegetable (e.g., flax, jute, hemp, sisal, and ramie). These fibers are mainly made of cellulose, hemicelluloses, lignin and pectin's, with a small number of extracts. The natural fiber composites are fabricated for the analysis of mechanical properties; natural fiber-based composites from many plants have been undertaken by researchers from around the world. Since plant fibers are naturally available abundantly in nature, the cost of purchasing raw materials, i.e., the cost of purchasing the natural fibers is gradually less when compared to other composites like metal composites, thermoplastic or thermosetting plastic composite. But, the implementing a plant/shrub fiber in the research work is not an easy task, because of many researchers would have made detailed research work over those plants/shrub fibers. So, implementing a new plant/shrub fiber, this is a little difficult for the research work. The following are the main reasons to select composites for certain applications, High strength to weight ratio (low density, high tensile strength), high tensile strength at elevated temperatures, and high toughness with high creep resistance. The objective of this work is to identify the best mechanical properties of natural fibers with the resin composition; from the composition of the Tinospora cordifolia and Tectona grandis with the resins of Epoxy and Bisphenol.

2. Literature review

Essabir et al. were studied the innovative natural fiber composite of doum fiber, the mechanical properties and its abundance allows. Doum fibers were alkali-treated to clean their surface and enhance polymer fibers interaction. The tensile and rheological properties were investigated to see the effect of fiber content on the composite properties. The results show that the tensile properties were enhanced when the fiber was added to the polymer and it has enhanced more with the use as a coupling agent [1]. Naveen et al. Investigates that, the mechanical and physical properties of sisal and hybrid sisal fiber reinforced polymer composites it was

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inferred that the new type of fibers to be identified for eco-friendly materials and environmental regulations [2]. Herrera and Gonzalez did their work in the pineapple fibers; the physical and tensile properties of the pineapple fiber were characterized. The tensile strength property of pineapple fibers is sufficient for their use as reinforcing composites with moderate strength, and noncritical applications [3]. Moudood et al. studied the environmental effects on the durability and the mechanical performance of flax fiber/bio-epoxy composites; it was found, that these properties can be partially regained after drying the water aged composites with a little effect on the bio-composites [4].

Mohanty et al. did surface modifications of two varieties of jute fabrics, i.e. hessian cloth (HC) and carpet backing cloth (CBC), involving de-waxing, alkali treatment cyanoethylation and grafting have been made with a view to their use as reinforcing agents in composites based on a biodegradable polymeric matrix. The Biopol 50% enhancement in tensile strength, 30% enhancement in bending strength, and 90% enhancement in impact strength, for the composites to the pure biopol sheets [5]. Valadez et al. studied the interfacial shear strength (IFSS) between natural fibers and the thermoplastic matrix has been improved by the morphological and silane chemical modification of the fiber surface. When the fiber is impregnated with the matrix, it results that the IFSS seems to be higher than that obtained for fibers which are treated only with a silane coupling agent, when it is measured with the fiber pull out the test. But, when the single fiber fragmentation test is used, the silanization results in higher IFSS values [6]. Venkateshwaran and Elayaperumal suggested the banana fiber reinforced with cement composites, their mechanical properties is good with the lesser of 25% of water absorption, which is suitable for the use of building material [7]. Zegaoui et al. studied the Multifunctional polymer materials with enhanced mechanical, thermal and gamma radiation shielding properties from dicyanate ester of bisphenol based benzoxazine resin, they was inferred that the enhanced mechanical, thermal and nuclear shielding properties promote the use of the as-developed hybrid composites in domestic and industrial applications [8]. Sathish, S. et al. studied the experimental testing on mechanical properties of various natural fibers reinforced epoxy hybrid composites, they inferred that the epoxy resin provide a good strength [9].

3. Methodology

3.1. Fabrication of composites

The fabrications of the natural fiber composites, the leaves of the shrubs are removed and then, the shrubs are air-dried at room temperature. The shrubs were beaten so that, the fibers from shrubs could be drawn easily and shrubs were cut such that, they look like very thin long thread. The long, thread like fibers were cut into a very small length of the fibers, smaller length of fibers sizes from 0.5 cm to 1.5 cm. The fabrication of the natural fiber composite plate made of the resin and the hardener are taken in the correct proportion 100 ml of epoxy resin VBR 8912 grade. A 100 ml of hardener VBR 1209 grade is measured by using measuring jar and blended for proper even mixture of the chemicals. The mould plate is first cleaned very well; none of the impurities are sticking into the mould for getting a good composite plate preparation. The mould plate is coated with wax polish then only; plate could be separated from the mould easily and without damaging the composite plate. After waxing the mould, half the amount of chemical mixture, i.e. the mixture of epoxy resin and hardener is evenly spread over the mould. Then, the small size chapped natural fibers are spread over the chemical mixture and the fibers are spread over the chemical mixture. Again, the chemical mixture is made to spread over the fibers such that, the composite plate is formed in the layer of the chemical mixture – natural fiber – chemical mixture pattern. After forming this pattern, a manual loading is applied over the pattern, the load of 15 kg is applied over the pattern. This set up is kept nearly 8 h because this pattern consumes too much of time to dry the composite plate completely. After 8 h of duration, the load applied over the composite plate is unmounted. Then, the composite plate is separated from the mould. Thus, the composite plate is formed for the 4 different composition fibers and resins. However, when it comes to the mixing of two fibers, each fiber is taken 50 gm, thus making 100 gm of the natural fiber, and the same proportion of the resin and hardener is maintained to form the other such composite plates (Fig. 1).

Sample – A = Tinospora cordifolia with epoxy resin;
Sample – B = Tectona grandis with Bisphenol;
Sample – C = Tectona grandis with epoxy resin;
Sample – D = Tinospora cordifolia with Bisphenol.

3.2. Mechanical testing

In the mechanical properties the tensile, flexural and compression strengths are very important for any composite materials; to confirm the standards to meet the automobile body and their applications [10]. The test specimens are prepared anchored in ASTM standards; the tensile test specimen made by ASTM D638 standard which is shown in Fig. 2. The Compression test specimen made was by ASTM D695 standard; which is shown in Fig. 3. The Flexural test specimen made by ASTM D790 standard, which is shown in Fig. 4. The composite materials test specimens were prepared with the help of abrasive water-jet cutting machine, which was operated under 320 psi working pressure with 2.5 mm min − 1 feed rate [11,12].

4. Results and discussion

4.1. Mechanical test

The tensile test, flexural test, and compression test were carried out as per the ASTM standard procedure and the results are shown in Figs. 5–7 respectively. Among the samples, the sample ‘D’ has the highest tensile strength when compared to other samples. The bonding property of tinospora cordifolia fiber with Bisphenol resin matrix bonding property is very good.

The Tinospora cordifolia with Bisphenol resins of sample ‘D’ tensile strength this 9.85 MPa, the Tectona grandis with Bisphenol’s of sample ‘B’ tensile strength is 2.05 MPa, Tectona grandis with epoxy resin of sample ‘C’ tensile strength is 1.73 MPa, Tinospora cordifolia with epoxy resin of the sample ‘A’ tensile strength is

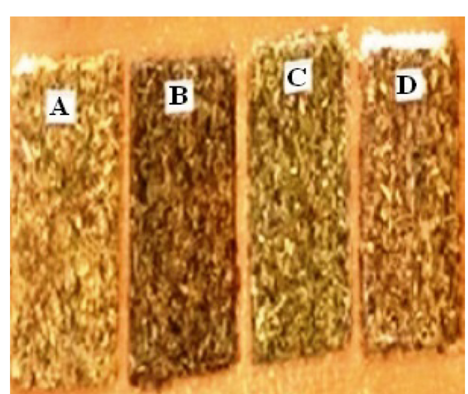

Fig. 1. Sample specimens of the NFC plates; Sample – A, Sample – B, Sample – C, Sample – D.

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Fig. 2. Tensile test samples.

Fig. 3. Compression test samples.

Fig. 4. Flexural test samples.

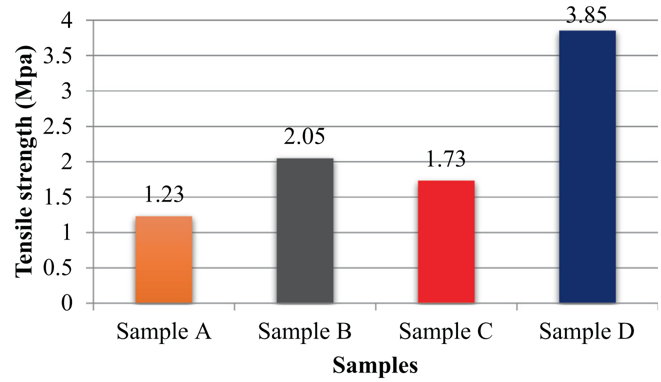

Fig. 5. Comparison of tensile strength.

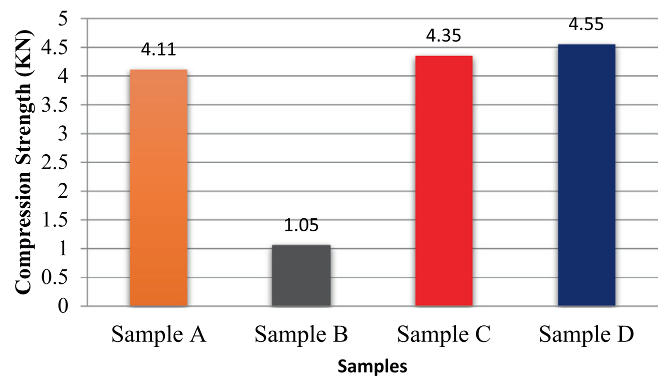

Fig. 6. Comparison of compression strength.

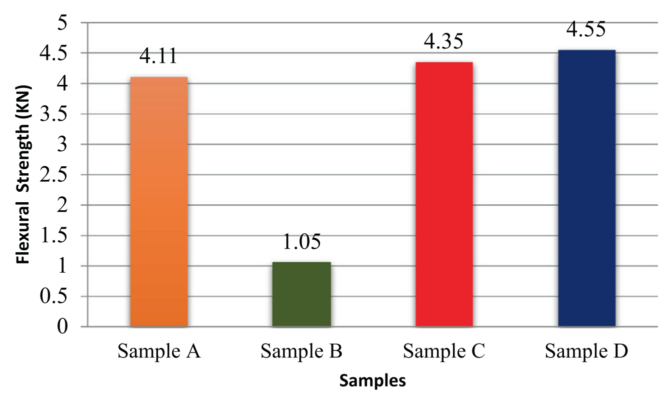

Fig. 7. Comparison of flexural strength.

1.23 MPa. From the tensile strength, it seems to that the Sample 'D' of Tinospora cordifolia with Bisphenol resin's performance is very good in tensile strength about 9.85 MPa.

The sample 'D' is the composition of tinospora cordifolia with Bisphenol resins, its compression strength is 4.55KN, the Tectona grandis with epoxy resin of sample 'C' compression strength is 4.35KN, the Tinospora cordifolia with epoxy resin of the sample 'A' compression strength is 4.11 KN and the Tectona grandis with Bisphenol's of sample 'B' compression strength is 1.05 KN. From the compression strength, it seems to that the Sample 'D' of Tinospora cordifolia with Bisphenol resins is very good in compression strength about 4.55KN and Tectona grandis with Bisphenol's of sample 'B' compression strength is very low.

The Tinospora cordifolia with Bisphenol resins of sample 'D' flexural strength is 0.27 kN, Tectona grandis with epoxy resin of sample 'C' flexural strength is 0.19 kN, the Tectona grandis with Bisphenol's of sample 'B' flexural strength is 0.18 kN, Tinospora cordifolia with epoxy resin of the sample 'A' flexural strength is 0.18 kN. From the flexural strength, it seems to that the Sample 'D' of Tinospora cordifolia with Bisphenol resin's performance is very good in flexural strength about 0.27 kN.

4.2. Surface morphology

The investigation of the mechanical characteristics; the surface morphological study plays an important role to confirm the composition of the material, size of the particle and the bonding of the composite material. The surface morphology of the broken sample's SEM images had shown in Figs. 8(a)–8(d). Fig. 8(a) shows the Surface morphology of Sample 'A' composite of Tinospora

Fig. 8a. Surface morphology of Sample 'A'.

Fig. 8b. Surface morphology of Sample 'B'.

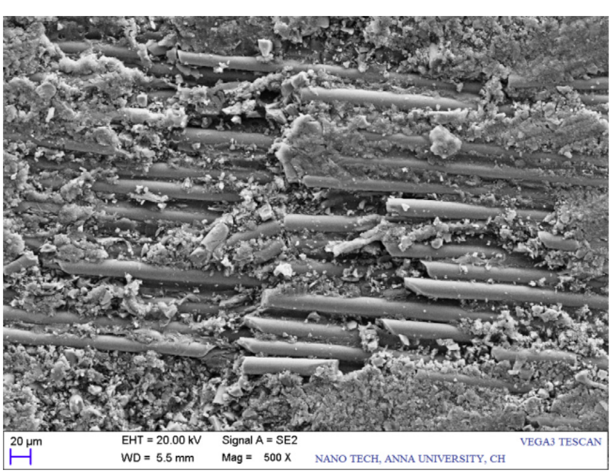

Fig. 8c. Surface morphology of Sample 'C'.

cordifolia with epoxy resin, Fig. 8(b) shows the Surface morphology of Sample 'B' composite of Tectona grandis with Bisphenol, Fig. 8(c) shows the Surface morphology of Sample 'C' composite of Tectona grandis with epoxy resin and Fig. 8(d) shows the Surface morphology of Sample 'D' composite of Tinospora cordifolia with Bisphenol. The surface morphology shows the crack zone of tensile strength, which states the cause of crack initiation.

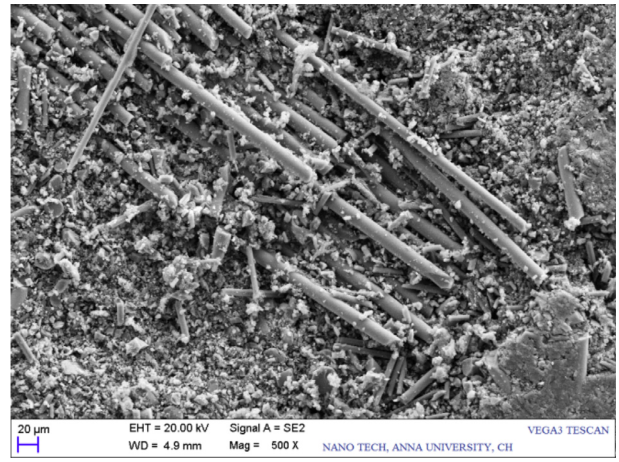

Fig. 8d. Surface morphology of Sample 'D'.

5. Conclusions

The Tinospora cordifolia, Tectona grandis fibers are used to make the composite materials for the application of the interiors of the automobile body; the epoxy and bisphenol resins were used as a bonding material. The four different combinations of the composite material were made, i.e. Tinospora cordifolia with epoxy resin, Tectona grandis with Bisphenol, Tectona grandis with epoxy resin and Tinospora cordifolia with Bisphenol. The Tinospora cordifolia with bisphenol resin composite material gives better results in the tensile strength of 9.85 MPa. The Tinospora cordifolia with Bisphenol resins composite material gives better compression strength of 4.55kN. The Tinospora cordifolia with Bisphenol resins composite material gives the good flexural strength of 0.27 kN. The results of the fabricated material show that the Tinospora cordifolia and Bisphenol combined composite material are superior in the tensile strength, compression, and flexural tests. From the analysis is observed that the fiber Tinospora cordifolia with the bisphenol resin combination of the composite material for both the fiber and resins were supported by each other during the blending process, which gives better mechanical properties.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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