

Experimental Comparison of Mechanical Stability and Morphology Between Tree Fibres and Shrub Fibres Reinforced Epoxy Bio-Composites

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ABSTRACT: This research article investigates the composite material property based on synthetic and natural fiber as a reinforcement. In this work, the epoxy bio-composites were prepared by natural tree fibres of *Morinda-citrifolia* and *Tamarindus-indica* with the shrub fibres of *Tinosporacordifolia* and *Ipomoea staphylina* for automobile structural components, aircraft interior products and civilian applications. The prime objective of this experimental work is to explicate the study and comparison of mechanical stability and microscopic study between tree fibers and shrub fibers. The composite was prepared by hand- layup method, in this work , untreated fibers were used and both resin and fibers are used 50%. The ASTM guidelines and the composite's morphology were followed in the preparation of the test specimens; it was studied with the help of FTIR and SEM. The mechanical test results show that ETI was superior to all other composites in the tensile strength maximum of 8.13 Mpa and which was maximum in compression strength of 5.98KN, But in hardness ,ETC has high results compare with others.

KEYWORDS: *Morindacitrifolia*, *Tamarindusindica*, *Tinosporacordifolia*, *Ipomoea staphylina*, SEM, Epoxy, Mechanical properties

1. INTRODUCTION

The rapidly growing world needs more new materials to compensate for the demand to meet industrial needs with appropriate strength and environmentally conscious materials. The recent researches were focuses on natural fiber-based composites to meet the ecofriendly natured materials, the natural fiber-based materials had more advantages in contrast to more traditional materials like synthetic fibres. The application of natural fibers and make use of available resources in nature is the best way to save nature and gives more effort to improving the material

characterization for extending the mechanical performance capabilities and applications is the sustainability of the industrial needs [1].

The improvement of the mechanical strength of the fibers at a macroscopic level can be achieved by adding of the polymer matrix is possible and the tribological behavior also to be improved [2]. Natural fibers are the replacement to man-made fibers which are used in recent industrial possibilities. The benefits of natural fibres include their low density, affordability, and biodegradability. Manikandan et al [3] revealed the surface-midified *morindacitrifolia* fiber

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adding 3 μm size silane modified chitosan particle with epoxy resin. They came to the conclusion that chitosan, Enhances superior mechanical, thermal, and water uptake behaviour when mixed with epoxy to create composites with surface-modified reinforcement that perform the original material. Vamsi Krishna Mamidi et al [4] examined the *Tinosporacordifolia* and *Tectona grandis* adding into epoxy and bisphenol resin. The authors confirmed that composite material is superior in the tensile strength, compression, and flexural tests. Through experimental evidence, Manikandan et al. [5] demonstrated the impact of incorporating *tamarindusindica* with epoxy and bisphenol resin, its shows better mechanical strength and the SEM images showed a good dispersion of the *Tamarindus* fibers in the matrix. In order to improve the interfacial shear strength between natural fibre and thermoplastic matrices, Valadez-Gonzalez et al. [6] tested and demonstrated fiber-matrix surface treatment. The alkaline treatment raises the quantity of cellulose exposed on the fibre surface and roughens the surface. The *morindacitrifolia* has in around 80 types of species in the worldwide. It is a medium height tree and fruits are in green until maturity [7]. *Tamarindus indica* was developed widely spreading and rounded tree, its common tree in West Africa and India [8, 9]. *Tinosporacordifolia* and *Ipomoea staphylina* are shrub fibers, it's commonly available in India and both fibers are used in different systems of traditional medication. *Tinospora* using hepatoprotective, immunomodulatory and anti-neoplastic activities [10]. And *Ipomoea* using anti-inflammatory, anti-diarrheal, gastro protective effect [11]. The composites prepared by using hand layup methods, since hand layup required low process parameters [12]. These composites made of trees and shrubs could be used in spacecraft, automobile structural parts, and commercial applications that call for high damping, low weight, and energy absorption.

2. METHODOLOGY

2.1 Material Preparation

This study used liquid bisphenol-A type epoxy resin diglycidyl ether (VBR 8912), a thermoset epoxy with a kinematic viscosity of 12000 cps and a mol. wt. of 195 g/mol. The epoxy resin was cured using a curing agent (VBR 1209): TETA with 20 cps was supplied by Vasavibala Resins (P) Ltd, India. Natural fibres *Morinda-citrifolia*, *Tamarindus-indica*, *Tinospora cordifolia* and *Ipomoea staphylina* were bought through Go Green Industrial Fibre India, (P) Ltd. After extraction fibres were shown in Fig. 28.1(a) *Morinda-citrifolia* tree fibre; 28.1(b) *Tamarindus-indica* tree fibre; 28.1(c) *Tinospora cordifolia* shrub fibre and 28.1(d) *Ipomoea staphylina* shrub fibre.



Fig. 28.1 (a) *Morinda-citrifolia* tree fibre, (b) *Tamarindus-indica* tree fibre, (c) *Tinosporacordifolia* shrub fibre and (d) *Ipomoea staphylina* shrub fibre

2.2 Preparation of Samples

The hand layup fabricated epoxy composites are examined for any defects by the visual inspection. The test samples were kept ready via hand layup methods. The metal molds are prepared required size, in this research using 15 cm x 15 cm square plate and stirring process occur by the help of ¼ hp motor. The mold for making the composite plate is first cleaned well so that none of the impurities is sticking into the mold. Then, the mold is coated with wax polish so that, when the plate is formed, it could be separated from the mold easily and without damaging the composite plate. After waxing the mold, half the amount of chemical mixture, i.e. the mixture of epoxy resin and hardener is evenly spread over the mold and the natural fibers are spread over the chemical mixture. The fibers are spread over the chemical mixture properly. After that to apply a chemical mixture, its form like as sanveg [13]. Forming pattern than manual load was applied over the pattern up to 50kg. The setup curing up to 4 to 6 hours at room temperature, than to remove the plate from the pattern by manual methods. Figure 28.2(a) shows epoxy *morinda-citrifolia* composite (EMC), 28.2(b) shows epoxy *tamarindus-indica* composite (ETI), 28.2(c) shows epoxy *tinoporacordifolia* composite (ETC) and 28.2(d) shows the epoxy *Ipomoea staphylina* composite (EIS).

3. CHARACTERIZATION TECHNIQUES

3.1 Infrared Spectroscopy using Fourier Transform

The materials' Fourier transform infrared (FT-IR) spectra were captured using an Attenuated Total Reflectance mode (ATR, PRO470-H) and an FT-IR spectrophotometer (from

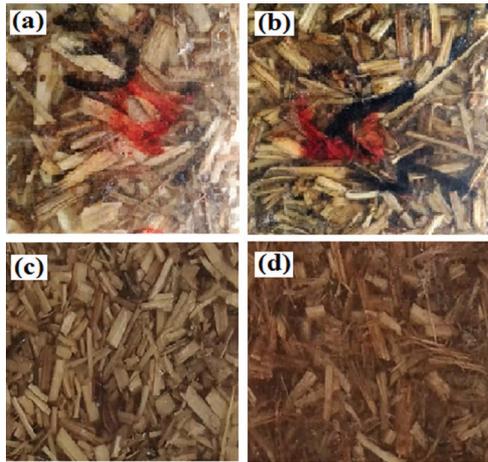


Fig. 28.2 (a) Epoxy morinda-citrifolia composite (EMC), (b) Epoxy tamarindus-indica composite (ETI), (c) Epoxy tinosporacordifolia composite (ETC) and (d) Epoxy Ipomoea staphylina composite (EIS).

BSA Univ, model name FT/IR-6300 type A). The incidence angle of 450 and a resolution of 4 cm^{-1} , the wavelength range was 399.193 cm^{-1} to 4000.6 cm^{-1} at a interval of data of 0.964233 cm^{-1} [14].

3.2 Scanning Electron Microscopy

The fractured portions of prepared epoxy composite (EMC, ETI, ETC, and EIS) were inspected using a Shimadzu model (SS-550) Scanning electron microscope. The shear failure surfaces of the specimens will demonstrate how varying surface treatments of the fibers affect the composite's effective properties. The targeted portions were coated in gold and subsequently examined to a width of 6mm. [15, 16].

3.3 Mechanical Testing

The tensile test and bending test were carried out to EMC, ETI, ETC, and EIS. The epoxy composites were evaluated in accordance with ASTM-D695 and ASTM-D 790 standards respectively. The universal testing machine was used for testing the composites with transverse speed and a load of 2.1 mm/sec and 40 Ton. The compression test was evaluated by ASTM-D 3039. A durometer according to ASTM-D 2240 was used to determine the microhardness (Shore-D) of the composites. In the study, square samples with dimensions of 50 mm x 50 mm were used. [17].

4. RESULT AND DISCUSSION

The FTIR spectroscopy was used to confirm fiber/matrix bonding, Figure 28.3 shows FT-IR spectra of the various samples. The fiber is taken 0.5 cm to 1 cm of a length. The

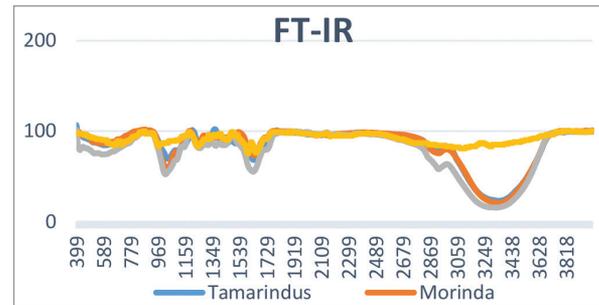


Fig. 28.3 FT-IR spectra of the samples

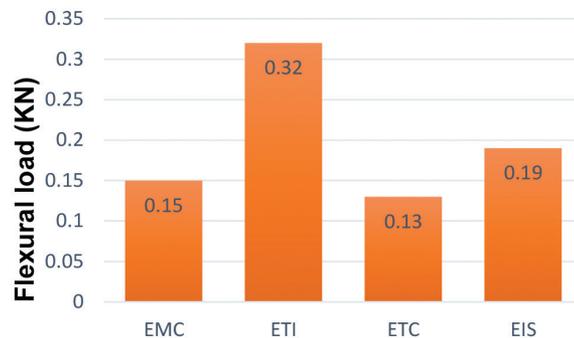
fibre is penetrated by the Infra-Red (IR) ray. Stretching vibrations at wave numbers 1637.27 cm^{-1} and 1039.44 cm^{-1} reveal absorption bands of characteristic groups exist in the sclerenchyma structure of Tamarindus indica, including hemicellulose, lignin and cellulose. Similarly, the vibrations observed at 1642.09 cm^{-1} and 1031.73 cm^{-1} in Morinda Citrifolia. In Tamarindus Indica at 3346.85 cm^{-1} and 2915.84 cm^{-1} and in Morinda Citrifolia at 3341.07 cm^{-1} and 2928.38 cm^{-1} a stretching signal was noticed corresponding to the hydroxyl groups and the C-H bond of the fibre. [5, 18]. In the stretching vibrations at wave numbers 1636.3 cm^{-1} and 1023.05 cm^{-1} , absorption bands of characteristic groups of the sclerenchyma structure, including hemicellulose, cellulose, and lignin present in Tinospora Cordifolia can be seen. Similarly, the stretching vibrations observed at 1633.41 cm^{-1} and 1020.16 cm^{-1} in Ipomoea Staphylina. An oscillatory feature was detected at 2922.59 cm^{-1} and 3299.61 cm^{-1} corresponding to the C-H bond and hydroxyl groups of the fibre in Tinosporacordifolia. Similarly, a vibration signal was detected at 2927.41 cm^{-1} and 3327.57 cm^{-1} corresponding to the C-H bond and hydroxyl groups of the fibre in Ipomoea Staphylina.

The mechanical performance of epoxymorinda-citrifolia, epoxy tamarindus-indica, epoxy tinospora-cordifolia and epoxy ipomoea staphylina composites are presented in Table 28.1. Tensile, flexural, compression and hardness tests results are presented in Fig. 28.4–28.6 which are completed as per the ASTM standards. It can be noted that the epoxy morinda, epoxy tamarindus and epoxy tinospora composites mechanical properties compared with epoxy ipomoea composites [4, 5, and 18]. The epoxy composites basically have good mechanical properties [19]. It is observed ETI has high tensile strength 8.13Mpa compared with others, tinospora has the least tensile values 1.23 Mpa. Binding property in between epoxy and tamarindus is a very good, binding property of epoxy with other composites EMC, EIS is moderate. Similarly, the flexural strength testing ETI have high load.

Caring capacity 0.32KN and ETC were very less load caring capacity 0.13KN, but in the other two composites,

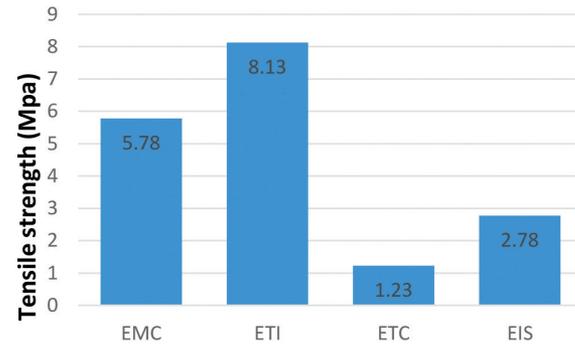
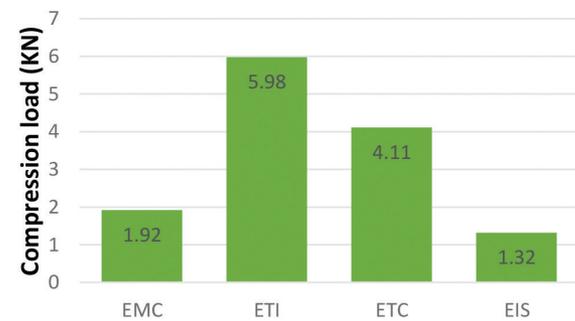
Table 28.1 Mechanical properties of EMC, ETI, ETC, EIS

Sample Id	Tensile Strength (MPa)	Flexural Load (KN)	Compression Load (KN)	Shore D° Hardness
EMC - Morindacitri- folia	5.78	0.15	1.92	46
ETI - Tamarindus indica	8.13	0.32	5.98	51
ETC - Tinospora- cordifolia	1.23	0.13	4.11	59
EIS - Ipomoea staphylina	2.78	0.19	1.32	45

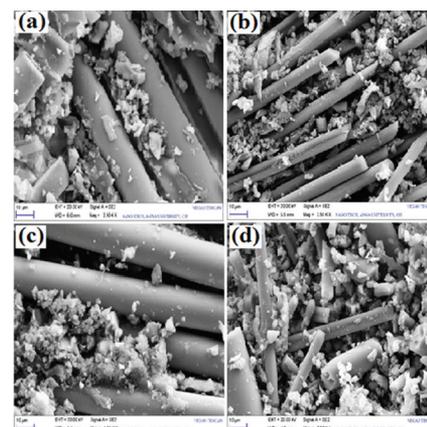

Fig. 28.5 Comparison of flexural load effect

EMC and EIS have a middle flexural load. Compared to EMC and EIS, the EMC shows good tensile property 5.78 Mpa and EIS shows good flexural property 0.19KN. In compression strength also ETI showed good strength 5.98KN but ETC has second high strength. Comparatively ETC shows least values in tensile and flexural strength but it has good compression property. EIS has the least compression values of 1.32 KN. From shore D0 hardness strength is observed, it's understood that the hardness of the epoxy composites. And the epoxy composite tinosporacordifolia possesses good hardness values 59. The ETI possesses good tensile strength and flexural loads, but in hardness test, it has less value 51. The epoxy resin possesses high hardness owing to the more efficient binding with the fibers. This phenomenon is evident from the Scanning Electron Microscope (SEM) images.

Figure 28.7 shows the morphological analysis of various composites specimens evaluated in this present study. It can be noted that contaminants and existence of parenchyma cells on surfaces of fiber plate [20]. Figure 28.7(a) shows the adhesion improved morinda-citrifolia fibers. It's clearly shows the impurities bonded in the composite fiber, which shows addition layers on fiber surface, Figure 28.7(b) shows epoxy with tamarindus-indica composite fractography image.


Fig. 28.4 Comparison of tensile strength

Fig. 28.6 Comparison of compression load

The use of the coupling agent removes the aggregation and shows a remarkable sense of pull out fibers in this composite. Figure 28.7(c) shows the surface morphology of epoxy tinosporacordifolia composite. The images demonstrated the enhanced adhesion of the reinforced tinosporafibre to the matrix and its good association with the load-sharing


Fig. 28.7 Surface morphology of composites. (a) Epoxy morinda-citrifolia composite, (b) Epoxy tamarindus-indica composite, (c) Epoxy tinosporacordifolia composite and (d) Epoxy Ipomoeastaphylina composite.

phenomenon. Figure 28.7(d) shows ipomoea staphylina fiber with epoxy resin composite. Even after the test was completed, there was still matrix debris on the fibres' surface. This demonstrates the fiber's enhanced adherence to epoxy.

5. CONCLUSION

The epoxy composites have been successfully prepared and characterized. The significant differences in the physical and mechanical properties of the developed natural composites are revealed through characterisation. By conducting various tests on epoxy morindacitrifolia, epoxy tamarindusindica, epoxy tinosporacordifolia and epoxy ipomoea staphylina, it was found out that compared to other composite fibres, epoxy TamarindusIndica has a high tensile strength materials. And the epoxy tinosporacordifolia has high hardness strength.

By this investigation, it can be concluded that compared to other composite fibres, Epoxy TamarindusIndica exhibits good tensile strength, compressive strength, hardness and flexural strength. Except flexural load test epoxy ipomoea Staphylina shows poor results when compared with the other three composites. The inhomogeneous distribution of mixture of natural fibres and epoxy resin composite fibre on the polymer matrix results in distinctly inferior properties. The SEM images showed a good dispersion of the epoxy and natural fibers in the matrix.

From in this study can observed the composites were light in weight, economical and possess good mechanical properties. These mechanically reinforced polymer matrix bio-composites could therefore find application in home appliances, sports goods, building construction, automotive interior components, and electronic packaging.

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Note: Every figure and table was created using the experimental work; none of them were taken from any publications or online.