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Development and Characterization of Natural Fiber-Reinforced Epoxy Composites from Prosopis Juliflora and Coconut for Potential Structural Applications

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ABSTRACT:

There has been a lot of time spent researching and developing composites. Yet, green composites have emerged in response to rising worries about climate change, waste production and management, environmental consciousness, and the depletion of fossil fuel reserves. Some natural fibers may even have better qualities than the synthetic fibers that have aided in this advancement. The objective of this work is to create a polymer composite using coconut trees and Prosopis juliflora as reinforcements in an epoxy resin matrix that is naturally occurring. Composition ratios of 60:40, 65:35, and 70:30 were utilized in the compression mold method to make composite plates. Ten parts resins to one part hardener was the ratio. The produced composites underwent mechanical property testing in accordance with ASTM standards. These tests included water absorption, impact, flexural, compressive, and tensile strengths.

Keywords : Prosopis juliflora, naturally occurring fibers, Coconut tree, fossil fuel, mechanical properties.

1. Introduction

In composite materials, reinforcement comes in various forms like fibers, flakes, or fabrics. These reinforcing elements are embedded within a matrix, which can be made of clay, polymers, or metals[1-8]. Since the primary function of composites is often to bear weight, the reinforcement is typically denser and stiffer than the surrounding matrix. This creates a structured network that distributes forces between the reinforcing elements. In some cases, the matrix also needs to handle loads applied across the fibers. The matrix plays a crucial role by being more flexible than the reinforcement[9-11]. This flexibility allows the composite to absorb energy and resist cracking. Additionally, the matrix protects the reinforcing elements from environmental damage during the manufacturing process and throughout the lifespan of the composite. On time and as planned, the dazzling attached fabric shows the target price for common materials. The auxiliary properties of composites make them useful in many applications, including electrical, thermal, tribological, and environmental packaging. Composites, which are multipurpose fabric frames, provide qualities that are impossible to achieve with any conventional material. They are structurally distinct, functionally optimal, and, on occasion, compositionally long-lasting systems that are physically integrated with at least outstanding components[12]. Composites, being a blend of two different materials, should not be considered indispensable. The blend has its own distinct residences in an exceptionally vast centrality. When compared to the two components separately or even when held to the same volume, it is significantly superior in terms of the unity of protection from heat or any other attractive first-class. In contrast to combinations, which lose some of the characteristics of the male or female additions when mixed, composites are able to make the most of the additives' strengths while compensating for their weaknesses, allowing for the creation of more complex substances, as he put it. Composites are made up of different types of materials that are in close proximity to one another on a microscopic scale; these substances are heterogeneous. Because their physical properties are consistent throughout, these materials can be considered homogenous at the microscopic level.. Using an epoxy matrix, researchers are currently working on creating hybrid composites of the Prosopis juliflora and coconut trees. Compression, hardness, water absorption, flexural, and impact strength are explored in mechanical homes[13].

Z. Salleh et al. [18] examined the mechanical characteristics of Kevlar and Fibre glass Hybrid Composite laminates using the hand layup method. The fibers utilized include short, long, and powder fibers. Different types of fibers have their tensile strengths studied. According to the results of the tests, long hybrid fiber composites have the greatest tensile strength and modulus. The scanning electron microscopy analysis revealed that the matrix fracture, fiber loss, matrix debonding, and fiber fracture were the causes of the surface failure.

Two sets of short kenaf composites were prepared independently using high-density polypropylene (PP), and polyethylene (PE), according to MohdSuhairilMeon et al.[14]. After soaking the kenaf fibers in NaOH solutions of 3%,6%, and 9% for one day, they were air-dried at 80 degrees Celsius for another. When compared to the untreated kenaf fibers, the treated kenaf had better tensile qualities. Enhanced tensile characteristics have been seen in both treated and untreated cases due to additional coupling agents such as MAPP and MAPE.

The glass fiber/epoxy/nano clay composite was studied by S Sivasaravanan et al. [15]using a hand layup technique to change the nano clay content from 1 to 5 weight percent. E-glass fiber can be wound in either direction; sometimes it is twisted 45 degrees. In comparison to the other combinations tested, the average 5% wt of nano clay demonstrated favorable impact outcomes.

A hybrid composite material made of unsaturated polyester and kenaf was created by Atiqah et al.[16]. Kenaf fibers can be combined with glass fibers to create mats. Researchers treated kenaf fibers with a 6% sodium hydroxide (NaOH) solution for three hours using a process called mercerization. Tests showed that these treated kenaf fibers, when combined with glass fibers in a 15/15 volume ratio (kenaf/glass), resulted in high tensile strength, flexural strength, and impact strength. Improved adhesion between the fibers and the surrounding resin is believed to be a key factor in the enhanced mechanical properties of these kenaf-glass composites (KG-UPE). This research builds on previous work by M. R. Sanjay et al. [17] the person who developed a composite material that combined jute with E-glass fiber mats that were reinforced with epoxy resin. Additionally, their research shown that the mechanical capabilities were enhanced by incorporating additional materials with natural fibers.

The objective of this work is to create a polymer composite using coconut trees and Prosopis juliflora as reinforcements in an epoxy resin matrix that is naturally occurring. Composition ratios of 60:40, 65:35, and 70:30 were utilized in the compression mold method to make composite plates. Ten parts resins to one part hardener was the ratio. The produced composites underwent mechanical property testing in accordance with ASTM standards. These tests included water absorption, impact, flexural, compressive, and tensile strengths.

2. Material Selection & Method

2.1 Material Selection

Hardener HY 951 from the coconut tree, Prosopis juliflora, and epoxy tar LY 556 were the primary ingredients in the final product. A polymer lattice is used to organize the COCONUT tree and Prosopis juliflora unevenly. The soluble base of the treated strands should be used to organize the tests. After being treated with salt in a 1% NaOH solution for 30 minutes to remove any oily substances and hemicellulose, the Prosopis juliflora and coconut trees were allowed to dry in natural sunlight. The second fiber was utilized to create epoxy composites of Prosopis juliflora and Coconut trees.

2.2 Process for Preparing and Fabricating Materials

According to the specifications laid out by the ASTM for Preparation Specimens, the form is made of wood. Once the overhead projector sheet is in place, the discharge specialist is connected to it and the inside of the form so that it may dry. It is necessary to remove any glassware from the container and wash it well with hot water thereafter. The same goes for any glass poles or stirrers. After that, the breaker is mixed with the specified amount of hardener and the specified amount of epoxy tar in a 10:1 ratio, and the mixture is left to mix for about 25 minutes. A uniform mix is the goal of this mixing process. Following the completion of the blending process and the subsequent 45 minutes of mixing, the specified quantity of filaments (in a proportion of 1:1) is added. After that, the shape was filled with the mixture, which was gently pressed into a uniform settling.

Fig 1. Fabrication of composite

3. Composite Material Characterizations

3.1 Water Absorption

Submersion in refined water at atmosphere temperature for 72,48,24 and 12 hours was used to study water ingestion of a polymer composite with Prosopis juliflora and Coconut trees. The water retention test uses a sample instance size of 5 millimeters X 5 millimeters, as specified by ASTMD-570. The polyester rubber was fastened to the instance's borders. The samples were left to dry for one day at a temperature of 50^{o}C. The precise weight was determined following a 24-hour testing period. After that, the samples were left in purified water at atmospheric temperature (12, 24, 48, and 72 hours).

Once the designated time was up, we took the tests out of the water and patted them dry with tissue paper to remove any leftover surface moisture. The composite's clamminess was assessed through the use of inadvertent fabric inspections between moments [18]. Speed of clamminess consumption is a measure of the amount by which the manual's mass is added to the fundamental mass. We used the procedure to determine the sample's weight gain, which was expressed as a percentage change in weight. The formula for weight gain as a percentage is wet weight minus sample weight divided by sample weight [weight] multiplied by 100.

3.2 Compressive and tensile tests

The Mechanised Universal Testing Machine, in accordance with ASTM D 3039[19], was used to carry out the ductile experiments. The graphic displayed the stacking procedure for the instance and an image of the device that was used. We have utilized examples with dimensions of 300 millimeter in length and 25 millimeter in breadth. Using a 10 kg load cell, the study was carried out at a speed of the head of 2 millimeter per minute. The normal quality was considered for each scenario, and three instances were utilized. Typically, UTM compressive test techniques are employed to ascertain the compressive quality.

3.3 Impact and Flexural Testing

The three-point twisting technique was used to determine the flexural quality of the composites. The adapted UTM machine is typically used to finish it according to ASTM D790[9]. The graphic displayed the stacking procedure for the instance and an image of the device that was used. Each composite sample measured 80 millimeter in length, 15 millimeter in width, and 5 millimeter in height. A crosshead velocity of 0.5 millimeter/min was used for the trials. Afterward, it was decided that the flexural quality should employ a simple minute contour of the essentially reinforced bar under the main stress. The Izod Effect Test was used to determine the effect quality using measurement examples.

4. Result & Discussion

4.1 Result of Water Absorption

A major drawback of more uses for natural fiber composites is their ability to absorb water. Hybrid composites' water absorption increases from 1% to 7.5% per hour, reaching its minimum and maximum levels after 10 hours.

4.2 Result of Impact Test

As shown in the picture, the presence of Prosopis juliflora composite can result in a wide range of effect quality depending on the fiber concentration. Composites of Prosopis juliflora and coconut trees showed superior sway characteristics in this case. As the volume fraction of filaments increases, the effect quality rises, reaching a maximum incentive of 55%. The effect quality follows a declining pattern after 55%. Composites have an extraordinary effect quality that ranges from 0.8 to 1.8 J. Prosopis juliflora and coconut trees treated with antacids showed an improvement in the quality of their effects.

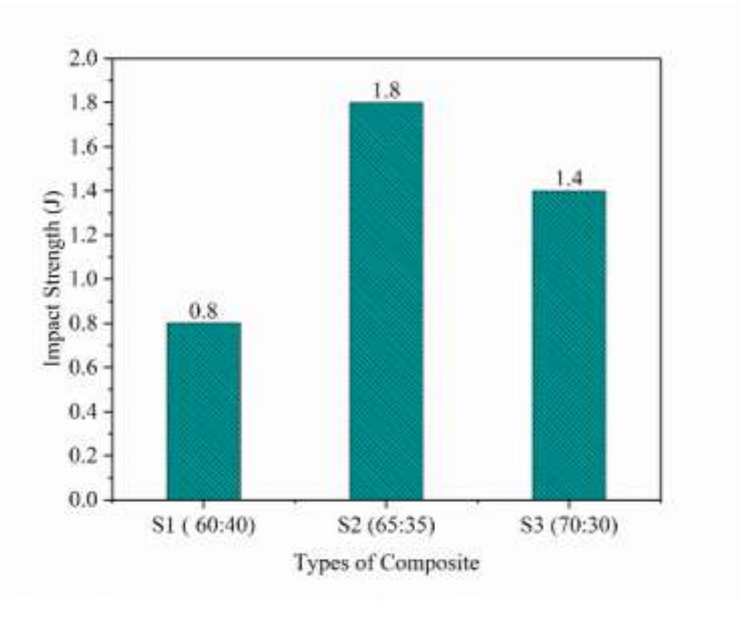

Fig.2. *Impact strength*

4.3 Result of compressive test

The figure shows that antacid-treated composites have varying compressive qualities according to fiber content. The compressive quality was assessed by testing a composite material made of Prosopis juliflora and coconut trees. After testing three different cases, we were able to account for the typical compressive quality. Up to 30%, the compressive quality increased at an exponential rate; after that, it changed very little. The compressive strength of coconut trees and Prosopis juliflora ranges from 21.74 MPa to 39.19 MPa.

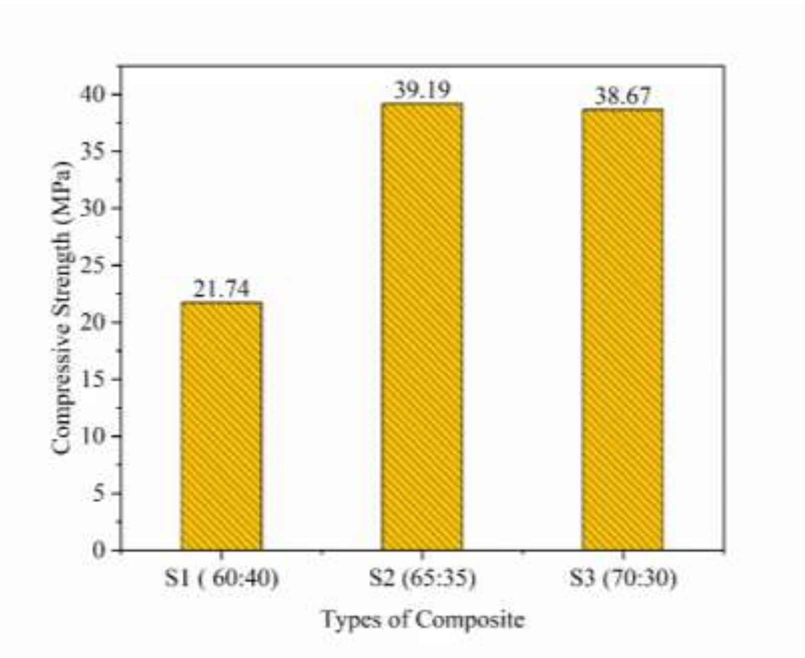

Fig.3. Compressive strength

4.4 Result of tensile and flexural test

Parameters pertaining to the composite's quality-related attributes are being impacted by the fiber's substance and fiber quality. So, fiber stacking's quality variation showed up in an unanticipated way. Composites with varying percentages of fiber content (60, 65, and 70 percent) exhibit different ductile and flexural qualities, as shown in Figures 4 and 5, respectively. For fibre contents of 50% and 60%, these numbers clearly demonstrate stiffness and flexural quality. In any case, the composite's pliability and flexural strength are reduced when the fiber level reaches 70%.

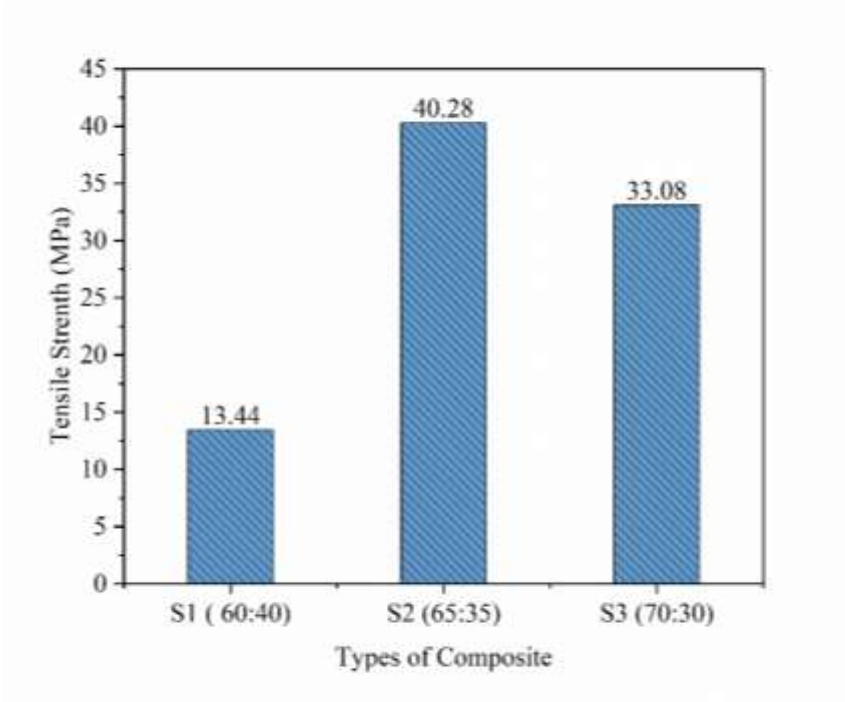

Figure 4. Tensile strength

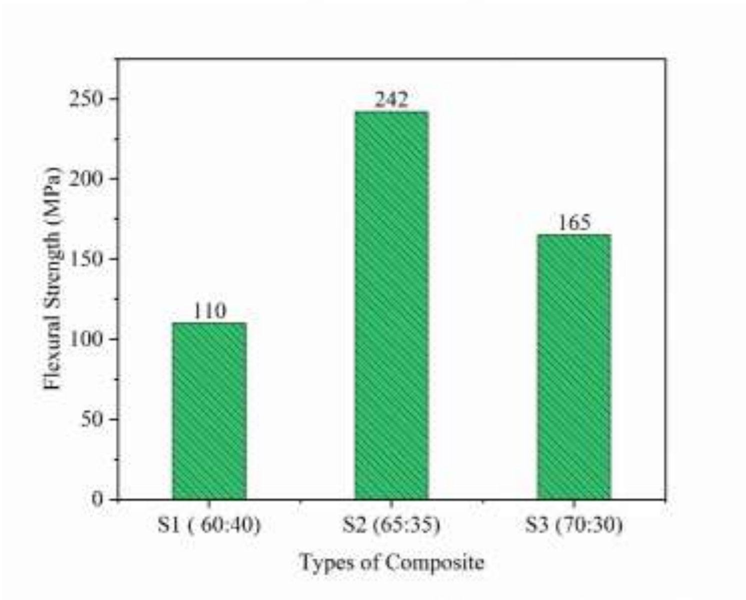

Fig.5.Flexural Strength

5. Conclusion

The mechanical properties of the composite material, which can be either Prosopis juliflora or coconut trees, are explained throughout this project. The tests include tensile, compression, flexural, and impact tests. Regarding mechanical properties, a 65:35 mixture yields better results in the tensile, flexural, compressive, and impact tests. The results of the tests are displayed near the values of the synthetic fiber composites as shown in the literature review. It turns out that natural fiber can take the place of synthetic fiber.

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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.

Data availability statement

The data used in this study will be made available upon request to the corresponding authors.

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