Flexural Test on Hybrid Biocomposite Materials

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Abstract

Aim: The main objective of this work is to fabricate the biocomposites exploitation natural fibres like Sisal, Banana, hibiscus, Sisal and banana (hybrid), banana and hibiscus (hybrid) and sisal and hibiscus and sisal (hybrid) with epoxy (bio) glue as a reinforcement exploitation molding methodology. Methods/Analysis: In the present study, the optimum combination of fibre and organic compound is achieved by exploitation Taguchi methodology. During this work, flexural rigidity of Sisal and banana (hybrid) at a quantitative relation of 1:1, banana and hibiscus (hybrid) at a quantitative relation of 1:1 and sisal and hibiscus (hybrid) at a quantitative relation of 1:1 composite were studied at dry and wet conditions. The main focus of the work is to predict the properties of fibre fabric of the NFRP composite and also the mathematical model of deflection of beams was developed and the values are compared and located to be in sensible agreement. The wet absorption characteristics of the fibres are vital to supply the natural fibre hybrid composite materials with the positive hybrid impact. Specimens were scanned using Scanning electron microscope. Findings: The wet composites reduce the flexural properties as the presence of wet degrades the fibre matrix interface strength and it makes poor stress transfer leading to a discount on the flexural strength. Each within the hibiscus and sisal fibre composites, it was found that the elongation of fibre increasing when it is immerse in the water. The explanation can be the presence of water attack on the polyose structure expectations and allow the polyose molecules to maneuver swimmingly. Application/Improvement: The application includes the replacement material for bone joints, artificial tissues, limbs, arteries, artificial tooth and skin. So, this work can be extended to other spheres of the biomaterials by extending the work and conducting other functional properties like stress distribution and biocompatibility etc.

Keywords: Bio Epoxy Resin, Flexural Rigidity, Natural Fibres, SEM

1. Introduction

Natural composites are replacing the conventional composite materials for low strength and non harshing regions as it requires low strength and non corrosive. Since the major advantage of using bio composites are bio degradable, low cost and abundant6. But the major drawback of using the biocomposites are the following: poor strength and properties cannot be tailored beyond certain extent. Besides the disadvantages, now a days majority of the conventional materials are being replaced. The major biocomposite materials are sisal, hibiscus, coir, banana fibre, neam etc1. In general, natural materials are used as a reinforcement and conventional materials are for matrix. The conventional matrix materials are epoxy resin, and metals like aluminum, copper, steel etc16.

The primary matrix materials for natural composites are generally polymers that are commonly known as polymer matrix composite4. Also, these fibres are comparatively high-priced and that they produce issues throughout recycling. Glass fibres, as an example, don’t burn during thermal recycling and stay as solid waste that should be land-filled. The planet is facing a challenge in having to decrease pollution levels whereas at an equivalent time considerably increasing industrial output. The answer to the above-named issues might be the utilization of renewable resources. The expansion in environmental awareness has led to the utilization of fibre strengthened

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composite materials. The most advantage of natural fibres is that their production needs very little energy and CO₂ is employed whereas O₂ is given back to the atmosphere. Plastic materials need to be strengthened with fibres to fulfill the demands of automotive industries.

Since natural fibres tend to degrade at lower temperature (above 200°C), the low thermal stability of those fibres limits the quantity of thermoplastics to be thought of as matrix material for fibre thermoplastic composites. Polypropylene, as a thermoplastic matrix, has received plenty of attention within the production of fibre strengthened thermoplastic composites. Polypropylene could be a semi-crystalline thermoplastic with excellent dimensional stability, low density, low price, excellent mechanical properties, good flex life. For the natural fibres to be able to contend with artificial fibres, an improvement in material properties of fibre strengthened composites is necessary and has been determined. Since the mechanical and thermal properties required for bio applications are quite moderate, natural fibres reinforced polymers are best suited for the present study.

Hibiscus, sisal and banana fibres are abundant in nature and it possesses very good mechanical and thermal properties. So, for the present study, the hybrid bio composites (hibiscus – banana, hibiscus - sisal) have been taken. The advantages of bio composites over the conventional materials like metal alloys (titanium alloys and stainless steels), polymers and ceramics are quite high. The biocompatibility is the major concern while selecting the material for body part replacement, in this regard, natural composites would be the better choice of selection. In addition to that, this bio composites can also be used for other applications like automobile parts.

2. Materials and Methods

The material used for the present work is shown in Table 1. Reinforcement materials like sisal, banana and hibiscus are available in the local areas.

| Material          | Type                        | Supplied by                  |
|-------------------|-----------------------------|------------------------------|
| Matrix            | Bio epoxy resin             | Lab chemicals, Chennai       |
| Catalyst          | Bio epoxy Hardner           |                              |
| Releasing agent   | Poly vinyl acetate          |                              |
| Reinforcement     |                             |                              |
| 1) Sisal & Roselle | Particle reinforced composite | India (especially in South India regions) |
| 2) Banana & Sisal  |                             |                              |
| 3) Banana & Roselle|                             |                              |

2.1 Chemical Treatment of Said Natural Fibres

The fibres are crushed and powdered, then the fibres are cleaned using water and dried. 200th NaOH is added and 80th of water is added and a solution is taken in the beaker. Fibres are dried for 2 to 3 hours and then soaked in the NaOH solution for 3 hours. After the fibres are taken out and washed in running water, these are dried for one more two hours. The fibres are then taken for subsequent fabrication method particularly the Procasting process.

2.2 Moisture Absorption Test Procedure

The test specimens were cut according to the American Society for Testing and Materials (ASTM) and the samples were sealed with polyester resin and subjected to moisture absorption test. The test specimens were first dried in oven at 50°C and then it was dried at 30°C. The specimens were taken out and wiped with filter paper and the specimens were weighed by physical balance at regular interval. The specimens were allowed to absorb the water during the immersion period until the saturation limit was reached. To avoid the error due to evaporation, it was weighed within 30 seconds and swelling of specimen were found out through ASTM D570 standard.

2.3 Flexural Test

Since the parts made for body replacement are subjected to bending stress, it has to be ensured that it possess adequate bending strength. Flexural tests were carried out according to the ASTM D790 standard and the test results were tabulated.

2.4 Mathematical Model of Bending of Beams

The bending of beam has been studied and analysed using mathematical model and it is been discussed here.
Let, \( M \) be the moment produced by the load action on the beam \( AB \),
\[
E = \text{Modulus of elasticity of the beam}
\]
\[
I = \text{moment of inertia of the cross section about } AB \text{ and}
\]
\[
R = \text{Radius of curvature of the elastic curve at } R
\]
The Bernoulli – Euler law states that,
\[
M = \frac{EI}{R} \quad (1)
\]
The maximum deflection of beam equation is
\[
\frac{w}{2p} \sqrt{\frac{EI}{P}} \tan \left( \frac{P}{\sqrt{EI/2}} \right) \quad (2)
\]

2.5 Scanning Electron Microscopy
The SEM images of test specimens were taken and it is shown in the Figure 1-6.

**Figure 1.** SEM of Sisal and banana (hybrid).

**Figure 2.** SEM of Roselle and banana (hybrid).

**Figure 3.** SEM of Roselle and sisal (hybrid).

**Figure 4.** SEM of Sisal and banana (hybrid).

**Figure 5.** SEM of Roselle and banana (hybrid)

3. Results And Discussions

3.1 Flexural Test
Table 2 shows the test result of 3 point bending test and the effect of flexural loading on the properties of the fabricated composites Figure 7-12. It was observed that the Sisal and Roselle (hybrid) fibre composites withstand more loading during flexural testing and it is due to the presence of sisal fibre reinforcement but due to the presence of sisal fibre and the moisture content in the composite, the flexural properties of hybrid composites goes down and it is listed in the Table 3.

**Figure 6.** SEM of Roselle and sisal (hybrid)

**Figure 7.** Comparison of Sisal and Banana (hybrid) (hybrid) in with and without moisture.

**Figure 8.** Comparison of Roselle and Banana in with and without moisture.
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**Table 2. Results of flexural test under with moisture and without moisture**

| Load (N) | Sisal and Roselle (Without Moisture) | Sisal and Roselle (With Moisture) |
|----------|--------------------------------------|----------------------------------|
|          | Deflection in Experimental results   | Deflection in mathematical model | Deflection in Experimental results | Deflection in mathematical model |
| 61.31    | 8.68                                 | 8.249                            | 8.48                                | 8.249                            |
| 122.6    | 16.8                                 | 16.844                           | 16.8                                | 16.844                           |
| 183.9    | 24.95                                | 24.256                           | 24.85                               | 24.256                           |
| 245.3    | 31.84                                | 31.285                           | 33.14                               | 31.285                           |
| 309      | 41.35                                | 41.275                           | 42.35                               | 41.275                           |
| 370.3    | 51.76                                | 51.285                           | 51.76                               | 51.285                           |
| 431.6    | 57.07                                | 56.377                           | 58.67                               | 56.377                           |
| 493      | 66.97                                | 65.385                           | 67.27                               | 65.385                           |
| 554.3    | 77.86                                | 76.893                           | 77.26                               | 76.893                           |
| 615.6    | 83.57                                | 84.987                           | 84.27                               | 84.987                           |

**Figure 9.** Comparison of Sisal and Roselle (hybrid) In with and without moisture.

**Figure 10.** Comparison of Sisal and Banana (hybrid) In with and without moisture.

**Figure 11.** Comparison of Roselle and Banana (hybrid) In with and without moisture.

**Figure 12.** Comparison of Sisal and Roselle (hybrid) In with and without moisture.

This is due to the well known fact that the presence of moisture reduces the fibre-matrix interface region strength, which results the poor transfer of load from fibre to matrix. In the Roselle and Sisal (hybrid) fibre composites the percentage elongation is found to be increasing after immersing the components in to water.
Figure 12. The presence of water molecule will distort the cellulose structure and it leads to the free movement of cellulose. It can be justified by observing the ductile property of the sisal hybrid composites increases. Upon loading condition, a brittle like failure was observed (less in % of elongation, Figure 10 and Figure 11). Flexural Test Where, Fr-Flexural rigidity

4. Conclusion

From the test results, the following conclusions are made: It was observed that the hybrid composites showed the better performance over others, the micrographs taken for the fractured sisal, banana, roselle and hybrid composites. The brittle like fracture were observed in the banana and sisal (hybrid) and banana and roselle (hybrid) fibre composites, under different loading conditions. Less fibre pull out causes the elliptical cracks and their quick propagation, and this is the reason for the flexural strength reduction. This is also been confirmed by the SEM image. This is due to more percentage elongation for the sisal and roselle (hybrid) fibre composites and the presence of moisture content reduces the strength and flexural properties of the composites. This is due to the fact that the fibre bridges through fibre pull out and the complete breaking of the fibre rather than pull out. this phenomenon is confirmed by the SEM analysis.

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