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Experimental investigation on the mechanical properties of woven hybrid fiber reinforced epoxy composite

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Abstract

For the past few decades, the demands for the natural fiber reinforced polymer composites were growing due to the advantages such as low cost, better strength to density ratio, availability and bio degradability etc. But due to their inherent nature they tend to absorb moisture, which results in weakening of the composite. In this work the hybrid fiber reinforced composite was developed by incorporating woven banana fiber and glass fiber in the Epoxy matrix. The effects of hybridization, stacking sequence and surface treatment of the banana fiber on the mechanical properties of the composite were investigated. Composite specimens were prepared by hand layup method followed by light compression. The specimens were evaluated for the mechanical properties as per ASTM standards, it was found that the stacking sequence had negligible effect on the tensile properties whereas the flexural and impact strength were largely affected by the stacking arrangement of the woven glass fiber and banana fiber. Similarly, the effect of chemical treatment on the

mechanical properties of the composites were also evaluated. SEM images were taken to assess the surface morphology of the composite sample.

Introduction

Fiber Reinforced Polymer (FRP) composite materials had been used in several applications for the past several decades due to their advantages such as better strength, low weight, corrosion resistant, ease of manufacturability, low cost and also, they can be easily tailor made based on the requirement of the application. Synthetic fibers such as Kevlar, carbon fiber, and Glass fiber were primarily used in most of the application. But, due to the environmental concerns and governmental policies the focus on using natural fibers as an alternative had been widely investigated by several researchers [1], [2], [3]. Natural fibers have several advantages such as environment friendly, ease of handling, low cost, availability and strength to weight ratio comparable to that of synthetic fibers. The structure of natural fiber mainly consists of lignin, cellulose, hemicellulose, and moisture. Natural fibers are hydrophilic in nature due to which they try to absorb moisture when exposed to wet conditions. Efforts had been made by the investigators to minimize the disadvantages by hybridizing [4], [5], [6] the natural fibers with synthetic fibers and also fiber surface treatment [7], [8], [9] had been suggested to improve the surface adhesion and reduce the drawbacks of natural fibers.

Mostafa [10] had conducted fatigue and tensile experiments to determine the effect of hybridization of glass–epoxy composite using Jute fiber. It was reported that the hybridization resulted in marginal reduction in the tensile strength, whereas the usage of the natural fiber increased significantly. It was also suggested that the fatigue life of the hybridized composites was comparable to that of pure glass fiber epoxy composites. Vigneshwaran et al. [11] have reported that the incorporation of filler particles such as seashell powder can result in improvement in the mechanical, thermal and vibration properties of the polymer composites. Dual et al. [12] prepared composites by using untreated coir fiber and sisal fiber, treated coir fiber and sisal fiber and also blend of sisal and coir fiber reinforced in Poly Lactic Acid (PLA) matrix. The results indicated that the composite prepared by using the alkali treated fibers had shown better properties compared with that of other fibers. Also, the hybridization had a positive effect on the mechanical properties of the PLA composite. Reddy et al. [13], [14] had shown that the hybridization of reinforcements can be performed with more than two fibers. Epoxy based composite was prepared by using Jute fiber, pineapple leaf fiber and glass fiber at the ratio of 1:1:1 with the total volume fraction of fibers varying from 18% to 42% v/v. it was reported the tensile and flexural strengths were increased by the addition of reinforcing fibers in the

epoxy matrix. Chemical treatment of sisal fiber surface was performed by Fiore et al [15]. Sodium Bi carbonate (10% w/w) was used treat the raw sisal fibers, the effect of chemical treatment was studied by using Fourier transform Infrared Spectroscopy (FTIR), pycno meter analysis and Thermo Gravimetric (TGA) analysis. It was found that treatment time of 120 hrs resulted in better mechanical properties. Low-density polyethylene (LDPE) composites were developed by Prasad et al. [15] by reinforcing treated and untreated banana fiber at different weight fractions. The effect of alkali treatment and acrylic acid on the mechanical properties were evaluated. It was shown that the acrylic acid treated banana fiber had shown better mechanical properties with the addition of compatibilizer. Sem images had shown better matrix – fiber interaction due to the surface treatment of the fiber [16], [17], [18], [19], [20].

In this work, a hybrid fiber reinforced Epoxy composite was developed by using woven banana fiber and glass fiber. The effect of layering arrangement, and chemical treatment on the mechanical properties was evaluated.

Section snippets

Materials and fabrication

Banana fiber and Glass fiber were used as reinforcements in this study and Epoxy resin was used as matrix material. Banana fiber was procured from M/s ROPE international Pvt Ltd, Chennai, India. The fiber was extracted from the pseudo stem of the banana tree and it was processed to remove any moisture content. The density and tensile strength of the fiber was given as 1.35 g/cm^3 and 600 MPa respectively. The fiber strands were then woven into a mat format with each strand containing 10–15…

Results and discussion

The experimental results of mechanical properties for the untreated woven hybrid fiber epoxy composites are listed in Table 2. Specimen A contains only banana fiber, Specimens B

and C contain three banana fiber fabrics and two glass fiber fabrics, specimens D and E contain two banana fiber fabrics and three glass fiber fabrics, and Specimen F contains only glass fiber. It was observed from the tensile test results that the specimen A have lower value of tensile strength, specimen F produced…

Conclusions

Hybrid fiber reinforced Epoxy composite specimens with pure banana fiber, pure glass fiber and hybrid fiber with varied stacking sequence were fabricated. The effect of hybridization, effect of stacking sequence and the effect of surface treatment by alkali on the mechanical properties were studied. The experiment results had shown that the hybridization resulted in significant increase in the mechanical properties of the banana fiber composite. Stacking sequence had negligible effect on the…

Declaration of Competing Interest

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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