International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2024.506

e ISSN: 2584-2854
Volume: 02
Issue:12 December 2024
Page No: 3436-3441

Study of Tensile Strength of Opuntia Ficus Indica Fiber Reinforced Epoxy Composites

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Abstract
In this present study, naturally available opuntia ficus indica (cactus) fiber is used, as reinforcing material. Cactus fiber belongs to the family cactaceae, which is reported to contain about 130 genera and nearly 1500 species. Composite materials are replacing standard Engineering metals and alloys for many applications. Since it is abundantly available in nature and majority of it is getting wasted without being used as reinforcement in engineering applications. In this work the mechanical properties cactus fiber reinforced with epoxy matrix. And also investigated the effect of fiber volume fraction on the tensile strength, flexural and compression strength, and hardness behavior of cactus fiber was studied. Cactus fiber reinforced with epoxy matrix composites is prepared with varied fiber lengths (8 mm and 10 mm) and for varied weight fraction (20%, 25% and 30%) of the fibers. The short cactus fibers are treated with 5% of Sodium Hydroxide (NaOH) solution. In the present work, the effect of the fiber treatment, fiber length and fiber loading on the mechanical properties are investigated. The results show that the Alkali Treated cactus fiber reinforced composites have better mechanical properties than untreated composites. The 10 mm fiber length reinforced composite shown improved mechanical properties than 5 mm fiber length reinforced composite. Increase in mechanical properties is seen when the fiber content in the composite is increased from 20% to 25% and 25% to 30%. The 30% weight of the cactus fiber reinforced composite has shown higher values of mechanical properties.
Keywords: *Composite Materials; Epoxy Resin; NAOH Solution; Short Cactus Fiber*

1. Introduction

A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous [1]. In general, fibers are the principal load carrying members while matrix keeps them at the desired location and orientation, acts as a load transfer medium between them, and protects them from environmental damages. The primary functions of the matrix are to transfer stresses between the reinforcing fibers/particles and to protect them from mechanical and/or environmental damage whereas the presence of fiber/particles in a composite improves its mechanical properties such as strength, stiffness etc. The objective is to take advantage of superior properties of both materials without compromising on weakness of either [2-7]. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. Composites produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer to choose an optimum combination. Composites have emerged as important materials because of their light –weight, high specific strength and stiffness, excellent fatigue resistance and outstanding corrosion resistance compared to most metallic alloys such as steel and aluminum. Other advantage of composite includes the ability to fabricate, directional mechanical properties, low thermal expansion coefficients and high dimensional stability. It is the combination of outstanding

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physical, thermal and mechanical properties that makes composites attractive to use in place of metals in many applications, particularly when weight-saving is critical. A judicious selection of matrix and the reinforcing phase can lead to a composite with a combination of strength and modulus comparable to or even better than those of conventional metallic materials. The physical and mechanical characteristics can further be modified by adding a solid filler phase to the matrix body during the composite preparation. Natural fibers are a major renewable resource material throughout the world specifically in the tropics. According to the food and agricultural organization survey, natural fibers like jute, sisal, coir, banana, etc. are abundantly available in developing countries. Recent reports indicate that plant fibers can be used as reinforcement in polymer composites replacing to some extent more expensive and non-renewable synthetic fibers such as glass, carbon, etc [9-13].

2. Method

The composite plates prepared initially are marked for required dimensions. They are cut to the markings using a wire saw for required dimensions. The edges of the specimens are rubbed against emery paper in order to bring them to the exact dimension. The specimens were prepared according to American Society for Testing of Materials (ASTM) standards. In the present work cactus fiber is used as reinforcement and epoxy as matrix material. The cactus fibers are chopped into lengths of 8 mm and 10mm and also the specimens were prepared for 8 mm and 10mm separately. In the proposed work specimens were prepared as shown in Table 1 for three different compositions.

Table 1 Weight Fraction Composition of The Cactus Fiber Composites Used

Serial number	Weight Fraction Compositions of cactus Fiber Composite
1	Short cactus fiber 30% + epoxy 70%
2	Short cactus fiber 25% epoxy 75%
3	Short cactus fiber 20% + epoxy 80%

According to ASTM D3039, the composites specimens were prepared for tensile testing for determine the tensile properties. Each test specimen of 250mm gauge length, 25mm wide and 6mm thickness were prepared. For this test UTM of capacity 200kN used, shown in figure 1.

Figure 1 Specimens Used for Testing

3. Experimentation

In this work Tensile test of cactus reinforced epoxy composites were conducted. Tensile tests were conducted using computerized universal testing machine. The Figure 2 shows the universal testing machine used in this work to obtain the Tensile Mechanical properties, Shown in figure 3 [14-19].

Figure 2 Computerized Universal Testing Machine

Figure 3 Tested Tensile Specimens

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4. Results and Discussion

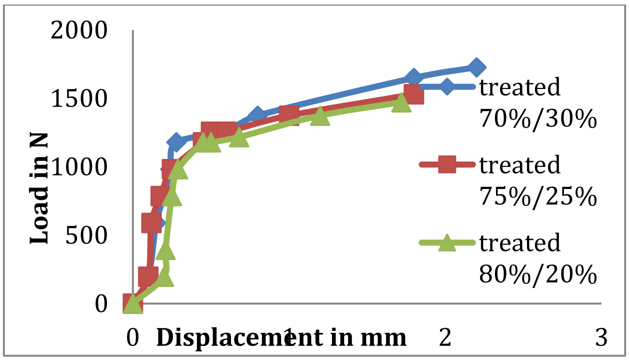

Figure 4 Load v/s Displacement Curve for Treated Cactus Fiber Reinforced with Epoxy Composite

The above Figure 4 shows the effect of treated fiber content on the tensile strength of the all combination of composites. From Fig.4 it is evident that as the load goes on increasing, the deformation increases. For treated 70% matrix and 30% fiber content the deformation is less compare to the other two fiber content. And it shows more tensile strength compare to the other fiber content. The decrease of tensile strength in composites with 80% and 20% fiber and matrix content may be due to the insufficient of fillers to reinforce the matrix of the composites. This is due to improper matrix addition with reinforcement. The treated composites showed superior impact properties than the untreated composites, because alkali treatment improves the adhesive characteristics of the surface of the fiber by removing the hemicelluloses and lignin [20-24].

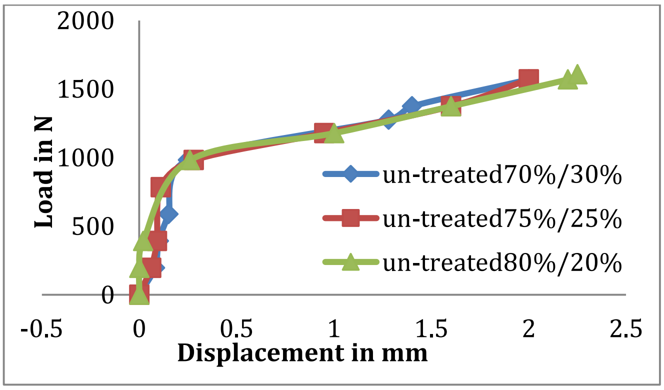

Figure 5 Load V/S Displacement Curve for Untreated Cactus Fiber Reinforced with Epoxy Composite

The reason for this is that the surface offers a good-matrix interface adhesion and an increase in mechanical properties [8]. The above Figure 5 shows the effect of untreated fiber content on the tensile strength of the all combination of composites. From Figure 5, it is evident that as load goes on increasing, the deformation increases. For untreated 80% matrix and 20% fiber content the deformation is more compare to the other two filler content. But 30% and 25% fiber show nearly same tensile strength. This is due to the improper matrix addition with reinforcement, Shown in Table 2 [25-30].

Table 2 Treated and Untreated Tensile Strength of Composites

Sl. No.	Comparison of treated and untreated fiber composition			
	Matrix -70% Treated Reinforcement-30%		Matrix-70% Untreated Reinforcement-30%	
	Load (N)	Displacement (mm)	Load (N)	Displacement (mm)
1	0	0	0	0
2	196	0.1	196	0.08
3	588	0.15	392	0.1
4	784	0.2	588	0.15
5	981	0.24	981	0.25
6	1177	0.28	1275	1.28
7	1255	0.6	1375	1.4
8	1373	0.8	1569	2
9	1648	1.8		
10	1726	2.2		

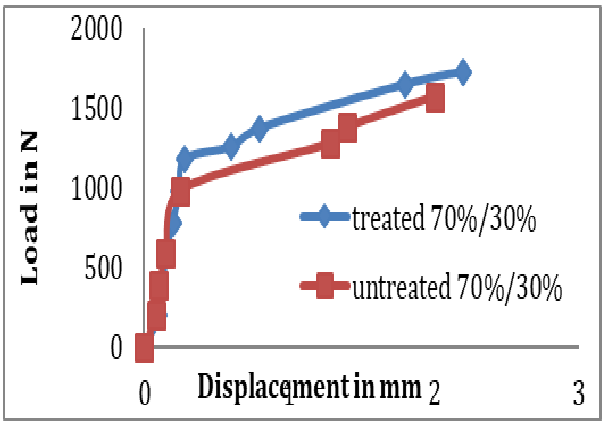

Figure 6 (a) Tensile Strength Effect of 30% Treated and Untreated Fiber Content

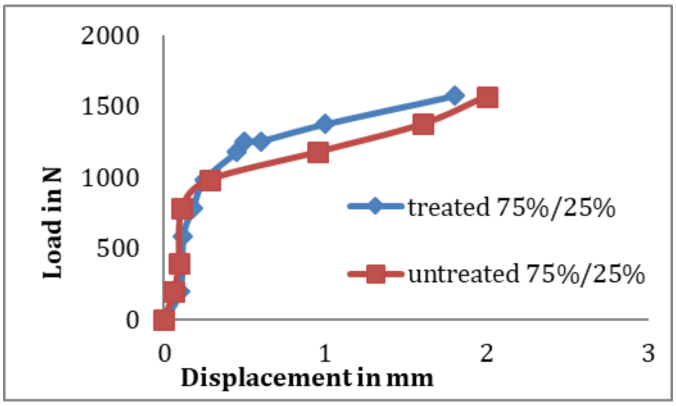

Figure 6 (b) Tensile Strength Effect Of 25% Treated and Untreated Fiber Content

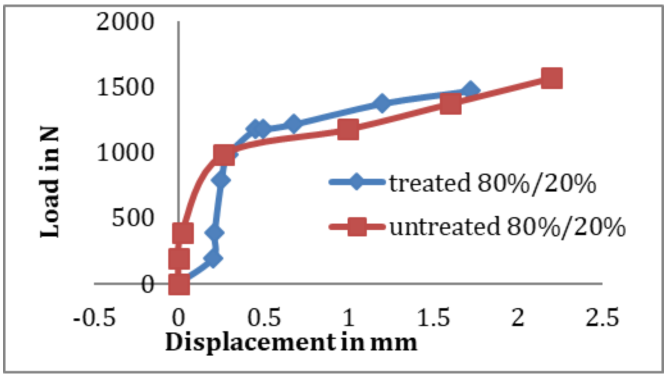

Figure 6 (c) Tensile Strength Effect of 20% Treated and Untreated Fiber Content

The above three Figure 6(a), Figure 6(b), Figure 6(c) shows the effect on tensile strength for treated and untreated fiber content natural fiber composites of different combinations. From Fig.6(a) it is observed that as the fiber content goes on increases the resistance to the elongation of the specimen increases. 30% treated fiber content shows the ultimate tensile strength than other 25% and 20% fiber content. By observing these figures the treated fiber content shows maximum load absorbing capacity as compare to the untreated fiber content specimens. This is due to Chemical treatment with NaOH solution this is because when the fibers are treated with alkali solution the strength of the fiber increases. This may be due to removal of amorphous hemi-cellulose and lignin content from the fiber surface. Also, alkali treatment increases the crystallinity of the fibers. And hence from all these graphs it is concluded that tensile strength increases with increase in fiber content with alkali treatment.

Conclusion

The mechanical properties of the NaOH treated opuntia Ficus Indica fiber content composites are when more compared to the untreated fiber content. Cactus fiber reinforced with epoxy composites found to have good strength at particular composition. It has been noticed that the mechanical properties of the composites such tensile strength of the composites are also greatly influenced by the fiber. It has been noticed, that all conducted tests show good mechanical properties for 70/30% volume fraction composites of NaOH treated fiber. Hence mechanical properties increases with increase in fiber content.

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