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Mechanical and Thermal Properties of Agave Fibre Surface Treatment of Epoxy Composite Samples Selected from Shivamogga District of Karnataka

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ABSTRACT

Natural fibre composites are considered to have a great potential to use as a reinforcing material in polymer matrix because of their good strength, stiffness, low cost, environmental friendly and biodegradable. In the present study, mechanical and thermal properties of agave fibre composites were evaluated. Here agave fibres are used as natural fibre reinforcement and epoxy resin as matrix. Agave fibre were treated with 10% KOH. Composites were prepared using hand layup technique. Mechanical properties of untreated and treated fibre composites were analyzed by flexural strength, impact strength and thermal properties by TGA and DSC were determined and results were reported. The alkali treated agave fibre composites exhibited better strength and thermal stability than untreated composites.

1. INTRODUCTION

Natural fibres, as reinforcement, have recently attracted the attention of both the academic sector and the industry as one of the best engineering materials. They are environmentally friendly, fully biodegradable, abundantly available, renewable, cheap, and have a low density. Plant fibres are light compared to glass, carbon, and aramid fibres. The biodegradability of plant fibres contribute to a healthy ecosystem. The rapid growth of industry and socio-economic developments require better utilisation of the available materials with desired properties. In this modern era, composite materials have emerged due to their strength, stiffness, density, lower cost, and improved sustainability[1]. A number of automotive components previously made with glass fibre composites are now being manufactured using environmentally friendly materials. The flexibility that can be achieved with composite materials is immense.Natural vegetable fibres consist of cellulose, lignocelluloses, pectin, and hemicelluloses, depending on the vegetable species. Worldwide, despite the availability of modern synthetic fibres, vegetable fibres remain in great demand and compete with wool, silk, and synthetics for quality resistance, durability, colour, and lustre.

India, being a tropical country, is blessed with plenty of renewable resources obtained from the plant kingdom. In the plant kingdom, one of the abundant sources of natural vegetable fibre is agave. Agave fibres are characterised by low density, high tenacity, and low cost. Agave is a long-leaved, thick, tropical, subtropical plant used for commercial and medicinal applications [2]. Agave fibre, with excellent properties such as length and strength, is used in the textile industry for producing fabric.

Surface modification of the natural fibres is done while preparing the composite materials to reduce the incompatibility [3]. Alkali treatment is one of the cost effective process and have widely used to improve surface interface. The natural fibre treated with NaOH presents better result in the composites strength and reduces water sorption [4]. Keeping in this view, in the present study mechanical and thermal properties of treated and untreated agave fibre composites is carried out.

2. MATERIALS AND METHODOLOGY

The agave plant is abundantly available in nature. It is found in various areas, like the sides of roads, farms, various rocky regions, droughty regions, etc. The agave leaves are collected manually from Shivamogga. All leaves standing at an angle of more than 45 degrees to the vertical are cut away from the bole of the plant with a sharp, flexible knife.The agave fibres are extracted by the decortications process. After the extraction process, the fibres are washed 2-3 times and dried at room temperature for 4 days. Epoxy resin L-12, K6 hardener and melamine was brought from CS marketing, Tamilnadu.

The extracted agave fibres are immersed in a solution of 10% KOH (potassium hydroxide). The fibres are kept in this alkaline solution for 30 minutes at a room temperature. Next, thoroughly washed in clean water to remove traces of acid and dried them at room temperature to get alkali-treated fibres .

A steel mouldwith a dimension of 200 mm × 200 mm × 10 mm was prepared for composite fabrication. The chopped agave fibre was mixed with epoxy resin by the simple stirring. In the matrix, epoxy resin mixed with hardener K6 in the ratio 10:1 and melamine 5%. Hand lay up technique was used to prepare the composites. The prepared composites were dried at room temperatures for 96 hours.

Fig a. Untreated Composites Fig b. Treated Composites

3. CHARACTERISATION

3.1 Mechanical Properties

The flexural tests for the different samples of agave fibre reinforced composite were carried out in a Universal Testing Machine (Zwick/Roell-Z020) according to ASTM-790-D standards.

The impact strength of the composites were prepared according to ASTM 6110-D and tested by UTM Zwick/Roell HIT50P.

3.2 Thermal properties

Thermogravimetric Analysis(TGA)of treated and untreated agave fibre composites were measured in a thermogravimetric analyser (Perkin Elmer 4000) from the temperature range25°C to 850°C.

Differential Scanning Calorimetry (DSC) of the composites were determined by using a Perkin Elmer 6000 DSC with a temperature range of 25°C to 200°C.

4. RESULT AND DISCUSSION

4.1 Flexural Strength

The flexural strength of agave fibre-reinforced composites was measured in order to determine their capacity to withstand bending forces. The test results of the composites revealed that the treated agave fibre composites have high strength compared to the untreated fibre composites. Alkali treatment of the fibres had a significant effect on the flexural strength of the composites.

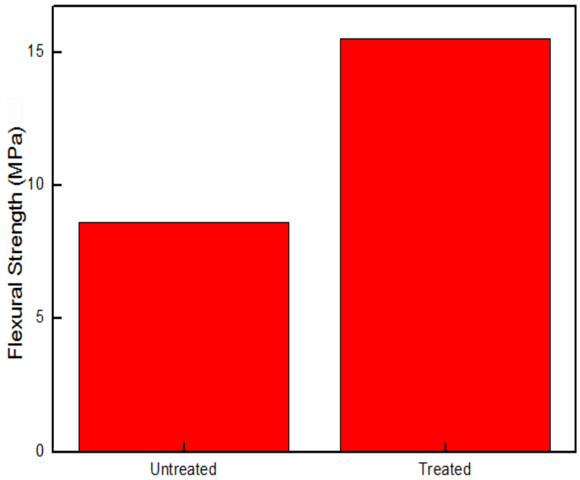

Figure 1. Flexural Strength of untreated and treated composites.

4.2 Impact Strength

The effect of surface modification on the impact strength of the composites is shown in Fig. The impact strength of untreated fibre composites is 3.32 KJ/m2, and that of treated fibre composites is 3.55 KJ/m².It is evident that the treated fibre composites demonstrated the best impact strength, and the amount of energy needed to break the sample is high compared to untreated fibre composites [5]. This is due to the interface bonding between the reinforcing materials and fibre properties.

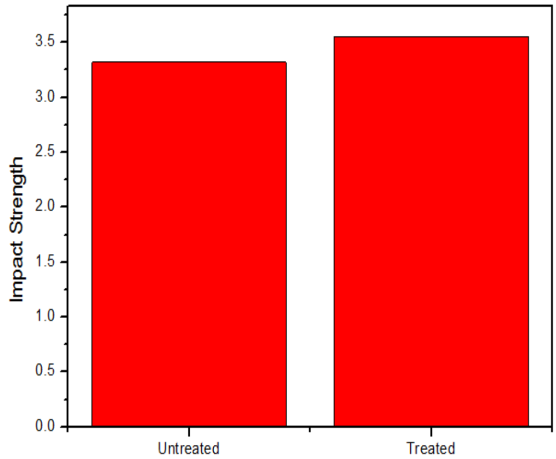

Figure 2. Impact strength of untreated and treated composites.

4.3 Differential Scanning Calorimetry (DSC)

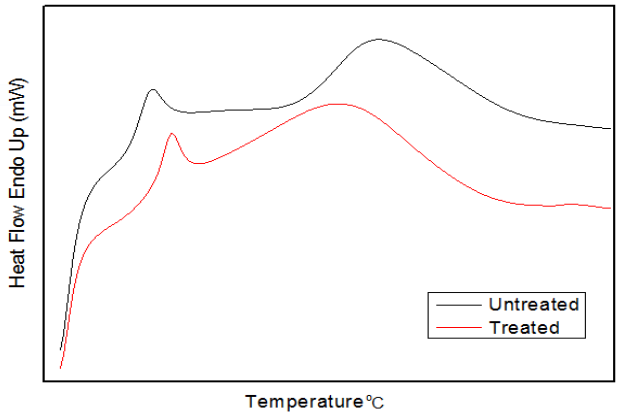

Figure 3. Differential Scanning Calorimetry of the composites.

The DSC test began for untreated and treated composites at 61.69 and 65.92; the half-endothermic reaction was completed at 71.17 °C and 73.92.98 °C , respectively. The specific heat was 0.373 J/g C and 0.35 J/g C. The melting temperature of untreated composites is 127 o, and that of treated composites is 118 oC, as shown in the DSC curves. The alkali-treated composites showed a broader melting peak than untreated agave fibre-reinforced composites.

4.4 Thermogravimetric Analysis (TGA)

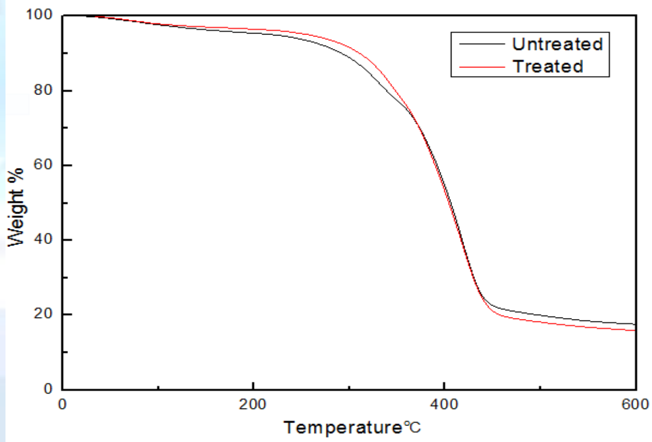

Figure 4. TGA of untreated and treated composites.

The TGA curve of agave fibre-reinforced untreated and treated composites demonstrates that the first peak degradation rate centred at 200 °C is 4.51% and 3.55%, respectively. The weight loss, that is, up to 600 °C, brought the residue down to 17.48 and 15.9%. The untreated and treated agave fibre composites showed a two-step decomposition process [6]. Treated fibre composites have better thermodynamic stability than untreated fibre composites, which is due to improved intermolecular bonding between fibre and matrix[7].

5. CONCLUSION

In this study, composites with good strength could be successfully developed using Agave fibre reinforced composites. Flexural Strength and impact strength of the alkali treated fibre composites have better strength than untreated composites. It also showed that good interface bonding between alkali treated agave fibre which plays a significant role in increasing the strength of the composites. The TGA and DSC showed that thermal stability of the composites increases with alkali treatment.The surface treated agave fibre composites exhibited better strength and thermal stability than untreated composites. These composites are environmental friendly and can be used for industrial applications.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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