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Compendious Characterization Studies on the Physio Mechanical Behaviour of Habara Plant Fiber Fortified Epoxy Composites

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Abstract

The present study deals with natural lignocellulose fibril extricated from habara plant. The fibrils are found to possess high level of amorphous constituents. KOH Surface modification of fibrils at 5wt% enhanced the crystallographic index of habara plant fibers. The thermal stability of the fibers is found to be promising in comparison with unexposed habara plant fiber. The reinforcement of habara plant fibers with epoxy matrix contributed to utmost tensile and flexural strength of 79 MPa and 121 MPa. Scanning electron microscope analysis exposed the intricate surface of habara plant fibers are porous and rough in nature of the fibers subjected to KOH modification. The foresaid composites as application in automobile interior will result in reduction of land filling caused by man made fibril fortified polymer composites.

Keywords

Habara Fiber, KOH, XRD, FTIR, SEM

Introduction

Increasing environmental awareness forced research community to move towards natural lignocellulose fibers owing to their lesser density, ultimate specific strength, and environment friendly and biodegradable in nature. Over the last ten years several natural fibrils have been extracted and reinforced with polymer matrix for a wide variety of application components. The natural fibrils can be grouped into three categories. The different forms of natural fibers are plant fibers, mineral fibers and animal fibers.

Polymer composite materials are finding promising role to play in our day to day house hold applications to aeronautical applications due to its high specific strength, less weight, low density and cost being lower in contrast with metal matrix composites. The comprehensive use of fossil fuel-based filler materials namely glass fiber, kevlar fibrils as fortification materials for the production of polymer composites resulted in environmental pollution and also waste management issues due to their non-degradability. Thus, there arises the need to develop partially or completely degradable polymer composite materials which can be achieved with the help of natural fibrils as fortification materials for the manufacturing of the same which overcome the foresaid issues.

For the past two decades several natural fibrils namely sisal [1], inflorescence [2, 3], banana [4], has been explored which are employed as fortification materials in the development of partially degradable composites. The natural fibers are selected as reinforcement materials due to its higher cellulose content, less density, increased stiffness and better mechanical properties. However, the natural fibers possess serious drawback that is poor interlocking with the polymer matrices during the manufacturing due to its hydrophilic tendency. The hydrophilic tendency is owing to the occupance of amorphous substance existing in the natural fibrils. The amorphous substances existing in the natural fibrils are hemicellulose, lignin, pectin, and wax. The amorphous substance has the moisture absorbing tendency which results in considerable decline in the mechanical, tribological and other related properties of lignocellulose fibril fortified polymer composites. Hence it is essential to remove amorphous substances

present in the natural fibers to achieve required properties based on the end use applications. Surface treatments [5] are the widely used method to remove amorphous substances present in the lignocellulose fiber by which the interfacial adhesion between the fibril and polymer matrices gets enriched. Therefore, by subjecting the natural fibers to surface treatments the interfacial adhesion can be improved and also the reinforcement of lignocellulose fiber with the polymer matrices results in partially degradable composite material with improved physical, mechanical and other related properties based on the end user application.

The natural fibril fortified polymer composites showcase better properties in comparison with the base polymer matrix. The mechanical, tribological, chemical resistance and thermal stability of natural fiber fortified composites are found to have ample improvement. In addition, the application of natural fibrils as fortification materials offers other advantages such as reduced density of the composites, partial bio-degradation of the resources, and control on the depletion of petroleum resources.

The improvement in composite properties, resistance to high temperature operating conditions and high level of dimensional stability makes thermosetting polymers as base materials for reinforcement of natural fibers. However, the increasing demand requires polymer-based materials to possess higher properties. So, the goal of the present research is to explore the enhancement in physical and mechanical characteristics of the habara fiber reinforced epoxy composites as a result of fortification of habara fibril with the polymer matrix.

Raw Materials Used

Habara Fiber is extracted from Habara Plant which is collected from local source as shown in figures 1 and 2 which is commonly known as Cylindrical Snake plant. The botanical name of the plant is Sansevieria cylindrical. It is a very striking succulent with striped, round leaves that are smooth and a green-gray in color. It grows fan-shaped, with its stiff leaves growing from a basal rosette. If grown in bright enough light this plant can produce a 3 foot (90 cm) spike-like raceme of pink-budded white flowers. The habara fibers were extracted by the process of retting followed by malleting and surface treated with 5% wt/vol of KOH solution [6] as shown in figure 3. The extracted fibers were reinforced with epoxy matrix by 10, 15, 20, 25 and 30 wt% for the development of composites by compression moulding technique.

Characterization Technique

To study the influence of surface treatment on the improvement of physical and mechanical properties the habara fibers are subjected to FTIR and XRD analysis.

FIGURE 1 Habara Plant

FIGURE 2 Extracted habara fiber

FIGURE 3 Surface modification of habara fiber

FTIR Spectrum Analysis

Fourier Transform Infrared Spectroscopy analysis was employed to investigate the influence of KOH on the functional groups present in the habara fibers. KBr pellet method is used for preparation of test specimens for FTIR analysis. Perkin – Elmer spectrometer was used to analyse the functional groups in the habara fibrils. The analysis was done at scan rate of 42 scans per minute with 2 cm^{-1} scan resolution in the wave length of 500 – 4000 cm^{-1}.

XRD Analysis

The crystallinity of inflorescence fiber is analysed using an X-Ray Diffractometer at 2Θ scale ranging from 10° to 60° for both untreated and alkali treated inflorescence fiber. The inflorescence fiber is converted into powder form for the prepartion of test specimen using KBr pellet technique. The crystallinity size and index is measured at an accelerating velocity of 45 Kv, with a current of 30 mA using Cu, Kα radiation.

Tensile and Flexural Strength

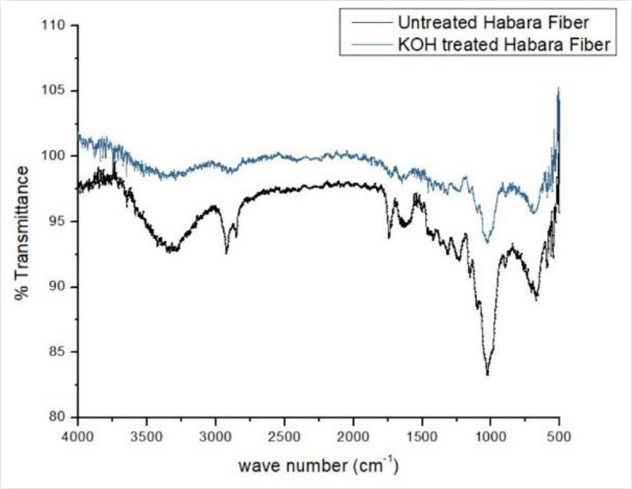
The fabricated composite samples were sized as per ASTM D638 [7] and ASTM D790 [8] standard for tensile and flexural test. The flexural test was conducted based on 3 point bending test.

Results and Discussions

FTIR Spectrum Analysis

The fourier transform infrared spectrum analysis of habara fiber confirmed the elimination of hydroxyl sensitive groups present in the fiber. The peaks 3250 cm^{-1}, 3000 cm^{-1}, 1750 cm^{-1},

FIGURE 4 FTIR plot of Untreated and 5% KOH treated habara fiber



1600 cm^{-1} and 1000 cm^{-1}, 650 cm^{-1} between untreated and KOH treated habara fiber confirms elimination of hemicellulose, lignin, pectin [3]. KOH modification had a noteworthy influence on the elimination of amorphous constituents present in the habara fibers. Figure 4 depicts the transmittance peaks of untreated and KOH treated habara fibers.

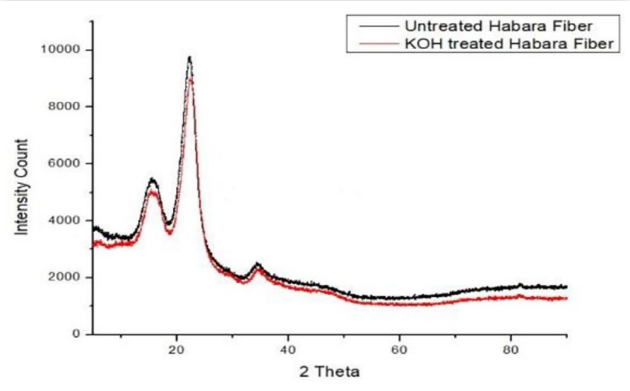
XRD Analysis

Increase in crystal size and index was observed between untreated and 5% KOH treated habara fibers. Reduce in intensity count between untreated and 5% KOH treated habara fibers leads to increase in crystal size and index between the fibers. Rearrangement of habara fibrils contributed to increase in size and index of the fibrils. The rearrangement of fibrils is due to elimination of amorphous constituents like hemicellulose, lignin, pectin and other surface impurities present in the fibers.

TABLE 1 FTIR Peaks and Functional group elimination

Wave number (cm^{-1})	Functional group	Inference
3250 cm^{-1}	C-H symmetrical stretching	elimination of hemicellulose
3000 cm^{-1}	O-H stretching vibration of hemicellulose	elimination of lignin and wax constituents
1750 cm^{-1}	carboxyl group stretching vibration	elimination of hemicellulose and lignin
1600 cm^{-1}	C=C aromatic stretching	elimination of pectin
1000 cm^{-1}	CO-O-CO stretching	elimination of wax and other oil covering constituents
650 cm^{-1}	C=C bending of alkene	elimination of hemicellulose

FIGURE 5 XRD plot of Untreated and 5% KOH treated habara fiber



Tensile Strength

The tensile strength found from one specimen which is fabricated from volume fraction mentioned above in specimen preparation shown in figure 6 was found to be increasing with increase in weight fraction of habara fibers. The maximum tensile strength of 79 MPa was found for 25 wt% reinforced habara fibers. When the fiber weight percentage is increased to 30% tensile strength decreases. This is due to agglomeration of fibers in the composites. The fibers were unable to transfer the load to the matrix thereby composite fails.

Flexural Strength

The flexural strength shown in figure 7 is a measure of how much the fiber were able to bend before plastic deformation. In the entire experiment the maximum flexural strength is found to 121 MPa for 25 wt% of habara fiber. When the weight fraction increased to 30% decrease in flexural strength was observed. This is the result of agglomeration of habara fibers in the composites, thereby the fibers were unable to shift the load to the matrix. Thereby the composite fails.

FIGURE 6 Tensile Strength of Habara Epoxy Composites

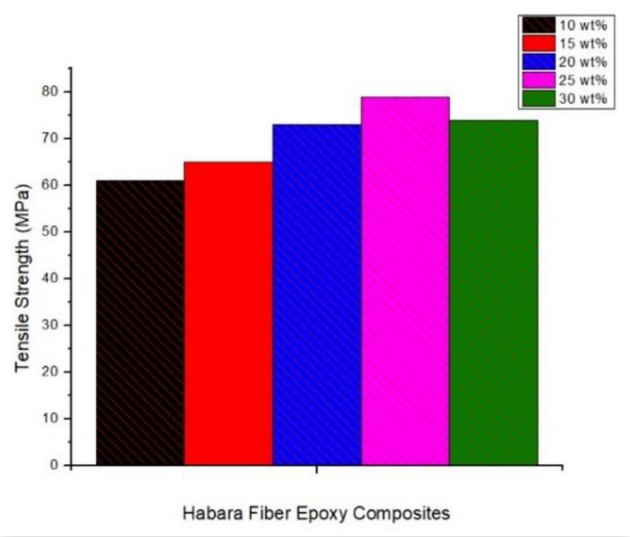
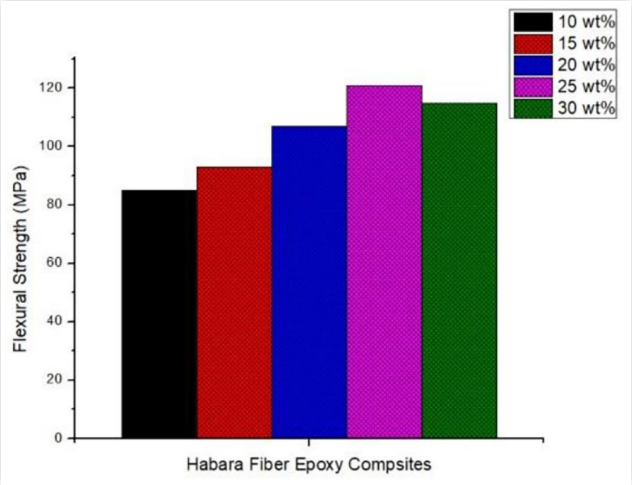


FIGURE 7 Flexural Strength of Habara Epoxy Composites



SEM Analysis

Scanning electron microscope analysis showcase the elimination of amorphous constituents because the fiber surface is porous and presence of cavities were observed. Wax substance elimination can be witnessed between untreated and 5% KOH treated habara fibers. Figure 8 and 9 shows SEM image of untreated and 5% KOH treated habara fibers which shows cavities and micro cracks formation as a result of KOH surface modification.

FIGURE 8 SEM image of untreated fiber

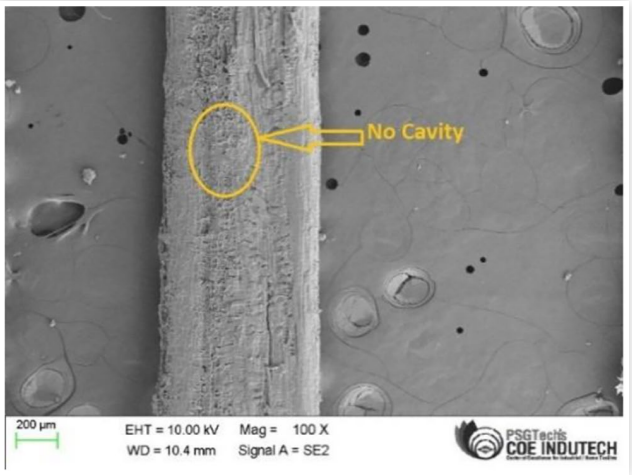
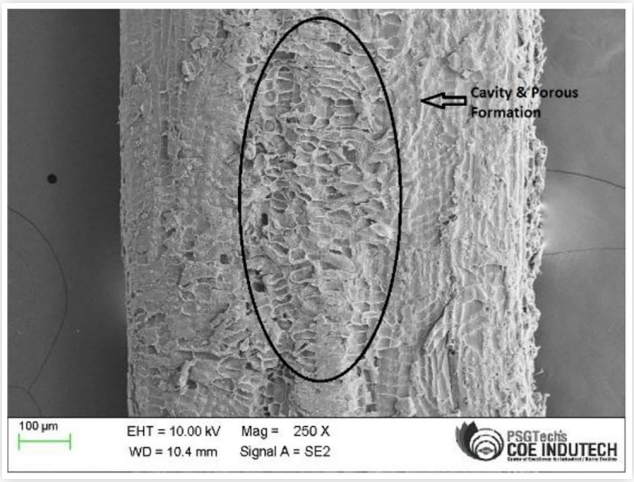


FIGURE 9 SEM image of KOH treated fiber



Conclusion

The extraction, KOH modification and fabrication of habara fiber and epoxy matrix draws the following conclusions.

1. Retting based extraction of habara fiber resulted in better fiber yield from the habara plant.
2. KOH modification of habara fibers resulted in elimination of hydroxyl groups thereby fiber matrix adhesion is better.
3. XRD and FTIR analysis confirmed the elimination of amorphous groups present in habara fibers.
4. Maximum tensile and flexural strength of 79 MPa and 121 MPa was observed for 25 wt% of habara fiber reinforced epoxy composites.
5. SEM morphology analysis revealed KOH treated fiber surface were porous and cavities were observed between untreated and KOH treated fibers.

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