Fabrication and evaluation of mechanical properties of alkaline treated sisal/hemp fiber reinforced hybrid composite

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Abstract: Fiber reinforced polymer composite have acquired a dominant place in variety of applications because of higher specific strength and modulus, the plant based natural fiber are partially replacing currently used synthetic fiber as reinforcement for polymer composites. In this research work going to develop a new material which posses a strength to weight ratio that for exceed any of the present material. The hybrid composite sisal/hemp reinforced with epoxy matrix has been developed by compression moulding technique according to ASTM standards. Sodium hydroxide (NAOH) was used as alkali for treating the fibers. The amount of reinforcement was varied from 10% to 50% in steps of 10%. Prepared specimens were examined for mechanical properties such as tensile strength, flexural strength, and hardness. Hybrid composite with 40wt% sisal/hemp fiber were found to posses higher strength (tensile strength = 53.13Mpa and flexural strength = 82.07Mpa) among the fabricated hybrid composite specimens. Hardness value increases with increasing the fiber volume. Morphological examinations are carried out to analyze the interfacial characteristics, internal structure and fractured surfaces by using scanning electron microscope.

Keywords: Hybrid composite, Sodium hydroxide, Mechanical properties, Scanning Electron Microscopy.

1. Introduction
Research have began to focus attention on natural fiber composites(i.e. coir, jute, sisal, banana, hemp and bagasse fibers) which are composed of natural or synthetic resins, reinforced with natural fibers. Natural fibers exhibit many advantageous properties; they are low density natural yielding relatively light weight composites with high specific properties. These fibers also have significant cost advantages and ease of processing along with being highly renewable resources. Natural fiber composites are very cost effective material especially in building and construction purpose packaging, automobile and railway coach interiors and storage devices. These can be potential candidates for replacement of high cost glass fiber for low load bearing applications. Natural fibers have the advantages of low density, low cost and biodegradability. However, the main disadvantages of natural fibers and matrix and the relative high moisture absorption. Therefore chemical treatments are considered in modifying the fiber surface properties [1].sodium hydroxide (NAOH) treatment on the fiber would remove the impurities like pectin, facts and lignin in the fiber, resulting in improvement in the adhesion between fiber and matrix also increases mechanical (tensile, flexural and compression) properties of fabricated component[2]. The hybrid composites were studied extensively by researchers and they concluded that hybrid composites can offer better resistance to water absorption, cost reduction, weight savings and increase modulus of materials. Girisha.c. etc al [3] fabricated composite specimen of different weight % of alkaline treated sisal fibers and performed...
mechanical characterization. Results indicate the tensile strength increases with increasing fiber percentage up to a certain limit. Dixit s. et al [4] studied the effect of hybridization on mechanical Properties of coir. Composites fabrication was done using compression moulding technique. The results demonstrated that hybridization plays an important role for improving the mechanical properties of composites. The tensile and flexural properties of hybrid composites are improved markedly as compare to un hybrid composites.

Ramesh.et [5] evaluated the tensile and flexural properties of hybrid of glass/sisal fiber and glass/jute fiber reinforced epoxy composites. Glass/sisal fiber reinforced epoxy composite exhibits more tensile strength and glass/jute fiber reinforced epoxy composite exists more flexural strength. Ousegun david Samuel .et al [6] evaluated the mechanical properties of ukam banana, sisal, hemp, coconut and e-glass fiber reinforced to access the possibility of using it as a new material in engineering application. Samples were fabricated by the hand layup process. Kabir et .al [7] studied the mechanical property of chemically treated hemp fiber reinforced composites. They found that due to the rapid climate changes in environment, the physical and geometrical characteristics of natural fiber and synthetic fiber components are affected. For better surface finish of the hemp fiber composites the Chemical treatment process like alkali, acetyl and silane treatments are carried out. Kobayashi et.al [8] investigated the processing and characterization of hemp fiber textile composites with micro-braiding technique and found that the hemp fiber is suitable reinforcement for textile composites. The literature survey indicates that the overall mechanical properties of natural fiber reinforced hybrid composites are completely depend on the amount and type of fibers used.

The present work is based on development of hybrid data sisal-hemp fiber reinforced epoxy composites and determination of mechanical properties at varying weight percentage further a comparative study of the various properties of the prepared composites are presented.

2. Materials and methods

2.1 Materials used

Chopped sisal and hemp fibers were used as reinforcement materials. Sisal and hemp fibers were procured from Sree Laxmi Groups, Vijayawada, Andhra Pradesh, India. Epoxy resin (MY740) and corresponding hardener-Amine based (HY 941) were used to fabricate hybrid bio-composite. This is a low temperature curing epoxy system. The matrix material was prepared with mixture of araldite epoxy and hardener at a ratio of 10:1.

2.3 Fiber Surface Treatment

NaOH treatment removes cementing materials present in the fiber namely lignin, hemicelluloses, pectin and waxes thus increase the surface area of the fiber. Increased fiber surface area leads to the better adhesion of the fiber and matrix thus increasing the tensile strength and other mechanical properties and also improves wettability.

Washed and dried sisal and hemp fibers were taken in separate trays, to these trays 10% NaOH solution was added, and the fibers were soaked in the solution for 10 hours. The fibers were then washed thoroughly with water to remove the excess of NaOH sticking to the fibers. Treated sisal and hemp fibers were dried in sun light for two days before using as reinforcement in the synthesis of composite.

2.4 Preparation of Hybrid Composite

A simple compression molding method was used to prepare the hybrid composites (sisal and hemp fibers) in cast iron mold at high pressure. Hydraulic pressing machine was used to fabricate the hybrid composite specimens. The mould was prepared according to the ASTM standard, the dimension of the mould is 250×250×6 mm. We prepared the specimens as that of mould size, the image of fabricated
composite specimen as shown in below fig.1 and after that we cut specimen according to the ASTM standard for evaluating the mechanical properties such as tensile and flexural test. Both male and female die are coated with wax polish to insure that the part will not adhere to the mould. Epoxy resin and hardener (10:1) were mixed in a bowl to prepare the matrix material. Sisal and hemp fibers were mixed and added in to matrix. The percentages of fibers used are 10%, 20%, 30%, 40%, and 50% by weight. A well-mixed mixture of matrix and fibers was poured into the female die cavity. The male die was placed on the female die and pressurized to 410.4 kg/cm$^2$ from hydraulic pressing machine for 3 hours. Test specimens of required size are cut out of the composite manufactured after curing.

![Fabricated Sisal/Hemp fiber reinforced hybrid composite](image)

**Fig.1 Fabricated Sisal/Hemp fiber reinforced hybrid composite**

### 3. Result and Discussion

#### 3.1 Mechanical Properties

Tensile, flexural test specimens were prepared according to ASTM D-3039 and ASTM790-03 standard. Test was carried out in computerized Universal Testing Machine. Four specimens were tested for each test and average value was considered for the analysis. Hardness test of polymers is most commonly measured by the shore-D (Durometer) test. Shore-D hardness test measures the resistance of plastics towards the indentation and provide empirical values. The tensile, flexural, and Hardness strength of sisal/hemp fiber reinforced epoxy resin hybrid composite at different percentage of fiber loading is shown in fig2, fig3, and fig4 respectively.

The tensile and flexural strength of hybrid composite increases with increasing fiber content up to 40 wt% probably due to the chemical bonding at the interface between fiber and matrix may be too strong to transfer strength. Sisal and hemp fiber are of higher modulus. Higher fiber concentration demands higher stress for the same deformation. Therefore, incorporation of sisal and hemp fibers into soft epoxy resin matrix resulted in increases of the strength. Further addition of fibers i.e (50 wt %) leads to decreases the strength. When the amount of fibers is not enough to restrain the matrix, large stresses will be developed at low strains and the distribution of these stresses will not be uniform. But after 40% fiber loading the fibers is sufficient to restrain the matrix, the stress distribution will be uniform and therefore the fibers start reinforcing the matrix.
The hardness value increases as increasing the fiber content, this is due to the fact that sisal and hemp fiber has higher density, good bonding nature and consistency of the matrix as well as better wettability between the fibers and the epoxy.

3.2 Scanning electron microscope analysis

To obtain the SEM images prepared specimens were cutted and subjected to sputter coating in order to obtain the conductive surface and also to avoid the splattering of electron beams while capturing the surface details. The SEM micrograph of the hybrid composite (sisal/hemp) samples subjected to tensile loading are presented in fig.5 from the images it can be seen that fracture of the fiber and matrix due to the applied tensile load are clearly observed and samples subjected to flexural loading are presented in fig.6 indicated that the fiber pull out and voids on the resin in the specimen.
4. Conclusion
The mechanical properties of fabricated sisal/hemp fiber reinforced hybrid composites are evaluated. The following conclusions have been derived from the experimental investigations.

1. The successful fabrication of Sisal/Hemp Fiber Reinforced Hybrid Composites with different percentage of fiber loading can be achieved by compression molding method.

2. 40 wt% of sisal/hemp fibers reinforced hybrid composite exhibits more tensile and flexural strength (tensile strength = 53.13Mpa; flexural strength = 82.07Mpa.) than other hybrid composites.

3. The hardness strength of sisal/hemp fiber reinforced epoxy resin hybrid composites are increases with the increasing the wt% of fiber content

4. From the morphological observations the interfacial characteristics, internal structures of the fractured surfaces, fiber failure mode, fiber pull out are clearly observed.
5. References

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