Synthesis and Characterization of Sisal & Hemp Fiber Reinforced Hybrid Composites

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Abstract— Now-a-days natural fibers such as sisal, flax, hemp, jute, bamboo, banana, coir etc. are widely used for environmental concern. In this work, a new material was developed which possess high strength to weight ratio. Two natural fibers such as sisal and hemp reinforced with epoxy matrix. These fibers were treated with NAOH (alkali treatment) for better fiber matrix adhesion, the hybrid composites were prepared by compression molding technique at room temperature with applied pressure 410.4 kg/cm2 for 3 hours pressurization time. The mechanical properties were characterized according to standards. The amount of reinforcement varied was 10%, 20%, 30% and 40%. Prepared specimens were examined for mechanical properties such as tensile strength and flexural strength. Hybrid composite with 30% wt of sisal & hemp fiber were found to posses higher strength (tensile strength = 25.11Mpa; and flexural strength = 96.14Mpa) among the fabricated hybrid composite specimens.

Key words: Natural fibers (sisal & hemp), Room temperature, Sodium hydroxide, Mechanical properties

I. INTRODUCTION

In recent years polymer based composites have been exploited for their beneficial properties and a wide variety of applications. Polymer composites are usually fabricated by synthetic fibers or natural fibers or hybridization of synthetic and natural fibers. Synthetic fibers (glass, carbon, aramid, Kevlar, etc.) are fabricated from petroleum based chemicals or petrochemicals. The natural fibers (coir, sisal, flax, hemp, bamboo, etc.) contain cellulose, hemicelluloses, lignin, pectin, moisture etc. The recent focus is on natural fiber reinforced polymer composites because of their advantageous properties like ease of decomposition in soil, less energy requirement to withdraw the fibers, low cost, low weight, non-toxic, renewability, low density, high specific strength, non-health hazardous, good insulation, and lower energy requirement to processing [1]. When compared to synthetic based polymer composites, a natural polymer based composites discloses few disadvantages like higher moisture absorption, poor wettability, lower strength, and stiff and typically less brittle [2]. Moisture absorption effects the dimensional changes which lead to micro-cracking. Natural fiber based polymer composites exhibit lower mechanical properties when compared to synthetic based polymer composites.

The natural fiber reinforced polymer composites have gained application in number of areas such as structural (door, table, walls etc), automobiles (outer casing of car body), electronic devices (outer casting of mobile phones), toys and railway coaches interior parts (bumpers and inner fenders). [3] glass reinforced polymer composites in automobile applications will extend the weight of components and also has negative environmental impact in terms of energy consumption. Since 1990 researchers are advising to automotive companies to avoid the synthetic fibers and use natural fibers since they are environmental friendly [4]. The natural fiber reinforced sections reduce 10 % of weight and 5 % of cost compared to synthetic based sections [5]. Chemically treated natural fiber reinforced composites possess slightly higher flexural and tensile properties than un-treated fibers [6]. Increasing the percentage weight of fiber in component gradually increases the strength and hardness of components. [7] It has been found that increase in the percentage weight of fiber, gradually increases the tensile and flexural strength of component at dry conditions. In this study experiments were conducted to study the mechanical properties and of the sisal and hemp fiber epoxy resin, composite specimens. Further, a comparative study of the various properties of the prepared composites is presented.

II. EXPERIMENTAL DETAILS

A. Materials Used

The sisal fibers were collected from local resource and hemp fibers were procured from Sreelaxmi groups, Vijayawada, Andhra Pradesh, India. The epoxy resin with brand name AW 106 and hardener with brand name HV 953 were used for the experimentation. Chemical composition and properties of sisal and hemp fibers are listed in below Table.

PROPERTIES	SISAL	HEMP
Density [g/cm3]	1.50	1.48
Tensile strength [N/mm2]	600-700	550-900
Stiffness [kN/mm2]	38	70
Elongation at break [%]	2-3	1.6
Moist absorption [%]	11	8
Price of raw fiber [$/kg]	0.6-0.7	0.6-1.8

Table 1:

B. Sisal Fiber

Fig. 1: Sisal fibers

Sisal is a natural fiber (Scientific name is Agave sisalana) of Agavaceae (Agave) family yields a stiff fiber traditionally used in making twine and rope. Sisal is fully biodegradable and highly renewable resource of energy. Sisal fiber is extracted by a process known as decortication, where leaves are crushed and beaten by a rotating wheel set with blunt knives, so that only fibers will remain.

C. Hemp Fiber

Hemp fiber is a natural fiber typically found in the northern hemisphere, is a variety of the "Cannabis Sativa" plant species that is grown specifically for the industrial uses of its derived products. It is one of the fastest growing plants and was one of the first plants to be spun into usable fiber; it can be refined into a variety of commercial items including papers, textiles, clothing, biodegradable plastics, paints, insulation, bio-fuel and animal feed.

Fig. 2: Hemp fibers

D. Fiber Surface Treatment

Both sisal and hemp fibers were chopped in to small size of about 10-15mm. The chopped fibers were initially washed in tap water and then soaked in 10 % NaOH solution for 10 hours. The NaOH treated fibers were again washed in distilled water three times to remove the sticking NaOH on fiber surface and then dried for 3 days in sunlight to completely remove moisture.

E. Preparation of Hybrid Composite

The traditional compression molding method was used to prepare the composite specimens. A mould with the dimension of 250 mm ×250mm × 6mm was used to prepare the composite specimen. A layer of Wax polish was applied to the male die and female die to obtain good surface finishing of the specimens. After 10 minutes a thin layer of poly vinyl alcohol (PVA) was coated to the both molds to facilitate easy ejection of the specimens from mold after drying. Epoxy resin and hardener were mixed in the ratio of 10:1 to prepare the matrix and 10wt % of fibers are added to matrix and mixed well in a boul. A well-mixed matrix and fibers mixture 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. The required specimens were extracted from the prepared composite for evaluation of mechanical properties.

Fig. 3: Male & Female Die

Fig. 4: Fibers Poured in Female Die

Fig. 5: Hydraulic Pressing Machine

III. Results and Discussion

A. Mechanical Properties

Tensile and flexural test specimens were prepared according to ASTM D-3039 and ASTM 790-03 standard respectively. The tests were carried out on computerized universal testing machine (UTM). The average value of the four test results was recorded. Hardness test of polymers is most commonly measured by the shore-D (Durometer). Shore-D hardness test measures the resistance of the specimen for the indentation and provide empirical values. The shore-D hardness test was carried out according to ASTM-D2240 standard.

Fig. 6: Universal Testing Machine (UTM)

Fig. 7: Test Specimens

	Tensile strength (MPa)	Bending strength (MPa)	Shore – D hardness
(sisal+hemp) (10%)	15.48 MPa	45.36 MPa	64
(sisal+hemp) (20%)	20.39 MPa	66.97 MPa	71
(sisal+hemp) (30%)	25.11 MPa	96.14 MPa	74
(sisal+hemp) (40%)	21.90 MPa	85.33 MPa	77

Table 2: Evaluation of properties

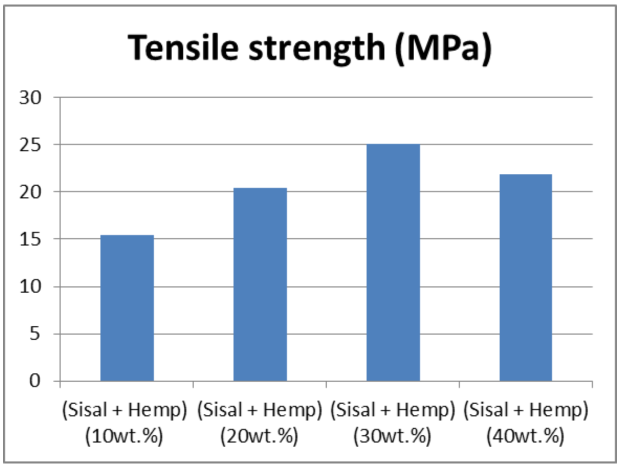

Fig. 8: Tensile strength of hybrid composites

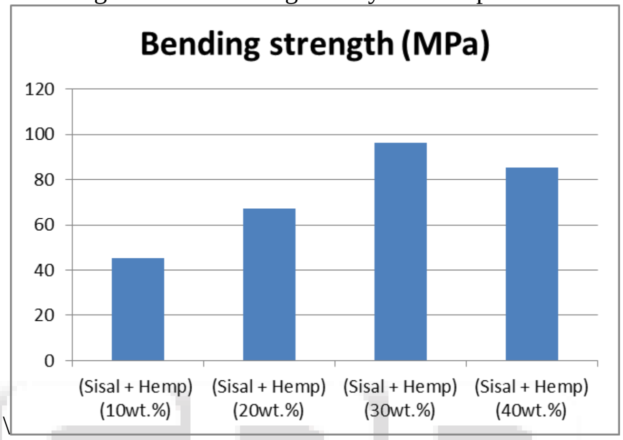

Fig. 9: Flexural strength of hybrid composites

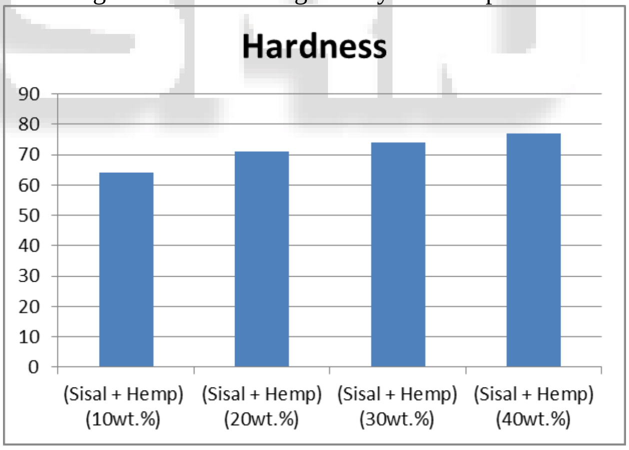

Fig. 10: Hardness number of hybrid composites

The 30%wt. sisal & hemp fiber reinforced hybrid composites shows more tensile and flexural strength than other hybrid composites as shown in fig.4 and fig.5 respectively. Shore-D hardness number increases with increasing the fiber percentage in composite as shown in fig.5.

B. Scanning Electron Microstructures

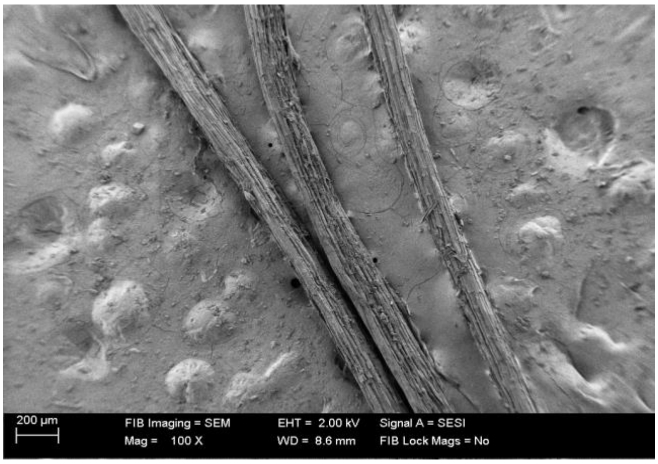

Fig. 11: Sisal fiber Untreated

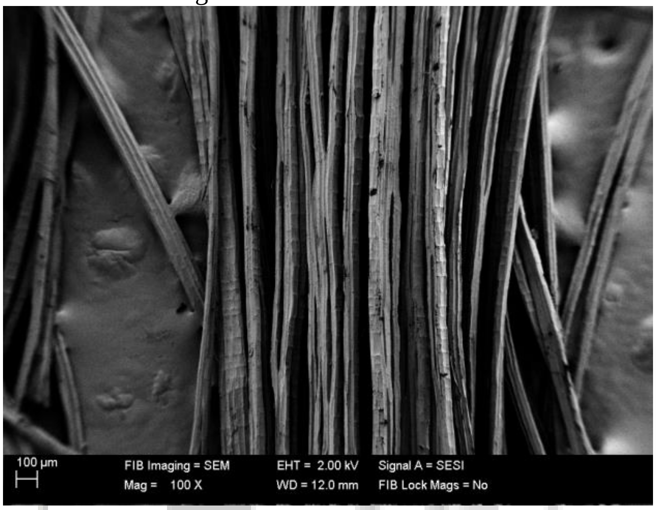

Fig. 12: Hemp fiber Untreated

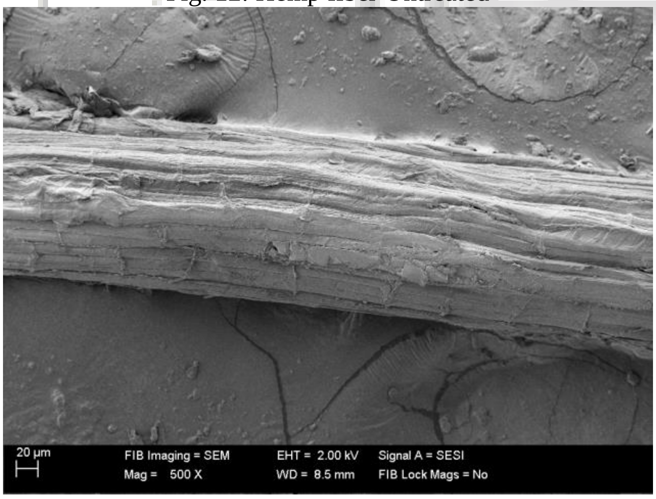

Fig. 13: Sisal fiber NAOH treated

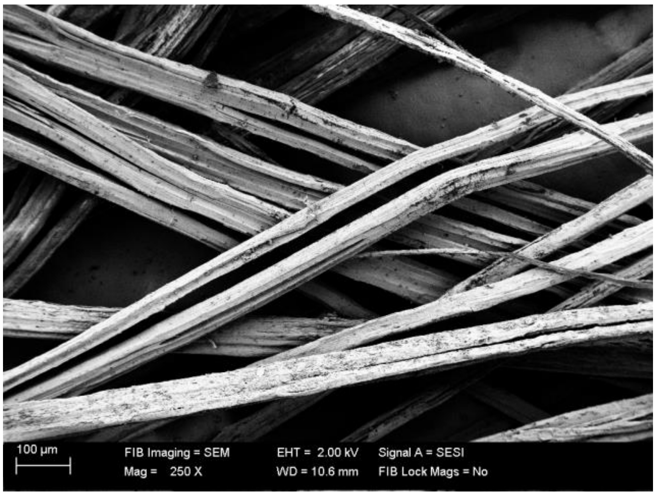

Fig. 14: Hemp fiber NAOH treated

IV. CONCLUSION

Experimental investigation of tensile strength, flexural strength and shore-D hardness number properties of different wt % of sisal & hemp fibers reinforced epoxy resin hybrid composites lead to the following conclusions.

1) The natural fiber reinforced epoxy hybrid composites are successfully fabricated using Compression molding technique.
2) 30%wt. sisal & hemp fiber reinforced hybrid composites discloses more tensile strength (25.11 MPa) than other hybrid composites.
3) 30%wt. sisal & hemp fiber reinforced hybrid composites discloses more flexural strength (96.14 MPa) than other hybrid composites.
4) Shore-D hardness number increases with increasing the fiber percentage.
5) It can be concluded that alkali (NAOH) treatment of the natural fibers is necessary to get composites with moderate mechanical properties as well as better adhesion between fibers and matrix.

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