Mechanical Characterization of Kenaf-Hair Reinforced Hybrid Composite

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ABSTRACT

Human hair & kenaf have solid malleable property; thus it could be utilized as a fiber reinforcement material. It gives great property at easier expense of generation. It additionally makes ecological issue for its deteriorations because of its non-degradable properties. To this end, an attempt has been made to study the potential utilization of human hair & kenaf which is economically and effortlessly found in India for making value added products. The objective of present work is to evaluate the mechanical properties of human hair & reinforced epoxy composites. The impact of fiber loading on mechanical properties like tensile strength, flexural strength, impact strength and hardness of composites is examined. Trials were directed on polymer composites with different contents of Kenaf & human hair fiber with constant fiber length of 10 mm. By testing of composites it has been observed that there is significant influence of Kenaf-human hair hybrid reinforcement on mechanical behavior of composites.

Keywords: kenaf, epoxy, flexural impact strength, hardness, malleable, reinforcement, tensile strength

1.INTRODUCTION

Kenaf, Hibiscus cannabinus L, belong to the family of hibiscus, a biodegradable and environmental friendly crop. Kenaf is mostly suitable for cultivation in tropical and subtropical regions. Jeyanthi found twisted kenaf-glass fibre reinforced polypropylene composites made by hot impregnation method possess better mechanical properties and can be used as passenger car bumper beam. Jain identified the improvement of mechanical properties in cement concrete while adding human hair in it. The hair fibre which is made of mainly keratin protein with primarily alpha-helix structure approximately 91%of the hair is protein made up of long chain of amino acid the long chain linked by peptide bond .The average composition of normal hair is composed of 45.68% carbon,27.9% oxygen, 6.6% hydrogen ,15.72% nitrogen and 5.03% sulphur .Amino acid present in hair contain cytosine, serine, glutamine,threonine ,glycine ,leucine, valine, arginine.Natural fibres, as actual and potential reinforcement composites, offer many advantages: good strength properties, low cost, high toughness, biodegradability, however, in the case of cellulose fiber some disadvantages due to their intrinsic characteristic, incompatibility with hydrophobic polymer matrix, tendency to form aggregates during processing and poor resistance to moisture, finite length and large diameter, pose an important challenge of their use in advanced composite.

2.LITERATURE SURVEY

In this paper, human hair fibre is incorporated in to epoxy at a 5, 10, 15, 20wt%. The composite are mixed in a two roll mill. Following mixing tensile bars are prepared by compression moulding at temperature 180C-190C over time period 0-10 min in each case with epoxy resin prepared in the same manner. For this research, kenaf fiber is used instead of other natural fiber. This is because kenaf requires less than 6months for attaining a size suitable for practical application been increasing interest in kenaf, primarily for its potential use as a commercial fiber crop for the manufacture of newsprint and other pulp and paper products, leading to collaborations between R&D, economist, and market research (H.P.S. Abdul Khalil 2010)[12]. The first and the most important problem is the fiber-matrix adhesion. The role of the matrix in a fiber reinforced composite is to transfer the load to the stiff fibers through shear stresses at the interface.

This process requires a good bond between the polymeric matrix and the fibers. Poor adhesion at the interface means that the full capabilities of the composite cannot be exploited and leaves it vulnerable to environmental attacks that may weaken it, thus reducing its life span. Insufficient adhesion between hydrophobic polymers and hydrophilic fibers result in poor mechanical properties of the natural fiber reinforced polymer composites (P. Wambua 2003) [11]. Alkaline treatment was applied in order to solve the problem of fiber–matrix adhesion when manufacturing biocomposites. Natural fibers are mainly composed of cellulose, whose elementary unit, an hydro d-glucose, contains three hydroxyl (–OH) groups. These hydroxyl groups form intermolecular and intermolecular bonds, causing all vegetable fibers to be hydrophilic. The alkaline solution regenerated the lost cellulose and dissolved unwanted microscopic pits or cracks on the fibers resulting in better fiber matrix adhesion (Feng D , 2001; Mutje P , 2006; Keener TJ 2004)[13]. The inherently polar and hydrophilic nature of lignocellulosic fibers and the nonpolar characteristics of most thermoplastics result in compounding difficulties leading to nonuniform dispersion of fibers within the matrix, which impairs the properties of the resultant composite. This is a major disadvantage of natural fiber reinforced composites (MayaJacobJohn*etal*.,2007[10]). Kenaf long fibre plastic composite could be used for a wide variety of applications if the properties were found to be comparable to existing synthesis composites. Since kenaf is always available in long fibre form, the mechanical properties found could be of use in many industrial applications such as insulators seals. In addition, kenaf fibre offers the advantages of being biodegradable, of low density, on-abrasive during processing and environmentally safe (Nishino T., 2003) [9].

3.OBJECTIVES OF THE WORK

Evaluation of mechanical properties (tensile strength, flexural, hardness, impact strength etc.).Besides the above all the objective is to develop new class of composites by incorporating Kenaf –Hair fiber reinforcing phases into a polymeric resin. Also this work is expected to introduce a new class of polymer composite that might find many engineering applications.

4.MATERIAL COLLECTION

4.1 Kenaf fiber

Kenaf fiber is a natural fiber extracted from Hibiscus cannabinus plant closelyrelated to cotton and jute. Its widely used in the form of ropes, sack cloth, handbags. Mostly kenaf is abundantly available in Asia. Our kenaf material is collected from Thottapadi village, Kallakurichi taluk, Villupuram district,Tamilnadu. Epoxy **LY556** (araldite) resin is used and hardener **HY951** is added as 10:1 ratio.

4.2 Human hair

Human hair is natural fiber formed by Keratin. The physical properties of human hair are elasticity, smoothness and softness. Cortex keratin is responsible for this property and which is besides being strong, is flexible. The thickness of hair vary from 9-14 microns. Human hair fiber is gathered from nearby saloon and then its treated with NaOH solution.

5. MATERIAL TREATMENT

5.1 Kenaf

It's chemically treated in 2% NaOH at room temperature [2]. Retting is a process by which bundles of cells in the outer layers of stalk are separated from non-fibrous matter by removal of pectins and other gummy substances. The period of retting varies from 6 to 10 days depending upon the maturity of the crop at the time of harvesting, the temperature of water and the types of microorganisms present [2]. Retted bundles are removed and the bark is peeled off from the root upwards. The strips are gently beaten with a mallet or stick and rinsed in water to separate the fiber from adhering tissue. The clean fiber is washed and dried in the sun and made into bundles.

Fig. 1 Kenaf fiber is treated with NaoH solution for 24hrs to remove impurities and increase the strength of the fiber

Retted bundles are removed and the bark is peeled off from the root upwards. The strips are gently beaten with a mallet or stick and rinsed in water to separate the fiber from adhering tissue. The clean fiber is washed and dried in the sun and made into bundles.

Fig.2 Treated fibre is dried in sunlight for 48 hrs

5.2 Human hair

Hair is collected, rinsed in hot water and dried at room temperature. At first, fibres were cut into lengths between 8-10mm prior to soaking in Sodium Hydroxide (NaOH) solution for 1 hour and later rinse with pure water and dried under the sun for 24 hours. [3] Sodium Hydroxide was used to improve fibre surface adhesive characteristics by removing artificial impurities.

Fig 3 Human hair is treated with NaoH solution of 24hrs to remove the impurities

6. MATERIAL PREPARATION

Material preparation is done by any one of this two methods viz, Hand layup method and Spray layup method

The specimen is prepared by hand-lay method which is very easy for small quantity production. It is a production method suitable for model making such as prototype and low volume production of fiber composite material parts. The hand lay-up process may be divided into four basic steps such as Mould preparation, Gel coating, Lay-up and Finishing.

Mould preparation is one of the critical and the most important steps in the lay-up process. Moulds can be made of wood, plastics, composites or metal depending on the number of parts, cure temperature, pressure, etc. Gel coating is a process of applying a coating on the surface of the mould so that the mould can be separated easily after curing. Lay-up is the method in which the chopped strand mat, fabric in the form of reinforcement is brushed or applied to the gel coat surface. Five different samples are prepared with different combinations of kenaf and human hair. The composite is completely cured under the ambient conditions and with the aid of external load for minimum of 24 hours duration. Finishing is the desired machining work to be carried out to make the specimen ready for the test.The composite is completely cured under the ambient conditions and with the aid of external load for minimum of 24 hours duration. Finishing is the desired machining work to be carried out to make the specimen ready for the test. The test samples were cutted into the required sizes prescribed in the ASTM standards.

Table 1- Composition of different samples

Composite	Composition
Sample A	Epoxy (60wt %) +Kenaf Fiber (fiber length 10mm) (40wt %)
Sample B	Epoxy (60wt %) +Kenaf Fiber (fiber length 10mm) (35wt %) +Hair (fiber length 10mm) (5wt %)
Sample C	Epoxy (60wt %) +Kenaf Fiber (fiber length 10mm) (30wt %) +Hair (fiber length 10mm) (10wt %)
Sample D	Epoxy (60wt %) +Kenaf Fiber (fiber length 10mm) (25wt %) +Hair (fiber length 10mm) (15wt %)
Sample E	Epoxy (60wt %) +Kenaf Fiber (fiber length 10mm) (20wt %) +Hair (fiber length 10mm) (20wt %)

7.MECHANICAL TESTING

7.1 TENSILE TESTING

The tensile test is generally performed on flat specimens. The commonly used specimens for tensile test are the dog-bone type and the straight side type with end tabs. During the test a uni-axial load is applied through both the ends of the specimen. The ASTM standard test method for tensile properties of fiber resin composites has the designation D 3039-76. The length of the test section should be 200 mm. The tensile test is performed in the universal testing machine (UTM) Instron 1195 and results are analyzed to calculate the tensile strength of composite samples.

Fig 4 Test specimens of tensile testing (230 X30 X 3) mm.

7.2 FLEXURAL TESTING

The short beam shear (SBS) tests are performed on the composite samples at room temperature to evaluate the value of flexural strength (FS). It is a 3-point bend test, which generally promotes failure by inter-laminar shear. The SBS test is conducted as per ASTM standard (D2344-84) using the same UTM. Span length of 40 mm and the cross head speed of 1 mm/min are maintained. The flexural strength (F.S.) of any composite specimen is determined using the following equation.

Flexural strength $=\frac{3FL}{2bt2^2}$ Where

F =load

L = length of support span

t = thickness

b = width

Fig 5 Flexural test specimens after testing (230 X 30 X 3) mm

7.3 HARDNESS TESTING

We study Brinell hardness number (BHN) of our material, using Brinell hardness test. Specimen is prepared as per ASTM STD E10.

$$BHN = \frac{2p}{\pi D\left(D-\sqrt{D^2-d^2}\right)}$$

Where P = load

D = diameter of indenter

d = diameter of indentation.

7.4 IMPACT TESTING

We study izod impact testing using izod impact setup in our laboratory. Specimen material prepared as per ASTM STD D256 (75X10X3) mm.

$$I = \frac{k}{A}$$

Where K= energy absorbed by the material during fracture.

A=cross sectional area.

8. RESULTS AND DISCUSSIONS

8.1 The influence of fibre parameters on tensile strength of composites

The influence of fiber parameters on tensile strength of composites is shown in GRAPH 4.1. It is found that for composites with 10 + 30% fibre loading (sample C), the tensile strength initially increases. And for 15 + 25% fibre loading (sample D), the tensile strength increases when compared to previous samples. And for 20 + 20% fibre loading (sample E), the tensile strength increases and attains the maximum value.

Table 2 The influence of fibre parameters on tensile strength of composites

Samples	Tensile strength (mpa)	Force applied(10^3)N
Sample A	10.32	71.208
Sample B	11.92	82.248
Sample C	13.70	94.530
Sample D	16.44	113.436
Sample E	18.92	130.548

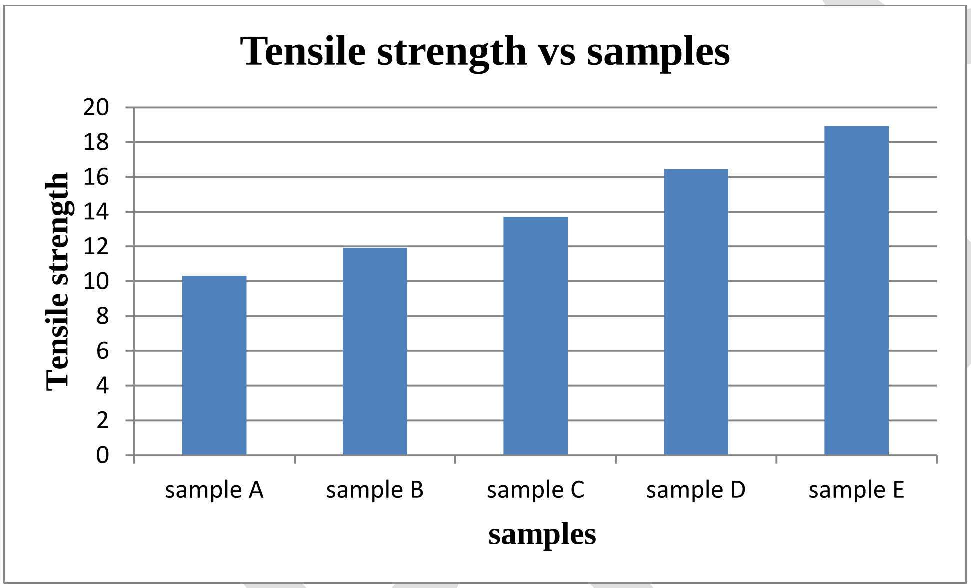

Fig 6 Tensile strength vs samples

8.2 The influence of fibre parameters on flexural strength of composites

The influence of fibre parameters on flexural strength of composites is shown in GRAPH 4.2. It is found that for composites with 10 + 30% fibre loading (sample C), the flexural strength increases comparatively higher than sample D. And for 15 + 25% fibre loading (sample D), the flexural strength increased slightly. And for 20 + 20% fibre loading (sample E), the flexural strength of the same gets maximum value compared to previous samples.

Table 3 The influence of fibre parameters on flexural strength of composites.

Samples	Flexural strength(Mpa)
Sample A	200
Sample B	229
Sample C	247
Sample D	268
Sample E	280

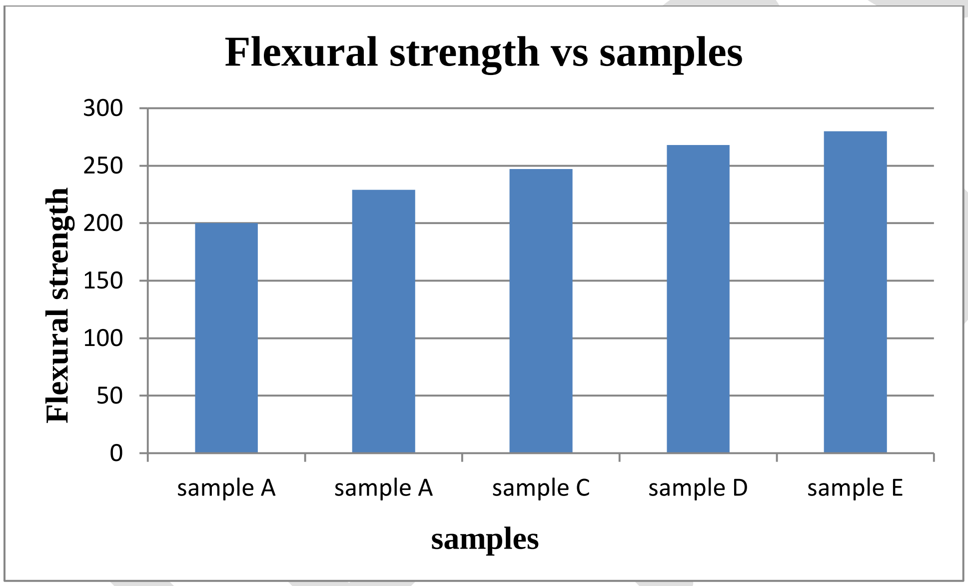

Fig 7 Flexural strength vs samples

8.3 The influence of fibre parameters on impact strength of composites

It is found that for composites with 5 + 35 % fibre loading (sample B), and 10 +30 % fibre loading (sample C), the impact strength value is same. And for 15+ 25 % fibre loading, the impact strength of composites decrease with increase in fibre loading of hair fibre percentage and after that starts gradually decreasing. And for 20 +20 % fibre loading there is irregular values obtained

Table 4 The influence of fibre parameters on impact strength of composites.

Samples	**Impact strength $(10^{-3})J/mm^2$**
Sample A	4
Sample B	4.6
Sample C	4.6
Sample D	4.2
Sample E	4.4

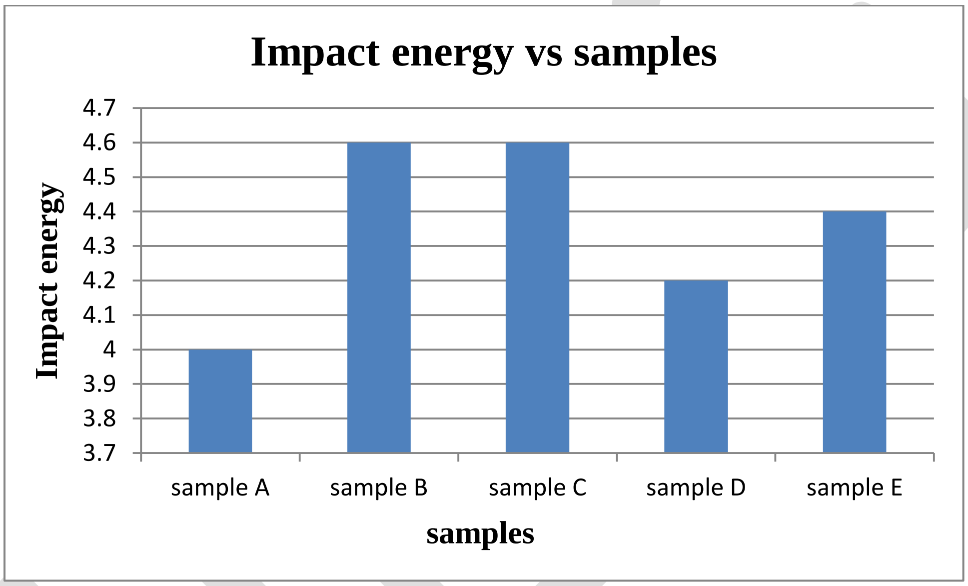

Fig 8 Impact strength vs samples

8.4 The influence of fibre parameters on Hardness of composites

The influence of fibre parameters on hardness of composites is shown in GRAPH 4.5. It is found that for composites with 10 + 30% fibre loading (sample C), the hardness initially increases. And for 15 + 25% fibre loading (sample D) , the hardness increases when compared to previous samples. And for 20 + 20% fibre loading (sample E), the hardness increases and attains the maximum value. From the below graph it show that increase in loading of hair fibre cause increase in hardness of the composites.

Table 5 The influence of fibre parameters on hardness of composites.

Samples	Hardness(BHN)
Sample A	23.75
Sample B	38.13
Sample C	45.74
Sample D	69.10
Sample E	82.91

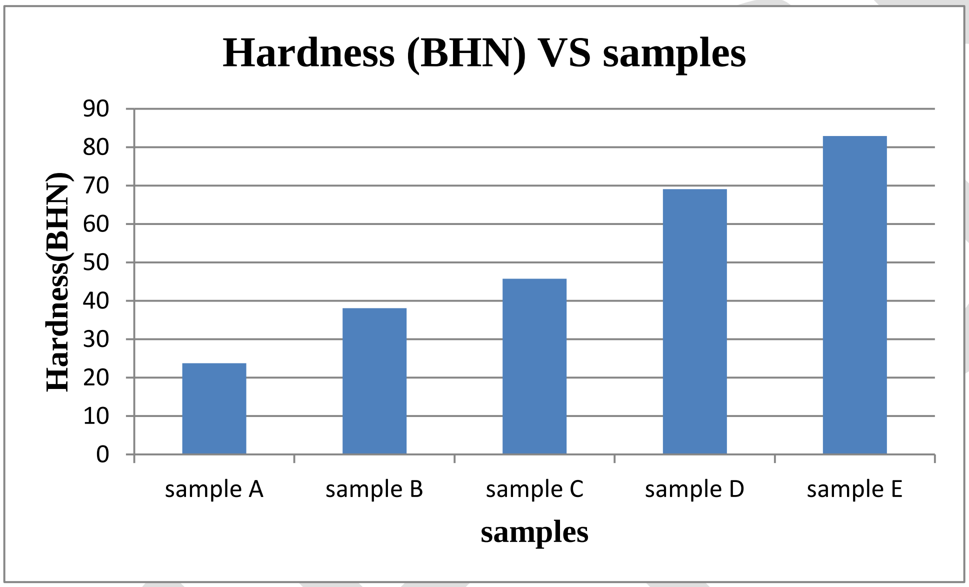

Fig. 9 Hardness (BHN) of samples

9.CONCLUSION & FUTURE ENHANCEMENT

The Mechanical analysis of Kenaf- human hair fibre based epoxy based composites shows the following conclusions:

- In this work the production Kenaf- hair fibre based epoxy composites with 10mm fibre lengths and diverse fibre loading.
- It should be recognized that the fibre parameters such as fibre loading and length has critical impact on the mechanical properties of the composites.
- The mechanical property like flexural strength, tensile strength and impact strength results are found best for composites reinforced with 20 + 20wt% fibre loading(sample E) with 1cm fibre length.

The utilization of waste such as human hair and agricultural waste Kenaf as a fibre reinforcement in composites enlarges the entryway for further research in the given field. The research can be further extended to study the influence of Kenaf-hair fibre on other properties of composites such physical, thermal and triblogical properties.

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