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CHARACTERIZATION OF HYBRID MATRIX NATURAL FIBRE COMPOSITE

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ABSTRACT

The developments in the field of composite materials are growing tremendously day by day. One such development is the use of natural fibres as reinforcement in the composite material. This is attributed to the fact that natural fibres are environmental friendly, economical, easily available and non-abrasive. The main objective of this experimental study is to fabricate the flax-kenaf fibres reinforced hybrid composites and to evaluate the mechanical properties such as tensile strength, flexural strength and impact strength. The Composites are fabricated by hand lay-up method by using flax and kenaf fibres as reinforcing material with Cashew Nut shell liquid and Polyester resin. The specimen is prepared according to ASTM standards and the experiment has been carried out by using universal testing machine (UTM). From the experimental results, it has been observed that the flax and kenaf fibres reinforced hybrid Polyester composites exhibited superior properties, when compared to the CNSL composites.

Keywords: hybrid composites, polyester resin, cnsl resin, flax-kenaf fibre composite, mechanical properties.

INTRODUCTION

In the present unsustainable environmental condition natural fibres are serving as better material in terms of biodegradability, low cost, high strength to weight ratio and corrosion resistance when compared to conventional materials. The benefits of components and products designed and produced in hybrid composite materials instead of metals recognized by many industries.

Michael Ikpi Ofem *et al*. [1] described the mechanical properties of a hybrid bio composite made of periwinkle shell, rice husk and cashew nut shell liquid. The results obtained show that for a 10 to 20% increase in filler content, the tensile strength increased by an average of 32%. It was concluded that the optimum properties can be achieved at 30% filler content. Meona *et al*. [2] studied the effect of alkali treatment of natural fibre. The fibre is soaked with 3%, 6% and 9% of sodium hydroxide (NaOH) for a day and then dried at atmospheric temperature for 24 hours. It was reported that the tensile properties of the treated kenaf fibres have improved significantly as compared to untreated kenaf fibres especially at the optimum level of 6% NaOH.

Njokua *et al*. [3], carried out a review on the effect of alkali treatment and fibre content variation on the tensile properties of coir fibre reinforced cashew nut shell liquid composite. Bio composite consisting of coir fibres and cashew nut shell liquid resin was produced using the hand lay-up technique. The fibres were treated with 5% NaOH and varied between 0% to 40% weight fractions. of 30% and improvement of interfacial fibre-matrix adhesion in the composites. It is observed that the tensile strength and modulus of the CNSL/COIR composite increased as the weight fraction of coir fibres was increased up to fibre content. L.Y. Mwaikamboa *et al*. [4] investigated the behaviour of untreated and treated hemp fibre in the concentration range of 0.8 to 8% NaOH and the change in surface morphology was elucidated using scanning electron microscopy. They have observed that the fibres with 4 and 6% NaOH treatment resulted in the highest Young’s modulus and tensile strength of 65GPa and 1064MPa respectively. C. W. Nguong *et al*. [5] used chemically treated and untreated natural fibres as reinforcement for the preparation of composites and were micromechanically characterized using pull out and single fibre fragmentation test.

Huda *et al.* [6], in their investigation, pointed out that surface treated fibre reinforced composites shown superior mechanical properties as compared to the untreated fibre-reinforced composites. A recent study of the fibre content on mechanical properties of kenaf fibre reinforced composite was carried out by Nishino *et al*. It was found that both Young’s modulus and tensile strength increased with the increase of fibre content and showed the maximum values (Young’s modulus; 6.4GPa, and the tensile strength; 60MPa) around a fibre content of 70 vol.%[7].

A lot of works on plant fibre reinforced composites were carried out using a Polyester resin matrix. Sanadi *et al*. [8-9] fabricated unidirectional hemp fibre reinforced Polyester composites. In all these studies it was shown that the mechanical properties of the composites were directly proportional to fibre content according to the rule of mixtures up to a limit where fibres are insufficiently wetted out.

According to Single-ton *et al* [10], although glass fibre-reinforced composites have been widely used for many years due to its advantages of low cost and moderate strength, to provide solutions to many structural problems, the use of these materials, induces a serious environmental issues that most western countries are concerned about. Recently, due to a strong emphasis on environmental awareness worldwide and the pressure on manufacturers of materials to consider the environmental impact of their products at all stages of their life cycle, including recycling and ultimate disposal, attention of researchers is shifting to the development of recyclable and environmentally sustainable composite materials. Thus biodegradable composites based on natural fibers and biodegradable polymeric matrices made from cellulose, starch, and other natural resources (green composites) have been developed because of their environmentally beneficial properties [11-13]. In general, the research and development of natural fibre biodegradable composites from renewable resources for a wide range of applications is increasing due to their advantages, such as eco-friendliness, lightweight, carbon dioxide reduction and biodegradable characteristics [14]. The other economic route is to use alternative cheap polymeric materials without compromising the properties of the composites. To achieve these objectives a search for easily renewable and cheap resin is becoming a matter of necessity. Plant-based chemical compounds exist which, are suitable for the manufacture of composite matrices. The most extensively studied of these natural substances is cashew nut shell liquid (CNSL).The extraction of phenol-based cashew nut shell liquid (CNSL) from the fruit of the cashew tree as a feedstock for thermosetting resins has environmental advantages. CNSL is used to produce resins and is isolated from cashew nut shells as a by-product of the cashew nut processing industry [15, 16]

Since the blending of Polyester and CNSL resin composites is not used so far, the present experimental work deals with the fabrication, testing of flax and kenaf fibre reinforced hybrid composites for its tensile strength. The flax-kenaf fibre reinforced composite composed of blending cashew nut shell liquid (CNSL) and Polyester resin as matrix materials are fabricated by hand lay-up process. The properties such as tensile, flexural and impact strengths have been studied and presented in detail. The sample materials are prepared by varying the resin content from (0, 20, 40, 60, 80 and 100) % wt. in alkali treated conditions.

EXPERIMENTAL DETAILS

Materials

In this experimental investigation the hybrid composites were prepared by using flax and kenaf fibre. The kenaf and flax fibres were supplied by Natural fibres Ltd., Chennai, India. The Polyester resin, Methyl Ethyl ketone peroxide (Hardener) and Cobalt ammine Napthanate (accelerator) were purchased from Kaamatchi resins, Puducherry, India. The Cashew nut shell liquid resins had been purchased from Kumarasamy chemicals, Panruti, India. The physical properties of banana and hemp fibres are presented in Table-1.

Treatment with alkaline solution

The flax and kenaf fibres were soaked in a tub containing the (6% wt.) concentration of NaOH aqueous solution for 24hrs.Then the treated fibre was washed with huge quantity of distilled water until all the sodium hydroxide was eliminated. Subsequently, the fibres were dried at ambient conditions till the moisture is removed from the fibre by natural means.

Composite fabrication

The hand lay-up technique was used in the production of composite laminates. The extracted cashew nut shell liquid resin was mixed with Polyester was varied from 0% to 100% and poured into a mould measuring 300 × 300 × 3mm. The care must be taken so that the resin does not cure in the curing pot itself. The inner surfaces of the mould were coated with wax to enhance the removal of the composite after curing. The resin and the hardener were mixed in the proportion of 10:1. 0.4% weight of Methylethyketone (MEKP) peroxide was added to act as accelerator for curing. The fibre weight fraction was 30% in alkali- treated conditions. The laminate was fabricated by using flax and kenaf fibres with CNSL and Polyester resin over the base plate. This laminate consists of four layers. Then the six sets of hybrid laminate had been cured under the loaded condition for 12 hours with the help of the weight press in order to minimize residual stresses. The fabricated samples are shown in Figure-1 (a) and (b). The characterizations of fabricated samples are presented in Table-2.

Table-1. Physical properties of banana and hemp fibres [23].

S #	Properties	Flax fibre	Kenaf fibre
1	Tensile strength (MPa)	500-900	295-1191
2	Young's modulus (GPa)	50-70	22-60
3	Specific modulus (GPa)	34-48	14-39
6	Density (Kg/m^3)	1400-1500	1220-1400
7	Moisture content (eq.) (%)	12	17

Figure-1. (a) Fabricated 100% polyester sample (b) Fabricated 100% CNSL sample.

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Table-2. Characterization of fabricated samples.

Sl. No.	Sample Id	Fiber 30%	Resin 70%	Resin Characterization
1	A	120g	280g	100% Polyester
2	B	120g	280g	80% Polyester+20% CNSL
3	C	120g	280g	60% Polyester+40% CNSL
4	D	120g	280g	40% Polyester+60% CNSL
5	E	120g	280g	20% Polyester+80% CNSL
6	F	120g	280g	100% CNSL

Mechanical testing

Tensile strength, flexural strength and Impact strength were determined in a Universal Testing Machine (UTM), while Universal Pendulum Impact System for Charpy tests. Tensile test specimens were made according to ASTM D638M is shown in Figure-3. The typical load–displacement curves for the 100% Polyester and 100% CNSL resin composites from the pull-out test are shown in Figure-2 (a) and (b). It can be noted that the curves exhibit the non-linear behaviour characteristics of a matrix. It can be seen that the load increases gradually and when it reaches a maximum value, there is a smooth transition and it begins to decrease in a linear fashion until the total embedded length of the fibre is pulled-out. This behaviour agrees well with the behaviour of a poor interphase that results because of the incompatibility between the hydrophilic fibre and the hydrophobic matrix. The flexural strength test samples were made according to ASTM D790M is shown in Figure-4, while the impact strength test specimens were made according to ASTM D256M. Six samples were tested for each composition and average results were used. Tensile strength, Flexural strength and Impact strength values were determined for various samples and are shown in Figure 3-5.

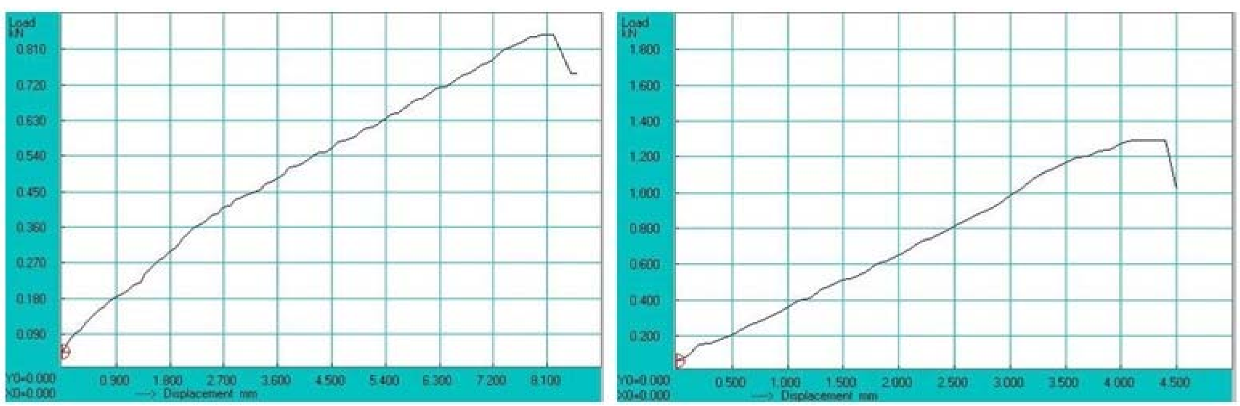


Figure-2. Load vs. displacement curve of (a) 100% Polyester sample (b) 100% CNSL sample.

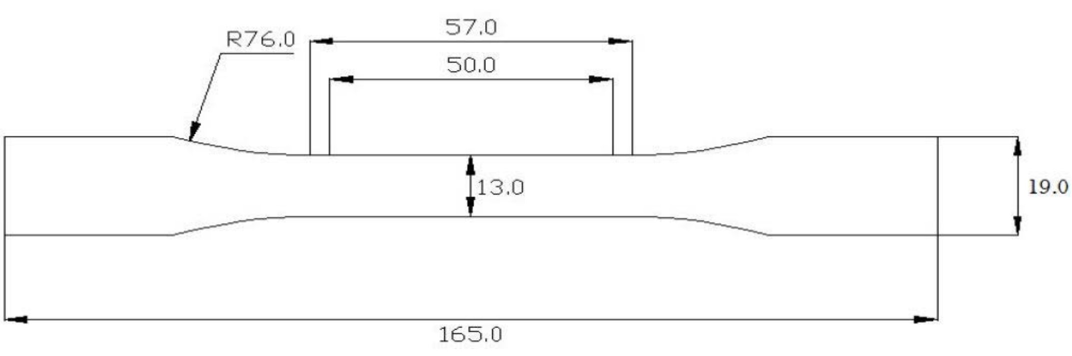
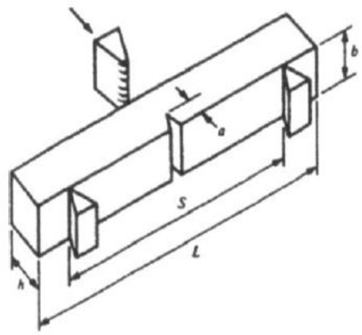


Figure-3. Dimensions of the tensile specimen as per ASTM – D638 standard [20].



Dimension	Description	Size (mm)
a	Notch length	2
b	Thickness	10
h	Height (depth)	7
L	Length	80
S	Span	40

Figure-4. Geometry of impact test and charpy specimen [11].

RESULTS AND DISCUSSION

Tensile strength

Referring to the tensile strength, 100% Polyester composite seems stronger, while 100% CNSL have lower strength. According to the Figure-5, it shows that the strength value of 100% Polyester composite is 17.8MPa, which is 35.4% higher than that of 100% CNSL composite because it can't withstand higher load. The tensile strength of alkali-treated natural fibre reinforced composite is presented in Figure-5 as a function of resin content. As shown in the Figure-5, the tensile strength of the composite material increases as the blending of Polyester adds with CNSL resin.

Flexural test

The flexural test or three point bending test was carried out on UTM for the specimens prepared as per the ASTM D790 standard. From the Figure-6, it is evident that 100% Polyester composites showed the maximum flexural strength of 3MPa over 1.28MPa showed by 100 % CNSL composites. The maximum force resisted by the jute epoxy composite before failure was 185 N and for jute Polyester it was 95 N. The displacements measured were found to be 4.6 and 15.1 mm respectively. The 100% Polyester composites were found to have 57.3 % increases in the flexural strength than the 100 % CNSL composite showed better results than the CNSL composite.

Impact test

The Charpy test specimens were made according to the dimensions of ASTM A370 in which the dimension is 55 x10 x 10 mm. The edges of the specimens are neatly finished and small 'v" notches are also provided by using hack saw blade. During the test the maximum energy that can be stored to break the specimens are noted for the entire specimen for analysis of results. One of the main reasons of concern for composites generally is the low values of impact energy. They show relatively low values of impact energy compared to metals. The ways to increase the impact energy of the composites are being made the major area of research. The impact test was carried out by Charpy test and the results were recorded are shown in Figure-7. The tests showed that the composites made with 100% Polyester resin composites were not very good with the impact stress as it showed very low values form the tests performed. The fibre provides strength for the composite material, as the kenaf and flax fibre percentage in the composite is only 30 percentages. The 100% Polyester composite have a better impact strength than the CNSL based composites.

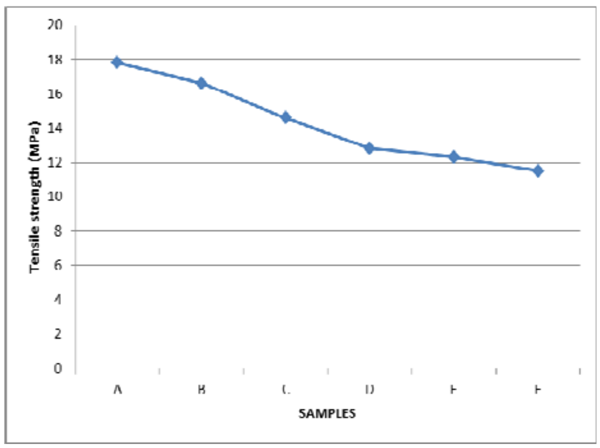


Figure-5. Effect of resin content variation on the tensile strength of hybrid composites.

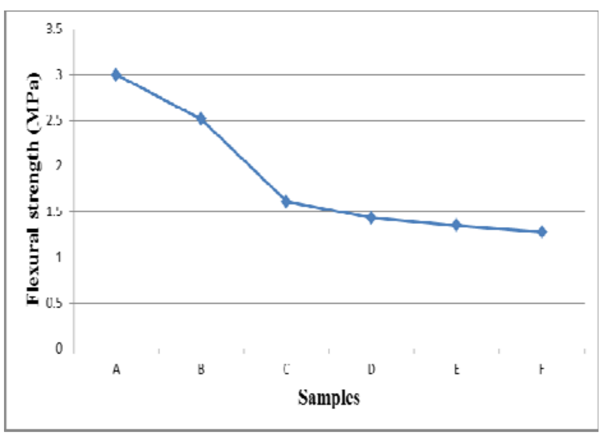


Figure-6. Effect of resin content variation of flexural strength on hybrid composites.

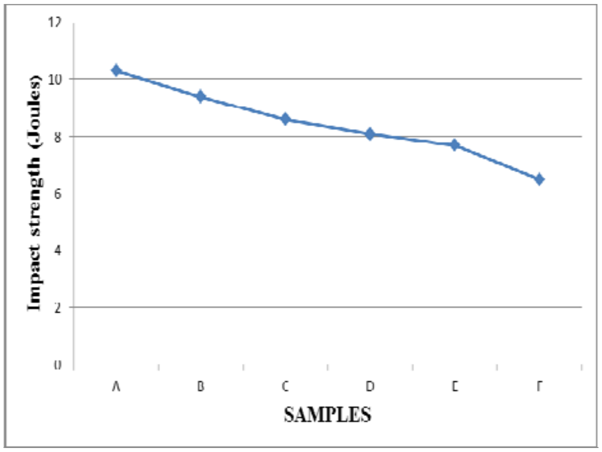


Figure-7. Effect of resin content variation on the impact strength of hybrid composites.

CONCLUSIONS

Hybrid composites with different resin contents have been developed. The effect of alkali treatment on the tensile, flexural and impact properties has been studied. The following conclusions can be drawn from the study:

- Tensile strength of 100% Polyester is 17.8MPa whereas 100% CNSL is 11.5MPa.
- The flexural strength of 100% Polyester is almost more than double the value of 100% CNSL. i.e. 3MPa and 1.28MPa respectively.
- The impact strength of 100% Polyester is 10.3J and the same for 100% CNSL is 6.5J.

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