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CHARACTERIZATION OF NATURAL FIBER REINFORCED POLYMER COMPOSITE

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ABSTRACT
Polymeric materials reinforced with synthetic fibers such as glass, carbon, and aramid provide advantages of high stiffness and strength to weight ratio as compared to conventional construction materials, i.e. Wood, concrete and steel. Despite these advantages, the widespread use of synthetic fiber-reinforced polymer composite has a tendency to decline because of their high-initial costs, their use in non-efficient structural forms and most importantly their adverse environmental impact. This work is concerned with the testing of mechanical properties on natural fiber (coconut and palm fiber) reinforced composite materials. Composites are fabricated by using chemically untreated coconut and palm fiber with epoxy resin and chemically treated coconut and palm fiber with epoxy resin. The fibers are treated with 5% of sodium hydroxide (NaOH) for one hour and the specimens were fabricated by hand lay technique. The fiber content in the composite is kept constant to 30% of weight ratio. The mechanical properties are tested on the specimen and the results are compared.

INTRODUCTION
The use of natural fibers as a replacement for synthetic fibers has received attention. While high performance carbon fibers remain superior to natural fibers in high-end applications, however natural fibers have comparable properties to glass fibers in high volume applications depending on their origin, natural fibers can be grouped into seed, bast, leaf and fruit qualities. Bast and leaf (the hard fibers) qualities are the most commonly used in composite applications.

PROBLEM IDENTIFICATION
The composite materials have a higher strength than many other materials. Normally the good quality fibers having highest cost,Synthetic fibers are non renewable fiber and the availability of the fiber was also difficult .Hence the naturally available Palmyra fiber and coconut fiber was identified. The Palmyra fibers are degradable .The cost of the Palmyra fibers and coconut are too low and having good strength.The mechanical properties of natural fiber reinforced composite material has high tensile, flexure and impact strength. In the investigation foud that a combination of stiffness is increased by a factor of 5.2 and strength of 2.3. In the biomedical and bioengineered field, the use of natural fiber mixed with biodegradable and bio-restorable polymers can produce joints and bone fixtures to alleviate pain for patients.

OBJECTIVES
The objectives of the project are outlined below, Fabrication of coconut/palm fibre reinforced epoxy based composite. Material evaluation of mechanical properties (tensile strength, flexure and impact strength etc).To enhance the adhesive force between the fiber and resin (matrix) of the composite material is to be chemically treated by the alkali treatment, also reinforced mechanical properties are tested. Besides the above all the objectives a new class of composites by incorporating coconut fiber/palm fiber reinforcing phases into a polymeric resin. Comparative study on experimental result with

analysis output parameters using Ansys 14.0 work bench software.Also this work is expected to introduce a new class of polymer composite that might find many engineering applications

METHODOLOGY

Flow chart steps involved in determination of mechanical properties & Erosion test.

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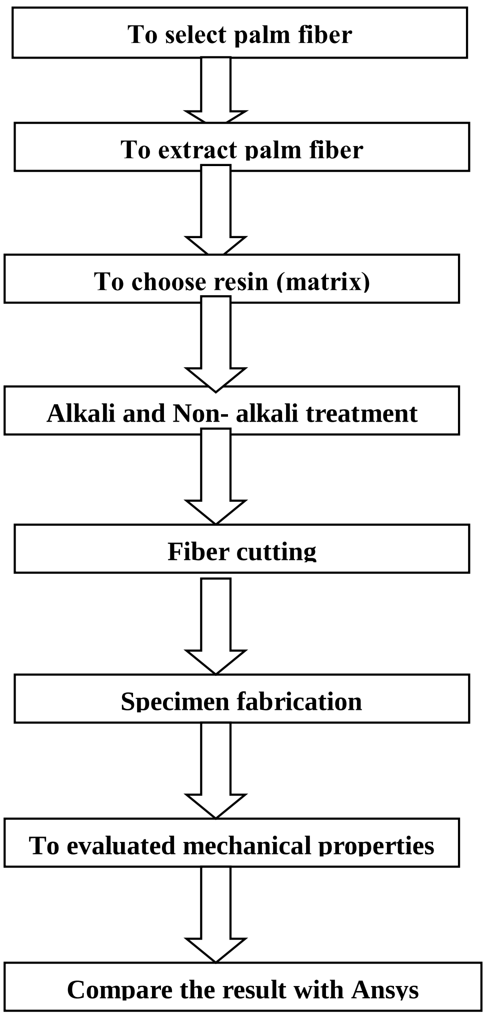

The usage of glass fiber or fabrics are non degradable and disposal of composites would be tough task when they are used as reinforcement. Moreover, the glass fibers are non renewable. To make environmental friendly composite, the trend is slowly shifting towards using natural fiber/fabric as reinforcement.To separate Palm fiber from Palm tree stem.To treat Palm fibers with NaOH and HCL. Scanning electron microscope (SEM) is to be conducted to show the absence of surface impurities.Water absorption experiment will be conducted to determine saturation mass gain. Chemical properties test should be undertaken to find wax, moisture, lignin, fatty acids, cellulose and hemi cellulose. To determine the thermal conductivity of the natural fiber composite sample.

Materials

Palm fibers were collected from the plants palm trees. The fiber was subjected to surface modifications by using alkali treatment.

Alkaline treatment

Treatment procedure

Palm fibers were soaked in distilled water with 5% NaOH solution for about 0.5 at room temperature. The fibers were then washed many times in distilled water. The fibers were then soaked in distilled water with 2.5% HCL solution for about 0.5 h at room temperature. The fibers were then washed many times in distilled water and finally dried. Alkali treatment of natural fibers, also called mercerization, is the common method to produce high-quality fibers. Mercerization leads to fibrillation which causes the breaking down of the composite fiber bundle into smaller fibers. Mercerization reduces fiber diameter, thereby increases the aspect ratio which leads to the development of a rough surface topography that results in better fiber/matrix interface adhesion and an increase in mechanical properties.

Moreover, mercerization increases the number of possible reactive sites, allows better fiber wetting and gets an effect on the chemical composition of the hemp fibers, degree of polymerization and molecular orientation of the cellulose crystallites due to cementing substances like lignin and hemicelluloses which were removed during the mercerization process.

As a result, mercerization had a long-lasting effect on the mechanical properties of hemp fibers, mainly on fiber strength and stiffness. If the treatment is done at high percentage of NaOH there could be an excessive extraction of lignin and hemicelluloses which can results in damage of the ultimate cells walls. Similar reduction of mechanical properties after alkali treatment have been reported in the literature .Alkali treatment is recognized to hydrolyses the amorphous parts of cellulose present in fibers so that after treatment the material contains more crystalline cellulose. Furthermore, it removes waxes and oils from the surfaces.

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Fig 4.1 5% Alkali treated fiber before cutting

Fig 4.2 5% Alkali treated fiber after cutting

MOULDING BOX PREPARATION

- In general composite plates are prepared by using moulding box. The moulding box contains upper plate, base plate, and Frame.
- Material is mild steel
- Base plate dimension 210*170*10
  Frame dimension 200*160*10
  Upper plate dimension 180*140*10

Fig 5.1 Moulding Box

Composite fabrications

Specimen are prepared with the mixing ratio of epoxy resin and palm fiber 60:40 respectively one by mixing the treated Palmyra fiber and untreated fibers is cleaned, dried and chopped into 1mm, 3mm, 5mm, 7mm and 10mm length. The intimately mixed palm fiber and epoxy resin are spreader uniformly in the mould of 180*140*10 and compressed by applying a load to get a single mat. The samples are prepared and cured at room temperature by continuously applying the load for 24 hours.

Selection of resin

Epoxy LY556 and hardener H7951 weight ratio of mixing epoxy, hardener and fiber was 4:1:1.Epoxy, hardener, fiber taken respectively 135, 34, and 34grams.

Fig 5.2 Hardener and Araldite (Epoxy resin

Fig 5.3 Treated Fiber

Fig 5.4 Mixing of epoxy, hardener

Fig 5.5 Preparation of mould

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TESTING OF MECHANICAL PROPERTIES

After fabrication the test specimens were subjected to various Mechanical testing as per ASTM standards. The mechanical tests that carried out are tensile test, flexural test, impact test. The specimen sizes are 3mm, 5mm and shape for corresponding tests are as follows.

Tensile test

ASTM D3039 tensile testing is used to measure the force required to break a polymer composite specimen and the extent to which the specimen stretches or elongates to that breaking point. The data is often used to specify a material, to design parts to withstand application of force and as a quality control check of materials. Since the physical properties of many materials at temperatures that simulate the intended end use environment. The most common specimen for ASTM D3039 has a constant rectangular cross section, 13mm wide and 165mm long. Optional tabs can be bonded to the ends of the specimen to prevent gripping damage. Fig shows the tensile test specimen.

Fig 6.1 Specimen for tensile test

Flexural Test

Flexural strength is defined as a materials ability to resist deformation under load. It is a 3-point bend test, which generally promotes failure by inter-laminar shear. This test is conducted as per ASTM D790 standard using UTM. The loading arrangement is shown in figure3.13. The dimension of the specimen is (13x127x3) mm. It is measured by loading desired shape specimen with a span length at least three times the depth. The flexural strength is expressed as modulus of rupture (MR) in psi (MPa) .

Flexural MR is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. However the best correlation for specific materials is obtained by laboratory tests for given materials and mix design. The MR determined by third-point loading is lower than the MR determined by centre-point loading, sometimes by as much as 15%. The maximum fiber stress at failure on the tension side of a flexural specimen is considered the flexural strength of the material. Thus, using a homogeneous beam theory, the flexural strength in a three-point flexural test is given by;

$$\sigma_f = (3P_{max} L)/2bh^2$$

Where

P_{max}= maximum load at failure

b = specimen width

h = specimen thickness

L = specimen length between the two support points

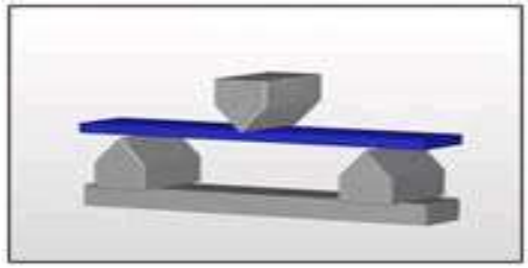

Fig.6.2 3-Point Bending Test Setup

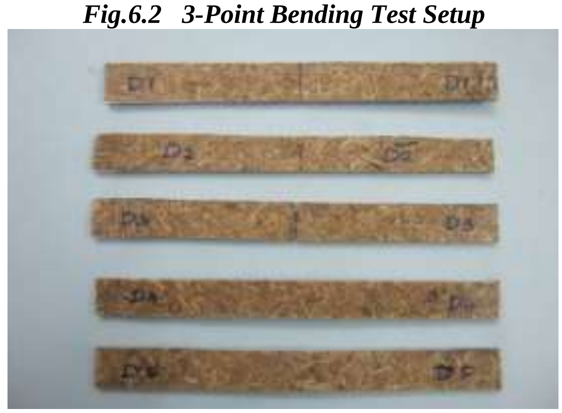

Fig 6.3 Specimen for Flexural test

Impact Test

Impact is a single point test that measures a materials resistance to impact from a swinging pendulum. Impact is defined as the kinetic energy needed to initiate fracture and continue the fracture until the specimen is broken. This test can be used as a quick and easy quality control check to determine if a material meets specific impact properties or to compare materials for general toughness. The standard specimen for ASTM D256 (13×66×3) mm and specimen prepared is shown.

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Fig 6.4 Specimen for impact

Impact strength=maximum energy absorbed/area of cross section

RESULT AND DISCUSSIONS

This chapter presents the mechanical properties of the treated/un-treated coconut/palm fiber epoxy composites prepared for this present investigation. Details of processing of these composites and the result are obtained by the experiment. The results of various characterization tests are reported. These includes evaluation of tensile strength, flexural strength, impact strength has been done.

Tensile Tests

Tensile testing of specimen prepared according to ASTM D 3039 type IV sample was carried out, using electronic tensile testing machine with cross head speed of 2mm/min and a gauge length of 115 mm.

The tensile modulus and elongation at break of the composites were calculated from the stress strain curve. Four specimens were tested for each set of samples and mean values were reported

Table 7.1 Tensile property of composite material

SPECIMEN	Engg. Stress (N / Sq mm)	Strain	Max Load (N)	Disp. In mm (at Max Load)	Min Load In (N)	Disp. In mm (at Min Load)
COCONUT/PALM FIBER – EPOXY COMPOSITE(3mm)						
A1	6.54	0.0139	254.98	0.6961	19.61	0.7301
A2	6.54	0.0139	254.98	0.6961	19.61	0.7385
A3	5.53	0.0163	215.75	0.8149	49.04	0.0594
A4	5.53	0.0163	215.75	0.8149	49.04	0.0594
A5	6.79	0.019	264.79	0.9508	49.04	0.034
COCONUT/ PALM FIBER – EPOXY COMPOSITE(5mm)						
C1	20.37	0.0584	794.37	2.9202	9.81	2.9542
C2	24.39	0.073	951.28	3.6503	49.04	0.034
C3	23.89	0.0708	931.67	3.5399	58.84	0.0594
C4	22.38	0.0699	872.82	3.4975	58.84	0.0679
C5	22.13	0.0489	863.02	2.4448	19.61	2.5127

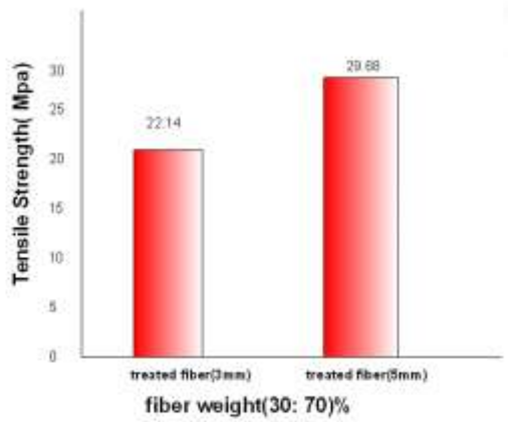

Fig 7.1 Variation of tensile strength of alkali treated coconut / palm fiber epoxy composite

As expected, surface modification by chemical treatment of fibers resulted in a significant increase in tensile strength. From the fig4.1 shows that it can be easily found that the alkali treatment provides batter improvement in the tensile strength. The range of the tensile strength was between 6.18-22.63MPa for 30 wt% fiber loading. The maximum tensile stress value of the alkali treated composites was 22.63MPa for 30 wt % fiber loading. The tensile strength of a composite material is mainly dependent on the strength and modulus of fibers, the strength and chemical stability of the matrix and fibers in transferring stress across the interface. When fiber reinforced composites are subjected to load, the fibers act as carries of load and stress is transferred from the matrix along the fibers leading to effective and uniform stress distribution, which results in a composite having good mechanical properties. Untreated fibers causing the bond between matrix and fiber is poor to break, leaving the matrix diluted by non-reinforcing deboned fiber. In the case of hybrid coconut/coconut shell powder/epoxy composite compare to coconut/epoxy composite have high tensile strength

Flexural test

The flexural test was performed by the three point bending method according to ASTM D 790, and cross head speed of 1 mm/min.

Table 7.2 Flexural property of composite material

SPECIMEN	Ult/Break Load (kN)	Disp. At FMAX (mm)	Max. Disp (mm)	Area (mm^2)	Flexural strength (Mpa)
COCONUT/ PALM FIBER –EPOXY COMPOSITE(3mm)					
A1	0.025	1.100	6.400	39	23.01
A2	0.025	0.900	3.400	39	24.23
A3	0.025	0.800	1.500	39	24.52
A4	0.015	0.900	4.400	39	24.88
A5	0.030	1.300	2.500	39	24.91
TREATED PALM FIBER –EPOXY COMPOSITE(5mm)					
C1	0.050	1.800	2.500	39	51.12
C2	0.035	0.900	2.000	39	51.14
C3	0.045	1.200	1.500	39	51.22
C4	0.040	1.200	1.700	39	51.28

Four specimens were tested, and the average was calculated. The specimen was freely supported by a beam, the maximum load was applied in the middle of the specimen, and the flexural modules is calculated from the slope of the initial portion of the load deflection curve.

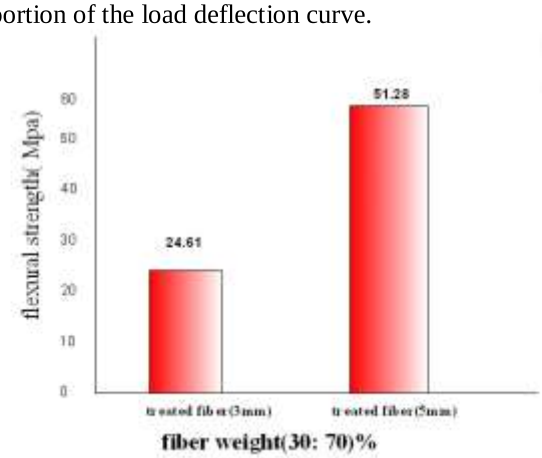

Fig 7.2 Variation of flexural strength of alkali treated coconut/palmfiber epoxy composite

The flexural properties of untreated/alkali treated coconut fiber/epoxy composites at 30% fiber loadings are shown in fig 4.3. Flexural strength is a combination of the tensile and compressive strength and varies with the interfacial shear strength between the fiber and matrix. Flexural test in various mechanisms such as tensile, compressive, shearing etc. will take place simultaneously. In order to achieve effective fiber reinforcement, interfacial strength between the fiber and matrix is the most essential factor. It was observed from figure 4.3 that the flexural strength and modulus of alkali treated coconut fiber /epoxy composite has high flexural strength. The maximum flexural stress of the composite was 51.28 MPa

Impact Test

Table 7.3 Impact property of treated composite material (3mm)

specimen	Area sqmm	Impact strength
I	625	8.08
II	625	8.22
III	625	8.05
IV	625	8.13
V	625	8.11

Table 7.4 Impact property of treate alkali composite material (5mm)

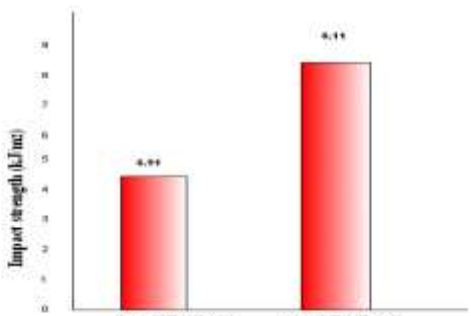

Fig 7.5 Variation of impact strength of alkali treated coconut/palm fiber epoxy composite

specimen	Area of specimen Sq mm	Impact strength kJ/m^2
I	625	4.94
II	625	4.92
III	625	4.96
IV	625	4.89
V	625	4.98

The relationship between fiber weight and impact strength is shown in Figure 4.5. The impact property of a material shows its capacity to absorb and dissipate energies under impact or shock loading. The impact energy level of the composites depends upon several factors such as the nature of the constituents, construction and geometry of the composites, fiber arrangement, fiber/matrix adhesion, and test conditions. The matrix fracture, fiber matrix de-bonding, fiber breakage and fiber pull out are important modes of failure in the fiber composites due to impact loading. The applied load, transferred by shear to the fibers, may exceed the fiber/matrix interfacial bond, and deboning may occur. The frictional force along the interface may transfer the stress to the deboned fiber. If the fiber stress level exceeds the fiber strength, fibers may breakage. The breakage fibers may be pulled out of the matrix, and this involves energy dissipation. The impact strength of alkali treated coconut fiber /epoxy composite has higher strength. However untreated/hybrid loading above this value caused a moderate decrease in impact strength. These results suggest that the fiber is capable of absorbing energy because of strong interfacial bonding between the fiber and matrix up to 30 wt. % fiber loading. But at higher loadings the inter fiber interaction decreases the effective stress transfer between the fiber and matrix. This contributes to a decrease in impact properties at higher fiber loadings. The impact strength of alkali treated coconut/epoxy composite has maximum strength 8.11 kJ

CONCLUSION

Natural fiber reinforced epoxy based composite specimen are fabricated using hand layup technique.The specimens were fabricated in thickness of 3mm and 5mm.The various testing on mechanical properties has been done such as tensile, flexure and impact, Different dimension of the specimen were compared with the experimental result.On the specimen the various testing like tensile, flexure and impact are done. The specimen were compared with the both results.Tensile test =29.8 Mpa,Flexure test=51.28Mpa,Impact test=8.11KJ/mmsq. The output result are compared with the Ansys 14.0 work bench software.In the biomedical and bioengineered field, the use of natural fiber mixed with biodegradable and bio restorable polymer can produce joints and bone fixture to alleviate pain for the patients.

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