STUDY ON MECHANICAL BEHAVIOR OF SURFACE TREATED COIR FIBER REINFORCED POLYMER MATRIX COMPOSITES

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
in
Mechanical Engineering

BY

VINAY V
Roll Number: 109ME0428

DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
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CERTIFICATE

This is to certify that the thesis entitled ***"Study on Mechanical Behaviour of Surface treated Coir Fiber Reinforced Polymer Matrix Composites"*** submitted by ***Vinay V (Roll Number: 109ME0428)*** in partial fulfillment of the requirements for the award of ***Bachelor of Technology*** in the department of Mechanical Engineering, National Institute of Technology, Rourkela is an authentic work carried out under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to elsewhere for the award of any degree.

Place: Rourkela
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A C K N O W L E D G E M E N T

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ABSTRACT

The need to pursue an environmentally safer future has prompted the researchers to look beyond the artificial or synthetic fibre based composites and engage in putting more thought into the utilisation of natural fibre based polymer composites. Although synthetic fibres have a lot of advantages but we can owe its declining use in recent years to its high initial cost, non bio-degradability, non -renewability , high energy consumption in manufacturing process and adverse environmental impacts. Natural fibres however more than compensate for their poor compatibility with the matrix, inherent high moisture absorption rate with their positive attributes like low cost, low density , non abrasivity, good thermal properties, enhanced energy recovery and bio degradability. Coir is an important lignocellulose fibre used for making variety of floor furnishing materials, yarn, rope etc. but they contribute to a very small percentage production of coir. So researchers are trying to find new areas for utilisation of coir as in reinforcement polymer composite. The present work deals with development and characterisation of coir fibre reinforced epoxy composites. The coir used in the composite is first treated with alkali (in varying concentrations and considering different time constraints for each composite) to improve its surface properties and improve its adhesion with the matrix. The mechanical properties of the composite such as tensile strength, flexural strength and hardness are tested. Finally SEM has been done to get a qualitative overview of the fractured surface and to understand the surface morphology better.

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CHAPTER 1

INTRODUCTION

1.1 Overview of the composites

Basically, Composites are a material system composed of two or more dissimilar materials which exist in different phases and are insoluble in each other. One or more discontinuous phases are, therefore, rooted in a continuous phase to form a composite. The discontinuous phase is usually harder and stronger than the continuous phase and is called the reinforcement, while, the continuous phase is termed as the matrix. The matrix material can be ceramic, metallic or can even be polymeric. When the matrix material is polymer, the composite is called polymer matrix composite (PMC). In composites the properties of the fibre and reinforcement combined is far superior to that of the original constituents. The property of a composite material depends upon the properties of constituent material, their geometric distribution and their interactions.

Components of a Composite

Composites are made up of:

- Matrix
- Reinforcement

Matrix is the component that exists in a continuous phase and surrounds and holds the fibre in its place. The composites matrix provides the composites compressive strength along with additional shear strength to prevent the fibres from shifting places relative to each other. They deform to distribute the stresses among the constituent reinforcement material under applied stress.

Reinforcement is the component in the discontinuous phase which imparts its special mechanical and physical properties to enhance matrix properties. The reinforcements provide tensile strength as well as shear strength to the composite. Reinforcements, which generally are in the form of fibres or particles, in themselves, are of little value to an engineer unless a matrix binds them and enables us to make use of them.

According to Bryan Harris [1] the matrix performs a variety of functions:

- The matrix binds the fibres together, holding them aligned in the important stressed directions. Loads applied to the composite are then transferred into the fibres, the principal load-bearing component, through the matrix, enabling the composite to sustain compressive, flexural , shear forces as well as tensile loads. The ability of composites reinforced with short fibres to support loads of any kind is dependent on the presence of the matrix as the load-transfer medium, and the quality of the bond between fibre and matrix directly affects the efficiency of this load transfer.
- The matrix must also isolate the fibres from each other so that they can act as separate entities. Many reinforcing fibres are brittle solids with highly variable strengths. When such materials are used in the form of fine fibres, not only are the fibres stronger than the monolithic form of the same solid, but there is the additional benefit that the fibre aggregate does not fail catastrophically. Moreover, the fibre bundle strength is less variable than that of a monolithic rod of equivalent load-bearing ability. But these advantages of the fibre aggregate can only be realized if the matrix separates the fibres from each other so that cracks are unable to pass unimpeded through sequences of fibres in contact, which would result in completely brittle composites.
- The matrix should protect the reinforcing filaments from mechanical damage (eg. abrasion) and from environmental attack. Since many of the resins which are used as matrices for glass fibres permit diffusion of water, this function is often not fulfilled in many GRP materials and the environmental damage that results is aggravated by stress. In cement the alkaline nature of the matrix itself is damaging to ordinary glass fibres and alkali-resistant glasses containing zirconium have been developed (Proctor

& Yale, 1980) in an effort to counter this. For composites like MMCs or CMCs operating at elevated temperature, the matrix would need to protect the fibres from oxidative attack.

- A ductile matrix provide effecient means of slowing down or stopping cracks that might have originated at broken fibres: conversely, a brittle matrix may depend upon the fibres to act as matrix crack stoppers.
- Through the quality of its 'grip' on the fibres (the interfacial bond strength), the matrix can also be an important means of increasing the toughness of the composite.

1.2 Classification of Composites

1. ***According to matrix material:*** On the basis of the kind of matrix constituent composites are classified as follows:
    - Organic Matrix Composites
        - -Polymer Matrix Composites
        - -Carbon Carbon Composites
    - Metal Matrix Composites
    - Ceramic Matrix Composites

Organic Matrix Composites

Organic matrix composites are further subdivided into two groups depending upon the type of organic matter used in the composite as matrix:

Polymer Matrix Composites

Polymers make ideal materials as they can be processed easily, possess lightweight, and desirable mechanical properties. Two main kinds of polymers are thermosets and thermoplastics. Thermosets have a cross linked polymer structure during the curing process helping them form a more stable bond. They can be retained in a partially cured condition too over prolonged periods of time, imparting Thermosets high flexibility. Hence, they get high preference as matrix bases for advanced conditions fibre reinforced composites. Thermoplastics have one- or two-dimensional molecular structure and they tend to at an elevated temperature and display exaggerated melting point. Another advantage is that the process of softening at elevated temperatures can be reversed so that composites regain their properties during cooling, aiding applications of conventional compress techniques to mould the compounds.

Carbon Matrix Composites

Carbon- Carbon composites are composite materials consisting of a carbon matrix reinforced by carbon fibre. They may be manufactured with different orientation of the reinforcing phase i.e. carbon carbon fibre : uni directional structure, bi directional structure, multi directional structure. They possess excellent thermal shock resistance, high modulus of elasticity, high thermal conductivity and have excellent heat resistance in non oxidising atmosphere.

Metal Matrix Composites

Composites in which metallic matrix are combined with ceramic or metallic dispersed phase is metal matrix composite. Most metals and alloys make good matrices.The low density of the light metals proves to be an advantage and renders the metal responsive. Aluminium ,Titanium, and magnesium are the popular matrix metals currently in trend, which are particularly useful for aircraft applications. Metallic matrix materials require high modulus reinforcements to offer high strength. The resulting composites can have high strength-to-weight ratios than most alloys.

Ceramic Matrix Composites

Composites in which ceramic matrix is combined with ceramic dispersed phase.Owing to the main disadvantage observed in conventional ceramics i.e. brittleness ,Ceramic Matrix Composites are designed with improved toughness. Because of high melting points, good corrosion resistance, stability at elevated temperatures and high compressive strength, ceramic-based matrix materials become a clear favourite for applications requiring a structural material that withstand temperatures above 1500ºC. Naturally, ceramic matrices are the first choice for high temperature applications.

2. According to reinforcement

Fibre Reinforced Composites Fibre Reinforced Composites are composed of fibres embedded in matrix material. If properties of the composite vary with fibre length such a composite is considered to be a discontinuous fibre or short fibre composite . Whereas, when increasing the length of the fibre does not cause any further increase in length in the elastic modulus of the composite, the composite is considered to be continuous fibre reinforced. Although the fibres have very good tensile properties they bend easily when pushed axially as they are small in diameter . These fibres need support to keep individual fibres from bending and buckling under load

Laminar Composites are composed of layers of materials bound together by matrix. An example of this category are the sandwich structures..

Particulate Composites are composed of particles distributed or embedded in a matrix body. The common form of the particles may be in flakes or in powder form. Concrete and wood particle boards are examples of this category.

Recently, the interest in natural fiber reinforced polymer composites has increased rapidly due to the growing environmental consciousness and understanding of the need for sustainable development to replace glass, carbon and other man-made fibers. The advantages of natural fibers include low density, low price, easy availability, and low abrasive wear of processing machinery. Further, natural fibres are biodegradable, recyclable and carbon dioxide neutral and their energy can be recovered in an environmentally acceptable way. A great deal of work has already been done to evaluate the potential of natural fibers as reinforcement in polymers.

Among various fibers, coconut coir is considered as one of the potential reinforcement for polymer composites due to many advantages such as easy availability, low cost and satisfactory mechanical properties. The use of coconut coir in different form has already been explored in various applications; however the coir in terms of fibre in polymer composites has hardly been reported. To this end, the present work is undertaken to study the effect of surface treatment on mechanical behaviour of coir fibre reinforced epoxy composites.

CHAPTER 2

LITERATURE REVIEW

This chapter gives an overview of the various studies conducted in the recent past on natural fibres and more specifically coconut coir fibres. A lot of researchers have studied the variation of mechanical properties of the natural fibres by varying various parameters.

The effect of alkaline treatment on the surface characteristics of jute fibres considering different soaking time for each specimen was studied along with the extent to which surface properties of the fibre are enhanced considering better interfacial adhesion between fibre and matrix. Increase in surface properties improves the mechanical property (like improved tensile and flexural property) as a whole. Conclusion was drawn that natural fibre composites can be used where they are subjected to lower values of loads like in household appliances [2]. The dynamic properties as a function of temperature of the vinylester resin matrix composite reinforced with alkali treated jute fibres has also been studied. It was found that the storage modulus in the composite increased with the increase of fibre loading due to the greater stress transfer at the interface imparted by the reinforcing fibres [3]. The flexural properties of unidirectional kenaf fibre reinforced epoxy composite have also been investigated and the properties of the treated and untreated kenaf fibre compared with each other. It was found that reinforcement of the composite with treated kenaf fibre increased the flexural strength of the composite by a large percentage due to improvement of the surface and thereby the interfacial adhesion after treatment with NaOH [4]. Sisal fibre was subjected to an alkaline treatment under different temperature and time conditions, and to report the mechanical properties and water absorption of the composite containing different percentages of fibre. Mechanical properties and aspect ratio were improved with treatment at low temperatures and short times. The elastic modulus and mechanical strength of the composites increase with fibre content, confirming the reinforcing action of the fibres. It was also found that critical strain energy release rate GIc of the composite increased when the fibres were treated, probably due to some toughening mechanisms that are activated by fibre treatment[5]. The properties of the admicellar-treated sisal fibre were examined by measuring its electrostatic charge and moisture absorption. Thermogravimetric analysis and film identification by FTIR was also carried out to study the thermal stability of the composite. It was found that the treatment improved the tensile and flexural properties, impact strength, and hardness of the composite. SEM micrographs of the tensile fracture surface of sisal/unsaturated polyester composites also shows improvement in interfacial adhesion of the composite prepared with admicellar-treated sisal [6]. The effect of alkali (NaOH) treatment with different concentration of NaOH (0%, 2% and 4%) solution on short pineapple leaf fibre (PALF) reinforced high impact polystyrene (HIPS) composites was inspected. The mechanical properties such as flexural strength ,tensile strength, tensile modulus, flexural modulus and hardness of short pineapple leaf fibre (PALF) reinforced high impact polystyrene (HIPS) composites were examined and compared. The results suggested that maximum improvement of the mechanical properties of the short pineapple leaf fibre was obtained with 4% NaOH concentration[7]. The tensile properties of alkali treated woven jute natural fibre and woven glass fibre reinforced Hybrid Composites Bolted Joint (TCBJ) and Untreated Hybrid Composite Bolted Joint Effect of stacking sequence and fibre treatment on tensile strength, hardness and impact strength were investigated experimentally. The results indicated that the properties of jute composites can be considerably improved by incorporation of glass fibre as extreme glass plies [8]. The effect of bleaching with carbamide peroxide agents at different concentrations was evaluated on the micro hardness and shear bond strength of composites and compomers. It was deduced that bleaching caused reduction in hardness of composite restorative materials [9]. The effect of H_2O_2 bleaching agent on the microhardness of composite resins was investigated. A significant reduction in microhardness of 3M was found after bleaching application and the results showed that there is a non significant reduction in micro-hardness of Tetric ceram [10]. The effect of alkali treatment, fibre loading and hybridization on tensile properties of sisal fibre, banana empty fruit bunch fibre and bamboo fibre reinforced thermoset composites has also been studied. Composites were developed by simple hand layup technique with varying process parameters, such as fibre condition (untreated and alkali treated), varying fibre percentages and various hybrid combinations (Sisal-bamboo, Banana-Bamboo and Sisal-Banana). The developed Sisal fibre, Banana empty fruit bunch fibre and Bamboo fibre reinforced composites were then subjected to tensile test and scanning electron microscopy. The results show that increase in the fibre percentage increases the tensile strength; however, after a certain percentage of fibre reinforcement, the tensile strength decreases. Moreover results suggested that hybridization of the fibres showed an increase in the tensile strength as compared with pure Epoxy (matrix). It was further concluded that alkali treatment of the natural fibres is necessary to develop composites with moderate mechanical properties as well as better adhesion between fibres and matrix [11]. The surface-property relationship of atmospheric plasma treated jute composites has also been studied. Jute fabric was treated for various periods of time under atmospheric plasma glow discharge (APGD) using helium (He), helium/nitrogen (He/N), and helium/acetylene (He/Ac) gases. It was found that 10 s of treatment was enough for all gases to significantly improve the wetting behaviour of the fabric. Different levels of improvement of inter-laminar shear stress ,flexural strength and flexural modulus respectively were observed in composites produced from plasma treated fabrics. The glass transition temperature and storage modulus were also enhanced .It was concluded that chemical nature of these species must have changed considerably depending on the type of gas mixture used which must have resulted in the improvement of the properties [12]. The characterisation and utilisation of natural coconut fibre composites was studied. Two thousand randomly taken fibres were analysed for their characteristics. The average length of the fibres, the average weight range of the fibres was investigated and composites were manufactured .The tensile strength of the composites was investigated [13]. The characterization of high density Polyethylene-coconut coir composite with stearic acid as compatibilizer was investigated. Composites of high density polyethylene with coconut coir as fibre and stearic acid as the coupling agent were fabricated by compression moulding. The mechanical properties and the thermal stability of the composites were investigated and it was found that treatment enhanced both mechanical properties as well as thermal stability of the composites [14]. The tensile behaviour of the coir fibre and related composites after NaOH treatment were evaluated. Coir fibres were treated with varying concentrations of NaOH (2%-10%) and the tensile strength of the alkali treated fibre was measured .It was found that the fibres showed a decreasing trend of fibre tensile strength with increasing NaOH density. Study further suggested that in lower concentrations of NaOH fibre detoriation was comparatively less and it was outweighed by the improvement in strength provided by the adhesion between fibre and the matrix [15]. The influence of fibre treatment on the performance of coir polyster composites has also been studied .Study suggested that mechanical properties of the composites like tensile, flexural, impact strength increase as a result of surface modification. Bleached coir polyster composite showed better flexural strength while alkali treated coir polyester composite showed significant improvement in tensile strength. Both hybrid and coir polyester composites showed significant reduction in water absorption due to surface modification of coir fibre [16]. The effect of lignin removal on the properties of coconut coir fibre wheat gluten bio-composite has also been investigated. Coconut fibre was treated with sodium chlorite to selectively decrease amounts of lignin and then fibre lignin content was reduced. The matrix glass transition ,mechanical properties, water sensibility and infrared spectra of bio-composites prepared with fibres containing various amounts of lignin were evaluated. The study suggested that addition of coconut fibre significantly improved the property of wheat gluten biomaterial. It also suggested that lignin removal is not an efficient way to improve the properties of natural fibre bio-composite [17]. The effect of lignin as a compatibilizer on the physical properties of coconut fibre-polypropylene composite was studied. The study demonstrated that composites with lignin as a compatibilizer possess higher flexural properties as compared to control composites. It suggested that incorporation of lignin does not improve the tensile properties. Results also suggest that size irregularities and fibre distribution may play a dominant role on the properties which may surpass the effect of improved compatibility. Lignin also reduces the water absorption and thickness swelling of the composites [18]. The characterization of single coir fibre for preparing polymer matrix composite has also been investigated. The single coir fibre was characterized by Fourier transform infrared (FTIR) spectroscopic analysis and scanning electron microscopy (SEM) and mechanical properties of single coir fibre was studied by conducting tensile tests. FTIR analysis showed the characteristic peaks of the coir fibres, while from SEM imaging, compact and smooth surface of single fibre was found. In mechanical testing, tensile properties were measured by varying the span length of fibre. It was found that an increase in span length increased the Young's modulus, whereas tensile strength and strain to failure decreased[19]. Njoku et al [20] studied the effect of alkali treatment and fibre content variation on the tensile properties of coir fibre reinforced cashew nut shell liquid (CNSL) composite. Bio composite consisting of coir fibres and cashew nut shell liquid resin was treated with NaOH and varying weight fractions. Keeping the fibre loading constant untreated coir fibres were used to produce composite laminates. The results showed that tensile strength and modulus of the CNSL/COIR composite increased as the weight fraction of coir fibres was increased up to a fibre content of 30%. Also the composites exhibited reduction in elongation at break as fibre content was increased. The effect of alkali treatment and fibre content on the mechanical properties of short coir/pbs biodegradable composites has been studied [21]. The effect of fibre content varying from on the mechanical properties of short coir/PBS composites was investigated. The effect of alkali treatment on mechanical properties of the composites was also studied. The study suggested that mechanical properties of alkali treated coir/PBS composites are significantly higher than those of untreated coir fibre. The best mechanical strength of short coir/PBS composites was achieved at fibre content of 20 wt.% in this study. Tensile and flexural modulus of the composites increased with increasing fibre content. The water absorption and mechanical properties Sisal/Coconut Coir natural fibres epoxy composites were studied [22]. Natural fibres (Sisal and Coconut coir) reinforced Epoxy composites were subjected to water immersion tests in order to study the effects of water absorption on the mechanical properties. Natural fibres like coconut coir (short fibres) and sisal fibres (long fibres) were used in hybrid combination and various fibre weight fraction were used for the fabrication of the composite. Water absorption tests were conducted by immersing specimens in a water bath at different temperatures for different time durations. The tensile and flexural properties of water immersed specimens were evaluated and compared with dry composite specimens.

Although the mechanical behaviour of natural fibre reinforced polymer composites have been discussed and experimentally analysed in various reports in literature. However, very limited work has been done on effect of treatment concentration and treatment time/soaking time on mechanical behaviour of coir fibre reinforced epoxy composites. Against this backdrop, the present project work has been undertaken, with the purpose of exploring the potential of alkali treated coir fibre as a reinforcing material in polymer composites and to investigate its effect on the mechanical behaviour of the resulting composites

2.1 Objectives of the Research Work

The objectives of the project are delineated below.

- To develop a new class of natural fibre based polymer composites to explore the potential of coir fibre.
- To study the effect of alkali concentrations and treatment time on mechanical behaviour of coir fibre reinforced epoxy based composites keeping the fibre length and fibre loading constant.

- Experimentation for determination and analysis of mechanical properties such as: tensile strength, flexural strength, tensile modulus and micro-hardness.
- To compare the tensile, flexural and hardness values of the surface treated composite with that of untreated one under the same conditions of fibre length and fibre loading.

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with process of preparation of the coir–epoxy composite and testing of the mechanical behaviour of the composite. The raw materials used are:

- Coconut Fibre
- Epoxy resin
- Hardener

3.1 Composite Fabrication

The fabrication of the composite is carried out by simple hand lay-up technique. Coir fibres are obtained from the rural areas of Odisha, India. These fibres are then cut into length of 5mm each for the preparation of the composite.

Alkali treatment of the coir fibres:

The cut coir fibres are then prepared for treatment with NaOH solution to improve its surface properties and provide better adhesion with the matrix after the removal of lignin and pectin from the surface of the fibre. The fibres after cutting are weighed and six stacks of 15 gm each are separated. NaOH solution is prepared for two separate concentrations 1% and 2%. Coir samples are first washed in distilled water. Out of the coir stacks of 15 gm each, 3 of them are then dipped in 1% NaOH solution while the remaining 3 are dipped in 2% NaOH solution. The time for which each stack are dipped in NaOH solutions are different for each concentration. The first stack is dipped for 3 hours, second one for 6 hours and third one for 9 hours in 1% solution while fourth , fifth and sixth stack are dipped for 3,6 and 9 hours respectively in 2% solution . The stacks are then taken out and washed with distilled water for 15-20 times. Then they are dipped in acetic acid solution for 30 -60 sec and taken out. Again the fibres are washed with water 4-5 times before drying. Treated fibres are first dried at room temperature for 48 hours .Further they are dried in a heat oven at 50°C for 1 hour each. Drying is done to remove moisture content and to prevent the sticking together and clogging of the fibres with each other.

For the preparation of the composite dried coir fibres are used as reinforcement and epoxy resin is used as the matrix material. It is mixed along with the corresponding hardener in a 10:1 ratio by weight. Six different samples are prepared corresponding to different concentrations of NaOH used for treatment and the treatment time for each composite. The designations of the sample are given in the Table 3.1. Figure 3.1 and 3.2 shows the coir fibre and coir fibre reinforced epoxy composites respectively. While mixing coir fibres are stirred in the epoxy continuously to enable uniform spreading of the fibres so the when they are put under load then they don't spread randomly and create gaps and regions of uneven thickness. The composites are cured under a load of 25kg for about 24 hours before it is removed from the mould. It is then post cured in the air for another 24 hours after removing from the mould. Specimens of suitable dimension have been cut for mechanical testing and utmost care has been taken to maintain uniformity in the samples.

Table 3.1 Designation of composites along with their composition

Composites	Fibre Length(mm)	Composition (wt %)	NaOH Concentration	Treatment Time(Hours)
S1	5	10 % Fibre + 90% Epoxy	-	-
S2	5	10% Fibre + 90% Epoxy	1%	3 Hours
S3	5	10% Fibre + 90% Epoxy	1%	6 Hours
S4	5	10% Fibre + 90% Epoxy	1%	9 Hours
S5	5	10% Fibre + 90% Epoxy	2%	3 Hours
S6	5	10% Fibre + 90% Epoxy	2%	6 Hours
S7	5	10% Fibre + 90% Epoxy	2%	9 Hours

3.1 Coconut fibre or coir

3.2 Coir fiber reinforced epoxy composites

3.2 Mechanical Testing

After fabrication of the composite specimens various mechanical tests are carried out on the specimens as per ASTM standards. The tensile test and flexural tests of composites are carried out using Instron 1195. A uniaxial load is applied through both the ends. Span length is fixed at 60mm and the crosshead speed is 2mm/min. Micro-hardness measurement is done using a Leitz micro-hardness tester. A load F is forced onto the material by a diamond indenter, in the form of a right pyramid with a square base and an angle 136° between opposite faces . The two diagonals D_1 and D_2 of the indentation left on the surface of the material after removal of the load are measured and their arithmetic mean L is calculated. Figure 3.3 and 3.4 shows the tensile and flexural test specimens respectively. Figure 3.5 shows the experimental set up and loading arrangement for the specimens for three points bend test.

Figure 3.3 Tensile Test Specimens

Figure 3.4 Flexural Test Specimens

Figure 3.5 Experimental set up and loading arrangement for the specimens for three points bend test

3.3. Scanning Electron Microscopy (SEM)

Scanning electron microscopy is conducted to study the morphology of the fractured surface of the specimen after the tensile test. The scanning electron microscope JEOL JSM-6480LV is used to view the fractured surface directly. The samples are cleaned properly and rubbed with sand paper to remove unwanted dirt particles sticking to the surface. It is then air-dried and coated with 100 Å thick platinum in JEOL sputter ion coater. The composite samples are mounted on stubs with silver paste. They are placed in vertical orientation in such a way that the fractured surface is observes directly under the SEM (at 20 kV).

Figure 3.6 Scanning electron microscope set up.

CHAPTER 4

MECHANICAL BEHAVIOUR OF COMPOSITES : RESULTS AND DISCUSSION

This chapter deals with the analysis of the mechanical properties of the composite specimens.The specimen was tested for tensile strength,flexural strength and hardness value . The results of the different tests conducted are reported along with comparison of the values of different composites prepared. SEM analysis is also presented along with the relevant photomicrographs for giving a better representation.

4.1 Mechanical Properties of Composites

Table 4.1 shows the mechanical properties of coir fiber reinforced epoxy composites.

Table 4.1 Mechanical properties of the composite

NaOH Concentration (%)	Time (hrs)	Tensile Strength (Mpa)	Tensile Modulus (Gpa)	Flexural Strength (Mpa)	Micro-Hardness (Hv)
Untreated	0	12.31	1.523	35.12	9.4
	3	0	0	0	0
	6	0	0	0	0
	9	0	0	0	0
1 % Concentration	0	0	0	0	0
	3	15.864	1.914	54.158	14.4
	6	19.189	2.35	68.321	18.8
	9	18.255	2.255	60.791	19
2% Concentration	0	0	0	0	0
	3	15.443	1.944	49.705	19.6
	6	17.973	2.272	54.2	23.8
	9	16.098	2.186	49.6	20.8

4.1.1 Effect of surface treatment on tensile properties of composites

Figure 4.1 and 4.2 shows the effect of surface treatment on tensile strength and tensile modulus of coir fiber reinforced epoxy composites respectively. It is evident from the figures that both tensile strength and tensile modulus of composites increases with surface treated fibers as compared to untreated one. This is because surface treatment with alkali removes the lignin and pectin to a certain extent and the new surface displays better adhesive properties with the matrix and hence better mechanical properties. The tensile strength of the composites treated with 1% NaOH solution display better strength as compared to that by 2% NaOH solution.This is because 1% NaOH improves the surface just the optimum amount by removing lignin, pectin etc such that fibre stregth is not compromised in comparison to 2% NaOH treated composite.

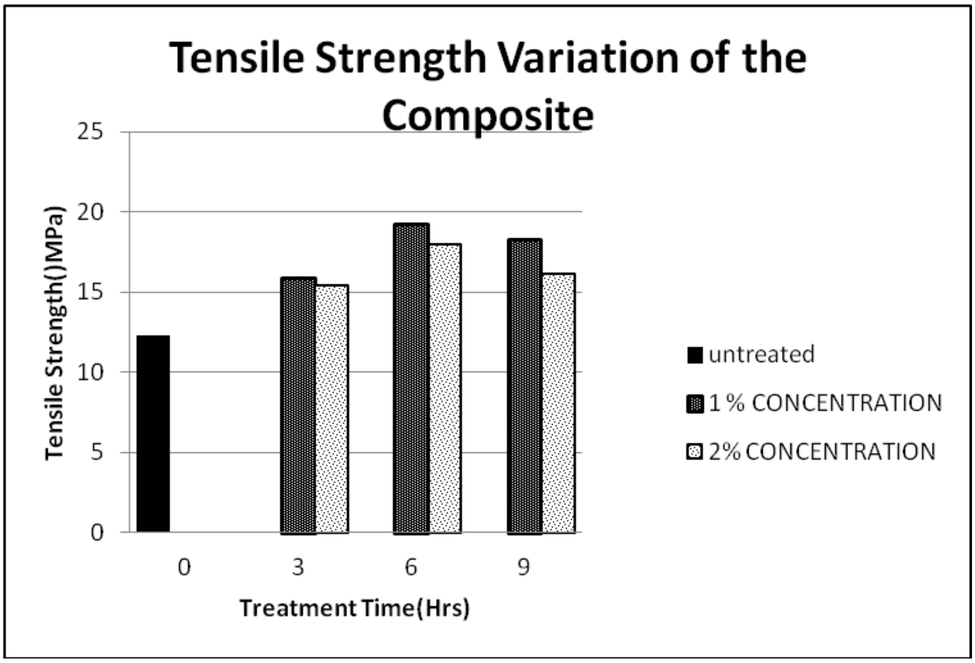


Figure 4.1 Effect of surface treatment on tensile strength of composites

It has also been observed that with the increase in the treatment time or the soaking time of the fibres increases the tensile properties to a certain extent and beyond that further increase in soaking time decreases the properties.This can be owed to the fact that at 6hrs enough surface modification takes place such that the resulting interfacial bonding with the matrix is stronger and hence tensile values are greater. But in case of 9hrs treatment time the degradation of surface is much more and it results in loss of strength of the fibre which cannot be even compensated by the strong interfacial bonding with the matrix. Hence the tensile strength values are lower than that of 6hrs specimen.The effect of time on tensile modulus of composites also shows the similar trend.

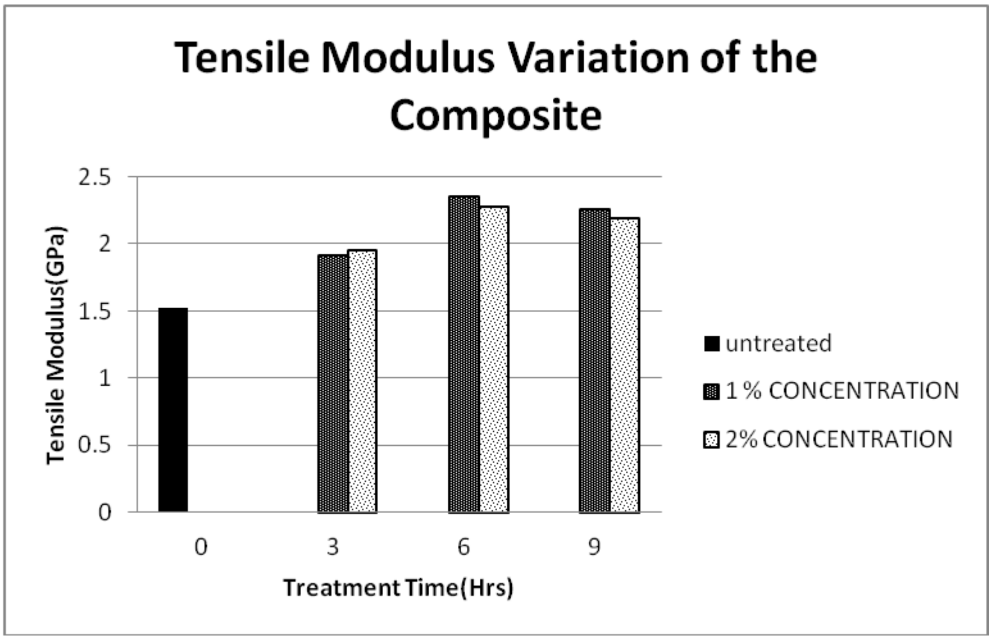


Figure 4.2 Effect of surface treatment on tensile modulus of composites

4.1.2 Effect of surface treatment on flexural strength of composites

Effect of surface treatment on flexural stength of composites is shown in Figure 4.3. It is clear from the figure that the flexural strength values of the untreated fibre are considerably lower than that of the treated fibre.The reason may be due to the removal of impurities from the fibre surface after treatment which leads to the better adhesion of the fibre with the matrix. It is also observed from the figure that the flexural stength values of composite specimen with treated fibers increases with treatment time from 3hrs to 6hrs and then decreases for 9hrs .This can be attributed to the fibres becoming rigid and somewhat brittle afterwards as treatment time progresses and developing more crystallinity causing high strength and low extensibility.When bending stress is applied these fibres tend to break due to increased brittleness and could not conduct effective stress transfer effectively which considerably reduces the strength of the composite. The flexural strength of the composites treated with 1% NaOH solution shows better as compared to that by 2% NaOH solution.

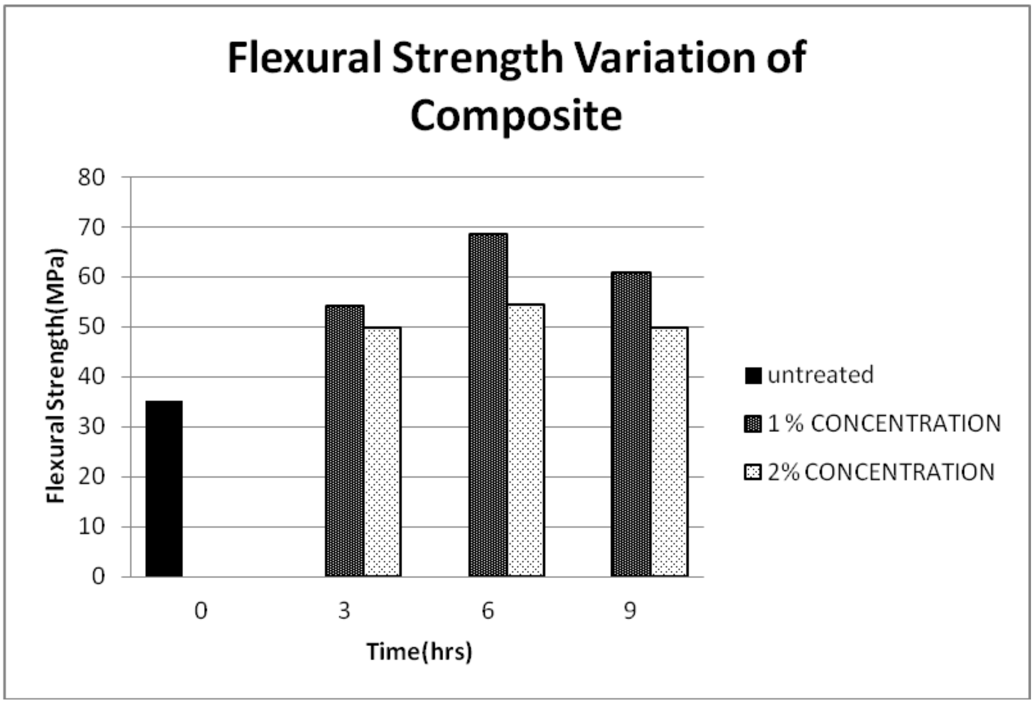


Figure 4.3 Effect of surface treatment on flexural strength of composites

4.1.3 Effect of surface treatment on hardness of composites

Figure 4.4 shows the effect of surface treatment on hardness of composites. It is evident from the figure that there is increase in hardness of composites with treated fiber as compared to untreated one. However, as far as effect of %concentration on NaOH is concerned, 2% NaOH concentration shows maximum hardness value irrespective of treatment time.

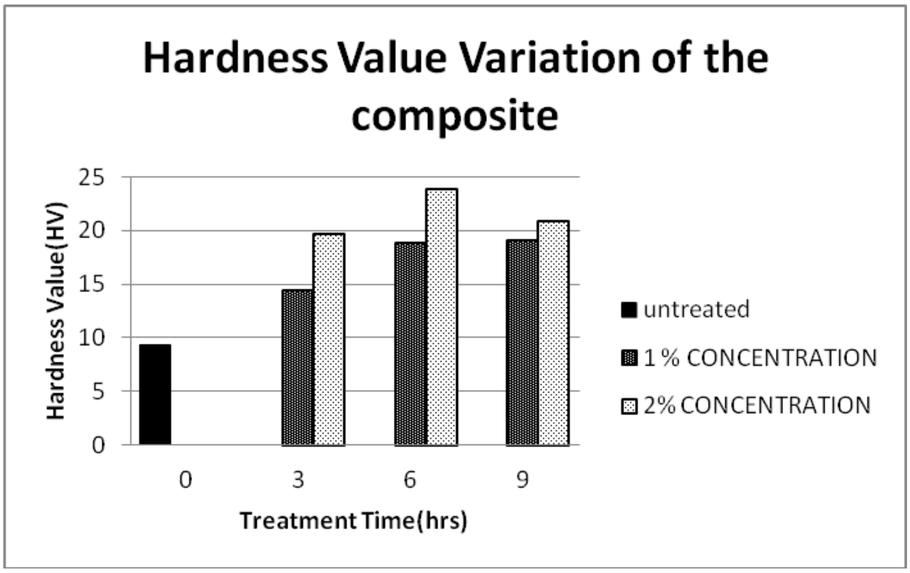
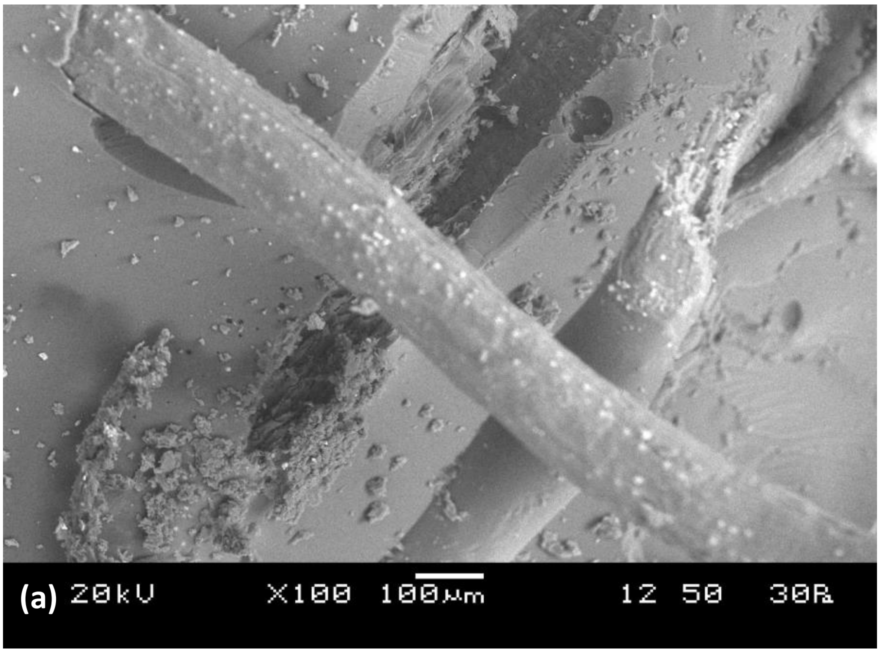
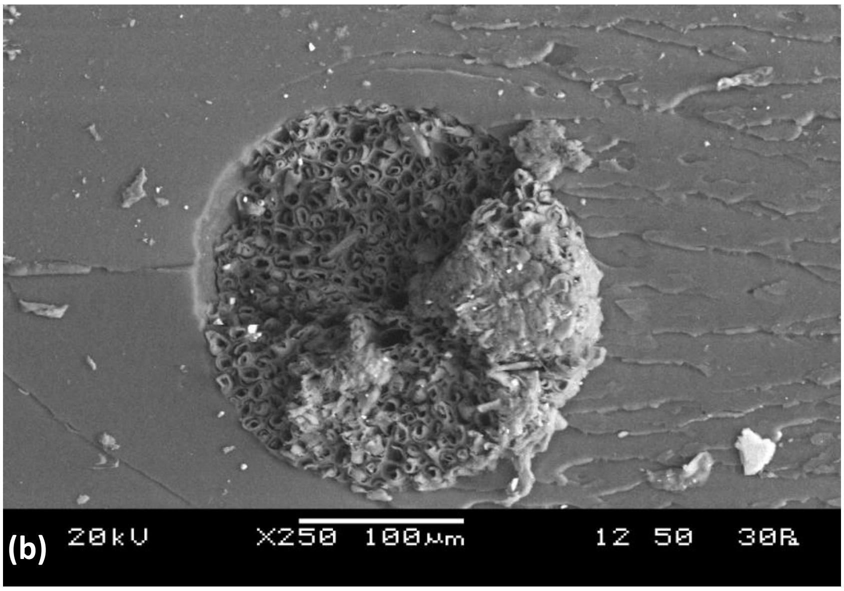


Figure 4.4 Effect of surface treatment on hardness of composites

4.2 Surface Morphology of Composites

The fractured surface study of the coir epoxy composite after the tensile test is shown in the Figures 4.5a-c.The SEM image of the fractured surface shows the various details of the fibre matrix interaction, fibre bonding ,fibre pullout, and surface topology. Figure 4.5a shows the tensile fracture of composite specimen reinforced with 10wt% fiber loading at 5mm fiber length. It can be clearly seen from the figure that the fibers pull out from the resin surface due to poor interfacial bonding. Fracture surface of composites reinforced with surface treated fibers with 1% NaOH concentration shows smooth surface and no pull out of fiber leads to the better compatibility between fibres and epoxy matrices as shown in Figure 4.5b. However, further increase in NaOH concentration up to 2% shows poor adhesion between fiber and matrix as shown in Figure 4.5c. From the figures it is clear that the surfacee modified composites shows better compatibility between fiber and matrix as compared to untreated fiber based composites.





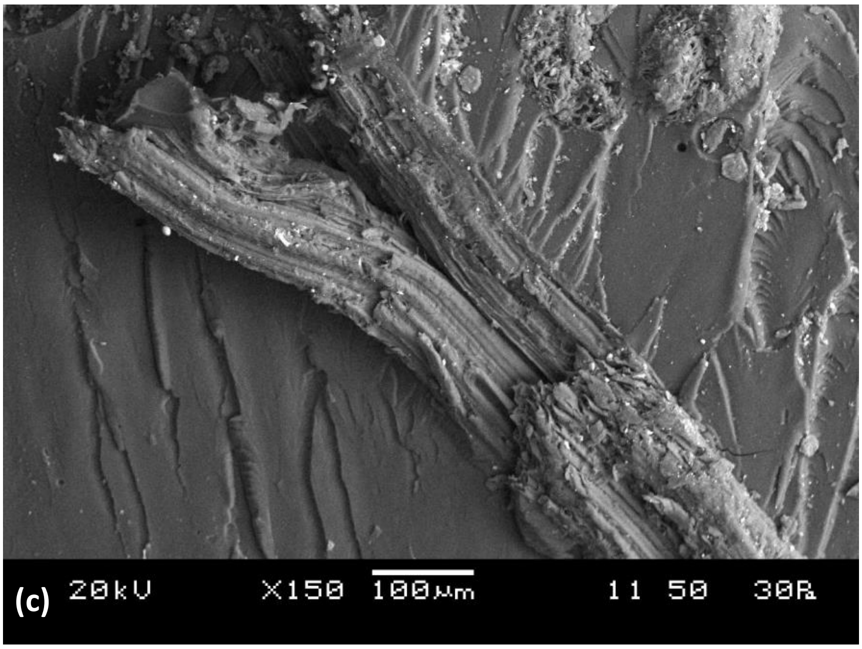


Figure 4.5 Scanning electron micrographs of coir fiber reinforced epoxy composite specimens after tensile testing with treated and untreated fibers

CHAPTER 5

CONCLUSIONS

This experimental investigation and analysis of mechanical behaviour of coconut coir reinforced epoxy composites leads to the following conclusions:

- Successful fabrication of alkali treated coir fibre reinforced epoxy composites is possible by simple hand lay-up technique.
- It has been noticed that the mechanical properties of the composites such as micro-hardness, tensile strength, flexural strength etc. of the treated composites are better than that of the untreated one.
- The study also shows that the mechanical properties such as tensile strength, flexural strength, micro hardness etc are greatly influenced by the different concentrations of alkali treatment and the treatment time for each specimen. The tensile and flexural strength of the composites treated with 1% NaOH solution shows better as compared to that by 2% NaOH solution.
- The fracture surfaces study of coir fibre reinforced epoxy composite after the tensile test has been done. From this study it has been concluded that better interfacial bonding resulting from better adhesion between matrix and fibre as a consequence of the surface treatment has improved the mechanical properties and fibre strength resulting in lesser fibre pull-out.

5.1 Future Scope

Future study on coir epoxy composite has wide scope in the future. Researchers can consider other aspects of study such as fibre length, fibre loading, matrix material, fibre orientation, loading pattern on the mechanical behaviour of the coir epoxy composite. Varying these parameters can extend the available knowledge of dependence of mechanical behaviour on these factors and the resulting experimental findings can be similarly analysed.

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