ISSN (Online): 2455-7838
SJIF Impact Factor : 6.093

EPRA International Journal of

Research & Development

(IJRD)

Monthly Peer Reviewed & Indexed
International Online Journal

Volume: 4, Issue:5, May 2019

Published By
EPRA Publishing

SJIF Impact Factor: 6.093 Volume: 4 | Issue: 5 | May| 2019 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Peer Reviewed Journal

MECHANICAL PROPERTY EVALUATION OF COIR – NYLON HYBRID COMPOSITE MATERIAL

Muralikrishnan V .R. P
Maha Barathi Engg College ,Cinnasalem, T.N, India

M.Muthuvel
Assistant Professor & HOD, Maha Barathi Engg College ,Cinnasalem, T.N, India

C.Yuvaraj
Assistant Professor, Maha Barathi Engg College ,Cinnasalem, T.N, India

ABSTRACT

Coconut fibers are gaining importance in the manufacturing of hybrid Fiber laminates. Coconut coir fibers should be chemically treated with diluted sodium hydroxide solution before using it to manufacture the composite material. The effect of surface modification on chemically treated fiber for mechanical properties such as tensile strength, flexural strength, impact strength and hardness of the composites were evaluated. Compared with the untreated coir composite and treated epoxy composites it was found that the tensile strength increased by 33% and elongation at break was found to be 20% greater. The flexural strength increased by 35% and impact strength doubled compared to the untreated coir composite material. The results showed that the chemical modification in the coir fiber led to easier permeating of the coir fiber and epoxy resin and promoted effective interfacial adhesion. It was concluded that the mechanical properties enhanced after chemical treatment and improved the formation of chemical bonds between the coir/nylon epoxy resins with the coupling agent.

CHAPTER 1
INTRODUCTION

Recenttechnological breakthroughs and the desire for new functions generate an enormous demand for novel hybrid materials. Many of the well-established materials, such as metals, ceramics or plastics cannot fulfil all technological desires for the various new applications. Scientists and engineers realized early on that mixtures of materials can show superior properties compared with their pure counterparts. One of the most successful examples is the group of composites which are formed by the incorporation of a basic structural material into a second substance, the *matrix.* Usually the systems incorporated are in the form of particles, whiskers, fibers, lamellae, or a mesh. Most of the resulting materials show improved mechanical properties and a well-known example is inorganic fiber-reinforced polymers. Nowadays they are regularly used for lightweight materials with advanced mechanical properties, for example in the construction of vehicles of all types or sports equipment.

The structural building blocks in these materials which are incorporated into the matrix are predominantly inorganic in nature and show a size range from the lower micrometre to the millimetre range and therefore their heterogeneous composition is quite often visible to the eye. Soon it became evident that decreasing the size of the inorganic units to the same level as the organic building blocks could lead to more homogeneous materials that allow a further fine tuning of materials' properties on the molecular and Nano scale level, generating novel materials that either show characteristics in between the two original phases or even new properties. Both classes of materials reveal similarities and differences and an attempt to define the two classes will follow below. However, we should first realize that the origin of hybrid materials did not take place in a chemical laboratory but in nature.

The concept 'green think green' has been introduced to raise the awareness of using environment friendly products in product development. There is increase in demand for environment friendly materials around the globe. These coir materials are generally cheaper than synthetic reinforcement composites. Natural fiber reinforced composites are green composites which are used in automobile industries, since these materials have good impact strength, flexural strength and low density. These composite materials can be produced with low cost and have good characteristics such as renewability, easy to process, low energy requirement for its manufacture.

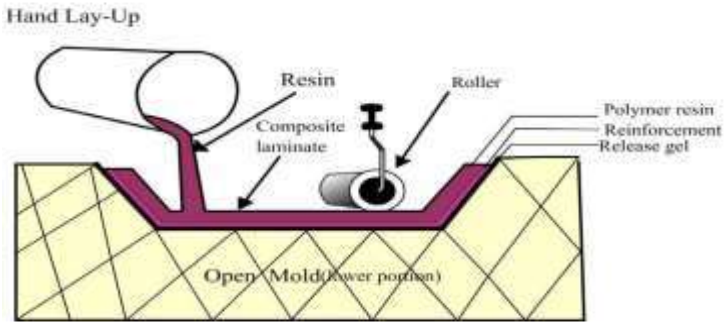
Synthetic fibers are being replaced by natural fibers because of their beneficial properties such as light weight and high strength. Coconut coir is a natural fiber which has been used for many applications such as manufacturing of ropes, floor mats, thermal insulators and also as fuel due of its huge availability (10 x 10^6 tons per year) in India. Research activities in the field of natural fiber materials resulted in this material having found applications in the manufacture of composite particle boards, thermal insulators and building materials.

The potential of incorporating natural fiber in polymers has been addressed well in many literatures. The hydrophilic nature of natural fiber materials because of the presence of lignin and pectin causes adverse effects. It results in issues with adhesion with polymers and reduces the mechanical properties of the produced composite material. Chemical treatment can improve the adhesion between natural fibers and polymers. It was found that the tensile strength and flexural strength improved as a result of alkali treatment. The tensile strength of composite material with palm fiber treated with Sodium Hydroxide was higher than the composite specimen which was not subjected to any treatment. The Sisal fiber reinforced epoxy composites and found that alkali treatment removed the hydrophilic nature of the fiber and improved the bonding strength of composites. Hybrid composite materials are relatively new class of composite material which incorporates two or more reinforcement materials in a single matrix. These materials are a step ahead of composite materials with single reinforcement element.

Hybrid composite material possess improved mechanical properties at low cost and have gained research interest around the globe during the recent years. Also here we have been used filler material for further cost reduction. The combined effect of properties of synthetic and natural fiber enhances the overall properties of the hybrid composite material and also reduces the environmental impact. In this project the effect of mechanical properties on the behavior of hybrid composite material is studied and the resulting property modifications on the prepared composite materials subjected to chemical treatment are discussed. Tensile strength, flexural strength, impact strength and morphological analysis were made on the hybrid composite material containing coconut coir and nylon mat as reinforcement materials on epoxy resin matrix with $CaCo_3$ filler.

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Reinforcement in the form of woven mats or chopped strand mats are cut as per the mold size and placed at the surface of mold after perspex sheet. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing agent) and poured onto the surface of mat already placed in the mold. The polymer is uniformly spread with the help of brush. Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied. After curing either at room temperature or at some specific temperature, mold is opened and the developed composite part is taken out and further processed. The schematic of hand lay-up is shown in figure 1.1. The time of curing depends on type of polymer used for composite processing. For example, for epoxy based system, normal curing time at room temperature is 24-48 hours. This method is mainly suitable for thermosetting polymer based composites. Capital and infrastructural requirement is less as compared to other methods. Production rate is less and high volume fraction of reinforcement is difficult to achieve in the processed composites. Hand lay-up method finds application in many areas like aircraft components, automotive parts, boat hulls, diase board, deck etc.

Fig: 1.1 Hand Layup Method



CHAPTER 2
LITERATURE REVIEW

The possibility of natural fibers for composite applications in India was initiated by the researchers in National Institute for Interdisciplinary Science and Technology, Council of Scientific & Industrial Research, Thiruvananthapuram, India (Sathyanarayana et. Al. (1982))[1]. Fibers from different structural parts of the coconut palm tree have been examined for properties such as size, density, electrical resistivity, ultimate tensile strength, initial modulus and percentage elongation by Sathyanarayana et. Al. (1982)[2] . They observed the width and density for various parts of coconut tree and their observation is given in Table 2.1. No significant variation of mechanical properties with change in diameter of the fibers was observed in the study conducted by Mukherjee et al (1984).

Satyanarayana et. Al. (1990) [3] has been observed that it becomes evident that newer composites using abundantly available natural fibers are on the horizon, thus bringing new trends in composite materials.

Table 2.1 Different types of fiber from coconut tree

Fibers	Width or diameter(μm)	Density (Kg/m³)
Rachis	350-400	610
Rachilla	200-400	650
Spathe	150-400	590
Leaf sheath (inside top)	300-600	630
Leaf sheath (thick fibers)	1100-1600	1190
Leaf sheath (middle fibers)	300-1000	750
Bark of the petiole	250-550	690
Root	100-650	1150
Coir	100-450	1150

For the development of coir products, Coir Board - a statutory body was established by the Government of India under a legislation enacted by the Parliament namely Coir Industry Act 1953 for the promotion and development of Coir Industry in India as a whole. The research works are carried out for the development of coir products at the following centres.

- Central Coir Research Institute , Alappuzha, Kerala
- Central Coir Research Institute , Alappuzha, Kerala
- National Coir Training & Design Centre (NCTDC), Alleppey, Kerala.
- Coir Research and Extension Centre, Thenkasi, Tamilnadu.

The Regional office of coir board is located in Tamilnadu at Pollachi to carryout research in locally available coir fibers. The support of Development officer, Coir board, Pollachi was utilized to strengthen this research work. Christy Fernandez (2003) [4] pointed out the need of R&D efforts in the field of coir fiber composites product innovation and diversification especially to make coir composites. There are also several other exciting opportunities for coir composites as in the field of automobile components, especially for its interiors, and for products like crates, pallets, corrugated containers etc. in the packaging industry, and many other household and restaurant articles like trays and plates. However it is their mechanical reliability, durability, recycle ability, end of the life disposability and above all cost effectiveness are the factors that determines the preference for use of coir composites.

Montero et al (2008) [5] evaluated structural characteristics and mechanical properties of coir fiber-polyester composites. They analysed variation of the flexural strength with the mass fraction of coir fibers and moulding pressure. The results obtained for flexural strength allowed the comparison of the technical performance of the composites with other conventional materials.

Static mechanical properties of randomly oriented intimately mixed Hibiscus sabdariffa fiber reinforced polymer composites such as tensile, compressive and wear properties were investigated as a function of fiber loading. By Singha et al (2008) [6].

Harish et al (2009) [7] investigated the mechanical properties of randomly oriented coir composites mixed with epoxy resin and suggested for low load applications. They reported that the Coir-epoxy composites exhibited average values for the tensile strength, flexural strength and impact strength of 17.86 MPa, 31.08 MPa and 11.49 kJ/m^2 respectively.

Mechanical strengths of composites reinforced with different natural fibers have been investigated by several researchers in the recent past. During characterization of jute fiber reinforced polypropylene composites, it was observed that the mechanical properties like tensile strength, flexural strength and impact strength were better when jute fibers are pre-treated with urea than when used as raw ones (Rezaur Rahman et al. 2010) [8]**.** A study on jute and glass fiber reinforced epoxy laminates reported that the tensile and flexural strength of composites were enhanced when glass fibers are used as extreme plies during fabrication (Soma Dalbehera & Acharya 2014) [9].

Diameter of fibers and its surface treatment has more influence on composite properties. An investigation on date palm fibers reinforced epoxy laminates showed an increase in tensile strength as a result of decrease in fiber diameter and the decrease in diameter happens during surface treatment (Abdal-hay et al. 2012) [10]. Investigations on oil palm fiber reinforced phenol formaldehyde composites reported that the incorporation of chemically modified oil palm fibers in composites improved the impact resistance and tensile properties (Sreekala et al. 2000) [11].

In another work areca fibers are chemically treated and reinforced in to epoxy matrix. The impact strength and hardness of composite increases directly with the fiber volume fraction and post curing time (Srinivasa & Bharath 2011) [12]. A study on flax fibers reported that tensile strength and tensile modulus of composites increased due to the inclusion of flax fibers in caseinate plastics when compared to plastics without reinforcements (Fossen et al. 2000) [13]. A research has been done to evaluate the tensile, flexural and impact strength of coir and bagasse fiber reinforced hybrid composites and concluded that a combination of 30 % coir and 10 % bagasse fibers when reinforced with polyester resin gives optimum values of mechanical strengths (Sivaraj & Rajeshkumar 2014) [14]..

CHAPTER 3
CONCEPT AND OVER VIEW OF COMPOSITES

3.1 COMPOSITES EFINITION

A composite material is made by combining two or more materials to give a unique combination of properties, one of which is made up of stiff, long fibres and the other, a binder or 'matrix' which holds the fibres in place.

Kelly very clearly stated that the composites should not be regarded simple as a combination of two materials. In the broader significance; the combination has its own distinctive properties. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them.

Beghezan defined as “The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings", in order to obtain improved materials.

Van Suchetclan explained composite materials as heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property

3.2 COMPOSITES PROPRTY

Composites consist of one or more discrete phases embedded in a continuous phase to produce a multiphase material which possesses superior properties that are not obtainable with any of the constituent materials acting alone. These constituents remain bonded together but retain their identity and properties. The continuous phase which is present in greater amount in composites is termed as matrix. The discrete phase is generally harder and stronger than the continuous phase and is called the reinforcement or reinforcing material. The geometry of the reinforced phase is one of the major parameter in determining the effectiveness of the reinforcement. Properties of composites are strongly depend on the characteristics of their constituent materials, their distribution and the interaction among them. Further, the need of composite for high strength to weight ratio, corrosion resistance, lighter construction materials and more seismic resistant structures has placed high emphasis on the use of new and advanced materials that not only decreases weight but also absorbs the shock & vibrations through tailored microstructures. Modern and ancient applications all make use of the fact that composites can possess enhanced strength, stiffness and fracture, toughness whilst not exhibiting an increase in weight. Composites are being used for prefabricated, portable and modular buildings as well as for exterior cladding panels.

3.3COMPOSITE CONSTITUENTS

Most composites consist of a bulk material (matrix) and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix.

Matrices materials in composites are required to fulfill the following functions:

- To bind together the fires by virtue of its cohesive and adhesive characteristics
- To protect them from environments and handling.
- To disperse the fibers and maintain the desired fiber orientation and spacing.
- To transfer stresses to the fibers by adhesion or friction across the fiber-matrix interface when the composite is under load, and thus to avoid any catastrophic propagation of cracks and subsequent failure of composites.
- To be chemically and thermally compatible with the reinforcing fibers.
- To be compatible with the manufacturing methods which are available to fabricate the desired composite components.

3.4 EPOXY RESIGN Epoxy resins are characterized by the presence of more than one1, 2- epoxide groups per molecule. Cross- linking is achieved by introducing curatives that react with epoxy and hydroxyl groups situated on adjacent chains.

3.5 REINFORCEMENT

The objective of the reinforcement in a composite material is to enhance the mechanical properties of the resin system. All of the distinct fibres that are used in composites have distinct properties and so affect the properties of the composite in different ways. For most of the applications, the fibres need to be arranged into some form of sheet, known as a fabric, to make handling possible.

CHEPTER 4
CLASSIFICATIONOF COMPOSITE
4.1PARTICULATE OMPOSITE

A particulate composite is composed of particles suspended in a mixture. As the name signifies itself that reinforcement is of particle nature. It may be spherical, cubic, tetragonal, a platelet, or other shape, but it is approximately equal. Normally, particles that are not very effective in improving fracture resistance, they increase the stiffness of the composite to a limited extent. There are two subclasses of particulates, flake and filled/skeletal. A flake composite is generally composed of flakes with large ratios of platform area to thickness, suspended in a matrix material. A filled/skeletal composite is composed of a continuous matrix filled. Particle fillers are widely used to improve the properties of matrix materials to modify the thermal and electrical conductivities, improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve machinability, increase surface hardness and reduce shrinkage.

4.2 FIBROUS COMPOSITES

A fiber is defined by its length which is much greater than its cross-sectional dimensions. Fibers are very effective in improving the fracture resistance of the matrix because reinforcement having a long dimension opposes the growth of cracks normal to the reinforcement that might otherwise lead to failure, particularly with brittle matrices. Fibers, because of their small cross-sectional dimensions are not directly usable in engineering applications. They are therefore embedded in matrix materials to form fibrous composites. The matrix serves to bind the fibers together, transfer loads to the fibers and protect them against environmental attack and damage due to handling. Fibrous composite can be subdivided into - continuous fiber (large aspect ratio), discontinuous (short) fiber (low aspect ratio) and hybrid.

The fibrous reinforcing constituent of composites may consist of thin continuous fibers or relatively short fiber segments. When using short fiber segments, fibers with high aspect ratio (length to diameter ratio) are used. Continuous fiber reinforced composites are generally required for high performance structural applications. The specific strength (strength to density ratio) and specific stiffness (modulus to density ratio) of continuous carbon fiber reinforced composites can be superior to conventional metal alloys. Also depending upon how fibers are oriented within the matrix, composites can be fabricated into products that have structural properties specifically tailored for a particular use. Polymer concretes are increasingly being used in buildings and other structures. They represent a new type of structural material capable of withstanding highly corrosive environments. The high strength to weight ratio and non-corrosive characteristics of these materials like fiber-reinforced plastics can be utilised to build innovative structures, which are, desirable and economical.

4.3 CONTINUOUS FIBER

Continuous fiber composites can be either single layer or multilayered. The single layer continuous fiber composites can be either unidirectional or woven, and multilayered composites are generally referred to as laminates. The material response of a continuous fiber composite is generally orthotropic.

4.4 DISCONTINUOUS FIBER

Material systems composed of discontinuous reinforcements are considered single layer composites. The discontinuities can produce a material response that is anisotropic, but in many instances the random reinforcements produce nearly isotropic composites.

4.5 HYBRID FIBRE

Composite materials incorporated with two or more different types of fillers especially fibers in a single matrix are commonly known as hybrid composites. Hybridisation is commonly used for improving the properties and for lowering the cost of conventional composites. There are different types of hybrid composites classified according to the way in which the component materials are incorporated. Hybrids are designated as i) sandwich type ii) interply iii) intraply and iv) Intimately mixed. In sandwich hybrids, one material is sandwiched between layers of another, whereas in interply, alternate layers of two or more materials are stacked in regular manner. Rows of two or more constituents are arranged in a regular or random manner in intraply hybrids while in intimately mixed type, these constituents are mixed as much as possible so that no concentration of either type is present in the composite material.

Traditional fiber reinforced polymer (FRP) composite that is often fabricated from single type of reinforcement has shown its ability to replace the conventional metallic material counterparts. However, due to several stringent requirements on ductility, this has affected the performance of FRP composites for the structural applications. Therefore, hybrid composites, which combine two or more fiber reinforcements, have been introduced.

CHAPTER 5

NATURAL FIBER COMPOSITES

Natural fibre composites mostly consists fibres of jute, cotton, hemp and non-conventional fibres such as coir and many empty fruit bunches. Natural fibre thermoplastic composites are attractive as they are cheaper, stiffer, paintable, rot-resistant and also can be given the look of wood in addition to all this they have more life- cycle. Natural fibre composites are attractive to industry because of their low density and ecological advantages over conventional composites Natural fibres are lingo cellulosic in nature. These composites are gaining importance due to their non-carcinogenic and bio-degradable nature. Natural fibre composites are very cost effective material especially in building and construction purpose packaging, automobile and railway coach interiors and storage devices. These can be potential candidates for replacement of high cost glass fibre for low load bearing applications. Table 5.1 shows the availability of natural fibers in India.

Fibre	Cellu. content (%)	Lignin content (%)	Dia (μm)	UTS (MN/m²)	Elong. Max. (%)	Elastic Modulus
Banana	64	5	50-250	700-780	3.7	27-32
Sisal	70	12	50-200	530-630	5.1	17-22
Pine apple	85	12	20-80	360-749	2.8	24-35
Coir	37	42	100-450	106-175	47	3-6
Talipot	68	28	80-800	143-263	5.1	10-13
Polymer	40-50	42	70-1300	180-250	2.8	4-6

Table 5.1: The availability of natural fibers in India.

Coir is a natural fibre extracted from the husk of Coconut fruit (Fig. 5.1). The husk consists of Coir fibre and a corky tissue called pith. It is a fibre abundantly available in India the second highest in the world after Philippines. It consists of water, fibres and small amounts of soluble solids. The Table 5.2 shows the percentage contribution of each of these fibres.

Because of the high lignin content coir is more durable when compared to other natural fibres. With increasing emphasis on fuel efficiency, natural fibres such as coir based composites enjoying wider applications in automobiles and railway coaches & buses for public

Items	Percentages %
Water Soluble	5.25%
Pectine and related compound	3.00%
Hemi – cellulose	0.25%
Lignin	45.84%
Cellulose	43.44%
Ash	2.22%

transport system. There exist an excellent opportunity in fabricating coir based composites towards a wide array of applications in building and construction such boards and blocks as reconstituted wood, flooring tiles etc. Value added novel applications of natural fibres and coir based composites would not go in a long way in improving the quality of life of people engaged in coir cultivation, but would also ensure international market for cheaper substitution.Natural fibres have the advantages of low density, low cost and biodegradability. However, the main disadvantages of natural fibres and matrix and the relative high moisture sorption. Therefore, chemical treatments are considered in modifying the fibre surface properties.

Table 5.2 Chemical composition of Coir

A better understanding of the chemical composition and surface adhesive bonding of natural fibre is necessary for developing natural fibre-reinforced composites. The components of natural fibres include cellulose, hemicelluloses, lignin, pectin, waxes and water soluble substances. The composition of selected natural fibres is shown in Table 5.2. The composition may differ with the growing condition and test methods even for the same kind of fibre. Cellulose is a semi crystalline polysaccharide made up of D-glucopyranose units linked together by β-(1-4)-glucosidic bonds and the large amount of hydroxyl group in cellulose gives natural fibre hydrophilic properties when used to reinforce hydrophobic matrix; the result is a very poor interface and poor resistance to moisture absorption. Hemicellulose is strongly bound to cellulose fibrils presumably by hydrogen bonds. Hemi cellulosic polymers are branched, fully amorphous and have a significantly lower molecular weight than cellulose. Because of its open structure containing many hydroxyl and acetyl groups, hemicellulose is partly soluble in water and hygroscopic. Lignins are amorphous, highly complex, mainly aromatic, polymers of phenyl propane units but have the least water sorption of the natural fibre components. Because of the low interfacial properties between fibre and polymer matrix often reduce their potential as reinforcing agents due to the hydrophilic nature of natural fibres, chemical modifications are considered to optimize the interface of fibres. Chemicals may activate hydroxyl groups or introduce new moieties that can effectively interlock with the matrix. The development of a definitive theory for the mechanism of bonding by chemicals in composites is a complex problem. Generally, chemical coupling agents are molecules possessing two functions. The first function is to react with hydroxyl group of cellulose and the second is to react with functional groups of the matrix.

Visualizing the increased rate of utilization of natural fibres the present work has been undertaken to review development of a polymer matrix composite (epoxy resin) using coir fibre as reinforcement and to study of its mechanical properties and environmental performance.

CHAPTER 6
SELECTION OF RAWMATERIAL
6.1 COCONUR COIR

Hybrid composite material comprising of a natural fiber and a synthetic fiber were to determine the changes in its mechanical properties and morphological behavior. An attempt was made to find the potential of using these unique combinations for making parts such as trays and containers for holding goods, doors, window panes, buckets and mugs. The reinforcement materials were composed of coconut fibers and nylon fibers in woven roving mat form. Epoxy resin provided the necessary binding as well as acted as the matrix material. The coconut coir fibers used in this project work was procured from local coconut husk processing unit in Salem. Coconut fibers were selected as reinforcement material because of its affordability and biodegradable characteristics. The coconut coir fibers were chopped into whiskers of length 10 ~ 20mm and diameter 0.3 mm respectively. To remove moistures from the whiskers it was dried under the sun light for 3 days.

6.2 NYLON FIBER

Nylons are aliphatic polyamides, which was the first synthetic fiber to be commercialized (1939). Nylons are derived from a diamine and a dicarboxylic acid. Because a variety of diamines and dicarboxylic acid can be produced, there are very large number of polyamide materials available to prepare Nylon fibers. The most common versions are Nylon 66 and Nylon 6. Nylon 66 which is widely used as fiber is made from adipic acid and hexamethylene diamine. The commercial production of Nylon 6 begins with carprolactum. Nylon fiber has outstanding durability and excellent physical properties. The main features are exceptional strength, high elastic recovery, abrasion resistance, lusture, washability, resistance to damage from oil and many chemicals, high resilience, colourability, smooth, soft and long lasting fibers from filament yarn, light weight and warm fabrics from spun yarn. Like polyester fiber, Nylon has high melting point which conveys good high temperature performance.

The nylon fiber mat measured 300 mm long and 300 mm wide. The diameter of nylon fibers was 0.3 mm approximately were used for our project.

6.3 EPOXY RESIN

Epoxy resin Araldite LY 556 was selected as the resin and Araldite HY 951 as the hardener was mixed in the ratio of 10:1. The combination of resin and hardener provided dual purpose of acting as binding agent and also as matrix element in the hybrid composite material.

Epoxy is the matrix materials used and it consists of medium viscosity, room temperature curing 9 hardener along with diluent DY 02. All these materials are supplied by Hindustan Ciba Giegy Ltd, Mumbai, India. The properties of the materials are listed in Table 6.1. In general, the thermoset polymeric epoxy resin consists of superior properties such as good mechanical properties, enhanced chemical and corrosion resistance and ease of processing. Due to its wide applications, epoxy resin was selected as the matrix material for the current study.

Table 6.1 Ingredient of Matrix System

Ingredients	Trade Name	Chemical Name	Density (g/cm³)	Supplier
Epoxy Resin	LY 556	Diglycidal Ether of bisphenol A (DGEBA)	1.16	Hindustan Ciba Giegy Ltd
Hardener	HY 951	Triethylenetetramine (TETA)	0.95	

6.4 CALCIUM CARBONET FILLER

Calcium carbonate, which is also referred to as Calcium tri-oxocarbonate ($CaCO_3$), is one of the most widely available chemical compounds on the earth.

It occurs naturally in the earth crust, and is said to make up approximately 7 % of the earth's crust.

The $CaCO_3$ has different common names such as calcite, limestone, chalk, pearl, marble, aragonite, etc. Here we used 5% for cost reduction.

6.5 MIXING RATIO

The binder cum matrix composing of resin and hardener mixture was taken in the ratio of 10:1. Hence 100 ml of hardener was added to one liter of epoxy resin. 8 vol. %of chemically treated coconut whiskers was mixed to the epoxy resin and hardener mixture long with 5% $CaCo_3$ filler.

CHAPTER 7
ALKALINE TREATMENT ON COIR FIBER

The hydrophilic nature of coconut coir acts as undesirable characteristics which makes it unsuitable for many industrial applications. Some of the ill effects of hydrophilic nature of coconut coir include the growth of pathogens and enlargement of coir by absorption of moisture from the surrounding air. The coconut coir was chemically treated in order to remove the lignin and pectin capable to degrading its properties under the influence of moisture.

The alkali treatment of the coir were carried out in a container. A solution containing 5 % Sodium Hydroxide (NaOH) in water was added to coir. The solution was allowed to react with the whiskers for 60 mins and then drained. The chemical reaction that takes place during the treatment of the coconut fiber is shown in equation

Coconut fiber + NaOH (O) + Na + Coconut threads

The resulting coconut whiskers with its hydrophilic nature removed were washed in distilled water to remove the traces of NaOH. The whiskers were then dried under sunlight for three days to remove excess moisture in its surface

CHAPTER 8
FABRICATION PROCEDURE

The specimens were manufactured to evaluate the variation in its mechanical properties and compare the same with the existing material for desired appliance. The composite materials were manufactured using hand layup technique because of its capability of making large sized composite material at relatively lower cost.

EHFUTC: Epoxy Resine, Hardner, Filer and Untreted

EHFUTC: Epoxy Resine, Hardner, Filer and Untreted

EHFUTC: Epoxy Resine, Hardner, Filer and Untreted

Figure 8.1: Samples of Hybrid Coconut Fiber with Epoxy Resin

Table 8.1: Code of Simples for Composite Materials

CODE	ABBREVIATIONS
EHFUTC	Epoxy resin hardener Filler and untreated coir
EHFTC	Epoxy resin hardener Filler and treated coir
EHFTCN	Epoxy resin hardener Filler and treated, coir with nylon

A flat metallic mould plate of size (300 X 300X5) mm was used for manufacturing of the composite materials. Polyethylene sheets covered with wax were used as separating layers to avoid sticking of the composite material to the mould. The binder cum matrix composing of resin and hardener mixture was taken in the ratio of 10:1. Hence 100 ml of hardener was added to one liter of epoxy resin with 5% of CaCo3 filler. 8 vol. %of chemically treated coconut whiskers was mixed to the epoxy resin and hardener mixture.

The resulting mixture was poured evenly over the polyethylene sheet which was laid over the metal mould plate. The nylon mat was placed over the binder cum coconut whisker mixture. The nylon mat was topped with a second layer of the binder cum coconut whisker mixture by hand layup technique. This arrangement gave 2/1 layup for the produced composite laminate. The polyethylene sheet was used as cover over the top layer of binder and whisker mixture. A flat wooden plate was place over the top polyethylene sheet. Then weights were kept over the surface of the wooden plate. The weights gave the necessary force to press the components of the composite material and spread it evenly along the nylon mat.

The excess materials which came out along the sides of the mould were scrubbed out. The layup was left untouched for duration of 24 hours so as to allow sufficient setting time and curing. Then the cured composite material was removed from the mould. The thickness of the composite material was measured as 3 to 5 mm (4+/-1). A second composite material was manufactured through the same process, but without the addition of nylon mat.

The thickness of the resulting composite material was same as the one produced with nylon mat. A third composite material was prepared with the absence of nylon mat. However this composite material had untreated composite whiskers to compare the variation of its properties under the influence of hydrophilic nature of the **CHAPTER 9**

MECHANICAL CHARACTERIATION

The mechanical properties such as tensile strength, flexural strength, impact strength and hardness were measured on the produced composite material. FIE Universal Testing Machine as shown in Fig. 9.3 having loading capacity of 10kN was used to conduct the tensile test on the composite materials. The specimen was cut into dog bone shape as per ASTM standard ASTM: D638-10 for taking the tensile test as shown in Figure 9.2.

Fig: 9.1 Specimen Size

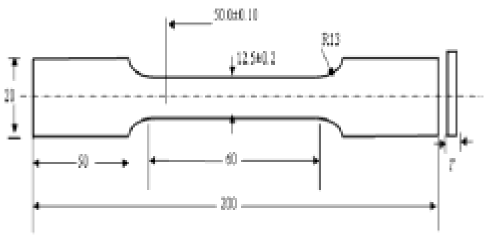


Fig: 9.2 Specimen Photo

Fig: 9.3 UTM Machine

CHAPTER 10
RESULTS AND DISCUSSION
10.1MECHANICAL PROPERTIES OF THE COMPOSITES

Mechanical properties of the three composite materials were evaluated to determine its capability to withstand externally applied load. The tensile strength as well as the percentage of elongation was noted to increase with the applied load after the solution treatment using NaOH. Impact strength of the solution treated component was found to decrease when compared with that of untreated counterpart. This was because as the reinforcement material which possessed higher hardness was included in the matrix element, it affected the overall properties of the composite material. The phenomenon was noticed with the presence of defects as the reinforcement composition increased. In comparison between the treated and untreated composite materials, the former had superior mechanical properties. The tensile strength increased by 33%, elongation was found to increase by 20%, while its impact strength lowered by 35%. The good bonding between the coir and epoxy was one of the reasons for this improved property modifications.

10.2 TENSILE STRENGTH

The tensile strength of three different composite samples is given in Table 10.1. The yield strength and the ultimate strength of the composite material with untreated coir was found to be 0.0096 kN/mm2 and 0.015 kN/mm2 respectively. The corresponding mechanical properties of the composite material with treated coir showed an increase of 40% and 12% respectively. However the same properties were found to increase by 61% and 51% after inclusion of nylon fibers as the reinforcement in the composite material. This indicates that the elastic nature of the nylon fabrics integrated into the overall properties of the produced composite material. The plot shown in Fig. 10.1 indicates that the yield strength increased linearly due to chemical treatment of the coir and also the inclusion of nylon fibers as its constituents. However the ultimate strength of the composite materials was noted to increase at a different rate. The chemical treatment of the coir resulted in improving its mechanical strength. However the treatment process on the coir made it to shift its nature towards brittle. This drawback was avoided by including the nylon fiber, which successfully shifted the composite material behavior to act as ductile material. Fig. 10.3 proves this claim, in which it can be observed that the chemically treated composite material had lower percentage of elongation (7.01%) compared to the composite material with non-treated coir (9.08%). The chart indicates that by adding nylon fibers the percentage of elongation of the resulting composite material increased to 9.60%.

Table 10.1 Tensile test results of different composites

Sl.no	Sample code	Yield strength (kN/mm^2)	Ultimate strength (kN/mm^2)	Elongation (%)	Hardness Barcol HBa
1	EHFUTC	0.0096	0.015	9.08	20.52
2	EHFTC	0.013	0.017	7.01	24.40
3	EHFTCN	0.015	0.022	9.60	24.48

. The relationship between stress and strain between the three composite materials are noted. Besides the brittle nature of composite material containing chemically treated coir the capacity to withstand higher stress was found to be higher than its counterpart with untreated coir. The addition of nylon fiber improved the stress bearing capacity of the composite material. The synthetic reinforcement material in the composite had higher mechanical properties compared to the natural matrix element. This resulted in the improvement of its stress bearing capability.

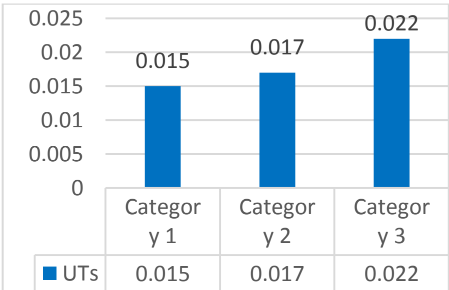


Fig. 10.1: Comparison Chart for Ultimate Strength

Category 1: Epoxy resin hardener Filler and treated coir

Category 2: Epoxy resin hardener Filler and treated coir

Category 3: Epoxy resin hardener Filler and treated coir with nylon

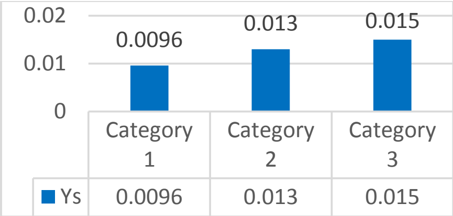


Fig. 3.2: Comparison Chart for Yield Strength

Category 1: Epoxy resin hardener Filler and treated coir

Category 2: Epoxy resin hardener Filler and treated coir

Category 3: Epoxy resin hardener Filler and treated coir with nylon

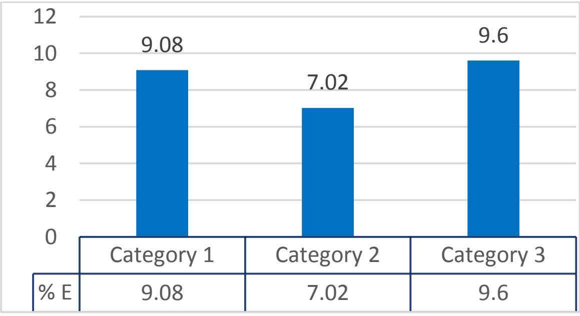


Fig. 3.3: Comparison Chart for Elongation

Category 1: Epoxy resin hardener Filler and treated coir

Category 2: Epoxy resin hardener Filler and treated coir

Category 3: Epoxy resin hardener Filler and treated coir with nylon

10.3 EFFECT OF CHEMICAL TREATMENT

The hydrophilic nature of coir induces undesirable properties such as increasing the porosity between the fiber and the epoxy resin matrix. This will hinder the transfer of stress evenly along the matrix and reinforcement, leading to mechanical failure during the usage of the composite material. The coir has to be treated chemically in order to remove the hydrophilic nature. If the epoxy resin flows properly around the coir fibers then the fibers will be held tight and grip within the matrix element. Many authors have indicated an increase in mechanical properties with chemical treatment. Increase in mechanical properties and fiber wettability was observed with chemical treatment. In this experiment, composite samples with chemically treated coir pith showed better tensile strength values compared to the samples with untreated coir pith. Treatment of coir pith in alkaline environment promotes the activation of hydroxyl groups of cellulose unit by breaking hydrogen bonds, which in turn makes its less hydrophilic.

10.4 CHEMICAL RESISTENCE TESTS

The incorporation of raw coir pith decreased the chemical resistance of epoxy resin. However, chemically treating the coir pith and inclusion of nylon fabric enabled to overcome the undesirable property reductions in the composite material. It was noted that though the values were found to be higher than raw coir epoxy the hybrid composites showed a lesser solvent uptake which increased chemical resistance compared to coir pith/epoxy composite without nylon fiber. Composite samples with chemically treated samples showed better solvent resistance which was higher than pure epoxy resin. This was due to increased interfacial bonding between pith and epoxy on chemical treatment resulting in reduced void content and also due to reduction in its hydrophilic nature. These factors offer higher resistance to solvent movement of solvent molecules into the composites system. Restricted equilibrium technique has been used as a tool by many researchers to analyze the filler-matrix bonding in the composites system. It was reported that increased interfacial interaction resulted in lower solvent uptake by composites systems. Therefore the solvent uptake in solvent resistance for composites systems with treated coir pith may due to the increased interfacial interaction between filler and matrix.

CHAPTER 11
CONCLUSION

The effect of surface modification on chemically treated fiber for mechanical properties such as tensile strength, impact strength of the composites were evaluated. Compared with the untreated coir composite and treated epoxy composites it was found that the tensile strength increased by 33% and elongation at break was found to be 20% greater. The flexural strength increased by 35% and impact strength doubled compared to the untreated coir composite material. The results showed that the chemical modification in the coir fiber led to easier permeating of the coir fiber and epoxy resin and promoted effective interfacial adhesion. It was concluded that the mechanical properties enhanced after chemical treatment and improved the formation of chemical bonds between the coir/nylon epoxy resins with the coupling agent.The hybrid coconuts coir fiber with epoxy and Calcium Carbonate filler composite materials were fabricated using hand layup technique successfully and it is a natural hybrid fiber and it very eco-friendly and it is biodegradable.

REFERENCES

1. Sathyanarayana et al (1982): Fibers from different structural parts of the coconut palm tree have been examined.
2. Christy Fernandez (2003): pointed out the need of R&D efforts in the field of coir fiber composites product innovation and diversification especially to make coir composites.
3. Montero et al (2008): evaluated structural characteristics and mechanical properties of coir fiber-polyester composites.
4. Singha et al (2008): Static mechanical properties of randomly oriented intimately mixed Hibiscus sabdariffa fiber reinforced polymer composites such as tensile, compressive and wear properties were investigated as a function of fiber loading.
5. Harish et al (2009): investigated the mechanical properties of randomly oriented coir composites mixed with epoxy resin and suggested for low load applications.