

ANALYSIS OF MECHANICAL PROPERTIES AND CHARACTERIZATION OF BANANA NATURAL FIBER COMPOSITES

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering degree in

Mechanical engineering.

by

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DEPARTMENT OF MECHANICAL ENGINEERING

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **JOESSAM MARIO. J (39150057)** and **KAILASH. S. V (39150060)** who carried out the project entitled **"MECHANICAL PROPERTIES OF ANALYSIS OF MECHANICAL PROPERTIES AND CHARACTERIZATION OF BANANA NATURAL FIBER COMPOSITES"** under my supervision from December 2022 to April 2023.

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ABSTRACT

Presently a day the Natural fiber supported composites definitely stand out enough to be noticed as a result of their benefits like Light weight, Low expense, High porosity, Non-poisonous, Non-grating, Greater explicit firmness, Specific strength, better recyclable. Regular fiber has contributed hugely effective innovation in vehicles and air ventures. Respects to this normal fiber a great deal of exploration has been done all around the world on account of its eco-accommodating nature and has a one-of-a-kind property contrast with engineered fiber. The point of this article is to give fitting as well as generally utilized normal fiber supported polymer composite and their applications. As further, it addresses outline of different surface medicines applied to normal filaments and their impact on properties. This article reports the Extraction cycle of normal fiber, Characterization of regular fiber and readiness of normal fiber built up composite by utilizing pressure shaping. In the grouping of fiber and Resin for both treated and untreated composite and 100 percent of Pure Epoxy Resin composite is are made. Contrasting the treated and untreated composite and unadulterated Epoxy Resin composite through mechanical and morphological examination and there has been a huge change in every single composite. The Mechanical Properties are Tensile strength, Impact strength, Flexural strength. In rigidity treated and untreated examples have shown higher than composite made of just Epoxy Resin. In flexural strength treated and untreated examples have shown higher than composite made of unadulterated Epoxy Resin. In Impact strength treated and unadulterated Epoxy tests have shown higher than composite made of untreated example. There has been a huge change in Nano innovation investigation are Scanned Electron Microscope (SEM), X-Ray Diffraction (XRD), Fourier Transform Infra-Red spectroscopy (FTIR) and Thermo Gravimetric Analysis (TGA). It additionally infers that compound treatment of normal fiber will further develop grip between fiber surface and polymer lattice.

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LIST OF SYMBOLS AND ABBREVIATIONS

LY	Epoxy Resin LY 556 resin LY 556
W_t	Weight of the sample after time t
W_0	Oven dry weight of the sample
MPa	Mega Pascals
I_c	Crystalline index
XRD	X-Ray Diffraction
TGA	Thermo Gravimetry
FTIR	Fourier Transform Infrared Spectrum
SEM	Scanning electron microscope
CQTD	Treated Distilled Water
CQTW	Treated Normal Water
CQTS	Treated Sea Water
CQUTD	Untreated Distilled Water
CQUTW	Untreated Normal Water
CQUTS	Untreated Sea Water

CHAPTER 1

INTRODUCTION

1.1 Natural fibers

Ordinary strands accept a basic part in the ongoing age. These are biodegradable substance, which is having less cost and by using less HR. To utilize as opposed to designed strands/counterfeit fibres we can use typical strands. Previously, all of the endeavours used materials that included composites that were given by man-made tailored fibres. Regardless, as time progresses, the world's resources for constructing composites are evolving to include fibres from natural and synthetic sources. Moreover, by and by, we will create a composite which is contained standard strands. From the tree's aerial roots, we shall get the fundamental material for our project. We'll be testing the composite made from banyan tree raised appends for a wide range of mechanical qualities, including manageability, impact, and flexural flexure.

Banyan tree flying fundamental foundations were used to separate completely biodegradable normal fibres. Antimicrobial qualities that may be employed in the form of a normal product for the benefit of health and hygiene. Fibre extraction conditions for regular, compound, and enzymatic treatments have improved. Prescriptions for blurring and loosening up were suggested for extra tone creation, individualization, and revamping the control of isolated strands. FTIR was used to determine the change in the compound component as a result of salt treatment.' One of the things we looked at using SEM was how various treatments affected fibres' surface shape. Other lignocellulosic strands and fibres with distinct physical and normal qualities were also investigated and distinguished. They discovered that banyan tree strands have the same physical qualities as other typical cellulosic fibres like sisal and jute. The strands feature a variety of qualities, including low strength, moderate stretching, and exceptional moisture recovery and support. In addition, they show mind boggling resistance against bacterial and infectious turn of events, which is exceptionally fascinating on the off chance that there ought to emerge an event of customary cellulosic fibres, making them sensible for conceivable use, especially in neatness things. Various applications to the extent

that fiber composites with fitting materials can similarly be considered.

Fiber is a contamination free material as they discharge less degree of gases that are hurtful to the climate. Numerous normal filaments have been investigated up to this point in order to determine whether or not they are suitable for use in the creation of robust composite designs, and this research has been documented. An investigation on the viability of using ordinary polyester thread as a better support medium in the production of a new standard composite. The filaments are as of now exposed to a few trial examinations like mechanical property, synthetic creation, actual property, warm solidness, glasslike property and morphological investigation, Strength, building up effectiveness. Engineered strands resemble glass fiber, carbon fiber, earthenware fiber, aramids are expensive and salvage to wellbeing in openness condition, and These are against regular filaments.

Normal filaments are biodegradable. They are acquired from nature. The normal strands are similarly reasonable for the climate. They are 100 percent biodegradable and compostable. The regular strands are utilized as composite material where the direction of filaments impacts the properties. Regular filaments are tangled into sheets. Most regular strands are known as a consumed of water and different fluids. These are enjoying benefits like Low thickness, Low expense, High porosity, Non-poisonous, Non-rough, Greater explicit solidness, Specific Strength, more protection from consumption, better recyclable, large weariness strength, more effect retention limit, Lower harmfulness, Plentiful accessibility, reuse capacity, can overrule the utilization of engineered fiber composite, Human government assistance in dealing with, Lightweight. The ongoing work expects to describe the regular strands are gathered from the stem of a Epoxy. This fiber is accessible close to our neighborhood, and our reference from the paper is appeared to have better Strength and hence to check reasonableness of fiber as better is the elective strategy has revealed the tests, we have performed on a characteristic fiber is written in this article. Anything that the examinations we have been accounted for are the Extraction interaction We have chosen calcium hydroxide $\text{Ca}(\text{OH})_2$ and finished the treatment. From that point forward, we have done The Mechanical Properties are Tensile Strength, Impact strength, Flexural Strength.

Morphological assessment is SEM, XRD, FTIR, and TGA and water ingestion test. There are two kinds of strands treated and untreated fiber. In the thermosetting polymer, it has prerequisites about the harder like Epoxy, etc. The thermostatic polymers like Epoxy depend on the fibers' cutting length they would be managed. The thermosetting polymer would be treated for the long length strands, and with the more restricted length the thermostatic polymer. The *Cissus quadrangularis* has taken in view of its high mechanical properties. In the past standard fiber, the Epoxy Resin LY556 and ECMAS Agencies Visakhapatnam, Andhra Pradesh.

The thermosetting polymer and thermostatic polymers have out and out various properties. The fundamental real difference is that thermostatics can be broken up indeed into a liquid, while thermoset is constantly remaining in a very sturdy solid state. Overall, thermoset things are made through the trim association then the liquid polymers and various experts are mixed into a structure pit. As the material cools and sets to the Epoxyn of the opening it goes to the alleviating framework.

Thermostatics are normal materials that disintegrate when warmed they are outlined in a thick stage this generally infers they are warmed, molded then cooled in their last shape. Thermostatics are used due to the loosen up when warmed are easy to frame into an arrangement of shapes and besides advance themselves to reusing. ordinary purposes for thermostatics polymers fuse the manifestations of lines, ropes, belts, separators. The conditioning spot of thermostatic polymers is extremely low basically 58°C to 60°C so it will in general be condensed in hot water and framed the most difficult way possible. It can similarly be cut or ousted safeguarded and biodegradable. Most thermostatics have a high nuclear weight.

The polymer chains collaborate with intermolecular powers which weaken while extending temperature. They are with fibers are connected with their high cellulose content anyway infinitesimal parts are being used in the field of feedstock and energy creation bio-composites have increased present day utilize that would convey the possible results to restrict the wastage of unlimited materials. It creates a non-food market for the agriculture industry. White, silky, and glistening, this medium-length fiber's

great adaptability makes it a favorite among fashionistas. It has a softer surface than other usual strands, and it ingests and retains a wide range of flavors. Process example of undertaking is shown in figure 1.1.

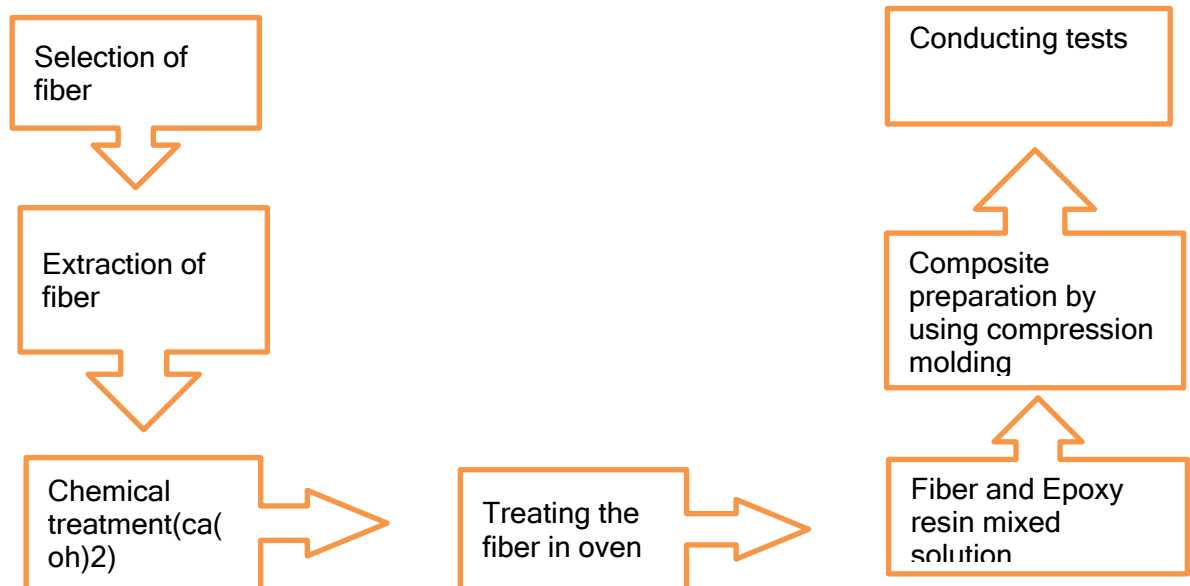


Fig:1.1 : *Process cycle of the project*

CHAPTER 2

LITERATURE SURVEY

Fibers from Banyan and Peepal trees The ICDAMS (2018) reinforced hybrid composites are made by hand Lay-up process... An eight-variety study of banyan-peepal hybrid composite hardness and flexural characteristics is the goal of this research. A variety of fiber composites are also on the list, including banyan-peepal-banyal-banyal fibre composite, peepal-bannyal-banyanal fiber composite, banyan-copper-banyal-copper fiber composite, and peepal copper peepal copper peepal fiber composite.

According to Basu and colleagues (2012) among the Agavaceae family, the most suited Agave sisalana was Agave sisalana (Basu et al., 2006). Semi-perennial, it lives for 7–10 years and yields 200–250 commercially useful leaves per year. In each leaf, an average of roughly 1000 white fibers may be seen. The dried fiber content of sisalana leaves is around 4% by weight. Temperatures over 25 °C and sunlight are ideal for sisal cultivation, making it tropical and sub-tropical in origin (Kirby, 1963). Indian sisal of a certain grade has been selected for export-class cordage production. As a result of import substitution, exporters see an improvement in profitability. Expanded industrial exploitation of natural resources.

Bessadok, A., S. Marais, F. Gouanve, L. Colasse, I. Zimmerlin, I. Zimmerlin, and M. Metayer Moreover, the adhesion between natural fibers and the polymer matrix is insufficient. The Alfa (*Stipa tenacissima*) fiber was subjected to a variety of chemical surface treatments in this research. With the use of substances such as S, acrylic acid, and maleic anhydride (MA), these therapies may be acetylated (MA). Fiber treatment effects have been studied using infrared spectroscopy, surface energy measurements, and microscopy. Alfa fibers water sorption properties have been thoroughly examined in this research study.

Sanjay and others (2019). Natural fiber reinforcement in composites, including preparation, processing, and characterization, is the subject of a detailed study. For natural fiber composites, this is a popular procedure that includes information on chemical treatment, extraction, as well as surface treatment.

Gaurav et.al, (2019). It declares the actual methods in making a composite like polymer matrix, metal matrix and ceramic matrix composite. Because the particles are non-fibrous and don't have lengthy dimensions, the reinforced composite uses particulate reinforcement. Matrix materials may benefit from the addition of these particles. Thermal conductivity, wear resistance, and abrasion resistance are all improved as a result. Fibers are incorporated into the polymer matrix to create a polymer composite. Composites benefit from its excellent tensile and elongation properties. These are classified as thermosetting and thermosstatic. From this the fiber reinforced composite also prepared by embedded fiber into matrix, here matrix bind with fiber and load transferred to fiber. Matrix protects from environment and damage due to handling it also reaches strength as conventional material

Baumbach, et.al., (2020). It declares that composite material selection is fabricated from their information jute or flax with Epoxy resin. It features the most efficient design in terms of stiffness and sectional strength. The maximum stress was found to be greatly raised when flange edge stiffeners were added to channel sections. The channels were fabricated by hand layup method and machine compressing method. In hand layup method the resin is applied with brush and roller on a fabric laid over a split mandrel and extracting after curing. In machine compressing the composite material is Epoxy on split mandrel and applying load on mandrel at certain temperature and extracting composite after curing.

Arun Kumar et.al., (2020). It declares the basic information about mechanical properties of a fiber and basic procedure of a mechanical properties and discussed about Tensile strength, Flexural strength and Impact strength. The tensile strength of the laminate was evaluated by ASTM using a Universal Testing Machine (UTM) with a load capacity of 400 KN and a loading rate of 5 mm/min on a sample prepared in accordance with the American standard for testing and materials (ASTM). Using UTM at room temperature, ASTM specifies a three-point bend test for the flexural test. By employing a Geotech Testing Machine (GTM), a notch is held at an angle of 90 degrees and tested at an ambient temperature according to ASTM standards, and the average load is recorded and also noted. The strength and resistance of the sample are also recorded.

Sudhir Chakravarthy et.al., (2020). It declares the extraction of fiber, chemical treatment and thermal stability analysis. In order to measure the thermal stability of various chemical components in a fiber, a TGA with a differential scanning calorimeter is utilized. In an alumina crucible, 10mg of dried *Cissus quadrangularis* powder was placed in a thermal analyzer. In the thermal analyzer, the temperature rises by 10 °C every minute from ambient temperature to 600 °C.

Siva et.al., (2020). SEM analysis is the subject of this statement. In the matrix of the composite, the microscopic particles may be scanned to assess the bonding of resin and fibers. It is necessary to trim down tensile samples for SEM analysis because of the higher breaking stress and bond between them and determine the particle size up to 10nm and magnification from 20x to 100x for Tensile samples because of the higher breaking stress and link between them.

Saravana Kumar et.al., (2019). It declares about the potential value *Cissus quadrangularis* over the synthetic fibers. Because the *Cissus quadrangularis* having a crystalline structure as same the synthetic fibers. As a stem fiber (CQSF), *Cissus quadrangularis* has established thermomechanical characteristics for polymer composite reinforcement. Chemical treatments such as mercerization and the deposition of cotton linters-based microcrystalline cellulose powder on fibre surfaces have been extensively studied. The mechanical and water absorption properties of 5 percent cellulose powder-treated polyester composites, for example,

were markedly enhanced.

Jayaprakash et.al., (2019). It explains the mechanical characteristics of Epoxy composites with natural fibers and/or particles, it clearly explained about the fiber Composites and their reaction with Epoxy resin. Describes about different type of natural fiber composite with Epoxy has their thermosetting polymer and properties of each one has described, mechanical strengths like tensile, impact and flexural test were done on different types of natural fibers with Epoxy.

Balaji et.al, (2020). It describes about methodology of making the composite on a compression molding process. The compression molding machine need to get a temperature of 200°C and after heating the PLA at a 200°C remove the molding from the machine and applying a wax removal to get a composite sheet easier removal and Placing the fiber in a molding and compressing the Epoxy Resin at a range of 40MPa for 20 — 30 min and cool the Epoxy Resin by using water coolant, wait until the temperature reaches to 100°C and after reaching remove the plate and apply load on a plate. After few minutes take composite from out of the mold and keep it in room temperature for 24 hours in a normal humidity.

Thomas et.al., (2004). Furthermore, Epoxy resin has high adhesion and strength capabilities and is also low shrinkage and corrosion resistant. Despite its price, the resin's mechanical and chemical qualities are excellent. Some of these natural fibers have been tested with Epoxy to see how it affects their performance. Pineapple nanofiber has yet to be studied. The fibers' surface is roughened during the alkalization process, improving mechanical grip. The Epoxy matrix and interfacial adhesion rendered strong owing to the deposition of usually green composites, also known as biopolymers, may be improved by a rough surface.

reinforced with natural fiber that are more environmentally friendly compared to fiber reinforced Epoxy. Other than that, green composites are also widely used in application range thus contribute the rapidly growth of composite industry.

Li Zhao et.al., (2020). It declares the morphological analysis of XRD and FTIR. In this case, XRD is primarily used to identify the crystalline structure of a molecule, such as the average crystalline diameter (L_a), average crystalline height (L_c), and inter-layer spacing (d_{002}). An area between 10° and 35° , as well as a minor peak at 40° , is sampled in the 2θ range, with a wide variation between the two points. The FTIR test included a scanning range of 4000 cm^{-1} to 400 cm^{-1} , a resolution of 4 cm^{-1} , and a total of 32 scans. The height, breadth, and area of the peaks are measured and recorded.

CHAPTER 3

AIM AND SCOPE OF THE PROJECT

3.1 Aim

This project's main intention is to compare the Pure Epoxy Resin LY 556 composite, Epoxy with Untreated natural fiber composite and Epoxy with treated fiber composite.

- To prepare Pure Epoxy Resin LY 556 composite, Epoxy with untreated fiber and Epoxy with treated fiber using a compression molding machine.
- In order to compare the mechanical and physical characteristics of three different composites.
- An objective of this study was to assess the mechanical properties of three composite materials.
- To examine the composite's SEM structure.
- To analyse the conditions of the composite under XRD, FTIR and TGA.

3.2 Scope of the project

Rather than manufactured and glass fiber, utilizing regular fiber is the best elective way. Due to the utilization of glass and manufactured fiber, ecological contamination will occur. Though utilizing normal fiber will be eco-accommodating, and the regular fiber cost is less contrasted with manufactured fiber. It is additionally simple to Manufacture the regular fiber composite. This exploration will assist us with arriving at the properties of composites.

CHAPTER 4

MATERIALS AND METHODS

4.1 MATERIALS REQUIRED

The aerial roots of the banyan Tree Roots, Epoxy Resin LY 556 Resin (LY556) and Hardener (HY951),
 $\text{Ca}(\text{OH})_2$

4.2 METHODOLOGY

The methodology of this project is divided into several stages

- The production of fiber
- Sample preparation
- Analysis

4.3 *The production of fiber*

The Banyan tree's Aerial roots have been taken from the surrounding environment. Which is located at KKakinada, East Godavari District, Andhra Pradesh state. The Banyan tree as shown in figure 4.1



Fig:4.1 : Banyan Tree

After collecting the aerial roots of the tree should be removed and by taking a sickle gently force is applied across the aerial roots of banyan tree. After that these are dipped in the bucket with normal water by retting process for 2 to 3 days.

After the soaking process is done the biological waste is removed from the top of the bucket by wearing gloves the outer layer of roots should be removed by scraping with nails or knife, Splitting the roots into two halves until the specified dimensions we needed to obtain fiber. These wet fibers are cleaned well with towel. After cleaning this fiber is sun dried for 1 day, after drying we have to cut the fibre into 25mm size.



Fig 4.2 Banyan Tree roots

For preparation of natural fiber composite the fiber is divided into two types they are treated fiber and untreated fiber.

- Untreated fiber
- Treated fiber

4.3.1 Untreated Fiber

For the preparation of untreated aerial roots of banyan tree fiber, as name itself has the meaning. The fiber is cleaned well with distilled water and distilled water is rinsed with a cloth. As shown in figure 4.2

4.3.2 Treated Fiber

For the preparation of treated fiber. *Aerial roots of banyan tree* fiber is treated

with 5% of $\text{Ca}(\text{OH})_2$ chemical in figure 4.3 mixed in the normal water. The fiber is kept for 2 hours in chemical water in figure 4.4, later it was washed well for 2 to 3 times with normal water and once with distilled water. After rinsing water as shown in figure 4.4

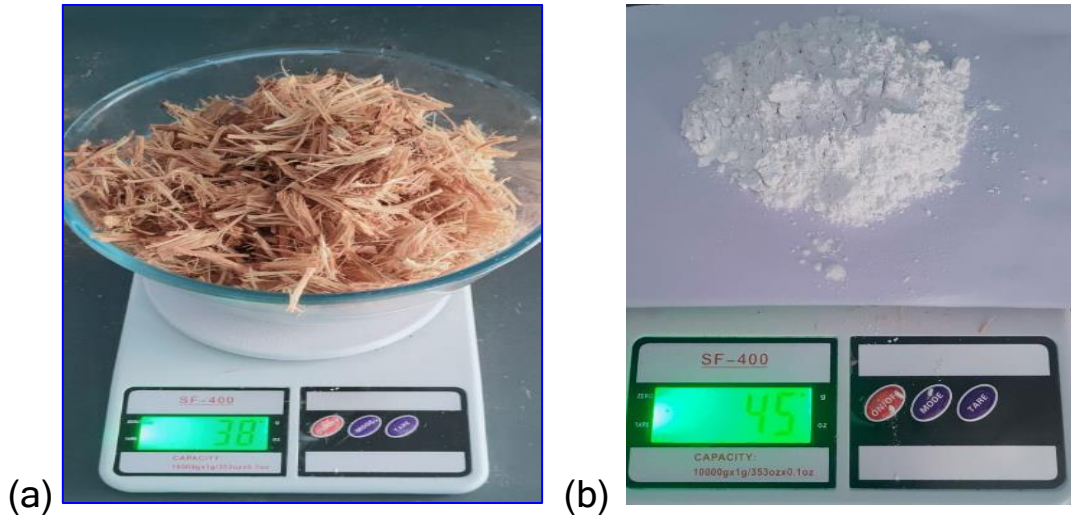


Fig:4.3(a)(b): Fiber and $\text{Ca}(\text{OH})_2$ chemical for 5% composite



Fig:4.4: Fiber treated with 5 % $\text{Ca}(\text{OH})_2$ chemical

For the preparation of treated fiber. *Aerial roots of banyan tree* fiber is treated with 10% of $\text{Ca}(\text{OH})_2$ chemical in figure 4.4 mixed in the normal water. The fiber is kept for 2 hours in chemical water in figure 4.4, later it was washed well for 2 to 3 times with normal water and once with distilled water. After rinsing water, the fiber is collected in a bowl as shown in figure 4.4

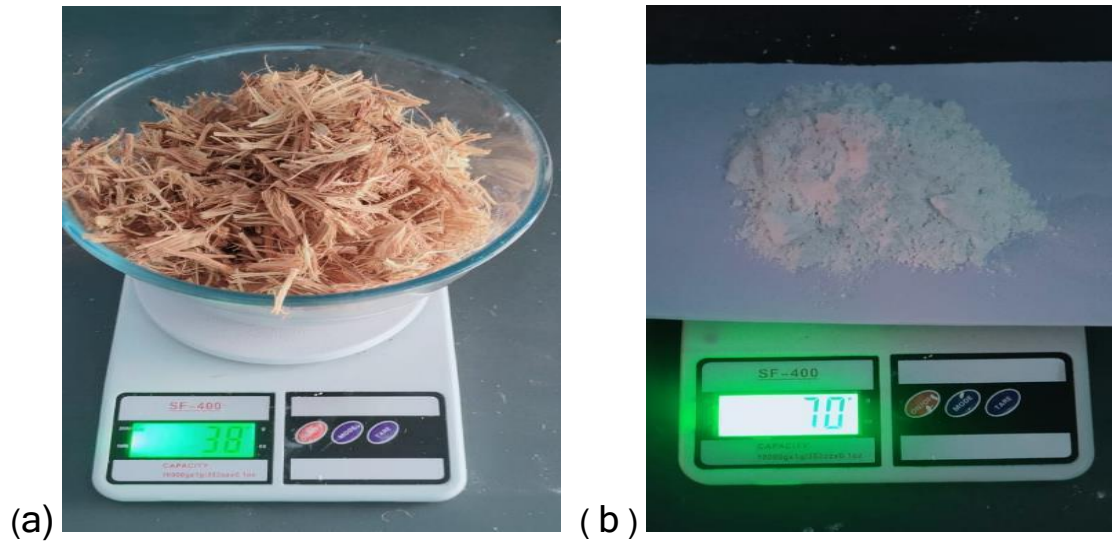


Fig:4.5(a)(b): Fiber and $Ca(OH)_2$ chemical for 10% composite



Fig:4.6: Fiber treated with 10 % $Ca(OH)_2$ chemical

For the preparation of treated fiber. *Aerial roots of banyan tree* fiber is treated with 15% of $Ca(OH)_2$ chemical in figure 4.6 mixed in the normal water (fiber to water ratio 1:10). The fiber is kept for an hour in chemical water in figure 4.5, later it was washed well for 2 to 3 times with normal water and once with distilled water. After rinsing water, the fiber is collected in a bowl as shown in figure 4.6

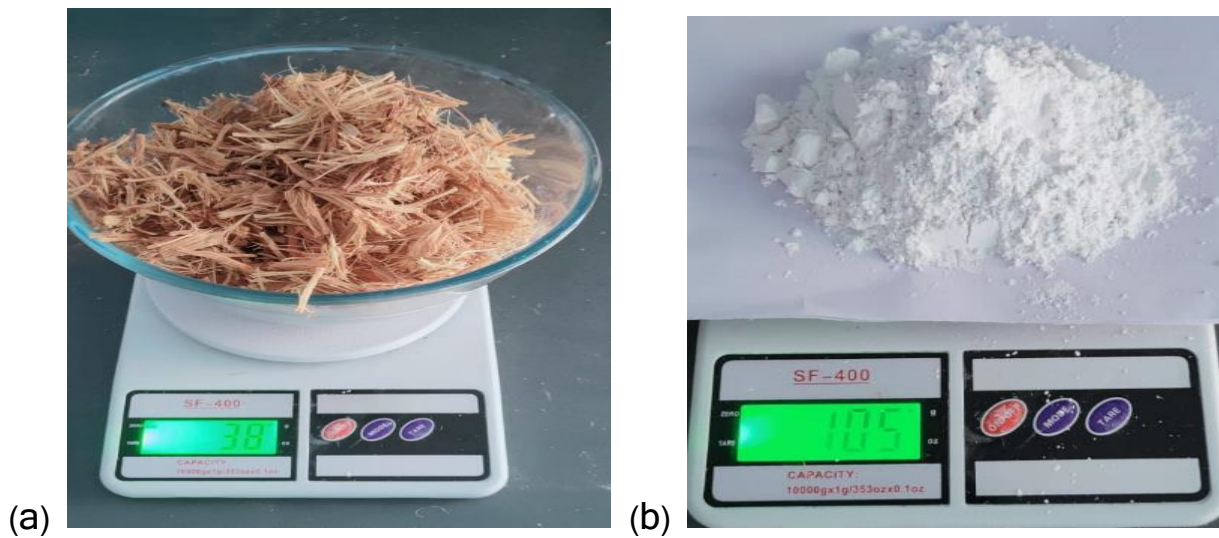


Fig:4.7(a)(b): Fiber and $\text{Ca}(\text{OH})_2$ chemical for 15% composite



Fig:4.8: Fiber treated with 15% $\text{Ca}(\text{OH})_2$ chemical

A beaker containing both treated and untreated fibers is placed in an oven at 100°C for 2 to 3 hours to completely eliminate moisture. After heating the fiber it is pack in zip covers without exposing it to air to prevent erosion.



Fig:4.9: Removing the moisture present in the fiber using oven

4.4 Sample Preparation

For the preparation of natural fiber composite, Epoxy Resin LY 556 which is purchased from ECMAS Agencies Unsaturated Polyester & resins & Construction Chemicals, Visakhapatnam, these Epoxy resin are suitable for compression molding process at a temperature of 60°C to 80°C this composite preparation process is divided into two stages.

- Mixing
- Compression

4.4.1 Mixing with Fiber and Epoxy resin

In this Mixing process which is held at Kelvn labs, Hyderabad, Telangana. Both Epoxy resin and fiber are both mixed like a solution.

4.4.2 Compression

In this stage of preparation, the Epoxy and fiber mixed solution will be compressed using compression molding machine figure 4.10. First compression molding machine turned on and set at a temperature of 60°C, after 5 minutes the molding Epoxy(150×150×3mm) are inserted into the machine and heated for 10 minutes.



Fig:4.10: Compression molding



a



b

Fig:4.11: Mold with Epoxy Resin LY 556

In the wake of compacting, it for 30 to 40 minutes temperature is diminished. This pressure is eliminated and the composite is taken out similarly three composites Epoxy were ready of aspects $150 \times 150 \times 3$ mm, same goes for Epoxy with untreated banyan root fiber and Epoxy with treated banyan root fiber as shown in figure 4.12, 4.13, 4.14.



Fig:4.12: Epoxy Composite



Fig:4.13: Untreated banyan root fiber + Epoxy composite



Fig:4.14: Treated banyan root fiber + Epoxy composite

After preparing the composite Epoxy Resin by using the compression molding machine. Tensile, flexural and impact samples were made from these composite Epoxytes as shown in figure 4.15, 4.16, 4.17.



Fig:4.15: Tensile, flexural and impact samples of Epoxy composite



Fig:4.16: Tensile, flexural and impact samples of treated banyan root fiber composite



Fig:4.17: Tensile, flexural and impact samples of untreated banyan root fiber composite

4.5 Analysis

In this project Mechanical properties, physical properties along with morphological analysis are done. Mechanical properties like Tensile, Flexural and Impact. Physical properties like SEM, morphological analysis like XRD, TGA, FTIR.

4.5.1 Tensile Strength

The most extreme burden a material can endure without breakage while being extended, partitioned by the first cross-sectional region of the material. It has aspects of power per unit region. At the point when the anxieties are under elasticity is eliminated and the material spans to its unique shape and size either totally or to some extent. Assuming that pressure arrives at the worth of rigidity, but assuming the material is bendable than it has previously started to stream quickly shapes a choked area called neck, where it cracks. The test is done according to the ASTM D3039 the testing system remembers the mounting for a machine and presenting to tension in testing machine and thereafter applying strain to it until it breaks. The bendable power is kept as component of extension in line length during usage of strain and prolongation of estimated region is kept in versus to applied power. The test is performed on Universal testing Machine with load limit of 400KN for the heap pace of 5mm/min.



Fig:4.18: Tensile strength apparatus

4.5.2 Flexural Strength

It educates about the obstruction regarding a material against disfigurement. It demonstrates how much power is expected to break a test of a characterized measurement. The higher the worth the additional affecting powers the material can endure. The motivation behind flexural test is to gauge the strength and modulus of a flexural test, the flexural strength is characterized as most extreme pressure at peripheral fiber on one or the other pressure or strain side of example.

The flexural strength is determined from underneath condition
 $\sigma_f = 3pl/2bd^2$ (1)

From the angle of the pressure against strain in an avoidance bend, the flexural modulus may be derived. – that is the situation

$E_f = L^3m/4bd^3$ (2)

The flexural strength is boosted at room temperature using three-point twist testing as determined by ASTM D-790, using an Instron model 5582 in the Universal Testing Machine. The speed of the cross head is 2mm/min



Fig:4.19: Flexural strength apparatus

4.5.3 Impact Strength

Impact strength refers to a material's ability to withstand a sudden and unexpected load and its ability to transmit this information in terms of energy. It is additionally estimated in Charpy impact strength and Charpy impact strength. It determines how much energy was expended by a substance during a break. Energy retention is a function of material toughness, brittleness, and adaptability. The temperature is brought down over a progression of tests to show the fragile temperature of a material. Prior to beginning the Charpy test the specimen is indented at a GTS Model-7045 MD in the wake of making a score at a point of 90 degrees and did the test on analyzer. The impact strength is determined from Impact strength and impact opposition of an example



Fig:4.20: Impact strength apparatus

4.5.4 SEM Analysis

In the matrix of the composite, the microscopic particles may be scanned to assess the bonding of resin and fibers. Since tensile samples have a greater breaking stress and bind between them, they must be chopped into smaller pieces for SEM examination of composites. These smaller pieces are then employed in the analysis to identify particle size down to 10 nm and magnifications ranging from 20x to 100x. Scanning using an electron beam, it produces an enhanced picture of the sample to aid in detection of contaminants or unknown particles, as well as finding out about surface topography and composition, after a visual study of the surface has been performed first.



Figure:4.21: SEM apparatus

4.5.5 TGA

TGA curves generated from the investigation of the fibre were utilised to assess the thermal stability of different chemical ingredients. A crucible containing

10mg of dried banyan roots powder was placed in a thermal analyzer. When the temperature within the thermal analyzer is raised to 600°C, the sample in the furnace is monitored for changes in weight on an analytical balance that stays outside the furnace and is heated at a rate of 10°C per minute.

Fiber is a pollution-free substance since it emits a lower quantity of hazardous gases. In the literature study, several natural fibers have been tested for their suitability for use in the construction of solid composite structures. As part of an investigation on the appropriateness of the new natural composite's natural fibers as a superior reinforcing medium. Numerous tests on the fibers have already been conducted, including mechanical properties such as strength and reinforcing efficacy; chemical composition; physical properties such as heat stability; crystallinity; and morphological analysis. Natural fibers, such as cotton and linen and wool and flaxseed, tend to be cheaper and more environmentally friendly than synthetic fibers like glass fiber, carbon fiber, ceramic fiber, and aramids.

It is possible to degrade natural fibers. Nature provides them. Natural fibers are just as good for the environment as synthetic ones. They are completely compostable and biodegradable. In composite materials, the direction of the fibers has an effect on the characteristics. Sheets of natural fibers are formed. It is well known that most natural fibers are capable of absorbing water and other liquids. It is non-toxic and does not abrade. It has low density, low cost and high porosity. Specific stiffness, Specific Strength, better corrosion resistance, and better recycling. Fatigue-resistant with a higher impact absorption capacity, lower toxicity and abundance, and the potential to be recycled, it may outweigh the use of synthetic fiber composites in many cases. Lightweight and humane handling. Epoxy stem was used to gather natural fibers for the present study, which attempts to describe those fibers. This fiber is readily accessible in the region where we live, and our reference from the study indicates that it has superior strength, so we tested its acceptability as an alternative approach and published our findings in this article, which were based on studies we conducted on a natural fiber. Whatever the findings of the research, the Extraction procedure is the same. After deciding on calcium hydroxide $\text{Ca}(\text{OH})_2$, the treatment was finished. Our work here is over. It's important to know

your mechanical properties, which include things like tensile, impact, and flexural strength.

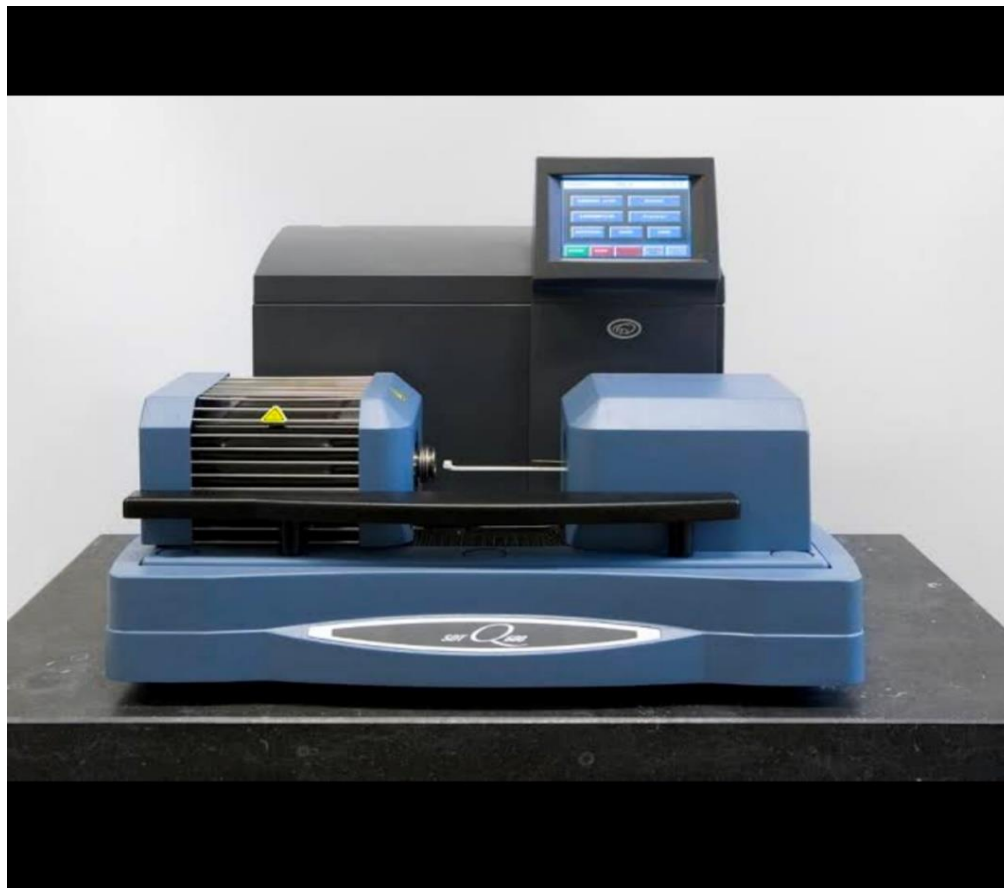


Fig:4.22: Thermogravimetric apparatus

4.5.6 XRD

This technique is most often used to determine the structure of molecules, such as the average diameter of the crystalline (L_a), average height of the crystalline (L_c) and inter-layer spacing (I_s) (d_{002}). The material is ground into a powder and scanned from 2 to 80 times.degrees in the 2 range and a wide area between 10 and 35 degrees with a little peak at 40 degrees. In the vicinity of 20°, a (002) peak, in the vicinity of 26°, and a (100) peak, in the vicinity of 40°, may all be found to be suitable. The peak placements, intensities, full width half maximums (FWHM), and regions were mapped out.



Fig:4.23: XRD apparatus

4.5.7 FTIR

FTIR is used to identify compounds such as compounded Epoxy, fillers, rubbers and resins. The infrared absorption spectra of a molecule may be analyzed to determine the nature of its chemical bonds. Method that can detect a variety of functional groups quickly and non-destructively and is sensitive to changes in molecular structure. Based on the chemical composition and physical condition of the whole sample, it offers information Testing was performed using an FTIR detector, which had an effective spectral resolution of 4 cm⁻¹ and an exposure period of 32 scans. The height, breadth, and area of the peak are measured.

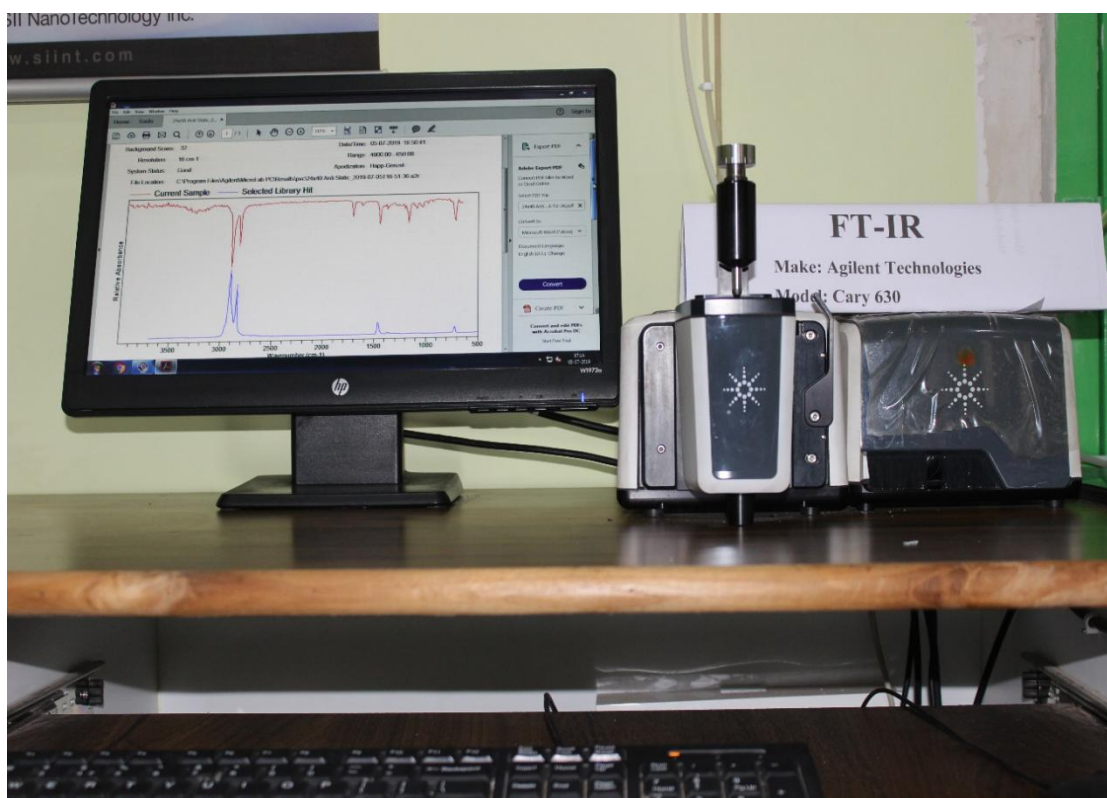


Fig:4.24: FTIR apparatus

CHAPTER 5

RESULTS AND DISCUSSION

In these results are discussed of the tests we have done on the composite materials like Tensile, Flexural, Impact, SEM, XRD, FTIR, TGA, and Water absorption test these are represented either by using bar graphs, pie charts or pictorial representation.

5.1 Tensile Strength

This tensile strength test is performed at KELVN Labs, Hyderabad, Telangana. By using universal testing machine.



Fig:5.1: Tensile samples of pure Epoxy

These are the tensile samples after testing the tensile strength. The composition of this composite is 100% Epoxy 0% Fiber



Fig:5.2: Tensile samples of untreated banyan roots fiber composite

In this figure 5.2 the tensile samples of untreated banyan root fiber composite are shown, 85% Epoxy and 15% of fiber.



Fig:5.3: Tensile samples of treated banyan roots fiber composite

In this figure 5.3 the tensile samples of treated banyan roots fiber composite are shown are 85% Epoxy and 15% of fiber.

Table 5.1: Pure Epoxy composite tensile strength results

Sample No	Tensile Strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	13.83	92.43	1.16
Sample 2	26.24	249.93	5.19
Sample 3	42.38	4631.6	1.90

Table 5.1 gives us the tensile strength results of the pure Epoxy along with modulus of elasticity and elongation. Average value of pure Epoxy tensile strength average of modulus of elasticity

Table 5.2: Epoxy + untreated banyan root fiber composite tensile strength

Sample No	Tensile Strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	13.83	165.85	1.16
Sample 2	17.02	488.15	1.69
Sample 3	42.38	1168.85	1.92

Table 5.2 gives us the tensile strength results of the Epoxy + untreated banyan root fiber along with modulus of elasticity and elongation. Average value of tensile strength is average of modulus of elasticity.

Table 5.3: Epoxy + 5 % Ca (OH)₂ treated banyan root fiber composite tensile strength

Sample No	Tensile Strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	14.76	285.71	0.52
Sample 2	24.93	1285.20	1.64
Sample 3	20.69	865.25	1.37

Table 5.3 gives us the tensile strength results of the Epoxy + 5 % Ca(OH)₂ treated banyan root fiber along with modulus of elasticity and elongation. Average value of tensile strength is average of modulus of elasticity.

Table 5.4: Epoxy + 10 % Ca (OH)₂ treated banyan root fiber composite tensile strength

Sample No	Tensile Strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	12.38	155.86	1.53
Sample 2	12.53	170.33	1.37
Sample 3	14.58	312.55	0.68

Table 5.3 gives us the tensile strength results of the Epoxy + 10 % Ca (OH)₂ treated banyan root fiber along with modulus of elasticity and elongation. Average value of tensile strength, average of modulus of elasticity.

Table 5.5: Epoxy + 15 % Ca (OH)₂ treated banyan root fiber composite tensile strength

Sample No	Tensile Strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	18.17	556.5	1.00
Sample 2	13.89	228.6	0.84
Sample 3	18.63	623.8	1.12

Table 5.3 gives us the tensile strength results of the Epoxy + 15 % Ca(OH)₂ treated banyan root fiber along with modulus of elasticity and elongation. Average value of tensile strength is average of modulus of elasticity.

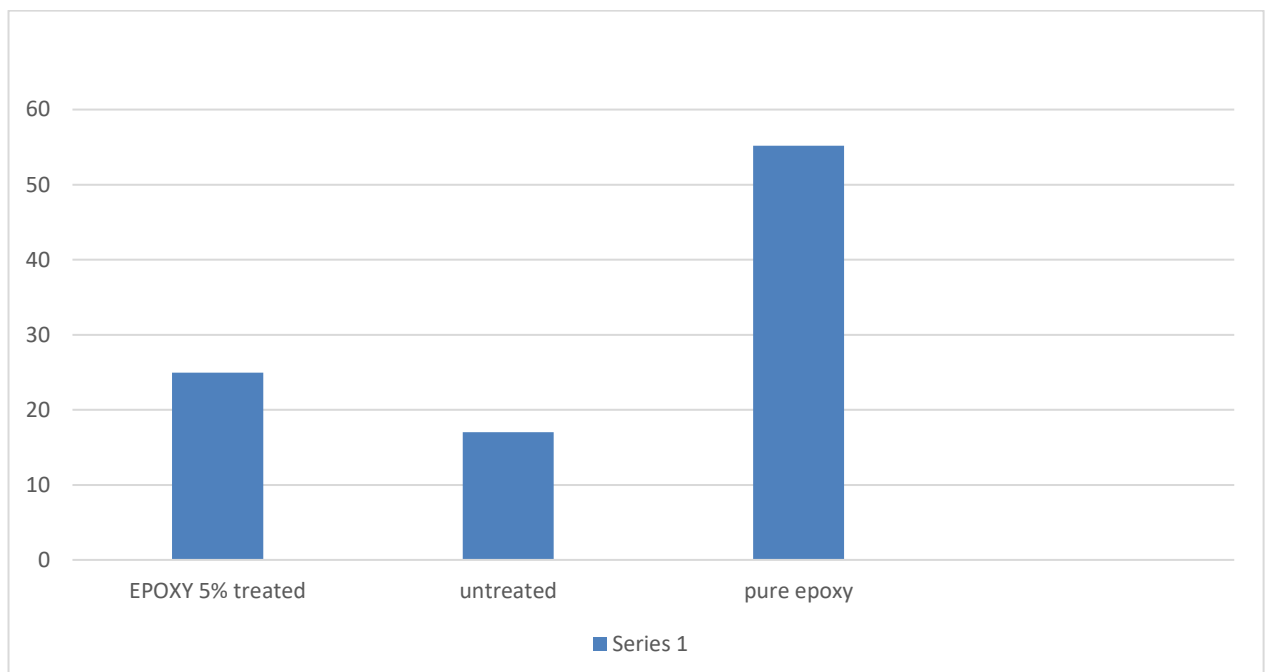


Fig:5.4: Average of three composites tensile modulus of elasticity

The modulus of elasticity is a function of the stress to strain ratio of hardened

elastic stage. In identical composites, the higher the modulus of elasticity of the material, the greater the rigidity.

As shown in Figure 5.5, Epoxy has an elastic strength modulus (N/mm²) that is much greater than that of the untreated fiber composite. Epoxy was used at this stage to distort the specimen. Furthermore, given that the treated fiber specimen had the highest modulus of elasticity measured, the interfacial bonding between the fiber and Epoxy formed as a result of alkaline treatment is the most likely cause of the increased tensile and modulus of elasticity.

5.2 Flexural Strength

This flexural strength test is performed at KELVN Labs, Hyderabad, Telangana. By using universal testing machine.

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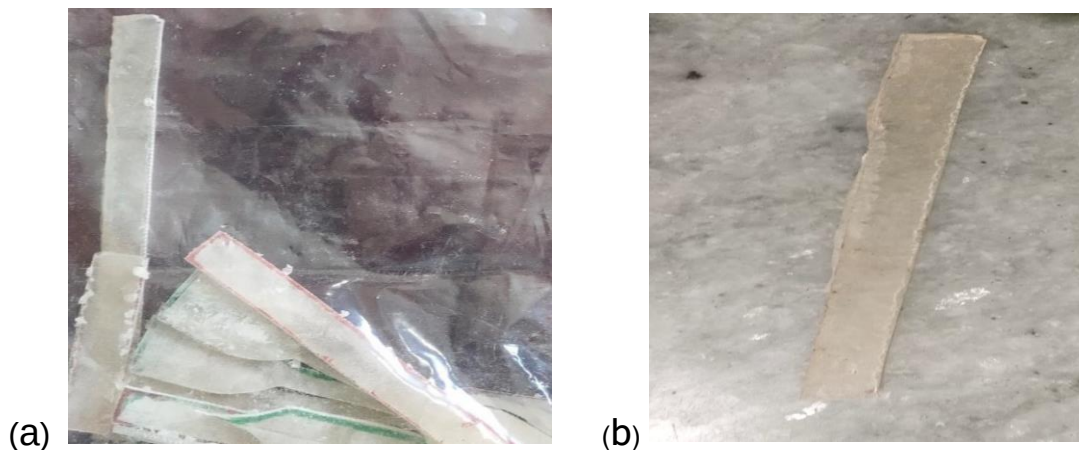


Fig:5.5: Flexural samples of pure Epoxy composite

In this figure 5.7 these are the flexural strength samples of pure Epoxy and the composition is 100% Epoxy Resin and 0% fiber



Fig:5.6: Flexural samples of Epoxy + Treated banyan root fiber

In this figure 5.6 these are the flexural strength samples of Epoxy + untreated banyan fiber composite and the composition is 85% Epoxy 15% fiber

In this figure 5.7 these are the flexural strength samples of pure Epoxy and the composition



is 100% Epoxy 0% fiber

Fig:5.7: Flexural samples of Epoxy + untreated banyan root fiber composite

In this figure 5.7 these are the flexural strength samples of Epoxy + untreated banyan fiber composite and the composition is 85% Epoxy 15% fiber in this figure

5.8 these are the flexural strength samples of Epoxy + treated banyan root fiber composite and the composition is 85% Epoxy 15% fiber

Table 5.6: Pure Epoxy composite flexural strength

Sample No	Flexural Strength (MPa)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	84.24	662.89	3.60
Sample 2	115.04	1299.01	3.60
Sample 3	112.78	1047.72	3.49

Table 5.4 gives us the flexural strength results of the Pure Epoxy along with modulus of elasticity and elongation. Average value of flexural strength is average of modulus of elasticity

Table 5.7: Epoxy + treated banyan root fiber composite flexural strength

Sample No	Flexural Strength (MPa)	Modulus of elasticity	Elongation (%)
Sample 1	29.77	782.54	6.70
Sample 2	29.34	687.32	6.56
Sample 3	34.79	857.97	5.87

Table 5.5 gives us the flexural strength results of the Epoxy + treated banyan root fiber along with modulus of elasticity and elongation. Average value of flexural strength.

Table 5.8: Epoxy + untreated banyan root fiber composite flexural strength

Sample No	Flexural Strength (MPa)	Modulus of elasticity (MPa)	Elongation (%)
Sample 1	32.63	739.68	4.86
Sample 2	24.74	538.25	4.86
Sample 3	26.54	455.86	4.97

Table 5.6 gives us the flexural strength results of the Epoxy + untreated banyan root fiber along with modulus of elasticity and elongation. Average value of flexural strength is 32.63MPa, average of modulus of elasticity is 2.5 ± 0.86 GPa and average of elongation is $4.89 \pm \%$

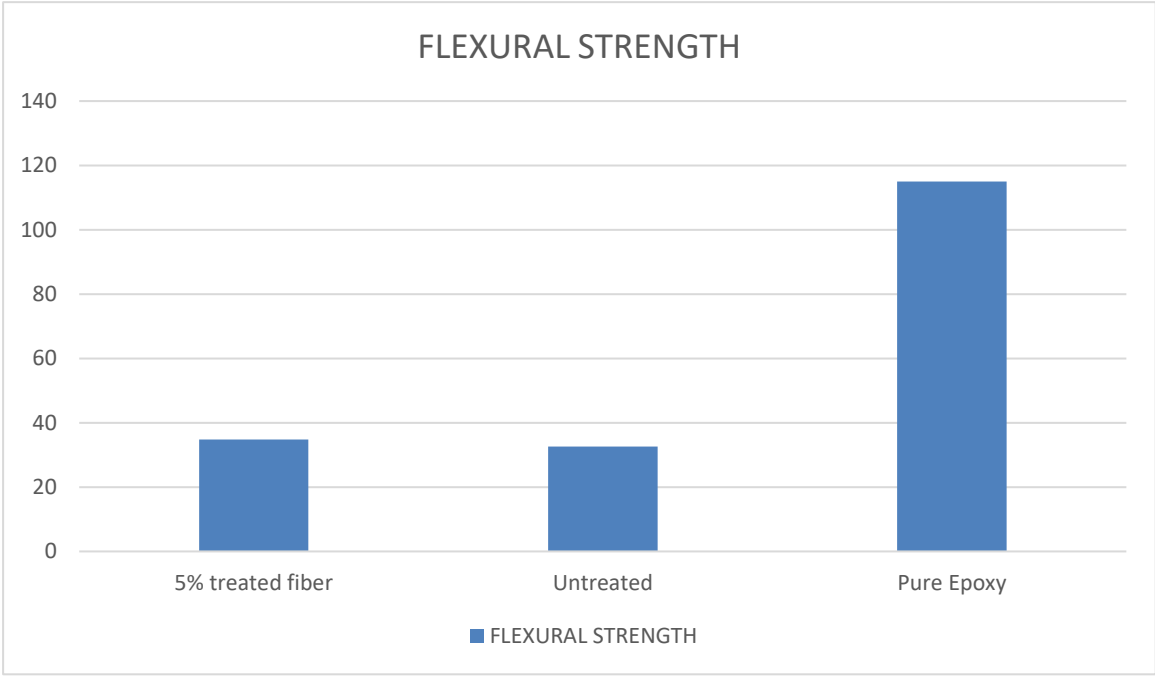


Fig:5.8: Comparison graph of flexural strengths

figure 5.8 It is the comparison of flexural strength of three composites of Pure Epoxy + untreated banyan root fiber and Epoxy + treated banyan fiber composites in which Epoxy + treated banyan root fiber composite is having maximum flexural strength of 77.48 MPa. Which is higher than untreated banyan root fiber. This may be due to alkali treatment, the composite's load transfer efficiency is improved significantly [3]. Compared to Epoxy + treated banyan root fiber, Epoxy + untreated banyan root fiber is having less flexural strength. Because the Epoxy resin couldn't get into the fibres, it resulted in the composite having a high porosity and minimal contact with the fibre core [53].



Fig:5.9: Impact samples of pure Epoxy

In this the samples of impact strength of Pure Epoxy are shown. Which are having the composition of 100% Epoxy and 0% fiber.



Fig:5.10: Impact samples of Epoxy + untreated banyan root fiber composite

figure 5.14 the samples of impact strength of Epoxy + untreated banyan root fiber is shown. Which are having the composition of 85% Epoxy and 15% fiber.



Fig:5.11: Impact samples of Resin LY 556 + treated banyan root fiber composite

Figure 5.15 the samples of impact strength of Epoxy + treated banyan root fiber is shown Which are having the composition of 85% Epoxy and 15% fiber.

Table 5.9: Impact strength of pure Epoxy samples

Samples	WIDTH (mm)	THICKNESS (mm)	W/d×1000 (J/m)	IMPACT STRENGTH (KJ/mm ²)
Sample 1	14.80	3.23	0.450	11.5
Sample 2	14.71	3.28	0.493	11.3
Sample 3	14.59	3.20	0.667	12.8

Table 5.7 the impact results of Pure Epoxy samples are discussed and sample 2 is having the high impact strength

Formula to calculate impact strength is

$$\text{Impact strength} = \text{work done} / (\text{thickness} \times \text{width}) \times 1000 \text{ kJ/mm}$$

Table 5.10: Impact strength of Epoxy + untreated banyan fiber samples

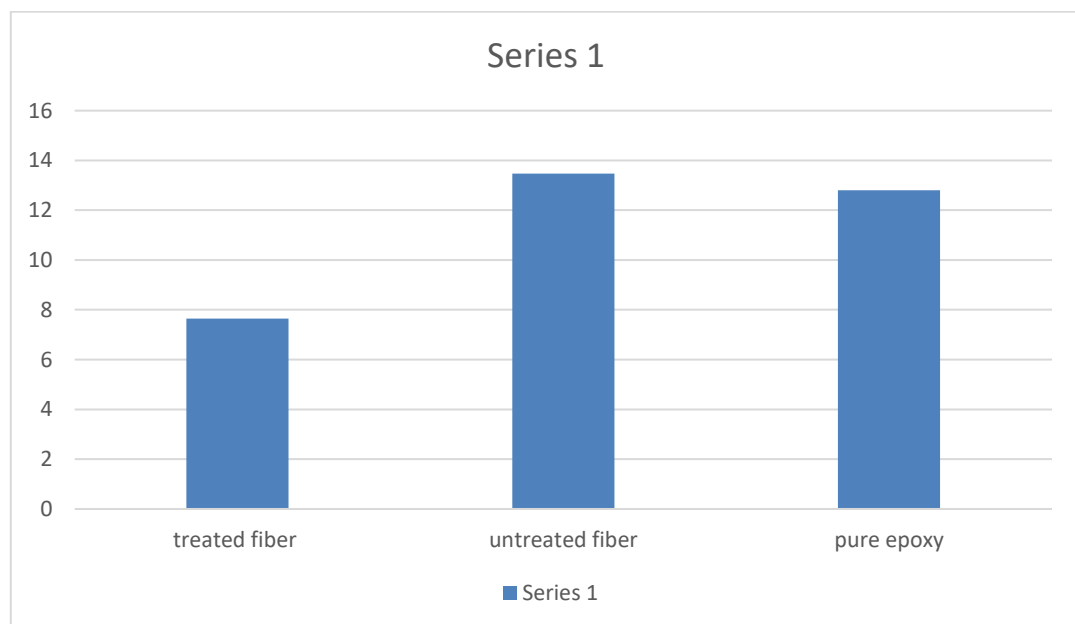
Samples	WIDTH (mm)	THICKNESS (mm)	W/d×1000 (J/m)	IMPACT STRENGTH (KJ/mm ²)
Sample 1	14.05	4.94	1.99	13.47
Sample 2	14.36	4.55	0.536	10.54
Sample 3	13.69	4.92	0.24	9.65

Table 5.8 the impact results of Epoxy + untreated banyan fiber samples are discussed and sample 1 is having the high impact strength

Table 5.11: Impact strength of Epoxy + treated banyan root fiber samples

Samples	WIDTH (mm)	THICKNESS (mm)	W/d×1000 (J/m)	IMPACT STRENGTH (KJ/mm ²)
Sample 1	14.09	4.10	0.240	6.53
Sample 2	13.33	4.12	0.281	6.72
Sample 3	14.37	4.14	0.579	7.64

Table 5.9 the impact results of Epoxy + treated banyan root fiber samples are discussed and sample

**Fig:5.12: Comparison of impact results of three composites**

5.3 Impact Test

figure 5.12 it shows the comparison between all three composites about impact test results. In which Epoxy + untreated banyan root fiber composite is having high impact strength of 13.47 KJ/mm². The high impact strength of untreated fiber, which is greater than Epoxy composite and higher than treated fiber composite, is largely owing to the strong bonding between matrix and fiber [24].

However, Izod impact strength was much lower in the treated composites than in the untreated composites, despite their similar mechanical characteristics. Aziz and Ansell [15] found the same tendency. During a collision, energy is absorbed by debonding, pull out, and fiber fractures. For example, pulling a fiber out of a matrix demands more energy than fiber breakage and debonding do. The high impact strength of untreated composites may be owing to a poor contact between the fibers and the matrix, which results in more fiber pullouts. Fiber fracture occurs instead of pull outs in treated composites. Comparatively speaking, the energy required for fiber breakage is less than that required for pull outs. This may explain why treated composites have a lower impact strength than untreated composites [7].

5.4 SEM Analysis

This SEM test has been done in KELVN Labs, Hyderabad, Telangana. It is a physical property test that uses a scanning electron microscope to obtain pictures of objects by scanning the surface with a concentrated stream of electrons. These electrons will contact with many atoms on the surface and create signals that provide information about the surface and composition of the object.

figure 5.17 SEM analysis is taken at the broken side of high tensile sample and we can see the bonding between the fiber and composite also the fiber position and there is also some porous hole on the composite and some weak bonding between fiber and polylactic acid composite. There are some void gaps because of improper composite mixing.

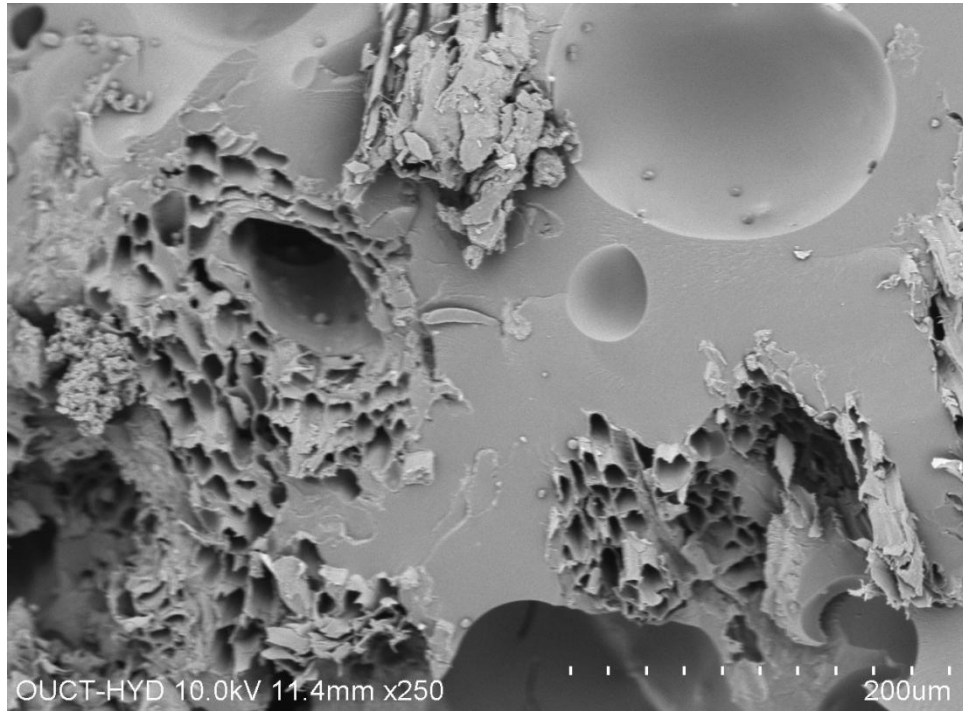


Fig:5.13: SEM analysis of broken side of high tensile strength sample

Higher tensile strength observed on treated fiber sample thus the composite made of 15% Fiber and 85% Epoxy was taken for micro structural analysis performed on tensile sample figure 5.17 shows the SEM image of sample, the presence of voids and broken fiber was observed in treated fiber composite.

A small number of cavities and damaged fibers were found in chemically treated fibers. Furthermore, resin penetration enhances the bond between the matrix and fiber. The porous surfaces of treated fiber indicate improved adhesion. The interfacial connection between fiber and matrix is stronger and better in chemically treated fiber. voids in the composite are caused by fibers being pulled out of the composite owing to poor bonding between the fibers and the matrix.

5.5 FTIR Analysis

This test FTIR is done at SRM University, Chennai, Tamil Nadu. Using this FTIR test, we can determine the functional groups present in the materials analyzed and the graph is displayed below.

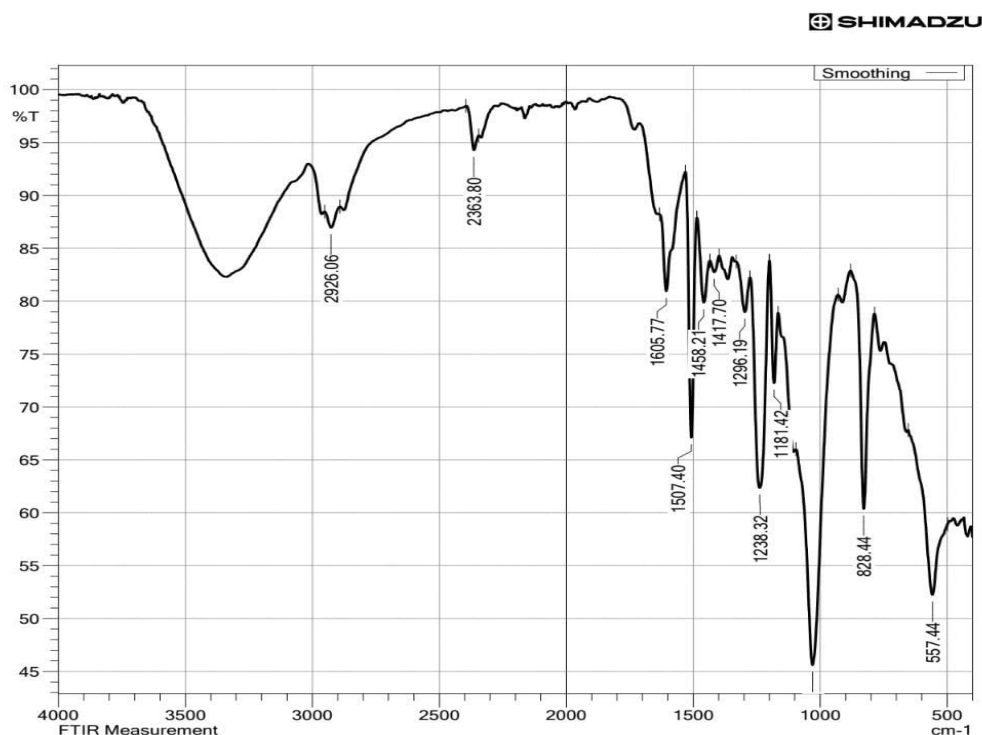


Fig:5.14 : FTIR analysis of treated fiber

The peaks observed in the FTIR spectrum are responsible for treated and untreated fiber particles. The band at 2995.50cm^{-1} & 2996.47cm^{-1} are responsible for the acidic O-H stretching [19] and the bond at 1624.09 , 1452.42 , 1382.02 and 1268.22 were to the C=O and C-O stretching [28]. the peak at 1042.54 , 1127.41 and 956.71 are the region of deformation vibration of outside the group [47]. The remaining peaks at 1382.02 , 1269.18 , 955.74 , 755.14 , 1452.42 , 1318.37 , 868.95 , 666.42 these were formed due to secondary metabolites [19]. The untreated peak indicates the elongation of the O-H bond in cellulose [47].

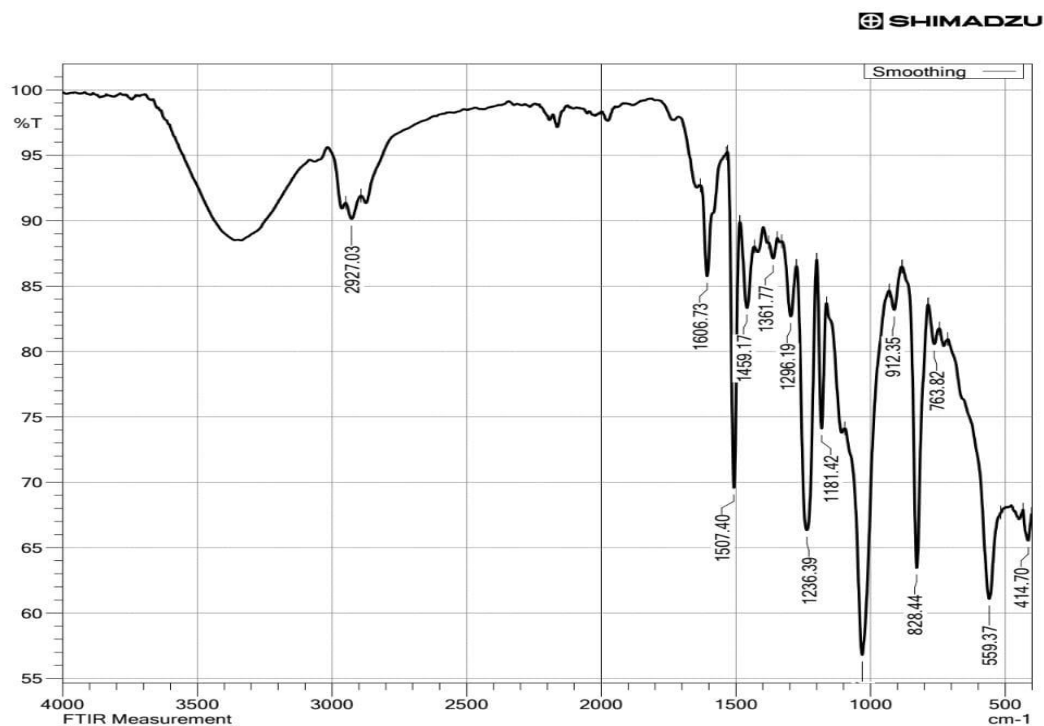


Fig:5.15: FTIR analysis of untreated fiber

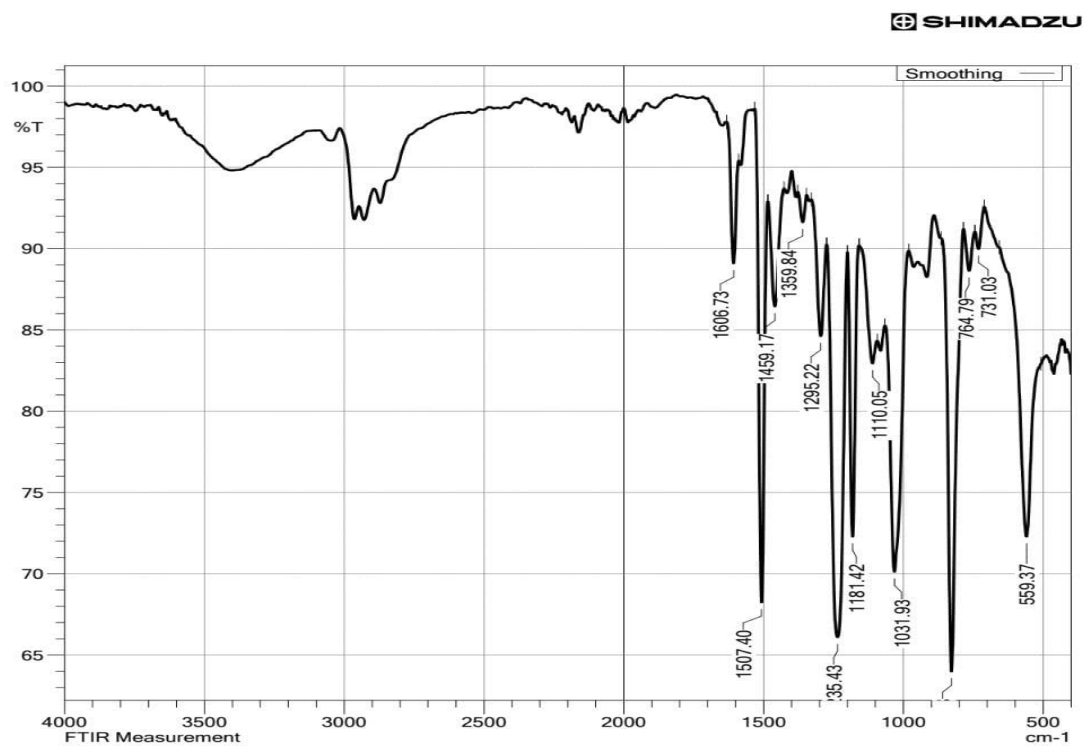


Fig:5.16: FTIR analysis of Pure Epoxy

5.6 XRD Analysis

The crystalline nature of *Cissus quadrangular* has been determined using XRD analysis. Graph 5.20 shows the impact of chemical treatment on fiber cellulose crystallinity, which was evaluated using an X-ray diffractometer. This finding is critical for observing changes in fiber amorphous content after chemical treatment. Having a higher crystallinity index indicates that a chemical treatment is more effective

Two of the three primary peaks are located at $2\theta = 14.70^\circ$ and 16.15° , respectively Alpha-cellulose and amorphous content are both indicated [32]. At $2\theta = 16.15^\circ$ and 13.98° , the untreated fiber exhibits two large peaks. 10.8 percent and 24.9%, respectively, of treated and untreated fibers had the same crystalline index (CI). The crystalline index of untreated fiber is more, compared to treated fiber. This may be due to increase amorphous constituents in treated fiber after chemical treatment [51] Crystalline index CI is calculated by using below equation.

$$CI = \frac{\text{Highest Peak} - \text{Lowest Peak}}{\text{Highest Peak}}$$

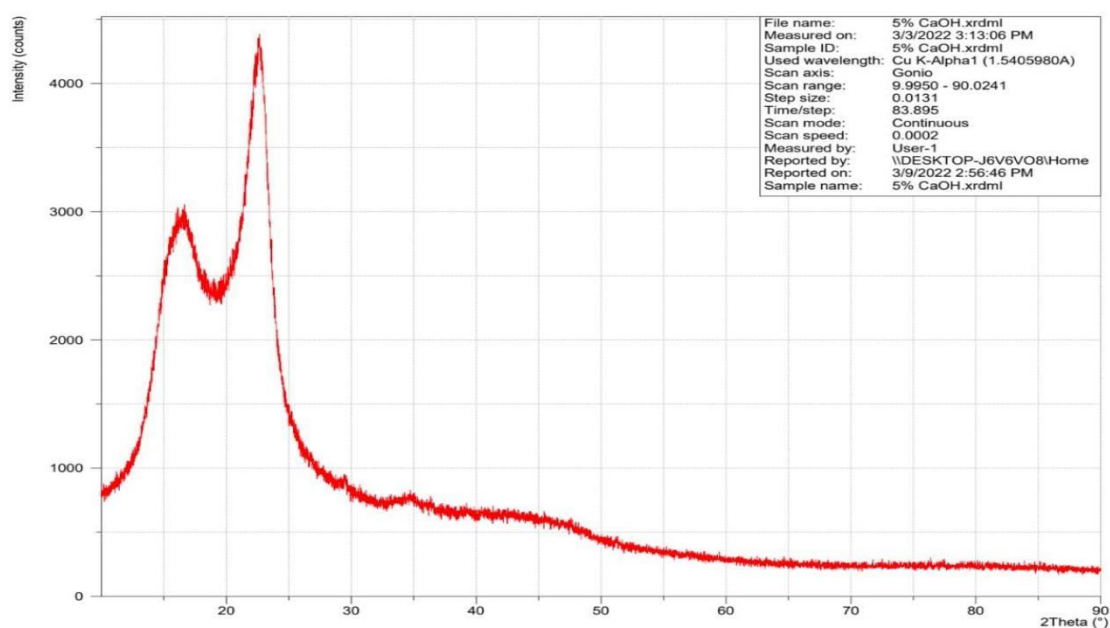


Fig:5.17 : XRD spectrum of treated fiber

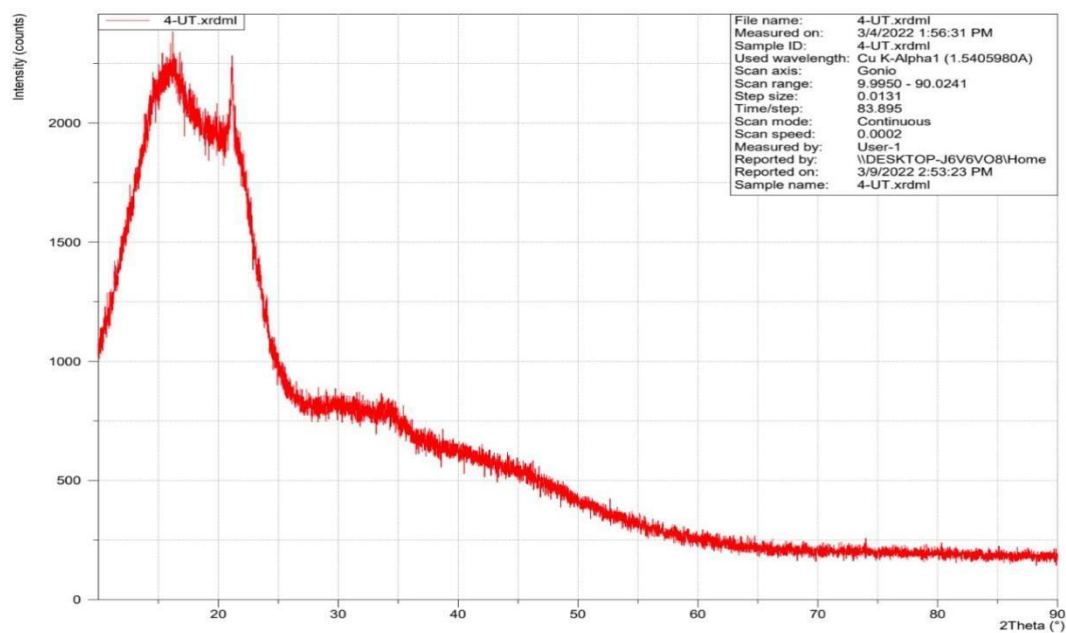


Fig:5.18: XRD spectrum of untreated fiber

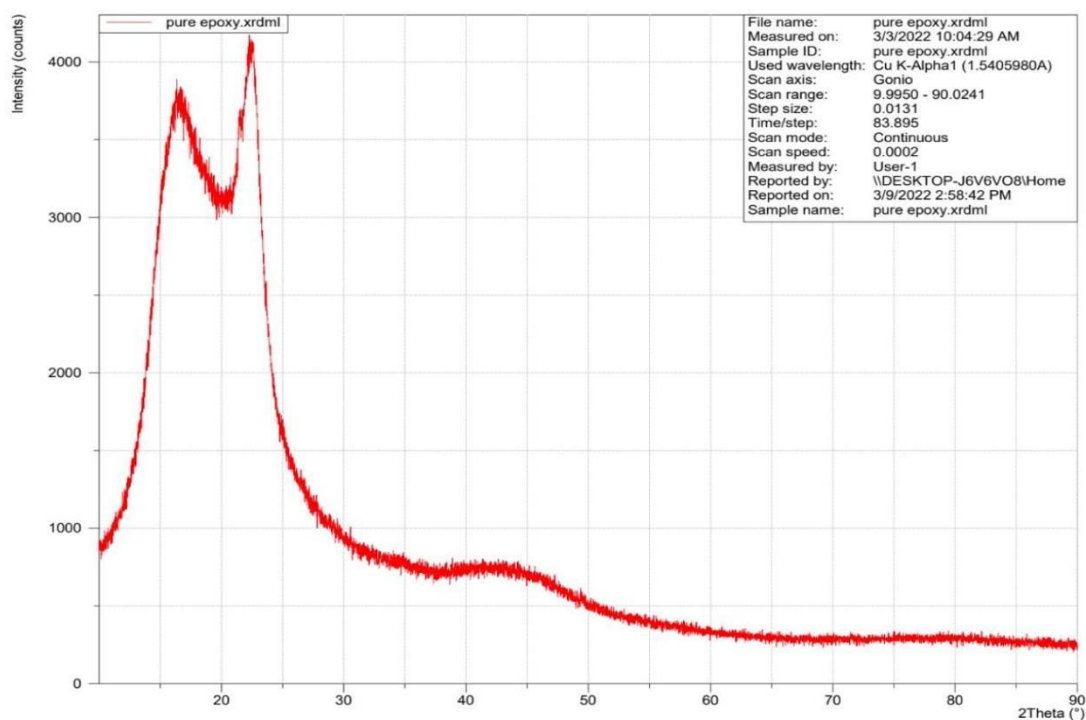


Fig:5.19: XRD spectrum of Pure Epoxy

5.7 THERMOGRAVIMETRIC ANALYSIS(TGA):

Thermogravimetric analysis (TGA) is done at Kelvin labs Hyderabad Telangana. This test is taken at the temperature range of 20°C to 600°C, and atmosphere N₂ and using crucible Al₂O₃. Heating rate is 10°C

TGA Analysis gives the comprehension of progress in mass of a material with regards to both time and temperature. In this technique the sample is warmed from surrounding to 1000 degree in nitrogen or air, then the resultant weight reduction is determined which happens because of semi unstable mixtures, polymer debasement, debris content, carbon dark and dampness. The deficiency of surface ingested dissolvable can be recognized from dissolvable in the gem cross section and from debasement misfortunes. The estimations are done in environments having controlled dampness and oxygen focus to uncover cooperation's with the medication substance, between drug substances, and between dynamic substances and excipients or bundling materials.

TGA

Sample: 5% CAO_H

Sample Size: 9.82100 mg

Operator:

Date of Experiment: 2022-02-25

File Path:

\\Ta-pc\ta\Data\SDT\FEBRUARY2022\SATHYABAMA

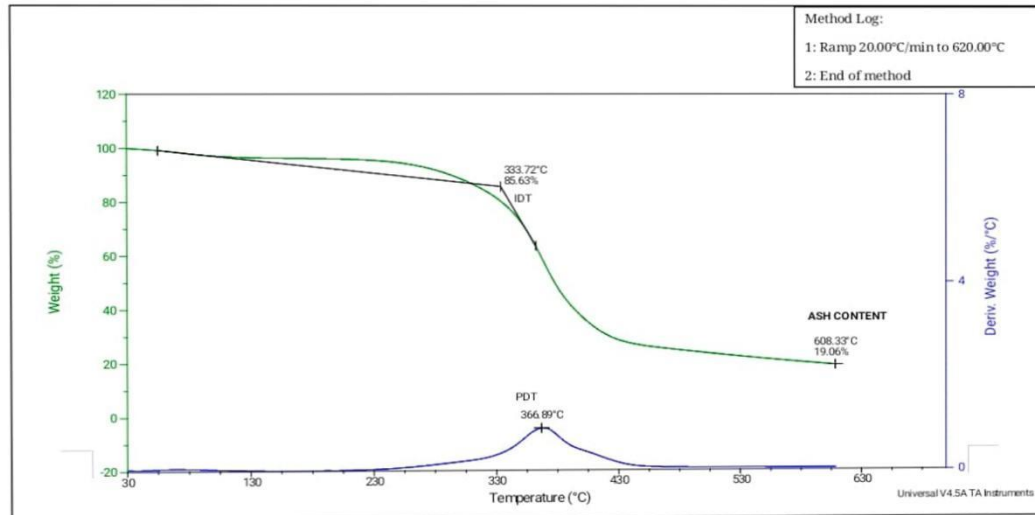


Fig:5.20: TGA Ca(OH)₂ treated fiber and Epoxy

TGA

Sample: Untreated

Sample Size: 12.3090 mg

Operator:

Date of Experiment: 2022-02-23

File Path:

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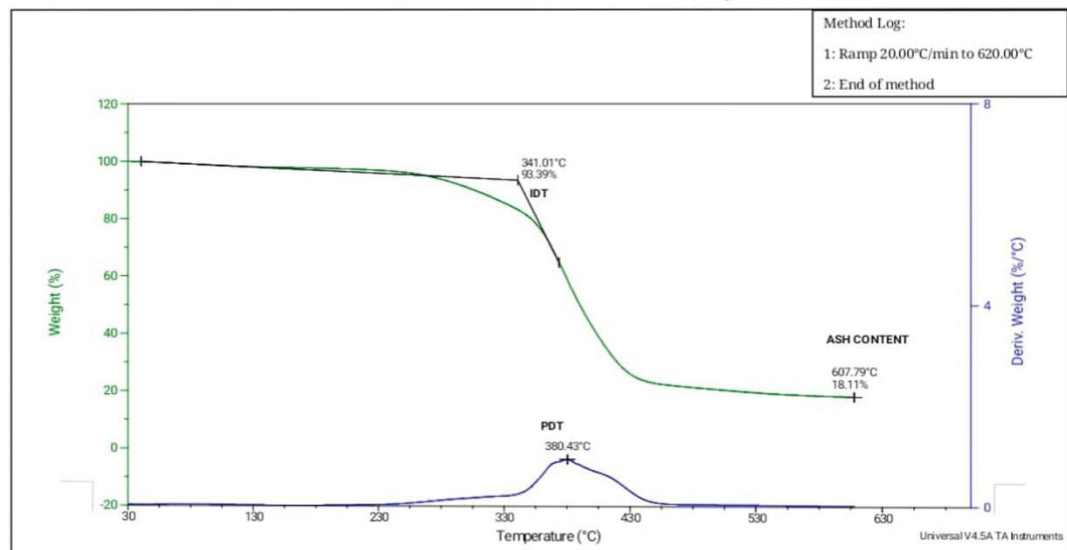


Fig:5.21: TGA Untreated fiber and Epoxy

TGA

Sample: EPOXY LY 556

Sample Size: 9.17700 mg

Operator:

Date of Experiment: 2022-02-23

File Path:

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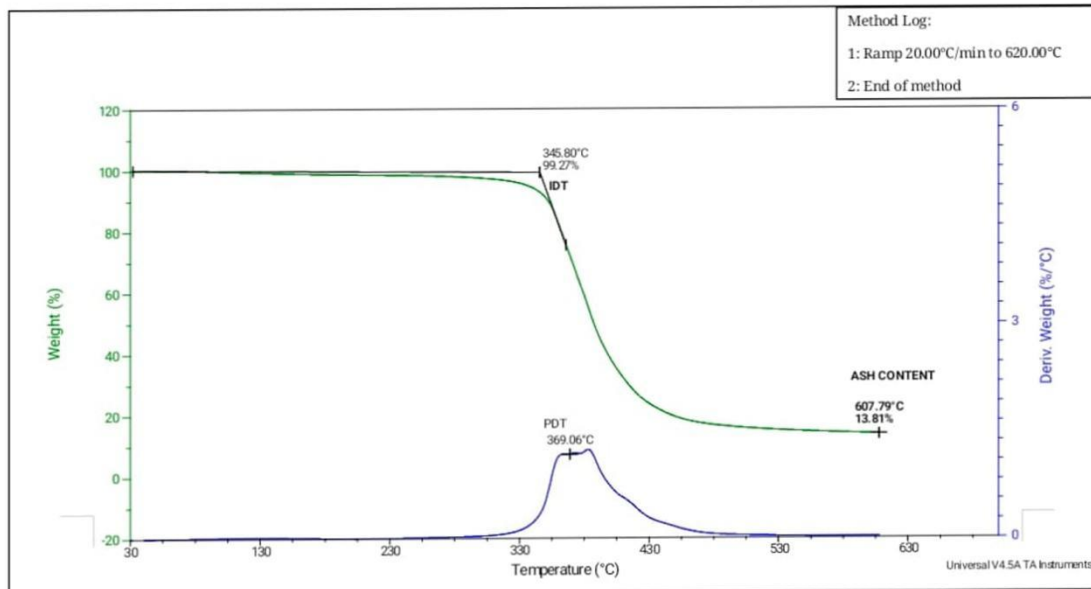


Fig:5.22: TGA Pure Epoxy

CHAPTER 6

SUMMARY AND CONCLUSION

Based on the study conducted on the Five composite specimens of Pure Epoxy, Untreated natural fiber composite and treated natural fiber composite of mechanical and morphological analysis were done

Our goal is to create a natural fiber composite using the fibers obtained from the aerial roots of the banyan tree. $\text{Ca}(\text{OH})_2$ Solution is used to treat the fibers harvested from the banyan tree's aerial roots prior to further chemical processing and cleaning. In addition, the natural fibers qualities are enhanced as a result of the treatment process, which mostly decides when the composite component derived from the treated natural fiber is built and evaluated for different compositions of the Composites

While $\text{Ca}(\text{OH})_2$ treatment yielded the most fibers in terms of yield, the overall study of characteristics of extracted fibers found that those extracted using sodium hydroxide were the best.

The physical properties of fibers extracted from aerial roots of banyan tree were found to be comparable to other cellulosic fibers like sisal, coir, and jute; with the added benefit that the aerial roots of banyan tree do not require cutting down the whole tree, and thus, this part of the plant can also be put to use commercially, as well. As a consequence, the produced fibers exhibit a rare mix of qualities, including low strength, moderate elongation, and good moisture recovery and retention. Along with this, Banyan tree fibers show good resistance to bacterial and fungal development, which is unusual in natural cellulosic fibers, making them suited for possible use in hygiene items such nonwovens in baby diapers, nursing pads, surgical masks, and so on. These fibers may be used in a variety of applications, including ropes and twines that are often used in the nautical and agricultural industries as well as in specialty paper, dartboards, filters, geotextiles, or as a microbe-resistant stuffing in mattresses.

REFERENCE

1. Banyan and peepal fiber reinforced hybrid composites, ICDAMS 2018, MATEC Web of Conferences 172, 04009 (2018) <https://doi.org/10.1051/matecconf/201817204009>
2. Basu, G., A. N. Roy, K. K. Satapathy, S. M. J. Abbas, L. Mishra, and R. Chakraborty. 2012. Potentiality for value-added technical use of Indian sisal. *Industrial Crops and Products* 36 (1):33–40. doi: 10.1016/j.indcrop.2011.08.001.
3. Bessadok, A., S. Marais, F. Gouanve, L. Colasse, I. Zimmerlin, I. Zimmerlin, and M. Metayer. 2007. Effect of chemical treatments of Alfa (*Stipa tenacissima*) fibers on water-sorption properties. *Compo. Sci. Technol* 67 (3–4):685–97. doi: 10.1016/j.compscitech.2006.04.013.
4. Devipriya .D, Selvaraj mohana roopan, *Cissus quadrangularis* mediated eco-friendly synthesis of copper oxide nanoparticles and its antifungal studies against *Aspergillus Niger*, *Aspergillus flavus*, *National library of medicine*, 2017.
5. Espinach F.X, Granda L.A, Tares. Q, Duran. J, Fullan-I-Palmer. P, Mutje. P, Mechanical and micromechanical tensile strength of eucalyptus bleached fibers reinforced polyoxymethylene composites, *Composites part B: Engineering*, volume-116, 2017, pg.no 333-339. <https://doi.org/10.1016/j.compositesb.2016.10.073>
6. Fong Sim, S., M. Mohamed, N. Aida Lu Mohd Irwan Lu, N. P. Safitri Sarman, and S. Nor Sihariddh Samsudin. 2012. Computational FTIR with PCA. *Bioresources* 7 (4):5367–80.
7. Fiore. V, G. Di Bella, Valenza. A, The effect of alkaline treatment on mechanical properties of kenaf fibers and their Epoxy composites, *Composites part B: Engineering*, volume-68, 2015, pg.no 14-21. <https://doi.org/10.1016/j.compositesb.2014.08.025>
8. Geethamma, V. G., L. A. Pothen, B. Rhao, N. R. Neelakantan, and S. Thomas. 2004. Tensile stress relaxation of short-coir-fiber-reinforced natural rubber composites. *Journal of Applied Polymer Science* 94 (1):96–104. doi:10.1002/app.20746.
9. Ghali, A. E., I. B. Marzoug, M. H. V. Baouab, and M. S. Roudesli. 2012. Separation

- and characterization of new cellulosic fibers from the *Juncus actus* Epoxy. *bioresources* 7 (2):2002–18. doi:10.15376/biores.7.2.2002-2018.
10. Gaurav, Hrithik gohal, Vishal kumar, and Hemalata jena, Study of natural fiber composite material and its hybridization techniques, *Materialstoday:Proceedings*, volume-26, part 2, 2019, pg.no 1368-1372.
<https://doi.org/10.1016/j.matpr.2020.02.277>
 11. Hazarika, D., N. Gogoi, S. Jose, R. Das, and G. Basu. 2017. Exploration of future prospects of Indian pineapple leaf, an agro waste for textile application. *Journal of Cleaner Production* 141:580–86. doi: 10.1016/j.jclepro.2016.09.092.
 12. Henriksson, G. et al., 1997. Identification and retting efficiencies of fungi isolated from dew-retted flax in the United States and Europe. *Appl. Environ. Microb.* 63, 3950–3956 Hong C.K, Hwang. K, Kim .N, Park D.H, and Hwang B.S, Mechanical properties of salinized jute–polypropylene composites, *Journal of industrial and engineering chemistry*, volume-14, 2008, pg.no 71-76.
<https://doi.org/10.1016/j.jiec.2007.07.002>
 13. Jie Chen, Xia Wang, Zhu Long, Lei wang, Jingxian Zhang, Preparation and performance of thermo Epoxy starch and microcrystalline cellulose for packaging composites: Extrusion and hot compressing, *National library of medicine, Int. J. Biol. Macromol*, 2020. <https://doi.org/10.1016/j.ijbiomac.2020.10.117>
 14. Hossain. S. I, Hasan .M, Hasan.MD. N, and Haasan. A, Effect of Chemical Treatment on Physical, Mechanical and Thermal Properties of Ladies Finger Natural Fiber, *Advances in materials science and engineering*, volume-13, 2013.
<https://doi.org/10.1155/2013/824274>
 15. Kaushik, N. K., A. Bagavan, A. A. Rahuman, D. Mohanakrishnan, C. Kamaraj, G. Elango, A. A. Zahir, and D. Sahal. 2013. Antipox Resin LY 556smodial Potential of Selected Medicinal Epoxy from Eastern Ghats of South India. *Experimental Parasitology* 134 (1):26–32. doi: 10.1016/j.exppara.2013.01.021.
 16. Kathirselvam .M, Kumaravel. A, Arthanarieswaran V.P, Saravana Kumar S.S, Isolation and characterization of cellulose fibers from *Thespesia popular* barks : a study on physicochemical and structural properties, *international journal of biological macromolecules*, volume-129, 2019, pg.no 396-406.
<https://doi.org/10.1016/j.ijbiomac.2019.02.044>

17. Kommula V.P, Obi reddy .K, Shukla .M, Marwala .T, Varada Rajulu .A, Physio-chemical, tensile, and thermal characterization of napier grass (native African) fiber strands, International journal of polymer analysis and characterization, volume-18, 2013, pg.no 303-314. <https://doi.org/10.1080/1023666x>
18. Lewin, M., and E. M. Pearce. 1985. Fiber chemistry of Handbook of fiber science and technology, Vol. 4. New York: Marcel Dekker, Inc.

Liu, W., M.Misra,P. Askeland,L. T. Drzal,and A.K.Mohanty.2005. 'Green'composites from soy-based Epoxy and pineapple leaf fiber: Fabrication and properties evaluation.Polymer 46 (8):2710–21. doi:10.1016/j. polymer.2005.01.027. <http://dx.doi.org/10.1016/j.msec.2017.05.130>
19. Reddy, N., and Y. Yang. 2009. Extraction and Characterization of Natural Cellulose Fibers from Common Milkweed Stems. Polymer Engineering and Science 49 (11):2212–17. doi:10.1002/pen.21469
20. Singh, G., S. Jose, D. Kaur, and B. Soun. 2020. Extraction and Characterization of Corn Leaf Fiber. Journal of Natural Fibers 1–11. doi:10.1080/15440478.2020.1787914.
21. Thakur, MK, Rana, AK & Thakur, VK 2014, Lignocellulosic Polymer Composites: A Brief Overview. in Lignocellulosic Polymer Composites: Processing, Characterization, and Properties. vol. 9781118773574, Wiley Blackwell, pp. 1- 15. <https://doi.org/10.1002/9781118773949.ch1>
22. Yan, Y. 2016. Developments in fibers for technical nonwovens. Advances in Technical Nonwovens 19–96. doi:10.1016/ b978-0-08-100575-0.00002-4.
23. Yu, T., J. Ren, S. Li, H. Yuan, and Y. Li. 2010. Effect of fiber surface-treatments on the properties of polylactic acid)/ ramie composites. Composites. Part A, Applied Science and Manufacturing 41 (4):499–505. doi:10.1016/j. compositesa.2009.12.006.
24. Madhusudhan reddy .B, Meenakshi reddy .R, Chandrasekhar reddy .B, Venkateshwar reddy .P, Raghavendra rao .H, Mohan reddy Y.V, the effect of granite powder on mechanical, structural and water absorption characteristics of alkali treated Cordia dichotoma fiber reinforced polymer composite, Polymer testing, volume-91, 2020. <https://doi.org/10.1016/j.polymertesting.2020.106782>
25. Manimaran .P, Saravanan S.P, Prithiviraj .M, Investigation of physical chemical

properties and characterization of new natural cellulosic fibers from the bark of
fiscus racemose, Journal of natural fiber, volume-18, issue 2, 2019, pg.no 274-284.
<https://doi.org/10.1080/15440478.2019.1621233>