

**CHARACTERIZATION AND ANALYSIS OF CHEMICALLY TREATED BANANA
FIBER REINFORCED POLYLACTIC ACID COMPOSITE**

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in
Mechanical Engineering

By

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(DEEMED TO BE UNIVERSITY)

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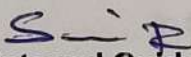
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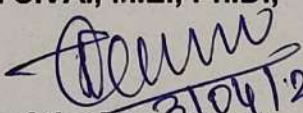
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of RONAN STEVE HAWES (Reg. No. 40150038) and SAM JEFRIN.C (Reg. No. 40150042) who carried out the project entitled "**CHARACTERIZATION AND ANALYSIS OF CHEMICALLY TREATED BANANA FIBER REINFORCED POLYLACTIC ACID COMPOSITE**" under my supervision from December 2023 to April 2024.

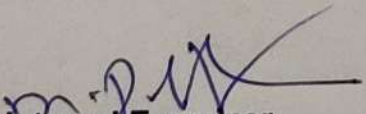

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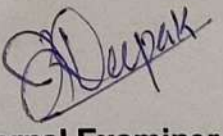
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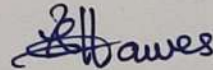
DECLARATION

We, RONAN STEVE HAWES (Reg. No. 40150038) and SAM JEFRIN.C (Reg. No. 40150042) hereby declare that the Project Report entitled "**CHARACTERIZATION AND ANALYSIS OF CHEMICALLY TREATED BANANA FIBER REINFORCED POLYLACTIC ACID COMPOSITE**" done by us under the guidance of Dr. R. SIVA, M.E., Ph.D., is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

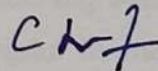
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ABSTRACT

The incorporation of natural fibers in composites leads to a notable enhancement in mechanical strength, hence resulting in greater structural stability of these materials. Moreover, these composite materials exhibit the supplementary advantages of environmental friendliness, cost-effectiveness, ease of production, and ease of construction. Natural fibers derived from plants are increasingly being favored over synthetic fibers due to their environmentally friendly nature, reduced density, and greater affordability. The enhancement of mechanical strength in natural fiber-reinforced composites can be achieved through the manipulation of many factors, including the augmentation of fiber density, the utilization of a greater quantity of binder, and the incorporation of additional filler material. Nevertheless, it is crucial to bear in mind that these parameters possess specific limitations; exceeding these limitations would lead to a deterioration of the attributes. It is imperative to bear in mind the existence of these limitations. The objective of this review was to provide an overview of various fiber types, as well as the techniques employed for their extraction, accompanied by an examination of their physical properties (such as single fiber tensile strength, density, and diameter) and chemical analyses. The potential application of reinforcement in composite material preparation is discussed in relation to characterization tests conducted on the fibers. These tests include Fourier-transform infrared spectroscopy (FTIR), X-Ray diffraction analysis (XRD), Thermogravimetric analysis (TGA), and morphological analysis.

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LIST OF SYMBOLS AND ABBREVIATIONS

PLA	Polylactic Acid
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

CHAPTER 1

INTRODUCTION

1.1 Natural fiber

Natural fiber plays an important role in the current generation. Natural fibers are essential to our everyday existence and have a long history and cultural heritage. Derived from plants, these fibers possess unique properties that have made them indispensable in various applications like clothing and textiles to construction materials and industrial products. Natural fibers have been utilized across diverse industries due to their versatility, sustainability, and eco-friendliness.

Natural fibers are biodegradable. They are obtained from nature. The natural fibers are equally suitable for the environment. They are 100% biodegradable and compostable. The natural fibers are used as composite material where the orientation of fibers impacts the properties. Natural fibers are matted into sheets. Most natural fibers are known as an absorber of water and other liquids. These are having advantages like Low density, Low-cost High porosity, Non-toxic, Non-abrasive, Greater specific stiffness, Specific Strength, more resistance to corrosion, better recyclable, large fatigue strength, more impact absorption capacity, Lower toxicity, Plentiful availability, recyclability, can overrule the usage of synthetic fiber composite, Human welfare in handling, Lightweight. The current work aims to characterize the natural fibers are collected from the stem of a plant. This fiber is available near our residential area. There are five types of fiber in plant

- Wood
- Stem
- Leaf
- Seed
- Grass

In these we selected banana stem fiber to make composite. We have selected *Musa genus plant* due to high tensile strength and other mechanical properties. Primarily *Musa genus plants* are grown for the fruit but the fiber from the stem can be extracted once the harvesting is done and the stem is then cut down and the outer layer of the stem are removed and exposed as the fiber. This process is done

manually or with the help of machinery, The stripped stems are soaked in water to soften the tissues and separate the fibers from the non-fibrous material. This process can take several days to weeks, Softened fibers are scraped or brushed to remove any remaining non-fibrous material and to separate the fibers from each other. The fibers are thoroughly washed to remove any impurities and retting residues. These fibers are dry natural or artificial using hot air oven

The chemical treatment is done to the fiber in these we selected sodium hydroxide (NaOH) for chemical treatment after chemical treatment the fiber are dry in the sun light naturally and cut down shorter size lesser than 3 mm and preheated Polylactic acid (PLA) and chemical treated fiber are allowed to run in two roll mill with the temperature of 120°C after mixing the PLA and fiber together it made into composite plate by using compression mould.

Composites are materials with unique mechanical and physical qualities that are employed in a variety of industries and are created for specific purposes. Composite materials offer a number of benefits over traditional materials, including tensile. The composite samples are subjected to various morphological analysis, strength, and impact strength tests.

Morphological analysis includes SEM, TGA, XRD and FTIR. There are two types of polymers such as thermoplastic and thermosetting polymers. Thermosetting polymers include epoxy which is a non-bio degradable whereas thermoplastic include polylactic acid (PLA) which is bio degradable. The PLA series depends on the process that is going to be used and the size of the fiber. For this fiber we have chosen polylactic acid granules (3052 D) taken from the nature tech Pvt. Ltd. This series of polylactic acid was chosen as it is suitable for use in a two mill roll machine with a temperature ranging from 130°C to 180°C.

CHAPTER 2

LITERATURE SURVEY

Cecchi et al. (2020). The goal of this study is to identify new environmentally acceptable applications for banana pseudo stem fiber. The morphological features of cellulosic fibers obtained from pseudo stems allow for the creation of fabrics with excellent mechanical properties. Fibers were physically extracted from banana pseudo stems, and their diameter, tensile strength, elongation at break, and morphological structure were measured using scanning electron microscopy. Mechanical tests revealed that natural fibers with identical chemical compositions and FTIR absorption bands, such as jute (249 MPa) and sisal (350 MPa), had much higher tensile strength (590 MPa). The fiber's form and high crystallinity (~67%) in the FTIR spectrum contribute to its exceptional mechanical strength. The created fibers proved to be among the strongest natural fibers, and they might be employed as a reinforcing material in composites, packaging, clothes, carpets, ropes, and decoration and design.

Tuan Anh Nguyen et al. (2022). In this experiment, natural fiber banana, was chosen to create bioavailable materials with improved mechanical properties. The banana fiber was mechanically removed from the banana sheath and then treated with NaOH at concentrations of 1, 2, 3, 4, and 5%. Treatment with NaOH effectively removes other impurities and roughens the fiber surface, increasing compatibility and bonding between banana fiber and PLA. The ideal NaOH concentration for the polylactic acid (PLA) composite/banana fiber material has been reported to be 5% banana fiber. The hot melt mixing procedure was used to make e composites (BF). The study indicated that adding 20% banana fiber by weight led to satisfactory mechanical strength values (52.57 MPa tensile strength, 70.35 MPa flexural strength, 155.45 J/m impact strength, and 23.8 Hv hardness). SEM studies showed that the NaOH treatment removed surface impurities from the fiber.

Manish Kumar Lila et al. (2019). The current study used three distinct processing methods to create bio composites based on short banana fiber (20 weight percent)

and polylactic acid: direct injection moulding (DIM), extrusion injection moulding (EIM), and extrusion compression moulding (ECM). To comprehend and contrast the performance of the created bio composites, dynamic mechanical analysis, thermal and mechanical characterization, and other procedures have been carried out. To look into the existence and kind of interfacial contact in the bio composites, FTIR analysis has been done. The bio composites' crystallinity was measured and their structure examined using XRD analysis. The bio composites made by EIM showed a notable improvement in their dynamic mechanical properties (storage modulus, loss modulus, and tan delta), as well as their mechanical properties (tensile and flexural parameters) and crystallinity.

Ranvijay kumar et al. (2024). This article focuses on how different machining limitations affect the cutting force (Pz) and surface roughness (Ra) of alkaline-treated banana fiber-reinforced polymer (T-BaFRP) composites. Mechanical characteristics are adequate at a weight fraction of 30%. DFA and TOPSIS are employed in the design of experiments and optimization with the Taguchi orthogonal array L25. Under compressed cooling air-cutting settings, an experimental study was carried out with pressure maintained at 8 bar. The results of an analysis of variance show that feed rate and depth of cut are the main determinants of cutting force and surface roughness. For surface roughness, the error between the anticipated and experimental values is 0.517%, and for cutting force, it is 1.181%. The ideal depth of cut, cutting speed, and feed rate were found to be 0.362 mm, 55 m/min, and 0.113 mm/rev for the DFA and TOPSIS optimization, and 0.8 mm, 154 m/min, and 0.12 mm/rev for the TOPSIS optimization. The obtained values are Ra of 2.594 μm and Pz of 14.258 N by DFA and 3.02 μm and 25.83 N by TOPSIS technique. Furthermore, the results of the TOPSIS and DFA appear to be closely aligned with the response parameters (surface roughness and cutting force), according to the confirmation test.

C. Thiagarajan et al. (2023). In order to better understand the tensile, bending, effect, and delamination failing of boiling composites, coir fibers and chemically treated bananas were strengthened and then treated with polylactic acid (a NaOH solution) as untreated (PLA). The fibers recovered by retting and manual procedures were used to create the composites. For both treated and untreated fibers, the composites are

made with 25, 30, and 35% of the fibers. A 4% NaOH solution has been applied to banana-coir fibers at room temperature. These composites are evaluated for delamination as well as tensile, bending, and impact strength after boiling and comparing to one another. Drilling was done at various feed rates and speed levels in response to delamination failure and input parameter changes. The Taguchi technique with L9 (34) Orthogonal array was selected in order to affect the delamination, tensile, bending, and impact strength for different fiber-reinforced composites based on the fiber contents and drilling parameters (chemical fiber, cutting speed, feed rate). The findings indicate that lower fiber, higher feed rate, and lower spindle rate have a significant impact on the inability of chemically treated banana coir fiber-PLA enhanced compounds to delaminate during the boiling process.

(Adugna Ayalew & Fenta Wodage, 2022) Sisal fibers are among the strongest natural fibers available and can be utilized as a support material for polymers. The fibers were treated with 2%, 6%, and 10% sodium hydroxide (NaOH) concentrations for 24, 48, and 72 hours of soaking time. Fourier transform infrared spectroscopy was used to characterize the functional groups of treated and untreated sisal fibers. The thermal stability of sisal fiber was assessed using thermogravimetric analysis (TGA). The elimination of lignin and hemicellulose as functional groups was confirmed by an FT-IR investigation, which revealed that either hemicellulose was eliminated or the peak intensity decreased gradually as alkali concentration increased. Sisal fiber exhibits significant mass loss at 59°C and 378°C, indicating the elimination of surface moisture. The sisal fiber sample's TGA arc shows a strong endothermic peak at 59°C. The peak observed at 378°C could be caused by water molecules absorbed in the interlayer. This condition is caused by dehydration of the sisal fiber's outer fiber surface and interlayer matrix. The results revealed that surface-treated sisal fibers were better resistant to temperatures of 260°C and below.

(Ray and Sarkar 2001) The effects of 5% NaOH solution treatment on jute fibers were tested for periods of 0, 2, 4, 6, and 8 hours. During the 2-hour treatment, hemicellulose content decreased from 22 to 12.90%, resulting in a 9.63% weight loss. After 8 hours of treatment, treated fibers' tenacity and modulus increased by

45% and 79%, respectively, while their breaking strain decreased by 23%. The crystallinity of the fibers increased only after 6 hours of treatment. Ray et al. 2001 studied the impact fatigue behavior of vinyl ester matrix composites reinforced with untreated and alkali-treated jute fibers. Because of the elimination of hemicellulose, longer alkali treatments increased crystallinity and improved fiber dispersion. Alkalization for 4 hours was the most effective treatment time for improving interfacial bonding and fiber strength. Alkali-treated jute fiber composites had a higher flexural strength than untreated jute fiber composites. This could be due to the alkali-treated jute fiber's increased surface area adhering to the polymer matrix. Describes the analysis and comparison of mechanical characterisation data for jute-epoxy and jute-polyester composite specimens made in accordance with ASTM standards. The tensile strength of jute-epoxy and jute-polyester composites was found to be 12.46 N/mm² and 9.23N/mm², respectively. 5% NaOH treated jute fiber reinforced composites appeared to have a higher tensile strength than 10% NaOH treated fiber reinforced epoxy composites by 18.67%, and polyester composites showed a 16.67% increase. The tensile modulus of jute epoxy composite was determined to be 1.046 GPa, while that of jute polyester composite was 0.811 GPa. The flexural strength of jute-epoxy and jute-polyester composites was calculated to be 38.68 and 44.71 N/mm², respectively.

Balaji et al, (2020). It declares about methodology of making the composite on a compression moulding process. The compression moulding machine need to get a temperature of 200°C and after heating the plates at a 200°C remove the mould plates from the machine and applying a wax removal to get a composite sheet ease removal and placing the fiber in a mould plate and compressing the plates at a range of 40MPa for 20 – 30 min and cool the plates by using water coolant, wait until the temperature reaches to 100°C and after reaching remove the plates and apply load on a plate. After few minutes take composite from out of the mould plates and kept in a room for 24 hours in a normal humidity.

Yeng-Fong Shih et al (2011). Melt blending was employed in this study to generate composites of polylactic acid (PLA) and banana fiber (BF). The BF was conjugated onto PLA chains by a coupling agent and a chemical modification. As a result, the addition of BF considerably increased the PLA's mechanical and thermal stability. Mechanical tests demonstrated that the fiber content of the composites greatly increased the tensile and flexural strengths, which reached 78.6 and 65.4 MPa when reinforced with 40 phr fiber, or approximately 2 and 1.66 times greater when manufactured from pristine PLA. Nonetheless, increasing fiber content reduces composite impact strengths slightly. The HDT of pure PLA in the composite improved from 62 °C to 139 °C with the addition of 40 phr BF, representing a 122% improvement. In addition to increasing the mechanical properties and thermal stability of materials, adding BF can reduce production costs while meeting environmental regulations.

CHAPTER 3

AIM AND SCOPE OF THE PROJECT

3.1 Aim

The primary goal of this project is to compare the PLA composite, PLA with untreated natural fibre composite, and PLA with treated fibre composites.

- To prepare a PLA composite with untreated fiber and PLA composite with treated fibers using a two-roll mill and a compression mould machine
- To determine the tensile strength, flexural strength and impact strength of this fiber
- To study the SEM structure of this composite
- To examine the characteristics of the composite using XRD, FTIR and TGA

3.2 Scope of the project

Instead of using synthetic fibers such as (nylon, polyester) using natural fiber has and is much more advantageous and a better alternative. Using synthetic fiber can cause a lot of environmental problems. Whereas using natural fibers is eco-friendly and the cost is relatively cheaper than synthetic fiber. Making of such natural fiber composite is also easy. This project allows us to understand the properties of these composites. This project also bridges the gap between theoretical knowledge and practical applications, enabling the development of more robust and versatile natural fiber composites. The resulting insights will aid in the creation of innovative solutions for industries such as textiles, automotive, construction, and packaging, which increasingly seek sustainable and environmentally friendly alternatives. Moreover, this comprehensive review acts as a catalyst for enhancing the overall understanding and application of commercial natural fibers, contributing to both economic growth and ecological sustainability.

CHAPTER 4

MATERIALS AND METHODS

4.1 Materials Required

Bananas stem fiber, PLA 302D, NaOH

4.2 Methodology

The methodology followed in this project is divided in several steps

- Extraction of fiber
- Chemical treatment on the fiber
- Preparation of natural fiber composites with PLA
- Testing and analysis

4.2.1 Chemical Treatment

The experiment was conducted on two types of fiber treatment

- Treated fiber
- Untreated fiber

4.2.1.1 Treated Fiber

For the preparation of Treated fiber, banana fiber is treated with chemical called NaOH with three different ratio 3%, 6%, 9% with is mixed in the distilled water This fiber is kept in the chemical water for an hour after the process the fiber are washed in the water for 3 to 4 times in normal water and once in distilled water after the process the fiber are collected in the bowl and dry in the natural sun light after that the fiber are allowed to dry in heat chamber for 2 hours at 100 °C



Fig 4.1 Dry Fiber



Fig 4.2 Fiber treated with NaOH chemical

4.2.1.2 Untreated Fiber

Untreated fiber involves no process like chemical treated with NaOH, extracted fiber are allow to dry and collected in the bowl, The fiber is placed in a beaker and heated in the hot chamber for 2 hours at 100°C



Fig 4.3 Untreated fiber dried with hot air oven



Fig 4.4 Removing excess moisture using hot chamber

4.2.2 Sample Preparation

For the preparation on natural fiber composites PLA granules (5032D) which are purchased from Naturtech Pvt.ltd, these PLA granules are suitable for compression molding process at a temperature of 190°C to 200°C this composite preparation process is divided into two stages.

- Blending
- Compression

4.2.2.1 Blending

In this blending the process is held at CIPET Kochi, Kerala the PLA granules were pre heated and both polylactic acid granules and fiber are blended into a sheet by using Two roller machine at a temperature between 150°C to 160°C. Two roller machine is used to prepare polylactic acid and fiber compounds, fiber and PLA granules are mixed together till the fiber and PLA blend together





Fig 4.5 Preparation of PLA and Banana fiber sheets using to roller machine

4.2.2.2 Compression

Using a compression molding machine the blended sheets will be compacted during this preparation. First, a 200°C temperature was adjusted for the compression molding machine. After 5 minutes, the 150 x 150 x 3 mm molding plates were placed into the machine and heated for 10 minutes. Following this, mold release wax was applied to the plates.

After 30 to 40 minutes of compression, the temperature is reduced using a water cooling system. Once the temperature drops from 200°C to less than 100°C, the compression mold plates are removed, and the composite is extracted.



Fig 4.6 Compression molding



Fig 4.7 Untreated banana fiber + PLA composite

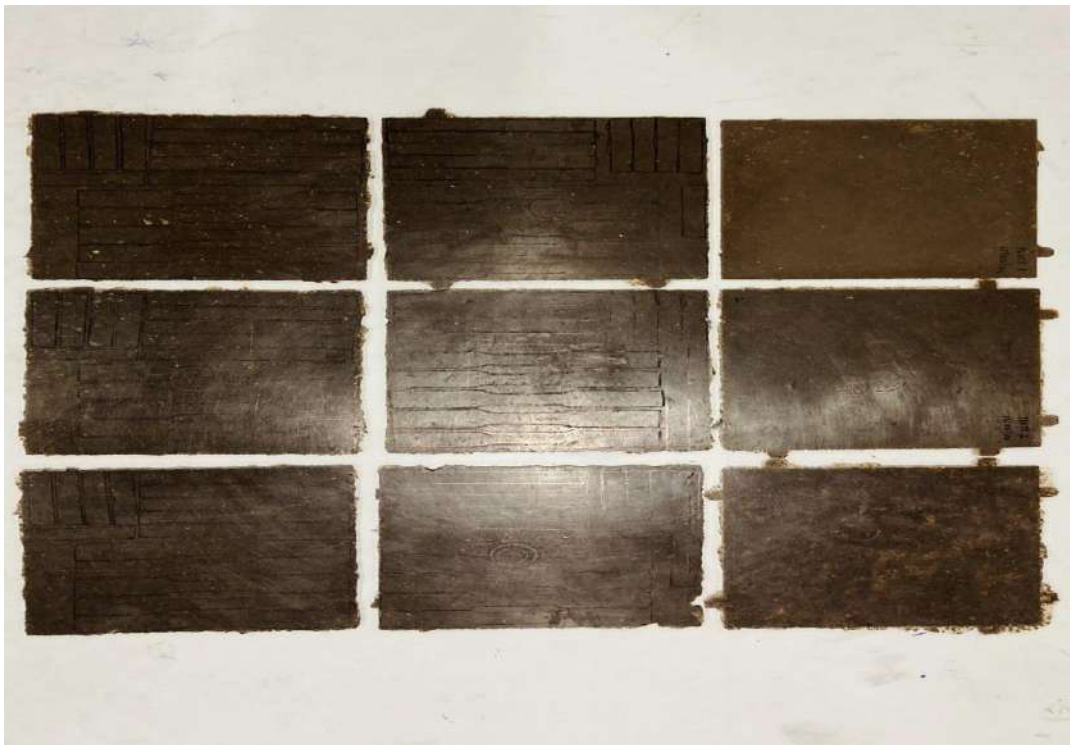


Fig 4.8 treated banana fiber + PLA composite

After preparing the composite plates by using the compression moulding machine. Tensile, flexural and impact samples were made from these composite plates as.

4.2.3 Analysis

In this project the 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, and FTIR.

4.2.3.1 Tensile test

The greatest load that a material can withstand without breaking when stretched, divided by its original cross-sectional area. Its dimensions are force per unit area. When the stresses are less than tensile strength, the material returns to its previous shape and size, whether entirely or partially. If stress surpasses tensile strength, the material will begin to flow rapidly and form a confined region known as the neck, where it will fracture. The test is carried out in accordance with ASTM D3039, which includes installing in a machine, exposing it to pressure in the testing machine, and then applying strain until it breaks. The ductile power is measured as an element of expansion in check length during strain application, and the lengthening of measured area is measured in relation to applied power. The test is run using a Universal Testing Machine with a load capacity of 400KN and a load rate of 5mm/min.





Fig 4.9 Tensile sample and measurements

4.2.3.2 Flexural strength

Flexural strength refers to the ability of a material to withstand bending or flexing without breaking. It is a measure of the maximum stress a material can withstand before it yields or fractures when subjected to bending forces, flexural test is to measure the strength and modulus of a flexural sample

The flexural strength is calculated from below equation

$$\sigma_{of} = 3pl/2bd^2 \quad (1)$$

Flexural modulus is calculated from slope of the stress vs strain in deflection curve. The equation is

$$EE_f = L^3m/4bd^3 \quad (2)$$

The flexural strength is carried out at a room temperature through three-point bend testing as specified in ASTM D-790.



Fig 4.10 flexural sample with measurements

4.2.3.3 Impact Strength

An impact test is a type of material testing method used to evaluate the ability of a material to withstand sudden loading or force, such as a sharp blow or a sudden impact. The primary purpose of an impact test is to assess the toughness, strength, and ductility of a material, which are crucial properties for determining its suitability for various applications. During an impact test, a standardized impact force is applied to a specimen under controlled conditions, and the material's response to this force is measured. This test helps in determining the material's resistance to fracture, crack propagation, and deformation under impact loading. Impact tests are commonly used in industries such as aerospace, automotive, construction, and manufacturing to ensure that materials and products meet specified requirements for safety and performance. The impact strength of the sample is then calculated from the impact strength and the impact resistance.

In terms of physical qualities, we conducted scanning electron microscope examination to investigate the bonding between the fiber and polylactic acid at the fractured region of the composite material. Scanning electron microscopes are used for this. Using this research, we may also investigate how the fiber interacts with the polylactic acid

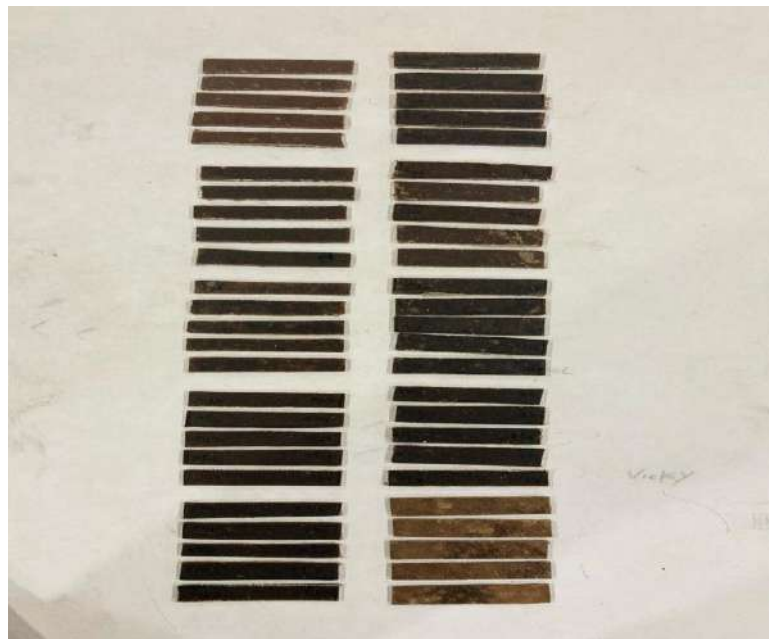




Fig 4.11 Impact samples with measurements

4.2.3.4 SEM Analysis

SEM stands for Scanning Electron Microscopy analysis. It is a powerful imaging technique used in materials science, biology, chemistry, and other domains to investigate sample surface appearance and composition at the microscopic level. SEM examination involves scanning a focussed beam of electrons across the sample's surface, yielding signals such as secondary electrons, backscattered electrons, and X-rays. These signals are then collected and analyzed to produce high-resolution photographs of the sample's surface topography, which reveal nanoscale details. SEM analysis can provide information on the sample's structure, composition, and even elemental analysis. SEM analysis is widely used in research, quality control and

failure analysis to investigate the microstructure of materials, study biological samples, characterize nanoparticles, and much more. It is a versatile tool that offers valuable insights into the properties and characteristics of a wide range of materials and samples.

4.2.3.5 TGA

TGA (Thermogravimetric Analysis) is an analytical technique for studying the thermal stability and composition of materials. During a TGA test, a sample is subjected to a controlled temperature program in a specialized instrument known as a thermogravimetric analyzer. As the sample is heated or cooled at a constant rate, the TGA instrument measures the change in the sample's weight as a function of temperature or time. This weight loss or gain provides valuable information about processes such as decomposition, oxidation, volatilization, or dehydration that occurs in the sample as it is heated. TGA analysis is widely used in various industries, including polymers, pharmaceuticals, chemicals, and materials science, to characterize the thermal properties of materials, assess their purity, understand decomposition mechanisms, and optimize processing conditions. TGA testing helps researchers and engineers gain insights into the thermal behavior and stability of materials under different conditions.

4.2.3.6 XRD

XRD is an abbreviation for X-ray diffraction, a powerful technique used to determine the atomic and molecular structure of crystalline materials. When X-rays impact a crystal, they scatter in various directions according to the arrangement of atoms within the crystal lattice. This scattering pattern, also known as a diffraction pattern, contains information on the atoms' spacing and orientation. Scientists can determine the crystal structure by analyzing the intensity and angles of diffracted X-rays, which include unit cell dimensions, atomic locations, and symmetry features. XRD is widely utilized in many domains, including materials science, chemistry, geology, and pharmacology, to characterize and identify crystalline compounds. It is critical in understanding material properties and behavior, allowing for the development of novel materials with tailored features for specific applications.

4.2.3.7 FTIR

FTIR stands for Fourier Transform Infrared Spectroscopy, a powerful analytical technique used to identify chemical compounds based on their absorption of infrared radiation. In FTIR, a sample is exposed to a broad spectrum of infrared light, which causes its molecules to vibrate at characteristic frequencies. The instrument then measures the absorbance of infrared light at different frequencies, producing a unique spectral fingerprint for the sample. This fingerprint can be compared to reference spectra to identify the compound or compounds present in the sample. FTIR is widely used in various fields such as pharmaceuticals, environmental science, materials science, and forensic analysis due to its high sensitivity, speed, and non-destructive nature. It can provide valuable information about molecular structure, functional groups, and chemical bonding, making it an indispensable tool for research, quality control, and process monitoring in many industries.

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 these are represented by using graphs,

5.1 Tensile Strength

This tensile strength test is performed at VIT college at Vellore. By using universal testing machine. The dimensions of the samples are 125×14×3mm. Table 5.1 shows the tensile sample of treated fiber.

Table 5.1 PLA + treated banana fiber composite tensile test result

Plate 1	Tensile strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	25.42	1037	2.45
Sample 2	31.18	1052.44	2.96
Sample 3	26.61	1132.37	2.35
Sample 4	26.65	1105.84	2.41
Sample 5	27.03	868.07	3.11
Average	26.42	1039.144	2.656

Plate 2	Tensile strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	27.69	882.42	3.13
Sample 2	28.97	838.91	3.46
Sample 3	26.67	540.10	4.93
Sample 4	21.46	984.38	2.17
Sample 5	29.46	917.98	3.19
Average	28.17	832.758	3.376

Plate 3	Tensile strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	27.007	845.56	3.19
Sample 2	25.95	727.87	3.56
Sample 3	23.80	871.09	2.73
Sample 4	23.23	621.20	3.72
Sample 5	26.44	802.0714	3.29
Average	25.28	773.55828	3.298

Plate 4	Tensile strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	28.76	976.96	3.298
Sample 2	29.76	953.12	3.298
Sample 3	28.80	925.89	3.298
Sample 4	29.25	1037.10	3.298
Sample 5	27.66	883.35	3.298
Average	28.76	955.284	3.298

Plate 5	Tensile strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	28.55	885.28	3.22
Sample 2	29.14	946.81	3.07
Sample 3	27.21	905.33	3.00
Sample 4	29.49	923.14	3.19
Sample 5	25.76	893.54	2.87
Average	28.03	910.82	3.07

Plate 6	Tensile strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	30.76	1000.75	3.07
Sample 2	31.94	926.1984	3.44
Sample 3	30.72	1007.06	3.05
Sample 4	33.80	972.71	3.47
Sample 5	34.82	905.12	3.84
Average	32.41	962.36768	3.374

Plate 7	Tensile strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	28.52	921.31	3.09
Sample 2	27.90	501.25	5.56
Sample 3	29.83	882.64	3.37
Sample 4	27.96	957.53	2.83
Sample 5	23.96	498.61	4.80
Average	27.54	752.268	3.93

Plate 8	Tensile strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	28.91	982.35	2.94
Sample 2	31.28	997.23	3.13
Sample 3	31.86	787.26	4.04
Sample 4	36.88	989.83	3.72
Sample 5	32.48	914.01	3.55
Average	33.12	934.136	3.476

Plate 9	Tensile strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	32.37	1036.93	3.12
Sample 2	29.09	1007.46	2.88
Sample 3	27.65	1023.34	2.69
Sample 4	19.97	576.34	3.46
Sample 5	27.89	1060.67	2.62
Average	29.25	940.948	2.954

Table 5.2 PLA + untreated banana fiber composite tensile test result

Plate 10	Tensile strength (N/mm ²)	Modulus of elasticity (N/mm ²)	Elongation (%)
Sample 1	21.99	1084.42	2.02
Sample 2	21.34	890.34	2.39
Sample 3	25.58	865.06	2.95
Sample 4	26.32	899.09	2.92
Sample 5	25.38	880.43	2.42
Average	24.12	923.868	2.54

These are the tensile samples after testing the tensile strength. The composition of this composite is 90% PLA 10% Fibre, 85% PLA Fibre 15%, PLA 80% fibre 20% respectively with dimensions of 125×14×3mm are shown in this picture. In this figure 5.2 the tensile samples of untreated fibre composite are shown, the dimensions of these samples are 125×14×3mm the composition of these samples are 80% PLA and 20% of fibre

5.2 SEM Analysis

This SEM test has been done in IRC, Sathyabama university Chennai. It is a physical property test, and the scanning electron microscope creates images of objects by scanning the surface with a focussed stream of electrons. These electrons will interact with many atoms on the surface, generating signals that include information about the surface's composition.

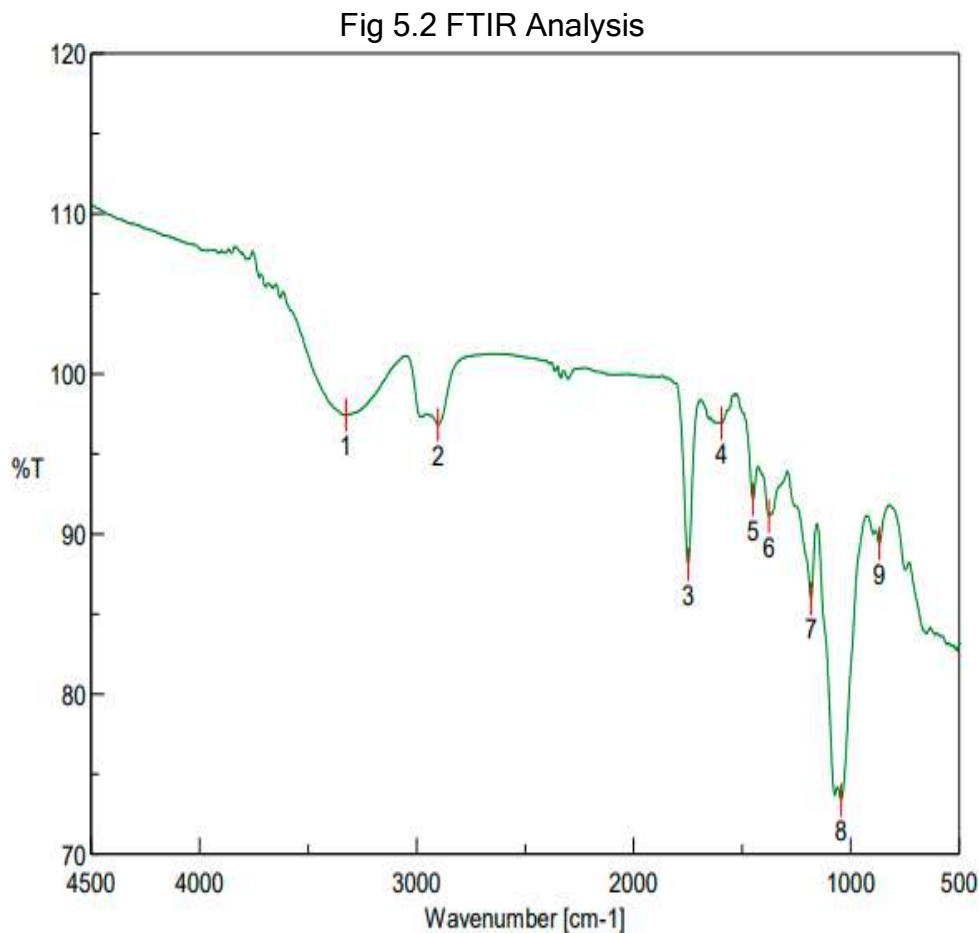


Fig 5.1 SEM Analysis of treated and untreated fiber

A SEM examination of the fractured side of the high-tensile sample reveals the position of the fibre, the bonding between it and the composite, some porous holes in the composite, and weak bonding between the fibre and the polylactic acid composite. Inadequate composite mixing has resulted in certain empty spaces.

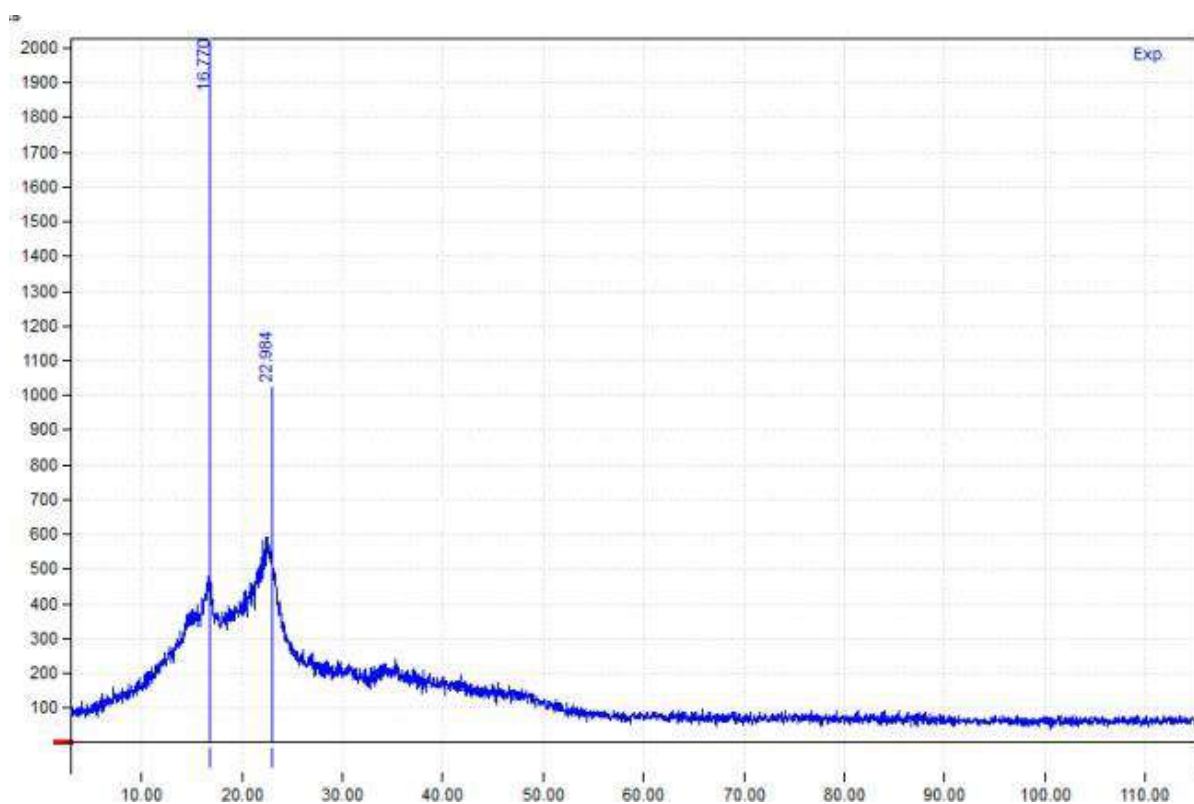
5.3 FTIR Analysis

This test FTIR is done at sathyabama university, Chennai, Tamil Nadu. This FTIR test is used to identify the functional groups present in the samples the FTIR analysis was performed and the graph is shown below The peaks observed in the FTIR spectrum are responsible for treated and untreated fiber particles. The band at 3487.43cm^{-1} & 2996.47cm^{-1} are responsible for the acidic O-H stretching [19] and the bond at 1824.09 , 1652.42 , 1382.02 and 1268.22 were to the C=O and C-O stretching [28]. the peak at 1142.54 , 1037.41 and 936.71 are the region of deformation vibration of outside the group



5.4 XRD

The crystalline nature of the fiber has been determined via XRD analysis. The effect of chemical treatment on fiber cellulose crystallinity was measured using an X-Ray diffractometer, as shown in graph 5.5 below. The CQ'S determination is critical for observing the change in amorphous content in the fiber following chemical treatment. A greater crystallinity index indicates the efficacy of chemical treatment.



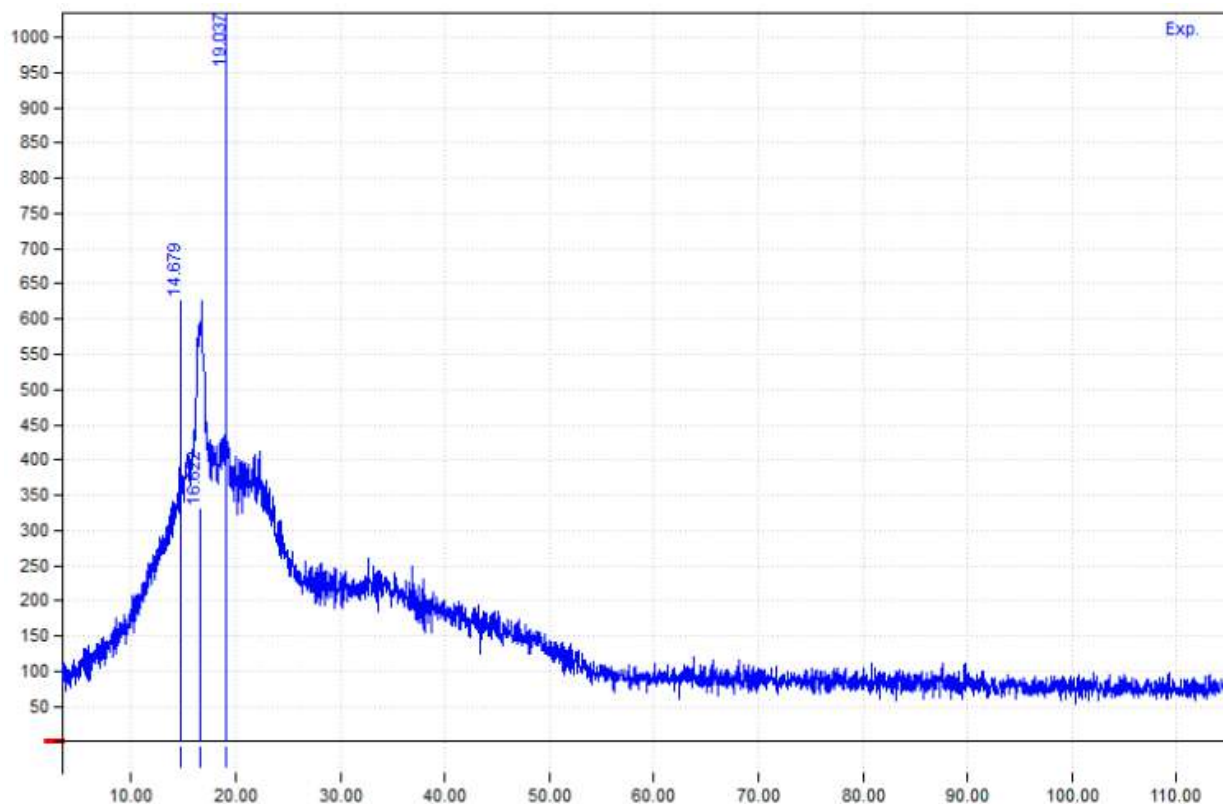


Fig 5.3 XRD Analysis

There are three significant peaks observed in treatment, with $2\theta = 16.77^\circ$ and 22.98° . It represents the existence of amorphous content and alpha cellulose. The untreated fiber exhibits two prominent peaks at $2\theta = 16.77^\circ$ and 22.98° . The crystalline index (CI) for treated and untreated fibers is 10.8% and 24.9%, respectively. The untreated fiber has a higher crystalline index than the treated fiber. This could be attributed to an increase in amorphous constituents in treated fiber following chemical treatment.

TGA analysis

Thermogravimetric analysis (TGA) is done at sathyabama university Chennai. This test is taken at the temperature range of 0°C to 1000°C , and atmosphere N_2 and using crucible Al_2O_3 . Heating rate is 10°C

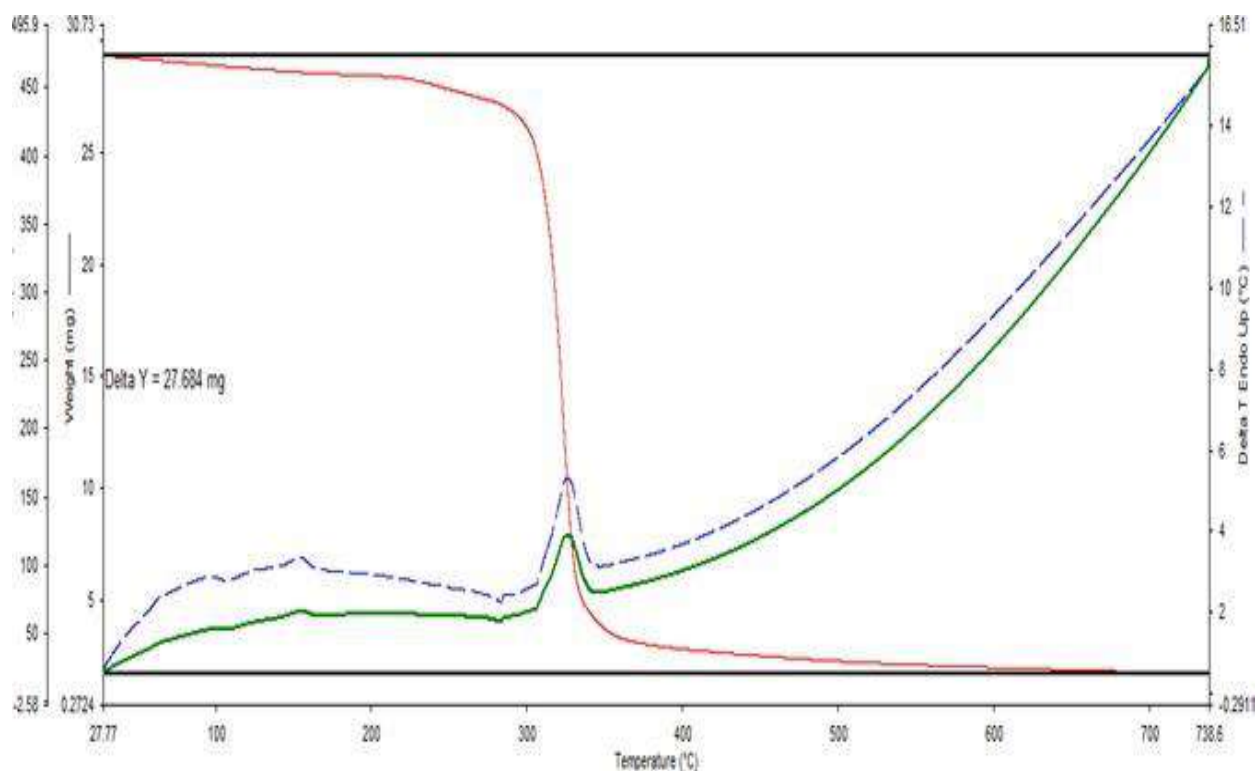
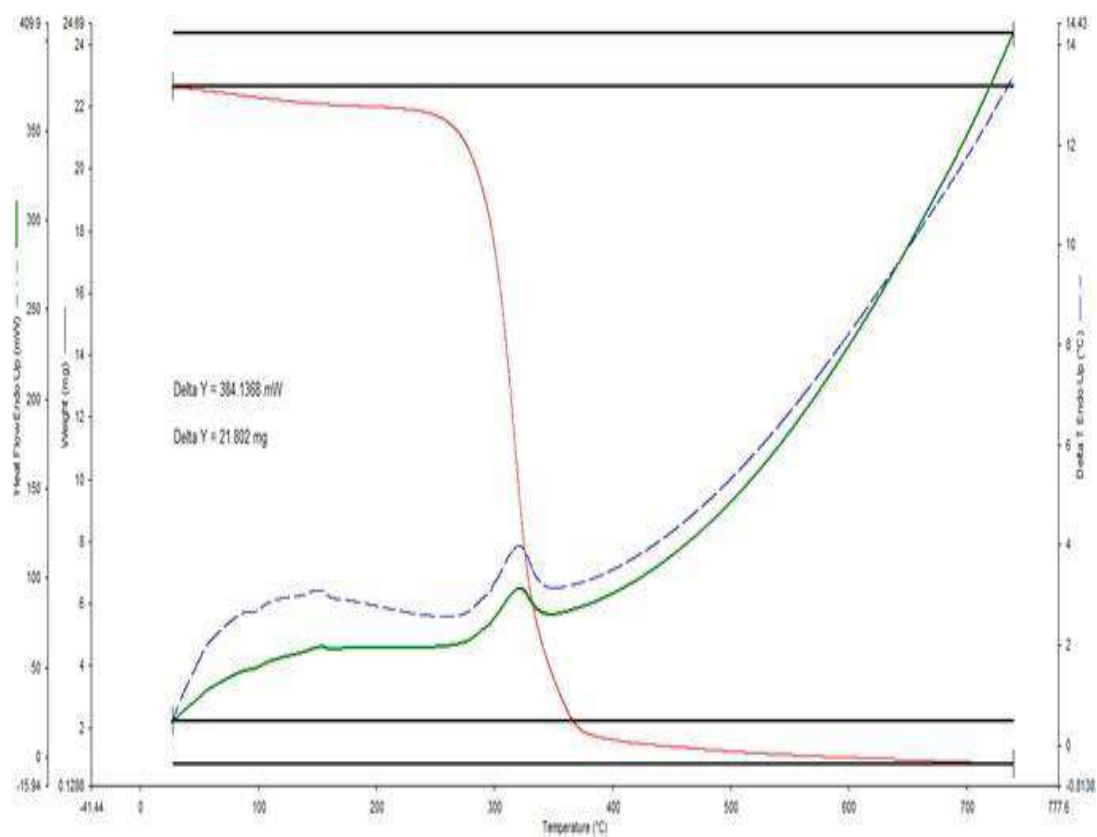


Fig 5.4 TGA Analysis

The thermal stability of the treated and untreated banana fiber, the composite powder was examined by TGA with DSC. Figures 5.6 and 5.7 show the corresponding TGA with DSC curves for treated and untreated fibers. The TGA curve's onset temperature (T_o) is approximately 180°C, at which 8% weight loss is observed; this weight loss is primarily due to moisture induced by structurally bound water molecules. As the temperature rises, thermal stability gradually declines, and thermal disintegration eventually occurs in three stages. For both treated and untreated fiber composite powders, the first step of disintegration occurs between 180 and 330°C. This implies a loss of hemicellulose and lignin content in the fiber.. The weight loss in this temperature range was about 15%.

The second stage of disintegration occurs at temperatures ranging from 330 to 600°C for treated and untreated fiber composite powders. Cellulose and lignin concentrations may degrade at these temperatures. Temperature-related weight loss is approximately 60%. The results showed that the disintegration temperature of the composite powder increased, indicating that the treated composite powder had a higher thermal stability by up to 20%. An inorganic material found in the untreated composite often improves the thermal stability of the treated composite. The final step of deterioration occurs when α -cellulose decomposes at 600°C - 940°C and 600°C - 930°C, resulting in weight losses of 40% and 55% for treated and untreated fiber, respectively. This may be due to presence of amorphous constituents in the treated fiber.

CHAPTER 6

SUMMARY AND CONCLUSION

Based on the study conducted on the ten composite specimens of treated natural fibre composite and untreated natural fibre composite of mechanical and morphological analysis were done

- Tensile strength of treated natural fibres of plate 8 with 20% fiber, 80% PLA, NaOH and 1% glycol 33.28 N/mm² has higher tensile strength. Tensile strength of untreated fiber composite is 23.81 N/mm². This shows that the treated fiber has a higher tensile strength than untreated fiber composite
- Tensile strength the ASTM D 3039 shown the treated fibre composite has higher value 33.125 N/mm².
- Tensile modulus of elasticity is higher in treated composite compared to untreated composite and PLA composite with the value of 1039 N/mm².
- Tensile elongation is higher in treated composite 3.93%..
- Presence of voids and broken fiber was observed in SEM analysis.
- In FTIR Analysis, the untreated sample peak given elongation higher in O-H bond in cellulose.
- In XRD analysis crystalline index of untreated fiber (24.9%) is higher than treated fiber composite (10.8%).
- Higher crystalline index emphasizes the effectiveness of chemical treatment.

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APPENDIX



Dry fiber



Fiber soaked in NaOH



Washed and dried fiber



Two roll mill



Banana fiber composite plate

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