

CHARACTERIZATION OF COMPOSITE MADE WITH NATURAL FIBERS EXTRACTED FROM BANANA INFLORESCENCE BRACTS

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)**

Accredited with Grade “A” by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of RELANGI NAGA VINAY KUMAR (38150091) and PERURI SURYA VAMSI KRISHNA (38150078) who have done the Project work as a team who carried out the project entitled "characterization of composite made with natural fibers extracted from banana inflorescence bracts" under my supervision from December 2021 to April 2022.

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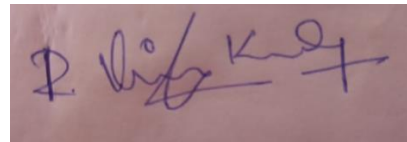
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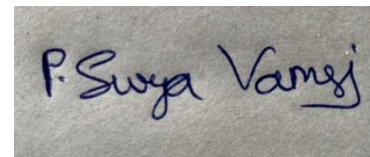
We RELANGI NAGA VINAY KUMAR (38150091) and PERURI SURYA VAMSI KRISHNA (38150078) hereby declare that the Project report entitled **“CHARACTERIZATION OF COMPOSITE MADE WITH NATURAL FIBERS EXTRACTED FROM BANANA INFLORESCENCE BRACTS”** done by us under the guidance of Prof. R.SIVA, M.E., Ph.D., is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE: 20-04-2022

PLACE: Chennai



SIGNATURE OF THE CANDIDATE



SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

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ABSTRACT

Banana is the most important plantations in world. All the parts of the banana plant i.e., trunk, fruit, leaves, flower bud, and the pseudo-stem, of the can be used. The fiber extracted from banana plant, is utilized in various applications. Present days the natural fiber supported composites definitely stand out on account of their benefits like light weight, low expense, high porosity, non-poisonous, nonabrasive, greater explicit firmness, specific strength, better recyclable. Normal fiber has contributed hugely productive innovation in autos and air enterprises. Respects to this regular fiber a ton of exploration has been done all around the world in light of its eco-friendly nature and has a special property contrast with engineered fiber. The point of this article is to give suitable as well as generally utilized normal fiber built up polymer composite furthermore, their applications. As further, it addresses rundown of different surface medicines applied to normal fibers and their impact on properties. This article reports the extraction interaction of normal fiber, characterization of regular fiber and planning of regular fiber supported composite by utilizing two-roll factory and pressure forming. In the centralization of 30% fiber and 70% polylactic acid (PLA) for both treated and untreated composite and 100 percent of Pure PLA composite is are made. Contrasting the treated and untreated composite and unadulterated PLA composite through mechanical and morphological investigation and there has been a tremendous change in every single composite. The mechanical properties are tensile strength, impact strength, and flexural strength. In elasticity treated and untreated tests have shown 5% higher than composite made of just PLA. In Impact strength treated and unadulterated PLA tests have shown 5% and composite made of untreated example. There has been a massive change in examination are SEM(Scanning Electronic Microscope), X-Ray Diffraction (XRD), FTIR(Fourier Transform Infra-Red spectroscopy) and TGA(Thermo Gravimetric Analysis). It likewise presumes that synthetic treatment of regular fiber will further develop bond between fiber surface and polymer network. Their number of applications has been grown steadily. The present project is subjected to the study of mechanical properties of composite made of fiber and PLA. The fiber taken is 30%

and 70% of PLA. The density of the banana fibers is 1.39 g/cc. In the current work, the effect of alkali treatment is compatibly good; it is observed that the alkali treated banana fiber absorbs less moisture than compared to other natural fibers. The alkaline treatment is done by using NaOH as the chemical.

TABLE CONTENTS

CHAPTER NO	TITLE	PAGE No.
	ABSTRACT	vii
	LIST OF TABLES	vii
	LIST OF TABLES	viii
1	INTRODUCTION	1
	1.2 Types of Natural Fibers	1
	1.2.1 Adjustment of Natural Fibers	3
	1.2.2 Advantages And Disadvantages Of Natural Fibers	4
	1.2.3 Frameworks for Natural Fiber Composites	5
	1.3 Fiber Reinforced Thermoplastic Composites For Automotives	5
	1.3.1 Petrochemical Based	5
	1.3.2 Bio-based	6
	1.3.3 Advantages	6
	1.3.4 Disadvantages	6
	1.4 POLYLACTIC ACID	7
	1.4.1 Synthesis	8
2	LITERATURE SURVEY	12
3	AIM AND OBJECTIVES	13
	3.1 Aim	13
	3.2 Objectives	13

4	EXPERIMENTAL AND METHODS	14
	4.1 Raw Materials	14
	4.1.1 Banana fiber	14
	4.1.2 PLA (Polylactic Acid)	15
	4.1.3 Chemical NaOH	16
	4.2 Methodology	16
	4.2.1 Extraction of Fiber	17
	4.2.2 Chemical Treatment	18
	4.2.3 Blending Process	20
	4.2.4 Two Roll-milling	20
	4.2.5 Compression	21
	4.2.6 Composite Making	23
	4.3 Analysis	24
	4.3.1 Tensile Strength	24
	4.3.2 Flexural	25
	4.3.3 Impact	26
	4.3.4 SEM(scanning electron microscope)	27
	4.3.5 XRD(X-Ray Diffraction)	28
	4.3.6 TGA(Thermo gravimetric analysis)	28
	4.3.7 FTIR (Fourier Transform Infrared Spectroscopy)	29
5	RESULTS AND DISCUSSION	31
	5.1 Tensile Test	31
	5.2 Flexural Test	34
	5.3 Impact Test	38
	5.4 SEM Analysis	41
	5.5 FTIR Analysis	43
	5.6 XRD Analysis	44

	5.8 Thermogravimetric Analysis	45
6	SUMMARY AND CONCLUSION	48
	REFERENCE	

LIST OF FIGURES

FIGURE NO	TITLE	PAGE NO
1.1	Classification of fibers	3
1.2	Processing of fiber	7
4.1	Banana Inflorescence	14
4.2	PLA (Polylactic acid) grade 3052 D	15
4.3	NaOH pellets	17
4.4	Process of Extraction	19
4.4(a) (b) (c)	Fiber Dipped In NaOH Solution, Horizontal view, Fiber is completely immersed in solution	19
4.5(a) (b)	Blending machine, Adding PLA And Fiber	20
4.6	Two Roll-milling	22
4.7	Hydraulic compression	
4.8 (a) (b) (c)	PLA, Treated compositex, Untreated composite	23
4.9	Tensile Strength machine	25
4.10	Flexural testing Machine	26
4.11	Izod Impact Testing Machine	27
4.12	TGA Testing Machine	29
4.13	FTIR Testing Machine	30
5.1	Pure PLA Sample	31
5.2	PLA + Treated Fiber	32
5.3	Comparison of tensile strength of three composites	34

5.2	Pure PLA Samples	35
5.3	5% treated + PLA sample	35
5.4	Untreated + PLA samples	35
5.5	Comparison graph of flexural strengths of three composites	37
5.6	Pure PLA Samples	38
5.7	PLA + Treated fiber sample	39
5.8	Untreated + PLA	39
5.9	Comparison graph of impact strengths of three composites	41
5.10	SEM Images	42
5.11	XRD spectrum of treated fiber	43
5.12	XRD spectrum of untreated fiber	44
5.13	TGA curve of PLA powder	45
5.14	TGA curve of PLA + Treated Fiber powder	45
5.15	TGA curve of PLA + Untreated Fiber powder	46

CHAPTER-1

1.1 Introduction

In the last two decades of time period natural fibers were started to be the alternative to the conventional man-made fibers in the May aspect like transportation, construction and the packing sector too. This will prevent the depletion of forest resources and ensure a good economic return; these are the two main strategies on which the development of natural fiber composite is based. The waste that has been generated from the plant is the fiber that has composite structure and properties that make the more worthy for composite, textile and paper manufacturing.

They are the said to be renewable, bio-degradable as well as cost saving by which they are suitable for bio-based economy. In this we discuss about the Argo-waste that is the bracts if banana inflorescence from the fiber is extracted and study its physical, chemical and thermal properties. It has been explored by many researchers in point of lightness and improved modulus in construction over the other materials such as wood, metals and steel. Composite materials using natural fiber have the advantage over the other traditional materials such as glass and carbon fiber because of their improved properties strength properties, easy availability, lightweight, ease of separation, enhanced energy recovery, high toughness, noncorrosive nature, low density, low cost, renewability, and biodegradability.

1.2 Types of Natural Fibers

Natural fibers are classified on the basis of the source supply, they are into three types

- Plant Fibers

- Mineral Fibers
- Animal Fibers

1. Plant Fibers: Plant fibers are usually consisting of cellulose: examples cotton, jute, bamboo, flax, ramie, hemp, coir and sisal. Cellulose fibers are used in various applications. Seed fibers are those which obtain from the seed e.g., Kapok, cotton and etc. Because of this reason these fibers are used in many applications such as packaging, paper and fabric. Fruit fibers are the fibers generally are obtained from the fruit of the plant, e.g., banana fiber and coconut fiber. Stalk fiber are the fibers which are obtain from the stalks (rice straws, wheat). Leaf fibers are obtained from the leaves (agave and sisal). Skin fibers are fibers that are obtain from the skin surrounding the stem of the plant.
2. Mineral Fibers: Mineral fibers are fibers that are obtain from the minerals. These are naturally occurring fiber. Asbestos is the main characteristically occurring mineral fiber. The difference in mineral fiber is the anthophyllite, serpentineand amphiboles. Metal fibers incorporate aluminums strands.
3. Animal Fibers: Animal fiber largely comprises of proteins; cases, silk, alpaca, mohair, downy. Animal hair are got from creatures e.g., Sheep's downy, alpaca hair, goat hair, horse hair. Silk fiber is the fibers gathered from dry saliva of bugs. Now a day's natural fiber composites application is usually found in building and automotive industry and the place where dimensional constancy under moist and high thermal conditions and load bearing capacity are of importance.

Natural fibers like cotton, sisal, jute, abaca, pineapple and coir have been studied a reinforcement and filler in composites already. Among natural fibers, banana fiber is said as a potential reinforced in polymer composites due to its many advantages likely easy availability, low cost, comparable strength properties etc.

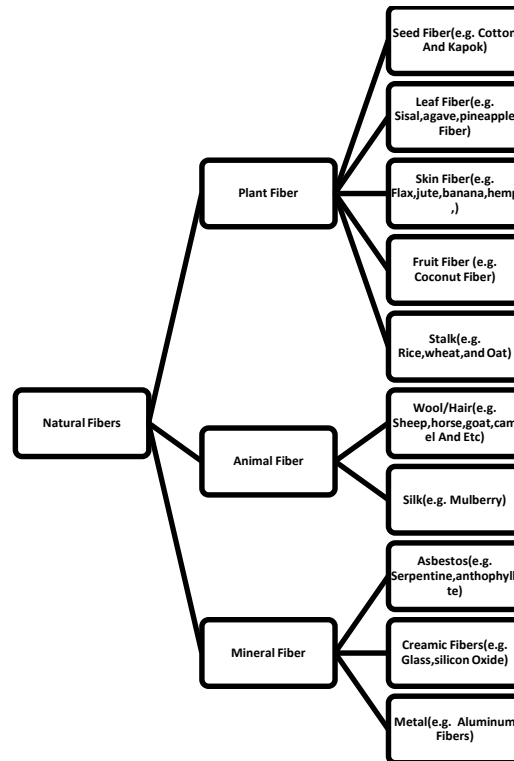


Figure 1.1: Classification of fibers

1.2.1 Adjustment of Natural Fibers

The fundamental hindrances of regular strands in particular composites are the unfortunate similarity among fiber and matrix and their generally high moisture absorption. Hence, regular fiber alterations are viewed as prompting a difference in the fiber surface properties to work on their grip with various networks. A model strength and firmness could be accomplished with a solid point of interaction that is extremely weak in nature with simple break spread through the grid and fiber. The productivity of stress move from the grid to the fiber could be decreased with a more vulnerable connection point.

Broad examination was done and announced in the writing, showing the significance of the connection point and the impact of different kinds of surface adjustments on the physical and mechanical properties of regular fiber supported composites. The noticed pattern shows an inclination for the synthetic alteration (basic, silane, acetylation, benzylation, acylation and acrylonitrile joining, malleated coupling,

permanganate, peroxide, and isocyanate treatment) contrasted with actual change (crown and plasma treatment). It has likewise been shown that malleated and silane treatment is turning into a decision technique due to helpful results.⁸⁻¹⁰ Additive providers worked on the added substances with higher measures of anhydride useful Gatherings than past grades (utilized in 1980s and 1990s), which make more locales for compound connections, bringing about huge execution improvement at low added substance. Utilizing coupling specialists diminished the water assimilation of the composites however has not brought about diminished long haul execution.

The utilization of compound innovation is turning out to be progressively significant for the handling of normal strands. As of now, the utilization of catalysts in the field of material and regular fiber alteration is additionally quickly increasing. A significant justification for embracing this innovation is the way that the use of chemicals is harmless to the ecosystem. The responses catalyzed are quite certain and have an engaged exhibition. Likewise, compound innovation could be financially savvy, further developed item quality contrasted with generally use malleated and silane alteration

1.2.2 ADVANTAGES AND DISADVANTAGES OF NATURAL FIBERS

ADVANTAGES	DISADVANTAGES
They have low density, so low weight.	The fibers absorb moisture that causes degradation.
It has higher specific strength and stiffness than the glass fiber.	They possess lower strength properties than glass fiber composites, particularly impact strength.
It has Good thermal and insulating properties.	Odor generation due to degradation process of the plant fiber.
It is a renewable resource, and is inexhaustible supply.	Relatively low durability, due to fungus attack, weathering, etc.

1.2.3 Frameworks for Natural Fiber Composites

The composites' shape, surface appearance, ecological resistance, and generally solidness is overwhelmed by the lattice while the stringy support conveys a large portion of the underlying burdens, hence giving perceptible firmness and strength. The polymer market is overwhelmed by ware plastics with 80% consuming materials in light of non-sustainable oil assets. Legislatures, organizations, and researchers are headed to find an elective framework to the customary oil-based network through open consciousness of the climate, environmental change, and restricted petroleum product assets. Accordingly bio-based plastics, which comprise of sustainable assets, have encountered a renaissance in the previous many years.

1.3 FIBER REINFORCED THERMOPLASTIC COMPOSITES FOR AUTOMOTIVES

Composites combine high strength fibers and lightweight matrices with high specific properties. Through careful selection of fiber length, material and architecture and the matrix polymer, it is possible to create an extensive range of engineering materials. Applications for these materials are varied and wide ranging, from short fiber reinforced injection molded thermoplastics for high volume manufacturing, through to high performance fiber composites for more demanding applications. There is a broad range of commercially available resin systems, fibers, and re impregnated composite materials. Thermoplastic matrix-based composites have become popular for large volume production of components and structures, as they offer a number of advantages over thermosetting composites. They are tough, can be formed or molded quickly through the application of heat, can be recycled easily and produce very little waste during manufacture.

1.3.1 Petrochemical Based

The impacts of the joining of normal strands in petrochemical-based thermoplastics and thermoset networks were broadly considered. PP, polyethylene (PE), polystyrene (PS), and polyvinyl chloride (PVC) were utilized for the thermoplastic

lattices. Polyester, epoxy gum, phenol formaldehyde, and vinyl esters were utilized for the thermoset frameworks and are purportedly the most broadly involved lattices for regular fiber supported polymer composites.

1.3.2 Bio-based

Numerous new polymers were created from sustainable assets, for example, starch, which is a normally happening polymer that was re-found as a plastic material. Others are PLA that can be created by means of lactic corrosive from fermentable sugar and PHAs, which can be delivered from vegetable oils close to other bio-based feed stocks and these, are the for the most part involved bio-based polymers in normal fiber supported composites. Other bio-based polymers, for example, soy-based biodegradable tar (polyol got from soybean oil), poly caprolactone (PCL) and polybutylene succinct (PBS) is likewise examined with regular strands.

However bio-based polymers encountering positive acknowledgment in composites region, yet bio-based polymers enjoy their own benefits as well as downsides. The star and contras of utilizing bio-based polymers are summed up beneath.

1.3.3Advantages

- Reasonable bio-plastics will assist with decreasing our reliance on oil.
- Reasonable bio-plastics are produced using inexhaustible sources.
- A large number of the bio-plastics are biodegradable.
- Bio-plastics are utilized and advanced for reused items.
- Item costs are getting more cutthroat because of the expanded oil costs.
- Proceeded with exploration will prompt better creation strategies and items that are greater climate amicable.

1.3.4 Disadvantages

- There is a restricted time span of usability for a portion of the economical bio-plastics.
- Some bio-plastics have a lesser presentation factor when contrasted with oil-based plastics.
- The assembling system of bio-plastics still depends on petrol-based energy.
- Studies have shown that different bio-plastics producing shifts in its ecological effect.
- There are worries that maintainable bio-plastics will agitate existing reusing techniques.

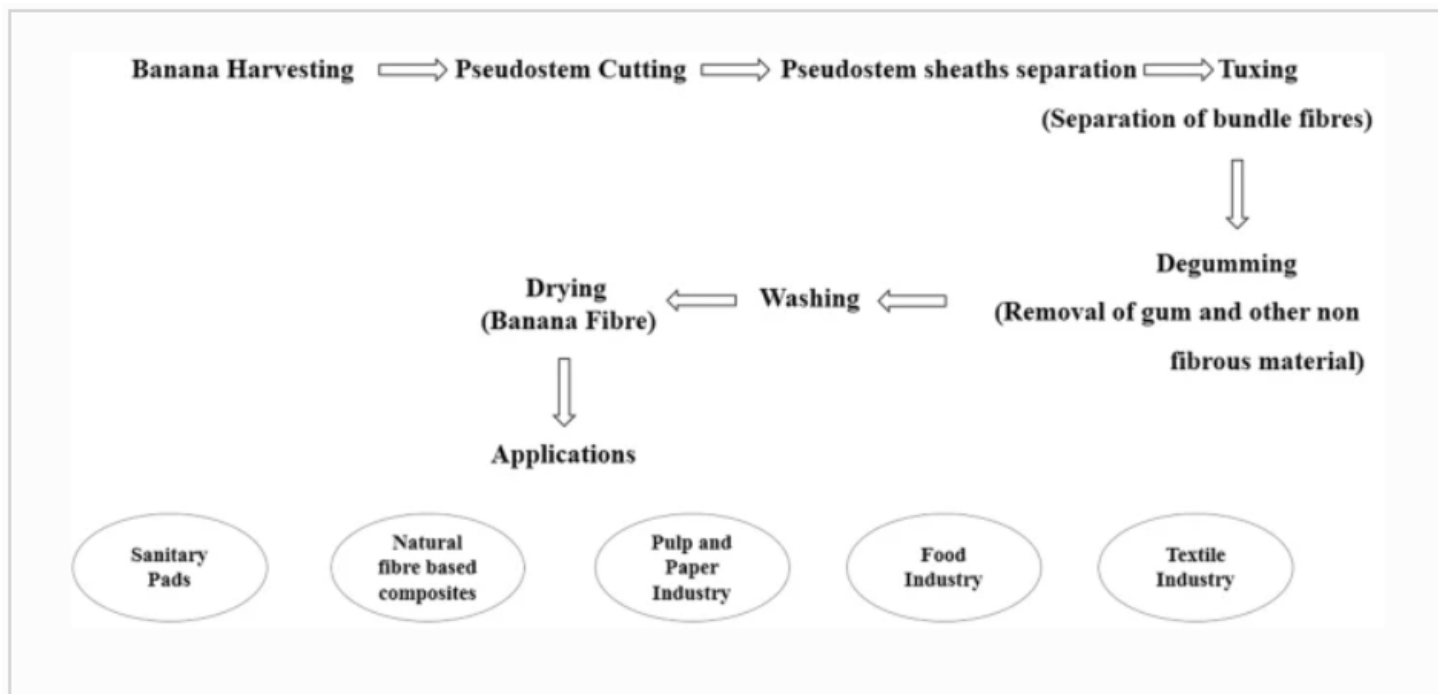


Figure 1.2: Processing of fiber

1.4 POLYLACTIC ACID

Developing natural mindfulness and public worries have prompted the chase after biodegradable plastics as an option in contrast to customary plastics. Biodegradable polymers are of various kinds in view of their production like PLA, cellulose esters, starch plastics, aliphatic polyesters/co-polyesters and poly are presently arising as planned swaps for no biodegradable ordinary plastics in different applications. PLA has been perceived starting around 1845,. PLA is aliphatic polyester with lactic Acid (LA) as its essential sacred unit. PLA is the most broadly examined and promising biopolymer with the possibility to supplant customary petrol-based polymers. PLA is an inexhaustible, biodegradable, recyclable and compostable polymer that shows extraordinary handling capacity. PLA has a few modern applications, for example, in bundling also, materials, biomedical and underlying applications as well as use in car fabricating Businesses because of its particular properties.

1.4.1 Synthesis

The PLA polymer can be blended from LA by direct polymerization (arrangement poly condensation and dissolve poly condensation) response or ring-opening polymerization (ROP) of the lactide monomer. Regardless, due to natural worries and inborn burdens of the typical blend procedure, other union strategies, like biosynthesis of PLA by enzymatic means, also as new arrangements fusing non-harmful impetuses, such as Magnesium (Mg), Calcium (Ca), Zinc (Zn), thus forward, are being created.

CHAPTER -2

LITERATURE SURVEY

K. Amutha et. al., (2020) it describes about the extraction of fibers of banana bracts by various methods. Three unique techniques were taken on to extricate the strands from the bracts of banana inflorescence, (1) new banana bracts, (2) water-drenched (retting) banana bracts and (3) water and chemical drenched (retting) banana bracts. Strands were removed physically due to a lack of any reasonable mechanical interaction. On account of new banana bracts, the fibers were separated utilizing a metallic brush physically. For additional extraction, the bracts were washed with water to eliminate the plump mass adhering to the strands. If there should be an occurrence of water-splashed banana bracts, the bracts were drenched for 2 hours in deionizer water for the retting system. On account of water and protein splashed banana bracts, the enzymatic retting process, the bracts were treated with 0.1% surfactant (cleanser nut) and 0.2% pectinase catalyst for 45 moment at 50°C for evacuation of undesirable substances from the fibers. The cleanser nut was dried and ground into powder structure. 4 g of powder was warmed with 400 ml water for 15 minutes at 60°C temperature, and afterward sifted to isolate the Surfactant. The homestead new banana bracts were picked and absorbed the arrangement of water, chemical, also, surfactant for 24 hours and they were searched by metal look over for getting. Among the three strategies took on for fiber extraction, the water and compound retting processes didn't further develop the brushing system and subsequently the new bracts were looked over physically and utilized for the principle study. And then dried the fibers in the sun light the prevent the water in the fiber, they are then test them for physical properties Cellulosic content of the fiber was nearer to half with semi-translucent design and the presence of cellulose was affirmed by the trademark Diffraction tops in the XRD. The fibers displayed sensibly great obstruction against warm. The banana inflorescence bract fibers can be used for different specialized and attire applications by appropriately mixing with other regular furthermore, engineered strands as a worth expansion approach.

R. PRITHIVIRAJAN ET AL. (2019) interestingly, petal strands were removed from banana plant bloom. Substance investigation, X-beam, and FTIR examination affirmed that the fibers are wealthy in cellulose content. The extricated fibers show better crystalline and warm solidness. The extricated fibers show a good tensile strength. Thinking about climate security from manufactured strands and polymers, an eco-friendly endeavor and minimization of agro-homegrown waste age utilized MPBP strands as a support part in polymer composite. The morphological, physicochemical, mechanical, and warm properties of the removed petal fiber will draw in additional interest with resulting necessity for polymer composites. The FTIR and XRD investigations stretch out to affirm the cellulose extravagance in fiber. The warm way of behaving of MPBP fiber was gotten to through the important instruments like TGA, DTG, and DSC examination. Extremely lengthy and dainty petal strands have more prominent dampness ingestion properties, moderate elasticity with lower extension when contrasted and different fibers. Mechanical properties of these fibers were estimated through single fiber malleable test and the results were broke down through Waybill likelihood dispersion measurable strategy. Lengthening at break, rigidity, Young's modulus are situated somewhere in the range of 1 and 4, so it is affirming the worthiness as support for polymer composites. The surface examination of the crude fiber was broke down through AFM and decided the surface unpleasantness boundaries. In this way, the *M. paradisiaca* L. bloom petal strands showed a decent physical, mechanical, and warm properties contrasted with other regular cellulosic fibers. The future objective of this exploration work is to connect this fiber with thermoset or thermoplastic polymer composites got from normal sources to break down both the fiber/network bond, concentrate on the mechanical properties of arranged composites, and surveying the need of a substance pretreatment. The waste produced from agro-homegrown activity would appear to be legit to safeguard our current circumstance by involving such squanders as recyclable and eco-friendly item

A.G. Adeniyi et al (2019) in this audit, it was seen that the most famous fiber treatment procedure is mercerization. Most specialists likewise really like to utilize hand layup strategy and pressure shaping (cold or hot press) in setting up the

composite. MEKP and cobalt naphthenate as impetus and accelerator, individually, are the more preferred selection of added substances to the composites. The mechanical properties of banana fiber-built up polyester composites announced in the audit is halfway for rigidity and poor for flexural strength contrasted with other regular strands. In contrast with different strands, the apparent decreasing request of elasticity of polyester composites is bamboo, vakka, banana, sisal, kenaf. The apparent diminishing request of flexural strength is bamboo, vakka, sisal, banana, kenaf. The mechanical properties of banana fiber-supported epoxy composites are intermediate contrasted with other normal strands (for rigidity, flexural strength, and effect strength). The apparent diminishing request of rigidity of epoxy composites is coir, sisal, banana, hemp, jute. The apparent diminishing request of flexural and Impact strength is sisal, banana, coir, jute. In any case, research has gone along method for demonstrating the appropriateness of banana and plantain fiber-built up composites for a long time applications through various thorough examinations utilizing different plastic pitches.

Ujendra Kumar Komal. et. al (2019) In the ongoing exploratory examination, the PLA based bio-composites joining Banana Fiber were manufactured utilizing three handling methods (DIM, EIM and ECM). The result of these handling courses on the way of behaving of the created bio-composites was tentatively examined and analyzed. The significant discoveries of the current examination are as per the following. The handling courses have no huge effect on the hardness, warm properties, compound structure what's more, glass progress temperature of the created bio-composites though it affects the appropriation, direction and wearing down of strands as well as the crystalline, mechanical properties and dynamic mechanical properties of the created bio-composites. Sound system magnifying lens investigation uncovered an improvement in the conveyance and direction of strands if there should arise an occurrence of EIMPLBF bio-composites. It likewise uncovered that the strands close to the outer layer of the form, adjusted in the stream bearing while adjusted haphazardly at the center locale. It additionally displayed that the direction of strands in the stream heading increments with an expansion in the

thickness of the soften. When contrasted with DIM-PLBF and ECM-PLBF bio-composites, the crystalline, as well as the pliable and flexural properties of EIM-PLBF bio-composites were viewed as unrivaled. The effect strength of DIM-PLBF Bio-composite was recorded most extreme. The capacity and misfortune modulus of EIM-PLBF bio-composites was found to be greatest. Optical and SEM pictures showing the appropriation, direction, steady loss of fibers and crack qualities approved the variety in properties of the created bio-composites. It is likewise presumed that the short banana fiber-based bio-composites can possibly be utilized in various lightweight and non-primary applications, for example, entryway boards, dashboard and other inside parts of a car. The developed bio-composites can likewise be utilized in items, for example, reflect packaging, paperweight and telephone packaging. Consequently, to guarantee the business suitability of these bio-composites, the legal choice of the handling strategy with lower handling time, straightforwardness in activity and capacity to produce the items with repeatability is required.

K. Harini ET. Al We has fostered a strategy for extraction of miniature and nano cellulose fibers from agro-based modern squanders. Microwave processing technique was viewed as compelling for the creation of miniature cellulose strands. Ball processing helped sanitation treatment of miniature cellulose fiber was ended up being an expected strategy for creation of nano cellulose strands. Banana strip and bract were assessed to have a high measure of cellulose content. Cellulose nano fibers removed from banana strip and bract was analyzed to be a possible hotspot for creation of acetyl and lauroyl cellulose. The altered cellulose nano fibers, with high warm solidness, can act as a potential ACCEPTED MANUSCRIPT 32 substitution for engineered petrochemical polymers. Being a biodegradable polymer, altered cellulose can lessen the amassing of petrochemical plastics in the climate.

J Polym Environ (2007) Natural fibers are considered as possible substitution for man-made strands in composite materials. Despite the fact that normal strands enjoy benefits of being minimal expense and low thickness, they are not thoroughly

liberated from issues. A major issue of normal fibers is their solid polar character which makes incongruence with most polymer networks. Surface medicines, in spite of the fact that having an adverse consequence on financial matters, are possibly ready to beat the issue of inconsistency. Synthetic medicines can expand the point of interaction grip between the fiber and lattice, and diminishing the water ingestion of fibers. Accordingly, synthetic medicines can be considered in altering the properties of normal fibers. A few mixtures are known to advance attachment by synthetically coupling the glue to the material, like sodium hydroxide, silane, acidic corrosive, acrylic corrosive, maleated coupling specialists, isocyanines, potassium permanganate, peroxide, and so on. Fiber modification strategies examined in this paper have unique adequacy in causing attachment between the grid and the fiber. However most compound medicines have accomplished different degrees of progress in further developing fiber strength, fiber wellness and fiber-network attachment in regular fiber built up composite.

CHAPTER – 3

AIM AND OBJECTIVES

3.1 Aim

To obtain a composite material, using the banana bracts fiber, and PLA (polylactic acid) matrix resin, by which we get best physical properties such tensile strength, flexural strength, impact strength to composite.

3.2 OBJECTIVES

- The central aim is to foster the high solidarity to weight proportion polymer lattice composite material utilizing banana plant bracts as fiber material since it is a ubiquitous species in India.
- To use the banana plant as support fiber in PMC, this is accessible in immense amount in India.
- The pre-arranged composite material must be precisely tried and it will be proposed for auto and modern applications in view of the trial and error.
- FTIR examination has been directed to explore the presence and kind of interfacial communication in the bio composites.
- XRD investigation was directed to research the structure and to measure the crystallinity of the bio composites.

CHAPTER – 4

EXPERIMENTAL AND METHODS

4.1 Raw Materials

4.1.1 Banana fiber

The material required here for extraction of fiber is Banana Inflorescence Bracts which is collected from the banana plant cultivation. Banana Bract fiber contains cellulose, hemicelluloses and lignin. Banana fiber is broadly valued for its attributes, for example, high strength, solid dampness assimilation, great brilliance, light weight, quick dampness ingestion and delivery, little extension, simple debasement. Banana fiber is uncommonly strong and low upkeep with negligible mileage.

The crude fiber strand was stopped into the fiber structure (normal length: 3 mm). The short fibers were absorbed water for 24h to dispose of the essence and different pollutions and along these lines dried in the open environment for 24 h to eliminated dampness and other foul gases. Totally dried in a oven (at 100°C for 2 hours).



Figure 4.1: Banana Inflorescence

4.1.2 PLA (Polylactic Acid)

Poly-lactic corrosive (PLA) (grade 3052 D) in pellet structure was provided by Nature Tech. India Pvt. Ltd., Chennai, India. PLA has turned into a well-known material because of it being monetarily delivered from sustainable assets. In 2010, PLA had the second most elevated utilization volume of any bio-plastic of the world. Its broad application has been blocked by various physical and handling shortcomings. PLA is the most generally involved plastic fiber material in 3D printing. PLA polymers range from undefined shiny polymer to semi-translucent and exceptionally glasslike polymer with a glass change 60-65 °C, a dissolving temperature 130-180 °C, and a Young's modulus 2.7-16 GPa. Heat-safe PLA can endure temperatures of 110 °C. The essential mechanical properties of PLA are between those of polystyrene and PET. Its hotness avoidance temperature can be expanded from roughly 60 °C to up to 190 °C by genuinely mixing the polymer with PDLA (poly-D-lactide)



Figure 4.2: PLA (Polylactic acid) grade 3052 D

4.1.3 Chemical NaOH

Sodium hydroxide is a profoundly scathing base and salt that disintegrates proteins at normal encompassing temperatures and may cause serious substance consumes. It is profoundly solvent in water, and promptly ingests dampness and carbon dioxide from the air. It frames a progression of hydrates $\text{NaOH} \cdot n\text{H}_2\text{O}$. The monohydrate $\text{NaOH} \cdot \text{H}_2\text{O}$ takes shape from water arrangements somewhere in the range of 12.3 and 61.8 °C. The monetarily accessible "sodium hydroxide" is frequently this monohydrate, and distributed information might allude to it rather than the anhydrous compound.



Figure 4.3: NaOH pellets

4.2 Methodology

- Extraction Of Fiber.
- Chemical Treatment.
- Blending.
- Two Roll-Milling.
- Compression.

4.2.1 Extraction of Fiber

The waste bracts of the banana bloom were gathered for the review. The mechanical and compound were utilized for the extraction of fiber from the bract. In mechanical technique three distinct devices

(Glass bar, metal brush and sheet of card clothing wire) were utilized. The glass bar, metal brush and wire sheet were utilized to strip on the banana bracts to eliminate sticky substances. The bracts were then washed to remove strands and opened for fiber extraction. In mechanical strategies, the fiber isolation is troublesome since rejecting and stripping over the banana bracts require a lot of time. Additionally, a few sticky substances stay joined to the fiber. Further extreme rejecting to eliminate those came about in fiber crack and harms. Ultimately, the removed bract fiber quality is low. This mechanical technique harms the fiber during extraction, in light of the fact that the process is done in dry condition. Along these lines, compound retting is liked. Retting of banana fiber is characterized as the partition of the fiber groups from the stem or bract, which causes incomplete assimilation of the establishing material (like lignin and hemi cellulose) between the fibers in the bundles. The preliminaries were completed to improve the handling conditions for synthetic retting.



Figure 4.4: Process of Extraction

4.2.2 Chemical Treatment

Basic treatment is one of the most utilized synthetic treatments of regular fibers when used to buildup thermoplastics and thermo sets. The significant adjustment done by soluble treatment is the interruption of hydrogen holding in the organization structure, in this way expanding surface harshness. This treatment eliminates a specific measure of lignin, wax and oils covering the outside surface of the fiber cell divider, de-polymerizes cellulose and uncovered the short length crystallites. Expansion of watery sodium hydroxide (NaOH) to normal fiber advances the ionization of the hydroxyl gathering to the alkoxide. Accordingly, basic handling straightforwardly impacts the cellulosic fibril, the level of polymerization and the extraction of lignin and hemi cellulose compounds.

In basic treatment, fibers are inundated in NaOH answer for a given timeframe and treated strands with 5% aqueous NaOH answer for 1 h at room temperature. Comparable medicines were endeavored by 10% soluble base answer for 1 h that these special is seen that soluble base prompted an expansion in under find cellulose content to the detriment of translucent cellulose.

It is accounted for that soluble treatment makes two impacts on the fiber:

- (1) it increments surface harshness coming about in better mechanical interlocking; and
- (2) it increment show much cellulose uncovered on the fiber surface, in this manner expanding the quantity of conceivable response locales.

Subsequently, basic treatment has an enduring impact on the mechanical way of behaving of strands, particularly on fiber strength and solidness and basic treatment surrendered to a 30% expansion in ductile properties. Basic treatment additionally essentially worked on the mechanical,

Impact weariness and dynamic mechanical ways of behaving of fiber-built up composites and analyzed the impact of NaOH focus 5% for treating banana fiber-supported composites and reasoned that greatest pliable strength came about because of the 5% NaOH treatment at room temperature. This is on the grounds that at higher salt fixation, overabundance delignification of normal fiber happens bringing

about a more vulnerable or harmed fiber. The pliable strength of the composite diminished radically later certain ideal NaOH fixation.



Soon after treated in the chemical it washed with distilled water and the water is drained out completely. Later it was exposed to sun light outside in the atmosphere. It was observed that its takes 24 hours of time to dry the fiber in sun light and then it was heated in the oven for 2 hours at 100 degrees Celsius by which the moister accumulated in the fiber is removed and set free from moister, soon after heating it is packed in the sealed cover to prevent atmospheric moisture.

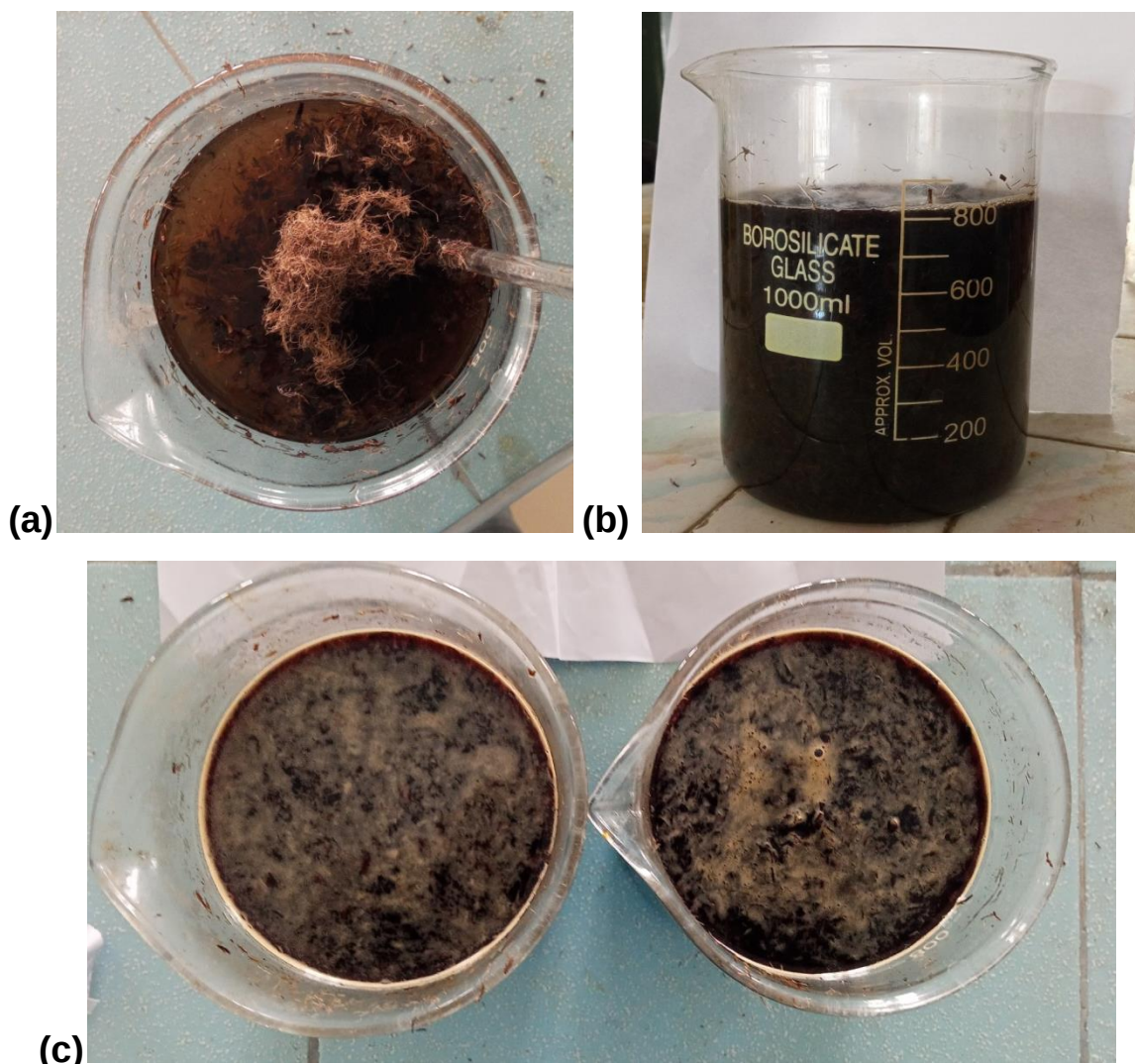


Figure (a)(b)(c): Fiber dipped in NaOH, Horizonta view,
Fiber completely immersed in solution

4.2.3 Blending Process

polylactic acid (PLA)/banana fiber (BF) composites were ready by melt blending technique. The BF was formed onto PLA chains using a coupling specialist and substance modification. Blending of PLA with normal fiber is a basic and productive strategy to further develop PLA properties and lessen the expense of creation. Mixing PLA with banana fiber would build the biodegradability of PLA and make the bio composite more ecological well disposed. The required amount of fiber is taken by calculating the fiber and the PLA (polylactic acid) where 30% volume of composite is fiber and 70% of PLA (polylactic acid). The blending machine is kept on and set at a temperature of 160 degrees, it takes 10 minutes of time to obtain the set temperature. Later fiber and PLA is added to it so that it mixes up properly.

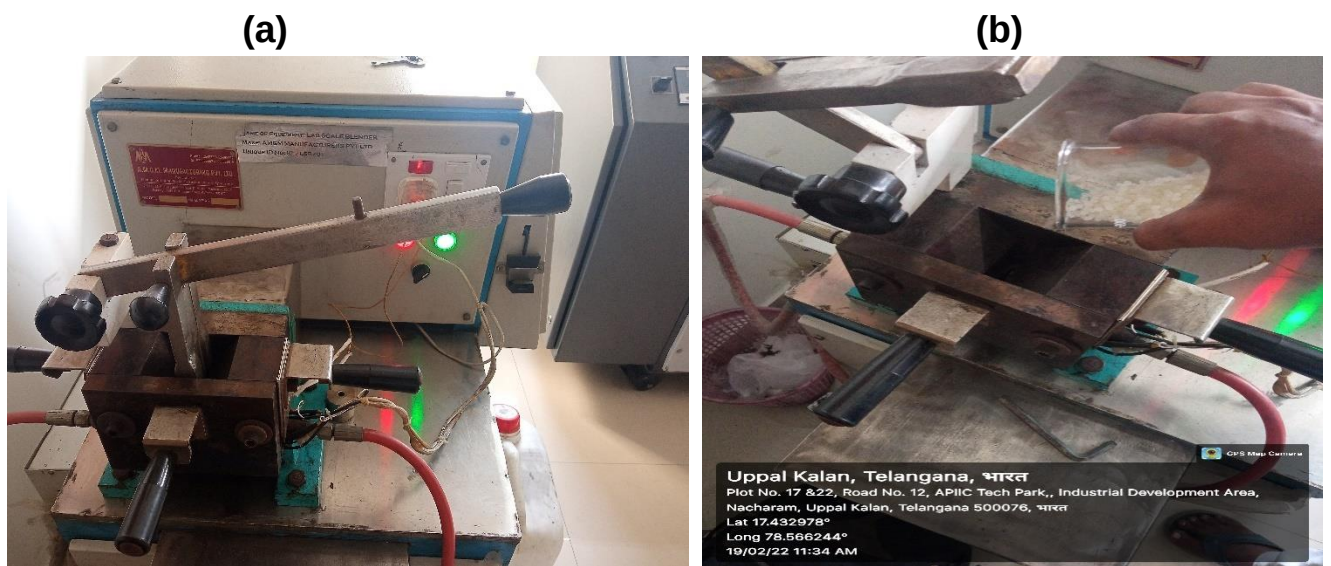


Figure 4.5(a) (b): Blending machine, Adding PLA And Fiber

4.2.4 Two Roll-milling

The roll plant is the most straightforward bunch blending hardware. The chief plan comprises of two level rolls, generally of equivalent size, organized one next to the other and pivoting toward one another at various paces. The material is charged between the rolls as protuberances, pellets, lumps, or powder. Because of turn, grip,

and rubbing, the material is entrained into the hole between the rolls, and upon release it sticks to one of the rolls, contingent upon their temperature contrast and speeds. Another component is the hole between the rolls. In cluster blending the material subsequent to stacking goes through the hole between the rolls a few times, and the blending activity is because of the various paces of the rolls. Both the shearing activity and entrainment of the material into the hole are vital in the blending system and shipping of the material through the unit. The main use is that it will mix the fiber and pla equally.

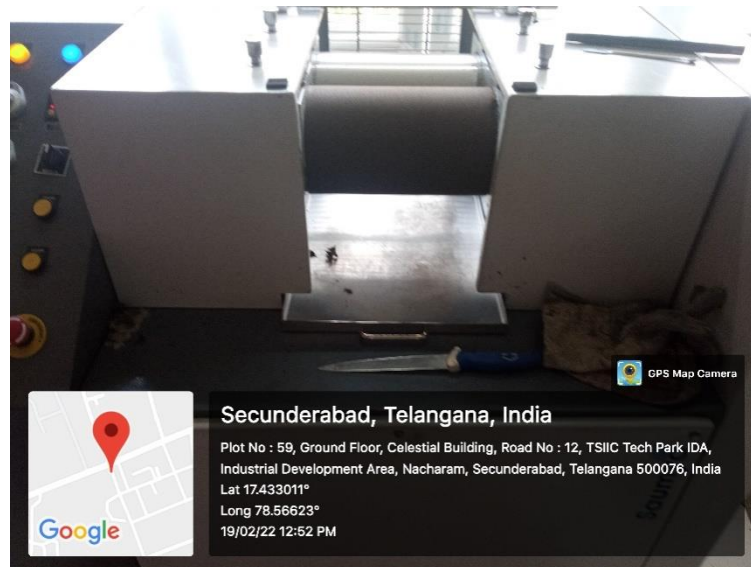


Figure 4.6: Two Roll-milling

4.2.5 Compression moulding

The pressure shaping, then again, is a more flexible strategy that can be utilized for all types of strands, albeit the framing system would require longer process durations when contrasted and infusion shaping. It is thusly sensible that the business has as of late fostered the infusion pressure forming innovation to take advantage of the advantages from both embellishment processes. An average pressure shaping machine includes top and base warming stages that can be warmed and cooled to

an ideal temperature. Regular fiber mats can be sandwiched or overlaid between thermoplastic sheets and pre-warmed at a pre-decided temperature and time. The pressure shaping, then again, is a more flexible strategy that can be utilized for all types of strands, albeit the framing system would require longer process durations when contrasted and infusion forming. It is along these lines sensible that the business has as of late fostered the infusion pressure forming innovation to take advantage of the advantages from both trim cycles. An ordinary pressure forming machine contains top and base warming stages that can be warmed and cooled to an ideal temperature, Natural fiber mats can be sandwiched or overlaid between thermoplastic sheets and pre-warmed at a pre-decided temperature and time. Pre-warming is a significant stage to sufficiently liquefy the thermoplastic sheet to forestall lopsided gum flow or tearing of the normal fiber mat due to unnecessary shear powers during pressure. The pre-warming is followed by pressure of the materials at a specific strain to permit the sap to inject into the normal fiber mats. A harmony between temperature, strain, and embellishment time during the pressure stage is fundamental to improve impregnation of the sap into the fibers while lessening warm debasement of both the fibers and sap. The form is in this way cooled by flowing chilled water into the warming stages while the tension on the materials is kept up with. When the formed part has sufficiently cooled and solidified, it will be de-formed, and overabundance tar on the sides of the moldings can then be taken out by crushing and trimming.



Figure 4.7: Hydraulic compression

4.2.6 Composite Making

In the above paper they have described the process of making composites using natural fiber the fibers which obtained from the plant waste, not only that they have use the bio polymers as the matrix. They have also discussed about the testing to be done on the composites which were make using fiber and then compared with the other fibers.



Figure 4.8 (a): PLA



Figure 4.8 (b): Treated composite



Figure 4.8 (c): Untreated composite

4.3 Analysis

In this analysis undertaking Mechanical properties, actual properties alongside morphological examination are finished. Mechanical properties like Tensile, Flexural and Impact. Actual properties like SEM, morphological examination like XRD, TGA, FTIR and furthermore Water ingestion is finished.

4.3.1 Tensile Strength

The greatest burden a material can endure without breakage while being extended, isolated by the first cross-sectional region of the material. It has aspects of power per unit region. Whenever the burdens are under rigidity is taken out and the material ranges to its unique shape and size either totally or then again to some extent. On the off chance that pressure arrives at the worth of rigidity, but assuming the material

is flexible than it has proactively started to stream quickly shapes a contracted district called neck, where it breaks. The test is done according to the ASTM D 3039 the testing process remembers the mounting for a machine and presenting to tension in testing machine and there after applying strain to it until it breaks. The pliable power is kept as component of development under tight restraints length during usage of strain and 5% treated sample has been possessing high tensile strength. The speed of the cross head is 10mm/min.



Figure 4.9: Tensile Strength machine

4.3.2 Flexural

Flexural testing estimates the power expected to twist a light emission material and decides the protection from flexing or solidness of a material. It illuminates about the obstruction regarding a material against disfigurement. It shows how much power is expected to break a test of a characterized width. The higher the worth the additional affecting powers the material can endure. The reason of flexural test is to gauge the strength and modulus of a flexural test, the flexural strength is characterized as most extreme pressure at furthest fiber on all things considered pressure or strain side of example. The flexural strength is determined from beneath equation.

$$\sigma_f = 3pl/2bd^2 \text{ ----- (a)}$$

Flexural modulus is determined from incline of the pressure versus strain in redirection bend.

the condition is

$$E_f = L^3m/4bd^3 \text{ ----- (b)}$$

The flexural strength is helped out at a room temperature through three-point twist testing as determined in ASTM D-790, utilizing instron model 5582 in Universal Testing Machine. The speed of the cross head is 10mm/min.



Figure 4.10: Flexural testing Machine

4.3.3 Impact

Impact tests are utilized in concentrating on the strength of material. Impact strength is the capacity of a material to oppose an immediately applied load and its communicated with regards to energy. A material's sturdiness is a variable of its capacity to retain energy during plastic distortion. Fragile materials have low sturdiness because of the limited quantity of plastic disfigurement that they can persevere. The effect worth of a material can likewise change with temperature. By

and large, at lower temperatures, the effect energy of a material is diminished. The size of the example may likewise influence the worth of the Izod Impact test since it might permit an alternate number of blemishes in the material, which can go about as pressure risers and lower the effect energy. It additionally estimated in Izod Impact strength what's more, Charpy Impact strength. It decides how much energy was consumed by a material during crack. The assimilated energy is a proportion of



Figure 4.11: Izod Impact Testing Machine

materials strength and weakness and bendable progress. The temperature is brought down over a series of tests to demonstrate the weak temperature of a material. Prior to beginning the Izod Impact test the example is scored at a GTM Model-7045 MD subsequent to making a score at a point of 90 degrees and did the test on Izod Impact analyzer. The Impact strength is determined from Impact strength and effect obstruction of a Test.

4.3.4 SEM(scanning electron microscope)

A filtering electron magnifying instrument (SEM) is a sort of electron magnifying lens that produces pictures of an example by examining the surface with an engaged light emission. The electrons collaborate with molecules in the example, creating different signs that contain data about the surface geography and sythesis of the example. It checks the little particles can analyze the holding of sap and fiber in the framework of composite. The largest number of tractable esteemed examples are utilized for SEM examination for composite and they are chopped down for little pieces as expected for Ductile examples due to its higher breaking pressure and connection among them and furthermore decide the molecule size up to 10nm and amplification from 20x to 100x. It examines the example with an electron bar to deliver an amplified picture for examination after we get a visual investigation of surface adds to ID of debases or obscure particles, the reason for disappointment and association among materials and furthermore used to acquire data about surface geology and arrangement.

4.3.5 XRD(X-Ray Diffraction)

XRD investigation, via the investigation of the precious stone design, is utilized to distinguish the translucent stages present in a material and in this manner uncover substance creation data. XRD principally used to decide the translucent design of a particles, for example, normal measurement of glasslike (La), normal tallness of glasslike (Lc) and bury - layer dispersing (d002). The example is diverted into powder and filtered from 2 to 80 2 θ degrees in 2 θ territory and a wide area somewhere in the range of 10 and 35 degrees and a little top close to 40 degree. Three fitting pinnacles can be gotten, which are γ top fitted close 20°, (002) top fitted close 26° and (100) tops fitted around 40°.The pinnacle positions, powers, full width half maximums (FWHM), not entirely set in stone.

4.3.6 TGA(Thermo gravimetric analysis)

Thermogravimetric examination (TGA) is a logical procedure used to decide a material's warm solidness and its negligible part of unstable parts by checking the

weight change that happens as an example is warmed at a consistent rate. Thermogravimetric examination (TGA) has arisen as another option, more affordable, quick, and simpler to utilize procedure for deciding sythesis of lignocellulosic biomass. TGA can be utilized to decide α -cellulose and hemicellulose happy with upgraded precision as contrasted and usually utilized wet substance strategies. TGA has been utilized in the examination of biochemical structure (lignin, cellulose, and hemicellulose) of Avicel, beechwood, basic lignin, switchgrass, and corn stover after pretreatment. TGA is helpful due to its high-throughput nature (at-line) and is great for surveying polymers like lignin, however this technique is damaging, and temperature inclining can cause changes in polymer analytes.



Figure 4.12: TGA Testing Machine

4.3.7 FTIR (Fourier Transform Infrared Spectroscopy)

Fourier Transform Infrared Spectroscopy (FTIR) recognizes substance bonds in an atom by creating an infrared ingestion range. The spectra produce a profile of the example, a particular atomic finger impression that can be utilized to screen and output tests for various parts. FTIR is utilized to distinguish mixtures like intensified plastics, fillers, rubbers and gums. It recognizes the substance bonds in an atom creating an infrared assimilation in range. Quick and non-damaging strategy can recognize scope of practical gatherings and is touchy to change atomic design. It

gives data on premise of substance structure and actual condition of entirety test. The FTIR test examining range was 4000 cm^{-1} to 400 cm^{-1} , the filtering goal was 4 cm^{-1} and the quantity of outputs were multiple times. The boundaries of top width, tallness and regions are acquired.

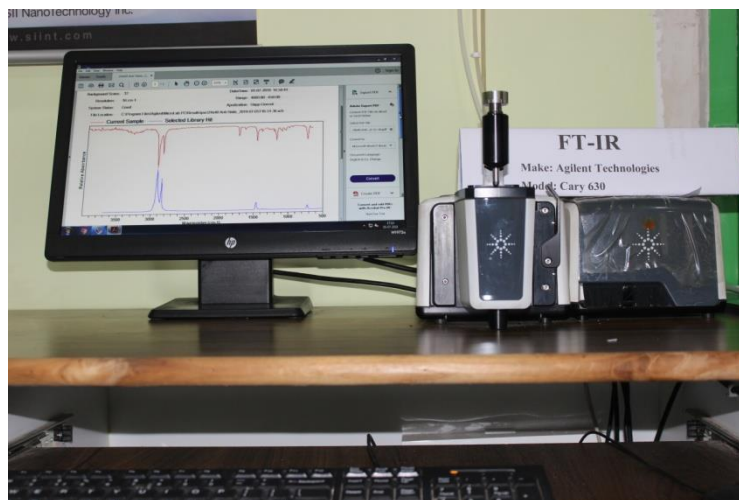


Figure 4.13: FTIR Testing Machine

CHAPTER 5

RESULTS AND DISCUSSION

In these outcomes are examined of the tests we have done on the composite materials like Tensile, Flexural, Impact, SEM, XRD, FTIR and TGA these are addressed either by utilizing structured presentations, pie diagrams or pictorial portrayal.

5.1 Tensile Test

This tensile test is performed at KELVN Labs, Hyderabad, Telangana. The elements of the examples are $125 \times 12 \times 3$ mm as displayed in the figure 5.1

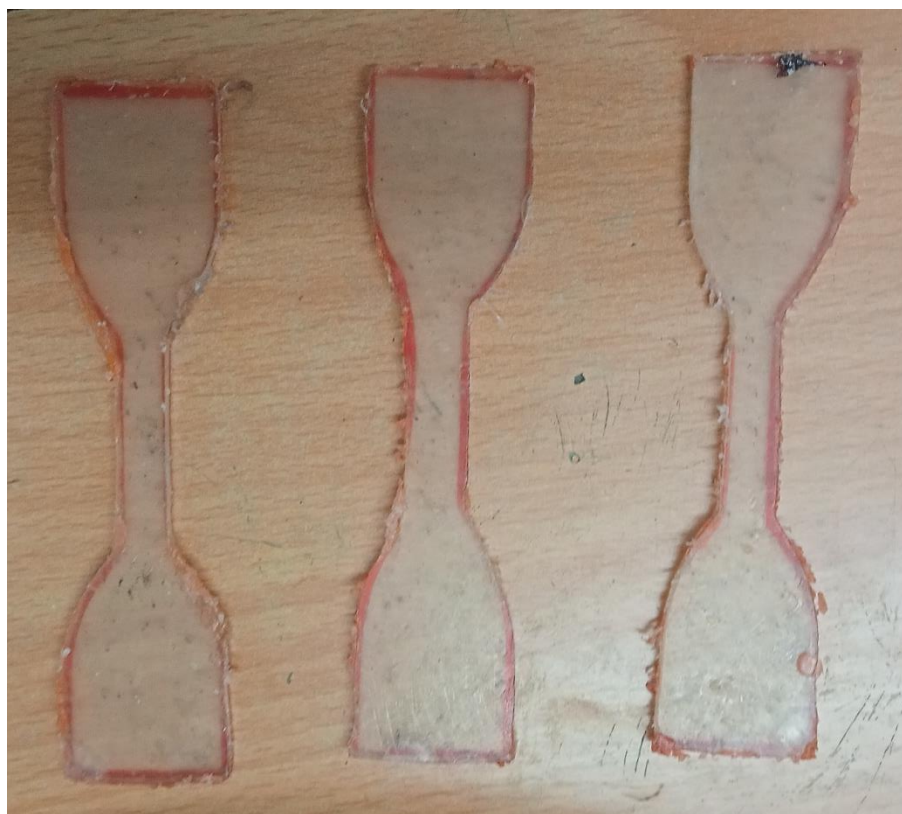


Figure 5.1: Pure PLA Sample

These are the pliable examples prior to testing the tensile. The arrangement of this composite is 100 percentage PLA and 0 percentages Fiber with aspects of 125×12×3mm are displayed in this above figure. And the figure 5.2 is the pliable examples prior to testing the tensile. The arrangement of this composite is 70 percentage PLA and 30percentages treated Fiber with aspects of 125×12×3mm.



Figure 5.2: PLA + Treated Fiber

Table 5.1: Pure PLA Sample Results

Sample No	Tensile strength (N/mm²)	Modules of elasticity (N/mm²)	n	Elongatio (%)
Sample 1	61.12	960.11		2.1
Sample 2	58.34	169.44		2.0
Sample 3	55.54	481.90		1.8

Table 5.2: PLA and Treated Fiber

Sample No	Tensile strength (N/mm²)	Modules of elasticity (N/mm²)	n	Elongatio (%)
Sample 1	63.54	70.96		5.03
Sample 2	61.71	1098.87		3.19
Sample 3	59.09	989.45		3.26

Table 5.3: PLA and Untreated Fiber

Sample No	Tensile strength (N/mm²)	Modules of elasticity (N/mm²)	n	Elongatio (%)
Sample 1	59.78	1006.98		3.66
Sample 2	55.89	941.78		3.90
Sample 3	51.89	842.53		3.09

Table 5.1 gives us the elasticity consequences of the unadulterated PLA alongside modulus of flexibility and extension. Normal worth of unadulterated PLA elasticity is 61.20 N/mm², normal of modulus of elongation is 960.11 N/mm² and normal of elongation is 2.1%.

Table 5.2 gives us the elasticity consequences of the pure PLA and treated fiber, alongside modulus of flexibility and extension. Normal worth of PLA and treated fiber elasticity is 63.54 N/mm², normal of modulus of elongation is 70.96 N/mm² and normal of elongation is 5.03%.

Table 5.2 gives us the elasticity consequences of the pure PLA and untreated fiber, alongside modulus of flexibility and extension. Normal worth of PLA and untreated fiber elasticity is 59.78 N/mm², normal of modulus of elongation is 1006.98 N/mm² and normal of elongation is 3.66%.

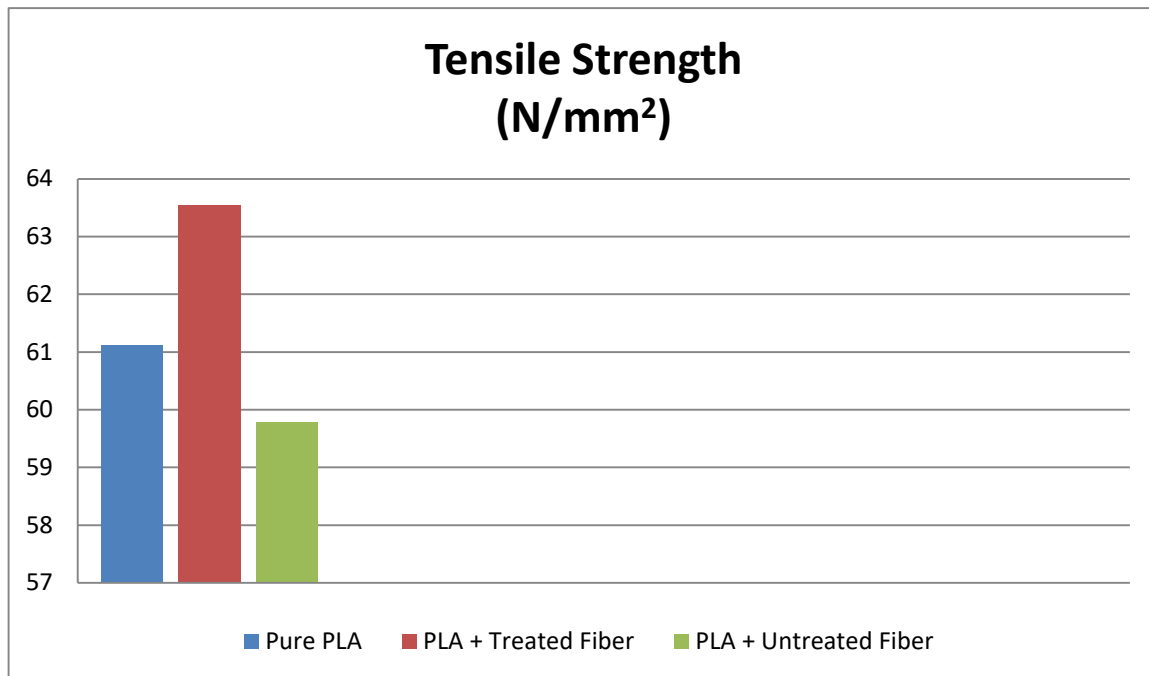


Figure 5.3: Comparison of tensile strength of three composites

Figure 5.3 shows the correlation of tensile strength of three composites in that PLA + treated fiber is having most extreme tensile strength of 63.54 N/mm².

When contrasted with untreated, 10%, and 15% fiber treated and unadulterated PLA, the acquired elasticity upsides of NaOH treated with 5% treated. Builds the fiber's elasticity, which could be inferable from underlying and substance changes on the fiber surface. The interfacial association among fiber and lattice is affected by these surface changes. It works on the mechanical association among fiber and framework by expanding the harshness on the fiber's surface. This outcome in great pressure move from network to filaments and ensuing supported strands, bringing down pressure fixation in the grid. The presence of less hemicelluloses and lignin in the filaments might bring about high rigidity. During the cycle, hemicelluloses and lignin were disposed of.

5.2 Flexural Test

This flexural test is done at KELVN Labs, Hyderabad, Telangana. By utilizing wide spread testing machine. The components of the examples are 150×135×3mm.



Figure 5.2: Pure PLA Samples



Figure 5.3: 5% treated + PLA sample



Figure 5.4: Untreated + PLA samples

In figure 5.2 they are the flexural strength tests of unadulterated PLA and the sythesis is 100 percent PLA 0% fiber with aspects 150×135×3mm. In this figure 5.3 they are the flexural tests of PLA + treated fiber composite and the arrangement is 70% PLA 30% fiber with aspects 150×135×3mm. In this figure 5.4 these are the flexural strength tests of PLA + untreated fiber composite and the piece is 70% PLA 30% fiber with aspects 150×135×3mm.

Table 5.4: Pure PLA Sample Results

Sample No	Flexural Strength (N/mm²)	Modules of elasticity (N/mm²)	Elongation (%)
Sample 1	105.67	4234.68	3.65
Sample 2	101.45	3876.55	3.23
Sample 3	97.35	3244.87	2.78

Table 5.4: PLA + 5% treated Sample Results

Sample No	Flexural Strength (N/mm²)	Modules of elasticity (N/mm²)	Elongation (%)
Sample 1	110.98	2675.56	6.45
Sample 2	106.23	3897.98	6.01
Sample 3	102.65	8480.55	5.90

Table 5.4: PLA + untreated Sample Results

Sample No	Flexural Strength (N/mm²)	Modules of elasticity (N/mm²)	Elongation (%)
Sample 1	102.34	2208.76	2.78
Sample 2	100.65	2256.88	2.65
Sample 3	97.67	3065.54	2.80

Table 5.4 shows the Pure PLA's flexural strength, as well as its modulus of flexibility and elongation. The flexural strength esteem is 105.67 N/mm², the modulus of flexibility is 4234.68, and the prolongation esteem is 3.65 percent.

Table 5.5 shows the PLA + treated fiber's flexural strength, as well as its modulus of flexibility and prolongation. Flexural strength is 110.98 N/mm², flexibility modulus normal is 2675.56 N/mm², and prolongation normal is 6.45 percent.

Table 5.6 gives us the flexural strength consequences of the PLA + untreated fiber alongside modulus of flexibility and prolongation. Table 5.6 gives us the flexural strength consequences of the PLA + untreated fiber alongside modulus of flexibility and lengthening. Normal worth of flexural strength is 102.34 N/mm², normal of modulus of flexibility is 2208.76 N/mm² and normal of extension is 26.78%

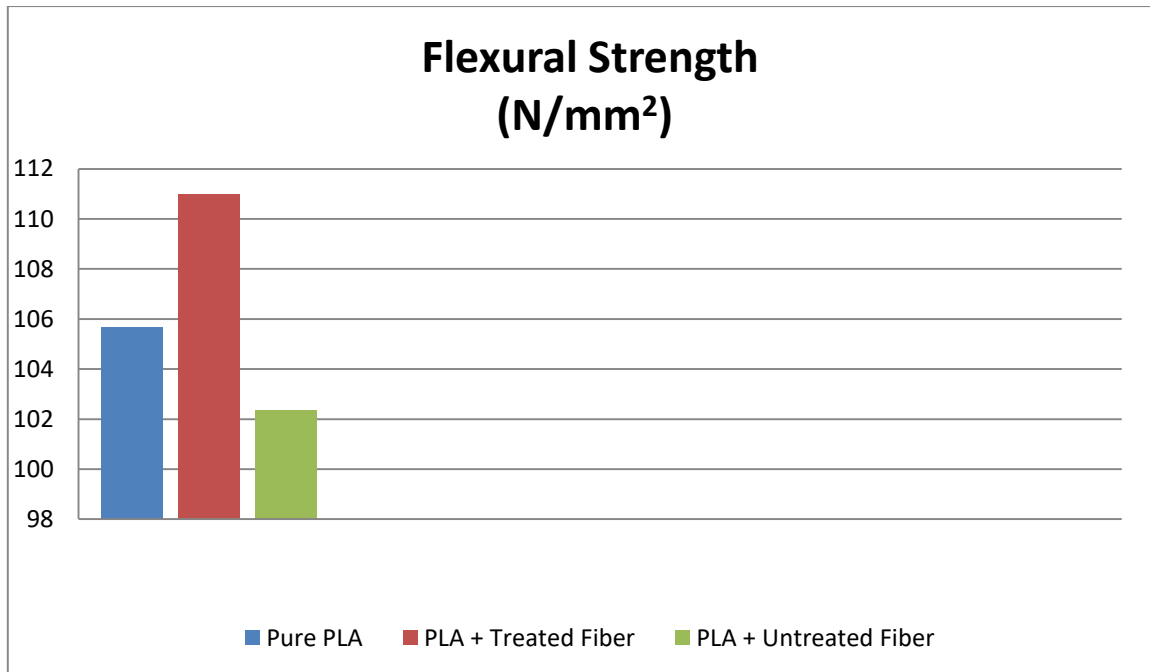


Figure 5.5: Comparison graph of flexural strengths of three composites

The correlation of flexural strength of three composites of Pure PLA, PLA + untreated CQ fiber, and PLA + treated CQ fiber composites is displayed in figure 5.2, with the PLA + 5% treated fiber composite having the most elevated flexural strength of 105.67 N/mm². Which is more noteworthy than untreated fiber and Pure PLA composite, individually? This could be on the grounds that the soluble base treatment further develops the heap transmission proficiency of the composites fundamentally. PLA + untreated fiber has lower flexural strength than PLA + 5% treated fiber. This could be on the grounds that the PLA gum couldn't infiltrate the strands, bringing about two peculiarities: extreme porosity in the composite and negligible contact between the center of the fiber and the encompassing framework.

5.3 Impact Test

KELVN Labs in Hyderabad, Telangana, conducts this effect strength test. With the assistance of an Izod sway machine. The examples have aspects of 65133mm, as demonstrated in figure 5.6. The effect strength of Pure PLA tests are introduced underneath. Which are having a 100% PLA and 0 percent fiber content Figure 5.14 shows sway strength tests of PLA + treated fiber displayed. These are comprised of

70% PLA and 30% percent fiber. Figure 5.15 shows sway strength tests of PLA + untreated fiber displayed. These are comprised of 70% PLA and 30 percent fiber.

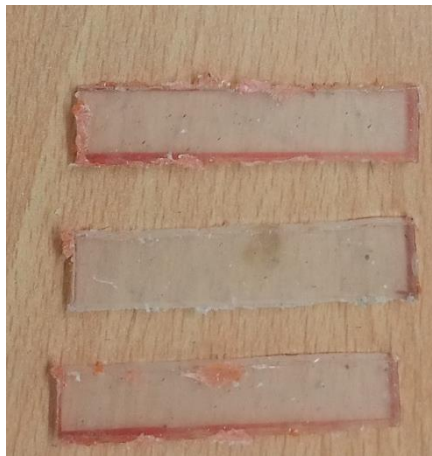


Figure 5.6: Pure PLA Samples



Figure 5.7: PLA + Treated fiber sample



Figure 5.8: Untreated + PLA

Table 5.5: Pure PLA Sample Results

Sample No	WIDTH (mm)	THICKNESS (mm)	W/d×1000 (J/m)	IMPACT STRENGTH (KJ/mm2)
Sample 1	12.34	3.67	0.876	24.67
Sample 2	11.30	4.12	0.934	25.76
Sample 3	11.92	3.80	0.760	20.68

Table 5.5 the impact results of Pure PLA samples are discussed and sample 2 is having the high impact strength of 25.76 KJ/mm². All dimensions are in mm Formula to calculate impact strength is Impact strength = work done/ (thickness × width) ×1000 kJ/mm².

Table 5.6: PLA + Treated Sample Results

Sample No	WIDTH (mm)	THICKNESS (mm)	W/d×1000 (J/m)	IMPACT STRENGTH (KJ/mm2)
Sample 1	12.65	3.94	0.818	25.36
Sample 2	13.12	3.74	0.760	19.13
Sample 3	13.17	3.94	0.818	19.60

Table 5.6 the impact results of PLA + treated fiber samples are discussed and sample 1 is having the high impact strength of 25.36 KJ/mm².

Table 5.6: PLA + Untreated Sample Results

Sample No	WIDTH (mm)	THICKNESS (mm)	W/d×1000 (J/m)	IMPACT STRENGTH (KJ/mm ²)
Sample 1	11.16	3.46	0.760	24.36
Sample 2	12.25	3.30	0.760	23.62
Sample 3	12.11	3.31	0.760	23.89

Table 5.6 the impact results of PLA + untreated fiber samples are discussed and sample 1 is having the high impact strength of 24.36 KJ/mm².

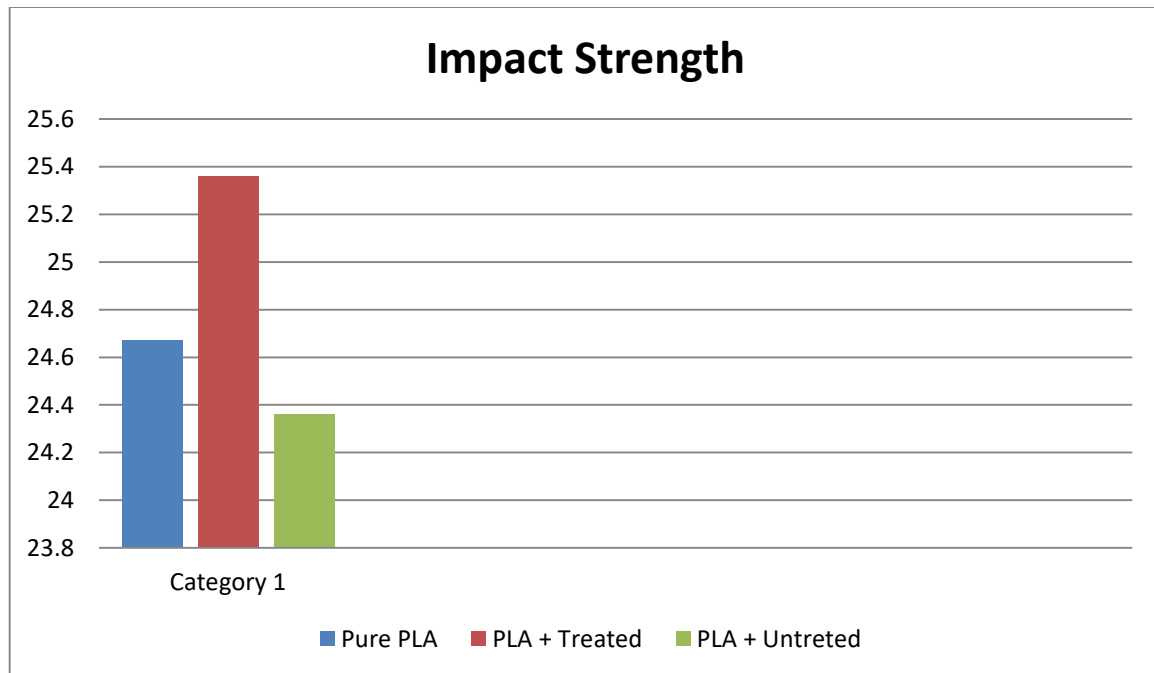


Figure5.9: Comparison graph of impact strengths of three composites

Figure 5.9 it shows the comparison between all three composites about impact test results. In which PLA + treated fiber composite is having high impact strength of 25.39 KJ/mm². Impact test conducted for treated, untreated fiber and PLA composites in which treated fiber shows high impact strength of 25.39 KJ/mm² which is higher than PLA composite and higher than untreated fiber composite, it is mainly occurs due to the high bonding between matrix and fiber. Unlike to tensile and

flexural properties, Izod impact strength of untreated composites was lower than the treated composite. Deboning, pull out and fiber fractures are the mechanisms of energy absorption during impact. Among these, fiber pull out requires higher energy than that of the fracture of fibers and de-bonding. High impact strength of untreated composites may be attributed to more fiber pull outs due to weak interface between the fiber and the matrix. In the case of treated composites, fiber fracture occurs instead of pull outs. This may be the reason for lower impact strength of untreated composites compared to treated composites.

5.4 SEM Analysis

This SEM test has been done in KELVN Labs, Hyderabad, and Telangana. It is a physical property test it is the scanning electron microscope which produces images of samples by scanning the surface with a focused beam of electrons on it. These electrons will interact with several atoms on the surface and produce signals which contain the information about the surface and composition. figure 5.10 SEM analysis is taken at the broken side of high tensile sample and we can see the boning 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.

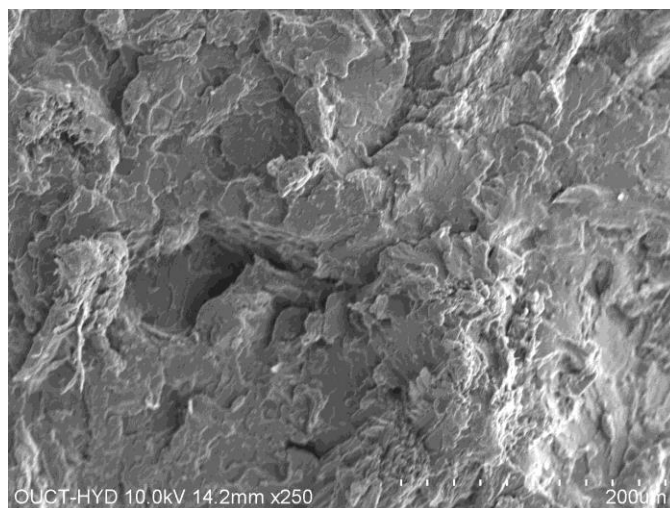


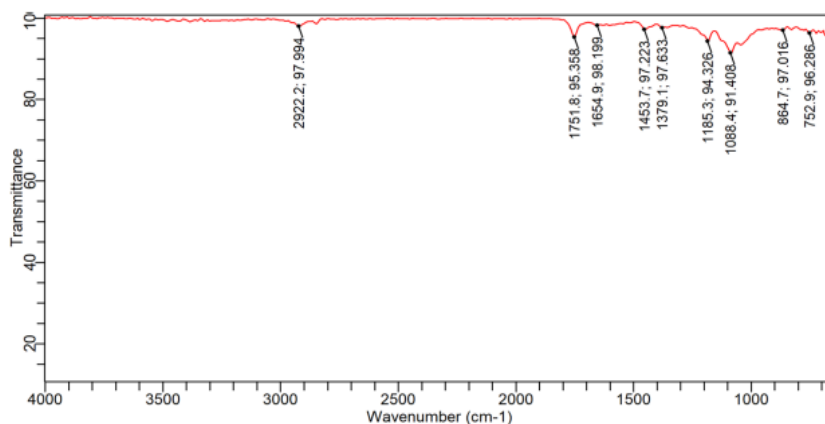
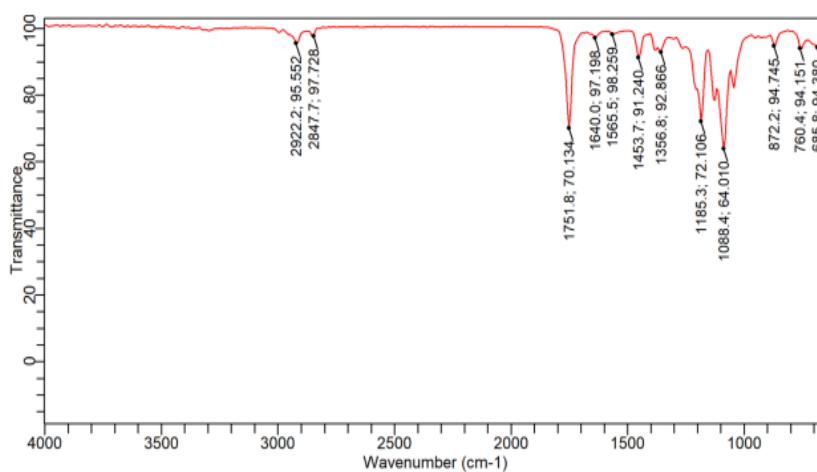


Figure5.10: SEM Images

In chemical treatment fiber, a limited number of voids and broken fibers were observed. Further, the penetration of resin increases the strength between matrix and fiber. In treated fiber, the surfaces are porous, which denotes better bonding. The interfacial bond between the fiber and matrix stronger and better in chemical treated fiber. Fiber pulled out, which is the main reason for voids present in the composite, occurs due to improper and low bonding between fiber and matrix.

5.5 FTIR Analysis

This test FTIR is done at SRM 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 2995.50cm⁻¹ & 2996.47cm⁻¹ are responsible for the acidic O-H stretching and the bond at 1624.09, 1452.42, 1382.02 and 1268.22 were to the C=O and C-O stretching. the peak at 1042.54, 1127.41 and 956.71 are the region of deformation vibration of outside the group. The remaining peaks at 1382.02, 1269.18, 955.74, 755.14, 1452.42, 1318.37, 868.95, and 666.42 these were formed due to secondary metabolites. The untreated peak indicates the elongation of the O-H bond in cellulose.

5.6 XRD Analysis

The crystalline nature of banana fiber and PLA has been determined using XRD analysis. It is illustrated in below graph 5.20 the effect of the chemical treatment on the fiber cellulose crystalline was determined using the X-Ray diffractometer are presented the banana fiber determination is crucial to observe the change in the amorphous content in the fiber after chemical treatment. A higher crystalline index emphasizes the effectiveness of chemical treatment. There are three major peaks found in treated, where $2\theta = 14.70^\circ$, and 16.15° It represents the presence of amorphous content and alpha-cellulose. The untreated fiber shows two major peaks at $2\theta = 16.15^\circ$ and 13.98° . The crystalline index CI for treated and untreated fiber is 10.8% and 24.9%, The crystalline index of treated fiber is more, compared to untreated fiber.

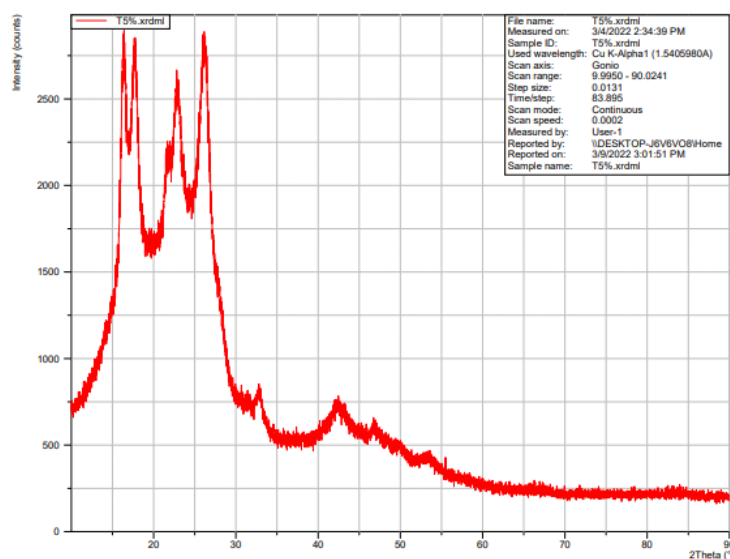


Figure 5.11: XRD spectrum of treated fiber

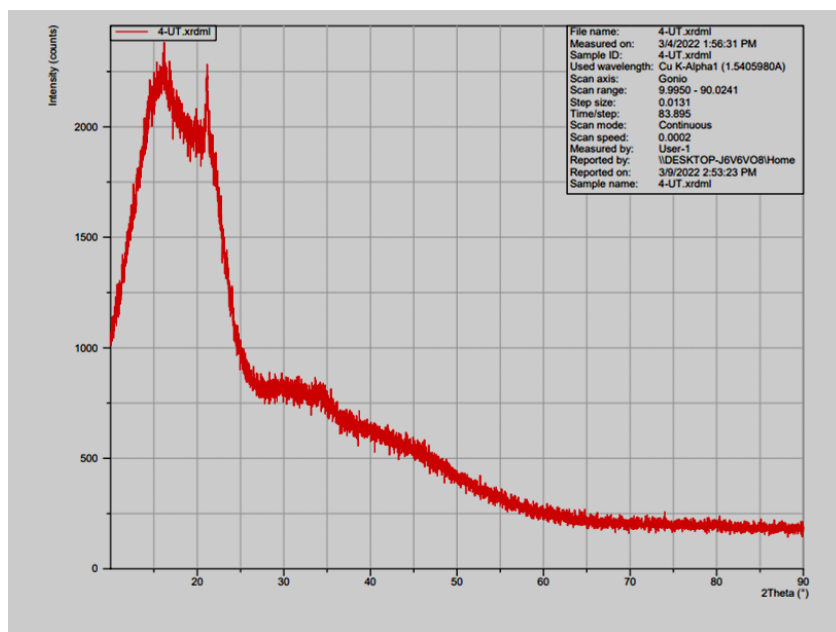


Figure 5.12: XRD spectrum of untreated fiber

5.8 THERMOGRAVIMETRIC ANALYSIS

Thermo gravimetric analysis (TGA) is done at KELVN Labs, Hyderabad, and Telangana. This test is taken at the temperature range of 0°C to 1000°C, and atmosphere N₂ and using crucible Al₂O₃. Heating rate is 10°C. The thermal stability of the treated and untreated, the composite powder investigated by TGA with DSC the resulting TGA with DSC curve of treated and untreated fiber is shown in figure 5.13 and figure 5.14. The onset temperature (T_o) of the TGA curve is around 180°C, the temperature at which 8% weight loss is reported, this weight loss is mainly due to moisture caused by structurally bonded water molecules. As the temperature raises the thermal stability gradually decreases and thermal decomposition finally takes place in three stages. First stage of disintegration occurs in the range of 180-330°C for the treated fiber and untreated fiber composite powder. This indicates the loss of hemi-cellulose and lignin content present in the fiber. The weight loss in this temperature range was about 15%. The second stage of disintegration occurs in the range of 330-600°C for treated fiber and untreated fiber composite powder. Cellulose and lignin contents may decompose at this range of temperature. Weight loss in the temperature is about 60% the results revealed that the disintegration temperature of the composite powder changed to greater temperature showing the higher thermal

stability of treated composite powder up to 20%. An inorganic material present in the untreated composite generally enhances the thermal stability of the treated composite.

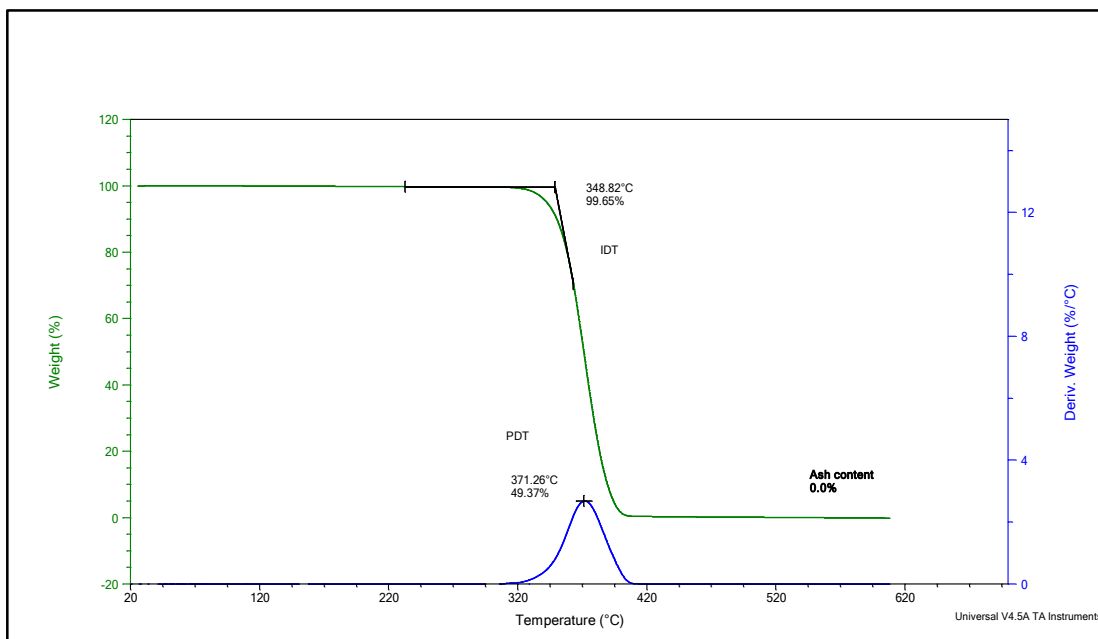


Figure 5.13: TGA curve of PLA powder

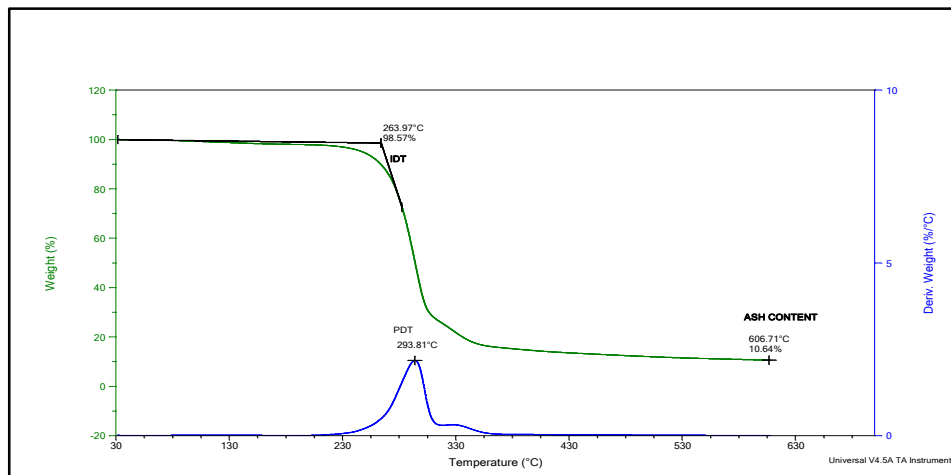


Figure 5.14: TGA curve of PLA + Treated Fiber powder

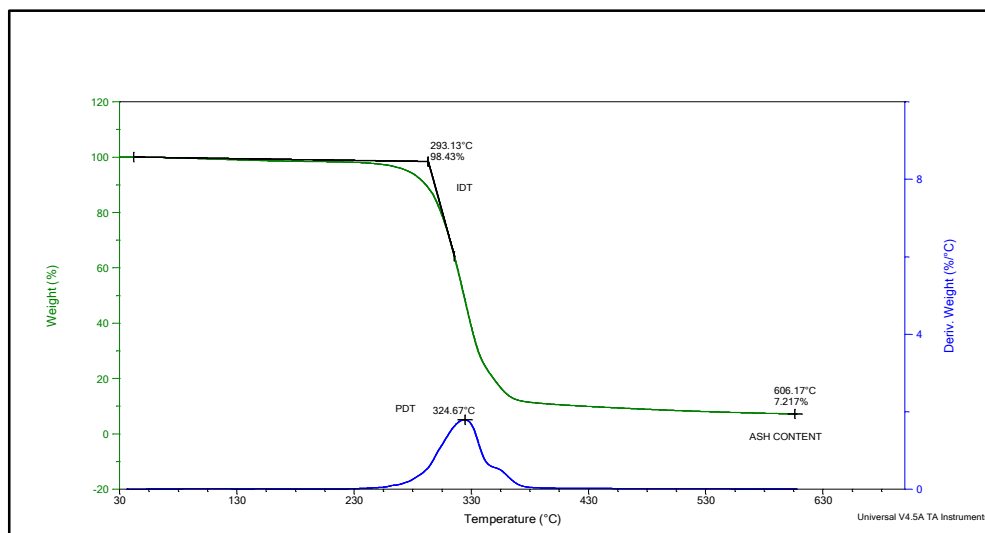


Figure 5.15: TGA curve of PLA + Untreated Fiber powder

The thermal stability of the PLA, Treated and untreated, the composite powder investigated by TGA curve of PLA, treated and untreated fiber are shown in figure 5.13 and figure 5.14, 5.15. The onset temperature (T_o) of the TGA curve is around 180°C, the temperature at which 8% weight loss is reported, this weight loss is mainly due to moisture caused by structurally bonded water molecules. As the temperature raises the thermal stability gradually decreases and thermal decomposition finally takes place in three stages. First stage of disintegration occurs in the range of 180-330°C for the treated fiber and untreated fiber composite powder. This indicates the loss of hemicelluloses and lignin content present in the fiber. The weight loss in this temperature range was about 15%. The second stage of disintegration occurs in the range of 330-600°C for treated fiber and untreated fiber composite powder. Cellulose and lignin contents may decompose at this range of temperature. Weight loss in the temperature is about 60% the results revealed that the disintegration temperature of the composite powder changed to greater temperature showing the higher thermal stability of treated composite powder up to 20%. An inorganic material present in the untreated composite generally enhances the thermal stability of the treated composite.

The final stage of degradation takes place due to decomposition of cellulose at range of 600°C - 940°C and 600°C - 930°C with a weight loss of 40% and 55% of treated

and untreated fiber. According to DSC curve degradation temperature range increases in the case of untreated fiber. 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 three composite specimens of Pure PLA, Untreated natural fiber composite and treated natural fiber composite of mechanical and morphological analysis were done.

- Tensile strength of treated fiber is 15% higher than the Pure PLA composite.
- Tensile strength the ASTM D 3039 shown the treated fiber composite has higher value 63.54 N/mm².
- Tensile modulus of elasticity is higher in treated composite compared to untreated composite and PLA composite with the value of 1098.87 N/mm².
- Tensile elongation is higher in treated composite 5.03%.
- Flexural strength of treated natural fibers are stronger than the Pure PLA and untreated composite with 110.98 N/mm²
- Flexural modulus of elasticity is higher in treated composite compared to untreated composite and PLA composite with the value of 8408.55 N/mm².
- Flexural elongation is higher in treated composite 6.45%.
- The flexural strength in ASTM D 790 shown the treated fiber composite has higher value 110.98 N/mm².
- Impact strength of untreated fiber composite is higher than the treated fiber composite and PLA composite 25.39 KJ/mm².
- 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. .
- First stage of disintegration occurs in the range of 180-330°C, second stage of disintegration occurs in the range of 330-600°C. 48.

- In first stage of disintegration 8% of weight loss is observed for both treated and untreated fiber.
- In second stage of disintegration 20% of weight loss is observed for both treated and untreated fiber.
- 15% composite samples absorbed more amount of water compared to PLA.

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