

**ANALYSIS OF MECHANICAL, CHEMICAL PROPERTIES AND
MICROSTRUCTURE OF NATURAL FIBER
(CISSUS QUADRANGULARIS)**

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechanical Engineering

By

Mobithis.M (Reg.No: 37150120)

Ravichandran.R (Reg.No: 37150153)

Under the Supervision of

Mr.R.Siva, M.E., (Ph.D)

Assistant professor

Department of Mechanical Engineering



**DEPARTMENT OF MECHANICAL ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI – 600119**

April - 2021



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY (DEEMED TO BE UNIVERSITY)

Accredited with "A" grade by NAAC
Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai-
600119
www.sathyabama.ac.in



DEPARTMENT OF MECHANICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of MOBITHIS.M (Reg.No.37150120) and RAVICHANDRAN.R (Reg.No.37150153) who carried out the project entitled "**ANALYSIS OF MECHANICAL, CHEMICAL PROPERTIES AND MICROSTRUCTURE OF NATURAL FIBER (CISSUS QUADRANGULARIS)**". Under our supervision from December 2020 to April 2021.

Internal Guide

Mr.R.SIVA, M.E., (Ph.D)

Head of the Department

Dr.G.ARUNKUMAR, M.E.,Ph.D.,

Submitted for Viva voce Examination held on _____

Internal Examiner

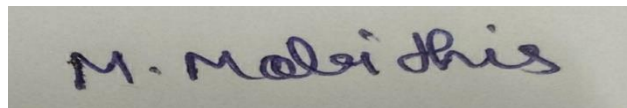
External Examiner

DECLARATION

I Mobithis.M (Reg.No.37150120) hereby declare that the Project Report entitled “**ANALYSIS OF MECHANICAL, CHEMICAL PROPERTIES AND MICROSTRUCTURE OF NATURAL FIBER (CISSUS QUADRANGULARIS)**” done by me under the guidance of **Mr.R.SIVA, M.E., (Ph.D)** at **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY-CHENNAI (600119)** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE: 01-04-2021

PLACE: Chennai

A rectangular box containing a handwritten signature in blue ink that reads "M. Mobithis".

SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

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

I convey my thanks to **Dr. S.Prakash, M.E., Ph.D.**, Dean, School of Mechanical Engineering and **Dr.G.ArunKumar, M.E.,Ph.D.**, Head of the Department, Dept of Mechanical Engineering for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide **Mr.R.SIVA, M.E., (Ph.D)** for his valuable guidance, suggestions and constant encouragement paved way for the successful completion of my project work.

I wish to express my thanks to all Teaching and Non-teaching staff members of the Department of Mechanical Engineering who were helpful in many ways for the completion of the project.

ABSTRACT

In recent days use of natural fiber in automobile industry and aero industry is getting increased due to use of synthetic fiber is more hazardous to human health. Environmentally friendly natural fiber extracted from the stem of *Cissus quadrangularis* stem plant (CQSF). The Single fiber tensile strength was carried out with different gauge length of 10mm, 20mm, 30mm, 40mm, 50mm of CQSF. The fiber with high tensile strength Of 10mm gauge length is carried out for chemical treatment with 5%, 10%, 15% of Sodium hydroxide (NaOH). The 15% chemical treated fibers have more tensile strength. The following chemical analyses, Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD) analysis, Thermo gravimetric analysis (TGA) and Scanning electron microscope (SEM) analysis carried out for untreated and 15% Sodium hydroxide (NaOH) treated *Cissus quadrangularis* stem fiber. The chemical analysis result shows that after alkali treatment, the cellulose content (70%) getting increased for CQSF and also hemicelluloses, lignin content decreased. This directly influenced tensile strength, crystallinity index, thermal stability and roughness of alkali treatment CQSF fiber. The study made on both raw and 15% NaOH treated CQSF indicates that alkali treated CQSF could be reinforcement for developing polymer composites.

KEYWORDS

Cellulosic fiber, *Cissus quadrangularis*, Alkali treatment, tensile strength.

TABLE OF CONTENTS

CHAPTER No.	TITLE	PAGE No.
	ABSTRACT	v
	LIST OF FIGURES	viii
	LIST OF TABLES	x
	LIST OF SYMBOLS AND ABBREVIATIONS	xi
1	INTRODUCTION	1
	1.1 FIBER	1
	1.2 CLASSIFICATION OF FIBER	1
	1.2.1 NATURAL FIBER	1
	1.2.1.1 COTTON	1
	1.2.1.2 COIR	1
	1.2.1.3 HEMP	1
	1.2.1.4 FLAX	1
	1.2.2 MAN-MADE FIBER	1
	1.2.2.1 RAYON	2
	1.2.2.2 NYLON	2
	1.2.2.3 POLYESTER	2
	1.2.2.4 ACRYLIC	2
2	LITERATURE SURVEY	5
3	AIM AND SCOPE	
	3.1 AIM	11
	3.2 SCOPE OF THE PROJECT	11
	3.3 METHODOLOGY	12
4	MATERIALS AND EXPERIMENTAL METHOD	
	4.1 EXTRACTION OF CQSF	13
	4.2 PHYSICAL ANALYSIS	15
	4.2.1 SINGLE FIBER TENSILE TEST	15
	4.2.2 DIAMETER MEASUREMENT	15

CHAPTER No.	TITLE	PAGE No.
	4.2.3 DENSITY MEASUREMENT	15
4.3	ALKALI TREATMENT	16
4.4	CHEMICAL ANALYSIS	18
4.5	FTIR ANALYSIS	19
4.6	XRD ANALYSIS	20
4.7	TGA ANALYSIS	21
4.8	SEM ANALYSIS	22
5	RESULTS AND DISCUSSION	
5.1	PHYSICAL ANALYSIS	23
	5.1.1 DENSITY OF CQSF	23
	5.1.2 SIGLE FIBER TENSILE STREGTH	23
5.2	CHEMICAL COMPOSITION	25
5.3	FTIR ANALYSIS	27
5.4	XRD ANALYSIS	28
5.5	TGA ANALYSIS	29
5.6	SEM ANALYSIS	31
6	SUMMARY AND CONCLUSION	
6.1	SUMMARY AND CONCLUSION	33
	REFERENCES	34
	APPENDIX	39

LIST OF FIGURES

FIGURE No	TITLE	PAGE No.
3.1	METHODOLOGY OF PROJECT	12
4.1	CQ PLANT	13
4.2	CQ STEM	13
4.3	CUT CQ STEM SOAKED IN WATER	13
4.4	CQS SOAKED IN WATER FOR 1 WEEK	13
4.5	MICROBIAL DEGRADATION OF CQ STEM	14
4.6	FIBER CAME OUT FROM CQ STEM	14
4.7	NATURAL CQ STEMS FIBERS	14
4.8	INSTRON 5500R MACHINE	15
4.9	WEIGHING 5 GRAMS OF NaOH	16
4.10	WEIGHING 10 GRAMS OF NaOH	16
4.11	WEIGHING 15 GRAMS OF NaOH	17
4.12	1 GRAM OF CQSF	17
4.13	NaOH MIXED WITH WATER	17
4.14	TREATED FIBER KEPT IN OVEN	17
4.15	TREATED FIBER PACKING	17
4.16	50 GRAMS OF NaOH	18
4.17	FIBER SOAKED IN 15% OF NaOH MIXED	18
4.18	TREATED FIBER KEPT IN OVEN	18
4.19	FTIR APPARATUS	19
4.20	XRD APPARATUS	20
4.21	TGA APPARATUS	21
4.22	SEM APPARATUS	22
5.1	UNTREATED FIBER TENSILE STRENGTH	24
5.2	TREATED FIBER TENSILE STRENGTH	25
5.3	CHEMICAL ANALYSIS	26
5.4	FTIR GRAPH FOR TREATED AND UNTREATED FIBER	28
5.5	XRD ANALYSIS GRAPH FOR UNTREATED AND TREATED FIBER	29

FIGURE No	TITLE	PAGE No.
3.1	METHODOLOGY OF PROJECT	12
5.6	UNTREATED TGA GRAPH FOR CQSF	30
5.7	TREATED TGA GRAPH FOR CQSF	30
5.8	CQ UNTREATED SEM IMAGE	31
5.9	CQ TREATED SEM IMAGE	32

LIST OF TABLES

TABLE No	TITLE	PAGE No.
5.1	SINGLE FIBER TENSILE STRENGTH FOR UNTREATED	24
5.2	SINGLE FIBER TENSILE STRENGTH FOR TREATED FIBER	25
5.3	UNTREATED AND TREATED CQSF CHEMICAL PERCENTAGE	26

LIST OF SYMBOLS AND ABBEREVIATIONS

CQ	<i>Cissus Quadrangularis</i>
CQSF	<i>Cissus Quadrangularis</i> Stem Fiber
UTM	universal testing machine
mm	Millimetre
cm	Centimetre
Kg	Kilogram
NaOH	Sodium hydroxide
FTIR	Fourier transforms infrared spectroscopy
XRD	X-ray diffraction
CI	crystallinity index
CS	crystalline size
TGA	Thermo gravimetric analysis
SEM	Scanning electron microscopy
MPa	Mega Pascal
GPa	Giga Pascal

CHAPTER 1

INTRODUCTION

1.1 FIBER

Fiber is a material that is considerably longer, whether it is natural or man-made. Fibers are commonly used to build other fabrics. Fibers, such as carbon fiber and ultra-high-molecular-weight polyethylene, are used in the toughest engineering materials.

1.2 CLASSIFICATION OF FIBER

1.2.1 *Natural Fiber*

Natural fibers, which include those created by plants, animals, and geological processes, grow or occur in the fiber form. Cotton, abaca, pia, ramie, hemp, jute, flax sisal, bagasse, and banana are examples of vegetable fibers based on cellulose arrangements, often with lignin. Plant fibers are used in the paper and textile industries.

1.2.1.1 Cotton

Cotton is a type of shrub. It thrives in a warm climate and black soil. Moderate rainfall is expected. Cotton is a soft fiber that grows around the cotton plant's seeds. Cotton is used to produce a wide range of textiles.

1.2.1.2 Coir

Coir is a coconut fiber made from the husk or outer covering of the coconut. Coconuts are normally kept in water for a few months. To obtain the fiber, the husk is removed from the nut and pounded with wooden mallets. The resulting fiber is spun, dyed, and ready for weaving.

1.2.1.3 Hemp

Hemp fibers are derived from the hemp plant's stem. Ropes, carpets, nets, clothing, and paper are all made from hemp fibers.

1.2.1.4 Flax

The fibers derived from the flax plant's stem are woven into linen cloth. Flax fibers are also used in the manufacturing of rope and fine paper.

1.2.2 *Man-made fiber*

Carbon fibers, also known as man-made fibers, are fibers that have had their chemical composition, structure, and properties greatly altered during the

manufacturing process. Regenerated and synthetic fibers make up man-made fibers.

1.2.2.1 Rayon

Rayon has properties that are similar to silk. It is a man-made fiber that is less expensive than silk. It's made out of wood pulp. To prepare bed sheets and carpets, it is infused with cotton or wool, respectively. Artificial silk is another term for it, and it can be colored in a variety of colors.

1.2.2.2 Nylon

These fibers are made from water, coal, and air and are solid, light, lustrous, and simple to wash. The fiber is made entirely of synthetic materials and it is stronger when compared to steel wire. Socks, tents, seat belts, curtains, ropes, toothbrushes, and other items are made from it. Ropes for climbing the rock and parachutes are made from this material.

1.2.2.3 Polyester

Polyester is made up of a lot of ester units. It's perfect for dressmaking because it's easy to wash and retains a crisp, wrinkle-free look. Terylene is widely used polyester. PET is a material that is used to produce a range of items such as bottles, utensils, films, and wires.

1.2.2.4 Acrylic

Most sweaters and blankets are made of acrylic, a synthetic fabric that looks like wool but isn't. Clothes made of acrylic are less expensive and last longer. Natural wool is less common than acrylic. Synthetic fibers, on the other hand, melt when heated. It could be extremely dangerous if they catch fire. The fabric adheres to the body of the person who wears it.

Fiber reinforced polymer composite materials (FRP) are used in a variety of industries. Researchers are particularly supportive of the automotive and aerospace industries. Synthetic fibers are glass polyester, nylon, acrylic, rayon, and other synthetic fibers are not only costly than natural fibers, but they are also toxic to human health. Using synthetic glass fiber causes DNA damages at high doses and genotoxic problems. Both Thymus-cell and Bone Marrow-cell stimulation resulted in a reduction in lymphocytes in the blood in fiber class staff. Allergies are also caused by an increase in eosinophil activators. Natural fibers

have more advantages than synthetic fibers, such as being biodegradable, having a low cost of fiber extraction, not being harmful to the human body during the manufacturing process, and being environmentally friendly. Synthetic fibers pollute the atmosphere because they are non-biodegradable. Natural fibers are increasingly being used in composite manufacturing, especially in the automotive, aerospace, building, and textile industries. The majority of natural fibers, their properties are outstanding. As a result, composite manufacturing firms are increasingly using natural fibers to make replacement for synthetic fibers in all applications. The fiber was extracted from various plant parts, including the stem, fruit, root and leaf.

As compared to synthetic fibers, the mechanical properties of *Cissus quadrangularis* stem fiber are superior with higher densities. *Cissus quadrangularis* (CQ) is a perennial plant that belongs to the Vitaceae family of grapes. Perandai is how Tamil people refer to it. It can be found primarily in India and Sri Lanka. In addition, it can be found in Arabia and Africa. CQ stem can reach a height of 2.5 meters. It has CQ sectioned branches with 1.5-1.8 cm thick internodes, and a length of 10-15 cm. In medicine, CQ is used to stabilize bones and treat ligament tears. In this research compare and contrast the mechanical, biological, and physical properties of untreated and chemically treated CQ fibers in this research paper. A single fiber tensile test and density measurement was used to investigate the physical properties of *Cissus Quadrangularis* stem fiber. Natural fibers absorb a lot of water and are hydrophilic. If natural fibers are hydrophilic, the frequency of the interfacial bonding between the fiber and the matrices will be decreased. As a result, appropriate surface treatments are needed to increase the surface roughness of natural fibers. Alkalization, acetylation, silane treatment, potassium permanganate treatment, benzyl peroxide treatment and are the most common chemical treatments used to change the surface properties. Performing the above chemical treatments will cause hydroxyl groups and extract impurities from the natural fiber's surface. Alkali treatment is a cost-effective and reliable process for reducing moisture absorption and reducing amorphous hemicellulose and lignin in natural fibers. Surface topography, crystalline index, and thermal stability will all improve with increasing NaOH concentration and treatment time. The percentages of cellulose, hemicelluloses, wax, pectin, lignin, ash, and moisture were measured

using a chemical analysis. Crystalline index and crystalline size are determined using X-ray diffraction (XRD) analyses and the existence of free functional groups is determined using Fourier transform infrared spectroscopy (FTIR) analyses. To find the thermal stability and thermal degradation temperature to withstand polymerization temperature, thermo gravimetric analysis (TGA) is used. The surface morphology of CQSF was studied use of a scanning electron microscope (SEM). Making new composites requires the discovery of a new natural fiber and can be applied to a variety of sectors, etc.

CHAPTER-2

LITERATURE SURVEY

Indran, et.al., (2014). In this journal *Cissus quadrangularis* stem fiber properties are discussed it's high durability once compare to previous natural fibers, and additionally its high cellulose content (82.73%), light-weight weight and extremely very low wax content of 0.18%. 270°C thermal stability within the polymerization temperature. In this fiber unwanted particles removed using meat brush. To preserve the tissues, the stems were cut into 494 small pieces of (10 × 10 mm) and immersed in Formaldehyde acetic acid ethyl alcohol (5ml F +5ml A +90ml 70% ethyl alcohol) for 24 hours. This fiber has high tensile strength when compare to other natural fiber.

Indran, et.al., (2014). In this paper the characterization results clearly shows that the *Cissus quadrangularis* root fiber may be a higher alternate material for standard unreal venturous fibers owing to its important physical, mechanical, and thermal degradation properties. It is less weight, more cellulose of 71.11% with less wax content (0.14%). Density is low when compare to E-glass fiber. The mechanical properties, on the other hand, are comparable to those of conventional fibers. These property combinations provide a high strength and high modulus for use in textile industry and other structural applications. The SEM image confirms the presence of micro fibrils with the smallest angle between them, which contributes to higher strength. Whereas the flaky cell surface has a good bonding property with the polymer matrix.

Senthamaraikannan, et.al., (2018). In this journal the raw *Coccinia grandis.L* fiber is treated with NaOH to increase their properties. *Coccinia grandis.L* fiber many blessings over different natural fibers solely when the alkalescent treated. Thermal stability increased after the alkaline treatment around 213.4°C to 220.6°C. After the alkali treatment all properties of *Coccinia grandis.L* fiber getting increased. As a result, they could be used to make car doors, car interiors dash boards, headliners, paneling, delivery shelves, pallets, spare-wheel woks, seat backs, and so on. Such could also be useful in application in seat, machine cover and bumpers.

Garette Jebadurai, et.al., (2018). The author says the presence of porous fraction on the surface of the fiber at the side of surface irregularities keeps bonding, according to microscopic image analysis. *Coccinia grandis* stem fiber polarized light microscopy and SEM reveal a hierarchical cell structure consisting of a primary and secondary cell membrane, cell lumen, and center lamellae. It reinforces in chemical compound composite its thermal stability up to 250°C. By the above analysis the *Coccinia grandis* stem must replace harmful synthetic fibers.

Vijay, et.al., (2018). In this paper the basic treated fiber has higher properties when put next to an untreated fiber. The contact angle of treated fiber is smaller amount once comparing to untreated *Tridax procumbens* that prove its higher wet ability with the liquid section. For the analysis of fiber diameter and tensile properties, the Weibull distribution was used. As a result, the significant change in the characteristics of alkali-treated *Tridax procumbens* will be worthwhile for producing advanced materials. It is used in light and moderate load applications such as table tops, chemical storage tanks, and so on.

Tamil Moli Loganathan, et.al., (2020). In this journal 1%, 3% and 5% NaOH area unit treated with fiber. On a balance the check results 3% NaOH treated fiber have sensible properties than untreated and different treated. By removing 17% of the hemicellulose, 3% of Sodium hydroxide treated *Cyrtostachys renda* fiber for 1 hour recorded the least density among the Sodium hydroxide treated fibers. The compounds existing at 2849 cm^{-1} in the treated *Cyrtostachys renda* fibers would improve load capacity and hardness while strengthening with polymeric matrix. When compared to untreated fibers, 3 percent Sodium hydroxide treated *Cyrtostachys renda* fiber for 1 hour had the high thermal stability.

Manikandan Ilangovan, et.al., (2020). In this journal *sausage* fibers conjointly possessed an anti-microbial activity against a common gram negative and a gram-positive bacterium. Tensile 484 MPa and thermal stability 300°C. In this alkali treatment remove hemicellulose and lignin. Overall, *sausage* fibers possess similar properties to cotton and superior to fibers gathered from a variety

of renewable resources. *Sausage* fibers with increased hydrophobicity and anti-bacterial characteristics could have been useful. The fibers could be used to make composites and non-woven fabrics. Even then, the fibers are coarser and smaller in length, making them unsuitable for traditional textile applications.

Arul Marcel Moshi, et.al., (2019). In this journal the *Ficus Religiosa* tree, also classified as Peepal tree, can reach a height of 30 meters and also has a life cycle of 900 to 1500 years. In which higher polysaccharide content of 55.58 wt.%. Carbon (67.48 wt. %), Oxygen (25.32 wt. %), and Chlorine (3.11 wt.%) were found to be the most abundant elements in the fiber structure, according to EDX results. The chemical groups show with polysaccharides (O=H), hemicellulose (C=O) was confirmed using FTIR analysis. Thermal stability (325°C), SEM and AFM outcomes show a comparatively the smoothest surface.

Belouadah, et.al., (2015). In this journal the ATR-FTIR and X-ray analysis confirmed that the *Lygeum Spartum L* fibers are wealthy in polysaccharide with crystallinity index of 46.19%. Modulus of elasticity, lastingness and strain at failure, tensile take a look at as 13.2 GPa, 280 MPa, and 3.7% severally. Brittle failure, which is commonly linked with fiber splitting, was revealed by the fracture behavior of *Lygeum Spartum L* fiber. Under tensile testing, it was discovered that both delaminating between fiber cells and fiber fracture are the most common failure mechanisms.

Balaji, et.al., (2017). In this journal the experimental results of the alkali treated *Saharan aloe vera cactus leaves* fibers square measure compared with those of different common natural fibers square measure hemp, bamboo, etc. The comparison results make sure that these fibers represent as valid various to those as reinforcement in compound composites. In this 5% NaOH solution is treated at 27 °C room temperature for 60 min. The removal of Sodium hydroxide contents throughout the fibers using red litmus paper ensured an improved pH value.

Ilaiya Perumal, et.al., (2020). In this journal in the anatomical study, higher strength gelatinous fibers with a traditional hierarchical cell wall were discovered. The anatomical study fiber secondary wall (~25 µm) and first wall (~15

μm) dimensions are present. An enough quantity of cellulose (63.3 wt.%) with the crystallinity index (58.15%) and crystallization size (11.92 nm) assured a high mechanical strength. It's less and surroundings. Two variables The Weibull statistical distribution revealed a good fit within the allowed confidence levels. Based on the results of the XPS analysis, it is clear that the main elements were oxygen, hydrogen, and carbon, indicating that the *Derris scandens* stem fiber are organic. Involved in the manufacturing process SEM images reveal important details about fiber surface irregularities.

Zouheyr Belouadah, et. al (2020). In this journal stems were stewed in 0.5% hydrated oxide (NaOH) or 10 percent metallic elements bicarbonate (NaHCO₃). In which NaOH has rough surface and NaHCO₃ has sleek surface by this NaOH has sensible properties. The overall polygonal shape is still visible after mild alkali treatment, with the epidermis clearly on the outside and the parenchyma inside, are for cellulose fibers linked in to the bundles by center lamellae xylem and phloem tubes.

Arul Marcel Moshi, et.al., (2020). In this journal the Mass density ($1.378 \pm 0.036 \text{ g/cm}^3$) is appropriate for light-weight application. Made quantity of polysaccharide content ($57.78 \pm 3.56 \text{ wt.}\%$). The thermal stability is 326°C, that suits the fiber to be used for top-temperature applications. The results of the morphological as well as atomic force microscopy study showed that the fiber has a rough surface even in raw state. As a result, it could be used to create composite specimens with higher quality bonding strength of fiber to polymer. The fiber has less amount of hemicellulose.

Sudhir Chakravarthy, et.al., (2020). In this journal it has Higher quantity of carbon (51.6 wt.%) and atomic number 8 (47.18 wt.%). *Cissus vitiginea* plant fiber had part rough surface. In this article nuclear magnetic response spectroscopy and Energy - dispersive spectrum analysis square measure done results shows its various replacements for non-ancient artificial fibers. It has high cellulose content (65.43 wt.%) and low hemicellulose 14.61 wt.%. The fiber's density (1287 kg/m^3) has been reported to be lower in comparing to most of the other published natural fibers and the few synthetic fibers, allowing the *Cissus vitiginea* plant fiber to be

used for compact structural applications.

Vijay, et.al., (2020). In this journal hydrochloric acid treatment reduced polysaccharide contents thanks to its additional acidic attack. However, Hydrochloric acid treatment shows additional surface harm reducing the mechanical strength. Within which NaOH has sensible properties. For less weight polymeric application, it is good reinforcement. When compared with untreated and treated *Pennisetum orientale* fibers, the thermal stability of Sodium hydroxide *Pennisetum orientale* fibers was greater, with 37% char residue. It is for light weight application. The cellulose presence is 65.1%. The crystalline size of treated fiber 62.02 nm is higher than untreated fiber of 42.92 nm.

Manimaran, et.al., (2020). In this journal the cellulose content of *Nendran Banana Peduncle* plants fiber is 73.20 wt.%. Would it be best once comparing to alternative plastic fibers, and additionally thermal stability is high 356°C with the reduction in mass of 50%. The crystallinity index is 53.3%. AFM analysis rough surface of the fiber. Tensile strength is about 65.51 MPa. It is used for making light load components in automotive industry.

Ganapathy, et.al., (2019). In this journal the quality of raw and alkalized the *aerial roots of banyan* tree fiber is verified for fiber strengthened plastics. The only fiber tensile check results showed that alkalization improved the durability of *aerial roots of banyan* tree fiber from 20.45 ± 12.20 MPa (alkalized *aerial roots of banyan* tree fiber) from 19.37 ± 7.72 MPa (raw *aerial roots of banyan* tree fiber). NaOH treated fiber have sensible properties once compare to untreated fiber. The results of SEM and AFM show the impurities and wax present in outer surface on the fiber was eliminated after alkali treatment. There is increase in tensile strength after alkali treatment.

Majed, et.al., (2019). In this journal four different date palm fibers show worthy difference in their cellulose content. It would be promising various property and biomass material for the isolation of several polyose nanofibers and polyose nanocrystals as potential reinforcement in compound composites. Furthermore, the levels of calcium in four date palm fibers are relatively high; additionally, *Date*

Palm Truck fiber exhibited 69.2 % crystallinity, which is lesser than *Date Palm* leaf stalk fiber 72.4 % crystallinity. Thus, the crystalline structure nature of *Date Palm fruit bunch stalk* fiber relates to its rigid structure, that may favor nanocomposite fabrication.

Ridzuan, et.al., (2015). In this journal Sodium hydroxide solutions of varied percentages (5%, 7%, 10%, 12% and 15%) and with 24h at temperature. The fiber with five 5% alkali-treated have the highest tensile stress. The 10, 12, and 15% alkali treatments reduced the final word tensile stress of the fibers; this was confirmed by SEM observations, that incontestable the broken textures, and also the twisted fibers. The moisture is decreased after alkali treatment. The morphological observations revealed as the alkali concentration increased, the fiber had become more compressed lead to the fall of the cell wall, the void content reduced, and the fiber's strength increased.

Saravanakumar, et.al., (2012). In this journal the conjointly consisted of an extremely hard outer primary wall and a secondary wall that consisted of gluey substance and a cell lumen. Higher polymer content of the *Prosopis juliflora* bark fiber offers comparatively higher rigidity as compared to the prevailing bark fibers and comparatively lower density of the *Prosopis juliflora* bark fiber could clearly modify lightweight weight applications for e.g., textile and automobile industries. It is appropriate replacement for typical fibers like glass and carbon in compound matrices. Tensile strength of the fiber is about 558 ± 13.4 MPa. Thermal stability about 217°C and 76.72 kJ/mol of kinetic activation energy.

CHAPTER-3

AIM AND SCOPE OF THE PROJECT

3.1 AIM

Aim of this project is to extract natural fiber from *Cissus quadrangularis* stem. Our intention is to compare both untreated fiber and alkali treated fiber results. For comparing the properties of the *Cissus quadrangularis* stem fiber the following analysis was carried out are, the tensile strength of a different gauge length and chemical treated fiber were compared. The untreated fiber and the chemically treated fiber with the highest tensile strength was further subjected to, Fourier Transform Infrared spectroscopy (FTIR) to find the chemical bonding of the fiber, X-Ray Diffraction (XRD) to find the crystalline structure, Thermo Gravimetric Analysis (TGA) to find the thermal stability of the fiber and Scanning Electron Microscopy (SEM) tests to find the surface morphology. A comparative study was performed between the existing untreated plant fiber and the newly developed fiber by chemical treatment.

3.2 SCOPE OF THE PROJECT

The composite manufacturing companies are using synthetic fiber such as glass fiber, aramid, ceramic fiber and carbon fiber, but it is more hazardous to human health the study shows it causing DNA damage, non-degradable and also costly. When compare to this natural fiber have many advantages like a non-pollutant, global warming potential, degradable, and less cost. The Manufacturing of natural fiber composite is also easy. The disadvantage of synthetic fibers indicates it must be replaced with natural fiber. So, based on the demand of natural fiber, in this article natural fiber is extracted and their properties are analyzed. This natural fiber analysis results are compared with some other synthetic and natural fiber, to indicates that this fiber can replace the harmful synthetic fiber in a composite manufacturing company

3.3 METHODOLOGY

The below figure 3.1 shows the methodology of CQSF

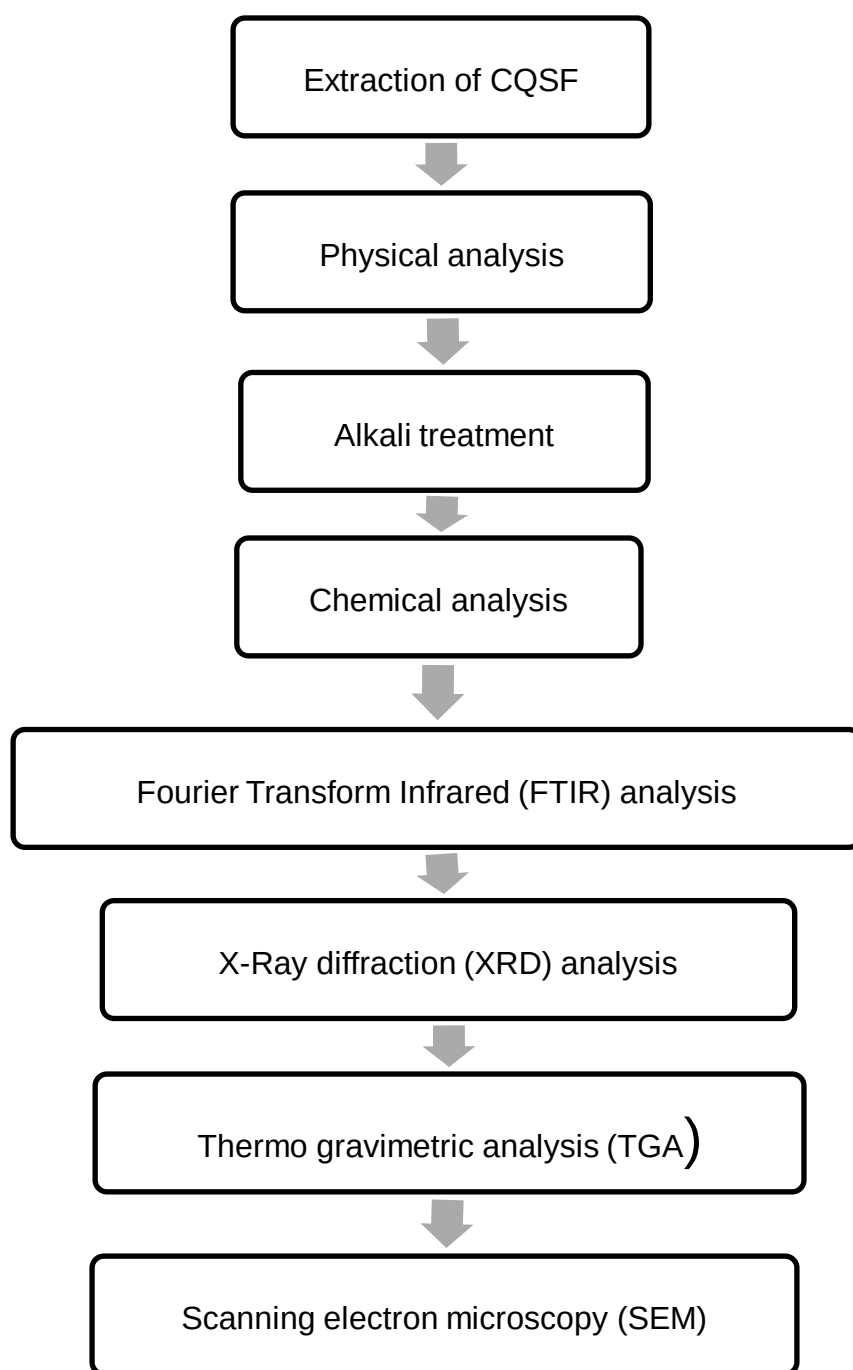


Fig 3.1 Methodology of project

CHAPTER 4

MATERIALS AND METHODS

4.1 EXTRACTION OF CQSF

The *Cissus Quadrangularis* plant was collected from Karai (village), Villupuram (District), TamilNadu, India. The CQ stems were cut into small, pieces and they were soaked in water for 15 days to undergo microbial degradation. The fibers were manually collected with a metal brush after 15 days and washed with water to eliminate impurities. We dried the fibers in the sun for two days to eliminate the moisture content, and then packed in a sealed plastic cover [11]. Figure 4.1 to figure 4.7 shows extraction of CQSF.



Fig 4.1 CQ plant



Fig 4.2 CQ stem



Fig 4.3 Cut CQ stem soaked in water



Fig 4.4 CQS soaked in water for 1 week



Fig 4.5 Microbial degradation of CQ stem

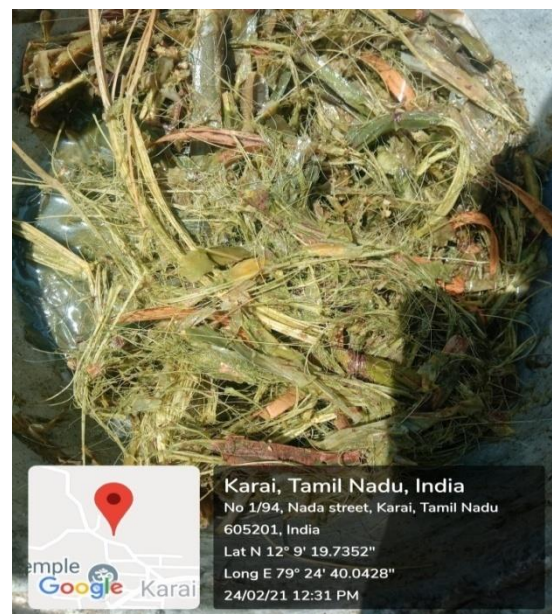


Fig 4.6 Fiber came out from CQ stem



Fig 4.7 Natural CQ stems fibers

4.2 PHYSICAL PROPERTIES

4.2.1 Single fiber tensile test

The tensile properties for raw and alkali treated CQSF were tested using INSTRON 5500R (Zwick roell) type UTM shows in Figure 4.8 as per the ASTM D 3822-01 standard Tensile test of single fibers was carried out for different gauge lengths of 10 mm, 20 mm, 30 mm, 40 mm and 50 mm [11]. 25 fiber samples from each fiber length were prepared. Crosshead speed of 5mm/min and a load cell of 1N. The tests are conducted at 23°C to 30°C ambient temperature with 64% relative humidity. Tensile strength of each gauge length was calculated by averaging the individual tensile strength values of 25 samples.

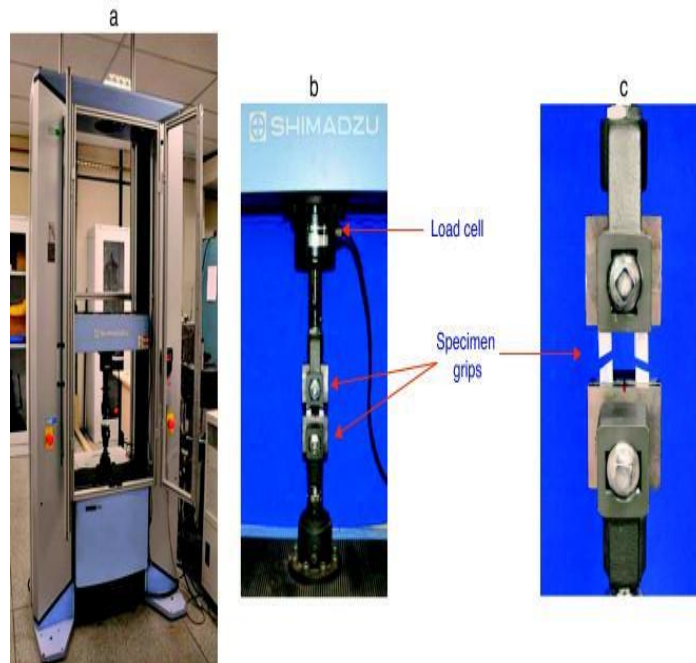


Fig 4.8 Instron 5500R Machine

4.2.2 Diameter measurement

The untreated and alkali treated CQSF diameter was measured using digital optical microscope. A total of 125 fiber samples with a length of 50mm are measured in 3 different places [23].

4.2.3 Density measurement

The density of the fiber was determined by liquid immersion test using toluene as a liquid in the pycnometer. The untreated CQSF and treated CQSF density was estimated using the below equation (1),

$$\rho_{\text{CQS F}} = \frac{(m_2 - m_1)}{(m_3 - m_1)(m_4 - m_2)} \rho_t \dots\dots\dots (1)$$

Where,

$\rho_{\text{CQS F}}$ is the density of CQS F fiber (g/cm^3), the density of toluene is indicated by $\rho_t(\text{g/cm}^3)$, the mass of an empty pycnometer is indicated by $m_1(\text{kg})$, m_2 represent the mass of a pycnometer (kg), the mass of a pycnometer with toluene is indicated by $m_3(\text{kg})$, and the mass of pycnometer with fibers and toluene is indicated by m_4 (kg).[11]

4.3 ALKALI TREATMENT

The dried CQS F were immersed in NaOH solution with 100mL of distilled water, 5%, 10%, and 15% for 1 hour of soaking time at room temperature. The NaOH solution was mixed with the CQS fiber (wt. ratio of NaOH solution: fiber = 5:1). The mixture was slowly stirred. Then NaOH treated fiber was taken from the beaker and washed several times using distilled water until the neutralized removed from the NaOH solution and washed several times using distilled water until the fiber were neutralized. Finally, NaOH treated fibers were kept in oven at 100°C for 2 hours [4]. Figure 4.9 to figure 4.18 shows alkali treatment process.



Fig 4.9 weighing 5 grams of NaOH



Fig 4.10 weighing 10 grams of NaOH



Fig 4.11 weighing 15 grams of NaOH



Fig 4.12 1 gram of CQSF



Fig 4.13 NaOH mixed with water



Fig 4.14 Treated fiber kept in oven



Fig 4.15 Treated fiber packing



Fig 4.16 50 grams of NaOH



Fig 4.17 Fiber soaked in 15% of NaOH mixed



Fig 4.18 Treated fiber kept in oven

4.4 CHEMICAL ANALYSIS

To assess the percentages of cellulose content, hemicellulose content, ash content, pectin content, lignin content, wax content, and moisture content presence in untreated and treated CQSF the following methods were used. Kurschner and Hoffer's method was used to measure the cellulose content percentage (1993) [20]. The percentage of hemicelluloses was measured using the neutral detergent fiber process [20]. The percentage of lignin was calculated using the APPITA P11s78 process [20]. Conrad's method was used to calculate the wax percentages [20]. The Technical Association of the Pulp and Paper Industry estimated the ash content level (TAPPI) [20]. Moisture content calculating

below equation (2).

$$\% \text{ of moisture content in CQSF} = \frac{(w_1 - w_2)}{w_1} \times 100 \quad \dots\dots\dots (2)$$

Where, W_1 is the fiber weight before moisture removal in grams and W_2 is the fiber weight after moisture removal in grams [20].

4.5 FTIR ANALYSIS

FTIR was carried out by powdering the untreated and alkali treated CQSF in a mortar and pestle and mixing it with KBr then formed into a pellet. In the native fiber, FTIR was used to determine the chemical functional groups and types of bonds. The samples were measured by using Alpha T with Attenuated Total Reflection FTIR spectrometer in the frequency range $4000\text{cm}^{-1} - 500\text{ cm}^{-1}$. [20]

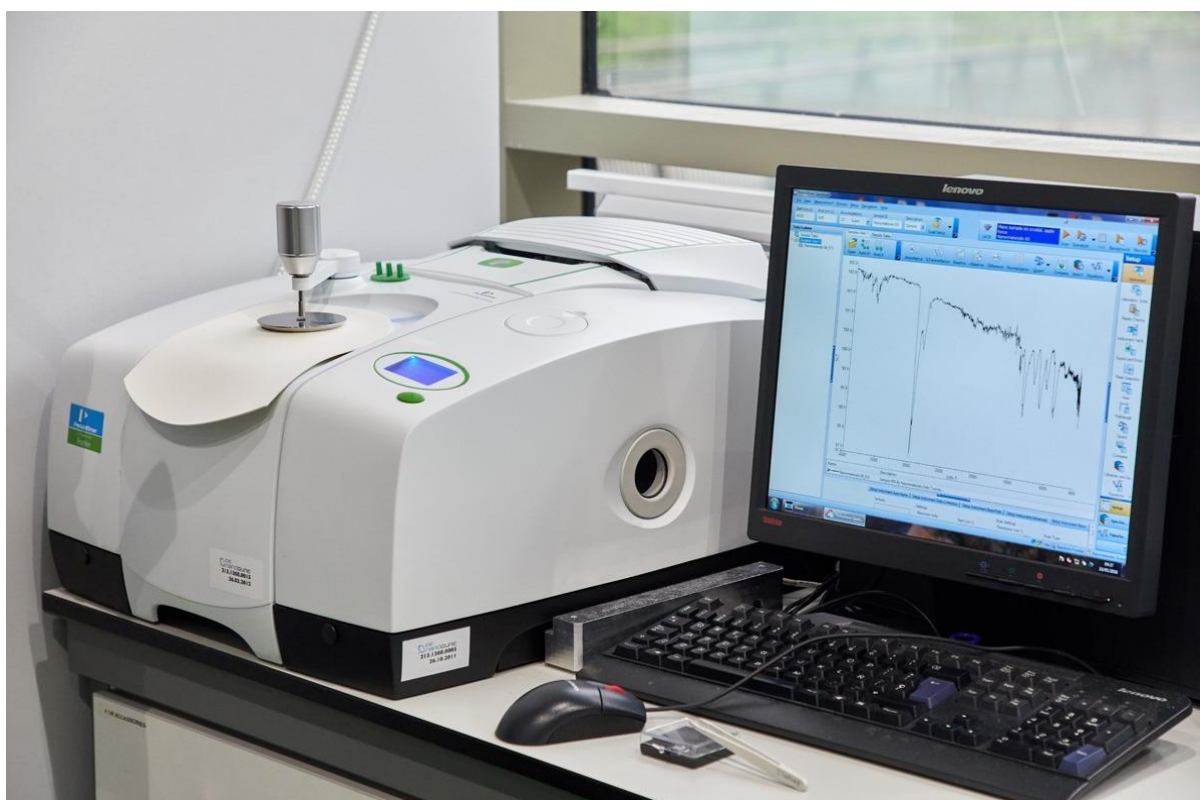


Fig.4.19 FTIR apparatus

4.6 X-RAY DIFFRACTION (XRD) ANALYSIS

Raw and alkali treated CQSF were powdered and analyzed using X-ray diffract meter with monochromatic intensity of Cu K α radiation and performance range between 20° and 80° with step size of 0.02°. Raw and alkali treated fiber samples, each of 10g were taken for the test. The CQ fibers crystallinity index was calculated according to the peak, height technique by using the empirical equation (3).

$$\text{Crystallinity index (CI)} = \frac{I_c - I_{am}}{I_c} \times 100 \quad \dots\dots\dots (3)$$

Where I_c -maximum crystalline region peak intensity, I_{am} -amorphous region peak intensity. The crystalline size (CS) is calculated using Scherrer's equation (4)

$$\text{Crystalline size (CS)} = \frac{K\lambda}{\beta \cos\theta} \quad \dots\dots\dots (4)$$

Where K - Scherrer's constant, λ - the radiation wavelength, β - the peak's full width at half-maximum in radians, and θ - the corresponding Bragg angle. [4]



Fig.4.20 XRD apparatus

4.7 TGA ANALYSIS

TGA was done to find the thermal stability of the raw and alkali treated CQSF. The test was conducting using TGA55 instrument and platinum HT pan. TGA was take place in a nitrogen atmosphere with 20 ml/min flow rate. For heating it from 30°C to 900°C, the heating rate is kept constant at 10°C/min. [21]



Fig.4.21 TGA apparatus

4.8 SEM

Under Field emission scanning electron microscopy (shows in figure 4.22), CQSF were observed after sputter coating with gold. The natural fiber surface roughness is measured using SEM analysis. Microscopic photographs of treated and untreated CQSF collected using a Field Emission Scanning Electron Microscope. [11]

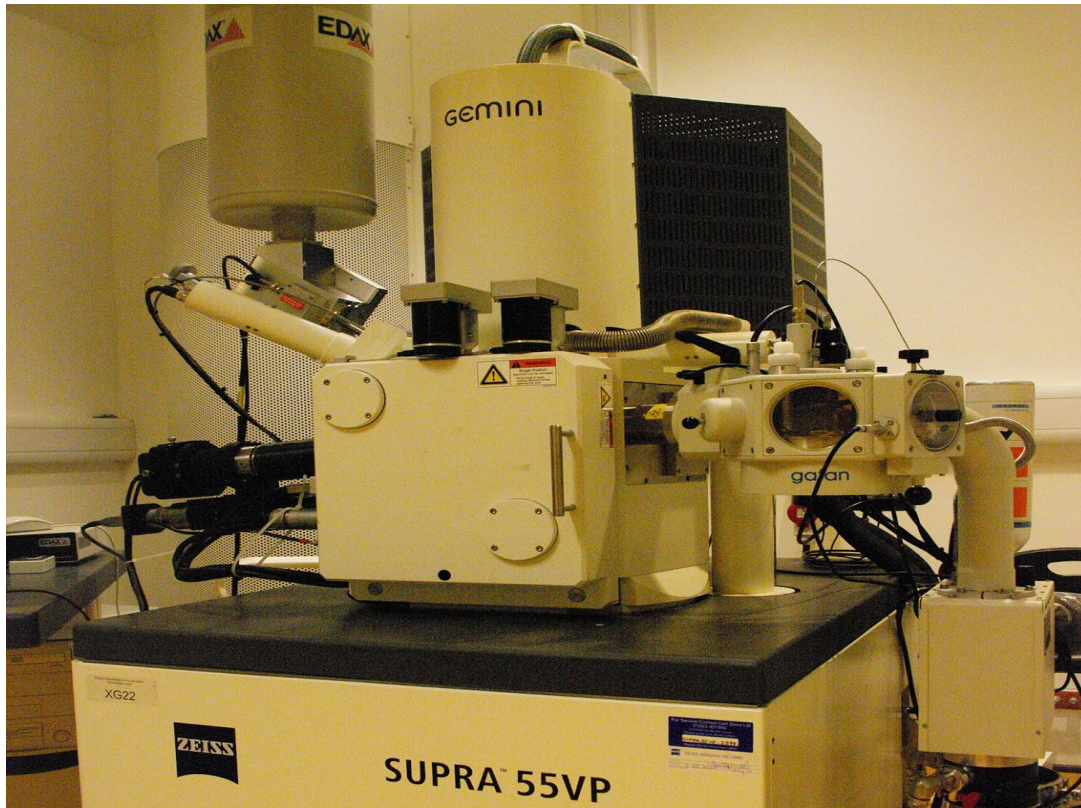


Fig 4.22 SEM apparatus

CHAPTER 5 RESULTS AND DISCUSSION

5.1 PHYSICAL ANALYSIS

First, the diameter of CQSF was measured. Based on the result of measurement the untreated CQSF have larger diameter when compare to alkali treated CQSF because of alkali treatment reduces the amount of hemicellulose content and lignin content [20]. The raw CQSF have mean diameter of 0.1190mm and treated CQSF have mean diameter of 0.1043 mm. After density measurement the alkali treated CQSF have density of 1.40 g/cm³ is high when compare to raw CQSF have density 1.18 g/cm³ due to alkali treatment fill pores and voids present in the surface of CQSF by this only alkali treated fiber have high density when compare to untreated fiber [20]. There is a decrease in diameter, increase in density good bonding surface, and also increasing rough surface after the alkali treatment [20].

5.1.1. Density of CQSF

The average density of the untreated and treated CQSF was found to be 1.18 g/cm³ and 1.40 g/cm³. When it is compared to Carbon fiber and E-glass fiber having density of 1.5 g/cm³ and 2.56 g/cm³ and also higher than Bamboo (0.91 g/cm³), Jute (1.3 g/cm³).[11]

5.1.2. Single fiber tensile strength

Table 5.1. Single fiber tensile strength for Untreated

Gauge length (mm)	Tensile strength at break (MPa)	Young's modulus (GPa)	Strain at break (%)	Cross Sectional Area of fiber (mm ²)
10	268.962 ± 50	7.219 ± 3.6	4.36 ± 2.9	0.0095 ± 0.003
20	234.824 ± 40	8.126 ± 4.42	3.54 ± 2.2	0.0083 ± 0.0025
30	216.780 ± 35	8.543 ± 4.27	2.98 ± 2.1	0.0089 ± 0.0028
40	200.397 ± 32	10.047 ± 5.87	2.26 ± 1.1	0.0103 ± 0.0025
50	183.160 ± 30	9.944 ± 4.08	1.94 ± 0.9	0.0112 ± 0.0026

Tensile strength for CQSF was calculated with different gauge length of 10 mm, 20 mm, 30 mm, 40 mm, and 50 mm is shows in table 5.1. In this different gauge length 10 mm gauge length fiber is having more tensile strength and strain at break respectively 268.962 ± 50 MPa and 4.36 ± 2.9% when compared to other

gauge length.

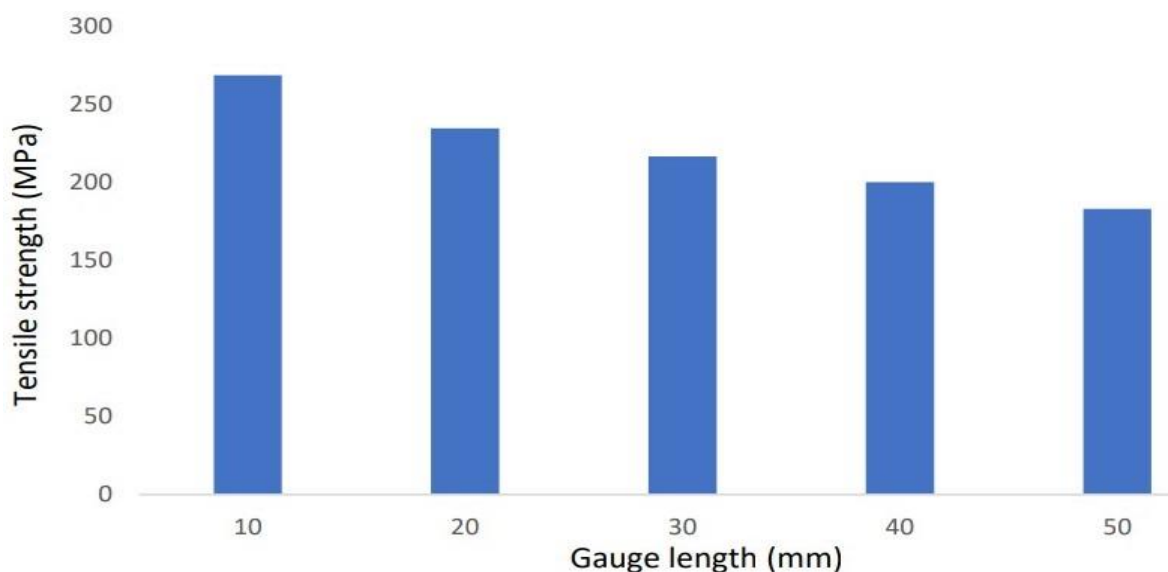


Fig 5.1 Untreated fiber tensile strength

Table 5.2. Single fiber tensile strength for treated fiber

NaOH percentage	Tensile strength at break (MPa)	Young's modulus (GPa)	Strain at break (%)	Cross Sectional Area of fiber (mm ²)
5% of NaOH	349.787 ± 90	6.237 ± 2.49	5.51 ± 1.4	0.0073 ± 0.004
10% of NaOH	377.199 ± 95	7.521 ± 4.00	5.06 ± 1.1	0.0085 ± 0.005
15% of NaOH	389.820 ± 97	7.577 ± 4.61	5.44 ± 1.7	0.0089 ± 0.006

Tensile strength for treated CQSF was calculated for different NaOH percentage 5% of NaOH, 10% of NaOH and 15% of NaOH is show in table 5.2. In this different percentage of NaOH treatment 15% of NaOH treated fiber having high tensile strength (389.820 ± 97 MPa). Because of alkali treatment increasing cellulose content, reduce hemicellulose content and lignin content, and also change soft surface to rough surface of fiber [2]. 15% of NaOH treated CQSF tensile strength is 389.820 ± 97 MPa. This high when compare to other natural fiber, *Arundo Donax* (248 MPa), *Coccinia grandis.L* (273 ± 27.74 MPa), *Kigelia Africana* (73.21 ± 32.48 MPa), *Manicaria saccifer palm* (72 MPa). The tensile

properties, diameter and microstructure of the fiber are determined by the plant source, extraction method of fiber, plant age [8]. The tensile strength results indicate when the gauge length increase, the tensile strength gets decreased that confirms that as gauge length increases and crack formation on fibers increases as well [3] [21].

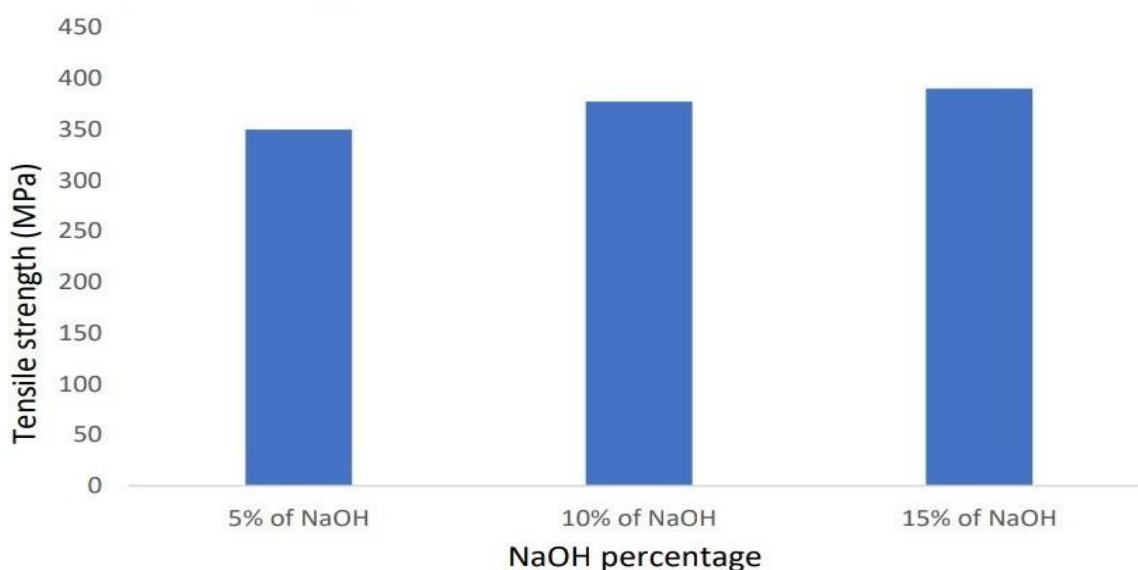


Fig.5.2 treated fiber tensile strength

5.2 CHEMICAL COMPOSITION

The table 5.3 shows the chemical analysis comparison of untreated and treated CQSF. Untreated fiber and treated fiber results shows cellulose content of 69.58% and 70.00% there is increase in cellulose content after alkali treated. High cellulose content ensures the CQSF have high tensile strength and modulus of elasticity [11]. The hemicelluloses of content of untreated fiber are 36.13% is reduced after the alkali treatment of 35.21%. When hemicellulose content is increased it will affect the fiber strength [2]. The lignin content of 10.85% for untreated fiber is less when compare to alkali treated fiber of 9.36%. Increase in lignin content affects the morphological characteristics and fiber structure [2]. The wax content 0.97% is high when compare to alkali treated fiber wax content of 0.40%, the higher level of wax content reduces the bonding capacity with matrix and increasing the fiber surface to smooth [11]. The moisture content of 9.98% of

treated fiber is reduced to 6.01% after the alkali treatment. The low moisture content increases the bonding strength between fiber and composite matrix [2]. The ash content of 5.76% untreated fiber is reduced to 4.80% after the alkali treatment. The ash content of a fiber, which leads to a reduction in its amorphous phase [2]. The pectin content of untreated fiber is 6.80% is reduced after the Alkali treated of 4.99%. So chemical composition test performed with 15% of NaOH treated fiber. There is no high difference in cellulose content for both untreated and treated fibers, but there is high difference in moisture and wax content after the alkali treatment. So, alkali treatment reduces the moisture and wax content on fiber.

Table 5.3. Untreated and treated CQSF Chemical percentage

Chemical composition	Untreated CQSF (%)	Treated CQSF (%)
cellulose	69.58	70.00
hemicelluloses	36.13	35.21
lignin	10.85	9.36
wax	0.97	0.40
moisture	9.98	6.01
ash	5.76	4.80
pectin	6.80	4.99

The cellulose content of alkali treated CQSF have 70.00% which is high when compare other natural fiber such as *Tridax procumbens* (45%), *Cocconia grandis.L* (68.47%), *Corchorus(jute)* (61%), *Pergularia Tomentosa L.* seed fiber (43.8%) and *Napier grass strands* (47.12%).

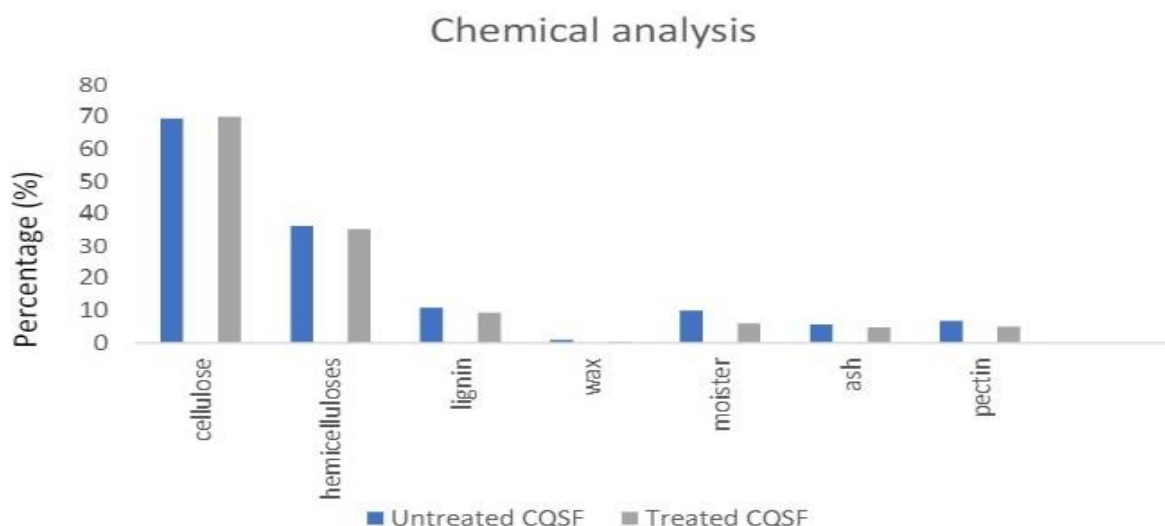


Fig.5.3 Chemical analysis

5.3 FTIR ANALYSIS

FTIR graph of raw and alkali treated CQSF was showed in figure 5.4. Based on the peak locations of raw and alkali-treated CQSF, as well as the chemical functional groups assigned to them as follows. The 3250 cm^{-1} for treated and 3150 cm^{-1} for untreated fibers peaks at graph are belongs to the acid O-H stretching because of the presence of cellulose content [10] and C-H stretching occurred because of the vibration of polyose, by a moderate peak of 2900 cm^{-1} for treated and 2800 cm^{-1} for untreated fiber [10]. The height of 2250 cm^{-1} for treated and 2150 cm^{-1} for untreated fiber within the CQSF indicates the presence of $\text{C}\equiv\text{C}$ alkynes cluster. A little peek of treated fiber at 1400 cm^{-1} and untreated fiber at 1350 cm^{-1} is indicate the presence of chemical group of $\text{C}=\text{C}$ stretching, that indicate the presence of hemicelluloses. The smaller peak represents less share content of hemicelluloses, which are advantageous as a result of higher content, can have an effect on the mechanical properties of CQSF. The $\text{C}=\text{C}$ aromatic elongating with a strong conjugated C-C bond is represented by the height at band 1300 cm^{-1} for treated fiber and 1270 cm^{-1} for untreated fiber. and his peak indicate the presence of lignin content within the fiber [10]. The ascribed to study chemical group C-O with overlapped C-H stretching of phenols and esters at peak band of 1200 cm^{-1} for treated and 1150 cm^{-1} for untreated fiber. The band 900 cm^{-1} for treated and 800 cm^{-1} for untreated fiber represents the alkoxy C-O normal bond

bending vibration [10] and therefore, the smaller peak at 750 cm^{-1} for treated and 700 cm^{-1} for treated fiber indicate the presence of saline content [10]

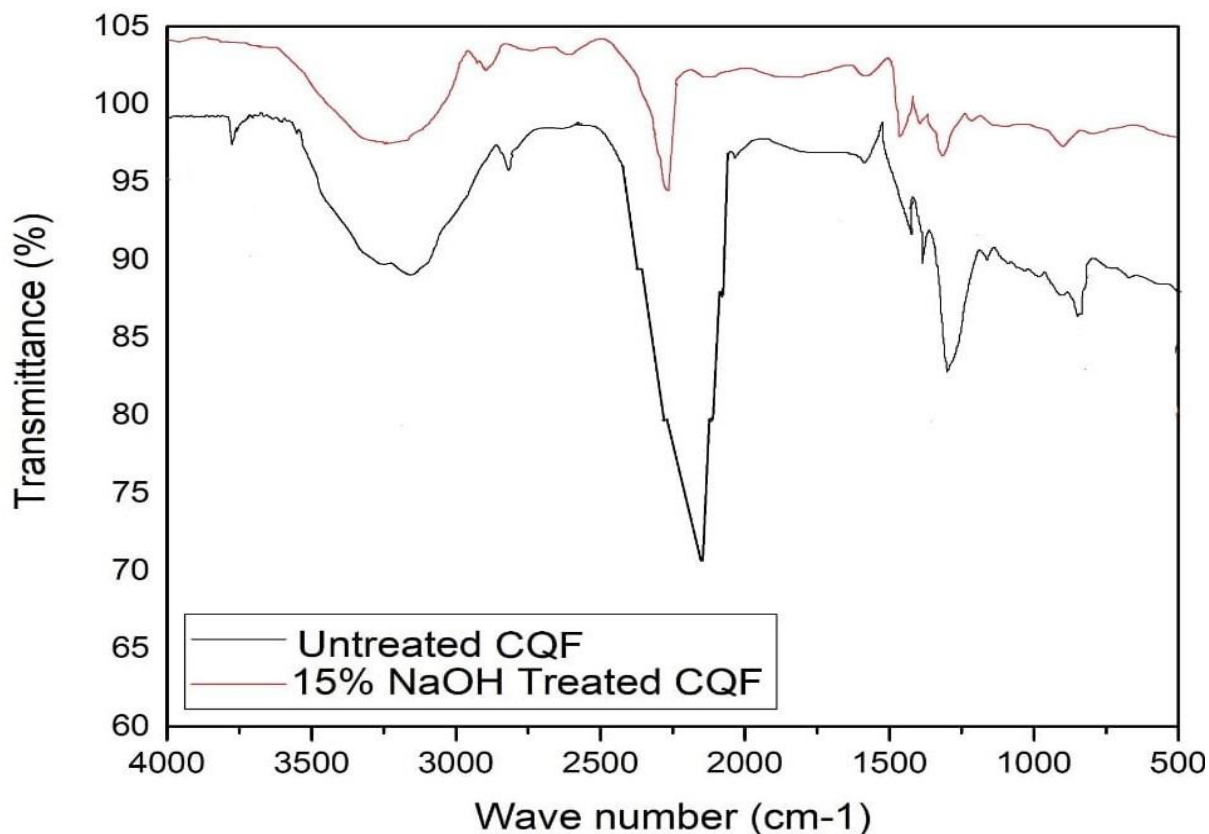


Fig.5.4 FTIR graph for treated and untreated fiber

5.4 XRD ANALYSIS

The XRD analysis of both untreated and treated CQSF shown in figure 5.5. The graph shows comparison between both untreated and 15 % of NaOH treated. The untreated fiber has small peak at $2\theta=24.5^\circ$ and high peak at $2\theta=27^\circ$ and treated fiber have small peak at $2\theta=23.5^\circ$ and high peak at $2\theta=28.5^\circ$ [8]. The peak (28.5°) of NaOH treated CQSF was amplified compared to raw CQSF, indicating that the Sodium hydroxide solution reaction with the fiber and decrease in molecular weight of CQSF. Materials with a low molecular weight like hemicelluloses content, wax content, and lignin content [23]. The untreated and treated CQSF crystallites index is 52.42% and 54.80%. The treated CQSF have crystallites index of 54.80% which is higher than *Wrightia tinctoria* seed fiber (49.2%), *Cordia dichotoma* (50.20%), *Coccinia grandis* L (52.17%), *Grewia tilifolia*

(41.7%), *Furcraea foetida* (52.6%). CQSFs crystallites are ordered in nature, as shown by the higher crystalline index value of 54.80%.

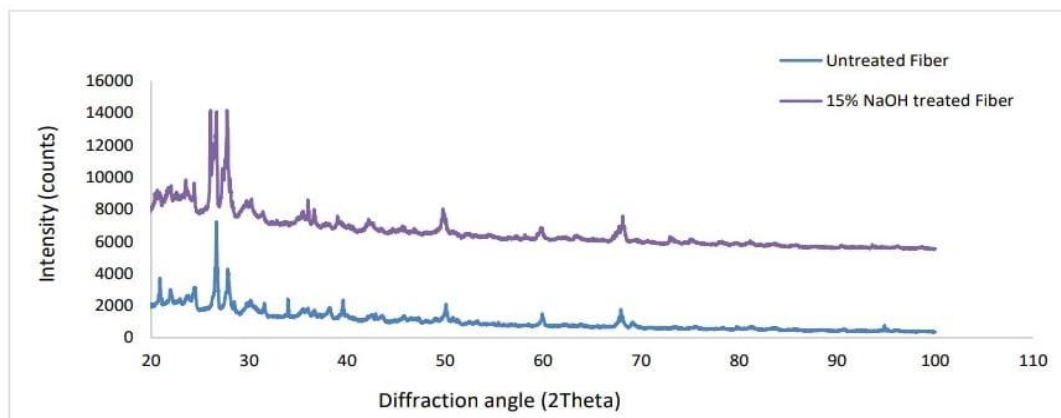


Fig 5.5 XRD analysis graph for untreated and treated

5.5 TGA ANALYSIS

TGA has been used to determine the temperature and thermal stability of the fiber's the more important components, such as cellulose, lignin and hemicelluloses.[16] TGA with DSC graph for untreated CQSF and treated CQSF are show in figure 5.6 and 5.7. The degradation of various CQSF ingredients is carried out in three stages. In the first stage the degradation for untreated CQSF and treated CQSF occurs at curve of (170°C to 360°C and 180°C- to 370°C) with weight loss of 24% and 18% due to removal of wax material from fiber surface and moisture vaporization [16]. The weight loss occurs at second stage in both untreated and treated CQSF is 60% and 50% the peak at second stage is at (360°C to 490°C and 370°C-500°C) for untreated and treated CQSF in this stage majority of cellulose, lignin and hemicellulose getting degradation [16]. In this third stage of cellulose degradation takes place between (490°C to 710°C and 500°C to 720°C) as well as corresponds to the degradation of wax and lignin, leaving ash as a residue, with weight of 55% and 40% [16]. The thermal stability and cellulose degradation temperature of treated CQSF increased from 170°C to 180°C and 490°C to 500°C [3]. The untreated and alkali treated fiber of *Prosopis juliflora*, *Coccinia grandis*.L, *Saharan aloe vera*, and *Cordia dichotoma* showed similar

degradation behavior. The TGA results shows treated CQSF fiber have good thermal stability when compare to untreated CQSF due to NaOH treatment remove amorphous contents in CQSF. [15

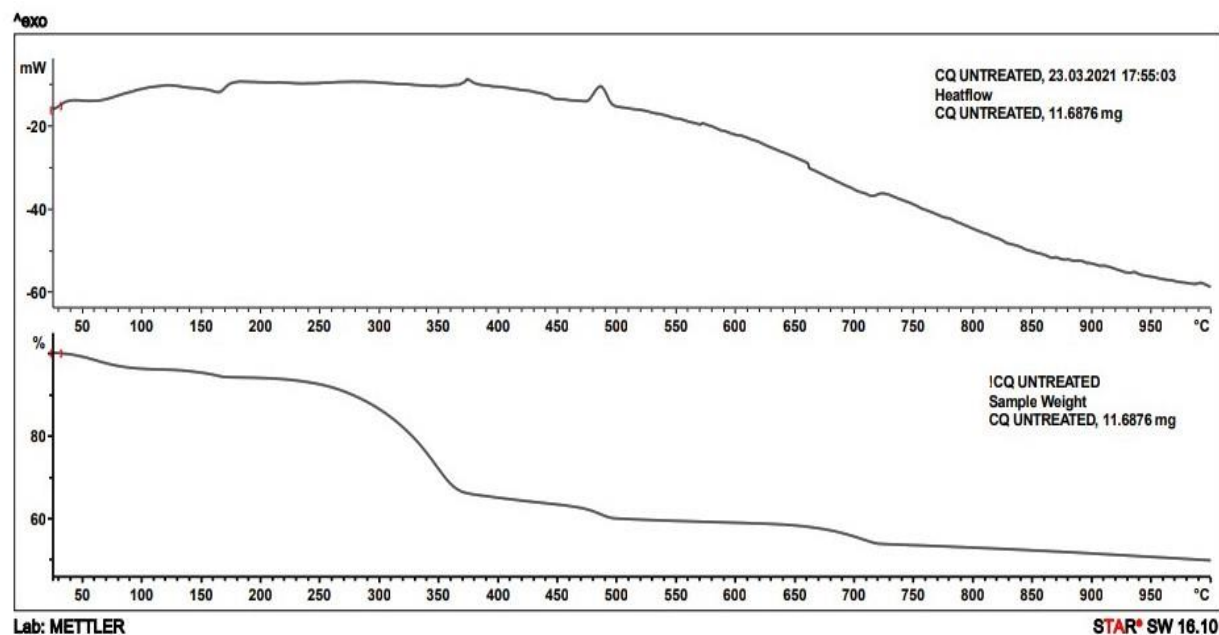


Fig.5.6 Untreated TGA graph for CQSF

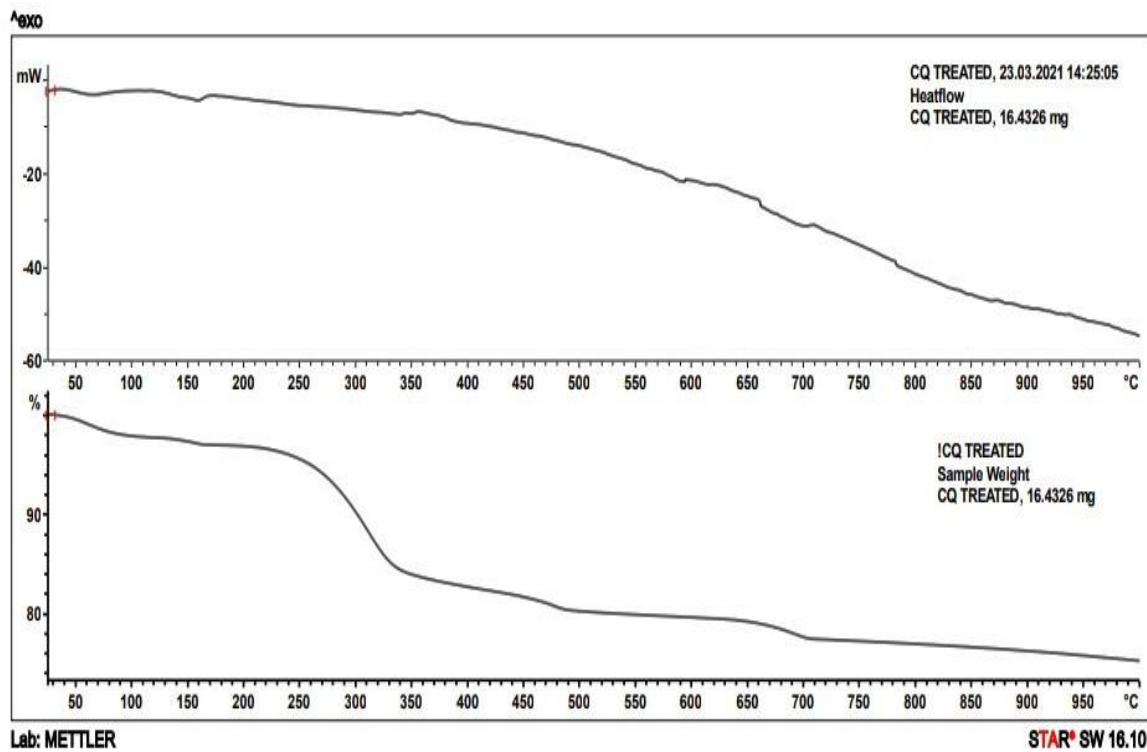


Fig.5.7 Treated TGA graph for CQSF

5.6 SEM ANALYSIS

SEM analysis is used to study the surface topography of fiber. In this, SEM analyses for both untreated and NaOH treated CQSF are carried out. The SEM image of untreated CQSF was shown in figure 5.8 in longitudinal direction. The hemicellulose content in the fiber surface is shown in white colour portion. The image shows the presence of hemicellulose, wax, pectin, lignin, and moisture on untreated fiber surface [2]. Another figure 5.9 shows the NaOH treated fiber in longitudinal direction. While comparing both the figure itself able to see the difference in their hemicellulose, wax, pectin, lignin and moisture content. There is high presence of moisture and wax content in untreated CQSF after the alkali treatment content of moisture and wax are getting highly decreased [4]. In figure 5.8 it shows untreated CQSF have smooth surface and treated fiber have highly rough surface shown in figure 5.9. From the above comparison made on both untreated and treated CQSF SEM analysis, surface of the fiber gets modified after the alkali treatment.

The SEM shows this CQSF has a higher proportion of bounded hemicellulose and Chemical treatments may be used to minimize the amount of cellulose in the product. When preparing the composite, equip the fiber to achieve optimal bonding with the matrix material [2].

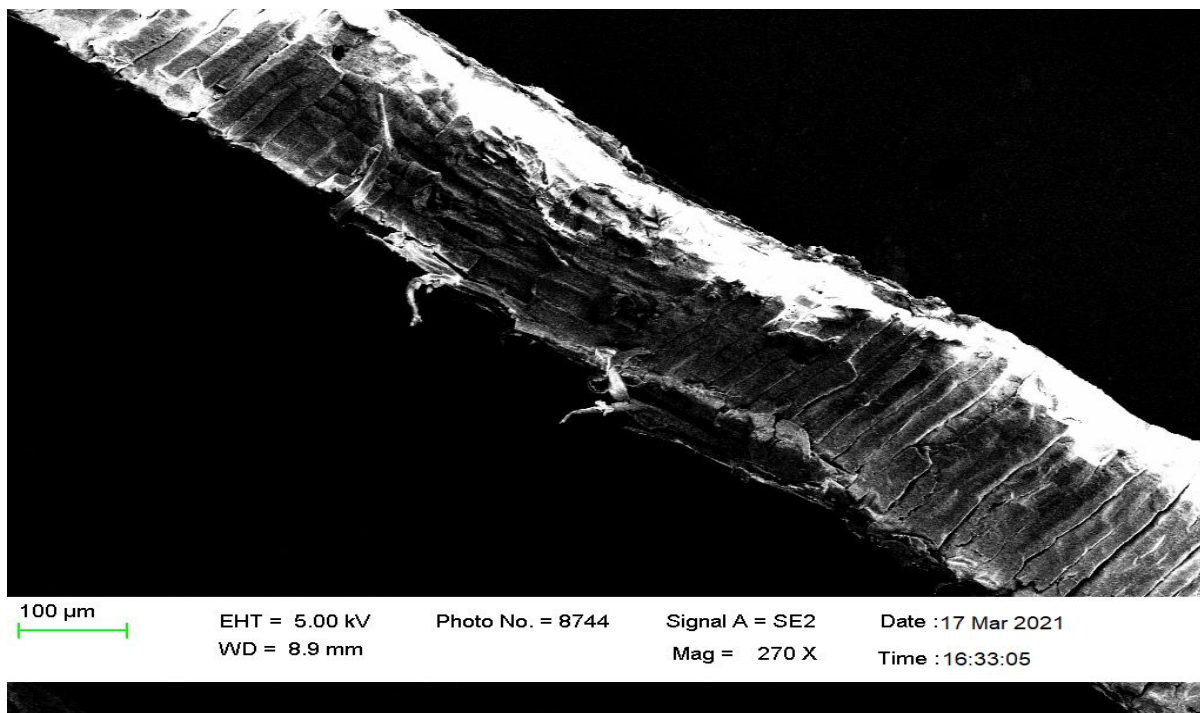


Fig 5.8 CQ untreated SEM image

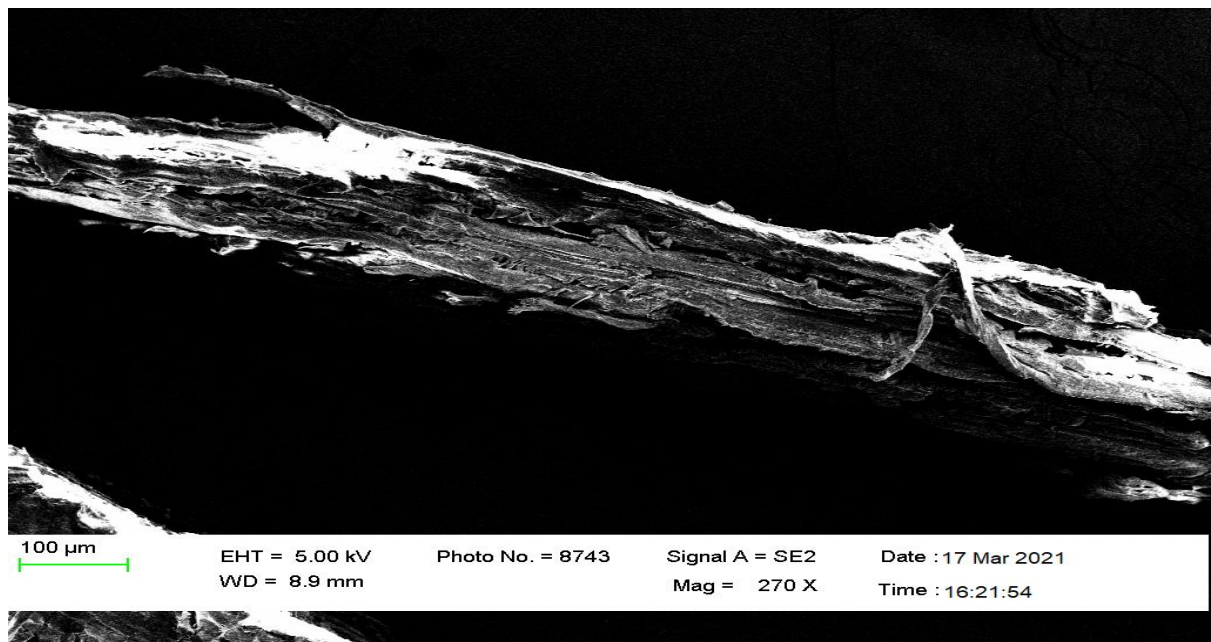


Fig 5.9 CQ Treated SEM image

CHAPTER-6

SUMMARY AND CONCLUSION

In this research paper the untreated and alkali treated CQSF properties were discussed. The alkali-treated CQSF diameter was significantly decreased, indicating the elimination of lignin and impurities from the treated CQSF surface, as reported by optical microscopic images. The treated CQSF density was lightly increased (1.40 g/cm^3). CQSF density is less when compare to E-glass fiber (2.50 g/cm^3) as well as carbon fiber (1.57 g/cm^3). Tensile strength of treated CQSF is $389.820 \pm 97 \text{ MPa}$ higher than untreated CQSF is $268.961 \pm 50 \text{ MPa}$. The treated fiber has higher cellulose percentage (70.0%) and lower wax percentage (0.40%) when compare to untreated fiber, it confirms that fiber reinforcement and matrix are stronger bonded in composite manufacturing. The chemical analysis revealed a decrease in hemicelluloses and alkali-treated CQSF lignin content, as evidenced by FTIR analysis. The crystallinity index (54.80%) of treated fiber high when compare to untreated CQSF. Thermal stability of alkali-treated CQSF cellulose improved from 280°C to 300°C improve chemical reactivity and water absorption of the material. The thermal stability of CQSF which was higher than thermosetting polymer compounds processing temperatures. The microscope image shows the availability of porous fraction on surface of fiber with irregularities in surface represents treated CQSF has good bonding while making polymer composite. The surface roughness of the CQSF improved after alkaline treatment, according to SEM photographs. All of the above analysis shows that alkali-treated CQSF were better for making composites.

REFERENCES

1. Anyakora, A. N., Mudiare, E., Chibudike, H. O., & Adeyoju, O. A., Investigation of properties of *oil palm* empty fruit bunch fiber in the strength and fracture performance of boards, *Journal of Engineering and Applied Sciences*, 7, 2011, 16-21.
2. Arul Marcel Moshi, A., Ravindran, D., Sundara Bharathi, S.R., Indran, S., Saravanakumar, S.S., Yucheng Liu, Characterization of a new cellulosic natural fiber extracted from the root of *Ficus religiosa* tree *Biological Macromolecules*, 142, 2019, 212-222.
3. Arul Marcel Moshi, A., Ravindran, D., Sundara Bharathi, S.R., Padma, S.R., Indran, S., Divya, D., Characterization of natural cellulosic fiber extracted from *Grewia damine* flowering plant's stem, *Biological Macromolecules*, 164, 2020, 1246-1255.
4. Balaji, A.N., Nagarajan, K.J., Characterization of alkali treated and untreated new cellulosic fiber from *Saharan aloe vera cactus* leaves, *Carbohydrate Polymers*, 174, 2017, 200-208.
5. Belouadah, Z., Ati, A., Rokbi, M., Characterization of new natural cellulosic fiber from *Lygeum Spartum L*, *Carbohydrate Polymers*, 134, 2015, 429-437.
6. De Rosa, I. M., Kenny, J. M., Puglia, D., Santulli, C., & Sarasini, F, Tensile behaviour of New Zealand flax (*Phormium tenax*) fibers., *Journal of Reinforced Plastics and Composites*, 29, 2010, 3450-3454.
7. Ganapathy, T., Sathiskumar, R., Senthamaraikannan, P., Saravanakumar, S.S., Anish Khan, Characterization of raw and alkali treated new natural cellulosic fibres extracted from the *aerial roots of banyan* tree, *Biological Macromolecules*, 138, 2019, 573-581.
8. Garette Jebadurai, S., Edwin Raj, R., Sreenivasan, V.S., Binoj, J.S., Comprehensive characterization of natural cellulosic fiber from *Coccinia grandis* stem., *Carbohydrate Polymers*, 207, 2018, 675-683.
9. Ilaiya Perumal, C., Sarala, R, Characterization of a new natural cellulosic fiber extracted from *Derris scandens* stem, *Biological Macromolecules*, 165, 2020, 2303-2313.

10. Indran, S., Raj, R. E., & Sreenivasan, V. S., Characterization of new natural cellulosic fiber from *Cissus quadrangularis* root., Carbohydrate Polymers, 110, 2014, 423-429.
11. Indran, S., Edwin Raj, R., Characterization of new natural cellulosic fiber from *Cissus quadrangularis* stem. Carbohydrate Polymers, 117, 2015, 392-399.
12. Maache, M., Bezazi, A., Amroune, S., Scarpa, F., & Dufresne, A., Characterization of a novel natural cellulosic fiber from *Juncus effusus* L., Carbohydrate Polymers, 171, 2017, 163-172.
13. Manikandan Ilangoan, Vijaykumar Guna, Prajwal, B., Qiuran Jiang, Narendra Reddy, Extraction and Characterisation of Natural Cellulose Fibers from *Kigelia Africana*, Carbohydrate Polymers, 236, 2020, 115-996.
14. Manimaran, P., Pitchayya Pillai, G., Vignesh, V., Prithiviraj, M., Characterization of natural cellulosic fibers from *Nendran Banana Peduncle* plants, Biological Macromolecules, 162, 2020, 1807-1815.
15. Majed., Alotabi, D., Basheer., Alshammari, A., Saba, N., Othman Al Othman., Sanjay, M.R., Zeyad Almutairi, Mohammad Jawaid, Characterization of natural fiber obtained from different parts of date palm tree (*Phoenix dactylifera* L.), Biological Macromolecules, 135, 2019, 69-76.
16. Porras, A., Maranon, A., & Ashcroft, I. A., Characterization of a novel natural cellulose fabric from *Manicaria saccifera* palm as possible reinforcement of composite materials, Composites Part B: Engineering, 74, 2015, 66-73.
17. Ridzuan, M.J.M., Abdul Majid, M.S., Afendi, M, Aqmariah Kanafiah, S.N., Zahri, J.M., Gibson, A.G., Characterisation of natural cellulosic fibre from *Pennisetum purpureum* stem as potential reinforcement of polymer composites, Materials Design, 89, 2015, 839-847.
18. Saravanakumar, S.S., Kumaravel, A., Nagarajan, T., Sudhakar, P., Baskaran, R., Characterization of a novel natural cellulosic fiber from *prosopis juliflora* bark, Carbohydrate Polymers, 92, 2012, 1928-1933.
19. Sarikanat, M., Seki, Y., Sever, K., & Durmuskahya, C., Determination of properties of *Althaea officinalis* L. (Marshmallow) fibers as a potential plant fiber in polymeric composite materials. Composites Part B: Engineering, 57, 2014, 180-186.

20. Senthamaraikannan, P., Kathiresan, M., Characterization of raw and alkali treated new natural cellulosic fiber from *Coccinia grandis*.L, Carbohydrate Polymers, 186, 2018, 332-343.
21. Siva, R., Valarmathi, T.N., Palanikumar, K., Antony, Samro, V., Study on a Novel natural cellulosic fiber from *Kigelia africana* fruit: Characterization and analysis. Carbohydrate Polymers, 244, 2020, 116-494.
22. Sudhir Chakravarthy, K., Madhu, S., Juvvi Siva Naga Raju., Jabihulla Shariff, Characterization of novel natural cellulosic fiber extracted from the stem of *Cissus vitiginea* plant. Biological Macromolecules, 161, 2020, 1358-1370.
23. Vijay, R., Lenin Singaravelu, D., Vinod, A., Sanjay, M.R., Suchart Siengchin, Mohammad Jawaid, Anish Khan, Jyotishkumar Parameswaranpillai , Characterization of raw and alkali treated new natural cellulosic fibers from *Tridax procumbens*. Biological Macromolecules, 125, 2019, 99-108.
24. Vijay, R., Vinod, A., Lenin Singaravelu, D., Sanjay, M.R., Suchart Siengchin, Characterization of Chemical Treated and Untreated natural fibers from *Pennisetum orientale* grass- A potential reinforcement for lightweight polymeric applications, Lightweight Materials and Manufacture, 4, 2020, 43-49.
25. Zouheyr Belouadah., Lotfi Toubal., Naima Belhaneche-Bensemra., Abdelaziz Ati, Characterization of ligno-cellulosic fiber extracted from *Atriplex halimus* L. Plant., Biological Macromolecules, 168, 2020, 806-815.