Di-electric and Band gap characterized of Indigenously Collected natural fibers.

Final Year Project Report

BS Physics

Submitted to:

COMSATS University Islamabad, Lahore Campus

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Project report

Natural fibers based organic Electrodes for Energy Storage Applications

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DECLARATION OF ACADEMIC INTEGRITY

We hereby declare that this project neither as a whole nor as a part there of has been copied out from any source. It is further declared that we have developed this project thesis and the accompanied report entirely on the basis of our personal efforts made under the sincere guidance of our supervisors. No portion of the work presented in this report has been submitted in support of any other degree of qualification of this or any other University or Institute of learning, if found we shall stand responsible.

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It is certified that **FAZEELA BASHARAT (CIIT\FA16-BPH-70\LHR**) **MUHAMMAD UZAIR SHAFIQ (CIIT\FA16-BPH-019\LHR)** have carried out all the work related to his undergraduate final year project thesis under my supervision at the Department of Physics, COMSATS Institute of Information Technology, Lahore.

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All praises are due to ALLAH, most merciful and beneficial, who blessed us ample strength to complete this work. We cannot thank HIM enough. All our devolutions and tributes to HIS Holy Prophet Muhammad (peace be upon him) for teaching us to recognize our CREATOR.

“The Prophet Muhammad (peace be upon him) said: "God, His angels and all those in Heavens and on Earth, even ants in their hills and fish in the water, call down blessings on those who instruct others in beneficial knowledge." (Al-Tirmidhi, Hadith 422).”

It is our privilege to express our sincerest regards to our project supervisor, Dr. Aamir Razaq and Co supervisor Ms. Aneeqa Masood for their valuable inputs, able guidance, encouragement, and whole-hearted cooperation throughout the duration of our project. As our teachers and mentors, they taught us more than we could ever give them credit for here.

Nobody has been more important for us in the pursuit of this project than the members of our families. We would like to thank our parents; their love and guidance in pursue of our studies. They are the ultimate role models for us.

We would like to thank for this opportunity to all the persons who directly or indirectly helped in our project work.

“With faith, discipline and selfless devotion to duty, there is nothing worthwhile that you cannot achieve.”

Muhammad Ali Jinnah

Abstract

Due to increase in demand for energy storage in today’s society, the development of inexpensive, flexible and light weight energy storage device is essential. In this respect, paper-based energy storage devices are highly being preferred. The aim of this thesis to evaluate the use of Banana, Papaya and Q2 source. Banana, Papaya and Q2 source are used for paper-based energy storage devices. We report the band gap and dielectric properties of indigenously collected natural fibers, by having the sources of Banana, Papaya and Q2 source. By making the sheets of the sources with 0%, 15%, 30% and 45% bleaching. Afterwards, their characterization Impedance, bending effect, energy storage capacity, dielectric properties are observed by having the equal weight of the entire sheets. Dielectric properties increased when we increased the fiber content because the no. of polar groups increased. Di-electric constant, dissipation factor, di-electric loss factor of natural fibers was high at low frequency. Di-electric values decreased when frequency increased for all hybrid composites. Photonic band gap fibers are similar to electron wave motion which is analyzed by Bloch formulation. Effect of design parameters are also observed in terms of variations of allowed and forbidden bands of band gap fibers. I concluded that banana is the best source in terms of flexibility for energy storage applications.

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Chapter 1
Introduction

1.1Natural fibers:

It stated as ;any hair like raw material directly attainable from vegetable, an animals or mineral source and convertible into tissue fabrics such as or paper or, after rotating into yarns, into woven cloth.

e.g.: Bamboo, hemp, jute, pineapple, sisal, palm, banana, and others.

Table 1.1 Natural Fiber Classification. Adapted from [1]

Natural Fiber	**Cellulose/ Lignocellulose**	Bast	Flax, Hemp, Jute, Kenaf, Ramie
		Leaf	Abaca, Banana, Pineapple, Sisal
		Seed	Cotton, Kapok
		Fruit	Coir
		Wood	Hardwood, Softwood
		Stalk	Wheat, Maize, Oat, Rice
		Grass/Reed	Bamboo, Corn
	Animal	Wool/Hair	Cashmere, Goat hair, Horsehair, Lamb wool Silk Mulberry
	Mineral	-	Asbestos, Ceramic fibers, Metal fibers

1.1.1 COTTON:

Cotton plant is a hedge. It grows better in black soil and warm climate. It is usually used for clothing and bedding. [2] The cotton plant has small green fruit called cotton boll. The boll has seeds inside which are surrounded by cotton fibers. [A]When cotton bolls mature, it splits open, its raw cotton fibers. The heat of sun dries these fibers. After the fibers have dried, the crop is harvested**.** [B]Once the cotton is harvested, it is sent for ginning, where the fibers are separated from seeds this separation is brought about with the help of strong air currents. Raw cotton before ginning and after ginning. [C] A fiber is cleaned and made into long thread like strands. yarn is then made into cotton fabrics by weaving. [D].[3]

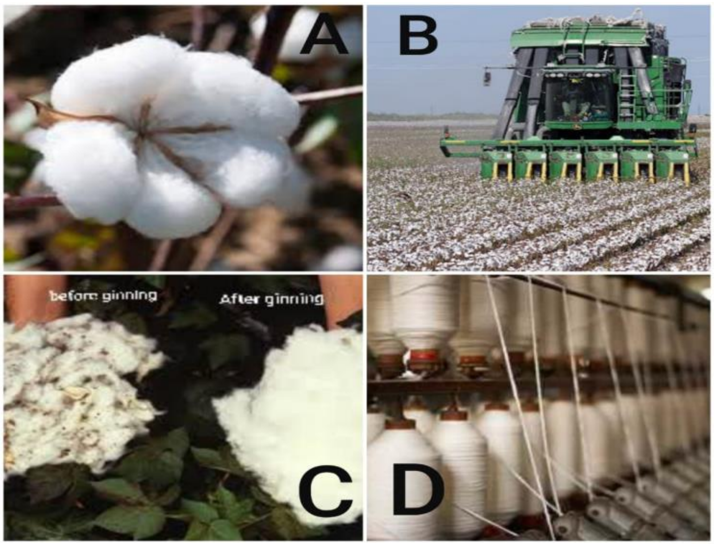


Fig:1.1.1: Process of converting cotton into yarn

1.1.2 Jute:

Jute is obtained from bark of jute plant. It grows best in loamy soil, clayey and sandy soil. Almost 80% of the world high quality jute originate Bangladesh. India, Nepal, China, Thailand, and Bangladesh are main agent of jute. It is reserved for carpet, wigs and floors in a home. [4]

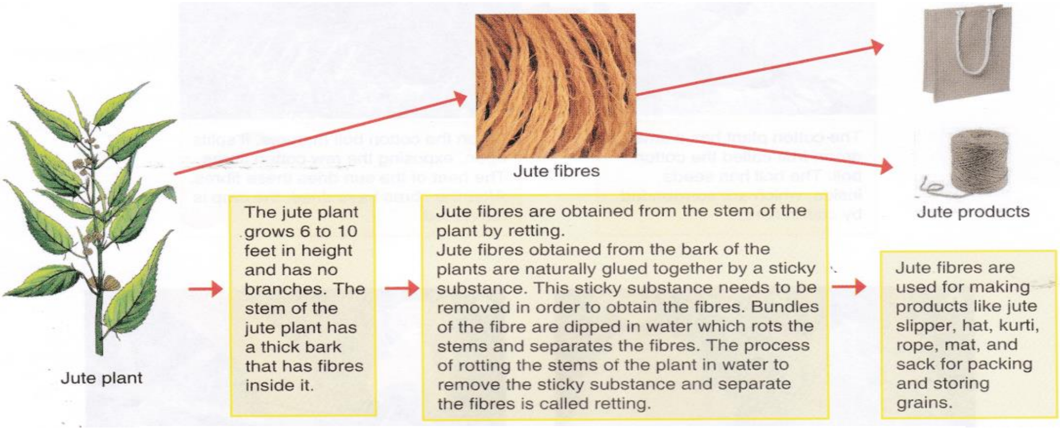


Figure 1.1.2: Process of converting jute plant to jute product

1.1.3 Silk:

Silk is a refined fiber and the most consistent of all the natural fabrics. This fiber is used for elegant dresses and attractive clothing as well as for bedding. It is obtained from the silk cotton tree also called kapok. The fruit of kapok tree hold fibers that are light and fluffy. When the fruit grown up, its bursts open, releasing the fibers.

Figure 1.1.3: Silk fibers

1.1.4 Hemp:

Hemp fibers are obtained from the hemp plant. This fiber is used for production of clothes, nets, carpets, ropes, and paper. This fabric is highly water-resistant and able to withstand hard conditions for widened periods of time. [5]

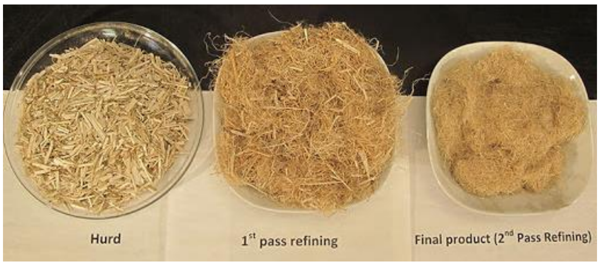


Figure 1.1.4: Unrefined Hemp herb converting into refined hemp

1.1.5 Flax:

Fibers acquired from the stem of flax plant are woven to make a fabric called linen. These fibers are used in the production of rope and high-quality paper. This material is easy to clean and maintain and highly durable too.[6]

Figure 1.1.5: Flax fibers converted in flax yarns.

1.2: SOURCES OF NATURAL FIBERS:

There are many sources of natural fiber that are shown in table1.1

Table1.1: Sources of natural fibers table (1.1) [7]

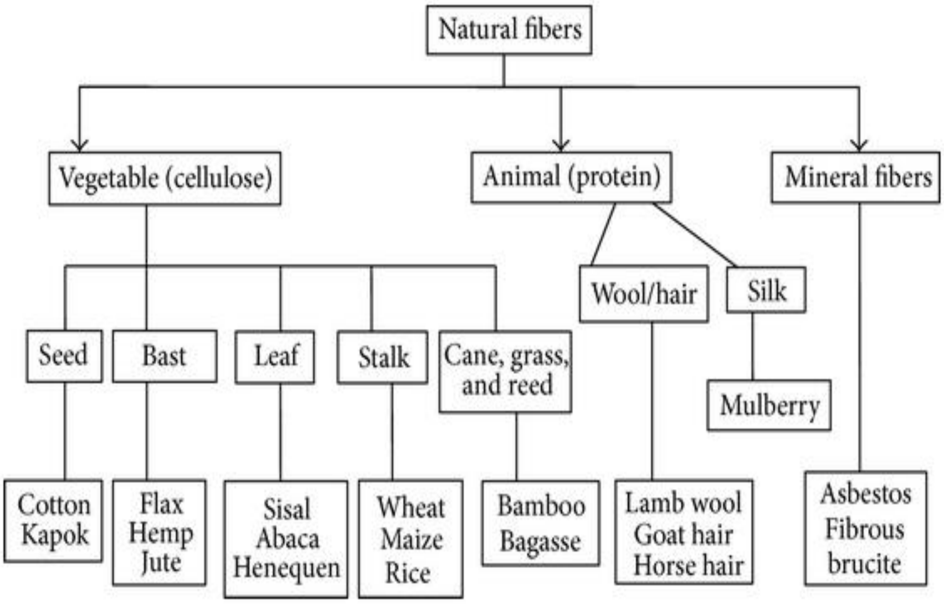


Table 1.2: Summary of Natural Fibers characteristics. [8]

Abaca	Abaca, also known as manila hemp, is a plant closely related to banana. Abaca plant looks similarly but unlike banana its fruit is not for human intake, being not achievable economically. Unlike banana, abaca plant grows only for fiber cultivation. [9]
Bamboo	Bamboo have been receiving interest because it has a high strength to weight ratio[8],one of the fastest growing plants, requires less water, no

	use of pesticides or herbicides and is harvested at its base, leaving the root intact. Also, the fiber surface is round and smooth and its l/d ratio is high. It is light, stiffer and stronger than glass fiber. [10] Department of Energy report clearly demonstrate that the energy consumption to produce a bamboo fiber mat represents a small fraction (17%) of the energy needed for the glass fiber counterpart. [11]
coir	Coir has great pull because it is more stable than most natural fibres, free of chemical treatment, its strong resistance to salt water and availability. [12]
cotton	Cotton fiber has an excellent permeability. [13] Cotton represents 46% of world production of natural and chemical fiber. [14]
Eucalyptus	Eucalyptus fiber is widely accessible but has low opposition to mold and fire attack. These bark fibres are adequate for insulation purposes. [15]
Flax	Flax fiber has better specific tensile when compared with glass fiber. In addition, it has low density, high strength and stiffness. [16]
hemp	Hemp fiber has excellent mechanical strength and young's modulus. [17] Good insulation properties. [18]
Jute	Jute fiber exhibits high aspect ratio (l/d), high strength to weight ratio and good insulation properties. [19]
pineapple	Pineapple fiber has excellent mechanical, physical and thermal properties. [20]
Ramie	Ramie fiber might have better specific strength and specific modulus than glass fiber. But it is not so popular when compared with the others natural fibres because it requires expensive pre-treatments. [21]
sisal	Sisal is easily refined with short restoration times. The fiber has high persistence and flexible intensity, abrasion resistance, saltwater resistance, acid and alkali resistance [22]
Kenaf	Kenaf fiber has low density and high specific mechanical properties [23]

1.3: APPLICATIONS OF NATIURAL FIBERS:

While the cost of natural fibers is impressive and plentiful, passenger cars have high potential in various industrial and commercial applications, such as false ceilings, partition boards, roof tiles, coir fibers, furniture applications for panels and partitions.

1.3.1 In the medical field:

Textile materials used in medical applications include fiber, yarn, fabrics and alloys. Depending on the application, the main requirements of medical garments are absorb

ability, stability, flexibility, softness and sometimes bio accessibility or biodegradability.
Fibers used in the medical field can replace natural fibers such as cotton, silk, reproductive wood fluff, polyester, poly amide, polyethylene, glass fiber. [24]

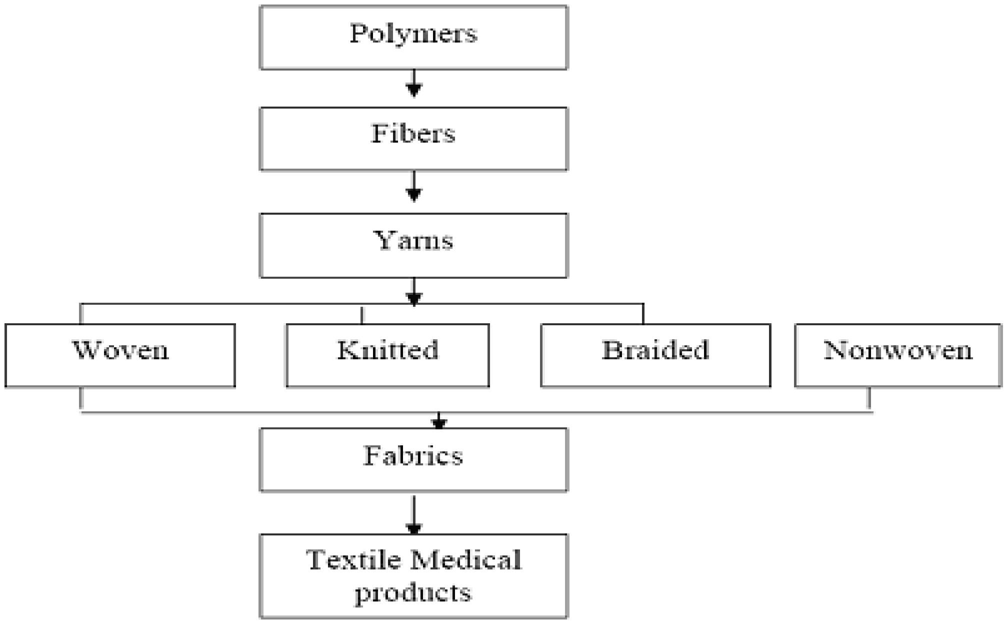


Table 3.1: Constituent element of Medical Textile products

The various applications of different fibers in the medical field are as follows:

- **Cotton:** Surgical Fabric Gown, Bed, Bed Sheets, Pillow Cover, Uniform, Surgical Hosiery
- **Viscose:** cap, mask, wipes
- **Polyester:** Gowns, Masks, Surgical Cover Curtains, Blankets, Cover stock
- **Poly amide:** Surgical Hosiery
- **polypropylene:** protective clothing
- **Polyethylene:** Surgical Covers, Curtains
- **Glass:** Caps Mask
- **Elastomeric:** Surgical Hosiery

Product application	**Fiber type**	**Fabric type**
Surgical clothing gowns	Cotton, Polyester, Viscose rayon, Polypropylene	Nonwoven, Woven
Caps masks	Viscose rayon, Polyester, Viscose, Glass	Nonwoven Nonwoven
Surgical covers Drapes cloth	Polyester, Polyethylene Polyester, Polyethylene	Nonwoven or Woven Nonwoven or Woven
Beddings,	Cotton, Polyester	Woven, Knitted

Blankets, Sheets Pillow covers	Cotton Cotton	Woven Woven
Clothing uniforms Protective clothing	Cotton, Polyester Polyester, Polypropylene	Woven Nonwoven
Incontinence Diaper sheet Cover stock Absorbent layer Outer layer	Polyester, Polypropylene Wood fluff Super absorbents Polyethylene fiber	Nonwoven Nonwoven Nonwoven
Cloths/ Wipes	Viscose rayon	Nonwoven
Surgical hosiery	Polyamide, Polyester, Cotton, Elastomeric yarns	Nonwoven Knitted

Table 2.2: Medical application of fibers in fabrics.

1.3.2: IN Antenna:

Wearable antennas (BAN) for in-on-body area networks are made of textile materials, are universally used and are available. The design of the antenna depends on their electrical and electromagnetic properties. The wearable computer is always on, does not limit user activity and is aware of the user's status. The wearable antenna connects the fabric to the communication system, making electronic devices less annoying. [25]
The structure of the system and the connection of the antenna are shown in the figure. Moisture antenna performance parameters change significantly when the fabric antenna absorbs water because water has a higher dielectric constant than fabric. Fibers constantly exchange water molecules with air and change the dynamic balance with air temperature and humidity. [26]
Variation of dimensions due to stretching and compression is unique to clothing. Changes in the resonant length of the antenna vary with its frequency band, whereas the thickness of the surface changes the resonant frequency as well as the input impedance bandwidth. The high geometric accuracy of the frame of the antenna allows for wavelengths and nonwovens, which are more stable fabrics than nits. In general, the accuracy depends on the thickness of the component yarn or fiber. For example, woven woven fabrics may allow an accuracy of 0.15 mm. For these reasons knitting to the dielectric of the wearable antenna may not be correct or stable. [27]

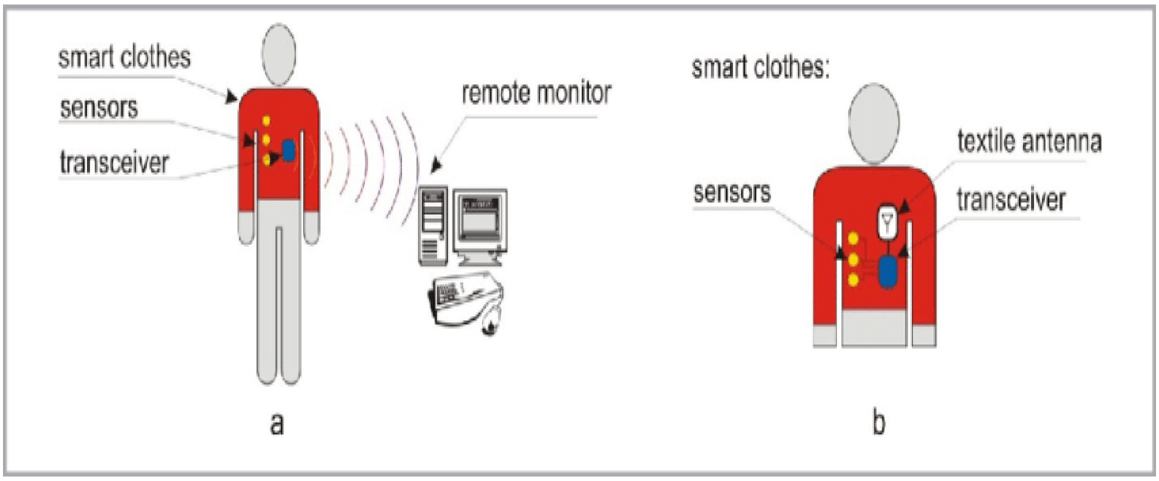


Figure 1.3: Antenna in wireless smart clothes(a)System (b) Antenna connection

Developed wearable antennas are the main ones Planner ones, especially microstrip patches Antennas, because they mainly transmit Plan structure and vertical as well Their ground plane effectively shields the human body. The substrate dielectric constant and its thickness affects the bandwidth and Capacity of micro strip antenna. Dielectric constant, Humidity, temperature, damage tangent, Thickness, conductivity, and deformation influence Features of wearable antenna. Wearable antennas are promising Improve and boast a great future Rapidly growing wireless development Communication technology and at least Communication system.

1.3.3 Energy storage Devices:

Energy storage involves altering energy from forms that are difficult to store to more usefully or economically storable forms. Energy comes in various forms including radiation, chemical, gravitational potential, electrical potential, electricity, elevated temperature, latent heat and kinetic. Mutual examples of energy storage are the rechargeable battery, which stores chemical energy readily convertible to electricity to work a mobile phone, the hydroelectric dam, which stores energy in a tank as gravitational potential energy, and ice storage tanks, which store ice frozen by cheaper energy at night to meet top daytime demand for cooling.

Two Important energy storage devices.

- Supercapacitors (SCs)
- Lithium-ion batteries (LIBs)

Super Capacitors:

Supercapacitors are electrochemical energy storage devices that can be fully charged or discharged in seconds. Due to the high-power density, low maintenance costs, wide thermal treatment range, and lengthy cycle life over secondary batteries, supercapacitors have charmed considerable research attention over the past decade. They have a higher energy density than traditional dielectric capacitors. The storage capacity of supercapacitors depends on the electrostatic separation between the electrolyte ions and the high surface area electrode. These integrated energy wires are flexible, lightweight, and appropriate for special applications. [28]

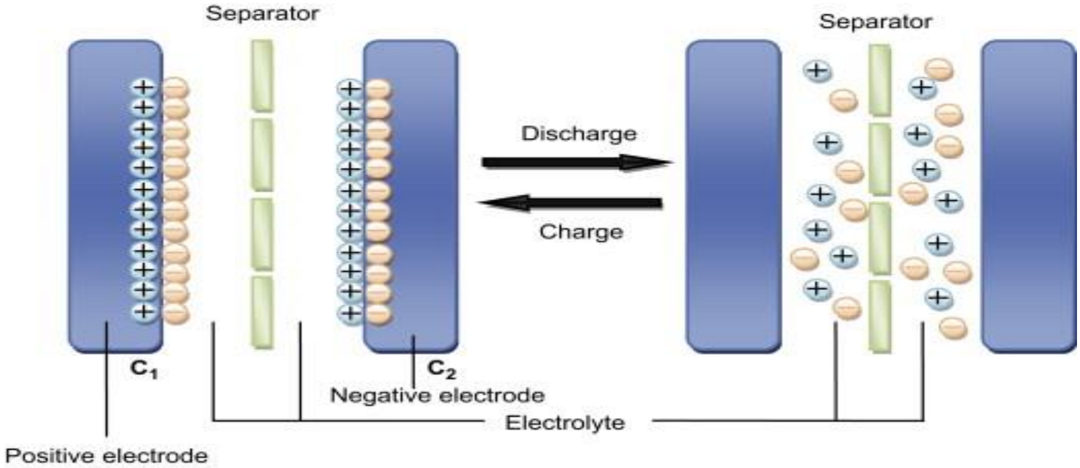


Figure: Schematic illustration of an electrochemical double-layer super capacitor (EDLC) and its equivalent circuit in a two-electrode system.

1.4 Literature Review:

1.4.1 Comparative Study of Dielectric Properties of Hybrid Natural Fiber Composites.

This review will be concentrated on the Di-electric properties like di-electric constant, dissipation factor, di-electric loss factor of natural fibers reinforced with polymer were studied with the various effect of various fiber loadings, fiber ratios frequencies and chemical modification of natural fiber. Dielectric properties increased when we increased the fiber content because the no. of polar groups increased. Di-electric constant, dissipation factor, di-electric loss factor of natural fibers was high at low frequency. Di-electric values decreased when frequency increased for all hybrid composites. Bleaching agent is used for the treatment of fiber to improve the adhesion b/w fiber and matrix. Dielectric of treated fiber are lowest as compared to untreated in frequencies. As weight percentage increased di-electric constant also increased. The fiber reinforced unsaturated polyester hybrid composites influenced higher values of di-electric properties as compared to the polymer. [29]

1.4.2 Dielectric properties of oil palm-natural rubber bio composites.

In the past, low-cost natural fibers from oil sources have proven to be of interest for dielectric applications, showing some potential for future application of dielectric on microchips and boards. The dielectric properties of oil palm / natural rubber composites are classified. Made of pure rubber with basic materials. In particular, it is generally observed that the dielectric constant increases slowly with fiber loading and decreases with high frequency. Studies on the electrical properties of these materials have suggested that the dielectric constant and volume resistivity values of the material are somehow affected by the effect of fiber, which can be achieved with fiber treatment with a reasonable increase in the dielectric constant of the damage factor. In contrast, the effect of the fiber content used to a lesser extent on the dielectric properties is less pronounced. The limited variation of the dielectric constant relative to the pure rubber found in materials with low fiber content suggests that the observation of a very small amount of fiber may almost never affect the dielectric properties, while at the same time achieving large advantages at low cost. And reduced environmental impact. [30]

1.4.3 Dielectric characteristics of sisal–oil palm hybrid bio fiber reinforced natural rubber bio composites.

The dielectric loss factor such as dielectric constant, volume resistance of bio-resistance and fiber composites are classified as functions of loading, frequency and chemical change of fiber. It has been found that the dielectric constant value for a fiber reinforced system is higher than the adhesive due to polarity by the addition of lignocellulosic fibers. Chemical transformation of fibers results in a decrease in the dielectric constant values and volume resistance values. It has been found that the volume resistance of composites with fiber loading decreases due to the hydrophilicity expressed by lignocellulosic fibers. The dissipation factor was found to be increased with the fiber content. The dissipation factor was seen to increase with loading which indicates that the electrical charges can be retained over a longer period of time. These profitable bio composites will therefore find its use in antistatic applications in order to dissipate static charges. Bio-fiber boosted composites lie in their low density and high strength. [31]

1.4.4: Analytical design of Photonic Band gap fibers and their dispersion characteristics:

Photonic band gap fibers are like electron wave motion which is analyzed by Bloch formulation. Effect of design parameters is also observed in terms of variations of allowed and forbidden bands of band gap fibers. The number of allowed band increases with the increase in difference between refractive indices of different layers. Similarly, due to increase in layer thickness the width of allowed and forbidden bands increases. Artificial photonic crystals or optical micro structured i.e. photonic band gap fibers in 1-D and photonic band gap crystals in 2-D and 3-D are produced on the theory of Yablonovitch. In fiber optics communication skills, proper selection of wavelength is important whereas in conventional fibers, the core and cladding glasses have similar spectral characteristics. Photonic band gap (PBG) material contains multilayered structured which have the spectral filtering which is based on Quantum theory of electron in solids. Narrow band pass and band rejection are based on absorptions, polarization, couplings, grating and multiple components with periodic spectral transmission. [32]

1.4.5: Micro-structured and Photonic Bandgap Fibers for Applications in the Resonant Bio- and Chemical Sensors:

Development in the field of novel fibers types and in the advancement of fiber micro-structured with functional material, it becomes much important in the recent times. There are two types of sensors. Firstly, which contain hollow core photonic band gap fibers exist with core guided mode is confined. Secondly, which contain metalized micro structured or photonic band gap waveguides and fibers where core guided mode exist which matches with Plasmon propagating. However, due to narrow absorption line in the line transmission spectrum, it outcomes as strong variation in the real part of the refractive index in the vicinity of the absorption of light.

Fiber based sensors that rely on detection on changes in the presence of target analyte. In the amplitude-based methodology wavelength is fixed and note down the result of changes in the amplitude of signal. All the sensor types including (Sensing Using Analyte-Filled Hollow Core Photonic Bandgap Fibers, Surface Plasmon Resonance-Based Fiber Sensors, Plasmon-Assisted Sensing Using Solid Core Micro-structured Fibers, Plasmon-Assisted Sensing Using Solid Core Photonic Band gap Fibers, Pseudo plasmon-Assisted Sensing Using Highly Porous Microstructure Fibers and Ferroelectric Layers in Terahertz Spectral Range) showed strong resonant dependence of the fiber absorption in the value of the analyte refractive index leading to the 0.000001 – 0.0004 RIU resolution in the real part of aqueous and gaseous analyte refractive index. Maximal sensor activity is independent of the sensor length. [33]

1.4.6 Bio-Inspired Band-Gap Tunable Elastic Optical Multilayer Fibers:

Morphology, characterization, and optical interface of biological enhances the knowledge about novel artificial photonic elements. By the seed of Margarita nobilis fruits, photonic structure is discovered. Through the interference of light concentrically layered architecture found inside every cell. The naturally produced seed has two characteristics. Firstly, technologically exploitable and color manipulation, by having micro scale cylindrical symmetry, which is the foundation of spectral filtering capabilities and color brilliance of a planner brag stack. Transparent and elastic synthetic materials produced high reflectance that is longitudinal mechanism strain. Soft photonic fiber produced the transition to novel fiber based flexible photonic materials and textiles with colors that are tunable over the entire visible spectrum. Nature's colors are divided into ordered, quasi-ordered or dis-ordered structures with lattice constants on the ordered of the wavelength. By inducing any interference or diffusion structural diversity alter the spectral composition. In the creation of structural colors one dimensional multi layers play an important role. Under directional illumination a planner multilayer interference can only display its bright coloration in the specular reflection direction. The hue of such planner Bragg stack strongly depends upon angle of incidence. Under diffused illumination the observed color blue shifts from increasing observing angle. Similarly, a part of the curved multilayer in much of the individual cell is oriented to satisfy the spectral reflection condition. [34]

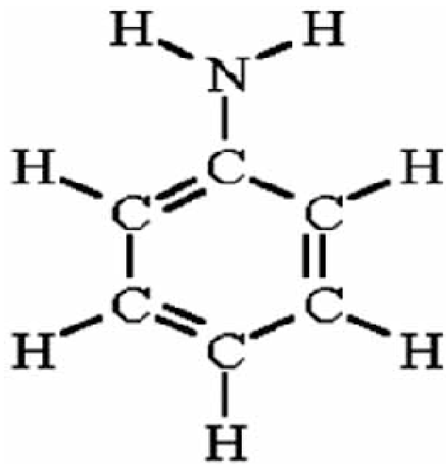
CHAPTER NO.2
Materials and Methods

2.1 Raw materials:

I. Aniline:

Aniline is the organic compound and the formula of aniline is $C_6H_5NH_2$. It consists of phenyl group attached with amino acid. It is the prototypical aromatic amine. Aniline is the flammable liquid chemical substance that has pungent order and slightly soluble in water. It can be colorless to brown, and it is oily to touch.

Molecular formula of aniline.



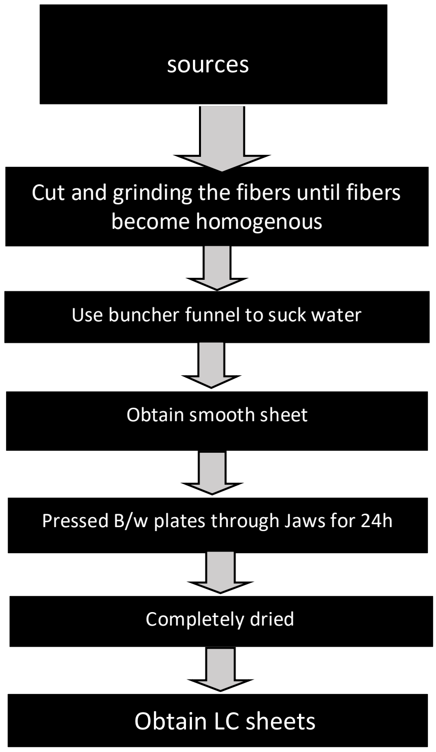
Structural formula of Aniline.

II. Sodium hypochlorite (NaOCl):

Sodium hypochlorite is used for water purification. It is a colorless or slightly yellow watery liquid with an odor of household bleach. It is used to remove mold strains, dental strains caused by fluorosis, and stains in crockery, those caused by the tannins in tea. It is also used in laundry detergents.

2.2 Synthesis of Natural sources:

I compared three sources Banana, Q2 and Papaya. **For banana**, LC fibers were mesh in motor pastel then filtered through then suction pump, these fibers took the sheet form and pressed for 24 h to achieve smooth surface of sheet. **For 15% bleaching, 30% bleaching, 45% bleaching** weight the sheets (2g) were dispersed in solution of 30ml,60ml,90ml sodium hypochlorite (NaOCl, 200 mL) respectively at magnetic stirrer for 1h. Buchner funnel (80 mm-d) was used to filter the bleached fibers, these fibers took the sheet form and pressed for 24h to achieve smooth surface of sheet. The yield of fibers we obtained after bleaching process was approximately 70% of dried weight. I repeated the same process for Papaya.



Flow chart of synthesis banana fiber

Without Bleaching:

Source 1 (Banana)

Source 2 (papaya)

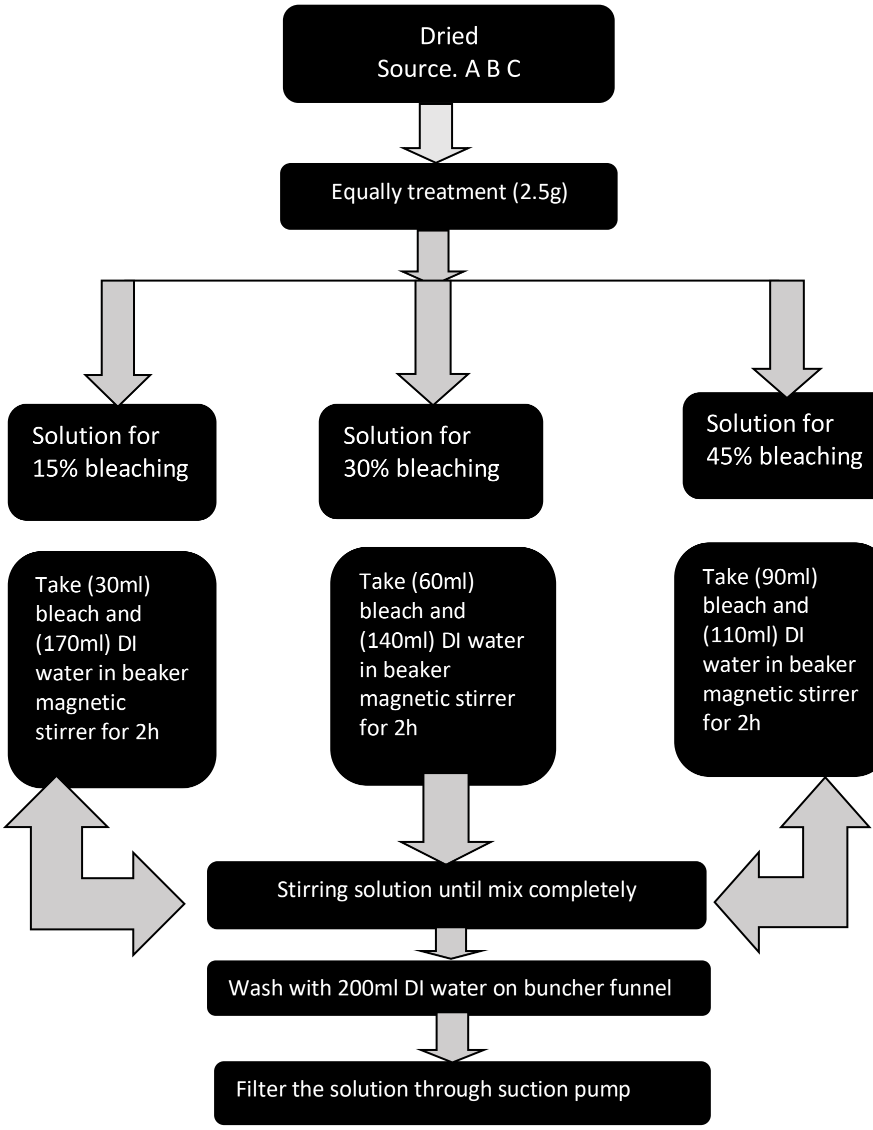
Source 3 (Q2)

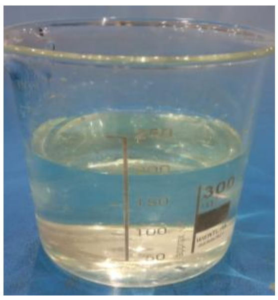
  

2.3 Synthesis of bleaching fibers:

I compared three sources Banana, Q2 and Papaya. **For Q2**, dried fibers were mesh in motor pastel. **For 15% bleaching, 30% bleaching, 45% bleaching** weight the sheets (2g) were dispersed in solution of 30ml,60ml,90ml sodium hypochlorite (NaOCl, 200 mL) respectively at magnetic stirrer for 1h. Buchner funnel (40 mm-d) was used to filter the bleached fibers, these fibers took the sheet form and pressed for 24h to achieve smooth surface of sheet. The yield of fibers we obtained after bleaching process was approximately 70% of dried weight.



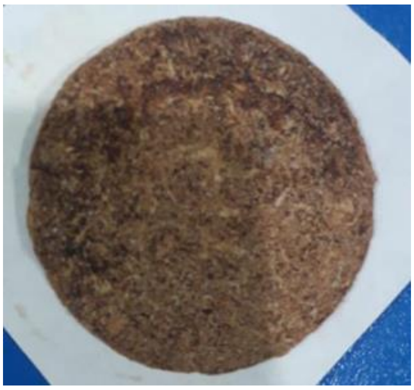
Flow chart of synthesis of bleaching fibers.

Firstly, we have banana source.

- 15% bleaching of banana source.

- 30% bleaching of banana source.



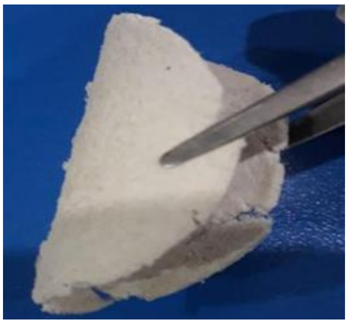
- 45% bleaching of banana source.

Secondly we have papaya source.

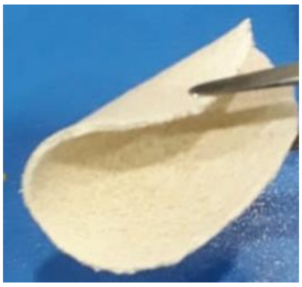
- 0% bleaching of papaya source.

- 15% bleaching of papaya source.

- 30% bleaching of papaya source.



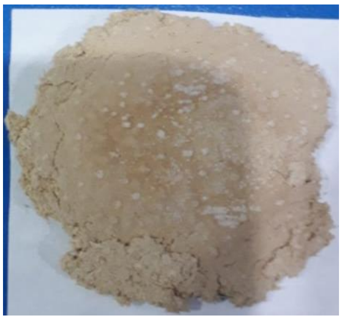
- 45% bleaching of papaya source.



Thirdly we have Q2 source.

- 0% bleaching of Q2 source.

- 15% bleaching of Q2 source.



- 30% bleaching of Q2 source.

- 45% bleaching of Q2 source.

2.4 PRECAUTIONS:

- Banana fiber is its high level of stiffness compared to papaya.
- Make the banana, papaya, and Q2 fibers homogenous.
- Use gloves during experimental work otherwise properties of material affected.
- The dried and damaged outer sheath parts were removed from the banana stems.

2.5 Characterization:

2.5.1 Optical microscope:

Optical microscope is used to learn the information of the morphology of fiber Sheets. Its operational principle same as the Scanning electron microscope (SEM) But in this method images are not clear as in SEM.

2.5.2 Tensile Testing:

Tensile testing is used to study the mechanical properties (bending, stretching etc.) of the material**.**

CHAPTER 3
RESULTS AND DISCUSSIONS

Physical Appearance:

Physical properties differ source to source. Banana sheets have strongest as well as best flexibility capacity as compared to the other sources. Q2 source contain the least flexibility capacity. The sources (Banana, Papaya, Q2) with bleaching shows different color spectrum by making the sheet. The sheet of Banana with 0% bleaching is much blackish as compared to the sheets of the same source with 15%, 30%, 45% bleaching. The sheet of Banana with 15% bleaching is less blackish than 0% bleaching and more blackish than 30% and 45% bleaching respectively. Similarly, the sheet of Papaya with 0% bleaching is less bright as compared to the sheet with 45% bleaching. Also, the sheet of Q2 source with 0% bleaching differs with other bleaching ratios.

Mechanical Properties:

Mechanical properties also vary as the bio-composites of banana fibers display a strength of 6.5MPa it indicates that 35% fiber volume fraction can produce composite material of 3.56MPa tensile strength and Young's modulus of 74.35MPa. Tensile properties of banana strengthen the properties of phenol formaldehyde whose tensile strength ranged between 1.98 and 4.58 MPa, Young's modulus ranged from 2 to 9.39 Gap and elongation ranged from 1.72% to 2.65%. The banana reinforced phenol formaldehyde contains a better load carrying capacity as compared to the plywood of same thickness. Comprehensive strength of banana composites 16.75MPa while the standard commercial medium density fiber board is 10MPa.

To determine factors influencing the mechanical properties (stress, strain and energy at failure and Young's modulus) of the papaya fruit are different parameters such as stage of ripeness (color break, quarter ripe, half ripe and three quarter ripe), test location (top, middle, and bottom of the test sample) and test position (radial, tangential, and vertical). The highest failure stress of 3315.30 kPa occurred for solo cultivar at color break, top section, and vertical position and 2684 kPa for sinta cultivar at color break, top section and tangential position, respectively. On the other hand, lowest failure stress occurred at 3/4 ripe, bottom section and vertical position for solo cultivar with a value of 22.80 kPa and 3/4 ripe, bottom section and radial position for sinta cultivar with 21.10 kPa. With regard to failure strain, a maximum value of 57.18% for sinta cultivar, 1/4 ripe, bottom section, and radial position was noted. On the other hand, a minimum of 4.92% for solo cultivar, 3/4 ripe, middle section, and radial position was derived. As to the failure energy, largest value of 0.7410 J at color break, bottom section, and tangential position and lowest value of 0.0111 J at 3/4 ripe, middle section, and vertical position.

Fourier Transform Infrared Spectroscopy (FT-IR)

FT-IR spectroscopy was used to investigate the changes in functional groups in the banana fiber, papaya and Q2 fiber. A spectrophotometer was used to provide the spectrum of each sample. Spectra were taken at a different resolution for each sample. The FT-IR spectrum of each sample was taken in different range in the transmission mode.

Scanning electron microscopy (SEM)

The surface morphologies and the cross-section of the banana fibers and the surface morphology of Papaya and Q2 were examined at by using scanning electron microscope. The specimens were coated with a thin gold layer using Sputter Coater to avoid electrical charge accumulation during examination. SEM rough surface morphology and fragments were observed on the surface of fiber, which is a typical characteristic of banana, papaya and Q2 fibers. The cross-section of banana fiber papaya and Q2 is clear that the inside fiber is hollow in nature. Surface area of the fiber is increased in the presence of rough surface and the hollow structure which is favorable for most of the applications of banana fiber, papaya fiber and Q2.

Table of different masses or sources without bleaching or with bleaching.

WITHOUT BLEACHING….0%-45%	WITH BLEACHING….15%-45%

sources	0%	15%	30%	45%	15%	30%	45%
Banana	2.5g	2.5g	2.5g	2.5g	1.9g	1.8g	1.64g
papaya	2.5g	2.5g	2.5g	2.5g	2.2g	2.0g	1.9g
Q2	1g	2g	2g	2g	1.6g	1.8g	1.7g

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