

ISOLATION OF NANOCELLULOSE FIBER FROM WATER HYACINTH PLANT AND ITS APPLICATION

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Technology degree in Biotechnology

by

R K Rohith(39230036)



DEPARTMENT OF BIOTECHNOLOGY

SCHOOL OF BIO AND CHEMICAL

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade “A” by NNAC

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May – 2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **R K Rohith(39230036)** who carried out the project entitled "**Isolation Of Nanocellulose Fiber From Water Hyacinth And Its Application**" under my supervision from December 2022 to April 2023.

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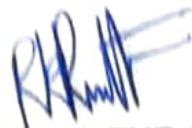
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DECLARATION

I **R K Rohith(39230036)** hereby declare that the Project Report entitled "**Isolation Of Nanocellulose Fiber From Water Hyacinth And Its Applications**" done by me under the guidance of **Dr. M. Bavanilatha Ph.D** and **Dr.P. PRAKASH Ph.D** is submitted in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Biotechnology.



SIGNATURE OF THE CANDIDATE

DATE: 11/05/2023
PLACE: CHENNAI

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ABSTRACT

The Water hyacinth, also known as *Eichhornia crassipes*, is a floating aquatic plant that is native to the Amazon basin. It is considered one of the most invasive aquatic plants in the world and has been introduced to many countries as an ornamental plant or for its potential use in wastewater treatment. The water hyacinth has long, spongy and shiny leaves that are arranged in a rosette pattern, with small lavender flowers that bloom above the water's surface. It has a rapid growth rate and can reproduce vegetatively, allowing it to quickly form dense mats on the surface of the water, blocking sunlight and reducing oxygen levels, which can harm aquatic life and negatively impact water quality. Despite its invasive nature, the water hyacinth has some beneficial uses. It can be used for phytoremediation, as it has the ability to absorb pollutants such as heavy metals and organic compounds from water. It can also provide habitat for some aquatic species, such as birds and insects. Efforts to control the water hyacinth have included physical removal, chemical treatments, and biological control using natural enemies such as weevils and moths. However, these methods have had varying levels of success, and the plant continues to be a significant problem in many parts of the world.

Keywords: Wasterwater treatment,Phytomediation,Ornamental plant

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LIST OF ABBREVIATIONS

WHC	Water hyacinth plant
SEM	Scanning Electron Microscope
TGA	Thermogravimetric analysis

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CHAPTER 1: INTRODUCTION

1.1. WATER HYACINTH

An aquatic plant recognised for its capacity to expand and reproduce quickly in warm, nutrient-rich water is the water hyacinth. It can be an invasive species and cause issues in some habitats, yet it can also be used for a variety of purposes.

One of these uses is as a natural water filter. Water hyacinth is a helpful instrument in the treatment of wastewater and in the purification of drinking water since it can remove toxins and impurities from water. Additionally, it can be applied to artificial wetlands to raise water quality before to release into rivers or other bodies of water. Additionally, water hyacinth can be used as a source of animal feed. The plant can be used as a protein supplement for cattle because it is high in protein. The plant can also be utilised to create biodegradable products like paper and textiles.

There are numerous possible uses for water hyacinth that could be advantageous to the economy and the environment. Although the plant must be managed to avoid becoming invasive in some habitats, its usage in a variety of applications can offer long-term answers to pressing problems including water pollution and the creation of renewable energy. The water hyacinth can have a significant impact on aquatic ecosystems, causing a variety of environmental problems. When the plant forms dense mats on the surface of the water, it can block sunlight and reduce oxygen levels, which can harm fish and other aquatic animals. The mats can also interfere with water flow, which can increase the risk of flooding and erosion. In addition, the water hyacinth can provide a breeding ground for mosquitoes, which can transmit diseases such as malaria and dengue fever.

The economic impacts of the water hyacinth are also significant. The plant can clog waterways, making it difficult for boats and ships to navigate. This can have a negative impact on fishing and transportation industries. The water hyacinth can also impact hydroelectric power generation, as it can interfere with the operation of turbines and other equipment. In addition, the plant can impact water treatment facilities, as it can clog intakes and filters.



Fig 1.1: Water Hyacinth

1.1.1 CHARACTERISTIC FEATURES OF WATER HYACINTH

Water Hyacinth is of the Pontederiaceae family its habitat is perennial free-floating, aquatic plant with long dark roots its leaves are formed in rosettes; petioles to 30 cm (12 in) or more, spongy, usually inflated or bulbous, especially near base; leaf blades roundish or broadly elliptic, glossy green, to 15 cm (6 in) wide. The flower showy spike above rosette, to 30 cm (12 in) long; lavender-blue with a yellow blotch, to 5 cm (2 in) wide, somewhat 2-lipped; 6 petals, 6 stamens. Water hyacinth has long, spongy, and shiny leaves that are arranged in a rosette pattern. The leaves are oval-shaped and measure up to 20 cm in length and 10 cm in width. The plant has small lavender flowers that bloom above the water's surface, and its roots are feathery and long, measuring up to one meter in length. The water hyacinth has a rapid growth rate and can reproduce vegetatively, allowing it to quickly form dense mats on the surface of the water.

1.2. CELLULOSE FIBER

Cellulose fiber is a natural, biodegradable, and renewable fiber derived from plant cell walls. It is one of the most abundant organic compounds on earth and can be extracted from a variety of sources such as wood, cotton, hemp, and bamboo. Cellulose fibers have excellent strength and moisture absorption properties, making them a popular choice for textile and paper production. In addition, they are also used in the production of biofuels, composites, and food additives. The sustainability and eco-friendliness of cellulose fibers make them an attractive alternative to synthetic fibers in the textile industry. However, the production of cellulose fibers requires significant amounts of energy and water, which can have negative environmental impacts if not managed properly. Cellulose fiber is a type of natural fiber that is known for its high strength and durability. It is naturally breathable, moisture-wicking, and hypoallergenic, making it a popular choice for clothing and bedding. One of the most unique properties of cellulose fiber is its ability to absorb moisture without feeling wet. This is due to the hydrophilic nature of the fiber, which allows it to absorb and release moisture easily. This makes cellulose fiber an ideal material for use in products that require moisture management, such as athletic wear and bedding.

Cellulose fiber is also naturally biodegradable and eco-friendly, making it a sustainable alternative to synthetic fibers. It is also hypoallergenic, making it a great choice for those with sensitive skin. Additionally, cellulose fiber is easy to dye and can be made into a variety of textures, making it versatile for use in various products. (Tserki, V., Matzinos, P., & Panayiotou, C. 2015).



Fig 1.2: Natural cellulose fiber from plants

1.2.1. CHARACTERISTIC FEATURES OF CELLULOSE FIBER

Cellulose fiber is a versatile and unique fiber with a number of characteristic features. Firstly, it is a natural fiber derived from plant cell walls, making it biodegradable and renewable. It is also lightweight and strong, making it a popular choice for textile and paper production. Additionally, cellulose fiber has excellent moisture absorption properties, which makes it ideal for use in textiles that need to be comfortable and breathable. It is also resistant to pilling and can be easily dyed, making it a versatile choice for a range of applications. However, cellulose fiber does have some limitations, such as its tendency to wrinkle and its susceptibility to degradation from exposure to sunlight and chemicals. Cellulose fiber is a natural fiber derived from plant-based sources such as cotton, bamboo, and wood. It is known for its strength, durability, and eco-friendliness, and is widely used in the textile industry to make clothing, bedding, and other textiles.

One of the most significant characteristics of cellulose fiber is its strength and durability. Cellulose fibers are known for their high tensile strength, which is the ability to resist stretching and breaking under tension. This makes them ideal for use in products that require strength and durability, such as clothing and bedding. The strength of cellulose fibers also makes them resistant to wear and tear, which means they can withstand repeated use and washing without losing their quality. Cellulose fiber is also known for its ability to absorb and release moisture easily. This is due to the hydrophilic nature of the fiber, which allows it to absorb moisture without feeling wet. This makes cellulose fiber an ideal material for use in products that require moisture management, such as athletic wear and bedding. The ability to absorb moisture also makes cellulose fiber naturally breathable, which helps to regulate body temperature and keep the wearer comfortable.. (Klemm, D., Kramer, F., Moritz, S., Lindström, T., Ankerfors, M., Gray, D., ... & Schmauder, H. P.(2011).

1.3. PREPARATION OF NANOCELLULOSE

Compound and mechanical methods would be used to remove cellulose from plant strands, and alkalization, dyeing, and corrosive hydrolysis might be used to recover it

in nano and miniature structures. The extraction and presentation of water hyacinth fiber (*Eichornia crassipes*) nanocellulose are described in this paper. After each stage of production, the creativity came from delving deeper into a wider variety of characteristics of exceptionally pure WHF examples.

Utilizing digester pulping and sonication allowed for segregation. The morphological changes caused by treatment were visualized using SEM (SEM). After compound treatment, the lignin and hemicellulose groups were reduced. The morphology of WHF was examined using transmission electron microscopy (TEM) and a molecule size analyzer after one hour of sonication (PSA). The width and length of the nanocellulose WHF, which were 15.61 and 147.4 nm, were determined using TEM separately.■

Nanocellulose is a promising material with a wide range of potential applications due to its unique properties such as high strength, biodegradability, and biocompatibility. To fully understand its properties and potential applications, various analytical techniques are used to analyze and characterize nanocellulose samples. Nanocellulose can be prepared using various methods, including mechanical and chemical treatments. The mechanical method involves breaking down the cellulose fibers using physical forces such as grinding, high-pressure homogenization, or microfluidization. On the other hand, chemical methods involve the use of chemical agents to dissolve and separate the cellulose fibers. In both methods, the resulting material is a suspension of nanocellulose in water or other solvents.

1.3.1. ISOLATION OF NANOCELLULOSE

The first step is the removal of lignin and hemicellulose, which can be achieved through a combination of chemical and mechanical treatments. In one study, water hyacinth was treated with a sodium hydroxide solution, followed by bleaching with hydrogen peroxide to remove lignin and hemicellulose. The resulting cellulose was then mechanically disintegrated using a high-pressure homogenizer to produce nanocellulose.

Another study used a combination of chemical and mechanical treatments to isolate nanocellulose from water hyacinth. The plant material was first treated with a mixture of sodium hydroxide and sodium chlorite to remove lignin and hemicellulose. The resulting cellulose was then mechanically disintegrated using a blender and a high-pressure homogenizer to produce nanocellulose.

The resulting nanocellulose from water hyacinth has been found to have good mechanical properties and high surface area, making it suitable for use in a variety of applications, such as reinforcing materials in composites, drug delivery systems, and water filtration.

CHAPTER 2: LITERATURE SURVEY

Nanocellulose, a type of cellulose fiber with dimensions in the nanometer scale, has gained significant attention in recent years due to its unique properties, such as high strength, biodegradability, and low toxicity. Nanocellulose can be isolated from a variety of natural sources, including plants, bacteria, and fungi. One such source is water hyacinth, an invasive aquatic plant that is abundant in many parts of the world.

Several studies have focused on the isolation of nanocellulose from water hyacinth and its potential applications. In one study, water hyacinth was first treated with a mixture of sodium hydroxide and sodium chlorite to remove lignin and hemicellulose. The resulting cellulose was then mechanically disintegrated using a blender and a high-pressure homogenizer to produce nanocellulose. The nanocellulose was found to have good mechanical properties and high surface area, making it suitable for use in a variety of applications, such as reinforcing materials in composites, drug delivery systems, and water filtration (Júnior et al., 2017).

In another study, water hyacinth was treated with a sodium hydroxide solution, followed by bleaching with hydrogen peroxide to remove lignin and hemicellulose. The resulting cellulose was then mechanically disintegrated using a high-pressure homogenizer to produce nanocellulose. The nanocellulose was found to have good thermal stability and mechanical properties, making it a potential candidate for use in biomedical applications (Kalia et al., 2013).

Water hyacinth nanocellulose has also been investigated as a potential reinforcement material in polymer composites. In one study, water hyacinth nanocellulose was added to a polyvinyl alcohol (PVA) matrix to produce a composite with improved mechanical properties. The composite showed a 25% increase in tensile strength and a 40% increase in Young's modulus compared to the pure PVA matrix (Júnior et al., 2017).

Water hyacinth nanocellulose has also been studied as a potential material for water filtration. In one study, water hyacinth nanocellulose was incorporated into a cellulose

acetate membrane to improve its water flux and rejection properties. The resulting membrane showed a 50% increase in water flux and a 40% increase in salt rejection compared to the pure cellulose acetate membrane (Phanthong et al., 2019).

In addition to its potential applications in composites and water filtration, water hyacinth nanocellulose has also been investigated for use in drug delivery systems. In one study, water hyacinth nanocellulose was used as a carrier for the delivery of curcumin, a natural antioxidant with potential health benefits. The resulting nanocellulose-curcumin composite showed improved solubility and stability compared to curcumin alone, indicating its potential as a drug delivery system (Gama et al., 2019).

In conclusion, water hyacinth is a promising source for the isolation of nanocellulose due to its high cellulose content and availability. Nanocellulose isolated from water hyacinth has shown potential for use in a variety of applications, such as reinforcement materials in composites, water filtration, drug delivery systems, and more. Further research is needed to optimize the isolation and production of water hyacinth nanocellulose and to explore its potential for other applications.

CHAPTER 3: AIM AND SCOPE

3.1 AIM:

- Isolation of cellulose from water hyacinth
- Characterization of cellulose fiber by sem edx test
- Evaluation of waste water before and after treatment

3.2 SCOPE:

The extent of this study incorporates the disengagement of nanocellulose strands from water hyacinth through a progression of substance and mechanical medicines. The morphology, crystallinity, thermal stability, and surface area of the nanocellulose fibers will all be examined in relation to their physicochemical properties. The nanocellulose fibers' potential uses, such as as drug delivery vehicles, adsorbents for wastewater treatment, and reinforcement materials in polymer composites, will be investigated.

CHAPTER 4: MATERIALS AND METHODS

4.1 MATERIALS:

- Water Hyacinth
- Ethanol
- Toluene
- Sodium Hypochlorite
- HCl
- Glacial acetic acid
- Distilled water
- 500ml beaker
- Heating Mantel
- Water Bath
- Magnetic Stirrer
- Sonicator
- Petri-plate

4.2 METHODS

4.2.1.CELLULOSE ISOLATION AND FIBER EXTRACTION

- 5kg of WHC plant was obtained from a pond near karanodai.
- It was washed and dried in the sun until crisp texture.
- Then converted into powder form of total mass 1kg.
- Fiber extraction was done using a beaker, toluene and ethanol.
- 30mg of WHC was put in a beaker of 500ml.
- 200ml of toluene and 100ml of ethanol was added to the beaker.
- Beaker was placed in a water bath and heated at 115 degree celcius.
- The solution was heated until completely dry and then washed in distilled water. Thus fibers were extracted from WHC plant.



Fig 4.1 Beaker in water bath

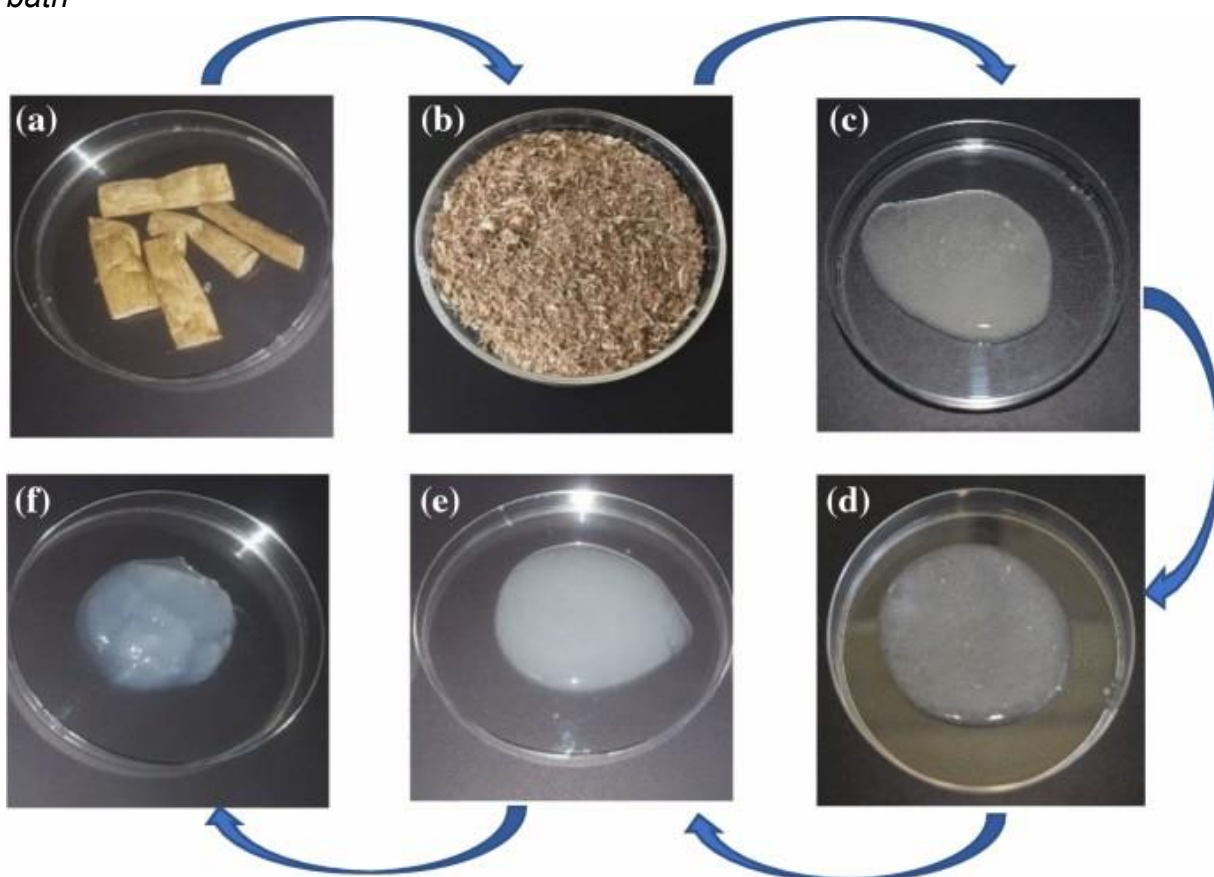


Fig.4.2 Cellulose isolation from WHC

4.2.2.BLEACHING AND HEMICELLULOSE REMOVAL

- The fiber was bleached using sodium hypochlorite 300ml.
- The solution turned from dark green to light brown colour.
- Solution was heated at 80 degree celcius using heating mantel until completely dry.
- Then hemicellulose was needed to be removed using NaOH 100ml and heated at 60 degree celcius.



Fig 4.3 bleached solvent



Fig 4.4 beaker in heating mantel

4.2.3. HYDROLYSIS AND CELLULOSE PRODUCT ACETYLATION

- HCl was used for hydrolysis and heated at 65 degree celcius.
- 25ml of glacial acetic acid and stirred at 40 degree celcius.
- The solution was sonicated for 2hrs.
- The solution was then transferred to a petri plate and placed on a magnetic stirrer for 1hr.
- The remaining semi-solid substance was stored in a cool and dry place and a new batch of WHC fiber extraction was conducted using the same



values.

Fig 4.5



WHC

Fig 4.6

WHC in magnetic stirrer

4.2.4. SONICATION

100 milliliters of refined water and 0.5% cellulose WHC (from the corrosive hydrolysis method) were used to accomplish this. Using an ultrasonic cell smasher SJIA-1200W, this suspension was sonicated for an hour at 20 kHz and 600 W until the nanocellulose fiber was completely broken down. The WHC cellulose suspension was kept at a temperature of less than 50 degrees Celsius. The resulting nanocellulose WHC suspension.

For an hour, the example is sonicated. Sonication is the process of using sound energy to stir up broken strands or particles in a fluid. Since ultrasonic frequencies (more than 20 kHz) are

regularly used, the methodology is generally called ultrasonication. A sonicator or an ultrasonic shower can be used to achieve sonication. In nanotechnology, sonication is frequently used to consistently scatter materials.

Additionally, it is used to decompose totals of colloidal particles with a micron size. Additionally, sonication can be used to initiate crystallization and even direct polymorphic crystallization. The use of sound waves to agitate particles in an answer is known as sonication. It transforms an electrical signal into a real vibration to isolate substances. These problems can mix things up, speed up the process of a solid breaking down into a fluid, like sugar breaking down into water, and remove broken gas from fluids.

4.2.5.SEM(Scanning electron microscope)

(SEM) makes a picture by expecting and separating a concentrated stream of electrons over a

surface. conveys high-goal symbolism that can be used to look for surface breaks, imperfections, debasements, or erosion in a variety of materials. In the example, electrons collaborate with particles to produce a variety of signs that convey information about the example's surface geography and creation. Using a raster check example, the electron shaft is examined and the power of the received signal is combined to create an image.

An auxiliary electron identifier (Everhart-Thornley locator) in the most well-known SEM mode is used to identify optional electrons produced by iotas stimulated by the electron bar. The number of optional electrons that can be identified and, consequently, the sign are not entirely determined by a few variables, such as location. Goals that require more than one nanometer can be met by some SEMs.

CHAPTER 5: RESULT AND DISCUSSION

5.1.CHARACTERIZATION STUDIES

The bleached fiber was given for Scanning electron Microscopy (SEM).

The Final fiber obtained was given for Scanning Electron Microscopy-energy dispersive X-ray analysis (SEM-EDX) and Thermogravimetric analysis(TGA).

5.2.SCANNING ELECTRON MICROSCOPE ANALYSIS

(SEM) makes a picture by expecting and separating a concentrated stream of electrons over a

surface. conveys high-goal symbolism that can be used to look for surface breaks, imperfections, debasements, or erosion in a variety of materials. In the example, electrons collaborate with particles to produce a variety of signs that convey information about the example's surface geography and creation. Using a raster check example, the electron shaft is examined and the power of the received signal is combined to create an image.

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5.3.Thermogravimetric Analysis (TGA)

Thermogravimetric Analysis (TGA) is a method of thermal analysis that, under controlled temperature conditions, measures changes in a sample's mass as a function of temperature or time. In materials science and chemistry, it is frequently used to investigate the thermal stability and composition of polymers, ceramics, and metals.

A furnace, a balance, and a sample holder make up the TGA instrument. The sample holder is commonly made of platinum or alumina and can hold a small sample size (normally a couple of milligrams). The sample's mass is measured with the balance while it is being heated in the furnace. The heater is constrained by a PC program that can increase the temperature up or down at a steady rate, or hold the temperature at a constant value.

The sample is heated in the furnace and placed in the sample holder during a TGA experiment. The sample undergoes thermal decomposition as the temperature rises, which leads to the release of volatile products and the formation of solid residues. The balance continuously measures the sample's mass and records the data as a function of temperature or time.

The information obtained from TGA tests can be utilized to determine various properties of the sample, including its thermal stability, decomposition energy, and composition. The most widely recognized investigation strategy includes plotting the weight reduction (or gain) of the sample as a function of temperature. The onset temperature of thermal decomposition, the rate of decomposition, and the total weight loss can all be determined using the weight loss curve. Analyzing the nature of the products released during decomposition can also be used to infer the sample's composition.

5.4.RESULTS

5.4.1 MEMBRANE PREPARATION

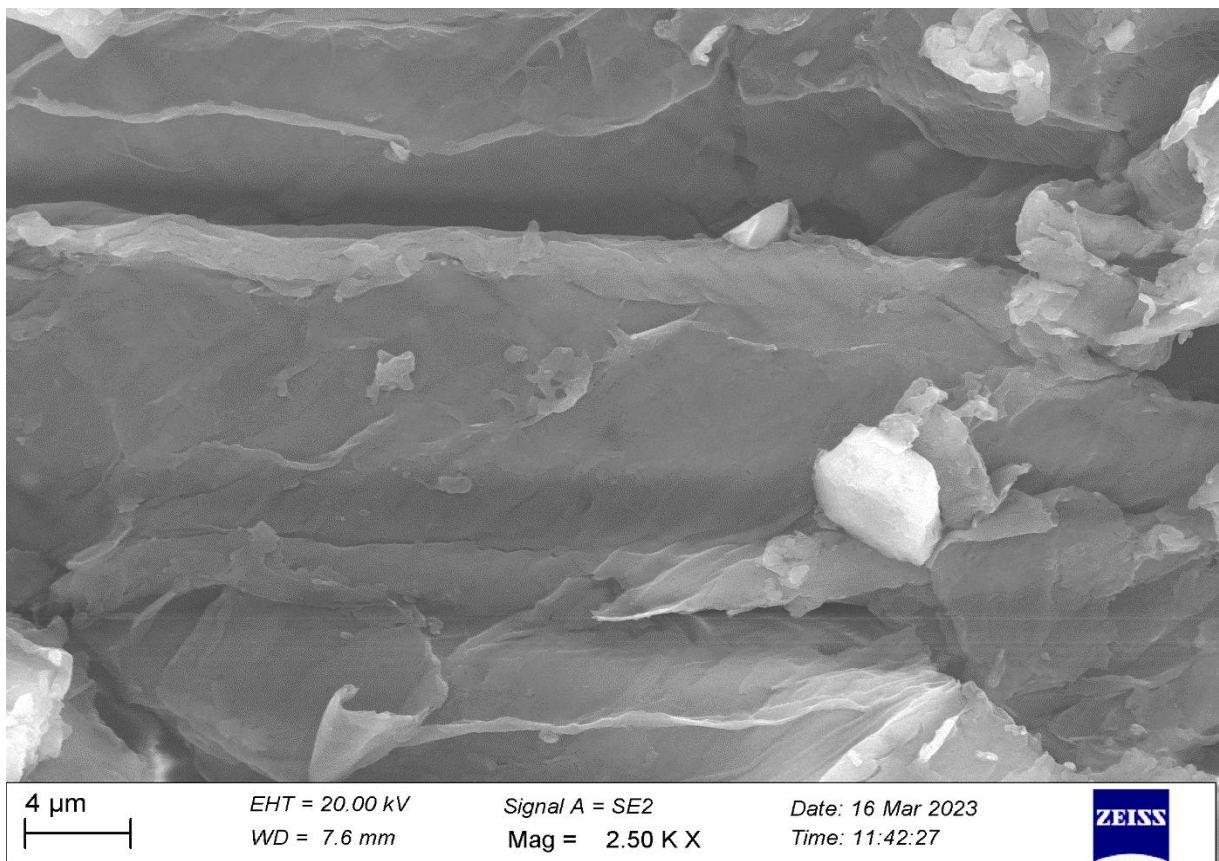
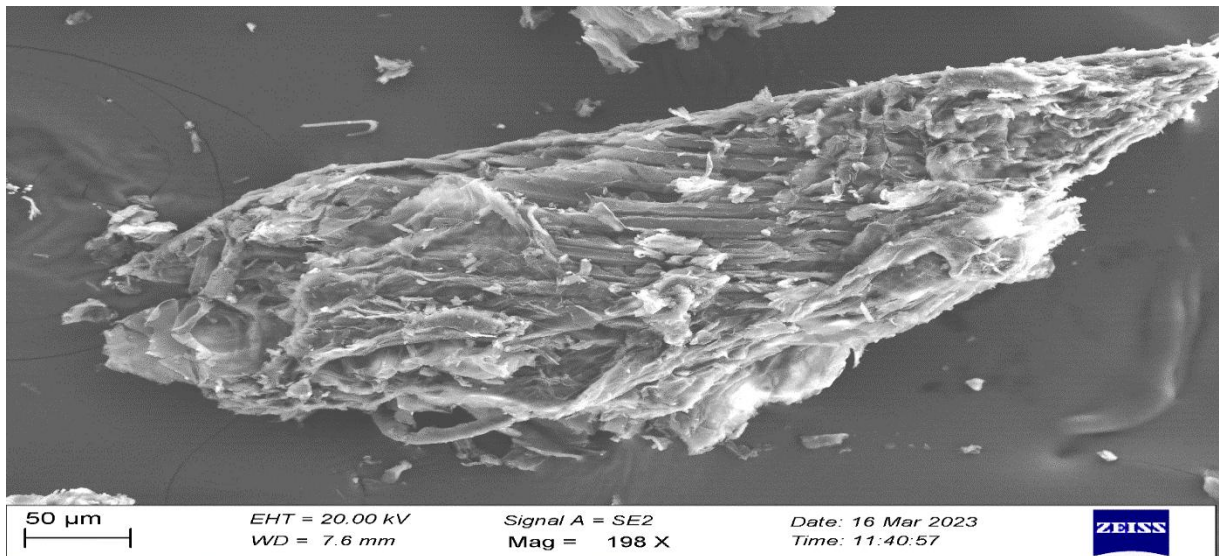
A thick membrane substance was obtained after mixing glacial acetic acid and letting it dry.

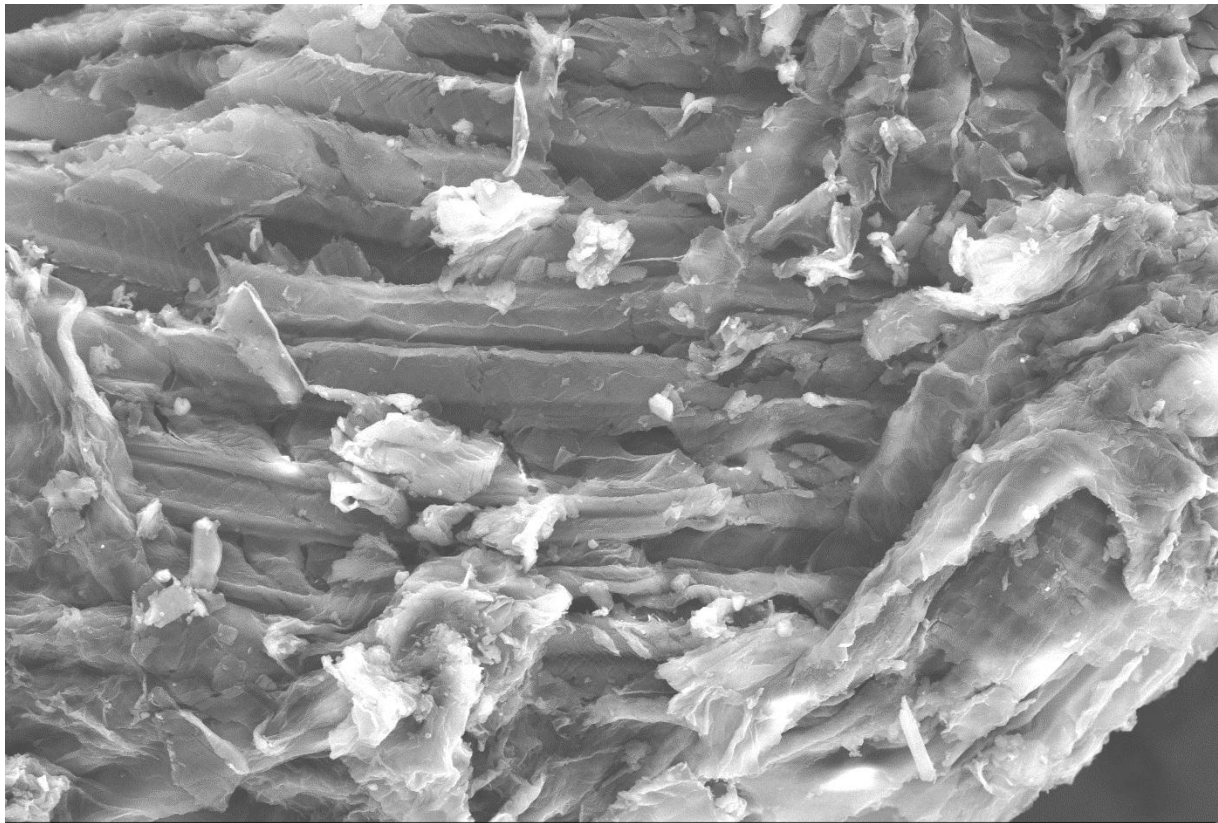


Fig 5.1 WHC after glacial acetic acid

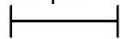
5.4.2. SCANNING ELECTRON MICROSCOPY (SEM)

(SEM) test result after bleaching





20 μm



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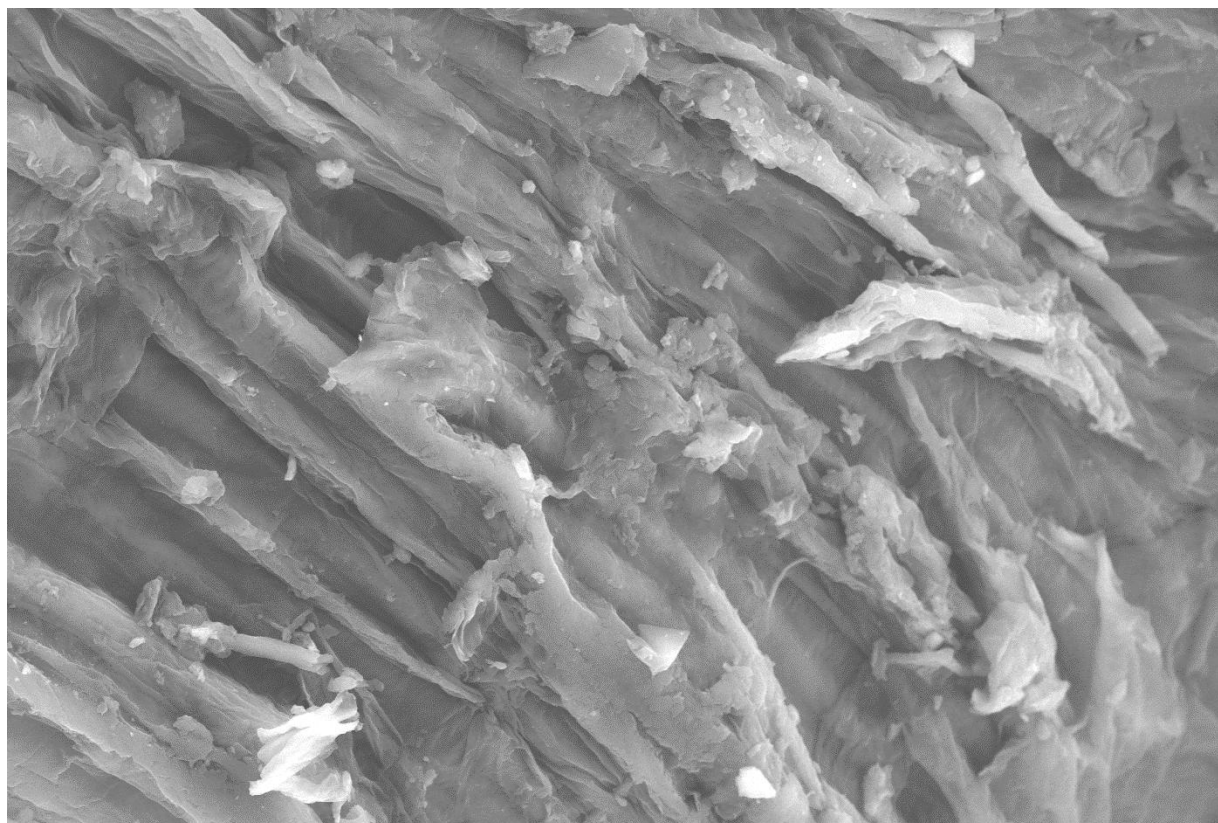
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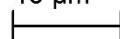
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10 μm



EHT = 20.00 kV

WD = 7.5 mm

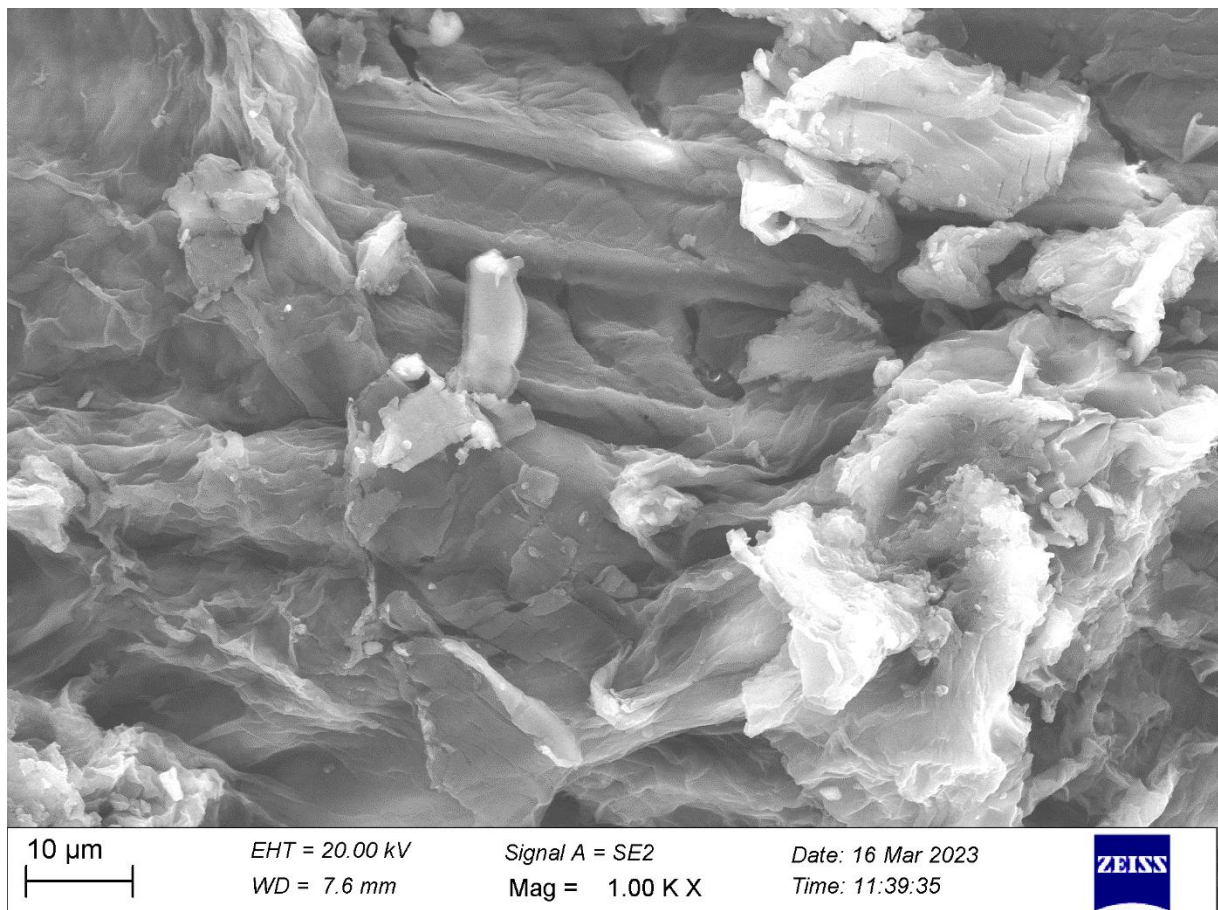
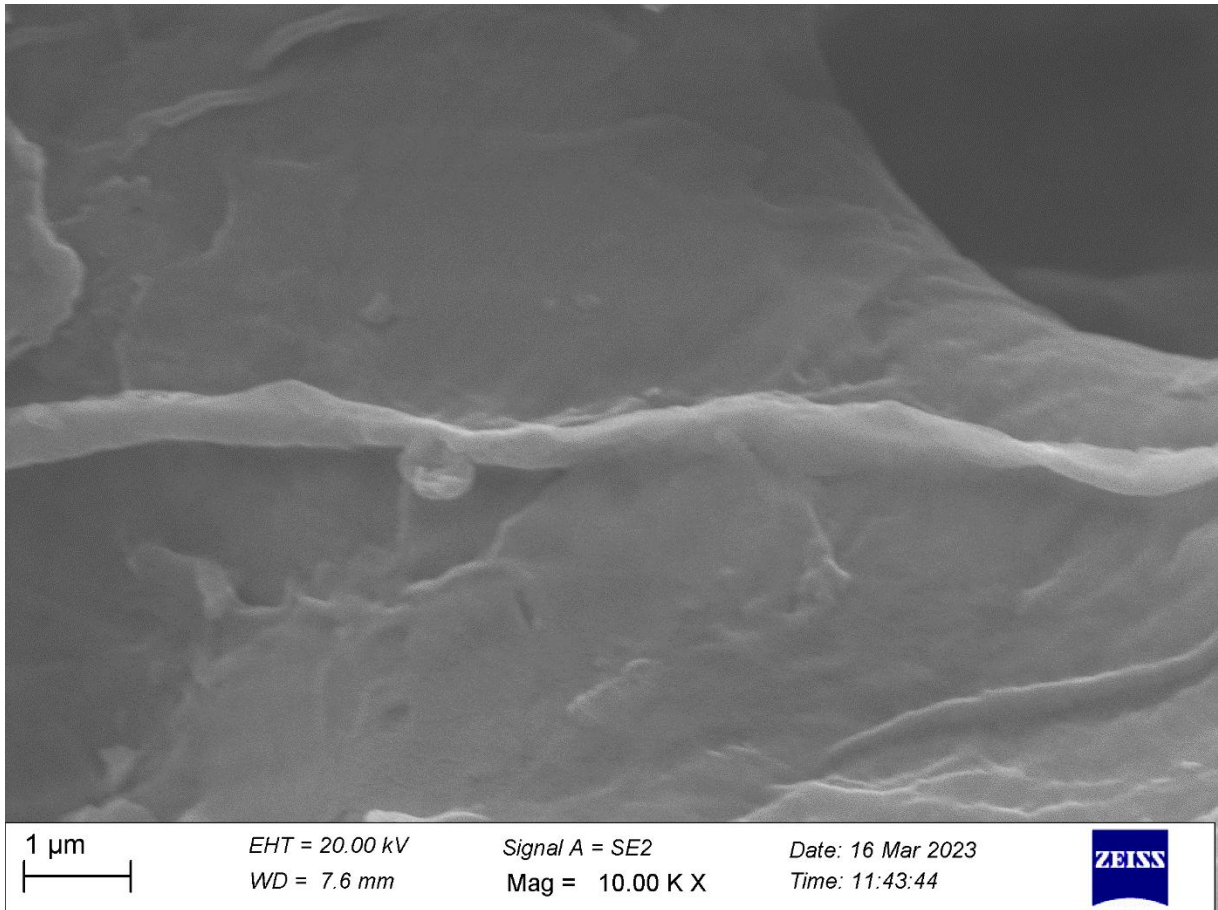
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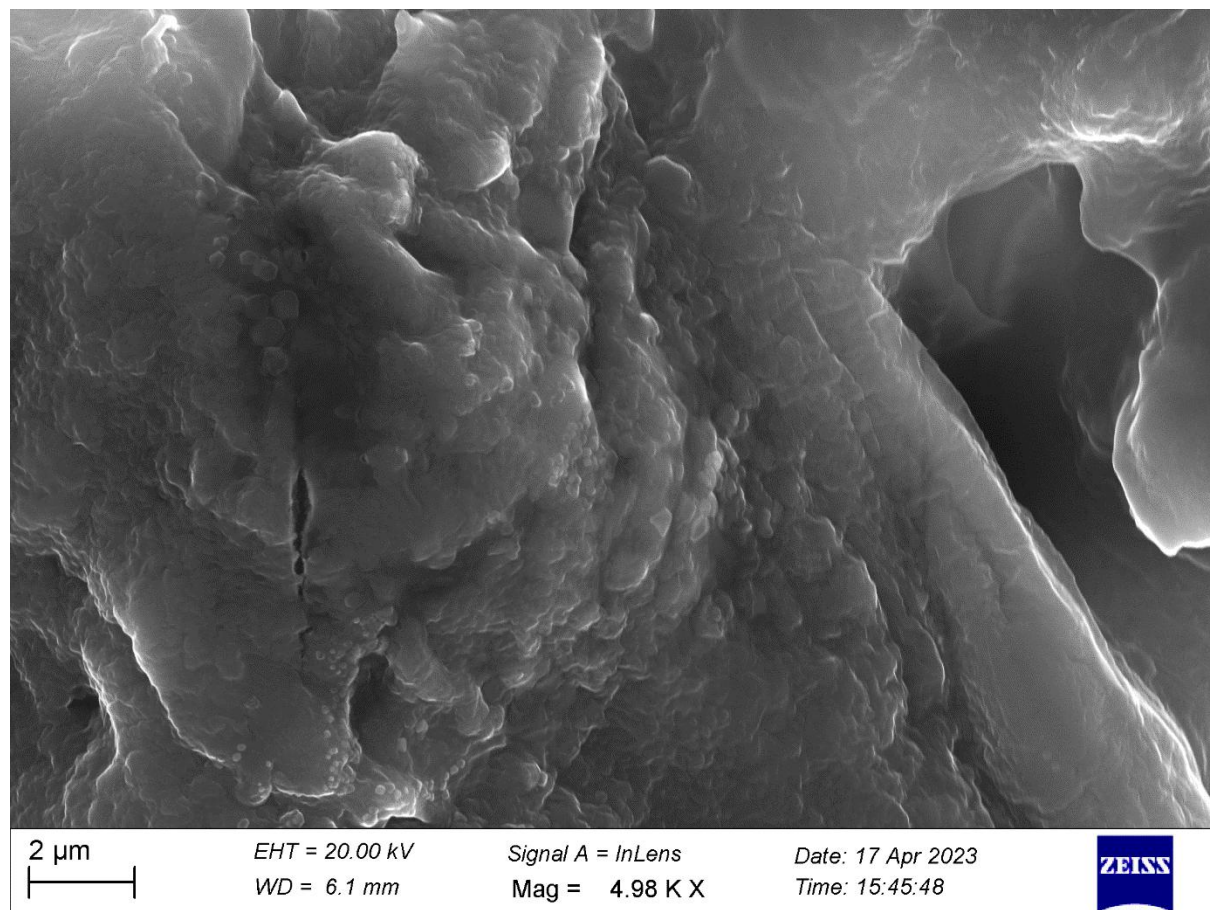
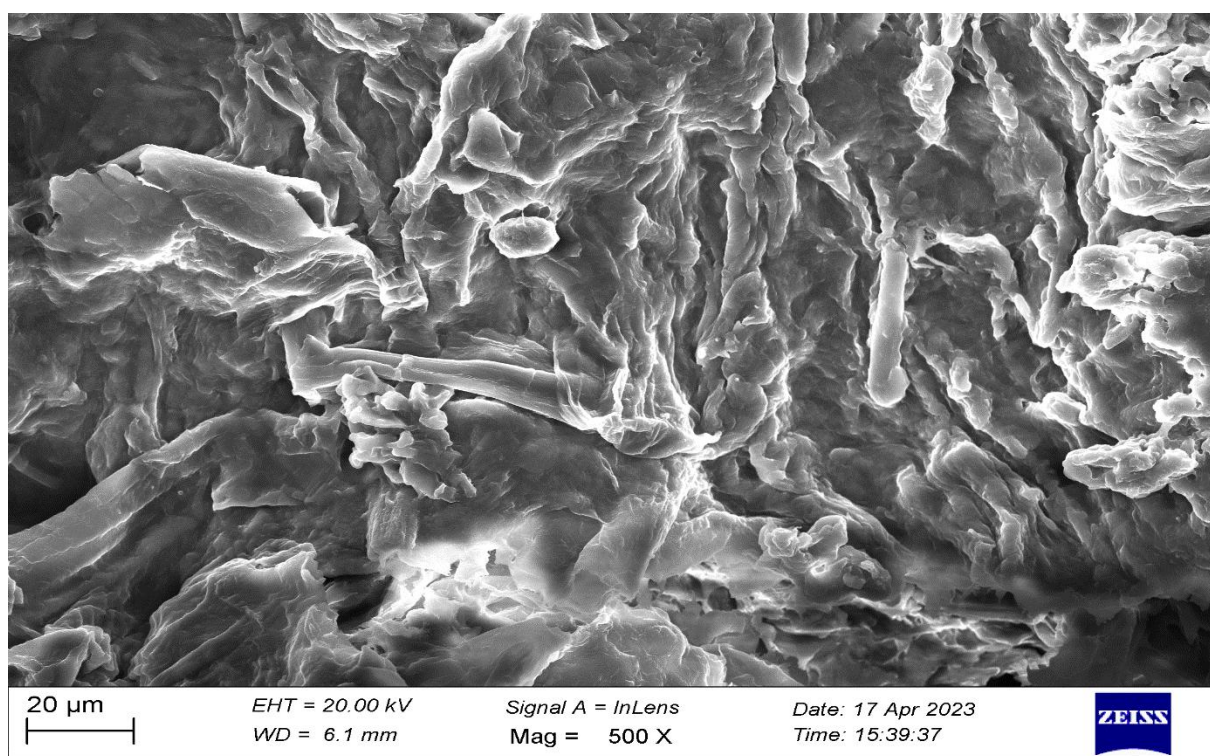
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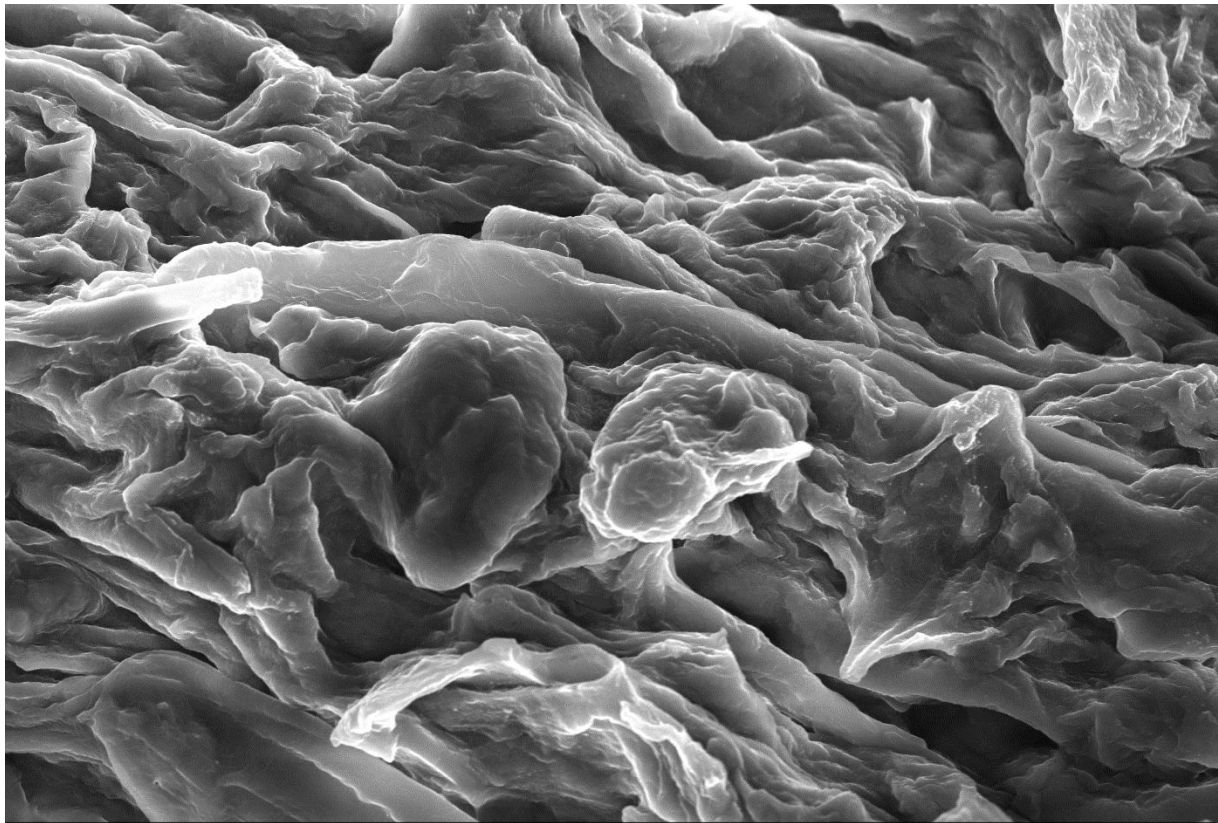
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Final (SEM-EDX) results after isolation of nanocellulose from WHC





10 μ m



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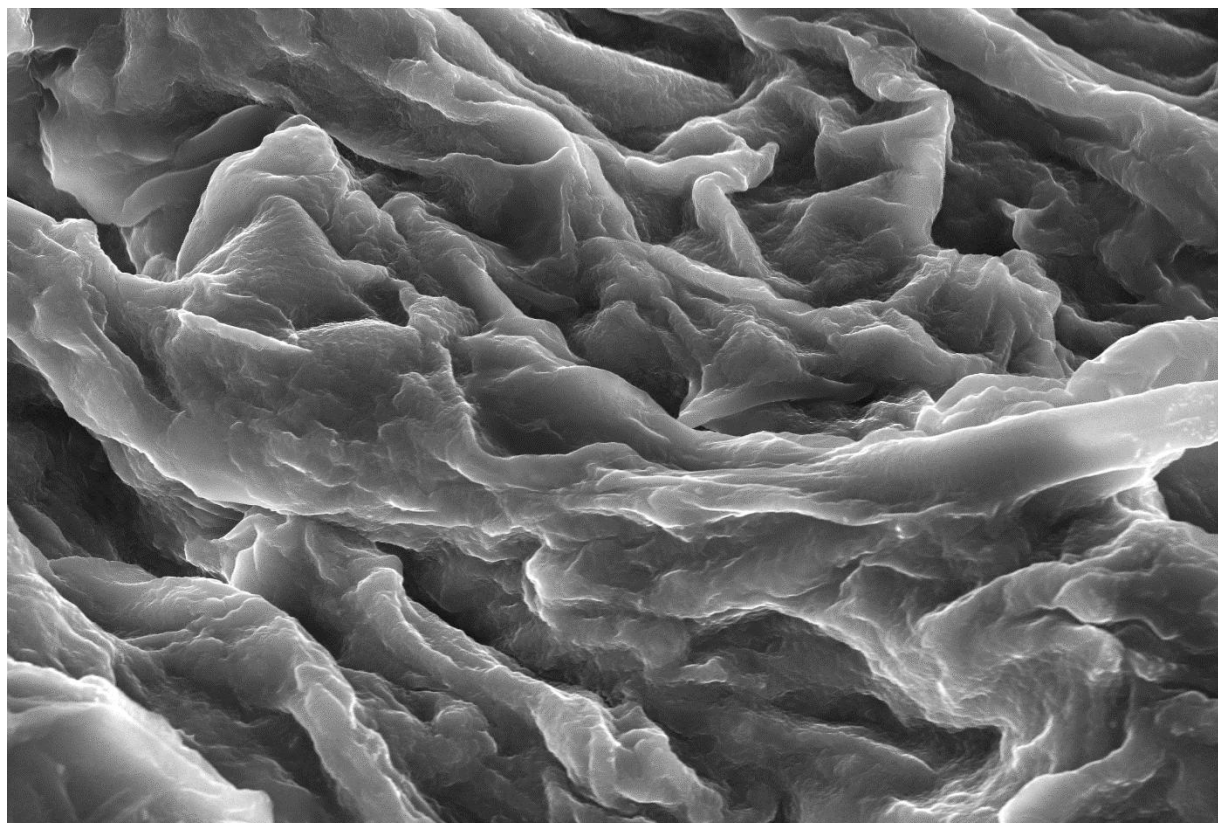
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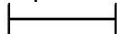
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5 μ m



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WD = 6.0 mm

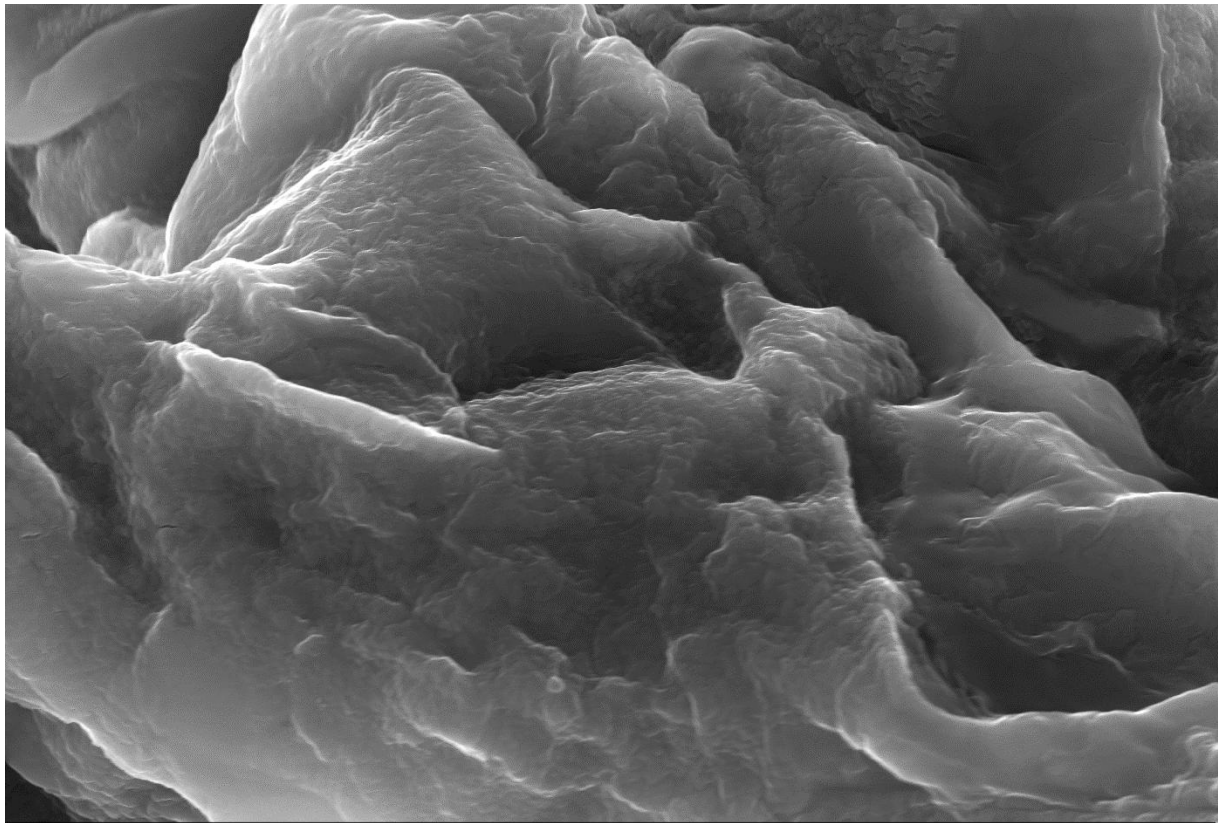
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2 μm



EHT = 20.00 kV

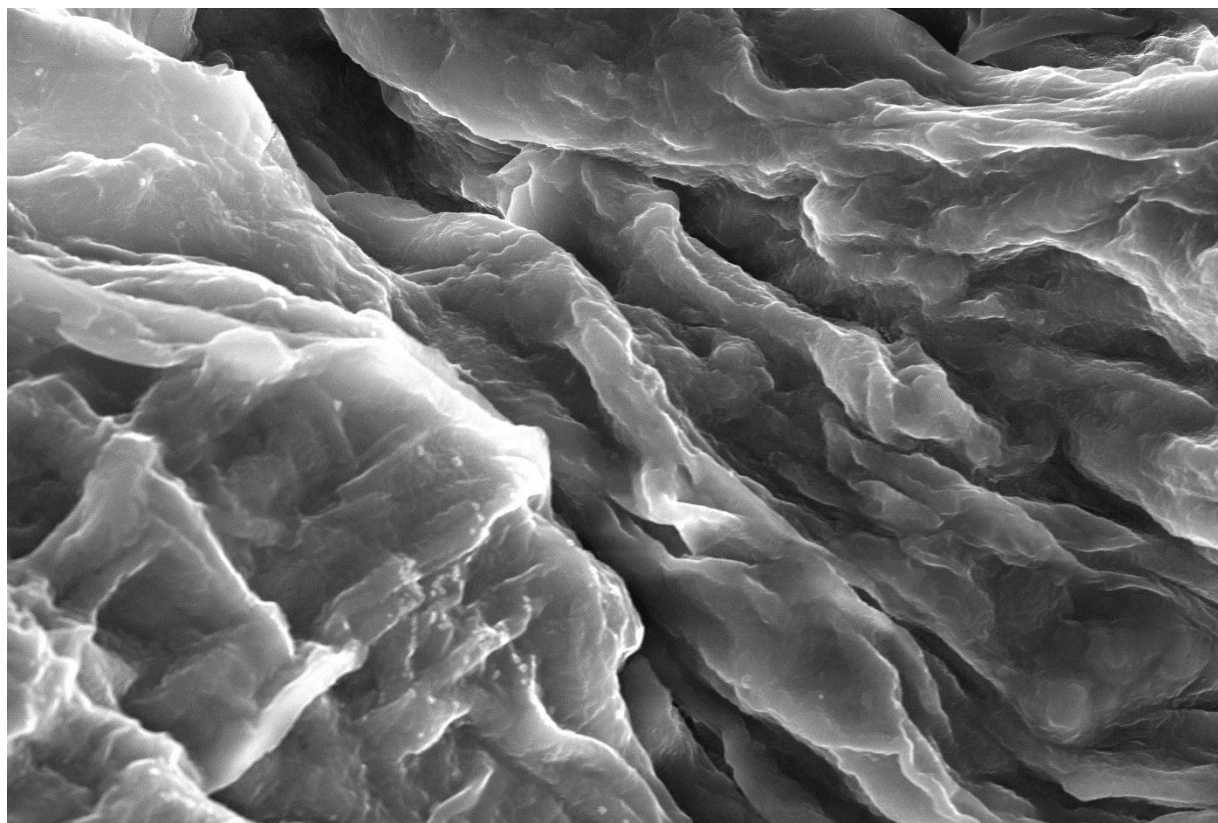
WD = 6.0 mm

Signal A = InLens

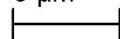
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Date: 17 Apr 2023

Time: 15:51:10



5 μm



EHT = 20.00 kV

WD = 6.0 mm

Signal A = InLens

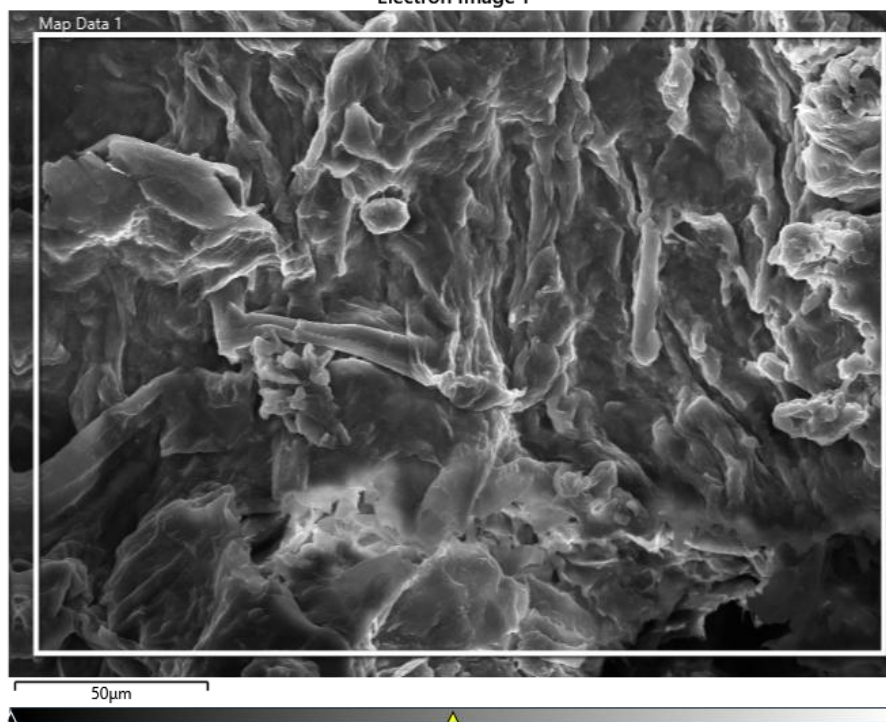
Mag = 2.01 K X

Date: 17 Apr 2023

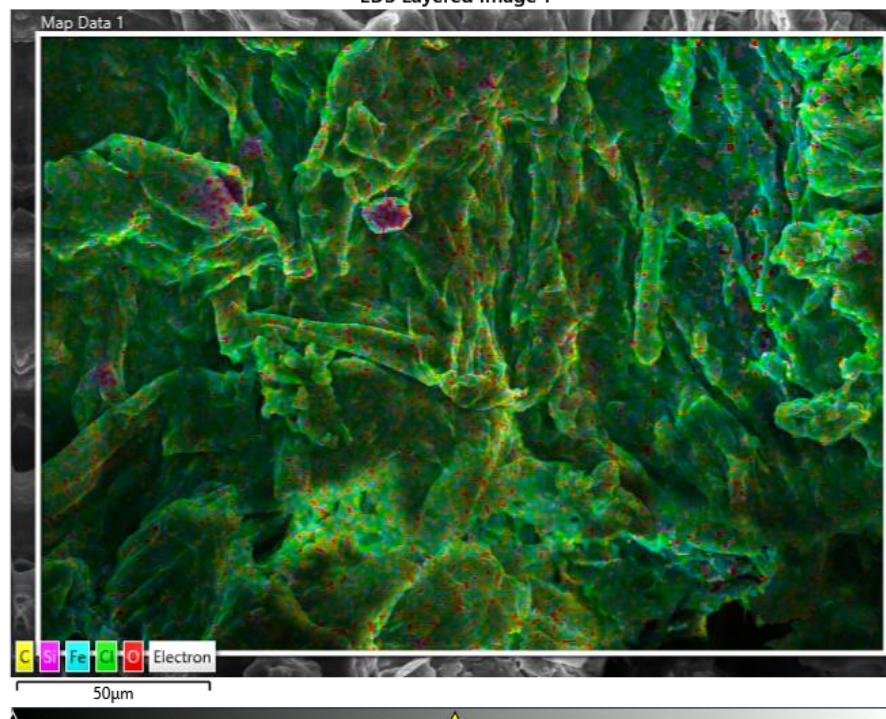
Time: 15:54:43

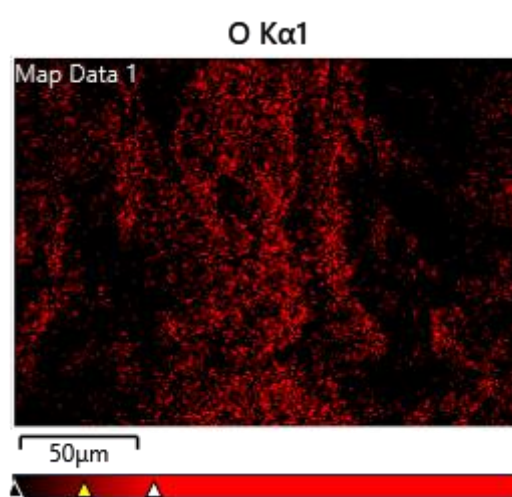
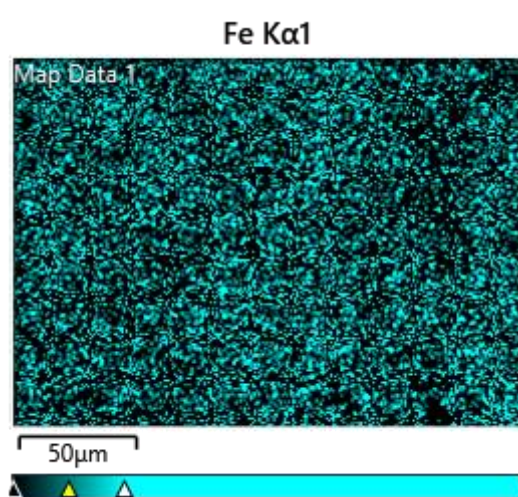
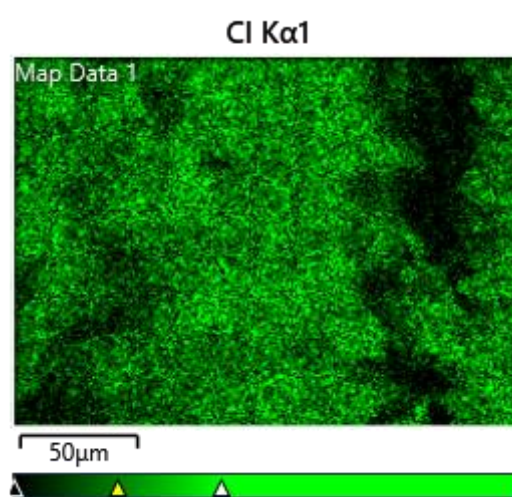
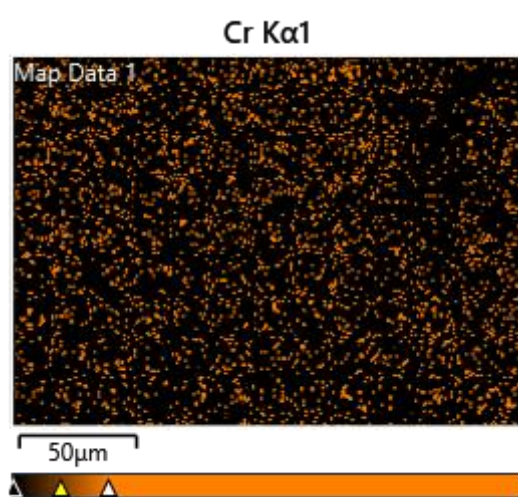
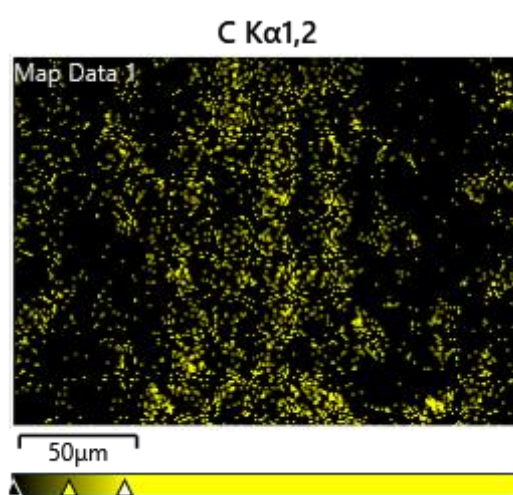
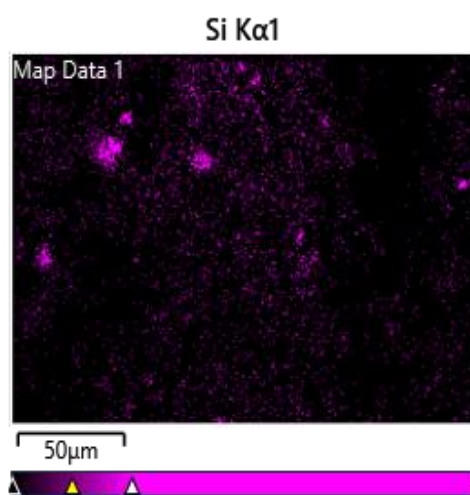


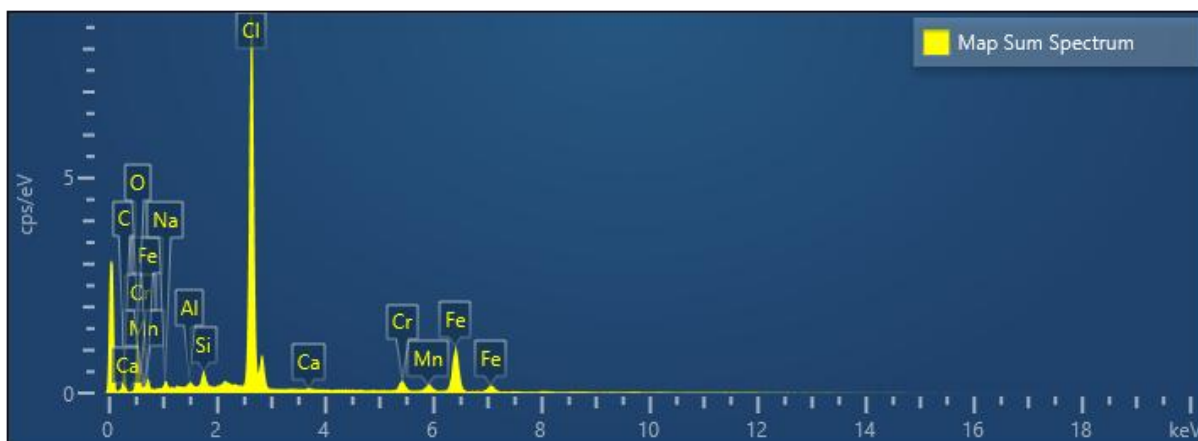
Electron Image 1



EDS Layered Image 1



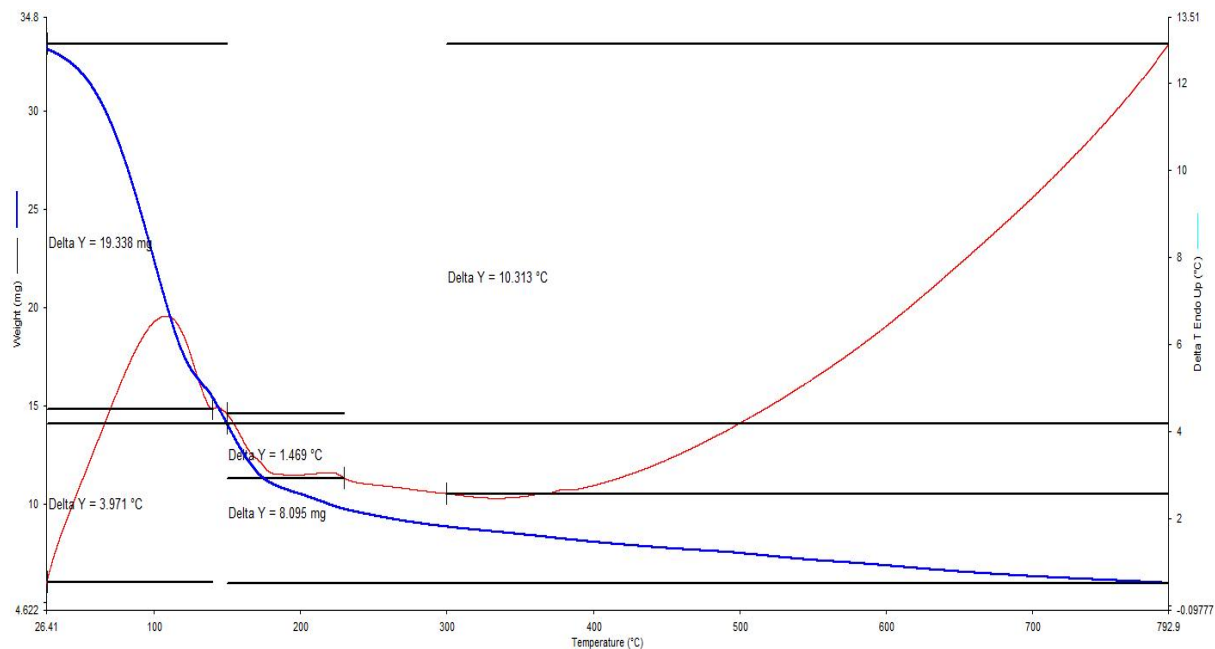




Map Sum Spectrum				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
C	K series	38.44	0.86	57.31
O	K series	22.52	0.45	25.21
Na	K series	0.72	0.06	0.56
Al	K series	0.27	0.03	0.18
Si	K series	0.79	0.04	0.50
Cl	K series	22.86	0.34	11.55
Ca	K series	0.12	0.03	0.05
Cr	K series	1.74	0.07	0.60
Mn	K series	1.18	0.08	0.39
Fe	K series	11.36	0.21	3.64
Total		100.00		100.00

5.4.3.THERMOGRAVIMETRIC ANALYSIS (TGA)

Final (TGA) test result of WHC after isolation of nanocellulose



In conclusion, this study has successfully demonstrated the isolation of nanocellulose fibers from water hyacinth plants. The nanocellulose fibers were characterized using SEM-EDX and TGA, which revealed their unique properties such as high aspect ratio, thermal stability, and biodegradability. The potential applications of nanocellulose fibers were also discussed, including their use in membrane filtration, biomedical applications, and reinforcing polymer matrices.

The SEM-EDX analysis showed that the nanocellulose fibers obtained from water hyacinth were highly uniform with a diameter of about 20-40 nm. The fibers contained primarily carbon, oxygen, and hydrogen, which are the elemental constituents of cellulose. TGA analysis revealed that the nanocellulose fibers had excellent thermal stability, with a decomposition temperature of around 300°C.

Based on these results, it can be concluded that water hyacinth is a promising source of nanocellulose fibers. The use of water hyacinth plants as a source of nanocellulose fibers has the potential to be a sustainable and eco-friendly alternative to traditional sources of cellulose. The properties of nanocellulose fibers obtained from water hyacinth make them suitable for various applications, including water purification, biomedical applications, and reinforcing polymer matrices.

Further research can be carried out to optimize the isolation process and improve the properties of the nanocellulose fibers. Additionally, investigations can be conducted to explore the potential of nanocellulose fibers obtained from water hyacinth for other applications. Overall, the isolation of nanocellulose fibers from water hyacinth represents a significant step towards the development of sustainable and environmentally friendly materials.

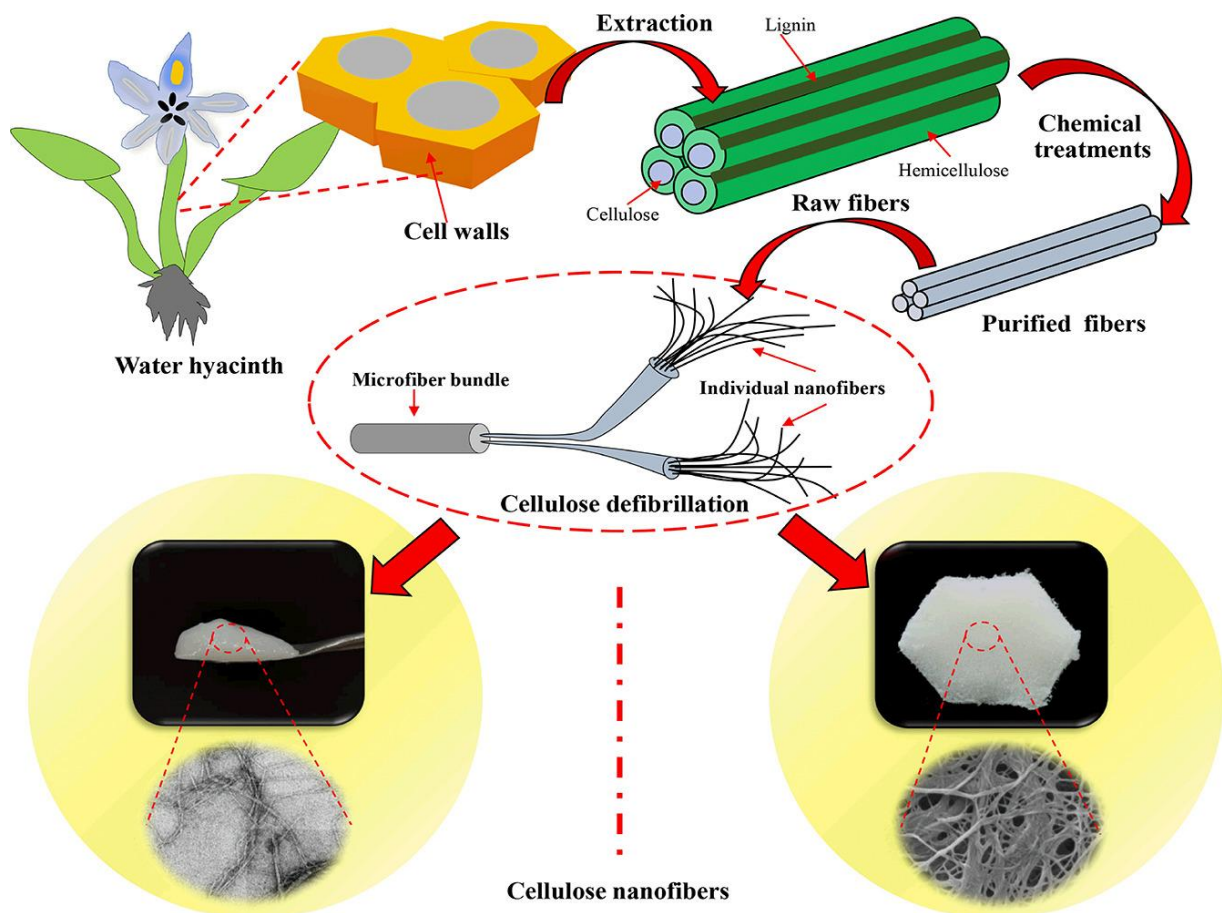


Fig 5.4.1 General depiction of isolation of cellulose from WHC

CHAPTER 6: SUMMARY AND CONCLUSION

6.1.SUMMARY

The present research is centred on extracting nanocellulose from water hyacinth fibre in order to build a cellulose acetate membrane with cellulose product acetylation. The water hyacinth has been powered, gone through chemical treatments and finally the membrane layer is formed, and the SEM-EDX/TGA analysis is shown

6.2.CONCLUSION

Membrane cellulose was successfully generated from WHC after a series of mechanical and chemical treatments. SEM and TGA are used to document the morphological changes in the WHC before and after treatment WHC disintegrated during bleaching and was depolymerized during corrosive hydrolysis. As indicated by SEM and molecule size studies, sonication delivered nano-sized filaments. Corrosive hydrolysis was demonstrated to be compelling in diminishing lignin and hemicellulose levels. Now, the chlorine level was very high (22.86 percent), but after sonication, the chlorine value fell. The low dampness retention and high chlorine values acquired suggest that sonicated WHC if treated may be a helpful supporting material for biocomposite film and in this way be utilized for cleaning sewage water.

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