

Development of Sweatpads Using *Eichhornia Crassipes* Fiber, Regenerated Cellulose Fiber Modal for Medicinal Application

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Abstract - The one feature of a well-developed, new textile is perspiration-absorbent properties, especially in situations with temperature extremes. This study focuses on the development of a breath-taking perspiration-absorptive substrate composed of *Eichhornia crassipes*-derived fibers and high-tenacity regenerated cellulose Modal fibers, engineered with enhanced hydrophilicity, moisture retention, and vapor permeability. Simultaneously, modal, a bio-based polymeric fiber, gives strength and tactile feel to the composite matrix. To enrich the olfactory neutrality of the substrate, Santalum album powder particulates are implanted in the fibrous matrix. Sandalwood, known for its volatile sesquiterpenoid constituents, acts like a natural antimicrobial and provides a long-lasting, aromatic diffusion, hence, it blocks the propagation of malodors via microbial inhibition. A complex combination of these chemicals creates a sweat-absorptive layer that ensures that the processes of temperature control, odor reduction, and the skin's reaction to the product are all harmonized. A newly developed prototype is intended for the least possible mass-density, the fastest biodegradation kinetics, and the least possible dermatological irritant properties. It is the prototype modeling the production track that develops step by step starting with the extraction and refinement of *Eichhornia crassipes* fibers, followed by the merging of these fibers together with modal filaments through nonwoven or laminar structuring methodologies, and ending with the integration of sandalwood microparticles into the matrix to make an equal olfactory dispersion. By employing phyto-originated and regenerative fiber composites, this innovation adheres to the imperatives of biodegradable personal protective textiles, while concurrently addressing the ecological ramifications of *Eichhornia crassipes* proliferation. The engineered sweat-absorptive construct encapsulates a dual-pronged approach - functional performance enhancement and sustainable bioresource valorization, underpinning its pertinence within meditech and hygiene-centric textile applications.

Index terms - *Eichhornia crassipes* fiber, regenerated cellulose, Santalum album, olfactory neutrality, phyto-originated, valorization, pertinence.

I. INTRODUCTION

1.1 TEXTILE FIBERS:

Textile fiber is the smallest unit of a fabric, is an individual, fine, hair-like substance that serves as the basic building block of textiles, derived from either natural or manufactured sources. Fiber usually are grouped and twisted together into a continuous strand called yarns. Next, yarns are used to create a variety of textile products, such as lace, knitted fabrics, and clothing. Without initially being turned into yarns, fiber can also be utilized to create fabric. Two types of fabric that are constructed entirely of fiber are felt and non-woven materials.

1.2 NATURAL FIBER:

Natural fibers are that occur naturally. There are two categories of textiles: Natural and synthetic fibers. Natural fibers comes from three sources: Plant fibers - cotton, linen, jute, hemp, ramie, Animal fibers - wool, silk, cashmere, alpaca, angora, and Mineral fibers - asbestos. Natural fibers are sustainable materials which are easily available in nature and have advantages like low-cost, lightweight, renewability, biodegradability, and high specific properties. The sustainability of the natural fiber-based composite materials has led to upsurge its applications in various manufacturing sectors.

The natural fibers have low density and high strength to weight ratio and reduction make them potential as light weight composite and reinforcement materials. The microstructure and chemical compositions of fibers affect the mechanical properties with the fiber

cross-sectional area is the most variable influencing the fiber strength.

In my project, the focus is on developing an eco-friendly underarm pad using *Eichhornia crassipes* plant stem, Regenerated cellulose fiber infusing it with the natural fragrance of *Santalum album* powder, it makes an eco-friendly product.

1.3 *Eichhornia crassipes* fiber:

Eichhornia crassipes fiber, which is harvested from the *Eichhornia crassipes* plant, is gaining significant attention in various industries due to its environmentally friendly and highly versatile properties. Native to the Amazon Basin, *Eichhornia crassipes* has spread across water bodies around the world, becoming one of the most notorious aquatic weeds. However, beyond its growth in aquatic environments, the plant offers a treasure trove of fibers that are proving to be extremely beneficial for sustainable production. The fibers come from the plant's long, spongy stems, which, when processed correctly, become incredibly pliable, strong, and durable. It is an incredible natural resource that combines eco-friendliness, versatility, and strength. Its lightweight nature, moisture-wicking abilities, biodegradability, and resistance to decay make it a standout material in the sustainable design movement.

1.4 Regenerated cellulose fiber Modal:

Regenerated cellulose fiber is a type of regenerated cellulose fiber made from European beech wood. It was developed by the Austrian company Lenzing in the 1980s and gained popularity at the end of the last century due to the growing demand for comfortable clothing. Regenerated cellulose fiber is considered eco-friendly as it is made from natural materials and is harmless to the environment, and it has several exceptional qualities that make it a sought-after fabric. Modal is a new high wet Regenerated cellulose

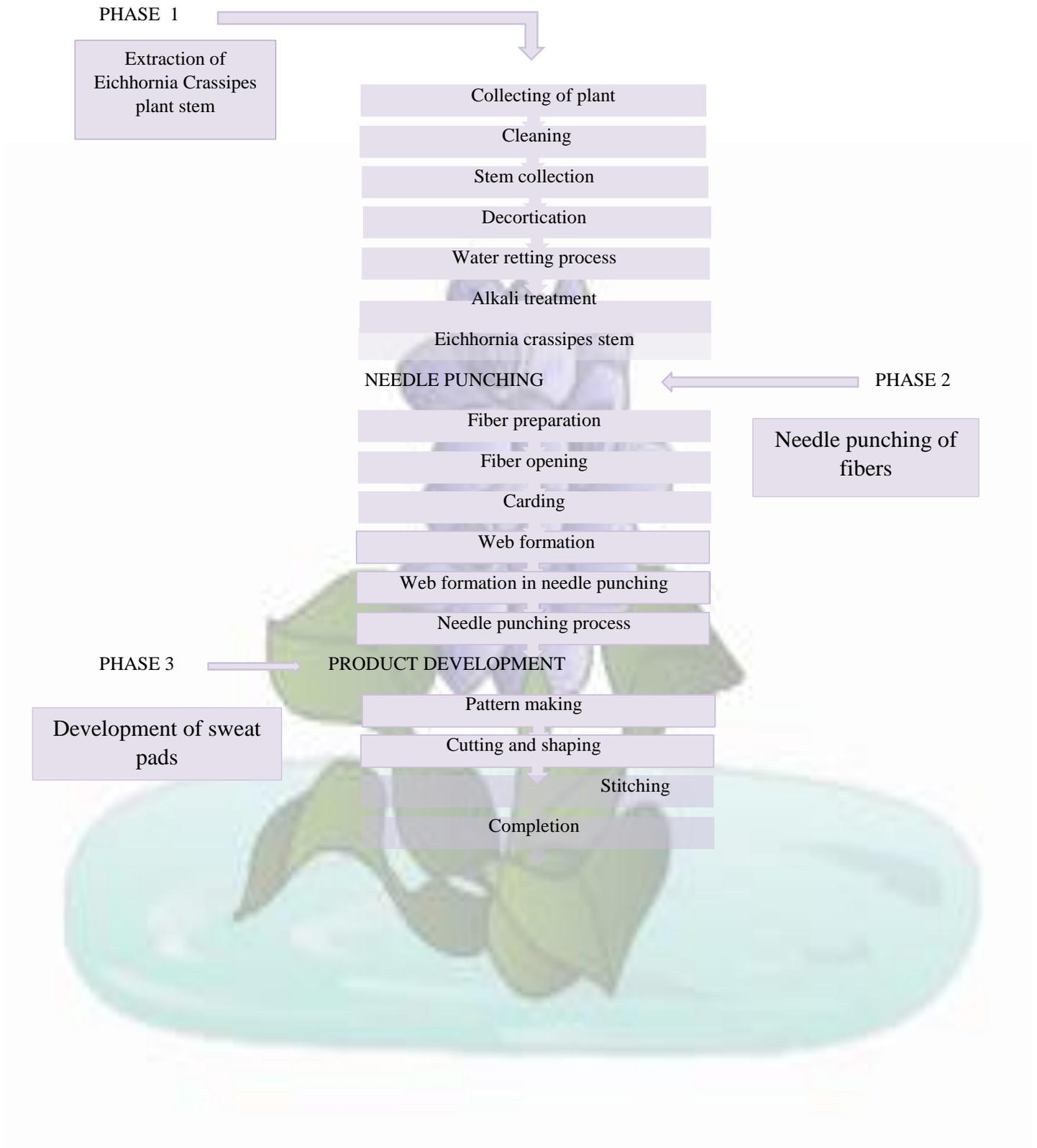
fiber and a new generation of regenerated cellulose fiber. The raw materials of this product are all-natural materials, which are made of beech wood from Europe. First, it is made into wood pulp and then processed into fiber through special spinning process. Regenerated cellulose fiber fabric has stable wearability, good clothing effect, strong shape stability, natural wrinkle resistance and no iron property, making it more convenient and natural to wear. Regenerated cellulose fiber is softer and brighter when washed. The development and utilization of Regenerated cellulose fiber caters to people's desire of "returning to nature" and using natural fiber.

II. OBJECTIVES

It aims to design a cutting-edge, eco-friendly sweat pad.

- ❖ For the promotion of eco-sustainable alternatives by replacing synthetic fibers with natural, biodegradable fibers.
- ❖ For the resource conservation through biotechnology of using invasive plants, such as *Eichhornia crassipes* plant fiber.
- ❖ For skin-tolerability and comfort through hypoallergenic materials, such as *Asphodelaceae* plant fiber, *Gossypium hirsutum* plant fiber.
- ❖ For enhanced sweat exudation through the wicking and high absorbency properties of *Regenerated cellulose* fiber and *Eichhornia crassipes* fibers.
- ❖ So as to promote zero-waste behaviors that turn the sweat pad into biodegradable waste after it is used.
- ❖ To reduce the carbon footprint of traditional synthetic sweat pads.

III. EXPERIMENTAL PROCEDURE:



PHASE I-EXTRACTION OF FIBER FROM EICHHORNIA CRASSIPES PLANT

3.1 Collecting of plants:

Eichhornia crassipes plant was harvested.



Plate I *Eichhornia crassipes* plant

3.2 Cleaning:

The harvested plants are thoroughly cleaned and removed soil and other unwanted dust and the stems are washed three times with cold water to remove impurities, it may affect fiber quality. After washing, excess surface moisture is air-dried for 2 hours.

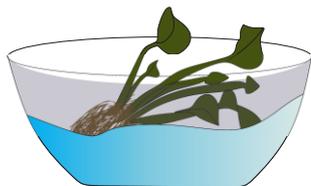


Plate II *Eichhornia crassipes* plant Cleaning

3.3 Stem collection

The plants roots and leaves were removed using a sharp knife and the stem is separated, as only the stems contain the desired fibers.

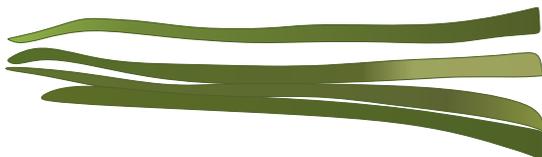


Plate III *Eichhornia crassipes* plant stem

3.4 Decortication

The stems were passed through a mechanical decortication machine, the machine is having a scrapping roller drums. Each drum has a diameter of 30cm and 8 blades arranged in the horizontal direction. The stems were inserted through the feeding inlet. Due to the high-speed rotating action of the scrapping roller drum, the stem was subjected to scrapping action. As a result, the fibers are separated in the first speed of machine. About 10 seconds are required to extract a single stem. After fiber

extraction, a mild combing was performed on the fibers.

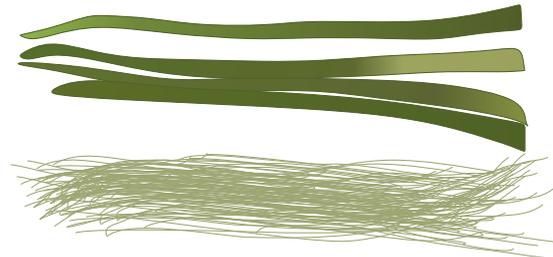


Plate IV *Eichhornia crassipes* fiber separate

3.5 Water retting process:

The length and weight of the *Eichhornia crassipes* stems were measured using a measuring scale and a weighing balance.



Plate V Retting process

3.5.1 AEROBIC CONDITION:

Aerobic retting, 30 stems weighing 400 g were taken and processed through the extraction machine. The fibers then obtained were washed and kept in an open container while water was poured on them by keeping a material to liquor ratio of 1:5. The retting was carried out for the duration of 5 and 7 days in separate containers.

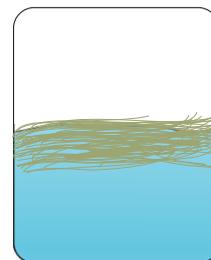


Plate VI Aerobic retting

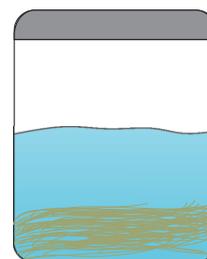


Plate VII Anaerobic retting

3.5.2 ANAEROBIC CONDITION:

Anaerobic retting, the above-said conditions were applied; however, the container was closed with a lid. The *Eichhornia crassipes* stems, along with water were gently stirred once in a day. From 4 days onward, the progress of the retting was monitored. After 5 and 7 days, the fiber was separated from the rotten stem by repeated combing using a hair comb and washed.



Plate X *Eichhornia crassipes* fiber opening



Plate XI Modal fiber opening

3.6 Alkali treatment:

After water retting, the detachment of the fibers from the stem was found to be good, but some of the stem and fleshy parts were found adhered to it. The fibers are treated with alkali with 10% NaOH (on the weight of the fiber) for 1 hour at 90°C for 30 minutes with fiber-to-liquor ratio of 1:50. After the alkali treatment, the fibers were washed in running water and neutralized using a 1.0% acetic acid solution and then with cold water.

Eichhornia crassipes stem fiber

Eichhornia crassipes fibers are taken.

PHASE II-NEEDLE PUNCHING THE FIBERS

3.7 Fiber preparation:

Eichhornia crassipes fiber and Regenerated cellulose fiber are taken for making non-woven sweat pads.



Plate VIII *Eichhornia crassipes* fiber



Plate IX Modal fiber

3.8 Fiber opening:

The extracted fibers under-go fiber-opening process, that separates individual strands and enhances their softness. During processing, only 20g of usable fiber is obtained from initial 100g input.

3.9 Carding:

Carding ensures the fibers are evenly aligned and distributed in parallel arrangement, ensuring even blending with modal fibers and making them ready for next process.



Plate XII Carding

3.10 Web formation and Needle punching:

The two fibers *Eichhornia crassipes* and Modal fiber and sandalwood powder is added for fragrance that are laid in lab formation to create a continuous sheet of material. This provides base structure for the sweat pad. The fiber web is passed through a needle punching machine equipped with barbed needles repeatedly penetrated and mechanically interlocked the fibers. This process plays a crucial role in strengthening the nonwoven fabric, ensuring improved durability and flexibility. This method made a sweat pad more eco-friendly without chemical binders.



Plate XIII Web formation

PHASE 3 – PRODUCT DEVELOPMENT

3.11 Pattern making:

3.12 Cutting and Shaping:



Plate XVII Pattern making and cutting

Plate XVIII layered and stitching

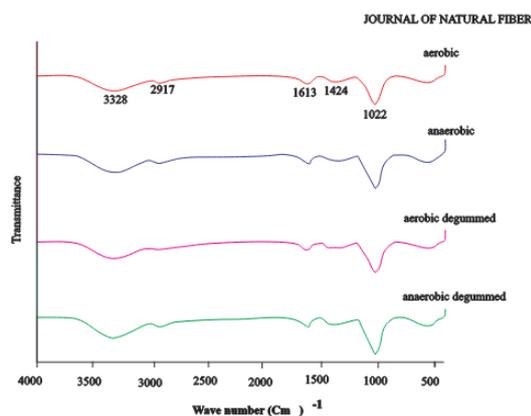
Table I. The physico-mechanical properties of *Eichhornia crassipes* fiber

Retting duration	Sample description	Fiber yield %	Diameter (m)	Bundle Strength (g/tex)	Fiber length (cm)	Liner density (tex)
10 days	Aerobic	0.83%	90.50(37.8)	7.63	17.8	0.021
	Anaerobic	0.87	73.29(43.9)	8.67	17.20	0.017
	Degummed anaerobic	NA	77.03(49.9)	8.80	20.60	0.018
	Degummed aerobic	NA	72.89(42.5)	9.58	19.01	0.016
5 days	Aerobic	1.22	87.00(42.9)	8.23	14.19	0.016
	Anaerobic	1.27	83.93(46.8)	8.41	13.89	0.015
	Degummed aerobic	NA	82.45(43.5)	9.12	15.8	0.017
	Degummed anaerobic	NA	74.52(46.4)	8.86	17.8	0.021

Table II. Comparison of physico-mechanical properties of *Eichhornia crassipes* fiber with other fibers

Fiber	Fiber yield %	Diameter (m)	Bundle Strength (g/tex)	Fiber length (cm)	Liner density (tex)	Moisture content(%)
<i>Eichhornia crassipes</i>	1.2-1.3	75-90	7.5-10	0.25-0.30	1.6-2.1	7.8-8.5

4.1 FTIR analysis



4.1 FTIR analysis

Since the highest yield and tensile strength were observed after 5 days of retting, the FTIR, SEM, chemical component analysis was performed with these fibers only. The FTIR spectra of 5 days retted and alkali-treated water hyacinth fibers in aerobic and

anaerobic condition. The spectrum shows all characteristic peaks corresponding to cellulose, hemicellulose, and lignin. The broad peak at (3328 cm^{-1}) corresponds to $-\text{OH}$ stretching vibration, mainly due to the presence of moisture content. A small, peak at 2917 cm^{-1} indicates the presence of $\text{C}-\text{H}$ stretching in alkanes (Pandey et al. 2018). The characteristic bands of hemicelluloses and lignin were observed around 1613 cm^{-1} due to the conjugated $>\text{C}=\text{O}$ stretching of ester and aldehyde groups (Basu et al. 2015). The small peak at 1424 cm^{-1} region indicates the vibration of CH_2 that is strong in crystalline cellulose and weak in amorphous cellulose. The strong peak in the region of 1022 cm^{-1} reveals the presence of $\text{C}-\text{O}$ stretching of cellulose, hemicellulose, or lignin (Hazarika et al. 2017 Pandey, Jose, and Sinha 2022). After alkali treatment, a marginal reduction in the intensity of the peaks at 2917 and 1022 cm^{-1} was observed, perhaps due to the removal of hemicelluloses, pectins, and lignin (Sun et al. 2003).

Plate XXI - FTIR spectra of aerobic retted, anaerobic retted, aerobic degummed, and anaerobic degummed.

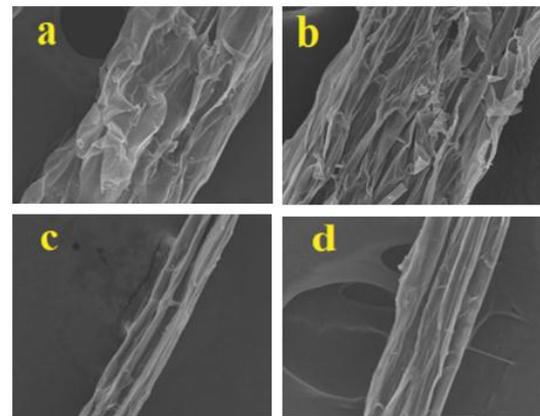


Plate XXII - SEM images of (a) 5 days aerobic retted fiber (b) 5 days anaerobic retted fiber (c) 5 days aerobic retted fiber after alkali treatment (d) 5 days anaerobic retted fiber after alkali treatment

4.2 SEM analysis

Plate 21 shows the surface morphology of *Eichhornia crassipes* fibers (5 days, anaerobic retting) under high magnification. In the case of retted fibers, the surface looks very rough with the adhesion of slight amount of fleshy materials, which remains on the fiber surface even after the combing and washing. After alkali treatment, the surface looks smooth and free from fleshy matter. As a result, a slight reduction in the fiber diameter was

also observed after degumming. The porous appearance of the fiber got transformed into a rigid structure. It is apparent from the SEM images that the degummed fiber would be much suitable for further processing such as composite preparation. Unlike other natural fibers like cotton, the surface of the water hyacinth fibers is having a channel-like structure and it is visible after the removal of gummy materials and other fleshy parts from the fiber through alkali treatment.

4.3 XRD ANALYSIS:

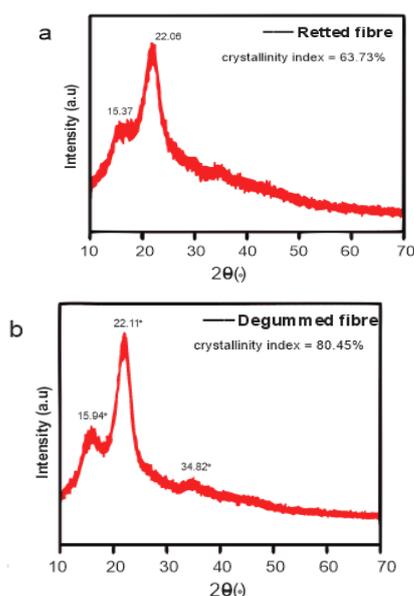


Plate XXIII - XRD pattern (a) retted and (b) degummed *Eichhornia crassipes* fiber after 5 days of retting.

Plate 22 depicts the comparison of the crystallinity index of retted and degummed water hyacinth fibers (5 days, anaerobic retting). Both the fibers showed peaks at an angle of 2θ 15–16, 22. Both the peaks resemble the XRD spectra of popular lignocellulosic fibers. However, after alkali treatment the peaks found to be sharp due to the removal of noncellulosic materials from the fiber. This caused by the increase in the crystallinity of the degummed fiber (Basu et al. 2015). Apparently, the crystallinity index of the retted fibers was enhanced from 63.73% to 80.45% after alkali treatment. This may be due to the removal of non-crystalline portions including hemicelluloses, pectins, and lignin (Basu et al. 2015)

VI. CONCLUSION

In my project, I worked on creating sweat pads using fibers from the *Eichhornia crassipes* plant and a type

of regenerated cellulose fiber called modal. These pads are mixed with a sandalwood powder scent to make them smell good. This combination provides a new and eco-friendly choice compared to traditional hygiene products. I have done SEM, FTIR, XRD testing provided crucial insights into their structural, chemical, and crystalline properties. SEM analysis confirmed a porous and fibrous structure, contributing to enhanced moisture absorption. FTIR analysis validated the presence of key functional groups associated with cellulose and lignin, ensuring the natural integrity of the material. Meanwhile, XRD analysis demonstrated the crystalline nature of the fibers, confirming their stability and durability.

V. REFERENCES

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