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Investigation of Physical, Chemical and Structural Characterization of Eichhornia crassipes Fiber

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ABSTRACT: *Researchers and scientists are looking forward for the new fiber sources for the sustainable processing. The ultimate goal is to produce an organic fibrous material that can be utilized in textile industry and to manufacture eco-friendly products. In this circumstance here emerges a fiber from water hyacinth (Eichhornia crassipes) an aquatic weed which has been attracted worldwide as a threat to biodiversity. Hence this paper highlights the physical, chemical and structural characterization of the fiber extracted from Eichhornia crassipes. The fiber was examined for the physical properties such as fiber length, diameter, elongation, moisture absorbency and fineness as well as mechanical properties by analyzing its tensile strength test. The structural and functional characterization of the fiber is examined using the Scanning Electron Microscope (SEM) and IR spectroscopy (FTIR). The thermal behavior of the fiber is analyzed using the Differential Scanning Calorimetry (DSC).*

Keywords: Eichhornia crassipes, fiber properties, SEM analysis, FTIR analysis, DSC.

I. INTRODUCTION

Now a days the textile market has the trend of manufacturing go green products. Ultimately the consumers are also aware of buying ecofriendly fabrics [1]. Specifically the present textile market is available with plenty of ecofriendly products made of emerging natural cellulosic fibers with top ranking fibers such as organic cotton, hemp and sisal. But in such cases there is a possible risk of getting a plenty of resources for bulk and continuous production. Keeping such factors in mind, the new fiber sources are identified by the researchers and scientists. But the goal is to produce an improved and sustainable products made of fibrous material which can be used in textile industry in various aspects such as garments, upholsteries and interior decorations.

Natural fibers are the class of traditional fiber materials of renewable sources which experiencing a great revival now-a-days [2]. And especially the plant fiber has the characteristics such as resistance to water, thermal insulation and related characteristics. Thus the new plant fiber has been identified to decrease the pressure of handful number of species for the small scale industry [3, 4].

Today a vast resource from water sources like pond, river, ocean and dams has given a generation to new fibrous materials called water hyacinth. Water hyacinth is a free floating aquatic herb belongs to the family *Potederiaceae*, closely related to the *Liliaceae* (lily family). It reproduces rapidly using vegetative means. The plant has the weight gain of 4.8% per day and double in every 11-15 days of field observation. Hence the water hyacinth (*Eichhornia crassipes*) leads to serious problems and considered as a threat to bio-diversity, where it also affects the water transportation, canal irrigation and power generation by blocking waterways [5]. Several steps has been adapted to control the growth of *Eichhornia crassipes* and some research is also been carried out to destroy the weed completely [6].

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On the other hand, *Eichhornia crassipes* plant is considered as a valuable resource due to some of their unique properties. Several researches has been done in the last decade to utilize this weed in an economical way to produce the products of different aspects [7].

II. Materials

The fibers can be obtained in large number from the matured stalks than in the younger ones [8]. Hence the matured *Eichhornia crassipes* plants were identified and collected from the Cauvery river of Erode district, Tamilnadu, India. The matured plants are about 15-30 inches long and 0.15-1.2 inches in diameter [9]. The stalks were separated from the leaves and roots, washed thoroughly in water and dried in shade for 2-3 days. The fibers are then extracted from the dried stalks manually using the needles [10].

III. Methods

A. Physical Properties of Eichhornia Crassipes Fiber

a) Fiber Length

The *Eichhornia crassipes* fiber is analyzed for its length manually using a calibrated metal scale. The fiber was stretched on the flat table and straighten with care to avoid elongation while measuring. The results are expressed in centimeters.

b) Fiber Diameter

The *Eichhornia crassipes* fiber diameter is analyzed using a Scanning Electron Microscope (SEM). The average value can be calculated by analyzing the ten different areas of an individual fiber.

c) Single Fiber Tensile Strength and Elongation

The tensile strength of the *Eichhornia crassipes* fiber is tested according to ASTM D 3822 using eureka single yarn strength tester. The principle of the machine is constant rate of traverse were the preconditioned fiber sample is mounted between the two jaws having the gauge length of 15 cm. The strength and elongation of the fiber is determined and noted at the point of rupture.

d) Moisture Regain and Moisture Content

The moisture regain and moisture content of the *Eichhornia crassipes* fiber is analyzed manually using BIS and ASTM D 629 methods. The predetermined amount of fiber (A) is conditioned in oven at 105^0 C and the constant mass of the fiber is obtained (B). Thus moisture properties are calculated from the measured values using (1) for moisture regain and (2) for moisture content.

$$\text{Moisture regain} = A - B / B \times 100 \quad (1)$$

$$\text{Moisture content} = A - B / A \times 100 \quad (2)$$

e) Fiber Fineness

The *Eichhornia crassipes* fiber fineness is analyzed according to ASTM D 1577 test method. The fibers of selected length (2 inches) were cut and bundled to the nearest weight of 0.001 mg and the number of fibers in the bundle were counted. Randomly twenty bundles are selected for testing and the average was calculated.

B. Chemical Composition of Water Hyacinth - (FT-IR Spectroscopy)

The fresh *Eichhornia crassipes* stalks generally comprises of 90-95% of water [11]. The analysis has been made on the *Eichhornia crassipes* fiber extracted from dried stalks and the results were obtained. The fiber was examined for the structural and chemical information by analyzing under FT-IR Spectrophotometer. The fiber pellet was prepared using 2 mg of powdered specimen with KBr powder and compressed to 1 mm thickness. Then the pellet was studied under SHIMADZU 4200 type FT-IR spectrophotometer in the range of 600 – 4000 cm^{-1} with a resolution of 2 cm^{-1}.

C. Structural Analysis of Eichhornia Crassipes Fiber

The surface morphology of *Eichhornia crassipes* fiber is analyzed using Scanning Electron Microscope (SEM). The surface of the fiber is coated with gold using Edward Sputter coater apparatus and then observed at an accelerating potential of 10 kV.

D. Thermal Behavior of Eichhornia Crassipes Fiber (DSC)

The presence of transition temperature of *Eichhornia crassipes* fiber is analyzed using Differential Scanning Calorimetry (DSC) of NETZSCH STA 449F3 type instrument. The fiber sample of known weight was sealed in an aluminium pan and heated from 30^0 C to 500^0 C under nitrogen atmosphere at the heating rate of 10^0 C/min.

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IV. Result and Discussion

A. Physical Properties of Eichhornia Crassipes Fiber

The length of the fibre depends upon the plant selected for extraction. *Eichhornia crassipes* fiber has the length vary from 15 cm – 20 cm and diameter of 320 µm. The tensile strength of the *Eichhornia crassipes* fiber was determined by randomly choosing the 20 samples from a lot and the accurate results are determined. The tensile strength of the *Eichhornia crassipes* fiber range between 45.5 gf – 384 gf with the average of 212 gf. The mean elongation of the *Eichhornia crassipes* fiber is found to be 2.5 % and the standard deviation of 1.1 %. The moisture regain and moisture content of the *Eichhornia crassipes* fiber is found to be 17.64 % and 15 % respectively. *Eichhornia crassipes* fiber has the fineness of 7 tex which shows the fibre is least bulk. (See Table I)

Table I Mechanical properties of *Eichhornia Crassipes* fiber

Mechanical Properties	Values of *Eichhornia crassipes* fiber
Single fiber length	15 cm – 20 cm
Single fiber diameter	320 µm
Tensile strength	212 gf
Fiber elongation	2.5 %
Moisture regain	17.64 %
Moisture content	15 %
Fiber fineness	7 tex

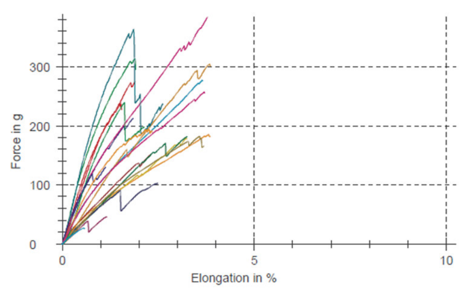

Figure 1. Tensile strength of *Eichhornia crassipes* fiber

The *Eichhornia crassipes* fiber has the water absorbency greater than that of cotton and other natural cellulosic fibers. Whereas the strength and elongation of *Eichhornia crassipes* is near to that of coir [12].

B. Chemical Composition of Eichhornia Crassipes Fiber - (FT-IR Spectroscopy)

The analysis has been made on the *Eichhornia crassipes* fiber and analyses shows that the fibre contains 63.75±0.24% (w/w) of cellulose, 12.33±0.08 % (w/w) of hemicellulose, 20.67± 0.13% (w/w) of lignin, 2.62± 0.05% (w/w) of ash and 0.65±0.02% (w/w) of extractives. The Spectroscopic study (FT-IR Spectroscopy) of the fiber shows the band at 1033.85 cm^{-1} & 1242.16 cm^{-1} of C-O stretching of strong intensity conforms the presence of cellulose, band at 1419.61 cm^{-1} of C-H bend of medium intensity shows the presence of lignin contents in the fiber [13].

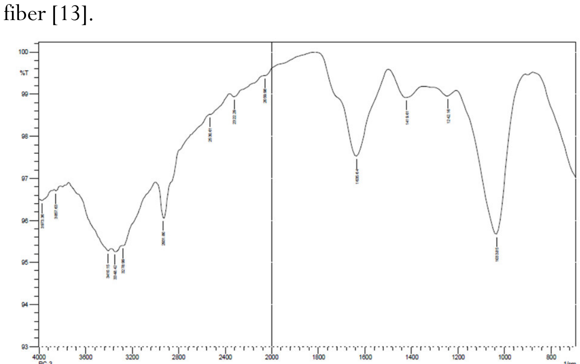

Figure 2. FT-IR Analysis of *Eichhornia crassipes* fiber

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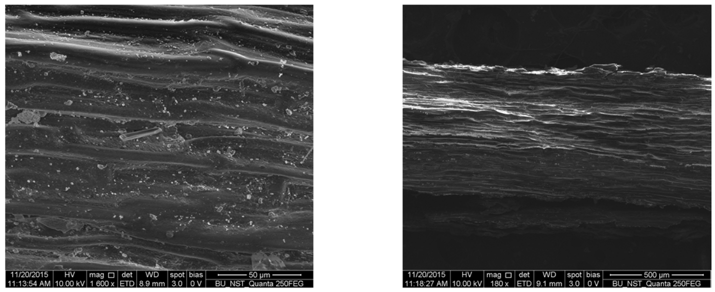
C. Structural Analysis of Eichhornia Crassipes Fiber

The SEM image is used to analyze the presence of lignin and hemicellulose coating over the cellulosic fibre [14]. The fibre density and composite properties are affected by the small empty spaced called voids or lumen of the fiber [15]. The figure shows the SEM analysis of *Eichhornia crassipes* fiber at the magnification of 400X (50 µm) and 180X (500 µm). The figure describes that the *Eichhornia crassipes* fiber are arranged as fibrills and has the hollow space describes that the fiber has the capacity to hold the liquid contents and also shows that the fiber has good absorbency.



(a) (b)

Figure 3. SEM Analysis of *Eichhornia crassipes* fiber (a) 50 µm (b) 500 µm

D. Thermal Behavior of Eichhornia Crassipes Fiber (DSC)

The Differential Scanning Calorimetry of the *Eichhornia crassipes* fiber was shown in the figure. The glass transition (T_g) of the fiber begins approximately in the range of 72.7^0 C. The natural fibre donot melt and has lacking melting point (T_m). The fiber withstands upto 498.3^0 C and left as residual mass without decomposing.

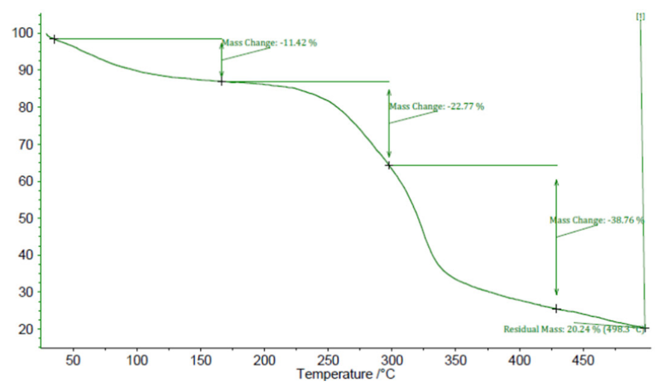


Figure 4. DSC/T_g Analysis of *Eichhornia crassipes*fiber

V. Conclusion

The investigation of water hyacinth (*Eichhornia crassipes*) proves that the fiber obtained from its dried stalk has good amount of cellulose, hemicellulose and lignin content which meets level of other available natural fibers. The fiber has good absorbency, medium strength and elongation. Less lignin content and high density of the fiber is more suitable for making non-woven and composites. DSC curves reveal that the fiber has good thermal resistivity suitable for acoustic materials. SEM analysis of the fiber shows that the fiber has many hollow pores which can be able to hold moisture and thus suitable for high absorbency materials such as napkins and wipes. As a result it is concluded that the water hyacinth (*Eichhornia crassipes*) stalks are the possible sources of fibers and a suitable alternate for presently available textile fibers.

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