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Investigating the Physical Characteristics of Sansevieria trifasciata Fibre

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Abstract- Sansevieria trifasciata fibre is a non – conventional lignocellulosic fibre extracted from the leaves of Sansevieria trifasciata plant. The extracted fibre was examined for its physical properties such as fibre strength, elongation, length, diameter and fineness. The fibre microstructure and functional elements were recorded using Scanning electron microscope and IR spectroscopy. Thermal properties and crystallinity index were analyzed using Differential Scanning Calorimetry and X- ray diffractometry.

Index Terms- Sansevieria trifasciata fibre, Physical properties of Sansevieria trifasciata fibre, FTIR analysis, SEM study, XRD, DSC

I. INTRODUCTION

The ecological aspect is gaining credence nowadays since people are more and more pollution conscious today than in the older days. Rapid industrialization and advancement in technology have added pollutants both to the product and to the environment. The situation has become so grave that our environment can no longer tolerate the deposition of pollutants. Among various polluting industries textile industry contributes to major portion due to chemicals which it uses rampantly at all stages from fibre to fabric. This has necessitated eco-friendly approaches in the production of textile materials which gains the attraction of the consumers. Ecofriendly textiles are those textile products which do not contain any hazardous or toxic substances and are bio degradable. The concept of eco-friendly and recyclable products are fully recognized which has brought natural fibres into focus.

There are many fibre yielding plants in our country, which have potential for use in diversified fields but they remain unexplored so far. The less explored natural fibres belong to leaf fibres. Hence in this work an attempt has been made to extract fibres from Sansevieria trifasciata leaves and it was examined for its structural aspects.

World wide there are more than 12 Sansevieria species present in different continents. The common species are S. cylindrica and S. trifasciata. S. trifasciata is also called as African bowstring hemp, leopard lily, tiger cat, mother – in – law's tongue, etc [1]. S. trifasciata (Fig. 1) is an herb with 2 – 6 leaves arising from the underground rhizome. The leaves has zedralike markings which are erect, sword – shaped, leathery with cross – banded dark and light green shades of 0.3 – 1 m long. The flowers are greenish white or grayish colour in fascicles on a raceme 40 – 75 cm long [2]. They grow anywhere in anything, in full sun or light shade but thrives well in a moist, fertile soil with a high organic matter content with minimum care [3].

Fig. 1 Sanseveria trifasciata Plant

II. EXPERIMENT

A.Materials

The S. trifasciata leaves were collected from the house garden in Salem district, Tamilnadu. The fibres were extracted from the leaves by stagnant water retting method (Fig. 2). Thus the extracted fibres were washed thoroughly to remove any traces of pulp adhering to the fibres and then they were dried in sunlight for about 5 – 7 hours to remove the moisture.

Fig. 2 Stagnant water retting

B. Methods

1) Breaking strength and elongation

Breaking strength of the fibres were tested using eureka single yarn strength tester according to ASTM D 3822. This instrument works on the principle of constant rate of traverse. The gauge length between the jaws was 15cm. The preconditioned fibre samples were fixed between the two jaws. After the rupture of the fibres the breaking force and elongation were noted.

2) Fibre length

The fibre length was measured using a calibrated metal scale by straightening the fibre over a flat table and the result is expressed in centimeters. Care should be taken that the fibre should not be elongated.

3) Diameter

SEM photograph of the individual fibres were used to identify the fibre diameter. To get accurate results scanning electron micrographs was taken at ten different areas and the average value was taken.

4) Fineness

The fibre specimen was tested for its fineness as indicated in ASTM D 1577 test method. A fibre bundle was cut in to the selected length (2 inches) weighed in an electronic balance in mg to the nearest 0.001mg and the number of fibres were counted in that bundle. Twenty fibre bundles were randomly selected for testing and the average was calculated.

5) Spectroscopic Study

S. trifasciata fibre was investigated by infrared technique with a SHIMADZU 4200 type FT-IR spectrophotometer (resolution- 2cm^{-1}) in the range of 400-4000cm^{-1}. Pellets were prepared mixing 2mg of powdered fibre sample with KBR powder of about 1mm thickness for identification.

6) SEM study

SEM analysis was performed to study the morphology of the fibre specimen by using a JEOL – MODEL 6390 electron microscope. The fibre surface was coated with gold before examination using Edward Sputter Coater apparatus and observed at an accelerating potential of 20Kv.

7) XRD analysis

X – ray diffraction gives distinct patterns for crystalline and amorphous regions which influence the physical properties of fibre. Wide – angle X – ray diffractogram of powdered fibre samples were analyzed using SHIMADZU (Model XRD-6000) with nickel filtered Cu Kα (λ - 1.5418Å) from an x-ray tube run at 40KV and 30Ma. The samples were scanned between the angles 0° - 90° to obtain the equatorial reflection.

8) DSC

The analysis of Differential Scanning Calorimetry was performed using the Mettler Toledo DSC 822e to assess the presence of transitions temperature in the fibre. The fibre sample of known weight was taken in a sealed aluminium pan. The sample was heated from 36°C to 400°C under nitrogen atmosphere at the heating rate of 10°C/ min.

III. RESULTS AND DISCUSSION

Now it is the time to articulate the research work with ideas gathered in above steps by adopting any of below suitable approaches:

1. Physical properties

The breaking force of S. trifasciata fibre was measured as 376g which is higher than S. cylindrica with less elongation value. Length to breadth ratio is considered as one of the essential properties of the textile fibre to convert into a yarn. The fibre should be atleast 100 times longer than its diameter or breadth with ratio of 100 : 1 [4]. Thus S. trifasciata fibre has L/D ratio value of around 4800 which is higher than majority of the natural fibres. The fibre diameter determined using Scanning electron microscope ranges between 112 µm – 128 µm with the average of 120 µm. The coefficient of variation (CV%) of the diameter was found to be 3.89 with the standard deviation value of 4.67. The fibres lack crimp when seen neither through naked eye nor under microscope. S. trifasciata fibre is finer than other leaf fibres with value of 9.8 tex. This increased in fibre fineness results in improved surface contact between fibre and matrix [5].

Table.1 Physical properties of Sansevieria fibres

Fiber Tests	**S. trifasciata fiber**	**S. cylindrica fiber**
Breaking force (g)	376.3	334
Elongation (%)	2.1	3.6
Length (cm)	109	117
Diameter (µm)	120	-
Fineness (tex)	9.8	9.0

2. FT-IR Spectra

FTIR analysis is performed to study the organic and inorganic compounds present in the materials [6]. IR spectra of S. trifasciata fibres were shown in Table.2. The broad and strong IR peak in the band 3421 cm^{-1} was attributed to the hydrogen bonded OH stretching of polysaccharides present in the fibre [7]. The absorbtions at 2941 and 1659 cm^{-1} were due to C-H stretching and O – H – O vibrations of water molecules [8,9].

Table.2 Assignment of FT-IR peaks and their relative intensities

Wave number range (cm^{-1})	Intensity	Origin
3421	Broad and very strong	Hydrogen bonded OH stretching
2941	Sharp medium	C – H stretching
1659	Broad and strong	Absorbed water vibration
1542	Medium	CH_2 bending
1337	Medium	O – H in plane bending
1054	Broad and strong	C – O stretching
605	Medium	Out of plane vibrations involving ring structure

The bands located in the region 1542 and 1337 cm^{-1} are for CH_2 of aromatic ring present in the lignin content and O – H of the fibre [10]. The strong broad band at 1054 and 605 cm^{-1} were assigned to C-O and C – OH of plane vibrations which confirms the presence of cellulose I in the fibre [11,12].

3. SEM analysis

The SEM picture of S. trifasiata fibre sample was shown in Fig.3 at 300X magnification. The illustration of surface characteristics evidently explains that the fibrils are clear with clean and smooth surface [13]. The surface of individual cells is clearly visible perhaps due to low wax content.

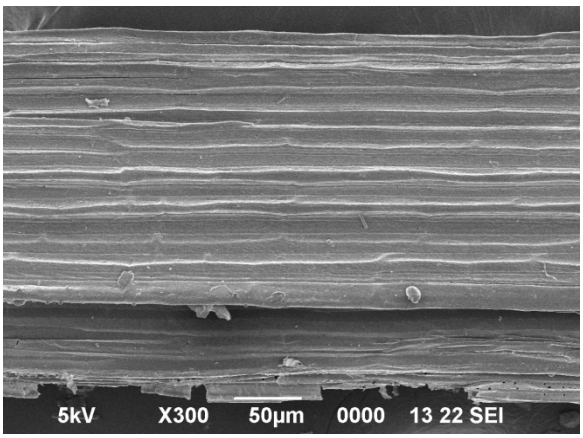

Fig. 3 SEM micrograph of S. trifasciata fiber

4. Degree of crystallinity

The crystallinity index and the degree of fibre orientation are two important qualities which influence the fibre properties [14]. The result of powdered XRD Fig. 4 shows two prominent diffraction peaks at 22.33° and 16.09°, which revealed the semi – crystalline nature of the fibre. The degree of crystallinity was found out as 70 % which is higher than other lingo cellulosic fibres.

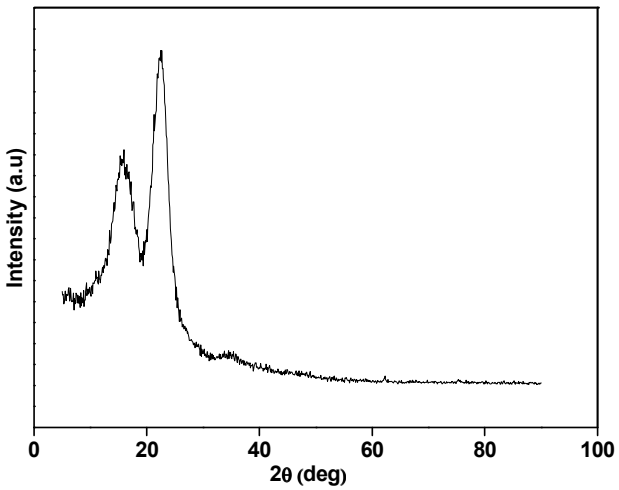

Fig. 4 XRD of S. trifasciata fiber

5. Differential Scanning Calorimetry Measurements

The DSC thermograms of S. trifasciata fibre was shown in Fig. 5. The glass transition (T_g) of the fibre begins approximately in the range of 50°C but in the case of sisal fibre the peak starts at 147°C. Since natural fibres do not melt they lack the melting point (T_m). The fibre withstands upto 350°C without decomposing [15].

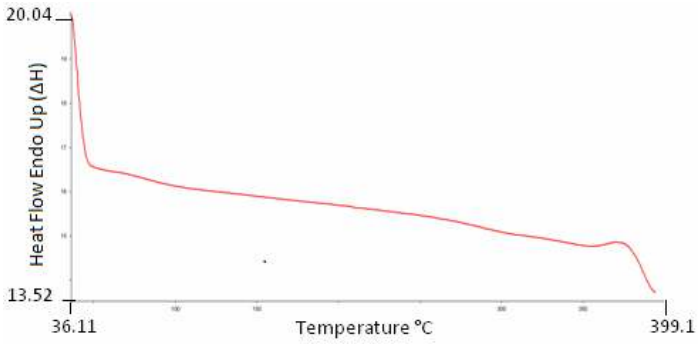

Fig. 5 DSC heating curve of S. trifasciata fiber

IV. CONCLUSION

S. trifasciata fibres extracted using retting method exhibits the following properties:

Physical properties show this fibre has good strength, fineness with low elongation. Length to breadth ratio of this fibre was 4800 which indicates that this fibre can be easily made into yarn of coarser count. FTIR examination confirms the occurrence of cellulose, lignin and polysaccharides in this fibre. The

microstructural analysis of S. trifasciata fibre depicts the presence of surface irregularities which provide good bond between the fibre and the matrix when used in the preparation of composites. The result of XRD shows that S. trifasciata fibre has semi crystalline structure which belongs to cellulose I_β with the diffraction peaks at (002) and (10$\bar{1}$) lattice plane. In addition the crystallinity percentage of S. trifasciata fibres is higher than those of cotton, bamboo and jute but nearer to that of ramie and flax. DSC measurement reveals that S. trifasciata fibre has unique property specifically capable of withstanding high temperature without any fibre degradation. Thus the above characteristics confirm that this fibre has wide scope in the field of textiles.

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