
Bamboo fibers: A Review
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Bamboo fiber is one of the new generation cellulosic fibers which are extracted from bamboo plants. It can be bast fiber or regenerated fibers based on its process of extraction. Bamboo fibers are getting very popular these days because of its unique properties in term of feel, comfort, natural shine, and its anti UV and antibacterial properties.

Botanically bamboo is a variety of grass. It belongs to the subfamily Bambusoideae of the family Poaceae. It is one of the fastest growing plants. Bamboos are found in tropical, sub-tropical or temperate zones which mainly consist of South Asia, south East Asia, South America and south east portion of the United States. The main country producing bamboo fibers is China. Mostly Phyllostachys pubescens and similar species are used to produce bamboo fibers. Phyllostachys pubescens is known as Moso bamboo in China. The chemical composition of Moso bamboo is given in the table below:

Chemical Name	Percentage
Cellulose	42 – 50 %
Lignin	24 - 26 %
Hemicellulose	24 – 28 %
Ash	1.3 – 2.0 %

Extraction of bamboo fibers

There are two different routes to manufacture bamboo fibers: Mechanical and Chemical methods.

The steps followed in mechanical method are described below:

1. The bamboo stems are cut into strips and crushed mechanically.
2. Crushed bamboo is boiled to loosen and remove inner fibers.
3. Degumming process is carried out using natural enzymes. After this process the crushed bamboo turns into a soft mass.
4. The soft mass is then dried and carded to get natural bamboo fibers.
5. The fiber length range 70 - 150 mm, but it can be cut into 38 - 40 mm for cotton spinning system. It can be spun as 100 % or be blended with other fibers such as cotton, viscose, modal, polyester etc.

This process is labor intensive and costly.

Figure 1: Fiber extracted from bamboo by mechanical method.

The chemical method is similar to that of production of viscose rayon from wood pulp. Regenerated bamboo viscose rayon was first manufactured in the year 2002 by Hebei Jigao Chemical Fiber Co. Ltd in China. The step wise process description of manufacturing of bamboo viscose is given below:

Preparation: The bamboo leaves, woody shoots, and soft inner pith from the hard bamboo trunk are extracted and crushed.

Steeping: The crushed bamboo is then soaked in 15 – 20 % solution of Sodium hydroxide at temperature between 20°C and 25°C for one to three hours to make sodium cellulose.

Pressing: Sodium cellulose is then pressed to remove any excess NaOH solution.
Shredding: Alkali cellulose is crushed by a grinder to increase its surface area for adequate reaction in subsequent process.

Ageing: The crushed sodium cellulose is left to dry for 24 hours in contact of air. Partial oxidation and breaking of molecular chains take place. This is very controlled process. Too much ageing will render inferior viscose solution.

Sulfurization: Carbon di sulfide is added to make jell of bamboo cellulose. The amount of Carbon di sulfide is one third of the bamboo cellulose.

Xanthation: The unreacted carbon di sulphide is removed by evaporation and the resultant mass is known as Sodium Cellulose Xanthogenate.

Dissolution: Dilute solution of sodium hydroxide is added to sodium cellulose xanthogenate to dissolve it and make viscous solution which contains about 5 % sodium hydroxide and 7 to 15 % bamboo cellulose.

Spinning: After subsequent ripening, filtering and degassing, the viscose bamboo cellulose is forced through spinneret nozzles into a large container of diluted sulfuric acid solution which hardens the viscose bamboo cellulose sodium xanthate and reconverts it into cellulose bamboo fibre filaments.

To make the process ecofriendly, N-methylmorpholine - N- oxide is used to dissolve the bamboo cellulose into viscose solution. Hydrogen peroxide is used as stabilizer. The spinning bath contains water, methanol or ethanol or similar alcohol.

Chemical Composition of bamboo fiber

Major content of bamboo fiber is cellulose. The cellulose content increases from raw bamboo to fiber during fiber production process. 90% of the dry weight of the fiber comprises of cellulose, hemicellulose and lignin. Protein, fat, pectin, tannins and pigments are also present in bamboo fiber. The IR and X-ray analysis show that the crystalline structure of bamboo fiber is cellulose I.

Physical properties of bamboo fibers

Structure

The longitudinal and cross-sectional views of original bamboo fiber are shown in the Figure2.

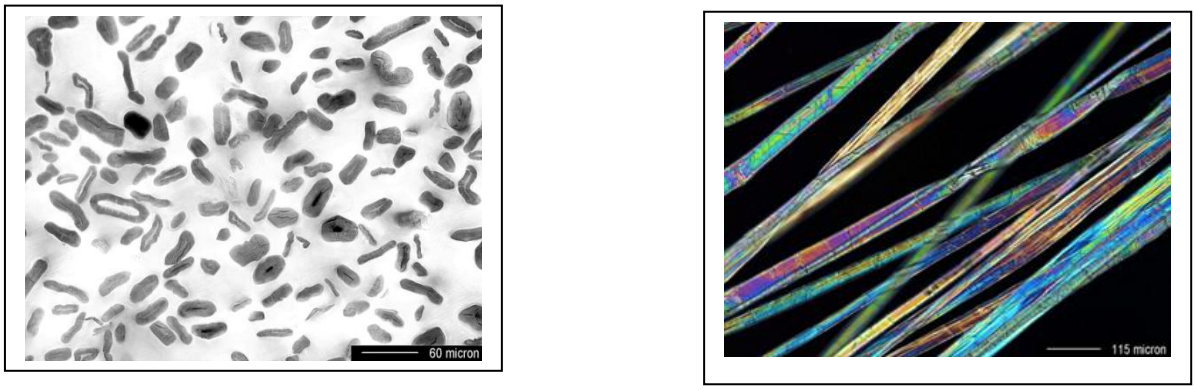

Figure 2: Cross-sectional and longitudinal views of original bamboo fiber

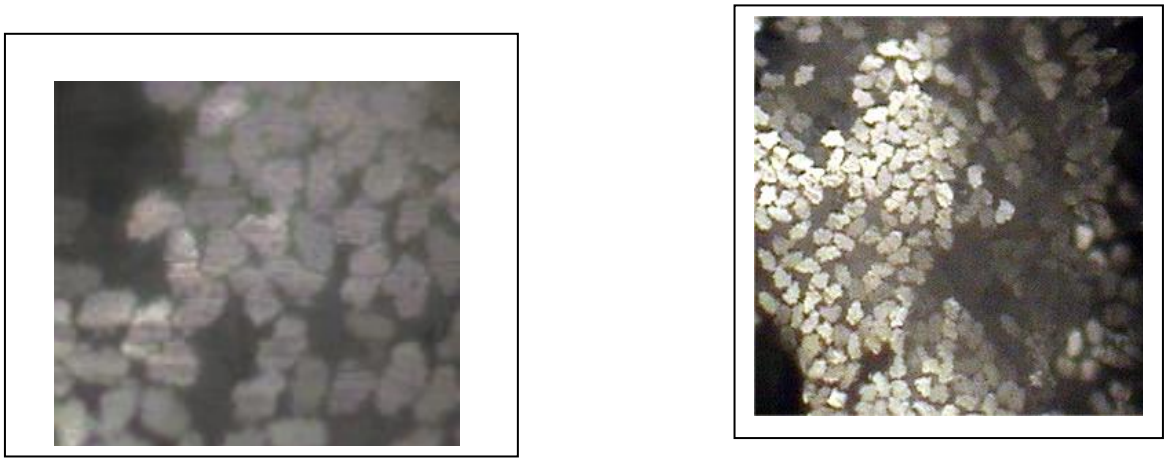

Figure 3: Cross-section of bamboo viscose rayon

The cross section of original bamboo fiber is very much varying from round to elongated ellipse. The cross-section shows cracks along the periphery of the fiber and lumen at the center. The cracks and groves along the edge of the fiber help to absorb and de-absorb moisture instantly by capillary action. The cross-section of regenerated bamboo fiber is very much similar to that of normal viscose rayon. The cross-sectional of bamboo viscose is shown in Figure: 3.

Length and fineness

The length of original bamboo fiber can range between 70 and 150 mm. They can be further cut in the range of 38 - 40 mm. The fineness range is 5.0 – 8.33 dtex. The fineness of bamboo viscose fibers can range from 1.33 dtex to 5.56 dtex.

Color

The color of bamboo fibers is white but fiber extracted by mechanical method is whiter than that of chemical method.

Mechanical Properties

Tenacity of both types of bamboo fibers are given along with other fibers for comparison in the table 1.

	Cotton	**Bamboo Pulp fiber**	**Original Bamboo**	**Lyocell**	**Viscose Rayon**	**Modal**	**Soybean**	**Wool**	**Silk**
Dry Tenacity cN/Tex	20 - 43	22 - 25	34.9	37 - 45	18 - 26	24 - 36	38 – 40	26 - 35	38 - 40
Wet Tenacity cN/Tex	27 - 56	13 - 17	13.7	30 - 39	9 - 15	12 - 24	25 – 30	8 - 10	21 - 28
Elongation at break %	6 - 10	14 – 24	5.1	12 - 16	15 - 25	13 - 25	18 – 21	14 - 25	11 - 16
Moisture Absorption %	7 - 8	10 - 13	13	11 - 12	10 - 16	12 - 13	8 – 9	13 - 18	11 - 14

The tensile strength of bamboo fiber depends on the process of making pulp from bamboo. The tensile strength also depends on portions of the plant used to extract fiber. Fibers extracted from the lower portion of the plant show higher tensile strength than at relatively higher height.

Antibacterial & UV protection Properties

The natural bamboo fiber contains “bamboo kun” which imparts the antibacterial, bacteriostatic and deodorizing properties to bamboo fibers. Bamboo kun protects bamboo growing in the fields. Bamboo viscose fiber has also good antibacterial effect against E. coli, staphylococcus aureus, Candida albicans and other harmful bacteria. The antibacterial property of blended fabrics decreases with decrease in the content of bamboo fiber.

Bamboo fibers possess good level of UV protection ability. The UPF value increases with increase in content of bamboo fiber in case of blended fabrics.

Breathability and cooling property

The apparels made from bamboo fibers are 1-2 degrees lower than normal apparels in hot summer. Apparel made from bamboo fiber is crowned as Air Conditioning Dress. Garment of bamboo fiber can absorb and evaporate human sweat very quickly. Such a garment makes people feel cool, comfortable and does not stick to skin in very hot summer.

Care

For bamboo fiber fabrics, cold washing with mild detergent is recommended. Hot washing will cause pilling and faster wearing of the fabric. Line or flat drying can be used for drying purposes. In case of using dryer, gentle cycle should be selected. Wet bamboo fabric has low tensile strength so there is possibility of distortion in the fabrics if dryer is set high. Low setting should be used for ironing.

Environmental Impact

The fibers are extracted from renewable bamboo grasses. It is one of the fastest growing plants on this planet. It can be harvested every one to three years. As bamboo is a grass, it does not require replanting. The cultivation of bamboo does not require pesticides. Bamboo requires less than 1/3 of the water that cotton uses in the growth phase. It also helps to cut down greenhouse gases. Bamboo sequesters more than five tons of CO_2 per acre and generates up to 35 % more oxygen compared to equivalent stands of trees. Besides this bamboo fiber is 100% biodegradable. It is also known as green fiber.

Applications

Bamboo fiber has got unique combination of characteristics such high moisture content, soft feel, shine, antibacterial, deodorizing and UV protective. 100 % bamboo fabric has natural shine and excellent drapability. Bamboo fibers are used for making of apparel, home furnishing products and medical textiles.
Bamboo fiber is used for making summer wear, underwear products, maternity wear, sport clothes, t-shirts and socks, towels, bathrobes, bedding sets, blankets and curtains.

Bamboo fibers are also used for making sanitary napkins, absorbing pads, masks, mattresses, bandages, surgical clothes, gauze, operating coat, nurse dresses etc. The baby diapers made of bamboo fiber perform better in terms of absorption capacity.

Conclusion

Bamboo fiber has got unique combination of properties and is used to make apparels, home furnishing products and textile based products in medical applications. It is 100 % biodegradable and is extracted from bamboo plants which is a renewable source. There is need of a lot of research in the area of fiber and yarn manufacturing to reduce the cost of production and improve performance quality.

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