Modern Applied Science

www.ccsenet.org/journal.html

Vol. 1, No. 4

November 2007

Structure and Property of Mulberry Fiber

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Abstract

In this paper, the chemical ingredients of mulberry bast was tested by quantitative analysis. Our objective was to substitute the slow and difficult to control retting process by a fast and well controlled process, i.e. the two-step boiled process treatment (TSBP) of mulberry bast which was treated by mechanism. During the TSBP treatment the pectin, Lignin and hemicelluloses are hydrolysed and rendered in water or alkali-soluble, the fibers being more easily degummed. The TSBP treatment was among the best conditions for the degumming and individualisation of the fibers. The two-step boiled samples were tested. The results indicated that the length of mulberry fiber is 23.0-35.0mm, fineness is 2.3-3.5 dT, breaking tenacity is 5.0-10.0cN/dT, breaking extension rate is 3.5-5.5%, moisture regain is 9-10%. The samples were observed by scanning electron microscopy (SEM), and the morphological aspects of the mulberry fibers are discussed.Structural disruption was observed by X-ray measurement.

Keywords: Mulberry fiber, Chemical composition, Degumming, Properties, Microscope, X-ray

1. Introduction

Considering to environment, more and more people pay much attention to the natural fiber resources. It is important to research new natural fiber resources, with the development of these conventional textile fiber resources (for example cotton and bast, silk, wool and so on). The mulberry fiber is a kind of natural cellulose textile fiber, which obtained from mulberry bast by degumming. In recent years, the domestic and foreign researchers pay much attention to the mulberry fiber.

It is the glorious history to plant the mulberry trees and raise silkworms in China. There are many kinds of mulberry and they are distributed a considerable extent. Since then, the mulberry leaves was carried to raise silkworms, but after the mulberry leaf was picked, the rest of mulberry branches must be cut down. It provides the massive raw material to extract the mulberry fiber. The natural mulberry fiber was named “green textile” or “ecology textile”, it both has cotton's characteristic and many hemp textile fiber's merits. It has the vital significance to develop the mulberry fiber.

2. Experiment

2.1 Materials

The material used in this study were supplied by Weifang Shandong province in China. The bast of mulberry were scutched by manual treatment in order to separate the shives from the fiber bundle strands. All the mulberry fibers used in this research were degummed by the following technology. The mulberry bast were subjected to pretreatment with hydrogen peroxide (7g/L) and urea (10g/L)at 75℃ for 1.5h using a material to liquor ratio of 1:15 and pH 9. The two-step boiled process were extracted with 10g/L NaOH (100℃,1h)and 12g/L NaOH, 8% sodium polyphosphate, 8%sodium silicate (100℃,4h) using a material to liquor ratio of 1:10. After alkali extraction, the samples were washed with running tap water followed by distilled water until no alkali was present in the wash water.

2.2 Chemical analysis.

The chemical ingredients of mulberry fiber were tested according to the GB5889-86 Method of quantitative analysis of ramie chemical components.

2.3 Scanning electron microscopy

The original and steam exploded mulberry samples after several successive extractions, were observed using a KYKY-2800 scanning electron microscope operating at 20 kV, after sputter-coating with gold-palladium.

2.4 X-ray scattering analysis

The samples were cut and pressed into a disk using a cylindrical steel mold (Φ=1.3 cm) with an applied pressure of about 7000kg/cm^{2}in a laboratory press. Ni-filtered CuKa radiation (l=0.1542 nm) was generated at 40 kV and 35 mA using a Bruker D8 X-RAYS. The X-ray diffractograms were recorded from 10 to 44.5^o, 2θ (Bragg angle) by a

goniometer equipped with scintillation counter at a scanning speed of 0.05[i]/s and a sampling rate of 2 data/s.

3. Results and discussion

3.1 Chemical composition

From the literature, the chemical composition of mulberry varies, according to the species, the area of production and the maturation of the plant. Tables 1 shows the mulberry bast contain mainly cellulose(44.3%), lignin (9.6%),pectin (22.7%), water soluble substance (18.8) and a smallamount of wax (1.7%) and others.

Table 1. The Chemical Ingredient of mulberry bast and the other kind bast fiber (%).

	Cellulose	Lignin	Pectin	Water Soluble substance	Wax	Ash
Mulberry	44.3	9.6	22.7	18.8	1.7	
hemp	78.1	6.2	6.7	2.1	1.4	0.8
Linen	80.5	5.2	3.7	3.4	2.7	1.1

3.2 Physical properties

The fabric properties of the durability, feeling, draping and comfortable are affected by the length, fineness and regain of the fiber. Therefore, we research the several properties of mulberry fiber. The result was in table 2.

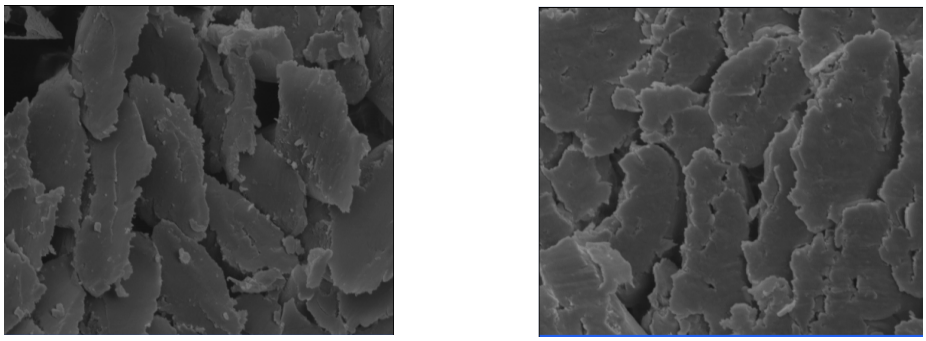
Table 2. The indexes of the mulberry fiber with the other natural fibers

	Mulberry fiber	Cotton	Linen
Length(mm)	23.0-35.0	23.0-31.0	60.0-250.0
Fineness (dT)	2.3-3.5	1.6-2.5	2.8-6.7
Breaking tenacity (cN/dT)	5.0-10.0	2.7-4.4	4.5-4.9
Breaking extension rate (%)	3.5-5.5	5-7	2-2.5
Moisture regain (%)	9-10	7-8	12.13

Table 2 shows that the length and the breaking extension rate of mulberry fiber are similar to cotton. The average fineness of mulberry fiber is thicker than cotton and it is similar to linen. The breaking tenacity of mulberry fiber is higher than any other fibers, and its moisture regain is lower than linen and higher than cotton, which indicates that the softness of mulberry fiber is acceptable.

3.3 Scanning electron microscopy

3.3.1Lateral-sectional structure



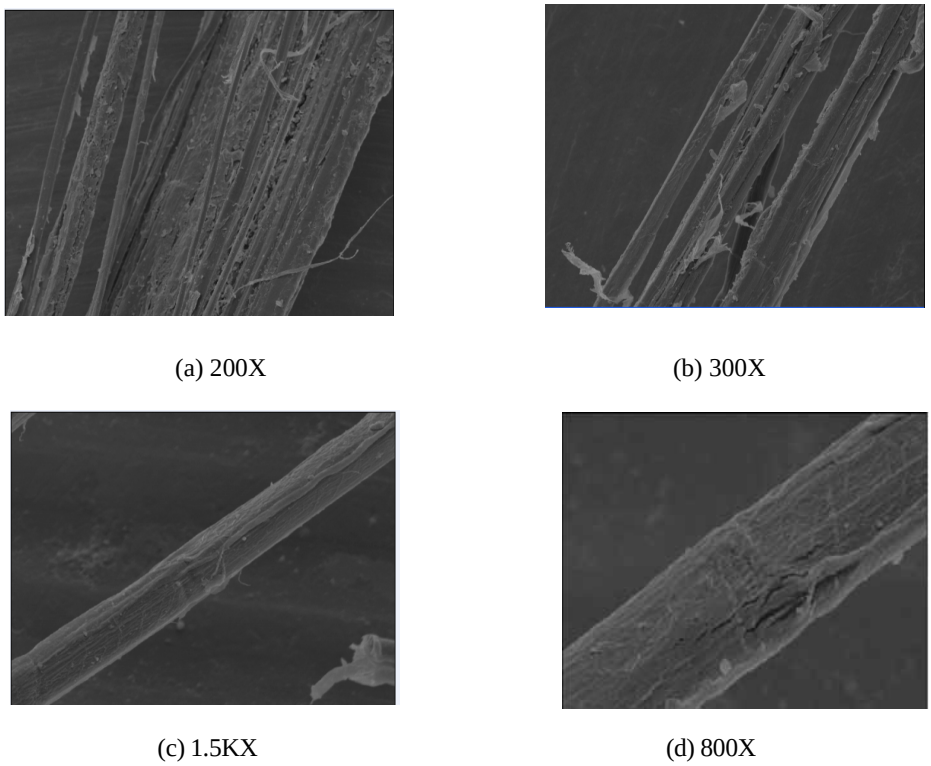
1.0KX 1.5KX

Figure 1. SEM of mulberry fiber

Figure 1 shows SEM photographs of the mulberry fiber lateral-sectional structure. The lateral-section structure of mulberry

fiber have some different shape, such as triangle, ellipse and polygons, in which the ellipse is majority. The lateral section center has the mesocoele.

3.3.2 The appearance of the mulberry fiber



(a) 200X (b) 300X

(c) 1.5KX (d) 800X

Figure 2. SEM images of (a) and (b) raw; (c) and (d) steam treated mulberry fiber.

Figure 2 shows SEM photographs of the original and steam treated mulberry fibers samples. It can be seen that most of the non-cellulosic components were removed after treatment. The fibers were separated into single. The surface covered with small lignin droplets and pectin is removed during the sodium hydroxide extraction, but the sodium hydroxide extraction resulted in some damage to the fibers. We can observe, the surface of the fiber is no longer smooth, but covered with grooves and ridges.

3.4 X-ray scattering results

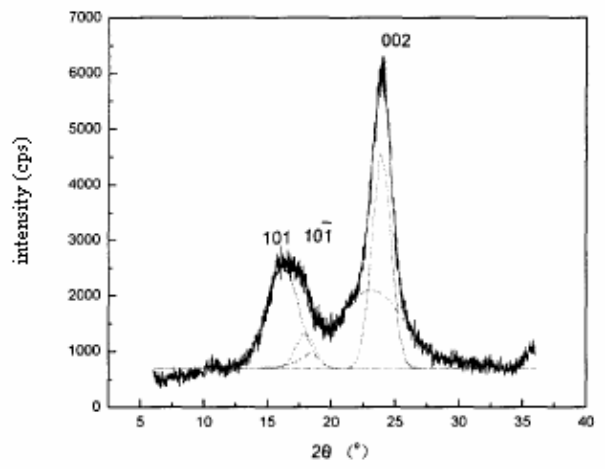


Figure 3. X-ray diffractogram of untreated and treated mulberry fiber

Figure 3 shows X-ray diffractograms of the untreated and steam extraction mulberry fibers. The major diffraction planes of cellulose namely 110, 11_0 and 020 are present at 15, 17, and 22.5º, 2èangle. Untreated fiber shows the characteristics of cellulose I. the alkaline treatment with NaOH caused no change to the cellulose structure. However, it caused an increase in intensity of the 020 plane. It is important to note that the crystallinity index was used to indicate the order of crystallinity

rather than the crystallinity of crystalline regions. This brought about the idea to measure the changing of each crystalline plane in cellulose separately. The crystalline order index was determined from the fraction of the ratio of the 020 to the sum of 110, 012 and 020 reflection areas. There was a variation of results in the solvent extracted sample. The crystallinity of fibers treated by NaOH was increased.

References

C. Garcia-jaldon, D. Dupeyre and M. R. Vignon. Fibres from Semi-retted Hemp Bundlesby by Steam Explosion Treatment. *Biomass and Bioenergy* Vol. 14. No. 3.

Hu, Rongxiu. (1990).*Preparation and Application of Mulberry Fiber Filter Paper*. CN1038474.

Hua, Jian and Peng, Xuedong . (2003). Structure and Property of Mulberry Fiber. *Silk*.10.

Jing Xueqian, Yang Peipeng and Wu, Hailiang. (2006). Preliminary study on Degumming Procedure of Mulberry Fiber. *Plant Fibers and Products*. 4.

Kawahara and Yutaka. (1999). Characterization of Microvoids in Mulberry and Tussash Silk Fibers Using Stanic Acid Treatment. J.*App1.Polym*. Sci. 73.3.

Mwaikambo LY and Ansell MP. (2002). *Journal of Applied Polymer Science*. 84.

Qiu, Xunguo and Yan, Qunsong. (2002). Development and Utilization of mulberry fiber. *Liaoning Tussah Silk*. 4.

S. Ouajai and R.A.Shanks. (2005). Composition. structure and thermal degradation of hemp cellulose after chemical treatments. *Polymer Degradation and Stability*. 89. 327-335.

Yin, Lide. (1996).*Development and Application of Mulberry fiber*. CNl137071.12. 04.