Study on Structure of Oxidized Raw Bamboo Fiber Treated with Sericin Protein

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Abstract: In order to improve the finishing effect of raw bamboo fiber treated with sericin protein, it was selectively oxidized by $NaIO_4$ and then treated with sericin solution. The morphology and structure of sericin proteinic raw bamboo fiber were analyzed by means of SEM, XRD, TG and DSC. The treatment results show that sericin protein could be directly coated onto the oxidized raw bamboo fiber without any other reagent and a covalence was formed between amido and aldehyde group. After being treated with sericin protein solution, the thermal stability and crystallinity of the oxidized raw bamboo fiber improved and the surface became smoother.

Keywords: Sericin protein, raw bamboo fiber, oxidation, structure, treat.

1. Introduction

Raw bamboo fiber is a new type of natural cellulose fibers extracted from bamboo by mechanical and physical methods. It has attracted extensive attention because it possesses excellent properties such as hygroscopic permeability, regeneration, and antibacterial property. However, raw bamboo fiber is rather rough and harsh and has great rigidity, all of these results in poor wrinkle resistance and scratchy sense in its wearing characteristics. These shortcomings limit its applications and development in high value-added textiles.

Sericin is a kind of water-soluble spherical protein, which possesses soluble, absorbent, antioxidant characteristics, gelation and so on. Sericin is made up of eighteen kinds of amino acids, of which eight kinds are essential for health of human beings. Therefore, sericin possesses affinity and health caring features. If we can graft sericin protein to raw bamboo fiber, we can not only alleviate scratchy sense, enhance crease-resistant property and UV-protective ability, but also get the silk-oriented effect. However, there is a shortage of those groups that can result in covalent crosslinking with cellulose in the sericin protein molecular structure, which will lead to relatively low fixation rate of sericin. In order to improve the modification effect of raw bamboo fiber treated by sericin protein, in this paper we firstly use $NaIO_4$ to implement selective oxidation on raw bamboo fiber. Then we use sericin protein solution to modify oxidized raw bamboo fiber. After the oxidation, the aldehyde groups on the surface of raw bamboo fiber will react with amino-groups in the sericin protein. Thus we can get sericin protein oxidized raw bamboo fiber.

In this paper, we use FT-IR to get the crystal structure of sericin protein oxidized raw bamboo fiber. And we also analyse its form, morphological structure and thermal property with the help of freeze cracking SEM, X-ray diffraction, thermal analysis and so on.

2. Experimental materials

2.1 The preparation of oxidized raw bamboo fiber

Weigh some raw bamboo yarns (29.5 tex) which have been scoured and bleached, put them into brown beaker flask and add a certain density of sodium periodate solution into it. Under a constant condition of 40℃, oxidize them in a shaking water bath pot in the dark for two hours. Then immerse them into glycerin solution (0.1*mol/L*) for one hour so as to remove the Unreacted sodium periodate. After that, we use deionized water to wash them fully and then immerse into deionized water for 24 hours. Thus the oxidized raw bamboo fiber is obtained. Further it is Dried and made to equilibrium and sealed for use.

2.2 The preparation of sericin protein oxidized raw bamboo fiber

Put the oxidized raw bamboo yarn into a certain density of sericin protein solution according to liquor

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ratio 1:30. Treat it under 30-100℃ for 0.5-5 hours, pre-dry it under 80℃ for 5 minutes, dry it under 150℃ for 3 minutes, wash it fully and air-dry it naturally.

3. Experiment test and apparatus

(1) Fourier infrared spectroscopy characterization
Apparatus: Infrared Spectrometer Nicolet 5700;
(2) Microstructure test
Apparatus: Scanning Electron Microscope S-570;
(2) X-ray diffraction test
Apparatus: X-ray Diffraction Apparatus Rint 2027 (made in Japan)
(4) Thermal analysis
Apparatus: Thermal Analysis Apparatus Diamond TG-DTA

4. Results and discussion

4.1 Infrared spectrum analysis of oxidized raw bamboo fiber treated by sericin protein

We use $NaIO_4$ to oxidize raw bamboo cellulose, which can cut the C_2-C_3 Chemical Bond in cellulose glucopyranose units (I), the two adjacent hydroxyl groups in the C_2 and C_3 position can be selectively oxidized into aldehyde groups, then 2,3-dialdehyde cellulose (II) is formed. The aldehyde groups have high activity, which possess the ability of forming covalent interaction with the amino-groups in sericin protein mocleular chain. They can react to form schiff base and coat on the surface of oxidized raw bamboo fiber, so the sericin proteinic raw bamboo fiber is prepared (Ⅲ). The reaction theory is shown in Figure 1.

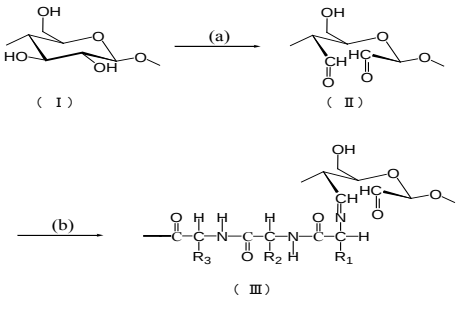

Figure 1 The reaction model of sericin protein and oxidized raw bamboo fiber.
(*a*) The selective oxidation of raw bamboo fiber
(*b*) The reaction of sericin protein and oxidized raw bamboo fiber

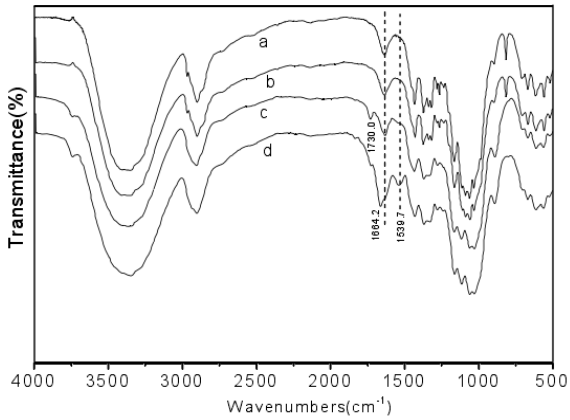

Figure 2 FT-IR spectra of raw bamboo fiber.
(*a*) raw bamboo fiber
(*b*) raw bamboo fiber treated by sericin protein (3*wt%*)
(*c*) oxidized raw bamboo fiber(4*g/L* $NaIO_4$, 2*h*)
(*d*) oxidized raw bamboo fiber treated by sericin protein(3*wt%*)

FT-IR spectra of raw bamboo fiber samples before and after treatment are shown in Figure 2. We can see that curve (b) is similar in shape to curve (a) and there is no obvious change in characteristic peak, which show that non- oxidized raw bamboo fiber has no chemical cross-linking with sericin protein. This is because raw bamboo fiber does not have the groups that can react with sericin protein macromolecules directly, thus there can not take place any chemical cross-linking reaction. Only a little sericin protein can be attached to the fiber by the way of physical absorption and will shed readily. While raw bamboo fiber is oxidized by $NaIO_4$, its infrared spectrum changes greatly. Comparing curve (*c*) with curve (*a*), we can see that characteristic peak of aldehyde group appears at the point of 1730cm^{-1}, which indicates that we can know raw bamboo fiber has been oxidized into dialdehyde cellulose. After being treated by sericin protein solution, characteristic peak of aldehyde groups (C=0) weakens, and a new characteristic peak appears at the point of 1539cm^{-1}(C-N) and 1664cm^{-1}(C=N). It shows that raw bamboo fiber is oxidized into active aldehyde groups, and the active aldehyde groups can combine with the amino-group on the sericin protein globin chain and form imine structure. Meanwhile, the corresponding wavenumber of stretching and vibrating absorption peak (O-H) in infrared curve (*d*) changes from 3350.9cm^{-1} to 3348.8cm^{-1}, it moves to the direction of lower wavenumber and the absorbance peak becomes sharp. All of these show that part of the aldehyde groups and hydroxyls in the oxidized raw bamboo fiber molecule can combine with polar groups on the sericin protein globin chain to form hydrogen