EFFECT OF TEMPERATURE ON BAMBOO OXIDANT-PROCESSING

by

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Oxidant-processing was applied to treat bamboo to remove bamboo's lignin. Various oxidants were adopted to investigate the possibility of oxidizing bamboo lignin. The paper concluded that temperature is the main factor of oxidant performance.

Key words: *temperature, bamboo, oxidant-processing*

Introduction

Bamboo is a perennial evergreen and fast-growing renewable resource, which possesses excellent anti-microbial, anti-ultraviolet, ammonia, and ill-smelling removing properties [1]. It offers great potential to be a new and primary material for textile fiber. Bamboo natural fiber inherits the superior properties of bamboo timber and has been classified into bast fibers in textile area.

Degumming is the major process to get the fibers from the raw plant materials. Typical degumming mainly relies on hot concentrated alkaline to remove the non-cellulosic substances, which causes severe environmental pollution and inevitable damages on fiber qualities. [2] Thus, more attempts are made to seek a sustainable way to reduce or avoid the pollution. Previous work on bast fiber extraction indicated that oxidants can be the substitutes for alkaline to carry out the chemical degumming and reduce the pollution on the environment. [3]. However, the structure and the main components of bamboo differ much from the traditional bast materials (ramie and flax). Bamboo timber shows extraordinarily compacted structure and contains more non-cellulosic substances (mainly lignin and xylan). Therefore, the requirement for degumming is higher. Pretreatment is helpful to open bamboo structure and make oxidants further penetrate into the bamboo.

In this work, various oxidants were applied to treat bamboo with the purpose to remove the main part of bamboo non-cellulosic substances, *i. e.* lignin. Temperature, regarding as the main factor to influence oxidant performance, was investigated here.

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Materials and methods

Materials

Two-year-old bamboo (*Phyllostachys*) was harvested from Zhejiang province, China. The epidermis was removed and the remaining bamboo culm was cut into strips. Bamboo strips were boiled in the diluted alkaline liquid to soften the structure and then laminated by glass rod and rinsed by diluted acids. Finally, the crude bamboo bundles were obtained and were kept for further oxidant processing. Various oxidants, including sodium percarbonate, sodium persulfate, sodium perborate, carbamide peroxide, and hydrogen peroxide, were involved to treat the crude bamboo bundles. The effective oxidation capacity was evaluated by the iodimetry method.

Methods

(1) Oxidant-processing on crude bamboo bundles

Five gram of crude bamboo bundles were placed in the Erlenmeyer flasks with a total solid-to-liquid ratio of 1:20. Various oxidants solution with the same oxidating capacity equals to 0.03 mol/L H_2O_2 were applied to treat the crude bamboo bundles. The reactions were carried out at pH 9 for 2 hours. Different treating temperatures, including 20 °C, 35 °C, 50 °C, 65 °C, 80 °C, and 95 °C, were tried to evaluate the influence toward oxidant-processing. After treating, all the samples were rinsed with hot water and boiled for 30 minutes to stop the oxidant reaction and avoid over oxidation of samples.

(2) Evaluation of oxidant-processing on bamboo

The ultraviolet spectrum of reaction liquid was recorded on a TU-1901 ultraviolet spectrophotometer (Purkinje General Instrument Co., Ltd., Beijing, China) to fast detect the content of dissolved lignin. Meanwhile, the reaction liquid was filtrated and evaporated to obtain the precipitates for Fourier transform infrared spectroscopy (FTIR) analysis using KBr pellets. Spectra were recorded on a FTIR spectrophotometer (Avatar380, USA) in absorption mode at 2 cm^{-1} interval over the wavelength range of 4000-500 cm^{-1}. The lignin content of oxidant-treated bamboo and the original bamboo were measured according to the method of GB5889-86 (the standard method of quantitative analysis of ramie chemical components of China).

Results and discussion

Effect of temperature on oxidant-processing

The effect of temperature on oxidant-processing are shown in fig. 1. The highest peak in the absorption spectra appeared at the wavelength of 290 nm, which is the characteristic wavelength for lignin. The lignin content is in direct proportion to the peak intensity. It is clearly presented in fig.1 that with the increase of temperature, the peak intensity raised. In other words, more lignin were removed from the bamboo and dissolved in the reaction liquid. When the treating temperature was below 50 °C, the effect of oxidant-processing was limited. The highest lignin yield was obtained when the temperature reached 95 °C. Therefore, high temperature benefited the oxidant-processing.

Characterization of the precipitates removed from bamboo

Figure 2 shows the FTIR spectra of precipitates removed from bamboo by oxidant-processing.

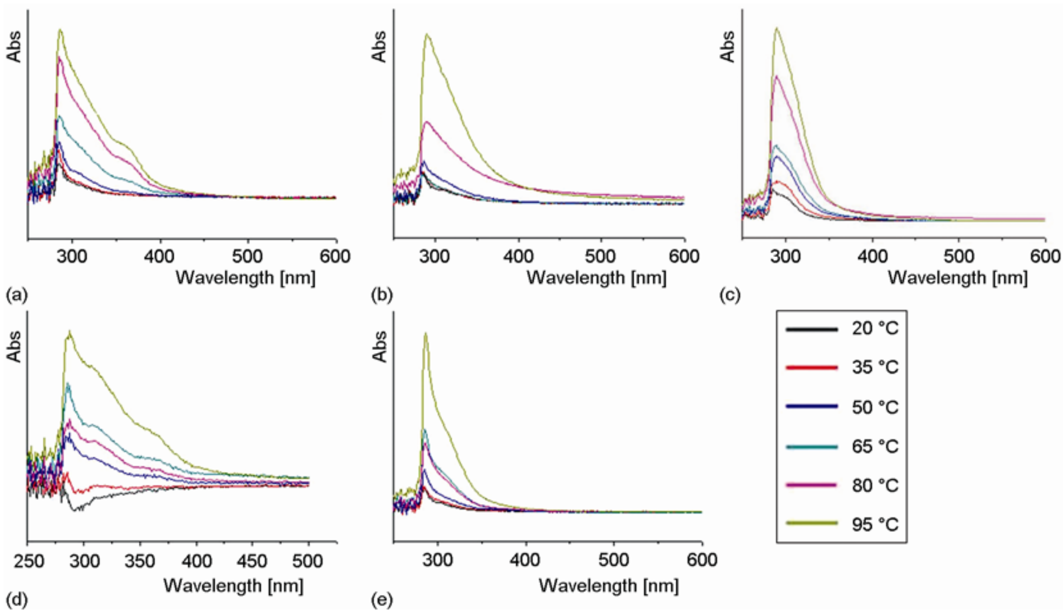

Figure 1. The ultraviolet spectra of reaction liquid; (a) sodium perborate, (b) sodium persulfate, (c) carbamide peroxide, (d) sodium percarbonate, (e) hydrogen peroxide

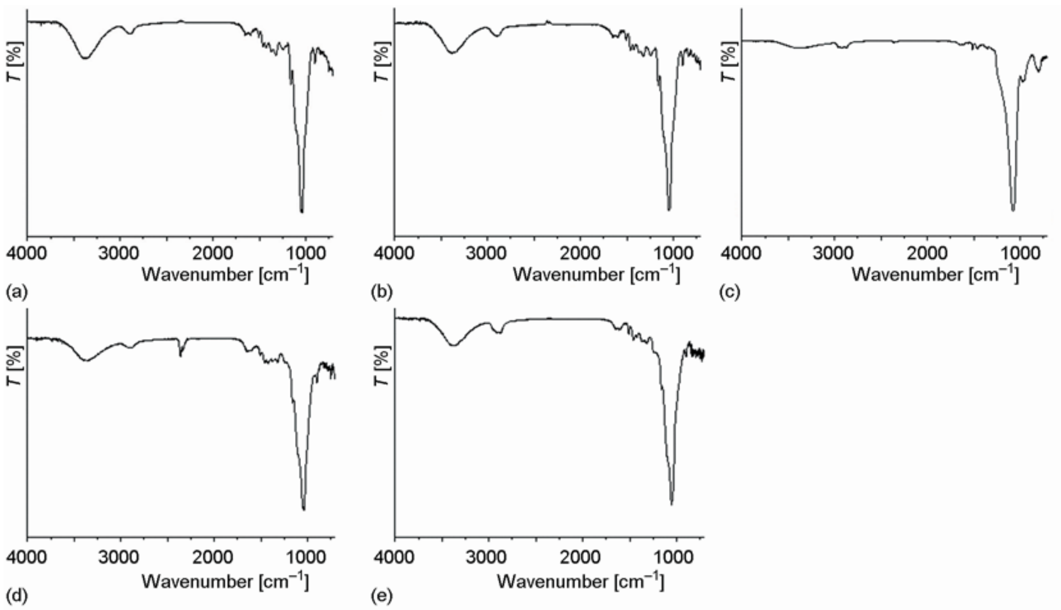

Figure 2. The FTIR spectra of precipitate removed from bamboo; (a) sodium perborate, (b) sodium persulfate, (c) carbamide peroxide, (d) sodium percarbonate, (e) hydrogen peroxide

Bands in the range from 1 632 cm^{-1} to 1 654 cm^{-1} were attributed to absorbed water and C=O stretching of lignin. Bands at 1450 cm^{-1}, 1500 cm^{-1}, 1580 cm^{-1}, and 1600 cm^{-1} were attributable to skeleton stretching vibration of aromatic rings, which were mainly concerned with the lignin in bamboo. Bands at 1460 cm^{-1} and 1380 cm^{-1} were the characteristic absorption peak from methylic. A band at around 1045 cm^{-1} indicated the existence of carboxylic ester, and a band at 966 cm^{-1} proved the presence of double bound structure with trans configuration. Bands in the range from 850 cm^{-1} to 900 cm^{-1} indicated the substitution structure on the 5th position of benzene ring. Bands in the range from 800 cm^{-1} to 860 cm^{-1}, and the range from 750 cm^{-1} to 800 cm^{-1} revealed the existence of benzene ring structure with two and three adjacent hydrogen, respectively. These observations seemed to point out that the precipitates were mainly composed of oxidized lignin.

Lignin content analysis

Analysis indicated that lignin content of bamboo treated by hydrogen peroxide, sodium percarbonate, sodium perborate, carbamide peroxide, and sodium persulfate reached 17.32%, 20.56%, 14.26%, 19.77%, and 18.53%, respectively. Compared with the lignin content of 24.74% in original bamboo, oxidants can help to remove lignin in bamboo through oxidation.

Conclusions

We have investigated the oxidant-processing on bamboo materials at different temperatures. It is concluded that for all the oxidants tried in this work, including sodium percarbonate, sodium persulfate, sodium perborate, carbamide peroxide, and hydrogen peroxide, high temperature of 95 °C benefited the oxidation of lignin, thus helped to remove the lignin from bamboo. This work paves the way for developing the oxidant-processing for bamboo fiber extraction.

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