

Some Physical Properties of Alkali-Treated Bhindi Fiber (*Hibiscus esculentus* linn.)

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Synopsis

Structural features of bhindi fiber have been studied by X-ray diffractometry, scanning electron microscopy, and infrared spectroscopy. The fiber has multicellular structure and on alkali treatment, it behaves like other lignocellulosic fibers. Infrared spectra indicated that alkali degradation of cellulose and hemicellulose was quite significant in the fiber and that substantial portion of uronic acid was removed as a result of alkali treatment.

INTRODUCTION

Bhindi fiber is lignocellulosic like jute fiber.¹ Bhindi fiber is obtained from the stalk of the bhindi plant by decortication and retting. It contains 10% lignin, 30% hemicellulose, and 53.5% α -cellulose as major chemical constituents.² Due to a short supply of raw materials in the pulp and paper industry, bhindi fiber may be used as raw material for manufacture of pulp and paper.

The main characteristics of bhindi fiber are its high α -cellulose content (53.5%) and low lignin content (10%), which indicate its potential for utilization as raw material in pulp, paper, and other cellulose based industries.³ For textile purposes, only coarse yarn can be produced from these fibers when processed in jute machinery along with jute.⁴

Structural transformation after alkali treatment was examined by X-ray diffraction and infrared spectroscopy and the surface structure by scanning electron microscopy.

This work was undertaken because no work has yet been systematically done on these properties of the fiber.

EXPERIMENTAL

Materials

The bhindi stalk was of desi 5 (five) edged variety, 196 days old. The samples were collected after the vegetable (pod) was harvested from "Krishi Vigyan Kendra," Nimpith, 24-Paraganas, West Bengal, India. The stems (stalk) of the plant were washed, cleaned, and decorticated following the method adopted for Ramie.⁵ The decorticated fibers were then retted chemically⁶ by treatment with 0.5% ammonium oxalate at 75–80°C for 8 h, and the resulting fibers were thoroughly washed with water and air-dried. The fibers were cleaned by light combing without damaging them.

The fiber sample was treated with alkali (sodium hydroxide, w/v) solution of different concentrations (i.e., 5%, 10%, and 18%) for 1 h at room tempera-

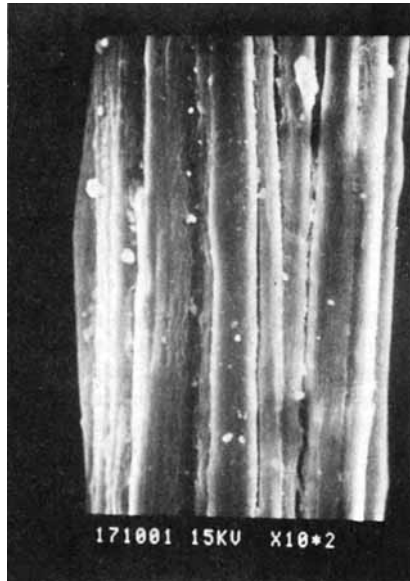


Fig. 1. SEM of 5% NaOH-treated bhindi fiber.

ture (30°C) with occasional shaking⁷ and washed with distilled water, dilute hydrochloric acid, and then finally distilled water.

Procedures

X-ray study was made following the method reported earlier.⁸

For scanning electron microscope studies, samples were mounted on standard specimen holders about 1 cm in diameter. The specimen was then coated



Fig. 2. X-ray photograph of 18% NaOH-treated bhindi fiber.

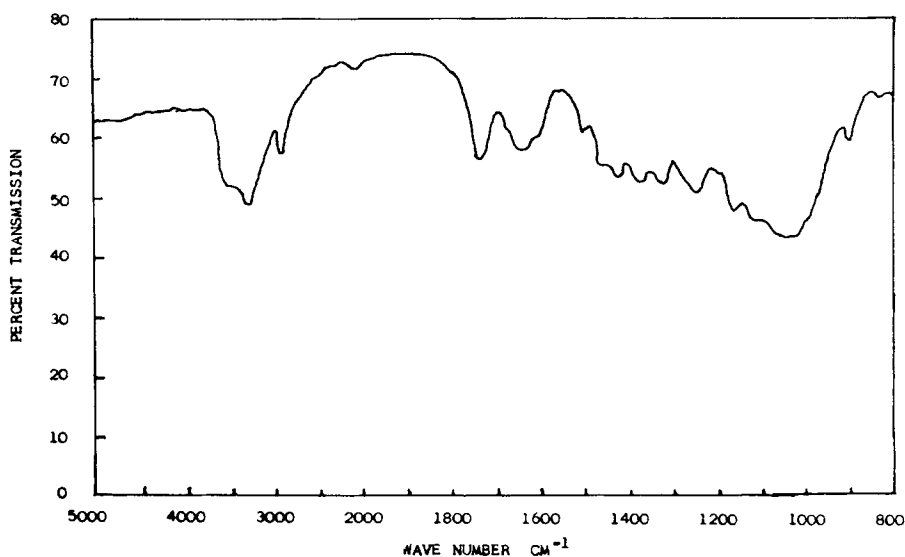


Fig. 3. Infrared spectrum of bhindi fiber (raw) (in KBr).

in vacuo with a silver layer of thickness 20 nm and finally examined in a scanning electron microscope (Hitachi S-430) at an accelerating potential of 15 kV.

The fiber was also examined by IR spectroscopy as reported by Sao et al.⁹

RESULTS AND DISCUSSION

Figure 1 shows the scanning electron micrograph of 5% NaOH—treated bhindi fiber. It shows the multicellular character of the fiber. The fibrillar structure of the individual ultimate fibers is not revealed due to the presence of some gummy materials on the fiber surface. Figure 2 shows the X-ray photograph of 18% NaOH-treated bhindi fiber. The photograph shows that there is partial conversion to cellulose II on 18% NaOH treatment as in other lignocellulosic fiber.⁸

The IR spectra of raw bhindi fibers and those treated with 5, 10, and 18% NaOH solution are shown in Figures 3–6. From Figure 3, the spectra of raw bhindi fiber, the following peaks may be observed:

The broad peak at 3400 cm^{-1} is the characteristic band for OH stretching, and the peak at 2900 cm^{-1} is the characteristic band for CH stretching. All other bands are similar to those obtained in jute.⁹

The broad peak at 3400 cm^{-1} goes on increasing in all the treated samples; Figures 4–6 being unlike what is observed in jute.⁹ This may be due to formation of more OH groups as a result of the breaking of crosslinks of lignin and hemicellulose with cellulose after treatment with NaOH. It appears that alkali degradation of hemicellulose and cellulose is more in bhindi fiber and, as such, more OH groups are generated which make the band at 3400 cm^{-1} more intense in alkali-treated bhindi fiber.

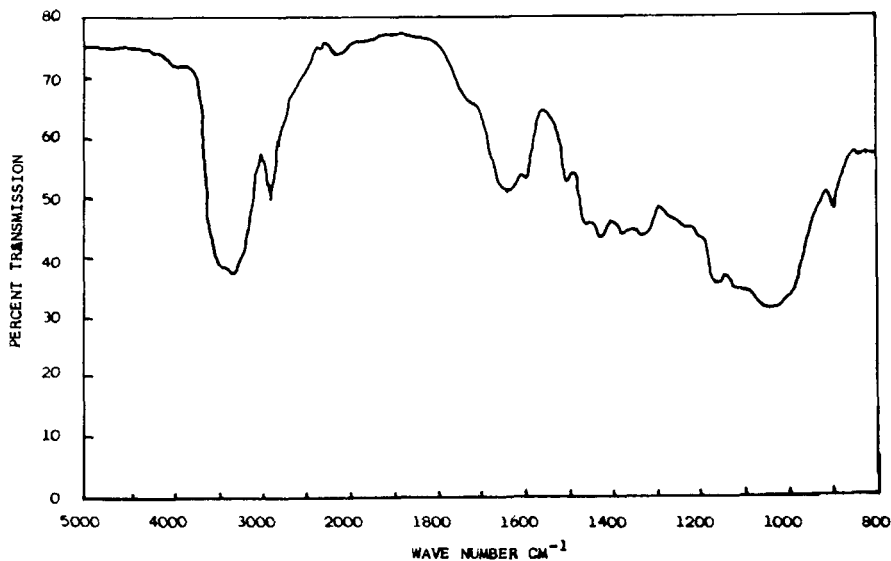


Fig. 4. Infrared spectrum of bhindi fiber (5% alkali treated) (in KBr).

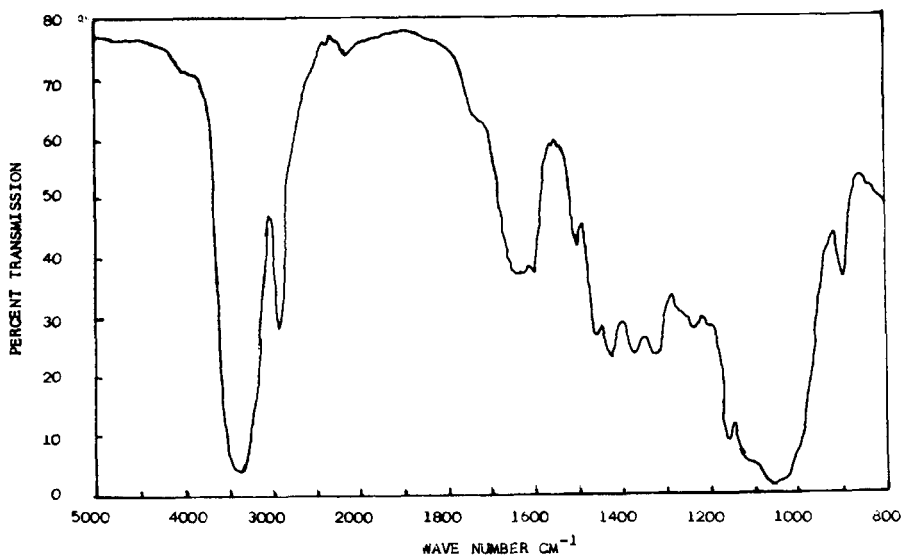


Fig. 5. Infrared spectrum of bhindi fiber (10% alkali treated) (in KBr).

The peak at 1740 cm^{-1} , which is the characteristic band for carbonyl ($\text{C}=\text{O}$) stretching, vanishes after treatment with alkali. This is found also in jute.⁹ It appears that in alkali treatment substantial portion of uronic acid, a constituent of hemicellulose xylan, is removed, resulting in the disappearance of this peak.

The peak at $1500\text{--}1510\text{ cm}^{-1}$, which is due to aromatic stretching frequencies in lignin, increases. The increase in this peak indicates that some of the

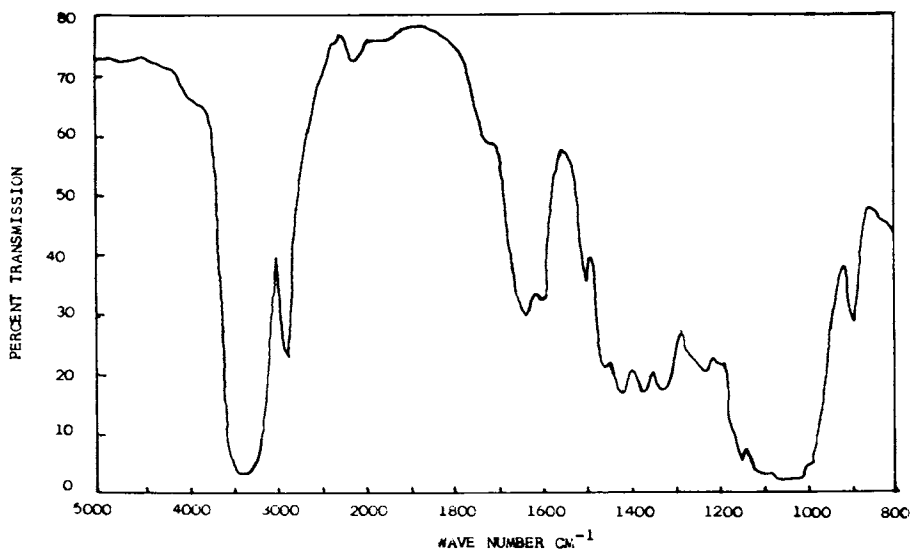


Fig. 6. Infrared spectrum of bhindi fiber (18% alkali treated). (in KBr).

lignin which was responsible for formation of ester or other crosslinks with hemicellulose or cellulose is released after treatment.

The increase in the peak at 900 cm^{-1} , which is for aromatic C—H out of plane deformation, appears to be due to the same cause.

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References

1. K. K. Sen, thesis, Patna University, 1985.
2. K. K. Sen, A. Day, P. Mojumder, S. K. Sen, and S. C. Shaw, *Indian Pulp Paper*, **39**, 5–6 (1984).
3. B. Biswas, D. R. Dhingra, and G. B. Lal, *Indian Text. J.*, **62** (Feb.), 297–299 (1952).
4. P. B. Sarkar and S. Paul, Annual Report, Indian Central Jute Committee, Calcutta, 1951.
5. K. Ghosh and T. Ghosh, *Jute Bull.*, **34** (Apr.–May), 15–18 (1971).
6. P. C. Dasgupta, D. Sardar, and A. K. Majumder, *Food Farming Agri.*, **8** (Sep.), 7–9 (1976).
7. A. C. Chakravarty, *Text. Res. J.*, **32**, 525–526 (1962).
8. P. K. Ray, B. K. Das, S. K. Banerjee, and S. K. Sen, *J. Polym. Sci., Polym. Lett. Ed.*, **21**, 263–270 (1983).
9. K. P. Sao, M. D. Mathew, A. K. Jain, and P. K. Ray, *Cellulose Chem. Technol.*, **21**, 17 (1987).

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