4

ON THE X-RAY DIFFRACTION PATTERNS OF BLEACHED JUTE FIBRE

By S. C. SIRKAR* and S. K. CHOWDHURY

PLATES IA & IB

ABSTRACT. The half widths of the (002), (020) and (120) reflections from jute fibre of five trade qualities in the bleached condition have been compared with those observed in the case of these fibres before bleaching. It is observed that the width of both (002) and (120) reflections becomes smaller and that of (020) reflection becomes larger with the bleaching of the fibre in the case of high quality white, Tossa and White top jute, but no marked change in the half widths of the reflections is observed with the bleaching of the fibre in the case of low quality White and Chinsura green jute fibre. It is pointed out that in the case of the former three qualities some of the linkages between the glucose residues are damaged on bleaching the fibre and thereby the length of the chain is diminished. Side bonds, however, are formed even in absence of the lignin molecules and the width of the micelles is thereby increased in these cases on bleaching the fibre. It is also pointed out that of all the qualities studied Tossa (high quality) has the largest chain length.

INTRODUCTION

In the preliminary investigations on the structure of bleached jute fibre Sirkar, Saha and Rudra (1944) observed that a faint broad ring passing through the (002) reflection in the pattern due to the untreated jute fibre disappears on bleaching the fibre. Later Sirkar and Saha (1946) pointed out that the results obtained by them in the case of high quality Bogi jute fibre indicated a diminution of the length of the micelles with the bleaching of the fibre. As these results have some bearing on the methods which may be employed for restoring the strength of the bleached jute fibre, the width of the (020), (002) and (120) reflections has been studied in the case of high quality White and Tossa, White top, low quality White and Chinsura green jute fibre in the bleached condition and these results have been compared with those observed in the case of these fibres before treatment. The results have been discussed in the present paper.

EXPERIMENTAL

Small bundles of samples, each about one foot in length, were collected to represent the five qualities of jute fibre mentioned above from the large bundles kindly supplied by the Director, Technological Reseach Laboratories, Indian Central Jute Committee. A small portion of each of these samples was dried in the sun and weighed. It was then bleached in aqueous solution of ClO_2 for two days, washed and dried in the sun and was again weighed. A loss of about 10% in the weight was observed in each case after the fibre had

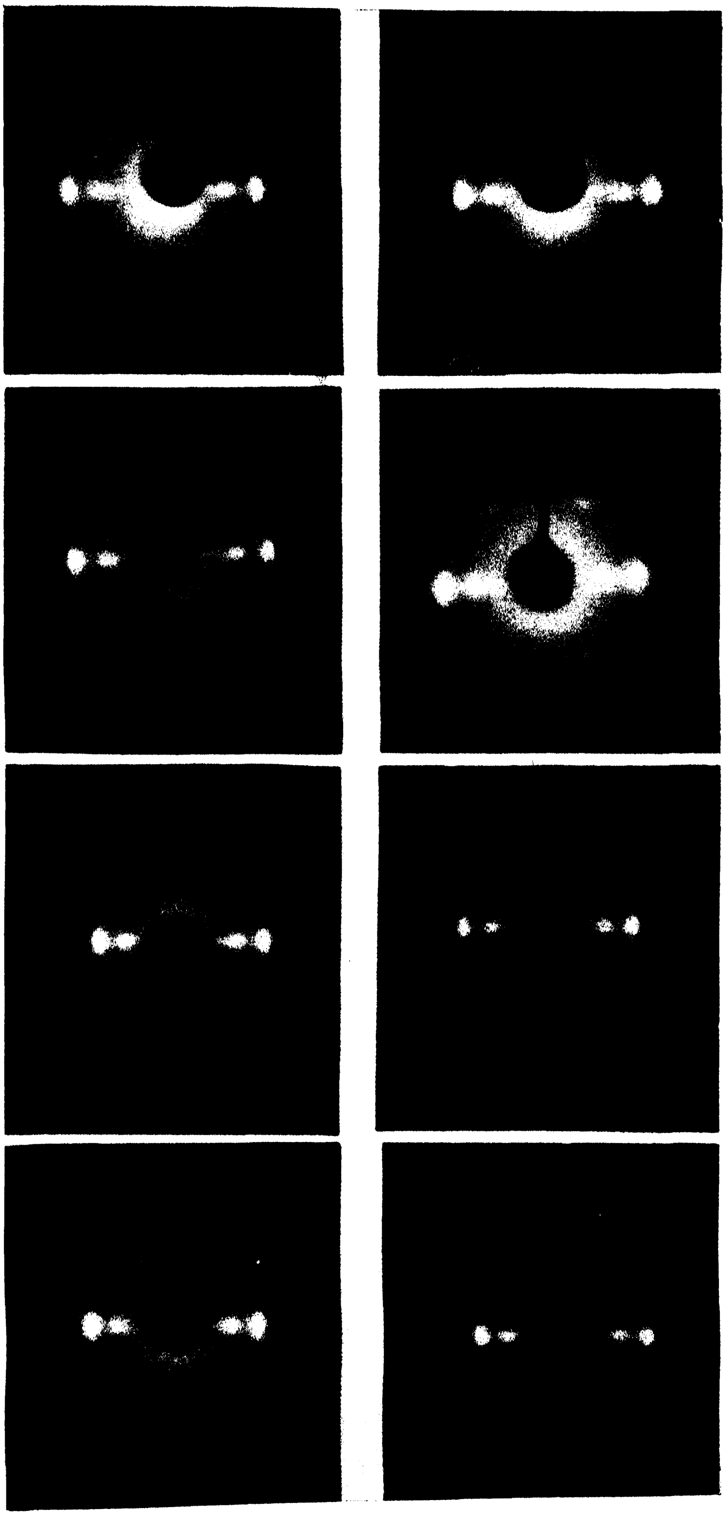
* Fellow of the Indian Physical Society.

been bleached. The X-ray diffraction patterns due to these bleached fibres were obtained with a technique similar to that used by Sirkar and Saha (1946). In each case the pattern due to the original untreated sample was also obtained under identical experimental arrangements. The slit system was narrow enough to allow the (020) reflection to be recorded clearly in the photograph of the diffraction pattern. Microphotometric records of the (002), (020) and (120) reflections were obtained with a Moll type self recording microphotometer. Care was taken to allow the spot of light focussed on the film to move through the middle of each of these reflections across its width.

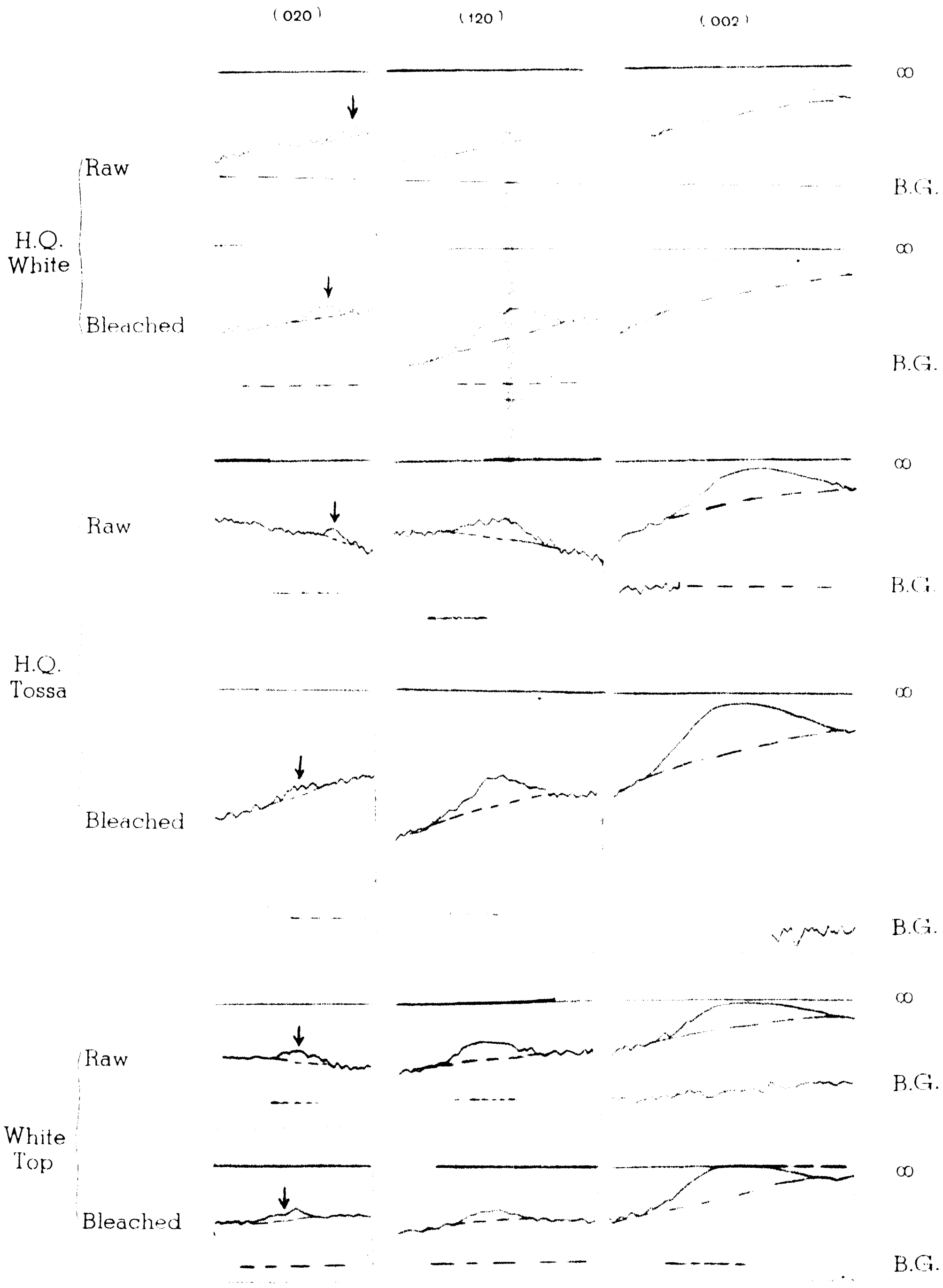
RESULTS & DISCUSSION

The photographs of the patterns due to four of the five qualities studied are reproduced in Plate IA. Those due to low quality white have not been reproduced. It is observed that in the case of all the five qualities the faint ring passing through the (002) reflection disappears completely with the bleaching of the fibre. This indicates that lignin in cellulose is amorphous and has a diffuse spacing of about 4.0 A.U. This is in agreement with the results obtained by Wedekind and Katz (1929) in the case of lignin extracted from cellulose, who also observed only one diffuse ring corresponding to a spacing of 4.0 A.U. The intensity of this ring observed in the case of jute fibre, however, is two small to account for the presence of 10% of lignin in the fibre. This fact shows that lignin is present only in very thin layers and the number of grating elements in the total thickness is too small to produce any diffraction pattern of large intensities. If the lignin molecule be quite large and the thickness of the layer of lignin within the fibre be such as can accommodate only one molecule, the x-ray pattern will hardly resemble the diffraction pattern due to a liquid or an amorphous substance, but on the contrary, it will resemble the pattern due to gaseous scattering which is diffuse and of small intensity. This feebleness of the ring due to lignin observed in the case of jute fibre probably indicates that the major portion of lignin present in the fibre forms a layer only about a molecule thick. A similar phenomenon has been observed by Katz and Mark (1925) in the case of absorption of water by cellulose fibre. Up to a certain percentage of water absorbed by the fibre they observed only a diffuse scattering which increased in intensity with the increase in the percentage of water absorbed and the ring due to water appeared only when the fibre was macroscopically wet.

Some of the microphotometric records obtained for measuring the widths of the (020), (120) and (002) reflections are reproduced in Plate IB which shows that although the (002) reflections produce large densities (020) reflections are rather feeble. Attempt has, however, been made to calculate the values of m_2 and m_3 which denote the number of times the unit cell is repeated along the *b*-and *c*-axis respectively by Laue's method employed previously by Sirkar and Saha (1946). The results are given in Table I. It can also be seen from Plate II



X-ray diffraction patterns of jute-fibres.



Microphotometric Records.

B.G. — Back-ground. ∞ - Infinite density.

that the half width of (120) reflection diminishes slightly on bleaching the fibre in the case of high quality White and Tossa jute and White top jute.

TABLE I

Quality of jute	Half width in radian		m_2	m_3
	(020)	(002)		
High White	.012	.022	11	8
,, ,, bleached	.015	.018	9	10
High Tossa	.009	.022	15	8
,, ,, bleached	.011	.018	12	10
White top	.011	.023	12	8
,, ,, bleached	0.014	.019	10	9

The results given in Table I show that in the case of each of the three qualities mentioned the chain length diminishes on bleaching the fibre while the value of m_3 increases. No such changes were observed in the case of low quality White and Chinsura green. In the case of bleached White top jute m_3 was calculated from the microphotometric record of a second photograph obtained with smaller exposure because the (002) reflection has infinite density in the record reproduced. The results given in Table I show that some of the oxygen bridges between glucose residues are broken up when lignin is removed by ClO_2, but the side bonds attach more such units together to increase the thickness of the micelle in absence of lignin. Hence it appears that although lignin molecules do not enter into the lattice of cellulose the micelles are held together by these molecules probably through some form of secondary bonds.

The values of m_2 are calculated in the present investigation direct from the width of (020) reflection and are therefore more accurate than those calculated by Sirkar and Saha (1946) from widths of other reflections. It is significant that high quality Tossa which has a strength larger than that of all the fibres studied has also the longest chain length ($m_2 = 15$). This fact corroborates the conclusion drawn by Sirkar and Saha (1946)from the results obtained by them that besides the presence of lignin, the length of the micelle is also partly responsible for the strength of the fibre. It is now quite evident from the above discussions that lignin does not act as a mere cement but some secondary chemical bonds are probably involved in making the jute fibre quite strong inspite of the fact that the length of its micelles are about one-tenth that of the micelles in ramie. The OH group of water absorbed by bleached jute fibre probably further weakens the oxygen bridges already damaged during removal of lignin and the chain length is still more diminished, so that in the wet condition bleached jute fibre possesses practically negligible tensile strength. Any attempt at restoring the strength of the bleached fibre should therefore be directed at finding some reagent which may help in the formation of bridges between neighbouring glucose residues, increasing thereby the length of the chain.

ACKNOWLEDGMENT

The work was done under a scheme drawn up by Prof. M. N. Saha, F.R.S., and financed by the Indian Central Jute Committee. The authors are indebted to Prof. Saha for his kind interest in the work and for providing all facilities for the work in the Palit Laboratory, and to the Indian Central Jute Committee for the financial help.

PALIT LABORATORY
PHYSICS DEPARTMENT,
UNIVERSITY COLLEGE OF SCIENCE,
CALCUTTA.

REFERENCES

Katz, J. R. and Mark, H. (1925), Sorption of water by cellulose, *Z. Physik. Chem* **115**, 385.

Sirkar, S. C., and Saha, N. N. (1946), The orientation and size of micelles in jute fibre. *Proc. Nat. Inst. Sc. India*, **12**, 151.

Sirkar S. C., Saha N. N. and Rudra, R. M. (1944), X-ray analysis of jute fibre of different qualities under various conditions. *Proc. Nat. Inst. Sc. India*, **10**, 325.

Wedekind, E. and Katz, J. R. (1929), Structure of lignin. *Ber.*, **62B**, 1172.