Indian Journal of Textile Research
Vol. 10, September 1985, Pp. 129-130

Moisture Absorption in Jute Fibre during Growth

P K RAY and B K DAS
Jute Technological Research Laboratories,
12, Regent Park, Calcutta 700040, India

Received 28 *March* 1985; *accepted* 22 *April* 1985

Moisture absorption in jute fibre during growth was studied along with changes in the amorphous fraction. Moisture absorption followed, by and large, the changes in the amorphous fraction. At a few stages of growth there was indication that the intermediate order in fibre structure plays an important role in determining the absorption of moisture.

Keywords: Jute fibre, Moisture absorption

Ray and Das[1] reported that crystallinity in jute fibre fluctuated throughout the life of the jute plant. The degree of crystallinity at about the 15th day of growth was about 60% and in the intermediate stages it fluctuated. At the mature stage the degree of crystallinity approached the value at the initial stage. This is due to changes in the arrangement of the chain molecules in the different layers of the cell wall at different stages of growth. Moisture absorption of jute fibres at different stages of growth was studied at different humidities[1]. Figs 1a and 1b show the variation of amorphous fraction and the variation of moisture absorption at 90% RH with the fibre growth. The changes in moisture absorption follow, by and large, those in amorphous fraction at several stages of growth, but not in all the stages of growth. For both the species of jute (JRC-212 and JRO-632) the amorphous fraction is lower but the moisture absorption is not proportionately lower, as, for example, at the 30th and the 60th day of growth (Fig. 1). This may be due to the intermediate order in the fibre structure. In fibre structure, there are some regions which can contribute to the coherence of X-ray reflection and may be simultaneously accessible[2,3]. In the measurement of crystallinity by X-rays, a part of the regions, counted as crystalline, is capable of absorbing moisture. It was found that the crystalline fraction as designated by X-ray method may be accessible to the extent of about 40%[4]. After deuterating and rehydrogenating ramie fibre, Okajima and Kai[5] found that remie could be divided into amorphous, intermediate and crystalline regions. Ray and Bandyopadhyay[2] pointed out that the role of the intermediate region in determining the effect of moisture on the degree of crystallinity in natural cellulose fibres is very important. In cotton fibres it was observed that at lower concentrations of NaOH, the conversion of cellulose I into amorphous regions predominates over the transformation to cellulose II; at higher concentrations, this order is reversed, indicating that at lower concentrations the regions of intermediate order are converted to amorphous regions[6]. Fig. 1 shows that at some stages of growth the higher amorphous fraction cannot account for the lower moisture absorption as at the 80th and 90th day for JRC-212 and at the 80th and 110th day for JRO-632. This may be due to changes in the intermediate order and in the state of pores and voids in the fibres which influence the density of fibres[1,7]. The moisture absorption data also indicate that some of the pores and voids in the fibres disappear with growth[1], so that liquid molecules cannot enter those spaces, and, as a result, the true densities are lower[1,7]. Chakravarty[8] reported that at the initial stages of moisture absorption in jute fibres, the increase in volume was less than the volume of added water, indicating thereby that water molecules are fitted closely into the structure filling the space available.

It therefore appears that right from the start of growth the structure of the fibre passes through more of the intermediate order, corroborating Stockmann's hypothesis[9] that a newly grown elementary fibril is in a metastable state. Again, the fibrils of the cell wall are encrusted by lignin and hemicelluloses. The encrusting substances counteract the inherent tendency for longitudinal contraction of fibrils favourable for disordered state. With the growth process the order in the intermediate region changes owing to the change in

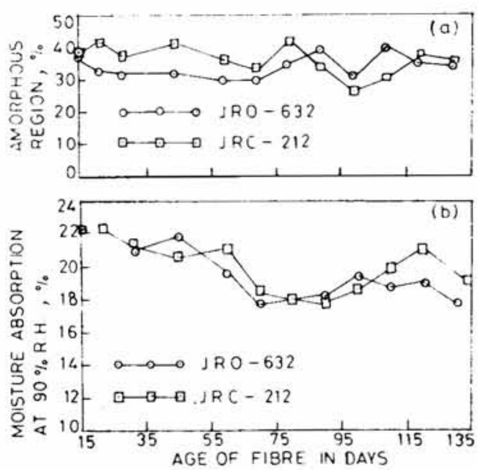

Fig. 1—Variation of (a) amorphous region and (b) moisture absorption with the growth of fibre

the counteracting forces due to the lignin network. Also, an increase in the counteracting forces with growth, owing to close association of lignin with cellulose structure[7], results in the transformation of some of the intermediate regions into crystalline regions.

Acknowledgement

The authors are thankful to the Indian Council of Agricultural Research for providing facilities for work.

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