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Fine Structure and Mechanical Properties of Jute Differently Dried After Retting

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Synopsis

Fine structure, density, and some mechanical properties have been studied in jute fiber dried differently after retting. It is observed that the fiber has a less compact structure before undergoing any drying processes after retting. Formation of hydrogen bonding during subsequent drying seems to be the cause of subsequent compactness of the molecules in the fiber.

INTRODUCTION

It has been reported[1–4] that in the case of some plant fibers, with increasing absorption of moisture, there is a fall in crystallinity whereas crystallite orientation improves. It was also found[4] that when dried jute filaments were moistened and then dried by solvent exchange method (methanol–benzene) instead of by direct evaporation, the molecular organization of the fiber was better preserved and the structure was more or less similar to that in the moist condition. The method of drying thus seems to have some influence on the molecular organization of the fiber.

The above results were based on commercial jute fibers which were dried at least once after retting in water. The experiments were, therefore, undertaken to see how far the structure of these fibers compared with those which were never dried directly from moist condition.

MATERIALS

Green barks in the form of ribbon contained in the fiber were obtained by passing the defoliated plant through ribboning machine.[5] The green ribbons were then chemically retted with ammonium oxalate and a suitable detergent.[6] The green fibers were then kept in distilled water. Each ribbon of fiber was then split in two halves longitudinally. One half was allowed to dry directly in air or initially at room temperature and then in an oven at 110°C. Water from the other half was removed indirectly by several exchanges of methanol and benzene,[4] the latter being finally removed by heating under vacuum. To minimize the variation of properties among the fibers of the two groups, test samples were manually extracted from corresponding regions of the ribbons dried in two ways. Samples were preserved in a desiccator con-

TABLE I
Degree of Crystallinity (D.C.), Hermans Average Angle of Orientation α_m, Density, Torsional Rigidity, and Extension at Break of the Directly and Indirectly Dried Fibers

Fiber	Condition of drying	Density, g/cc	Torsional rigidity $\times 10^{10}$ dynes/cm^2	Extension at break, %	(D.C.)	(α_m)
JRC-321	direct	1.390	0.350	2.18	64	9°14′
	indirect	1.382	0.264	2.62	53	8°04′
JRO-878	direct	1.389	0.264	1.75	60	8°56′
	indirect	1.372	0.208	2.50	45	7°54′

taining fused calcium chloride. Two varieties of jute JRC-321 and JRO-878 were examined.

EXPERIMENTAL

Crystallinity and orientation were determined according to Hermans and Weidinger's[7] method. A fixed weight of the fibers was made into a thin bundle and mounted in a stretching frame. Isotropic distribution of intensity was obtained by a rotation of the film during exposure. Three-dimensional randomization was not possible inasmuch as preparation of randomized pellets disturbs the drying conditions.

Measurements of density and torsional rigidity were made in a similar way as described earlier.[4] Tensile properties of the filaments were determined with the help of an Instron tester, the test length being 1 cm and the rate of extension, 0.5 cm/min.

RESULTS

The results are given in Table I. The values for the degree of crystallinity were obtained with reference to ramie fiber as standard.

DISCUSSION

The results in Table I show that the crystallinity in the directly dried fibres is appreciably higher than that in indirectly dried fibers. The results of mechanical properties and density are also consistent with these.

The change in each of the different parameters of these fibers in the two dried states is, however, more than that observed earlier in the case of fibers once dried, rewetted, and dried again. This additional change in the properties is probably because, in once-dried commercial jute fiber, the formation of hydrogen bonding at initial drying was to some extent permanent due to excess drying after retting. Thus, once formed, these hydrogen bonds between hydroxyl groups on neighboring fibrils imparts rigidity to the fibers.

Recently, Ingram et al.[8] found, that cotton fiber never regained the moisture content which it had during its botanical growth inside the boll. Thus the structure of cotton was more open in the green state. The crystallinity of

never-dried cotton, was also found by them, to be less than that of the fiber, dried after opening of the boll.

Comparison of the elongation data in Table I, reveals that elongation to break is more in the solvent-dried state. This higher extensibility also shows the higher interfibrillar mobility in this fiber. This is in agreement with the results reported by Ingram et al.[8] in cotton fiber.

CONCLUSIONS

Adoption of the suitable mode of drying seems to be one of the ways of preserving the molecular organization of the fiber in humid state, as it would make it more pliable and hence more suitable for technological processing.

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