The Structure of Bast Fibers

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In a previous article[1] the writer described experiments with elementary flax fibers, on which an opinion as to their cellular structure was based.

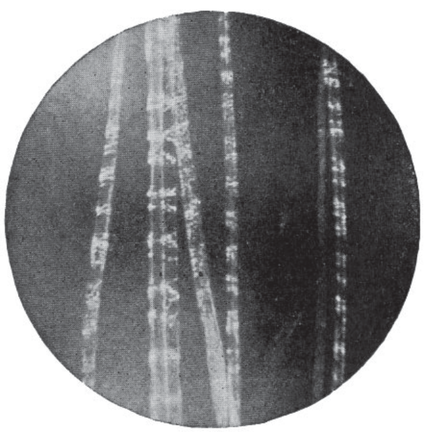
Further treatment of other fibers in the same manner has showed that this cellular structure is peculiar to all bast fibers of the dicotyledonous plant. Beside flax (linum usitatissimum L.), hemp (cannabis sativa L.), kendyr (apocynum sibiricum L.), ramie (boehmeria nivea L.), jute (couchorus capsularis L.), and kenaf (gambo hemp hibiscus cannâbinus L.) were investigated.

The study of the structure of all these fibers confirmed the previously expressed opinion, that the cellules are a component part of the cellulosic cell-wall (secondary layer) and that throughout the length of the fiber they are enclosed in the outer layer or epidermis. While remaining in the epidermis the cellules cannot separate and form "displacements." As they swell, the cellules press against this primary epidermis, forming characteristic, knotty swellings. Only when this epidermis is destroyed or weakened sufficiently can the cellules separate, which they do just as soon as their connection with each other is destroyed.

Such a breaking up into cellules is seen easily with all the fibers mentioned here if the elementary fibers, after previous treatment with either a half saturated or other concentration of chromic acid solution, are subjected to the action of an NaOH solution of 30-40° Bé.

All these fibers also form "displacements" when treated with HCl 23° Bé or NaOH solution 40° Bé. This is very evident when a fiber treated with HCl 23° Bé is observed in polarized light with crossed Nicols.

Kendyr fibers separated from a living stalk show hardly any displacements in ordinary light and appear homogeneous, but in polarized light a large number of clearly defined displacements become visible (see Figure No. 1). This proves that the displacements may be formed during the growth of the plant. Figure No. 1 shows untreated elementary fibers of kendyr just after they were separated from a living stalk. The fibers have a large number of displacements which are visible very clearly in polarized light (Figure No. 1). On treating these fibers with HCl 23° Bé, the displacements become still more noticeable because the cellules then go further and further apart on account of their swelling and on account of the weaken-



Elementary kendyr fibers, just after being separated from the stalk, not treated, in polarized light (with crossed Nicols).

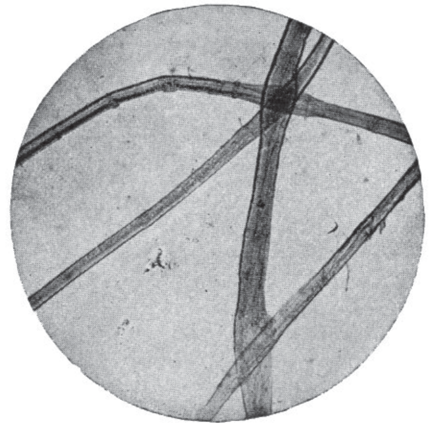


Figure 2
Elementary kendyr in ordinary light.

[1]The Melliand, vol. I, No. 1, page 83: "The Microscopy of Flax Fiber."

ing of the connection between each other.

Fig. 2 shows the elementary kendyr fibers in ordinary light. Fig. 3 shows the cellules of kendyr fibers. Fig. 4 depicts the cellules of hemp fibers.

In the group of bast fibers described, the jute and kenaf (gambo hemp) are in a class by themselves. The elementary fibers of these plants are remarkable for their insignificant length. For instance, the elementary jute fibers are from .8 to 4.1 mm. long, those of kenaf are from 1.16 to 2.72 mm. long, while elementary flax fibers have a length of 4 to 66 mm., hemp from 4 to 55 mm. and kendyr from 30.5 to 80.5 mm. In contrast to flax, hemp and kendyr fibers, there is nothing in present literature regarding displacements in jute and kenaf fibers.[2] In fact when the elementary fibers of these plants are scrutinized in ordinary light there is no sign of a displacement to be noticed. But careful examination in polarized light using a high magnification renders displacements visible as faint transverse lines. Displacements can be noticed here and there on the fibers. Fig. 6 shows the cellules of kenaf fiber. In Fig. 7 we see the cellules of elementary jute fibers.

It should be noted that a stronger treatment with oxidizing agents is required to break up jute or kenaf fibers into cellules even if previously macerated elementary fibers are used. This can be accomplished either by a longer treatment or by using more concentrated solutions. From this fact it can be seen that the material connecting the cellules in these fibers is more tenacious. It seems reasonable also to conclude that these elementary fibers are more stable than elementary fibers of, for instance, flax, hemp or kendyr on account of the strength of the connection between the cellules. But the following well-known facts, viz., the short length of service of jute goods and its almost complete lack of any resistance to atmospheric influences (moisture particularly), etc., are in opposition to this assumption. This contradiction is seen to be only an apparent one

Figure 3
Cellules of kendyr fibers.

Figure 4
Cellules of hemp fibers.

By using the ordinary method (treatment with H_2CrO_4 and NaOH) it is possible to split up elementary jute or kenaf fibers into cellules.

Fig. 5 shows kenaf fibers in polarized light.

when the variety of conditions is considered which determine the moment when the various fibers are consumed completely.

For instance, at the instant that a cotton fiber is consumed completely, basic changes occur in the ultramicroscopic (micellular) structure of the fiber, and the cellulose of which it is composed is changed chemically.

Flax, hemp, kendyr, and the other "long

[2]For instance, Dr. T. F. Kanausek says in his "Textbook of Technical Microscopy," (p. 77) in describing jute, "Flattened places and so-called displacements have not been observed. This probably has some connection with the absence of any stratification of the cell-wall." Dr. F. Zetschce also says on page 36 in his book, "The Most Important Fibrous Materials in European Industry," under the description of jute, "Displacements are entirely lacking." When describing kenaf (gambo hemp) none of the authors make any mention of displacements but all agree that the anatomical structure of jute is entirely similar.

fibered" plants can be consumed completely as soon as the connection between the cellules is weakened and the fiber separated along the displacement lines. The ultramicroscopic structure of the cellules may remain unattacked, the cellulose of the fiber being at the same time unchanged chemically. In this manner the length of service of these bast fibers may be even shorter than in the case of the cotton fiber. It is a matter of practical experience that the process consumption of linen fabrics is entirely different from that of cotton fabrics, which is in complete agreement with this explanation.

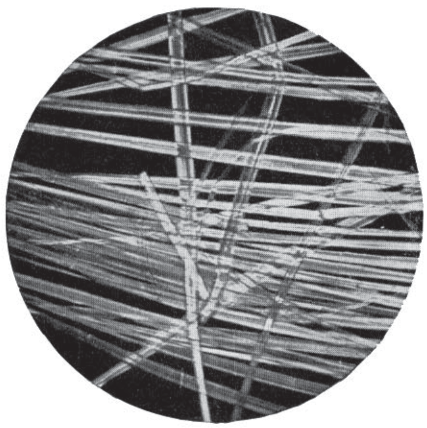


Figure 5
Kenaf fibers in polarized light (with crossed Nicols).

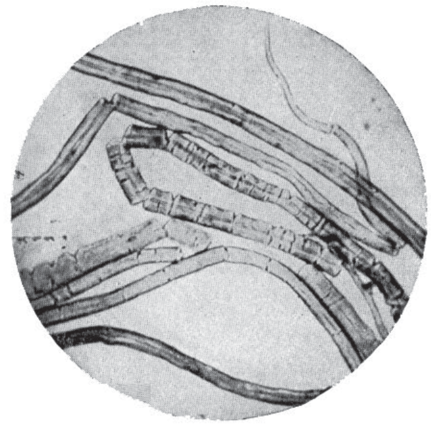


Figure 6
Cellules of kenaf fibers.

Goods made of jute and kenaf, naturally will be consumed still more quickly. The moment that these goods are consumed completely may be determined by the weakening of the connection between the short elementary fibers composing the commercial fiber, either through change, destruction or more or less complete removal of the incrusting materials, which firmly unite the elementary fibers. When the incrusting material is injured the connection between the elementary fibers is weakened and the commercial fiber loses its strength and breaks up into sound, uninjured, elementary fibers. On account of the insignificant length (up to 4 mm.) these elementary fibers are useless and appear as a fine dust to the naked eye. If they were longer these fibers still would be useful commercially as very strong fibers after this break-up, just as the elementary fibers in linen fabrics made from the commercial flax fiber are still useful in goods long after being completely "cottonized" in the bleaching process. The ease with which jute goods deteriorate by the action of moisture, heat, light, etc., is in accord with the foregoing and is understood readily when the ease with which jute fibers undergo bacteriological processes is considered. In order to lengthen the life of these fibers, a chemical treatment will have to be discovered which will increase the resistance of the incrusting materials to moisture, heat, and microbiological processes. Then jute fibers would be much more durable in service than at present.

Figure 7
Cellules of jute fibers.