Formation of Cotton Fiber Structure

Z.U.Ortiqov
Senior teacher of Andijan State University
ozaynobuddin@gmail.com +99891 478 37 31

ABSTRACT

The article provides information about the stages of formation of the structure of cotton fiber, biosynthesis processes, the ordered arrangement of cellulose macromolecules during the formation of the structure of cotton fiber, the effect of chemicals on the properties of cellulose.

Keywords: cotton , cotton fiber , cellulose , carbohydrate , cell , biosynthesis , epidermis , protoplasm , fibrillar fibers

Introduction

As a photophilous plant, cotton is mainly grown in regions with a warm climate. A long-term study of the characteristics of this plant shows the duration of the growing season. Cotton fiber is a valuable raw material for the textile industry. The structure of the cotton fiber is formed in the process of its maturation. Ripe cotton fiber is a flattened elongated cell, the upper end of which has a conical shape, and the lower end is attached to the seed. In the process of the formation of the structure of the cotton fiber, the biosynthesis of cellulose and the ordered arrangement of the macromolecules of this substance occur. The main morphological element of cotton fiber is the primary wall of the cuticle, the secondary wall of the roller layer and the third wall with a central channel. The primary wall of the cuticle has a high chemical activity and is covered with a thin layer of lipid-wax substance. It is a thin outer shell containing pectin, a waxy substance.

Methods

In the first days of seed development, epidermal cell division occurs, outgrowths are formed by active epidermal cells, and some cells turn into fibrils. There are two stages in the development of fiber and seed for 25-30 days. The first stage of development is characterized by the growth of fibers in length, while the main fibers grow rapidly. Within 15-16 days they reach half of their final length. The process of formation and increase in the diameter of the fibers occurs within 12-15 days. Along the length of the fibers, their diameter is not the same. The largest diameter is either at the base or in the middle of the fiber. When the fibers are elongated, the walls remain thin, consist of fiber of the adipose substance - cutin , which is called the cuticle.

Behind the primary wall is the secondary wall, which is characterized by a uniform high content of fibrils of cellulose fibers (Fig. 1). Fibrillar fibers are twisted helically with respect to the axis of the fiber.

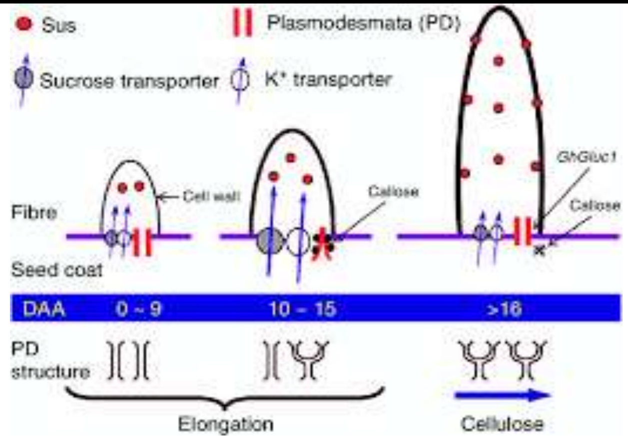


Fig. 1 The beginning of the development of cotton fiber basis fibers is secondary wall, which consists of from cellulose.

In the channel in the form of protoplasm residues, there are nitrogenous substances. The chemical composition of the fiber includes cellulose 94.5-96%, waxy substances 0.5-0.6%, pectin substances 1.0-1.2%, nitrogenous substances 1.0-1.2 %, mineral substances 1, 14%, other substances 1.32%, may contain natural dyes. The chemical composition may change depending on changes in climatic conditions.

The quality of the fiber is determined by the length, fineness, strength, degree of maturity. The length depends on the variety and ranges from 12 to 50 mm. The fineness is from 15-24 microns, the tensile strength is 4-5 G., the elongation at break is on average 8%, the specific gravity is 1.52. Hygroscopic fiber at relative humidity contains 6-8% moisture. Under the action of copper ammonia solution $Cu(NH_3)_4(OH)_2$ the fiber quickly swells and becomes bead- shaped. Under prolonged action of this solution, the fiber completely dissolves.

In the second stage, the formation of the inner part occurs, while thickening of the walls occurs by laying layers of fiber; this process begins at 20-25 days of age with an irrigated culture, from 40-45 days of age, the intensity of fiber laying gradually slows down. In the process of fiber development, layers of cellulose are deposited, and the walls acquire a layered structure, which is clearly seen in the cross section (Fig. 2). The formed fiber has from 25 to 30 layers. During early defoliation, in bolls of different maturity on the bush, the number of fiber layers in the walls of the fibers is not the same: the closer to the maturation of the bolus, the more layers of fiber are deposited in the walls of its fibers, their wall is thicker.

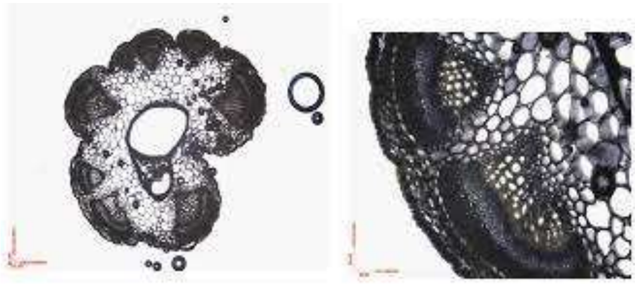


Fig. 2 Layered structure of the walls of cotton fibers in a cross section.

The thickness of the fiber layers depends on the hereditary characteristics of the type and variety of cotton, as well as the growing conditions. Intensively, fiber is deposited on the walls of fibers in varieties with coarse fiber and in varieties of early maturing, the more favorable the environmental conditions, the more intense it is. deposition of fiber (Fig. 3). A spiral fibrillar structure has fiber layers of the walls of the fibers, which is clearly visible under a microscope when pressing on the preparation.

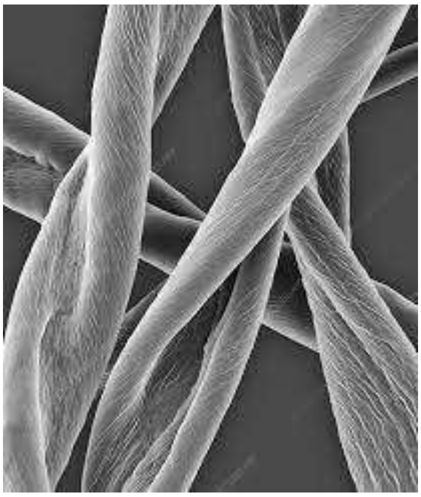


Fig. 3 Cotton fiber has the shape of a flat ribbon twisted in a corkscrew shape a-longitudinal section, b-cross section

Like a plant cell, the internal content of the fiber consists of protoplasm with a nucleus and cell sap. At the beginning of fiber development, protoplasm occupies the entire cell, cell sap fills the vacuole. By the beginning of the deposition of fiber layers, the protoplasm moves to the walls in the form of a thin layer and the vacuoles of the cell sap unite and fill the cavity of the fiber. As the walls of the fiber thicken when layers of fiber are deposited, the tubule gradually narrows.

The area immediately adjacent to the fiber channel is considered to be the tertiary wall, which contains a large number of pores, weakly ordered cellulose fibrils, protoplasm protein impurities, and pectin substances. The fiber channels are filled with protein substances containing a large amount of minerals, as well as a complex of microelements.

Results

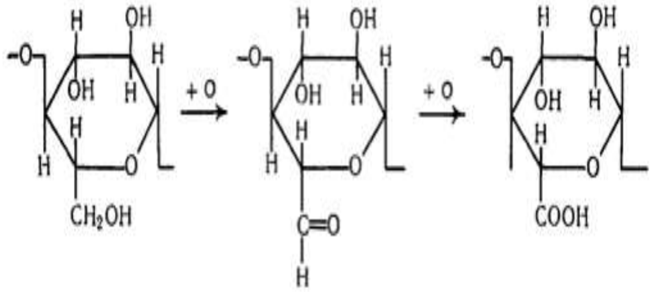
Being the main substance of cotton, cellulose, as a high-molecular compound belonging to the class of carbohydrates, gives strength to the fiber,

elasticity, flexibility. Empirical formulas (C6H1005)m. Cellulose is resistant to dilute alkali solutions. When treated with a solution of caustic soda, the concentration of which is 10-25 *g/l,* cellulose remains practically unchanged. In the presence of atmospheric oxygen at an elevated temperature (120-140°C), treatment with a dilute alkali solution can lead to the oxidation of cellulose.

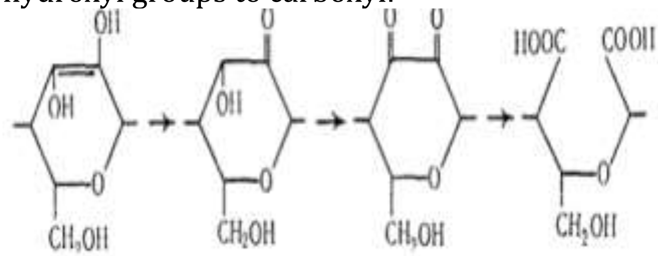
In the case of a short-term action of a concentrated solution of caustic soda (240-280 *g/l)* and at a temperature of 25° C, the cellulose of the fiber quickly swells, acquires shine, and its reactivity increases. At In this case, chemical processes take place with the formation of C6H10O5 • NaOH and an alcoholate-type compound (CH6 O9 O4Na).

This processing is called mercerization. For a mature fiber, the cross-sectional cavity is 4-8 %. During the maturation of cotton fiber, the biosynthesis and ordered arrangement of cellulose macromolecules formed by monomers of β-D glucose residues connected by glucosidic bonds characteristic of organic compounds.

Under the action of oxidizing agents, cellulose changes quite easily, for example , if at a temperature of 50-60° C it is treated with a solution of sodium hypochlorite (active chlorine 3-4 *g / l), the fiber* is weakened as a result of the formation of a heterogeneous substance oxycellulose , which consists of cellulose and products of various degrees its destruction. During oxidation, hydroxyl bonds can be broken along the oxygen bridge, the oxidation of hydroxyl groups into aldehydes, and aldehydes into carboxyl groups. In an acidic environment, oxidation proceeds to the formation of aldehyde groups, which are oxidized to carboxyl:



In an alkaline environment, there is a faster oxidation of primary and secondary hydroxyl groups to carboxyl:



The distinctive properties of hydroxycellulose are its acidic nature and the ability to stain with basic dyes. Depending on the oxidation conditions, it can also have reducing properties (due to the formation of aldehyde groups at the site of rupture of glucosidic bonds).

If cellulose is treated with low concentration sodium hypochlorite (active chlorine 0.5-1 *g/l)* at a temperature not exceeding 25°C, the cellulose changes practically little.

When exposed to light, cellulose is able to be oxidized by atmospheric oxygen to form hydroxycellulose . It has been established that the strength of cotton decreases by 50% when exposed to direct sunlight for 940 *hours.*

The temperature resistance of cellulose depends on the processing time. In the case of short-term treatment of fabric at a temperature of 100 ° C, cellulose does not change its properties: hygroscopic moisture is only partially removed from it. Under the same conditions, but with prolonged processing, the fiber becomes hard, brittle and low-elasticity. If the temperature is briefly raised to 125-150°C, cellulose will also not change its properties. But if the fiber is treated for a long time under these conditions, the moisture will quickly be removed, the fiber will turn slightly yellow and there will be a danger of weakening it. The decomposition of cellulose occurs at high temperatures (200-275°C and above).

In the process of cotton growth, waxy, pectin, nitrogenous, mineral and coloring substances are formed. By their chemical nature, they are complex compounds, their exact composition has not yet been established. Some of these substances are easily removed from the fiber when it is treated with hot water, while others require more complex processing - boiling and bleaching. Being in the primary wall of the fiber, they interfere with its wettability , which negatively affects the dyeing and printing process.

The composition of waxy substances includes high-molecular monohydric fatty alcohols: gossypil C30 H61 OH, montanil C28 H57 OH, ceryl C26 H53 OH and carnaubyl C24 H49 OH. All these alcohols are insoluble in water, alkali acids and other chemicals. In addition to the above alcohols, waxy substances include free fatty acids (palmitic C15 H31 COOH, stearic C17 H35 COOH, oleic C17 H33 COOH and their esters), as well as higher solid hydrocarbons - triacontane C30 H62 , gentriacontan C31 H61 and others.

It has been established that in waxy substances most of them are unsaponifiable and difficult to remove compounds that can be brought into solution by emulsification. Esters contained in waxy substances are easily saponified when treated with a hot alkali solution to the corresponding alcohols and acids. Fatty acids, both remaining in waxy substances and released as a result saponification of esters, when interacting with caustic soda, they form sodium soaps:

C17 N35 COOH + NaOH – C17 H35 COOHa + H2O.

These soaps not only dissolve in water themselves, but also contribute to the partial emulsification of insoluble high molecular weight alcohols and solid hydrocarbons.

Discussion

Waxy substances in cotton fiber have a negative effect on the dyeing and printing processes. Therefore, their removal is one of the main tasks of whitening. Pectins are complex organic compounds found predominantly in the primary fiber wall.

They hydrolyze well, especially in the presence of caustic soda. The fibrous canal contains nitrogenous substances. They are remnants of protoplasm and belong to the class of proteins. Part of the nitrogenous substances can be removed by treatment with a hot solution of weak alkali. Most of these are removed by treating the fiber with a sodium hypochlorite solution. In this case, hydrochloric acids are formed, which with caustic soda give water-soluble sodium salts. All plant fibers contain minerals. They exist in cellulose in the form of various salts - coal, sulfate, phosphate and silicon, and also form salts with pectin substances - pectants. The amount of minerals depends on the nature of the fiber, soil and climatic conditions.

Most minerals are soluble in water. Natural dyes give the fiber a yellow-brown or yellow-brown color. Their content in fiber is not so high, they cannot be separated by purely modern analytical methods. Therefore, the composition and properties of these paints are still insufficiently studied.

It has been established that the color of the fiber does not change under the action of weak alkaline solutions; paint is destroyed by oxidizing agents (sodium hypochlorite, sodium chlorite and hydrogen peroxide solutions). Cotton fiber contains 6-8% hygroscopic moisture, depending on growth conditions, which gives the fiber flexibility and elasticity. Unlike other fibrous plants, cotton is characterized by a high fiber content of 95-96%, waxy, dyes make up 4-5%. Cotton raw materials contain macroelements (K, Na, Ca, Mg), which promote the growth of fungal spores, and microelements (Fe, Cu, Zn), which affect the development of microorganisms.

Conclusion

Cotton can be contaminated with microorganisms during harvesting, transport and storage. Cellulose can change its properties under the influence of not only chemicals, but also bacteria or mold. Cellulose hydrolysis occurs with the formation of hydrocellulose as a result of the activity of microorganisms under conditions of long-term storage of tissues in a humid environment.

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