THE STRUCTURE OF COTTON FIBER IN RELATION TO DYEING.

The organic structure of the various cotton fibers of commerce, as affecting their use in spinning and weaving, was considered in a previous article. Let us now examine briefly the influence of fiber-structure upon the work of the dyer.

In what manner does the fiber receive the dye, and what changes are wrought in the structure and chemical composition of the fiber in the processes of dyeing?

The fiber, as we have seen, is a slender, twisted, usually more or less flattened cellular tube, the outer walls of which show no openings even under a powerful microscope. When perfectly ripe the fiber consists of almost perfectly pure cellulose, a compound of carbon, hydrogen, and oxygen ($C_6H_{10}O_5$), having but slight affinity for other substances, except strong acids and alkalies.

Obviously there are many supposable ways in which such a structure can be dyed: by the laying on of dyestuff like paint upon the surface of the fiber; by the filling of the tube with liquid dye, which may or may not afterward be precipitated in solid form; by saturating the cell walls with dye; by a chemical union of the substance of the fiber with the dyeing materials, etc.

It is quite probable that each and all of these methods will be found to operate singly or in combination under the varying conditions obtaining in dye houses.

The fixation of the color in the fiber is effected, according to Chevreul, in three ways: by chemical affinity, by simple mixture with the fibers, or by a combination of the two. The English investigator, Mr. Walter Crum, holds that in the dyeing of cotton fiber the action is purely mechanical, and that reactions which occur in the fiber are not effected by the chemical composition of the fiber. The fiber, he says, serves simply as a containing vessel, and is as inert as a glass tube might be. The peculiar structure of the cotton fiber, however, enables it to take in liquids which contain coloring matter in a feeble combination with the solvent liquor, and to retain such matter when the liquid is removed or the dye precipitated by a reagent. The energy of the absorbent action of cotton fiber is so great that some dyes will penetrate the fiber even when the dyestuff is applied in a condition almost solid. Other dyes do not so strongly support the theory of Mr. Crum. Thus, aniline colors, which are eagerly absorbed by silk and wool, have little effect upon unprepared cotton fiber, except to stain the surface.

The more recent investigator, Mr. F. H. Bowman, reviews in his new work the grounds of Mr. Crum's position, and decides that something more than mechanical action is needed to account for the conditions observed under the microscope. With respect to their action upon the fiber of cotton he finds three classes of dyeing substances:

(1) Those which are colored in themselves; simple dyes having a direct affinity for the fiber without the intervention of a mordant.

(2) Those which are true chemical precipitates formed within the fiber walls; with these the fiber acts mechanically and does not in itself undergo any change.

(3) Those requiring a mordant. With these the color is not produced by the simple union of the coloring matter with the fiber, but by the action of various reagents upon the mordant, which unites with the fiber and thus fixes the color.

He adds that it is not possible to draw a sharp line of demarkation between these three classes of action, because in the relationship of various coloring matters to the fibers they shade into one another; and there are many instances in which the difference is only one of degree. Examples of the appearance of fibers under the microscope, after treatment with the different types of dyestuffs, are shown by Mr. Bowman in a series of beautifully colored illustrations.

Turmeric yellow and indigo blue illustrate the action and appearance of the first class of dyeing material. With turmeric yellow the coloring matter is simply dissolved in hot water; immersed in the decoction the fiber speedily acquires a bright yellow color, which is rendered as permanent as the color will permit by simply drying the yarn. The coloring matter is not merely entangled in the cell structure of the fiber, for it cannot be dissolved out by a reapplication of water. There is an evident union of some sort with the fiber substance. The aggregation of coloring matter within the cell walls shows further that the fiber has the power of attracting the dye from the water, which is left considerably less colored than the fiber which has been immersed in it. When examined under the microscope by transmitted light the coloring matter is found to be irregularly distributed, the color lying in detached masses in the cellulose walls. In some places, especially when the fiber is kempy or immature, the fiber seems to have no affinity for the dye and is incapable of receiving it. How far and in what way the presence of foreign matter, such as wax, oil, and cell contents, interferes with the proper action of the cellulose layers and prevents uniform dyeing, does not appear.

The affinity of cotton fiber for indigo is such that the fiber tends to accumulate the indigo within the cell walls in quantity almost proportionate to the time during which it is in operation. With a sufficient quantity of cotton all the indigo may be extracted from the solution.

When the dyed fiber is viewed under the microscope the cloudy deposit of indigo is seen distributed irregularly through the fiber, in some places forming dark, almost black, masses in the central cavity. There is also a certain degree of surface coloration, and an accumulation of color in the creases, on the wrinkled and broken surface of the collapsed tubes, or in the ridges and furrows occasioned by the hollows of the twisted fibers. To the reflecting surfaces so formed the solid and even appearance of this dye is largely due. A careful examination of the best dyed fibers, however, convinces Mr. Bowman that we are far from the standard of perfect dyeing, and that the mechanical treatment of the fiber is much more advanced than the chemical.

The second class of dyeing substances, where true chemical precipitates are formed within the fiber walls, is best illustrated by the pure mineral dyes, such as chrome yellow, Prussian blue, etc. In these the reaction within the fiber producing the color is exactly the same as that which occurs in the test glass on the laboratory table, when testing for lead or iron; and the great problem for the dyer to solve is so to prepare the fiber that it will best receive the solution from which the coloring matter is to be precipitated.

Mr. Bowman finds that in many cases with these purely mineral dyes the cellulose may be entirely dissolved away by properly selected solvents, leaving the dyes in an unchanged condition, showing that they had not entered into chemical union with the fiber. In other cases there seems to be a degree of affinity between impure cellulose as it always exists in the cotton fiber, and the first solutions in which the fiber is immersed in order to produce the purely mineral dyes, so that they may act to some extent as mordants. Thus he found by experiment that when cotton fiber was steeped in acetate of lead (the first process in the dyeing of amber), or in nitrate of iron (the first step in dyeing Prussian blue), he could not by any process which did not entirely destroy the fiber remove all traces of these bases. The inference was that something more than mere mechanical union had taken place between them and the fiber; and although the cellulose itself might play no part in the subsequent reactions, the fixity of the color seemed to be due in part at least to the reaction of the bases upon the cellulose, making the dyes to a certain extent chemical as well as mechanical.

The third class of dyeing substances (where a mordant is used) is greatly variable in nature and application. In some cases there seems to be what may almost be called the formation of a new surface within the fiber walls, or even upon the surface of the thread (but permanently attached to it), upon which the coloring matter is deposited. Thus pure cotton fiber will not receive and hold an aniline dye, but when first treated with a solution of tannic acid the fiber will take up the color in large quantity and hold it permanently.

Under the microscope fiber dyed with any of the aniline colors shows a much greater uniformity in the levelness of the dyeing than obtains with indigo. Sections of the fiber seem to be uniformly colored all through the cell walls, and there is a comparative absence of surface coloring and the tendency to form detached masses of dye. Some fibers indeed seem to be perfectly dyed in every part, as though the mordant had penetrated every portion of the cell walls. This is true only of perfect fibers; unripe fibers naturally resist the color.

To make these refractory fibers receive the dye they have to be treated with strong alkali, "mercerized," which has the effect of thickening the cell walls and increasing their power of absorption. Mr. Bowman finds that such unripe fibers could also be made to receive aniline dyes by first bleaching them or by boiling them for a time in a weak solution of alkali. This increased capacity for dyeing, he thinks, may arise from the removal of waxy matter from the outer layer, or else from the opening of the pores of the fiber, although the same treatment seems to diminish the power of the tube wall to act as a dialyzer when treated with salts of alumina.

Alumina has a special interest in connection with cotton fiber, not only because of its peculiar property, when in its hydrated condition, of throwing down and heightening the brilliancy of many vegetable and animal coloring matters, but also because of its being separated from its various compounds by the dialytic action of the fiber alone, and thus retaining these coloring matters within the cell walls in an insoluble condition. Upon this action depends the process of dyeing Turkey red, one of the most stable of all colors.

The manner in which coloring matters of this class are associated with different fibers—kempy, unripe, fully ripe, etc.—is admirably shown in Mr. Bowman's illustrations. After treatment with lake of alumina and madder the kempy fiber shows many parts quite uncolored. In the unripe, horny fiber the coloring matter is confined to a thin layer, which by the act of shrinking has separated into detached flakes distributed irregularly through the thin tube. The fully dyed fiber shows the accumulation of coloring matter in the interior of the tube. In the transverse sections of fiber some are faintly colored in spots; others show the dye collected in clots within the tube. The distribution of the dye in the cell walls is also irregular. Sometimes the dye lies in layers; other fibers are uniformly tinted throughout; still others show an uncolored outer skin with a well dyed interior.

After considering at length the conditions of the fiber and the accidents of handling which interfere with the work of the dyer, Mr. Bowman expresses the opinion that increased efficiency in the coloring of yarn and fabrics must be looked for in the discovery of new preparatory processes which, like the strong alkali treatment, will increase the capacity of the fiber for receiving dye, especially imperfect and immature fibers, and also give to the mature fiber greater toughness and strength. Here would seem to be a promising field for investigation and invention. The wonderful change which occurs in the manufacture of parchment paper, by which the strength of the paper is increased eight or ten fold, indicates that there must lie within the reach of possible discovery a corresponding chemical process of strengthening cotton yarn while dyeing it, since both the paper and the yarn have the common basis, cellulose.

REPRODUCTION OF MEDALS, ETC.

There are several methods by which medals may be reproduced, and of these the following are the simplest and afford the most satisfactory results:

THE STEREOTYPE PROCESS.

The medal, thoroughly cleansed, dried, and coated with a thin but uniform film of pure sperm or olive oil, is bound around the edge with a piece of cardboard so as to form a box, the bottom of which is the medal. A small quantity of finest plaster of Paris is then mixed up quickly into a thin cream and applied all over the exposed surface of the medal with a camel's-hair pencil so as to fill all depressions and exclude air bubbles. A thicker cream of plaster is then at once poured in until the box is nearly or quite filled. When the plaster has properly hardened the cardboard is taken off, and the plaster adhering to the rim of the medal trimmed off with a knife; the medal can then be easily detached from the cast. Another cast may then be taken of the reverse side of the medal in a similar manner. These casts, after trimming, are set aside in a warm place until they become quite dry, and are then clamped securely, face upward, in a small shallow iron tray, so that their face is about half the thickness of the medal distant below the top or edge of the tray. The spaces in the tray about the casts are then filled up even with the inferior edge of the casts with plaster, *papier mâché*, or clay (dry). The tray thus arranged is put into an oven until the temperature of its contents is uniformly heated to about 250° Fah., when it is removed and immersed wholly below the surface of a potful of ordinary type metal heated just hot enough to make it quite liquid. As soon as air bubbles cease to escape the tray is slowly and steadily raised out of the pot, and the contents allowed to chill and harden in the air (sometimes it is preferable to plunge it in water, so as to facilitate the removal of the "cake" from the tray). When the plate of type metal is cut out of the tray a correct (reversed) copy of the plaster moulds will be found on its under surface, and when the superfluous metal has been cut away and the pieces trimmed to proper dimensions and thickness they may be soldered together back to back, and the edges cut, turned, or milled, as the case requires to produce a correct imitation of the original medal. Cleansed by dipping momentarily in a strong hot solution of caustic potash, and, after quickly rinsing in running water, in hydrochloric acid, it may be coated with silver or copper, if desired, by electro deposition.

BY ELECTROTYPY.

Melt pure white wax, and stir well into it while cooling about one-fifth its weight of finest flake white (plumbic carbonate). Having uniformly coated the faces of the medal with a film of finest graphite or plumbago, arrange it in the box of cardboard as in taking the plaster stereo cast, and pour in the wax preparation previously heated just enough to make it semi-fluid. Having thus obtained a mould in wax of both faces of the medal, harden the wax in a cool place, then coat it perfectly with a film of pure graphite, wrap about the edges a number of turns of clean copper wire, and brush on plumbago so that the film of the latter may have contact with the wax and wire all around. Suspend the wax cast thus prepared by the copper wire in a saturated (or nearly saturated) aqueous solution of *pure* sulphate of copper, jarring it so that all bubbles of air may escape from the deep lines of the cast. Close in front, but not touching the immersed mould (or its connections), suspend by a copper wire a sheet of clean copper. Connect the copper by stout copper wire with the silver (or carbon) pole of a Smee battery of three cells (in series), and the copper wire on the mould, in a similar manner, with the zinc pole of the same battery, and let the deposition of copper on the mould proceed until it becomes thick enough to separate without breaking (about as thick as this paper). Then carefully detach it from the mould, embed the pieces, face downward, in dry plaster, and fill up (after drying) with melted type metal (or fusible metal). Trim to proper size and thickness, solder the pieces together, back to back, and cut or mill the edges to proper form. These *copies* may be coated with a thin film of silver by electro deposit. The surfaces may be given an *aged* appearance by immersing them for a few moments in a dilute solution of sulphide of soda in warm water.

When a copy, as produced by stereotypy, of a medal is taken in metal, the latter coated with plumbago, and immersed in a bath composed of three-quarters of a pound of sulphate of nickel and ammonia per gallon of water, under the conditions described in electrotyping with copper, a hard shell of nickel is obtained, which, when separated and backed with type metal, may be used as a die. It is difficult, however, for an amateur in electro-metallurgy to obtain good results in this way. Steel dies cannot be produced in this way. Moulds for stereo or ordinary casting should be heated.

For a fusible silver-white alloy melt type metal and mix it with one-eighth its weight of grain tin, remove from the fire, and stir well before pouring.

Proposed Exhibition in Boston.

After several months' inquiry the committee appointed to investigate the feasibility of holding a World's Fair in Boston have reported in favor of the enterprise, provided $5,000,000 can be secured. The property known as Beacon Park has been offered as a site for the fair free of rental.