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DEYEING.

DYEING is the art of staining textile substances with permanent colours. To cover their surfaces with colouring matters removable by dyes. Dyestuffs can penetrate the minute pores of vegetable and animal fibres only when presented to them in a state of solution, and dye can consequently be used only by passing afterwards into the state of indissoluble compounds with the fibres themselves. Dyeing thus appears to be altogether a chemical process, and to require for its due execution and practice an acquaintance with the chemical nature of the substances that took place. Mankind, equally in the rudest and most refined state, have always sought to gratify the love of distinction by staining their dress, sometimes even their skin, with gayly coloured materials. Modes of treatment, dyed blue, and purple, and scarlet, and of sheep-tim dyed red,—circumstances which indicate no small degree of tintorial skill. He enjoins purple stuffs for the works of the tabernacle and the vestments of the high priest.

In the article CYLINDRICAL PRINTING we have shown from Pliny that the ancient Egyptians cultivated that art with some degree of scientific precision: seeing that they knew the use of mordants, or of those substances that imparted a colour of a different kind to a dyed stuff, described by Pliny under the names of purpure and baccaum; and was extracted from a small vessel, or two, in their vessels, the amount of only one drop from each animal. A darker and inferior colour was also procured by crushing the whole substance of the buccinum. A certain quantity of the juice collected from a vast number of shells being treated with sea-salt, was allowed to ripen for three days; after which it was diluted with five times its bulk of water, kept at a moderate heat for six days more, occasionally skimmed to separate the animal membranes, and then clarified and applied directly as a dye to white wool, previously prepared for this purpose by the action of lime-water, or of a species of lichen called fucus. Two operations were requisite to complete the finest Tyrian purple: the first consisted in plunging the wool into the juice of the purpure; the second, into that of the buccinum. Fifty dozens of wool required one hundred of the former animal, and two of the latter. Sometimes a preliminary tint was given with coccius, the kerns of the present day, and the cloth received merely a finish from the previous animal juice. The colours, though possibly not so brilliant as those procured by our cochineal, seem to have been very durable, for Plutarch says, in his Life of Alexander (chap. 30), that the Greeks found in the treasury of the King of Persia a large quantity of purple cloth, which was as least as 200 years old. The difficulty of collecting the purple juice, and the tedious complication of the dyeing process, made the purple wool of Tyre so expensive at Rome that in the time of Augustus a pound of it cost 200,000 denarii. Notwithstanding this enormous price, such was the wealth accumulated in that capital, that many of its leading citizens decorated themselves in purple attire, till the emperors arrogated to themselves the privilege of wearing purple, and prohibited its use to every other person. This prohibition so much discouraged the art of dyeing purple as eventually to occasion its extinction, first in the western and then in the eastern empire, where, however, it existed in certain imperial manufactories till the 11th century. Dyeing was little cultivated in ancient Greece. The people of Athens wore, generally, woolen dresses of the natural colour. But the Romans must have bestowed some pains upon this art. In the games of the circus, particularly in the races of the gladiators, the soldiers wore tunics adorned with blue, and purple, and green, and red, and yellow, and white. The following ingredients were used by their dyers: a crude native alum mixed with copperas, copperas itself, blue vitriol, alkanet, lichen rubens, or racemos, brown, marner, wool, nut-galls, the seeds of pomegranate, and of an Egyptian acacia.

The moderns have obtained from the New World several dye-stuffs used by the ancients, such as cochineal and indigo. Brazil, which is described by Pliny,—the green, the orange, the gray, and the white. The following ingredients were used by their dyers: a crude native alum mixed with copperas, copperas itself, blue vitriol, alkanet, lichen rubens, or racemos, brown, madder, woad, nut-galls, the seeds of pomegranate, and of an Egyptian acacia. The moderns have obtained from the New World several dye-stuffs used by the ancients, such as cochineal and indigo, which the Romans knew only as a pigment. But the vast superiority of our dyeers over those of former times must be ascribed principally to the employment of pure alum and solution in water, and to the use of those substances which give to our common dye-stuffs remarkable depth, durability, and lustre. Another improvement in dyeing of more recent date is the introduction of metallic compounds, such as Prussian blue, chrome yellow, manganese brown, &c.

Indigo, the innoxious and beautiful product of an interesting tribe of tropical plants, which is adapted to form the most useful and substantial of all dyes, was actually denounced as a dangerous drug, and forbidden to be used, by our parliament in the reign of Queen Elizabeth. An Act was passed authorizing searchers to burn both it and logwood in every dye-house where they should be found. This Act remained in full force till the time of Charles II.; that is, for a great part of a century. The purposer of this statute was probably to check the use of an instrument which was supposed to be dangerous; but the legislation was suggested by the growers or makers of certain English drugs, to favour their monopoly.

Mr. Delaval made many ingenious experiments to prove that the property of dye-stuffs possessed of reflecting light, and that, therefore, when viewed upon a dark ground, they all appear black, whatever colour they may exhibit when seen by light transmitted through them. He hence inferred that the difference of colour shown by dyed cloths is owing to the white light which is reflected from the textile fibres being decomposed in its passage through the superfine colouring particles. We think it more probable that this conclusion is in some respects incorrect, and that the aluminium, iron, and tin bases form combinations with dye-stuffs which are capable of reflecting light, independent of the reflection from the fibre itself. There can be no doubt, however, that the latter is in some way connected to the brightness of the tints, and that the whiter the textile substance is, the better dye it will generally speak, receive. It is for this reason that scorching or bleaching of the stuffs is usually prescribed as a process preliminary to dyeing.

Bergman appears to have been the first who referred to chemoal affinities the phenomena of dyeing. Having plumbed wool and silk into two separate vessels, containing solution of indigo in sulphuric acid and distilled with a great deal of water, he observed that the wool abstracted much of the colouring matter, and took a deep blue tint, but that the silk was hardly changed. He ascribed this difference to the greater affinity existing between the particles of sulphate of indigo and wool, than between those silk and acid. He showed that the affinity of the wool is sufficiently energetic to render the solution colourless by extracting the whole of the indigo, while that of the silk absorbs only a little of the dye. He hence concluded from these experiments: that both the permanence and depth to the intensity of that attractive force.

We have therefore to consider in dyeing the play of affinities between the liquid medium in which the dye is dissolved and the fibrous substance to be dyed. When wool is plumbed in a solution containing cochineal, tartar, and acid of tin, it readily assumes a beautiful scarlet hue; but when cotton is subjected to the same bath, it receives only a feeble pink tinge. Dufay took a piece of cloth woven of woolen warp and cotton weft, and having exposed it to the fulling-mill in order that both kinds of fibres might receive the same treatment, subjected it to the scarlet dye; he found that the woollen threads became of a vivid red, while the cotton continued white. By studying these differences of affinity, and by varying the preparations of the dyes, we may obtain an indefinite variety of colours of variable solubility and depth of shade.

Dye-stuffs, whether of vegetable or animal origin, though susceptible of solution in water, and, in this state, of penetrating the pores of fibrous bodies, seldom possess alone the power of fixing their particles so durably as to be capable of resisting the action of water, light, and heat. To this purpose they require to be aided by some other bodies, already alluded to, which bodies may not possess any colour in themselves but serve in this case merely as a bond of union between the dye and the substance to be dyed. These bodies, therefore, in proportion to the parts of the art, to which the fibres by an agency analogous to that of the teeth of animals, and were hence called mordants, from the Latin verb mordre, to bite. But the term derived from it has gained so footing in the language of the dyer that all writers upon his art are compelled to adopt it.

Mordants may be regarded, in general, as not only fixing but also occasionally modifying the dye, by forming with the colouring particles an insusceptible compound, which is deposited within the textile fibres.
DYEING.

Such dyes as are capable of passing from the soluble into the insoluble state, and of thus becoming permanent, without the addition of other matters, have been called substantive, and all the others have been called adherent. Indigo and tannin are perhaps the only dyes of organic origin to which the substantive can be applied, and yet they are probably altered by atmospheric influences in their fixation upon stuffs, as to form no exception to the true theory of dyes.

Dyes are of primary importance in dyeing; they enable us to vary at will, and almost indefinitely, with the same dye, to increase their lustre, and to give them a durability which they otherwise could not possess. A mordant is not always a simple agent; but in the case of which its employment varies according to the materials or types of which it consists various compounds may be used, but that the substances may not act directly, but through a series of transformations. The Chinit blue process (CALCIO PRINTING) affords a fine illustration of this truth. Sometimes the mordant is mixed with a gum, sometimes it is applied by itself first of all to the stuff; and at others both these methods are conjoined. We may dye successively with lampo or containing different substances, which will act differently according to the different mordants successively employed. One solution will give up its base to the stuff only when added by heat; another acts better and more uniformly when cold, though this is a rarer case.

The first principle of dyeing fast colours, we have seen, consists in causing the colouring matter to undergo such a change, when deposited upon the wool or other stuffs, as to become insoluble in the liquor of the dye-bath. The more powerful it resists the action of other reagents, the better; and, speaking generally, a piece of well-dyed cloth should not be materially affected by hot water, by soap and water, by exposure to air and light, by dilute nitric acid, or even by very dilute aqueous acetic acid.

In the following details concerning the art of dyeing we shall consider principally its application to wool and silk, having already treated, in the article CALCIO PRINTING, of what is peculiar to cotton and linen. The operations to which wool and silk are subjected preparatory to being dyed are intended, 1, to separate certain foreign matters from the fibres of the stuff; and 2, to render more apt to unite with such colouring substances as the dyer wishes to fix upon it, as also to take therefrom a more lively and agreeable tint, as well as to be less liable to soil in use. The matters foreign to the fibre are either such as are naturally assimilated by the fibre or given to it by the animal, or those that have been added to it in the spinning and weaving operations, or such as have been accidentally applied.

Silk is secured by means of boiling in soap and water, whereby it is freed from a gum, improperly called gum. This consists of an acelose compound, which may be separated in a gelatinous form by coagulating the hot water saturated with it. It constitutes about a fourth part of the weight of most raw silks, and contains a little colouring matter of an orange or yellow hue. When silk is required to be extremely white, either to be worn in that state, or to receive the brightest and purest dye, it should be exposed to the action of a strong sulphuric acid. For dark dyed cloth, no harm will be secured at all, in which case it preserves its whole weight. Wool is first washed in running water to separate its coarser impurities; it is then deprived of its fine fibre of wool (a species of splint) by the use of warm water, and given to the sheep) either by means of an ammoniacal urine, by soap and water, or by a weakly ly of carbonate of soda. Common wool loses in this way from 20 to 50 per cent. of its weight, and merino wools still more. They receive their final bleaching by means of boiling sulphur, or by aqueous sulphuric acid.

Wools present remarkable differences in their aptitude of combining with various colours, depending upon the different structure of the fibres of the filaments. The colouring particles seem to insinuate themselves at those pores with greater or less facility, and to be retained with greater or less force, according to the magnitude and form of the morard, have a power in dyeing, therefore, not only to the repulsive action of fatty matters, as has been commonly supposed, since it still exists in wool even when every particle of grease has been removed, but to the attraction for the green copperas. A boiling in a pail of hot brine is often had recourse to, in order to make wool take the dye more readily and equally; but a hot lye containing one-half per cent. of crystallised carbonate of soda answers much better. When heated to the temperature of 140 or 145° Fahr., the wool should be immersed in that liquor, and turned about for half an hour. The wool receives a dark blue bath, but it is exposed to white light during exposure to air; or it may be whitened at once by passing through tepid water containing a very small quantity of muriatic acid. The yellow colour is most probably occasioned by the reaction of the stuff, and iron contained in the water.

According to the experiments of Thiemard and Roard, alum combines with wool in the state of a salt, without separation of its acid constituent. It is suggested that a mixture of tartaric acid and alum will give this colour entirely; some of the acid and a little of the tartaric combine with the wool, while a neutral turtrate of potash remains in the bath. This fact is interesting in reference to the scarlet dyes, showing the important part which tartaric acid plays in their constitution.

Tintorial colours are either simple or compound. The simple are black, brown, orange, blue, yellow, and red; the compound are grey, green, orange, purple, crimson, magenta, and other hues producible by the mixture of simple colours. We shall treat here of only black and brown, in the present place.

1. Black.—If we apply to a white stuff blue, red, and yellow, in certain proportions, the resulting colour will be black. Proceeding on this principle, Castel asserted that 15 parts of blue, 5 of red, and 3 of yellow, will produce a perfect black; but in making this statement he was influenced rather by theoretical than practical considerations. In fact he has afforded us no means of procuring these simple colours in an absolute state. It is undoubtedly true, however, that red, yellow, and blue, employed in adequate quantities, will produce black: because blue obstruct the passage of red; red, yellow, and blue, or, in other words, cause its total privation; whence blackness must result. If we suppose an experience over those three colours, we have a perfect black, we shall have a tint corresponding to the colour that is in excess; as, for example, a blue, a violet, red, or greenish black; and with paler tints we shall have a bluish, violet, red, or greenish grey.

Gall-nuts, and a salt of iron, so generally employed for the black dye, give merely a violet or greenish-grey, and never a pure black. The pyrrhohumate of iron, which contains a brown haemoglobinous matter, produces a brown inclining to greenish-yellow in light shades, and to chestnut-brown in dark hues. By boiling cotton and silk, after a bath of pyrrhohumate of iron, and repeating the processes several times, a tolerably pure black may be procured. Gall-nuts, or the product of the deposit of copper salts on a silk gauze, produce merely a very deep violet-blue; but if they be applied to wool in a hot bath, with frequent exposure to air, the dye wood induces a brownness which is favourable to the formation of black.

The black dye for hats is communicated by logwood, copperas, and verdigris mixed in certain proportions in the same bath; from that mixture there results a vast quantity of an ochreous muddy precipitate, amounting to 25 per cent. of the copperas employed. This mud forms a deposit upon the hats which not only corrodes the fine baeve filaments, but causes both them and the felt to turn speckly of a rusty brown; and should not be removed. A well-dyed black should have the appearance of a mass of wrinkles, and present the appearance as if it was, a condition seldom realised. Beaver hats, however, to which these remarks refer, have been almost superseded by those covered with silk-plush, to which a different brown, by the animal, and which alone forms the blue precipitate. When a black of the best possible shade is to be given, the wool should be first ground with indigo, then passed through a bath of logwood, sumach, and propionate of iron (green copperas). Sumach and nut-galls may also be employed in the proportion of 6 to 21; or the sumach may be replaced by nut-galls, if they be equal to one-third of the sumach prescribed. A good black may be dyed upon an indigo ground with 300 lbs. of wool, by taking 200 lbs. of logwood, 60 lbs. of sumach, 21 lbs. of galls, and 20 lbs. of green copperas; and giving three hours of steam each to the wool, with airings between. A good black, without an indigo ground, 100 lbs. of logwood, by boiling it in a bath of 25 lbs. of alum and 674 of tartar; grounding it with meal and sodium; then passing it through a bath of 200 lbs. of logwood, 60 lbs. of sumach, and 24 lbs. of indigo; taking it out and boiling it 5 lbs. of copperas; half, giving it three hours of steam each time.

The best French black, according to Hellot, may be given to wool by first dyeing it a dark blue in the indigo vat; then washing and rinsing into the indigo vat for every 20 lbs. 5 lbs. of galls, and as much logwood tied up in a coarse canvas bag, and boiling them for twelve hours. One-third of the bath thus prepared is to be filtered into another, and poured over the cloth, or stuff, or stuff is to be worked in this solution without immersion for two hours: the bath being kept hot, but not boiling. After taking out the stuff, another third part of the first bath is to be added along with the second, and the stuff must be kept boiling until being dissolved, and the bath being refreshed with a little cold water, the stuff is to be worked through it for half an hour, and then aired. Lastly, the residuary third of the first bath is to be now introduced, taking care to squeeze out the bag. From 8 to 10 lbs. of
A beautiful brown tint, on wool or silk, may be obtained by first giving a pale blue shade in the indigo vat, then mordanting with alum, and then dyeing in a madder bath, then mordanting again in alum, and finishing in the bath for another hour. It is next washed at the river and dried. A finish is prescribed in the madder bath, but this is often given after boiling; but this is of doubtful utility, especially when a little soap has been used in the fulling-mill. Vitalis prefers the pyrogallic to the sodium mordant for dyeing for dye, and says it gives a better and more velvety colour—an opinion which some English chemists dispute.

The black vat, as it gets exhausted, is employed to dye grays of various shades.

Silk is dyed black in two methods, according to the mordant for which it is made. When sold by weight, as was formerly the practice at Tours, and is now with silk thread in this country, it is an object with the dyer to load it with as much colouring or other matter as possible. Sugar is at present much employed to falsify the weight of English silk thread, as any person may discover by applying a hank of it to his tongue, if he has, given the stuff more than doubled in weight by this fraudulent device. Such silk is called English black by the French, who are not suffered to practise this deception. When silk is sold by weight, the measure, on the other hand, must be made to object to give it a black colour with as little weight of materials as possible. Hence the distinction now made in the trade of heavy and light silks. In this, as in many similar examples of adulteration, a desire of making the moths under sell their neighbours is probably produced the evil in the first instance; and then the others joined in the fraud for self-defence.

The 25 per cent. of weight which silk has lost in scouring may be in a great measure recovered by giving it a sufficient dose of galls. For this purpose a bath is made by boiling galls equal to two-thirds or three-fourths the weight of the silk for three or four hours in a sufficient quantity of water, and then letting the decoction stand for two or three hours. The silk must be steeped in this bath from twenty to thirty-six hours, and then washed in clear water. The first galling, is, however, commonly given with a bath somewhat spent; and for heavy black silk. Several successive immersions in gall baths, and of considerable duration, are usually given to silk, with intervening washings and wringings at the press.

The stuff kept from year to year by a black vat, often of very complex composition. The essential constituents of the vat are sulphate of iron and gum; but many vegetable matters, as well as filings of iron, are usually added. This bath being heated short of boiling, and then allowed to settle for about an hour, the silks are worked in with much manipulation, occasional wringing out, airing, and redipping. As the copperas and gum get exploded, the bath must reduce in turbidity, and the proportion of these ingredients to the proportions of the gall and verdigris is very useful to the black silk, and is now generally made. A ground of walnut peels is a good and cheap preparation for this dye.

Dyes and dye colour.—This dye is not so common in England as on the Continent, where the colouring matter is generally produced at a very cheap rate by steeping ripe walnuts with their peels in water for a year or two, till the vat acquires a deep brown colour and a foul smell. This infusion affords very agreeable and permanent brown tints without any mordant; while it preserves the downy softness of the wool, and requires but a simple and economical process. In dyeing with this infusion, a quantity, of it proportional to the shade required is to be put into the copper, diluted with water, and made to boil. The cloth or yarn needs merely to be moistened beforehand with tepid water, to be then plunged in the bath, and turned about till sufficiently dyed. Then remove, give the stuff a preparatory mordant of alum, and leave it to drain for twenty-four hours before subjecting it to the bath of walnut peels.

It is generally employed in this country to dye fawns, and some browns; but more beautiful browns may be given to woollen stuffs by boiling them first with one-fourth their weight of alum and some tartar and copperas, washing, and afterwards dyeing them in a madder bath. The shade of colour is in proportion to the thickness of the copperas to the alum.

A good brown may also be obtained by mordanting every pound of the stuff with 1 lb. of alum and an ounce of copperas in a pound of lye of lye, and then dyeing it in a bath of logwood to which some copperas has been added; or the stuff dried red in the madder bath may be turned about in the black dye vat till the required shade is produced.

The finest browns are produced by boiling each pound of the wool with two ounces of alum, dyeing it in a cochineal bath, and then transferring it to a boiling bath containing a little copperas, and then passing the stuff in the bath of cochineal, the archi or cudbear bath may be used, with a little sumach or galls. This forms a cheaper but a more fugitive colour.

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with great advantage; and that if colonists could be taught how to
extract and concentrate the true colouring principle of these woods,
much unprofitable labour and expense might be spared. May, more,
the concentrated dye-stuff might be profitably imported from places
from which the cost of carriage would altogether prevent the importa-
tion of the dyestuff in its raw state. This is a matter of great prac-
tical importance, and one which has not yet received that attention it
deserves. There are no doubt difficulties in the way; but after the
many triumphs which man has achieved, we surely need not be
deterred by any ordinary difficulties."

To the above we may add a few valuable observations, made by Mr.
Simmonds in his 'Commercial Products of the Vegetable Kingdom,'
on the useful qualities of many simple and well-known plants, and
other substances, as dye-materials. "The beauty of the dyes given by
common materials, in the Highlands of Scotland, to some of the cloths
which were exhibited [at the Great Exhibition of 1851], should lead
our botanists and chemists to examine more closely than they have
hitherto done, the dyes-stuffs that might be extracted from British
plants. Wool, and the dyers' yellow wood, are both well known. A
piece of tweed, spun and woven in Ross-shire, was dyed brown and
black by such cheap and common dyes as moss and Alder-bark; and
the colours were unexceptionable. Sutherlandshire tweeds and stock-
ing, possessing a rich brown colour, were produced with no more
valuable dye than soot; in another piece, beautifully dyed, the yellow
was obtained from stony rag; brown from the crop of young heather;
and purple from the same, but subjecting the yarns to a greater action
of the dye than was necessary to produce brown. There is very little
doubt but that beautiful and permanent dyes, from brown to a very
rich purple, might be cheaply produced by scientific preparations of the
common heather. The inhabitants of Skye exhibited cloth with a
peculiarly rich dye, obtained from the Crobal moss."

It has been shown in former articles [BLEACHING; CALICO PRINTING]
that the legislature has sought to throw a shield of protection around
the women and children employed in bleach and print works; that
this attempt succeeded so far as concerned print works; but that
bleach works still remain exempt from the operation of the Factory Acts.
We are now to add that dye works are in the same category as bleach
works. In the years 1855-57, both classes of establishments were
subject to many parliamentary discussions, and to inquiries by com-
misssioners—ending by a postponement of all legislation thereon.