Colour, and Colour-*Making*, in *Calico-Printing*. The preparation of colours for calico-printing, conſtitutes one great branch of that beautiful art, and involves in it a ſeries of intereſting and important proceſſes. As an art, its operations are more dependent than almoſt any other, on thoſe minute differences and changes in the conſtitution of bodies, which it is the buſineſs of chemiſtry to inveſtigate. Hence that liability to error and uncertainty which, in the hands of the ignorant, pervades many of its proceſſes, though conducted according to long eſtabliſhed and approved formulæ. Our preſent volume would ſcarce ſuffice for the various receipts in which the art abounds; yet, in the following article, we ſhall endeavour to lay down general principles, rather than more practical directions; convinced, that by preſenting our readers with a clear and conciſe theory, deduced from ſuch practical illuſtrations, as may be neceſſary for this purpoſe, we ſhall render them a more acceptable ſervice.

The term *cola*, in calico printing, is applied not only to thoſe vegetable, animal, and mineral ſolutions, which impart their own colour to the cloth on which they are applied, but alſo improperly to thoſe earthy or metallic ſolutions, which, poſſeſſing little or no tingent properties themſelves, yet retain or fix the colours of other ſubſtances, when afterwards applied to the cloth. Thus the acetite of alumine, or printers' red liquor, when pure, is almoſt colourleſs, and only becomes red by the proceſs of dyeing, as will be explained hereafter. The acetite of iron, or iron liquor, is like manner, when uſed of a determinate ſtrength, is called *black colour*, and when weaker *purple colour*, though the cloth impregnated with theſe ſolutions becomes black or purple, only as being raiſed, like the other, in the dye-copper.

1. The colours produced by means of theſe earthy or metallic ſolutions (which, in the language of ſcience, are called *mordants*), form the moſt valuable and important ſeries, whether conſidered with regard to the almoſt infinite variety of ſhades, or to their ſolidity and durability. Theſe colours, from the mode in which they are produced, (the mordant being firſt applied to the cloth, and the colour afterwards raiſed by dyeing), are called *dyed colours*.

2. Sometimes the mordant is previouſly mixed with a ſolution of colouring matter, and in that ſtate applied to the cloth, ſo as to paint or ſtain it, at one operation, and without the proceſs of dyeing. Thus, another claſs of colours is produced, many of them poſſeſſing great brilliancy indeed, but much inferior to the former in durability. The colours called chemical, by calico printers, belong chiefly to this claſs.

3. In the third and laſt claſs, we may place all thoſe where the colouring matter is ſimply held in ſolution by an acid or alkali, and in this ſtate applied to the cloth, without the intervention of any mordant. To one or other of the foregoing claſſes, may be referred all the colours uſed in calico printing; with the exception, however, of thoſe ſyſtems of colours which have been produced by calico printers in this country, within a ſhort period, by proceſſes, and upon principles which have hitherto not been made known.

Claſs I.

The colours of this, as has been already obſerved, are produced, by firſt impregnating the cloth with an earthy or metallic ſolution, or mordant, and raiſing the colour afterwards by dyeing. In this article we ſhall confine ourſelves to the preparation of the different mordants, and the enumeration of colours they afford, with different colouring ſubſtances. The operations of the dye-houſe, and the mode of raiſing the colours in the dye-copper, will be detailed hereafter.

The two great and moſt important mordants uſed in calico printing, are thoſe that we have already noticed, *viz.* the ſolution of iron in acetous acid or vinegar, called iron liquor, and the acetous ſolution of alumine, or the earth of alum, called red liquor, or red colour, and ſometimes yellow liquor.

With theſe two ſolutions, either ſeparately applied, and of of various ſtrengths, or mixed together, and in various proportions, an infinite variety of ſhades of colour are produced. Almoſt all the hues in nature may be obtained by raiſing them, and their various combinations with different colouring ſubſtances. From madder, with the acetite of alumine, or red liquor, we obtain various ſhades of red, from the darkeſt blood colour to a pink. From weld and quercitron bark, yellows, varying in intenſity from a deep orange to a pale ſtraw colour, according to the ſtrength of the mordant employed. From logwood, various ſhades of violet; from cochineal, Brazil, and Hicaragua wood, pink and crimſons of different hues; and, in ſhort, from almoſt every different colouring ſubſtance, a different ſhade of colour. With the acetate of iron, or iron liquor, of different ſtrengths, we obtain from madder all the intermediate hues between black and pale purple, or lilac. From weld and bark, olives, browns, and drabs, of various hues; from ſumac, logwood, galls, and other aſtringent ſubſtances, all the varieties of grey, from the paleſt ſhades to the deepeſt, in which all the minute differences of hue are loſt till they approach to black. Theſe various ſhades are further modified by applying two or more colouring ſubſtances to the ſame mordant, as madder and weld, for example, to the acetite of alumine, which produces orange, light cinnamon, nankeen, &c.; and again ſtill further, by mixing the mordants themſelves in various proportions, and raiſing them with either one or more of the different colouring matters. By theſe means ſhades, and varieties of colour, may be produced from a few ſubſtances only, which baffle deſcription, and for which language has no preciſe or definite terms.

The acetite of iron, or iron liquor, is variouſly prepared. In this country it is chiefly made with the pyroligneous acid, which Fourcroy has proved to be identical with the acetous. Malt acid is preferred by many on account of its being free from volatile oil and reſinous matter, with which the other abounds; but the great difference in price, and the facility with which it is obtained, has brought the acid of wood almoſt into general uſe. A ſeries of caſks filled with ſcraps and turnings of iron upon which the acid is poured, is almoſt the only apparatus neceſſary for making iron-liquor; yet when the conſumption is great, or when it is prepared for ſale, vats capable of holding ſeveral hundred gallons are ſubſtituted for caſks, and the acid is kept in a ſtate of circulation through the iron by means of pumps. The ſaturation is much accelerated by this motion, which prevents any depoſition on the ſurface of the iron which might defend it from the action of the acid, and alſo brings freſh portions of unſaturated acid more frequently in contact with the metal. In a few weeks, ſooner or later in proportion to the ſtrength of the acid, the ſaturation is completed, and the liquor is then removed from the vat into caſks for uſe, and freſh acid poured upon the iron as before. This is an eaſy and ſimple mode of making iron liquor, and as it requires but little trouble and attention, is the one moſt generally in uſe. The precautions neceſſary to be obſerved are, that the acid, if it be the pyroligneous, ſhould not be uſed too ſoon after its preparation. It holds much eſſential oil and reſin in ſolution, part of which ſeparates on being kept a few weeks, and the clear acid may then be drawn off. It may be ſtill further freed from reſin by boiling; a portion of eſſential oil is thus thrown off, and the reſin, if held ſuſpended, is precipitated after ſtanding ſome time. We ſhall have occaſion to recur to this ſubject again, when we come to treat of the pyroligneous acid, and its formation, under the article *Diſtillation of* Wood. It is neceſſary alſo, that the iron ſhould be perfectly clean and all of it malleable. Caſt iron is not ſoluble in acetous acid. Hoop iron cut into lengths of from eight to ten inches is preferable to any other. It is readily cleaned and more eaſily taken out of the vat, and returned into it again than miſhapen maſſes ſold under the name of old iron. When malt acid is employed, ſimple heating and waſhing is ſufficient to free it from any foulneſs it may have contracted in the vat; but when the pyroligneous acid has been uſed, it becomes ſo coated with reſin on its upper ſurface after a ſecond or third ſolution, as to prolong the period of ſaturation to twice or thrice its uſual length. In this ſtate it muſt be removed from the vat and heated to redneſs in oven, through which there is a current of air. The reſin is conſumed, and the iron by heating is freed from any remains of carbonaceous matter that may adhere to it, and is again ready for the vat.

The only objection to this mode of making iron liquor is the time required to ſaturate the acid, which to thoſe, whoſe conſumption is very great, or who manufacture it for ſale, is oftentimes of importance. Different proceſſes have therefore been deviſed to remedy this inconvenience, in many of which the ſaturation is accelerated by means of heat which is applied in various ways, as beſt ſuits the convenience of the manufacturer; but the moſt expeditious mode is that of preſenting the iron to the acid in a ſtate of oxydation, by which means the ſolution is effected immediately. Calico printers have long been in the habit of uſing an extemporaneous acetite of iron, formed by mixing together ſolutions of acetite of lead and ſulphate of iron. A very pure acetite of iron may be obtained by this means, but the price of acetite of lead renders this mode too expenſive for general uſe. By forming a ſolution of lead, however, in pyroligneous acid and decompoſing it with ſulphate of iron or copperas, an iron liquor may be obtained ſufficiently cheap to render this proceſs advantageous in many caſes, though ſtill more expenſive than the ordinary mode. A patent was lately taken out for making iron liquor by a proceſs ſomewhat ſimilar to this, which, however, we underſtand has not anſwered the expectation formed of it. A ſolution of lead in pyroligneous acid is digeſted on clear metallic iron. The iron becomes oxydated at the expence of the lead and is diſſolved, whilſt the lead is precipitated in the metallic ſtate, and may again be uſed for a freſh ſolution. All theſe modes are evidently more expenſive than the ordinary one of ſimple ſolution of metallic iron in pyroligneous acid, and the only conſideration with the manufacturer is, whether this extra expence is counterbalanced by the economy of time or not.

The proceſs adopted ſome years ago by Mr. Thomſon, is perhaps the moſt expeditious, and next to the common mode, the moſt economical of any yet in uſe. It conſiſts in ſaturating the pyroligneous acid with quicklime, and pouring the clear boiling ſolution on as much ſulphate of iron or copperas as will precipitate the whole of the lime. A caſk of iron liquor may be made by this mode in a few hours, and when care has been taken rightly to proportion the ingredients ſo as to produce complete decompoſition, it is inferior to no ſolution whatever in any of its properties.

The properties of the acetous ſolution of iron fit it eminently above all others for the purpoſe of the calico printer, and having detailed its preparation we ſhall endeavour to point out in what this ſuperiority conſiſts.

The acetite of iron exiſts in two ſtates, dependent on the quantity of oxygen combined with the iron. When pure, and recently prepared, it is of a pale greeniſh hue, but by expoſure to air ſoon becomes tinged with brown. In this ſtate the iron is at its loweſt point of oxydation, ſtrongly attractive of oxygen, and if precipitated by an alkali, of a deep green colour. By expoſure to the atmoſphere, and conſequent absorption of air, the solution passes to a deep red brown, and, if concentrated, deposits orange oxyd of iron, and becomes strongly acidulous. With this excess of acid, the solution now becomes permanent; the iron is almost wholly at the maximum of oxydation; and, when precipitated, of a dark red colour.

The same takes place only in a less degree, and more slowly with the sulphuric and muriatic solutions of iron. Of a pale greenish hue in their recent state, they gradually attract oxygen from the atmosphere, and become slightly red, deposit red oxyd of iron and pass to a state of acidity, at which the solution becomes permanent, and the oxydation of the iron proceeds no further.

If the solutions, properly thickened with gum or flour, are applied to cloth, the same change takes place, but with more rapidity, from their diffusion over a thin surface, and more complete exposure to the air. The aqueous and volatile part of the solution speedily evaporates, and as the oxydation goes on, the oxyd of iron is deposited on the cloth, and a portion of acid set free. When this acid is volatile, as is the case with the acetous, and also in a great degree with the muriatic, it is dissipated. The oxydation of the iron then goes on, fresh portions of acid are again liberated and drawn off till the whole of the solution is decomposed, and the oxyd of iron deposited in the cloth. When the acid is not volatile, however, as is the case with the sulphuric, the first portions of acid that are liberated not being drawn off, the oxydation proceeds more slowly till the excess of acid becomes so great as wholly to interrupt it, and great part of the iron in the operation of rinsing is again carried off the cloth. Another and more serious inconvenience attending the use of the sulphuric solution is its action on the cloth itself. The disengaged acid being in a state of great concentration acts upon its fibres, weakens, and at last destroys them. The same takes place with the muriatic solution also, for though the excess of acid is slowly dissipated, yet it has sufficient time and concentration to act very powerfully, and is, if possible, still more destructive than the sulphuric, since its action is not confined to the part on which it is applied, but from its volatility extends over the whole surface of the cloth.

It is necessary, therefore, that the acid should be not only volatile, but harmless in its action on the vegetable fibre, which conditions are more completely fulfilled by the acetous than by any other solution whatever. From the preceding observations on the properties of the acetite of iron, and the changes it undergoes on the surface of the cloth, may readily be deduced the reasons for that exposure to heat and air which calico printers have, from long experience, found necessary to goods printed with this solution. By exposure to air the iron becomes oxygenated and deposited on the cloth, whilst the heat favours the liberation of the acid, and accelerates the process. From what has gone before it may also be inferred, that the acetite of iron should be used in its recent or *green* state, since in that state the acetous acid is capable of holding a greater quantity of oxyd of iron in solution, and that consequently after its saturation and removal from the iron, it should not be too much exposed or agitated in contact with the air. On this account, also, it is wrong to pump the liquor in the vats too much when it approaches the point of saturation, since the oxygenated iron is almost all precipitated, and fresh portions immediately dissolved, so that the liquor might in time be rendered quite thick with precipitated oxyd of iron.

The preceding ideas are at variance with the general opinion respecting the state in which the acetite of iron should be employed. All the speculative writers, and even many well acquainted with the processes of calico printing, recommend the oxygenation of the solution by exposure to air and removal from the iron, as essential to the goodness of the iron liquor. Even Berthollet, in the last edition of his "Elements of the Art of Dyeing," has fallen into the same mistake, the source of which, and the facts which seem to countenance it, we shall point out in a future article.

It is an object of importance to the calico printer to know the precise strength of his iron liquor, and to be able to ascertain this at all times, with little trouble or chance of error. Great mischief and inconvenience often arises from uncertainty in this respect, especially in the pale shades of purple, which are obtained from madder, with diluted acetite of iron. The hydrometer has been objected to, as indicating not merely the quantity of iron in a solution, but also the essential oil, resin, and mucilage which these impure solutions often contain. This objection, however, only applies where the same instrument and graduation is employed to ascertain the relative strengths of iron liquors, prepared with different acids, as the pyroligneous which contains much essential oil and resin, and malt acid which abounds in mucilage. In this case the hydrometer may indicate great differences in solutions containing equal quantities of acid and iron, but varying in the quantities of mucilage, oil, or resin. Iron liquor, however, prepared constantly by the same process, and from the same acid, varies so little in the relative proportion of its ingredients, that the hydrometer may be used to ascertain its strength in preference to any other mode whatever; provided the necessary precautions are used to correct any error arising from variation of temperature.

In a work of this kind, not illustrated by actual specimens, and without reference to some particular kind of iron liquor, it is impossible to point out the specific gravities of the different solutions required for producing the various shades, we have enumerated. An acetite of iron, of specific gravity 1.047, with madder or logwood, will produce a black, and with weld or sumac an olive, and diluted with six, eight, or ten times its bulk of water, various shades of purple, drabs, or olives, according to the colouring matter employed. A standard solution of iron once obtained, the necessary strength for producing the different varieties of colour is easily ascertained by actual experiment, and to this we must refer our readers.

When thickened with flour or gum, and tinged with a decoction of logwood or Brazil, the better to enable the workman to observe the progress and state of his work, it forms, as we have before observed, the printers black colour, a purple colour, &c. according to the strength of the solution and the purpose it is intended for. Various ingredients were formerly added to iron liquor, to improve its quality, or vary the hue of colour it produced. Verdigrise and copperas were added to the solution intended for black; and sal ammoniac or nitre to the diluted solutions for purple. These are, however, now almost universally laid aside, as being for the most part useless, and often hurtful: the simple acetite of iron being found to answer every purpose of the more complicated and heterogeneous solutions.

The *acetite of alumine*, or red liquor, is always prepared by the decomposition of alum, by an earthy or metallic salt, since the aluminous earth is not soluble in acetous acid, except in its newly precipitated and minutely divided state. The purest solution, and that which is generally used for the finest and most delicate colours, is produced by decomposing alum with Dutch sugar of lead, generally in the proportion of two parts by weight of the former, to one of the latter. The proportion of the two salts, and also the quantities of each gallon, as used by different calico printers, vary yet

with

with little difference in effect. The alum in general predominates so far as completely to saturate the liquor. The printers' aluminous mordant therefore is a compound solution. It is an aceto-sulphate of alumine, consisting of a saturated solution of common alum, and more or less acetite of alumine, according to the quantity of sugar of lead employed. In the neighbourhood of London, the proportions are 6lb. of alum, and 3lb. of sugar of lead to a gallon of water: when these are completely dissolved, one ounce of Spanish white is added, and the whole briskly stirred till the effervescence has in great measure subsided. In a few hours the solution becomes clear, and forms a standard liquor from which, by greater or less dilution, may be obtained all the various shades of red, yellow, &c. already enumerated. In the above formula the proportion of alum is somewhat too great, a part of it remains undissolved, or immediately recrystallizes, and falls to the bottom along with the precipitated lead. This excess of alum is however strongly insisted on by many calico printers, as essential to the purity of the mordant, from an idea that the *purest* part of the alum only is taken up in the solution. This fact however may be readily disproved by employing this undissolved or recrystallized alum in the formation of fresh solutions, whose purity will be found in no respect inferior to the former. The purity of the alum and sugar of lead, and especially their being free from iron, is of great importance in the preparation of this mordant, and on this account the Dutch sugar of lead is preferred; but its high price renders it too expensive except for the pale reds of light chintz, and other kinds of work, whose great delicacy in the red tints is required. A substitute for it has been found in the solution of litharge in vinegar, or pyroligneous acid, which is afterwards decomposed by the addition of alum, and the excess of acid neutralized by Spanish white as in the former case. Great part of the acetite of alumine manufactured and sold under the name of red liquor is prepared in this manner. It is in general used for yellows, dark shades of red, and for those compound mordants into which the acetite of iron enters, and when its purity is of course of little consequence. The acetite of lime has long been substituted with great advantage by the writer of this article for the solution of lead, and its use is becoming daily more known and extended. When carefully prepared, it is scarce inferior to the best sugar of lead, and the impure solutions answer equally with the best, for the compound mordants before mentioned. The theory of these processes is the same in all. The object being to obtain a solution of alumine or earth of alum in acetous acid. On mixing acetite of lead, and sulphate of alumine together, a change of bases takes place; the sulphuric acid unites with the lead, and falls down in the form of a white heavy precipitate, whilst the earth of alum combines with the acetous acid, and remains in solution. The same takes place with the solution of litharge in pyroligneous acid, which is indeed an impure acetite of lead, and when the acetite of lime is employed instead of lead, the sulphuric acid and lime unite and form an insoluble powder, which subsides, though less quickly than the other, whilst the acetite of alumine remains in solution above; the addition of the Spanish white is necessary to saturate a small excess of acid which exists in the solution. This excess is taken up by the lime, and immediately converted into acetite of alumine, by the decomposition of a fresh portion of alum.

The acetite of alumine when pure, is almost colourless. It has a slight acetous smell, and when boiling throws off acetous acid in great abundance, and deposits a portion of alumine. When evaporated it acquires a thick gummy consistence, but does not crystallize a property which gives it a decided advantage over common alum as a mordant. It unites readily with gum, but when concentrated and holding much alum in solution, forms with flour a watery pulpy kind of paste, which has little adhesion, and from which the fluid soon separates. The sulphuric salts have indeed all a disposition to injure the thickening quality of flour.

The affinity of cotton for the earth of alum, is so strong as to separate it from its combinations even with the mineral acids. When a solution of common alum properly thickened is applied to cloth, a portion of alumine unites with it, and the acid, which held it in solution, is set free. When this is accumulated to a certain degree, it prevents any further decomposition, and in rinsing carries off the greater part of the earth again. When the acid however is volatile, like the acetous, and is dissipated as soon as disengaged, there being no longer any obstacle, the decomposition goes on till the whole of the acid is driven off, and the alumine combined with the cloth. In the infancy of calico printing, and before the theory and constitution of the different mordants was properly understood, a variety of substances were added to the solution, some of which are retained to this day. Verdigrise in the proportion of two ounces to a gallon, is recommended by many as tending to exalt the hue of yellows, and may in some cases be useful. Corrosive sublimate has been but lately laid aside, and the nitro-muriate of tin was long thought to give fixity and brillancy to reds, when used in a small proportion with the aluminous mordant. In general, however, the aceto-sulphate of alumine is found adequate to every purpose of the calico printer; we shall not, therefore, perpetuate error by detailing any of those unmeaning mixtures which are still retained by the ignorant and prejudiced. These two mordants, the acetites of iron and alumine, and their various combinations, are those only in general use in calico-printing, for producing colour of the first class. This application is so extensive, and at the same time so simple, as to supersede the necessity of any other. The solutions of copper are sometimes used as mordants, but they afford colours of little solidity. The solutions of tin have also been employed, but we shall speak of these and other earthy and metallic solutions which have been used with partial success, when we come to treat of mordants in general.

Class II.

In this class the colours are produced by combining a solution of colouring matter with some earthy or metallic salt, capable of giving it fixity when applied to the cloth. The mordant and colouring matter are here applied at once, and the cloth is painted, as it were, or stained, with the colour it is intended to retain, and requires, in general, no farther operation than that of rinsing, to free it from the paste or gum with which it was thickened.

The colour of this class possesses, as we have before observed, in general great brilliancy, but wants that solidity and fixity which characterise the colours of the former class. The union of the mordant with the cloth is weakened by its previous combination with the colouring matter, and not being favoured by heat, as in the former case; the triple combination of vegetable fibre, mordant, and colouring matter, wants that solidity which is so necessary to constitute what is called a fast colour.

Many of these, however, are sufficiently durable to be partially introduced, and intermixed with other colours of greater durability, and some are indispensably necessary, as no better mode has yet been devised of producing them. When the chemist's chemiſt's art ſhall have diſcovered means of giving fixity to colours thus topically applied, the art of calico printing will have arrived at perfection. Syſtems of colours may then be combined, which are at preſent incompatible, and the tedious operation of dyeing and bleaching, with their attendant difficulties, be baniſhed from the art. Nor is the hope ſo chimerical as might at firſt be imagined; ſeveral of the moſt uſeful and permanent colours are of this deſcription, as will be ſhewn hereafter.

We ſhall content ourſelves with deſcribing the leading and moſt uſeful colours of this claſs, giving, at the ſame time, the theory of their conſtitution. The mere enumeration of all the varieties that have or may be formed, would be endleſs, and foreign to our purpoſe.

Chemical Black.

This is the moſt uſeful colour of the claſs, and one of indiſpenſible neceſſity in certain combinations of colours, where, for inſtance, it is mixed with drab, olive, and yellow, raiſed in the dye-copper with weld quercitron bark, or any ſimilar colouring matter, and where the preſence of any ſubſtance, ſuch as logwood or madder, capable of producing a full black, would be ruinous to the other colours. A deep olive, approaching to black, might, indeed, be produced, by employing a ſtrong iron liquor, as mordant, and uſing ſumac in the dye-copper; yet as this would bear no compariſon in point of intenſity with the madder or logwood black, and as the force of the colouring in ſuch courſe of work greatly depends on contraſt, the topical or chemical black, which has all the intenſity required, is almoſt conſtantly employed. The conſtitution of this black is pretty nearly the ſame in all the different formulæ in uſe. It conſiſts always of a ſolution of iron combined with a ſolution of colouring matter generally of an aſtringent nature. On the right proportion of theſe two ſolutions, and on their due ſpecific gravity or ſtrength depends, in a great meaſure, the goodneſs of the black.

1. If to a decoction of Aleppo galls, in five times their weight of water, made into a paſte with flour, a ſolution of iron in nitrous acid of ſpecific gravity 1.25 be added, in the proportion of one meaſure of nitrate of iron to eighteen or twenty of the former, a black will be formed fit for almoſt all the purpoſes of calico printing, and poſſeſſing the chief requiſites of this colour, namely, tolerable fixity, and a diſpoſition to work well with the black.

2. In lieu of nitrate of iron, ſome calico printers employ copperas, in the proportion of one pound to a gallon of the decoction of galls. Half the copperas is directed to be diſſolved in the gall-liquor before it is thickened with flour; the remaining half, diſſolved by heat in as much aquafortis as will cover it, is added afterwards. This black has tolerable fixity, but does not work ſo well as the preceding.

3. Copperas diſſolved in various proportions of from four to twelve ounces per gallon, will form, with decoction of galls or logwood, blacks of leſs ſolidity indeed than the former, yet applicable, nevertheleſs, in many caſes where the others are not.

The conſtitution of the two laſt-mentioned blacks differs ſomewhat from the firſt. We ſhall point out this difference, and explain, as conciſely as poſſible, the rationale of the foregoing proceſſes.

When a ſolution of iron in nitrous acid is added to a decoction of galls, as in the firſt example, the ſolution is decompoſed, the iron unites with the gallic acid and tanning principle, whilſt the nitrous acid is diſengaged. This is proved by the blackneſs which the ſolutions aſſume immediately on being mixed. The diſengaged acid, however, ſhortly re-acts on the new compound, the blackneſs gradually diſappears, and in a few days, if the nitrate of iron has been added in proper quantity, the paſte, inſtead of black, is of a dirty olive green. If the proportion of nitrate of iron be greater than $\frac{1}{18}$, this change will be effected ſooner; and if ſo high as $\frac{1}{10}$, the paſte, when applied to the cloth, will be a bright orange, like the acetite of iron. By expoſure to heat and air, this colour generally deepens, becomes grey, and at laſt a full black. In this ſtate it is permanent, and adheres powerfully to the cloth. Theſe changes of colour depend on the ſolution of the tannate and gallate of iron in the diſengaged nitrous acid, and the evaporation of the acid when expoſed to heat and air on the cloth. This ſolution of the tannate and gallate of iron is indeed an eſſential requiſite in the goodneſs of the chemical black. If the diſengaged acid is not ſufficient to effect this, or if it is in too great a ſtate of dilution, the colour has but a feeble adherence to the cloth; it is not preſented in a ſtate favourable to its union with it, ſince the combination into which the iron has entered is inſoluble in water. It lies merely on the ſurface, but does not penetrate its fibres, and yields readily in the various operations to which it is ſubjected. The chemical black, therefore, of the firſt example is a ſolution of the tannate and gallate of iron in nitrous acid.

The black of the ſecond, but more particularly of the third example, differs from the preceding in the circumſtance of the iron in the ſolution being in a leſs oxygenated ſtate. We may conſider this black in its recent ſtate as a mixed ſolution of green ſulphate of iron, and gallic acid, and tanning principle; for the decompoſition of the ſulphate is not complete till by expoſure to air on the cloth the iron becomes fully oxygenated. When this black is recently applied to the cloth, it is of a pale greyiſh colour, has little fixity, ſimple rinſing in cold water being ſufficient to fetch nearly the whole away. By gradually abſorbing oxygen, it becomes deeper, and at laſt black. The ſulphuric acid has no longer any action on it, and is removed in the firſt operation in which it is immerſed in water.

The decoction of galls uſed for chemical black is variouſly prepared. Many calico printers infuſe the galls cold in caſks of vinegar, or pyroligneous acid, ſuffering them to remain ſeveral months, occaſionally drawing off the lower part, and returning it on the galls. Others ſteep them in urine. Both theſe modes are vicious, particularly the laſt. Simple boiling in water, till all the ſoluble matter is extracted is ſufficient, taking care to incloſe the galls in a ſack, that when ſoft they may not render the decoction thick.

Grey.

By diluting the chemical black of the firſt example with once, twice, thrice, &c. its bulk of water, and thickening the ſolution with gum, various ſhades of grey are obtained, which require rinſing off in water only, and the deeper ſhades of which have tolerable permanence.

The theory of theſe mixtures is the ſame as of the black, from whence they are derived. On the addition of water to the olive-green ſolution, mentioned in the preceding article, the colour inſtantly becomes deep purple, approaching to black. This is occaſioned by the dilution of the free acid, which being no longer able to hold the tannate and gallate of iron in ſolution, ſets part of it at liberty, which inſtantly regains its colour. For the reaſon already aſſigned, this has leſs adherence to cloth than that in which the ſolution is more perfect. The addition of a ſmall quantity of nitrous acid effects this. The olive-green colour of the ſolution is reſtored,

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which, by expoſure to the air, and conſequent evaporation of the acid, diſappears, and leaves the tannate and gallate of iron more firmly fixed on the cloth. The complete precipitation of the combination is afterwards effected in the operation of rinſing off in water.

Yellow.

The falſe or chemical yellows are generally prepared with decoctions of French or Turkey berries, and ſometimes with quercitron bark. The latter ſubſtance produces pale yellows or ſtraw colour, but does not afford the deep bright orange yellow of the berries. Dr. Bancroft, to whom the public is indebted for the introduction and knowledge of this moſt uſeful dyeing drug; indeed, aſſerts the contrary in his work on "Permanent Colours;" and has given a receipt for the bark-yellow, which has, however, never ſucceeded in our hands.

Berry-yellow. Boil two pounds of good berries, ſlightly bruiſed, in a gallon of water during three hours, taking care to replace, from time to time, the evaporated water with liquor obtained from the ſecond boiling of a former quantity of berries. When the liquor is cool, add to it eight ounces of alum, and if it is intended for the block thicken it with flour. If it is meant for thoſe ſmall objects in printed goods, which are generally touched with the pencil, two ounces of ſugar of lead ſhould be added with the alum, and the colour thickened with gum dragon. This yellow is generally paſſed through lime water as the firſt part of the operation of rinſing; by this means the greater part of the earth of alum, which would otherwiſe have been carried off in the operation, is precipitated on the cloth, and the colour conſiderably heightened.

When this operation of liming cannot be performed without injury to ſome other colour, a greater proportion of ſugar of lead ſhould be added. This decompoſes the alum, and forms an acetite of alumine, which being more readily decompoſed by the colouring matter and the cotton than ſulphate of alumine, does not require the aſſiſtance of an alkaline ſolution to precipitate it on the cloth.

The proportion of berries above directed is for a full yellow; one-fourth or one-third leſs will form, with the ſame quantities of ſalts, yellows of great brightneſs. Some calico printers add a ſmall quantity of nitrate of copper to the yellows intended to be ſimply rinſed off without liming. This heightens the colour, but what is gained in intenſity is loſt in brightneſs; for if the ſolution of copper be added in ſufficient quantity to produce any very perceptible effort, it imparts a dulneſs to the hue which is very detrimental. This is the invariable effect of copper in any ſhape, whether the acetite, ſulphate, or nitrate of copper be employed.

Bark-yellow. For a lemon or ſtraw colour, it will be ſufficient to make a decoction of bark by boiling from four to ſix pounds in as much water as is neceſſary during two hours, and after evaporating down the decoction to one gallon, add to it two ounces of ſugar of lead, and eight ounces of alum. If not limed, the proportion of ſugar of lead ſhould be doubled. For ſtrong yellows, Dr. Bancroft directs the addition of both nitrate of copper and nitrate of lime in quantities ſo great, as near ſeven ounces of the former to a gallon of colour. Experience, however, though it has done juſtice to the merits of Dr. Bancroft's diſcovery of the uſe of quercitron bark, has not verified the expectations he had formed of it as a ſubſtitute for the Turkey berries in the topical or chemical yellow.

The conſtitution of theſe colours, whether formed with the ſulphate and acetite of alumine, or with the ſolutions of copper is the ſame. Alumine, or the earth of alum, and the oxyd of copper, have an affinity both for colouring matter and vegetable fibre. They form the connecting link between theſe ſubſtances, which would otherwiſe counteract a feeble union. When a ſolution of alum is added to a decoction of berries or of bark, a ſlight precipitation takes place by the union of a portion of colouring matter with the earth; the greater part however remains ſuſpended or held in ſolution by the acid of the alum. When applied to the cloth the farther decompoſition of the ſalt is aided by the affinity of this ſubſtance for alumine, and, when the acid is volatile, as the acetous for example, by its conſequent evaporation. The ſame takes place with the ſolutions of copper. The operation of rinſing farther aids the precipitation of the colouring matter and alumine, by thus largely diluting with water; and laſtly, when the goods are previouſly paſſed through the lime tube, the decompoſition is complete, the laſt portions of earth or oxyd are precipitated, and the colour thereby conſiderably exalted.

The ſolutions of tin are capable of forming very bright and beautiful yellows, with decoctions of different yellow colouring ſubſtances; but the exceſs of acid which theſe ſolutions neceſſarily contain, and their powerful action on the cloth, renders their application leſs general than the preceding. The ſolution of tin moſt proper for yellows is the muriatic, and is formed by digeſting, in a low heat for ſeveral days, the common muriatic acid, or ſpirits of ſalt, on fine grain tin. This ſolution forms, with bark, a pale and lively yellow, and with berries a yellow bordering more on orange. Theſe ſpirit yellows, however, as they are improperly called, are ſeldom uſed except upon dyed grounds, and of this preparation for ſuch purpoſes we ſhall treat at large under the head of *Diſcharged* Work.

Blue.

The only blue belonging to this claſs is that produced by combining the colouring matter of logwood with the oxyd of copper. It is but ſeldom uſed ſince the mode of dipping China blue has become generally known; and indeed its want of durability renders it of little value. It may be produced by combining almoſt any of the ſolutions of copper with a decoction of logwood.

1. Boil two pounds of logwood in a gallon of water, and to the decoction, thickened with gum, add eight ounces of ſulphate of copper.

2. To a decoction of logwood as above, add two ounces of ſulphate of copper, and two ounces of verdigriſe.

Their colours may either be rinſed off or limed, as beſt ſuits the ſtyle of work. The theory of theſe combinations is the ſame as the preceding.

Green.

The chemical or falſe green is a compound colour, and conſiſts of a mixed decoction of logwood and berries, or bark, and a ſolution of copper. Though fugitive, its uſe is in ſome degree authorized by the impoſſibility of obtaining a green of greater durability that can be applied in figures with the block. The faſt green of the calico printers is the product of two operations, and is of courſe limited in its application, and tedious in its uſe. The production of a faſt green at one operation, or rather by one application to the cloth, either with the pencil, block, or preſs, is one of the great *deſiderata* of calico printing.

1. One pound of logwood and two pound of berries boiled together during two hours, and ſtrained whilſt hot

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upon two ounces of ſulphate of copper, and two ounces of verdigriſe, and thickened with gum, form a good and lively green, the hue of which may be varied at pleaſure by the increaſe or diminution of the proportion of logwood. To this ſome calico printers add two ounces of common ſalt, and two ounces of ſal enixon or acidulous ſulphate of potaſh.

2. To one meaſure of blue of the firſt example in the preceding article, add two, three, four, &c. meaſures of a decoction of bark, made by boiling ſix pounds as before directed for the yellow, and to which, when reduced to one gallon, two ounces of ſulphate of copper, and two ounces of verdigriſe have been added. The tone of the green depending on the relative proportions of blue and yellow, it is, in general, beſt to keep the two decoctions ſeparate, to be mixed, when wanted, in ſuch proportions as may beſt ſuit the purpoſe required. The theory of theſe mixtures is the ſame as of the blue and yellow already deſcribed. To the eye of the mere ſpeculative chemiſt, the addition of common ſalt and acidulous ſulphate of potaſh in the firſt example, may appear unneceſſary and unmeaning. They indeed affect little, either the hue or fixity of the colour, but experience has proved that this addition facilitates its working with the block, more eſpecially when thickened with gum dragon. The cauſe of this, in the particular inſtance before us, is perhaps not very clear. The ſulphuric ſalts in general, ſuch as the ſulphates of alumine, iron, and copper, are all unfavourable to working, as their ſolutions, eſpecially when concentrated, neither thicken well with flour nor gum. A ſaturated ſolution of copperas cannot be thickened with flour, nor can a ſtrong ſolution of the aceto-ſulphate of alumine, in which the alum is in great exceſs; even with gum it unites with difficulty. But if to a ſolution of copperas, which refuſes to form a paſte with flour, a ſmall portion of nitrate of iron be added, the whole forms a good and ſubſtantial paſte that works admirably with the block; and half a pound of common ſalt added to the aceto-ſulphate of alumine has a ſimilar effect. In the inſtance more particularly before us, the addition of common ſalt forms a muriate of copper by the decompoſition of the ſulphate; but this laſt is in too ſmall a quantity to affect the working of the colour very ſenſibly. The cauſe of theſe effects is to be ſought for in the very complicated play of affinities, which exiſt in ſuch compounds, and which future inveſtigation and diſcovery may perhaps unfold. The ſpeculative philoſopher, who is ignorant of the minute details of an art, that involves in it conſideration and difficulties, unſuſpected in the laboratory, will hence learn to ſuſpend his judgment in deciding on the merits of a formula, till experience ſhall have proved the inutility of thoſe ingredients which theory would reject as abſurd.

But to return to our ſubject, there is a wide field open for experiment and diſcovery in the production of greens, into which logwood does not enter. A calico printer near London, celebrated for his ingenuity and invention in colours of this claſs, has long employed a green which, from its beauty and durability, when compared with the foregoing colours, indicate the preſence of indigo as a conſtituent part. Pruſſian blue, in a minutely divided ſtate, and mixed with bark or berry-yellow has been employed; but the blue in this caſe has ſo little adherence to the cloth, that mere mechanical force, the operation of rinſing and waſhing is ſufficient to diſengage it. With one or other of theſe ſubſtances, however, it is likely that greens much ſuperior in beauty, and probably alſo in durability to thoſe generally in uſe, might, by a ſeries of patient and well conducted experiments, be readily obtained.

Pink.

The pale, and more delicate ſhades of red, belonging to this claſs, are chiefly ſought after in calico printing. They are employed in giving relief or effect to other admixtures of a more ſober caſt, and all the ſkill of the colour-maker is exerted in giving them brilliancy and richneſs of tint. They are chiefly produced from decoctions of Brazil, nicaragua, or peachwood, and cochineal, raiſed and fixed on the cloth with ſolutions of tin, rarely with the aluminous mordants, though delicate and lively colours may be produced this way.

The nitro-muriate of tin is chiefly employed, though the relative proportion of the two acids, and their degree of ſaturation with tin, varies almoſt with every calico printer. The ſolution itſelf, made according to eſtabliſhed rule, and with the ſame properties, varies ſo conſiderably at different times, as wholly to alter the nature of its compounds, without any apparent cauſe of failure. The ſource of this diſcordance is to be ſought for in the conſtitution of the ſolution itſelf, which, from cauſes that we ſhall endeavour to explain, is ſubject to conſiderable variation.

Firſt, from the ſtrength or concentration of the acids employed, which are ſeldom uniform or conſtant; muriatic acid from the ſame manufacturer varying often in ſpecific gravity from 1.12 to to 1.18, and nitrous acid not leſs than from 1.15 to 1.23, without reference to the common diſtinction of ſingle and double aquafortis.

When the ſpecific gravity of the acids is neglected, as is but too generally the caſe, theſe differences occaſion ſerious inconveniences in the uſe of ſolutions, whoſe properties often depend on the accuracy of their proportions, and on determinate degrees of ſaturation.

Secondly, from the impurity of the acids. The muriatic acid of commerce always contains iron and ſulphuric acid; if the former exiſt in any notable proportion, it is unfit for the ſolution of tin; the preſence of the latter is of leſs importance, though, on the whole, unfavourable to delicate colours. The nitrous acid varies conſiderably in its purity, being ſubject to greater or leſs admixture with the muriatic; the nitre it is made from being ſeldom free from marine ſalt. The aquafortis of commerce is, in fact, an aqua regia. This variation of the proportion of muriatic acid in the nitrous, is of the utmoſt importance, ſince the properties of the ſolution eminently depend upon this. With muriatic acid only, tin forms a colourleſs and permanent ſolution, one of whoſe diſtinguiſhing properties is, its ſtrong affinity or attraction for oxygen. With decoction of cochineal, it forms a deep and dull purple-coloured precipitate, which, however, gradually abſorbs oxygen, and becomes crimſon, eſpecially when expoſed on the filtre. With decoctions of Brazil and peachwood, it affords crimſon precipitates, varying in intenſity with their ſaturation with tin. It decompoſes all the combinations of iron with colouring matter, deoxygenating the iron which it carries off, leaving the tin in combination with the colouring matter. Thus a madder black becomes a red on the application of muriate of tin. On this property is founded the art of printing on dyed grounds, of which we ſhall treat hereafter. With nitrous acid, unleſs very dilate, tin contracts a very feeble union, and is generally precipitated as ſoon as diſſolved, in a ſtate fully ſaturated with oxygen. The addition of a ſmall quantity of muriatic acid renders this ſolution more permanent, provided it be not fully ſaturated with tin, and the addition

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of larger portions approximates the ſolution ſtill more to the nature of the former, and renders it capable of ſupporting a greater degree of ſaturation. The properties of the ſolution depend greatly on the proportion of muriatic acid, and conſequently of muriate of tin contained in it. When ſmall, the precipitate with cochineal is bright carmine ſcarlet. It does not decompoſe the combinations of iron with colouring matter, unleſs the ſolution be far from ſaturation, and this effect is then due to the diſengaged acid only.

The purity of the tin is another requiſite which ſhould be carefully attended to. The fine tin of Cornwall, commonly called grain tin, ſhould be employed. If alloyed with lead, it is wholly unfit for theſe purpoſes.

In lieu of muriatic acid, ſal ammoniac and common ſalt are oftentimes employed to form an aqua regia with nitrous acid. The ſolution differs little from that formed by a mixture of the two acids, the allowance being made by the portion neutralized by the alkali of the neutral ſalt.

From this ſhort outline of the hiſtory of the ſubſtances employed in the formation of the ſolutions of tin, and of the properties of the ſolutions themſelves, may be deduced ſuch general ideas as will elucidate and explain many anomalous effects in their combinations with different colouring matters, and ſeem to direct future experiment in the diſcovery of thoſe minute, but often important, conditions neceſſary to the formation of particular ſhades of colour.

The following examples of ſpirit reds, as they are improperly called by calico printers, will illuſtrate ſome of the preceding obſervations, and may be conſidered as ſpecimens of the moſt beautiful and brilliant colours it is poſſible to form upon cotton.

1. Prepare an equa regia by diſſolving two oz. of ſal ammoniac in one pound of nitrous acid of ſpecific gravity 1.25. To this add two ounces of fine grain tin; decant it carefully off the ſediment, and dilute it with $\frac{1}{4}$ its weight of pure or diſtilled water.

To one gallon of water add one pound of cochineal, ground as fine as flour; boil half an hour; then add two ounces of finely pulverized gum dragon, and two ounces of cream of tartar, and ſtir till the whole is diſſolved. When the liquor is cool, add one meaſure of the preceding ſolution of tin, to two of the cochineal liquor, and incorporate well by ſtirring. Apply this with the pencil or block, ſuffer it to remain in the cloth ſix or eight hours, then rinſe off in ſpring water. This colour will be a bright and beautiful ſcarlet.

2. Boil 12 pounds of Brazil chips during an hour in as much water as will cover them. Draw off the decoction, and pour on freſh water, and boil as before. Add the two liquors together, and evaporate ſlowly down to one gallon. To the decoction whilſt warm add four ounces of ſal ammoniac, and as much gum dragon or ſenegal as will thicken it for the work required. When cool, add one of the ſolution of tin before deſcribed, to four, ſix, or eight of the Brazil liquor, according to the colour wanted. Suffer it to remain from 18 to 24 hours on the cloth, then rinſe off in ſpring water as before. The colour will be a pale and delicate pink. If it is required deeper, the decoction muſt be made ſtronger, and uſed in the proportion of three or four to one of the ſolution of tin. Nicaragua or peachwood, though not ſo rich in colouring matter as Brazil, yields a colour, however, which is, if poſſible, more delicate and beautiful. The fine pinks produced by certain houſes, which have for years been the envy and admiration of the trade, are afforded by this fine dye-wood.

Theſe colours require no liming, ſimple affuſion with water being ſufficient to precipitate the colouring matter in combination with the tin. The theory of theſe mixtures is the ſame as the preceding. They require, however, a greater exceſs of acid to hold the colouring matter in ſolution. A decoction of cochineal poured into a ſaturated ſolution of tin, occaſions an inſtant precipitate which is not rediſſolved, and the greater part of which, if applied to cloth, would come off in the operation of rinſing. It is ſometimes neceſſary to add a ſmall quantity of muriatic acid to prevent this precipitation, or to correct it when it happens, and ſal ammoniac is ſuppoſed to have the ſame effect, probably by engaging the water of the ſolution.

With the aluminous ſalts, the decoction of cochineal and Brazil forms colours leſs brilliant than thoſe we have juſt deſcribed, but which are applicable in caſes where the exceſs of acid in the ſolutions of tin is attended with inconvenience.

1. To one gallon of water, add eight ounces of finely ground cochineal, and two ounces of bruiſed galls; boil half an hour, ſtrain the liquor whilſt hot through a fine cloth, upon four ounces of cream of tartar and four ounces of gum, and thicken with gum dragon. This colour requires liming.

2. Upon 6lbs. of Brazil and 2 oz. of galls, pour one gallon of water, let them ſoak ſome time, then boil two hours, replacing the evaporated liquor with freſh water. Strain through a fine cloth upon 4lb. of gum ſenegal, and add one pint of the acetite of alumine, deſcribed in a former part of this article.

The addition of galls in the two preceding formulæ is ſuppoſed to import ſolidity to the colours in ſome way analogous to the operation of galling in ſilk and cotton dyeing, of which we ſhall have occaſion to ſpeak hereafter. Their conſtitution is otherwiſe the ſame as the berry and bark yellows, and moſt others of this claſs of colours.

Purple.

1. If the ſolution of tin directed for the pink in the laſt article be mixed with ſix times its bulk of a decoction of logwood poured whilſt hot upon four ounces of ſal ammoniac, and $2\frac{1}{2}$ lbs. gum ſenegal, a bright and lively purple will be obtained, the hue of which varies with the ſtrength of the decoction and the proportion of ſolution of tin employed.

2. If inſtead of the ſolution of tin, the acetite of alumine before alluded to, be uſed in various proportions of one ſixth, eighth, &c. purples differing in ſhade and intenſity will be formed, applicable in ſome caſes, but poſſeſſing leſs ſolidity than moſt of the colours already deſcribed.

The conſtitution of theſe compounds is the ſame as the preceding.

Olive.

Olives are variouſly compounded, according to the colour required.

1. By mixing chemical black in various proportions with berry or bark yellow. The depth and fulneſs of the olive depends on the quantity of black.

2. By a decoction of logwood added in greater or leſs quantity to the bark or berry yellow.

3. By the addition of copperas or nitrate of iron to decoctions of yellow or aſtringent colouring matters, ſuch as bark, ſumac berries, weld, &c. each of theſe produces a different hue, varying from the green olive to a drab or cloth colour. By mixing theſe decoctions in different proportions, and by varying their ſtrength, and the quantities of copperas

or nitrate of iron added to each, a multiplicity of ſhades may be produced, of which it is impoſſible to convey any preciſe or definite ideas.

Theſe colours may be indifferently thickened with flour or gum, as beſt ſuits the work required, but when nitrate of iron is added to ſolutions containing gum, the inſtant coagulation that takes place muſt be counteracted by the addition of a portion of free nitrous acid. This effect ariſes from the ſtrong action exerted by metallic oxyds, at the maximum of oxydation, on mucilage or gum. When the decoction is very concentrated, and contains ſufficient colouring matter to engage the whole of the iron, this effect takes place in a leſs degree, but with ſolutions adapted to the production of the foregoing colours, a coagulation invariably takes place, unleſs counteracted by the preſence of a portion of free acid. Of this action of metallic oxyds on the ſolution of gum we ſhall further treat under the article Gum.

Claſs III.

In this claſs, the colouring matter is ſimply held in ſolutions, by an acid or alkali, and in that ſtate applied to the cloth without the intervention of any mordant.

The moſt important of theſe colours, is the alkaline ſolution of indigo which forms the topical or.

Pencil Blue.

1. Prepared ſolution of pot-aſh, by boiling together 7½lbs. of quick lime, and 15lbs. of pot-aſh, in 10 gallons of water. Decant off the clear liquor, and ſeparate the remainder from the lime by means of the filter. To one gallon of this ſolution, add 1lb. of red arſenic, or orpiment, and 1lb. of fine indigo, both previouſly ground together in a mill with ſufficient water to form a thick paſte. Bring them up gradually to a boil, ſtirring carefully all the time, and then withdraw the fire. Thicken the ſolution with the beſt gum ſenegal, and for the pale ſhades of blue, dilute with one, two, &c. meaſures of gum-water.

The quantities and relative proportions of pot-aſh, orpiment, and indigo in a gallon of pencil blue vary conſiderably with different calico printers, and within certain limits, it appears, that the accuracy of theſe proportions is not of great importance. Hauſman, an intelligent French printer, employs 15lbs. of pot-aſh, 6lbs. of orpiment, and 8lbs. of indigo, to 12 gallons of water; and Oberkampf, proprietor of the celebrated manufactory of Tony, a ſtill greater proportion of indigo. Some printers add brown ſugar, and Bancroft has propoſed to ſubſtitute this for the orpiment, but without ſucceſs.

The ſolution, when recently made, is a yellowiſh green, but by expoſure to air, becomes gradually deeper, and at laſt blue. In this ſtate, it is wholly unfit for uſe, it contracts no union with the cloth, and is detached from it in the firſt operation of rinſing.

Of the peculiar nature and properties of indigo, we ſhall have occaſion to treat hereafter, under its proper head, at preſent it will ſuffice to obſerve, that it owes its colour and inſolubility in alkalies, to a portion of oxygen intimately combined with it. To render it ſoluble, therefore, it muſt be deprived of this oxygen, by the action of a ſubſtance having a more powerful affinity for it, and the ſulphuret of arſenic, or orpiment, is uſed for this purpoſe. Sulphate of iron, has a ſtrong affinity for oxygen, and is employed in de-oxygenating indigo for certain purpoſes; but the oxyd of iron not being ſoluble in alkalies, the ſolutions of indigo, formed by it, become quickly regenerated by the abſorption of oxygen, and cannot even be transferred from one veſſel to another. The ſulphuret of arſenic, on the contrary being very ſoluble in alkalies, preſents the double advantage of de-oxygenating the indigo, and of retaining it awhile in that ſtate, till on its application to cloth, it becomes expoſed ſo completely to the action of atmoſpheric air, as to regain its oxygen, colour, and inſolubility; and becomes fixed in its original or blue ſtate.

The copper coloured pellicles, which forms on the ſurface of pencil blue, and is renewed immediately on its removal, ariſes from the abſorption of oxygen, which, in ſpite of the action of the orpiment, is continually taking place. Hence ariſes that diſpoſition to unevenneſs, which is the great diſadvantage of this blue; the unavoidable expoſure to air of ſmall portions of the colour during its application with the pencil, reviving greater or leſs portions of indigo, and conſiderably reducing its ſtrength.

Moſt calico printers boil up the quicklime with the other ingredients, thinking its preſence not leſs neceſſary than the pot-aſh and orpiment; by this means a conſiderable portion of the ſolution of indigo is taken up by the ſediment, which careful waſhing does not wholly ſeparate. As the action of the lime is confined merely to the alkali, which it renders cauſtic, and capable of acting with greater force on the other ingredients; it is certainly much more economical to render the pot-aſh cauſtic before its addition to the indigo. A conſiderable waſte of colour is by this means prevented, and the ſolution may be thickened the moment the ebullition has ceaſed without waiting for the depoſition, which in the old mode takes place.

Orange.

The oxyd of iron, when diſſolved in acetous acid, forms one of the moſt uſeful and important mordants, as we have already ſhewn in the former part of this article. It is alſo capable of imparting a very pleaſing and permanent colour itſelf to cotton, when applied in ſolutions of tolerable ſtrength and purity, and forms the orange, buff, and gold colour of the calico printers.

1. The ſolutions of iron in vinegar, ſtrengthened by the addition of copperas may be uſed, but the pureſt and brighteſt gold colours are obtained from copperas and ſugar of lead, in the proportion of 5lbs. of the former, and 1lb. of the latter, to a gallon of water. When thickened with gum, and employed undiluted, it affords, when limed, a full ſtrong gold colour, and with two, four, ſix, &c. times its bulk of water, various ſhades of orange and buff, which reſiſt the action of air, alkalis, and ſoap; and are rather exalted than impaired by frequent waſhing. The addition of ſugar of lead, is to increaſe the ſtrength of the ſolution. A gallon of water diſſolves about 4lbs. of copperas. The addition of a pound of ſugar of lead, enables it to take up another pound nearly, and the ſtrength of the ſolution may be ſtill further increaſed by equal additions of the two ſalts. The operation of liming is a ſimple precipitation of the oxyd of iron on the cloth, and in caſes when this cannot be performed, the proportion of ſugar of lead muſt be increaſed to nearly that of the copperas. It is only the paler ſhades of orange, however, which are to be obtained this way. The deep gold colour before named, is not to be procured without the aid of a precipitant. Spaniſh brown is ſometimes added to a ſolution of iron, and employed in ſuch a caſe, but it contracts no union with the cloth, and is readily removed by ſimple waſhing and beating. When the orange, or gold colour, is thickened with flour, a ſmall portion of nitrate of iron muſt be added to the paſte, for reaſons we have aſſigned on a former occaſion.

2. A beautiful, but fugitive orange, is obtained by boiling

ing half a pound of annotta with 1lb. of caustic pot-ash in a gallon of water, and thickening the liquor with gum. This colour acts powerfully on the sieves and blocks, which it very soon destroys, and on this account, and also from its want of permanence is seldom used. It may either be simply rinsed off, or first passed through water rendered slightly acidulous with sulphuric acid, or what is still better through alum-water. This operation is the very reverse of liming, for here the colouring matter to be precipitated, being held in solution by an alkali, an acid must be employed for that purpose. The colour by this means is considerably heightened, and when applied with the pencil, is useful in some cases where the other colours will support the action of alum-water without injury.

Borax, and even spirits of wine, are sometimes added to the alkaline solution of annotta, and are supposed to contribute to its strength and fixity, though on what principle it is not easy to discover.

Green.

The oxyd of copper, dissolved in volatile alkali, affords a pale and delicate green, which is sometimes employed intermixed with other colours. Turnings of copper, or verdigrise, which is more generally used, may be digested in a low heat with spirits of sal ammoniac. Care must be taken that the heat be very moderate, and the vessel in which the solution is made, well stopped, the ammoniac will otherwise be driven off, and lost. When the alkali has taken up as much copper as it can dissolve, the solution must be thickened with gum, and applied with the block or pencil. In a few days the ammoniac evaporates and leaves the oxyd of copper on the cloth, which must be rinsed to free it from the gum and superfluous colour.

The blues produced by alternate immersion in copperas and lime, and also in the solution of indigo, by the same substances, properly come under this class of colour, as they are solutions of colouring matter in lime and alkalis. As the processes by which they are applied, differ however very materially from all those that we have been treating of, they claim a separate and distinct notice. For the details of these operations, and the mode of preparing the pastes for bark and pale blue dipping, and the colours for China blue, we must therefore refer our readers to the article *Dipping* Blue.

Colours, in *Dyeing*.—There are five simple, primary, or mother colours, used by the dyers: from the mixture whereof all the other colours are formed; these are blue, red, yellow, black, and brown colour; each of which see under their proper head, Blue, Red, &c.

Of these colours, mixed and combined, other colours are formed, which are infinitely various, according to the proportion of the different ingredients that are employed, or the processes by which they are blended. Thus a mixture of *blue* and *yellow* forms *green*, which is distinguished by dyers into a variety of shades, according to the depth of the shade, or the prevalence of either of the component parts. Hence we have *sea-green*, *grass-green*, *pea-green*, &c. &c. *Blue* and *red* form different shades of *violet*, *purple*, and *lilac*. A mixture of *yellow* and *red* produces *orange*. Mixtures of *black* with other colours constitute *greys*, *drabs*, and *browns*. For a more particular account of these and other colours; and the method of procuring and applying them; see the article Dyeing. See also the preceding article.

The greatest perfection in the art of colours would be to find the means of preparing the finest colours without the use either of acid or alkaline salts, which usually subject the colours to change, or else are apt to prey upon the cloth, canvas, &c. as we see in verdigrise, the blue and green crystals of copper, &c. It appears highly probable, that the Indians, for making the fine bright and durable colours, wherewith their chintzes and callicos are stained, make use of metalline solutions; for some stained callicos, brought from thence, having been kept 40 or 50 years, the bright colours have been observed to eat out the cloth, exactly in the same manner as acid spirits, which dissolve metals, are found to do.

Since these, then, are the inconveniences attending such colours, we ought to search for menstruums with which to extract colours, which are neither acid nor alkaline; and for such metalline oxyds, precipitates, or powders, as will not lose their colours, by being well washed to get out their salts; to prepare certain metalline matters, by mere calcination, or the bare assistance of fire; and lastly, to look out for native colours, wherein no saline matter abounds.

Mr. Geoffroy has given a very curious process for making two clear, spirituous, inflammable liquors, which differ very little in taste and smell, and being mixt together give a fine carnation colour, without any sensible fermentation.

To make the first of these liquors, put a small handful of dried red roses into a glass bottle; pour on them rectified spirit of wine, till it covers them an inch; let this stand in a cold infusion four or five hours; then pour off the liquor, which will be clear and colourless, as when put on. The second liquor is made by dropping into rectified spirit of wine, so much oil of sulphur, by the bell, or spirit of vitriol, as will be borne in it without giving it any very sensible acidity when tasted. When these liquors are thus prepared, let a small quantity of the latter be dropped into some of the former, and the whole will become of a fine carnation colour, though there is no fermentation, nor any other change perceived in it, but barely that of colour. If instead of this last liquor, there be added to the first a few drops of the spirit of sal ammoniac, the whole will become green.

Make a slight infusion of galls in water, so as not to colour the water; make also a weak solution of green vitriol in water, so that it may appear colourless; mix these two colourless liquors together, and an inky blackness is immediately produced; add to this black liquor a little oil of vitriol, and the liquor becomes pellucid and colourless again; then add to this a little salt of tartar, and the whole is black again.

Put a little bruised camphor into rectified clear oil of vitriol; shake the mixture, and it will become black, and the camphor will be dissolved; add to this a little water, and the liquor becomes clear, and the camphor is found separated at top, in its own form, and native whiteness.

Infuse lignum nephriticum in cold water, and pour off the clear liquor. This held up against the light, appears of a fine yellow, but viewed from the light, of a beautiful blue: a little spirit of nitre put to this liquor makes it lose the power of reflecting the blue rays; and a little oil of tartar, afterwards added, recovers that power again.

Logwood, infused in water, gives a red colour. Put to this a little spirit of urine, and it becomes of a fine purple; and drop in afterwards a little spirit of salt, and it becomes of a pale red.

A beautiful blue tincture may be made from filings of copper, by digesting them in spirit of wine, hartshorn, or the like. The addition of oil of vitriol destroys the blue colour; and a little spirit of salt turns it green.

Pellucid oil of vitriol, mixed with pellucid oil of turpentine, produces a thick red balsam. And common oil, mixed with fair water, by means of a little wax, and continued rubbing,

rubbing, turns into a thick white balsam, called cold cream.

Oil of vitriol, distilled from quicksilver, leaves a white powder behind, which, if water be poured on it, becomes yellow.

Dissolve quicksilver in spirit of nitre, and to part of it add spirit of urine, and a white powder is precipitated; to another part of the solution add oil of tartar, and a yellow powder falls to the bottom.

Dip a new pen in spirit of vitriol, and write with it on common blue paper, and the letters will appear red.

A pellucid solution of saccharum saturni being written with on paper, becomes invisible when dried; but the bare fumes of an infusion of quick lime, and orpiment, in water, will render the invisible writing black and legible.

Volatile salt of sal ammoniac, which is white, mixed with crystals of copper, which are green, produce a fine purple.

The original and simple, as well as the mixt, colours are producible by mixture. Thus, if the sun's rays pass through two pieces of glass, the one blue, and the other yellow, and be afterwards received upon a white paper, the colour there seen is green. The dyers make cloth blue with woad, and then turn it green by the yellow herb called luteola, or dyers' weed. To a yellow solution of gold in aqua regia add a blue one of copper in spirit of urine, and the mixture becomes green. The painters every day practise this art of producing new colours by mixture.

Metalline and mineral matters are reducible to a considerable degree of subtlety, or smallness of parts by fire, or dry calcination, so as to leave them durably possessed of their native or adventitious colours. Thus lapis lazuli, by being calcined, becomes the fine rich blue called ultramarine; light ochre, by the same treatment, becomes a light red, or flesh colour, the most useful flesh-colour in painting. Lead, by calcination, becomes durably red, and iron durably brown; but a proper method seems wanting for the dry calcinations of the nobler metals, gold and silver; though, for the uses of gilding, these are easily prepared by dipping linen rags in their respective solutions, and then drying, and burning them to ashes, whereby a dry and fine metalline powder is procured.

Colour, in *Heraldry*, the heraldic colours are nine, and were anciently expressed by the word *tincture*, *viz*. or, argent, azure, gules, sable, vert, purpure, tenney, and sanguine, and also by precious stones and planets; the armorial colours are blazoned in different terms, according to the rank and dignity of the person whose arms are described, as follows:

Colours.	For Commoners by Tinctures.	For Peers by Precious Stones.	For Emperors, Kings, and Princes, by Planets.
Yellow,	Or,	Topaz,	Sol.
White,	Argent,	Pearl,	Luna.
Blue,	Azure,	Sapphire,	Jupiter.
Red,	Gules,	Ruby,	Mars.
Black,	Sable,	Diamond,	Saturn.
Green,	Vert,	Emerald,	Venus.
Purple,	Purpure,	Amethyst,	Mercury.
Orange,	Tenney,	Jacinth,	Dragon's head.
Dark red,	Sanguine,	Sardonix,	Dragon's tail.

For a fuller account of each, see under the respective heads.

Or, and argent are metals, and it is an invariable rule in heraldry not to put colour upon colour, or metal on metal; that is if the field be of a colour, the charge or bearing must be of a metal.