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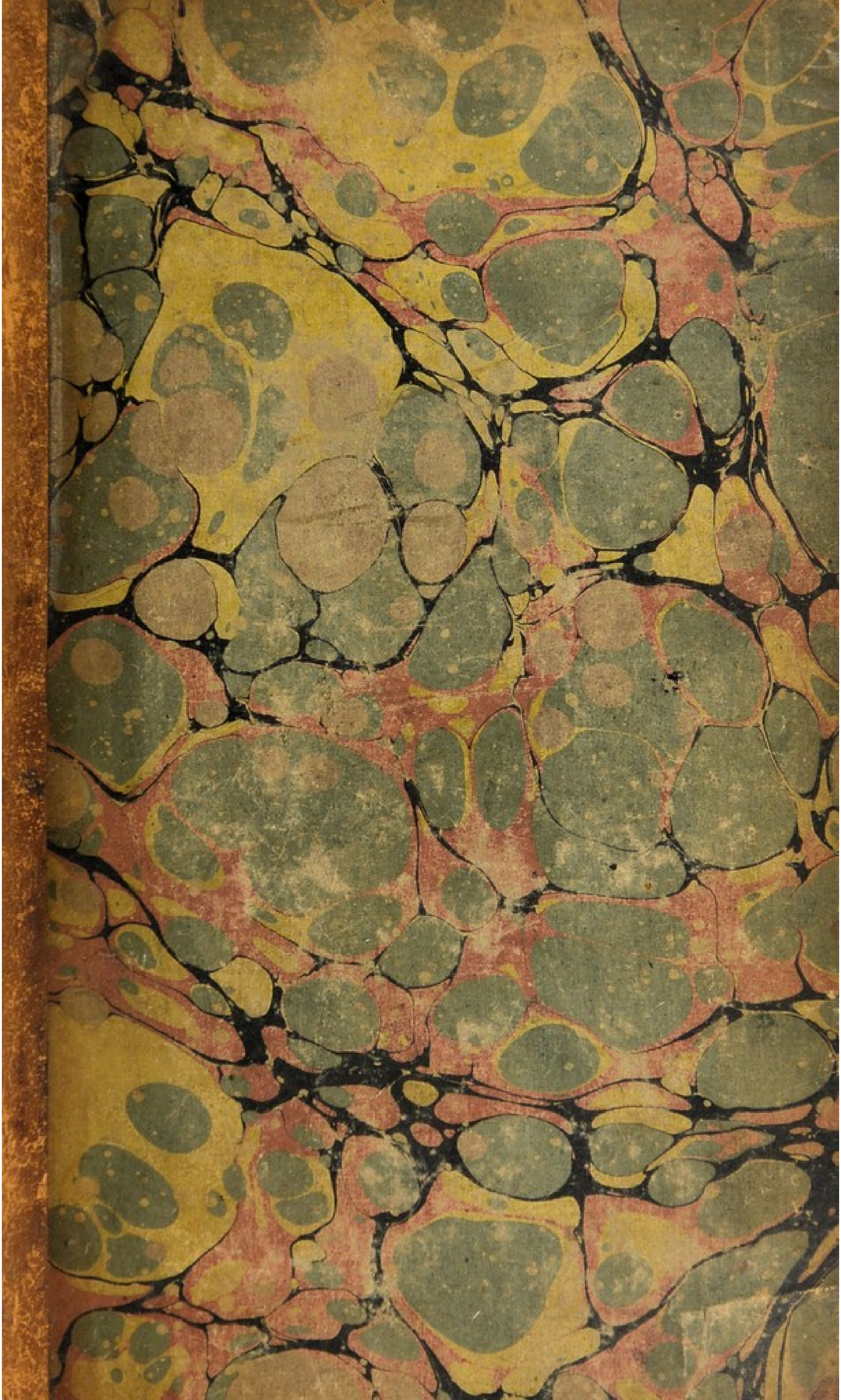

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ELEMENTS

OF THE

ART OF DYEING.

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TRANSLATED FROM THE FRENCH

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Phyſician to the London-Hoſpital, and Lecturer on Chemiſtry.

VOL. I.

LONDON:
PRINTED BY STEPHEN COUCHMAN,
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M DCC XCI.

TRANSLATOR's PREFACE.

THAT tranſlations of the works of eminent foreign writers are of great utility to ſcience and the arts is a truth which has long been known and acknowledged, and indeed ſo rapid is the progreſs of improvement in modern times, that ſuch tranſlations are every day becoming more important: an ardent ſpirit of inquiry having pervaded the greater part of Europe: and almoſt every nation in this quarter of the globe, having given birth to men of ſuperior talents and induſtry, who are deeply engaged in exploring the operations of nature.

It is evident, that every country muſt be much benefited, which by means of early tranſlations, poſſeſſes itſelf of the fruits of

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the labours of foreign nations. It collects as it were into a focus, the ſcattered lights which are ſtruck out in different parts of the world, and thus reaps an immediate advantage from diſcoveries which had a diſtant origin. Although the Philoſophers of our own country have been eminently diſtinguiſhed by that zeal for the advancement of ſcience, which is one of the characteriſtic features of the preſent age, yet it muſt be acknowledged that in the application of ſcientific chemiſtry to the arts, we have been ſurpaſſed by our neighbours on the continent. The principles of the art of dyeing in particular, ſeem to have been neglected by us, or at leaſt do not appear to have obtained that degree of attention to which they were entitled, from their importance both to the manufacturer and the man of ſcience.

No ſyſtematic treatiſe on this ſubject has hitherto appeared in our language, excepting a tranſlation of Hellot, with which the

the public are very little acquainted. It is true, we meet with ſome very ingenious and ſcientific remarks on dyeing, in Lewis's Commercium Philoſophico Technicum; but theſe are confined almoſt ſolely to the black dye. We have likewiſe ſome valuable obſervations on this ſubject, in the tranſlation of Macquer's Chemical Dictionary. Theſe works, together with a few books of receipts taken from Hellot, d'Apligny, Macquer, and Dufay, comprehend almoſt every thing I have yet ſeen in the engliſh language on the art of dyeing.

The intelligent reader will perceive that in the preſent work, much light is thrown on the principles of the art of dyeing by the late improvements in chemiſtry. From an attentive peruſal it will appear, that by means of the properties of the different gaſes, by an attention to the influence of light and to complicated chemical combinations, the ingenious author has been enabled ſucceſsfully to explain many important facts, the cauſes of which were formerly involved in obſcurity. Conſidered in this point of view, it is conceived, that the work which I have undertaken to tranſlate will be highly acceptable to the philoſophical chemiſt; but it is to the manufacturer that this work is principally addreſſed. He will find in it methods of conducting his proceſſes equally new and ſimple. He will learn from it to aſcertain with greater certainty the ſucceſs of his operations; it will furniſh him with an opportunity of comparing his own proceſſes with thoſe of other artiſts, and of adopting the improvements derived from the labour and ingenuity of his predeceſſors and cotemporaries.

In this treatiſe particularly, he will find a certain mode of determining the qualities of the materials he employs, which will enable him to proportion the quantities ſo accurately to each other as to avoid all wáſte, and direct him to the value of any article of which he can procure a ſample. This improvement principally depends on the uſe of the acids, and more eſpecially of thoſe which have been termed oxygenated.

With a view to facilitate the mode of obtaining the acids, I have ventured to add a deſcription and drawing of an apparatus for the diſtillation of thoſe ſubſtances, which from experience I find more ſimple and advantageous than any that I have yet ſeen.

Reſpect for the author has induced me to retain the new french nomenclature, which is at preſent becoming faſhionable; although it might have been more acceptable to many of my readers, if I had ſubſtituted the terms in common uſe, for thoſe that have been employed by Mr. Berthollet. With a view, however, to prevent any miſtakes that might ariſe from

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this ſource, I have ſubjoined a vocabulary, and have likewiſe added an index, without which no important work ſhould appear.

In a few inſtances, I have endeavoured to illuſtrate the obſervations of our author by notes. Theſe are not ſo copious or numerous as I could have wiſhed, but I was ſolicitous to make my countrymen acquainted with this valuable work as early as poſſible, and certain circumſtances, with which it is unneceſſary to trouble the reader, have obliged me to finiſh the tranſlation within a limited time.

I ſhall only add that in tranſlating a philoſophical work, which conſiſts chiefly of a detail of important facts and inferences, I have deemed it right to prefer perſpicuity to elegance.

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INTRO-

INTRODUCTION.

A STRONG deſire of attracting attention is obſervable in man in his moſt uncultivated ſtate. Amongſt the means of gratifying this deſire, the beauty of brilliant colours naturally preſents itſelf. Thus even ſavage nations paint their ſkins, and adorn themſelves with feathers, ſtones, and ſhells of lively hue.

The women of Gaul on their feſtival days uſed to ſtain themſelves of a brown olive colour with woad, and this no doubt exerciſed the vanity of thoſe of higher rank.

The origin of the art of dyeing is certainly therefore of great antiquity, and very poſſibly nations, little civilized, where nature had furniſhed colouring materials of eaſy application, might poſſeſs ſpecies of tints which poliſhed nations may have highly eſteemed: thus the Gauls prepared ſome colours which even the Romans did not deſpiſe. The art however muſt have waited the progreſs of induſtry and luxury, to be much extended or improved.

The Egyptians, according to Pliny [a], had diſcovered a mode of dyeing, ſomewhat reſembling that which we uſe for colouring printed linens; the ſtuffs, probably after having been impregnated with different mordants [b], were immerſed in vats, where they received various colours. It is to be preſumed however, that the induſtry of a people, whom ſacerdotal power, by expreſs laws, forbad to change even their moſt indifferent cuſtoms, could not be very active.

When we wiſh to eſtimate the progreſs of the human mind in remote times, we turn our attention to Greece; but there we find a ſtriking difference between the fine arts, and thoſe ſubſervient to our convenience or luxury; a difference, the cauſe of which, may be perceived. Public opinion placed thoſe arts at an immenſe diſtance from each other; for while glory was attached to the former, the

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[a] Hiſt. Nat. lib. xxxv. chap. 2.

[b] It does not appear that the Engliſh artiſts have any term appropriated to this claſs of bodies compoſed chiefly of earthy and metallic ſalts, employed in the preparation of ſtuffs, to fit them for the reception of more durable colours, I have therefore thought it beſt to retain the original word. T.

latter were confounded with diſgraceful and ſervile employments.

The diſtinction however was in part well founded. The painter, the ſtatuary, the architect, ſtamped their genius on their productions; their art did not require long continued efforts for its increaſe, nor the accidents and experiments of ages for its ſlow improvement. Their invention was able at once to paſs the limits of time, and thoſe maſter pieces of art, which ſo rapidly ſucceeded each other in Greece, have juſtly become the admiration of poſterity.

Yet this nation however fruitful in genius, or productive of great men, ſuffered itſelf to be led away by its inclinations, and beſtowed its eſteem too partially. For while crowns and the moſt ſplendid honours were decreed to thoſe who excelled in wreſtling, boxing, and running, the uſeful arts were degraded, even in the eyes of philoſophers.

This is one of the moſt ſtriking characters by which the philoſophy of the ancients is diſtinguiſhed from that of the moderns. The ancients were chiefly engaged in ſpeculations, which might procure them the reſpect of a people, who, while they diſpenſed glory, thought the uſeful arts unworthy their attention.

This contempt deſcended to the Romans; for Pliny ſpeaking of dyeing, awowedly neglects the deſcription of operations which are unconnected with the liberal arts; *nec tingendi rationem omiſſiſſimus, ſi unquam ea liberalium artium fuiſſet.*

Modern philoſophers, above the vulgar, yet deſpiſed by the great (whoſe pride is ſupported by pretenſions wholly foreign to human ſcience) have given themſelves up to cold calculation, and to the humble deſcription of what nature and art preſent to them. They have traced the connexion of the numberleſs wonders that have occurred to them, and have diſcovered in the labours of induſtry, as well as in commerce, the ſource of national proſperity, the ſeeds of extenſive population, and the grand ſupport of agriculture. But it was the academy of ſciences of Paris which firſt attempted to ſhed the light of ſcience upon all the arts, which formed the project of publiſhing the deſcription of them, and which in the midſt of prohibitory regulations, formed the elevated idea, that the induſtry of a nation cannot fail to be enlightened and increaſed by a free communication of all the proceſſes it uſes, and that the ſacrifices it makes by this publicity, are amply compenſated by the advantages it derives from it.

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This plan was extended to all the objects of knowledge by the Encyclopædia, the moſt magnificent monument ever raiſed to philoſophy and reaſon.

The art of dyeing among the Greeks could have had but little aſſiſtance from ſcience; but the activity of genius is communicative, and induſtry multiplies its efforts when ſolicited by luxury. Let us ſee then what progreſs luxury had made in Greece. Let us conſult the philoſophical picture which has been lately drawn of its manners.

A number of the citizens of Athens paſſed their time in the different tribunals, for which they received three oboli, that is nine ſous per day (about 4½d. Eng.) The medium price of a ſeptier (twelve buſhels) of corn, which is the moſt natural ſtandard of compariſon, was thirteen livres (10s. 10d. Eng.); that is a little more than half the medium price with us; ſo that a citizen of Athens with the daily pay he received for the diſcharge of the moſt important duties of the republic, might purchaſe a meaſure of corn, the price of which at preſent is fifteen ſous (7½d. Eng.) In order then to form an idea, not of the public magnificence, nor of that of ſome individuals, but of the eaſe and luxury of the ordinary claſs of citizens, we muſt conſider, what they would be at Paris, if the ſalary of the public offices was fifteen ſous per day.

" Many of them (the Athenians) went bare-
" footed. The dreſs of the people was made
" of cloth which had received no dye, and
" which might be waſhed (reblanchir). The
" rich preferred coloured cloths[c]; they eſteem-
" ed ſuch as were dyed ſcarlet by means of
" certain grains of a reddiſh colour; but they
" valued ſtill more highly thoſe of a purple
" dye."

Silk, which is ſubjected to the greateſt variety of the proceſſes in dyeing, comes originally from China. The annals of that nation inform us, that the wife of the emperor Hoang Ti, was the firſt who ſpun threads from the natural ſilk cocoons, found on the trees. From this country, ſilk was carried into Indoſtan, and thence to Perſia, Greece, and Rome, where however it was not known till a very conſiderable time after the firſt employment of it. Some have concluded from a line in Virgil's Georgics[d], that it was in uſe at Rome in the time of Auguſtus. What Pliny ſays on the

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[c] Voyage du jeune Anacharſis.

[d] Velleraque ut foliis depectant tenuia Seres Georg. lib. ii.

ſubject is leſs ambiguous. In the reign of the emperor Juſtinian, ſilk ſtill bore ſo high a price that it ſold for its weight of gold[e]. It was about this time, that ſilk worms eggs were brought by certain monks, from India to Conſtantinople, where a method of hatching them, and of ſpinning from their cocoons was diſcovered[f]. Silk worms ſeem to have been firſt introduced into Italy about the time of the Cruſades.

The art of dyeing linen appears not to have been known in Greece before Alexander's invaſion of India, where, according to Pliny, they dyed the ſails of his veſſels of different colours. The Greeks ſeem to have borrowed this art from the Indians.

India was the nurſery of the arts and ſciences, which were afterwards ſpread and perfected among other nations. Accidents which had a tendency to improve the art, could not fail to be multiplied rapidly, in a country rich in natural productions, which requires little labour for the ſupport of its inhabitants, and the population of which was favoured by the bounty of nature, and the ſimplicity of manners,

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[e] Voltaire, Eſſai ſur les Moeurs, &c.

[f] Procop. lib. iv. cap. 17. de bello Gothico.

ners, till it was oppoſed by the tyranny of ſucceeding conquerors. But religious prejudices and the unalterable diviſion in caſts, ſoon put ſhackles upon induſtry; the arts became ſtationary; and it would ſeem that the knowledge of dyeing cotton in that country (for ſilk was then unknown, or at leaſt very ſcarce) was as far advanced in the time of Alexander, as it is at preſent.

The beautiful colours which we obſerve in thoſe Indian linens, to which we uſed to give the name of *Perſes*, becauſe they came to us from Perſia, would lead us to think that the art of dyeing had there attained a high degree of perfection; but we find by the deſcription which Beaulieu gave (at the requeſt of Dufay) of ſome operations performed under his own eye[g], that the Indian proceſſes are ſo complicated, tedious, and imperfect, that they would be impracticable in any other country, on account of the difference of the price of labour.

European induſtry has far ſurpaſſed them in correctneſs of deſign, variety of ſhade, and facility of execution, and if we are inferior to them with reſpect to the livelineſs of two or three

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[g] Traité ſur les toiles peintes dans lequel on voit la maniere dont on les fabrique aux Indes & en Europe.

three colours, it is only to be attributed to the ſuperior quality of ſome of their dyes, or perhaps to the length and multiplicity of their operations.

We may then conclude, that the art of dyeing was much more limited, and leſs perfect, among the ancients than among the moderns; but they were in poſſeſſion of one ſpecies of dye, which has been either loſt or neglected, which was an object of the moſt refined luxury; that is, purple: its proceſſes have more attracted the attention of philoſophers, and been more carefully preſerved in hiſtorical records, than thoſe of any other colour.

I ſhall paſs over the fables with which they have endeavoured to embelliſh the origin of the purple dye; but it is probable, that it was diſcovered at Tyre, and contributed much to the opulence of that celebrated city.

The liquor uſed in dyeing purple was obtained from two kinds of ſhell fiſh, the larger of which was called the purple, the other was a ſpecies of whelk: they were each ſubdivided into many varieties, and were ſtill further diſtinguiſhed, as they afforded a more or leſs beautiful colour, according to the coaſt where they were taken, &c.

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The colouring liquor for purple is found in the throat of the fiſh, in each of which was contained only a ſingle drop; they uſed to bruiſe the whelks, which likewiſe contained a very ſmall quantity of a red liquor with a black tinge (nigricantis roſæ. Plin.)

When they had obtained a certain quantity of the colouring liquor, they mixed with it a proportion of common ſalt; they macerated them together for three days, and then added five times the quantity of water; this mixture they kept in a moderate degree of heat, and ſeparated, from time to time, the animal parts which roſe to the ſurface; theſe operations laſted ten days, after which they aſcertained with a piece of white wool, whether the liquor had acquired the proper ſhade.

The ſtuff was prepared for receiving the dye in various ways; ſome immerſed it in lime water, ſome prepared it with a kind of *fucus*, which ſerved, like ſome of our mordants, to render the colour more fixed (ſolide).

We do not know preciſely the marine plant to which the ancients gave the name fucus, but its uſe was ſo extenſive in dyeing, that the word became a generic term, including all ſorts of colouring ſubſtances. Mr. le Pileur d'Apligny conjectures that it might be a kind of archil, which is found on the coaſt of Candia[h]; others again prepared their cloth with alkanet.

The liquor of the whelk alone did not afford a durable colour, but it increaſed the brightneſs of that obtained from the other kind of ſhell fiſh. The Tyrian purple was prepared by two operations, a firſt dye was communicated by the liquor of the purple, and a ſecond by that of the whelk, hence it was called by Pliny *purpura dibapha*. In other proceſſes they employed a mixture of the liquor of both the ſhell fiſh; for inſtance, for 50 lb. of wool, they uſed 200 lb. of the liquor of the whelk, and 100 lb. of that of the purple fiſh; thus they obtained an amethyſt colour; ſometimes they gave a ground with *coccus*, which is our kermes, and then dyed with the liquor of the purple fiſh; in fine, by different combinations of the above methods they obtained a great variety of purples, which they diſtinguiſhed by different names; the Tyrian purple, according to Pliny, was of the colour of coagulated blood; the amethyſt purple had that of the ſtone, ſo called; another kind more reſembled the colour of the violet, &c. &c.[i].

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[h] Eſſai ſur les moyens de perfectionner l'art de la teinture.

[i] Thoſe who wiſh for further information reſpecting the

It appears that ſome of the kinds of purple preſerved their colour for a very long time; for Plutarch in his life of Alexander relates, that the Greeks found in the treaſury of the king of Perſia a great quantity of purple, which had not loſt its beauty though it was one hundred and ninety years old.

The very ſmall quantity of liquor obtained from each ſhell fiſh, and the tedious proceſs of the dyeing, raiſed the price of purple ſo high, that in the time of Auguſtus a pound of wool of the Tyrian purple dye, could not be purchaſed for one thouſand denarii, about ſeven hundred livres of our money (£29 11s. 8d. Eng.)

Prieſts, who have always ſought to derive advantages from whatever could make impreſſion on the multitude, attributed in former times a ſacred character to purple. It was a colour pleaſing to the divinity, and was to be appropriated to his worſhip, and although the uſe of it has been long diſcontinued, the pride

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purple of the ancients, may conſult the following modern works. Fabii Colomne Lyncœy purpura; G. Gottlob Richter progr. de purpura antiquo & novo pigmento; Reaumur mem. de l'acad. 1711; and above all a learned work of Mr. Biſchoff, entitled Verſuche einer geſchicte der faberkunſt, &c. 1780.

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of the name is ſtill preſerved in our ſacerdotal hierarchy.

The purple has been, almoſt every where, a mark of diſtinction attached to high birth and dignities. It was an ornament of the firſt offices of Rome; but luxury, which was carried to great exceſs in that capital of the world, rendered the uſe of it common among the opulent, till the emperors reſerved to themſelves the right of wearing it: ſoon afterwards, it became the ſymbol of their inauguration.

They appointed officers to ſuperintend the manufactories, principally eſtabliſhed in Phenicia, where it was prepared ſolely for their uſe. The puniſhment of death was decreed againſt all who ſhould have the audacity to wear it, though covered with another colour.

The penalty ſo tyrannically denounced againſt this whimſical ſpecies of treaſon, doubtleſs occaſioned the loſs of the art of dyeing purple; firſt in the Weſt, but much later in the Eaſt, where it flouriſhed conſiderably till the eleventh century.

The ancients obtained from the *coccus*, now known by the name of kermes, an account of which is given (Sect. III. Part II.) a colour which was almoſt as highly eſteemed as the purple, and which was ſometimes mixed with it, as we have before remarked. Pliny informs us, that it was employed in the preparation of the imperial robes. It was generally called ſcarlet, but ſometimes it was confounded with the purple.

It appears, that it was not till the time of Alexander and his ſucceſſors, that the Greeks attempted materially to improve the black, blue, yellow, and green dyes.

Among the Romans it was cuſtomary from the earlieſt times, for newly married women to wear a yellow veil, and this colour was appropriated to matrons.

In the games of the circus there was a kind of quadrill [k], the diviſions of which were diſtinguiſhed by the colours, green, *color praſinus*, orange, *rufatus*, aſh coloured, *venetus* [l], and the white.

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[k] This term denotes a troop of cavaliers pompouſly dreſſed and mounted for the performance of certain games, &c. It is borrowed from the French quadrille, or ſquadrille, and that probably from the Italian quadriglia. They were never compoſed of leſs than four diviſions, nor of more than twelve, and each diviſion conſiſted of twelve cavaliers at moſt, and at leaſt of three. T.

[l] This, rendered in the original by *le cendré*, is alſo, and I believe more commonly, uſed to denote a light blue, or ſky blue. T.

We are enabled to judge of the qualities of theſe colours by the ſubſtances uſed in making them. I ſhall enumerate after Mr. Biſcoff, who has minutely examined the ſubject, the ingredients employed at that time, in the art of dyeing, in addition to the coccus and the purple ſhell fiſh.

1. Alum. It ſeems probable from what is obſerved in the firſt part of this work (Sect. III.) that the ancients were unacquainted with our alum in its ſtate of purity.

2. Alkanet. Suidas ſays, that this ſubſtance was alſo uſed by women as a paint.

3. The blood of birds, which was uſed among the Jews.

4. The fucus. That of Crete was preferred, and it was generally employed as a ground for valuable colours.

5. Broom.

6. The violet; from which the Gauls prepared a colour which reſembled one kind of purple.

7. Lotos medicago arborea. Snail trefoil (luzerne en arbre). The bark was uſed in dyeing ſkins, and the root in dyeing wool.

8. The bark of the walnut-tree, and the peel of the ſhell.

9. Madder. We do not know whether the madder plant of the ancients was the ſame as ours, or whether it was another root of the ſame tribe.

10. Woad. (glaſtum). This plant was undoubtedly in uſe among the ancients, but we do not know whether their preparation of it was the ſame as ours.

Although the ancients might have employed ſome ſubſtances, of which we have no account, we eaſily perceive that our acquiſitions, more eſpecially ſince the diſcovery of America, give us a decided ſuperiority in many colours. With reſpect to the regret which has been often felt for the loſs of the art of dyeing the celebrated purple, it may be queſtioned whether it is well founded, and whether we are not able to produce a purple equally beautiful?

The ſhell fiſh which furniſhed the purple dye, probably exiſt now, in as great abundance as formerly. They have been ſo accurately deſcribed that they may be recognized; and in fact, Thomas Gage informs us, that ſhell fiſh have been found near Nicoya, a ſmall Spaniſh town in South-America, which poſſeſs all the properties deſcribed by Pliny, and others of the ancients. Theſe ſhell fiſh it appears, are at preſent uſed in dyeing cotton, on the coaſts of Guagaquil and Guatimala [m].

Cole, in the year 1686, diſcovered ſome of them on the Engliſh coaſt, and Plumier found a ſpecies of them at the Antilles. Reaumur has made many experiments on the whelks, which he obtained from the coaſts of Poitou, and Duhamel has minutely examined the colouring liquor of the purple ſhell fiſh, which he found in great abundance on the coaſt of Provence. He obſerved, that this liquor does not take a purple colour without the action of light, a circumſtance which Reaumur had before remarked reſpecting that of the whelk; that though at firſt white, it becomes of a yellowiſh green, which deepens to a ſort of blue, that it afterwards reddens, and in leſs than five minutes becomes of a very fine deep purple [n], now the purple of the ancients poſſeſſed theſe characters.

Further, we have a very minute deſcription of the manner of catching the ſhell fiſh which produced the purple, by an eye witneſs, Eudocia Macrembolitiſſa, daughter of the emperor

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[m] Hiſt. philoſoph. & polit. du comm. des Indes. liv. vi.

[n] Mem. de l'Acad. 1736.

Conſtantine the eighth, who lived in the eleventh century [o].

Our indifference as to procuring the purple, and our negligence of the experiments of ſome modern philoſophers reſpecting it, ariſe, I think, from our being already in poſſeſſion of more beautiful, as well as much leſs expenſive colours; and I am not ſingular in this opinion [p]. In fact, the kermes affords a colour which was almoſt as highly eſteemed by the ancients, as the purple, and contributed to that which they diſtinguiſhed by the name *Color Hyſginus*. Now we know how to employ the kermes probably to greater advantage than they did, becauſe we poſſeſs a pure alum, which prepares the ſtuff to receive a more beautiful and durable colour; yet our dyers have been induced almoſt entirely to diſcontinue the uſe of it, becauſe they can obtain from cochineal a colour beyond all compariſon more beautiful.

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[o] Eudocia Macrembolitiſſa was married to one of the Conſtantines, and after his death to Rom. III. who was made emperor in 1068. The work is to be found in a collection publiſhed by Mr. d'Anſe de Villoiſon, under the title of *Anecdota græca e regia Pariſienſi & e veneta S. Marci bibliothecis deprompta*. T. i. 1781.

[p] Biſchoff verſuche, &c. Goguet de l'origine des loix, des arts, & des ſciences, 2e partie, liv. ii.

If we ſuppoſe that the ſlight difference obſervable between the colour obtained from the kermes, and that of the Tyrian purple, is compenſated by the advantage we derive from the employment of our alum, we may conſider this admired purple, which on pain of death, none but the Cæſars could wear, as ſimilar to that blood red we ſee in old tapeſtry, which was produced by kermes.

The ſuppoſition that the colour which we obtain from the kermes, is preferable to that obtained from it by the ancients, is ſupported by the teſtimony of Pliny, who inſinuates that it was not a durable colour; now the colour we give by means of kermes, to wool prepared with alum, is exceedingly durable.

The ancients were not acquainted with that uſeful ſubſtance ſoap*, which muſt give us a ſuperiority in ſcouring, and ſome parts of the art of dyeing. Inſtead of it, with a view to get greaſe out of wool, and to waſh linen, they made uſe of a plant, called by Pliny radicula, and by the Greeks ſtruthion, and which ſome think was our ſaponaria, ſoap-wort; they likewiſe employed with the ſame view, another plant, which Pliny deſcribes as a ſpecies of poppy. Homer repreſents the princeſs Nauſica

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* Goguet, ibid. part. i. liv. ii.

and

and her attendants waſhing their linen clothes in the ditches, by trampling on them with their feet. We are informed by other authority, that the ancients uſed aſhes in waſhing; and ſome of the bolar earths were likewiſe employed for that purpoſe.

From the new world, we have acquired ſeveral ſubſtances that have been found uſeful in dyeing, namely cochineal, braſil wood, logwood, and anotta.

But above all, we are indebted for the ſuperiority of our colours to our preparation of alum, and the ſolution of tin, which give ſo much brilliancy to many of our dyes. Our very general uſe of ſilk, which takes ſuch lively and beautiful colours; the rapid intercourſe of trade, which brings the luxury of China and the Indies within the reach, even of the vulgar; the activity of induſtry, enlightened and ſtimulated by jealouſy, and a contention for ſuperiority among the different nations of Europe; theſe circumſtances have raiſed us very much above the ancients, and have made colours common among us, with which the moſt opulent among them, were unacquainted: but previous to the acquiſition of this ſuperiority, Europe experienced all the devaſtations of barbariſm.

In the fifth century, all the arts were loſt throughout the Weſt; except a few, which in a ſtate of decay, were preſerved in Italy; and no traces were left of knowledge, induſtry, or humanity.

Muratori [q] quotes a manuſcript of the eighth century, in which we find a deſcription of ſome dyes, principally for ſkins, and ſome proceſſes connected with other arts; but the Latin, which is almoſt unintelligible, and the chaſms we find here and there, prevent us from being able to form a juſt idea of theſe proceſſes [r].

The arts were better preſerved in the Eaſt, where articles of luxury were procured by ſome of the great, even ſo late as the twelfth century.

During the cruſades, the Venetians derived their power from the barbarous mania of the

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[q] Diſſ. de textrina & veſtibus ſæculor. rudium. *Antiq. Ital.* vol. ii.

[r] I ſhall quote literally a deſcription of alum, which ſeems to prove that they employed only aluminous ſtalactites, or a volcanic earth impregnated with alum.

De Alumen.

Alumen autem metallum, eſt terra floriens de Eritarin. Eritarin terra eſt alba facilis ad piſandum.

age; their fleets were loaded with proviſions for our deſtructive emigration; their commerce increaſed, the arts were eſtabliſhed among them, and improved by the induſtry of the Greeks, and ſpread from thence through the other parts of Italy. In the year 1338, Florence contained two hundred manufacturers, who are ſaid to have made from ſeventy to eighty thouſand pieces of cloth, which, as an object of commerce, was worth twelve hundred thouſand crowns of gold.

It is ſaid, that archil was accidently diſcovered by a Florentine merchant, about the year 1300. Having obſerved that urine imparted a very fine colour to a certain ſpecies of moſs, he made experiments, and learned to prepare archil.

He kept his diſcovery ſecret for a long time; his poſterity, a branch of which ſtill exiſts, according to Dominique Manni, have retained the appellation *Ruccellai*, from *Oreiglia*, the Spaniſh term for that kind of moſs.

The arts continued for a long time to be cultivated in Italy with increaſing ſucceſs. In the year 1429, the firſt collection of the proceſſes employed in dyeing, appeared at Venice, under the name *Mariegola del' arte de i tentori*: a ſecond edition of it, much improved, came out

out in 1510. A certain perſon called *Giovan Ventura Roſetti*, formed the deſign of rendering this deſcription more uſeful and extenſive. He travelled through the different parts of Italy and the neighbouring countries, where the arts had begun again to flouriſh, in order to make himſelf acquainted with the various proceſſes employed; and he publiſhed under the title Plictho, a collection, which according to Mr. Biſchoff, is the firſt that united the different proceſſes, and which ought to be regarded as the leading ſtep toward the perfection which the art of dyeing has attained[s].

It is remarkable that in the work entitled Plictho, not a word is ſaid either of cochineal or of indigo, probably theſe two dyes were not employed in Italy.

Pliny, indeed, ſpeaks of a ſubſtance which came from India, which he calls *Indicum*, but

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[s] *Plictho de l'arte de tentori, che inſegna tenger panni, tele banbaſi & ſede, ſi per l'arte magiore, come per la commune vinczia*, 1548.

This work has been tranſlated into French, under the title of Suite du teinturier parfait, ou l'art de teindre les laines, ſoies, fils, peaux, poils, plumes, &c. comme il ſe pratique a Veniſe, Genes, Florence, & dans tout le Levant, & la maniere de paſſoz en chamois tout ſorte de peaux, traduit de l'Italien, Paris 1716.

it was only uſed in painting. It is very probable however, that the Indians employed it in dyeing. The firſt of it uſed in Europe, appears to have been brought to us from the Eaſt-Indies, by the Dutch. The cultivation of it in America, was firſt eſtabliſhed at Mexico, and afterwards in other parts, where it acquired a quality ſuperior to that which we ſtill get from India.

For a long time, Italy, and eſpecially Venice, poſſeſſed the art of dyeing almoſt excluſively; a circumſtance which contributed to the proſperity of their manufactories and commerce: by degrees it was introduced into France. Giles Gobelin, to whom the proceſs for making the true ſcarlet had been communicated, eſtabliſhed a manufactory in the place, which ſtill bears his name. This undertaking was deemed ſo raſh, that it was termed *Gobelin's folly*; but his aſtoniſhing ſucceſs, at length induced our anceſtors to think he had made a compact with the devil. The diſcovery of ſcarlet may be conſidered as the moſt remarkable æra in the art of dyeing. The ancients, as we have ſeen, applied the name ſcarlet to the colour obtained from kermes, which was much inferior in beauty to the colour we diſtinguiſh by that appellation.

The Spaniards having obſerved that the inhabitants of Mexico employed cochineal in painting their houſes, and dyeing their cotton, gave their government an account of the beauty of that colour; and Cortes, in the year 1523, was ordered to promote the increaſe of the valuable inſect, from which it is obtained: the natural colour however, which the cochineal gives, is but a dull crimſon.

Soon after cochineal was known in Europe, a great chemiſt, of the name of *Kuſter*, *Kuffler*, or *Kepſler*, found out the preſent proceſs for making ſcarlet, by means of a ſolution of tin, and carried the ſecret to London in the year 1643.

A Flemiſh painter called *Kloeck* or *Gluck*, got poſſeſſion of this ſecret, and communicated it to Gobelin. The knowledge of the proceſs, afterwards ſpread throughout all Europe. Gluck travelled into the Eaſt, where there were ſtill ſome remains of Grecian induſtry, and afterwards ſettled in Flanders, where he ſpent a long and proſperous life. According to Mr. Francheville, this man who had been ſo uſeful to his country, died about the year 1550[t].

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[t] Mem. de Berlin, 1767.

The uſe of indigo, which was likewiſe a great acquiſition to the art of dyeing, was not ſo eaſily eſtabliſhed as that of cochineal; it was ſtrictly prohibited in England, in the reign of Elizabeth, as was alſo logwood, which was ordered to be burned if found in any manufactory; this prohibition was not taken off till the reign of Charles the ſecond.

In like manner the uſe of indigo was proſcribed in Saxony; in the edict againſt it (which brings to one's mind the edict againſt the employment of antimonial emetics) it is ſpoken of as a corroſive colour, and called food for the devil, *Freſſende Teufels* [v].

This is a ſtriking example of the errors into which an unenlightened adminiſtration may fall, which liſtens to the ſuggeſtions of intereſted individuals.

Thoſe who dyed blue, and were accuſtomed to uſe paſtel and woad, repreſented, that indigo would deſtroy the ſale of theſe two articles, which were the produce of the country. Such a reaſon, which would appear ſpecious to many even in the preſent day, eaſily produced a prohibition, which would be ſoon eluded by paying a tribute to the induſtry of other na-

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[v] Biſchoff verſuche, &c.

tions. The prejudice againſt indigo was likewiſe communicated to France, and Colbert's inſtruction forbad the uſe of more than a certain quantity in the paſtel vats.

The induſtry of France, which had remained in a languid ſtate during the ſtormy adminiſtration of Richlieu and Mazarin, received a ſupport from Colbert, which ſoon raiſed it to preeminence among the nations of Europe; he invited the moſt ſkilful artiſts, he rewarded their talents, and eſtabliſhed many manufactories; and it is curious to remark, that thoſe of Vanrobais and Sedan were called in the letters patent which were granted them, manufactories of fine cloth, after the Dutch and Engliſh faſhion. In the year 1672, he publiſhed a table of inſtructions for dyeing [w], which merits attention.

The legiſlator firſt preſents us with the reaſons that ſhould induce us to think the object he is conſidering, an object of conſequence;

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[w] General inſtruction for dyeing wool, and woollen manufactures of all colours, and for the culture of the drugs or ingredients employed in them. This work was reprinted in 1708, under the following title. Le Teinturier parfait, ou inſtruction nouvelle et generale pour la teinture des laines et manufactures de laine de toutes couleurs, et pour la culture des drogues ou ingredients qu'on y emploie.

" If the manufactories of ſilk, wool, and thread, " are to be reckoned among thoſe which moſt " contribute to the ſupport of commerce; " dyeing, which gives them that ſtriking vari- " ety of colour, by which they reſemble what " is moſt beautiful in nature, may be conſidered " as the ſoul of them, without which the body " could ſcarcely exiſt.

" Wool and ſilk, the natural colour of " which rather indicates the rudeneſs of former " ages, than the genius and improvement of " the preſent, would be in no great requeſt, " if the art of dyeing did not furniſh attractions, " which recommend them even to the moſt " barbarous nations. All viſible objects are " diſtinguiſhed and recommended by colours; " but, for the purpoſes of commerce, it is not " only neceſſary that they ſhould be beautiful, " but that they ſhould be good, and that their " duration ſhould equal that of the materials " they adorn." But though Colbert inſtituted many uſeful regulations for the inſtruction of the farmers and of the artiſts, he ſubmitted to that feudal ſpirit, which from views to the revenue, multiplying the checks on commerce, induſtry, and agriculture, impreſſed almoſt all Europe with the idea, that ſuch reſtraints were neceſſary. Inſtead of confining himſelf to ſuch meaſures as might ſecure honeſty of manufacture, and goodneſs of colour; inſtead of encouraging the ſeeds of commercial honour, the object of which is the public confidence, his reſtraints were exceſſive. In the dyeing of black cloth, he inſiſted upon it, that the operation ſhould be begun with the dyers in grain, or thoſe who give durable colours, and finiſhed by thoſe who employ only fading colours (*teinturiers en grand teint, & teinturiers en petit teint*); each was confined to a certain number of ingredients, and neither was ſuffered to have Brazil wood, &c.

The bad effects of this prohibition were moderated by the facility of eluding it, and by the rewards beſtowed on thoſe, whoſe experiments promoted the progreſs of the art, and whoſe diſcoveries were afterwards to be publiſhed, and to modify the exiſting regulations. French induſtry loſt its preeminence by the criminal revocation of the edict of Nantz, which, carrying deſolation into our manufactories, diſperſed our workmen throughout Europe.

Since that time, the department of adminiſtration, to which the ſuperintendance of arts and manufactures belongs, has conſtantly ſought to repair our loſſes and encourarge our

exertions,

exertions, and particularly by diffuſing knowledge, which, under wiſe laws, is the moſt efficacious means that can be employed.

Dufay, Hellot, and Macquer, have been ſucceſſively charged with the care of improving the art of dyeing, and to their labours we are indebted for very valuable acquiſitions. Dufay was the firſt who entertained juſt, though incomplete ideas, reſpecting the nature of colouring ſubſtances, and the powers by which they adhere; he examined with great ſagacity certain proceſſes, and eſtabliſhed the ſureſt methods that could at that time be employed for determining the goodneſs of a colour, and this he did, in an eaſy and familiar manner. Hellot publiſhed a methodical deſcription of the proceſſes uſed in dyeing wool, which even now is the beſt treatiſe we have on the ſubject. Macquer has given an exact deſcription of the proceſſes employed in dyeing ſilk; he has made us acquainted with the combinations of the colouring principle of Pruſſian blue; he has endeavoured to make an application of it to the art of dyeing, and has given us a proceſs for communicating the moſt brillant colours to ſilk, by means of cochineal.

The ſolicitude of government on this ſubject, has, in the opinion of foreigners, been crowned ed with the ſucceſs it merited. Mr. Anderſon attributes the ſuperiority, which certain articles of French manufacture maintain over thoſe of the nations who poſſeſs the moſt beautiful wool, to the perfection of our dyes[x], and Mr. Home expreſſes himſelf in the following manner. "The French are indebted to the academy of "ſciences, for their ſuperiority in many of "the arts, and eſpecially that of dyeing; but "many diſtinguiſhed philoſophers have purſued "with equal ſucceſs, the example of the acade-"my of ſciences[y]."

Macquer intended to have publiſhed a general treatiſe on the art of dyeing, the proſpectus of which he gave us in the year 1781, but the indiſpoſition which ſo long led us to expect his loſs, prevented his engaging in it; he died in 1784, before he had been able to carry into effect any part of his plan. I ſucceeded him in his place of truſt, under the commercial department of adminiſtration, and was charged with the care of the arts connected with chemiſtry, and principally that of dyeing, ſince which time, almoſt all the inveſtigations which I have inſerted in the memoirs of the academy,

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[x] Hiſtory of commerce.

[y] Eſſay on bleaching.

in the Journal de Phyſique, and the Annales de Chymie, relate more or leſs to the theory and practice of the arts.

Chemiſtry has experienced a general revolution, which, by ſubſtituting fact in the place of hypotheſis, with which we have heretofore been obliged to be contented, has afforded us an explanation of many obſcure phenomena of nature and art.

Of all the arts, that of dyeing, perhaps with reſpect to its theory, requires the moſt extenſive knowledge of natural philoſophy; becauſe it is that which preſents the greateſt number of phenomena to analyze, of uncertain changes to aſcertain, and of relations to eſtabliſh, with air, light, heat, and many other agents, of which our knowledge hitherto has been very imperfect.

Although the labours of the ingenious men above mentioned, and thoſe of others, foreigners as well as Frenchmen, may have been very uſeful, whether in determining the eſſential circumſtances of proceſſes, and thus rendering them more ſimple and methodical; or in analyzing many ſubſtances employed in dyeing, and thus extending the reſources of the art; or laſtly, in diſcovering the cauſes of ſome particular phenomena; yet they have not been able

able to form a theory which connects the art in all its branches, which does not even leave a great deal to wiſh for in every particular explanation, and above all, which brings into one point of view, the proceſſes of induſtry, and the operations of nature.

I have endeavoured to take my ſituation between the philoſopher, and artiſt; to the firſt, I have ſhewn where it is that the phenomena of the art of dyeing, and the phenomena of nature meet, and what are the principles which their diſcoveries have eſtabliſhed.

I have endeavoured to refer all the combinations produced in the formation of colours, to the laws of attraction, and all the changes which the colouring particles undergo, to the approximation of the elements of the new combination. In this diſtinction, I conſider only two effects of attraction; one, that by which the firſt combination is produced; the other, that by which the elements of this combination obey their mutual attractions. The firſt is analogous to the formation of neutral ſalts; the ſecond, to combuſtion, putrefaction, and many other operations of nature. In the ſecond part of my treatiſe, I have furniſhed them with a ſummary account of a very extenſive art, which deſerves their utmoſt attention, and which preſents to their ſagacity, a great number of intereſting reſearches. They will pardon me if I frequently preſent objects with which they are familiar, if I ſometimes repeat the ſame idea, and if out of regard to thoſe who are not uſed to ſpeculation, I dwell on illuſtrations, which to them would be uſeleſs.

To artiſts, I have preſented the principles of Chemiſtry, ſo far as they are required in the explanation of the phenomena of dyeing; or rather, I have endeavoured to make them feel the neceſſity of an acquaintance with them; I have invited their attention to thoſe objects moſt nearly connected with their art, and have furniſhed them with a ſketch of the operations for making the ſubſtances they employ, with a view to induce them to qualify themſelves for preparing ſuch articles as they want, whenever that may be deemed advantageous; and alſo with a view, to give them an exact idea of the nature and properties of theſe ſubſtances. They ought however to excuſe me, if while I have aimed at preciſion in deſcribing proceſſes, I have omitted any thing eſſential; if I have not always pointed out the beſt, and if ſome that are intereſting have eſcaped me; the myſtery which prevails in moſt

moſt manufactures, is a great obſtacle to thoſe who labour for the improvement of the arts.

Both the philoſopher and the artiſt will find me diſpoſed to profit by their information, and to rectify the errors I may have committed, I wiſh them to conſider me as a fellow-labourer, who deſires to ſtrengthen the ties by which they ought to be united; and as a friend of reaſon, who enjoys, in retirement, the progreſs of knowledge, from whatever ſource it flows.

While they are granting indulgence to my weak attempts, I wiſh them to conſider in me the civiſme of the arts and ſciences.

Experiments which relate to dyeing, are attended with peculiar difficulties. Since the beauty of a colour depends on a nicety of ſhade, which the ſlighteſt circumſtance may effect, we are often diſappointed, and what ſucceeds in a ſmall eſſay, may fail in an operation on the large ſcale; evaporation, which goes on proportionally faſter in a ſmall veſſel, than in a large caldron, variations in the degrees of heat, the great difficulty of obtaining uniformity of colour, inequalities in the alternation of the action of the liquor, and of the air, the more difficult precipitation of the groſſer parts, unite in rendering it very difficult to apply the moſt accurate experiments, to operations on a large ſcale. Thus I have rather hinted, than propoſed the changes, which may be attempted in the proceſſes commonly employed ; I have deſcribed thoſe which may be depended upon, or which are found in thoſe works which moſt merit our confidence, confining myſelf, however, to circumſtances which ſeem eſſential. The deſcription of the proceſſes is preceded by chemical experiments, which furniſh us with a knowledge of the nature of the colouring materials employed in them, and more eſpecially in the effects which may be produced by the ingredients uſed, or which might be uſed as means of uniting the colouring matter with the ſtuff (intermédes): this is generally followed by obſervations on the moſt ſtriking operations, on the differences required according to the intention, or according to the nature of the ſtuff, and on the application of the principles eſtabliſhed in the firſt part of the work.

Hence it is evident that I have guarded againſt leading artiſts into error, by inducing them to change their proceſſes prematurely ; it has been my deſign to qualify them for making experiments in their art, for explaining the phenomena that may occur, for ſelecting obſervations, and gradually introducing into their

their manufactories, more ſimple, more varied, and more perfect methods.

In vain ſhould I have conceived the hope of ſeeing artiſts enlightened by ſcience, which teaches them to go back to cauſes, thence (as it were) to calculate effects; if there were no chance of inducing a change in the uſual mode of their education. But philoſophy has paved the way for a reform, which is ſo conſonant to the order eſtabliſhed on the ruins of prejudice, and ſo powerfully recommended by illuſtrious example, more eſpecially in a neighbouring nation, which has hitherto preceded us in the path of reaſon; that I flatter myſelf I ſhall not be diſappointed. The advancement of the arts ought to attract a conſideration proportioned to its uſefulneſs, and to the knowledge it demands; more eſpecially when the illuſions of vanity, to the imputation of which the french character may have been liable, ſhall be for ever baniſhed from the nation.

ELEMENTS
OF THE
ART OF DYEING.

PART THE FIRST.

OF DYEING IN GENERAL.

SECTION I.

Of the general Properties of Colouring Subſtances.

CHAPTER I.

Of Colouring Particles, and their Attractions.

AS the phyſical theory of colour is foreign to the ſubject of the preſent work, I ſhall make only a few obſervations on the action by which the particles of bodies, by abſorbing certain rays of light, and tranſmitting or reflecting others, produce colours, before I enter on the conſideration of the properties of colouring ſubſtances.

Newton has demonſtrated in his optics, that tranſparent bodies reflect the rays of one colour, and tranſmit thoſe of another, according to the difference of their thickneſs or denſity. Mr. Delaval [a] has endeavoured to apply the Newtonian theory to the colours of all permanently coloured bodies, and has collected a great number of experiments, in order to prove, that the difference of colour in theſe bodies is exactly proportioned to the denſity of their conſtituent parts.

The application of the ingenious experiments on the colours reflected by thin and tranſparent laminæ, to the caſe of permanently coloured bodies, is founded upon analogies which did not eſcape the penetration of Newton; but the ſubject does not yet appear to admit of any direct proof, or inference, reſpecting particular colours; for firſt, the very ſame colours are ſucceſſively produced by laminæ, the thickneſs of which is increaſed in a certain progreſſive order; ſo that we cannot determine by the kind of colour produced by a tranſparent lamina, which of all the different degrees

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[a] Experimental inquiry into the cauſe of the permanent colours of opake bodies.

of thickneſs capable of producing the colour, that particular lamina poſſeſſed.

Secondly, the ſmalneſs and the denſity of the particles of bodies, àre, according to Newton, two qualities, which combine to produce colour in tranſparent laminæ, and the thickneſs of the laminæ of water, of air, and of glaſs, muſt be different, in order to reflect the ſame colour; but we have no means whereby we can determine either the ſmalneſs or the denſity of the particles of bodies; their ſpecific gravity will not anſwer this purpoſe, for ſmall particles, with very numerous pores, may give the ſame ſpecific gravity as larger pores and a ſmaller number of larger particles.

When Mr. Delaval aſſerts, that the ſeries of colours which the metals communicate to glaſs, depends upon their ſpecific gravity, he refutes himſelf by the facts which he relates; for he obſerves, that yellow glaſſes may be made either with iron, lead, or ſilver, which are very different in ſpecific gravity.

Mercury, combined with a ſmall quantity of oxygen [b] is black, but by its union with a larger

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[b] It may be proper to inform ſuch readers as are not acquainted with the new nomenclature, adopted by many of

larger quantity it aſſumes a red colour. Iron is capable of acquiring almoſt any colour, according to the quantity of oxygen with which it is combined, and the variations of ſpecific gravity, reſulting from theſe proportions of oxygen are very ſmall, and much leſs conſiderable than the difference in the ſpecific gravities of theſe metals.

The ſame author aſſerts, that alkalis change ſeveral vegetable blue colours to a green, becauſe they increaſe the denſity of their particles; and that acids change them to a red, becauſe they leſſen it by ſolution; but alkalis

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of the french chemiſts, that by this term is to be underſtood, that part of the pure or dephlogiſticated air, which is united to metals during calcination; it has therefore been alſo called the *baſis of pure air* (ſee the annexed vocabulary).

What the other conſtituent part or parts of this fluid are, does not ſeem yet determined; by ſome, it is ſuppoſed to be the matter of light; by others, to be that of heat, called in the above-mentioned nomenclature, caloric (*calorique*); and by others, both are conceived to concur in its formation. Analogy, and even ſome obſervations, have led me to believe that light is not in every caſe neceſſary to the production of this fluid in its elaſtic ſtate, but experiments are ſtill wanting on the ſubject.

The etymology of the term is from Οξυς, acid, and γείνομαι, I generate, it being ſuppoſed the univerſal parent of acidity. T.

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alſo diſſolve moſt of the colouring ſubſtances, and render them much more miſcible with water than they are naturally; they ought therefore to act like acids; beſides, acids diſſolve ſome blue colouring ſubſtances without changing their colour; thus the ſolution of indigo in the ſulphuric (vitriolic) acid, retains its blue colour, even when diluted with a very large quantity of water, though according to Mr. Delaval's theory, the denſity of the blue particles muſt have ſuffered a material alteration. Finally, many vegetable ſubſtances become red or green, by means of a very weak acid, or a very ſmall quantity of alkali, without its being poſſible to perceive the ſhades which ought to intervene.

The ſmalneſs and denſity of the particles are not the only circumſtances which ought to be taken into the account; it appears even from Newton's experiments, that their chemical properties have a conſiderable influence on their colour, for doubtleſs a force which acts powerfully in refracting the rays, muſt likewiſe influence their reflection.

By comparing the refractive power of different bodies, Newton found that inflammable ſubſtances poſſeſs it in a much greater degree, than ſuch as are not inflammable;

from

from his obſervations on this ſubject, he drew the wonderful concluſion, that the diamond contained a large quantity of inflammable matter, that water was an intermediate ſubſtance, between the inflammable and uninflammable bodies, and that it ſupplied vegetables with the inflammable principle; which truths have been ſeen and demonſtrated only in the preſent day.

Many important obſervations ſtill remain for thoſe, who would follow the ſteps of that great man, and compare the refracting powers of the different gaſes, and other ſubſtances, the conſtituent principles of which are now known. Is it the hydrogen [c] or the charcoal (charbon [d]) which contributes moſt to the refracting power of inflammable ſubſtances? The experiments made on the diamond, would lead us to conſider it as a pure, cryſtallized charcoal; but in the oil of turpentine, which has a conſiderable refracting power, the hydrogen is predominant.

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[c] The name given to the baſis of inflammable air in the new french nomenclature, derived from Υδωρ, water, and γείνομαι, I generate. T.

[d] It is ſuppoſed the author here means that ſubſtance, which in the ſame nomenclature is denominated *carbone* (*pure charcoal*) ſee vocabulary. T.

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Many chemical experiments prove that oxygen has alſo a great attraction for light; it combines with it, without ſeparating the rays, and it recovers its elaſtic form in conſequence of this combination, when it is not retained by a ſuperior attraction (affinité); hence when oxygenated (dephlogiſticated) muriatic acid, in which the oxygen is retained with but a ſmall degree of force, is expoſed to the light, it quits the acid and aſſumes its elaſtic form, as it becomes ſaturated with the matter of light; a ſimilar ſeparation takes place when the nitric (dephlogiſticated nitrous) acid is expoſed to the rays of the ſun, but with greater difficulty, becauſe the oxygen is more intimately united with this acid. The oxygen may alſo be ſeparated in the ſame manner, from ſome oxyds or metallic calces.

When a particular principle enters into the compoſition of any ſubſtance in a large proportion, it commonly ſhews its own properties by thoſe which it imparts, however modified; thus oxygen by its union with metals, enables them to act more powerfully on the rays of light, but with different degrees of force, on the different kinds of rays, until its attraction is ſo far weakened by heat, that all the rays may unite with it, and give it its elaſtic form.

Hence it is, that metallic oxyds change their colour, from ſmall differences in the proportion of their oxygen. The oxyd of Manganeſe affords us a remarkable phenomenon in this reſpect; when ſaturated with oxygen, it appears black, if the particles are very cloſe; but if they are diffuſed or diſperſed, as in glaſs, which contains a certain quantity of this ſubſtance, it has a red tinge, which ſhews that its appearing black, ariſes only from the red particles being too near each other; if it be deprived of a great part of its oxygen, either by means of charcoal, or any other ſubſtance which is capable of ſeparating that principle, the glaſs becomes quite tranſparent, and loſes its colour; but it may be reproduced by nitre, or any other ſubſtance which reſtores to the Manganeſe the oxygen it had loſt. In this way, its uſe in glaſs-making is explained; it deſtroys the carbonaceous or coaly matter which might injure the purity of the glaſs, and thus at the ſame time, becomes itſelf incapable of producing any colour, if it be employed in proper quantity.

In metallic oxyds, and many mineral ſubſtances, all the parts are equally coloured; but this is not the caſe in vegetable and animal ſubſtances; their colour is generally derived from particles, which are mixed or combined with thoſe of which theſe ſubſtances are formed, and vegetables commonly contain different colouring particles at different times of their growth, or in their different parts.

It is almoſt ſolely the colouring particles of vegetable and animal origin, that are uſed in dyeing, but they are frequently modified by different *intermedes* [c]. It is to theſe, that the name of colouring particles is given in this treatiſe *(parties colorantes)*.

Theſe colouring particles are not ſo ſimple in their compoſition, as thoſe of mineral origin, and oxygen does not act upon the colours of both in the ſame way. How it acts upon, and changes them, will be explained in one of the ſucceeding chapters.

Some chemiſts have conſidered iron as the cauſe of all vegatable and animal colours; and Mr. Becker, in order to ſupport this opinion, makes uſe of the argument drawn from the property which this metal ſo generally diffuſed over nature, has, of aſſuming a great variety of

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[c] This term and that of mordant ſeem pretty nearly ſynonimous, both being applied to ſubſtances that modify colours, and make them ſtrike, as it is commonly expreſſed by our dyers. Vid. Introduction, page xxzvi. T.

colours, when its oxyd (calx) is in a ſtate of ſolution, or of vitrification[f].

Iron does in fact, appear to be contained in all vegetable and animal ſubſtances, but only in a very minute proportion. Oak, which is one of thoſe vegetable ſubſtances that ought to afford the greateſt proportion of reſiduum, leaves after combuſtion, only $\frac{1}{200}$ of its weight of aſhes, and theſe do not contain $\frac{1}{200}$ of their weight of iron. Is it poſſible by ſo very ſmall a quantity, to account for the rich and brilliant colours with which vegetables are adorned? Is there any remarkable connexion between the changeableneſs of ſome of theſe colours, by means of acids, alkalis, or air, and the regular ſucceſſion of colours in iron, according to its degree of oxydation (calcination).

I know that the opinion which I am now oppoſing, may be ſupported by the ſuffrage of Bergman, who has attempted to prove that indigo owes its colour to the iron it contains[g]; but I ſhall take the liberty of replying, that it is eaſy to ſhew, that this great chemiſt was

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[f] Specimen ſiſtens experimenta circa mutationem colorum quorundam vegetabilium a corporibus ſalibus, cum corollariis; auctore I. F. Adolpho Becker, 1779.

[g] Analyſe chymique de l'Indigo. Mem. des Sav. etrang. tom. ix.

miſtaken

miſtaken in this particular. By means of the pruſſiat of alkali [h], he extracted from the aſhes of one ounce of indigo, from thirty to thirty-two grains of Pruſſian blue, the iron of which he eſtimates to be from eighteen to twenty grains; but in other places, he ſhews that the iron contained in a ſubſtance, does not at the utmoſt exceed one fifth of the Pruſſian blue obtained from its ſolution; and in every other inſtance, he makes uſe of this calculation, which is very accurate. The quantity of iron therefore, he obtained from an ounce of indigo, ought to be reduced to ſix grains; in the experiments which follow, he ſhews that the greater part of this iron may be diſſolved in the muriatic acid, without any change being produced in the colouring particles, ſo that the largeſt ſhare of that metal did not enter into their compoſition. Hence it clearly follows, that the colouring particles in this ſubſtance muſt contain a quantity of iron, ſo ſmall, as to have but very little influence on its colour. I am alſo inclined to think phyſiologiſts wrong, in concluding from the ex-

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[h] By this term is to be underſtood alkali, which has been boiled upon Pruſſian blue, commonly called phlogiſticated alkali. T.

periments of Menghini, that iron is the immediate cauſe of the colour of the blood.

We are not only incapable by any of the means of chemical analyſis we poſſeſs, of aſcertaining the compoſition of the colouring particles, with a degree of preciſion, ſufficient for diſcovering the principles to which they owe their properties; but it is alſo obvious that very different compoſitions may produce the ſame colour. The conſtituent matter of indigo is very different from that, to which moſt of our blue flowers owe their colour. We have a great number of yellow ſubſtances which afford colours very ſimilar in their appearance, yet they are very different in their properties. There are ſimple colours, and there are others which reſult from a mixture of theſe, conſequently of a compound nature. Newton has laid down a rule for the production of any given colour, by means of the other priſmatic colours. Le Blon has ſhewn that all the colours required in painting, may be produced by different mixtures of red, blue, and yellow [i]. Dufay has found, that the ſame might be accompliſhed in dyeing, and has

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[i] L'Harmonie du coloris dans la peinture reduite en pratique.

thence inferred that there are only three primitive colours in nature, which produce all the reſt, and this opinion has been adopted by many philoſophers, though it is eaſy to prove it to be without foundation.

There is this difference between ſimple colours, and thoſe produced by the union of different coloured rays, that the former viewed by means of a priſm, retain their ſimplicity, while the latter are decompoſed. Thus the green produced by the rays of that colour, ſuffers no decompoſition by the priſm, and has therefore the property of a ſimple and primitive colour; but that which is compounded, ſeparates into blue and yellow. Although the green employed in dyeing, reſults from the mixture of blue and yellow, all greens are not to be conſidered as compoſed of two kinds of colouring particles; thus, the green in the oxyd of copper, cannot ariſe from particles of different kinds; and that of plants is certainly of a homogeneous nature, but this ſubſtance may produce green, either by reflecting the green rays, or by reflecting the blue and yellow; and there are many colours neceſſarily produced by the reflection of ſeveral different ſpecies of rays. If the green of plants aroſe from two ſubſtances, the one yellow, and the other blue, it would appear extraordinary, that theſe could not be ſeparated from each other, nor their proportions changed by means of menſtrua; yet there are ſome ſubſtances which contain colouring particles of different kinds; ſuch is madder, as will preſently appear.

Green, which I take as an example of the colours in dyeing, that are really of a compound nature, demonſtrates, that the colouring particles cover only a part of the ſurface of the ſtuff, though its colour may appear full and uniform; for after it has been dyed blue, the yellow particles ſtill attach themſelves, and produce green; and a proof that they are attached to the ſtuff principally, and not to the particles of indigo, is, that, though the proceſs has been begun by applying the yellow firſt, provided it be not of too fixed a nature *(ſolide)* it may be deſtroyed by the air, and more eſpecially by chemical agents, while the blue remains nearly unchanged.

Hence we ſee, that by mixing rays of different colours together, we may have the impreſſion of a ſimple colour. In fact, an uniform colour may be produced by the mixture of different coloured wools; and in painting, ſimple ſhades reſult from the mixture of different ingredients which do not unite together.

The colouring particles form different combinations, and attach themſelves either alone, or previouſly combined with other ſubſtances, to wool, ſilk, thread, and cotton. The art of dyeing conſiſts in employing theſe attractions of the colouring particles, in order to extract, diſſolve, apply, and fix them in the ſubſtances to be dyed.

It has been propoſed to divide the colouring particles into extractive and reſinous; but ſuch a diviſion can convey only partial and erroneous ideas of their properties; for there are ſome colouring particles, which not being ſoluble in water, would be conſidered as reſinous, and yet they are not ſoluble in alcohol; ſuch are the red colouring particles of baſtard ſaffron, carthamus *(carthame)* which are only ſoluble by means of alkalis; and alſo, indigo, which is neither ſoluble in water, nor in alcohol, and diſſolves in alkalis, only under particular circumſtances, but very eaſily in the ſulphuric acid.

The colouring particles which are ſoluble in water, cannot be conſidered as ſimilar to the mucilaginous and extractive parts of vegetables, becauſe the property of diſſolving in water, like theſe ſubſtances, conveys no idea of the properties which it is eſſential to remark in them, ſuch as their affinities with the chemical agents employed in dyeing, with the air, with light, and with animal and vegetable ſubſtances.

The progreſs of true theory is alſo impeded by attempts to explain the properties of colouring ſubſtances, from the mucilaginous, reſinous, earthy, ſaline, or oily particles, which are ſuppoſed to enter into their compoſition, in the way Mr. Poerner has done; ſuch attempts are ſimilar to the vain explanations frequently offered reſpecting the action of medicines. (Vide Cartheuſer's Mater. Med.)

We have juſt ſeen, that in explaining the cauſe of colour, and the nature of colouring particles, two great inconveniences have ariſen; firſt in the attempt to illuſtrate the action which the particles of colouring ſubſtances have on the rays of light, in conſequence of their denſity and thickneſs, without having any means of aſcertaining this, and without any regard to the attractions, which reſult from their chemical compoſition; ſecondly, in comparing the colouring particles to mucilages and reſins, from ſome very faint reſemblances; and in attempting to explain their colouring properties by conjectures, formed reſpecting their component parts, while theſe properties ought

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rather to be aſcertained by direct experiment, than explained by an imaginary compoſition. It was alſo departing from true theory, which is the reſult of obſervation alone, to aſcribe to laws purely mechanical, the adheſion of the colouring particles to the ſubſtances dyed, the action of the mordants, the difference between the true or durable, and the falſe or fading dyes. Hellot, to whom we are indebted for the beſt treatiſe extant on dyeing, was completely wrong on this ſubject, and his theoretical ideas frequently influenced his obſervations, and the principles he laid down, as may be ſeen by conſulting the work itſelf. Some judgment may be formed reſpecting his theory, from the following paſſage, "I believe it may be "laid down as a general principle in the art "of which I am now treating, that all the "inviſible mechaniſm of dyeing, conſiſts in "dilating the pores of the body to be dyed, "in depoſiting in them, particles of foreign "matter, and retaining them there by a kind "of covering not liable to be affected by "water, rain, or the rays of the ſun; in "chooſing colouring particles of ſuch a degree "of fineneſs, as to be rendered ſufficiently "fixed in the pores of the ſtuff, opened by "the heat of the boiling water, and again "conſtricted by cold, and alſo coated by the "kind of varniſh (maſtic) which the ſalts em-"ployed in its preparation had left in theſe "pores; whence it follows, that the pores of "the fibres of the wool, which has been "wrought, or is to be wrought into cloth, "ſhould be cleanſed, enlarged, coated over, "and then conſtricted, ſo that the colouring "particles may be retained in them, nearly in "the ſame manner as the diamond is retained "in the collet of a ring[k]."

It is ſurpriſing that Macquer, who was amongſt the firſt who entertained juſt notions reſpecting chemical attractions, was led aſtray, by the ideas of Hellot. "I ſhould now ex-"plain (ſays he) the action of mordants in "dyeing, and unfold the cauſes of durable "and fading dyes; but this ſubject has been "treated of with ſo much ſagacity by Mr. "Hellot, that I ſhall refer the reader to "him[l]."

Dufay

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[k] L'Art de la Teinture des Laines, p. 42.

[l] This refers to a treatiſe on dyeing ſilk, publiſhed by Macquer, in 1763, entitled *Art de la Teinture en Soie. avant propos*, pag. 8, but that he was afterwards led to correct this opinion, is evident from the following paſſage, taken from the article dyeing, in his chemical dictionary, publiſhed in 1778, with his name affixed, vol. iv. pag. 26, "That the above "(alluding

Dufay however had before obſerved, that the colouring particles were naturally diſpoſed to

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“ (alluding to Hellot's theory) is not the only reaſon however, is evident from a fact very well known in dyeing.

“ If after having alumed as completely as poſſible a pound of wool, and a pound of ſilk, each of them be dyed ſeparately in a cochineal bath, they will both acquire a very fine and durable crimſon; but with equal quantities of cochineal in each bath (*bain*) the colour of the wool will be much more full and intenſe, than that of the ſilk, and the difference in this reſpect is ſo great, that the ſilk will not acquire ſo deep a crimſon as the wool, unleſs more than double the quantity of cochineal be employed; that is, two ounces and a half of cochineal are requiſite for giving the pound of ſilk as full a crimſon, as that which is produced in the pound of wool by one ounce of the ſame ſubſtance; and we cannot ſay with Mr. le Pileur d'Apligny, that this proceeds from the pores of the ſilk being much ſmaller than thoſe of the wool, and being able to receive only the fineſt colouring particles of the cochineal, while the wool receives them all, becauſe its pores are either larger or more numerous; if this were the caſe, the bath in which the ſilk had taken up all that it was capable of receiving, ſhould ſtill retain a conſiderable quantity of the colouring matter; but this by no means happens; on the contrary, it is certain, that ſilk dyed with the proportion of two ounces and a half of cochineal to the pound, leaves its bath as clear and as much exhauſted of its colour, as one prepared for the ſame quantity of wool, with only one ounce of cochineal.” And he afterwards proceeds to attribute it, to a chemical union of the colouring particles to the matter

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to adhere more or leſs firmly, to the filaments which receive them [m]; he remarks very juſtly, that without this diſpoſition, ſtuffs would never aſſume any colour, but that of the bath, and would always divide the colouring particles equally with it; whereas the liquor of the bath ſometimes becomes as limpid as water, giving off all the colouring particles to the ſtuff; “ which ſeems to indicate (ſays he) that the “ ingredients have leſs attraction for the water,

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of the ſtuff dyed, either immediately or by the intervention of mordants; and concludes thus: “ From theſe effects “ we ſee evidently, why the extractive colouring particles “ cannot ſtrike a colour, without the aſſiſtance of a mordant “ previouſly applied to the ſtuff to be dyed; it is plain, “ that the compoſition of the mordant, the precipitation of “ earthy, or metallic baſis, and finally the union of the “ colouring particles with theſe earthy or metallic ſubſtances, “ take place in the ſtuff impregnated with the mordant, “ when it is immerſed in a decoction, which holds this “ colouring matter in ſolution; and hence it follows, that “ in all caſes of colours ſtruck in this manner, which are “ very numerous, it is not the ſtuff immediately which “ takes the colour, but the earthy or metallic part of the “ mordants; ſo that when ſtuffs are well dyed by theſe “ proceſſes, it is owing to theſe coloured precipitates being “ capable of adhering to them, more or leſs forcibly.” D'un maniere plus ou moins ſolide.

[m] Obſervations phyſiques ſur le melange de quelques couleurs dans la teinture. Mem. de l'Academ. 1737.

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" than for the particles of the wool;" he adds, that many other phenomena might be accounted for in the ſame way; but that ſuch an explanation ſtill leaves a great deal to be wiſhed for, and that he would relinquiſh it readily, if a more probable one ſhould be propoſed.

Bergman ſeems to have been the firſt who referred phenomena of dyeing, entirely to chemical principles[n]; having dyed ſome wool and ſome ſilk in a ſolution of indigo, in very dilute ſulphuric acid, he explains the effects he obſerved in the operation, by attributing them to the precipitation occaſioned by the blue particles having a ſtronger attraction for the particles of the wool and ſilk, than for thoſe of the acidulated water; he remarks, that this attraction of the wool is ſo ſtrong, as to deprive the liquor entirely of the colouring particles; but that the weaker attraction of the ſilk, can only diminiſh the proportion of theſe particles in the bath; and he ſhews, that both the durability of the colour, and the degree of intenſity it is capable of acquiring, depend on theſe different attractions. This is, in fact,

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[n] Analyſe de l'indigo. Mem. des Sav. etran. tom. ix. and in the notes on Scheffer's treatiſe.

the true light in which the phenomena of dyeing ſhould be viewed; they are real chemical phenomena which ought to be analyzed in the ſame way as all thoſe dependant on the actions which bodies exert, in conſequence of their peculiar nature.

The colouring particles poſſeſs chemical properties, that diſtinguiſh them from all other ſubſtances; they have attractions peculiar to themſelves, by means of which they unite with acids, alkalis, metallic oxyds, and ſome earths principally alumine. They frequently precipitate oxyds and alumine, from the acids which held them in ſolution; at other times they unite with the ſalts and form ſupracompounds [°], which combine with the wool, ſilk, cotton, or linen. And with theſe, their union is rendered much more cloſe by means of alumine or a metallic oxyd, than it would be without their intervention.

The difference in the attractions of the colouring particles for wool, ſilk, and cotton, is

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[°] In the original *ſurcompoſitions*, by which is to be underſtood compounds of more than two ingredients. I have rendered it by the above word, as the idea ſeems borrowed from Beccher and Stahls mixts, compounds, decompounds, and ſupradecompounds, though the application of the term is more vague. T.

ſometimes ſo great, that they will not unite with one of theſe ſubſtances, while they combine very readily with another; thus cotton receives no colour in a bath which dyes wool ſcarlet. Dufay got a piece of ſtuff made, the warp of which was wool and the woof cotton, which went through the proceſs of fulling, that he might be certain that the wool and the cotton received exactly the ſame preparation; but the wool took the ſcarlet dye, and the cotton remained white. It is this difference of attraction which renders it neceſſary to vary the preparation, and the proceſs, according to the nature of the ſubſtance which we wiſh to dye of a particular colour.

Theſe conſiderations ought to determine the road to be purſued, for the purpoſe of improving the art of dyeing.

It is certainly proper to endeavour to aſcertain, what are the conſtituent principles of the colouring particles; for though ſuch an inveſtigation cannot of itſelf lead to an extenſive application at preſent, yet it would appear, that we have attained a knowledge of the nature of the modifications produced in theſe particles by different agents.

The eſſential circumſtances are, to determine the affinities of a colouring ſubſtance, firſt, with the ſubſtances which may be employed as menſtrua;

ſtrua; ſecondly, with thoſe which may by their combinations modify the colour, increaſe its brilliancy, and help to ſtrengthen its union with the ſtuff to be dyed; thirdly, with the different agents which may change the colour, and chiefly with air and light.

It muſt be remembered, that the qualities of the uncombined colouring particles are modified when they unite with a ſubſtance; and if this compound unites with a ſtuff, it undergoes new modifications; thus the properties of the colouring particles of cochineal are modified, by being combined with the oxyd of tin, and thoſe of the ſubſtance reſulting from this combination, are again modified by their union with the wool or ſilk; ſo that the knowledge we may acquire by the examination of colouring ſubſtances in their ſeparate ſtates, can only inform us reſpecting the preparations that may be made of them; that which we acquire reſpecting their combinations with ſubſtances which ſerve to fix them, or to increaſe their beauty, may inform us what proceſſes in dyeing ought to be preferred or tried; but it is only by direct experiment made with the different ſubſtances employed in dyeing, that we can confirm our conjectures and eſtabliſh the proceſſes.

In the courſe of theſe obſervations, we ſhall frequently be able to point out the rationale of the circumſtances in operations, that depend only upon practice unenlightened by ſcience, but yet enriched by the trials of many ages; we ſhall be able to retrench what is ſuperfluous, to render ſimple what is complicated, and to employ analogy for the purpoſe of transferring to one proceſs, that which is advantageous in another; but ſtill a conſiderable number of facts will occur, which we cannot explain, and which are not reducible to any theory: we muſt then content ourſelves with detailing the proceſs of art, without attempting to give new explanations, and wait for further light from experience.

From the preceding obſervations, it follows, that the changes produced by acids and alkalis on many vegetable colours, ſuch as the chemiſts often employ, in order to diſcover the nature of different ſubſtances, are owing to the combinations which take place between theſe colouring particles and the acids and alkalis. The compounds reſulting from theſe combinations, may be compared to neutral ſalts, which poſſeſs qualities different from thoſe of their component parts, but in which one of theſe parts may be in exceſs, and its qualities conſequently be predominant. This ſtate of combination is obſervable between the colouring particles of

cochineal

cochineal and acidulous tartrite of pot-aſh, or cream of tartar; by evaporating ſlowly, a ſolution of this ſalt in a decoction of cochineal, cryſtals are formed, which retain a fine ruby colour, much more bright and intenſe than that of the liquor in which they were formed.

There are ſome acids, particularly the nitric, which after having combined with the colouring particles, change the colour which they at firſt produced, make it yellow, and deſtroy it. They then act by means of one of their principles, the oxygen, in a manner which will be explained, in treating of the action of air and oxygenated muriatic acid, on the colouring particles. Blue colours are not the only ones which become red by the addition of acids, and green by that of alkalis; moſt red colours, as that of the roſe, e. g. are heightened by acids, and made green by alkalis; and ſome green colours, ſuch as that of the green decoction of burdock, according to Mr. Noſe[p], and the green juice of buckthorn. *(Rhamnus Catharticus)* according to Mr. Becker, are reddened by acids. This property, which is common to moſt of the ordinary colours of vegetables, ſeems to prove, that there is a great analogy between their colouring particles; and

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[p] Verſuche einiger beytrage zur chymie.

it is not without foundation, that Linnæus ſuppoſed[q], that the red in vegetables was owing to an acid, and indicated its preſence[r]; but there are alſo many vegetables which contain acid in a diſengaged ſtate, without having a red colour.

The colouring particles then have attractions for acids, alkalis, earths, and metallic oxyds, which conſtitute a part of their chemical properties; and in conſequence of which, their colours are more or leſs changed.

Theſe particles then form, with the ſtuff[s] on which they are fixed, a compound, which retains only ſome of their original properties; they are alſo modified by their union with alumine, metallic oxyds, and ſome other ſubſtances, as are alſo thoſe new compounds, when they are further combined with the ſtuff; all theſe modifications

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[q] Amænitatum acad. tom. iv.

[r] There are ſome flowers, the colour of which ſeems to be naturally modified by a very weak acid, without being properly red; ſuch are the flowers of the violet, the red juice of which becomes blue, when ſuffered to remain for ſome time in a tin veſſel; probably becauſe the acid which it contained, combines with the oxydated (calcined) part of the ſurface of the tin; ſuch alſo are the flowers of mallow, which become blue by ſimple exſiccation; the original colours are reſtored by a very minute portion of acid. *Obſerv. phyſico-chym. ſur les couleurs, par M. Opoix, Journ. de Phyſ. tom. viii.*

[s] In the courſe of this work, by ſtuff, is meant any ſubſtance that is dyed, whatever may be its nature or form.

are analogous to what is obſerved in other chemical combinations: we ſhall now proceed to the conſideration of them in detail.

CHAP. II.

Of Mordants.

THE title Mordant is applied to thoſe ſubſtances which ſerve as intermedes between the colouring particles and the ſtuff to be dyed, either for the purpoſe of facilitating or of modifying their combination.

Mordants merit the greateſt attention; as, by their means colours are varied, brightened, made to ſtrike, and rendered more durable.

The analyſis of the action of mordants in particular, conſtitutes dyeing a chemical art, and a more complete knowledge of their effects, would contribute in an eminent degree to the perfection of that art.

In the third ſection, I enumerate the eſſential qualities of the chemical agents moſt employed as mordants. I aſcertain, when ſpeaking of each colouring ſubſtance, the effects they produce on it.

In this chapter, I ſhall examine the nature of the action of the principal mordants, and ſhall endeavour to determine, how their attractions ſerve to unite the colouring particles with the ſtuff, and how they affect the qualities of the colours.

A mordant is not always a ſimple agent, and new combinations are ſometimes formed by the ingredients that compoſe it; ſo that the ſubſtances employed, are not the immediate agents, but the compounds which they have formed.

Sometimes the mordant is mixed with the colouring particles, and ſometimes the ſtuff is impregnated with it; on other occaſions, both theſe modes are united; and finally, we may dye ſucceſſively with liquors containing different ſubſtances, the laſt of which only can act on the particles with which the ſtuff is impregnated.

As the art of printing linen affords many proceſſes, in which it is eaſy to obſerve the effects of mordants: I ſhall quote a few examples from it, which will render the theory hereafter propoſed, more intelligible.

The mordant employed for linens intended to receive different ſhades of red, is prepared by diſſolving in eight pounds of hot water, three pounds of alum, and one pound of acetite of lead, or ſugar of lead, to which two ounces of pot-aſh, and afterwards two ounces of powdered chalk, are added [a].

The alum is decompoſed by the acetite of lead, becauſe the oxyd of lead combines with the ſulphuric acid, and forms an inſoluble ſalt which is precipitated; the baſe of the alum or alumine *(the argillaceous earth)* at the ſame time combines with the acetous acid, and produces an acetite of alumine; the chalk and pot-aſh ſerve to ſaturate the exceſs of acid.

One advantage reſulting from the formation of the acetite of alumine is, that the alumine is retained in it by a much weaker attraction than in the alum, ſo that it more eaſily quits its menſtruum, to combine with the ſtuff and the colouring particles.

A ſecond advantage is, that the acid liquor from which the alumine is ſeparated, has much leſs action on the colour when it conſiſts of the acetous, than when it conſiſts of a ſtronger acid, ſuch as the ſulphuric.

Finally, the acetite of alumine not having the property of cryſtallizing, the mordant, which is thickened with ſtarch or gum to prepare it for being applied to the block on which the deſign

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[a] We ſhall enter into the detail of this operation, when treating of madder, in the ſecond volume.

is engraved, does not curdle as it would if it contained alum, which would cryſtallize.

Let us attend to the operation performed upon a piece of linen cloth: when it has been impregnated by the mordant, in the manner determined by the deſign, it is put into a bath of madder; the whole of the cloth becomes coloured, but the tinge is deeper in thoſe parts which have received the mordant; there the colouring particles have combined with the alumine and the cotton, ſo that a triple compound has been formed, and the acetous acid ſeparated from its baſis is carried off in the bath.

The colouring particles combined with the alumine and the ſtuff, are much more difficultly affected by external agents, than when they are in a ſeparate ſtate, or combined only with the ſtuff, without any intermediate bond of union; and it is on this property that the operations, to which the cloth is afterwards ſubjected, are founded: after it has been maddered, it is boiled with bran, and ſpread upon the graſs; and theſe operations are alternately repeated, until the ground becomes white. The colouring particles which have not united with the alumine, are altered in their compoſition, diſſolved, and ſeparated, whilſt thoſe that have combined with it, remain, and are preſerved, without alteration; and thus, the deſign alone remains coloured.

This deſtruction of the colouring particles by expoſure on the graſs, and boiling with bran, ſeems to be accompliſhed in the ſame manner as that of the colouring particles of flax, and to admit of the ſame explanation. The only difference conſiſts in ſubſtituting bran for alkalis, becauſe they would diſſolve a part of the colouring matter which is fixed by the alumine, and would change its colour; inſtead of which, the bran having a much weaker action on this ſubſtance, affects only the colouring particles, which, by the action of the air, have been diſpoſed to a more eaſy ſolution.

If, inſtead of the mordant I have mentioned, a ſolution of iron be employed, the ſame phenomena take place; the colouring particles decompoſe the ſolution of iron, and form a triple compound with the ſtuff; but, inſtead of red, we get from the madder brown colours of different ſhades, down even to black; and, by uniting theſe two mordants, alum and iron, we have mixed colours, inclining to red on the one hand, and to black on the other, ſuch as mordoré and puce colour.

Finally, we get other colours, by ſubſtituting dyers weed for madder, and by means of theſe

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two colouring ſubſtances, indigo, and the two mordants above mentioned, we obtain moſt of the different ſhades obſerved in printed ſtuffs.

The ſubſtances which compoſe a mordant, are ſometimes incapable of decompoſing each other ſolely by their own attractions; but the attraction of the ſtuff for one of their conſtituent parts, brings about a decompoſition and new combinations, and ſometimes this effect is not produced or completed without the aid of the attraction of the colouring particles. This appears to be the caſe in the mixture of alum and tartar, one of the moſt common mordants employed in the dyeing of wool.

I diſſolved equal weights of alum and of tartar, the latter ſalt by this mixture acquired a greater degree of ſolubility than it naturally poſſeſſes; but, by evaporation and a ſecond cryſtallization, the alum and the tartar were ſeparated, ſo that they had not decompoſed each other. I boiled for an hour, half an ounce of alum with an ounce of wool; a precipitate was formed, which I waſhed carefully; it conſiſted chiefly of ſmall filaments of wool incruſted with earth: to this I added ſulphuric acid, and evaporated to dryneſs, diſſolved it, and obtained cryſtals of alum; ſome carbonic particles ſeparated from it: I evaporated the liquor in which the wool had been boiled, but obtained from it only a few grains of alum; the remainder would not cryſtallize: I rediſſolved it, and precipitated the alumine by an alkali; the precipitate was of a ſlate colour, it grew black upon a red-hot coal, and emitted alkaline vapours.

By this experiment we ſee, that the wool had decompoſed the alum; that a part of the alumine had combined with its moſt detached filaments, which were leaſt retained by the force of aggregation; that a part of its animal ſubſtance had been diſſolved, and precipitated by the alkali, from the triple combination which it had formed.

I made the ſame experiment with half an ounce of alum and two drams of tartar; no precipitation took place; I obtained by evaporation a ſmall portion of the tartar, and ſome very irregular cryſtals of alum; the reſt would not cryſtallize: this I diluted with water, precipitated by pot-aſh, and obtained, by evaporation, a ſalt which burned like tartar.

The wool which had been boiled with the alum felt harſh, but the other had preſerved its ſoftneſs. The firſt had acquired from the madder a more dull though lighter tint, but the colour of the latter was more full and bright.

I cannot enter into a minute explanation of what took place in theſe experiments; but we ſee,

ſee, firſt, that the wool had begun a decompoſition of the alum, that it had united with a part of the alumine, and that even the part of the alum which retained its alumine, had diſſolved ſome of the animal matter: ſecondly, that the tartar and alum, which cannot decompoſe each other ſolely by their own attractions, become capable of acting on each other, when their attractions are aſſiſted by that of the wool: thirdly, that the tartar appears principally uſeful for moderating the too powerful action of the alum upon the wool, whereby it is injured; for tartar is not uſed in the aluming of ſilk and thread, which have leſs action on the alum than wool has.

As the decompoſition of alum by the tartar and wool, takes place in conſequence of attractions which nearly balance each other, and the proceſs muſt therefore go on ſlowly, we ſee why it is uſeful to keep the ſtuff impregnated with alum and tartar, for ſome days in a moiſt place, as is recommended.

The final effect of aluming, in whatever manner performed, and whatever chemical changes may have taken place in it, conſiſts in the combination of alumine with the ſtuff: this union has probably been imperfect, and the acids only partially ſeparated, but becomes complete when the cloth has been boiled with the madder, as we have ſeen in the caſe of printed ſtuffs.

An acid or an alkali may, however, form a ſupracompound with the ſtuff, the colouring matter, and the alumine; for there are ſome colours which are changed by an acid and reſtored by alkalis, or by calcareous earths, which take the acid from them, or vice verſa: but this ſupracompoſition does not take place with reſpect to thoſe colours which are eſteemed durable, being unchangeable by alkalis or acids, which are not ſtrong enough to deſtroy their compoſition.

The attraction of alumine for animal ſubſtances, is not merely indicated by uncertain appearances, nor ſuppoſed, for the purpoſe of being employed in explanations, but is proved by direct experiment. I united them together, by mixing an animal ſubſtance with a ſolution of alum, a double exchange took place, the alkali entered into combination with the acid of the alum, and the alumine, combined with the animal ſubſtance, was precipitated [b].

I proved the attraction of alumine for animal ſubſtances by another experiment; having mixed a ſolution of glue with a ſolution of alum, I precipitated the alumine by an alkali, and the

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[b] Mem. de l'acad. 1784.

glue with which it had combined, fell down along with it. This compound has the appearance of a ſemitranſparent jelly, and grows dry with difficulty [c]. Thus we have alſo ſeen in the preceding experiments, that the alkali precipitated the alumine combined with the animal ſubſtance, from the uncryſtallizable reſidue of the alum which had been boiled with the wool.

The attraction of alumine for moſt colouring ſubſtances, may alſo be ſhewn by direct experiment. If a ſolution of a colouring ſubſtance be mixed with a ſolution of alum, a precipitation ſometimes takes place; but if to the liquor we add an alkali, which decompoſes the alum, and ſeparates the alumine, the colouring particles are then precipitated, combined with the alumine, and the liquor remains clear: this compound has got the name of Lake. In this experiment, too much alkali muſt not be added, becauſe alkalis are capable of diſſolving moſt lakes.

No direct experiment has yet ſhewn, that alumine attracts any vegetable ſubſtance except the colouring particles; its attraction for them ſeems much weaker than that which it has for animal ſubſtances; hence the acetite of alumine, as has been already obſerved, is a better mordant

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[c] Ann. de Chymie, tom. iv. p. 155.

dant for cotton and linen than alum is, and upon this depend the different means employed to increaſe the fixity of the colouring particles of madder in the dyeing of theſe ſubſtances.

Metallic oxyds have ſo great an attraction for many colouring ſubſtances, that they quit the acids in which they were diſſolved, and are precipitated in combination with them.

On the other hand, all metallic oxyds have the property of uniting with animal ſubſtances; and I have formed theſe different compounds, by mixing an alkali ſaturated with an animal ſubſtance, with metallic ſolutions[d].

It is not ſurpriſing, therefore, that metallic oxyds ſhould ſerve as a bond of union between the colouring particles and animal ſubſtances; but, beſides the attraction of the oxyds for the colouring particles and for animal ſubſtances, their ſolutions in acids poſſeſs qualities, which render them more or leſs fit to act as mordants: thus, thoſe oxyds which eaſily part with their acids, ſuch as that of tin, are capable of combining with animal ſubſtances, without the aid of colouring particles; it is ſufficient to impregnate the wool or the ſilk with a ſolution of tin, although they be afterwards carefully waſhed,

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[d] Mem. de l'acad. 1784.

which is not the caſe with other metallic ſolutions.

Some metallic ſubſtances afford in combination, only a white and colourleſs baſis; and ſome, by the admixture of their own colour, modify that which is proper to the colouring particles; but in many metallic oxyds, the colour varies according to the proportion of oxygen they contain, and the proportion of this is eaſily liable to change. Upon theſe circumſtances, which will be examined in the concluſion of this ſection, their properties in dyeing principally depend.

The attraction of metallic oxyds for ſubſtances of vegetable origin, ſeems much weaker than that which they have for animal ſubſtances, and we are even ignorant whether they be capable of contracting a real union with them or not: metallic ſolutions are therefore ill fitted to ſerve as mordants for colours in cotton or linen, except iron, the oxyd of which unites firmly with vegetable ſubſtances, as is ſhewn by iron moulds, which are owing to a real combination of this oxyd.

When the colouring particles have precipitated a metallic oxyd from its menſtruum, the ſupernatent liquor contains the diſengaged acid, which is commonly capable of diſſolving a portion of the compound of colouring ſubſtance and oxyd, ſo that the liquor remains coloured; but ſometimes the whole of the colouring particles are precipitated, when the proportions have been accurately adjuſted: this precipitation is facilitated, and rendered more complete, by the preſence of the ſtuff, which aſſiſts, by the tendency it has to unite with the compound of oxyd and colouring particles.

Uncombined metallic oxyds have alſo a very evident action on many colouring ſubſtances when boiled with them, and modify their colour; the oxyd of tin in particular, increaſes the brightneſs and fixity of ſeveral.

The compounds of oxyds and colouring ſubſtances may be compared to many other chemical compounds, which are inſoluble, when the principles of which they are formed are properly proportioned; but which are capable of being ſuperſaturated by an exceſs of one of the principles, and thence of becoming ſoluble. Thus a metallic oxyd united with a colouring ſubſtance in exceſs, will produce a liquor, the colour of which will be modified by the oxyd, whereas, when the colouring matter is not in exceſs, the compound will be inſoluble, or nearly ſo[e];

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[e] Obſervations on the combination of metallic oxyds with the aſtringent and colouring matter of vegetables. Ann. de Chym. tom. i.

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theſe effects are very evident in the combination of iron with the aſtringent principle.

Neutral ſalts, ſuch as nitre, and particularly muriat of ſoda (common ſalt) act as mordants, and modify colours; but it is difficult to aſcertain the manner in which they act. I have found, that the muriat of ſoda was contained in ſubſtance, in the precipitates produced by ſome ſpecies of colouring particles, and that theſe precipitates retained a conſiderable degree of ſolubility; it would ſeem, that a ſmall part of the ſalt becomes fixed with the colouring particles and the ſtuff.

Salts with calcareous baſes alſo modify colours; but as theſe modifications are nearly ſimilar to thoſe which would be produced by the addition of a ſmall quantity of lime, it is probable that they are decompoſed, and that a little of the lime enters into combination with the colouring particles and the ſtuff.

If we attend to what has been now ſaid, we ſhall eaſily diſcern, what combinations are formed by the agency of the different reactives employed in the analyſis of colouring ſubſtances; but we muſt not forget, that the mordants and the colouring particles have a mutual action on each other, which may change their properties.

We already perceive, that by varying the mordants, we may multiply prodigiouſly the ſhades obtained from a colouring ſubſtance; to vary their mode of application even, may be ſufficient: thus we ſhall have different effects, by impregnating the ſtuff with the mordant, or by mixing the mordant with the bath; by applying heat, or uſing exſiccation; for we operate upon three elective attractions; that of the colouring particles, that of the ſtuffs, and that of the principles of the mordant; and many circumſtances may cauſe variations in the reſult of theſe attractions; circumſtances which merit further explanation. Exſiccation favours the union of the ſubſtances which have an attraction for the ſtuff, and the decompoſitions which may reſult from that union; becauſe the water which held theſe ſubſtances in ſolution, by its attraction, oppoſed the action of the ſtuff; but the exſiccation ſhould be ſlow, in order that the ſubſtances may not be ſeparated before their mutual attractions have produced their effect. Hence we learn, how the repeated exſiccations employed in ſome proceſſes produce their effect.

The greater or leſs diſpoſition of the ſtuff to unite with the colouring particles, ſometimes occaſions conſiderable differences in the mode of employing the mordant; thus, when this diſpoſition is ſtrong, the mordant may be mixed with the colouring ſubſtance; the compound then formed, unites with the ſtuff immediately: but if it be weak, the compound formed by the colouring particles, and the ſubſtance employed as intermede, may ſeparate, and be precipitated, before it can be attached to the ſtuff. To prevent this inconvenience, we muſt begin, by attaching to the ſtuff, the ſubſtance which is to ſerve as the medium of union between it and the colouring particles. From theſe obſervations, I ſhall deduce the explanation of the differences that occur in the proceſſes employed in dyeing wool or ſilk black, or with cochineal.

To judge of the effects of mordants, and of the moſt advantageous manner of employing them, we muſt then, independently of the conſiderations afterwards to be mentioned, pay attention, firſt, to the combinations which may be produced, either by the action of the ſubſtances which compoſe them, or by that of the colouring particles and the ſtuff; ſecondly, to the circumſtances which may concur, in bringing about theſe combinations more or leſs quickly, or in rendering them more or leſs complete; thirdly, to the action that the liquor in which the ſtuff is immerſed may have, either on its colour or texture; and in order to foreſee what that action may be, it is neceſſary to know the proportions of the principles which enter into the compoſition of the mordant, and what will be left in an uncombined ſtate in the liquor.

Mordants are not obtained from the claſs of ſalts alone; vegetable and animal ſubſtances ſerve as mordants for each other under certain circumſtances; thus, in the proceſs for Adrianople red, of which there is a deſcription in the ſecond volume, the cotton ought to be impregnated, or rather combined with an animal ſubſtance; and thus, the aſtringent principle is often employed as a medium of union between colouring particles and ſtuffs.

No one has hitherto varied mordants, and their mode of application, more than Mr. Poerner, and in that reſpect, his works may be of great utility, particularly that which has been juſt tranſlated [f].

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[f] Inſtruction ſur l'art de la teinture, & particuliérement ſur la teinture des laines; chez Cuchet, rue & hotêl ſerpente.

CHAP. III.

Of the Action of different Subſtances, particularly of Air and Light on Colours.

WE have hitherto conſidered the colouring particles, only as ſubſtances capable of forming different combinations, by which their properties are modified; but they may be altered in their compoſition, either by other external agents, or by the ſubſtances with which they unite.

It is proper to begin with an examination of the changes produced by external agents, becauſe they are more eaſily aſcertained.

The ſtability of a colour conſiſts in its power of reſiſting the action of vegetable acids, alkalis, ſoap, and more eſpecially that of the air and light; but this power varies exceedingly, according to the nature of the colour and the ſpecies of the ſtuff; for the ſame durability is not required in the colours of ſilk as in thoſe of wool.

There is no obſcurity in the action of water, acids, alkalis, or ſoap; it is a ſolution brought about by theſe agents; and it appears that a ſmall quantity of acid or of alkali, ſometimes unites with the compound which gives the colour;

becauſe the colour is not deſtroyed, but only changed, and may be reſtored, by taking away this acid, as for example, by means of chalk or ammoniac (volatile alkali).

This is not the caſe with reſpect to the action of air and of light. Hitherto, the nature of their action was not underſtood; but at preſent, conſiderable advances being made in this theory, it is found that nothing but experiment is wanting, to lead us to an accurate knowledge of the ſubject.

Scheele had obſerved, that the oxygenated marine acid rendered vegetable colours yellow, and he attributed that effect, to the property it had of taking up the phlogiſton which entered into their compoſition.

I have ſhewn [a] that the properties of the oxygenated marine acid, were owing to the combination of its oxygen, with the ſubſtances expoſed to its action; that it commonly rendered the colouring particles yellow; but that by a continuance of its action, it deſtroyed their colour; without determining in what this action conſiſted.

Mr. Fourcroy has ſince made ſeveral obſervations on the action of oxygen on the colouring particles, which throw a great deal of

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[a] Mem. de l'acad. 1785.

of light on the nature of the changes they undergo, chiefly when watery ſolutions of them are left expoſed to the air, or have been ſubjected to a boiling heat; he obſerved, that in conſequence of the action of the air, vegetable decoctions formed pellicles, which loſt their ſolubility and underwent ſucceſſive changes of colour; he marked the gradations of colour thus produced, and concluded from his obſervations, that oxygen entered into the compoſition of the colouring particles; that when it combined with them, their ſhade was changed; and that the more they received, the more fixed did their colour become; and that the beſt method of obtaining permanent unchangeable colours for painting, was to chooſe ſuch as had been expoſed to the action of the oxygenated marine acid [b]. I have been employed more particularly, in a memoir of which I ſhall now give an abſtract, in attempting to aſcertain, in what the action of the air on colours of different kinds conſiſts, by analyzing that of the oxygenated marine acid [c].

In conſidering the effects of air on colours, it is neceſſary to make a diſtinction between

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[b] Ann. de Chym. vol. v.

[c] Ibid. vol. vi. Mem. ſur l'action que l'acide muriatique oxygené exerce ſur les parties colorantes.

thoſe produced by metallic oxyds, and thoſe produced by the colouring particles. I had proved that the modifications of the former, were entirely owing to different proportions of oxygen, as already mentioned in the firſt chapter of this ſection; but obſervation led me to form a different opinion reſpecting the modifications of the latter.

I have obſerved, that the oxygenated marine acid exhibited different phenomena with the colouring particles, that ſometimes, it diſcharged their colour and rendered them white, that moſt frequently it changed them to a yellow, fawn colour *(fauve*[d] *)* brown, or black, according to the intenſity of its action; and that, when their colour appeared only diſcharged or rendered white, heat, or a length of time, was capable of rendering them yellow. I compared the effect produced by the oxygenated marine acid, when the particles are rendered yellow, fawn coloured, or brown, with the effect of a ſlight degree of combuſtion, and ſhewed that they were the ſame, that they

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[d] Though fauve is here tranſlated in the uſual manner (fawn colour) it does not appear to mean what we commonly underſtand by that appellation; for in other parts of the work, it is called *root colour*, and applied to that kind of brown which is produced by walnut peels, &c.

were owing to the deſtruction of the hydrogen, which combining with the oxygen, more eaſily, and at a lower temperature than charcoal does, leaves it predominant, ſo that the natural colour of charcoal, is more or leſs blended with that which before exiſted.

This effect becomes very evident, when ſugar, indigo, or the infuſion of the gall nut, or of ſumach, are expoſed to the action of oxygenated muriatic gas (dephlogiſticated marine acid air); the ſugar and the indigo aſſume a deep colour, and afford indiſputable marks of a ſlight combuſtion; the infuſion of the gall nut, and that of ſumach, let fall a black precipitate, which is nearly pure charcoal.

Theſe phenomena are analogous, to thoſe which are obſerved in the diſtillation of organized ſubſtances; in proportion as the hydrogen is extricated in the form of oil, or of gas[e],

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[e] This term is adopted by moſt of the french chemiſts, to denote thoſe permanently elaſtic fluids, commonly called airs by engliſh chemiſts. It occurs firſt, I believe, in Van Helmont's treatiſe de Aquis Spadanis, wherein he calls the carbonic acid gas of the authors of the new french chemical nomenclature, the fixed air of Drs. Black, Prieſtley, &c. by the name of gas, or gas ſylveſtre, ſuppoſed to be derived from the German *Geiſt*, ſpirit. T.

the ſubſtance grows yellow, and at length, there remains only a black coal. If the hydrogen be expelled from an oil by heat, it grows brown in the ſame manner.

Other experiments which I had made on alcohol and on ether, had ſhewn me, that the oxygen united to the marine acid, had the property of combining with the hydrogen, which abounds in theſe ſubſtances, and of thereby forming water.

When therefore the oxygenated marine acid renders a colour yellow, fawn coloured, or brown, this effect proceeds from the colouring matter having undergone a ſlight combuſtion, by which, more or leſs of its hydrogen has been converted into water; and the charcoal thus rendred predominant, has communicated its own colour.

I have ſhewn that the art of bleaching linen by means of the oxygen of the atmoſphere, of the dew, and of the oxygenated marine acid, depended on this change of the colouring matter. The colouring particles of the flax are rendered ſoluble in the alkaline lixivia, the action of which ought to alternate with that of the oxygen. Theſe colouring particles may be afterwards precipitated from the alkali, and by evaporation and drying become black, and prove the truth of this theory, both by the colour they have acquired, and by the quantity of charcoal which they yield by analyſis.

The alkaline ſolution of the colouring matter of linen, which is of a dark brown colour, loſes its colour almoſt entirely, by the addition of a certain quantity of oxygenated marine acid; and the ſame effect is obſervable in many other ſubſtances, which have aſſumed a colour proceeding from an incipient combuſtion.

A piece of linen which appears white may yet grow yellow in the courſe of time (more eſpecially if expoſed to a certain degree of heat) if the oxygenated parts have not been removed by a ſufficiently ſtrong lixivium; in like manner, the green parts of vegetables are rendered white by the oxygenated marine acid, but become yellow by being boiled.

Theſe facts ſhew that oxygen is capable of whitening, or rendering paler, the colouring matters with which it unites, perhaps by having produced the effects of a ſlight combuſtion upon them; or poſſibly, theſe effects take place only afterwards in a ſlow manner, but more readily, when the whole is expoſed to a certain degree of heat. It is very probable that in all caſes a part of the oxygen unites with the colouring matter, without being combined with the hydrogen in particular, and that it is in this way, that oxygen renders the colouring matter of flax more ſoluble in alkalis.

Oxygen has certainly an influence in many other caſes, on the changes which take place in the colouring particles of vegetables; theſe particles are formed chiefly in the leaves, flowers, and inner bark of trees; by degrees they undergo a ſlight combuſtion, either from the action of the atmoſpheric air which ſurrounds them, or from that of the air which is carried by a particular ſet of veſſels, into the internal parts of vegetables; hence, moſt trees contain fawn coloured particles, inclining more or leſs to yellow, red, or brown, which, in conſequence of this combuſtion, grow thick, and are at laſt thrown out of the vaſcular fibres of the bark, the greateſt part of which I have found compoſed of them.

Theſe obſervations teach us how the air acts upon colouring matters, of an animal, or vegetable nature; it firſt combines with them, renders them weaker and paler, and by degrees occaſions a ſlight combuſtion, by means of which, the hydrogen, which entered into their compoſition is deſtroyed; they change to a yellow, red, or fawn colour; their attraction for the ſtuff ſeems to diminiſh; they ſeparate from it, and are carried off by water: all theſe effects vary, and take place more or leſs readily, and more or leſs completely, according to the nature of the colouring particles; or rather, according to the properties which they poſſeſs, in the ſtate of combination into which they have entered.

The changes which occur in the colours produced by the union of the colouring particles with metallic oxyds, are effects, compounded of the change which takes place in the colouring particles, and of that which the metallic oxyd undergoes.

The light of the ſun conſiderably accelerates the deſtruction of colours; it ought therefore (if the theory I have propoſed be well founded) to favour the combination of oxygen, and the combuſtion thereby produced.

Mr. Sennebier has given us a great number of intereſting obſervations on the effects of light on different ſubſtances, and particularly on their colours; he attributes theſe effects to a direct combinaton of light with the ſubſtances[f].

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[f] Mem. phyſico-chymiques ſur l'influence de la lumiere ſolaire, &c. vol. ii & iii.

The effects of light on the colour of wood, have been long ſince obſerved; it preſerves its natural appearance while kept in the dark, but when expoſed to the light, it becomes yellow, brown, or of other ſhades. Mr. Sennebier has remarked the varieties which occur in this particular, in different kinds of wood, and has found, that the changes were proportioned to the brightneſs of the light, and that they take place even under water, but that wetted wood underwent theſe changes leſs quickly than that which was dry; that ſeveral folds of ribband were required to defend the wood completely, that a ſingle leaf of black paper was ſufficient, but that when paper of any other colour was ſubſtituted, the change was not prevented; a ſingle covering of white paper was inſufficient, but two intercepted the action of the light.

That philoſopher has extended his experiments to a great number of vegetable ſubſtances, in a manner which may ſerve to illuſtrate many phenomena of vegetation, which I do not enter into at preſent. But to ſhew, in what manner the ſun acts upon colours, it may be ſufficient to examine the appearances, preſented by a ſolution of the green part of vegetables in alcohol.

If ſuch a ſolution, which is of a fine green colour, be expoſed to the light of the ſun, it very ſoon acquires an olive hue, and loſes its colour in a few minutes. If the light be weak, the effect is much more ſlow; and in perfect darkneſs, the colour remains without alteration, or if any change does take place, it requires a great length of time. Mr. Sennebier aſſerts that an alkali reſtores the green colour; but if the change of colour in the liquor has been completed, the alkali has no effect. He has obſerved that no change of colour takes place in azotic gas (phlogiſticated air) nor in a bottle which is quite full.

I inverted over mercury a bottle half full of this green ſolution, and expoſed it to the light of the ſun; when the colour was diſcharged, the mercury was found to have riſen in the bottle, and conſequently, vital air had been abſorbed, the oxygen having united with the colouring matter. I did not obſerve that precipitate which Mr. Sennebier mentions; the liquor had continued tranſparent and retained a ſlight yellow tinge.

I evaporated this liquor; its colour was immediately rendered darker, and became brown; the reſiduum was black, and in the ſtate of charcoal.

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The light therefore produced its effect by favouring the abſorption of oxygen, and the combuſtion of the colouring matter; at firſt, the marks of combuſtion are not evident; the liquor retains only a ſlight yellow tinge, but by the aſſiſtance of heat, the combuſtion is completed, the liquor becomes brown, and leaves a black reſiduum. If the veſſel in which the liquor is, contains no oxygenous gas, the light has no effect on the colouring matter; azotic gas in this ſituation ſuffers no diminution.

The above obſervation, that ribbands, or a ſingle leaf of white paper, do not prevent the action of light, merits attention, by proving that light can paſs through coverings which appear to be opake, and exert its energy at ſome diſtance within.

Beccaria, and afterwards Mr. Sennebier, have compared the effects of light on ribbands of various colours; but the differences they have obſerved, are rather to be attributed to the nature of the colouring matters, than to the colours, for a ribband dyed with braſil wood, will loſe its colour much ſooner than one dyed with cochineal, though the ſhade ſhould be perfectly the ſame in both.

Although light greatly accelerates the combuſtion of colouring matter, and appears even neceſſary to its deſtruction in ſome caſes, yet in others it is not required. Having put ſome plants into a dark place, in contact with vital air, I found that it was abſorbed by ſome. I alſo remarked that the roſe ſuffers a change, and becomes of a deeper hue, when it is not in contact with vital air; doubtleſs, becauſe it contains a little oxygen, the combination of which becomes more intimate; but many flowers retain their colour perfectly in azotic gas.

I placed tincture of turnſole in contact with vital air over mercury, both in the dark, and expoſed to the light of the ſun; the former continued unchanged for a conſiderable length of time, and the vital air had ſuffered no diminution; the other, loſt much of its colour, became red, and the air was in a great meaſure abſorbed, and a ſmall quantity of carbonic acid was produced, which no doubt had occaſioned the change of colour from blue to red.

This obſervation may lead us to form an idea of ſome of the changes of colour, produced by a particular diſpoſition of the component principles of vegetable ſubſtances, when by their combination with oxygen, they undergo the effects of a ſlight combuſtion, which may generate an acid, as in the leaves in autumn, which grow red, before they become yellow, and in the ſtreaks (panachures) obſervable in flowers, the vegetation of which is growing languid.

It is therefore proved, that light promotes the abſorption of oxygen by the colouring matter, and that thence ariſes a combuſtion, the common effect of which is, the predominance of carbonic particles.

To the ſame cauſe, is alſo to be attributed the injury which ſtuffs themſelves are found to ſuffer, from the action of light. "Among "ſeveral examples which I might give, ſays "Dufay, I ſhall adduce only one, of a curtain "of crimſon taffeta, which had remained drawn "in a window for a great length of time; all "the parts which were oppoſite to the panes "of glaſs, had entirely loſt their colour, while "thoſe which were behind the wood of the "caſement, were much leſs faded; and further, "the ſilk itſelf was almoſt entirely deſtroyed "in the parts without colour, where the curtain might be torn by the ſlighteſt effort, "while in the other parts, it retained nearly "the uſual degree of ſtrength [g]."

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[g] Mem. de l'acad. 1737.

Here an apparent contradiction occurs. The action of the ſun's light produces colours in vegetables; it extricates oxygen from the nitric and oxygenated muriatic acids, from ſome metallic oxyds, and from plants in a ſtate of vegetation: in theſe inſtances, its action ſeems to be the reverſe of combuſtion; but when it contributes to the deſtruction of colour, it ſerves to fix oxygen, and produces a kind of combuſtion. In like manner, phoſphorus is not affected by the oxygenated muriatic acid, even aſſiſted by heat, while in the dark; but when the action of light concurs, it is converted into phoſphoric acid[h].

I am unacquainted with the circumſtances, and the attractions, which determine ſometimes the production of one effect, ſometimes that of the other, but both of them are equally demonſtrated. They ſeem to bear a reſemblance to double elective attractions. It is very certain that calcareous earth yields the ſulphuric acid to pot-aſh, but yet that calcareous earth is capable of expelling the pot-aſh, by means of a double elective attraction.

There are beſides in nature a great many phenomena of the ſame kind; thus, during

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[h] Mem. ſur l'acide marin dephlogiſtiqué. 1785.

the vinous fermentation, hydrogen is accumulated in the liquor, but by a continuance of the ſame proceſs, the proportion of hydrogen is diminiſhed; it unites with the oxygen, which becomes predominant, as ſoon as the fermentation has advanced to the acid ſtage. The putrefaction too, which takes place in animal ſubſtances, may be conſidered as the reverſe of the phenomena of growth and nutrition.

Colouring ſubſtances therefore reſiſt the action of the air more or leſs, according as they are more or leſs diſpoſed to unite with oxygen, and thereby to ſuffer more or leſs quickly, a ſmaller or greater degree of combuſtion. Light favours this effect, which in many caſes is not produced without its aſſiſtance; but the colouring matter in its ſeparate ſtate, is much more prone to this combuſtion, than when united to a ſubſtance, ſuch as alumine, which may either defend it by its own power of reſiſting combuſtion, or by attracting it ſtrongly, weaken its action on other ſubſtances, which is the chief effect of mordants; and finally, this laſt compound acquires ſtill greater durability, when it is capable of combining intimately with the ſtuff.

Thus the colouring matter of cochineal diſſolves eaſily in water, and its colour is quickly changed by the air; but when united to the oxyd of tin it becomes much brighter, and almoſt inſoluble in water, though it is ſtill eaſily affected by the air, and by oxygenated marine acid; it reſiſts the action of theſe better however, when it has formed a triple compound with a woollen ſtuff.

It muſt not be inferred from the above obſervations, that all yellow colours are owing to the carbonic part of the colouring ſubſtance; very different compounds are capable of producing the ſame colour; thus, indigo is very different from the blue of our flowers, from that of oxyd of copper, and from that of pruſſian blue.

Nor do I aſſert, that oxygen may not unite in a ſmall proportion with ſome colouring ſubſtances, without weakening their colour, or changing it to yellow. In the chapter on indigo, it will appear, that it becomes green by uniting with an alkali, with lime or a metallic oxyd; but that it reſumes its colour, and quits theſe ſubſtances, when it recovers a ſmall portion of the oxygen which it had loſt. The liquor of the whelk employed to dye purple, is naturally yellowiſh; but when expoſed to the air, and more eſpecially to the ſun, it quickly paſſes through various ſhades, and at length aſſumes that colour ſo precious in the eyes of the ancients [i].

It may even be conſidered as a general fact, that colours become brighter by their union with a ſmall portion of oxygen; for this reaſon, it is found neceſſary to air ſtuffs, when they come out of the bath, and ſometimes even to take them out of it from time to time, expreſsly for this purpoſe; but the quantity of oxygen, which thus becoming fixed, contributes to the brightneſs of the colour, is very inconſiderable in ſome caſes, and the deterioration ſoon commences.

The action of the air affects not only the colouring matter and the ſtuff, but alſo metallic oxyds, when they are employed as intermedes; becauſe the oxyds, which have at firſt been deprived of a part of their oxygen by the colouring particles, as will be ſhewn when we come to explain the action of aſtringents, may abſorb it again. Thoſe then, the colour of which varies according to their proportion of oxygen, have thereby an influence in changes of colour. It is doubtleſs to this cauſe, that

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[i] Decouverte d'une nouvelle teinture de pourpre &c. par Reaumur. Mem. de l'acad. 1711. According to Eudocia, the purple did not aſſume its brilliancy nor arrive at perfection, but by expoſure to the rays of the ſun.

we are to attribute the change obſervable in the blue given to wool, by ſulphat of copper (blue vitriol) and logwood. This blue ſoon becomes green by the action of the air; now it is well known, that copper which has a blue colour, when combined with a ſmall proportion of oxygen, aſſumes a green one, by its union with a larger quantity. The change which the colouring particles undergo, may indeed contribute to this effect; but the colouring particles of the logwood which have themſelves a dark colour, ſhould rather become brown by combuſtion, than grow yellow, which would be neceſſary in order to produce a green with the blue.

I have obſerved, that colouring particles in a ſtate of combination, were leſs diſpoſed to be changed by the action of the air, than in an uncombined ſtate. This is commonly the caſe, but there are ſome exceptions; an alkali produces a contrary effect.

I half filled a matraſs with an infuſion of cochineal, and expoſed it to the light, over mercury; a ſimilar matraſs contained an infuſion of cochineal made with a little tartar; and in a third, I had added a ſmall quantity of alkali to the infuſion. The ſecond matraſs appeared leaſt altered in the ſame ſpace of time, and in it, the abſorption had been leaſt conſiderable. In the third, the colour of the liquor became firſt brown, and was then diſcharged, and the abſorption of air, though inconſiderable, was greater than in the two others. I evaporated it; it aſſumed a brown colour, and left a yellowiſh brown reſiduum.

I made ſimilar experiments on many colouring ſubſtances; the alkali darkened their colour, which grew more and more brown, and promoted the abſorption of air. Madder ſeemed to be the only exception to this rule; its colour, which became darker at firſt, ſtood better, than that of the infuſion made without alkali.

The common effect of alkalis on the colouring particles, is conſonant to that which it produces on many other ſubſtances, ſuch as ſulphur; it favours the abſorption of air becauſe it has a ſtong attraction, for the ſubſtance which is the reſult of that abſorption.

From this effect of alkalis I explain a fact obſerved by Mr. Becker[k]; that a vegetable infuſion rendered green by an alkali, becomes gradually yellow, if left expoſed to the air, and that when the yellow is completely formed (etabli) acids cannot reſtore the original colour:

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[k] Specimen, &c.

but that this is not the caſe, when a vegetable colour reddened by means of an acid, has been kept in like manner for ſome time. We muſt however except thoſe inſtances in which acids have been employed, which act by giving off their oxygen in a way we ſhall preſently ſee, for then, the colour is likewiſe deſtroyed.

CHAP. IV.

Of the Yellow Colour produced in Animal Subſtances by the Nitric and oxygenated Muriatic Acids.

THE action of the nitric and oxygenated muriatic acids, upon animal ſubſtances, has ſuch a connexion with the preceding ſubject, that I thought it improper to place them far aſunder, though the yellow colour they produce in wool, and more eſpecially in ſilk, might merit a place among the proceſſes of the art.

Mr. Brunwiſer [a] having obſerved that wood

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[a] Verſuche mit mineraliſchen ſauern geiſtern, aufden holzen farben zu ziehen, 1770, in abhandlungen der Baieriſchen akademie.

aſſumed different colours by expoſure to the air, endeavoured to aſcertain whence thoſe colours proceeded, and to produce them artificially: he obſerved, that by moiſtening the ſurface of wood with nitric acid, particularly that of young wood not yet quite dry, it aſſumed a yellow colour, and that by performing the ſame operation, with the muriatic and ſulphuric acids, it aſſumed a violet colour, which he conſidered as compoſed of a blue and a red.

From theſe obſervations he concludes, that, as all colours are produced by a mixture of yellow, blue, and red, all thoſe which are obſerved in the leaves, fruits, and flowers, are owing to the colouring particles which exiſt in the wood, and are there diſguiſed by an alkali; that the mineral acids, by taking up this alkali, ſet the colouring particles at liberty, and that the fixed air, by penetrating the leaves, fruits, and flowers, produce naturally the ſame effect, by combining with the alkali which kept them diſguiſed. The author has endeavoured to apply his experiments, and pretended diſcovery, to the arts[b]. Having moiſtened pieces of

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[b] Entdeckung verſchiedener vegitabiliſchen farbematerialien, ſeiden und wollen zeuge ſchón und dauerhaft gelb zu farben 1771.

wood with nitric acid, he poured water upon them, filtered the liquor, and employed it to dye ſtuffs of wool, ſilk, and goats hair, of a durable yellow, which, in his opinion, is produced by the yellow colouring particles contained in the wood, and extracted, or diſengaged by the nitric acid.

De la Folie [c] relates that, having immerſed a ſkein of white ſilk in nitric acid, or aqua fortis of the ſtrength it is generally met with in commerce, the ſilk in three or four minutes aſſumed a fine jonquille yellow. He waſhed it ſeveral times in water, that it might not be affected by any adhering acid; the colour ſuſtained ſeveral trials to which he ſubmitted it, and the ſilk preſerved its luſtre unimpaired. If it be dipped into an alkaline ſolution it aſſumes a fine orange colour.

We find ſeveral experiments on this proceſs, in a diſſertation by Mr. Gmelin [d], who ſays that he has given a fine brimſtone colour to ſilk, by keeping it for the ſpace of a day in cold nitric acid, or ſome hours only, when the acid was warm. Boiling with ſoap and

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[c] Journal de Phyſ. t. iv. pag. 349.

[d] T. Frieder. Gmelin prof. Gotting. de tingendo per nitri acidum, ſive nudum, ſive terra aut metallo ſaturatum ſerico. Erfurti 1785.

water diminiſhed the brightneſs of this colour. It was changed to a fine lemon colour, by being kept for twelve hours in an alkaline ſolution, and it aſſumed a fine gold colour when the ſolution was employed hot.

All ſolutions of metals in nitric acid communicated a more or leſs deep yellow to ſilk, as did alſo the ſolution of alumine in the ſame acid; but thoſe of calcareous earth and magneſia produced no effect.

According to la Folie [e], ſolution of tin mixed with a ſolution of gold, gives a purple, which fixes on ſilk; but Mr. Gmelin obtained in this way, only common yellow. Mr. Gmelin alſo ſhews, that the different yellows, which Mr. Struve had ſaid were obtained by different metallic ſolutions [f], depend only on the acid they contain. The only exception, perhaps, occurs in the caſe of mercury, the ſolution of which gives ſilk a copper colour.

Bergman was acquainted with this proceſs, when he publiſhed his notes on Scheffer's treatiſe [g]: He ſays that common aqua fortis gives wool and ſilk a clear, beautiful, and

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[e] Journ. de Phyſ. t. viii.

[f] Berneriches magazin der naturhunſt und wiſſenſchaften, vol. i.

[g] Eſſai ſur l'art de la Teinture.

durable yellow, in three or four minutes; that they ought to be waſhed immediately, and that the more the acid is *dephlogiſticated*, the greater is the effect produced.

In my earlieſt experiments on oxygenated muriatic acid, I found that it alſo had the property of tinging animal ſubſtances yellow; but it does not give them nearly ſo deep a colour as the nitric acid does, and it weakens them much more than that acid properly diluted; ſo that for the purpoſes of art, the nitric acid is greatly preferable.

To recapitulate theſe obſervations then, the nitric acid diluted with a certain quantity of water gives ſilk a yellow colour, which is more or leſs deep, according to the concentration of the acid, its temperature, and the time of immerſion; the ſilk muſt be carefully waſhed as ſoon as taken out of the acid: this colour poſſeſſes conſiderable brightneſs; it may be made deep without ſenſibly weakening the ſilk, ſo that this proceſs may prove of real utility. The colour may be modified by alkalis.

The ſolutions of calcareous earth and magneſia produce no effect upon ſilk, becauſe they do not contain an exceſs of acid; the ſolution of alumine and of all metallic ſubſtances, on the contrary, produce a more or leſs deep yellow,

becauſe

becauſe they all contain more or leſs exceſs of acid, which acts upon the ſilk, like uncombined acid; it was alſo the acid alone, which dyed the animal ſubſtances yellow in Mr. Brunwiſer's experiments, and not the matter extracted from the wood.

The yellow colour in theſe caſes, is not owing to iron, as de la Folie ſuppoſed; for the pureſt nitric acid, which conſequently contains no iron, produces it, as well as that, in which the preſence of that metal might be ſuſpected.

If ſilk be put into concentrated nitric acid, it quickly aſſumes a deep yellow colour, loſes its coheſion, and is diſſolved; during this ſolution, the azot (phlogiſticated air) which enters into the compoſition of animal ſubſtances, is extricated, with a long continued efferveſcence [h]: if heat be applied, it expels much nitrous gas, and the liquor immediately acquires a deep colour and grows brown. At this time, the oxygen of the nitric acid certainly combines with the hydrogen, which abounds in animal ſubſtances, forming the oil which is obtained from them by diſtillation, and which renders them ſo inflammable. When

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[h] Mem. de l'acad. 1785.

the acid begins to act and to render the ſilk yellow, the ſame effect ſhould alſo begin to take place. I therefore ſuppoſe that the yellow colour ariſes from a commencement of combuſtion, as explained in the preceding chapter. This combuſtion being very ſlight, does not ſenſibly weaken the ſilk; but if the acid is a little too ſtrong, or the immerſion too long continued, or if the whole of it is not carried off by careful waſhing, the ſilk immediately becomes weak, and in vulgar language, which is here quite accurate, it is *burnt.*

We therefore now ſee, why, as Bergman obſerved, the nitric acid which he called dephlogiſticated, is preferable in this operation, to that which is ſaturated with nitrous gas; for in the former, the proportion of oxygen being greater, it is thence better fitted for producing the effects of combuſtion, until it is reduced to the ſtate of nitrous acid.

The ſame explanation ought doubtleſs to apply to the action of the oxygenated muriatic acid, on animal ſubſtances; it differs however in ſome eſſential circumſtances, ſome of which I do not yet underſtand, and which require a greater number of obſervations.

Silk takes a yellow which is much lighter, when the oxygenated muriatic acid is employed, than

than when the nitric acid is uſed: the ſulphureous acid diſcharges it in a great meaſure, but has no effect on the yellow produced by the dilute nitric acid. The oxygenated muriatic acid has however, a much ſtronger action on the ſilk; it ſoon weakens, and even diſſolves it: if the ſilk be left for ſome time in this fluid, the yellow which at firſt appeared grows lighter; in conformity to what I have remarked, that oxygen by being accumulated, is capable of diſguiſing the yellow colour occaſioned by the combuſtion, which it had at firſt produced.

I have endeavoured to explain [i] the effects which ſulphureous acid produces on colours, by the facility with which it gives off its oxygen, and have compared them to thoſe of the oxygenated muriatic acid; but although it is true, that oxygen adheres much more weakly to the ſulphureous, than to the ſulphuric acid, I do not believe that that explanation is well founded.

According to the obſervation of la Folie [k], roſes whitened by the vapour of burning ſulphur, become green in an alkaline lixivium,

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[i] Suite des exper. ſur l'acide ſulfureux. Ann. de Chym. t. ii.

[k] Journ. de Phyſ. 1774.

and red in acids; I have myſelf obſerved, that the ſulphureous acid reddened the tincture of turnſole, which has a very fading colour, and that it acted only like other acids on infuſions of fuſtic, brazil wood, and logwood. I have further obſerved, that ſilk which has been expoſed to the vapour of ſulphur, exhaled the ſmell of ſulphureous acid, when moiſtened with ſulphuric acid, although that odour was not before perceptible.

I conceive then, that the ſulphureous acid commonly unites with the colouring particles, and with the ſilk, without giving off its oxygen to them, and conſequently, without producing any combuſtion; that the product of that combination ſometimes loſes its colour entirely, which is probably owing to the ſemi-elaſtic ſtate of the oxygen; but ſometimes combuſtion may, and even commonly ſhould take place by degrees, ſo that the colouring particles, which have long been diſguiſed, ought at laſt to leave a yellow colour. This point ſeems capable of being eaſily cleared up by a few experiments.

CHAP. V.

Of Aſtringents in general, and particularly of the Gall-nut.

ASTRINGENTS merit particular attention, not only from their great uſe in dyeing, but becauſe they poſſeſs a property which is common to a great number of vegetables.

There is perhaps no property of vegetables, reſpecting which, we have been contented with ſuch vague ideas: frequently ſome ſlight reſemblance in taſte only has been attended to, and under the name of aſtringents, alum, and many vegetables of very different properties have been confounded together, both in medicine and in the arts: moſt frequently every ſubſtance which renders a ſolution of iron black, has been conſidered as aſtringent; it is ſuppoſed that this effect is owing to one identical principle exiſting in all the ſubſtances which produce it, and the title aſtringent or acerb, has been beſtowed on that principle, and it is at preſent conſidered as a particular acid, to which, the name of gallic acid has been given,

given, from galls or the gall-nut, in which it has been found.

Many learned chemiſts however, have lately made a great number of intereſting obſervations on aſtringents; of theſe I ſhall give an abſtract, but as the gall-nut has been the common ſubject of theſe obſervations, it ought firſt to be deſcribed.

The gall-nut is an excreſcence found on the young branches of the oak, eſpecially of that kind called *rouvre*, which grows in the Levant, Iſtria, Provence, and Gaſcony. This excreſcence is produced by the puncture of an inſect, which depoſits its eggs in the ſmall inciſion, which it makes in the ſpring; the ſap which eſcapes by this opening, grows thick, increaſes in quantity, and ſerves as a defence for the young inſect, until it is able to make its eſcape; when there is no hole in the nut, the inſect is found dead within; ſometimes after it has quitted its abode other inſects come to occupy it.

There are different kinds of the gall-nut; ſome inclining to white, yellow, green, brown, or red; others are aſh-coloured or blackiſh; they alſo differ greatly in magnitude, and are either round or irregular, heavy or light, ſmooth or covered with protuberances: thoſe which are ſmall, blackiſh, knotted, and heavy, are the beſt; they are known by the name of Aleppo galls, and come from Aleppo, Tripoli, and Smyrna.

Galls are almoſt totally ſoluble in water by long ebullition, ſixteen drams afforded Neuman fourteen of extract; from the remaining two drams, alcohol extracted only four grains.

The ſame quantity treated firſt with alcohol, and then with water, afforded twelve drams and two ſcruples of ſpirituous extract, and four ſcruples of watery extract; the reſiduum weighed half a ſcruple more than in the preceding experiment. The ſpirituous extract has a more ſtrong and diſagreeable taſte than the other [a].

Mr. Monnet, to whom chemiſtry is indebted for a great number of important obſervations [b], conſiders Macquer as the firſt, who aſcribed the formation of ink to a precipitation of iron, by the aſtringent principle, and he himſelf gives the theory of it; he ſuppoſes that the iron has a greater attraction for this principle, than for the acid with which it was

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[a] The chemical works of Caſpar Neuman, &c. by William Lewis.

[b] Traitè des eaux minerales, pag. 304.

united; but the acid diſſolves a part of this precipitate, unleſs it be largely diluted with water.

Iron is not the only metallic ſubſtance which may be precipitated from its menſtruum by the aſtringent principle; Mr. Monnet has obſerved, that gold, ſilver, copper, zinc, cobalt, platina, and mercury, were alſo precipitated.

The metallic ſubſtance moſt eaſily precipitated is mercury; its ſolution, mixed with an infuſion of galls, aſſumes a brick colour, but the precipitate which is formed, ſoon becomes of a reddiſh gray.

Copper is precipitated pretty eaſily; the precipitate is at firſt green, but becomes of an aſh gray, and acquires a reddiſh coppery tinge in drying.

Zinc forms a dirty green precipitate.

The precipitate from cobalt is of a light blue: but does not long retain that colour, becoming ſoon of an aſh gray.

Silver is precipitated very ſlowly; the precipitate which has at firſt the colour of roaſted coffee, aſſumes a ſhining ſilvery brightneſs, as it dries on the filter.

Gold alſo falls down, only inſenſibly; the precipitate collected and dried, perfectly reſembles that of Caſſius. Mr. Monnet collected on a filter the precipitate of iron by the aſtringent principle, it was found to be of a fine deep blue: and that chemiſt is of opinion, that it might be advantageouſly employed in painting. He endeavoured to diſſolve it in the nitric and ſulphuric acids; they attacked it but ſlowly: having accelerated their action by heat, he obtained by filtration, fine yellow tinctures (particularly from the nitric acid) which reſembled a ſolution of gold. Theſe liquors let fall no precipitate, but remained always clear and tranſparent; alkalis occaſioned no precipitation in them, but only rendered their colour deeper. Mr. Monnet was led, by obſerving this, to diſſolve the precipitate immediately in a ſolution of fixed alkali, in which he made it boil; a blood red ſolution was produced, in which water occaſioned no precipitation. To theſe facts, the academicians of Dijon have added many intereſting obſervations[c].

The gall-nut yields, by diſtillation, a limpid phlegm, which becomes brown by degrees, then a yellow oil, and afterwards one that is more dark coloured and empyreumatic. All theſe liquors precipitate ſulphat of iron or vitriol of a black colour, the coaly reſiduum retains no diſtinct properties; it grows red in the fire without being reduced to aſhes. Water even

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[c] Elem. de Chym.

in the cold, diſſolves the aſtringent principle; an ounce of galls yielded in this way three drams of extract, which was very ſtyptic, and not deliqueſcent.

Fixed and volatile oils and ether, diſſolve the aſtringent principle.

Infuſion of galls reddens blue paper, and tincture of turnſole [d]; but it has no effect on ſyrup of violets.

Sulphuric acid acquires a red colour from galls; the nitric, an amber colour; and the muriatic acid becomes brown; theſe three acids when ſaturated with an alkali, precipitate ſulphat of iron black.

The acetous acid, loaded with the aſtringent principle, does not require the addition of an alkali to produce this black precipitate.

Phoſphoric acid produces no change in the infuſion of galls, but this mixture renders the ſolution of ſulphat of iron turbid, and produces a white precipitate.

Sulphuret of alkali (alkaline liver of ſulphur) is decompoſed by the infuſion of galls; and upon filtering the liquor, that which paſſes, precipitates iron black, but the reſiduum does not; the liquor appears to be a compound of alkali and the aſtringent principle.

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[d] I alſo found that this infuſion reddened that of radiſhes.

Carbonat of fixed alkali (mild fixed alk.) produces a reddiſh colour in the infuſion of galls; this mixture forms a brown precipitate with ſulphat of iron.

Cauſtic alkali tinges the infuſion of galls of a dark red, and then precipitates the ſulphat of iron black; this precipitate, when well waſhed, is not attracted by the magnet; it diſſolves without effervefcence in the mineral acids, but is not acted upon by the acetous acid.

A mixture of pruſſiat of alkali, and tincture or alcohol of galls, produces a black precipitate with the ſolution of iron; ſulphuric acid at firſt increaſes the intenſity of the colour, and afterwards deſtroys it.

The ſame work contains a great number of other obſervations upon the metallic precipitates produced by the aſtringent principle. Galls produce no effect on the ſolutions of arſenic, and the addition of this oxyd to the infuſion of galls, does not prevent its action on iron. The aſtringent principle forms ink with all acid ſolutions of iron, except thoſe in the phoſphoric and arſenical acids.

Finally, we find in it ſome experiments on ink, and on the ſediment it yields, by large dilution with water. The acetous acid does not decompoſe ink, but the mineral acids quickly diſcharge its colour, the addition of ſulphuric acid

acid produces heat, without effervefcence; the liquor becomes yellow, and depoſits a grayiſh ſediment. Alkalis reſtore the colour which the acids have diſcharged; but, by frequent alternation of the action of acids and alkalis, the colouring principle is at length deſtroyed.

The ſame academicians have alſo obſerved another circumſtance, which may be found to be of importance, and to which it appears, that Mr. Delaval has paid more attention; it reſpects the action of galls on iron. Their infuſion imparts a violet tinge to filings of iron in the cold; but, by ebullition, part of the iron is diſſolved, and the liquor aſſumes a violet colour ſtrongly inclining to black.

Mr. Delaval[e] ſays, that he had long ago obſerved, that galls ſimply infuſed in diſtilled water, diſſolved iron very readily; that he had produced with this ſimple ſolution, not only the deepeſt black and the moſt indelible ink, but alſo, that having immerſed in it ſilk and woollen ſtuffs, he had, without the addition of any acid, dyed them of the deepeſt and moſt indeſtructible black.

Dr. Prieſtley obtained inflammable air, or hydrogenous gas, from a mixture of filings of

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[e] Experimental inquiry.

iron, powdered galls and water[f]. This proves that galls act upon iron, like thoſe acids which favour the decompoſition of water, and diſengage its hydrogenous gas.

Before Mr. Monnet aſcertained the manner in which the aſtringent principle acts upon iron, and produces black colouring particles, capable of precipitation, Lewis had made ſome important obſervations on this combination[g], and had endeavoured more particularly to render it uſeful in the arts.

He obſerves, that if we dilute common ink with a ſufficient quantity of water, the black part precipitates, and the liquor remains clear; he remarks that it is this black part, which, fixing in ſtuffs, produces colour in them. He endeavours afterwards to determine the fitteſt proportion of the aſtringent, and ſolution of iron, both with a view to the quantity and quality of the black precipitate.

The experiments of Scheele have ſo great an influence on the opinion formed reſpecting the nature of the aſtringent principle, that I ſhall relate them as delivered by himſelf[h].

"I paſſed

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[f] Obſervations on different branches of natural philoſophy, vol. ii. page 131. Of the new edition in 3 vols. 8vo. Birmingham, 1790, page 194. T.

[g] Philoſophical commerce of arts, vol. ii. page 227.

[h] Journal de phyſ. janvier 1787.

" I paſſed through a coarſe ſieve a pound of powdered galls, which I infuſed in a kanne (two pints and three quarters french, nearly three quarts engliſh) of pure water in a glaſs receiver, for four days, during which time it was frequently ſtirred with a glaſs rod; I then filtered the liquor[i], which was clear and of the colour of french wine, I left it expoſed to the open air in the ſame glaſs veſſel, with no other covering than a piece of gray paper; this was done in the month of June. A month after, I examined the infuſion, and found it covered with a thick mouldy pellicle; no precipitation had taken place, its taſte was not more aſtringent than before, but more acid: I returned it into the ſame veſſel, covered with paper as before. Five weeks after, I examined it again; the half of it had evaporated: I found in it a precipitate, two fingers breadth in depth; and above, a mucous pellicle; it had loſt its ſtyptic taſte entirely, but ſtill made vitriol of iron black. I filtered it, and expoſed it again to the open air; the following autumn, it was found, that the greateſt part of it had evaporated; but what remained, was mixed with a conſiderable quantity of precipitate. I mixed

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[i] " If we employ hot water, or digeſt the mixture with heat, the fluid is not clear, which determined me to employ cold water, and infuſion in the cold."

all the precipitates together, and added cold water; after they had ſettled, I decanted the water, and poured on as much hot water as was neceſſary for their ſolution: I filtered the whole; the liquor was of a yellowiſh brown colour; I evaporated it with a gentle heat; during the evaporation, ſome part of it was precipitated like fine ſand, and another part formed radiated cryſtals at the bottom; this ſalt was gray, and notwithſtanding repeated ſolutions and cryſtallizations, I could not make it any whiter.

The ſalt of galls has the following properties:

1. Its taſte is acid, it effervеſces with chalk, and reddens the infuſion of turnſole.

2. It requires an ounce and a half of boiling water for the complete ſolution of half an ounce of the ſalt; but as ſoon as the ſolution cools, the whole forms a concrete maſs compoſed of ſmall cryſtals; half an ounce requires twelve ounces of cold water for its ſolution.

3. It diſſolves very readily in ſpirit of wine; for half an ounce of the ſalt, only half an ounce of boiling ſpirit of wine is required; but if cold ſpirit of wine be employed, two ounces are neceſſary to half an ounce of the ſalt.

4. Expoſed to the naked fire in a crucible, it takes fire readily and melts, exhaling an agreeable odour, but leaves a coal which is

difficultly

difficultly reduced to aſhes; diſtilled in a retort, it firſt becomes fluid, yielding an acid phlegm; no oil comes over, but at laſt a white ſublimate riſes, which adheres to the neck of the retort, and remains fluid while it continues hot, but afterwards cryſtallizes; a conſiderable quantity of charcoal remains in the retort. This ſublimate, as to its ſmell and taſte, nearly reſembles the benzoic acid, or ſalt of benzoin; it is ſoluble both in ſpirit of wine and water, it reddens the infuſion of turnſole, and what is remarkable, it precipitates metallic ſolutions of different colours, and vitriol of iron black.

5. A ſolution of the ſalt of galls poured into a ſolution of gold, renders it of a dull green colour, and at length precipitates a powder, which is revived gold.

6. The ſolution of ſilver becomes brown, and depoſits, when heated, a gray powder, which is revived ſilver.

7. The ſolution of mercury is precipitated of a deep yellow.

8. The ſolution of copper affords a brown precipitate.

9. The ſolution of vitriol of iron becomes black; the more the water is loaded with it, the deeper is the colour.

10. Lead diſſolved in vinegar, is precipitated white.

11. Biſmuth affords a lemon-coloured precipitate.

12. The molybdic acid becomes of an obſcure yellow, but no precipitation takes place.

13. Platina, zinc, arſenical acid, tin, cobalt, and manganeſe, ſuffer no change.

14. Solutions of lime, magneſia, alumine, and barytes, are not decompoſed; but lime water affords an abundant gray precipitate.

15. The ſalt of galls is changed into ſaccharine acid, by diſtillation with nitrous acid in the ordinary way.

The white precipitate obtained from acetated lead by galls, may again be decompoſed by the vitriolic acid, and the ſalt of galls is obtained in its greateſt purity: now, as infuſion of galls precipitates acetated lead, I thought this ſalt might be procured in a ſtill more expeditious way; but I did not ſucceed, for when I had decompoſed that precipitate by means of the vitriolic acid, I recovered my infuſion of galls with its ordinary aſtringent taſte.

If galls be diſtilled with a ſtrong heat, we obtain an acidulous phlegm of by no means a diſagreeable ſmell; no oil comes over, but at length a volatile ſalt ariſes, like that obtained in the diſtillation of the ſalt of galls (No. 5) and which has the ſame properties. Hence it appears, that this ſalt exiſts ready formed in the infuſion of galls, though it cannot be obtained by the ordinary mode of cryſtallization, for it is ſo intimately united with ſome mucilaginous principle or other matter, that it cannot be ſeparated, without an internal commotion or fermentation."

Theſe experiments of Scheele have led moſt chemiſts, to conſider the gallic acid as the aſtringent principle, and to conclude, that it exiſts in all vegetable ſubſtances which precipitate the ſolutions of iron black, and that this precipitate is a compound of the gallic acid and the iron, which quits the other acids to unite with it.

I have repeated and varied Scheele's experiments on galls, and have obſerved,

1. That when the proceſs indicated by that great chemiſt was employed, greeniſh pellicles were formed in ſucceſſion, owing to a byſſus which could not be produced in a veſſel cloſely ſtopped.

2. That in ſuch a veſſel, where no evaporation could take place, pure, tranſparent, and yellow cryſtals were depoſited in winter, without the

the influence of the external air; that conſequently the gallic acid exiſted in the gall-nut, and was not owing to the abſorption of oxygen, as I had ſuppoſed[k].

3. That if the liquor was evaporated to one half before being encloſed in the veſſel, it acquired a dark colour during evaporation, and depoſited afterwards a much larger quantity of cryſtals, but leſs pure and of a darker colour.

4. That the acid obtained in this manner, or by Scheele's proceſs, and afterwards diſſolved in water, was always decompoſed by evaporation; that black pellicles were ſeparated from it, that it grew brown by ſimple expoſure to the air, that after repeated operations, only a maſs of a confuſed cryſtallization was obtained, of a gray, yellowiſh, or browniſh colour, and that if the evaporation was frequently repeated, the ſalt was even totally deſtroyed. Heat, and particularly ebullition, haſten this deſtruction; this I conceive to be the true reaſon why we do not obtain this ſalt, by evaporating the decoction of galls; there then remains an extract, which completely reſembles that of galls, and which immediately precipitates ſolutions of iron black.

5. The ſolution of gallic acid aſſumed a fine green colour with alkalis, both fixed and volatile,

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[k] Ann. de Chym. tom. i.

in their pure ſtate, or combined with the carbonic acid, and this colour becomes ſo deep, as to appear black, if the ſolutions of gallic acid and alkali are in a very concentrated ſtate: the gallic acid aſſumed a reddiſh brown colour with lime water; the red tinge diſappeared, and a copious ſediment of a gray colour inclining to brown, was produced.

I obſerved no efferveſcence in the mixture of gallic acid with alkaline carbonats, nor with thoſe of lime, or magneſia; though this ſubſtance reddens tincture of turnſole, of radiſhes, &c. like acids.

6. The infuſion of common galls produces the ſame effect on vegetable colours, that the gallic acid does, but the infuſion of white galls has no action on them.

Paper ſtained with turnſole was not affected by infuſion of ſumach, of ſloe or walnut-tree bark, or quinquina.

Having made four ſucceſſive decoctions of galls, which had previouſly been treated in the manner recommended by Scheele, the two laſt did not redden paper ſtained with turnſole, though they ſtill precipitated iron copiouſly from its ſolutions. From theſe two laſt decoctions I obtained no marks of gallic acid by ſpontaneous evaporation.

7. A ſolution of ſulphat of iron, mixed with a ſolution of gallic acid reduced to as great a degree of purity as poſſible, does not grow turbid immediately, nor aſſume any particular colour; it only becomes black by degrees, without loſing its tranſparency, or at leaſt, it does not begin to loſe it for ſome hours: a ſmall quantity of the infuſion of galls inſtantly produces a much more intenſe colour and greater opacity.

Theſe obſervations indiſputably prove, that it is not the gallic acid, which communicates the aſtringent property to the ſubſtances that poſſeſs it; that the acid itſelf poſſeſſes that property, in a degree inferior to other aſtringents; and indeed ſumach, treated like the galls in Scheele's proceſs, afforded me no gallic acid, though it poſſeſſes a high degree of aſtringency: walnut peels treated in the ſame manner alſo afforded none.

It appears that the property which the infuſion of common galls has, of reddening certain vegetable colours, proceeds only from the gallic acid; ſince the infuſions of ſumach, or of ſloe bark, which very readily produce a black precipitate, that of walnut-tree bark, or of quinquina, did not exhibit this property; and thence it is evident, that the gallic acid does not exiſt in white galls; though the infuſion of theſe expoſed to the air, might eaſily deceive us in this reſpect, becauſe it depoſits a copious ſediment, which however is not gallic acid.

If the aſtringent property was owing to an individual principle, which was always the ſame, diſtributed in different vegetables, the precipitates obtained by their means, from a ſolution of iron, would always form the ſame compounds, and exhibit the ſame appearances and properties; but it is quite otherwiſe: the precipitate produced by galls, is of a blackiſh blue, that by logwood, has a different ſhade of blue; that by oak is of a fawn colour or blackiſh brown; that by quinquina a blackiſh green; they fall down with different attendant circumſtances, and when fixed on ſtuffs are diſcharged by alum and tartar, ſome much more eaſily than others; and doubtleſs by multiplying experiments, many other remarkable differences will be diſcovered in the properties of theſe different precipitates. Aſtringents then form with iron different ſpecies of compounds, and conſequently, do not derive their properties from one individual principle found in different vegetables; but there muſt be a property common to different ſubſtances, to enable them to act in an uniform manner on ſolutions of iron, and to produce precipitates which are more or leſs black, and appear of the ſame nature when not attentively conſidered.

I have obſerved, when inveſtigating the effects of mordants, that the metallic oxyds which unite with the colouring particles, modify their colours; but ſome metallic oxyds, and particularly that of iron, have colours which vary according to the quantity of oxygen they contain. Iron when united with only a ſmall quantity of oxygen, has a black colour, and forms what is called *martial ethiops.* If any ſubſtance by uniting with the oxyd of iron, had the property of taking from it a part of the oxygen which it has, when precipitated from its ſolution in an acid, this would be ſufficient to give it a black colour; and if the peculiar colour of this ſubſtance was not predominant, or was of itſelf inclining to black, the compound formed would have a black colour, thus nitrous gas, either uncombined or weakly attached to the nitrous acid, renders ſolutions of iron black, as I have ſhewn [1], and even precipitates the metal, by taking away part of its oxygen.

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[1] Mem. de l'acad. 1785, p. 338. The cauſe of the production of black by the gallic acid, has not eſcaped the ſagacity

It is alſo by acting in the ſame way, that ammoniac is capable of producing a black precipitate with the ſolutions of iron; the hydrogen of the ammoniac then forms water, with the oxygen ſeparated from the oxyd of iron.

Now galls, according to the obſervations of Mr. Monnet and the academicians of Dijon, which have been already related, precipitate gold and ſilver from their ſolutions, by reducing them to their metallic ſtate. They therefore have the property of ſeparating the oxygen from thoſe metals, to which it adheres but ſlightly, and from others, that portion which is leaſt ſtrongly retained.

The infuſion of galls, of itſelf, quickly aſſumes a deep brown colour by expoſure to the air; yet I have found that it abſorbed but a ſmall quantity of vital air. The infuſion of ſumach, and that of moſt other vegetable ſubſtances, particularly woods and barks, likewiſe acquire a dark colour by expoſure to the air, ſo that when acting upon the oxyd of iron by ſeparating a part of its oxygen, an aſtringent

city of Mr. Fourcroy, *it tinges iron black*, ſays he, *becauſe it brings it near to its metallic ſtate.* Elem. de Chym. t. iii. pag. 243.

ought itſelf to acquire a darker colour, which ſhould aſſiſt the black.

We ſee then in what manner, various ſubſtances, which have in other reſpects different properties, may produce black with ſolutions of iron. Among theſe ſubſtances, there are ſome which are real colouring particles, and employed as ſuch, in dyeing; for example, logwood, and even moſt kinds of colouring particles, form brown or blackiſh precipitates with iron. Sometimes the aſtringent effect is not inſtantaneous, but produced by degrees, and the colour of the precipitate is at firſt light; it grows deeper gradually, being darkened in proportion as the iron loſes its oxygen; this is obſervable in the infuſion of fuſtic, which produces with the ſolution of iron, a yellow precipitate that grows brown by degrees, and at length becomes black.

Although the property of precipitating ſolutions of iron black, does not indicate the preſence of the ſame individual principle in the ſubſtances which poſſeſs it, yet there is no inconvenience in calling it by the name of aſtringent principle, provided we convey by that term, only a property which is common to a great number of ſubſtances, and which they may poſſeſs in different degrees.

The aſtringent principle precipitates iron from almoſt all acids: it appears from the experiments of the Dijon academicians, that the acids of phoſphorus and arſenic only, have a ſtronger attraction than it has, for iron; and phoſphoric acid was known to have the property of ſeparating iron from the ſulphuric acid; but all acids except the acetous, and probably ſome other vegetable acids which have not been tried, rediſſolve the precipitate, and make the colour diſappear, until they are ſaturated with an alkali. We need not be ſurpriſed, that the aſtringent principle can unite with metallic oxyds without having the qualities of an acid, for animal ſubſtances, oils, even alkalis, and lime, poſſeſs this property.

It is the precipitate compoſed of iron and the aſtringent principle, which by remaining ſuſpended in the liquor forms ink; this ſubject is ſufficiently intereſting in itſelf, and by its connexion with the black dye, to merit a ſhort digreſſion.

When a ſmall quantity of a ſolution of iron is poured into an infuſion of galls, the liquor at firſt grows black at the points of contact; but the precipitate which has been formed, is rediſſolved in the aſtringent liquor, but by continuing to add enough of the ſolution of iron,

iron, the whole of the liquor grows black, and loſes its tranſparency: if in this ſtate, it be very largely diluted with water, the precipitate falls down by degrees; but the depoſition goes on very ſlowly, when only a ſmall portion of ſolution of iron has been employed; but on the contrary, it proceeds much more rapidly, if ſo large a quantity of ſolution of iron has been added, that the whole of the aſtringent may enter into a ſtate of combination, a ſuperabundance of ſulphat of iron ſtill further accelerates this effect.

Here we remark the ſame phenomena that are obſervable in many other precipitations. The precipitate produced, is ſoluble to a certain degree in the aſtringent liquor; when the ſolution is further advanced, a precipitation commences; but the precipitate ſtill remains ſuſpended, until the action of the aſtringent principle is ſufficiently weakened by the addition of water: if the iron be in ſufficient quantity to exhauſt the action of the aſtringent principle, the precipitate is not retained, and falls down much more quickly.

The gum which is added to ink, oppoſes the depoſition of the colouring particles; it ſerves the purpoſe, of applying a greater quantity of theſe colouring particles on the ſame ſtroke of the

the pen, and of hindering it from running, and defending it from the action of the air. According to Lewis, cherry or plumb-tree gum anſwers this purpoſe, as well as gum arabic.

The principles which I have laid down, ſerve to explain many obſervations which Lewis has made on this ſubject, the chief of which I ſhall now mention.

The ink which is made by ſimple infuſion, is pale and grows black only by keeping; but if we wiſh to produce a black ink immediately, we muſt imitate the dyers, who boil their aſtringents a long time in water, and then add ſulphat of iron: firſt, by boiling we diſſolve much more of the aſtringent principle: ſecondly, by adding ſulphat of iron to the liquor while it is ſtill very hot, we much more quickly obtain an effect analogous to a ſlight combuſtion, which takes place by the union of oxygen with the aſtringent principle.

Freſh ink, as well as newly dyed ſtuffs, always acquires a deeper black by expoſure to the air; the reaſon of this ſeems to be, that the oxygen which galls are capable of ſeparating from the iron, is not ſufficient to produce in them the degree of combuſtion, requiſite for making them contribute as much as poſſible to blackneſs; and that this combuſtion is com-

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pleted by the oxygen which they attract from the atmoſphere.

The ink in which a large proportion of ſulphat of iron has been employed, ſoon grows brown, by the action of the ſun and air, and at length becomes yellow, becauſe the iron which is not ſaturated with the aſtringent principle continues ſtrongly to attract the oxygen, and thereby loſes its black colour, acquiring one inclining more and more to yellow, while at the ſame time the combuſtion of the aſtringent principle goes on rapidly, particularly with the aſſiſtance of the light; but the ink is much more durable, if the aſtringent principle be in ſufficient quantity. The beſt ink according to Lewis, is compoſed of three parts of galls and one of ſulphat of iron. He found, that by moiſtening writings which had grown brown or yellow, with infuſion of galls, their colour was reſtored. Dr. Blagden employed with ſucceſs, pruſſiat of alkali to reſtore writings which age had rendered illegible [m], and found it more uſeful than galls.

Although chemiſts have conſidered the aſtringent principle as always the ſame, experience had taught us, that all aſtringent ſubſtances were not equally proper for producing a beau-

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[m] Journ. de Phyſ. mars. 1788.

tiful and durable black; it is of importance to aſcertain which of them may be employed with ſucceſs; but it muſt be obſerved, that it is very difficult to make comparative experiments on this ſubject with perfect accuracy, becauſe ſome ſubſtances require much longer boiling than others to extract their aſtringency; becauſe a difference in their coarſeneſs or fineneſs, when ſubjected to ebullition, is ſufficient to produce differences in the reſults; and becauſe the colouring particles have a greater or leſs diſpoſition to combine with the ſtuff, according to the proportion of ſulphat of iron which has been employed.

It muſt alſo be obſerved, that ſolutions of iron in different acids, may produce differences in the reſults, according to the ſtate of oxygenation of the iron in them, according as the proportion of that metal is greater or leſs, and according to the ſtrong or weak action, which the different acids when diſengaged, are capable of exerting on the newly formed compound. Finally, in the dyeing of a ſtuff, its greater or leſs attraction for the colouring particles may alſo occaſion differences in the reſults.

Lewis has obſerved, that a decoction of logwood employed, inſtead of ſimple water, for the infuſion of galls, increaſed the beauty of ink without rendering it paler; ſumach, ſloe tree, or pomegranate bark, pomegranate flowers, biſtort, or tormentil root, and oak bark were not ſo powerful as galls. In his experiments on dyeing, he found that ſumach, oak bark, or the ſaw-duſt of that wood, could not ſupply the place of galls without being employed in much greater quantities.

Mr. Beunie has publiſhed a great number of intereſting experiments [n], the object of which was, to determine the beſt proceſs for giving cotton a durable black. He firſt tried, what ſolution of iron gave the fineſt black to galled cotton; he afterwards combined different ſolutions, and examined the durability of the blacks which he produced; and made the ſame experiments on galled cotton, with other metals and ſemimetals; he employed in like manner, a great number of aſtringents, and tried with them cotton which had received different preparations. The proceſſes to which theſe numerous experiments have led, will be found in that ſection of the ſecond volume which treats of the black dye.

[n] Mémoire ſur la teinture en noir, qui a remporté le prix de la ſociete de Bruxelles en 1771. Rotterdam 1777.

Of twenty-one ſpecies of aſtringents, compared with galls; oak ſaw-duſt, the galls of the country, and yellow myrobolans, were the only ſubſtances which produced a fine black, but which was ſtill neither ſo fine, nor ſo durable, as that obtained by means of the common gall. He found that the oak ſaw-duſt was preferable to the bark, which is employed by the dyers of thread, and he obſerves that it is cheaper.

Meſſrs. Lavoiſier, Vandermonde, Fourcroy, and I, were deſired to try experiments on the different aſtringents, for the purpoſe of making a report to the academy. The ſubſtances upon which we thought it proper to inſtitute experiments of compariſon, are galls, oak bark, raſpings of heart of oak, of the external part of oak, of logwood, and ſumach. To determine the portion of aſtringent principle contained in theſe ſubſtances, we took two ounces of each ſeparately, which we boiled half an hour in three pounds of water; after the firſt water we added a ſecond, which underwent a ſimilar ebullition, and continued theſe operations until the ſubſtances appeared exhauſted: we then mixed together the decoctions we had ſucceſſively obtained. We made uſe of a tranſparent ſolution of ſulphat of iron, in which

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we knew exactly the proportions of water and ſulphat. We firſt eſtimated the quantity of the aſtringent principle, by the quantity of ſulphat which each liquor could decompoſe, and afterwards by the weight of the black precipitate which was formed. In order to ſtop preciſely at the point of ſaturation, we muſt proceed very ſlowly in the precipitation, and towards the end add the ſolution of ſulphat only drop by drop, and ceaſe at the moment when the laſt added quantity, no longer augments the intenſity of the black colour. When the liquor is too opake to allow its ſhade of colour to be diſtinguiſhed, a ſmall quantity of it is largely diluted with water, and by adding to this, a little of the ſolution of ſulphat of iron at the end of a glaſs tube, it is diſcovered whether or not the point of ſaturation has been attained: if we then wiſh to get the precipitate which is formed, the whole muſt be largely diluted with water.

This operation merits attention, as being an eaſy and accurate mode for manufacturers to determine the proper proportions of aſtringents, and ſolutions of iron.

To ſaturate the decoction of two ounces of galls, three drams and ſixty-one grains of ſulphat of iron were required; the precipitate when

when collected and dried, weighed ſeven drams, twenty-four grains.

The decoction of oak bark is of a deep yellow; a very ſmall portion of ſulphat of iron gives it a dirty reddiſh colour, and a larger one changes it to a deep brown. The quantity of ſulphat required to ſaturate the decoction of two ounces of this bark, was eighteen grains. The precipitate collected and dried, formed coarſer and more compact grains, and weighed twenty-two grains; the inner bark of the oak afforded very nearly the ſame reſult.

The decoction of the raſpings of the heart of oak, required for its ſaturation, one dram, twenty-four grains, and the precipitate weighed one dram, twenty-four grains; the decoction of the external wood of the oak produced very little precipitate.

The docoction of ſumach acquired a reddiſh violet colour when a ſmall quantity of the ſulphat of iron was added. The quantity required for its ſaturation was two drams, eighteen grains. An accident prevented us from aſcertaining the weight of this precipitate; it perfectly reſembled that afforded by the galls.

The decoction of logwood became of a ſapphire blue colour, by the addition of ſulphat

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of iron: if we go beyond the point of ſaturation, the blue becomes greeniſh and dirty. The exact quantity required for ſaturation was found to be one dram, forty-eight grains, and the weight of the precipitate was two drams, twelve grains. All the precipitations by means of oak take place readily; that by logwood a little more difficultly, but ſtill more eaſily than that by galls.

We then aſcertained by trials made with cloth, that the quantity of aſtringent ſubſtances required to give a black colour of equal intenſity, to an equal weight of the ſame cloth, was proportional to the quantities of aſtringent principle, which we had already eſtimated in each kind from the foregoing experiments; but the black obtained by means of the different parts of the oak, does not reſiſt *proofs* or teſts of colour *(debouilli)* nearly ſo well as that produced by galls.

It does not appear that logwood alone is capable of producing ſo intenſe a black as galls or oak; and beſides, the colour which it produces does not ſtand the teſt of proofs ſo well as that produced by galls.

In the memoirs of Stockholm for the year 1663, it is ſaid, that we may ſubſtitute for galls the

the uva urſi gathered in autumn, and dried carefully, ſo as to preſerve the leaves green.

The theory I have given reſpecting aſtringents, is very far from being complete in all its parts; but it eſtabliſhes principles, which may afterwards be applied by means of experiments, which ſhould be much more numerous and accurate than thoſe that have been hitherto tried. We ought however to confine ourſelves in this reſpect, to the examination of the principal aſtringents, becauſe moſt vegetables poſſeſs more or leſs of the aſtringent property, as may be ſeen by the experiments of Bergius [o] and Mr. Durande [p].

After having conſidered the aſtringent principle, with reſpect to its affinities with ſolutions of iron, it ought alſo to be conſidered, with reſpect to its property of combining with vegetable and animal ſubſtances, particularly the latter. Silk acquires by galling *(engallage)* which conſiſts in macerating a ſtuff in a decoction of galls [q], a weight which cannot be

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[o] Materia medica e regno vegetabili.

[p] Mem. ſur les parties aſtringentes indigenes. Acad. de Dijon, 1783.

[q] I ſhall apply the term galling to the operation by which an aſtringent is combined with a ſtuff, whatever may be the nature of the aſtringent, or ſpecies of ſtuff.

taken from it, or diminiſhed beyond a certain degree by repeated waſhing; after which operation, the ſtuff when put into a ſolution of iron is dyed black, becauſe the aſtringent principle, decompoſing the ſulphat of iron, forms a triple compound with the oxyd of iron and the ſtuff.

A galled ſtuff is likewiſe capable of combining with other colouring particles, the colours of which thereby acquire fixity, if they do not naturally poſſeſs it; ſo that the aſtringent communicates its durability to the triple compound, or perhaps the more complex one which is formed; but the colour commonly becomes deeper by this union.

The aſtringent principle by combining with animal ſubſtances, renders them incapable of corruption, and tends to render their texture more compact; in this the art of tanning conſiſts, which is the baſis of the preparation of leather.

The prize lately offered by the academy of ſciences relative to this important art, will undoubtedly procure us great information, and increaſe its progreſs; but I hope that the conjectures I had formed will not be uſeleſs to thoſe engaged in the ſubject.

An ounce of galls diſtilled with a ſtrong heat, yielded three drams of charcoal; an ounce of ſugar, two drams, twelve grains; an ounce of the colouring particles of flax, two drams, twenty-four grains; an ounce of dry plumb-tree, one dram, forty-eight grains; an ounce of dry walnut-tree, alſo one dram, forty-eight grains; ſo that galls yield almoſt double as much charcoal as hard and dry wood. I have elſewhere remarked[r], that when an infuſion of galls or of ſumach was decompoſed by means of oxygenated muriatic acid, a copious precipitation of charcoal took place, eſpecially in the former.

In conſequence of theſe obſervations, I conſider the abundance of charcoal, as the eſſential characteriſtic of the aſtringent principle; the hydrogen which it contains only in ſmall quantity, is however very much diſpoſed, partially to combine with oxygen; hence it is, that when an infuſion of galls is left in contact with vital air, a ſmall quantity of the air only is abſorbed, and yet the colour of the infuſion becomes much deeper; for in conformity with the theory laid down in Chap. III. and more particularly in the annals of chemiſtry[s], the

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[r] Ann. de Chym. tom. vi.

[s] Ibid.

charcoal readily becomes predominant, in conſequence of the ſlight combuſtion, and the colour grows deeper and becomes brown.

A ſubſtance that contains much charcoal, and can undergo only a ſlight degree of combuſtion, ought to poſſeſs conſiderable durability, becauſe charcoal does not combine with oxygen in the ordinary temperature of the air, unleſs its union be aſſiſted by other attractions, and becauſe ſlight variations of temperature produce no change in the dimenſions of charcoal; on the contrary, ſubſtances which contain much hydrogen, and in which the particles of the hydrogen are in a ſtate of diviſion, ought to be eaſily decompoſed, by the combination of the hydrogen with azot or oxygen. The diſunion of their parts ought to take place from ſmall variations of temperature, becauſe hydrogen is dilatable by heat, which the carbonaceous particles are not; agreeably to this, Mr. Monge ingeniouſly remarks, that a very fuſible metal united to one much leſs ſo, renders it brittle at ſuch a degree of heat, as by melting the firſt, deſtroys the continuity of the parts of the mixture.

When therefore the aſtringent principle combines with an animal ſubſtance, it communicates to it, the properties which it derives from

from the charcoal; the animal ſubſtance becomes leſs liable to change from ſlight variations of temperature; inſtead of growing putrid, it ſuffers a ſlight degree of combuſtion, by the action of the air; for the proceſs of tanning probably could not go on in a perfectly cloſe veſſel: the effect of this combuſtion is the conſtriction of the parts, which alſo, afterwards aſſiſts as a cauſe of preſervation. The preliminary operations in tanning, conſiſt principally, in extracting all the fatty particles diffuſed through the cellular texture of the ſkins, that the aſtringent principle, and even the air, may have free acceſs every where.

In conſidering the analyſes that have been made of indigo, which may be looked upon as the colouring matter leaſt liable to change, of any we are acquainted with, I find, that this ſubſtance leaves in diſtillation, a greater proportion of charcoal than even galls themſelves (Sect. II. Vol. II). I neglect in this eſtimate, the charcoal which enters into the compoſition of the thick oil, which is obtained chiefly from indigo, and that which is extricated in the form of carbonic acid, and hydrogenous carbonic gas.

I conceive that it is alſo to this abundance of charcoal, that the durability of the colour of indigo is to be attributed, and that the proportion of this principle is the chief cauſe of the difference obſerved in the durability of colours; but the force of adheſion may alſo have great influence, for a principle which combines intimately with another ſubſtance, ought to form with it a more permanent compound, than one which has only a ſlight diſpoſition to unite with it; now the aſtrigent principle poſſeſſes a very ſtrong diſpoſition to form intimate combinations, eſpecially with animal ſubſtances. I ſhall explain upon the ſame principles, the fixity communicated to colouring particles by alumine, and by thoſe metallic oxyds which are not liable to contain different proportions of oxygen, ſuch as oxyd of tin.

All the colouring ſubſtances which are capable of uniting with metallic oxyds, have an action upon them, which is analogous to that of aſtringents.

The oxyds are thus deprived of more or leſs of their oxygen, according to the force with which they retain it, the ſtrength of attraction with which the colouring particles tend to combine with them, the proportions in which they meet with each other, and the greater or leſs diſpoſition of the colouring particles towards combuſtion. The colouring particles alſo, ſuffer a change in their conſtitution from theſe circumſtances; thus, the ſolutions of iron render brown, all the colours into which oxyd of iron can enter, although it has only a green or yellow colour, in the ſtate in which it is held in ſolution by acids, and this effect goes on increaſing to a certain degree; but the alteration of the colouring particles may afterwards be puſhed ſo far, as to ſpoil their colour, and to diminiſh their tendency to combination; the oxyd of iron is then brought back to the yellow colour, by the oxygen which it attracts, and is capable of retaining. The action of metallic oxyds and the colouring particles on each other, explains the changes obſerved in ſolutions of the colouring particles, when mixed with metallic ſolutions. The effect is gradual, as I have ſhewn with reſpect to fuſtic. Sometimes, the mixture does not even grow turbid immediately, but loſes its tranſparency by degrees; the precipitation begins; the ſediment is formed, and its colour grows more and more deep. Light has ſometimes a conſiderable influence in producing theſe effects.

CHAP. VI.

Recapitulation of the Theory laid down in this Section.

METALLIC colours muſt be diſtinguiſhed from thoſe which are peculiar to vegetable and animal ſubſtances.

The colours of metals are modified and changed by oxydation, and by the proportion of oxygen combined with them.

Vegetable and animal ſubſtances may themſelves poſſeſs a peculiar colour, which varies in the different ſtates through which they paſs, or they may owe their colours to tinging particles, either combined, or ſimply mixed with them. Theſe are the particles which are extracted from different ſubſtances, and which undergo different preparations, to fit them for the purpoſes of dyeing.

The colouring particles have chemical properties which diſtinguiſh them from all other ſubſtances: the attractions which they have for acids, alkalis, earths, metallic oxyds, oxygen, wool, ſilk, cotton, and linen, conſtitute the chief of theſe properties.

According to the attraction which the colouring particles have for wool, ſilk, cotton, and linen, they unite more or leſs readily, and more or leſs intimately with each of theſe ſubſtances; and thence ariſes the firſt cauſe of variation in the proceſſes employed, according to the nature of the ſtuff and of the colouring ſubſtance.

By the attraction which the colouring particles have for alumine and metallic oxyds, they form compounds with theſe ſubſtances, in which their colour is more or leſs modified, becomes more fixed, and more difficultly affected by external agents than before. This compound being formed of principles, which have ſeparately the power of uniting with vegetable ſubſtances, and more eſpecially with animal ſubſtances, preſerves this property, and forms a triple compound with the ſtuff; and the colour which has been again modified by the formation of this triple union, acquires a greater degree of fixity, and of indeſtructibility by external agents.

The colouring particles have frequently ſo great an attraction for alumine and metallic oxyds, that they ſeparate them from acids which held them in ſolution, and fall down with them; but the attraction of the ſtuff is ſometimes neceſſary, in order to produce this ſeparation.

The metallic oxyds which combine with the colouring particles, modify their colours, not only by their own, but alſo by acting upon their compoſition by means of their oxygen. The change which the colouring particles thereby ſuffer, is ſimilar to that occaſioned by the air, which injures all colours more or leſs.

Of the two principles which compoſe the air of the atmoſphere, it is only the vital air or oxygenous gas, which acts upon the colouring particles: it combines with them, weakening their colour, and rendering it paler; but preſently, its action is principally exerted on the hydrogen which enters into their compoſition, and it then forms water. This effect ought to be conſidered as a true combuſtion, whereby the charcoal which enters into the compoſition of the colouring particles, becomes predominant, and the colour commonly changes to yellow, fawn colour, or brown; or the injured part, by uniting with what remains of the original colour, produces other appearances.

Light favours the combuſtion of the colouring particles, which frequently cannot take place without its aid, and it is thus that it contributes to the deſtruction of colours. Heat promotes it alſo, but leſs powerfully than light, provided that it has not a certain degree of intenſity.

To a ſimilar combuſtion are to be attributed the effects of the nitric acid, of the oxygenated muriatic acid, and even of the ſulphuric acid, when they make the colour of the ſubſtances upon which they act, paſs to a yellow, and even to black [a].

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[a] There are a great number of other natural phenomena beſides thoſe which I have pointed out (*Ann. de Chym.* tom. vi.) in which the formation of water appears to me indiſputable: thus the acerb flavour of unripe fruits, is probably owing to the oxygen being weakly combined in them; but by maturation, the fruit from having been hard, grows ſoft; water is formed; the juice becomes abundant and ſweet; now, ſugar contains a conſiderable portion of charcoal. When their maturity advances too far, and the fruits undergo that decay which is peculiar to them, their colour indicates a ſuperabundance of charcoal. It appears by the experiments of the celebrated Mr. Ingenhouze (*Exp. ſur les végét,* tom. ii.) that combuſtion takes place on the ſurface of fruits expoſed to the ſun, ſo ſtrongly, as to produce carbonic acid.

Dung, either by itſelf or mixed with ſtraw, is changed into mould, by a degree of combuſtion which is even accompanied with conſiderable heat, ſo that the charcoal becomes ſuperabundant in it; hence probably ariſe many of the phenomena of vegetation.

The effects of combuſtion however, may be concealed, by the oxygen combining with the colouring particles, without acting particularly on the hydrogen.

Colours are more or leſs durable, or more or leſs fixed, according to the greater or leſs diſpoſition of the colouring particles, to ſuffer this combuſtion, and to allow it to go on to a more or leſs advanced ſtage.

Some ſubſtances are alſo capable of acting on the colour of ſtuffs, by a ſuperiority of attraction, or by a ſolvent power; and in this conſiſts the action of acids, alkalis, and ſoap, a ſmall quantity of theſe agents however, may ſometimes form ſupracompounds with the ſtuff, and thereby change its colour.

Metallic oxyds produce in the colouring particles with which they unite, a degree of combuſtion, proportioned to the quantity of oxygen, which can be taken from them by theſe particles.

The colours which the compounds of metallic oxyds and colouring particles aſſume then, are the product of the colour peculiar to the colouring particles, and of that peculiar to the metallic oxyd; but the colouring particles and metallic oxyds muſt be conſidered in that ſtate, to which they have been reduced by the diminution

diminution of oxygen in the oxyd, and the diminution of hydrogen in the colouring particles.

Hence it follows. Firſt, that the metallic oxyds, to which the oxygen is only ſlightly attached, are not fit to ſerve as connecting media for the colouring particles, becauſe they produce in them too great a degree of combuſtion; ſuch are the oxyds of ſilver, gold, and mercury.

2. That the oxyds which undergo conſiderable changes of colour, by giving off more or leſs of their oxygen, are alſo bad intermedes, eſpecially for light ſhades, becauſe they produce changeable colours; ſuch are the oxyds of copper, of lead, and of biſmuth.

3. That the oxyds which ſtrongly retain their oxygen, and ſuffer very little change of colour by the loſs of a part of it, are beſt fitted to anſwer this purpoſe; ſuch is particularly the oxyd of tin, which quits its menſtruum eaſily, which has a ſtrong attraction for the colouring particles, and which affords them a baſis which is very white, and proper for giving a brightneſs to their ſhades, without altering them by the admixture of another colour. The oxyd of zinc poſſeſſes ſome of theſe qualities.

In order to account for the colours, which reſult from the union of the colouring particles with the baſis which a mordant gives them, we muſt attend to the proportion in which the colouring particles unite to that baſis; thus, the ſolution of tin, which produces a very copious precipitate with a ſolution of colouring particles, and which thereby proves, that the oxyd of tin enters in a large proportion into the precipitate, has a much greater influence on the colour of the precipitate, by the whiteneſs of its baſis, than the ſolution of zinc, or that of alum, which generally produce much leſs copious precipitates. The precipitates produced by theſe two laſt ſubſtances, retain very nearly the natural tint of the colouring particles.

We muſt then diſtinguiſh in the action of mordants, the combinations that may take place by their means, between the colouring particles, the ſtuff, and the intermede; the proportions of the colouring ſubſtance and intermede, the modifications of colour, which may ariſe from the mixture of the colour of the colouring particles, and of that of the baſis to which they are united, and finally, the changes which the colouring particles may ſuffer, from the combuſtion that may be produced by the intermede.

Aſtringents do not derive their characteriſtic property from an acid, or from any other individual principle which is always the ſame, but from the property which they poſſeſs, of uniting with the oxyd of iron, of reducing it to the ſtate of black oxyd, and of acquiring themſelves a dark colour, by the combuſtion they thereby experience; galls, which are to be conſidered as the type of aſtringents, readily undergo a ſlight combuſtion, which gives them a deep brown colour; but this combuſtion, which requires but a ſmall quantity of oxygen, ſoon ceaſes, without injuring their properties.

Galls owe their ſtability to the large proportion of charcoal they contain; and as they have the property of combining with ſome vegetable ſubſtances, with ſeveral colouring matters, and particularly with animal ſubſtances, they ſerve as intermedes for them, and impart to them their own ſtability.

SECTION II.

Of the Proceſſes of Dyeing in General.

CHAP. I.

Of the Differences between Wool, Silk, Cotton, and Linen, and the Operations, by which theſe Subſtances are prepared for taking the Dye.

ARTICLE I.

Reflections on the Difference between Vegetable and Animal Subſtances.

THOUGH we cannot hope to account for many properties which depend upon the compoſition of organized bodies; yet the knowledge we have acquired reſpecting the compoſition of vegetable and animal ſubſtances, may afford us ſome light reſpecting the cauſe of the different diſpoſitions of wool, ſilk, cotton, and linen, to unite with the colouring particles, and with the baſes ſupplied by mordants.

Wool and ſilk, are animal ſubſtances; cotton, flax, and hemp, are vegetable productions.

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The compoſition of animal ſubſtances is diſtinguiſhed from that of vegetables, by their abounding in a particular principle *azot,* which, when in its elaſtic form, conſtitutes what is called *phlogiſticated gas, phlogiſticated air, &c.* which is found only in ſmall quantity in vegetables; ſecondly, by their containing much more hydrogen, or baſe of inflammable air.

From theſe two cauſes, ariſe the differences obſerved in the diſtillation of animal and vegetable ſubſtances. The former yield a large quantity of ammoniac (volatile alkali) which is compoſed of azot and hydrogen; the latter afford very little, and commonly yield even an acid; the former yield a great deal of oil, the predominant principle in which, is hydrogen, which is very volatile and diſpoſed to fly off by a ſmall increaſe of temperature, while the latter ſometimes do not yield it in the leaſt ſenſible quantity. In conſequence of this compoſition, animal ſubſtances, when ſet on fire, produce a bright flame, which breaks out at the beginning, but is ſoon ſtifled as it were, by the charcoal which is formed, and which has peculiar properties; their combuſtion is accompanied with a penetrating odour, owing to the ammoniac and oil which are produced and eſcape unconſumed: they are liable to putrefaction, in which proceſs ammoniac is produced, as well as in their diſtillation, by a more intimate union of the azot and hydrogen; while vegetable ſubſtances, on the contrary, undergo the vinous or acetous fermentation. I barely mention theſe ideas here, which I have explained at length in ſome memoirs.

As animal ſubſtances contain a conſiderable quantity of principles diſpoſed to aſſume an elaſtic form, they have leſs coheſive force among their particles than vegetables have, and a greater diſpoſition to combine with other ſubſtances; hence they are more liable to be deſtroyed by different agents, and are more diſpoſed to combine with colouring particles.

Thus, pure or cauſtic fixed alkalis deſtroy animal ſubſtances, becauſe they combine with them, and are ſaturated by them, loſing their cauſticity (*Mem. de l' Acad.* 1783). The conſequence of this action of alkalis on animal ſubſtances, is, that they cannot bear leys, and that alkalis ſhould be uſed with great caution, in the proceſſes employed for dyeing them; whereas, no danger is to be apprehended from the uſe of alkalis with vegetable ſubſtances.

The nitric and ſulphuric acids have alſo conſiderable action on animal ſubſtances; the former decompoſes them, extricates the azot, ſeparates the fatty matter, and forms carbonic and oxalic acids with a part of the hydrogen and a part of the charcoal: the latter extricates the inflammable gas, probably azotic gas, and reduces the other principles to the ſtate of charcoal.

Silk appears to bear ſome reſemblance to vegetable ſubſtances, by being leſs diſpoſed to combine with colouring particles, and by reſiſting the action of alkalis and acids more powerfully; which may ariſe either from the ſame principles being more intimately combined in it than in wool, or more probably, from its containing leſs azot and hydrogen: but though the action of alkalis and acids upon ſilk is weaker than upon wool, they ſhould ſtill be employed with great caution, becauſe the brightneſs of colour required in ſilk, appears to depend upon the ſmoothneſs of its ſurface, which ſhould therefore be preſerved unimpaired.

Cotton withſtands the action of acids better than flax or hemp, and is difficultly deſtroyed even by the nitric acid.

ARTICLE II.

Of Wool.

THE principal differences in wool conſiſt in the length and fineneſs of its filaments. That which

which has the fineſt filaments, is reſerved for fine cloths. The moſt beautiful wool is brought to us from Spain. Mr. d'Aubenton has ſhewn, that it may be produced in France, of a quality not inferior to that of Spain, by folding the ſheep through the whole year, and chooſing the rams with care. Simple inſpection may eaſily lead to error reſpecting the fineneſs of wool, which it is ſo important the manufacturer ſhould know with accuracy; he has propoſed a method of attaining that accuracy, by employing a micrometer for comparing, by means of a microſcope, the fineneſs of the wool to be examined, with that of other wools choſen as ſtandards[a].

Although the long wool is not ſo fine as the Spaniſh, and cannot be employed for fine cloths, it is ſtill very uſeful for thoſe commonly known by the name of engliſh cloths; and as the ſheep which produce it, have much larger fleeces, the profit they bring, is not inferior to that of the fine woolled ſheep; beſides, the cloths made of their wool, being cheaper, have a much more extenſive ſale; and the proſperous ſtate of the commerce of England, is partly owing to the abundance of this wool. But the breed of ſheep,

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[a] Mem. de l'acad. 1779. Inſtructions to ſhepherds and proprietors of flocks.

which produces one or the other kind of wool, is connected with the nature of their paſture, which ought to determine us in the choice of them.

The multiplication of our flocks and the improvement of our wool, is of ſo great importance to our induſtry, that no opportunity ſhould be loſt of calling the attention of the public to that object.

Wool is naturally covered with a kind of greaſe, called *ſuint*, which preſerves it from moths[b], ſo that it is not ſcoured until it is about to be dyed, or ſpun.

In order to ſcour wool, it is put for about a quarter of an hour into a kettle, containing a ſufficient quantity of water, mixed with a fourth of putrid urine, heated to ſuch a degree as the hand can juſt bear, and it is ſtirred from time to time with ſticks; it is then taken out, and put to drain: it is next carried in a large baſket to a ſtream of running water, where it is moved about until the greaſe is entirely ſeparated, and no longer renders the water turbid; it is then taken out, and left to drain. It ſometimes loſes

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[b] Reaumur has obſerved, that rubbing a ſtuff with greaſy wool, was ſufficient to preſerve it from moths. Mem. de l'acad. 1728.

in this operation more than a fifth of its weight. The ſcouring ſhould be carefully performed, becauſe the wool is thereby better fitted to receive the dye.

The ammoniac, or volatile alkali, formed in putrid urine, unites with the greaſe, producing a kind of ſoap, which is ſoluble in water.

The wool is died in the fleece, or before it is ſpun, chiefly when it is intended to form cloths of mixed colours; or elſe it is dyed after being ſpun, and it is then intended principally for tapeſtry: but it is moſt commonly dyed, after having been wrought into cloth.

When wool is dyed in the fleece, its filaments being ſeparate, abſorb a larger quantity of the colouring particles than when it is ſpun; for the ſame reaſon, woollen yarn takes up more than cloth: but cloths themſelves vary conſiderably in this reſpect, according to their degree of fineneſs, or the cloſeneſs of their texture; beſides the variety in their dimenſions, the different qualities of the ingredients employed in dyeing, and a difference of circumſtances in the proceſs, prevent us from relying upon the preciſe quantities we find recommended for the proceſſes deſcribed. This conſideration ought to extend to all dyes.

For

For moſt colours, wool requires to be prepared by a bath, in which it is boiled with ſaline ſubſtances, principally with alum and tartar; this is called the *bouillon*, which will be accurately deſcribed in the different proceſſes: but there are ſome dyes for which the wool does not require ſuch a preparation; then, it muſt be well waſhed in warm water, and wrung out, or left to drain. This is a general rule which ſhould be obſerved with reſpect to all the ſubſtances we wiſh to dye, in order that the colour may penetrate them more eaſily, and be diſtributed more uniformly.

Mr. Monge has explained the operation of felting *(feûtrage)* and the effects of fulling, by the external conformation of the wool and hair of animals. He has made ſome curious obſervations[e] on this ſubject, the chief of which I ſhall now relate.

Nothing particular can be diſcovered by means of the microſcope, in the filaments of wool or in the hairs of animals; yet the ſurfaces of theſe bodies are not ſmooth; they muſt be formed either of ſmall laminæ placed over each other in a ſlanting direction from the root towards the point, like the ſcales of fiſh, which cover

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[e] Obſervations ſur la mechaniſme du feûtrage. Ann. de Chym. tom. vi.

each other, from the head of the animal to the tail; or more probably, perhaps, of zones placed one upon another, as we ſee in the horns of animals.

If a hair be laid hold of by the root in one hand, and drawn between the fingers of the other, from the root towards the point, ſcarce any friction or reſiſtance is perceived, and no noiſe is heard; but if graſping it by the point, it is paſſed in the ſame manner between the fingers of the other hand, from the point towards the root, a reſiſtance is felt which did not take place in the former caſe, and a tremulous motion is perceptible to the touch, and a noiſe ſenſible to the ear.

We perceive then, that the texture of the ſurface of hair is not the ſame, from the root towards the point, as it is from the point towards the root, and that a hair when preſſed, muſt meet with greater reſiſtance, in ſliding or moving towards the point, than towards the root; but as it is this texture itſelf, which forms the principal ſubject of Mr. Monge's memoir, it is neceſſary to confirm it by ſome further obſervations.

If, after having laid hold of a hair between the thumb and fore finger, we rub them againſt each other, in the longitudinal direction of the hair,

hair, it acquires a progreſſive motion in that direction towards the root. This effect depends neither on the nature of the ſkin of the finger, nor on its texture; for if the hair be turned, ſo that the point ſhall be placed where the root was before, its motion will now be in an oppoſite direction, that is, it will ſtill be towards the root.

Theſe obſervations, to which Mr. Monge adds ſome others, are related of human hair, taken as an example, but they are equally applicable to the filaments of wool, to horſe hair, and to that of animals in general. The ſurface of all theſe bodies then, is formed of rigid laminæ, laid upon each other like tiles, from the root to the point, which allow a progreſſive motion towards the root, but oppoſe one towards the point.

This ſtructure is the principal cauſe of the diſpoſition to felting *(feûtrage)* which the hair of animals generally poſſeſſes; the hatter, by ſtriking the flocculi of wool with the ſtring of his bow *(archet)* detaches and diſperſes in the air, each of the filaments ſeparately; theſe fall back one upon another, in all directions, on the table, where they form a layer of a certain thickneſs; the workman then covers them with a cloth, upon which he preſſes in all parts, with his hands extended.

The preſſure brings the filaments of wool nearer to each other, and multiplies the points of contact; the agitation gives each of them a progreſſive motion towards its root, by means of which, they entangle each other, and the laminæ of each filament, taking hold of thoſe of the other filaments, which are in an oppoſite direction, the whole is retained in the ſtate of cloſe contexture, which it had acquired by the preſſure

In proportion as the texture becomes cloſer, the preſſure of the hands ought to be increaſed, both in order to make it ſtill more compact, and to keep up the progreſſive motion, and intermixture of the filaments, which now meet with greater reſiſtance: but during the whole of this operation, the filaments of wool lay hold of each other only, and not of the cloth, the fibres of which, as has been already obſerved, are ſmooth, and have not the ſame properties in this reſpect.

The aptitude for felting in wool and hair, does not depend entirely on the ſtructure of their ſurface; it is not enough, that each filament ſhould have a progreſſive motion towards its root; nor that the inclined laminæ, by laying hold of each other, ſhould retain the contexture in the ſtate to which it has been reduced

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by compreſſion: it is alſo neceſſary, that the filaments ſhould not be ſtraight like needles; for, by a continuance of the motion and preſſure, each of them would continue its courſe progreſſively, without changing its direction, and the effect of the operation would be, to remove them all from the centre, without producing any contexture. It is therefore neceſſary, that each filament ſhould be crooked, ſo that the exremity neareſt the root, ſhould be diſpoſed to change its direction continually, to entwine itſelf round freſh filaments, and to return back upon itſelf, if it ſhould be ſo determined, by any change in the poſition of the reſt of its length.

Wool poſſeſſing this ſtructure naturally, is peculiarly fitted for this kind of work, and may be employed in it, without being ſubjected to any previous preparation; but the furs of rabbits, hares, and beaver, are naturally ſtraight, and cannot be employed alone for felting, without having undergone a previous operation, which is called *ſecretage*, which conſiſts in rubbing them before they are ſtripped, with a bruſh moiſtened with a ſolution of mercury in nitric acid; this liquor, by acting only on one ſide of the hairs, changes their rectilinear direction, and communicates to them that diſpoſition for felting, which wool has naturally.

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The operation of *fulling* woollen ſtuffs is ſo cloſely connected with felting, that I cannot avoid entering a little into that ſubject at preſent.

The aſperity of the ſurface of the filaments of wool, and their diſpoſition to acquire a progreſſive motion towards the root, forms an obſtacle to the ſpinning of wool, and the working it into ſtuffs, all the filaments muſt therefore be covered with a coat of oil, which by filling the cavities, renders the aſperities leſs ſenſible, juſt as a coat of oil renders a fine file ſtill ſmoother. When the piece of ſtuff is wrought, it muſt be freed from that oil, which gives it a diſagreeable ſmell, renders it dirty, and would prevent it from taking the colour we wiſh to dye it; for this purpoſe, it is taken to the fulling-mill, where it is beaten with large beetles, in a trough of water, through which ſome clay has been diffuſed. The clay uniting with the oil, renders it ſoluble in the water, and both are carried off together, by freſh water brought thither by the machine; and after ſome time, the ſtuff is found clean ſcoured.

But ſcouring is not the only object in fulling; the alternate preſſure of the beetles on the ſtuff, particularly when the ſcouring is advanced, produces an effect analogous to that of the preſſure of the hatter's hands; the filaments of wool

wool which compoſe a thread of the warp or of the woof, acquire a progreſſive motion, inſinuate themſelves into the adjoining threads, then into thoſe which are next, and preſently, all the threads both of the warp and woof, are felted together. The ſtuff is now found contracted in length and breadth, and participates both of the nature of cloth and of felt; it may be cut without being ſubject to ravel, and there is no neceſſity for hemming the different pieces of it employed to make a garment. If it be common woollen ſtocking web, the ſtitches are now no longer ſubject to run, when one of them happens to ſlip; finally, the threads of the warp and the woof, being now no longer ſo well defined, nor ſo diſtinct from each other, and the ſtuff being alſo thickened, forms a warmer clothing.

ARTICLE III.

Of Silk.

SILK is naturally coated with a ſubſtance, which has been conſidered as a gum, to which it owes its ſtiffneſs and elaſticity; that which is moſt commonly met with in our climate, contains beſides, a yellow colouring matter.

Moſt

Moſt of the purpoſes for which ſilk is employed, require that it ſhould be deprived not only of its colouring matter, but alſo of its gum. Both theſe purpoſes are anſwered by means of ſoap, and the term ſcouring *(décreuſage)* is applied to this operation, by which it acquires its ſuppleneſs and whiteneſs. The ſcouring ought not to be ſo complete for ſilks which are to be dyed, as for thoſe which are intended to remain white, and a difference ought even to be made, according to the colour we mean the ſilk ſhould have.

This difference conſiſts chiefly in the quantity of ſoap employed; thus, for common colours, it is generally thought ſufficient, to boil the ſilk for three or four hours, in a ſolution of twenty pounds of ſoap for each hundred of ſilk, taking care to fill up the kettle with water from time to time, that there may be always a ſufficient proportion of fluid. The quantity of ſoap is increaſed for thoſe ſilks which are to be dyed blue, and more eſpecially for thoſe that are to be ſcarlet, cherry-colour, &c. becauſe, for theſe colours the ground muſt be whiter, than for ſuch as are leſs delicate. In treating of each colour, the quantity of ſoap proper for the ſilk intended to receive it, is mentioned.

When ſilk is to be employed white, it undergoes three operations, the firſt is called *dégommage;* it conſiſts in keeping the hanks of ſilk in a ſolution of thirty pounds of ſoap to a hundred of ſilk: this ſolution ought to be very hot, but not boiling; when that part of the hanks which is immerſed is entirely freed from its gum, which is known by the whiteneſs it acquires, the hanks are turned upon the ſkein ſticks, ſo that the part which was not before immerſed, may undergo the ſame operation*; they are then taken out of the kettle, and wrung out, according as the operation is completed.

The ſecond operation, is the *cuite.* The ſilk is put into bags of coarſe cloth, five and twenty or thirty pounds in each bag, which is called a boiling bag *(poche)*; a bath of ſoap is prepared like the former, but with a leſs quantity of ſoap; in this the bags are boiled for an hour and a half, taking care to keep them conſtantly ſtirred, that thoſe which touch the bottom of the kettle, may not receive too much heat.

The third operation is called *blanchiment*, which is principally intended to give the ſilk a ſlight caſt, to make the white more pleaſing, and from which it derives different names,

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* This is called by our workmen, *ſhaking over.*

names, ſuch as china white, ſilver white, azure white, or thread white. A ſolution of ſoap is prepared, the proper ſtrength for which is determined, by its mode of frothing when agitated; for the china white, which ſhould have a ſlight tinge of red, a ſmall quantity of anotta is added, and the ſilk is ſhaken over in it, until it has acquired the deſired ſhade. To the other whites, more or leſs of a blue tinge is given, by adding a little blue to the ſolution of ſoap; though ſome had before been put into the *cuite*.

To prepare the azure, fine indigo is taken, and after being well waſhed two or three times in moderately warm water, it is ground fine in a mortar, and boiling water poured on it; it is then left to ſettle, and the liquor alone is employed, which retains only the moſt ſubtile parts; this is called azure. A ſmall quantity of the liquor of a freſh vat of indigo, may be ſubſtituted for azure.

At Lyons, where they make a more beautiful white than at Paris, no ſoap is uſed in the third operation; but after the ſecond, the ſilks are waſhed, fumigated with ſulphur, and azured with river water. In this method, it is of importance to employ very clear water.

When the ſilk has become very uniform, and

and has acquired the deſired ſhade, it is wrung out and dryed.

The white obtained by theſe means is not yet ſufficiently bright, for the ſilk intended for white ſtuffs; but muſt ſtill be expoſed to the vapour of ſulphur: this operation is deſcribed under the article ſulphur.

As ſoap ſeems to impair the luſtre of ſilk, the academy of Lyons, in 1761, propoſed as the ſubject of a prize diſſertation, to find a method of ſcouring ſilks without ſoap; and the prize was adjudged to Mr. Rigaut, of St. Quentin, who propoſed ſubſtituting for ſoap, a ſolution of ſoda, or carbonat of ſoda, ſo much diluted with water as not to injure the ſilk; but ſome inconvenience muſt have attended the practice of this method, as it is not adopted, though generally known and eaſy of execution.

The Abbé Collomb [d] has publiſhed ſome obſervations highly worthy of attention, reſpecting the ſcouring of ſilk by the action of water alone. Having perceived that a ſkein of yellow ſilk, which he had boiled for about three hours in common water, had loſt nearly one eighth of its weight, he repeated the boiling twice, and

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[d] Obſervations ſur la diſſolution du vernis de la ſoie. Journ. de Phyſ. Août, 1785.

thereby brought the diminution to nearly one quarter.

The ſilk which has ſuffered this loſs of weight, ſtill retains a yellow or rather chamois colour, which renders it unfit for white ſtuffs, or for ſuch as are intended to receive any colour, the beauty of which depends on the whiteneſs of the ground, upon which it is applied; but it takes thoſe colours very well which cannot be injured by the tinge it retains; thus the black which it took, ſeemed preferable to that of ſilk ſcoured with ſoap.

The ſilk remains very firm and ſtrong after this operation, the threads of it, compared with ſimilar ones ſcoured with ſoap, ſupported weights which broke the others.

Eight hours of briſk ebullition are required, to diſſolve the whole gummy coat of ſilk, and it thereby loſes a little more than one fourth of its weight; but the boiling ought to be continued longer, when the barometer is low, becauſe the greater the weight of the atmoſphere, the higher is the degree of heat at which water boils.

This conſideration led Mr. Collomb to try the effect of boiling ſilk in Papin's digeſter, and he found that only one hour and a quarter were required, to complete the ſolution of the gummy coat, although the degree of heat muſt have been inferior to that, which produced many of thoſe effects obſerved by philoſophers, in that concentrated kind of ebullition.

I have ſeen a pattern of ſilk ſtuff ſcoured by Mr. Collomb; it ſeemed to have the qualities which he mentions; but it had leſs ſuppleneſs and ſoftneſs than ſilk ſcoured with ſoap.

Mr. le Camus, a learned naturaliſt of the academy of Lyons, gave me a ſmall quantity of the ſubſtance ſeparated from ſilk by the water, in one of Mr. Collomb's operations; it was black, brittle, and of a ſhining fracture, and afforded by diſtillation the uſual products of animal ſubſtances; it diſſolved eaſily in warm water, and left very little reſiduum on the filtre; the ſolution which is tranſparent and of a greeniſh yellow colour, was not ſenſibly affected by acids or alkalis.

Solution of alum produced in it, a dirty white precipitate; that of copper, a dark brown precipitate; that of ſulphat of iron, a brown precipitate; nitro muriatic ſolution of tin (ſolution of tin in aqua regia) a white precipitate; acetite of lead, a brown precipitate. All theſe precipitates are in ſmall quantity, and more or leſs viſcous. The infuſion of galls and that of ſumach, produce a white precipitate.

Alcohol does not diſſolve this ſubſtance even by ebullition, taking up only a yellow colouring matter; this ſolution by evaporation, afforded a reſiduum of ſcales of an amber yellow.

I added ſome drops of muriatic acid to nearly two ounces of alcohol, and boiled it on twenty grains of the ſilk gum, a ſolution took place, but on cooling, this ſubſtance put on the appearance of jelly.

The ſubſtance taken from the ſilk in the ſcouring then, appears to be of an animal nature, and therefore, the ſoap ſuds uſed in that operation ſoon become putrid; when ſeparated from the ſilk, it is eaſily diſſolved in water, but not in alcohol. Though not of a vegetable nature, it may with conſiderable propriety be called a gum. That part which gives it the yellow colour is ſoluble in alcohol, and when it is ſeparated, the gum becomes brown. It is not improbable that this colour is occaſioned by the heat to which it is expoſed in the boiling, becauſe, when only the yellow colouring part is ſeparated by Mr. Beaume's proceſs, which I ſhall preſently deſcribe, the ſilk is whitened.

In

In Mr. Collomb's proceſs, the gum is ſeparated, and takes with it only ſome of the colouring particles; and in the proceſs of ſcouring by ſoap, the gum and the yellow colouring particles are carried off together.

I boiled ſome yellow ſilk in a retort, where as the vapours did not eſcape ſo freely as from an open veſſel, a degree of heat muſt have been produced, ſuperior to that of water boiling in the open air. After having been boiled for four hours, the ſilk had loſt one fourth of its weight, but it had almoſt entirely retained its colour.

I boiled another pattern in the ſame way, in a quantity of water impregnated with common ſalt, it became whiter, but loſt leſs of its weight, though the degree of heat was certainly increaſed by the addition of the ſalt, which reſtrained the evaporation of the water; poſſibly, a part of the ſalt had united with the ſilk. Experiments might be made with other ſalts, and perhaps we ſhould find ſome, that, without injuring the ſilk, might be more uſeful in diſſolving the gum and colouring particles.

When ſilk is intended for the manufacture of blonds and gauzes, its natural elaſticity and ſtiffneſs ſhould be preſerved; the greateſt part of what is produced in theſe climates, is of a yellow colour, but it is the white china ſilk that is principally uſed for theſe purpoſes; this is ſo dear, that our manufacturers cannot vie with the Engliſh, from whom we get it, as they always reſerve the fineſt for their own manufactures; it has therefore been a deſideratum, to find out the means of depriving the yellow ſilk of its colouring particles, without deſtroying the gum, and thereby depriving the ſilk of its elaſticity. Mr. Beaumé has ſolved this intereſting problem, but has kept his proceſs ſecret: ſome artiſts however, to whom he intruſted it, or who had been led to the diſcovery by their own obſervations, ſucceeded in the execution of it; but the proceſs appears to be liable to accidents, which by occaſioning loſs, increaſe expence, ſo that hitherto, notwithſtanding the advantages it preſents, it has not been carried into execution. I ſhall communicate what has tranſpired reſpecting it.

A mixture is made with a ſmall quantity of marine acid and alcohol, in which the ſilk is immerſed; the marine acid muſt be pure, and not contain any nitric acid, which makes the ſilk yellow. To give it an uniform white colour ſeems to be one of the moſt difficult parts of the proceſs, eſpecially when we operate on large quantities. There is likewiſe great difficulty in dyeing the whitened ſilk, ſo as to prevent its curling, it ought certainly to be kept conſtantly ſtretched during the drying. The alcohol that has been impregnated with the colouring part, muſt be again ſeparated from it, ſo as to ſerve for ſubſequent operations, otherwiſe the proceſs would be too expenſive; for this purpoſe it is to be diſtilled by a gentle heat, in a glaſs or ſtone ware veſſel.

It appears from the experiments above related, that the marine acid is uſeful in this proceſs, by ſoftening the gum, and thus aſſiſting the alcohol to diſſolve the colouring particles combined with it.

The preparation with alum muſt be conſidered as one of the general operations in dyeing ſilk, for without aluming, the greateſt part of the colours applied, would poſſeſs neither beauty nor durability.

The preparation with alum conſiſts in mixing in a tun or vat, about forty or fifty pails of water with forty or fifty pounds of roman alum, that has been previouſly diſſolved in warm water; this muſt be carefully ſtirred during the mixture, to prevent the cryſtallization of the alum.

After having waſhed and beetled the ſilk, and wrung it out with the jack and pin[e], in order to ſeparate any ſoap it may have retained, it is immerſed in the alum liquor, where it is left for eight or nine hours, after which, it is wrung out by hand, over the vat, and waſhed in a ſtream of water.

In the above quantity of liquor, one hundred and fifty pounds of ſilk may be prepared, without the addition of any more alum, but when it begins to grow weak, which thoſe who are in the habit of employing it, can eaſily diſtinguiſh by the taſte, twenty or twenty-five pounds of diſſolved alum muſt be added as before, and this addition muſt be repeated, until the liquor acquires a diſagreeable ſmell; and then, it may be employed in the preparation of ſtuffs intended for darker colours, ſuch as browns and marones, till it has loſt all its ſtrength.

The preparation of ſilk with alum is always made in the cold, becauſe when the liquor is

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[e] This is a contrivance for wringing more ſtrongly, than can be done by the hands alone; the pin introduced through the hank at one end, or into a twiſt of the cloth, is ſecured in a fixed poſition, while the other end or twiſt is fixed to the hook of the jack, which can be forcibly turned round by means of a winch connected with it. When this degree of force is not neceſſary, and the hands only are employed in the operation, it is called *wringing out by hand*. T.

employed hot, the luſtre of the ſilk is liable to be impaired.

ARTICLE IV.

Of Cotton.

COTTON is the down or wool contained in the pods of a tree or ſhrub[f] which grows in warm climates. This down is ſeparated from the ſeeds, which it covers, by a kind of mill.

Climate has great influence on the qualities of cotton, and the ſpecies of the cotton tree ſeem to differ according to the heat of the country in which they grow[g]; great variety of them are found in the american iſlands, but it appears from Mr. Bennet's account[h], that the

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[f] Of the four ſpecies of the cotton plant (Goſſypium) only one is perennial, and therefore called the *arboreum* which grows to ſix or eight feet high. That from which our cotton is commonly got is the *herbaceum*, Lin. which grows only to about two feet in height. The third is the *hirſutum* or hairy american cotton, two or three feet high. The fourth is the *Barbadenſe* or Barbadoes ſhrubby cotton, which riſes to four feet. Theſe three are all annual plants. T.

[g] Eſſai ſur les caracteres qui diſtinguent les cotons des diverſes parties du monde, &c. par M. Quatremere Diſjonval.

[h] Tranſactions of the ſociety inſtituted at London for the encouragement of arts, manufactures, and commerce, vol. i.

inhabitants have hitherto neglected to chooſe thoſe ſpecies, which would be found moſt advantageous, and have thus loſt much of the benefit, that might be derived from this valuable article.

Cottons differ principally in the length of the filaments, their fineneſs, their ſtrength and colour.

Cotton is of different ſhades from a deep yellow to a white; the darkeſt coloured comes from Siam and Bengal, and is often made into ſtuffs without changing its natural colour. The moſt beautiful is not always the whiteſt, it is neceſſary to bleach it, by proceſſes ſimilar to thoſe employed in the bleaching of linen. The operations neceſſary however in bleaching cotton, are leſs various, and more expeditious, than thoſe for bleaching linen. Inſtead of theſe operations, we may employ oxygenated marine acid, and with the aſſiſtance of time[i] we can thus produce a more beautiful white, than by the ordinary way of bleaching, and the cotton afterwards appears better fitted for the reception of a fine colour in dyeing, as Mr. Decroiſille has obſerved. I have ſucceeded in bleaching the yellow cotton of St. Domingo, which has been prohibited on ac-

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[i] Annal. de Chymie. tom. ii.

count of its bad colour, which it ſo obſtinately retains.

In order to diſpoſe cotton to receive the dye, it muſt undergo an operation called ſcouring. Some boil it in ſour water*, but more frequently alkaline ley is uſed, the cotton muſt be boiled in it for two hours, and then wrung out, after which it muſt be rinſed in a ſtream of water, till the water comes off clear, and then dried.

The cotton ſtuffs which are to be prepared, muſt be ſoaked for ſome time in water, mixed with at moſt one fiftieth of ſulphuric acid, after which they muſt be carefully waſhed in a ſtream of water and dried. I have obſerved that the acid which had been uſed in this operation, had taken up a quantity of calcareous earth and iron, which would have injured the colours.

We may conſider aluming and galling as operations generally employed in the dyeing of cotton and linen.

In the preparation with alum, about four ounces of it are required to each pound of ſtuff, it muſt be diſſolved with the precautions mentioned in the preceding article, and ſome add a ſolution of ſoda in the proportion of one ſixteenth of the alum, others a ſmall quantity of tartar and arſenic. The thread is well

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* Vid. chap. xii. ſect. iii. vol. i. T.

impregnated by working it pound by pound in this ſolution, it is then put altogether into a veſſel, and what remains of the liquor is poured upon it; this is left for twenty-four hours, and then removed to a ſtream of water, where it is ſuffered to remain for an hour and an half or two hours, in order to extract a part of the alum, and it is then waſhed. I have ſound that cotton gains about one fortieth of its weight in this operation.

In the operation of galling, different quantities of galls or other aſtringents are employed, according to the quality of the aſtringents, or the effect deſired.

The galls powdered, are boiled for about two hours, in a quantity of water proportioned to that of the thread to be galled; the liquor is then ſuffered to cool to a temperature which the hand can ſupport, after which it is divided into a number of equal parts, that the thread may be wrought pound by pound, and what remains after the operation, is poured upon the whole together, as before deſcribed in the proceſs of aluming. It is then left for twenty-four hours, eſpecially when intended for maddering for black, but for other colours twelve or fifteen hours are ſufficient. After this it is to be wrung out and dried.

When

When ſtuffs are galled which have already received a colour, the operation muſt be performed in the cold, that the colour may not be injured.

I have found that cotton which has been alumed, acquired more weight in the galling, than that which had not undergone that proceſs; although alum adheres but in ſmall quantity to cotton, it communicates to it a greater power of combining, both with the aſtringent principle and with the colouring particles.

ARTICLE V.

Of Flax.

AS flax and hemp poſſeſs the ſame properties ſo far as relates to dyeing, we have generally made no diſtinction between them in this work.

If cotton be an important object for the exerciſe of our induſtry, flax and hemp are of ſtill greater conſequence, both as they are the product of our own country, and as they afford a ſource of very extenſive employment to the lower orders of the community. The manufacture is extended to all parts of the country, and is divided into various branches, from that of the ſtrongeſt cordage, to the fineſt kind of thread; it is a means of collecting together the families of the peaſants in the intervals of more laborious employment, and thus gives them ſome ſhare in the enjoyments of ſociety; it affords an eaſy occupation for infancy and age, which may inure the former to habits of induſtry, and afford a relief to the latter.

As we are at preſent paying ſo much attention to the draining of marſhes, and as the number of ſmall tenures is likely to be increaſed, it is of ſome conſequence to obſerve, that marſhy grounds which have been drained, are the beſt calculated for the culture of hemp, and that this is a kind of produce that would be found particularly convenient to the inferior farmers [k].

Flax muſt undergo ſeveral preparations before it is in a proper ſtate to receive the dye; the firſt is the watering, by which the fibrous parts of the plant become diſpoſed to ſeparate, ſo as to be rendered fit for ſpinning. The watering is an operation of ſo much conſequence, from its influence on the quality and quantity of the product, and from its deleterious effects

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[k] Inſtruction familiere ſur la culture & le roui du chanvre, a l'uſage des gens de la campagne; par M. de Pertuis.

on the air, that it appears proper that I ſhould give ſome information reſpecting the place in which it ought to be conducted.

In the watering, a glutinous juice which holds the green colouring part of the plant in ſolution, and which is the medium of union between its cortical and ligneous parts, undergoes a greater or leſs degree of putrefaction, according to the mode of conducting the operation; this appears from the extrication of carbonic acid and inflammable gas, which Mr. Roſier[1] has obſerved to take place.

This ſubſtance appears greatly to reſemble the glutinous part, that is held diſſolved in the juice we get from green plants by preſſure, which is ſeparated along with the colouring particles by a heat approaching to that of ebullition, which becomes putrid, and which affords ammoniac by diſtillation: but though this ſubſtance is held in ſolution in the expreſſed juice of plants, it is probable however, that water alone cannot ſufficiently ſeparate it from the cortical parts; whence it happens, that the hemp which has been watered in too ſtrong a current, is deficient in ſuppleneſs and ſoftneſs.

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[1] Eſſai ſur la culture & le rouiſſage du chanvre; par M. l'abbé Roſier.

If,

If, on the contrary, the water employed in this operation be ſtagnant and putrid, the hemp acquires a brown colour, but more eſpecially loſes its firmneſs, and exhales very pernicious vapours.

It appears then that this proceſs is performed to the greateſt advantage, in watering pits ſituated on the banks of rivers, where the water may be changed often enough to prevent a putrefaction, that would injure the hemp, and be prejudicial to the workmen; yet not ſo often, as to hinder the degree of putrefaction neceſſary for rendering the glutinous ſubſtance ſoluble in water.

Mr. Roſier has found that the operation went on when the hemp was covered with a layer of earth, and he recommends that method. Mr. Prozet[m] has propoſed the mixing a ſmall quantity of cauſtic alkali with the water, with a view of increaſing its ſolvent power, and preventing putrefaction; but it appears from Dr. Home's experiments, that the alkali retards the operation, and renders the flax liable to break[n].

During the watering of the flax, and the degree of drying it may have undergone both

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[m] Mem. ſur le rouiſſage du chanvre.

[n] Eſſay on the bleaching of linen, pag. 370.

before and after, its green colouring particles ſuffer a change, ſimilar to what we obſerve in the green ſubſtance of plants expoſed to the action of air, and the influence of light.

Their colour changes to a yellow, fawn colour, and even becomes brown, from that combuſtion, the theory of which I have given in the firſt ſection. A great part is then ſoluble in alkalis without requiring a higher degree of oxygenation, ſo that, by treating the dreſſed flax with an alkaline ſolution, we can deprive it of a conſiderable portion of the colouring matter, which perhaps remains combined with a part of the gluten. The proceſſes publiſhed by the prince of S. Séver for obtaining fine dreſſed hemp, depends on a ſolution of theſe colouring particles *. He directs us to lixiviate the dreſſed hemp in a ſolution of two parts of ſoda, and one of lime, then to impregnate it with ſoap and keep it in digeſtion, to waſh it well and afterwards to hackle it.

I have endeavoured to whiten dreſſed hemp completely, by the method I employed for thread, but though we ſhould expect that its filaments would by this means loſe but little of their firmneſs, yet they become ſo much diſpoſed to ſplit, and ſeparate from each other,

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* Journ. de Phyſ. introd. tom. ii.

that they would prove much more difficult to twiſt, and would give a much weaker thread. I have made experiments on dreſſed hemp prepared in the prince de S. Séver's method, and on ſome prepared in the ordinary way, with a view of comparing the proceſſes; the firſt afforded a greater proportion of tow, and the thread produced from it, was not better in appearance than that of the ſecond, after it had been leyed; the firſt was alſo leſs firm, but it poſſeſſed one advantage which merits attention, that in the hackling, it did not produce that duſt which is ſo pernicious to the workmen.

The beauty which may be communicated to dreſſed hemp by leying before it is wrought, does not appear to poſſeſs the advantages, which its appearance might lead us to expect, ſince by this means, we diſſolve only that portion of the colouring matter, which would have been carried off by the firſt leys uſed in the beginning of the bleaching of the cloth. The great fineneſs given it, probably cannot be produced, but at the expence of the length and firmneſs of the filaments.

A clergyman of the department of Somme, has rendered his miniſtry reſpectable, by directing his attention to an object with which the

the public happineſs is very nearly connected. Mr. Brâle has eſtabliſhed near Amiens, a kind of public ſchool, in which he examines the methods employed in the culture of hemp, both with reſpect to the watering, and the dreſſing with a view of ſelecting the beſt, and rendering them as complete as poſſible [p].

He employs a proceſs, which probably is not liable to the inconveniences occaſioned by leying the dreſſed hemp; he waters the hemp as ſoon as pulled, and he ſeparates the cortical part by a peculiar kind of operation immediately after the watering, and having ſoaked it in a weak ſolution of black ſoap, he waſhes it with great care; previous to the drying, the colouring particles which would have afterwards been ſoluble only in alkalis, may be diſſolved and extracted by water, with the addition of a ſmall quantity of ſoap, the hemp becomes much whiter and divides better and more minutely without however being injured; and the leys preparatory to the bleaching become unneceſſary.

Common thread and the linen made of it, contain then a colouring ſubſtance which may

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[p] Analyſe pratique ſur la culture & la manipulation du chanvre.

be extracted by ſimple leys, but there is likewiſe a part of this ſubſtance, which is really combined with the vegetable fibres, and which cannot be taken away except by the deſtruction of its nature, by the combuſtion it undergoes during its combination with oxygen, as I have explained in the firſt ſection, Chap. III. thread loſes by the operations employed in bleaching, from $\frac{1}{4}$ to $\frac{1}{3}$ of its weight.

Flax intended to be dyed, muſt be ſubjected to the operations which cotton undergoes, in the ſcouring, aluming, and galling.

CHAP. II.

Of Dye-Houſes, and the Operations employed in the Art of Dyeing.

WHEN we conſider it as a general principle, that works carried on in a great manufactory are more advantageous, than thoſe conducted in a detached manner, the ſubdiviſion of employment affording an opportunity for each workman, by being engaged by one object, of acquiring celerity and perfection of of execution, the whole being ordered with one general view, and carried on in all its parts without loſs of time; this principle muſt be conſidered as peculiarly applicable to the art of dyeing, becauſe what remains after one operation may often ſerve for another. A bath which has been too much weakened for a particular colour, or even for the lighter ſhades of that colour (ſuites) may be found ſerviceable, by affording a ground for other ſtuffs, or forming a new bath by the addition of freſh ingredients. The galls that have been employed in the galling of ſilk, may be uſeful in other operations, on wool or cotton; a great number of inſtances of the ſame kind might be enumerated.

It would be eaſy by conſiderations of this kind to prove, that the progreſs of the art of dyeing is very much impeded, by its diviſion into two branches, one comprehending the good or durable dyes, the other, the falſe or fading colours, by the claſſification of dyers as they work in ſilk, wool, or thread, and by the regulations which forbid one claſs to keep the ingredients deſtined for the uſe of the other. We ought, I think, on the contrary, to encourage extenſive works in dyeing; and thoſe who direct them, ought to lay down a plan of operations which might connect the whole, and prevent all loſs of ingredients, of time, of fuel, and of work; and this plan ought to be regulated by the ſuppoſed demands of trade.

A dye-houſe ſhould be ſpacious, well lighted, and as near as poſſible to a ſtream of water; it ought to be floored with lime and plaſter *(ciment)* and channels ſhould be made for carrying off water, or ſpent baths; and the whole ſhould be contrived with the ſtricteſt attention to cleanlineſs.

The caldrons, the ſize and poſition of which are to be regulated by the operations for which they are deſigned, ſhould be made of braſs or copper, unleſs for ſcarlet, in the preparation of which, it is better to uſe tin veſſels, as well as for other delicate colours in which a ſolution of tin is employed. Braſs is leſs liable to be acted upon by ſaline ſubſtances, and to ſpot the ſtuffs than copper. It is of great conſequence that the caldrons or coppers be well cleaned after each operation; and thoſe of a large ſize, ought to have at the bottom a pipe with a cock, for the purpoſe of emptying them. Above each copper, a hole ſhould be made in the chimney, or in the wall, for the reception of poles, for draining the ſkeins of wool or ſilk, as well as ſtuffs, ſo that the liquor may fall back again into the copper.

For

For the pieces of ſtuff, a winch or reel is uſed, the ends of which are placed on two iron forks, which may be put at pleaſure into the holes made in the curb which ſupports the edges of the coppers.

Many dyes for ſilk, where a boiling heat is not required, are prepared in long copper or wooden veſſels, called troughs or backs.

As the greateſt parts of the colours uſed for ſilk are very delicate, they require to be quickly dried, that they may not change. For this purpoſe, a drying room is neceſſary, conſiſting of a chamber heated by means of a ſtove; the ſilk is ſtretched on a moveable pole, called a ſhaker, which is hung up, and kept continually in motion, in order to haſten the drying.

It would be neceſſary to enter into a very minute detail, if I undertook to deſcribe every thing neceſſary in the conſtruction of a dye-houſe; more accurate ideas may be at once gained by inſpection, than the moſt laboured deſcription could convey; beſides, the diſpoſition of a dye-houſe, muſt bear a relation to the operations for which it is intended, and ſhould be ſo conſtructed, that thoſe operations may beſt ſucceed.

But it is to be wiſhed, both for the progreſs of the art, and even of ſcience, that a little place ſhould be reſerved for keeping an apparatus for the common experiments in chemiſtry, as well as for particular experiments relative to dyeing.

The manipulations in dyeing, are neither difficult nor complicated, their object is, to impregnate the ſtuff to be dyed with the colouring particles diſſolved in the bath; to cauſe the action of the air to concur, both in fixing the colouring particles, and in giving them brightneſs, and carefully to remove ſuch as have not been fixed in the ſtuff.

I ſhall content myſelf with giving a deſcription of the moſt common.

When whole pieces of ſtuff, and even many of theſe, are to be dyed at once, the winch above deſcribed muſt be uſed. One end of the ſtuff being firſt laid acroſs it, by turning it round pretty quickly, the whole paſſes over it in ſucceſſion. It is then to be turned the contrary way; ſo that the part of the ſtuff firſt immerſed, may be the laſt in the ſecond immerſion, and thus the dyeing be as equal as poſſible. If the piece of ſtuff be of conſiderable length, or if ſeveral pieces are to be dyed of the ſame colour, the two ends are joined together, the winch then paſſed within, and put on the forks.

If wool is to be dyed in the fleece, a kind of broad ladder, with the rounds very cloſe[a], is to be placed over the copper, on which the wool is to be put, in order to be drained and aired, or when the bath is to be changed.

If the wool is in ſkeins, rods are to be paſſed through them, and the operation is the ſame as for ſilk or thread, it conſiſts in turning the hanks of ſilk, and the ſkeins of thread or wool, upon the ſkein ſticks in the liquor; this is called ſhaking over *(liſer)* and the rod is called *(liſoir)* ſkein ſtick.

When the ſilk or thread is dyed, it muſt be wrung out, in order to ſeparate the ſuperabundant colouring particles. This operation is performed with a cylindrical piece of wood, one end of which is fixed in the wall or in a poſt, and is called *(l' eſpart)*; when this operation is repeated ſeveral times ſucceſſively, for the purpoſe of drying and giving luſtre, it is called *(cheviller)*[b].

When a certain quantity of ingredients are added to a liquor, they ſay they give it a *(brevet)* and that they rake it, when they ſtir it about, and mix it with the rake.

Sometimes they give a firſt colour with an

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[a] Called by our dyers a ſcraw or ſcray. T.

[b] See a deſcription of the method employed by our dyers, page 144. T.

intention of applying another upon it; and thus making a compound colour, and then they are ſaid to give a ground *(donner un pied)*.

To rinſe, is to waſh a ſilk from the dye, or from the ley, in a ſmall quantity of water, and this they call rinſing *(diſbrodure)*.

When they are under the neceſſity of paſſing a ſtuff ſeveral times through the ſame liquor, each particular operation is called a dip *(paſſe)*.

A colour is ſaid to be roſed *(roſé)* when the yellow tinge of a red colour is changed to a ſhade inclining to a crimſon or ruby colour, and when they change a yellow red to a more complete red, they are ſaid *(virer une couleur)*.

Although the manipulations of dyeing are not very various, and appear extremely ſimple, they require very particular attention and an experienced eye; in order to judge of the qualities of the bath, to produce and ſuſtain the degree of heat ſuited to each operation, to avoid all circumſtances that might occaſion inequalities of colour, to judge accurately, whether the ſhade of what comes out of the bath ſuits the pattern, and to eſtabliſh the proper gradation in a ſeries of ſhades.

I do not mean to ſpeak of the management of the vats, nor, above all, of the compoſition of colours, in which the art principally conſiſts, and

and where nice combinations are frequently required.

CHAP. III.

Of Fuel.

AS fuel is a principal article of expence in dyeing, it is of great importance to diminiſh the conſumption of it as much as poſſible, and to ſelect that which may produce the deſired effect, with the leaſt poſſible expence; it is proper therefore to diffuſe the knowledge of the philoſophical principles of the production of heat by combuſtion, and of the powers which influence its communication, in order that they may be applied as circumſtances require.

When bodies are burnt, none of their principles are deſtroyed; they had previouſly formed together one kind of compound, and they now ſeparate from each other, at the high temperature to which they are expoſed, in order to form others with the vital air in contact with them: ſuch of the principles as cannot unite with the vital air, that is the earth, ſome ſaline and

and ſome metallic particles compoſe the cinder.

The new compounds formed, are carbonic acid, or fixed air, and water: the proportion of theſe varies according to the proportion of the carbonic particles, and of the hydrogen or baſis of inflammable gas, that had been contained in the inflammable body. Let us take common charcoal as an example.

If we burn a hundred grains of charcoal in a glaſs bell inverted over mercury, after the combuſtion, we find a quantity of carbonic acid, equal in weight to that of the coal conſumed, and of the vital air changed. One hundred parts of this newly formed acid contain ſixty-two of oxygen, or baſe of vital air, and twenty-eight of charcoal *(charbon)*; a ſmall quantity of water is alſo formed, which is diſſolved in the carbonic acid, and the vital air likewiſe holds a little of it in ſolution. As theſe quantities are not known, the above eſtimate cannot be conſidered as perfectly accurate.

If we burn alcohol or ſpirit of wine, we have a reſult conſiderably different; we obtain a quantity of water greater in weight than the ſpirit of wine, becauſe the inflammable principle of the alcohol is chiefly hydrogen: now hydrogen forms water, by combining with oxygen,

or

or the baſis of vital air; for the ſame reaſon alſo, oil affords a great quantity of water. We may conſider charcoal and alcohol, or rather ether, as the two extremes; the former affording by combuſtion, ſcarce any thing but carbonic acid, and the latter water; and other combuſtibles we may conſider as intermediate, approaching one or other of theſe extremes, in a greater or leſs degree, according to their compoſition.

While the hydrogen and carbon combine with the vital air, which forms about one-fourth of the atmoſphere, the caloric, or principle of heat, which was united with the vital air, and which gave it its elaſtic form, is in a great meaſure diſengaged; perhaps, there is alſo extricated from it a portion of carbon, and above all of hydrogen, which was contained in the combuſtible body; ſuch is the origin of the heat produced in combuſtion [a].

Thoſe

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[a] Although the theory of heat has been conſiderably improved lately, and has been the ſubject of many ingenious diſquiſitions, we ſhall always, perhaps, be obliged to conſider the principles received reſpecting its nature and combinations, as ſuppoſitions only, by means of which we may be able to connect the phenomena it preſents, and explain the laws by which it is governed.

When we conſider vital air as the ſource of the heat diſengaged

Thoſe who wiſh to be more particularly acquainted with the experiments of which we have

gaged in combuſtion, we do not mean to ſay, that the burning body does not itſelf contribute to the production of that heat, though by fixing our attention on the principal cauſe of the phenomenon, we are ſometimes apt to content ourſelves with mentioning it alone. The whole theory (which has met with ſome oppoſition) contradicts ſuch a ſuppoſition: but if we obſerve, that in combuſtion accompanied with flame, the vital air loſes its elaſtic ſtate in a greater or leſs degree, while the burning body, ſo far from being diminiſhed in bulk, enters into a combination which increaſes it; and if we conſider, that the heat diſengaged, is proportioned to the quantity of vital air combined, and that in thoſe caſes, where little heat is produced by the combination of oxygen, a great deal may afterwards be extricated from the compound, as we ſee in the caſe of nitre, and oxygenated muriat of pot-aſh; we muſt acknowledge, that this theory is at leaſt probable and ſatisfactory.

Among the bodies which moſt powerfully contribute to the production of heat, hydrogenous gas ought certainly to hold the firſt rank; now the theory which aſcribes to vital air principally, the heat diſengaged in combuſtion, affords in like manner an explanation of the heat produced by this gas; though ſome, by a falſe application of Dr. Crawford's experiments, have thence deduced an objection, which they have propoſed with a degree of inſolent diſdain.

I ſhall not here examine whether Dr. Crawford's hypotheſis ought to be admitted or not. He endeavours * to prove, that the heat diſengaged in combuſtion, ought to be attributed to a change of capacity for heat in the burning bodies,

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* On animal heat, &c.

have juſt given a ſlight ſketch, and with the theory of combuſtion at large, ſhould conſult ſeveral memoirs of Mr. Lavoiſier, in the tranſactions of the academy of ſciences, and his

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bodies, as appears by comparing the capacity of the body before it is burnt, with the capacity of its reſiduum after combuſtion. Dr. Crawford has found, it is ſaid, that hydrogenous gas contains five times as much ſpecific heat as vital air; it ought therefore to contribute much more to combuſtion than vital air; the heat therefore diſengaged in combuſtion, proceeds principally from the burning body, and not from the vital air.

According to Dr. Crawford, there are two ways of aſcertaining the ſpecific heat of bodies, by comparing the ſubjects of experiment, by bulk or by weight. Dr. Crawford has adopted the latter, which perhaps is more fallacious and more inconvenient than the former. It is in this way then, that we muſt compare the weights of the oxygenous and hydrogenous gaſes, which combine in combuſtion, in order to determine the quantity of heat diſengaged from each in proportion to their ſpecific heat. We muſt therefore take eighty-five parts of oxygen to fifteen of hydrogen. The quantity of heat then diſengaged from vital air or oxygenous gas, ought to be to that produced by hydrogenous gas, as eighty-five to ſeventy-five, or as ſeventeen to fifteen.

But what ſtill increaſes the proportion of the heat produced by vital air, according to Dr. Crawford, is, that the ſpecific heat of hydrogenous gas is not five times greater than that of vital air, but only, as 21,4000 to 47,490, and that not ſo much as fifteen parts of hydrogen are required to eighty-five of vital air.

elements

elements of chemiſtry, for to him we are principally indebted for this beautiful theory [b].

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[b] In juſtice to my friend Dr. Crawford, I think it my duty to give the reader a ſhort account of the diſcoveries reſpecting heat, to which the author alludes, and to ſupply a few dates, the accuracy of which I can anſwer for from my own knowledge: with theſe dates, it is not ſurpriſing that the ingenious author ſhould have been unacquainted, as notwithſtanding the high character of Dr. Crawford's work, it has not yet been tranſlated into French, and ſome of them indeed are not contained in the work itſelf.

The firſt in the order of theſe diſcoveries, are thoſe of Dr. Black, made in the year 1759, by which it was proved, that ice during its converſion into water, and water during its converſion into vapour, abſorbed a large quantity of heat, or elementary fire; hence it was concluded, that other bodies, when they became fluid, and in their converſion into vapour, abſorbed heat. Theſe diſcoveries and inferences form what is called the doctrine of latent heat. The ſame philoſopher proved by experiments on metals, that bodies of different kinds have different capacities for containing heat. Dr. Irvine diſcovered by a ſeries of experiments made prior to the year 1777, that, when bodies give off heat, in conſequence of a change of form, their capacities for heat are diminiſhed, and that the reverſe of this takes place, when they abſorb heat.

In the ſpring of the year 1777, Dr. Crawford inſtituted a ſeries of experiments, with a view to diſcover the cauſe of animal heat. In the courſe of his inquiry, he found, that blood contains a much greater quantity of fire, or of abſolute heat, than the elementary ſubſtances of which it is compoſed: hence he inferred, that this fluid muſt neceſſarily attract heat from the air, in the proceſs of reſpiration:

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In order to obtain the greateſt poſſible effect from any combuſtible body, it is neceſſary that all

the pure air of the atmoſphere muſt therefore contain more heat, than the fixt air into which it is converted during that proceſs; and as it was well known, that the change produced in the air by the inflammation of combuſtible bodies, was in a variety of reſpects, ſimilar to that which it underwent in reſpiration, he ſuppoſed, that the evolution of heat from pure air, was the cauſe, not only of animal heat, but likewiſe of that of combuſtion. This ſuppoſition was afterwards confirmed, in the ſummer of the ſame year, by experiments made to determine the comparative heats of ſulphur and oil of vitriol, of metals and their calces.

Hence it appears, that ſo early as the ſummer of the year 1777, the theory of animal heat and of combuſtion, which is now generally received over Europe, was eſtabliſhed by Dr. Crawford, as an inference derived from fact and experiment.

This diſcovery he communicated to his friends at the univerſity of Glaſgow, where he then reſided. In the autumn of the year 1777, it was publickly known at Edinburgh; and in the courſe of the winter, it was explained to a numerous aſſembly of the ſtudents in the royal medical ſociety.

We are told indeed, that Mr. Lavoiſier propoſed as a conjecture, a theory nearly ſimilar to Dr. Crawford's, in a paper which is ſaid to have been read before the academy of ſciences at Paris in the year 1777; but we do not find any account of this theory in the tranſactions of the academy, till the year 1780. Admitting, however, that Mr. Lavoiſier's conjecture was coeval with Dr. Crawford's experiments, it cannot be affirmed with propriety, that he all the parts of it, which are capable of combining with vital air, ſhould unite with it; it is conſequently neceſſary, that there ſhould be neither ſmoke nor ſoot, this is principally to be accompliſhed by properly proportioning the inferior opening of the furnace, the fire place, and the chimney.

The current of air which ſupports the combuſtion ought to have eaſy acceſs, but if the chimney be too large, the carbonic acid formed is not removed without ſome difficulty, it remains in contact with the fuel, and thus oppoſes its combuſtion. If the chimney be not ſufficiently high, a part of the hydrogen reduced to the form of vapour eſcapes without being burnt; as do alſo the coaly particles which form the ſoot, hence ariſes a diminution of the effect which the inflammable body ought to have produced. A higher column of air rarified and rendered lighter by heat, and the condenſation of the vapours of water and carbonic acid at the top of the chimney, would have concurred in producing a more rapid current of air. Theſe effects are more particularly obſervable in reverberatory furnaces, in which we eaſily ſee the importance of having the opening of the chimney properly proportioned

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is the diſcoverer of what he is only ſaid to have conjectured. T.

to the ſize of the furnace, the power of which is ſingularly increaſed by adding pipes of a certain length to the top. But too long a chimney occaſions another inconvenience which we ſhould be careful to avoid, for when the combuſtible parts which riſe, have time to cool below the degree of heat required for their combuſtion, they conſtitute a maſs, which by its weight impedes the circulation of the air.

Theſe conſiderations will appear minute to ſome, but they may be often productive of an œconomy that is too much neglected in the arts, in which heat is employed. An attention to the circumſtances of combuſtion merely, is not ſufficient, it is alſo neceſſary to endeavour to obtain all the advantage we can from the heat that is produced, ſo that the whole of what is diſengaged by combuſtion, may be as effectually as poſſible employed for the different purpoſes required.

There are ſome bodies which tranſmit heat eaſily, ſuch as metals, while others on the contrary conduct it ſlowly, and with difficulty, ſuch as glaſs, earthen ware, bricks, and particularly charcoal. On this property of charcoal, the celebrated Dr. Black, to whom we are principally indebted for our knowledge of the powers of heat, has conſtructed a well contrived furnace, which I think it right to deſcribe, as a model capable of a great variety of application.

The furnace is compoſed of plate-iron, which ſerves as a covering, coated internally with a compoſition of one part argillaceous earth, and four parts charcoal [e], of the thickneſs of from fifteen to ſixteen lines; and in order to prevent its being deſtroyed by the fire, it is covered with a coat of clay mixed with ſand, of about eight lines in thickneſs, and which is capable of reſiſting the action of the fire.

In the ſide of the aſh-pit, an opening is made, to which a plate of braſs is adapted, with eight holes of different diameters, to each of which is fitted a braſs ſtopper. The admiſſion of air by one or other of theſe holes produces a more or leſs powerful combuſtion, and in order to regulate it at pleaſure, we have only to employ a combuſtible of an uniform nature, which Dr. Black finds in the coke of certain kinds of pitcoal.

The charcoal coat of the furnace prevents the

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[e] The mixture which I have uſed, has conſiſted of nearly equal parts of charcoal duſt and pure pipe clay, in which the clay was in the larger proportion. I have not been able to make a mixture in which the charcoal duſt was in larger proportion adhere. T.

the loſs of heat, which is almoſt entirely employed in producing the effect we wiſh: the regulation of the heat by the mode of giving acceſs to the air, and the uniform nature of the combuſtible ſubſtance, enable us to calculate not only the duration and power of the fire employed in an operation, but even the quantity reſerved for every particular part of the operation.

A coating of charcoal might be applied to the indigo vats, inſtead of wrapping them up in cloths, and alſo, to veſſels in which we wiſh to preſerve for a long time the heat of any liquor, for this purpoſe an earthen or glaſs veſſel is preferable to a metallic one, which more eaſily tranſmits the heat to the ſurrounding air.

When water is reduced to vapour, it carries off a great quantity of heat, which it gives out on being again reſtored to its liquid form, we may therefore by covering a boiling caldron, ſave a great quantity of heat which might be employed for various purpoſes, and we might thus even procure a heat of an equable temperature, as in a water bath.

One might conſtruct either a ſand bath, which might be uſeful in many operations, or a ſucceſſion of caldrons which require different degrees of heat, by erecting a long furnace in ſuch a manner that the fire being placed at one end, the flame and heated air might be carried by a horizontal flue to the other extremity of the furnace, where the chimney is placed, through which the air eſcapes after having given off almoſt all its heat.

Even the heat communicated to the chimneys in ordinary furnaces ought not to be loſt, ſtoves and drying rooms might be placed in the ſituations through which the chimneys paſs; but inſtead of trying to retain the heat in theſe chimneys, as is proper in furnaces, we ought to endeavour on the contrary to rob them of it; thus the part which paſſes through the place we wiſh to heat, ought to be of metal; but we ſhould avoid carrying off the heat required for the inflammation of the combuſtible vapours.

After having given ſome idea of the phenomena of combuſtion, and pointed out the means of employing the heat produced to the beſt advantage, it remains that I ſhould conſider the different kinds of combuſtibles, in relation to the advantages they afford.

In order to compare the effect of different kinds of fuel, we may employ the method deſcribed by Mr. Lavoiſier[d]; this conſiſts in burning each ſpecies of fuel in the ſame furnace with a caldron adapted to it, into which a certain quantity of boiling water is put, and what evaporates, is gradually replaced in each operation, by an equal quantity ſupplied by a cock. The quantities of each fuel required for the evaporation of the ſame quantity of water are then compared. It is obvious, that the qualities of the fuel, are proportional to the quantity neceſſary for the production of the ſame effect, we have therefore only to compare the quantity of fuel employed in each operation, with the reſpective price of each, in order to determine which is moſt advantageous, and ought to be preferred. In this calculation, it is of no conſequence, whether we eſtimate the quantity of each fuel by weight or by meaſure, provided we know its price.

Inſtead of evaporating a given quantity of water, we ſhould obtain the reſult we want, by burning either the ſame weight, or the ſame meaſure of each ſpecies of fuel, and afterwards comparing the quantities of water evaporated.

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[d] Mem. de l'acad. 1781.

As the meaſure and weight of fuel ought to be compared with the price it bears, and as this varies conſiderably in different countries, we can arrive at no invariable determination reſpecting that which it is moſt advantageous to employ; in one place, it will be coal, in another, wood or turf: the relative prices of theſe ſubſtances may vary in a very ſhort time, by the opening of a canal, the working of a coal mine, or the deſtruction of woods.

Many artiſts entertain prejudices againſt the uſe of pitcoal, but it is ſufficient to remark, that it is at preſent uſed in ſo great a number of manufactories, without producing any inconvenience, that it may doubtleſs be ſubſtituted for other fuel; but as in proportion to its bulk it affords much more heat, it will be neceſſary to learn by practice how to moderate its effects.

The conſtruction of furnaces in which coal is to be uſed, ſhould be ſomewhat different from that of the furnaces in common uſe. As it does not eaſily inflame, it requires a grate which may afford a paſſage to a current of air.

Though it ſhould be proved by experience that no advantage would ariſe, in a particular country, by preferring coal to wood, ſtill it would be proper to recommend its uſe, becauſe it is very probable that the price of wood will continue to increaſe, and on the contrary, that that of coal will diminiſh, becauſe the working of coal mines will be encouraged, and more ſucceſsfully conducted, than has hitherto been the caſe in France, and becauſe we have reaſon to hope that the number of canals, which would facilitate its carriage, will be multiplied.

Pitcoal is reduced to the ſtate of a true charcoal, by an operation called cokeing, which is analogous to that employed in charring wood. This charcoal is of conſiderable advantage in the furnaces for ſmelting iron ore, for the pitcoal ſwells and runs together when ſtrongly heated, and thus chokes up the furnaces, inconveniences which do not attend it when reduced to coke; but for other uſes, it is better to employ it in its natural ſtate, becauſe all the bituminous oil which is burnt during the charring, is carried off without producing any effect, and beſides, the operation itſelf requires labour, which is attended with expence.

Peat may alſo be charred, but this operation preſents a difficulty which is not eaſily ſurmounted: when newly charred peat is expoſed to the air, it inflames ſpontaneouſly like pyrophorus; this inconvenience however may be prevented.

What has been ſaid on the ſubject of pitcoal is applicable to turf; whenever we can, it is better to employ it in its natural ſtate, than be ſubject to the expence of charring it, and at the ſame time of loſing all that is conſumed in that operation, which might have afforded heat.

CHAP. IV.

Of the Means of judging of the Goodneſs of a Colour.

AS there is a great difference in colours, with reſpect to their power of reſiſting the action of air and light; and as it is in this, that their durability and goodneſs chiefly conſiſt, independant of their brightneſs, it is of importance, in order to ſecure the public confidence in the manufacture, to be able by eaſy means, to determine the degree of goodneſs in a colour. Theſe means muſt have appeared of ſtill greater importance, when the rigour of laws impeded the progreſs of induſtry, and anxiouſly eſtabliſhed the diſtinction between the dyers of durable and of fading colours. By

By a whimſical effect of theſe regulations, a dyer of fading colours, might be liable to puniſhment for producing colours of too durable a nature.

I have but little to add to the remarks of Hellot; he informs us of the method employed by Dufay, whoſe obſervations laid the foundation of the regulations made on this ſubject, and examines them with conſiderable acuteneſs.

" As we have not been able exactly to
" aſcertain, either by the information of dif-
" ferent dyers, or by the peruſal of the old
" regulations, the preciſe diſtinction between
" the colours of the fading and the durable
" kind, we are under the neceſſity, with a view
" of gaining the knowledge we want, of adopt-
" ing a method, which though it is the moſt
" tedious and difficult, is yet the moſt certain,
" or indeed the only one upon which we can
" rely. The late Mr. Dufay of the royal
" academy of ſciences, who had been ſelected
" by government, as a perſon whoſe labours
" might greatly improve the art of dyeing,
" made experiments on the ſubject, by dyeing
" wool of all colours, and even with dyes of
" all ſorts, uſed either for durable or fading
" colours; he even ſent to the different pro-

vinces for ſuch as are not employed at Paris; and finally, he collected moſt of the different ſubſtances, which he conceived might be employed in the art, and tried a very great number of them, inveſtigating their good or bad qualities, without paying any regard to the prejudices of the dyers.

“ His firſt experiments were made on woollen yarn, but he afterwards uſed pieces of white cloth, which he found more ſuitable to his purpoſe.

“ With a view to know what colours were, and what were not durable and fading, he expoſed to the ſun and air, for twelve days, ſome patterns of all colours, which had been dyed in his own houſe with known compoſitions. It appears that this time was ſufficient for a trial of them, for the durable colours are not at all, or but little injured, while the fading ones are almoſt entirely obliterated; ſo that, after twelve days expoſure to the heat of the ſun, and the dampneſs of the night air in ſummer, there can be no doubt as to the claſs, in which each colour ſhould be placed.

“ But there ſtill remained a difficulty, which was this, that as all theſe colours had not been expoſed to the air, preciſely at the

“ ſame

" ſame time and in the ſame ſeaſon, ſome " might have had more ſun, and conſequently " might have ſuffered a greater change in the " twelve days, than others expoſed in more " cloudy weather, or when the days were " ſhorter. But he diſcovered a remedy for " this inconvenience, which removed all diffi- " culty and doubt as to the accuracy of the " experiments; he choſe one of the worſt " colours, that is, one on which the ſun had " produced the greateſt effect in twelve days. " This colour ſerved as a ſtandard in his expe- " riments, and whenever he expoſed patterns " to the air, he always expoſed a piece of this " ſtuff along with them; ſo that he did not " calculate by the number of days, but by " the colour of his ſtandard, always keeping " the pattern expoſed, till it had loſt as much " as that would have done, by twelve days " expoſure in ſummer. As he always noted " the day on which he expoſed his patterns, " he was led to obſerve, that in winter it was " only neceſſary to leave them four or five " days longer expoſed to the air than in ſum- " mer. By purſuing this method, he removed " all doubt as to the accuracy of his expe- " riments. In this trial by expoſure to the " air and to the rays of the ſun, he had a

" ſtill further object, which was, to find the " proper proof for each colour; what is called " proof *(deboulli* [a]*)* is the trial of a ſtuff with " a view to diſcover whether its dye be permanent " or not: a pattern is boiled with " alum, tartar, ſoap, vinegar, lemon juice, &c. " and its quality is judged of, by the effect " theſe ſubſtances produce. The proofs uſed " in 1733 were ſo inſufficient, that they did " not even aſſiſt Mr. Dufay in diſcovering " more certain ones, they even deſtroyed ſome " good colours, while they produced very " little effect upon the bad; ſo that he was " obliged to fix upon ſeveral, each of which " ſerves for a great number of colours. The " following is a ſhort deſcription of the method " he purſued, in order to diſcover them.

" After having obſerved the effect of air " on each colour, whether good or bad, he " tried the ſame ſtuff with different proofs, " and ſtopped when he found one which pro- " duced the ſame effect with the air; then " noting the weight of the ingredients, the " quantity of the water, and the length of the " trial, he was ſure to be able to produce on " a colour, an effect equal to that which the " air would have produced, ſuppoſing it had

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[a] Sometimes called by our artiſts *boiling*.

" been

" been dyed in the ſame way with his; that is, " according to the methods employed by the " dyers of true and falſe colours. Having thus " examined all the colours, and all the ingre- " dients employed in dyeing, he found out a " method, which may be conſidered as accu- " rate, of diſtinguiſhing the good or bad " qualities of each colour, by making, by " means of the proof, a ſort of analyſis of the " materials which compoſed it. We cannot " without injuſtice, refuſe to acknowledge, " that the means Mr. Dufay employed, in " the diſcovery of theſe proofs or teſts for " colour, are ingenious; for the trial by air " and ſun, cannot be made on thoſe, where it " is neceſſary to judge immediately, whether " a ſtuff expoſed to ſale at a fair or elſewhere, " as of a true dye, be really ſo or not.

" The proofs mentioned in the new regu- " lations, made in conſequence of Mr. Dufay's " memoirs, diſcharges in a few minutes, as " much of a colour, when it is not dyed of a " durable colour, as would be loſt by twelve or " fifteen days expoſure to the air. But as gene- " ral rules for ſuch trials muſt be liable to many " exceptions, which either cannot be foreſeen, " or though foreſeen, cannot be particularized, " without the riſk of cauſing confuſion, or of

" affording matter for innumerable diſputes, " it follows, that thoſe rules conſidered perhaps " as too general, are alſo too ſevere in many " caſes, wherein light colours require ſalts, " or quantities of ſalts, which ſhall be leſs " active than thoſe neceſſary for deep or " loaded colours *(chargées)*, which may allow " a conſiderable portion of their colouring " matter to be carried off by a proof, with- " out ſhewing any very viſible alteration. It " would therefore have been neceſſary, to " preſcribe a proof for almoſt every ſhade, " which from their infinite variety, would be " impoſſible. Thus the air and the ſun, will " always be the true teſt; and every colour " which is not changed by them, in a certain " length of time, or which, by expoſure, " acquires what the dyers call a body *(fond)* " ought to be conſidered as a ſtanding colour, " even though it ſhould be conſiderably " changed by the proofs preſcribed by the " new regulation. Of this we have an ex- " ample in ſcarlet; as ſoap almoſt entirely " diſcharges this colour, it has been ſubmitted " to the trial by alum; and when it has been " dyed with cochineal alone, without any " mixture of other ingredients, it ought to " aſſume a purple colour, in a boiling ſolution

“ of alum: if ſcarlet be expoſed to the ſun, it loſes ſome of its brightneſs, and becomes deeper; but this deep ſhade is not ſimilar to that imparted by alum. Proofs then, in certain caſes, cannot be ſubſtituted for the action of the air and ſun, at leaſt, ſo far as reſpects ſimilarity of effect.

“ By means of braſil wood, which like almoſt all the other woods loaded with colour, gives a fading dye, I prepared a red, which was much finer than the madder reds, and as bright as thoſe made with kermes; this red remained expoſed to the air for the two laſt months of the year 1740, which were very rainy, and for the two firſt of 1741: and notwithſtanding the rain and bad weather it ſtood, upon account of its peculiar preparation which will be mentioned in the proper place, and was ſo far from loſing, that it acquired body. Yet this ſame red which is ſo durable in the air, does not reſiſt the trial by tartar. Would it then be proper, to proſcribe this colour, becauſe that ſalt diſcharges it, or are the ſtuffs we employ for clothing intended to be boiled with tartar, alum, or ſoap? I do not however mean to diſapprove of the trial by proofs; they are uſeful, becauſe they are ready, but there

" are caſes in which they ought not to ſerve
" as a ground for pronouncing a ſentence of
" confiſcation; eſpecially when they cannot
" ſhew, that a colour which ſhould have been
" dyed with materials for durable colours, has
" been dyed with thoſe of a fading nature."

It is therefore evident, that there has been hitherto only one ſure mode of determining the durability of colours, that is, expoſure to the action of the air, ſun, and dew, for a certain length of time: proofs, whatever pains may be beſtowed on the choice of them, can only be applicable to the proceſſes performed agreeably to the regulations, and not to thoſe which have been diſcovered or improved ſince they were made.

The oxygenated muriatic acid affords a quick and eaſy method of determining the degree of durability a colour may poſſeſs, becauſe it acts like the air itſelf: thus, when we wiſh to examine a colour, we need only put a pattern of the ſtuff into oxygenated muriatic acid, along with a pattern of the ſame colour which has been dyed properly; the comparative power of reſiſting its action, ſhewn by the colours of the two patterns, becomes the meaſure of their goodneſs; but as this liquor has a very ſtrong action on the colouring particles, it muſt be employed in a very dilute ſtate. This proof has alſo the advantage of ſhewing us very nearly the ſhades and changes through which a ſtuff muſt paſs, when it comes to be acted upon by the air. Still however, were it neceſſary to examine a colour juridically, I ſhould not venture to rely entirely upon the action of the oxygenated muriatic acid, and would only decide with confidence, from the reſults afforded by expoſure to the air.

In order to try the colours of ſilk, it is generally thought ſufficient, to expoſe them to heat in acetous acid, or lemon juice; and they are conſidered as good and permanent colours, if they ſtand this teſt; and indeed, when the woods or archil alone have been employed, the colours are made red by the action of a vegetable acid, but if the ſolution of tin has been uſed to dye with theſe ſubſtances, the colour which has been prepared in an acid liquor, is not afterwards affected by vegetable acids, and in that caſe a colour may be reputed good, which has been much leſs expenſive, and will prove leſs durable; ſo that for ſilk alſo, we muſt employ the oxygenated muriatic acid, and more eſpecially expoſure to the air.

There is alſo another kind of proof, which ſeems to me very uſeful; it is intended for enabling us to eſtimate the comparative goodneſs of colouring ſubſtances of the ſame kind. We have hitherto been confined to mere inſpection, or to ſome other marks, which afford only uncertain indications, and could by no means furniſh a ſcale of compariſon. The oxygenated muriatic acid ſeems to anſwer this purpoſe, as completely as could be deſired; becauſe when we compare indigo with indigo, the nature of the colouring particles is the ſame, or nearly the ſame, and no foreign affinity can interfere, to prevent the action of the oxygenated muriatic acid from determining the proportional quantity of colouring matter.

If it ſhould happen, that any conſiderable difference occurred, even in the nature of colouring particles ſuppoſed to be the ſame, it is very probable, that the action of the oxygenated muriatic acid would ſtill be a meaſure of their comparative goodneſs.

When therefore we wiſh to compare together two or more colouring ſubſtances of the ſame nature, and to determine the relative quantity and quality of the colouring particles in each, we need only compare the quantities of the ſame oxygenated muriatic acid, required to produce the ſame degree of deterioration in an equal weight of each; the qualities of theſe ſubſtances,

ſtances, or the quantity of colouring particles they contain, are directly proportionate to the quantities of liquor required to produce the ſame effect on each; but in this experiment, it is neceſſary, that the colouring matter of each ſubſtance ſhould have been diſſolved in a proper liquor, and that all the circumſtances in the proceſs of compariſon, ſhould be ſimilar.

If we wiſh for example to compare ſeveral kinds of indigo, we take an equal weight of each, powder them carefully, and put them into ſeparate matraſſes, with eight times their weight of concentrated ſulphuric acid: theſe are to be kept for twenty-four hours in a heat of from thirty to forty degrees (100 to 122 Farhenheit) for which purpoſe a dunghill may be employed: each ſolution is then to be diluted with a quantity of water, filtered, and the reſidua found on the filters to be collected, and ground in a glaſs mortar, and again digeſted with the addition of a little more ſulphuric acid: the laſt ſolutions are alſo diluted with equal quantities of water, filtered, and each added to its correſponding liquor; finally, to each ſolution is added as much oxygenated muriatic acid as will diſcharge the colour, or rather bring them all to the ſame ſhade of yellow. The qualities of the different kinds of indigo, are proportionate to the quantities of oxygenated muriatic acid required to deſtroy their colour.

The proofs of ſuch colouring particles as are ſoluble in water, are much more ſimple; it is only requiſite after having exhauſted them as much as poſſible, to mix oxygenated muriatic acid with equal bulks of the decoction of the ſame weight of each ſubſtance, and to compare the quantity of acid required to bring them all to the ſame hue.

Whatever uncertainty may attend the employment of the proofs preſcribed by the regulations in many caſes, I am very far from condemning their uſe entirely; for I ſhould think it unjuſt, that a colour which might ſtrike us by a fugitive brightneſs, ſhould be preferred to a ſtanding colour, prepared at a much greater expence, and with a ſtrict regard to honeſty.

How are we to reconcile the intereſts of commerce, and the freedom from reſtraint which induſtry demands, with the ſecurity of the conſumer? This is a problem of difficult ſolution, and that requires all the prudence of the legiſlature; and though a ſubject foreign to my preſent purſuit, it is perhaps my duty to mention

mention the ideas which have occurred to me reſpecting it.

That part of the regulations which relates to black, ought, I think, to be retained, becauſe the proof recommended is proper for determining whether the cloth has received a blue ground, and of what intenſity that has been.

That which reſpects ſcarlet, and the ſhades approaching to ſcarlet, ought to be ſuppreſſed, as taking it for granted, that pinks (langouſtes) for example, are to be made without employing fuſtic or other yellow ingredients, which is impoſſible, or which at leaſt cannot be accompliſhed, without incurring inconveniences as great as thoſe which would ariſe from the fading nature of the colour of the ingredients. With reſpect to theſe colours I conceive we may truſt merely to the beauty, of which every body is a judge; becauſe we cannot ſubſtitute any thing for cochineal, without injuring the brightneſs of the colour.

Soap is mentioned as the proof for greens; but we thus proſcribe the Saxon greens, which do not ſtand this proof, but are eſteemed on account of their brightneſs, though they are leſs durable than the greens dyed in the blue vat (bleu de cuve).

I ſhould wiſh that all modes of dyeing were equally permitted, that the diſtinction between grain and other dyers was aboliſhed, as it can no longer be preſerved, ſince the ingredients allotted for falſe or mock colours, are now frequently employed for ſtanding colours, that each artiſt might give the greateſt ſcope to his induſtry and ſpeculations; but that the public ſhould be informed by a mark, of the colours to be relied upon as durable; that conſequently, thoſe colours which had ſtood the teſt of the proofs eſtabliſhed by law, ſhould be marked with a lead, declaring them to be true or ſtanding colours, whatever proceſs might have been employed in dyeing them;

That thoſe which ſhould be offered as ſtanding or true colours, but yet ſhould not be found capable of ſuſtaining the preſcribed proofs, ſhould merely be reſerved for the trial by expoſure to the air;

That if they ſupported the action of the air, as well as a pattern of the ſame colour of known goodneſs, they ſhould ſtill be marked with the lead as ſtanding colours;

That in ſuch a caſe, which would occur but very rarely, a chemiſt ſhould be employed to prepare a proper reactive for immediately diſtinguiſhing that kind of dye.

I ſhould prefer to moſt of the teſts which have been recommended, that of the oxygenated muriatic acid, which is more ſimple, more indicative, and more general, being applicable to colours in ſilk, cotton, and wool; but I ſhould wiſh, before it was adopted, that its excellence ſhould be eſtabliſhed, by a great number of trials made in preſence of ſeveral dyers and merchants, and that the concluſions drawn from them, when the proof turned out unfavourable, ſhould alſo be only proviſional. The proofs preſcribed in the regulations, may however be advantageouſly employed on certain occaſions: it is poſſible to render them more accurate and to direct their application more judiciouſly, and I have not a ſufficient confidence in the ideas which I have juſt ſtated, to decide, that better methods can be ſubſtituted: theſe conſiderations have determined me to mention them.

In making the proper compariſon, whatever mode of trial we adopt, we ought to employ a pattern, of not only the ſame colour, but one which is very nearly of the ſame kind of ſtuff.

Cotton and linen ſtuffs, which are to be leyed, muſt be tried by means of alkalis.

INSTRUCTION

Reſpecting the Uſe of Proofs for Wool and Woollen Stuffs.

"AS it has been found, that the method " for proving the dye of cloth, ſerges, " and other woollen goods, preſcribed by the " thirty-ſeventh article of the regulations for " dyers of true and ſtanding colours, publiſhed " in Auguſt 1669; and by the two hundred and " twentieth and following articles of the gene-" ral inſtruction of the 18th of March 1671, " for dyeing wool of all colours, and for the " culture of the drugs and ingredients employed " in that art, is not ſufficient to ſupply the " means of forming an accurate judgment of " the goodneſs or badneſs of many colours, " and that this method may moreover ſome-" times lead to error and give riſe to diſputes, " various experiments have been made, by " order of his majeſty, on the wools deſigned " for the manufacture of tapeſtry, in order to " aſcertain the degree of goodneſs of each co-" lour, and the proofs beſt ſuited to each.

" For this purpoſe, fine wools have been " dyed of all colours, both in true and falſe " or mock colours, and have been expoſed " to

" to the action of air and of the ſun for a proper
" length of time.

" The good colours were not at all changed,
" whilſt the falſe were more or leſs diſcharged,
" in proportion to their degree of badneſs;
" and as no colour ought to be reputed good,
" but in proportion to its power of reſiſting
" the action of the air and of the ſun; this
" proof has been the ſtandard for deciding,
" reſpecting the goodneſs of different colours.

" On the ſame wools, patterns of which had
" been expoſed to the air and ſun, different
" trials by proofs have been afterwards made,
" and it has been immediately perceived, that
" the ſame ingredients could not be indiſcrimi-
" nately employed as proofs for all colours,
" becauſe it ſometimes happened that a colour,
" the goodneſs of which was aſcertained by
" expoſure to the air, was conſiderably changed
" by the proof, while a mock colour reſiſted
" the action of the very ſame teſt.

" Theſe different experiments pointed out
" the inutility of lemon juice, vinegar, ſour
" water[a], and aqua fortis, on account of the
" impoſſibility of aſcertaining the degree of
" acidity of theſe liquors; and it appeared to
" be the ſureſt method, to uſe common water

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[a] Of this, ſee the preparation, chap. xii. T.

" with ingredients of an uniform degree of
" ſtrength.

" In purſuing this object, it has been thought
" neceſſary to divide all the colours of which
" wool can be dyed, whether in grain or other-
" wiſe, into three claſſes, and to determine the
" ingredients to be employed as proofs of the
" colours comprehended in each.

" The colours of the firſt claſs, are to be
" proved by roman alum; thoſe of the ſecond,
" by white ſoap; and thoſe of the third, by red
" tartar.

" But it is not ſufficient, with a view of
" aſcertaining the goodneſs of a colour by a
" proof, to employ for that purpoſe, ingredients
" of an uniform power; it is likewiſe neceſſary
" that the duration of the operation, and even
" the quantity of liquor ſhould be fixed; for
" a greater or leſs quantity of water, conſiderably
" diminiſhes or increaſes the activity of the in-
" gredients. The proceſſes for different proofs,
" ſhall be what the following articles direct.

ARTICLE I.

" The proof with roman alum ſhall be as
" follows:

" A pint

" A pint of water with half an ounce of alum, " muſt be put into a pan or other earthen veſ- " ſel, which is to be placed on the fire, and " when the water boils briſkly, the wool to be " proved muſt be put into it, and left to boil " for five minutes; after which it is to be taken " out and waſhed in cold water: the weight of " the pattern ſhould be about a dram.

ARTICLE II.

" When ſeveral patterns are to be proved at " the ſame time, the quantity of alum and " water muſt be double or even triple, which " will produce no change in the power or ef- " fect of the proof, provided the proportion of " alum and water be obſerved; ſo that there " be always half an ounce of alum to each pint " of water.

ARTICLE III.

" The proof with white ſoap ſhall be as " follows:

" Two drams of white ſoap, cut into ſmall " pieces, muſt be put into a pint of water, " and when the veſſel is ſet on the fire, the " water muſt be ſtirred about with a ſtick, in

" order to make the ſoap diſſolve; when it is " diſſolved, and the water boils briſkly, the " pattern of wool is to be put in, which muſt " likewiſe be boiled for five minutes, reckoning " from the time of putting it in, which " muſt not be till the water thoroughly boils.

ARTICLE V.

" When ſeveral patterns of wool are to be " proved together, the method preſcribed " Art. II. muſt be obſerved; that is to ſay, " to each pint of water, two drams of ſoap " muſt always be added.

ARTICLE VI.

" The proof with red tartar, is to be made " preciſely in the ſame way, and with the ſame " quantities and proportions, as the proof with " alum; taking care, however, to powder the " tartar well, before it is put into the water, " that it may be entirely diſſolved before the " pattern of wool is put in.

ARTICLE VII.

" The following colours muſt be proved " with roman alum, viz. crimſons of all

" ſhades,

" ſhades, venetian ſcarlet, flame-coloured ſcar-
" let, cherry-coloured and other ſhades of ſcar-
" let, violets and gridelins, *gris de lin,* of all
" ſhades, purples, pinks *(langouſtes)* jujubes,
" pomegranate flower, blues, ſlate grays *(ar-*
" *doiſés)* lavender grays *(lavandés)* *violents,*
" *vineux,* &c.

ARTICLE VIII.

" If, contrary to the regulations reſpecting
" dyes, any ingredients for mock colours ſhall
" be employed in dying fine wools of a crimſon,
" the deception will be eaſily diſcovered by the
" alum proof, which only deepens the fine
" crimſon, that is, gives it a gridelin tinge,
" while it deſtroys the lighter ſhades of the
" falſe crimſon; ſo that this proof diſtinguiſhes
" with certainty, the mock from the true crim-
" ſon.

ARTICLE IX.

" The kermes or grain ſcarlet, commonly
" called *venetian ſcarlet,* is not at all injured
" by this proof; it deepens the flame-co-
" loured or cochineal ſcarlet to a purple,
" and makes the low ſhades more intenſe,
" ſo

" ſo that they acquire a gridelin tinge. It " almoſt entirely deſtroys the falſe braſil ſcarlet, and reduces it to a colour reſembling " the outer coat of an onion: on the deep " ſhades of this falſe colour, it produces a ſtill " more ſenſible effect.

" The ſame proof almoſt entirely deſtroys " all the ſhades of the ſcarlet dyed with *bourre.*

ARTICLE X.

" Although violet is not a ſimple colour, but " is made up of ſhades of blue and red, it nevertheleſs is ſo important a colour, that it " deſerves a particular examination. The " roman alum proof produces ſcarce any effect on the fine violet, while it very much " injures the falſe; but it is neceſſary to obſerve, that it does not always diſcharge the " colour of the falſe violet in an equal degree, " becauſe ſometimes that colour has been prepared by a ground of paſtel or indigo, and " this ground being a ſtanding dye, is not removed by the proof; the redneſs however is " effaced, the brown ſhades become almoſt " blue, and the pale ſhades of a diſagreeable " colour reſembling wine lees.

ARTICLE XI.

“ With regard to the half grain violets, pro-
“ hibited by the preſent regulation, they are to
“ be claſſed with the falſe violets, and are
“ equally incapable of reſiſting the proof.

ARTICLE XII.

“ The good gridelins may be diſtin-
“ guiſhed from the bad in the ſame manner,
“ but the difference is ſlight; the former only
“ loſe a little leſs than thoſe dyed of a mock
“ colour.

ARTICLE XIII.

“ The good purples ſtand the proof by alum
“ perfectly, whereas the bad loſe the greateſt
“ part of their colour.

ARTICLE XIV.

“ The colours of langouſte *(pinks)* jujubes,
“ pomegranate flowers, will incline to purple
“ after the proof, if they have been dyed with
“ cochineal, but will grow conſiderably paler, if

“ fuſtic,

" fuſtic, the uſe of which is forbidden, has
" been employed.

ARTICLE XV.

" Good blues, whether dyed with paſtel or " with indigo, loſe none of their colour, while " the mock colour is in a great meaſure diſ" charged.

ARTICLE XVI.

" Slate grays *(ardoiſés)* lavender grays *(lavendés) violents, vineux*, loſe almoſt the whole " of their colour, when of the mock kind; " but remain perfectly unchanged when good.

ARTICLE XVII.

" The following colours are to be proved " with white ſoap; viz. yellows, jonquilles, " lemon and orange colours, and all thoſe " ſhades that incline to yellow; all the ſhades " of green from the yellow green (pomona " green) *verd naiſſant* to cabbage and parrot " green *(verd de perroquet)* madder reds, cinna" mon, and ſnuff colours, and the like.

ARTICLE

ARTICLE XVIII.

" This proof ſhews perfectly, whether yel-
" lows and the ſhades allied to them, are true
" or mock colours, for it carries off moſt of
" their colour when they have been dyed with
" french berries *(graine d'Avignon)* [b], annotta [c],
" turmeric [d], fuſtick *(fuſtet)* [e], or ſaffron, the uſe
" of which for true colours is prohibited; but
" it does not change the yellows dyed with
" ſaw-wort *(ſarette)* [f], dyers broom *(geneſtrolle)* [g],
" bois jaune [h], weld *(gaude)* [i], and fenugreek [k].

ARTICLE XIX.

" The ſame proof will alſo diſcover com-
" pletely the goodneſs of greens, for the mock
" ones loſe almoſt the whole of their colour,
" or become blue, if they have had a ground
" of indigo or paſtel; but thoſe of the true
" kind loſe ſcarce any of the colour, and re-
" main green.

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[b] Rhamnus infectorius.——[c] Bixa orellana.——[d] Curcuma longa.——[e] According to the author, Rhus Cotinus, vide notes to pages 268 and 281, Vol. II.——[f] Serratula tinctoria.——[g] Geniſta tinctoria.——[h] Morus tinctoria. Called by our botaniſts and dyers *fuſtic*.——[i] Reſeda luteola.——[k] Trigonella fænugrecum. T.

ARTICLE XX.

“ Pure madder reds do not loſe any of their “ colour by the proof with ſoap, which even “ renders them more beautiful; but if braſil-“ wood has been mixed with it, they loſe co-“ lour in proportion to the quantity of it which “ has been employed.

ARTICLE XXI.

“ Cinnamons, ſnuff colours, and others of “ the ſame kind, are ſcarcely affected by this “ proof, when good, but loſe much of their “ colour, if annotto, fuſtic, or *fonte de bourre*, “ have been employed.

ARTICLE XXII.

“ The proof by alum can be of no uſe and “ may lead to error with reſpect to many co-“ lours of this ſecond claſs, for it does not “ injure fuſtic or annotto, which cannot reſiſt “ the action of the air, but carries off a part “ of the colour of ſaw-wort and of weld, which “ notwithſtanding, give very good yellows and “ greens.

ARTICLE XXIII.

" All fawn and root colours are proved with " red tartar: under this title are included all " thoſe colours which do not proceed from " the five primitive colours; they are made " with walnut peels, walnut-tree root, alder[1] " bark, ſumach or roudoul, ſanders and ſoot; " each of theſe ingredients affords a great number of different ſhades, all of which are comprehended in the general name of fawn or " root colour.

ARTICLE XXIV.

" The ingredients mentioned in the preceding article are all good, except ſanders " and ſoot, which are ſomewhat inferior, and " which make the wool harſh, when employed " in too large a quantity: all that the proof " therefore can do in theſe caſes, is to ſhew " whether they have been overloaded with ſanders or ſoot, for then, they loſe conſiderably " by the proof with tartar: and if they have " been dyed with the other ingredients, or " with the addition of a moderate quantity of " ſanders or of ſoot, they ſtand much better.

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[1] Rhamnus frangula. T.

ARTICLE XXV.

" As black is the only colour which cannot " be referred to any of the three claſſes above- " mentioned, ſince it is neceſſary to employ " a much more active proof to diſcover whether " the wool has had a deep blue ground, agree- " ably to the regulations, the proof is to be " made in the following manner: an ounce of " roman alum, and as much red tartar, in the " form of powder, are to be put into a pound " or pint of water, and the whole made to " boil, the pattern of wool is to be put in, " and a briſk ebullition continued for a quarter " of an hour, it is then to be waſhed in cold " water, when it will be eaſy to diſcern whether " it has had the proper blue ground, for if ſo, " the wool will remain of a blue colour ap- " proaching to black, but if otherwiſe, it will " become very gray.

ARTICLE XXVI.

" As it is cuſtomary in ſome caſes to brown " colours with galls and copperas, and as this " operation called browning, *bruniture*, which " ought to be permitted in dyeing durable co- " lours, may produce particular effects in the " proofs of theſe colours; it is to be ob-

" ſerved

“ ſerved that though after the boiling, the li-
“ quor ſhould appear loaded with the dye,
“ from its having carried off the browning, the
“ wool is nevertheleſs to be conſidered as dyed
“ properly, if it has retained its body; if on
“ the contrary, it loſes its body, or its ground
“ of colour, it muſt be declared a mock co-
“ lour.

ARTICLE XXVII.

“ Although the browning with galls and cop-
“ peras is of a durable nature, yet as it com-
“ monly renders the wool harſh, it is proper
“ rather to employ as much as poſſible the uſe
“ of the indigo or paſtel vat.

ARTICLE XXVIII.

“ The common grays dyed with galls and
“ copperas ought not to be ſubmitted to any
“ trial by proofs, becauſe they are true co-
“ lours, and cannot be dyed otherwiſe; but
“ care muſt be taken to gall them firſt, and to
“ add the copperas to a ſecond bath not nearly
“ ſo hot as the former, becauſe in this way, they
“ are rendered more beautiful and more fixed
“ *aſſurés.*”

SECTION III.

Of Chemical Agents employed in Dyeing.

CHAPTER I.

Of Acids.

ACIDS are known by their ſharp taſte, by their reddening the blue colour of ſome vegetables, ſuch as that of turnſole, and ſyrup of violets, and by the effervеſcence they occaſion when mixed with calcareous earth and alkalis not in a cauſtic ſtate.

A great number of acids are already known, and probably many more will be diſcovered by chemiſts, but we ſhall ſpeak only of thoſe which are uſed in dyeing, and we ſhall deſcribe only thoſe properties, which it is neceſſary to know, in order to appreciate their action or direct their uſe in this art.

ARTICLE I.

Of the Sulphuric or Vitriolic Acid.

THE pure ſulphuric acid is without ſmell, without colour, tranſparent like water, and has an an unctuoſity reſembling oil, when it is concentrated; whence it has the name of oil of vitriol, an appellation which might lead to ſome miſchievous miſtakes reſpecting its nature.

This acid was formerly obtained from the ſulphat of iron, or vitriol of iron, by diſtilling it with a ſtrong fire, whence it had the name of vitriolic acid; but at preſent, almoſt all that is uſed in the arts, is obtained from ſulphur by a much leſs expenſive proceſs. This acid is the reſult of the combuſtion of ſulphur, which, while it burns, is combined with the baſe of vital air or oxygen, which exiſts in atmoſpheric air, and in nitre, of which laſt a certain quantity is added to the ſulphur [a]. The mixture of ſulphur and nitre is inflamed, and the vapours are received in a chamber, the inſide of which is lined with lead, and the bottom of which is covered with water; the vapours which are collected, and unite with the water, form ſulphuric acid, which is to be conſidered as ſulphur completely burned.

The ſulphuric acid, on being taken from the leaded chamber, is not in a concentrated ſtate, but is mixed with a certain ſuperabundance of

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[a] Mr. de Morveau has pointed out a proceſs in which nitre is diſpenſed with (Encyclop. pag. 359.); and it appears that a ſimilar proceſs is in uſe in England. Journal de Phyſ. Septembre 1790.

water, and it has the ſmell of the ſulphureous acid, which differs from ſulphuric acid in not being ſaturated with oxygen; it contains likewiſe a little nitrous acid, which comes from the nitre which had been mixed with the ſulphur. If it be expoſed for ſome time to the air, the ſmell of the ſulphureous acid is diſſipated; but to remove this ſmell, and a part of its water at the ſame time, it is evaporated in open veſſels.

A very ſmall quantity of vegetable or animal ſubſtance gives the acid a brown colour, and what is met with in the market, is never quite limpid; but it may be made ſo, by boiling it a little while in a retort. By this operation, we take away at the ſame time a portion of nitrous acid, which is met with in the common ſulphuric acid, and a portion of water; it becomes colourleſs and tranſparent, and the concentration is proportioned to the quantity of water that has been diſtilled from it. If we wiſh to have it perfectly pure, it is neceſſary, after having ſeparated the firſt portion which is weakly acid, to continue the diſtillation to dryneſs, when there remains a little alkali, which came from the nitre, and which is united with an exceſs of ſulphuric acid, a combination known by the name of *acidulated ſulphat of pot-aſh*;

pot-aſh; there is often found likewiſe a little ſulphat of lead.

For this rectification we ought to chooſe a low necked retort, and to fix it well in the furnace, that the motion which the ebullition of the acid occaſions, may not break it. If this accident ſhould take place, it is proper to withdraw ourſelves to a diſtance quickly, in order to avoid the ſulphureous vapours which are evolved in abundance, when the acid falls upon the burning coals.

The ſulphuric accid attracts ſtrongly the humidity of the air, and to preſerve it in a concentrated ſtate, it muſt be kept in veſſels of glaſs cloſely ſtopped.

When it is mixed with water, a great degree of heat is produced, ſo that the mixture muſt be made gradually, leſt the veſſel ſhould break. To make the mixture complete, it is neceſſary that the liquor be well ſtirred with a glaſs rod, for notwiſtanding the ſtrong attraction of this acid for water, the difference in the ſpecific gravity of the two fluids, is an obſtacle to their mixture.

The ſulphuric acid highly concentrated, has a ſpecific gravity nearly double that of diſtilled water. When it is weak, that is, diluted with a good a good deal of water, the fallacious name of *ſpirit of vitriol* is given to it.

In order to obtain uniform reſults, it is right to employ for the ſame operations, ſulphuric acid of the ſame degree of concentration. Its ſpecific gravity may be aſcertained by the areometer of Farhenheit, but it is more expeditious, and it is ſufficient to employ that of Mr. Baumé, which is ſo well known.

The acid is to be put into a cylinder of glaſs, and the areometer for ſalts is to be immerſed in it; the heavier the liquor is, the leſs is the areometer immerſed, and the degree of the ſcale even with the ſurface of the liquor, points out the degree of concentration. Sixty-eight degrees of this areometer point out a highly concentrated ſulphuric acid [b].

Hitherto we have uſed the ſulphuric acid in dyeing, only to diſſolve indigo, and for this purpoſe, a very concentrated and pure acid is required; but a good deal is employed to prepare cotton ſtuffs for printing, and in the bleaching of linen and thread, either by the

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[b] This degree, eſtimated by one of thoſe inſtruments which I got from France, but the accuracy of which I cannot anſwer for, correſponds to 1,840, the ſpecific gravity of diſtilled water being taken as 1000. T.

oxygenated muriatic acid, or by expoſure on the graſs. It has not been yet uſed in France for this laſt purpoſe, though it has in England a long time, according to Dr. Home; and the experiments which have been made in bleaching by the oxygenated muriatic acid, prove that it may be ſubſtituted for ſour milk, which is uſually employed in this country.

For theſe laſt purpoſes, a very concentrated ſulphuric acid is not required; if then, we are in the neighbourhood of a manufacture of ſulphuric acid, it is more advantageous to buy it before it has been concentrated, and to ſave the expence of this operation; but if at a diſtance from ſuch a manufacture, it may be more advantageous, by leſſening the expence of carriage, to purchaſe it in a concentrated ſtate.

Sulphuric acid forms different compounds with alkalis, earths, and metallic ſubſtances. In order to point out the acid principle in theſe compounds, the name of ſulphats is given to them; thus the combination of the vegetable alkali or pot-aſh, is called ſulphat of pot-aſh. We ſhall hereafter treat particularly of the ſulphats which are uſed in dyeing; at preſent we ſhall mention two, the names of which ſometimes occur in works on that art.

The

The ſulphat of pot-aſh or vitriolated tartar, has a bitter and biting taſte: it requires ſixteen parts of water at ſixty degrees of Farhenheit to diſſolve it: it is contained in the aſhes of many vegetables. Hellot conſidered it from its ſmall ſolubility, as proper for fixing colours in the pores of cloth; but this opinion is unfounded. It has little action upon the colouring particles.

Sulphat of ſoda or Glauber's ſalt, is much more ſoluble than the former; it effloreſces, that is, it parts with its water of cryſtallization to the air, and aſſumes the appearance of flour. It is found naturally in ſome ſubterraneous places, and in ſome waters, ſo that it is obtained from the reſidua of the waters, which are evaporated in the ſalt works of Lorrain. It is this ſalt which is uſually ſold under the name of ſalt of Epſom; but Epſom ſalt is a ſulphat of magneſia and not of ſoda.

The ſulphat of lime, or the combination of lime with ſulphuric acid, abounds in nature. It is this which forms gypſum, or plaſter of Paris. It requires near five hundred times its weight of water to diſſolve it, at twelve degrees of Reaumur (59 Farhenheit).

ARTICLE II.

Of Nitrous Acid.

CHEMISTS have given different names to this acid, according to the proceſſes by which it is obtained from nitre; they have called what is obtained from a mixture of nitre and clay, *aqua fortis;* what is obtained by diſtilling nitre with ſulphat of iron, *ſpirit of nitre;* and what is procured from a mixture of nitre and ſulphuric acid, *ſmoking nitrous acid.* Theſe diſtinctions are not made in trade, and the name of aqua fortis is equally given to this acid by whatever proceſs it has been made. In fact, it is always the ſame acid, and it differs only in its concentration and in its colour; ſometimes it is pale, ſometimes red and ſmoking: it owes its colour and property of ſmoking to nitrous gas, which it holds in ſolution, as we ſhall explain hereafter.

If we expoſe the reddeſt acid to a ſufficient heat, the nitrous gas is ſeparated, and the acid becomes pale. It is in this ſtate called *nitric acid*, and in its red ſtate it is called nitrous acid.

As there is no great conſumption of nitrous acid in the art of dyeing, and as this is carried on very frequently at a diſtance from any manufactures of the acid, it may be convenient and may ſave expence, for the dyer to prepare it himſelf. I ſhall on this account deſcribe the proceſs for obtaining it from nitre, by means of the ſulphuric acid.

We powder pure nitre, called nitre of the third boiling, becauſe it is the reſult of the third cryſtallization; we put it with half its weight of ſtrong ſulphuric acid into a retort, which is choſen of ſuch a ſize, that it ſhall be only half filled, ſo that the matter during its bubbling, may not be forced into the receiver; we fix to the neck of the retort a bent tube, the orifice of which, is large enough to admit the neck of the retort; we introduce the extremity of this tube, which ſhould have a much ſmaller diameter, through a cork, into a receiver with two necks; to the other neck of the receiver, we fix a tube which is to be immerſed in a little water contained in a matraſs, which is to ſerve as a ſecond receiver. The joints of the retort with the firſt tube, and of the firſt receiver, ſhould be ſmeared and carefully ſtopped with a greaſy lute, compoſed of white clay and linſeed oil, which has been boiled with a little litharge (this lute ſhould be beaten for a long time in a mortar, to render it pliant and ductile) and then covered with ſlips of linen ſoaked in white of egg, and ſprinkled with powdered lime. It is advantageous to uſe a tubulated retort, and to have the whole apparatus prepared, before the ſulphuric acid is introduced by the opening in the upper part of the retort.

The ſecond receiver ſhould have a free communication with the air, in order that the vapours, which could not be condenſed in the water, may eſcape. The quantity of water put into the ſecond receiver, ſhould be proportioned to the quantity of acid we are preparing. The fire ſhould be kept very low at the beginning, and increaſed ſlowly toward the end of the operation. The acid obtained in the firſt receiver is highly concentrated; that in the ſecond, is weakened by the water in which the acid vapours are condenſed. The colour of the latter is green or blue: theſe colours are owing to the nitrous gas, and their difference depends upon the proportion of water, ſo that if a little water be added to what is green, it turns it blue; if the gas be expelled by heat, the liquor becomes pale. The acid in the ſecond receiver is always pure; but that in the firſt ſometimes contains ſome ſulphuric acid, which may happen when the fire has not been kept ſufficiently low at the beginning of the operation; for I have frequently found that when the fire has been carefully regulated, the acid has been perfectly pure.

It is of importance to examine the nitric acid prepared for ſale, becauſe it often contains a conſiderable quantity of ſulphuric acid, either from the diſtillation having been conducted careleſsly, or from its having been added purpoſely, to increaſe the ſpecific gravity of the nitrous acid. The examination is made by diluting a ſmall quantity of it with diſtilled water, and adding a little of the ſolution of barytes or heavy earth in nitric acid. If any ſulphuric acid is contained, a precipitation takes place, becauſe the ſulphuric acid ſeparates the barytes from the nitric acid, and forms with it an inſoluble compound. The nitric acid may alſo contain muriatic acid, from the common ſalt which is often met with in nitre. This mixture is not injurious in any of the operations of dyeing; if, however, we wiſh to know, whether it exiſts or not, the nitric acid is to be diluted with diſtilled water, and a little of the ſolution of ſilver in nitric acid added; if there be any muriatic acid, a precipitate is let fall.

In order to free nitric acid from ſulphuric acid, it may be rediſtilled from a little nitre, or from a ſolution of lead: the latter method alſo purifies it from muriatic acid.

The nitric acid may be employed for many metallic ſolutions, the uſe of which, as mordants, may be various; but it is principally employed for making aqua regia, or the nitro-muriatic acid, which will be treated of in a ſeparate article.

It is neceſſary, in order to underſtand a great variety of phenomena, that we ſhould form a juſt idea of the nature of nitric acid, and of its action upon other ſubſtances.

The nitric acid is compoſed of two ſubſtances, which, when ſeparate, aſſume an elaſtic, aeriform, or gaſeous ſtate; they are the two gaſes which conſtitute our atmoſphere. One is incapable of ſupporting life and combuſtion; this is the *azotic gas* or *phlogiſticated air;* the other alone ſerves combuſtion, is the principal ſource of the light afforded by it, and maintains, in a remarkable degree, the life of animals that breathe it, whence it is called *vital air;* it is alſo called oxygenous gas, becauſe when it becomes fixed in many ſubſtances, it communicates to them acid properties.

Azot and oxygen which have loſt their elaſticity, and which are combined in favourable circumſtances, form the nitric acid; but theſe two ſubſtances may unite in various proportions, and upon theſe proportions depend the different ſtates in which the acid is obſerved.

Azot completely ſaturated with oxygen, forms a colourleſs nitric acid; the azot is then in the proportion of about a fifth part of the weight of the oxygen; if the proportion of the azot be much greater, and nearly equal to that of the oxygen, nitrous gas is formed, which by itſelf, is in an elaſtic ſtate, but which may be diſſolved in large quantity in the nitric acid; this is the gas, which, by its ſolution, gives to the acid a colour of any ſhade from pale yellow to deep red, and changing into green and blue by the addition of water; this gas attempting to eſcape and to combine with the air of the atmoſphere, produces the red vapours of the nitrous acid.

The nitric acid ſometimes enters into combination without being decompoſed; this is the caſe, when it unites with alkalis and ſome earths; ſometimes it is decompoſed, becauſe the oxygen is taken from it by another ſubſtance: this happens with metallic ſolutions; if the metal acts weak. It is obtained likewiſe by diſtilling ſea ſalt with ſulphuric acid. As it fetches ſo high a price in France, that a great part of that which is ſold at Paris, and even ſent to Lyons, comes from England; and, as we may be often at a conſiderable diſtance from the places in which it is prepared, I ſhall deſcribe a method by which it may be advantageouſly obtained.

This proceſs is very ſimilar to that which has been deſcribed for obtaining the nitric acid. I ſhall content myſelf with pointing out the differences.

The retort to be made uſe of, ſhould be tubulated. The ſalt is introduced into it, and afterwards half its weight of ſulphuric acid. The upper opening ſhould be ſtopped quickly; the reſt of the apparatus ſhould be prepared before. It conſiſts of two bottles, into which a quantity of water, equal in weight to that of the ſalt employed, is put; but as the vapour which is ſeparated, is very miſcible with water, a vacuum is very apt to be formed, which occaſions the liquor of the ſecond, to paſs into the firſt, and from this into the retort. To avoid theſe inconveniences, the firſt bottle ſhould be furniſhed with a tube of ſafeguard, invented by Mr. Welter. This is a tube of glaſs of two or three lines diameter, one extremity

tremity of which reaches to the ſurface of the water which has been put into the bottle, and the other communicates with the atmoſphere. This tube is introduced by a ſeparate opening, or ſtill better, by one of the corks through which the tube of communication paſſes.

If a vacuum be formed, the atmoſpheric air gets into the bottle; but while the vapour is ſeparated, and preſſes upon the liquor, this is raiſed in the tube, until the weight of the column counterbalances the preſſure of the vapour [c]. It ſhould be carefully luted, becauſe the vapours of muriatic acid are very penetrating, and when they have made a paſſage through the lute, it is very difficult to ſtop it. If however this accident happens, the beſt method of remedying it, is to rub the place where the acid iſſues with alkali, in order to ſaturate the acid, and to apply lute to it immediately. We ſhould wait till the efferveſcence produced by adding the ſulphuric acid be over, before we put fire underneath the retort, which ſhould be placed in a ſand bath, and the fire ſhould be kept very low, eſpecially at the beginning of the operation.

The acid in the firſt bottle is very concentrated and ſmoking. It ſometimes contains

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[c] Ann. de Chym. tom. ii.

ſulphuric acid, which is diſcovered by diluting it with diſtilled water, and adding a little of the ſolution of barytes, which produces a precipitation. If we mean to purify it, it ſhould be rediſtilled from a little common ſalt.

The acid of the ſecond bottle is much leſs ſtrong; if it be too weak for the purpoſes it is intended for, it may be uſed inſtead of water for a ſecond diſtillation: it has the advantage however, of being pure.

Muriatic acid may be employed for various metallic ſolutions, which may be uſed as mordants; thus the ſolution of tin or the muriat of tin, may be uſeful on many occaſions. In order to prepare this ſalt, tin ſhould be diſſolved by the aſſiſtance of heat, in a ſtrong muriatic acid, and the liquor ſhould be evaporated till all the ſalt which will cryſtallize is ſeparated. Mr. Baumé relates that he has prepared large quantities of this ſalt for printing linens. I do not believe that it is at preſent employed for that purpoſe. The muriat of lime, and that of magneſia, acts upon colouring ſubſtances, as other ſalts of earthy baſis.

The muriat of ſoda or common ſalt, which is obtained from ſea and other ſalt water, has a remarkable action upon colouring bodies;

in general, it tends to deepen their ſhade and to render them more fixed.

Sal gem is the common ſalt obtained from mines which are found in the boſom of the earth.

Muriat of ammoniac or ſal ammoniac, is compoſed of muriatic acid and ammoniac or volatile alkali. A great quantity of this ſalt is brought from Egypt, where it is prepared; it is manufactured likewiſe in many parts of Europe. That which comes from Egypt is darker than what is made in Europe, and it is ſoiled with ſoot, ſo that it is leſs pure, and conſequently leſs fit for dyeing. Nevertheleſs many artiſts prefer it. Sal ammoniac diſſolves eaſily in water, and cryſtallizes by evaporation, in quadrangular priſms terminated by quadrangular pyramids. Theſe cryſtals have a flexibility, which enables them to bend in any direction without breaking. Sal ammoniac renders colours in general deeper and more ſaturated.

Mercurial muriat or corroſive ſublimate, is the compound of muriatic acid with mercury, containing a great quantity of oxygen. This preparation is made by various proceſſes, which all agree in combining mercury with oxygen, and uniting it in this ſtate with muri-

atic

atic acid. This ſalt acts upon many colours, rendering them deeper, more duſky, and more fixed.

It may be conſidered as a general property of muriatic ſalts, to render colours deeper and more fixed.

ARTICLE IV.

Of Oxygenated Muriatic Acid.

THE muriatic acid aſſumes entirely new properties when it is combined with oxygen: its taſte is rough, inſtead of being acid; its ſmell is very penetrating; it loſes with difficulty its ſtate of gas, and does not combine readily with water: when water is ſaturated with it at a low temperature, it becomes ſolid. It has a powerful action upon colours, but different from that of acids. It at length deſtroys them.

We may eaſily ſatisfy ourſelves that theſe new properties depend upon the oxygen or baſe of vital air, by expoſing a phial filled with this liquor, to the light of the ſun, furniſhed with a bent tube, which paſſes under an inverted jar filled with water. For we ſee

ſmall

ſmall bubbles iſſuing from all parts of the liquor, and collecting in the jar; and if this gas be examined, it is found to be vital air, or oxygenous gas, and the liquor which remains in the phial is common muriatic acid.

I have deſcribed [d] the proceſs by which great quantities of oxygenated muriatic acid, for bleaching thread and linen cloth, are prepared, as well as the operations employed in the bleaching; but there are caſes in which this acid may be uſeful in dyeing, and it may be foreſeen, that the application of this powerful agent will become more general. I ſhall therefore deſcribe the proceſs, by which a ſmall quantity of this acid may be obtained, and where we do not mean to uſe the apparatus which is employed in preparing it for commerce, a deſcription of which is found in the Annales de Chymie.

A retort with a bent neck, or which has a bent tube fixed to it, muſt be fitted to a bottle with three openings, to one of which the tube of ſafeguard already deſcribed, muſt be fixed, and immerſed in a little water. In addition to the firſt, which ſhould be ſmall, three more bottles ſhould be employed, which ſhould ſtand one behind another and communicate by tubes;

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[d] Ann. de Chym. tom. ii.

each tube of communication ſhould open into the upper part of the bottle which precedes it, and into the middle of the bottle which follows it; the three laſt bottles ſhould be almoſt filled with water, and have each a tube of ſafeguard, except the laſt, which ought to have a free communication with the air.

The retort ſhould be tubulated; or inſtead of a tubulated retort, a matraſs may be employed, which is made to communicate by a tube with the firſt bottle. All the tubes ſhould communicate in the inſide of the veſſels by ſtoppers of cork, which fit well, and which ſhould be covered very carefully with a greaſy lute, or with one ſtill more convenient, which is compoſed of equal parts of linſeed meal, and almond paſte (pate d'amende) to which a proper conſiſtence is given by ſtarch. We may ſee if the gas has got iſſue, by preſenting the mouth of a phial filled with ammoniac to the different parts which are luted; for if any vapours eſcape, a white cloud is formed.

When the apparatus is prepared, we introduce into the retort by its ſuperior opening, or into the matraſs, five ounces of ſea ſalt, and an ounce and half of oxyd of mangaueſe powdered, and well mixed with the ſea ſalt; we then add four ounces of concentrated ſulphuric acid, previouſly

viouſly mixed with an equal quantity of water; for this quantity of ingredients the three bottles ſhould contain from twelve to ſixteen pints of water (about ſixteen quarts Engliſh).

At the beginning, the fire for the diſtillation ſhould be very low, and it ſhould be increaſed ſlowly; towards the end of the proceſs the liquor ſhould boil. We know when the operation is nearly finiſhed by the degree of heat communicated to the firſt matraſs, which is intended to receive the unoxygenated muriatic acid.

The liquor which is in the firſt of the large bottles, is of a yellow green colour, it is much ſtronger than that in the ſecond bottle; that in the third is very weak. The mixture of the three liquors is ſufficiently ſtrong for moſt operations. It ſhould be kept in a bottle well ſtopped, and not expoſed to the rays of the ſun.

The apparatus I have deſcribed, as well as that I have propoſed for operations on a large ſcale, may be executed in different ways: the chief object is to facilitate the combination of the diſengaged gas with the water, by extenſion of ſurface, by preſſure, and even by agitation.

The oxygenated muriatic acid, as has been already explained, may be employed as a teſt of ſtrongly upon the oxygen, it takes up the whole of it, and azot is ſeparated by itſelf, in the form of gas; but commonly it takes only a part of the oxygen, and the other part forms the combination which eſcapes in the ſtate of nitrous gas. hence ariſes the effervеſcence which the nitrous acid produces with metals.

In like manner the nitrous acid may act merely like an acid upon colouring ſubſtances, without undergoing any decompoſition; but a part of the oxygen is taken from it ſooner or later by theſe ſubſtances, and they then undergo changes, analogous to thoſe which they would ſuffer in combining with the oxygen of the atmoſphere, and which are the reſult of a true combuſtion.

We ſhould guard againſt the prejudices which have prevailed, reſpecting the vapours which are ſeparated by metals from the nitric acid, and the ſtrength of this acid when it has become ſmoking. It is eaſy to make it ſmoke, by adding a little iron, or any thing that can furniſh nitrous gas; it muſt have indeed a certain degree of ſtrength, to become ſmoking, but, at the ſame time, it may be very concentrated, and have no colour.

The nitrat of pot-aſh is, as its name expreſſes, a combination of nitric acid with pot-aſh. This ſalt is obtained from old mortar and artificial mixtures of rubbiſh, in which it is formed by the concurrence of atmoſpheric air. It has little action upon colouring ſubſtances; nevertheleſs, it renders their colours a little more clear and lively.

The nitrat of lime and that of magneſia are among the ſalts of earthy baſis, which are found in many waters, and, like thoſe waters, tend to give a deeper ſhade to many colours.

ARTICLE III.

Of the Muriatic or Marine Acid.

THIS acid is commonly known under the name of marine acid, or ſpirit of ſalt; it has a peculiar ſmell, reſembling that of ſaffron; when it is concentrated, it gives out white vapours to the air, which are produced by the combination of this acid, with the water which is contained in the atmoſphere. When it is ſaturated with water, it ceaſes to afford vapours; it has uſually a yellow colour, but this is derived from a little iron; when it is quite pure, it is colourleſs as water.

This acid is obtained for commerce, by diſtilling ſea ſalt with clay; but it is then always weak.

of the durability of colours, and for comparing the goodneſs of colouring ſubſtances of the ſame kind. It is uſed for whitening the ground of ſome printed linens; it may be uſed to deſtroy the colours of pieces which have ſuffered ſome accident in dyeing, or which have been ſpoiled by keeping, and thus fit them for receiving a new dye; but it leaves a yellow colour in wool and ſilk. Linens are completely whitened by it, unleſs iron entered the compoſition of the mordant uſed in dyeing them; in which caſe they ſhould be paſſed through water acidulated by ſulphuric acid. If the colouring particles have not been entirely removed, a weak ley will diſſolve them.

Some perſons uſe the oxygenated muriatic acid to brighten ſeveral colours, and to render them clear. I do not know exactly their method; I only know that it is often uſeful in this caſe to employ oxygenated muriatic acid united to pot-aſh. To obtain this ſpecies of combination, from four to five ounces of common pot-aſh ſhould be diſſolved in a pound of water, and only the bottle which contains this ſolution is to be placed after the matraſs intended to receive the acid which is not oxygenated; the alkali renders the abſorption of the gas eaſy.

ARTICLE V.

Of Aqua Regia, or the Nitro-muriatic Acid.

THIS compound acid has received the name of aqua regia, becauſe it poſſeſſes the property of diſſolving gold, by ſome ſtyled the king of metals: but with regard to its nature, we ought to conſider it as a mixture of the muriatic and nitric acids, which combine their powers to produce ſolutions, that ſeparately they were unable to effect. Their mode of action I have elſewhere explained[e].

The nitro-muriatic acid may be prepared either by ſimply mixing together nitric acid and muriatic acid, or by diſſolving ammoniacal muriat, or muriat of ſoda, in nitric acid. We might make uſe of other ſalts, nitre, or nitrat of pot-aſh, for inſtance, diſſolved in muriatic acid, and employ many other proceſſes, which it would be ſuperfluous to mention.

We ſhall examine the nitro-muriatic acid chiefly with reſpect to the ſolution of tin, as that is the principal uſe made of it in dyeing.

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[e] Mem. de l'acad. 1785.

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The dyers do not all prepare the ſolution of tin, to which they give the name of compoſition, in the ſame way: every one has his receipt. The effects produced by the ſolution, however, are different, according to the manner in which it is prepared: it is of ſpecial conſequence therefore, that the ſame artiſt prepare it always in the ſame manner, in order to obtain uniform effects, his obſervations on which, may ſerve to guide him in his ſubſequent operations.

Several dyers uſe merely the common aqua fortis of the ſhops, which is a kind of nitro-muriatic acid; as it is prepared from an impure nitre, which is mixed with a greater or leſs quantity of marine ſalt: this quantity, however, being various, and the concentration of the aqua fortis alſo ſubject to great variation, its effects muſt be uncertain.

Pure nitric acid attacks tin with violence, and reduces it to an oxyd or calx, of which little remains diſſolved; ſo that, if the aqua fortis ſhould happen to be pure, the ſolution made with it would not be fit for uſe. Yet Mr. Vogler aſſerts[f], that the nitric acid is the beſt ſolvent of tin. Suppoſing him to have employed pure nitric acid, I ſhould endeavour

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[f] Crel. chemiſch. ann. 1785.

to explain his opinion, which is contrary to the experience of every other chemiſt, by the manner in which he treated the tin: this he reduced into plates, and, by the kind of hardening which he thus gave it, he defended it, as it were, from the too violent action of the nitric acid, and rendered it but little ſoluble in the nitro-muriatic acid; for, according to him, the latter diſſolves it with difficulty, though every other chemiſt has found the contrary. Mr. Vogler obſerved, that his nitric ſolution readily became a jelly: this is a conſiderable inconvenience; for the greater part of the jelly is precipitated in water, inſtead of diſſolving in it. The formation of this jelly he prevented, by mixing with the nitric ſolution from a tenth to a fifteenth part of muriat of ſoda, or ammoniacal muriat diſſolved in water: but he might as well have employed at once the nitro-muriatic acid, which eaſily diſſolves the tin, and is not liable to thoſe inconveniences which occur when we attempt to make the ſolution with nitric acid alone.

Hellot took eight ounces of nitric acid, which he mixed with an equal quantity of filtered water. In this mixture he diſſolved gradually half an once of very white ſal ammoniac, and two drams of pure nitre, and afterwards half an ounce of grain tin. Scheffer diſſolved one part of tin in four parts of nitro-muriatic acid[g]. Macquer diſſolved three parts of tin in eight parts of nitric acid, with which he mixed one part of ſal ammoniac and ſix parts of water. Mr. Poerner put an ounce and half of ſal ammoniac into a pound of nitric acid mixed with a pound of water, and in this liquor he diſſolved two ounces of tin. Mr. Guhliche mixed a pound of fuming nitrous acid with a pound of water and two ounces of ſal ammoniac, and this liquor he ſaturated with as much tin as it could diſſolve, adding it by ſmall quantities at a time[h]. The proportion of tin in this caſe was more conſiderable than thoſe before mentioned.

It is obvious, that theſe ſolutions, which I have taken only from thoſe who have written on the art of dyeing, muſt have very different properties: in all, there is an eſſential defect; the preparation is not conſtantly uniform. To obviate this, it is indiſpenſably neceſſary to employ a pure nitric acid, and to aſcertain its ſpecific gravity by means of the areometer. After many trials, which it would be uſeleſs to relate, the proceſs by which I have obtained

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[g] Eſſai ſur l'art de la Teinture.

[h] Vollſtändiges Farbe und Blaichbuch, &c. Band. iv.

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the ſolution that gave me the moſt beautiful colour with cochineal, both on wool and ſilk, and that will alſo keep the longeſt without the formation of a gelatinous precipitate, conſiſts in taking nitric acid at thirty degrees[i], diſſolving in it one eighth of its weight of muriat of ammoniac, adding by ſmall portions an eighth of its weight of tin, and afterwards diluting the ſolution with a fourth of its weight of water.

A pure tin, ſuch as that of Malacca, or good engliſh tin, ſhould be choſen, becauſe the common tin contains copper and lead, each of which is prejudicial to the beauty of the colour. There is ſome copper even in the fine engliſh tin: but the common tin ſometimes contains near half its weight of lead, and alſo, antimony and biſmuth[k]. The tin ſhould be grained, by melting it, and pouring it into water agitated with a bundle of ſmall rods. This operation ought to be performed cautiouſly, to prevent the tin from ſplaſhing about.

In general a ſmall quantity of a blackiſh

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[i] This I find by an experiment ſimilar to that mentioned page 212, makes the ſpecific gravity of this acid compared with diſtilled water as 1,240 to 1000. T.

[k] Recherches ſur l'E'tain; par M M. Bayen & Charlard.

ſediment is formed, from which it is neceſſary to decant the ſolution.

The ſolutions which contain a large proportion of tin are brown, and give deeper and leſs bright colours: yet there are caſes in which they may be found the more uſeful ones. A ſolution highly charged with tin, that may be employed with advantage in certain caſes, may be procured by decompoſing in a retort, with a pretty ſtrong heat, muriat of ammoniac, mixed with an equal weight of oxyd of tin; the reſiduum is to be diſſolved, filtered, and evaporated till it cryſtallizes: thus cryſtals of a triple ſalt, compoſed of muriatic acid, ammoniac, and oxyd of tin, will be obtained. When this ſalt is uſed, a ſmall portion of muriatic acid muſt be added to the ſolution, to prevent the precipitation of the oxyd of tin.

The ſolution of tin does not affect colours by the proportion of metal it contains merely. When ſal ammoniac, nitre, or marine ſalt, has entered into the compoſition of the aqua regia, the liquor which is ſupernatant after the precipitation of the colouring particles is leſs acid, than when a mere mixture of nitric and muriatic acids is employed: in the former inſtance, therefore, the liquor has leſs action upon the ſtuff, and upon the colour, than in the latter.

Hence it follows, that when a ſolution of tin is to be uſed, with a ſubſtance, the colour of which is eaſily affected by acids, as madder or braſil-wood, we ſhould chooſe a ſolution of tin that would retain little exceſs of acid, or uſe it only for the preparation of the ſtuff.

The art of dyeing does not poſſeſs another mordant capable of producing ſuch advantageous effects as the ſolution of tin. I ſhall repeat the explanation I have given of its properties in the firſt ſection. 1. The oxyd of tin has a great diſpoſition to quit its ſolvent to unite either with the ſtuff, or with the colouring particles. 2. It gives the colour a white baſis not liable to alteration. 3. It produces no perceptible combuſtion in the colouring particles moſt diſpoſed to change of hue from that cauſe, as thoſe of ſumach and galls.

The ſolution of tin acquires a gelatinous conſiſtence more or leſs readily. When this happens, the dyers ſay, that the compoſition has turned. To avoid it, the preparation ſhould be made but a little while before it is uſed. When the jelly is only beginning to form, the ſolution may be recovered by adding to it a ſolution of marine ſalt. This inconvenience ariſes from the tin's continuing to oxydate by means of the oxygen which it attracts from the

the atmoſphere, or receives from the nitric acid, whence it becomes inſoluble in the acid, and falls down. Heat favours this effect; on which account the ſolution of tin does not keep ſo long in ſummer as in winter.

Conſtant obſervation teaches, that a leſs lively and agreeable colour is obtained by employing a ſolution of tin made with rapidity and the diſengagement of much vapour, than by uſing a ſolution made ſlowly and without effervеſcence. The reaſon is, that in the former caſe, the tin acquires more oxygen, the ſuperabundant part of which is more diſpoſed to quit it, and to occaſion a combuſtion of the colouring particles. On this account we ſhould prefer freſh ſolutions, made with caution, to old ones, however carefully prepared.

Other ſolutions which may be of uſe in dyeing, are made with nitro-muriatic acid. De la Folie has propoſed that of biſmuth: and though he begins to diſſolve the metal in nitric acid, it is a combination of it with the nitro-muriatic acid which is formed in the proceſs, by means of the marine ſalt employed. The ſolution in nitric acid alone could not be made uſe of, becauſe as ſoon as it is mixed with water, the metallic oxyd precipitates, ſo that it ſeparates,

rates, before it is able to unite with the colouring particles.

According to the deſcription given by Mr. Dambournay of this proceſs, which he has frequently employed [1], one part of biſmuth is to be diſſolved in four parts of nitric acid, this ſolution is then thrown into the bath, which contains tartar, and a ſolution of marine ſalt is poured in at the ſame time.

I have found, that, whether the ſolution of biſmuth be made immediately in aqua regia, or the ſolution in nitric acid be mingled with a ſolution of marine ſalt and tartar, a conſiderable precipitate is always formed on mixing it with water, though leſs than when water is mixed with the ſimple ſolution in nitric acid. I have alſo remarked, that the precipitate formed by this ſolution with the decoctions of colouring ſubſtances had an unequal colour and ſpeedily grew brown.

ARTICLE VI.

Of Tartar and ſome other Acids.

TARTAR is a ſalt depoſited on the ſides of caſks, from which it is afterwards ſeparated. It

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[1] Recueil de procédés & d'expériences ſur les Teintures ſolides.

is naturally mixed with impurities, depoſited at the ſame time with it; and when it is ſeparated from red wine, it retains a conſiderable portion of the colouring matter of the wine, whence it is diſtinguiſhed by the name of red tartar.

Tartar is purified at Montpellier and at Venice, by different proceſſes. At Montpellier, it is diſſolved in water, and cryſtallized by refrigeration. The cryſtals are boiled in another veſſel, with the addition of five or ſix pounds of white argillaceous earth of murviel to each quintal, and by evaporation is obtained the purified tartar, *cream of tartar*, *acidulous tartar of pot-aſh*. The laſt of theſe names points out the nature of the ſalt, which conſiſts of a peculiar acid combined in exceſs with pot-aſh. All the acid may be ſeparated from the alkali by means of lime, which has a greater attraction for it than the alkali has, and forms with it a ſalt ſcarcely ſoluble, whilſt the alkali remains in the liquor. If, inſtead of lime, carbonat of lime be employed, the acidulous tartar will be deprived only of the exceſs of acid, when a truly neutral ſalt, *tartrite of pot-aſh*, *vegetable ſalt*, may be obtained by cryſtallization.

The proceſs employed at Venice, conſiſts, according to the deſcription of it given by

Mr. Deſmarets[m], in firſt, drying the tartar in iron pots: ſecondly, pounding it, and diſſolving it in hot water; when, by refrigeration, cryſtals of a purer tartar are obtained: thirdly, in rediſſolving theſe cryſtals, and clarifying the ſolution with whites of eggs and aſhes.

In the latter proceſs, the alkali of the aſhes muſt decompoſe a portion of the acidulous tartar; the calcareous earth muſt alſo effect a decompoſition; and tartrite of pot-aſh, or vegetable ſalt, muſt be produced at the end of the evaporation.

The acidulous tartrite of pot-aſh, or cream of tartar, always retains a ſmall portion of calcareous tartrite.

An ounce of water, at ten degrees of Reaumur (54½ Farh.) diſſolves only four grains of this ſalt; but boiling water diſſolves much more.

The acidulous tartar of pot-aſh, which, throughout this work, I ſhall generally call by the ſimple name of tartar, is much uſed in dyeing. It is indiſpenſably neceſſary to employ that which is purified, for delicate colours, and it is beſt to uſe it in all caſes. In ſome proceſſes red tartar has been recommended, on the ſuppoſition, that its colour would contribute to that intended to be given to the ſtuff; but on

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[m] Journal de Phyſique, 1771.

diſſolving the tartar, its red particles ſeparate, and ſhould be conſidered as prejudicial impurities.

There is another ſalt which bears ſome analogy to tartar, and which would perhaps produce good effects in many caſes; this is the *acidulous oxalate of pot-aſh*, or ſalt of ſorrel, extracted from the juice of ſorrel, in Switzerland and in ſome parts of Germany. Scheele has ſhewn, that the acid of this ſalt is the ſame with that obtained from ſugar, and ſeveral animal and vegetable ſubſtances, by treating them with nitric acid; but it is found combined in exceſs with alkali.

Pure oxalic acid forms an inſoluble ſalt with calcareous earth, with which it has more affinity than any other acid, on which account it is proper for detecting the preſence of calcareous earth in liquids, particularly in water. The acidulous oxalate of pot-aſh may alſo be employed for this purpoſe; but the circumſtance which may render it moſt uſeful, is its property of readily diſſolving the oxyds of iron, and diſcharging the ſpots produced by them.

Vinegar, or the acetous acid, is too well known to require being noticed. Moſt vegetable ſubſtances afford a weak acid liquor, if left to ferment, and diluted with a ſufficient

quantity

quantity of water: but as it may be of importance, on many occaſions, to procure an acid liquor of a certain ſtrength readily and at a ſmall expence, I ſhall relate an experiment, deſcribed by the illuſtrious Mr. de Morveau, on the acid obtained from wood by diſtillation[a], to which has been given the name of pyroligneous. Nothing more is neceſſary than to diſtil ſmall bits of very dry beech wood, in an iron retort, in a reverberatory furnace, and to rectify the product by a ſecond diſtillation, or at leaſt to change the receiver, as ſoon as the oily part begins to riſe, which is eaſily perceived, by its imparting a deeper colour to the acid. Fifty-five ounces of very dry chips of beech, afforded ſeventeen ounces of rectified acid.

CHAPTER II.

Of Alum, or Sulphat of Alumine.

ALUM is of ſuch extenſive uſe in the arts, and particularly in dyeing, the greater part of the phenomena of which are found to be connected with its properties, that it is an object

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[a] Encyclop. méthod. t. i. àu mot *acide ligniqne.*

object of no ſmall importance in commerce. The manner in which it is manufactured has therefore a claim to our attention, and I imagine it will not be uſeleſs, to ſpeak of it at ſome length.

What we call alum, is a ſalt compoſed of ſulphuric or vitriolic acid, and pure argil. To the latter has been given the name of alumine, from its property of forming the baſe of this ſalt. According to Mr. Kirwan, one hundred parts of alum contain about twenty-four of acid, eighteen of earth, and fifty-eight of water, which may be driven off by heat, without decompoſing the ſaline combination.

This ſalt is found in ſome ſprings of mineral water: it effloreſces on the ſurface of ſchiſts, in coal-mines, or on lava in the neighbourhood of volcanos, and on many rocks: but the greater part of the alum made uſe of, is procured from ores, or manufactured by artificially combining alumine with ſulphuric acid.

Alum is mentioned in the works of the ancients, and that of Melos was particularly celebrated amongſt the Greeks[a]; but the learned Bergman[b] imagines, that the alum of the ancients

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[a] Voyage du jeune Anacharxis, t. iv.

[b] Bergman *de confect. alum. opuſc. vol. i.* This diſſertation was written in 1767. Mr. Beckmann maintained the ſame opinion in the Gottingen memoirs, 1778.

cients was a native ſubſtance, that differed greatly from the ſalt which we call by that name; and that the ſpecies of alum of which Dioſcorides ſpeaks, were rather ſtalactites, which might indeed contain alum, but only in a ſmall quantity, and mixed with other vitriolic ſubſtances. Nothing can be concluded from the deſcription of Pliny, which is taken only from inaccurate relations.

Factitious alum was firſt known in the Eaſt: we cannot tell preciſely when or where it began to be fabricated. One of the moſt ancient manufactories was that of Roche, a city of Syria, now called Edeſſa; whence aroſe the appellation of roch alum, ſtill, by an abuſe of words, applied to alum in cryſtallized maſſes. In the fifteenth century, this art was carried into Italy, from which country it ſpread into Germany and the reſt of Europe.

At the Solfatara, near Naples, is found an alum ore, under the form of a white earth. In this ore, alum is produced by the action of ſulphureous acid, diſengaged by the heat of the volcano, or argillaceous lava. This requires only to be diſſolved and cryſtallized.

The pureſt of alum ores, is that of Tolfa, near Civita-Vecchia. It is compoſed, according to Mr. Monnet, who firſt analyſed it, of forty

parts

parts of ſulphur, fifty parts of clay, that is a mixture of argil and ſiliceous earth, a ſmall quantity of carbonat of pot-aſh, and a very ſmall portion of iron. Bergman has alſo analyſed it, and gives nearly the ſame proportions.

The other ores from which alum is obtained, are ſchiſts, more or leſs pyritous, and more or leſs bituminous. Thoſe which are too pyritous, ought to be rejected, becauſe they afford an alum containing much ſulphat or vitriol of iron, from which they cannot eaſily be freed.

The operations by which alum is obtained from theſe ores, when it is not found ready formed in them, as at the Solfatara, have for their objects alumination, or the formation of the alum, the extraction of the alum, and its cryſtallization.

Moſt of the ores aluminate, when expoſed to the air and rain, without preparation; but thoſe which contain too much bitumen, or too much ſulphur, require to be roaſted before they are expoſed to the action of air and moiſture; and this operation accelerates the formation of alum in all.

Alumination conſiſts in the combination of oxygen, which, uniting with the ſulphur, converts it into ſulphuric acid, as Mr. Lavoiſier has ſhewn: but it is in general, ſulphat of iron that

that is formed, which, acquiring an exceſs of oxyd by expoſure to the air, is decompoſed by the alumine. We know not any ore, except that of Tolfa, in which the acid appears to combine immediately with the alumine.

When the alum is formed, the ore muſt be lixiviated, and the lixivium muſt be evaporated, till it is in a proper ſtate for affording cryſtals. Theſe firſt cryſtals are waſhed, rediſſolved in a very ſmall quantity of boiling water, and the ſolution poured into a kind of caſk, the ſtaves of which are afterwards looſened, that the maſs of alum formed in it may be extracted.

The reſiduum of the cryſtallizations is mixed with a greater or leſs quantity of the ſolution of the ore, and evaporated till it is in a fit ſtate for cryſtallization; and thus the workmen go on, adding the reſidua of the preceding cryſtallizations to freſh ſolutions of the ore.

There are here two eſſential circumſtances to be obſerved: the firſt, that the ſolution obtained from the ore of alum, contains an exceſs of ſulphuric acid, according to the obſervation of Bergman; the ſecond, that ſulphat of iron is always found in it, in greater or leſs quantity, and that this metallic ſalt remains chiefly in the reſidua of the cryſtallizations; for, according

according to Mr. Monnet, it cannot form mixed cryſtals with the alum.

The exceſs of ſulphuric acid tends to prevent the cryſtallization of the alum, ſo that, if it be not abſorbed, a conſiderable quantity of the ſalt will be loſt. It is with this view, that ſome add to the liquor, pot-aſh; others, putrid urine, which contains ammoniac. The latter ought not to be employed, becauſe, according to Bergman, the alum produced by it, has the effect of altering colours. That learned chemiſt propoſed to ſaturate the exceſs of acid with argil, which would not only abſorb the acid, but, at the ſame time increaſe the quantity of alum. Mr. Chaptal aſſerts, that this does not fulfil the intention: he ſays, that the alum itſelf diſſolves an exceſs of argil, and lets it fall at the end of the evaporation; that then, there is obtained only a granulous precipitate, without any appearance of cryſtals; or, if we ſucceed in procuring a cryſtallization of the alum, without adding an alkali, the cryſtals have neither the ſame hardneſs, nor the ſame weight, as they have in common[c]. Mr. Décroizille is of opinion, that the alkali contributes to the cryſtallization of the alum, not by ſubtracting the acid, but by the combination

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[c] Ann. de Chym. t. iii.

which takes place between the ſulphat of pot-aſh and ſulphat of alumine; and he informs me, that he obtained this cryſtallization equally well, by employing ſulphat of pot-aſh inſtead of alkali.

Iron is ſometimes found in a conſiderable quantity in alum, to which it is very prejudicial, particularly if it be uſed for lively and bright colours. This mixture might be avoided, by ſetting aſide the reſidua, called mother waters, which are uſually mixed with the liquors for cryſtallization. From theſe reſidua, which frequently contain alſo ſulphat of magneſia and other ſaline ſubſtances, alum of an inferior quality might be procured for other uſes mentioned by Bergman.

The alum of Tolfa, or roman alum, is generally preferred to every other kind. Its ſuperiority conſiſts, according to Bergman, in its containing much leſs iron: but by a careful cryſtallization, and not mixing with the ſolutions of the ore, the reſidue of the preceding cryſtallizations, other kinds of alum may be rendered even ſuperior in quality. The roman alum contains a ſmall portion of iron, in a peculiar ſtate, to which is owing, according to the ſame chemiſt[d], that roſy tinge by which it

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[d] Opuſc. t. iii. de prod. volcan.

it is diſtinguiſhed. An alum is prepared at Brunſwick, to which the ſame tinge is imparted by means of a ſmall portion of cobalt.

Mr. Décroizille is of opinion, that the roman alum differs from other kinds, and particularly from the Engliſh, in containing much leſs ſulphat of pot-aſh, and a larger portion of alumine. He has precipitated the alumine from engliſh and roman alum with carbonat of ſoda, and found, that the latter required one third more than the former.

As good alum ores are ſcarce in France, endeavours have been made to ſupply their deficiency, by a direct combination of the ſulphuric acid with alumine.

Common clay is a mixture of alumine, or that earth which conſtitutes the baſis of alum, and ſiliceous earth, in very various proportions. It contains alſo more or leſs iron, and other kinds of earth. We ſhould chooſe then the pureſt clays, that is, thoſe which contain the leaſt iron and calcareous earth.

Mr. Chaptal, having found, after many trials, that this proceſs was too expenſive to be purſued with advantage in the province of Languedoc, has ſought after more ſimple and œconomical methods.

He

He forms into balls of five or ſix inches diameter a clay, which is carefully ſelected. Theſe he calcines, breaks to pieces, and expoſes to the vapour of ſulphuric acid, at the moment of its formation, in a large chamber, conſtructed of wood coated with varniſh, which he ſubſtitutes to the common ones of lead. The clay thus impregnated with ſulphuric acid he leaves for ſome time under a ſhed; then lixiviates it, and proceeds to the cryſtallization. Far from making a ſecret of a manufacture which required many expenſive trials, Mr. Chaptal has given a deſcription of it, to be found in the memoirs of the academy for 1788, an abſtract of which has been inſerted in the third volume of the *Annales de Chymie*.

Mr. Décroizille, who has paid great attention to the manufacture of alum, aſſures me, that he is in poſſeſſion of a method of combining the earth with ſulphuric acid, much more ſpeedy and œconomical than Mr. Chaptal's; and that he hopes France may ſoon have no further occaſion to import alum, of which ſhe at preſent procures a conſiderable quantity from foreign countries.

It appears, that in the choice of alum there are two principal objects of inquiry: Firſt, Does it contain iron? To find this, the infuſion of galls may be employed, which will give a black tinge to a ſolution of the alum, if there be iron in it. Secondly, Does it contain much alkali in the form of ſulphat? The method employed by Mr. Décroizille may be recurred to for the purpoſe of aſcertaining this, taking true roman alum for the ſubject of compariſon.

Thirty parts of water at the common temperature, are required to diſſolve one of alum, according to Bergman, and of boiling water three parts are ſufficient.

Alum is decompoſed not only by alkalis, but even by the carbonats of lime and magneſia: yet it is to be obſerved, that even alkalis take away only a part of the acid, the precipitate retaining nearly half of it, and being a ſalt with a deficiency of acid, as Mr. Baumé has ſhewn.

If this precipitate be diſſolved in an acid, as the nitric acid or muriatic, this acid ſeizes the exceſs of alumine, and re-eſtabliſhes the proportions which conſtitute alum: ſo that by evaporation we obtain cryſtals, which appear different from thoſe of alum, but, on a careful examination, their form appears referable to one of the varieties of the cryſtals of that ſalt. This I have aſcertained on cryſtals procured from a ſolution of the precipitate of alum in nitric acid, which I requeſted Abbé Haüy to examine: I alſo ſatisfied myſelf, that it was the ſulphuric acid which entered into the compoſition of thoſe cryſtals. The alumine may be deprived of the acid which it retains when precipitated, by digeſting it in a ſolution of fixed alkali, or of ammoniac: in this caſe no cryſtals will be obtained from its ſolution in the nitric or muriatic acid.

Lime and cauſtic alkalis, mixed with the ſolution of alum in certain proportions, determine that ſalt to aſſume a cubical form, which phenomenon was, I believe, firſt deſcribed by Mr. Sieffert[e], and has given occaſion to many intereſting obſervations from Mr. le Blanc[f]; but the ſpecies of combination formed in theſe mixtures, and the proportions it admits, have not yet been aſcertained. It appears, that the lime and alkali united with the alum,

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[e] Siefferts Verſuch mit einheimiſchen Farbematerien, &c. 1775.

Mr. Sieffert quotes a diſſertation on cubic alum, which he publiſhed in the Hamburg magazine. To obtain this cubic alum, he directs twelve parts of common alum to be mixed with one part of lime ſlacked in the air, to diſſolve the mixture in boiling water, and to evaporate ſlowly.

[f] Journ. de Phyſique, 1788.

facilitate the ſeparation of the alumine, and conſequently its combination with the ſubſtances ſubmitted to the proceſs of aluming. This proceſs is employed with ſucceſs in dyeing linen and cotton.

I have a few more remarks to add on the combination of the colouring particles with alumine, and of alumine with the alkalis.

It would be ſuperfluous to repeat here the manner in which alum acts in the proceſſes of dyeing; as in the theory I have laid down, I have particularly called the reader's attention to that ſubject.

The name of lake is ſometimes given to the combination of colouring matter with alumine, obtained by mixing alum with a ſolution of colouring matter, and adding a proper quantity of alkali to effect or complete the precipitation. The term lake, however, has ſeveral ſignifications: it originated from an extract of lac, a colouring ſubſtance, of which I ſhall treat in the ſecond volume: it was afterwards applied to dry paſtels coloured with lac, for the uſe of painters; and at length to dry paſtels and powders of various colours, and different natures.

Alumine diſſolves pretty copiouſly in pure or cauſtic alkalis, eſpecially if aided by calcination.

nation. Macquer paid great attention to this ſolution, and conſidered it as a very advantageous mordant, particularly for dyeing cotton with madder [g]. I have repeated and varied his experiments, but I confeſs, that I have been far from ſucceeding in the degree he profeſſes to have done: it even appeared to me, that the colouring particles have too great an attraction for the alkali to ſeparate from it, and fix in ſufficient quantity on the ſtuffs, from which the alkali itſelf has the property of taking them. On this ſubject, however, I ſuſpend my opinion, becauſe I find Mr. Hauſſman alſo, whoſe authority is of great weight, conſiders the combination of alumine and pot-aſh, which he ſtyles alumine of pot-aſh, as well calculated for the purpoſe of a mordant [h].

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[g] In a memoir not publiſhed, which he read at a meeting of the academy.

[h] Lettre de M. Hauſſman. Ann. de Chym. tom. vii.

CHAP.

CHAP. III.

Of the Sulphat of Iron, or Martial Vitriol.

THE ſulphat or *vitriol of iron*, *martial vitriol*, *green copperas*, is cryſtallized in rhombs, of a beautiful green colour, tranſparent when recently cryſtallized. In a hundred parts, it contains twenty-four of ſulphuric acid, twenty-four of iron, and fifty-two of water.

The ſulphat of iron may be made directly with iron, and ſulphuric acid diluted with a certain quantity of water. This ſolution exhibits phenomena far from unintereſting to the chemiſt, but which it is not our buſineſs to conſider at preſent. The ſulphat of iron formed in this manner, bears a price which does not permit it to be employed in the arts, and nature furniſhes us with means of obtaining it at a much cheaper rate.

Native ſulphat of iron is found in coal-mines, in the cavities of pyritous ores, and in ſchiſts: but the greater part of what is conſumed, is obtained from martial pyrites.

Pyrites are ſtones conſiſting of oxyds of iron, ſulphur, argil, ſiliceous earth, and ſometimes calcareous earth, in various proportions. The formation of the ſulphat of iron in theſe ſtones is effected by expoſing them a conſiderable time to the action of the air and moiſture, or by roaſting them in the open air, and leaving them afterwards expoſed to its action. It is even neceſſary ſometimes to repeat this operation. The ſulphat, when formed, is obtained by lixiviation and evaporation.

Sulphat of iron is alſo prepared with mineral waters, which hold copper in ſolution. The copper is precipitated by means of iron, and the ſolution, which ſtill retains a ſmall portion of copper, is made to cryſtallize.

The ſulphat of iron of Goſlar, commonly contains a little zinc; that of Hungary, and that of Saxony, a little copper [a]. The ſulphats of England and of France are more pure. Theſe, however, ſometimes contain alum; particularly the latter.

Sulphat of iron might be made, free from copper or alum, if care were taken to keep pieces of iron in the evaporating veſſel, as

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[a] Kirwan's Mineralogy.

Mr.

Mr. Monnet adviſes [b]; ſince iron has the property of precipitating both copper and the baſe of alum. It appears, that the ſuperiority of the engliſh vitriol is owing to this precaution, which is obſerved alſo in the two manufactories near Alais [c]. There is only zinc which will not be precipitated in this way; but that is ſeldom found in ſulphats of iron, and never in any quantity.

The copper contained in many ſorts of ſulphat of iron, appears not to be prejudicial to the black dyes, for which this metallic ſalt is chiefly employed. If, however, it be required to free them from it, it may be done by keeping plates of iron for twenty-four hours immerſed in a cold ſolution of the ſalt, when the whole of the copper will be precipitated on theſe plates. Cryſtallization is incapable of producing the effect, becauſe, as Mr. Monnet obſerves, the ſulphats of iron and of copper form a mixed ſalt, and will not ſeparate.

Alum is probably more detrimental to black than copper; for when a black ſtuff is boiled with that ſalt, it diſcharges the colour by diſſolving it. It is apparently on this account,

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[b] Traité de la Vitrioliſation.

[c] Chaptal's Elements of Chemiſtry, vol. ii.

that the engliſh vitriol is ſo much eſteemed.

Sulphat of iron may be freed from alum alſo, by keeping it ſome time in digeſtion with iron filings: but this decompoſition is more difficult and leſs complete, than that of the ſulphat of copper.

It is only from want of care in the cryſtallization however, that the ſulphat of iron retains alum: for, as obſerved by Mr. Monnet, theſe two ſalts cannot combine into mixed cryſtals, ſo that they may be ſeparated by a careful cryſtallization.

When ſulphat of iron is kept long expoſed to the air, it tarniſhes and becomes yellowiſh: its ſolution grows turbid by boiling, a part of the iron is precipitated in the form of a yellow powder, and it loſes the property of forming cryſtals. Theſe phenomena are owing to the iron attracting oxygen, or the baſe of pure air, from the atmoſphere, with which when it is ſaturated to a certain point, it cannot be kept in ſolution but by an exceſs of acid. Hence it continues to be precipitated, till what remains is capable of being held in ſolution by the acid which is found in due proportion. To avoid this kind of decompoſition, the ſulphat of iron ſhould not be

diſſolved

diſſolved till the moment it is wanted, and it ſhould be diſſolved with the leaſt poſſible heat. I have remarked, that a ſolution made with a low degree of heat, kept much longer expoſed to the air without growing turbid, or depoſiting a ſediment, than a ſolution made by boiling, and afterwards filtered.

Sulphat of iron is of great uſe in dyeing, particularly for black, gray, and other hues, which are darkened by its means. I have ſhewn, in the firſt ſection, how it acts by combining with the aſtringent principle and the colouring particles.

Solutions of iron in the acetous and ſome other vegetable acids, are alſo uſed in dyeing: but theſe preparations are made in the places where they are uſed, and their deſcription will be found with that of the proceſſes, of which they make a part.

All the ſolutions of iron differ greatly in the ſtate in which the metal exiſts in them, and in the property of attracting more or leſs oxygen from the air.

The ſolution in nitric acid, according to the obſervation of Mr. Hauſſman [d], ſhews no marks of abſorbing vital air, even when agi-

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[d] Journ. de Phyſique, 1787.

tated in contact with it; but it retains a great exceſs of acid.

The ſolution in acetous acid is at firſt of a pale green; by abſorbing vital air it grows more and more yellowiſh; and at length acquires a very deep reddiſh yellow colour. It takes a great proportion of iron, and abſorbs oxygen without forming a ſediment.

The ſolution in ſulphuric acid attracts oxygen more ſlowly than the preceding one, forms a depoſit of oxyd proportionate to the quantity of that principle, and thence acquires a gradually increaſing exceſs of acid.

The muriatic acid diſſolves oxyd of iron in whatever ſtate it finds it: but if it contain much oxygen, a part of the acid is diſengaged in the form of oxygenated muriatic acid, as Mr. Fourcroy has obſerved.

Theſe properties of the ſolutions of iron, may ſerve to explain the differences they exhibit, when employed in the arts.

CHAP. IV.

Of the Sulphat of Copper, or Blue Vitriol.

THE ſulphat of copper, *blue vitriol*, *cyprus vitriol*, *blue copperas*, is a ſalt compoſed of oxyd of copper and ſulphuric or vitriolic acid. This ſalt readily forms blue cryſtals of a rhomboidal form. The quintal contains thirty pounds of acid, forty-three of water, and twenty-ſeven of copper. At the temperature of twelve degrees of Reaumur (59 Farh.) it requires nearly four parts of water to diſſolve it.

Sulphat of copper is of no great uſe in the arts, whence little attention has been paid to the different proceſſes by which it may be prepared.

In making the ſulphat of copper for commerce, two methods are employed. The firſt conſiſts in calcining copper pyrites, or the mat which reſults from the fuſion of copper ore, and which is a compound of copper and ſulphur, and leaving the product of the calcination to effloreſce. By this means the copper is oxydated, and the ſulphur converted into

into ſulphuric acid. The ſalt formed is then extracted and cryſtallized. The ſecond method is to calcine an artificial mixture of ſulphur and copper, to leave it in like manner to effloreſce, to lixiviate the ſalt, and cryſtallize it.

There are ſome waters that contain copper combined with the ſulphuric acid, which might be employed when we want to uſe ſulphat of copper.

Lime and the alkalis produce, with the ſulphat of copper, a greeniſh blue precipitate, which ſoon becomes green in the air. Ammoniac produces a beautiful blue precipitate, which it quickly rediſſolves, and which alſo becomes green in the air. Theſe differences of colour depend on the proportions of oxygen combined with the copper: if it be in ſmall quantity, the oxyd is blue; if in a larger, it is green: whence the blue oxyd becomes green in the air, by combining with the oxygen which it attracts from the atmoſphere.

Oxyd of copper eaſily combines with moſt kinds of colouring particles, by which it is precipitated from acids. It frequently imparts to them a pleaſing colour: but as its own colour, which influences that of the combination, is eaſily changed by the air, the colours

lours reſulting from its mixture are variable, and of little duration, ſo that there are few occaſions on which it can be employed with advantage.

It has been remarked, that the ſulphat of copper attacks cloths more than that of iron [c]. This effect is partly owing to its poſſeſſing a much greater quantity of active acid than the latter: for, according to Mr. Kirwan's calculation, one hundred parts of ſulphat of iron contain twenty parts of ſulphuric acid, and a hundred parts of ſulphat of copper contain thirty. This acid is ſet free when the oxyd combines with the colouring particles, and exerts its action on the cloth, or rather on the combination of the cloth with the colouring particles. But what more eſpecially augments on one hand the quantity of acid ſet free, and conſequently its action on the cloth, and on the other, the influence of the oxyd of copper on the qualities of the colour, is, that this oxyd enters in a large proportion into the combination which it forms with the colouring particles. I have precipitated an equal quantity of decoction of ſuſtic (bois jaune) with ſulphat of copper, and with ſulphat of iron,

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[c] Inſtruction ſur l'art de la Teinture: by Mr. Poerner.

and found the precipitate produced by the former, much more conſiderable than that produced by the latter: conſequently there was more ſulphat of copper decompoſed by the ſame quantity of colouring matter, than ſulphat of iron. The quantity of acid ſet free is more conſiderable therefore, on two accounts.

A proof, that the action on the cloth is not owing principally to the oxyd of copper, is, that the ſame objection is not made to verdegris as to blue vitriol.

CHAP. V.

Of Sulphat of Zinc, or White Vitriol.

THE ſulphat of zinc, *vitriol of zinc, white vitriol, white copperas*, is compoſed of ſulphuric acid and oxyd, or calx of zinc. A little more than twice its weight of water is required to diſſolve it at a temperature of twelve degrees of Reaumur (59 Farh.) and by evaporation we obtain cryſtals in the form

form of a tetrahedral priſm, terminated by a quadrilateral pyramid. According to Mr. Kirwan, a hundred parts of ſulphat of zinc contain twenty-two of acid, twenty of zinc, and fifty-eight of water.

The greater part of the ſulphat of zinc met with in commerce, is prepared at Goſlar, where, after having roaſted and diſtilled the ore which contains the zinc, the reſiduum is thrown red-hot into water, lixiviated, and the liquor evaporated, by which means this metallic ſalt is obtained.

The ſulphat of zinc of the ſhops always contains iron, and when a ſolution of it is left expoſed to the air, or made to boil, it grows turbid, and a portion of the iron precipitates; but the greater part always remains, and cannot be entirely precipitated but by boiling the ſolution with filings of zinc: even by this proceſs it is difficult to ſeparate the whole of the iron.

Hitherto little uſe has been made of this metallic ſalt in dyeing. When it has been employed, it has been found to render the colours deeper; which effect is owing, in a great meaſure, to the iron which it always contains. I have made ſulphat of zinc by diſſolving zinc in ſulphuric acid: ſome of this ſolution I have poured into infuſions of ſumach, galls, madder, and cochineal, and compared the effects it produced with thoſe of a ſolution of common ſulphat of zinc, which had been long made, and had depoſited all the iron that expoſure to the air would throw down. The latter rendered the colours much deeper than the former. The depoſit produced by the pure ſulphat with the infuſion of ſumach was a violet lilac; with the infuſion of galls, a little deeper; with that of madder, bright purple; with that of cochineal, firſt red, afterwards a beautiful purple. In general the precipitates produced by the ſulphat of zinc grow a little darker with time; which indicates, that the oxyd of zinc produces a ſlight combuſtion of the colouring matter: it appears, moreover, to combine with it but in ſmall proportion. Hence we ſee the reaſon why it renders colours darker than the oxyd of tin, though they are equally white.

CHAP. VI.

Of Verdegris, and Acetite of Copper.

FORMERLY verdegris was prepared only at Montpellier, and in its neighbourhood. The proceſs followed there conſiſted in fermenting the ſtalks of grapes with wine-lees, ſtratifying plates of copper with theſe ſtalks, taking them out after ſome time, ſetting them up edgewiſe in a corner of the cellar, where they were again ſprinkled with wine-lees, and ſcraping off the verdegris which ſwells up from the laſt operation. The ſame proceſs was repeated on the plates of copper, after having removed the verdegris.

At Grenoble they uſe vinegar ready made, with which they ſprinkle the plates of copper. The verdegris prepared in theſe two ways differs in ſome of its properties.

The copper is reduced to an oxyd from the ſame cauſes as lead is in the making of white lead, that is, from the concurrent action of the atmoſpheric air, and the acetous acid, which is employed, or which forms in the grape-ſtalks: but as veſſels of copper are much uſed, it may not be improper to conſider the manner in which acids act on that metal ſomewhat at length.

For copper to diſſolve in acids, it is neceſſary, as with other metals, that it be combined with oxygen, or reduced to a calx or oxyd. It is requiſite, therefore, that it attract oxygen from the atmoſphere, or that the acids furniſh it, or indeed that it decompoſe the water. The laſt caſe requires circumſtances which do not occur in the proceſſes of dyeing.

Vegetable acids cannot impart oxygen to copper: but the action they exert on it favours its combination with oxygen ſo much, that it readily attracts the atmoſpheric air, by which it is reduced to an oxyd, and becomes ſoluble in the acid liquor. But that the copper may be capable of attracting the oxygen of the atmoſphere, it is neceſſary, that the liquor be cold: hence vegetable acids whilſt hot do not attack copper, and the ſame thing holds with reſpect to oils, and other ſubſtances which act on that metal, unleſs a portion of copper be previouſly oxydated, in which caſe it readily diſſolves, whatever be the temperature of the liquor. From this we ſee the neceſſity of never ſuffering liquids capable of attacking copper to grow cold in veſſels of that metal, and of taking care to keep them always extremely clean,

clean, that no oxyd may be ſound formed on their ſurface.

The nitric acid, and nitro-muriatic acid, or aqua regia, have the property, though diluted with water, of imparting oxygen to copper, and of diſſolving it, eſpecially when the liquor is in a ſtate of ebullition. Thus it is impoſſible to prevent a portion of the metal from being diſſolved in baths into which is put ſolution of tin, for inſtance, unleſs the copper be carefully tinned. One circumſtance, however, tends to diminiſh this effect, the action of the nitric acid being exerted on the vegetable ſubſtances, and ſtill more on the animal ſubſtances, that are in the bath with it.

The copper in verdegris, then, is reduced to an oxyd, and combined with a portion of acetous acid more or leſs conſiderable. When the oxyd of copper is completely ſaturated with this acid it is wholly ſoluble in water, and by evaporation forms blue rhomboidal cryſtals, which, fixing on little ſticks, produce thoſe groups known by the name of *cryſtallized verdegris*, *cryſtals of Venus* (diſtilled verdegris). The difference between this ſalt and verdegris is, that in the former, the oxyd of copper is completely ſaturated with acetous acid, or it is the acetite of copper; and that in the verdegris there is only a portion of the oxyd of copper in the ſtate of acetite. This ſaline portion may be ſeparated by ſolution in water, the oxyd of copper, which is inſoluble in water, remaining undiſſolved: but this may eaſily be diſſolved in acetous acid, and thus reduced to the ſame ſaline ſtate[a]. Sometimes verdegris contains very little acetite; at others, on the contrary, it contains ſcarcely a fourth of its weight of uncombined oxyd of copper. To this is owing the difference which diſtinguiſhes the verdegris of Grenoble from that of Montpellier: the former containing much more acetite of copper; the latter, of oxyd of copper uncombined.

Theſe obſervations may be uſeful to any one who ſhould attempt to make verdegris, or diſtilled verdegris, for himſelf, which might be done in different ways, according to circumſtances; and for judging of the qualities of verdegris, which will be more or leſs fit for any particular uſe, according to its nature. Then, if it be neceſſary, that the verdegris ſhould be diſſolved, the greater part of what was uſed would be waſted if it contained but little acetite: in this caſe, the uncombined oxyd might be diſſolved in vinegar, and then

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[a] Mem de l'acad. 1782.

the whole rendered fit for the purpoſe required. In other circumſtances, it is the oxyd that is uſeful; when we ſhould chooſe verdegris that contains little acetite, or even diſſolve the acetite, and reſerve it for other occaſions.

The verdegris uſed in dyeing black acts principally, and perhaps ſolely, by its uncombined oxyd. This oxyd ſerves to precipitate the iron combined with the aſtringent principle, by combining with the ſulphuric acid; which will explain the obſervations of Mr. Clegg, that I am going to relate[b].

Mr. Clegg, endeavouring to diſcover ſome cheaper ingredient, that might be ſubſtituted inſtead of verdegris for dyeing black, obſerved, that the copper of the verdegris precipitated the iron of ſulphat of iron, held in ſolution with aſtringent ſubſtances, in the ſtate of oxyd. But I have remarked, that the iron was combined with the aſtringent principle, when precipitated by the oxyd of copper, and even that the oxyd of iron cannot be precipitated by the oxyd of copper but on account of the double affinity which reſults from the

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[b] Tranſactions of the ſociety, inſtituted at London, for the encouragement of arts, manufactures, and commerce, vol. i. pag. 181.

action of the aſtringent principle. Conſidering the verdegris as a precipitant of iron, Mr. Clegg ſought to ſubſtitute for it other ſubſtances calculated to precipitate iron from its ſolvents. He firſt tried alkalis, which appeared to ſucceed in a ſmall way, but would not anſwer on a large ſcale: in fact, alkalis do not precipitate the combination of iron and the aſtringent principle, but form with it a ſupra-compound, and give it a reddiſh tinge. He afterwards aſcertained, by repeated experiments, that the purpoſe of verdegris might be fully anſwered by a mixture of ſulphat of copper and pot-aſh. The ſulphat of copper he directs to be diſſolved, and a ſolution of pot-aſh to be added till the blue colour diſappears, that is to ſay, till the whole of the copper is precipitated. Nearly equal weights of ſulphat of copper and of the alkali are requiſite for this purpoſe: and Mr. Clegg aſſures us, that theſe will ſupply the place of a quantity of verdegris equal to the weight of both, particularly in dyeing hats; in which much verdegris is employed.

The advantages of this proceſs depend on the comparative prices of ſulphat of copper, of pot-aſh, and of verdegris. Inſtead of the ſulphat, we may uſe the ſolution of copper in nitric acid made in the operation of parting.

CHAP. VII.

Of the Acetite of Lead, or Salt of Saturn.

THE acetite of lead, or ſalt of ſaturn, is a combination of lead, reduced to an oxyd or calx, with acetous acid or vinegar. It is generally cryſtallized in fine confuſed needles; if, however, it be cryſtallized by a ſlow evaporation, white cryſtals in flat parallelipipedons, terminated by two ſurfaces inclining in oppoſite directions, will be obtained.

This ſalt has, with a ſlight aſtringency, a ſaccharine taſte, from which it has acquired the improper appellation of ſugar of lead. It is in ſome degree decompoſed by water, and forms with it a milky liquor, that depoſits a white powder, partly owing to the oxyd of lead which has forſaken the acid: but this depoſition may be prevented by the addition of a certain quantity of acetous acid; a proceſs that may be uſeful when this ſalt is employed

ployed in dyeing. Beſide this depoſit, which takes place even in diſtilled water, another occurs in waters containing ſulphat, which is owing to a combination of the oxyd of lead with the ſulphuric acid, and is proportional to the quantity of that acid. The ſalt reſulting from the muriatic acid is ſufficiently ſoluble not always to form a depoſit.

The acetous acid does not attack lead in its metallic ſtate, unleſs in contact with the air: but if the air touch its ſurface, the lead gradually becomes oxydated, by means of the oxygen it attracts, and is thus rendered ſoluble in the acid.* As this manner of preparing acetite of lead, however, would be diſadvantageous, both becauſe it would require much time, and becauſe a great part of the acetous acid would evaporate, recourſe is had to other proceſſes.

White lead is an oxyd of lead which appears to be combined with a ſmall portion of acetous acid. To form it, lead in ſheets is ſuſpended over vinegar, in earthen veſſels, which are buried in dung, that the heat may keep up the evaporation of the vinegar, which, in exhaling, reduces the lead to an oxyd by the aſſiſtance of the air. This oxyd, which is powdered with great care, forms white lead: but

but a part of it, falling into the vinegar, diſſolves in it, and forms acetite of lead, which requires only to be evaporated, and purified by a ſecond cryſtallization.

Acetite of lead is prepared for the moſt part with diſtilled vinegar, obtained from beer or wine, and white lead, which, as has been ſaid, is an oxyd of lead reduced to a very ſubtile powder, and conſequently in the moſt favourable ſtate for ſolution. Deſcriptions of the proceſſes by which it is prepared in the large way may be ſeen in the *Art du Diſtillateur* of Mr. de Machi, and more particularly in the *Dictionnaire de Chymie* of Mr. de Morveau, under the article *Acétite de Plomb*.

If a perſon find himſelf in want of acetite of lead, he may eaſily make it, by diſſolving an oxyd of lead in diſtilled vinegar, and evaporating the ſolution to the proper point for cryſtallization. Various oxyds of lead may be employed for this purpoſe. White lead diſſolves more eaſily than any other, except ceruſe but this ſhould be rejected, becauſe it is a mixture of white lead and chalk. Litharge, or the ſemi-vitrified oxyd of lead, may be taken inſtead of white lead; but minium diſſolves with more difficulty.

In many caſes, it would be ſufficient, to diſſolve the oxyd of lead in white wine vinegar, the extractive part of which, that conſtitutes its principal difference from diſtilled vinegar, would not injure colours. Neither would the exceſs of acid which this ſolution might retain be detrimental, and it might prevent the formation of the precipitate that takes place when acetite of lead is diſſolved in water. As the acetite of lead is of ſome price, this proceſs might be employed with advantage where much is uſed.

The acetite of lead forms, in general, a copious precipitate with ſolutions of the colouring particles.

It deepens colours, and renders them more permanent, but leſs bright. The greateſt uſe made of it is for the compoſition of the principal mordant employed for printed linens, in which it ſerves, as has been ſaid, to form a combination of the baſe of alum with acetous acid.

CHAP. VIII.

Of Fixed Alkalis.

IN chemiſtry two alkalis are diſtinguiſhed: fixed alkali, and volatile alkali, or ammoniac. The former reſiſts the action of fire; the latter evaporates at every degree of temperature to which our atmoſphere is liable. Each has a powerful action on the colouring particles: but as the volatile alkali is not uſed in dyeing, or, at leaſt, not in an uncompounded ſtate, fixed alkali only will be conſidered here.

Fixed alkali is divided into two kinds: vegetable fixed alkali, or pot-aſh, and mineral alkali, or ſoda.

ARTICLE I.

Of Vegetable fixed Alkali, or Pot-Aſh.

THIS alkali is extracted from the aſhes of various vegetable ſubſtances, whence it has obtained the name of vegetable alkali: and as it is more or leſs pure, more or leſs cauſtic, according to the ſubſtance from which it is procured,

procured, and the circumſtances attending its preparation, many varieties are made of it in commerce, to which have been given different names, indiſpenſably neceſſary to be diſtinguiſhed. Firſt, however, we muſt conſider alkali, independently of the mixtures by which its properties are modified.

Vegetable alkali may be pure, and free from all combination, or it may be combined with carbonic acid. In the former ſtate it is *pot-aſh*, the *pure pot-aſh* of chemiſts, *cauſtic vegetable fixed alkali:* in the latter, it is *carbonat of pot-aſh, efferveſcent vegetable fixed alkali.*

Pure or cauſtic pot-aſh has a very acrid lixivial taſte. It attracts the humidity of the air ſo powerfully, that it cannot be made to cryſtallize but by peculiar proceſſes. In this ſtate it combines with oils to form ſoap. But the purity of alkali is never abſolute; it always retains earths in ſolution; unleſs alkohol or ſpirit of wine, be employed to purify it [a]. Hence when we ſaturate it with an acid, a ſediment is formed, which ſometimes aſſumes the appearance of a jelly: this ſediment is produced by the earth, which ſeparates.

The carbonat of pot-aſh is the ſalt juſt mentioned ſaturated with carbonic acid. In this

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[a] Mem. de l'acad. 1782.

ſtate it no longer holds earth in ſolution, and it produces an effervefcence with acids, owing to the carbonic acid, which eſcapes, and aſſumes the form of gas. This ſalt has a ſavour analogous to that of pure alkali, but much weaker, and without cauſticity. It ought to be conſidered as a true neutral ſalt, and is reducible into cryſtals, like moſt other ſalts of this ſpecies. Lime mixed with it ſeizes its carbonic acid, and precipitates, thus rendering it cauſtic. It likewiſe parts with its carbonic acid when urged by a ſtrong heat.

The alkali obtained from aſhes, or found in commerce under different denominations, is a compound of pure alkali and carbonat of potaſh. The proportion of theſe varies, not only in ſalts ſold under different names, but even in thoſe which are prepared in the ſame way. A difference in the degree of heat employed is ſufficient to produce a difference in cauſticity; and they are beſides mixed with greater or leſs quantities of earth, and heterogeneous ſalts.

The moſt ſimple method of ſeparating alkali from earths, and heterogeneous ſalts, is to leave it expoſed to the air in a moiſt place: the alkali attracts the humidity of the air; and the earth, with the greateſt part of the heterogeneous ſalts, forms a ſediment, from which is to be poured off the liquor, improperly called oil of tartar by deliqueſcence. The part combined with carbonic acid, which, if alone, would have formed cryſtals, diſſolves by means of the cauſtic part: but it is to be obſerved, that, if the ſolution be long left expoſed to the air, it gradually attracts the carbonic acid which always exiſts in the atmoſphere, and at length cryſtallizes, as Bohn and Montet long ago remarked. If a more ſpeedy method of purifying the alkali be required, nothing more is neceſſary than to mix it well with an equal weight of cold water, and filter the liquor, or let it ſettle, and decant it when clear. An equal quantity of water may be poured on the reſiduum; but the alkali thence obtained will be much leſs fine than the former.

Salt of tartar is an alkali obtained from the combuſtion of tartar, wrapped up in cones of paper. The reſiduum of this combuſtion is diſſolved in water, the ſolution is concentrated on the fire, the heterogeneous ſalts are ſeparated as they precipitate, and by deſiccation is obtained the ſalt of tartar, the pureſt alkali to be met with in commerce, but at the ſame time the deareſt. The alkali of ſalt of tartar has little cauſticity.

Cendres gravelées abound in alkali, but are leſs pure than ſalt of tartar. They are produced from the combuſtion of wine-lees and the aſhes of vine-twigs.

The pot-aſh of commerce is the reſult of the combuſtion of wood, burnt for that purpoſe in ſome of the northern countries where foreſts abound, chiefly in Ruſſia and Sweden. According to Linnæus, birch or alder is burnt with a ſlow fire; the aſhes are made into a kind of paſte with water; billets of fir or pine are laid in a row, and covered with this paſte; on this row another, covered in like manner with the paſte, is laid tranſverſely; and this is repeated, till the pile riſes to a conſiderable height: this pile is then ſet on fire, and when the aſhes begin to run, it is overturned, and the melted aſhes are beaten with flexible rods. By this operation they are mixed with the logs, and become as hard as ſtone.

It appears from this account, that pot-aſh muſt contain much earth; but it ſeems too, that lime is ſometimes mixed with it. Dr. Home found it principally in a kind of pot-aſh, called *caſhub aſhes*, which are much uſed by the bleachers in Flanders and Artois[b].

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[b] Eſſay on Bleaching.

An excellent judge, Mr. Chaptal, thinks, that a ſaving might be made by the eſtabliſhment of a manufacture of pot-aſh in ſome of the foreſts in France. He ſays, he has found from nice calculations, that a pot-aſh which he cauſed to be manufactured in ſome of the foreſts of Languedoc, came not to more than half the price given for that which is brought us from the North [c]. He obſerved, that the aſhes of hard woods generally contained the moſt; and aſhes of box afforded him twelve or fourteen pounds in the hundred. According to Mr. Sage, a hundred pounds of oak give only half a pound of aſhes [d].

The action of aſhes in ley is owing to the alkali they contain; hence float-wood, having been deprived by the water of the ſaline and extractive matter, from which the alkali ought to be diſengaged by combuſtion, affords inactive aſhes.

It is eaſy to ſee, that the pot-aſh of commerce, the vegetable alkali chiefly uſed in the arts, muſt differ conſiderably, according to the mixtures naturally found in it, or added to it, and the circumſtances attending its making. Now, to aſcertain the real quantity of alkali

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[c] Elements of Chemiſtry, vol. i.

[d] Journal de Phyſique, 1789.

contained in it, would be of no ſmall advantage. By the taſte, we ſhould eaſily be deceived; for that pot-aſh which contained alkali in a more cauſtic ſtate, would appear far more acrid than that in which the alkali was combined with a greater quantity of carbonic acid. Trials on leys, or on colouring matter, might prove fallacious, for the ſame reaſon. A certain method of eſtimating it would be, to diſſolve a given weight in water, to filter the liquor, and to compare the quantity of acid it would require to ſaturate it, and render it incapable of turning green the ſyrup of violets, infuſion of radiſhes, or any other vegetable colour calculated for ſuch a teſt, with the quantity neceſſary to produce the ſame effect on a known weight of pure alkali.

Pot-aſh is of very extenſive uſe in dyeing: in general it facilitates the ſolution of the colouring matter, and deepens its colour.

Some direct the uſe of ſalt of tartar, or *cendres gravelées*, in certain proceſſes: but pot-aſh may be ſubſtituted inſtead of them in all caſes, if care be taken to purify it as I have directed; unleſs, indeed, an alkali containing much carbonic acid be required; and even this quality may be given to the ſolution of pot-aſh, by leaving it ſome time expoſed to the air. As theſe alkalis differ greatly in price, this merits ſome attention.

As fixed alkali has a powerful action on ſubſtances of an animal nature, and diſſolves them when it is in a cauſtic ſtate, great attention ſhould be paid to the proportions of this ſalt employed in proceſſes to which theſe ſubſtances are ſubjected, and to the degree of cauſticity it poſſeſſes.

ARTICLE II.

Of Mineral Alkali, or Soda.

THE epithet mineral has been affixed to this alkali becauſe it is frequently found in the bowels of the earth, on its ſurface, or in ſubterraneous cavities. Thus in Egypt, where it is called natron, it is obtained from two lakes, which grow dry in ſummer. It is alſo found in ſeveral parts of Barbary, in Syria, Perſia, the Eaſt-Indies, and China, and even in our climates. The greater part of what is uſed, however, is obtained from the combuſtion of plants growing on the ſea-ſide, particularly from the kali, or ſoda; whence the generic name of ſoda has been given it by moſt modern chemiſts.

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The natron contains ſea-ſalt and ſulphat of ſoda, or Glauber's ſalt, in different proportions.

Mineral alkali exhibits the general characters deſcribed in ſpeaking of pot-aſh: but it differs from it principally, firſt, in affording different neutral ſalts with the acids; ſecondly, in being always ſaturated with carbonic acid in its natural ſtate, and affording cryſtals, which, far from attracting the humidity of the air, yield to it their water of cryſtallization, and thus effloreſce, aſſuming the appearance of flour. The ſoda of commerce contains a greater or leſs quantity of earth, ſea-ſalt, ſulphat of ſoda, or Glauber's ſalt, coal, and ſulphuret of alkali or liver of ſulphur. That which is of a good quality, does not yield above five or ſix ounces of ſalt of ſoda (per pound) which may be ſeparated by ſolution and cryſtallization. The beſt is that obtained from barilla[e], on the coaſt of Spain, and known by the name of alicant ſoda. Mr. Chaptal is convinced, that this plant might be cultivated with the greateſt ſucceſs on the coaſts of the Mediterranean.

A plant, known by the name of *ſalicor*, which affords ſoda of a good quality, is cultivated on

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[e] See a deſcription of this plant, by Juſſieu, in the memoirs of the French Academy for 1727.

the borders of ponds in Languedoc and Provence.

A kind of ſoda, known by the name of kelp, *cendre de varech*, is prepared on ſeveral of our coaſts. It contains but little ſalt of ſoda, and its ſaline parts is ſometimes wholly ſea-ſalt. In general, plants that grow without culture, produce ſoda of an inferior quality.

The method above directed for trying the quality of pot-aſh, is equally applicable for determining that of ſoda.

To free the mineral alkali from heterogeneous ſalts, it ſhould be diſſolved in water, and the different ſalts ſeparated as they precipitate or cryſtallize: the cryſtals of ſalt of ſoda are the laſt that form.

When ſalt of ſoda is uſed, it is eſſential to attend to its ſtate; for when it is in cryſtals, it contains more than half its weight of water of cryſtallization, ſo that when it has fallen into efflореſcence, one part will produce as great effect as two of the cryſtals.

Salt of ſoda is a carbonat of ſoda, a combination of carbonic acid with pure ſoda. Lime acts on this ſalt in the ſame manner as on the carbonat of pot-aſh; that is, it takes from it its carbonic acid, and renders it cauſtic: in this ſtate it is pure ſoda, or ſimply the *ſoda* of chemiſts, the *ſoap-boilers ley*.

In ſome places, the appellation of *aqua-fortis*, or *ſoap-boilers aqua-fortis*, is given to a ſolution of cauſtic or pure ſoda[f]. Such a denomination may eaſily occaſion miſtakes, and make this alkaline ſolution be confounded with nitric acid, or common aqua-fortis. Hellot informs us, that he was thus deceived with reſpect to the manner of preparing an indigo-vat, for which directions had been given him.

Lately, ſeveral proceſſes have been diſcovered for extracting the ſoda from ſea-ſalt or muriat of ſoda, of which it is the baſe. Of many the ſecret has not been diſcloſed. If theſe proceſſes be not too expenſive for extracting the ſoda with profit, they ought to be conſidered as very beneficial, as this ſalt is of extenſive uſe in ſeveral of the arts, and we are obliged to procure it from foreign countries.

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[f] Procès-verbal des Opérations de Teinture faite à Yvetot, par François Gonin.

CHAP. IX.

Of Soap.

SOAP is a combination of oil with alkali; but that this combination may take place, it is neceſſary that the alkali ſhould be pure, that is, free from carbonic acid. Vegetable alkali, or pot-aſh, and mineral alkali, or ſoda, are both capable of forming ſoap: yet the latter is preferred, becauſe the ſoap made with pot-aſh has not an equal degree of ſolidity.

To make the ſoap of commerce, we begin with rendering the ſoda cauſtic. For this purpoſe, one part of good alicant ſoda and two of quick lime, are boiled in a ſufficient quantity of water; the liquor is filtered, and evaporated to ſuch a degree, that a phial which would contain only eight ounces of pure water, will hold eleven ounces of this liquor, called *ſoap-boilers ley*. One part of this ley, and two of oil, boiled together, till, on taking up ſome of the mixture with a ſpatula, it does not adhere, and ſpeedily coagulates, form ſoap.

In almoſt all manufactories the ley is prepared cold, by filtering water through a mixture of equal bulks of powdered alicant ſoda and quick lime. This lye is then mixed with oil in the boilers, and their combination is promoted by the action of heat. The ley that paſſed laſt through the filter, and which is the weakeſt, is put into the boiler firſt, and ſtronger ley is added gradually, till the end of the operation.

To make mottled ſoap, ſoda in its native ſtate, ſulphat of copper, or blue vitriol, cinnabar, &c. are employed, according to the colour ſought.

A ſoft ſoap alſo is prepared[a] by boiling a ley made of ſoda, pot-aſh, or even common wood aſhes, with the cake left after preſſing out the oil of olives, nuts, or rape, with fats, with fiſh oils, &c. which make black or green ſoap. Mr. de Bullion has propoſed to make ſoaps with animal fats[b]: I have been aſſured, that a learned chemiſt has a manufacture of this kind of ſoap in England. In America, ſoap is made with green wax.

All the acids, even the carbonic acid, decompoſe ſoap, and ſeparate the oil by combining with the alkali. Salts, with earthy or metallic baſes, have the ſame property; but they effect

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[a] Chaptal's Elements of Chemiſtry, vol. ii.

[b] Journ. de Phyſique.

it by a double decompoſition: whilſt the acid unites with the alkali, the oil combines with the earth or metallic oxyd, from which reſult the earthy and metallic ſoaps I have elſewhere deſcribed[c], that probably might be of ſome utility in the arts.

The principal uſe of ſoap in dyeing, is for whitening the ſilk. For this purpoſe, a white, hard ſoap, prepared with olive oil, ſhould be choſen: whence it is, that the beſt ſoap is made only in places where this oil abounds, as Portugal, Spain, or Marſeilles.

The ancients uſed a plant, called by Pliny, *radicula*[d], ſuppoſed to be our ſoap-wort, for the purpoſe of cleanſing woollens: for bleaching linen, they employed a plant, that appears to be a ſort of ſpurge.

C H A P. X.

Of Sulphur.

SULPHUR is found combined in different minerals; but what is made uſe of, is chiefly extracted from volcanic earths, particularly from the Solfatara near Mount Veſuvius,

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[c] Mémoires de l'Academie, 1780.

[d] Plin. lib. xix. cap. iii.

where it is purified, and caſt into moulds, that give it the form under which it is called *roll brimſtone.*

When ſulphur is burnt ſlowly, it is reduced into a volatile acid, of a very penetrating ſmell, and called ſulphureous acid. If this acid be left in contact with a ſufficient quantity of atmoſpheric air in a cloſe veſſel, all the pure part of the air, that is, its oxygen, is gradually abſorbed, and the ſulphureous acid is changed into ſulphuric acid; ſo that the difference between the two acids depends on the proportion of oxygen, and the ſtate in which the oxygen exiſts in them.

In the ſulphuric acid the oxygen has loſt the caloric to which it owed its expanſive ſtate: in the ſulphureous acid it has retained ſuch a quantity, that the combination it has juſt formed, is volatile, and loſes its elaſtic ſtate with difficulty. Thus in the former, the oxygen is much more concentrated, and much better combined: in the latter, its affinity is divided between the caloric which it has retained and the ſulphur. For this beautiful theory of the nature and formation of acids, we are indebted to Mr. Lavoiſier.

Sulphuric acid acts on colouring matters like other acids: but the ſulphureous acid, particularly

particularly when in an aeriform ſtate, deſtroys ſeveral colours.

It is a property of ſulphureous gas to diſcharge the colour of the colouring matter with which it combines: but the colour in general is reſtored on ſaturating it with an alkali. The colour thus reſtored, however, vaniſhes in time, becauſe a combuſtion takes place ſimilar to that produced by nitric acid, or oxygenated muriatic acid, which is owing to the weak adheſion of the oxygen in the ſulphureous acid.

Sulphuration, or expoſure to the vapour of ſulphur, is employed to give woollens or ſilk deſigned for white ſtuffs, the greateſt poſſible degree of whiteneſs.

For this purpoſe, a ſeparate chamber, without a chimney, and through which a current of air may be directed when neceſſary, is choſen.

To a hundred pounds of ſilk extended on poles at the height of ſeven or eight feet, about a pound and half, or two pounds of ſulphur are taken. This ſulphur being groſsly powdered, is put into an earthen veſſel or iron pot in the bottom of which is a ſmall quantity of aſhes, and ſet fire to in ſeveral places. The chamber is then ſhut cloſe, to prevent the fumes

fumes from eſcaping. The next day the windows are opened, to let out the fumes and dry the ſilk: but in winter, as ſoon as the ſulphureous ſmell is gone, the windows are again ſhut, and to dry the ſilk, chafing diſhes with live coals are placed in the room.

This operation not only gives the ſilk a great whiteneſs, but at the ſame time a kind of tremulous elaſticity, or ruſtling, perceptible on preſſing it between the fingers.

As this ruſtling of ſilk is attended with a certain ſtiffneſs, that which is intended for making watered ſilks ſhould not be ſulphurated, becauſe it would offer too great reſiſtance to the impreſſions of the calender, under which ſtuffs are paſſed to water them.

Neither can ſulphuration be employed for ſilks deſigned for felt *(bonneterie)* as it would corrode the iron and ſteel of the tools uſed in manufacturing it, and produce ruſt.

Silk which has been ſulphurated takes moſt colours badly, and if it be neceſſary to dye it, it muſt firſt be deprived of its ſulphur, by repeated ſoaking and ſhaking over in hot water (vide page 135).

When ſilk is ſulphurated, if it be not blue enough for the ſhade deſired, it muſt be azured

a ſecond

a ſecond time in clear water without ſoap, and after that, again ſulphurated.

The properties of ſulphurated ſilk are owing to the ſulphureous acid combined with it, the exiſtence of which is rendered ſenſible by means of ſulphuric acid, for this immediately diſengages from it ſulphureous vapours. The ſulphuration of woollen cloths is performed in nearly the ſame manner as that of ſilk: but it muſt be remarked, that if the operation be not managed with caution, and if the combuſtion of the ſulphur be carried on with too great rapidity, ſulphuric acid will be formed, which, collected in drops, will corrode the cloth; an inconvenience not eaſily to be avoided.

CHAP. XI.

Of Arſenic.

ARSENIC is a metallic oxyd found in commerce in white lumps, powdery at the ſurface, and internally cryſtalline, tranſparent, and as it were vitrified. Expoſed to the air it ſoon becomes opake, and is gradually reduced

reduced to a kind of flour; which may occaſion the moſt fatal accidents, if miſtaken for other ſubſtances; but is eaſy to be diſtinguiſhed by throwing a little of it on burning coals, when it immediately riſes in a thick ſmoke, and gives out a ſtrong ſmell of garlic. If the proportion of oxygen be increaſed by means of nitric acid, this oxyd aſſumes the characters of a peculiar acid, termed the arſenical: if, on the contrary, it be deprived of its oxygen, by being urged in the fire with oily ſubſtances, it ſublimes, and takes the form of a ſemimetal.

Oxyd of arſenic diſſolves in fifteen or twenty parts of boiling water, but it requires a much larger quantity of cold water. Formerly arſenic was much uſed in many dyes, and particularly for printed linens: but the inutility of this poiſonous ſubſtance being now acknowledged, it is uſed in very few proceſſes, and even in theſe it appears to be uſeleſs. The following preparation, however, may be excepted.

Fixed alkali has the property of combining with arſenic, as Macquer has ſhewn [a]. To effect this combination, oxyd of arſenic in powder muſt be thrown into warm water containing a conſiderable proportion of alkali,

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[a] Mem. de l'Acad. 1746.

till no more will diſſolve. The liquor becomes of a dark brown colour, and acquires the conſiſtence of glue. This mixture, on cooling, becomes hard and brittle; but it attracts the moiſture of the air, and again becomes viſcous. Mr. Vogler has obſerved, that it was a very proper mordant for linen and cotton to be dyed with madder[b]. For preparing it he employed a ſolution of common pot-aſh: others uſe pot-aſh in its pure or cauſtic ſtate[c].

Orpiment is a compound of oxyd of arſenic with ſulphur, found native, and imitable by art. The more ſulphur it contains, the more its colour inclines to red. It is alſo known by the names of yellow or red arſenic, realgar, ſandarach, &c. According to a late analyſis of Mr. Weſtrumb[d], one hundred parts of orpiment contain twenty parts of ſulphur, ſeventy-nine of oxyd of arſenic, and one of iron. This ſubſtance is employed in ſome proceſſes of dyeing, particularly in certain indigo vats.

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[b] Ann. de Chym. tom. iv. p. 122.

[c] Sieffert's Verſuche mit einheimiſchen Farbematerien.

[d] Kleine Phyſ. chem. Abhandlungen.

CHAP. XII.

Of Water.

THE qualities of different waters are eſſential objects to the dyer: but it is perhaps of leſs importance to point out the injurious effects they are capable of producing, than to deſtroy the prejudices to which they frequently give riſe.

It would be ſuperfluous to ſay, that water employed in dyeing ſhould not be muddy, nor contain putrid ſubſtances; and that waters ſo loaded with heterogeneous principles as to be termed mineral, which are eaſily diſtinguiſhable by the taſte, ought not to be uſed. With theſe exceptions, water acts on colouring matter, principally by means of the ſalts with earthy baſes it contains. Theſe ſalts are nitrat of lime and of magneſia, muriat of lime and of magneſia, ſulphat of lime, and carbonat of lime and of magneſia.

All theſe ſalts with earthy baſes oppoſe the ſolution of the colouring particles, cauſe various kinds of them to precipitate, in conſequence of their combining with the earth they contain, and render their colour deeper and frequently more dull.

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The carbonats of lime and of magneſia have alſo the inconvenience of being precipitated by boiling, which drives off the exceſs of carbonic acid that held them in ſolution, ſo that theſe earths adhere to the ſtuff to be dyed, make it dirty, and prevent the colouring matter from penetrating it.

It is of conſequence, therefore, to diſtinguiſh the ſeveral kinds of water called hard, that they may be avoided in moſt operations of dyeing. Chemiſts are furniſhed with means not only of detecting the different principles contained in water, but even of aſcertaining the quantity of each with preciſion: but the proceſſes neceſſary for theſe analyſes frequently require profound ſkill, and a readineſs of practice, which thoſe who are employed in dyeing cannot be preſumed to poſſeſs. Happily an eaſy and common experiment is ſufficient, to ſhew whether water contains ſuch a quantity of theſe ſalts as may be injurious; the ſolution of ſoap.

All ſalts with earthy baſes decompoſe ſoap by a double affinity: their earth combines with the oil of the ſoap, whilſt their acid unites with its alkali; and this combination of oil and earth forms an earthy ſoap, which, being inſoluble in water, produces the curdling obſerved on ſuch occaſions [a].

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[a] Mem. de l'Acad. 1780.

If then, a water be clear, not ſtagnant, void of ſenſible flavour, and diſſolve ſoap well, it may be deemed proper for dyeing; and all waters poſſeſſed of theſe qualities are equally proper.

But as it is not always in our power to chooſe our water, means of correcting bad waters, at leaſt thoſe which are ſo to a certain degree, have heen ſought; particularly for the purpoſe of dyeing delicate colours. For this end, water in which bran has been made to grow ſour, generally known by the name of ſour water, or *ſours*, is commonly employed.

For preparing the ſour water, twenty-four buſhels of bran are put into a tub or vat that will contain about ten hogſheads: a large boiler is filled with water, which, when juſt ready to boil, is poured into the vat: the acid fermentation ſoon commences, and in twenty-four hours the liquor is fit for uſe.

I conceive, that the ſour water acts by decompoſing the carbonat of lime and magneſia, from which its acid, being more powerful, diſengages the carbonic acid: thus the earthy ſediment, which I have ſaid is occaſioned by boiling, is prevented from taking place.

Mucilaginous plants are boiled with water to correct it alſo. The mucilage coagulates, and

and carrying with it the earths that ſeparate by ebullition, as well as thoſe which might happen to be ſimply mixed with the water and render it turbid, forms a ſcum which is taken off.

Salts with earthy baſes, which are in general prejudicial in dyeing, may be in ſome caſes uſeful, and ſerve to modify tints. Thus a water of this kind would give a crimſon hue to the colour of cochineal.

As the water of a river may contain a greater or leſs quantity of ſalts with earthy baſes, according as its bed is greater or leſs, it happens ſometimes, that the ſame ſhade is only obtained at certain times, though exactly the ſame proceſs is followed; or that, to obtain the ſame reſult, certain variations muſt be made in the proceſs, according to the ſtate of the river.

Water which decompoſes common ſoap, and forms calcareous ſoap, is improper for bleaching; not only on account of the loſs of ſoap, which is decompoſed in waſte, but more eſpecially becauſe the calcareous ſoap, which is inſoluble in water, adheres to the cloth, gives it a greaſy feel, and even grows yellow in time, and ſhakes off in little flakes.

END OF THE FIRST VOLUME.

E R R A T A.

Page 21, line 9, *after* referred, *inſert* the.
—— 142, — 12, *for* Beaumé, *read* Baumé.
—— 178, — 9 from bottom, *for* independant, *read* independent.
—— 240, — 3, *for* Dambournay, *read* d'Ambourney.
—— 295, — 10 from bottom, *for* felt, *read* ſtocking web.