the outside, but inside pure white and free from impurities. It melts at 50° C., and becomes a yellow greasy resin, dissolves in alcohol or in ether, and then crystallizes in beautiful needles. When heated it gives off a peculiar odor like acrolin. By saponification with potash it yields an acid which Brazier proves to have a composition similar to palmitic acid.

There is a mineral waxy resin called Guyaquillite, which is found in extensive deposits in the marshy plains near Guyaquil, in South America, which has a similar composition to bog butter.

Johnson gives it as—

Carbon.....	76.67
Hydrogen.....	8.17
Oxygen.....	15.16

It has been proved that the slow decomposition or change in the vegetable peat or moss will produce elements of which these hydrocarbons are made. —*Chemical News.*

THE NEWER ARTIFICIAL COLORING MATTERS DERIVED FROM BENZENE.*

By R. J. FRISWELL, F.C.S., F.I.C.

Methyl Aniline Violets.—It is, no doubt, well known to many here that the earliest violets obtained by artificial means were those produced by the action of pure aniline, or phenylamine, on roseine, in the presence of an organic acid. A study of this reaction by Hofmann led to his discovery of the action of the iodides of the alcoholic radicals, methyl and ethyl, on roseine base, with the production of the well-known "Hofmann violets." These were found to be substitution products of rosaniline, in which one, two, or three atoms of hydrogen in the molecule are replaced by the radicals methyl or ethyl, according as the iodide of either has been used.

Now roseine itself is, as is well known, produced by the action of arsenic acid or other oxidizing agents on a mixture of aniline and toluidine. The chemical formula then adopted for it led to the conclusion that it was produced by the coalescence of the residues of two molecules of toluidine and one of aniline, thus:

O. and E. Fischer have recently shown that this formula was partly erroneous, and that the reaction could also occur between two molecules of aniline and one of paratoluidine—

but this does not affect the inference drawn from what was, till recently, supposed to be the constitutional formula of the body in question, and this inference was that the methylated derivatives of roseine could be obtained by the oxidation of the methylated derivatives of aniline, just as roseine was by the oxidation of aniline and toluidine. The inference was somewhat rash; the methyl groups in dimethylaniline replace the hydrogens in the amido group; and on oxidation might, perhaps, be destroyed. However, on oxidation dimethylaniline did, indeed, produce a very brilliant violet color, which, having been discovered by M. Lauth, and improved and patented by Messrs. Poirrier and Chappat, was introduced into commerce under the name of Paris violet. This achievement led to a demand for the production of the methyl anilines on a large scale, and, in a very short time, this was attained. It was well known that methylaniline could be produced by the action of methyl iodide, or bromide, upon aniline, the dimethyl compound resulting from the use of two molecules of the alcoholic compound; thus

but it was evidently necessary to produce the required compound in a cheaper way. This was eventually done by heating aniline hydrochloride and methylic alcohol together under pressure, in strong cast-iron vessels, enameled inside, and known as "autoclaves." Various proportions of the bodies have been employed—among others, the following giving good results: Aniline, 33.6; hydrochloric acid, 37.9; methylic alcohol pure, 23.5; heat to 250° C. for eight hours. Messrs. Poirrier have also employed a mixture of 100 parts aniline and 250 methyl nitrate. In the latter case the mixture requires only a temperature of 100° C.; but the alcoholic nitrate is an exceedingly dangerous compound to deal with; in all probability it was the one that led to the lamented death of Mr. E. T. Chapman, and a very disastrous and fatal explosion at Messrs. Poirrier's works was also caused by it.

Methylaniline is now largely made by the action of methyl chloride on aniline. As is well known, the former body has of late years been obtained in immense quantities in France, from a product of the destructive distillation of residues obtained in the manufacture of beet sugar. This body reacts upon aniline just as the corresponding iodide or bromide does; it is cheap, the reaction takes place with ease, and a remarkably pure product is produced: in fact, dimethylaniline can now be obtained by the ton, free from unaltered aniline, and containing only 3 per cent. of the monomethylated compound.

From dimethylaniline the violet is obtained by oxidation; formerly, various oxidizing agents were used, among them a mixture of iodine and potassium chlorate; it is, however, now well known that very gentle oxidizers will produce the color if a metallic salt is present, the one preferred being copper. If I heat, in this tube, some copper filings with a mixture of dimethylaniline and chloral hydrate, the whole will shortly become a mass of semi-solid violet. It is, however, obvious that so costly a method could not be employed on a manufacturing scale, and, accordingly, the following process is in very general use: Twenty parts pure crystallized cupric nitrate are dissolved in 20 parts of acetic acid; some common salt is now stirred into the mixture, which is carefully cooled down to the ordinary temperature, and 50 parts of dimethylaniline are added; the whole is then thoroughly mixed with about 250 to 300 parts of white sand and the stiff mass thus produced is moulded into large cakes two feet long by fifteen inches wide, and four inches thick; these, arranged on copper plates, are placed in a chamber, and heated to a temperature of 60° C. for 48 hours. At the end of that time, they have become perfectly hard and brittle and of a bright brassy color. They are broken into a coarse powder and thrown into water, sulphide of sodium being added until the whole of the copper salt has been decomposed. The mass is now washed with water and extracted with dilute hydrochloric acid at a boiling temperature. After partial cooling and filtration, to remove some resinous by-products, the coloring matter is precipitated with common salt, and, after drying, it is ready for use.

* A recent lecture before the Society of Arts, London.

The sand, which simply serves to spread the mixture over a large surface, can be used for a fresh operation.

The product thus obtained is very brilliant in color, and in shade is that known as 3 B, dahlia, etc.; it is, however, not the bluest that can be produced. The bluest shades are made by dissolving it in alcohol, converting it into base by the cautious addition of caustic soda, and then heating the alcoholic solution of the base with benzyl chloride—a body having the formula $C_6H_5CH_2Cl$, and produced by the action of chlorine on toluene. The spirit and unaltered benzyl chloride are recovered, and the basic color, on conversion into the hydrochloride, is ready for use. In a similar way, by the action of methyl chloride, the well-known methyl green was produced; it is now, however, replaced by the malachite green, discovered by Oscar Doebner, and produced by the action of molecule of benzoyl trichloride, $C_6H_5CCl_3$, on two molecules of dimethylaniline or of benzoylhydride, or bitter almond oil, C_6H_5COH , on the same in the presence of zinc chloride or of sulphuric acid.

The latter color much surpasses the former in fastness and power of standing rough treatment in the dyeing process. The myth, and, still more, the iodine green obtained during the manufacture of blue shades of Hofmann violet, were fugitive and easily altered by heat, so that the latter could not be boiled without changing to a violet.

Before leaving the methylaniline colors, I may briefly allude to a question of scientific interest in connection with them. It is well known that Hofmann himself, at one time, considered the violets obtained by the methylation of rosaniline and those from methylaniline to be identical. On the other hand, there was much evidence against this view, for the methylaniline color was readily rendered bluer in shade by benzyl chloride, which was almost without action on the Hofmann one; it was also more brilliant, had a much greater affinity for animal fabrics, and was less permanent when exposed to light. For these reasons, the Hofmann color is still in demand, and, indeed, has recovered some of the ground it at first lost to the more brilliant color. The researches of Brunner and Brandenburg, following those of Caro and Graebe, have shown that the methylaniline violets are not identical with those obtained by Hofmann's process.

Diphenylamine Blue and Alkali Green.—The ordinary aniline blues are obtained by the action of aniline upon roseine base, in the presence of an organic acid, at a temperature which ultimately approaches the boiling point of the aniline used. The ultimate product of this reaction is an exceedingly intense blue, the hydrochloride of which is known as opal blue, and is, really, the hydrochloride of triphenylrosaniline. This, on dry distillation, yields diphenylamine, and the latter body, on oxidation, yields a blue which is identical with that obtained from rosaniline, but somewhat greener in shade, and is therefore in demand for certain uses. The diphenylamine is prepared by heating, under pressure, a mixture of aniline and dry aniline hydrochloride, when the following reaction occurs:

Diphenylamine is readily oxidized if heated with oxalic acid, and the resulting melt, purified from unaltered oxalic acid, diphenylamine and resinous matters, is readily converted into either of the sulphonic compounds discovered by Nicholson. Blues of a redder shade can be also obtained by the oxidation of methyl or ethyl diphenylamine.

I have now to call your attention to a green obtained from this body, discovered by Mr. R. Meldola, and now under his investigation. It is obtained by the oxidation of a diphenylamine derivative. After oxidation the color is obtained in a state corresponding to the well-known opal-blue, and, like that, forms sulphonic acids. It is remarkable as being the first green obtained having this property. The sodium salt of the sulphonic acid is soluble in water, and, if wool is immersed in this solution (which is nearly colorless), and kept warm, it apparently undergoes but slight change. I have here a piece of Berlin wool which has been thus treated, and subsequently dried. You will observe that it is, apparently, only rather dirtier than undyed wool. When, however, I immerse it in warm water, acidulated with sulphuric acid, a brilliant green is immediately developed. The color is remarkably fast; and, since it requires exactly the same dyeing process as do the Nicholson blues for wool, one would have supposed that it would have been much liked by the dyers; but this is not at present the case. It was exhibited at the late Paris Exhibition by the firm of Brooke, Simpson, and Spiller.

As time is getting on, I must now leave this very interesting field—the colors produced by the oxidation of the secondary and tertiary amines—after a very brief and incomplete glance at a few of them, and pass on to the consideration of a totally distinct group of coloring matters, which are now attracting much attention in color-chemists' laboratories, and which have already taken an important place among artificial dyes, though, as yet, the range of shades is somewhat limited. These are obtained from substances produced by the action of nitrites on amido compounds, and are known as the azo-yellow, oranges, and scarlets.

The effect of nitrites on organic compounds is very various according to the subsequent treatment they undergo: thus, if nitrous gas is passed through a solution of diphenylamine in acetic acid, a mixture of nitroso-nitro-diphenylamines results; and this, on heating with an alkali, decomposes so far as the nitroso groups are concerned, and a mixture of mono and dinitro diphenylamine results, which was introduced as a yellow dye by Mr. R. Meldola. A somewhat similar reaction occurs if the sulphonic acid of alpha naphthol is similarly treated, and dinitronaphthol may be obtained while, if a nitrite is added to an aniline salt, and the resulting compound boiled, or if rosaniline salts are similarly treated, the whole of the nitrogen is eliminated with effervescence, and phenol in the one case, rosolic acid in the other—both of them non-nitrogenous substances—result. Before this boiling takes place, there are, however, in the two latter cases very different bodies in solution; these bodies, which behave in the manner just mentioned on boiling, are known to chemists as "azo compounds."

In the earlier days of organic chemistry, the prefix "azo" was applied by Mitscherlich, Laurent, Zinin, and others to many bodies containing nitrogen, such as azo-benzene, $C_6H_5N=NC_6H_5$, produced by the imperfect reduction of nitro-benzene, and also to others, like the compounds obtained by Laurent by the action of ammonia on bitter-almond oil and other bodies. In 1864, however, P. Griess published a magnificent memoir, in which he described a number of bodies obtained by the action of nitrous acid on aniline, and various substitution products obtained therefrom. In this paper, he proposes that the prefix "azo" should be held to mean that the compound to which it was applied contained one atom of nitrogen occupying the place of one atom of hydrogen. This definition is now generally accepted, and thus the term "azo" has obtained a definite signification.

The azo compounds are, as a rule, very easily prepared; in most cases, it is only necessary to add a solution of metallic nitrite to an acid solution of a given amide, in order to obtain the diazo compound of the radical contained in the amide; thus, if I take a solution of aniline hydrochloride, and add to it an equivalent quantity of sodium nitrite solution, the reaction at once takes place, and diazobenzene is produced; it can be readily separated from its solution, and obtained in the solid state, one method being to add a solution of potassium dichromate when the chlorochromate of diazobenzene is produced. This salt, when dry, is terribly explosive, and at one time was suggested for use in warlike operations; however, it very rapidly decomposes when kept losing nitrogen, and becoming no longer efficient.

This explosiveness is readily understood when we consider the constitution of the body which contains the group $N=N$. It is manifestly in a state of unstable equilibrium and a very slight disturbance is sufficient to bring about its decomposition; and, for the same reason, you will at once see that its chemical activity, as measured by its tendency to combine with other bodies, will be great; so that if I add to it another molecule of aniline salt, or, what amounts to the same thing, if I add to two molecules of aniline only one of sodium nitrite, the diazobenzene formed at once attacks the free aniline salt, and what is known as diazoamidobenzene is formed, which, in the presence of an aniline salt, becomes amidoazobenzene— $C_6H_5N=NC_6H_5NH_2$. The oxalate of this body was once in pretty general use as a yellow dye, but, as it happened to be volatile at a very low temperature, it soon evaporated from the dyed article, and was, therefore, discarded.

A compound having a very similar constitution and mode of preparation has, however, long been in use, and is one of the most permanent of the aniline colors, under the name of "Bismarck Brown." It is obtained as follows:

Metadinitrobenzene is prepared by boiling ordinary nitrobenzene with nitric acid. The compound thus produced is added cautiously, with constant agitation, to coarse iron borings, kept boiling in a large quantity of water acidulated with hydrochloric acid. A violent reaction soon commences (I could readily show you the experiment, but for the steam and unpleasant odor produced); the four oxygen atoms contained in the dinitrobenzene are replaced by hydrogen, thus:

We have thus produced diamidobenzene, and this, when purified from a little dissolved iron, is attacked with sodium nitrite solution; the reaction here is analogous to the one last described, the final product of the reaction being a tri-amido-azobenzene, the hydrochloride of which constitutes the well-known coloring matter. We have thus two terms of a possible series—first, the amido-azobenzene (yellow, volatile, and fugitive), and triamido-azobenzene (brown, and perfectly fast). Dr. Witt set himself the task of filling up the intermediate link, expecting an orange color, and a moderate stability for the diamido-azobenzene he sought. In this he was not disappointed. A study of the two compounds, from a purely scientific point of view, led him to a perfectly accurate prediction; and the discovery of "chrysoidine," as the new color was called, and its production—by the addition of diazobenzene chloride to a solution of diamidobenzene—was one of the first of a series of researches which have, in various hands, enriched our science and our dyers with a number of magnificent colors.

The further development of these colors commenced with the introduction of a sulphonic group into one of the amido compounds, the conversion of the sulphonic acid thus produced into a diazo body, and then using it as before; for instance, if sulphanilic acid—produced by the action of strong sulphuric acid on aniline—is converted into diazosulphanilic acid, and this added to a solution of diamidobenzene-hydrochloride, the scarlet body produced is the sulphonic acid of chrysoidine. Again, the same body will act on resorcinol to produce a color only differing from the last in that it contains hydroxyl instead of amido groups; this body has been used as a dye, under the name of Tropæoline O. Witt also produced, by substituting diphenylamine for the resorcinol, or diamidobenzene, another beautiful orange, known in commerce as Tropæoline OO. Other compounds were subsequently prepared, and have obtained greater prominence; these were those in which a naphthol was substituted for the phenolic or amido portion of the molecule, beautiful oranges being produced by the action of diazobenzene sulphonic acid on both α and β naphthol; but these colors were much improved by the introduction of sulphonic groups into both portions of the molecule, α or β naphthol-sulphonic acid being, in fact substituted for the naphthol only; still, so far, the improvement was in the direction of stability mainly, the shades still being yellow or orange; the red was yet to come.

Chemists will not be surprised to hear that the higher homologues of benzene are found, when converted into amido compounds, to give an increased redness of shade; thus, with a given phenol or amine, diazosulphotoluidinic acid, which differs from diazosulphanilic acid by having an atom of hydrogen in the benzene ring replaced by methyl, gives redder shades than does the latter, while the substitution of another hydrogen in the same way, as is the case with the diazo compound derived from sulphonylidenic acid, produces a scarlet. Messrs. Meister, Lucius, and Bruning were among the first to produce a scarlet by this method, but they also introduced both the sulpho groups into one side of the molecule—that of the naphthol. In their patent they describe the preparation of two isomeric beta naphthol-disulphonic acids, the sodium salts of which are differently soluble in alcohol, the most insoluble one giving a redder color than the other. On one or other of these they act with diazoxylene chloride, produced by the action of a nitrite on xylylene chloride. The most insoluble salt above mentioned gives a scarlet closely approaching cochineal, and perfectly fast.

Mr. R. Meldola has also taken out a patent for a scarlet, in which no less than three sulpho groups are engaged. He prepares diazosulphoxylicidic acid; and with this acts on β naphthol disulphonic acid; on the addition of ammonia, the color is immediately thrown down, as you perceive. This is, after a slight purification, ready for use. By certain modifications, a scarlet, closely approaching the scarlet obtained by dyeing cochineal in the presence of oxichloride of tin, is produced.

So far, we have only oranges and scarlets by these reactions. Whether other colors can be similarly produced remains to be seen; but I may mention that Mr. Meldola has recently communicated a paper to the Berlin Chemical Society, in which he describes a violet color—unfortunately not a dye—obtained in a somewhat similar way. If we act on dimethylaniline—the body from which the violets described in the first part of my lecture are derived—with a

nitrite—not an azo, but a nitroso dimethylaniline, is produced thus: $C_6H_4NON(CH_3)_2$. This body is as ready to combine with others as an azo body is, and does so in a very similar way, the oxygen atom being eliminated in the process, so that if we act with it on β naphthol the following combination takes place:*

The oxygen of the nitroso group going off with two hydrogens from the β naphthol, the place of which is taken by a group, which is equivalent to azo dimethylaniline. The color crystallizes magnificently, but its dyeing powers are very feeble.

I must now conclude a very imperfect sketch of some of the recent advances of color chemistry. If I have succeeded in showing some that practical results do come from purely scientific researches, I am content. Hard things are often said of the aniline dyes; they are looked on as poisonous and fleeting. The first accusation is untrue, properly used they are perfectly harmless. The second is only true of some few of the series, and many of the older dyes are equally evanescent, while none are so beautiful and brilliant—though this may be considered a fault, for some highly æsthetic persons look on the producer of brilliant colors almost as a criminal.

The color-chemist may contemplate all these hard sayings with an even mind. In the humble position of a scavenger, he takes some of the most noxious waste products of our civilization, those produced in the gas manufacture, and converts them into useful and beautiful coloring matters. If these are improperly applied to the cloth or fabric, that is not his fault; while if they are inartistically used, our æsthetic friends have the remedy in their own hands.

DISCUSSION.

Mr. Spiller was much pleased to be able to express his obligation to the reader of the paper for what he considered to be a very good account of the latest outcome of the benzene color industry. It would be manifest to the audience, although they might not in every particular have been able to follow the theory of the matter, or understand all the hard names, that this benzene dye industry had, of late years, made gigantic strides. From his own connection with this class of work for ten or twelve years, he was able positively to say that the number of new coloring matters gained within that period was considerable, and he would put it on a more forcible basis than even Mr. Friswell had done, and say that, at the time when he first occupied himself with this work, it was the rule to select out the benzole of the coal-tar and naphtha, and throw away a large residual product which was then known as dead-oil. As its name implied, dead-oil would manifestly be a waste product thrown away, or used for confessedly inferior purposes. But the requirements of the latest forms of coloring matter, those which had just been mentioned, particularly the orange and scarlet, demanded that a certain quantity of the dead-oil should be worked with a view to extract from it these materials which were formerly worthless. For instance, it was necessary to save toluene, and also to save for the purposes of manufacturing the new scarlets, the xylene. These were now economized. And they were also making considerable strides toward working up naphthalene. Now, naphthalene had, for a great number of years, been a perfect bugbear in scientific industry. It was produced in immense quantities in the manufacture of gas, and whilst anthracene had been, by the labors of Perkin and Graebe, admirably employed in the manufacture of artificial coloring matters, which were substitutes for madder, naphthalene, the lower term in the series, had been thrown away. But, however, they had a chance of using it in the production of the beautiful colors brought forward that evening, particularly the scarlet, one of the colors which had been so well described by Mr. Friswell.

Dr. Armstrong, F. R. S., said he did not know what right Mr. Friswell had to speak of coal tar as a noxious product. He thought that it was harmless when left alone, and Mr. Friswell had shown, when properly treated, it was capable of exhibiting itself in a very different light. The paper he had read ought to convey a very sound lesson to the objectors to abstract science, because they knew very well that, practically speaking, the whole of these colors were the result of investigations originally undertaken entirely without any practical aim. Chemists were led to investigate these various substances from pure love of their science, with the object of learning more about them, and, in the course of a very brief period, their discoveries had acquired an enormous practical value. He should not be far out, probably, in saying that, at the present time, with the exception of indigo, nine-tenths of the coloring matters used were artificial, produced from coal-tar, and that fact ought to be encouraging to holders of gas shares. There was a large amount of material still remaining in coal-tar not utilized, and there was, no doubt, a great future in that direction. These colors, which Mr. Friswell had spoken of in particular, afforded a striking illustration of the advantage of working on these subjects and taking no heed whatever of the objections raised against chemists using long names and complicated formulæ. It was not more than ten or twelve years ago that it was found that alizarine and Turkey red could be produced artificially, and now practically all the Turkey red which was used was made artificially. A few years ago the substances used in the preparation of these colors were substances which even chemists were almost afraid to handle. Those so-called diazo compounds, originally discovered by Dr. Griess, were very difficult to manipulate, and extremely unstable; and even chemists would have laughed at the idea of using such unstable compounds for the preparation of coloring matters on a large scale. One feature was of particular interest, namely, that the great part of this work had been the outcome of theoretical views. The work of Dr. Witt, to which allusion had been made, was entirely such. He had formed certain ideas with regard to the theory of the constitution of coloring matters, that coloring matters ought to be bodies having certain constitutions, and he set himself to work to prepare bodies having certain constitutions, and realized his ideas, and still more chemists were rapidly getting a distinct notion of the theoretical constitution of coloring matters, so as to be able to say not only that a certain body would be a coloring body, but would have a certain shade.

Mr. Meldola said he cordially sympathized with the remarks which Dr. Armstrong had made, as to these valuable discoveries being the indirect outcome of researches, undertaken from a purely unpractical point of view; but, al-

though Dr. Armstrong would lead many present to suppose that the science had arrived at that happy state when we could predict, to a certain extent, what colors would be produced by certain compounds, he must say that, speaking practically, they had not yet arrived at that happy position. In fact, it was owing to the great doubts which still surrounded many of the reactions, that new coloring matters had been produced. It was not possible to start from a given point of view and say you would produce colors of a particular hue. There was no doubt that a great many of the products that now run down our drains would one day become quite as valuable as many of those which were employed in factories, and which gave rise to these coloring matters. The complex formulæ of diazo compounds having been referred to, must be his excuse for making a few more remarks on the same subject. Mr. Friswell had explained how diazobenzene chloride, for instance, acting upon another benzene nucleus containing in either an amido or phenolic group, the two benzene nuclei became linked together by the diazo group, giving rise to a complex molecule such as constituted the substance of these oranges and scarlets. The beginning of these substances was Dr. Witt's "chrysoidine," by acting on metadiamidobenzene with the chloride or any other salt of diazobenzene, Dr. Witt produced $C_6H_4N_2$, $C_6H_4(NH_2)_2$, and you had two benzene nuclei grouped together by the diazo group. There had recently been another step made in this direction, and W. von Müller had described colors built up on this type, plus the addition of another benzene nucleus. Taking the ordinary aniline yellow, amidazobenzene, he showed that two molecules of hydrogen could be taken out and replaced by nitrogen and another benzene nucleus thus attached, so that the formulæ of these diazo compounds were becoming more and more complex every day, and their number might go on increasing indefinitely. The whole subject illustrated very well the truth, that in the opinion of the chemist there was no matter which might not some day be turned to useful account; and very often the products which were at one time most despised suddenly became famous.

The Chairman said he had now a pleasing duty to perform of proposing a vote of thanks to Mr. Friswell, and he regretted it had not fallen to the lot of Mr. Perkin, who had gained a European renown in this form of chemistry; but, unfortunately, he had been unable to take the chair to-night, having a previous engagement. This was not a branch of chemistry with which he was sufficiently familiar to be able to take a very active part in the discussion, but irrespective of the technical points of the paper, they had learnt much. They had heard very valuable observations made by Mr. Spiller, from a technical point of view, in which he referred to the fact, now clearly before them, that naphthalene, which had been for a long time not merely valueless, but a considerable nuisance to the gas engineer, was about to yield considerable results, which might be as brilliant as those yielded by anthracene; and they must all agree with Professor Armstrong that, after all, knowledge which was subsequently to become of value in technical operations, could only be built up, not by mere empiricism, but by scientific investigation. It would be perfectly impossible for any one present to take those different bottles, and add the contents of one to the other, and expect to be able to obtain numbers of beautiful products; on the contrary, they might produce some very unpleasant results. These valuable and important bodies were not built up in that empirical way. They were the result of long previous scientific research; and when it was remembered that Faraday, before any of them were born, discovered benzene, and that long ago Undverdorben discovered aniline, it was evident that there must have been, from that time, a considerable amount of pure scientific research carried on before manufacturers were able at last to make use of these useful products of the coal distillation, and convert them into the valuable dyeing materials which we now possess. They had heard from the speakers that there was yet a very large and important field which had not been investigated; and inasmuch as the last fifty years, since the discovery of benzole, had produced such enormous results, more especially within the last twenty years, they might also assume that the next fifty years would utilize all, or almost all, of those numerous products which were now obtained from the destructive distillation of coal, and were at present considered useless. He had much pleasure in tendering to Mr. Friswell the hearty thanks of the meeting, for the very able and clear account he had given of the more recent work of this line of chemical activity. He had been very modest with regard to his own contributions to it, but they were indebted to him and to many others for the increase of knowledge in these matters.

SULPHUR IN COAL.

By DR. W. WALLACE, Glasgow.

It has been assumed that sulphur exists in coal chiefly, if not exclusively, in the form of bisulphide of iron, the presence of which can be detected in almost all varieties of the mineral. Grace-Calvert asserted many years ago that in some cases, at least, sulphur existed in coal in the form of a sulphate, and he gave a process for the estimation of the sulphur existing in this form. Some analyses which I have recently made have shown conclusively, however, that in some coals the greater part of the sulphur exists as an organic compound. These coals contain but a small proportion of iron—not nearly enough to form bisulphide with the iron that exists in them—and one well known description known as the Ell coal was found not to contain a trace of sulphuric acid when tested by Grace-Calvert's method. The others were not tested.

The following table shows the relative quantities of total sulphur and that existing as pyrites, as calculated from the iron found in the ash of the coal, assuming that all the iron exists as bisulphide, which is not always the case, as some coals contain carbonate of iron.

	Total Sulphur.	S. as Bisulphide.
Ell coal (Lanarkshire).....	0.91	0.11
Main coal ".....	0.60	0.42
Splint ".....	0.46	0.14
Pyotshan ".....	0.68	0.17
Soft coal from Fife.....	0.93	0.49

The estimations of sulphur were made by Pattinson's method, and also by fusion with sodic carbonate and potassium nitrate. When carefully performed and blank experiments made to eradicate sources of error, these methods give concordant results. It is well-known that boiling with nitric acid does not give the whole of the sulphur, and I find that the amount obtained usually corresponds close with that existing as pyrites.

The following analyses of the coals referred to may be useful for comparison with English varieties, of which

the composition is given in several works on chemical technology.

	Ell.	Main.	Splint.	Pyotshan.	Fife.
Carbon.....	71.37	67.35	70.05	72.21	61.88
Hydrogen.....	5.13	5.03	5.24	4.79	4.89
Oxygen.....	8.88	12.66	12.37	9.77	12.78
Nitrogen.....	1.44	1.40	1.36	1.51	1.14
Sulphur.....	0.91	0.60	0.46	0.60	0.93
Ash.....	0.91	3.60	3.80	2.74	3.92
Water at 100° C.....	11.36	9.36	6.72	8.30	14.46

	100.00	100.00	100.00	100.00	100.00
Spec. grav.....	1.255	1.293	1.282	1.280	1.250
Heat units, C.....	7,190	6,628	6,929	7,062	6,132
Heat units, F.....	12,942	11,932	12,472	12,711	11,037
Lb. of water evap'd by 1 lb. of coal (theoretical).....	13.20	12.18	12.74	13.00	11.21

In calculating the last figure allowance has been made for the evaporation of the water contained in the coal. Some authorities give the results of analyses of coals in the dried state, but such statements are of little practical value and are apt to mislead consumers of fuel. The water in coal, although readily expelled by heat, varies very little in samples taken from the pit at different times, and, in fact, is as constant as the composition of the coal itself, which varies sensibly in different portions of the field.—*Chemical News.*

[Continued from SUPPLEMENT No. 221, page 3524.]

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BRIEF REVIEW OF THE MOST IMPORTANT CHANGES IN THE INDUSTRIAL APPLICATIONS OF CHEMISTRY WITHIN THE LAST FEW YEARS.

By J. W. MALLET.

MANUFACTURE OF GLASS.

Materials.—Improvement has of late years been observable in the more general use of comparatively pure materials, even the sand being, in consequence of cheapened transportation, more carefully selected than formerly; but especially have the alkalies been obtainable in much purer forms and at lower prices. As the result of this, colorless glass has noticeably replaced for many common purposes, as in the case of most apothecaries' bottles for dispensing medicines, perfumery, etc., the coarser "green glassware" formerly in use. There has also been improvement in the pains bestowed upon ascertaining and using the best proportions of the materials with a view to homogeneity and definiteness of composition in the glass, thus diminishing the risk of "devitrification" and ready alteration of the surface of the glass in use by water or other reagents. There seems, however, to be still room for advance in this direction, both as to investigation and application of its results in practice. Of comparatively new materials used, zinc oxide in Belgium and barium carbonate in France and the north of England hardly deserve to be considered as more than experimental additions.

Furnaces.—Decidedly the most important improvement made for a long time in the manufacture of glass has been the adaptation to the special use of the Siemens regenerative furnace with gaseous fuel. Originally arranged to work with the glass pots of the types long in use, the furnace in its improved form, designed by Siemens, dispenses with the use of these vessels altogether, thereby saving much expense, labor, and risk, and provides for the complete preparation of the glass in the hearth itself, this being divided into three compartments, in the first of which the mixture of raw materials is fused, in the second glass is "fired" or cleared, and in the third it is brought down to the proper temperature and therefore consistence for working.

Except perhaps iron puddling and steel making, no application of this valuable invention brings out more prominently its peculiar merits—the continuous action, crude material going in at one end and finished glass coming out of the other; the purely gaseous atmosphere of the hearth, free from soot or ash; the extremely high temperature readily obtainable, affording the means of perfect fusion and easy separation of sand grains, gas bubbles, etc.; the effective mixture of the molten glass as it flows under and over the partition walls of the hearth; and the complete command of temperature for working purposes, both of the glass itself and of the working openings for reheating.

Processes of Glass Working.—For the production of glass in sheets for windows, the "crown glass" process of "flashing," long a distinctively English industry, has almost completely ceased to be employed, while in its place the "cylinder" process has undergone marked extension and improvement as to the scale upon which its product is turned out, the size of the sheets made by it—reaching even to 84 × 42 inches—and the smooth, even condition of the surface of the flattened sheets. Plate glass too has been brought more and more widely into use, both in the original form of sheets polished on both sides after casting, and perhaps still more largely with rough surfaces as taken from the casting table, and with flutings and other figures embossed, or perforations made beneath the roller. Immense plates, extending up to more than 20 × 10 feet, have become familiar to us, the limit of size being found in fact more in the difficulty of safely moving and setting in place such magnificent slabs than in that of originally producing them. In the manufacture of hollow ware perhaps the most noteworthy change has been the growth of the process of pressing in moulds without blowing. The development of this especially American industry has been rapid, and marked by much varied ingenuity as to the details of the moulds and other tools.

Annealing.—Beside minor improvements in the construction of kilns for ordinary annealing with movable soles or floors, a marked novelty has been the introduction by De la Bastie and others of the practice of rapid cooling of articles of glass to a temperature still much above that of the atmosphere, giving rise to the manufacture of these called "hard glass" or "toughened glass," in the production of which the articles to be treated are, at a low red heat or a temperature just low enough to secure rigidity, plunged suddenly into a bath of heated oil, glycerine, or other suitable material.

The process of Pieper, involving exposure of the hot glass to a current of superheated but colder steam, and that of F. Siemens, forcing the glass into hollow moulds, generally of metal, kept at determinate temperatures in their different parts by the circulation of water, while actual contact with the face of the mould is prevented by the interposition of a layer of wire gauze or other material, produce essentially the same sort of effect. For some purposes the resulting great

* This formula is given under reserve, as a complete investigation of the compound has not yet been published.