WEALTH FROM RUBBISH.

COAL-TAR—ANILINE DYES.

CHEMISTRY is the most picturesque of sciences. Its votaries, more than those of any other, are frequently surprised by results altogether unlooked for, and just as often baffled in the search for what they believe certain constituents should produce. The history of chemical discoveries, well written, would read like a romance, just as lectures by such masters of the craft as Tyndall or Faraday, illustrated by experiments, are far more attractive than any public amusement. But though chemistry has its poetical side, its operations are carried out with mathematical exactness; and, though the result may be a flower, the means by which it is reached is often through dry and uninteresting labour. While then full of magical attractiveness, chemistry, properly so called, is also the most useful of sciences. It touches our daily life, and our individual comfort, on all sides; and to its investigations and discoveries we owe more perhaps than to any of its fellows'. One author has said that "if chemistry is not the king, it is at least the viceroy of manufactures," and that is nowhere more apparent than in the story of how the world was put in possession of coal-tar dyes.

Twenty years ago gas companies were at their wit's-end to get rid of the coal-tar produced in the distillation of gas. Nobody would buy it, people could hardly be persuaded to accept it as a gift, and sanitary inspectors were wont to grumble when it was being secretly carted from the works, to be cast ignominiously out of sight. This was the most useless of all kinds of rubbish, and in many respects the most noxious. Now and then some venturesome housewife sent one of her children for a canful, to polish her best-room grate when the winter fires were finally put out, but the ire of husband and the nausea of children rendered the first experiment the last; or some stingy landlord, or hard-fisted farmer—too mean to buy paint—plastered it on paling or gable-end; but, to all intents and purposes, coal-tar was a nuisance so hideous that men only asked to be well rid of it. A young chemist—who had been taken in hand by the celebrated Hofmann, and who, from an East-end Mechanics' Institute, where he showed a considerable aptitude for chemical studies, had been transported to the laboratory of the great man—solved the problem for the wrathful but helpless gas-managers in the year 1856. But he solved it in a way as unexpected as it has turned out to be remunerative. The story is interesting and instructive. William Perkin—that was the name of the young chemist—was, at the time of the splendid discovery, engaged in an occupation which has always had attractions for his co-investigators—the endeavour to produce natural organic bodies artificially. How often and how surprisingly they have succeeded, the history of chemistry emphatically shows. Mr. Perkin was trying to make quinine chemically. For this purpose he selected a substance into the composition of which nitrogen, hydrogen, and carbon enter in nearly the same proportions as they do in the natural product. He proposed to act on toluidine with iodide of allyle so as to form allyle-toluidine, and he thought that by mixing bichromate of potassium with the neutral sulphate an artificial quinine would result. What was his horror when, carefully adding the precise proportions of the missing ingredient, instead of the colourless alkaloid he got a dirty reddish powder! Perkin might well have given up in despair, or have scornfully tossed his red powder into the fire; but, balked in one trial, he began again—having very carefully laid his powder aside for further investigation—and this time he determined upon trying a different base. Very fortunately for him, for the gas companies, and for the world at large, he selected aniline, which he treated with sulphuric acid and bichromate of potash; and now, instead of a red powder, or the much-desired quinine, he got a black deposit, more resembling the compound near a pit-head on a wet day than anything else. He persevered with his new and unpromising material, which he purified, dried, digested with spirits of wine, and found to be a splendid aniline purple, or what has since been known as "mauve dye." The writer well remembers, one December night in 1868, sitting in a crowded audience in the theatre of the Society of Arts, to hear the first of the Cantor Lectures for the year, which was to be delivered by Mr. Perkin, and being charmed to see the "battle of the dyes" fought over again. It was a "far cry" from 1856 to 1868, short as were the years, and from the student in Hofmann's laboratory to the successful producer of aniline colours. Twelve years had passed, but in that time the practice and theory of dyeing, and printing in colours, had been revolutionised; coal-tar, instead of being looked upon as rubbish, was cherished by gas-managers as gold; and ladies all over the world had gone mad over the splendid new colours which every year grew out of the original "black stuff" which was got in the search for quinine. Mr. Perkin solved the problem like a true chemist by turning rubbish into gold.

Aniline had long been known to chemists before Mr. Perkin found out its real secret in 1856, but up to that time it had been looked on simply as a laboratory curiosity. A chemical toy it might have remained but for the lucky hit of Mr. Perkin, though it was discovered so long ago as 1826 by Unverdorben while distilling indigo. Englishmen, however, will be proud to know that their own grand discoverer, Faraday, is intimately connected with the actual result. Faraday discovered benzol in 1825, and in that lay the germ of Perkin's dyes. The next step is due to Zinin, who formed aniline from nitro-benzol. Other chemists were unconsciously made to contribute their mite to the ultimate discovery, and among these must be mentioned Runge who got aniline from a distillation of coal, Fritsche who obtained it in indigo treated with hydrate of potassium, and Mitscherlich who discovered nitro-benzol in 1834. The last-named chemist inaugurated the manufacture of oil of almonds, then called essence of myrbane, and stimulated perfumers to add to the scents so largely used. It was, however, reserved for Hofmann to gather into a focus all these interesting and, so far, isolated discoveries. Unverdorben called his aniline "crystalline;" Runge his, "kyanol;" Zinin his, "benzidam," and they were thought to be different substances. Hofmann showed that they were all "aniline," and in 1845 first pointed out that it existed largely in coal-tar. So that to Faraday, Zinin, and Hofmann some share of the glory is due; and Bechamp, who first improved upon Zinin's process of converting nitro-benzol into aniline by the use of iron filings and acetic acid—the means generally adopted to-day in the manufacture of the aniline dyes—must not be forgotten. Who knows how many others have been more or less remotely connected with the modern discovery actually due to Mr. Perkin? So we see the poet is right when he sings that

> "——men may rise on stepping-stones
> Of their dead selves, to higher things."

Coal-tar is known to all of us as the black oily fluid formed in the production of gas from the submerged forests of former ages. It is, chemically, one of the most complex of bodies; and, like Englishmen, never knows what it is to be conquered. For many years chemists have been pulling it to pieces, and when they think they have completely analysed it, something else is sure to turn up. Over fifty distinct substances have been found in it, and, as almost every year sees a new one, there is no predicting how many more it may hide in its mysterious bosom. It would be too much to inflict upon the reader a complete list of its known contents, but we may name a few. Among these it will be enough for our purpose to mention benzol, naphthalene, toluol, phenol, paraffin, ammonia, and aniline. Benzol is in some respects the most important of these, because from it, in conjunction with nitric acid—called nitro-benzol—are directly obtained the crystals which yield the dyes. The process broadly is that the coal-tar is distilled in large receivers; the light or volatile oils, of course, first pass over, and these contain the largest percentage of crude naphtha; by continuing the process the heavy or "dead" oils are also given off, till nothing but pitch remains in the original receptacle. With this and other ingredients we shall deal hereafter, but now only the naphtha interests us. Purified by successive distillations with steam and concentrated sulphuric acid, the naphtha is rendered a colourless fluid. This is subjected to a second process to get at the benzol, which being the lightest of its constituent parts is first given off. The benzol is treated with nitric acid, when a chemical change takes place. At first the mixture turns dark brown, then heat appears, fumes are given off, and it enters into a state of ebullition. The result is that the nitro-benzol on the addition of water sinks to the bottom in the form of a thick yellow oil. The nitro-benzol is placed in an iron receiver in which a stirrer revolves, a stream of super-heated steam is passed through it, acetic acid and iron filings are added in certain proportions, and the aniline distills over. The aniline is now treated with dilute methylated spirit, which absorbs all the colouring matter, and only a small percentage of the brown resinous substance which at first gave the discoverer such trouble to get rid of. It is chiefly sent to market in paste or solution. Mr. Perkin tells us that out of 100 lbs. of coal, 10 lbs. 12 oz. of coal-tar are obtained. This yields 8½ oz. of naphtha, 2¾ oz. of benzol, 4¼ oz. of nitro-benzol, 2¼ oz. of aniline, and ¼ oz. of mauve dye. The small quantity of dye obtainable would seem at first sight to be so insignificant as to stand in the way of any large manufacture, but when we consider the intensity of the colouring matter in the quarter of an ounce of paste we cannot be surprised. One grain of the mauve is sufficient to make nine or ten gallons of water a dye, and therefore a quarter of an ounce would suffice for 1,100 gallons of water. This would be capable of dyeing thousands of yards of wool and silk.

From the first discovery of mauveine—or purple dye—have sprung all the other colours. For instance, what is known as aniline blue is simply hydrochlorate of aniline treated with dilute chloride of lime and precipitated by salt. This produces a blue-violet colour, and the material dyed in it has only to be steamed to assume the brilliant blue tint. The most famous of all the aniline dyes has probably been magenta, but its discovery depended upon that of mauve. Neither the aniline directly produced from coal-tar nor that obtained from indigo would have led to it, and the many colours that followed magenta would consequently have been unknown. Among the substances in coal-tar the reader will observe toluol, which, treated with iron and acetic acid, forms toluodine. Benzol and toluodine having been separately obtained—or, what is the same thing, in the process of distillation a certain proportion of toluol is allowed to pass over with the benzol—they are mixed in suitable proportions to produce the various shades of magenta. This is the discovery of Dr. Hofmann, but in an industrial sense M. Virguin, of Lyons, introduced it as a marketable commodity in 1859. The manufacture was first rendered successful by treating the aniline-toluol mixture with tetrachloride of tin, but the process which has superseded that and many others was discovered by Mr. Medlock and patented in January, 1860—viz., by the use of arsenic acid. The crude product obtained by heating aniline and toluol with arsenic acid is boiled in water and filtered, salt is added to precipitate the colouring matter, and this, on being dissolved and filtered deposits magenta crystals which are ready for the market. These crystals consist of an organic base which Dr. Hofmann named rosaniline. In the formation of magenta another product called phosphine is obtained, from which scarlet dyes are extracted. Blue of Lyons is got by mixing aniline and rosaniline with a feeble acid. All the violet tints are obtained by treating rosaniline with iodide of methyl. This iodide is produced by the distillation of alcohol, phosphorus, and iodine ; but for commercial purposes, especially in Germany, hydrochlorate of rosaniline, iodide of ethyl, and alcohol alone are used.

The next shades to be discovered were the aniline greens. A certain M. Luath—among scores of others—proposed a special mode for getting aniline blue, but the product was useless as a dye on account of its evanescence. A dyer named Chirpin, to whom it had been introduced, endeavoured to "fix" it, but after repeated efforts failed. In his extremity he consulted a friend who was a photographer in the town, who advised him to try hyposulphite of sodium. M. Chirpin made the experiment, but instead of fixing his blue, found it turned into a splendid green colour, now known as aldehyd green. It is chiefly used for dying silks. There is another green, called iodine green, which is obtained by slightly altering the Hofmann process for the manufacture of magenta, the chief agent being picric acid. The pinks, yellows, and all other shades and colours rapidly followed the first discovery, and it would be useless to enter into details regarding them here.

All these coal-tar colours contain carbon, hydrogen, and nitrogen, and they are generally organic bases ; but they differ essentially from all the dyeing products that preceded them. Indeed their success was at first imperilled because they would not combine with the ordinary mordants used by dyers and printers. However, expedients were soon forthcoming, and every year has seen them grow in favour.

Marvellous as has been the result of the application of these dyes to silk, wool, and calico or cotton goods, it has been none the less noticeable in other industries. Printers and lithographers use them almost exclusively for colour-work, wall-paper is almost invariably dyed with them, and even artists use them in various forms. Simple and certain in their action, they are easily capable of being rendered permanent. Since their introduction manufacturers of ink are able to provide us with a fluid which does not lose its colour by age, and to tempt us with blues, violets, and mauves, besides other shades unknown to our fathers.

Considering that the aniline mauve was only used for the first time at the end of 1856, and that now thousands of persons at home and abroad are employed in the manufacture of the various tints, quite a national industry has been created. But that is not all. We are now no longer dependent upon Turkey, Holland, and other countries for our colouring matter. Enough coal-tar is obtained in these kingdoms yearly to produce, by the aid of better apparatus and improved methods, more dye-stuffs than we can use ; and we may become, as France and Germany are bidding fair to do, exporters of these beautiful dye-stuffs to other countries.

When Mr. Perkin first gave the result of his studies in these aniline dyes to the Chemical Society in June, 1861, Hofmann, to whom he owed his earliest lessons in independent research, Faraday, the father of chemists, and many others of fame were among his audience ; and the veteran discoverer of benzol, when asked to say a few words, remarked, "What an encouragement it affords to the young chemist to pursue his studies earnestly and heartily, when he finds that such a small thing as the separation of benzol from other matters may lead to such large results !" And we may add, how important it is that the young chemist should never throw anything away without further inquiry, however unlike it may be to that of which he is in search !

However, the fact for us in all this is that nothing is useless—there is no such thing actually as rubbish. What we call so is only useless because we are ignorant of the purposes to which it may be applied, and as soon as we know these it becomes our humble servant and a new source of wealth. When we find that thick, oily coal-tar carries secreted in its bosom substances producing all the colours of the rainbow, surely we ought not to be so ready to waste much which science has shown to be capable of utilisation ; and science herself may be far more proud of what she has done to assist the artisan, the mechanic, and the manufacturer, than of all the beautiful but merely theoretical discoveries of which she is sometimes too ready to boast.

W. GIBSON.

GOOD-BYE !

GOOD-BYE ! Too oft an idle word,
Yet holding thousand meanings fast
That bind us sadly to the past,
Or strike on Hope's sweet harp a chord
Whose music whispers in each heart,
"'Tis sweet to meet, if sad to part."

Adieu ! Good-bye ! Ah, who can tell
If those who smiling part shall see
Each other more ; or if shall be
This light "God speed !" their last farewell ?
The loving hand's last pressure o'er,
And lone hearts moaning, "Nevermore !"

JULIA GODDARD.