the liquid to flow from a receptacle through an orifice, has a very appreciable error due to the specific gravity of the oil.

The torsion viscosimeter is manufactured and sold by Bullock and Crenshaw, 528 Arch street, Philadelphia.

PROGRESS IN THE MANUFACTURE AND USE OF ARTIFICIAL COLORING MATTERS.[1]

BY OTTO N. WITT, PH.D., PROFESSOR AT THE POLYTECHNIC INSTITUTE OF BERLIN.

HAVING been requested to deliver an address before this congress, I know of no better subject to call your attention to than the one with which I have been familiar from the beginning, the chemistry of artificial coloring matters and their relation to dyeing and calico printing.

Unfortunately the subject is one of such vast dimensions, that I should fail to give you anything like a complete description of it, even if I could venture to trespass much longer upon your valuable time than it is my intention of doing. I had to choose a certain chapter from it, and in so doing I have preferred, mindful of the eminently practical turn of this country, to bring before you rather the practical side of the recent development of coloring matters, than the theoretical one. Thus I shall avoid among other things the use of complicated structural formulas which, though indispensable to the modern organic chemist, are apt to be looked upon with disfavor by no small number of eminent and accomplished chemists.

The question of artificial coloring matters is, I am sorry to say, one which has hitherto been left entirely in the hands of the chemists of the old world, who, I need not assure you, would be only too glad to collaborate in this matter as well as in so many others, with their colleagues in the United States. But it seems that quite peculiar conditions are required to develop this particular flower on the vigorous and imposing tree of general chemistry and we have, even in the old world, noticed the remarkable fact that the industry of artificial dye stuffs, born in France, has left that country to settle in England; and here again it has not been able to reach its full development, but has

[1] Read before the World's Congress of Chemists, August 21, 1893.

preferred, with no apparent cause, to make the German Empire its final emporium. But here at last it has grown to such imposing magnitude, that the world has now, for more than a decade, been ringing with its praise and admiration. And this praise has not been bestowed with injustice. The whole life and thought of some of our greatest scientists have been spent in considering and mastering the intricate problems connected with the chemistry of aromatic compounds, to which all synthetical dyestuffs belong and every progress of the manufacture of these interesting substances has been the result of masterly work in the domain of pure science. The method, now so generally recognized, of applying scientific principles to every practical question, however trivial it may at first seem to be, has never been more successfully adopted than in the manufacture and use of dyestuffs, where nothing may be guessed or discovered, but everything concluded and invented.

The new brilliant era in the chemistry of artificial coloring matters was inaugurated by the discovery of the law, which governs the connection of the chemical constitution with the properties of artificial dyestuffs. It would lead too far to set before you on this occasion these laws themselves and to expound the many examples of their correctness and universal applicability. But it is quite natural, that, when once these laws were established, the production of dyestuffs ceased to be the result of lucky circumstances and became the object of profound and in many cases brilliant logical argument, and thus it is that today coloring matters may be produced by thousands, all of which are absolutely and perfectly new and the properties of which may be established with perfect certainty before even the smallest sample of them has ever been prepared. So great is the number of new dye-stuffs for the production of which we have every means at our disposal, that it seems quite impossible that all of them will ever be prepared even as laboratory specimens.

Now it will be easily seen that science whilst placing a treasure of such imposing magnitude at the disposal of the manufacturer, has not only benefitted him, but that she has also vastly increased his work and responsibilities. And thus we see the old fashioned factories, such as I remember them from the days of my youth, consisting of a few sheds and a snug little laboratory, replaced by the enormous places which now serve the same purpose and of which you may see an excellent representation in the exhibition of the German chemical industry in the World's Fair; places resembling towns or cities, consisting of hundreds of buildings of vast proportions and over-shadowed by dozens of huge chimneys: with laboratories much larger than those of the most renowned universities, and in which hundreds of chemists and assistants are constantly at work ; and in the workshops themselves the few casks and stirrers which used to be the main implements of the manufacturer of dye-stuffs, have been replaced by costly machinery, too varied and complicated to attempt its description.

Now it seems natural to ask whether all this is but temporary or lasting; or, in other words, whether such complicated means for the production of artificial dye-stuffs will forever be necessary or whether, in the near future to come, all this may not be much simplified. It seems but natural to start from correct scientific principles and to conclude that we do not want such a large number of dye-stuffs as we are actually capable of producing. We know that there are a few primary colors from which all the other shades may be produced by mixture. Why not, therefore, select amongst the vast number of dye-stuffs at our disposal a few which, whilst being cheap and easy of manufacture, represent our primary shades. Let us then dye everything with these and neglect the rest, from a practical point of view. This seems sound reason, and the enormous apparatus which is at present used by the manufacturer seems to involve an unnecessary complication.

I regret to say that this way of looking at the subject proves quite erroneous if we examine it a little more closely. The simple laws of the combination of colors in the physical sense of the word are not applicable to dye stuffs used for dyeing textile materials. Coloring matters of given shades may be blended together, but it is impossible to produce, by their mixture, shades of such freshness and purity as the same shade produced by one individual chemical compound would possess.

It is easy to explain the causes of this fact, but in order to be brief we will take it as granted, and we will then see at once why such a large number of intermediate shades have to be prepared. Thus, for instance, a careful silk dyer would never think of producing a purple from a mixture of blue and red, although physically this would seem possible. He would always, to insure a good result, use any or either of the purple dye stuffs now in the market. I may say that there are at present about thirty different purples sold, and that no one of them is a mixture but a well-defined individual compound of different shade and properties.

But the color which may be produced on a textile material by a certain dye-stuff is not the only point to be considered in using this dye-stuff. Here we come to the most interesting side of the question—to the relation between the coloring matter and the process of its application.

What is the process of dyeing? This is a question which has for a long time puzzled the minds of many scientists. It is now generally admitted that it is a chemical process, a process of actual combination between the substance of the dye-stuff and the substance of the fiber. But the impossibility of establishing in the majority of cases any molecular proportions in the chemical reaction which is taking place has for a long time been the stumbling block of those who wished to examine this reaction more closely. It is only quite recently that the true nature of the process has been recognized. Dyeing is certainly a chemical process, but one of those in which simple molecular proportions can no longer be established. These processes have of late been more closely investigated, and we now comprise them under the heading of solutions. If I dissolve sugar in water, a chemical reaction, a combination of the two ingredients takes place, and the solution formed is a chemical compound, whatever be the proportion of its constituents. And the same rule applies in a great many other cases.

The difficulty in grasping the true scientific sense of the word "solution" lies in the fact that we have from our childhood been accustomed to consider a solution as something liquid. This is by no means a necessity, and there are quite as many solid solutions as liquid ones. To give you an example I will take blue glass. This is a solution of sodium-cobaltic silicate of an intensely blue color in colorless normal crown or flint glass. Both the constituents of this solution are solids, and so is the solution itself; still the two compounds in combining together do so according to exactly the same principles as sugar and water in producing a liquid solution.

Without going into details I may state that every dyed fiber may be looked upon as a solid solution of exactly the same character as blue glass. Its mode of formation is different, but the result is none the less the same.

Taking this as established, we may at once draw an interesting conclusion. If for dissolving sugar we take spirit instead of water we find at once that sugar is much less soluble in this medium. Now there is quite as much difference between silk and cotton as there is between spirit and water, and thus we understand why the different textile fibers can not be dyed with equal facility. The chemical substance of the fiber being the solvent for the dye-stuff, it is but natural that its solvent power should not be equal in all cases. Thus it is that we have to use different dye-stuffs for the various textile fibers, and, as the number of the latter is rather on the increase than the reverse, we shall have to meet in the future a demand for an increased variety of the dye-stuffs produced.

The discovery of the true relation between the dye-stuff and the fiber has coincided with some of the most important forward steps in the industry of artificial coloring matters, and in some respects has been instrumental in facilitating such progress.

The majority of the older dye-stuffs have been remarkable for their solubility in, or, as the chemists of the old school would express it, for their affinity for silk and wool rather than for cotton and the other cellulose fibers. In applying them to cotton certain artifices had to be used, known as mordanting, processes into the nature of which we need not enter, but which made the dyeing of cotton both difficult and expensive. But when we remember that the relation of the two solvents, spirit and water, to sugar is not a universal one; that there are a great many substances which dissolve easily in spirit and sparingly or not at all in water, we see at once that there is no reason why the same should not apply to dye-stuffs and why there should not be dye-stuffs which, contrary to those hitherto produced, dissolve more easily in cotton than in silk or wool. If such dye-stuffs could be produced, their production would of necessity represent an immense progress in the dyeing of all vegetable fibers, of which, as you are aware, about ten times as large a quantity is consumed all over the world as of silk and wool taken together.

Well, this progress was realized about eight years ago, when the first synthetical dye-stuff more soluble in cotton than in animal fibers was put on the market under the name of Congo. This compound dyes cotton a brilliant scarlet without the use of a mordant. Ever since its discovery many chemists have been at work inventing new dye-stuffs which, whilst being endowed with the same important property, would supply the other shades, and at present we have several hundreds of them, dyeing every shade of the spectrum and placing the cotton dyer on the same convenient footing with the silk and wool dyer. I need hardly add that the relations between the constitution of these dye-stuffs and their interesting new properties have been fully cleared up, and that the production of all the varied shades of this new class of coloring matters is the result of truly scientific and logical work, and not in the least that of lucky chance.

There are many more things of general interest which I might bring before you, but I prefer to limit myself to the discussion of but one more important subject.

This important subject is the question of the fastness of artificial dye-stuffs, of their power of resistance to the chemical action of the various conditions to which a dyed textile fabric must of necessity be exposed.

I may state at once that there are few things in chemistry about which so many and such unfounded popular prejudices are afloat as this question of the fastness of artificial coloring matters.

It is true that the first synthetical dye-stuffs placed on the market, magenta and its derivatives, were of a rather fugitive character. But there is no logical connection between this unfortunate fact and the artificial production of the substances to which it applies. If by some chance we should discover that magenta occurs as a natural constituent of some gorgeously colored flower or fruit, it would be equally fugitive; whilst alizarine and indigo, when prepared by artificial means, showed themselves quite as fast and permanent as when extracted from the plants in which they occur. In fact, I need not point out to an assembly of chemists that there is no barrier which divides natural coloring matters from artificial ones, that permanent and fugitive substances occur in both groups, and that it is the task of the colorist to make a proper selection amongst them. But in order to be able to make such a selection he requires a very large stock to choose from, and thus modern organic chemistry in placing at our disposal an overwhelming number of new coloring matters has conferred upon us a boon which can not be over estimated,—the possibility of choosing our dyeing materials not only according to the beauty of their shade, but also according to their more hidden, inherent value. We possess now artificial dye-stuffs of such a degree of permanence that neither indigo nor any other of the most renowned old natural dye-stuffs can even approach them. Most interesting and severe tests have been made which prove this beyond any doubt, and I can only invite you to look at the specimens illustrating these tests and exhibited in the collective exhibition of the German chemical industry in the Manufactures Building.

The researches on the permanence of artificial dye-stuffs, which have yielded these important results, have also been instrumental in exposing another silly and illogical popular prejudice. This prejudice consists in the belief that all bright and brilliant dyes are necessarily of a fugitive nature and that on the other hand permanent coloring matters are invariably of sombre and subdued shades. Recent researches have shown that no such relation exists between the brilliancy of dye-stuffs and their fastness. Whilst both these properties are functions of the constitution of dye-stuffs, there seems to be no inherent connection between them. And thus I may confidently recommend to the ladies among this audience to continue the use of bright and pleasing colors without any fear of their being fugitive merely on account of their brilliancy. Rhodamine, the new pink, surpassing in its beauty even the delicate leaves of the rose, is not only a brilliant, but also a fast color, and it does by no means stand alone amongst modern artificial dye-stuffs in combining these two most valuable properties.

And now, ladies and gentlemen, I will not trespass upon your time any longer. My sketch of the recent progress in the chemistry of artificial dye-stuffs has of necessity been short and incomplete; but if I have succeeded in convincing you that this domain of organic chemistry has not been lying dormant of late and that all its progress has been the result of laborious and difficult, but in its final results, brilliant and successful scientific work, I shall consider myself amply rewarded.

HOW CHEMISTRY IS BEST TAUGHT.[1]

BY CHARLES F. MABERY.

THE subject, "How Chemistry Is Best Taught," which has been proposed to us for discussion, has a serious interest for all persons who are engaged in teaching chemistry, and it is of especial importance to those of us who have in charge the preparation of young men for professional employment. In view of the prominence of scientific subjects and methods in the present systems of education, it is encumbent upon the adherents of these methods to demonstrate by their results that they are not in error in assuming that science should have an equivalent place with other departments of knowledge. In the higher institutions this question has received a definite answer; in the secondary schools evidently much has yet to be accomplished in the direction of general education as well as in the preparation for higher study.

That the importance of a knowledge of elementary chemistry is apparent to all who are capable of appreciating its usefulness is evident in the recent extension of instruction in the secondary

[1] Read before the World's Congress of Chemists, August 26, 1893.