

## The Application of Spectral Analysis to Pharmacy.\*

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Perhaps the most startling discoveries of the present day have been those which bear some relation to experimental physics, and more particularly to that branch which treats of optical phenomena.

Not very long ago the supposition of a close relationship between light and chemical action would have been ridiculed, and indeed was so. Now, however, the education of a chemical student must include the fundamental laws and properties of light. The chemist, in his analyses, is constantly invoking the aid of light in some way or other to help him in revealing the hidden secrets of nature. Sometimes the magic touch of a polarized ray will point to each individual granule of starch as it lies hidden by a multitude of other cells; nay, more, it will even tell him the name of the plant from which it was derived; and if this were not enough, the solar rays themselves are actually compelled to reveal to the student their nature and the composition of the sun from which they radiate.

Within the last few years the labours of Kirchhoff, Bunsen, Sorby, and Huggins have been richly rewarded by fresh victories from the study of spectral analysis in chemistry, mineralogy, and astronomy. So much has been said and done lately by scientific observers in this direction, that one's attention is naturally attracted to other materials more intimately connected with every-day life.

It is with the hope of suggesting a practical use of spectral analysis to your notice in a more immediate relation to our own profession, that I venture to introduce my present subject. I do so with diffidence, because I have as yet only just passed the threshold of experiment, but have already seen enough to indicate that a large field of inquiry and interest lies before us. I hope therefore these few remarks may prompt some one present to work out the numerous details necessary for a more complete elucidation of the subject.

Perhaps at the outset the question may arise, "What is spectral analysis?" I will, therefore, ask my more experienced brethren to bear with me while I give a short explanation before describing the method of working and showing some of its results.

Works on the subject are nearly all filled with the phenomena of the spectra of flames. In the beautiful work of Professor Roscoe just published, this is the case; only seven pages are devoted to what is commonly called "the absorption spectrum."

You will all remember that Sir I. Newton, by passing a ray of light through a circular opening and then through a glass prism, showed what has been known ever since as "the solar spectrum," the several rays being separated in order of their refrangibility.

Light may be regarded as an ethereal medium in an intense state of vibration, varying in rapidity from 470 to 800 millions of millions per second. The waves of light, too, as might be expected, vary in size proportionably to the rate of vibration. For instance, a ray of light that gives to the eye an idea of red vibrates, at the rate of 477 millions of

millions in every second of time, each wave measuring about the one forty-thousandth of an inch. When the rate of vibration reaches 622 millions of millions, the wave measures only the one fifty-one-thousandth of an inch, and then produces the impression on the retina which we term blue. If the vibration exceeds 727 millions of millions, the eye cannot respond, and unless we use certain precaution, there is no visible colour produced. The vibrations, nevertheless, are there, because the chemical or actinic power is most intense.

Colour, then, is not a substance *per se*, but is a certain impression produced upon the retina, varying according to the intensity of vibration.

The red rays of the spectrum vibrate so weakly that they can only penetrate the thin end of the prism. Those of greater intensity are capable of penetrating the thicker portions of the glass, and are thereby refracted at a greater angle.

It was formerly thought that the three primary and pure colours of the spectrum were red, yellow, and blue, and that neither of these could be further resolved, the intermediate tints being formed by the mixture of different waves of light.

Later discoveries, however, by Professor Maxwell, Helmholtz, and Sir John Herschel seem to prove that the pure colours of the spectrum are red, green, and blue; that the mixture of yellow and blue cannot in any way be made to produce green, but one of red and green will form yellow.

In the year 1802 the far-sighted Wollaston, instead of passing the beam of light through a circular orifice, made use of a slit one twentieth inch wide, the sides of which were parallel to those of a flint-glass prism. To his astonishment, instead of a continuous band of colours, the spectrum was crossed by six dark lines.

Thirteen years afterwards, M Fraunhofer, of Munich, found that instead of six, he could map out more than six hundred, and discovered the important fact that these lines were always exactly constant, both in number and position, and consequently ever since they have been called "Fraunhofer's lines."

When the light from the sun, planets or fixed stars is observed, these lines appear black, but when from the electric spark or an incandescent body, the lines are bright, but nevertheless occupy the same position as the dark ones.

These phenomena are now explained by the grand discovery of spectral analysis by Kirchhoff and Bunsen in 1860. They found that when certain metals were burnt in a colourless flame they produced bright lines, which perfectly coincided with certain of the dark ones noticed in the solar rays. For instance, sodium gives a bright yellow line which exactly fits Fraunhofer's line D.

Potassium produces two lines, one coincident with the solar line A. and the other at the commencement of the violet, and so on with the rest of the metals.

The extreme delicacy of spectral testing is almost incredible. It is nearly impossible often to get a flame free from the sodium line, so minutely universal is its distribution. Lithium only a few years since was supposed to be comparatively rare, because the quantity sometimes present was too small to be recognizable by the ordinary tests. Now we find it in almost everything. The spectroscope detects it in the ocean and mineral

springs, in felspar and granite, in the ashes of plants and milk of animals, in the ash of a cigar and the juice of a grape.

The object of my present paper is not to explain the bright lines of incandescent bodies, but the appearances of solutions and other liquids when subjected to spectral observations.

When certain solutions are thus observed, they show that part of the transmitted light is absorbed, giving rise to shadow-like bands called "absorption bands."

These bands are constant and give a spectrum peculiar to each preparation, as I will presently endeavour to show by exhibiting and explaining the appearances of many of the well known articles of the Pharmacopœia.

Most solutions when greatly diluted are said to be transparent, but this is only comparatively correct. Even air and water deprive the solar light of some of its rays during its passage through these media. The more coloured the solution, the more decided is the effect produced.

Thus an ammoniacal solution of cupric sulphate will transmit the red and violet rays, and absorb all the rest.

An ammoniacal solution of nickel will absorb the violet, but allow the blue and red to pass.

A solution of ferric sulphocyanide will only transmit the yellow and red, while the green, blue, and violet are totally absorbed.

Many substances forming nearly colourless solutions, yet afford very strong absorption bands, e.g., the salts of didymium, manganese, hæmatine, or crumrine.

The absorptive powers of fluid spectra explain the bluish haze of a distant landscape and the green colour of deep water.

The spectroscope used in these experiments is one made by Mr. Ladd, of Beak Street. It is a very excellent instrument, reliable and easily worked. To use it, the eyepiece by itself is inserted into the tube of a microscope, the slit between the lenses opened and the object focussed. The tube containing the prism is then replaced and the slit gradually closed till a good spectrum is obtained. Should any part of the spectrum not be clear, it must be focussed by means of the milled head attached to the eye lens.

An indispensable addition to the microspectroscope is a small side prism which enables the observer to see the spectra of two solutions at the same time.

Strict attention must be paid to the strength of the solutions under examination. If too strong, too much light will be absorbed, and instead of well marked lines, large, cloudy and obscure bands will be seen.

Mr. Gladstone (Q. J. Chem. Soc. 1079) used wedge-shaped vessels, so that he could examine any thickness of the fluid, for the darker any solution is, the thinner must be the stratum, and the weaker the solution, the deeper the stratum.

I prefer a bit of glass tube, because more generally at hand and easily made. A common 1 oz. or ½ oz. phial will answer well, or, what is still better, the little tube bottles used by the homœopathic chemist. The tubes I usually employ are about 3/16ths of an inch in diameter.

The solution or tincture is diluted till the spectrum is most advantageously seen. The rate of dilution varies from two to ten times or more. For instance, Tinct. Hyosc. Bienn. would require three or four times its volume of proof spirit, while Tinct. Cannab. Ind. is

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