

form in which he presented it has become merely of historical interest. But there is also a minority opinion. Prof. E. T. Whittaker² points out that Pauli's spin matrices of 1927 are simply Hamilton's i, j, k , and says³, "I am inclined to conjecture that if the present range of problems were not extended, physicists would continue to prefer vector-analysis; but that the development of relativity and quantum mechanics will sooner or later require quaternion methods for the more difficult problems (as in Professor Conway's paper, referred to in my original article); and that when the physicists have thus been forced to learn quaternions, they will use them for all purposes, and vector-analysis will be forgotten".

¹ NATURE, 1891-93. *Mathematical Gazette*, 25, 106 and 298 (1941).

² *Mathematical Gazette*, 24, 158 (1940).

³ *Mathematical Gazette*, 25, 300 (1941).

DEVELOPMENTS IN MICRO-CHEMICAL ANALYSIS

By E. J. VAUGHAN

A SYMPOSIUM on micro-chemical analysis arranged by the Micro-Chemical Club, the South Yorkshire Section of the Royal Institute of Chemistry and the Sheffield Metallurgical Association was held at Sheffield on October 9, and was preceded by a demonstration of micro-chemical methods and an exhibition of micro-chemical apparatus. The exhibition was very complete in character and included the latest design of micro-chemical balance, capable of weighing one milligram of substance accurately to 1/500 mgm., some physical instruments now used as the tools of the micro-chemist—notably the polarograph and photo-electric absorptiometer—and a variety of graduated flasks, pipettes, burettes and mixing vessels. Of the micro-glassware exhibits one of the most interesting was the Wigglesworth-type burette which was used in the determination of the sodium chloride content of the body fluid of a single gnat. This burette is usually home-made by the micro-chemist, being obtained by drawing out a piece of glass tube to an extremely fine bore, waxing the interior and exterior surfaces and mounting in a suitable glass tube. The waxing overcomes surface tension effects, a drop size something less than that of the head of the average pin is obtained, and each drop breaks cleanly away from the burette end.

The symposium included a number of papers covering a wide range of subjects, and produced some accounts of noteworthy advances made in the application of micro-chemical methods to the analysis of inorganic materials. The study of micro-organic and micro-biological methods has had considerable prominence in the scientific world, and from the evidence submitted it would now appear that the inorganic micro-chemist is advancing as rapidly as his colleagues in the other spheres.

Exigencies of the War have made many demands of the chemist, and not the least of these is the necessity of establishing the composition of metallic compounds when only limited samples are available. A detailed study of this problem has resulted in the formation of micro-chemical methods for the determination of alloying elements in steels and aluminium alloys. It is possible to determine manganese, titanium, copper, vanadium, molybdenum, phosphorus, nickel, chromium and silicon in steels on

amounts of sample ranging from 10 mgm. in the case of the first three elements mentioned down to 2 mgm. in the case of the last two, and iron, manganese, nickel and copper in aluminium alloys, the weights of sample required being 10 mgm., 10 mgm., 2 mgm. and 1 mgm. respectively.

The methods are unusual in that they employ a chemical opening out and a physical finish. In all cases, the chemical procedure followed is to take the alloy into a suitable acid solution and then, by application of chemical reagents, form, with the element which it is desired to determine, a complex which gives rise to a coloured solution. The Spekker photo-electric absorptiometer is then employed to determine the light absorption of the solution, the chemical technique having been so arranged that the measured absorption is directly proportional to the concentration of the element being determined. The measured absorption may be obtained as the result of a single reading or the difference between two readings. An example of the former occurs in the silicon method, in which a silico-molybdate complex is formed and reduced by the addition of stannous chloride to molybdenum blue, the final condition of the solution being such that the other elements present do not give rise to a measurable absorption. The determination of manganese provides an example of the latter, for the oxidation of manganese to permanganate by potassium periodate also gives rise to the partial oxidation to dichromate of chromium. The total absorption is first measured, a drop of sodium nitrite to decolorize the permanganate then added, and the absorption due to chromium as dichromate measured.

The most recent advance in this field of work has established a composite method for the determination of manganese, molybdenum, chromium and nickel on a single 4 mgm. sample. This result has been achieved by the use of monochromatic light obtained through the use of a mercury lamp as light source, with suitable filters in the absorptiometer and the provision of specially manufactured micro-cells which may contain as small an amount of solution as 0.5 ml. but yet permit the passage of a narrow beam of light through a long column.

The actual weights of the elements under consideration present in the solution measured are of interest. Assuming each element to be present to the amount of 0.1 per cent of the sample, the weights in the absorption cell are:

Manganese	4×10^{-6} gm.
Molybdenum	1.6×10^{-6} gm.
Nickel	4×10^{-7} gm.
Chromium	3.2×10^{-7} gm.

Accuracy of the determination of such small amounts is claimed, and in each case a ten-division drum movement reading of the absorptiometer is recorded.

An example of a mainly chemical method of attack was provided by an account of a micro-method of gas analysis. The gas bubbles occurring in glass have been studied, means for their extraction developed and a technique for their analysis formulated. The whole process has been so well developed that bubbles of gas of the order of 4×10^{-3} c.ml. can be analysed for sulphuretted hydrogen, carbon dioxide, carbon monoxide, sulphur dioxide, oxygen and hydrogen. In order to extract a bubble of gas, the glass containing the bubble is ground down until it is 1/1000 in. thick, and the glass is then broken under glycerine. The bubble of gas floats to the surface of

the glycerine, where it is retained by a microscope slide and its diameter measured by means of a microscope. The bubble is then removed by using a bent capillary pipette with an inner diameter not much smaller than that of the bubble, and transferred to a solution of cadmium acetate. Five minutes contact with this solution removes the sulphuretted hydrogen and the bubble is then transferred by means of the special pipette first to a glycerine-washing solution and then to the original glycerine solution for diameter measurement. The process can be repeated using 10 per cent caustic soda in glycerine for the removal of carbon dioxide, sodium hydro-sulphite for the removal of oxygen, ammoniacal cuprous chloride for the removal of carbon monoxide and colloidal palladium solution containing sodium picrate for the removal of hydrogen.

A spot technique has also been devised whereby a very rapid qualitative test for the presence of a single gas can be made. For this purpose, specially constructed instruments for piercing glass are employed, to the contact ends of which the chemical reagents are applied, a microscope being used where necessary to observe any reaction. As an example of this spot technique for the detection of sulphur dioxide, a gramophone needle as the piercer holds at its point an acid solution of fuchsine decolorized with formaldehyde, and after piercing, the formation of a reddish-purple colour indicates the presence of sulphur dioxide in the gas. Although great accuracy is not claimed for this method owing to the fact that the gas bubbles are not always spherical and some of the constituent gases show partial solubility in glycerine, very valuable results have been obtained. It is proposed to compensate for solubility errors by carrying out the same process on samples of known composition.

Of the latest advances in micro-chemical analysis as applied to organic chemistry, the use of mercuric oxycyanide was cited. This micro-chemical reagent has been employed with advantage in the determination of sulphur, by making use of its reaction with barium chloride to form barium hydroxide. The normal sulphur method is followed so far as the precipitation of barium sulphate, a known amount of an accurately standardized solution of barium chloride being added, however, and then hydrochloric acid is removed by evaporation, and the barium hydroxide formed from the excess barium chloride by the addition of mercuric oxycyanide is determined by titration with standard sulphuric acid. The method has distinct advantages in that it permits a smaller sample weight than the gravimetric method, employs the accurate alkali-acid titration finish and overcomes errors due to incomplete precipitation of barium sulphate or co-precipitation of barium chloride. The application of this reagent to bring about an acid-alkali titration finish has been extended to the determination of ionic iodine and the methoxy radicle.

The polarograph has been employed for a number of years for micro-chemical analysis, but a recent innovation is the use of this instrument for amperometric titration. An outstanding example of an amperometric titration is the determination of copper and zinc using quinaldine acid as the titrating medium. Using the polarograph to give a constant applied potential of -0.9 volt to the solution of copper and zinc, the changes in current flowing are recorded against successive increments of quinaldine acid. From the resulting graph, concentrations of copper and zinc are determined.

During the meeting, attention was directed to the lack of facilities in Great Britain for teaching micro-chemistry. The view was expressed that it can be taught to undergraduates successfully and should be included in the normal chemical syllabus. Details of a six weeks course, which had been successfully introduced in a university degree course, were given.

In discussion, regret was expressed that facilities are lacking for the pooling of micro-chemical knowledge—the symposium being specially arranged and being the first of its kind for four years. The meeting concluded by passing a resolution expressing its desire that everything possible should be done to further activities of micro-chemists, and appointed an *ad hoc* committee to consider the best means by which this aim could be achieved.

PROBABLE FUNCTION OF HISTONE AS A REGULATOR OF MITOSIS

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UNTIL the recent discovery of chromosomin¹, the histones (and protamines) were regarded as the typical proteins of cell nuclei, a view which was fairly well founded as regards fish spermatozoa², but which lacked any certain experimental basis with respect to other and more typical forms of nuclei. Kossel³ and Ackermann⁴ had, it is true, demonstrated the presence of a histone in the nuclei of avian erythrocytes by extracting it directly from the isolated nuclei, but no detailed study was made of its chemical composition and properties. Apart from this instance, no histone has, so far as we are aware, been extracted directly from any nuclei other than those of spermatozoa. Nevertheless, histones have been isolated from various tissues, in particular from the thymus gland; more recently, Mirsky and Pollister⁵ have prepared nucleoproteins, in which the protein component is believed to be either a histone or protamine, from a variety of animal tissues. There is thus presumptive evidence that, while the traditional view that the protein components of nuclei are chiefly or entirely histones is, as we have shown¹, incorrect, histones do nevertheless occur widely among the constituents of nuclei. Nothing, however, is known concerning the function of histone in the nucleus. Of the two other main constituents, chromosomin, the principal component of the chromosomes, must, according to our experiments, represent the chemical basis of inheritance, while there seems little doubt that nucleic acid is concerned mainly with spindle formation during mitosis and, in combination with chromosomin, with protein synthesis during the resting stage, the nucleoprotein then formed by their union being analogous to the self-propagating nucleoproteins of which the viruses are now believed to be composed.

This picture of the cell nucleus at first sight leaves no place for histone. Partly with the object of gaining information regarding its function we have therefore determined the content of histone, as well as of the other constituents, in the nuclei from a number of cells of different types by direct extraction from the isolated nuclei. A few of the results were