INDEX TO THE LITERATURE ON SPECTROCHEMICAL ANALYSIS 1920–1937

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Introduction

About 100 years ago, a number of observers (J. Hershel, Wheatstone, Brewster, Talbot, Angström, Alter, *et al.*) of spectroscopic phenomena suggested the possibility of recognizing chemical substances spectroscopically, but the practicability of this procedure was first emphasized in 1860 by Kirchhoff and Bunsen in a paper entitled, "Chemical Analysis by Means of Spectral Observations" (*Pogg. Ann.* 110, 160–189 (1860)). For several decades thereafter the main purpose of most spectroscopic research was to develop this new method of chemical analysis, but when it was found that sodium appeared omnipresent, that many chemical elements change spectra with the type of light source, and differ enormously in spectral detectability and in spectral structure, interest lagged in making practical use of spectra, and text books of chemistry confined themselves to simple spectra of alkali salts made luminous in a Bunsen flame. Except for a few enthusiasts (Hartley, deGramont) who, in spite of discouragement and ridicule, persisted in trying to demonstrate the utility of spectra for qualitative and also for quantitative chemical analysis, the methods were discredited, ignored or forgotten by most chemists and physicists.

In 1910, H. Kayser wrote, in his monumental *Handbuch der Spektroskopie:* "Under these circumstances there is little prospect that in the future qualitative analysis will apply spectroscopic methods to a large extent" (5, p. 12), and, "summarizing all the mentioned investigations, I come to the conclusion that quantitative spectroscopic analysis has shown itself as impractical" (5, p. 27).

When K. Burns came to the National Bureau of Standards in 1913, he brought with him some of deGramont's faith in the utility of the spectrograph, and established the first general spectrochemical service in the Western hemisphere. Many hundreds of analyses of miscellaneous materials were made each year. In 1922, Meggers, Kiess and Stimson published a paper illustrating the application of deGramont's methods to the analysis of nearly pure metals. The senior author, in January, 1923, received from deGramont (who died October 21, 1923) a letter which, because of its historical interest, may be quoted in part: "I have read with the greatest interest the memoir which, with Kiess and Stimson, you have published on 'Practical Spectrographic Analysis' in the *Scientific Papers* of the National Bureau of Standards. I am happy that you sent me a copy, and as it defends and approves the methods of analysis which I have tried to popularize in France since 1895, I should like to obtain 10 to 12 extra copies. I wish to give some copies to the laboratories of mineral chemistry and metallurgy, and to laboratories teaching analytical chem-

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istry, to convince them of the utility of spectrography as a control of gravimetric mineral analyses. Unfortunately, the routinish spirit and backwardness of our country shows itself there again; the French chemists have an indolent dread of spectral analysis. In Paris, only the municipal Laboratory of Chemistry and the Mineralogical Laboratory of the National Museum of Natural History employ with success spectral analysis by means of spark spectra. M. —— and his pupils refuse to employ anything but arc spectra. M. —— and his pupils refuse even to inform themselves about spectral analysis of any kind whatsoever. As to the faculty of ——, M. —— who teaches physics there has declared publicly that ever since Bunsen and Kirchhoff, spectral analysis has been a deception (!) and has made no progress from a practical point of view.

"However, The University of Liége (Belgium) is installing my method of dissociation spectra in its laboratories of metallurgical chemistry, and the great manufacturer of munitions at —— has sent someone to see my installation in the laboratory of the Faculty of Sciences (Sorbonne). It must be added that all the apparatus and instruments are my property, and have been installed at my expense. The Faculty furnishes me only water, gas, electricity and compressed air. My assistant is paid entirely by myself; I instructed him entirely and he has never passed any examinations except those of primary school. As regards the spectrographic installation of the laboratory of mineralogy in the Museum which I mentioned, I donated all this to that institution.

"These are the reasons I desire to procure copies of your recent and altogether interesting memoir *Scientific Paper No. 444.*"

A year later, F. Löwe brought to the attention of scientists meeting in Innsbruck, Germany, "A Forgotten Method of Quantitative Spectral Analysis." "A few, familiar with the fundamental work of Hartley, Leonard and Pollack, and deGramont, returned to spectral analysis and developed it with success for a quantitative analytical method which, during the war and after, in France and North America, but only there, has given valuable practical results, while it has remained forgotten in the remaining centers of the steel industry, England, Sweden, Germany, and Austria" (*Z. tech. Physik.* **5**, 567 (1924)).

The next year, Wa. Gerlach enlisted as a promoter for applied spectroscopy with the following statement: "Truly forgotten—and especially just in those circles for which it was created, and is today more than ever important—was chemical spectral analysis. The pioneer work of deGramont, of Hartley, and of several other investigators, built on the discovery of Bunsen, is now—at least for Germany—exhumed (*ausgegraben*) by the physicist of the Zeiss works, Doctor Löwe" (*Z. anorg. Chem.* **142**, 383 (1925)).

The past dozen years mark a new epoch in the history of applied science; they witnessed the publication, at a high rate of acceleration, of a veritable flood of papers and booklets dealing with chemical analysis by means of atomic emission spectra. The contagion quickly spread throughout the civilized world, and papers appeared in Dutch, English, French, German, Italian, Russian, Spanish, etc. Applications were soon made to many branches of science and industry: Physics, chemistry, medicine, biology, mineralogy, criminology, metallurgy, agriculture, production control of metals, alloys, chemicals, etc. Naturally, this deluge of papers embraced not only a variety of tongues but scattered itself throughout so many scientific and technical journals, domestic

and foreign, that no single abstract journal could be expected to find it all. That applied spectroscopy has yielded such a profusion of publications is due in part, perhaps, to its purely empirical development which resulted in an excessive variety of "methods," of light sources, electric circuits, spectrographs, photographic materials and calibrations, choices of spectral lines for identification and for quantitative determinations of the chemical elements, etc. Remarkable progress in quantitative analysis resulted from the development and application of microphotometers. Briefly, spectral analysis, notwithstanding certain limitations, has aided and extended gravimetric and colorimetric chemical methods, has already displaced gravimetric analysis in many instances of routine or control work, has opened new fields in science and industry, and bids fair to go still further.

But the present and future workers in this field are unable either to orient themselves, or to profit by the experiences of others, unless they can locate the voluminous and far-flung literature of the subject. To facilitate this, a number of reviews, each containing numerous references to particular applications, have been published in various books and journals. Outstanding in size and merit are the Bibliography of Literature on Spectrum Analysis (195 books and papers of metallurgical interest) compiled in 1935 by D. M. Smith, and Spectrochemical Abstracts, 1933-1937 (228 papers), compiled by F. Twyman. To date, however, no general catalogue and comprehensive index of spectrochemical literature has appeared.

For nearly a quarter century, the spectroscopy section of the Bureau of Standards has maintained for information purposes a card catalogue of current publications on atomic spectra, one section of which was dedicated to practical applications to chemical identification and quantitative analysis. The latter, containing more than 900 items, was brought to the attention of the A.S.T.M. Committee E-2 on Spectrographic Analysis and the suggestion that it be made generally available resulted in a recommendation that it be published by the Society. As regards a plan of presentation, it was decided to arrange all papers, from 1920 to 1937 inclusive, in chronological order, and in alphabetical order of author in each calendar year. All paper titles are given in English, but book titles have not been translated.

Instead of printing an abstract with each paper, references to already published abstracts are given. A large majority of these papers have been listed and abstracted in *Chemical Abstracts* (*C. A.*), but some additional ones were found in *Biological Abstracts* (*B. A.*), *Mineralogical Abstracts* (*M. A.*), and in *Science Abstracts* (*S. A.*). Since most of the papers have been abstracted in *Chemical Abstracts*, which is probably accessible to all scientific and technical workers, it can easily be determined if, and which, original papers need be consulted for further details.

Finally, each publication listed in this bibliography was given a serial number for use in a detailed index. In so far as it is known to the compilers, the content rather than the title of a paper, was used in the preparation of this index so that it might indicate most, if not all, of the literature pertaining to any particular application, determination, instrument, method or closely related topic. An effort was made to distinguish all quantitative analyses with *Chemical Abstracts* abbreviations "detn." or "quant."

Notwithstanding restriction of the bibliography to chemical analyses by means of atomic emission spectra (ex-

cluding all references to absorption, reflection, fluorescence, and Röntgen spectra) it has 956 entries. It will be appreciated that not all papers listed are of equal quality but the compilers have attempted impartially to include all the literature which came to their attention. They will be grateful for any information concerning important contributions which may have been overlooked.

Appreciation of the progressive spirit and generous aid of the A.S.T.M. in publishing this bibliography for the benefit of science and industry is hereby expressed.

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