

CHREV. 107

## SOME TRENDS IN THE DEVELOPMENT OF ANALYTICAL CHEMISTRY AND CHROMATOGRAPHY AS DEDUCED FROM AN ANALYSIS OF THE LITERATURE

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### I. INTRODUCTION

The study of trends in the development of analytical chemistry is of considerable interest. The development of any branch of science can be evaluated from a study of the pertinent literature covering definite periods. This method has been widely used for evaluating trends in the development of certain branches of science<sup>1</sup>, for instance, analytical chemistry and chromatography. In analyzing trends in the development of analytical chemistry, workers usually consider the distribution of the publications with respect to the analytical method, the objects of the analytical investigation, changes in the characteristics of the publications with time, etc. This paper, as well as previous papers on similar subjects<sup>2-6</sup>, postulates that the development of analytical chemistry is adequately reflected in the literature. However, using the adopted procedure, it is impossible to isolate objectively and evaluate correctly promising methods and future directions from the recent literature, because of the slow-moving nature of the system as a whole. In addition, this approach reflects developing lines, but fails to cover fully the scope of their practical application, as this is not reflected comprehensively enough in the early stages. However, despite these limitations, the data obtained are of general interest and should be taken into account in planning future programmes.

### II. EVALUATION OF THE LITERATURE

We have considered the principal lines of development of analytical chemistry for the period from 1965 to 1976. It was found possible to recognize certain interesting regularities by comparing the data obtained as a result of the statistical treatment of abstracts and bibliographical data in the journals *Chemical Abstracts*<sup>7</sup>, *Analytical*

*Abstracts*<sup>8</sup> and (as we were particularly interested in the development of chromatography) *Journal of Chromatography*<sup>9</sup>.

It is interesting to consider the development of analytical chemistry compared with the general development of chemistry. The number of publications on analytical chemistry is assumed to be equal to the number of publications in *Analytical Abstracts*<sup>2</sup>, and the total number of chemical publications to be equal to that in *Chemical Abstracts*. The investigations were carried out for 1965, 1970 and 1975 and the results are given in Table 1.

TABLE 1

## NUMBER OF PUBLICATIONS ON ANALYTICAL CHEMISTRY

Values in parentheses are based on the assumption that only half of the papers on analytical chemistry are abstracted in *Analytical Abstracts*.

Subject	1965		1970		1975	
	Number	%	Number	%	Number	%
Chemistry	180,000	100	276,600	100	332,300	100
Analytical chemistry	6640	3.7 (7.4)	9820	3.6 (7.2)	8980	2.7 (5.4)

It follows from the table that, in spite of the increase in absolute number of chemical publications, the share of publications on analytical chemistry in each year of the 1965–1970 period is practically the same. This agrees fairly well with the data published by Fischer<sup>2</sup>, Brooks and Smythe<sup>3</sup>, and Orient<sup>4</sup>. The numerical estimate of the relative number of publications on analytical chemistry, however, differs from the data obtained by us. This is due to the fact that (as is assumed, for instance, by Fischer<sup>5</sup>) *Analytical Abstracts* publishes abstracts of only about 50% of the total number of publications on analytical chemistry, and therefore one should introduce a correction factor of about 2. We have taken Fischer's factor into account and added the corresponding data in Table 1 in parentheses.

In 1975 one can observe an appreciable decrease (25%) in the share of publications on analytical chemistry, whereas the absolute number of publications decreased only slightly (8.6%).

We investigated statistically the literature on the various branches of analytical chemistry. The information was derived from *Analytical Abstracts*, which abstracted 6640 publications in 1965, 9820 in 1970 and 8980 in 1975. Table 2 lists data on the relative frequency of citation of the various analytical methods.

TABLE 2

## PERCENTAGE OF PUBLICATIONS ON SEPARATE BRANCHES OF ANALYTICAL CHEMISTRY

Method	1965	1970	1975
Chromatographic	24	30	27
Gas chromatographic	8	11	9
Spectroscopic (EPR, NMR, photometry)	36	37	36
Electrochemical	10	13	20
Gravimetric, titrimetric, etc.	30	20	17

The number of newly developed procedures using classical methods of analysis (gravimetric, titrimetric) has fallen by almost half in the past 10 years owing to the wider application of physicochemical and physical methods of analysis. It can be seen that spectral methods enjoy the greatest popularity (36%), while chromatographic methods, which occupied third place in 1965 (24%), moved into second place in 1975 (27%). A comparison of the data presented here with those given earlier<sup>5</sup> shows that the general trends in the publication of papers on the various branches of analytical chemistry largely agree with the results presented in Table 2. When analyzing the trends in the development of analytical chemistry, it is necessary to make allowance for the specificity of the methods and their fields of application. For instance, if we purposely consider only publications that describe procedures for the analysis of organic compounds and gases, then, as follows from the data in Table 3, chromatographic methods are the most frequently used. This is understandable, because in the analytical chemistry of organic compounds the samples are usually complex mixtures of compounds with similar properties, for which the most effective method involves separation.

TABLE 3

PERCENTAGE OF PUBLICATIONS ON DIFFERENT BRANCHES OF THE ANALYTICAL CHEMISTRY OF ORGANIC COMPOUNDS AND GASES

<i>Method</i>	<i>1965</i>	<i>1970</i>	<i>1975</i>
Chromatographic	39	48	44
Gas chromatographic	14	17	15
Spectroscopic (EPR, NMR, photometry)	29	29	31
Electrochemical	17	16	18
Gravimetric, titrimetric, etc.	15	8	7

Table 3 shows the distribution of publications describing methods of analysis of organic compounds and gases in *Analytical Abstracts*. In 1965–75, chromatographic methods for the analysis of organic compounds and gases were used in almost 50% of the publications cited, about 15% being gas chromatography. The slight increase in the application of chromatographic methods to the analysis of organic compounds resulted in corresponding decreases in the use of the other methods of analysis, particularly classical methods. The deceleration in the relative increase in chromatographic publications in 1970–75 is not surprising. Similar trends, when the number of publications reaches “saturation”, are characteristic of the development of other branches of science as well. Usually, a substantial theoretical or methodological “breakthrough” is followed by a sharp increase in the number of publications on a particular subject and then a period of consolidation.

The trends in the development of the various branches of chromatography is of great interest. Berezkin *et al.*<sup>5</sup> and Janák<sup>6</sup> considered in detail the trends in the development of gas chromatography. It should be noted, however, that the last 5–10 years were characterized by an increased research interest in such branches as column liquid and thin-layer chromatography. In our opinion, the Bibliography Section of the *Journal of Chromatography*<sup>9</sup> reflects comprehensively the number of publications on all principal branches of chromatography. Since prior to 1969 the Bibliography Section of the *Journal of Chromatography* did include liquid chromato-

TABLE 4

DISTRIBUTION OF PUBLICATIONS ACCORDING TO TYPE OF CHROMATOGRAPHY (%)

<i>Type</i>	<i>1970</i>	<i>1975-76</i> <i>(first 6 months)</i>
Gas chromatography (GC)	29	26
Paper chromatography (PC)	13	7
Thin-layer chromatography (TLC)	32	28
Column liquid chromatography (CLC)	26	39

graphy, we considered the publications for the period 1970-76 (first 6 months). The results of this study are given in Table 4, which indicate a considerable decrease in the number of publications on paper chromatography and a sharp increase in the number of publications on column liquid chromatography.

Table 5 gives data on the distribution of publications for the various branches of chromatography according to subject. It shows that the number of publications on experimental techniques in thin-layer chromatography increased in the period 1970-75. There was also an increase in the number of surveys and books on column liquid chromatography, which is to be expected because the increasing amount of information requires periodical reviews; the number of theoretical publications also increased, which indicates that attention was focused on column liquid chromatography. The number of publications on experimental techniques in column liquid chromatography increased very sharply (5-fold), which indicates recent developments in the equipment used.

TABLE 5

DISTRIBUTION OF PUBLICATIONS BY SUBJECTS FOR DIFFERENT BRANCHES OF CHROMATOGRAPHY (%)

<i>Subjects of publications</i>	<i>1970</i>				<i>1975-76 (first 6 months)</i>			
	<i>GC</i>	<i>PC</i>	<i>TLC</i>	<i>CLC</i>	<i>GC</i>	<i>PC</i>	<i>TLC</i>	<i>CLC</i>
Surveys and books	5	2	2	1	3	4	1	4
Fundamentals, theory and general problems	8	2	2	2	7	4	2	6
Experimental technique	24	4	8	3	24	3	13	16
Analytical chemistry	63	92	88	94	66	89	84	74

It is also interesting to consider the distribution of publications according to the different types of chromatographic techniques. A study of the Bibliography Section of the *Journal of Chromatography*, however, showed that an analysis of the distribution of papers according to types of experimental technique for 1970 is feasible only for gas chromatography, while in 1975-76 (first 6 months) this becomes possible also for gas, thin-layer and column liquid chromatography. The results are given in Table 6.

The changes in the distribution of publications relating to the various branches of chromatography according to the aims of investigation are illustrated in Table 7.

TABLE 6

## DISTRIBUTION OF PUBLICATIONS ACCORDING TO BRANCHES OF EXPERIMENTAL TECHNIQUES IN CHROMATOGRAPHY (%)

<i>Experimental technique</i>	1970: GC	1975-76 (first 6 months)		
		GC	TLC	CLC
Detectors	21	19	15	6
Efficiency and filling of columns	17	22	—	23
Equipment and materials	22	24	23	14
Automation	10	9	11	4
Measurement of physicochemical characteristics	13	16	—	8
Others	17	10	51	15

In recent years there has been an increasing interest in certain classes of substances. Whereas the proportion of publications on the gas chromatography of hydrocarbons, aromatic and oxygen-containing organic substances decreased by a factor of 1.5 in the period 1970-1976 (first 6 months), the number of publications on the investigation of biologically active and pharmaceutical substances increased 3-fold as a result of the intensive development of biochemistry in the last 5-10 years. The halving of the number of publications on the analysis of insecticides by gas chromatography was offset by an increase in the application of other types of chromatography for such analyses. It can also be seen that column liquid chromatography is the method most frequently used for the analysis of nitrogen-containing substances (65%).

In general, this survey shows that the number of investigations on analytical chemistry has remained at an approximately constant level in the last 5-10 years, and

TABLE 7

## DISTRIBUTION OF CHROMATOGRAPHIC METHODS ACCORDING TO AIMS OF INVESTIGATION (%)

<i>Aims of investigation</i>	GC		CLC		PC		TLC	
	1970	1975-76*	1970	1975-76*	1970	1975-76*	1970	1975-76*
Hydrocarbons, aromatic compounds, polymer synthesis products	19	13	5	2	6	2	10	3
Oxygen-containing substances (phenols, carbohydrates, organic acids, alcohols, etc.)	28	19	14	13	24	24	28	28
Biologically active and pharmaceutical substances	8	25	4	5	14	13	16	20
Nitrogen-containing substances	9	13	67	64	36	34	22	21
Insecticides and pesticides	12	6	1	2	2	3	6	12
Others	24	24	9	14	19	24	18	16

\* First 6 months.

that in the analytical chemistry of organic compounds attention has been focused primarily on the development of chromatographic and spectroscopic methods of analysis.

### III. SUMMARY

The principal lines of development of analytical chemistry during the past 10 years are considered on the basis of an analysis of publications in abstracts journals. Emphasis is placed on the development of the analytical chemistry of organic compounds and gases and on the chromatographic methods most frequently used for their analysis.

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