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EVALUATION OF THE ROLE OF CHROMATOGRAPHY IN ANALYTICAL CHEMISTRY BASED ON THE ANALYSIS OF THE SUBJECT MATTER OF PUBLICATIONS

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In recent decades ever increasing attention has been paid to the dynamics of progress in various fields of chemistry, representing the trends and advances in individual fields, including analytical chemistry.

In the period of 1976 to 1980, a number of interesting scientometric studies appeared on analytical chemistry, amongst others that of Braun, Bujdoso and Lyon[1–4]. In 1976 we published a paper[5] dealing with trends in the development of analytical chemistry, based on the analysis of the subject matter of relevant chromatographic publications. These papers dealt mainly with comparisons of the progress of chemistry in general with that of analytical chemistry and the distribution of publications on analytical chemistry amongst various countries and periodicals. Previously Janák[6] and Berezkin *et al.*[7] had examined in detail trends in the development of gas chromatography.

The present paper is a continuation and extension of our previous work[5] and is concerned primarily with the role played by chromatography in analytical chemistry. It is based on statistical processing of abstracts from *Chemical Abstracts* and *Analytical Abstracts*. For the analysis of individual trends in chromatography, bibliographical references were used, as well as papers from the *Journal of Chromatography*, which offered the larges number of papers on the topic (Table I).

Table 2 shows the progress of analytical chemistry compared to the development of chemistry in general, assuming the number of publications on analytical chemistry to be equal to that of the abstracts published in *Analytical Abstracts* and the number of publications on chemistry to correspond to those appearing in *Chemical Abstracts*, for the period 1975 to 1980. As Fisher[8] contends that about half the publications on analytical chemistry are covered by *Analytical Abstracts*, we used a correction factor of 2 and in Table 2 the numbers in parentheses refer to this factor. The results show a growing number of publications both on chemistry in general and in analytical chemistry. The proportion of analytical chemistry publications has decreased slightly, but the absolute number of publications has grown by 22%, this result being in agreement with the earlier findings of Orient[9] and Brooks and Smythe[10].

Statistical processing of papers published in analytical chemistry provided a basis for the study of the dynamics of variations in the number of publications in various branches of analytical chemistry. The results, showing 8980 papers in 1975

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TABLE 1 (ref. 2)

FIFTY LEADING JOURNALS ON ANALYTICAL CHEMISTRY RANKED ACCORDING TO THE NUMBER OF PAPERS ABSTRACTED BY *ANALYTICAL ABSTRACTS* IN 1977

No.	Journal	No. of publications	No.	Journal	No. of publications
1	*J. Chromatogr.*	710	26	*Rev. Sci. Instrum.*	52
2	*Anal. Chem.*	511	27	*Lab. Pract.*	51
3	*Anal. Chim. Acta*	338	28	*J. Clin. Chem. Clin. Biochem.*	51
4	*Zh. Anal. Khim.*	315	29	*Pharmazie*	46
5	*Anal. Biochem.*	300	30	*Appl. Spectrosc.*	45
6	*Z. Anal. Chem.*	212	31	*Quim. Anal.*	40
7	*J. Ass. Offic. Anal. Chem.*	206	32	*Ukr. Khim. Zh.*	37
8	*Talanta*	198	33	*Environ. Sci. Technol.*	37
9	*Bunseki Kagaku (Jap. Anal.)*	171	34	*J. Electroanal. Chem.*	35
10	*Zavod. Lab.*	170	35	*Biochem. Med.*	34
11	*Chem. Anal. (Warsaw)*	169	36	*Appl. Opt.*	34
12	*Clin. Chem.*	161	37	*J. Amer. Oil Chem. Soc.*	33
13	*J. Radioanal. Chem.*	147	38	*Bull. Environ. Contam. Toxicol.*	33
14	*Analyst (London)*	146	39	*Int. J. Appl. Radiat. Isot.*	32
15	*J. Pharm. Sci.*	132			
16	*Microchim. Acta*	116	40	*Z. Lebensm.-Unters.-Forsch.*	31
17	*Clin. Chim. Acta*	109	41	*X-Ray Spectrom.*	31
18	*Anal. Lett.*	92	42	*At. Adsorpt. Newsl.*	31
19	*Chromatographia*	91	43	*J. Phys. Sci. Instrum.*	30
20	*Radiochem. Radioanal. Lett.*	85	44	*Nucl. Instrum. Methods*	29
21	*J. Chromatogr. Sci.*	76	45	*An. Quim.*	29
22	*Rev. Chim. (Bucharest)*	75	46	*Yakugaki Zasshi*	28
23	*J. Agr. Food Chem.*	71	47	*Curr. Sci. (India)*	28
24	*Indian J. Chem., Sect. A*	60	48	*Acta Pol. Pharm.*	28
25	*Farmatsiya (Moscow)*	52	49	*Z. Chem. (Leipzig)*	27
			50	*Chem. Pharm. Bull.*	27

and 10,980 publications in 1980. are listed in Table 3. It is noteworthy that the relative numbers of procedures involving the use of chromatographic and spectrometric techniques showed marked increases, by 33% and 11%, respectively. In terms of the number of publications, spectrometric methods continue to rank first, although the rate of progress in this field diminished substantially. The proportion of publications on electrochemical and classical analytical methods also decreased significantly.

TABLE 2

DYNAMICS OF VARIATION IN THE NUMBER OF PUBLICATIONS ON ANALYTICAL CHEMISTRY

Subject matter of publication	*1975*		*1980*	
	No. of publications	*%*	*No. of publications*	*%*
Chemistry	332,300	100	479,000	100
Analytical chemistry	8980	2.7(5.4)	10,980	2.3(4.6)

TABLE 3

DYNAMICS OF VARIATION IN THE PROPORTIONS OF PUBLICATIONS (%) ON INDIVIDUAL METHODS OF ANALYTICAL CHEMISTRY

Method	*1975*	*1980*
Chromatographic methods	27 (9*)	36 (13*)
Spectroscopic methods (optical spectroscopy, photometry, EPR, NMR, nuclear spectroscopy, etc.)	36	40
Electrochemical methods	20	12
Classical methods (gravimetric analysis, titrimetry, etc.)	17	12

* Gas chromatography.

In our opinion one should also take into consideration the types of compounds subjected to analysis, when examining a particular group of analytical methods. Table 4 presents data on the dynamics of variations in the number of publications in different branches of analytical chemistry, in the analysis of organic compounds and gases. In this field chromatographic methods are the most commonly applied (50% of publications). It is of interest that the proportions of publications on gas chromatography, spectroscopy and classical methods of analysis remained constant, whereas the proportion of electrochemical methods decreased sharply and that of chromatographic methods increased, primarily due to the growth in the number of publications on liquid chromatography.

In the analysis of advances made in individual fields of chromatography, bibliographical references and articles published in the *Journal of Chromatography* were used. Unlike our previous paper[5] we placed the emphasis on some new aspects of progress in chromatography. The distribution of publications amongst various types of chromatography (Table 5) was obtained by statistical processing of material published in the bibliography section of the *Journal of Chromatography*. Here it can be seen that liquid (column) chromatography advanced at a greater rate (to 52% of all publications) than any other type of chromatography and the proportion

TABLE 4

DYNAMICS OF VARIATION IN THE PROPORTIONS OF PUBLICATIONS (%) ON INDIVIDUAL METHODS OF ANALYSIS OF ORGANIC COMPOUNDS AND GASES

Method	*1975*	*1980*
Chromatographic methods	44 (15*)	50 (15*)
Spectroscopic methods (optical spectroscopy, photometry, EPR, NMR, etc.)	31	32
Electrochemical methods	18	11
Classical methods (gravimetric analysis, titrimetry, etc.)	7	

* Gas chromatography.

TABLE 5

DISTRIBUTION OF PUBLICATIONS AMONG VARIOUS TYPES OF CHROMATOGRAPHY (%)

Type of chromatography	*1975*	*1980*
Gas chromatography	25	20
Liquid (column) chromatography	39	52
Thin-layer chromatography	28	25
Paper chromatography	7	3

of publications on this technique increased by 13% during the period 1975 to 1980. During this same time the proportion of publications on gas chromatography declined by 6% and that on thin-layer (TLC) and paper chromatography by 7%.

Table 6 demonstrates the pattern of subject matter distribution in publications on different types of chromatography. It can be seen that the percentage of publications on experimental procedures in gas chromatography increased, possibly due to its wide-spread use and the marked progress of capillary gas chromatography. An appreciable decline in the relative number of publications on experimental techniques in TLC (by 8%) could be ascribed to the extensive introduction of standard TLC procedures, primarily photometric scanning for quantitative determinations. The same factor should also be responsible for the increased percentage of publications on analytical uses of TLC.

TABLE 6

PATTERN OF SUBJECT MATTER DISTRIBUTION (%) IN PUBLICATIONS ON DIVERSE TYPES OF CHROMATOGRAPHY

Subject matter of publications	*Gas chromatography*		*Liquid (column) chromatography*		*Thin-layer chromatography*		*Paper chromatography*	
	1975	*1980*	*1975*	*1980*	*1975*	*1980*	*1975*	*1980*
Reviews and books	3	2	4	3	1	1	4	1
Fundamental research and general problems	7	7	6	3	2	2	4	4
Experimental techniques	24	28	16	14	13	5	3	2
Analytical applications	66	63	74	80	84	92	89	93

It may be of interest to look at the distribution of publications amongst various aspects of experimental techniques in chromatography. The bibliographic section of the *Journal of Chromatography* provides data for the analysis of publications relating to experimental techniques. These results are shown in Table 7 and would seem to indicate that one of the main concerns of workers in this field is the preparation of columns and the enhancing of column efficiency.

Table 8 illustrates the distribution of chromatographic techniques in relation to the types of compounds analysed. The data show a growing interest on the part of chromatographers in the field of natural raw materials of organic origin.

TABLE 7

DISTRIBUTION OF PUBLICATIONS (%) AMONG INDIVIDUAL ASPECTS OF EXPERIMENTAL TECHNIQUES IN CHROMATOGRAPHY

Technique	*Gas chromatography*		*Liquid (column) chromatography*		*Thin-layer chromatography*	
	1975	*1980*	*1975*	*1980*	*1975*	*1980*
Detectors	19	21	16	18	4	5
Column efficiency and column preparation techniques	22	31	23	30	—	16
Apparatus and materials	24	24	14	11	23	26
Determination of physico-chemical characteristics	16	7	8	6	—	2
Other aspects of experimental technique	10	7	15	10	53	32
Automation	9	10	24	25	20	19

TABLE 8

DISTRIBUTION OF CHROMATOGRAPHIC TECHNIQUES (%) IN TERMS OF TYPES OF COMPOUNDS

Compounds	*Gas chromatography*		*Liquid (column) chromatography*		*Paper chromatography*		*Thin-layer chromatography*	
	1975	*1980*	*1975*	*1980*	*1975*	*1980*	*1975*	*1980*
Aliphatic and aromatic hydrocarbons, polymer synthesis products	13	18	2	9	2	7	3	11
Oxygenated compounds (phenols, carbohydrates, organic acids, alcohols, etc.)	19	11	13	12	24	29	28	26
Biologically active substances and drugs	25	26	5	18	13	13	20	20
Nitrogenous compounds	13	11	64	48	34	24	21	27
Insecticides and pesticides	6	5	2	2	3	—	12	7
Other compounds	24	29	14	11	24	25	16	9

In our analysis particular emphasis was placed on the role of the various types of detectors in gas and liquid (column) chromatography and Table 9 shows the popularity of mass spectrometric detection in gas chromatography, which permits the obtention of detailed and precise information on the components chromatographed. It should be noted that the proportion of publications on the employment of flame-ionization and electron-capture detectors remains constant and fairly high. The percentage of publications on the use of low-sensitivity thermal of electrical conductivity detectors has decreased by a factor of about 2 during the period of 1975 to 1980. It is noteworthy that a large majority of publications on liquid chromatography (83%) describe the use of UV photometric detectors.

TABLE 9

DISTRIBUTION OF PUBLICATIONS (%) IN TERMS OF DETECTORS USED IN GAS AND LIQUID CHROMATOGRAPHY

Detector type	*Gas chromatography*		*Liquid chromatography*	
	1975	*1980*	*1975*	*1980*
Mass spectrometer	24	31	4	9
UV spectrophotometer	2	4	74	83
Fluorescence	—	—	11	5
Flame ionization	25	27	—	0.5
Electron capture	22	23	—	0.5
Electrical conductivity	5	3	1	4
Thermal conductivity	6	2	—	—
Other types	16	10	10	4

Table 10 shows the progress in selected fields of gas chromatography. The number of publications on the use of open capillary columns in gas chromatography experienced a two-fold increase, due to the appearance in the past few years of adequately reproducible methods of preparation of open capillary columns with their high separation efficiencies and also the advances made in capillary chromatography on quartz columns. Mention should also be made of the considerable interest shown in the employment of capillary columns in liquid chromatography.

TABLE 10

PROGRESS IN SELECTED SUBDIVISIONS OF GAS CHROMATOGRAPHY

Subdivision	*1975*	*1980*
Open capillary columns	13	29
Packed capillary columns	6	4
Chemical methods	37	36
Analysis of impurities	18	16

In conclusion we would like to point out that analysis of publications, as shown here, offers a means of ascertaining objectively which fields of analytical chemistry enjoy the greatest popularity among research workers. The results of such an analysis could be helpful in research planning and production of relevant equipment and materials.

SUMMARY

Publications on the principal techniques of analytical chemistry during the time from 1975 to 1980 were analysed, special emphasis being placed on chromatographic methods. It was found that while the relative number of publications on analytical chemistry showed a slight decrease compared to the total of all publications

on chemistry, the absolute number of publications on analytical chemistry rose by more than 20% in the period studied.

It is shown that in the field of analytical chemistry of organic compounds and gases chromatography plays a leading role and also that liquid (column) chromatography is progressing at a particularly high rate.

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