Bibliometric Mapping: Eight Decades of Analytical Chemistry, with Special Focus on the Use of Mass Spectrometry

Cathelijn J. F. Waaijer[1] and Magnus Palmblad[2]

[1] *c.j.f.waaijer@cwts.leidenuniv.nl*
Centre for Science and Technology Studies, Faculty of Social and Behavioural Sciences, Leiden University, P.O. box 905, 2300 AX, Leiden (the Netherlands)

[2] *n.m.palmblad@lumc.nl*
Center for Proteomics and Metabolomics, Leiden University Medical Center, Postzone L4-Q, P.O. Box 9600, 2300 RC Leiden (the Netherlands)

Introduction[a]

Bibliometric mapping tools and other scientometrics analyses may be used to study the historical development of a research field. In our paper, we use automatic bibliometric mapping tools to visualize the history of analytical chemistry from the 1920s until the present, with special focus on the application of mass spectrometry (MS).

Data and methods

Co-word maps were based on noun phrases (nouns and preceding adjectives) parsed from titles and abstracts of all papers published between 1929 and 2012 by *Analytical Chemistry*, a key journal in the field of MS. Maps were constructed by determining the co-occurrence of noun phrases and visualized using VOSviewer software (Waltman & van Eck, 2010).

Results

Evolution of topics in analytical chemistry 1929-2012

Co-word maps were based on all texts published in *Analytical Chemistry* except for advertisements (1929-1995) or on all articles, letters and reviews published in *Analytical Chemistry* (1996-2012). Table 1 shows a summary of the different clusters in the co-word maps (due to space constraints, the maps themselves could not be included).

The maps show that inorganic chemistry has been an important topic within analytical chemistry for a long time; from 1929 until 1990 there were one or more clusters on inorganic chemistry. In the 1991-2000 period it was merged with the topics of electrochemistry and sensors. Much attention was given to (the development of) different apparatuses between 1929 and 198. A cluster on general and editorial issues can be found in almost every period. Topics that have developed over time include electrochemistry, chromatography and mass spectrometry. Electrochemistry shows up as its own cluster in the 1951-1960 period, but terms relating to the subject can also be found in the inorganic chemistry and metals cluster from 1941. This suggests the topic of electrochemistry has developed from inorganic chemistry and metals to form its own subfield. Chromatography is apparent in the maps from the 1951-1960 period onwards; mass spectrometry from the 1971-1980 period. The maps suggest the widespread use of mass spectrometry in analytical chemistry primarily developed through its coupling to chromatography; for the 1971-1980 period terms relating to mass spectrometry can be discerned in the maps, but the cluster is still dominated by chromatographic techniques and applications. However, from the 1981-1990 period, mass spectrometry broke off and formed its own subfield. Finally, from 2001 a cluster on separations and microfluidics emerged. This cluster also contains terms relating to theory and simulations (of such microfluidic systems).

Use of different techniques in analytical chemistry

Next, we analyzed the development and use of a number of techniques *within* analytical chemistry. As a proxy, we determined how many articles mentioned the technique in their titles during the 1929-2012 period. This shows that titration techniques reached their publication peak in the 1950s, gas chromatography in the 1960s, and liquid chromatography in the 1980s (Fig. 1). Of these techniques, only the latter was still mentioned in the titles of over 5% of papers published in the 2001-2012 period. On the other hand, microfluidics is an example of a technology not mentioned before 1990 that has really taken off in this 2001-2012 period. A technique not mentioned to a great extent in the titles of *Analytical Chemistry* papers is nuclear magnetic resonance (NMR). As the co-word maps already suggested, the mention of mass spectrometry increased throughout the entire period. Whereas in the 1929-1940 period none of the *Analytical Chemistry* papers mentioned mass spectrometry in their title, the percentage of papers that did increased to eighteen in the 2001-2012 period (Fig. 1). This indicates *Analytical Chemistry* has made a shift towards the publication of research using mass spectrometry instead of other techniques.

Table 1. Main topics in mass spectrometry within the field of analytical chemistry.

Clusters per period
1929-1940
Apparatuses
Inorganic chemistry
Gases
Industrial applications, hydrocarbons and food
1941-1950
Apparatuses
Inorganic chemistry: gases/halogens
Inorganic chemistry: metals
Industrial applications and hydrocarbons
Organic and food chemistry
General/editorial
1951-1960
Apparatuses
Inorganic chemistry: metals
Electrochemistry
Chromatography
General/editorial
1961-1970
Inorganic chemistry
Electrochemistry
Chromatography
General/editorial and "informatics"
1971-1980
Apparatuses
Inorganic chemistry
Gases
Electrochemistry
Chromatography
General/editorial
1981-1990
Inorganic chemistry
Electrochemistry
Chromatography
Mass spectrometry
General/editorial
1991-2000
Inorganic chemistry, electrochemistry and (bio)sensors
Chromatography
Mass spectrometry and proteomics
Electrophoresis
General/editorial
2001-2012
Mass spectrometry
Detection, electrochemistry and (bio)sensors
Small molecules and quantitation
Separations, microfluidics, and theory and simulations

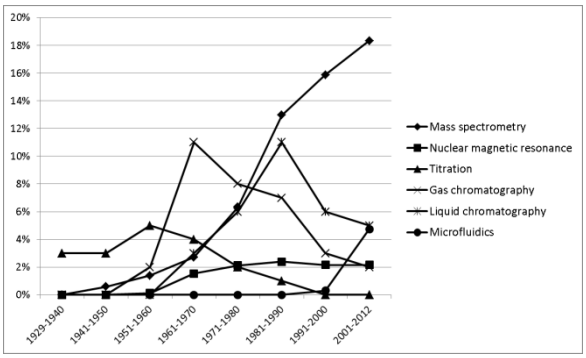

Figure 1. Use of different techniques in *Analytical Chemistry*. Search terms used were "mass spectro*", "nuclear magnetic resonance" or "NMR", "titration", "gas chromato*", "liquid chromato*", and "microfluid*", searched against the titles of *Analytical Chemistry* papers.

Additional work

Additional results, such as the trends in research topics in analytical chemistry research using MS, an assessment of which research fields use MS, and a citation network of research using MS, will be included on our poster.

Endnote

[a]A manuscript with the same title has been published in *Analytical Chemistry* as a Feature.

References

Waltman, L. & van Eck, N. J. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*, 523-538.