

THE GROWTH OF PUBLISHED PAPERS ON FLOW INJECTION ANALYSIS

Elo Harald HANSEN and Jaromir RUZICKA

Chemistry Department A, Technical University of Denmark,

Building 207, DK-2800 Lyngby, Denmark.

The first paper on Flow Injection Analysis (FIA) appeared in 1975 [1]. Over the intervening decade, the method has developed from an approach for merely rapidly conducting serial chemical assays into a novel concept in solution handling in analytical chemistry and a diagnostic tool to be exploited for general analytical studies. It has promoted new and exciting developments in the field of continuous flow analysis. This broad acceptance of FIA is reflected in the wealth of papers published in the international literature which, counting contributions from more than 35 different countries, has increased exponentially and by the end of 1985 exceeds 1000. At this Department we have continuously attempted to monitor the development of FIA by maintaining an up-to-date FIA bibliography. Recently we had the opportunity to analyse the growth and scrutinize the contents of all the FIA papers published - to the extent that they have been accessible to us - the results of which was published last year [2] while an updated version soon is to appear [3]. In the following a few aspects of this analysis are presented.

If the growth in the number of FIA publications is depicted in a semilogarithmic diagramme, showing the cumulative number of publications as a function of time (Fig. 1), the doubling time, T_D (i.e., the time span required for the literature to double in size) can be read out as the slope of the curve. Initially, this doubling time is seen to be less than one year, but of course the absolute number of FIA publications was then modest. With the doubling time increasing to 1.2 years, it nevertheless required six years to reach the first monograph on Flow Injection Analysis [4], while it took less than an additional four years to reach the ca. 750 papers published by the end of 1984, the doubling time of the curve now having attained a value of 1.8 years. Compared to other analytical techniques, for which similar type of analysis has been made, this doubling time is very short; thus the T_D values for other subsets of analytical chemistry are, for example: amperometry 8.0 years, conductometry 6.4 years, general electroanalysis 4.6 years, potentiometry 4.0 years, and voltammetry 2.8 years. Interestingly, the doubling times of the entire world chemical and analytical literature are even longer: 13.9 and 14.5 years, respectively [5].

This broad acceptance of FIA is undoubtedly due to its versatility, which allows the method to be used in conjunction with a wide variety of detectors and analytical techniques, and for the assay of a multitude of organic and inorganic substances. A closer look at the variety of detection principles used

in conjunction with FIA reveals that optical methods (and particularly visible spectrophotometry) predominate. This is not surprising considering that spectrophotometry generally accounts for approximately 50% of all detection principles used in analytical chemistry. Yet, a statistical scrutiny of the data for the two time periods of 1975-1980 and 1981-1984 clearly reveals that the highest *relative increases* in detectors used with FIA actually are encountered in the areas of electrochemistry and optical methods (excluding spectrophotometry), and in the latter domain notably atomic absorption (AAS) and inductively-coupled plasma spectrometry (ICP) dominate, followed by chemiluminescence and fluorometry. This trend is likely to continue, because Flow Injection systems enhance the performance of AAS and ICP, by increasing the sensitivity over 100 times, by allowing speciation and by removing matrix effects. For kinetic reasons, FIA is an ideal vehicle for chemiluminescence.

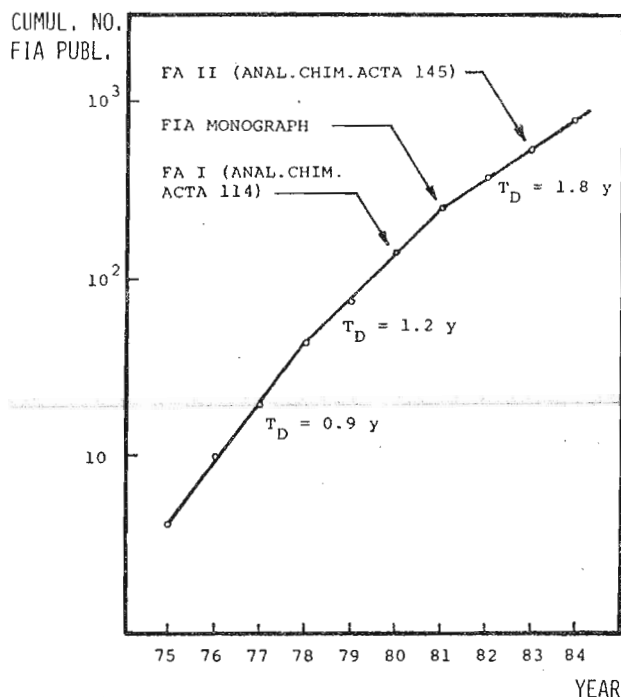


Fig. 1. Growth of publications on Flow Injection analysis from 1975 to 1985. FA I and II refer to the two international conference on Flow Analysis held in Amsterdam (Holland) and Lund (Sweden), respectively, FA III having taken place last September in Birmingham (United Kingdom).

When the FIA publications are arranged according to their country of origin (Fig. 2), the story of FIA is highlighted. As observed from the figure, the USA and Japan clearly dominate the field at present - each accounting for 20-30% of all the papers published annually over the past five years - closely followed by Great Britain. Obviously, in these countries, there are various groups working independently on FIA. In fact, according to N. Ishibashi [private communication] over 60 groups are conducting FIA research in Japan where even a FIA Society has been established, publishing the *Journal of Flow Injection Analysis*, which is the only existing periodical in the world exclusively devoted to FIA. Significant contributors to the growth of FIA are also countries like Holland, Brazil and Sweden, which all were fairly early to embark on FIA, and where the absolute number of publications in recent years

has amounted to approximately 10 to 15 per year. In most other countries represented on the FIA list of contributors, the absolute number of publications is of the order of a few papers per year (thus, the very first paper originating in the USSR was published in a Russian periodical in 1985), notable exceptions being, however, China, Spain and Germany, where the growth curve within the last few years, after a long incubation time, has exhibited a sharply increasing value (Fig. 2).

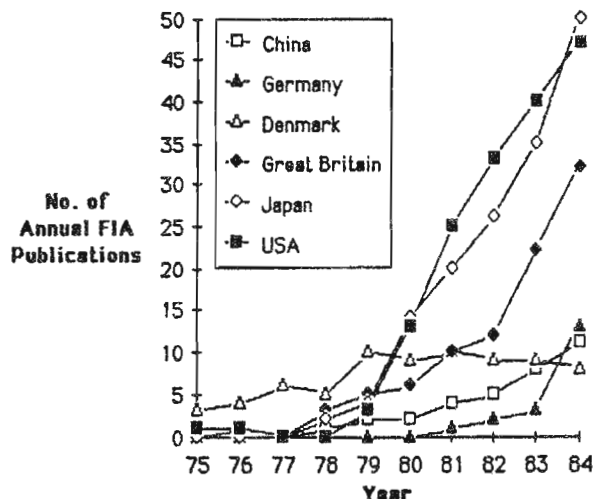


Fig. 2. Growth of the number of FIA papers published annually in 6 different countries, where Japan, USA and England represent the three most prolific countries, while China and Germany are examples of nations where the number of publications, after a long delay time, is now increasing significantly.

One of the reasons for the longer delay time in some countries is undoubtedly the time it has required to produce commercially available FIA instrumentation. Obviously, in order for a new concept like FIA to disseminate amongst practicing analytical chemist it is necessary that proper analytical equipment is available. Although commercial instrumentation for FIA now is produced in Sweden (Bifok-Tecator), USA (FIatron, Lachat, Control Equipment), Japan (Hitachi) and Brasil (Micronal) - the manufacturers being arranged in the same sequence in which they introduced their equipment - it is, nevertheless, significant that Japan over the past 5 years has attained such a commanding rôle within the field of FIA. Considering the vigorous level of activity and the high quality of the Japanese FIA publications there is every reason to believe that this trend will continue, to which the Japanese researchers are to be heartily congratulated.

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