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Advances in Analytical Chemistry Benefit Science and Society

Dear Editors,

It is with great pleasure that I write this letter in this *International Year of Chemistry* to provide my personal perspectives concerning *Analytical Chemistry* and its contribution to the wider field of chemistry and to the scientific community as a whole. I thank you as Editors-in-Chief of Talanta, the Associate Editors, and the Advisory Board for giving me this opportunity and in doing so I congratulate you for your outstanding efforts in ensuring that Talanta continues to be one of the leading international journals for the publication of papers of the highest quality over a wide range of Analytical Chemistry.

As Analytical Chemists, we all view the field as the most important of all chemistry fields and we should take pride in the fact that nearly every field of chemistry and numerous other scientific endeavors make use of Analytical Chemistry in some way. Looking back over the past few years it is evident that instrumental methods have dominated Analytical Chemistry and these have enabled the determination of analytes at lower and lower concentrations. Such low concentrations have been demanded by our expanding interest in our environment and by our need to understand how our technological advances have affected the world we live in. Also, in health, Analytical Chemistry has made enormous advances and has contributed significantly to the understanding of the physiological processes that make up living organisms. One very recent example is the report of a rapid test to differentiate between bacterial and viral infections enabling clinicians to make a correct diagnosis in a much shorter time period than previously possible.

There have been spectacular advances made in the capabilities of large instruments and these are often combined in hyphenated instrumentation. Such techniques have led to the determination of analytes in numerous types of samples. Often these techniques are used in conjunction with sample preconcentration or pretreatment using solid phase extraction or with devices such as hollow fibers to enrich the analyte. The application that perhaps gives Analytical Chemistry the highest public profile is the use of GC–MS and LC–MS in the determination of performance enhancing drugs in sport, particularly during the Olympic Games.

Traditional separation techniques such as solvent extraction and ion-exchange are also crucial to the preconcentration and pretreatment of samples before instrumental analysis. More recently, membrane separation techniques have attracted considerable attention and these include supported liquid membranes (SLMs) and the more recent polymer inclusion membranes (PIMs). Polymer inclusion membranes consist of an extractant immobilized in a polymer substrate (commonly poly(vinyl chloride) or cellulose acetate) which have considerably more stability than supported liquid membranes. PIMs can be used to extract an analyte which is then stripped from the membrane in a second process or can be used in a transport cell which enables extraction and back extraction to be carried out in a single step. In the latter mode, I believe polymer inclusion membranes will find increased use in the future in on-line separation modules for automated analysis. Also, I feel polymer inclusion membranes will find an important role in passive sampling since the membrane composition can be manipulated to control the diffusion coefficient of an analyte across the membrane into the inner receiving phase.

Membranes have also played an important role in chemical sensing in both ion-selective electrodes and in optodes. Since 1970 polymer membranes have been used as the sensing membrane in ion-selective electrodes and such membranes are synonymous with polymer inclusion membranes with one important distinction which is associated with the relative amounts of carrier used in the membrane composition. For ion sensing, the requirement is to have fast ion-exchange at the membrane/sample interface with an extremely low transport rate across the membrane while, for separation, both fast ion-exchange and fast transport are required. These conditions are achieved by manipulation of the membrane composition, i.e., for fast separation, high concentrations of carrier (>30%) are used while for sensing the amount of carrier is small (1–2%).

One particular type of ion-selective electrode is the so-called "coated-wire" electrode (CWE) and I would like to take this opportunity to pay tribute to the contribution to Analytical Chemistry and to Separation Science made by Professor Henry Freiser at the University of Arizona. The CWE was first developed in Freiser's laboratory in 1971. In 2010, Henry celebrated his 90th birthday and I wish to acknowledge the enormous influence he has had in the development of Analytical Chemistry and Separation Science not only in the USA but also in many countries around the world including my own country, Australia. I feel very privileged to have had the opportunity to spend two sabbatical leaves in his laboratory where I first appreciated the importance of Analytical Chemistry research and it was this influence that led me to initiate my own interests in ion-selective electrodes, optodes, flow methods of analysis and membrane separation. I believe this sentiment is felt by numerous other researchers from around the world who have been associated with Henry.

Much of the recent work on ion-selective electrodes has been directed towards lowering the limit of detection and it is now possible to detect down to picomole and even femtomole levels. This provides ISEs with the ability to compete with much more

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costly instrumental techniques such as ICP. Potentiometric ISEs have dominated ISE research but their voltammetric analogues have been shown to be capable of providing sensors that are fast in response and highly sensitive. Research on CWEs has continued to be extensive and has been focused on stabilizing the ion to electron transfer at the membrane/solid interface using conducting substrates such as polypyrrole and polythiophene-based polymers. This research has produced extremely stable and reproducible sensing devices for real-time and remote monitoring in clinical and environmental applications and I expect this will be a focus of research on ISEs in the future. Very recently, there has been a report on a response model for ISEs that employ controlled-potential thin-layer coulometry with an eventual aim of producing recalibration free sensors. Such sensors will be of great interest in applications such as remote field monitoring where periodic calibration is difficult or impossible.

Automated Analytical Chemistry systems have made an impact for on-line monitoring of analytes and the future will see increased activity in this area for environmental and clinical applications. In this regard, the development of flow injection analysis by Jarda Růžička and Elo Hansen must rate as one of the most significant advances in automated Analytical Chemistry. Their work has prompted others to employ numerous computer controlled flow-based techniques for a wide range of applications.

There is considerable research activity in the area of paper-based microfluidic systems and such systems promise to provide cheap, simple and sensitive methods for use in the developing world for clinical use and in-field environmental applications. Paper-based devices rely on capillary action to transport solutions and flow channels can be fashioned on paper using simple inkjet printing. Colorimetric reactions are ideally suited to this technology but other signal interrogation methods such as electrochemical and chemiluminescence can be adapted to these devices. One exciting development in this *IYC* year has been the first use of a cell phone camera to catch the signal from a chemiluminescence reaction generated electrochemically in a paper-based device. I expect many highly significant advances to be made in this technology in the near future.

I think it is quite a natural response when considering the state of Analytical Chemistry in the world to reflect on the contribution one's own country has made to the overall status of the field, however small that may be. Australia is a country with a relatively small population but has for many years had a very active scientific research culture. The most significant contribution in Analytical Chemistry to emerge from Australia was the invention of Atomic Absorption Spectrometry by the late Sir Alan Walsh at the Commonwealth Scientific and Industrial Research Organization (CSIRO) in the 1950s. Since then, Analytical Chemistry has emerged as a mature field of chemistry in Australia and is taught in most of its 38 Universities with large research groups in a number of these. The Analytical and Environmental Chemistry Division of the Royal Australian Chemical Institute has the largest membership of all the Institute Divisions.

Research groups in Australia cover a wide range of Analytical Chemistry including separation science, biosensors and chemical sensors, chemometrics and chemical metrology, electroanalytical chemistry, chemiluminescence, mass spectrometry, water chemistry, pesticide analysis, passive sampling, flow methods of analysis, paper-based microfluidics, and forensic science. I expect the interest in Analytical Chemistry will expand significantly in the future in Australia with demands for the determination of analytes at extremely low concentrations in increasingly complex samples and for the need to develop portable instrumentation particularly for field use and for real-time remote monitoring.

One example of this is some very recent research from the Australian Centre for Research on Separation Science (ACROSS). This Centre is well advanced on the development of a new screening technology that can detect the inorganic components of explosives much faster than existing technology with an initial screen requiring only 30 s. It is proposed that the portable instrumentation could be used at airports, mail-handling centers, and entertainment and sporting events as well as for field military applications.

I think it is evident from my comments in this letter that I firmly believe that Analytical Chemistry in this *IYC* is in a very healthy state in the world and is well placed to tackle the increasingly difficult problems that will present themselves as our technological inventiveness evolves. We face serious challenges particularly to our environment and Analytical Chemistry will continue to play an important role in meeting these challenges.

Once again, I thank you most sincerely for giving me the opportunity to express my thoughts on a subject that is not only my profession but also my hobby. I am sure many Analytical Chemists reading this letter will identify with this last sentiment.

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