Modern Chemistry & Applications

Trojanowicz, Mod Chem appl 2013, 1:4
http://dx.doi.org/10.4172/2329-6798.1000e113

Editorial Open Access

Challenges of Modern Analytical Chemistry

Marek Trojanowicz*

Department of Chemistry, University of Warsaw, Warsaw, Poland

Editorial

Analytical chemistry is a branch of modern chemistry of special social importance, which affects numerous areas of contemporary life, welfare and safety of societies, progress in all fields of modern technologies. Thorough presence of chemical analysis in all areas of human activity, includes first of all control functions of chemical analysis, namely control of materials of all fabricated items and devices, control of effects of the civilisation development on natural environment, indispensable support of clinical diagnostics, or prevention of terrorist attacks. The progress of material science, which is essential for development of all areas of technology significantly depends on abilities, and technical possibilities of the most precise and accurate control of the chemical composition of materials and in fact it is the main purpose and goal of chemical analysis, and the subject of its improvement in scientific research in the field of analytical chemistry.

Applications

Modern analytical chemistry includes numerous fields of experimental and theoretical studies in terms of applications and measuring methodologies of different specificity and requirements from the end-users of analytical information. Its main areas include environmental and industrial analysis, food control, clinical and pharmaceutical analysis. It includes also investigation of metabolic pathways in living organisms and humans, and development especially sensitive methods for fighting with doping in sport. Continuous progress of analytical methods one can observe in process analysis, and generally in analytical examination in materials science. Much more specialized areas of application of new analytical methods and analytical instrumentation are archaeometry and examination of art objects, and also design of especially sophisticated instrumentation for space exploration missions.

The main objectives of environmental analysis are improvement of detection limits of trace anthropogenic organic pollutants of different origin and their most complete detection, examination of transport pathways and transformations, as well as toxicity towards living flora, fauna and humans. The objects of particular interest in recent decade are perfluo-rinated organic compounds [1], or trace residues of pharmaceuticals, especially those which are not removed by commonly employed technologies for water and waste treatment. In analysis of inorganic compounds a special attention in recent decades is focused on speciation and metabolic transformations of trace elements, their effects on living organisms and transport in environment. Increasing demands are addressed to analysts in terms of quality of control of foods, as it is of the most route of uptake of anthropogenic pollutants from environment by living organisms and humans. Particular challenges for analysts in this case are very complex matrices of real samples to be analyzed, and very often limited supply of certified reference materials (CRMs). Because of wide need for quality control of food, methods developed for such applications should be accurate, fast and robust. One of examples can be current trend of developing new methods for detection of genetically modified organisms in foods [2] Analytical methods developed for clinical analysis should be characterized first of all by high specificity, which is especially achieved employing immunochemical assays. They should require a very small amount of sample, and can not be affected for heavy loaded matrices of physiological fluids of tissue extracts. The pharmaceutical analysis includes quality control of pharmaceutical preparations, examination of metabolism of pharmaceutics in organisms, and also mentioned already determination of environmental residues of pharmaceuticals [3]. In this particular range of analytical applications a large attention is devoted to development of enantioselective methods for determination of chiral purity of pharmaceuticals.

Process analysis is another crucial area of application of chemical analysis directly fort technological purposes. Instruments for process analysis placed within or at the plant installations have to exhibit extreme durability and chemical resistivity in harsh ambient conditions, and provide reliable long-term monitoring with remote control of operation. Main purposes of design of process analyzers is cost-effective carrying of controlled technological processes, ensuring safety of humans, installation and natural environment. It may be considered as coming directly from definition of analytical chemistry, that it is main instrument to control the composition of materials developed for different technological applications. A rapidly increasing field in this case is nanotechnology, where in search for new materials all most sophisticated modern methods are being employed for elucidation of structures and chemical properties.

A very intense progress of application of analytical measurements is observed in archaeometry, where especially challenging task is development of non-destructive and microanalytical methods of analysis, of which results cannot be overestimated for conservation of art objects and for historians of arts, with special importance of isotope-based or chemical dating. Indispensable contribution has modern analytical chemistry in space exploration where fully automated and remote miniaturized instruments are being developed with predominated spectroscopy methods, but also high-performance separation methods and miniaturized sensors [4].

Methodologies and Instrumental Developments

A permanent object of improvement of analytical instrumentation for different applications is improving the basic functional parameters of each measuring device such as selectivity of response and concentration range of response, and also in case of multianalyte determinations, the reproducibility of measurements, or possibility as most versatile data processing. The improvement leading to enhancement of signal resolution concerns both separation methods, as well as spectroscopic, or selected electroanalytical methods. In structural investigations in recent 2-3 decades, methods of absorptive molecular spectroscopy have been significantly replaced by resonance methods and mass spectrometry. The most advanced chromatographic and capillary electrophoretic methods reach their full analytical potential in

***Corresponding author:** Marek Trojanowicz, Department of Chemistry, Laboratory for Flow Analysis and Chromatography, University of Warsaw, 02-093 Warsaw, Poland, Tel: +48-22-822-3532; E-mail: trojan@chem.uw.edu.pl

Received May 29, 2013; **Accepted** June 04, 2013; **Published** June 07, 2013

Citation: Trojanowicz M (2013) Challenges of Modern Analytical Chemistry. Mod Chem appl 1: e113. doi:10.4172/2329-6798.1000e113

increasingly used systems hyphenated with mass spectrometry (MS). A parallel trend is an intensive development of integrated chemical sensors and biosensors for different applications, and employing in their construction various transducers. Although they are designed mostly for fast and simple single component determinations in various samples, also for instance for determination of optical isomers [5], it has to be admitted a design of multisensor measuring systems, as matrices of sensors described as electronic noses or tongues. They require, however, a very tedious calibration and usually complex data process-sing. A particularly important factor in design of integrated sensors is the application of suitable chemical or biochemical methods of molecular recognition. Applications of such systems are widely reported in flow methods of analysis [6].

In majority of applications of analytical methods, especially in trace analysis or determinations in complex matrices, an indispensable step is sample pretreatment. Also in this area one can observe a very intensive progress in methodologies and instrumentation. They include e.g. clean-up samples, preconcentration of analytes, or their derivatisation. Development of new methods of extraction and preconcentration is strongly supported by application of nanometerials [7]. They find also wide applications in enhancement of various detection methods, as well as in improvement of resolution in high-performance separation methods. Increasing number of applications find also molecularly imprinted polymers as well as methods based on specific biochemical interactions with antibodies, receptors, DNA and aptamers. Basic trends in instrumentation of those processes is their mechanization, automation and application of robotics.

Other General Trends of Development

The progress in analytical chemistry in recent years is also influenced by some other general trends. The necessity of improving measurement methodologies for fundamental scientific investigations of different groups of chemical compounds of similar properties and functions in living organisms has determined research fields described by names, which are analogous to genomics that dealt with determination of genome of living organisms, and all related subjects. Several important and active fields of investigations were formulated such as proteomics or metabolomics, but also e.g. lipidomics, metallomics etc. Those fields are frequently overlapped with studies on elemental speciation. They are almost entirely based on multicomponent analyses, which are possible only with application of analytical methods of the highest resolution and detection limits, with particular need of identification of compounds at trace concentration levels and commonly in heavy loaded matrices of biological materials.

Another such general trend in development of analytical instrumentation is its miniaturization, commonly required by particular applications, or needs of routine chemical analysis, or it is a consequence of development of many other branches of technology. This is for instance observed in recent decades very common construction of laboratory portable devices oriented towards field applications in environmental monitoring, industry, oceano-graphic research and geological surveys. To a broad range of portable spectroscopic and electrochemical analyzers, in recent years are added mass analyzers, chromatographs and also NMR spectrometers. Miniaturization of measuring systems for flow measurements is reflected in chip systems for gel and liquid capillary electrophoresis, and also microfluidics in which sample processing is integrated with detection in lab-on-a chip systems or described as micro total-analytical-systems. Miniaturization of sensors and biosensors results mainly in construction of medical diagnostic devices and hand-held devices for personal monitoring. Additional impact in this direction is also provided by progress in nanotechnology allowing to employ nanostructural phenomena in design of new instruments.

The importance of chemical analysis in many fields of contemporary life is demonstrated also by a very common tendency observed in routine analytical laboratories about introduction official mechanisms to asses required quality of analytical measurements. Suitable accreditation of laboratories taking into account all aspects of their activity (instrumentation, personnel, instrumentation, kind of samples analyzed), and validation of obtained analytical information have a substantial importance in all filed of application of chemical analysis.

References

1. Trojanowicz M, Musijowski J, Koc M, Donten MA (2011) Determination of total organic fluorine (TOF) in environmental samples using flow-injection and chromatographic methods. Anal Methods 3: 1039-1045.
2. Trojanowicz M, Latoszek A, Poboży E (2010) Analysis of genetically modified food using high-performance separation methods. Analytical Letters 43: 1653-1679.
3. Trojanowicz M (2012) Flow-injection analysis as a tool for determination of pharmaceutical residues in aqueous environment. Talanta 96: 3-10.
4. Trojanowicz M (2008) Modern chemical analysis in archaeometry. Anal Bioanal Chem 391: 915-918.
5. Trojanowicz M, Kaniewska M (2009) Electrochemical chiral sensors and biosensors. Electroanalysis 21: 229-238.
6. Trojanowicz M (2008) Advances in flow analysis. Wiley-VCH, Weinheim, Germany.
7. Trojanowicz M (2006) Analytical applications of carbon nanotubes: a review. TrAC Trends in Analytical Chemistry 25: 480-489.

Citation: Trojanowicz M (2013) Challenges of Modern Analytical Chemistry. Mod Chem appl 1: e113. doi:10.4172/2329-6798.1000e113