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Flow Injection Analysis: An evergreen Technique in Modern Analytical Chemistry

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Flow injection analysis (FIA) is an important branch of modern analytical chemistry. It has several advantages as compared to other techniques like being simple, fast, highly efficient, low sample requirement etc. FIA is very useful for monitoring the real time changes in chemical process. The roots of inventions of FI is from the study of chemical interactions in flowing conditions using column chromatography in the Institute of Plant Physiology of University of Warsaw, Poland, at the beginning of the 20th century. The flow injection systems can be characterized into three basic modes of operations, *viz* flow, sequential and batch injection analysis methods. In flow injection analysis (FIA), sample is injected into the stream of flowing carrier while in sequential injection analysis (SIA) sequential introduction of sample is done into the carrier solution. In batch injection analysis (BIA) systems sample can be directly injected on to the sensing element of the detector. However, FIA is the most widely used mode. Extensive developments of measurement procedures have expanded the applications of FIA. FIA depends on a combination of reproducible sample injection volumes, controllable sample dispersion, and reproducible timing of the injected sample through the single or multi-line manifolds. The injected sample is then dispersed in the carrier stream due to the combination of laminar flow (in which a parabolic velocity profile develops between the center stream line and the wall) and diffusion. The characteristics of fluid flow in closed medium are utilized for the transport of samples, the chemical pretreatment of samples and sample introduction into an instrument. Since both standards and samples have identical residence times the kinetic limitations of conventional analytical methods (in which samples and standards arc handled in parallel) are eliminated. Therefore the attainment of equilibrium is not very important and also the analysis is not impeded by poor stability of the reagents and products involved. The determination is carried out by measuring the analytical signal in the flowing conditions leading to greater sample throughput and improved values of limits of detection and qunatitation. There is an ongoing research

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and development for the miniaturization of FIA as this has various advantages like reduced volumes of sample, reagent and secondary waste, increased diffusion of the sample into the reagent stream, repeatability of the determination, robustness of the system, easy automation and implementation in an industrial setup.

FIA has extensive applications in various fields. The monitoring of environmental parameters by measuring the organic compounds is possible. The coupling of FI with ICP-MS has also proved important for trace level metal ion determination. Increasing concern about the dissolved organic carbon (DOC) has led to the development of several FI methods based on UV photooxidation coupled to FI detection methods (conductimetry, spectrophotometry, fluorimetry).

The obligation toward “green chemistry” advances FI techniques which operate in contained environment and use very less reagents leading to reduced secondary waste generation. Environmental pollution and remediation is becoming a concern for many researchers and monitoring of the toxic species using FI based techniques becomes more attractive due to its advantages. Further advancements for environmental applications will be the development of FI based analyzers which can be used for determination of multi-parameters. The recent inclination towards miniaturization is considered to be due to availability of low-power detectors. The increasingly sophisticated and adaptable software coupled to data telemetry promote the use of FI for in situ high-resolution monitoring. This would be quite attractive as it is economical and also can be used in remote locations and can be coupled to already existing technology. These developments will play an important role in the elucidation of the biogeochemical cycles of environmentally relevant elements.