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Applications of Electrochemical Sensors for Flow-Based Systems

Electrochemical detection is certainly the most widely used and extensively reported technique in flow –based systems such as flow injection analysis (FIA), sequential injection analysis (SIA), high performance liquid chromatography (HPLC) and electrophoresis. Amperometry is the most popular detection mode because of its ease to operation and minimal background current contributions. This technique is accomplished by applying a constant potential to the working electrode and then measuring the current as a function of time. The redox reactions of the analyes will be expedited by applied potential, while the current output is proportional to the concentration of the analytes. Moreover, the current is directly proportional to the number of moles of analyte oxidized or reduced at the working electrode surface. Tuneable selectivity is achieved through cautious choice of detection potential, with the optimal potential being obtained from construction a hydrodynamic voltammograms. In addition, stripping technique is another popular choice which is useful for trace metal analysis.

Development of flow-based systems with amperometry in recent years has brought several new achievements in the design of detection schemes. It is succeeded in the development of new methods for the determination, as well as in the use of various kinds of material for working electrodes.

Selective detection in flow-based system can be achieved through proper choice of the working electrode material and the applied potential. Working electrodes utilized for monitoring in flow-based systems have been fabricated from several materials. There are two general types of working electrode: unmodified and modified electrode. Carbon electrodes were commonly used in flow-based systems due to their minimal fouling, lower overpotential and background noise, and wider potential range for organic compounds than metal electrodes. The majority of carbon-based electrodes that have been in flow-based systems and related techniques were composed of glassy carbon (GC) electrode [1], screen-printed carbon (SPE) electrode [2], and boron-doped diamond (BDD) thin film electrode [3].

In our research group, BDD electrodes have gained interest in a variety of electrochemical applications. After a BDD electrode was coupled with a hydrodynamic voltammetry such as that for FIA, SIA or HPLC, it can be useful for detection with very high sensitivity and reproducibility. Therefore, the use of BDD as an electrode material in electrochemistry has been extensively reviewed [4]. Several analytes have been detected with BDD electrodes, such as captopril [5], tiopronin [6], amino thiols [7], lipoic acid [8], tetracyclines [9], sulfonamides [10], parabens [11], N-acetyl-L-cysteine [12] and mercury ions [13].

During recent decades, the high potential of metal nanoparticles in analytical applications has been demonstrated and has led to the numerous publications and advances. This finding explores the potentialities and advantageous features of this approach of constructing sensors exhibiting enhanced performance with respect to proposed designs.

Recently, we are particularly interested in the development of new materials based on nanoparticles for electrochemical sensing devices for flow-based systems. For example, we introduced the use of screen-printed carbon nanotube electrode modified with bismuth film for the determination of heavy metals contaminated in herbs [14] and coupled to SIA to obtain the fully automatic system. We also proposed the use of gold nanoparticles modified screen-printed carbon electrode as a detector for the detection of thiram, disulfiram, and their derivative compound following their separation by HPLC [15].

Moreover, we also proposed the development of silver nanoparticles modified GC electrode and BDD electrode as a chemical sensor for the detection of total cholesterol in bovine serum [16-17].

In addition, finding the modern analytical methods based on flow-based system are our challenging. We also have developed the microfluidic devices named Lab-on-a-chip and Lab-on-a-paper for clinical and environmental monitoring [18-19].