Chemically modified electrodes based on carbonaceous nanostructured materials used in bioanalysis

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Abstract

Recent developments in nanotechnology are impacting existing technology and leading to the development of novel tools and techniques through improvements in precision and speed, lower sample requirements and the ability to perform multiple tasks in smaller devices. It is now considered to be one of the most promising fields in analytical chemistry. Moreover, the huge interest in nanomaterials is driven by their many desirable properties (in particular, the ability to tailor the size and structure) which offers excellent prospects for designing novel sensing systems and enhancing the performance of the (bio)analytical assays. Carbon based nanostructured materials gained a lot of attention in research and subsequently application in a myriad of fields. This has been particularly possible mainly because they have large surface area, acceptable biocompatibility, chemical and electrochemical stability, good electrical conductivity, are inexpensive, are readily available from organic sources and their ability to be structurally and chemically tenable. Their ease of structural tenability is evidenced by the variety of forms of these nanomaterials which include single walled carbon nanotubes, multi-walled carbon nanotubes, graphene oxide nanosheets and fullerenes.

Advances in nanofabrication of sensing interfaces are one major area where nanotechnology has dramatically impacted on electrochemical sensor research. With regards to fabricating sensing interfaces the rise of chemically modified layers has been particularly important in giving molecular level control over the fabrication of the sensing interface. Using chemical functionalities has resulted in better performing sensors offering also new opportunities in developing new types of transduction mechanisms in sensors which are more sensitive and selective. Chemically modified electrodes employing immobilized redox mediators can facilitate the electron transfer of such analytes as shown in Figure 1 [1].

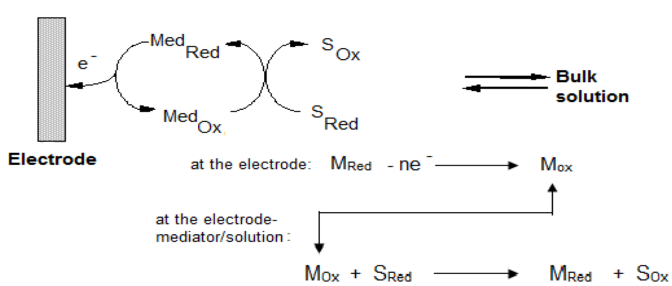

Fig. 1. The model of the electrocatalytic reaction on CME, where S_{Ox}/S_{Red} and M_{Ox}/M_{Red} are the oxidized and reduced forms of analyte to be detected and of mediator respectively.

The ability to manipulate the molecular architecture of the bulk matrix of an electrode and its surface in particular has led to a wide range of analytical applications of chemically modified electrodes (CMEs) and created powerful opportunities for electroanalysis. Large number of applications can be found in the literature on applications of carbonaceous nanostructured materials as electrode materials or modifiers of conventional working electrodes in analytical voltammetry [2,3]. Different strategies for constructing electrochemical sensors, the electrochemistry and electroanalytical chemistry of the carbonaceous nanostructured materials are summarized and discussed, along with some relevant contributions in the development of electrochemical sensors. We highlight some modern aspects of CMEs based on carbonaceous nanostructured materials used in amperometric sensing, a detection method which has already found a large number of applications in health care, food industry and environmental analysis. Some relevant applications of CMEs to real sample analysis of some important biochemicals (like neurotransmitters and DNA molecule) and some possible future trends are presented [1-7].

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