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Preparation of Indium Tin Oxide Nanoparticle-Modified 3-Aminopropyltrimethoxysilane-Functionalized Indium Tin Oxide Electrode for Electrochemical Sulfide Detection

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Abstract : Sulfide ion is water soluble, highly corrosive, toxic and harmful to the human beings. As a result, knowing the exact concentration of sulfide in water is very important. However, the existing detection and quantification methods have several shortcomings, such as high cost, low sensitivity, and massive instrumentation. Consequently, the development of novel sulfide sensor is relevant. Nevertheless, electrochemical methods gained enormous popularity due to a vast improvement in the technique and instrumentation, portability, low cost, rapid analysis and simplicity of design. Successful field application of electrochemical devices still requires vast improvement, which depends on the physical, chemical and electrochemical aspects of the working electrode. The working electrode made of bulk gold (Au) and platinum (Pt) are quite common, being very robust and endowed with good electrocatalytic properties. High cost, and electrode poisoning, however, have so far hindered their practical application in many industries. To overcome these obstacles, we developed a sulfide sensor based on an indium tin oxide nanoparticle (ITONP)-modified ITO electrode. To prepare ITONP-modified ITO, various methods were tested. Drop-drying of ITONPs (aq.) on aminopropyltrimethoxysilane-functionalized ITO (APTMS/ITO) was found to be the best method on the basis of voltammetric analysis of the sulfide ion. ITONP-modified APTMS/ITO (ITONP/APTMS/ITO) yielded much better electrocatalytic properties toward sulfide electro-oxidation than did bare or APTMS/ITO electrodes. The ITONPs and ITONP-modified ITO were also characterized using transmission electron microscopy and field emission scanning electron microscopy, respectively. Optimization of the type of inert electrolyte and pH yielded an ITONP/APTMS/ITO detector whose amperometrically and chronocoulometrically determined limits of detection for sulfide in aqueous solution were 3.0 µM and 0.90 µM, respectively. ITONP/APTMS/ITO electrodes which displayed reproducible performances were highly stable and were not susceptible to interference by common contaminants. Thus, the developed electrode can be considered as a promising tool for sensing sulfide.

Keywords : amperometry, chronocoulometry, electrocatalytic properties, ITO-nanoparticle-modified ITO, sulfide sensor
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