ZnO Nanonails: Synthesis and Their Application as Glucose Biosensor

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Well-crystallized zinc oxide nanonails were grown in a high density by thermal evaporation process and were used as supporting matrices for glucose oxidase (GOx) immobilization to construct efficient glucose biosensor. The GOx attached to the surfaces of ZnO nanonails had more spatial freedom in its orientation, which facilitated the direct electron transfer between the active sites of immobilized GOx and electrode surface. The fabricated biosensor showed a high sensitivity of 24.613 $\mu$A cm$^{-2}$ mM$^{-1}$ with a response time less than 10 s. Moreover, it shows a linear range from 0.1 to 7.1 mM with a correlation coefficient of $R = 0.9937$ and detection limit of 5 $\mu$M.

Keywords: ZnO Nanonails, Glucose Biosensor, Electrochemical Properties.

1. INTRODUCTION

To increase the selectivity and sensitivity of amperometric glucose biosensors, artificial mediators are often used in the fabrication of biosensors, which are used to transfer electrons between the enzyme and the electrode to allow operation at low potentials. Due to the exotic and versatile properties of different biocompatible nanomaterials, it was observed that nanomaterials could be the promising mediators for enzyme immobilization, which can increase the sensitivity and selectivity of amperometric biosensors. Moreover, the nanomaterials can keep the activity of enzymes due to desirable microenvironment and enhance the direct electron transfer between the active sites of enzyme and the electrode. Several research groups presented the fabrication of glucose biosensors by modifying the electrochemical electrodes using the nanocrystalline diamond, silicon nanowires, carbon nanotubes, nanoporous ZnO matrix, etc. As a remarkable and functional material, ZnO has attracted extent of scientific and technological attentions. The nanostructures of ZnO are of particular interest as they combine different properties such as high specific surface area, optical transparency, biocompatibility, non-toxicity, chemical and photochemical stability, ease of fabrication, and so on. Even having versatile properties, the biosensor applications of ZnO nanostructures are infrequent. Zhang et al. fabricated a ZnO-based reagentless uric acid biosensor by immobilizing of uricase on ZnO nanorods synthesized by thermal evaporation. In another approach, Li et al. developed a mediator-free phenol biosensor based on immobilizing tyrosinase to sol-gel prepared ZnO nanoparticles. Wang et al. fabricated the glucose biosensor using ZnO nanocombs, prepared by vapor-phase transport method. These nanocombs glucose biosensors showed a sensitivity of 15.33 $\mu$A cm$^{-2}$ mM$^{-1}$ with a detection limit of 20 $\mu$M. Glucose biosensor based on glucose oxidase immobilized on ZnO nanorods grown by hydrothermal decomposition method was also demonstrated by Wei et al., exhibiting a sensitivity of 23.1 $\mu$A cm$^{-2}$ mM$^{-1}$ with detection limit of 10 $\mu$M.

In this paper, we report a high sensitive glucose biosensor based on the glucose oxidase immobilized on ZnO nanonails, prepared by a non-catalytic thermal evaporation process. To the best of our knowledge, the sensitivity and detection limit of ZnO nanonails based glucose biosensor, reported in this paper, is highest among all the ZnO-based glucose biosensors. The glucose oxidase (GOx) immobilized on ZnO nanonails was used as an enzyme to detect the glucose. The GOx attached to the surfaces of ZnO nanonails had more spatial freedom in its orientation, which facilitated the direct electron transfer between the active sites of immobilized GOx and the electrode surface. The ZnO nanonails-derived electrode retained the enzyme bioactivity and enhanced the electron transfer between the enzyme and electrodes, and thus produced a high sensitivity. The fabricated biosensor showed a high sensitivity of 24.613 $\mu$A cm$^{-2}$ mM$^{-1}$ with a response time less than 10 s. Moreover, it shows a linear range from 0.1 to 7.1 mM with a correlation coefficient of $R = 0.9944$ and detection limit of 5 $\mu$M.

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