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Non-enzymatic glucose biosensors for smart wearables

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Abstract:
With the increasing technology on wearable and smart devices, many researchers have focused on developing new materials for various applications utilizing scalable techniques. Among these applications, the electrochemical sensor platforms play an important role in areas such as the public healthcare, food industry, agriculture systems and clinical - medical industry. Utilization of carbon fiber (CC) based textiles as the sensing material has several advantages in electrochemical sensing applications due to their flexibility, high conductivity, porous structure, biocompatibility and robustness in the corrosive environment. However, in order to develop highly selective, sensitive and fast-responsive electrochemical- and biosensors, it is necessary to functionalize the material with appropriate surface moieties. Here we present that by coating the CC with nanostructured metal oxides, we can achieve enhanced sensing characteristics, due to the increased surface area and good electrocatalytic activity of metal oxides. This approach has enabled effective detection of glucose.

Key words: Biosensor, non-enzymatic, glucose, wearable, flexible.

Introduction

Over the last few years, development of biosensors for convenient, fast and accurate monitoring of glucose level in the human body has attracted considerable attention [1, 2]. Most previous studies on this field involved the use of enzyme for specific recognition of glucose and its derivatives. However, enzymatic sensors have some drawbacks such as high cost, complicated immobilization steps, and sensitivity to temperature and humidity which cause easy degradation of sensing materials [3]. These shortcomings prevent to obtain long-term stability for continuous monitoring of metabolite levels in living organisms. Therefore, non-enzymatic biosensor systems have attracted tremendous interest in order to solve these problems. In this regard, metal oxides [4], carbon nanotubes [5], metal alloys and polymeric materials [6] are used to prepare electroactive surfaces for electro-oxidation of glucose. Non-enzymatic biosensors exhibit several advantages such as low detection limit, fast response, high sensitivity, reversibility and low cost comparing their enzymatic analogs.

In this study, our main goal is to design flexible electrochemical sensors with high sensitivity and selectivity, low cost, good stability, and biocompatibility. Here, we report the use of wearable carbon-based textile incorporating electroactive species as the sensing electrode for electrochemical sensor and biosensor applications.

Experimental

Carbon fiber based clothes (CC) were cleaned in acetone, ethanol and deionized (DI) water several times and were dried at 40 ^{0}C for 1 h. Binary metal oxide nanoneedles were synthesized using $NiCl_2.6H_2O$ (2 mmol), urea (10mmol) and NH_4F (5mmol) dissolving in 40mL deionized water via hydrothermal method. The annealing process performed at 350 ^{o}C followed the electroless deposition of MnO_x layers to the surface using $KMnO_4$ solution. Then, the CC sample was calcinated at 400 ^{o}C in a furnace. The samples were stored in desiccator. The obtained samples were abbreviated as MnO_x@NiO-CC.

Characterizations of MnO_x@NiO-CC electrodes were performed by Raman Spectroscopy and SEM techniques (Fig.1). They were tested as the glucose sensor using different electrochemical techniques such as chronoamperometry, cyclic voltammetry, and electrochemical impedance spectroscopy. MnO_x@NiO-CC electrodes showed a linear amperometric response at an applied potential of 0.5 V towards the detection of glucose from 1 to 20 μM with a detection limit of 0.110 μM and its sensitivity was found to be 170 mA mM^{-1} cm^{-2}. The selectivity of the biosensor was investigated in the presence of possible interfering agents such as fructose, sucrose, lactic acid, vitamin E, urea, Ca^{2+}, K^{+}, and cysteins and will be presented.

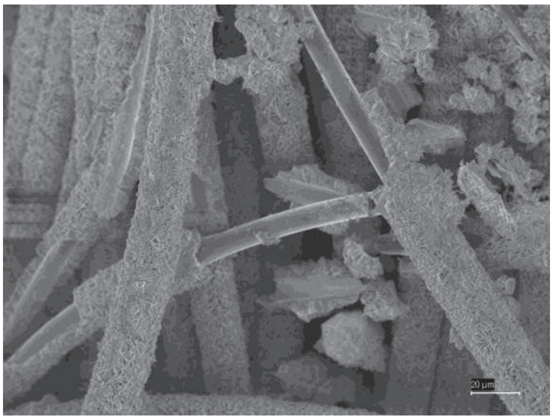

Fig. 1. SEM image of the MnO_x@NiO-CC electrode.

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