The Development of Non-Enzymatic Glucose Biosensors Based on Electrochemically Prepared Polypyrrole–Chitosan–Titanium Dioxide Nanocomposite Films

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Abstract: The performance of a modified electrode of nanocomposite films consisting of polypyrrole–chitosan–titanium dioxide (Ppy-CS-TiO2) has been explored for the developing a non-enzymatic glucose biosensors. The synergy effect of TiO2 nanoparticles (NPs) and conducting polymer on the current responses of the electrode resulted in greater sensitivity. The incorporation of TiO2 NPs in the nanocomposite films was confirmed by X-ray photoelectron spectroscopy (XPS) spectra. FE-SEM and HR-TEM provided more evidence for the presence of TiO2 in the Ppy-CS structure. Glucose biosensing properties were determined by amperometry and cyclic voltammetry (CV). The interfacial properties of nanocomposite electrodes were studied by electrochemical impedance spectroscopy (EIS). The developed biosensors showed good sensitivity over a linear range of 1–14 mM with a detection limit of 614 µM for glucose. The modified electrode with Ppy-CS nanocomposite also exhibited good selectivity and long-term stability with no interference effect. The Ppy-CS-TiO2 nanocomposites films presented high electron transfer kinetics. This work shows the role of nanomaterials in electrochemical biosensors and describes the process of their homogeneous distribution in composite films by a one-step electrochemical process, where all components are taken in a single solution in the electrochemical cell.

Keywords: nanomaterials; non-enzymatic glucose biosensors; nanocomposites; electrodeposition; titanium dioxide nanocomposite; X-ray photoelectron spectroscopy (XPS); electrochemical impedance spectroscopy (EIS)

1. Introduction

Organic–inorganic nanocomposite materials have gained widespread attention because of the combined properties of organic and inorganic components discovered in these materials [1–3]. Conductive polymers and metal oxide nanocomposites with nanoscale dimensions are of special interest for improving the properties of sensors [4–11]. Metals oxides, such as copper oxide (CuO), titanium oxide (TiO2), and iron oxide (Fe3O4), are very often recognized as nano oxides in their