Synthesis and characterization of $\alpha$-Fe$_2$O$_3$/polyaniline nanotube composite as electrochemical sensor for uric acid detection

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We report the synthesis of $\alpha$-Fe$_2$O$_3$/polyaniline nanotube (PAn NTs) composite as an electrochemical sensor for uric acid (UA) detection. Field emission scanning electron microscopy (FESEM) indicates a hexagonal shape of the $\alpha$-Fe$_2$O$_3$, while a nanotube morphology of the PAn. Impedance spectroscopy results confirm a significant decrease in the charge transfer resistance of the glassy carbon electrode (GCE) modified with $\alpha$-Fe$_2$O$_3$/PAn NTs due to the presence of PAn NTs. The results show that the increase in the conductivity of $\alpha$-Fe$_2$O$_3$ in the presence of PAn NTs could improve the catalytic performance of $\alpha$-Fe$_2$O$_3$/PAn NTs composite, compared to the pure $\alpha$-Fe$_2$O$_3$ nanoparticles. From differential pulse voltammetry, a linear working range for the concentration of UA between 0.01 μM and 5 μM, with a LOD of 0.038 μM (S/N = 3) was obtained. The sensitivity of the linear segment is 0.433 μA μM$^{-1}$. The reliability of the modified electrode towards the detection of UA was investigated in the presence of interfering acids such as ascorbic acid, citric acid and succinic acid.

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1. Introduction

In recent decades, metal oxide nanoparticles (NPs) have been used in various applications such as sensors, solar cells and catalysts, thus have gathered considerable attention for the synthesis of different types of morphologies and particle sizes of the metal oxide NPs [1,2]. $\alpha$-Fe$_2$O$_3$ has recently attracted much attention, due to its good biocompatibility, low cost, widespread availability and chemical stability. Different morphologies and sizes of $\alpha$-Fe$_2$O$_3$ can be synthesized by various methods such as forced hydrolysis, wet chemical synthesis, hydrothermal and sol-gel method [3–5]. The hydrothermal synthesis is an exceptionally facile method due to its low processing time, lower cost, giving products with high purity, crystallinity and homogeneity.

Recently, investigations on the electrochemical sensing performance of $\alpha$-Fe$_2$O$_3$ showed that it can effectively mediate the electrochemical redox process of the analyte [6–9]. On the other hand, it is well known that the surface area and electrical conductivity have special roles on the electrochemical properties of the electrode material [10–12]. Zhang et al. [13] reported the electrocatalytic property of $\alpha$-Fe$_2$O$_3$–chitosan nanocomposite while Goyal et al. [14] reported the electro-catalytic activity of $\alpha$-Fe$_2$O$_3$ modified GCE towards the oxidation of dopamine. The electrochemical sensing mechanism of GCE modified with $\alpha$-Fe$_2$O$_3$ for the detection of glucose was investigated by Cao et al. [15]. V. Narayanan et al. [16] synthesized $\alpha$-Fe$_2$O$_3$ NPs by hydrothermal method and showed that the $\alpha$-Fe$_2$O$_3$ NPs have higher electro-catalytic activity for the detection of uric acid (UA). Most researchers believe that the high porosity of the $\alpha$-Fe$_2$O$_3$ NPs in the presence of conductive materials could enhance the diffusion process of organic molecules and could also significantly improve the electrochemical/photocatalytic performance.

Electroactive polymers such as polypyrrole and polyaniline (PAN) are good candidates for improving the conductivity of polymer/inorganic oxide nanocomposites. Among the conducting polymers, PAN is the most widely used due to its good electrical conductivity, environmental stability and lower cost. Moreover, the facile synthesis of PAN in a wide range of aqueous and non-aqueous solvents has gained significant attention from researchers [17,18]. It is well known that the morphology of PAN significantly

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