



Electrochemically Deposited Conducting Polyaniline-Fe₃O₄ Nanocomposites onto FTO coated Glass Electrode based Film for Immunosensing Applications

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ABSTRACT

Conducting PANi/Fe₃O₄ nanocomposites is used as a thin film layer on FTO glass for signal transduction and immobilization of antibody owing to its electrical property. The electrode surfaces were characterized with FESEM, XRD and UV-Vis. The experiment outcome indicated that a conducting layer was formed on the FTO coated glass at a range of -1.5 to 0.5 V at 0.10 V s⁻¹ in a solution of PANi-Fe₃O₄. Electrochemical impedance changes occur only after PANi/Fe₃O₄ is bound to the surface of bare FTO, confirming deposition and the transducing ability of the new modified electrode for the immobilization of biomarker.

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INTRODUCTION

The Polyaniline advantages in the field of biosensor among others are enzyme amplifier (Dhand *et al.*, 2011) to provide notable signal amplification and elimination of unwanted accumulation of electrode (Wan *et al.*, 2010). PANi shows two redox couples in the convenient potential range to enable effective enzyme-polymer charge transfer and must be supported on the electrode (Dhand *et al.*, 2011). Recently, the use of fluorine and indium tin oxide (FTO & ITO) film coated glass has attracted increasing interest (Dai & Compton, 2006; Wan, 2008) due to its prominent characteristics and low cost. In this work conducting PANi/Fe₃O₄ nanocomposites were synthesized and deposited on FTO coated glass by electrochemical deposition.

METHODOLOGY

Preparation of PANi-Fe₃O₄ composites

PANi-Fe₃O₄ nanocomposites were synthesized in a typical procedure, 0.2 mL

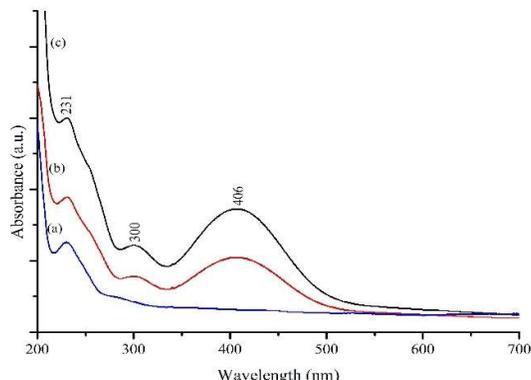
aniline monomer was mixed with H₃PO₄ (0.07 mL) and different wt % of Fe₃O₄ dissolved in 15 mL of deionized water under ultrasonic irradiation for 10 min. Then 0.46 g of APS were added to the mixture. The reaction was kept by ultrasonic mixing for 4 h between 25 and 30°C. The resulting precipitate was obtained by filtering and washing the reaction mixture with distilled water and ethanol, respectively. Finally, the product was vacuum dried at 70°C for 24 h.

Fabrication of the transducing layer

Nanocomposites deposition on the FTO was carried out by cyclic voltammetry (CV) in a three-electrode electrochemical cell containing 10 mL of colloidal suspension of PANi/Fe₃O₄ which was electrodeposited on FTO at an applied voltage of +1.5 V for 10 min. The CV with the potential swept from -1.0 to 1.0 and a scan rate of 0.1 V/s was used for the interrogation of the electrode at different modification stages.

RESULTS AND DISCUSSION

FESEM morphology of different electrode surfaces during each step of the



fabrication

Bare FTO showed a rough but homogeneous surface (Figure 1a), whereas PANi/Fe₃O₄/FTO showed the nanotube lying next to each other.

The nanocomposites were dispersed on the substrate during the deposition process, this has proven the successful deposition of PANi/Fe₃O₄ nanocomposites on the FTO coated glass (Figure 1 b).

Figure 1: FESEM images of (a) bare FTO (b) PANi/Fe₃O₄ (c) PANi/Fe₃O₄/FTO

XRD patterns of Bare FTO, Fe₃O₄, PANi/Fe₃O₄ and PANi/Fe₃O₄/FTO electrode

The XRD pattern of the prepared Fe₃O₄ nanoparticles are observed in the spectra of PANi/Fe₃O₄ nanocomposites which includes the peaks at $2\theta = 22.84^\circ, 32.64^\circ, 46.80^\circ$ and 58.43° . The analysis shows that the obtained

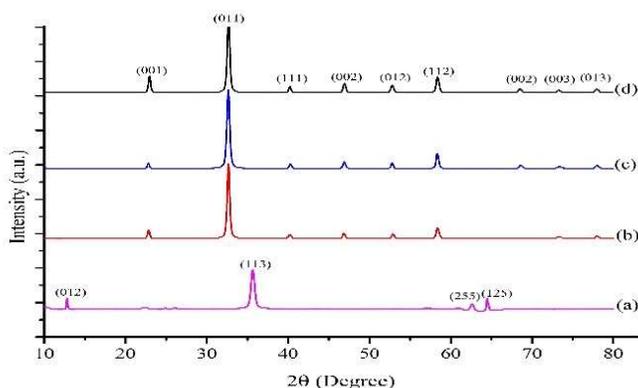


Figure 2: XRD patterns of (a) Bare FTO (b) Fe₃O₄ nanoparticles (c) PANi/Fe₃O₄ (d) PANi/Fe₃O₄/FTO

PANi/Fe₃O₄ nanocomposites is amorphous but contains crystalline Fe₃O₄ nanoparticle embedded in it.

UV-visible Studies

The UV-vis band seen at 231 nm is common to all the three curves corresponds to $\pi \rightarrow \pi^*$ transition of the

benzenoid ring. The peak at 300 nm could indicate the formation of polarons during polymerization process. The absorbance spectra Figure 3c shows a small blue shift in the bands around 406 nm in indicate the formation of the conducting layer of the PANi/Fe₃O₄ nanocomposites on the FTO coated glass.

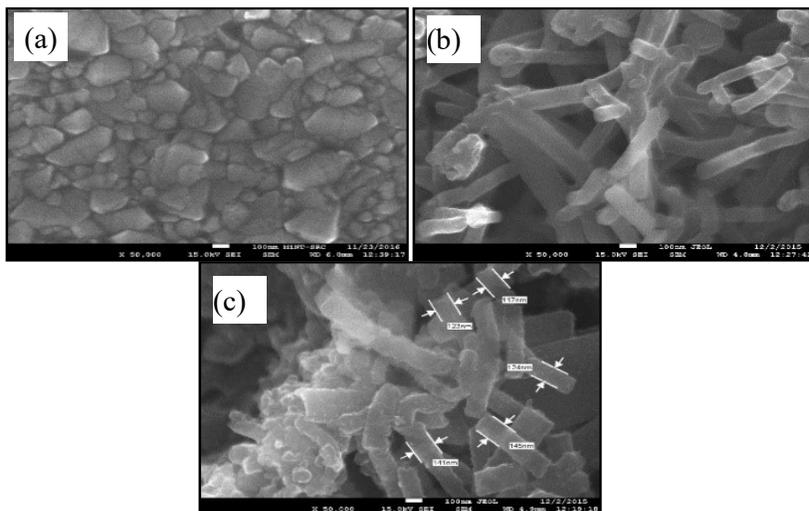


Figure 3: UV-vis spectra of (a) Aniline dimer-COOH (b) PANi/Fe₃O₄ (c) PANi/Fe₃O₄/FTO electrode

Electrical Conductivity of the Electrode

The room temperature conductivity of the electrode increases with deposition time and reaches its optimum value of 1.482×10^{-3} S/cm after 30 mins of deposition

Figure 4a. This results indicates the formation of a conductive layer for the electrochemical transduction.

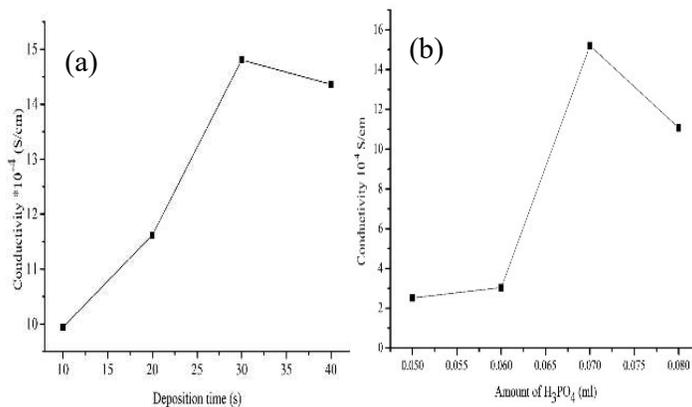


Figure 4: Room temperature conductivity of (a) PANi/Fe₃O₄ at different amount of H₃PO₄ (b) PANi/Fe₃O₄/FTO at different deposition time

Increase in the amount of the dopant (H₃PO₄) also increases the conductivity. This increased conductivity was also reported by (Adamu, Mustafa, & Ruslan, 2015)

Electrochemical Deposition of PANi/Fe₃O₄ onto surface of FTO

From Figure (5 a and b), we can find out that both the anodic and cathodic current decreases after PANi/Fe₃O₄ was

adsorbed on FTO electrode indicating that the membrane is becoming less conductive

due to slow movement of the electrons.

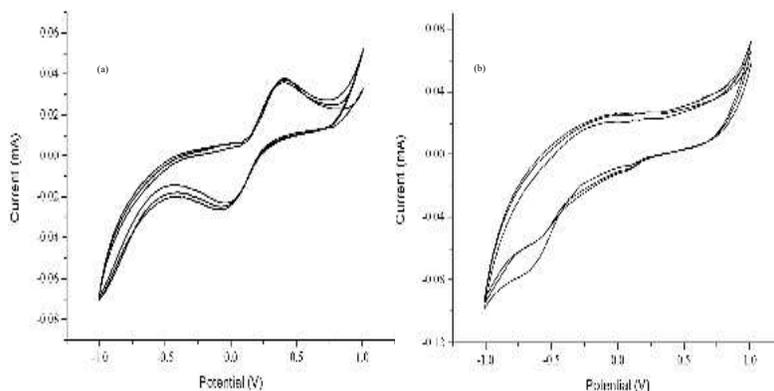


Figure 5. Cyclic voltammograms of (a) bare FTO (b) PANi/Fe₃O₄/FTO modified electrode

CONCLUSION

In this study, after synthesizing PANi/Fe₃O₄ nanocomposites, a sensitive conductive electrode was fabricated based on PANi/Fe₃O₄ nanocomposite via electrochemical deposition onto Fluorine-tin-oxide (FTO) coated glass substrate to serve as transducing matrix/support for the immobilization of anti- β -amyloid. FESEM Images confirm the nanocomposites formation, deposition and immobilization of anti- β -amyloid. The AFM micrograph of the nanocomposites reveals the distribution of the nanocomposites on the modified electrode. The new modified electrode PANi/Fe₃O₄/FTO is found to be stable and electrically conductive. The high surface roughness observed signifies porous morphology and enhanced roughness in the case of modified electrode surface as compared to unmodified one, allowing more adsorption of antibodies to the surface.

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