

Cu/Cu₂O Nanocomposites for Sensitive Detection of Hydrogen Peroxide

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Abstract:

In this work, Cu/Cu₂O nanocomposites were prepared by potential oscillation. The composition and morphology of Cu/Cu₂O nanocomposites were characterized by X-ray diffraction, scanning electron microscopy, energy-dispersive spectroscopy and X-ray photoelectron spectroscopy. The Cu/Cu₂O/FTO electrode showed super electrocatalytic activity for hydrogen peroxide (H₂O₂) oxidation because of the synergistic effects of Cu and Cu₂O. The electrocatalytic performance of Cu/Cu₂O/FTO was evaluated by linear sweep voltammetry and amperometry. Electrochemical studies showed that the developed biosensor exhibited a wide linear range of 0.2–2000 μM with detection limit of 0.04 μM (S/N = 3). The proposed sensor was successfully applied for the determination of H₂O₂ in milk, indicating a promising platform for the practical applications.

Key words: potential oscillation, Cu/Cu₂O nanohybrid, H₂O₂ oxidation, amperometry.

Introduction

Hydrogen peroxide (H₂O₂) has been widely used in the field of textile, medicine, food, environmental degradation, and chemical industries because of the strong oxidizing and reducing properties [1]. Due to health concerns, the FDA regulation limits residual H₂O₂ in finished food packages [2]. The accurate determination of H₂O₂ is essential.

Preparation of Cu/Cu₂O/FTO

The electrochemical deposition of Cu/Cu₂O and Cu₂O film onto the cleaned FTO substrates followed previous work by Cheng [3]. The electrolyte solution contains 3 M lactic acid and 0.3 M cupric sulfate. The pH of the electrolyte solution was adjusted by 5 M sodium hydroxide. The Cu/Cu₂O /FTO and Cu₂O/FTO electrodes were electrochemically deposited at −0.4 mA/cm² at room temperature.

FE-SEM characterization

Fig. 1 and the inset show morphology of the Cu/Cu₂O nanocomposites at low and high magnification, respectively. The film was composed of nanoparticles with diameters of about 50 nm.

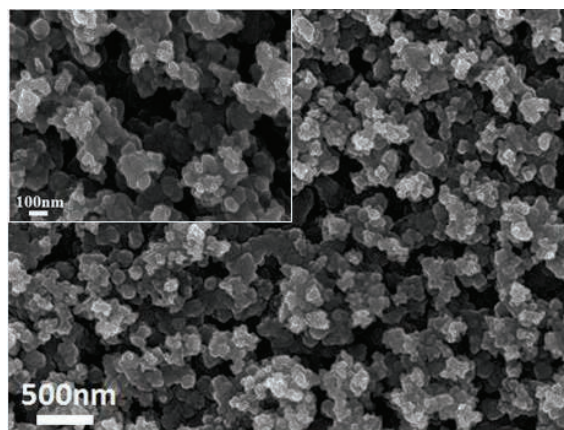


Fig. 1. FE-SEM images of the Cu/Cu₂O nanohybrids. The inset is FE-SEM image at higher magnification.

Electrochemical property

In order to study the electrocatalytic activity of bare FTO, Cu₂O/FTO and Cu/Cu₂O/FTO electrode toward H₂O₂ oxidation, linear sweep voltammetry (LSV) was obtained in 0.1 M NaOH containing 0.5 mM H₂O₂. As shown in Fig. 2, the biggest peak current density was obtained for Cu/Cu₂O/FTO electrode, indicating that the addition of Cu could improve the electrocatalytic activity of Cu₂O towards H₂O₂.

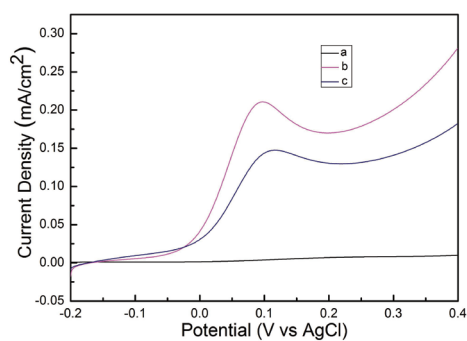


Fig. 2. LSVs of the bare FTO (a), $\text{Cu}_2\text{O}/\text{FTO}$ (b) and $\text{Cu}/\text{Cu}_2\text{O}/\text{FTO}$ (c) in the presence of 0.5 mM H_2O_2 in 0.1 M NaOH (scan rate of 10 mV/s).

The amperometric responses curves of $\text{Cu}/\text{Cu}_2\text{O}/\text{FTO}$ electrode with different concentrations of H_2O_2 were shown in Fig. 3. The result showed that the $\text{Cu}/\text{Cu}_2\text{O}/\text{FTO}$ electrode exhibited excellent electrocatalytic property towards H_2O_2 oxidation over a linear range of 0.2–2000 μM (Fig. 3B) with detection limit of 0.04 μM . The non-enzyme biosensors had been successfully applied to the detection of milk sample with pleasant recovery.

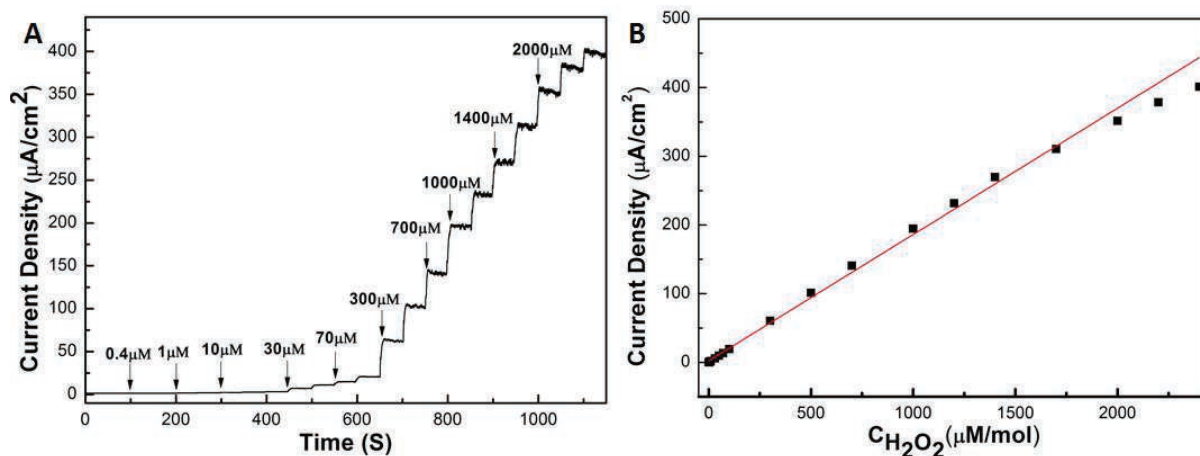


Fig. 3. (A) Current–time curves obtained at $\text{Cu}/\text{Cu}_2\text{O}/\text{FTO}$ upon different concentrations of H_2O_2 in 0.1 M NaOH at +0.1V. Inset: current–time responses for low concentrations; (B) relationship between the amperometric responses and the H_2O_2 concentrations.

Conclusion

We synthesized $\text{Cu}/\text{Cu}_2\text{O}$ nanohybrid via potential oscillation. The $\text{Cu}/\text{Cu}_2\text{O}/\text{FTO}$ electrode could be used for quantitative determination of H_2O_2 with good sensitivity.

Acknowledgements

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