Facile one-step electrochemical deposition of copper nanoparticles and reduced graphene oxide as nonenzymatic hydrogen peroxide sensor

Pooria Moozarm Nia a,b,*, Pei Meng Woi a,b, Yatimah Alias a,b,*

a University of Malaya Centre for Ionic Liquids, Department of Chemistry, University of Malaya, Kuala Lumpur 50603, Malaysia
b Department of Chemistry, University of Malaya, Kuala Lumpur 50603, Malaysia

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A B S T R A C T

For several decades, hydrogen peroxide has exhibited to be an extremely significant analyte as an intermediate in several biological devices as well as in many industrial systems. A straightforward and novel one-step technique was employed to develop a sensitive non-enzymatic hydrogen peroxide (H₂O₂) sensor by simultaneous electrodeposition of copper nanoparticles (CuNPs) and reduced graphene oxide (rGO). The electroreduction performance of the CuNPs-rGO for hydrogen peroxide detection was studied by cyclic voltammetry (CV) and chronoamperometry (AMP) methods. The CuNPs-rGO showed a synergistic effect of reduced graphene oxide and copper nanoparticles towards the electroreduction of hydrogen peroxide, indicating high reduction current. At detection potential of −0.2 V, the CuNPs-rGO sensor demonstrated a wide linear range up to 18 mM with a detection limit of 0.601 mM (S/N = 3). Furthermore, with addition of hydrogen peroxide, the sensor responded very quickly (<3 s). The CuNPs-rGO presents high selectivity, sensitivity, stability and fast amperometric sensing towards hydrogen peroxide which makes it favorable for the development of non-enzymatic hydrogen peroxide sensor.

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1. Introduction

Fast and easy determination of H₂O₂ has attracted much attention due to its importance in pharmaceutical, clinical, environmental, mining, textile and food manufacturing applications [1]. Several methods such as titrimetry [2], spectrophotometry [3], chromatography [4], chemiluminescence [5], and colorimetry [6] are available for determination of H₂O₂ [7].

In recent years, graphene-based materials have been attracting tremendous attention as sensing materials because of their particular advantages including superior electrical conductivity, ease of functionalization, large surface area, fast electron transportation, mass production and many potential applications in nanotechnology and nanomaterials [8–12].

Beside other graphene-based materials, reduced graphene oxide (rGO) has several advantages as an excellent platform in sensing applications. Reduced graphene oxide can be fabricated by the thermal, chemical and electrochemical reduction of graphene oxide (GO). Based on the process of reduction, oxygen-containing groups are partly eliminated from the surface and the sp² conjugation is restored to some extent, accordingly allowing the rGO sheet to be electrically conductive [13]. Based on the formal potential of target analytes, rGO can be reduced or oxidized. Large electrochemical potential window, easy processing solution and oxygen moieties strewn across its carbon lattice make rGO electrochemical reactions happen [14].

The introduction of reduced graphene oxide into electrochemical sensors has undoubtedly led to the dramatic development of different organic materials including glucose [15], DNA [16], ascorbic acid [17], H₂O₂ [18–20], hydrazine [21] and dopamine [22,23].

Metal nanoparticles have attracted extensive research attention for decades due to their unique electronic, catalytic, and sensory properties [24–28]. They may serve as interconnections for nanodevices [29], substrate for high performance catalysts [30] and active species for sensory materials [31]. The unique properties of metal nanoparticles could be ascribed to their excellent electron transfer abilities inherent from the bulk counterpart as well as the ultra-high surface area derived from their nanoscale size [32,33]. Among various kinds of metal nanoparticles, the ones of noble metals, such as Pt, Pd, Au, Ag are under substantial scientific...