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A novel strategy to synthesize Au nanoplates and their application for enzymeless H_2O_2 detection

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ABSTRACT

The present communication reports a novel and simple strategy to synthesize Au nanoplates (AuPs) by heating an aqueous solution of $HAuCl_4$ in the presence of poly [(2-ethyldimethylammonioethyl methacrylate ethyl sulfate)-co-(1-vinylpyrrolidone)] (PQ11). Direct placing of the resultant dispersion on a glassy carbon electrode (GCE) surface gives a very stable AuPs-containing film exhibiting remarkable catalytic performance toward both the oxidation and reduction of H_2O_2. This enzymeless H_2O_2 sensor shows a fast amperometric response time of less than 3 s and the corresponding linear range and detection limit are estimated to be from 0.1 mM to 50 mM (r = 0.999) and 4 μM at a signal-to-noise ratio of 3, respectively.

1. Introduction

It has been established that H_2O_2 as a metabolic intermediate is involved in many biological reactions and plays an important role in the fields of chemistry, biology, clinical control and environmental protection [1–3]. This has raised extensive demands for establishing protocols for H_2O_2 detection. Till now, various techniques including spectrometry, titrimetry, chemiluminescence, and electrochemistry have been employed for determination of H_2O_2 [4–8]. Among them, electrochemical methods have attracted considerable attention owing to their high sensitivity, good selectivity, low-cost, and ease of operation [9]. Most previous studies on this subject involved the use of enzymes which can accelerate the electron transfer between the electrodes and H_2O_2 [10,11]. Their application, however, is limited because enzymes are expensive and easily denatured [12]. With the rapid development in nanotechnology, nanomaterials such as noble metal nanoparticles, carbon nanotubes, and reduced graphene oxide were designed as catalysts to catalyze the oxidation or reduction of H_2O_2 [13–18], leading to enzymeless H_2O_2 sensors.

On the other hand, Au nanomaterials have been widely used in biomedical fields due to their excellent biocompatibility, nontoxicity, catalytic activity and offer a hospitable environment for biomolecules [19]. Hence, there is increasing research attention to biosensors based on Au nanomaterials [20,21]. Au nanoparticles provide a stable immobilization of biomolecules retaining their bioactivity and facilitating electron transfer between the target molecules and electrode substrates and hence have advantages for the construction of electrochemical biosensors with enhanced analytical performance [22,23]. Although Au nanoparticles based electrochemical biosensing has been largely studied [24–26], little attention has been paid to electrochemical sensing application of two-dimensional Au nanoplates (AuPs) [27]. More recently, we have prepared AuPs in aqueous solution at room temperature using tannic acid (TA) as a reducing agent and found that these AuPs exhibit notable catalytic performance toward the oxidation and reduction of H_2O_2 [28]. In order to obtain stable AuPs films, however, chitosan was used as an immobilization support matrix which may block electron transfer at the modified electrode [29].

In this study, we report on a novel and simple strategy to synthesize AuPs by heating an aqueous solution of $HAuCl_4$ in the presence of poly [(2-ethyldimethylammonioethyl methacrylate ethyl sulfate)-co-(1-vinylpyrrolidone)] (PQ11). A very stable AuPs-containing film exhibiting remarkable catalytic performance

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