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ORIGINAL PAPER

Non-enzymatic hydrogen peroxide sensor based on a nanoporous gold electrode modified with platinum nanoparticles

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A novel non-enzymatic electrochemical sensor based on a nanoporous gold electrode modified with platinum nanoparticles was constructed for the determination of hydrogen peroxide (H_2O_2). Platinum nanoparticles exhibit good electrocatalytic activity towards hydrogen peroxide. The nanoporous gold (NPG) increases the effective surface area and has the capacity to promote electron-transfer reactions. With electrodeposition of Pt nanoparticles (NPs) on the surface of the nanoporous gold, the modified Au electrode afforded a fast, sensitive and selective electrochemical method for the determination of H_2O_2. The linear range for the detection of H_2O_2 was from 1.0×10^{-7} M to 2.0×10^{-5} M while the calculated limit of detection was 7.2×10^{-8} M on the basis of the 3σ/slope (σ represents the standard deviation of the blank samples). These findings could lead to the widespread use of electrochemical sensors to detect H_2O_2.

Keywords: hydrogen peroxide, platinum nanoparticles, nanoporous gold, electrodeposition, enzyme-free, amperometric sensor

Introduction

H_2O_2 is cytotoxic to cellular life and acts as an indicator of oxidative stress (Lases et al., 2000; Yorek, 2003); it is the product of several biological, enzyme-catalysed reactions (Clark, 1970; Ruiz et al., 1993; Yang et al., 1995, 2006; Thomé-Duret et al., 1996; Niwa et al., 1998; Armstrong & Wilson, 2000; You et al., 2003). This has motivated the development of stable hydrogen peroxide sensors with high sensitivity, low limit of detection and a rapid and accurate response for utilisation in the food industry, in environmental waste management and in medical diagnostics. Many H_2O_2 analytical methods have been developed, including titrimetry, spectrophotometry, chemiluminescence and electrochemistry (Wang et al., 2005; Thenmozhi & Narayanan, 2007; Zhang et al., 2008a; Chen et al., 2009; Ma et al., 2009).

Many enzyme-based biosensors have been constructed to achieve H_2O_2 oxidation (Vianello et al., 2007; Kafi et al., 2008; Mala Ekanayake et al., 2008; Zhou et al., 2010), but the application of these H_2O_2 enzymatic biosensors is limited, in part due to the disadvantages represented by their rigorous environment, high cost, the instability of enzymes and the complicated process to achieve enzyme immobilisation (Jia et al., 2002; Zhou & Ju, 2004; Lin et al., 2007). In comparison with enzyme-based sensors, non-enzymatic sensors exhibit a high stability, free from the influence of temperature.

Metal nanoparticles have been studied extensively because of their unique functions (Lewis, 1993; Heath, 1998; Bönnemann & Richards, 2001; Roucoux et al., 2002; Link & Ei-Sayed, 2003). The catalytic behaviours of the metal NPs have been investigated because of their high catalytic activity in many chemical reactions. In particular, Pt NPs have been demonstrated to reduce the H_2O_2 oxidation–reduction overvoltage efficiently and investigated for their catalytic activity in H_2O_2 reduction. Pt NPs have found many

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