Development of an ultrasensitive biosensor based on the highly porous Pt/CuO/Pt hybrid electrode

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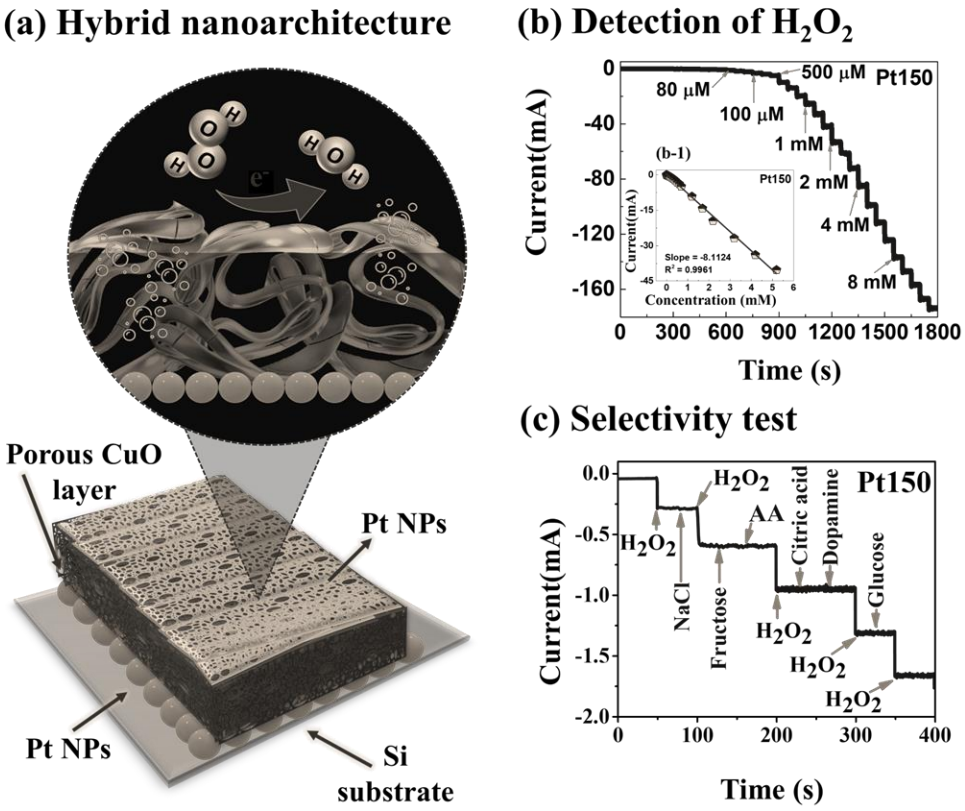

Fig. 1. Fabrication of porous Pt/CuO/Pt biosensor and electrochemical detection of H_2O_2. (a) Schematic of porous Pt/CuO/Pt hybrid electrode. (b) Chronoamperometry (CA) response towards H_2O_2 detection. (c) Selectivity response against various interfering species. [1]

Hydrogen peroxide (H_2O_2) has an important role as a signal molecule to regulate a fundamental environmental, chemical and biological process [2]. The porous Pt/CuO/Pt electrode is an

electrochemical hybrid biosensor composed of Pt NPs decorated on a porous CuO/Pt template fabricated utilizing a physio-chemical technique for the detection of hydrogen peroxide (H_2O_2) as shown in Fig. 1(a). The porous CuO layer is constructed using an electrochemical deposition method known as the dynamic hydrogen bubbling technique and the metallic Pt NP decoration is accomplished via PVD and post-annealing. The hybrid platform achieved improved electrocatalytic performance with the rapid electron transfer between the analyte's redox centers and the electrode surface [3]. The platform demonstrated a superior sensitivity of 16,694 μA mM^{-1} cm^{-2} with a limit of detection of 2.91 nM (S/N = 3) which is ~8 times better than the only CuO/Pt template as shown in Fig. 1(b). A biosensor exhibited a broad linear range of selectivity against interfering chemicals such as NaCl, fructose, ascorbic acid, citric acid, dopamine, and glucose shown in Fig. 1(c). The super-porous CuO layer dramatically improves the electrochemically active surface area, and the Pt NP coating improves conductivity and charge buildup for H_2O_2 reduction substantially [4][5].

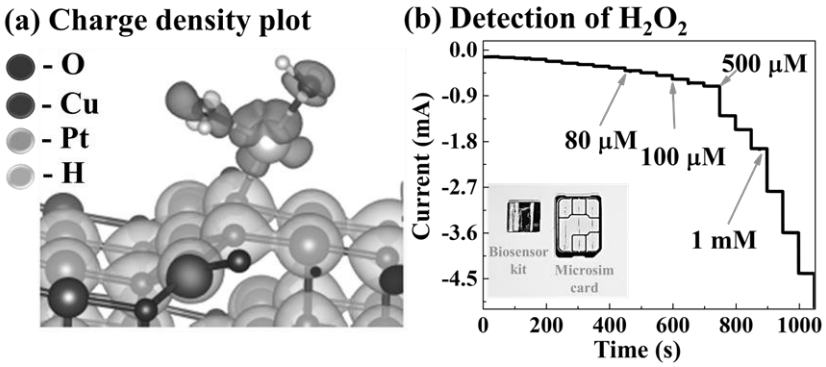

Fig. 2. DFT simulation and H2O2 detection through biosensor kit. (a) Charge density simulation of Pt/CuO after adsorption of H2O2. (b) CA response towards H_2O_2 detection for biosensor kit. [1]

The density functional theory (DFT) simulations verify the superiority of CuO over Cu_2O and Pt over Pd for H_2O_2 detection established through adsorption energy, the density of states, and

charge accumulation calculations. A charge accumulation was seen at the Pt atom oriented towards the bonds, and this charge gain has the potential to disrupt the O-H bond when H2O2 is bonded over the Pt atom [6] as shown in Fig. 2(a). Furthermore, a biosensor kit fabricated on a single chip exhibited a sensitivity of 11,325 μA mM^{-1} cm^{-2} with a limit of detection of 4.1 nM (S/N = 3) as shown in Fig. 2(b). It indicates the feasibility of practical applications with good performance.

Keywords – Hybrid biosensor, Porous CuO, Pt nanoparticles, Elerctochemical detection, H_2O_2 detection, DFT simulation.

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