Nanoparticulate modified microelectrode for acetylcholine detection by fast-scan cyclic voltammetry

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1. Introduction

Acetylcholine (ACh) is an essential neurotransmitter that presents in both the peripheral and central nervous systems of the brain. Which has an important role in processing memory and learning. Therefore, the lack of it is associated with a brain disorder such as Alzheimer's disease, Parkinson's disease [1]. Fast-scan cyclic voltammetry (FSCV) is the real-time monitoring of neurotransmitters in the brain. Moreover, FSCV offers many advantages, including millisecond time resolution, moderate selectivity, and high sensitivity [2]. Metal oxide nanoparticles modified electrodes have shown a good performance through increasing the surface area and enhancing the mass transport. Iron oxide (Fe_2O_3) and copper oxide (CuO) are exhibited good electrical conductivity which is ubiquitous in electrocatalytic behavior [3].

This study aimed to develop and modify the flexible microelectrode with metal oxide nanoparticles and multiwall carbon nanotubes (MWCNTs) as the electrochemical sensor for acetylcholine detection.

2. Experimental procedures

2.1 Fabrication and modification of micro-electrode

The microelectrodes were applied onto a flexible polyimide substrate pattern with Cu and Au layer by laser patterning with a diameter of 100 µm.

The preparation of microelectrodes for the electrochemical measurement was achieved by mixing metal oxide and MWCNTs nanoparticles. The mixture was dispersed with deionized water to obtain a suspension and underwent hydrothermal at 120 ºC for 3 hours.

2.2 Electrochemical measurement

The Fe_2O_3 and CuO modified microelectrodes were determined using Fast-scan cyclic voltammetry (Waveneuro, Pine Research). The Ag/AgCl was used as a reference electrode. A triangular voltage waveform from -0.4 to +1.3 V with the scan rate at 400 V/s was applied. The modified microelectrodes were conducted in choline acetate solution ($C_7H_{17}NO_3$, Sigma Aldrich) with a concentration between 0 to 100 µM.

3. Results

The electrochemical performance of the Fe_2O_3 and CuO modified microelectrodes were evaluated using FSCV. As shown in Fig.1, the cyclic voltammogram showed the peak current corresponding to the oxidation reaction of Fe_2O_3 and CuO for acetylcholine at the applied potential of 0.59 and 0.18 V, respectively. The sensitivity of microelectrodes showed that the CuO modified microelectrode a linear response of acetylcholine with high sensitivity was observed. Due to the morphology of nanoparticles that CuO has a smaller size than Fe_2O_3 which enhances active sites of surface area, leading to the easy shuttling of electrons between the electroactive interference [4].

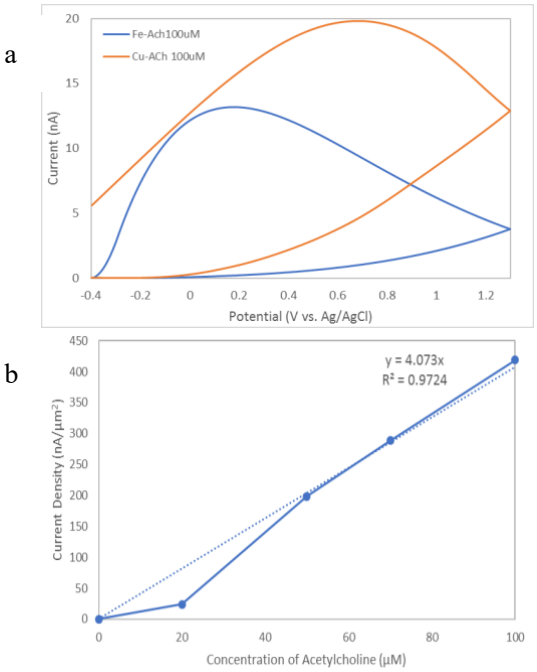

Fig. 1 (a) CV curve of Fe_2O_3 and CuO modified microelectrode conducted in acetylcholine solution with concentration at 100 µM and (b) Sensitivity of CuO modified microelectrode

Acknowledgment

This work was partially supported by ASEAN University Network/Southeast Asia Engineering Education Development Network (AUN/SEED-Net, ICE-Matter Consortium) and JST-CREST (JPMJCR1651).

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