Determination of 4-nitrophenol in Water using Free-Standing Cu Nanowire Electrode

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While Au and Ag are widely used as the electrocatalysts for sensing 4-nitrophenol (4-NP), Cu is seldom studied probably due to the fact that its performance is not as good as those of Au and Ag. In this work, the electrocatalytic activity of a free-standing Cu nanowire (CuNW) electrode for 4-NP reduction, as well as its performance as a sensor for detection of 4-NP in water, has been studied. The electrochemical impedance spectroscopy analysis indicates that, owing to its a porous network structure with CuNWs serving as both conductive substrate and electrocatalyst, the free-standing CuNW electrode possesses a much lower electron transfer resistance and a much higher electrochemical active surface area than a CuNW-modified glassy carbon electrode (GCE). A comparative study on the electroreduction of 4-NP at different Cu electrodes by cyclic voltammetry (CV) reveals that no reduction peak appears at a Cu wire electrode with low active surface area but fast charge transfer while a broad peak is observed at the CuNW-modified GCE with slow charge transfer but relatively higher active surface area. Benefitting from the combination of fast electron transfer and high active surface area, however, the 4-NP reduction peak at the free-standing CuNW electrode is narrow and positively shifted with its current being more than 30 times higher than that observed at the CuNW-modified GCE. These features allow an investigation of this free-standing CuNW electrode as a 4-NP sensor via a simple electrochemical technique (namely CV), and the results obtained demonstrate that this sensor exhibits a linear range of 4 to 2200 μM , a sensitivity of 4.831 $\mu\text{A}/\mu\text{M}$, and a detection limit of 1.0 μM at a signal-to-noise ratio of 3. Compared with the reported porous Cu-modified graphite pencil electrode, our Cu-based 4-NP sensor not only possesses a lower detection limit but also has a much broader linear range and higher sensitivity.

Keywords: Cu nanowires; Electrochemical sensor; Free-standing electrode; 4-Nitrophenol

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