Direct self-assembly of CuHCF-PPy nanocomposites on rGO for amperometric nicotine sensing at high concentration range

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A R T I C L E  I N F O

Keywords:
Copper hexacyanoferrate
Nanocomposite
Self-assembly
Nicotine sensor

A B S T R A C T

Copper hexacyanoferrate-polypyrrole (CuHCF-PPy) nanocomposite as nicotine electrochemical sensor was deposited directly on reduced graphene oxide (rGO) by a direct self-assembly technique for the first time. FTIR and EDX confirmed the formation of CuHCF-PPy whereas combination of cubic CuHCF-PPy globules morphology was determined by FESEM. The electrochemical properties were studied via CV and its equivalent circuit fitted from EIS was described in details. The linear range of the proposed sensor was between 0.03 and 5 mM, which is the highest among the previous report, with a compatible sensitivity of 0.21 mA cm\textsuperscript{-2} mM\textsuperscript{-1}. Additionally, the sensor was applied for the detection of nicotine content in vape (e-cigarette) real sample.

1. Introduction

Nicotine (NIC) is an alkaloid in tobacco products and the main addictive agent accountable for continued smoking behaviour. Recently, the e-cigarettes (vape) have become the current smoking trend, especially among youth, due to its realistic look and taste [1]. Nonetheless, there is lack of regulation on its nicotine level labelling in this type of tobacco-product. Also, NIC can bring some potential health problem, especially on cardiovascular and respiratory related conditions [2]. Pharmacologically, NIC which works on the central nervous system can cause mood elevations and increased energy. Besides that, studies have been performed to understand its medical value towards the diseases such as ulcerative, Alzheimer’s and Parkinson’s disease [3]. Therefore, the detection of NIC is vital in the fields of chemistry, toxicology, pharmacology, and clinical.

Electrochemical sensor is cheap, simple to use and enable real-time detection. Hence, it is a promising alternative for sensing of nicotine and researchers are working on the development of electrochemical sensor. Up to date, < 20 materials were explored for the electrochemical detection of nicotine, including gold-carbon nanocomposite [4,5] and TiO\textsubscript{2} nanoparticles [6], as well as the expensive palladium hexacyanoferrate (PdHCF) [7]. This is mainly owing to the fact that the NIC oxidation/reduction process occurs at extremely positive or negative potentials, which are out of the potential window of the conventional electrodes. Therefore, this area remains an enormous challenge to fabricate a simple, low-cost electrochemical sensor towards detection of this interesting analyte-NIC. Moreover, the ability of easy chemical alteration of electrode will improve its potential in sensing field.

Metal hexacyanoferrates (MeHCF) has been investigate extensively for development of various applications, especially in electrochemical sensing. Prussian blue (PB) or known as iron hexacyanoferrates is one the most used MeHCF for the development of electrochemical sensors, especially in hydrogen peroxide (H\textsubscript{2}O\textsubscript{2}) sensors [8,9].

Preparation of PB films by the direct self-assembly (SA) method was initially developed in 2001 [10] but the preparation of PB-PPy nanocomposites formed by direct SA method without any linking agent on glassy carbon is firstly reported in our previous publication [11]. The benefits of forming a nanocomposites with highly conductive PPy could improve sensitivity for sensor applications [12], as well as the synergistic effect between two components which might generate novel characteristic. As described in our previous work, PB-PPy nanocomposites was prepared with a facile SA method. This approach can precisely control thickness of the nanocomposites and consequently its sensitivity towards analyte and its electrochemical behaviours. Besides that, in-situ modification of electrode was accomplished. Taking the account of the low-cost, simplicity and the ability to simultaneously formation of two components, the direct SA technique has become one of the most promising technique to produce MeHCF films [13].

Apart of PB, its analogues such as copper (CuHCF) [14–16], cobalt [17] and nickel hexacyanoferrate [18], have been extensively evaluated in the development of electrochemical sensors for various analytes. It is expected that the same synthesis method to prepare PB can be used to