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Boron-doped Diamond Electrodes for sensing narcotics using Electrochemiluminescence

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Summary:

In this study, we increase the range of applications of boron-doped diamond electrodes as electrochemical sensor for narcotics detection, using electrochemiluminescence (ECL) principles. The method involves the enhancement of the chemiluminescence from permanganate ions upon oxidation of narcotic molecules in electrolytic solution, and has been demonstrated e.g. for Δ-9-tetrahydrocannabinol (THC) with typical limits of detection below 15 ng/mL (47.7 nM).

Keywords: boron-doped diamond electrodes, electrochemical sensor, electrochemiluminescence, narcotics detection, reusable electrodes.

Boron-doped diamond (BDD) is a very interesting electrode material due to the variety of assets it features when compared to more conventional electrode materials. The polycrystalline structure of boron doped diamond ensures high stability including resilience to corrosion, alongside with a low double layer capacitance and wide potential window in aqueous media.[1] In addition, such electrodes may be electrochemically pretreated before measurements to overcome the issue of fouling. For instance using sequences of current pulses with high densities has proven effectiveness to achieve this goal [2]. All these properties made BDD electrodes suitable for electrochemiluminescence (ECL) in sensor applications, potentially offering better sensitivity than standard amperometric methods. Besides, the increase of recreational drugs consumption has become a major societal issue nowadays. In the context of road safety, conventional sensors for control generally use antibodies, functionalised with a tracer. As saliva samples are being analysed, the low solubility of the drugs in aqueous media make it challenging to detect molecules in trace amount. Thus second post toxicology analyses, using traditional methods in laboratory, are required for legal validation, which also present limitations [3]. These constrains have conducted to develop new reliable sensors for drug detection. In this context, ECL has shown promising results for drugs detection with a fast, sensitive and scalable method [4].

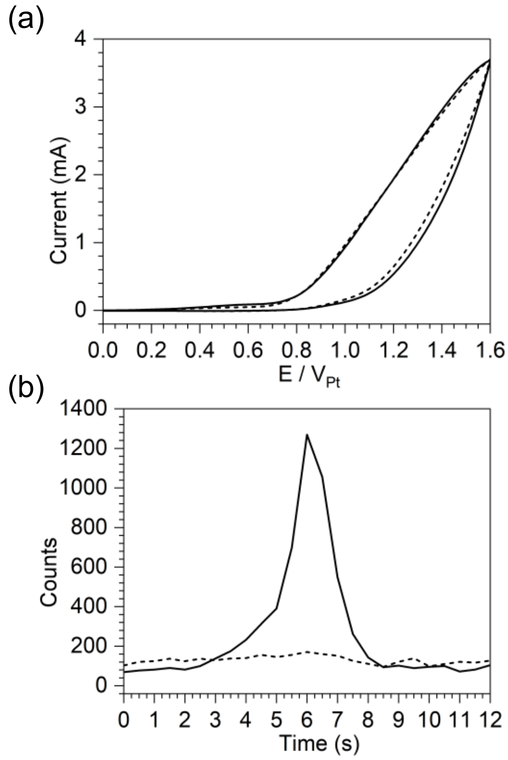

Figure 1: Electrochemiluminescence measurement with (a) cyclic voltammetry of $KMnO_4$ 152 µM pH 3 buffer in Na_2SO_4 0.1 M (dash) and 2 µL of THC 24.5 nM deposited on the electrode surface in $KMnO_4$ buffer (line) and the corresponding ECL measurement (b) with $KMnO_4$ (dash) and in presence of THC (line)

In this work, we were able to detect a variety of illicit substances (THC, Amphetamine, Cocaine, Methamphetamine, Benzoylecgonine, rac-MDMA, morphine, etc) using BDD electrodes while carefully selecting the ECL luminescent probes, leading to quenching / enhancing properties upon exposure to narcotics, depending on the choice of co-reactants. For instance, we identified permanganate ions as efficient ECL probes in aqueous media. To our knowledge permanganates have been reported as chemiluminescent probes when associated with long chains of polyphosphates [5], but not as electrochemiluminescent probe before. Figure 1 shows the ECL detection of THC in the presence of permanganate at a concentration of 24.5 nM. At this concentration levels cyclic-voltammetry curves do not show any significant oxidation signal due to the presence of THC (Figure 1.a). By contrast, Figure 1.b shows the resulting ECL response. Here the blank solution of $KMnO_4$ does not exhibit any light emission within the voltage range of 0 V to 1.6 V. However, after drop casting 2 µL of THC at a concentration of 24.5 nM on the electrode surface, a peak of luminescence is detected leading to the detection of THC. These results will be discussed further during the conference and more results presented with other narcotic compounds.

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