

Electrochemical behaviour of catechol at electrochemically pretreated pencil graphite electrode

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Abstract - Simple electrochemical method is utilized for the micro level detection catechol (CC) using electrochemically Pretreated Pencil Graphite Electrode (PPGE). Pencil Graphite Electrode (PGE) was electrochemically pretreated in phosphate buffer solution (PBS) by sweeping the potential between 1.0 V to 2.0 V. PPGE was characterized by cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) in $Fe^{2+/3+}$ redox probe, cyclic voltammetry results shows that the electro analytical performance of this PPGE sensor has been enhanced effectively. In addition to that, PPGE sensor remarkably increases the redox peak current of CC compared with the non-pre-treated PGE. Further, Differential pulse voltammetry method is utilized for the detection and quantification limit.

Keywords: pencil graphite electrode, electrochemical sensor, catechol, cyclic voltammetry.

1. INTRODUCTION

Catechol (1,2-dihydroxy benzene, CC) is present in wide range of natural compounds and produced in most of the industrial processes. It is found mainly in biological, particularly in neurological compounds [1,2]. In addition to that, it has wide range of applications such as, precursor to flavors, fragrances, pesticides and photographic chemicals [3,4]. Besides these application, its concentration in various body fluids gives the information about the neural diseases such as neuroblastoma [5], its increased concentration levels toxic to the aquatic, plants, animals and human life [6], so the detection of CC is significant. Various analytical methods have been developed for the detection of CC, such as capillary electrophoresis [7], liquid-phase chromatography [8], electrochemical [9] and flow injection analysis [10] which were most commonly used techniques. Among these, electrochemical method has great importance due to its simple, cost effective and fast response. Carbon electrodes such as graphite, glassy carbon and its modification such as, boron doped diamond, graphene oxide, electrochemical pretreatment and Carbon nanotubes have shown better results as sensor materials [11]. In the present study,

electrochemically pretreated pencil graphite electrodes (PPGE) was used as sensor for the detection of CC was analyzed.

2. Experimental

2.1. Reagents

CC was purchased from Alfa Aesar. The pencil graphite electrode was available as pencil lead from Kokuyo Camlin Ltd., Mumbai, India. The diameter of the received lead was 2.0 mm of type 2B. All other chemicals were of analytical grade and used without further purification. All solutions were prepared with triply distilled water.

2.2. Instrumentation

The electrochemical experiments were carry out in a conventional three electrode system using CHI760C instruments. The three electrode configuration composed of a PGE or PPGE electrode as working electrode, Ag/AgCl (1M KCl) as the reference electrode and the platinum wire as the auxiliary electrode.

2.3. Fabrication of PPGE

The pencil lead was cut into 4 cm length and tightly coated with Teflon band leaving its tip for polishing on weighing paper to a mirror finish. Potentiodynamic electrochemical pretreatment was carried out by scanning the potential between 1.0 V and 2.0 V reference with Ag/AgCl (1M KCl) for 100 cycles with a scan rate of 100 mV/s in 0.1M phosphate buffer solution (pH 7.0).

3. Results and discussion

Fig.1. shows the CV responses of PPGE and PGE in the presence of 0.5mM CC in 0.1 M PBS (pH 7.0). It can be seen that the oxidation and reduction peak potentials of CC at PGE are 0.189 V and 0.097 V with peak potential

separation (ΔE_p) of 92 mV. However, oxidation and reduction peak potentials of CC at PPGE were 0.169 V and 0.135 V with ΔE_p of 34 mV. Furthermore, At PPGE, anodic peak potential shifted negatively and cathodic peak potential shifted positively with enhanced anodic and cathodic current response compared with that of non pretreated PGE.

Fig.2. illustrates the electrocatalytic behaviour of CC at various pH buffer solutions; CV results show that by increasing the pH, the anodic and cathodic peak potentials shifted more negatively and the redox current response also gradually increases on increasing the pH from 5.0 up to 7.0 then it starts to decrease on increasing the pH from 7.0 to 9.0. So pH 7.0 was chosen for further analysis to get better sensitivity and stability.

Fig.3. depicts the CV responses of scan rate effect on the peak current of CC at PPGE electrode within the range from 10 mV/s to 100 mV/s. From the CV results, we can see that by increasing the scan rate the current response also increasing, in addition to that anodic peak potential shifted more positively and cathodic peak potential shifted more negatively in 0.1M PBS (pH 7.0) buffer solution containing 0.5 mM CC.

Fig.4. shows that the differential pulse voltammetry (DPV) responses of PPGE at various concentration of CC (0, 1, 2, 3, 4, 5, 6 and 10 μ M) in 0.1M PBS (pH 7.0). DPV results illustrate that the anodic peak current of CC occurred at the potential of 0.13 V which increases linearly with increasing concentration of CC, suggesting the enhanced electrocatalytic behaviour of PPGE on the oxidation of CC with the continuous accumulation of CC on PPGE.

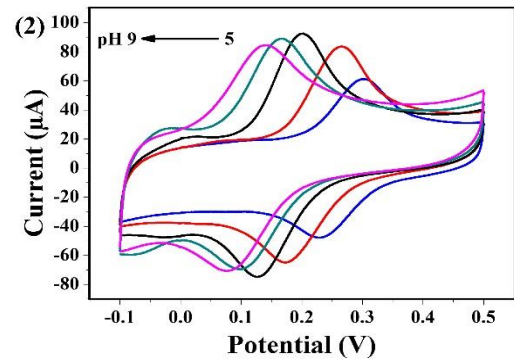


Fig. 2. CV responses of PPGE recorded in the presence of 0.5 mM of CC in 0.1 M PBS (pH 7.0), at different pH values 5.0 – 9.0, scan rate 100mV/s

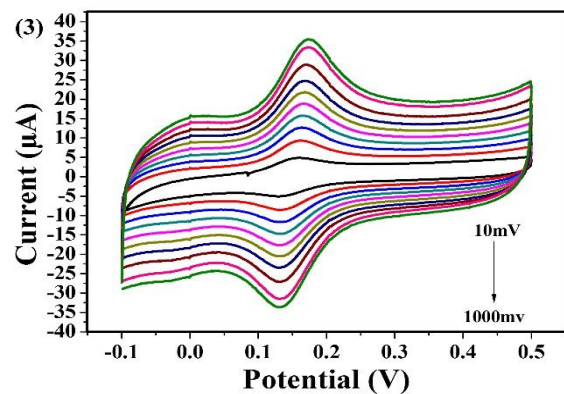


Fig. 3. CV responses of PPGE recorded in the presence of 0.5 mM of CC in 0.1 M PBS at various scan rate: from 10 to 100 mV/s.

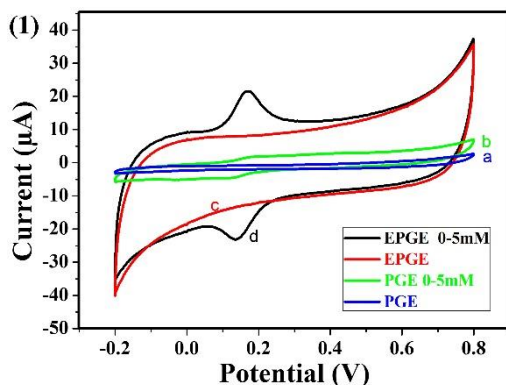


Fig. 1 . CV responses of PGE (a) and PPGE (b) recorded in the absence and presence of 0.5 mM of CC in 0.1 M PBS (pH 7.0), scan rate 100mV/s.

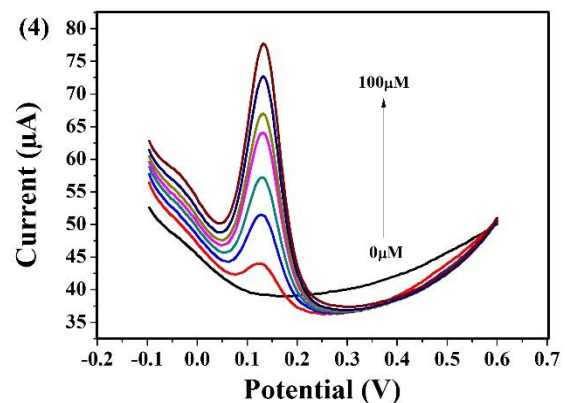


Fig. 4. DPV responses of increasing concentration of CC from 10 to 100 μ M at PPGE in 0.1M PBS (pH 7.0).

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4. CONCLUSIONS

In this work, a simple and quickly prepared electrochemical sensor based on pencil graphite electrode was fabricated and utilized for the analysis of electrochemical behaviour of catechol. The electrocatalytic activity of CC at PPGE has been enhanced effectively, suggesting an increased active surface area during electrochemical pretreatment. The DPV analysis showed a wide range of linear responses from 10 to 100 μM of CC at PPGE. These results demonstrated that the fabricated PPGE sensor has the potential to be used as an electrochemical sensor for sensitive detection of 1,2-dihydroxy benzene.

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