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Development of disposable antibiotic drug sensor based on screen-printed electrode modified with magnetic nanocomposites

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Summary:
This research work reported the development of a new disposable electrochemical chloramphenicol (CAP) sensor based on the use of a screen-printed electrode)SPE(modified with an iron oxide magnetic nanoparticles doping on graphene. The electrochemical and electrocatalytic characteristics of the modified SPE were recorded using cyclic voltammetry (CV) and differential pulse voltammetry)DPV(. The proposed sensor showed fast response to CAP and good sensitivity. The sensor had a detection range over the concentration ranges of 0.5 to 700 µM, with a detection limit of 95.4 nM (S/N=3).

Keywords: antibiotic drug, electrochemical sensor, differential pulse voltammetry, screen-printed electrode, magnetic nanocomposite

Introduction

Chloramphenicol (CAP) is an effective antibiotic drug against a wide variety of gram-positive and gram-negative bacteria. However, CAP have an extremely bad effect on human health, which can even lead to diseases [1]. The Food and Drug Administration in many countries have set a strict residue limit for CAP [2]. Based on this fact, there is an urgent need for a sensitive and accurate method for the determination of CAP in milk samples. Up-to-now most of the analytical methods towards this determination require a well-equipped laboratory, trained personnel, high capital expenditure and involve time-consuming sample preparation steps [3-4]. These added to the cost and complexity of assay. Among the variety of sensors reported, electrochemical methods that have shown potential applications in the detection of CAP rely on low instrumental cost, high simplicity, sensitivity, accuracy, reliability, and fast analysis [5-7]. Interestingly, so far an iron oxide magnetic nanoparticles doping on graphene nanocomposite (Fe_3O_4/Gr) has not been developed for the electrocatalytic detection of CAP. Herein, we developed a new type of disposable electrochemical sensor for rapid determination of CAP by the use of the Fe_3O_4/Gr nanocomposite.

Method

The fabrication of Fe_3O_4/Gr nanocomposites was described elsewhere [8]. Briefly, GO 20 mg was dispersed into EG 60 ml by ultrasonic treatment. $FeCl_3 \cdot 6H_2O$ 1.6 g, NaOH 1 g and urea 6 g were added into the above solution following magnetic stirring. The resultant homogenous mixture was transferred to a Teflon-lined stainless-steel autoclave, sealed and heated at 200 °C for 12 h. Then, the solution was cooled down and washed by deionized water and ethanol for several times.

The synthesized Fe_3O_4/Gr was modified on SPE by drop casting and dried in a desiccator.

Results and Discussion

The pH value and the accumulation time were determined in order to find an optimal operational condition for CAP sensing. Thus, the pH value was optimized by measuring the CV responses of modified electrodes in 0.5 mM CAP. As given in Fig. 1A, it was seen that the oxidation peak current change increased (from pH 4.0 to 7.0) and then slightly decreased for higher pH values. Then, pH 7.0 was chosen for used as the supporting electrolyte in all subsequent analytical experiments.

The effect of accumulation time on the differential pulse voltammetry (DPV) response current at modified electrode was studied in the range of 5 to 120 second. As shown in Fig. 1B, the peak current of 50 µM CAP at modified electrode increases as the accumulation time increases from 5 to 10 seconds. The result might attribute to the increased amount of CAP molecules on the nanocomposite at electrode surface. After 10 second, the current response was then decreased gradually. Thus, the accumulation time of 10 s was chosen as optimal accumulation time for CAP. The possibility of this phenomenon was due to the rapid adsorption and blocking of excess CAP at modified electrode surface which could be limited the amount of molecules on electrode surface lead to surface saturation.

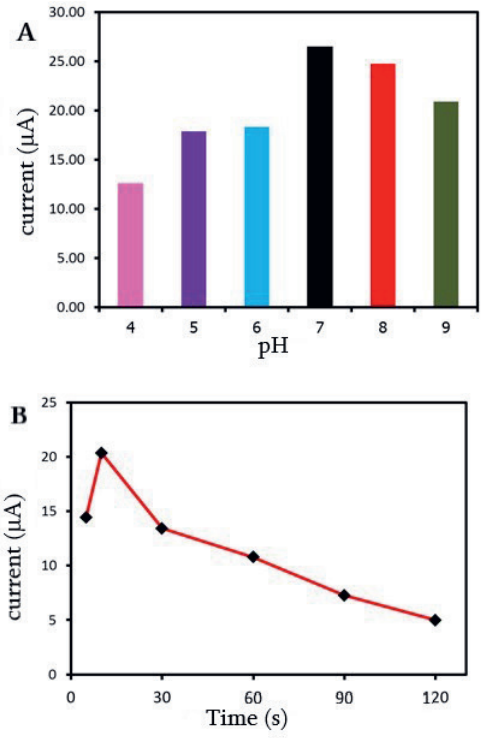

Fig. 1. The effect of the pH (A) and accumulation (B) on the peak current of 50 µM CAP at Fe_3O_4/Gr/SPE.

In order to study the electrochemical performance of Fe_3O_4/Gr/SPE to CAP, the experiments were carried out by DPV under the optimum conditions. Fig. 2 displayed the DPV signal response for different concentrations of CAP from 0.5 µM to 700 µM. As expected, the oxidation peaks current increased with the increased of analytes concentration. The resulting calibration plots (inset in Fig. 2) are a good linear over the range from 0.5 µM to 600 µM with the corresponding linear regression equation of y= 0.0238x + 2.6909 (R^2 = 0.984) and a sensitivity of 238 µA/µM. The detection limit was calculated to be 95.4 nM at a signal-to-noise ratio of 3 (S/N=3). The developed sensor is a promising sensor for simple, inexpensive and sensitive detection of CAP.

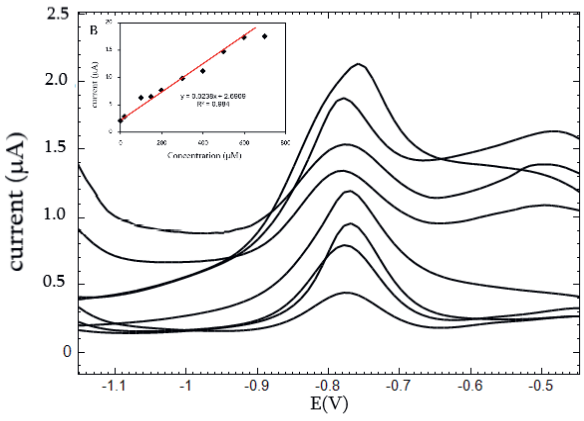

Fig. 2. DPVs of the Fe_3O_4/Gr/MSPE at the CAP concentration from 0.5 µM to 700 µM. Inset: Calibration curve between the peak current and CAP concentration.

Conclusion

We have successfully developed the disposable electrochemical sensor for the rapid determination of CAP using iron oxide magnetic nanoparticles doping on graphene. The results indicated that the sensor show an excellent electrocatalytic activity, high selectivity, sensitivity, wide range and low detection limit.

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