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Development of an Electrochemical Biosensor Based on Carbon Nanotubes and Benzocrown for the Detection of Cd^{+2} ions

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ABSTRACT

Cadmium (Cd^{2+}) is an extremely potent heavy metal found in phosphate fertilizers, and its presence poses a significant risk to the safety of food. This is a pressing concern as it can cause severe health issues. Therefore, it is crucial to create effective analytical techniques to track these hazardous materials. To address this, a new biosensor has been developed with polyaniline, carbon nanotubes, and benzocrown immobilized on a glassy carbon electrode's surface via electropolymerization. Electrochemical cyclic voltammetry indicates that polyaniline electrodepositing, and nanocomposites have improved surface conductivity of GCE. A simple electrochemical biosensor for cadmium detection has been successfully fabricated with biopolymer nanocomposites PANI/SWCNT/BEZOCROWN on GCEs. The biosensor demonstrated a wide linear range (10-14mol/L_10-10mol/L), and a limit of detection of 0.45 × 10^10 M (S/N=3).

Keywords: Nanocomposites, Carbon Nanotubes, Detection Cadmium, Electrochemical biosensor.

1 Introduction

The chemical and metalworking industry in Algeria is the primary source of metallic pollutants, with a significant portion of these residues being soluble and heavy metals.To address the evolving challenges associated with analytical issues, there is a significant demand for conducting multiple analyses simultaneously and rapidly on identical samples. This necessitates the use of efficient analytical methods characterized by high sensitivity and selectivity [1]. This study aims to improve the detection characteristics of a biocapteur based on nanomaterials, particularly carbon nanotubes (NTC), which have been widely used in composite materials and electronic devices due to their unique properties. The nanocomposites SWCNTs-CS-BCE have shown good chemical stability, biocompatibility, and excellent conductivity [2, 3]. The development of these biocapteurs offers promising solutions for environmental control, water control, and chemical industries. [4] In this study, we developed a new electrochemical sensing technology for the detection of cadmium metal on glassy carbon electrodes (GCE) modified with PANI\SWNT\CS|BCE functionalized films. The film combines the unique properties of single-walled carbon nanotubes with the specific ability to detect cadmium ions. PANI\SWCNT|CS\BCE nanocomposites exhibit good chemical stability.

2 Experimental

5 mg of chitosan and 5 mg of carbon nanotube were added into 2.5 ml of 1 wt. % acetic acid solution then sonicated for 15 min to give a homogeneous solution. A volume of 15 µl of prepared mixture is chemically deposited on the modified electrode surface. The electrode was immersed in a t solution of BCE, which contains 1mM for 3h.

3 Results and discussion

The results are presented and discussed including, if necessary, in this experiment, the electrode was modified into a biosensor composed of polyaniline (PANI), single-walled carbon nanotubes (SWCNT), chitosan (CS), and BCE. The self- assembly process of the biosensor was demonstrated and its performance was studied by cyclic voltammetry (CV). Current curves of the modified biosensor showed differences compared to electrodes modified with polyaniline alone, indicating significant effects on electron transfer Fig2 and specific surface area. Further modification with SWCNT/CS/BCE appears to

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result in a reduction in charge Fig2, suggesting a possible effect on electron transfer. Additionally, modifications of other biomolecules progressively reduced electron transfer, suggesting the presence of specific interactions.

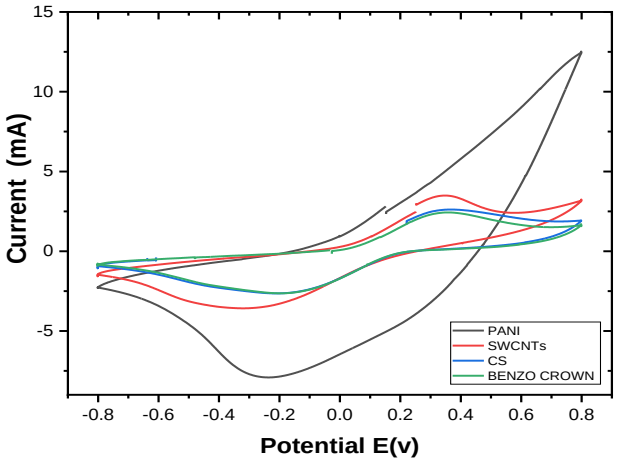

Figure1: Cyclic voltamogram obtained from PANI\SWCNT|CS\BCE functionalized glassy carbon electrode and bare electrode in 2 mM mixture of K3Fe(CN)6 and K4Fe(CN)6 recorded in solution of 0.1 M KCl. Deposition scan rate: 80 mV s^{-1} vs. Ag/AgCl

This study focuses on the characterization of electrochemical methods presented in our work, Cyclic voltamogram. A new selective carbon electrode based on a polyaniline membrane and carbon nanotube has been developed for cadmium ion detection. The developed electrode has a high response and good selectivity for cadmium (II) ion determination in acidic pH 4.5. The developed electrochemical sensors has a low detection limit, large linearity range, and better selectivity compared to zinc ions. The results are presented in the figure2 and figure3

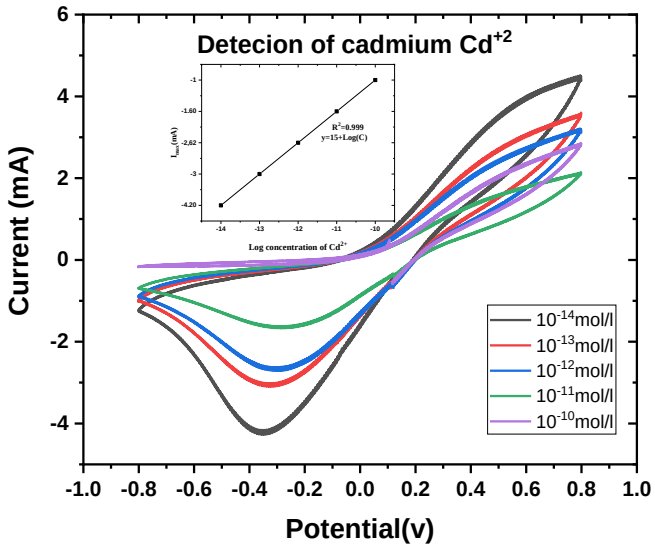

Figure2: Cyclic voltamogram obtained from detection of Cadmium Cd+2 PANI\SWCNT|CS\BCE functionalized glassy carbon electrode Deposition scan rate: 80 mV s^{-1} vs. Ag/AgCl.

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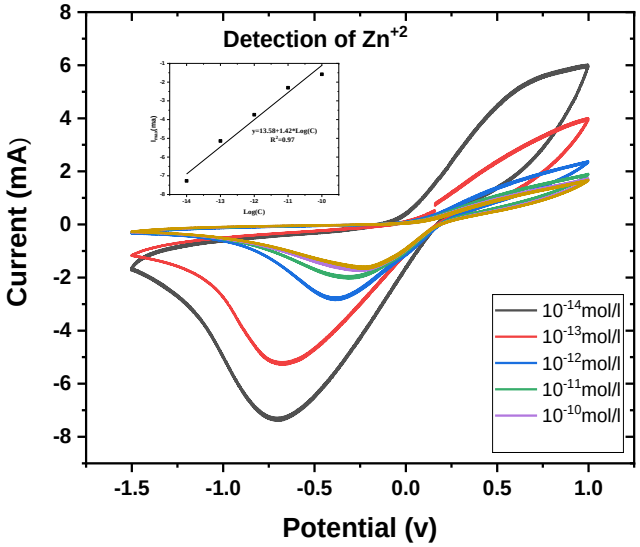

Figure3: Cyclic voltamogram obtained from detection of Zinc Zn^{+2} PANI\SWCNT|CS\BCE functionalized glassy carbon electrode. Deposition scan rate: 80 mV s^{-1} vs. Ag/AgCl

4 Conclusions

In this work, glassy carbon electrodes were functionalized PANI\SWNT\CS|BCE is used for this purpose Cadmium detection by electrochemical cyclic voltammetry. This study demonstrates that the proposed sensor exhibits high selectivity for Cd^{2+} ions when compared to other metal ions. It achieves a low limit of detection (LOD) of 0.45 × 10^ 10 M and demonstrates a linear detection range from 10^-14 to 10^-10 M. The findings highlight the potential of these nanomaterials in advancing the detection of metal ion pollutants in real-world scenarios, thereby contributing to the improvement of safety for individuals and the environment

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