CARBON PASTE ELECTRODE MODIFIED WITH BIOCHAR FOR SENSITIVE ELECTROCHEMICAL DETERMINATION OF CARBENDAZIM IN ENVIRONMENTAL WATER SAMPLES

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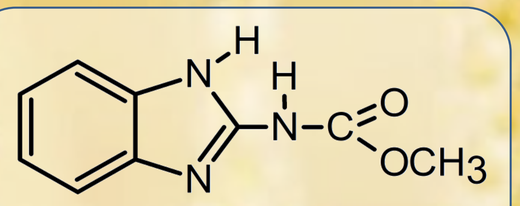
INTRODUCTION

Electrochemical sensing is considered one of the most relied upon non-destructive, commercially viable, and effective techniques for the rapid, sensitive, and *on-site* detection of pesticides. Recently, as a member of the carbon family, biochar (BC) has been increasingly of interest to researchers. BC properties can be utilized for electrode construction and fabricating cost-effective sensors for different target compounds. Since persistent organic pollutants accumulate in the environment and have potential toxicity, there is a requirement to develop selective and sensitive analytical methods such as voltammetric ones for the detection of low-concentration levels of persistent and frequently used pesticides in the environmental water samples. Herein, wheat straw-derived BC was used for bulk-modification of carbon paste electrode (CPE) to prepare simple and sensitive electrochemical sensor for a systemic broad-spectrum fungicide carbendazim (CBZ).

EXPERIMENTAL

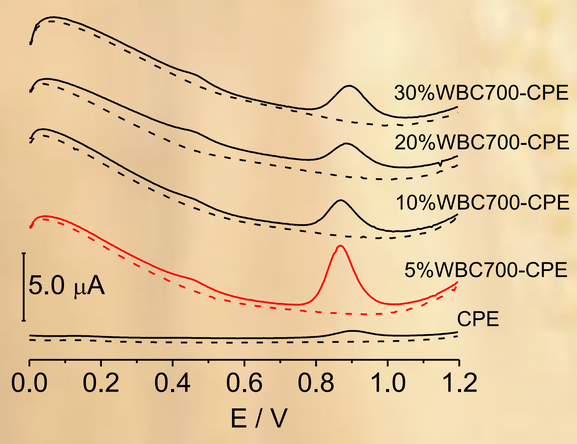
The stock solution of CBZ (5.0 μg mL^{-1}) was prepared in methanol. Britton-Robinson (B-R) buffer was used as supporting electrolyte. BC from a wheat straw was synthesized *via* pyrolysis process at 700 °C (WBC700). Voltammetric measurements were performed on Metrohm DropSens μStat-i 400s using DropView 8400 software. A three-electrode system was applied with an unmodified or WBC700-modified CPE as the working electrode, a saturated calomel electrode as a reference, and a platinum wire as an auxiliary electrode. In all voltammetric experiments, the twice-diluted B-R buffer solution with double-distilled water served as a blank/baseline.



Chemical structure of CBZ

RESULTS AND DISCUSSION

1.



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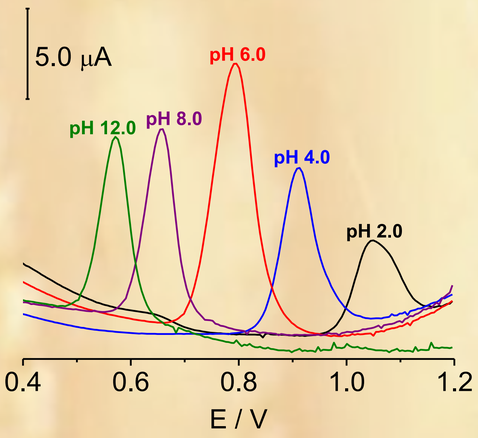

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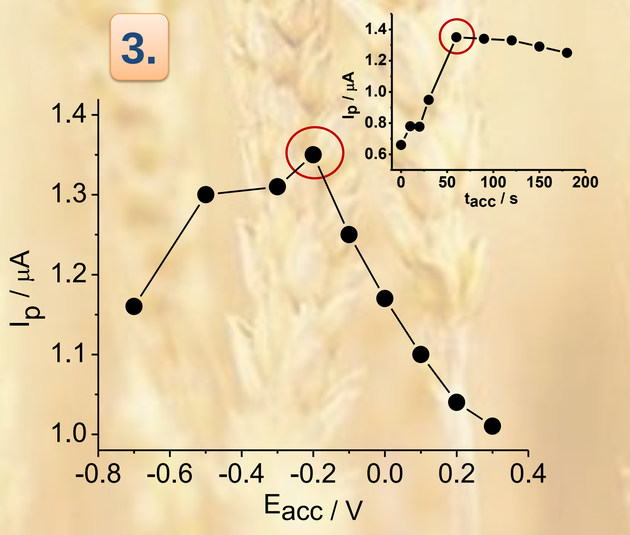

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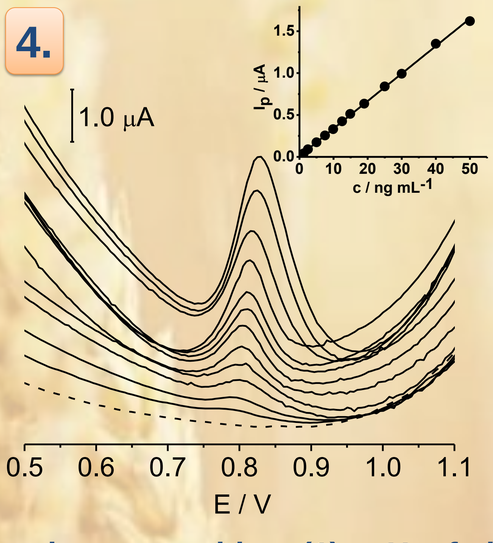

Various parameters were optimized to access the best electroanalytical performance of the sensor, including the **electrode composition (1)**, **pH of the supporting electrolyte (2)** and **adsorption parameters (3)**. The amount of WBC700 in CPE ranged from 0 to 30 wt%, and the most pronounced oxidation signal of CBZ (0.99 μg mL^{-1}) was obtained using **5%WBC700-CPE**. The effect of the pH (2.0–12.0) of B-R buffer on the shape and intensity of CBZ signal (0.99 μg mL^{-1}) was also investigated, whereby the **pH 6.0** was selected as optimal. The optimal adsorption parameters of the CBZ (0.04 μg mL^{-1}) on the electrode surface were: accumulation potential **E_{acc}=-0.2 V** and accumulation time **t_{acc}=60 s**. Under optimized conditions of SW-AdSV method, the BC-based CBZ sensor exhibits a **linear concentration range from 1.25 to 50.0 ng mL^{-1}** with a **limit of detection 0.38 ng mL^{-1}** and **relative standard deviation lower than 2.5%**.

The practical applicability of the 5%WBC700-CPE was examined for the **determination of CBZ in environmental water samples (5)** such as **surface water** and **wastewater**. The good recovery and reproducibility confirm the potential of the proposed BC-based sensor for the rapid and reliable determination of pesticides in contaminated water, offering a sustainable alternative to traditional methods.

5. Determination of CBZ in spiked environmental water samples

Sample	Added [ng mL^{-1}]	[a]Found [ng mL^{-1}]	[b]Recovery [%]	RSD [%]
Surface water	9.98	10.13	101.5	2.1
Wastewater	9.98	9.92	99.4	1.5

[a]Mean value (n=3)

[b]Recovery = [(Found–Added)/Added] × 100 + 100%

Acknowledgement: ***This research was supported by the Science Fund of the Republic of Serbia, #10810, Sustainable solutions in environmental chemistry: exploring biochar potential–EnviroChar.***