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

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Abstract

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-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). Various parameters were optimized to access the best electroanalytical performance of the sensor, including the electrode composition, pH of the supporting electrolyte and adsorption parameters. The amount of BC in CPE ranged from 0 to 30 wt%, and the most pronounced oxidation signal of CBZ was obtained using 5% BC-CPE. The effect of the pH (2.0–11.98) of Britton-Robinson buffer on the shape and intensity of CBZ signal was also investigated, whereby the pH 6.0 was selected as optimal. Since the adsorption plays a significant role in the oxidation mechanism of CBZ, additional studies were performed using square wave adsorptive stripping voltammetry (SW-AdSV) regarding the optimization of accumulation potential (E_{acc}) and accumulation time (t_{acc}) of the target analyte on the electrode surface. Under optimized conditions (E_{acc}=-0.2 V, t_{acc}=60 s, pH 6.0), 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% BC-CPE was examined for the determination of CBZ in environmental water samples 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.

Keywords: *carbendazim, biochar, carbon paste electrode, square wave adsorptive stripping voltammetry, surface water, wastewater.*

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