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Development of the Method for the Detection of Benziso-thiazolinone

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Summary:

Benzisothiazolinone (BIT) serves as an antimicrobial agent in water-based products, acting as a preservative. Exposure to BIT in such products can lead to sensitization and allergic contact dermatitis upon dermal contact. This study aims to detect BIT using portable electrochemical sensors, specifically investigating screen-printed electrodes with carbon and gold-based working electrodes. Cycle voltammetry and square wave voltammetry were employed and compared to establish an effective detection method for BIT.

Keywords: isothiazolinone-based biocide, electrochemical sensors, cyclic voltammetry, square wave voltammetry, screen-printed electrodes.

Title

Development of the Method for the Detection of Benzisothiazolinone.

Headlines

Fast Detection and Monitoring of Benzisothiazolinone biocide by portable electrochemical sensors.

Background, Motivation an Objective

Benzisothiazolinone (BIT) functions as an antimicrobial agent present in a range of products, including laundry detergents, water-based paints, and food packaging materials, among others, contributing significantly to municipal wastewater contamination. Exposure to BIT can lead to skin sensitization and allergic reactions, particularly in individuals with pre-existing skin conditions. Its introduction into water through direct discharge or runoff poses risks to aquatic ecosystems, affecting fish and algae. The persistent nature of BIT underscores the necessity for novel detection and monitoring methods. Electrochemical techniques offer promising solutions due to their simplicity, rapid response times, affordability, and widespread acceptance. Among these, cyclic voltammetry (CV) is commonly used despite its limitations, notably capacitive contributions affecting sensitivity. To mitigate this, pulse techniques like square wave voltammetry (SWV) have been developed, offering faster and more sensitive detection. In this study, we employ two electrochemical voltammetric techniques using screen-printed electrodes to detect BIT.

Description of the New Method or System

Two types of screen-printed electrodes (SPE) were utilized: one with a carbon-based working electrode and the other with a gold-based working electrode. The counter and reference electrodes remained consistent, consisting of platinum and silver, respectively. Electrochemical measurements were conducted using the portable potentiostat PalmSens. The initial study involved the use of the redox probe $Fe(CN)_6^{3-/4-}$ to evaluate screen-printed electrodes. Cyclic voltammetry (CV) covered a potential window from 0 V to 1 V with a step size of 10 mV, while square wave voltammetry (SWV) ranged between 0.2 V and 0.9 V with a step size of 10 mV.

Results

A concise evaluation of the electrochemical behavior of $Fe(CN)_6^{3-/4-}$ at carbon-based and gold-based SPE was depicted in Fig. 1, demonstrating the better performance of the gold-based electrode in terms of peak-to-peak separation and peak maximum. Further analyses of SPEs were done using CV and SWV in the BIT solution at different concentrations. The electrochemical detection of benzisothiazolinone biocide relies on irreversible oxidation, manifested by a peak at 0.7 V vs. Ag/AgCl in the voltammogram. We utilized cyclic voltammetry and square wave voltammetry to construct calibration curves, determining sensitivity and limit of detection (LOD) under specific conditions (Fig. 2). SWV notably enhanced sensitivity for carbon-based SPE electrodes compared to CV, while gold-based SPE exhibited similar sensitivities with both methods. For gold-based SPE, CV and SWV showed comparable LOD and LOQ for BIT detection, whereas SWV proved superior for BIT detection and monitoring with carbon-based SPE electrodes. While the redox behavior suggested superior performance for the gold-based electrode, both cyclic voltammetry and square wave voltammetry revealed that the carbon-based electrode exhibited better performance.

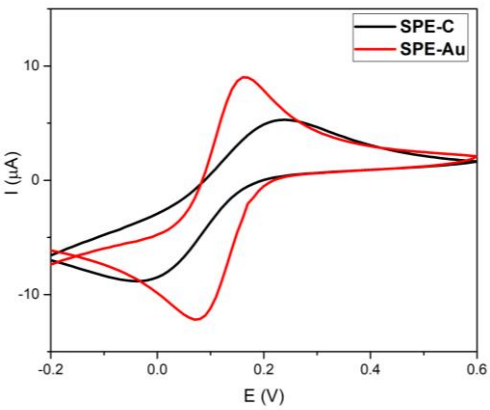

Fig. 1. Redox behavior of $Fe(CN)_6^{3-/4-}$ using carbon-based and gold-based SPE.

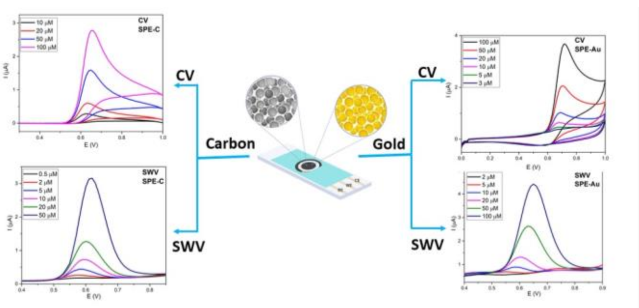

Fig. 2. Carbon and gold-based SPE for comparison of CV and SWV voltammograms [3].

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