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Morphology and atomic configuration control of heavy metal attraction modified layer on screen-printed electrode to enhance electrochemical sensing performance

Abstract

The sensitivity of screen-printed electrochemical (SPE) sensors is heavily dependent on the selection of appropriate modifiers that can optimize the chemical (functional ligands, surface charge, binding energy) and physical (morphological structure) properties of the sensor surface. This study aimed to investigate the impact of these chemical and physical factors on the sensitivity of modified SPEs for the detection of lead and cadmium. The study employed anodic stripping voltammetry to evaluate the sensing performance of SPEs modified with different modifiers, including cellulose acetate, chitosan, Nafion, nylon-6, and silver nanoparticles. Results showed that metal-attracting functional groups and surface charged electrode were the dominant factors affecting the sensitivity of SPEs in heavy metal sensing. Specifically, negatively charged electrode surfaces and metal-attracting -SO32- ligands, as found in Nafion-modified SPE, were identified as the key factors in improving sensor selectivity, rather than the rough physical morphology of the SPE, which was believed to provide more metal detection sites. This conclusion was supported by the combination analyses of electrochemical impedance spectroscopy, electrochemically active surface area and computational molecular binding energy of bare and modified SPEs. The findings of this study provide valuable insights for selecting appropriate SPE modifiers and designing sensor architectures for heavy metal detection.

Keywords

Electrochemical sensor; Electrode modification; Heavy metals; Screen-printed electrode; Stripping voltammetry