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Voltammetric Determination of Hg^{2+}, Zn^{2+}, and Pb^{2+} Ions Using a PEDOT/NTA-Modified Electrode

Jasim M. S. Alshawi, Mohammed Q. Mohammed,* Hasan F. Alesary,* Hani K. Ismail, and Stephen Barton

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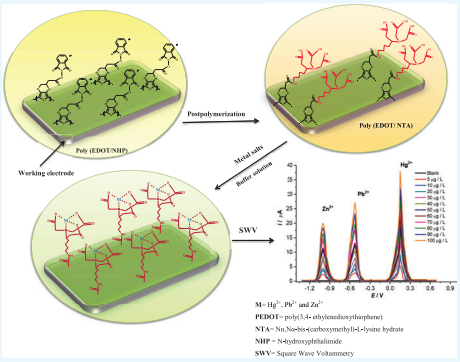
ABSTRACT: A novel electrochemical sensor for determining trace levels of Hg^{2+}, Pb^{2+}, and Zn^{2+} ions in water using square wave voltammetry (SWV) is reported. The sensor is based on a platinum electrode (Pt) modified by poly(3,4-ethylenedioxythiophene) and N_{α},N_{α}-bis-(carboxymethyl)-L-lysine hydrate (NTA lysine) PEDOT/NTA. The modified electrode surface (PEDOT/NTA) was prepared via the introduction of the lysine-NTA group to a PEDOT/N-hydroxyphthalimide NHP electrode. The (PEDOT/NTA) was characterized via cyclic voltammetry (CV), Fourier transform infrared (FTIR) spectroscopy, and scanning electron microscopy (SEM). The effects of scan rates on the electrochemical properties of the polymer electrode were also investigated. The electrochemical results were used to estimate the coverage of the electrode polymer surface and its electrostability in background electrolyte solutions. Several analytical parameters, such as polymer film thickness, metal deposition time, and pH of the electrolyte, were examined. Linear responses to Hg^{2+}, Pb^{2+}, and Zn^{2+} ions in the concentration range of 5−100 μg L^{-1} were obtained. The limits of detection (LODs) for the determination of Hg^{2+}, Pb^{2+}, and Zn^{2+} ions were 1.73, 2.33, and 1.99 μg L^{-1}, respectively. These promising results revealed that modified PEDOT/NTA films might well represent an important addition to existing electrochemical sensor technologies.



1. INTRODUCTION

Environmental contamination from metals such as zinc, cadmium, lead, copper, cobalt, nickel, and mercury is a serious concern even at trace concentrations,[1−3] requiring the development of sensitive, selective, and accurate analytical methods to monitor such species.[4] To date, many diverse techniques have been used for their detection, such as absorption,[5] emission,[6] fluorescence spectrometry,[7] optical techniques, atomic absorption,[8] and electrochemical technologies.[9−11] Electroanalytical methods are considered an efficient means of detecting a broad range of organic, inorganic, and heavy-metal ions because of their high accuracy, adaptability, sensitivity, rapid responses, and the fact that they are relatively inexpensive.[12−14]

Accumulation of these heavy metals can lead to serious damage to organs such as the liver and kidneys and further to conditions such as anemia, respiratory disorders, cancers, lung damage, digestive issues, and osteomalacia.[15] World organizations like the WHO state that the highest allowable concentrations of Hg^{2+}, Pb^{2+}, and Zn^{2+} in terms of human exposure are 1, 50, and 5000 μg L^{-1}, respectively.[16−18] Environmental monitoring has become an important issue over recent years as a result of increased public awareness and concern about pollution. This has driven the need to develop sensory tools that are sensitive, selective, portable, and inexpensive. The efficiency of electroactive polymers in this regard has been demonstrated in a number of areas, such as conductometric, potentiometric, amperometric, and chemical sensors.[19,20]

The detection of metal ions using conducting polymers can be improved by modification of electrode surfaces through various chemical methods and functionalization techniques.[23,24] When functional groups are sited on a polymer surface, they can perform various functions such as catalysis, sensing, and chemiluminescence.[21] Furthermore, functionalized surfaces have the smart ability to change their physical and chemical structures on exposure to specific stimuli.[22] This study has focused on the detection of Hg^{2+}, Pb^{2+}, and Zn^{2+} ions using a novel electrochemical sensor based on the modification of polymer electrodes with high sensitivity.[25] The fine-tuning of the chemoanalytical features of polymer electrodes to facilitate interaction with particular analyte species can be accomplished via the introduction of specific

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