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ORIGINAL PAPER

Use of a Schiff base-modified conducting polymer electrode for electrochemical assay of Cd(II) and Pb(II) ions by square wave voltammetry

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Abstract
The work herein describes the electrochemical detection of heavy metal ions, specifically cadmium and lead. The introduction and modification of functional groups such as Schiff bases leads to an enhanced sensitivity of the electrode to analytes. In this study, a platinum electrode has, for the first time, been modified with poly(3,4-ethylenedioxythiophene) (PEDOT/Schiff base) in CH_2Cl_2 containing Bu_4NPF_6 to detect cadmium(II) and lead(II) ions. The structures and morphologies of the polymer coatings were characterised via Fourier transform infrared spectroscopy and scanning electron microscopy, respectively. The electrochemical synthesis and redox state response in monomer-free synthesised films have been studied via cyclic voltammetry. Moreover, the effect of scan rate on the electrochemical behaviour of the modified electrodes was also studied. The voltammetric findings have been used to calculate the surface coverage required for the polymer films and the stability of polymer electrodes in the monomer-free solutions. Square wave voltammetry was applied for the determination of cadmium(II) and lead(II) ion concentrations and to assess the effects of pH on aqueous samples. The limits of detection for the modified electrode for cadmium(II) and lead(II) were found to be 0.95 μg L^{-1} and 1.84 μg L^{-1}, respectively. These findings revealed that modified films can be considered good candidates for application in electrochemical detection devices.

Keywords Square wave voltammetry · Electrochemical detection · Conducting polymers · Modified electrode poly(3,4-ethylenedioxythiophene) · Schiff base

Introduction

Globally, the pollution of the planet is one of most vital problems mankind faces because of the widespread and critical damage such pollution can cause (Intarakamhang et al. 2013; Huang et al. 2016). Heavy metal ions like Cu, Hg, Zn, Pb, Ni, and Cd are considered toxic even in extremely low concentrations (Morante-Zarcero et al. 2015). These metal ions can cause significant harm and damage in human organs such as the kidneys, liver, brain, and the lungs and respiratory system (Lu et al. 2018). Recently, contamination from heavy metals has become a significant problem as a result of the rapid development of industrial activities (Muralikrishna et al. 2017). Contamination of the environment, especially with cadmium(II) and lead(II) ions, poses a real danger to human health because these ions are toxic, non-biodegradable, and accumulate in the body over time (Yao et al. 2019). According to World Health Organisation (WHO), the maximum permitted concentrations of cadmium(II) and lead(II) in drinking water are 5 μg L^{-1} and 50 μg L^{-1}, respectively (Gumpu et al. 2015); thus, it becomes necessary to find fast, sensitive, and selective methods for the detection of cadmium and lead in various sample types. There have been several reports of electrochemical methods used to detect cadmium(II) and lead(II) (Xu et al. 2019), and these methods have many positive features compared with other techniques

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