



Selective electrochemical sensor based on the electropolymerized *p*-coumaric acid for the direct determination of L-cysteine



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ABSTRACT

Novel electrochemical sensor based on poly(*p*-coumaric acid) electrodeposited on the surface of multi-walled carbon nanotubes modified glassy carbon electrode (poly(*p*-coumaric acid)/MWNT/GCE) has been developed for the direct determination of L-cysteine. Poly(*p*-coumaric acid) has been obtained by potentiodynamic electrolysis under the optimized conditions (0.10 mM *p*-coumaric acid in 0.1 M NaOH using 5 cycles in the potential window of 0–1.0 V and the scan rate of 25 mV s⁻¹) providing highest voltammetric response of L-cysteine. Sensor surface has been studied by scanning electron microscopy (SEM), cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). The porous structure of polymeric film provides 6.9-fold increase in effective surface area and 4.2-fold lower charge transfer resistance in comparison to GCE. Under conditions of DPV, the sensor response is linear in the ranges of 7.5–50 and 50–1000 μM of L-cysteine with the detection and quantification limits of 1.1 and 3.6 μM, respectively. The excellent sensor selectivity to L-cysteine in the presence of glucose, uric and ascorbic acids, dopamine, L-tyrosine and S-containing substances (homocysteine, glutathione, L-methionine, L-cystine and α-lipoic acid) has been observed. Applicability of the sensor to real samples analysis has been shown on example of human urine.

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1. Introduction

L-cysteine is one of the S-containing amino acids playing an important role in living systems. It participates in synthesis of proteins and affects on their functionality and bioactivity [1]. L-cysteine is also one of the endogenous components of the antioxidant defense system of cells protecting them from the harmful effect of free radicals and preventing oxidative stress [2]. L-cysteine is considered as essential biomarker since its health effect depends on the concentration. The low concentrations of L-cysteine can lead to heart diseases, hair depigmentation, liver damage while high concentrations causes L-cystinuria and one of the pathogenetic factors of Parkinson's disease and acquired immune deficiency syndrome [3]. Thus, control of L-cysteine contents in biological fluids is required for the human health monitoring.

A wide range of methods for the L-cysteine quantification has been developed including chromatography with UV- [4,5], mass-spectrometric [6] and electrochemical [7,8] detection, colorimetry [3], spectrophotometry based on surface plasmon resonance [9],

capillary zone electrophoresis [10] and chemiluminescence [11]. L-cysteine is electrochemically active molecule due to the presence of thiol group that allows application of voltammetry for the analytical purposes. But the absence of L-cysteine voltammetric response or very weak signal at high overpotential have been usually observed on traditional electrodes [12,13]. These limitations have been overcome using stripping voltammetry of the product of L-cysteine chemical reaction with appropriate reagent (Cu-Cysteine complex [14], 1,4-Michael addition reaction with electrogenerated *o*-quinone [15]) or chemically modified electrodes based on the carbon nanomaterials [13,16,17], metal and metal oxide nanoparticles [18–20] including core-shell type structures [21], nanosized redox mediators [12,22–24] and their different combinations [25–29]. Taking into account high affinity of thiol group towards heavy metals, the majority of the electrochemical sensor was based on the Au nanoparticles [30–33] as sensitive layer providing accumulation and retention of L-cysteine on the electrode surface and, therefore, high sensitivity of the determination. Another way of electrode surface modification is based on the formation of polymeric films. In application to L-cysteine, this approach did not get enough attention although combination of polymers with Au nanoparticles [32–34] and CuGeO₃ nanowire [35] has been described. There is

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