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ORIGINAL PAPER

Fast and sensitive determination of captopril by voltammetric method using ferrocenedicarboxylic acid modified carbon paste electrode

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Abstract A ferrocenedicarboxylic acid modified carbon paste electrode was constructed and used as a fast and sensitive tool for the determination of captopril at trace level. It has been shown by direct current cyclic voltammetry and double step chronoamperometry that ferrocenedicarboxylic acid can catalyze the oxidation of captopril in aqueous buffer solution and produces a sharp oxidation peak current at about +0.49 vs. Ag/AgCl reference electrode. The square wave voltammetric peak currents of the electrode increased linearly with the corresponding captopril concentration in the range of 3.0×10^{-7}–1.4×10^{-4}M with a detection limit of 9.1×10^{-8} M. The influence of pH and potential interfering substances on the determination of captopril were studied. Electrochemical impedance spectroscopy was used to study the charge transfer properties at the electrode–solution interface. Finally, the sensor was examined as a selective, simple, and precise new electrochemical sensor for the determination of captopril in real samples, such as drug and urine, with satisfactory results.

Keywords Ferrocenedicarboxylic acid · Captopril · Electrocatalysis · Carbon paste electrode

Introduction

Captopril, 1-(3-mercapto-2-D-methyl-1-oxopropyl) proline (Scheme 1), an orally active inhibitor of the angiotensin-converting enzyme (ACE), has been widely used for the treatment of hypertensive diseases [1], alone or in combination with other drugs. This thiol drug can also be used to moderate heart failure [2]. It is also sometimes prescribed for angina pectoris (crushing chest pain), Raynaud's phenomenon (a disorder of the blood vessels that causes the fingers to turn white when exposed to cold) and rheumatoid arthritis [3]. Unfortunately, administering captopril for therapeutic purposes leads to undesirable side effects. Preliminary research has indicated significant loss of zinc in urine due to the intake of captopril [4]. Therefore, the determination of this compound is very important.

Several methods have been proposed for the determination of captopril including high-performance liquid chromatography with pre- or post-column derivatization [6–11], colorimetry [5, 12], fluorimetry [13–15], chemiluminescence [16–18], capillary electrophoresis [19–22], and spectrophotometry [23–27]. Electrochemical methods, including amperometry [28] using carbon paste electrode (limit of detection >0.015 μM), differential pulse voltammetry using modified carbon paste electrode (limit of detection >1.1 μM) [29], cathodic stripping voltammetry using Hg electrode (limit of detection >0.5 μM) [30, 31], square wave voltammetry using Hg electrode (limit of detection >0.3 μM) [32], and cyclic voltammetry using boron-doped diamond thin film electrode (limit of detection >25 μM) [33] have been used for captopril determination. Mercury electrode is one of the most widely used electrodes for the voltammetric determination of captopril [30–33]. However, this electrode is poisonous and environmentally is not safe to use.

In this study, we describe the use of ferrocenedicarboxylic acid as a suitable mediator for the electrooxidation of captopril in aqueous media and then as a sensitive and fast tool for captopril determination in pharmaceuticals and urine samples. Also, the suitability of the ferrocenedicarboxylic acid modified carbon paste electrode (FDCMCPE)

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