Colloids and Surfaces B: Biointerfaces 83 (2011) 133–138

Contents lists available at ScienceDirect

Colloids and Surfaces B: Biointerfaces

journal homepage: www.elsevier.com/locate/colsurfb

Electro-oxidation and determination of antihistamine drug, cetirizine dihydrochloride at glassy carbon electrode modified with multi-walled carbon nanotubes

Roopa H. Patil, Rajesh N. Hegde, Sharanappa T. Nandibewoor*

P. G. Department of Studies in Chemistry, Karnatak University, Pavate Nagar, Dharwad-580 003, Karnataka, India

ARTICLE INFO

Article history:
Received 19 June 2010
Received in revised form 29 October 2010
Accepted 9 November 2010
Available online 16 November 2010

Keywords:
Cetirizine dihydrochloride
Multi-walled carbon nanotubes
Voltammetric determination
Modified electrode

ABSTRACT

A multi-walled carbon nanotube (MWCNT) film-modified glassy carbon electrode (GCE) was constructed for the determination of an antihistamine drug, cetirizine dihydrochloride (CTZH) using cyclic voltammetry (CV). Owing to the unique structure and extraordinary properties of MWCNT, the MWCNT film has shown an obvious electrocatalytic activity towards oxidation of CTZH, since it facilitates the electron transfer and significantly enhances the oxidation peak current of CTZH. All experimental parameters have been optimized. Under the optimum conditions, the oxidation peak current was linearly proportional to the concentration of CTZH in the range from 5.0×10^{-7} to 1.0×10^{-5} M. The detection limit was 7.07×10^{-8} M with 180 s accumulation. Finally, the proposed sensitive and simple electrochemical method was successfully applied to CTZH determination in pharmaceutical and urine samples.

1. Introduction

Drug analysis is one of the important tools for drug quality control. Therefore, the development of simple, sensitive, rapid and reliable method for the determination of drug is of great importance. Cetirizine dihydrochloride ([2-[4-[(4-chlorophenyl)phenylmethyl]-piperazin-1-yl]ethoxy] acetic acid, dihydrochloride) (CTZH) (Fig. 1) is an active metabolite of hydroxyzine, a first generation H1-receptor antagonist [1]. Marked affinity of cetirizine for peripheral histamine H1 receptors results in anti-allergic properties, but has the advantage that it lacks the CNS depressant effects often encountered in anti-histamines [2]. The pK_a values of CTZH as a basic compound with three ionizable groups, the carboxylic group, the tertiary amine group and the nitrogen heterocyclic group are 2.2, 2.9 and 8.0 respectively [3]. It is used for the treatment of seasonal and perennial allergetic rhinitis and chronic urticaria [4].

Literature survey reveals that various analytical methods have been reported in literature for determination of CTZH in its pharmaceutical preparations. These include gas chromatography [5], ion-selective electrode [6], fluorimetry [7], high-performance thin-layer chromatography [8], liquid chromatography [9], titration [10], calorimetry [11], high-performance liquid chromatography [12], spectrophotometry [13] and potentiometric methods [14]. Most of the reported methods require sample pretreatment and extraction of the drug prior to the analysis. These methods are time consuming, intensive solvent-usage and require expensive devices and maintenance. Apparently, there is a need for the development of highly selective, low-cost, stable, and facile CTZH sensors for complex matrixes of pharmaceuticals and industrial fields.

Electrochemical detection of analyte is a very elegant method in analytical chemistry [15]. The interest in developing electrochemical-sensing devices for use in environmental monitoring, clinical assays or process control is growing rapidly. Electrochemical sensors satisfy many of the requirements for such tasks particularly owing to their inherent specificity, rapid response, sensitivity and simplicity of preparation for the determination of organic molecules, including drugs and related molecules in pharmaceutical dosage forms and biological fluids [16,17]. Carbon electrodes, especially glassy and paste electrodes are widely used in electrochemical investigations. Till date there is only one report on electro-oxidation of CTZH with glassy carbon electrode [18].

Electrochemical sensors based on carbon nanotubes (CNTs) represent a new and interesting alternative for quantification of different analytes. There are reports on the synthesis of multi-walled carbon nanotubes (MWCNTs) [19] and single-walled carbon nanotubes (SWCNTs) [20]. These materials have attracted enormous interest because of their unique structural, mechanical, electronic and chemical properties [21]. Some of these properties include high chemical and thermal stability, high elasticity, high tensile strength and in some instances, metallic conductivity. The subtle

* Corresponding author. Tel.: +91 836 2770524; fax: +91 836 2747884.
E-mail address: stnandibewoor@yahoo.com (S.T. Nandibewoor).

0927-7765/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.colsurfb.2010.11.008

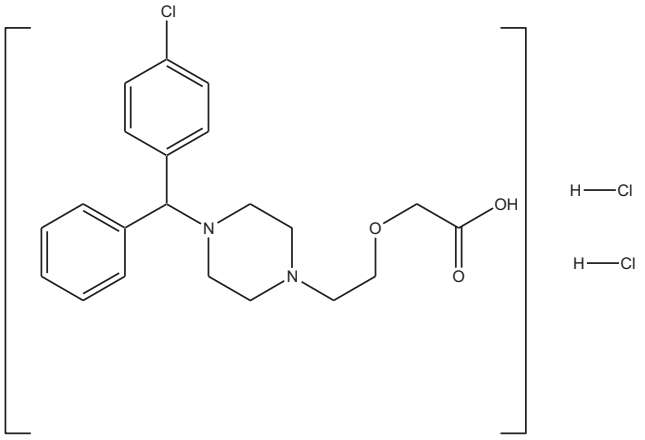

Fig. 1. Chemical structure of cetirizine dihydrochloride.

electronic properties suggest that CNTs have capability to promote electron transfer reactions and improve sensitivity in electrochemistry and thus they are widely used as electrodes [22]. CNT modified electrodes have been proved to have excellent electroanalytical properties, such as wide potential window, low background current, low detection limits, high sensitivities, reduction of over potentials and resistance to surface fouling. There are reports which reveal that CNT modified electrodes have shown electrocatalytic behavior [23–25] with excellent performance in the study of a number of biological species [26].

To the best of our knowledge, there is no report on the electro-oxidation and determination of CTZH at glassy carbon electrode (GCE) modified with MWCNTs. The objective of the present work is to develop a convenient and sensitive electroanalytical method for the determination of CTZH based on the unique properties of MWCNT modified electrode. Here we report the electro-oxidation of CTZH by cyclic voltammetric method at GCE modified with MWCNTs. The ability of the modified electrode for voltammetric response of CTZH was evaluated. The experimental results showed that the oxidation peak current of CTZH was found to increase to a greater extent for GCE modified with MWCNTs than that of bare GCE. We optimized all the experimental parameters for the determination of CTZH and developed an electroanalytical method for its determination. The modified electrode was also tested for the analysis of CTZH in pharmaceutical and urine samples. The resultant biosensor exhibits high sensitivity, rapid response, good reproducibility and it is independent from other potentially interfering species.

2. Experimental

2.1. Apparatus

Electrochemical measurements were carried out on a CHI1110A electrochemical analyzer coupled with a conventional three-electrode cell (CH Instrument Company, USA). A three-electrode cell was used with a Ag/AgCl as reference electrode, Pt wire as counter electrode and a bare GCE of diameter 3 mm as working electrode, respectively. pH measurements were performed with Elico LI120 pH meter (Elico Ltd., India). All the potentials are given against the Ag/AgCl (3 M KCl).

2.2. Reagents

CTZH was obtained from Dr Reddy's Laboratory, India, and used without further purification. A stock solution of CTZH (1.0×10^{-3} M) was prepared in doubly distilled water. Multi-walled carbon nanotubes were purchased from Sigma–Aldrich (>90%, O.D.: 10–15 nm, I.D.: 2–6 nm, length: 0.1–10 μM). Phosphate buffer solutions (Ionic strength = 0.2 M) were prepared according to the reported method [27]. The tablets containing CTZH (Zyncet, Unichem Lab. Ltd, India) were purchased from a local pharmacy. All other reagents used were of analytical grade and their solutions were prepared with doubly distilled water.

2.3. Preparation of MWCNT modified electrode

MWCNTs were refluxed in the mixture of concentrated H_2SO_4 and HNO_3 for 4–5 h, then washed with doubly distilled water and dried in vacuum under ambient conditions. The MWCNT suspension was prepared by dispersing 10 mg of MWCNTs in 10 ml acetonitrile using ultrasonic agitation to obtain a relatively stable suspension. The GCE was carefully polished with 0.30 and 0.05 μM α-alumina slurry on a polishing cloth, and then washed in an ultrasonic bath of methanol and water, respectively. The cleaned GCE was coated by casting 40 μl of the black suspension of MWCNTs and dried in air. The surface areas of the MWCNT-modified GCE and the bare GCE were obtained by cyclic voltammetry using 1.0×10^{-3} M $K_3Fe(CN)_6$ as a probe at different scan rates. For a reversible process, the Randles–Sevcik formula [28] has been used, which is as given below,

$$I_{pa} = (2.69 \times 10^5) n^{3/2} A D_o^{1/2} C_o^* \upsilon^{1/2} \quad (1)$$

where I_{pa} refers to the anodic peak current, n is the number of electrons transferred, A is the surface area of the electrode, D_o is diffusion coefficient, υ is the scan rate and C_o^* is the concentration of $K_3Fe(CN)_6$. For 1.0×10^{-3} M $K_3Fe(CN)_6$ in 0.1 M KCl electrolyte, $n = 1$, $D_o = 7.6 \times 10^{-6}$ cm^2 s^{-1}, then from the plot of I_{pa} vs $\upsilon^{1/2}$, the electroactive area was calculated. In bare GCE, the electrode surface area was found to be 0.04822 cm^2 and for MWCNT-modified GCE, the surface was nearly 3.0 times greater than that of bare GCE.

2.4. Analytical procedure

The MWCNT-modified GCE was activated in the potential range 0–1.60 V in presence of phosphate buffer (pH 3.0, Ionic strength = 0.2 M) until stable cyclic voltammograms were obtained. Then electrodes were transferred into another cell of phosphate buffer (pH 3.0, Ionic strength = 0.2 M) containing proper amount of CTZH. After accumulating for 180 s at open circuit under stirring and following quiet for 10 s, potential scan was initiated and cyclic voltammograms were recorded between 0.60 and 1.40 V, with a scan rate of 50 mV s^{-1}. All measurements were carried out at room temperature of 25 ± 0.1 °C.

2.5. Sample preparation

Ten pieces of CTZH tablets were powdered in a mortar. A portion equivalent to a stock solution of a concentration of about 1.0×10^{-3} M was accurately weighed and transferred into a 100 ml calibrated flask and diluted with water and was followed by sonication for 10 min for complete dissolution. Appropriate solutions were prepared by taking suitable aliquots of the clear supernatant liquid and diluting them with the phosphate buffer solutions. Each solution was transferred to the voltammetric cell and analyzed by standard addition method. The parameters for cyclic voltammetry were set at sample interval 0.001 V and scan rate of 50 mV s^{-1}. The cyclic voltammograms were recorded between 0.60 and 1.40 V after open-circuit accumulation for 180 s under stirring. The oxidation peak current of CTZH was measured. To study the accuracy of the proposed method and to check the interferences from excipients used in the dosage form, recovery experiments were carried