Journal of Electroanalytical Chemistry 738 (2015) 188–194

Contents lists available at ScienceDirect

Journal of Electroanalytical Chemistry

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

Electroanalytical application of a boron-doped diamond electrode: Improving the simultaneous voltammetric determination of amlodipine and valsartan in urine and combined dosage forms

Guilherme Roberto Mansano, Ana Paula Pires Eisele, Luiz Henrique Dall'Antonia, Sabrina Afonso, Elen Romão Sartori *

Universidade Estadual de Londrina (UEL), Centro de Ciências Exatas, Departamento de Química, Rodovia Celso Garcia Cid, PR 445 Km 380, Londrina – PR, C.P. 10.011, 86057-970, Brazil

ARTICLE INFO

Article history:
Received 28 August 2014
Received in revised form 15 November 2014
Accepted 19 November 2014
Available online 27 November 2014

Keywords:
Amlodipine determination
Antihypertensive
Diamond electrode
Valsartan determination
Voltammetry

ABSTRACT

A new voltammetric method was developed for simultaneous determination of amlodipine (AML) and valsartan (VAL) in synthetic urine and combined pharmaceutical formulations. The anodic peak potentials of AML and VAL oxidation at a cathodically pretreated boron-doped diamond electrode were found to be 0.791 V and 1.37 V (vs. Ag/AgCl (3.0 mol L^{-1} KCl)), respectively, by cyclic voltammetry, in Britton–Robinson buffer solution (pH 5.0). Using square-wave voltammetry, the obtained analytical curves were linear in the AML and VAL concentration range from 0.497–28.0 μmol L^{-1} and 19.8–280 μmol L^{-1} with detection limits of 0.0764 μmol L^{-1} and 0.193 μmol L^{-1}, respectively. The proposed method was successfully applied in the simultaneous determination of AML and VAL in various combined dosage forms available in the market, with results similar to those obtained using a comparative chromatography method. Additionally, adequate recovery results were obtained for the simultaneous determination of AML and VAL in synthetic urine sample. Due to its adequate linearity, the proposed method could be a good alternative for simultaneous determination of AML and VAL in all the different dosages available in the market, even in synthetic urine sample.

1. Introduction

Hypertension is the most prevalent disease in adult population. Most of this hypertensive population requires treatment with antihypertensive agents, as example, amlodipine besylate (AML) and valsartan (VAL).

AML and VAL comprise two effective antihypertensive agents with complementary mechanisms of action. Amlodipine besylate (3-ethyl 5-methyl 2-[(2-aminoethoxy)methyl]-4-(2-chlorophenyl)-6-methyl-1,4-dihydropyridine-3,5-dicarboxylate) is a calcium channel blockers and valsartan (3-methyl-2-[pentanoyl-[[4-[2-(2H-tetrazol-5-yl)phenyl]phenyl]methyl]amino]butanoic acid) is an angiotensin II receptor antagonists [1]. These compounds are formulated together in commercial tablets or capsules in different dosages as oral antihypertensive medication for patients whose high blood pressure is not adequately controlled on either component monotherapy [2]. When ingested, more than 80% of orally administered of each drug is absorbed, and most of these adsorbed drugs are excreted via the kidney (10–15% of it unchanged) [1]. Hence, because AML and VAL are an antihypertensive combination of great pharmacological significance, controlling its content in commercial formulations is important, even vital for patients' health during treatment. Consequently, the development of a simple and selective analytical method for simultaneous identification and determination of AML and VAL in biological and pharmaceutical samples is highly desirable, especially for quality control in routine analysis.

Several analytical methods to determine simultaneously AML and VAL in pharmaceutical formulations and biological fluids have been reported in the literature, including those capillary electrophoresis [3], chromatography [4–10], spectrofluorimetry [11], and spectrophotometry [12,13]. Some of these methods, such as chromatography and spectrophotometry, require a prior separation steps and tedious analytical process during analysis, the use of organic solvents, thereby generating high amounts of waste, time-consuming derivatization steps and high implementation costs, thus justifying the need for reliable, low cost and simpler methods.

Electroanalytical methods are increasingly being used in the determination of a wide range of compound of pharmaceutical

* Corresponding author. Tel.: +55 43 3371 4811; fax: +55 43 3371 4286.
E-mail address: elensartori@uel.br (E.R. Sartori).

http://dx.doi.org/10.1016/j.jelechem.2014.11.034
1572-6657/

interest. They represent the useful alternative methods widely applied in analysis of pharmaceuticals, because it involving operation simplicity, low-cost instrumentation, high sensitivity and rapidity of data acquisition, and there is also the possibility of analysis of colored or solutions with suspended solids. In this way, electrochemical methods have been sufficiently used in combination with boron-doped diamond (BDD) electrode for the development of analytical procedures for pharmaceutical compounds, as evidenced by studies reported in scientific literature in the last decade [14–25]. BDD electrode is particularly attractive in electroanalytical applications for pharmaceutical compounds due to wide working potential window in aqueous solutions, which allows for the quantification of electroactive species without the interference of water decomposition, long term stability, inertness of the surface to adsorption of reaction products, good resistance to passivation, high chemical stability, lower residual current, and low sensitivity to dissolved oxygen [15,27–29]. So far, to the best of our knowledge, a simultaneous electrochemical determination of AML and VAL on this respective electrode material has not been previously described in the literature.

Some analytical voltammetric procedures were developed for the individual determination of AML in pharmaceutical and biological samples [24,30–33]. Recently, Švorc et al. [24] employed a BDD electrode to quantification of AML in tablets and biological samples using differential-pulse voltammetry (DPV), with a good repeatability. Kazemipour et al. [30] determined AML in some commercial products using a carbon paste electrode by means of anodic stripping voltammetry. Gazy [31] used a GC electrode to adsorptive square-wave anodic stripping voltammetric determination of AML in pharmaceutical and biological samples. These authors emphasize the adsorption nature of the AML at the GC electrode surface, which it was a form base for the electroanalytical determination of this antihypertensive. Altiokka et al. [32] developed a voltammetric procedure to determination of AML in pharmaceutical formulations using a GC electrode under rotating conditions by the DPV. Goyal and Bishnoi [33] used a single- and multi-walled carbon nanotubes modified edge plane pyrolytic graphite (EPPG) electrodes to square-wave voltammetric determination of AML.

Few methods have been described for the voltammetric determination of VAL in pharmaceutical and biological samples. Mercury film electrode (MFE) [34], hanging mercury drop electrode (HMDE) [35], and GCE [36] have been employed for individual determination of this antihypertensive.

A literature survey reveals that there is only one voltammetric method related in the literature for simultaneous voltammetric determination of AML and VAL. Erden et al. [37] used a GC electrode for a development of simultaneous determination of AML and VAL in pharmaceutical and biological samples. This method presents a linear concentration range of 1.0–35.0 μmol L^{-1} for AML and 1.5–32.0 μmol L^{-1} for VAL, with LOD of 0.31 μmol L^{-1} and 0.36 μmol L^{-1}, respectively, exploring differential-pulse voltammetry. A high relative standard deviation (RSD) was obtained in precision studies (inter- and intra-day repeatability) for AML. The linearity of the analytical curves obtained by these authors do not allows the simultaneous quantification of AML and VAL in different combined dosage forms available in market, such as in amlodipine:valsartan capsules labeled 5:320 mg, underscoring the importance of this work for publication.

In this work, we report on the evaluation of cathodically pretreated BDD electrode on the development of a novel electroanalytical method for the simultaneous determination of AML and VAL by square-wave voltammetry (SWV). The proposed method is simple, selective, precise, rapid and accurate for simultaneous quantitative determination of AML and VAL in different samples (pharmaceutical and synthetic urine) with minimal sample pretreatment. Excellent inter- and intra-day repeatability was obtained using this electrode, without adsorption effects of reaction intermediates and products on the BDD surface and no need for renewal of the electrode surface was observed after each measurement.

2. Experimental

2.1. Reagents and solutions

Amlodipine (as besylate), valsartan, and sulfuric acid were purchased from Sigma–Aldrich; boric acid, acetic acid, orthophosphoric acid, sodium hydroxide, and ethanol were acquired from Synth; acetonitrile and methanol, grade HPLC, were purchased from LiChrosolv®. All solutions were prepared with ultra-purified water supplied by a Milli-Q system (Millipore®) with resistivity greater than 18 MΩ cm.

Combined dosage forms samples used in this study were: AML:-VAL capsules labeled 6.9:80 mg, 13.8:160 mg, and 6.9:320 mg, which AML 6.9 mg and 13.8 mg is equivalent for 5 mg and 10 mg of amlodipine base per capsule, respectively. These samples were purchased from local drugstore in city of Londrina, state of Paraná, in Brazil.

Stock solutions of AML and VAL at concentration of 10 mmol L^{-1} were daily prepared in ethanol. Both AML and VAL working solutions were prepared by dilution of these stock solutions with a Britton–Robinson (BR) buffer solution (pH 5.0). This BR buffer solution was used as supporting electrolyte for all experiments. It was prepared by mixing 0.04 mol L^{-1} acetic, orthophosphoric, and boric acid solutions; the final pH was adjusted by adding suitable amounts of a 2.0 mol L^{-1} sodium hydroxide solution.

2.2. Apparatus

Voltammetric measurements were carried out using a PalmSens potentiostat/galvanostat controlled with the PalmSens PC software. The pretreatment of the BDD electrode was carried out in a MQPG-01 potentiostat (Microquímica). A three-electrode single-compartment glass cell at room temperature (25.0 ± 0.5 °C) containing a BDD electrode (8000 ppm; Adamant, Switzerland) with geometric area of 0.25 cm^2 as the working electrode, an Ag/AgCl (3.0 mol L^{-1} KCl) reference electrode (which hereinafter all working electrode potentials are referred) and Pt wire as auxiliary electrode. Diamond film was synthesized on a silicon substrate by Hot Filament Chemical Vapor Deposition (HFCVD) technique, where the gaseous phase consisted of methane with excess hydrogen gas and trimethylboron as doping [38]. Prior to the experiments, the BDD electrode was electrochemically pretreated in a 0.5 mol L^{-1} H_2SO_4 solution: first an anodic pretreatment (0.5 A cm^{-2}, 30 s), which was followed by a cathodic one (−0.5 A cm^{-2}, 120 s). With the cathodic pretreatment, the BDD electrode surface is made predominantly hydrogen terminated [39–41].

The pH was measured at 25.0 ± 0.5 °C using a pH-meter (Hanna Instruments), model HI-221, employing a combined glass electrode with an Ag/AgCl (3.0 mol L^{-1} KCl) external reference electrode.

The HPLC determinations of AML and VAL were carried out using a LC Thermo Electron Corporation Finnigan Surveyor PDA Plus and ACE 5 C18 column (250 × 4.6 mm, 5 μm).

2.3. Analytical procedures

Cyclic voltammetry (CV) and SWV were employed to investigate the electrochemical behavior and the quantification of AML and VAL compounds.