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Simultaneous determination of acetaminophen, dopamine and ascorbic acid using a PbS nanoparticles Schiff base-modified carbon paste electrode

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ABSTRACT

A highly sensitive method was investigated for the simultaneous determination of acetaminophen (AC), dopamine (DA), and ascorbic acid (AA) using a PbS nanoparticles Schiff base-modified carbon paste electrode (PSNSB/CPE). Differential pulse voltammetry peak currents of AC, DA and AA increased linearly with their concentrations within the ranges of 3.30×10^{-8}–1.58×10^{-4} M, 5.0×10^{-8}–1.2×10^{-4} M and 2.50×10^{-6}–1.05×10^{-3} M, respectively, and the detection limits for AC, DA and AA were 5.36×10^{-9}, 2.45×10^{-9} and 1.86×10^{-8} M, respectively. The peak potentials recorded in a phosphate buffer solution (PBS) of pH 4.6 were 0.672, 0.390, and 0.168 V (vs Ag/AgCl) for AC, DA and AA, respectively. The modified electrode was used for the determination of AC, DA, and AA simultaneously in real and synthetic samples.

1. Introduction

Acetaminophen, or paracetamol (*N*-acetyl-*p*-aminophenol), is an antipyretic and minor analgesic drug that practically has no anti-inflammatory action [1]. It is non-carcinogenic and an effective substitute for aspirin to be used for the patients who are sensitive to aspirin, and it is safe up to therapeutic doses [2]. However, overdoses will cause liver and kidney damage and finally lead to death [3]. Dopamine [4-(2-aminoethyl) benzene-1,2-diol (DA)], the most significant among the class of catecholamines, plays an important role in the function of the central nervous, cardiovascular, renal and hormonal systems [4]. Insufficient DA concentration due to the loss of DA-producing cells may lead to a disease called Parkinson's disease [5]. Vitamin C or ascorbic acid (AA), a water-soluble vitamin, is widely present in many biological systems and in multivitamin preparations [6]. Ascorbic acid (AA) is very popular for its antioxidant properties, and is present in the human diet as a vital vitamin. Moreover, it is also used for the prevention and treatment of common cold, mental illness, infertility, cancer and AIDS [7]. Ascorbic acid is known for its reductive properties (antioxidant activity). Hence, it represents an important quality indicator that contributes to the antioxidant properties of food [8].

AC, DA and AA are electrochemically active compounds and can be determined by electrochemical techniques [9]. AA has an oxidation potential similar to that of DA. These facts can largely affect the determination of DA in the presence of AA [10]. On the other hand, important drugs, such as AC will interfere with catecholamine measurements in biological samples [2]. Thus, a major problem is that the oxidation peaks of AA and DA appear

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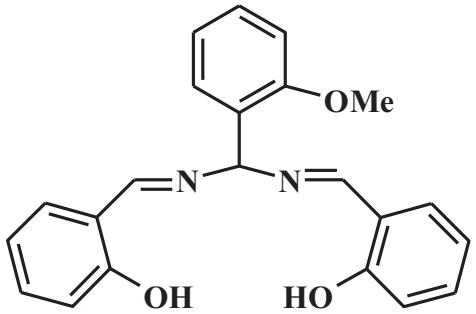
almost at the same potential at an unmodified electrode, resulting in overlapping voltammetric responses and making their discrimination highly difficult. Therefore, electrochemically individual and/or simultaneous determinations of AC, DA and AA on traditional electrodes are very difficult [11]. For this purpose, many attempts have been made with a variety of electrodes for the selective determination of DA in the presence of AA and/or AC [12–18]. He et al. [9] have studied the use of a Cu–zeolite A/graphene-modified glassy carbon electrode for simultaneous electrochemical determination of dopamine and ascorbic acid. Zhang et al. reported that layer-by-layer assembled CNTs modified electrodes have good selectivity to DA in the presence of AA [19]. Yang et al. [20] proposed an AuNPs@polyaniline core–shell nanocomposite-modified electrode for simultaneous electrochemical determination of dopamine and ascorbic acid. Chen and Chzo [21] have studied the simultaneous voltammetric detection of dopamine and ascorbic acid using didodecyl. Tavakkoli et al. have proposed an electrocatalytic determination of AA using a palladium-coated nanoporous gold film electrode [22]. Zare et al. have reported the application of a hematoxylin multi-wall carbon nanotube-modified carbon paste electrode (HMWCNT–CPE) as a chemical sensor for simultaneous determination of DA and AC [23]. A survey of the literature shows that there are only few electrochemical methods for the simultaneous determination of AC, DA and AA. Wang et al. [10] reported the electrocatalytic response for the oxidation of AC on carbon-coated nickel magnetic nanoparticle-modified electrodes and the simultaneous determination of AC, DA, and ascorbic acid.

Carbon paste electrode (CPE) was introduced by Adams in 1958. The ease and speed of preparation, the creation of a new producible surface and the low cost of carbon paste are some advantages of CPEs over other electrodes [24]. In further researches, a wide variety of modifiers has been used with these versatile electrodes [25]. Carbon paste electrodes are convenient conductive



N, N'- bis (salicylidene)-2-methoxyphenyl methanediamine

Fig. 1. Chemical structure of the used Schiff base.

matrixes for preparing chemically modified electrodes (CMEs) by the simple mixing of a graphite/binder paste and a modifier [26]. The modified electrode has good electrocatalytic activity, sensitivity, and selectivity; it has also a low detection limit compared to traditional carbon paste electrodes [27]. Recently, attention has been paid to develop a new generation of modified electrodes involving Schiff bases and nanoparticles due to the unique properties of these materials [17]. Nanoparticles are the most widely employed to prepare CMEs owing to their excellent physical and catalytic properties [28–30].

In the current work, a simple and fast procedure was used for the fabrication of a carbon paste electrode modified with PbS nanoparticles and a Schiff base (Fig. 1) (PSNSB/CPE). The obtained electrode, suitable for the simultaneous determinations of AC, DA and AA by anodic differential pulse voltammetry in phosphate buffer solution as the supporting electrolyte, is described. It is also intended to evaluate this sensor for simultaneous

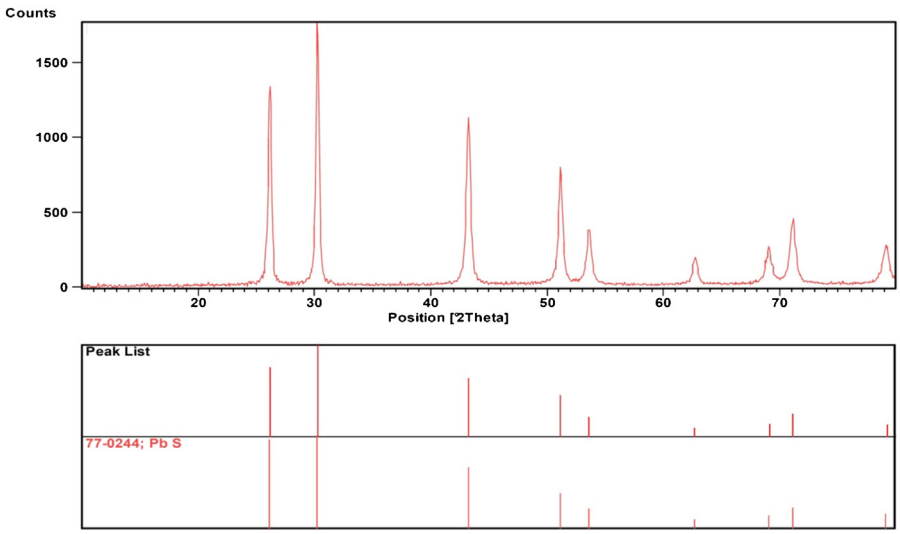


Fig. 2. XRD pattern of the PbS nanoparticles.