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Full Paper

Cyclic Voltammetric Investigations of Dopamine at Poly(Losartan) Modified Carbon Paste Electrode

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Abstract- The poly (losartan) film was prepared on the surface of carbon paste electrode by electrochemical method using cyclic voltammetric technique. The poly(losartan) film modified carbon paste electrode was calibrated with standard potassium ferrocyanide solution in 1 M KCl as supporting electrolyte. The prepared poly(losartan) film coated electrode exhibits excellent electrocatalytic activity towards the detection of dopamine at neutral pH. The effect of scan rate, concentration and pH was studied. The overall process was found to be diffusion-controlled.

Keywords-Losartan, Electropolymerisation, Dopamine, Ascorbic Acid, Cyclic Voltammetry, Modified Carbon Paste Electrode

1. INTRODUCTION

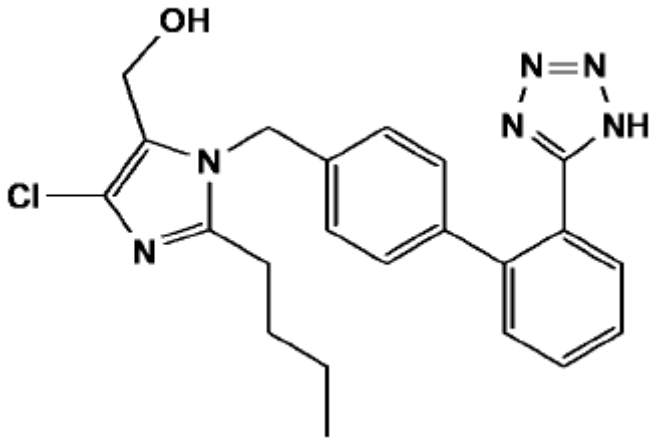
Dopamine (DA) is chemically 3,4-dihydroxyphenylethylamine and belong to a family of catecholamine and it is the most important neurotransmitters and plays a significant role in the functioning of central nervous system. In the brain, dopamine functions as a

neurotransmitter activating the five dopamine receptors D_1, D_2,D_3, D_4, and D_5 and is produced in various areas of the brain such as the substantia nigra and the ventral tegmental area. DA is also a neurohormone released by the hypothalamus. Its main function as a hormone is to inhibit the release of prolactin from the anterior lobe of the pituitary [1]. DA has been shown to be involved in the control of movements, the signaling of error in prediction of reward, motivation, and cognition. Cerebral DA depletion is the hallmark of Parkinson's disease [2]. Other pathological states have also been associated with dopamine dysfunction, such as schizophrenia, autism, and attention deficit hyperactivity disorder, as well as drug abuseTherefore it is significant to develop sensitive and simple methods for the determination of DA. Many methods were introduced to determine DA, such as spectroscopy, chromatography and electrochemistry [3-6]. Since DA is an oxidizable compound it can be easily detectable by electrochemistry methods based on anodic oxidation. [7, 8]. Electrochemical techniques have attracted great interest in many cases and these techniques can be fast in detections, low costs and with merits of low detection limits and high accuracy [9].Carbon paste electrode has very much attracted towards the determination of biologically active molecules, because of easy preparation of modified electrode, renewability, low background current and fast response. A number of modified carbon electrode was developed for the determination of DA by using voltammetric techniques [10-13]. Modified carbon paste electrode can be prepared by adding different types of modifiers. Modification can be done by grinding in an agate mortar [14-16], by electropolymerisation [17-20] and also by immobilization method [21-23]. In recent years polymer modified electrodes have attracted great attention as polymeric film has good stability and reproducibility [24-25]. A number of researchers have employed polymeric film modified electrode to detect DA. So far different methodologies have been used for depositing polymeric films. Electropolymerisation is a good approach to immobilize polymers because adjusting the electrochemical parameters can control film thickners, permeation and charge transport characteristics [26].The modified electrode has good electrocatalytic activity such as sensitivity, selectivity and also low detection limit when compared to traditional carbon paste electrode. Ongera et al studied the simultaneous determination of dopamine in presence of ascorbic acid at electropolymer modified carbon paste electrode [27, 28, 20]. Shreenivas et al carried the detection of DA using poly(gabapentin) modified electrode[29]. Gabriela Broncova et.al used poly (neutral red) modified electrode for determination of citrate in soft drinks [30]. M. Pandurangachar et.al prepared poly (patton’s and reeder’s) film coated carbon paste electrode for simultaneous detection of dopamine [31].

Losartan,(2-butyl-4-chloro-1-{[2'-(1H-tetrazol-5-yl)biphenyl-4-yl]-methyl}-1H-imidazol-5-yl)methanol (Scheme-1). Losartan is an angiotension II receptor blocking drug used mainly in the treatment of hypertension (high blood pressure) [32, 33]. It works by relaxing blood vessels. This helps to lower blood pressure. It is used to treat kidney problems caused by

diabetes (diabetic nephropathy) and also used to decrease the risk of stroke in people who have high blood pressure and a heart condition called left ventricular hypertrophy (enlargement of the walls of the left side of the heart).

In continuation of our research work [34-37] on the development of new electrochemical sensors for the determination of DA. The present work reports the voltammetric behavior of DA at bare and poly(losartan) film modified carbon paste electrode. In comparing with Losartan modified carbon paste electrode, poly (losartan) electrode shows six fold increases in current and as well as potential peak difference (ΔE_p) is 55 mv with respect to losartan chemically modified carbon paste electrode (ΔE_p is 70 mv). This indicates poly (losartan) modified carbon paste electrode shows electrocatalytic activity than chemically modified losartan carbon paste electrode [38].



Scheme 1. Structure of Losartan

2. EXPERIMENTAL

2.1. Reagent and Chemicals

Losartan was obtained as gift sample from AET Labortoreis Pvt Ltd., Hyderabad. Graphite powder (50 micrometer particle size) was purchased from Lobo Chemie and silicon oil was purchased from HIMEDIA. DA stock solution was prepared in 0.1 M perchloric acid ($HClO_4$) solution. The phosphate buffer solution (0.2 M) was prepared using the appropriate mixtures of disodium hydrogen phosphate and sodium dihydrogen phosphate and used as supporting electrolyte in the investigation of DA. Chemicals mentioned above were all purchased from Fluka, were analytical grade and used without purification .

2.2. Apparatus

The electrochemical experiments were carried out using an Electrochemical Workstation (Model CHI660c). All experiments were carried out in a conventional three-electrode system. The electrode system contained a working carbon paste electrode, homemade cavity of 3mm diameter, a platinum wire as counter electrode and saturated calomel electrode as reference electrode.

2.3. Preparation of bare carbon paste electrode

The bare carbon paste electrode was prepared by mixing 70% graphite powder and 30% silicon oil in an agate mortar by hand mixing for about 30 min to get homogenous carbon paste. The paste was packed into the cavity and smoothened on weighing paper .

2.4. Preparation of poly (losartan) film coated carbon paste electrode

The 0.5 mM aqueous losartan was placed in the electrochemical cell along with 0.2 M phosphate buffer solution of pH 10. The CPE was scanned 10 multiple cycles between the potential ranges from −400 mV to 1800 mV at 100 mVs^{-1} scan rate. After this process, the electrode was immersed in 0.2 M phosphate buffer solution of pH 7.0 until use.

3. RESULTS AND DISCUSSIONS

3.1. Electrocatalytic response of DA at poly (losartan) film coated carbon paste electrode

DA being an easily oxidizable catecholamine, its voltammogram was recorded in the potential range from -250 mV to 600 mV with supporting electrolyte 0.2 M phosphate buffer solution of pH 7 at 100 mVs^{-1} scan rate. Fig. 1 showed a pair of redox peak for 5×10^{-5} M DA at bare CPE (dashed line) with E_{pa} at 225 mV and E_{pc} 170 mV (*vs*. SCE) in 0.2 M phosphate buffer solution as supporting electrolyte. The peak to peak separation (ΔE_p) was found to be 55 mV. However, for the poly (losartan) film coated carbon paste electrode a pair of redox peaks is obtained with significant increase in both anodic and cathodic peak current (dotted line). The E_{pa} was located at 216 mV and the corresponding cathodic peak potential was located at 185 mV (*vs*. SCE). The peak-to-peak separation was calculated as 31 mV. The poly (losartan) film coated carbon paste electrode shows no redox peak in the absence of DA (Solid line). This result shows the poly (losartan) film coated carbon paste electrode was not interfering in the detection of DA between the potential windows -250 to 600 mV. The modified electrode shows good electrocatalytic property and the results were compared the previously reported literature [38].

3.2. Effect of Scan rate

The voltammogram showed increase in the both anodic peak current and cathodic peak currents of the DA with increase in scan rate (Fig. 2A) at the poly (losartan) film coated carbon paste electrode. The graph of anodic peak current (I_{pa}) *vs.* square root of scan rate ($\nu^{1/2}$) was plotted and showed linearity with correlation coefficient r^2=0.99699 (Fig. 2B) in the range from 100 mVs^{-1}-450 mVs^{-1}. This indicates that, the electrode transfer reaction was diffusion controlled [19-21, 39].

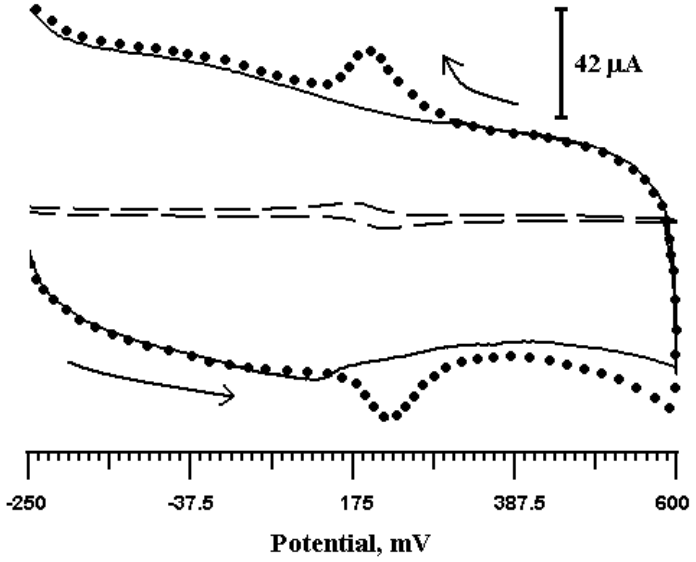


Fig. 1. Cyclic voltammogram of 5×10^{-5}M DA in 0.2 M phosphate buffer solution at pH 7 at bare CPE (dashed line), poly (losartan) film coated carbon paste electrode (dotted line) and without DA (solid line) at 100 mVs^{-1} scan rate

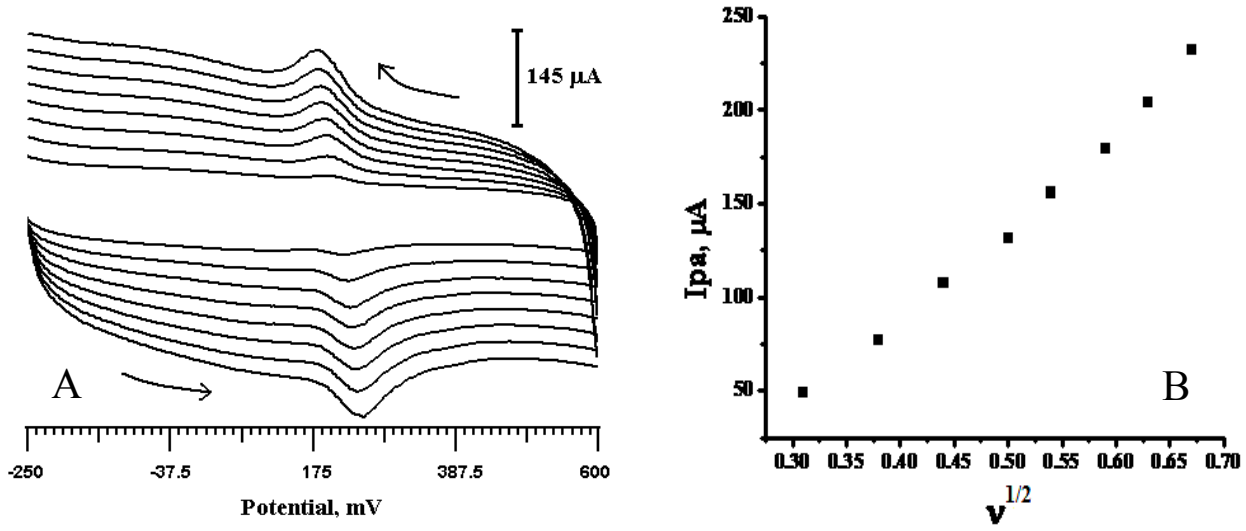


Fig. 2. A) Cyclic voltammogram of 5×10^{-5} M DA in 0.2 M phosphate buffer solution at different scan rate (a-g; 100, 150, 200, 250, 300, 350, 400 and 450 mVs^{-1}) B) Graph of current *vs.* square root of scan rate

3.3. Effect of DA concentration

The electrocatalytic oxidation of DA was carried out by varying the concentration at poly (losartan) film coated carbon paste electrode (Fig. 3A). By increasing the concentration of DA the I_{pa} and I_{pc} also increased from 5×10^{-5} M to 200×10^{-5} M. The graph of I_{pa} *vs.* concentration of DA was plotted and graph shows increase in electrochemical peak current (Fig. 3B).

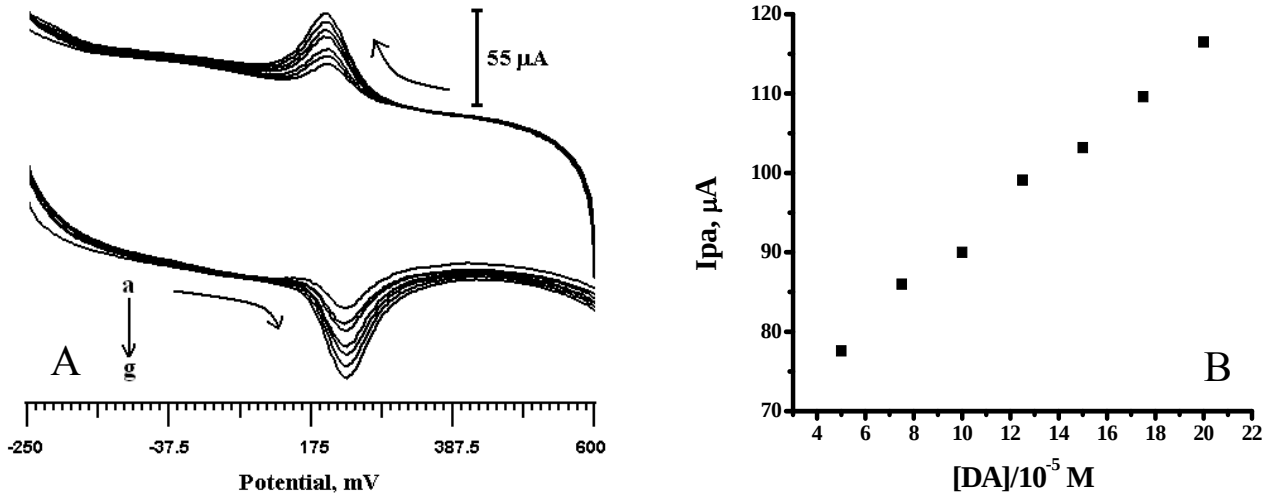


Fig. 3. A) Cyclic voltammogram for different concentration of DA (a) 5×10^{-5} M, (b) 7.5×10^{-5} M, (c) 10.0×10^{-5} M, (d) 12.5×10^{-5} M, (e) 15.0×10^{-5} M, (f) 17.5×10^{-5} M and (g) 20×10^{-5} M at poly (losartan) film coated carbon paste electrode with scan rate 100 mVs^{-1} B) Graph of current *vs.* concentration of DA

3.4. Effect of pH

The effect of pH from 3 to 12 on the electrocatalytic oxidation of dopamine at poly (losartan) film coated carbon paste electrode was studied and the current signals obtained for DA were dependent on pH. However the better shape of the voltammogram of the redox peak was obtained at pH 7. Fig. 4 shows the graph of E_{pa} *vs.* pH and from the graph it was found that the anodic peak potential (E_p) decreased with increase in pH with slope 64.3 mV/pH indicating that equal number of protons and electrons takes part in the reactions [39].

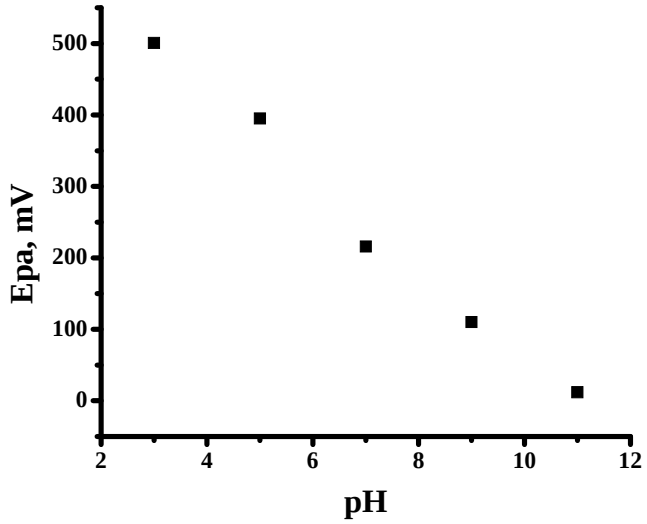


Fig. 4. Graph of E_{pa} *vs.* pH

4. CONCLUSION

In this work, losartan used as the modifier to study the electrochemical response of an interesting neurotransmitter DA by electropolymerising on the surface of carnon paste electrode. The poly (losartan) film coated carbon paste electrode enhanced both anodic and cathodic peak currents. The increase in the concentration of DA and scan rate results in greater the enhancement of electrochemical anodic and cathodic peak currents. Therefore this approach can readily be applied to the development of electrochemical sensors for dopamine and related neurotransmitters.

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