



Tacrolimus and sodium dodecyl sulphate modified carbon paste electrode for Electrochemical determination of dopamine : A Cyclic Voltammetric study

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ABSTRACT

Tacrolimus and anionic surfactant modified carbon paste electrode was fabricated to study the electrochemical behaviour of dopamine. The results showed that electrocatalytic activity towards the oxidation of dopamine at tacrolimus modified carbon paste electrode was showed decrease in the peak current as compare to bare carbon paste electrode. But Tacrolimus/SDS modified carbon paste electrode showed good electrocatalytic activity is confirmed by enhancement of anodic peak current as compare to bare carbon paste electrode. Electrochemical parameters were thoroughly investigated. Tacrolimus/SDS modified carbon paste electrode can also used for the detection of AA, UA individually.

Keywords: Dopamine, Tacrolimus, Modified Carbon Paste Electrode, Sodium dodecyl sulphate (SDS), Cyclic voltammetry.

1. INTRODUCTION

Tacrolimus is a Immunosuppressant drug. It is used to prevent the rejection of liver, heart, kidney, pancreas and bone marrow after transplantation. Tacrolimus subsequently used to treat autoimmune diseases such as psoriasis, rheumatoid arthritis and Crohn's disease [1,2].used for the treatment of various dermatological disorders such as atopic dermatitis (AD) [3] .

Dopamine is a unique neurotransmitter compound extensively distributed in the brain for message transfer in the mammalian central nervous system, 3,4-Dihydroxyphenyl ethylamine is commonly known as dopamine (DA). Dopamine was discovered to be an important neurotransmitter in mammalian central nervous system in the late 1950s and it is found in high amounts (50 nmol/g) in a region of the brain known as the "caudate nucleus" [4]. It plays a very significant role in the central nervous system, renal, hormonal and cardiovascular systems [5] and [6]. Message transfer in the central nervous system mainly depends on dopamine. The low level concentration of dopamine lead to serious diseases such as Parkinson's and HIV infection [7,8 and 9]. Ascorbic acid is an essential vitamin. Vitamin C also known as ascorbic acid, Ascorbic acid found in fruits and vegetables. The main sources of Ascorbic acid are citrus fruits, hips, strawberries, peppers, tomatoes, cabbage, spinach and others [10]. Due to its antioxidant and therapeutic properties it helps the body in forming connective

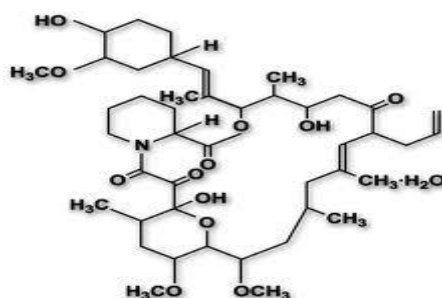
tissues, bones, teeth, blood vessels and it improve the part of body defense system against reactive oxygen species and free radicals.

Uric acid (UA) is produced by xanthine oxidase from xanthine and hypoxanthine, it also generated by metabolism of purines. Its oxidation product is allantoin. Uric acid is more toxic to tissues high concentrations, leads some diseases as hyperuricaemia, gout, and the Lesch–Nyan disease [11].

Surfactants are surface active agents, they are kind of amphiphilic molecules with a hydrophilic head on one side and a long hydrophobic tail on the other side, they have been widely applied in electrochemistry to improve the property of the electrode/solution interface [12, 13] and they can change the nature of electrochemical process [14].

In the present paper we employed tacrolimus modified carbon paste electrode for the detection of dopamine, ascorbic acid and uric acid the tacrolimus modified carbon paste electrode showed a decrease in sensitivity towards the dopamine, ascorbic acid and uric acid but further modified Tacrolimus/SDS carbon paste electrode showed a good sensitivity towards dopamine, ascorbic acid and uric acid. Tacrolimus/SDS carbon paste electrode preparation is easy and easily we get good surface generation by simple polishing on weighing paper.

The modified electrode have a several advantages in electroanalysis. it is sensitive towards dopamine, ascorbic acid, uric acid they are essential nutritional factors they play very important role in central nervous system, cardiovascular system and it helps to monitor several diseases so it gain a more attention to develop a sensitive sensor for their detection.



Structure of Tacrolimus

2. EXPERIMENTAL PART

2.1. Reagents and chemicals

Tacrolimus was received from Cyclosporine was kindly supplied by PerkinElmer (Waltham, MA, USA). Dopamine(DA) were obtained from Himedia chemical company with analytical grade used without further purification. 25 mM dopamine stock solution was prepared in 0.1 M perchloric acid. SDS, potassium ferric cyanide and KCl was prepared in double distilled water. Graphite powder of 50 mm size was purchased from Loba and silicon oil was purchased from Himedia. The chemicals for preparation of buffer solution were purchased from Merck. Phosphate buffer (0.2 M pH 7.4) was used as supporting electrolyte.

2.2. Instrumentation

Cyclic voltammetric experiments were performed using a model CHI-660c (CH Instrument-660 electrochemical workstation). All experiments were carried out with a conventional three electrode cell. The electrode system contained a carbon paste working electrode (3.0 mm in diameter), platinum wire as a counter electrode and saturated calomel as a reference electrode.

2.3. Preparation of bare carbon paste electrode

The carbon paste electrode was prepared by graphite powder and silicon oil at a ratio of 70:30 (w/w) in an agate mortar by hand mixing to get homogenous paste. The prepared carbon paste was tightly packed in to the cavity of a homemade carbon paste electrode then polished the surface by rubbing on a weighing paper.

2.4. Preparation of modified carbon paste electrode

The modified carbon paste electrode was prepared by using 4mg of tacrolimus and graphite powder and silicon oil at a ratio of 70:30 (w/w) in an agate mortar by hand mixing to get homogenous paste. The modified carbon paste electrode was tightly packed in to the cavity of a homemade carbon paste electrode then polished the surface by rubbing on a weighing paper. The Tacrolimus modified carbon paste electrode was further modified by immobilization using SDS solution (10 μ L) on the surface of Tacrolimus modified carbon paste electrode then allowed for 5mints. Later electrode was thoroughly rinsed with distil water to remove unabsorbed modifier and dried in air at room temperature.

3. RESULTS AND DISCUSSION

3.1. Cyclic voltammetric response of $K_4Fe(CN)_6$ at Tacrolimus /SDS MCPE

The Cyclic voltammetric response at Tacrolimus/SDS MCPE was studied using 1mM $[K_4Fe(CN)_6]$ in 1M KCl as a supporting electrolyte with scan rate 100 mVs^{-1} was shown in figure 1. The Cyclic voltammogram at modified Tacrolimus/CPE shows decrease in current signal (dotted line) as compare to BCPE (solid line). The **Tacrolimus** /SDS MCPE (dashed line) showed a good enhancement of peak current which indicates that the electrocatalytic response of $[K_4Fe(CN)_6]$ is apparently improved by SDS as compare to BCPE and modified Tacrolimus/CPE. The presence of SDS on the surface of **Tacrolimus** / MCPE alter the electrochemical response of $[K_4Fe(CN)_6]$ and increases the rate of electron transfer.

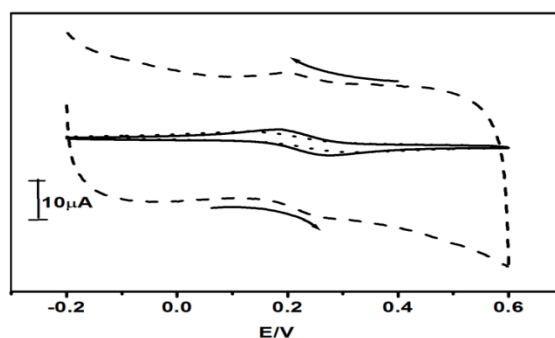


Fig 1 Cyclic voltammogram of 1mM $[K_4Fe(CN)_6]$ at BCPE (solid line), **Tacrolimus** /MCPE (dotted line) and **Tacrolimus** /SDS MCPE (dashed line) in 1M KCl scan rate 100 mVs^{-1}

3.2. Electrochemical oxidation of DA at Tacrolimus /SDS MCPE

The Electrochemical oxidation of DA at **Tacrolimus**/SDS MCPE was studied using 1mM dopamine in 0.2 M phosphate buffer with scan rate 100 mVs^{-1} , at pH 7.4 was shown in figure 2

The cyclic voltammogram of dopamine at pH 7.4 and scan rate 100 mVs^{-1} at **Tacrolimus** /SDS MCPE showed increase of anodic peak current(dashed line) as compare to BCPE(solid line) but the **Tacrolimus** /MCPE showed

a decrease in redox current signal it indicates that the electrochemical response of dopamine is improved by SDS surfactant on the surface of *Tacrolimus* /MCPE. SDS greatly influence the enhancement of electrochemical reaction [15].

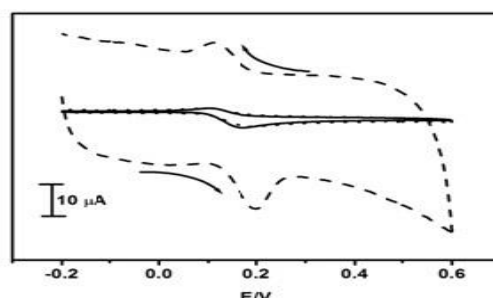


Fig 2 Cyclic voltammogram of 1mM dopamine in 0.2 M phosphate buffer solution, pH 7.4 with scan rate of 100mVs^{-1} at BCPE (solid line), *Tacrolimus* /MCPE (dotted line) and *Tacrolimus* /SDS MCPE (dashed line) 1mM DA with scan rate of 100mVs^{-1}

3.3. Effect of Scan rate on *Tacrolimus* /SDS MCPE

Figure 3a shows the cyclic voltammograms of dopamine were recorded at different scan rate, pH 7.4 and using 0.2 M phosphate buffer as a supporting electrolyte at *Tacrolimus* /SDS MCPE.

Scan rate has a great influence on the peak current redox peak current gradually increases with increasing the scan rate range of 50 to 400mVs^{-1} . The graph of anodic peak current (I_{pa}) v/s square root of scan rate showed a linear relationship of I_{pa} and scan rate. The correlation coefficient was found to be 0.9944 figure (3b) it indicates that the electrode process was diffusion controlled. With increasing the scan rate the difference between the anodic and cathodic peak potential (ΔE_p) also increases [16-18].

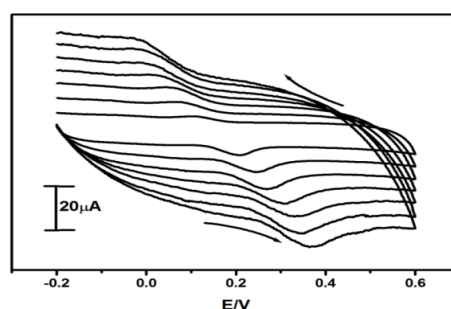


Fig 3a Cyclic voltammogram of dopamine at different scan rate.

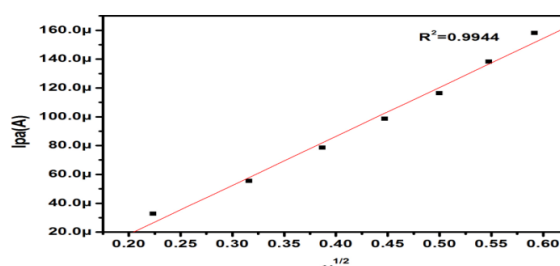


Fig 3b Graph of current V/S square root of scan rate.

3.4. cyclic voltammograms of DA with different concentrations at Tacrolimus /SDS MCPE

The cyclic voltammograms of different concentration of dopamine in 0.2 M phosphate buffer, pH 7.4 and scan rate 100 mVs^{-1} at *Tacrolimus* /SDS MCPE as in figure (4a). It indicates that the anodic and cathodic peak current was increases with increasing the concentration of dopamine from 1 mM to 4 mM and the anodic peak potential shifts towards the positive side and cathodic peak potential shifts towards negative side.

The graph of I_{pa} v/s dopamine concentration figure (4b) indicates the linear relationship between I_{pa} and dopamine concentration.

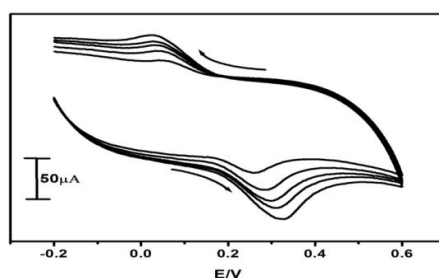


Fig 4a. Cyclic voltammogram of different concentration of DA at *Tacrolimus* SDS MCPE in 0.2M PBS at pH 7.4

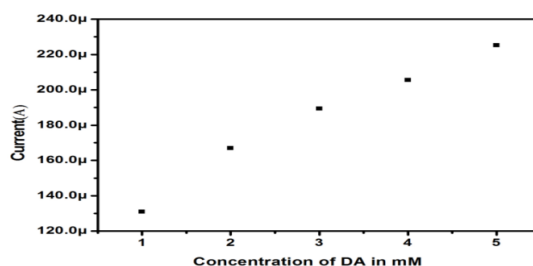


Fig 4b Graph of current V/S concentration of DA at scan rate 100 mVs^{-1} at pH 7.4

3.5. Cyclic voltammograms of DA with different Concentration of SDS at Tacrolimus MCPE.

The cyclic voltammograms of dopamine at different concentration of *Tacrolimus* /SDS MCPE was showed in figure (5a) and Figure (5b) showed the relationship between anodic peak current and concentration of SDS goes on increases with increasing the concentration of SDS (μl) up to 10 μl . After that it shows the decrease in current signal with increasing the concentration of SDS. 10 μl of SDS shows good sensitivity with high anodic peak current (I_{pa}) and low background current. So we chosen 10 μl of SDS for our study.

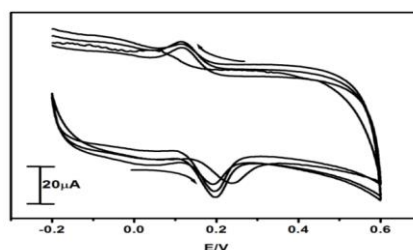


Fig 5b Cyclic voltammogram of dopamine at different concentration of SDS at *Tacrolimus*/SDS MCPE in 0.2M PBS of pH 7.4

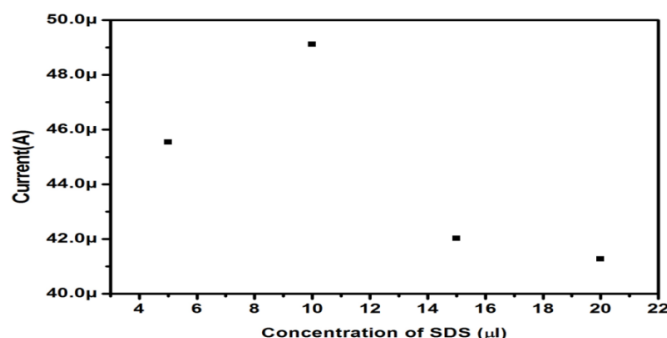


Fig 5b. Graph of current V/S concentration of SDS at scan rate 50mVs^{-1} of pH 7.4

3.6. Cyclic voltammetric studies of UA at Tacrolimus/SDS MCPE

Figure 6 shows the cyclic voltammograms of uric acid in 0.2 M phosphate buffer at pH 7.4 and scan rate 100mVs^{-1} at Tacrolimus /SDS MCPE.

The Cyclic voltammogram at modified *Tacrolimus*/MCPE shows decrease in current signal(dotted line) as compare to BCPE (solid line) the modified *Tacrolimus*/SDS MCPE showed a good enhancement of peak current(dashed line) as compare to BCPE.

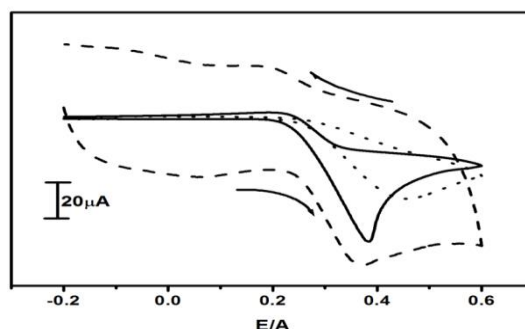


Fig 6. Cyclic voltammogram of uric acid at BCPE (solid line) and *Tacrolimus* MCPE (dotted line) and *Tacrolimus* /SDS MCPE(dashed line) in 1mM UA with scan rate of 100mVs^{-1}

3.7. Cyclic voltammetric studies of AA at Tacrolimus /SDS MCPE

Figure 7 shows the cyclic voltammograms of Ascorbic acid in 0.2 M phosphate buffer at pH 7.4 and scan rate 100mVs^{-1} at *Tacrolimus* /SDS MCPE.

The Cyclic voltammogram at modified *Tacrolimus*/MCPE shows decrease in current signal(dotted line) as compare to BCPE (solid line) the modified *Tacrolimus* SDS MCPE showed a good enhancement of peak current(dashed line) anodic potential shift towards positive side as compare to BCPE.

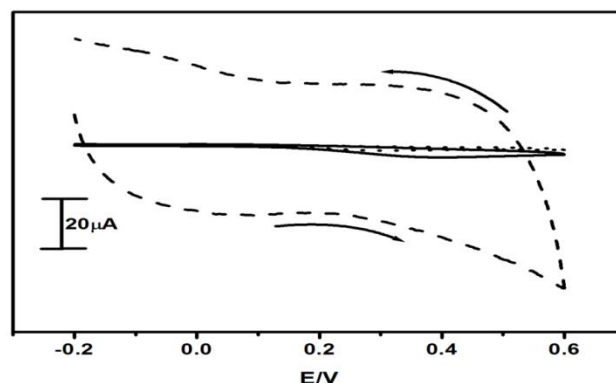


Fig 7 Cyclic voltammogram of Ascorbic acid at BCPE (solid line) and *Tacrolimus* MCPE (dotted line) and *Tacrolimus* /SDS MCPE(dashed line) in 1mM AA with scan rate of 100mVs⁻¹

4. CONCLUSION

In the present work, Tacrolimus/SDS modified carbon paste electrode demonstrate the good electrochemical response towards the dopamine as compare to bare carbon paste electrode at pH 7.4. and it shows the increasing electrochemical sensitivity towards ascorbic acid and uric acid. The developed method can also be used as other bioactive molecules by developing modified sensor.

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