Int. J. Electrochem. Sci., 4 **(2009)** 662 - 671

International Journal of ELECTROCHEMICAL SCIENCE
www.electrochemsci.org

Electrochemical studies of Dopamine at Eperisone and Cetyl Trimethyl Ammonium Bromide Surfactant modified Carbon paste electrode: A Cyclic Voltammetric Study

J.G.Manjunatha[1], *B.E. Kumara Swamy*[1*], *R.Deepa*[2], *V.Krishna*[2], *G.P.Mamatha*[3], *Umesh Chandra*[1], *S.Sharath Shankar* [1] *and B.S. Sherigara*[1]

[1] Department of P.G. Studies and Research in Industrial Chemistry, Kuvempu University, Jnana Sahyadri, Shankaraghatta, Karnataka, India
[2] Department of P.G. Studies and Research in Biotechnology, Kuvempu University, Jnana Sahyadri, Shankaraghatta, Karnataka, India
[3] Department of Chemistry AVK College for women Davanagere, Karnataka, India
[*]E-mail: kumaraswamy21@yahoomail.com

Received: 4 March 2009 / *Accepted:* 4 April 2009 / *Published:* 4 May 2009

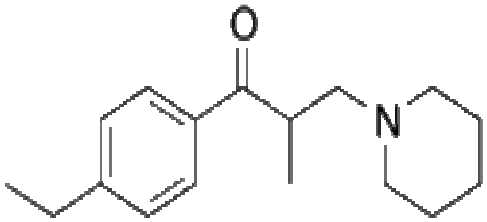
Carbon paste electrode modified with Eperisone drug has been investigated for voltammetric determination of dopamine. The immobilization of the cetyl trimethyl ammonium bromide (CTAB) surfactant on the carbon paste leads to modification of the electrode surface that causes increase in the peak signal of the dopamine probably due to formation of an inclusion complex between eperisone and dopamine used with analytical by developing a cyclic voltammetric (CV) method to determine dopamine.

Keywords: dopamine, eperisone, carbon paste electrode, Cetyl trimethyl ammonium bromide, cyclic voltammetry

1. INTRODUCTION

Eperisone (EPS) (4'-ethyl-2-methyl-3-piperidino) propiophenone hydrochloride (Formulated as the Eperisone hydrochloride salt) is an antispasmodic drug, a new generation antispasmodic drug registered for treatment of relaxing both skeletal muscles and vascular smooth muscles, and demonstrates a variety of effects such as reduction of myotonia, improvement of circulation and suppression of the pain reflex. The drug inhibits the vicious cycle of myotonia by decreasing pain, ischaemia, and hypertonia in skeletal muscles, thus alleviating stiffness and spasticity, and facilitating muscle movement

Dopamine (DA) is a catecholamine neurotransmitter released by neurons in a number of regions of the mammalian brain, and is thought to be important in the expression of a wide variety of behaviors [1-3]. DA in the basal ganglia is involved in motor control, and a causative link has been established between loss of DA in the dorsal striatum, due to neurodegeneration, and Parkinson's disease in humans [4]. In the prefrontal cortex, DA regulates cognitive functions [5]; DA imbalance in this region can lead to attention disorders and has been implicated in the pathophysiology of schizophrenia [6-9]. Another important role for DA has been established in the expression of 'rewarding' behaviors [10,11], such as eating [12,13] and sexual activity [14,15]. Indeed, many of the common drugs of abuse (e.g., cocaine [16], amphetamine [17] and 'ecstasy' [18]) have specific actions on brain DA systems, and this mechanism may be involved in the addictive properties of these agents. The ability to monitor a real-time index of DA release in discrete brain areas during well defined behaviors, and in response to pharmacological challenges, would provide an important key to understanding more fully the role this molecule plays in brain function. Many methods were introduced to determine DA, such as spectroscopy, chromatography and electrochemistry [19-23]. Because of its electrochemical activity, DA can also be determined with electrochemical method [24,25].



Scheme 1. Structure of Eperisone

One of the most common routes is to use a modified carbon paste electrode which has the ability to eliminate the interfering substances from DA determination. The study of electrochemical determination of DA with different modified electrode for sensitive and selective. The modification can be done by adding different types of modifiers. One of the modifiers chosen for the determination of electrochemical response of DA is EPS and it is immobilized with cetyl trimethyl ammonium bromide surfactant.

Surfactant is a liner molecule with a hydrophilic (attracted to water) head and a hydrophobic (repelled by water) end. Due to its unique molecular structure, surfactant was extensively used in the fields of electrochemistry and elelctroanalytical chemistry for various purposes. Surfactants, containing hydrophobic and hydrophilic groups, can change the properties of the electrode/solution interface and subsequently influence the electrochemical processes of other substances [26]. Adsorption of surfactant aggregates on the electron transfer, gently enhance the peak current, change the redox potential or charge transfer coefficients or diffusion coefficients, as well as alter the stability of electro generated intermediates or electrochemical products [27-32]. Related work has been done our research group (33-39)

The aim of the work is to establish a simple and sensitive electrochemical method for the determination of dopamine by EPS modified CPE and with CTAB surfactant. The oxidation peak

current of dopamine increases at the CPE suggesting significant improvement of determining sensitivity .The proposed work some obvious advantages including high sensitivity, extreme simplicity, rapid response and low cost.

2. EXPERIMENTAL PART

2.1. Reagents and chemicals

EPS received from Sigma Aldrich India, Bangalore, CTAB was dissolved in double distilled water to form 10^{-6} M stock solution, potassium ferricyanide ($K_3Fe(CN)_6$) and 25mM dopamine stock solution was prepared in 0.1 M perchloric acid. All other chemicals were of analytical grade quality and were used with out further purification; the water used was a double distilled. In all the measurements, the supporting electrolyte used was 1M KCl and 0.2M phosphate buffer.

2.2. Apparatus and procedure

Cyclic voltammetry (CV) was performed in a model EA-201 Electroanalyser (EA-201 Chemilink system). All the experiments were carried out in a conventional electrochemical cell. The electrode system contained a carbon paste working electrode (3.0mm in diameter) a platinum wire as counter electrode and a potassium chloride (KCl) saturated calomel reference electrode.

The carbon paste electrode was prepared as fallows 70% graphite powder and 30% silicone oil were mixed by hand to produce a homogeneous carbon paste was then packed into the cavity of a home made carbon paste electrode and smoothed on a weighing paper.

3. RESULTS AND DISCUSSION

3.1. Electrochemical response of $K_3Fe(CN_6)$ at a EPSMCPE

The electrochemical responses of $K_3Fe(CN_6)$ at EPS modified carbon paste electrode was shown in Fig.1 at a scan rate of 100mV/s owing to the complex properties and the roughness of the electrode surface, the cyclic voltammogram of $K_3Fe(CN_6)$ in the absence of EPS is low signal (solid line). However, the voltammetric response is apparently improved in the presence of EPS, reflected by the enlargement of anodic peak current (I_{pa}) (dashed line). The probable mechanism is the EPS molecule diffuses in to the carbon paste electrode along with the $K_3Fe(CN_6)$ results increase in the signal.

3.2. Electrochemical response of dopamine at EPS modified carbon paste electrode.

Fig. 2 shows the cyclic voltammogram for 1mM dopamine in buffered solution with pH 7.0 (0.2M phosphate) at the surface of unmodified (solid line) and Eperisone modified CPE (dashed line)

it shows quasi reversible voltammogram. At scan rate 100 mV/s the BCPE shows EPA was found to be 238mV and E_{pc} 120mV (vs. SCE). The ΔE_p 118mV and the I_{pa}/I_{pc} was 3.34 which were characteristics of quasi reversible electrode process. The formal peak potential (E^0), which is the mid point of E_{pa} and E_{pc} was obtained as 179mV. However at EPSMCPE, a pair of redox peak is obtained with increase in both anodic cathodic peak current. The anodic peak potential at 243mV and cathodic peak potential (E_{pc}) at 122mV.The separation of redox potential peaks (ΔE_p) was found to be 121mV and the ratio of peak current (I_{pa}/I_{pc}) was 2.57μA and E^0 was 182.5mV. So the voltammogram obtained for EPSMCPE shows good enhancement of oxidation peak current. It can be found that the response of dopamine at the Eps modified electrode is much higher than that obtained at the bare one. In the experiment shows that modified electrode is stable enough for analytical utilization.

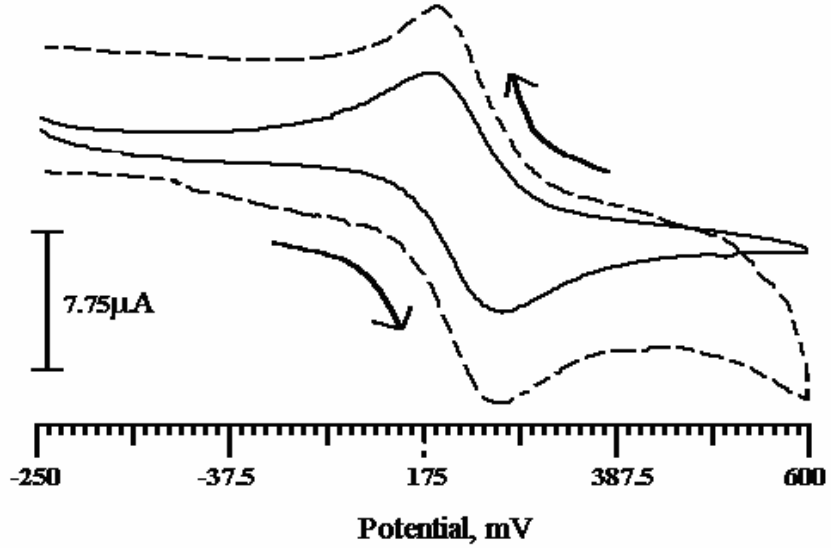


Figure 1. Electrochemical response of $K_3Fe(CN_6)$ at EPS modified carbon paste electrode(dashed line)and bare carbon paste electrode (solid line).

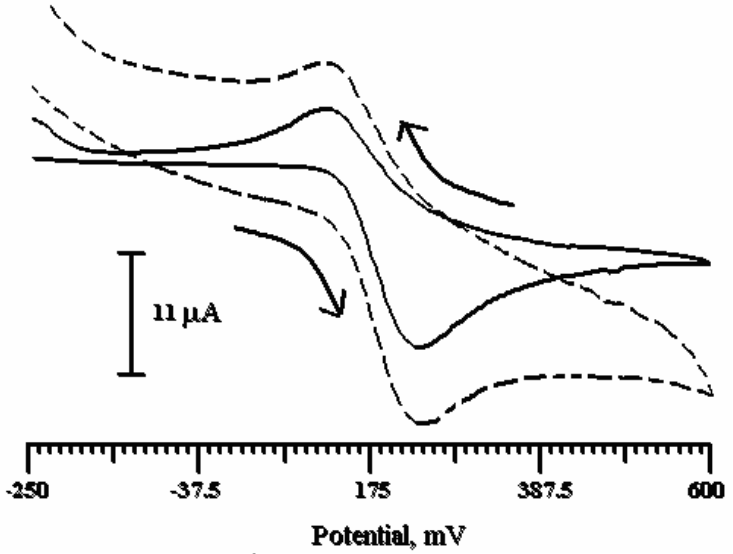


Figure 2. Cyclic voltammogram of $1X10^{-3}$ M DA in 0.2 M phosphate buffer solution of pH 7.0 at bare CPE (solid line) and EPSMCPE (dashed line).

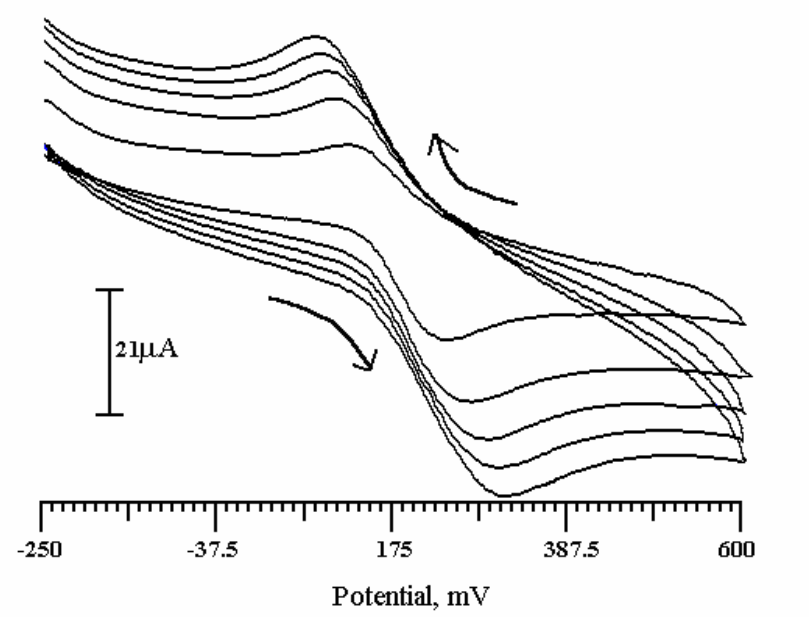


Figure 3. Variation of scan rate for DA at EPSMCPE (a-h: 100mVs^{-1} to 400mVs^{-1}).

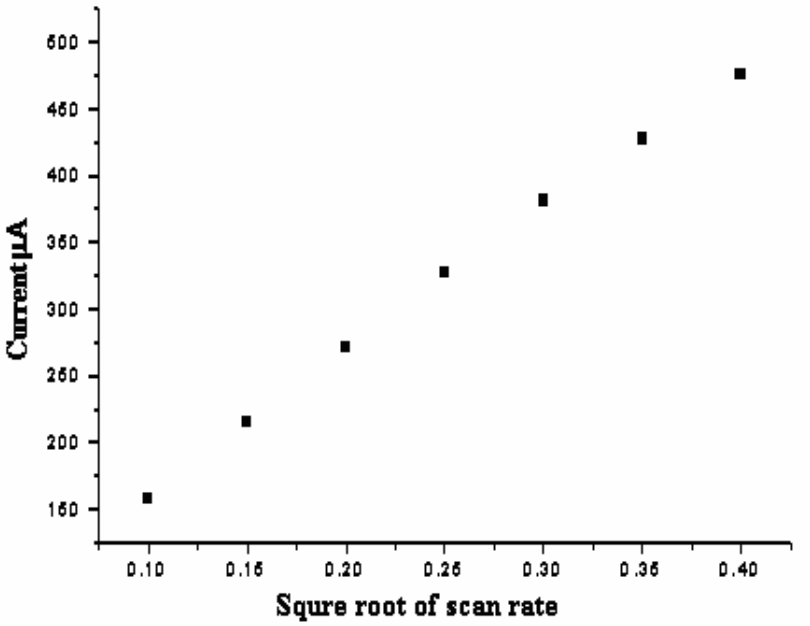


Figure 4. Graph of current vs. square root of scan rate.

3.3. Effect of scan rate

Fig 3 shows the effect of varying the scan rate on the oxidation peak current of dopamine was studied. The cyclic voltammogram were recorded in 0.2M phosphate buffer of pH 7.0 as a supporting

electrolyte. The oxidation peak current increased linearly with square root of the scan rate over the range 100mV/s to 400mV/s .The graph of anodic peak current (Ipa) vs. square root of scan rate ($\nu^{1/2}$) showed linear relationship (Fig. 4). The correlation co-efficient was found to be 0.97899. This result showed the electrode process was diffusion controlled. The difference between the anodic peak potential and the cathodic peak potential ΔEp is increasing with the scan rate (33-35).

3.4. Effect of pH

The effect of variation of pH was studied in the range from 2.0 to 8.0 using 0.2M phosphate buffer as a supporting electrolyte at a scan rate of 100mV/s. The peak potential was very high at pH 7.0 and then later there was a gradual decrease in the anodic peak potential up to pH 8.0 as shown in Fig .5 (36,37).

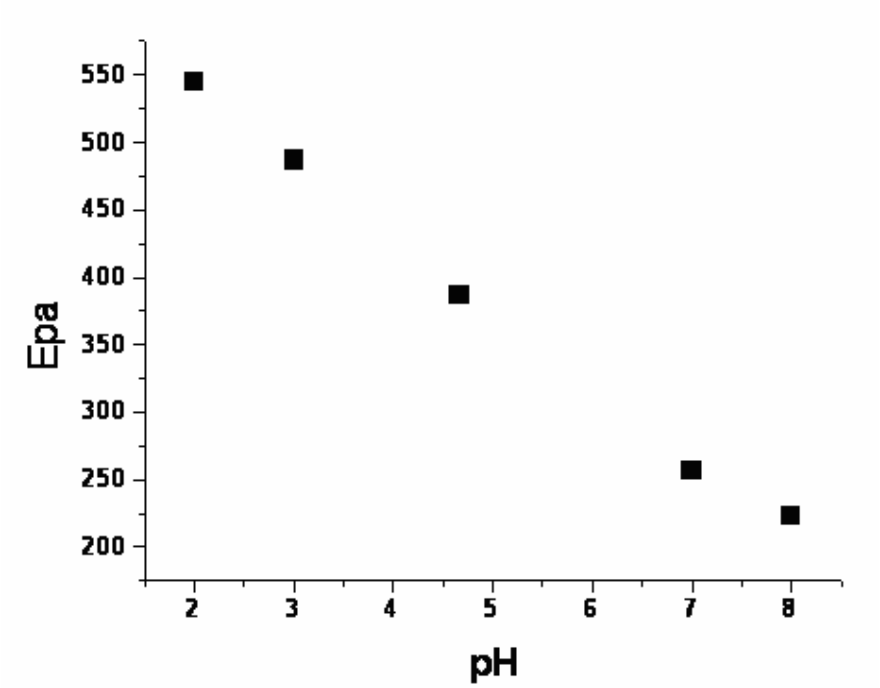


Figure 5. Graph of Epa vs pH

3.5. Effect of surfactant

Fig 6 showed the electrochemical response of dopamine at CTAB immobilized EPSMCPE when compare to bare cpe and EPSMCPE. The CTAB surfactant showed great influence on voltammogram of DA, the voltammogram effectively promote the signals of dopamine even for a trace amount of CTAB. (38,39)

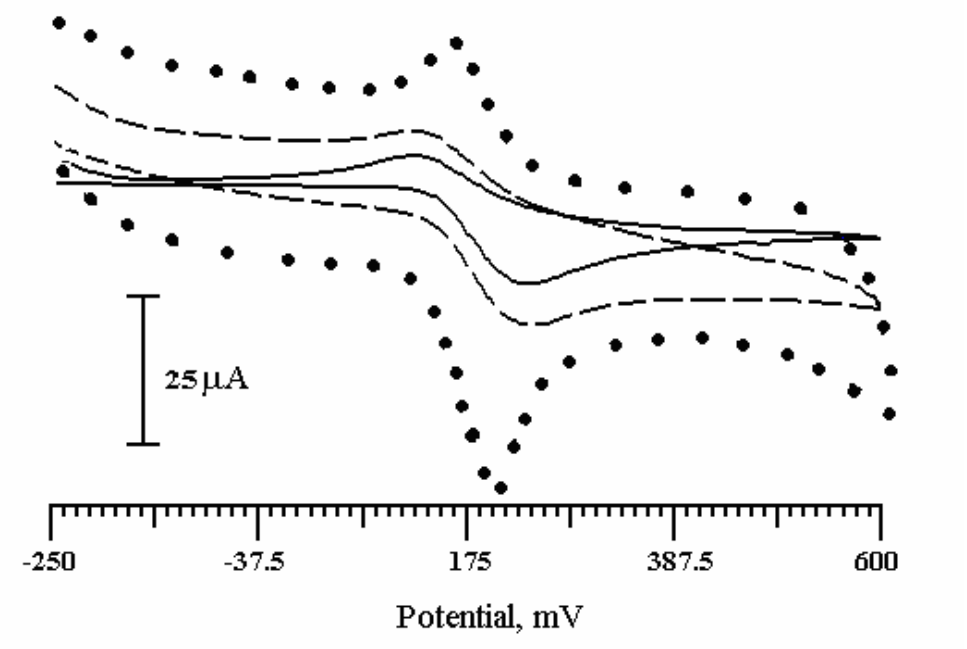


Figure 6. Effect of surfactant (Bare(solid line), EPSMCPE(dashed line)CTAB/ EPSMCPE(dotted line)

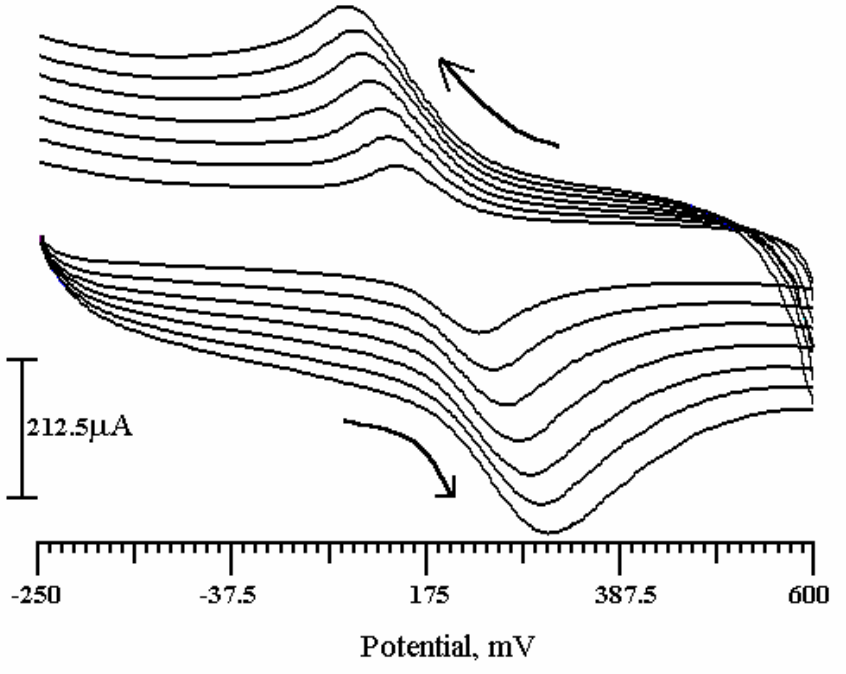


Figure 7. The effect of scan rate of dopamine at surfactant immobilized EPSMCPE

3.6. The effect of scan rate of dopamine at CTAB surfactant immobilized EPSMCPE

Fig7 showed the scan rate increasing, the anodic peak current increased and potential shifted positively. It was found that peak current was linear to scan rate from 100 to 400mVs^{-1}, The graph of Ipa vs. square root of scan rate showed very good linearity with correlation coefficient of 0.99919.

Fig. 8 confirming that the electrode process at the electrode surface has some adsorption also the plot of peak potential (Ep) vs. log of scan rate was linear and this behavior was consistent with chemical response of dopamine in the presence of CTAB surfactant at the EPSMCPE could be utilized to investigated the adsorptive behavior of CTAB at a carbon paste electrode which might be able to explain the enhancement effects of surfactants in some electro analytical systems (35-39).

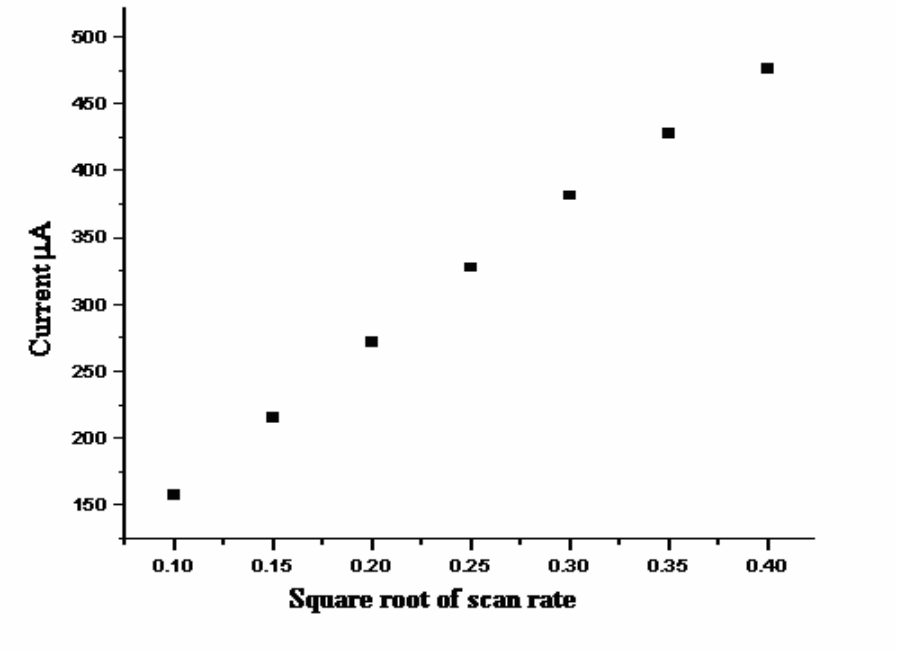


Figure 8. Graph of the peak potential (Ep) vs. log of scan rate

4. CONCLUSIONS

In the present work, incorporation of CTAB cationic surfactant in the matrix of EPS modified CPE is introduced as a new and very efficient method of enhancement in voltammetric response of the modified Carbon paste electrode. The modified electrode has been shown to be able to show high sensitivity for voltammetric peaks of dopamine .Dopamine having reducing property in the biological systems and therefore very similar to analytical detection methods .The high sensitivity and very easy preparation and surface regeneration of the modified electrode and the reproducibility of the voltammetric response make prepared modified system very useful in the determination of dopamine

in pharmaceuticals formulations is, selective, sensitive. These characteristics are helpful in clinical applications

References

1. P.R Montague, S.E. Hyman and J.D. Cohen, *Nature,* 431 (2004) 760.
2. M.A Pezze, J.Feldon, *Prog. Neurobiol,* 74 (2004)301.
3. D.B. Rye, *Neurology,* 63 (2004) 52.
4. M.R Gluck, L.A Santana, H.Granson, M.D. Yahr, *J. Neural Trans*, 111 (2004) 713.
5. R Cools, T.W. Robbins, *Phil. Trans. Roy. Soc. Lond Ser. A - Math. Phys. Engin. Sci.* 362 (2004), 2871.
6. A.Leng, J. Feldon, B.Ferger, *Pharmacol. Biochem. Behav.* 77 (2004) 371.
7. J.Lynel, B.D. Kelly, W.T. O'Connor, *Irish J. Med. Sci.*173 (2004) 155.
8. E.Palsson, D.Klamer, C.Wass, T.Archer, J.A.Engel, L. Svensson, *Brain Res.* 157(2005)139.
9. J.H Zhang, J.A. Engel, B .Soderpalm, L.Svensson, *Psychopharmacology* 135 (1998) 401.
10. P.A Garris, M. Kilpatrick, M.A. Bunin, D.Michael, Q.D.Walker, R.M. Wightman, *Nature* 398 (1999)67.
11. J.N.J. Reynolds, B.I. Hyland, J.R. Wickens, *Nature* 413 *(*2001) 67.
12. S.M. Antelman, H.Szechtman,. P. Chin, A.E. Fisher, *Brain Res*99*(* 1975) 319.
13. M.F Roitman, G.D.Stuber, P.E.M. Phillips, R.M. Wightman, R.M. Carelli, *J. Neurosci.* 24(2004)1265.
14. S.Ahlenius, A. Carlsson, V.Hillegaart, . *Eur. J. Pharmacol*144(1987) 77.
15. M. Mas, *Neurosci. Biobehav. Rev.* 19(1995) 261.
16. P.E.M .Phillips, G.D Stuber. M.L.A.V. Heien, R.M. Wightman, R.M. Carelli, *Nature* 422(2003) 614.
17. S.A Ferguson, B.J.Gough, A.M. Cada, *Physiol. Behav.* 80(2003)109.
18. J.E .Sprague, S.L. Everman, D.E. Nichols, *Neurotoxicology.* 19(1998) 427.
19. S.Sarre, Y. Michotte, P. Herregodts, D.Deleu, N. D.Klippel,G.Ebinger, *Journal of Chromatography*.575(1992)207.
20. C.L.Guan, J. Ouyang, Q. L. Li, B. H. Liu, W. R. G. Baeyens. *Talanta*, 50,(2000) 1197.
21. Y. W.Cheng, X. W Zhi, P. Z. Ai, Y. H. Xiao. *Sensors,* 6(2006)1523.
22. F. B.Salem, *Talanta*, 34(1987)810.
23. T. F. Kang, G. L. Shen, R. Q. Yu, *Analytica Chimica Acta* , 354(1997)343.
24. S.Wei, Y. Maoxia, J. Kui. *Analytical Bioanalytical Chemisry*, 389(2007)1283.
25. J. W. Mo, B. Ogoreve. *Analytical Chemistry,* 73(2001)1196.
26. M .Plavsic, D. Krznaric, B.Cosovic. *Electroanalysis,* 6(1994)469.
27. J. F. Rusling, A, F. Nassar. *J Am Chem Soc,* 115(1993) 11891.
28. J .Yang, N, F. Hu, J, F. Rusling. *J Electroanal Chem,* 463(199)53.
29. J, X Gao, J.F.usling. *j Electroanal Ckem,* 449(1998)1.
30. X, I.en, J.H.Jia, Z, L. Liu, *Talanta.* 50(1999)1027.
31. S.S.Hu. Q.He, Z.F. Zhao. *Anal Chim Acta,* 248(1991)103.
32. W Guo, X, F Kang, J, F. Song. *Anal Lett,* 32(1999) 2335
33. J.G.Manjunatha, B.E. Kumara Swamy,G.P.Mamatha, Umesh Chandra,E.Niranjana, and B.S.Sherigara.*Int. J. Electrochem. Sci.,* 4 (2009) 187 .
34. S. Chitravathi, B.E.Kumaraswamy, E. Niranjana, Umesh Chandra, G.P.Mamatha and B.S.Sherigara. *Int. J. Electrochem. Sci.,* 4 (2009) 223.
35. E. Niranjana, R. Raghavendra Naik, B.E. Kumara Swamy, Yadav D. Bodke, B.S. Sherigara, H.Jayadevappa and B.V. Badami. *Int. J. Electrochem. Sci*., 3 (2008) 980.

36. M. Panduranga Char, E. Niranjana, B.E. Kumara Swamy, B.S. Sherigara and K. VasantakumarPai. *Int. J. Electrochem. Sci*., 3 (2008) 588.
37. E. Niranjana, R. Raghavendra Naik, B.E. Kumara Swamy, B.S. Sherigara and H.Jayadevappa. *Int. J. Electrochem. Sci*., 2 (2007) 923 .
38. R. Raghavendra Naik, E. Niranjana, B. E. Kumara Swamy , B. S. Sherigara and H. Jayadevappa. *Int. J. Electrochem. Sci.,* 3 (2008) 1574.
39. Umesh Chandra, Ongera Gilbert, B.E. Kumara Swamy, Yadav D Bodke and B.S Sherigara. *Int. J. Electrochem. Sci.,* 3 (2008) 1044.