ISSN 2347-4289

Voltammetric Study Of Sildenafil Citrate Using Glassy Carbon Electrode

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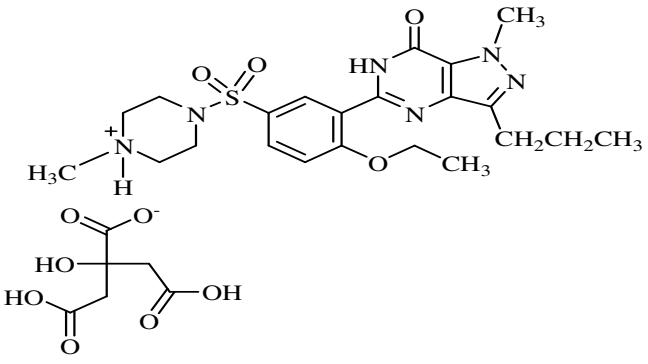
Abstract: The voltammetric study of sildenafil citrate has been studied on glassy carbon electrode using cyclic voltammetry and differential pulse voltammetry method. Sildenafil citrate gives a single irreversible oxidation wave over the wide pH range studied. Using differential pulse voltammetry and cyclic voltammetry, sildenafil citrate yielded a well defined voltammetric response in Britton-Robinson buffer solution, pH 3.26 at 1200 mV verses Ag/AgCl.

Key words: Viagra, GCE, CV

1. Introduction

1.1. General background

Sildenafil citrate (Viagra) is a drug useful for treating male erectile dysfunction (ED).[1-5] It is also effective for treatment of pulmonary arterial hypertension (PAH).[6] The release of this drug have a very large impact. This was due to the fact that the drug was a breakthrough for men suffering from ED. They represent a significant part of the male population : it is estimated that 10% of men suffer from erectile dysfunction, and as much as 52% for men between 40 and 70 years old.[7] In 1998, the drug Viagra was introduce as an effective way to treat male erectile dysfunction.[8] It goes by the generic name of sildenafil citrate. It has quickly become one of the most popular and most prescribed drugs in the world. Sildenafil citrate was synthesized by a group of pharmaceutical chemists working at Pfizer's research facility in England. It was discovered by accident while attempting to produce a drug to treat coronary heart disease. It became the first oral treatment accepted by the Food and Drug Administration (FDA) to treat MED. Sildenafil citrate is designated chemically as 1-[[3-(6,7-dihydro-1-methyl-7-oxo-3-propyl-1*H*-pyrazolo[4,3-*d*] pyrimidin-5-yl)-4- ethoxyphenyl] sulfonyl]-4-methylpiperazine citrate and has the following structural formula.[9, 10]



Chemical formula: $C_{28}H_{38}N_6O_{11}S$
Molecular weight: 666.7 $g/mole$

Figure 1.1. *The chemical structure of sildenafil citrate*

1.2. Objectives of the study

General Objective

The general objective of this thesis is to study the voltammetric behavior of sildenafil citrate.

Specific Objective

- ✓ To check pH dependence of the oxidation property of sildenafil citrate
- ✓ To study the oxidation property of sildenafil citrate at different scan rate
- ✓ To examine the oxidation property of sildenafil citrate using CV and DPV

2. Experimental part

2.1. Chemicals and Reagents

All reagents are of analytical grade and the solutions were prepared using distilled water. The following chemicals were use throughout the study;

- ✓ Methanol (Blulux)
- ✓ Sildenafil citrate (Viagra)
- ✓ Acetic acid (Blulux), boric acid (Blulux) and O-phosphoric acid (Blulux)
- ✓ Sodium hydroxide (Blulux)

The working electrode was pretreated by polishing it with aluminium oxide powder and rinsed in distilled water.

2.2. Apparatus

The voltammetric experiments were performed using the BAS 100B, electrochemical analyzer [Bioanalytical systems (BAS), USA], which was connected to a computer system. The pH of the buffer solution was measured with a Jenway instruments digital pH meter with a combination glass electrode. Mass of solid reagents was measured using Denver instrument balance. All the p otentials are determined with respect to a Ag/AgCl reference electrode.

2.3. Electrochemical cells and Electrodes

This work was performed using a three electrode system with a one-compartment glass voltammetric cell, Ag/AgCl electrode as a reference electrode and platinum wire as an auxiliary electrode. The working electrode is glassy carbon electrode (GCE).

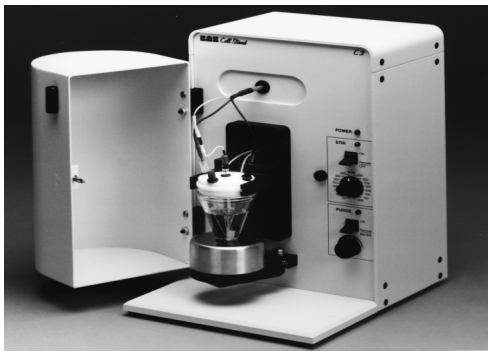


Figure 4.1. *Complete voltammetric cell stand.*

2.4. Procedure

2.4.1. Preparation of standard solution and Buffer solution

For both cyclic and differential pulse voltammetric study, 1.49 × 10^{-3} M of sildenafil citrate stock solution was prepared by dissolving 0.1gram of sildenafil citrate in 100 ml of methanol. 0.04 M of Briton-Robinson buffer was prepared by mixing the required amount of Acetic acid, Boric acid and O-phosphoric acid and the pH was adjusted by adding drops of sodium hydroxide. Serial dilution of the stock solution was made with aqueous buffer solution to obtain the working solutions from 1.10 × 10^{-4} M to 1.54 × 10^{-4} M for CV analysis and 1.1013 × 10^{-5} M to 9.912 × 10^{-5} M for DPV analysis.

3. Result and Discussion

In this paper the electrochemical oxidation of sildenafil citrate has been studied using cyclic voltammetry and differential pulse voltammetry. The optimum pH needed to study the electrochemical behavior of this compound using the above mentioned electroanalytical techniques was pH 3.26.

3.1. Electrochemical Behavior of sildenafil citrate in Cyclic Voltammetry

3.1.1. The Cyclic Voltammogram of sildenafil citrate

The electrochemical behavior of sildenafil citrate was studied using cyclic voltammetry at treated GCE. It shows one irreversible oxidation peak at about 1.23 V as shown in Figure 3.1 below. The obtained peak corresponds to the oxidation of piperazine ring.

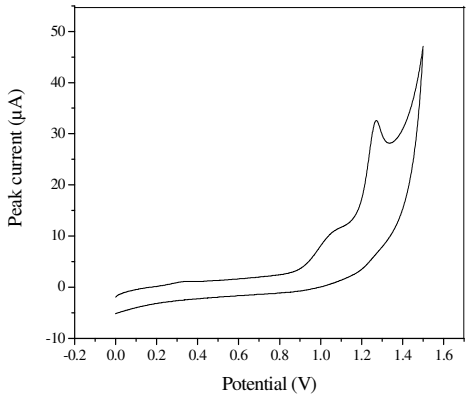


Figure 3.1 *Cyclic voltammogram of 1.32 × 10^{-4} M sildenafil citrate at GCE in 0.04 M Briton-Robinson buffer (pH = 3.26) at a scan rate of 100 mV/s*

a. Effect of pH

The influence of pH on peak current of sildenafil citrate has been studied in the pH range of 1.81- 5.01. When the pH of the supporting electrolyte is increases, the peak current of the voltammograms is shifted to a more negative potential. The peak current obtained in a buffer of 5.01 is much less than that obtained for the buffer solution of pH 3.26. Figure 3.2 shows Cyclic voltammogram of 1.32 × 10^{-4} M sildenafil citrate at different pH range in 0.04 M Briton-Robinson buffer. The maximum peak current was observed at pH 3.26. The peak current is low at high pH ranges and starts increasing as the pH decreases and reaches a maximum value at pH 3.26. As shown in Figure 3.3 the peak potential was also varied as the pH of buffer varies.

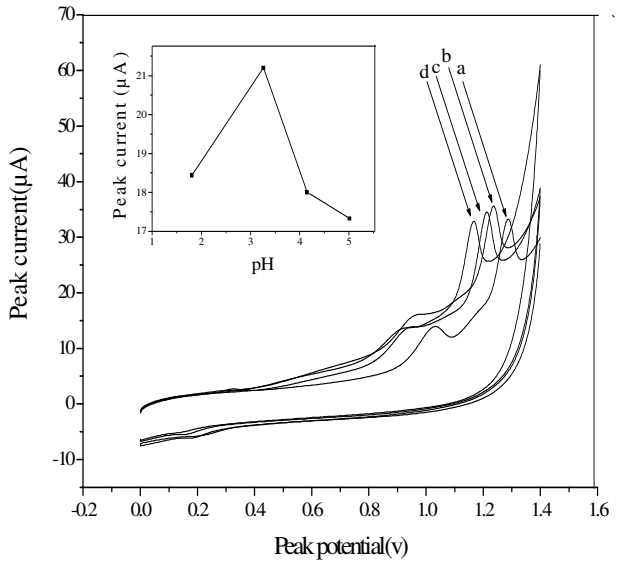


Figure 3.2. *Cyclic voltammogram of 1.32 × 10^{-4} M Sildenafil citrate at different pH range (a. 1.81, b. 3.26, c. 4.15, d. 5.01) in 0.04 M Briton-Robinson buffer at a scan rate of 100 mV/s*

Inset: Plot of peak current versus pH

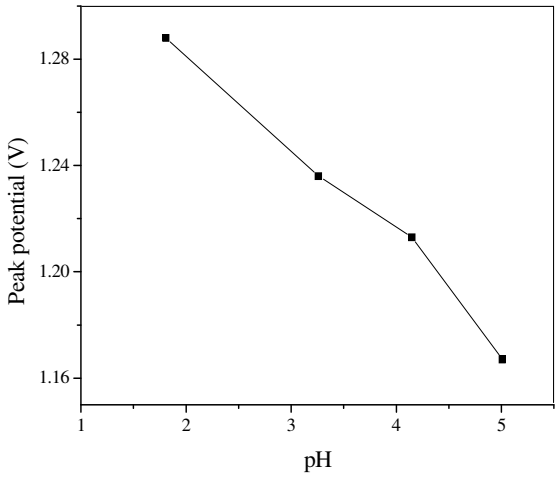


Figure 3.3. *Plot of the dependence of peak potential on pH for the voltammogram shown in Figure 3.2*

b. Effect of Concentration

The effect of concentration was studied using cyclic voltammetry. The results are shown in Figure 3.4. When the concentration of sildenafil citrate increases the peak current increases successively.

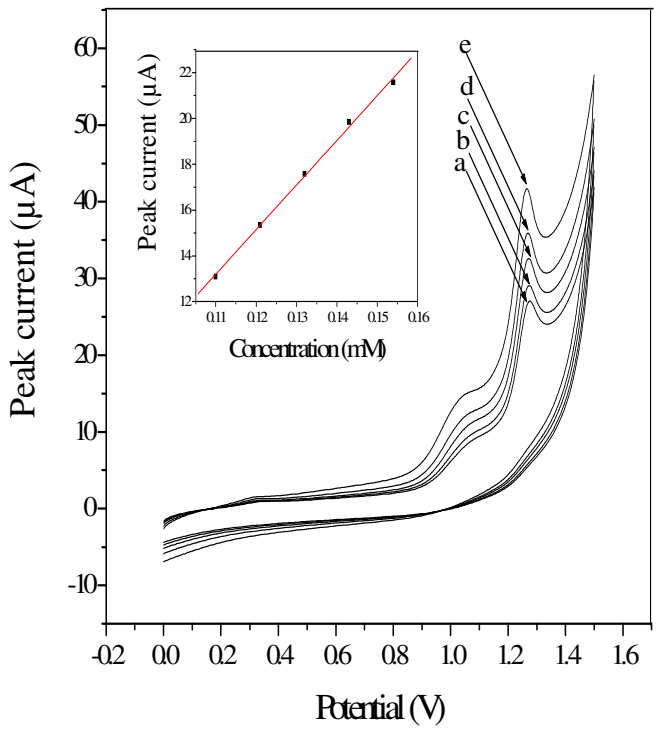


Figure 3.4. *Cyclic voltammogram of sildenafil citrate at different concentrations (a. 1.10 × 10^{-4} M, b. 1.21 × 10^{-4} M, c. 1.32 × 10^{-4} M, d. 1.43 × 10^{-4} M, e. 1.54 × 10^{-4} M) in 0.04 M Britton-Robinson buffer (pH = 3.26) at a scan rate of 100 mV/s*

Inset: Plot of peak current as a function of concentration

The linear dependence of peak current on sildenafil citrate concentration is shown in the inset of Figure 3.4 With R = .998 and slope of (0.195). The linear fit follows the equation:

i_p = -8.25 × 10^{-6} + 0.195 [SC], where SC is sildenafil citrate

c. Effect of scan rate

The cyclic voltammogram of sildenafil citrate solution was run at different scan rates (Figure 3.5). As the scan rate changes from 50 to 250 mV /s, there is an increase in the value of anodic peak current with constant anodic peak potential.

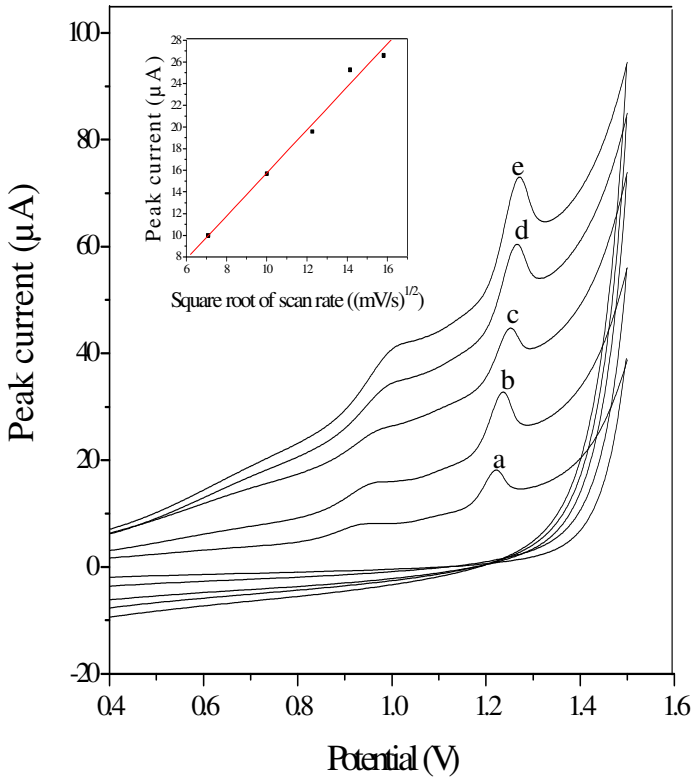


Figure 3.5. *Cyclic voltammogram of 1.5 × 10^{-4} M sildenafil citrate at different scan rates a. 50, b. 100, c. 150, d. 200, e. 250 mV/s*

Inset: Plot of square root of scan rate versus peak current

The plot of peak current versus square root of scan rate shows a linear relationship with R = 0.993. The result suggest that its electrode reaction is diffusion controlled.

3.2. Electrochemical behavior of sildenafil citrate in Differential Pulse Voltammetry

3.2.1. The differential pulse voltammogram of sildenafil citrate

The electrochemical behavior of sildenafil citrate was studied using differential Pulse Voltammetry at treated GCE. It shows one irreversible oxidation peak at about 1.23 V as shown in Figure 3.6 below. The obtained peak corresponds to the oxidation of piperazine ring.

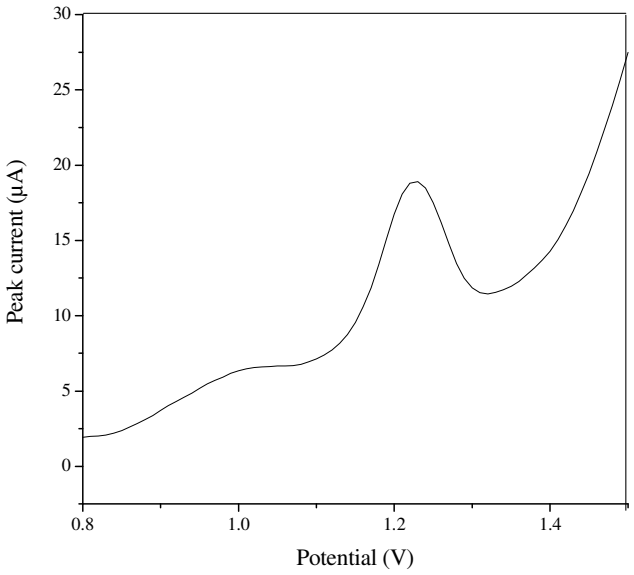


Figure 3.6. *Differential pulse voltammogram of 5.5066 × 10^{-5} M sildenafil citrate at GCE in 0.04 M Briton-Robinson buffer (pH = 3.26) at a scan rate of 50 mV/s*

a. Effect of Concentration

The effect of concentration can be shown by recording the DPV at each concentration (1.1013 × 10^{-5} - 9.912 × 10^{-5} M). The resulting differential pulse voltammogram consists of current peaks, the height of which is directly proportional to the sildenafil citrate concentration as shown in the Figure 3.7.

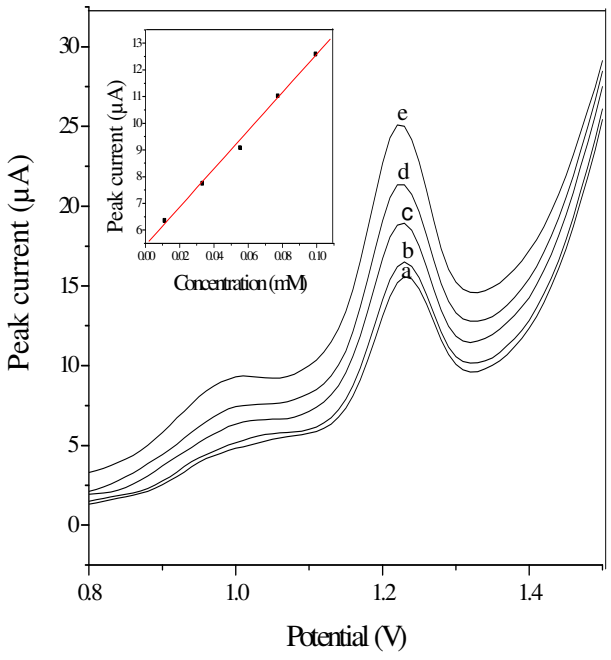


Figure 3.7. *Differential pulse voltammogram of sildenafil citrate at different concentrations (a. 1.1013 × 10^{-5} M, b. 3.3039 × 10^{-5} M , c. 5.5066 × 10^{-5} M, d. 7.709 × 10^{-5} M, e. 9.912 × 10^{-5}M) in 0.04 M Britton-Robinson buffer (pH = 3.26) at a scan rate of 50 mV/s*

Inset: Plot of peak current as a function of concentration

The linear dependence of peak current on sildenafil citrate concentration is shown in the inset of Figure 5.7 with R = 0.997 and slope of (0.072). The linear fit follows the equation:

$$i_p = 5.43383\text{x}10^{-6} + 0.072[\text{SC}]$$

b. The Effect of Pulse Amplitude

The effect of pulse amplitude was varied from 10 - 50 mV. The Peak current is increase with an increasing in pulse amplitude. There was peak broadening when the amplitude was less than 40 mV and the symmetry of voltammogram was not good beyond 40 mV as shown in Figure 3.8, as a result, an amplitude of 40 mV was choosen. The effect of pulse amplitude on peak current is shown in the inset of Figure 3.8.

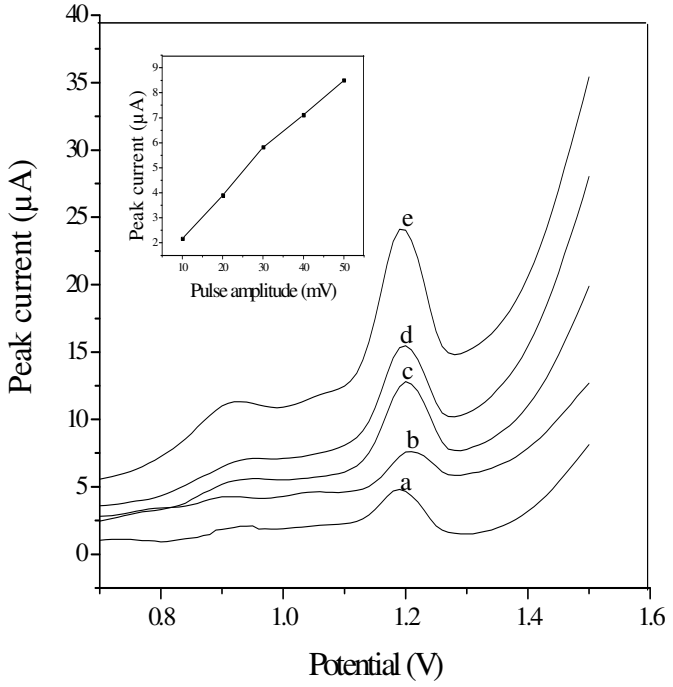


Figure 3.8. *Differential pulse voltammogram of 1.21 x 10^{-4} M sildenafil citrate at different pulse amplitude*

Inset: Plot of peak current as a function of differential pulse amplitude

4. Conclusion and Recommendation

4.1. Conclusion

The electrochemical oxidation of sildenafil citrate in 0.04 M Britton-Robinson media was successfully studied by electroanalytical techniques, namely, CV and DPV at a glassy carbon electrode. Several voltammetric parameters have been optimized and their influence in peak current and peak potential was studied . The pH effect of electrolyte solution has been studied in CV. As the pH increases the anodic peak potential drastically shift to the negative potential.

4.2. Recommendation

The electrochemical behavior of Solid sildenafil citrate has been determined using CV and DPV techniques. The methods can be used for the qualitative and quantitative determination of sildenafil citrate in a given pharmaceutical samples.

5. References

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