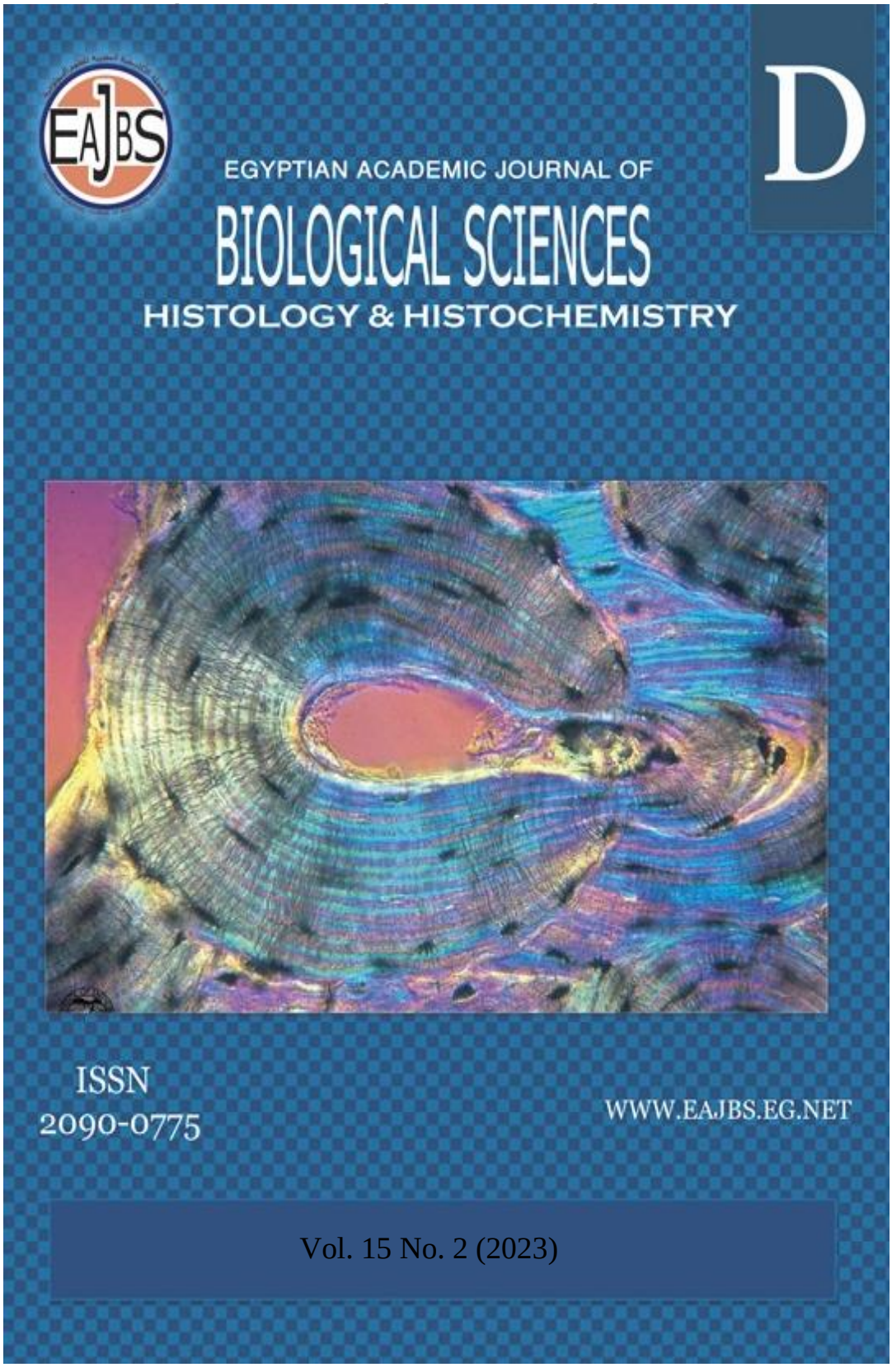
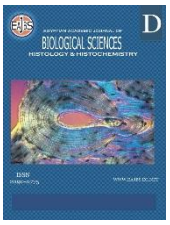



**Citation:** Egypt. *Acad. J. Biolog. Sci. (D-Histology and histochemistry) Vol.15(2) pp59-71(2023)*
**DOI: 10.21608/EAJBSD.2023.321668**

Egypt. Acad. J. Biology. Sci., 15(2): 59-71 (2023)

Egyptian Academic Journal of Biological Sciences
D. Histology & Histochemistry
ISSN 2090 – 0775
http://eajbsd.journals.ekb.eg



# Square-wave Voltammetric Determination of Ant-hypertension (Azilsartn medoxomil) and Real Samples of Biological Applications

**Shihab A. Shihab* and Muthana S. Mashkour**
Faculty of Science, Department of Chemistry, University of Kufa, Iraq.
***E-mail:** shihabirsjwk1998@gmail.com

**ARTICLE INFO**
Article History
Received:28/8/2023
Accepted:15/ 10/2023
Available:19/10/2023

***Keywords*:**
Glassy carbon electrode; SWV; CV; Azilsartin; hypertion.

**ABSTRACT**

Voltammetry was used to study the electrochemical behavior of Remdesivir at a Glassy carbon electrode for the first time. The electrochemical behavior of (AZL) was novelty diagnosed in way through employment (CV, SWV) techniques. (AZL) showed an irreversible oxidation peak a about +1.490 Vat Glassy carbon electrode, the scan rate study in the range 0.02–5 V/s indicates that the process is an electrode process that is completely irreversible and oxidation of AZL on the surface of GCE is diffusion controlled. Optimum operational parameters and the effects of experimental conditions to achieve the best experimental conditions for the voltammetric determination of AZL at GCE have been investigated. An excellent linear dependence of the SWV oxidative peak current on the concentration of AZL was observed in the range of 10-100 ppm with limits of detection (LOD) and quantification (LOQ) of 0.059 and 0.19 ppm, respectively. In addition, excellent recovery results were obtained for the analysis of AZL in pharmaceutical injection and real samples. The proposed approach was effectively employed in the determination of AZL in pharmaceutical and real samples. The novel proposed procedure is quick and affordable; sample preparation is not required.

## INTRODUCTION

Hypertension is a progressive CV syndrome arising from complex and interrelated etiologies. Early markers of the syndrome are often present before BP elevation is sustained; therefore, hypertension cannot be classified solely by discrete BP thresholds. Progression is strongly associated with functional and structural cardiac and vascular abnormalities that damage the heart, kidneys, brain, vasculature, and other organs and lead to premature morbidity and death. (Kannel1996) Reduction of BP when target organ damage is demonstrable or the functional precursor of target organ damage is present and still reversible generally reduces the risk for CV events. Note that we separate elevated BP (one manifestation of the disease) from hypertension the disease (Availability 2011) Hypertension is the most common modifiable risk factor for cardiovascular disease and death, and lowering blood pressure with antihypertensive drugs reduces target organ damage and prevents cardiovascular disease outcomes. Despite a plethora of available treatment options, a substantial portion of the hypertensive population has uncontrolled blood pressure. The unmet need of controlling blood pressure in this population may be addressed, in part, by developing new drugs and devices/procedures to treat hypertension and its comorbidities. In this Compendium Review, we discuss new drugs and interventional treatments that are undergoing preclinical or clinical testing for hypertension treatment.

New drug classes, eg, inhibitors of vasopeptidases, aldosterone synthase and soluble epoxide hydrolase, agonists of natriuretic peptide A and vasoactive intestinal peptide receptor 2, and a novel mineralocorticoid receptor antagonist are in phase II/III of development, while inhibitors of aminopeptidase A, dopamine β-hydroxylase, and the intestinal Na+/H+ exchanger 3, agonists of components of the angiotensin-converting enzyme 2/angiotensin(1–7)/Mas receptor axis and vaccines directed toward angiotensin II and its type 1 receptor are in phase I or preclinical development. The two main interventional approaches, transcatheter renal denervation and baroreflex activation therapy are used in clinical practice for severe treatment-resistant hypertension in some countries. Renal denervation is also being evaluated for treatment of various comorbidities, eg, chronic heart failure, cardiac arrhythmias and chronic renal failure. Novel interventional approaches in early development include carotid body ablation and arteriovenous fistula placement. Importantly, none of these novel drug or device treatments has been shown to prevent cardiovascular disease outcomes or death in hypertensive patients.

Azilsartan medoxomil (AZL) is a chemically 2-ethoxy-3-[[4-[2-(5-oxo-2H - 1, 2, 4-oxadiazol-3-yl) phenyl]phenyl] methyl] benzimidazole-4-carboxylic acid. It was approved by the U.S. Food and Drug Administration (FDA) as Edarby tablets on 25 February 2011 to treat hypertension in adults. Azilsartan is an Angiotensin 2 Receptor Blocker. The mechanism of action of azilsartan is as an Angiotensin 2Type 1 Receptor Antagonist. The physiologic effect of azilsartan is by means of Decreased Blood Pressure. Theazilsartan is mainly used in the therapy of hypertension (Chaitanya *et al.,* 2013).

It is associated with a low rate of transient serum aminotransferase elevations but has yet to be linked to instances of acute liver injury and lowering blood pressure reduces the risk of fatal and nonfatal cardiovascular events, primarily strokes and myocardial infarctions. These benefits have been seen in controlled trials of antihypertensive drugs from a wide variety of pharmacologic classes. The chemical structure of Azilsartan is shown in Figure (1) As a result, REM-containing medications are subject to stringent quality control, which necessitates the development of straightforward, quick, and precise analytical processes for the detection and measurement of this chemical in pharmaceutical and biological samples. Drugs' redox features are able to provide information on their medicinal effectiveness or metabolic destiny in vivo redox mechanisms (Chou. *et al.*, 1984). Additionally, it has been demonstrated that electroanalytical techniques are excellent for determining medicinal substances in various matrices. ( Guidellil *et al.,* 2014) Contrary to excipients, many of the active ingredients in formulations are easily oxidized. Differe (Chrzescijanska *et al.,* 2014) nt electroanalytical methods are occasionally used for the purpose with a high degree of accuracy, facile operation, selectivity, highly sensitive and less expensive, their simplicity, and high dynamic range compared to other methods for environmental, pharmaceutical, and biological applications (Farghaly *et al.,* 2014). Two-dimensional electrochemical measurements relate the current to quantitative properties and the potential to qualitative properties. As a result, electrochemical techniques can be used to specifically detect substances(Gordon, *et al.*, 2020).The objectives of the present work aimed to derive new novel detection such an electro analytical methods for investigating behavior AZL at GCE surface and find an accurate, sensitive, fast and simple electrochemical method for determination of anti-hypertension drugs

in pharmaceutical formulation and in real human sample, by employing different voltammetric techniques to characterize the electrochemical properties in detail and understand the electrochemical process (Oxidation or Reduction)occurring by different voltammetry methods of anti-hypertION drug with glassy carbon electrode in appropriate supporting electrolyte.

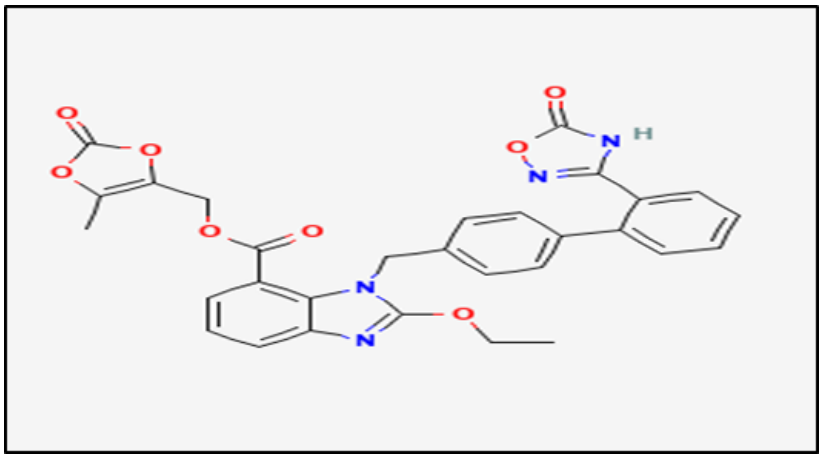


**Fig. 1:** Chemical Structure Azilsartan medoxomil C30H24N4O8 Molecular Formula.

## MATERIALS AND METHODS

### Chemicals and Solutions:

Nanjing Duly Biotechnology Co., Ltd provided the AZL (purity 99%), and Merck provided the 95% pure NaOH. All additional compounds were of the analytical variety. All solutions were made with DIwater from a Milli-Q system. The supporting electrolyte solution in the electrochemical tests, unless otherwise stated, was 0.05M NaOH, which was used each day to make a 0.01M AZL standard solution.

### Apparatus and Procedure:

Voltammetric measurement was performed utilizing potentiostat /Galvanostat (DY-2000-USA) coupled to a three-electrode electrochemical cell, using a GCE electrode (1 mm in diameter) working electrode, a Pt electrode as a counter electrode, and an Ag/AgCl (3.0 M KCl) reference electrode. The bare GCE Eelectrode surface was methodically hand polished, Two types of polishing suspensions have been used for the GCE i.e. diamond polish suspension and alumina polish slurry. The next step includes the following procedure the polished electrode was chemically treated via submit-ted to potential cycles at scan rate 0.05V s−1 for 20 scans and was conditioned by cyclic sweeping between −1.0 to +1.0 V vs. Ag/ AgCl in 0.5 M HCl solution until to obtain a stable voltammetric profile. The experimental conditions for (CV) and (SWV) sequentially were: initial 1.1 E(V) to final 1.65 E(V), step potential 0.02E(V), modulation amplitude 0.05 (V), pulse period 0.02 (sec), pulse width 0.01(sec), sampling width0.005 (sec). (SWV): initial 1.1 E(V) to final 1.65 E(V), step potential 0.022 E(V), modulation amplitude 0.049 (V), Frequency 50 (Hz). One commercial pharmaceutical formulation from Injection as lyophilized vial powder acquired in the local market commercialized as lyophilized powder label value of 100 mg was analyzed as “Edabri-100” (EDR-Pharmaceuticals Int'I Pvt. Ltd, India). Appropriate solutions of the Injection were prepared by taking the micro amount of the aliquots of the supernatant liquid after dissolving it in the supporting electrolyte to prepare a stock solution of approximately $1\times10^{-3}$ M AZL solution and the unknown concentrations were determined from the calibration graph. For real sample analysis, 10 mL of the real samples were filtered using the Whatman filter paper (0.45 µm pore size) filter and then diluted 5 times with the supporting solution (with NaOH). The resulting solution was transferred into the

cell to be analyzed, and a suitable amount of a standard solution of drugs was added to the real samples without any further pretreatment to check the applicability of the method.

**Electrochemical Procedure:**

The electrochemical behavior of AZL at GCE, by different voltammetry methods experiments, was performed for the quantitative electrochemical analysis, a conventional three-electrode electrochemical cell (volume of 50 mL). Cyclic voltammograms were recorded between 0.0 and 2.0 V at a scan rate of (50-100) mV $s^{-1}$. All Electrochemical measurements voltammograms were repeated multiple times and before each experiment, to achieve an optimal electrochemical response of (AZL) at GCE, Different experimental parameters affecting the electrode response were optimized using voltammetry methods such as (CV, SWV)

**Effects of Supporting Electrolyte, Base:**

**Concentration,Preconcentration**

**Potential , Scan rateand Temperature:**

The effect of supporting electrolytes on the oxidation process of REM was studied by recording CV for $1.0\times 10^{-3}$ M for (AZL) in 0.1 M solutions of BR-BS, NaOH, PBS and ABS graphical representation was presented in Figure (2). The results indicated the peak current is highest was found to be best when NaOH was used as a supporting electrolyte. Therefore, NaOH was chosen as a supporting electrolyte for further experiments. The influence of the NaOH concentration was then examined between (0.01 and 0.5) M, the best results are shown in Figure (3). The upper analytical response was obtained from the 0.05 M NaOH solution. Hence, this concentration solution was selected for all further experimentations.CV technique was employed initially intended for preconcentration potential optimization as a result of continuously shifting the initial potential value and keeping the end potential (1.9 V) constant. Initial potential varies from -1 to 1.2 V through the increment in every single measurement. After the cyclic voltammogram was created it was detected, that high current influence shown by the electrode towards the electro-oxidation of AZL in the potential window from 1.0 to 1.9 V. So this potential window (1.0 –1.9) V is optimized for the continuing analysis of AZL.The percentage of current gotten at different potentials were presented. The consequence of accumulation time secondly was performance, the oxidation peak current of $1\times10^{-3}$ M AZL has been studied, through CV mode. The domino influence is plotted. The oxidation peak current is better gradually within the first 60s indicating the boost of AZL concentration at the GCE electrode surface. Up until the 60s, the peak current developed with longer accumulation times before falling. For a duration longer than the 60s, demonstrating the drug's saturation of the GCE electrode to cause electrode fouling (Pandey,2020), a 60-second accumulation time was chosen to evaluate the best employment situations according to the provided practice.

## RESULTS AND DISCUSSION

**The Influence of The Optimization of Experimental Parameters**:

The electrochemical behavior of AZL at glassy carbon electrode was investigated using firstly (CV).

:

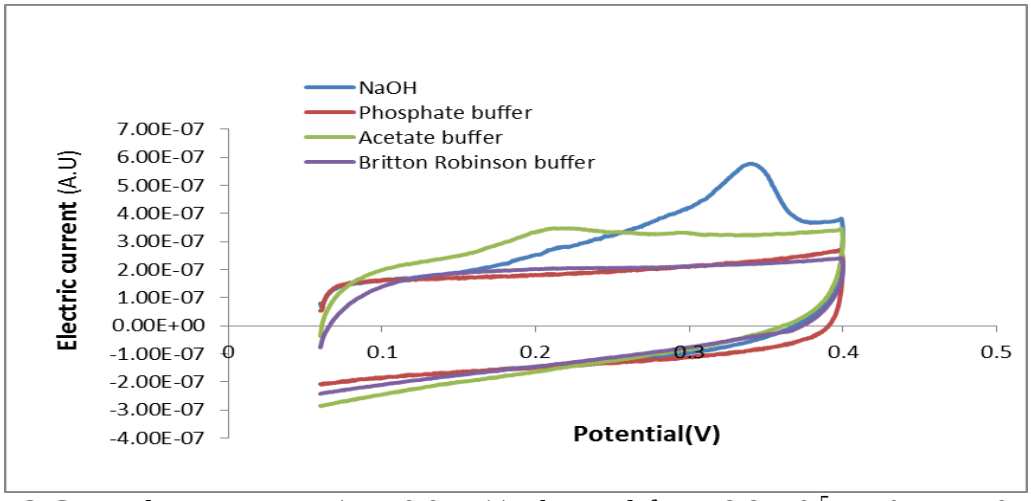



**Fig. 2:**CV Voltammograms (v = 0.02V/s) obtained for a $8.8\times10^{-5}$ M AZL in 0.1 M different buffer solution at GCE.

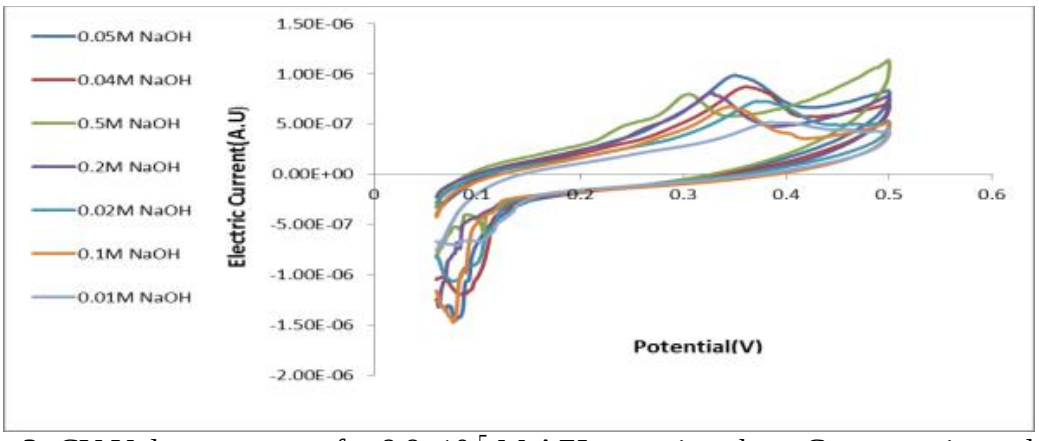



**Fig. 3:** CV Voltammograms for $8.8\times10^{-5}$ M AZL at various base Concentration values (from 0.01 to 0.5) M.

Using the GCE electrode, it was examined how the scan rate (from 0.02 to 5) V/s affected the electrochemical response to $8.8\times10^{-5}$ M of AZL in 0.05 NaOH solution. The overlay voltammograms are given in Figure (4). Moreover, a linear relation between peak current and the square root of scan rate points toward that process is a totally irreversible electrode process see Figure (5). Furthermore, a plot of log i vs log υ showed a linear relationship Figure. (6) with a slope equal to 0.62 which is very close to a theoretical value of 0.50 for a diffusion-controlled process. All these results suggest that oxidation of AZL on the surface of GCE is diffusion controlled (Mishra, 2020 - Wang, J1988)

According to Laviron's (. Shrivastava, *et al.*, 2013,) conclusion, a linear relation between the peak potential Ep and ln ν for AZL determination on the GC electrode was observed graphically Figure (7). For an irreversible electrode process, based on Laviron equation from the slope of the above equation b = RT/αnF, where α is 0.5 for an irreversible electrode process and other symbols have their usual meanings. Substituting the value of b as 0.0265, which allows us to conclude that the AZL electro-oxidation process on the GCE electrode involves two electrons, the value of na is calculated as 1.91 (~2) which confirms that two electrons are involved in AZL oxidation (Taei, *et al.*, 2015)

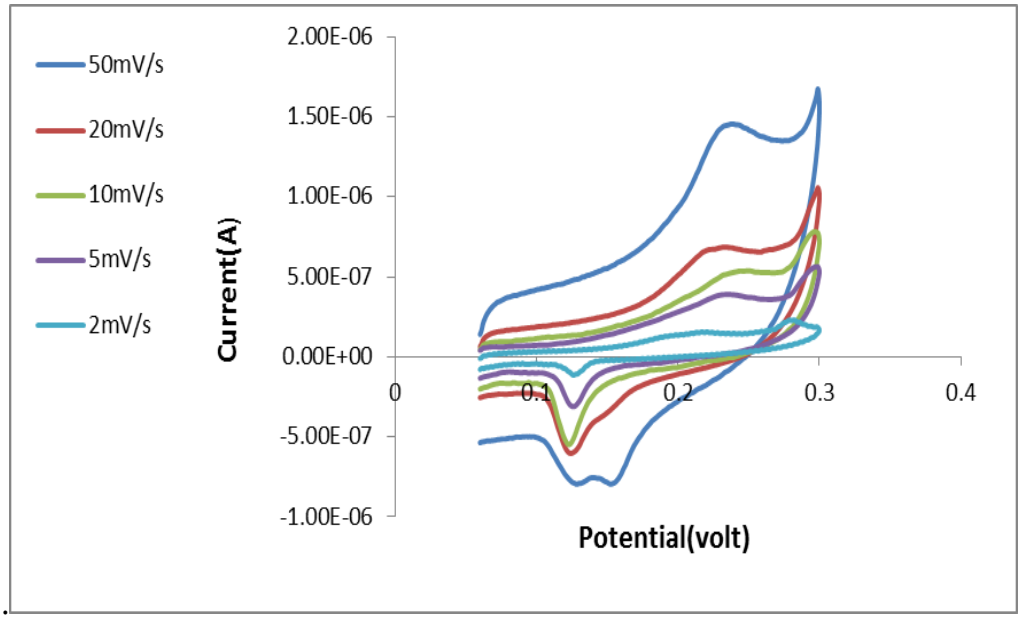



**Fig. 4:** Cyclicvoltammograms obtained for an $8.8\times10^{-5}$ M AZL in 0.05 M NaOH solution at GCE electrode at different scan rates.

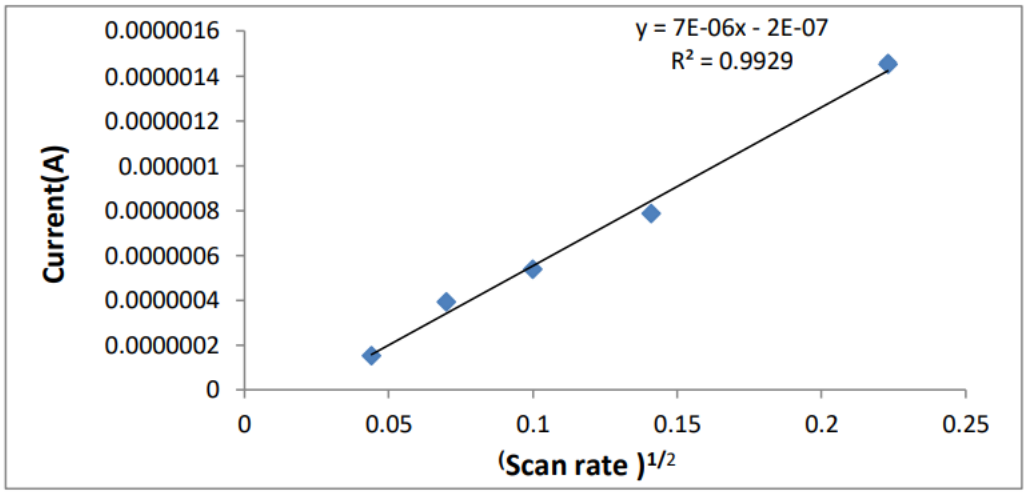



**Fig. 5:** Plot Corresponding anodic peak currents vs. square root of the scan rate forAZL.

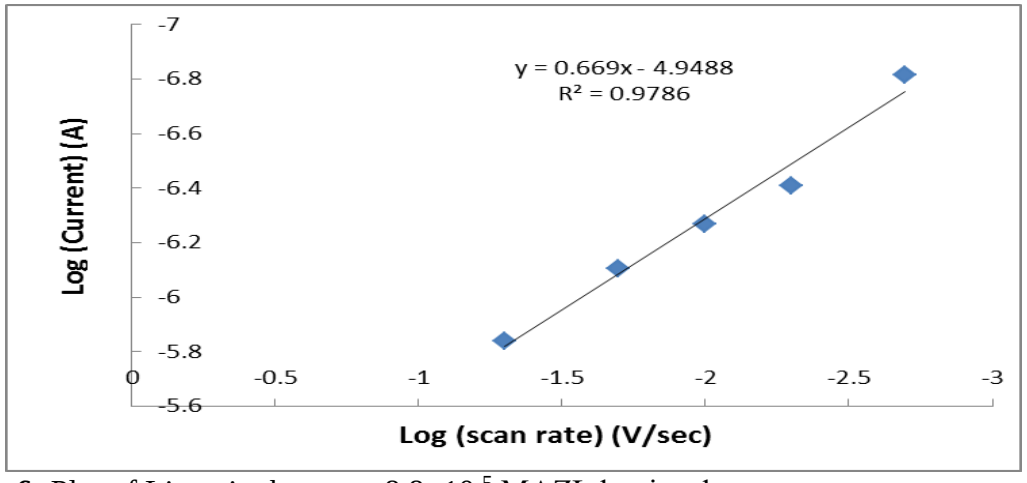



**Fig. 6:** Plot of Linearity between $8.8\times10^{-5}$ MAZL log i vs log υ.

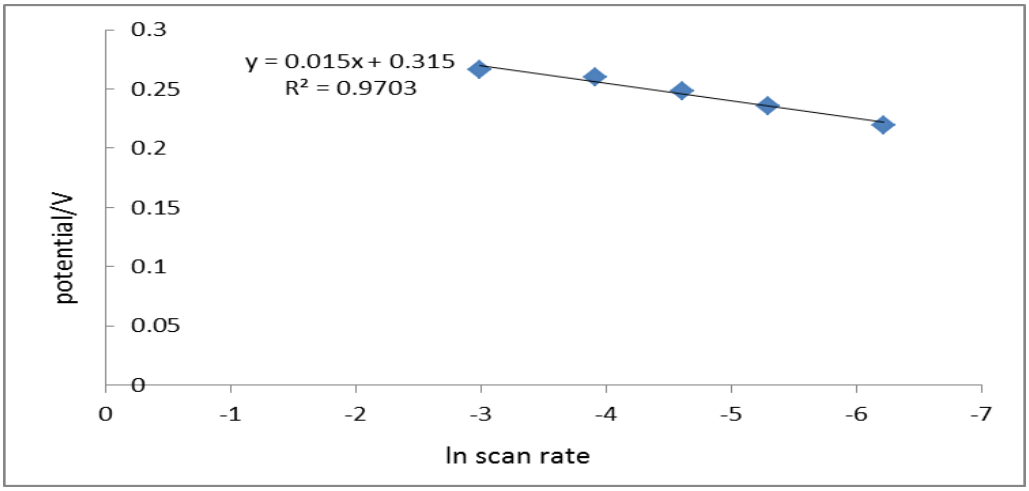
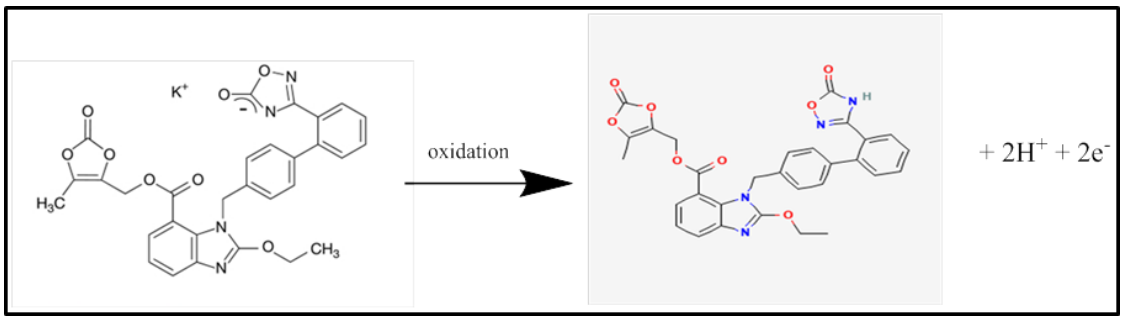



**Fig. 7:** Plot of Variation between $8.8\times10^{-5}$ MAZL potential vsln scan rate.

The influence of pH on the oxidation process of AZL was determined as a result of recording CV approach voltammograms for $8.8 \times 10^{-5}$ M AZL at pH values ranging from 0.4 to 1.3 graphical illustration of which is presented in Figure (8). At a constant scan rate, the plot of Epvs pH showed that the oxidation peak potential of AZL moved towards a lower potential when pH increased from 12 to 13.699 The relationship between oxidation peak potential and pH was linear with regression equation, Ep(v) = - 47.72 pH + 961.13 (R2 = 0.988), value of slope was comparable with theoretical value (0.059 V pH-1), indicating that the uptake of electrons is accompanied by an equal number of protons. The mechanistic scheme for exemplified AZL oxidation at GCE based on the results obtained in scan rate and Ph scan, which confirm each other in the number of electrons transferred, reaffirm the mechanics (Mishra,2020) (proton number/electron number) ratio was obtained at 1:1. The electro-oxidation of AZL involvement of 2e-, the plausible mechanism is shown in Scheme 1.




**Scheme** 1 The probable mechanism of electrochemical oxidation of AZL.

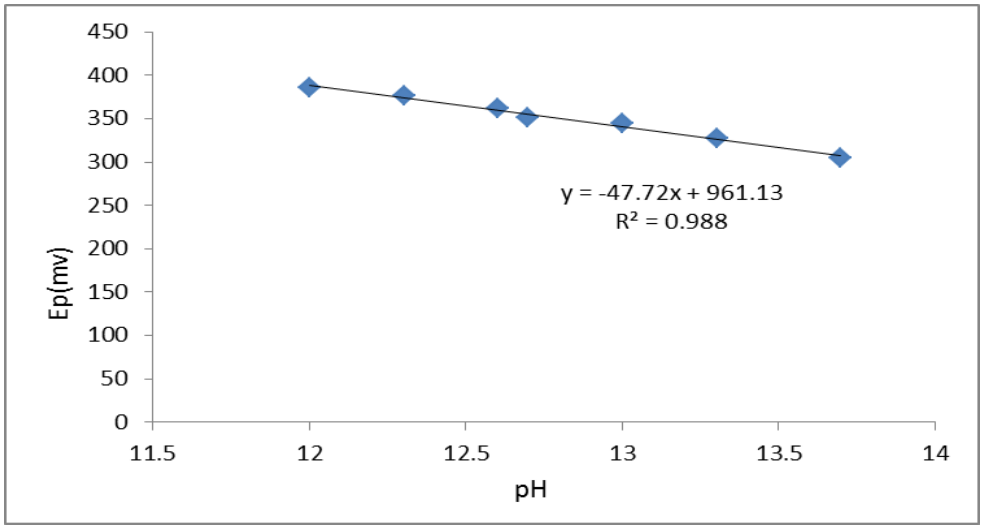



**Fig. 8**: Influence of pH on the oxidation peak potential and peak current of $8.8\times10^{-5}$ M AZL.

The effect of temperature was explored to study the analytical performance and the kinetic and thermodynamic parameters to be evaluated Furthermore the observed impact of temperature (on the oxidation reaction), and the dependence on temperature allowable by CV voltammograms for AZL were taken at several temperatures (10-40°C), the results showed in Figure (9), and at (0.1 V/sec) with $8.8\times10^{-5}$ M concentration of AZL in 0.05M NaOH solution. The effect of temperature was considered to calculate the kinetic and thermodynamic parameters corresponding to the apparent activation energy (Ea), standard enthalpy (ΔH◦) and entropy changes (ΔS◦). The plot of the log (Ipa) versus 1/T is represented in the Figure (10) (Özkan, *et al.*, 2003) was given a straight line with a slope equal to -475.82 The enthalpy ΔH and entropy ΔS for the oxidation reaction can be calculated from the slope and intercept values of Eyringequation. According to Table 1, the redox process becomes more spontaneous and simpler as the free enthalpy, ΔG, drops. The positive entropy of activation can be attributed to the diffusive property of the oxidized analyte in terms of its diffuses along the electrode surface, while the positive enthalpy of activation supports the endothermic nature of the electrode process. The trend toward diffusivity of the AZL analyte toward the electrode surface is indicated by the increase in "ΔS" at high temperatures (Özkan, *et al.*,2003 - Kim, 2020) The plot of the log (Ipa/T) versus 1/T is represented in the Figure (11).

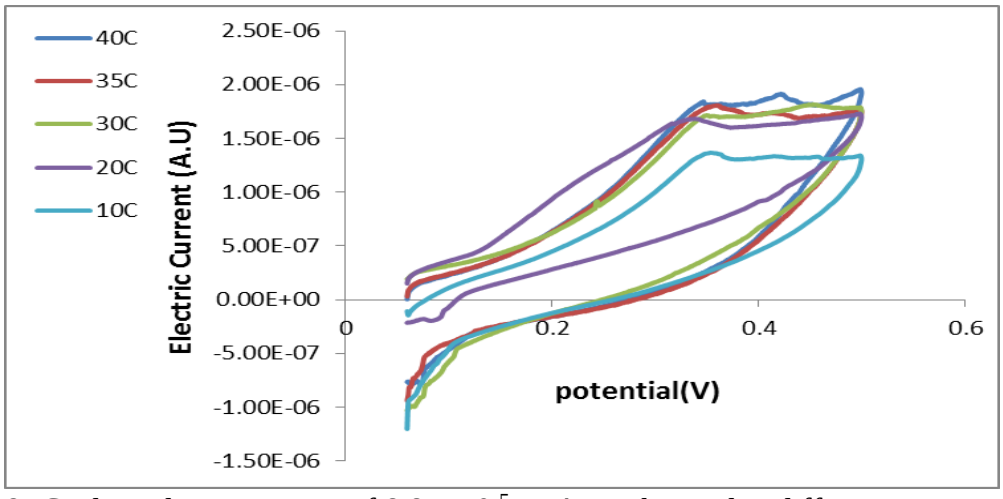



**Fig. 9:** Cyclic voltammograms of $8.8 \times 10^{-5}$ M AZL obtained at different temperatures in 0.05M NaOH at 0.02V/s.

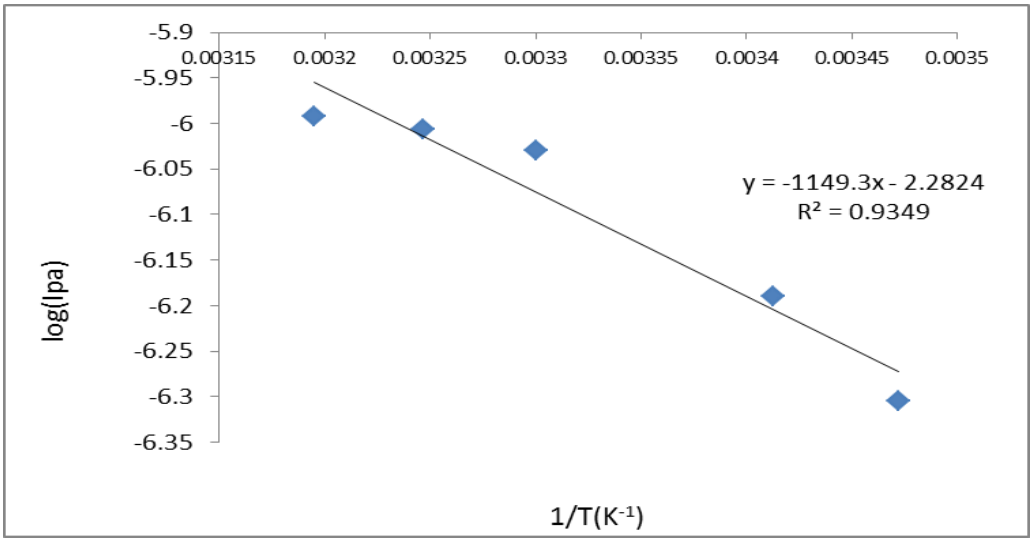



**Fig. 10:** Plots of log ip vs. 1/T for evaluation of thermodynamic parameters of the $8.8\times10^{-5}$M AZL in 0.05 M NaOH

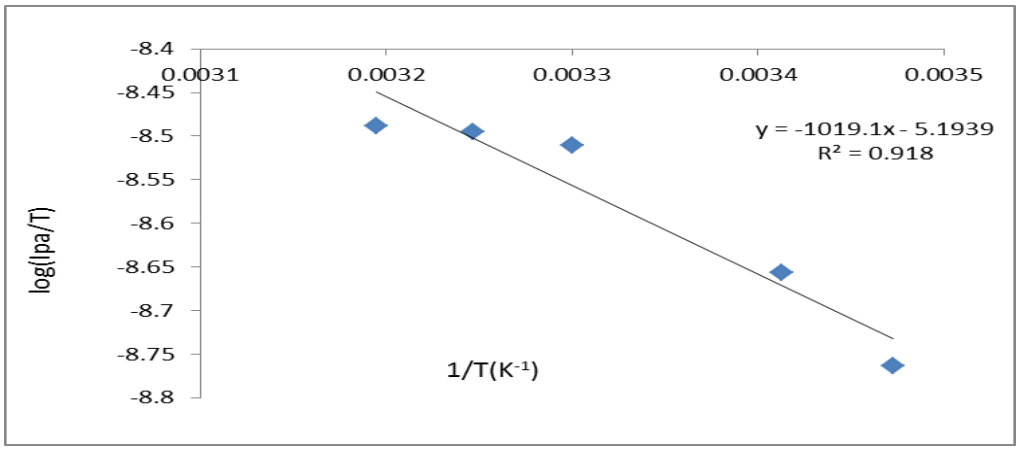



**Fig. 11:** Plots of log ip/T vs. 1/T for evaluation of thermodynamic parameters of the $8.8\times10^{-5}$ M AZL in 0.05 M NaOH.

**Table 1.** Thermodynamic and kinetic parameters of the oxidation processes of AZL.

| Ea (K J mol−1) | ΔG (K J mol−1) | ΔH (K J mol−1) | ΔS (J K−1 mol−1) |
|---|---|---|---|
| 12.444 | -24.552 | 10.293 | 80.333 |

**Electrochemical Behavior of AZL:**

The electrochemical behavior of AZL at glassy carbon electrode was investigated using cyclic voltammetry and Square Wave Voltammetric Figures. (12) shows the cyclic voltammograms of $8.8\times10^{-5}$ M AZL in 0.05 M NaOH as supporting electrolyte solution, by scanning the potential range from 1.0 – 1.9 V with a scan rate of 0.1 V/s, on bare GCE. The absence of a peak in the backward scan indicates that the oxidation process is irreversible on bare GCE. It is evident from the obtained cyclic voltammograms that the oxidation of AZL at GCE electrodes produced better electrochemicals a remarkable response (1.490 V, $1.596\times10^{-5}$A). The electrochemical oxidation of AZL at GCE was studied using differential voltammetry. No peak was observed at the voltammogram of supporting blank in buffer solution while there was a sharp oxidative peak in the presence of $8.8\times10^{-5}$ M AZL in 0.05 M NaOH.

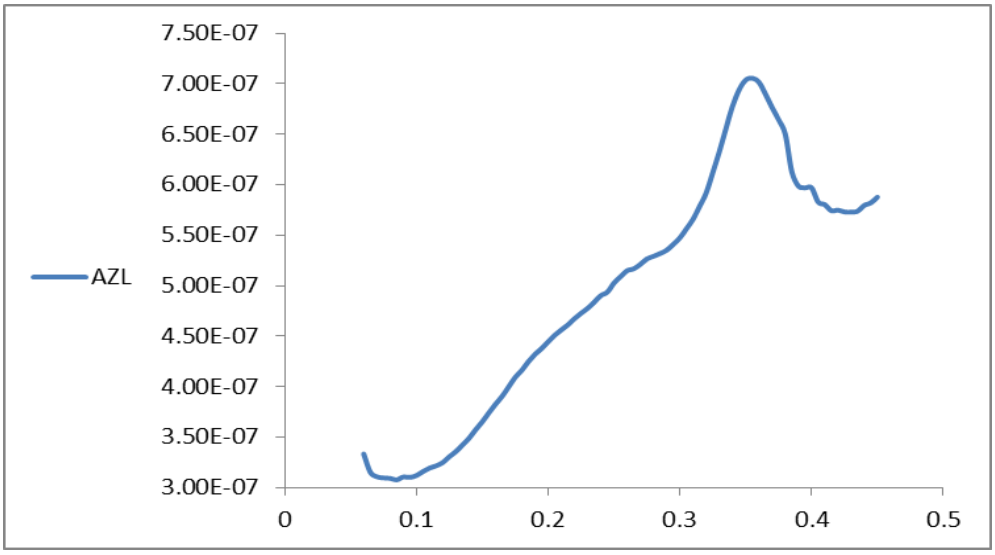



**Fig. 12:** Square Wave voltammograms recorded for a 50 ppm AZL in 0.05M NaOH solution at opimum conditions.

**Interference Study:**

In order to evaluate the selectivity of the GCE electrode towards the oxidation of AZL, the effect of various substances, which are commonly present with the AZL in commercial pharmaceutical injection Edabri-80, such as (mannitol, microcrystalline cellulose,fumaric acid, magnesium stearate,Sodium hydroxide and hydroxypropylcellulose) were studied using SWV technique, and the results are incorporated in Figures (13 and14) which indicated the effect of A 10-fold excess of various foreign species had no influence on the voltammetric determination of AZL on proposed GCE. However, were found the above results ascertained that the majority of the coexisting substances do not interfere with the determination of AZL and confirmed the acceptable selectivity of the proposed GCE electrode.

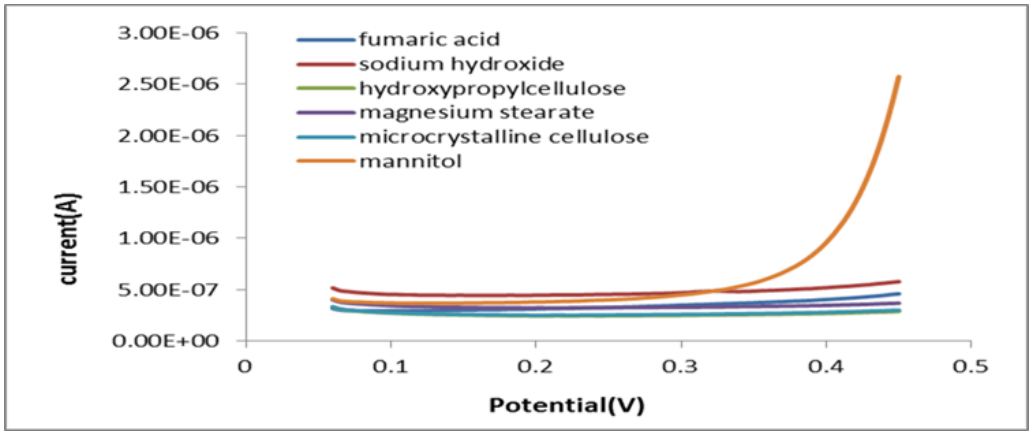



**Fig. 13:** The effect of interferences of SWVs of list of excipients in AZL drug.

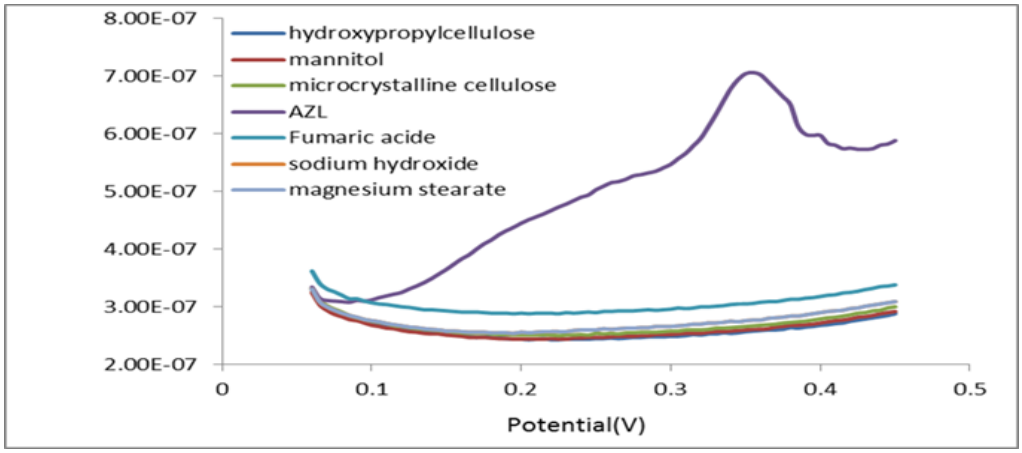



**Fig. 14:** The effect of interferences of SWVs of list and AZL drug.

**Calibration Graph for AZL:**

In order to validate this analytical method for the detection and quantification of AZL we selected the SWV mode, for pharmaceutical and real samples, AZL signals at different concentrations were recorded on the GCE electrode in (0.05 M AZL). Figures (15 and 16) shows the voltammetric response of the oxidation peaks for each AZL in the Table .2 .

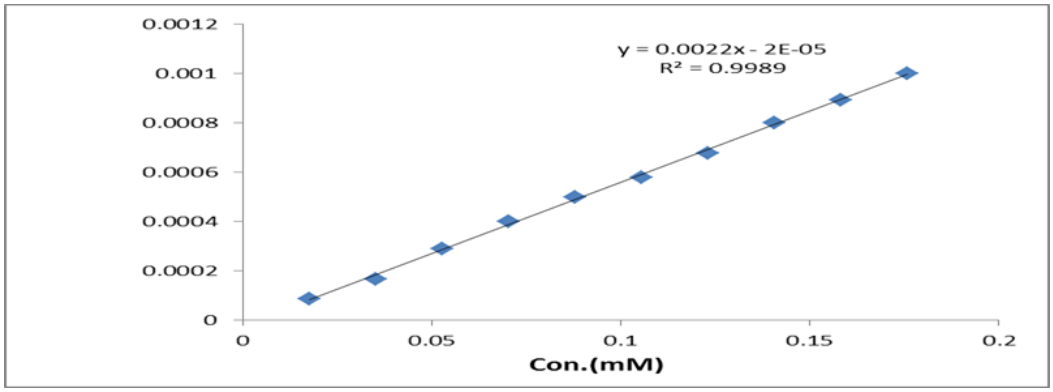



**Fig. 15:** Calibration Graph of SWV of AZL in 0.05 M NaOH in the concentration range of 10 ppm to 100 ppm on GCE.

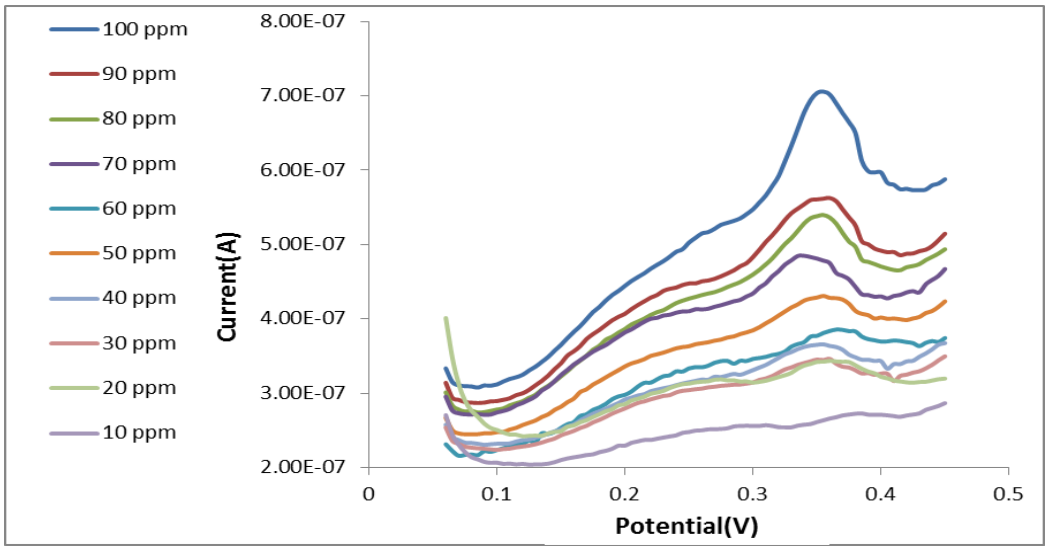



**Fig. 16:** Calibration Graph of SWV of AZL in 0.05 M NaOH in the concentration range of 10 ppm to 100 ppm on GCE.

**Table 2:** Analytic parameters of AZL calibration plot using SWV at GCE.

| | |
|---|---|
| **Linearity range (ppm)** | **10-100** |
| **Slope of the calibration plot** | **0.0022** |
| **Intercept** | **$2\times10^{-5}$** |
| **Correlation coefficient** | **0.9989** |
| **Number of data points** | **10** |
| **LOD (mM)** | **$6.1\times10^{-5}$** |
| **LOQ (mM)** | **$2.0\times10^{-4}$** |
| **SD (mM)** | **$0.447\times10^{-7}$** |
| **RSD (%)** | **1.1096** |

## Analytical Application AZL:

In order to evaluate the applicability of the proposed method SWV techniques were selected, in the pharmaceutical sample analysis containing AZL namely, Edabri-100 containing 100 mg of the drug, injection and some human serum and urine as the real samples were prepared. The SWV signals of the GCE were recorded in the presence of the various samples. Analysis of the samples presented the recovery rates. Recovery studies were carried out after the addition of known standard solution quantities of the drug to various pre-analyzed formulations of AZL. The results are listed in (Tables 3 & 4). The detection results are in good agreement with the content marked on the label. The calibration graph was used for the determination of the addition of AZL in various samples.

**Table 3:** Determination of AZL in pharmaceutical formulations**.**

| Sample (mg/tablet) | Declared Amount | Found (mg/tablet) | S.D* | CV* |
|---|---|---|---|---|
| EDABRI- (AZL, Hikma) | 80.00 | 99.76 | 0.5120 | 0.5530 |

**Table 4:** Determination of AZL in real sample.

| Samples | Added (mg/L) | Found (mg/L) | Recovery % | S.D* | SWV* |
|---|---|---|---|---|---|
| **Urine** | 12.00 | 11.95 | 99.60 | 0.1210 | 1.0130 |
| | 24.00 | 23.95 | 99.80 | 0.1268 | 0.5290 |
| | 36.00 | 35.94 | 99.97 | 0.1185 | 0.3300 |
| **Serum** | 12.00 | 12.05 | 100.42 | 0.0999 | 0.8290 |
| | 24.00 | 24.02 | 100.08 | 0.1020 | 0.4250 |
| | 36.00 | 36.01 | 100.03 | 0.1139 | 0.3160 |

***Average of five replicates**

## Conclusions

Starting to employ different voltammetry techniques to analyze the behavior of the drug under study, and the results showed that these drugs exhibit an electrochemically irreversible oxidation process. A higher analytical response was obtained for a 0.05 M NaOH solution as a supporting electrolyte solution. Therefore, this solution was selected for all additional experiments on all drugs. The results of the current study indicated that the studied electroanalytical procedure could be successfully applied to the detection of drug in pharmaceutical formulation and real samples with excellent selectivity, sensitivity, stability, and reproducibility. This analytical method is simple, precise and affordable; it also requires no complex pre-treatment of the active principle to be determined. The procedure and its application to a pharmaceutical form of the drugs represent a good alternative in the routine of the laboratory analysis Currently, there has not been reported a direct electrochemical method for quantitative determination by GCE of AZL drug. Therefore, it is concluded that the studied electrochemical method could be utilized as a promising method to determine AZL in various analyte samples.

## REFERENCES


Availability A..M, 2011; 76 FR 14024:1–12Food and Drug Administration and the Department of Health and Human Services. Notice. Guidance for Industry on Hypertension Indication: *Drug Labeling for Cardiovascular Outcome Claims*; 76 FR 14024:1–12.

Azeem, I., Mohiuddin S. and Fatima A.2016., Cyclic voltammetry of trazodone as [piperazin-1-yl] antidepressant drug and bovine serum albumin binding. Journal of Basic & Applied Sciences, 2016, 12, 351-357 12: p.351-357.

Chaitanya.R. S, and Kola L. P. 2013. "Development and Validation of New Spectrophotometric Methods for the Estimation of AZL in Bulk Drug and Its Formulaion Using 1,10-Phenanthroline and Mbth. *Chemical Reagents*,01(01): 47–51.

Chitravathi, S., *et al.* 2013, Determination of salbutamol sulfate by Alcian blue modified carbon paste electrode: A cyclic voltammetric study. 3: p. 5.10.

Chou.T. C, and Paul.T. 1984. "Quantitative Analysis of Dose-Effect Relationships: The Combined Effects of Multiple Drugs or Enzyme Inhibitors." *Advances in Enzyme Regulation*, 22(C): 27–55.

Chrzescijanska E. , Elzbieta. K. and Jacek. R. 2014. "Study of Acetylsalicylic Acid Electroreduction Behavior at Platinum Electrode." *Journal of Electroanalytical Chemistry*, 713:17–21.

Daneshgar, P., et a2009 l., A dysprosium nanowire modified carbon paste electrode for determination of nanomplar level of diphenhydramin by continuous square wave voltammetry in flow injection system. 4: p.444

Farghaly. O. A., Abdel. H and Abd A. H. 2014. "Analytical Application Using Modern Electrochemical Techniques." *International Journal of Electrochemical Science*, 9(6): 3287–3318

Guidelli, R., *et al.* 2014., Defining the transfer coefficient in electrochemistry: *An assessment (IUPAC Technical Report)*, 86(2): p. 245-258.

Kannel W.B.1996 Blood pressure as a cardiovascular risk factor: prevention and treatment. *JAMA.;* 275: 1571–1576.

Kim, T., 2020., Applications of voltammetry in lithium-ion battery research. *Journal* of *Electrochemical Science* and Technology, 11(1): p. 14-25.

Okpara, E.C., *et al.*, 2021.Green synthesis of copper oxide nanoparticles using extracts of Solanum macrocarpon fruit and their redox responses on SPAu electrode. *Heliyon,7*(12): p. e08571.

Özkan, S.A., B. Uslu, and H.Y. Aboul-E.2003, Analysis of pharmaceuticals and biological fluids using modern electroanalytical techniques. *Critical Reviews in Analytical Chemistry*, 33(3): p. 155-181.

Shrivastava, A., J. S 2013, and V. Soni, Various electroanalytical methods for the determination of uranium in different matrices. *Bulletin of Faculty of Pharmacy, Cairo University*, 51(1): p. 113-129

Taei, M., F. Hasanpour, and M. Shavakhi,2015 Application of N-4, 4'-azodianiline (ferrocenyl Schiff base) for electrocatalytic determination of atenolol on modified carbon paste electrode. *Quarterly Journal of Iranian Chemical Communication*, 3(1, pp. 1-71, Serial No.6): p. 16-25.