

*Full Paper*

## **Poly (alizarin) Modified Glassy Carbon Electrode for the Electrochemical Investigation of Omeprazole: A Voltammetric Study**

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*Received: 28 January 2014/ Accepted after minor revision: 5 April 2014/*

*Published online: 30 April 2014*

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**Abstract-** A glassy carbon electrode was electropolymerized with alizarin by using cyclic voltammetric technique (CV) and electrochemical properties of Omeprazole were studied. From the scan rate effect the overall electrode process was controlled by diffusion. The peak currents and concentrations of omeprazole shows a good linear response in the range from  $4 \times 10^{-4}$  –  $1 \times 10^{-3}$  M ( $r^2=0.9975$ ) with the detection limit of  $7.15 \times 10^{-7}$  M and sensitivity was found to be  $0.0181 \mu\text{A } \mu\text{M}^{-1}$ . This method has been applied successfully to the analysis of Omeprazole in tablets.

**Keywords-** Glassy carbon electrode, Omeprazole, Cyclic voltammetry, Electropolymerization

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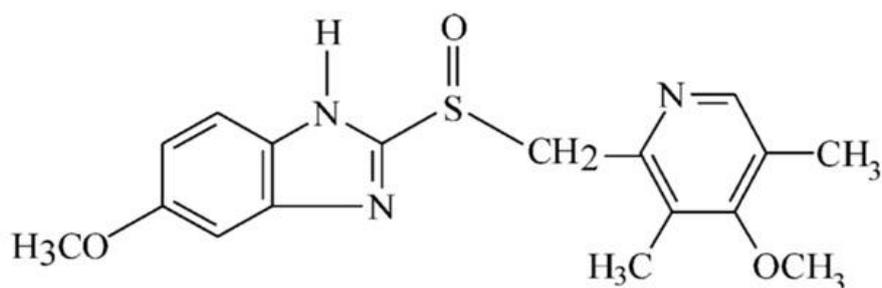
### **1. INTRODUCTION**

Omeprazole (OMZ) (Scheme.1) is a (RS)-5-methoxy-2-((4-methoxy-3,5-dimethylpyridin-2-yl)methylsulfinyl)-1H-benzo[d]imidazole and its empirical formula  $\text{C}_{17}\text{H}_{19}\text{N}_3\text{O}_3\text{S}$  with molecular weight  $345.4 \text{ g mol}^{-1}$ . It was a selective and irreversible proton

pump inhibitor used in the treatment of various acid-related disorders such as dyspepsia, peptic ulcer disease (PUD), gastroesophageal reflux disease (GORD/GERD), laryngopharyngeal reflux (LPR) and Zollinger–Ellison syndrome. OMZ was one of the most widely prescribed drugs internationally and available in some countries. OMZ was combined with the antibiotics clarithromycin and amoxicillin (or metronidazole in penicillin-hypersensitive patients) in the 7–14 days eradication triple therapy for *Helicobacter pylori*. Infection by *H. pylori* is the causative factor in the majority of peptic ulcers [1,2]. OMZ suppresses gastric acid secretion by specific inhibition of the hydrogen–potassium adenosine triphosphatase ( $H^+$ ,  $K^+$ -ATPase) enzyme system found at the secretory surface of parietal cells. It inhibits the final transport of hydrogen ions (via exchange with potassium ions) into the gastric lumen. Since the  $H^+$ ,  $K^+$ -ATPase enzyme system was regarded as the acid (proton) pump of the gastric mucosa and OMZ was known as a gastric acid pump inhibitor. The inhibitory effect was dose-related. OMZ inhibits both basal and stimulated acid secretion irrespective of the stimulus [3]. Many analytical methods, such as liquid chromatography [4], spectrophotometry [5–7], high-performance liquid chromatography (HPLC) [8–10], thin layer chromatography (TLC) [11], capillary electrophoresis (CE) [12,13] and etc. The development of new techniques capable of determining drugs in pharmaceutical and biological samples formulations was important. Electroanalytical methods are fast, highly sensitive and can allow direct measurement in biological samples with very little or no sample pretreatment. They have been successfully used for the detection and determination of several drugs [14–17]. The oxidation process and voltammetric method for quantitative determination of OMZ has been described [18,19]. The electrochemical oxidation of OMZ at a carbon paste electrode was studied by cyclic and differential pulse voltammetry (DPV) [18]. A determination method was developed and successfully applied to the analysis of OMZ in capsules. The oxidation process of OMZ at glassy carbon electrode (GCE) in different supporting electrolytes was investigated by using CV and DPV techniques [19]. Electrochemical redox behavior of OMZ using a glassy carbon electrode cyclic voltammetry and square wave voltammetry was studied [20]. A proposed method in phosphate buffer solution (pH 7) was utilized for the determination of OMZ in drug enteric-coated tablets. In recent years, polymer-modified electrodes have attracted a great attention as polymeric film has good stability and reproducibility [21]. A number of researchers have employed polymeric film modified electrode to detect OMZ. So far, different methodologies have been used for depositing polymeric films. Electropolymerization is a good approach to immobilize polymers, because of the adjusting the electrochemical parameters can control film thickness, permeation and charge transport characteristics.

Although voltammetry has been exhaustively used for the determination of OMZ, a systematic investigation of the oxidation mechanism of the drug has been very less undertaken. Therefore, in this work the electrochemical oxidation behavior of OMZ was

studied on a poly(alizarin)/GCE over at different molarities of NaOH concentration using cyclic and differential pulse voltammetric techniques.



**Scheme 1.** Chemical structure of OMZ

## 2. EXPERIMENTAL

### 2.1. Chemicals

OMZ was purchased from sigma and Alizarin (AZ) was obtained from Himedia chemical company and of analytical grade used without further purification. 25 mM OMZ was prepared by dissolved in dimethyl sulfoxide (DMSO) and then further diluted in sodium hydroxide (0.1 M). Water used in the preparation of solutions was double distilled water.

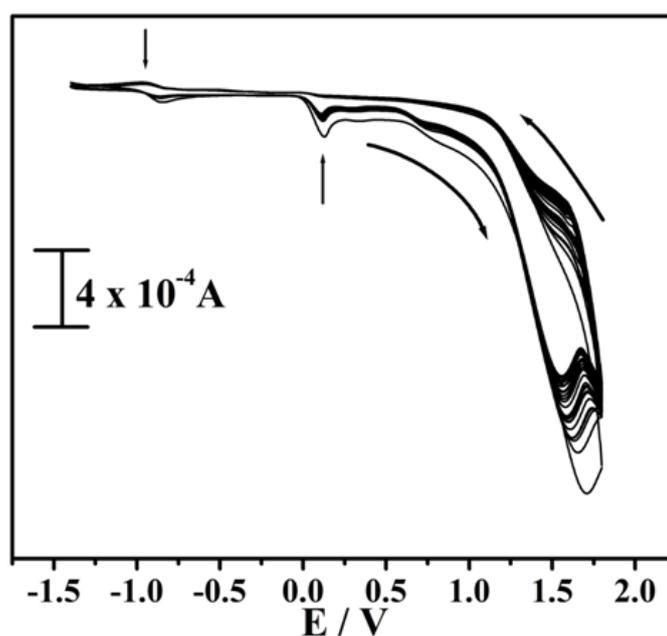
### 2.2. Apparatus

The electrochemical experiment was carried out using a model CHI-660c (CH Instrument-660 electrochemical workstation). The electrode system contained the working electrode was GCE and Poly(AZ)/GCE, a platinum counter electrode and saturated calomel as reference electrode.

### 2.3. Preparation of poly(AZ)/glassy carbon electrode

Before performing the electrochemical experiments, the GCE was polished to a mirror-like surface with 1.0 and 0.05  $\mu\text{m}$  gamma alumina slurry on a polishing cloth and rinsed thoroughly with doubly distilled water between each polishing step. The polished electrode was electrochemically cleaned and characterized by potential cycling between -1.4 and 1.8 V at 0.1  $\text{Vs}^{-1}$  for 11 multiple cycles in 0.1 M  $\text{H}_2\text{SO}_4$  until a stable cyclic voltammogram for the cleaned GCE dried was obtained and the electropolymerisation of AZ was carried out with potentiostatic technique. In Fig.1 the monomer concentration was 1.0 mM AZ in 0.1 M NaOH, the potential was controlled from -1.4 and 1.8 V at 0.1  $\text{Vs}^{-1}$  with 30 multiple cycles.

In the first potential scan, an anodic peaks (a) were observed near a potential values of  $E_{pa1} = -0.84$  V,  $E_{pa2} = 0.13$  V and reduction peak  $E_{pc} = -0.98$  V. Oxidation and reduction peaks were hardly observed. From the second cycle on, two obvious anodic peaks appeared, smaller peaks were observed upon continuous scanning. These facts indicated AZ was deposited on the surface of GCE by electropolymerization mode. It can be observed that film growth was faster in the thirtieth cycles. After the thirtieth cycle, the film was no longer growth. A uniform adherent AZ polymer film was formed on the GCE surface during electropolymerization. After that, the electrode was rinsed with double distilled water.

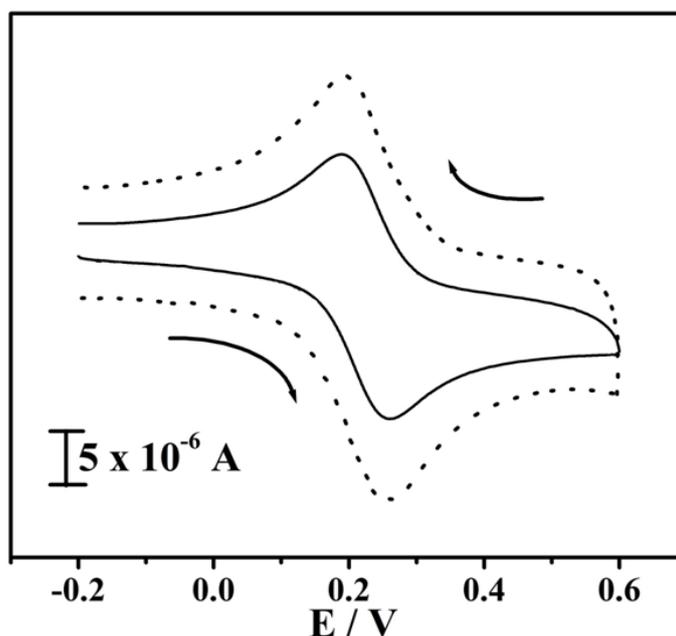


**Fig.1.** Cyclic voltammograms for electrochemical polymerization of alizarin on bare glassy carbon electrode in 0.1 M NaOH by 30 cycles (Scan rate  $0.1 \text{ Vs}^{-1}$ )

### 3. RESULT AND DISCUSSION

#### 3.1. Electrochemical characterization of poly(AZ)/GCE using standard potassium ferrocyanide system

The freshly prepared 1.0 mM potassium ferrocyanide in 1.0 M potassium chloride solution was placed in the electrochemical cell. The Fig. 2 shows the cyclic voltammograms recorded for the 1.0 mM potassium ferrocyanide at both BGCE (solid line) and at poly(AZ)/GCE (dotted line) at scan rate of  $0.05 \text{ Vs}^{-1}$ . The low redox peak currents signal was observed at BGCE and the increased current signal was observed for the poly(AZ)/GCE with electrocatalytic property.

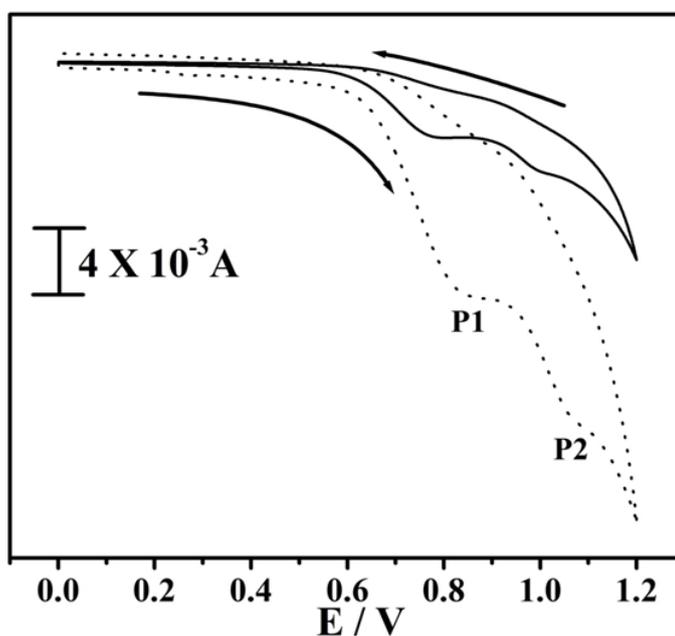


**Fig.2.** Cyclic voltammograms of 1.0 mM potassium ferrocyanide at BGCE (solid line) and Poly (AZ)/GCE (dotted line) in 1.0 M potassium chloride at scan rate of 0.05 Vs<sup>-1</sup>

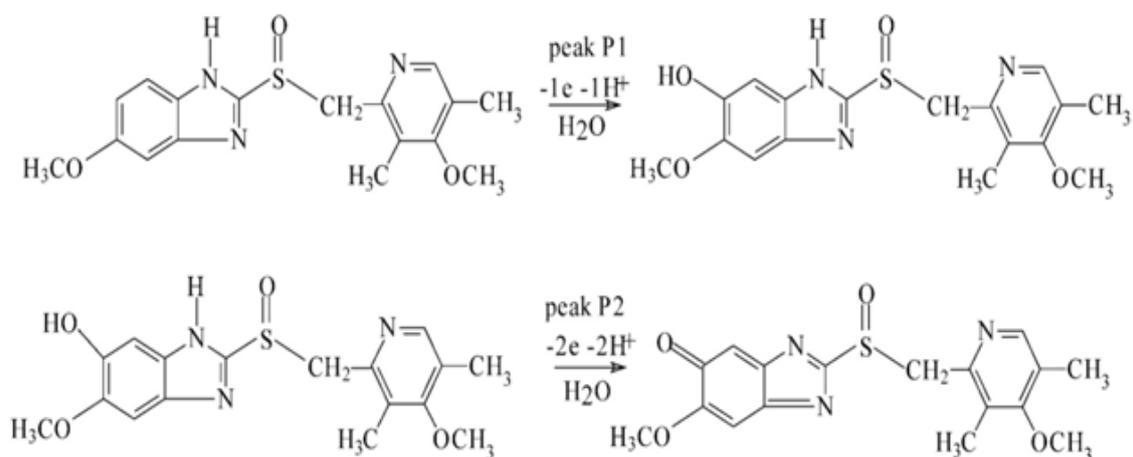
### 3.2 Electrochemical response of OMZ at poly(AZ)/GCE

Fig.3 shows the cyclic voltammograms of 1.0 mM OMZ at BGCE and poly(AZ)/GCE in 0.1 M NaOH solution at scan rate 0.05 Vs<sup>-1</sup>. At the BGCE the cyclic voltammogram of OMZ (solid line) showed two oxidation peaks, first peak potential at 0.78 V and second peak potential at 1.0 V with low current signals. The electrochemical response of OMZ at poly(AZ)/GCE showed well defined oxidation waves of OMZ with strong increase of the oxidation peak currents (dotted line). The oxidation peak potential occurs at 0.86 V and second oxidation peak potential at 1.06 V respectively and the negligible shift in the oxidation peak potentials shows the characteristics of the irreversible natured voltammogram. By increasing the scan rate, the main peak P1 current increases (Fig. 3), following a linear relationship with scan rate as expected for an adsorbed species reaction. Such a kind of behavior was already described for OMZ oxidation on a carbon paste electrode [18] and on glassy carbon electrode [20]. In the first step, peak P1, one electron is removed, followed by deprotonation to produce a cation radical, which reacts with water and leads to the formation of hydroxylated species. The second oxidation step, peak P2, with a two-electron and two-proton transfer, involves the hydroxylated and amino groups in the benzimidazole moiety leading to the formation of species similar to quinines (Scheme 2) [20]. The modified electrode exhibited strong promoting effect and high stability towards the electrochemical oxidation of OMZ. It was observed that the peak currents enhanced at the poly(AZ)/GCE,

which provides more evidence for asserting that the polymerization of AZ on the GCE possessed high electrocatalytic activity towards the OMZ detection.



**Fig. 3.** Cyclic voltammograms of 1.0 mM OMZ at BGCE (solid line) and at Poly(AZ)/GCE (dotted line) in 0.1 M NaOH solution at scan rate 0.05 Vs<sup>-1</sup>

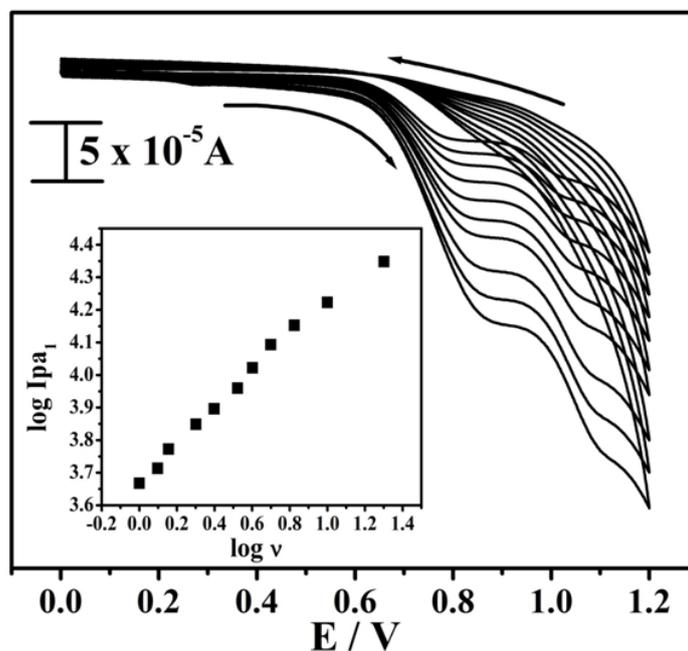


**Scheme 2.** Oxidation mechanism of OMZ

### 3.3. Effect of scan rate

The influence of the scan rate on the 1.0 mM OMZ for first anodic peak current ( $I_{pa1}$ ) at poly(AZ)/GCE in 0.1 M NaOH was studied as shown in Fig.4. The logarithm peak current for the anodic oxidation of OMZ is linear relationship with increase scan rate from

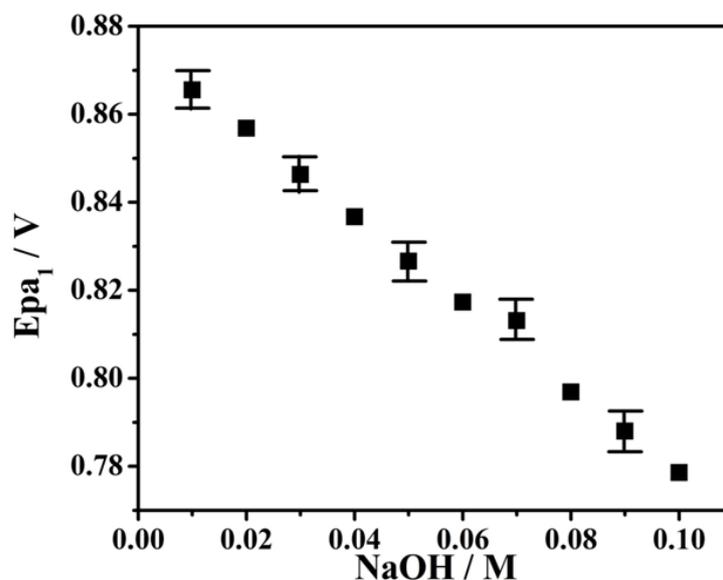
0.05 to 1.0  $\text{Vs}^{-1}$ . The determined slope of 0.5398, obtained from  $\log I_{pa_1}$  vs.  $\log v$  plot inset Fig. 4 is in close agreement with the theoretical value of 0.5 for a diffusion-controlled process [22]. Suggest that the electrode process was controlled by diffusion of analyte.



**Fig. 4.** Cyclic voltammograms of 1.0 mM OMZ with different scan rates from 0.05 to 1.0  $\text{Vs}^{-1}$  for the Poly(AZ)/GCE in 0.1 M NaOH solution and inset graph of the logarithm first anodic peak current ( $\log I_{pa_1}$ ) versus the logarithm of the scan rate ( $\log v$ ) for OMZ in the range from 0.05 to 1.0  $\text{Vs}^{-1}$

### 3.4. Effect of NaOH supporting electrolyte molarities on poly(AZ)/GCE

From Fig.5 shows the molarities of NaOH affected the electrocatalytic property of that electrode. The poly(AZ)/GCE was characterized by increasing the molarities of NaOH from 0.01 to 0.1 M in the detection of OMZ. The increase of molarity of NaOH results the decrease of anodic peak potential it favors the oxidation at 0.1 M NaOH and the first anodic peak potential ( $E_{pa_1}$ ) decreases with the electrode shows good electrocatalytic activity at 0.1 M NaOH compared to other molar solutions which suggested that 0.1 M NaOH was chosen for further studies was selected for OMZ.



**Fig. 5.** Graph of first anodic peak potential ( $E_{pa_1}$ ) vs Molarity of NaOH

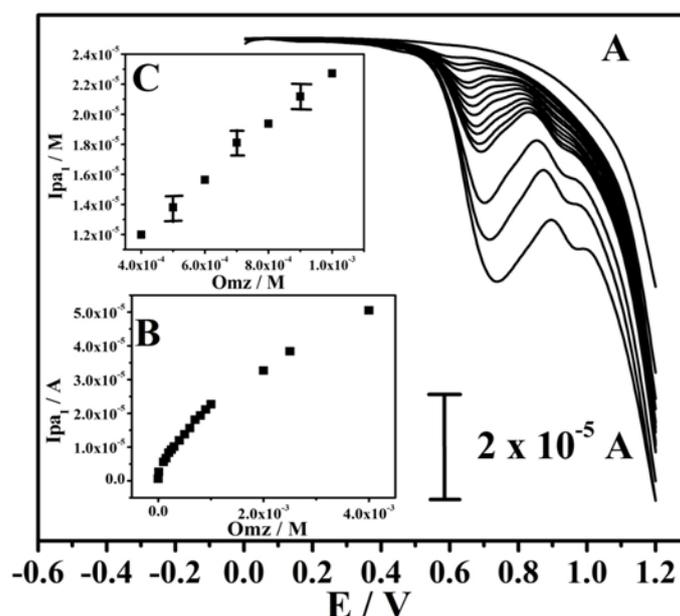
### 3.5. Differential pulse voltammetry

#### 3.5.1. Effect of concentration

The DPV plots were recorded in the poly(AZ)/GCE at 0.1 M NaOH at concentrations of OMZ was analyzed in the range from  $1.0 \times 10^{-6}$  to  $4.0 \times 10^{-3}$  M (Fig.6 A & Fig.6 B). There was enhancement in the first anodic current. The anodic peak current ( $i_{pa_1}$ ) was proportional to concentration of OMZ and the better linearity occurred in the range from  $4 \times 10^{-4}$  to  $1 \times 10^{-3}$  M and the linear regression equation was  $i_{pa_1}(A) = 0.0181 C M L^{-1} + 4.879 \times 10^{-6}$  ( $n=6$   $r^2=0.9975$ ) (Fig.6 C). The limit of detection (LOD) for OMZ in the lower concentration range was  $7.15 \times 10^{-7}$  M and quantification limit was  $2.38 \times 10^{-6}$  M for poly(AZ)/GCE. The detection limit and quantification limits was calculated by using the formulas (1) and (2) [23,24], where S is the standard deviation and M is the slope obtained from the three calibration plots. The detection limit of various electroanalytical methods proposed for determination of OMZ is compared with other electrodes data in Table 1. From the data shown, a lower limit of detection (LOD) can be achieved using the proposed method [18,19,21,25].

$$LOD = 3S/M \quad (1)$$

$$LOQ = 10S/M \quad (2)$$



**Fig. 6.** (A) Differential pulse voltammograms from  $1.0 \times 10^{-6}$  to  $4.0 \times 10^{-3}$  M OMZ individually in 0.1 M NaOH for Poly(AZ)/GCE; (B) Graph of the first anodic peak current ( $I_{pa1}$ ) versus the concentration of OMZ in the analyzed range  $1.0 \times 10^{-6}$  to  $4.0 \times 10^{-3}$  M and (C) Graph of the first anodic peak current ( $I_{pa1}$ ) versus the concentration of OMZ in the better linearity range  $4 \times 10^{-4}$  to  $1 \times 10^{-3}$  M

**Table 1.** Comparison of the detection limit for different modified electrodes

Electrode	Sensitivity	Detection limit	Techniques	Reference
HMDE	$0.011 \mu\text{A } \mu\text{M}^{-1}$	$0.145 \mu\text{M}$	DPP	[25]
GCE	-	$0.19 \text{ mg L}^{-1}$	DPV	[19]
CPE	$0.49 \mu\text{A } \mu\text{M}^{-1}$	$0.025 \mu\text{M}^{-1}$	DPV	[18]
NiOxNP-GCE	$40.1 \text{ nA } \mu\text{M}^{-1} \text{ cm}^{-2}$	$0.4 \mu\text{M}$	Amperometry	[21]
Poly (alizarin)/GCE	$0.0181 \mu\text{A } \mu\text{M}^{-1}$	$0.715 \mu\text{M}$	DPV	Present Work

### 3.6. Analytical applications

The poly(AZ)/GCE was applied for the analysis of OMZ containing capsule. The OMZ capsule was purchased from medical stores with a specified content of OMZ  $20 \text{ mg each capsule}^{-1}$  and the capsule was used after suitable dilution. 0.1 M NaOH was used for diluting the capsule and the results are shown in Table.2. The recovery and R.S.D. was acceptable, showing that the proposed methods could be efficiently used for the detection of

OMZ in capsule with recovery in the range 96.68–97.81%. These results indicate that the proposed method has high accuracy and it can be used for routine analysis in drug quality control laboratories.

**Table 2.** Detection of OMZ in capsule (n=5)

Sample	Content (mg mL <sup>-1</sup> )	Found (mg mL <sup>-1</sup> )	RSD(%)	Recovery(%)
1	2.0	1.9562 ± 0.008	1.98	97.81
2	4.0	3.8848 ± 0.0154	2.76	97.12
3	6.0	5.808 ± 0.0362	3.21	96.68

#### 4. CONCLUSION

In the present work, polymerization of AZ on glassy carbon electrode was characterized by using standard potassium ferrocyanide. Electrode transfer reaction was controlled by diffusion. Increasing the concentration of NaOH in the detection of OMZ the anodic peak potential decreases and the detection limit was found to be  $7.15 \times 10^{-7}$  M. The modification of the GCE electrode with AZ is a stable sensor for OMZ. The proposed method can be applied to the detection of OMZ in drug. Therefore, the present method can be extended to various clinical and pharmaceutical preparations. Hence poly(AZ)/GCE was acting as electrochemical sensor for the detection of OMZ.

#### Acknowledgment

One of the authors, K. R. Mahanthesha is thankful to University Grants Commission, New Delhi, INDIA for awarding Rajiv Gandhi National Fellowship. UGC letter No.: F. 14-2(ST)/2009 (SA-III) Dated: 08 December 2010.

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