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*Full Paper*

# Electrochemical Determination of Antibacterial Drug Moxifloxacin Hydrochloride Using Chloranil Modified Carbon Paste Electrode

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**Abstract**- A highly sensitive electroanalytical method for the determination of moxifloxacin hydrochloride using differential pulse voltammetry was described. The electrochemical behavior of the used drug was investigated in Britton-Robinson buffer in the pH range of 2.0 to 11.0 at chloranil modified carbon paste electrode. The anodic peak currents increased linearly with the concentration in the range of $4.0\times10^{-7}$ to $3.6\times10^{-6}$ mol $L^{-1}$. The limits of detection and quantification were $6.74\times10^{-8}$ mol $L^{-1}$ and $2.25\times10^{-7}$ mol $L^{-1}$, respectively. The relative standard deviation was found in the following range: 0.569-0.974%. The percentage recovery was found in the following range: 99.28-100.60%. The method was successfully applied to the determination of moxifloxacin hydrochloride in tablets without previous separation.

**Keywords-** Moxifloxacin Hydrochloride, Chloranil, Oxidation, Differential Pulse Voltammetry, Tablets

## 1. INTRODUCTION

Analytical chemistry plays a critical role in the development of a compound from its synthesis stage to its marketing stage as a part of a drug formulation and analysis. The instrumental methods for quantitation which are most commonly used in a pharmaceutical laboratory fall into four basic categories: chromatography, spectrophotometric,

electrochemical and radiometric analysis [1]. Electroanalytical chemistry along with the use of oxidation-reduction reactions and other charge-transfer phenomena had its origins eight decades ago. It is one of the fundamental subdisciplines of analytical chemistry. Voltammetric methods have become a popular tool for the study of electrochemical reactions [2], for the study of electrochemically generated free radicals [3], in model studies of enzymatic catalysis [4], in coordination chemistry [5], in environmental monitoring [6], in industrial quality control and in the determination of trace concentrations of biological and clinically important compounds [7-10].

Moxifloxacin hydrochloride (MXF) as shown in Fig. 1, a fourth generation fluoroquinolone, is a broad spectrum antibiotic used in the prevention and treatment of a variety of ocular infections [11]. Recent reports based on several in vivo studies have shown the potency of moxifloxacin in preventing anterior eye infections such as bacterial conjunctivitis and keratitis [12]. With the increasing worldwide use of moxifloxacin, there is an urgent need to develop a simple, rapid, reliable and low cost analytical method for the determination of MXF.

Different methods for the quantification of MXF have been reported which include chromatography [13-26], capillary zone electrophoresis [27-29], spectorphotometry [30-33], spectrofluorimetry [34,35], chemiluminescence [36,37], voltammetry [38-41] and polarography [42,43].

The aim of this work is to develop an efficient method for rapid analysis of MXF using cyclic and differential pulse voltammetry (DPV) through the construction of a chemically modified carbon paste electrode by incorporation of chloranil (CA) as the modifying species to obtain chloranil modified carbon paste electrode (CACPE). And thus in continuation to our previous work [44-51].

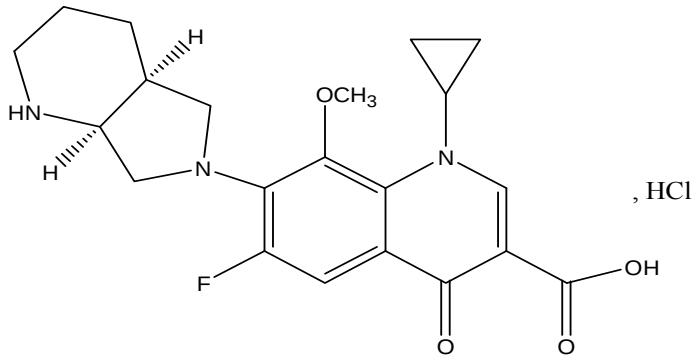


**Fig. 1.** The chemical structure of MXF

## 2. EXPERIMENTAL

### 2.1. Apparatus

Voltammetric measurements were carried out using a computer-driven AEW2 analytical electrochemical workstation with ECProg3 electrochemistry software (Sycopel, England) in combination with a C-2 stand with a three-electrode configuration: a carbon paste electrode (BAS model MF-2010) working electrode, an Ag/AgCl/3 mol $L^{-1}$ NaCl (BAS model MF-2063) reference electrode and a platinum wire (BAS model MW-1032) counter electrode. Origin 7.0 software was used for the transformation of the initial signal. A cyberscan 500 (EUTECH Instruments, USA) digital pH-meter with a glass combination electrode served to carry out the pH measurements.

### 2.2. Reagents

MXF was supplied from Eva Pharma Company, Egypt. Its pharmaceutical form (Moxifloxacin tablets) was provided by Sabaa International Company, Egypt. Stock solution of MXF $1.0\times10^{-3}$ mol $L^{-1}$ was prepared by dissolving an appropriate amount of MXF in ethanol which was obtained from El-Nasr Pharmaceutical Company, Egypt. The stock solution was stored in a refrigerator. Britton-Robinson (BR) and phosphate buffers were prepared as described before [52,53]. Graphite powder and chloranil were supplied from Aldrich. Paraffin oil was purchased from Sigma.

### 2.3. Preparation of the modified electrode (CACPE)

A 1.0% (w/w) CA spiked carbon powder was made by dissolving a given quantity of CA in ethyl ether and by hand mixing with, 99 times its weight, graphite powder with a mortar and pestle. The solvent was evaporated by stirring. Paraffin was added to the previous mixture using a syringe and the mixture was mixed for 20 min until a uniformly wetted paste was obtained. The paste was then packed into the hole of the electrode body and smoothed on a filter paper until it had a shiny appearance. A carbon paste electrode (CPE) without CA was prepared according to the above procedure without CA addition.

## 3. RESULTS AND DISCUSSION

### 3.1. Electrochemical behaviors of MXF

The electrochemical behavior of CACPE was studied by using cyclic voltammetry. Fig. 2a shows the cyclic voltammograms of CACPE in BR buffer (pH 7.0). As can be seen, the cyclic voltammogram exhibits an anodic peak at forward scan and a cathodic peak at the reverse scan related to the oxidation and reduction of CA. The cyclic voltammogram of CPE shows no any anodic and cathodic peaks (Fig. 2b). Therefore the experimental results show that well defined and reproducible anodic and cathodic peaks related the presence of CA.

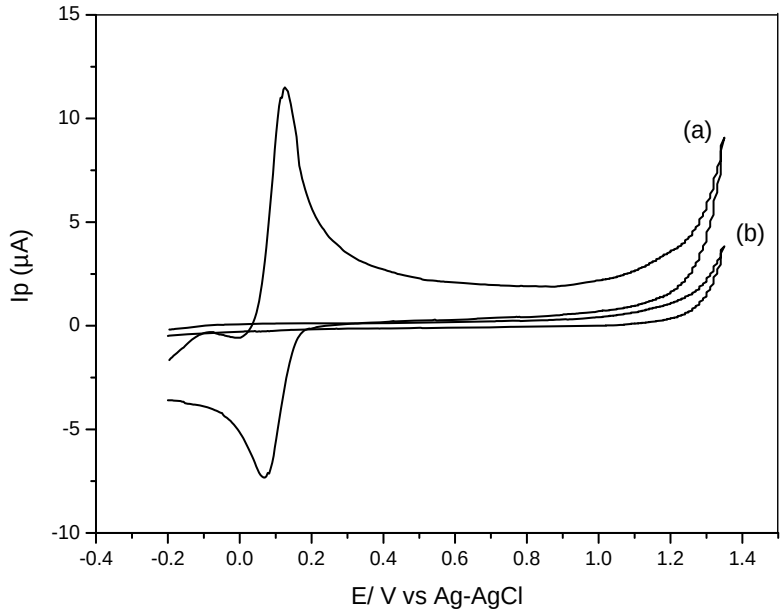


**Fig. 2.** Cyclic voltammograms in case of CACPE (a) and CPE (b) in BR buffer of pH 7.0. Scan rate 100 mV $s^{-1}$

Fig. 3 shows the cyclic voltammograms of $4.0\times10^{-5}$ mol $L^{-1}$ MXF solution in BR buffer of pH 7.0 in case of modified carbon electrode CACPE and CPE. Each voltammogram exhibits one well defined anodic peak, with no peak on the reverse scan, suggesting the irreversible nature of the electrode reaction. It is obvious from the figure that CACPE is better than CPE for electrochemical determination of MXF, which suggests that CA is an effective mediator in the electrocatalytic oxidation of MXF.

### 3.2. Effect of pH

The effect of pH on MXF at CACPE was studied in the electrolytic cell containing 5 mL of BR buffer and the cyclic voltammogram was recorded. Fig. 4 shows the plot of peak current ($I_p$) *vs*. pH. It is obvious from the figure that the peak current reaches its maximum value at pH 7.0.

### 3.3. Effect of buffer type

Fig. 5 shows the cyclic voltammograms of $4.0\times10^{-5}$ mol $L^{-1}$ MXF solution in BR and phosphate buffers at pH 7.0. It is obvious from the figure that the anodic current response in case of BR buffer is higher than that in case of phosphate buffer at the optimum pH value. BR buffer is suitable for electrochemical determination of MXF.

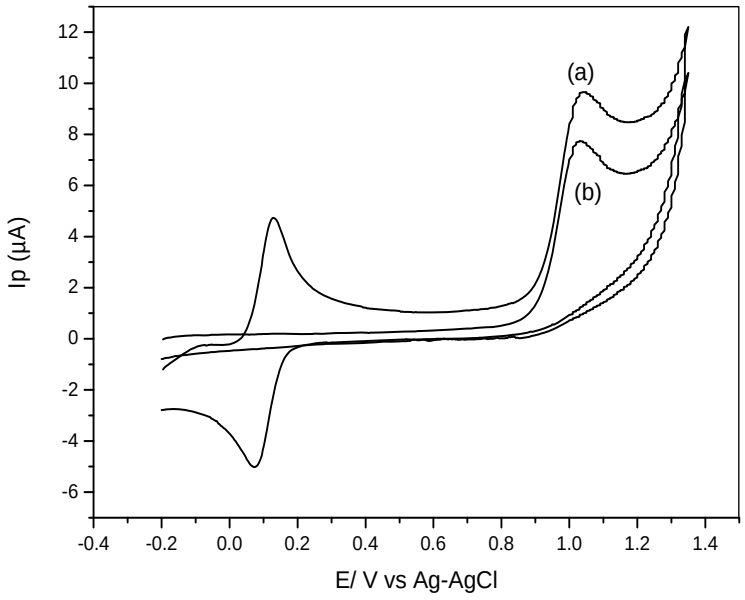


**Fig. 3.** Cyclic voltammograms of $4.0\times10^{-5}$ mol $L^{-1}$ MXF solution in BR buffer of pH 7.0 in case of CACPE (a) and CPE (b). Scan rate 100 mV $s^{-1}$

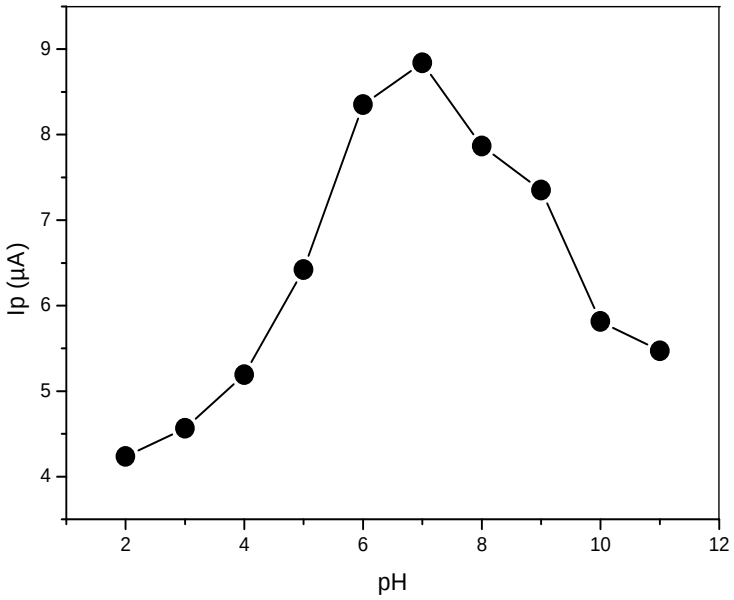


**Fig. 4.** Effect of pH on peak current of $4.0\times10^{-5}$ mol $L^{-1}$ MXF solution in BR buffer at CACPE. Scan rate 100 mV $s^{-1}$

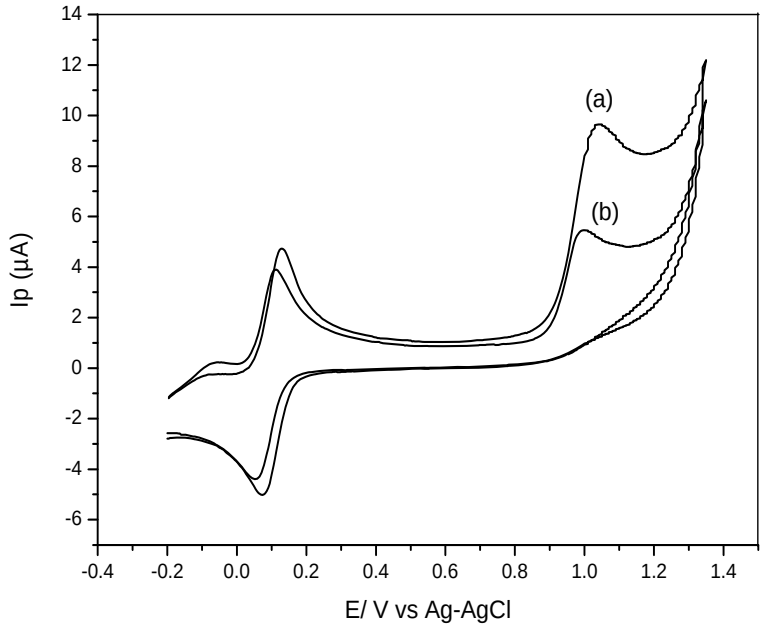


**Fig. 5.** Cyclic voltammograms of $4.0\times10^{-5}$ mol $L^{-1}$ MXF solution at CACPE in BR (a) and phosphate (b) buffers of pH 7.0 at a scan rate of 100 mV $s^{-1}$

### 3.4. Effect of scan rate

The effect of scan rate (υ) on the peak current ($I_p$) of MXF was carried out by immersing the working electrode in BR buffer solution of pH 7.0 which contains an appropriate amounts of $1.0\times10^{-3}$ mol $L^{-1}$ drug solution, and the cyclic voltammograms were recorded at different scan rates over the scan range 10-250 mV $s^{-1}$. Fig. 6 shows linear relationship between log $I_p$ and log υ over the scan range 10-250 mV $s^{-1}$ and corresponds to the following equation: $I_p$=-0.62+0.79 log υ. The slope of 0.79 indicates to diffusion controlled process with some adsorption character [54].

### 3.5. Effect of accumulation time

The effect of accumulation time on the anodic peak current of $4.0\times10^{-5}$ mol $L^{-1}$ MXF solution was studied at CACPE in BR buffer of pH 7.0 at open circuit condition. The results were shown in Fig. 7. From the figure we note that the anodic current response reaches its maximum value at accumulation time 5.0 second and after this value the anodic current decreases till reaching a constant value. Accumulation time 5.0 second is chosen as the optimum accumulation time.

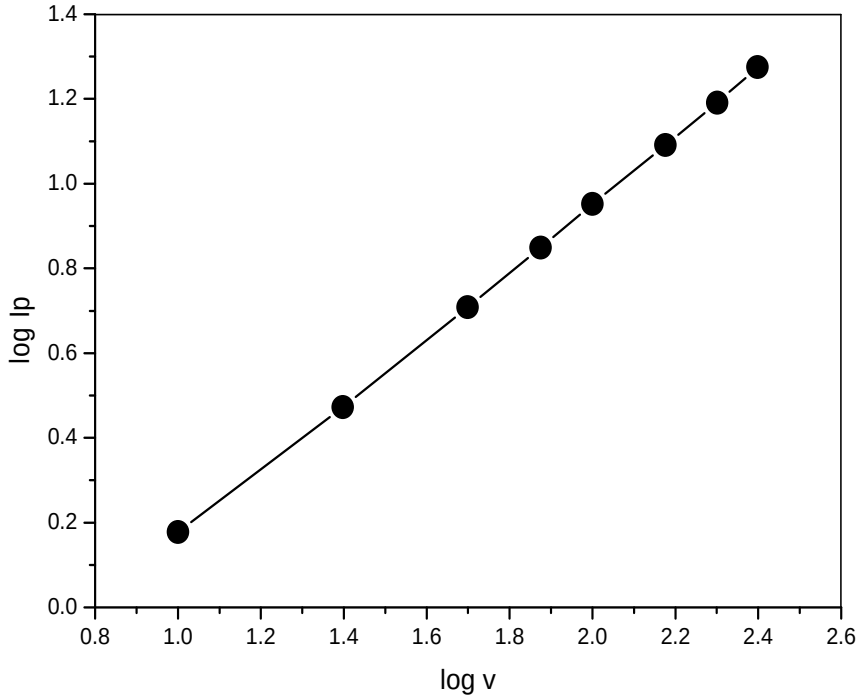


**Fig. 6.** Anodic peak current response of $4.0\times10^{-5}$ mol $L^{-1}$ MXF solution as a function of scan rate (υ) in BR buffer of pH 7.0 at CACPE

### 3.6. Electrochemical determination of MXF

DPV method was developed for the determination of MXF depending on the electrochemical oxidation of MXF at CACPE. Voltammetric analyses were performed in 5.0 mL of BR buffer. Aliquots of the drug solution ($1.0\times10^{-3}$ mol $L^{-1}$) were introduced into the electrolytic cell and the voltammograms were recorded. The method was linear relation in the range of $4.0\times10^{-7}$ mol $L^{-1}$ to $3.6\times10^{-6}$ mol $L^{-1}$ as shown in Fig. 8. The calibration plot was described by the following equation:

$I_p$ (μA) = 0.089 C (μ mol $L^{-1}$) + 0.536 $r^2$ (Correlation coefficient) = 0.9998

The limit of detection (LOD) and the limit of quantification (LOQ) were calculated by using the following equations: LOD=3 S.D. /m and LOQ=10 S.D./m, where "S.D." is the standard deviation of the intercept of the calibration curve and "m" is the slope of the calibration curve [55]. The LOD and LOQ were $6.74\times10^{-8}$ mol $L^{-1}$ and $2.25\times10^{-7}$ mol $L^{-1}$, respectively.

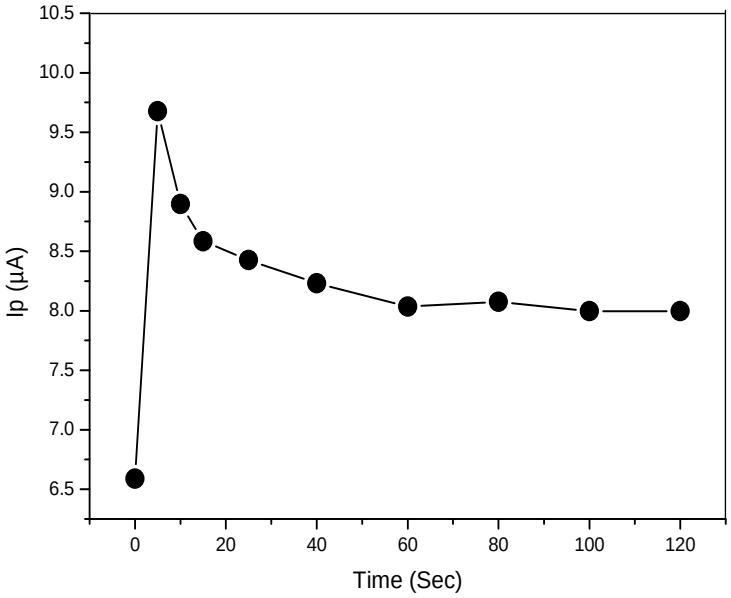


**Fig. 7.** Effect of accumulation time on the peak current of $4.0\times10^{-5}$ mol $L^{-1}$ MXF solution in BR buffer of pH 7.0 at CACPE

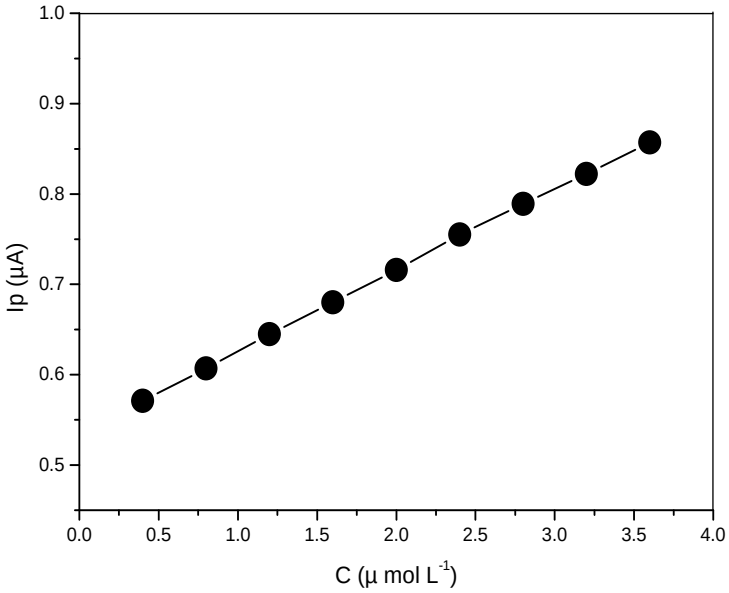


**Fig. 8.** Calibration curve of MXF at CACPE, pulse amplitude 50 mV and scan rate 20 mV $s^{-1}$

### 3.7. Precision and accuracy

Precision is degree of repeatability of an analytical method under normal operation conditions. The precision and accuracy were determined with standard quality control samples prepared at different concentration levels covering the entire linearity range. The precision of assay was determined by repeatability and reported as the percent relative standard deviation (RSD) for a statistically significant number of replicate measurements. Accuracy expresses the closeness of agreement between the value found and the value that is accepted as a reference value. It is very common to evaluate accuracy by performing recovery experiments. Data from five determinations over five concentration levels covering the specified range were obtained. The relative standard deviation was found in the following range: 0.569-0.974%. The percentage recovery was found in the following range: 99.28-100.60%. Analytical parameters of the calibration plots for the determination of MXF were listed in Table 1.

**Table 1.** Analytical parameters of the calibration curve of MXF

| Parameter | DPV method |
|---|---|
| Linearity range (mol $L^{-1}$) | $4.0\times10^{-7}$-$3.6\times10^{-6}$ |
| Slope | 0.089 |
| Intercept | 0.536 |
| Correlation coefficient ($r^2$) | 0.9998 |
| LOD (mol $L^{-1}$) | $6.74\times10^{-8}$ |
| LOQ (mol $L^{-1}$) | $2.25\times10^{-7}$ |
| RSD* (%) | 0.569-0.974 |
| Recovery (%) | 99.28-100.60 |

* Five different concentration of MXF; number of replicates (n) = 5

The proposed method is more sensitive than the following methods which have higher detection limits: capillary zone electrophoresis method: $3.494\times10^{-6}$ mol $L^{-1}$ [28] and chemiluminescence method: $3.0\times10^{-7}$ mol $L^{-1}$ [37]. Also our method is more sensitive than spectrophotometric methods: $2.28\times10^{-6}$-$2.28\times10^{-5}$ mol $L^{-1}$ [32] and $1.827\times10^{-6}$-$1.370\times10^{-5}$ mol $L^{-1}$ [33] and voltammetric method: $2.0\times10^{-7}$-$1.4\times10^{-6}$ mol $L^{-1}$ [39].

### 3.8. Analysis of MXF in tablets

The proposed DPV method was successfully applied to the determination of MXF in its commercial tablets; there was no need for any extraction step prior to the drug assay. Replicate analyses have been carried out to obtain the accuracy and precision of the proposed

method; the results were given as shown in Table 2. The linearity range was $4.0\times10^{-7}$-$3.6\times10^{-6}$ mol $L^{-1}$ with mean recovery of 100.2% and mean relative standard deviation of 0.817%. The results were obtained in acceptable limits.

The proposed method is more sensitive than that of capillary zone electrophoresis method which has higher detection limit: $1.815\times10^{-6}$ mol $L^{-1}$ [27]. Also our method is more sensitive than the following methods: chromatographic method: $2.740\times10^{-5}$-$9.591\times10^{-5}$ mol $L^{-1}$ [25], spectrophotometric method: $1.370\times10^{-6}$-$2.274\times10^{-5}$ mol $L^{-1}$ [30] and voltammetric methods: $5.0\times10^{-6}$-$1.5\times10^{-5}$ mol $L^{-1}$ [38] and $4.4\times10^{-7}$-$1.0\times10^{-5}$ mol $L^{-1}$ [41].

**Table 2.** Determination of MXF in tablets

| Parameter | DPV method |
|---|---|
| Linearity range (mol $L^{-1}$) | $4.0\times10^{-7}$-$3.6\times10^{-6}$ |
| RSD* (%) | 0.668-0.988 |
| Recovery (%) | 99.35-101.2 |

* Five different concentration of MXF; number of replicates (n) = 5

## 4. CONCLUSION

A convenient simple, sensitive and rapid method has been developed for estimation of MXF either in bulk powder or in pharmaceutical dosage forms. The proposed method can be easily and conveniently adopted for routine analysis of MXF. Our method can be applied in laboratories lacking sophisticated and expensive instruments such as GC-MS or LC-MS. It was concluded that the developed method is equally accurate, sensitive and precise and could be applied directly and easily to the pharmaceutical formulation with a good recovery .

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