International Journal of Management, IT & Engineering
Vol. 9 Issue 5, May 2019,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell’s Directories of Publishing Opportunities, U.S.A

EXPIRED GANCICLOVIR DRUG AS SUSTAINABLE CORROSION INHIBITOR ON MILD STEEL (MS) IN 3 M HCL SOLUTION: ATOMIC ABSORPTION SPECTROSCOPY, POTENTIODYNAMIC POLARIZATION, NYQUIST PLOT AND SCANNING ELECTRON MICROSCOPY STUDIES

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Abstract- *The adsorption tendency of expired Ganciclovir drug on mild steel (MS) in 3 M HCl solution was demonstrated by using atomic absorption spectroscopy, potentiodynamic polarization, impedance spectroscopy and scanning electron microscopy (SEM) studies. The atomic absorption spectroscopy studies shows that, the protection rate enhances with rise in the concentration of expired Ganciclovir drug on the MS in 3 M HCl solution. The potentiodynamic polarization studies show that, the investigated nontoxic corrosion inhibitor act as mixed type corrosion inhibitor. The Nyquist plots and SEM studies shows that, formation of protective invisible film is due to the adsorption of expired Ganciclovir drug molecules on the MS surface in 3 M HCl solution.*

Keywords-- Expired Ganciclovir drug, mild steel, atomic absorption spectroscopy, potentiodynamic polarization, scanning electron microscopy

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I. INTRODUCTION

The unique properties of mild steel (MS) makes considerable attention in the field of engineering and science (Chandrabhan Verma et al., 2018; Verma et al., 2017). In several industrial processes it will contact with hydrochloric solution, which leads to dissolution, disintegration or corrosion of mild steel. The corrosion of mild steel in industrial sections directly effects on the nation economy. For this purpose, the organic corrosion inhibitors are highly used (Zheng et al., 2015; Murulana et al., 2012; Yesudass et al., 2016; Verma et al., 2016). But, their applications in several industries as corrosion inhibitors are limited due to their toxic nature, expensive and lower solubility. Majority of corrosion inhibitors contaminate the surrounding atmosphere after their application (Olasunkanmi et al., 2015; Verma et al., 2015; Gupta et al., 2016; Singh et al., 2016; Narasimha Raghavendra and Jathi Ishwara Bhat 2018). Whereas, the expired drug compounds are nontoxic, highly soluble in corrosive solutions and biodegradable. Because of increase in the demand of nontoxic and sustainable approach, the expired drug products are being employed as potential agents for MS corrosion inhibition. Generally, similar to synthetic organic corrosion inhibitors, the expired drug contains electron rich elements which expected to serve as adsorption centers. Therefore, the present study focuses to demonstrate the effect of expired Ganciclovir drug on the adsorption and corrosion inhibition behavior on the MS surface in 3 M HCl solution. The protection efficiency of the expired Ganciclovir drug was studied by atomic absorption spectroscopy, Tafel plot and Nyquist plot studies. The SEM technique used for the surface studies.

II. EXPERIMENTAL STUDIES

Materials and methods

The expired Ganciclovir drug was collected from the local shop. **Figure 1** shows the chemical structure of Ganciclovir. The inhibitor with concentrations of 0.1 mg, 0.2 mg, 0.3 mg and 0.4 mg were used for the atomic absorption spectroscopy, Tafel plot and AC impedance spectroscopy studies. The atomic absorption spectroscopy (AAS) was carried out with 100 ml of 3 M HCl solution. The AAS experiment carried out three times and average values are reported. From the calculated values of amount of dissolved iron content in protected and unprotected systems. The protection efficiency of the corrosion inhibitor can be calculated from the relation shown below;

$$\text{Corrosion protection (inhibition) efficiency} = \frac{B-A}{B} \times 100,$$

Where, B= Amount of dissolved iron content in the absence of expired Ganciclovir drug and A= Amount of dissolved iron content in the presence of expired Ganciclovir drug.

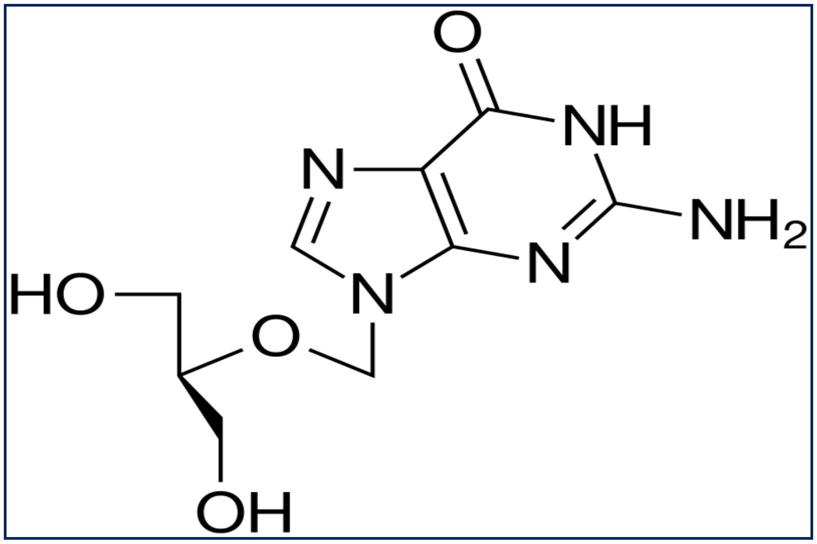

Figure 1. The chemical structure of Ganciclovir drug

The electrochemical studies was performed by using CHI660C workstation (MS= working cell, Pt= counter cell and calomel electrode= reference cell). The electrochemical plots are recorded at ± 250 mV. The scan rate used for the electrochemical studies is 1 mV/S.

The protection efficiencies are derived from the following equations;

$$\text{Protection efficiency} = \left[1 - \frac{i'_{corr}}{i_{corr}}\right] \times 100,$$

$$\text{Protection efficiency} = \frac{R_{ct\,(inh)} - R_{ct}}{R_{ct\,(inh)}} \times 100,$$

Where, i'_{corr} = Inhibited corrosion current density, i_{corr} = Uninhibited corrosion current density, R_{ct} = Uninhibited charge transfer resistance and $R_{ct\,(inh)}$ = Inhibited charge transfer resistance.

To support the atomic absorption spectroscopy, Tafel plot and impedance spectroscopy results, the SEM analysis was performed for MS surface in protected and unprotected systems.

III. RESULTS AND DISCUSSION

Atomic absorption spectroscopy technique

The effect of expired Ganciclovir drug on the mild steel (MS) in the 3 M HCl solution is shown in the **Table I**. From the table, it is clear that, the adsorption of expired Ganciclovir drug on the MS surface in the 3 M HCl solution, which decreases the dissolved iron content in the 3 M HCl solution. The amount of iron content in the 3 M HCl solution is decreases with rise in the expired Ganciclovir drug on the MS surface. The maximum protection efficiency obtained from the atomic absorption spectroscopy (AAS) is 96 %. At higher corrosion inhibition concentration, the inhibitor prevents the molecular decomposition, etching molecular and fragmentation.

Table 1. Atomic absorption spectroscopy results

Concentration (mg)	Amount of dissolved iron content in 3 M HCl solution	Protection efficiency in percentage
Bare	0.050	
0.1	0.023	54.000
0.2	0.013	74.000
0.3	0.0035	93.000
0.4	0.0020	96.000

Potentiodynamic polarization technique

Figure 2 shows the potentiodynamic polarization curves for mild steel (MS) in 3 M HCl solution without and with expired Ganciclovir drug. The results obtained from the potentiodynamic polarization curves are shown in the **Table II**. It is observed that, the corrosion current density values are reduces substantially in the presence of expired Ganciclovir drug on the MS in the 3 M HCl solution, which indicates the adsorption of expired Ganciclovir drug on the MS surface. The process of adsorption results the blockage of active sites of MS surface which blocks the MS dissolution or disintegration. The investigated corrosion inhibitor can be classified into cathodic, anodic or mixed type corrosion inhibitor based on the variation in the cathodic, anodic Tafel slope values and corrosion potential values. In present investigation, introduction of expired Ganciclovir drug to the 3 M HCl solution does not vary the anodic Tafel and cathodic Tafel slope values and corrosion potential values to the greater extent. Hence, screened expired Ganciclovir drug corrosion inhibitor can be classified into the mixed type corrosion inhibitor.

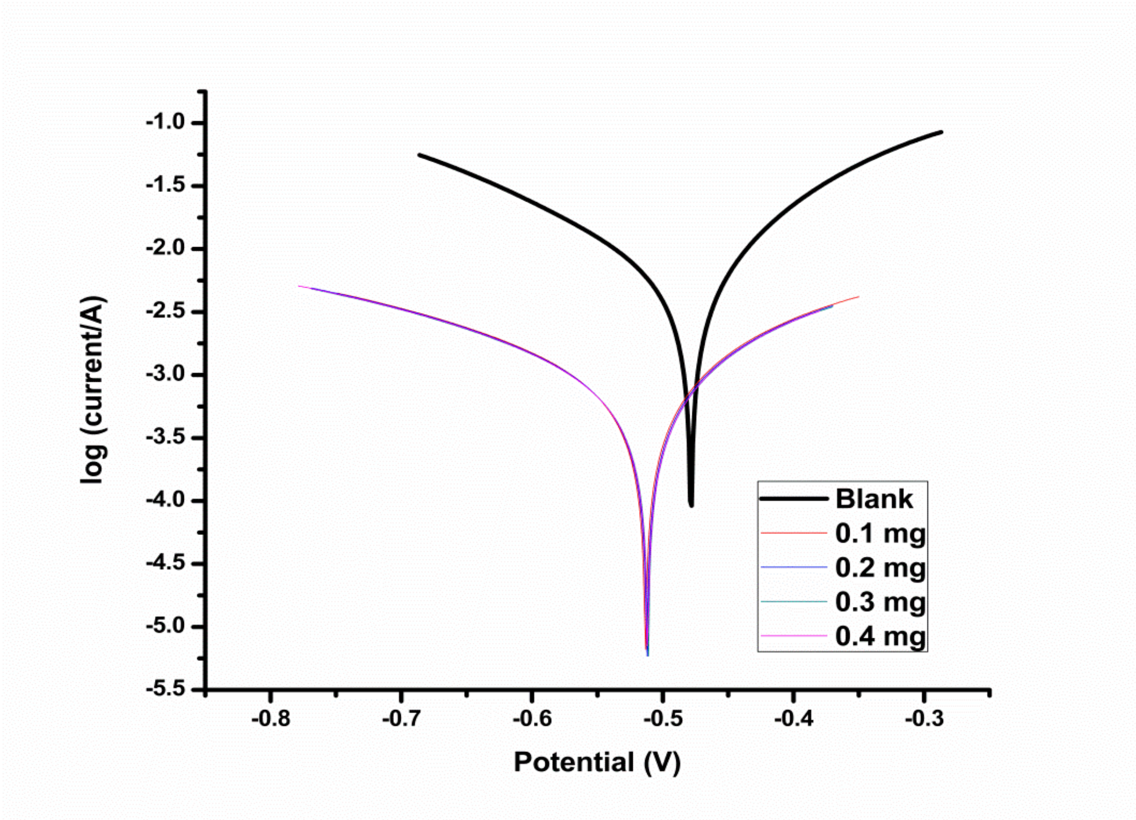

Figure 2. Tafel plots without and with expired Ganciclovir drug

Table 2. Potentiodynamic polarization (Tafel plot) results

Concentration (mg)	Corrosion potential (mV)	Cathoidc Tafel slope (V/dec)	Anodic Tafel slope (V/dec)	Corrosion current (A)	Protection efficiency
Bare	-478	5.792	7.183	0.006398	
0.1	-513	4.790	5.557	0.0008322	86.992
0.2	-512	4.802	5.593	0.0008139	87.278
0.3	-511	4.798	5.587	0.0008104	87.333
0.4	-512	4.800	5.626	0.0007948	87.577

Impedance spectroscopy technique

Nyquist plots for the MS in the 3 M HCl solution without and with expired Ganciclovir drug are presented in the **Figure 3.** The results obtained from the Nyquist plots are presented in the **Table III.** The diameter of the charge transfer resistance is large in the presence of expired Ganciclovir drug when compared to the bare solution. The differences in the diameter of the Nyquist plots in the protected and unprotected systems clearly indicate the corrosion inhibition property of expired Ganciclovir drug on the MS surface in 3 M HCl solution. The common behavior of the Nyquist plots in protected and unprotected metallic species are very similar which indicating that, the molecules of expired Ganciclovir drug inhibits the dissolution process by without altering the mechanism of MS corrosion. The highest protection efficiency obtained by AC impedance spectroscopy technique is 88.600 %.

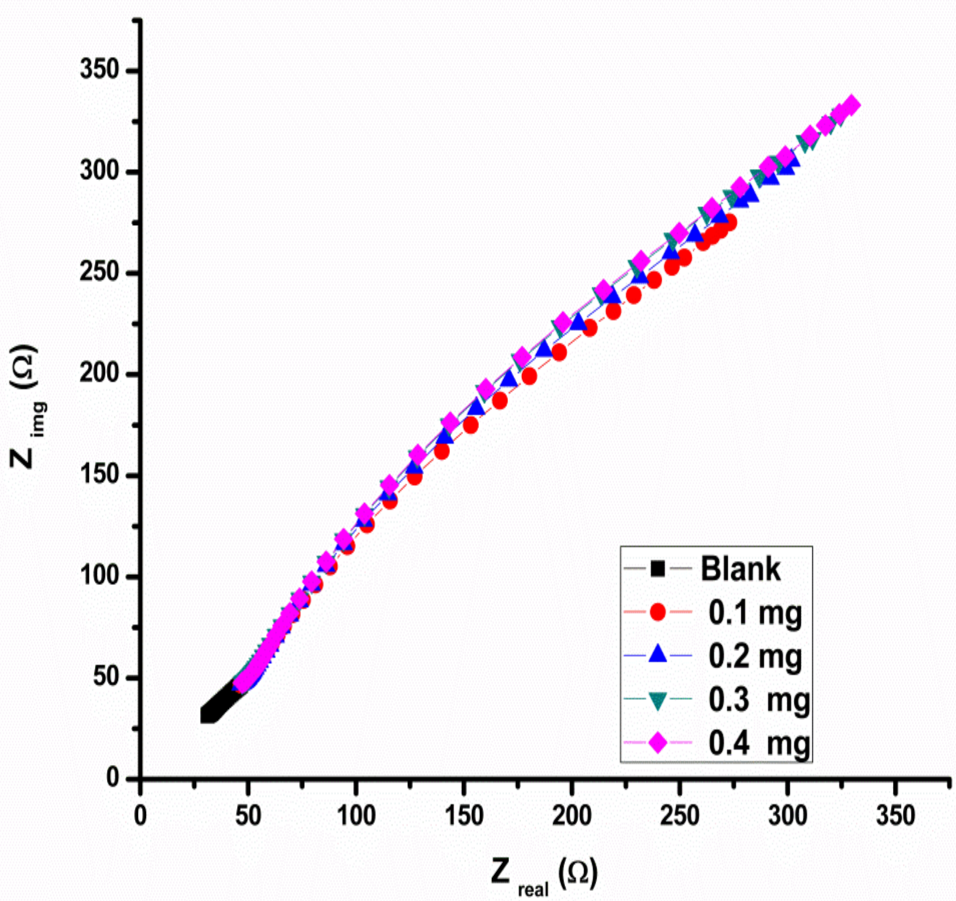

Figure 3. Nyquist plots in the absence and presence of the inhibitor

Table 3. AC Impedance studies

Concentration (mg)	Charge transfer resistance (Ω)	Protection efficiency (%)
Bare	37.8	
0.1	264.0	85.681
0.2	298.9	87.353
0.3	325.3	88.379
0.4	331.6	88.600

Scanning electron microscopy (SEM) technique

SEM photographs of MS surfaces for immersion period of 3 hour without and with expired Ganciclovir drug of 0.4 mg are shown in the **Figure 4.** It is observed that, the MS surface is highly damaged in the absence of expired Ganciclovir drug owing to aggressive attack of hydrochloric acid solution. Whereas, in the presence of 0.4 mg of expired Ganciclovir drug of MS in the 3 M HCl solution, the surface appears as smooth layer which is due to adsorption of expired Ganciclovir drug species on the MS surface in 3 M HCl solution.

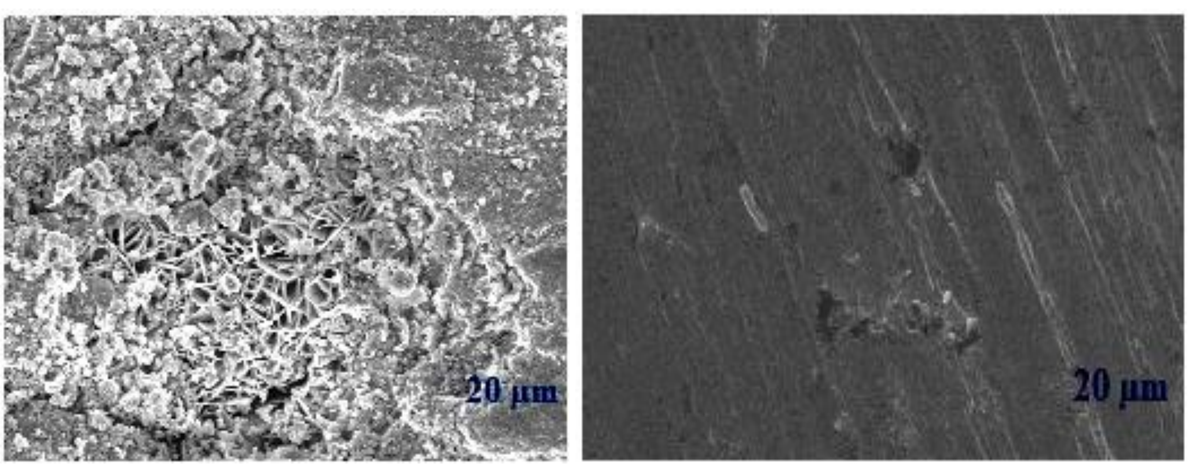

Figure 4. SEM images without and with inhibitor

IV. CONCLUSION

In current investigation, the protection effect of expired Ganciclovir drug on the MS surface in 3 M HCl solution was investigated thoroughly through atomic absorption spectroscopy, potentiodynamic polarization, impedance spectroscopy and scanning electron microscopy techniques. The protection efficiency enhances with rise in the concentration of the expired Ganciclovir drug species in 3 M HCl system. The potentiodynamic polarization (Tafel plots) shows that expired Ganciclovir drug inhibits the MS corrosion in 3 M HCl solution by blocking the both cathodic and anodic dissolution process. The charge transfer resistance values obtained from the AC impedance spectroscopy technique and SEM observations strongly proves the corrosion inhibition property of expired Ganciclovir drug on the MS surface in 3 M HCl solution.

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