



The Corrosion Inhibition Study of Expired Doxercalciferol Drug as Nontoxic Inhibitor for Mild Steel (MS) in 3M HCl Medium

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ABSTRACT

For this study, corrosion inhibition role of expired Doxercalciferol drug was studied on the mild steel (MS) corrosion in 3 M HCl medium at 333 K by electrochemical (Tafel curves and AC impedance spectroscopy), atomic absorption and scanning electron microscopy techniques. Tafel plot studies confirm that, the corrosion inhibition property of expired Doxercalciferol drug is of mixed type. The impedance study proves that, the corrosion inhibition property enhanced with increase in the expired Doxercalciferol drug concentration. The atomic absorption spectroscopy and scanning electron microscopy (SEM) results fully supports the adsorption of electron rich elements of expired Doxercalciferol drug on the MS surface in 3 M HCl medium.

Keywords: Expired doxercalciferol; Mild steel; Tafel curves; Impedance; Atomic absorption spectroscopy

INTRODUCTION

It is well known that, mild steel (MS) widely used in machinery manufacturing, transportation industry, marine industry, oil and gas transportation and bridge construction [1-3]. But, MS corrosion in HCl solution is a universal problem leads huge loss of energy and economy. Therefore, inhibition of MS corrosion in acidic systems has become hot topic for the current years. Corrosion inhibitors are the important method significantly used for derusting in the industrial section units [4-7]. Hence, adding corrosion inhibitors in acidic environment is most effective method for the prevention of metal dissolution process. It is broadly accepted that, corrosion inhibitors was adsorbed on the metal surface to create a protective invisible layer to mitigate the metal corrosion. Traditional effective corrosion inhibitors are poisonous organic species possessing N, O, P and S, which will leads to the serious negative effects to the environment. Hence, invention of new nontoxic corrosion inhibitor is urgent in the future [8-10].

Expired medicinal compounds attain more attention in the industrial and academic fields in current years, which consisting heteroatom's in their moieties. Compared to the traditional organic corrosion inhibitors, expired drug compounds are eco-friendly nature. Thus, it is very helpful to study the effect of expired medicinal species on the MS surface in acidic systems. The purpose of present study is to investigate the influence of expired Doxercalciferol drug in corrosion resistance performance for MS in 3 M HCl solution at 333 K. The chemical structure of

Doxercalciferol is shown in the Figure 1. The corrosion inhibition property of expired Doxercalciferol drug was investigated by atomic absorption spectroscopy, potentiodynamic polarization (Tafel plot) and impedance spectroscopy techniques. The surface features of MS in the absence and presence of expired Doxercalciferol drug was screened by scanning electron microscopy (SEM) technique.

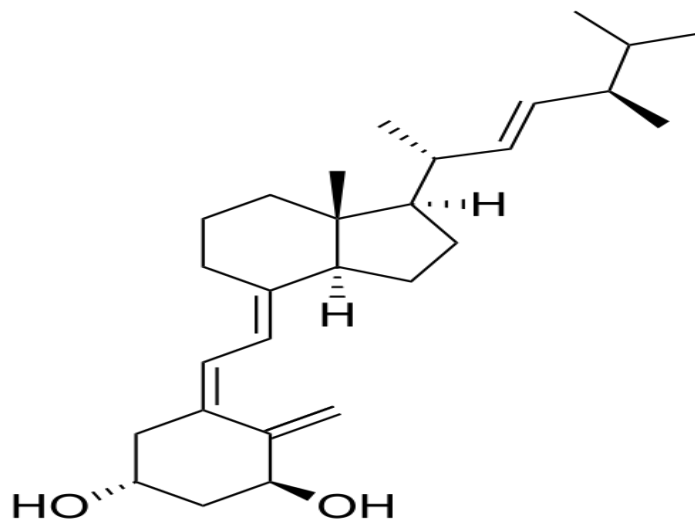


Figure 1. Chemical structure of Doxercalciferol

MATERIALS SECTION

The 99 % purity of MS was polished with different grades of sand papers and dried at ambient temperature. The expired Doxercalciferol drug of concentration 0.1 mg, 0.2 mg, 0.3 mg and 0.4 mg was used for the atomic absorption spectroscopy, Tafel plot, impedance spectroscopy and scanning electron microscopy studies. The atomic absorption spectroscopy (AAS) technique is used to determine the iron content in the 3 M HCl solution without and with expired Doxercalciferol drug of concentration of 0.1 mg, 0.2 mg, 0.3 mg and 0.4 mg. The protection efficiency can be calculated from the amount of iron content in the unprotected and protected systems.

The CHI660C work station was used for the electrochemical experiments with three electrode system (MS=working cell, Pt= counter cell and calomel= reference cell). Prior to the potentiodynamic polarization and AC impedance spectroscopy studies, the MS metal immersed in the 3 M HCl solution for about one hour of stabilization period. The electrochemical plots are recorded at $\pm 250\text{mV}$ with 1 mV s^{-1} scan rate.

The inhibition efficiency can be obtained by with the help of following equations;

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

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

Where, i_{corr}' =Protected corrosion current density, i_{corr} =Unprotected corrosion current density, R_{ct} =Unprotected charge transfer resistance, and $R_{\text{ct}}(\text{inh})$ =Protected charge transfer resistance.

The scanning electron microscopy (SEM) technique was used to study the surface morphology of MS in 3 M HCl solution without and with expired Doxercalciferol drug.

RESULT AND DISCUSSION

Atomic Absorption Spectroscopy Technique

The results of atomic absorption spectroscopy (AAS) are shown in the Table 1. The table shows that, the protection efficiency of the corrosion inhibitor enhanced with rise in the expired Doxercalciferol drug concentrations. This is due to fact that, addition of different amounts of expired Doxercalciferol drug reduces the amount of dissolved iron content in the 3 M HCl solution by forming compact invisible protective layer on the MS surface in 3 M HCl solution. The reduction in the amount of dissolved iron content in the 3 M HCl solution is a clear hint of protection role of the expired Doxercalciferol drug on MS surface in 3 M HCl solution.

Table 1. AAS results

Concentration (mg)	Amount of dissolved iron content in 3 M HCl solution	Protection efficiency in percentage
Bare	0.050	
0.1	0.025	50.000
0.2	0.015	70.000
0.3	0.0048	90.400
0.4	0.0023	95.400

Tafel Plot Studies

Figure 2 shows the potentiodynamic polarization curves of MS in 3 M HCl solution without and with expired Doxercalciferol drug of four different concentrations namely 0.1 mg, 0.2 mg, 0.3 mg and 0.4 mg. The results of Tafel parameters are listed in the Table 2. The clear observation of Figure 2 shows that, the shape of Tafel plots without and with four different amounts of expired Doxercalciferol drug is same, which manifests the mechanism of MS corrosion does not change with introduction of four different amounts of expired Doxercalciferol drug. It is also observed that, the MS corrosion current density values reduce to lower region with augment of concentration of the expired Doxercalciferol drug. The resulted table also shows that, the protection property enhanced with augment of the concentration of the inhibitor. It is also noticed that, the corrosion potential, cathodic and anodic Tafel slope values undergoes slight variation when expired Doxercalciferol drug of four different amounts is added to the 3 M HCl solution. This clearly indicates the mixed corrosion inhibition property of expired Doxercalciferol drug (control of both anodic and cathodic MS reaction) on the MS surface in 3 M HCl solution.

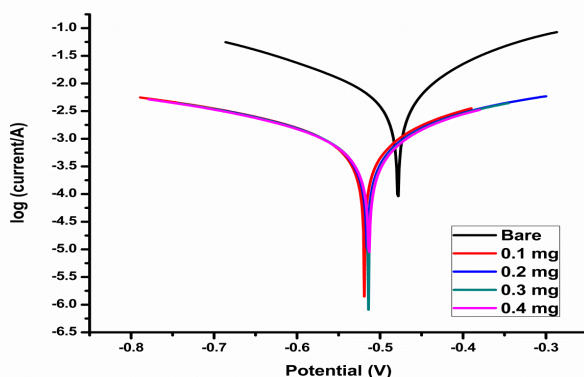


Table 2. Tafel plots without and with inhibitor

Concentration (mg)	Corrosion potential (mV)	Cathodic Tafel slope d (V/dec)	Anodic Tafel slope (V/dec)	Corrosion current (A)	Protection efficiency
Bare					
0.1	-478	5.792	7.183	0.006398	85.282
0.2	-519	4.623	5.623	0.0009416	86.225
0.3	-515	4.753	5.522	0.0008813	86.691
0.4	-514	4.756	5.596	0.0008515	86.967
0.4	-513	4.773	5.565	0.0008338	

Impedance Studies

The electrochemical impedance (Nyquist plots) is shown in the Figure 2. The corresponding results obtained from the Nyquist plots are presented in the Table 3. The diameter of the depressed semicircle is enhances with rise in the expired Doxercalciferol drug concentration, which indicates that, the MS corrosion process is mainly controlled by the charge transfer process. This is further confirmed by variation in the charge transfer resistance values in protected and unprotected systems. The corrosion of MS in 3 M HCl solution was protected due to difficulty of charge transfer in the presence of four different amounts of expired Doxercalciferol drug in 3 M HCl solution. The corrosion inhibition property of expired Doxercalciferol drug on MS surface in 3 M HCl is mainly due to adsorption of invisible compact layer on the MS surface in studied corrosive environment. The results of impedance studies fully support the Tafel plot and atomic absorption spectroscopy results.

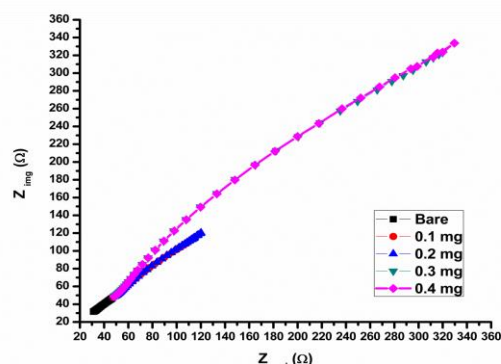


Figure 2. Nyquist plots without and with inhibitor

Table 3. AC impedance studies

Concentration (mg)	Charge transfer resistance (Ω)	Protection efficiency (%)
Bare	37.8	
0.1	92.77	59.254
0.2	97.92	61.397
0.3	323.3	88.308
0.4	332.1	88.617

Scanning Electron Microscopy

Figure 3 shows the SEM photographs of MS in the blank and inhibited solution. It is observed that, the MS surface badly attacked by HCl solution in bare system. Hence, rough surface observed. Whereas, in the presence of expired Doxercalciferol drug, the MS surface become smooth this is due to adsorption of protective film on the MS surface in 3 M HCl solution.

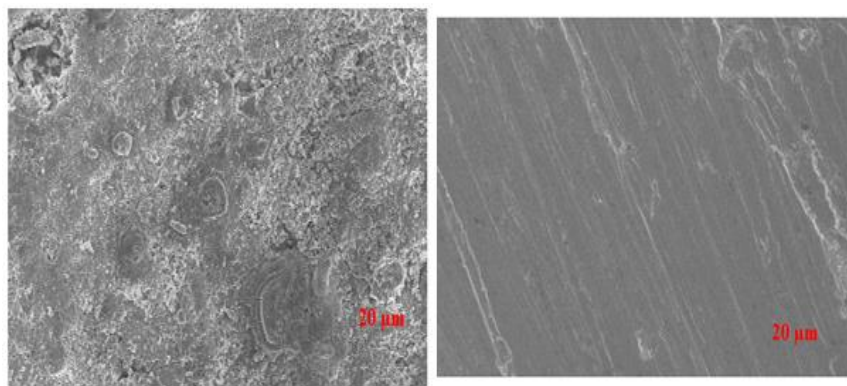


Figure 3. SEM images without and with corrosion inhibitor

CONCLUSION

According to experimental research; the following conclusion can be drawn:

- From the atomic absorption spectroscopy technique, it is clear that, the increase in the concentration of expired Doxercalciferol drug increases the corrosion inhibition efficiency.
- Tafel plot reveals the mixed corrosion inhibition property of expired Doxercalciferol drug on the MS surface in the 3 M HCl solution.
- Impedance studies shows that, the charge transfer process plays very vital role in the inhibition of MS corrosion in 3 M HCl solution.
- SEM studies fully support the atomic absorption spectroscopy, Tafel plot and impedance studies.

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