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Research Article

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New Application of Expired Olopatadine Drug as a Non-toxic Corrosion Inhibitor for Copper Metal Submerged in HCl Environment

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Abstract In current study, we report the first study related to the effect of expired Olopatadine drug on the behavior of copper corrosion in 5 M HCl solution. The present investigation was realized by using the mass loss (weight loss), Tafel plots (potentiodynamic polarization), AC impedance spectroscopy and scanning electron microscopy (SEM) technique. The weight loss technique shows that, expired Olopatadine drug blocks the copper metal corrosion process by adsorption process. Potentiodynamic polarization plots clearly confirm the anodic corrosion inhibition property of studied corrosion inhibitor on the surface of copper in the 5 M HCl solution. Further, Nyquist plots and SEM studies fully support the adsorption property of expired Olopatadine drug on the metal surface in the corrosive environment.

Keywords Expired Olopatadine drug, Tafel plots, Copper corrosion, Adsorption process, Nyquist plots

1. Introduction

Among the many methods of prevention of corrosion, use of corrosion inhibitors is the significant approach for the mitigation of metal corrosion process. The corrosion inhibitors attracted great attraction because of its effective adsorption property on the metal surface [1-3]. The corrosion inhibitors are the chemical species that in low quantities retards the degradation of industrial important metals in the hostile fluid atmosphere. Synthetic organic species widely used for this purpose, because, it contains N, O, P and S elements in their moieties. Many scientists reported the corrosion inhibition property of organic compounds on the various metals in the different corrosive environments [4-7]. The organic compound possessing nitrogen, sulfur, phosphorus and sulfur elements adsorb on the surface of metal and block the metal active sites and decrease the metal corrosion rate. The inhibitive film formed on the metal surface is responsible for the inhibition of metal corrosion process. The protection efficiency of the corrosion inhibitor is mainly depends upon the structure and nature of protective film on the surface of the metal. The protection efficiency generally follows the sequence P > S > N> O. Many organic species show the good metal corrosion behavior on the surface of different metals in the various corrosive environments, but utilization of these organic compounds in industries is banned because of toxic and expensive nature of the synthetic corrosion inhibitor. Hence, nowadays research focused on the investigation of non-toxic corrosion inhibitor on the industrial important metals in the corrosive media [8-11]. Expired drugs are not useful to the consumers. Expired drugs retain its inhibiting effect even though, after its expired date. Hence, in this investigation selected expired Olopatadine drug and studied their corrosion inhibiting action against copper in the 5 M HCl solution with the aid of weight loss (mass loss), Tafel plot (potentiodynamic polarization) and AC impedance spectroscopy techniques. The surface studies were carried out by scanning electron microscopy (SEM) techniques.

2. Experimental Section

The expired Olopatadine drug was obtained from the local medical shop. The concentrations of 0.1 mg/L, 0.2 mg/L, 0.3 mg/L and 0.4 mg/L of expired Olopatadine drug was used for the corrosion test. A weight loss experiment was carried out without and with corrosion inhibitor with an immersion period of 2, 4, 6, 8 and 10 hours. The protection efficiency can be calculated from the following equation;

$$\text{Corrosion protection efficiency (\%)} = \frac{(W_1 - W_2)}{W_1} \times 100,$$

Where, W_1= Weight loss of copper in unprotected system, and W_2= Weight loss of copper in the protected system.

Electrochemical studies were performed by using the CHI instrument with three electrode systems (copper= working electrode, platinum=counter electrode and calomel= reference electrode).

The electrochemical readings are recorded in the potential range of + 250 mV to – 250 mV at a scan rate of 0.1 v/S and impedance plots are measured in the frequency of 10^5 Hz to 1 Hz with 10 points per decade. Surface studies were carried out by scanning electron microscopy (SEM) technique.

3. Results and Discussion

3.1. Weight loss technique

The data obtained from the weight loss (gravimetric) technique are shown in the Table 1. From the Table 1, it is clear that, the protection efficiency (corrosion inhibition efficiency) enhances with a rise in the concentration of the expired Olopatadine drug over the surface of copper in the 5 M HCl solution. The presence of expired Olopatadine drug in the 5 M HCl solution generates a protective layer on the surface of the copper in the acidic environment. The protective layer blocks the direct attack of corrosive ions on the surface of copper in the 5 M HCl solution. Hence, corrosion rate of the metal decreases with a rise in the concentration of the expired Olopatadine drug. The protection efficiency enhances with a rise in the concentration of the inhibitor. The maximum protection rate (corrosion inhibition efficiency) obtained from the weight loss (mass loss) technique is 93.548 % at immersion period of two hours. From the Table 1, it is also observed that, the increase in the contact time from 2 hour to 10 hours slightly increases the corrosion rate (protection efficiency) of the copper. This nature is due to the instability of protective film (which is generated on the metal surface) for a longer immersion period. The increase in the contact time, gradually increases the desorption process. Due to the desorption process, the protective film on the copper surface losses its stability. Hence, hydrochloric acid ions directly contact with the copper surface. As a result of this, the protection efficiency slightly decreases with a rise in the contact time.

Table 1: Gravimetric results

Concentration (mg/L)	Contact time (hours)	Protection efficiency in percentage
Bare	2	
0.1		85.000
0.2		87.500
0.3		90.000
0.4		92.500
Bare	4	
0.1		75.806
0.2		82.258
0.3		90.322
0.4		93.548
Bare	6	
0.1		67.441
0.2		73.255
0.3		79.069
0.4		82.558
Bare	8	
0.1		61.165
0.2		66.019
0.3		70.873

0.4		75.728
Bare	10	
0.1		62.204
0.2		67.716
0.3		72.440
0.4		80.314

Tafel plot studies

The potentiodynamic polarization plots and its are shown in the Figure 1 and Table 2. From the Table 2, it is clear that, the copper corrosion density values decrease with a rise in the concentration of the expired Olopatadine drug. This nature is due to the formation of protective layer on the surface of copper in the 5 M HCl solution. The decrease in the corrosion current density values is an indication of an increase in the protection rate of the metal in the aggressive hydrochloric acid medium. The Tafel plots show the anodic corrosion inhibition property of expired Olopatadine drug on the copper in the 5 M HCl solution. The maximum corrosion inhibition efficiency obtained from the Tafel plot study is 98.112 %.

Table 2: Potentiodynamic polarization results

Concentration (mg/L)	Corrosion potential (mV)	Cathodic Tafel slope (V/dec)	Anodic Tafel slope (V/dec)	Corrosion current (A)	Protection efficiency
Bare	-245	2.490	1.592	0.01258	
0.1	-107	3.686	7.521	0.0007125	94.336
0.2	-112	3.051	7.930	0.0006845	94.558
0.3	-114	2.838	1.073	0.0002865	97.558
0.4	-092	5.108	1.073	0.0002375	98.112

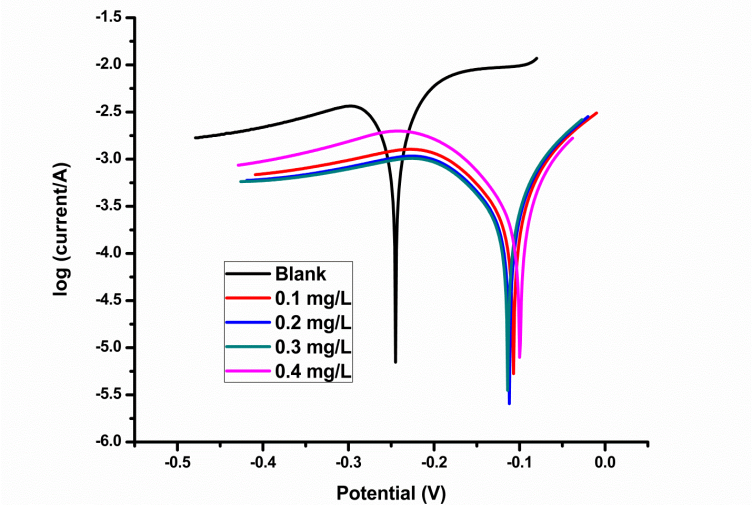


Figure 1: Tafel plots without and with inhibitor

AC impedance spectroscopy

The results of Nyquist plots (Figure 2) of copper in the 5 M HCl solution without and with corrosion inhibitor are shown in the Table 3. From this table, it is clear that, the charge transfer resistance value enhances with a rise in the concentration of the expired Olopatadine drug. The increase in the concentration of the expired Olopatadine drug blocks the attack of corrosive ions on the surface of copper in the 5 M HCl solution. The highest charge transfer resistance value obtained from the impedance spectroscopy (Nyquist plots) technique is 242.5 Ω. The results of Nyquist studies are in good agreement with the weight loss and Tafel plot results.

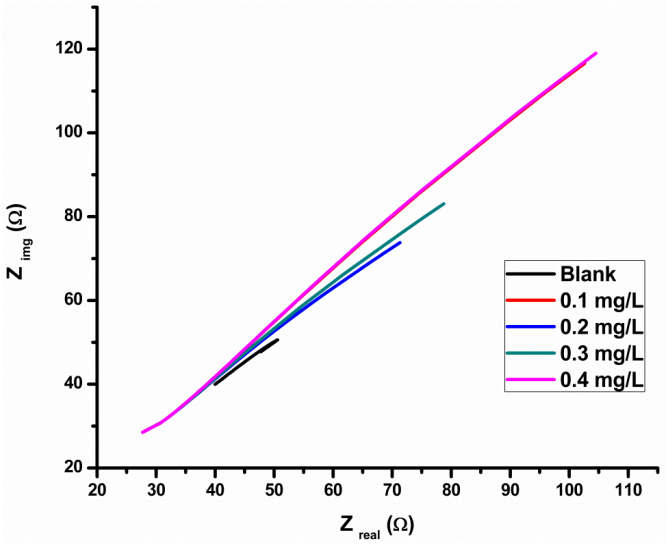


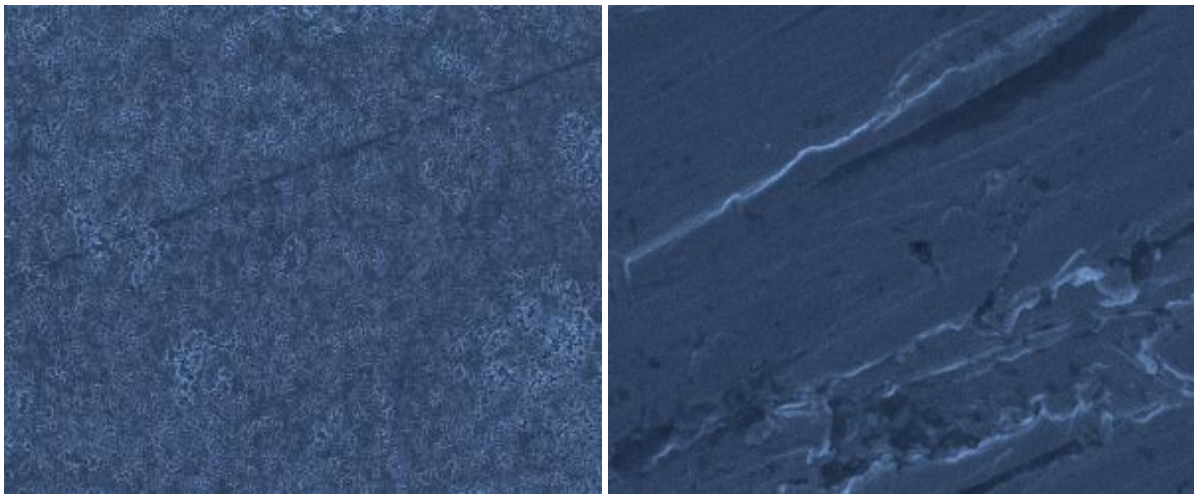
Figure 2: Nyquist plots in the absence and presence of inhibitor

Table 3: Nyquist plot results

Concentration (mg/L)	Charge transfer resistance (Ω)	Protection efficiency (%)
Bare	49.91	
0.1	97.70	48.915
0.2	98.38	49.268
0.3	122.30	59.190
0.4	242.5	79.418

Scanning electron microscopy (SEM) technique

Figure 3 (a, b) is the SEM images of copper in unprotected and protected (in the presence of expired Olopatadine drug) system. The unprotected system has a high roughness compared to the protected system. This is due to the adsorption of protective layer on the surface of copper in the 5 M HCl solution. The adsorbed protective blocks the attack of corrosive ions on the surface of copper in the acidic system. As a result of this, corrosion rate decreases with an increase in the concentration of the inhibitor.



(a) **(b)**

Figure 3: SEM images without (a) and with inhibitor (b)

4. Conclusion

Present investigation shows that, expired Olopatadine drug act as good corrosion inhibitor for the copper in the 5 M HCl solution. Weight loss studies show that, increase in the concentration of the expired Olopatadine drug on the copper surface in the 5 M HCl solution increases the protection efficiency of the inhibitor. Due to desorption at higher solution temperature, the protection efficiency slightly decreases. Tafel plot studies show the anodic corrosion inhibition property of expired Olopatadine drug on the copper surface in the 5 M HCl solution. AC impedance spectroscopy results show that, the charge transfer resistance values enhances with a rise in the concentration of the inhibitor. SEM studies fully support the weight loss, Tafel plot and AC impedance spectroscopy studies.

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