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Use of Expired Naftifine Drug as Corrosion Inhibitor for Copper in Hydrochloric Acid

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ABSTRACT

An evaluation of expired Naftifine drug act as nontoxic corrosion inhibitor for copper in 5 M HCl solution was evaluated by weight loss (mass loss), Tafel plots and AC impedance spectroscopy techniques. The chemical and electrochemical results were complemented by scanning electron microscopy (SEM) techniques. Weight loss studies shows that, increases in the concentration of the expired Naftifine drug enhance the protection rate of copper metal in acidic environment, but decreases with rise in the immersion period. Tafel plots show the mixed corrosion inhibition role of expired Naftifine drug over the surface of copper. Further, AC impedance plots and SEM topography shows the adsorption property of expired Naftifine drug on the surface of copper.

1. Introduction

Copper is the most used metal in industrial and constructional applications greatly in the hydrochloric acid environment. But copper is highly susceptible to corrosion in hydrochloric acid environment [1-3]. The use of corrosion inhibitors is the most effective approach for the protection of the copper metal against dissolution or disintegration process. Synthetic compounds are highly efficient corrosion inhibitors, but they are expensive, and dangerous to the living creatures [4-7]. For these reasons, corrosion people focused research on nontoxic and cheap corrosion inhibitors in current years [8-10]. Corrosion researchers reported the several expired medicinal products as effective and nontoxic corrosion inhibitors for different metals (including copper) in hydrochloric acid environment. Thus, the use of expired medicinal products as corrosion inhibitors for different metals in various corrosive environments is not only effective but also nontoxic nature. Hence, in current study chosen expired Naftifine drug. The interest in expired Naftifine drug is due to presence of N and pi-electrons in their groups (Fig. 1). Thus, the vital goal of present research article is to examine the possibility of using the expired Naftifine drug as a nontoxic corrosion inhibitor for copper metal in 5 M HCl solution. The corrosion test was performed by employing the weight loss (mass loss), Tafel plots and AC impedance spectroscopy techniques. The SEM technique used for the topography examination.

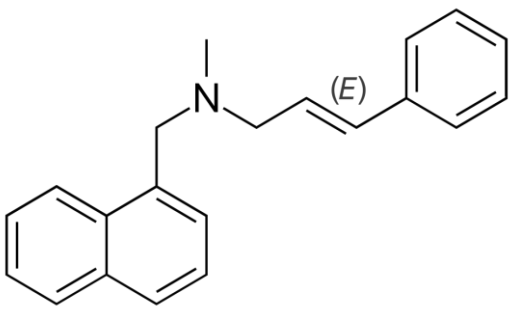

Fig. 1 The Naftifine drug used for the present study

2. Experimental Methods

The expired Naftifine drug was collected from the local medical shop. The inhibitor with concentration range of 1 mg/L, 2 mg/L, 3 mg/L and 4 mg/L was prepared. The copper specimens were cleaned with sand papers and acetone. The 5 M HCl is prepared to be used as corrosion solution. The weight loss studies were carried out by 100 mL of 5 M HCl solution without and with 1 mg/L, 2 mg/L, 3 mg/L and 4 mg/L of expired Naftifine drug. The protection rate of the expired Naftifine drug was calculated by below relation,

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

where, W_1= Copper weight loss without expired Naftifine drug and W_2= Copper weight loss with four different amounts of expired Naftifine drug.

The electrochemical techniques (both Tafel plot and AC impedance spectroscopy) were carried out by three electrodes (copper= working electrode, Pt= counter electrode and calomel= standard electrode). Before starting the Tafel plots and Nyquist plots, the copper metal is submerged in the 100 mL of HCl solution for about one hour in order to attain the open circuit potential (OCP).

The potential range used for the electrochemical studies are ± 250 mV at 1 mV/s. The protection efficiency can be calculated from the below relation. The corrosion protection efficiency of the expired Naftifine drug was calculated from the below relations.

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

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

where, i'_{corr} = Protected copper corrosion current density, i_{corr} = Unprotected copper corrosion current density, R_{ct} = Unprotected copper charge transfer resistance, $R_{ct\ (inh)}$ = Protected copper metal charge transfer resistance. The topography of copper metal in 5 M HCl solution was visualized by scanning electron microscopy (SEM) technique.

3. Results and Discussion

3.1 Weight Loss (Mass Loss) Technique

The summary of weight loss (mass loss) results showing the protection efficiency of the corrosion inhibitor (expired Naftifine drug) at 1 mg/L, 2 mg/L, 3 mg/L and 4 mg/L of corrosion inhibitor with immersion periods

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of 2, 4, 6, 8 and 10 hours are shown in the Table 1. The protection efficiency enhances with rise in the concentration of the expired Naftifine drug, which shows the decrease in the copper weight loss which is due to enhance in the adsorption of expired Naftifine drug surface. Thus, the rise in the protection efficiency with enhancing in the concentration of the expired Naftifine drug can be interpreted on the basis of adsorption and which is increases with rise in the concentration of the expired Naftifine drug. Further, with increase in the contact time, the weight loss of copper increases. As a result of this, lower protection efficiency is observed. The lower protection efficiency obtained from the expired Naftifine drug at higher immersion period is due to the higher desorption process.

Table 1 Weight loss (gravimetric) results

Concentration (mg/L)	Contact time (hours)	Protection efficiency (%)
Bare	2	
1.0		82.500
2.0		85.000
3.0		87.500
4.0		90.000
Bare	4	
1.0		66.666
2.0		74.603
3.0		79.365
4.0		84.126
Bare	6	
1.0		59.770
2.0		66.666
3.0		73.563
4.0		78.160
Bare	8	
1.0		54.368
2.0		59.223
3.0		63.106
4.0		68.932
Bare	10	
1.0		52.755
2.0		59.055
3.0		62.992
4.0		68.511

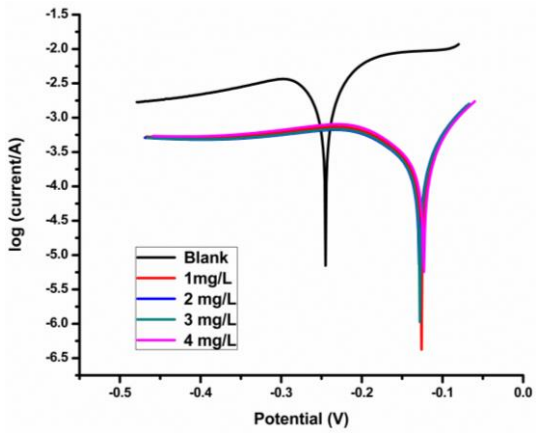

Fig. 2 Tafel plots without and with inhibitor

Table 2 Tafel curves results

Concentration (mg/L)	Corrosion potential (mV)	Cathoidc Tafel slope (V/dec)	Anodic Tafel slope (V/dec)	Corrosion current (A)	Protection efficiency
Bare	-245	2.490	1.592	0.01258	
1.0	-126	1.867	1.070	0.0003641	97.105
2.0	-129	1.598	1.045	0.0003632	97.112
3.0	-128	1.655	1.071	0.0003601	97.137
4.0	-123	2.106	1.073	0.0003536	97.189

3.2 Tafel Plot Studies

The Tafel plots for copper in the 5 M HCl solution at 333 K without and with four different amounts (1mg/L, 2 mg/L, 3 mg/L and 4 mg/L of expired Naftifine drug) are shown in the Fig. 2. The results obtained from the Tafel plots are shown in the Table 2. For the uninhibited system, copper corrosion density values are low compared to the bare solution. This observation shows that, protection efficiency enhances with rise in the concentration of the expired Naftifine drug on the surface copper in 5 M HCl atmosphere. Further, there is no significant variation in the cathodic and anodic Tafel plots values in the protected and unprotected systems. This indicates the mixed corrosion inhibition property of expired Naftifine drug on the surface of copper in the 5 M HCl solution. The maximum protection efficiency obtained from the electrochemical potentiodynamic polarization studies is 97.189 %.

3.3 AC Impedance Spectroscopy Technique

Nyquist plots for copper in the 5 M HCl solution without and with expired Naftifine drug (1 mg/L, 2 mg/L, 3 mg/L and 4 mg/L) is shown in the Fig. 3. The results obtained from the Nyquist plots are shown in the Table 3. From the resulted table it is clear that, the charge transfer resistance values (Rct) are directly proportional to the concentration of the expired Naftifine drug (means charge transfer resistance values increases with rise in the concentration of the expired Naftifine drug). The increase in the diameter of depressed semicircle with rise in the concentration of the inhibitor is due to the adsorption of expired Naftifine drug over the copper surface in 5 M HCl solution. The high charge transfer resistance values in the presence of expired Naftifine drug of 1 mg/L, 2 mg/L, 3 mg/L and 4 mg/L amounts compared to the uninhibited system is an indication of corrosion protection role of the expired Naftifine drug. The depressed Nyquist plot in the absence and presence of corrosion inhibitor is due to the roughness of the copper surface. The maximum protection efficiency obtained from the AC impedance spectroscopy technique is 73.452 %.

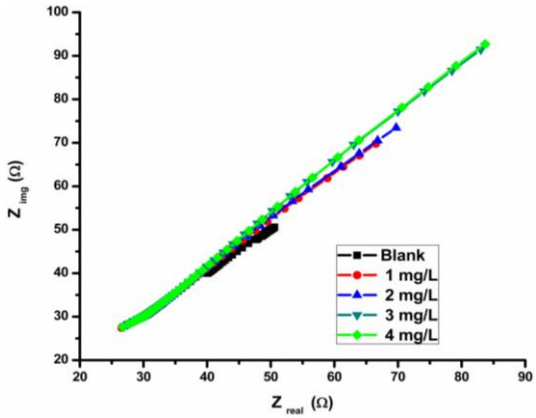

Fig. 3 Nyquist plots without and with inhibitor

Table 3 AC Impedance studies

Concentration (mg/L)	Charge transfer resistance (Ω)	Protection efficiency (%)
Bare	49.91	
1.0	104	52.009
2.0	110.2	54.709
3.0	175.3	71.528
4.0	188	73.452

3.4 Scanning Electron Microscopy (SEM) Technique

SEM photographs of copper without and with 4 mg/L of expired Naftifine drug was shown in Fig. 4. From the Fig. 4a, it is clear that, the copper metal exposed to the 5 M HCl solution without addition of expired Naftifine drug is highly corroded, which is due to the direct attack of hydrochloric acid solution. As a result of this, large number of cracks appeared on the surface of copper. In other case, copper metal is exposed to the 5 M HCl solution with 4 mg/L of expired Naftifine drug. The smooth surface observed which is due to adsorption of expired Naftifine drug molecules on the copper surface in 5 M HCl solution.

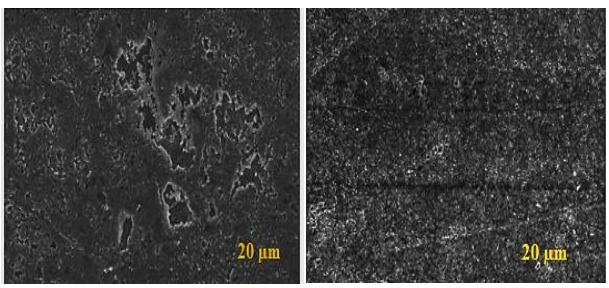

Fig. 4 SEM images without and with corrosion inhibitor

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4. Conclusion

An investigation of expired Naftifine drug as a nontoxic corrosion inhibitor for copper in 5 M HCl solution has been successfully carried out. It is observed that, expired Naftifine drug act as robust corrosion inhibitor for copper metal in 5 M HCl solution. It is also observed that, the corrosion protection efficiency is mainly depending upon the inhibitor concentration and exposure time. Mixed corrosion inhibition behavior of expired Naftifine drug was confirmed by Tafel plots. The Adsorption behavior of expired Naftifine drug on the copper surface in 5 M HCl solution was further confirmed by AC impedance spectroscopy and SEM techniques.

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