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Inhibition by using (ethyl-2-aminothiazole-4-Carboxylate) for copper corrosion in an acidic media

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Abstract

The influence of Ethyl-2-aminothiazole-4-carboxylate as a copper corrosion inhibitor in 1M HCl acid was investigated using both weight loss and polarization techniques. At 40 ^oC by raising the inhibitor concentration reduces corrosion current density and rate while improving inhibition efficiency and surface coverage, on the other hand the efficiency decreases as temperature rises at 50 and 60 ^oC. By Increasing inhibitor concentrations led to higher activation, enthalpy, and free adsorption energy, as well as lowering entropy energy, demonstrating that the inhibitor have sufficient energy to initiate the adsorption process, through creation of a layer of film on the surface of the metal due to the presence of molecules of both amines and thiazole, as well as the presence of nitrogen, oxygen and sulfur atoms, which have an effective effect on inhibition and corrosion prevention indicating that it is an excellent form of inhibitor.

Keywords: polarization, weight loss, enthalpy, entropy, corrosion, inhibition, activation energy

1. Introduction

Corrosion is a term used to describe the various interactions between the environment and matter that cause degradation in the properties of materials [1-8]. During the process of growth, which controls interaction and proliferation with the help of oceanic oxygen, oxide layers form. As a result, the material may be passivated to prevent further oxidation [9-13]. Due to the presence of oxygen, which works on the dissolution of the copper metal and its alloys used widely in the industry are unable to remove hydrogen from the acidic solution [14-19]. Hydrochloric acid is widely used in the chemical industry for the removal of salts, cleaning, and pickling associated with metal dissolution, therefore corrosion inhibitors must be applied to prevent corrosion [20-25]. Copper is widely used in domestic and industrial water pipelines, heat exchangers, the electronics industry, and telecommunications because it is a good conductor of electricity, has a high thermal conductivity, and has a good mechanical susceptibility. The deterioration problems that threaten technology and the global economy, resulting in a reduction in progress [20-30]. The treatment of continuous coating of steel structures is the fact that these steels are exposed to corrosion and have a growing problem [32-35]. When corrosion inhibitors are added to a solution, they reduce corrosion and improve efficiency. Because copper is widely used in the metals industry, it is subject to corrosion as a result of exposure to harsh conditions such as acids, salts, and other chemicals. This occurrence must be reduced by applying corrosion inhibitors to safeguard the metal [27-31].

2. Experimental work

In present work, weight-loss method has been used and the samples of coupons with dimensions of 2.5 cm in length prepared which polished, dried, and weighed, the samples of copper metal with a width of 0.1 cm and a thickness of 0.15 cm, then it were immersed in a 1 M hydrochloric acid solution with and without the corrosion inhibitor " Ethyl-2-aminothiazole-4-carboxylate".After that, it were washed, dried, and weighed again, and the corrosion rate and efficiency were determined. In addition to the polarization method, a computerized potentiostat and three poles,

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which include the sample, were used. At range temperatures of 40-60 oC, a pole, a standard, and platinum are placed inside the cell, and the potential and current density was measured and inhibitor concentrations level of 100, 200, 300 and 400 ppm were used [4-15].

3. Results and Discussions

The anodic and cathodic profiles in the relationship between potential and current density are depicted in Fig. 1. The corrosion current density declines as the corrosion inhibitor concentration increases in hydrochloric acid at a temperature of 40 oC. As a result, the efficiency of inhibition improved, similarly at temperatures between 50 and 60 oC, the efficiency of inhibition also shows improvement. As seen in Figs. 2, 3, and 4, the mixed type of polarization between the cathodic and anodic polarization decreases as the temperature rises [12-23].

3.1 Measurement of polarization

An efficient dynamic polarization technique was conducted for 30 minutes using a carbon steel sample cleansed in 1 M hydrochloric acid medium, with various inhibitor doses (100-400 ppm). Carbon steel, standard calomel electrode (SCE), and platinum electrode make up the electrode fitting. Polarization curvatures were detected by spontaneously changing the cathodic potential from -200 mV to +200 mV at a frequency scan rate of 0.01 V/S, resulting in polarization investigations. The corrosion potential, as well as the cathodic and anodic curves, may be used to calculate current corrosion density (icorr) and potential corrosion (Ecorr). The corrosion rate was calculated using the equation below [11-21].

$$\eta\ \% = \frac{(I_{corr})_w - (I_{corr})_i}{(I_{corr})_w} * 100 \quad (1)$$

Where the corrosion current densities without and with inhibitor are $(I_{corr})_w$ and $(I_{corr})_i$, respectively.

The curves of anodic and cathodic between the connection between potential and current density are shown in Figure 1. At a temperature of 40 oC, Carbon behavior in hydrochloric acid has been studied without and with inhibitor corrosion concentrations, with reduced corrosion current density and, as a result, higher inhibition efficiency with increasing inhibitor corrosion concentration. At 50 and 60 oC , the efficacy of inhibition also increases. The anodic and cathodic polarization of the mixed kind, are shown in Figures 2 and 3, also shown in table 1 [14-26].

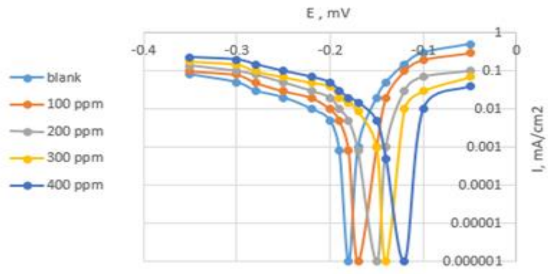

Fig.1: polarization curves in acidic conditions at various concentrations at 40 °C

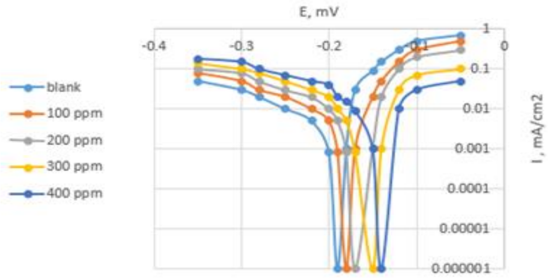

Fig. 2: polarization curves in acidic conditions at various concentrations at 50 °C

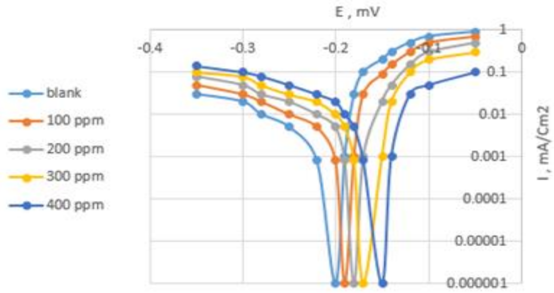

Fig. 3: polarization curves in acidic conditions at various concentrations at 60 °C

Table 1: Using the polarization method, effect of inhibitor concentrations on potential corrosion, corrosion rate, and inhibition efficiency at various temperatures

Inhibitor conc. ppm	E corr , mV			Corrosion current density mA/cm^2			Efficiency of inhibition %		
	40 °C	50 °C	60 °C	40 °C	50 °C	60 °C	40 °C	50 °C	60 °C
Blank	184	193	202	0.013	0.017	0.022	0	0	0
100	170	182	191	0.022	0.034	0.043	72.5	70.3	68.2
200	154	174	183	0.037	0.045	0.056	80.1	77.1	73.0
300	142	151	174	0.051	0.059	0.064	86.3	81.7	75.3
400	123	142	151	0.064	0.073	0.088	89.8	84.4	80.5

It can be observed from Figure 4 raising the concentration of inhibitor, which increases the efficiency at different temperatures, which is in a good agreement with many researchers.[22-30]

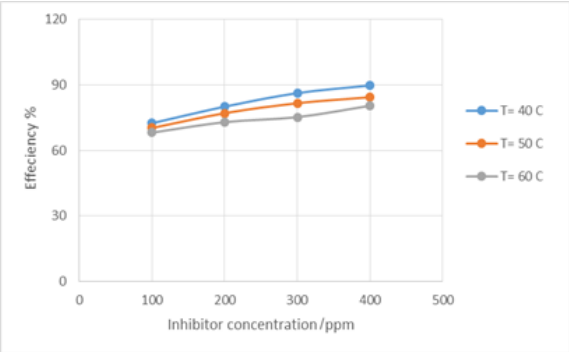

Fig.4 : Plot shows the relationship between polarization technique efficiency and inhibitor concentration.

3.2 Measurement of Weight loss

The weight or mass loss at different concentrations of inhibitor and temperatures from 40-60°C for 6 hours was determined using samples pre-treated in 1 M HCl acid. Weight loss tests were conducted. The formulae below were used to calculate the rate of corrosion and the corrosion inhibition efficiency [11-20].

$$(C.R) = \frac{87.6 * w}{D * A * t} \quad (2)$$

Where **C.R** denotes corrosion rate, **w** denotes weight or mass loss, **t** denotes time, **D** denotes density, and **A** denotes area.

$$\eta\,\% = \frac{(C.R)w - (C.R)i}{(C.R)w} * 100 \quad (3)$$

Where **(C.R)w** denotes corrosion rate without inhibitor and **(C.R)i** denotes corrosion rate with inhibitor.

The weight loss as a function of time at specified temperature without inhibitor and with different level of inhibitor, as shown in figures 5,6, and 7, it can seen that the greater the inhibitor concentration and low temperature, the less weight loss with time. Table 2 illustrates the influence of corrosion rate at different temperatures of the inhibitor concentration, with corrosion rate reducing at 40 C, with the concentration of a rising inhibitor, but rises at 50 and 60 C, as shown in Figure8. At 40 C, the efficiency rises as the inhibitor concentration increases, whereas at 50 and 60 C, the efficiency declines [15-27].

Table 2: Effect of inhibitor concentration on the rate and efficiency of the corrosion current at different temperatures using weight loss technique.

Inhibitor conc. ppm	Corrosion rate , mmpy			Inhibition efficiency %		
	40 ºC	50 ºC	60 ºC	40 ºC	50 ºC	60 ºC
Blank	1.20	1.37	1.54	0	0	0
100	0.25	0.57	0.69	79.2	58.5	55.3
200	0.14	0.44	0.53	88.3	67.4	65.5
300	0.10	0.25	0.40	91.6	81.3	74.6
400	0.08	0.11	0.18	93.1	91.5	88.4

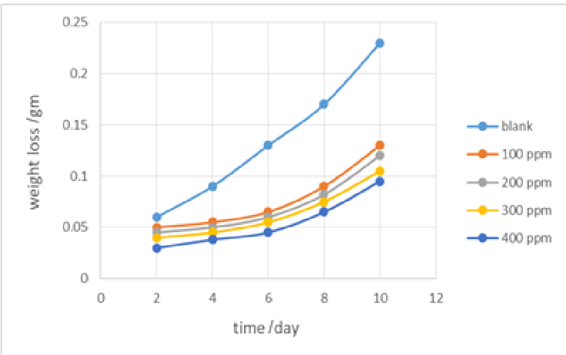

Fig. 5: Plot effect weight loss with time at 40 ºC

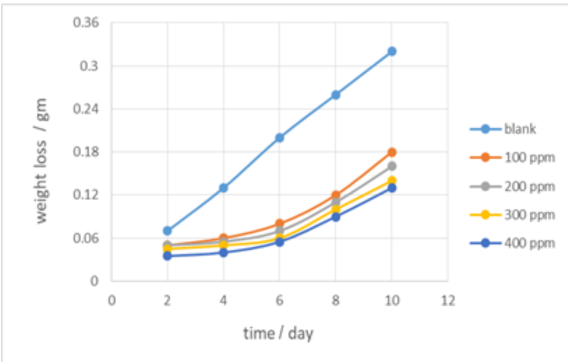

Fig. 6: Plot effect weight loss with time at 50 ºC

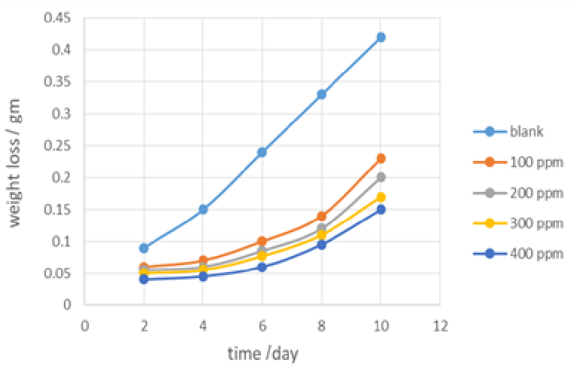

Fig. 7: Plot effect weight loss with time at 60 ºC

Figure 8 below represents the relationship between corrosion rates with the presence of inhibitors. Which indicates the higher the concentration of the inhibitor, the lower the corrosion rate [9-18].

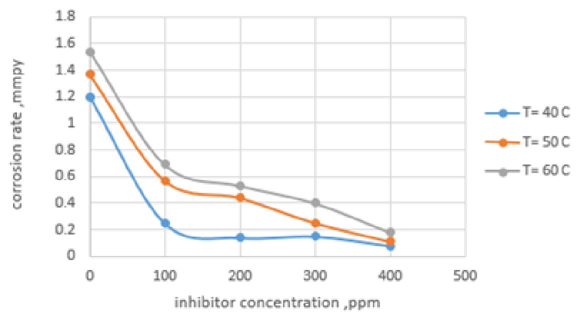

Fig. 8 : Plot shows the influence of inhibitor concentration on corrosion rate

3.3 Effect of temperature

The impact of various temperatures on carbon steel metal in 1 molar of hydrochloric acid was investigated. Increasing the temperature from 40 to 60 ℃ reduces the corrosion prevention efficiency as a result of increased corrosion rates [23-35].

$$(C.R) = A\ exp \frac{-Ea}{RT} \qquad (4)$$

Where **T** denotes temperature**, Ea** denotes activation energy, **R** denotes gas constant, and **A** denotes constant.

As shown in Fig 9 and 10, the activation energy was calculated.

The activation energy of carbon steel corrosion runs with and without inhibitors was calculated according to the methodology (Figure 9) and is listed in Table 3 below. The results have been noticed that activation energy was more effective with inhibitors than without inhibitors. The activation energy values were increased, indicating that the corrosion was prevented when the inhibitor concentration was raised. The activation energy drops as the temperature rises, increasing the rate of corrosion. The parameters of thermodynamic activation energy, ΔH, ΔS, and ΔG, were determined using Equation 5 (Figure 10): [11-26]

$$(C.R) = \left(\frac{RT}{Nh}\right) exp \frac{\Delta S}{R}\ exp \frac{-\Delta H}{RT} \qquad (5)$$

Where **N** is denotes to Avogadro number, **R** is denotes to gas constant, **h** is denotes to Planks constant, and **T** is denotes to temperature.

The enthalpy and entropy energy are computed using the Fig 10, as well as the equation below.

$$\Delta H = Ea - RT \qquad (6)$$

$$\Delta G = \Delta H - T\Delta S \qquad (7)$$

where ΔG denotes to Free adsorption energy.[13-21]

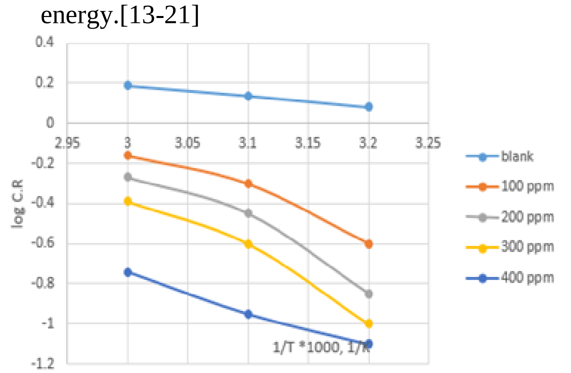

Fig. 9 : Plot shows the relation between log C.R and 1/T for various inhibitors.

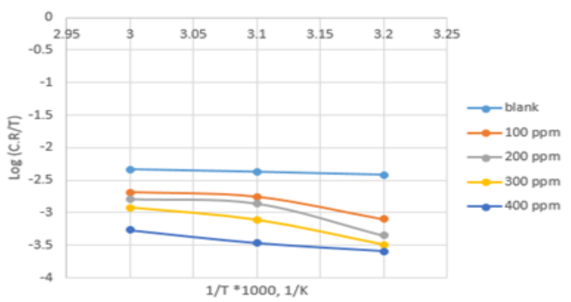

Fig.10 : Plot shows the relation between log (C.R/T) and 1/T for various inhibitors

Table 3 : Thermodynamic characteristics for carbon steel in 1 M HCl with various inhibitor concentrations

Inhibitor conc. ppm	Ea (kJ/mole)	ΔH (kJ/mole)	ΔS (kJ/mole.K)	ΔG (kJ/mole)
blank	4.489	3.408	$8.8 * 10^{-10}$	3.408
100	3.658	17.209	$10.4 * 10^{-10}$	17.209
200	4.822	22.905	$11.2 * 10^{-10}$	22.905
300	5.071	23.902	$11.9 * 10^{-10}$	23.902
400	2.993	13.510	$12.5 * 10^{-10}$	13.510

Table 3 shows that as the concentration of the inhibitor increases, the activation energy of the reaction, enthalpy, and free energy of adsorption increases also, indicating the formation of a film layer which protects the metal from external influences due to the inhibitor's high capacity performance on the carbon steel surface. The system is endothermic if ΔH has a positive value. due to the presence of molecules of both amines and thiazoles, as well as nitrogen ,oxygen and sulfur atoms as shown in Fig. 11, a layer of film which forms on the metal's surface, which has an efficient inhibitory and corrosion-preventive action.[20-35]

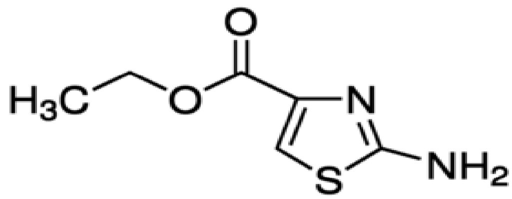

Fig. 11 : Structure of " Ethyl-2-aminothiazole-4-carboxylate

4. Conclusions

This study used weight loss and polarization methods to investigate the impact of (ethyl-2-aminothiazole-4-carboxylate) as a copper corrosion inhibitor in 1M HCl acid solution. At 40 ºC, increasing the inhibitor concentration reduces corrosion current density and rate, while increasing efficiency of inhibition and coverage of surface, while at 50 and 60 ºC, efficiency falls as temperature rises. Higher concentration of the inhibitor causes increased activation, enthalpy, adsorption energy and decreasing entropy energy, which indicates that the inhibitor has sufficient energy to activate the process of adsorption and desorption as a chemical from good-type inhibitor. The film's creation layer is owing to the discovery of oxygen, nitrogen, and sulphur molecules, all of which play an important role in the film formation and characteristics.

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