Study A Corrosion Inhibitor Of 1-Isoquinolinyl Phenyl Ketone For Mild Steel In Acidic Medium As HCl Acid

Raheem  A.H. Al-Uqaily¹, Subhi   A. Al-Bayaty²

¹Department of Chemistry, College of Science, Wasit University, Wasit , Iraq
²Department of Chemistry, College of Science, Wasit University, Wasit , Iraq
Email: raheem197131@yahoo.com

Abstract. In this research, a study was "1-isoquinolinyl phenyl ketone" as a corrosion inhibitor with concentrations (100, 125, 150, and 200 ppm) for mild steel in acidic media as HCl acid at temperatures (25, 35 and 45 C) by using the polarization and weight loss methods. The results showed that the inhibitor is good kind especially in high concentrations for inhibitor, where inhibition efficiency increased with increasing of inhibitor concentrations and temperatures, the inhibitor is mixed type revealed, presence nitrogen and oxygen atoms in structure of inhibitor its influential role in adsorption process and formation film layer on metal. Thus study effect inhibitor concentration on thermodynamics kinetic parameters E_a, H, S, and G_ads and adsorption is chemical kind.

Keywords: 1-Isoquinolinyl Phenyl Ketone, Corrosion, Polarization, HCl acid

1. Introduction

Many industrial applications such as storage and transport of various chemical solutions are made of mild steel being generally employed. Therefore, these solutions kept or spread its corrosive properties and then the dissolution of the metal, causing significant economic losses for many industries [1].

There are several ways, including cathodic protection, coatings, lubrication, and electroplating, used to protect metals from corrosion. As well as the presence of an important other way is the use of corrosion inhibitors which adsorbs (either chemically or physically or both) on the metal, which is working to reduce the contact surface between the metals and corrosive material surfaces by creating a film on metal surface [2].

To reduce the corrosion rate add inhibitors are chemical compounds in small quantities [3]. Avoids economic losses and the corrosion process keeps its rate to a lowest due to metallic corrosion. Organic or Inorganic are type's corrosion inhibitors [4]. Inhibitors slow corrosion processes by decreasing the movement or diffusion of ions to and from the metallic surface, decreasing the anodic and cathodic reaction rapidity, and growing the electrical resistance of the metal surface. [5]
Investigators [6] studied the effects of Pyrimidine, Pyridine, 2-Picoline, Lutidine, Quinoline and Isoquinoline on the corrosion inhibition of 1060 Al in 0.1N concentration of trichloroacetic acid at varying temperature of 30°C and 40°C by weight loss method in conjunction to the concentration of rusting media, in immersion of alloy at the temperature 30°C with respect to activation energy, the concentration of inhibitor and adsorption isotherms are plotted to explain the mechanism of adsorption of inhibitor on alloy surface and corrosion potential inclinations are towards cathodic region.

Researchers [7] investigated the inhibition effects of 3-formyl 8-hydroxy quinoline (FQ) and 8-hydroxy quinoline (HQ) on mild steel corrosion in hydrochloric acid was investigated. They were studied polarization, weight loss and electrochemical impedance spectroscopic methods. The consequences demonstrated that inhibition efficiency and surface coverage were increased with increasing inhibitor concentration, and decreased with growing in temperature and acid concentration. The thermodynamic factors were calculated. The inhibitors are follow Langmuir adsorption isotherm. The compound FQ is more inhibition efficiency than compound HQ.

2. Experimental Work

In this paper, the use of both the polarization and loss of weight techniques as in polarization was measured potential and current density through potentiostat device computerized with the help of the three main poles as the sample, the platinum standard calomel, and are taking readings potential and for current density at different temperatures within range 25-45 C and different concentrations of corrosion inhibitor "1-Isoquinolinyl phenyl ketone" within the range of 100-200 ppm. As for weight loss technique, it is the weight of the sample before and after the addition of corrosion inhibitor concentrations after sample and washed, dried and weighed after cleaning, thus immersion in HCl acid where have coupons the dimensions was 2.3 cm length, 0.26 cm wide and 0.11 cm thickness.

3. Results and Discussion

Fig. 1 shows the curves polarization both the anode and cathode and note mild steel behavior in hydrochloric acid without and with the presence of inhibitor corrosion 1-Isoquinolinyl phenyl ketone, the results showed that the inhibitor corrosion like this type above gave adsorption clear by decreasing both the potential and current density, and it grown inhibition efficiency and surface coverage of adsorption at 25 C as shown in Table 1, and a similar manner as in Fig. 2 and 3, so that if increased temperatures of 35-45 C increase efficiency, the polarization tendencies toward mixed type between the anodic and cathodic, This is being done through the method of polarization, either in the way of loss of weight, we find that Table 2 shows as well as decrease the corrosion rate in the degree of 25 C, and it increases the efficiency of inhibition, as well as at temperatures 35-45 C decreasing corrosion rates depending on the increasing temperatures and thus efficiency increases gradually. The inhibition efficiency was evaluated agreeing to the follow rule: [6,7,8]

\[
E = \frac{I_{ui} - I_{ui}}{I_{ui}}
\]

Where:

- \( I_{ui} \) = corrosion current density without inhibitor, mA/cm²
- \( I_{ui} \) = corrosion current density with inhibitor, mA/cm²
Fig. 1: Polarization curves for mild steel at various concentrations of 1-Isoquinolinyl phenyl ketone in 1 M HCl at 25°C

Fig. 2: Polarization curves for mild steel at various concentrations of 1-Isoquinolinyl phenyl ketone in 1 M HCl at 35°C

Fig. 3: Polarization curves for mild steel at various concentrations of 1-Isoquinolinyl phenyl ketone in 1 M HCl at 45°C
Table 1: Effect concentration of inhibitor on corrosion current density, corrosion potential and efficiency with various temperatures using polarization method.

| Conc. of inhibitor ppm | $E_{\text{corr}}$, mV | Corrosion current density, $\mu$A/cm$^2$ | Inhibition efficiency | Surface coverage |
|------------------------|-----------------------|------------------------------------------|-----------------------|-----------------|
|                        | 25°C  | 35°C | 45°C | 25°C | 35°C | 45°C | 25°C | 35°C | 45°C | 25°C | 35°C | 45°C |
| Blank                  | -410  | -421 | -452 | 183  | 151  | 132  | ---  | ---  | ---  | 17.4 | 15.8 | 24.2 |
| 100                    | -421  | -450 | -472 | 151  | 127  | 100  | 17.4 | 15.8 | 24.2 | 0.17 | 0.16 | 0.24 |
| 125                    | -453  | -472 | -491 | 130  | 102  | 74   | 28.9 | 32.4 | 43.9 | 0.29 | 0.32 | 0.44 |
| 150                    | -472  | -491 | -502 | 110  | 89   | 50   | 39.9 | 41.0 | 62.1 | 0.40 | 0.41 | 0.62 |
| 200                    | -490  | -500 | -524 | 88   | 62   | 38   | 51.9 | 58.9 | 71.2 | 0.52 | 0.59 | 0.71 |

Table 2: Effect concentration of inhibitor on corrosion current rate and efficiency with various temperatures using weight loss method.

| Conc. of inhibitor ppm | Corrosion rate (mmpy) | Inhibition efficiency |
|------------------------|------------------------|-----------------------|
|                        | 25°C  | 35°C | 45°C | 25°C | 35°C | 45°C |
| blank                  | 1.45  | 1.31 | 1.22 | ---  | ---  | ---  |
| 100                    | 1.15  | 1.06 | 0.89 | 20.43| 18.57| 26.86|
| 125                    | 1.01  | 0.85 | 0.67 | 30.26| 34.55| 44.93|
| 150                    | 0.90  | 0.77 | 0.48 | 37.63| 40.53| 60.58|
| 200                    | 0.68  | 0.56 | 0.36 | 52.84| 56.89| 70.27|

Fig. 4: Effect inhibitor concentration on corrosion rate with various temperatures.
From Fig. 4 we note corrosion rate decreased with increasing inhibitor concentration. Fig. 5 show that when inhibitor increased, the inhibitor efficiency increased at high temperatures.[6,7]

Fig. 6 represents Arrhenius plot Log C.R vs. 1/T inhibited and uninhibited, where corrosion rate (C.R) is calculated by:

\[
(L. H) = \frac{8 \cdot 6 \cdot w}{D \cdot u \cdot t}
\]  

(2)
Where, $C.R$ is rate of corrosion (mm/py), $w$ is weight loss (mg), $D$ is alloy density (g/cm³), $a$ is exposed area (cm²), $t$ is exposure time (hr). [9]

$$k = \frac{Ae^{-E/R}}{R}$$

(3)

Where, $k$ is the rate of a reaction, $T$ is absolute temperature, $A$ is pre-exponential factor, $E_a$ is the energy of activation, and $R$ is the universal gas constant.

Kinetic parameters may be evaluated from the influence of temperature, enthalpy and entropy from an alternative formulation of Arrhenius equation is:[10]

$$I_{corr} = \frac{RT}{Nh} e^{\left(\frac{\delta S}{R}\right)} e^{\left(\frac{\Delta H}{R}\right)}$$

(4)

Where, $I_{corr}$ is corrosion current, $h$ the Plank’s constant $= 6.626 \times 10^{-34}$ J.s, $N$ is the Avogadro’s number$=6.022 \times 10^{23}$ mol$^{-1}$, $S$ and $H$ the entropy and enthalpy energies, respectively.

Fig. 7: Represent Arrhenius plot Log C.R vs. 1/T without and with inhibitor

Table 3: effect inhibitor concentration on thermodynamics kinetic parameters $E_a$, $H$, $S$, and $G_{ads}$

| Conc. of inhibitor ppm | $E_a$ (kJ/mol) | $H$ (kJ/mol) | $S$ (kJ/mol.K) | $G_{ads}$ (kJ/mol) at 298 K |
|------------------------|----------------|--------------|-----------------|----------------------------|
| blank                  | 31.23          | 17.459       | -0.098          | 46.663                     |
| 100                    | 42.95          | 3.563        | -0.0100         | 6.543                      |
| 125                    | 67.94          | 6.334        | -0.0102         | 9.373                      |
| 150                    | 105.42         | 12.273       | -0.0104         | 15.372                     |
| 200                    | 109.33         | 11.877       | -0.0105         | 15.006                     |

$$\Delta G = \Delta H - T \Delta S$$

(5)

Where, $\Delta G$ is energy free of adsorption.
Table 3 demonstrates the influence of inhibitor corrosion thermodynamics kinetic factors $E_a$, $H$, $S$, and $G_{ads}$ were calculated from the Fig. 6 and 7 showed that whenever increase the inhibitor concentration, increased energy activation, enthalpy and free of adsorption and almost constant entropy energy, and this demonstrations that the inhibitor has good energy to activate the process of adsorption, and desorption be chemical type in concentration 150 ppm and above where that values activation energy more than 80 kJ/mol, and creation layer of film because of present oxygen and nitrogen molecules which have a essential role to build the film layer [6,7,11,12], thus the constant entropy energy that mean the regularity and arrangement in steady conditions at different concentrations of inhibitor but without addition inhibitor is high value entropy energy and then decreased in conc. 100 ppm after that constant until 200 ppm, results are according to researchers [6,7] as shown in Fig.8.

![Fig. 8: Structure of inhibitor 1-Isoquinolinyl phenyl ketone](image)

### 4. Conclusions

In this paper, the results showed that:

- The results showed that the inhibitor is good type particularly in high concentrations for inhibitor.
- Inhibition efficiency enlarged with increasing of inhibitor concentrations and temperatures.
- The inhibitor 1-Isoquinolinyl phenyl ketone is mixed type revealed between anodic and cathodic for process.
- Presence nitrogen and oxygen atoms in structure of inhibitor its important role in adsorption process and creation film layer on metal surface. Thus study effect inhibitor concentration on thermodynamics kinetic parameters $E_a$, $H$, $S$, and $G_{ads}$, where showed that adsorption is chemical type, where increase the inhibitor concentration, increased energy activation, enthalpy and free of adsorption and almost constant entropy energy.

### References

[1] Schmitt, G., (1984). "Application of inhibitors for acid media", Br. Corros. J., 19, 4, 165- 176.
[2] I.Ahamad, R. Prasad, M. A. Quraishi, (2010)." Thermodynamic, electrochemical and quantum chemical investigation of some Schiff bases as corrosion inhibitors for mild steel in hydrochloric acid solutions", Corros. Sci. 52, 933-942.
[3] Lopez, D.A.; Simison, S.N.; de Sanchez, S.R, (2005). "Inhibitors performance in CO$_2$ corrosion EIS studies on the interaction between their molecular structure and steel microstructure". Corros. Sci., 47, 735–755.
[4] El-Etre, A.Y., (2007). "Inhibition of acid corrosion of carbon steel using aqueous extract of olive leaves". J. Colloid Interface Sci., 314, 578–583.
[5] Emregu, K.C., Orhan Atakol, E.D., (2006). "The application of some polydentate Schiff base compounds containing aminic nitrogens as corrosion inhibitors for mild steel in acidic media". Corros. Sci., 48, 3243–3260.
[6] Arvnabh Mishra, D. R. Godhani and Anil Sanghani, (2011). "Inhibitive Properties of Nitrogen Containing Heterocyclic Compounds over Aluminium Alloys in Organic Acid Environment", J. Chem. Pharm. Res., 3(2):388-396.
[7] Ganesha Achary, H.P. Sachin, Y. Arthoba Naik, (2008)." The corrosion inhibition of mild steel by 3-formyl-8-hydroxy quinoline in hydrochloric acid medium", Materials Chemistry and Physics ,Volume 107, Issue 1, 44–50.
[8] Winston Revie, R. and Uhlig, Herbert H. (2008). "Corrosion and Corrosion Control", by John Wiley & Sons, Inc.
[9] Muhamath, Ali, B.M., Kulanthai., and Kannan , (2009). "Inhibition effect of Parthenium Hystophrous L extracts on the corrosion of mild steel in sulphuric acid". J. App. Sci. and Envi. Man.13(1) , 27 – 36.
[10] Abd El-Rehim S.S., Refaey S.A.M., Taha F.,Saleh M.B.,Ahmed R.A. , (2001)."Corrosion inhibition of mild steel in acidic medium using 2-amino thiophenol and 2-cyanomethyl benzothiazole", J. Appl. Electrochem. 31,429-435.
[11] Ghazoui , R. Saddik1, N. Benchat1, M. Guenbour , B. Hammouti1, S.S. Al-Deyab , A. Zarrouk, , (2012)."Comparative study of pyridine and pyrimidine derivatives as corrosion inhibitors of C38 steel in molar HCl ", Int. J. Electrochem. Sci., 7,7080 – 7097.
[12] James AO, Oforka NC, Olusegun K. Abiola. (2007)."Inhibition of acid corrosion of mild steel by pyridoxal and pyridoxol hydrochlorides", International of Electrochemical Science.;(2):278-284.