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Inhibition by 1-Methyl Isoquinoline for Mild Steel Corrosion in 1 M HCl Media

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Abstract

In this study, the usage of the inhibitor 1-Methylisoquinoline with various concentrations from 100-600 ppm, and its influence on corrosion of mild steel 1M hydrochloric acid and the results proved that this type of inhibitors as efficient and good quality , and efficiency increases with the concentration of the inhibitor in temperature of 303 K , and whenever increased temperature of 313-323 K decreased efficiency and was used weight loss and hydrogen gas evolution methods , and the activation energy enlarged with increasing inhibitor concentration as well as energy enthalpy and free energy of adsorption ,adsorption be physically in low concentrations ,while mixed type in high concentrations.

***Keywords*:** corrosion; mild steel; 1-methylisoquinoline; HCl media; weight loss; hydrogen gas evolution.

1. Introduction

Corrosion is loss of metal for properties due bare to aggressive environments, such as, the employ of acid solutions for pickling, chemical and electrochemical engraving of metal, industrial acid clean-up, cleaning of oil refinery equipment, acid removing sediments and oil well acidizing [1,2].The corrosion of the major industrial metal equipment problems that have attracted a lot of investigators in recent years , there is still cause a lot of concern for scientists, engineers and researchers , as it affects the metalworking, chemical and oil industries [3,4]. Inhibitors generally operate through adsorption on the surfaces of metals, depending on the nature of the surface adsorbed metal and aggressive media for the metal part and synthetic molecules of inhibitor and its interaction with the metal surface [5]. Beforehand been examined of organic inhibitors for mild steel in hydrochloric acid media [6,7].

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Some previous studies about inhibitor quinoline and its derivatives as inhibitor, Researchers [8],were observed about quinoline (QL) and its derivatives, quinaldic acid (QLDA), quinaldine (QLD) were investigated as inhibitors by weight loss method at temperatures various in hydrochloric acid for the steel corrosion .With rising in the concentration,Inhibition efficiency enlarged of the studied compounds, but reduces of efficiency with increase in temperature. The arrangement of inhibition efficiency as shown by results explain that is QLDA > QLD > QL. The inhibitors adsorption on the steel surface follows to Langmuir models in kinetic thermodynamic.

Investigators [9] were showed the results exhibited corrosion surface coverage and inhibition efficiency were developed with increase in inhibitor concentration and reduced with progression in temperature and acid concentration when examined inhibition influences both for 3-formyl 8-hydroxy quinoline (FQ) and 8-hydroxy quinoline (HQ) in hydrochloric acidfor corrosion of mild steel. The electrochemical impedance spectroscopic, polarization as well as weight loss methods were studied. Thus calculated thermodynamic factors for corrosion inhibition process. Langmuir adsorption isotherm for the inhibitors. The complex FQ demonstrated more corrosion inhibition efficiency than HQ.

Scientist [10] ,were studied the corrosion inhibition effect of two quinoline derivatives, viz. 2-chloro quinoline 3-carbaldehyde (CQC) and (2-chloro-quinoline-3ylmethyl)-*p*-tolyl-amine (CQA) on mild steel (MS) in 1N HCl solution using linear polarization , electrochemical impedance spectroscopy ,weight loss and potentiodynamic polarization,. The losses in weights of MS tasters have proved that both CQC and CQA are effective inhibitors of corrosion. For electrochemical polarizations, the mixed mode of inhibition. The results of electrochemical impedance spectroscopy have exhibited differences in the impedance parameters similar charge transfer resistance and double-layer capacitance that confirmed that on the MS surface is strong adsorption of inhibitors.

This paper shows the inhibition effects of 1- Methyl isoquinoline on mild steel corrosion in hydrochloric acid by weight loss and hydrogen gas evolution methods with various temperatures 303-323 K and concentration of inhibitors 100-600 ppm.

2. Experimental Work

Mild Steel specimen of composition, (wt. %): 0.15% C, 0.34% Mn, 0.19% Si, 0.06% S, 0.42% P, 0.023% Cu, and bal. Fe. The metal sample were ready, removed grease and clean as beforehand described .By using weight loss method, seven mild steel coupons of dimension 4cm x 2cmx0.2cm were used in the experiments containing 1M HCl with the six different concentrations 100,200,300, 400,500 and 600 ppm of 1-Methylisoquinoline (Purity, 97 %) used as inhibitor.Thus test was using hydrogen gas evolution method with 50 ml volume every experiment without and with inhibitors.

3. Results and Discussion

Figure 1 shows large deviation of weight loss with time without and with inhibitor, when addition inhibitors we note weight loss or corrosion rate reduce of mild steel in HCl, accord equation 1 in below, when a gradual increase of the inhibitor concentration, decreased weight loss of mild steel in acid media.at temp.30 C, as well as observe the same indicator in Figure 2 and 3 at temperature 40and50 C, respectively. These results are according to researchers [8,11].

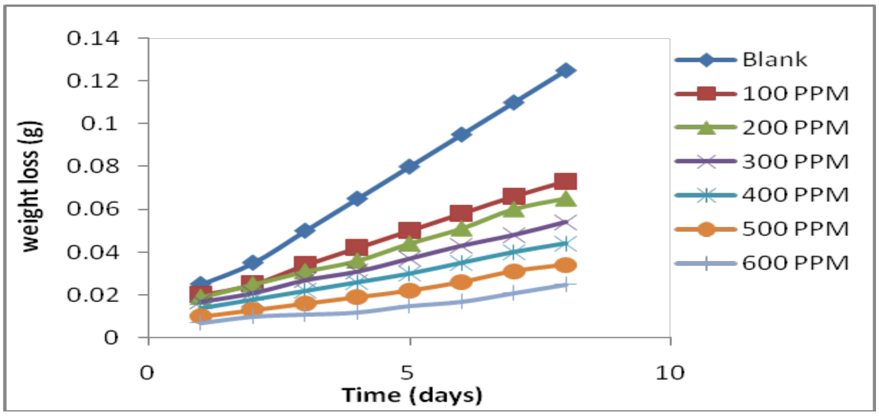

Figure 1: Variation of weight loss with time for mild steel in 1M HCl acid solution containing different concentrations of 1- Methyl isoquinoline at 30ºC

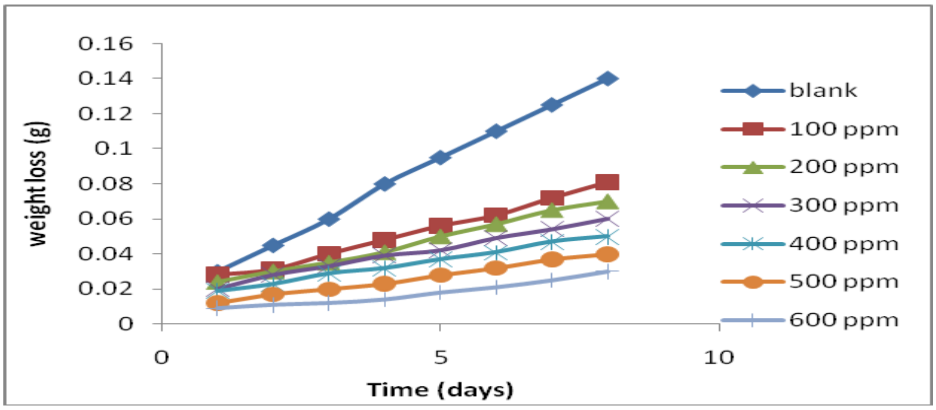

Figure 2: Variation of weight loss with time for mild steel in 1M HCl acid solution containing different concentrations of 1- Methyl isoquinoline at 40ºC

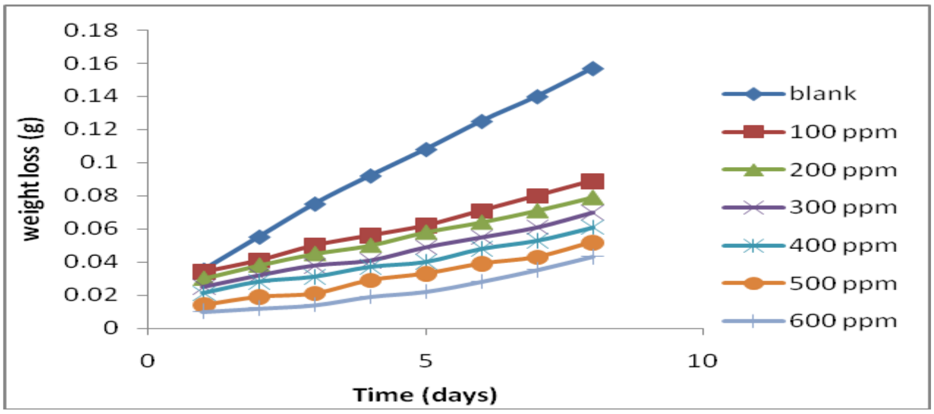

Figure3: Variation of weight loss with time for mild steel in 1M HCl acid solution containing different concentrations of 1- Methyl isoquinoline at 50ºC

Figure 4 show relation between volume of hydrogen gas evolution and time, we illustrate that decrease hydrogen gas evolution with time without and with of concentration inhibitors.

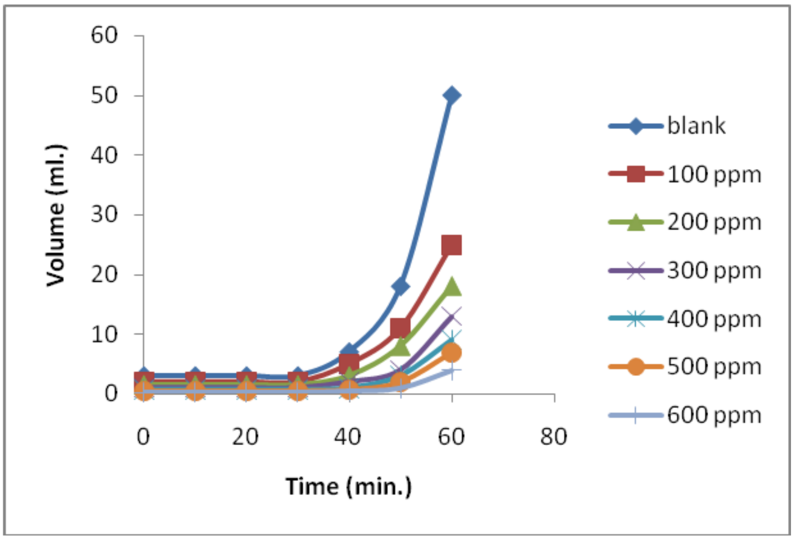

Figure 4: Relation between volumes of hydrogen gas evolved with time (minutes) for the inhibition of mild steel in 1M HCl acid solution containing different concentrations of 1- Methyl isoquinoline at 30ºC

Table 1 show that the increase in inhibitor increased corrosion inhibition efficiency at a temperature of 30 C and when increases the temperature decreases the efficiency of inhibition.

The inhibition efficiencies (%*E*) were estimated from the equation below:

$$\% E = \frac{W_u - W_i}{W_u} \qquad 1$$

Where w_u and w_i are the weight loss data of metal coupons uninhibited and inhibited respectively.

Table1: Effect inhibitor concentration on percentage inhibition efficiency at different temperature.

Inhibitor conc.	percentage inhibition efficiency %		
	30 C	40 C	50 C
Blank	0	0	0
100	41.3	31.2	25.4
200	47.8	40.3	35.6
300	56.2	48.5	42.2
400	64.6	56.2	49.3
500	73.1	65.1	56.2
600	80.2	73.1	65.7

Figure 5 shows that the increase in temperature that leads to decrease the efficiency of inhibition and the greater the concentration of the inhibitor increased efficiency of1- Methyl isoquinoline on mild steel corrosion in HCl.

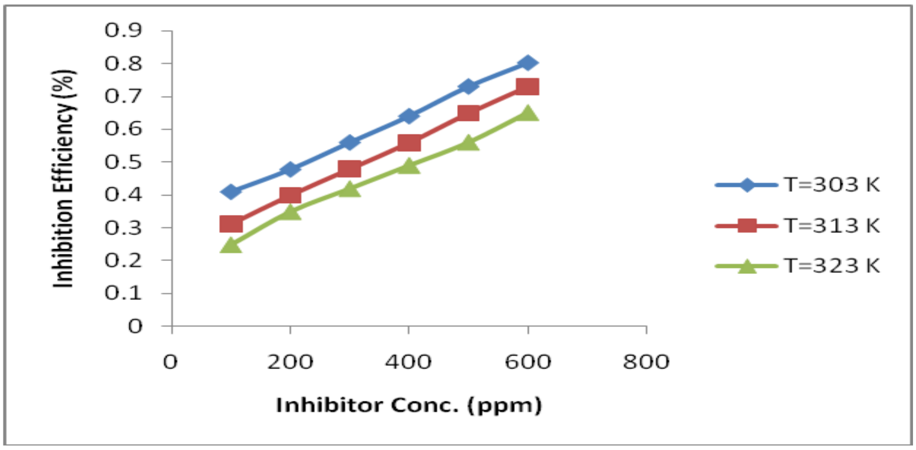

Figure 5: Variation of inhibition efficiency with inhibitor concentration for mild steel in 1M HCl acid solution containing different concentrations of 1- Methyl isoquinoline

Figure 6, represents Arrhenius plot, Log C.R vs. 1/T without and with inhibitor where corrosion rate (C.R) is calculated by**:**

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

Where, *C.R* is corrosion rate (mmpy) , *w* is weight loss (mg) , *D* is alloy density (g/cm^3) , *a* is exposed area (cm^2), *t* is exposure time (hr).[12]

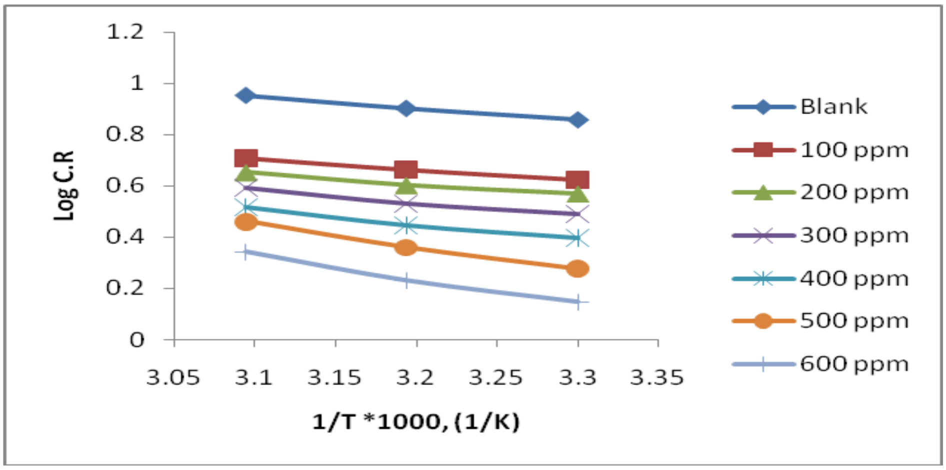

Figure 6: Relation between log(C.R) and 1/T for different inhibitors conc.

Figure 7, show relation between Log C.R/T and 1/T, where was calculated factors ΔH and ΔS from slope and intercept respectively as in Table 2.

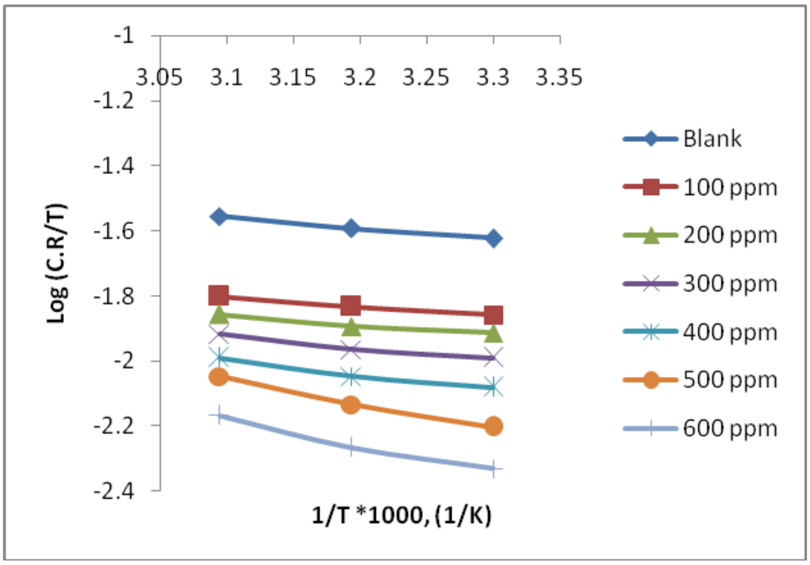

Figure 7: Relation between log(C.R/T) and 1/T in 1M HCl for different inhibitors conc.

Table 2: Thermodynamic adsorption parameters Ea , ΔH , ΔS and ΔG_{ads} for mild steel in 1M HCl acid solution without and with concentrations of 1- Methyl isoquinoline

Conc, of inhibitor ppm	E_a(kJ/mol)	ΔH (kJ/mol)	ΔS (kJ/mol.k)	ΔG_{ads} (kJ/mol)at 298 K
Blank	39.36	27.88	-0.0962	56.54
100	34.44	22.96	-0.0981	52.19
200	34.85	23.37	-0.0985	52.72
300	41.00	29.52	-0.0989	58.99
400	49.61	36.90	-0.0993	66.49
500	75.44	63.96	-0.0997	93.67
600	80.36	66.83	-0.1005	96.77

The activation energy E_a, the enthalpy energy ΔH, the entropy energy ΔS and free energy ΔG for mild steel in 1M HCl acid solution without and with concentrations of 1- Methyl isoquinoline and from Arrhenius equation were calculated ,eq.(3 ,4 and 5).[13,14]

$$R_{corr} = Ae^{-Ea/RT} \quad 3$$

$$R_{corr} = \frac{RT}{Nh} e^{(\frac{\Delta S}{R})} . e^{(-\frac{\Delta H}{RT})} \quad 4$$

$$\Delta G = \Delta H - T\Delta S \quad 5$$

where, R_{corr} is the rate of corrosion from weight loss, A is the frequency factor, N is Avogadro's number ,h is Planck's constant and R is the universal gas constant.

There are two types of adsorption processes, chemisorption and physisorption , where the activation energy is greater than 80KJ/mol is chemisorption ,thus the activation energy is less than about 40 KJ/mol is physisorption [4].

Due the existence of cationic surfactants we note the activation energy E_a rise by increasing concentration inhibitor. These point to that the creation adsorption layer by a physical mechanism.

The process of inhibitors adsorption on the steel surface is endothermic processthis indicates the existence of the positive values of ΔH.The activated complex is the rate determining step and represents association rather than dissociation this leads to the negative values of ΔS without and with inhibitor [15] .

Interactions between empty d-orbitals of iron and π-electrons of the heterocyclic of donor-acceptor are foundation of this adsorption. Thus, that the steel surface in acid solution are carries positive charges. [16]

1- Methyl isoquinoline molecules may be adsorbed on the metal surface through the physisorption mechanism as in Figure 8.

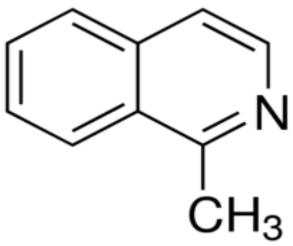

Figure 8: Chemical structure of 1- Methyl isoquinoline

4. Conclusions

- Corrosion inhibitor of 1- Methyl isoquinoline is high efficient and excellent quality .
- The results showed by weight loss and hydrogen gas evolution methods that the inhibition efficiency increases with the concentration of the inhibitor at a temperature of 303 K and when the temperature

increased 313 and 323K, less efficiency in it.

- Activation energy increases with the concentration of the inhibitor as well as enthalpy energy and free energy for adsorption.
- Adsorption is physical type in low concentration while in high concentration is physicochemical.

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