Effect of inhibition by " 2-(2-methoxyphenoxy) benzylamine hydrochloride " for corrosion of mild Steel in HCl media

HUSSEIN ALI AWAD [1], RAHEEM A.H. AL-UQAILY [2], SUBHI A. AL-BAYATY [3]

[1] *Department of Biology, College of Science, Wasit University*
[2, 3] *Department of Chemistry, College of Science, Wasit University*

Abstract

In this paper, the effect of inhibition "2- (2-methoxyphenoxy) benzylamine hydrochloride"of mild steel corrosion has been studied in the existence of a hydrochloric acid medium. The method of weight loss and hydrogen gas evolution was used with different inhibitor concentrations ranging from 100-500 parts per million at different temperatures from 35-55 ° C. Where results presented that when increasing the inhibitor concentrations and temperature, lead to increases the inhibition efficiency and this indicates the adsorption of a layer of film on a surface of metal and the effectiveness of inhibitor by the presence of the amine molecule and the oxygen and nitrogen atoms that have an active role in the adsorption process. In this study the activation, entropy, and enthalpy energy, were calculated and exhibited good results.

***Keywords*:** mild steel, 2- (2-methoxyphenoxy) benzylamine hydrochloride, weight loss, inhibition, hydrogen gas evolution.

I. INTRODUCTION

Corrosion is the process of converting a steel to a further chemically steady form or returning to its ores such as oxide or hydroxide and is from pollution forms. On the other hand, is the slow damage of the metal through chemical interaction with its surrounding. Corrosion is defined as the breakdown of metal structures by their interaction with the surrounding atmosphere. Metals are used to manufacture many things such as pipes, structures, etc. Corrosion is an important factor in the chemical industry, as it is the main and major cause of many problems facing operations in production lines and is usually responsible for breakdowns and interruptions in production. Product leakage from corrosive units is polluting the environment and endangering public health [1-3]. Mild steel is generally used in the gas, oil and chemical industries because its mechanical properties are good, and steel is used in industry for its lower cost compared to anti-corrosive metals or alloys.[4,5].In spite of this, this alloy is subject to corrosion by contact with the conditions causing corrosion, particularly that having chloride ions. [6].The use of acids, such as hydrochloric acid, is still a good way to improve productivity, and this is that we observe in many industrial processes that specialize in treating gas and oil, such as cleaning pipelines from deposits.[7].Inhibitors are chemicals substances for very small concentrations, in parts of a million (ppm) , are added to the acidic, basic or saline solution through adsorption on metal surfaces, depending on the nature of the adsorbed metal surface and the media. The inhibitors work to reduce the rate of corrosion or oxidation of the minerals.[8-10]

Investigator [11] , studied and investigated inhibition by 4-Chloro-2-fluorobenzylamine Hydrochloride for corrosion of mild steel in HCl acid with inhibiting concentrations 100-300 ppm and temperatures 40-60 °C using methods of weight loss and hydrogen gas development in the process, the results presented that above inhibitor is a good kind of mild steel, and leads to increased inhibition efficiency as the greater the inhibitor concentrations and temperature decreases, as well as the activation energy increases with increasing the inhibitor concentration as well as increasing the energy permeability and free energy for absorption, in this case chemical adsorption. The presence of chlorine, fluorine, and H_2N atoms in the inhibitor structure has a clear indication of the formation of a film layer on the surface of the metal and stops the corrosion process.

Scientists [12], have investigated effect of Benzylamine-N- (p-methoxybenzylidene) on corrosion inhibition of Al Mg alloys in 2.0 M HCl by using of methods of galvanic polarization and weight loss. The results showed that the inhibition efficiency rises with increasing concentration of inhibitor and decreasing with increasing temperature. Adsorption of Langmuir and mixed type.

Researcher [13], have studied the effect of using 2-methoxy methyl-benzylamine to inhibit the corrosion of steel in hydrochloric acid. The concentration of the inhibitor ranges from 0.0001 -0.1 ppm and temperatures from 313 to 333 K, using polarization and weight loss methods. The results exhibited that the efficiency of inhibition increased with increasing inhibitor concentration and temperature. The adsorption is mixed kind.

II. EXPERMENTAL WORK

Mild Steel specimen of composition, (wt. %): 0.13% C, 0.36% Mn, 0.15% Si, 0.09% S, 0.45% P, 0.026 % Cu, and bal. Fe. Mineral specimens are prepared, degreased and cleaned, ,the weight loss method, seven mild steel samples with dimensions of 5 cm x 3 cm x 0.4 cm were used in experiments containing 1 molar of hydrochloric acid at different concentrations 100, 200, 300, 400, and 500 ppm with a 2- (2-methoxyphenoxy) benzylamine hydrochloride inhibitor with different temperatures 35, 45and 55 C . The test was using a hydrogen gas evolution method of 50 ml with and without inhibitors.[14]

III. RESULTS AND DISCUSSIONS

Figure 1 below is a graphic relationship between weight loss with time without and with the addition of corrosion inhibitors, where we note that if the inhibitor is added gradually, the weight loss or the rate of corrosion decreases with a temperature of 35 ° C, that leads to the inhibition efficiency increases. Likewise Fig. 2 and 3 in the same way as the rate of corrosion decreases with increasing temperatures 45 and 55 ° C, which is compatible with researchers.[11-15]

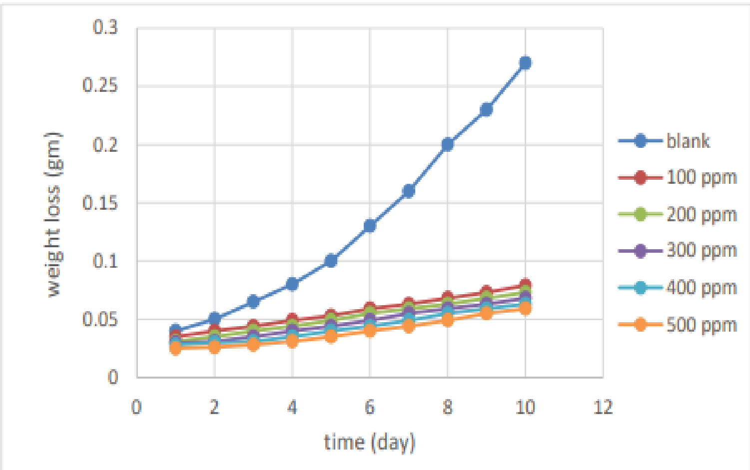

Fig. 1: Plot of weight loss with time for 35 ºC with and without inhibitor

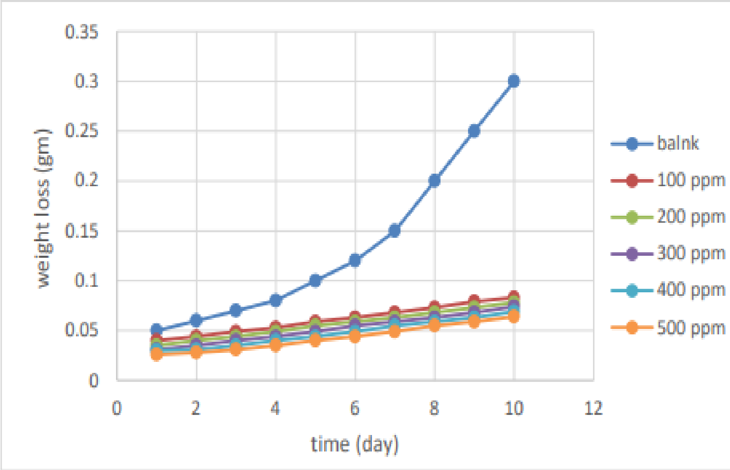

Fig. 2: Plot of weight loss with time for 45 ºC with and without inhibitor

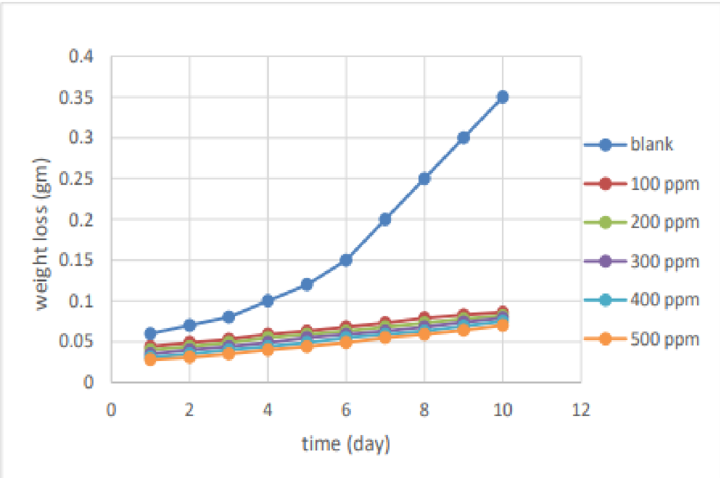

Fig. 3: Plot of weight loss with time for 55 ºC with and without inhibitor

Figure 4 below, illustrations the relationship between the volume of the hydrogen gas evolution and the time. We note that the volume of the hydrogen gas decreases with an increased concentration of corrosion inhibitor at a temperature of 35 ° C. This indicates that if gas decrease, becomes the metal more protects and resistant from corrosion and inhibition efficiency increases.[15,16]

$$Fe + H_2O + O_2 = Fe^{+2} + H_2 + OH^{-1}$$

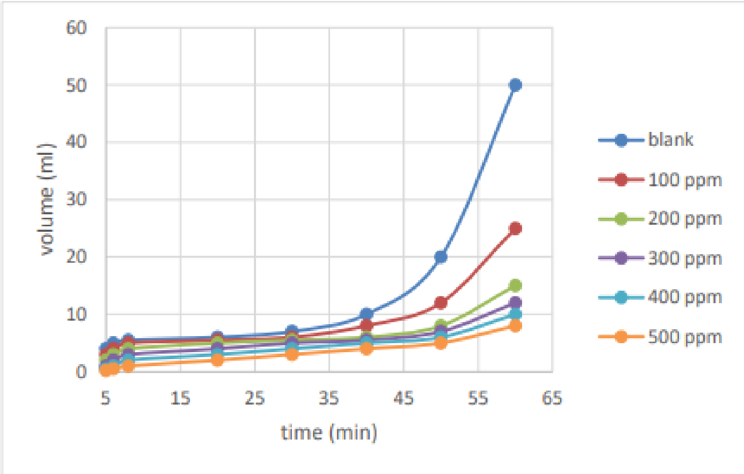

Fig. 4: Plot of volumes of hydrogen gas evolution with time for 35 C with and without inhibitor

We can calculate the corrosion inhibition efficiency by the following law:

E= (Wu-Wi) / Wu *100 % …..(1)

Where: *E* is efficiency, W_u is weight loss for uninhibited, *Wi* is weight loss for inhibited

Depending on Figures 1, 2 and 3, the inhibitory efficiency without and the presence of corrosion inhibitor with different concentrations are as follows:[11-13]

Table 1: Influence inhibitor concentration on percentage inhibition efficiency in various temperatures

Inhibitor concentration (ppm)	Percentage inhibition efficiency (%)		
	35 C	45 C	55 C
Blank	---	---	---
100	70.7	72.3	75.4
200	72.1	74.2	76.4
300	74.8	76.3	78.5
400	76.9	77.8	79.7
500	78.14	78.7	80.0

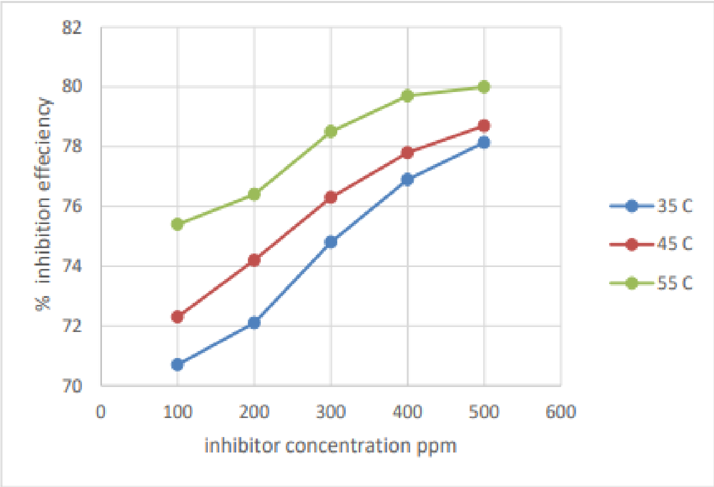

Fig. 5: Plot of inhibition efficiency with concentrations of inhibitor for different temperatures

Figure 5 show that increasing of efficiency by increasing of concentration of inhibitor in various temperatures.

Corrosion rate is written accordingly the following equation:

$$C.R = 87.6\ w / D.a.t \quad ....(2)$$

Where, **C.R** is corrosion rate measured in (mmpy), w is loss of weight measured in (mg), **D** is density measured in (g/cm^3), **a** is area measured in (cm^2), **t** is time measured in (hr) .[17]

We can write the Arrhenius equation to measure the activation energy through the following corrosion rate equation following:

$$C.R = A\ e^{-Ea/RT} \quad ....(3)$$

Where **A** is frequency factor, E_a is activation energy, **R** is universal gas constant, **T** is absolute temperature. [18,19]

We also measure the energy of the enthalpy and entropy by equating the number of Avogadro and Planck constant following:

$$C.R = [R.T/N.h].e^{\Delta S/R} . e^{-\Delta H/RT} \quad .....(4)$$

Where : **h** is Planck's constant , **N** is Avogadro's number, **ΔS** is entropy energy, **ΔH** is enthalpy energy. [18, 19]

Through the energy of enthalpy and entropy above, we obtain the free energy of the reaction according to the following equation:

$$\Delta G = \Delta H - T\Delta S \quad ......(5)$$

Where **ΔG** is free energy for adsorption. [19,20]

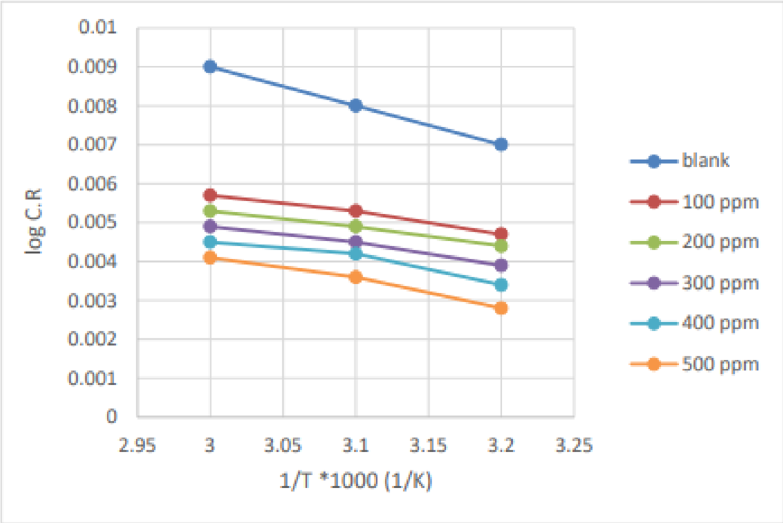

Fig. 6: Plot of log C.R with 1/T for different concentrations

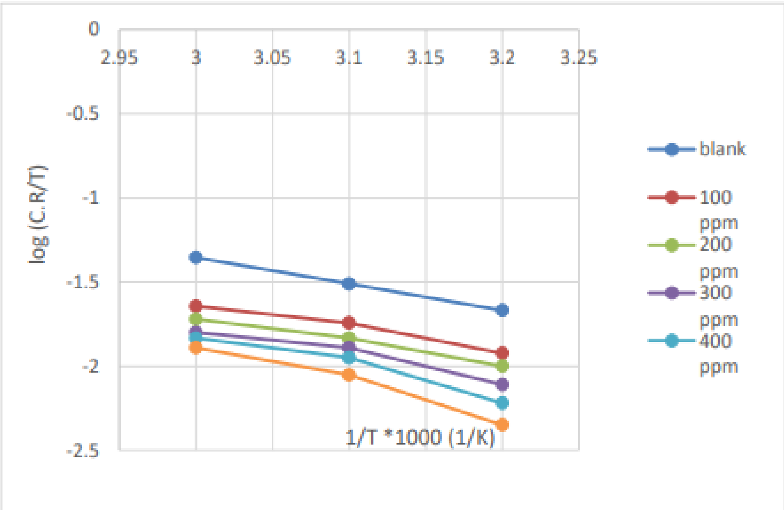

Fig. 7: Plot of log (C.R/T) with 1/T for different concentrations

From Figures 6 , 7 we get on parameters of kinetics activation ,enthalpy, entropy and free energies from through Arrhenius equation previous as shown in Table 2 below:[21,22]

Table 2: Thermodynamic adsorption parameters Ea , ΔH , ΔS and ΔG_{ads}

Cons. of inhibitor (ppm)	E_a (kJ/mol)	ΔH (kJ/mol)	ΔS (kJ/mol.K)	ΔG_{ads} (kJ/mol) at 35 C
Blank	83.14	13.35	$-4.6 * 13^{-7}$	13.35
100	24.94	13.21	$-5 * 13^{-7}$	13.21
200	37.41	11.59	$-5.3 * 13^{-7}$	11.59
300	41.57	14.57	$-5.9 * 13^{-7}$	14.57
400	45.72	16.34	$-6.5 * 13^{-7}$	16.34
500	54.04	19.12	$-7.2 * 13^{-7}$	19.12

We calculated from Table 2 activation, enthalpy, entropy energies , and free energy of adsorption through Figures 1 and 2. We note the increase in the activation values and the enthalpy energy, and the decrease in the entropy energy by increasing the inhibitor, as an adsorbent layer of the inhibitor consists of the film on the surface of the metal, and there are two types of chemical and physical adsorption. In our work, we notice the occurrence of mixed adsorption of two types, ranging from 40 to 80 kJ / mol. The reaction is endothermic because the values of the enthalpy are positive. Also, the presence of amine group molecules, oxygen and nitrogen atoms where inhibitors have the main role in the adsorption process that occurs through the mechanism as Figure 8 as shown in below.[23-26]

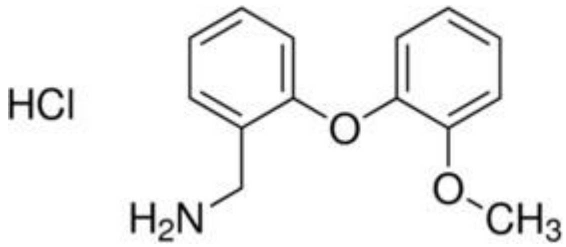

Fig. 8: structure of 2-(2-methoxyphenoxy) benzylamine hydrochloride inhibitor

IV. CONCLUSIONS

In this research, the effect of inhibition " 2- (2-methoxyphenoxy) benzylamine hydrochloride " of mild steel corrosion has been investigated in the existence of a hydrochloric acid medium. The techniques of weight loss and hydrogen gas evolution was used with various inhibitor concentrations from 100-500 ppm in various temperatures from 35-55 ° C. Where results presented that when increasing the concentrations of the inhibitor and temperature, increases the efficiency of inhibition and this indicates the adsorption of a layer of film on a surface of metal and the efficacy of the inhibitor by the presence of the amine molecule and the oxygen and nitrogen atoms that have an active part in the adsorption process. In this paper the activation, enthalpy, entropy and free energy of adsorption energies were exhibited good results with by increasing the values of activation and enthalpy energy and decrease entropy energy and this indicates to occurrence of good adsorption to the inhibitor and adsorption of mixed type (physical and chemical).

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