Studying the effect of Moringa inhibitor on the corrosion of mild steels in 0.5 M H_2SO_4 at temperatures 40 °C and 50 °C

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ABSTRACT

The purpose of this study is to investigate the effect of an inhibitor, the Corrosion inhibition potential of Mild steel using Moringa leaves alcoholic extract , the study was carried out using the weight loss technique. the results obtained show Moringa leaves alcoholic extract as potential inhibitors of mild steel corrosion in 0.5 M Sulfuric (H_2SO_4). An acidic environment was created to act as a catalyst enhancing the corrosion process. These experiments were all carried out at temperature 40-50°C. The results obtained showed that the inhibition efficiency of the extract increases with an increase in the concentration of the extract. The best optimum efficiency in both cases was obtained from 40ml concentration of Moringa alcoholic leave extract with inhibition efficiency of 75.19 % . the effects of inhibitor concentration on the corrosion rate of low steel have been found to increase with inhibitor concentration at both temperature 40 and 50 °C.

This experimental condition ensured that the catalyst was the only driving force in the corrosion process. These results obtained here are largely consistent with other studies using plant extract that show that corrosion inhibition is highest (or most efficient) at the highest concentration of the extracts in solution.

***Key Words* :** Corrosion inhibition **,** Sulfuric acid , Mild Carbon Steel, , Moringa, Adsorption Isotherm .

1. Introduction:

Corrosion is defined as the deterioration of a metal due to its interaction with the environment. Due to corrosion many useful properties of a metal such as malleability, ductility and electrical conductivity are lost. Synthetic organic compounds are widely used as corrosion inhibitors for the prevention of corrosion of many metals and alloys in various aggressive environments. Because of their hazardous nature, researchers focus their attention on developing cheap, non-toxic, biodegradable and environment friendly natural products of plant origin as corrosion inhibitors [1-10]

1.1. Types of corrosion

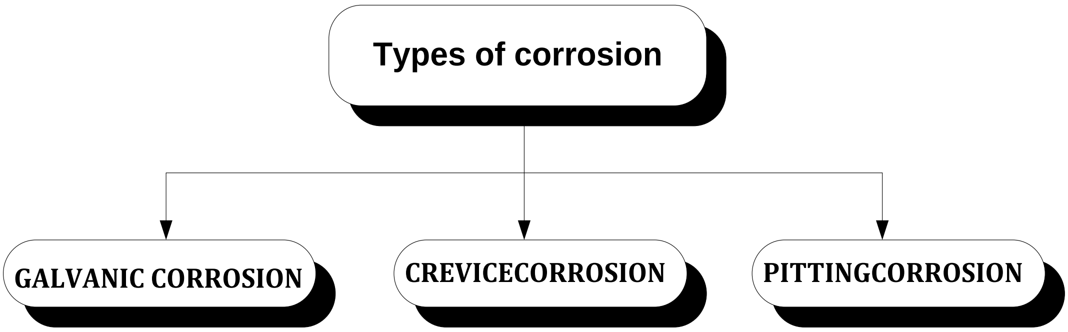


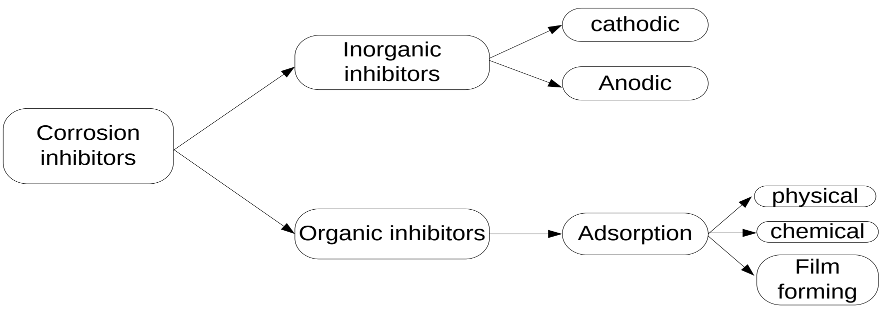
Figure (1) Types of corrosion.

1.2. Corrosion Inhibitors

Corrosion inhibitors have widespread application in suppressing or at least mitigating the corrosion process of metals in different fields, spanning from industrial sectors to construction materials to surface treatments for cultural heritage.

1.3.Classification of Corrosion Inhibitors

Corrosion inhibitors have widespread application in suppressing or at least mitigating the corrosion process of metals in different fields, spanning from industrial sectors to construction materials to surface treatments for cultural heritage[11].



Figure(2) Classification of inhibitors.

1.4. Moringa oleifera

Moringa oleifera is a widely cultivated tree considered as a multi-purpose plant. It includes its use as functional food, cleaning water material, oil extraction for biofuel production, and other applications. In a traditional way, it is used with medicinal purposes around the world due to empiric observations. [12-14].

Moringa oleifera is one of the vegetables of the Brassica order and belongs to the family Moringaceae.

The Moringaceae is a single genus family with 13 known species[15].

The Leaves of Moringa oleifera are rich source of minerals like calcium, potassium, zinc, magne-

sium, iron and copper. The Leaves has low calorific value so can be used in the diet of obese. The leaves also contain all essential amino acids and are rich in protein and minerals [16].

2. Materials and experimental

2.1. Materials:

The starting materials used in this analysis are:

1. Mild Carbon Steel Sample 2.Moringa 3.Sulfuric acid 4.Ethanol

Fig. 3: (a) Mild Carbon Steel Sample, and (b) showing the same Moringa leaves after being dried and grinded

(c) The green leaves of this Moringa tree

2.2. Preparation of Moringa leaves

The leaves was washed with distilled water and then kept on a clean surface to air dry for over 24 hours at room temperature , for preparation of stock solution of Moringa leaves (alcoholic Extracts of the Moringa leaves): 20 g of dried and grounded Moringa leaves powder in 200 ml of ethanol , the mixture was heated at about 80°C for 24 hour on an electronic hot plate to obtain the plant extract then filtered using both filter paper and a cloth sieve.

3- Results and discussion

3.1. Chemical composition of Mild Carbon Steel

Table (3.1) indicates the chemical composition data for the mild carboon steel, as determined by x-ray florescence technique (XRF).

3.2. Corrosion Rate (CR)

The data of weight loss and corrosion rate calculations for the steel samples using alcoholic extract moringa are given in table (3.2). From the obtained results and figure (3.1), we noticed that the rate of corrosion increases with

Table (3.1) - Chemical compositions of Mild Carbon Steel

Fe	C	Si	Mn	P	S	Al	Cu	Cr	Ni	Cl
95.0	0.45	1.30	0.911	0.111	0.256	0.641	0.491	0.334	0.202	0.183

absence of damper and increase the temperature. In addition, when we add the damper, we notice that the corrosion rate increases when temperature increases, and decreases as the inhibitor concentration increases. This is explained by the fact that the damper works at high temperatures and the compatibility of the extract with the surface of the metal in general. Regardless of the concentration of the inhibitor, as the temperature increases, the corrosion rate decreases, and the efficiency of the inhibitor increases, which indicates that the inhibitor molecules are adsorbed and provide a barrier on the metal surface [17].

Table (3.2) weight loss and corrosion rate calculations for the steel samples using alcoholic extract moringa.

Sample No.	Inhibitor concentration in 0.5M H_2SO_4	CR (mg)/cm² .min*10^{-3}, 40 °C	CR (mg)/cm² .min*10^{-3}, 50 °C
1	0.5	0.146	0.517
2	10 %	0.123	0.135
3	20 %	0.059	0.106
4	30 %	0.055	0.069
5	40 %	0.043	0.048

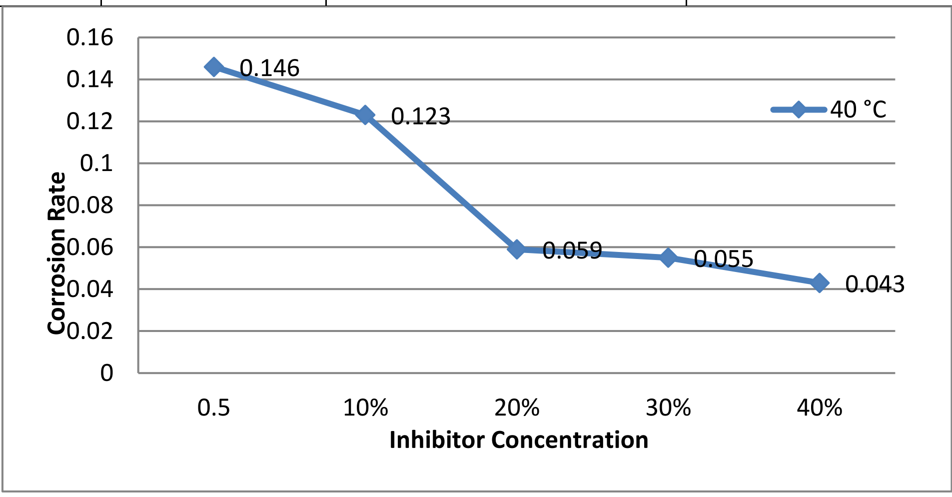


Fig. (3.1) The Relationship between Corrosion Rate and Inhibitor Concentration at 40C

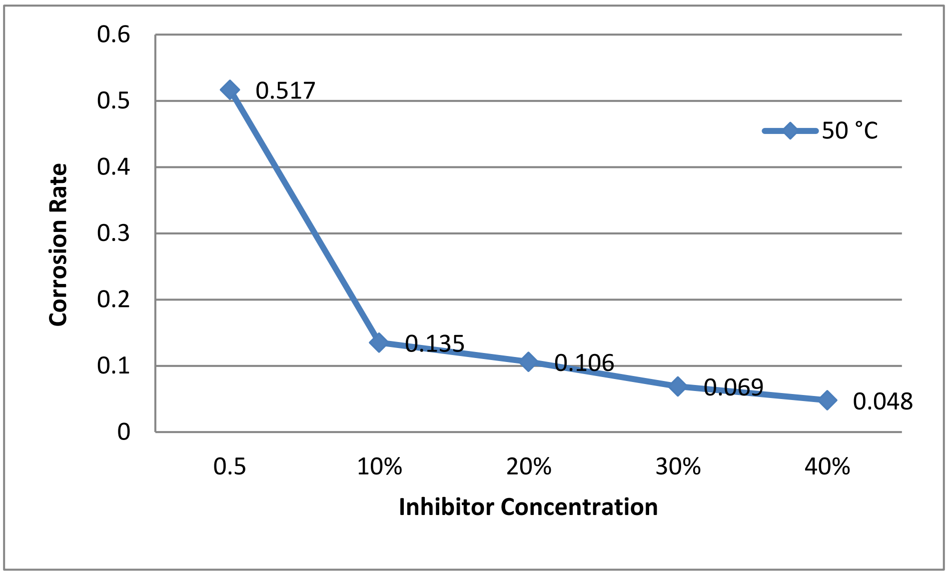


Fig. (4.2) The Relationship between Corrosion Rate and Inhibitor Concentration at 50C

3.3. Inhibition Efficiency

The Inhibition Efficiency (IE %) is presented in table (3.3) and for compassion in figure (3.2|) for both temperatures 40 and 50 °C. The results show a consistent increase in inhibition efficiency as the concentration of the extract in solution is increased.

From table (3.3), we found that the values of efficiency and surface area covered increase with increasing concentrations of the used inhibitor, but decrease with high temperatures.

The increasing in rates of inhibition efficiencies maybe referred to the adsorption of the inhibitor within the solution gradually increase, which lead to complete coverage or corrosion of active places [18,19

Table (3.3) Calculations of the inhibitory efficiency of the alcoholic extract moringa at temperatures of 40 and 50 °C

Sample No.	Log (I)	IE % at 40 °C	IE % at 50 °C
1	0.00	0.00	0.00
2	-1	43.40	34.44
3	-0.699	46.65	42.03
4	-0.523	58.82	54.36
5	-0.398	75.19	63.96

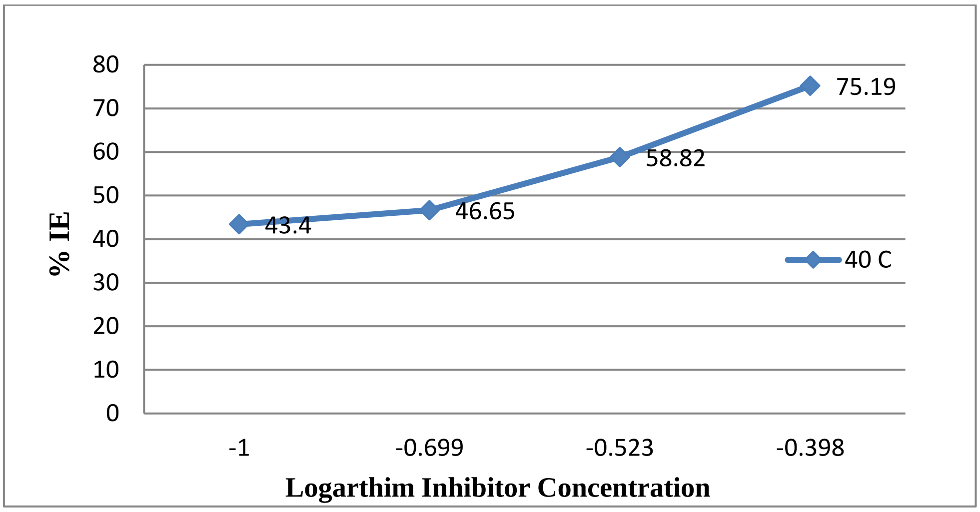


Fig. (3.3) The Variation Inhibition Percentage With the Logarithm of the Concentration of “Alcoholic Extract Moringa “Sulphur Containing Inhibitor Compound, at 40°C.

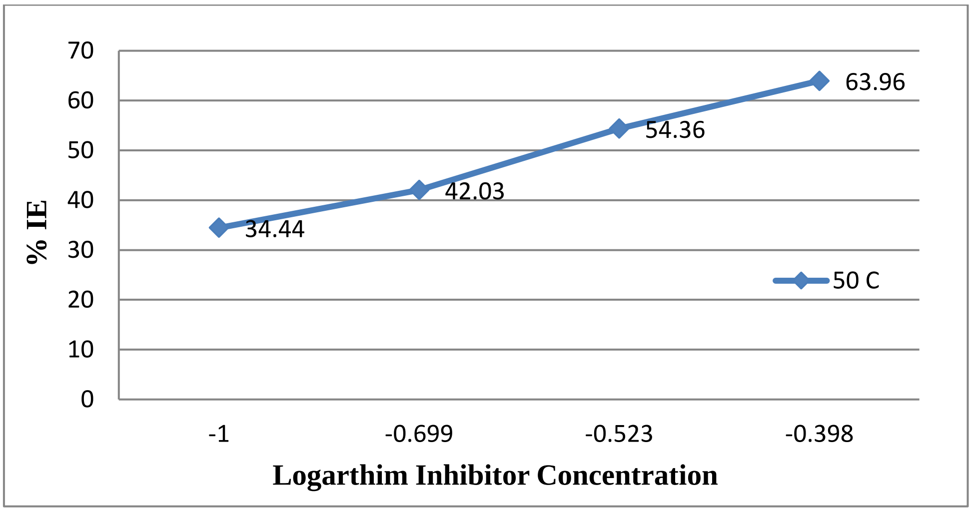


Fig. (3.4) The Variation Inhibition Percentage With the Logarithm of the Concentration of " Alcoholic Extract Moringa " Sulphur Containing Inhibitor Compound, 50°C

3.4. Adsorption isotherm

In general, adsorption is governed by a number of forces such as covalent bonding, electrostatic attraction, hydrogen bonding, non-polar interactions between the adsorbed species, lateral associative interaction, solvation, and desolvation [20].

3.4.1. Langmuir Adsorption isotherm

Table (3.4) provides estimated inhibitor surface coverage and adsorption energy at temperatures 40 and 50 C

The obtained results are shown in table (3.4) show that the inhibitor follows isotherms of the Langmuir R is high at all temperatures, the Langmuir model assumes that the particles of this is due to the tendency 2 The inhibitor adsorbs in a dense monomolecular layer on the metal surface [21] The value of adsorption constant " K " at each inhibitor concentration were calculated for a two temperatures as shown on tables (3.4) and (3.5). The obtained values of adsorption constant were used to determine the Gibb's free adsorption energy (ΔG_{ad}) using the following equation [22]:

$$K=1/55.5\ e^{\wedge}\ (-\Delta G_{ads}/RT) \qquad (3.1)$$

where R is the universal constant "8.314 J mol^{-1} K^{-1}" and T is the absolute temperature of " 40 and 50 ℃ ", and the constant value of " 55.5 " is the concentration of water in solution in mol L^{-1}. Adsorption process on a surface in general, negative values of Gibbs energy indicate ads

in ΔG^0 Metallurgy takes place automatically and when the Gibbs energy values the charged metal is known as physical adsorption [23]. The process of adhesion to the surface or electrostatic interference by charged particles of the inhibitor with a surface.

This explains that the degree of surface coverage plays a crucial role in improving the adsorption process in corrosion media

Table (3.4) Estimated Inhibitor Surface Overage and Adsorption Energy at Temperature of 40 °C.

Sample No.	Surface Overage (θ)	Adsorption constant (K) M^{-1}	Adsorption Energy (ΔG_{ads})

			KJ/mol
1	0.00	0.00	0.00
2	0.4340	766.78	-48.63
3	0.4665	437.21	-44.51
4	0.5882	476.12	-45.14
5	0.7519	357.65	-48.54

Table (3.5) Estimated Inhibitor Surface Overage and Adsorption Energy at Temperature of 50 °C.

Sample No.	**Surface Overage (θ)**	**Adsorption constant (K) M^{-1}**	**Adsorption Energy (ΔG_{ads}) KJ/mol**
1	0.00	0.00	0.00
2	0.3444	525.32	-57.32
3	0.4203	362.51	-53.93
4	0.5436	397.02	-54.76
5	0.6396	243.67	-55.77

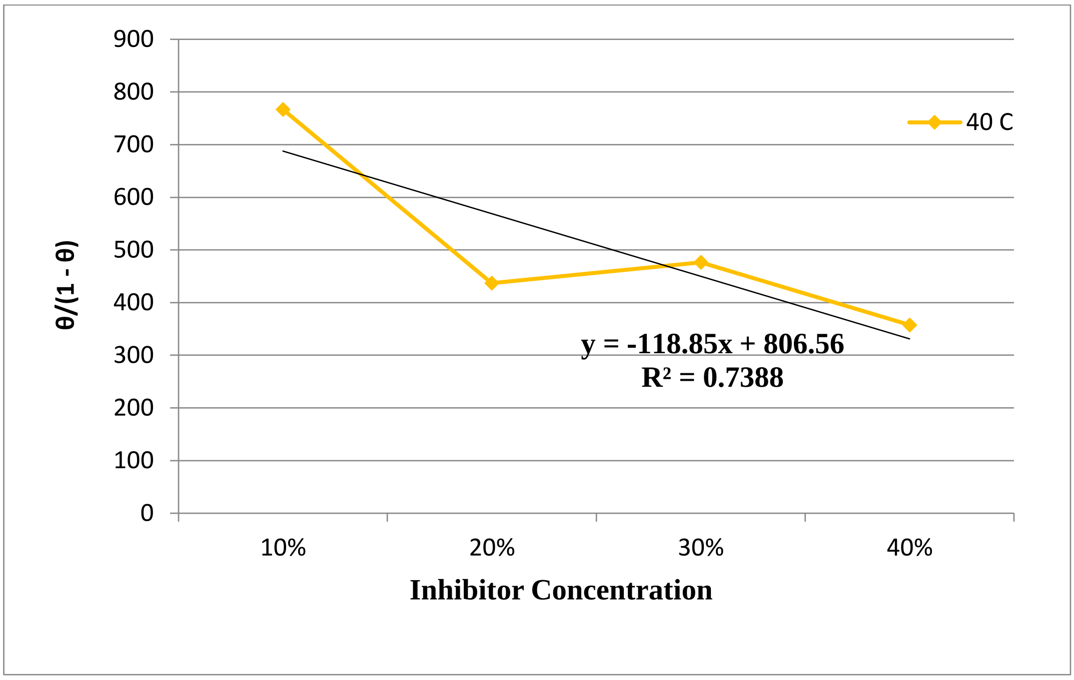


Figure (3.5) : Langmuir Adsorption Isotherm of " Alcoholic Extract Moringa " Inhibitor on Mild Carbon Steel in 0.5 M H_2SO_4 at 40 °C.

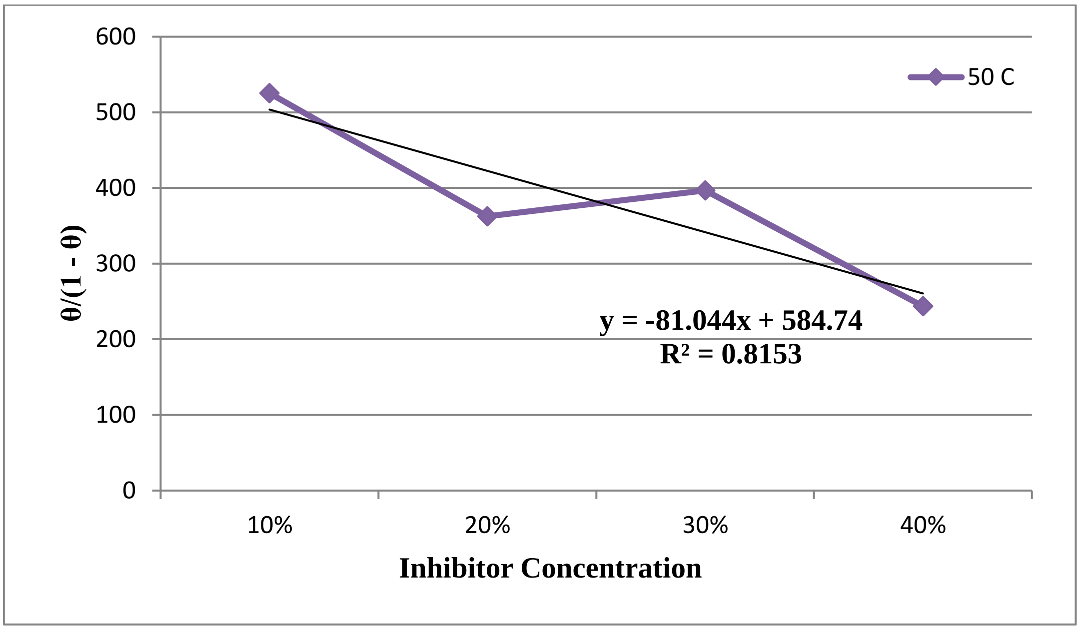


Fig. (3.6) : Langmuir Adsorption Isotherm of " Alcoholic Extract Moringa " Inhibitor on Mild Carbon Steel in 0.5 M H_2SO_4 at 50 °C.

3.4.2. Temkin Adsorption Isotherm:

The activation energy indicates that the inhibitor covered a surface and accordingly, the studied results confirm that the inhibitor provides an active barrier that covers the surface of the metal and hinders corrosion activity metal by physical adsorption [24]. Depending on temperature and inhibition efficiency as well as comparing values, the activation energy in the absence and presence of the inhibitor gives insight into the potential mechanism of inhibitor uptake.

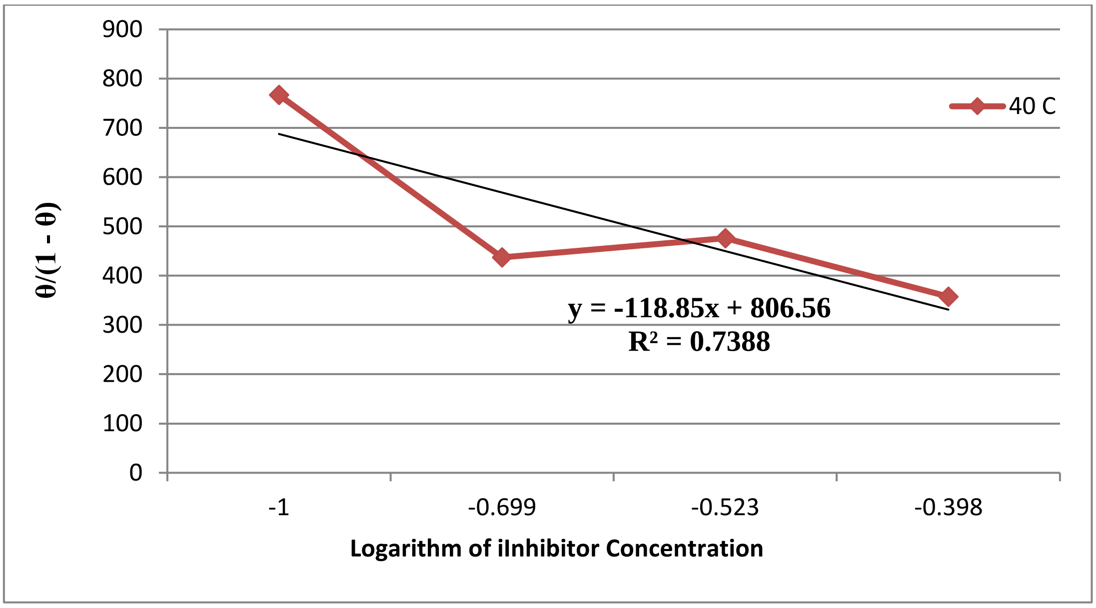


Figure (3.7) : Temkin Adsorption Isotherm of " Alcoholic Extract Moringa " Inhibitor on Mild Carbon Steel in 0.5 M H_2SO_4 at 40 °C.

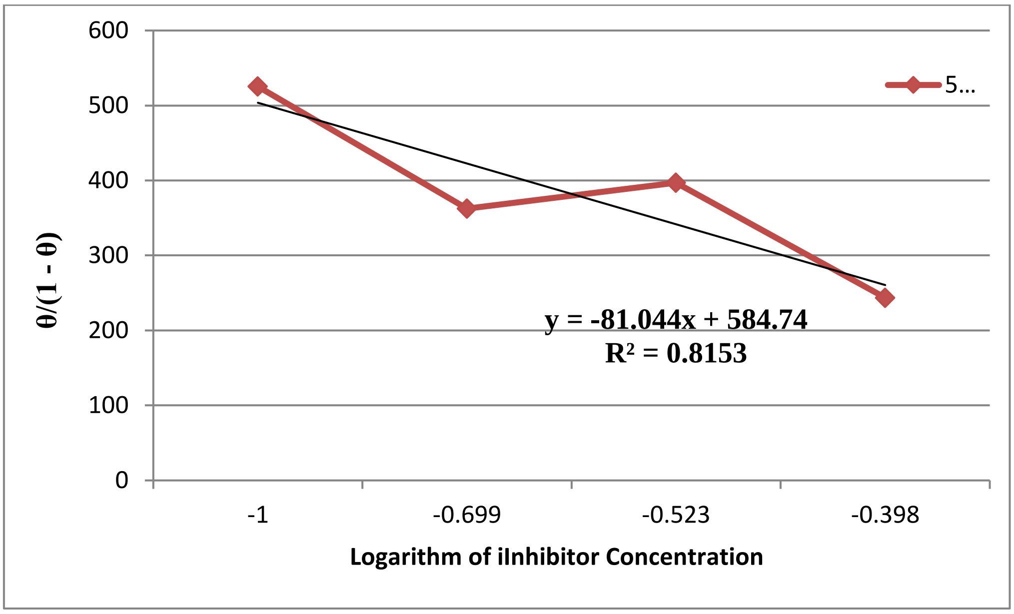


Fig. (3.8) : Temkin Adsorption Isotherm of " Alcoholic Extract Moringa " Inhibitor on Mild Carbon Steel in 0.5 M H_2SO_4 at 50 °C

3.4.3. Freundlich Adsorption isotherm

The Freundlich model of isotherm adsorption has been chosen fourthly to evaluate adsorption potential of the adsorbent and adsorbed solution. The Freundlich isotherm is given by {25}.

$$\text{Log } \theta = \log K \text{ ads} + n \log I \qquad (3.2)$$

Where K ads is the adsorption equilibrium constant, n is the interaction parameter and I is the inhibitor concentration.

As shown on figure (3.9) and (3.10) a perfectly linear plot was obtained with regression constant (R^2) (0.9536) at inhibitor temperature 40°C and (0.9933) at temperature of 50 °C

Table (3.6) : Freundlich Adsorption Isotherm of the alcoholic extract moringa at temperatures of 40 and 50 C

Sample No.	Log (Θ) 40 °C	Log (Θ) 50 °C
1	0.00	0.00

2	-0.363	-0.463
3	-0.332	-0.376
4	-0.230	-0.265
5	-0.124	-0.195

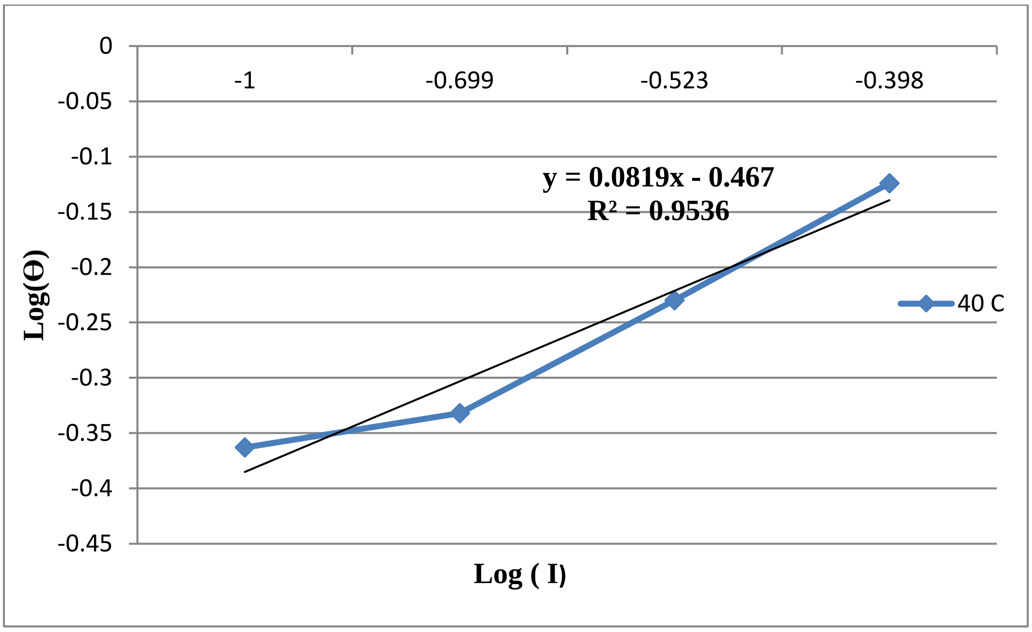


Fig. (3.9) : Freundlish Adsorption Isotherm of " Alcoholic Extract Moringa " Inhibitor on Mild Carbon Steel in 0.5 M H_2SO_4 at 40 °C.

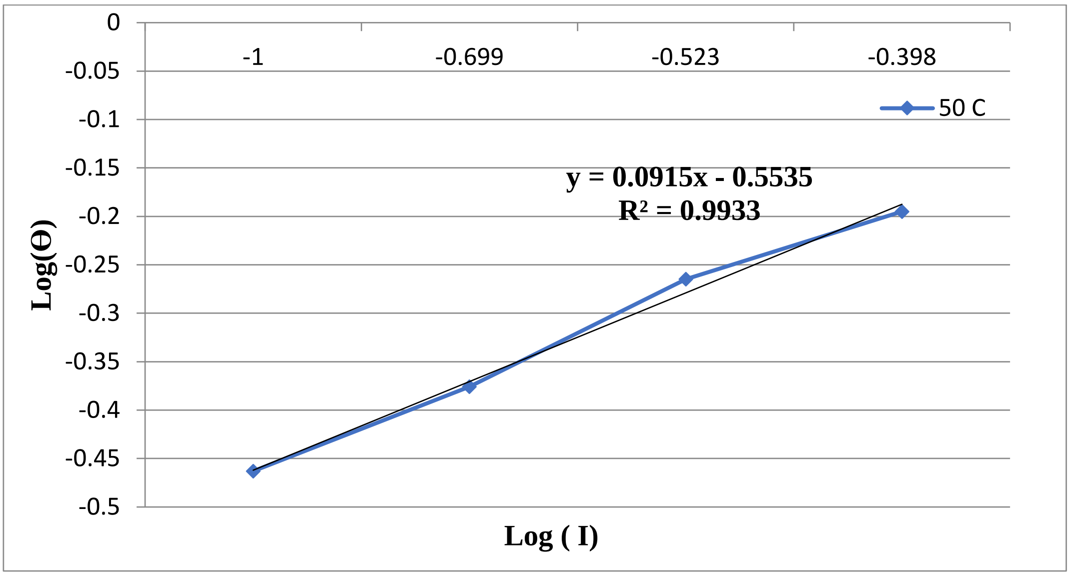


Fig. (3.10) : Freundlish Adsorption Isotherm of " Alcoholic Extract Moringa " Inhibitor on Mild Carbon Steel in 0.5 M H_2SO_4 at 50 °C.

3.5. FTIR of the Moringa

The infrared spectra of the morenge represented in figure.(3.11). The IR spectra of the morenge display broad band at 3410 cm-1 which is attributed to the existence of -OH group. Meanwhile, the same spectra show band at 1439cm-1 attributed to υ-C=C vibration . Also the same spectra exhibit bands at 2910 cm-1 and 1066 cm-1 due the presence of groups C≡C and υ(C-O), respectively. These bands in range of 779 -697 and 590 cm-1 are assigned to υ(C=C) and υ(C–O) vibrations

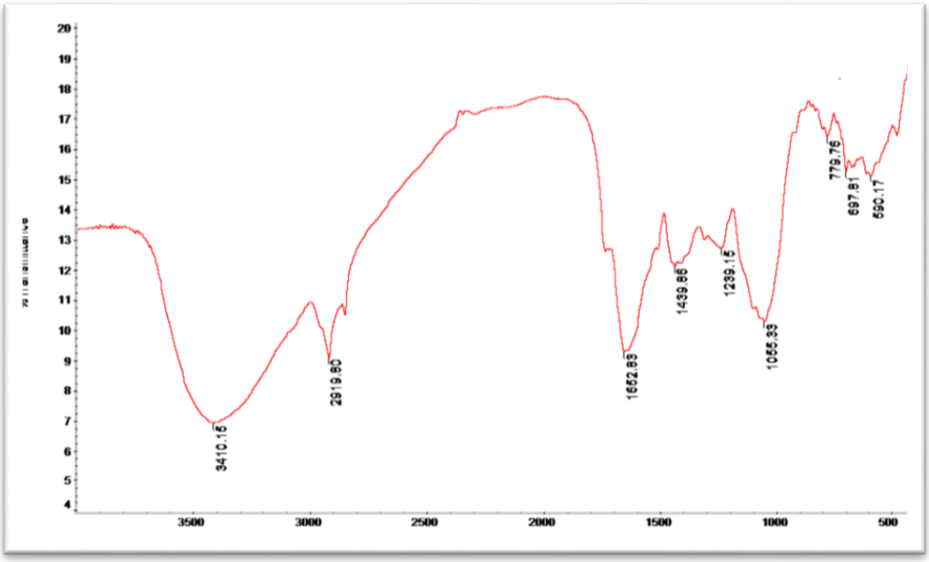


Figure (3.11) : FTIR of " Alcoholic Extract Moringa "

4.1 .Conclusion

Based on this research, the following conclusion can be drawn;

1. Moringa leaves are environmentally acceptable, inexpensive, readily available, a renewable source of materials and ecological acceptable inhibitor.

2. The weight loss of mild steel bar were observed, measured and duly recorded. The corrosion rate of the steel bar in H_2SO_4 solution was found to decrease with increasing concentration of the leaf extract of Moringa.

3. The inhibition efficiency of the leaf extract of Moringa is dependent on the concentration of the extract, and it increases with increasing concentration of the extract in the acidic medium

4.2. Recommendation

1. Given that the maximum inhibition concentration was not determined, an increase in the concentration of the extracts used can be considered.

5.References

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