

# Study of Corrosion Inhibition of *Moringa Oleifera* Leaves Extract Blended With Soluble Oil on Mild Steel in Hydrochloric Acid Solution

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## ABSTRACT

Corrosion inhibition of *Moringa Oleifera* extract blended with soluble oil on mild steel in Hydrochloric acid solution has been studied spectrophotometrically with phytochemical screening. The corrosion rate was studied with varying concentrations of the inhibitors of 0, 0.5, 1.0, and 1.5 g/ml and durations of 168, 336, 504, 672, and 840 hours respectively. The results of the study reveal that *Moringa Oleifera* leaves extract inhibits the corrosion rate of mild steel surface. The inhibition efficiency is as high as 91.08%. The Langmuir, Temkin and Frumkin isotherms principles are obeyed with the linearity in plots of  $C/\theta$  against concentration (C),  $\theta$  against  $\log C$  and percentage inhibition efficiency (% IE) against  $\log C$  respectively.

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## Introduction

Corrosion is the disintegration of metal (material) or its properties by reaction when interacting with the surrounding atmosphere. It is a destructive phenomenon which affects almost all metals. It is the gradual destruction of material (usually metals) by chemical reaction with their environment [1]. The consequences of corrosion are many including:- reduction of metal thickness leading to loss of mechanical strength and structural failures, reduced value of goods due to deterioration of appearance; perforation of vessels and pipes allowing escapes of their contents and possible harm to the surrounding among others [2]. Corrosion is an electrochemical process involving the oxidation of metal (the anodic reactions) and the corresponding reduction reactions (the cathodic reactions) [3].

Inhibitors are substances added in small concentrations to particular environments with the aim of slowing down the rate of corrosion at such sites. Co-inhibitor is achieved when two or more inhibitors are used at the same time to achieve better inhibition than a single inhibitor used separately. The major use of inhibitors in acid solutions is in pickling processes, Oil well cleaning, descaling and industrial acid cleaning. Anodic inhibitors such as Sodium tungstate are found to be the most effective and readily available, but it has low oxidizing potential and high cost. This is due to the fact that Tungstate ions alone cannot shift the potentials of the metal into the passive region substantially [4].

Mild steel has generally being used as the main constituent material for down hole tubes, marine lines, flow lines and

transmission pipelines in petroleum industry. To reduce the aggressive attack of the acid on tubing, construction equipment, marine ship components and casting materials, inhibitors are added to the acid and applied on the mild steel parts before use [5]. Mild steel are widely used for many industrial application and manufacturing on the account of their low cost and ease of fabrication, they are classified on the basis of their carbon content as the major alloying element (Steel with carbon content 0.25-0.65%) are classified as medium carbon, while those within the range of 0.65- 1.50% are high carbon steels. Steels with less than 0.25 % are termed low carbon steels. However there are other elements contained in the metal which aids corrosion [6]. Chemical analysis is an essential part of corrosion monitoring as it reveals the elemental concentration detecting which can reduce or increase the corrosion rate [7].

*Moringa Oleifera* is commonly found purplish or greenish-white with fragrant and bisexual flowers. It is rich in vegetable oil and has medicinal properties [8]. Soluble oil is an efficient performance general purpose oil formulated with selected base oils, coupling agents and a high level of emulsifiers, it forms a very stable emulsion when mixed with relatively hard water. It is formulated with significant levels of detergency agents and reserve alkalinity, low foaming tendencies and biocides to help combat the wide spectrum of bacteria found in sumps and reservoirs which is one of the reason for its wide usage as an anti-corrosion agent. Soluble oils forms a milky white emulsion when mixed with water, its robust base oil and high reserve alkalinity contributes to reduced acid formation and assists in machine rust

protection, balanced base oil, emulsifier and coupling agent formation helps maintain stable, long-life emulsion performance. Also, its high level of reserve alkalinity and effective biocide agent improves the emulsion resistance to bacterial degradation [9].

### Materials and Method

The materials used for this research work included mild steel bar used as coupons to check its corrosion and its inhibition. Hydrochloric acid was used as the solution and medium of corrosion. *Moringa Oleifera* leaves extract was used as the corrosion inhibitor as well as soluble oil as a catalyst or enhancer of corrosion inhibition. The chemical composition of the mild steel was determined using x-ray diffraction. The reason for the chemical analysis was to ascertain its type and identification as mild steel. The physical properties of *Moringa Oleifera* leaves was determined using density bottle (Density) and color chart paper (Color).

*Moringa Oleifera* leaves (free from dirt's) was properly dried and grinded to powder using blender. A standard procedure (ASTM D1298) of 200 g of the *Oleifera* leaves (powder) and 300 ml of 99.8% Methyl alcohol was added to it [10], the volume of Methyl alcohol was then increased to 400 ml. A foil paper and the solution were then poured in a conical flask standing, and occasionally shaken for settling. After three days, the solution was decanted and filtered using cotton wool and the alcohol evaporated giving a sticky mass. This sticky mass was left over night in open air for complete dryness. This procedure (as a stock solution) was repeated over and over until the quantity desired for the research was obtained. (i.e. Phytochemical and mineral studies).

The phytochemical screening of *Moringa Oleifera* leaves extract was done using quantitative screening where Methanol extract were screened using standard procedure of qualitative screening spectrophotometrically. The mineral composition of *Moringa Oleifera* leaves extract was done using Flame Atomic Absorption Spectrophotometry (FAAS). This extract was dissolved in concentrated nitric acid, diluted in deionized water and the absorbance of the samples read directly on the FAAS. The working standard solutions of nitrogen, phosphorus, and calcium were prepared from stock solution and adsorbance of each element and the samples were noted using FAAS.

The mild steel rod (specimen/ coupons) of length 30 mm and 12 mm diameter were prepared from the mild steel rod using lathe machine, and the initial weight ( $w_0$ ) recorded. They were then immersed in the corrosion media (HCl) with/ without the concentration inhibitor in the range (0.0, 0.5, 1.0 and 1.5 g/ml) in corked containers for 7 days (168 hrs), 14 days (336 hrs), 21 days (504 hrs), 28 days (672 hrs), and 35 days (840 hrs) respectively for the corrosion rate and inhibition efficiency investigations. The

mild steel coupons were then taken out of the medium (HCl) solution after every seven (7) days, descaled with grid papers, properly washed and rinsed with distilled water to remove loosed deposits from their surfaces and then dried. The steel samples were then reweighed as (Fw) and weight loss ( $\Delta w$ ) taken as the difference between the initial and final weights. The corrosion rate in millimeter per year (*mmpy*) was estimated using Eq. 1.

$$\text{Corrosion Rate} = \frac{87.6\Delta w}{\rho AT} \quad (1)$$

where  $\Delta w$  = weight loss (g),  $\rho$  = density of the specimen ( $\text{g/cm}^3$ ), A = area of the test specimen ( $\text{cm}^2$ ), and T = exposure time in hours.

The Solvent extract Inhibitor Efficiency (IE %) was obtained using Eq. 2.

$$IE (\%) = \frac{1 - w_1}{w_2} \times 100 \quad (2)$$

where  $w_1$  and  $w_2$  are the weight losses for the mild steel in the presence and absence of additives respectively.

### Results and Discussion

The result of the chemical composition of the Mild steel is presented in Table 1. The average Carbon and Iron content are 0.192 and 99.3% respectively which could place it under corrosive attack [11]. The result of the physical properties of *Moringa Oleifera* leave extract is presented in Table 2 showing amber color and density of  $1.42 \text{ g/cm}^3$ . The result of the phytochemical analysis is shown in Table 3 with traces of tannin (9.34 g) and steroid (3.21 g) respectively, which can react together to serve as corrosion inhibitor /fatty oil [11].

Table 1. Chemical composition of Mild steel

Element	% Avg. Cont.	Element	% Avg. Cont.	Element	% Avg. Cont.
C	0.192	Al	0.032	B	<0.0005
Si	0.028	Cu	0.0025	Sn	<0.0010
Mn	0.354	Co	<0.0015	Zn	<0.0020
P	0.014	Ti	<0.0010	As	0.0067
S	0.0079	Nb	<0.0030	Bi	<0.0020
Cr	0.014	V	<0.0010	Ca	0.0044
Ni	0.0051	W	0.015	Ce	<0.0030
Mo	<0.0020	Pb	0.0089	Zr	0.0028
La	0.0014	Fe	99.3		

Table 2. Physical properties of *Moringa Oleifera* leaves

Properties	Results
Density	$1.42 \text{ g/cm}^3$
Color	Amber

Table 3. Phytochemical properties/ constituents of *Moringa Oleifera* leave extract

Chemical	Result	
	Qualitative	Quantitative (g/100g)
Alkaloid	+	3.10
Tannin	+	9.34
Steroid	+	3.21
Phenolic	+	0.32
Saponin	+	1.42
Flavonoid	+	3.85

+ indicates presence of the phytochemicals

The inhibitive effect of *Moringa Oleifera* leave extract blended with soluble oil on the corrosion of mild steel in Hydrochloric acid came as a result of the presence of the phytochemicals heteroatoms such as Nitrogen, Oxygen, Sulphur and Phosphorus (Table 4) giving the extract a complex chemical composition resulting in corrosion inhibitive action on the mild steel. Soluble oil contributes in the corrosion inhibitive effect of the extract due to the presence of oil and fats in it [12].

The result of weight loss of samples (coupons) in varying concentrations of inhibitor is presented in Table 5. In the time

range of 168, 336, 504, and 840 hours of immersion of the coupons, the result showed a direct relationship between weight loss and the time that is the higher the time the mild steel stays in the corrosive media, the higher it corrodes and losses weight, agreeing that there is direct relationship between weight loss and time [13].

Table 4. Mineral composition of *Moringa Oleifera* leaves extract.

Minerals	Composition (g/100g)
Nitrogen	3.05
Sulphur	0.85
Phosphorus	0.46
Potassium	1.60
Copper	0.01
Oxygen	1.48
Iron	0.03

Table 5. Weight loss (without/with varying concentration of inhibitor).

Inhibitor conc. (g/ml)	168 hrs		336 hrs		504 hrs		672 hrs		840 hrs	
	Fw(g)	$\Delta w(g)$	Fw(g)	$\Delta w(g)$	Fw(g)	$\Delta w(g)$	Fw(g)	$\Delta w(g)$	Fw(g)	$\Delta w(g)$
0.0	17.93	0.45	17.73	0.65	17.89	0.89	17.11	1.27	16.81	1.57
0.5	18.23	0.15	18.17	0.21	18.11	0.27	17.99	0.39	17.96	0.42
1.0	18.28	0.10	18.25	0.13	18.23	0.15	18.17	0.21	18.07	0.31
1.5	18.32	0.06	18.30	0.08	18.30	0.08	18.29	0.09	18.24	0.14

Fw= Final weight,  $\Delta w$  = Change in weight

Table 6. Adsorption parameters for Mild steel in HCl acid solution with different concentration of *Moringa Oleifera* extract blended with soluble oil and with different time intervals

Inhibitor conc. (g/ml)	168 hrs		336 hrs		504 hrs		672 hrs		840 hrs		Log C
	$\theta$	$C/\theta$	$\theta$	$C/\theta$	$\theta$	$C/\theta$	$\theta$	$C/\theta$	$\theta$	$C/\theta$	
0.5	0.67	0.8	0.68	0.7	0.70	0.7	0.69	0.7	0.68	0.7	0.30
1.0	0.78	1.3	0.80	1.3	0.83	1.2	0.83	1.2	0.81	1.2	0
1.5	0.87	1.7	0.88	1.7	0.91	1.6	0.93	1.6	0.91	1.6	0.18

Adsorption isotherms are useful in order to understand the adsorption mechanism of inhibitors on the metal surface during corrosion reaction of the Mild steel. Inhibitor reduce the corrosion of Mild steel in HCl by getting adsorbed on the metal surface forming a thin film which acts as a barrier between the metal and the aggressive media leading to effective corrosion inhibition. To study the mechanism of corrosion inhibition the Langmuir, Temkin and Frumkin adsorption isotherms were studied, with the surface coverage ( $\theta$ ) values for different

concentrations (Table 6) of the inhibitors from the weight loss data (Table 5).

The result of the isotherms shown in Table 6 showed incremental outcomes of ( $C/\theta$ ) against c, the surface coverage ( $\theta$ ) against log C, and the plot of % IE against log C (Table 7). This confirms that the Langmuir, Temkin and Frumkin adsorption isotherm are obeyed [14].

The graphs of Langmuir, Temkin and Frumkin adsorption isotherm for mild steel in HCl solution containing various

concentrations of inhibitor at different time interval are presented in figures 1, 2, and 3. They showed linearity in the graphs, which agree with inhibition principles [15].

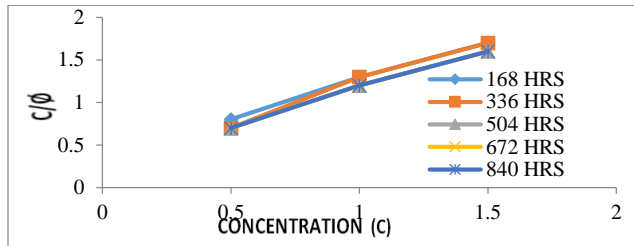


Figure 1: Graph of Langmuir adsorption isotherm for Mild steel in HCl solution with different concentration and time.

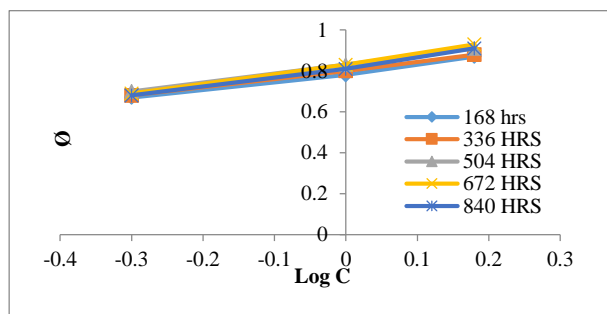


Figure 2. A graph of Temkin adsorption isotherms for *Moringa Oleifera* extract blended with soluble oil at different time interval.

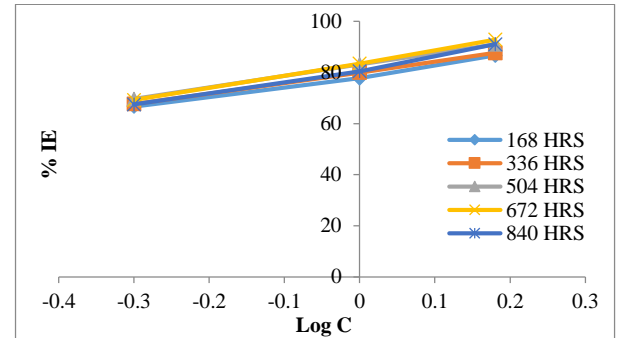


Figure 3. Frumkin adsorption isotherms for *Moringa Oleifera* extract blended with soluble oil at different time intervals.

Table 7. Inhibitor efficiency/corrosion rate (without/ with varying concentration of inhibitor)

Inhibitor conc. (g/ml)	168 hrs		336 hrs		504 hrs		672 hrs		840 hrs	
	CR (mmpy)	% IE	CR (mmpy)	% IE	CR (mmpy)	% IE	CR (mmpy)	% IE	CR (mmpy)	% IE
0.0	0.0265	0	0.0191	0	0.0174	0	0.0187	0	0.0185	0
0.5	0.0088	66.67	0.0062	67.69	0.0053	69.66	0.0057	69.29	0.0049	67.52
1.0	0.0059	77.78	0.0038	80.00	0.0029	83.15	0.0031	83.46	0.0036	80.50
1.5	0.0035	86.67	0.0024	87.69	0.0016	91.01	0.0013	92.91	0.0016	91.08

The linearity of the different adsorption models (Langmuir, Temkin and Frumkin) isotherms reveal the adsorption of *Moringa Oleifera* extract blended with soluble oil showed the interaction with other molecules adsorbed [16]. From the results, the inhibitor efficiency (IE) increased with increase in concentration of *Moringa Oleifera* leave extract blended with the soluble oil (Table 7), these agrees with [15] that there is decrease in weight loss of the steel samples. This means the presence of the *Moringa* leave extract blended with soluble oil tend to retard the corrosion of Mild steel in HCl solution.

### Conclusion

Based on the experimental results/observations obtained the following conclusions are drawn:

- Moringa Oleifera* leaves extract blended with soluble oil acts as a good corrosion inhibitor on mild steel in HCl acid solutions because of the presence of the heteroatoms.
- The rate of corrosion of mild steel in HCl acid solution decreased as the concentration of the inhibitor was increased for different time range.
- The inhibition efficiency value increases with the increase in inhibitor concentration and time of exposure.
- The adsorption process of the inhibitor on mild steel in HCl acid solution obeyed the Langmuir, Temkin and Frumkin isotherm
- The mild steel type is low carbon steel.



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