Anti-Corrosive Behavior of the Seed Extract of *Amomum sabulatum*

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Abstract- An aqueous extract of *Amomum sabulatum* seeds was evaluated for anticorrosive effects on mild steel in the presence of HCl. Weight loss measurements were taken to determine the corrosion rate and inhibition efficiency at various concentrations. With the increasing concentrations of plant extract, the results showed an improvement in inhibition efficiency and a decrease in corrosion rate. In the presence of 1500 ppm concentration of plant extract, it has an inhibition efficiency of 82.08 % at 303 K. The scanning electron microscope was used to examine the surface, which proves that while the extract was there, a protective layer formed on the metal surface.

Keywords- Inhibition efficiency, *Amomum sabulatum* seeds, SEM, weight loss measurements, adsorption isotherm, corrosion.

1. Introduction

Corrosion is the degradation of physical, metallurgical, and mechanical qualities of materials caused by a chemical or electrochemical attack. It is one of the confined or uniform 'genetic infections' of metals and their compounds. Nowadays acidic corrosion is very common as acid solutions are widely utilised in a variety of industrial procedures, including acid pickling, commercial acid cleaning, acid ultrasonic cleaning, and acidizing oil wells.. The life of metallic components is then jeopardised, and their service life may be drastically decreased. As a result, scientists are constantly seeking for new techniques to reduce the rate of corrosion of metallic components, particularly mild steel, in acidic environments. Because of their extensive range of industrial applications, particularly in the petroleum industry and power plants, mild steel and especially its alloys have been the focus of countless studies. Several methods have been utilised to overcome the corrosion process of mild steel, and the effective methods applied are the use of corrosion inhibitors. Organic chemicals have been employed as corrosion inhibitors in several earlier investigations. These compounds frequently contain nitrogen and oxygen

atoms, as well as some effective groups, which aid in their adsorption on the surface of steel, reducing corrosion rates and improving inhibition efficiency.

Many scientists have recently become interested in the use of natural, organic plant extracts as green corrosion inhibitors. Green corrosion inhibitors provide a number of advantages over chemical corrosion inhibitors, including the fact that they are disposable, harmless, ecologically friendly, and ecologically tolerable, in addition to being cost-effective, readily available, renewable, and safe to use. Natural chemicals present in herb plants, for example, have lately been employed as inhibitors in the development of new green cleaning solutions. Several research on the use of natural compounds as corrosion inhibitors in various media have been published. The majority of natural goods are harmless, biodegradable, and widely available. Plant parts such as seeds, fruits, flowers, and leaves, were isolated and employed as corrosion inhibitors.

2. Weight loss measurements

One of the simplest approaches for determining corrosion inhibition efficiency is to evaluate weight

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loss. For this measurement mild steel plate was cut with the dimensions of 1x1 cm². All the mild steel plate specimens were mirror finished by abrading with 100-1200 grades of emery paper.

Before starting the experimental process, all the dried MS specimens were carefully weighed on the analytical balance and reported as the initial weight of the mild steel plate. These specimens were subsequently dipped into a beaker containing 100 mL of test solution (prepared by using different concentrations of stock solution diluted with 1M HCl) via the hole, thread, and capillary. Test specimens were taken out after 24 hours of exposure to an acidic solution and rinsed with acetone and dried. The dried specimens were correctly re-weighed after immersion. In the absence, presence and increasing concentrations of the inhibitor extract, the weight loss was measured by subtracting the weights of the samples before and after hanging them in the corrosive solution.

The percentage inhibition efficiency ($\eta\%$) and surface coverage (θ) is being calculated by the use of formulas shown below and shown in Fig.1.

$$\eta\% = \frac{w_0 - w_i}{w_0} \times 100$$

$$\theta = \frac{w_0 - w_i}{w_0}$$

Sr. No.	Concentration of solution	Initial weight of mild steel plate [w ₀] (in g)	Final weight of mild steel plate [w _i] (in g)	Weight loss [w ₀ - w _i]	Inhibition efficiency (in %)	Surface coverage (θ)
1.	0	6.918	5.203	1.715	-	-
2.	100	6.828	5.600	1.228	28.39	0.28
3.	200	6.506	5.565	0.941	45.13	0.45
4.	300	7.013	6.090	0.923	46.18	0.46

5.	400	6.993	6.198	0.795	53.64	0.53
6.	500	7.068	6.334	0.734	57.20	0.57
7.	600	6.258	5.821	0.437	74.51	0.74
8.	700	5.949	5.284	0.665	61.22	0.61
9.	800	5.687	5.133	0.554	67.69	0.67
10	900	5.493	5.085	0.408	76.20	0.76
11	1000	6.119	5.754	0.365	78.71	0.78
12	1500	6.194	5.887	0.307	82.09	0.82

Inhibition efficiency- The efficiency of inhibition increases as the concentration of plant extract increases as shown in the graph given below-

Sr.no.	Concentration of solution	Percentage inhibition efficiency ($\eta\%$)
1.	100	28.39
2.	300	46.18
3.	500	57.20
4.	700	61.22
5.	900	76.20
6.	1500	82.09

Fig. 1. Inhibition efficiency at various inhibitor concentrations.

UV-Visible spectroscopy

The UV-Visible spectroscopic study demonstrates the shifts in the value of maximum absorbance and the position absorbance between the before and after immersion of MS specimens into the plant extract inhibitor in 1500 ppm concentration submerged in 1 M HCl solution for 24 hours, indicating the development of a metal complex, as shown in Fig.2. This is observed at wavelength range of 200 to 800 nm by using UV-Vis spectrophotometer (UV-1900, Shimadzu)

Fig. 2. UV spectra of the acidic solution of extract before and after corrosion tests.

Adsorption isotherm-

The surface coverage data is used to determine the adsorption process, which is crucial for predicting the isotherm. The adsorption isotherm can provide enough information about the inhibitor's interaction with the metal surface. The degree of surface covering for various concentrations of *A. sabulatum* extract was calculated using the weight loss method. The corrosion inhibitor decreases metal corrosion by adsorption on the metal surface, after that, a protective layer is created. Various isotherms, including Langmuir, Frumkin, and El-awady, were used to match experimental data, in order to analyse the adsorption behaviour of *Amomum sabulatum* plant extract.

Langmuir adsorption isotherm-

The Langmuir isotherm is predicated on the presumption that the molecules that are adsorbed behaves exactly as they should, and create a monolayer. The adsorbate and adsorbent molecules have no lateral interactions. The Langmuir adsorption isotherm equation is

$$C/\theta = 1/K + C$$

Where K is the inhibitor adsorption equilibrium constant, C is concentration, and θ is the proportion of the inhibitory coating on the metal surface as an adsorption value. Because the Langmuir plot is linear, it's possible that the experimental data for *A. sabulatum* plant extract follows the Langmuir adsorption isotherm. The Langmuir isotherm provided the best fit (strong correlation $R_2 = 1.29811$). A straight line emerged from a plot of C/θ against concentration, demonstrating the inhibitor adsorption on a monolayer over the mild steel surface, as shown in Fig. 3. This shows that in the 1 M HCl media, the inhibitor (plant extract) follows the Langmuir adsorption isotherm. It means that the adsorbing *A. sabulatum* plant extract binds to the metal/solution contact in the normal adsorption sites.

Fig. 3. Langmuir adsorption isotherm of the *Amomum sabulatum* extract.

El-awady adsorption isotherm- the equation for this isotherm is:

$$\log \left[\frac{\theta}{1-\theta} \right] = \log K + y \log C$$

Plotting $\log \left(\frac{\theta}{1-\theta} \right)$ against $\log C$ for the extract, where straight line relationships were obtained suggesting the validity of this model for the present case.

Where C is the extract concentration, θ is the degree of surface covering, K_{ad} is the adsorption process equilibrium constant, and $K_{ad} = K^{1/y}$. The number of active sites y is incorporated in this model. Multilayer adsorption is shown by $1/y$ values less than one, but if $1/y$ is larger than one, the inhibitor molecule is occupying more than one active site. This plot produced straight lines, indicating that the data suited the isotherm nicely, as shown in Fig. 4.

Fig. 4. El awadi adsorption isotherm of the *Amomum sabulatum* extract.

3. SEM

The surface morphological changes were monitored using a scanning electron microscope with a 20 keV accelerating voltage. MS plates were polished with emery paper before being dipped in media of 1M HCl for 24 hours in the presence and absence of 1500 ppm inhibitors. SEM observations revealed the creation of a surface protective coating on the MS surface by the green inhibitors.

The surface of a clean mild steel specimen appears to be perfectly fine, yet the mild steel specimen without inhibitor appears to be seriously injured. The mild steel had been soaked in corrosive medium, which caused the surface to corrode, whereas the surface of the inhibited steel coupon is significantly enhanced due to the inhibitor's adsorption. The SEM images of cleaned steel surface, corroded and inhibited steel surfaces are shown in Fig. 5, Fig. 6 and Fig. 7 respectively.

Fig. 5. SEM micrograph of cleaned steel surface.

Fig. 6. SEM micrograph of corroded steel surface.

Fig. 7. SEM micrograph of inhibited steel surface.

4. Conclusion

The extract of *Amomum sabulatum* was tested for the anti-corrosive behavior and it is found to have 82.09% inhibition efficiency for steel in acidic medium. The results obtained from surface analysis are in favor of the formation of a protective layer on the steel surface which can resist corrosion.

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