GREEN CORROSION INHIBITOR AND ADSORPTION CHARACTERISTICS OF *CARALLUMA INDICA* STEM EXTRACT ON MILD STEEL IN ACID MEDIUM

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ABSTRACT

The stems of the plant Caralluma indica are used to create medication. Most people concur that one of the greatest ways to prevent metal from rusting is to use natural plant extract. They are easily accessible, non-toxic, friendly to the environment, biodegradable, extremely effective, and renewable resources. The effects of the Caralluma indica stem extract on the suppression of corrosion by 1M HCl solutions are the primary subject of this research. Weight loss procedures and isotherms adsorption are used to gather the necessary data. Based on the findings, it can be concluded that the extracts produced from 1M HCl solutions were effective corrosion inhibitors. When the concentration of the extract was raised, there was a corresponding rise in the efficiency of the inhibition. An inhibiting action can be produced by the Caralluma indica extract. The successful performance of the inhibitor can be attributed to phytochemical components with functional groups found in extracts of plants that have been adsorbed on the surface of the metal. Plant extract accurately mimics the corrosion of steel in acidic conditions, as indicated by data from weight deficit studies and adsorption isotherms, which validates the adsorption mechanism. Findings suggest that Caralluma indica stem extract acts as a corrosion inhibitor and can boost surface protection by covering up metal's active sites.

Keywords: *Caralluma indica*, Phytochemicals, corrosion, metal, extract

INTRODUCTION

The utilization of various metals and alloys is extremely important to the sector. Protecting metals from corrosion is one of the most challenging and time-consuming tasks that the industry must complete. The problem of corrosion is one that is always present and continues to be of significant importance in a wide range of industrial applications and products. In the processing and manufacturing industries, it shortens the lifespan of many components and can even cause some systems and components to fail. Additionally, it can lead to the dismantling of systems and components. The prevention of corrosion in metals and alloys is a time-consuming and costly operation; hence, the industry invests significant sums of money in this endeavor. It is believed that the expenses of corrosion in developed countries like the United States and the European Union represent somewhere in the range of three to five percent of their gross national product[1-3].

There are a number of ways to prevent corrosion damage, including the upgrading of materials, the mixing of production fluids, the regulation of the process, and chemical inhibition[4,5]. The usage of corrosion inhibitors is regarded as the most effective strategy for preventing the destruction or degradation of metallic surfaces when exposed to corrosive media among these

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approaches[6,7]. The application of corrosion inhibitors is the method that is both the most cost-effective and the most applicable for lowering the caustic assault on metals. Synthetic or natural substances that, when applied to an environment in trace amounts, prevent further corrosion are known as corrosion inhibitors. Slow down the rate at which metals are corroded by the environment. We are aware that a variety of synthetic chemicals[8,9] can be utilized as effective corrosion inhibitors for various metals. However, the use of synthetic chemicals as corrosion inhibitors is becoming less common and popular as a result of increasingly stringent regulations governing the environment and the destructive impact that synthetic compounds have on both human and animal life[10,11]. As a result, there is a pressing need to create a new category of eco-friendly corrosion inhibitors that are very effective whilst having low toxicity and a low impact on the environment.

People have relied on plants for centuries to meet their most fundamental requirements, including the manufacture of food, shelter, clothing, fertilizer, flavors and perfumes, and medicines; in particular, corrosion inhibitors have been derived from food, shelter, clothing, fertilizers, and flavorings and perfumes. Pickling baths were employed for the first time as extracts from Chelidonium majus plants and other plants for the first time in H_2SO_4. The use of natural compounds as corrosion inhibitors dates back to the 1930s. Subsequently, there was a significant increase in interest in the utilization of natural substances as corrosion inhibitors, and researchers from all over the world have reported several plant extracts[12,13] and phytochemical lines as a promising green anticorrosive[14]. Although some plants and the phytochemicals they produce have been identified as having anticorrosive properties, the vast majority of plant species have not yet been adequately tested to determine whether or not they possess such properties.

In recent years, a broad range of corrosion inhibitors that are gentle on the environment have been developed. These inhibitors may be found in many different products. Consider, for example, the anticorrosion properties of Zygophyllum album L. Leave[15] and Anacyclus pyrethrum L. stem[16] and an extract from the leaves of Mentha Pulegium[17] have both been successfully reported. The findings that were observed revealed that each of the plants that were described had a good influence on corrosion, and more importantly, that they are helpful to the environment. In the present research, an extract of the stem of Caralluma indica, the leaves of Phoenix pusilla, and the leaves of Sansevieria roxburghiana were tested to see whether or not they were efficient as a natural inhibitor against the corrosion of mild steel in 1M hydrochloric acid. The weight loss technique and the adsorption isotherm were used throughout this inquiry. The Langmuir and Temkin model came next once these two methods had been completed.

MATERIALS AND METHODS

Preparation of alcoholic extract

Caralluma indica sample of the stem was collected in Sengipatti, Thanjavur and Tamil Nadu. The sections of the plant that were collected were dried in the shade, and a mixed grinder was used to generate a fine powder from the dried plant material. During the extraction process, 10 g of *Caralluma indica* stem powder were utilised. To obtain an extract, a cold extraction was performed utilizing the maceration method in ethanol solvents for twenty-four hours while employing the intermittent shaking method. This approach was used to carry out the extraction. After passing through a Whatman filter No. 1, the extract was filtered, and the resulting filtrate was put through phytochemical testing and evaluated for its ability to inhibit corrosion.

Qualitative Preliminary analysis

The preliminary estimation of phytochemicals performed in accordance with the established protocol[18,19].

Anticorrosive study

Effect of Caralluma indica stem extract on mild steel

Experiments on mass loss were done for 72 hours at 37 degrees Celsius in 100 milliliters of blank 1M HCl and test solutions of Caralluma indica stem extract (5, 10, 30, 50, 70, and 100 parts per million). After the reaction, samples were washed, dried, and weighed. No sample was obtained. The following equation calculates corrosion rates, which are represented as mass loss per square centimeter each hour.

$$\text{Corrosion Rate (CR) } (g.cm^{-2}\ h^{-1}) = \frac{W_1 - W_2}{A \times T}$$

Where, W_1 = initial weight of rod, W_2 = weight of rod after treatment, $W_1 - W_2$ = weight loss (g), A = surface area, T = time in hours. The surface coverage (Θ) as a result of adsorption of inhibitor and inhibition efficiency (%) were calculated from corrosion rate values by using the following equation

$$\text{Surface coverage } (\Theta) = (CRB - CRI) / CR_B$$

$$\text{Inhibition efficiency \%} = \frac{CR_B - CR_I}{CR_B} \times 100$$

Where, CR_B = Corrosion Rate Blank and CR_I = Corrosion Rate Iinhibitor.

Adsorption Isotherm

The adsorption of *Caralluma indica* stem extract onto the surface of the mild steel can provide an explanation for the inhibitory effect. According to the Langmuir and Temkin model, the stem extract of *Caralluma indica* acts as a substitute for the water molecules that are present at the metal interface[16,17].

Atomic Absorption Spectroscopy (AAS)

The use of atomic absorption spectroscopy allowed for the observation of the action of an inhibitor on a specimen of mild steel. It was determined whether or not the stem extract of *Caralluma indica* was effective against 1 M HCl by incubating mild steel at 303 1.00 K for three hours in the absence and presence of an inhibitor at concentrations of 5, 10, 30, 50, 70, and 100 ppm[18]. After the appropriate amount of time had passed, the corrosive solutions were examined to determine the concentration of dissolved ions present in each solution. This allowed the IE% to be calculated using the following formula:

IE % = B-A/B × 100

where, A and B represents the amount of dissolved ions in the uninhibited and inhibited (with different concentration of inhibitor) corrodent solutions

RESULTS AND DISCUSSION

Plant Extract Phytochemical Screening

This study examines the phytochemical composition of Caralluma indica stem extracts. Tannin, saponin, flavonoids, steroids, terpenoids, triterpenoids, alkaloids, anthroquinone, polyphenol, and glycoside were found in stem alcoholic extracts.

Weight Loss Method

The weight loss approach is both the simplest and the one that is utilised most frequently when determining the percentage of inhibition efficiency and the corrosion rate. It is one of the various experimental procedures that are available. Within the scope of this investigation, the experiments were carried out by adjusting the inhibitor's concentration at each stage. This research is conducted not just at a single temperature but also at a range of temperatures, with a total immersion time of seventy-two hours. The weight loss is expressed as a difference in grammes between the weight of the metal coupon before and after it was immersed in an inhibitory solution. This difference is used to determine the weight loss. The rate of corrosion of mild steel in a solution of 1M hydrochloric acid was evaluated using the blank solution weight loss method and with varying concentrations of *Caralluma indica* stem. This was done in order to determine the rate of corrosion.

Effect of Concentration of Caralluma indica stem extract

The values for the inhibition efficiency and the corrosion rate were calculated for each of the tested inhibitors in addition to the blank system. These data are provided in Table 1, along with the other values. An increase in the content of Caralluma indica stem extract brings about a simultaneous reduction in the rate of corrosion as well as an increase in the effectiveness of the inhibition for every kind of inhibitor. During this particular experiment, the concentration was varied from 5 to 100 ppm, and the metal was submerged in the inhibitor solution for a period of three days at room temperature (Figure 1). The effectiveness of the inhibition increases as a result of the fact that the molecules of inhibitors that are present in the stem extract get adsorbed on the surface of the metal. When inhibitors are present at high concentrations (100 ppm), the effectiveness of the inhibition is at its highest possible level, and the rate of corrosion is reduced. On the other hand, the least effective level of inhibition is shown when inhibitors are present at concentrations as low as 5 ppm (23.68%).

Table 1: Effect of *Caralluma indica* stem extract in corrosion rates, inhibition efficiency and surface coverage at various concentrations

Concentrations (ppm)	Weight loss (gm.cm^{-2})	Corrosion rate (g.cm^{-2} /h) × 10^{-4}	Surface coverage (Θ)	Inhibition efficiency (%)
Control	1.14	3.29	-	-
5	0.87	2.51	0.23	23.68
10	0.64	1.85	0.43	43.85
30	0.48	1.38	0.57	57.89
50	0.38	1.09	0.66	66.66
70	0.26	0.75	0.77	77.19
100	0.21	0.60	0.81	81.57

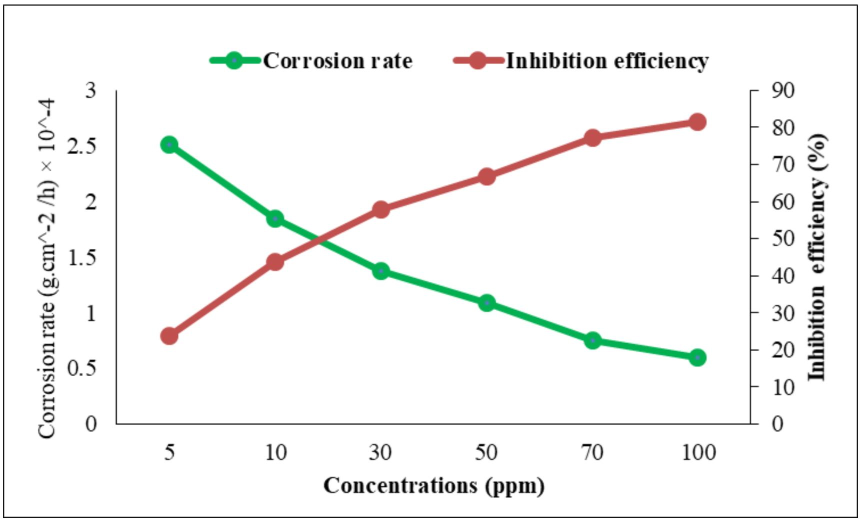

Figure 1: Effect of *Caralluma indica* stem extract in anti-corrosion activity

Inhibition Adsorption Isotherm model

The adsorption of *Caralluma indica* stem extract onto the surface of the mild steel can provide an explanation for the inhibitory effect. According to figures 2 and 3 of the Langmuir and Temkin model, the stem extract acts as a substitute for the water molecules that are present at the metal interface.

It was determined to use the Langmuir adsorption model. When the experimental data for C/ against C were plotted against C, the outcome was a straight line, as can be seen in Figure 2. *Caralluma indica* stem extract has an inhibitory concentration that is measured in parts per million (ppm), and the surface coverage is denoted by.

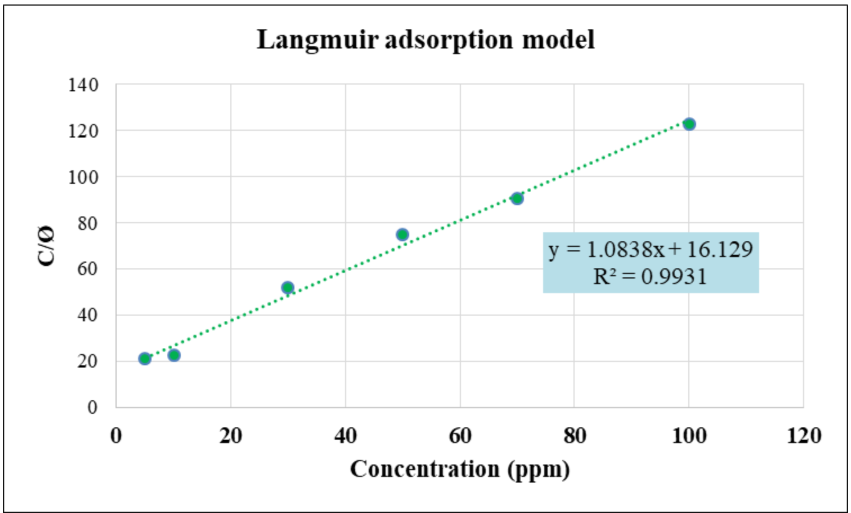

Figure 2: Langmuir Adsorption Isotherm plot for mild steel in 1M HCl with different inhibitory concentration of *Caralluma indica* stem extract

It is abundantly clear that the adsorption conforms to the Langmuir adsorption isotherm, as shown by the correlation coefficient (R) value of 0.996 and the slope value of 1.083. These values are in accordance with what was predicted by the Langmuir model, which was then implemented by Ali and Mahrousb[19,20].

$c/\theta = c + 1/K_{ads}$

Therefore, the adsorption of stem extract as a corrosion inhibitor behaved in a way that was consistent with the Langmuir adsorption isotherm. The inverse of the plot intercept was used to evaluate the effectiveness and durability of the adsorbed layer that was generated by the stem extract of *Caralluma indica*.

It was discovered that the Kads was equivalent to 0.062 $ppm^{-1.}$ Figure 3 shows the result of fitting data to the Temkin model by comparing log(/C) to. The correlation coefficient R for the straight line that was produced after the adjustment was 0.962. As a result, the Temkin model is less acceptable than the Langmuir model due to the fact that its R value is lower[21].

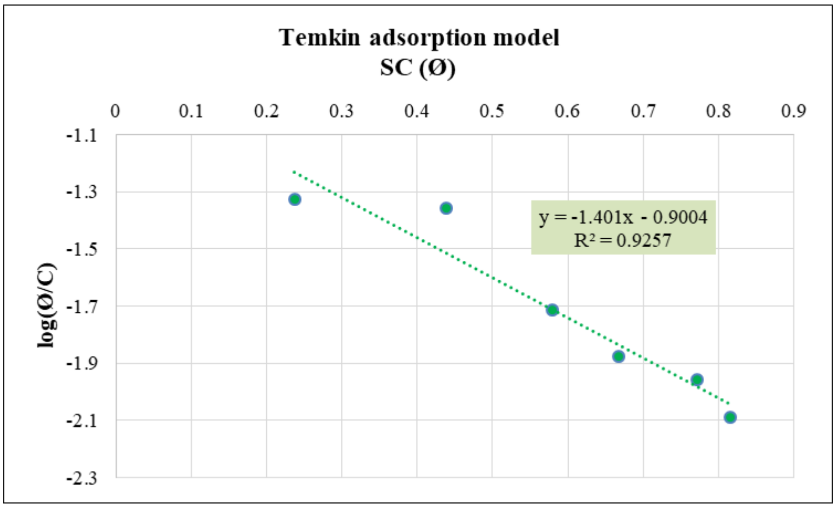

Figure 3: Temkin Adsorption Isotherm plot for mild steel in 1M HCl with different inhibitory concentration of *Caralluma indica* stem extract

Atomic Absorption Spectroscopy

AAS was used to compare dissolved ion analyses in corrodent solutions with and without inhibitors (five, ten, thirty, fifty, seventy, and one hundred parts per million). Table 2 shows that corrosion inhibition is concentration-dependent, confirming the mass loss measurement. At 303 1.00 K, 100 ppm 1 M HCl inhibited corrosion by 79.83%. An evaluation of acid inhibitors' effect on iron pigment corrosion. It seems that active Caralluma indica elements adsorb onto metal, producing a protective coating, to prevent corrosion dependent on extract concentration. This avoids oxidation and lowers ferrous ion diffusion.

Table 2: AAS study of dissolved ferrous (iron) ions in corrodent solution against 1 M HCl control and different concentrations of *Caralluma indica* stem extract inhibitor

Concentrations (ppm)	Amount of ferrous (iron) corrodant (mg/l)	Inhibition efficiency (%)
Control	27.18	-
5	21.72	20.08
10	18.46	32.08
30	13.73	49.48
50	9.38	65.48
70	7.05	74.06
100	5.48	79.83

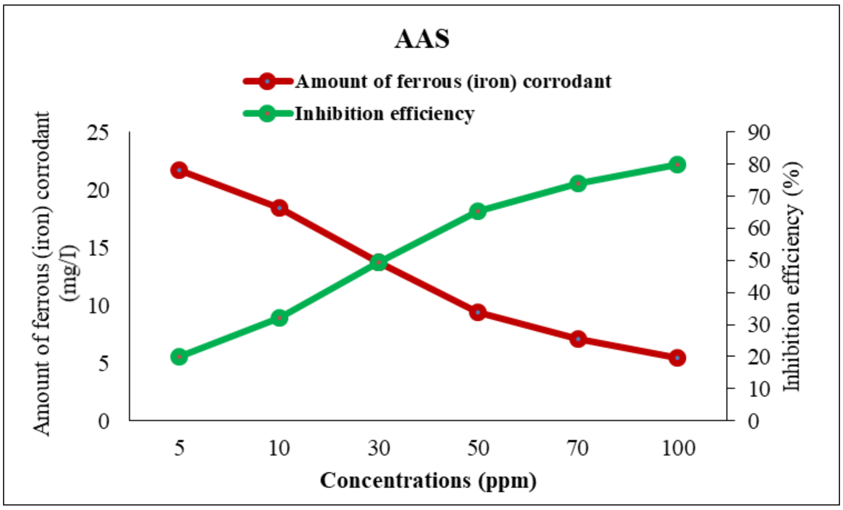

Figure 4: AAS study of dissolved ferrous (iron) ions in corrodent solution against 1 M HCl control and different concentrations of *Caralluma indica* stem extract inhibitor

In the current study, the efficacy of *Caralluma indica* stem extract as an ecologically friendly inhibitor was established by analysing the mass loss behaviour of mild steel in solutions of 1 M HCL. This was done so that the researchers could show that the extract is effective.

This demonstrates that the stem extract of Caralluma indica has a high degree of sensitivity toward the inhibition of mild steel in acidic medium. In addition to this, it was found that the Langmuir and Temkin isotherm model is followed by adsorption.

Conclusion

The prevention of corrosion of mild steel by extracts of Caralluma indica stem in a 1M HCl medium has been shown to show outstanding promise by these extracts. The anti-corrosion properties were brought to the public's attention by the media. It was discovered that the effectiveness of the inhibition had a direct correlation with the concentrations of the extract. The Langmuir and Temkin adsorption isotherms were completed, which showed that inhibitor adsorption was occurring on the surface of the mild steel. Further research is needed on the architecture of the corroded and the bioactive components that prevent mild steel from corroding in acidic environments. Because of this, we are able to carry on with the investigation.

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