ANTICORROSIVE ACTIVITY OF *PHOENIX PUSILLA* LEAVES EXTRACT ON MILD STEEL IN HYDROCHLORIC ACID SOLUTION

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ABSTRACT

Reducing metal corrosion has practical, financial, environmental, and aesthetic benefits. The usage of corrosion inhibitors is highly recommended. Since organic corrosion inhibitors leave behind dangerous chemicals in the environment, researchers have been seeking for non-toxic, biodegradable substitutes. Products made from plants have several advantages, including low cost, vast availability, and an endless supply of new products. They also have positive effects on the environment and are generally well-accepted by society. There has been investigation into the anticorrosive properties of phytochemicals in plants. Weight-loss methods and isotherm adsorption are used to examine the corrosion-inhibiting characteristics of *Phoenix pusilla* extract of leaves in 1M HCl solutions. The results showed that extracts have significantly reduced corrosion. The inhibitory effectiveness increased with increasing extract concentration. Adsorption isotherms and weight-loss study results support the existence of the adsorption mechanism (Temkin and Freundlich). The corrosion of steel is mimicked by using a plant extract in acidic circumstances. Results show that *Phoenix pusilla* leaf extracts have anti-corrosive capabilities and may improve surface protection by preventing active areas on metal.

Keywords: Mild steel, Phytochemicals, *Phoenix pusilla*, Corrosion, AAS

INTRODUCTION

Metal deteriorates due to corrosion when it is attacked by chemicals or reacts with its surroundings. This is an ongoing issue that is difficult to resolve permanently[1]. Elimination may not be possible or desirable, but prevention is. Soon after the protective barrier is broken, corrosion activities begin, followed by a cascade of events that fundamentally alter the surface chemistry of the metal and its immediate surroundings. Oxide formation, cation transport in the coating matrix, pH variations at the surface, and electrochemical potential are only a few examples[2]. Corrosion research into mild steel and iron has gotten a lot of attention because of the huge theoretical and practical relevance of the topic. Corrosion inhibitors are used to protect metals from acid solutions used for industrial acid cleaning, decalcification acids, pickling acids, and acidifying oil wells. Effective yet hazardous to persons and ecosystems are synthetic organic and inorganic corrosion inhibitors. Plant extracts are abundant, making the study of corrosion protection utilising plant-based corrosion inhibitors, in particular for mild steel, of significant interest[3].

Low- or no-cost, low- or no-toxicity, biocompatibility, and absence of heavy metals are the hallmarks of green corrosion inhibitors. Natural compounds have been used

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successfully by certain research teams to prevent metal corrosion in both acidic and alkaline conditions[4]. There have been several developments in recent years of corrosion inhibitors that are also kind to the environment. Some plants have been shown to have anticorrosion characteristics; they include Zygophyllum album L. Leave, Anacyclus pyrethrum L. stem and Mentha Pulegium leaf extract. All of these plants were shown to have a significant anticorrosion impact and were also found to be environmentally benign. Using the weight loss technique and Adsorption Isotherm followed by the Langmuir and Temkin model, this research looked into the antioxidant and natural inhibitor properties of *Phoenix pusilla* leaves extract against the corrosion of mild steel in 1M HCl[5].

MATERIALS AND METHODS

Preparation of alcoholic extract

Sengipatti, Thanjavur, Tamil Nadu is where we gathered the *Phoenix pusilla* leaves. The gathered leaves were shade dried and then ground into a powder in a blender. To get the extract, 10 grammes of powdered *Phoenix pusilla* leaves were employed. For 24 hours, we used the "intermittent shaking" technique of cold extraction by macerating the material in ethanol solvent. Phytochemical analysis and anticorrosive activity were performed on the filtrate, which was obtained by filtering the extract using Whatman filter No 1 paper.

Qualitative Preliminary phytochemical analysis

Standard procedures were used to conduct preliminary tests of the phytochemical composition[6,7].

Anticorrosive study

Effect of Phoenix pusilla leaves extract in various concentrations on mild steel

Researchers investigated mass loss over a period of 72 hours at 37°C using 100 ml of blank 1M HCl and test solutions of different concentrations of *Phoenix pusilla* leaves extract (5, 10, 30, 50, 70, and 100 ppm). After the reaction was finished, the samples were taken out, cleaned, dried with an air dryer, and weighed. Treat this as a blank as no real sample was utilised. The corrosion rate (weight loss in grammes per square centimetre per hour) was calculated using the following equation[8,9].

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

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

Surface coverage (Θ) = $(CR_B - CR_I)/ CR_B$

Inhibition efficiency % = $(CR_B - CR_I)/ CR_B \times 100$

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

Adsorption Isotherm followed by Langmuir and Temkin model

Asphyxiation of *Phoenix pusilla* leaves extract onto the surface of mild steel accounts for the inhibitory action. According to the Langmuir and Temkin model, the extract from *Phoenix pusilla* leaves may sub in for water molecules at the metal's surface.

Atomic Absorption Spectroscopy (AAS)

Using atomic absorption spectroscopy, the inhibitor's impact on the mild steel specimen was studied. After incubating mild steel for 3 hours at 303 1.00 K with and without inhibitor (5, 10, 30, 50, 70, and 100 ppm), the effectiveness of an extract from the leaves of the *Phoenix pusilla* was evaluated against 1 M HCl[9]. To determine the IE%, the concentration of dissolved ions in each corrosive solution was measured after a certain amount of immersion time.

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

Preliminary Phytochemical Screening

This study's objective was to examine the phytochemical content of alcoholic extracts of *Phoenix pusilla* leaf material. The leaves of *Phoenix pusilla* included tannin, saponin, flavonoids, steroids, terpenoids, triterpenoids, alkaloids, anthroquinone, polyphenol, and glycoside, as well as indications of the presence of additional chemicals**.**

Weight Loss Method

The weight loss approach is the simplest and most often used experimental method for estimating the percent inhibition efficiency and corrosion rate. Different inhibitor dosages were used in each of the trials included in this study. This experiment used a variety of temperatures with a consistent immersion duration of 72 hours. The weight loss is a percentage of the metal coupon's initial weight before and after submersion. Using the weight-loss technique and *Phoenix pusilla* leaves, the corrosion rate of mild steel in 1M hydrochloric acid solution was determined.

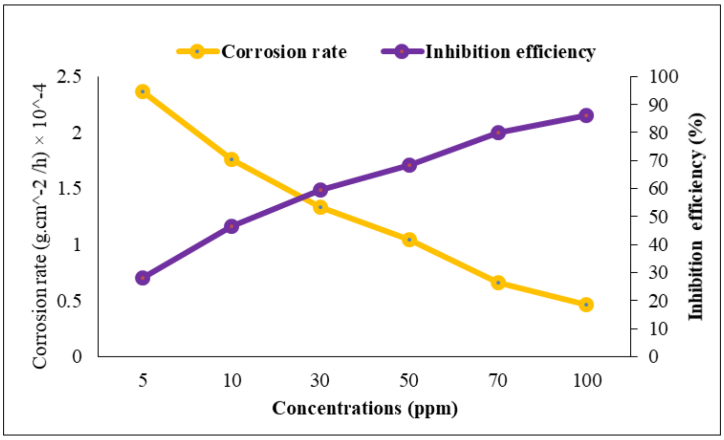
Effect of Concentration of Phoenix pusilla leaves extract

The inhibition efficiency and corrosion rate statistics for each of the studied inhibitors and the blank system, as well as the blank system, are provided in Table 1 and Figure 1. *Phoenix pusilla* leaves extract, at concentrations ranging from 5% to 100%, prevents metal corrosion for 72 hours in a room-temperature corrosive solution by decreasing the corrosion rate and enhancing the inhibitor's effectiveness. Adsorption of inhibitor molecules from an extract of the leaves of *Phoenix pusilla* onto a metal surface enhances the effectiveness of the inhibition (Figure 1). At a high inhibitor concentration (100ppm), the efficacy of the inhibitors is 85.96%, resulting in a reduced corrosion rate, whereas at a low inhibitor concentration (5ppm), the effectiveness of the inhibitors is just 28.07%.

Table 1: Effect of *Phoenix pusilla* leaves 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	0.82	2.37	0.28	28.07
10	0.61	1.76	0.46	46.49
30	0.46	1.33	0.59	59.64
50	0.36	1.04	0.68	68.42
70	0.23	0.66	0.79	79.82
100	0.16	0.46	0.85	85.96

Figure 1: Effect of *Phoenix pusilla leaves* extract in anti-corrosion activity



Inhibition Adsorption Isotherm model

The adsorption of *Phoenix pusilla* leaf extract onto the surface of mild steel is responsible for the inhibitory action. According to the Langmuir and Temkin model, shown in Figures 2 and 3, the extract from *Phoenix pusilla* leaves takes the role of water molecules at the metal contact.

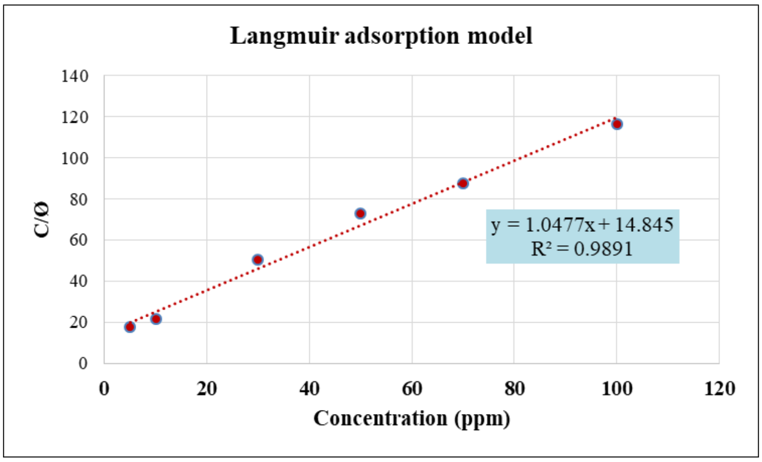


Figure 2: Langmuir Adsorption Isotherm plot for mild steel in 1M HCl with different inhibitory concentration of *Phoenix pusilla* leaves extract

For this purpose, we used the Langmuir adsorption model. The experimental data (C/ against C) was plotted against the constant (C), and the straight-line fit is shown in Figure 8.

The extract from *Phoenix pusilla* leaves has an inhibitory concentration of and a surface coverage of. R = 0.994 and a slope of 1.047 show that the adsorption fits the Langmuir adsorption isotherm, which agrees with the predictions of the Langmuir model used by Ali and Mahrousb[9].

c/ θ = c+1/K_{ads}

This means that the Langmuir adsorption isotherm was not disrupted by the addition of *Phoenix pusilla* leaves extract as a corrosion inhibitor. *Phoenix pusilla* leaf extract created an adsorbed layer, the strength and stability of which was measured by taking the inverse of the plot's intercept. The value of 0.067 ppm-1 for the Kads was determined.

In Figure 9, we see the log (/C) versus plot that characterises the Temkin model. The resultant line is straight with a correlation value of R = 0.974 (which may be changed). Therefore, due to a lower R value, the Temkin model is less preferable than the Langmuir model[10].

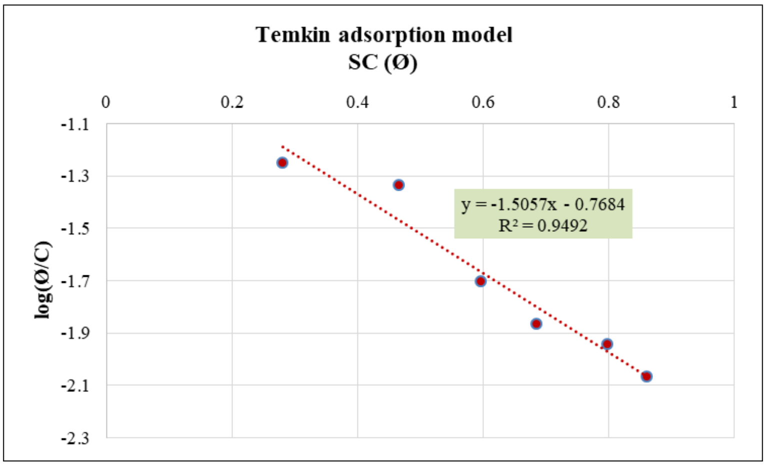


Figure 3: Temkin Adsorption Isotherm plot for mild steel in 1M HCl with different inhibitory concentration of *Phoenix pusilla leaves* extract

Atomic Absorption Spectroscopy

AAS was used to compare the dissolved ion profiles of corrodent solutions with and without inhibitors of varying concentrations (5, 10, 30, 50, 70, and 100 ppm). Corrosion inhibition was shown by mass loss measurement (Table 2) and was shown to be concentration dependent. At a temperature of 303 1.00 K, 100 ppm inhibited corrosion by 1 M HCl to an optimal level of 80.46 percent. Investigating the effectiveness of an acid inhibitor in halting the corrosion of ferrous (iron) pigments. The concentration-dependent inhibitory effectiveness of plant extract may be attributed to the adsorption of active components of *Phoenix pusilla* leaves onto metal, generating a protective layer that prevents oxidation and inhibits the diffusion of ferrous (iron) ions in corrosive solution.

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

Concentrations (ppm)	Amount of ferrous (iron) corrodant (mg/l)	Inhibition efficiency (%)
Control	27.18	-
5	21.14	22.22
10	17.91	34.10
30	12.95	52.35
50	8.75	67.80
70	6.85	74.79
100	5.31	80.46

The current study established the usefulness of an extract from *Phoenix pusilla* leaves as an ecologically friendly inhibitor by assessing the mass loss behaviour of mild steel in 1 M HCL. This means an extract of *Phoenix pusilla* leaves may decrease mild steel's activity in acidic solutions. The Langmuir and Temkin isotherm model fits adsorption well.

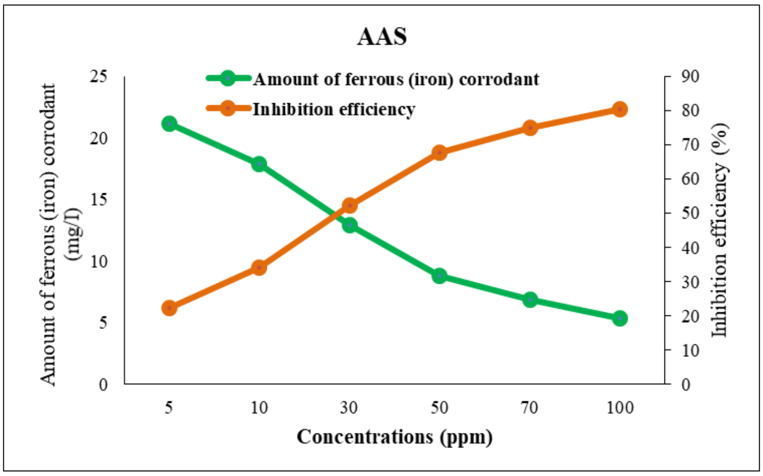


Figure 4: AAS study of dissolved ferrous (iron) ions in corrodent solution against 1 M HCl control and different concentrations of *Phoenix pusilla* leaves extract inhibitor

Corrosion Inhibition Mechanism

Phoenix pusilla leaves extract protects metal surfaces from acid and neutralizes corrosion. Two absorbed intermediates characterize inhibitory molecule-induced lag in anodic dissolution. Sulfur, nitrogen, and oxygen coordinate mild steel's iron atoms. Adsorption of plant chemicals via their pair of electrons and p-solitary d-orbital electrons on mild steel suppresses corrosion[11,12].

Due to their unbound electron pairs, N, O, and S may form a covalent bond with the metal, preventing it from working. The procedure may seal trouble locations, reducing corrosion. These phyto components of the aqueous leaf extract may be adsorbed on the metal, reducing the cathodic or anodic corrosion area. When dissolved in acid, the inhibitor's active components generate protonated species that adsorb in mild steel's cathode-ray areas and limit hydrogen generation. Heteratomy of the inhibitor's active components at the anode achieves adsorption. phenolic components including luteoline-7-glucoronide, carnosol, and others prevented corrosion on stainless steel 304 in 1M HCl[13]. Inconclusive corrosion-inhibiting action of Osanthus aromatic leaf extract in 1 M HCL. Geissospermum alkaloid extract decreased the Langmuir adsorption isotherm for mixed typhoid on C38 steel in 1 M HCl [14].

CONCLUSION

Phoenix pusilla leaf extracts inhibit rusting in 1 M HCl. Higher extract concentrations block better. As the inhibitor adsorbs onto mild steel, it follows adsorption isotherms and Langmuir and Temkin equations. More study is required to characterise corrosion morphology and find active phytochemicals that reduce mild steel corrosion in acidic settings.

REFERENCES

1. Bhuvaneswari TK, Vasantha VS and Jeyaprabha C. Pongamia pinnata as a green corrosion inhibitor for mild steel in 1N sulfuric acid medium, Silicon. 2018; 10: 1793–1807p.
2. Torres VV, Amado RS, De Sá CF, Fernandez TL, et al. Inhibitory action of aqueous coffee ground extracts on the corrosion of carbon steel in HCl solution, Corros. Sci. 2011; 53: 2385–2392p.
3. Quraishi MA, Singh A, Singh V, et al. Green approach to corrosion inhibition of mild steel in hydrochloric acid and sulphuric acid solutions by the extract of *Murraya koenigii* leaves, Mater. Chem. Phys. 2010; 122: 114–122p.
4. Faustin M, Maciuk A, Salvin P, et al. Corrosion inhibition of C38 steel by alkaloids extract of Geissospermum laeve in 1 M hydrochloric acid: Electrochemical and phytochemical studies. Corros. Sci. 2015; 92: 287–300p.
5. Fadare OO, Okoronkwo AE and Olasehinde EF. Assessment of Anti-Corrosion Potentials of Extract of *Ficus asperifolia* –Miq (Moraceae) on Mild Steel in Acidic Medium. Afr. J. Pure and Appl. Chem. 2016; 10: 8-22p.
6. Victor Arokia Doss, Prasad Maddisetty, Mohanasundaram.S. Phytochemical screening, quantification and in vitro antidiabetic activity of Strychnos nux-vomica leaf extract. J Global Trends Pharm Sci. 2016;6(4): 2892 – 2898p.
7. Mohanasundaram, Bharathi, Thirumalai, et al. Studies on phytochemicals, antibacterial efficacy and antioxidant potency of Capparis sepiaria on enteric pathogens. International J. of Biomolecules and Biomedicine, 2011; 1 (3): 01-07p.
8. Ali AI, Mahrousb YS. Corrosion inhibition of C-steel in acidic media from fruiting bodies of Melia azedarach L extract and a synergistic Ni2+ additive. RSC Adv. 2017; 7: 23687–23698p.
9. Arun J, Mohanasundaram S, Pennarasi, et al. Determination of Invitro antioxidant poetency, antibacterial efficacy, antifungal and phytochemical activity of Withania somnifera. IJIPSR. 2014; 2(2): 610 – 619p.
10. Faiz M, Zahari AA, Awanga K, et al. Corrosion inhibition on mild steel in 1 M HCl solution by Cryptocarya nigra extracts and three of its constituents (alkaloids). RSC Adv. 2020; 10: 6547–6562p.
11. De Souza FS, Spinelli A. Caffeic acid is a green corrosion inhibitor for mild steel. Corrosion science. 2009; 51(3): 642-649p.
12. Oguzie EE. Corrosion inhibition of aluminium in acidic and alkaline media by Sansevieria trifasciata extract. Corrosion science. 2007; 49(3): 1527-1539p.
13. Soltani N, Tavakkoli N, Khayatkashani M, et al.Green approach to corrosion inhibition of 304 stainless steel in hydrochloric acid solution by the extract of Salvia officinalis leaves. Corros. Sci. 2012; 62: 122–135p.
14. Li L, Zhang X, Lei J, et al. Adsorption and corrosion inhibition of *Osmanthus fragran* leaves extract on carbon steel. Corros. Sci. 2012;63: 82–90p.