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Experimental Studies of Phoenix Dactylifera Bark Extract as Green Corrosion Inhibitor for Mild Steel Wire Substrate in Acidic Condition

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Abstract

Corrosion of mild steel in acidic environments is a chief industrial concern, leading to material degradation, economic losses, and reduced material life. The present study was undertaken to explore an eco-friendly and sustainable alternative to conventional toxic corrosion inhibitors. The corrosion inhibition performance of *Phoenix dactylifera* bark extract was evaluated on mild steel in 0.5 M nitric acid medium. The butanoic extract was prepared using the Soxhlet extraction method and its inhibitory action was assessed by the gravimetric weight loss method. Results showed that the extract significantly reduced the corrosion rate, with inhibition efficiency increasing at higher concentrations. The adsorption of phytochemical constituents followed the Langmuir adsorption isotherm, resulting in effective surface coverage and the formation of a protective film. These findings highlight the potential of *P. dactylifera* bark extract as a green, cost-effective, and environmentally benign corrosion inhibitor.

Key words : Anticorrosive, Green inhibitor, Corrosion Inhibition, Weight loss method

Introduction

The mild steel is one of the top most skeletal material used in construction and industries due to its low cost, desired mechanical properties and easy availability.[1] The main problem associated with mild steel is its corrosion by acidic medium. The acid solutions are corrosive medium responsible for both atmospheric corrosion and in industrial corrosion due to its use in industrial cleaning, acid pickling etc.[2-4] The use of corrosion inhibitors[5-8] is attaining very much interest of researchers for corrosion defense of metals, alloys and their coatings. A corrosion inhibitor is a matter when introduce in a minute concentration to an environment lessen the corrosion rate of a metal or alloy exposed to that environment. It can be use either internal addition into the plating bath as additive[9,10] or by addition in exposing environment[11]. The contemporary world is focusing on environment friendly natural corrosion inhibitors due to hazardous effects of organic and inorganic corrosion inhibitor on ecosystem. The plant extracts earn the focus to acquire as corrosion inhibitor because they are ecologically acceptable due to its biodegradability and ease of availability at low cost.[12] The anticorrosion behavior of inhibitors is linked with the electronic structure, presence of pi bonds, heteroatoms like N,P, O and S in the skeleton of inhibitor. it is believed that these heteroatoms and lone pair of electrons coordinated with the atoms of metal present in the alloys and form a protective layer on the surface of the metallic substrate. The Phoenix Dactylifera is a plant of Arecaceae family which is the oldest cropping tree grown in middle east Asia and in some north African countries. The P. Ductylifera is enriched with several bioactive compounds *e.g.* Phenolic acids, flavonoids, phytosterols, carotinoids and hetero atoms containing compounds. The GC/MS analysis of Phoenix Ductylifera fruit performed by W. M. Ismail and various phytochemicals are found by them.[13] These phytochemicals can be proven as a good corrosion inhibitor so to investigate the corrosion inhibition properties of Phoenix ductylifera bark extract on mild steel wire in nitric acid medium, gravimetric weight loss method has been implied and the adsorption isotherm is perceived.

Experimental Work :

Preparation of Bark Extract:

The bark of phoenix Dactylifera was collected in May 2024 from Rajendra Nagar Indore (M.P.) The fresh plant stem is washed and were dried in a sunlight and grinded into powder. About 30 gm of powdered stem was taken and washed with distilled water and soaked in 55% v/v ethanol for 24 hours and then extraction were done in Soxhlet apparatus for 8 hours .The extract was collected and concentrated up to 30%.

Preparation of Testing Medium: The corrosive solution (2M Nitric Acid) was prepared by dilution of analytical grade Nitric acid with distilled water. The testing solution volume was 50 my with and without the addition of different concentration of P. Dactylifera extract ranging from 2 g/L to 8 g/L.

Preparation of Specimen :

The square 1x1X0.1 cm dimensional mild steel samples were mechanically cut by metal cutter and then polished with 300 grade emery paper. Each sample is rinsed by distilled water and dried using acetone and stored in desiccators.

Corrosion detection by Gravimetric (Weight Loss) Method :

The most conventional technique of corrosion rate determination is weight loss method. In this method the sample is exposed to a corrosive environment for a fixed time duration and the corrosion has been monitored using weight loss during the process. The mild steel sample were immersed in 50 ml itric acid environment in absence and presence of corrosion inhibitor at two different temperature. The MS sample was tested for 8 hour at two different temperatures 304 K and 314K (1). The weight of the sample was taken before and after immersion in corrosion environment using DHONA 200 D digital single pan balance with sensitivity of 0.1mg. the test were performed in a triplicate series to ensure the reliability of results and the mean value was taken for corrosion rate calculation. the corrosion rate is calculated assuming uniform corrosion of tested sample surface. The corrosion rate is calculated using the following formula:

$$Corrosion\,rate\ (mm/year) = \frac{k \times w}{A \times \rho \times t}$$

Here,

K= Constant i.e. 8.76 x10^4

W= weight loss of substrate in time t

T= time in Hours

A=Area of Substrate exposed for corrosion testing

ρ= density of material used as substrate (g/cm^3)

The degree of surface coverage by inhibitor and inhibitor efficiency was calculated using equation (2) & (3).

$$\theta = \frac{W1 - W2}{W1}$$

$$\%\, I.E. = \frac{(W1 - W2)}{W1} \times 100$$

Here, θ = Surface Coverage

% I.E. = Percent inhibitor efficiency

W1= Corrosion Rate in absence of P. Dactylifera Bark Extract

W2=Corrosion Rate in presence of P. Dactylifera Bark Extract

Result & Discussion

Corrosion Analysis :

The corrosion inhibitive properties of P. Ductylifera extract for Mild steel immersed in 0.5 M Nitric acid medium for 8 hours has been studied by weight loss measurement technique at two different temperatures. Table 1 & 2 contain the corrosion rate, percent inhibitor efficacy and surface coverage of P. Dactylifera Bark extract at 304K and 314K. It is observed that the increment in the concentration of P. Dactylifera bark extract shows a significant decrement in corrosion rate and wider surface coverage of MS sample which indicated the sure absorption of Extract on to the MS Surface at metal-solution interface. As the concentration of corrosion inhibitor increased in the 2M Nitric acid medium the percentage inhibitor efficacy increases and at lower temperature *i.e.* 314K and is highest 99% for 8 g/L Concentration of P. Ducylifera bark extract. This indicated the adsorption of phytochemical constituents of P. Ductylifera bark extract which could act as barrier from corrosion of MS Coupon.

Table 1. Corrosion parameters of MS coupon tested in 0.5 M Nitric acid medium in presence and absence of Phoenix Ductylifera bark extract at 304K.

S. No.	Inhibitor Concentration (g/L)	Weight Loss (g)	C.R. (mm/ Year)	Θ (Surface Coverage)	% I.E.
1	Blank	0.005	2.21986	-	-
2	2	0.0026	1.15433	0.48	48
3	4	0.0021	0.93234	0.58	58
4	6	0.0018	0.79915	0.64	64
5	8	0.0016	0.71036	0.68	68

Table 2. Corrosion parameters of MS coupon tested in 0.5 M Nitric acid medium in presence and absence of Phoenix Ductylifera bark extract at 314K

S. No.	Inhibitor Concentration (gm/L)	Weight Loss (g)	C.R. (mm/ Year)	Θ (Surface Coverage)	% I.E.
1	Blank	0.0549	24.3741		
2	2	0.0388	17.2261	0.2933	29.3260
3	4	0.0326	14.4735	0.4062	40.6193
4	6	0.0281	12.4756	0.4882	48.8160
5	8	0.0192	8.5243	0.6503	65.0273

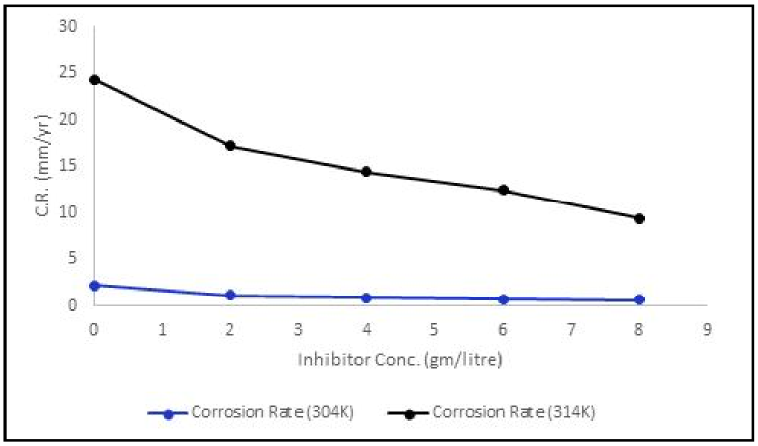

Figure 1 : Corrosion rate of MS Coupon in various concentration of Phoenix Ductylifera bark extract at 304K and 314K in 0.5M HNO_3 Medium

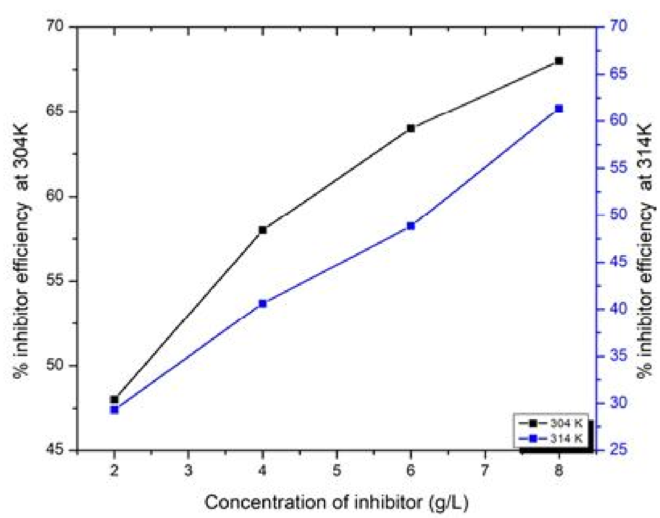

Figure 2 : % inhibitor Efficiency of various concentration of Phoenix Ductylifera bark extract on MS Coupon in at 304K and 314K in 0.5M HNO_3 Medium

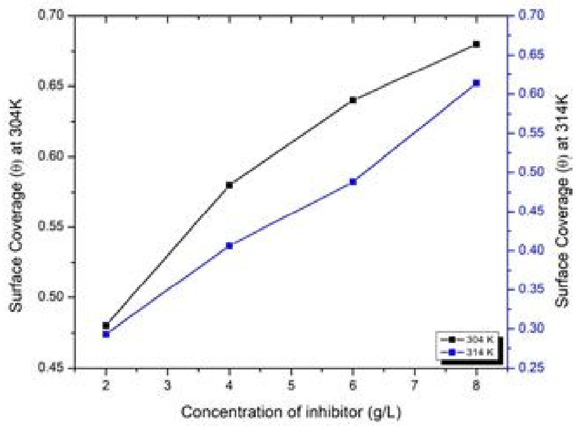

Figure 3: Surface coverage of various concentration of Phoenix Ductylifera bark extracts on MS Coupon at 304K and 314K in 0.5M HNO_3 Medium

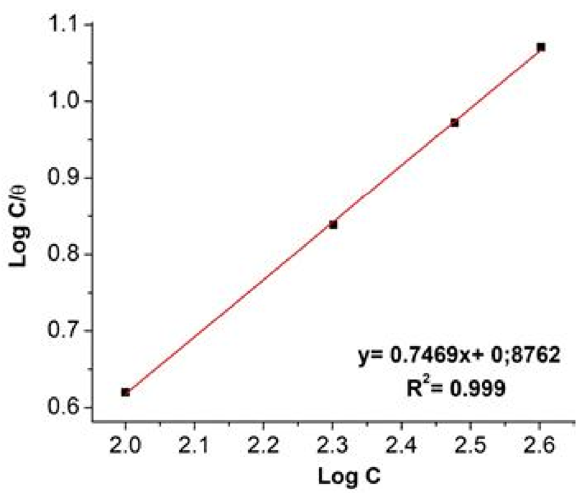

Figure 4: Langmuir adsorption isotherm plot for the adsorption of different concentration of Phoenix Ductylifera bark extract on MS Coupon at 304K in 0.5M HNO_3 Medium

Figure 2 & 3 indicated that the inhibitor efficiency increases with the increase in the inhibitor concentration at both temperatures. The inhibition efficiency increases from 48% to 68% at 304 K and from approximately 47% to 65% at 314 K as the concentration of P. Ductylifera bark extract increases from 2 to 8 g/L. The surface coverage (θ) also increases with the increase in concentration. The surface coverage increases from approximately 0.48 to 0.68 at 304 K and from 0.47 to 0.65 at 314 K. The inhibitor efficiency and surface coverage are slightly higher at 304 K than at 314 K at all concentrations. This shows that the inhibition efficiency is better at 304 K than at 314 K. The decrease in inhibition efficiency and surface coverage with the increase in temperature shows that the adsorption process is exothermic.

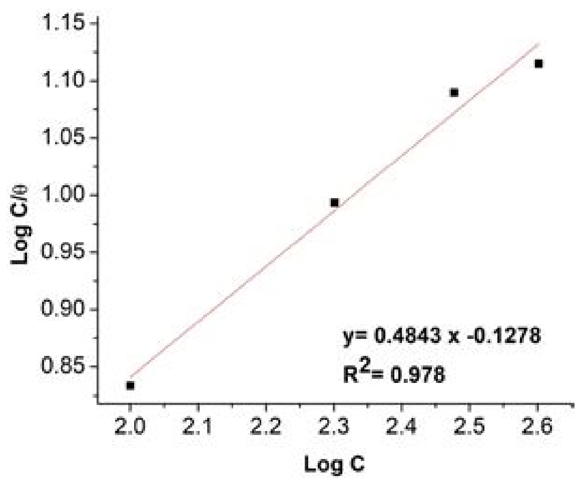

Figure 5: Langmuir adsorption isotherm plot for the adsorption of different concentration of Phoenix Ductylifera bark extract on MS Coupon at 314K in 0.5M HNO_3 Medium

Adsorption Isotherm :

The corrosion inhibition process on the metal surface was interpreted through adsorption isotherm analysis, which provides an overview of the interaction between inhibitor molecules of Green inhibitor and the mild steel wire substrate. Among the various models examined, the Langmuir adsorption isotherm adequately represented the experimental data at 304 & 314

K, indicating monolayer adsorption of inhibitor species. The Langmuir relationship is expressed as:

$$\frac{C}{\theta} = \frac{1}{K_{ads}} + C$$

where C denotes the inhibitor concentration, θ represents the fraction of surface covered by the adsorbed species, and K_{ads} corresponds to the adsorption equilibrium constant. The linear plots of C/θ against C, exhibiting slopes close to unity confirm that the adsorption behavior of the inhibitor conforms to the Langmuir model.

However, the adsorption capacity is lower at 314 K than at 304 K. R^2 value is comparatively low at 314 K, the overall adsorption efficiency is decreasing with the increase in temperature.

Conclusion

The results confirm that *Phoenix dactylifera* bark extract is an effective green corrosion inhibitor for mild steel wire substrate in nitric acid medium at ambient temperature. The inhibition efficiency increased with inhibitor concentration due to enhanced adsorption of inhibitor molecules on the metal surface. The adsorption process followed the Langmuir adsorption isotherm, signifying the formation of a homogeneous protective monolayer. Increased surface coverage at higher concentrations effectively suppressed the corrosion process. Therefore, butanoic extract of *P. dactylifera* bark exhibits substantial corrosion inhibition performance and can be considered a promising eco-friendly corrosion inhibitor for the protection of mild steel in acidic environment.

References

1. Uddin, N. and Nasir, M., 'Analysis of the Mechanical Characteristics of Mild Steel Using Different Heat Treatment.' *World Journal of Advanced Research and Reviews*, vol. 21, no. 2, 2024, pp. 1611–16. https://doi.org/10.30574/wjarr.2024.21.2.0230. (2024).
2. Samie, F., *et al.,* 'Atmospheric Corrosion Effects of HNO—method Development and Results on Laboratory-exposed Copper.' *Atmospheric Environment*, vol. 39, no. 38, pp. 7362–73. https://doi.org/10.1016/j.atmosenv.2005.09.022.
3. Nadi, I., *et al.*, 'Sargassum Muticum Extract Based on Alginate Biopolymer as a New Efficient Biological Corrosion Inhibitor for Carbon Steel in Hydrochloric Acid Pickling Environment: Gravimetric, Electrochemical and Surface Studies.' *International Journal of Biological Macromolecules*, vol. 141, pp. 137–49. https://doi.org/10.1016/j.ijbiomac.2019.08.253. (2019).
4. Gupta, R. K., *et al.*, 'Functionalized Graphene Oxide as a New Generation Corrosion Inhibitor for Industrial Pickling Process: DFT and Experimental Approach.' *Materials Chemistry and Physics*, vol. 236, p. 121727. https://doi.org/10.1016/j.matchemphys.2019.121727. (2019).
5. Cheng, F., 'Novel Inhibitors Containing Multi-functional Groups for Pipeline Corrosion Inhibition in Oilfield Formation Water.' *CORROSION*, https://doi.org/10.5006/1875.
6. Himeur, T., *et al.*, 'Plant extracts and essential oils as green corrosion inhibitors for steel in acidic media: A review.' *Journal of Molecular Structure*, Vol. 1367, pp. 146143. https://doi.org/10.1016/j.molstruc.2026.146143 (2025).
7. Murungi, P. I., and Aliyu Adebayo Sulaimon (2022). 'Ideal Corrosion Inhibitors: A Review of Plant Extracts as Corrosion Inhibitors for Metal Surfaces.' *Corrosion Reviews*, vol. 40, no. 2, pp. 127–36. https://doi.org/10.1515/corrrev-2021-0051.
8. Kokalj, A., 'Corrosion Inhibitors: Physisorbed or Chemisorbed?' *Corrosion Science*, vol.

196, p. 109939. https://doi.org/10.1016/j.corsci.2021.109939 (2021).

9. Kumar, U. P. *et al*. (2019). 'Anti-corrosion and Microstructural Properties of Ni–W Alloy Coatings: Effect of 3,4-Dihydroxybenzaldehyde.' *Heliyon*, vol. 5, no. 3, p. e01288. https://doi.org/10.1016/j.heliyon.2019.e01288.
10. Auepattana-Aumrung, K., *et al.*, 'Polymer-corrosion Inhibitor Conjugates as Additives for Anticorrosion Application.' *Progress in Organic Coatings*, vol. 163, p. 106639. https://doi.org/10.1016/j.porgcoat.2021.106639. (2021).
11. Zhang, W., *et al.*, 'Excellent Performance of Dodecyl Dimethyl Betaine and Calcium Gluconate as Hybrid Corrosion Inhibitors for Al Alloy in Alkaline Solution.' *Corrosion Science*, vol. 207, p. 110556. https://doi.org/10.1016/j.corsci.2022.110556. (2022).
12. Dutta, D., and Nandan S., 'Application of Natural Extracts as Active Ingredient in Biopolymer Based Packaging Systems.' *Journal of Food Science and Technology*, vol. 60, no. 7, pp. 1888–902. https://doi.org/10.1007/s13197-022-05474-5. (2022).
13. Ismail, W. M., *et al.*, 'GC-MS based nutritional and aroma profiling of date palm seeds collected from different Egyptian cultivars for valorization purposes.' *Scientific Reports*, Vol. 15, no. 1, pp. 16531. https://doi.org/10.1038/s41598-025-00171-7 (2025).