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Preparation of corrosion inhibitor from leaf extract of *Salvadora oleoides* for mild steel immersed in an acidic environment

Kumawat Y[1], Mathur P[2], Arora SK[3] and Sharma A[4]

[1&2]Department of Applied Science and life science, Bhagwant University, Ajmer.

[3]Department of Chemistry, SPC Government College Ajmer.

[4]Department of Chemistry, Seth K. N. Modi Government College Gudhagaorji Jhunjhunu

Abstract:

The viability of using the leaves of *Salvadora oleoides*, a well-known medicinal plant, as an efficient corrosion inhibitor for mild steel in HCl media has been studied and the results are summarized in this paper. Methods including weight loss monitoring, thermo-logical techniques have been used. The nonpolar phytochemicals that are abundant in ethanol extracts but deficient in water extracts provide them a stronger anticorrosive activity. As the temperature increases, the efficiency decreases, indicating that plant components are physisorbtion onto the metal surface. These phytochemicals adsorb according to the Langmuir unimolecular model.

Keyword: *Salvadora oleoides*, weight loss, physisorption.

Introduction

Corrosion is a ubiquitous problem that continues to be of great relevance in a wide range of industrial applications and products; it results in the degradation and eventual failure of components and systems both in the processing and manufacturing industries and in the service life of many components[1]. Corrosion damage can be prevented by using various methods such as upgrading materials, blending of production fluids, process control and chemical inhibition. The use of corrosion inhibitors is the most economical and practical method in reducing corrosive attack on metals[2].

Corrosion inhibitors are chemicals either synthetic or natural which, when added in small amounts to an environment, decrease the rate of attack by the environment on metals. Generally, inhibitors containing π-bonds and heteroatoms (P, S, N, and O) with lone pair electrons are the most potent and efficient. Because both inorganic and organic inhibitors are usually hazardous, researchers are looking for more environmentally friendly substances, often known as green or natural inhibitors[3]. Nevertheless, the popularity and use of synthetic compounds as a corrosion inhibitor is diminishing due to the strict environmental regulations and toxic effects of synthetic compounds on human and animal life[4-5].

The eco-friendly extracts of plant material provide an excellent alternative that substitutes toxic traditional (organic and inorganic) corrosion inhibitors. The plant extracts are renewable and readily available; thus, they occupy a unique position in the family of green inhibitors[6]. The plant extract contains several bioactive compounds, such as flavonoids, tannins, polyphenols, phenolic acids, glycosides, flavonols, etc., which possess experienced significant interest as anti-corrosive agents[7]. Most such phytochemicals have polar functional groups like amide ($-CONH_2$), hydroxyl (-OH), ester ($-COOC_2H_5$), amino ($-NH_2$), and carboxylic acid (-COOH) that assist in their absorption. These plant extracts contain several heteroatoms like phosphorus, nitrogen, sulfur, oxygen, etc., which are adsorbed on the metallic surface and form an inert protective layer that protects metal from a corrosive environment[8].

Salvadora oleoides is an evergreen shrub or tree with a dense crown of numerous, drooping branches. In leaves of *S. persica*, major identified compound classes were flavonoid glycosides, the glucosinolate glucotropaeolin, phenyl- and benzylglycoside sulfates, and megastigmane glycosylsulfates. The *S. persica* leaves contain high concentration of 2-methoxy-4-vinylphenol (25.4%), cis-3-hexenyl benzoate (16.8%), phytol (13.9%), n-hexadecanoic acid (6.9%), and trans-ß-damascenone (2.1%). The leaves are used to relieve cough. The leaves are heated and then tied up in a cloth and applied as a poultice on areas affected by rheumatism. They are a favourite domestic remedy for the treatment of rheumatic pains.

In order to find out non-toxic, cheap and effective green corrosion inhibitors from renewable sources, in the present study, we report the corrosion inhibitive effect of alcoholic leaf extract of plant *S. persica.*

Materials

Extraction of plants Shrubs

This study investigated the potential corrosion-inhibitory effects of an extract from *Salvadora oleoides* leaves using mass loss and electrochemical methods. The leaves were collected from Ajmer region. After being crushed into a powder and dried outdoors, the gathered leaves were immersed in 95% ethanol for three days. The extract was then made using the Soxhlet method[9].

Weight Loss Method

Weight loss is the most widely used method for assessing damage caused by corrosion. You can determine how much metal an object would lose due to corrosion by weighing it both before and after exposure[10].

Using the following formula, the inhibitor's efficacy in preventing inhibition was determined:

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

IE- Inhibition efficiency; W is the weight loss with (i) or without (0) influence of the inhibitor.

Surface coverage (θ) was calculated using the following formula

$$\text{Surface Coverage } (\theta) = \frac{\Delta M_u - \Delta M_i}{\Delta M_u}$$

Langmuir Adsorption Isotherm

Several adsorption isotherms, including as Langmuir, Frumkin and Freundlich, were used to characterise the adsorption of leaves extracts on the mild steel surface in HCl solution. The Langmuir adsorption isotherm best described the experimental data, which can be expressed as

$C/\theta = (1/K_{ads}) + C$

Where C is a concentration of inhibitor molecules, θ is surface coverage, and Kads is the equilibrium constant of the adsorption process.

Determination of activation energy (Ea)

The following Arrhenius equation was employed for calculating the activation energy for the corrosion of mild steel in an aqueous media[10].

$$CR = A \exp\left(\frac{-Ea}{RT}\right)$$

Where, CR - Corrosion Rate of mild steel, A = Arrhenius or pre-exponential constant

Ea = Apparent activation energy, R = Universal gas constant, T = Absolute temperature.

The logarithms of both sides of equation-

$$\log CR = \log A - \left(\frac{Ea}{2.303RT}\right)$$

Applying the formula Ea = - 2.303 × R × Slope

Results and Discussion

Following immersion in 0.1 N HCl solution in open air at 298 ±1.0 K, the impact of several concentrations (i.e., 50, 100, 200, and 500 ppm) of the plant *Salvadora oleoides* leaves extracts (ethanol fraction) was examined, as well as the estimated average corrosion rate. The table shows that when the corrosion rate falls, the corrosion inhibition efficiency (IE%) rises. This is explained by a decreased acid attack at high inhibitor doses. A 500 ppm concentration of leaf extract possessed the highest inhibitory effectiveness8. This can be explained by the larger amounts of inhibitor molecules found in the plant parts extract, which enhanced the mild steel specimen's surface coverage[11].

Table 1 displays the corrosion metrics for extracts from *Salvadora oleoides* leaves, such as surface coverage (θ), inhibition efficiency percentage (IE %), and corrosion rates (mmpy). Additionally, Figure 1 illustrates the relationship between inhibitor concentration and corrosion inhibition effectiveness. The weight loss–time curves for mild steel in 0.1 N HCl at various intervals (1, 6, and 24 hours) at 298 K temperature, with and without varying amounts of shrub extract, are displayed in the figures. Area of exposure - 7.75cm2

Inhibitor Conc.	Log c	Mass Loss(ΔM) mg			Inhibition Efficacy (IE %)			Corrosion Rate (mmpy)			Surface Coverage(θ)			log(θ/1-θ)		
(ppm)		1Hr	6Hr	24Hr	1Hr	6Hr	24Hr	1Hr	6Hr	24Hr	1Hr	6Hr	24Hr	1Hr	6Hr	24Hr
Blank	0	92	406	573	0.00	0.00	0.00	132.47	97.433	34.377	0.00	0.00	0.000	0.00	0.00	0.00
50	1.698	42	365	448	54.35	10.10	21.82	60.475	87.594	26.878	0.54	0.101	0.218	0.075	-0.949	-0.554
100	2	37	248	367	59.78	38.92	35.95	53.276	59.515	22.018	0.59	0.389	0.359	0.172	-0.195	-0.250
200	2.301	27	152	251	70.65	62.56	56.20	38.877	36.477	15.059	0.70	0.625	0.562	0.381	0.223	0.108
500	2.698	18	99	154	80.43	75.62	73.12	25.918	23.758	9.239	0.80	0.756	0.731	0.614	0.491	0.434

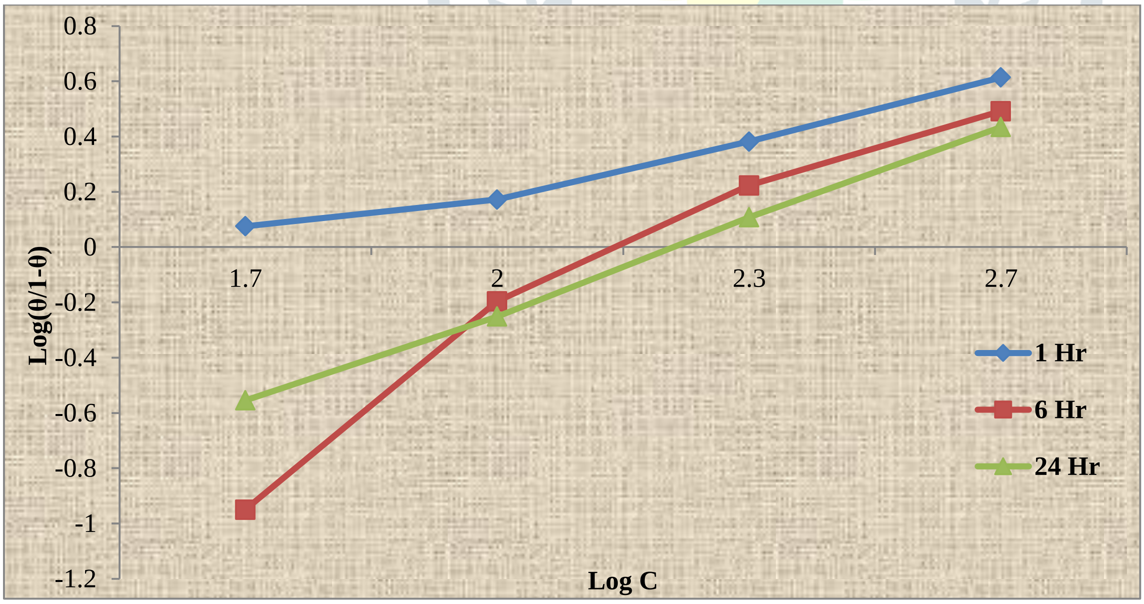

Fig 1 Mass loss curves in between variation of log (θ /1-θ) with log C using *Salvadora oleoides* leaves extract for Mild steel in 0.1 N HCl at 298 ±1.0 K, Time at 1 h, 6 h, 24 hrs.

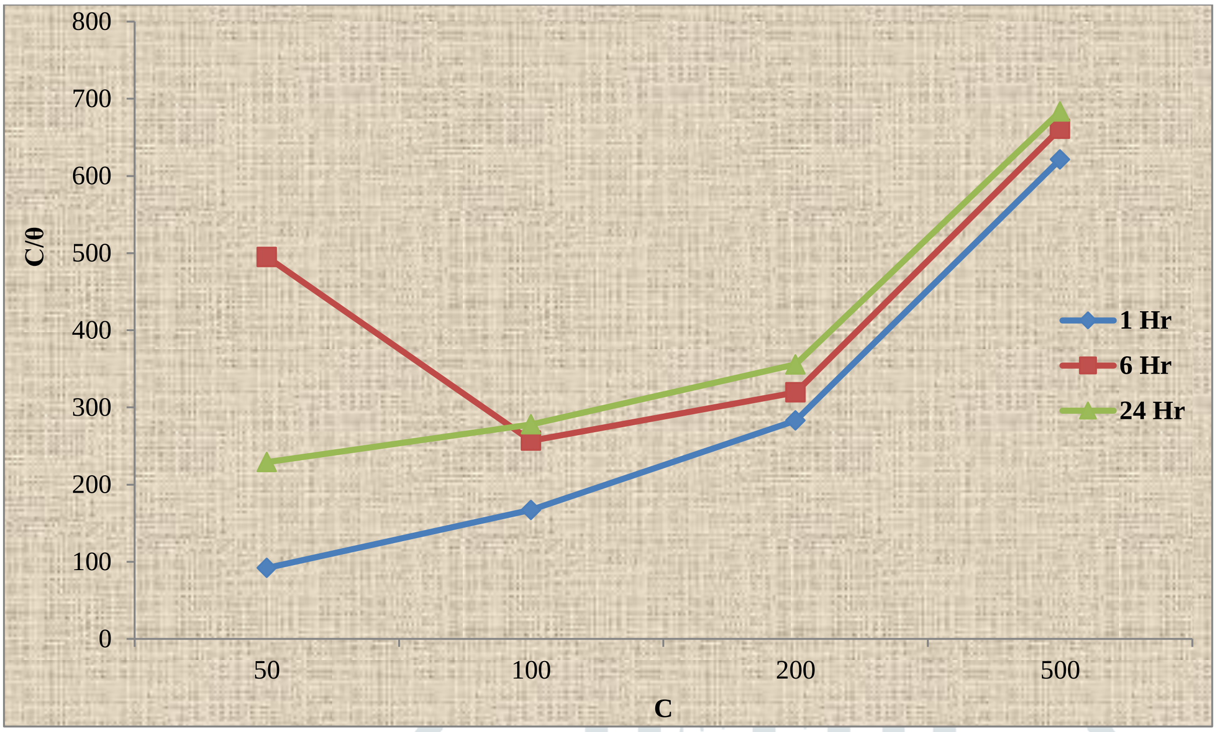

Fig. 2 Mass loss curves in between variation of C/θ with C using *Salvadora oleoides* leaves extract for Mild steel in 0.1 N HCl at 298 ±1.0 K, Time at 1 h, 6 h, 24 hrs.

According to Langmuir adsorption isotherm straight line should be obtained when a graph is plotted **Log (θ/1- θ)** versus **Log c** with gradient equal to one. In our study, the deviation from unit behavior can be explained on the basis of the interaction of the adsorbed molecules on the metal surface[12].

The corrosion rate and weight loss reduced with higher inhibitor (leaf extracts) concentrations but increased with higher temperatures[13]. As the temperature increased while leaf extract was present, the inhibitory efficacy decreased, which could be because physical adsorption weakened[14-15].

Table 2. Comparisons of Inhibition Efficacy (η%) at different temperature in HCl medium using *Salvadora oleoides* leaves extract after duration 6 hrs.

S. NO.	**Inhibitor Concentration**	**Inhibition Efficacy (η%)**	**Corrosion Rate (mmpy)**	**Inhibition Efficacy (η%)**	**Corrosion Rate(mmpy)**	**Inhibition Efficacy (η%)**	**Corrosion Rate(mmpy)**
	0.1 N HCl	298K		308K		318K	
1	Blank	0.00	97.43333	0.00	85.9141155	0.00	84.23423
2	50	10.10	87.594	9.22	77.9946579	7.69	77.75467
3	100	38.92	59.51592	20.67	68.1553318	23.36	64.55558
4	200	62.56	36.4775	60.34	34.0776659	47.01	44.63694
5	500	75.62	23.75837	72.63	23.5183892	70.09	25.19827

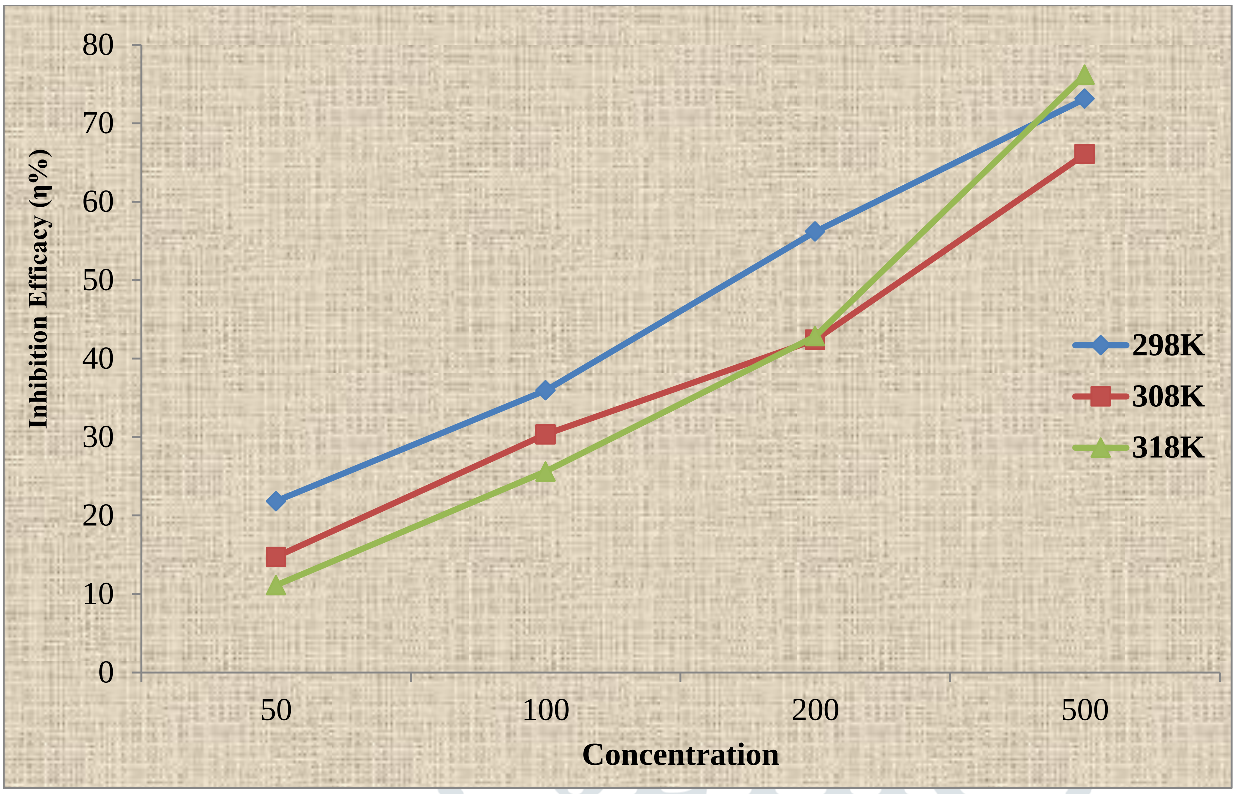

Fig 3 Changes in Inhibition Efficacy (η%) with Inhibitor *Salvadora oleoides* leaves extract at various temperature in 0.1 N HCl.

Table-3 Calculation of E_a (KJ/ Mol) by using slope of graph plotted between Log (Corrosion Rate) & 1/T in HCl medium for 6 hour.

S. NO.	Inhibitor Concentration	Log CR at 298 K	Log CR at 308 K	Log CR at 318 K	**Activation energy (Ea) (KJ/ mol)**
1	Blank	1.988708	1.934065	1.925489	5.778607
2	50	1.942474	1.892065	1.890727	4.740832
3	100	1.774633	1.8335	1.809934	-3.28182
4	200	1.562025	1.53247	1.649694	-7.80629
5	500	1.375817	1.371408	1.401371	-2.28425

It is evident that the inhibited solution has a larger activation energy Ea value than the uninhibited solution. Because of the inhibitor's attachment to the metal surface, it provides a protective coating and, as a result, lowers iron dissolution, the corrosion reaction will be more challenging and the energy barrier of the reaction will increase.

Conclusion

The alcoholic leaves extracts of *Salvadora oleoides* are found to be influential inhibitor in acid media giving up to 80.43 % efficiency at higher concentration (500ppm) and can be safely used without toxic effects and pollution.

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