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INHIBITION EFFICIENCY OF OPUNTIA COCHENILLIFERA EXTRACT ON THE CORROSION OF MILD STEEL IN ACID MEDIA

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Abstract : The corrosion inhibition efficiency of stem extract of *Opuntia Cochenillifera (OC)* on the corrosion behaviour of mild steel in 1N hydrochloric acid was investigated in the present study. Experimental methods include weight loss measurements, Fourier Transformed Infrared Spectroscopy and Scanning Electron Spectroscopic techniques. The Inhibition efficiency was increased with increase in concentration and decreased in corrosion rate. The extract acts as an excellent corrosion inhibitor. The maximum inhibition efficiency value reached to 98 % at 2.5 % v/v concentration of extract. In temperature studies the maximum inhibition efficiency of 97.07 % was observed at 2.5 % v/v extract concentration for *OC* extract at 323K. The mild steel surface in the absence and presence of the inhibitor was analysed by scanning electron microscope (SEM).The surface analysis results showed that the *OC* stem extract absorbed protective layer on the surface of the mild steel.

Keywords: **Opuntia Cochenillifera, Mild Steel, Phytochemical, Inhibition Efficiency, Corrosion Rate.**

I. INTRODUCTION

Mild steel is popular in the construction of different structures like pipeline, thermal chemical reactor and cooling system, since it is excellent in performance, highly recyclable, high life span, strength as well as more ductile [1]. Metals are affected by different forms of corrosion in various environments. The exposures can be most severe, but in many cases the corrosion may be controlled by inhibitors. Most of the well known acid inhibitors are organic compounds containing nitrogen, sulphur and oxygen atoms [2, 3]. These organic compounds can observe on the metal surface, block the active sites on the surface and thereby reduce the corrosion rate. The toxic effects of most synthetic corrosion inhibitors have led to the use of natural products which are eco friendly and harmless. The use of natural products as corrosion inhibitors are well documented [4]. In this present study the inhibition efficiency of OC stem extract in 1N HCl acid media through weight loss method and surface examination techniques has been investigated.

II. MATERIALS AND METHODS

Figure 1 ***Opuntia Cochenillifera***

Preparation of Plant Extract

Opuntia Cochenillifera stem (Figure 1) collected from Panjampatti, Dindigul District, Tamil Nadu, India, were cleaned and shade dried. The dried stem were powdered and stored in dessicator to prevent moisture contents. 25 gm of dried stem powder were boiled in 500 mL of 1N HCl in reflux condenser for 3 h and was kept overnight. The extract was filtered and filtrate volume was made up to 500 mL using 1N HCl medium.

Preparation of Mild Steel Coupons

Mild steel specimens of size 5 x 1 x 0.2 cm were polished with 400 and 600 grade emery paper, washed with distilled water, degreased with acetone, dried, and kept in a dessicator to avoid the adsorption moisture [5].

Phytochemical Analysis

Standard protocols were used for qualitative analysis of stem extract to check for the presence of alkaloids, carbohydrates, flavonoids, phenols, saponins, tannins, terpenoides, quinines and proteins [6, 7]

Weight Loss Method

Pre weighed mild steel specimens were suspended with the help of glass hook in 100 mL of 1N HCl acid solution in the absence and presence of inhibitor at various concentrations under an immersion time of 1h, 3 h, 5 h, 7 h, and 24 h at room temperature. The specimens were removed after specified time interval, washed with distilled water, dried and reweighed. The experiment was also conducted at high temperatures as done at room temperature for a period of 1h in the absence and presence of inhibitor in 1N HCl acid using the thermostat, set at higher temperatures of 303 K to 343 K.

The rate of the dissolution of the metal was calculated in the term of Corrosion Rate (CR) using the expression [8, 9],

$$\text{Corrosion Rate (CR)} = 87.6 \times W / DAT \text{ (mm/y)}$$

Where, mm/y - millimeter per year, W - loss in weight in milligrams, D - metal density in g/cm^3 (7.86g/ cm^3), A - area of the sample in square centimeters, T - time of exposure of the metal surface in hours.

The percentage inhibition efficiency (IE %) of the inhibitors in terms of concentration has been calculated from the expression [10],

$$\text{Inhibition Efficiency (IE \%)} = \frac{\text{Weight loss without inhibitor} - \text{Weight loss with inhibitor}}{\text{Weight loss without inhibitor}} X\ 100$$

Where W_0 and W_i are the weight loss values in absence and in presence of the inhibitor respectively.

Scanning Electron Microscopy

The surface morphology study of corroded sample was examined by Scanning Electron Microscopy. The mild steel samples were immersed in 1N HCl with and without corrosion inhibitor, for 3 h. After the immersion, the samples were rinsed with distilled water and dried with an air drier [11]. SEM was taken at Karunya University, Coimbatore, India. Using Model: JOEL 6390 Japan.

III. RESULTS AND DISC

Phytochemical Analysis

Phytochemical analysis of *Opuntia Cochenillifera* stem extract showed the presence of Proteins, Tannins, Carbohydrates, Phenols, Flavonoids, Saponins, Glycosides, Steroids, Terpenoids and Alkaloids.

Weight Loss Measurement

The inhibitive effect of *Opuntia Cochenillifera* stem extract tested at various concentrations and different temperatures on the corrosion of mild steel in 1N HCl solution obtained from weight loss method are given in Table 1. The weight loss measurements showed that the inhibition efficiency increased with increase in concentration of the inhibitor from 0.1 to 2.5 % v/v at room temperature. The maximum inhibition efficiency was 97.65 % in case of *OC* stem extract for the immersion period of 5h at a concentration of 2.5 %v/v. With increase in concentration of plant extracts, more phyto constituents are being adsorbed on to the surface of the metal, enhancing the increasing inhibition efficiency with increasing inhibitor concentration [12]. Figure 2 showed that the corrosion rate and inhibition efficiency of mild steel with different concentration of *OC* at different immersion periods. Evaluation of the results revealed that the corrosion rate was associated with inhibitor concentration and the plant extract performed good inhibition efficiency.

The increase in efficiency of the inhibitor with increase in concentration may be attributed to increase in number of molecules occupied by the inhibitor on the steel–acid solution interface. As the number of molecules increases, the corrosion reactions are prevented from occurring over the active sites of the mild steel surface covered by adsorbed inhibitor species, whereas the corrosion takes place on the surface not covered by the inhibitor molecules. Thereby, one may conclude that the greater the surface coverage the greater the inhibition efficiency. This assumption has been applied to deduce the effect of concentration on the adsorption of inhibitors [13, 14].

Table 1 Inhibition Efficiency and Corrosion Rate of *Opuntia Cochenillifera* in 1N HCl against Mild Steel at Various Concentration and Different Immersion Periods

Conc. of extract	Corrosion Rate and Inhibition Efficiency									
	1 h		3 h		5 h		7 h		24 h	
v/v %	**CR mm/y**	**IE %**	**CR mm/y**	**IE %**	**CR mm/y**	**IE %**	**CR mm/y**	**IE %**	**CR mm/y**	**IE %**
Blank	33.99	-	43.69	-	43.60	-	37.59	-	35.93	-
0.10	2.79	91.80	3.05	93.03	2.36	94.58	2.36	93.01	2.96	91.75
0.50	1.89	94.42	1.86	95.75	1.78	95.91	1.45	96.15	2.30	93.59
1.00	1.56	95.41	1.71	96.09	1.56	96.42	1.42	96.61	2.03	94.34
1.50	1.45	95.74	1.30	97.02	1.23	97.19	1.24	96.69	1.84	94.88
2.00	1.34	96.07	1.26	97.11	1.14	97.39	1.15	96.95	1.69	95.29
2.50	1.23	96.39	1.08	97.53	1.03	**97.65**	1.10	97.07	1.51	95.78

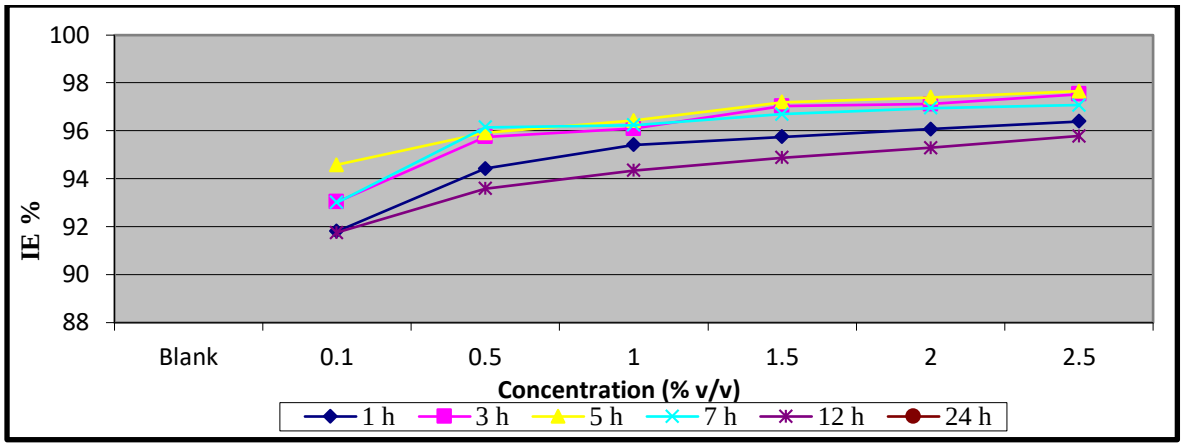

Figure 2 Inhibition Efficiency of different concentration of *Opuntia Cochenillifera* Stem Extract at Different Immersion Periods

Temperature Studies

The effect of temperature on corrosion rate and inhibition efficiency was studied in the temperature range from 303K to 343K. The results of the weight loss measurements at different temperatures are given in Table 2. The maximum inhibition efficiency of 97.07 % was observed at 2.5 % v/v extract concentration for OC extract at 323K. Decrease in inhibition efficiency thereafter with increasing time may be due to shift in adsorption and desorption equilibrium which takes place simultaneously on prolonged exposure to corrosive media [15]. Effects of temperature on corrosion rate and inhibition efficiency of mild steel with various concentration of OC extract are shown in the Figure 3.

Table 2 Inhibition Efficiency and Corrosion Rate of *Opuntia Cochenillifera* in 1N HCl against Mild Steel at Various Concentration and Different Temperatures

Conc.of extract	Corrosion Rate and Inhibition Efficiency									
	303K		313K		323K		333K		343K	
v/v %	CR mm/y	IE %	CR mm/y	IE %	CR mm/y	IE %	CR mm/y	IE %	CR mm/y	IE %
Blank	22.62	-	67.09	-	144.44	-	199.27	-	337.47	-
0.10	2.34	89.65	6.24	90.69	8.80	93.90	20.28	89.82	38.56	88.57
0.50	2.01	91.13	4.68	93.02	7.13	95.06	11.80	94.07	32.10	90.49
1.00	1.56	93.10	3.59	94.35	6.57	95.45	11.59	94.18	23.52	93.03
1.50	1.34	94.09	3.00	95.51	4.68	96.76	8.58	95.69	18.61	94.48
2.00	1.23	94.58	2.79	95.85	4.56	96.84	7.02	96.48	18.39	94.55
2.50	1.11	95.07	2.34	96.51	4.24	97.07	6.46	96.76	17.27	94.88

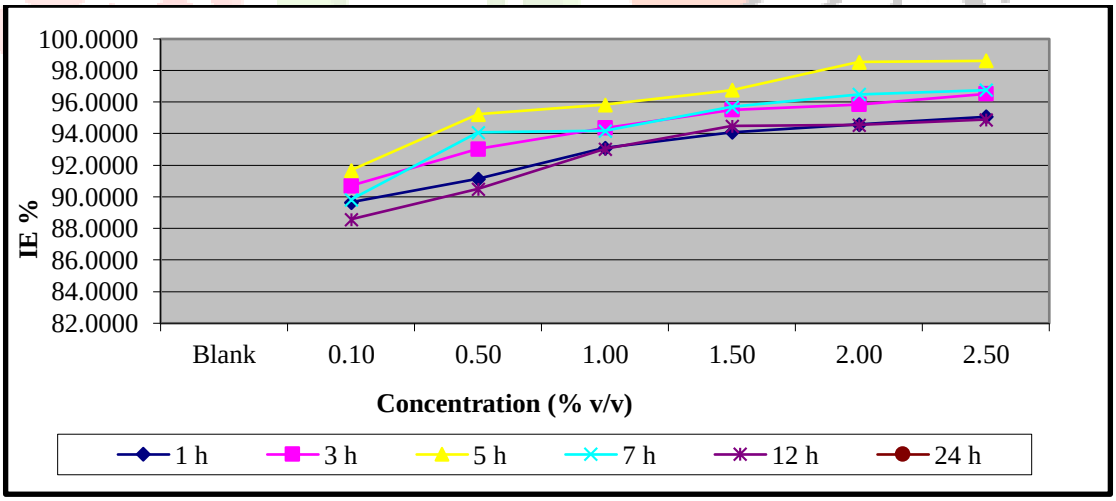

Figure 3 Effect of Temperature on Inhibition Efficiency of Mild Steel of with Various Concentrations

SEM Photograph of Mild Steel Sample

Surface examination studies through scanning electron microscopy for the mild steel specimens exposed to 1N HCl at room temperature for 3 h in the absence and presence of 2 % v/v concentration of the *OC* stem extract are shown in Figure 4 (a) and 4 (b). *OC* / 1N HCl show the inhibitive layer on surface that has ability to produce a good protection on metal surface [16].

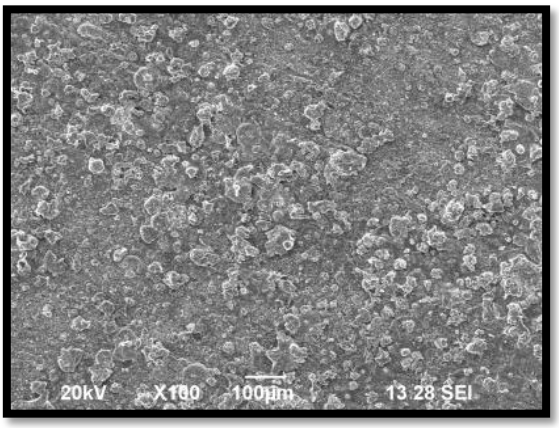

Figure 4 (a) Mild steel exposed to 1N HCl medium

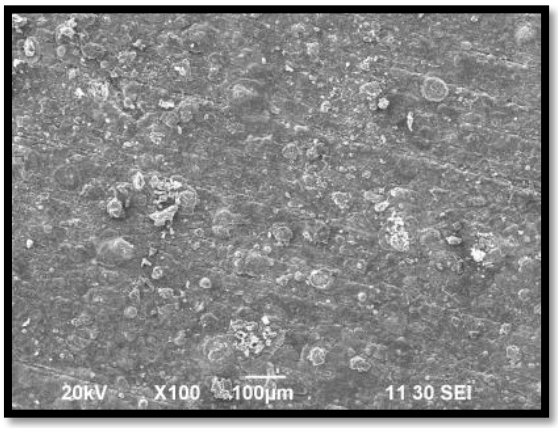

Figure 4 (b) Mild steel exposed to 1N HCl + 2.5 % OC extract

Energy Dispersive X-ray Spectroscopy (EDX) Studies

EDX spectra employed to examine the composition of corrosion scales on mild steel immersed for 3 h in 1N HCl without and with inhibitor containing 2 % v/v concentration of *OC* stem extract are shown in Figure 5 (a) and 5 (b). The EDX results showed in Table 3, 4 and 5 indicate the presence of oxygen and chlorine elements on mild steel surface exposed to *OC* / 1N HCl.

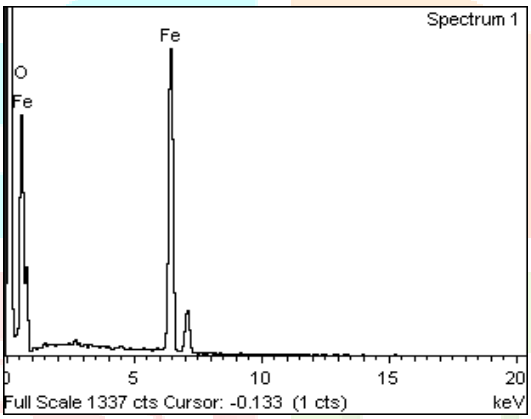

Figure 5 (a) EDX spectrum of mild steel in 1N HCl

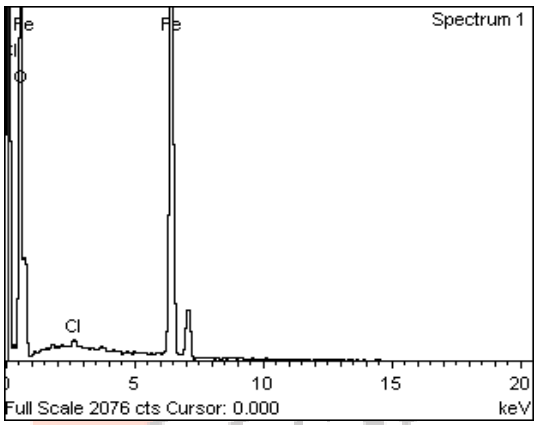

Figure 5 (b) EDX spectrum of mild steel in *OC*/1N HCl

Table 3 EDX Analysis Element Weight Percentage of the Sample

Sample	Element weight %		
	Fe	**Cl**	**O**
Mild steel exposed to HCl	96.25	-	3.75
Mild steel exposed to extract	37.02	0.90	62.08

Table 4 EDX Analysis Result of Mild Steel Immersed in 1N HCl

Element	Weight	Atom
Fe	96.25	88.02
O	3.75	11.98
Total	100	100

Table 5 EDX Analysis Result of Mild Steel Immersed in *OC*/ 1N HCl Extract

Element	Weight	Atom
Fe	37.02	67.05
Cl	0.90	0.74
O	62.08	32.21
Total	100	100

IV. Conclusion

Present studies conclude that *Opuntia Cochenillifera* stem extract can act as a corrosion inhibitor because of the presence of various phytochemical constituents such as Alkaloids, Phenol, Flavonoids, Protein, Carbohydrate, Terpenoids, Saponins, Glycosides, Quinones, Cumarins, and Phytosterols. Weight loss method revealed maximum inhibition efficiency of 97.65 % at 5 h in 2.50 % v/v. The temperature effect showed that *OC* stem extract exhibits efficiency upto 323 K. Surface examination studies showed the protection by *OC* stem extract on mild steel surface. EDX study indicates oxygen and chlorine elements on mild steel exposed to *Opuntia Cochenillifera* in 1N HCl that confirmed the presence of absorbed inhibitor molecules on mild steel surface.

Reference

[1] Hmimou, J. Rochdi, A. Touir, R. Ebn Touhami, M. Rifi, E. El Hallaouti, A. Anouar, A. and Chebab, D. 2012. Study of Corrosion Inhibition of Mild Steel in Acidic Medium by 2-Propargyl-5-p-Chlorophenyltetrazole. Part I. Journal of Materials and Environmental Science, Vol.3:543-550.

[2] Jayalakshmi, M. and Muralidharan, V.S, 1998. Journal Chemistry Technology, Vol. 5:16.

[3] Popova, A. Christov, M. Ravicheva, S. and Sokolova, E. 2004. Corrosion Science. Vol.46:1333.

[4] Raja, P. B. Sethuraman, M. G. 2008. Materials. Letter, Vol.62:113.

[5] Kavitha, V. and Dr. Gunavathy, N. 2014. Evaluation of Daucus Carota aerial extract as corrosion inhibitor of mild steel in hydrochloric acid medium. International Journal of Research in Advent Technology. Vol. 2(7): 146-154.

[6] Harborne, J. B.1984. Phytochemical Methods- A Guide to Modern Techniques of Plant Analysis. Chapman and Hall, London, 2rd Edition.

[7] Kokate, A. 1999. phytochemical Methods. Phototherapy Res., Vol.78:126-129.

[8] Karthikaiselvi, R. Subhashini, D. S. Rajalakshmi, R. 2009. Biodegradable green inhibitor (Myristica Frangans) as a corrosion inhibitor of mild steel in1M HCl. The Journal of corrosion science and engineering. Vol.12.

[9] Bhat, J. I. and Alva, V.2009. Corrosion inhibition of aluminium by 2- chloronicotinic acid in HCl medium. Indian Journal of Chemical Technology. Vol. 16(3): 228-233.

[10] Abdallah, M. Megahed, H. E. Radwan, M. A. Abdfattah, E. 2012. Polyethylene glycol compounds as corrosion inhibitors for aluminium in 0.5 M hydrochloric acid solution. Journal of American Science. Vol. 8(11): 49-55.

[11] Deepa Rani, P. and Selvaraj, S. 2010. Inhibitive and Adsorption Properties of Punica granatum Extract on Brass in Acid Media. Journal of Phytology. Vol. 2(11): 58-64.

[12] Chowdhary, R. Jain, T. Rathoria, M.K. Mathur, S.P. 2004. Corrosion Inhibition of Mild Steel by Acid Extracts of Prosopis juliflora Bull. Electrochemistry, Vol. 20 (2):67-75.

[13] Abboud, Y. Abourriche, A. Saffaj, T. Berrada, M. Charrouf, M. Bennamara, A. Cherqaoui, A. Takkyet, D. 2006. The Inhibition of Mild Steel Corrosion in Acidic Medium by 2,2'-bis (benzimidazole). Application. Surf. Science, Vol. 252: 8178-8184.

[14] Putilova, I.N. Barannik, V.P. Balezin, S.A.1960. Metallic Corrosion Inhibitors. Pergamon Press. 30-32.

[15] Vijayalakshmi, P.R. Rajalakshmi, R. and Subhashini, S. 2011. Corrosion inhibition of aqueous extract of Cocos nucifera - Coconut palm-petiole extract from destructive distillation for the corrosion of mild steel in acidic medium. Portugaliae electrochemical Acta, Vol.29(1):9.

[16] Satapathy, A.K. Gunasekaran, G. Sahoo, S.C. Amit, K. and Rodrigues, P.V. 2009. Corrosion inhibition by Justicia gendarussa plant extract in hydrochloric acid solution, Corrosion. Science. Vol.51:2848- 2856.

[17] Anbarasi, K. Vasudha, V.G. 2014. Mild Steel Corrosion Inhibition by Cucurbit maxima Plant Extract in Hydrochloric Acid Solution. Journal of Environmental. Nanotechnology. Vol.3(1):16-22.