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CereusRepandus as an Inhibitor of Mild Steel Corrosion in Acid Media

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Abstract

The inhibition efficiency of *CereusRepandus* (CeR) plant stem extracts at different concentrations and temperatures on mild steel corrosion in 1N sulphuric acid (H_2SO_4) was investigated by using weight loss methods, Potentiodynamic polarization, surface analysis by Scanning Electron Microscopy (SEM) and Fourier Transformed Infrared Spectroscopy (FTIR). The corrosion rates which were calculated from the weight loss data showed that the inhibition efficiency of the extract increased in the inhibitor concentration and decreased with raise in temperature. The maximum inhibitor efficiency was observed at an optimum concentration of 2.5% v/v. The surface analysis confirmed the presence of active compounds and deposition of extract on metal surface. Polarization curves reveal that the adsorption obeyed Langmuir adsorption isotherm and inhibition on the metal surface. Evaluation methods and the factors that influence the corrosion inhibition efficiency of plant extract are discussed.

Keywords: *CereusRepandus (CeR), Mild Steel, H_2SO_4, SEM, FTIR, polarization*

1. INTRODUCTION

Industries depend heavily on the use of metals and alloys. One of the most challenging and difficult tasks in industries is the defense of metals from corrosion[1]. Some investigations have in recent times been into the corrosion inhibiting properties of natural products of plant origin and have found to generally exhibit good inhibition efficiencies [2, 3]. Corrosion is a general term used to describe various interactions between a material and its environment leading to degradation in the material properties[4, 5]. In a wet environment aqueous corrosion can occur due to electrochemical process which depends upon the metal ion transport and reaction. Corrosion is a process of formation of the compound of pure metal with the chemical reacting between metallic surface and its environment [6,7]. It is oxidation process, it causes loss of metal sand hence disintegration of a metal by its surrounding chemicals through a chemical reaction the surface of the metal is called corrosion[8, 9]. Corrosion prevention of mild steel has been an important topic of research due to its high technological issues and expands the range of industrial aspects.

2. MATERIALS AND METHOD

2.1.Collection of Plant Materials

Figure 1. *CereusRepandus*

Study was carried out using *CereusRepandus* (*CeR*) stem (Figure 1) extract. Stem was collected from Karumathampatti, Coimbatore District, Tamilnadu, India, cleaned and shade dried and ground into powder using an electronic blender, sieved and the fine powder was stored in air tight container.

2.2.Preparation of the Inhibitor

25 gm of dried *CeR* stem powder was boiled in 500 mL 1N sulphuric acid with a reflux condenser for 3 h and was kept overnight to extract its phytonutrient. Extract was filtered and the filtrate volume was made up to 500 mL using respective acid. Extract was taken as 5 % stock solution and from this other concentrations were prepared[10].

2.3. Weight loss Method

Polished and pre weighed mild steel specimens were immersed in 100 mL test solution without and with inhibitor of different concentration. After the specified time of exposure, specimens were removed and then reweighed. Experiments were performed with concentrations 0.10, 0.50, 1.00, 1.50, 2.00, 2.50 % v/v at time intervals. 1h,3 h,5 h,7 h and 24 h. Corrosion rate were calculated using [11,12, 13].

$$\text{Corrosion Rate (CR)} = 87.6 \times W / DAT \text{ (mm/y)} \qquad (1)$$

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.

2.4. Potentiodynamic Polarization Measurement

Experimentally, one can measure polarization characteristics by plotting the current response as a function of the applied potential. Since the measured current can vary over several orders of magnitude, usually the log current function is plotted against potential on a semi-log chart. In order to measure and control the potential and current flow of a corroding metal specimen, it is necessary to use a three electrode system: the specimen or working electrode, auxiliary electrode and a reference electrode. Thus, a plot of potential against the logarithm of the applied current density provides the polarization curve[14].

2.5. Surface Examination Studies

The surface morphology of mild steel specimens was examined using Scanning Electron Microscope (SEM) analysis. Though the inhibition was due to the formation of a protective film on the mild steel surface, the changes of morphology of the mild steel surface in the absence and presence of acidic solution were studied. For this study, the mild steel specimens were immersed in the 100 mL test solution 1N H_2SO_4 for 3 h in the absence and presence of optimum concentration of inhibitor. After 3 h the specimens were removed and dried. The nature of the metal surface was analyzed by Fourier Transformed Infrared (FTIR) spectroscopic studies. The inhibiting action of plant extracts on mild steel corrosion was also investigated by FTIR technique, revealing the formation of protective film.

3. RESULTS AND DISCUSSION

3.1. Weight Loss Method

Mild steel samples exposed to various concentrations of extract ranging 0.10 %v/v to 2.50 % v/v in 1N H_2SO_4 were investigatedusing weight loss techniques.Table 1, 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 96.46 % in case of *CeR* stem extract for the immersion period of 5h at a concentration of 2.5 %v/v. Figure 2 showed the corrosion rate and inhibition efficiency of mild steel with different concentration of *CeR* at different immersion periods. Evaluation of the results revealed that the corrosion rate was associated with inhibitor concentration and the plant extract performs good inhibition efficiency.

Table 1.CR of Mild Steel and IE of *CereusRepandus* Stem Extract in 1 N H_2SO_4 Acid in Various Concentrations for Different Immersion Periods

Conc. of Extract in v/v %	Corrosion Rate and Inhibition Efficiency									
	1 h		3 h		5 h		7 h		24 h	
	CR mm/y	**IE %**	**CR mm/y**	**IE %**	**CR mm/y**	**IE %**	**CR mm/y**	**IE %**	**CR mm/y**	**IE %**
Blank	35.78	-	36.22	-	36.60	-	36.75	-	36.63	-
0.10	5.80	83.80	5.28	85.43	5.22	85.74	5.38	85.35	5.82	83.63
0.50	3.45	90.34	3.27	90.97	4.21	90.80	4.17	88.64	4.29	87.93
1.00	2.79	92.21	2.93	91.89	2.03	94.45	3.01	91.81	3.19	91.02
1.50	2.56	92.83	2.53	93.02	1.81	95.06	2.04	94.45	2.34	93.43
2.00	2.34	93.45	2.12	94.15	1.54	95.79	1.56	95.75	2.11	94.08
2.50	2.12	94.08	1.71	95.28	1.29	**96.46**	1.34	96.36	1.42	96.02

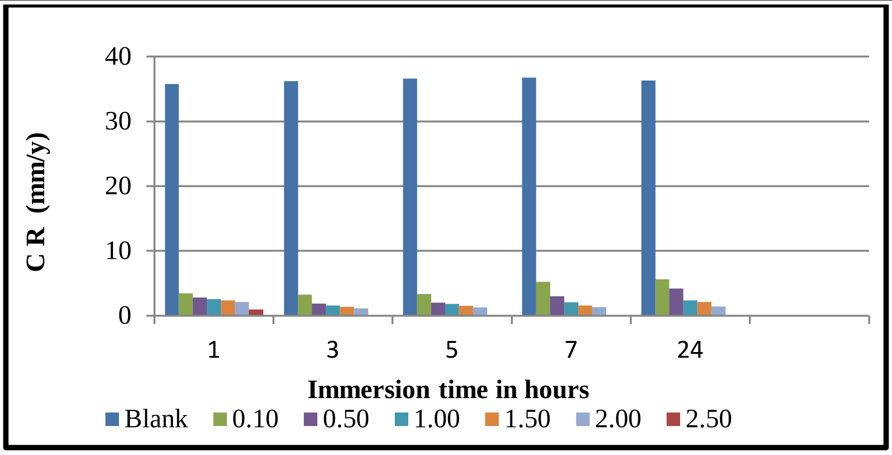


Figure 2.Effect of Immersion Time on CR of Mild Steel in 1 N H_2SO_4Without and With *CeR*Extract

3.2. Temperature Studies

To test the stability of the inhibitor at higher temperature, experiments were performed at different temperature in the range of 303 K - 343 K in acid media. The results obtained are shown in Table 2. Variation of CR of mild steel with temperature for the various concentrations of the plant extracts is shown in Figure 3.Corrosion rate of mild steel in acid increases with respect to increase in temperature [15,16, 17].

Table 2. Effect of Temperature on Mild Steel Corrosion in 1N H_2SO_4 in Absence and Presence of *CeR* Stem Extract

Conc. of Extract v/v %	Corrosion Rate and Inhibition Efficiency									
	303K		313K		323K		333K		343K	
	CR	**IE %**	**CR**	**IE %**	**CR**	**IE %**	**CR**	**IE %**	**CR**	**IE %**
Blank	56.95	-	124.94	-	267.48	-	376.14	-	567.73	-

0.10	14.49	74.56	45.70	63.43	85.48	68.04	138.31	63.23	211.09	62.82
0.50	11.37	80.04	29.87	76.09	61.41	77.04	115.57	69.27	181.89	67.96
1.00	6.13	89.24	27.08	78.32	42.69	84.04	63.19	83.20	136.08	76.03
1.50	5.13	91.00	15.71	87.42	32.77	87.75	53.61	85.75	86.15	84.83
2.00	4.57	91.98	12.59	89.92	21.29	92.04	37.78	89.96	79.13	86.06
2.50	4.24	92.56	6.69	94.65	11.37	**95.83**	35.66	90.52	64.64	88.61

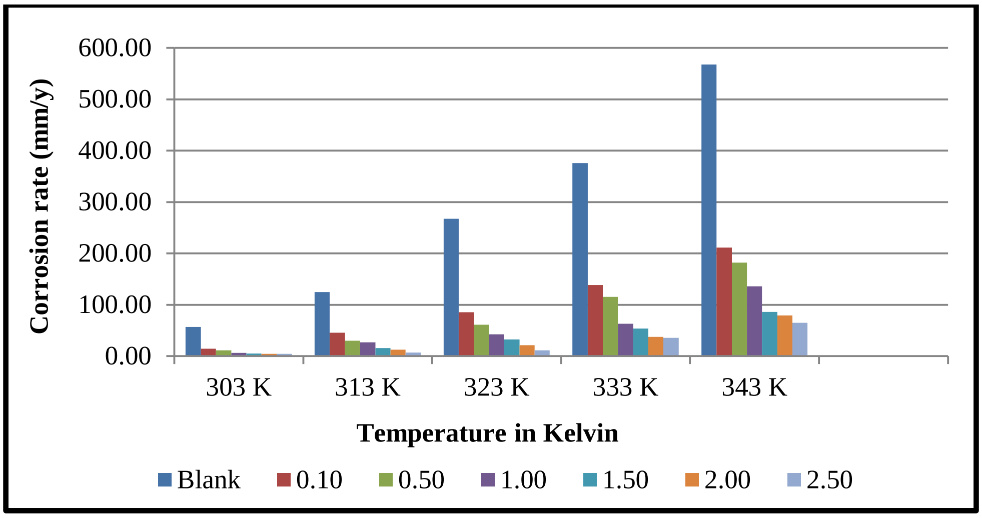


Figure 3. Effect of Temperature on Corrosion Rate *CeR* Stem Extract in 1 N H_2SO_4

The inhibition efficiency of the plant extracts varies inversely with temperature. In extract, inhibition efficiency increases with increasing inhibitor concentrations. In the case of a *CeR* stem extract, inhibition efficiency increases up to 323 K. This observation confirms the mode of corrosion inhibition by plant extracts is being attributed to physical adsorption of the plant constituents. The maximum inhibition efficiency of 95.83% was observed at 2.5 % v/v extract concentration for *CeR* stem extract.

3.3. Potentiodynamic Polarization Studies

The polarization behaviour of mild steel functioning as cathode as well as anode in the test solutions are shown in Figure.4 for 1N sulphuric acid with *CeR* stem extract at various temperatures. From the electrochemical data obtained it was evident that *CeR* bring about considerable polarization of cathode as well as anode. The Tafel slopes for different inhibitor concentration revealed that the inhibitor act through the process of being interfered with the mechanism of the corrosion processes at the cathode as well as the anode. The values were decreased with increasing concentration of the inhibitors, which indicated that the corrosion process was controlled by adding a *CeR* extract[18].

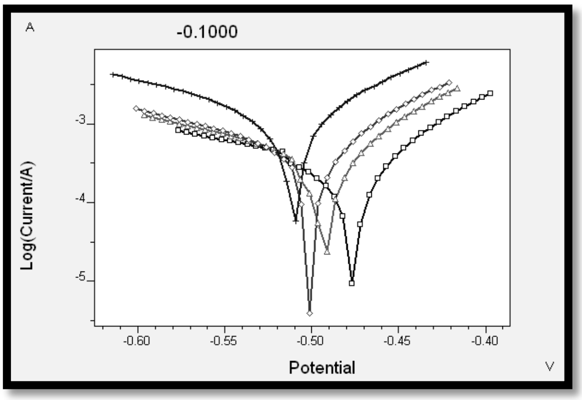
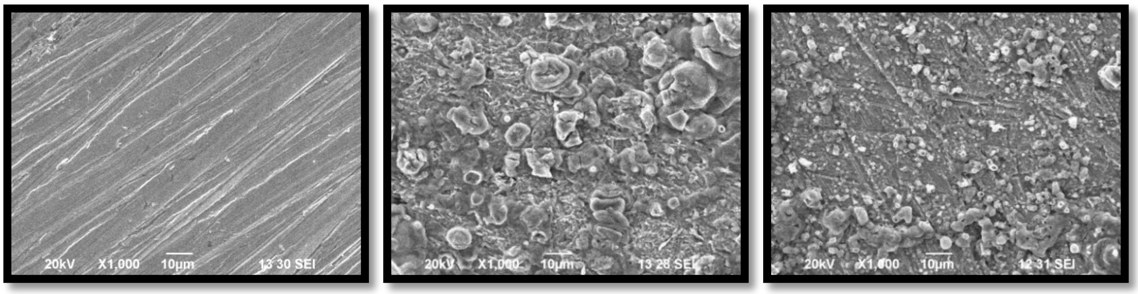


Figure 4.Tafel Plots Showing Effect of Increasing Concentration of *CeR* Stem Extract

3.4. Surface Examination Studies

The SEM micrographs of metal surface before and after absence and presence of exposing inhibitor are shown in Figure.5 a) indicating that the surface of mild steel was damaged and roughened in the absence of the extract while that in Figure.5 b) revealed the SEM images of mild steel surfaced immersed in 1N H_2SO_4. Figure.5 c) very clearly showed the formation of a film due to adsorption of active *CeR* stem constituents on the mild steel and there was notable corrosion inhibition[19, 20].



(a) (b) (c)

Figure 5.SEM Image of Mild Steel Surface 5.a) Mild Steel 5.b) Mild Steel in 1N H_2SO_4, 5.c) Mild steel in1N H_2SO_4 Solution with 2.5 % v/v of *CeR* Stem Extract

3.5. FTIR Analysis

FTIR is a powerful technique for studying the modification in mild steel surface with addition of corrosion inhibitor. FTIR is used to proof the interaction between organic compounds in the plant extract and mild steel surface. These results (Figure.6) strongly support the presence of interaction between the natural products in *CeR* and the metal surface, confirming the occurrence of adsorption process[21,22].

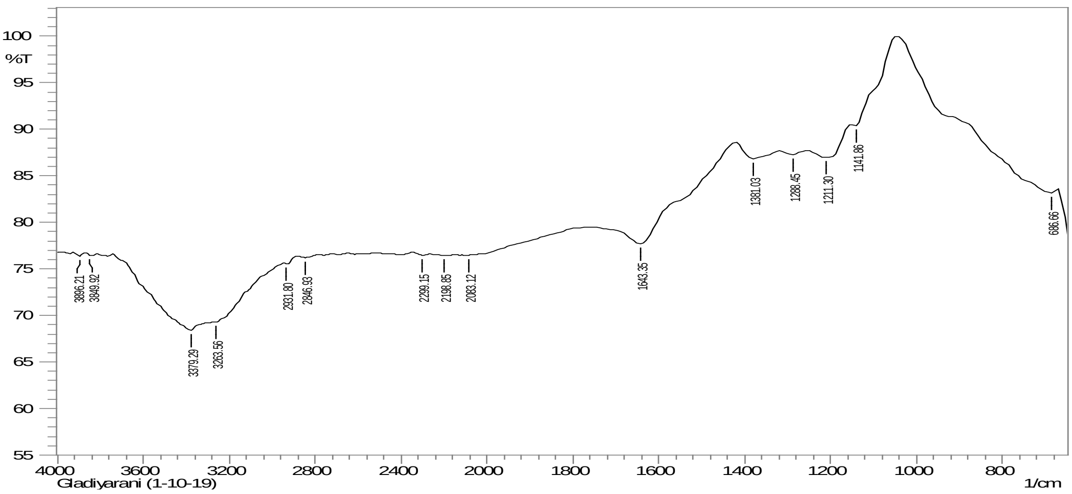


Figure 6. FTIR Spectra of Mild Steel in *CeR* Stem Extract in 1N H_2SO_4

The stem extract of *Cereus Repandus* subjected to FT-IR spectroscopic analysis showed the availability of carboxylic acid (O-H stretch), aliphatic primary amine (N-H stretch),alcohols(O-H stretch),alkenes(C=C), aldehyde,(C-H)stretch and halo compound(C-Br)stretch with the major peaks at 3849.92, 3379.29,3263.56, 2931.80, 1643.35, 1381.03, 1141.86, 686.66 cm^{-1} respectively.

4. CONCLUSION

- Value of inhibition efficiency increases with increase in the inhibitor concentration and decrease with rise in the temperature.
- In immersion study, the maximum inhibition efficiency was 96.92 % in case of CeR stem extracts in 1N sulphuric acid for the immersion period of 3h at a concentration of 2.5 % v/v.
- Temperature studies reveal maximum inhibition efficiency of 95.83% at 2.5 % v/v extract concentration for CeR stem extract. The corrosion of mild steel in acid medium was significantly reduced upon the additions of CeR stem extract. The maximum inhibitor efficiency was observed at an optimum concentration of 2.5% v/v.
- Tafel plots were found to be lowest for corrosive acid medium with high inhibitor concentration. Corrosion rate of mild steel was found to decrease with increase in extract concentrations. Thus inhibitor obeys the Langmuir adsorption isotherm.
- The surface analysis by SEM confirms the presence of protective film on mild steel surface in the presence of inhibitors.FTIR analysis showed the presence of active functional groups.

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