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Henna Leaves Extract as Green Corrosion Inhibitor for 304 Stainless Steel in Sulphuric Acid Solution

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Abstract: ***The corrosion inhibition of 304 stainless steel in 1.0 M H_2SO_4 has been investigated in the presence of Henna leaves (Lawsonia Inermis) extract using weight loss measurement and Scanning Electron Microscope (SEM) analysis. The study indicates that the corrosion inhibition efficiency increases with the increase in concentration of Henna leaves extract and decreases with increase in temperature. SEM analysis indicated the changes in metal surface morphology in the presence of inhibitor. The result obtained indicated that Henna leaves extract act as an efficient green corrosion inhibitor for 304 Stainless Steel.***

Keywords: 304 Stainless Steel, Henna leaves extract, SEM, green corrosion inhibitor.

I. INTRODUCTION

304 stainless steel is covered with a highly protective film of chromium oxyhydroxide [1,2] and is resistant to corrosion in many aggressive environments. However, it suffers from uniform as well as pitting corrosion under certain drastic conditions [3]. As 304 Stainless Steel has many applications in acidic medium in a variety of industries, therefore the corrosion mechanism of 304 stainless steel in acidic medium is of great interest. The use of inhibitor is one of the most important methods for protection of 304 stainless steel against corrosion in acidic media. The extract of plant leaves also known as green inhibitors such as Carica Papaya and Camellia Sinensis [4], Euphorbia hirta [5], Vernomia Amygdalina [6,7], Cassia tora [8] and many others have been studied for corrosion inhibition of metals and alloys in various media. All these studies reveals that the plant extract contains nitrogen, oxygen, and sulphur as most of the well-known organic compounds contains which act as corrosion inhibitors. The aim of the present study was to evaluate the inhibitive effect of Henna leaves extract on the corrosion of 304 stainless steel in 1.0 M Sulphuric acid solution, using weight loss measurement and the morphology of inhibited 304 stainless steel surface has been examined by SEM.

II. EXPERIMENTAL

A. Materials Preparation

All the chemicals used were of AR grade and double distilled water was used for preparing solutions. Rectangular specimens of 304 stainless steel of size 2 x 4 cm^2 of the following composition were used for weight loss measurements.

Element	C	Mn	S	P	Si	Ni	Cr	Fe
% (w/w)	0.045	1.47	0.008	0.06	0.37	7.98	17.04	Balance

B. Preparation of Inhibitor

Freshly collected Henna leaves were washed with tap water and then with double distilled water for 10 minutes. Washed leaves were allowed to dry in the shadow for a few days. The dried leaves were ground to fine powder. Henna Leaves powder was extracted by boiling with the water for 3 hours. After filtration, water was evaporated from the extract. The solid residue left behind was dried in vacuum and was used to prepare various concentrations of the inhibitor.

C. Weight Loss Method

Weight loss experiments were carried out with the help of rectangular specimens of 304 stainless steel of size 2x4 cm^2. Experiments were performed using 100, 200 and 400 ppm concentrations of Henna leaves extract in 1.0 M Sulphuric acid solution at 20, 30 and 40^0 C temperatures. The exposure time of specimens was 12 hours. The specimens in uninhibited and inhibited solutions were weighed using electronic balance before and after exposure to calculate the loss in weight due to corrosion.

D. Surface Morphology Study

Scanning Electron Microscope (SEM), (Model JSM-840, JEOL Make) was used for studying the morphology of the corroded specimens. The specimens were exposed to 1.0 M Sulphuric acid solution for 12 hours for studying their surface characteristics.

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III. RESULTS AND DISCUSSION

Percentage inhibition efficiency data calculated using weight loss method for 304 stainless steel in presence of 100, 200 and 400 ppm concentrations of Henna leaves extract at 20, 30 and 40^0 temperature are recorded in Table 1. The results in table one reveals that Henna leaves extract provides good inhibition efficiency towards the corrosion of 304 stainless steel in 1.0 M sulphuric acid solution. The inhibition efficiency increases with increase in concentration from 100 to 400 ppm and decreases with the rise of temperature from 20 to 40^0 C. When the concentration of the inhibitor was increased from 100 to 200 ppm the inhibition efficiency increases rapidly but only a slight increase in efficiency is observed when the concentration of the inhibitor is further increased to 400 ppm. Maximum inhibition efficiency (96.2%) obtained at 400 ppm concentration of inhibitor in 1.0 M sulphuric acid solution at 20^0 C.

Table 1
Percentage inhibition efficiency of Henna leaves extract for corrosion of 304 stainless steel in 1.0 M Sulphuric acid solution by weight loss method (Exposure Time 12 hours)

Concentration of Inhibitor (ppm)	Temperature (^{0}C)	Weight Loss (mg)	Corrosion Rate(mpy)	Inhibition Efficiency (%)
Nil	20	79.50	359.77	----
	30	143.80	650.76	----
	40	194.52	880.29	----
100	20	8.58	38.82	89.2
200	20	3.89	17.6	95.1
400	20	2.97	13.4	96.2
100	30	26.13	118.25	81.8
200	30	10.95	49.55	92.3
400	30	9.10	41.18	93.6
100	40	46.52	210.52	76.0
200	40	17.68	80.01	90.9
400	40	17.17	77.70	91.1

Fig. 1(a) shows the Scanning Electron Microscope (SEM) of 304 stainless steel surface exposed to 1.0 M sulphuric acid solution for 12 hours and Fig. 1(b) in presence of 200 ppm of inhibitor. Fig. 1(a) clearly indicated that 304 stainless steel surface is severely corroded in the absence of the inhibitor. It is obvious from the Fig. 1(b) that the surface of 304 stainless steel in the presence of inhibitor is in much better condition than in absence of inhibitor. This indicates that Henna leaves extract is adsorbed on 304 stainless steel surface and the adsorbed film of the inhibitor provides corrosion resistance to 304 stainless steel in 1.0 M sulphuric acid solution.

Fig. 1(a) SEM Micrograph of 304 Stainless Steel surface exposed to 1.0 M Sulphuric Acid solution for 12 hours. (X800)

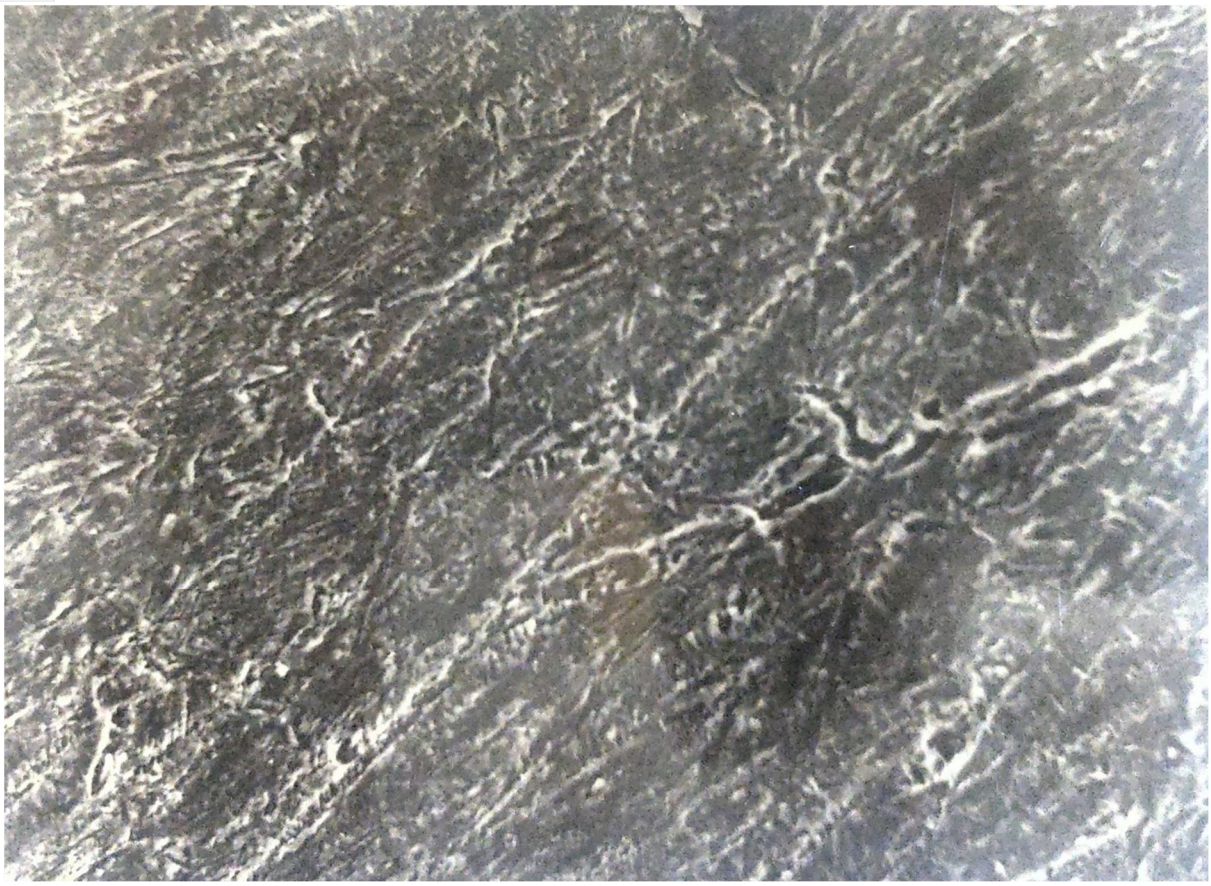

Fig. 1(b) SEM micrograph of 304 stainless steel exposed to 1.0 M Sulphuric acid solution in presence of 200ppm of Heena leaves extract for 12 hours (X800).

IV. CONCLUSIONS

A. Heena leaves extract is a very good corrosion inhibitor for the protection of 304 stainless steel in 1.0 M sulphuric acid solution and provides maximum inhibition efficiency (96.2%) at 20^0 C.

B. The inhibition efficiency increases with increase in the concentration of the inhibitor.

C. The Inhibition efficiency decreases with decrease in temperature.

D. SEM micrographs show that protective layer formed over the metal surface by the inhibitor molecules and prevent from the further corrosion.

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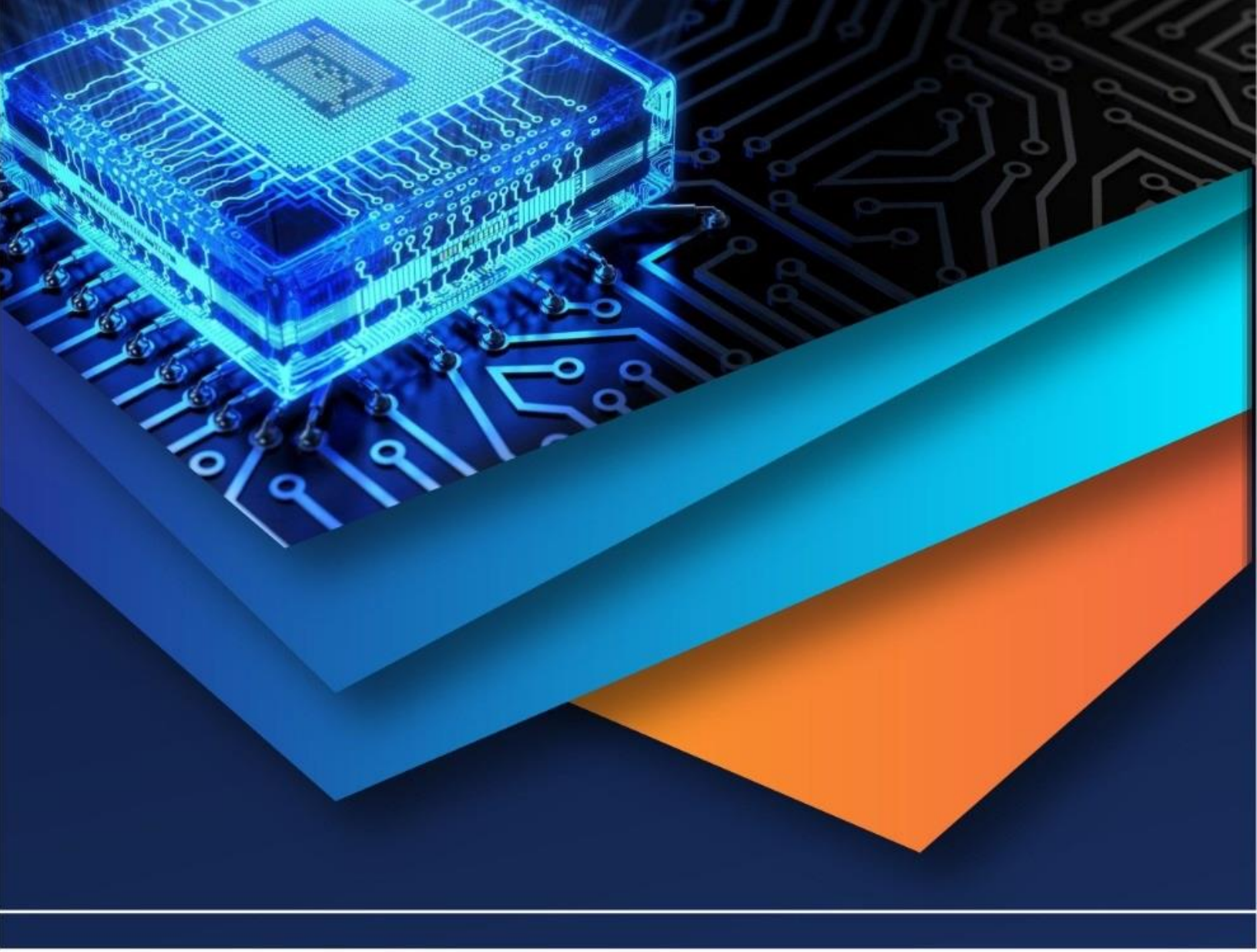

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