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Inhibition of Mild Steel Corrosion in 1N H_2SO_4 Medium by Acid Extract of *Nyctanthes arbortristis* Leaves

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Abstract: Efficiency of acid extract of dry *Nyctanthes arbortristis* (Night Jasmine, Coral Jasmine) leaves as corrosion inhibitor for mild steel in 1N H_2SO_4 medium was investigated in the present study. Experimental methods include weight loss and polarization studies. The results indicate *Nyctanthes arbortristis* leaves to be a good corrosion inhibitor of a mixed type and having efficiency as high as 90% at 1% inhibitor concentration.

Keywords: *Nyctanthes arbortristis*, Corrosion inhibitor, Plant products, Mild steel, Acid medium.

Introduction

Mild steel finds application in many industries due to its easy availability, ease of fabrication, low cost and good tensile strength besides various other desirable properties. It suffers from severe corrosion when it comes in contact with acid solutions during acid cleaning, transportation of acid, de-scaling, storage of acids and other chemical processes. The heavy loss of metal as a result of its contact with acids can be minimized to a great extent by the use of corrosion inhibitors. Inorganic compounds like chromates, phosphates, molybdates *etc*. and a variety of organic compounds containing heteroatom like nitrogen, sulphur and oxygen are being investigated as corrosion inhibitors[1-6].

Pure synthetic chemicals are costly, some of them are not easily biodegradable and their disposal creates pollution problems. Plant extracts are environment friendly, bio-degradable, non-toxic, easily available and of potentially low cost. Most of the naturally occurring substances are safe and can be extracted by simple procedures. Recent literature is full of researches which test different extracts for corrosion inhibition applications. The examples are numerous such as fenugreek[7], henna[8,9], olive[10], jojoba[11], black pepper[12], occimum viridis[13],

andrographis paniculata[14], Phyllanthus amarus[15], onion, garlic[16], Eugenia jambolans[17], Pongamia glabra[18], opuntia[19] and eugenol[20] *etc*. Many of these naturally occurring substances proved their ability to act as corrosion inhibitors for the corrosion of different metals and alloys in different aggressive media.

The aim of the present study is to investigate the corrosion inhibition effect of *Nyctanthes arbortristis* (Night Jasmine, Coral Jasmine) leaves as a cheap and environment friendly corrosion inhibitor for mild steel in 1N H_2SO_4 medium by weight loss and polarisation measurements.

Experimental

Sheet of mild steel obtained locally and of 2 mm thickness was mechanically cut in to coupons of 5x1 cm^2 size, having a hole of uniform diameter to facilitate suspension of the coupon in the test solution. The coupons were mechanically cleaned followed by polishing with emery sheet of fine quality to expose shining polished surface. To remove any oil and organic impurities coupons were degreased with acetone and finally with de-ionised water, dried and stored in a desiccator. Accurate weight of the samples was taken using electronic balance. For polarization studies mild steel specimens with an exposed area of 1cm^2 were used.

Inhibitor material

5% Stock solution of the inhibitor material (NAL extract) was prepared by refluxing 10 g of dry *Nyctanthes arbortristis* leaves powder with 200 mL of 1N H_2SO_4 for 3 hours. The refluxed solution was allowed to stand overnight and filtered through ordinary filter paper. The residue was repeatedly washed with small amounts of 1N H_2SO_4 and the filtrate made up to 200 mL. From this solution, different concentrations of inhibitor solutions ranging from 0.01 to 1% were diluted. The chemicals used were of Analar grade.

Weight loss method

Pre weighed mild steel specimens (in triplicate) were suspended for 1 hour in 1N H_2SO_4 with and without the inhibitor in different concentrations ranging from 0.01 to 1%. After the specified time the coupons were removed from test solution, thoroughly washed with $NaHCO_3$ solution and de-ionised water, dried well and then weighed. The percentage of inhibitor efficiency (IE %) for various concentrations of the inhibitor were calculated as

$$\text{I.E.\%} = \frac{\text{Weight loss without inhibitor} - \text{weight. loss with inhibitor}}{\text{Weight loss without inhibitor}} \times 100$$

Polarisation and impedance studies

Potentiodymamic anodic and cathodic polarization curves were obtained with a scan rate of 2 mv/s in the potential range from -0.2 mv to -0.8 mv relative to the corrosion potential (Ecorr). Values of the corrosion current density (Icorr) were obtained by extrapolation of the cathodic branch of the polarization curve back to Ecorr. Measurements of Rp in the vicinity of Ecorr were also carried out. Impedance spectra were recorded at Ecorr in the frequency range 0 to 10000 Hz. The values were computed using Solatron 1280B.

Results and Discussion

Table 1 shows the percentage of inhibition efficiency obtained with different concentrations of the plant extract in H_2SO_4 medium by weight loss method. The IE was found to increase with increase in the concentration of the extract with maximum IE of 90% at 1% concentration.

There is a gradual increase in inhibition efficiency from 0.01 to 1% inhibitor concentration, but above that there is not much change in efficiency. From the values of IE % it is evident that the corrosion inhibition may be due to adsorption of the plant constituents on the metal surface. The adsorption of the phytoconstituents on the metal surface makes a barrier for mass and charge transfers thus protecting the metal surface from corrosion. The degree of protection increases with the increasing surface fraction occupied by the adsorbed molecules.

Table 1. Effect of *Nyctanthes arbortristis* on corrosion of mild steel in H_2SO_4 (Weight loss method).

Concentration of inhibitor %v/v	IE, %
0.01	66
0.05	77
0.1	88
0.5	90
1	90
1.5	89
2	89

Polarisation and impedance behaviour of mild steel in 1N H_2SO_4 in the presence and absence of the plant extract is shown in the Figures 1 & 2 respectively. The polarization and impedance parameters are presented in the Tables 2 & 3 respectively. From the shape of the polarization curves it is seen that both the anodic as well as cathodic reactions are inhibited. The Tafel regions of the plot further indicate that the electrode reactions are kinetically controlled.

The values given in the Table 2 show that corrosion current (I_{corr})decreases markedly in the presence of extract and the magnitude of change increases with increasing extract concentration This confirms the inhibitive action of the extract in H_2SO_4 medium. With increase in plant extract concentration, the corrosion potential (E_{corr}) is not varying much. The values of both anodic and cathodic Tafel constants b_a and b_c respectively are markedly changed in the presence of the extract. This confirms the mixed mode of inhibition of the extract. The increasing linear polarization (R_p) values also confirm the corrosion inhibitive nature of the plant extract. The calculated values of inhibition efficiency indicate that IE % increases with increasing extract concentration.

Table 2. Potentiodynamic polarization parameters for mild steel in 1N H_2SO_4 in the presence of NAL extract.

Concentration of Inhibitor % v/v	$-E_{corr}$ V	Icorr mAmp/Cm^2	b_a mV/dec	b_c mV/dec	R_p Ohm/cm^2	% Inhibitor Efficiency	
						Tafel	Linear
Blank	0.4934	8.1029	243.31	172.65	4.7509	-	-
0.05	0.4858	2.6874	137.68	105.33	5.7188	67.03	16.92
0.1	0.4927	1.8206	115.19	97.029	6.2158	77.53	23.56
0.5	0.4738	1.6446	153.24	104.75	11.307	79.70	57.98
1	0.4708	0.1364	67.172	57.069	16.933	98.31	71.94

The Nyquist plot (Figure 2) shows semicircles with single capacitive loop and increasing diameter as the concentration of the plant extract increases. The C_{dl} values shown in the Table 3 are found to decrease with increase in the inhibitor concentration. This shows that the plant constituents are adsorbed on the metal surface resulting in a decrease in double layer capacitance. The increasing charge transfer resistance R_{ct} values imply reduced corrosion rate in the presence of the plant extract. Thus it is confirmed that the plant extract NAL shows good corrosion inhibition efficiency. The results of weight loss, polarization and impedance studies are in good agreement

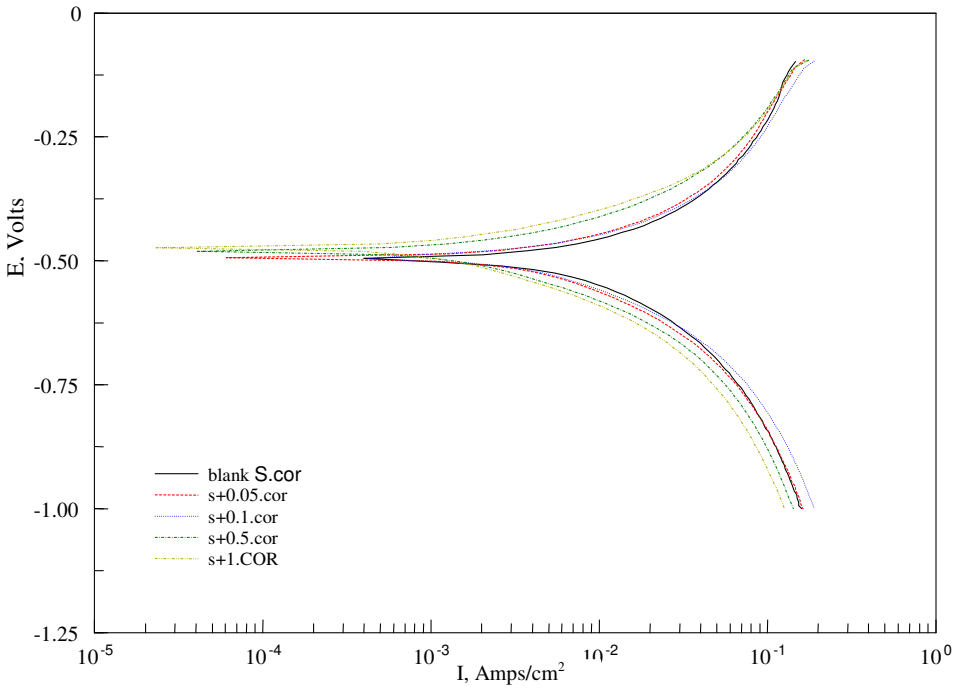

Figure 1. Potentiodynamic polarisation of mild steel in 1N H_2SO_4 with and without NAL extract.

Table 3. Impedance parameters for mild steel in 1N H_2SO_4 in the presence of NAL.

Concentration of Inhibitor, % v/v	C_{dl} µ farads	R_{ct} ohms	Inhibitor Efficiency Tafel	Linear
Blank HCl	265.12	6.6023	-	-
0.05	255.1	6.6214	3.77	0.288
0.1	233.91	8.1229	11.77	18.72
0.5	212.46	22.538	19.86	70.71
1	203.27	23.809	23.32	72.27

Phytoconstituents in the leaves of *Nyctanthes arbortristis* contain an alkaloidal principle named Nyctanthine. Leaves also contain mannitol, astringent principles, resinous substances, colouring matters, tannic acid, flavonoids and iridoid glucosides[21,22]. Due to the presence of these heterocyclic compounds adsorption of the plant constituents on the metal surface is facilitated. Inhibition efficiency of NAL extract may be explained as due to the adsorption of these compounds on the metal surface thereby blocking the surface and protecting the metal from the aggressive atmosphere.

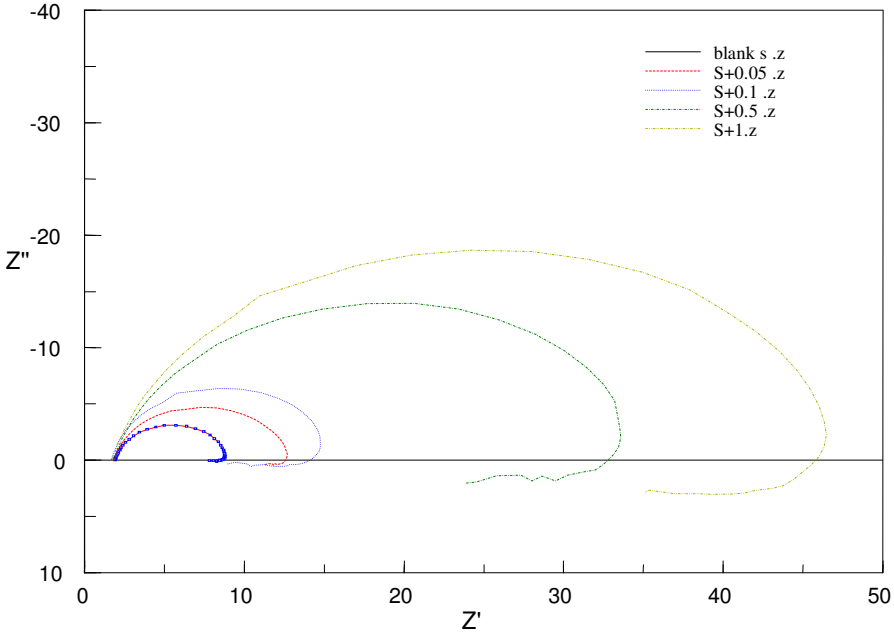

Figure 2. Nyquist plot of mild steel immersed in 1N H_2SO_4 with and without plant extract NAL.

Conclusion

Acid extract of *Nyctanthes arbortristis* leaves acts as good corrosion inhibitor for mild steel in 1N H_2SO_4 medium. Inhibition efficiency increases with inhibitor concentration and maximum inhibition efficiency was 90% at the inhibitor concentration 1% v/v. Corrosion inhibition may be due to the adsorption of the plant constituents on the mild steel surface. Polarisation studies indicate the inhibitor to be of a mixed type inhibiting both cathodic as well as anodic reactions.

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