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A STUDY OF *MUSA ACUMINATA* (AAA GROUP) 'RED DACCA' FLOWER EXTRACT AS CORROSION INHIBITOR FOR MILD STEEL IN ACID MEDIA

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ABSTRACT

The inhibitive effect of *Musa acuminata* Red Dacca flower extract in 1N HCl / H_2SO_4 acid on mild steel was calculated using weight loss method and surface examination study by FTIR. The extract of the Red Dacca flower extract was subjected to preliminary phytochemical screening to identify the chemical constituents of the plant. The results revealed strong presence of tannins and steroids and moderate presence of, alkaloids, terpenoids, reducing sugar and coumarins. The corrosion inhibition efficiency studied showed that the inhibition efficiency increased with increase in the concentration of the extract. RD flower extract showed a maximum efficiency of 99.40% and 96.99% at 2.5 % v/v in 1N HCl and 1N H_2SO_4 respectively.

Keywords: *Musa acuminata* Red Dacca, flower extract, acid medium, mild steel, FTIR.

1. INTRODUCTION

Mild steel finds a wide range of applications in industries, because of its availability, low cost, ease of fabrication and high tensile strength. But mild steel has a high tendency to corrode easily (Vinod Kumar *et al.*, 2010). Use of inhibitors is one of the most practical methods for protection against corrosion. Present study deals with description of methods used in characterization of plant material and corrosion monitoring techniques. Corrosive inhibitive effect of flower extract of *Musa acuminata* Red Decca (Figure 1) in 1N HCl / H_2SO_4, on mild steel was carried out using conventional weight loss method and surface examination analysis (FTIR).

Fig. 1. Photograph of *Musa acuminata* Red Dacca flower

2. MATERIALS AND METHODS

2.1. Phytoanalysis

2.1.1. Collection of plant materials

Study was carried out on *Musa acuminata* Red Dacca flower extract, obtained from cultivated farm in Salem, Tamil Nadu, India. Dried sample was ground into powder (Figure 2) using an electronic blender, sieved and fine powder stored in air tight container.

Fig. 2. RD Flower powder

2.1.2. Phytochemical screening

Extract of *Musa acuminata* Red Dacca flower extract was subjected to preliminary phytochemical screening to identify chemical constituents of plant, as described by various researchers Kotate (1999), Kotate 2010 and Harborne (1984, 1998).

2.2. Corrosion studies

2.2.1. Preparation of the Inhibitor

25 gm of dried powder of flower was boiled in 500ml of 1N HCl / H2SO4 acid with reflux condenser (Figure 3) for three hours and kept overnight to extract its phytonutrients. Extract filtered and filtrate volume made up to 500ml using respective acids. Extract so prepared was taken as 5% stock solution and from this other concentrations were prepared.

Fig. 3. Photograph of Experimental Set up for Obtaining Plant Extract

2.2.2. Weight Loss Method

2.2.2.1. Preliminary treatment of mild steel

Rectangular mild steel coupons of size 5 × 1 × 0.2 cm (Figure 4) cut from a large sheet of mild steel, with a small hole of about 1.0mm diameter near the 1.5cm side end for suspending were polished using silicon carbide emery papers of grade 200, 400, 600, washed with distilled water, dried, degreased with acetone and dried and kept in desiccators to avoid adsorption of moisture.

Fig. 4. Photograph of Mild Steel Coupons

2.2.2.2. Immersion study

Weight loss studies were conducted at room temperature. Mild steel specimens were weighed accurately in electronic balance. After initial weighing, the specimens were fully immersed using glass hooks in beakers containing 100ml of 1N HCl/ H_2SO_4 wihout and with inhibitor of different concentrations (0.1, 0.5, 1.0, 1.5, 2.0, 2.5 % v/v) at various intervals of time (1, 3, 5, 7, 12 hours) (Figure 5). After the specified period of immersion, the specimens were removed, washed with distilled water, dried and reweighed.

2.3. Surface examination studies

Surface analysis studies FTIR of mild steel specimens were done in order to study changes that occur during corrosion of mild steel in presence and absence of inhibitor in acid media (Raja and Sethuraman, 2008, 2009).

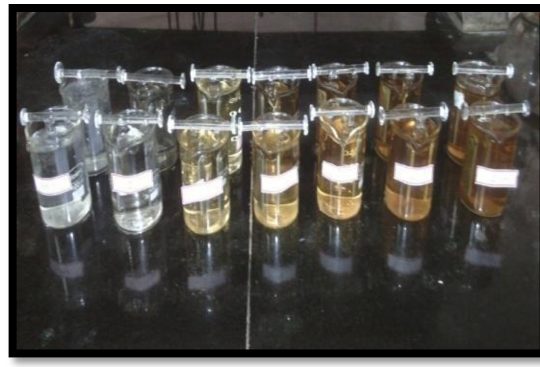


Fig. 5. Photograph of specimens fully immersed in acid medium without and with inhibitor

2.3.1. Preparation of the specimen for surface analysis.

Mild steel specimens (5 ×1 × 0.2 cm) were abraded with emery paper of grade 400 and 600 to a mirror finish, washed with distilled water and then rinsed with acetone and dried by hot air drier (Hegazy *et al*., 2011).

2.3.2. Surface morphology studies by Fourier Transform Infrared spectroscopy

Mild steel specimens were immersed in 1N HCl / H_2SO_4 solution in absence and presence of 2% v/v concentration of RD flower extracts for a period of three hours at room temperatue, removed,washed carefully with distilled water without disturbing the suface and dried. FTIR spectra of the samples were taken at Bharathiar University, Coimbatore, India (Model : Shimazdu).

3. RESULTS AND DISCUSSION

3.1. Qualitative phytochemical analysis

Phytochemicals present in aqueous flower extract of *Red Dacca* are summarized in Table 1. Results indicated that reducing sugar, saponins, coumarins and steroids were moderately present in the RD (F) extract. RD (F) extract showed the active presence of alkaloids and terpenoid. Exceptional factor was tannin content seem to be high in RDF extract of *Red Dacca* flower. It is evident from the tabulation that the other phyto chemicals like carbohydrates, flavonids, phlobotannins, cycloglycosides, total phenols, quinones and anthraquinones were absent in extract of *Musa acuminata* Red Dacca flower.

These results suggest the presence of primary bioactive metabolites of commercial importance which acts as the precursors for the synthesis of secondary metabolites. These in turn help in development of new bio products as corrosion inhibitor for future.

Table 1. Phytochemical constituents present in the extract of *Musa acuminata* Red Dacca flower

Phytocompound	RD (F) extract
Carbohydrates	+
Reducing sugars	++
Alkaloids	+
Saponins	++
Tannins	+++
Flavonoids	-
Terpernoids	+
Phlobotannins	-
Coumarins	++
Cycloglycosides	-
Total phenols	-
Quinones	-
Anthraquinones	-
Steroids	++

Key: '+++' active compound copiously present, '++' active compound moderately present, '+' active compound present,'_' active compound absent.

3.2. Weight loss studies

Mild steel was found to corrode in 1N HCl / H_2SO_4 acid solution. This was evidenced by the decrease in the original weight of the metal coupons. With addition of plant extract to the acids, it was found that weight loss decreases with increase in concentration from 0.1 to 2.5% v/v due to adsorption of plant nutrient and protects from dissolution of metal (Loto, 2011).

3.2.1. Effect of Concentration of RD flower Extract on Concentration Rate and Inhibition Efficiency

Variation of inhibition efficiency and corrosion rate with change in concentration of the inhibitor is presented in Table 2 and Table 3. It is obvious from the data that there was decrease in the corrosion rate with increase in the inhibitor concentration for all immersion periods. The decrease in corrosion rate and increase in inhibitor efficiency was usually attributed to the adsorption of flower extract constituents on the surface of mild steel which makes a barrier for mass and charge transfers and protects further attack by the acid (Saratha and Vasudha, 2009).

Table 2. CR of mild steel and IE of RD (F) extract in 1N HCl acid in various concentration and immersion period.

Conc. of Extract (%)	1h		3h		5h		7h		24h	
	CR mm/y	IE (%)	CR mm/y	IE (%)	CR mm/y	IE (%)	CR mm/y	IE (%)	CR mm/y	IE (%)
Blank	32.32	-	35.66	-	37.22	-	44.73	-	83.72	-
0.1	6.68	79.31	4.82	85.08	15.15	59.29	31.84	29.20	2.55	25.65
0.5	5.57	84.56	2.22	93.13	4.68	87.42	3.82	91.37	2.46	28.27
1.0	3.34	89.6	1.85	94.27	3.34	91.02	1.75	94.74	2.32	32.06
1.5	3.34	90.62	1.48	95.40	2.00	94.62	1.91	95.72	2.04	40.52
2.0	2.22	92.1	1.11	96.56	1.33	96.42	1.59	96.44	1.57	54.22
2.5	1.20	93.1	0.74	97.70	0.22	99.40	1.11	97.51	1.48	56.85

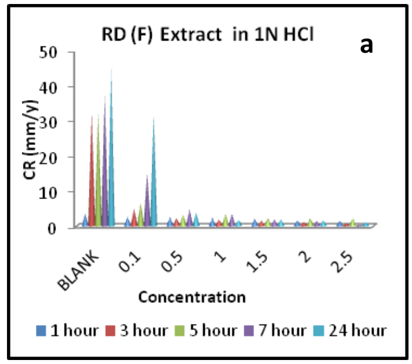
Table 3. CR of mild steel and IE of RD (F) extract in 1N H_2SO_4 acid in various concentration and immersion period.

Conc. of Extract (%)	1h		3h		5h		7h		24h	
	CR mm/y	IE (%)	CR mm/y	IE (%)	CR mm/y	IE (%)	CR mm/y	IE (%)	CR mm/y	IE (%)
Blank	42.35	-	75.22	-	79.57	-	79.28	-	83.72	-
0.1	10.03	71.87	22.38	70.74	15.15	80.96	10.50	86.75	27.76	66.84
0.5	7.80	78.12	9.93	88.03	10.47	86.84	7.80	90.16	23.77	71.60
1.0	5.57	86.84	8.08	89.36	6.90	91.32	5.87	92.57	19.87	76.25
1.5	4.45	89.49	7.05	90.64	5.34	93.28	3.98	94.97	16.85	79.87
2.0	3.34	92.11	5.01	93.35	4.01	94.96	3.02	96.19	14.48	82.69
2.5	2.22	94.22	4.17	94.68	3.78	95.24	2.38	96.99	13.83	83.47

3.2.2. Effect of Immersion Time on Corrosion Rate and Inhibition Efficiency

Variation of inhibitor efficiency with inhibitor concentration and immersion time is given in figure 6a and 6b. The inhibition efficiency increased with increase in concentration of the inhibitor from 0.1 to 2.5% at room temperature. The maximum inhibition efficiency was 99.40 % in case of RD (F) extract in 1N HCl for the immersion period of 5h and 96.99 % for RD (F) extract in 1N H_2SO_4 for the immersion period of 7h at a concentration of 2.5 %v/v. The decrease in inhibition efficiency thereafter with increasing time may be due to the shift in adsorption and desorption equilibrium which takes place simultaneously on prolonged exposure to the corrosive media (Putilova, 1960). These results suggest that the adsorption model arrangement and orientation of the constituents present in the *Red Decca* extract on the surface of mild steel may change with time (Rekha Nair, 2010). At low concentration, the aromatic rings of the phyto constituents may be oriented perpendicularly with respect to the metal surface. But at higher concentrations of inhibitor, the molecules may be reoriented to the parallel mode on the surface of mild steel. Therefore for higher concentration of inhibitor, more number of inhibitor molecules gets adsorbed on the surface of mild steel (Patel, 2009).

The adsorption of the phyto constituents on the metal surface makes a barrier for mass and charge transfers and thus protects the metal surface fraction occupied by the adsorbed molecules (Shymala and Arulanantham, 2009).



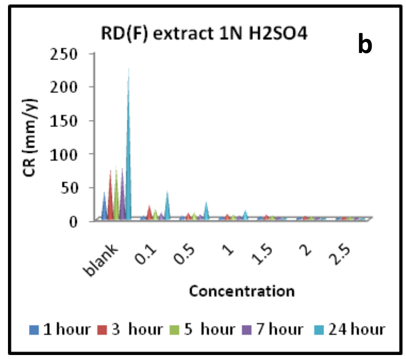


Fig. 6. Effect of concentration on CR of mild steel in (a) 1N HCl (b) 1N H_2SO_4 without and with RD (F) Extract.

3.4. Fourier transform infrared spectroscopy (FTIR) studies

Results of FTIR of Mild steel exposed to 1N HCl and 1N H_2SO_4 in the presence of *Musa acuminata* Red Dacca Flower extract and possible functional group (Harajothi Mazumdar 2010), are represented Table 4 Table 5.

Table 4. FTIR peak values and possible functional group of adsorption layer formed on mild steel surface exposed to 1N HCl without and with RD (F) inhibitor.

Mild Steel in 1N HCl	Possible groups	Mild Steel in 1N HCl with RD(F) extract
	Methylene CH asy/sym (S)	2850.27
	Methoxy O-CH_3	
	Methyl ether C-H(S)	
	Methylamino	2785.67
	N-CH_3,CH(S)	
2678.64		
		2669.00
2608.25		
2508.94		
		2552.33
	N-H ammonium ions	2505.08
2440.47	Multiple broad peaks	
		2400.94
2392.26		
		2366.26
2347.91		
2334.41		

		2316.09
2291.98	Nitrile	
	Isocyanate –N=C=O	2268.84
	Aliphatic cyanide/nitrile	
	Transition metal carbonyl	2046.10
	Fluoro alkanes	
	Skeletal C-C vibration	1056.80
	Primary alcohol C-O (S)	
1015.34	Aromatic CH in plane bend	
	Aromatic fluoro compounds	
	C-F(S)	
554.43	Aliphatic iodo compounds	
	C-I (S)	

Table 5. FTIR peak values and possible functional group of adsorption layer formed on mild steel surface exposed to 1N H_2SO_4 without inhibitor.

Mild steel in 1N H_2SO_4	Possible groups	Mild steel in 1N H_2SO_4 with RD(F) extract
	Primary alcohol / Phenol	3639.02
	OH (S)	3532.95
	Heterocyclic amines N-H (S)	3440.39
	Dimeric OH (S)	
	OH carboxylic acid	
	NH primary amine	
	Normal polymeric OH	3297.68
	Alkynes	3232.11
	N – H, ammonium ions	3156.90
	Multiple broad peaks	
	Methylene C-H (S)	2892.70
	Alkyl C=H	
	Aldehyde CHO	
	Methoxy C-H (S)	2811.70
	Alkyl C=H	
	Aldehyde CHO	
2790.49		
2655.50		
2592.82		
2519.54		
		2491.58
2458.80	N-H Ammonium ions	
	Multiple broad peaks	
		2413.48
2393.23		
		2354.66
		2335.37
2333.45		
2268.20	Nitrile	
	Cyanate OCN, C-OCN	
	Isocyanate –N=C=O asy (S)	
2239.91	Isothiocyanate (-NCS)	
2116.49	C≡C terminal alkynes	
	CH alkynes	707.75
	C-H (b) of aromatic	
	Cis C-H out of plane bend	
	Aliphatic chloro compounds	
	C-Cl (S)	

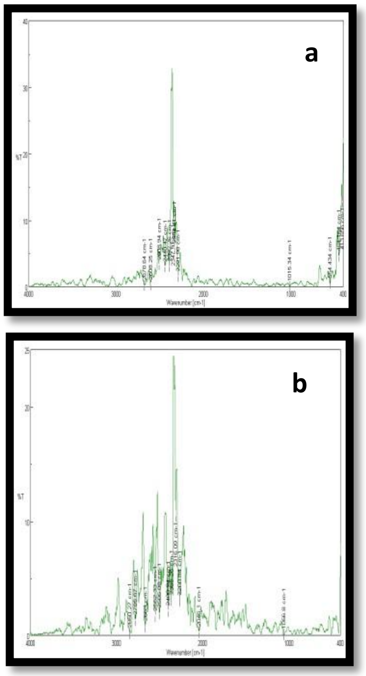


Fig. 7. FTIR spectra of adsorption layer formed on the mild steel surface immersion in 1N HCl acid (a) without (b) with RD (F) extract.

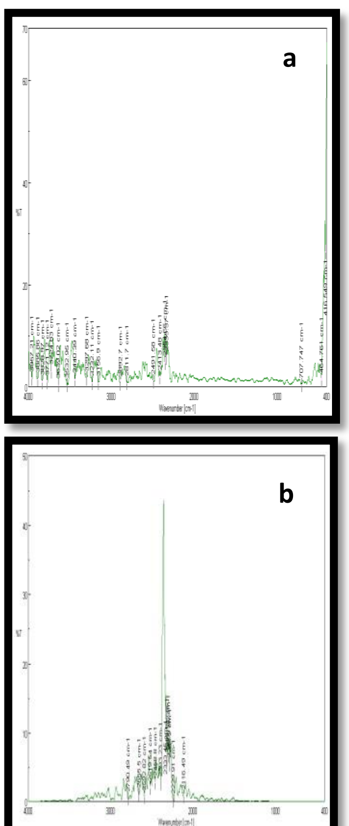


Fig. 8. FTIR spectra of adsorption layer formed on the mild steel surface immersion in 1N H_2SO_4 acid (a) without (b) with RD (F) extract.

3.4.1. Analysis of FTIR spectra

FTIR spectra of mild steel treated with 1N HCl /H_2SO_4 without and with RD flower extract displayed in Figure 7a and 7b and 8a and 8b, showed either a decrease in the transmittance or disappearance of some of the above said bands, giving a strong evidence for the interaction between the metal and the functional groups such as OH, NH_2 and C=O leading to the formation of film of large surface coverage which serve as a barrier between the corrosive acid medium and the metal thereby inhibiting corrosion and also revealing the fact that *Musa acuminata* Red Dacca flower nutrients can absorb on the metal surface on the basis of donor-acceptor interactions between lone-pair electrons of N and the vacant d-orbital of Fe substrate (Deng 2011 a,b).

5. CONCLUSION

Qualitative analysis of *Musa acuminata* Red Decca flower extract showed presence of alkaloids, saponins, tannins, flavonoids, terpenoids, coumarins, phenols and steroids. Corrosion of mild steel in 1N HCl / H_2SO_4 acid medium was significantly reduced upon the additions of RD flower extract. Inhibition efficiency increased with increasing concentration of inhibitor. Maximum inhibitor efficiency was observed at an optimum concentration of 2.5 % v/v. The flower extract of RD showed maximum efficiency of 99.40 % in 1N HCl at 5 hours of immersion. The flower extract of RD showed maximum efficiency of 96.99 % in 1N H_2SO_4 at 7 hours of immersion. RD (F) extract showed better inhibitive effect in 1N HCl when compared to H_2SO_4. Whereas RD (F) had better inhibitive effect spread throughout the various concentrations from 0.1 to 2.5 % v/v in HCl medium. All the results of the present study indicate that the extracts *Red Decca* flower in 1N HCl / H_2SO_4 acid can be used as corrosion inhibitors for mild steel. Further, as these extracts are environmental friendly, they can be considered as green corrosion inhibitors.

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