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Corrosion Inhibition of Mild Steel by the Fruit Extract *of Emblica officinalis, Tinospora cordifolia, Terminalia arjuna, Glycyrrhiza glabra, Bauhinia variegate and Voila odorata* in Sulphuric Acid Solution.

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ABSTRACT

Emblica officinalis fruits, *Tinospora cordifolia*, *Terminalia arjuna*, *Glycyrrhiza glabra*, *Bauhinia variegate* and *Voila odorata* were investigated as corrosion inhibitor for mild steel in 1 M H_2SO_4 solution by weight loss method. Plants showed good inhibition efficiency at different concentrations. Inhibition was found to increase with increasing concentration of plant extract. The results obtained show that the fruit extract of plants could serve as an effective corrosion inhibitor for mild steel in sulphuric acid medium.
Keywords: *Emblica officinalis* fruits, *Tinospora cordifolia*, *Terminalia arjuna*, *Glycyrrhiza glabra*, *Bauhinia variegate and Voila odorata,* Mild Steel, Weight Loss.

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INTRODUCTION

Steel is widely used in industries and machinery and many other fields. Acids are used in industries during pickling, cleaning, descaling etc [1]. Inhibitors are used in acid solution to prevent metal dissolution. The use of organic inhibitors is most effective and most economical method for protection of metallic corrosion. The efficiency of an organic compound as an inhibitor depends upon on its ability to get adsorbed on the metal surface by replacing water molecules with metal surface [2]. A number of organic compounds have been reported as effective corrosion inhibitors [3-8]. But most of them are highly toxic to both human being and environment. The toxic effects of these inhibitors have led to the use of naturally occurring products as corrosion inhibitors [9]. Sulphur and nitrogen containing compounds are more effective as corrosion inhibitor in acid medium [10].

The adsorption of an inhibitor is influenced by the electronic structure of inhibiting molecules steric factors, aromaticity, electron density at donor site, presence of functional groups, molecular area and molecular weight of the inhibitor molecule [11, 12]. The adsorption requires the existence of attractive forces between the adsorbate and the metal [13]. Adsorption can be physisorption, chemisorption or a combination of both [14]. Most of the commercially available inhibitors are toxic in nature Thus, the development of non-toxic corrosion inhibitors of natural source and non-toxic type, has been considered to be more important and desirable [15].

EXPERIMENTAL

Preparation of plant extract

Dried plants were soaked to deionised water (500 ml*)* and refluxed for 5h.The aqueous solution was filtered and concentrated to100 ml. This concentrated solution was used to prepare solutions of different concentrations by dilution method.

Weight loss measurements

Mild steel strips composed of (wt%) Fe 99.30%, C 0.076%, Si 0.025%, Mn 0.125%, P 0.012%,Cr 0.050%, Al 0.023% and Cu 0.135% were abraded with emery paper (600,800.1000,120) then cleaned with double distilled water, degreased with acetone and dried. The rectangular specimens with dimension 2.5 cm× 2.0 cm were used in weight described previously [16]. Weight loss measurements were performed at 308 k for 3 hours by immersing the mild steel coupons into acid solution (50 ml) without and with various amounts of inhibitors. After the elapsed time, the specimen were taken out, washed, dried and weighed accurately. All the experiments were conducted in aerated 1 M H_2SO_4. All the concentrations of inhibitors for weight loss were taken in mgL^{-1} by weight. The inhibition efficiency   and surface coverage (ϑ) was determined by using following equation:

$$\theta = \frac{w_0 - w_i}{w_0} \tag{1}$$

$$\eta\% = \frac{w_0 - w_i}{w_0} \times 100 \tag{2}$$

where, w_i and w_0 are the weight loss values in presence and absence of inhibitor, respectively.
The corrosion rate (C_R) of mild steel was calculated using the relation:

$$C_R \,(mm/y) = \frac{87.6 \times w}{atD} \tag{3}$$

where, w is corrosion weight loss of mild steel (mg), a the area of the coupon (cm^2), t is the exposure time (h) and D the density of mild steel (g cm^{-3}).

RESULTS AND DISCUSSION

Weight loss measurements

The weight loss results obtained for mild steel in 1 M H_2SO_4 in the presence and absence of different concentration of plants are summarized in Tables. The corrosion rate (mg cm^{-2}) values of mild steel in 1N H_2SO_4 decreases as the concentration of inhibitor increases i.e., the inhibition efficiency increases as the concentration of inhibitor is raised.

Table 1: Corrosion parameters for mild steel in 1 M H_2SO_4 in absence and presence of different concentrations of *Emblica officinalis* fruits from weight loss measurements for 3 hours.

Acid solution	Inhibitor concentration (mgL^{-1})	Weight loss (mgcm^{-2})	η(%)	θ	C_R(mm year^{-1})
1 M H_2SO_4	00.00	28.98	00.00	.0000	106.41
	30.00	25.97	10.38	.1038	95.36
	60.00	23.18	20.01	.2001	85.12
	90.00	22.72	21.60	.2160	83.43
	120.00	20.40	29.60	.2960	74.91
	180.00	20.40	29.60	.2960	74.91
	240.00	17.39	39.99	.3999	63.85
	300.00	15.30	47.20	.4720	56.18
	600.00	12.60	56.52	.5652	46.26
	1000.00	05.79	80.02	.8002	21.26
	2000.00	05.11	82.36	.8236	18.76

Table 2: Corrosion parameters for mild steel in 1 M H_2SO_4 in absence and presence of different concentrations of *Glycyrrhiza glabra* from weight loss measurements for 3 hours.

Acid solution	Inhibitor concentration (mgL^{-1})	Weight loss (mgcm^{-2})	η(%)	θ	C_R(mm year^{-1})
1 M H_2SO_4	0	37.12	00.00	.0000	137.72
	30	29.47	20.60	.2060	109.34
	60	21.05	43.29	.4329	78.10
	90	18.53	50.08	.5008	68.72
	180	16.19	56.65	.5665	59.69
	300	14.73	60.31	.6031	54.65
	600	11.04	70.25	.7025	40.96
	1000	10.54	71.60	.7160	39.10
	2000	06.32	82.97	.8297	23.44

Table 3: Corrosion parameters for mild steel in 1 M H_2SO_4 in absence and presence of different concentrations of *Terminalia arjuna* from weight loss measurements for 3 hours.

Acid solution	Inhibitor concentration (mgL^{-1})	Weight loss (mgcm^{-2})	η (%)	θ	C_R(mm year^{-1})
	0	35.143	00.00	.0000	130.39
	180	30.172	14.14	.1414	111.94
	300	26.83	23.65	.2365	99.54
	600	24.13	31.30	.3130	89.56
1 M H_2SO_4	1000	22.68	35.46	.3546	84.14
	2000	19.83	43.57	.4357	73.57

Table 4: Corrosion parameters for mild steel in 1 M H_2SO_4 in absence and presence of different concentrations of *Tinospora cordifolia* from weight loss measurements for 3 hours.

Acid solution	Inhibitor concentration (mgL^{-1})	Weight loss (mgcm^{-2})	η (%)	θ	C$_R$(mm year^{-1})
1 M H_2SO_4	0	33.68	00.00	.0000	124.96
	60	16.84	50.00	.5000	62.48
	120	14.73	56.26	.5626	54.65
	180	10.77	68.02	.6802	39.95
	600	10.29	69.44	.6944	38.17
	1000	10.28	69.47	.6947	38.14
	2000	8.04	76.12	.7612	29.83

Table 5: Corrosion parameters for mild steel in 1 M H_2SO_4 in absence and presence of different concentrations of *Bauhinia variegate* from weight loss measurements for 3 hours.

Acid solution	Inhibitor concentration (mgL^{-1})	Weight loss (mgcm^{-2})	η (%)	θ	C$_R$(mm year^{-1})
1 M H_2SO_4	0	34.63	00.00	.0000	128.48
	30	26.15	24.48	.2448	97.02
	60	18.34	47.04	.4704	68.04
	90	16.85	51.34	.5134	62.51
	120	14.00	59.57	.5957	51.94
	180	12.35	64.33	.6433	45.82
	240	12.07	65.14	.6514	44.78
	1000	10.52	69.62	.6962	39.03
	2000	6.31	81.77	.8177	23.41

Table 6: Corrosion parameters for mild steel in 1 M H_2SO_4 in absence and presence of different concentrations of *Voila odorata* from weight loss measurements for 3 hours.

Acid solution	Inhibitor concentration (mgL^{-1})	Weight loss (mgcm^{-2})	η(%)	θ	C$_R$(mm year^{-1})
1 M H_2SO_4	0	36.06	00.00	.0000	133.79
	30	27.53	23.65	.2365	102.14
	120	21.06	41.59	.4159	78.13
	240	16.21	55.04	.5504	60.14
	300	12.23	66.08	.6608	45.37
	1000	10.52	71.71	.7171	39.03
	2000	8.42	76.65	.7665	31.24

Mechanism of Action

The first stage in the action mechanism of inhibitor in acid medium is adsorption on the metal surface [17]. In most inhibition studies, the formation of donor accepter surface complexes between π- electrons of inhibitors and the vacant d- orbital of metal were postulated [18-20].

CONCLUSION

The examined fruit extracts of plants inhibits the corrosion of mild steel in 1 M H_2SO_4 via adsorption. Inhibition efficiency increases with increase in the concentration of inhibitors.

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