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Ecofriendly Extract of *Euphorbia hirta* as Corrosion Inhibitor on Mild Steel in Sulphuric Acid Medium

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The influence of the addition of acid extract of *Euphorbia hirta* on the corrosion of mild steel in 1 M H_2SO_4 was studied by weight loss measurement. The inhibition efficiency increases with extract concentration and immersion period. The effect of temperature studied indicated that inhibition efficiency increased with temperature. The negative value of the free energy of adsorption indicates spontaneous adsorption. The inhibitor obeys Temkin adsorption isotherm. The inhibition activity is due to the adsorption of active components which are found in the *Euphorbia hirta* extract.

Key Words: Mild steel, Plant extract, Corrosion inhibitor, Acid inhibitors Temkin adsorption.

INTRODUCTION

Mild steel is a material of choice due to low cost, easy availability and fabrication of machineries. Sulphuric acid has been widely used in pickling baths and descaling operations. Hence, in present studies, H_2SO_4 medium was chosen. Recently extract of many common plants such as *Nypa fructicans* wurmb[1], *Acalypha indica*[2], *Lawsonia*[3], *Enicostemma axillare*[4], *etc*. were reported to be effective acid corrosion inhibitors because of its biodegradability and ecofriendliness. The natural organic compounds having hetero atoms are also found to have higher basic properties and electron density, which assist in corrosion inhibition[5]. *Euphorbia hirta* is an erect small plant common in waste ground throughout the hotter parts of India. It belongs to family *Euphorbiaceae*. Hydrolysable tannins, flavones, sterols and triterpenes including phytosterols, cardiac glycosides, diterpenes, alkaloids and anthocyanins were isolated from this plant. The screening procedures were adapted from Mojab *et al.*[6]. Hydrochloric acid extract was subjected to preliminary phyto-chemical testing for the detection of bio active ingredients. The results indicate that the acid extracts of *Euphorbia hirta* contained tannin, saponin, alkaloid, ketonic terpenoids and glycosides. Hence attempts are made to utilize the acid extracts of *Euphorbia hirta* as anti corrosion agent on mild steel in H_2SO_4 medium.

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EXPERIMENTAL

Reagent grade acid was used for preparation of acid extract of *Euphorbia hirta*. Five per cent of stock solution of the extract was prepared by refluxing 50 g of the dried and crushed leaves of *Euphorbia hirta* with 1000 mL of 1 M H_2SO_4 for 3 h and leaving it over night. Next day the filtrate volume was made up to 1000 mL using the same 1 M H_2SO_4. Mild steel strips of size 1 cm × 5 cm × 0.2 cm, with 2 mm diameter hole near the upper edge of the specimens, were polished with buffing, washed with Clark solution (1 L of HCl + 50 g stannous chloride + 20 g antimony trioxide) then rinsed with distilled water, finally dried with filter paper and stored in a desiccators. The coupons were weighed and fully immersed in 100 mL of acid solution, with the help of glass hooks, with and without inhibitor at different concentrations (0.05, 0.1, 0.2, 0.3, 0.5, 0.7 and 0.9 %). Experiments were carried out in 1 M H_2SO_4 at 298 K for 0.5, 2, 4, 6, 8, 24 and 48 h, respectively. The influence of temperature on the corrosion of mild steel has also been studied, at five different temperatures ranging from 298 to 343 K in the absence and presence of the inhibitors at different concentrations, for 0.5 h. The inhibition efficiency (IE) was calculated using the following formula

$$IE\ \% = \frac{W_u - W_i}{W_u} \times 100 \quad (1)$$

where W_u and W_i are the weight losses in the absence and presence of inhibitor, respectively.

RESULTS AND DISCUSSION

Table-1 shows the values of percentage of inhibition efficiency (IE) obtained from weight loss measurement for different concentration of the extract in 1 M H_2SO_4 at 298 K. The percentage of inhibition efficiency increases with increase in the extract concentration, over the entire concentration range studied, in all cases. The maximum inhibition efficiency of the extract was found to be 88.57 % at a concentration of 0.7 % and further increase in concentration did not cause any appreciable change in the performance of inhibitor. The results seem to be consistent more or less with an inhibition mechanism involving chemisorptions of some phytochemical ingredients in the leaves extract of *Euphorbia hirta*. The results obtained from preliminary phytochemical screening of extract are displayed in Table-2. The maximum inhibition efficiency was observed for 6 h of contact at 298 K. Table-3 shows the values of percentage of inhibition efficiency (IE) obtained from weight loss measurement for different concentration of the extract in 1 M H_2SO_4 at 298 to 343 K. The inhibition efficiency was found to increase with increasing temperature. Considering the influence of temperature on the behaviour of acid extract of *Euphorbia hirta*, it is noted that the inhibition efficiency increased up to 323 K and then slightly decreased. This may be due the fact that chemisorptions increases with temperature due to the strengthening of chemical bonds, as a result inhibition

TABLE-1
INHIBITION EFFICIENCY OF *Euphorbia hirta* EXTRACT ON MILD STEEL IN 1 M H_2SO_4 AT DIFFERENT IMMERSION PERIOD FROM WEIGHT LOSS METHOD AT ROOM TEMPERATURE

Concentration (%)	Inhibition efficiency (%)					
	0.5 h	2 h	4 h	6 h	8 h	24 h
0.05	26.59	39.02	42.07	50.33	49.83	43.37
0.10	45.38	54.42	56.56	61.57	56.69	54.55
0.20	57.96	63.92	71.21	70.74	61.41	59.21
0.30	66.37	74.34	78.56	77.69	73.68	71.50
0.50	72.46	78.37	80.09	83.22	80.84	78.68
0.70	80.84	85.06	87.80	88.57	84.95	82.68
0.90	78.75	86.98	86.25	88.17	82.56	80.85

TABLE-2
PRELIMINARY PHYTOCHEMICAL SCREENING OF EXTRACT OF *Euphorbia hirta*

Plant	Saponins	Tannins	Flavonoids	Alkaloids	Cardiac glycosides	Cyanogenic glycosides
E. hirta	+	+	-	+	-	+

TABLE-3
INHIBITION EFFICIENCY OF *Euphorbia hirta* EXTRACT ON MILD STEEL IN 1 M H_2SO_4 FOR DIFFERENT CONCENTRATION USING WEIGHT LOSS METHOD AT DIFFERENT TEMPERATURES

Concentration (%)	*Inhibition efficiency (%)*				
	298 K	313 K	323 K	333 K	343 K
0.05	27.67	34.16	43.81	55.65	43.08
0.10	40.25	46.38	51.65	69.03	57.90
0.20	54.61	60.52	61.65	76.65	66.13
0.30	59.75	66.77	71.85	80.48	73.98
0.50	67.30	73.04	80.41	82.25	78.63
0.70	76.73	78.68	82.78	84.27	81.98

efficiency increases with temperatures up to 323 K and thereafter the decomposition of the inhibitor may occur. This indicates that the chemical adsorption of the inhibitor on the metal surface. The maximum inhibition efficiency was found to be 84.27 % at 323 K for 0.7 % concentration of the extract. Energy of activation (E_a) was calculated with the help of the Arrhenius equation:

$$\log \frac{\rho_2}{\rho_1} = \frac{E_a}{2.303 \times R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right] \quad (2)$$

ρ_2 and ρ_1 are the corrosion rates at T_2 and T_1, respectively. The free energy of adsorption (ΔG_{ads}) at different temperatures was calculated from the following equation[7].

$$\Delta G_{ads} = -2.303 \times 8.314 \times T \times \text{Log}(K \times 55.5) \quad (3)$$

$$K = \frac{\theta}{(1-\theta)\,C}$$

where θ is the surface coverage on the metal surface, C is the concentration of the inhibitor in percentage and K is the equilibrium constant. Table-4 shows the calculated average values of activation energy (E_a) over the temperature range 298 to 333 K and free energy of adsorption (ΔG_{ads}), for mild steel corrosion with and without inhibitor. E_a value for 1 M H_2SO_4 is 75.55 KJ/mol and 69.54 KJ/mol for 0.7 % of the inhibitor. It is observed that this E_a value is less than that of the uninhibited system. The magnitude of E_a obtained supports the assertion that chemical adsorption is involved. To explain the nature of the adsorption of the inhibitor, adsorption isotherm model of Temkin was employed. Fig. 1 represents θ against log C for mild steel in 1 M H_2SO_4 containing acid extract of *Euphorbia hirta* for 4 h at room temperature and 333 K temperature. Straight lines suggest that the inhibitor follows the Temkin adsorption isotherm. The negative values of ΔG_{ads} indicated spontaneous adsorption and a string interaction of the compound on the mild steel surface.

TABLE-4
CALCULATED VALUES OF ACTIVATION ENERGY (E_a), FREE ENERGY OF ADSORPTION FOR MILD STEEL CORROSION IN 1 M H_2SO_4 WITH AND WITHOUT ACID EXTRACT OF *Euphorbia hirta*

Conc. (%)	E_a (KJ/mol)	Free energy adsorption (ΔG_{ads}) (KJ/mol)					Average	Enthalpy	Entropy
		298K	313K	323K	333K	343K			
Blank	75.55	-	-	-	-	-	-	72.87	-
0.05	69.91	20.70	22.53	24.35	26.42	25.77	23.67	67.23	0.282
0.10	67.25	20.38	22.06	23.33	26.09	25.49	23.04	64.57	0.272
0.20	68.65	20.10	21.74	22.57	25.24	24.52	22.44	65.97	0.275
0.30	65.24	19.62	21.39	22.72	24.75	24.43	22.24	62.56	0.263
0.50	65.57	19.16	20.84	22.62	23.66	23.71	21.78	62.90	0.263
0.70	69.54	19.50	20.77	22.14	23.13	23.36	21.54	66.86	0.275

Conclusion

The extract of *Euphorbia hirta* leaves act as a good inhibitor for the corrosion of mild steel in acidic medium. The inhibition efficiency was found to increase with concentration, immersion period and temperatures studied. The adsorption of the extract of *Euphorbia hirta* on mild steel obeys Temkin adsorption isotherm. The thermodynamic parameters such as activation energy (E_a), free energy of adsorption (ΔG_{ads}) obtained from the study indicated the spontaneous adsorption of inhibitor on the surface of the metal. The inhibitive action of this plant extract may be due to the strong chemisorptions of the active ingredients of the acid extract.

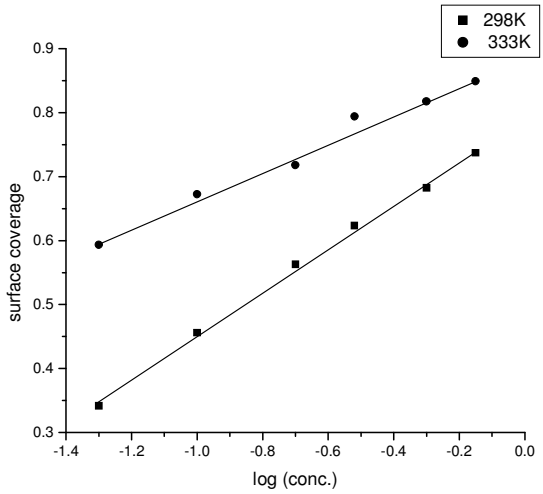

Fig. 1. Temkin adsorption isotherm of *Euphorbia hirta* on the surface of mild steel

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