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Original Research Paper

Inhibition Effect of Eco-friendly Extract of *Euphorbia hirta* on Dissolution of Mild Steel in Hydrochoric Acid Medium

P.K. Kasthuri and A. Arulanantham*
Department of Chemistry, PPG Institute of Technology, Coimbatore-641 035, T. N., India
*Department of Chemistry, G.C.T, Coimbatore-641 013, T. N., India

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ABSTRACT

The influence of the addition of acid extract of *Euphorbia hirta* on the corrosion of mild steel in 1M HCL 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.

INTRODUCTION

Mild steel is a material of choice due to low cost, easy availability and fabrication of machineries. HCl has been widely used in pickling baths and descaling operations. Hence, HCl was the choosen medium. Recently extracts of many common plants such as *Nypa fructicans* (Orubite-Okorosaye & Oforka 2004), *Acalypha indica* (Kasthuri et al. 2006), *Lawsonia* (EL-Etre et al. 2005), *Enicostemma axillare* (Kalpana & Mehta 2003), etc. were reported to be effective acid corrosion inhibitors because of their biodegradability and ecofriendliness. Also, the natural organic compounds having hetero atoms are found to have higher basic properties and electron density, which assist in corrosion inhibition (Chandrasekaran & Murali Sankar 2006). *Euphorbia hirta* is an erect small plant growing commonly in wastelands 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 Fraz Mojab et al. (2003). Hydrochloric acid extract was subjected to preliminary phytochemical testing for the detection of bioactive ingredients. The results indicate that the acid extracts of *Euphorbia hirta* contain tannin, saponin, alkaloids, ketonic terpenoids and glycosides. Hence, attempts are made to utilize the acid extracts of *Euphorbia hirta* as anticorrosion agent on mild steel in HCl medium.

MATERIALS AND METHODS

Reagent grade acid was used for preparation of acid extract of *Euphorbia hirta*. Five percent of stock solution of the extract was prepared by refluxing 50g of the dried and crushed leaves of *Euphorbia hirta* with 1000 mL of 1M HCl for 3 hours and leaving it overnight. Next day the filtrate volume was made up to 1000 mL using the same 1M HCl. Mild steel strips of size 1 × 5 × 0.2 cm with 2mm diameter hole near the upper edge of the specimens, were polished with buffing, washed with Clark solution (1L of HCl + 50g stannous chloride + 20g antimony trioxide), rinsed with distilled water, finally dried with filter paper and stored in a desiccator. The coupons were weighed and fully im-

mersed in 100mL 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 1M HCl at 298K temperature for 0.5, 2, 4, 6, 8, 24 and 48 hours respectively. The influence of temperature on the corrosion of mild steel has also been studied at five different temperatures ranging from 298K to 343K in absence and presence of the inhibitors at different concentrations for 30 minutes. The inhibition efficiency (IE) was calculated using the following formula.

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

Where, W_u and W_i are the weight losses in 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 concentrations of the extract in 1M HCl at 298K temperature. The percentage of inhibition efficiency increases with increase in the extract concentration over the entire concentration range studied in all the cases. The maximum inhibition efficiency of the extract was found to be 97.46% 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 chemisorption of some phytochemical ingredients in the leaf 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 4 hours of contact at 298K temperature. Table 3 shows the values of percentage of inhibition efficiency (IE) obtained from weight loss measurement for different concentrations of the extract in 1M HCl at 298K to 343K temperature. 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 333K temperature and then slightly decreased. This may be due the fact that chemisorption increases with temperature due to the strengthening of chemical bonds, and as a result inhibition efficiency increases with temperatures up to 333K and thereafter the decomposition of the inhibitor may occur. This indicates the chemical adsorption of the inhibitor on the metal surface. The maximum inhibition efficiency was found to be 84.87% at 333K temperature for 0.7% concentration of the extract. Energy of activation (E_a) was calculated with the help of Arrhenius equation (Ebenso 2004).

$$Log \frac{r_2}{r_1} = \frac{E_a}{2.303 \times R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right] \quad \text{...(2)}$$

Where, r_2 and r_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 (Shand et al. 1995).

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

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

Where, θ is the surface coverage on the metal surfaces, C is the concentration of the inhibitor in

Table 1: Inhibition efficiency of *Euphorbia hirta* extract on mild steel in 1M HCl at different immersion periods from weight loss method at room temperature.

Conc. (%)	Inhibition Efficiency (%)					
	1/2 hr	2 hrs	4hrs	6hrs	8hrs	24hrs
0.05	34.16	64.16	72.37	61.7	56.21	41.05
0.1	45.61	73.98	79.89	70.5	70.58	56.51
0.2	56.28	81.46	89.21	88.09	84.39	76.53
0.3	62.34	87.53	93.59	92.81	90.95	82.66
0.5	68.25	91.27	96.71	96.25	93.29	89.37
0.7	78.71	92.35	97.46	96.45	95.2	91.05
0.9	75.18	89.64	92.74	91.57	90.46	89.54

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 1M HCl for different concentrations using weight loss method at different temperatures.

Conc.(%)	Inhibition efficiency (%)				
	298K	313K	323K	333K	343K
0.05	34.16	40.65	52.16	59.30	49.60
0.10	45.61	54.36	60.33	67.21	58.99
0.20	56.28	67.07	70.43	71.78	69.37
0.30	62.34	72.7	73.32	79.39	74.02
0.50	68.25	75.58	76.92	81.73	78.24
0.70	73.71	79.84	81.13	84.87	81.93

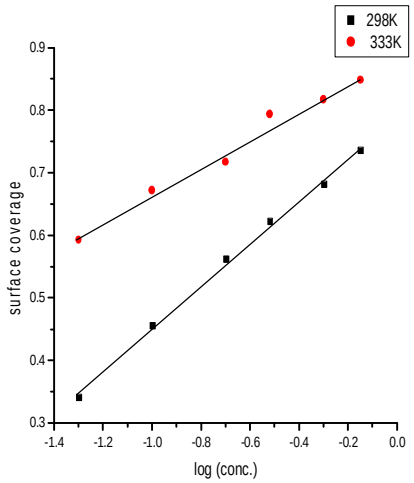

Fig. 1: Temkin adsorption isotherm of *Euphorbia hirta* on the surface of mild steel.

percentage and *K* is the equilibrium constant. Table 4 shows the calculated average values of activation energy (E_a) over the temperature range of 298K to 333K and free energy of adsorption (ΔG_{ads}) for mild steel corrosion with and without inhibitor. E_a value for 1M HCl is 58.16 kJ/mol and 57.72 kJ/mol for 0.5% 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 (Sankarapapavinasam et al. 1989). To explain the nature of the adsorption of the inhibitor, adsorption isotherm model of Temkin was employed. Fig. 1 represents the θ against log *C* for mild steel in 1M HCl containing acid extract of *Euphorbia hirta* for 4 hours at room temperature and 333K temperature. Straight lines suggest that the inhibitor fol-

Table 4: Calculated values of activation energy Ea and free energy of adsorption for mild steel corrosion in 1M HCl with and without acid extract of *Euphorbia hirta.*

Conc.(%)	Ea kJ/mol	Free energy adsorption(ΔG_{ads}) kJ/mol					
		298K	313K	323K	333K	343K	Average
67.01	-	-	-	-	-	-	
0.05	60.35	21.45	23.25	25.25	26.83	26.52	24.41
0.1	62.84	20.92	22.89	24.28	25.86	25.62	23.65
0.2	62.00	20.27	22.48	23.62	24.53	24.94	22.91
0.3	62.08	19.89	22.13	22.92	24.56	24.44	22.48
0.5	61.34	19.27	21.19	22.06	23.56	23.65	21.63
0.7	61.39	19.09	20.95	21.84	23.26	23.35	21.40

lows 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.

CONCLUSION

The extract of *Euphorbia hirta* leaves acts 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 (Ea) and free energy of adsorption (ΔG_{ads}) obtained from the study indicated spontaneous adsorption of inhibitor on the surface of the metal. The inhibitive action of the plant extract may be due to strong chemisorptions of the active ingredients of the acid extract.

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