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RESEARCH ARTICLE

Comparative study of mild steel corrosion in 1N Sulphuric acid using Aloe vera and Lawsonia inermis extract

***V. Kumaravelan[1], D. Dhivya priya[2]**

1. Department of Chemistry, Mahendra Arts and Science College, Namakkal, TamilNadu.

2. Department of Chemistry, VSA Group of Institutions, Salem, TamilNadu.

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****Corresponding Author***

V. Kumaravelan

Abstract

Inhibitive action of the extracts of Aloe vera and Lawsonia inermis on the corrosion of mild steel in 1 N H_2SO_4 has been studied using conventional weight loss method. The effect of temperature on the corrosion behavior of mild steel was studied in the range of 303 -333 K. It was found that both extracts inhibit remarkably the corrosion of mild steel in acidic solution. The inhibitor efficiency is obtained from weight loss experiments were in good agreement and shows that inhibition efficiency increases with increase in extracts concentration. On comparison of both plants extract finally 5% of Lawsonia inermis extract is found to be good inhibitor in corrosion inhibitor of mild steel in acid medium. Maximum inhibition efficiency obtained is found to be 80 % at 323 K.

Introduction

Corrosion is defined as the deterioration of a metal due to its interaction with the environment. Due to corrosion many useful properties of a metal such as malleability, ductility and electrical conductivity are lost [1-3]. Mild steel is extensively used as a constructional material in many industries because of its excellent mechanical properties, ductability, weldability and low cost [4]. Mild steel has diverse applications found but it suffers severe corrosion in acidic environment [5].The use of corrosion inhibitors has become an answer to the corrosion attack of mild steel which always lead to damage and total replacement of these mild steels. Most studies on corrosion inhibitor reported that a large number of inhibitors are organic compound with N, S, and O hetero atoms, they have higher electron density and making them the reaction centers [6-10]. These compounds are adsorbed on the metallic surface and block the active corrosion sites; most of them are highly toxic to both human beings and the environment. Because of their hazardous nature, researchers focus their attention on developing cheap, non-toxic, biodegradable and eco-friendly and harmless natural products of plant origin as corrosion inhibitors [11-17]. Hence the use of Natural medicinal plants as corrosion inhibitors has gained popularity [18-20]. Plant extracts are an incredibly rich source of naturally occurring organic compounds contains proteins, Polycarboxylic, polysaccharides acids, tannin, alkaloids and pigments etc. These compounds work as potential inhibitors for many metals in acidic environment. This is because they can be extracted at low cost, easily available, biodegradable and poses no harm to the environment. The aim of the present work is to investigate the comparative studies of corrosion inhibitive property of aloe vera and Lawsonia inermis by using weight loss method in 1N H_2SO_4 for mild steel.

Material and Methods

Collection of sample:

The bark of aloe vera and Lawsonia inermis were collected from Namakkal district, Tamilnadu, India.

Preparation of plant extract:

Fine powder from the shadow-dried leaves of Lawsonia inermis (L) (100g) was extracted to exhaustion with 1 N sulphuric acid using a Soxhlet apparatus. The extract is then filtered by using filter paper. The extract of Aloe Vera also prepared by above similar procedure.

Preparation of specimens:

The entire test specimens of mild steel were cut to an overall apparent size of 5.0 cm X 1.0 cm. The specimens were polished with different grades of emery papers namely 150, 320, 400, 800, 1200 and 2000 .These specimens were degreased with trichloroethylene dried and finally weighed.

Preparation of solution:

Sulphuric acid:

Sulphuric acid solution of strength 1N was prepared by dissolving 28 ml of Sulphuric acid in 1000 ml of distilled water.

Aloe vera extracts solution:

Aloe vera extract solution of 1 % was prepared by dissolving 1 ml of Aloe vera in 99 ml of 1 N sulphuric acid solution. Similarly 2%, 3%, 4%, 5% and 6% aloe vera extract were prepared.

Weight loss method:

Pure mild steel specimens were cut to get length of 5 cm and width of 1 cm and used for this study. They were pickled in 2-3 % sulphuric acid for 3 minutes and washed with distilled water. They were then polished to mirror finish by using 150, 320, 400, 800, 1200 and 2000 emery papers and degreased with trichloroethylene. Finally, they were weighed in a digital electronic balance. The specimens were immersed in solution of 1 N sulphuric acid containing 1%, 2%, 3%, 4%, 5% and 6% of Lawsonia inermis extract and aloe vera extract separately. The same procedure is repeated at various temperatures i.e. 303 K, 313 K, 323 K and 333 K respectively.

After the duration of 5 hours the specimens, were removed from thermostat and cleaned with distilled water, dried and finally weighed. The difference in weight was noted. From the weight loss the corrosion rate can be calculated from the equation

$$\text{Corrosion rate } (C_R) = \frac{87.6 \times W}{A \times T \times D} \text{ mmpy} \qquad \text{---------- (1)}$$

Where W is the weight loss of mild steel (mg), A the area of the specimen, T the exposure time (h) and D is the density of mild steel (gms/cm^3)

From the corrosion rate, inhibition efficiencies of the plant extracts (%) and the surface coverage (θ) as a result of adsorption of the components of the extracts were determined using Equations (2) and (3), respectively.

$$IE\ \% = \frac{W_b - W_i}{W_b} \times 100 \qquad \text{---------- (2)}$$

$$\theta = \frac{IE\%}{100} \qquad \text{---------- (3)}$$

Where W_b and W_i are the weight loss of the mild steel specimens in absence and in presence of inhibitors, respectively.

Result and Discussion

Weight Loss Method:

The corrosion behavior of mild steel in 1N sulphuric acid at various temperatures (ranges from 303-333 K) for both extract have been studied by weight loss method. The results are tabulated (Table.1).

From the Table.1, it can be seen that the corrosion rate of mild steel in 1N sulphuric acid is found to be increasing with increasing in temperature from 303-333 K. It indicates that the increasing in hours enhanced the corrosion process by the corrosion rate. It has been evident from the straight line behavior obtained by plotting a graph between corrosion rate Vs temperatures which shown in figure I.

The corrosion behavior of mild steel in 1N sulphuric acid after addition of 1% to 6% of "lawsonia inermis" and "Aloe vera" extracts separately at room temperature in 3 hours has been studied. The corrosion rate, inhibitor efficiency and surface coverage are calculated and results are tabulated. The rate of corrosion of mild steel in 1N sulphuric acid decreases with increasing % of both Lawsonia inermis and Aloe vera extract which shown in figure II and III.

From the table II & III, it can be seen that corrosion rate of mild steel decrease with increasing percentage of Lawsonia inermis extract up to 5 %. The Lawsonia inermis extract has less effect after addition of 6 % extract, since it increases the corrosion rate. It is also observed that the inhibitor efficiency is found to increase with respect to the concentration of inhibitor increase up to 5 % then decrease due to desorption of the inhibitor from the mild steel surfaces. It is also evident from the graph obtained by plotting percentage of inhibitor efficiency against percentage of inhibitor which shown in figure.4. The inhibitor efficiency is also equal to surface coverage (θ) and the maximum inhibitor efficiency obtained is 80.68 % at 323 K at room temperature.

From the table IV & V, it can be seen that corrosion rate of mild steel decrease with increasing percentage of Aloe vera extract up to 4 %. The Aloe vera extract has less effect after addition of 5 & 6 % extract, since it increases the corrosion rate. It is also observed that the inhibitor efficiency is found to increase with respect to the concentration of inhibitor increase up to 5 % then decrease due to desorption of the inhibitor from the mild steel surfaces. It is also evident from the graph obtained by plotting percentage of inhibitor efficiency against percentage of inhibitor which shown in fig.4. The inhibitor efficiency is also equal to surface coverage (θ) and the maximum inhibitor efficiency obtained is 80.31 % at 323 K at room temperature.

On comparing the two plants extract finally 5 % Lawsonia inermis extract is found to be good inhibitor in inhibition of mild steel corrosion in 1N sulphuric acid at 323 K since the maximum efficiency observed is 80.68 %

Table.1: Corrosion rate of mild steel in 1 N sulphuric acid with Lawsonia inermis and Aloe vera extract at various temp 303-333 K

Temperature in 'C'	Lawsonia Inermis				Aloe vera			
	Weight of mild steel				Weight of mild steel			
	Initial (g)	Final (g)	Difference (g)	Corrosion rate (mmpy)	Initial (g)	Final (g)	Difference (g)	Corrosion rate (mmpy)
303	13.4826	13.3581	0.1245	9.25	11.1479	10.9637	0.1842	13.69
313	12.4812	12.2876	0.1936	14.38	11.3414	10.9962	0.3452	25.65
323	12.1456	11.7241	0.4215	31.32	11.4244	10.9262	0.4982	37.02
333	12.8632	12.2316	0.6316	46.93	11.4216	10.7404	0.6812	50.61

Table 2: Corrosion rate of mild steel in 1 N sulphuric acid with Lawsonia inermis extract at 303 & 313 K

S.No	Concentration of Lawsonia inermis extract (%)	Initial weight (g)	Final weight (g)	Weight loss (g)	Corrosion rate (mmpy)	Inhibitor Efficiency (%)	Surface coverage (g)
Room temperature 303 K							
1	0	13.4826	13.3581	0.1245	9.25	-	-
2	1	12.9586	12.8654	0.0932	6.92	25.14	0.2514
3	2	12.3245	12.2430	0.0814	6.06	34.54	0.3454
4	3	12.8981	12.8279	0.0702	5.21	43.61	0.4361
5	4	13.1264	13.0636	0.0628	4.67	49.56	0.4956
6	5	12.4816	12.4304	0.0512	3.80	58.87	0.5887
7	6	12.2632	12.2046	0.0586	4.35	52.93	0.5293
Room temperature 313 K							
1	0	12.4812	12.2876	0.1936	14.38	-	-
2	1	12.9814	12.8579	0.1235	9.18	36.21	0.3621
3	2	12.1236	12.0090	0.1146	8.51	40.81	0.4081
4	3	13.1145	13.0159	0.0986	7.33	49.07	0.4907
5	4	12.2687	12.1861	0.0826	6.14	57.33	0.5733
6	5	13.8142	13.7414	0.0728	5.93	62.39	0.6239
7	6	12.8314	12.7472	0.0842	6.26	56.31	0.5651

Table 3: Corrosion rate of mild steel in 1 N sulphuric acid with Lawsonia inermis extract at 323 K & 333 K

S.No	Concentration of Lawsonia inermis extract (%)	Initial weight (g)	Final weight (g)	Weight loss (g)	Corrosion rate (mmpy)	Inhibitor Efficiency (%)	Surface coverage (g)
Room temperature 323 K							
1	0	12.1456	11.7241	0.4215	31.32	-	-
2	1	12.8423	12.5881	0.2542	18.89	39.69	0.3969
3	2	12.9347	12.7360	0.1987	14.76	52.85	0.5285
4	3	13.1432	13.0007	0.1425	10.59	66.19	0.6619
5	4	12.8631	12.7699	0.0932	6.92	77.88	0.7788
6	5	12.3892	12.3078	0.0814	6.00	80.68	0.8068
7	6	12.4329	12.3096	0.1233	9.16	70.74	0.7074
Room temperature 333 K							
1	0	12.8632	12.2316	0.6316	46.93	-	-
2	1	12.1841	11.7213	0.4628	34.39	26.72	0.2672
3	2	12.4330	12.0418	0.3912	29.07	38.06	0.3806
4	3	12.5819	12.2582	0.3237	24.05	48.74	0.4874
5	4	12.782	12.5404	0.2416	17.95	61.75	0.6175
6	5	12.6841	12.5209	0.1632	12.16	74.16	0.7416
7	6	12.8146	12.6165	0.1981	14.72	68.64	0.6864

Table 4: Corrosion rate of mild steel in 1 N sulphuric acid with Aloe vera extract at 303 K & 313 K

S.No	Concentration of Lawsonia inermis extract (%)	Initial weight (g)	Final weight (g)	Weight loss (g)	Corrosion rate (mmpy)	Inhibitor Efficiency (%)	Surface coverage (g)
Room temperature 303 K							
1	0	11.1479	10.9637	0.1842	13.69	-	-
2	1	11.9812	11.8598	0.1214	9.02	34.09	0.3409
3	2	10.7634	10.6670	0.0964	7.16	47.67	0.4767
4	3	10.8186	10.7369	0.0817	6.07	55.64	0.5564
5	4	11.1526	11.0883	0.0693	5.14	62.38	0.6238
6	5	11.2234	11.1511	0.0732	5.44	60.26	0.6026
7	6	10.9215	10.8403	0.0812	6.03	55.92	0.5592
Room temperature 313 K							
1	0	11.3414	10.9962	0.3452	25.65	-	-
2	1	11.6872	11.4704	0.2168	16.10	37.19	0.3719
3	2	11.1439	10.9787	0.1652	12.27	52.14	0.5214
4	3	11.1348	11.0185	0.1163	8.64	66.31	0.6631
5	4	11.1619	11.0623	0.0996	7.40	71.15	0.7115
6	5	10.9811	10.8713	0.1098	8.16	68.19	0.6819
7	6	11.3214	11.2080	0.1134	8.43	67.15	0.6715

Table 5: Corrosion rate of mild steel in 1 N sulphuric acid with Aloe vera extract at 323 K & 333 K

S.No	Concentration of Lawsonia inermis extract (%)	Initial weight (g)	Final weight (g)	Weight loss (g)	Corrosion rate (mmpy)	Inhibitor Efficiency (%)	Surface coverage (g)
Room temperature 323 K							
1	0	11.4244	10.9262	0.4982	37.02	-	-
2	1	11.9143	11.6251	0.2892	21.49	41.95	0.4195
3	2	11.1126	10.9041	0.2085	15.49	57.55	0.5755
4	3	11.1781	11.0208	0.1573	11.69	68.43	0.6843
5	4	11.5516	11.4454	0.1062	7.89	80.31	0.8031
6	5	11.4347	11.3212	0.1135	8.43	77.22	0.7722
7	6	11.0356	10.8765	0.1591	11.82	68.07	0.6807
Room temperature 333 K							
1	0	11.4216	10.7404	0.6812	50.61	-	-
2	1	11.3493	10.8475	0.5018	37.28	26.33	0.2633
3	2	11.4912	11.0728	0.4184	31.09	38.58	0.3858
4	3	11.8518	11.5105	0.3413	25.36	49.89	0.4989
5	4	11.6319	11.3741	0.2578	19.15	62.15	0.6215
6	5	11.5818	11.2806	0.3012	22.38	55.78	0.5578
7	6	10.9914	10.6271	0.3643	27.07	46.52	0.4652

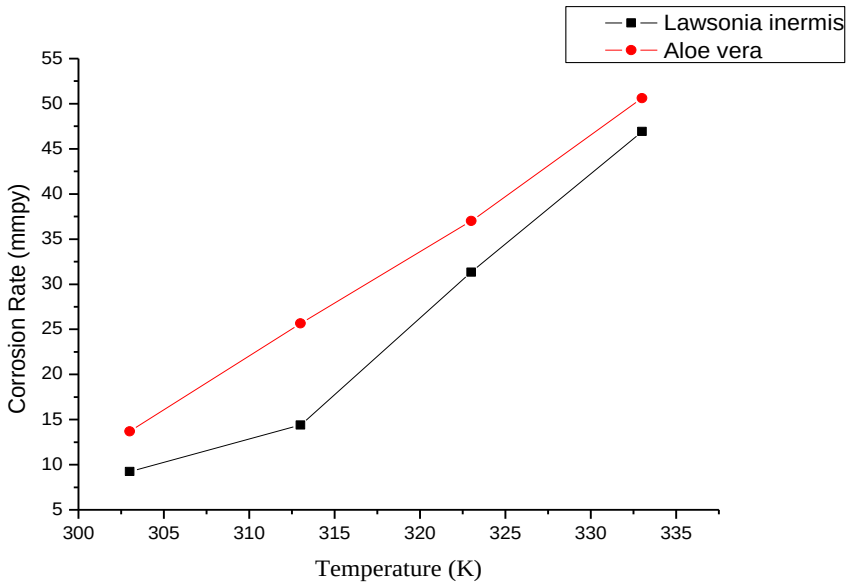

Figure.1. Corrosion rate Vs various temperature

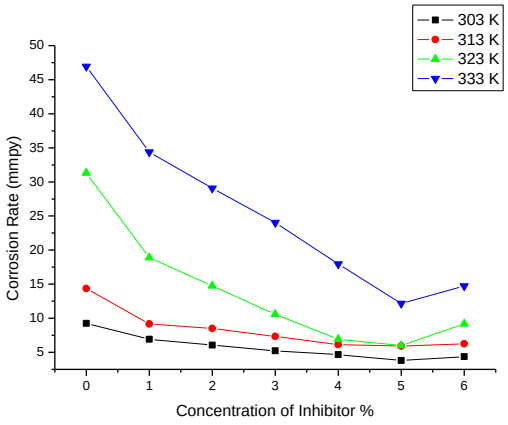

Figure.2. corrosion rate vs concentration of Lawsonia inermis extract

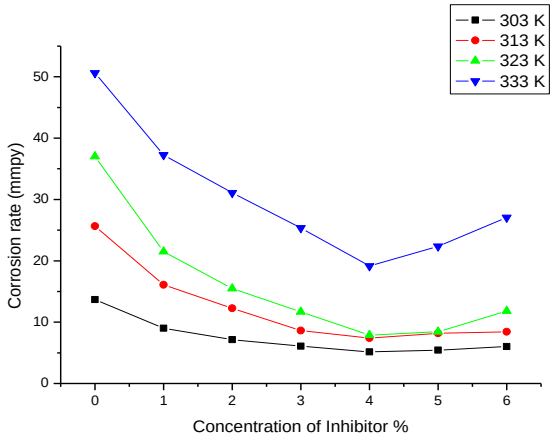

Figure.3. corrosion rate vs concentration of aloe vera extract

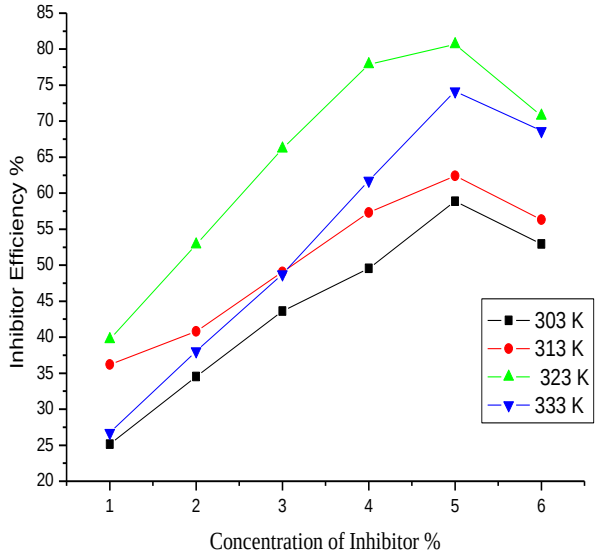

Figure.4. Inhibitor efficiency Vs concentration of inhibitor (Lawsonia inermis)

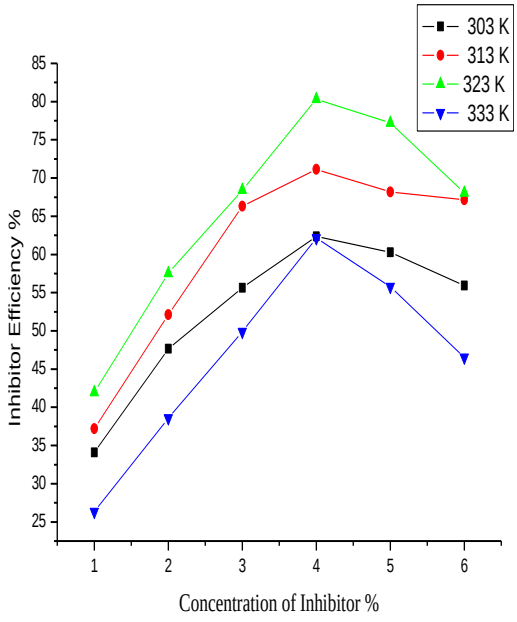

Figure.5. Inhibitor efficiency Vs concentration of inhibitor (Aloe vera)

Conclusion:

The Study of corrosion rates of mild steel in 1 N sulphuric acid are found to be increased with increase in the temperature using two medicinal plants Lawsonia inermis extract and Aloe vera extract. From comparing the two plants extract finally 5 % lawsonia inermis extract is found to be good inhibitor in inhibition of mild steel corrosion in 1N sulphuric acid at 323 K, since the maximum efficiency observed is 80.68 %.

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