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CORROSION INHIBITION OF IRON BY HYDROCHLORIC ACID SOLUTION BY *TEPHROSIA PURPURIA* PLANT

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ABSTRACT

Mass loss has been used to study the inhibition of iron corrosion in HCl solution by extracts of different parts of *Tephrosia purouria*. The values of inhibition efficiency obtained by the mass loss method is in good agreement and depends upon the inhibitor and the acid.

Key words: Corrosion inhibitor, Iron, Acid, *Tephrosia purpuria*, Plant powder.

INTRODUCTION

Iron finds a variety of applications owing to its excellent strength and use. It is used widely for mechanical and structural engineering purposes in bridgework, structural reactors, boiler plates, automobiles etc. It is the material of choice for most of the tanks, pipelines and buried structures. It is commonly used for ship hulls, offshore drilling platforms and other immersed structures.

Metallic corrosion is a very common but a serious problem, causing considerable revenue loss throughout the whole word. Mitigation of corrosion requires the application of various engineering techniques and scientific knowledge on the role of the alloying elements in the reduction of the corrosion losses and application of the film forming inhibitors are well known[1].

However, iron, when left open to surroundings to corrode, the corrosion of iron in atmosphere is affected by various factors like humidity[2], temperature, metal composition, the presence of pollutants like sulphur dioxide[3]; for buried structure, the moisture, type of soil[4], etc. These factors influence the corrosion rate and therefore, the life of the article.

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Generally, the organic compounds having hetero atoms O, N, S are found to have higher basicity and electron density and thus, assist corrosion inhibitor[5]. Oxygen, nitrogen and sulphur are the active centers for the process of adsorption on the metal surface. Numerous naturally occurring substance like. *Terminalia chebula*, *Egenia imbolans*[6], *Annona squamosa*, *Pongamia glabra*[7], *Acacia conciana*[8], *Swertia aungustifolia*[9], *Eucalyptus* leaves[10], Beet-root[11,12], *Henna*[13], *Prosopis joliflora*[14], *Ficus rligeousa*[15] and *Tephrosia purpuria*[16-17] as well as very popular Ayrvedic powder Mahasudarshana churna have been evaluated as effective corrosion inhibitors.

Tephrosia purpuria grows as common wasteland weed. It is used traditionally as folk medicine. In many part, it is under cultivation as green manure crop. According to Ayurvda, this plant is digestive, anthelmintic, antipyretic, asthma and cures diseases of lever, heart, blood, leprosy etc.

The importance of this study lies in the fact that such naturally occurring plant products are environmentally compatible, non-polluting, less toxic, easily available, bio-degradable and are cheaper corrosion inhibitors.

EXPERIMENTAL

Specimen preparation

Rectangular specimens of iron (dimension 1.5 × 2.5 × 0.036 cm.) with a small hole of about 2 mm diameter near the upper edge were employed for the determination of mass loss measurements.

The chemical composition of test specimen used was C = 0.12%, Mg = 0.40%, Si = 0.14%, S = 0.04% and remaining was Fe. Buffing to produce a mirror finish with the help of emery paper cleaned specimen was then degreased with acetone. Each specimen was suspended by a glass hook and immersed in a beaker containing 50 mL of test solution at 299 ± 2 K and left exposed to air. Evaporation losses were made up with distilled water. The test specimens were cleaned with benzene [18]. Duplicate experiments were performed in each case and mean values of the mass were calculated.

Test solution preparation

The solution of 1N HCl was prepared using doubly distilled water. The *Tephrosia purpuria* extract was obtained by boiling 5 g dry powder of roots, branches leaves and seeds in 100 mL 1N HCl for 2 hrs. on a water bath at 500º C and then kept overnight. Next day, the filtrate volume was made 100 mL using distilled water to make 1 N concentration of 5%

of w/v *Tephrosia purpuria* contents. The acid solution was prepared by using A.R. grade reagent and inhibition solution.

The percentage inhibition efficiency was calculated as[19] -

$$I.E. = 100\ (\Delta Mu - \Delta Mi)/\ \Delta Mu \qquad \ldots(1)$$

Where ΔMu and ΔMi are the mass loss of the metal in uninhibited acid and inhibited solution, respectively.

The degree of surface coverage can be calculated as [20] -

$$\theta\ = (\Delta\ Mu - \Delta Mi)/\ \Delta Mu \qquad \ldots(2)$$

Where θ is surface coverage and ΔMu and ΔMi are the mass loss of the metal in uninhibited acid and inhibited solution, respectively.

The corrosion rate in mmpy (milli meter per year) can be obtained by the following equation.

$$\text{Corrosion rate (mmpy)} = \frac{\text{Mass loss} \times 87.6}{\text{Area} \times \text{Time} \times \text{Metal density}} \qquad \ldots(3)$$

Where mass loss is expressed in mg, area is expressed in inch of metal surface exposed, time is expressed in hours of exposure, and metal density is expressed in g/cm^3.

Results of inhibitor concentration

Effect of inhibition efficiency (I.E.) was calculated from the mass loss measurement for 1 N HCl. It was found that efficiency increases with the increase of inhibitor concentration for seeds, leaves, braches and roots extracts from 0.5% to 5%.

RESULTS AND DISCUSSION

Effect of immersion period

The effect of inhibition efficiency (I.E.) was calculated from the mass loss measurement for 1 N HCl. It was found that seeds extracts inhibitor efficiency increases up to 72 hrs for 0.5% to 2.5% inhibitor concentration but in case of 5% concentration, inhibitor efficiency decrease up to 72 hrs.

Inhibitor efficiency increases up to 36 hrs and then shows a decline for leaves extracts.

Inhibitor efficiency increases up to 72 hrs in branches and roots extracts inhibitor.

Effect of acid solution

It was found that the roots, branches, leaves and seeds extracts with 1N HCl have a good property to inhibit the corrosion of iron, even when the exposure time is also large.

Root extracts with 1 N HCl acid have shown the inhibitor efficiency from 55.55% to 88.88% for 3 hrs. whereas after 72 hrs. duration, the efficiency was obtained in range of 58.82% to 90.19% for 0.5%-5% concentration (Table 1)

Table 1: Inhibition efficiencies for iron in 1 N HCl with *Tephrosia purpuria*

Root conc.	**Inhibitor efficiency η (%)**						
%	**3 hrs**	**12 hrs**	**24 hrs**	**36 hrs**	**48 hrs**	**60 hrs**	**72 hrs**
0.5	55.55	58.06	58.33	55.00	59.52	60.86	58.82
1.0	62.96	64.51	61.11	70.00	69.04	67.39	72.54
1.5	66.66	67.74	69.44	75.00	71.42	71.73	76.47
2.0	70.37	70.96	77.77	77.50	80.95	78.26	78.43
2.5	77.77	77.41	83.33	82.50	85.71	82.60	86.27
5.0	88.88	83.87	88.88	87.50	83.33	86.95	90.19

Branch extracts with 1 N HCl acid have shown the inhibitor efficiency from 44.44% to 81.48% for 3 hrs. whereas after 72 hrs. duration, the efficiency was obtained in range of 64.70% to 88.23% for 0.5%-5% concentration (Table 2)

Leaves extracts with 1 N HCl acid have shown the inhibitor efficiency from 48.14% to 85.18% for 3 hrs. whereas after 72 hrs. duration, the efficiency was obtained in range of 54.90% to 86.27% for 0.5%-5% concentration (Table 3).

Table 2: Inhibition efficiencies for iron in 1 N HCl with *Tephrosia purpuria*

Branches conc.	Inhibitor efficiency η (%)						
%	3 hrs	12 hrs	24 hrs	36 hrs	48 hrs	60 hrs	72 hrs
0.5	44.44	45.16	47.22	50.00	54.76	56.52	64.70
1.0	48.14	51.61	52.77	55.00	59.52	69.56	68.62
1.5	55.55	54.83	58.33	60.00	66.66	65.21	70.58
2.0	62.96	64.51	66.66	67.50	71.42	71.43	76.47
2.5	74.07	74.19	75.00	72.50	80.95	76.08	82.35
5.0	81.48	80.64	80.55	80.00	85.71	84.78	88.23

Table 3: Inhibition efficiencies for iron in 1 N HCl with *Tephrosia purpuria*

Leaves conc.	Inhibitor efficiency η (%)						
%	3 hrs	12 hrs	24 hrs	36 hrs	48 hrs	60 hrs	72 hrs
0.5	48.14	48.38	50.00	52.50	52.38	53.33	54.90
1.0	59.25	54.06	58.33	60.00	57.14	63.04	64.70
1.5	62.96	58.06	66.66	65.00	69.04	73.91	74.50
2.0	66.66	74.19	72.22	72.50	76.19	80.43	80.39
2.5	70.73	70.64	80.55	80.00	78.57	78.26	84.31
5.0	85.18	83.87	83.33	88.00	80.95	89.13	86.27

Seeds extracts for 1 N HCl acid have shown the inhibitor efficiency from 51.85% to 81.48% for 3 hrs. whereas after 72 hrs. duration, the efficiency was obtained in range of 60.78% to 74.50% for 0.5%-5% concentration (Table 4)

Table 4: Inhibition efficiencies for iron in 1 N HCl with *Tephrosia purpuria*

Seeds conc.	Inhibitor efficiency η (%)						
%	3 hrs	12 hrs	24 hrs	36 hrs	48 hrs	60 hrs	72 hrs
0.5	51.85	54.83	55.55	57.50	57.14	58.69	60.78
1.0	55.55	58.06	58.33	62.50	54.76	60.86	62.74
1.5	59.25	64.51	63.88	67.50	59.52	67.39	66.66
2.0	44.44	67.74	61.11	70.00	64.28	69.56	70.58
2.5	66.66	70.76	72.22	72.50	71.42	71.73	72.54
5.0	81.48	77.41	75.00	75.00	69.04	73.91	74.50

Table 5: Effect of acid extracts of root, branches, leaves and seeds of *Tephrosia purpuria* on mass loss data for iron in 1N HCl

Effective area of specimen: 7.50 cm^2 Temperature: 299 ± 2 K Immersion time: 72 hrs

Inhibitor concentration (%)	Mass loss (mg)	Corrosion rate (mmpy)	Inhibitor efficiency η (%)	Surface coverage (θ)
Uninhibited	102	1.848		
Root				
0.5	42	0.761	58.82	0.5882
1.0	28	0.505	72.54	0.7254
1.5	24	0.436	76.47	0.7647
2.0	22	0.398	78.43	0.7843
2.5	14	0.253	86.27	0.8627
5.0	10	0.181	90.19	0.9019

Cont…

Inhibitor concentration (%)	Mass loss (mg)	Corrosion rate (mmpy)	Inhibitor efficiency η (%)	Surface coverage (θ)
Branches				
0.5	36	0.652	64.70	0.6470
1.0	32	0.580	68.62	0.6862
1.5	30	0.543	70.58	0.7058
2.0	24	0.435	76.47	0.7647
2.5	18	0.326	82.35	0.8235
5.0	12	0.217	88.23	0.8823
Leaves				
0.5	46	0.833	54.90	0.5490
1.0	36	0.652	64.70	0.6470
1.5	26	0.363	74.50	0.7450
2.0	20	0.290	80.39	0.8039
2.5	16	0.253	84.31	0.8431
5.0	14	0.254	86.27	0.8627
Seeds				
0.5	40	0.725	60.78	0.6078
1.0	38	0.688	62.74	0.6274
1.5	34	0.616	66.66	0.6666
2.0	30	0.543	70.58	0.7058
2.5	28	0.505	72.54	0.7254
5.0	26	0.471	74.50	0.7450

CONCLUSION

The acid extracts of *Tephrosia purpuria* are found to be effective inhibitors in acid giving efficiency up to 90% and can be safely used with out hydrogen damage, toxic effects and pollution problems.

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