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Studies on the Inhibition Activity of Rhoeo Discolor Plant (Leaves) Extract on Carbon Steel In Acid Media

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Abstract
There is an intensive support for new plant origin corrosion inhibitors for metal subjected to various environmental conditions. These efforts have been motivated by the desire to replace toxic inhibitors used for mitigation of corrosion of various metals and alloys in aqueous solutions. Plants represent a class of interesting source of compounds currently being explored for use in metal corrosion protection in most systems, as possible replacement of toxic synthetic inhibitors. In the present work the use of eco-friendly, biodegradable, non toxic, easily available Rhoeo discolor leaves extract as corrosion inhibitor in 0.1M - 0.5M HCl solution with different concentration of inhibitor by weight loss method at room temperature (30° C) are studied. The Rhoeo discolor plant extract acts as an efficient inhibitor on carbon steel at various concentration of HCl solution. The various concentration of HCl taken for the study were 0.1M,0.2M, 0.3M,0.4M, and 0.5M respectively. For 0.1M HCl concentration and 0.5g/L dosage at 120hr contact time highest efficiency of 75.31% was observed by weight loss method.

Key words: Carbon steel, HCl, Weight loss method, Inhibition efficiency

Introduction

Corrosion is the destruction or deterioration and consequent loss of metals through chemical or electrochemical attack by the environment [1]. The process of corrosion in reality is the transformation of pure metal in to its undesired metallic compounds. The life of metal object gets shortened by corrosion process. Corrosion can be fast or slow process depending upon the metal and the environment in which it is undergoing corrosion. The corrosion is a slow process taking place mainly on the metal surface, but the losses incurred due to corrosion are of high order [2]. The losses cannot be estimated by considering only the metal loss. The indirect losses are much higher. As industrial acid cleaner and pickling acid HCl is very often used [3] in order to remove scales from the surface pickling and is usually applied prior to hot-dip coating or electroplating. A less severe treatment than pickling like acid cleaning is used for final finish of metal surfaces before plating, painting, or storage. The organic inhibitors which are most

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effective and efficient are the compounds containing π bonds, phenyl rings, conjugated double bonds, heteroatom's (N, S, O, P) etc [4]. Bearing non-toxic characteristics and negligible negative environmental impact, drugs (chemical medicines) have emerged as ideally suited candidates to replace the conventionally used toxic corrosion inhibitors. It was observed that the expired drugs, in addition to being promising corrosion inhibitors, can provide a cost-effective are toxic to environment and human health too. The extract of plant leaves contains various organic compounds like alkaloids, flavonoids, amino acids and proteins. The organic compounds existed in the extract include many aromatic rings and functional groups containing N, S or O heteroatom's [5]. Research is being done to assess some naturally occurring substances as corrosion inhibitors for different metals in various environments ,as well as crude extracts and pure components isolated from the extracts. Often medicinal plants available as natural herbs consist of huge amount of organic and inorganic compounds that inhibit corrosion rates. Synthetic inhibition grossly affect human by their toxicity are costly and hence their use is limited. Recent research work published include study of natural plant inhibitors like as curcuma longa extract [6], eriobotrya japonica lindl leaves extract[7], parsley extract[8], potato peel[9],Henna leaves extract[10], Adhatoda Vasica [11-12]. All show good prospects naturally occurring plant based phenols have anticorrosive properties. In this regard, the following plausible elementary processes were used as a basis to propose an inhibition mechanism: (1) electrostatic attraction between the charged metal and the charged inhibitor molecules, (2) vacant d-orbital's of Fe atoms in the metal interacting with lone pair electrons of heteroatom's (N, S or O), (3) vacant d-orbital of Fe atoms in the metal interacting with π electrons in aromatic rings and when possible (4), a combination of some of these three processes

Present study is based on ecofriendly plant extract of Rhoeo discolor and leaves rich in phenolic compounds [13]. It was planned to work on the inhibition of corrosion in carbon steel in presence of HCl (from 0.1M to 0.5M) along with addition of extract of Rhoeo discolor plant at dosage of 0.1g/L to 0.5 g/L at 30^0C.

Experimental Methods

Weight loss studies

The polished, degreased specimens of carbon steel is weighed and immersed in 150ml beakers containing 100ml 0.1M to 0.5M HCl. It is followed by measuring weight loss once in every 24 hour for 5 days. Later measurement is done after the specimen is cleaned in distilled water, rinsed in acetone and dried. The experiment is repeated with different known amount of inhibitor in 0.1-0.5M hydrochloric acid medium.

Surface Analysis

The surface of mild steel is analyzed by JEOL JSM6380LA using analytical scanning electron microscope and EDX. Steel specimen of size 1cm x 1 cm x 0.5 cm is immersed in 0.1M HCl for 24 hrs in presence and absence of inhibitor. Further, the specimens is removed, cleaned with double distilled water, rinsed with acetone, dried and analyzed by SEM.

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Methodology

Inhibitor Preparation

Approximate 4-5 kg of leaves collected and washed in double distilled water to be placed in water for overnight. Filtered the leaves and washed with cloth to remove water. Leaves are placed in grinder to remove extract from the leaves about half an hour. Extract is treated with ethanol. After aqueous layer is removed it is treated with ether to remove chlorophyll. The extract was washed with acetone and double distilled water several times and kept for drying in room temperature.

Specimen Preparation

Table A: Carbon steel specimen showed following composition.

Carbon steel	Carbon	Manganese	Phosphorous	Silicon	Iron
Composition in %	0.07	0.13	0.025	0.08	Balance

Specimen of dimension of 4 x 3x 0.1cm is prepared by carbon steel cutting into pieces. The specimen is polished using emery papers of the following grades 100,120, 160, 220, 320, 600, 1000, and 1500 grits. They were then thoroughly cleaned with double distilled water rinsed with acetone, dried and desiccated.

Electrolyte Preparation

Hydrochloric acid 1M (86.2ml) is diluted using double distilled water to 1000 ml and then HCl is standardized by standardized sodium hydroxide solution. Required lower standard HCl solutions 0.1-0.5 M are prepared from standardized HCl with proper addition of double distilled water.

Results and Discussions

The percentage of inhibition efficiency was evaluated from the weight loss measurement using the formula.

$$IE\% = \frac{W_o - W_i}{W_o} \times 100 \qquad [14]$$

Where IE is inhibition efficiency, W_o & W_i is weight loss in 'g' W_o is absence of inhibitor; W_i is presence of inhibitor.

The results of weight loss with exposure time for carbon steel specimen immersed in 0.1M-0.5M with varied concentration of plant extract. The plot of graph percentage efficiency against Concentration indicates that as concentration of inhibitor increases efficiency of corrosion inhibition also increases and decreases the rate of corrosion. It indicates that the inhibitor forms a thin coating on surface of metal. As we plot Percentage efficiency against time, the efficiency increases as from day 1- days 5; it indicates there is interaction of inhibitor with an electrolyte forming an electrolytic double layer. As we plot graph, Weight loss vs. Time, there is weight loss of carbon steel from day 1- day 5 but when added with inhibitor, weight loss will be not decreased as we compare to blank. So it can be concluded that in the

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presence of an inhibitor the weight loss of metal is not increased and rate of inhibition efficiency is increases.

From the Table 1- 5 observe that inhibition efficiency increase as concentration of inhibitor and it also depends on acid strength.

Table 1. Weight loss of carbon steel in 0.1M HCl at 30° C with Rhoeo discolor plant extract.

Concentrations in g/L	weight loss in g					% efficiency				
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 2	Day 3	Day 4	Day 5
0	0.321	0.341	0.371	0.389	0.401	-	-	-	-	
0.1	0.314	0.291	0.284	0.271	0.264	2.18	14.66	23.45	30.33	34.16
0.2	0.298	0.273	0.254	0.241	0.213	7.16	19.94	31.53	38.04	46.88
0.3	0.282	0.264	0.243	0.237	0.207	12.14	22.58	34.5	39.07	48.37
0.4	0.277	0.253	0.239	0.218	0.156	13.7	25.8	35.57	43.95	61.09
0.5	0.253	0.221	0.114	0.107	0.099	21.18	35.19	69.27	72.49	75.31

Table 2. Weight loss of carbon steel in 0.2 M HCl at 30° C with Rhoeo discolor plant extract

Concentrations in g/L	weight loss in g					% efficiency				
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 2	Day 3	Day 4	Day 5
0	0.459	0.473	0.486	0.491	0.514					
0.1	0.443	0.452	0.442	0.431	0.426	3.48	4.43	9.05	12.21	17.12
0.2	0.428	0.437	0.413	0.394	0.37	6.75	7.61	15.02	19.75	28.01
0.3	0.413	0.416	0.397	0.371	0.355	10.02	12.05	18.31	24.43	30.93
0.4	0.371	0.378	0.347	0.336	0.214	19.17	20.08	28.6	31.24	34.6
0.5	0.347	0.354	0.311	0.297	0.159	24.4	25.15	36	39.51	69.06

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Table 3. Weight loss of carbon steel in 0.3M HCl at 30° C with Rhoeo discolor plant extract

Concentrations in g/L	weight loss in g					% efficiency				
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 2	Day 3	Day 4	Day 5
0	0.543	0.567	0.584	0.612	0.547					
0.1	0.521	0.514	0.487	0.514	0.453	4.05	9.34	16.6	16	17.18
0.2	0.511	0.502	0.463	0.436	0.384	5.89	11.46	21.23	28.75	29.79
0.3	0.476	0.446	0.411	0.418	0.362	12.33	21.34	29.62	31.69	33.82
0.4	0.412	0.396	0.369	0.387	0.318	24.12	30.15	36.81	36.76	41.86
0.5	0.382	0.354	0.344	0.311	0.214	29.46	37.56	56.24	49.18	60.87

Table 4. Weight loss of carbon steel in 0.4M HCl at 30° C with Rhoeo discolor plant extract

Concentrations in g/L	weight loss in g					% efficiency				
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 2	Day 3	Day 4	Day 5
0	0.417	0.574	0.611	0.647	0.714					
0.1	0.398	0.487	0.514	0.476	0.516	4.55	15.15	15.87	26.42	27.73
0.2	0.345	0.423	0.445	0.421	0.463	17.26	26.3	27.16	34.93	35.15
0.3	0.327	0.396	0.418	0.397	0.386	21.58	26.3	31.58	38.63	45.93
0.4	0.314	0.354	0.391	0.356	0.322	24.7	38.32	36	44.97	54.9
0.5	0.284	0.348	0.343	0.141	0.314	31.89	39.37	43.86	51.93	56.02

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Table 5. Weight loss of carbon steel in 0.5M HCl at 30° C with Rhoeodiscolor plant extract

Concentrations in g/L	weight loss in g					% efficiency				
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 2	Day 3	Day 4	Day 5
0	0.653	0.664	0.689	0.701	0.799					
0.1	0.624	0.614	0.621	0.625	0.623	4.44	7.53	9.86	10.84	22.02
0.2	0.583	0.596	0.612	0.603	0.59	10.71	10.24	11.17	16.56	26.15
0.3	0.571	0.548	0.547	0.574	0.517	12.57	17.46	20.6	22.53	35.29
0.4	0.447	0.432	0.511	0.512	0.476	31.54	34.93	25.83	26.96	35.91
0.5	0.422	0.429	0.432	0.406	0.389	35.37	35.39	37.3	42.08	51.31

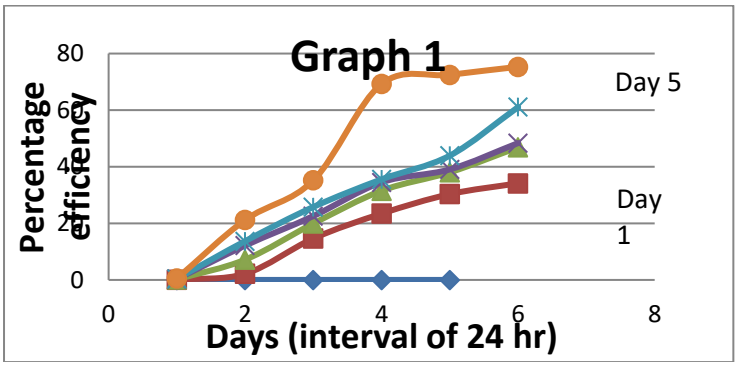

Figure.1 – Percentage efficiency of carbon steel in 0.1M HCl with different time intervals.

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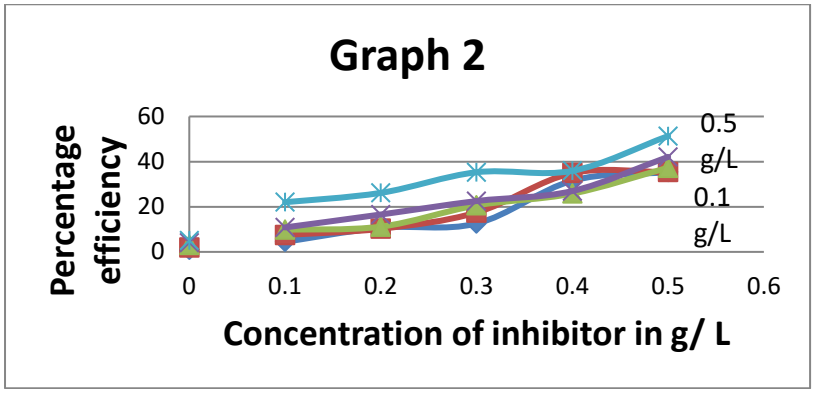

Figure.2 – Percentage efficiency of carbon steel in 0.1M HCl with different concentration of inhibitor

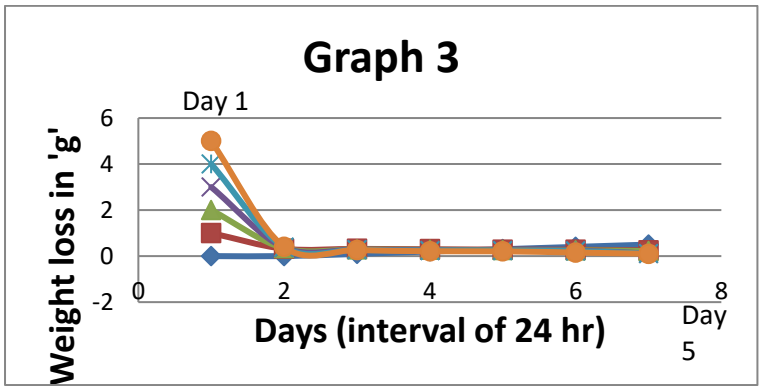

Figure.3 – Weight loss of carbon steel in 0.1M HCl with different intervals of time

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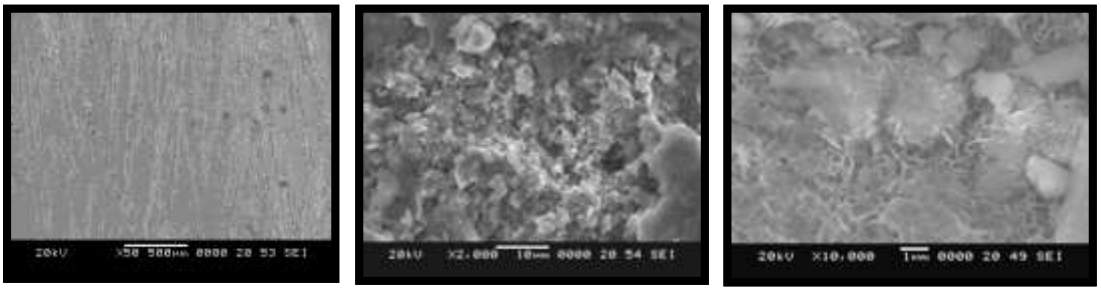
Surface Analysis

Fig.4 exhibits the morphological features of specimens before and after soaking in an acidic aggressive environment for 30 minutes. By contrast the surface of C-steel is comparatively smooth and the corrosion grooves are apparently minor compared with blank solution in the presence of corrosion inhibitor. A barrier layer is developed between the metal and the acid medium as corrosion inhibitor becomes adsorbed on the C-steel surface, which effectively suppresses the dissolution reaction



Polished specimen **Absence of inhibitor** **Presence of inhibitor**

Figure.4 – SEM Analysis Image of carbon steel presence and absence of inhibitor.

Conclusion

The Rhoeo discolor plant extract acts as an efficient inhibitor on carbon steel at various concentration of HCl solution. The various concentration of HCl have taken for the study were 0.1M,0.2M,0.3M,0.4M, and 0.5M respectively. For 0.1M HCl concentration 0.5g/L dosage at 120hr contact time. The efficiency was 75.31% by weight loss method. For 0.2M HCl concentration 0.5g/L dosage at 120hr contact time. The efficiency was 69.06 % by weight loss method. For 0.3M HCl concentration 0.5g/L dosage at 120hr contact time. The efficiency was 60.87% by weight loss method For 0.4M HCl concentration 0.5g/L dosage at 120hr contact time. The efficiency was 56.02% by weight loss method For 0.5M HCl concentration 0.5 g/L dosage at 120hr contact time. The efficiency was 51.31% by weight loss method.

The Rhoeo discolor plant inhibitor which mainly constituting of hetero atoms Nitrogen, sulphur, and oxygen forming week coordinate bonds which protect the metal surface is the inhibition mechanism on mild steel.

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