



ANTI-CORROSIVE STUDY OF ADATHODA VASICA EXTRACT IN 1M HCL ON THE CORROSION OF MILD STEEL

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Abstract

In the current era, natural products extracts are used for corrosion inhibition activity. This method is an ecovative and non-toxic technique. Many researchers do their research on inhibition of corrosion on this green method. The efficiency of corrosion inhibition carried out by weight loss method. In the present study, the leaves extract of *Adathoda vasica* was studied as corrosion inhibitors by weight loss method. The variation of corrosion rate, percentage inhibition efficiency and surface coverage with increasing concentration were measure in this work.

Keywords: *Adathoda vasica*; corrosion inhibitor; weight-loss method; Anti-corrosive study

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1. Introduction

Corrosion is an inevitable natural process of deterioration of metals/materials by chemical or electrochemical process with their environment. It is one of the sources of waste [1]. Corrosion is called a billion-dollar thief because every year several billion loss occur due to this corrosion. As per International Zinc

Association at 2021, India loses 5-7% [2] of Gross Domestic Product (GDP),

Corrosion is a natural, spontaneous and it is thermodynamically stable process favoured by nature. So, nobody prevents or stop corrosion. But, the rate of corrosion can be controlled (i.e) just like postponing the death of material. There are many methods to control corrosion and an usage of inhibitors in small quantities is a common process. Suppose chromates were used as corrosion inhibitors, environmental

scientists pointed out the health hazards caused by chromium (VI) ions. Hence corrosion research scientists go for eco-friendly, innovative, non-toxic natural products extracts as corrosion inhibitors.

2. Experimental procedure:

2.1 Materials:

For the weight loss measurements, a mild steel rod (C 0.2% by wt) with approximate size of 2.5×2.5×0.1cm were used. Before that a pre surface treatment of dipped in pickling solution for the removal of rust and then it is polished on emery paper. After that the rod was washed and degreased by using alcohol and acetone.

2.2 Corrosion Medium

$$\text{Corrosion Rate (CR) (g.cm}^{-2} \text{ h}^{-1}) = \frac{W_1 - W_2}{A \times T}$$

Where, W₁= initial weight of rod, W₂ = weight of rod after treatment,

W₁— W₂ = weight loss (g), A = surface area, T = time in hours

The surface coverage (θ) as a result of adsorption of inhibitor and inhibition efficiency (η%) were calculated from corrosion rate values by using the following equation:

$$\text{Surface coverage } (\theta) = \frac{CR_B - CR_I}{CR_B}$$

$$\eta\% = \frac{CR_B - CR_I}{CR_B} \times 100$$

Where, CR_B and CR_I are the corrosion rates in absence and presence of the inhibitor respectively. Corrosion of mild steel in HCl is found to be following a first order reaction [3]. The rate constant and half-life (t_{1/2}) were calculated by using the following expression:

$$K = \frac{2.303 RT}{t_{1/2}} \log \frac{W_1}{W_2} \quad t_{1/2} = 0.693/k$$

4. Anticorrosive activity:

In the current study, the *Adathoda vasica* leaves extract was investigated as corrosion inhibitors by weight loss method. The variation of corrosion rate, percent inhibition efficiency and surface coverage with increasing concentration is given in Table-1. Graphical representation of

1M HCl solution was prepared by using 37% HCl (Merck Products) and double distilled water. This acid solution was used for corrosion analyses.

3. Gravimetric measurements

3.1 Effect of concentration

The loss in weight studies were carried out at 35°C in 100 ml of blank 1M HCl and test solutions of various concentrations of *Adathoda vasica* extract (0.5, 1.0, 1.5, 2.0, 2.5, 3.5 and 5g/l) for 72 hours. At the end of the reaction the steel specimens were taken out, washed with water, dried with air drier and weighed. Corrosion rates (decrease in weight in gram per cm² per hour) were calculated using following expression.

dependence of corrosion rate, surface coverage and inhibition efficiency with concentration is allocated in figure-1, 2 and 3 respectively. The plots showed that corrosion rate was significantly lowered down in presence of inhibitor and inhibition efficiency increased with increasing the concentration. The order of their inhibition efficiency has been found as follows:

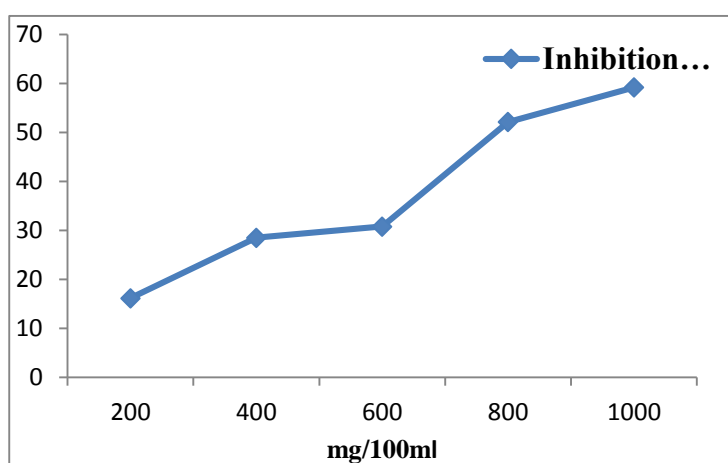
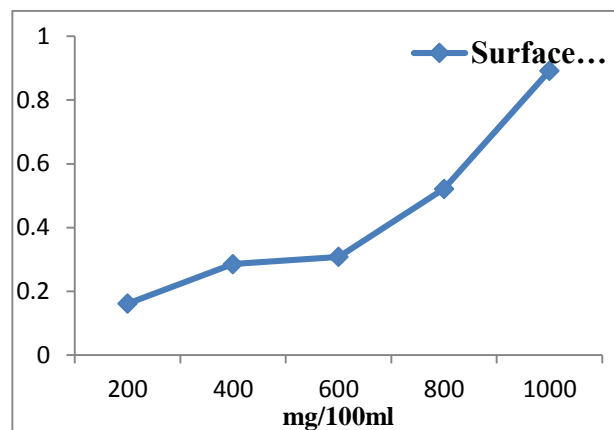
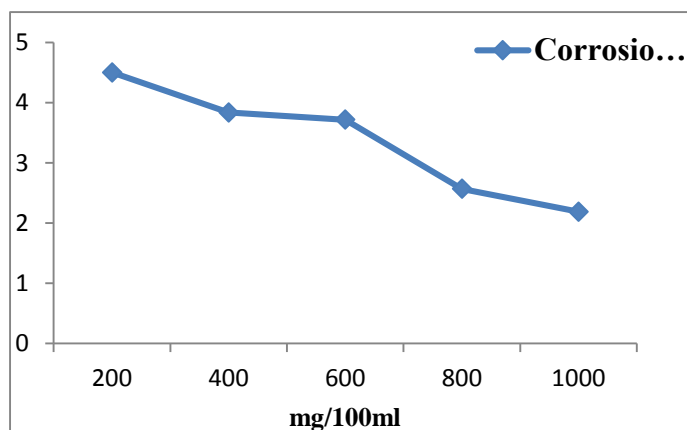
The higher inhibitive performance of *Adathoda vasica* is due to the presence of delocalized p-electrons. This extensive delocalized p-electron favours its greater adsorption on the mild steel surface, thereby giving rise in very high inhibition efficiency (59.21%) at a concentration of

1000mg.

The surface coverage also increased with increasing concentration. The decreasing corrosion rate and the increasing inhibition efficiency was attributed to the fact that the adsorption of inhibitor on the metal surface. The adsorption of the extract creates a barrier that prevents corrosion.

Table 1: Values of corrosion rates, inhibition efficiency, surface coverage, rate constant and half time of *Adathoda vasica* at various concentrations

S.No.	Inhibitory concentrations (gm/100ml)	Initial weight of Steel sample (gm)	Final weight of Steel sample (gm)	Weight loss (g) (W1 – W2)	Corrosion rate $(\times 10^{-4})$	Surface coverage (θ)	Inhibition efficiency (%)	Rate constant $(k \times 10^{-3}) (h^{-1})$	Half time $(t_{1/2})$ (H)
1	200	78.280	76.230	2.05	4.5036×10^{-4}	0.1614	16.14	6.822	0.1015
2	400	77.760	75.960	1.8	3.839×10^{-4}	0.2852	28.52	6.6842	0.1036
3	600	80.570	78.830	1.74	3.7168×10^{-4}	0.3079	30.79	6.6815	0.1037
4	800	93.850	92.320	1.53	2.5695×10^{-4}	0.5215	52.15	6.9390	0.0998
5	1000	75.840	74.730	1.11	2.1904×10^{-4}	0.8921	59.21	6.6709	0.1038
6	Blank (Distilled water)	73.540	71.130	2.41	5.3710×10^{-4}	0	0	0	0



In acidic solutions, transition of the metal/solution interface is attributed to the adsorption of the inhibitor molecules at the metal/solution interface, forming a protective film. The rate of adsorption is usually rapid, and hence, the reactive metal surface is shielded from the acid solutions [4]. The adsorption of an inhibitor depends on its chemical structure, its molecular size, the nature and charged surface of the metal, and distribution of charge over the whole inhibitor molecule. In fact, adsorption process can occur through the replacement of solvent molecules from the metal surface by ions and molecules accumulated near the metal/solution interface. Ions can accumulate at the metal/solution interface in excess of those required to balance the charge on the metal at the operating potential. These ions replace solvent molecules from the metal surface, and their

centres reside at the inner Helmholtz plane. This phenomenon is termed specific adsorption, contact adsorption. The anions are adsorbed when the metal surface has an excess positive charge in an amount greater than that required to balance the charge corresponding to the applied potential. The exact nature of the interactions between a metal surface and an aromatic molecule depends on the relative coordinating strength towards the given metal of the particular groups present [5].

Generally, two modes of adsorption were considered. In one mode, the neutral molecules of leaves extract can be adsorbed on the surface of mild steel through the chemisorption mechanism, involving the displacement of water molecules from the mild steel surface and the sharing electrons between the heteroatoms and iron. The inhibitor molecules can also adsorb on the

mild steel surface based on donor-acceptor interactions between p-electrons of the aromatic/heterocyclic ring and vacant d-orbitals of surface iron. In another mode, since it is well known that the steel surface bears the positive charge in acidic solutions [6], so it is difficult for the protonated leaves extract to approach the positively charged mild steel surface (H_3O^+ /metal interface) due to the electrostatic repulsion. Since chloride ions have a smaller degree of hydration, thus they could bring excess negative charges in the vicinity of the interface and favour more adsorption of the positively charged inhibitor molecules, the protonated leaves extract adsorbed through electrostatic interactions between the positively charged molecules and the negatively charged metal surface.

The inhibitor molecules may then combine with Fe^{2+} ions on the metal surface, forming metal inhibitor complex. The resulting complex, depending on its relative solubility could either inhibit or catalyse further metal dissolution. Plant extracts are viewed as an incredibly rich source of naturally synthesized chemical compounds. These large numbers of different chemical compounds may form adsorbed intermediates (organo-metallic complexes) which may either inhibit or catalyse further metal dissolution. From the observed results it can be inferred that the insoluble Fe- plant extract complexes dominate the adsorbed intermediates and thus the resultant inhibitive effects. This conclusion is in line with those of Jaen *et al.* (1999) [7].

Over 300 compounds have been isolated and characterized from the plant. Among these are: terpenoids, saponin, flavonoids are structurally related compounds. Most of these compounds have complicated molecular structures, large molecular weights and significant number of oxygen, sulphur and nitrogen atoms incorporated in the structure. These compounds can adsorb on the metal surface via the lone pairs of electrons present on their oxygen, sulphur and nitrogen atoms.

The adsorption of such compounds on the metal surface creates a barrier for charge and mass transfer leading to a decrease in the interaction between the metal and the corrosive environment. As a result, the corrosion rate of the metal is decreased. According to Patel (2009) [8], the inhibition properties of plant extracts may be due to the presence of nitrogenous compounds in the extract and tannins [9]. Tannins are complex astringent aromatic glycosides found in various plants. They are made up of polyphenols and their acidic and heterocyclic derivatives. Polar organic compounds containing N, S, O atoms are good corrosion inhibitors [10]. They may have been responsible for the formation of an oriented film layer which essentially blocks discharges of H^+ and dissolution of metal ions. Acid pickling inhibitors containing organic N, amine, S and OH groups behave similarly to inhibit corrosion. Since plant extract possess several heteroatoms containing active constituents, therefore there may be a synergism between the molecules accounting for the good inhibition efficiencies.

5. Conclusion:

The leaves extract of *Adathoda vasica* was investigated as corrosion inhibitors by weight loss method. The results showed that the extract of leaves of *Adathoda vasica* inhibited the corrosion of steel rod in 1M HCl solution significantly increased with increasing extract concentrations. The surface coverage increased with increasing concentrations in *Adathoda vasica* extract. The decreasing corrosion rate and the increasing inhibition efficiency were observed in *Adathoda vasica* extract. The *Adathoda vasica* leaves extract, showed potential corrosion inhibitor. From the trend in inhibition efficiencies of *Adathoda vasica* extract present at highest concentration in the leaves, is assumed to contribute significantly to the adsorbed organic compounds responsible for the

inhibitive effects of the *Adathoda vasica* extract. Based on the trend of corrosion inhibition is attributed to chemical adsorption of the phytochemical components of the plant on the surface of the steel.

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