A Study on the effect of seed extract of Cajanus Cajan on the corrosion of mild steel.

S. Parameshwari[1], Padaki Srinivas[2]

[1]Research Scholar, Dept. of Chemistry, PDA College of Engineering, Kalaburagi,

[2]Professor and Head of Department, Dept. of Chemistry, PDA College of Engineering, Kalaburagi.

Abstract

In the present work, the seed extract of Cajanus Cajan is used for the study of corrosion inhibition on mild streel in 0.1 M HCl. This study was done using the method of weight loss at 298 K. It was found that as the volume of seed extract increased, the inhibitor efficiency also increased drastically indicating the possibility of using the seed extract of Cajanus Cajan a natural corrosion inhibitor.

Keywords: Cajanus Cajan, Corrosion inhibition, inhibitor efficiency, Corrosion Rate.

1. INTRODUCTION

Corrosion is natural process that converts refined metal into a more chemically stable form such as oxides, hydroxide or sulphides. It's a gradual destruction of materials by chemical or electrochemical reaction with the environment and is an irreversible process. According to IUPAC [1], "Corrosion is an irreversible interfacial reaction of a material (Metal) with its environment which results in its consumption or dissolution into the material of a component of that environment. Often, but-not necessarily, corrosion results in effects detrimental to the usage of the material considered. Exclusively physical or mechanical process such as melting and evaporation abrasion or mechanical fracture is not included in the term corrosion"

Hence, there is a continuous search of materials which can act as inhibitors. Inhibitor is a substance which slows down or prevents a general chemical reaction. Corrosion Inhibitor is a form of inhibitor which slows down the corrosive action [2]. It was observed that, electronegative functional groups and pi electrons in conjugated system with double or triple bonds show good inhibitor properties by supplying electrons through pi orbital's [3]. Along with them heteroatom's like Nitrogen, Sulphur, Oxygen with free lone pair of electrons are also found to be good inhibitors.

There are different types of corrosion inhibitors available [4] such as:
1. Anodic inhibitor
2. Cathodic inhibitor
3. Mixed inhibitor
4. Volatile inhibitor
5. Organic inhibitor
6. Inorganic inhibitor
7. Green inhibitor etc.

Anodic Inhibitor also called as passivasion inhibitor which suppresses rate of anodic reaction by producing sparingly soluble salts. Cathodic inhibitor reduces rate of cathodic or reduction reaction by protective layer on cathodic area. Mixed inhibitor is the one which is influenced by both anodic and cathodic reaction site. Further, based on the chemical nature, inhibitors can be organic, where most of them are mixed inhibitors or Inorganic inhibitors where inorganic substances act as inhibitor. Green corrosion inhibitors are those inhibitors which are obtained from natural products such as plants and their parts.

An effective corrosion inhibitor should be cost effective, compatible, and it should produce desired effect with small concentration of it. Corrosion inhibitor is found to act by, forming a film adsorbed on metals surface, by producing a corrosion product (example, Iron Sulphide (FeS) acts as a passivator), by yielding precipitates that eliminate or inactivate an aggressive constituent. Among many inhibitors available our interest is more in the natural inhibitors which are non-toxic, eco-friendly cost effective and sustainable.

In recent years, there have been some previous work in this direction. Methanolic extract of Mollugo Cerviana plant on 1M HCl by Weight loss method, Potentiodynamic, Polarization method, Electrochemical impedance spectroscopy by five different plant extract concentration starting from 25 to 1000 mg/L was observed [8]. The inhibition efficiency increased till 500 mg/L and then decreased. So, it was good corrosion inhibitor on mild steel in 1M HCl.

Even food source such as Rice husk extract was used to reduce corrosion rate of mild steel in 1M H_2SO_4 solution. This was studied [5] using Weight loss method. Here the X - ray diffraction method was used to analyze silica structure of rice husk extracts. Inhibitor was added in various concentrations (0, 10, 15, 20, 25 ml) at different immersion time (2, 4, 6, 8 hrs). Results showed that above 90% Inhibition efficiency was reached.

Corrosion inhibition of Barley grains residue extract by weight loss measurement, polarization curves, electrochemical impedance and scanning electron microscope was carried [6]. About 92% of inhibition efficiency was found in presence of 100 mg/L for 24 hrs immersion time.

Corrosion inhibition by Cajanus Cajan leaves extract on mild steel in 1M HCl by weight loss method and scanning electron microscopy analysis was also tried [7]. Inhibition rate was also studied with different temperatures. The study showed a inhibition efficacy of 79 to 90 %.

The inhibition efficiency of Allium Sativum (Garlic extract) on mild steel by weight loss method was conducted [8]. They showed that the efficiency of 10 ml of extract was around 90%.

Study of Vigna Unguiculata extract on Aluminium in 0.5M NaOH and H_2SO_4 was done by weight loss method at 30^0 and 60^0 C [9]. Inhibition increased with increase in concentration of inhibitor because of the alkaloids and fatty acids constituents of Vigna Unguiculata. It was spontaneously adsorbed on the metal surface.

The preliminary study of the papers mentioned above and many more, resulted in some of the observations that Amino acid, oxalic acid, Pyridoxol hydrochloride, Malic acid, vitamins , fatty acids, Alkaloids , etc. can give rise to inhibitor properties. Amino acids as corrosion inhibitor of Iron, Carbon Steel, Zinc, Copper, Aluminium alloy and Tin were reported in many works [10]. Glutamic acid is a kind of amino acid where two carboxyl groups act as inhibitor. Hence we selected bio-degraadable Cajanus Cajan seed as a natural inhibitor on mild steel in 0.1N HCl medium. Since it contains proteins, fatty acids, Nitrogen and Oxygen containing compound. The study was carried out at 25^0 C (Room Temp.) using weight loss method.

2. Materials and Methodology

Since corrosion is found to be maximum in acidic conditions, we have chosen as HCl as acidic medium for our work. The concentration of HCl to be used was found out from our experiment. We varied concentration from 0.1 M to 1M of HCl it was found maximum corrosion in 0.1M HCl Therefore for our further studies we considered 0.1M HCl as our standard acidic condition for our experiment.

Corrosion of mild steel in 0.1 M HCl at different time intervals without inhibitor was done. The time intervals are (10, 20, 30, 40, 50 mins, 1hr, 2hr, 3 hr, 4hr, 5hr). It was observed that the maximum corrosion occurred at 2 hrs. Hence we chose the time period as two hours for our further studies.

Sample used in our study is Stainless steel rods used in constructions of building and the surface area was nearly 4.5 cm^2. The Mild Steel contains less amount of carbon as against the cast iron. Chemical composition of mild steel are: Carbon - .16 to .18 % (maximum .25%) Manganese - .7 to .9% Silicon .4%

Extraction of Inhibitor: the Cajanus Cajan seed powder extract is made by adding 10 g of seed powder in 100 ml 3.5% solution of NaCl Then it is stirred on magnetic stirrer for 15 minutes and then centrifuged for 15 minutes at 3000 rpm and the supernatant liquid is taken as respective seed extract.

Formulae Used:

1. Corrosion rate formula [11]

$$V_0 \text{ or } V_1 = \frac{W_1 - W_2}{At}$$

Where ,

V_0 = corrosion rate without inhibitor

V_1 = corrosion rate with inhibitor
W_1 = weight of sample before immersion
W_2 =weight of sample after 2 hrs. of immersion
$A = l * \pi d + 2*(\frac{\pi}{4} d^2)$
l =length of rod
d = diameter of rod
t = time interval= 2hrs.

2. Formula to calculate the inhibition efficiency percentage:
Inhibitor Efficiency= $\frac{V_0 - V_1}{V_0} * 100$

3. RESULTS AND DISCUSSION:

Many experiments were conducted with seed powder extract of Cajanus Cajan as corrosion inhibitor on mild steel sample in 0.1M HCl for 2 hrs as shown in Table 1 at 298K.

The table 1 shows the values of corrosion rate and inhibitor efficiency against volume of inhibitor. The corresponding plots are shown in the figure 1. As the volume of inhibitors increased from 1 ml to 5 ml, the corrosion rate decreased from $3.29*10^{-4}$ to $1.11*10^{-4}$. This resulted in increase in inhibitor efficiency from 55.54% to 85.13%.

1. Corrosion rate Vs. Volume of inhibitor

Table 1 Corrosion Rate and Inhibitor Efficiency at different volumes of inhibitors

Sl. No.	Volume of Inhibitor (ml)	Corrosion Rate	Inhibitor Efficiency (%)
1	1	$3.29*10^{-4}$	55.54
2	2	$3.27*10^{-4}$	55.81
3	3	$3.17*10^{-4}$	57.16
4	4	$2.16*10^{-4}$	70.81
5	5	$1.11*10^{-4}$	85.13

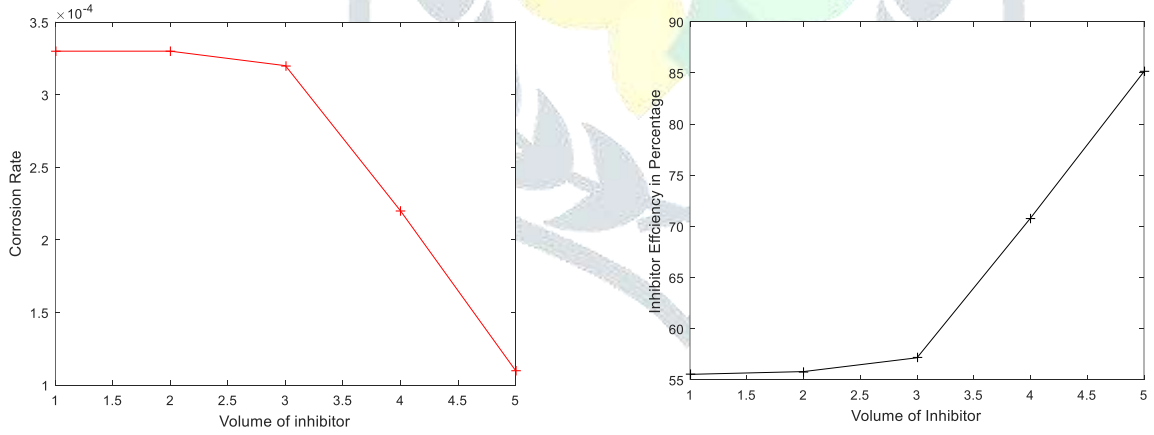

Figure 1. Plots of Corrosion rate and Inhibitor efficiency versus Volume of inhibitor

Then, the experiments were conducted for various time periods starting from 20 min to 120 min at each of the volumes of inhibitor as shown in table 2.

2. Weight loss Vs. Volume of inhibitor

Table 2 Weight loss versus Volume of inhibitor

S.NO	volume of inhibitor	wt loss at 20 mins	wt loss at 40 mins	wt loss at 60 mins	wt loss at 80 mins	wt loss at 100 mins	wt loss at 120 mins
1	1	$6.79*10^{-5}$	$1.69*10^{-5}$	$7.7*10^{-6}$	$8.49*10^{-6}$	$6.98*10^{-6}$	$5.49*10^{-6}$

2	2	$4.46*10^{-5}$	$1.69*10^{-5}$	$7.6*10^{-6}$	$5.55*10^{-6}$	$5.51*10^{-6}$	$5.45*10^{-6}$
3	3	$4.53*10^{-5}$	$1.13*10^{-5}$	$7.7*10^{-6}$	$5.6*10^{-6}$	$5.32*10^{-6}$	$5.29*10^{-6}$
4	4	$4.56*10^{-5}$	$1.14*10^{-5}$	$7.74*10^{-6}$	$5.7*10^{-6}$	$4.51*10^{-6}$	$3.6*10^{-6}$
5	5	$2.205*10^{-5}$	$0.55*10^{-5}$	$3.67*10^{-6}$	$2.75*10^{-6}$	$2.34*10^{-6}$	$1.86*10^{-6}$

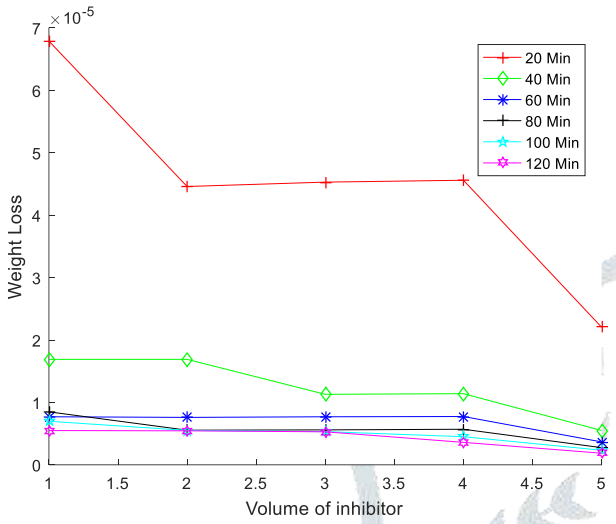

Figure 2. Plot of weight loss versus Volume of inhibitor

As can be seen from the table and the plot in figure 2, as volume of inhibitor increases the weight loss decreased. At any given volume of the inhibitor, the weight loss also decreased with increase in the time. Thus, the volume of inhibitor and time of reaction seems to be helpful for the corrosion inhibition.

When the information was plotted as corrosion rate versus log concentration and Inhibitor efficiency versus log concentration, the results are shown in table 3 and figure 3.

3. Corrosion rate Vs. Log concentration and Inhibitor efficiency Vs. Log concentration

Table 3 Corrosion rate Vs. Log concentration and Inhibitor efficiency Vs. Log concentration

Sl. No.	Volume of Inhibitor (ml)	Log concentration	Corrosion Rate	Inhibitor efficiency in Percentage
1	1	$2*10^{-2}$	$3.29*10^{-4}$	55.54
2	2	$4*10^{-2}$	$3.27*10^{-4}$	55.81
3	3	$6*10^{-2}$	$3.17*10^{-4}$	57.16
4	4	$8*10^{-2}$	$2.16*10^{-4}$	70.81
5	5	$10*10^{-2}$	$1.11*10^{-4}$	85.13

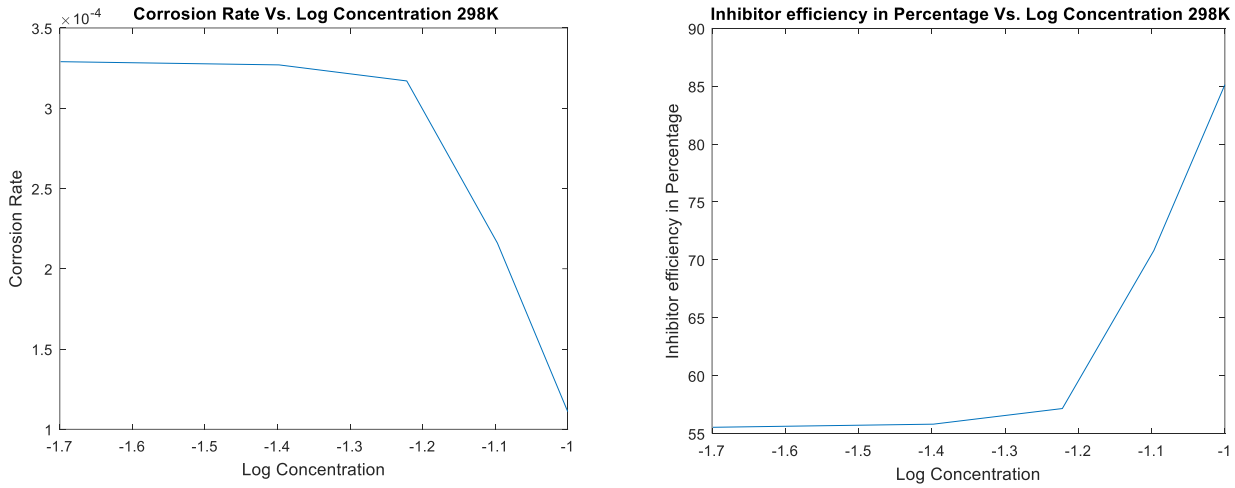

Figure 3. Plots of corrosion rate Vs. Log –concentration and Inhibitor efficiency Vs. Log concentration

Similar trends were observed in these plots also. Corrosion rate decreased with increase in the log- concentration while inhibitor efficiency increased.

4. CONCLUSION

From the above experimental observation by weight loss method shows that the Cajanus Cajan seed powder extract works as a good corrosion inhibitor on mild steel at room temperature in 0.1M HCl when immersed it for 2 hrs. The inhibition efficiency percentage was increasing with the increase in the volume of the inhibitor. This is due to the presence of high concentration of proteins, vitamin B2 [11], and amino acids. The hetero atoms like Nitrogen and Oxygen might have helped in inhibitor efficiency. But, above 5 ml there was saturation attained and the maximum efficiency was found at 5 ml i.e. around 85.13%.

5. REFERENCES

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