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Short Communication

A STUDY ON THE CORROSION INHIBITION PROPERTIES OF *MACROTYLOMA UNIFLORUM* (HORSE GRAM) ON MILD STEEL

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ABSTRACT

In this research work, the seed extract of the lentil, *Macrotyloma uniflorum* (Horse gram) was used for the study of corrosion inhibition on mild streel in 0.1 M HCl. The experimental study was done using the method of weight loss at various temperatures. It was found that as the volume of seed extract increased, the inhibitor efficiency also increased drastically. The same behavior was observed at different temperatures also.

Keywords: *Macrotyloma uniflorum,* Corrosion, Green Inhibitor.

1. INTRODUCTION

Corrosion is a process of slow deterioration or degradation of a solid material due to various chemical reactions. It is commonly observed in most of the metals. To describe it in a simple manner, the corrosions is said to have occurred when refined metals naturally gets converted into its most stable form like, oxides, hydroxides and Sulphide states which results in the subsequent deterioration or failure of the material [1]. The corrosion reactions are found to be electro-chemical in nature [2] (oxidation and reduction of metals) and that they are spontaneous too. Corrosion is strongly affected by the environment. The process of corrosion can be written as:

Metal+substances of Environment=Metal Oxides or Metal hydroxide. For example, the corrosion of $4Fe + 3O_2 + 6H_2O \rightarrow 4\ Fe(OH)_3$ iron can be represented by the equation as shown below:

1.1. Common types of corrosions observed are [3]:

1.1.1. Uniform corrosion

Uniform or general corrosion is a as a type of corrosion attack that is more or less uniformly distributed over the entire exposed surface of a metal. Uniform corrosion is a commonly seen in ferrous metals.

1.1.2. Galvanic corrosion

Galvanic corrosion is a form of fast corrosion of a metal because of its contact with a more noble metal in an electrolyte.

1.1.3. Crevice corrosion

Crevice corrosion is a localized attack on a metal next to a crevice between two joining surfaces.

1.1.4. Pitting corrosion

Pitting corrosion is a localized phenomenon confined to smaller areas. Pitting corrosion is normally found on passive metals and alloys such as aluminum alloys, stainless steel and alloys when the oxide film is chemically or mechanically damaged and does not re-passivate.

1.1.5. Selective corrosion

Here corrosion acts on selective chemical of a metal. Examples are de-zincification, de-aluminification and inter-granular corrosion.

1.1.6. Erosion corrosion

Erosion corrosion is the deterioration of metals and alloys due to relative movement between metal surfaces and corrosive fluids.

1.1.7. Cavitation corrosion

Cavitation corrosion is a particular form of erosion caused by the 'implosion' of gas bubbles on a metal surface which cause pits on the metal surface. It is commonly seen in fluid pipes.

1.1.8. Flow-assisted corrosion

Flow-assisted corrosion, or flow-accelerated corrosion, occurs when a protective layer of oxide on a metal surface is dissolved or removed by wind or water, exposing the underlying metal to further corroding and deteriorate.

1.1.9. Stress corrosion

Stress corrosion cracking (SCC) refers to failure under simultaneous presence of a corrosive medium and a tensile stress.

Damages due to corrosion is an important matter because some studies have shown that, the cost of corrosion can be as high as 3% to 4% of a country's Gross Domestic product [4]. This is more than the allocation for education in some of the developing countries. Hence a small reduction in the corrosion can lead to huge saving of money. Use of inhibitors is one of the many important ways to reduce 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 [5]. It was observed that electronegative functional groups and pi electrons in conjugated system with double or triple bonds show good inhibitive properties by supplying electrons through pi orbitals [6]. Along with them heteroatoms like Nitrogen, Sulphur, Oxygen with free lone pair of electrons are also found to be good inhibitors.

There are different types of corrosion inhibitors [7] available such as: Anodic inhibitor, Cathodic inhibitor, Mixed inhibitor, Volatile inhibitor, Organic inhibitor, Inorganic inhibitor, Green inhibitor etc. The inhibitors can be both organic and inorganic. Though there are many in-organic inhibitors, owing to sustainability and toxicity issues, there has been a shift in the research towards identifying the green corrosion inhibitors. Green corrosion inhibitors are those inhibitors which are obtained from natural products such as plants and their parts. These are non –toxic and are bio-sustainable.

The 4(N,N-dimethylamino) benzaldehyde nicotinic acid hydrazine was used [8] in a study that used methods such as weight loss, FE-SEM and AFM etc. It showed good corrosion inhibition with increased concentration. Similar studies on, *Hunteria umbellata* seed husk extracts [9], pectin[10], leaves of *Morinda tinctoria* [11], quinoline derivatives [12]carried out by various authors, mostly in HCl medium, showed an improved corrosion resistance with increased concentration. Others have studied the corrosion inhibitors in acids such as HNO_3 [13], H_2SO_4 [14, 15].

In our effort to find out various green alternatives, especially which are locally available, various food grains were experimented to see if it can be used as corrosion inhibitor. Our earlier study has shown that *Cajanus Cajan* [16] works as a good inhibitor on mild steel in HCl medium. The present study focusses on the use of *Macrotyloma uniflorum* (*horse gram),* which is one of the common cereals used in Indian sub-continent. This, being a food item, is completely toxic free and environmental friendly.

2. METHODOLOGY

Since corrosion is commonly found to be accelerated in acidic mediums, we have selected HCl for the acidic medium. The concentration of HCl to be used was found out by trial and error. We varied concentration from 0.1 M to 1M of HCl. It was found that maximum corrosion occurred in 0.1M HCl which resulted in choosing of 0.1M HCl as our standard acidic condition for our further studies.

At first the corrosion study of mild steel in 0.1 M HCl was carried at different time intervals without inhibitor. The time intervals chosen were (10 min, 20min, 30min, 40min, 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 2 hours for our studies. Stainless steel rods, used in constructions of building, with surface area of about 4.5 cm^2 were used as samples.

2.1. Extraction of Inhibitor

The *Macrotyloma uniflorum* seed powder extract was made by adding 10 g of the seed powder in 100 ml-3.5% solution of NaCl. Then it was stirred on magnetic stirrer for 30 minutes and then centrifuged for another 30 mins at 4000 rpm. The resulting supernatant liquid was taken for the study.

Formulae Used:

1. Corrosion rate formula [17]

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

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

Series of experiments were conducted with seed powder extract of *Macrotyloma uniflorum*as corrosion inhibitor on mild steel rod sample the in 0.1M HCl for 2hrs. The temperatures used for conduction of experiments were 25°C (298 K), 30°C (303 K), 35°C (308 K), and 40°C (313 K). The Table 1 shows the experimental results of corrosion of mild steel for various volumes of inhibitor at room temperature of 25 degree Celsius or 273 K. The table has the values of corrosion rate and the inhibitor efficiency (in percentage) against the volume of inhibitor. The corresponding plots are shown in figs. 1 and 2. As can be seen from table and plot there is a decrease in the corrosion rate accompanied by the increased inhibitor efficiency.

Table 1: Corrosion Rate at different volumes of inhibitors at 273K

Sl. No.	Volume (mL)	Corrosion Rate*10e^{4}	Inhibitor Efficiency (%)
1	1	3.511236	52.55
2	2	3.470615	53.09
3	3	2.340824	68.37
4	4	2.251745	69.57
5	5	1.170412	84.18

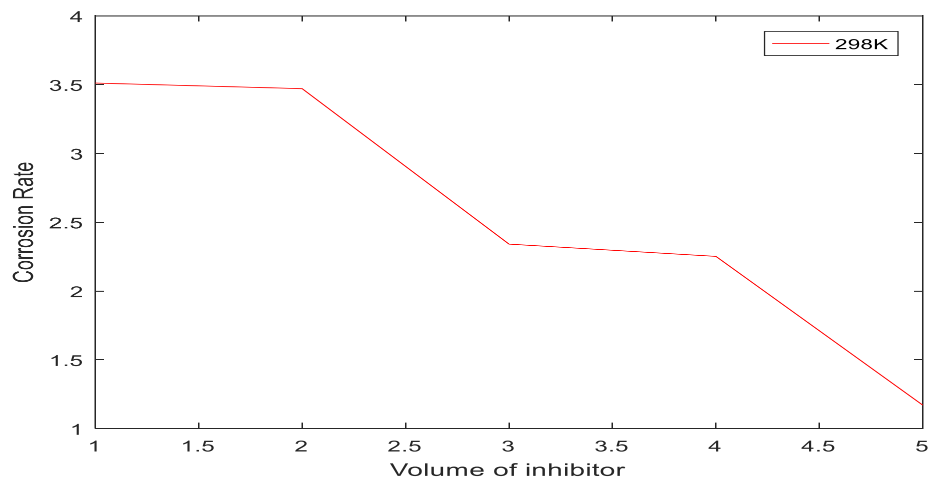

Fig. 1: Plot of Corrosion rate versus Volume of inhibitor

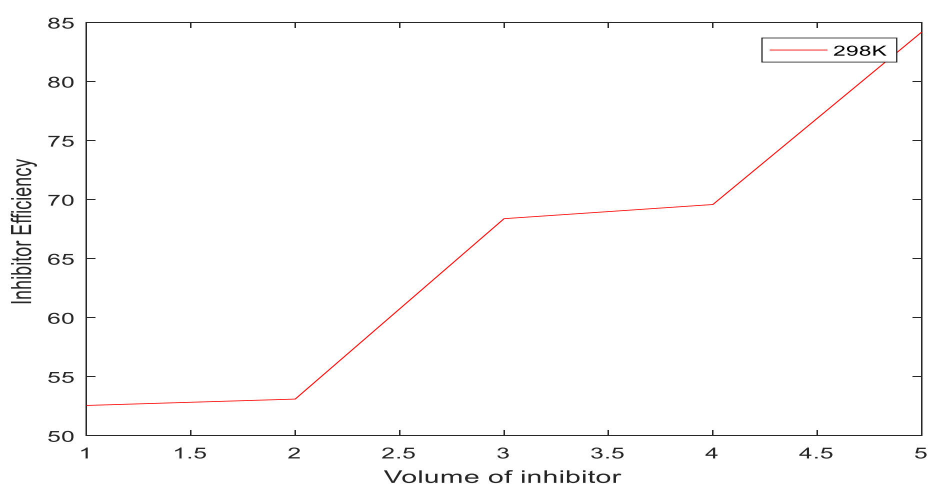

Fig. 2: Plot of Inhibitor efficiency versus Volume of inhibitor

Therefore, we can say that at room temperature, the inhibitor is doing its intended job of reducing corrosion. The experiment was then repeated for temperature of 303. The data are available in table 2 and plots in figs. 3 and 4. Here also the same trend can be observed.

Table 2: Corrosion Rate at different volumes of inhibitors at 303K

Volume (mL)	Corrosion Rate*10e4	Inhibitor Efficiency (%)
1	4.738214	35.97
2	3.481894	52.95
3	3.470615	53.09
4	3.390597	54.18
5	2.156567	70.86

Table 3: Corrosion Rate at different volumes of inhibitors at 308K

Sl. No.	Volume (mL)	Corrosion Rate*10e4	Inhibitor Efficiency (%)
1	1	6.145526	16.95
2	2	4.836759	34.64
3	3	4.759638	35.68
4	4	3.460208	53.24
5	5	3.357207	54.63

Now the same experiment was repeated for higher temperatures of 308 K and 313 K. The respective data are available in table 3 and table 4. The plots are in figs 5 to 8. There are no variation in the trends observed with respect to earlier cases. The consistency of the plots clearly demonstrates that, the inhibitor is actually working well in reducing the corrosion.

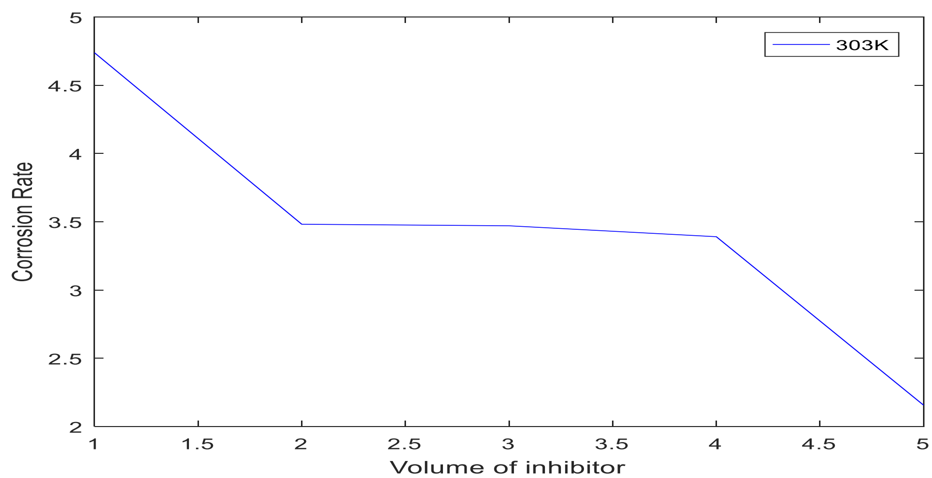

Fig. 3: Plot of Corrosion rate versus Volume of inhibitor

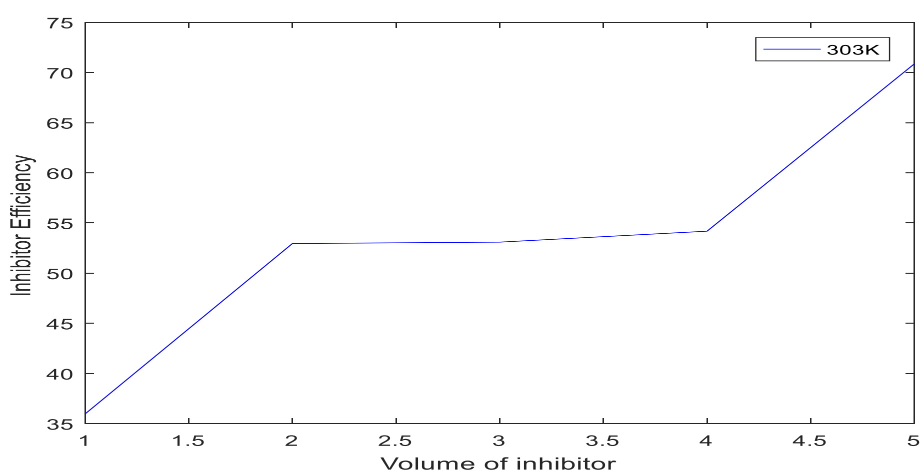

Fig. 4: Plot of Inhibitor efficiency versus Volume of inhibitor

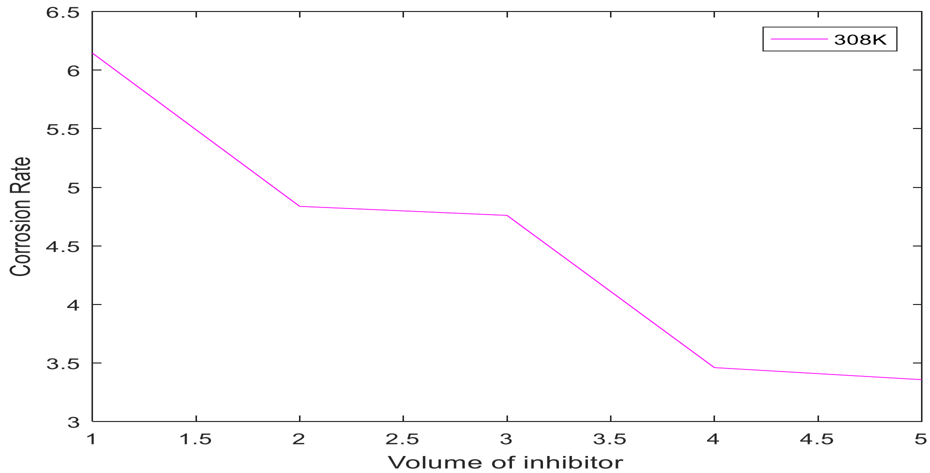

Fig. 5: Plot of Corrosion rate versus Volume of inhibitor

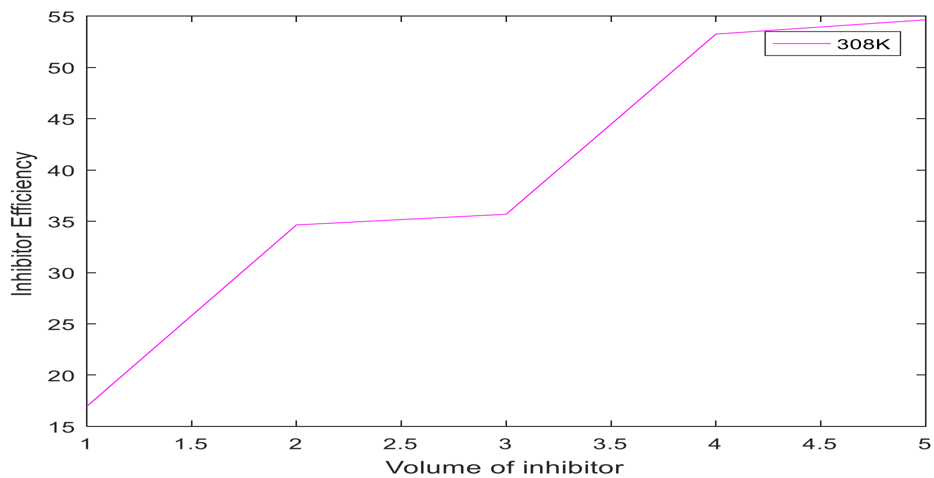

Fig. 6: Plot of Inhibitor efficiency versus Volume of inhibitor

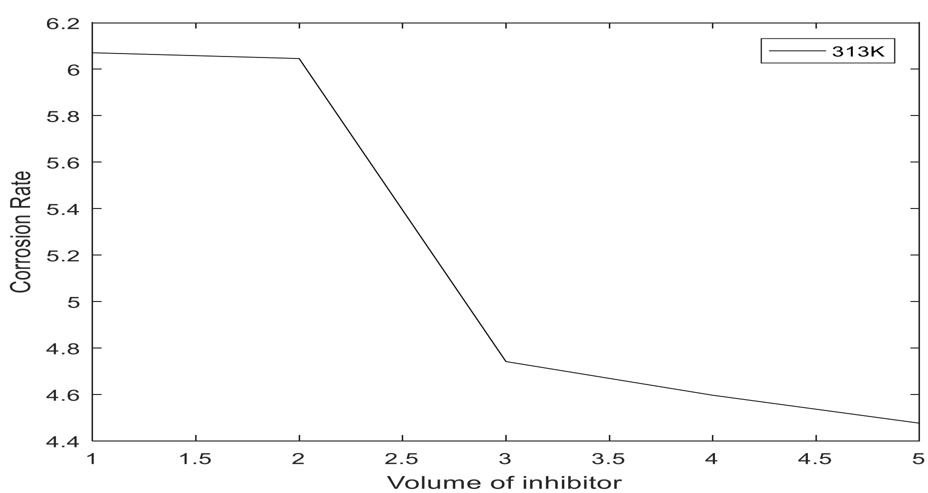

Fig. 7: Plot of Corrosion rate versus Volume of inhibitor

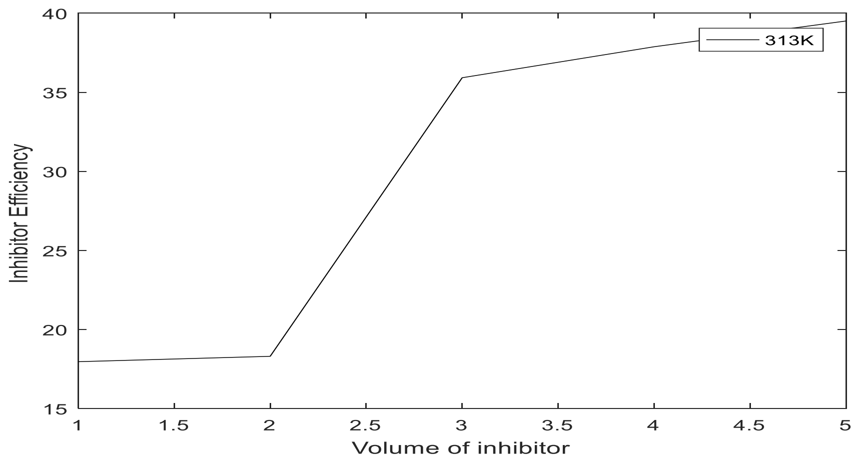

Fig. 8: Plot of Inhibitor efficiency versus Volume of inhibitor

Table 4: Corrosion Rate at different volumes of inhibitors at 313K

Sl. No.	Volume (mL)	Corrosion Rate*10e4	Inhibitor Efficiency (%)
1	1	6.070908	17.96
2	2	6.045949	18.30
3	3	4.741584	35.92
4	4	4.596644	37.88
5	5	4.476276	39.51

4. CONCLUSION

The plots clearly demonstrate that seed powder extract of *Macrotyloma uniflorum* has the high potential to be used as corrosion inhibitor. As already stated, this is a non-toxic environment friendly alternative to existing inorganic inhibitor. Further studies are being carried out to see if different but locally available plants' seed extracts can be used as corrosion inhibitors.

Conflict of Interest

There is no conflict of interest in this research work

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