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CORROSION INHIBITION OF MILD STEEL IN ACIDIC ENVIRONMENT USING LEAF EXTRACT OF VERNONIA AMYGDALINA

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Abstract

Corrosion inhibition of mild steel in acidic environment using vernoniaamygdalina (bitter) leaf extract has been studied. Weight loss method was used in which the test coupons, with known weight, were immersed in the test media; leaves extract of vernoniaamygdalina, and dilute H_2SO_4, for a total exposure time of five days. The weight loss was measured at an interval of 24hours i.e. a day, and the corrosion penetration rate was determined. The result revealed that the rate of corrosion of mild steel in dilute H_2SO_4 increases with increase in the concentration of the acid and that the extract of leaves of vernoniaamygdalina inhibits the corrosion of mild steel in dilute H_2SO_4. The inhibition efficiency of the extract increases with increase in the concentration of the extract. The inhibition was assumed to occur via adsorption of the inhibitor molecules on the metal surface.

Introduction

The corrosion of metallic materials in acidic solution causes considerable cost. Metals and their alloys are exposed to the action of acids in industrial processes which causes severe problem such as increase in mass and corrosion of surfaces resulting in economic losses. These effects are of serious consequences in the mild steel industry as most of the substances are made of mild steel, like other organic and inorganic substances are prone to corrosion; thereby causing significant impact on the degradation of constructional materials and the maintenance or replacement of products lost as a result of corrosion reaction. These corrosive effects on different constructional materials in all phases of processing and production of the basic needs of life, are all too common.

The material used for most equipment is mild steel which is selected because of its strength, ductility weldability and also because it is amenable to heat treatment for varying mechanical properties.

Mild steel however, corrodes easily because all common structural metals form surface oxide films when exposed to pure air but the oxide formed on mild steel is readily broken down, and in the presence of moisture it is not repaired. Therefore, a reaction between steel (Fe), moisture (H_2O), and oxygen (O_2), takes place to form rust. This reaction is complex but can be represented by a chemical equation of the following type:

$$4Fe + 2H_2O + 3O_3 2Fe_2O_3.H_2O + Fe_2O_3.H_2O. \quad (1)$$

This is the rust, and as it is not usually protective, the corrosion process is not impeded.
Mild steel as a constructional material is often exposed to acidic environment to a great extent during service. This exposure can be under condition of varying temperature, flow rate, $P^H$and other factors; all of which can alter the rate of corrosion. The relative acidity of the solution is the most important factor to be considered; at low P^H, the evolution of hydrogen tends to eliminate the possibility of protective film formation so that the steel continues to corrode but in alkaline solutions, the formation of protective film greatly reduces corrosion rate.

Several studies have been carried out on the inhibition of corrosion of metals by plant extract (green inhibitors). In most of these and other studies not much has been reported on the use of *Vernoniaamygdalina* (bitter) leaf extract on the corrosion of mild steel in dilute H_2SO_4. Therefore, the present study is aimed at investigating the inhibitive properties of the leaves extract of *vernoniaamygdalina (*bitter leaf) on the corrosion of mild steel in dilute H_2SO_4.

Vernoniaamygdalina is an annual, erect, branched and hairy herb, having a height of 30 – 120 cm. The leaves of the plant are simple and alternate. The plant is geographically spread across West African Countries including Nigeria. According to Gill in A.O. Odiongenyi, S.A. Odoemelam and N.O. Eddy, Corrosion Inhibition and Adsorption Properties of Ethanol Extract of VernoniaAmygdalina for the Corrosion of Mild Steel in H_2SO_4, the extract is medicinal and is used in curing headache and fever. Notable constituents of vernoniaamygdalina are

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glycoside-vernoniside, vernonium, sesquiterpenes lactones, others are Cu, Zn, Cr, Fe,Mn, S, P and other elements that contribute to the corrosion inhibition.

Experimental

Material preparation

The materials used for the study were mild steel sheet of composition (wt. %) C (0.4), Mn (0.9), P (0.04), Si (0.2), S (0.4), Cu (0.3), Cr (0.1), and Ni (0.11) and the rest Fe.The sheet was mechanically pressed-cut to form different coupons, each of dimension, 5x2x0.10cm. Each coupon was polished with different grades of emery paper of grit size 220 and above. The specimens were washed thoroughly with distilled water and dried to a temperature of 100^0C using heat treatment furnace; and was finally degreased with acetone.The specimens were allowed to cool before weighing using digital weighing machine to get the initial weight. The acid used for the study was dilute H_2SO_4 with molar concentrations of 0.5mole to 2.0moles. The molar concentration of the acid was calculated using the formula below:

$$Vc = \frac{MVZ}{10PS} \quad (2)$$

Where

Vc = volume of the concentrated acid to be diluted.
M = molarity of the diluted solution
Z = molar mass of the acid
V = volume of the container (beaker)
P = percentage composition of the solution
S = specific gravity

Preparation of Plant Extracts

Samples of vernoniaamygdalina extracts used was obtained locally from OnweonwiyaIzzi Local Government Area of Ebonyi State. The leaves were collected and used fresh that is not dried, sunned or allowed to undergo any other process. The leaves were plucked and ground immediately using manual grinding machine. To obtain the extract, the ground leaves which already contained some water were then placed in a sieve cloth and squeezed to discharge the extract laden solution into a container. This became the stock inhibitor solution from which measured volumes were purposely introduced into the acid solutions for experimentation. Inhibitor volumes of 20mls, 30mls, 40mls and 50mls were used in 0.5M, 1.0M, 1.5M and 2.0M concentrations of acid solution together with a control for 0.5M to 2.0M.

Chemical Analysis of Plant Extract

Samples of vernoniaamygdalina extract used were analysed and the following results obtained (wt. %): Cu (0.7), Zn (0.3), Cr (0.3), Fe (9.5), Mn (1.0), Na (12.40), S (0.67), and p (0.73). The aim of this analysis is to ascertain the elements contained in the extract that aid in preventing corrosion. It was discovered that some elements such as S, P and Cr react to form organic compounds such as glycoside-vernoniside, vernonium, sesquiterpes lactones that contributed to corrosion inhibition.

Weight-loss method

Each beaker represents environmental set up. The beaker was allowed for five days which is 120hrs. The specimens were cleaned with acetone and weighed, the difference in weight from the initial weight (before immersion in environment) noted. The difference between the initial and final weight is called weight loss W. The weight loss in the coupons removed after 24hrs, 48hrs, 72hrs, 96hrs, and 120hrs from each of the beakers were calculated using

$W = W_1 - W_2$

Where

W = weight loss
W_1 = initial weight
W_2 = final weight

The procedure was repeated for five days.

Results and Discussion

Figures 1.0 to 4.0 show the variation of weight loss with time during the corrosion of mild steel in 0.5M, 1.0M, 1.5M and 2.0M concentration of diluteH_2SO_4, containing various volumes of leaf extract of *vernoniaamygdalina*.

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The figures revealed that weight loss of mild steel increases linearly with time, indicating that the rate of corrosion of mild steel in H_2SO_4 increases with time. The graphs also reveal that the weight loss of mild steel in H_2O_4 increases with the time of contact, but decreases with the concentration of extract of leaves of *vernoniaamygdalina,* indicating that the extract inhibits the corrosion of mild steel in H_2SO_4. In general, the weight losses in the exposed coupons increased with time, an indication of progressive increase in corrosion rates of mild steel in the different concentrations of H_2SO_4 with time. Relatively, the losses in weight with time are more pronounced in control samples (without inhibitor) than others with various volumes of inhibitor.

Furthermore, Fig. 1.0 shows the variation of weight loss with time for the corrosion of mild steel in various volumes of *vernoniaamygdalina* leaves extract and 0.5M H_2SO_4. From the graph it can be seen that in control, weight loss of mild steel increases linearly with time, indicating that the rate of corrosion of mild steel increases with time. It was also observed that the addition of various volumes of*vernoniaamygdalina* leaves extract to the corrodent led to a reduction in weight loss of mild steel compared to that of control. This indicate that leaves extract of *vernoniaamygdalina* inhibited the corrosion of mild steel in dilute H_2SO_4.

From figure 1.0, it can equally be seen that the best inhibition was observed when 50ml of leaves extract of vernoniaamygdalina was introduced to the corrodent. This buttress the point that the inhibition efficiency of the extract increase with increase in the concentration of the extract. Figure 2.0 variation of weight loss with time for the corrosion of mild steel in various volumes of vernoniaamygdalina leave extract and 1.0MH2SO4.

From the figure, it was observed that in control weight loss of mild steel increases progressively with time, given a clear gap between the control and those with inhibitor. This is a clear indication that the rate of corrosion of mild steel in dilute H_2SO_4, increases with increase in the concentration of the acid. Again it was observed that leaves extract of *vernoniaamygdalina* inhibit corrosion of mild steel in dilute H_2SO_4, irrespective of the concentration of the acid.

However, in figures 3.0 and 4.0 variations of weight loss with time for the corrosion of mild steel in various volumes of *vernoniaamygdalina* leaves extract and 1.5M and 2.0M of H_2SO_4, respectively. From fig. 3.0 and 4.0, it was also observed that in control there were tremendous increase in weight loss of mild steel with time, creating a gap between the controls and those with inhibitor. The gap increases with increase in the concentration of the acid.

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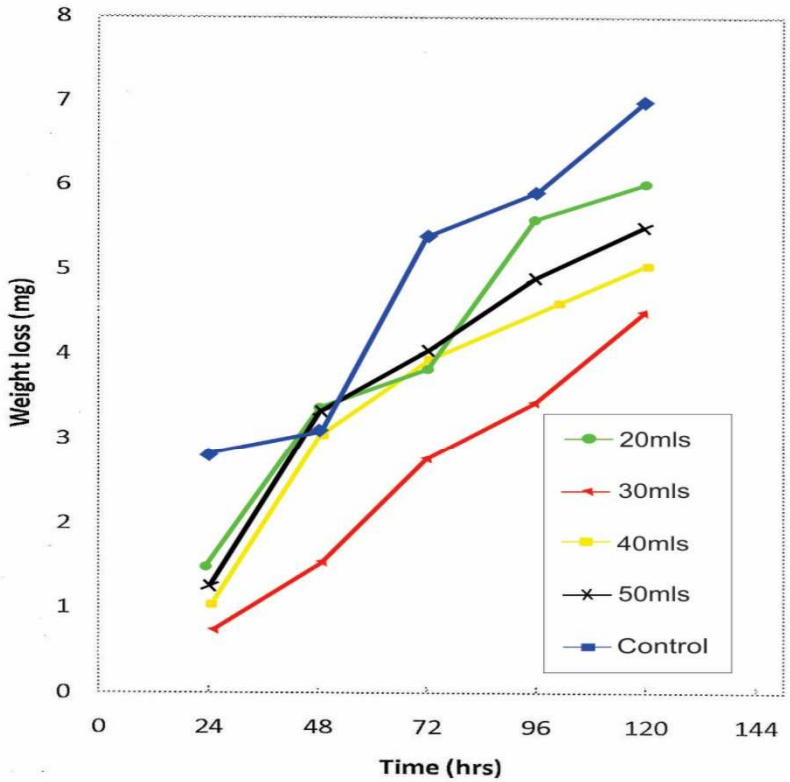

Fig.1.0 Variation of weight loss with time for the corrosion of mild steel in various volumes of vernonia amygdalina leaves extract and 0.5M H_2SO_4

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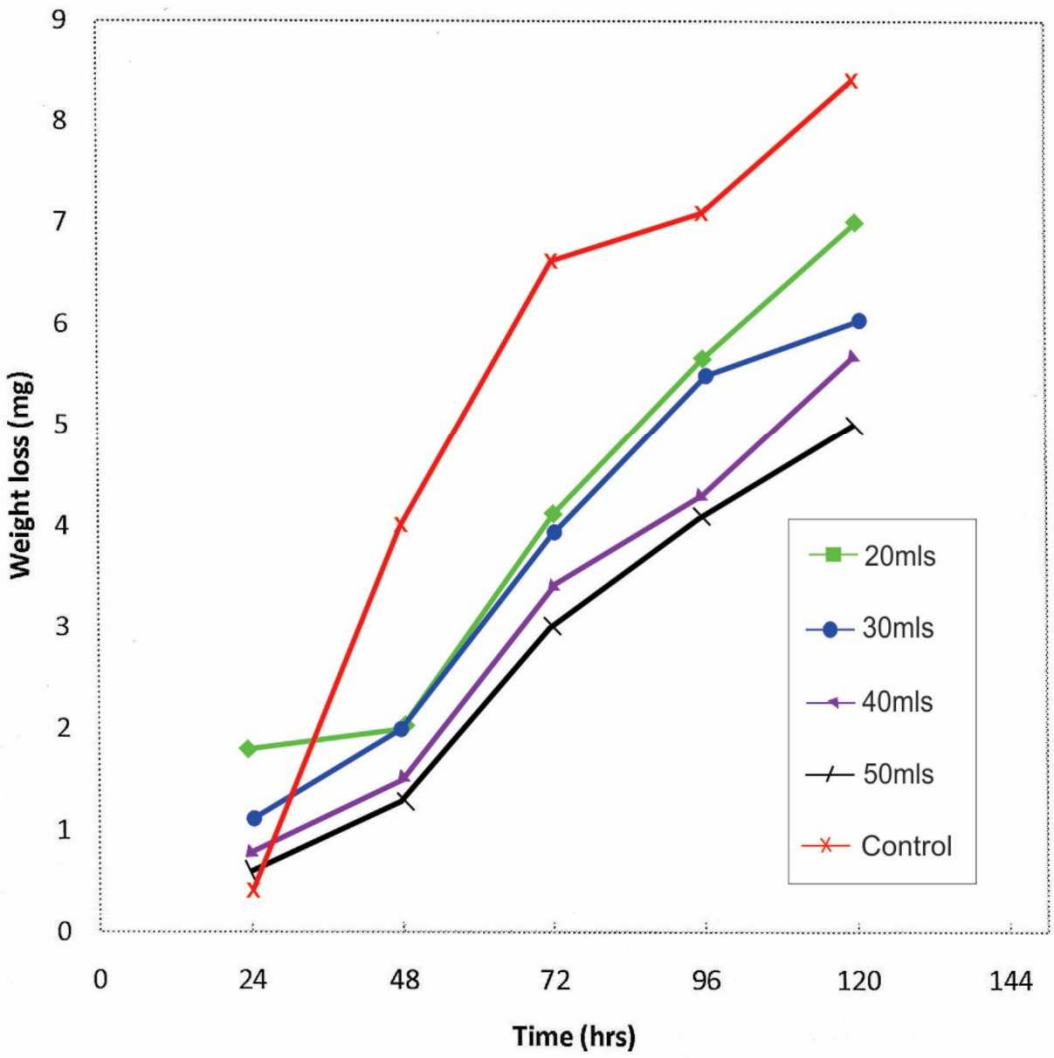

Fig.2.0 Variation of weight loss with time for the corrosion of mild steel in various volumes of vernonia amygdalina leaves extract and 1.0M H_2SO_4

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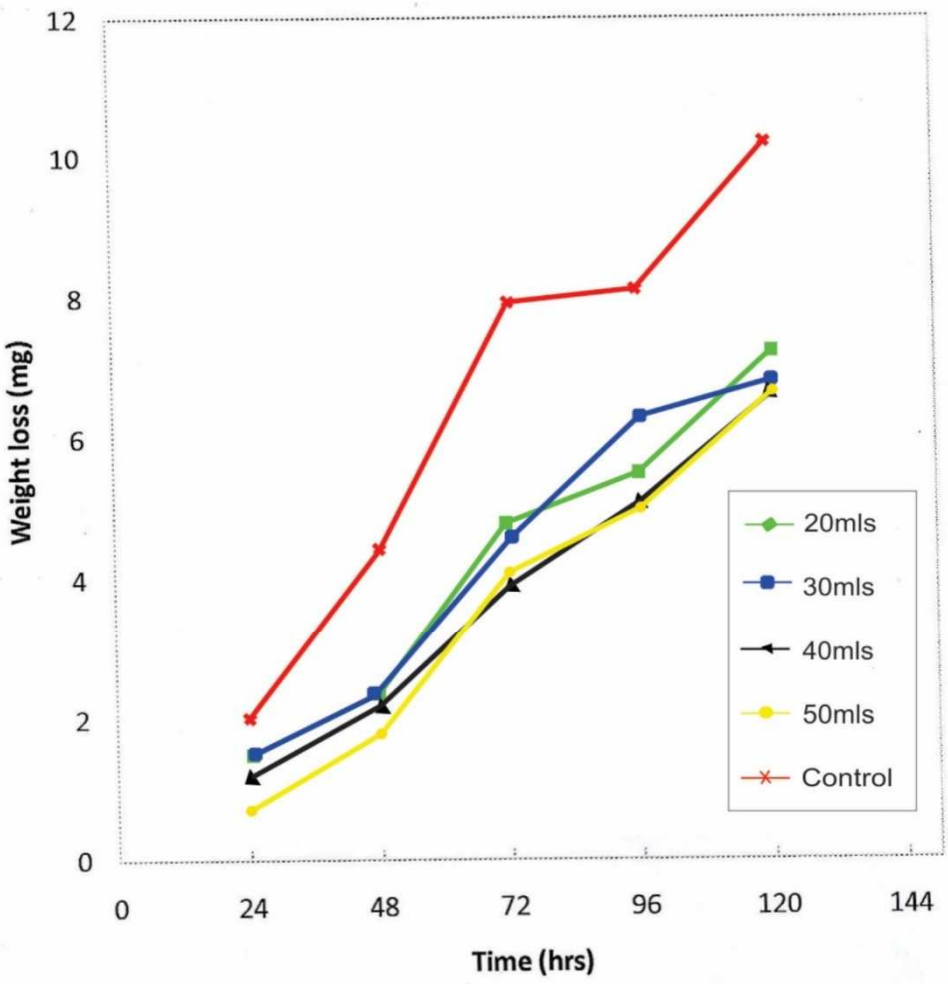

Fig. 3.0 Variation of weight loss with time for the corrosion of mild steel in various volumes of vernonia amygdalina leaves extract and 1.5M H_2SO_4

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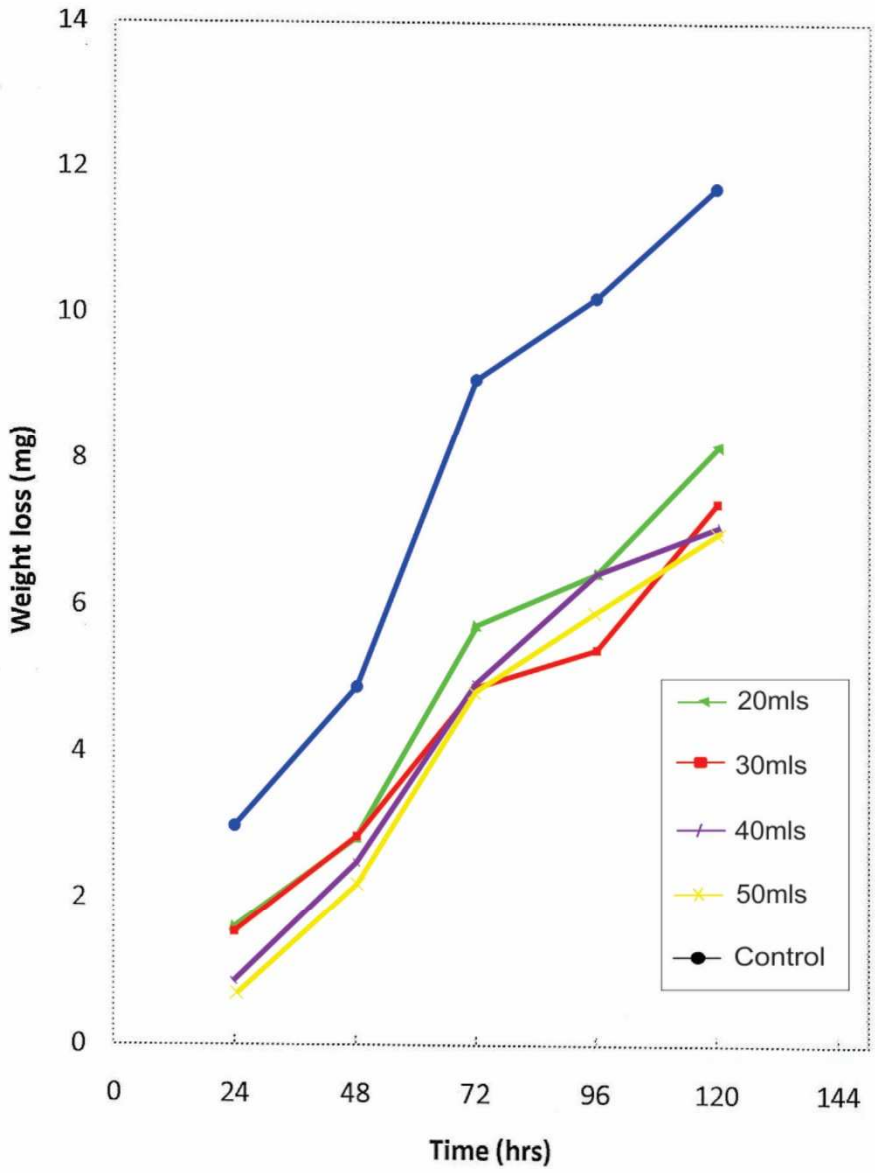

Fig. 4.0 Variation of weight loss with time for the corrosion of mild steel in various volumes of vernonia amygdalina leaves extract and 2.0M H_2SO_4

CONCLUSIONS

In summary, weight losses in the exposed coupons increased with time, an indication of progressive increase in the corrosion rates of mild steel in different concentrations of H_2SO_4 with time.

It can be reasonably concluded that weight loss of mild steel in H_2SO_4 increases with time of contact, but decreases with the increase in the concentration of the extract of the leaves of *vernoniaamygdalina*; an indication that the extract inhibits corrosion of mild steel in H_2SO_4.

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In general, the best result was obtained when 50ml of leaves extract of *vernoniaamygdalina* was introduced to the corrodent. This buttress the point that the inhibition efficiency of the extract increases with the increase in the concentration of the extract.

The research also shows that the inhibition of mild steel with the leaves extract of *vernoniaamygdalina* could afford a reasonable protection at the right inhibitor dosage.

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