

## Examining the Effectiveness of Bitter Leaf Extract in Fighting Corrosion

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**Abstract:** In this study, bitter leaf extract were used as an inhibitor on M- steel in 1 mol HCl and 0.5 mol H<sub>2</sub>SO<sub>4</sub>. Corrosion act of M- steel in the company and devoid of inhibitor (bitter leaf extracts) were deliberated with potentiodynamic polarization and electrochemical impedance process. The tests were done at diverse concentrations, temperatures and durations. Potentiodynamic polarization arcs for M- steel in 1 mol HCl and 0.5 mol H<sub>2</sub>SO<sub>4</sub> solutions in company with devoid of bitter leaf extort. In 1 mol HCl environment, incorporation of inhibitor declines the oxidization rate i.e. swings in cathodic and anodic polarization archs to lesser worth of current densities to greater level. Thus, reactions of anodic and cathodic were inhibited, same act was observed in 0.5 mol H<sub>2</sub>SO<sub>4</sub> solution. It could be due to the intake of inhibitor on the active corroded shell. Inhibitor has impeded effect on the metal termination with the rate of hydrogen evolution reaction. Thus, bitter leaf can be termed a varied-kind inhibitor. It was disclosed by (EIS) that addition of bitter leaf extract in tart corrodents induces the charge shift fighting to enhance, whilst tumbling the double coating capacitance. Effectiveness of inhibition is found to enhance with bitter leaf extract addition. This shown that extract of bitter leaf is a fine corrosion fighter for steel. Inhibitor particles were chemisorbed on electron shell according to the Langmuir adsorption isotherm.

**Keywords:** Acid, Bitter Leaf, Corrosion, Extort, Inhibitor

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### I. Introduction

Solutions of acid were used in processing industries as acid picking, descaling, cleaning and oil well acidizing and inhibitors are needed. [1]. Mineral acids are propelled in side the well to counter the creation of the bung by clays or dissolved equipments in the acidisation operation of oil well for improved oil revival. Exposures may be harsh but corrosion inhibitors are incorporated in industry to thwart or reduced oxidization rates of metals in acid media [2]. Several unprocessed compounds have been accounted as efficient corrosion inhibitor[3-8]. Majority of these inhibitors are poisonous to human their environs. Noxious outcomes of the inhibitors fronted to the utilize of natural manufactured goods as oxidization inhibitors [9]. Nitrogen with sulphur incorporated mixes are effectual corrosion inhibitors in media acid [10].

Extorts of natural products have various mixes that are recyclable. Extorts of *Azarieta indica*, *Fenugreek leaves*, *Zenthoxylum alatum*, *Opuntia*, *Nypa frutricans*, *Ocimum viridis*, *Phyllanthus amarus*, *Chamomile*, *Halfabar*, black cummin with nitrogen and sulphur as essential particles were examined as oxidization fighters in HCl and sulphuric acid medium [11 – 15].

Sighting the high act of plant extracts, examination on the inhibitive performance of bitter leaf extorts on oxidization of M-steel in HCl and H<sub>2</sub>SO<sub>4</sub> by potentiodynamic polarization as well as electrochemical impedance spectroscopy. Bitter leaf is utilized for its medical properties.

### II. Experimental

#### 2.1. Preparation of plant extort

Leaf of bitter leaf were separately sun dehydrated for three days. After sun drying, they were separately crushed to enhance the surface area and kept in clogged containers. 30 grams of crushed leaf were got and awash in

1000ml of distilled water for 48 hours. After 48 hours, the blend was sifted. The filtrate got is a combination of the extract and distilled water.

Test were carried out on a shell of M- steel in the chemical composition of C = 0.06, Si = 0.04, Mn = 0.06, Cu = 0.08, Cr = 0.07 and remainder Fe were utilized. M- steel samples were implanted in polyester and 0.4062 cm<sup>2</sup> surface area was in touch with the acidic media. Cu- wire was utilized for electrical link. Surface grounding of the samples was done by abrasive paper (120, 400 and 800 grade), greased-free using acetone, rinsed with purified water and desiccated at ambient temperature. The bitter leaf was locally sourced at Fegge- Onitsha, Anambrs State. The metal sheet was sourced locally from market at Aba, Abia state and analysed with spectrometer at Hoxg Nigera Ltd., Amueo Odofin, Lagos. Tetraoxosulphate (vi) acid (H<sub>2</sub>SO<sub>4</sub>) used was of BDH AR grade, 98%. Hydrochloric acid (HCl) used was of Pro Analysis AR, 37%.

## 2.2 Electrochemical measurements

The tests were conducted in 1.0M HCl and 0.5M H<sub>2</sub>SO<sub>4</sub> with and without bitter leaf extract. Electrochemical tests were executed with a normal three-electrode cell containing M-steel rod as a electrode, a portion of platinum with surface area of 1 cm<sup>2</sup> oppose electrode, and Ag/AgCl orientation electrode by means of CHI 660B model electrochemical analyzer in CPU. Cell was- covered and Qlinked to a steady temperature runner. Preceding the electrochemical tests, a stable time of 1 hr was permitted which is enough to reach a steady value for the open circuit corrosion potential (E<sub>corr</sub>). EIS tests were conducted at the incidence of 10<sup>5</sup> to 10<sup>-3</sup> Hz at E<sub>corr</sub> using 5 mV amplitude. Electrochemical parameters of corrosion procedures might be resolute by Tafel extrapolation of the cathodic arc to the cathodic linear region rear to the corrosion potential.

Linear polarization learn were performed from cathodic potential of -0.02V vs OCP to anodic potential of + 0.02V vs OCP at a sweep rate of 0.125 mVs<sup>-1</sup> to scrutinize the polarization resistance (R<sub>p</sub>). From the calculated polarization resistance value, the inhibition effectiveness has been computed applying the link:

$$E (\%) = \frac{R_p^I - R_p^O}{R_p^I} \times 100 \quad (1)$$

Where R<sub>p</sub><sup>O</sup> and R<sub>p</sub><sup>I</sup> be the polarization resistance with and without the bitter leaf.

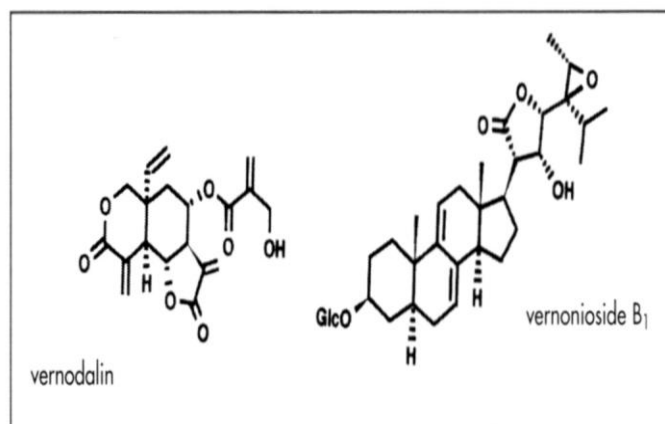


Fig. 1. Structure of vernodaline and vernonioside better leaves

Prospective zilch charge of M-steel was designed by gauging the R<sub>p</sub> values at open – circuit oxidation potential at ± 0.175 V (Ag/AgCl) potential arrays from open – circuit corrosion maximum of the scheme is defined as potential of zero charge.

## III. Iii Results

### 3.1. Potentiodynamic polarization results for bitter leaf extract.

Polarization test were conducted to differentiate the outcome of bitter leaf on the anodic and cathodic responses. Distinctive potentiodynamic polarization arcs for M-steel in 1 mol HCl and 0.5 mol H<sub>2</sub>SO<sub>4</sub> consisting diverse concentrations of bitter leaf. Fig. 1.2 shows the potentiodynamic polarization arcs for M- steel in 1 mol HCl and 0.5 mol H<sub>2</sub>SO<sub>4</sub> solutions with and without bitter leaf extort. At 1 mol HCl environment, incorporation of the inhibitor leads to the reduction in oxidization rate i.e. moves cathodic and anodic polarization arcs to lesser values of current densities to an extent. Alternatively, anodic and cathodic reactions were reserved, same actions was scrutinized in 0.5 mol H<sub>2</sub>SO<sub>4</sub> solution. It was due to the intake of inhibitor on the decomposed

surface. Inhibitor has retarding effect on metal termination and the speed of hydrogen evolution response. Thus, bitter leaf could be termed a varied-type inhibitor.

Thus, electrochemical parameters of oxidization procedures might be got by Tafel stretching of the cathodic arc to the cathodic linear district rear the oxidization potential. It was revealed that in Tafel stretching technique, utilizing of anodic and cathodic Tafel areas is chosen over the utilization of Tafel area. In recent, (Amin et al.2006) suggested that the corrosion parameters could be got by stretching the cathodic polarization arc, and appropriating the anodic area by 10–150 mV (vs.  $E_{corr}$ ).

So, it is likely to compute the anodic Tafel line from the figures. The technique is satisfactory due to its reliable with other techniques of oxidization rate resolution. Worths of corrosion current densities ( $i_{corr}$ ), corrosion potential ( $E_{corr}$ ), cathodic Tafel slope (bc), anodic Tafel slope (ba) with inhibition efficiency (IE%) were summed up in Table1.0: In 0.5 M  $H_2SO_4$ , incorporation of bitter leaf extract shifts  $E_{corr}$  slightly to a negative, showing that bitter leaf extract could be placed as a predominant cathodic inhibitor. Also,  $E_{corr}$  do not change amazingly with inhibitor, in the studied environment showing that the inhibitor is varied-type inhibitor, inhibition is by geometric blocking outcome.

Inhibition result comes from the lessening the reaction area on the exterior of the corroding metal. Tafel slopes of bc and ba alters with the incorporation of inhibitors, showing that inhibitor particles are taken on the anodic and cathodic locations leading to the changing laws of the potential with recent.

Results in Table 1.0, shows that the corrosion current density  $I_{corr}$  reduced significantly with bitter leaf extract contrasted to the uninhibited solution and reduced with a raise in addition of the extort, this was observed in the environments investigated. The inhibition efficiency was got with the following:

$$IE\% = \left( \frac{I_{corr(bl)} - I_{corr(inh)}}{I_{corr(bl)}} \right) \times 100 \quad (1.0)$$

$I_{corr(bl)}$  and  $I_{corr(inh)}$  stands for the corrosion current density with and without inhibitor. Uppermost inhibition efficiency of (94.7%) and (77.5%) were obtained in 1 mol HCl and 0.5 mol  $H_2SO_4$ , at the application of 1000 mg/L bitter leaf extract.

With inhibitor,  $I_{corr}$  values reduces to reasonable point. At higher concentration of 1000 mg/L bitter leaf extract,  $I_{corr}$  decreases sharply comparing with what is obtainable in the absence of bitter leaf extract or even at low concentration of bitter leaf extract in both solutions, meaning that the steel corrosion is significantly retarded. This result proves that inhibitor have a fine inhibitive upshot on the M- steel surface.

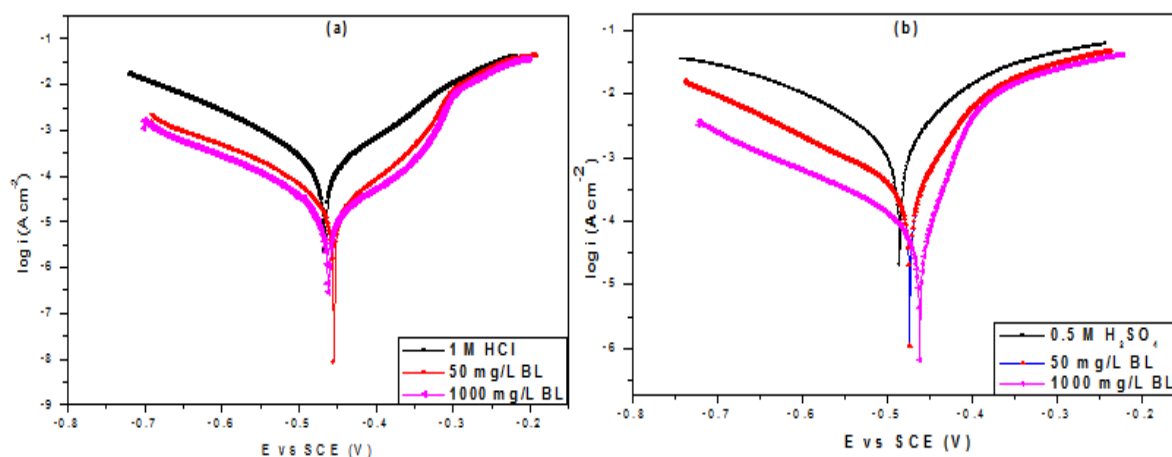


Fig. 2.0. Potentiodynamic polarization arcs for M-steel in: (a) 1 mol HCl and (b) 0.5 mol  $H_2SO_4$  in the presence and absence of diverse concentrations of bitter leaf extracts.

**Table 1.0** Polarization Parameters for M-Steel in 1 mol HCl and 0.5 mol H<sub>2</sub>SO<sub>4</sub> With and Without bitter leaf extort.

System	E <sub>corr</sub>	I <sub>corr</sub>	b <sub>a</sub>	b <sub>c</sub>	IE (%)
1 mol HCl	-466.4	183	100.6	122.7	
50 mg/L BL	-454.9	21.3	75.1	115.1	88.4
1000 mg/L BL	-461	9.6	71.4	104.2	94.7
0.5 mol H <sub>2</sub> SO <sub>4</sub>	-454.3	1340	119.5	181.2	
50 mg /L BL	-452.4	803	116.2	202.4	40.1
100 mg/l BL	-450.6	301.4	61.2	165.7	77.5

3.2: Electrochemical impedance spectroscopy (EIS)

Fig.3.0. show the Nyquist drawing for M-steel in 1 mol HCl with 0.5 mol H<sub>2</sub>SO<sub>4</sub> environments with and without BL. The figures have related shape for every experimental conditions, showing roughly did not alter the corrosion mechanism owing to incorporation of inhibitor. Nyquist designs takes the shape of a disheartened semicircle in the elevated frequency region, showing charge-transfer control of the process which matches a time constant in the Bode scheme. Single era stable might be accredited to the small time disclosure in the corrodent, thus, it is inadequate to disclose damage of the substrate (Martinez *et al*, 2001). Despair of the Nyquist semicircle with center below the actual axis is archetypal for hard metal electrodes that illustrate regularity of dispersal of the impedance data.

Nyquist impedance spectra plots were properly examined by appropriating to the equivalent circuit model R<sub>s</sub>(Q<sub>dl</sub>R<sub>ct</sub>). The matching electrochemical parameters shown in Table 2.0. disclose that incorporation of bitter leaf extract to the corrodents leads the charge transport resistance to enhance, whereas plummeting the double layer capacitance. It is prominent with incorporation of more bitter leaf extract. Boosting in R<sub>ct</sub> values in inhibited solutions shows better oxidation resistance owing to the oxidation inhibiting action of bitter leaf extort, while lessen in C<sub>dl</sub> values, this results from a reduction in the dielectric constant or a raise in the double-layer thickness, it could be credited to the intake of bitter leaf extort onto the metal/electrolyte interface. It means that bitter leaf extort diminishes the oxidation rate of the M- steel sample in 1 mol HCl as well as in 0.5 mol H<sub>2</sub>SO<sub>4</sub> as a result of their intake on the metal surface when submerge in the acid media, thus preventing the metal from acidic attack.

Effectiveness of inhibition is viewed from Table 2.0. it enhances with addition of bitter leaf extract. Their worth were predicted by evaluating the worth of the charge movement resistance in the without(R<sub>ct,bl</sub>) and with inhibitor (R<sub>ct,inh</sub>) as shown in equation 1.0. Which showed that only Langmuir and Freundlich isotherms best explained the adsorption behavior of this inhibitor on the surface of M- steel and aluminium. Langmuir adsorption isotherm can be expressed as:

$$(\Theta) = \frac{KC}{1+KC} \tag{2.0}$$

The parameter n is believed to be the gauge of surface in homogeneity, and its boost in the reserved solution evaluated with the unadulterated acid is linked with a reduction in heterogeneity resulting from inhibitor intake.

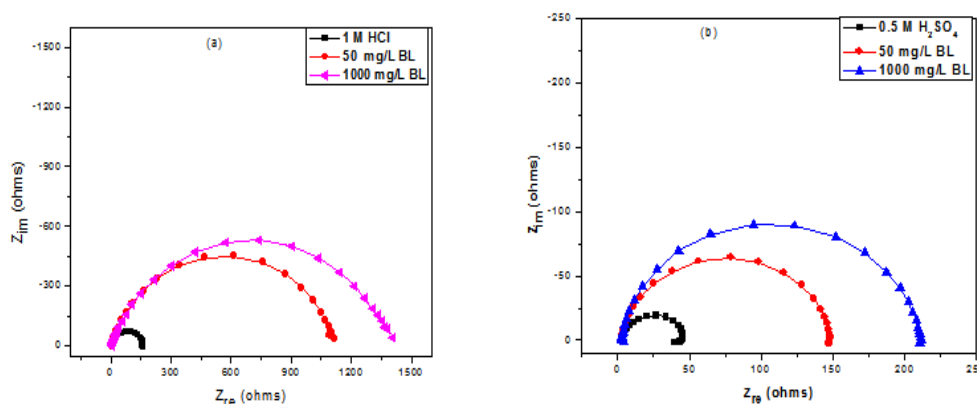


FIGURE 3.0 : ELECTROCHEMICAL IMPEDANCE SPECTRA OF M- STEEL CORROSION IN 1 M HCL SOLUTION WITHOUT AND WITH BITTER LEAF EXTRACT.

**Table 2.0.** Electrochemical Impedance Parameters of M- Steel in 1 M HCl and 0.5 M H<sub>2</sub>SO<sub>4</sub> in the Absence and Presence of BL at 30°C.

System	R <sub>s</sub> (Ω cm <sup>2</sup> )	R <sub>ct</sub> (Ω cm <sup>2</sup> )	N	C <sub>dl</sub> (F cm <sup>-2</sup> )	I.E (%)
1 M HCl	1.659	102.7	0.89	6.908E-5	
50 mg/L BL	2.865	1114.6	0.89	5.940E-5	90.8
1000 mg/L BL	3.428	1468.9	0.89	5.111E-5	93
0.5 M H <sub>2</sub> SO <sub>4</sub>	2.063	28.02	0.89	1.131E-4	
50 mg/ L BL	2.481	149.2	0.89	5.998E-5	81.2
1000 mg/ L BL	2.723	216.7	0.89	5.642E-5	87.1

#### IV. Conclusions

1) The inhibitor has retarding effect on metal termination and the speed of hydrogen evolution reaction. Thus, bitter leaf could be termed as a varied-type inhibitor.

(2) There is a reduction in the oxidization rate in 1 mol HCl with incorporation of inhibitor. That is, there was a shift in cathodic with anodic polarization arcs to lesser values of current densities to an extent. It means that anodic and cathodic reactions were reserved, the same performance was detected in 0.5 mol H<sub>2</sub>SO<sub>4</sub> solution. It is due to the intake of inhibitor over the active decomposed surface.

(3) Corrosion current density I<sub>corr</sub> reduced significantly with bitter leaf extract when evaluated with the uninhibited solution thus there is a reduction with an increase extract addition, this was observed in the environments investigated.

(4) Potentiodynamic polarization arcs for M-steel in 1 mol HCl and 0.5 mol H<sub>2</sub>SO<sub>4</sub> with diverse concentrations of bitter leaf. Fig. 1.2 shows the potentiodynamic polarization arcs for M-steel in 1 mol HCl and 0.5 mol H<sub>2</sub>SO<sub>4</sub> solutions without and with bitter leaf extract. In 1 mol HCl environment, the occurrence of the inhibitor leads to the reduction in the oxidization speed i.e. moves the cathodic and anodic polarization arcs to lesser values of current densities to an extent. Thus, anodic and cathodic reactions were inhibited, same performance was viewed in 0.5 mol H<sub>2</sub>SO<sub>4</sub> solution.

(5) Fig.3.0. illustrate the Nyquist diagrams for M- steel in 1 mol HCl and 0.5 mol H<sub>2</sub>SO<sub>4</sub> environments with and without bitter leaf extort. The figures are alike all through, signifying that there is nearly nix change in the oxidization mechanism owing to addition of the inhibitor. Nyquist plots have the structure of one depressed semicircle in the elevated frequency region, it shows that the procedure is under charge-transfer control and matches the one time constant in the Bode plots.

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