

# Oxystelma Esculentum Leaves Extracts As Corrosion Inhibitor For Mild Steel In Acid Medium

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**Abstract:** Oxystelma esculentum leaves inhibition effects on the corrosion of steel in 0.5M H<sub>2</sub>SO<sub>4</sub> solution were investigated using polarization and electrochemical impedance techniques. The results revealed that Oxystelma esculentum leaves acts as a corrosion inhibitor in 0.5M H<sub>2</sub>SO<sub>4</sub> solution. The inhibition efficiency increased with an increase in inhibitor concentration. The inhibition is attributed to adsorption of the inhibitor on the steel surface.

Key words: Inhibitor, Mass loss, Impedance, Polarization, oxystelma esculentum

## 1. INTRODUCTION

Corrosion inhibitors are widely used in industry to reduce the corrosion rate of metals and alloys in contact with aggressive environments. Most of the corrosion inhibitors are synthetic chemicals, expensive, and very hazardous to environments. Therefore, it is desirable to source for environmentally safe inhibitors [1-3]. There are some reports on the inhibition effects of non-toxic compounds on the Corrosion of metals. We have recently reported the inhibition effect of amino acids on the steel [1] and aluminum [4] corrosion in acidic media. The rare earth metals have been proposed as corrosion inhibitors [5-8]. The inhibition effects of some non-toxic organic compounds have been also reported for steel corrosion [9, 10] but they are expensive. The aim of this study was to investigate the inhibition effect of Oxystelma esculentum extract as a cheap, raw and non-toxic corrosion inhibitor on mild steel corrosion in 0.5M H<sub>2</sub>SO<sub>4</sub>. The electrochemical measurements were used to evaluate the inhibition efficiencies.

## 2.0 MATERIAL AND METHODS:

### 2.1 Preparation of oxystelma esculentum extract

An aqueous extract of oxystelma esculentum extract was prepared by grinding 5g of plant leaves, with distilled water, filtering the suspending impurities, and making up to 100 ml. The extract was used as corrosion inhibitor in the present study.

### 2.2 Preparation of specimens:

Carbon steel specimens (0.022% S, 0.038% Mn, 0.027%P, 0.086 C) of dimension 1.0 cm \*4.0cm\*0.2cm were polished to a mirror finished with the emery sheets of various grades and degreased with trichloroethylene.

### 2.3 Weight loss method.

Carbon steel specimens in triplicate were immersed in 100 mL of the inhibited and uninhibited 0.5M H<sub>2</sub>SO<sub>4</sub> solutions in the presence and absence of KI for two hours. The weight of each specimen before and after immersion was determined using shimadzu balance, model Ay 62. The inhibition efficiency (IE) was then calculated using the expression[12];

$$IE\% = \left( \frac{W_1 - W_2}{W_1} \right) \times 100$$

Where W<sub>1</sub> and W<sub>2</sub> are the corrosion rates in the absence and presence of the inhibitor, respectively.

### 2.4 Electrochemical impedance measurements

The electrochemical impedance measurements were carried out using a Potentiostat/Galvan stat/FRA (PARSTAT 2273, Princeton Applied Research, USA). Data acquisition was performed utilizing the Power Suite software and analyzed using Zsimp Win software (version 3.21). A three electrode set up was employed with Pt foil as the auxiliary electrode and a saturated calomel electrode as the reference electrode. The Teflon coated mild steel rod, with the surface prepared as described in the weight loss experimental method, served as the working electrode. The measurements were carried out in the frequency range 10<sup>6</sup>–10<sup>-2</sup> Hz at the open circuit potential by superimposing sinusoidal AC signal of small amplitude, 10 mV, after an immersion period of 30 min in the corrosive media. The double layer capacitance (C<sub>dl</sub>) and charge transfer resistance (R<sub>ct</sub>) were obtained from the impedance plots as described elsewhere<sup>11</sup>. Because R<sub>ct</sub> is inversely proportional to corrosion current density, it was used to determine the inhibition efficiency (IE%) using the relationship;

$$IE\% = \frac{R_{ct} - R_{ct}^0}{R_{ct}} \times 100$$

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Where  $R_{ct}$  and  $R_{0ct}$  are the charge transfer resistance values in the inhibited and uninhibited solutions respectively.

## 2.5. Polarization measurements

The potentiodynamic polarization curves were recorded using the same cell setup employed for the impedance measurements. The potentials were swept at the rate of 1.66mV/s, primarily from a more negative potential than  $E_{ocp}$  to a more positive potential than  $E_{ocp}$  through  $E_{corr}$ . The inhibition efficiencies were calculated using the relationship

$$IE\% = \frac{I_{corr}^0 - I_{corr}}{I_{corr}^0} \times 100$$

Where  $I_{corr}^0$  and  $I_{corr}$  are the corrosion current densities in the absence and in the presence of inhibitor, respectively

## 3. RESULTS AND DISCUSSION

### 3.1 Analysis of results of mass loss method

The corrosion rates and inhibition efficiency values, calculated using weight loss data, for various concentrations of oxystelma esculentum extract in the presence and absence of KI the corrosion of carbon steel in 0.5M H<sub>2</sub>SO<sub>4</sub> solution are presented in Table.1. It is apparent that the inhibition efficiency increased with the increase in inhibitor concentration in the presence and absence of KI. This behavior can be explained based on the strong interaction of the inhibitor molecule with the metal surface resulting in adsorption. The extent of adsorption increases with the increase in concentration of the inhibitor leading to increased inhibition efficiency. The maximum inhibition efficiency was observed at an inhibitor concentration of 100 ppm. Generally, inhibitor molecules suppress the metal dissolution by forming a protective film adsorbed to the metal surface and separating it from the corrosion medium. The corrosion suppressing ability of the inhibitor molecule originates from the tendency to form either strong or weak chemical bonds with Fe atoms using the lone pair of electrons present on the O and  $\pi$  electrons in benzene ring. It is also seen from table.1 that the leaf extract of oxystelma esculentum at 25 ppm and 100 ppm concentrations shows 55.55 % and 66.00 % inhibition efficiencies respectively, Then the values increased to 80.14 % after adding 25 ppm of KI solution in 0.5M H<sub>2</sub>SO<sub>4</sub> solutions containing 100 ppm of plant extract respectively. This showed a good synergistic effect between oxystelma esculentum extract and KI.

**Table1.** Corrosion rate (CR) of mild steel in 0.5M H<sub>2</sub>SO<sub>4</sub> solutions the absence and presence of inhibitor and the inhibition efficiency (IE) obtained by weight loss method.

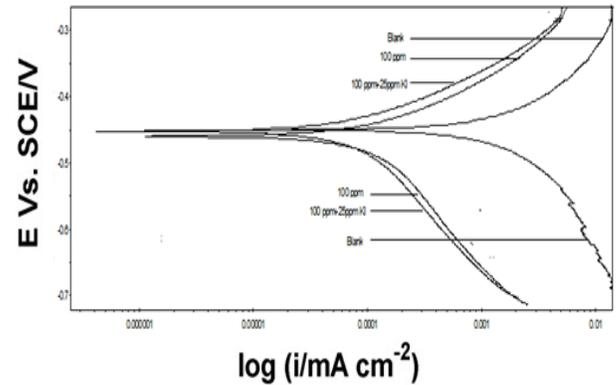
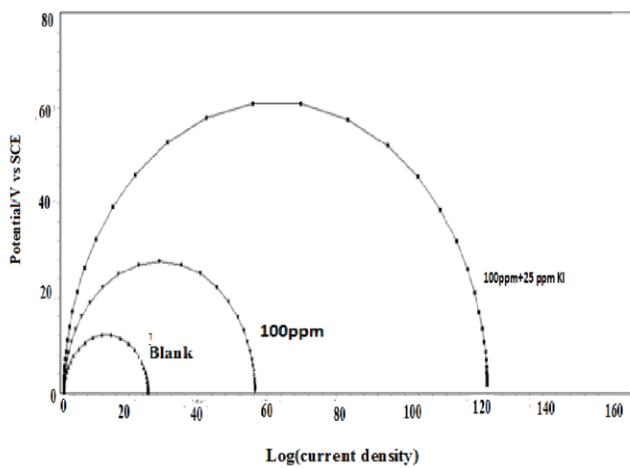
Inhibitor concentration (mL)	KI (0) ppm	
	CR (mdd)	IE %
0	136.00	-
10	65.21	52.05
25	60.65	55.40
50	51.93	61.81
75	47.00	65.44
100	46.12	66.10

### 3.2 Influence Of KI On The Inhibition Efficiency Of Leaves Extracts

Inhibitor concentration (100ppm)	KI (25) ppm	
	CR (mdd)	IE %
100	25.65	80.14

### 3.3 Electrochemical impedance spectroscopic measurements (EIS)

Impedance spectra obtained for corrosion of mild steel in 0.5 M H<sub>2</sub>SO<sub>4</sub> contains a semicircle, representing the interaction of metal surface with the corrosive environment.. The-R(CR) model best describes this situation. The semicircle in the impedance plots contain depressed semicircles with the centre below the real axis. The size of the semicircle increases with the inhibitor concentration, indicating the charge transfer process as the main controlling factor of the corrosion of mild steel. It is apparent from the plots that the impedance of the inhibited solution has increased with the increase in the concentration of the inhibitor. The experimental results of EIS measurements for the corrosion of mild steel in 0.5 M H<sub>2</sub>SO<sub>4</sub> in the absence and presence of inhibitor are given in Table 3. Said that sum of charge transfer resistance ( $R_{ct}$ ) and adsorption resistance ( $R_{ad}$ ) is equivalent to polarization resistance ( $R_p$ ).



**Fig 2.** Potentiodynamic polarization curves of mild steel immersed in 0.5M H<sub>2</sub>SO<sub>4</sub> solution in the absence and presence of inhibitors

**Table 3.** Impedance curves obtained from electrochemical impedance studies.

Inhibitor concentration ppm	R <sub>ct</sub> Ohm cm <sup>2</sup>	C <sub>dl</sub> μF	IE%
0	17.2	9.2578×10 <sup>-3</sup>	-
100	52.00	3.062×10 <sup>-6</sup>	66.80
100+25ppmKI	90.5	1.759×10 <sup>-6</sup>	81.00

**Table 4.** Corrosion parameters in the presence and absence of inhibitor obtained from polarization

Inhibitor concentration ppm	-E <sub>corr</sub> (mV)	β <sub>c</sub> (mV/dec)	β <sub>a</sub> (mV/dec)	I <sub>corr</sub> ×10 <sup>6</sup> μA	IE%
0	447	127	68	1.35	-
100	450	173	72	0.465	65.5
100+25ppmKI	453	195	94	0.259	80.8

The polarization curves obtained for the corrosion of mild steel in the inhibited (100 ppm) and uninhibited 0.5 M H<sub>2</sub>SO<sub>4</sub> solutions in the absence and presence of KI are shown in Fig.2. Electrochemical parameters such as corrosion potential (E<sub>corr</sub>), corrosion current density (I<sub>corr</sub>), cathodic and anodic tafel slopes (β<sub>c</sub> and β<sub>a</sub>) and percentage inhibition efficiency according to polarization studies are listed in table 4. Here I<sub>corr</sub> decreased with increasing inhibitor concentration. From the figures, it can be interpreted that the addition of this inhibitor to corrosive media changes the anodic and cathodic tafel slopes. The changes in slopes showed the influence of the inhibitor both in the cathodic and anodic reactions. However, the influence is more pronounced in the cathodic polarization plots compared to that in the anodic polarization plots. Even though β<sub>c</sub> and β<sub>a</sub> values (table.3) change with an increase in inhibitor concentrations, a high β<sub>c</sub> value indicates that the cathodic reaction is retarded to a higher extent than the anodic reaction [13]. From Fig.2 it is also clear that the addition of the inhibitor shifts the cathodic curves to a greater extent toward the lower current density when compared to the anodic curves. The E<sub>corr</sub> value is also shifted to the more negative side with an increase in the inhibitor concentration. These shifts can be attributed to the decrease in the rate of the hydrogen evolution reaction on the mild steel surface caused by the adsorption of the inhibitor molecule to the metal surface[14]. It has been reported that a compound can be classified as an anodic and cathodic type inhibitor on the basis of shift of E<sub>corr</sub> value. If displacement of E<sub>corr</sub> value is greater than 85 mv, towards anode or cathode with reference to the blank, then an inhibitor is categorized as either anodic or cathodic type inhibitor otherwise inhibitor is treated as mixed type[15, 16]. In our study, maximum displacement in E<sub>corr</sub> value was around 6 mV, indicating the inhibitor is a mixed type and more anodic nature and does not alter the reaction mechanism. The inhibition effect has occurred due to simple blocking of the active sites, thereby reducing available surface area of the corroding metal[17, 18]. The increase in inhibitor efficiency of inhibited (10mL) 0.5M H<sub>2</sub>SO<sub>4</sub> solution for the corrosion of mild steel after adding 25 ppm KI shows synergism between inhibitor molecules and KI.

### 3.5 Conclusions:

The effect of acid concentration and the effect of addition the aqueous extract of oxystelma esculentum leaves on the corrosion of Mild steel has been studied. The following conclusions may be drawn:

- 1) The chemical results showed that the corrosion rate of mild steel sample is increase with increasing acid concentrations 25ppm to 100 ppm
- 2) The polarization measurements also showed that, the increase of 0.5 M H<sub>2</sub>SO<sub>4</sub> concentration leads to displacement of the anodic and cathodic curves to high current densities (I<sub>corr.</sub>), also increase the corrosion rate will be found.
- 3) The electrochemical impedance measurements showed that the corrosion of mild steel sample is mainly controlled by charge transfer process.
- 4) The aqueous extract of oxystelma esculentum plant acts as good inhibitor for the corrosion of mild steel in 0.5 M H<sub>2</sub>SO<sub>4</sub> solution.
- 5) Electrochemical polarization results indicates that the oxystelma esculentum aqueous extract act as mixed type inhibitor and impedance results showed that the corrosion of mild steel is mainly controlled by a charge transfer process and the presence of oxystelma esculentum leaves extract in acid solution does not alter the mechanism of mild dissolution.

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