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Corrosion Behaviour of Mild Steel in Acidic Medium in Presence of Aqueous Extract of Clitoria Ternatea Stem

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Abstract

The corrosion inhibitive action of flower extracts of clitoria ternatea stem on mild steel corrosion in 0.5 M H2SO4 solution was studied using weight loss method, potentiodynamic polarization and EIS measurements. The results obtained indicate that the extracts functioned as good inhibitors in 0.5 M H2SO4 solution. Inhibition efficiency was found to increase with extract concentration. The adsorption of constituents in the plant extract on the surface of the metal is proposed for the inhibition behavior.

Keywords: Inhibitor, Mass loss, Impedance, Polarization, Clitoria ternata.

Introduction

Corrosion is a common phenomenon associated with almost all the metals except noble metals and is particularly severe in the case of iron that forces the many industries to invest more for the control of corrosion by various techniques. Due to the various industrial applications and the remarkable economic importance of aluminium and its alloys, its protection against pitting corrosion has attracted much attention [1±8]. One of the available methods is the use of soluble inhibitors. Unfortunately, many of the inhibitors used are inorganic salts [9±12] and organic compounds [10, 13±16] with toxic properties or limited solubility. Increasing awareness of the health and ecological risks has drawn attention to finding more suitable inhibitors, which are nontoxic. Investigations have been made recently into the corrosion inhibiting properties of natural products of plant origin, which was found to exhibit good inhibition efficiencies (F. Zucchi, I. H. Omar, 1985)(M. Kliskic, J. Radosevic, S. Gudic and V. Katalinik, 2000)(A. Y. El-Eter, 2003)(M. Abdallah, 2004)(E. E. Oquzic, 2006). The use of natural products for metals protection is of much importance because in addition to being inexpensive, readily available and renewable sources of materials, plant products are environmentally friendly and ecologically acceptable. clitoria ternatea stem extract is organic in nature and can be use in the production of green inhibitor and it is one of natural inhibitor which has an inhibitive action on the corrosion of metals To the best of our knowledge, nothing has been published on the use of the Clitoria ternata plant stem extract for the inhibition of mild steel corrosion in acidic medium by various methods weight loss measurements, the polarization method and electrochemical impedance spectroscopy (EIS).

Material and Method

Preparation of Clitoria ternata plant leaves extract:

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

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.

Weight loss method.

Carbon steel specimens in triplicate were immersed in 100 mL of the inhibited and uninhibited 0.5 M H_2SO_4 solutions in the presence and absence of TBAB 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;

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

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Where W_{1and} W_2 are the corrosion rates in the absence and presence of the inhibitor, respectively.

Electrochemical impedance measurements

The impedance measurements were performed using a computer –controlled potentiostat (model Solartron SI-1260) and the data were analysed using gain phase analyser electrochemical interface (Solartron SI-1287). 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 10^6–10^{-2} 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_{dl}) and charge transfer resistance (R_{ct}) were obtained from the impedance plots as described elsewhere[22]. Because R_{ct} is inversely proportional to corrosion current density, it was used to determine the inhibition efficiency (IE%) using the relationship;

$$IE\% = \frac{Rct - R^{\circ}ct}{Rct}\times 100$$

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

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 [23];

$$IE\% = \frac{I^{\circ}corr - Icorr}{I^{\circ}corr}\times 100$$

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

Results and Discussion

Analysis of results of mass loss method

The corrosion rates and inhibition efficiency values, calculated using weight loss data, for various concentrations of Clitoria ternata plant leaves extract in the presence and absence of TBAB the corrosion of carbon steel in 0.5M H_2SO_4 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 TBAB. 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 π electrons in benzene ring. It is also seen from table.1 that the leaf extract of Clitoria ternata plant leaves at 2 mL and 10mL concentrations shows 43.40 % and 76.17 % inhibition efficiencies respectively, Then the values increased to 89.38 % after adding 25 ppm of TBAB solution in 0.5M H_2SO_4 solutions containing 10mL of plant extract respectively. This showed a good synergistic effect between sounder roja leaves and TBAB.

Table1.Corrosion rate (CR) of mild steel in 0.5M H_2SO_4 solutions the absence and presence of inhibitor and the inhibition efficiency (IE) obtained by mass loss method.

. Inhibitor concentration (mL)	TBAB (0) ppm	
	CR (mg cm^{-2} h^{-1})	IE %
0	126	-
2	39	69.04
4	29	76.98
6	27	78.57
8	22	82.53
10	21	83.33

Influence if TBAB on the on the inhibition efficiency of clitoria ternatea stem

Table2.Corrosion rate (CR) of mild steel in 0.5M H_2SO_4 solutions the presence of inhibitor with TBAB and the inhibition efficiency (IE) obtained by mass loss method

Inhibitor concentration (mL)	TBAB (25) ppm	
	CR (mg cm^{-2} h^{-1})	IE %

10mL+25ppmTBAB	9	92.86

Electrochemical impedance spectroscopic measurements (EIS)

Impedance spectra obtained for corrosion of mild steel in 0.5 M H_2SO_4 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_2SO_4 in the absence and presence of inhibitor are given in Table 3. Said that sum of charge transfer resistance (R_{ct}) and adsorption resistance (Rad) is equivalent to polarization resistance (Rp).

Table 3. Impedance parameters obtained from electrochemical impedance studies.

Inhibitor concentration mL	Rct Ohm cm^2	C_{dl} µF	IE%
0	**17.2**	**9.2578×10^{-3}**	**-**
10	**107.5**	**3.481×10^{-6}**	**84.00**
10+ 25ppm(TBAB)	**262.2**	**0.782×10^{-6}**	**93.44**

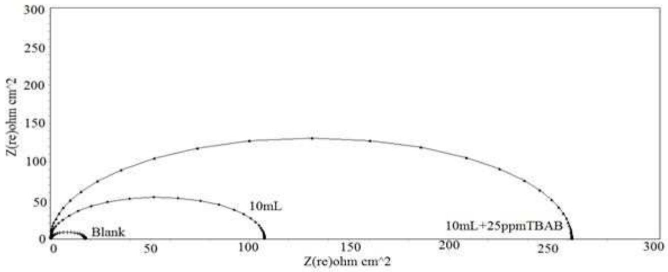


Fig.1 Impedance spectra obtained Clitoria ternate stem in 0.5 M H_2SO_4 solution

Potentiodynamic Polarization studies :

The polarization curves obtained for the corrosion of mild steel in the inhibited (100 ppm) and uninhibited 0.5 M H_2SO_4 solutions in the absence and presence of TBAB are shown in Fig.2. Electrochemical parameters such as corrosion potential (E_{corr}), corrosion current density (I_{corr}), cathodic and anodic tafel slopes (β_c and β_a) and percentage inhibition efficiency according to polarization studies are listed in table 4. Here I_{corr} 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_c and β_a values (table.3) change with an increase in inhibitor concentrations, a high β_c value indicates that the cathodic reaction is retarded to a higher extent than the anodic reaction[28].

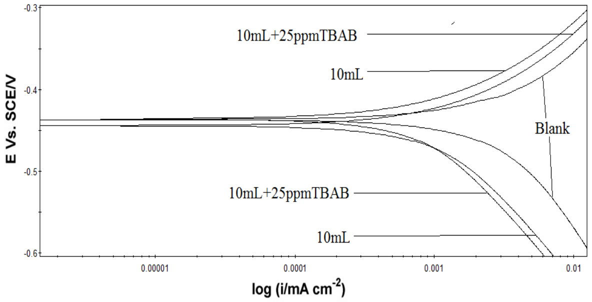
From Fig.2 it is also clear that the addition of the inhibitor shifts the cathodic curves to a greater extent toward the lower current density when compared to the anodic curves. The E_{corr} value is also shifted to the more negative side with an increase in the inhibitor concentration. These shifts 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[29]. It has been reported that a compound can be classified as an anodic and cathodic type inhibitor on the basis of shift of E_{corr} value. If displacement of E_{corr} 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[26, 27]. In our study, maximum displacement in E_{corr} value was around 12 mV, indicating the inhibitor is a mixed type and more cathodic nature 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[24,25,30,31]. The increase in inhibitor efficiency of inhibited (10mL) 0.5M H_2SO_4 solution for the corrosion of mild steel after adding 25 ppm TBAB shows synergism between inhibitor molecules and TBAB.

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

Inhibitor concentration ppm	$-E_{corr}$ (mV)	β_c (mV/)	β_a (mV)	$I_{corr}\times$ 10*6 µA	IE%
0	457	127	60	1.35	-
10	461	151	71	0.225	83.86

10+ 25ppm(TBAB)	464	159	78	0.093	93.08

Fig.2 Impedance spectra obtained Clitoria ternate stem in 0.5 M H_2SO_4 solution



Conclusion

The effect of acid concentration and the effect of addition the aqueous extract of Clitoria ternata stem extract 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_2SO_4 concentration leads to displacement of the anodic and cathodic curves to high current densities (I_{corr}.), 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 Magnolia Clitoria ternata stem extract acts as good inhibitor for the corrosion of mild steel in 0.5 M H_2SO_4 solution.

5) Electrochemical polarization results indicates that the Clitoria ternata stem 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 Clitoria ternata stem extract in acid solution does not alter the mechanism of mild dissolution.

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