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Corrosion Inhibition Effect of Artemisia Herba Alba Extract on Carbon Steel in Hydrochloric Acid

[H. Derfouf, Y. Harek and L. Larabi]

Abstract---The inhibition of the corrosion of mild steel in hydrochloric acid solutions by the extract of Artemisia Herba-Alba has been studied using gravimetric and electrochemical measurement. Inhibition was found to increase with increasing concentration of the inhibitor. Values of inhibition efficiency calculated from weight loss and potentiodynamic polarization are in good agreement. This value goes up to 89 %. Polarization curves reveal that extract of Artemisia Herba-Alba act as cathodic inhibitor. The results obtained showed that the extract Artemisia Herba-Alba could serve as an effective inhibitor of the corrosion of mild steel in hydrochloric acid media.

Keywords—**Corrosion, Green inhibitor, Polarization, Artemisia herba-alba L, Hydrochloric acid.**

I. Introduction

The use of inhibitors for the control of corrosion of metals and alloys which are in contact with aggressive environment is an accepted practice. Large numbers of organic compounds were studied and are being studied to investigate their corrosion inhibition potential. All these studies reveal that organic compounds especially those with N, S and O showed significant inhibition efficiency. But, unfortunately most of these compounds are not only expensive but also toxic to living beings. In recent days many alternative eco-friendly corrosion inhibitors have been developed [1-6].Plant extract have become important because are biodegradable and environment friendly. They are the rich sources of ingredients which have very high inhibition efficiency.

In the present study, the corrosion inhibition effect of acid extract of Artemisia herba-alba (A.herba alba L) on steel in 1M hydrochloric acid medium was studied by weight loss measurements and polarization curves. Inhibition on metal surface was verified by plotting Langmuir's adsorption isotherm. Scanning electron microscopy observation of the steel surface confirmed the protective roles of the inhibitor.

Manufacture of essential oils, oleoresins, terpenes and the oil has both antibacterial and anti-fungal properties.

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II. Experimental

A. Materials and Methods

Dried A. herba-alba (10 g) plant leaves were soaked in 1M HCl solution (500 mL) and refluxed for 5 h. The aqueous solution was filtered and concentrated to 100 ml. This concentrated solution was used to prepare solutions of different concentrations by dilution method [1].

B. Gravimetric measurements

For the weight loss measurements, the experiments were carried out in solution of 1M HCl (uninhibited and inhibited) on carbon steel containing (wt. %): 0.15% C; 0.50% Mn, 0.03% P, 0.03% S, 99.29% Fe. Specimens of size 1.3×1.2×0.2 were used. They were polished successively with different grades of emery paper (grade 600, 800, 1000 and 1200). Each run was carried out in a glass vessel containing 100 ml test solution with and without addition of inhibitor at different concentrations. After 3h, the specimen was rinsed with distilled water, degreased with acetone, dried and weighted .The weight loss was used to calculate the corrosion rate in milligrams per square centimeter per hour.

C. Electrochemical measurements

Disc electrode (0.95 cm^2 area) was prepared from the investigated carbon steel. The electrode was polished with emery papers (grade 600, 800, 1000 and 1200) rinsed with distilled water, degreased by acetone, washed thoroughly with distilled water

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and dried at room temperature. Platinum disc was used as a counter-electrode (CE) and a saturated calomel electrode as a reference electrode (SCE). The latter was connected through a Luggin's capillary to the cell. The working electrode (WE) was immersed in a test solution for 2 h until a steady state open-circuit potential (E_{ocp}) was obtained [7].

III. Results and discussion

A. *Gravimetric measurements*

Values of the inhibition efficiency and corrosion rate obtained from the weight loss measurements of carbon steel for different concentrations of inhibitor in 1M HCl at 30 °C after 3 h of immersion are given in **Table 1**. From the calculated weight loss values, the inhibitor efficiency *P %* was calculated using the equation:

$$P\,\% = \left(1 - \frac{W_{corr}}{W_0}\right) \times 100 \qquad (1)$$

Where W_{corr} and W_0 are rates of corrosion ($g/cm^2.h$) with and without inhibitor, respectively.

Table1. shows that the inhibition efficiency increases with the increasing inhibitor concentration. Values of inhibition efficiency attains approximately 89 %.

TABLE 1: Corrosion rate and inhibition efficiency

Concentration (mg/L)	W_{cor} ($10^{-3}.g.h^{-1}.cm^{-2}$)	P (%)
0	0,77730	-
200	0,24616	69,13
600	0,11905	84,27
800	0,10045	87,20
1000	0,08762	89,01

B. *Polarization curves*

Figure.1 shows the cathodic and anodic polarization curves of carbon steel in 1M HCl blank solution and in the presence of different concentrations of A.herba-alba.

The value of the corrosion potential change regularly around the corrosion potential of steel in the presence of acid without inhibitor. This proves that our inhibitor is a cathodic inhibitor.

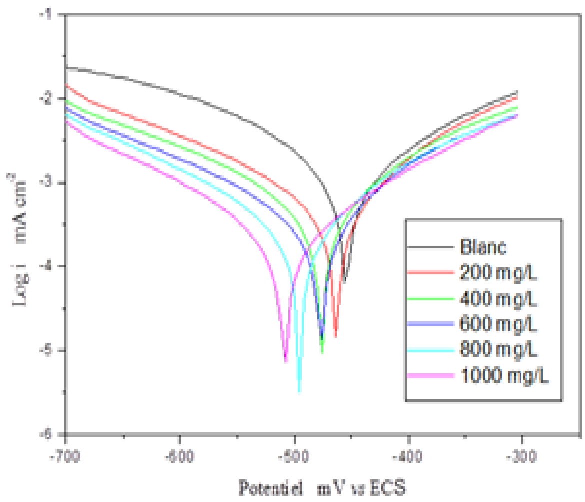

Figure 1: Polarization curves for carbon steel in 1M HCl containing different concentration of A.herba alba.

Table 2 gives the values of kinetic corrosion parameters as the corrosion potential E_{corr}, corrosion current density I_{corr}, Tafel slope b_c, and inhibition efficiency for corrosion of carbon steel in 1M HCl with different concentration of A .herba-alba.

Table 2 shows that an increase in inhibitor concentration resulted in increased inhibition efficiency. This indicated a remarkable decrease in corrosion reaction. It is clear that the values of $-E_{corr}$. increased in a regular manner in the presence of various concentration of A. herba-alba. This result indicated that the inhibitor acts can be classified as cathodic inhibitor.

TABLE 2: Potentiodynamic polarization parameters for corrosion of carbon steel in 1M HCl with various concentrations of A.herba-alba.

Concentration (mg/L)	$-E_{corr}$ (mV/ECS)	I_{corr} ($mA.cm^{-2}$)	$-b_c$ ($mV.dec^{-1}$)	P (%)
Blanc	456	1.352	132	-
200	464	0.425	130	68.52
400	475	0.323	127	76.07
600	476	0.219	124	83.78
800	496	0.165	117	87.78
1000	507	0.142	115	89.48

C. *Adsorption isotherms*

To understand the mechanism of corrosion inhibition, the adsorption behavior of the Artemisia erba alba adsorbate on the metal surface must be known. Two main types of interaction can describe

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the adsorption of organic compounds: physical adsorption and chemisorption. These are influenced by the chemical structure of the inhibitor. The type of the electrolyte and the charge and nature of the metal. The surface coverage θ of the metal surface by the adsorbed inhibitor was calculated using the equation:

$$\theta = \frac{P\,\%}{100} \qquad (2)$$

The values for different inhibitor concentrations were tested by fitting to various isotherms. By far the best fit was obtained with Langmuir's isotherm [8]. According this isotherm, θ is related to concentration C via:

$$\frac{C}{\theta} = {}^{1}/_{K} + C \qquad (3)$$

With: $$K = \frac{1}{999}\,exp\left(-\frac{\Delta G^{\circ}_{ads}}{RT}\right) \qquad (4)$$

Where 999 are the concentration of water in solution expressed (g/l), R is gas constant and T absolute temperature [6].

Figure.2 gives the result of Langmuir's plot corrosion inhibition data of the compounds under investigation. Thus, the adsorption phenomena obeys a modified Langmuir isotherm proposed by Villami and al [9]. The slope equal or nearly equal to 1.00. The standard adsorption free energy (ΔG°_{ads}) was calculated using the values of K and equation (4). The average value of (ΔG°_{ads}) was: -23.59 $kJ.mol^{-1}$. The negative value of (ΔG°_{ads}) ensure the spontaneity of the adsorption process and stability of the adsorbed layer on metal surface [10]. It is well known that values of (ΔG°_{ads}) -20 $kJ.mol^{-1}$ are lower indicate a physisorption, those of order of -40 $kJ.mol^{-1}$ are higher indicate chemisorption. Thus, the (ΔG°_{ads}) value obtained here shows that in the presence of 1M HCl, physisorption of Artemisia Herba Alba on the carbon steel may occur.

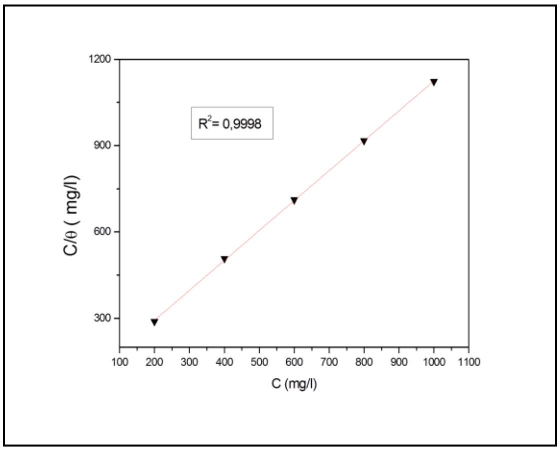

Figure 2: Langmuir adsorption plot for carbon steel in 1M HCl containing different concentrations of A.herba alba.

D. *Scanning electron microscope studies*

The SEM photographs showed that the surface of metal has pits, pores and cracks when exposed to 1M HCl solution (Figure.3). In the presence of inhibitor, the photograph indicated the formation of protective layer of the inhibitor on metal surface (Figure.4).

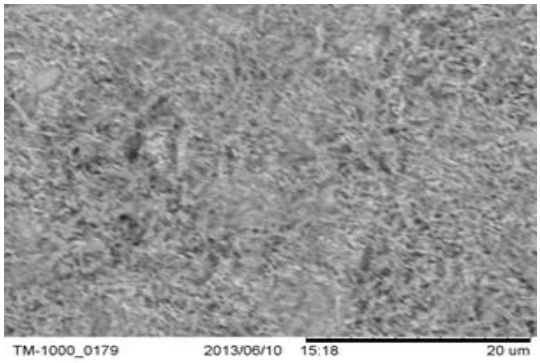

Figure 3: SEM image for carbon steel in 1M HCl alone.

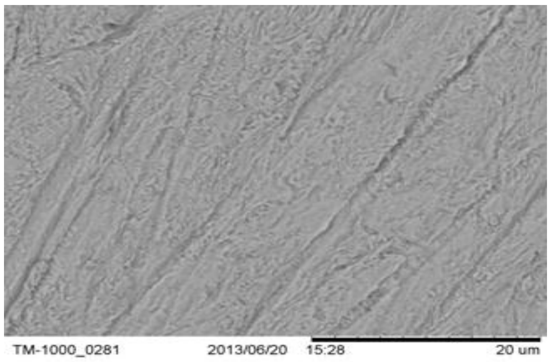

Figure 4: SEM image for carbon steel l after 3 h of immersion in 1M HCl + 1g/L A. Herba Alba.

IV. Conclusion

Results obtained from electrochemical and weight loss techniques are in reasonably good agreement and show increased inhibitor efficiency with increasing inhibitor concentration. Adsorption of inhibitor fits a Langmuir isotherm model. SEM studies reveal the protection of the metal from corrosion in acid medium by Artimisia Herba Alba

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