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Essential Oil Extract of Artemisia herba-alba as Green Inhibitor against the Corrosion of X52 Steel in 20% Sulfuric Acid Medium

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ABSTRACT

Artemisia herba-alba is a medicinal plant widely used for its particular properties beneficial to human health. In this context, we will present a potentiokinetic study of the efficacy of inhibition of plant extracts caused by the corrosion of X52 steel in an acid medium. The results indicated that the inhibition efficiency increases with increasing extract concentration. Tafel curve analysis showed that the inhibition rate was around 98.29%. The plant seems to be a good corrosion inhibitor of cathodic type based on the obtained results.

Keywords: *Artemisia Herba-Alba, Corrosion Inhibition, Acidic Medium, Potentiokinetic Study.*

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1. INTRODUCTION

Given the huge impact of corrosion phenomena on the cost of rehabilitation of industrial facilities and the balance of the ecosystem, the search for new materials leading to the stopping or delaying this kind of adverse reaction seems to be economically very beneficial. The majority of research work in recent decades has been oriented towards the valorization of Biomass. Natural substances such as medicinal plants are an inexhaustible source that is attracting more and more attention from researchers. Thus, in this context the present research was performed for the assessment of *Artemisia herba-alba* (commonly known as chih) (Allaoui et al., 2017; Benahmed et al., 2015; Djeddi et al., 2015; Chebouat et al., 2013; Allaoui et al., 2013; Benmenine et al., 2011; Namoussa et al., 2010; Hameurlaine et al., 2010). The essential oils of this spontaneous plant is widely exploited in Algeria. According to the work of M. Benabdellah et al (Gherraf et al., 2009) this plant is mainly composed of β-Thujone whose structure is represented in the following figure:

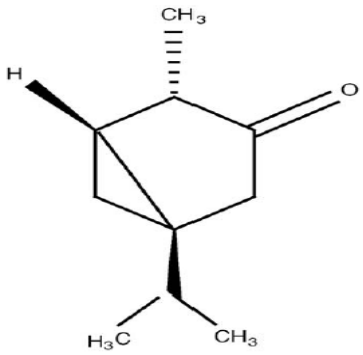

Figure 1. β-Thujone Molecule

The present work concerns the study of corrosion rate of X52 steel using Tafel curves obtained in acid medium (H_2SO_4 20%) in the presence and absence of extracts of *Artemisia herba-alba*.

2. MATERIAL AND METHODS

Artemisia herba-alba was collected in the region of Ouargla in July 2016. The oil extract was obtained by hydro-distillation

using a Clevenger apparatus. The nominal chemical composition of X52 steel is given in the following table:

Table 1. Nominal Composition of X52 steel

Element	W(%)	Element	W(%)
C	0.1038	Al	0.032
Si	0.1261	Co	<0.05
Mn	0.971	Cu	<0.01
P	<0.0021	Nb	0.0419
S	0.0021	Ti	0.0025
Cr	<0.0021	V	<0.005
Mo	<0.005	W and Si	<0.005
Ni	<0.005	Fe	<0.98

Aggressive solutions were prepared (H_2SO_4 20%) by dilution of a stock solution of sulfuric acid (98%, 1.18). A typical three-electrodes cell with a working electrode made up of carbon steel X52 with an active surface of 1 cm^2 was used. The auxiliary electrode was a platinum plate (1 cm^2) and the reference electrode was represented by a saturated calomel electrode (SCE). Potentiodynamic polarization curves were obtained with the scan rate of 0.5 mV s^{-1}, in the potential range of -750 to -200 mV. The immersion time of the X52 plates in the blank as well as in the presence of different concentrations of essential oil of *Artemisia herba-alba* was 40 minutes in open circuit at room temperature.

The temperature was thermostatically maintained at 25 °C. Oxygen was removed from the corrosive medium by bubbling nitrogen for 2 min before each measurement.

Under these operating conditions the inhibition efficiency (E%) was calculated according to the following expression:

$$E\% = 100 \times (1 - I_{corr}/I^{\circ}_{corr}) \qquad (1)$$

I°_{corr} and I_{corr} are respectively the current densities before and after addition of the inhibitor.

3. RESULTS AND DISCUSSION

3.1. Potentiodynamic polarization measurements

The potentiodynamic polarization behavior in the Tafel region for the steel in acidic medium with and without the addition of the oil extract is shown in Figure 1. The corrosion kinetic parameters such as corrosion potential (E_{corr}), corrosion current density (i_{corr}) and Tafel constants (β_a and β_c) derived from the figure are given in Table 2.

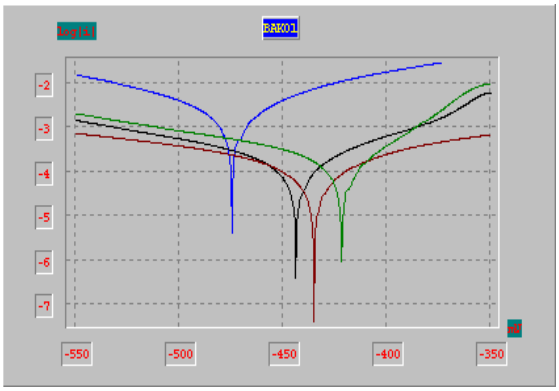

Figure 2. Tafel Curves at different concentrations. Blue: 0 ppm. black: 1200 ppm. brown: 1400 ppm. green: 1600 ppm.

Table 2: Electrochemical parameters of carbon steel in H_2SO_4 20 % medium

input	medium	βc (mV/dec)	βa (mV/dec)	Ecorr (mV)	Rp (Ohm.cm^{-2})	Vcorr (mm/an)	E(%)
(1)	H2S04 20 %	-89.0	99.1	- 473.6	7.34	33.88	-
(2)	(1)+1200 ppm	-54.7	50.4	-434.1	16 6.71	0.576	98.29
(3)	(1)+1400ppm	-49.5	34.4	-420.3	86.86 1	1,936	94.20
(4)	(1) +1600 ppr	-344.5	117.4	-484.6	147.63	4.954	85.37

It can be seen from fig. 2 that the increase in the concentration of the extract will lead to a displacement of the corrosion potentials (Ecorr) towards the most cathodic values.

This suggests that the inhibition efficacy of *Artemisia herba-alba* is predominantly cathodic. On the other hand, the reduction of the corrosion rate can be explained by the adsorption of the inhibitor on the cathodic sites by creating an energy barrier preventing the reduction of the H^+ ions. The strong adsorption is attributed to the carbonyl group of β-thujone, which has a very important dipole moment (Figure 1) favoring the formation of a layer impermeable to hydrogen ions (Dakmouche et al., 2009).

3.2. Adsorption isotherms

The Langmuir isotherm gives the relation between bulk and surface concentration. This relation is usually based on model assumptions. In the simplest model every adsorption site is equivalent, only monolayer adsorption occurs and no interactions exist between molecules at adjacent sites

$$\text{Langmuir: } \frac{\theta}{(1-\theta)} = KC \qquad (2)$$

$$\text{Rearrangement gives: } \frac{C}{\theta} = \frac{1}{K} - a.c \qquad (3)$$

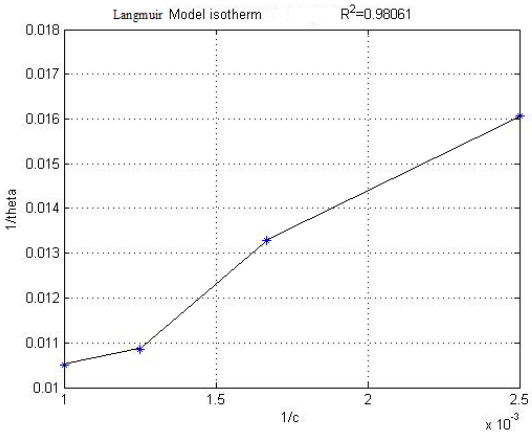

Figure 3: The Langmuir isotherm

The application of Langmuir isotherm to the adsorption of oil extract of *Artemisia herba-alba* on surface of carbon steel indicated that there is no interaction between the adsorbate and adsorbent. The R^2 value of 0.98061 indicates strong adherence to Langmuir adsorption isotherm. As a consequence, molecules of oil extract of *A. herba-alba* adsorption obey the Langmuir isotherm without interaction between the adsorbed molecules.

4. CONCLUSION

This work allowed us to highlight the inhibitory effect of oil extract of *A. herba-alba* on the corrosion of steel X52 in sulfuric acid 20%. Results revealed that the extract act efficiently as cathodic type inhibitor which obeys well to Langmuir adsorption isotherm. Additional analyzes allowing the determination of activation energies and the surface recovery rate are essential for understanding the reaction mechanism involved.

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