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Effect of an Aloe Vera As a Natural Inhibitor on The Corrosion of Mild Steel in 1 wt. % NaCl

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Abstract: ***The effect of the new natural corrosion inhibitor known as an aloe vera (mannose–6– phosphate) on the corrosion inhibitor for mild steel in (1 wt. % NaCl) was investigated by using potentiodynamic polarization measurement. Obtained results revealed that this compound was very good inhibitor and behave better in NaCl solution. Polarization studies showed that the aloe vera behaves as mixed type of inhibitor for mild steel in sodium chloride solution. The inhibition efficiency reached (81.81%) at concentration of (75 µml).***

Keywords:

Mild steel; Sodium Chloride; Electrochemical measurement; Natural inhibitor; Tafel line.

1. Introduction

The toxic effect of most synthetic organic compounds as corrosion inhibitors reoriented researchers to find the new alternative of naturally occurring, environmentally friendly, in an expensive, readily an available and a renewable source of materials. Plant extracts and oils as well as natural compounds become more and more environmentally acceptable [1 – 3].

The use of natural substances will establish both the economic and environmental goals. Plant extracts and oils constitute a rich source of naturally synthesized chemical compounds that can be extracted and purified with low cost [4].

Inhibition of metals may be occurred by natural compounds, such as a monoacids, a mino esters, peptides and their derivatives [5 – 7].

Aloe vera is a genus of shrubby succulent plants in the lily family (liliaceae). It is a very short–stemmed succulent plant growing to 80–100 cm tall, spreading by offsets and root sprouts. The leaves are lanceolate, thick and fleshy, green to grey–green, with a serrated margin [8].

Studies showed that aloe vera contains polysaccharides, steroids, a polygol, organic acids, and essential elements, such as nitrogen, allantion, tannins natural a nalagastics, and antibiotics besides its nutritional components [9]. The extracted compounds of aloe vera especially the tannin compound can adsorb on the metal surface and block the ctive sites on the surface thereby reducing the corrosion rate [10].

The aim of this study is to obtain better understanding of the mode of inhibitory action of leaf extracts of aloe vera on mild steel in 1 wt. % NaCl in DI water using the electrochemical measurements. The effects of different concentrations on the efficiency of the aloe vera are also investigated.

2. Experimental

2.1 Preparation of specimens

Mild steel specimens (0.18% C, 0.013%P, 0.44% Mn, 0.019%S, 0.13%Si, 0.12% Cr, 0.24% Cu and the reminder is Fe) of dimensions (1) cm^2 were grounded and polished with emery paper up to 400 grade, rinsed with distilled water, dried on a clean tissue paper, degreased by methanol for 5 sec, and then dried with cool air at room temperature.

2.2 Inhibitor Preparation

The plant extract was prepared by grinding the fresh extract of aloe vera (mannose–6– phosphate) gel and filtering. A series of solution was prepared with different concentrations (50 to 250) µml.

2.3 Potentiodynamic Polarization

The polarization studies were carried out in a cell containing three electrodes, which are mild steel as working electrode, a platinum wire as counter electrode, and reference electrode. During the polarization study, the scan rate was 0.01 V s^{-1}. Starting from the open circuit potential with respect to saturated calomel electrode, the applied potential was manually increased in 10 mV steps in the anodic or cathodic direction.

Corrosion current densities, I_{corr} in the presence and absence of inhibitor, were used to calculate the corrosion rate and thereby IE as followed:

$CR = [(3.27 \times 10^{-3} \times I_{corr} \times EW) / D]$ …1

$IE\ \% = [(I_{corr} - I_{corr(inh)}) / I_{corr}] \times 100$ …2

Where;

CR is the corrosion rate (mm/yr), D the density (g/cm^3), EW the equivalent weight of the specimen and $I_{corr(inh)}$ and I_{corr} are the corrosion current density (µA/cm^2) values with and without inhibitors, respectively.

3. Results and Discussion

The polarization study is used to investigate the formation of protective film on the metal surface [11]. The polarization curves of mild steels immersed in various solutions are shown in Figure 1. The corrosion parameters such as corrosion potential (E_{corr}) and corrosion current (I_{corr}) were determined from E vs log I plots and tabulated in Table 1. When mild steel immersed in 1 wt. % NaCl, the corrosion potential is (-673.5 mV) SCE. When 75 µml of aloe Vera is added, the corrosion potential is shifted towards the anodic side, (-642.3 mV) SCE indicating that the aloe Vera controls the anodic reaction predominantly by forming Fe^{2+}-mannose–6–phosphate complex on the anodic sites of the metal surface [12-13]. Furthermore, the corrosion current decreases from (50.39 µA/cm^2 to 16.39 µA/cm^2).

Table . 1 Corrosion parameters obtained from polarization of the mild steel in (1 wt. % NaCl) containing various concentrations of aloe Vera at 25˚C for 2 hours.

Additive	E_{corr} (mV)	I_{corr} (µA/cm^2)	W (mm/yr)	%IE	Θ
Blank	-673.5	50.39	0.585	-	-
75 µml	-642.3	16.39	0.109	81.36	0.813

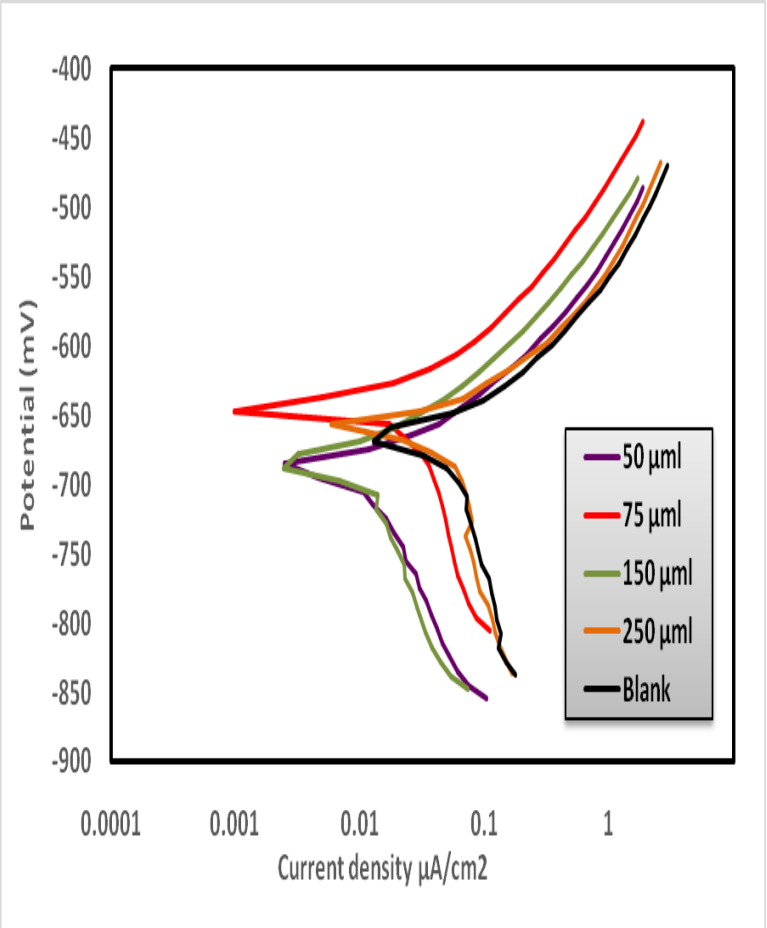

Fig. 1 Polarization curves of mild steels immersed in various test solutions.

Table 2 shows the values of corrosion rates , inhibition efficiencies and coverage ratio obtained from Potentiodynamic polarization measurements of different concentrations of aloe Vera extract. (75 µml) of the aloe Vera offered (81.81%) corrosion inhibition efficiency and (0.818) coverage ratio to the mild steel immersed in 500 ml (1 wt. % NaCl). This lead to conclude that the molecular diffusion of the inhibitor is increased thereby the adsorption of the inhibitors' molecules on the surface of the mild steel are also increased. When the concentration of the aloe Vera was increased above 75 µml the inhibition efficiency decreased and corrosion rate increase as shown in Figures 2 and Figures 3. This may be attributed to the fact that when higher concentrations of the aloe Vera are added, the protective film of Fe^{2+}-mannose–6–phosphate complex formed on the metal surface comes out to the solution and thus destroying the protective film [14]. It may be considered that the protective film formed on the steel surface may

go in to transpassive state, where the film is broken down .

Table .2 Corrosion parameters obtained from Potentiodynamic polarization measurements.

Additives	Inhibitor Conc. (µml)	W (mm/yr)	%IE	Θ
Blank	0.0	0.583	-	-
Aloe Vera	50	0.131	77.53	0.775
	75	0.106	81.81	0.818
	150	0.198	66.03	0.660
	250	0.120	79.41	0.794

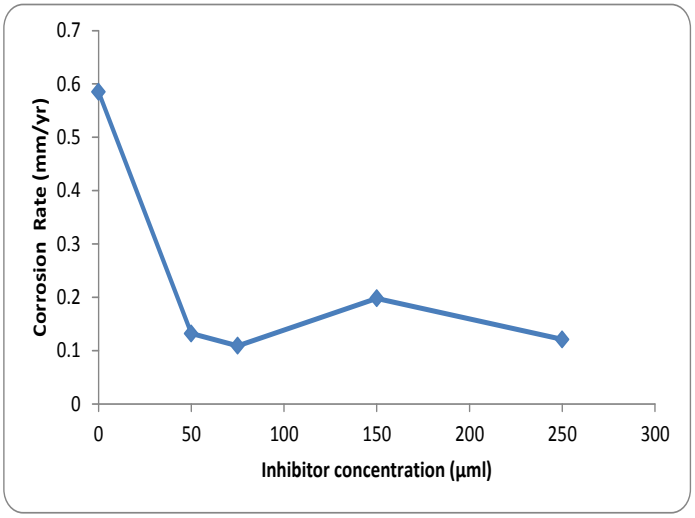

Fig.2 Corrosion rate for mild steel in (1 wt. % NaCl) in the presence and absence of inhibitor.

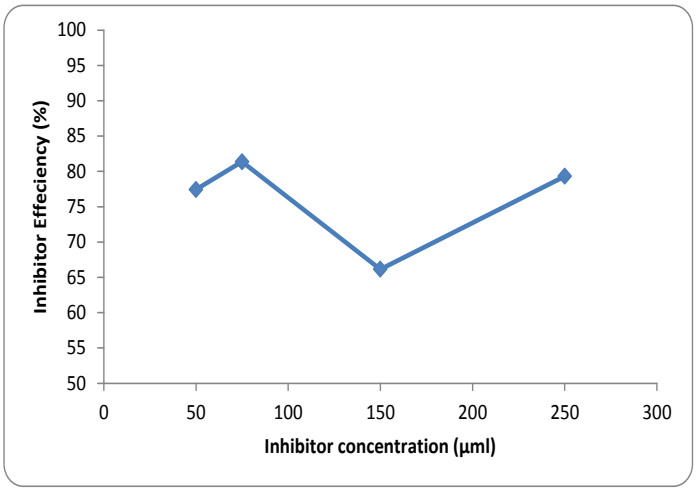

Fig.3 Variation of the efficiency of inhibitor with concentrations of inhibitor in (1% wt. NaCl) on the surface of mild steels.

4. Conclusions

The present study of the corrosion of mild steels in the presence of sodium chloride and aloe vera lead to the following important conclusions:

1- Aloe vera was found to be an efficient inhibitor for mild steel in (1 wt. % NaCl), and can be used to replace inhibitors containing toxic chemicals.

2- The efficiency and coverage ratio increased with an increase in aloe vera content up to (75 µml) to reach (81.81%) and (0.818) respectively.

3- While the concentration of the aloe Vera was increased above 75 µml, the inhibition efficiency and coverage ratio decreased.

4- The results obtained from the polarization studies revealed that the extract behaved as a mixed type of inhibitor.

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