# Anti-Corrosive Effect of Jordanian-Bay- Leaves Aqueous Extract on Mild Steel in 1.0 M Hydrochloric Acid Solution

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***Abstract***: - Natural inhibitors are the most crucial manner to lessen the corrosion price of various business metals. There are several strategies being used with corrosion inhibitors. One technique being used is the Electrochemical strategies. The gain with this technique is their brief size time and mechanistic information. It is beneficial in the corrosion's layout safety techniques besides the layout of the brand new inhibitors, there are 3 styles of corrosion inhibitors as anodic inhibitors, cathodic inhibitors, over one inhibitor. The corrosion inhibition of slight metallic in 1.0 M HCl solution with the aid of using Jordanian -Bay- leaves extract has been studied with the use of potentiodynamic polarization technique. Results received a display that Bay- leaves aqueous extract behaves as an anodic inhibitor for slight metallic in 1.0 M HCl solution. The inhibitor capabilities thru adsorption following Temkin adsorption isotherm. The impact of parameters like temperature and inhibitor awareness at the corrosion of slight metallic has additionally been studied.

Key-words: Jordanian-Bay-Leaves, mild steel, corrosion inhibitor, potentiodynamic polarization, hydrochloric acid, chemisorption
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## 1. Introduction

Corrosion has resulted in a loss of lives accorded with damage costs in almost all engineering fields, Acid corrosion inhibitors find out widespread software program within the enterprise concern as components in acid pickling, acid cleaning, oil well acidizing, acid descaling, etc. Most of the inexperienced inhibitors applied in an organization are herbal compounds having one or greater heteroatoms of their chemical shape mainly nitrogen. [1] Numerous protective measures were taken to a controller and prevent the corrosion one each of them being the use of inhibitors [2-3]. A corrosion inhibitor is a substance which, at the same time as delivered to a corrosive surrounding, notably decreases the expenses of corrosion attack as a consequence of the surroundings. Corrosion inhibitors are typically delivered in small portions to pickling acids, acid stimulation fluids, cooling waters, oil, and gasoline line production streams, each continuously or intermittently to control corrosion. Mild metal is the cheapest and most usually applied in manufacturing material, were used significantly for masses of years in plenty of regions such as: intended for water pipes, boats, docks, and tanks. Because of its structural defects, mild metallic. in interaction with extraordinary metals, corrodes almost in all environments [4,5]. Mild metal can be blanketed via using herbal or inorganic species to inhibit the corrosion reaction in acidic media. The inhibitors are based mostly on inorganic nitrites, nitrogen-based materials, and their derivatives which include: sulfur-containing compounds [6], aldehydes, acetyl compounds as well as numerous alkaloids which include: strychnine, quine, and nicotine were used as inhibitors. In independent media, benzoate, nitrite, chromate, and phosphate act as incredible inhibitors [6, 7]. The form of adsorption of inhibitor relies upon the composition of the metallic, the shape and the form of inhibitor, and the temperature [8-10]. These paintings intend to observe the inhibition impact of the use of potentiodynamic polarization approach of Bay-leaves extract as a cheap, raw and non-toxic corrosion inhibitor on moderate metallic in 1.0 M hydrochloric acid solution. The toxic outcomes of synthetic corrosion inhibitors have added approximately the search for substances that might be eco-friendly, lots much less toxic, lots much less luxurious and non-polluting consequently can considerably be used with outside impact. [11-18]. So this study tried a natural oils extracted from Bay-leaves as corrosion inhibitor for mild steel, that used in many fields, as food processing machines.

# 2. Experimental Procedure

## 2.1 Preparation of Specimens

Mild steel specimens of composition (wt. %): Fe 99.520, C 0.047, Si 0.013, P < 0.005, Mn 0.240, Cu 0.013, Al 0.044, Ni 0.044, and V < 0.005 (Construction Materials and Structures S.O. Ekolu et al. (Eds.) IOS Press, 2014) were used in this study. The sample of 10 mm diameter and 8 mm length was polished successively with 1/0 - 5/0 grade emery papers, thoroughly cleaned with soap water, rinsed with distilled water, then with alcohol, and finally dried in air. The sample was tightly fitted to one end of the Teflon holder, which exposes a polished surface area of 0.695 cm2.

## 2.2 Acidic Media

## 2.3Preparation of Test Solutions

The test solutions of this inhibitor were prepared in M 1.0 HCl solutions to get different inhibitor concentrations (25, 50, 75, and 100) ppm.

## 2.4 Polarization Studies

The Tafel polarization studies were performed by using a Winking potentiostat (LB95L) and a three-electrode cell containing 400 mL of the electrolyte at room temperature (RT) with and without the inhibitor. The steady-state open circuit potential (OCP) concerning the saturated calomel electrode was noted at the end of 25-30 min. The polarization studies were then made from–250 mV versus OCP to +250 mV versus OCP with a scan rate of 20 mV per minutes from the cathodic side and the corresponding steady-state currents were measured. The experiments were repeated for 35, 40, and 45 °C temperatures. The temperatures were accurately maintained (within ± 1 °C). From Tafel plots of potential versus log I, the corrosion current density (Icorr), corrosion potential (Ecorr) were determined. The corrosion rate (CR) and percentage inhibition efficiency (%IE) were calculated in the absence and presence of various concentrations of the studied inhibitor in 1.0 M HCl solutions. The results were also confirmed by using the linear polarization technique.

# 3. Results and Discussion

The inhibition effect of Bay-leaf aqueous extract on the corrosion of mild steel in 1.0 M HCl solutions at different temperatures and different inhibitor concentrations was studied by potentiodynamic polarization technique and the results are presented in Table 1

Table 1 – The corrosion rate (CR) and percentage inhibition efficiency (%*IE*) of mild steel by various concentrations(ppm) of Bay leaves aqueous extract in 1.0 M HCl solution at different temperatures.

| *T* (°C ) | *c* ppm ) | CR (mpy) | IE(%) |
|---|---|---|---|
| 25 | 00 | 291.09 | - |
| | 25 | 4.08 | 98.80 |
| | 50 | 3.72 | 98.72 |
| | 75 | 3.80 | 98.70 |
| | 100 | 4.63 | 98.40 |
| 35 | 00 | 427.91 | - |
| | 25 | 9.90 | 97.69 |
| | 50 | 9.17 | 97.86 |
| | 75 | 10.19 | 97.63 |
| | 100 | 10.28 | 97.60 |
| 40 | 00 | 512.32 | - |
| | 25 | 12.23 | 97.61 |
| | 50 | 11.06 | 97.84 |
| | 75 | 10.83 | 97.89 |
| | 100 | 10.48 | 97.95 |
| 45 | 00 | 547.26 | - |
| | 25 | 12.81 | 97.66 |
| | 50 | 12.66 | 97.68 |
| | 75 | 11.79 | 97.85 |
| | 100 | 10.54 | 98.07 |

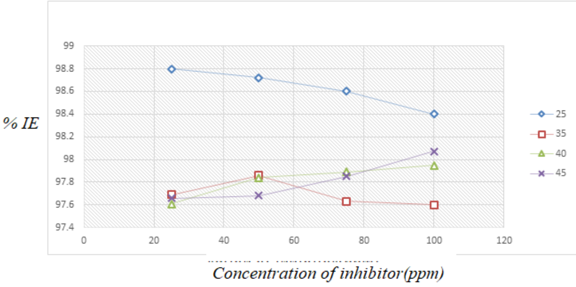
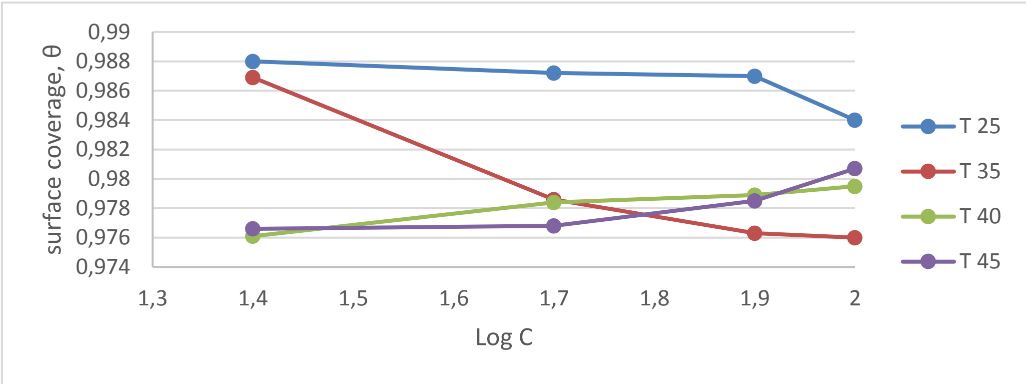



**Fig.1:The percentage inhibition efficiency (%IE) and concentration of inhibitor at a different temperature.**



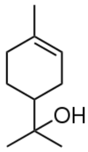
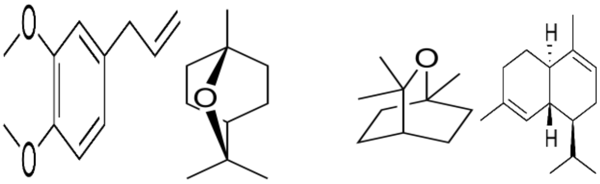




Fig.2 Surface coverage (θ) and log Concentration



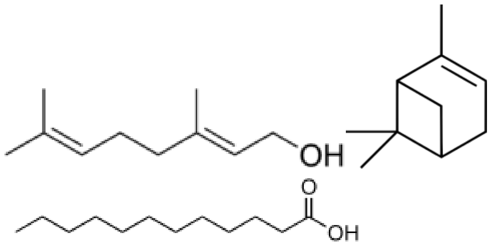




Fig 3 Structure of organic compounds are found in Bay-leaves.

A crucial exam of the end result suggests that the inhibition performance of Bay-extract isn't temperature sensitive. The maximum percentage of corrosion inhibition (98.72%) was found at a concentration of 50 ppm at 25 °C in 1.0 M HCl solution. The percentage of corrosion inhibition slightly decreases at 35 °C compared with 25 °C, but it is almost the same for other temperatures (40 °C and 45 °C) as shown in Table 1. The Shift in corrosion capacity suggests that the Bay leaves aqueous extract is an anodic inhibitor, which offers an average percentage of corrosion inhibition as excessive as ninety-eight percentages at various temperatures.

The constituents of the studied inhibitor boom the corrosion inhibition performance possibly due to the adsorption of these compounds to the surface of the mild steel surface, due to formation of coordinate bonds. The percentage inhibition efficiency (%IE) of the inhibitor and the surface coverage (θ) had been calculated using the following equations (1, 2):

$$\% IE = I_{corr} - I_{corr\ (inh)}) / Icorr \quad (1)$$

$$\Theta = \% IE / 100 \quad (2)$$

Where, $I_{corr}$ and $I_{corr\ (inh)}$ are the corrosion current densities in the absence and presence of inhibitor respectively. The corrosion rate (CR) was calculated by using following equation (3). Corrosion rate (mpy) = $0.1288 \times I \times eq.\ wt. / D$

Where, (I) is the current density in μA/cm2, D is the specimen density in g/cm3, eq. wt. is the specimen equivalent weight in grams and 0.1288 is the metric and time conversion factor [10]. The values of the free energy of adsorption of this inhibitor were calculated using equation (4):

$$\Delta G ads = - RT \ln (55.5\ K) \quad (4)$$

Where, $K$ is equilibrium constant in moles $L^{-1}$, $R$ is universal gas constant in J/K/mol, $T$ is the temperature in kelvin and 55.5 is the concentration of water in the solution in moles $L^{-1}$. The values of $\Delta G$ads for the studied inhibitor at higher temperatures were greater in negative values than 40 KJ/mole indicating that inhibitor molecules are adsorbed on the mild steel surface by chemisorption [11]. The negative values of $\Delta G_{ads}$ (Table 2) indicate spontaneous adsorption of the inhibitor on the mild steel surface [12, 13].

The surface coverage (Θ) shows a linear relation with log c indicating that adsorption of this inhibitor at the metal surface obeys Temkins' adsorption isotherm; Temkin isotherm model takes into account the effects of indirect adsorbate/adsorbate interactions on the adsorption process; it is also assumed that the heat of adsorption of all molecules in the layer decreases linearly as a result of increase surface coverage [14]. A bonding of adsorbed corrosion inhibitor into the metal has been defined in phrases of standards of "hard - tender acid and bases" and electro sorption valence. Since inhibitors are used to minimize acid corrosion on metal, understanding the use of acid inhibitors requires a basic understanding of the nature of the corrosion process on metal. The Inhibition efficiencies alternate with the character of the constituents within the inhibitor [15]. Temkins' adsorption isotherm verifies the idea of mono-layer adsorption on a uniform, homogeneous mild steel surface [16]. The activation energies, Ea have been calculated by the usage of the Arrhenius equation. The values of Ea (Table 2) suggests that the dissolution of the mild steel is retarded in the presence of the studied inhibitor [17-20]. containing different concentrations of Bay leaves aqueous extract at 25, 35, 40 and 45 □C - $\Delta G_{ads}$ (KJ/ mol)

Table 2 –
Thermodynamic parameters for the corrosion of mild steel in 1.0 M HCL

| Inhibitor concentration (ppm) | $E_a$ (KJ/mol) | K mol/L | 25 □C | 35□C | 40 □C | 45 □C |
|---|---|---|---|---|---|---|
| 00 | 32.80 | - | - | - | - | - |
| 20 | 42.17 | $3.6x10^{-10}$ | 43.95 | 44.10 | 44.88 | 45.32 |
| 40 | 38.20 | $3.4x10^{-10}$ | 42.34 | 42.55 | 43.61 | 43.28 |
| 60 | 58.57 | $3.2x10^{-10}$ | 40.71 | 41.21 | 41.63 | 42.54 |
| 80 | 54.03 | $3.0x10^{-10}$ | 38.58 | 40.60 | 40.84 | 41.80 |

# 4. Conclusion

The potentiodynamic polarization technique reveals that the Jordanian Bay leaves aqueous extract is an excellent anodic corrosion inhibitor for mild steel in acidic media.
The values of inhibition efficiency are nearly constant between the studied temperatures. The reasons for these observations may not be far from the hypotheses of mass movement of inhibitor molecules to the metal surface and the detachment at a high flow rate due to shear stress. We should increase temperature more than 25 °C The inhibition of this inhibitor is directly related to the spontaneous and strong adsorption of the constituents of this inhibitor on the surface of the mild steel as explained from Ea and negative values of ΔGads. The constituents of Jordanian Bay aqueous extract from a chemisorbed film on the mild steel surface following Tomkin's' adsorption isotherm. The percentage of inhibition efficiency reaches as high as 98.72% at a concentration of 50 ppm at 25 °C in 1.0 M HCl solution.

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*References*

[1]. Ameh, Paul, Natural polymers as corrosion inhibitors, LAP Lambert *Academic Publishing*,2012

[2]. Lekan Taofeek Popoola, Organic green corrosion inhibitors (OGCIs): a critical review, Corrosion Reviews,37(2) ,2019:71-102

[3]. María V. Fiori-Bimbi Patricia E. Alvarez, Corrosion inhibition of mild steel in HCL solution by pectin, Corrosion Science Vol 92, 2015: 192-199.

[4]. JA McLeod, RG Wilks, NA Skorikov, LD Finkelstein, M Abu-Samak, EZ Kurmaev, A Moewes, Band gaps and electronic structure

of alkaline-earth and post-transition-metal oxides, Physical Review B, ,81(24):2010, 245123

[5]. Muralidharan S M & Iyer S V, Anti - Corros Methods Mater, Vol:44 (1997) 100.

[6]. Preparation, Physicochemical characterization and biological evaluation of some hesperidin metal complexes S Daoud, FU Afifi, AG Al-Bakri, V Kasabri, II Hamdan - Iranian journal of pharmaceutical research: IJPR, 2014

[7]. Desai M N, Thanki G H & Gandhi M H, Anticorrosion, (1968) 12.

[8]. Nahlé, A, Abdel-Rahman, I, Alfarouk, M. "Effect of Temperature on the Inhibition of Corrosion of Carbon Steels by Semicarbazides and Thiosemicarbazides ", *Bull. Electrochem* , 21,2005, , 353.

[9]. Mohammad Ramezanzadeh, Ghasem Bahlakeh, Zahra Sanaei, Bahram Ramezanzadeh,Corrosion inhibition of mild steel in 1 M HCl solution by ethanolic extract of eco-friendly Mangifera indica (mango) leaves: Electrochemical, molecular dynamics, Monte Carlo and ab initio study, Applied Surface Science, Volume 463, 2019, Pages 1058-107

[10]. Patel M M, Patel N K & Vora J C, Trans SAEST, 12 (1977) 39.

[11]. Strams A M, Din El, El Hosary a A, Salch R M & Abd El Khader J M, Workst Korros, 28 (1977) 26.

[12]. I. Najjari, A. M. Almehdi, F. Errachidi, Y. Kandri Rodi, M. Ramdani, I. Abdel-Rahman, F. Ouazzani Chahdi, H. Steli, L. El Ghadraoui, H. Elmsellem, "Anti-corrosion effect of Morrocan flax seeds oil as a eco-friendly inhibitor on mild steel in acidic media", *Int. J. Corros. Scale Inhib* , 9(4), 2020,1402-1418.

[13]. Moore M L & Crossly F S, in Organic Synthesis, vol.3, edited by Horning E C (Wiley, New York), 1962, 599:617.

[14]. Thomas J G N, in Corrosion, vol. 2, edited by Shreir L L, Jarman R A & Burstein G T (Butter Worth – Heinemann), 2000, 17: 58.

[15]. M. Aiboudi, F. Yousfi, G. Fekkar, L. Bouyazza, M. Ramdani, M. El Azzouzi, I. Abdel-Rahman, "Eco-friendly Allium cepa L. seeds extracts as corrosion inhibitor for mild steel in 1 M HCl solutions, *J. Mater. Environ. Sci.*, , 10 (4), 2019,339-346.

[16]. Ateya B G, Andouli B E & Nizami F M, Corros Sci, 24 (1984) 509.

[17]. Desai M N & Desai M B, J Electrochem Soc India, 30 (1981) 351.

[18]. Ailor W H, Handbook on Corrosion Testing & Evaluation (John Wiley & Sons, Inc, New York, London), 1971,

[19]. R.Haldhar[a]D.Prasad[b],etal Anticorrosive properties of a green and sustainable inhibitor from leaves extract of *Cannabis sativa* plant: Experimental and theoretical approach J.Colloids and Surface,12(6),2021:211

[20]. By Omnia S. Shehata, Lobna A. Korshed and Adel Attia, Green Corrosion Inhibitors, Past, Present, and Future OASPA, 2017.