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Assessment of inhibition of Extracted jojoba oil as green Inhibitor for acidic-induced C-steel `10

Mohei EL-Din Solliman^{1&2}, Hany M. Abd El-Lateef³, Heba Allah A. Mohasseb^{1&2}
and Adnan M. ALdughaish³

*1*Plant Biotechnology Department, College of Agricultural and Food Sciences, King Faisal University, P.O. Box 400, Al-Ahsa 31982, Kingdom of Saudi Arabia.

*h*mohasseb@kfu.edu.sa (H.A.A.M.); *ms*solliman@kfu.edu.sa (M.E.-D.S.)

*2*Plant Biotechnology Department, National Research Centre, Dokki-Egypt, Cairo; P.O. Box. 12622; Egypt

3 Chemistry Dept., College of Sciences, King Faisal University, P.O. Box 400, Al-Ahsa 31982, Kingdom of Saudi Arabia. *hm*ahmed@kfu.edu.sa

3 Chemistry Dept., College of Sciences, King Faisal University, P.O. Box 400, Al-Ahsa 31982,

*Correspondent author: msolliman@kfu.edu.sa; solliman@yahoo.com

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Abstract: Jojoba oil has been studied as a potential green inhibitor for corrosion in various industries, including the protection of carbon steel against acidic-induced corrosion. The inhibitory properties of jojoba oil can be attributed to its chemical composition, which includes long-chain fatty acids and esters. To assess the inhibition efficiency of jojoba oil, experimental methods such as weight loss measurements, electrochemical techniques (e.g., polarization curves, electrochemical impedance spectroscopy), and surface analysis techniques were employed. These methods can provide insights into the corrosion rate reduction and the protective film formation on the carbon steel surface. It is important to note that the effectiveness of jojoba oil as a corrosion inhibitor may vary depending on factors such as the concentration of the acidic solution, temperature, exposure time, and the presence of other corrosive species. Therefore, comprehensive studies and further research are necessary to evaluate the inhibitory performance of jojoba oil under specific conditions. In this era of rapid technological advancement, sustainable development is an urgent concern. As a result, using renewable resources is crucial to achieving the Sustainable Development Goals (SDGs). Most researchers, both in academia and business, have focused on the polyols obtained from renewable resources, such as cellulose, lignin, chitosan, vegetable oils, and so on, as well as the polymers created from them. To create a system with additional value, bio-based polymers derived from vegetable oils are beginning to emerge with various features. This study will provide an overview of the various vegetable oil-based self-healing polymers and their applications, as well as how coatings made from vegetable oils can improve their corrosion-resistant qualities using fillers or systemic molecular structure modifications.

1. Introduction

Every oil has a built-in rust inhibitor. However, jojoba oil does reasonably well in comparison to the others. When seasoning cast iron cookware, it creates a polymer matrix that effectively prevents rust and makes the surface nonstick (Saidi *et al.*, 2015). Before Miwa did a study on these combinations, it was believed that jojoba wax esters were composed of random combinations of acids and alcohols (Spencer *et al.*, 1977). He demonstrated a substantial discrepancy between the estimated findings using a random association of alcohols and acids and the actual results. For example, the following results were noted (acid/alcohol, % experimental (% random): (C20:1/C'20:1, 28.0% (31.8%)), (C20:1/C'22:1, 10.3% (5.7%)), (C22:1/C'20:1, 41.4% (32.0%)), and (C22:1/C'22:1, 1.9% (5.7%)). This suggests that the association of eicosenoic acid and docosenol is the preferred method for the biosynthesis of eicosenyl docosenoate ester. These pairings show that plants prefer connections based on their genetic makeup. Analytically speaking, this finding provides a useful technique for identifying tainted oil and effectively differentiating between genuine Jojoba wax and its synthetic counterparts (Subhajit *et al.*, 2021).

Carbon steel is mechanically and environmentally resilient, yet it corrodes when it reacts with the environment. The oil and gas sector uses a variety of inorganic and organic corrosion inhibitors to eliminate this weakness. According to studies, organic molecules conjugated with N, S, and O atoms in the system are efficient corrosion inhibitors. Nonetheless, toxicity could emerge as a problem during the manufacture or use of these substances. Researchers have used plant extracts to create ecologically benign inhibitors in response to the increased awareness of green chemistry. Plant materials can be easily and affordably extracted and include certain active compounds with inhibitory characteristics (Abd El-Latee *et al.*, 2020, Emran *et al.*, 2017).

The world's largest producer of jojoba oil, it has primarily been utilized in the pharmaceutical sector and as an ingredient in cosmetics, shampoos, lipsticks, cleansers, and lotions for the face, hands, and body. Most of the oil produced from jojoba is used to make biodiesel, while its usefulness for purposes other than the pharmaceutical sector has been questioned. Thus, it is suggested to use low-quality jojoba oil to produce corrosion inhibitors to promote sustainable development. Using electrochemical methods such as linear polarization resistance, open circuit potential measurements, and electrochemical impedance spectroscopy, the effectiveness of the produced inhibitors was assessed (Subhajit *et al.*, 2021).

This study details the application of "green inhibitors," a novel class of metal corrosion inhibitors. This work aims to assess the inhibitory effectiveness of jojoba oil against C38 carbon steel corrosion in HCl (1M) using measuring and electrochemical techniques. Steel C38 corrodes because of jojoba oil's reduction in corrosion current density in the three mediums. As the concentration of the inhibitor rises, so does the oil's inhibitor efficiency. This study also reports a vivid insight into the jojoba oil used as a corrosion inhibitor for mild steel and compares their corrosion inhibition efficiency with each other.

2. Methodology

2.1 Experiments

2.1.1. Phytochemical qualitative analysis by GC-MS.

Analysis (GC-MS): The modified samples underwent GC-MS analysis following filtration with a 0.22 μm pore size syringe filter. They were selected due to their high total biochemical active ingredients in oil and jojoba oil extract, which were deemed potential therapies.

GC-MS apparatuses and instruments were used to perform GC-MS analysis under the following conditions: HP-5MS capillary column running in electron impact mode at 70 eV. Utilizing splitless operation and an ion source temperature of 280°C and an injector temperature of 250°C, pure helium gas with an integrated purifier was used at a steady flow rate of 1.0 ml/min. The following was the step temperature program: After setting the oven to 220°C for five minutes, it was ramped up to 300°C at a rate of 5°C per minute for an additional fifteen minutes. It was sufficient to post-run at 300°C for 5 minutes before injecting the next sample.

2.1.2. Biochemical active compounds identification

Mass spectra were obtained at 70 eV using a mass analyzer operating in full scan mode, covering m/z 40-550. Using the mass spectral library of the National Institute of Standards and Technology (NIST) version 2.0 and the Automated Mass Spectral Deconvolution and Identification (AMDIS) software version 2.70 to deconvolute the chromatography peak at the corresponding retention time, manual spectral matching was determined for the compound identification ([Michnowicz and Munson 1970](#)).

Note that the obtained chromatograms indicate certain bioactive chemicals in the unsaponifiable fraction of the jojoba callus extracts of each treatment, in addition to those that belong to saponifiable compounds.

3. Results and Discussion

3.1 Anti-rust Jojoba Oil for Metal Castings

Anti-rust jojoba oil is becoming more and more necessary for clients to use to safeguard metal castings. because harmful materials and pollutants are absent from jojoba oil. They can therefore be used as an anti-rust coating on stove parts and other metal castings that are associated with the environment, food, water, and human health. Another name for jojoba oil is "rust-proof veggie oil," and it's a type of anti-corrosive oil primarily composed of plant oil. This oil can dry fast, leave a translucent, thin oil layer on the surface of metal castings, and provide excellent rust protection. Jojoba oil's greatest benefit is, of course, its lack of toxicity and contamination. They also have two other strong characters:

1. They may solidify into a coating on the casting's surface, making it difficult for hands to get soiled with the dry oil.
2. Because they are transparent, the surface repair locations and casting flaws are visible.

For rust protection, jojoba oil differs from regular oil. Typical anti-rust oil is used on machining surfaces, so it can also be used as a lubricant. However, it is difficult to dry and remains somewhat sticky after drying, making it ideal for protecting machine surfaces but not for protecting the rough surfaces of metal castings.

The following images, which we took in our lab, demonstrate some of the facts we have proven. You can also see what jojoba oil can do to prevent rust. The iron castings with the Jojoba oil coating are shown in the first picture, where you can see how excellent they look. In the second picture, the oil-coated iron castings are still in good condition, but some of them have rusted in different places. However, those that were left in water and lacked an oil covering have rusted.



Figure 1. Shows the Jojoba Oil as anti-rust for Metal casting surfaces: a) Surface is better after Jojoba oil coating., b) Rusted positions on the left side and right side without Jojoba oil coating and coated by vegetable oil., c) Surface after is rusted without Jojoba oil coating by water.

3.2. Screening of jojoba oil GC-MS analysis:

The chemical composition of samples was performed using (GCMS-QP2010 SE) Instrument with a direct capillary column Rtx-5MS (30 mx 0.25 mm x 0.25 μ m film thickness). The column oven temperature was initially held at 50°C for 2 min and then increased by 10°C/min to 150°C then increased by 10°C/min to 28°C. The injector temperature was kept at 250°C. Helium was used as a carrier gas at a constant flow rate of 1 ml/min sample of 1 μ l was injected automatically using auto sample AOC-20S coupled with GC in the splitless mode. E1 mass spectra were collected at 70 eV ionization voltages over the range of m/z 50-500 in full scan mode. The ion source and transfer line temperature were set at 250 and 300 °C respectively. The components were identified by comparison of their retention times and mass spectra with those of NIST 05 mass spectral database.

3.3. Jojoba oil content

Although the fatty acid content of jojoba oil may vary significantly depending on many known variables, such as the soil composition in which the plant is grown and when in the plant's lifecycle it is harvested, a typical jojoba oil fatty acid composition is shown in **Table 1**. In one or more embodiments, the oil mixture may comprise one or more of the components of **Table 1** in amounts defined by ranges that include plus or minus 5 mol. %, 4 mol. %, 3 mol. %, 2 mol. %, or 1 mol. % of the amounts listed in **Tables 1, 2 and 3**.

In embodiments, the plant-based oil may comprise or consist essentially of jojoba oil. Jojoba oil is the oil extracted from the seeds of the jojoba plant (*Simmondsia chinensis*). It is comprised almost entirely of (that is, about 97%) mono-esters of long-chain fatty acids, such as mono-esters of gondoic acid and alcohols. Accordingly, the jojoba oil may comprise from 65 mol. % to 85 mol. % species comprising one or more gondoic acid moieties. For example, the jojoba oil may comprise from 65 mol. % to 80 mol. %, from 65 mol. % to 75 mol. %, from 65 mol. % to 70 mol. %, from 70 mol. % to 85 mol. %, from 70 mol. % to 80 mol. %, from 70 mol. % to 75 mol. %, from 75 mol. % to 85 mol. %, from 75 mol. % to 80 mol. %, or from 80 mol. % to 85 mol. % one or more species comprising gondoic acid moieties.

Table 1: Extraction of jojoba oil using diethyl ether:

Rt	Area %	Formula	M.wt	Compound Name
5.223	0.87	C ₁₅ H ₂₄ O	220	Butylated Hydroxytoluene
7.755	3.24	C ₂₀ H ₄₀ O ₂	312	Eicosanoic acid
7.926	18.21	C ₁₈ H ₃₄ O	266	9-Octadecenal,(Z)-
8.395	1.5	C ₁₈ H ₃₄ O	266	Cyclopropaneoctanoic acid, 2-[[2-[2-ethylcyclopropyl)methyl]cyclopropyl]-, methyl ester
8.6	4.83	C ₁₈ H ₃₄ O ₂	282	9-Octadecenal,(Z)-
8.693	3.14	C ₁₈ H ₃₄ O	266	9-Octadecenal,(Z)-
8.868	4.2	C ₁₈ H ₃₄ O	266	9-Octadecenal,(Z)-
9.152	13.2	C ₂₀ H ₄₀ O ₂	312	Ethanol, 2-(9-octadecenyloxy)-,(Z)-
9.383	0.84	C ₂₅ H ₅₀ Br ₂	508	Erythro-9,10-Dibromopenacosane
9.565	1.06	C ₁₈ H ₃₄ O	266	9-Octadecenal,(Z)-
9.623	5.33	C ₁₈ H ₃₄ O	266	Ethanol, 2-(9-octadecenyloxy)-,(Z)-
10.011	10.78	C ₂₀ H ₄₀ O ₂	312	Ethanol, 2-(9-octadecenyloxy)-,(Z)-
10.451	19.17	C ₂₀ H ₄₀ O ₂	312	Ethanol, 2-(9-octadecenyloxy)-,(Z)-
10.542	0.88	C ₁₅ H ₂₈ O ₂	240	Cyclopentadecanone, 2-hydroxy-
10.896	1.67	C ₁₅ H ₂₈ O ₂	240	Cyclopentadecanone, 2-hydroxy-
10.942	0.66	C ₁₅ H ₂₈ O ₂	240	Cyclopentadecanone, 2-hydroxy-
11.35	1.96	C ₂₂ H ₃₁ FO ₂	346	[1,1'-Bicyclohexyl]-4-carboxylic acid, 4-propyl-,4-fluorophenyl ester
11.4	4.3	C ₂₀ H ₄₀ O ₂	312	Ethanol, 2-(9-octadecenyloxy)-,(Z)-
11.571	1.57	C ₁₅ H ₃₀ O	226	Z-11-Pentadecenol
13.957	2.59	C ₂₉ H ₅₀ O ₂	430	Cholestan-7-one, cyclic 1,2-ethandiyl acetal, (5.alpha.)-

Table 2: Extraction of jojoba oil using Methanol:

Rt	Area %	Formula	M.wt	Compound Name
19.326	2.06	C17H34O2	270	Hexadecenoic acid, methyl ester
20.965	1.13	C22H38O2	334	Cyclopropaneoctanoic acid, 2-((2-ethylcyclopropyl) methyl) cyclopropyl methyl)-, methyl ether
21.035	13.37	C19H36O2	296	7-Octadecenoic acid, methyl ether
21.075	0.68	C19H36O2	296	7-Octadecenoic acid, methyl ether
21.253	0.87	C17H34O3	296	Methyl 16-hydroxy-hexadecanoate
22.539	23.43	C18H36O	268	9-octadecen-ol, (z)-
22.855	40.97	C21H40O2	324	cis-11-Eicosenoic acid, methyl ether
24.223	11.42	C24H46O2	366	(z)- 14-Tricosenyl formate
24.474	5.01	C23H44O2	352	Methyl 11-docosenoate
28.383	1.06	C44H78O2	638	Cholesterol margarate

Table 3: Extraction of jojoba oil using n-Hexane:

Rt	Area %	Formula	M.wt	Compound Name
17.8	7.24	C15H30O2	242	Pentadecanoic acid
18.129	1	C20H38O2	312	Eicosanoic acid
21.833	1.81	C11H16O4	212	Phenol,2,2-methylenbis(1,1-dimethylethyl)-4-methyl
22.753	55.98	C24H38O4	390	DEHP
38.599	33.97	C15H28O2	240	Cyclopentadecanone,2-hydroxy

3.4. Analysis of jojoba oil by HPLC and GC/MS.

They successfully developed different analysis methods, and we can conclude that In the next, we will also continue to optimize the best way for that according to our recommendations here:

- The determination of Simmondsin in jojoba oil can be achieved with extraction by 80% aqueous ethanol and analysis by HPLC at wavelength 220nm.
- The GC/MS analysis of jojoba oil using methanol extractions showed a high extraction efficiency of fatty acid when compared with the other extraction methods using diethyl ether and n-hexane.

3.5. Study of jojoba oil aging by FTIR

Jojoba oil is utilized in many industries, including biodiesel, dietetic food, cosmetics, pharmaceuticals, lubrication, polishing, and animal husbandry. For this reason, it was crucial to investigate how the oil ages at high temperatures through oxidation. This study created a Fourier-transform infrared spectroscopy (FTIR) approach to track the accelerated oxidative breakdown of jojoba oils. Principal component analysis (PCA) was employed to distinguish between samples based on their origin and method of acquisition as well as oxidative conditions used on oils. FTIR is a method for obtaining an infrared spectrum of a solid, liquid, or gas's absorption or emission. To summarize the oxidation phenomenon, two spectroscopic indices were computed. Multivariate curve resolution-alternative least square approach (MCR-ALS) provided deeper and more reliable results. Using a SIMPLISMA pretreatment, made it possible to determine the chemical species generated or broken down during the thermal treatment.

The ATR-FTIR spectra of all the jojoba oil samples are similar (Fig. 5), showing distinctive bands of aliphatic hydrocarbons influenced by vibrations at 3000–2800, 1460–1377, and 720 cm^{-1} , respectively. Additionally, bands unique to esters can be seen at 1738 and 1170 cm^{-1} . Based on PCA applied to the ATR-FTIR spectra of jojoba oils, the two initial major components (representing 49% and 41% of the total) are classified based on the farm origin (Fig. 5).

The FTIR spectrum of jojoba oil obtained by Cary 360 FTIR from Agilent Technologies shows that jojoba oil contains the functions group of OH from carboxylic acid (3000-2400), CH at 2920, C=O of Ketone (1720-1750), amines N-H stretch (1300-900), C-O at 1200-1400.

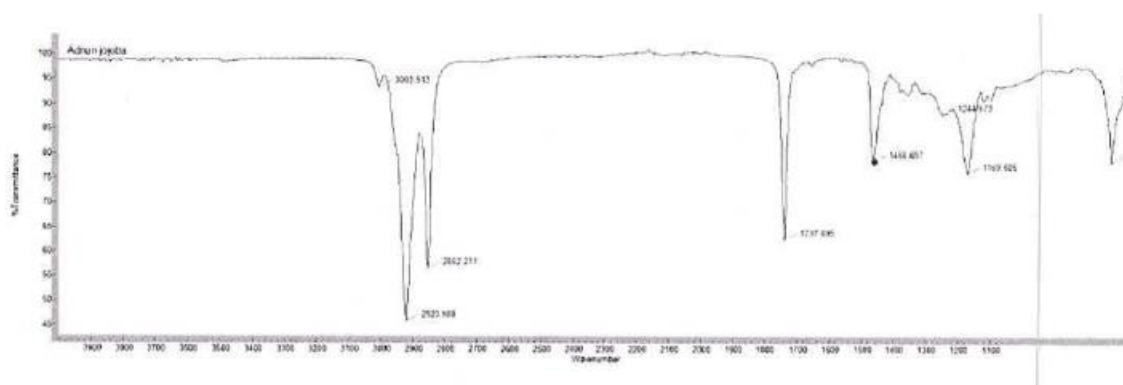


Figure 5. FT-IR spectroscopy: a Jojoba oil sulfited jojoba oil

3.6. PDP

The polarization plots for C-Steel in 1.0 M HCl with different Extracted jojoba oil concentrations at 25 °C are revealed in [Fig. 6](#). The presence of EJO significantly alters the polarization curves of steel,

as shown in Fig. 5. Fig. 6 shows that the corrosion current values significantly dropped in the presence of EJO while the form of the polarization curve remained unchanged, indicating that the inhibition of EJO inhibits the active site present on the steel surface while maintaining the same corrosion mechanisms. This result suggests that the EJO alters the rate of corrosion rather than the cathodic and anodic reaction processes. It is possible to deduce that EJO slows down the hydrogen evolution reaction at cathodic sites. As a result, the steel is shielded from the solution's corrosive attack. The related corrosion strictures, current density (i_{cor}), corrosion potential (E_{cor}), and anodic and cathodic Tafel slope (β_c and β_a) are tabulated in **Table 4**.

The outcome further indicates that EJO functions as a mixed-type corrosion inhibitor because the maximum E_{cor} value displacement for inhibited samples to unregulated samples was below 85 mV (Abd El-Latee *et al.*, 2020, Dehghani *et al.*, 2020). It was found that the exposed specimen's i_{cor} value dropped dramatically from 453.9 to 0.31 Acm⁻² when exposed to 200 ppm EJO solutions. This could be a result of the dense inhibitor layers that have formed on the metal surface, which stop the corrosion process. The increased double-layer thickness caused by the complex compound generated at the solution/metal interface may be the cause of the lower i_{cor} at higher EJO concentrations. This outcome demonstrates the strong ability of EJO to lower the rate of steel corrosion through the production of films and/or adsorption on the active sites. At 298 K, the protection capacity of EJO is 56.42% at 5.0 ppm and was increased to 99.31% at 200 ppm (Table 4). EJO has three main purposes: it displaces water molecules on metal surfaces, binds to active sites to block them, and forms a barrier layer that prevents corrosion (Moganavally *et al.*, 2016). Due to the presence of many fatty acids and polyunsaturated fatty acids, the EJO molecule is better able to form a strong bond with the metal and provides more efficient defense against the steel surface.

Figure 6: PDP plots for C-Steel in 1.0 M HCl with different Extracted jojoba oil concentrations at 25 °C.

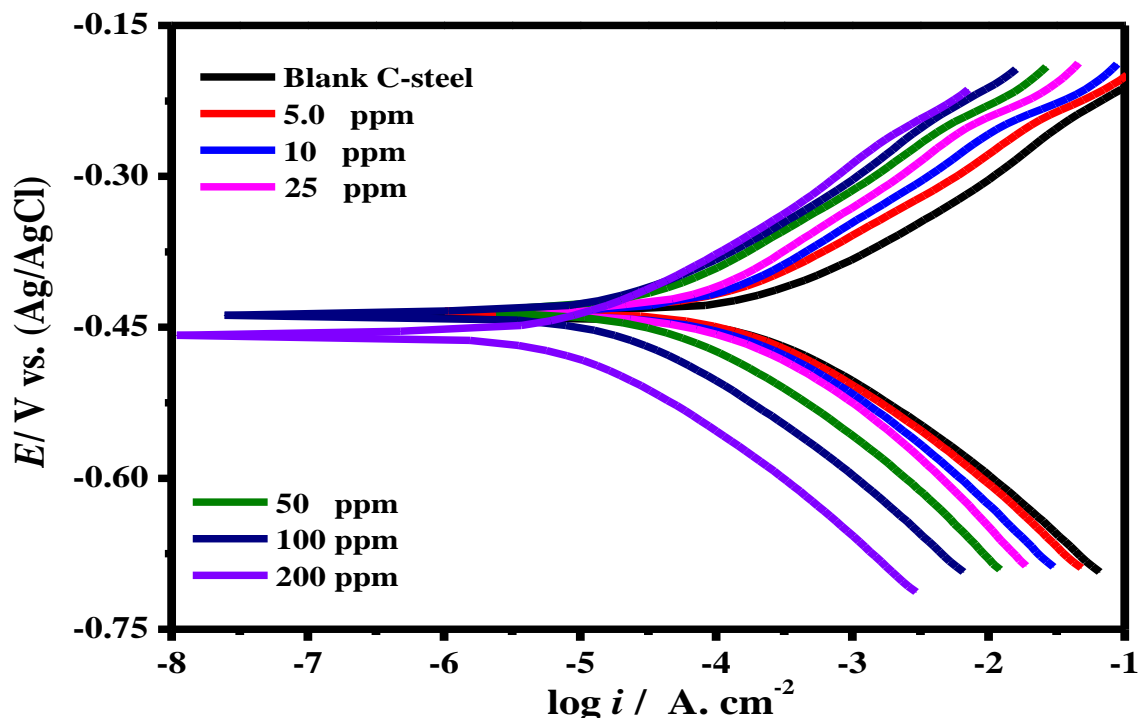


Table 4: PDP parameters and protection efficiency for C-steel in HCl solution with different Extracted jojoba oil concentrations at 25 °C

Inhibitors code	$C_{inh.}/$ ppm mg/L	$i_{cor}/$ μAcm^{-2} $\pm\text{SD}$	$E_{cor}/$ V (Ag/AgCl)	$\beta_a/$ mV dec^{-1}	$-\beta_c/$ mV dec^{-1}	θ	$IE_{PDP} / \%$
Blank	0.0	453.9±29.1	-0.438	83.18	168.27	-	-
EJO	5	197.8±11.3	-0.433	88.08	164.91	0.564	56.42
	10	148.7±9.6	-0.440	85.11	176.77	0.672	67.23
	25	88.3±7.3	-0.435	86.07	179.34	0.805	80.54
	50	40.3±3.1	-0.434	87.03	158.28	0.911	91.12
	100	15.2±1.4	-0.439	92.97	150.57	0.966	96.65
	200	3.1±0.5	-0.458	90.09	172.72	0.993	99.31

3.7. EIS studies

EIS was used to investigate the mechanism of EJO molecules' corrosion inhibition on C-steel further. During 60 minutes of immersion of the C-steel specimen in molar HCl without and with varied concentrations of EJO at 25 °C, the OCP reached a steady state. The Nyquist and Bode plots for the C-steel electrode at a constant OCP were obtained as a result and are shown in Fig. 7A. The resulting EIS findings are shown in Nyquist and Bode modules, respectively, in **Figures 7 A and B**. The charge transfer mechanism is responsible for regulating the corrosion of C-steel in molar HCl with and without EJO inhibitor and is frequently linked to the double-layer performance, as this **Figure** amply depicts. All impedance spectra feature a single capacitive loop ([Ramezanzadeh et al., 2020](#)). Furthermore, since these graphs are the same for all concentrations examined, the corrosion mechanism is unaltered ([Al Kiey et al., 2022](#)). These Nyquist graphs are not ideal semicircles, which may be due to the frequency dispersion of interfacial impedance ([Cao et al., 20](#)). This effect is caused by chemical inhomogeneity, coarse surfaces, and the adsorption-desorption of inhibiting molecules on surfaces of C- steel ([Mansfeld 1990, Valcarce and Vázquez 2009](#)). The diameter of the semicircle in the presence of the EJO inhibitor is also greater than that seen in a molar HCl (blank solution) and increases with increasing inhibitor doses, which may be connected to the expansion of the surface covering of inhibitive chemicals on the C-steel surface.

The proper Bode impedance modules for C-steel electrodes submerged in molar HCl with and without different EJO dosages at its OCP are shown in **Figure 7B**. The improved protection with rising EJO concentration is confirmed by the Bode plot's increase in absolute impedance at low frequencies ([Valcarce and Vázquez 2009](#)). A rise in absolute impedance reveals a higher EJO inhibitor concentration in 1.0 M HCl. Because more inhibitor molecules are absorbed at higher quantities on the surface of the C-steel, this suggests enhanced inhibitive action ([Flis, 1996](#)).

The capacitance semi-circle depression, which corresponds to surface inhomogeneity brought on by contaminants, surface roughness, grain boundaries, displacements, additive adsorption, growth of porous layer, etc., is clarified by the use of the CPE element. The following equation describes the impedance CPE function ([Boubour, 2000; Badry and El-Taib, 2022](#)):

$$Z_{CPE} = \frac{1}{Q(j\omega)^\alpha} \tag{2}$$

where; j represents the imaginary number ($j^2 = -1$), Q signifies the CPE magnitude, and ω characterizes the angular frequency. α epitomizes the deviation restriction ($-1 \leq \alpha \leq +1$), which has the significance of a phase shift. The CPE denotes a pure resistor when $\alpha = 0$, a pure capacitor when $\alpha = +1$, and an inductor when $\alpha = -1$ (Cao *et al.*, 20). Additionally, the following equation was used to get the double-layer capacitances, C_{dl} , for a circuit that has a CPE (Badry and El-Taib, 2022; Abd El-Lateef and Khalaf, 2020):

$$C_{dl} = Q(2\pi\omega_{max})^{\alpha-1} \tag{3}$$

where ω_{max} is the maximum frequency value at the imaginary part of the EIS range. The electrochemical parameter values such as R_s , R_p , C_{dl} , Y_0 , and $\eta_E/\%$ (inhibition capacity) of EJO were attained from EIS and recorded in Table 2. As the concentration of the inhibitor rises, the R_p values upsurge and the C_{dl} values decrease. The uppermost R_p (1046.2 $\Omega \text{ cm}^2$ for) has been found at an optimal dose (200 ppm). The EJO inhibitor causes an increase in R_p values, which denotes a decrease in the exposed surface. The EJO inhibitor may, however, work by adsorption at the metal/medium interface, as suggested by a decline in C_{dl} , which may be caused by a fall in the local dielectric constant and/or an increase in the thickness of the electrical double layer. When the concentration of this EJO inhibitor exceeds 200 ppm, the values of inhibitory efficiency rise to 96.2%. These results provide further evidence of the examined compound's potent C-steel inhibiting performance in an HCl solution. It is significant to note that, as shown in Table 5, the inhibitory efficiencies reported by electrochemical measures are essentially in agreement with those determined by PDP.

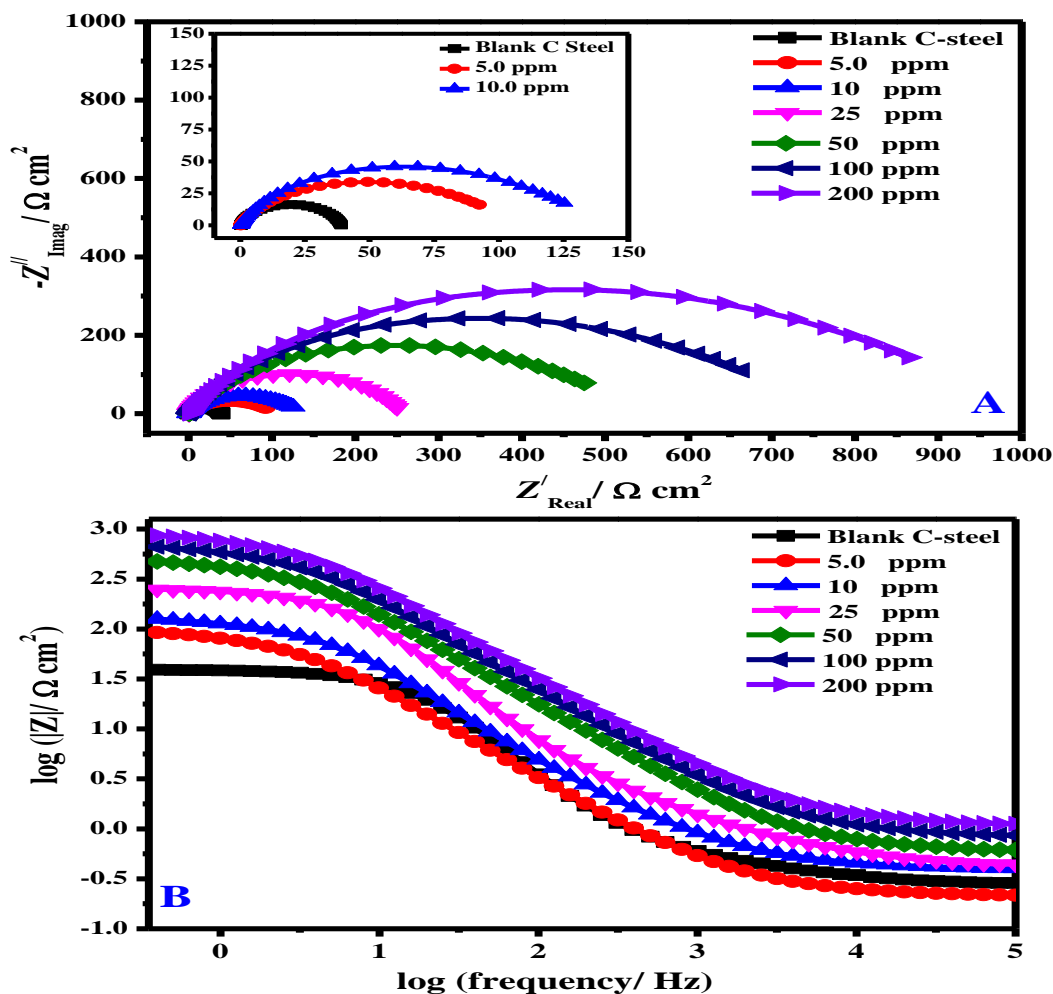


Figure. 7. Nyquist (A) and Bode (B) plots of C-steel electrode in HCl solution with different Extracted jojoba oil concentrations at 25 °C

Table 5: EIS corrosion parameters of C-steel electrode HCl solution with different Extracted jojoba oil concentrations at 25 °C

Inhibitors code	$C_{inh.}/$ ppm mg/L	$R_s/$ Ω cm^2	$R_p/$ Ωcm^2 $\pm SD$	$C_{dl}/$ $F cm^{-2}$ $\times 10^{-6}$	Q_{CPE}		χ^2 $\times 10^{-4}$	θ	$\eta_E/\%$
					$Y_0/$ $\mu\Omega^{-1}$ $s^n cm^{-2}$	n			
Blank	0.0	0.39	39.3±2.3	568.7	75.32	0.752	5.57	--	--
EJO	5.0	0.42	93.5±6.8	228.5	47.36	0.831	4.56	0.579	57.9
	10	0.55	156.6±9.3	184.7	33.61	0.854	4.53	0.749	74.9
	25	0.64	294.2±17.2	103.7	24.71	0.898	5.12	0.866	86.6
	50	0.78	618.9±23.7	44.4	9.88	0.876	5.65	0.936	93.6
	100	0.89	845.7±35.5	39.7	3.76	0.898	5.54	0.953	95.3
	200	1.08	1046.2±46.3	16.4	2.86	0.908	5.48	0.962	96.2

Conclusion

These techniques can shed light on the creation of a protective film and the decrease in corrosion rate on the surface of carbon steel. It is crucial to remember that jojoba oil's efficiency as a corrosion inhibitor can change based on several variables, including temperature, exposure duration, the concentration of the acidic solution, and the presence of additional corrosive species. As a result, in-depth analyses and additional studies are required to assess Jojoba oil's inhibitory effectiveness in particular situations. A pressing challenge in this age of fast technical advancement is sustainable development. Accordingly, the Sustainable Development Goals (SDGs) must be achieved using renewable resources. Most studies conducted by academic and commercial researchers have concentrated on polyols derived from renewable resources including cellulose, lignin, chitosan, vegetable oils, and so on, as well as the polymers created from them. Bio-based polymers generated from vegetable oils are starting to appear with different properties to build a system with extra value. An overview of the numerous self-healing polymers based on vegetable oils and their uses will be given in this study, along with information on how fillers or systemic molecular structure alterations might enhance the corrosion-resistant properties of coatings manufactured from vegetable oils.

References

- Abd El-Lateef, H.M. Khalaf, M.M. (2020) Fabrication and characterization of alumina-silica/poly(o-toluidine) nanocomposites as novel anticorrosive epoxy coatings films on carbon steel, *Microchem. J.* 158 (2020).
- Abd El-Lateef, H.M. Shalabi K., Tantawy A.H., (2020) Corrosion inhibition and adsorption features of novel bioactive cationic surfactants bearing benzenesulphonamide on C1018-steel under sweet conditions:

- Combined modeling and experimental approaches, *J. Mol. Liq.* 320: 114564. <https://doi.org/10.1016/j.molliq.2020.114564>.
- Al Kiey, S.A. Hasanin, M.S. El-Taib Heakal, F. (2022) Green and sustainable chitosan–gum Arabic nanocomposites as efficient anticorrosive coatings for mild steel in saline media. *Sci. Rep.* 12(1) (2022) 13209. <https://doi.org/10.1038/s41598-022-17386-7>
- Boubour, E. Lennox, R.B. (2000) Stability of ω -Functionalized Self-Assembled Monolayers as a Function of Applied Potential, *Langmuir*. 16 (2000) 7464–7470. <https://doi.org/10.1021/la000514b>.
- Cao, K. Yu, Z. Yin, D. Che. L. n, Jiang, Y. Zhu L, (2020) Fabrication of BTA-MOF-TEOS-GO nanocomposite to endow coating systems with active inhibition and durable anticorrosion performances, *Prog. Org. Coatings.* 143 (2020) 105629. <https://doi.org/10.1016/j.porgcoat.2020.105629>.
- Dehghani, A. Mostafatabar A.H., Bahlakeh G., Ramezanzadeh, B. (2020) A detailed study on the synergistic corrosion inhibition impact of the Quercetin molecules and trivalent europium salt on mild steel; electrochemical/surface studies, DFT modeling, and MC/MD computer simulation, *J. Mol. Liq.* 316 (2020) 113914. <https://doi.org/https://doi.org/10.1016/j.molliq.2020.113914>.
- El Badry M. Mohamed, El-Taib Heakal F., (2022) Potential application of carbon-based/ionophore electrical sensor for the highly sensitive diltiazem HCl quantification in its pharmaceutical products and biological samples, *Electroanalysis* 34 (2022) 1-16. doi.org/10.1002/elan.202200041
- Emran, K.M. Ali S.M., Al Lehaibi H.A., (2017) Green methods for corrosion control, Chapter 3, in: M. Aliofkhaezraei (Ed.), *Corrosion Inhibitors, Principles and Recent Applications*, IntechOpen, 2017. <https://doi.org/10.5772/intechopen.72762>.
- Flis, J. Zakroczymski, T. (1996) Impedance Study of Reinforcing Steel in Simulated Pore Solution with Tannin, *J. Electrochem. Soc.* 143 (1996) 2458–2464. <https://doi.org/10.1149/1.1837031>.
- Mansfeld, F. (1990) Electrochemical impedance spectroscopy (EIS) as a new tool for investigating methods of corrosion protection, *Electrochim. Acta.* 35 (1990) 1533–1544. [https://doi.org/10.1016/0013-4686\(90\)80007-b](https://doi.org/10.1016/0013-4686(90)80007-b).
- Michnowicz J, Munson B. (1970) Studies in chemical ionization mass spectrometry. *Org Mass Spectrom.* 1970;4(S1):481-492.
- Moganavally, P. Deepa, M. Sudha, P.N. Suresh, R. (2016) Adsorptive Removal of Lead and Cadmium Ions using Cross-Linked CMC Schiff Base: Isotherm, Kinetics and Catalytic Activity, *Orient. J. Chem.* 32 (2016) 441–453. <https://doi.org/10.13005/ojc/320150>.
- Ramezanzadeh, M. Ramezanzadeh, B. Mahdavian M., Bahlakeh, G. (2020) Development of metal-organic framework (MOF) decorated graphene oxide nanoplateforms for anti-corrosion epoxy coatings, *Carbon N. Y.* 161 (2020) 231–251. <https://doi.org/10.1016/j.carbon.2020.01.082>.
- Saidi, N. H. Elmsellem, M. Ramdani, A. Chetouani, K. Azzaoui, F. Yous, A. Aouniti, Hammouti B. (2015) Using pectin extract as eco-friendly inhibitor for steel corrosion in 1 M HCl media, *Der. Pharma. Chem.* 7: 87-94.
- Spencer, G.F.; Plattner, R.D.; Miwa, T. (1977) Jojoba oil analysis by high-pressure liquid chromatography and gas chromatography/mass spectrometry. *J. Am. Oil Chem. Soc.* 1977, 54, 187–189.
- Subhajit K., Mahuya Das, and Debarati Mitra (2021) Current Status, Opportunities, and Challenges of Green Corrosion Inhibitors. *Materials Research Foundations* 107, 1-29.
- Valcarce, M.B. Vázquez, M. (2009) Carbon steel passivity examined in solutions with a low degree of carbonation: The effect of chloride and nitrite ions, *Mater. Chem. Phys.* 115 (2009) 313–321. <https://doi.org/10.1016/j.matchemphys.2008.12.007>.
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