Corrosion Inhibition of Aluminum in Soduim Hydroxide Basic Medium by Ketoprofen Expired Drug

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Abstract
The inhibitory effect of expired drug molecules, ketoprofen, on aluminum pure corrosion in 0.2 M NaOH solution was investigated using the weight loss approach (20, 30, 40, and 50 C). When the inhibitor concentration is increased, the efficiency of inhibition improves. Adsorption is governed by the Langmuir isotherm model. As a result, the effectiveness of inhibition is dependent. in the presence or absence of the inhibitor. The highest inhibition efficiency of 93.25 percent was obtained with the strongest inhibitor. maximum concentration and temperature.
Keywords: Aluminu, Basic solusion , Corrosion , Expire Drug , Ketoprofen, Inhibitor.

1. Introduction

Corrosion is an irreversible interfacial reaction between a material and its environment that causes it to dissolve and be consumed. Corrosion frequently has negative consequences for the material in question.[1]

The reaction normally begins on a metal surface, which can be determined by the metal's weight or changes in chemical or physical properties over time. [2]

Corrosion is a natural occurrence that occurs when metals and their briefly unstable forms, such as ores or natural minerals, have a strong desire to transition to a more thermodynamically stable state. Because of their surroundings, metals exist in many forms, such as oxides, hydroxides, and other forms. [3]

Because of their high strength-to-density ratio, aluminum and its alloys are among the most cost-effective and durable metals available today. Transportation, aviation, two-wheelers, hiking equipment, inline skating frames, and hang glider frames are only a few of the uses. [4]

Aluminum, a nonferrous metal, is the most widely used. It's vital that this metal doesn't corrode. Corrosion inhibitors are a typical method of corrosion prevention. [5]

An inhibitor is a chemical compound or mixture of substances that successfully prevents or reduces corrosion in corrosive environments without creating significant reactivity with the environment's components.

Corrosion inhibition research has moved its focus to human health and safety issues. The researchers have concentrated on using substances that are safe for the environment, such as plant extracts, for this purpose, a number of organic compounds are used. [6]

Amino acids, alkaloids, pigments, and tannins are examples of green alternatives to poisonous and harmful compounds. Because of their biodegradability, eco-friendliness, low cost, and widespread availability, extracts of some common plants and plant products have been studied as corrosion inhibitors for various metals and alloys in a variety of environments. [7]

Expired drugs turned out to be ideal and cost-effective corrosion inhibitors rather than pharmaceutical elements that had to be thrown away, which was a pleasant surprise. [8]

This distinctive feature motivates worldwide study into the potential of medicines as corrosion inhibitors. Drugs that are environmentally benign and non-toxic are more suitable for environmental requirements than dangerous inhibitors. As a result, fresh and expired medications have been used as corrosion inhibitors in numerous research studies. [9]

Some of the most important properties that must be present in inhibitors are as follows:

- It must provide good corrosion protection even at low inhibitor concentrations.
- It must keep all exposed items safe from corrosion.
- It must be able to function effectively in harsh environments (higher temperature and velocity).
- The corrosion rate should not significantly increase if the inhibitor dosage is either too low or too high; it should suppress both uniform and localized corrosion.
- It must be effective over a long period of time.

2. Expermintal part

Extraction of Expired Drugs

Expired medicines with a higher water solubility were used to create today's corrosion inhibitors. Figure 1 depicts the molecular structure of ketoprofen. In addition, Table 1 shows the chemical characteristics of ketoprofen.

The active substance of the green inhibitors, which include ketoprofen, was extracted from an expired medicine. The drug is mashed with a pestle, mixed

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with distilled water, left for 24 hours, filtered for 36 hours, and then dried for 4 hours every day in an oven at 80 degrees Celsius. [10]
To recover materials from expired medications, some inspections and tests were completed, including high-performance liquid chromatography (HPLC) to determine the amount of active substance in the extract and fourier transform infrared spectroscopy to ensure the existence of effective aggregates in the extract (FTIR).

Sample Preparation

Pure aluminum was used to study the corrosion test (weight loss).

Specimens were generated first. Cutting the specimen is a significant parameter in corrosion resistance, and achieving a consistent surface is essential. Square specimens (3 cm, 3 cm, 1 nm) were cut using an electrical saw before being molded into a final specimen with a hole drilled on one side for easy suspension in the corroding solution.
The specimens were then ground and polished with various papers in a succession of (220, 400, 600, 800, 1000, 1500, and 2000) to achieve a smooth and scratch-free surface. The samples were buffed using. suspension of alumina After that, the samples were rinsed with distilled water. The polished samples were reduced in size with acetone, then dried and stored in a plastic container. The samples were weighed using a four-digit electronic scale, and their dimensions were measured using an electronic vernier. [11]

Table (1) : Chemical properties of ketoprofen	
Color	White yellow
Formula Molecular	C16H14O3
Weight in Molecules	254.281 g/mol
Company	Sanofi
Country of origin	Franch

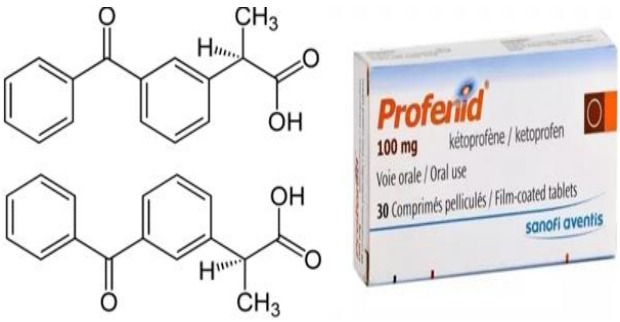

Figure (1): Appearance and chemical structure of ketoprofen

Preparation of Corrosion Medium

Corrosion media, including a 0.2M NaOH solution, were used in this study. This medium was made with distilled water and placed in flasks with capacities of 500 mL that were filled with varied drug concentrations.

Fourier Transform Infrared Spectrum (FTIR)

By mixing a sample of the extract with KBr and recording the spectra, the FTIR technique is used to determine the active groups in pharmaceuticals after they have been extracted.
A representation of Perkin Elmer's spectrum (65).

Atomic Force Microscopy (AFM)

The roughness of the surface was measured using AFM and the topography of the surface was presented.

Scanning Electron Microscope (SEM)

After the requisite study, SEM was used to examine the surface morphology of pure aluminum.

3. Result and Discussion

Weight Loss Measurement

Pure aluminum specimens were utilized to determine how much weight had been removed. After being cleaned and dried, the specimens were thoroughly immersed in 200 mL of 0.2M NaOH.
For three hours, a solution with and without an inhibitor (ketoprofen) was evaluated. The materials were cleaned, dried with an electric drier, and weighed using an analytical balance.
Weight loss was assessed using varied inhibitor concentrations (25, 75, 125, 175, 225, 275) and temperatures (20, 30, 40, and 50 C) in trials (K).
The following expression was used to compute the corrosion rate (CRcorr). [12]
Where (CR) is the corrosion rate, (W) is the weight loss in grams, (A) is the sample area in (t), m2 is the immersion duration in days, and corrosion rates are expressed in g/m2 day (gmd) The efficiency ratio is calculated using the equation below, given the corrosion rate: [13]
The rate and potency of damping were investigated under various implementation circumstances, including temperature and concentration, and the results were collected in Table 2. Where (CRuninhibit) and (CRinhibit) are the corrosion rates in the absence and presence of different concentrations of inhibitory, the rate and potency of damping were examined under various implementation circumstances, temperature and concentration, and the results were collected in Table 2.
It explains why corrosion accelerates with rising temperature and slows with increasing inhibitor concentration. In terms of efficiency inhibition, it rises in tandem with the inhibitor concentration and temperature.

The Effect of Inhibitory Concentration on Corrosion of Pure Aluminum

The addition of ketoprofen medication extracts significantly reduces the corrosion rate, as shown in Table 2, and the corrosion rate of aluminum generally increases with temperature. The higher the concentration, the lower the rate of ketoprofen corrosion (0.2M NaOH). As a result, ketoprofen delayed aluminum corrosion in (0.2M NaOH), indicating that it could be used in the future. as a corrosion inhibitor for that metal, as shown in Figures 2, and 3. [14]

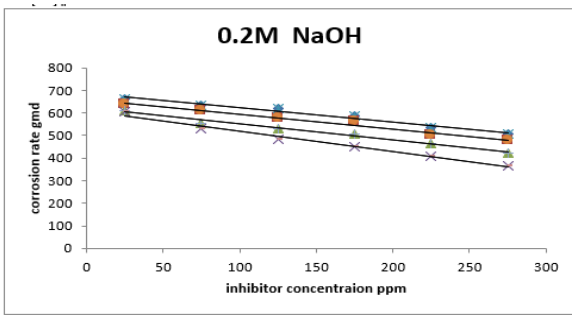

Fig. (2): Inhibitor concentration effects (ketoprofen extract) on the corrosion rate of aluminum in 0.2 NaOH

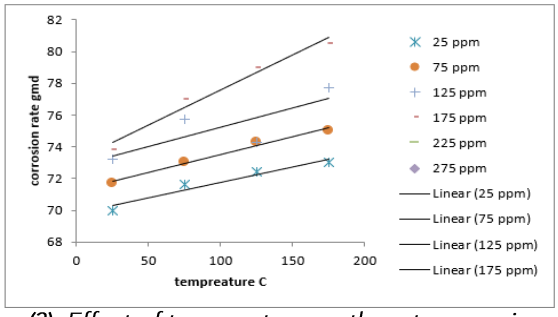

Fig. (3): Effect of temperature on the rate corrosion of aluminum in (0.2M NaOH) at various inhibitor concentration(ketoprofen extract).

Table (2) Show the effect of temperature on the corrosion rate, inhibition efficiency and surface coverage of aluminum pure in (0.2M NaOH) in absence and presence of Ketoprofen extract

Time (3h)							
Run	Cinh (ppm)	T (°C)	A . T	Δ W . T	CR (gmd)	Θ (surface coverage)	IE%
1	Blank	20	85.3734	0.8110	2279.86	0	0
2		30	84.6756	0.158	2312.25	0	0
3		40	82.3596	0.7994	2329.49	0	0
4		50	81.2106	0.7975	2356.83	0	0
5	25	20	87.8484	0.2031	554.86	0.756	75.6
6		30	86.1924	0.1831	509.83	0.779	77.9
7		40	84.54.96	0.1573	446.50	0.808	80.8
8		50	82.2342	0.1362	397.49	0.83	83
9	75	20	88.4466	0.1853	502.81	0.779	77.9
10		30	87.1428	0.1683	463.51	0.799	79.9
11		40	85.1442	0.1411	397.72	0.829	82.9
12		50	82.8234	0.1173	339.90	0.86	86
13	125	20	85.1316	0.1621	456.98	0.799	79.9
14		30	83.6112	0.1425	409.03	0.823	82.3
15		40	81.7584	0.1160	340.51	0.853	85.3
16		50	80.1680	0.0954	285.60	0.878	87.8
17	175	20	85.1082	0.1478	416.78	0.817	81.7
18		30	83.241	0.1232	355.20	0.846	84.6
19		40	81.2688	0.1015	299.74	0.871	87.1
20		50	79.3158	0.0754	228.15	0.903	90.3
21	225	20	88.209	0.1368	372.20	0.836	83.6
22		30	86.7882	0.1126	311.37	0.865	86.5
23		40	84.213	0.0890	253.64	0.891	89.1
24		50	82.2456	0.0668	194.92	0.917	91.7
25	275	20	84.2628	0.1181	336.37	0.852	85.2
26		30	82.6584	0.0833	241.86	0.895	89.5
27		40	80.9166	0.0682	202.28	0.913	91.3
28		50	79.188	0.0462	140.02	0.94	94

Inhibitor Performance and Adsorption Studies

The corrosion rate can be reduced to exceptionally low levels by increasing the inhibitor concentration from 25 to 275 ppm. The corrosion rate reaches its minimum value when the inhibitor concentration is low (275 ppm).

This could be due to the fact that the inhibitor concentration (275 ppm) is high enough to cover the metal surface in the temperature range (20, 30, 40, and 50 °C). The surface coverage (θ) data is particularly important for studying adsorption characteristics. The surface coverage of an inhibitor at a given concentration is calculated using equation (1). The corrosion rate data can be used to investigate the adsorption mechanism.

$$\theta = \frac{IE}{100} \dots\dots\dots\dots\dots (1)$$

Where ϴ surface coverage

IE inhibition efficiency

Langmuir Adsorption Isotherm

It is calculated using the equation (2). Figure 6 shows graphs of (Ci//θ) versus (Ci) for (ketoprofen) extract inhibitors in (0.2M NaOH) at (293,303,313, and 323 K), according to equation (4). (3). Because the data fits straight lines, inhibitors are adsorbed according to the Langmuir adsorption isotherm.

It could also explain the increase in inhibitory efficacy caused by an increase in the number of solvent molecules that adsorb on the aluminum surface, shielding active sites from acid attacks and therefore protecting metals from corrosion. [15]

$$\frac{Ci}{\theta} = \frac{1}{Kl} + Ci \ \ldots\ldots\ldots\ldots (2)$$

where (ɵ) is grade of surface coverage, C is the concentration inhibitor, kads is the adsorptive static equilibrium, and the molecular interaction parameters.

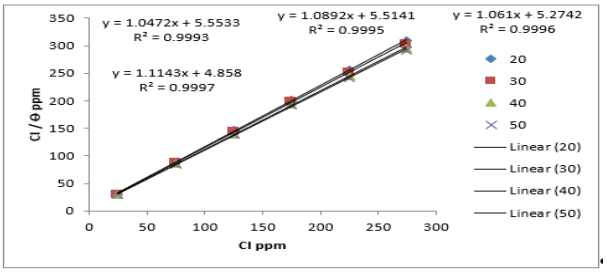

Fig. (4): Langmuir adsorption isotherm of (ketoprofen extract) for aluminum corrosion in (0.5M HCL).

Table (3): Show the (Kads), (ΔG°ads), and (R2) for Langmuir type adsorption isotherm of(ketoprofen extract) for aluminum corrosion in 0.5 M HCL (at different temperatures.			
Temperature(K)	KL (L/mg)	ΔG° (KJ/mol)	R2
293	0.1800	- 5.6066	0.9993
303	0.1813	- 5.8161	0.9995
313	0.1896	- 6.1245	0.9996
323	0.2058	- 6.5404	0.9997

Freundlich Adsorption Isotherm

It is calculated using an equation (3). Plotting (ln) versus (lnCi) with slope and intercept yields the values of (n") and (KF," respectively. Freundlich does not appear to apply well to this system because the correlation coefficient values are poor. The Langmuir isotherm, however, applies because the correlation coefficient values are high, giving the adsorption isotherm system more fitness. [16]

$$Ln\theta = LnKf + n\ LnCi \ \ldots\ldots\ldots\ldots (3)$$

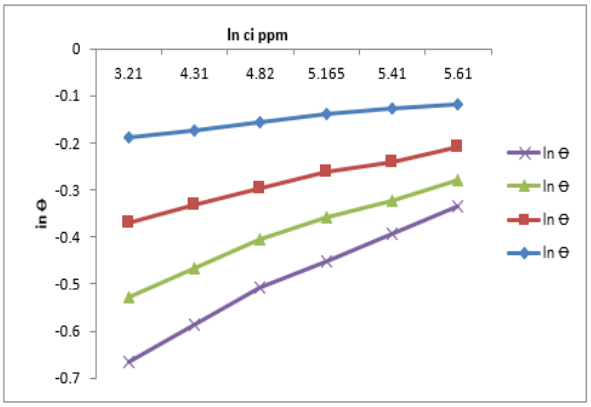

Fig. (5): Isotherm Freundlich adsorption of (ketoprofen extract) for aluminum corrosion in (0.5M HCL).

Table (4):Show the (K_F), slope (n), and (R^2) for Freundlich type adsorption isotherm of (ketoprofen extract) for aluminum corrosion in (0.5M HCL) .			
Temperature(K)	KF (L/mg)	n	R2
293	1.3423	0.0303	0.9202
303	1.3460	0.0343	0.9342
313	1.3249	0.0365	0.9607
323	1.2893	0.0332	0.8827

Timken Adsorption Isotherm

Equation (4), which was determined, was used to explain the adsorption of the extracts on the aluminum metal surface.

Figure (6) shows the plot of surface coverage (ɵ) versus (ln Ci), with the slope and intercept producing the values of (a) and (KT), respectively. The Timken isotherm clearly does not apply because the correlation coefficient values are lower.

In this configuration Because the correlation coefficient values are high, the Langmuir adsorption isotherm is the best (17).

$$\theta = \frac{1}{-2a} LnKT - \frac{1}{2a}\ LnCi \ \ldots\ldots\ldots\ldots (4)$$

The (L/gm) equation (6) can be plotted as surface coverage (ɵ) vs (lnCi), where slope and intercept produce a and KT values, respectively. [17]

The kinematic data is shown in Table 3,4 and 5. In their model of action, the inhibition obeys the Langmuir adsorption isotherm description more than the Freundlich adsorption isotherm and even more than the Timken adsorption isotherm, showing that corrosion-inhibiting chemicals work near the metal's surface.

The highest correlation coefficients (R2) were obtained with monolayer formation according to adsorption using the Langmuir isotherm. The type of adsorption is physical because G°ads is less than 20 kJ.mol-1 and has negative values.

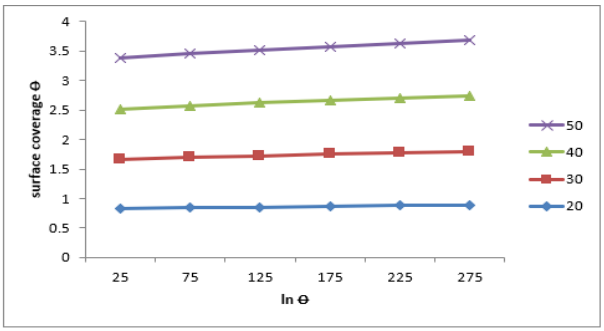

Fig. (6): Timken adsorption isotherm of (ketoprofen extract) for aluminum corrosion in (0.5M HCL).

Table (5): Show the (K_T), slope (a), and (R^2) for Timken type adsorption isotherm of (ketoprofen extract) for aluminum corrosion in (0.5M HCL).			
Temperature(K)	a	K_T	R^2
293	0.0003	2.2745	0.9874
303	0.0003	2.2942	0.9919
313	0.0003	2.3410	0.9778
323	0.0003	2.3702	0.9952

FTIR Studies

According to Figure 7, the peak at 3413.9 cm-1 was assigned to (O-H) stretching, and the peak at 3057.4 cm-1 was attributed to (C-H)AR stretching and the peak at 2930.7 cm-1 was attributed to (C-H)Alph. stretching. The stretching peaks for (C=C) were discovered at 1653.5 cm 1, respectively. The stretching peaks for (C=O) were discovered at 1079.2 cm-1 and the peak at 2930.7 cm-1 was attributed to (C-O).

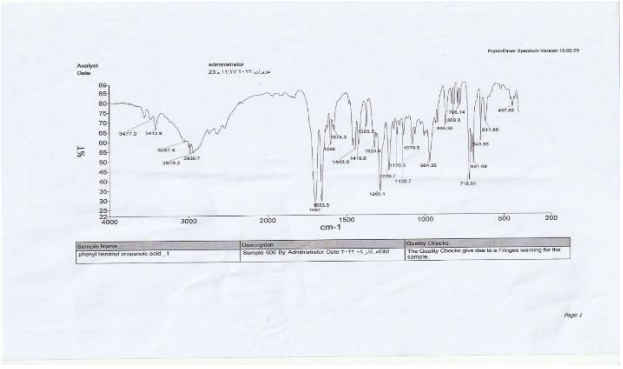

Fig.(7): FTIR spectra of ketoprofen extract

Atomic Force Microscope Studies

The surface aluminum pure morphology was examined using AFM technology in the absence and presence of ketoprofen extract. Inhibition was higher when the extract was higher. [18]

Microscopic analysis of the atomic force (AFM) provides a measure of rate roughness Ra (mean deviation from all points of profile roughness from the average streak along the rating), root–mean–squared roughness (Rq), mean height measured, and length of valuation measured from the average line for distractions taken into account (Figures 8–10). [19]

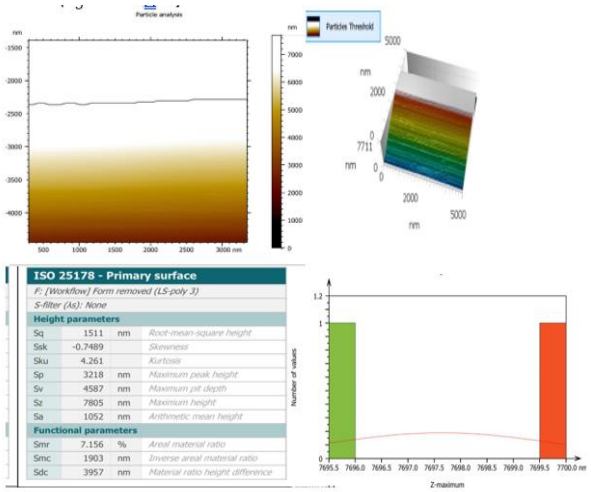

Fig. (8): 2D and 3D images of AFM for polished aluminum surface.

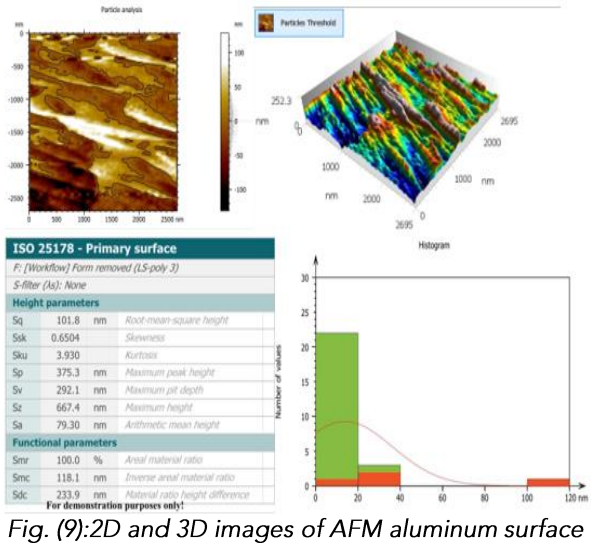

Fig. (9):2D and 3D images of AFM aluminum surface immersed in (0.2M NaOH).

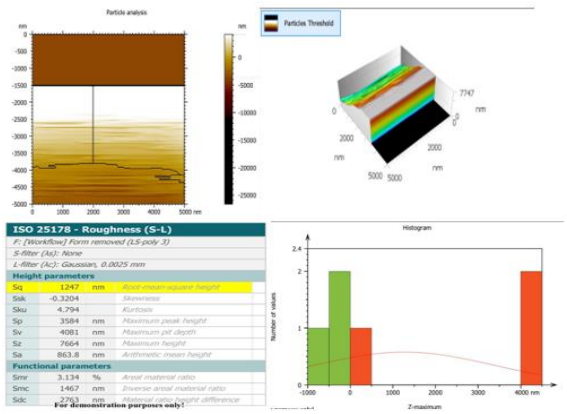

Fig. (10):2D and 3D images of AFM aluminum surface immersed in (0.2M NaOH) presence (275 ppm) of ketoprofen extract.

4. Acknowledgement

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