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RESEARCH ARTICLE

EFFECT OF PANTOPRAZOLE DRUG AND PANTOPRAZOLE EXPIRED DRUG AS A CORROSION INHIBITOR FOR ALUMINIUM IN ACID SOLUTIONS

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ABSTRACT

In different industries organic compounds are used as corrosion inhibitor in acid solution. Organic compounds are highly cost and it may not be economical to use. Organic inhibitors make a thin layer on the metal's surface that may absorb on the cathode or anode surface or both. Decrease corrosion rate. This article discuss about some organic drug that has been used as an inhibitor of corrosion. These drug compounds has been used in two types: drug and expired drug. This method decrease the cost in corrosion field. In this experiment EIS test has been used to major the polarization resistance and the capacity of electrical double layer. The drug has been used with these concentrations 500-100-1500ppm. Drug pantoprazole with the concentration of 1500 ppm was the best inhibitor among other compounds. And it has been observed that the active type of the drug works better as an inhibitor than another type.

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INTRODUCTION

Aluminum and its alloys find extensive application in the industrial constructions. Aluminum being a highly reactive metal, corrodes rapidly in acidic(pH<6) media. Hence it has to be protected when it is likely to come in contact with acidic solutions during cleaning or acid pickling. HCl solutions are used for pickling, chemical and electrochemical etching of aluminum (Safak *et al*., 2012). The corrosion inhibition of aluminum in acidic solutions is based on organic compounds containing nitrogen, oxygen, sulfur atoms and multiple bonds in the molecules that facilitate adsorption on the aluminum surface (Khaled and Al-Qahtani, 2008). The inhibition efficiency of organic compounds is related to their adsorption properties. The use of an organic or inorganic corrosion inhibitor is one of the most useful ways to prevent metal dissolution. Adsorption depends on the nature and the state of the metal surface, on the type of corrosive medium and on the chemical structure of inhibitor (Branzoi *et al*., 2003). In this study the expired pantoprazole drug was selected as corrosion inhibitor. This compound has similar structures with organic compound and usually is affordable and easily available. The aim of this study is to investigate the inhibition behavior of expired pantpprazole drug on corrosion of aluminum in HCL solution. To study the inhibition efficiency tafel polarization and electrochemical impedance spectroscopy techniques were used.

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Experimental Procedure (Model)

The chemical composition of aluminum alloy that were used as working electrode is shown in Table 1.

Table 1. Chemical composition of aluminum alloy in weight percent

Element	Al	Fe	Si	Cu	Mn	Zn	others
Weight percent	Balance	0.55	0.5	0.015	0.02	0.1	0.06

The pantoprazole with chemical composition of $C_{14}H_9F_2N3O_5$ used as corrosion inhibitor. Fig. 1 shows the chemical structure of pantoprazole.

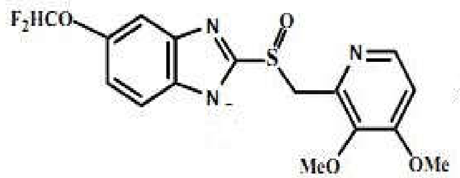

Fig.1. Chemical structure of pantoprazole (Hazzazi and Abdallah, 2013)

The electrode surface was polished with different grades of emery papers up to 600 grades in order to obtain a smooth surface, degreased in acetone, washed by distilled water and dried. Polarization measurements were carried out on aluminum electrode in 1.0 M HCl in presence and absence of different concentration of the inhibitor using solarton162. Measurements were carried out in a three electrode cell. A titanium foil was used as a reference electrode and a platinum foil was selected as an auxiliary electrode. E vs. log I curves were recorded. The corrosion kinetic parameters such as cathodic Tafel slope and anodic Tafel slope were calculated from the linear region from polarization curves. The corrosion current density and corrosion potential were determined from the intersection of the linear parts of cathodic and anodic curves. The inhibition efficiency was calculated from following equation (Hazzazi and Abdallah, 2013):

$$\% \, IE = \left[1 - \frac{I_{add}}{I_{free}} \right] 100$$

Where I_{free} and I_{add} are the corrosion current densities in the absence and presence of inhibitors (Hazzazi and Abdallah, 2013).

Electrochemical EIS measurements were also carried out on aluminum electrode in 1.0 M HCL solution in different concentrations of the inhibitor used at 25 C.

RESULTS AND DISCUSSION

Fig 2 shows nyquist plots for Al in 1.0 M HCl solution without and with different concentrations of pantoprazole drug .The nyquist plot contain depressed semi-circle with the center under the real axis.

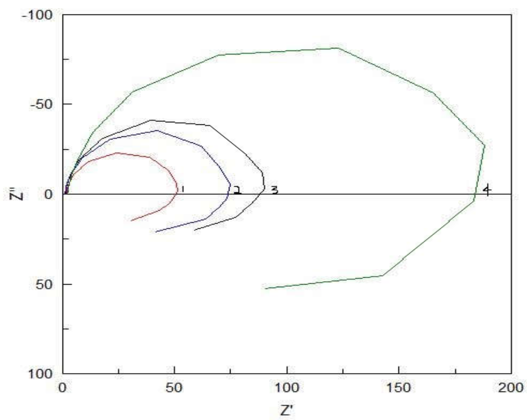

Fig.2. Thenyquist plots for aluminum in 1.0 M HCL solution in different concentrations of pantoprazole drug at 25 C. (1) 0 ppm inhibitor (2) 500 ppm inhibitor (3) 1000 ppm inhibitor (4) 1500 ppm inhibitor

Table 2. EIS parameters obtained by fitting the Nyquist plots shown in Fig. 2

Inhibitor concentration (ppm)	Rct (Ω cm^2)	Inhibitor efficiency
0	53	-
500	86	38.37
1000	119	55.46
1500	174	69.54

$$\% \, IE = \left[\frac{(1/R_{ct})_0 - (1/R_{ct})}{(1/R_{ct})_0} \right] 100$$

Where (Rct)0 , (Rct) are the uninhibited and inhibited charge transfer resistance (Hazzazi and Abdallah, 2013).

According to Fig. 2, inhibitor with 1500 ppm concentration has the best efficiency in compare with other concentrations. The reason for increased efficiency is in increasing the adsorption of inhibitor in surface of aluminum.

Fig. 3 shows nyquist plot for Al in 1.0 M HCl solution with different concentrations of pantoprazole expired drug.

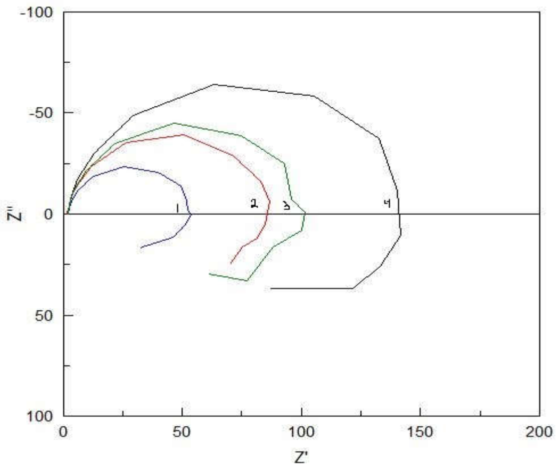

Fig.3. The nyquist plots for aluminum in 1.0 M HCL solution in different concentrations of pantoprazole drug at 25 C. (1) 0 ppm inhibitor (2) 500 ppm inhibitor (3) 100 ppm inhibitor (4) 1500 ppm inhibitor

Table 3. EIS parameters obtained by fitting the Nyquist plots shown in Fig. 3

Inhibitor concentration (ppm)	Rct (Ω cm^2)	Inhibitor efficiency %
0	53	-
500	74	29.33
1000	92	42.39
1500	134	59

$$\% \, IE = \left[\frac{(1/R_{ct})_0 - (1/R_{ct})}{(1/R_{ct})_0} \right] 100$$

Where $(R_{ct})_0$, (R_{ct}) are the uninhibited and inhibited charge transfer resistance.

In Fig. 3.inhibitor with 1500 ppm concentration has the best efficiency in compare with other concentrations. In constant inhibitor concentration the inhibition efficiency of expired drug compared with non- expired drug were less. Fig. 4 shows potentiodynamic polarization curves for Al in 1.0 M HCl solution with different concentrations of pantoprazole drug at 25 C.Inspection of Table4 reveals that the value of β_a ,β_c were changed with addition of pantoprazole expired drug. This indicates that, this compound affects both anodic dissolution and hydrogen evolution reaction (Hazzazi and Abdallah, 2013).With the increase of pantoprazole concentration corrosion inhibition efficiency was increased. Corrosion potential in solution contains pantoprazole was less than the solution without pantoprazole.

Table 4. Corrosion parameters obtained from potentiodynamic polarization techniques shown in Fig. 4

Inhibitor concentration ppm	β_A m V dec^{-1}	β_c m V dec^{-1}	$-E_{corr}$ m V .(SCE)	I_{corr} mA cm^{-2}	%I E
0	-136	383	1234	7.41	-
500	-122	130	510	4.86	**34.41**
1000	-227	145	952	3.91	**47.23**
1500	-49	105	862	2.14	**71.2**

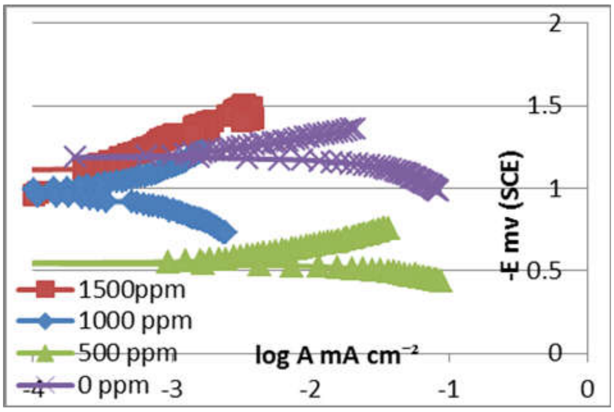

Fig. 4. Potentiodynamicpolarization curves forAl in 1.0 M HCl solution with different concentrations of pantoprazole drug at 25 C

Fig .5, potentiodynamic polarization curves for Al in 1.0 M HCl solution without and with different concentrations of pantoprazole expired drug at 25 C

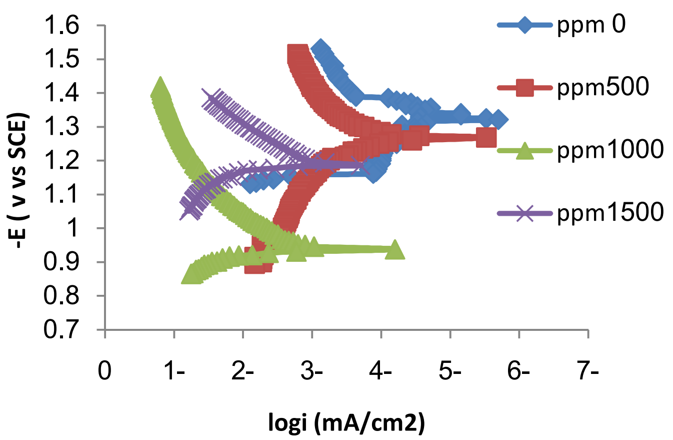

Fig.5.Potentiodynamic polarization curves for Al in 1.0 M HCl solution without and with different concentration of pantoprazoleexpired drug at 25 c.

Inspection of Table 5 reveals that the value of β_a ,β_c were changed with addition of pantoprazole expired drug. This indicates that, this compound affects both anodic dissolution and hydrogen evolution reaction.

With the increase of expired pantoprazole concentration corrosion inhibition efficiency was increased. Corrosion potential in solution contains expired pantoprazole was less than the solution without expired pantoprazole. Basic information on the interaction between the surface of aluminum and inhibitor can be determined from several adsorption isotherms.

Table 5. Corrosion parameters obtained from potentiodynamic polarization techniques shown in Fig. 5

Inhibitor concentration ppm	β_A m V dec^{-1}	β_c m V dec^{-1}	$-E_{corr}$ m V .(SCE)	I_{corr} mA cm^{-2}	%I E
0	-127	383	1234	7.41	-
500	-190	182	1098	5.17	**30.23**
1000	-488	120	1020	4.52	**39**
1500	-49	105	862	3.64	**50.87**

Adsorption isotherms with are commonly used are Temkin, Frumkin, Langmuir and Flory-Huggins isotherm. The degree of surface coverage for different concentration of inhibitor can be evaluated. The data were plotted on a curve to determine suitable adsorption isotherm. The curve parameters are C/Ө and C, an straight line with a coefficient is almost equal to 1.0. Indicating that adsorption of the inhibitor on the aluminum surface obey the Langmuir adsorption isotherm. According to the Langmuir isotherm, the surface coverage is related to inhibitor concentration by equation (Li*et al.*, 2008):

$$\frac{C_{inh}}{\theta} = \frac{1}{K_{ads}} + C_{inh}$$

Where,

K_{ads}=the adsorption equilibrium constant.

K_{ads} is related to the standard free energy of adsorption by equation:

$$K_{ads} = \frac{1}{C_{solvent}} \exp\left(-\frac{\Delta G^{o}_{ads}}{RT}\right)$$

Where,

$C_{solvent}$= molar concentration of solvent

R= the gas constant

T= the absolute temperature

Generally, the value of G $_{ads}$ up to -20Kj.mol^{-1} suggests electrostatic interactions between the charge molecules inhibitor and the charge metal. On the contrary, the value of G $_{ads}$ above -40kj.mol^{-1}, involve charge sharing or transfer from the inhibitor molecules to the metal surface to form a coordinate bond (Karakus *et al.*, 2005).

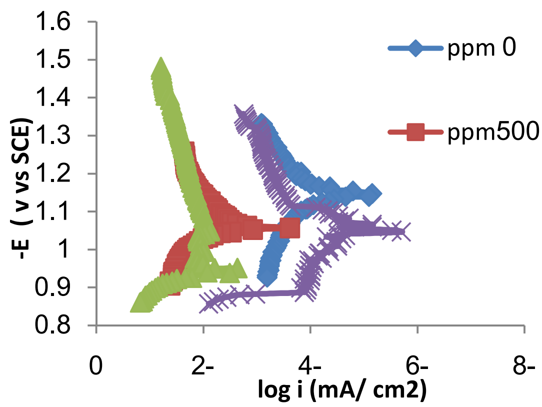

Fig. 6. Langmuir adsorption isotherm of aluminum surface in 1.0 M HCl at different concentrations of pantoprazole drug at 25 C

Table 5. Thermodynamic parameters for the adsorption of pantoprazole drug and pantoprazole expired drug on aluminum in 1.0 M HCl at 25 C

Type of drug	K_{ads}(M^{-1})	- G_{ads} (KJ mol^{-1})
Pantoprazole drug	0.00003	35.75
Pantoprazole expired drug	0.00005	34.49

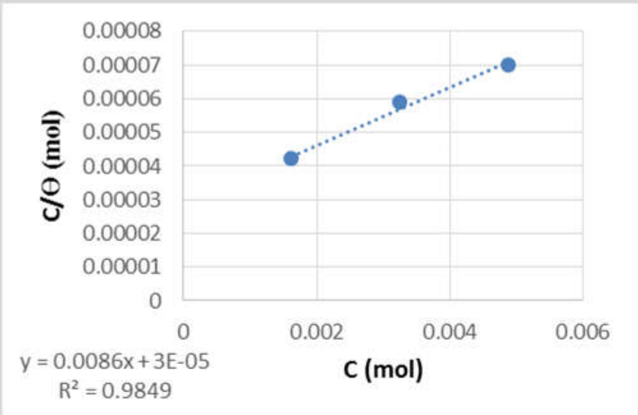

Fig. 6. Langmuir adsorption isotherm of aluminum surface in 1.0 M HCl at different concentrations of pantoprazole drug at 25 C

Fig.7. Langmuir adsorption isotherm of aluminum surface in 1.0 M HCl at different concentrations of pantoprazole drug at 25 C

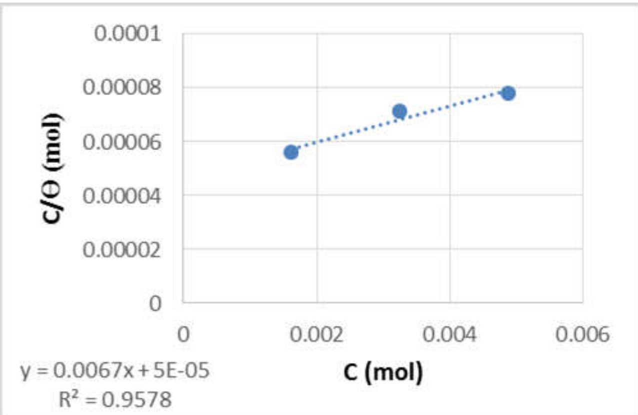

Fig.7. Langmuir adsorption isotherm of aluminum surface in 1.0 M HCl at different concentrations of pantoprazole expired drug at 25 C

In our measurements, the calculated G_{ads} at 25 C for pantoprazole drug is -35.75 KJ mol^{-1} and G_{ads} for pantoprazole expired drug is -34.49 KJ mol^{-1}, which suggests the adsorption of inhibitors on the aluminum surface involves both physical and chemical process. The adsorption of pantoprazole on aluminum surface is more than expired pantoprazole because pantoprazole has lower G_{ads}.

Conclusion

Based on this study the following conclusion can be drawn:

1- Both pantoprazole and expired pantoprazole can inhibit the corrosion of aluminum in HCl 1.0 M solution
2- The best inhibition efficiency of the investigated compounds was for pantoprazole drug with 1500 ppm concentration.
3- The inhibition efficiency of expired drug is less than non-expired drug.
4- Both pantoprazole and expired v on the aluminum surface obeys the Langmuir adsorption isotherm.
5- The adsorption of pantoprazole drug and pantoprazole expired drug on the aluminum surface involves both physical and chemical process.

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