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Study of some drugs as corrosion inhibitors for mild steel in 1M H_2SO_4 solution

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Abstract

This work is focusing on some drugs (Amoxicillin, Cefixim and Cephalexin) to use as corrosion inhibitors for the mild steel in 1M H_2SO_4 aqueous solution. Weighting loss measurements were used for 24 hours at 30^{o}C. The results of corrosion process showed that higher inhibition efficiency values of these drugs have obtained with the highest concentration. The increasing of inhibitor concentration was accompanied with corrosion rate to be decreased, inhibition efficiencies increased and surface coverage degree increased. The adsorption free energy values were predicted physisorption effect for (Amoxicillin, Cefixim and Cephalexin) which explained the interaction nature between the organic molecule as corrosion inhibitors and metal surface.

Keywords: Corrosion, mild steel, inhibition efficiency, physisorption.

1. Introduction

The use of various inhibitors substances is one of the most universal and economical measures to combat corrosion of metals [1 – 2]..Acidic conditions were applied in many industrial methods and processing, such as industrial metal cleaning and treating, chemical descaler, and the oil and gas *industry*[3–5]. An organic corrosion inhibitor is a chemical material that applied to a liquid or gas within industrial processes to decreases the corrosion rate of a metal or it alloy[6]. The organic compounds that are containing atoms with lone pair of electrons (N, O, S and P) can play important role to prevent or decrease corrosion process of a metal in aqueous acidic solutions [7]. The drugs were studied as corrosion inhibitors [8-10]. Antibiotic drugs come in a wide variety of molecular weights with carboxylic or heterocyclic systems making many of them suitable for use as corrosion inhibitors [11- 14]. The advantages of corrosion protection of the B-lactam group (largest group of antibacterial agents used in clinical medicine) of antibiotics have attracted too much attention in recent years [15]. . Drugs are not poisonous, Extensive use, harmless effects on environment, so it suggested using instead of the conventional toxic organic inhibitors of corrosion [16].Drugs as inhibitors that can be favorably with green inhibitors of corrosion and that applied as corrosion inhibitors is depended on that drug molecule contained active centers (O, N and S) atoms. In addition, drugs are completely an environmental friend and can be easily prepared and purified [17].

This work,from this some drugs of aims to study the effect (Amoxicillin, Cefixim and Cephalexin) as corrosion inhibitors for the mild steel in 1M H_2SO_4 aqueous solution. Weighting loss method was used for 24 hours at 30^{o}C.

2. Materials and Methods

All chemicals were purchest forrm BDH company and used some drugs (Amoxicillin, Cefixim and Cephalexin) from Arab company for antibiotics Industries (ACAI) is a joint Arab company established in Iraq used without further purifications. FTIR 8300 Fourier transform infrared spectrophotometer of Shimatsu company as a potassium chloride disc in the wave number wave range of (4000-400)cm^{-1}.

2.1. Preparation of aggressive solution

A solution of one molar of sulfuric acid was prepared by dilution of 98% H_2SO_4(analytical grade) with deionized water. Drugs inhibitor concentrations are (0.0005-0.01M) were prepared by using 1M H_2SO_4 solution at 30^{o}C.

2.2. Weight loss measurements

The mild steel used has the composition percentages (0.002% P, 0.288% Mn, 0.03% C, 0.0154% S, 0.0199% Cr, 0.002% Mo, 0.065% Cu, 0.0005% V, and the remainder iron). The mild steel had a disc shape with diameter (2.5 cm). These disc shapes were polished with emery to get very smooth surface. Then they were washed with absolute ethanol and acetone. The treated specimens were kept in a moisture-free desiccator. The specimen of mild steel was initially weighed by a sensitive balance. After that the specimens were hanged and completely submerged in glass beaker containing 1M sulphuric acid with and without of drugs. The specimens were taken away after 24 hours as exposure time at 30ºC, rinsed with water to eject any products of corrosion and finally rinsed with acetone, dried and reweighed. Mass loss measurements were carried out using ASTM method described previously [18,19] the tests were applied in duplicate to confirm the reliability of the obtained data and the mean value of the weight loss is recorded. Weight loss gave calculation of the corrosion rate in (mg cm^{-2} h^{-1}). The corrosion rate(W) of mild steel was Represent by using the relationship [20].

$$W = \frac{\Delta m}{st} \qquad (1)$$

Where (Δm) is the mass loss, (s) the area and (t) is the submerged time. The percentage inhibition efficiency [IE (%)] was listed using the relationship [21]:

$$IE\% = \left(\frac{W_{corr} - W_{corr(inh)}}{W_{corr}}\right) \times 100 \quad (2)$$

Where W_{corr} and $W_{corr\ (inh)}$ are the corrosion rates of mild steel in the absence and presence of inhibitor, respectively.

3. Results and Discussion

The FT-IR spectra were confirmed the structure formation of Amoxicillin, Cefixim and Cephalexin (Figures 1-3), respectively. All drugs showed of stretching (C=O) band from (1772- 1755 cm^{-1}) Amoxicillin, Cefixim and Cephalexin, respectively. The FT-IR spectral data and physical properties of antibiotic compounds (Amoxicillin, Cefixim and Cephalexin) are summarized in the Table (1).

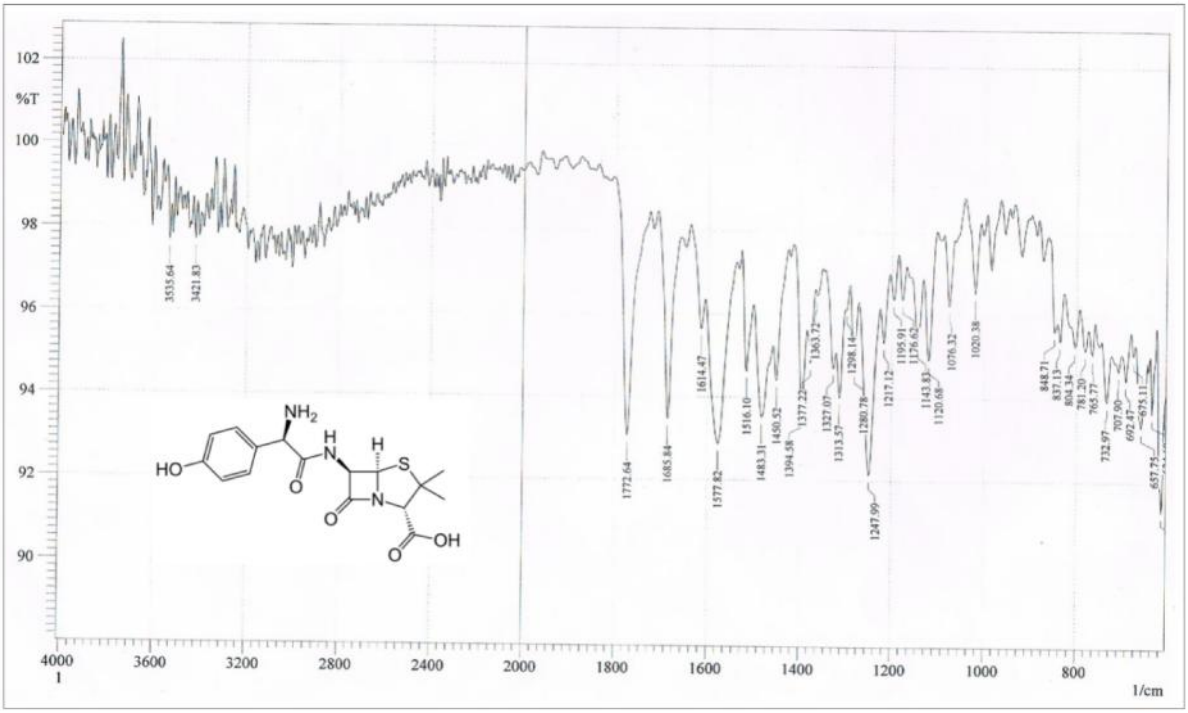

Figure 1: FTIR spectrum of compound (Amoxicillin)

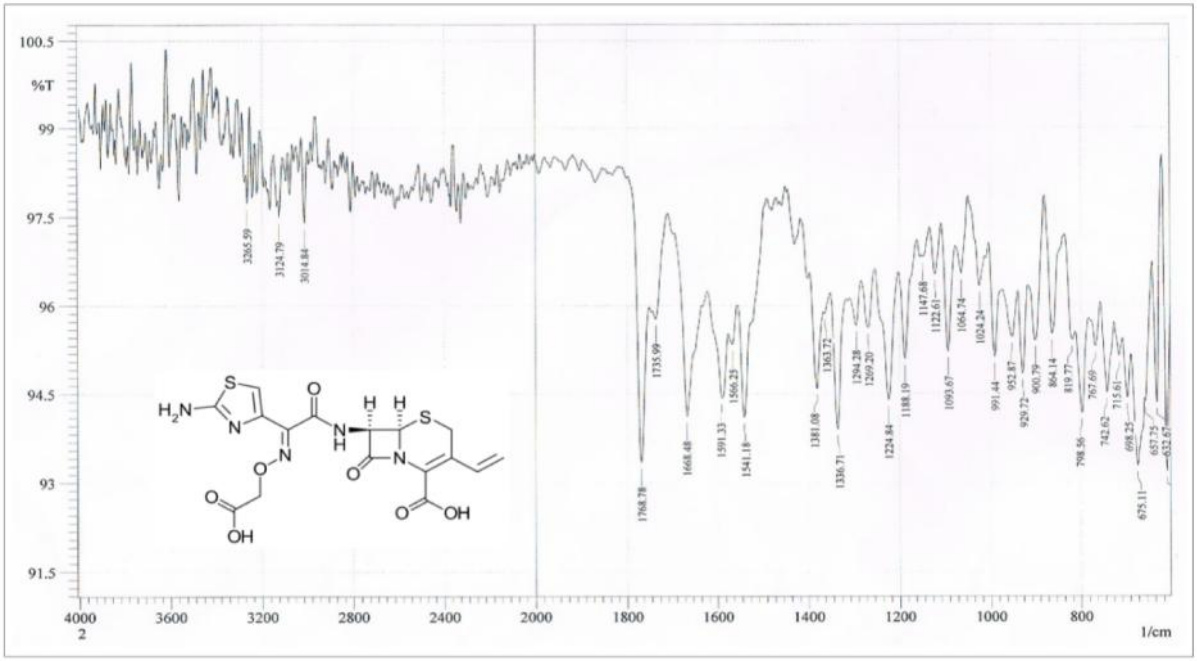

Figure 2: FTIR spectrum of compound (Cefixim)

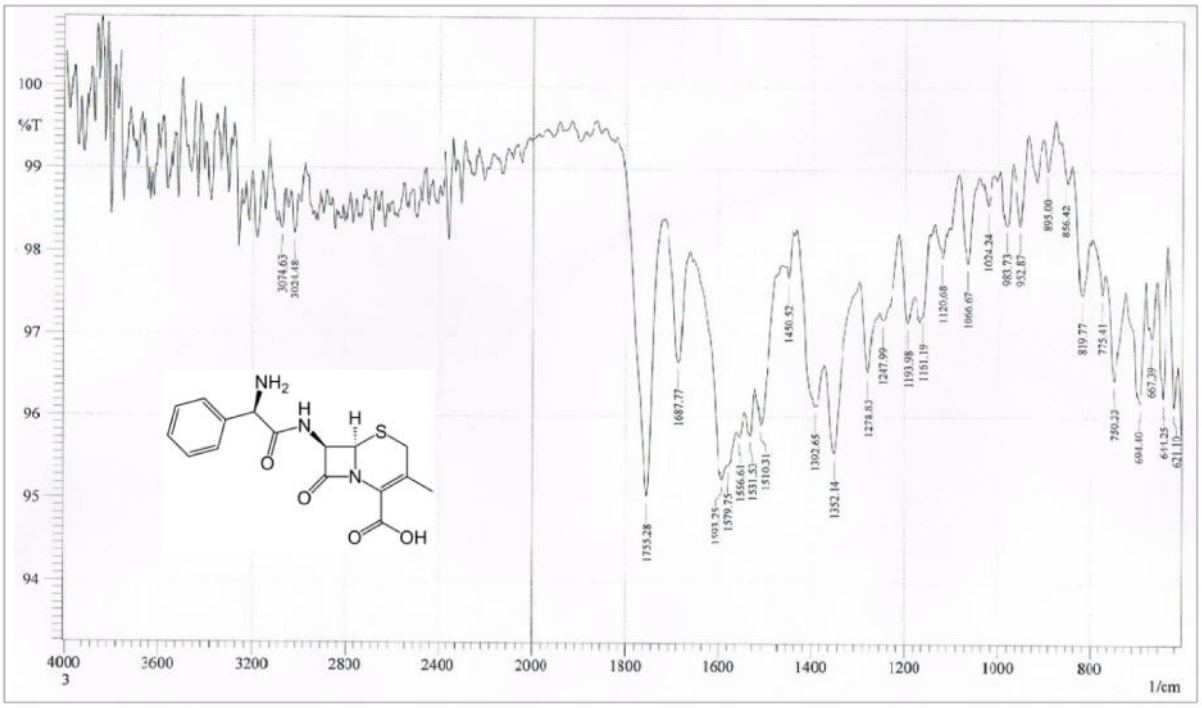

Figure 3: FTIR spectrum of compound (Cephalexin)

Table (1): Physical and analytical data of the antibiotics compounds

Drug	Chemical formula	Color	M.W (g/mol)	M.P.°C	FT –IR (cm^{-1},stretching)
Amoxicillin	$C_{16}H_{19}N_3O_5S$	White	365.40	194-196	Aromatic (C-H)3050, Aromatic (C=C)1557, Carboxylic acid (C=O)1772, Aliphatic (C-H)2890, Amine(N-H)3350, Amide(C=O) 1685, O-H (2800), -COOH(1772)
Cefixim	$C_{16}H_{15}N_5O_7S_2 .3H_2O$	White	507.50	218-220	Aromatic (C-H)3100, Aliphatic (C-H)2900, Amine(N-H)3400, Amide(C=O) 1685, Imin(N=CH)1668, O-H (2700), -COOH(1768), Alkenes(=CH)3014
Cephalexin	$C_{16}H_{17}N_3O_4S$	White	347.38	326-328	Aromatic (C-H)3100, Aliphatic (C-H)2950, Amine(N-H)3350, Amide(C=O) 1687, O-H (2800), Carboxylic acid C=O (1755), Alkenes(C=C)1610

The results of corrosion rate and inhibition efficiency that obtained from weight loss measurements with different concentrations of suggested inhibitors (Amoxicillin, Cefixim and Cephalexin) after 24 hours immersion at 30°C are summarized in Table (2).Table (2) indicates that the corrosion efficiency increases with increasing the inhibitors concentration of all drugs and the maximum inhibition efficiencies were achieved at higher concentration. The comparative study of experimental data reveals that the order of inhibition efficiency can be arranged: Cefixim> Cephalexin >Amoxicillin. The variety of inhibition efficiency of drugs (Amoxicillin, Cefixim and Cephalexin) is due to the variety of the molecular structure and atomic active centers of suggested drugs [22]. The reducing rate of corrosion by using different drug concentrations could be explained by formation a protective barrier by molecules of drugs on the metal surface [23].

The adsorption isotherms are useful calculation to elucidate thethe nature of interaction among the organic molecules and surface of metals. Therefor ,, the degree of surface coverage values (θ) at different drugs concentrations in 1M H_2SO_4 was achieved by using weight loss method (θ = E (%)/100) (see Table 2) at 30°C and determinded with Langmuir isotherm relationship (3):

$$C/\theta = 1/K_{ads} + C \qquad (3)$$

Where K_{ads} is the equilibrium constant of the adsorption process.

With related to the Langmuir isotherm, K_{ads} values can be account from the intercepts of the straight line of plotting C/θ versus C (see Fig. 5). K_{ads} is known as standard free energy of adsorption (ΔG^{o}_{ads}), as showing in the equation (4):

$$K_{ads} = \frac{1}{55.5} exp\left(\frac{-\Delta G^{\circ}_{ads}}{RT}\right) \qquad (4)$$

Where the value (55.5) is the molar concentration of water in the solution in molar unit).

Table (2): Corrosion rate, inhibition efficiency,surface coverage (θ) and standard free energy of adsorption for mild in (1M H_2SO_4) by using weight loss measurements during the time of 24 hours.

Inhibitor concentration (M)	1 M H_2SO_4				
	M(g)Δ	Corrosion rate (mg cm^{-2} h^{-1})	E%	θ	G^{o}_{ads}Δ (kJ /mol)
Uninhibited	0.1795	1.5230			
Amoxicillin					
0.00005	0.1218	1.0335	32.01	0.3214	-33.303 R^2=0.9964
0.0001	0.0942	0.7993	47.52	0.4752	
0.0005	0.0835	0.7085	53.48	0.5348	
0.001	0.0701	0.5948	60.95	0.6095	
Cefixim					
0.00005	0.0982	0.8332	45.29	0.4529	-33.697 R^2= 0.9972
0.0001	0.0805	0.6830	55.15	0.4529	
0.0005	0.0512	0.4344	71.47	0.7147	
0.001	0.0358	0.3038	80.06	0.8006	
Cephalexin					
0.00005	0.0882	0.7480	45.29	0.4529	-33.697 R^2=0.9992
0.0001	0.0721	0.6117	59.83	0.5983	
0.0005	0.0658	0.5583	63.34	0.6334	
0.001	0.0414	0.5313	76.94	0.7694	

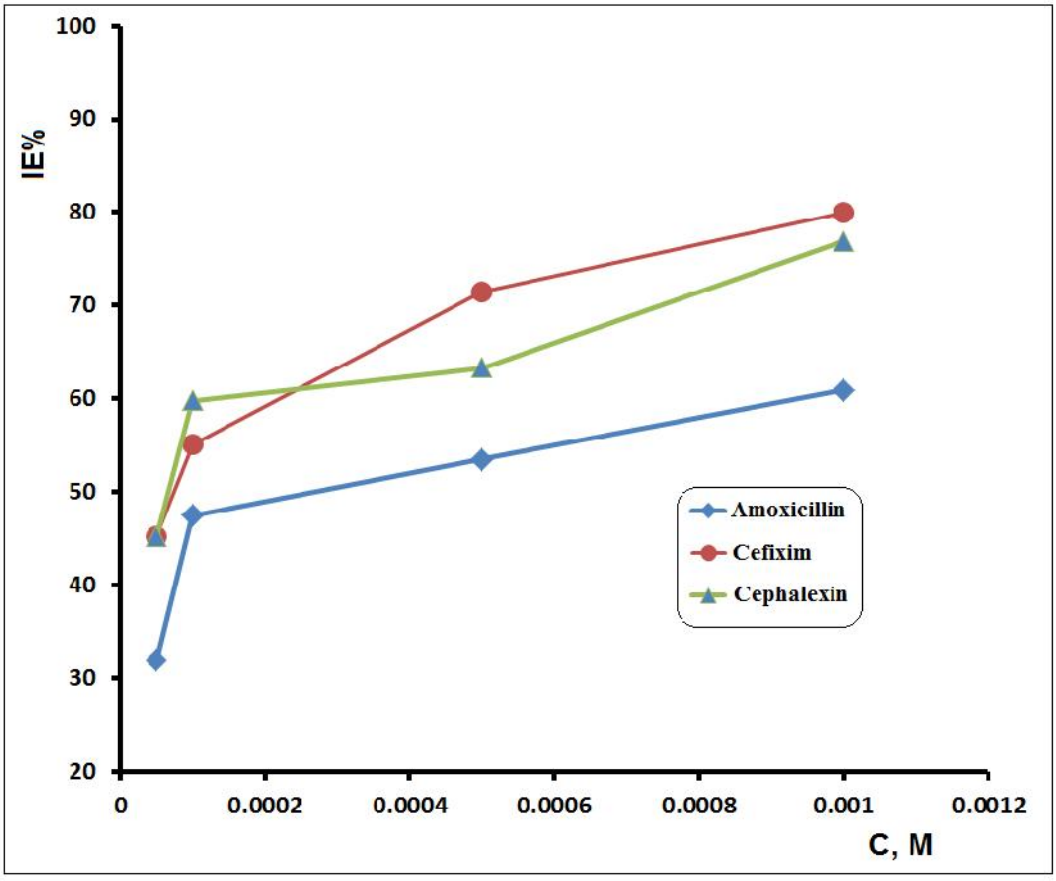

Figure 4: Effect of inhibitor concentration on the efficiencies of mild steel obtained at 30°C in 1M H_2SO_4 containing different concentrations of drugs after 24 hours immersion.

As shown in Table 2, the values of (ΔG^{o}_{ads})are negative to point out that the adsorption processes of all suggested inhibitors(Amoxicillin, Cefixim and Cephalexin)were spontaneous processes with the surface of mild steel after 24 hours immersion at 30^{o}C.It's clear that kind of interaction between drug molecules and metal surface. The nature of interaction attributed to adsorbed drug molecules to the surface of metal by sharing electrons with that of the surface atoms of metal which causes physisorption for (Amoxicillin, Cefixim and Cephalexin)[24,25].

The mechanism organic corrosion inhibition depends on the formation of mono protective layer on the metal surface [26].

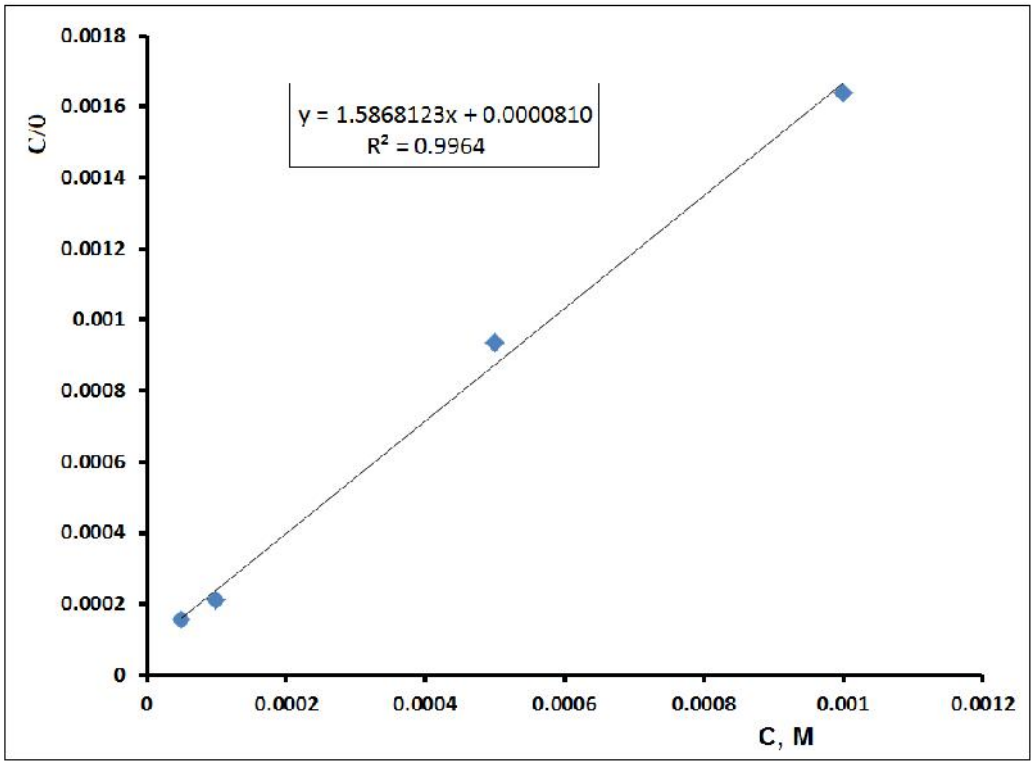

Figure 5: Langmuir adsorption isotherm plot for mild steel in 1M H_2SO_4 solution in the presence of various concentrations of inhibitor (Amoxicillin).

4. Conclusion

All suggested inhibitors(Amoxicillin, Cefixim and Cephalexin)were achieved successfully as corrosion inhibitors for the mild steel surface in 1M H_2SO_4 solution at 30^{o}C for 24 hours. The data of inhibitive efficiency (IE %) which obtained by using weight loss method were showed inhibitive effects of suggested inhibitors. The values free energy of adsorption showed physisorption effect for (Amoxicillin, Cefixim and Cephalexin) and provide dinteresting information to elucidate the nature of interaction between organic molecule and the metal surface.

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