

Synthesis , Identification and Study of Some New Schiff Bases as Inhibitors for Brass Corrosion and Bacterial Growth

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Abstract

Three Schiff bases were synthesized namely (4-dimethyl amino benzaldene – 3-amino benzoic acid) , (piperonaldehyde – 4-amino – 2-nitro toluene) and (4-dimethyl amino benzaldene - 4-amino – 2-nitro toluene) . These Schiff bases have been identified by microanalysis (CHN) , infrared , ¹H-NMR , ¹³C-NMR and GC-Mass spectroscopy . The study also included the use of these Schiff bases as inhibitors for corrosion of brass in acidic media (0.5 M HCl) . The rate of corrosion was determined by two methods (electrochemical and weight loss methods) . It was found agreement between them . Different studies such as ; the effect of temperature on the corrosion rate at (298 °K , 308 °K and 318 °K) , measurement of some thermodynamic parameters (corrosion current , activation energy and free energy) , and comparison of inhibition effect for prepared Schiff bases with their primary amines were achieved . The results indicated that these Schiff bases inhibited the corrosion efficiently . Furthermore , antibacterial activity of prepared Schiff bases and standard inhibitor (AK3) was also studied on the two types of bacteria ,Staphylococcus aureus and Escherichia coli . It was found that the Schiff bases under study were considered inhibitors for bacterial growth with variation extents .

Key words : Schiff bases , Corrosion inhibitors , Brass , Antibacterial activity

Introduction

Compounds containing an azomethine group (-CH=N-) are known as schiff bases . They are usually formed by condensation of a primary amine with a carbonyl compound [1] . Schiff bases of aromatic aldehydes having an effective conjugated system , are more stable while those of aliphatic aldehydes are relatively unstable and are readily polymerizable [2-6] . In chemistry , schiff bases find a versatile use [7,8] ; some of them are the basic units in certain dyes , whereas , some are used as liquid crystals . In organic synthesis , schiff bases reactions are useful in making carbon – nitrogen bonds . Schiff bases appear to be important intermediates in number of enzymatic reactions involving interaction of an enzyme with an amino or carbonyl group of the substrate [9] . Stereo chemical investigations [10] carried out with the aid of molecular models showed that schiff bases formed between methylglyoxal and the amino groups of the lysine side chains of proteins can bend back

in such a way towards the N atoms of peptide groups that a charge transfer can occur between these groups and the oxygen atom of the schiff bases .

On the other hand , Schiff bases derived from furyl glyoxal and p-toluidine show antibacterial activity against Escherichia coli , Staphylococcus aureus , Bacillus subtilis and Proteus vulgaris [11,12] . Thiazole and benzothiazole Schiff bases [13] possess effective antifungal activity against Candida albicans and Trichophyton rubrum . Schiff bases [11] derived from sulfane thiazole and salicylaldehyde and their complexes show toxicities against insects . Several Schiff bases possess anti-inflammatory allergic inhibitors reducing activity [14] , radical scavenging [14] , analgesic and anti-oxidative action [15] .

An interesting application of schiff bases is their use as an effective corrosion inhibitor , which is based on their ability to spontaneously

form a monolayer on the surface to be protected . Many compounds have been studied in acidic or basic solutions aiming obtain corrosion protection of Al , Cu , and stainless steel [16-19] . Some commercial inhibitors include aldehydes or amines , but presumably due to the C=N bond the schiff bases function more efficiently in many cases [20]. The principal interaction between the inhibitor and the metal surface is chemisorption [21]. The inhibitor molecule should have centers capable of forming bonds with the metal surface by electron transfer . In such cases the metal acts as an electrophile and the inhibitor acts as lewis

base . Nucleophilic centers , such as oxygen and nitrogen atoms , of the protective compound have free electron pairs which are readily available for sharing .Together with the atoms of benzene rings they create multiple absorption sites for the inhibitor thus enabling stable monolayer formation [22,23] .

The aim of the present study is :

- 1- Synthesis of some new Schiff bases
- 2- Studying efficiency of these Schiff bases in inhibiting brass corrosion at different temperatures in acidic media .
- 3- Study of Schiff bases as antibacterial compounds

Experimental Materials

The chemical composition of the brass alloy used in the present study was 68.75% Cu , 28% Zn , 1% Fe , 1.2% Al and trace amount of (Mg , Si , Pb , As , Ni) . All solvents were

redistilled at least once before using . List of chemicals and reagents used are given in table (1) .

Table (1) : List of chemicals and reagents used in the present study

Chemicals and reagents	Source
Ethanol	Merck
Dimethyl sulfoxide	Merck
Glacial acetic acid	BDH
Hydrochloric acid	Fluka
Piperonal	Fluka
4- dimethyl amino benzaldehyde	Fluka
3- amino benzoic acid	Fluka
4- amino 2- nitro toluene	Fluka
Calcium carbide	Fluka

Instruments

The instruments used in the present study were at different sites as shown in the table (2) .

Table (2) : List of instruments used in the present study

Name	Model	Site
Melting point apparatus	Gallen kamp	University of Basrah – College of Education
Elemental analyzer (C.H.N)	Euro Vector EA 3000 A Italy	University of Al-albait – Jordon
Corrosion rate measurement apparatus	350 A (EG and PARC)	University of Basrah– Science College
Grinding and polishing apparatus	E Comet II (Buehler LTD)	University of Basrah– College of Science
Infrared spectrophotometer	Shimadzu - Japan	Petrochemical company - Basrah
¹ H and ¹³ C-NMR spectrophotometer	Acquisition parameters Sfol 300 MHz	Centre of water researches – University of Al-albait – Jordon
Gas – Chromatograph mass spectrophotometer	QP – 5050 A - Shimadzu - Japan	Centre of water researches – University of Al-albait – Jordon

Methods

Preparation of (4-dimethyl amino benzaldene – 3-amino benzoic acid) (S₁) [24,25]

This schiff base was prepared by adding a 50 cm³ from 4- dimethyl amino benzaldehyde ethanolic solution (0.01 mole ,1.49 gm) to ethanolic solution of 3-amino benzoic acid (50 cm³ , 0.01 mole ,1.37 gm) in the presence of a few drops of glacial acetic acid .The mixture was stirred and refluxed for 2 hours .A clear orange – colored solution was obtained . The

resulting solution was evaporated under vacuum to remove the solvent . The product was collected by filtration ,washed several times with cold ethanol and recrystallized from hot ethanol . This product dried under vacuum and kept in desiccator till further use . The structure and some physical properties of this Schiff base were given in table (3) .

Preparation of (piperonaldehyde – 4-amino – 2-nitro toluene) (S₂) [24,25]

4- amino – 2- nitro toluene (0.01 mole , 1.52 gm) dissolved in ethanol (25 cm³) was mixed with pypironal (0.01 mole , 1.50 gm) dissolved also in ethanol (75 cm³) . A few drops of glacial acetic acid were added , then the mixture was refluxed for 3 hours . A clear pale yellow – colored solution was obtained . The produced

Schiff base was isolated by filterization after evaporation and volume reduction take place .The product was recrystallized by ethanol and then was dried under vacuum and kept in desiccator till further use . The structure and some physical properties of this Schiff base were given in table (3) .

Preparation of (4-dimethyl amino benzaldene - 4-amino – 2-nitro toluene) (S₃) [24,25]

4- amino – 2- nitro toluene (0.01 mole , 1.52 gm) dissolved in ethanol (25 cm³) was mixed with 4- dimethyl amino benzaldehyde (0.01 mole , 1.49 gm) dissolved also in ethanol (75 cm³) . A few drops of glacial acetic acid were added , then the mixture was refluxed for 3 hours . A clear dark yellow – colored solution was obtained . The produced Schiff base was

isolated by filtration after evaporation and volume reduction .The product was recrystallized by ethanol then was dried under vacuum and kept in desiccator till further use . The structure and some physical properties of this Schiff base were given in table (3) .

Table (3) : Some physical properties for prepared Schiff bases

Compound	Chemical structure	Physical state	Color	Milting point (°C)	Yield (%)
S ₁		Powder	Orange	191-193	80
S ₂		Crystal	Pale yellow	118-119	87
S ₃		Crystal	Dark yellow	132-133	84

Preparation of chemical corrosion samples [26]

Brass coupons (samples) were prepared by the following steps :

1- The coupons were catered to different forms (spherical forms with diameter 1 cm , width 2 mm and cylindrical forms with diameter 1.4 cm , high 2.9 cm) . These samples were washed with 10% of hydrochloric acid .

Measurement of corrosion rate

Corrosion rate of brass in 0.5 M HCl as corrosion media was measured using electrochemical method and weight loss method.

Electrochemical method was carried out by corrosion measurement apparatus from tafel plots technique .

Weight loss method was carried out depending the following steps [27] :

1- Preparation of brass coupons as mentioned above .

2- Brass coupons were weighted by sensitive balance before and after corrosion .

3- Surface area was measured for brass samples then placed in 0.5 M HCl at different times (1-4 hours) .

4- The coupons were removed from corrosion media and cleaned .

2- The coupons were softened by silicon carbide paper .

3- The coupons were washed with water and acetone then were polished by grinding apparatus and placed in dissector containing silica gel to prevent moisture .

5- The coupons were dried and weighed .

6- Corrosion rate of these samples was measured by the following equation [28] :

$$CR = W . K / A . d . t$$

Where : CR : Corrosion rate , W : Weight loss (gm) , K : Constant (534)

A : Area of brass species (inch²) , d : Density of brass samples (gm / cm³) , t : Time (hrs)

7- The steps (1-6) retained after adding 0.01 M of inhibitors (prepared Schiff bases) to corrosion media .

8- The steps (1-7) were retained at different temperatures 298 °K , 308 °K and 318 °K .

Result and discussion

Identification of prepared Schiff bases

The Schiff bases under study were isolated and identified by many techniques . The microanalysis is given in table (4) . Infrared , ¹H NMR , ¹³C NMR and Mass spectral data are

given in tables (5-8) and spectra are shown in figures (1-12) .

The obtained data from these techniques confirm the expect chemical structures of these prepared Schiff bases .

Table (4) : Microanalysis data for prepared Schiff bases

Compound	molecular weight (gm/mole)	%C	%H	%N
		Calculated Found	Calculated Found	Calculated Found
S ₁	268	71.64	5.97	10.44
		71.58	5.91	10.30
S ₂	284	63.38	4.22	9.86
		63.29	4.12	9.77
S ₃	283	67.89	6.00	14.84
		67.77	5.89	14.82

Table (5) :Characterized bands in the infrared spectra(cm^{-1}) for prepared Schiff bases

Compound	ν OH	ν CH Arom	ν CH Aliph.	ν C=O	ν C=N	ν C=C	ν C-N	ν C-O
S ₁	3420 br	3080 w	2940 w	1660 m	1590 m	1540 m	1380 m	1185 m
S ₂	-	3090 w	2935 w	-	1650 m	1530 m	1350 m	1050 m
S ₃	-	3070 w	2940 w	-	1600 m	1525 m	1375 m	1170 m

br = broad m = medium s = strong w = weak

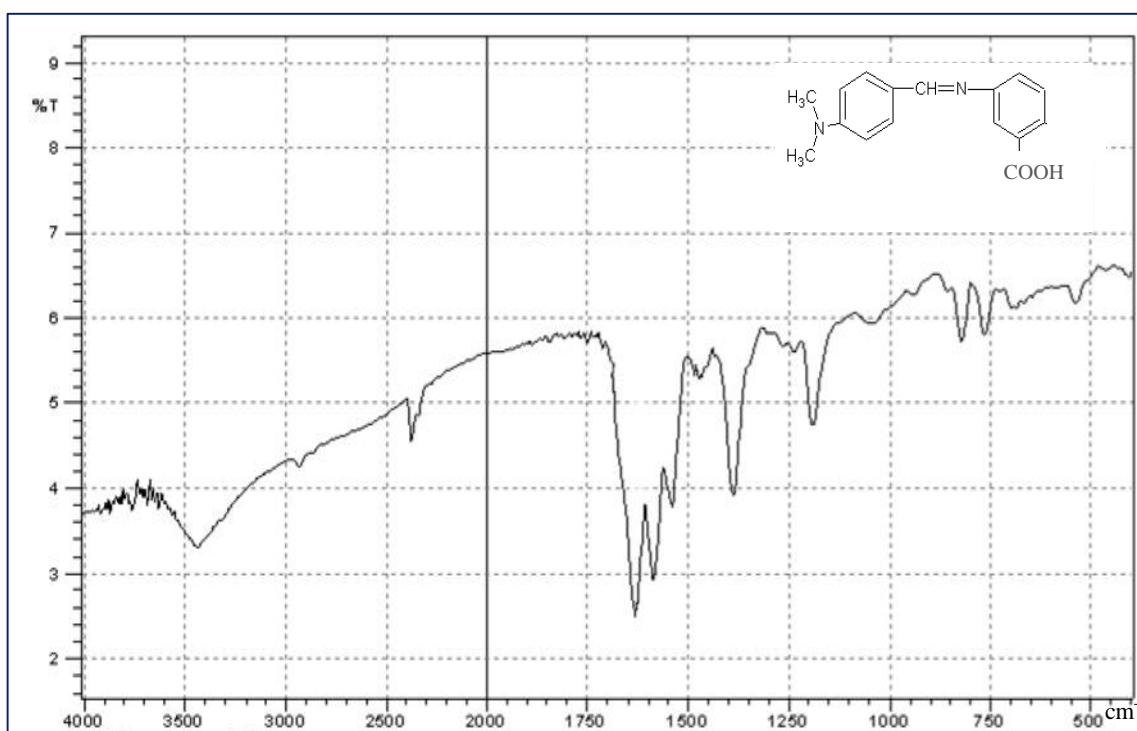


Figure (1) : Infrared spectrum for Schiff base (S₁)

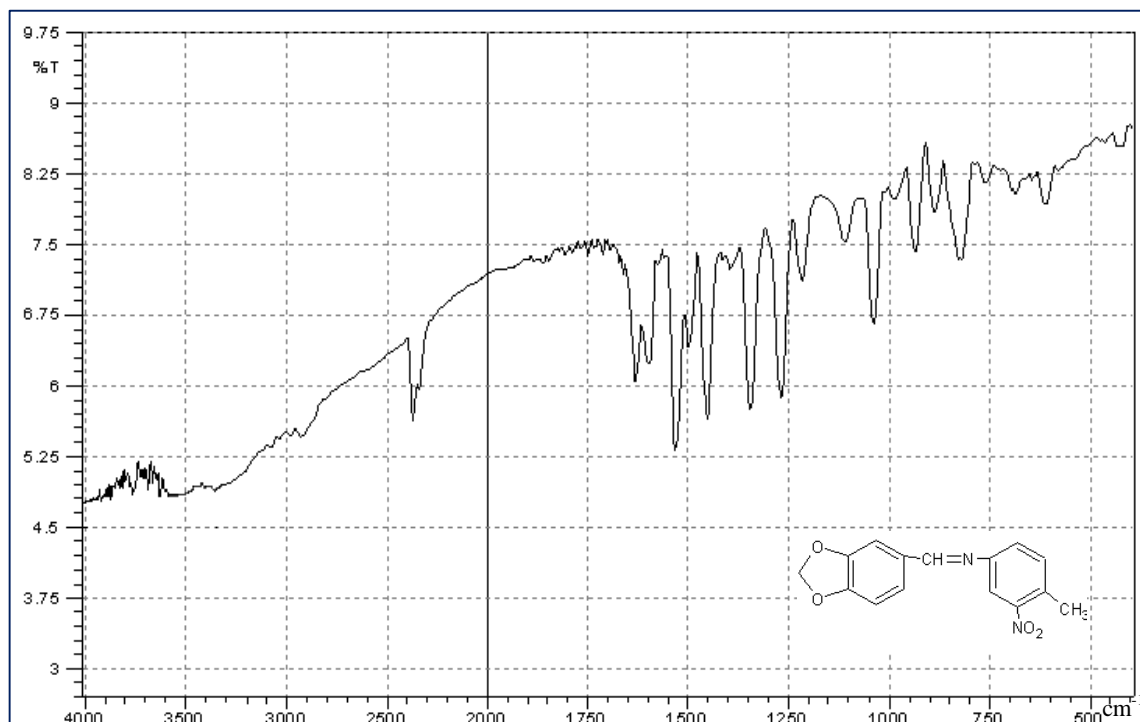


Figure (2) : Infrared spectrum for Schiff base (S₂)

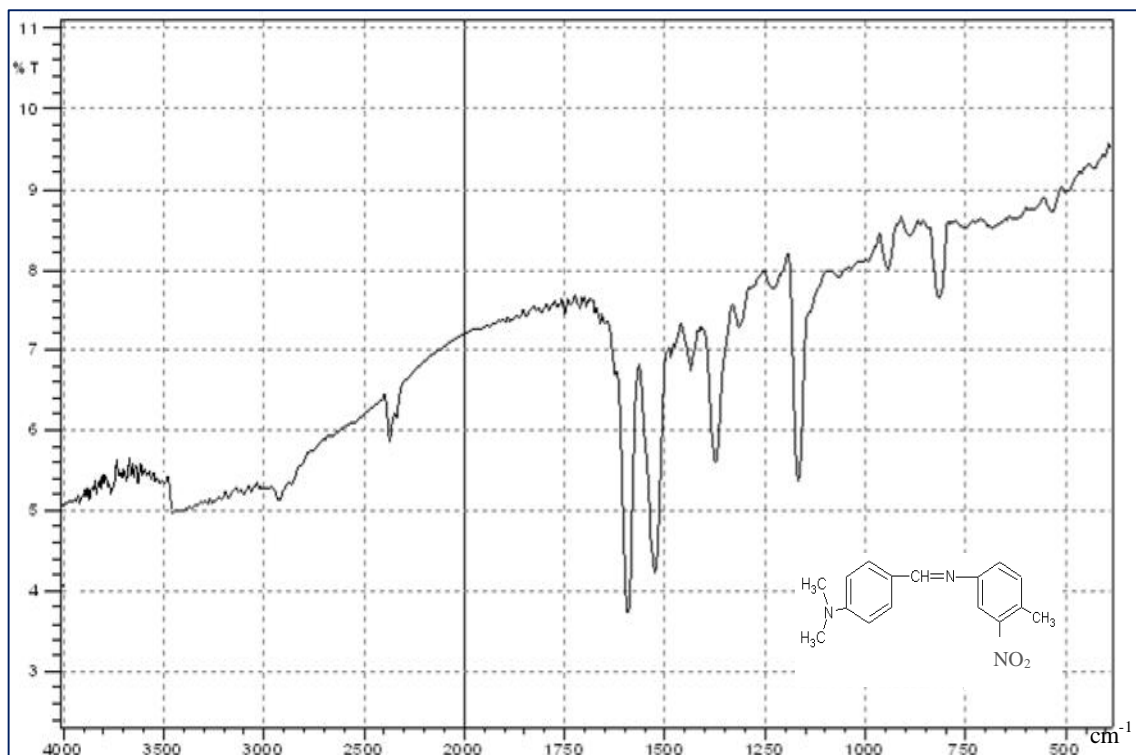
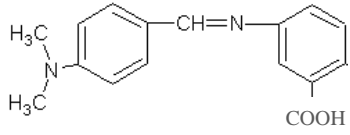
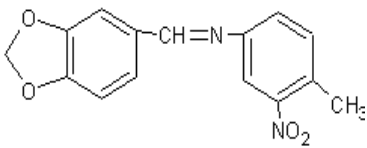
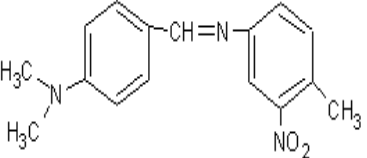


Figure (3) : Infrared spectrum for Schiff base (S₃)

Table (6) : Chemical shifts of ^1H NMR for prepared Schiff bases in d DMSO

Compound	Chemical structure	Chemical shift (δ ppm)
S ₁		3.12 (S , 6H , CH ₃) , 6.57-8.04 (m, 8H, Ar-H) 8.58 (S , 1H , HC=N) 15.62 (S , 1H , OH)
S ₂		3.35 (S , 3H , CH ₃) , 7.06-7.85 (m , 6H , Ar-H) 6.13 (S , 2H , CH ₂) 8.62 (S , 1H , HC=N)
S ₃		3.02 (S , 6H , CH ₃) , 6.77-7.77 (m , 7H , Ar-H) 8.50 (S , 1H , HC=N)

s = singlet , m = multiplet

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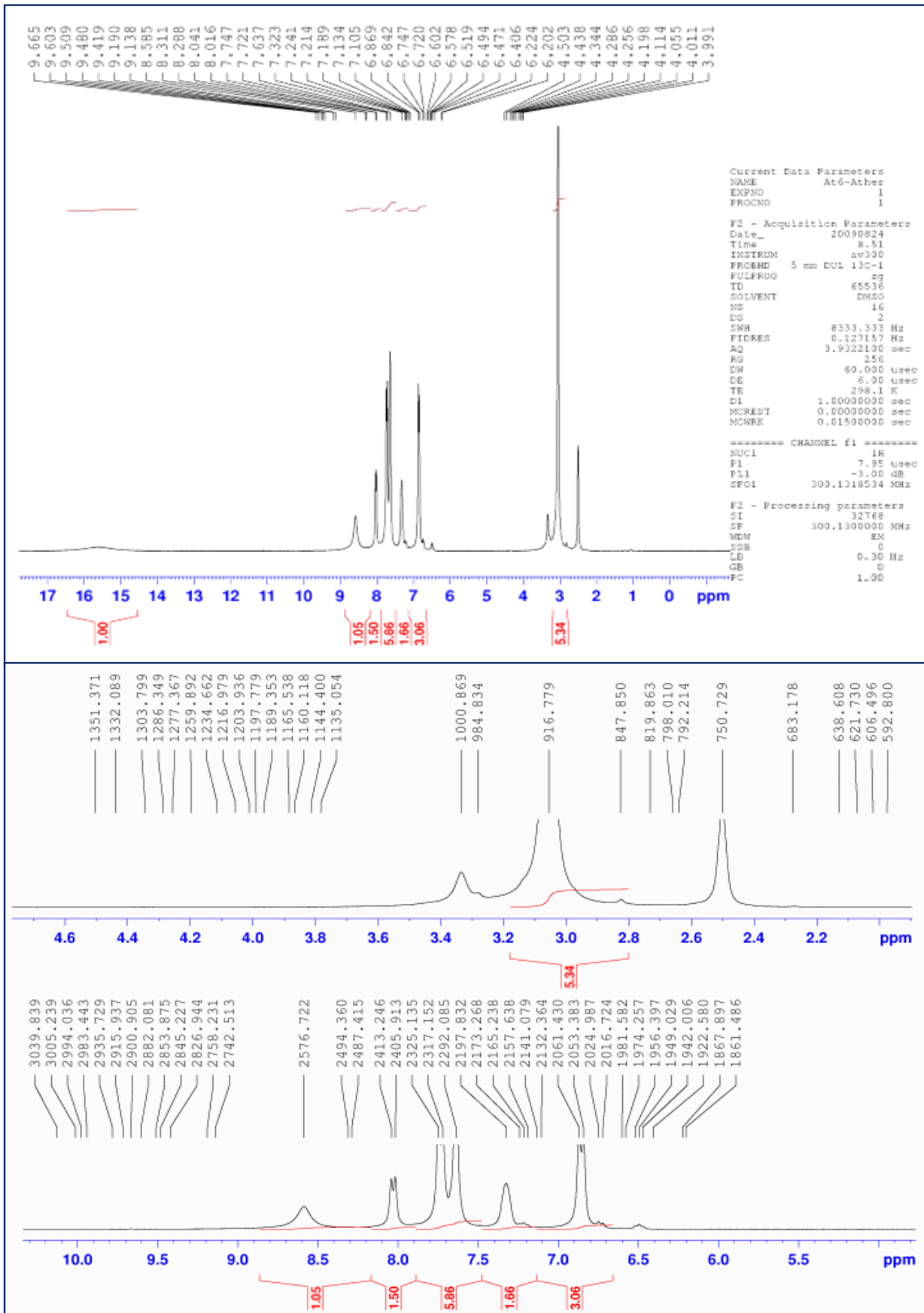


Figure (4) : ¹H NMR spectrum for Schiff base (S₁)

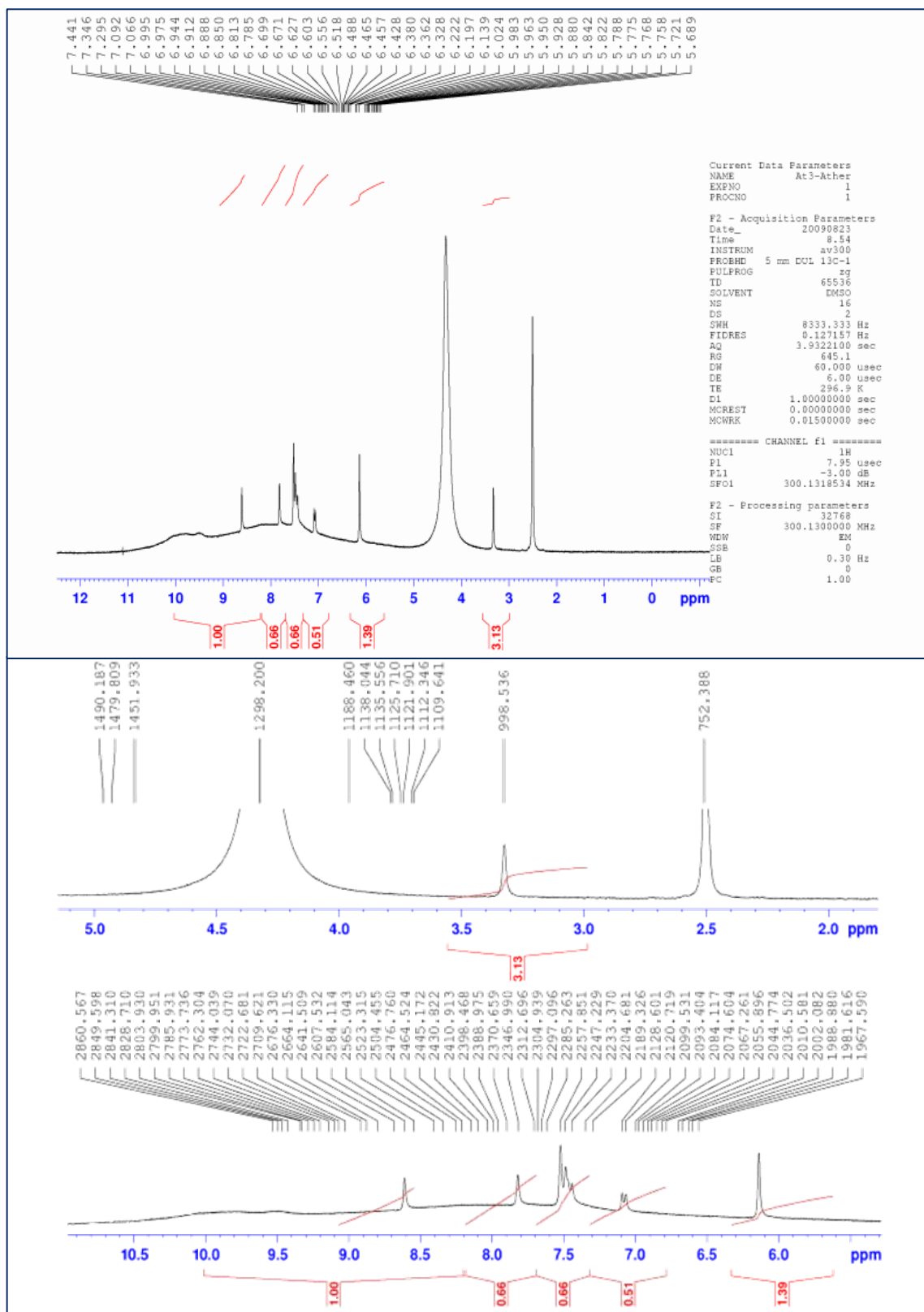


Figure (5) : ^1H NMR spectrum for Schiff base (S_2)

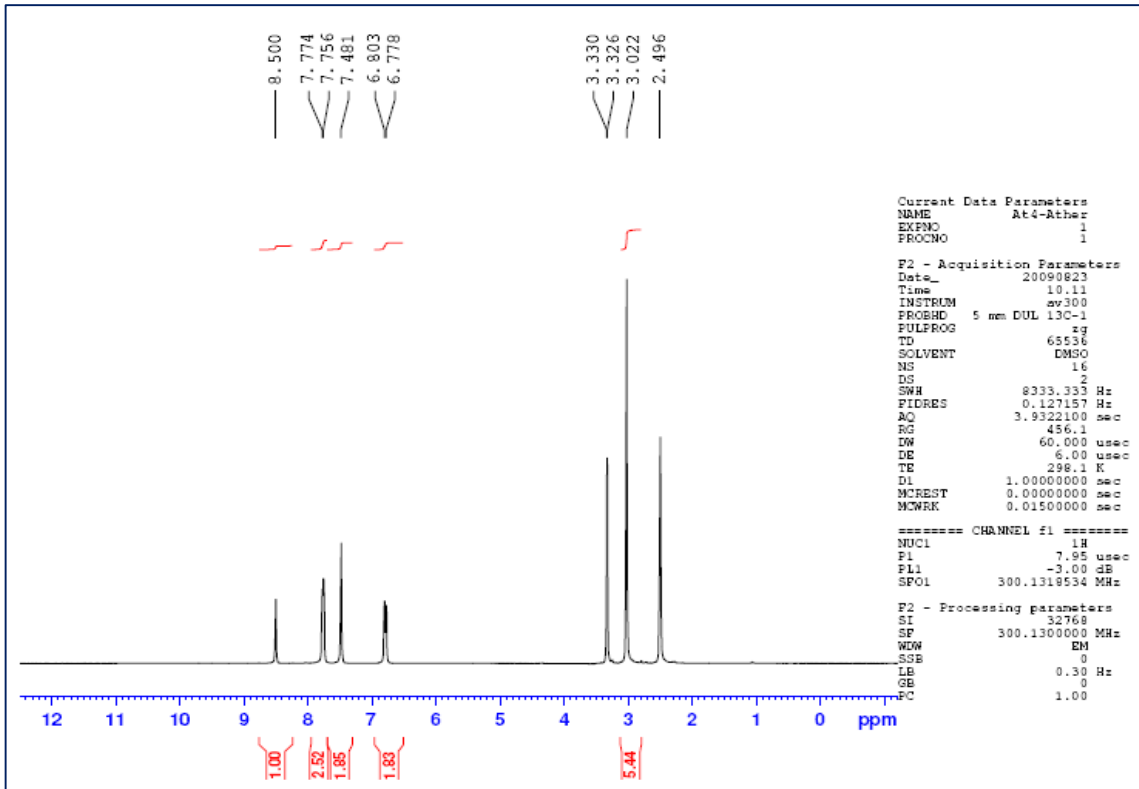
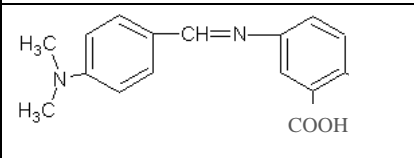
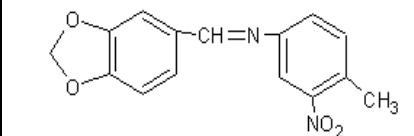
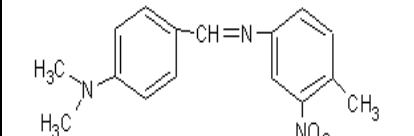


Figure (5) : ¹H NMR spectrum for Schiff base (S₂)

Figure (6) : ¹H NMR spectrum for Schiff base (S₃)

Table (7) : Chemical shifts of ¹³C NMR for prepared Schiff bases in d DMSO

Compound	Chemical structure	Chemical shift (δ ppm)
S ₁		40 (2C , CH ₃) , 111.88 – 151.54 (12C , Ar-C) 162.26 (1C , HC=N)
S ₂		102.15 (1C , CH ₂) 106.75-151.96 (12C , Ar-C) 170.03 (1C , HC=N)
S ₃		40 (2C , CH ₃) , 112.29 – 154.04 (12C ,Ar-C) 167.36 (1C , HC=N)

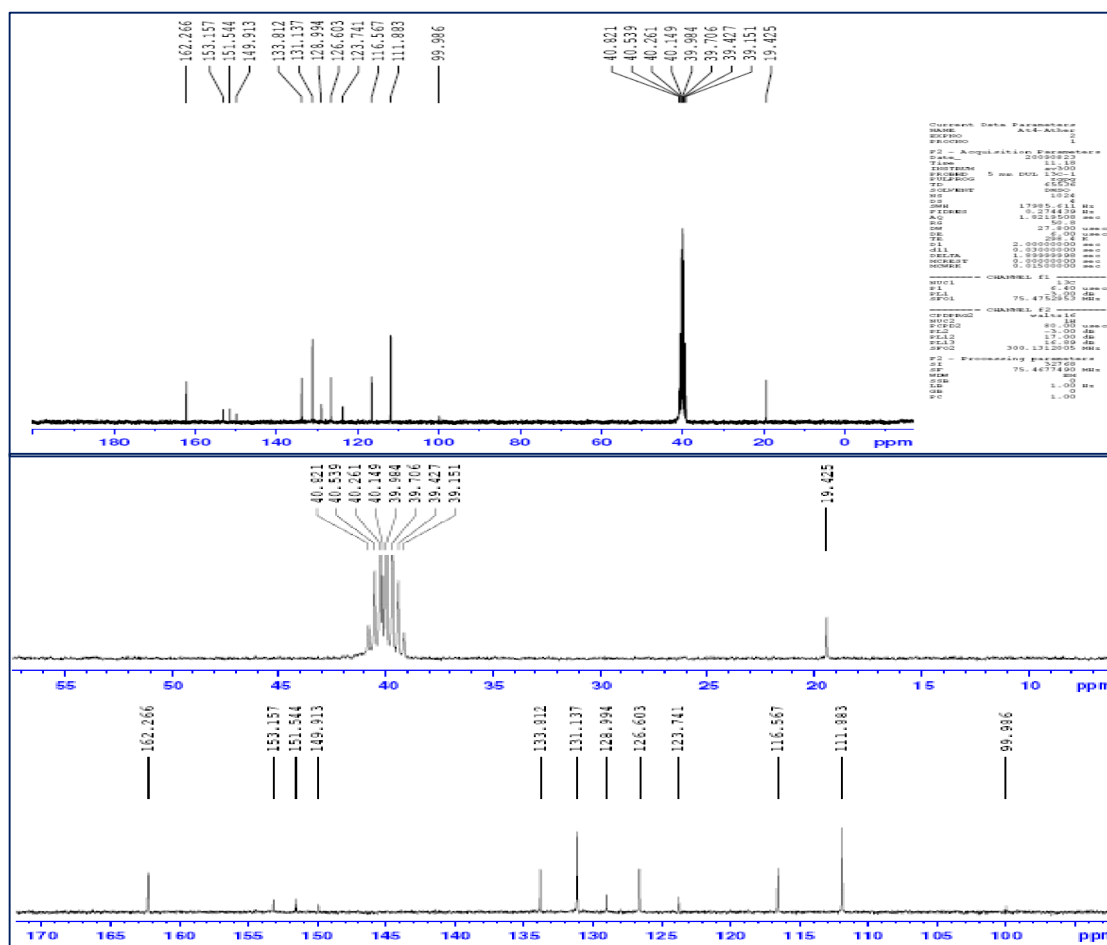


Figure (7) : ¹³C NMR spectrum for Schiff base (S₁)

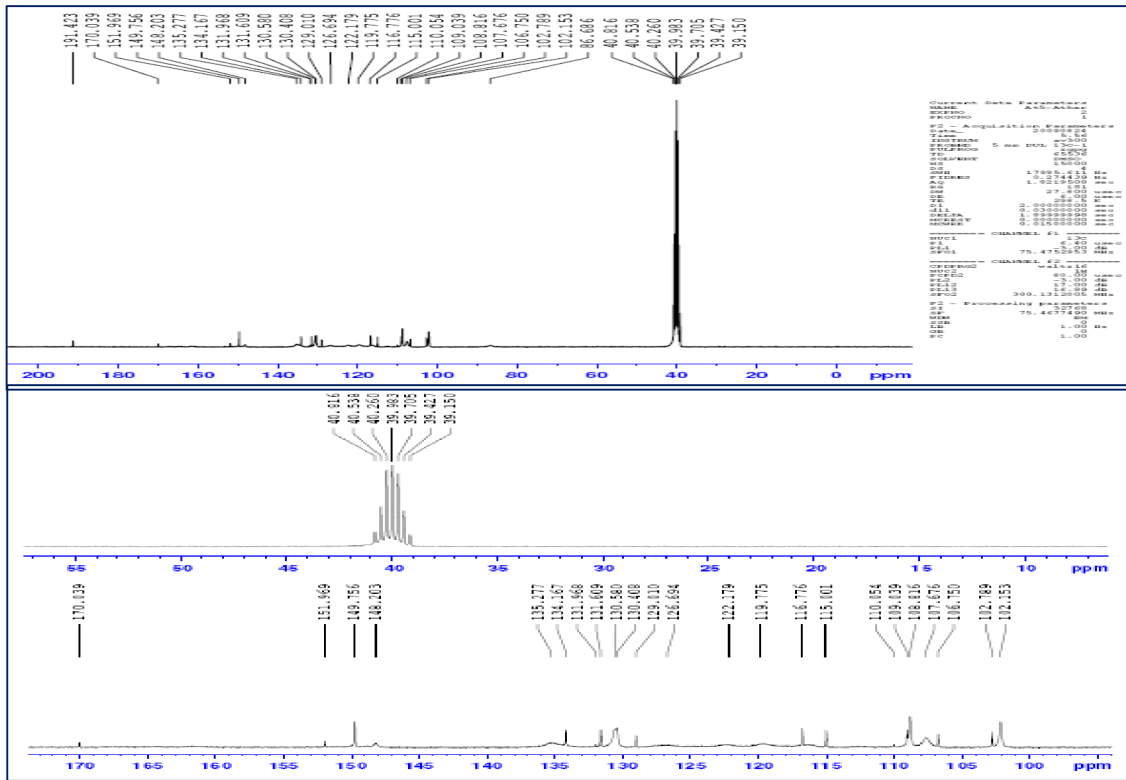


Figure (8) : ^{13}C NMR spectrum for Schiff base (S_2)

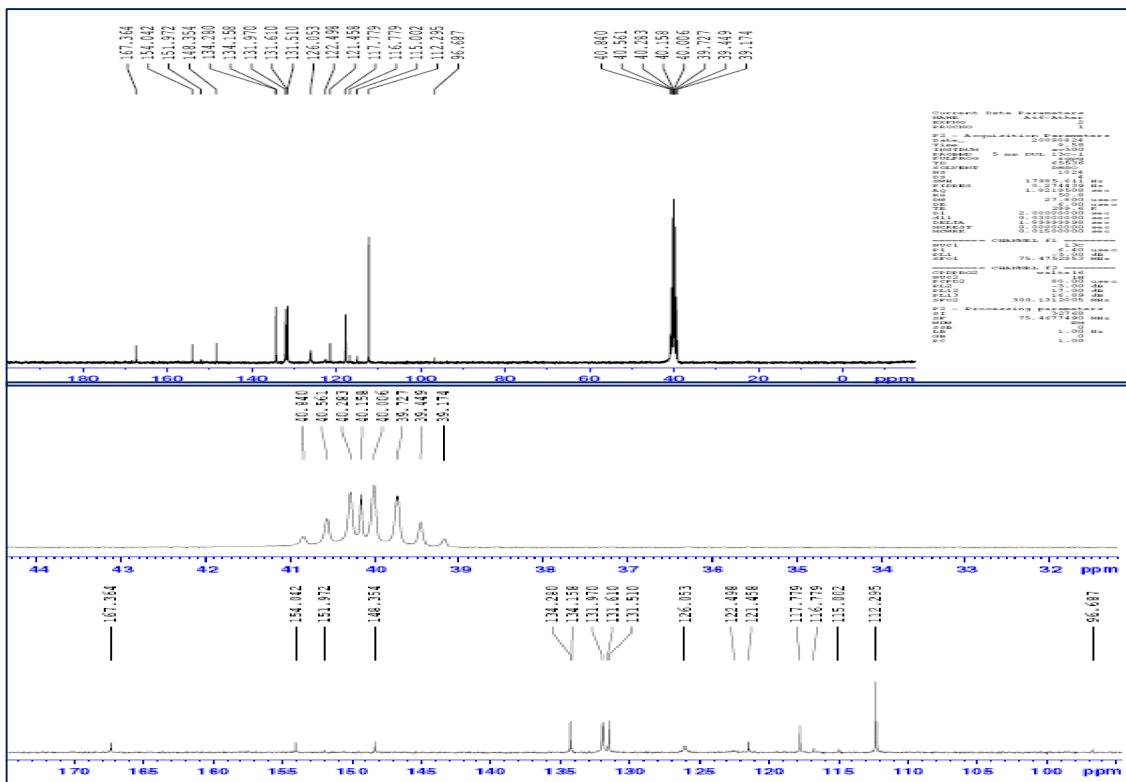


Figure (9) : ^{13}C NMR spectrum for Schiff base (S_3)

Table (8) : Important fragments appeared in mass spectra for prepared Schiff bases

Compound	m/z	Intensity (%)	Fragment
S ₁	268	18	[M] ⁺
	223.3	7	[C ₁₄ H ₁₀ NO ₂] ⁺
	149	5	[C ₈ H ₆ NO ₂] ⁺
	78	69	[C ₆ H ₆] ⁺
	63	100	[C ₃ H ₃] ⁺
S ₂	284	20	[M] ⁺
	238	7	[M-NO ₂] ⁺
	121	10	[C ₇ H ₅ O ₂] ⁺
	77.9	73	[C ₆ H ₆] ⁺
	63	100	[C ₃ H ₃] ⁺
S ₃	283	55	[M] ⁺
	147	11	[C ₉ H ₁₁ N ₂] ⁺
	118	100	[C ₈ H ₈ N] ⁺
	78	64	[C ₆ H ₆] ⁺
	63	80	[C ₃ H ₃] ⁺

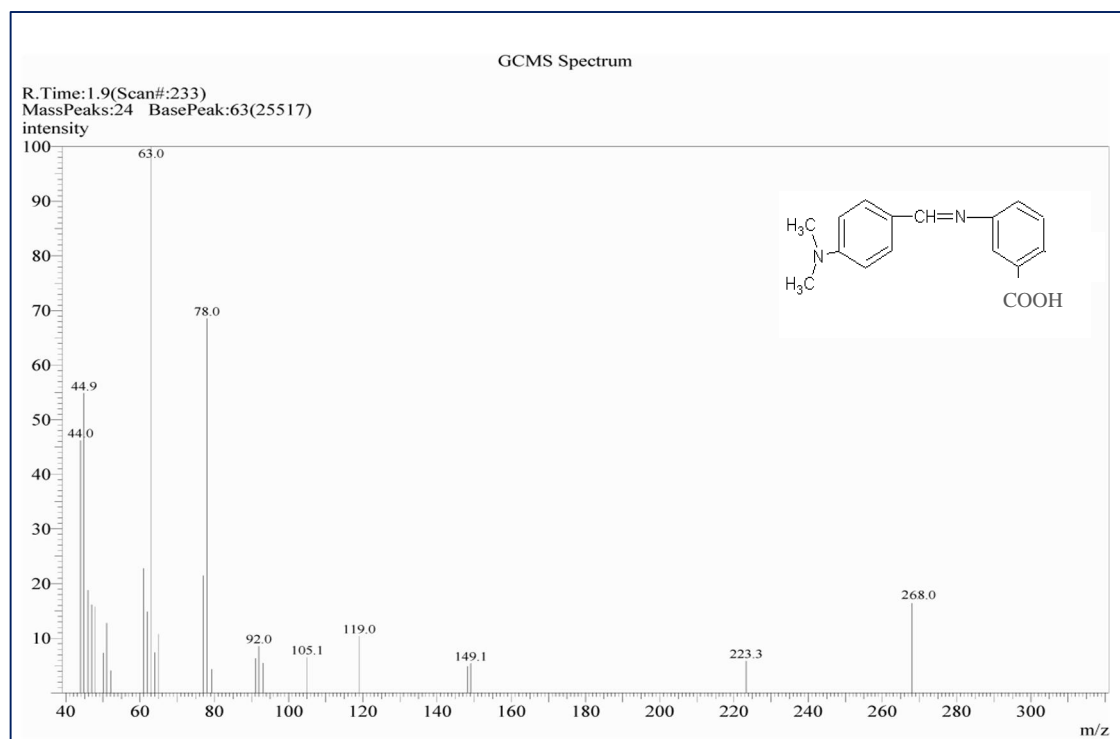


Figure (10) : Mass spectrum for Schiff base (S₁)

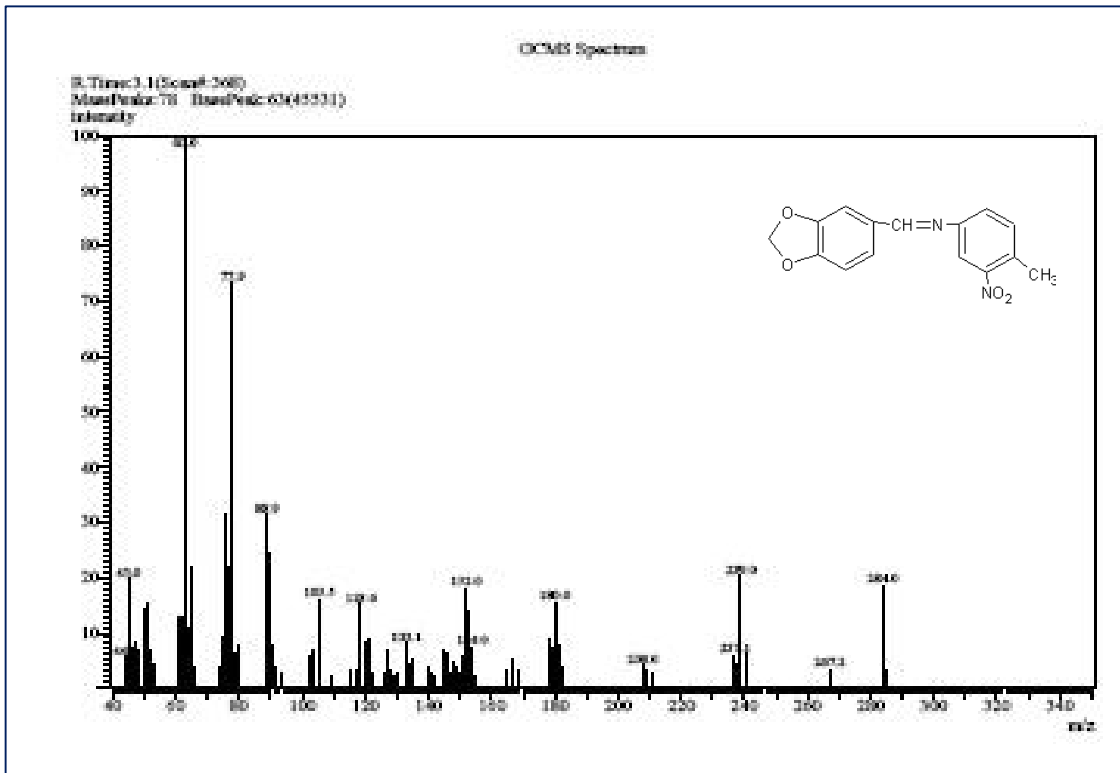


Figure (11) : Mass spectrum for Schiff base (S₂)

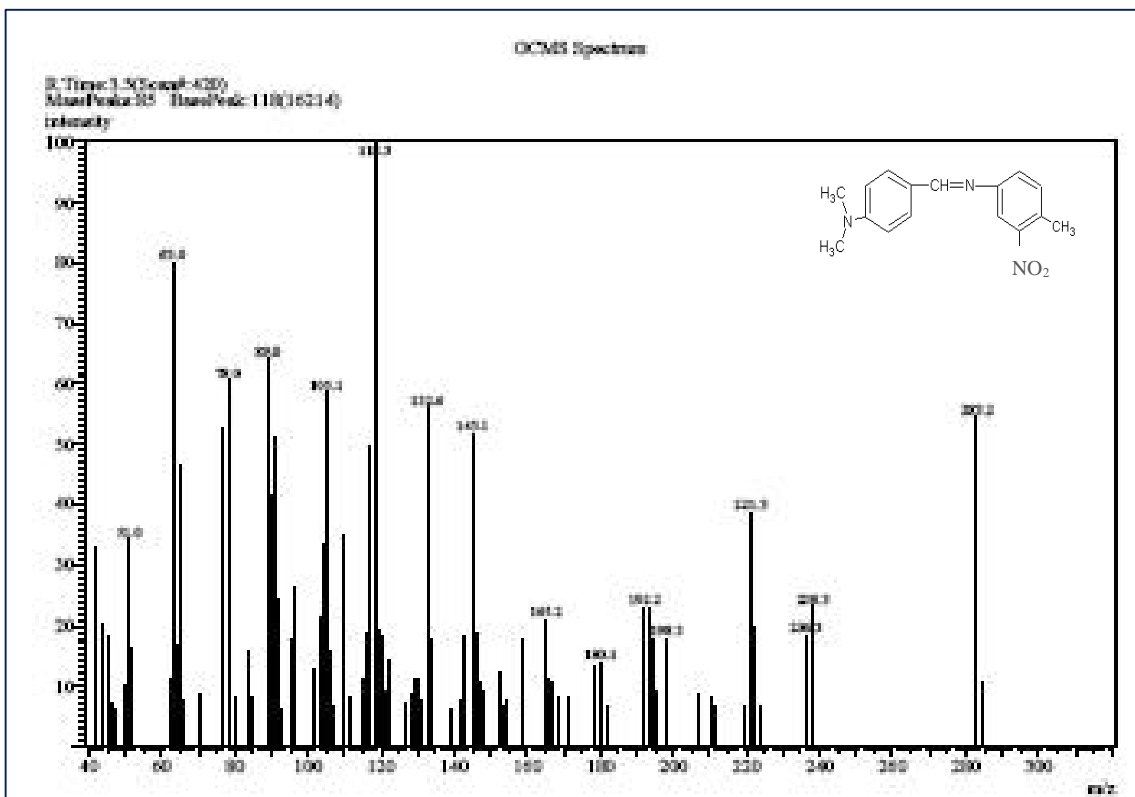


Figure (12) : Mass spectrum for Schiff base (S₃)

Chemical corrosion

Corrosion rate of brass samples was measured in acidic media (0.5 M HCl) by electrochemical and weight loss methods . Then

the prepared Schiff bases were used as corrosion inhibitors .

Electrochemical method

Corrosion rate of brass samples was measured by electrochemical method that depend on tafel plot . Tafel plot of brass corrosion in 0.5 M HCl was compared with tafel plot using 0.01 M of prepared Schiff bases at constant temperature of 298 °K .The results given in figures (13-16) and table (9) indicated that these Schiff bases act as inhibitors for corrosion because they reduce corrosion rate (CR), corrosion current (I corr) and corrosion potential (E corr) in comparison with using HCl alone .

Inhibitor efficiency (IE %) and surface coverage (θ) were also calculated by the following equations [29] :

$$IE \% = \theta \times 100$$

$$\theta = CR_{uninh} - CR_{inh} / CR_{uninh}$$

where :

CR unin : Corrosion rate without inhibitors

CR inh : Corrosion rate with inhibitors

It is observed in table (9) the values of inhibitor efficiency and surface coverage were high reached to 97.6276 % in the presence of Schiff base (S₁) .This is indicate that they are good corrosion inhibitors .

Table (9) : Some electrochemical parameters of corrosion for brass in acidic media at 298 °K

Corrosion media	E corr (volt)	I corr (μA/cm ²)	CR (mpy)	θ	%IE
0.5M HCl	-0.215	238.461	114.61	-	-
0.5M HCl+0.01S ₁	-0.074	5.657	2.719	0.9762	97.6276
0.5M HCl+0.01S ₂	-0.285	8.826	4.242	0.9629	96.2987
0.5M HCl+0.01S ₃	-0.231	96.960	46.60	0.5934	59.3403

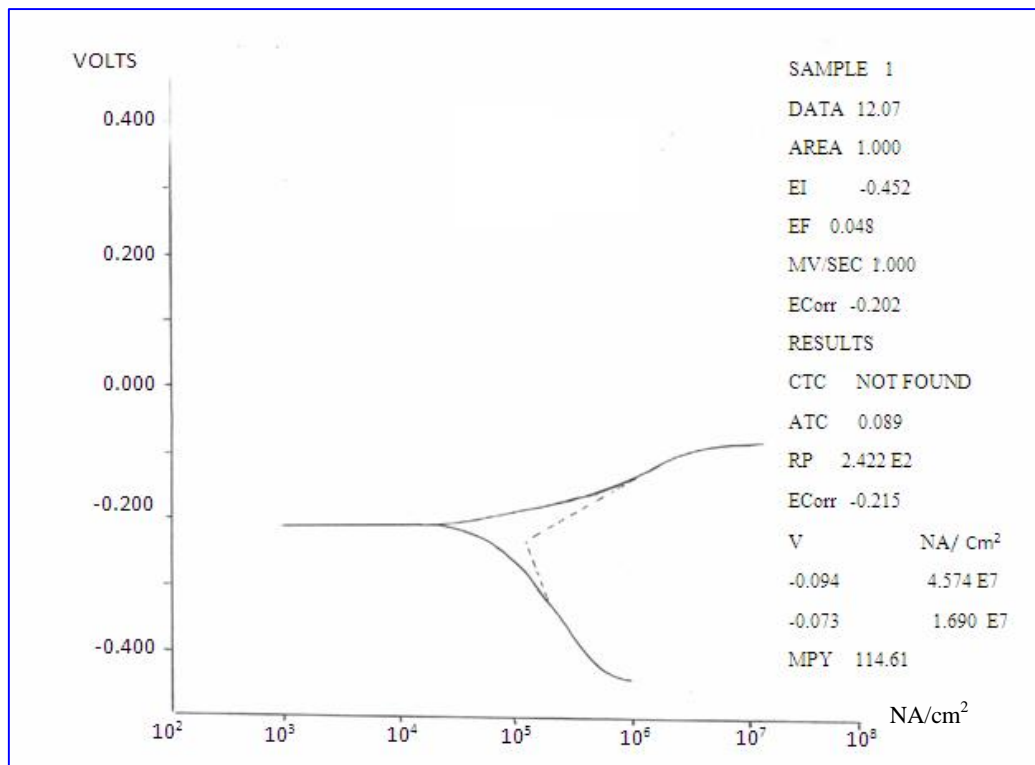


Figure (13) : Tafel plot of brass alloy in the absence of inhibitors at 298 °K

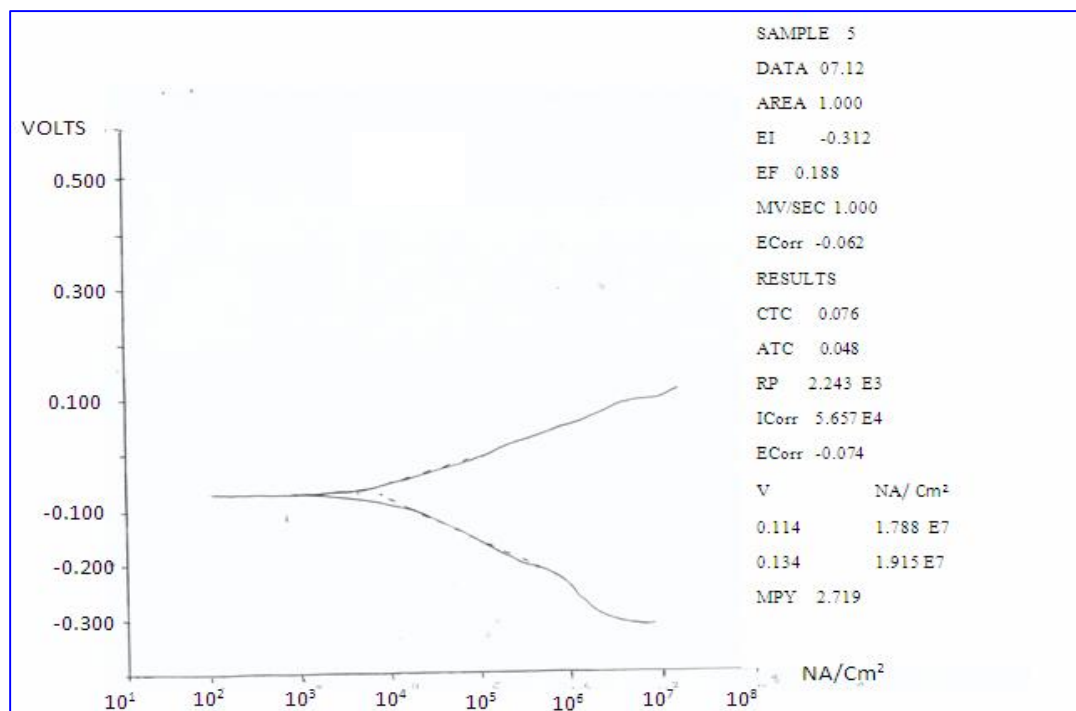


Figure (14) : Tafel plot of brass alloy in the presence of inhibitor (S₁) at 298 °K

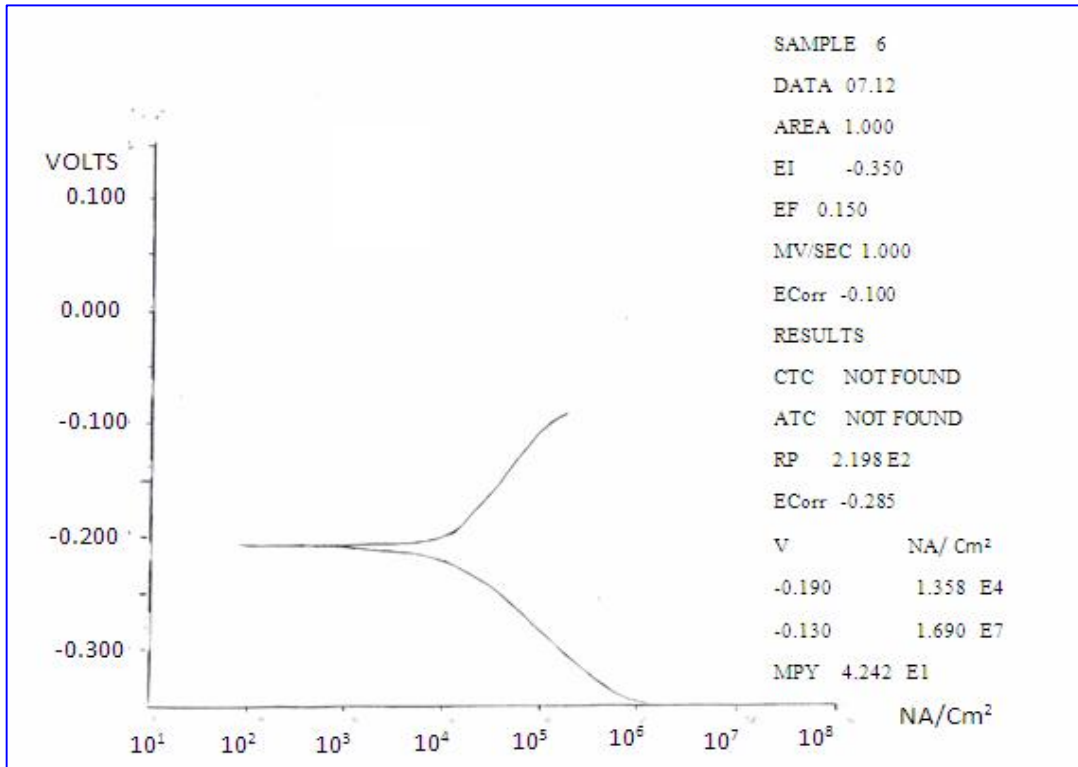


Figure (15) : Tafel plot of brass alloy in the presence of inhibitor (S₂) at 298 °K

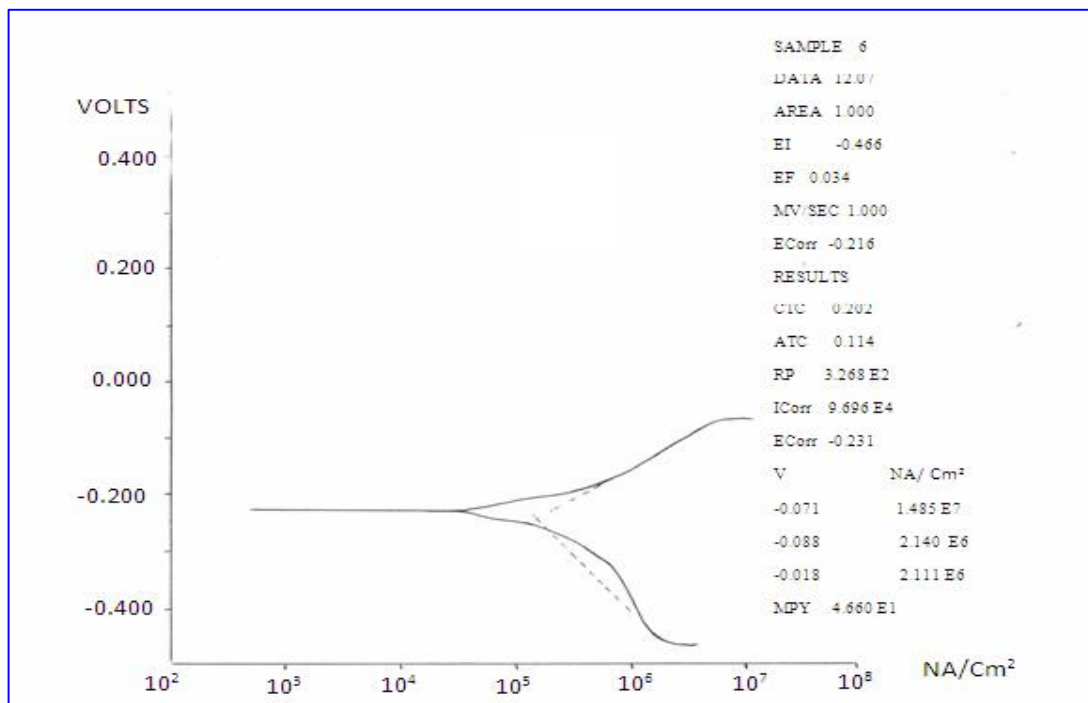


Figure (16) : Tafel plot of brass alloy in the presence of inhibitor (S₃) at 298 °K

Weight loss method

Corrosion rate of brass in 0.5 M HCl as corrosive media was measured by Weight loss method at different temperature (298 °K , 308 °K and 318 °K). The results shown in table (10) indicate that weight loss and corrosion rate were increased with increasing temperature , thus these parameters values were equal 0.0085 gm and 48.081 mpy after 4 hrs at 298 °K while they became 0.0156 gm and 88.244 mpy at 318 °K .

In addition , the effect of Schiff bases (0.01 M) on the brass corrosion in acidic media was studied as shown in tables (11-13) and figures (17-22) .The results indicate that the weight loss of brass sample decreased in comparison with absence of Schiff bases (inhibitors) , because these Schiff bases were formed prevented layer on the metal surface as a result of presence azomethine group (-CH=N-) and aromatic cycles in the Schiff bases [30] .

Furthermore , inhibition efficiency was studied . Figures (23-25) show that inhibition efficiency is high and it was decreased with increasing time due to reduction of inhibitor concentration in solution and this lead to decreasing adsorption of inhibitor on the metal surface .

On the other hand , the effect of temperature (298 °K , 308 °K and 318 °K) on the brass corrosion was studied . It was found that weight loss and corrosion rate were increased with increasing temperature while inhibition efficiency was not obviously as shown in figure (26-31) and tables (14) and (15) . This is due to the increasing kinetic energy of molecules in the high temperature in addition to the presence of the substituents that increase or decrease electron density of azomethine group in studied inhibitors [31] .

Table (10) : Weight loss and corrosion rate of brass alloy in acidic media at different temperatures

Temp. (°K)	1hr		2hr		3hr		4hr	
	W (gm)	CR (mpy)	W (gm)	CR (mpy)	W (gm)	CR (mpy)	W (gm)	CR (mpy)
298	0.0042	95.032	0.0062	70.142	0.0074	55.812	0.0085	48.081
308	0.0059	133.497	0.0086	97.294	0.0120	90.506	0.0156	88.244
318	0.0152	343.92	0.0203	229.662	0.0289	217.970	0.0359	203.307

Table (11) : Weight loss and corrosion rate of brass alloy in the presence of inhibitor (S₁) at 298 °K

Parameter	Time (hrs)			
	1	2	3	4
W(gm)	0.0003	0.0010	0.0023	0.0027
CR(mpy)	6.7880	11.3133	17.3471	15.2730

Table (12) : Weight loss and corrosion rate of brass alloy in the presence of inhibitor (S₂) at 298 °K

Parameter	Time (hrs)			
	1	2	3	4
W(gm)	0.0001	0.0006	0.0011	0.0017
CR(mpy)	2.2626	6.7880	8.2964	9.6163

Table (13) : Weight loss and corrosion rate of brass alloy in the presence of inhibitor (S₃) at 298 °K

Parameter	Time (hrs)			
	1	2	3	4
W(gm)	0.0004	0.0009	0.0012	0.0015
CR(mpy)	9.0506	10.1820	9.0506	8.4850

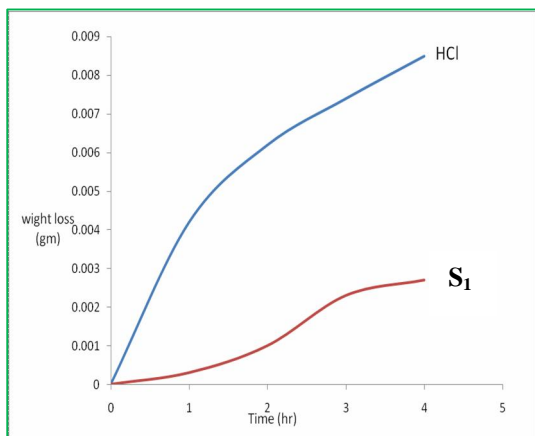


Figure (17) : Weight loss as function for time in the absence and presence of inhibitor (S₁)

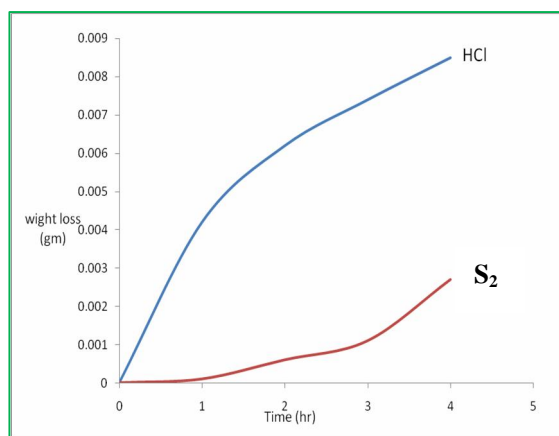


Figure (18) : Weight loss as function for time in the absence and presence of inhibitor (S₂)

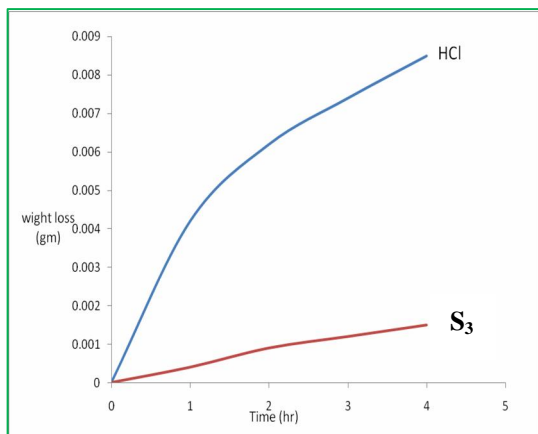


Figure (19) : Weight loss as function for time in the absence and presence of inhibitor (S₃)

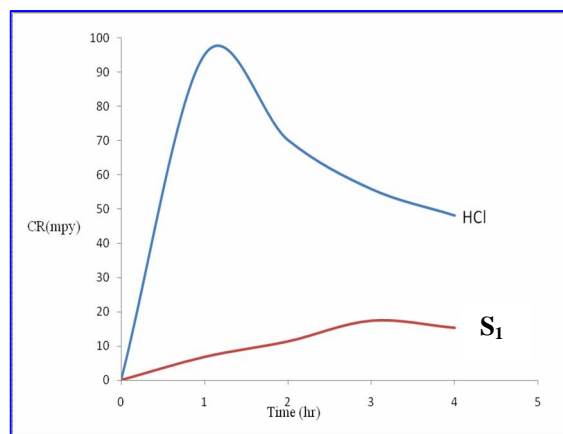


Figure (20) : Corrosion rate as function for time in the absence and presence of inhibitor (S₁)

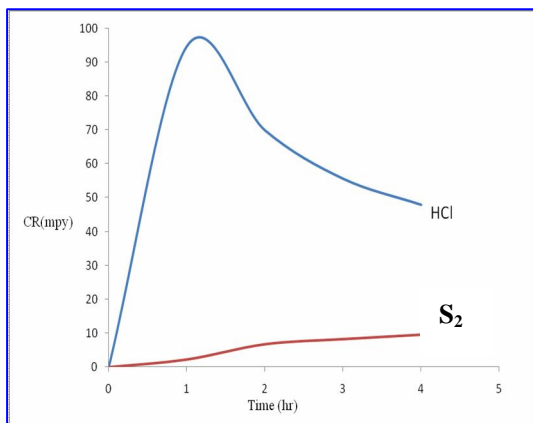


Figure (21) : Corrosion rate as function for time in the absence and presence of inhibitor (S₂)

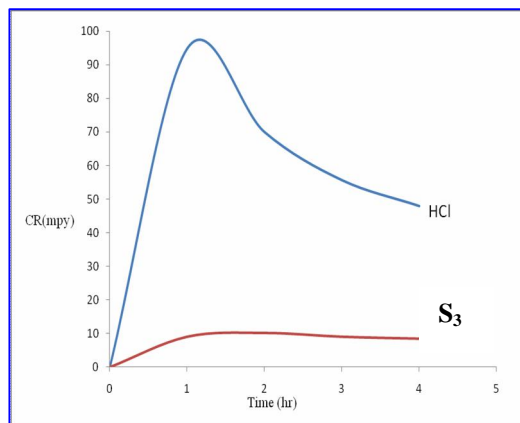


Figure (22) : Corrosion rate as function for time in the absence and presence of inhibitor (S₃)

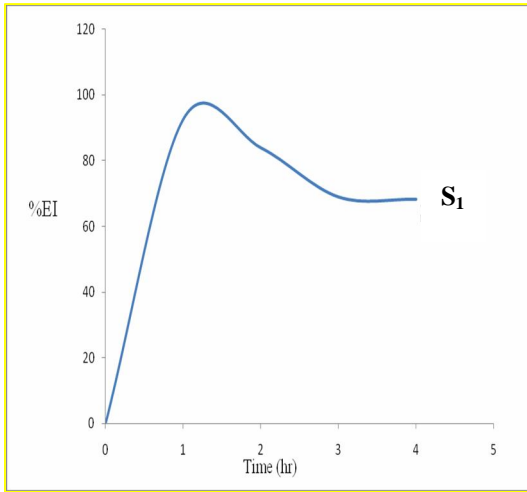


Figure (23) : Inhibitor efficiency as function for time in the presence of inhibitor (S_1)

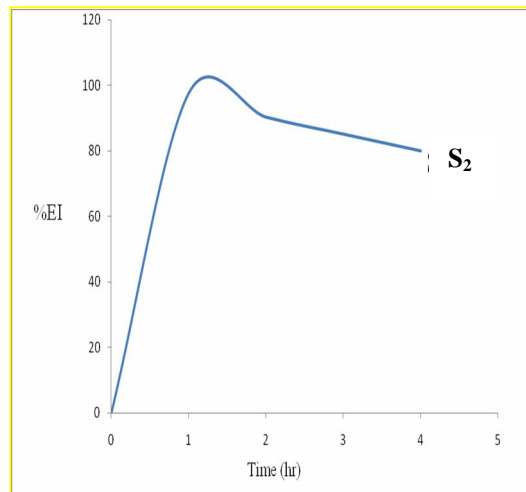


Figure (24) : Inhibitor efficiency as function for time in the presence of inhibitor (S_2)

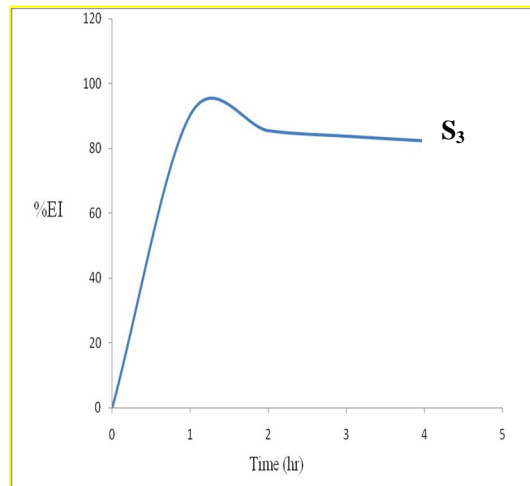


Figure (25) : Inhibitor efficiency as function for time in the presence of inhibitor (S_3)

Table (14) : Weight loss and corrosion rate of brass alloy in the presence and absence of inhibitors at different temperatures and 4 hrs

Temp. ($^{\circ}$ K)	HCl		S_1		S_2		S_3	
	W (gm)	CR (mpy)	W (gm)	CR (mpy)	W (gm)	CR (mpy)	W (gm)	CR (mpy)
298	0.0085	48.081	0.0027	15.273	0.0017	9.616	0.0015	8.485
308	0.0156	88.244	0.0062	35.071	0.0051	28.849	0.0038	21.495
318	0.0358	303.307	0.0077	43.556	0.0081	45.819	0.0072	40.728

Table (15) : Inhibitor efficiency and surface coverage of brass alloy in the presence of inhibitors at different temperatures and 4 hrs

Temp. ($^{\circ}$ K)	S_1		S_2		S_3	
	%IE	θ	%IE	θ	%IE	θ
298	68.235	0.682	80.000	0.800	82.352	0.823
308	59.814	0.598	67.307	0.673	75.641	0.756
318	78.576	0.785	77.463	0.774	79.967	0.799

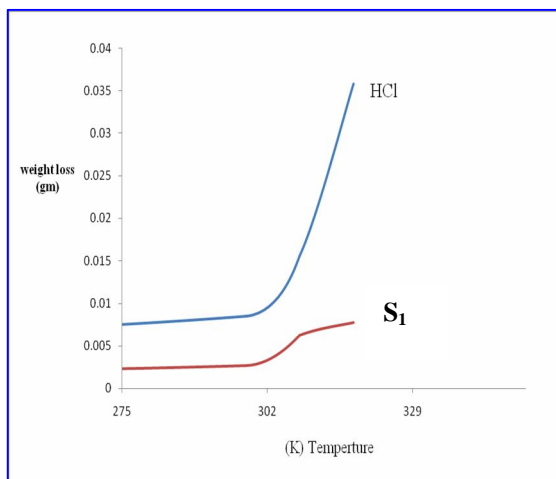


Figure (26) : Weight loss as function for temperature in the absence and presence of inhibitor (S_1)

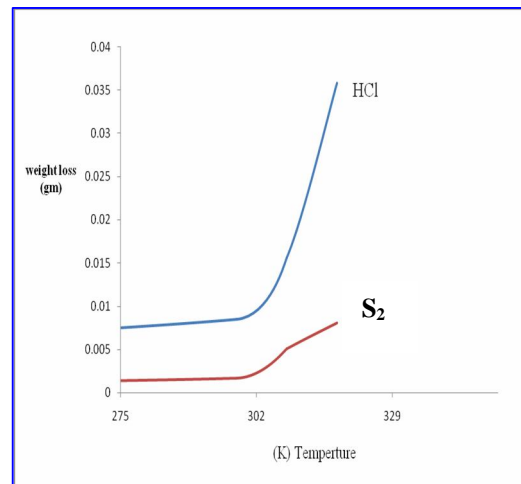


Figure (27) : Weight loss as function for temperature in the absence and presence of inhibitor (S_2)

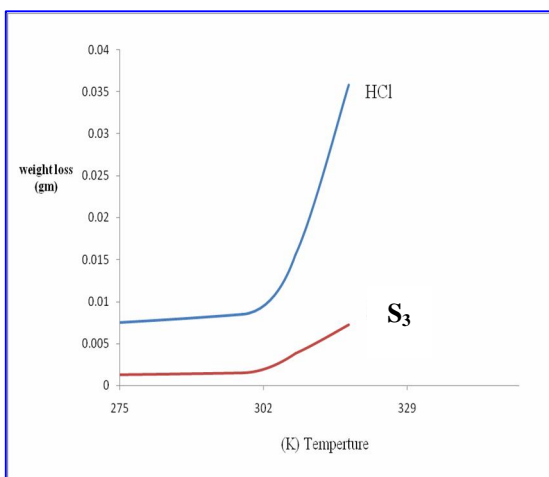


Figure (28) : Weight loss as function for temperature in the absence and presence of inhibitor (S_3)

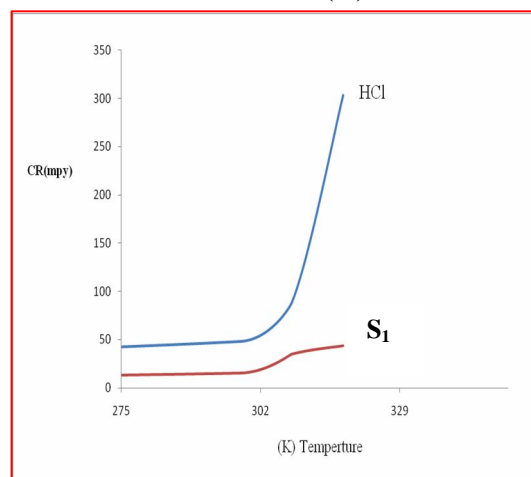


Figure (29) :Corrosion rate as function for temperature in the absence and presence of inhibitor (S_1)

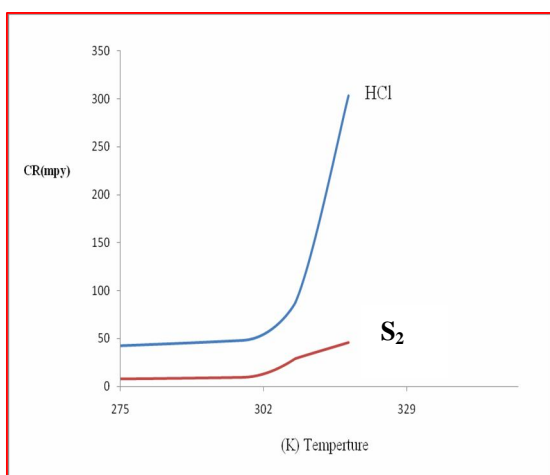


Figure (30) :Corrosion rate as function for temperature in the absence and presence of inhibitor (S_2)

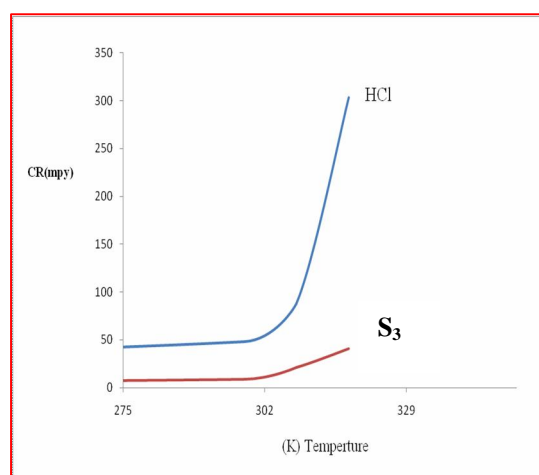


Figure (31) :Corrosion rate as function for temperature in the absence and presence of inhibitor (S_3)

Effect of temperature on the thermodynamic parameters

Corrosion current

Corrosion current was calculated by the following equation [32] :

$$I_{\text{corr}} = (2 \cdot 1000 \cdot W \cdot F) / (A_w \cdot t \cdot A)$$

Where :

I_{corr} : Corrosion current , F : Faraday constant (96487 C. mole⁻¹)

W : Weight (gm) , t : Time (sec) , A_w : Atomic weight , A : Area of brass (cm²)

The results in table (16) show that corrosion current was increased with increasing temperature because of free motion of molecules

Table (16) : Corrosion current of brass alloy in the presence and absence of inhibitors at different temperatures and 4 hrs

Temp. (°K)	I _{corr} (mA/cm ²)			
	HCl	S ₁	S ₂	S ₃
298	0.2175	0.0691	0.0434	0.0384
308	0.3990	0.1585	0.1304	0.0972
318	0.9183	0.1969	0.2072	0.1842

Activation energy

Activation energy in the presence and absence of inhibitors was calculated by the following equation [31] :

$$\ln (r_2 / r_1) = E_a (T_2 - T_1) / R (T_1 T_2)$$

Where :

E_a : Activation energy , r_1 : Corrosion rate at 308 °K , r_2 : Corrosion rate at 318 °K

R : Gas constant (8.3143 Jole. K⁻¹. mole⁻¹) , T_1

T_2 : Absolute temperatures

Table (17) show that activation energy in the presence of inhibitors is less in comparison with using acidic media only . Properly this indicates that the formation of the adsorption occurs by chemical mechanism involved the share or transfer of charge from the molecules to the surface to form a coordinate type as well as forming physical adsorption [33] .

Table (17) : Activation energy of brass alloy in the absence and presence of inhibitors at different times

Time (hrs)	Activation energy (KJ/mol)			
	HCl	S ₁	S ₂	S ₃
1	77.061	68.269	53.685	56.446
2	69.941	18.588	45.140	59.640
3	71.572	22.562	37.999	56.446
4	67.966	17.644	37.673	52.043
average	71.635	31.772	43.624	56.144

Free energy

Free energy of brass corrosion in the presence of inhibitors was calculated at different temperature by the following equation [34] :

$$\Delta G = - RT \ln [(55.5 \theta / C (1 - \theta))]$$

Where :

ΔG : Free energy , R : Gas constant , T : Absolute temperature ,

C : Concentration (M) , θ : Surface coverage

The results shown in table (18) indicate that free energy at 318 °K is high negatively in

comparison with others temperatures because the corrosion reactions at this temperature is readily . The negative values of the free energy indicate spontaneous adsorption of these inhibitors on the brass alloy [33] .

On the other hand , the inhibition effect for prepared inhibitors and their starting materials

were also studied . It was found that amines and aldehydes (starting materials) give low inhibition for brass corrosion in comparison with their Schiff bases as summarized in table (19) and (20) . This is attributed to the Lon pair found on the nitrogen atom related azomethine group in the Schiff bases .

Table (18) : Free energy of brass alloy in the presence of inhibitors at different temperatures and 4 hrs

Temp. (°K)	ΔG (KJ/mol °K)		
	S ₁	S ₂	S ₃
298	-23.2579	-24.7964	-25.1779
308	-23.0964	-23.9266	-24.9799
318	-26.2302	-26.0590	-26.4538

Table (19) : Some parameters of corrosion for brass alloy in the presence of amines used as starting materials at 298 °K

Time (hrs)	3-amino benzoic acid			4-amino 2-nitro toluene		
	W(gm)	CR(mpy)	%IE	W(gm)	CR(mpy)	%IE
1	0.0019	42.990	54.761	0.0021	47.516	50.000
2	0.0037	41.859	40.322	0.0031	35.071	50.000
3	0.0052	39.219	29.729	0.0042	31.677	43.243
4	0.0059	33.374	30.388	0.0061	34.505	28.235

Table (20) : Some parameters of corrosion for brass alloy in the presence of aldehydes used as starting materials at 298 °K

Time (hrs)	4- dimethyl amino benzaldehyde			Piperonal		
	W(gm)	CR(mpy)	%IE	W(gm)	CR(mpy)	%IE
1	0.0026	61.093	35.729	0.0032	70.145	26.186
2	0.0040	44.124	37.094	0.0045	53.159	24.199
3	0.0051	39.217	29.735	0.0061	44.511	20.286
4	0.0061	35.069	27.057	0.0073	40.165	16.483

Antibacterial activity

Because of the corrosion formed by the bacteria , antibacterial activity of prepared Schiff bases was evaluated on the two types of bacteria ,Staphylococcus aureus (they are gram – positive cocci and can grow on all culture media) and Escherichia coli (they are gram – negative rod –shaped cells and can grow in the presence of oxygen) . To we know activity of prepared Schiff bases , it was dissolved 0.01 gram from these Schiff bases in the 1 cm³ DMSO , then bacterial plates were injected with

0.1 cm³ from these solutions and incubated for 24 hrs at 37 °C . These plates were out of from incubator and measured zone diameters of inhibition as shown in table (21) and figure (32) . The results were assigned that the prepared Schiff bases were active towards the two types of the bacteria in comparison with standard inhibitor (AK3). This activity attributes properly to dioxomethylene and nitro groups in these Schiff bases [35] .

Table (21) : Diameters of inhibition against bacteria for prepared compounds and standard inhibitor

Inhibitor	Zone diameter of inhibition (mm)	
	ST. bacteria	E-coli bacteria
S ₁	31	26
S ₂	29	24
S ₃	30	27
AK3 (standard inhibitor)	30	25

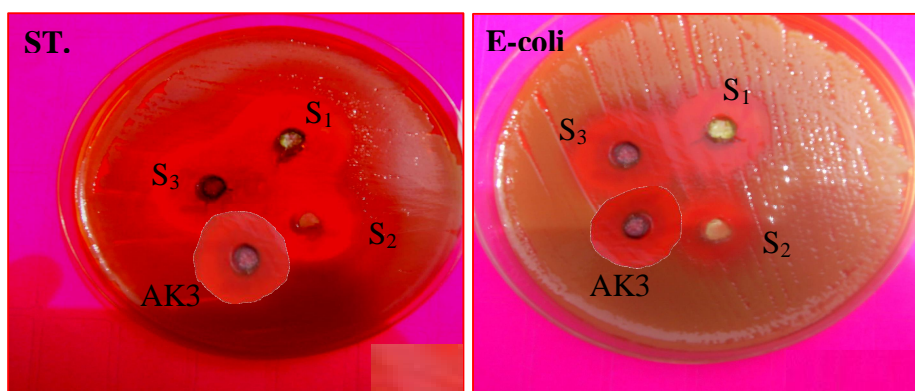


Figure (32) : Inhibited effect for prepared Schiff bases and standard inhibitor on the growth of Staphylococcus aureus and Escherichia coli

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الخلاصة

تم تحضير ثلاث قواعد شف وهي (4-dimethyl amino benzaldene – 3-amino benzoic acid) و (4-dimethyl amino benzaldene-4-amino –2-nitro piperonaldehyde- 4-amino-2-nitro toluene) و (piperonaldehyde- 4-amino-2-nitro toluene) . شخصت قواعد شف المحضرة بواسطة تحليل العناصر الدقيق (CHN) ومطيافية الأشعة تحت الحمراء والرنين النووي المغناطيسي للبروتون ($^1\text{H-NMR}$) والرنين المغناطيسي للكربون ($^{13}\text{C-NMR}$) ومطيافية الكتلة GC-Mas . تضمنت الدراسة أيضا استعمال قواعد شف المحضرة كمثبطات لتآكل البراص في الوسط الحامضي (0.5 M HCl) ، حيث قيس معدل سرعة التآكل بطريقتين هما الطريقة الكهروكيميائية وطريقة الفقدان بالوزن وقد وجد ان هناك توافق بين نتائج الطريقتين . فضلاً عن ذلك اجريت دراسات مختلفة في مجال التآكل وهي : تأثير تغيير درجة الحرارة على معدل سرعة التآكل عند (318 °K , 308 °K , 298 °K) ، وحساب بعض الدوال الثرموديناميكية مثل تيار التآكل وطاقة التنشيط والطاقة الحرة اضافة الى مقارنة التأثير التنبيطي لقواعد شف المحضرة مع اميناتها الاولية وقد بينت النتائج بان قواعد شف المحضرة ذات كفاءة جيدة في تثبيط التآكل . ومن جانب اخر تم دراسة الفعالية المضادة للبكتيريا لقواعد شف المحضرة والمادة القياسية (AK3) على نوعين من البكتيريا وهما البكتيريا الموجبة لصبغة غرام و البكتيريا السالبة لصبغة غرام وقد اشارت النتائج ان قواعد شف قد تثبط النمو البكتيري وباقطار تثبيطية مختلفة .