

Study on the effects of some inhibitors on the inhibition of equipment's corrosion using analytical physical techniques

Ali abduh Mutair*, Huda .A. Al-Wahed,Niyazi A. S. Al-Areqi, Samia A. Al-Wasee*

Abstract— The inhibitive effects of essential oils (EO) and synthetic compounds (COMP), two types inhibitors compounds, on the corrosion of carbon steel (CS) and stainless steel L-316 (316SS) in 1M HCl, industrial waste water (Iww), basic active detergent past (ADP) respectively have been investigated using chemical (weight loss) techniques. It was found that the inhibition efficiencies of EO and COMP remarkably increase as the inhibitor concentration increases, and drop with increasing temperature. COMP and EO adsorbed on the surface of CS and 316SS according to the Temkin adsorption isotherm model at all the concentrations and temperatures studied. The mechanism of physical adsorption of COMP and EO on the surface of CS and 316SS were also proposed based on the thermodynamic parameters obtained. The synergistic contribution of some inorganic anions such as I^- , Br^- , and SCN^- to the effectiveness of EO in the corrosion inhibition was also investigated.

Index Terms — Corrosion, CS, HCl, Inhibitor, 316SS, EO, COMP.

1 INTRODUCTION

The corrosion of steel alloys is of the greatest global problems. Recently, many attempts have been made to attain highly appreciable inhibition to such a corrosion, and consequently minimizing the accompanied economic loss which is increasingly estimated annually. The introduction of corrosion inhibitors are the best ways to prevent metallic corrosion and save the great economic loss of country [1].

Generally many chemical compounds is used as corrosion inhibitors. Most of the effective inhibitors are used to contain heteroatom such as O, N, and S and multiple bonds in their molecules through which they are adsorbed on the metal surface [2].

In the present work has been carried out which reveals the adsorption behavior and corrosion prevention properties of EO such as Sweet almond oil (SAO), Rose oil (RO), carnation oil (CO) and (COMP) such as Ethyl 5-cyano-2-methyl-4-phenyl-6-thioxopiperidine-3-carboxylate (Comp-1), Ethyl 3-amino-2-carbamoyl-4,5,6,7,7a-hexahydro-6-methyl-4-phenylthieno[2,3-b]pyridine-5-carboxylate (Comp-2), 3-(4-chlorophenyl)-2-cyano thion acrylamide (Comp-3) on the corrosion of two of the most important steel alloys, viz CS and 316SS in different corrosive media dilute HCL, Iww and ADP respectively. synergistic contribution of some inorganic anions such as I^- , Br^- and SCN^- to the effectiveness of essential oils in the corrosion.

2 Materials & Methods.

The chemical composition of CS used in the present study is the rest Fe and had traces of (C 0.200%, Si 0.003%, Mn 0.350%, P 0.024%). It was taken from Yemen Company For Industry & commerce (YCIC) Taiz.

And chemical composition of 316SS used in the present study is the rest % Fe and had traces of (Cr 16%, Ni 11%, Mn 1%, P 0.054%, C 0.02%, Si 1%, Mo 3%, Cu 0.2%). It was taken from Yemen Company For Ghee & Soap Industry (YCGSI) Taiz. Analytical

TABLE 1
THE CHEMICAL STRUCTURE OF SAO[3]

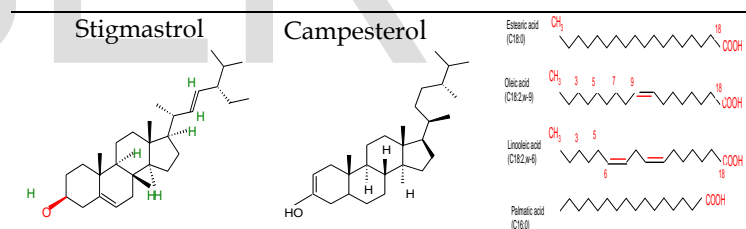
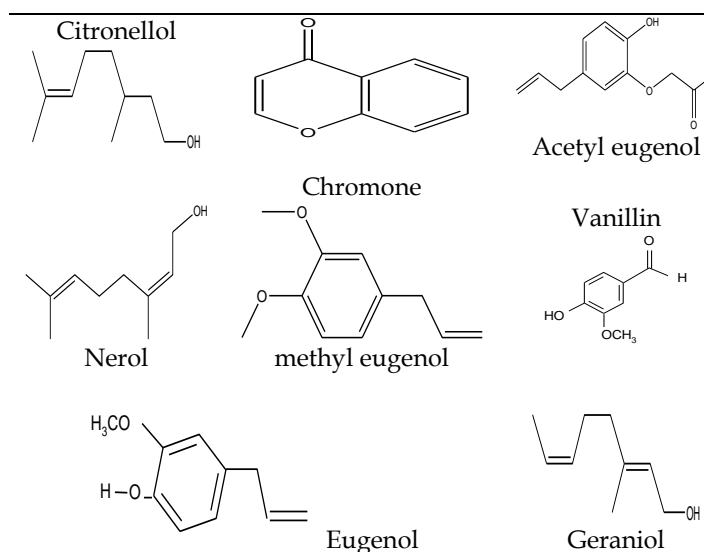


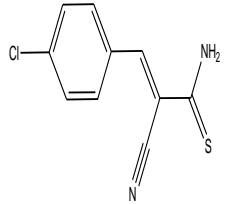
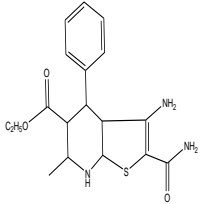
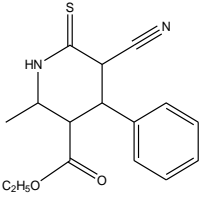
TABLE 2
THE CHEMICAL STRUCTURE OF RO[4,5], CO[6,7]



* Department of Chemistry, Faculty of Applied Science, Taiz University, Taiz, Yemen. *Corresponding Author E-mail: alimutair01@yahoo.com (A. A. Mutair); sami-aabdulwasee@gmail.com (Samia A. Al-Wasee).

TABLE 3

THE CHEMICAL STRUCTURE OF SYNTHETIC COMPOUNDS

Chemical Structure of Comp-3	Chemical Structure of comp-2	Chemical Structure of Comp-1
		

grade HCl was purchased from BDH Prolabo chemicals VWR (Germany). RO, SAO, and CO were of analytical grade and purchased from royal healing presses Taiz.

The specimens are polished according to the methods described earlier [8,9] the corroding media were prepared as aqueous solution of HCl with concentrations of $(1 \times 10^{-5}$ to 11×10^{-3}) M. An aqueous solution of 1M HCl was used as a blank solution, Iww were taken from storage that used for collecting industrial waste water-environmental treatment unite in(YCIC), ADP were taken from equipment that used in sulfonating unit-main material of saponification in (YCGSI) Taiz.

The inhibitors were added to the HCl solution in concentrations of 1×10^{-5} to 11×10^{-3} M, Iww, and ADP in concentration of 0.05, 0.01, 0.5 and 0.1 g/100 ml, The EO were prepared (1M) by dissolving suitable weight of each material 1gm in 100ml in dimethyl sulfoxide (DMF), The COMP were prepared (10^{-2} M) by dissolving suitable weight of each material in 100 ml ethanol, The salts of KI, KBR, KSCN were prepared (10^{-2} M) by dissolving suitable weight of each material in 100 ml distilled water.

The tested specimens were used in the form of sheets of dimensions (2cm x 2cm). The steel sample was chemically cleaned [10] weighed and suspended in 100 ml of test solution, and then again weighed at the end of the reaction after fully drying.

3 Results & discussion

3.1. Weight-loss technique

The weight loss of effectiveness of the EO(SAO, CO and RO) and COMP(1 to 3) as inhibitors for the corrosion of 316SS and CS in different corrosive media has been investigated by varying their concentration in the corrosive media ranging from 0.01 to 0.50 w/v%, 1×10^{-5} to 1×10^{-3} M) at ambient temperatures. Figs. 1 and 2 shows the weight loss-time curves for CS in (Iww), 316SS in (ADP) in the absence and presence of different concentrations of sweet almond oil(SAO) and illustrated in Tables 4 and 6. Similar curves were obtained for the other two compounds (RO&CO) not shown. The weight loss - time curves of 316SS, CS in ADP, Iww, 1M HCl in the absence and presence of different concentrations of SAO, and comp-1 at 35°C and 30°C are presented in Figs. 1, 2 and 3 respectively. Similar curves were obtained for the other two compounds (comp-2 & comp-3) not shown and their calculated data are listed in Tables 4, 5 and 6.

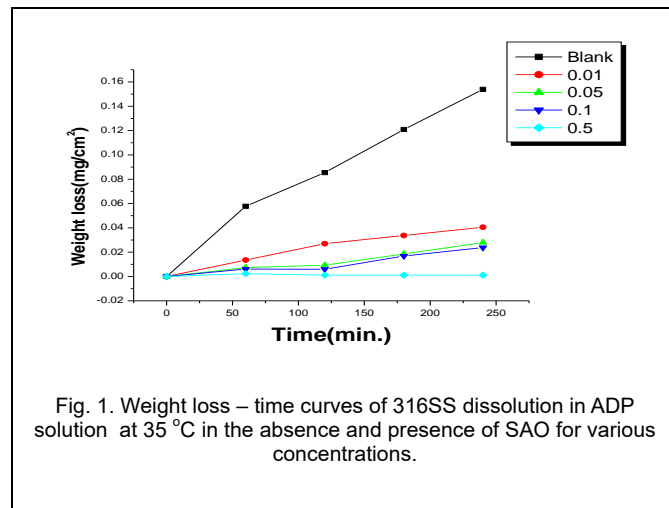


Fig. 1. Weight loss – time curves of 316SS dissolution in ADP solution at 35 °C in the absence and presence of SAO for various concentrations.

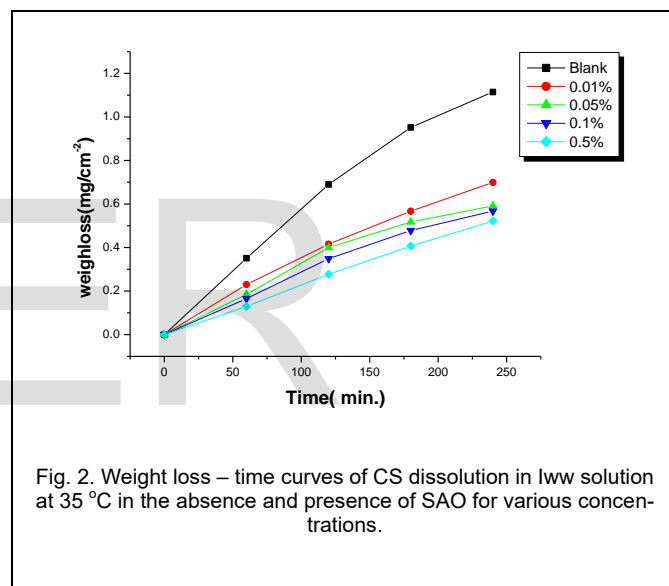


Fig. 2. Weight loss – time curves of CS dissolution in Iww solution at 35 °C in the absence and presence of SAO for various concentrations.

It is clear that the corrosion rate of steel generally decreases with increasing inhibitor concentration in HCl, ADP, Iww solutions. The corrosion rate (CR), surface coverage area (θ) and the inhibition efficiency (IE %) were calculated computed using the following equations [11,12] and are listed in Tables 4, 5 and 6.

$$CR \text{ (g cm}^{-2}\text{min}^{-1}\text{)} = (W_1 - W_2) / At \quad (1)$$

$$IE \% = [(W_{\text{blank}} - W_{\text{inh}}) / W_{\text{blank}}] \times 100 \quad (2)$$

$$\theta = 1 - CR_{\text{inh}} / CR_{\text{blank}} \quad (3)$$

W_1 is weight of steel specimen without inhibitor and W_2 is weight of steel specimen with inhibitor, A is the surface area in cm^2 and t is the time in hours. where CR_{inh} and CR_{blank} are the corrosion rates of the steel with and without the inhibitor respectively.

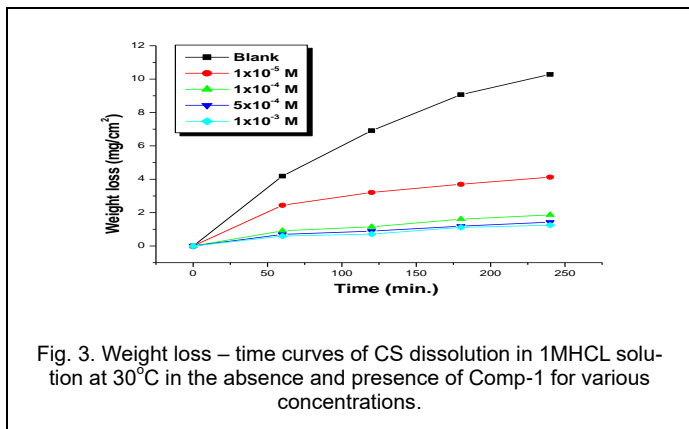


Fig. 3. Weight loss – time curves of CS dissolution in 1MHCL solution at 30°C in the absence and presence of Comp-1 for various concentrations.

TABLE 4

DATA OF WEIGHT LOSS, CORROSION RATE, SURFACE COVERAGE AND INHIBITION EFFICIENCY OBTAINED FROM WEIGHT LOSS MEASUREMENTS FOR CS IN IWW WITHOUT AND WITH VARIOUS CONCENTRATIONS OF SAO AT 35 °C

SAO (M)	Time (hour)	wt loss (mg/cm ²)	rCorr (mg.cm ² .h ⁻¹)	θ	IE
0.01	1	0.230	0.0038	0.617	61.7
	2	0.41572	0.0035	0.824	82.4
	3	0.56689	0.0032	0.884	88.4
	4	0.69917	0.00291	0.908	90.8
0.05	1	0.18477	0.00308	0.692	69.2
	2	0.39955	0.00333	0.831	83.1
	3	0.51737	0.00287	0.894	89.4
	4	0.59128	0.00246	0.922	92.2
0.1	1	0.0125	0.00258	0.742	74.1
	2	0.00868	0.00299	0.848	84.8
	3	0.00806	0.00247	0.909	90.9
	4	0.00747	0.00231	0.927	92.7
0.5	1	0.12934	0.00216	0.784	78.4
	2	0.27716	0.00231	0.882	88.2
	3	0.4065	0.00226	0.916	91.6
	4	0.52201	0.00218	0.931	93.1

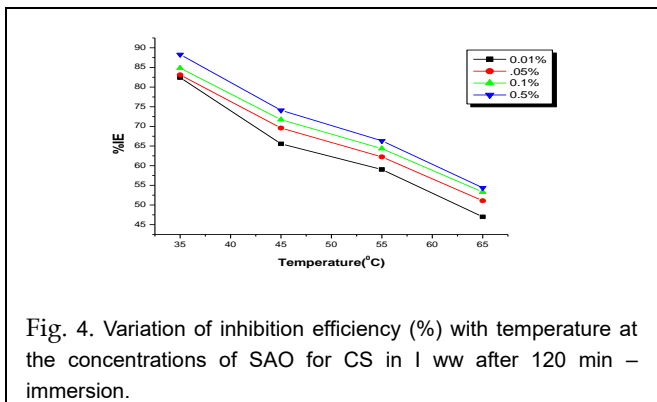


Fig. 4. Variation of inhibition efficiency (%) with temperature at the concentrations of SAO for CS in I ww after 120 min – immersion.

TABLE 5

DATA OF WEIGHT LOSS, CORROSION RATE, SURFACE COVERAGE AND INHIBITION EFFICIENCY OBTAINED FROM WEIGHT LOSS MEASUREMENTS FOR CS IN 1M HCL WITHOUT AND WITH VARIOUS CONCENTRATIONS OF C OMP-1AT 30 °C

Comp-1 (M)	Time (hour)	wt loss (mg/cm ²)	rCorr (mg.cm ² .h ⁻¹)	θ	IE
1x10 ⁻⁵	1	2.42902	0.04065	0.592	59.2
	2	3.21138	0.02676	0.809	80.9
	3	3.69919	0.02055	0.870	87.0
	4	4.12602	0.01719	0.899	89.9
1x10 ⁻⁴	1	0.9127	0.01521	0.847	84.7
	2	1,15079	0.00959	0.931	93.1
	3	1.60714	0.00893	0.943	94.3
	4	1,86508	0.00777	0.954	95.4
5x10 ⁻⁴	1	0.49603	0.00827	0.917	91.7
	2	0.71429	0.00595	0.957	95.7
	3	1.19048	0.00661	0.958	95.8
	4	1.42857	0.00595	0.965	96.5
1x10 ⁻³	1	0.59524	0.00992	0.90	90.0
	2	0.81349	0.00678	0.951	95.1
	3	1.13095	0.00628	0.960	96.0
	4	1.34921	0.00562	0.967	96.7

TABLE 6

DATA OF WEIGHT LOSS, CORROSION RATE, SURFACE COVERAGE AND INHIBITION EFFICIENCY OBTAINED FROM WEIGHT LOSS MEASUREMENTS FOR 316SSIN ADP WITHOUT AND WITH VARIOUS CONCENTRATIONS OF SAO AT 35 °C

SAO (M)	Time (hour)	wt loss (mg/cm ²)	rCorr (mg.cm ² .h ⁻¹)	θ	IE
0.01	1	0.0135	2.24921E-4	86.3	86.3
	2	0.02699	2.24921E-4	90.7	90.7
	3	0.03374	1.87434E-4	94.5	94.5
	4	0.04049	1.68691E-4	96.1	96.1
0.05	1	0.00734	1.22333E-4	0.925	92.58
	2	0.00929	7.74473E-5	0.968	96.82
	3	0.01859	1.03263E-4	0.970	97.01
	4	0.02788	1.16171E-4	0.973	97.3
0.1	1	0.00611	1.01833E-4	0.938	93.8
	2	0.00595	4.95442E-5	0.979	97.9
	3	0.01684	9.35556E-5	0.972	97.2
	4	0.02378	9.90884E-5	0.977	97.7
0.5	1	0.00232	3.86667E-5	0.976	97.6
	2	0.00113	9.44822E-6	0.996	99.6
	3	0.00113	6.29882E-6	0.998	99.8
	4	0.00113	4.72411E-6	0.998	99.8

The study of the temperature effect on the corrosion rate of carbon steel, stainless steel in 1M HCl solution, industrial waste water Iww , basic active detergent past (ADP) respectively, in the absence and presence of different concentrations of Inhibitors. Figs. 4,5 and 6 show the effect of increasing temperature on the corrosion rate of CS,316SSl in Iww,1MHCL,ADP were studied at varying temperatures (35,30-60 and 65 °C) in the absence and presence of different concentration of SAO,comp-1. Similar curves in Figs. 4,5 and 6 were obtained not shown.Values of IE% are given in tables 7,8 and 9.

the inhibition efficiency increases with increasing the concentration of these inhibitors and decreases with increasing the temperature. indication that increase in number of components of inhibitors adsorbed on steel surface, which block the active sites of metal from acid attack and protect the metallic corrosion [13]. Further the decrease in % I.E. with rise in temperature suggests electrostatic interaction (physical adsorption) of the inhibitor molecules on steel surface. This further indicates desorption of adsorbed inhibitor species at higher temperatures and metal dissolution takes place[14].

TABLE 7

THE ESTIMATED VALUES OF INHIBITION EFFICIENCY (% IE) FOR DIFFERENT ESSENTIAL OILS OF VARYING CONCENTRATIONS OF THE ESSENTIAL OILS ON THE CORROSION OF CS AFTER 120- MIN IMMERSION IN IWW AT VARIABLE TEMPERATURES

inhibitor	Conc	% IE			
		35 °C	45 °C	55 °C	65 °C
SAO	0.01	82.4	65.6	59	46.9
	0.05	83.1	69.6	62.2	51
	0.1	84.8	71.7	64.3	53.3
	0.5	88.3	74.1	66.3	54.4
RO	0.01	77.7	66.7	57	49.5
	0.05	82.7	69.4	61.2	52.1
	0.1	86.1	72.1	65.7	57.5
	0.5	87.5	83.4	70.8	63.1
CO	0.01	77.9	64.9	56.8	46.9
	0.05	79.8	69.5	58.2	50.7
	0.1	83.0	74.3	59.3	52.1
	0.5	84.4	77.7	61.3	52.6

3.2. Thermodynamic and activation parameters

The apparent activation energy E_a^* , the enthalpy of activation ΔH^* and the entropy of activation ΔS^* for the corrosion of CS and 316SS in corrosive solutions in the absence and presence of different concentrations of additives at different tempera-

ture are given in Tables (10,11,12) were calculated from the Arrhenius equation [15,16]

$$CR = A \exp(-E_a^* / RT) \tag{4}$$

where CR is the rate of corrosion. and transition-state equation

$$CR = RT / Nh \exp(\Delta S^* / R) \exp(-\Delta H^* / RT) \tag{5}$$

where A is the frequency factor, h is the Planck's constant, N is Avogadro's number and R is the universal gas constant.

Figs. 7,8 and 9 represent the relation between log CR and 1/T for CS and 316SS in Iww,1MHCL and ADP in the absence and presence of different concentrations of the studied SAO,comp-1. A straight lines were obtained with slope equal to $-E_a^* / 2.303R$. A straight line was obtained with slope equal with slopes of $\Delta H^* / 2.303 R$ and the intercepts equal to $\log R/Nh + \Delta S^* / 2.303R$ The values of activation energies in presence of inhibitor were found higher than in uninhibited solution.

This indicates the formation of higher energy barrier in corrosion reaction by inhibitor molecules. The increase in E_a for corrosion process in inhibitor solution further interpreted as physical adsorption of inhibitor species on to the metal surface [17,18,19] Values of ΔH^* were found positive indicate endothermic nature of steel dissolution process[20]. Endothermic process further indicates that steel dissolution reduces at lower temperatures and increases with in temperatures Negative values of ΔS^* are indicative of formation of activated complex[21,22].

TABLE 8

THE ESTIMATED VALUES OF INHIBITION EFFICIENCY (% IE) FOR DIFFERENT SYNTHETIC COMPOUNDS OF VARYING CONCENTRATIONS OF THE SYNTHETIC COMPOUNDS ON THE CORROSION OF CS AFTER 120- MIN IMMERSION IN 1M HCL AT VARIABLE TEMPERATURES

inhibitor	Conc	%IE			
		30 °C	40 °C	50 °C	60 °C
Comp-1	1x10 ⁻⁵	80.9	76.5	62.3	55.9
	1x10 ⁻⁴	93.2	88.9	70.8	61.6
	5x10 ⁻⁴	95.8	96.6	96.5	86
	1x10 ⁻³	95.2	97.9	97.7	95.8
Comp-2	1x10 ⁻⁵	79.4	68.2	62.3	55.9
	1x10 ⁻⁴	79	69.7	67.9	63.2
	5x10 ⁻⁴	86.8	86.3	82.5	75.8
	1x10 ⁻³	91.2	89.6	86.2	81.5
Comp-3	1x10 ⁻⁵	76.2	74	66.7	52.5
	1x10 ⁻⁴	82.3	76.3	67.1	64.1
	5x10 ⁻⁴	85.4	85.5	81.3	73.2
	1x10 ⁻³	87.2	86.4	84.9	79.8

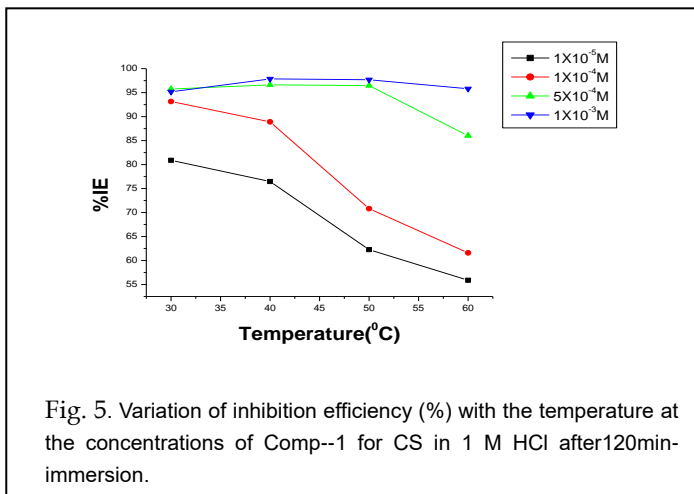


TABLE 10

THERMODYNAMIC ACTIVATION PARAMETERS FOR THE CORROSION OF CS IN 1M HCL IN ABSENCE AND PRESENCE OF SYNTHETIC COMPOUNDS AT DIFFERENT CONCENTRATIONS.

Medium	T (oK)	ΔE_a^* (kJ/mol.)	ΔH^* (kJ/mol.)	ΔS^* (J/mol/degree e)
Comp-1	0	59.4	18.15	-62.54
	1×10^{-5}	98.7	26.2	-64.08
	1×10^{-4}	139.9	29.61	-64.46
	5×10^{-4}	1082.4	42.27	-67.33
Comp-2	1×10^{-3}	191.7	57.34	-70.59
	0	66.04	18.99	-64.64
	1×10^{-5}	61.38	18.83	-64.94
	1×10^{-4}	65.24	21.74	-65.90
Comp-3	5×10^{-4}	72.162	22.99	-66.85
	1×10^{-3}	73.36	25.14	-68.29
	0	74.06	14.44	-62.54
	1×10^{-5}	45.72	11.20	-64.84
	1×10^{-4}	60.50	12.28	-65.42
	5×10^{-4}	63.46	19.11	-68.29
	1×10^{-3}	69.22	19.46	-69.25

TABLE 9

THE ESTIMATED VALUES OF INHIBITION EFFICIENCY (% IE) FOR DIFFERENT ESSENTIAL OILS OF VARYING CONCENTRATIONS OF THE ESSENTIAL OILS ON THE CORROSION OF 316SS AFTER 120- MIN IMMERSION IN ADP AT VARIABLE TEMPERATURES.

inhibitor	(% IE)				
	Conc	35 0C	45 0C	55 0C	65 0C
SAO	0.01	90.8	87.2	73.1	58.3
	0.05	96.8	89.2	79.8	67.4
	0.1	97.9	94.9	84.4	81.6
	0.5	99.6	99.3	97.3	88.7
RO	0.01	83.02	63.7	61.5	44.4
	0.05	87.9	71.8	65.7	51.1
	0.1	91.9	84.9	82.8	76.7
	0.5	98.9	95.6	89.1	85.2
CO	0.01	77.5	65.6	61.2	52.3
	0.05	83.9	70.6	68.1	65.1
	0.1	88.1	79.9	76.6	70.4
	0.5	91.2	84.8	83.3	75.3

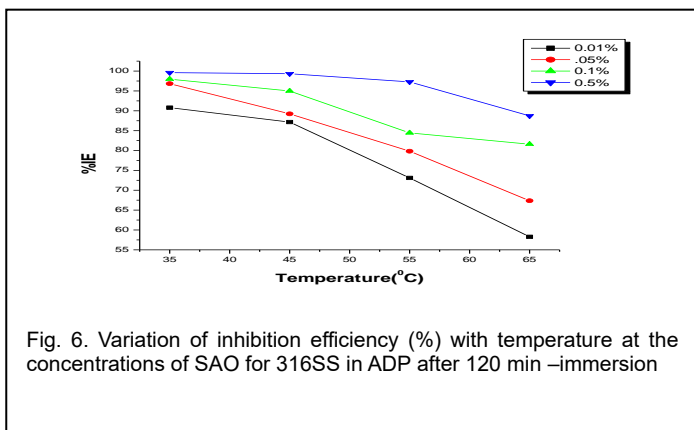


TABLE 11

THERMODYNAMIC ACTIVATION PARAMETERS FOR THE CORROSION OF 316SS IN ADP IN ABSENCE AND PRESENCE OF ESSENTIAL OILS AT DIFFERENT CONCENTRATIONS

Medium	conc	ΔE_a^* (kJ/mol.)	ΔH^* (kJ/mol.)	ΔS^* (J/mol/degree e)
SAO	0	53.70	18.41	-74.9
	0.01	100.29	25.26	-76.9
	0.05	105.86	25.98	-78.82
	0.1	98.78	24.87	-81.9
	0.5	112.78	28.26	-85.52
RO	0	24.44	13.54	-75.95
	0.01	65.70	17.17	-77.68
	0.05	72.30	17.53	-79.30
	0.1	47.43	18.63	-81.12
	0.5	77.03	22.55	-82.65
CO	0	8.03	6.801	-76.10
	0.01	21.66	10.253	-76.33
	0.05	26.8	11.810	-76.71
	0.1	43.82	12.80	-77.67
	0.5	48.103	20.20	-77.79

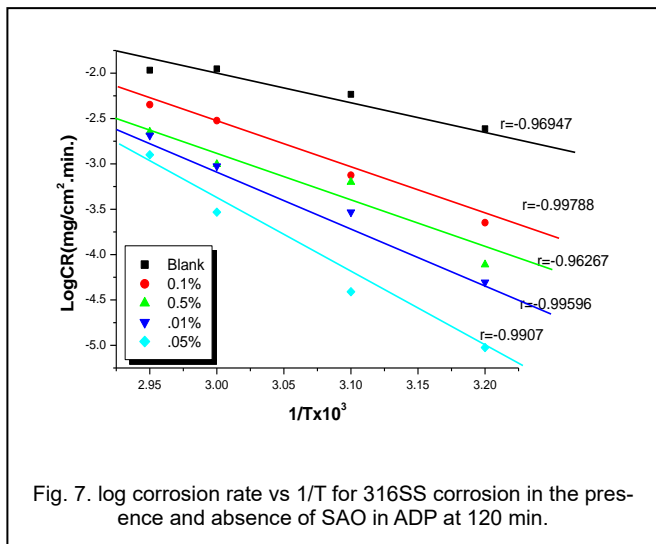


Fig. 7. log corrosion rate vs 1/T for 316SS corrosion in the presence and absence of SAO in ADP at 120 min.

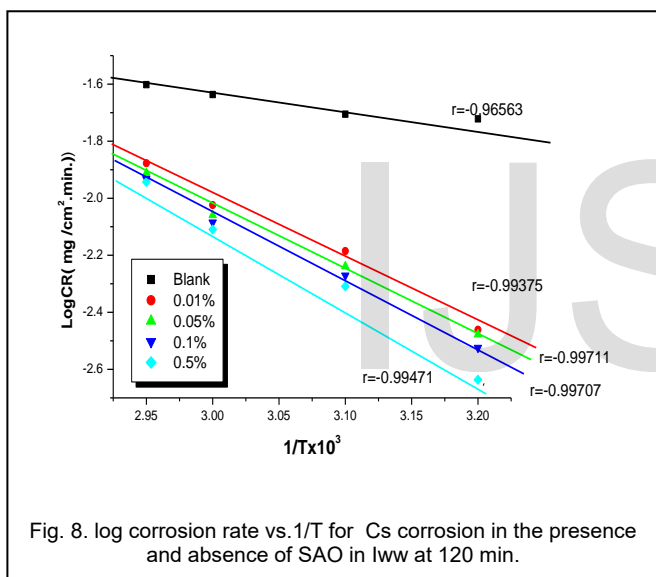


Fig. 8. log corrosion rate vs. 1/T for Cs corrosion in the presence and absence of SAO in lww at 120 min.

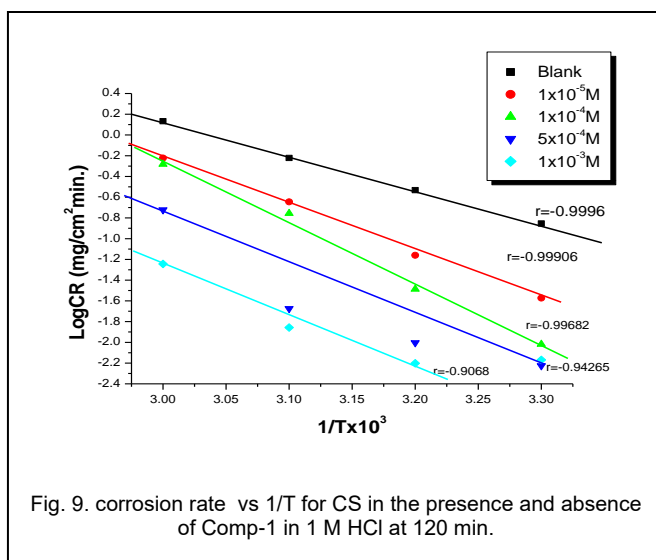


Fig. 9. corrosion rate vs 1/T for CS in the presence and absence of Comp-1 in 1 M HCl at 120 min.

TABLE 13
ADSORPTION PARAMETER OF CS IN IWW WITH ESSENTIAL OILS

Medium	T(°C)	K _{ads}	-ΔG* (kJ/mol)	-ΔH* (kJ/mol)	-ΔS* (J/mol/degree)
SAO	35 °C	0.515	-10.30	-64.78	-176.65
	45 °C	0.275	-8.38		-177.061
	55 °C	0.15	-6.29		-178.02
	65 °C	0.06	-3.39		-172.75
RO	35 °C	0.55	-10.92	-26.38	-50.19
	45 °C	0.3	-7.79		-58.45
	55 °C	0.1	-5.08		-64.93
	65 °C	0.04	-2.19		-73.73
CO	35 °C	0.525	-10.35	-26.21	-51.14
	45 °C	0.225	-7.69		-58.39
	55 °C	0.09	-4.79		-64.94
	65 °C	0.03	-1.45		-71.04

TABLE 12

THERMODYNAMIC ACTIVATION PARAMETERS FOR THE CORROSION OF CS IN IWW IN ABSENCE AND PRESENCE OF ESSENTIAL OILS AT DIFFERENT CONCENTRATIONS.

inhibitor	conc	ΔEa* (kJ/mol.)	ΔH* (kJ/mol.)	ΔS* (J/mol./degree)
SAO	0	16.43	4.31	-73.08
	0.01	30.78	12.28	-75.45
	0.05	45.11	9.94	-75.59
	0.1	49.10	10.78	-75.71
	0.5	63.34	15.13	-75.95
RO	0	45.33	4.37	-72.33
	0.01	45.94	10.95	-74.03
	0.05	45.81	8.64	-74.42
	0.1	54.70	12.70	-74.61
	0.5	57.99	15.24	-74.99
CO	0	23.32	4.26	-73.46
	0.01	27.54	8.25	-74.99
	0.05	31.17	9.16	75.18
	0.1	31.28	16.79	-75.37
	0.5	49.97	21.27	-75.47

3.3. Adsorption isotherm and Gibbs energy

The nature of adsorption can be explained by the process at metal/electrolyte interface. Further to understand the nature of adsorption, obtained surface coverage θ were fitted in different adsorption isotherms. Temkin adsorption isotherm was the best fit. The mathematical expressions for Temkin adsorption isotherm can be expressed by the following equation [23]

$$a\theta = \ln KC \quad (6)$$

where, $0.1 < \theta < 0.9$ and a is a parameter characterizing the interaction in the adsorption layer.

Figs. 10,11 and 12 show the plots of θ vs $\log C$ (Temkin ad-

TABLE 14
ADSORPTION PARAMETER OF 316SS IN ADP WITH ESSENTIAL

inhibitor	T(OC)	K _{ads}	-ΔG* (kJ/mol)	-ΔH* (kJ/mol)	-ΔS* (J/mol/degree)
SAO	35 °C	0.8	-12.074	-71.527	-193.11
	45 °C	0.85	-11.003		-190.327
	55 °C	0.4	-8.589		-191.889
	65°C	0.1	-8.898		197.271
RO	35 °C	0.4	-9.168	-32.10	-45.5
	45 °C	0.2	-6.751		-51.14
	55 °C	0.1	-4.806		-55.77
	65°C	0.03	-1.4066		-70.43
CO	35 °C	0.45	-10.19	-25.49	-49.50
	45 °C	0.22	-7.47		-56.50
	55 °C	0.15	-6.24		-58.14
	65°C	0.05	-2.93		-66.55

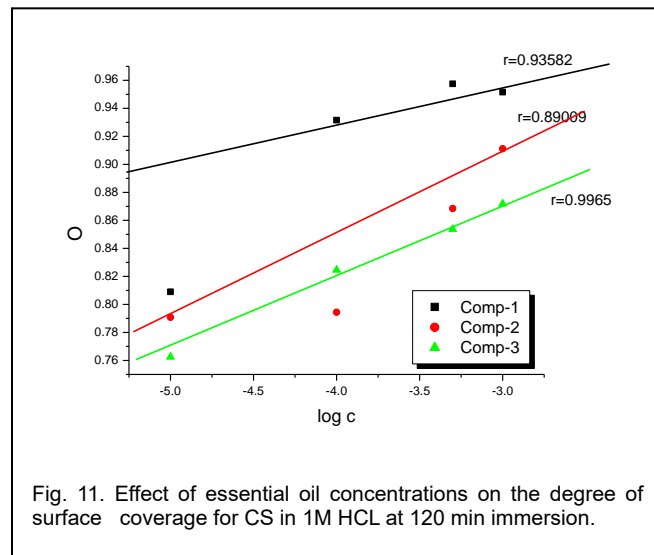


Fig. 11. Effect of essential oil concentrations on the degree of surface coverage for CS in 1M HCL at 120 min immersion.

sorption of additives on the CS and 316SS in Iww,1M HCl and ADP at 35 and 30°C. Thermodynamic parameters for adsorption of the inhibitors in the corrosive media are given in Tables 13,14 and 15. The negative values of free energy of adsorption ΔG°_{ads} indicates that the inhibitors are spontaneously adsorbed on the metal surface [24]. Generally, the magnitude (plots) of ΔG°_{ads} is around to -20 kJ mol⁻¹ or less negative, which can be assumed that a electrostatic interaction exists between the inhibitor and the charged metal surface (i.e. physisorption). Standard free energy of adsorption (ΔG°_{ads}) for adsorption of additives on the CS surface in around -40 kJ mol⁻¹ or more negative indicates that a charge sharing or transferring from organic species to the metal surface occurs to form a coordinate type of bond (i.e. chemisorptions) [25-26] and vice versa The negative values of ΔH°_{ads} and ΔS°_{ads} obtained here indicate that the adsorption process is exothermic with an ordered phenomenon. Similar report has been documented [27].

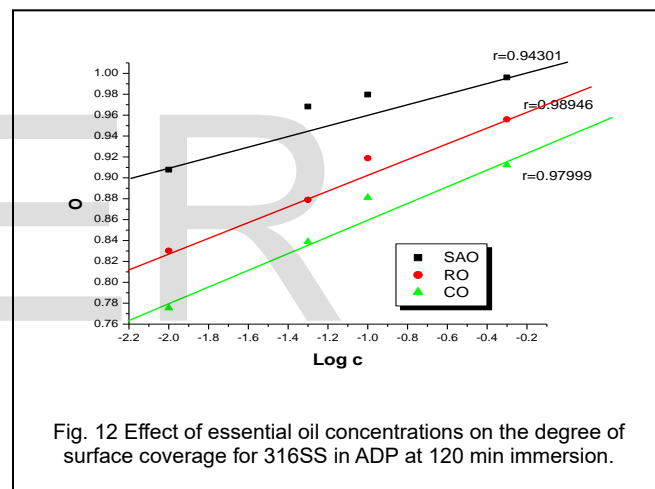


Fig. 12 Effect of essential oil concentrations on the degree of surface coverage for 316SS in ADP at 120 min immersion.

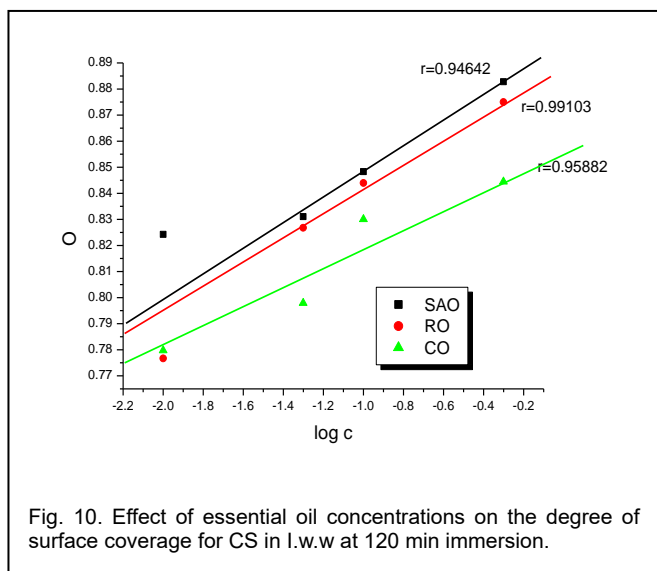


Fig. 10. Effect of essential oil concentrations on the degree of surface coverage for CS in l.w.w at 120 min immersion.

3.4.Synergistic effect on corrosion inhibition

The inhibitive effect of essential oil on CS corrosion in 1M hydrochloric acid solution as studied using by weight loss method the influence of halides viz .KI, KSCN and KBr on corrosion inhibition of EO were also investigated. The results show that EO alone provided satisfactory inhibition on the corrosion of CS and it was also found that the inhibition efficiency increased synergistic in the presence of halide ions .the synergistic effect of halide ions was found to follow the order : KI>KSCN>KBr .the inhibition reduced the corrosion rate through adsorption process inhibition efficiency are given in Table 16.

TABLE 15
ADSORPTION PARAMETER OF CS IN 1M HCL SOLUTION WITH SYN-
THETIC COMPOUNDS.

inhibitor	T °C	K _{ads}	-ΔG* (kJ/mol)	-ΔH* (kJ/mol)	-ΔS* (J/mol/degree)
Comp -1	30 °C	0.55	-10.8	-63.79	-174.8
	40 °C	0.4	-9.7		-172.8
	50 °C	0.2	-6.9		-176.1
	60 °C	0.1	-4.5		-177.8
Comp -2	30 °C	0.45	-10.4	-59.58	-162.2
	40 °C	0.4	-9.2		-160.7
	50 °C	0.25	-7.2		-161.9
	60 °C	0.12	-5.6		-162.08
Comp -3	30 °C	0.35	-8.8	-76.05	-192.2
	40 °C	0.25	-7.6		-194.4
	50 °C	0.15	-6.2		-188.2
	60 °C	0.03	-1.4		-197.1

TABLE 16
EFFECT OF TEMPERATURE ON CS CORROSION IN 1M HCL IN THE
PRESENCE AND ABSENCE OF EO AND ANION SALT AT 35 °C

inhibitor	Temp	IE% (KI)	IE% (KSCN)	IE% (KBR)
SAO	60	76.14	76.24	73.97
	120	87.90	84.99	86.67
	180	92.27	89.33	87.34
	240	92.94	90.86	90.01
RO	60	67.16	68.84	66.02
	120	85.21	79.62	82.39
	180	90.02	86.02	85.61
	240	91.10	88.82	88.19
CO	60	58.71	52.97	53.51
	120	76.93	75.53	76.01
	180	86.27	84.0	81.71
	240	87.97	87.61	87.14

4 CONCLUSION

- 1- The adsorption on the metal surface was found to obey Temkin isotherms.
- 2- Corrosion rates with in temperature and decrease with in inhibitor concentration.
- 3- Result showed that essential oils and synthatic compound are good corrosion inhibitors for steel indifferent corrosive solution.
- 4- EO and COMP show a good inhibitive effects on the corrosion of CS and 316SS in 1MHCL, Iww, ADP media and their inhibition efficiency follows the order:

SAO > RO > CO
Comp-1 > Comp-2 > Comp-3

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