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Characterization of *Acacia Sieberiana* (AS) Gum and Their Corrosion Inhibition Potentials for Zinc in Sulphuric Acid Medium

[1]Paul Ocheje Ameh, [2]Nnabuk Okon Eddy

[1]Physical Chemistry Unit, Department of Chemistry, Nigeria Police Academy, Wudil, P.M B. 3474, Kano State Nigeria
[2]Department of Chemistry, Ahmadu Bello University, Zaria Kaduna State, Nigeria

Abstract: **GCMS analysis of AS gum indicated the presence of camphene (2.15 %), sucrose (23.76 %), hexadecanoic acid (37.32 %), verbenol (5.12 %), octadecanoic acid (10.93 %) and 16-methyl-octadecanoic acid (20.72 %). Through the knowledge of the chemical structures of compounds in AS gum, the potential inhibition potential of the gum was ascertain and investigated using weight loss, thermometric and scanning electron microscopy methods. The gum exhibited efficient inhibition potential between the temperature and concentration ranges of 303 to 333 K and 0.1 to 0.5 g/L respectively. After examining the trend for the variation of inhibition efficiency of the gum with temperature and the magnitude of calculated values of activation and standard free energies of adsorption, the mechanism of physical adsorption was established for the adsorption of the inhibitor on the surface of zinc. The adsorption of the inhibitor on the metal surface was also found to be spontaneous, exothermic and occurred with increasing degree of association. The failure of the Langmuir adsorption model to account for the existence of molecular interaction parameter was addressed through the fitness of the Frumkin adsorption model, which revealed the attractive behavior of the inhibitor. Scanning electron micrographs of the metal with and without the inhibitor clearly revealed the formation of protective layer on the surface of the inhibitor by the gum.**

Keywords: **Corrosion, zinc, inhibition, gum, mechanism.**

I. INTRODUCTION

Corrosion is a serious problem in industries where contact between a metal (or its alloy) and aggressive medium is inevitable [1]. Several damages due to corrosion attack have been reported in some oil pipelines, hot water systems, fertilizer installation plant, metallurgical and other industries [2]. Efforts aimed at abating the destructive role of corrosion have led to the development of several control measures including painting, oiling, electroplating, etc. However, one of the most effective options involves the use of chemical substances that can reduce the rate of corrosion, i.e the use of corrosion inhibitors [3].

Several compounds have been tested and confirmed to be effective as corrosion inhibitors. Some of these compounds include nitrite, chromate, dichromate and vanadic salts. However, most of these compounds are toxic, expensive, non-biodegradable and are not eco-friendly [4]. Therefore, current researches are centered on the need to discover green corrosion inhibitors in order to replace the toxic ones [5].

Extracts of several plants and animals have been extensively investigated as inhibitors for the corrosion of some metals [6]. They are often considered as green corrosion inhibitors because most of them are natural and are less toxic. Several research groups have investigated the corrosion inhibition potentials of several polysaccharides and most of them were

found to be effective as corrosion inhibitors [2, 7 – 11]. Polysaccharides have advantage of forming large surface area of adsorption. They are less toxic, biodegradable and eco-friendly [12].

Acacia sieberiana (*AS*) is an economic tree extensively grown in the Northern Nigeria particularly Yobe Jigawa and Sokoto states. The purified gum is widely used in pharmaceutical, cosmetic, confectionary and paper industries as binders and foaming agents. Although literature is scanty on the chemical composition of *AS* gum, it is believe to exhibit some properties similar to other natural polymers. Natural polymers are polysaccharides composed of large forms of units with varying chemical compositions, large derivatizable groups and a wide range of molecular weights. They are characterized by low toxicity, high stability and biodegradability. An appropriate evaluation of the physical and chemical composition of *AS* gum will determine its suitability for various applications.

Generally, organic corrosion inhibitors are chosen from the knowledge of their chemical structures. The presence of hetero atoms (N, O, P or S), suitable functional groups (such as –OH, COOH, C=O, C=C and NH) as well as aromatic or long carbon chain in the chemical structure of an organic compounds have been found to confer viable corrosion inhibition properties. .

The present study is aimed at investigating the chemical constitution of *Acacia sieberiana* gum exudate and its potential as a corrosion inhibitor for zinc in solution of tetraoxosulphate (VI) acid.

II. EXPERIMENTAL

2.1 Materials preparation

The sheets of zinc, A72357 type used for this study were obtained from the Novara group Limited England. Each sheet was 0.4 mm in thickness and were mechanically pressed cut into 5 x 4 cm coupons. *Acacia sieberiana* (AS) gum exudate was obtained from Dutsinma Local Government Area of Katsina State, Nigeria. The exudates were purified following the method of Ameh (2012). The concentrations of inhibitor (AS) prepared and used in the study were 0.1-0.5 g/l. Concentrations of H_2SO_4 used for thermometric and weight loss studies were 2.5 and 0.1 M respectively.

2.2 GC-MS analysis

GC-MS analysis was carried out on a GC Clarus 500 Perkin Elmer system comprising of a AOC-20i auto-sampler and gas chromatograph interfaced to a mass spectrometer (GC-MS) instrument employing the following conditions: column Elite-1 fused silica capillary column (30 x 0.25 mm ID x 1µM df, composed of 100% Dimethylpoly diloxane), operating in electron impact mode at 70eV; helium (99.999%) was used as carrier gas at a constant flow of 1 ml /min and an injection volume of 0.5 µI was employed (split ratio of 10:1) injector temperature 250 ºC; ion-source temperature 280ºC. The oven temperature was programmed from 110 ºC (isothermal for 2 min), with an increase of 10 ºC/min, to 200ºC, then 5ıC/min to 280ºC, ending with a 9min isothermal at 280ºC. Mass spectra were taken at 70 eV; a scan interval of 0.5 seconds and fragments from 40 to 450 Da. Total GC running time is 36 min.

Interpretation on mass spectrum GC-MS was conducted using the database of National Institute of Standard and Technology (NIST) Abuja, having more than 62,000 patterns. The spectrum of the unknown component was compared with the spectrum of the known components stored in the NIST library. The name, molecular weight and structure of the components of the test materials were ascertained. Concentrations of the identified compounds were determined through area and height normalization.

2.3. Gravimetric Method

In the weight loss experiment, the pre-cleaned zinc coupon was dipped in 20 mL of the test solution maintained at 303, 313, 323 and 333 K in a thermostated bath respectively. The weight loss was determined by retrieving the coupons at 24 hours interval progressively for 168 hours (7 days). Prior to measurement, each coupon was washed in 5 % chromic acid solution (containing 1% silver nitrate) and rinsed in deionized water. The difference in weight was taken as the weight loss of zinc.

International Journal of Novel Research in Physics Chemistry & Mathematics
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From the average weight loss (mean of three replicate analysis) results, the inhibition efficiency (%I) of the inhibitor, the degree of surface coverage (θ) and the corrosion rate of zinc (CR) were calculated using the following equations,

$$\%I = \left(1 - \frac{w_1}{w_2}\right) \times 100 \quad (1)$$

$$\theta = \left(1 - \frac{w_1}{w_2}\right) \quad (2)$$

$$CR = \frac{w_2 - w_1}{At} \quad (3)$$

where W_1 and W_2 are the weight losses (g) for zinc in the presence and absence of the inhibitor in H_2SO_4 solution, θ is the degree of surface coverage of the inhibitor, A is the area of the zinc coupon (in cm^2), t is the period of immersion (in hours).

2.4. Thermometric Method

This was also carried out as reported elsewhere [3]. From the rise in temperature of the system per minutes, the inhibition efficiency was calculated using equation 4:

$$\%I = \frac{RN_{aq} - RN_{wt}}{RN_{aq}} \times 100 \quad (4)$$

where *RNaq* is the reaction number in the absence of inhibitors (blank solution: 2 M H_2SO_4) and *RNwi* is the reaction number for the system containing the studied inhibitor.

2.5. Scanning Electron Microscopy (SEM) Study

The surface morphology of the mild steel before and after inhibition was studied using a JSM-5600 LV scanning electron microscope (SEM) of JEOL, Tokyo, Japan. The sample was mounted on a metal stub and sputtered with gold in order to make the sample conductive, and the images were taken at an accelerating voltage of 10 kV.

III. RESULTS AND DISCUSSION

3.1 GC MS Study

Fig. 1 shows the GC-MS spectrum of *Acacia sieberiana* (AS) gum. From the spectrum, it is evident that there are six prominent peaks, hence six identified compounds in the gum. Since area under a given peak in a GCMS spectrum corresponds to the concentration of the compound, area normalization was carried out and the results obtained, are presented in Table 1. Table 1 also presents, retention time and fragmentation peaks for each compound. In Fig. 2, chemical structures of the identified compounds are presented and labeled according to the peak or line number in the spectrum.

In the GCMS spectrum of AS gum, line 1 indicated the presence of 2.15 % camphene, which was separated under a retention time of 15.05 minutes and was characterized with a mass peak value of 21 and six (6) fragmentation peaks. Line 2 in the spectrum revealed the presence of sucrose (23.76 %) at characteristic retention time and mass peak values of 24.467 minutes and 26 respectively. Sucrose is one of the major components of most plant gum and the gummy ability of *AS* gum may be largely attributed to the presence of sucrose (Eddy *et al*., 2012c,d). In line 3, 37.32 % of hexadecanoic acid was identified at a retention time of 26.54 minutes and the mass peak value was 64.50. In line 4, 5.12 % of a commercially viable compound, verbenol was identified under a retention time and mass peak values of 28.257 minutes, and 80 respectively. Similarly, octadecanoic acid (10.93 %) and 16-methyl-octadecanoic acid (20.72 %) were identified in lines 5 and 6 respectively. These compounds were separated after a retention time of 26.328 and 24.582 minutes respectively.

International Journal of Novel Research in Physics Chemistry & Mathematics
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3.2 Corrosion inhibition study

From the chemical structures of compounds in *AS* gum (Fig. 2), it can be seen that the gum is expected to be a good corrosion inhibitor because the chemical structures possess one or more of the following,

(i) Suitable functional groups (-OH, C=C, etc)

(ii) Hetero atom

(iii) Aromatic or bond carbon chain systems

In view of the above, AS gum was investigated as an inhibitor for the corrosion of zinc using weight loss and thermometric method. Fig. 3 shows plots for the variation of weight loss with time for the corrosion of zinc in 0.1 M H_2SO_4 containing various concentrations of AS gum at 303, 313, 323 and 333 K respectively. The plots revealed that weight loss of zinc increases with increase in the period of contact but decreases with increase in the concentration of *AS* gum indicating that *AS* gum inhibited the corrosion of zinc in solution of H_2SO_4. Weight loss of zinc was also found to decrease with increasing temperature. Therefore the rate of corrosion of zinc increases with increase in temperature indicating that the inhibition efficiency of *AS* gum decreases with increase in temperature, a condition that favours the mechanism of physical adsorption.

Values of inhibition efficiency of AS gum, degree of surface coverage of the gum and the corrosion rate of zinc in various media are presented in Table 2. The results obtained, revealed that the inhibition efficiency of *AS* gum increases with increase in concentration but decreases with increasing temperature. A plot showing the variation of inhibition efficiency with time (Fig. 4) also indicated that the inhibition efficiency tends to decrease with time. However, at 323 K and at AS gum concentrations of 0.4 and 0.5 g/L, inhibition efficiency of the gum first decreases with time up to the 100 hours of immersion but started increasing with time after this period. This may be attributed to the enhancement in the rate of diffusion of the inhibitor's molecules to the surface of the metal at these concentrations and at the corresponding time. Inhibition efficiencies obtained from thermometric measurements at 0.1, 0.2, 0.3, 0.4 and 0.5 g/L were 40.20, 45.80, 51.10, 56.90 and 60.00 % respectively. These values are higher than those obtained from weight loss measurements indicating that the instantaneous inhibition efficiency of *AS* gum is higher than the average inhibition efficiency of the gum.

3.3 Kinetic study

The corrosion of zinc in the absence and presence of AS gum was found to be first order. Hence the application of equation 5

$$log\left(\frac{[W]_t}{[W]_0}\right) = -\frac{k_1 t}{2.303} \qquad 5$$

where $[W]_0$ and $[W]_t$ are weight loss of zinc at time, t = 0 and at some other time, t. k_1 is the first order rate constant. Plots of $log\left(\frac{[W]_t}{[W]_0}\right)$ versus t were linear (plots not shown) and the first order rate constant was deduced from the slope of the graph (Table 4). From k_1 values, values for the half-life of zinc were estimated using the relation, $t_{\frac{1}{2}} = 0.693/k_1$. Calculated values of $t_{\frac{1}{2}}$ are also presented in Table 4. The half lives of zinc in the absence of the inhibitor are seen to be lower than those calculated for the inhibition systems indicating that *AS* gum increases the half-life of zinc in solution of H_2SO_4.

3.4 Effect of temperature

Activation energies for the corrosion of zinc in 0.1 M H_2SO_4 and in the presence of various concentrations of AS gum as an inhibitor were calculated using the Arrhenius equation, which can be written as follows [13],

$$CR = Aexp\left(\frac{E_a}{RT}\right) \qquad 6$$

International Journal of Novel Research in Physics Chemistry & Mathematics
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where CR is the corrosion rate of zinc, A is Arrhenius or pre-exponential constant, E_a is the activation energy, R is the gas constant and T is the temperature. From the logarithm of both sides of equation 6, equation 7 was obtained,

$$log(CR) = log(A) - \frac{E_a}{2.303RT} \qquad 7$$

Comparison of equation 7 with the general equation of a straight line implies that, plots of log CR versus 1/T are expected to be linear if the Arrhenius model is obeyed. Fig. 5 shows the Arrhenius plots for the corrosion of zinc in the absence and presence of the inhibitor. Excellent correlation coefficients (R^2) were obtained for all the plots. A and E_a values were calculated from the intercept and slope of the plots respectively. The results obtained indicated that the E_a for the blank was higher than those obtained for the inhibited systems indicating that the adsorption of the inhibitor requires lower energy compared to the energy needed for the corrosion of the metal. The activation energies were also found to be within the range of values expected for the mechanism of physical adsorption. It has been found that while activation energy is related to enthalpy change, the Arrhenius constant is related to the degree of disorderliness of a system (that is entropy change). However, in this study, 'A' values were found to decrease with increase in the concentration of AS gum suggesting that the degree of association of the molecule (or orderliness) of the system increases with increasing concentration. Such trend is expected for an efficient inhibition system.

3.4 Thermodynamic/adsorption study

Enthalpy and free energy changes for the adsorption of AS gum on zinc surface were calculated using the transition state equation, which can be written according to equation 9 [14],

$$CR = \frac{RT}{Nh} exp\left(\frac{\Delta S^0}{R}\right) exp\left(\frac{-\Delta H^0}{RT}\right) \qquad 9$$

where R is the gas constant, T is the temperature, N is the Avogadro's number, h is the Plank constant, ΔS^0 *and* ΔH^0 are the entropy and enthalpy changes for the adsorption of *AS* gum on the surface of zinc. From the logarithm of both sides of equation 9, equation 10 was obtained,

$$log\left(\frac{CR}{T}\right) = log\left(\frac{R}{Nh}\right) + \frac{\Delta S^0_{ads}}{2.303R} - \frac{\Delta H^0_{ads}}{2.303RT} \qquad 10$$

The mathematical implication of equation 10 is that ΔS^0 *and* ΔH^0 can be obtained from the intercept and slope of the linear plot of $log\left(\frac{CR}{T}\right)$ versus 1/T. Fig. 6 shows the transition state plots for the adsorption of AS gum on the surface of zinc. R^2, ΔS^0_{ads} *and* ΔH^0_{ads} values, deduced from the plots are presented in Table 4. Excellent correlations were obtained for the plots and values of ΔS^0_{ads} were negative, which implies that there is an increasing degree of orderliness in the adsorption of AS molecules. Negative values obtained for ΔH^0_{ads} indicated that the adsorption of *AS* gum on the surface of zinc is exothermic.

The adsorption characteristics of *AS* gum for zinc was investigated by fitting curves for different adsorption isotherms and it was found that Langmuir and Frumkin adsorption isotherms gave best values for the degree of linearity (i.e R^2).

The assumptions of the Langmuir adsorption model can be expressed as follows,

$$log\left(\frac{C}{\theta}\right) = logb_{ads} - logC \qquad 11$$

where C is the concentration of the inhibitor in the bulk electrolyte, θ is the degree of surface coverage of the inhibitor and b_{ads} is the adsorption equilibrium constant, which is related to the standard free energy of adsorption (ΔG^0_{ads}) according to equation 12,

$$b_{ads} = \frac{1}{55.5} exp\left(\frac{\Delta G^0_{ads}}{RT}\right) \qquad 12$$

Using equation 12, plots of $log\left(\frac{C}{\theta}\right)$ versus logC were linear (Fig. 7). R^2 values (Table 5) were very close to unity indicating the application of the Langmuir model to the adsorption of *AS* gum on the surface of zinc. However, calculated

values of the slopes (Table 5) were not equal to unity as expected by equation 11. The basic assumption of the Langmuir adsorption isotherm is the absence of interaction between the inhibitor and the metal surface. Since calculated slope values are less than unity in this study, it is significant to state that there is some interactions between the adsorbate and the adsorbent. This led us to the investigations of other supporting models and the Frumkin adsorption model was found to be the best isotherm that describes the interaction between the adsorbed species.

The expression for the Frumkin adsorption model is as follows [15],

$$log\left(\frac{1}{1-\theta}\right)[C] = logb_{ads} + 2a\theta \qquad 13$$

Equation 13 reveals that linear relationship exist between values of $log\left(\frac{1}{1-\theta}\right)[C]$ plotted against values of θ. Therefore the slope and intercept of such plots can be used to calculate values of $logb_{ads}$ and the interaction parameter ('a') respectively. Fig. 8 shows the Frumkin isotherms for the adsorption of *AS* gum on the surface of zinc. As in the Langmuir adsorption model, R^2 values calculated from the Frumkin adsorption isotherms (Table 5) are very close to unity, which also indicates the application of the Frumkin isotherm to the adsorption of *AS* gum on the surface of zinc. Calculated values for the molecular interaction parameters (Table 5) were positive, which compromises with the attractive behavior of the inhibitor.

The standard free energy of adsorption is a parameter than can be used to predict the direction of a chemical reaction, including corrosion reaction. In this study, values of free energy of adsorption were calculated by substituting values of b_{ads} into equation 12. The results obtained are also presented in Table 5. Free energy data calculated through the Langmuir and Frumkin parameters are comparable to each other. The free energies are negatively less than the threshold value (- 40 kJ/mol) required for the mechanism of chemical adsorption. Hence the adsorption of *AS* gum on the surface of zinc is spontaneous and supported the mechanism of physical adsorption.

3.6 Scanning electron microscopic studies

Fig. 7 shows scanning electron micrograph of zinc in 0.1 M H_2SO_4 without an inhibitor (i.e Fig. 7a) and in the presence of 0.5 g/L of *AS* gum, as an inhibitor (Fig. 7b). A close examination of the two micrographs revealed that the surface morphology of zinc during corrosion displayed the existence of some pitches and unsmooth surface but in the presence of *AS* gum as an inhibitor, the surface of the metal is seen to be protected against corrosion by the formation of a protective layer or film.

IV. CONCLUSION

The study revealed that AS gum is a good corrosion inhibitor for the corrosion of zinc in solution of H_2SO_4. The inhibitor functions effectively between the temperature range of 303 and 333 K and between concentration range of 0.1 to 0.5 g/L. The inhibitive action of the gum is due to its potential to be adsorbed on the surface of the metal and the subsequent formation of protective layer that retarded the corrosion of the metal through molecular interaction with the metal. The adsorption behavior of the inhibitor compromises with the assumptions of Frumkin isotherm.

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APPENDIX - A

Table 1: Characteristics of suggested compounds identified from GC-MS of AS gum

Line No	IUPAC Name	Molecular formula	Molar mass (g/mol)	RT(s)	Mass peak	% C	Fragmentation peak
1	Camphene	$C_{10}H_{16}$	136	15.050	21	2.15	30(30%), 31(30%), 33(48%), 47(100%), 63(50%), 76(30%)
2	Sucrose	$C_{12}H_{22}O_{11}$	342	24.467	26	23.76	30(20%),31(5%), 40(30%),55(62%),66(60%), 82(40%),100(50%),125(32%), 145(100%), 177(40%).
3	Hexadecanoic acid	$C_{16}H_{32}O_2$	256	26.540	64	37.32	30(2%), 31(80%), 50(70%), 63(90%), 75(30%), 88(20%) 100(10%), 125(40%), 143(2%) 157(2%), 161(3%), 175(10%), 199(5%), 210(15%), 225(5%), 250(20%).
4	Verbenol	$C_{10}H_{16}O$	152	28.257	80	5.12	31(79%), 33(100%), 40(70%), 53(80%), 65(25%), 78(10%), 110(10%), 120(10%), 143(5%),157(8%), 171(7%),185(10%),199(6%), 213(20%), 227(8%), 256(20%)

5	Octadecanoic acid	$C_{18}H_{36}O_2$	284	26.328	62	10.93	31(85%), 63(75%), 105(10%), 175(5%), 213(5%), 250(5%), 284(30%).	33(100%), 75(20%), 120(20%), 185(10%), 225(5%),	47(60%), 78(10%), 145(5%), 190(5%), 231(20%),
6	16-methyl-octadecanoic acid	$C_{19}H_{36}O_2$	296	24.582	72	20.72	31(50%), 69(70%), 78(15%), 227(15%), 260 (30%).	33(100%), 84(50%), 98(45%),	33(38%) 75(40%), 112(20%),

Table 2: Inhibition efficiency of AS gum and corrosion rate (g/cm^2h) of in various systems

System	%I (303 K)	%I (313 K)	%I (323 K)	%I (333 K)	CR_1 (303 K)	CR_2 (313 K)	CR_3 (323 K)	CR_4 (333 K)
Blank	-	-	-	-	1.23×10^{-4}	1.55×10^{-4}	1.81×10^{-4}	2.18×10^{-4}
0.1 g/L	37.70	34.36	.29.70	28.31	8.02×10^{-5}	1.03×10^{-4}	1.21×10^{-4}	1.56×10^{-4}
0.2 g/L	42.53	.39.73	30.53	31.60	7.44×10^{-5}	9.33×10^{-5}	1.25×10^{-4}	1.48×10^{-4}
0.3 g/L	45.29	.40.69	31.03	30.89	7.08×10^{-5}	9.21×10^{-5}	1.23×10^{-4}	1.43×10^{-4}
0.4 g/L	.50.57	.42.42	39.77	38.00	6.41×10^{-5}	8.94×10^{-5}	1.09×10^{-4}	1.28×10^{-4}
0.5 g/L	.57.93	.52.21	45.38	43.89	5.40×10^{-5}	7.40×10^{-5}	9.85×10^{-5}	1.16×10^{-4}

Table 3: Kinetic parameters for the inhibition of the corrosion of zinc in solution of H_2SO_4 by various concentrations of AS gum at 303 to 333 K

T (K)	C (g/l)	k_1	$t_{1/2}$ (day)	R^2
303 K	Blank	0.0037	3	0.9578
	0.1	0.0032	4	0.9826
	0.2	0.0032	4	0.9794
	0.3	0.0028	4	0.9867
	0.4	0.0025	5	0.9541
	0.5	0.0021	5	0.9904
313 K	Blank	0.0051	2	0.9921
	0.1	0.0035	3	0.9947
	0.2	0.0034	3	0.9894
	0.3	0.0032	4	0.9793
	0.4	0.0028	4	0.9705
	0.5	0.0029	4	0.9646
323 K	Blank	0.0048	2	0.9936
	0.1	0.0037	3	0.9887
	0.2	0.0035	3	0.9884
	0.3	0.0038	3	0.9908
	0.4	0.0033	3	0.9825
	0.5	0.0034	3	0.9909
333 K	Blank	0.0083	1	0.9947
	0.1	0.0079	1	0.9907
	0.2	0.0047	2	0.9756
	0.3	0.0037	3	0.9826
	0.4	0.0035	3	0.9855
	0.5	0.0051	2	0.9840

International Journal of Novel Research in Physics Chemistry & Mathematics
Vol. 1, Issue 1, pp: (25-36), Month: September-December 2014, Available at: www.noveltyjournals.com

Table 4: Activation energy and thermodynamic parameters for the adsorption of AS gum on zinc surface

C (g/l)	Arrhenius parameters			Transition state parameters		
	A	E_a (J/mol)	R^2	$\Delta H^0_{ads}(J/mol)$	ΔS^0_{ads} (J/mol)	R^2
Blank	42395.07	59.55	0.9957	-0.16	-197.01	0.9955
0.1	3122.49	46.99	0.9802	-0.13	-197.13	0.9799
0.2	3719.29	48.35	0.9915	-0.13	-197.12	0.9901
0.3	8385.74	47.39	0.9931	-0.13	-197.13	0.9895
0.4	896.04	40.46	0.995	-0.11	-197.20	0.9879
0.5	774.94	40.30	0.9963	-0.11	-197.20	0.9930

Table 5: Langmuir parameters for the adsorption of AS gum on zinc surface

Isotherm	T (K)	Slope	Intercept	a	$\Delta G^0_{ads}(J/mol)$	R
Langmuir	303	0.7524	0.1898		-11.20	0.9904
	313	0.7842	0.256		-11.96	0.9842
	323	0.7521	0.3141		-12.70	0.9537
	333	0.7553	0.3243		-13.16	0.9696
Frumkin	303	0.8455	0.3042	0.42275	-11.88	0.9945
	313	0.8221	0.267	0.41105	-12.05	0.9617
	323	0.6599	0.1699	0.32995	-11.84	0.9632
	333	0.6858	0.176	0.3429	-12.24	0.9707

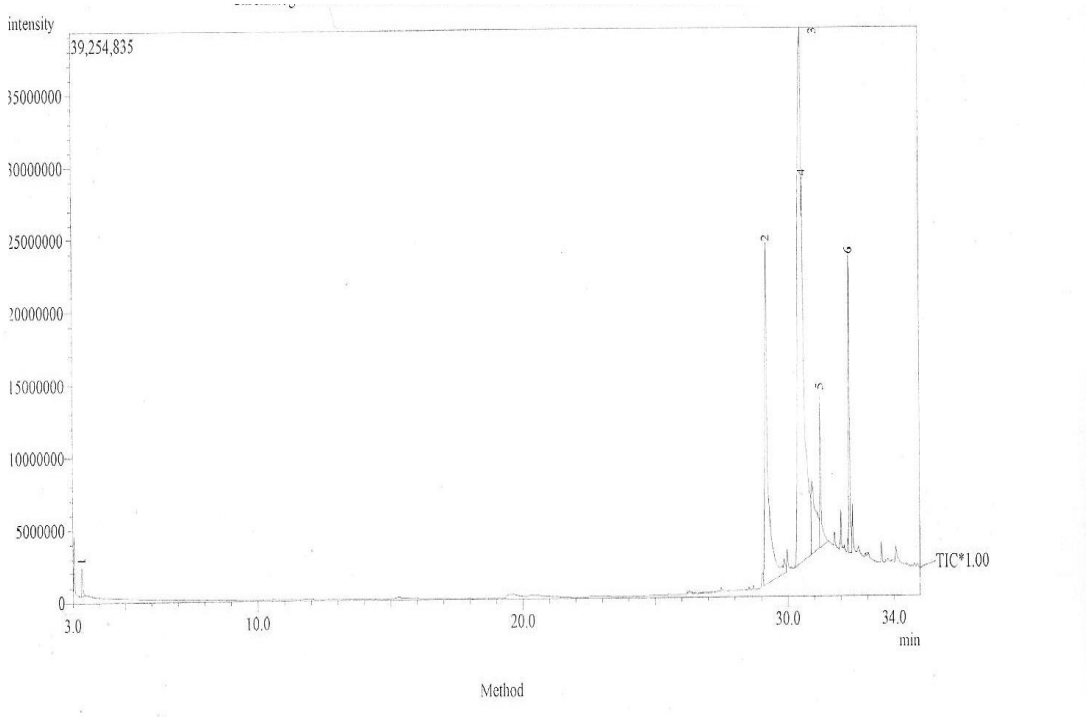


Fig. 1: GCMS spectrum of AS gum

International Journal of Novel Research in Physics Chemistry & Mathematics
Vol. 1, Issue 1, pp: (25-36), Month: September-December 2014, Available at: www.noveltyjournals.com

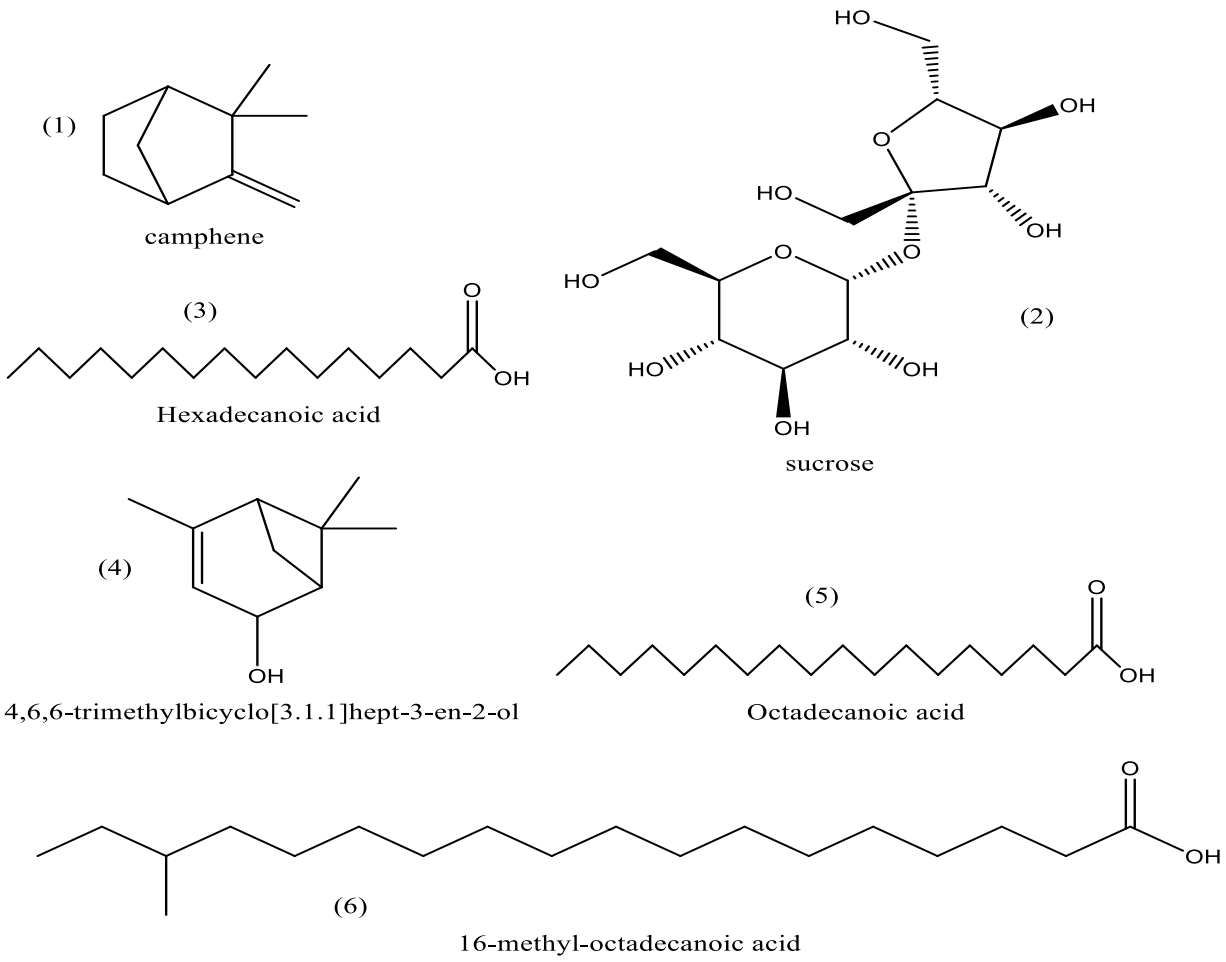


Fig. 2: Chemical structures of compounds identified in the GCMS spectrum of *AS* gum (Numbering on the structures corresponds to the line number in the spectrum)

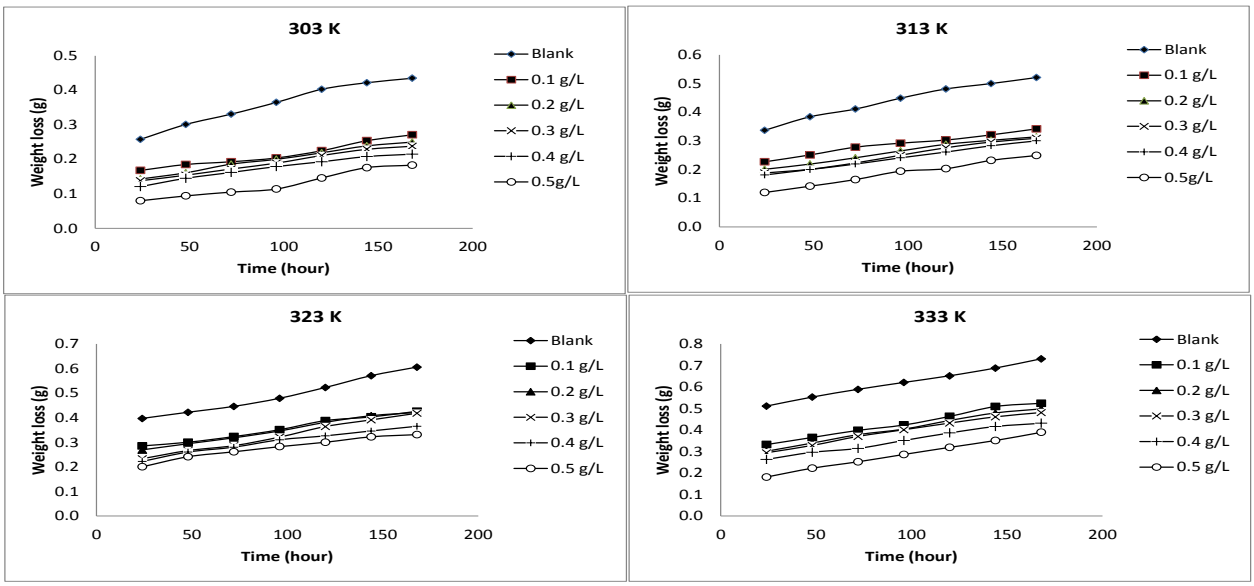


Fig. 3: Variation of weight loss with time for the corrosion of zinc in 0.1 M H_2SO_4 (the blank) containing various concentrations of AS gum at various temperatures.

International Journal of Novel Research in Physics Chemistry & Mathematics
Vol. 1, Issue 1, pp: (25-36), Month: September-December 2014, Available at: www.noveltyjournals.com

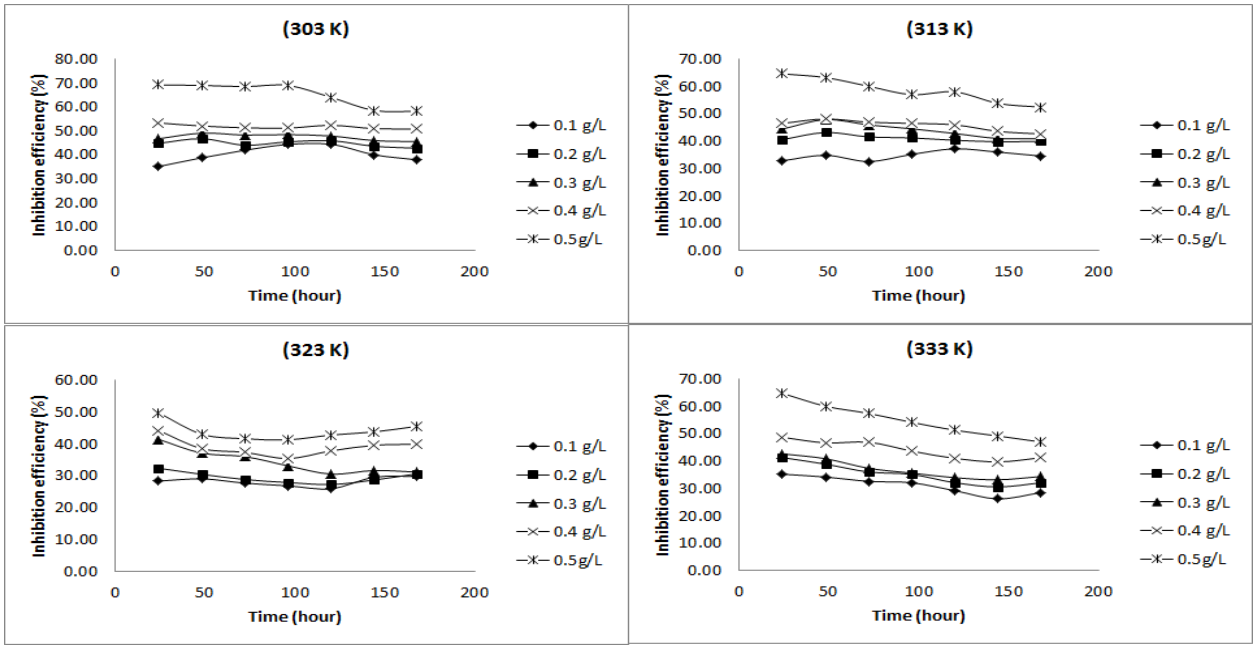


Fig. 4: Variation of inhibition efficiency of AS gum with time

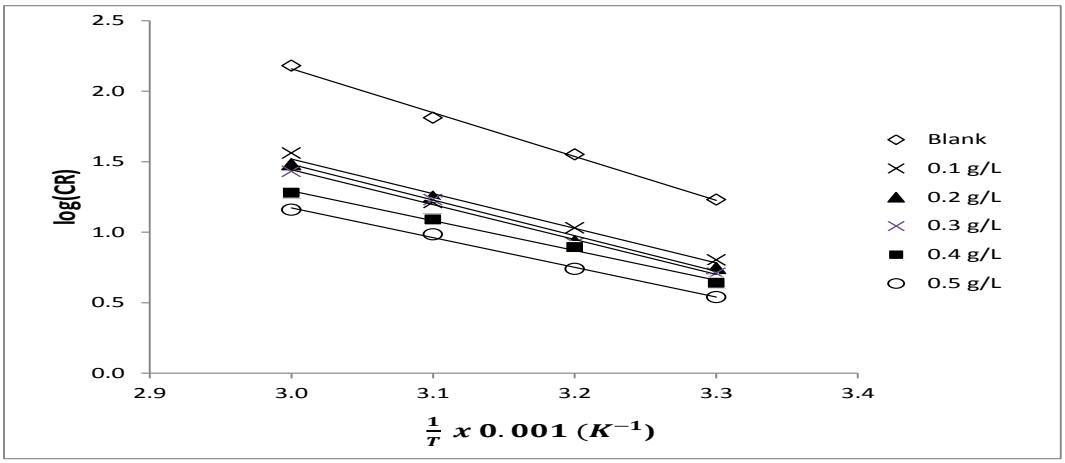


Fig. 5: Variation of log CR with 1/T for the adsorption of AS gum on the surface of zinc

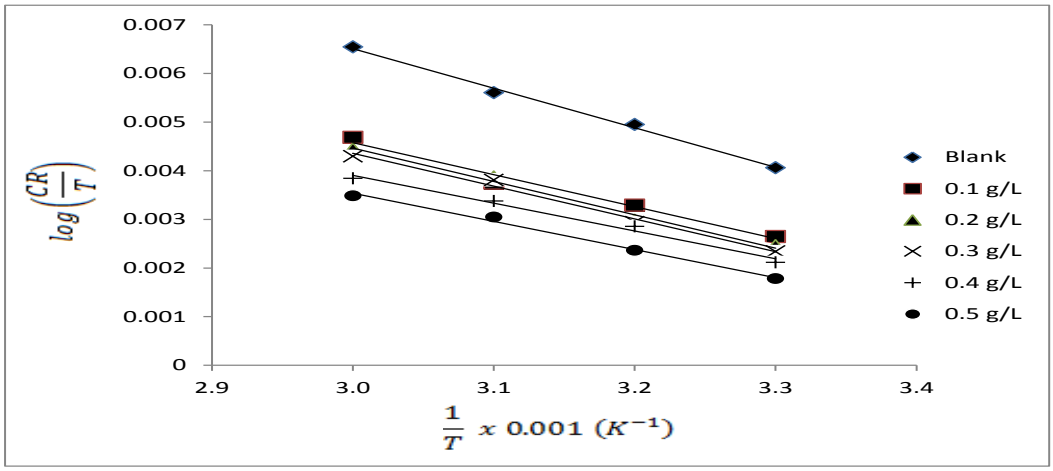


Fig. 6: Variation of log (CR/T) with 1/T for the adsorption of *AS* gum on the surface of zinc

International Journal of Novel Research in Physics Chemistry & Mathematics
Vol. 1, Issue 1, pp: (25-36), Month: September-December 2014, Available at: www.noveltyjournals.com

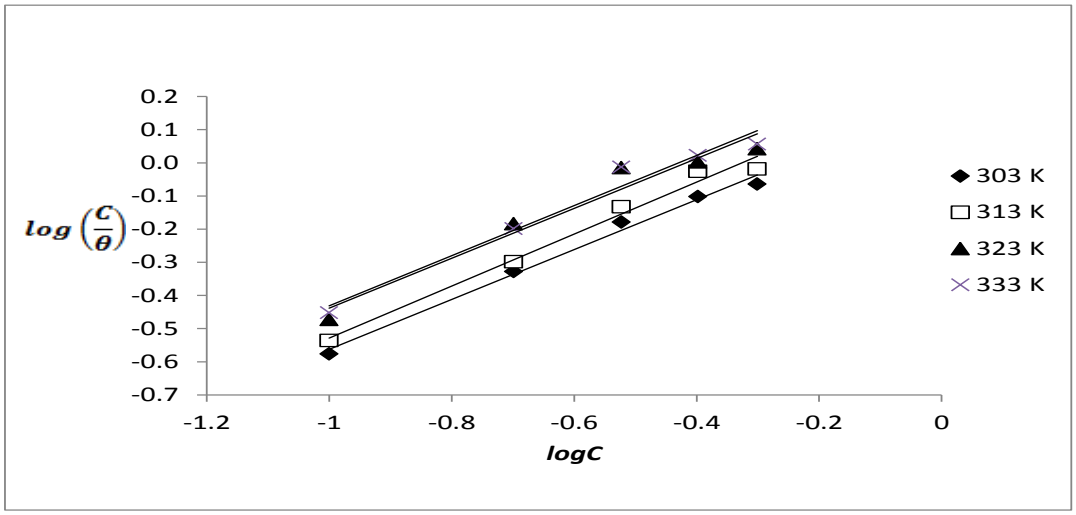


Fig. 7: Variation of log(C/θ) with logC for the adsorption of *AS* gum on the surface of zinc

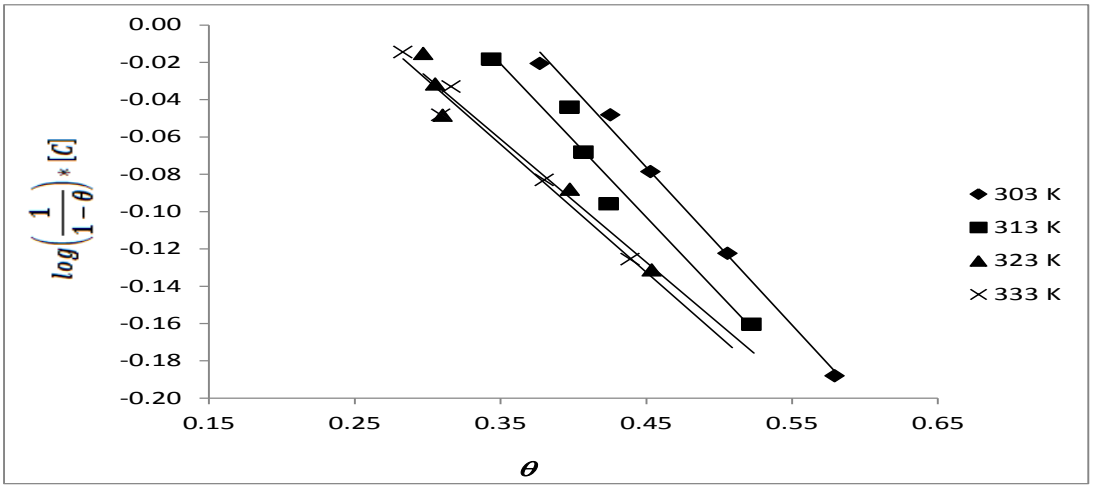
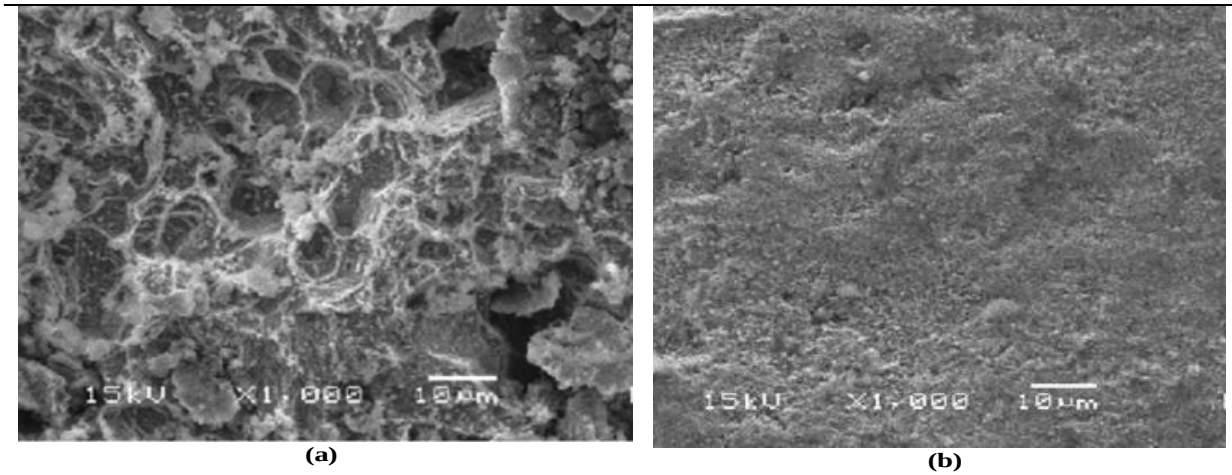


Fig. 8: Variation of $log\left(\frac{1}{1-\theta}\right)[C]$ *with* θ for the adsorption of *AS* gum on the surface of zinc



(a) **(b)**

Fig. 9: Scanning electron micrographs of zinc in (a) 0.1 M H_2SO_4 (b) 0.1 M H_2SO_4 containing 0.5 g/L of AS gum as an inhibitor