

Chemical Information from GCMS of *Ficus Platyphylla* Gum and its Corrosion Inhibition Potential for Mild Steel in 0.1 M HCl

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Chemical constituents of purified sample of *Ficus platyphylla* gum was investigated using GCMS technique. The results obtained indicated the presence of methoxy-phenyl-oxime (0.79 %), 1-methoxyethyl benzoate (4 %), palmitic acid (7.58 %), oleic acid (10.15 %), octadecanoic acid (6.2 %), 1-phenanthrenecarboxylic acid (podoca) (17.78 %), albietic acid (19.28 %), (6,8,9-trimethyl-4-(1-phenylethyl)-3-oxabicyclo[3.3.1]non-6-en-1-yl)methanol (1.16%) and tetracosamethylcyclododecasiloxane-(2,2,4,4,6,6,8,8,10,10,12,12,14,16,16, 18, 18, 20, 20,22,22,24,24-tetracosamethyl cyclododecasiloxane) (31.07 %). *Ficus platyphylla* gum exudate has been found to be a good adsorption inhibitor for the corrosion of mild steel in solutions of HCl. The inhibition efficiency of the gum increased with increasing concentration but decreased with increase in temperature. Analysis of FTIR spectra revealed that *Ficus platyphylla* gum inhibited the corrosion of mild steel in solutions of HCl through the formation of inhibitor-metal complex (via C=O and NH₂ bonds) and adsorption through OH bond. The adsorption of the inhibitor was also found to be spontaneous, exothermic and supported the mechanism of physical adsorption.

Keywords: *Ficus platyphylla* gum, chemical constituents, corrosion inhibition

1. INTRODUCTION

Corrosion inhibitors are needed in industries where contact between metal and aggressive medium is inevitable [1,2]. In view of this, several organic compounds have been found to be good corrosion inhibitors for acidic, basic and salt media [3,4]. Available literatures reveal that these inhibitors have suitable functional groups and hetero atoms that can facilitate their adsorption onto the metal surface [5,6]. However, the toxic nature of some of these inhibitors has been a subject of concern

to researchers and to the environment. Consequently, the search for green corrosion inhibitors is ongoing. The basic requirements for green corrosion inhibitors are [7];

- (i) they should be less toxic and eco friendly
- (ii) they should be biodegradable
- (iii) they should be relatively cheap and easily available

The potentials of some antibiotics, extract of some plants, amino acids, carbohydrates etc., have been investigated as possible replacements for the toxic corrosion inhibitors [1,8,9]. It has also been found that most polymers function as corrosion inhibitors because, through their functional groups, they form complexes with metal ions and on the metal surfaces. These complexes occupy a large surface area, thereby blanketing the surface and protecting the metals from corrosive agents present in the solution. Also, some plant gums are less toxic, they are complex natural polysaccharides consisting of surface-active units such as amino (-NH₂), hydroxyl (-OH) and carboxyl (-COOH), indicating that they are electrochemically active and can therefore interact with metallic surfaces through these units and inhibit corrosion. Because of their prospect in acting as green corrosion inhibitor, some gums have been studied and utilized as inhibitors for several corrosive systems. For example, Umoren *et al.* [10] investigated the anti-corrosive effect of *Pachylobus edulis* exudate gum in combination with halides ions (Cl⁻, Br⁻ and I⁻) for aluminium corrosion in HCl at temperature range of 30 to 60 °C using weight loss method. Results obtained showed that the naturally occurring exudate gum acted as an inhibitor for aluminium corrosion in acidic environment. Inhibition efficiency (%I) was found to increase with increase in concentration of the exudate gum and synergistically increased to a considerable extent on the addition of the halide ions. The inhibitive effect of the gum exudate from *Acacia seyal* var. *seyal* on the corrosion of mild steel in drinking water was investigated using potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) techniques. The results obtained show that gum exudates could serve as effective inhibitors for the corrosion of steel in drinking water network. The percentage inhibition increases with increasing the concentration of the gum at 30 °C. The percentage inhibition efficiency above 95 % was attained at gum concentration of 400 ppm. The corrosion rates of steel and inhibition efficiencies of the gum exudates obtained from impedance and polarization measurements were in good agreement [11]. Abdallah [12] investigated the inhibition potentials of Guar gum for the corrosion of carbon steel in 1 M H₂SO₄ solution using weight loss and Tafel polarization techniques. The results showed that the inhibition efficiency increases with increasing concentration of guar gum, which acted as an inhibitor of the mixed type. The inhibition action of guar gum was attributed to horizontal adsorption on the metal surface. The adsorption follows Langmuir adsorption isotherm. The effect of the presence of chloride ion in pitting corrosion was also analyzed by the potentiodynamic anodic polarization technique and it was found that the pitting corrosion potential changes with the concentration of Cl⁻ ion according to a sigmoid S-shaped curve. This behaviour was explained on the basis of the formation of passivable, active and continuously propagated pits.

In spite of the broad spectrum of information available for some gums and their corrosion inhibition potentials, a survey of literature reveals that *Ficus platyphylla* gum (FP gum) has not been used as a corrosion inhibitor for mild steel in solutions of HCl. Therefore, the present study is aimed at

investigating the chemical constituents of FP gum and its corrosion inhibition potential for mild steel in solutions of HCl.

2. MATERIALS AND METHODS

Materials used for the study were mild steel sheet of composition (wt %, as determined by quantimetric method) Mn (0.6), P (0.36), C(0.15) and Si (0.03) and the rest Fe. The sheets were mechanically pressed cut into different coupons, each of dimension, 5x4x0.11cm. Each coupon was degreased by washing with ethanol, cleaned with acetone and allowed to dry in the air before preservation in a desiccator. All reagents used for the study were Analar grade and double distilled water was used for their preparation. The FP gum exudates used for the studies was purified and concentrations of 0.1 – 0.5 g/l were used.

2.1. Gravimetric method

In the gravimetric experiment, a previously weighed metal (mild steel) coupon was completely immersed in 250 ml of the test solution in an open beaker. The beaker was covered with aluminium foil and inserted into a water bath maintained at 303 K. After every 24 hours, the corrosion product was removed by washing each coupon (withdrawn from the test solution) in a solution containing 50 % NaOH and 100 g l⁻¹ of zinc dust. The washed coupon was rinsed in acetone and dried in the air before re-weighing. The experiment was repeated at 333 K. In each case, the difference in weight for a period of 168 hours was taken as the total weight loss. 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 mild steel (CR) were calculated using equations 1, 2 and 3 respectively [13];

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

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

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

where w_1 and w_2 are the weight losses (g) for mild steel in the presence and absence of the inhibitor, θ is the degree of surface coverage of the inhibitor, A is the area of the mild steel coupon (in cm²), t is the period of immersion (in hours) and ΔW is the weight loss of mild steel after time, t .

2.2 Gasometric method

Gasometric methods were carried out at 303 K as described in literature [14]. From the volume of hydrogen evolved per minute, inhibition efficiencies were calculated using equation 4 below;

$$\%I = \left(1 - \frac{V_{Ht}^1}{V_{Ht}^o} \right) \times 100 \quad 4$$

where V_{Ht}^1 and V_{Ht}^o are the volumes of H_2 gas evolved at time 't' for inhibited and uninhibited solutions respectively.

2.3. FTIR analysis

FTIR analyses of the gums and that of the corrosion products (in the absence and presence of the respective gum) were carried out using Shimadzu FTIR-8400S Fourier transform infra red spectrophotometer. The sample was prepared using KBr and the analysis was done by scanning the sample through a wave number range of 400 to 4000 cm^{-1} .

2.4. GC-MS analysis

GC-MS analysis was carried out on a GC clarus 500 Perkin Elmer system comprising 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 1 μ M df, composed of 100% Dimethyl poly 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 μ l was employed (split ratio of 10:1) injector temperature 250 $^{\circ}C$; ion-source temperature 280 $^{\circ}C$.

The oven temperature was programmed from 110 $^{\circ}C$ (isothermal for 2 min), with an increase of 10 $^{\circ}C$ /min, to 200 $^{\circ}C$, then 5 $^{\circ}C$ /min to 280 $^{\circ}C$, ending with a 9min isothermal at 280 $^{\circ}C$. 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 36min.

Interpretation on mass spectrum GC-MS was conducted using the database of National Institute Standard and Technology (NIST) 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.

3. RESULTS AND DISCUSSION

3.1. GC-MS study

Fig. 1 shows GC-MS spectrum of FP gum, which is characterized with ten peaks. Chemical structures of compounds identified through a reliable spectral library are presented in Fig. 2 while Table 1 presents the characteristics of the identified compounds. Concentrations of each component in the various peaks were obtained through area normalization. From Table 1, it can be seen that line 1

indicates the presence of 0.79 % of (Z)-methyl N-hydroxybenzimidate (methoxy-phenyl-oxime). The mass peak for the compound was 5.

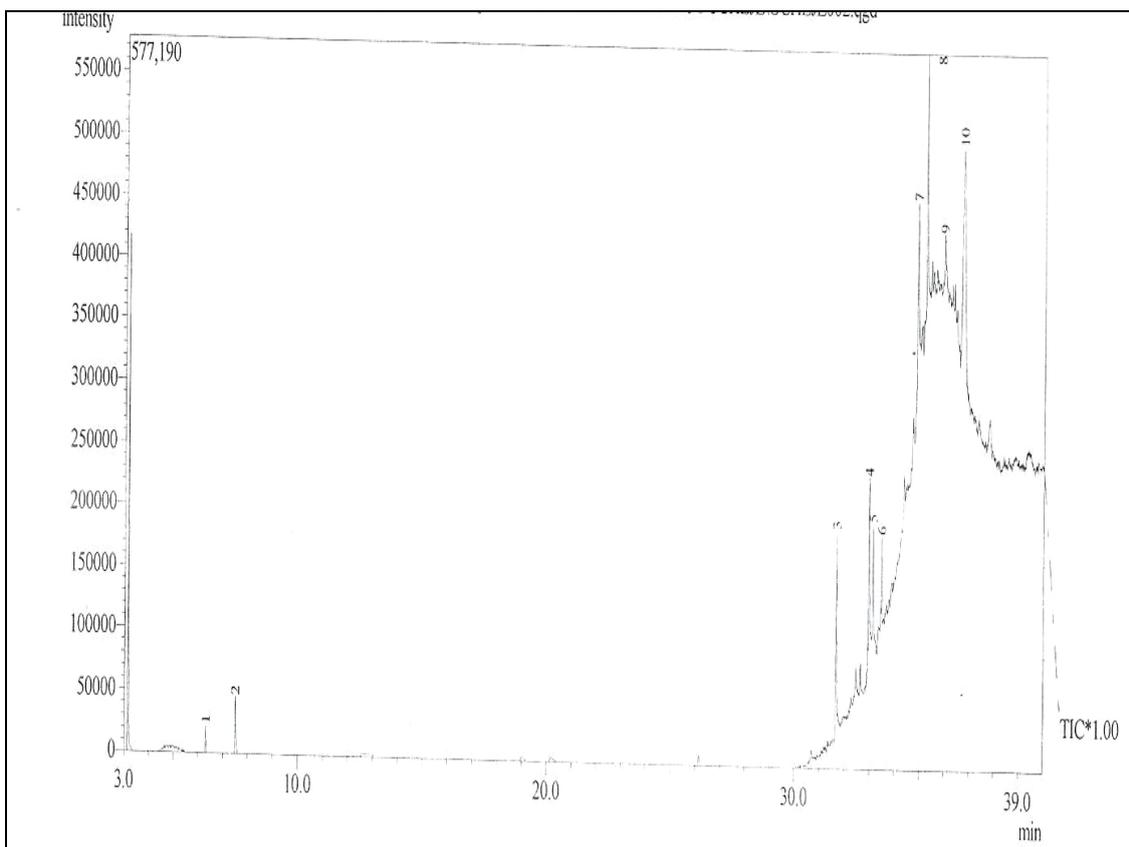
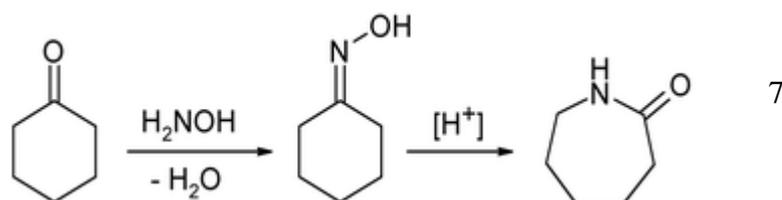


Figure 1. GC-MS spectrum of FP gum

Oxime is a chemical compound belonging to the imines, with the general formula $R^1R^2C=NOH$, where R^1 is an organic side chain and R^2 may be hydrogen, forming an aldoxime, or another organic group, forming a ketoxime. O-substituted oximes form a closely related family of compounds. Amidoximes are oximes of hemiaminals with general structure $RC(=NOH)(NRR')$. In their largest application, oxime is an intermediate in the industrial production of caprolactam, a precursor to Nylon 6. About half of the world's supply of cyclohexanone, more than a billion kilograms annually, is converted to the oxime. In the presence of sulfuric acid catalyst, the oxime undergoes the Beckmann rearrangement to give the cyclic amide caprolactam as shown in the equation below,



Oxime compounds are also used as antidotes for nerve agents. A nerve agent inactivates acetylcholinesterase molecules by phosphorylation of the molecule.

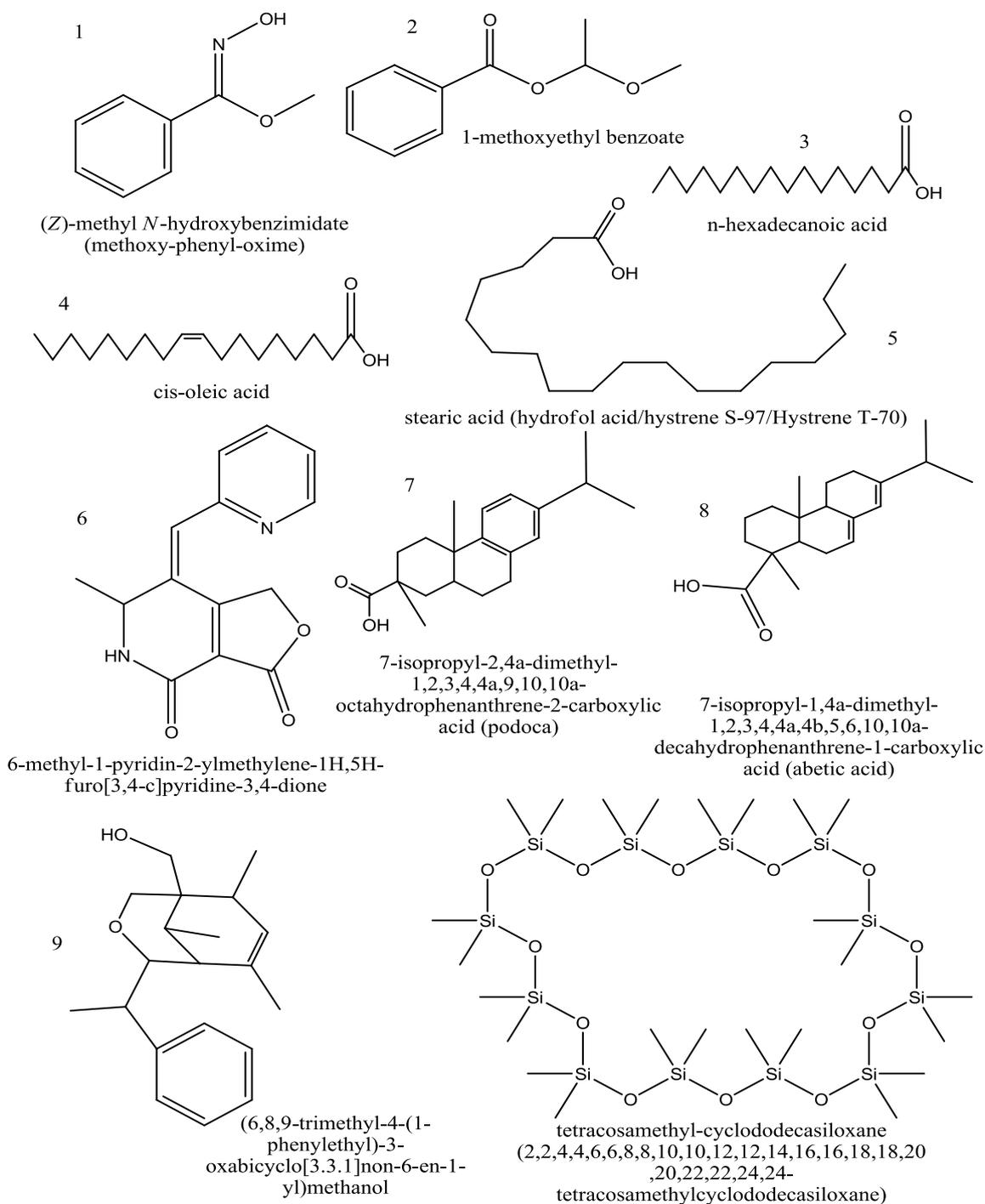


Figure 2. Chemical structures of compounds identified in GC-MS spectrum of FP gum (Numbering correspond to the GC line number)

Oxime compounds can reactivate acetylcholinesterate by attaching to the phosphorus atom and forming an oxime-phosphonate which then splits away from the acetylcholinesterase molecule.

Table 1. Summary of GC-MS results for peaks in FP gum spectrum

Peak NO	Peak area	C (%)	Compound	MF	MW	RT	Fragmentation peak
1.	0.3	0.90	Oxime -, methoxyl -phenyl	C ₈ H ₉ NO ₂	151	6.317	68 (55%), 77 (50%), 133 (100%), 151 (70%)
2	0.5	1.50	Ethanol, 1-methoxy benzoate. 1- Methoxyethyl benzoate	C ₁₀ H ₁₂ O ₃	180	7.5	43(10%), 51 (20%), 59(100%), 75(30%), 105(40%), 121(5%), 149 (2 %), 165 (2 %)
3	2.3	6.89	n- Hexadecanoic acid n- Hexadecoic acid Palmitic acid	C ₁₆ H ₃₂ O ₂	256	31.7	27 (20%) 41(80%), 43 (100%), 60(90%), 73(100%), 85(20%), 98(15%), 115 (15%), 129 (30 %), 143(5%), 157 (10%), 171(10%), 185(10%), 213(20%), 256(50%)
4	2.8	8.38	Oleic acid 9- Octadecanoic acid	C ₁₈ H ₃₄ O ₂	282	33.0	27 (25%), 41(100%), 55 (80%), 69(40%), 83(30%), 97(20%), 123(2%), 137 (2%), 264 (5 %).
5	2.3	6.89	Octadecanoic acid Stearic acid	C ₁₈ H ₃₆ O ₂	284	33.1	27 (18%) 41(80%), 57 (70%), 73(70%), 85(30%), 98(35%), 115 (10 %), 129 (40 %), 143(5%), 171(5%), 185(20%), 199(5%), 241(20%), 284(80%).
6	2.2	6.59	6-methyl-1-pyridine	C ₁₄ H ₁₂ N ₂ O ₃	254	33.5	39 (1%) 64(1%), 78 (1%), 91(1%), 108(1%), 119(1%), 128(1%), 146 (1%), 155(30%), 169(2%), 185 (2%), 198(10%), 211(1%), 226(2%), 239(5%), 254(100%).
7	5.3	15.87	1-phenanthrene carboxylic acid	C ₂₀ H ₂₈ O ₂	300	34.9	41(20%) , 43(40%), 69(2%), 77(2%), 91(5%), 105(2%), 117(10%), 131(10%), 141 (20 %), 159(10%), 169 (5%), 183(5%), 197(40%), 239(20%), 285(100%)
8	6.7	20.06	Abeitic acid 1-phenanthrene carboxylic acid	C ₂₀ H ₃₀ O ₂	302	35.2	29(10%), 41(45%) , 67(25%), 79(40%), 91(80%), 105(85%), 121(50%), 136(80%), 143 (30 %), 157 (30%), 171(10%), 185 (20%), 213(40%), 241 (50%), 259(50%), 287(20%)
9	5.1	15.27	Methanol, 6,7,8-trimethyl-4- (2-phenylethyl)-3- oxabicycl[3.3.1] non-6-en-1-yl	C ₂₀ H ₂₈ O ₂	300	35.9	39(20%), 41(40%) , 43(30%), 65(20%), 79(30%), 91(100%), 107(70%), 121(80%), 133(90%), 147 (15 %), 239(40%), 252 (10%), 300(30%)
10	5.9	17.67	Tetracosemethyl- cyclodecasiloxane	C ₂₄ H ₇₇ O ₁₂ Si ₁₂	888	36.7	59(2%), 74(8%) , 147(100%), 207(30%), 221(100%), 267(8%), 281(65%), 295(30%), 325 (5 %), 341 (20%), 355(100%), 369 (10%), 401(10%), 429 (100%), 475(2%), 503(10%), 563(2%), 651(2%).

The most effective oxime nerve-agent antidotes are pralidoxime (also known as 2-PAM), obidoxime, methoxime, HI-6, Hlo-7, and TMB-4. The effectiveness of the oxime treatment depends on the particular nerve agent used. Perillartine, the oxime of perillaldehyde is used as an artificial sweetener in Japan, as it is 2000 times sweeter than sucrose.

In line 2, 4 % of 1-methoxyethyl benzoate was identified as the likely compound. The mass peak for the compound was 3 and three fragmentation peaks were found in the mass spectrum of the sample. Also, in line 3, 4 and 5 carboxylic acids were identified. These included palmitic acid (S1=86, concentration = 7.58 %), oleic acid (S1= 84, concentration = 10.15 %) and octadecanoic acid (S1= 69, concentration = 6.2 %) respectively. These compounds had characteristics mass peak values of 36, 39 and 46 respectively. 11, 10 and 13 fragmentation ions were also found in the respective lines.

In line 6, 6-methyl-1-pyridin-2-ylmethylene-1H,5H-furo[3,4-c]pyridine-3,4-dione was identified as the likely compound (S1= 64, concentration = 3.50 %). 12 fragmentation ions were likely in the mass spectrum of the compound and the mass peak value was 36. in line 7, a commercial compound 1-phenanthrenecarboxylic acid (podoca) (S1 = 66, concentration = 17.78 %) was identified. This compound is a derivative of abietic acid and is mostly used as components of adhesives for food packaging, transporting, or holding food. In line 8, another derivative of abietic acid was also identified (S1 = 81, concentration = 19.28 %). The concentrations of these compounds

are relatively higher in the FP gums than other component indicating that FP gum may be a green source of abietic acid. The mass peaks for the abietic acids identified in lines 7 and 8 were 69 and 83 and there were 15 and 16 fragmentation ions in their respective mass spectrum.

In line 9, 1.16% of (6,8,9-trimethyl-4-(1-phenylethyl)-3-oxabicyclo[3.3.1]non-6-en-1-yl)methanol was the most likely compound (S1 = 62). The identified compound had a mass peak value of 57 and undergoes fragmentations into 14 fragmentation ions. As can be seen in the chemical structure of the compound, it is a bicycle carboxylic acid. Finally, tetracosamethylcyclododecasiloxane-(2,2,4,4,6,6,8,8,10,10,12,12,14,16,16,18,18,20,20,22,22,24,24-tetracosamethylcyclo dodecasiloxane) was identified in line 10 with concentration of 31.07%. This suggests that this compound is the most abundant component of FP gum.

3.2. Corrosion inhibition study

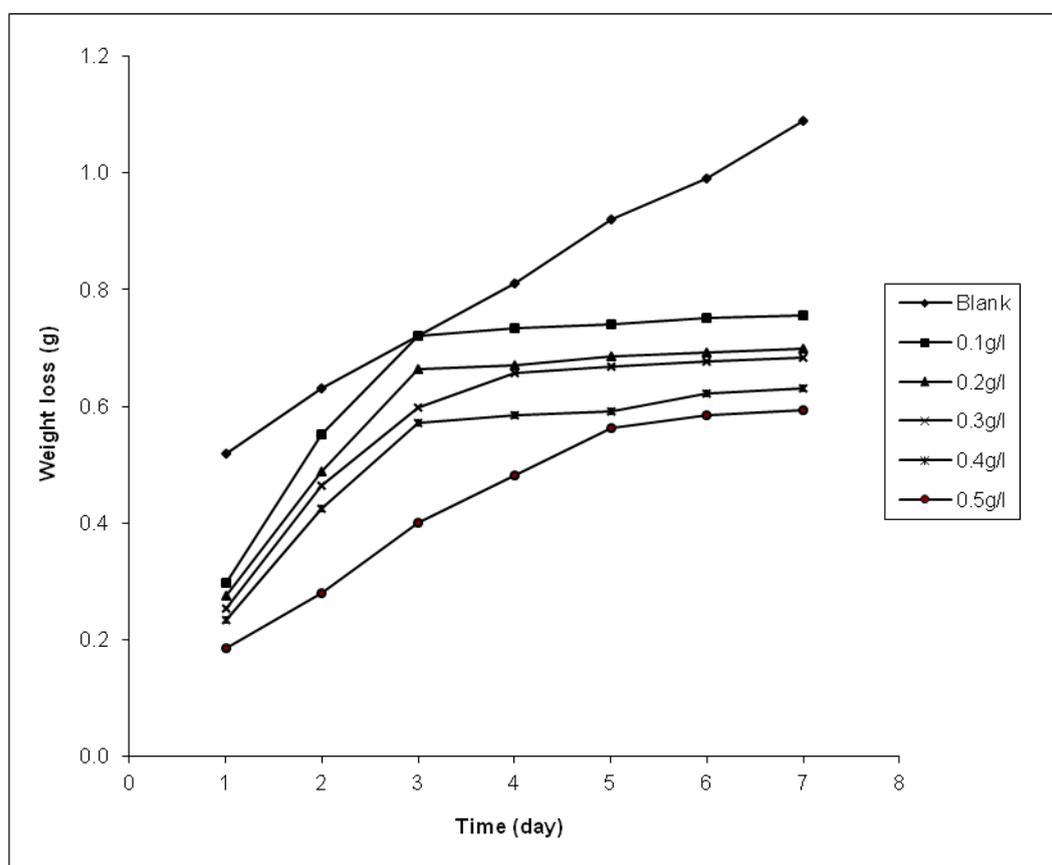


Figure 3. Variation of weight loss with time for the corrosion of mild steel in 0.1 M HCl containing various concentrations of FP at 303 K

Fig. 3 shows the variation of weight loss of mild steel in 0.1 M HCl in the presence of various concentrations of FP gum at 303 K. From the figure, it is evident that weight loss of mild steel increases with increase in the period of contact but decreased with increase in the concentration of FP gum. These indicate that the rate of corrosion of mild steel in solution of HCl decreases with increase

in the concentration of FP gum but increases with increase in the period of contact. Weight loss of mild steel was also found to increase with increasing temperature, which also indicated that the rate of corrosion of mild steel in solution of HCl increases with increase in temperature.

Table 2. Corrosion rates of mild steel and inhibition efficiencies of FP gum at 303 K for the corrosion of mild steel in 0.1 M HCl

System	%I (weight loss)		%I (hydrogen evolution)		Corrosion rate ($\text{gcm}^{-1}\text{h}^{-1}$)	
	303 K	333K	303 K	333K	303 K	333 K
Blank	-	-	-	-	0.000329	0.001863
0.1	53.83	51.64	62.34	56.01	0.000174	0.001217
0.2	59.62	56.20	64.45	60.00	0.000270	0.001211
0.3	62.95	60.57	68.33	66.10	0.000268	0.001201
0.4	66.80	65.82	72.44	68.23	0.000202	0.001182
0.5	71.05	68.66	78.22	71.02	0.000197	0.001170

In Table 2, values of corrosion rate of mild steel and inhibition efficiencies of FP gum are presented. Calculated values of inhibition efficiencies are within the range of values reported for most inhibitors [1-5]. From the results obtained, it is evident that the corrosion rate of mild steel increases with increasing temperature and with the period of contact but decreases with increase in the concentration of FP gum. These indicate that FP gum retarded the rate of corrosion of mild steel in solution of HCl and is thus a good inhibitor for mild steel in solution of HCl. On the other hand, the inhibition efficiency of FP gum was found to decrease with increasing temperature but increases with increase in the concentration of the gum, indicating that the adsorption of FP gum on mild steel surface supports the mechanism of physical adsorption. It has been established that a physical adsorption mechanism is characterized with decreasing values of inhibition efficiencies as the temperature increases as observed in this study. However, for chemisorption, the extent of adsorption of the inhibitor on mild steel surface tends to increase with increasing temperature [6]. Data obtained from hydrogen evolution measurements correlated favourably with those obtained from weight loss measurements. However, the inhibition efficiencies in this case were relatively higher than those of weight loss indicating that the instantaneous inhibition efficiency of FP gum is better than its average inhibition efficiency.

The effect of temperature on the corrosion of mild steel in H_2SO_4 , in the presence and absence of various concentrations of FP gum was studied using the logarithm form of the Arrhenius equation, which can be written as follows[7];

$$\log \frac{CR_2}{CR_1} = \frac{E_a}{2.303R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

where CR_1 and CR_2 are the corrosion rates of mild steel at the temperatures, T_1 (303 K) and T_2 (333 K) respectively, E_a is the activation energy and R is the gas constant. Values of E_a calculated from equation 8 are presented in Table 3.

Table 3. Activation energy and heat of adsorption of FP gum on mild steel surface

C (g/dm ³)	E_a (J/mol)	Q_{ads} (J/mol)
Blank	48.97	-
0.1	54.46	-80.39
0.2	42.02	-71.04
0.3	42.00	-78.64
0.4	49.46	-97.25
0.5	49.88	-78.55

The activation energies are within the range of values expected for the mechanism of physical adsorption. Therefore, the adsorption of FP gum on mild steel surface is consistent with the mechanism of charge transfer from charged inhibitor to charged metal surface, which supports physical adsorption.

The heat of adsorption (Q_{ads}) of FP gum on mild steel surface was calculated using the following equation [4];

$$Q_{ads} = 2.303R \left(\frac{\theta_2}{1 - \theta_2} - \frac{\theta_1}{1 - \theta_1} \right) \times \left(\frac{T_1 \times T_2}{T_2 - T_1} \right) \tag{6}$$

where R is the universal gas constant, θ_2 and θ_1 are the degree of surface coverage at the temperatures T_1 (303 K) and T_2 (333 K) respectively. Values of Q_{ads} calculated from equation 9 are also presented in Table 3. From the results, it is evident that the adsorption of FP gum on mild steel surface is endothermic.

In order to established the best isotherm for the adsorption of FP gum on mild steel surface, plots were developed for different adsorption isotherms including Langmuir, Freundlich, Florry-Huggins, El Awardy, Temkin and Frumkin adsorption isotherms. The tests revealed that the adsorption of FP gum on mild steel surface is best described by the Langmuir adsorption model which can be written as follows [9,14];

$$\log \frac{C}{\theta} = \log C - \log b \tag{7}$$

where C is the concentration of the inhibitor in teh bulk electrolyte, θ is the degree of surface coverage of the inhibitor and b is the equilibrium constant of adsorption. Langmuir isotherm for the adsorption of FP gum on mild steel surface is presented in Fig. 4. Values of adsorption parameters deduced from the Langmuir isotherms are presented in Table 4.

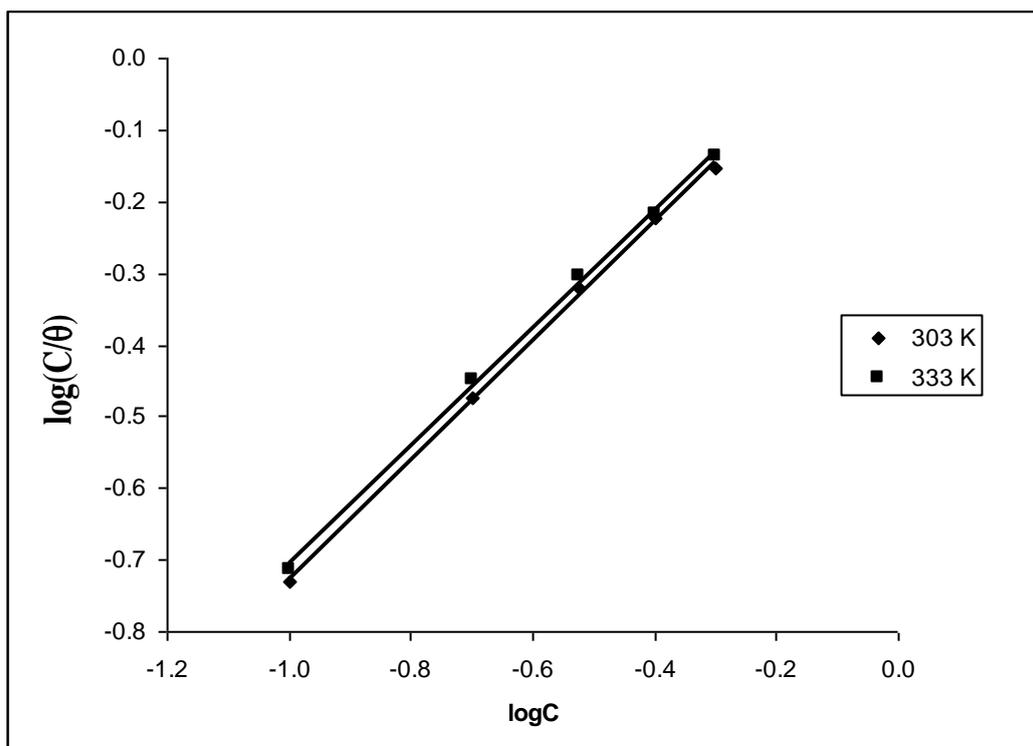


Figure 4. Langmuir isotherms for adsorption of FP gum on mild steel surface at 303 and 333 K

Table 4. Langmuir parameters for the adsorption of FP gum on mild steel surface

Inhibitor	T (K)	Slope	Logb	ΔG^0_{ads} (J/mol)	R^2
FP	303	0.8337	0.1065	-35.44	0.9993
	333	0.8206	0.1152	-35.60	0.9986

The results indicates that the slopes and R^2 values are very close to unity, indicating the application of the Langmuir model to the adsorption behaviour of FP gum on mild steel surface [15,16].

The equilibrium constant of adsorption calculated from the Langmuir adsorption isotherm is related to the free energy of adsorption according to the following equation,

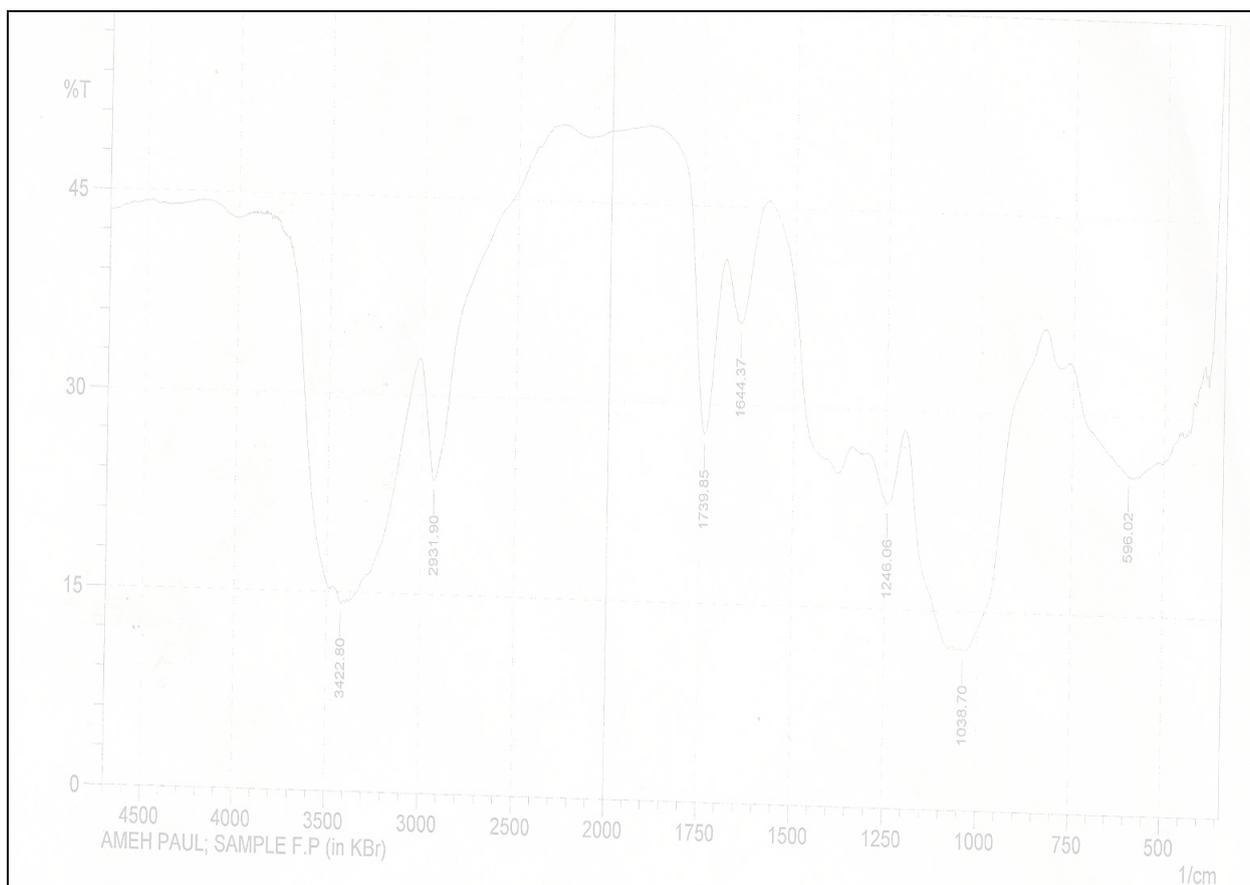
$$\Delta G_{ads} = - 2.303RT\log(55.5b) \tag{8}$$

where R is the gas constant in kJ/mol, T is the temperature in Kelvin, b is the equilibrium constant of adsorption and 55.5 is the molar concentration of HCl in water. Calculated values of ΔG_{ads} are also presented in Table 4. The free energies are negatively less than the threshold value of $- 40$ kJ/mol. Therefore the adsorption of FP gum on mild steel surface supports the mechanism of physical adsorption [3].

3.3. FTIR study

Table 5. Peaks, wavelength, peak area, % concentration and assignments of functional group for FTIR adsorption by FP

Wave number (cm ⁻¹)	Intensity	Area	Assignments
596.02	25.55	90.59	Finger print
1038.70	12.05	4.43	C-N stretch
1246.06	22.93	33.17	C-N stretch
1644.37	36.22	23.45	C=C stretch
1739.85	27.70	66.86	C=O stretch
2931.90	23.60	266.75	-CH stretch
3422.80	14.09	24.23	-OH stretch

**Figure 5.** FTIR of FP gum

The FTIR spectra of the corrosion products of mild steel [(in the absence (Fig. 5) and presence of FP gum (Fig. 6)] and that of FP gum (Fig. 7) have been analysed. Frequencies and wave numbers of adsorption deduced from the spectra (Figs. 6 and 7) are presented in Tables 5 and 6. It should be noted that the FTIR spectrum of the corrosion product without inhibitor did not show significant adsorption.

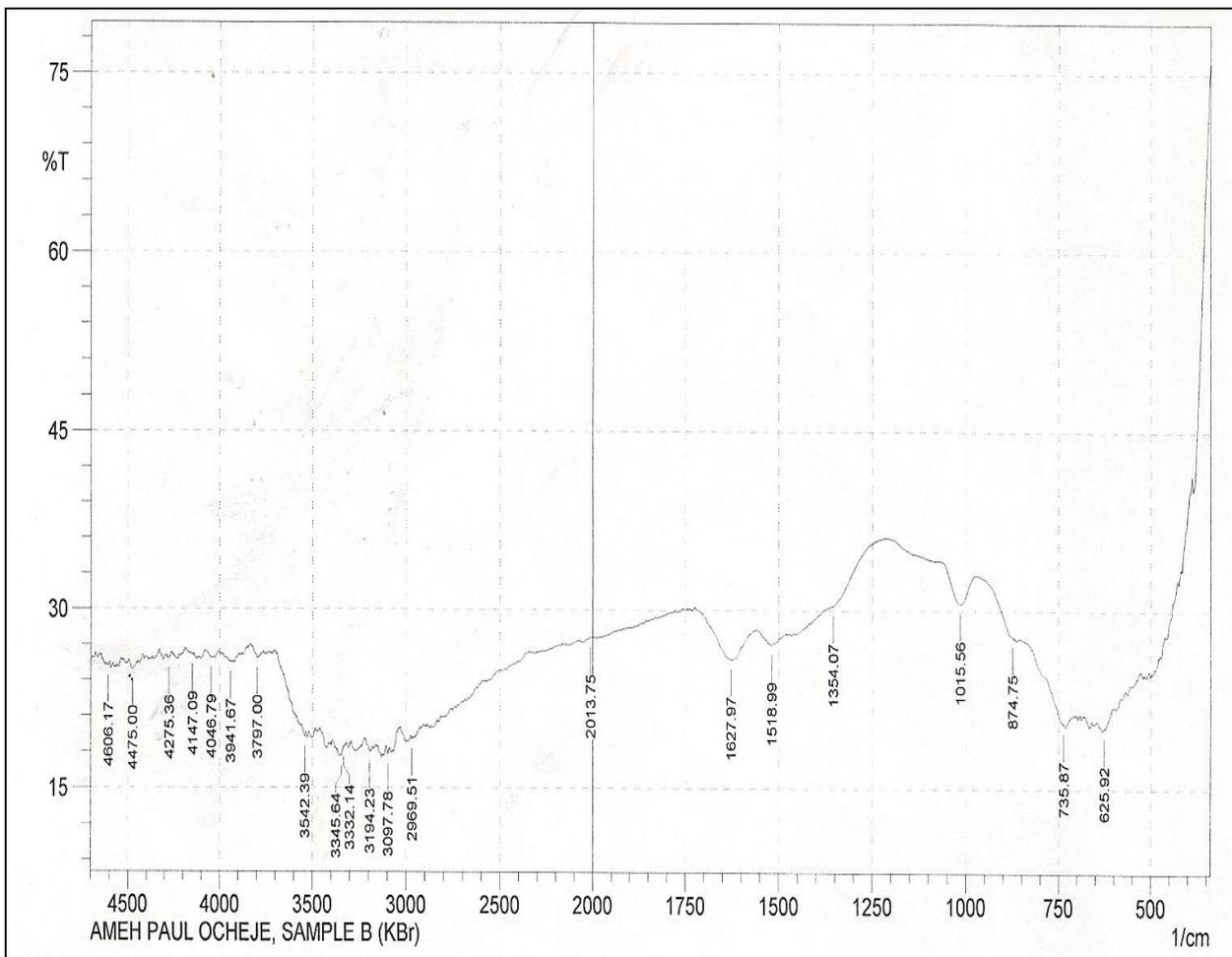


Figure 6. FTIR spectrum of the corrosion product of mild steel when FP gum was used as an inhibitor

Table 6. FTIR spectrum of the corrosion product of mild steel in the presence of FP gum as an inhibitor

Peak (cm ⁻¹)	Intensity	Area (cm ²)	Assignment (functional group)
1015.56	30.590	44.272	C-O stretch
1354.07	30.363	64.660	NO ₂ symmetrical stretch
1518.99	27.053	9.817	N-O symmetric stretch
1627.97	25.846	4.529	NH bend
2969.51	19.044	6.917	C-H aliphatic stretch
3097.78	17.763	11.463	=C-H stretch
3194.23	18.013	7.130	C=O stretch due to alcohol or phenol
3332.14	18.318	2.838	OH stretch
3345.64	17.593	9.394	N-H stretch
3542.39	19.238	6.868	OH stretch

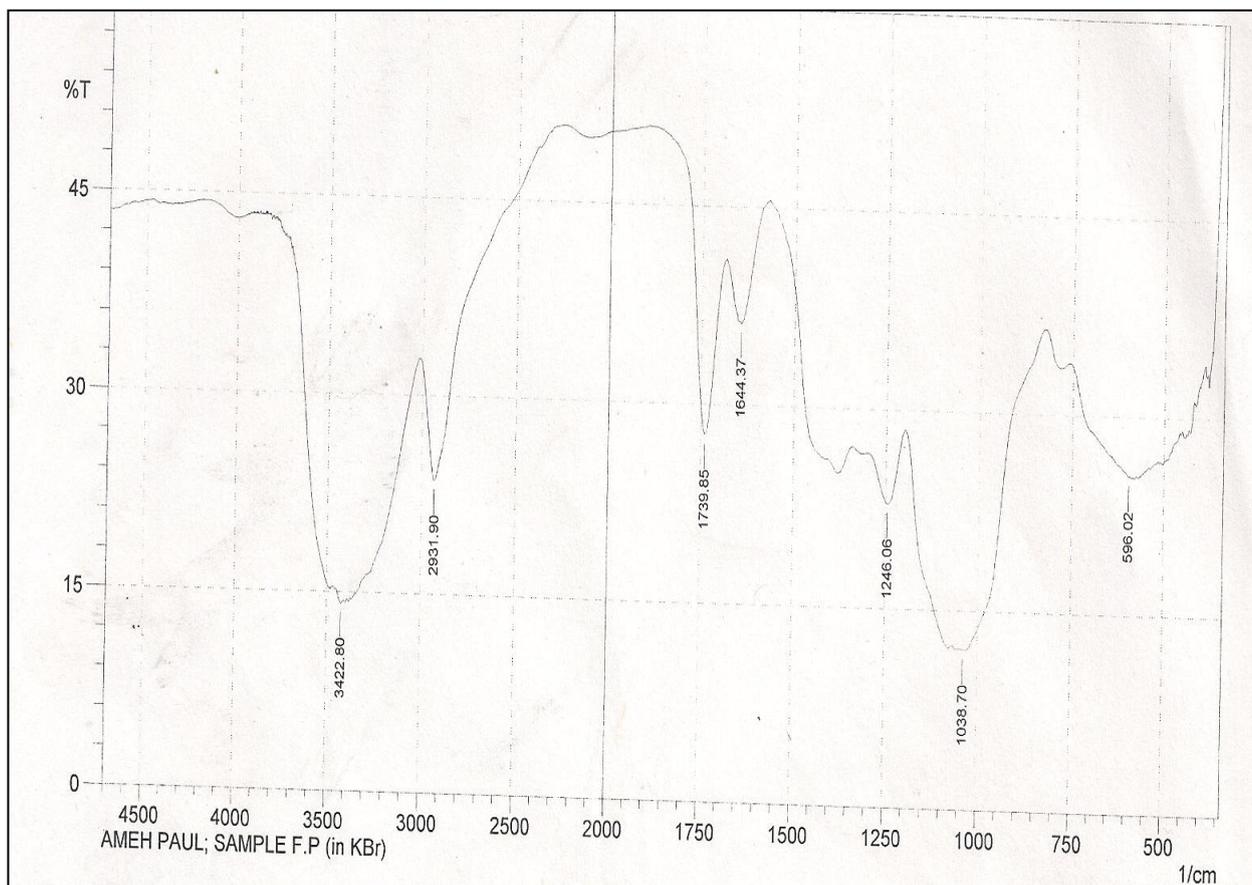


Figure 7. FTIR spectrum of FP

The essential requirements for any corrosion inhibitor, is for the compound to possess hetero atom(s) in its aromatic or long carbon chain[17]. The presence of suitable functional groups has also been found to facilitate the adsorption of the inhibitor on the surface of the metal, which is the initial mechanism for any corrosion inhibition process. In order to study the level of interactions between chemical bonds (or functional groups), FP gum and the surface of mild steel, FTIR spectra of the corrosion products of mild steel (in the absence and presence of the inhibitor) and that of the inhibitor sample were taken and analysed for missing bonds, shift in frequencies of adsorption and formation of new bonds. The results obtained from the analysis are summarized as follows,

Comparison of the spectra of the corrosion product of mild steel (Fig. 5) with that of FP gum (Fig. 6) revealed that the C-O stretch at 1038.70 was shifted to 1015.56 cm^{-1} , the C=C stretch at 1644.37 was shifted to 1627.97 cm^{-1} and the CH aliphatic stretch at 2931.90 was shifted to 2969.51 cm^{-1} indicating that there is interaction between the inhibitor and the metal surface[13]. However, C-O stretch at 1246.06 , the C=C stretch at 1739.85 , the CH stretch at 2931.90 and the OH stretch at 3422.80 cm^{-1} were missing in the spectrum of the corrosion product indicating that FP gum was adsorbed onto the metal surface via these missing functional groups. Also, the NO_2 and NO symmetrical stretches at 1354.07 and 1518.99 cm^{-1} , =CH stretch at 3097.78 , C=O stretch at 3194.23 , NH stretch at 3345.64 and OH stretches at 3332.14 and 3542.39 cm^{-1} were found in the spectrum of the corrosion product indicating that they were used in forming inhibitor-metal complex or new bond.

4. CONCLUSION

From the results of our study, the following conclusions are made,

- (i) FP gum is a good corrosion inhibitor for mild steel in acidic medium.
- (ii) The adsorption of FP gum on mild steel surface is exothermic, spontaneous and favours the mechanism of physical adsorption
- (iii) The use of FP gum as an inhibitor for the corrosion of mild steel in acidic medium is hereby advocated.

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