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Examining The Unique Properties Of Guava Leaf Extract As A Corrosion Inhibitor

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Abstract: *Guava leaf as a Natural extract was studied as corrosion inhibitor for mild steel, using 0.1, 0.3 and 0.5 mol H_2SO_4 as corrodent. The inhibitor (guava leaf extract) was characterized using (FT-IT). Gravimetric method was exploit in the corrosion study. Inhibition efficiency was optimized by response surface methodology (RSM). Shifting mechanism of the inhibitors' functional groups of the metal was determined using FTIR spectroscopy. Psychiatry of plant extract revealed the presence of functional groups (C-H bend, C-X fluoride, ≡C-H stretch, hydrogen-bonded O-H stretch, O-H stretch carboxylic acid, hydrogen-bonded O-H Stretch and N-H stretch). The optimum inhibition efficiency of the extract of 96.82% determined by response surface methodology (RSM) of the design expert software did not differ much from that got from gravimetric weight loss. This shows that response surface methodology (RSM) is an effective means to achieve optimization. The inhibitor inhibited M- steel corrosion in acidic environment. Corrosion inhibition efficiencies increased on increasing the addition of inhibitor. Metal in 0.1 mol H_2SO_4 , inhibitor was observed to show maximum inhibition efficiencies 97.60% for Guava, at the concentrations of 10g/lolo and mostly at 60^0C. Temperature studies (30 – 60^0C) showing increased inhibition efficiency at the elevated temperatures, this is an indicative of chemisorptions mechanism. These were corroborated by kinetic and activation energy factors considered. The inhibitor adsorption characteristics obeyed Freundlich adsorption isotherms.*

Keywords: *Corrosion , Extract, Guava, Inhibitor, Mild steel*

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I. Introduction

Metallic materials, such as mild steel and others are widely used group of materials in engineering, transportation and the construction firms. In their service the metals come in contact with acid environments which affect their stability in service negatively. This effect on metals is referred to as corrosion. Hence, corrosion is viewed as the ruin of materials due to their contact and interaction with environment [1]. Inhibitors for corrosion are employed in industries to minimize the speed of metal corrosion and their alloy. Corrosion is an electrochemical deterioration of a metal due to the reaction with its environment. However, metal corrosion is an vast industrial and economic setback. Attempts to build up more efficient and environmentally compliant means to avert corrosion have been ongoing for a long time. Best way to manage corrosion of an vigorous metal is to apply a protective surface coating. Reducing the corrosion problem in these environments, inhibitive effects of assorted chemical compounds and naturally occurring substances have been reported as helpful inhibitors [2].

II. Literature Review

Corrosion is the demolition of material when exposed and interacted with the environment. Corrosion may also be termed as the deterioration of a metal or its properties due to its reaction with its environment [3]. Use of organic and inorganic substances to hinder corrosion of metals in our environments is well established [4]. Extort from leaves, seed, heartwood bark, roots and fruits of plants were detailed to hinder metallic corrosion in acidic media [5]. Also [6] invstigated the action of inhibitors of leaves (LV), root

(RT),seeds (SD) extracts of *Azadirachata indica* on mild steel corrosion in H_2SO_4 solutions using weight loss with gasometric techniques. Results got pointed out that the extracts is a good inhibitors in H_2SO_4 solutions. Inhibition efficiency increased by extracts concentration and temperature. It trailed the style; SD>RT>LV.

11.EXPRIMENTAL

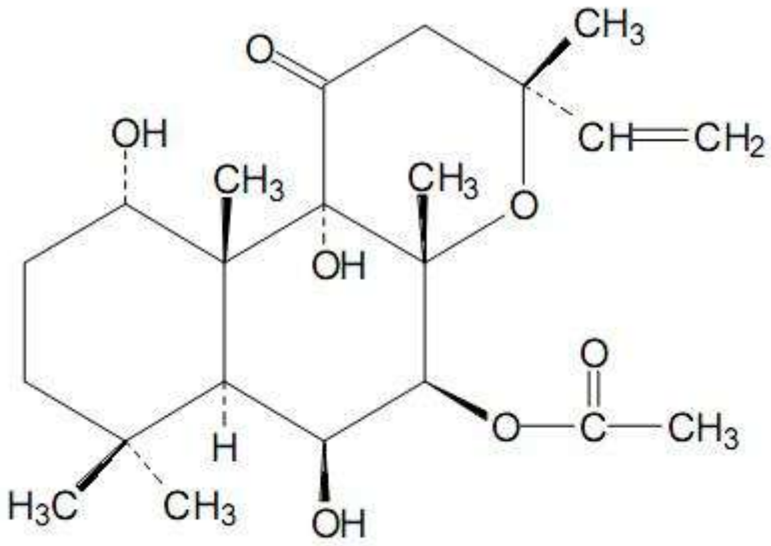
2.1. Collection of samples

The materials used in this study were guava leaf obtained from Onitsha city, Anambra state, Nigeria. Tetraoxosulphate (vi) avid (H_2SO_4) of BDH AR grage, 98% Mild steel sheets with weight-percent composition of C= 0.04, Si = 0.02, Mn = 0.04, Cu = 0.06, Cr = 0.05 and Fe were used. Ethanol, Acetone, Electronic weighing balance, Thermostatic water bath, Potentiostat /galvanostat which is standard electrochemical cell with a separate compartment for the reference electode that were used for electrochemical measurements.

2.2. Preparation of Mild steel

Sheet of mild steel was press cut mechanically into 2cm x 2cm x 2 cm. Small opening was pierced at the one end of the voucher to allow their suspension into test solution. Coupons were utilized without extra polishing but were degreased in ethanol, dehydrated in acetone, weighed and kept in damp-free desiccators before being used for corrosion studies.

Test solution were set using serial dilution principle. A stock solution of 0.5 M, 0.4M, 0.2M and 0.1M of H_2SO_4 were first prepared. Thereafter, five different concentrations of inhibitor of leaf include 2 g/l, 4g/l, 6g/l , 8g/l and 10 g/l were prepared. Blank of 0.5, 0.4, 0.3, 0.2 and 0.1mol of H_2SO_4 solution as solvents were used.



Structure of guava leaf

III. Results And Discussion

3.1. FT-IR RESULT OF GUAVA LEAF EXTRACT

The FT-IR result of guava leaf extract is presented in Fig. 1. The spectrum of the graph shows the peaks in the absorbance versus wave number relationship. FT-IR spectrum is a diagram of infrared light absorbance on the vertical axis Vs wave number (which is also called frequency) on the horizontal axis. The unit of the wave number is cm^{-1} . The peaks and their matching intensities represent the functional groups of the extract [12-14]. Examination of guava leaf extract revealed the presence of C-H bend, C-X fluoride, ≡C-H stretch, hydrogen-bonded O-H stretch, O-H stretch carboxylic acid, hydrogen-bonded O-H Stretch and N-H stretch.

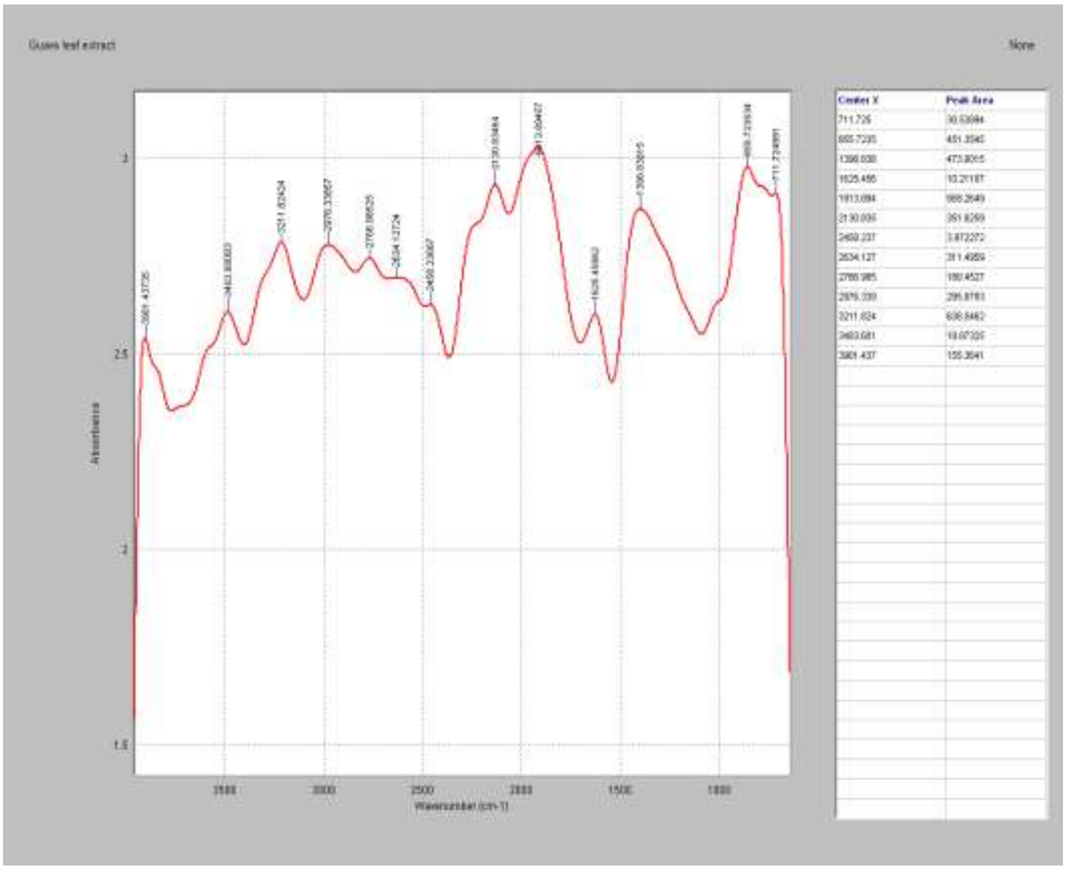


Fig.1: The FTIR spectrum of the guava leaves extract.

3.2. GRAVIMETRIC (WEIGHT LOSS) MEASUREMENTS

Mild Steel Corrosion

Corrosion rates of mild steel coupons in 0.1, 0.3 and 0.5 M H_2SO_4 with guava leaf extract as a corrosion fighter were studied using gravimetric technique were studied at varing temperatures of 30 to 60^0C.

3.2. Effect of inhibitor concentration on mild steel corrosion

(i) Guava leaf extract, in 0.1, 0.3 and 0.5 M H_2SO_4

The worth of corrosion rates, inhibition efficiency and degree of surface coverage for M- steel corrosion in 0.1, 0.3 and 0.5 M H_2SO_4 with and different concentrations of the inhibitor as a role of time (in hr and days), corrosion rate (mm/yr), inhibitor concentration (g/l) and acid concentrations (mol) were presented in Table 1 below and Figures 1to3 . Examination of the figures disclosed that corrosion rate was highest with mild steel coupon in 0.5 M H_2SO_4 and was lowest in that of 0.1 M H_2SO_4 with inhibitor. Corrosion rate of mild steel coupon declined with raise in inhibitor concentration and increased also by means of increase in temperature. It indicated that inhibitor used actually restrained the dissolution of mild steel in 0.1, 0.3 and 0.5 M H_2SO_4 environments. Furthermore, there was decline in the corrosion rate with respect to temperature decrease. This could be due to reduction in the strength of the acid caused by arrest of the acid molecules by the molecules of the inhibitors studied. As a result, there was defeat of strength of the destructive solutions with the temperature.

Effect of inhibition efficiency on the M- steel corrosion

Inhibition efficiency of inhibitor studied in 0.1 M H_2SO_4 were shown in figures1. It was viewed that the inhibition enhances with increasing concentrations of inhibitors. Guava has 98.81% at the 10 g/l concentration of 0.1 M H_2SO_4 as maximum inhibition efficiency had 54.03% at 2 g/l concentration of guava leaf extract in 0**.**1 M H_2SO_4 . Calculated values of corrosion rate, inhibition efficiency with the degree of surface coverage are presented in Table 1 .

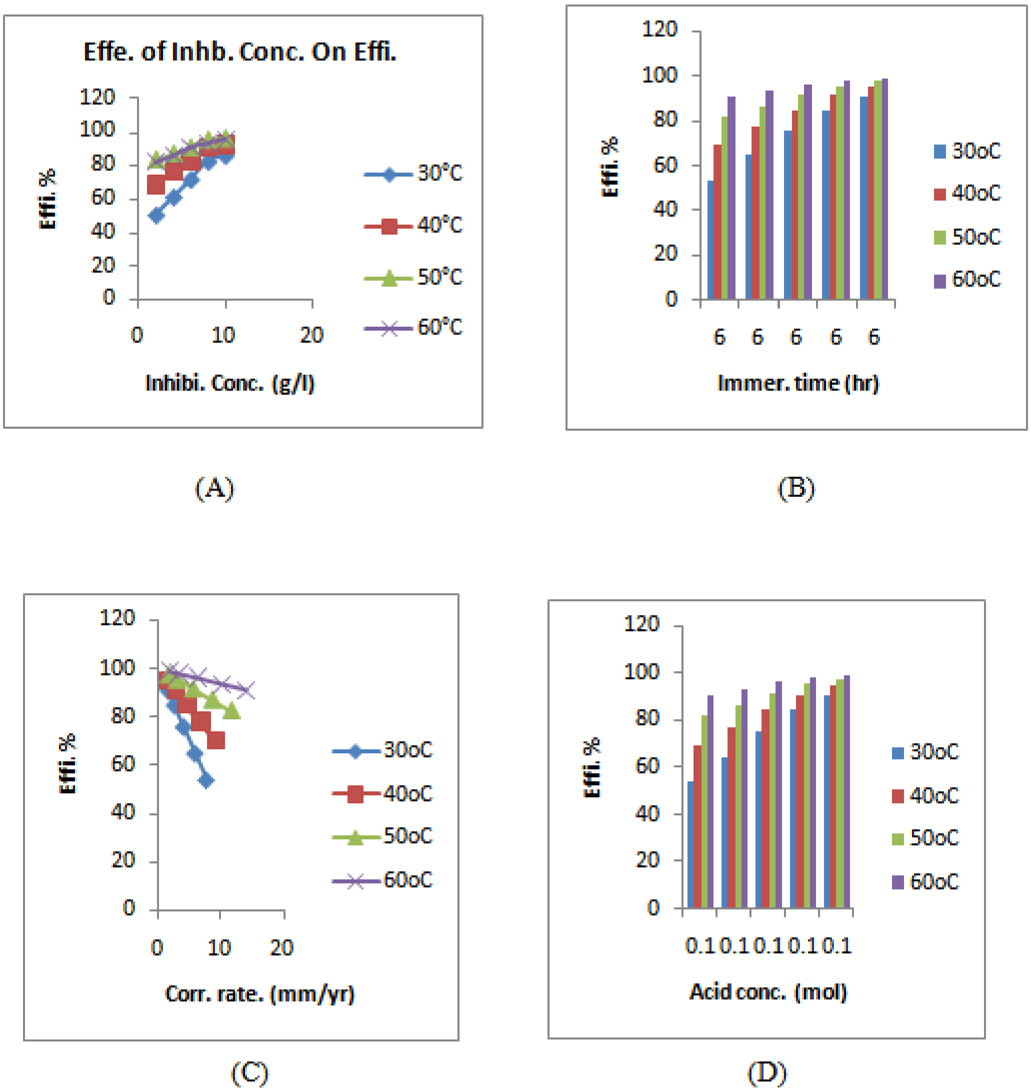
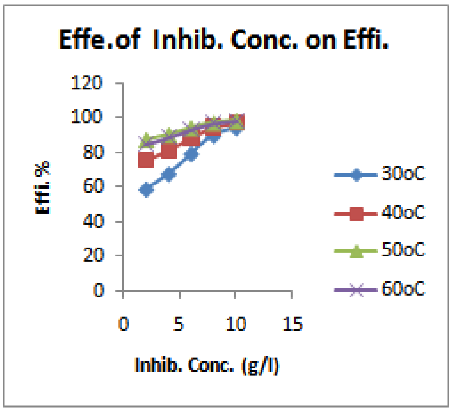
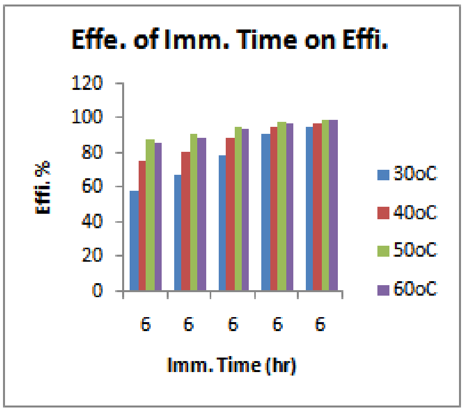


Fig. 2 Effect of inhibition concentration (a), immersion time (b), corrosion rate (c) and acid concentration (d) on the inhibition efficiency of steel in 0.1M H_2SO_4 at different concentration of guava leaf extract inhibitor and at various temperatures.



(A)



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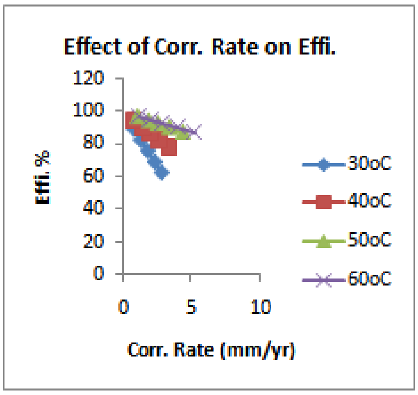
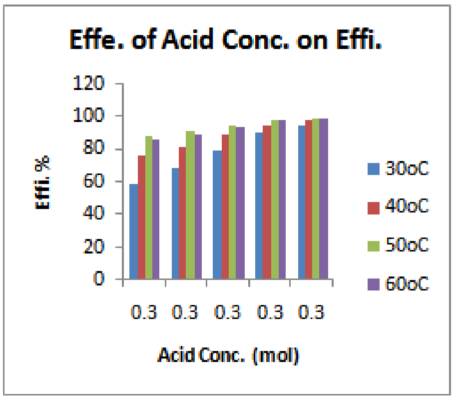
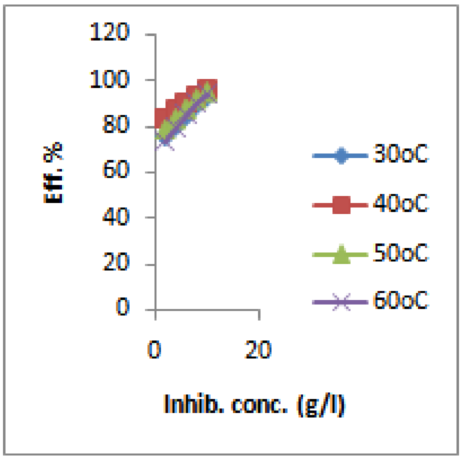


(C)

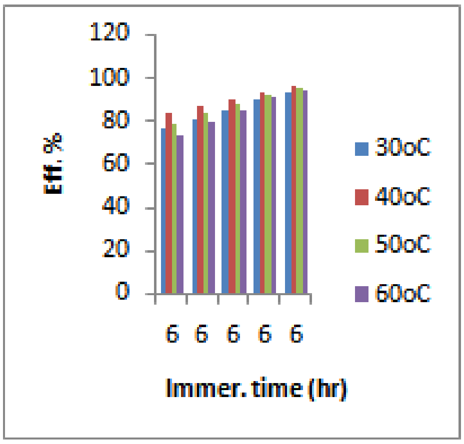


(D)

Fig. 3 Effect of inhibition concentration (a), immersion time (b), corrosion rate (c) and acid concentration (d) on the inhibition efficiency of steel in 0.3M H_2SO_4 at different concentration of guava leaf extract inhibitor and at various temperatures



(A)



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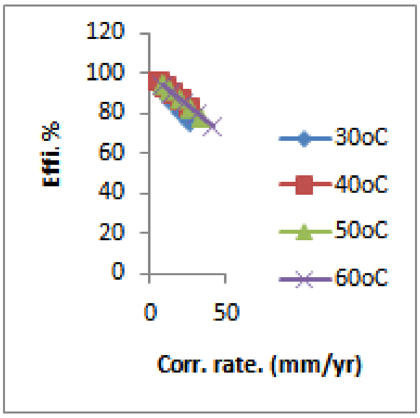
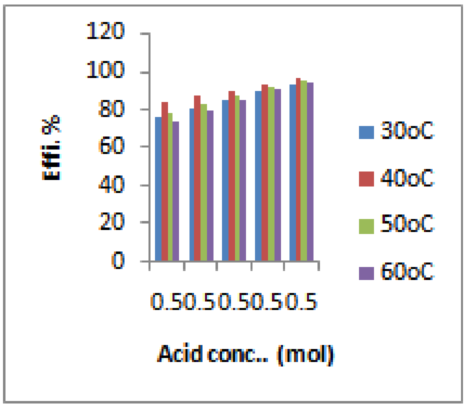


(C)



(D)

Fig. 4 Effect of inhibition concentration (a), immersion time (b), corrosion rate (c) and acid concentration (d) on the inhibition efficiency of steel in 0.5M H_2SO_4 at different concentration of guava leaf extract inhibitor and at various temperatures.

3.3. Effect of Inhibitor Concentration on mild steel corrosion

(i) Guava leaf extract 0.1, 0.3 and 0.5 M H_2SO_4

The worth of corrosion rates, inhibition efficiency with degree of surface coverage for mild steel corrosion in 0.1,0.3 and 0.5M H_2SO_4 with diverse concentrations of these inhibitors as a role of time (in hr), corrosion rate (mm/yr), inhibitor concentration (g/l) and acid concentrations (mol) were presented in the Tables 1 and Figs. 2 to 4 above. Examination of the figs. exposed that corrosion rate was highest with mild steel coupon in 60^{0}C H2SO4 and was lowest with that of 30^{0}C H_2SO_4 in with inhibitor, corrosion rate of mild steel coupon lessen with raise in inhibitor concentration and increases also when increases in temperature. It indicated that the inhibitor used really withdrawn the dissolution of mild steel in H_2SO_4 environment. Furthermore, there was decrease in the corrosion rate with respect to temperature decrease. This could be due to reduction in the strength of the acid caused by arrest of the acid molecules by the molecules of the inhibitors studied. As a result, there was a defeat of strength of the destructive solutions with the temperature.

3.4. Effect of Inhibition Efficiency on the Mild Steel Corrosion

Inhibition efficiency of guava leaf extract inhibitor studied for mild steel corrosion in and 0.1,0.3 and 0.5 mol H_2SO_4 were shown in figs. 2 to 4 above. It was viewed that inhibition enhances with increasing the concentrations of inhibitor. Guava has 98.81% at the 10 g/l concentration of 0.1 M H_2SO_4 as maximum inhibition efficiency

Tables 1 presents the corrosion data for mild steel corrosion with and without the inhibitors at diverse temperatures. Figs. 2 to 4 showed the plots of efficiencies against time, corrosion rate, inhibitor concentrations and acid concentrations. It was observed that mild steel corroded progressively with temperature rise in the uninhibited. However, in the inhibited solutions, corrosion rate of mild steel improved from 30 to 60^{0}C . This behavior could attributed to initial chemical adsorption.The figures also illustrate the inhibition was concentration dependent, it was observed that the highest concentration of 10 g/l inhibited better than the lower concentration of 2 g/l. This suggested that the inhibitors molecules were entangled and this helped the temperature of study to set them into mobility required to get the molecules adsorbed on the metal surface.

Table 1:corrosion rates (MM/yr), inhibition efficiency (%)with degree of surface coverage (Ө) for mild steel corrosion in 0.1, 0.3 and 0.5 mol H_2SO_4 at different concentrations of guava leaf extract inhibitor at various temperature.

Time (Hour) 6 Hr	Inhibitor conc. (g/L)	Corrosion rate (mm/yr)				Inhibition efficiency (%I)				Degree of surface coverage (Θ)			
		30°C	40°C	50°C	60°C	30°C	40°C	50°C	60°C	30°C	40°C	50°C	60°C
0.5 M H_2SO_4	BLANK	88.89	155.23	155.23	155.23								
	2g/LOLE	21.55	25.93	33.67	41.08	75.76	83.3	78.31	73.54	0.76	0.83	0.78	0.74
	4g/LOLE	17.51	20.71	26.43	31.65	80.3	86.66	82.97	79.61	0.8	0.87	0.83	0.8
	6g/LOLE	13.47	15.66	19.7	23.23	84.85	89.91	87.31	85.04	0.85	0.9	0.87	0.85
	8g/LOLE	9.09	10.44	12.8	14.98	89.77	93.27	91.75	90.35	0.9	0.93	0.92	0.9
	10g/LOLE	5.89	6.57	8.25	9.43	93.37	95.77	94.69	93.93	0.93	0.96	0.95	0.94
0.3 M H_2SO_4	BLANK	30.3	60.61	155.23	155.23								
	2g/LOLE	12.46	14.82	19.19	23.4	58.88	75.55	87.64	84.93	0.59	0.76	0.88	0.85
	4g/LOLE	9.76	11.45	14.65	17.51	67.79	81.11	90.56	88.72	0.68	0.81	0.91	0.89
	6g/LOLE	6.23	7.07	8.75	10.27	79.44	88.34	94.36	93.38	0.79	0.88	0.94	0.93
	8g/LOLE	3.03	3.37	4.04	4.55	90	94.44	97.4	97.07	0.9	0.94	0.97	0.97
	10g/LOLE	1.68	1.85	2.19	2.53	94.46	96.95	98.59	98.37	0.94	0.97	0.99	0.98
0.1 M H_2SO_4	BLANK	16.84	30.3	66.67	155.23								
	2g/LOLE	7.74	9.09	11.62	13.97	54.04	70	82.57	91	0.54	0.7	0.83	0.91
	4g/LOLE	5.89	6.73	8.59	10.27	65.02	77.79	87.12	93.38	0.65	0.78	0.87	0.93
	6g/LOLE	4.04	4.55	5.56	6.23	76.01	84.98	91.66	95.99	0.76	0.85	0.92	0.96
	8g/LOLE	2.53	2.69	3.03	3.2	84.98	91.12	95.46	97.94	0.85	0.91	0.95	0.98
	10g/LOLE	1.52	1.52	1.68	1.85	90.97	94.98	97.48	98.81	0.91	0.95	0.97	0.99

3.5. Adsorption Considerations

It has been widely reported that most corrosion inhibitors act by adsorption on the metal surface [7]. This is controlled by the nature and surface change of the metal, the nature of destructive electrolyte and the chemical arrangement of the inhibitors. Therefore vital information on the contact between the inhibitor and the metal surface can be provided by the adsorption isotherm. For this , values of surface coverage (Θ) at diverse concentrations of the inhibitors used in H_2SO_4 media at temperatures (30 – 60 ^{0}C) were used to clarify the best isotherm to decide the adsorption process. Adsorption of an organic adsorption onto metal/solution interface could be expressed as a replacement on adsorption process among the organic molecules in the aqueous solution, $Org_{(sol)}$ with the water molecules on the metallic surface $H_2O_{(ads)}$ **[8]**

$$\mathbf{Org_{(sol)}\ and\ {}_{X}H_2O_{(ads)}} \ \_\_\_\_\_\_\_\_\ Org_{(ads)} + xH_2O_{(sol)} \qquad (1)$$

$Org_{(sol)}$ and $Org_{(ads)}$ were the organic molecules in the aqueous solutions and adsorbed on the surface of metal, $H_2O_{(ads)}$ the water molecules on the metallic surface and x is the ratio size representing the number of water molecules substituted by one molecule of organic adsorbate.

In this study, efforts have been made to position these (Θ) values to different isotherms and only Langmuir and Freundlich isotherms best portrayed the intake behavior of these inhibitors on the surface of mild steel and aluminium. Languir adsorption isotherm con be expressed thus:

$$(\Theta) = \frac{KC}{1+KC} \qquad (2)$$

Reshuffling this equation gives

$$C/\Theta = 1/K + C \qquad (3)$$

While Freundlich adsorption isotherm is of the general form :

$$\Theta = KC^n \qquad (4)$$

Which in logarithmic form gives

$$\log\Theta = \log K + n\log C \qquad (5)$$

Plot of C/Θ Vs C in Fig. 4 yield a straight line proving that the adsorption of the inhibitors in solution on the mild steel surface follows the Langmuir adsorption isotherm. Their strong correlation (R^2 =0.994 for days 1and 2, 0.995 for day 3,0.989 for day 4 and 5 0.987 for day 5 in Guava leaf extracts) for the isotherm plots confirmed the validity of this approach. In addition, adsorption of the inhibitors in H_2SO_4 onto mild steel surface also obeys Freundlish adsorption, presented in Figures 5 below. Inspection of the figures showed liner correlation. The linear correlations indicate that inhibitors were adsorbed onto the mild steel surface.

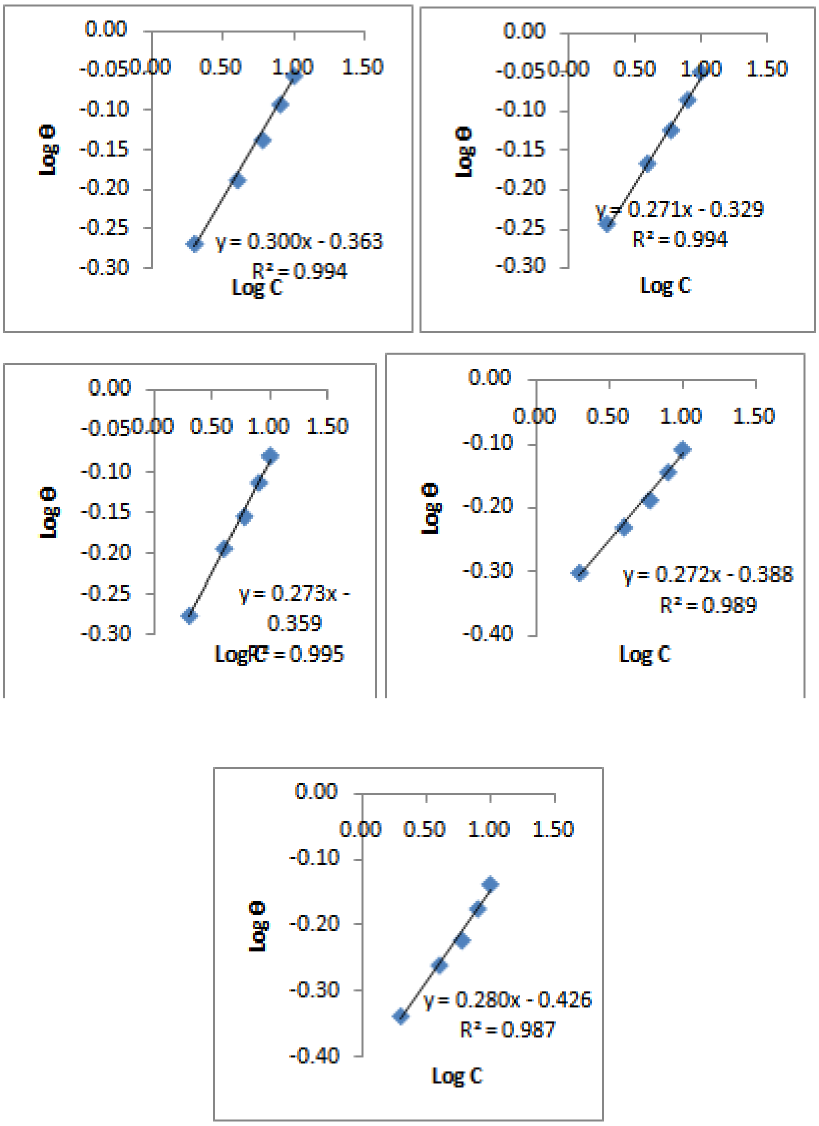


FIG. 5: Freundlich isotherms data for guava leaf extracts adsorption on mild steel surface from 0.1M H_2SO_4 solution.

3.6. The results of the weight loss (technique) using RSM

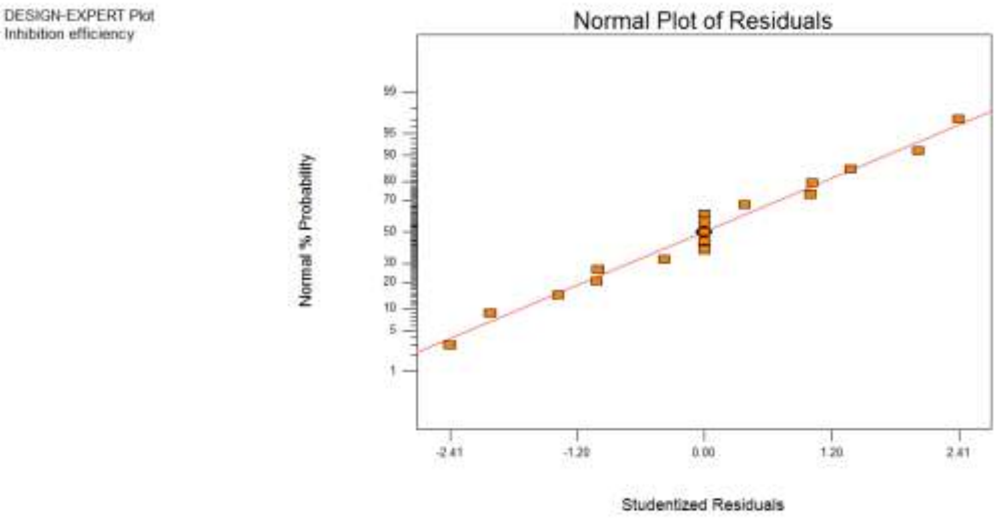
Responses for oxidation rate, inhibition efficiency with surface coverage to the factors of temperature, inhibitor concentration with medium's concentration for the oxidation inhibition of metals in media with guava leaf extract is presented in Table 2. The data show the disparity of oxidation rate with temperature, inhibitor concentration and medium concentration of the metal mild steel in acid medium. The corrosion rate increase with increase in temperature and medium concentration but diminished with boost in the inhibition concentration. Decrease in oxidation rate with increase in concentration of the inhibitor is an indication that inhibitor inhibited the oxidation of mild steel in acid medium. Increase in concentration of inhibitor increases the inhibition efficiency with surface coverage. Inhibition efficiency reduces as temperature rises. [9 and 10].

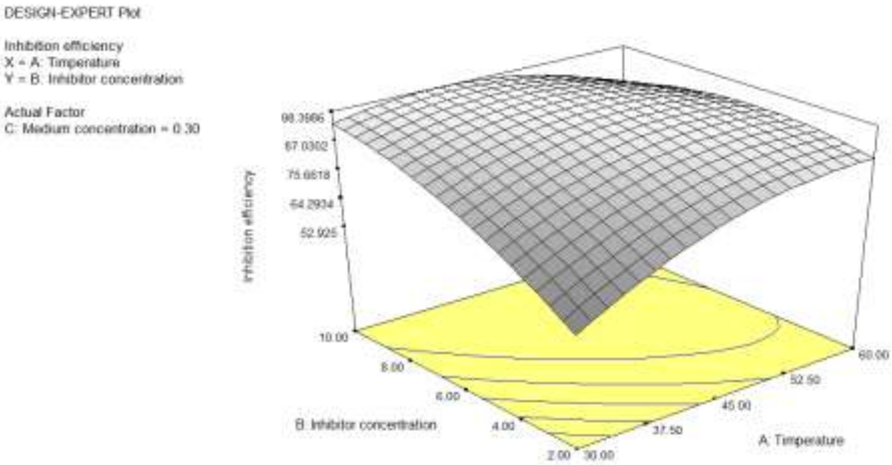
Table 2. presents the results of oxidation inhibition of mild steel in H_2SO_4 . From the Table, guava leaf has highest efficiency of 96.82%. Guava leaf has good inhibition efficiency. Occurrence of C-H bend, C-X fluoride, ≡C-H stretch, hydrogen-bonded O-H stretch, O-H stretch carboxylic acid, hydrogen-bonded O-H Stretch and N-H stretch could be attributed to it's good efficiency.

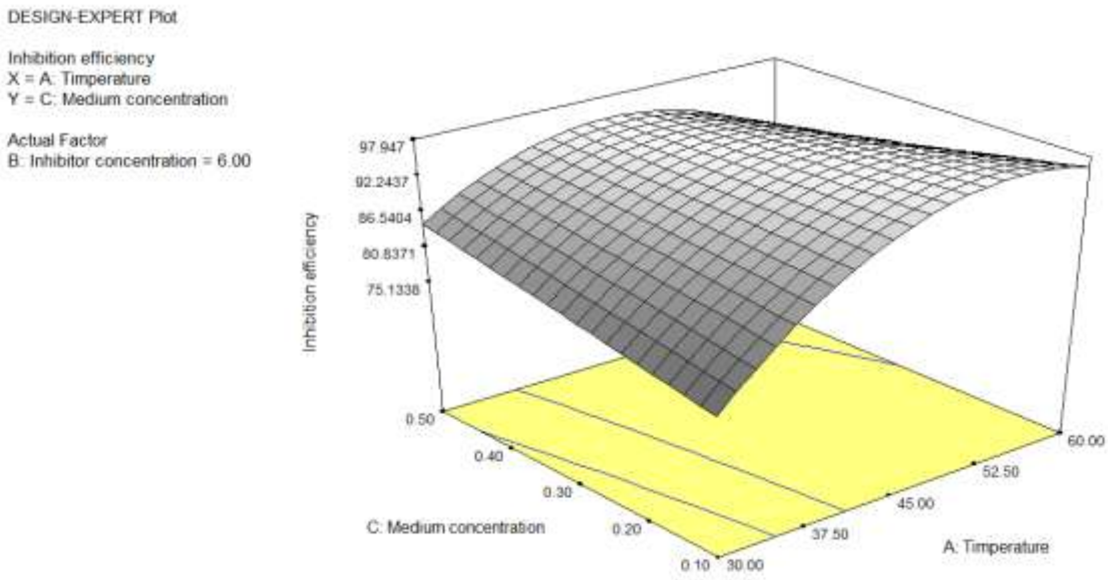
Disparity of inhibition efficiency with concentration, temperature and time were further analyzed using graphs and mathematical model resolute by response surface methodology (RSM) of the design expert software. RSM is an effective means to realize optimization by analyzing and modeling the effects of numerous variables and their responses and finally optimizing the process.

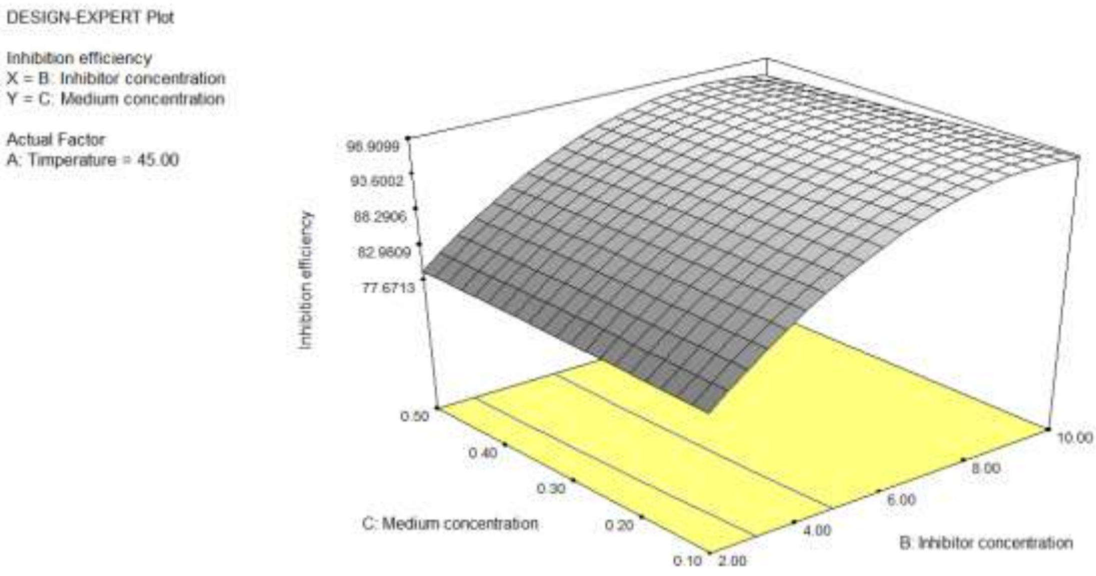
Table 2: Result of RSM for corrosion inhibition of St. in H_2SO_4 in guava leaf extracts.

Std	Run	Factor 1; A: Tempt. oC	Factor 2; B: Inhibior conc. (g/l)	Factor 3; C : Medium conc.(M)	Response 1; Corrosion rate (mm/yr)	Response 2; Inhibitor efficiency (%)	Response 3; Surface coverage (K)
17	1	45.00	6.00	0.30	7.99	94.85	0.95
12	2	45.00	10.00	0.50	7.66	95.07	0.95
13	3	45.00	6.00	0.30	7.99	94.85	0.95
5	4	30.00	6.00	0.10	4.04	76.01	0.76
9	5	45.00	2.00	0.10	10.45	78.86	0.79
6	6	60.00	6.00	0.10	6.23	95.99	0.96
1	7	30.00	2.00	0.30	12.46	50.86	0.51
7	8	30.00	6.00	0.50	13.47	84.85	0.85
10	9	45.00	10.00	0.10	1.6	96.82	0.97
15	10	45.00	6.00	0.30	7.99	94.85	0.95
3	11	30.00	10.00	0.30	1.68	94.46	0.94
8	12	60.00	6.00	0.50	23.23	85.04	0.85
11	13	45.00	2.00	0.50	29.97	80.7	0.81
2	14	60.00	2.00	0.30	23.4	84.93	0.85
14	15	45.00	6.00	0.30	7.99	94.85	0.95
4	16	60.00	10.00	0.30	2.53	85.37	0.85
16	17	45.00	6.00	0.30	7.99	94.85	0.95









IV. CONCLUTION

1.In summary, weight loss and FT-IR were engaged to examine the corrosion inhibition with adsorption behavior of guava leaf extract in the oxidization of mild steel in H_2SO_4 medium.

2.The weight loss measurement result obtained showed that guava leaf extract is a fine oxidization inhibitor for mild steel

3.Inhibition efficiency was reliant on inhibition concentration. The higher the inhibitor concentration, the better the inhibitive recital .

4.The inhibitor molecules were adsorbed on the metal surface following the Freundlich adsorption isotherms.

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