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Evaluation of the Adsorption and Corrosion Inhibition Effects of *Piliostigma thonningii* Extract on Mild Steel in 1.0 M Hydrochloric Acid

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Abstract: The effect of the adsorption of *Piliostigma thonningii* extract as inhibitor and the corrosion behavior of mild steel (MS) in 1.0 M HCl was investigated using gravimetric analysis at concentrations of inhibitor ranging from 0.2 g/L to 1.0 g/L, temperatures ranging from 303 K to 333 K, and time intervals ranging from 24 to 120 hrs respectively. When compared to a blank, the results showed that *Piliostigma thonningii* extract is a good inhibitor, and the inhibition efficiency (%IE) of the plant stem extract increases with increasing inhibitor concentrations. Surface coverage (θ) increases from 0.00 to 0.89 as concentration of inhibitor increases from 0.2 to 1.0g/L . In contrast, the corrosion rate increases with increasing temperature, whether with or without inhibitor; this could be due to an increase in the average kinetic energy of the reacting molecules. Four distinct peaks were observed from the FTIR result around 3354, 2922, 1625, and 1162 cm1, corresponding to phenols of -OH stretching, alkanes C-H stretching, alkenes -C=C- stretching, and protein C-N stretching vibrations, indicating the presence of potential biomolecules and functionalities in the plant extract. Based on the thermodynamic and adsorption isotherms investigated, the Langmuir, Freundlinch and El-Awady models best described the inhibitor adsorption on the Mild Steel coupons.

1. Introduction

Mild steel has been used in a variety of industries for a variety of purposes due to its extremely light form, affordability, malleability, ductility, and ease of recycling when compared to other forms of steel. Mild steel is commonly used in our homes and workplaces for construction, the manufacture of poles and pipelines, cookwares and cutlery, and so on. When acidic substances such as hydrochloric acid (HCl), sulfuric acid (H_2SO4) and other acidic solutions come into contact with mild steel, they cause corrosion if not mitigated (Chahul *et al*., 2015 & 2019). The transfer of electrons from the anode to the cathode causes corrosion; the anode is oxidized, while the cathode is reduced. The main issue with the use of mild steel in construction companies/industries is its corrosion resistance, particularly in acidic environments. This has resulted in an exponential rise in the cost of maintaining mild steel-based equipment, resulting in increased costs for the majority of companies/industries (Eduok *et al.* 2012, Nnanna *et al*., 2014).

Painting, electroplating, and the use of inhibitors (inorganic and organic) have all been used to reduce and prevent corrosion of metals for construction companies/industrial use over the years (Peter *et al*., 2015). Green corrosion inhibitors are non-toxic, environmentally friendly, and less expensive. This significant advantage has accelerated the search for the rapid scientific application of naturally occurring plant extracts for the study of metal corrosion inhibition (Ayuba *et al*., 2013, Oguzie *et al*., 2012). Organic compounds such as saponin, tannin, alkaloids, steroids, amino acids, and glycosides are responsible for the inhibitive effects of organic extracts on metals (Ayuba *et al*. 2013, Chahul et al., 2017). In general, organic molecules with electron-releasing substituents like NH2, OH, COCH3, CH3, etc. are better corrosion inhibitors than those with electron-drawing substituents like NO2, CN, COOH, etc. (Peter *et al*. 2015, Uwah *et al*., 2013). Plant stem, leaf, and root inhibitors have been shown in studies to be effective metal inhibitors in corrosive media such as seawater (Momoh-Yahaya *et al*., 2012, Peter *et al*., 2015).

Piliostigma thonningii (P. *thonningii*) stems, roots, and leaves are used for a variety of medicinal purposes in most African countries. The leaves and bark contain decoctin, which is used to treat ulcers, wounds, heart pain, arthritis, malaria, pyrexia, leprosy, sore throats, diarrhea, toothaches, gingivitis, coughs, and bronchitis (Nwaehujor *et al*. 2015, Ighodaro *et al*., 2012). The use of plant extracts as corrosion inhibitors is one of the green approaches used in controlling the corrosion of metals and alloys in acidic environments (Eddy *et al*., 2010). The purpose of this study is to investigate and evaluate the inhibitive and adsorptive behavior of P. *thonningii* extract on the corrosion of mild steel in a 1.0 M hydrochloric acid solution using weight loss measurement and testing the various adsorption isotherm.

2. Methodology

2.1 General

The chemicals used for this study were purchased from Kofar Kaura chemical shop in Katsina State, Nigeria; they include hydrochloric acid, n-hexane, ethyl acetate, ethanol, acetone. Mild Steel obtained from pipeline construction company, Kaduna with chemical composition (wt%): 98.63% Fe, 0.47% Mn, 0.43% Si, 0.26% C, 0.13% Al, 0.04% Cr, 0.02% Ni, 0.01% S, 0.01% P was used as test samples. They were fabricated into 3.0 × 2.0 cm the Mild Steel has a thickness of 0.4cm. Analytical digital weighing balance (ACCULAB STARTORIUS GROUP), Fourier transform infrared spectrophotometer (Agilient Cary 630 FTIR), UV/Vis Spectrophotometer (JASCO 630), and Thermostat water bath was also used for the study.

2.2 Preparation of standard solution

The standard solution of the acid was prepared from analytical grade 1.0 M HCl solution. It was prepared by adding 83.3mL. of 12.0 M HCl to distilled water making it up to 1L.

2.3 Collection of plant material

Samples of P. *thonningii* plant were obtained from the Botanical Garden, Biological Science Department, Umaru Musa Yar'Adua University, Katsina State, Nigeria. The stem back was collected and identified using standard procedures.

2.4 Extraction of inhibitor

P. *thonningii* stem-back samples obtained were washed under running water to remove dust and other particles before being dried in a 313K oven for 6 weeks and pulverized with a pestle and mortar; the finely powdered samples were sieved and stored in a polyethylene bag for analysis. The pulverized stem barks were extracted for 72 hours at 300K using n-Hexane, ethyl-acetate and ethanol solution and filtered using Soxhlet extraction. The filtrate was then concentrated in a water bath to make thick syrup, which was then air dried. The extracted plant extracts were used to make different concentrations of the plant extract by dissolving 0.2, 0.4, 0.6, 0.8, and 1.0 g/L in 1.0 M HCl. (Ijuo *et al*., 2016, & 2016 Fayomi *et al*., 2021)

Figure 1. *Pilliostigma thonningii* stem

2.3 Weight loss experiment

The pre-weighed mild steel coupons were immersed in 1.0 M HCl for 1 hour at 303K, 313K, and 323K in a water bath, both without and with different concentrations of the extracts. They were retrieved, cleaned, and reweighed to determine the weight loss caused by the acidic medium and the inhibitor. This experiment was repeated twice, and the mean values of the weight losses (g) were used to calculate the corrosion rate (CR), inhibition efficiency (%IE) and the degree of surface coverage (θ) as shown in Eqn. (1), (2) and (3) below (Momoh-Yahaya *et al*. 2012, Femi *et al*. 2015, Louis *et al.* 2017, Pheobe *et al*., 2021).

$$CR_{(gh^{-1}cm^{-2})} = \frac{Weight\ Loss}{AT} \quad (1)$$

$$\%IE = \frac{CR_{(Inh)}}{CR_{(Blank)}} \times 100 \quad (2)$$

$$\theta = \frac{IE}{100} \quad (3).$$

2.4 Adsorption Analyses

The adsorption behavior of P. *thonningii* extracts was investigated by comparing various adsorption isotherm models to see which one best fit the experimental results. Freundlich, Langmuir, El-Awady, Temkin, and Frumkin adsorption isotherm models were all tested (Ahanotu *et al*., 2022).

3.0 Results and Discussion

3.1Inhibitor Concentration Effect

Figures 2 and 3, show the effect of P. *thonningii* stem extract concentration on corrosion rate (CR) and inhibition efficiency (%IE) at 303K for mild steel corrosion in 1.0M HCl in the absence and presence of various plant extract concentrations.

Figure 2, shows that:

(1) The weight loss (g) of mild steel coupons in 1.0 M HCl decreased as the concentration of the plant extract increased.

(2) As the concentration of the plant extract increased, so did the surface coverage (θ) of the adsorbed plant stem extract on the mild steel coupons, which served as a barrier or cover for further corrosion,

as shown in **Table 1** from 0.00 to 0.89, this is in agreement with the study carried out (Oguzie *et al*. 2012, Obot *et al*. 2013, Magu *et al*. 2017 Wang *et al*., 2020).

Figure 3: (1) As shown in **Figure 3**, as the concentration of the plant extract increased, the corrosion rate (gh-1 cm2) of mild steel coupons in 1.0 M HCl decreased. (2) As the concentration of the plant extract increased, the surface coverage (θ) of the adsorbed plant stem extract on the mild steel coupons, which served as a barrier or cover against further corrosion, increased from 0.00 to 0.89, as shown in **Table 1**, which is consistent with the findings of the study (Ugi *et al*., 2016, Suleiman *et al.,* 2020).

Figure 4: The inhibition efficiency (%IE) of the plant stem extract increased with increase in inhibitor concentrations. The increase may have resulted from the increase in the surface covered (θ) by the adsorbed constituents of the plant stem extract (Uwah et al., 2013). The corresponding values of the corrosion rate (CR), inhibition efficiency (%IE) and surface coverage (θ) of various concentration of *P. thonningii* stem extract in 1.0M HCl obtained from the plots are presented in **Table 1**.

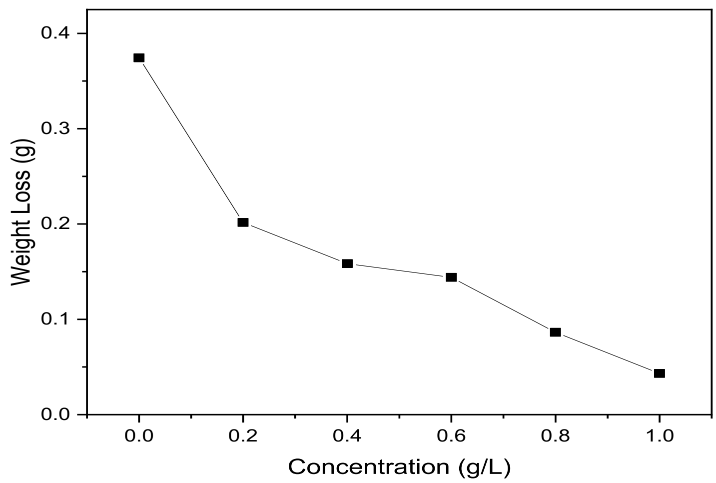

Figure 2. The variation of Weight loss of mild steel against various concentration of *P. thonningii* stem extract in 1.0M HCl at 303K in 24hrs.

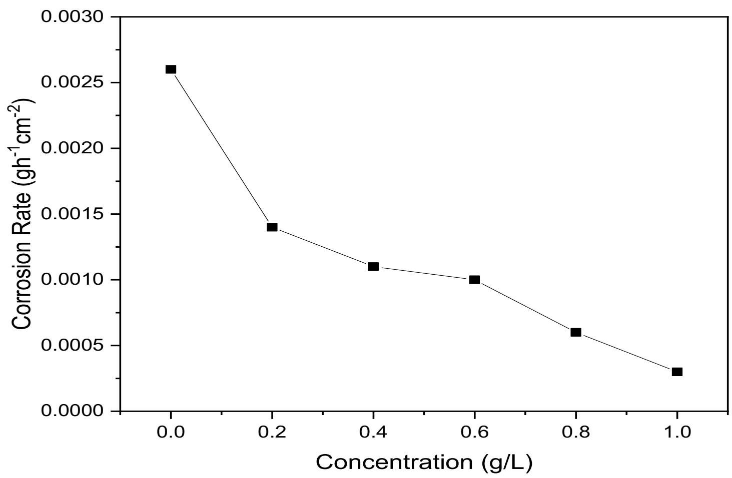

Figure 3. The variation of Corrosion Rate ($gh^{-1}cm^{-2}$) of mild steel against various concentration of *P. thonningii* stem extract in 1.0M HCl at 303K in 24hrs.

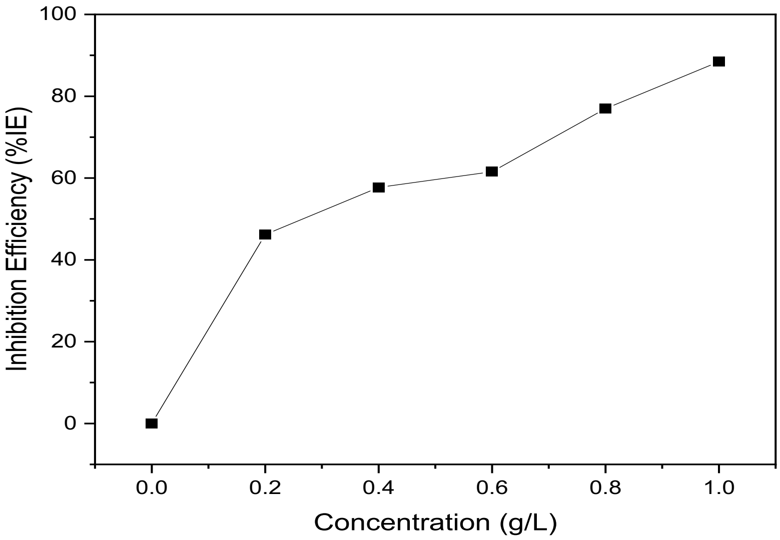

Figure 4. The variation of Inhibition Efficiency (%IE) against various concentration of *P. thonningii* stem extract on mild steel in 1.0M HCl at 303K in 24hrs.

Table 1. Corrosion Rates of Mild steel and Inhibition Efficiency of *P. thonningii* stem Extract in 1.0M HCl at 303K for 24hrs immersion time.

Concentration (g/L).	303K			
	Weight Loss (g)	Corrosion Rate (g/cm^2h)	Inhibition Efficiency(%IE)	Surface coverage (θ)
Blank	0.3744	0.0026	-	-
0.2	0.2016	0.0014	46.15	0.46
0.4	0.1584	0.0011	57.69	0.58
0.6	0.144	0.0010	61.54	0.62
0.8	0.0864	0.0006	76.92	0.77
1.0	0.0432	0.0003	88.46	0.89

3.2 Effect of Immersion Time

Figure 5, shows the effect of immersion time on the weight loss of Mild steel in 1.0M HCl at 303K in the absence and presence of different concentrations of the extract ranging from 0.2g/L to 1.0g/L. From **Figure 5**, it is evident that the weight loss of Mild steel increased with time. From **Figure 6**, it is evident that the corrosion rates of the mild steel coupons in the presence of the extract decreased with increasing inhibitor concentration. From **Figure 7**, it is evident that, the inhibition efficiency decreased with time, but increased with increase in the concentration of the inhibitor. **Table 2, 3** and **4** shows the parameters of the effect of immersion time (hrs.) on Mild steel in 1.0M HCl in the Absence and Presence of *P. thonningii* stem extract at 303K

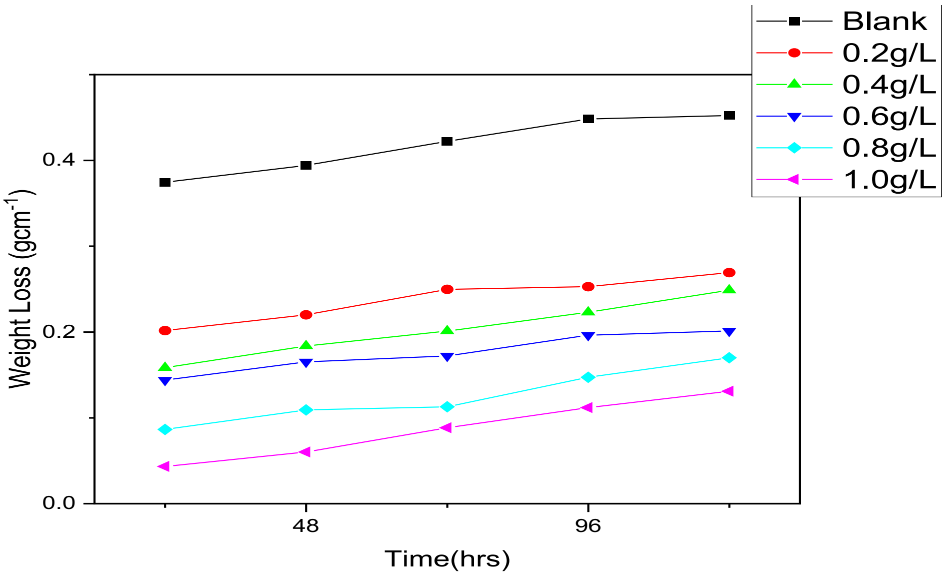

Figure 5. Effect of Immersion Time (hrs.) on Weight Loss (gcm^{-1}) of Mild Steel in 1.0M HCl in the Absence and Presence of *P. thonningii* stem extract at 303K

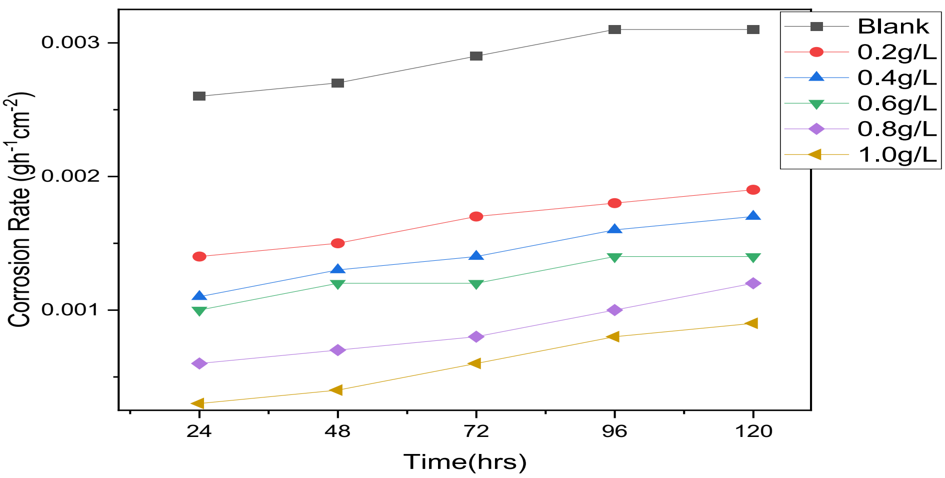

Figure 6. Effect of Immersion Time (hrs.) on Corrosion Rate of Mild Steel in 1.0M HCl in the Absence and Presence of *P. thonningii* stem extract at 303K

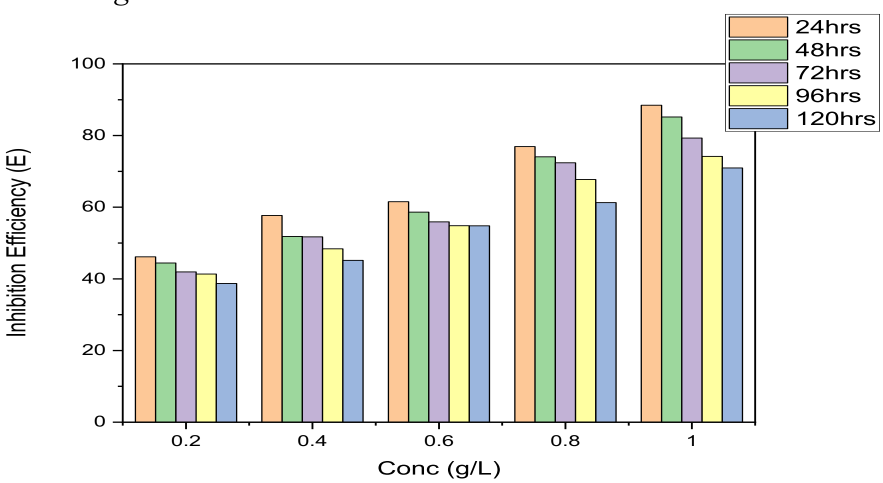

Figure 7. Effect of Immersion Time (hrs.) on Inhibition Efficiency (%IE) of Mild Steel in 1.0M HCl in the Absence and Presence of *P. thonningii* stems extract at 303K

Table 2. Parameters of the effect of immersion time (hrs.) on Weight Loss of Mild steel in 1.0M HCl in the Absence and Presence of *P. thonningii* stem extract at 303K

Concentration	Weight Loss (gcm^{-1})				
(g/L)	24hrs	48hrs	72hrs	96hrs	120hrs
Blank	0.3744	0.3943	0.4222	0.4482	0.4523
0.2g/L	0.2016	0.2200	0.2497	0.2528	0.2692
0.4g/L	0.1584	0.1837	0.2011	0.2230	0.2487
0.6g/L	0.1440	0.1652	0.1721	0.1962	0.2012
0.8g/L	0.0864	0.1091	0.1129	0.1472	0.1699
1.0g/L	0.0432	0.0601	0.0884	0.1119	0.1310

Table 3. Parameters of the effect of immersion time (hrs.) on Corrosion Rate of Mild steel in 1.0M HCl in the Absence and Presence of *P. thonningii* stem extract at 303K

Concentration	Corrosion Rate ($gh^{-1}cm^{-2}$)				
(g/L)	24hrs	48hrs	72hrs	96hrs	120hrs
Blank	0.0026	0.0027	0.0029	0.0031	0.0031
0.2g/L	0.0014	0.0015	0.0017	0.0018	0.0019
0.4g/L	0.0011	0.0013	0.0014	0.0016	0.0017
0.6g/L	0.0010	0.0012	0.0012	0.0014	0.0014
0.8g/L	0.0006	0.0007	0.0008	0.0010	0.0012
1.0g/L	0.0003	0.0004	0.0006	0.0008	0.0009

Table 4. Parameters of the effect of immersion time (hrs.) on Inhibition Efficiency (%IE) of Mild steel in 1.0M HCl in the Absence and Presence of *P. thonningii* stem extract at 303K

Concentration	Inhibition Efficiency (%IE)				
(g/L)	24hrs	48hrs	72hrs	96hrs	120hrs
Blank	-	-	-	-	-
0.2	46.15	44.44	41.94	41.34	38.71
0.4	57.69	51.85	51.72	48.39	45.16
0.6	61.54	58.62	55.92	54.84	54.80
0.8	76.92	74.07	72.41	67.74	61.29
1.0	88.46	85.19	79.31	74.19	70.97

3.3 Temperature Effect:

Figure 8 shows that the corrosion rate of mild steel, with or without inhibitor, increased as temperature increased. This is due to the fact that the rate of corrosion of mild steel increased as temperature rose.

This could be due to the increasing average kinetic energy of the reacting molecules. The corrosion rate, however, is reduced in the presence of plant stem extracts. **Figure 9,** depicts the temperature dependence of inhibition efficiency; it is clear that corrosion rates increased as temperature increased in both the uninhibited and inhibited processes. Plant extracts' inhibition efficiency decreases as temperature rises. This could be due to the mild steel's adsorption of the protective inhibitor. As a result, these coupons are susceptible to dissolution in acidic media (Oguzie *et al*. 2012, Nnanna *et al*. 2014). **Table 5,** presents the corrosion rate (g/hcm^2) and Inhibition Efficiency (%IE) for Corrosion of Mild Steel in the Absence and Presence of various Concentrations of the *P. thonningii* stem Extract in 1.0M HCl

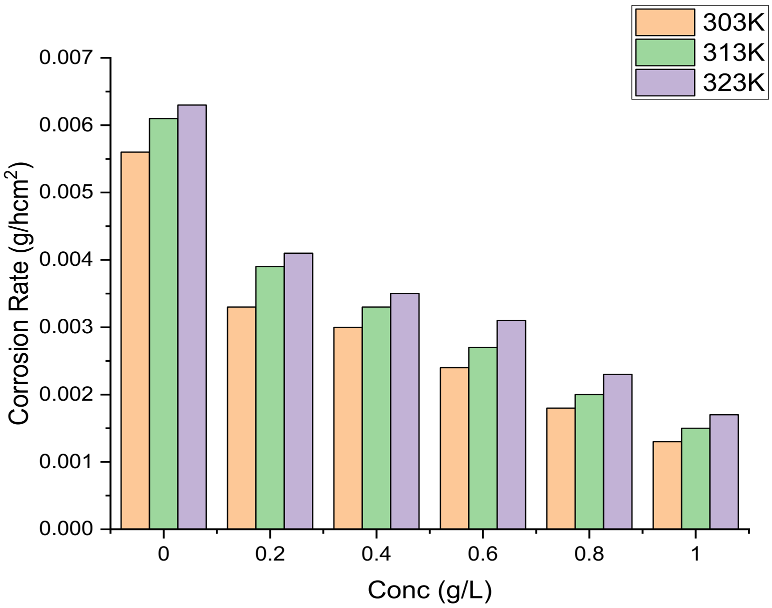

Figure 8. Variation of Corrosion Rate (g/cm^2hr) against Temperature for the Corrosion of Mild Steel in 1.0M HCl in the presence and absence of *P. thonningii* stem extract.

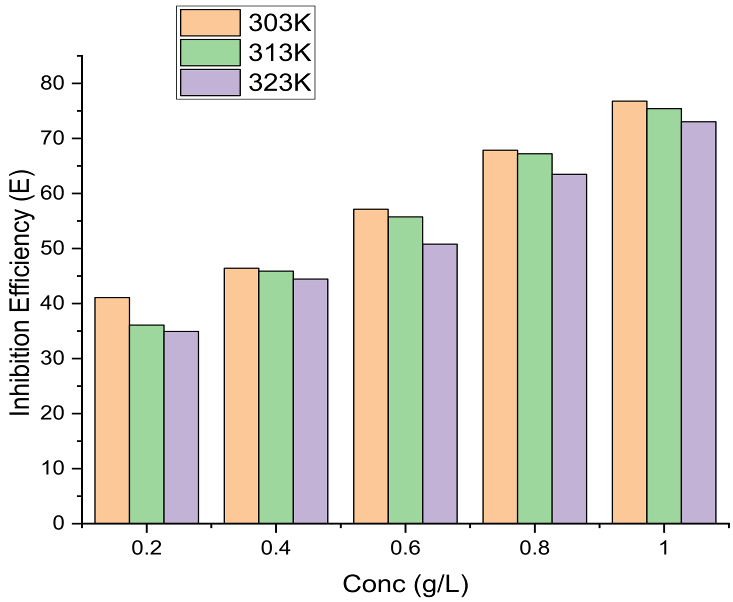

Figure 9. Variation of Inhibition Efficiency (%IE) against Temperature for the Corrosion of Mild Steel in 1.0M HCl in the presence and absence of *P. thonningii* stem extract.

Table 5. Corrosion Rate (g/hcm^2) and Inhibition Efficiency (%IE) for Corrosion of Mild Steel in the Absence and Presence of various Concentrations of the *P. thonningii* stem in 1.0M HCl

Concentration(g/L)	Corrosion Rate (g/hcm^2)			Inhibition Efficiency (%)		
	303K	313K	323K	303K	313K	323K
Blank	0.0026	0.0029	0.0031	-	-	-
0.2	0.0014	0.0017	0.0019	46.15	41.38	38.71
0.4	0.0011	0.0013	0.0017	57.69	55.17	46.16
0.6	0.0010	0.0013	0.0016	61.54	55.17	48.39
0.8	0.0006	0.0008	0.0011	76.92	72.41	64.52
1.0	0.0003	0.0004	0.0006	88.46	86.21	80.65

3.4 Determination of adsorption isotherms and constants

Adsorption isotherms are commonly used to investigate the adsorption process. **Figures** 10, 11, 12 are the graphs that depict the interaction of the adsorbates and adsorbents. The adsorption characteristics of P. *thonningii* stem extracts were studied and investigated by fitting the data obtained for the degree of surface coverage (θ) from weight loss experiments at 303K to 323K into the various adsorption isotherms and were found to best fit the Langmuir, Freundlinch, and El-Awady models.

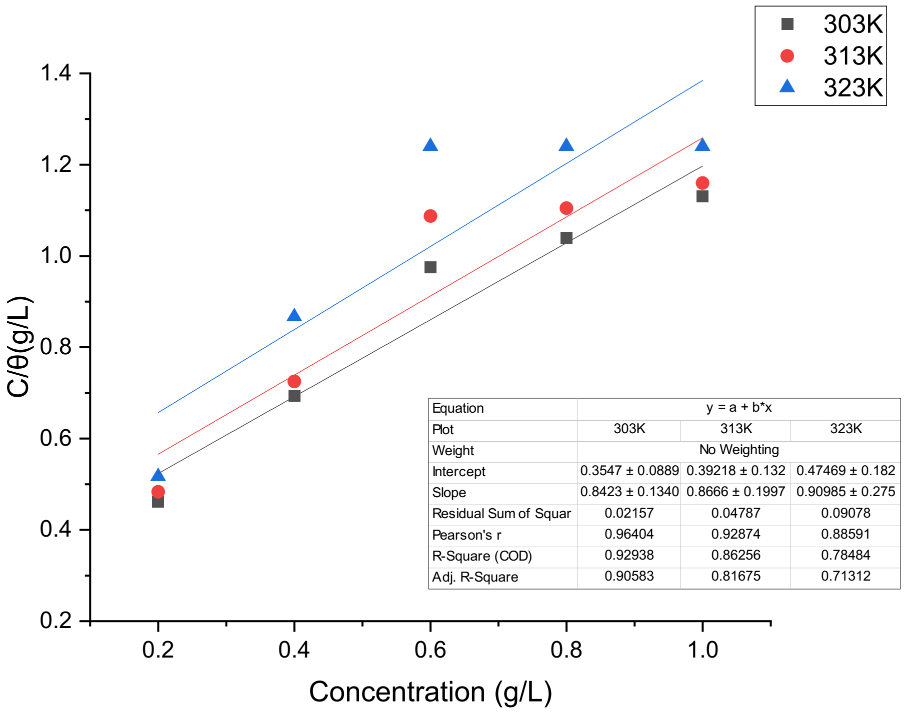

Figure 10. Langmuir adsorption isotherm plot

Langmuir, Temkin, Freundlich, and El-Awady isotherms were tested using the **equations (4), (5), (6), and (7),** respectively (Chahul *et al*., 2015 & 2019, Fayomi *et al*. 2021, Ijuo *et al.*, 2016 & 2016):

$$\frac{C}{\theta} = \frac{1}{K_{ads}} + C \tag{4}$$

$$\theta = lnC + K_{ads} \tag{5}$$

$$log\theta = lnC + nlogC \tag{6}$$

$$\log\left(\frac{\theta}{1-\theta}\right) = ylogC + logK \tag{7}$$

Where C is the concentration, θ is the degree of surface coverage, K_{ads} is the equilibrium constant of the adsorption. The data from the study gave the best fit for 3 adsorption isotherm with adsorption models presented on **Table 5,** taking into cognizance that the plots gave linear slopes with regression coefficients R^2 values. **Table 6,** shows the parameters of the linearization for each adsorption model.

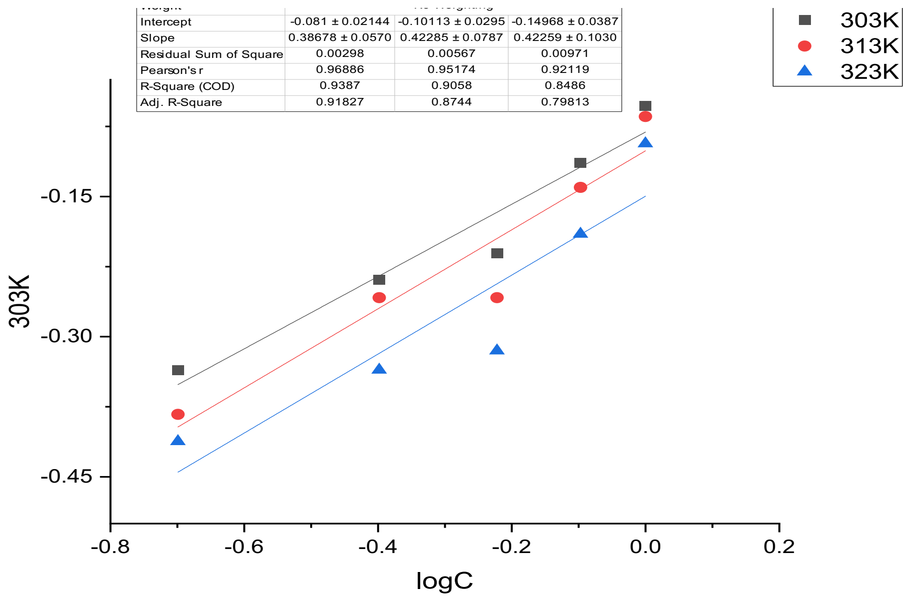

Figure 11. Freundlich isotherm plot

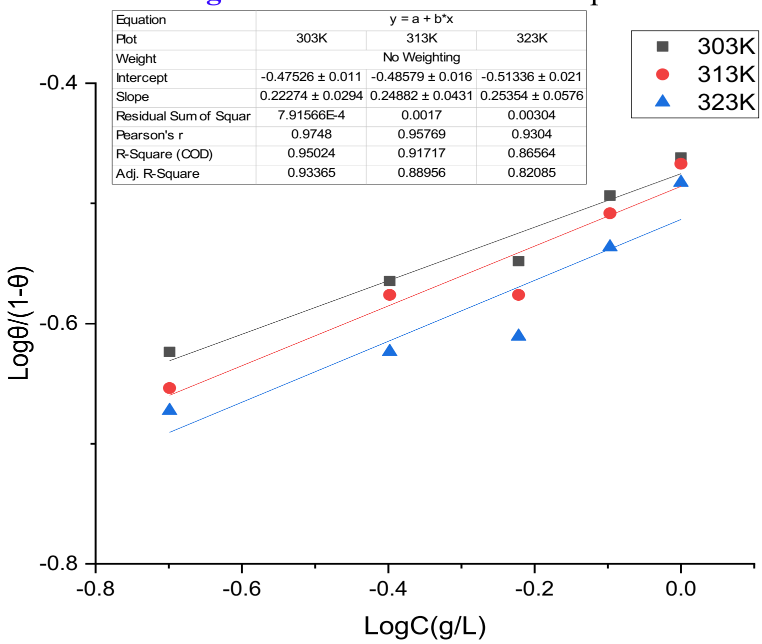

Figure 12. El-Awady isotherm plot.

Table 6. Parameters of Langmuir and Freundlinch and El-Awady Adsorption Isotherms for the Adsorption of *P. thonningii* stem extract on mild steel surface at 303-323K

Isotherm	Intercept	Slope	K_{ads}	R^2
Langmuir				
303K	0.3547	0.8423	1.1872	0.9294
313K	0.3922	0.8666	1.1539	0.8626
323K	0.4747	0.9099	1.0990	0.7848
Freundlinch				
303K	-0.0810	0.3868	2.3663	0.9387
313K	-0.1011	0.4229	2.3646	0.9058
323K	-0.1497	0.4226	2.5853	0.8486
El-Awady				
303K	-0.4753	0.2227	4.4903	0.9502
313K	-0.4858	0.2488	4.0193	0.9172
323K	-0.5134	0.2535	3.9448	0.8656

3.1 Thermodynamic Studies

The energy of activation (E_a) of the corrosion of mild steel coupons in 1.0M HCl in the presence and absence of *P. thonningii* stem extract was evaluated using the values of the corrosion rates (CR) of the mild steel coupons at different temperature (K) (Chahul *et al*. 2015 & 2019, Phoebe *et al*., 2021):

$$logCR = -\frac{E_a}{2.303RT} + logA \quad (8)$$

Where CR is the corrosion rate of mild steel, A is the Arrhenius constant, E_a is the activation energy, T is the absolute temperature in Kelvin, and R is the universal gas constant.

Plot of logCR versus 1/T represented in **Figure 14**, gave a straight-line graph with slope of $\left(-\frac{E_a}{2.303R}\right)$ and an intercept of [log A] from which the values of the activation energy was evaluated. **Table 6,** presents Energy of activation(E_a) , Enthalpy change ΔH_a and Entropy change ΔS_a values from the plotted graph in **Figure 13** and **14**. The values of the activation energy (E_a), Enthalpy change (ΔH_a) and (ΔG_a) in **Table 7,** were observed to be greater in the presence of the *P. thonningii* stem extract showing positive signs, reflecting the endothermic nature of the corrosion reaction process (Bammou *et al*., 2013). The value of activation energy was determined to be 7.32 $kJmol^{-1}$ for 1.0M HCl and increased with increase in concentration of the inhibitor, with the highest value at 28.82 $kJmol^{-1}$ for 1.0g/L concentration. This shows that addition of inhibitor decreased the rate of degradation of the Mild steel due to the increase in the activation energy (Chahul et al., 2015, Phoebe *et al*., 2021).

E_a values greater than 80$kJmol^{-1}$ shows chemisorption, when the E_a value is lesser than 80$kJolmol^{-1}$, physisorption mechanism is followed. The experimental data for E_a evidently showed that the adsorption of the inhibitor on mild steel coupons surfaces followed a physisorption mechanism (Chahul *et al*., 2019).

Enthalpy change (ΔH_a) from Table 7 indicates positive values, which showed that the reaction process is endothermic for 1.0M HCl and different concentration of the inhibitor. The negative values of Entropy change (ΔS_a) indicate an increasing level of the degree of disorderliness, which showed a greater association of the inhibitor's molecules rather than dissociation, in this respect, the comparison of the inhibiting action of the investigated compounds in HCl will be of definite interest (Chahul *et al*. 2015, Ugi *et al*. 2016, Verma *et al*., 2018). The values of ΔG_a were positive and showed a limited increase with increasing temperature, indicating that the activated complex was not stable and that the probability of its formation decreased slightly with increasing temperature. As a result, the increase in corrosion rate with increasing temperature in Table 7, can be attributed to a large number of corrosion species passing into an activated state with a lower configuration. However, ΔG_a values for inhibited systems were higher than for uninhibited systems, indicating that in the presence of inhibitor addition, the activated corrosion complex becomes less stable than in its absence (Salhi *et al*., 2017).

Table 7. Activation parameters.

Concentration (g/L)	E_a (kJmol^{-1})	ΔH_a (kJmol^{-1})	E_a - ΔH_a (kJmol^{-1})	ΔS_a (kJmol^{-1})	ΔG_a (kJmol^{-1})
Blank	7.32	4.66	2.66	-14.57	9.08
0.2	12.70	10.03	2.66	-13.91	14.25
0.4	18.10	15.44	2.67	-13.10	19.41
0.6	19.54	16.88	2.66	-12.88	20.56
0.8	25.21	22.55	2.66	-12.13	26.23
1.0	28.82	26.16	2.66	-11.82	29.74

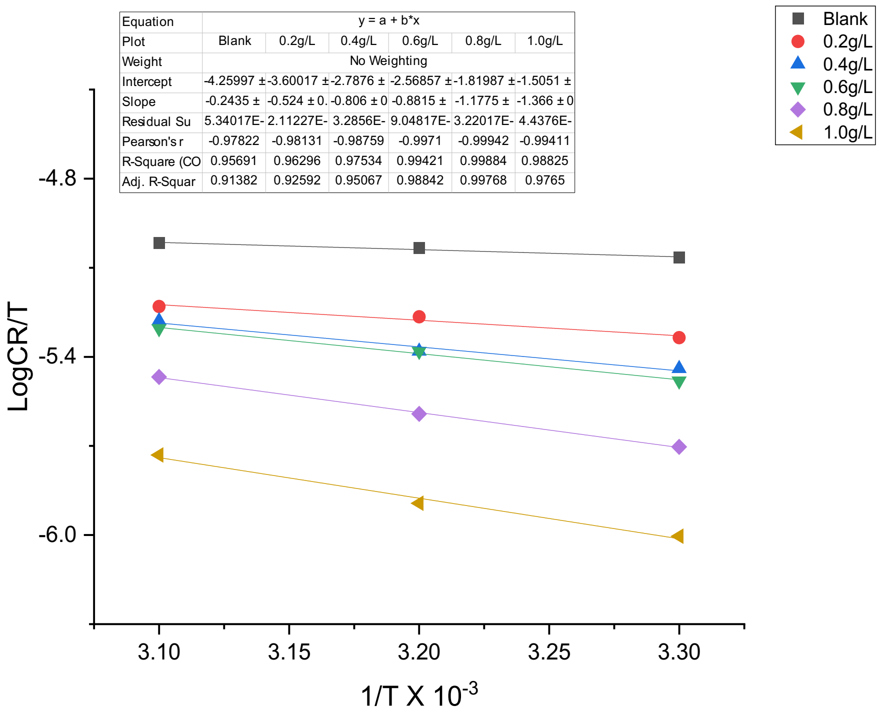

Figure 13. Eyring plot of the temperature-dependence of the corrosion rate of mild steel in 1.0M HCl (Transition state plot for determination of ΔH and ΔS)

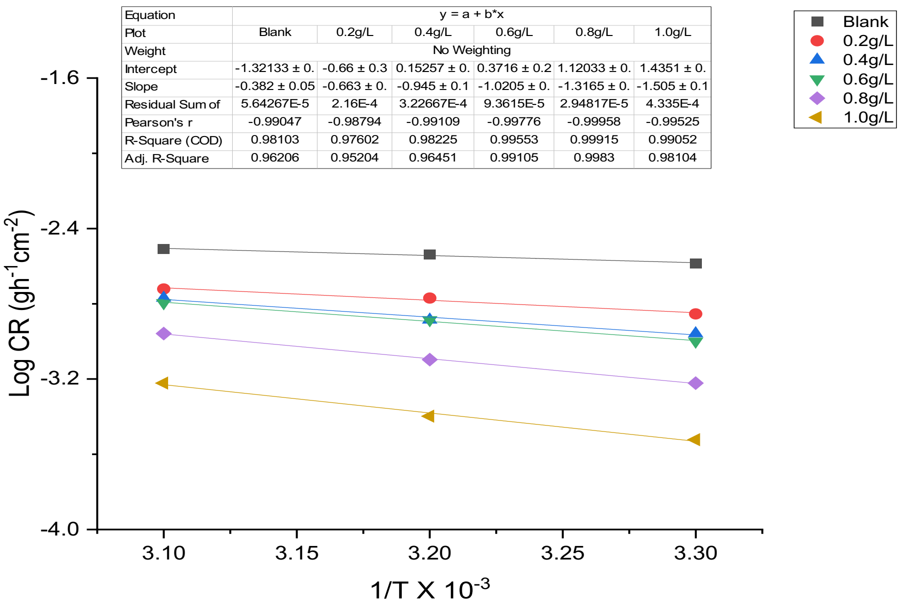

Figure 14. Arrhenius plot of the temperature dependence of the corrosion rate of mild steel/1M HCl

Table 7 indicated that the difference E_a - ΔH_a is 2.66 $kJmol^{-1}$ (equal RT); this provides substantial evidence that the corrosion reaction is unimolecular (Lgaz *et al*., 2016; Zarrok *et al*. 2013). Survey literature indicated that H^+ reduction on metallic surface consists of three steps: the Volmer, Heyrovsky and Tafel steps, according to :

Volmer step $$H_3O^+ + e^- \rightarrow H_{ads} + H_2O \quad (9)$$

Heyrovsky step $$H_{ads} + H_3O^+ + e^- \rightarrow H_2 + H_2O \quad (10)$$

Tafel step $$2H_{ads} \rightarrow H_2 \quad (11)$$

where H_{ads} is the atomic hydrogen adsorbed on the metal surface (Vogel *et al*., 1975; Bus *et al*. 2005; Shinagawa *et al*. 2015).

3.5 FTIR Analysis

The FTIR spectroscopy was used to investigate, detect and identify the potential biomolecules and functionalities of the plant extract. The obtained spectrum were shown in **Figure 15** below, four prominent peaks were observed around 3354, 2922, 1625, 1162cm-1.

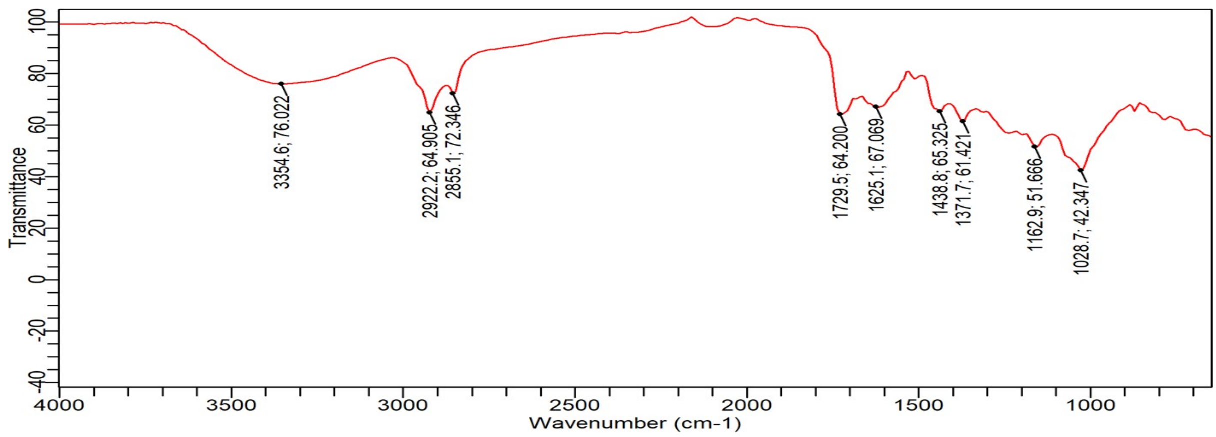

Figure 15. FTIR Pattern of *P. thonningii* stem extract

The peak around 3354 can be assigned to alcohol and phenols of -OH stretching, the peak around 2922 correspond to alkanes C-H stretching, the peak at 1625 corresponds to –C=C- stretching of alkanes while the peak at 1162 corresponds to C-N stretching vibration of the proteins depicting the presence of biomolecules such as saponin, tannin, alkaloids, steroids, amino acids and glycosides responsible for the inhibition of corrosion of the mild steel coupons. Steel inhibition protection by natural extracts is always viewed as an intermolecular synergistic effect of the extract's various components. These additives are rich in aromatic rings and heteroatoms such as nitrogen, oxygen, and sulfur in conjugated electron systems to facilitate adsorption of molecules on metal surfaces by creating a barrier that protects metals from aggressive ions such as H+ (Maliki *et al.*, 2020, Ahanotu *et al.*, 2022).

Conclusion

The P. *thonningii* stem extract reduced the rate of corrosion of Mild Steel coupons in an acidic environment (i.e., 1.0 M HCl solution). It was discovered in the study that the rate of corrosion increased with time and temperature. The inhibitory effect was due to the presence of some biomolecules such as steroids, saponin, glycosides etcetera or functional groups such as -OH and -CN present in the plant extracts, as evidenced by the FTIR analysis. The Langmuir, Freundlinch and El-Awady models best describe the inhibitor adsorption on the mild steel coupon based on the thermodynamic and adsorption isotherms studied.

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