ISSN No:-2456-2165

The Inhibitive Effect of Ficus Thonningii Leaves Extract In 1m HCL Solution as Corrosion Inhibitors on Mild Steel

H.C. Olisakwe [a], K.K. Ikpambese[b], T.D. Ipilakyaa[b] , I. E. Ekengwu[a]
[a] Department of mechanical Engineering, Nnamdi Azikiwe University, Awka, Nigeria
[b] Department of Mechanical Engineering, University of Agriculture Makurdi, Nigeria

Abstract:- The inhibitive Effect of Ficus thonningii leaves using Maceration (Cold water) extraction method on mild steel in 1M HCl solution was investigated using weight loss and potentio-dynamic polarization method. The extract has the potentials to contribute to the development of renewable, biodegradable and environmentally friendly corrosion inhibitors. The Phytochemical analysis shows the presence of active anti corrosion constituents such as Alkaloids, Saponins, Flavonoids, Glycosides, Polyphenols and Tannins. Corrosion rates for all concentration of Ficus thonningii Leaves extract decreased steadily with increasing exposure time as well as extract concentration, except at extract concentration of 0.0g/dm^3 where a rapid increase in corrosion rates was observed. The inhibitive efficiency of Ficus thonningii Leaves was 81.74% at room temperature, over immersion period of 240 hours at extract concentration 1.0g/dm^3, while at elevated temperatures, the inhibitive efficiency at immersion period of 8hrs, 1.0g/dm concentration was 51.46 at 298K and 43.95 at 328K. The correlation coefficient (R^2) value was high (0.9971 -0.9989) at room temperature, exposure period 240 hours, it adheres to Langmuir adsorption Isotherm. Potentiodynamic polarization results confirms Ficus thonningii Leaves as good corrosion inhibitors, the open circuit potential time (OCPT) stability test shows that the leave extract was stable at high and low (1.0g/dm^3 and 0.2g/dm^3) concentration. Ficus thonningii Leaves can be registered as good substitute for corrosion inhibition of mild steel in HCl solution.

Keywords:- *Ficus Thonningii Leaves, Cold Water Maceration, Inhibition Efficiency, Langmuir Adsorption Isotherm And Mild Steel.*

I. INTRODUCTION

Recently, so much attention has been focused on the need to design and develop organic corrosion inhibitors that will replace toxic ones. For sustainable development (Ashwe *et al* 2016) the use of plant extracts as corrosion inhibitors are justified by chemical substances with molecular properties similar to those of conventional (inorganic) molecules (Karahan et al 2011). The used of organic extracts as corrosion inhibition has played a major role in corrosion study in engineering (Ikpambese and yaji 2020). The demand for different organic extracts is on the increase based on the advantageous importance of organic extracts (Agha and Charles 2017).

Literature available shows the Ficus thonningii Leaves is yet to be investigated as corrosion inhibitors on a mild steel in acidic medium. Ficus thonningii is a tropical plant grown all over Africa particularly in Nigeria. All parts of Ficus thonningii plant are medicinally useful, the bark exude latex which is associated with potency (Ahur et al 2010), a lot of therapeutic claims are associated with Ficus thonningii Plant (Ndukwe et al 2007). Research on Ficus thonningi revealed the presence of many metabolites which include but not the least, carbohydrates, steroids, tannins, saponins, triterpenes, alkaloids, flavonoids, terpenoids, luteolin 6,10,14 trimethy 1-2 penta decanone etc. (Ango et al 2016, Ogunwande et al 2008, Greenham et al 2007).

Ficus thonningii leaves has also been investigated for therapeutic use (Ishaku *et al* 2016, Arbonnier, 2004 and Alawa *et al* 2002), the corrosion inhibitive properties of Ficus thonningii Leaves is novel research, hence the stability of the inhibition on the surface of the metal was also investigated.

II. EXPERIMENTAL

➢ *Materials preparation*

For this study, Ficus thonningii leaves was collected from the surroundings of Yaikyo, Gondo district Makurdi, Benue State Nigeria. The mild steel was purchased from a shop in Makurdi Metropolis, Benue State. The leaves were washed under running water, Air dried for twenty-eight days, then pulverized, sieved and stored ready for extraction.

➢ *Extraction procedure*

Maceration (cold water) extraction method was carried out by carefully measuring 500g of sieved pulverized samples and placing the sample in a container with an air tight lid, as the sample occupied about 30% of the total space of the container. Distilled water was poured into the container containing the samples, the quantity of water was more than thrice the quantity of the sample, properly covered and left to stand for 72 hours with intermittent agitation.

After 72 hours, the entire content was emptied on a sieve, the residue was pressed against the sieve, the cake residue was retuned back to the container and some quantity of cold distilled water was poured into it, this rinsing and sieving process was repeated until a colourless mixture emerges when cold water was added.

The filtered mixture of extract and water was collected and carefully placed on a wide dish and was kept on a safe place so that the water can evaporate naturally, it took 26 days for the whole water to evaporate from the mixture and the extracts were left on the dish, scraped, weighed and store.

- *Characterization of mild steel*

Energy dispersive X-ray fluorescence (EDXRF) analyzer of model 6890 series was used to characterize the mild steel used for the research, to ascertain the presence of elements and their composition present in mild steel used.

- *Phytochemical Analysis*

Phytochemical analysis was conducted on Ficus thonningii Leaves extracts to determine the presence of Alkaloids, Saponins, Flavonoids, Glycosides, Polyphenols and Tannins using the Harbone J. B.,1973 and Pearson 1976 methods as reported by Richard *et al* (2016) and Nwafor *et al* (2017).

- *Weight loss test at room and elevated temperatures*

Weight lost test was conducted at room and elevated temperatures, the 1mm thick mild steel plate, was cut into rectangular shape 20mm by 50mm coupons, a hole was drilled on the metallic surface for easy attachment, the drilled coupons were properly filed then polished with emery papers, the finished coupons were degreased using acetone, rinsed in distilled water, sundried, weighed, conspicuously tagged. The Ficus thonningii Leaves extract was weighed 0.2, 0.4, 0.6, 0.8 and 1.0 grams respectively and carefully placed in to 1000ml measuring flask containing 100ml of 1M HCl solution. The acidic solution dissolved the extracts in the flask, and the acidic solution was further added into the flask until it got to the 1000ml mark on the measuring flask. The six (6) measuring cylinders were composed of 0.0, 0.2, 0.4, 0.6, 0.8 and 1.0 g/dm^3, the cylinder with the $0.0 g/dm^3$ was the control and does not contain any extract.

Each of the flask containing the extracts and the acidic solution were properly labelled and tagged, the coupons were noted and dropped inside the flask containing the corresponding extract concentration (g/dm^3) and was left for 48hours. After 48hours, the coupons were removed from the flask containing the acidic medium, then immersed in a basic solution of 2M NaOH for 5 minutes, then placed under a running tap water for few minutes before dipping the coupons in a beaker containing Acetone, then placed on a polymeric material to dry. The coupons were re-weighed (at least three times) and the average value was recorded. The coupons were immediately and carefully returned back to the same flask where it was removed from. The same process was repeated for 96hours, 144hours, 192hours and 240hours. Weight loss test at elevated temperature was also conducted, the procedure was similar to weight loss test at room temperature, the only two differences were the time of exposure (2,4,6 and 8 hours) and the application of heat energy (25,35,45 and 55 ^oC) using a water bath with a thermostat.

The weight loss, corrosion rate, percentage inhibition efficiency and degree surface coverage were calculated using equation (1) (2) and (3) (4)

$$\text{Weight loss } (\Delta w) = \text{Original weight} - \text{final weight} \quad (1)$$

$$\text{Corrosion Rate (mm/yr)} = \frac{87.6\Delta w}{\rho A T} \quad (2)$$

Δw = weight loss of mild steel coupon (kg)
ρ= Density of mild steel (kg/cm^3)
A=Surface area of mild steel (cm^2)
T= immersion time (hrs)
Inhibition efficiency (IE%)

$$\text{IE\%} = \frac{r_o}{r_o - r} \times 100 \quad (3)$$

$$\theta = \frac{r_o}{r_o - r} \quad (4)$$

- *Adsorption Isotherm*

A graph of concentration/Surface coverage (C/Θ) was plotted against concentration (C) for Ficus thonningii leave extract, it yielded a linear pattern which confirms to Langmuir Adsorption Isotherms both at room and elevated temperatures. This was possible after series of trails using other adsorption isotherms.

- *Activation Energy*

The activation Energy for Ficus thonningii leave extract was calculated using equation (5)

$$\log CR = \log A - \frac{E_{act}}{2.303\ RT} \quad (5)$$

Where;

A	-	Arrhenius pre-exponential factor
C.R	-	Corrosion rate
T	-	absolute Temperature
R	-	Universal Gas constant

The slope of the graph of log CR against I/T, after inserting the constants and factors values respectively, gives the value of activation energy at various temperature(s).

- *Potentio dynamic polarization investigation*

The electrochemical experiment was carried out using the electro chemical analysis (model 600E). the test was performed using three electrode corrosion set up, the metallic coupon (working electrode) was attached to the green electrode, the graphite rod (counter electrode) attached to the red electrode, the sensor (reference electrode, silver/silver chloride) was attached to the white electrode. 200 ml of the test solution with different concentration of extracts 0.0, 0.2, 0.4, 0.6, 0.8 and 1.0 g/dm^3 was carefully poured into the beaker. All experiment were conducted at room temperature (25 ± 2^oC) on a stationary condition. The working electrode was immersed in a test solution for 30 minutes until a stable open circuit potential was attained, the test was carried out

ISSN No:-2456-2165

using a scan rate of 1.0mV/s at a potential initiated at -250Mv to 250 Mv.

The Linear Tafel of the anodic and cathodic curves were extrapolated to corrosion potential to obtain the corrosion current densities (I corr) and Corrosion potential (E corr). The inhibition efficiency of corrosion current density was calculated using equation (6).

$$IE_{I_{Cor}}(\%) = \frac{I^{O}{}_{corr} - I_{Corr}}{I^{O}{}_{corr}} \times 100 \qquad (6)$$

Where, $I^{O}{}_{corr}$ and I_{Corr} are the corrosion current density values in the absence and presence of inhibitor, respectively.

- *Inhibition Stability*

The stability of the inhibitions on the metal surface was investigated using open circuit potential time (OCPT) method, the experimental procedure was the same with that of potentiodynamic polarization test except that the graphite rod (counter electrode) was not connected to the setup, the duration of this experiment was 300 seconds and only $0.0g/dm^3$, $0.2g/dm^3$ and $1.0g/dm^3$ extract concentration were used for the investigation.

III. RESULTS AND DISCUSSION

- *The elemental analysis of mild steel*

The results of fluorescence spectra (quantitative analysis) in Figure 1 and Table 1 shows that mild steel is made up of mainly iron (Fe) 94.525%, with other elements such as Si (0.9217%), Al (0.828%) etc, Fe is the major constituent of the mild steel. This result is similar to the result obtained by Lucica *et al* 2010 in their study on Energy dispersive X-ray fluorescence analysis of mild steel

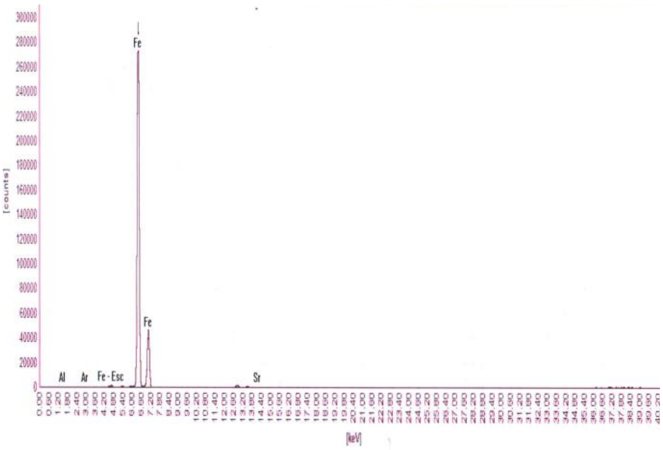

Fig 1: Energy Dispersive X-Ray Fluorescence (EDXRF) result of Mild steel

Element	Peak(cps/mA)	Concentration (%)
Fe	289600	94.525
Si	145	0.9217
Al	24	0.828
P	16	0.0328
S	104	0.03606
Ti	1340	0.2253
Mn	1687	0.4323
Ca	167	0.0798
K	157	0.1210
Cu	32	0.00809
Zn	13	0.00189
Cr	315	0.0276
V	226	0.0194
Pb	1	0.00140
Ga	3	0.00015
Cl	89	0.0602
W	3	-0.070
Ce	336	-10.00

Table 1: The elemental composition and concentration of a mild steel

- *Phytochemical test result*

From the phytochemical analysis result presented in Figure 2, the Ficus thonningii leave extract has 1.2% Alkaloids, 0.3% Saponins, 0.4608% Flavonoids, 0.2645% Glycosides, 1.765% Polyphenol and 1.01% Tannins respectively.

These are active anti corrosion constituents, which can easily form salts with ferric ions that protect the metal surface as a result of strong cross-linked network of ferric salt, they also contain some functional group such as (C=C, O-H, C-N etc) that protect the metal surface from hydronium (H_3O^+) ion attack (Ideisan *et al*2010)

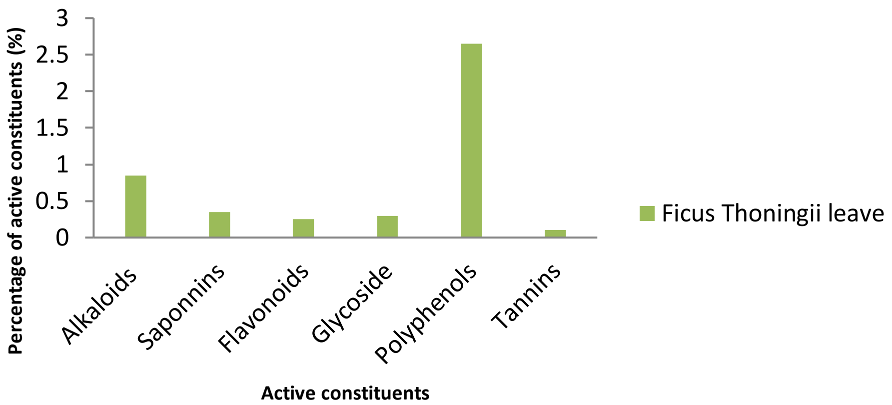

Fig 2: Percentage of Active Constituents of the Extract

➢ *Weight loss at room and elevated temperature*

Corrosion rate was observed to decrease steadily with increasing extract concentration (Ikpambese and Yaji, 2020) as presented in Figure 3. F.thonningii leave has a corrosion rate value 0.712 x 10^{-3} mm/yr at 1.0 g/dm^3 extract concentration. This is a sharp contrast with uninhibited corrosion rate value of 17.07 x 10^{-3} mm/yr. The decrease in corrosion rate depends on the concentration of the extracts, this was in accordance with the work done by Alaneme *et al* (2015). It was also observed that corrosion rate at all concentration of F.thonningii leave extracts decrease steadily with increasing exposure time, except at 0.0 g/dm^3 concentration, this could be as a result of the formation of protective film of metal-inhibitor complex coating leading to reduced corrosion rate as earlier experienced by Flores-De *et al* (2015).

From the result of corrosion rate at elevated temperature shown in Figure 4, it was discovered that the rate of corrosion increases as temperature increase irrespective of the concentration of the extract used, the average kinetic energy of the reacting molecules increases, the dissolution of mild steel occurs more spontaneously as temperature increases, the molecules collide faster, increasing the rate of consumption of the reactant and formation of product. Temperature increase has effect on both the inhibitive and uninhibited acid solution, corrosion rates decrease with increases in inhibitors concentration (Hawraa *et al* 2018).

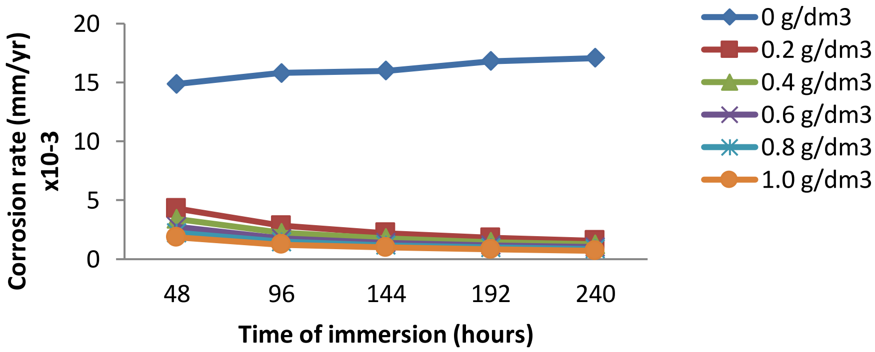

Fig 3: Corrosion rate at room temperature.

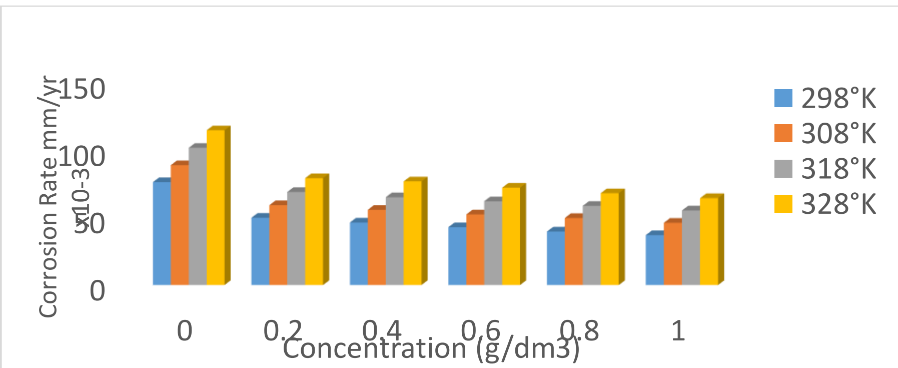

Fig 4: Corrosion rate at elevated temperature temperatures

ISSN No:-2456-2165

➢ *Adsorption isotherm at room and elevated temperature*

Figure 5 show the result of Langmuir adsorption isotherm of F.thonningii leave extract on mild steel in an acidic medium at room temperature. Adsorption isotherm were quite informative in studying the nature of interaction between inhibitors and the metal substrates on the surface. The degree of surface coverage (Θ) obtained from the weight loss test was used to investigate the best isotherm that fit the experimental data obtained. The plot of C/Θ against C was a linear, indicating the adsorption of the inhibitors on the surface of the mild steel, it is also consistence with Langmuir isotherm (Tan *et al* 2020). The correlation coefficient (R^2) value obtained were high (0.9971-0.9989), this shows that Langmuir isotherm fitted very well and it explains the effect of the adsorbed molecules on the metal surface as reported by Akaleze *et al* (2020) with R^2 value of 0.9987. While Figure 6 shows the values of correlation coefficient (R^2) (0.9814-0.9987) for F. thonningii leave extracts at elevated temperatures, the plot of C/Θ against C was a linear, indicating the existence of physical adsorption of inhibitor on the surface of the mild steel, consistent with Langmuir isotherm. The values of R^2 obtained was within the range of values (0.9424-0.9934) obtained by Alaneme *et al* (2015) at elevated temperature.

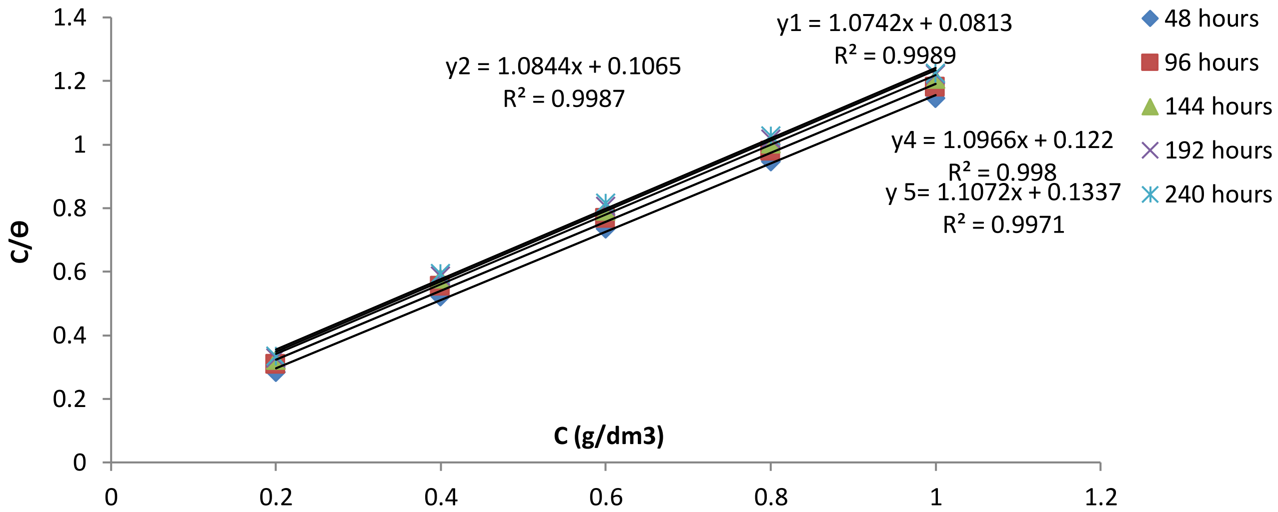

Fig 5: Langmuir Adsorption Isotherms at room temperature.

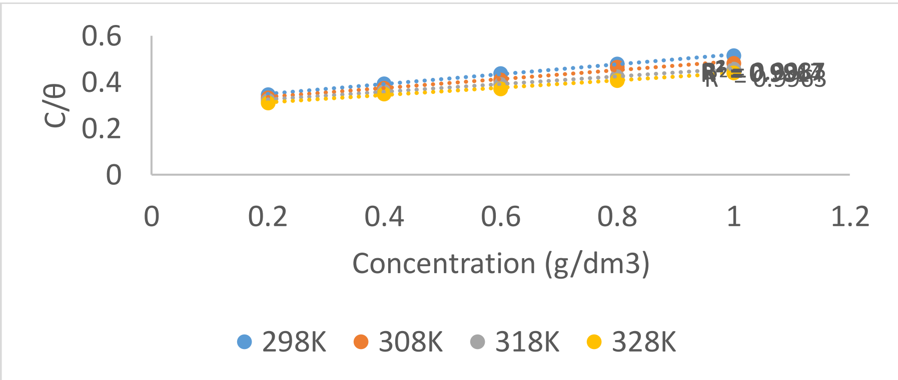

Fig 6: Langmuir Adsorption isotherms at elevated Temperature

➢ *Activation energy of the extracts*

The plot of log CR against 1/T at various concentrations as shown in Figures 7 yielded a perfect fit, which is an indication of the consistency of the results of the experimental data. The slopes obtained were used to calculate the activation energy using equation (5). The activation energy evaluated at different concentration are presented in Table 2. Activation energy increases as extract concentration increases; this trend is in accordance with the work done by Okafor *et al* (2012) in their study on inhibitive action of Artemisia Annua extract on mild steel. F. thonningii leave extracts has activation energy value of 11488.29J/mol at extract concentration of 1.0 g/dm^3 and activation energy value of 8479.50J/mol at extract concentration of 0.0 g/dm^3. The increase in activation energy in the presence of an inhibitor was due to the formation of complex microstructures as a result of phytochemical constituents from the extract, which build a barrier that will require a higher activation energy to break for the dissolution of the metal (Erna *et al*, 2019).

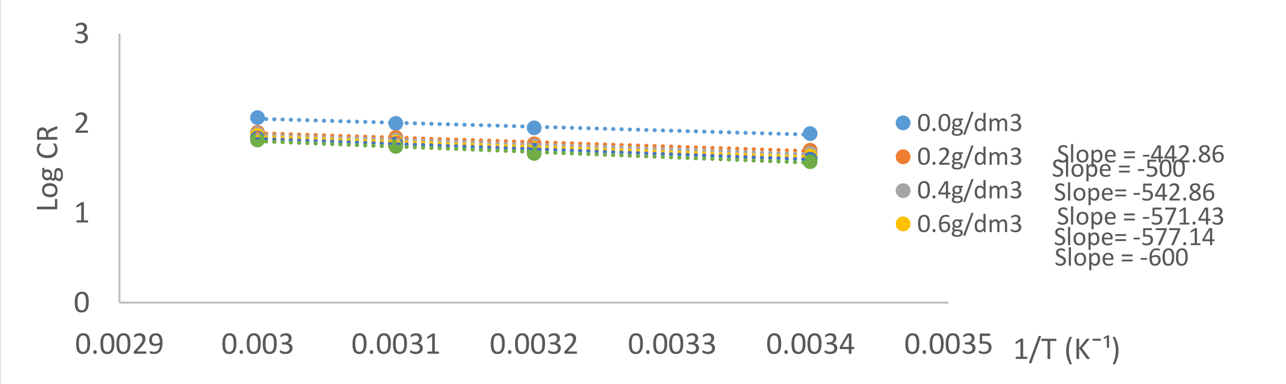

Figure 7: Corrosion rate (CR) Versus 1/T of the Extract

Table 2: Activation Energy of the Extract

Extracts Concentration (g/dm^3)	**Ficus thonninggi Leave (J/mol)**
0.0	8479.50
0.2	9573.57
0.4	10394.23
0.6	10941.25
0.8	11050.58
1.0	11488.29

➢ *Potentiodynamic polarization test*

The results as shown in Figure 8 and Table 3 clearly show that the test samples containing F. thonningii leave extracts had corrosion current less than that of the uninhibited sample, a smaller corrosion current signifies better anti corrosion properties. Corrosion current for F. thonningii leave extract at 1.0 g/dm^3 was 3.190 x 10^{-3} A, while that of the control is 1.685 x 10^{-2} A. These values were in accordance with the work done by Eken *et al* (2018). From the results on the Table, the corrosion rate for F. thonningii leave extracts at 1.0 g/dm^3 was 7.171 x 10^1 mpy, while the control sample has a corrosion rate of 2.608 x 10^3 mpy. The extract inhibited the corrosion of mild steel in an acidic medium, it is a mixed type inhibitor affecting both the cathodic and anodic reaction as experienced by onukwuli and omotioma (2017).

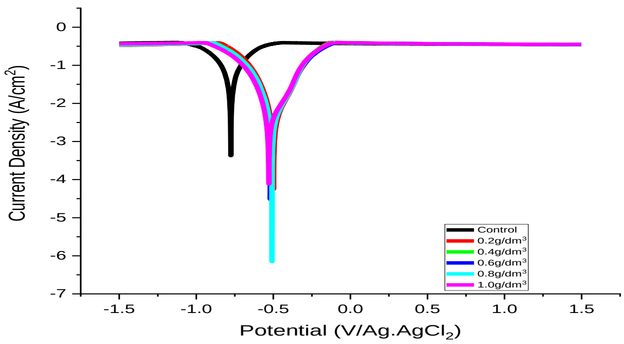

Fig 8: Variation of Current Density with Potential for Ficus thonningii Leave Extract

Table 3: Potentiodynamic parameter for Ficus thonningii leave extract

GROUP (g/dm^3)	**POLARISATION (ohm)**	**CORROSION DENSITY (A)**	**CORROSION RATE (mpy)**	**CATHODIC SLIP ($\frac{1}{V}$)**	**ANODIC SLIP ($\frac{1}{V}$)**
0.2	3	7.419× 10^{-3}	1.668× 10^2	9.161	9.130
0.4	102	3.065× 10^{-4}	6.891	12.680	1.271
0.6	4	5.133× 10^{-3}	5.577	8.876	10.247
0.8	979	1.705× 10^{-5}	1.852× 10^{-1}	19.635	6.403
1.0	6	3.190× 10^{-3}	7.171× 10^1	9.154	12.010
Control	1	1.685x10^{-2}	2.608 x10^3	4.754	5.093

➢ *Inhibitor's stability*

The results shown in Figure 8, clearly show that Ficus thonningii leave extract is a stable corrosion inhibitor, it maintains potential value of (-0.425V/Ag-$AgCl_2$) throughout the analysis at a concentration of 1.0 g/dm^3, even at low concentration of 0.2 g/dm^3, the inhibitor was stable (-0.445V/Ag-$AgCl_2$), the potential value of the control is (-0.46V/Ag-$AgCl_2$), the inhibitor shift the stable potential towards less negative value, this may be attributed to the formation of protective film on the metal surface. Result obtained by Shuyun *et al* (2017) had the same trend with the results shown in Figure 8, the potential value at 1.0 g/dm^3 was (-0.455V/Ag-$AgCl_2$) and (-0.475V/Ag-$AgCl_2$) at 0.0 g/dm^3 or control.

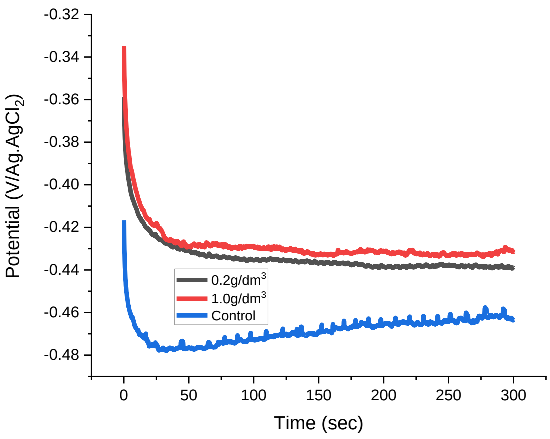

Fig 9: Open circuit potential time (OCPT) variation with Ficus Thonningii leave extract

IV. CONCLUSION

The following conclusions were arrived at:

- ➢ The phytochemical analysis result revealed that Ficus thonningii leave has active anti corrosion constituents such as Alkaloids, Saponins, Flavonoids, Glycosides, Polyphenols and Tannins, capable of preventing corrosion of mild steel in acidic medium.
- ➢ The corrosion rates were found to decrease with increase in concentration with optimum corrosion rate of 0.712 x 10^{-3} mm/yr at 1.0 g/dm^3 extract concentration, while that of the uninhibited is 17.07 x 10^{-3} mm/yr, the rate of corrosion increases with increase in temperature.
- ➢ The inhibition efficiency of Ficus thonningii leave extract was 81.74% at room temperature, over immersion period of 240 hours at extract concentration 1.0 g/dm^3, while at elevated temperature, the inhibition efficiency at immersion period of 8 hours, extract concentration 1.0 g/dm^3 are 51.46 % at 298K and 43.95 % at 328 K.
- ➢ The correlation coefficient (R^2) values conform to Langmuir adsorption isotherm (0.9814- 0.9987), this established the absorptive interaction between the inhibitor and the metal surface.
- ➢ The activation energy of the extracts increases as extract concentration increase, the potentiodynamic result confirms the anti-corrosion property of Ficus thonningii leave, the extract is a stable inhibitor at high and low concentration, hence very good substitute for corrosion inhibition.

V. CREDIT AUTHOR STATEMENT

All authors contributed to the study conception and design. Olisakwe H.C. and Ikpambese K.K: Conceptualization; Formal analysis; Investigation; Resources; Software; Validation; visualization; Writing-original draft; Writing-review and editing.

Ipilakyaa T. D and Ekengwu I.E: Conceptualization; Methodology, Supervision; Project administration.

REFERENCES

[1]. Agha I. N. and Charles N. A. (2017). Predictive corrosion inhibition model for mild steel in sulphuric acid (H_2SO_4)

[2]. by leave paste of sida acuta plant. Journal of civil construction and environmental engineering. Vol. 2, No 5,2017 pp123-133 doi: 10.11648/j. jccee.20170205.11

[3]. Ahur, V.M., Madubunyi, I., Adenkola, A.Y. and Udem, S.C. (2010). The effect of ethyl acetate extract of *Ficus thonningii* (Blume) leaves on erythrocyte osmotic fragility and haematological parameters in acetaminophen-treated rats. *Comparative Clinical Pathology* 10:1107-1111.

[4]. Akalezi C. O., Maduabuchi A. C., Enenebeaku C. K., Oguzie E. E. (2020).Experimental and evaluation of adsorption

[5]. and inhibitive properties of moringa oliefera extract on mild steel corrosion in acidic media. Arabian Journal of chemistry (2020) 13 9270-9282

[6]. Alaneme, K.K., Daramola, Y.S., Olusegun, S.J., Afolabi, A.S. (2015). CorrosionInhibition and Adsorption

[7]. Characteristics of Rice Husk Extracts on Mild Steel Immersed in 1MH_2SO4 and HCL Solutions. International Journal of Electrochemical Science. 10, 3553-3567.

[8]. Alawa, J.P., Jokthan, G.E. and Akut, K. (2002). Ethnoveterinary medical practice for ruminants in the sub-humid zone of the northern Nigeria. Preventive Veterinary Medicine 54:79-90.

[9]. Ango, P.Y., Kapche, W.F.G. and Fatso, G.W. (2016). Thonningii flavanonol A. and Thonningii flavanonol B, two

[10]. novel flavonoids and other constituent of *F.thonningii* Blume (Moraceae), *Journal of Bioscience,* 71:3-4. *Science*: 6; 158-167

[11]. Arbonnier, M.A. (2004). *Trees, Shrubs and Lianas of West African Dry Zones.* 2nd edition, Margraf, Netherlands, p. 412.

[12]. Ashwe, A, Ikpambese, K.K., Yaji, P.M. (2016). Study of Hyptis Suaveolen L Poit leaves extract as corrosion inhibitor

[13]. on mild steel in H_2SO_4 solution. International Journal of Engineering Sciences and Management Research. Vol. 2(5). 1-9. http://www.ijesmr.com
[14]. Eken Taha Yasin, Sarioglu Cevat and Kuccuk Israfil (2018). Comparison of Tafel extrapolation and linear polarization resistance reading for TRC 8006 Aluminum alloy in 3.5 wt. % NaCl aqueous solution
[15]. Erna M., Herdini H. and Dedi F. (2019). Corrosion inhibition mechanism of mild steel by Amylose
[16]. Acetate/carboxymethyl chitosan composites in acidic media. International Journal of chemical engineering, Vol.2019, article ID 8514132, 12 pages, 2019.
[17]. Flores-De les Ries JP, Sanchez- Carrilo M, Nava-Dino C.G, Chacon-Nava JG, Escobedo-Bretado MA, Monreal-
[18]. Romero HA (2015). Corrosion inhibition of mild steel using Agavoieae Extract in 1M HCl solution. International Journal of electrochemical science 2015, 10: pg1021-10222
[19]. Greenham, J.R., Grayer, R.J., Harbone, J.B. and Reynolds, V. (2007). Intra-and Interspecific variations in vacuolar flavonoids among *Ficus* species from the Budongo forest, Uganda. *Biochemical Systematics and Ecology*, 35:81-90.
[20]. Harbone J. B. (1973). Phytochemical methods: A guide to modern techniques of plant analysis. 2nd Edition, Chapman and Hall limited London 49-188.
[21]. Hawraa Khaleel, Adnan A. Afeeq, Amjed A. Ali (2018). The effect of Temperature and inhibitor on corrosion of
[22]. carbon steel in Acid solution under static study. International Journal of applied Engineering Research ISSN 0973-4562 volume 13, November 6,2018. Pp.3638-3647. Research India publication.htt://www.ripublication.com
[23]. Ideisan A., Ibrahim A. and Maysoon A. (2010) UAE Neem extract as a corrosion inhibitor for carbon steel in HCl solution. International journal of corrosion, vol 2010, Article ID 460154, 9 pages 2010.
[24]. Ikpambese Kumaden K. and Maseshin Yaji (2020). Inhibitive effect of Hyptis suaveolens (L) poit extract and natural
[25]. honey on corrosion of mild steel in H_2SO_4 solution. Annals of faculty Engineering Hunedoara-International Journal of Engineering. ISSN 1584-2665 PP99-106.
[26]. Ishaku A., Abubakar S., Osuji C E., Mowobi G G. and Onwuka O.E. (2016). In vitro efficacy of three ethnomedicinal
[27]. plant used in Gbagi land against salmonella enterica serovar typhi. Journal of Environmental and life science 2016 vol 1, (issue 1) 56-66
[28]. Karahan, B., Turhan, A., Ince, I., Ekinci, H., Albayrak, A., Cakir, A. (2011). Inhibition of EN 10204 steel in by a
[29]. Mixture of Hyperricum Perforatum plant Extract and Natrite based Inorganic Inhibitors. Conference paper. Accessedat www.researchgate.net/publication/259718452.
[30]. Lucica G.T, Rodica M.I, Radu C. F, Nelu I, Ileana N.P (2010). Energy Dispersive X-ray Fluorescence (EDXRF)
[31]. analysis of steel. Journal of science and art Year 10, No 2(13), pp. 385-390, 2010
[32]. Ndukwe, I.G., Bello, A.I., Habila, J. D. and John, C. (2007). Phytochemical and antimicrobial screening of the crude petroleum spirit and methanol extracts of the stem bark, leaves and roots of *Ficus thonningii* (Blume). *African Journal of Biotechnology* 16:2645-2649.
[33]. Nwafor F.I, Egonu S. N., Nweze N. O. and Ohabuenyi N. S (2017). Effect of processing methods on the nutritional values and anti-nutritive factors of Adenanthera pavonine L (Fabaceae) seeds. African Journal of Biotechnology. Vol. 16(3) pp. 106-112, Doi: 10,5897/AJB 2016.15782
[34]. Ogunwade, I.A., Sonibare, M.A., Thangi, T.D., Dung, N.X., Soladaye, M.O. and Monohunfolu, O.O. (2008). Comparative analysis of the oils of three *Ficus* species from Nigeria. *Journal of Essential Oil Research,* 20.
[35]. Onukwuli O. D. and Omotioma M. (2017). Study of bitter leaves extracts as inhibitive agents in HCl medium for the
[36]. treatment of mild steel through pickling. Portugaliae Electrochimaca Acta 2019, 37 (2), 115-121 DOI: 10,4152/pea 201902115
[37]. Pearson (1976). Chemical analysis of food 7th Edition. Henry Edward company, Church-chill, Livingstone. London pp 218-236
[38]. Richard R., Denwe D. S. Yerima M. B., Olatunde K. S. (2016). Qualitative phytochemistry and antibacterial resistance
[39]. pattern of leaves and stem bark extracts of Jatrpha curcas. American Journal of microbiological research. 2016, 4 (5):143-146. Doi: 10.12691/ajmr-4-5-3
[40]. Shuyun C., Dan L.,Peng Z.,Lixia Y., Peng Y., Hui L. and Jianzhou G.(2017). GreenBronsted acid ionic liquid as novel
[41]. corrosion inhibitors for carbon steel in acidic medium. Scientific report /7.8773/ DOI: 10.1038/s 41598-017-07925-Y
[42]. Tan J., Guo L., Yang H., Zhang F., El Bakri Y. (2020). Synergistic effect of potassium iodide and sodium dodecyl
[43]. sulfonate on the corrosion inhibition of carbon steel in HCl medium: a combined experimental and theoretical investigation. RSC adv. 10. 15163-15170