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Talinum triangulare (Waterleaf) Methanol Leaf Extract as Corrosion Inhibitor on Mild Steel Surface in H_2SO_4

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Abstract: The inhibition effects of methanol leaf extract of *Talinum triangulare* on the corrosion of mild steel in 0.4, 0.5, 0.6 and 2.5M H_2SO_4 solution were determined in this study. The inhibition efficiency was evaluated and the mechanism of inhibition determined, with a view to determining the inhibitive potentials of the inhibitor with regard to corrosivity of acid solutions used in oil pipelines, water treatment systems and descaling of equipment. Weight loss and gasometric techniques were used for the corrosion study of the metal. The weight loss method of corrosion tests was carried out at 2, 4, 6, 8 and 10 hours of exposure using various concentrations of extract (0.2, 0.4 and 0.6) g/L at different temperatures (303K, 313K and 323K) in varying acid concentration (0.4M, 0.5M and 0.6M). The gasometric measurements were carried out at 5, 10, 15, 20, 25 and 30 minutes exposure time using various concentrations of extract (0.2, 0.4 and 0.6) g/L in 2.5M H_2SO_4 solution. Weight loss measurements were also carried out concurrently with gasometric measurements to compare methodological variation in data between them. The phytochemical screening results revealed the presence of tannins, saponnins, flavonoids, terpenes, steroids and alkaloids. From the results, the corrosion rates decreased with increase in inhibitor concentration. The maximum inhibition efficiency of the extract for the weight loss measurements are 70.77% for 0.6g/L in 0.4M H_2SO_4 at 303K, 54.86% for 0.6g/L in 0.5M H_2SO_4 at 303K and 61.66% for 0.6g/L in 0.6M at 303K. In 2.5M H_2SO_4, the maximum inhibition efficiency was observed to be 59.31% for 0.6g/L inhibitor concentration at 308K for the gasometric method and 53.38% for 0.6g/L at 308K for the weight loss method. The kinetic and thermodynamic studies showed that the activation energy (E_a) in the presence of inhibitor is greater than in the absence of inhibitor at all the temperatures studied. The reaction was proposed to be first order having shown good correlation ($R^2 \approx 1$) with the first order rate law, and the half-life ($t_{1/2}$) values were obtained from the graphs of the rate law. The mechanism of physical adsorption was proposed for the extract, as within the temperature range investigated the E_a and ΔG^o_{ads} values are less than 80kJ/mol and -20kJ/mol respectively.

Keywords: Methanol Leaf Extract, *Talinum triangulare*, Corrosion Inhibition

1. Introduction

The relatively low cost of manufacture of mild steel has made it a readily available option for industrial applications. It has found uses in the manufacturing of industrial equipment like cooling water tanks, cement mixers, heavy duty machines and for piping in the oil and gas sector. However when mild steel encounters an acidic medium it begins to corrode and thus its lifespan is greatly reduced, except with the application of protective measures to inhibit or prohibit corrosion.

Even though there has been great improvement in the development of corrosion resistant alloys over the past few decades, carbon steel still constitutes a high percentage of the material used for piping in the oil and gas industry [1]. It is usually the most cost effective option, though its poor resistance in aggressive environment makes it a difficult option.

From domestic to industrial uses, carbon steel has found very wide application and as such has necessitated the huge interest in protection studies. There is also the need to protect expensive or essential equipment or structures, which replacement or damage might be catastrophic or adverse to the polity, economy or environmental safety [2]. One way to achieve this aim has been the use of inhibitors. However, some of these inhibitors have also produced new challenges: eco-toxicity and high costs. Thus, there arose a need for inhibitors of 'green' nature: readily available, renewable, eco-friendly and cheap [3]. Several organic inhibitors have shown good efficiency for corrosion inhibition [4-8]. This study intends to explore the potential of the methanol leaf extract of *Talinum triangulare* as an available and new 'green' inhibitor with the available technology, to ascertain the viability of same to inhibit mild steel corrosion.

2. Experimental Methods

2.1. Materials Preparation

The leaves of *Talinum triangulare* were collected, identified in the Plant Science Department of the University of Nigeria, Nsukka, dried under shade for two weeks and pulverized. Cold maceration was used for the extraction, as follows: Powdered samples (500.0g) of *Talinum triangulare* was weighed into 1000mL conical flask and a litre of methanol was added to the sample. The conical flasks were placed on a shaker for 24h, and filtered using muslin cloth, same as described by Ajiwe and Ejike, 2019 [9]. The filtered extracts were concentrated using the rotary evaporator and air-dried for 48h. The dry extracts were stored in well corked sample bottles in a refrigerator. 2.0g of the leaf extract was dissolved in 100mL of distilled water to obtain a stock solution of 2g/100mL i.e. 20g/L. Serial dilutions of 1mL of stock solution in 100mL of test solution which gave 0.2g/L was resolved to represent one aliquot. Therefore each 1ml aliquot of stock solution in 100mL of test solution represented 0.2g/L.

Mild steel coupons of 2cm x 3cm x 0.2cm were cut out of a metal sheet obtained from the Nsukka building materials market. Holes were drilled into the top edge of the coupons to aid in the suspension of the metal in solution. The coupons comprised of %wt: 0.18% C, 0.55% Mn, 0.08% P, 0.04% S and the remainder Fe. The metal coupons were washed with detergent to remove sand and grease, and cleaned with sandpaper to a glossy finish. They were then rewashed with detergent, rinsed twice in distilled water, degreased in acetone and dried in the electric oven at 313K for 2h. The dry coupons were stored in desiccators.

2.2. Phytochemical Screening

Preliminary qualitative phytochemical analysis was performed as described by Ajiwe *et al*, 2008; Sofowora, 2008; Obianime and Uche, 2008 [10-12] for the following active principles: Tannins, Saponins, Glycosides, Flavonoids, Terpenes, Steroids and Alkaloids.

2.3. Weight Loss Technique

Aliquots of the extract solution (1mL, 2mL and 3mL representing 0.2g/L, 0.4g/L and 0.6g/L respectively) were drawn into three 200mL beakers and each made up to 100mL with 0.4M H_2SO_4. 100mL of 0.4M H_2SO_4 was introduced into an empty 200mL beaker to serve as a control. The beakers were introduced into a water bath for 2mins to acclimatize at 303K. Four mild steel coupons were weighed and one coupon suspended in each of the test solutions using a hook and glass holder. The experiment was timed with the stopwatch on a two-hourly duration, after which each coupon was withdrawn, quenched in a solution containing 20% NaOH and 200g/L Zinc dust, washed in detergent and lightly brushed, rinsed twice in distilled water and degreased in acetone. The coupon was then weighed and reintroduced into the experiment media. The process was thereafter repeated for five consecutive measurements spanning 10hrs. The same experiment was repeated twice at the same experimental conditions using new coupons, making three independent measurements. Other experiments were conducted at varying temperatures (303K, 313K and 323K) and acid concentrations (0.4M, 0.5M and 0.6M).

The difference in weight of the coupon was taken as the weight loss (ΔW) defined as

$$WL = W_o - W_t \quad (1)$$

Where W_o = initial weight, W_t = final weight

Corrosion rates (CR) were calculated from the weight loss data using the equation given by Olasehinde *et al*, 2013 [13] as follows:

$$CR = \frac{WL}{A.t} \quad (2)$$

Where WL = weight loss in mg, A = metal surface area and t = time of immersion in hours.

The percentage inhibition (I%), which indicates the efficiency of inhibition by the plant extracts were determined from the equation:

$$I\% = \left[\frac{CR_{blank} - CR_{Inh}}{CR_{blank}}\right] \times 100 \quad (3)$$

$$\theta = \left[\frac{CR_{blank} - CR_{Inh}}{CR_{blank}}\right] \quad (4)$$

Where CR_{blank} and CR_{inh} are the corrosion rates in the absence and presence of plant extracts respectively.

2.4. Gasometric Technique

1mL aliquot of extract solution was introduced into a 200mL conical flask with side nozzle, and made up to 100mL with 2.5M H_2SO_4. The side nozzle was connected through an air hose to an inverted burette standing in a 500mL beaker filled with water. The water level in the beaker was adjusted to the last graduated mark on the burette to represent a zero reading. The 200mL conical flask was then introduced into a water bath at 298K. This experimental set-up used for the gasometric method is as reported by Ajiwe and Ejike, 2019 [9]. One mild steel coupon was removed from the desiccator, weighed and introduced into the test solution and immediately stoppered. Volume of gas collected in the burette was recorded every 5 minutes for six consecutive measurements (i.e. 30 minutes). The coupon was then retrieved, quenched in a solution of 20% NaOH and 200g/L Zinc dust, washed and rinsed twice with distilled water, degreased in acetone and air dried. The dry coupon was then weighed. The experiment was repeated twice with different coupons at the same temperature. Furthermore, 2mL and 3mL aliquots representing 0.4g/L and 0.6g/L respectively were in turn used for the measurements as stated above at 298K. Further measurements were conducted using various aliquots of extract solution (1mL, 2mL and 3mL) at 303K and 308K respectively.

The percentage inhibition (I%) and the degree of surface coverage (θ) were determined from the equations below:

$$I\% = \left[\frac{V_{H0}-V_{H1}}{V_{H0}}\right] \times 100 \quad (5)$$

$$\theta = \left[\frac{V_{H0}-V_{H1}}{V_{H0}}\right] \quad (6)$$

Where V_{H0} and V_{H1} are the volume of gas evolved in the absence and presence of plant extract respectively.

3. Results and Discussion

3.1. Phytochemical Screening

Table 1. *Qualitative phytochemical results for methanol leaf extract of Talinum triangulare.*

PHYTOCHEMICAL	
TANNINS	+
SAPONNINS	+
FLAVONOIDS	+
TERPENES	+
STEROIDS	+
ALKALOIDS	+

+ = present, - = absent.

The presence of alkaloids, flavonoids, terpenes, steroids, tannins and saponins has proven to be good corrosion inhibitors in acidic media [7]. It was reported by Raja *et al*, 2010 [14] that the adsorption of green inhibitors could occur through the formation of a bond with metal, involving the sharing of the lone pair of electrons of alkaloid constituents (-NH, -OH and C=O) present in the neutral alkaloid molecule and the metal. The inhibitive properties of tannins have been attributed to the reaction of the polyphenolic fraction of the tannin moieties, which ensures protection of the metal surface [15]. Flavonoids contribute to the inhibition efficiency of the inhibitors possibly due to being a cyclic compound with O atoms attached to it [16].

3.2. Weight Loss Results

3.2.1. Effect of Inhibitor Concentration on Weight Loss

The weight loss was found to decrease with increase in extract concentration, same as reported by Aisha and Nabeeh, 2012 [4], possibly due to increase in the number of adsorbed inhibitor molecules on the metal surface, forming a film that completely covers the metal surface. The methanol leaf extracts of *Talinum triangulare* contain alkaloids, flavonoids, tannins etc (Table 1), and adsorption of these compounds on mild steel surfaces greatly reduces the surface area available for corrosion. Therefore a higher degree of protection would ordinarily result from an increase in the concentration of the extract [17-18].

3.2.2. Effect of Temperature on Weight Loss

Weight loss was observed to increase with increase in temperature of the corroding media. This can be attributed to higher agitation in the system which displaced inhibitor molecules from their individual adsorption sites on metal surface. It could also result from more energized acid particles knocking off the more bulky organic particles from the adsorption sites.

3.2.3. Corrosion Rate and Inhibition Efficiency

Table 2. *Corrosion rate of mild steel in various concentrations of H_2SO_4 at 303K, 313K and 323K in the presence and absence of methanol leaf extract of Talinum triangulare.*

CORROSION RATE (x 10^{-3}) (mg cm^{-2} hr^{-1})									
CONC	0.4M			0.5M			0.6M		
	303K	313K	323K	303K	313K	323K	303K	313K	323K
0.2g/L	1.0379	1.5329	2.5571	1.6714	1.8114	2.8457	1.7636	2.0443	3.0421
0.4g/L	0.9450	1.1193	2.3236	1.0779	1.4350	2.6679	1.3086	1.4714	2.7921
0.6g/L	0.6536	1.0400	1.9900	1.0393	1.2979	2.2307	1.1736	1.3143	2.3886
BLANK	2.2357	2.4657	2.8600	2.3026	2.7164	3.3907	3.0614	2.8143	3.1343

Table 3. *Inhibition efficiency of methanol leaf extract of Talinum triangulare in various concentrations of H_2SO_4 at 303K, 313K and 323K.*

PERCENTAGE INHIBITION EFFICIENCY									
CONC	0.4M			0.5M			0.6M		
	303K	313K	323K	303K	313K	323K	303K	313K	323K
0.2g/L	53.5761	37.8310	10.5909	27.4125	33.3162	16.0734	42.3924	27.3603	2.9416
0.4g/L	57.7314	54.6052	18.7552	53.1877	47.1727	21.3171	57.2549	47.7170	10.9179
0.6g/L	70.7653	57.8213	30.4196	54.8641	52.2198	34.2112	61.6646	53.2992	23.7916

From the values observed in Table 2, corrosion rate was found to decrease with increase in extract concentration at the same temperature and acid concentration similar to the results reported by Subir and Bikash, 2012 [17]. This can be attributed to an increased surface protection by the extract molecules on the metal surface. However, at the same extract concentration, increasing the reaction temperature resulted in an increase in corrosion rate. This is due to the fact that chemical reactions increase with increase in concentration of active species, temperature (as a result of increase in the vibration of the active species) and time of reaction. Similar observations had been reported by Umoren and Ebenso, 2008; Ebenso *et al*, 2008; Umoren *et al*, 2006 [19-21]. Likewise, increase in acid concentration also resulted in increase in corrosion rate. This is attributed to an increase in the number of corroding species reacting on the metal surface.

It was similarly observed from Table 3 that inhibition efficiency increased with increase in concentration of extract, same as reported by Mourya *et al*, 2014 [22], but decreased with increase in temperature and acid concentration. Increase in inhibition efficiency with rise in temperature is suggestive of chemical adsorption whereas decrease in inhibition efficiency with increase in temperature (as obtained in this study) is suggestive of physical adsorption [23].

3.2.4. Reaction Order

An assumption of a first order reaction was made in the corrosion of mild steel in various concentrations of H_2SO_4 and methanol leaf extracts of *Talinum triangulare*. When In (w_f/w_o) was plotted against time in hours, a linear variation was observed, which confirms a first order reaction kinetics with respect to mild steel in H_2SO_4 in the presence and absence of extract. The reaction order is obtained from the equation below:

$$\ln \frac{w_f}{w_o} = -kt \quad (7)$$

where k is the rate constant, weight of coupons after corrosion treatment is w_f, the initial weight before the experiment is w_o and t is time. The half-life of the reaction is obtained from the equation:

$$t_{1/2} = \frac{0.693}{k} \quad (8)$$

The values obtained are as observed in Tables 4-6.

Table 4. *First order reaction parameters for the corrosion of mild steel in 0.4M H_2SO_4 in the presence and absence of methanol leaf extracts of Talinum triangulare at 303K, 313K and 323K.*

0.4M									
CONC	**303K**			**313K**			**323**		
	k (x 10^{-2})	**R^2**	**$t_{1/2}$**	**k (x 10^{-2})**	**R^2**	**$t_{1/2}$**	**k (x 10^{-2})**	**R^2**	**$t_{1/2}$**
0.2g/L	0.099	0.983	700	0.172	0.998	403	0.376	0.987	184.3
0.4g/L	0.088	0.968	787.5	0.175	0.999	396	0.365	0.998	190
0.6g/L	0.061	0.97	1136.1	0.145	0.998	477.9	0.283	0.997	245
BLANK	0.199	0.958	348.2	0.217	0.907	319.4	0.404	0.957	171.5

Table 5. *First order reaction parameters for the corrosion of mild steel in 0.5M H_2SO_4 in the presence and absence of methanol leaf extracts of Talinum triangulare at 303K, 313K and 323K.*

0.5M									
CONC	**303K**			**313K**			**323**		
	k (x 10^{-2})	**R^2**	**$t_{1/2}$**	**k (x 10^{-2})**	**R^2**	**$t_{1/2}$**	**k (x 10^{-2})**	**R^2**	**$t_{1/2}$**
0.2g/L	0.155	0.974	447.1	0.199	0.993	348.2	0.289	0.907	239.8
0.4g/L	0.101	0.964	686.1	0.197	0.995	351.8	0.281	0.961	246.6
0.6g/L	0.093	0.972	745.2	0.176	0.996	393.8	0.282	0.984	245.7
BLANK	0.248	0.964	279.4	0.2	0.748	346.5	0.307	0.94	225.7

Table 6. *First order reaction parameters for the corrosion of mild steel in 0.6M H_2SO_4 in the presence and absence of methanol leaf extracts of Talinum triangulare at 303K, 313K and 323K.*

0.6M									
CONC	**303K**			**313K**			**323**		
	k (x 10^{-2})	**R^2**	**$t_{1/2}$**	**k (x 10^{-2})**	**R^2**	**$t_{1/2}$**	**k (x 10^{-2})**	**R^2**	**$t_{1/2}$**
0.2g/L	0.187	0.977	370.6	0.206	0.999	336.4	0.420	0.988	165
0.4g/L	0.128	0.98	541.4	0.233	0.999	297.4	0.392	0.997	176.8
0.6g/L	0.113	0.975	613.3	0.134	0.998	517.2	0.347	0.999	199.7
BLANK	0.292	0.966	237.3	0.362	0.986	191.4	0.427	0.981	162.3

3.3. Kinetic and Thermodynamic Considerations

The temperature dependence of the corrosion reaction of mild steel in H_2SO_4 is given by the modified Arrhenius equation:

$$\ln CR = lnA - \frac{E_a}{RT} \quad (9)$$

Where CR = corrosion rate, A = frequency factor, R = Universal gas constant, E_a = activation energy and T = absolute temperature. A plot of ln CR against 1/T gave a slope ($-E_a/R$) from which the activation energy values in Table 7 were obtained.

$\Delta H^{\ddagger}$ and $\Delta S^{\ddagger}$ values were also obtained from modified Eyring equation shown below:

$$ln\left(\frac{CR}{T}\right) = ln\left(\frac{k_B}{h}\right) + \left(\frac{\Delta S^{\ddagger}}{R}\right) - \left(\frac{\Delta H^{\ddagger}}{RT}\right) \quad (10)$$

Where CR is corrosion rate, k_B is Boltzmann's constant, T is absolute temperature, h is Plank's constant, $\Delta S^{\ddagger}$ and $\Delta H^{\ddagger}$ are changes in entropy and enthalpy of activation respectively.

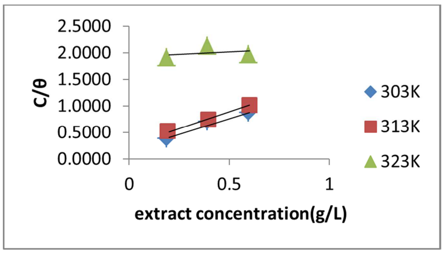

Figure 1. *Langmuir plot for methanol leaf extract of Talinum triangulare in 0.4M H_2SO_4.*

Table 7. *Calculated values of activation energy (Ea), change in enthalpy of activation ($\Delta H^{\ddagger}$), change in entropy of activation ($\Delta S^{\ddagger}$) and Average E_a for corrosion of mild steel in H_2SO_4 in the presence and absence of different concentrations of methanol leaf extract of Talinum triangulare.*

	0.4M				**0.5M**				**0.6M**			
	E_a	**Avg E_a**	**$\Delta H^{\ddagger}$**	**$\Delta S^{\ddagger}$**	**E_a**	**Avg E_a**	**$\Delta H^{\ddagger}$**	**$\Delta S^{\ddagger}$**	**E_a**	**Avg E_a**	**$\Delta H^{\ddagger}$**	**$\Delta S^{\ddagger}$**
BLANK	10.01		7.41	-271.41	15.75		13.14	-252.27	0.88		1.7	-299.05
0.2g/L	36.69		34.08	-189.88	21.53		18.92	-236.26	22.11		19.51	-233.74
0.4g/L	36.43	39.47	33.82	-192.1	36.79	29.77	34.19	-189.52	30.67	27.18	28.06	-208.37
0.6g/L	45.29		42.68	-165.46	30.99		28.38	-208.94	28.76		26.15	-215.51

From Table 7, E_a values in the presence of extract are higher than in the blank solution indicating a slower corrosion process in the presence of extract. A higher E_a in the presence of extract is also indicative of physical adsorption. More so, since the observed E_a values are less than 80KJ/mol, physical adsorption is therefore inferred [6, 24]. Physical adsorption results from electrostatic attraction between charged metal surface and charged species in the solution in contact with the metal surface [25]. The positive $\Delta H^{\#}$ values show the endothermic nature of the dissolution process, whereas the large negative $\Delta S^{\#}$ values implies that the activated complex is the rate determining step, rather than the dissociation step [26].

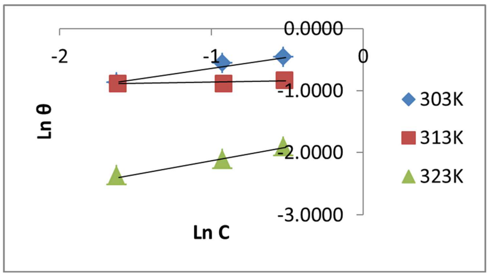

Figure 2. *Freundlich plot for methanol leaf extract of Talinum triangulare in 0.4M H_2SO_4.*

Table 8. *Langmuir adsorption parameters for methanol leaf extracts of Talinum triangulare on mild steel in 0.4M, 0.5M and 0.6M H_2SO_4 at 303K, 313K and 323K.*

	303K			**313K**			**323K**		
	K_{ads}	**R^2**	**ΔG^o_{ads}**	**K_{ads}**	**R^2**	**ΔG^o_{ads}**	**K_{ads}**	**R^2**	**ΔG^o_{ads}**
0.4M	6.135	0.961	-14.6868	3.8911	0.986	-13.9859	0.5227	0.114	-9.0421
0.5M	2.0242	0.795	-11.8936	3.1545	0.996	-13.4399	0.8969	0.577	-10.4918
0.6M	4.6948	0.997	-14.0128	1.9881	0.935	-12.2387	0.1162	0.932	-5.0047

Table 9. *Freundlich adsorption parameters for methanol leaf extracts of Talinum triangulare on mild steel in 0.4M, 0.5M and 0.6M H_2SO_4 at 303K, 313K and 323K.*

	303K			**313K**			**323K**		
	K	**slope (1/n)**	**R^2**	**K**	**slope (1/n)**	**R^2**	**K**	**slope (1/n)**	**R^2**
0.4M	0.7672	0.2370	0.8390	0.7401	0.4010	0.9390	0.4747	0.9450	0.9890
0.5M	0.8462	0.6660	0.8920	0.6643	0.4180	0.9750	0.4422	0.6570	0.9150
0.6M	0.7581	0.3510	0.9660	0.7772	0.6280	0.9530	0.6269	1.9020	1.0000

From the Langmuir plots of C/θ against Concentration of extract, the values of K_{ads} were obtained. ΔG^o_{ads} values were then calculated from the K_{ads} values using the equation below:

$$\Delta G^{\circ}_{ads} = -RTln(55.5K_{ads}) \quad (11)$$

Where R is the universal gas constant, T is absolute temperature and 55.5 is the molar heat of adsorption of water.

To further ascertain the nature of adsorption, the surface coverage (θ) for the methanol leaf extract of *Talinum triangulare* in H_2SO_4 for mild steel corrosion at temperatures of 303K, 313K and 323K were fitted into the Langmuir and Freundlich adsorption isotherm models and correlation coefficient (R^2) were used to determine best fit (values of R^2 closest to unity). The Langmuir model presented a good fit at lower temperatures indicating a monolayer adsorption on the metal surface. However, the Freundlich model provided the best fit with the values of the slope (1/n) less than 1. Usually, when $0 < 1/n < 1$, adsorption is believed to be easy, and moderate or difficult when 1/n= 1 or 1/n > 1 respectively [27], thus the adsorption of the extract on the metal surface is termed easy.

From the calculated values as observed in Table 8, ΔG^o_{ads} was found to be negative and less than 40 kJ/mol; indicating a spontaneous adsorption and suggesting a physical adsorption mechanism [28].

3.4. Gasometric Results

Table 10. *Rate of hydrogen evolution (ml/min) and Corrosion rate (mgcm^{-2}hr^{-1}) of mild steel in 2.5M H_2SO_4 at 298K, 303K and 308K in the presence and absence of methanol leaf extract of Talinum triangulare.*

HYDROGEN EVOLUTION RATE/CORROSION RATE IN 2.5M H_2SO_4						
CONC	298K		303K		308K	
	HE (mL/min)	WL (x10^{-3}) (mgcm^{-2}hr^{-1})	HE (mL/min)	WL (x10^{-3}) (mgcm^{-2}hr^{-1})	HE (mL/min)	WL (x10^{-3}) (mgcm^{-2}hr^{-1})
0.2g/L	0.4179	11.3286	0.9036	14.0857	1.3714	15.3714
0.4g/L	0.3393	11.2429	0.7850	10.2143	0.8864	12.3857
0.6g/L	0.3200	10.5857	0.6279	9.6857	0.7379	9.0714
BLANK	0.5679	12.6714	1.3771	17.7714	1.8136	19.4571

Table 11. *Inhibition efficiency of methanol leaf extract of Talinum triangulare on mild steel corrosion in 2.5M H_2SO_4 at 298K, 303K and 308K.*

PERCENTAGE INHIBITION EFFICIENCY (2.5M H_2SO_4)						
CONC	298K		303K		308K	
	HE	WL	HE	WL	HE	WL
0.2g/L	26.41	10.60	34.38	20.74	24.38	21.00
0.4g/L	40.25	11.27	43.00	42.52	51.12	36.34
0.6g/L	43.65	16.50	54.40	45.50	59.31	53.38

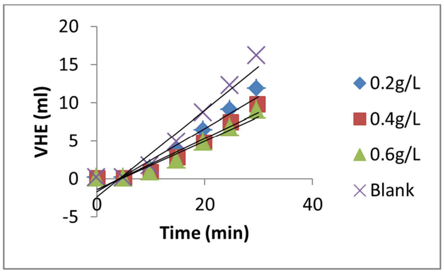

Figure 3. *Variation of volume of Hydrogen evolved (VHE) with time for mild steel in 2.5M H_2SO_4 with and without extract TT at 298K.*

Plots of volume of hydrogen gas evolved against time, showed that volume of gas evolved decreased with increase in extract concentration. An increase in temperature resulted also in an increase in volume of hydrogen evolved. Corrosion rates also increased with increase in temperature but decreased with increase in extract concentration, indicative of physical adsorption. The weight loss and gasometric methods in 2.5M H_2SO_4 showed similar trends of increase or decrease along the table suggesting that both methods give an accurate representation of the corrosion process. However, the gasometric method gave higher values than the weight loss method. The maximum inhibition efficiency for the gasometric method is 59.31% in 0.6g/L inhibitor concentration at 308K, while the maximum inhibition efficiency for the weight loss method is 53.38% in 0.6g/L inhibitor concentration at 303K.

4. Conclusion

The results of this study show that the methanol leaf extract of *Talinum triangulare* is an efficient green inhibitor for the corrosion of mild steel in H_2SO_4. The qualitative phytochemical screening of the plant extracts revealed the presence of alkaloids, tannins, saponins, flavonoids, terpenes and steroids which possess active moieties that act as inhibitors for mild steel in acidic medium. It was found that the corrosion rate of the mild steel decreases with increase in extract concentration. The results of the weight loss measurements show maximum inhibition efficiency to be 70.77% for 0.6g/L inhibitor concentration at 303K in 0.4M H_2SO_4, 54.86% for 0.6g/L inhibitor concentration at 303K in 0.5M H_2SO_4 and 61.66% for 0.6g/L inhibitor concentration at 303K in 0.6M H_2SO_4. The effect of immersion time on inhibition efficiency shows that the inhibitor is effective even for longer immersion periods at low concentration. The corrosion inhibition reaction was observed to obey the first order rate law. The E_a values obtained were found to be less than 80KJ/mol suggesting a physical adsorption mechanism. The Langmuir isotherm model presented a good fit for the adsorption behaviour of the extract at 303K and 323K suggesting monolayer coverage of the metal surface with negative ΔG^o_{ads} values less than 40 KJ/mol, indicative of a spontaneous reaction and a physical adsorption mechanism. The Freundlich isotherm had better correlation values, indicating the ease of adsorption obtained from the values of 1/n. Gasometric and weight loss measurements in 2.5M H_2SO_4 show, that both methods give a good representation of the corrosion process and the extract's corrosion inhibition potentials.

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