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ACID EXTRACT OF *ALOE VERA* AS INHIBITOR
FOR THE CORROSION OF MILD STEEL IN ACIDIC MEDIA

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Abstract

The corrosion inhibition of mild steel in acidic media at 303 – 333K in 0.1 - 0.5M acids (hydrochloric acid - HCl and trioxonitrate (v) acid - HNO_3) and 0.01-0.03g/L *Aloe Vera* extract (AVE) were investigated by standard weight loss method. The corrosion rate was calculated in the absence and presence of the inhibitors. The inhibition efficiencies of AVE in both acid media increased with increase in concentration and decreased with increase in temperature and period of immersion. Results showed that acid extract of *Aloe Vera* (AV) could act as adsorption inhibitor and that inhibition efficiency of up to 77.32% could be obtained. Values of the activation energy obtained in AVE are greater than that of the blank. Thermodynamic results indicated that adsorption of AVE on mild steel surface was spontaneous, physically controlled and occurred according to Langmuir adsorption isotherm.

Key words: Aloe Vera, corrosion inhibition, HCl, HNO_3, mild steel

1. Introduction

The use of metal in many countries has increased with technological and economic development. However, metals destruction by environmental factors is a major challenge facing metal and construction industries. When metals and their alloys come in contact with aerated water, corrosion takes place. This is because of their thermodynamic instability in cooling system (Ciomaga and Nemtoi, 2017; Tosun and Ergun, 2006). The common approach for corrosion protection is to use only durable materials. However, this approach involves huge cost and investment. The use of local inhibitors is one of the best methods of protecting metals against corrosion at a relatively low cost (Ndibe, 2011).

An inhibitor can be chosen from compounds that have heteroatom**s** in their aromatic ring system or synthesized from cheap raw materials (Ebenso et al., 2008). The known hazardous effects of most synthetic corrosion inhibitors led to research into the use of some natural products. The recent trend is towards environmentally friendly inhibitors (Gazquez, 2006). Most of the natural products are non-toxic, cheap, biodegradable and readily available in abundance (Dubey and Singh, 2007).

Several works have been reported with an effort to use natural products like plant extract as corrosion inhibitors. Research has shown that plant such as *Musa acuminate* peel (Eddy et al., 2008), aqueous extract of *Fenugreek* leaves (Ehteram, 2007), extract of Kalmegh (*Andrographis Paniculata*) leaves (Singh et al., 2010), the root of ginseng (Obot and Obi-

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Egbedi, 2009), acid extract of *Vernonia Amygdalina* (Ndibe et al., 2011), *Azadirachta indica* (Valek and Martinez, 2007) and *Lawsonia* (El-Etre et al., 2005) have been used to inhibit the corrosion of metals in acidic and alkaline solution. Green corrosion inhibitors are known to be biodegradable and do not contain toxic compounds or heavy metals (Odiongenyi et al., 2009). Most green inhibitors are obtained from acid, aqueous, ethanol, methanol or formaldehyde extract of plants (Jones, 1996).

The protective efficiency of these extracts is based on the adsorption ability of their molecules, where the resulting adsorbed film acts as a barrier separating the metal from the corroding medium. According to Oguzie (2006), the inhibitor acts as the interphase created by corrosion product between the metal and aqueous corroding solution. Thus, the nature of inhibitor interaction with the metal and efficiency may be dependent on the chemical, mechanical and structural characteristics of this adsorbed film layer (Oguzie, 2006). The extent of inhibition depends (Arab and Al-Turkustani, 2006) on the nature of the metal, the metal surface condition, the mode of adsorption, the chemical structure of the inhibitor and the type of corrosion media.

The inhibitor under investigation is the acid extract of *Aloe Vera (AV)*. *Aloe Vera* is of plant kingdom, a member of *Asphodelaceae* family and order of *Asparagales* (Abiola et al., 2007). AV is of species of succulent plant that probably originated from Northern Africa, the Canary Islands and Cape Verde. The species are rich in heterocyclic compounds (Eddy and Odoemelam, 2009; Hong et al., 2008) of high molecular weight with atom like oxygen and nitrogen incorporated in their molecular structure.

In the past, AV extract have been used in corrosion studies (Abiola and James, 2010; Mehdipour et al., 2014; Sribharathy et al., 2013). For instance, Arab et al. (2010) found aqueous extract of Aloe plants as good inhibitor for the corrosion of Aluminum metal in HCl solution. Kalada and James (2014), studied the inhibitive effect of Aloe Vera Barbadensis Gel on copper in HCl. Abiola et al. (2010) investigated the corrosion inhibition of zinc in 2M HCl solution by Aloe Vera with inhibition efficiency of 67% at 10%v/v inhibitor concentration.

The general aim of the present work is to investigate a naturally occurring, cheap and environmentally safe substance (*Aloe Vera leaves extract*) that could be used for corrosion inhibition of mild steel in HCl and HNO$_3$. Specifically, *Aloe* plant leaves' extract used in corrosion inhibition studies have been prepared using various methods, which in our judgment will affect corrosion inhibition properties of the extract. For instance, Abiola and James (2010) obtained the inhibitor test solutions by squeezing-out the gel of the fresh leaves and diluting same with appropriate quantity of 2 M HCl, while Mehdipour et al. (2014) obtained the test solution from the plant leaves by boiling in hot water, evaporating to a gel and further diluting with H$_2$SO$_4$. Sribharathy et al. (2013) merely conducted their corrosion inhibition

studies using only aqueous extract of the AV plant in sea water. Since the authors aforementioned obtained various results using different techniques, most of which involved multi-steps, the present study is designed to obtain the AV leaves extract following a single step with HCl and HNO$_3$ as the extracting solvents and corroding agent as well. Inhibitive properties of plant extracts are attributable to the phytochemical components of the extract. From the literature reviewed, the authors found out that the secondary metabolites or phytochemicals of the plant extracts (AV) have not been determined. Another aim of the study is therefore to assay these phytochemicals with a view to inferring the components of the extract responsible for the inhibition properties of the material. Furthermore, AV corrosion inhibition of mild steel in HCl and HNO$_3$ at 303K-333K was investigated for the effect of temperature on corrosion process in two different media, in addition to the evaluation of the time it takes half the initial material to corrode.

2. Materials and methods

2.1. Coupon preparation

Mild steel sheet (of dimension 5cm x 3cm x 0.1cm) less than 0.25% carbon, with elemental analysis shown in Table 1, was mechanically cut to different coupons. The coupons were polished, drilled at one end and numbered by punching. The polished samples were degreased in ethanol and dipped in acetone to aid drying (ASTM, 1990). The chemical reagents used for the study were of analytical grade and were all prepared using distilled water.

Table 1. Analysis of the experimental mild steel with ARL 3460 metal analyser

Parameter	*Symbols*	*Composition (wt %)*
Iron	Fe	90.42
Lead	Pb	0.73
Zinc	Zn	Nil
Copper	Cu	2.08
Manganese	Mn	0.02
Phosphorus	Pb	1.31
Sulphur	S	2.5
Fixed Carbon	C	0.94

2.2. Extraction of Aloe Vera extract (AVE)

10g, 20g and 30g samples of fresh Aloe Vera leaves were weighed, grounded and soaked into various 500 mL of HCl and HNO$_3$ at 0.1, 0.3 and 0.5M concentrations. The mixture was left for 48 h and resultant filtrate made up to 500 mL using the various corresponding acid concentrations (Quraishi et al., 2008).

2.3. Phytochemical analysis

Phytochemical analysis of the extract was carried out according to standard methods as reported

by Harborne (1973), Kirk and Sawyer (1998), Mir et al. (2013) and Onyeka and Nwambekwe (2007). For the quantitative determination of alkaloids, steroids, condensed tannin, anthocyanins and flavonoids were determined using a standard method as reported in Onyeka and Nwambekwe (2007) and the gram percent of the extract calculated using Eq. (1).

$$\frac{W_{DP}}{W_{DS}} \times 100 \tag{1}$$

where W_{DP} is the weight of dried precipitate and W_{DS} is the weight of the fresh AVE sample

2.4. Corrosion weight loss measurement

Weighed samples of mild steel were immersed completely in 100 mL of the test media for 5days. The mild steel specimens were taken out of the solution every 24 h. After the test, any corrosion product(s) on the coupon were removed by cleaning in water, washing in liquor and drying in acetone. The mild steel samples were reweighed and the weight lost taken as the difference between the initial and final weights. The rate of corrosion (CR), surface coverage (θ) and inhibition efficiency (IE) were calculated using Eqs. (2), (3), and (4), respectively expressed below (Ebenso et al., 2008):

$$CR = \frac{W_1 - W_2}{AT} \tag{2}$$

$$\theta = 1 - \frac{W_s}{W_b} \tag{3}$$

$$IE\% = 1 - \frac{W_s}{W_b} \times 100 \tag{4}$$

where: W_1 = initial weight (g), W_2 = final weight (g), A= Area of the coupon (cm^2), T = exposure time (h), W_s is coupon weight loss in solution with inhibitor. W_b is the coupon weight loss in solution without inhibitor, θ = surface coverage, IE (%) = inhibition efficiency, CR = corrosion rate (gcm^{-2}hr^{-1}).

The variable parameters used for the present study are given below:
- Acid Concentrations: 0.1, 0.3 and 0.5M
- Inhibitor Concentrations: 0.01, 0.02 and 0.03g/L
- Temperatures: 303, 313 and 333K
- Times: 24, 48, 72, 96 and 120h

3. Results and discussions

3.1. Phytochemical analysis of Aloe Vera extract

This analysis shown in Table 2 was carried out to determine the quantitative values of the phytochemicals present in the AVE. The composition indicates that AVE contains condensed tannins, alkaloids, anthocyanins, flavonoids and steroids. These constituents contain fused benzene rings with mainly conjugated double bonds and heteroatoms in the rings (Fig. 1) which are responsible for the adsorption of the phytochemicals to the surface of the metal, thereby blocking (inhibiting) access of the corroding agent to the metal. The possible reaction centres can be unshared electron pair of heteroatoms and/or p-electrons of aromatic ring (Chen et al., 2013). The predominant adsorption mode depends on different parameters such as extract composition, type of acid anion, chemical changes to the extract and the nature of the charge on the metal surface.

Table 2. Phytochemical characteristics of *Aloe Vera* extract in gram percent

S/No	Phytochemical	gram%
1	Alkaloids	0.18
2	Anthocyanins	1.2
3	Flavonoids	1
4	Condensed Tannins	0.19
5	Steroids	0.06
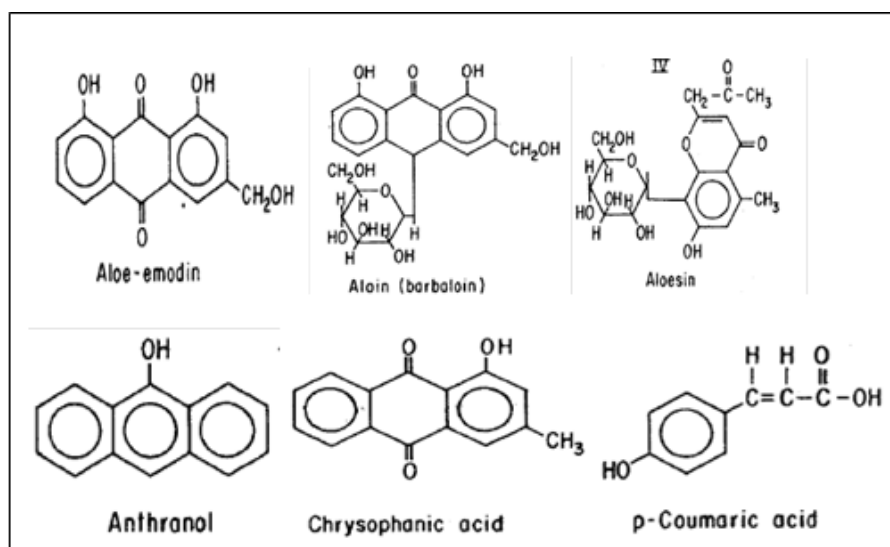
Fig. 1. Structural formulas of compounds isolated from *Aloe* barbadensis Miller (*Aloe Vera*) (Source: Waller et al., 1978)

A negative surface charge will permit the adsorption of cations whereas positive surface charge favours anion adsorption (Lecante et al., 2011). Waller et al. (1978) shows the existence of *Aloin*, *Aloesin* etc. in *Aloe Vera* (Fig 1) and the chemical complexity of these phytochemicals makes it difficult to assign the inhibitory properties of the AVE to a single constituent or group of constituents (Chen et al., 2013; Li et al., 2012; Nnanna et al., 2014). It has been observed that organic inhibitor molecules may be adsorbed on metal surfaces in one or more of the following ways (Chen et al., 2013; Lecante et al., 2011; Tian et al., 2012);

(a) electrostatic interaction between the charged (protonated) molecules and the negatively charged metal surface (cathodic sites);

(b) dipole-type interaction of unshared electron pairs in the molecule with the metal;

(c) interaction between p-electrons of the aromatic cycles with the vacant, low energy d-orbitals of metal atoms surface (anodic sites);

(d) a combination of types (a–c).

3.2. Weight loss results

3.2.1 Effects of concentrations of acid and inhibitor.

Figs. 2 and 3 show the variation of weight loss with time for the corrosion of mild steel in 0.1, 0.3 and 0.5M concentrations of HCl and HNO_3 without inhibitor at 333K. From Figures it can be seen that weight loss of mild steel increases linearly with time. The figures reveal that weight loss increases as time and concentrations of acid increase, indicating that the rate of corrosion of mild steel increases with concentration of acid and period of immersion.

Values of weight loss are also found to vary with concentration of HCl and HNO_3 in such a way that the trend of increase in weight loss with time is 0.5> 0.3 >0.1M for both HCl and HNO_3. Similar trends of plot (not shown) are obtained for 303 and 313K. Fig. 4 shows the variation of weight loss with time for the corrosion of mild steel in 0.5M of HCl and HNO_3 containing various AVE concentrations at 333K. The figure reveals that weight loss increases as time increases but decreases as the concentration of the acid extract of *Aloe Vera* increases, indicating that the AVE inhibited the corrosion of mild steel in both media. Similar results (not shown) are obtained for 0.1 and 0.3M of both HCl and HNO_3 at 303 and 313K. The inhibitory effects of AVE are very apparent considering the wide margin in magnitude of weight loss between inhibited and uninhibited phases.

Figs. 5 and 6 show the variation of weight loss with time for the corrosion of mild steel in 0.5M of HCl and HNO_3, respectively at different temperatures. The figures reveal that increase in temperature increases the rate of corrosion in both acids. It should be noted that generally, the rate of reaction increases with increase in temperature, following induced higher collision of reacting species at high temperature. It can be inferred from Figs. 2-6 that rate of corrosion of mild steel in acidic medium is affected by concentration of acid, concentration of inhibitor, period of immersion and temperature.

3.2.2 Effect of acid extract of Aloe Vera on the corrosion of mild steel.

Tables 3 and 4 show the values of corrosion rate *(CR)* and the Inhibition Efficiency *(IE %)* of AVE on mild steel in 0.5M HCl and HNO_3 at 303, 313 and 333K for 120 h immersion time. The results obtained show that corrosion rate, obtained in (Eq. 2) decreases as the concentration of AVE increases but increases with an increase in temperature. The values of corrosion rate in blank are higher than that of inhibited medium. This shows that acid extract of Aloe Vera slow down the corrosion of mild steel in both media (Dubey and Singh, 2007).

The rate of corrosion increases with temperature showing that the rate of chemical reaction is affected with an increase in temperature. There is insignificant difference in the values of corrosion rate recorded for mild steel corrosion in HCl and HNO_3. The representative result of *IE (%)*, obtained from Eq. (4) is displayed in Tables 3 and 4.
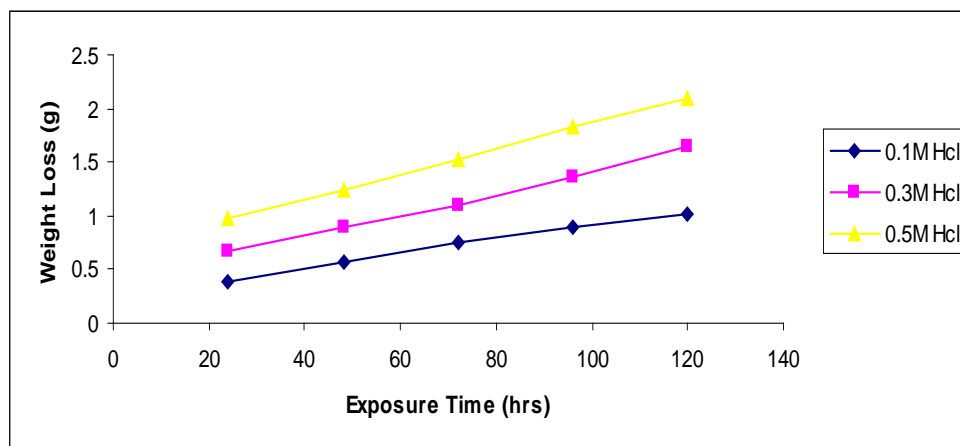

Fig. 2. Weight loss as a function of time for the corrosion of mild steel in varying acid concentration of HCl at 333K
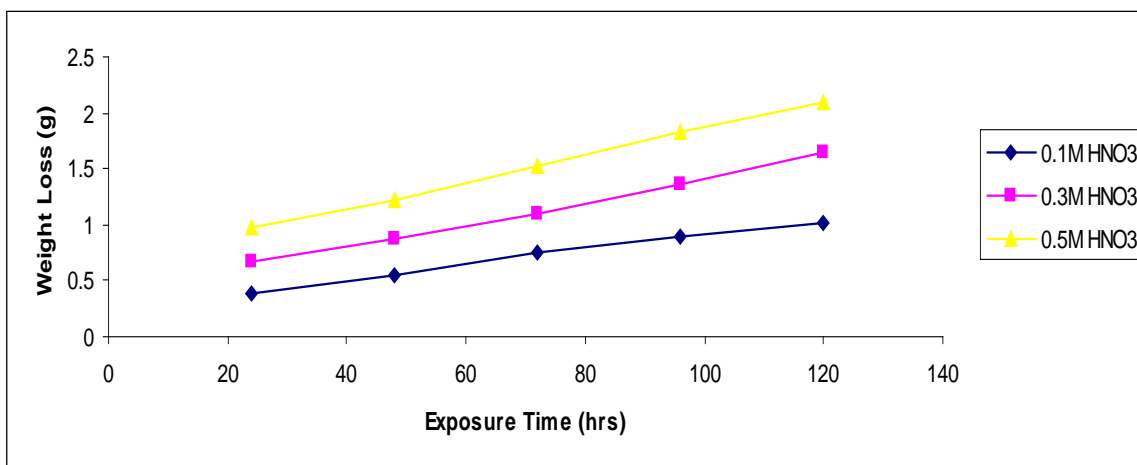
Fig. 3. Weight loss as a function of time for the corrosion of mild steel in varying acid concentration of HNO$_3$ at 333K
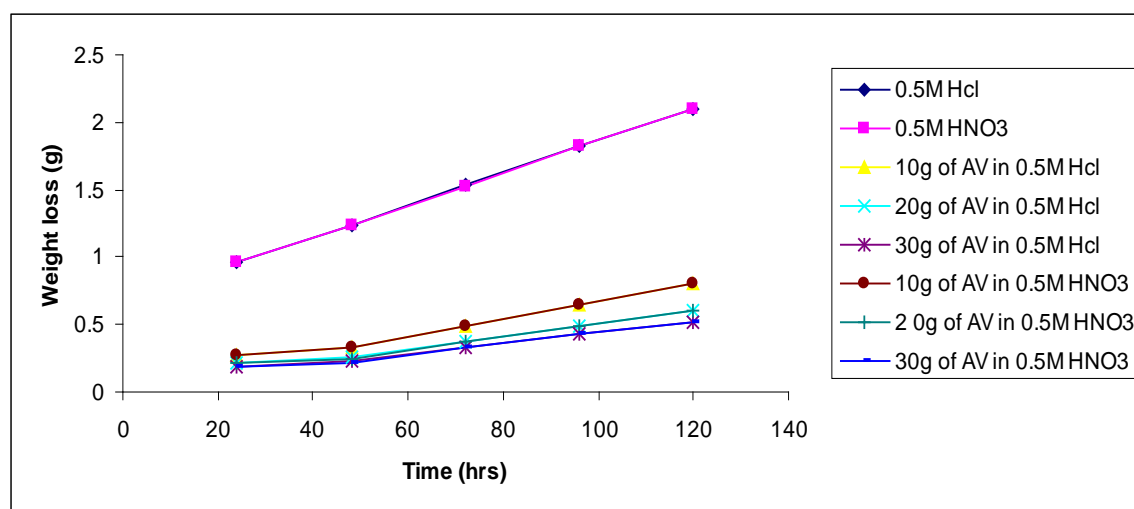

Fig. 4. Variation of weight loss with time for the corrosion of mild steel in 0.5M acid containing various concentration of *Aloe Vera* at 333K
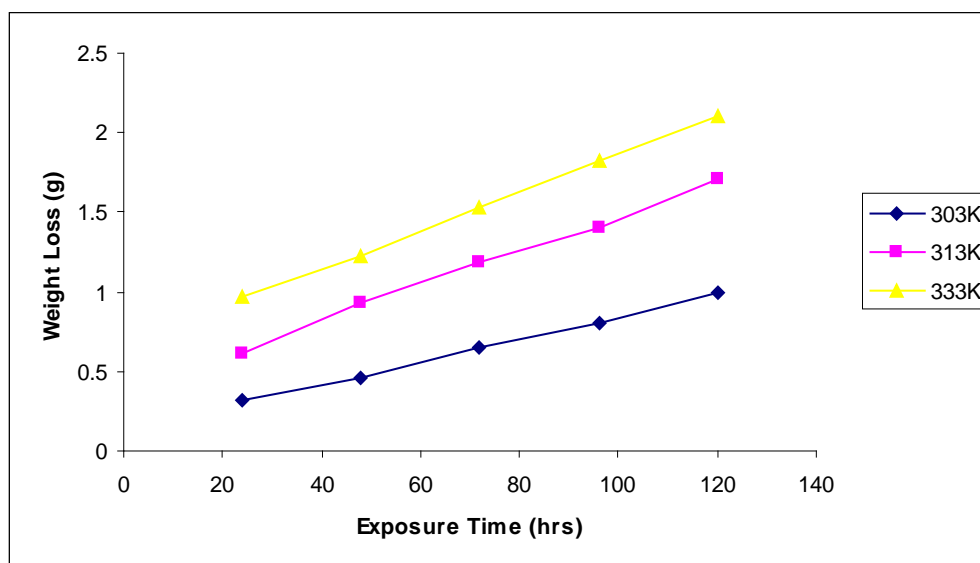

Fig. 5. Weight loss as a function of time for the corrosion of mild steel in 0.5M HCl at different temperatures
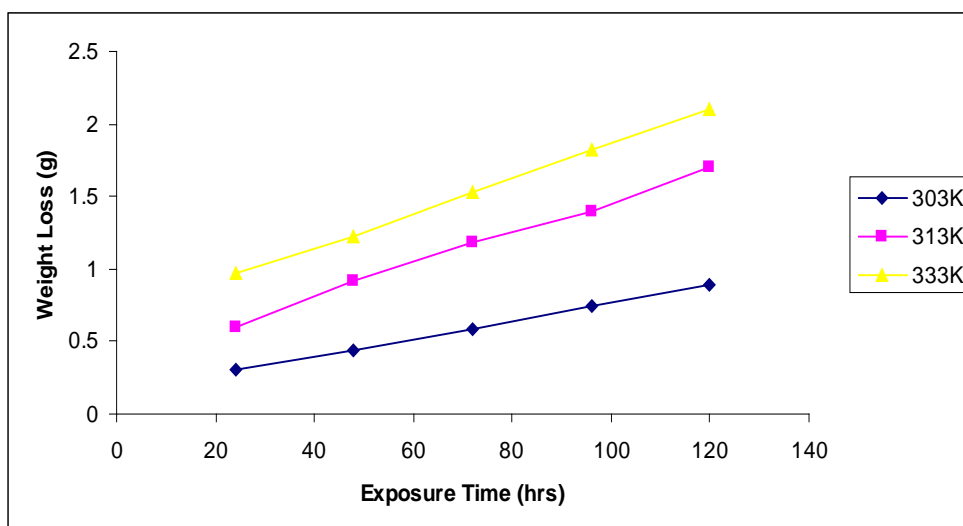
Fig. 6. Weight loss as a function of time for corrosion of mild steel in 0.5M HNO₃ at different temperatures

Table 3. Variation of Corrosion rate and inhibition efficiency with concentrations of *AVE* for the corrosion of mild steel in 0.5M HCl at different temperatures

Conc. (g/L)	Inhibition Efficiency (%IE)			Corrosion Rate (g/cm²hrs) x 10⁻⁵		
	303K	*313K*	*333K*	*303K*	*313K*	*333K*
Blank 0.5M HCl	-	-	-	57.50	86.01	101.10
0.01	69.85	64.83	62.88	8.25	9.23	11.23
0.02	71.90	69.91	67.90	7.01	8.60	10.00
0.03	75.31	73.30	70.32	6.36	7.01	8.75

Table 4. Variation of Corrosion rate and inhibition efficiency with concentrations of *AVE* for the corrosion of mild steel in 0.5M HNO₃ at different temperatures

Conc. (g/L)	Inhibition Efficiency (%IE)			Corrosion Rate (g/cm²hrs) x 10⁻⁵		
	303K	*313K*	*333K*	*303K*	*313K*	*333K*
Blank 0.5M HNO₃	-	-	-	57.40	85.07	99.99
0.01	69.89	64.84	62.89	8.23	9.20	11.20
0.02	71.94	69.93	67.93	6.93	8.55	9.75
0.03	77.32	73.35	70.34	6.34	7.00	8.64

It could be observed that inhibition efficiency of AVE for the corrosion of mild steel in the acidic media increases with an increase in the concentration of the inhibitor but decreases with increase in temperature, suggesting that the extract is physical adsorption inhibitor (Dubey and Singh, 2007). For a physical adsorption mechanism, efficiency of an inhibitor decreases with temperature but for a chemical adsorption mechanism, the efficiency is expected to increase with temperature. Values of inhibition efficiency (*%IE*) obtained at 333K are lower than the values obtained at 303K, indicating that at higher temperature the inhibitors are gradually desorbed from the surface of mild steel.

3.3 Adsorption studies

The adsorption characteristic of the inhibitor is also studied by fitting data obtained for degree of surface coverage into different adsorption isotherms. The tests reveal that the adsorption of acid extract of AV on the surface of mild steel is best described by Langmuir adsorption isotherm. Hence, no further consideration of other models is attempted. The near-perfect applicability of Langmuir isotherm in the adsorption of AVE to steel surface is an indication that the film formed in the metal surface is monolayer. The Langmuir adsorption isotherm can be expressed as (Damaskin et al., 1971) (Eq. 5):

$$K_L C = \frac{\theta}{1-\theta} \tag{5}$$

where *C* is the concentration of the inhibitor (g/L), K_L is the Langmuir adsorption constant (g/L) and θ = surface coverage.

The Langmuir adsorption isotherm can be rearranged to obtain Eq. (6):

$$\frac{C}{\theta} = \frac{1}{K_L} + C \tag{6}$$

Taking logarithm of both sides of Eq. 6, yields (Eq. 7)

$$log\ C/\theta = log\ C - log\ K_L \tag{7}$$

By plotting values of log (C/θ) against log C, linear plots were generated (Figs. 7 and 8), for the evaluation of log K_L from the intercepts. Values of adsorption parameters obtained from the isotherms are presented in Table 5. The values of R^2 obtained from Figs. 7 and 8 indicate a good fit, though it can be viewed that Langmuir isotherm best applies at 303K. The implication of these results is the absence of interaction between the adsorbed species and that the adsorption behavior of the inhibitor is strongly influenced by temperature.

3.4. Corrosion thermodynamics

The activation energy, E_a for both inhibited and uninhibited corrosion of the steel are evaluated using Arrhenius Eq. (8), linearized into Eq. (9) and simultaneously solved for T_1 and T_2 as (Abiola and Oforka, 2007) (Eq. 10):
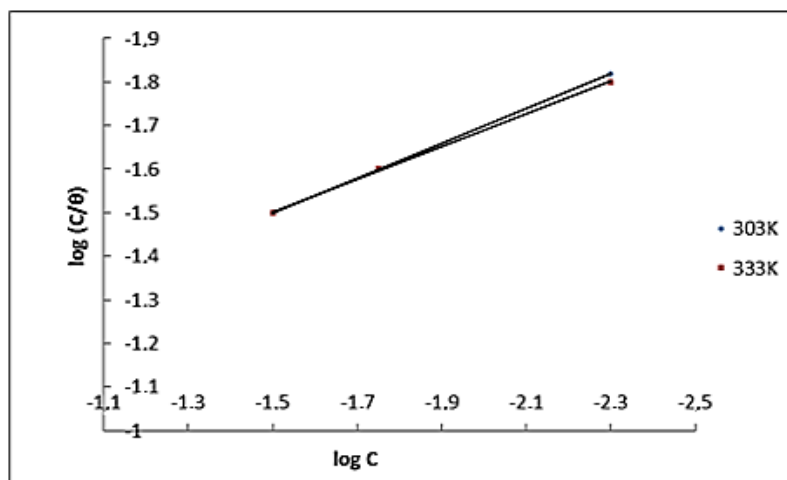
$$CR = A \exp\left(\frac{-E_a}{RT}\right) \tag{8}$$

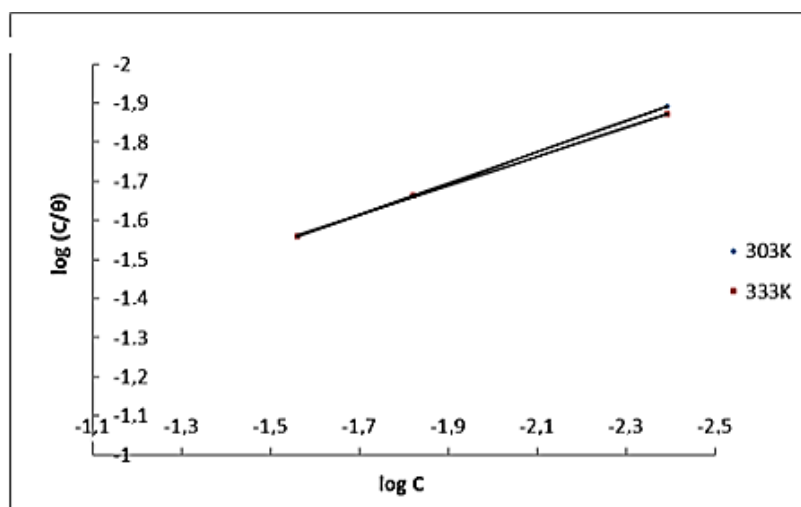$$\log CR = \log A - \frac{E_a}{RT} \tag{9}$$

$$\log \frac{CR_2}{CR_1} = \frac{E_a}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \tag{10}$$

Table 5. Langmuir isotherm for the adsorption of AVE in 0.5M (HCl and HNO₃) on mild steel surface

Parameters	0.5M HCl medium		0.5M HNO₃ medium	
	(303K)	(333K)	(303K)	(333K)
log K_L	0.0148	0.1557	0.0201	0.1567
K_L(g/L)	1.0346	1.4311	1.0473	1.4344
Slope	0.9153	0.8188	0.9028	0.8183
R^2	1.000	0.9993	0.9999	0.9993

Fig. 7. Langmuir adsorption isotherm for AVE at 0.5M HCl

Fig. 8. Langmuir adsorption isotherm for the AVE at 0.5M HNO₃

R is the gas constant, CR_1 and CR_2 are the corrosion rates at temperatures T_1 (303K) and T_2 (333K), respectively. Values of E_a calculated from Eq. (10) are recorded in Table 6. These values are found to range from 27.81 to 23.05kJ/mol in HNO_3 and 28.05 to 23.14kJ/mol in HCl. The observed results indicate that the adsorption of these extracts is in line with physical adsorption mechanism. The activation energy is always less than 80kJ/mol for physical adsorption mechanism as shown in Table 6 (Zucchi and Omar, 1985).

The values of Ea recorded in Table 6 for the acid extract of the inhibitor are higher than the values obtained in blank. This shows that the acid extract of the inhibitor slows down corrosion of mild steel in both media (Okafor et al., 2007), indicating a strong inhibitive action of the investigated compounds, which leads to increasing the energy barrier for the corrosion process. The heat of adsorption of acid extract of *Aloe Vera* on the surface of mild steel is calculated using Eq. (11) (Ebenso et al., 2008). Values of Q_{ads} calculated are recorded in Table 6 below. The values are negative and relatively low, an index of exothermic process.

$$Q_{ads} = 2.303R\left(Log\frac{\theta_2}{1-\theta_2} - Log\frac{\theta_1}{1-\theta_1}\right) \times \frac{T_1T_2}{T_2-T_1} \quad (11)$$

The thermodynamic parameter, ΔG for corrosion adsorption is calculated from Eq. (11) on transforming Eq. (12) into Eq. (13) (Noor, 2008):

$$K_L = \frac{1}{C_{solvent}}\exp\left(\frac{-\Delta G_{ads}}{RT}\right) \quad (12)$$

$$\Delta G_{ads} = -2.303RT\log(999K_L) \quad (13)$$

where: $C_{solvent}$ represents the molar concentration of the solvent (999g/L in the case of water).

Results posted in Table 7 are negative, indicating spontaneous adsorption of the inhibitor on the surface of mild steel. The ΔG_{ads} values are negatively lower than the threshold value of -40kJ/mol required for chemical adsorption (Noor, 2008); hence the adsorption of acid extract of the inhibitor on the surface of mild steel is spontaneous and favored the mechanism of physical adsorption. Generally, the more negative the value of ΔG_{ads} the stronger the strength of adsorption. Also shown in Table 7 are the entropy values obtained for the process using Eq. (14).

$$\Delta S = \frac{(Q_{ads} - \Delta G)}{T} \quad (14)$$

The positive values of ΔS indicate an increase in disorder of the system due to loss of interfacial water available to adsorbent and adsorbate surfaces. It can be argued that the driving force behind the adsorption process significantly results from entropy effect.

3.5. Corrosion Kinetics

Data obtained from weight loss measurement are fitted into Eq. (15) to test for the order of corrosion reaction in the presence of AVE.

$$ln(weight\ loss) = k_1t \quad (15)$$

where: k_1 is the first order reaction constant and t is time.

The tests reveal that the plots (not shown) of ln (weight loss) versus time (in days) are linear with R^2 close to unity. This indicates that a first order kinetic is applicable to the corrosion of mild steel in the presence of acid extracts of the inhibitor (Ita, 2005). Therefore, the corrosion of mild steel in the acid extracts of the inhibitors can be significantly represented by Eq. (15). In addition, the half-lives ($t_{1/2}$) of the corrosion of mild steel in the various media are calculated using Eq. (16).

$$t_{1/2} = \frac{0.693}{k_1} \quad (16)$$

Values of rate constant (k_1) obtained from the slope of the plots of Eq. (15) and the half-life calculated from Eq. (16) are presented in Table 8. From the results obtained, it is significant to note that half-life of mild steel to corrosion reaction increases with increase in concentration of acid extracts of AV. This shows that the half-life of mild steel in the acids increases with increasing concentration of the inhibitors.

Also from Table 8, it can be shown that the half-life of the acid extracts of the inhibitors at 333K is lower than that at 303K. This indicates that inhibition efficiency was inversely related to temperature. Similar results are reported elsewhere (Eddy et al., 2013; Nkuzinna et al., 2011).

Table 6. Activation energies and adsorption heat w.r.t. AVE on mild steel surface in 0.5M acid solution

Concentration (g/L)	E_a (kJ/mol)		Q_{ads} (kJ/mol)	
	HNO₃	HCl	HNO₃	HCl
Blank 0.5M	4.785	10.112	-	-
0.01	27.81	28.048	-10.233	-6.125
0.02	24.278	24.431	-4.372	-5.81
0.03	23.048	23.137	-2.59	-2.112

Table 7. Evaluated values of ΔG and ΔS

Conc. (g/L)	0.5MHCl				0.5MHNO₃			
	303K		333K		303K		333K	
	ΔG (kJmol⁻¹)	ΔS (JK⁻¹mol⁻¹)	ΔG (kJmol⁻¹)	ΔS (JK⁻¹mol⁻¹)	ΔG (kJmol⁻¹)	ΔS (JK⁻¹mol⁻¹)	ΔG (kJmol⁻¹)	ΔS (JK-1mol⁻¹)
0.01	-349.785	1.134	-316.422	0.932	-317.069	1.013	-316.422	0.919
0.02	-316.895	1.027	-316.340	0.933	-316.940	1.032	-316.341	0.937
0.03	-316.895	1.039	-316.273	0.943	-316.940	1.037	-316.273	0.942

Table 8. Kinetic parameters for the corrosion inhibition of steel by AV extracts

C(g/L)	k_1(1/hour)				$t_{1/2}$(hour)				R^2	
	HNO₃-AVE		HCl-AVE		HNO₃-AVE		HCl-AVE		HNO₃-AVE	HCl-AVE
	(303K)	(333K)	(303K)	(333K)	(303K)	(333K)	(303K)	(333K)		
Blank	0.268	0.289	0.261	0.286	2.68	2.40	2.79	2.44	0.959	0.956
0.01	0.247	0.278	0.240	0.274	2.91	2.51	2.99	2.52	0.987	0.987
0.02	0.199	0.273	0.196	0.267	3.67	2.61	3.69	2.62	0.985	0.985
0.03	0.191	0.269	0.184	0.263	3.81	2.64	3.92	2.69	0.979	0.976

4. Conclusions

Acid extract of *Aloe Vera* has shown good adsorption inhibition for the corrosion of mild steel in HCl and HNO₃ at the conditions of the experiment. The inhibition is due to the phytochemical constituents of the extract.

These phytochemical constituents enhance the adsorption behavior of the inhibitors. Inhibition efficiency increases with increase in concentration of the acid extract of *Aloe Vera* but decreases with increase in temperature. The adsorption of the inhibitors on the surface of mild steel is spontaneous, physically controlled and in line with Langmuir isotherm.

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