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EFFECT OF TEMPERATURE ON PROTECTIVE PROPENSITY OF ACACIA NILOTICA ON ACID CORROSION OF COPPER

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Abstract:

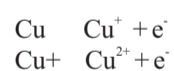
The inhibition effect of *Acacia nilotica* P ethanolic extract on copper corrosion in 0.5N hydrochloric acid has been studied by weight loss method between 303-353K temperatures. The inhibition efficiency increased with increase in concentration of plant extract. The corrosion rate increased with increase in temperature and decreased with increase in concentration of inhibitor compared to blank. The adsorption of inhibitor on Cu metal have been found to obey Langmuir adsorption isotherm. The values of activation energy (E_a), free energy of adsorption (ΔG_{ads}), enthalpy of adsorption (ΔH), and entropy of adsorption (ΔS) were calculated. The G values indicate that the adsorption of *EE_{an}P* on copper metal surface is physical in nature. Surface analysis (FT-IR) was also carried out to establish the mechanism of corrosion inhibition on copper corrosion in hydrochloric acid medium.

KEYWORDS:

Acacia nilotica, Copper, Acid corrosion, Adsorption isotherm, Kinetic parameters.

INTRODUCTION:

Copper is of important category of materials due to their wide range of industrial applications and household products. Copper a comparatively inactive metal is slowly corroded by air and water in the presence of weak acids [1]. Copper dissolution in chloride solutions is very important in the electropolishing and electromachining industries. Due to these reasons attention has focused on the behaviour of copper in chloride solutions. In the absence of different complexing agents in the corrosion medium, such as Cl⁻ ions, anodic dissolution of copper proceeds in two steps:

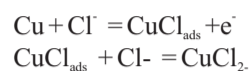


In neutral aqueous solutions, where oxygen is present, the overall reaction of anodic copper dissolution proceeds as follows:



When complexing agents, such as Cl⁻, are present in the corrosive aqueous medium, complex copper ions, such as CuCl₂, must be considered. In the near-neutral pH range of oxygen-containing media, the anodic reactions (at least at the immersion time) are as follows:

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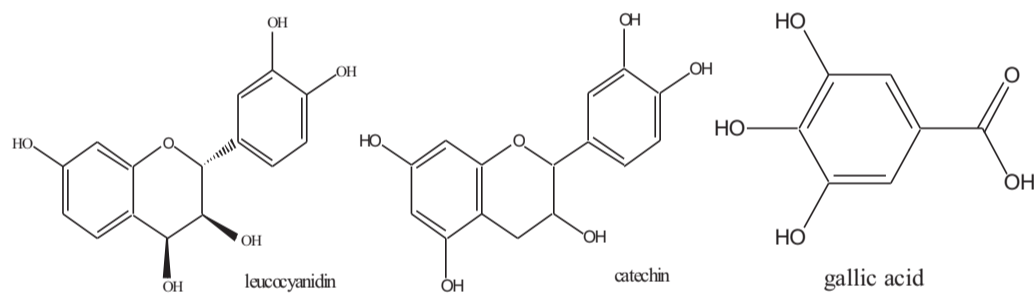


Mass transfer effects have been shown to be significant during the anodic dissolution of copper in chloride media with cuprous chloride complexes as the major product species[2].

Use of inhibitors is one of the most practical methods for protection against corrosion especially in acid solutions to prevent unexpected metal dissolution and acid consumption [3-5]. Most of the previous studies were focused on the inhibition of metals in acid or alkaline solutions using organic compounds containing nitrogen, sulphur and oxygen atoms as corrosion inhibitors. The toxicity of organic corrosion inhibitors to the environment has prompted the search for green corrosion inhibitors as they are biodegradable and do not contain heavy metals or other toxic compounds. Some research groups have reported the successful use of naturally occurring substances to inhibit the corrosion of metals in acidic and alkaline environment. Investigations of corrosion inhibiting abilities of tannins, alkaloids, organic, amino acids and organic dyes of plant origin are of interest, as in addition to being environmentally friendly and ecologically acceptable, plant products are inexpensive, readily available and renewable sources of materials. Moreover, they can be extracted by simple procedures with low cost.

Acacia nilotica is a species of acacia trees of the leguminosae family. The plant extract, which tested positive for tannins, gave intensities of corrosion inhibition of the same order as Gallic acid. The no toxicity of this organic plant constituents, its anti-microbial properties and sustainable sources of production present as having a wide scope of applications as green corrosion inhibitors. The acacia extract provides a good protection to aluminium and copper against corrosion. Alcoholic extract of Acacia nilotica pod contains Terpenoids, Tannins, alkaloids, Saponins, Glycosides, Nitrogen, phosphorus. Gallic acid, Chlorogenic acid, galloylated flavan-3,4-diol (leucocyanidin), catechin and 7,3',4',5,-tetrahydroxyflavan-3,4-diol have been reported from the pods[6-9].

STRUCTURE



EXPERIMENTAL

Sheet of copper obtained locally and of 0.16cm thickness was mechanically cut in to coupons of 3x2.4 cm² size, having a hole of uniform diameter of 0.12mm to facilitate suspension of the coupon in the test solution. The coupons were mechanically cleaned followed by polishing with emery sheet of fine quality to expose shining polished surface. To remove any oil and organic impurities coupons were degreased with acetone and finally with de-ionised water, dried and stored in a desiccator. Accurate weight of the samples was taken using electronic balance.

INHIBITOR MATERIAL

Plant material (Pods of Acacia nilotica) in natural condition was air dried (shade dried) for 20-25 days in shade. Then grained & powered. 35 g of finely powered dried material was taken in 1litre round bottom flask & sufficient quantity of ethyl alcohol (350ml.) was added to cover the powder completely. The RBF was covered with stopper & left for 8-10 days. On the completion of soaking period, the ethanolic solution is refluxed for 24 hrs. To concentrate the inhibiting chemicals. Thereafter, it is distilled & then filtered to remove any suspended impurities. The stock solution of the extract was stored in a clean corked bottle for further use. Or the extract of pods of Acacia nilotica was obtained by refluxing it in Soxhlet in ethanol.

PREPARATION OF TEST SOLUTIONS

The solution of 0.5N HCl was prepared using doubly distilled water. 50 ml. of the aggressive solution (0.5N HCl) was measured in six separate 100ml. beakers labelled as C-0, C-1, C-2, C-3, C-4, & C-5. EEAnP was added in the order of increasing concentration so as to have 0.0488, 0.0976, 0.244, 0.488 & 1.0248g/L in C-1, C-2, C-3, C-4 & C-5 beakers respectively. No extract was added to the first beaker (C-0). All chemicals used were of AR grade.

WEIGHT LOSS MEASUREMENT:

Each specimen was suspended by a V-shaped glass hook made of capillary and plunge into a beaker containing 50mL of the test solution (HCl) at different temperatures (303K to 353K). After the sufficient exposure, test specimens were washed with running water and finally washed with acetone. After that they were dried by hanging in the dessicator for sufficient time period and reweighed.

Surface analysis:

Fourier- Transform infrared (FTIR) spectroscopy

The nature of film formed on the surface of the metal specimens was analyzed by FT-IR. The dried specimens were scratched off and the resultant powder mixed with KBr (1:100 ratio) to prepare pellets, then the pellets was introduced into Fourier Transfer Infra-Red spectrophotometer FT-IR,8400's SHIMADZU, Japan to analyse the sample and the analysis was done by scanning the samples through a wave number range of 400 to 4000 cm.

RESULTS AND DISCUSSION

Weight loss Studies

Table 1 shows the value of inhibition efficiency [IE%], Corrosion Rate [ρ_{corr}], and Adsorption Equilibrium Constant [K_{ad}] obtained at different concentration of the inhibitors in 0.5N hydrochloric acid solution for an immersion period of 48hours at various temperature.

From the mass loss value, the inhibition efficiency [IE%] was calculated using the following equation.

$$\%IE = [(\Delta M_u - \Delta M_i) / \Delta M_u] \times 100 \quad (1)$$

Where ΔM_u is mass loss without inhibitor and ΔM_i is weight loss with inhibitor.

The corrosion rate in millimetre penetration per year (mmpy) can be obtained by following equation

$$\text{Corrosion rate (mmpy)} = (\Delta M \times 87.6) / \text{area} \times \text{time} \times \text{metal density} \quad (2)$$

Where ΔM weight loss expressed in mg, area expressed in square cm of metal surface exposed, time expressed in hours of exposure and metal density expressed in g/cm^3 .

Table 1. Corrosion Parameters for copper in 0.5N HCl in Absence and Presence of Various Concentrations of Ethanolic Extract of Acacia nilotica from Weight Loss Measurements at higher temperatures

Temperature (±1K)	EEAnP Concentration (g/L)	Cu			
		Weight loss (mg)	Corrosion rate (ρ_{corr}) (mmpy)	Inhibition Efficiency (%IE)	Adsorption Equilibrium Constant (K_{ad})
303	C0	219	2.7751	-	
	C1 0.0488	170	2.1542	22.37	5.9064
	C2 0.0976	115	1.4572	47.48	9.2658
	C3 0.244	90	1.2418	58.90	5.0602
	C4 0.488	55	0.9377	74.88	4.0152
	C5 1.0248	31	0.3928	85.84	5.9177
313	C0	260	3.2946	-	
	C1 0.0488	210	2.6610	19.23	4.8790
	C2 0.0976	150	1.9007	42.31	7.5137
	C3 0.244	110	1.3938	57.69	5.5887
	C4 0.488	85	1.0771	67.31	4.2189
	C5 1.0248	60	0.7602	76.92	3.2526
323	C0	320	4.0549	-	
	C1 0.0488	270	3.4213	15.62	3.7948
	C2 0.0976	190	2.4076	40.62	7.0103
	C3 0.244	150	1.9008	53.12	4.6448
	C4 0.488	110	1.3939	65.62	3.9121
	C5 1.0248	80	1.0137	75	2.9274
333	C0	395	5.0052	-	
	C1 0.0488	345	4.3716	12.66	2.9698
	C2 0.0976	265	3.3580	32.91	5.0262
	C3 0.244	200	2.5343	49.37	3.9959
	C4 0.488	150	1.9007	62.02	3.3470
	C5 1.0248	110	1.3938	72.15	2.5282
343	C0	455	5.7655	-	
	C1 0.0488	410	5.1953	9.89	2.2491
	C2 0.0976	340	4.3083	25.27	3.4655
	C3 0.244	300	3.8015	34.06	2.1175
	C4 0.488	244	3.0918	46.37	1.7720
	C5 1.0248	200	2.5343	56.04	1.2441
353	C0	500	6.3357	-	
	C1 0.0488	470	5.9556	6	1.3080
	C2 0.0976	420	5.3220	16	1.9516
	C3 0.244	380	4.8152	24	1.2942
	C4 0.488	340	4.3083	32	0.9643
	C5 1.0248	300	3.8015	40	0.6505

It could be seen from the table that the addition of inhibitor to the acid had reduced the corrosion rate. The inhibition efficiency increased with increase in concentration of inhibitors and decreased with increase the temperature from 303 K to 353 K in 0.5N hydrochloric acid.

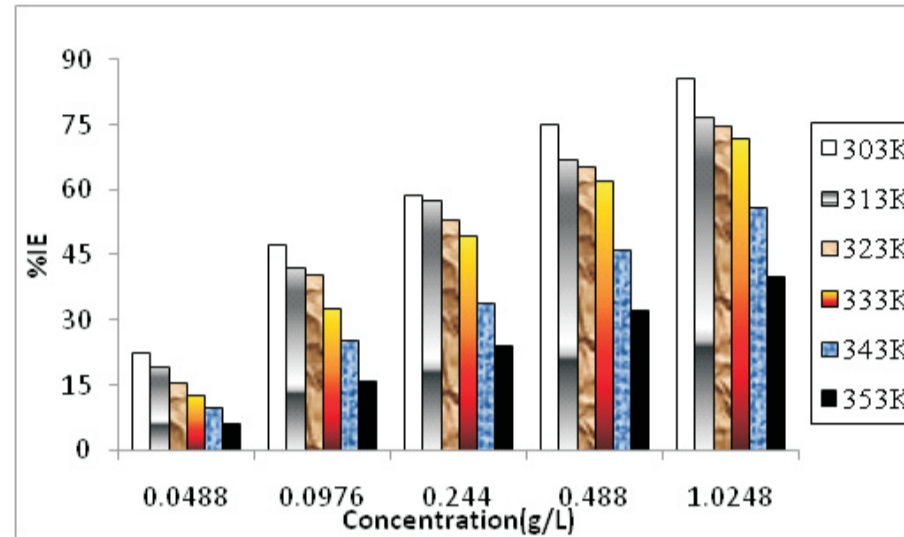


Fig:1 : IE (%) vs various concentration of EE_{An}P at different temperatures (303-353K) at Immersion time period 48h.

Inspection of the figure shows that the Inhibition efficiency (%IE) of the metal varies linearly with concentration and was increased in the presence of the inhibitor compared to the free acid solution. Further inspection of the figures reveals that Inhibition efficiency (%IE) increases with rise in Immersion time period and Lowest Inhibition efficiency (%IE) was obtained at 353K for the copper metal alloy. The maximum efficiency i.e (85.48 %) has been observed at highest inhibitor concentration (i.e. 1.0248g/L) at 303K for copper at 48h immersion period. The decrease of inhibition efficiency with the increased in temperature may be supports that the adsorption of Acacia nilotica extract on the copper surface is physical in nature. As the temperature increases, the number of adsorbed molecules decreases, leading to a decrease in the inhibition efficiency.

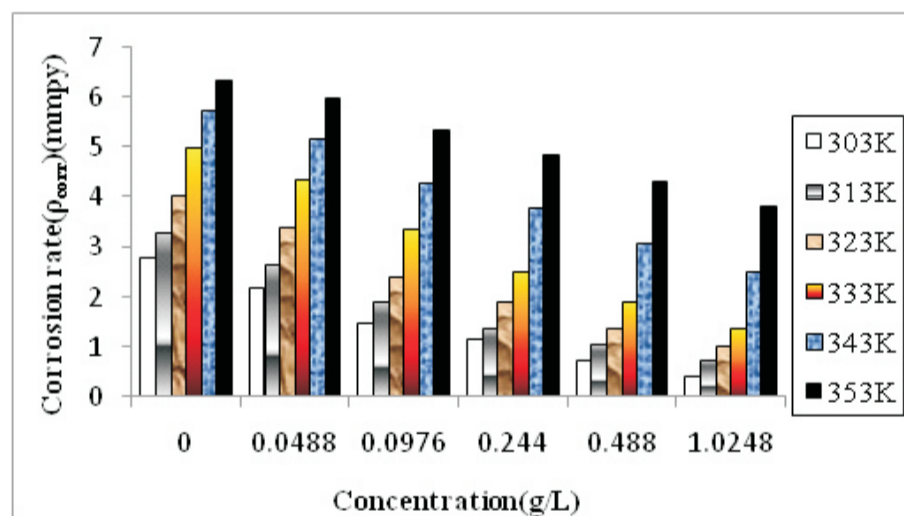


Figure 2: Corrosion rate (mm y⁻¹) vs various concentration of EE_{An}P at different temperature (303-353K) at Immersion time period 48h.

Graphical representation show that corrosion rate decreases when we add inhibitor in aggressive solution and more decreases as we increases concentration of inhibitor, but corrosion rate increases as we increases the temperature

Kinetic treatment of weight loss results

Assuming that the corrosion rate of aluminium against the concentration of the EE_{An}P obeys the kinetic relationship as shown:

$$\log \rho_{corr} = \log k + B \log C \tag{3}$$

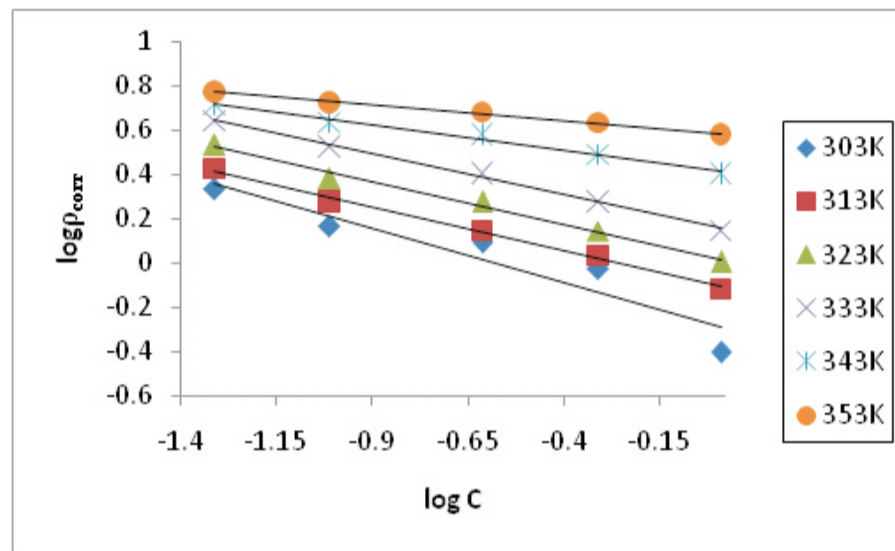


Fig 3 : log_{corr} vs log C at 48h for various temperature

The plot of log ρ_{corr} vs. log C at various studied temperature resulted in straight lines (Fig-3). The kinetic parameters (k & B) could be calculated by equation-3 and the values are tabulated in table-2. The slopes of the lines were observed negative, depicting that the rate of corrosion process is inversely proportional to EE_{An}P concentration, i.e. EE_{An}P becomes more effective as its concentration is increased. At each temperature a linear variation was observed in presence of EE_{An}P it is confirming a first order kinetics.

Table

Temperature (K)	48h		
	B	k	R ²
303	-0.494	0.750	0.891
313	-0.398	0.900	0.996
323	-0.385	1.019	0.991
333	-0.370	1.172	0.996
343	-0.228	1.517	0.986
353	-0.143	1.797	0.994

Kinetic parameters of energy of activation:

The weight loss measurements were conducted in the temperature range of 303-353K in the absence and presence of different concentrations of EE_{An}P in 0.5N HCl for copper. The dependence of corrosion rate on temperature can be expressed by Arrhenius equation:

$$\log CR = \log A - Ea/2.303RT \tag{4}$$

Activation energy values, Ea were calculated from the slope of the plots of fig. 4 and are given in table 3

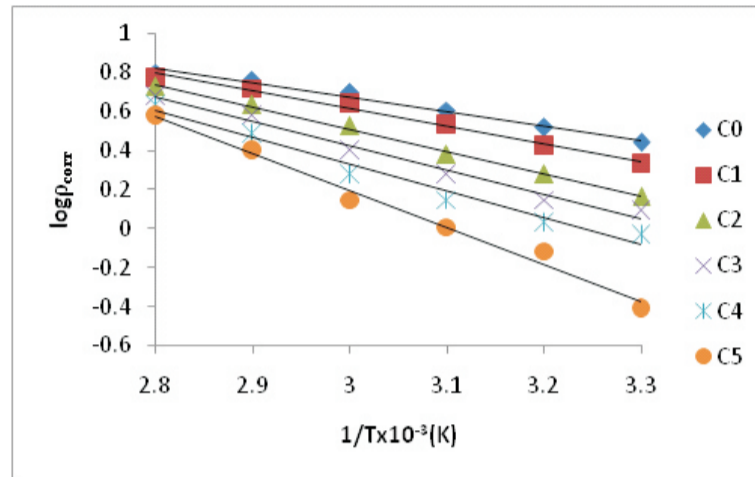


Fig 4. : log_{corr} vs 1/T (K) for different concentration at 48h immersion period.

The enthalpy, ΔH and entropy of adsorption, ΔS were obtained from the Transition state equation:

$$\log p_{corr}/T = [\log(R/Nh) + (S/2.303R)] - H/2.303RT \quad (5)$$

The calculated values are presented in Table 3 for copper in 0.5N HCl without and with varying concentration of EE_{an}P.

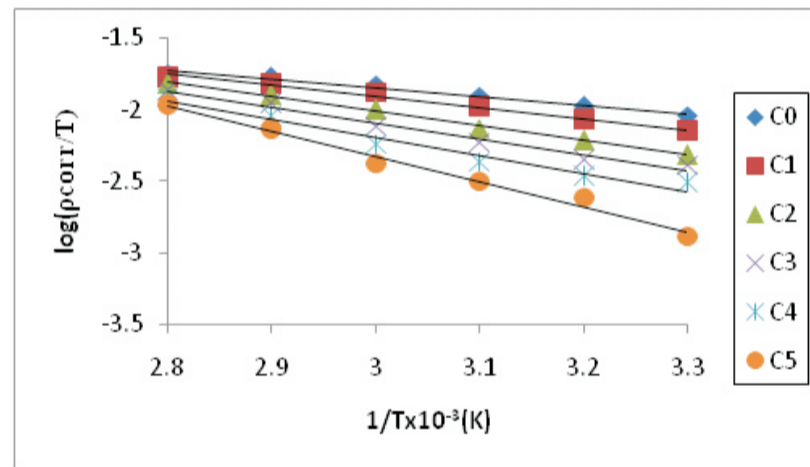


Fig 5 : log (p_{corr}/T) vs 1/T (K) at 48h immersion period

Table-3

Concentration g/L	48h		
	(Ea) (kJ mol ⁻¹)	ΔH (kJ mol ⁻¹)	ΔS (J/mol k)
C0	-14.2837	-11.7563	-197.674
C1	-17.4238	-14.8772	-189.421
C2	-21.9999	-19.4534	-177.722
C3	-23.9338	-21.3872	-173.548
C4	-26.3654	-23.8189	-168.13
C5	-36.2836	-33.7562	-140.845

Thermodynamic parameters

$$K = 1/55.5 \exp [-\Delta G_{ads}^{\circ}/RT] \quad (6)$$

The values obtained are presented in Table 4. Results presented in the Tables indicate that the values of ΔG_{ads}° are negative in all cases. The negative values indicate a spontaneous adsorption of the inhibitor molecules. Generally, values of ΔG_{ads}° up to -20 kJ mol^{-1} are consistent with electrostatic interaction between charged molecules and a charged metal (which indicates physical adsorption)

The thermodynamic parameters ΔH and ΔS for adsorption of $EE_{An}P$ on copper can be calculated from the following equation-

$$\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ} \quad (7)$$

Where ΔH and ΔS are the enthalpy and entropy of adsorption process. The calculated values are given in Table 4.

Table 4: Thermodynamic parameters of acid corrosion of Copper without and with various concentrations of $EE_{An}P$ at different temperatures (303-353K) at immersion time 48h

Concentration g/L	ΔG_{ads}° kJ mol ⁻¹						ΔH_{ads}° kJ mol ⁻¹	ΔS_{ads}° J mol ⁻¹ K ⁻¹
	303K	313K	323K	333K	343K	353K		
C0	-	-	-	-	-	-		
C1 0.0488	-14.5946	-16.442	-14.3695	-14.1356	-13.7671	-12.5772	-31.5	0.052
C2 0.0976	-15.7293	-17.7096	-16.0182	-15.5928	-15.0004	-13.752	-32.91	0.052
C3 0.244	-14.205	-16.8406	-14.9125	-14.9574	-13.5951	-12.5462	-31.36	0.051
C4 0.488	-13.6221	-16.0152	-14.4513	-14.4667	-13.0871	-11.6824	-31.19	0.052
C5 1.0248	-14.5995	-15.2516	-13.6724	-13.6897	-12.0782	-10.5268	-41.29	0.085

In the present case of study, the ΔG_{ads}° values were found lower than -20 kJ/mol which indicate physical adsorption of the molecule on copper surface. The negative sign of ΔH reveals that the adsorption of inhibitor molecules is an exothermic process. The increase in positive values of entropies (ΔS) imply that the spontaneous adsorption and activated complex formation [10-11].

Adsorption isotherm

Adsorption isotherm provides useful insights into the mechanism of corrosion inhibition. The adsorption equilibrium constant, K_{ad} , is expressed as:

$$K_{ad}C = \theta / (1-\theta) \quad (8)$$

Different adsorption models were considered for the best fit of experimental data. The best fitted straight line was obtained for the plot of $C\theta / (1-\theta)$ versus $C\theta$ with slopes around unity. This suggests that the adsorption of $EE_{An}P$ on the metal surface obeyed Langmuir adsorption isotherm, mathematically expressed as:

$$C / \theta = C + 1 / K_{ad} \quad (9)$$

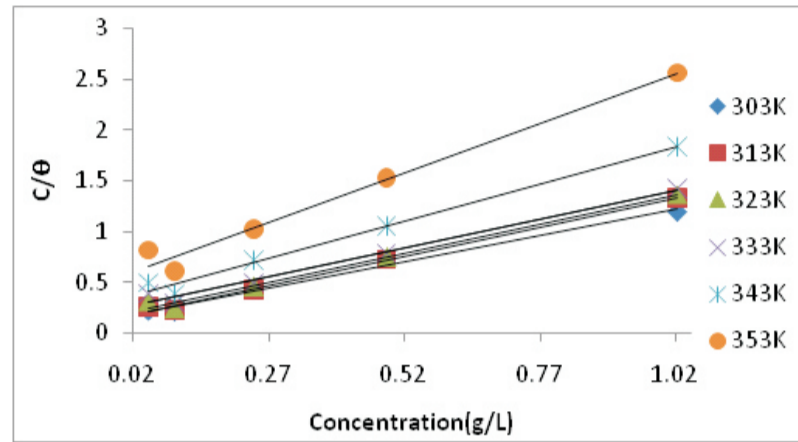


Fig: 6: C/θ against C at different temperature at immersion period 48h.

Table: 5 The correlation coefficient and slopes from Langmuir adsorption isotherm at different temperature

Temperature (K)	48h	
	Correlation coefficient (R^2)	K (adsorption coefficient)
303	0.985	6.0606
313	0.996	6.4102
323	0.990	5.2910
333	0.985	4.0816
343	0.987	2.9069
353	0.981	1.7636

The degree of linearity of Langmuir adsorption isotherm as measured by value of R^2 in the range (0.996 R^2 . 9 8s nearly equal to one and slope is almost unity, monolayer of the inhibitor species must have been attached to copper surface without lateral interaction between the adsorbed species.

SURFACE-ANALYSIS:

FT-IR spectroscopy:

The formation of the adsorbed protective film over the surface of copper coupon was further established by carrying out FT-IR spectroscopic investigations. FT-IR was conducted on 8400 Shimadzu, Japan FT-IR spectrometer in the IR range from 4000 to 400 cm^{-1} .

The FT-IR spectrum of the protective film was recorded by carefully removing the film, mixing it with KBr & making the pellet

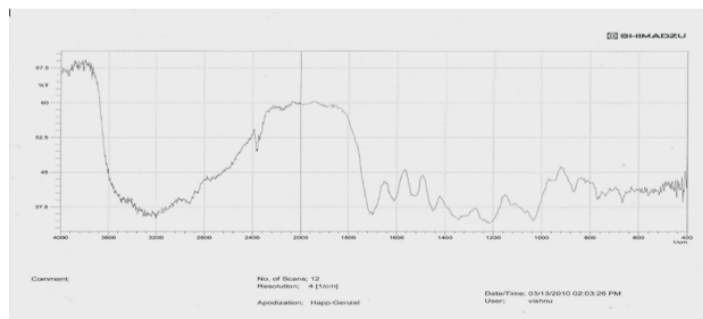


Fig: 7 FTIR spectra of EE_{Ah}P

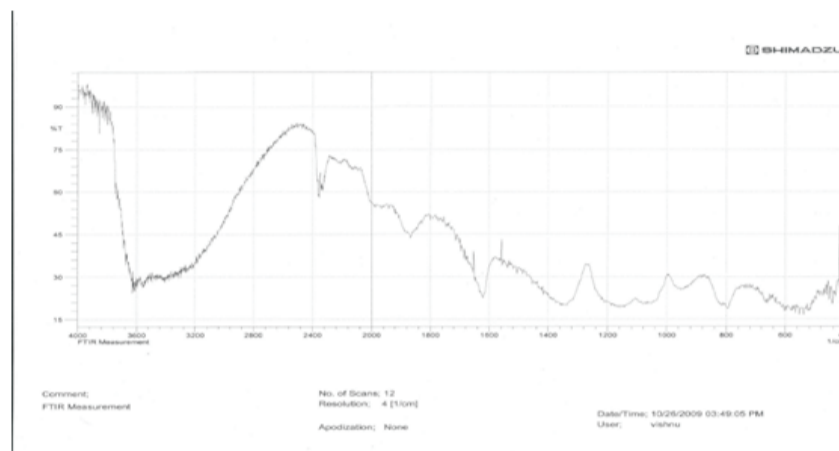


Fig: 18 FTIR spectra of adsorbed film of $EE_{An}P$ over copper metal exposed in 0.5 N HCl containing 1.0248g/L at immersion period 48h at 333K.

Prominent peaks obtained from reflectance FTIR spectroscopy

Frequency (cm^{-1}) band assignment

- 1080 C- O stretching
- 1226 C- O stretching
- 1373 C- H bending (methyl)
- 1725 C=O stretching
- 2880 C- H stretching
- 3268 O- H stretching

Due to electrostatic interaction, the protonated constituent's molecules are adsorbed (physisorption) and high inhibition is expected. Acacia nilotica pod extract molecules can also adsorb on the metal surface on the basis of donor-acceptor interactions between π -electrons of aromatic ring and vacant d-orbitals Cu. This assumption could be further confirmed by the FTIR results that Acacia nilotica pod extract could adsorb onto Cu metal surface to form a dense and more tightly protective film covering both cathodic and anodic reaction sites and thus retarding corrosion phenomenon.

Proposed Mechanism for Inhibition by $EE_{An}P$

Corrosion of copper in 0.5N HCl is retarded in presence of different concentrations of the Acacia nilotica pods extract. The results clearly showed that the inhibition mechanism involves blocking of copper surface by inhibitor molecules via adsorption. In general, the phenomenon of adsorption is influenced by the nature of metal and chemical structure of inhibitor. The values of thermodynamic parameters for the adsorption of inhibitors can provide valuable information about the mechanism of corrosion inhibition. The adsorption mechanism of extract on copper surface involves a physisorption. It means that the extract is able to electrostatically adsorb on the metal surfaces. The temperature study (303-353K) shows that at higher temperature desorption of the inhibitor from the metal surface occur. The Kinetic and thermodynamic parameters also confirm that there is electrostatic kind of interaction between the extract and metal surface. The mechanism of inhibition of corrosion is generally believed to be due to the formation and maintenance of a protective film on the metal surface which is clear by FTIR. Acacia nilotica pods constituents are Terpenoids, Tannins, alkaloids, Saponins, Glycosides, Nitrogen, phosphorus. Gallic acid, m-digallic acid, protocatechuic, Chlorogenic acid, galloylated flavan-3,4-diol (leucocyanidin), catechin and 7,3',4',5,-tetrahydroxyflavan-3,4-diol, it also contains crude protein, crude fibre, crude fat, carbohydrates,. As, these compounds contain heteroatoms (oxygen, nitrogen) and aromatic rings, which allow adsorption on the metal surface. Gallic acid has oxygen scavenging properties [12]. Therefore, another mechanism for inhibition is attributed to oxygen scavenging characteristic of Acacia nilotica pods extract. We suppose that the adsorption of these organic molecules could be also occurred due to the formation of a links between the d-orbital of aluminium atoms, involving the displacement of water molecules from metal surface, and the lonely electron pairs present on the N and O atoms of the

heterocyclic rings. It can be concluded that, due to the suitable inhibitive characteristics of compounds present in *Acacia nilotica* pods extract effective inhibitor for copper corrosion.

CONCLUSIONS:

The principle conclusions are:

The EEAnP inhibit corrosion of copper metal surface up to 85.48% respectively at room temperature in 0.5N HCl at highest concentration (1.0248g/L) for copper.

The inhibition efficiency increased with respect to the concentration of inhibitor and decreased with rise in temperature from 303K to 353K for metal alloy.

The Corrosion rate may be increased with temperature due to thermal activated kinetics.

Temperature study gave more information about the performance of *Acacia nilotica* pods extract and the nature of adsorption and therefore to evaluate the activation processes. Thermodynamic parameters revealed that the adsorption process is spontaneous and physical adsorption of the extract on both the metal surface.

The inhibition action of EE_{An}P is performed via adsorption of the extract species on copper alloys surface.

The adsorption is spontaneous and follows Langmuir adsorption isotherm in HCl at all temperatures.

The values of ΔG_0 are lower than -20kJ/mol at all temperatures for copper supports the physical adsorption mechanism.

The *Acacia nilotica* pods extracts is an eco-friendly corrosion inhibitor for copper in HCl solution and can be rightly chosen substitute of toxic chemicals.

FTIR spectra further confirm the formation of the protective film.

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REFERENCES

1. Da-Quan Zhang, Li-Xin Gao, Guo-Ding Zhou, "Inhibition of Copper Corrosion in Aerated Hydrochloric Acid Solution by Amino-acid Compounds" J. Appl. Electrochem., 35 (2005)1081-1085.
2. Mohammed A. Amin, "Weight loss, polarization, electrochemical impedance spectroscopy, SEM and EDX studies of the corrosion inhibition of copper in aerated NaCl solutions", J. Appl. Electrochem., 36, (2006) 215-226.
3. L. A. Nnanna 1, B. N. Onwuagba, I. M. Mejeha, K. B. Okeoma, "Inhibition effects of some plant extracts on the acid corrosion of aluminium alloy", Afric. J. Pure. Appl. Chem., 4(1), (2010) 11-16.
4. M. Lebrini, F. Robert, C. Roos, "Alkaloids Extract from *Palicourea guianensis* Plant as Corrosion Inhibitor for C38 Steel in 1 M Hydrochloric Acid Medium", Int. J. Electrochem. Sci., 6, (2011) 847-859.
5. K. Barouni, L. Bazzi, R. Salghi, M. Mihit, B. Hammouti, A. Albourine, S. El Issami, "Some amino acids as corrosion inhibitors for copper in nitric acid solution" Mater. Lett., 62 (19), (2008) 3325-3327.
6. S. Malviya, S. Rawat, M Verma, A Kharia, "Preliminary Phytochemical Investigations of *Acacia nilotica* Linn Plant", Current Pharma Research, 1(2), 2011, 91-100.
7. R. Chaubal, A. Tambe, "Isolation of new straight chain compound from *Acacia nilotica*", Ind. J. Chem., 45(B) (2006) 1231-1233.
8. S. Malviya, S. Rawat, A Kharia, M Verma, "Medicinal attributes of *Acacia nilotica* Linn. - A comprehensive review on ethnopharmacological claims", Int. J. PHARMACY & LIFE SCIENCES, 2 (6) (2011)
9. V. Verma, U. K. Singh, A. K. Sharma, S. Sharma, B. Singh, P. Goyal, R. Singh, "A Review on *Acacia nilotica* Linn. And its ethnobotany, phytochemical and pharmacological profile", Int. J. Of pharmaceutical Research and development, 4 (3) (2012) 251-256.
10. J. Dubey, P. Sharma, A. Chaturvedi, R.K. Upadhyay, "Effect of Temperature on Corrosion Inhibition Efficiency of *Withania Somnifera* (Ashwagandha) on Aluminium in HCl Solution", J. Corros. Sci. Engg., 13 (1) (2010).
11. M. Hazwan Hussin* and M. Jain Kassim, "Thermodynamic characterisation of mild steel corrosion and inhibition adsorption of *Uncaria gambir* and catechin in 1 M HCl", J. Corros. Sci. Engg., 13 (1) (2010).

- 12.A. Ostovari, S. M. Hoseinien, M. Peikari, S. R. Shadizadeh and S. J. Hashemi; in: "Corrosion inhibition of mild steel in 1M HCl solutions by heena extract: A comparative study of the inhibition by heena and its constituents (Lawsone, Gallic acid, D-Glucose and Tannic acid)", *Corros.sci.*, 51 (2009)1938.
- 13.B.C. Smith, *Fundamentals of Fourier transform infrared spectroscopy*, CRC Press, London, UK (1996).
- 14.E. A. Noor, "Temperature effects on the corrosion inhibition of mild steel in acidic solution by Aqueous extract of Fenugreek Leaves", *Int. J. Electrochem. Sci.*, 2 (2007) 996.
- 15.A. M. Abdel-Gaber, "Effect of Immersion Time and Temperature on the Inhibition of the Acid Corrosion of Zinc by Fenugreek Seeds Extract", *Int. J. App. Chem.*, 3 (3) (2007) 231.
- 16.I.B. Obot1, N.O. Obi-Egbedi, S.A. Umoren, "Adsorption Characteristics and Corrosion Inhibitive Properties of Clotrimazole for Aluminium Corrosion in Hydrochloric Acid", *Int. J. Electrochem. Sci.*, 4, (2009) 863 – 877.
- 17.J. Buchweishaija, G.S. Mhinzi, J. Buchweishaija, "Natural Products as a Source of Environmentally Friendly Corrosion Inhibitors: The Case of Gum Exudate from *Acacia seyal* var. *seyal*", *Portug. Electrochem. Acta*, 26 (2008) 257-265.

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