

Corrosion Inhibition of mild steel in Acid Media by Alpina galanga Extract

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Abstract: The corrosion inhibition nature of Alpina galanga extract for the corrosion of mild steel in 0.5 N H₂SO₄ was investigated using weight loss, electrochemical impedance and potentiodynamic polarization methods. The results revealed that Alpina galanga extract acts as a corrosion inhibitor in 0.5 N H₂SO₄ medium. The inhibition efficiency increased with an increase in inhibitor concentration. The inhibition is attributed to adsorption of the inhibitor on the steel surface.

Key words: Inhibitor, Mass loss, Impedance, Polarization, Ginger affinale

I. Introduction

Environmental friendly inhibitors have attracted several researchers. Nontoxic natural products have been widely used as corrosion inhibitors. Natural products such as tannins [1-3] have been used as inhibitors. Extracts of plants such as cerampetroselinum, Lupine, Doum and orangesheels have been used as corrosion and scale inhibitors [4]. Pomegranate [5], Swertia angustifolia [6] and Azadiractaindica [7] have a good inhibitive property. The scale inhibition efficiencies of the aqueous extracts of plant materials, namely Cordia Latifolia, Eucalyptus and Jasmine auriculatum have been evaluated [8]. Caffeine has been used as inhibitor in controlling corrosion of mild steel immersed in an aqueous solution containing 60ppm of Cl⁻ [9]. Longo, et al [10], synthesized a number of different porphyrins and their metallic derivatives and used them as corrosion inhibitors for pure iron (Armco) and pure aluminium in 1% sodium chloride (NaCl) solution. Award has used the extracts of the plants Calotropis procera and Diopyros mespiliformis to control corrosion of mild steel in 0.1N hydrochloric acid (HCl) solutions, by adopting weight loss measurements and polarization studies [11]. The present work investigated the inhibition efficiency of an Methanolic extract of plant material, Alpine galanga extract, in controlling corrosion of carbon steel (CS) immersed in an 0.5 N H₂SO₄ solution containing in the absence and presence of KI using a mass loss study, potentiodynamic polarization and impedance methods.

II. Materials And Methods

Preparation of extract.

An methanolic extract of Alpine galanga was prepared by powdered extracted with boiling methanol, then removes gangues from the suspended one. The extract was used as corrosion inhibitor in the present study.

Preparation of specimens

Carbon steel specimens (0.022% S, 0.038% Mn, 0.027% P, 0.086 C) of dimensions 1.0 cm * 4.0 cm * 0.2 cm were polished to a mirror finished and degassed with using trichloroethylene.

Mass loss method.

Relevant data on the 0.5 N H₂SO₄ used in the study are given in table 1. Carbon steel specimens in triplicate were immersed in 100 mL of the solutions containing various concentrations of the inhibitor in the presence and absence of KI for two hours. The weight of the specimens before and after immersion was determined using shimadzu balance model Ay 62. The inhibition efficiency (IE) was then calculated using the equation.

$$IE\% = \left(\frac{W_1 - W_2}{W_1} \right) \times 100$$

Where W₁ and W₂ are the corrosion rates in the absence and presence of the inhibitor, respectively.

Electrochemical measurements

2.4. Impedance measurements

The electrochemical impedance measurements were carried out using a Potentiostat/Galvanostat/FRA (PARSTAT 2273, Princeton Applied Research, USA). Data acquisition was performed utilizing the PowerSuite software and analyzed using ZsimpWin software (version 3.21). A three electrode set up was employed with Pt foil as the auxiliary electrode and a saturated calomel electrode as reference electrode. The mild steel cylinder,

with surface prepared as described in the weight loss experimental method, served as the working electrode. The measurements were carried out in the frequency range 10^6 – 10^{-2} Hz at the open circuit potential by superimposing a sinusoidal AC signal of small amplitude, 10 mV, after immersion for 30 min in the corrosive media. The double layer capacitance (C_{dl}) and charge transfer resistance (R_{ct}) were obtained from the impedance plots as described elsewhere [12]. Because R_{ct} is inversely proportional to corrosion current density, it was used to determine the inhibition efficiency (IE%) using the relationship:

$$IE\% = \frac{R_{ct} - R_{ct}^0}{R_{ct}} \times 100$$

where R_{ct} and R_{ct}^0 are the charge transfer resistance values in the uninhibited and inhibited solutions respectively.

2.5. Polarization measurements

The potentiodynamic polarization curves were recorded using the same cell setup employed for the impedance measurements. The potentials were swept at the rate of 1.66mVs⁻¹, primarily from a more negative potential than E_{ocp} to a more positive potential than E_{ocp} through E_{corr} . The inhibition efficiencies were calculated using the relationship [13]:

$$IE\% = \frac{I_{corr}^0 - I_{corr}}{I_{corr}^0} \times 100$$

where I_{corr}^0 and I_{corr} are the corrosion current densities in the absence and in the presence of inhibitor, respectively.

III. Results And Discussion

Analysis of result of mass loss method

The corrosion rate (CR) of carbon steel immersed in 0.5 N H₂SO₄ in the absence and presence of inhibitor systems are given table 2. The inhibition efficiencies (IE) are also given in this tables.

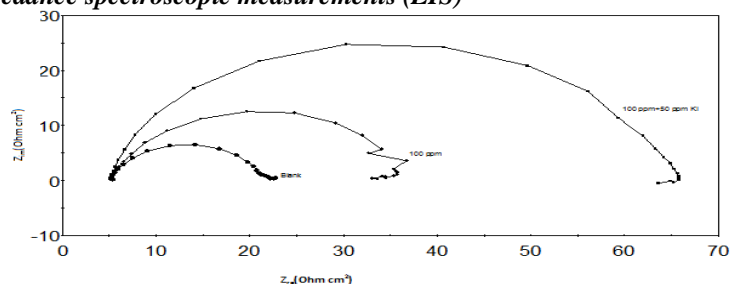
It is seen from table.2 that the rizhome extract of Alpina galinga shows 38.92% in 0.5 N H₂SO₄ inhibition efficiency for the corrosion of carbon steel in well water and it increases with increase in volume of stock solution added to the corrosive media.

Table1. Corrosion rate (CR) of carbon steel in 0.5N H₂SO₄ in the absence and presence of inhibitors, and the inhibition efficiency (IE) obtained by mass loss method.

Immersion period: 2 hours; Inhibitor :Methanolic Extract of Alpine galinga(AG)-KI.

AC Extract (ppm)	KI (0)ppm		KI (50)ppm	
	CR (mg cm ⁻² h ⁻¹)	IE %	CR (mg cm ⁻² h ⁻¹)	IE %
0	112.81		112.81	
10	68.90	38.92	34.69	69.25
25	65.63	41.91	33.44	70.35
50	62.81	44.32	32.50	71.19
100	56.88	49.57	31.88	71.75

Electrochemical impedance spectroscopic measurements (EIS)



The Impedance measurements of mild steel immersed in sea water in the absence and presence of inhibitors are in Fig 2.

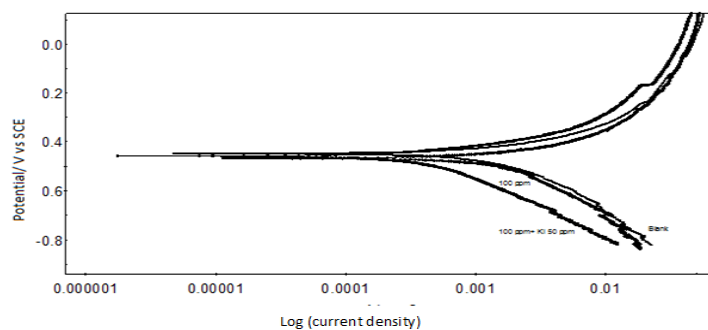
Table 2. Impedance parameters obtained from electrochemical impedance studies.

Inhibitor concentration ppm	Rct Ohm cm ²	C _{dl} μF	IE%
0	17.2	9.2578×10 ⁻³	
100	39	1.0149×10 ⁻⁵	55.89
100 ppm + 50ppm(KI)	62	6.384×10 ⁻⁶	72.25

Impedance spectra obtained for corrosion of mild steel in 0.5 N H₂SO₄ contains two semicircles in which the second one represents the interaction of metal surface with the corrosive environment . The first semicircle represents the nature of the corrosive media .Since the conductivity of the corrosive medium is very low ,this also behaves like a leaky capacitor . The CR-CR model best describes this situation. The second semicircle in the impedance plots contain depressed semicircles with the centre below the real axis. The size of the semicircle increases with the inhibitor concentration, indicating the charge transfer process as the main controlling factor of the corrosion of mild steel. It is apparent from the plots that the impedance of the inhibited solution has increased with the increase in the concentration of the inhibitor. The experimental results of EIS measurements for the corrosion of mild steel in 0.5 N H₂SO₄ in the absence and presence of inhibitor are given in Table 2.Papova et al. said that sum of charge transfer resistance (Rct) and adsorption resistance (Rad) is equivalent to polarization resistance (Rp).

Polarization studies :

Electrochemical parameters like corrosion potential (E_{corr}),corrosion current density (I_{corr}),cathodic tafel slope (β_c) Anodic tafel slope (β_a) and percentage inhibition efficiency according to polarization studies are listed in table 3. Here I_{corr} decreased with increasing inhibitor concentration. It is clearly observed that the Ginger afinale reduce the corrosion current density.



The potentiodynamic polarization curves of mild steel immersed in sea water in the absence and presence of inhibitors are in Fig 2.

Table 3. Corrosion parameters in the presence and absence of inhibitor obtained from polarization measurements.

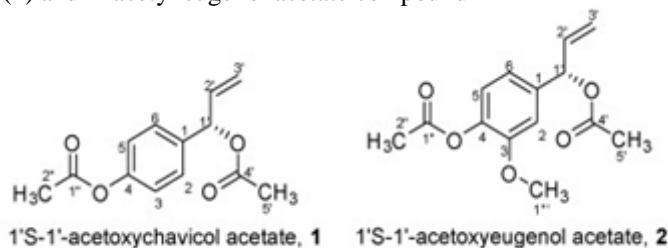
Inhibitor concentration (ppm)	-E _{corr} (mV)	β _c (mV/)	β _a (mV)	I _{corr} ×10*6 μA	IE%
0	448	127	68	1.628	
100	446	133	69	0.619	62.0
100+50ppmKI	472	168	78	0.210	87.1

Corrosion current density decreased noticeably with inhibitor concentration, indicating the increased inhibition efficiency with the increase in the concentration of the inhibitor. E_{corr} value shifted towards more negative potential .It has been reported that a compound can be classified as an anodic and cathodic type inhibitor on the basis of shift E_{corr} value.If displacement of E_{corr} value is greater than 85 mv ,towards anode or cathode with reference to the blank ,then an inhibitor is categorized as either anodic or cathodic type inhibitor .otherwise inhibitor is treated as mixed type. In our study ,maximum displacement in E_{corr} value was around around 24 mV. Indicating inhibitor is a mixed type inhibitor with more anodic nature . β_c and β_a values changed with respect to the inhibitor concentration. Therefore, Alpina galinga extract could be classified as a mixed type inhibitor suggesting that the presence of the inhibitor does not alter the reaction mechanism, and that the inhibition effect has occurred due to simple blocking of the active sites, thereby reducing available surface area of the corroding metal. [14-15]

Active principle for corrosion

Adsorption of organic molecules may be explained by the presence of an oxygen atom (a hetroatom), _ electron of aromatic rings and electron donating groups. The hetro-atoms such as oxygen are the major adsorption center in organic compounds for its interaction with the metal surface [17]. The adsorption can also occur via electrostatic interaction between a negatively charged surface, which is provided by a specifically adsorbed anion (Cl⁻) on iron, and the positive charge of the inhibitor [18] This observation suggests that inhibitor molecules adsorb on the metal surface by blocking the active sites on the metal surface [16]

The active principle for corrosion inhibition is an aqueous methanolic extract of Alpina galinga is having 1'-acetoxychavicol acetate (1) and 1'-acetyl eugenol acetate compound



1'-acetoxychavicol acetate (1) and 1'-acetyl eugenol acetate

IV. Conclusions

1. Plant inhibitors inhibited mild steel corrosion in Acid solutions.
2. Corrosion inhibition of mild steel in acid solution is under mixed control.
3. Inhibition efficiency of plant extracts increases with increase in concentration.
4. The mass loss measurements are in good agreement with electrochemical method.
5. From the results obtained we can conclude the following. Alpina galinga perfectly inhibits the corrosion of a mild steel in 0.5N H₂SO₄ solution, The high inhibition efficiency is attributed to the strong adsorption of AG on the MS surface

Reference

- [1] J.P.Moresby, Corros. Australas 10 (1988) 10
- [2] J.I.Bregman, Corrosion Inhibitors (New york, NY, London, UK :Macmillan, (1963) 33,48,99,107.
- [3] U.R.Evans, The corrosion and oxidation of Metals (London, UK, Edward Arnold Ltd., 1960) 170, 171,178.
- [4] A.A.El – Hosary, R.M.Saleh, H.A.El-Dahan, “Corrosionand Scale inhibition in cooling water by Naturally Occuring Substance”, “Proc.of 7th European symp. On Corrosion Inhibitors (Ferrara,Italy: University of Ferrara), 1 (1990) 725
- [5] A.A. El-Hosary, R.M. Saleh, A.M.Shans El Din, Corros. Sci. 12 (1972) 897.
- [6] S.J. Zakvi, G.N. Mehta, J.Electrochem Soc. 37(1988) 237.
- [7] M.Manimegalai, P.Rajeswari, S.Mohanam, S.Maruthamuthu, N.Palanisawamy “Biocidal and Inhibition Effect of Naturally Occuring Substacnes –Azodirectaindica on mild steel in fresh water”, Procof 10th National congress on corrosion control, heldsept 6-8 (Madurai, India, 2000) 153.
- [8] I.H. Farooqui, M.A. Quraishi, “Break through in Sclae and Deposit Control. Quert Publication, Mumbai, India. Sponsor : NACE International, India Section, Corrosion Sci. Society of India”, Procof Industrial Corrosion causes and Mitigation CORCON 2000 (Mumbai, India), 2 (2000) 103.
- [9] S.Rajendran, S.Vaibhavi, N.Anthony, D.C. Trivedi, Corrosion 59 (2003) 529.
- [10] F.R.Longo, J.J.DeLuccia, V.S.Agarwala, “Prophyrisas corrosion inhibitors”, Proc. 6th Europeansymp. On corrosion inhibitors, vol.1 (Ferrara, Italy: University of Ferrara, 1985) 155.
- [11] G.H.Awad, “Effect of some plant Extracts on the corrosion of Mild steel in 0.1 N Hydrochloric Acidsolution”, Proc. 6th European symp. On corrosioninhibitors, vol.1 (Ferrara, Italy: University of Ferrara, 1985) 385.
- [12]. H. Ashassi-Sorkhabi, B. Shaabani, D. Seifzadeh, Electrochim. Acta 50 (2005) 3446.
- [13]. M. Shahin, S. Bilgie, H. Yilmaz, Appl. Surf. Sci. 195 (2003) 1.
- [14] Felicia Rajammal Selvarani, S.Santhanalakshmi, J. Wilson sahayaraja, A. John Amalraj, and Susai Rajendran , *Bull. Electrochemistry*. 20 (2004) 561-565.
- [15] Susai Rajendran S. Mary Reenkala, Noreen Anthony and R. Ramaraj *Corros Sci*, 44 (2002) 2243-2252.
- [16]. H. Ashassi-Sorkhabi, B. Shaabani and D. Seifzadeh, *Electrochimica Acta*, 50(2005) 3446
- [17]. E. Rocca, C. Rapin and F. Mirambet, *Corrosion Science*, 46(2004)653
- [18]. K. Tebbji, H. Oudda, B. Hammouti, M. Benkaddour, M. El Kodadi and A. Ramdani, *Colloids and Surfaces A: Physicochem. Eng. Aspects* 259(2005)143