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Emilia Sonchifolia Extract as Green Corrosion Inhibitor for Mild Steel in Acid Medium using Weight Loss Method

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Abstract
The effect of naturally occurring Emilia Sonchifolia (ES) was investigated as corrosion inhibitor for mild steel in 1.0M H_2SO_4 using gravimetric measurement at 30^oC and 60^oC. The extract was found to retard corrosion rate of Mild steel. The inhibition efficiency (IE %) increased with increase in concentration of the ES extract up to 74.77% at 1.0 M. Increase in temperature increased the corrosion rate in the absence and presence of inhibitor but decreased the inhibition efficiency. ES was found to obey Langmuir adsorption isotherm and Kinetic-Thermodynamic Model of El-Awady et al. at all the concentrations and temperatures studied. Phenomenon of physical adsorption is proposed from the activation parameters obtained. Thermodynamic parameters reveal that the adsorption process is spontaneous.
Keywords: Emilia sonchifolia, corrosion, inhibitors, mild steel, acid, weight loss

Introduction

Numerous Studies have been carried out on the corrosion of metals in different environment and their inhibition and most of the known inhibitors suitable for the corrosion of mild steel are heterocyclic compounds [1], [2].
For these compounds their adsorption on the metal surface is the initial step of inhibition [3],[4],[5]. The two main modes of adsorption that occur as a result of interaction between organic inhibitors and the metal surfaces are physical and chemical adsorption. The adsorption of inhibitor can be enhanced by the presence of heteroatoms such as N, O, P, S, and long carbon length as well as triple bond and aromatic structures [6],[7],[8].
It has also been reported that the extent of adsorption of an inhibitor is greatly influenced by the nature and surface coverage of the metal, chemical structure of the inhibitor, mode of adsorption, distribution of the charge on the molecule, the nature of the aggressive medium, concentration of the inhibitor, concentration of dissolved oxygen and immersion time [9], [10].
Some naturally occurring compounds such as ethanol extracts of plants have been found to be good green corrosion inhibitors due to the presence of tannin, saponin and other photochemical constituents [11],[12],[13]. The needs for biodegradable compounds that do not contain heavy metals or other toxic substances have intensified the use of green corrosion inhibitors. The successful use of naturally occurring substances to inhibit the corrosion of metals in acidic and alkaline media have been reported by some groups [14],[15]. In most of these studies, the use of ethanol extracts of *Emilia sonchifolia* as inhibitor has not been reported.
The present study on ethanol extract *of Emilia sonchifolia* is aimed at investigating the adsorption and inhibitive properties on mild steel in H_2SO_4 (acidic medium).

Materials and Methods

Sample collection

Emilia Sonchifolia (ES) was obtained from the botanical garden in Nnamdi Azikiwe University, Awka, Anambra State, located in the Eastern Nigeria.

Materials preparation

The mild steel sheet used was 0.14cm in thickness and mechanically pressed cut into coupons of dimension 5cm x4cm (surface area 42.52cm^2). For surface treatment they were degreased using absolute ethanol, dried in acetone and stored in moisture free desiccators

Preparation of plant extracts

50g of powdered sample was soaked in 125 ml of ethanol for 48 hours, it was cooled and filtered. The filtrate was subjected to evaporation at 352K to leave the sample free of the ethanol. The filtrate was then used for phytochemical analysis (Tests for carbohydrates, saponins, oils, fats, flavonoids, terpenoids, alkaloids etc.,) and different concentrations of the extract was prepared by dissolving 0.1, 0.2, 0.3, 0.4 and 0.5 grams of the extract in 1litre of 1.0M H_2SO_4 respectively.

Gravimetric Method (weight loss)

The pre-cleaned mild steel coupons were dipped in 200 ml of the respective inhibitor/blank solutions maintained at 30^oC and 60^oC in a thermostatic water bath. The weight loss was determined for 120 hours (5 days). Prior to measurement, each coupon was washed in 20% NaOH solution (containing 100 g/l of zinc dust), rinsed in deionized water, dried in acetone and reweighed[16],[17],[18]. The weight loss was recorded using digital analytical weighing balance. The same experiment was repeated in the presence of inhibitor (ES). From the weight loss, the inhibition efficiency (IE%) of the extract and the corrosion rate (CR) of mild steel were calculated using the equations below.

$IE\% = (1 - W_2/W_1) \times 100$ ………………. (1)

$CR\ (gh^{-1}\ cm^{-2}) = \Delta W / AT$ ………………… (2)

W_1 and W_2 are weight loss of mild steel in the absence and presence of the inhibitor respectively. A is the surface area of the coupon in cm^2, T is the period of immersion in hours and $\Delta W = W_1 - W_2$. The degree of surface coverage (θ) was calculated from the equation below.

$\theta = (1 - W_2 / W_1)$ ………………..(3)

Results and Discussion

Phytochemical Screening of Emilia sonchifolia

Table 1 shows the results obtained from phytochemical analysis performed on *Emilia sonchifolia*. These compounds contain oxygen and nitrogen atoms which are the centre of adsorption. The ES extracts establish their inhibitive action through adsorption of phytochemical component molecules on the metal surface. The results of phytochemical screening is shown in Table I.

Table .1: Preliminary Phytochemical Screening of Emilia sonchifolia

S.NO	Compound	Emilia sonchifolia
1	Carbohydrates	+
2	Cardio glycosides	+
3	Saponins	+
4	Fats and oils	+
5	Terpenoids	-
6	Alkaloids	+
7	Steroids and Sterols	-
8	Tannins and Phenol compounds	+
9	Amino acids	+
10	Flavonoids	+
11	Quinones	+

+ = Presence, - = Absence

The results in Table 2 show that the corrosion rate ($gh^{-1}cm^{-2}$) for mild steel was lower in the presence of the extract compared to the blank (H_2SO_4). It is also seen that the corrosion rate increases with increase in temperature, and decreases as the concentration of the extract increases. The decrease in weight loss and corrosion rate of mild steel in the presence of these additives is evidence that the extract derived from ES actually inhibited the corrosion of mild steel in acidic environment. Inhibition efficiency presented in Table 2 was observed to increase with increase in concentration of extract. It is seen that inhibition efficiency of ES.

Table 2**:** Calculated values of CR ($gh^{-1}cm^{-2}$), for mild steel in 1.0 M H_2SO_4 in the absence and presence of ES extract at different concentrations and temperature.

CONCENTRATION (g/l)	**CR × 10^{-4} ($gh^{-1}cm^{-2}$)**		**IE%**	
	30^0C	60^0C	30^0C	60^0C
BLANK	8.62	14.30	-	-
0.1	4.31	10.30	50.00	21.16
0.2	3.23	8.72	62.50	38.87
0.3	2.49	7.70	71.14	46.02
0.4	2.31	7.06	73.18	50.55
0.5	2.18	6.66	74.77	53.30

extracts decreases with increase in temperature. Decrease in inhibition efficiency with increase in temperature is suggestive of physical adsorption mechanism (physisorption). The inhibitive effect of the extract could be attributed to the presence of some phytochemical constituents in the extract.

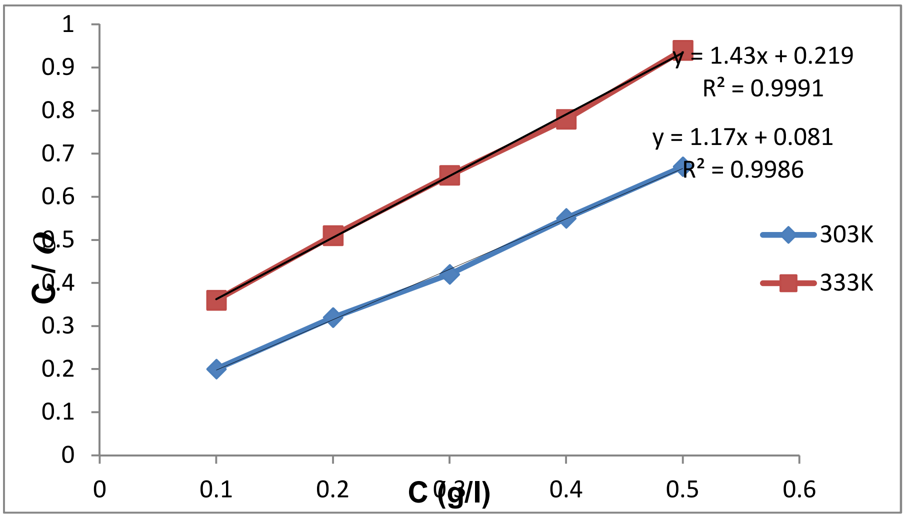

Fig. 1: Langmuir adsorption Isotherm plot of C/θ versus C for ES extract at 30°C and 60°C.

Though, the linearity of the Langmuir plot may be interpreted to suggest that the experimental data for ES obeys the Langmuir adsorption isotherm (Fig.1), the considerable deviation of the slope from unity shows that the isotherm cannot be strictly applied.

From Table 3, the obtained values of 1/y are greater than one showing that a given ES occupies more than one active site. It is also seen from the table that K_{ads} decreases with increase in temperature indicating that adsorption of ES extract on the mild steel surface was reduced at higher temperatures.

Table 3: Calculated parameters from Langmuir and El-Awady Adsorption Isotherm

Inhibitor temperature ^0C	Langmuir Isotherm				El- Awady Isotherm			
	K_{ADS}	$\Delta G^0_{ads} \times 10^3$ (kJ/mol)	SLOPE	R^2	K_{ads}	$\Delta G^0_{ads} \times 10^3$ (kJ/mol)	1/y	R^2
30^0C	12.346	-16.45	1.17	0.998	5.188	-14.27	1.43	0.984
60^0C	4.566	-15.32	1.43	0.999	1.879	-12.87	1.48	0.993

Table 4: Calculated values of activation energy (Ea) and heat of adsorption (Q_{ads}) for mild steel dissolution in 1.0M H_2SO_4 in the absence and presence of ES at 30 and 60^0C

CONCENTRATION (g/l)	Ea($kJmol^{-1}$)	Q_{ads}($kJmol^{-1}$) $\times 10^3$
BLANK	14.30	-
0.1	24.24	-9.02
0.2	27.24	-27.05
0.3	31.27	-29.62
0.4	31.27	-26.40
0.5	30.64	-27.69

The higher value of Ea in the presence of ES extract compared to that in its absence and the decrease of its IE% with temperature increase can be interpreted as an indication of physical adsorption.

From Table 4, it is evident that in all cases the values of Q_{ads} are negative and ranges from -9.02×10^3 kJ/mol to -27.69×10^3 kJ/mol. This implies that inhibitor adsorption efficiency decreases at high temperature, thus supporting the earlier proposed physisorption mechanism.

The negative values of ΔG^0_{ads} for ES as given in Table 3 ensure the spontaneity of adsorption process and stability of the adsorbed layer on the mild steel surface. Generally, the value of -20kJ/mol or lower is consistent with physisorption.

Conclusion

Emilia sonchifolia (ES) was found to be a good inhibitor of mild steel corrosion in acidic medium (1.0M H_2SO_4). It is readily available, less toxic and biodegradable. Weight loss method shows that Inhibition efficiency increased with an increase in ES extract concentration but decreased with rise in temperature. Adsorption of these compounds on mild steel was found to obey Langmuir adsorption isotherm and kinetic-thermodynamic model of El-Awady et al from the fit of experimental data. The presence of ES increased the corrosion activation energy. The free energy and heat of adsorption gave negatives values. The values obtained support the physical adsorption mechanism.

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REFERENCES

1. *E.E. Ebenso, P.C. Okafor, U. J. Ibok, U.J. Ekpe* and *A.I. Onuchukwu* (2004), The joint effect of Halide ions and methylene blue on the Corrosion inhibition of aluminum and mild steel in acid corrodent, *J. Chem. Soc. Nig. 29(2):* 15-25.
2. *S. Acharya* and *S.N. Opadhyay* (2004), The inhibition of corrosion of mild steel by some fluoroquinolones in sodium fluoroquinolones in sodium chloride solution, Trans Indian Inst. Met. 57(3): 297- 306.
3. *L. Bilgic,* and N. *Caliskan* (2001), An investigation of Schiff bases as corrosion inhibitors for austenite chromium-nickel steel in H_2SO_4, *J. of Appl. Electrochem. 31*: 79-83.
4. *H.E. El Ashry, E. Khamis* and *A.K. Ibrahim* (2000), Synergistic action of vinyl triphenylphosphonium bromide with various anions on corrosion of steel. *British corrosion, J. 35*: 150-164.
5. *Z. Quan, S. Chen, Y. Li,* and *X. Cui* (2002), Adsorption behavior of Schiff base and corrosion protection resulting film to copper substrate. Corrosion Sci. 44: 703-715.
6. *S.A. Umoren, E.E. Ebenso, P. C Okafor* and *U.J. Ekpe* (2006), Effect of halides on the corrosion inhibition of mild steel in acidic medum using polyvinyl alcohol. Pigment & Resin Technol. 35(5): 284-292.
7. *E.E. Ebenso* (2004), Effect of methyl red and halide ions on the corrosion of aluminum in H_2SO_4. Part 2, *Bull. Electrochem. 12*: 551-559.
8. *M. Ehteshanmzade, T. Shahradi* and *M.G. Hosseini* (2005), Inhibition of copper corrosion by self assembled films of new Schiff bases and their modification with alkanethiols in aqueous medium. Appl. Surf.Sci. 252: 2949-2959.
9. *H. Ashassi-sorkhabi* and *N. Ghalesaolz-Jeddi* (2005), Inhibition effect of polythene glycol on the corrosion of carbon steel in sulphuric acid. Mat. Chem. & Phys., pp 480-486.
10. Minhaj, P.A. Saini, M.A. Quraishi, and I.H. Farooqi (1999), "A study of natural compounds as corrosion inhibitors for industrial cooling systems", Corrosion Prevention and Control, UK, 46(2): 32-38.
11. *E.E. Oguzie, B.N. Okolue, E.E. Ebenso, G.N. Onuoha* and *A.I. Onuchukeu* (2004a), Evaluation of the inhibitory effect of methylene blue dye on the corrosion of aluminum in HCI. Mat. Chem. & Phy., pp 394-401.
12. *E.E. Oguzie, G.N. Onuoha* and *A.I. Onuchukwu* (2004b), Inhibition of corrosion of mild steel in hydrochloric acid medium by extract of Fruticans wurb fruits. *Proc. Of Chem. Soc. Of Nig. (Suppl. To the J. of the chem. soc. Of Nig)*, pp 62-66.
13. *E.E. Oguzie, B. N. Ogunkwe, B.N. Okolue, G.N. Onuoha* and *A.I. Onuchukwu* (2004c), Corrosion Inhibition of corrosion of mild Steel in Sulphuric acid solution by congo red dye. 1: influence of halides of ions. *Proc. Of Chem Soc. Of Nig.*, pp. 59-62.
14. *M. Abdallah* (2004a), Guar gum as corrosion inhibitor for corrosion of for carbon steel in sulphuric acid solutions. Portugaeliae Electrochima Acta, pp 161-175.
15. *M.A. Bendahou, M.B.E. Bendellah*, *B.B. Hammouti* (2006), A study of rosemary oil as a green corrosion inhibitor for steel in 2M H_2SO_4. Pigment and Resin Technol. 35: 95-100.
16. I. M. Iloamaeke, T. U. Onuegbu ,V.I.E. Ajiwe and U. C. Umeobika (2012a), Corrosion Inhibition Behaviour Of *Emilia Sonchifilia*Leaves Extract As A Green Corrosion Inhibitor For Mild Steel In Hydrochloric Acid Medium. *International Journal Of Basic And Applied Chemical Sciences*.2(2): 48-58.
17. I . M. Iloamaeke, T. U. Onuegbu, V. I. E. Ajiwe and U. C. Umeobika (2012b), *C*orrosion Inhibition Of Mild Steel By *Pterocarpus Soyauxi* Leaves Extract In Hcl Medium. International Journal of Plant, Animal and Environmental Sciences. 2(3):22-28.
18. T.U. Onuegbu , I.M. Iloamaeke , E.T. Umoh V.I.E. Ajiwe and N.L. Umedum (2012), Ethanol Extract of *Vitex Doniana* as a Green Corrosion Inhibitor for Mild Steel in Hydrochloric Acid Medium J. Chem. Chem. Eng. 6, 708-714.