Eupatorium Odoratus As Eco-Friendly Green Corrosion Inhibitor Of Mild Steel In Sulphuric Acid

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Abstract : - This work studies the use of *Eupatorium odoratum* (E.O) as corrosion inhibitor of mild steel in 1.0M H_2SO_4 acid. The effects of temperatures on the inhibition efficiency of *Eupatorium odoratum* were also tested at temperature of 30^0C and 60^0C respectively. The weight losses of the mild steel were taken for complete four days, for the two temperatures. The rates of corrosion of the mild steels were found to increase with increase in concentration of the acid and also decreases with increase in concentration of the *Eupatorium odoratum..* The *Eupatorium odoratum* gave an inhibition efficiency of 71% at the concentration of 0.5g/l, which shows that it is a good corrosion inhibitor of mild steel in acidic medium. This efficiency was found to decrease as the temperature increases and also the activation energy value calculated showed that the *Eupatorium odoratum* is physically adsorbed on the mild steel coupons.

Keywords: - *Eupatorium Odoratus,* Corrosion, Inhibitor, Mild Steel, Sulphuric Acid

INTRODUCTION

The continuous use of organic and inorganic inhibitors to secure metal against corrosion has come under severe criticism. Huge amounts of sulphuric acid are being used in the chemical industry for the removal of undesired scales and rust (Prabhu et al, 2008). Mild steel has been extensively used under different conditions in chemical and allied industries in handling alkaline, acid and salt solution. One way of protecting mild steel from corrosion is the use of organic inhibitors (Hosary et al, 1990). Most of these organic inhibitors are compounds with nitrogen, sulphur and oxygen, hetero-atoms having higher electron density, making them the reactions centres (Li et al, 2008). The exploration of natural products as corrosion inhibitor is becoming the subject of extensive investigation due to the low cost and eco-friendliness of these products and their biodegradability. This method is fast replacing the synthetic and expensive hazardous organic inhibitors (Arab and Noor, 1993). The yield of these compounds as well as their corrosion inhibition abilities varies widely depending on the part of the plant and its location (Okafor et al, (2008). The extracts from the leaves, seeds, heart wood, bark, root and fruit of plant have been reported to inhibit metallic corrosion in acid media. Researchers have reported the use of local plant such as Italian *Vernonia amygdalina* as corrosion inhibitor for Aluminum (Ali et al, (2008). In line with this *Nypa fruticans Wurmb,* has also been reported as an effective inhibitor for mild steel in hydrogen chloride medium (Saratha and Priya, (2007). Plant extracts used as corrosion inhibitor have recently been studied (Anuradha et al, 2008 and Ebenso 2003). The aim of this work is to study the effect of the leave extract of *Eeupatorium odoratum* on the corrosion rate of mild steel in 1.0M H_2SO_4 acid using weight loss measurements.

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EXPERIMENTAL

Materials

The reagents were bought from Head Bridge market Onitsha and the plants were collected from Awka, Anambra State. The experiments were performed at Biochemistry laboratory, Nnamdi Azikwe University, Awka, Anambra State. The mild steel was obtained from a local welder in Eke Awka Main Market, Awka.

Methods:

1. Preparation of mild steel

The sheet of mild steel obtained locally was cut into rectangular shapes of dimension 4 by 3 by 0.11 cm. This experiment was performed using a cold mild steel coupon. The coupons (shaped mild steel) were mechanically polished; a hole was drilled at one end for free suspension and was numbered. The specimens were degreased by washing with 99% ethanol, rinsed in double distilled water and were dried using acetone. The dried coupons were stored in calcium chloride moisture free desiccators before the corrosion studies to avoid contamination.

2. Preparation of the Plant Extract

The fresh green leaves of *Eupatorium odoratum* were collected locally, washed thoroughly with distilled water and air dried for five days. The dried leaves were pulverized using manual grinding machine. About 500g of the dried sample was soaked in 99% ethanol in 1000ml round bottom flask and sufficient quantity of the ethanol was added to cover the powder completely. The flask was covered left in a cool dried cupboard for 48hrs. The content of the flask was filtered using a filter paper. The filtrate were concentrated using a water bath at a temperature of 70^0C to vaporize the ethanol content of the filtrate. The concentrate were used to prepare the different concentrations of the plant extract needed (0.1, 0.2, 0.3, 0.4, 0.5g/l) with distilled water. These concentrations were kept in air tight plastic containers to avoid contamination.

3. Weight loss method (gravimetric method)

The samples of the coupons were first weighed using a digital weighing balance, ADAM model AFP-800L least count of 0.01g labeled and suspended in the test solution with help of nylon thread. The coupons were suspended in different concentrations of the acid with and without the plant extract for 96hrs (4days). This experiment was carried out at two different temperatures (30^0C and 60^0C). The coupons were retrieved every 24hrs, washed in 20%NaOH in 100g/l zinc dust to stop the corrosion reaction and dried using acetone before reweighing it. The reweighing is done to determine the weight loss of the coupons (Orabite, and Oforka 2004). From the weight loss data, the corrosion rates (CR), corrosion efficiency, and adsorption parameters were calculated using the formula:

$$CR = \frac{Wl}{At}$$

Where CR is the corrosion rate (mg cm^{-2} hr^{-1}) and Wl is the weight loss (mg), A is the total surface area (cm^2) and t is time(hr). From the corrosion rate, the surface coverage (X) as a result of adsorption of the inhibitor molecules, and inhibition efficiencies of the molecules (X%) were calculated using the following equations(Raja, 2008).

$$X = \frac{CR(blank) - CR(inhibitor)}{CR(blank)}$$

$$X\% = \left(\frac{CR(blank) - CR(inhibitor)}{CR(blank)}\right) x100$$

where CR (blank) and CR (inhibitor) are the corrosion rate in the absence and presence of the inhibiting material.

RESULTS AND DISCUSSION

Weight loss measurement: Tables 1&2 show the effect of the inhibitor(plant extract) on the weight loss of the mild steel for the complete four days (96hrs) at different concentrations of the plant extract (PE) measured in gram per litre (g/l). These values were compared with the blank (without inhibitor) at 1.0M of the H_2SO_4

Table 1: Effect of the plant extract (PE) on the weight loss of the Mild Steel at 30^0C

Concentration (g/l) of PE / Time (day)	0.00 (blank)	0.10	0.20	0.30	0.40	0.50	
1	0.19	0.18	0.17	0.14	0.11	0.08	Weight loss(gram)
2	0.23	0.21	0.19	0.15	0.13	0.10	
3	0.27	0.23	0.21	0.18	0.14	0.12	
4	0.30	0.24	0.23	0.19	0.14	0.13	

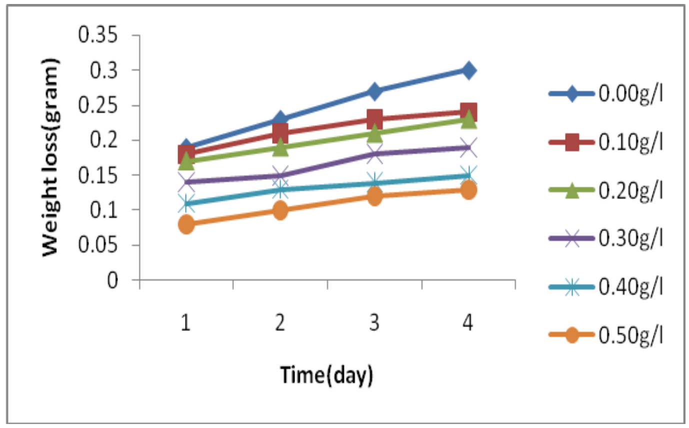

Fig. 1: Weight loss against time for the different concentrations of the PE in 1.0M H_2SO_4 at 30^0C

Table 2: Effect of plant extract (PE) on the weight loss of the Mild Steel at 60^0C

Concentration (g/l) of PE / Time (day)	0.00	0.10	0.20	0.30	0.40	0.50	
1	0.22	0.20	0.16	0.15	0.12	0.11	Weight loss(gram)
2	0.28	0.22	0.18	0.17	0.13	0.12	
3	0.31	0.23	0.19	0.18	0.16	0.12	
4	0.33	0.25	0.21	0.20	0.17	0.14	

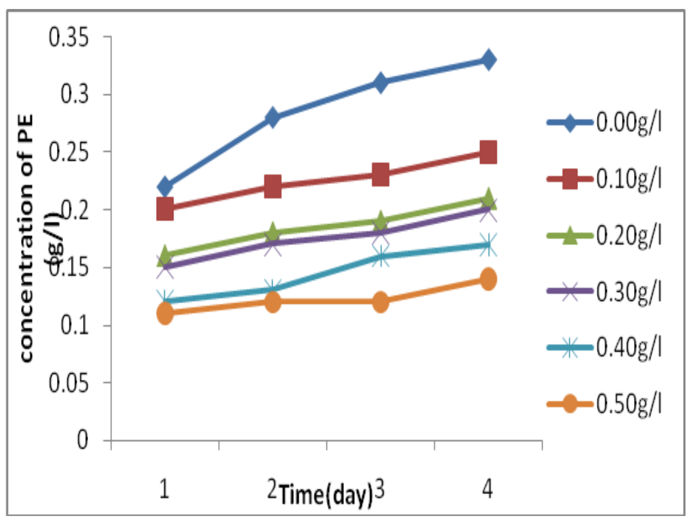

Fig. 2: Weight loss against time for the different concentrations of the PE in 1.0M 0f H_2SO_4 at 60^0C

From the graph it can be seen that the rate of corrosion or the loss in weight of the mild steel decreases with increase in the concentration of the plant extracts. The highest weight loss was recorded without the inhibitor (0.00g/l). At a point between 0.10g/l and 0.20g/l in the graph, it was observed that the weight loss is almost the same on the fourth day. This is due to the low concentration of the extract at the two concentrations so the difference is not much. The weight loss at 60^{0}C was found to be greater than those at 30^{0}C. This shows that the inhibitor's strength decreases with increase in temperature of the system. The gap between the blank and the inhibited sample shows that the plant extracts (PE) is inhibiting the corrosion of mild steel since it was able to reduce the weight loss on first day.

The corrosion rate of the system

The corrosion rate (CR) can thus be defined as the rate of corrosion of the metal per unit time Raja, 2008). Table 3&4 show the calculated CR of the mild steel (of cross sectional area 25.54cm^2) in solution of 1.0M H_2SO_4 with different concentrations of the PE at the two temperatures (30°C and 60°C)

Table 3: The effect of concentration of PE on the corrosion rate of the Mild Steel at 30^{0}C

Day (hr)	1	2	3	4	Concentration of the PE(g/l)
Corrosion rate (mg cm^2 hr^{-1})	0.30	0.19	0.15	0.12	Blank
	0.29	0.17	0.13	0.10	0.10
	0.28	0.16	0.12	0.09	0.20
	0.23	0.12	0.09	0.07	0.30
	0.18	0.11	0.07	0.05	0.40
	0.13	0.08	0.06	0.04	0.50

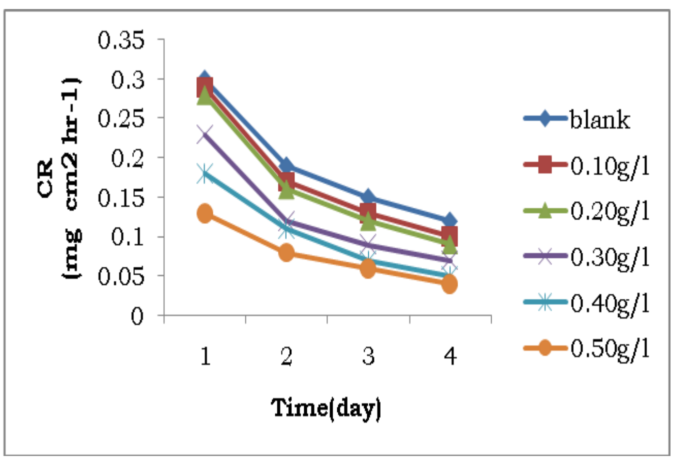

Fig.3: corrosion rate (CR) against time for different concentrations of the plant extract at 30^{0}C

Table 4: The effect of concentration of the plant extracts (PE) on the corrosion rate of the Mild Steel at 60^{0}C

Days (hr)	1	2	3	4	Concentration of the PE(g/l)
Corrosion rate (mg cm-2 hr^{-1})	0.36	0.23	0.17	0.14	Blank
	0.33	0.18	0.13	0.10	0.10
	0.26	0.15	0.10	0.08	0.20
	0.25	0.14	0.09	0.07	0.30
	0.20	0.11	0.08	0.06	0.40
	0.18	0.10	0.07	0.05	0.50

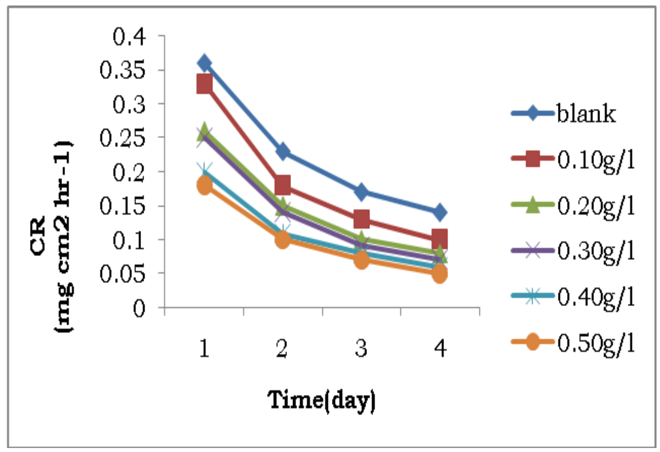

Fig. 4: Corrosion rate (CR) against time for the different concentrations of the PE at 60^{0}C

Fig. 3 & 4 shows the decrease in corrosion rate due to increase in the concentration of the plant extract. This can be attributed to the increase in the amount of PE adsorbed on the metal surface, thus reducing the available sites for the acid attack (Olusegun et al, 2004). It will also be discovered that the corrosion rate decreases with time. This is because the acid's main reacting agent (hydrogen ion) is being evolved without replacement thus leaving the reaction system insufficient of the major component of the reaction. This reduces the rate of the oxidation of the mild steel, thus increases the efficiency of the plant extract to inhibit its corrosion.

Determination of Inhibition efficiency and surface coverage by weight loss method

Graph of inhibitor efficiency against concentration of the extract for the two temperatures are shown in Fig.5&6.

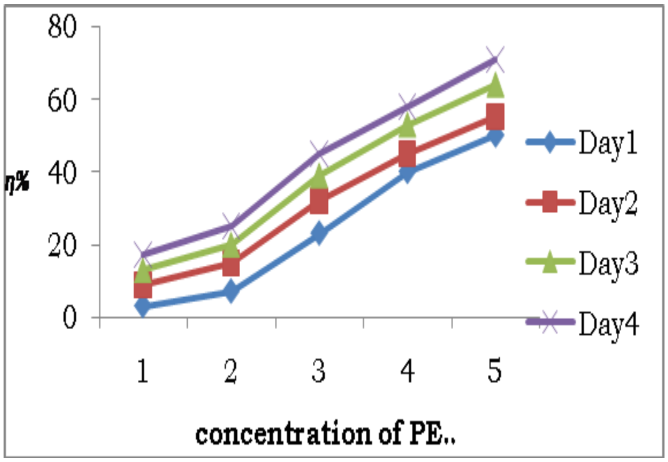

Fig.5: Inhibition efficiency against the concentration of the PE at 30^{0}C for the different days.

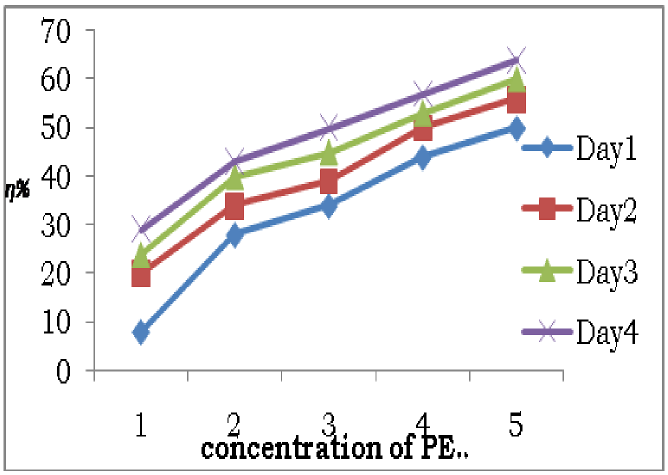

Fig.6: Inhibition efficiency against the concentration of the PE at 60^{0}C for the different days.

From Fig.5&6 we can see that the maximum inhibition efficiency recorded was 71% and 67% for 30^{0}C and 60^{0}C respectively. The inhibition efficiency was observed to increase with increase in the concentration of the plant extract but also decreases with increase in temperature of the system. The rate of inhibition efficiency is appreciable at lower concentration than at higher concentration. The maximum inhibition efficiency 71% recorded was due to the adsorption of the plant constituents on the mild steel. It is revealed that the phytoconstituents in the PE is found to be big molecules which are able to cover a large surface area on adsorption (Minhaj et al, 1994). A similar conclusion has been reached by researchers (Rajendran et al, 2005) who studied the inhibitive effect of thiosemicarbozides on the corrosion of mild steel in phosphoric acid. It can also be seen from Fig.7&8 that the percentage inhibition efficiency of the PE was reduced with increase in the temperature of the system. This suggests that mechanism of adsorption of the PE on the surface of the mild steel is a physical adsorption (Gunase and Chanhan 2004). From the efficiency value we can firmly say that *Eupatorium odoratum* is a good corrosion inhibitor for mild steel in acidic medium since at a concentration of 0.5g/l it was able to give 71% inhibition efficiency.

Langmuir Isotherm

Using the expression: $C/_{\Theta} = 1/_{K} + C$

C=concentration of inhibitor; Ѳ = surface coverage

A linear plot was obtained for the two temperatures when $C/_{\Theta}$ was plotted against C as shown below:

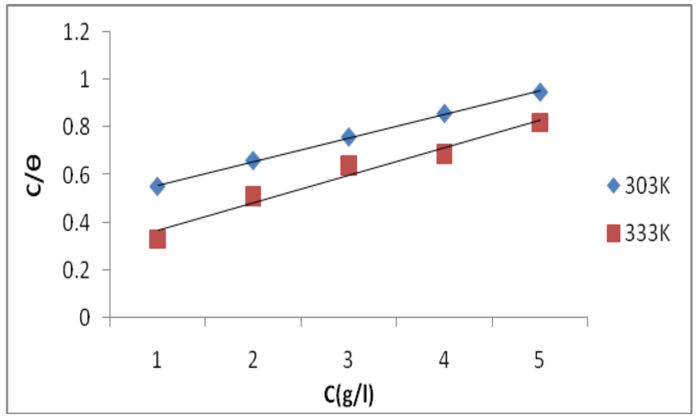

Fig.7: Graph Of C/Ѳ Against The Concentration(C) Of the PE at 60^{0}C & 30^{0}C (333k & 303k)

The ability to fit the Langmuir isotherm graph shows that the plant is physically adsorbed on the mild steel coupon (Chaieb et al, 2004). It can also be observed that it fitted more for 303K than 333K. This shows that it is a better inhibitor at low temperature than at higher temperature this also shows that the plant is physically adsorbed (Rajendran et al, 2005).

Conclusion

The results presented in this paper shows that the extract from the leaves of *Eupatorium odoratum* inhibits the corrosion of mild steel in H_2SO_4 solution to a reasonable extent. The inhibition efficiencies of the plant extracts were found to increase with increase in the concentration of the plant extract and decreases with increase in temperature of the system. The increase in inhibitors efficiency with decrease temperature and ability to fit Langmuir isotherm show that the plant is physically adsorbed on the mild steel coupon. Therefore, the plant extract can be considered as a source of relatively cheap, eco-friendly and effective green corrosion inhibitor in acid medium.

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