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Corrosion inhibition using flower extracts in mild steel

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Abstract:

Metals play an important role in every part of our life. Corrosion is a major problem and it is inevitable. Developing an inhibitor is an important aspect of research. This method of corrosion prevention is an easiest method. Green inhibitors are chosen in this study. The corrosion rate and inhibition efficiency were calculated from weight loss measurements. The corrosion rate at higher temperatures was also measured. Langmuir &Tempkin adsorption parameter for the adsorption of the Flower extract on Mild steel in sea water were also plotted.The electrochemical impedance measurements are carried out using CHI Electrochemical workstation.Potentiodynamic polarization studies revealed thattheextract compounds suppresses both cathodic and anodic corrosion. Fourier-transform infrared spectroscopy was recorded to identify the nature of substituents.

Keywords :*Corrosion, Corrosion inhibitors, mild steel*

Introduction:

The stable form of a metal gets affected by corrosion is a spontaneous process. Various compounds were under research to reduce corrosion were reported during past two decades [1-4]. The inhibitive effect of various plant extracts was reported in the literature survey. The inhibitive action was reported for eucalyptus leaf [5], lupine extract [6], Zenthoxylumalatum [7], Stevia rebaudiana [8],and various plant extracts [9-13] have been reported. The adsorption of natural corrosion inhibitors on metal surfaces is influenced by a number of factors including nature of metal, testing media, chemical structure of inhibitor, nature of substituents present in the inhibitor, presence of additives, solution temperature and solution concentration. The most effective inhibitors are organic compounds.

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Materials and Methods:

Inhibitors used:

The inhibitors chosen for this study are the flowers of *Cocos nucifera* and *Bougain villea*. The flowers were separated from the plant. The separated flowers were shade dried, without exposing the material to sunlight. After drying, it was powdered in a mixer and the fine powder was collected.

Preparation of extract:

The powdered flower sample was weighed and 15 gram of the sample was added to the RB flask fitted with the condenser containing sea water. It was boiled in the hot water bath at 100^{o}C for 1 hour. The extract was obtained by filtering the sample. The filtered sample was used to prepare various concentrations of inhibitors by diluting 5, 10, 15, 20 and 40 mL in 100 mL SMF.

Weight Loss Measurements:

Mild steel specimens of size 2.5 x 5 cm, with a small hole of about 1 cm diameter near its upper edge were used for weight loss studies. The sample were abraded using emery papers of 1/0, 2/0, 3/0, 4/0 grade, washed with distilled water and acetone and finally dried at room temperature in order to obtain reproducible results.

The initial weight of each specimen was noted before immersion using an analytical balance. Then the specimens were immersed in 100 mL of sea water solution without and with a known concentration of the inhibitor for a period of time. After that, the mild steel specimens were taken out and then washed under running tap water using a brush to remove corrosion products, rinsed with distilled water, dried and reweighed. The experiments were done in triplicate to ensure reproducibility. The mean values of weight loss were calculated.From the weight loss measurements, the corrosion rate and inhibition efficiency was calculated.

Effect of concentration:

Under various concentration of the inhibitor, the corrosion rate was calculated using weight loss measurements. Table1 and 4 shows the effect of concentration of sea water on corrosion rate of mild steel at 303K at 333K respectively.

Table 2 depicts the effect of *Cocos nucifera* extract in sea water at 303 K. The increase in the inhibitor concentration was accompanied by a decrease in the weight loss and an increase in percentage inhibition efficiency. Also, the effect of *Bougain villea* extract in sea water at 303K was represented in table 3.These results lead to the conclusion that, the inhibitors under investigation are fairly efficient inhibitors for mild steel dissolution in sea water solution.

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Table 1.Effect of concentration of sea water on corrosion rate of Mild steel at 303 K

Medium used	Weight Loss (g)	Corrosion rate (g/cm^2)
Sea water	0.0355	0.0316

Table 2.Effect of Cocosnucifera Extract in sea water at 303 K

Concentration of inhibitors (ppm)	R_{corr} g/cm^2	I.E %	θ
5	0.0256	1.4997	0.0149
10	0.0235	1.4412	0.0144
20	0.0168	1.0027	0.0100
30	0.0166	1.0347	0.0103
40	0.0150	0.8600	0.0086

Table 3: Effect of Bougainvillea Extract in sea water at 303 K

Concentration of inhibitors (ppm)	R_{corr} g/cm^2	I.E %	θ
5	0.0258	1.3621	0.0136
10	0.0228	1.3153	0.0131
20	0.0175	1.0362	0.0103
30	0.0166	0.9597	0.0095
40	0.0106	0.6422	0.0064

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Table 4.Effect of Concentration of Sea water on corrosion rate ofMild steel at 333k

Medium used	Weight Loss (g)	Corrosion Rate (g/cm^2)
Sea water	0.0439	0.0391

Effect of Temperature:

The corrosion rate for the inhibitors was calculated at higher temperature by weight loss methods. The results obtained from the temperature studies revealed that in increase in temperature increases the corrosion rate and decrease the inhibition efficiency at 303K. At higher temperature (333 K), the inhibition efficiency decreases. Table 5 illustrates the effect of *Cocos nucifera* extract in sea water at 333K. Table 6 demonstrates the effect of *Bougain villea* extract in sea water at 333K. The decrease in inhibition efficiency with rise in temperature suggests that, there is a possibility of desorption of some of the adsorbed inhibitor from the metal surface at high temperature. This suggests that the mechanism of adsorption of the inhibitor may be mainly due to physisorption, which is due to weak van der waal's forces, disappears at elevated temperatures. The decrease in inhibition efficiency with increase in temperature suggested the physical adsorption mechanism.

Table 5.Effect of Cocosnucifera Extract in sea water at 333 K

Concentration of inhibitors (ppm)	R_{corr} g/cm^2	I.E%	θ
5	0.0417	2.6703	0.0267
10	0.0401	2.5423	0.0254
20	0.0378	2.2314	0.0223
30	0.0292	1.7557	0.0175
40	0.0239	1.4616	0.0146

Table 6: Effect of Bougainvillea Extract in sea water at 333 K

Concentration of inhibitors (ppm)	R_{corr} g/cm^2	I.E %	θ
5	0.0337	1.8379	0.0183

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10	0.0249	1.4457	0.0144
20	0.0242	1.4162	0.0141
30	0.0167	1.0211	0.0102
40	0.0130	0.7605	0.0076

Adsorption isotherm

Langmuir and Tempkin adsorption isotherms have been tested to determine the nature of adsorption. The value of $\Delta G^o$is found to be negative which shows the spontaneous adsorption process. Figure 1 shows the adsorption isotherms for *Cocos nucifera*. Adsorption isotherms for *Bougain villea* extract was represented in Figure2.

Figure1. Adsorption isotherm for Cocosnucifera

a. **Langmuir isotherm for the adsorption of Cocosnucifera extract on Mild steel in sea water at 303 K**

b. **Tempkin isotherm for the adsorption of Cocosnucifera extract on Mild steel in sea water at 303 K**

c. **Langmuir isotherm for the adsorption of Cocosnucifera extract on Mild steel in sea water at 333 K**

d. **Tempkin isotherm for the adsorption of Cocosnucifera extract on Mild steel in sea water at 333**

e. **K**

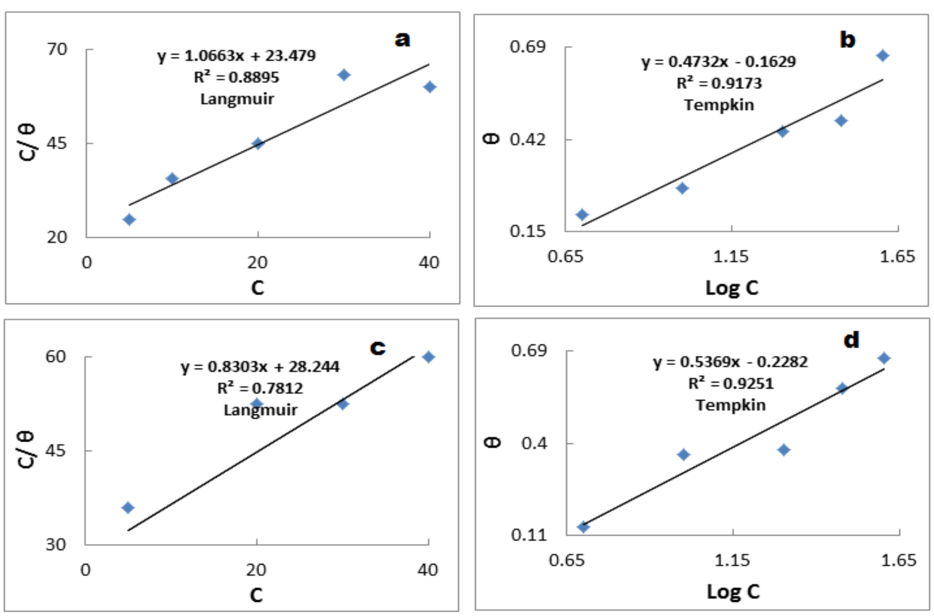

Figure 2.Adsorption isotherm for Bougainvillea

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a. Langmuir isotherm for the adsorption of Bougainvillea extract on Mild steel in sea water at 303 K

b. Tempkin isotherm for the adsorption of Bougainvillea extract on Mild steel in sea water at 303 K

c. Langmuir isotherm for the adsorption of Bougainvillea extract on Mild steel in sea water at 333 K

d. Tempkin isotherm for the adsorption of Bougainvillea extract on Mild steel in sea water at 333 K

Electrochemical impedance measurements

The same type of mild steel specimens and the cell steps used in the electrochemical polarization studies were used for measuring the impedance parameters. The impedance were collected at the open circuit corrosion potential.

The electrochemical impedance measurements are carried out using CHI electrochemical workstation. Depending on the concentration of the additives, values of the steady state E_{corr} were attained in 10-15 min.

To ensure the stability of E_{corr}, the working electrode was maintained at its corrosion potential for further 5 minutes in sea water solution.The impedance diagrams are given by Tafel plot representation. The double layer capacitance (C_{dl}) values were computed from the Tafel plot and the R_{ct} values. C_{dl} values are used to study about the corrosion efficiency. The values obtained for the flower extracts are 0.0009452, 0.0003006. Figure 3 and 4 shows the bode plot for *Cocos nucifera* and *Bougain villea* respectively.

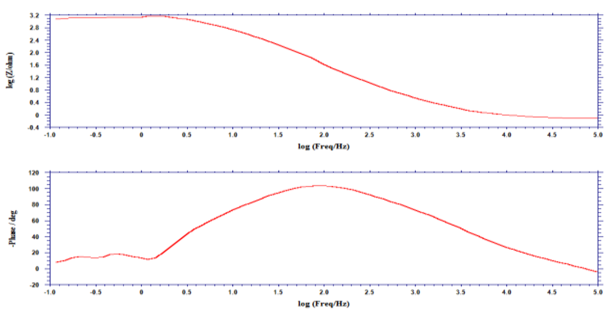

Figure 3.Bode plot for Cocosnucifera

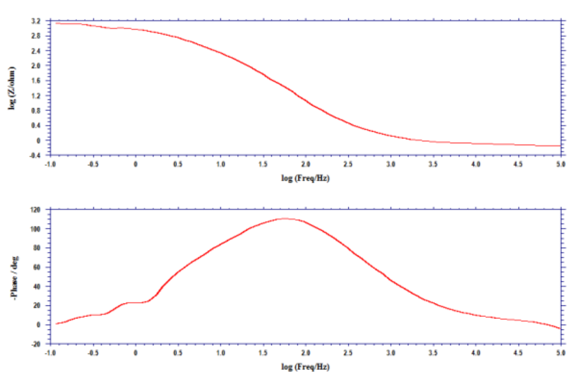

Figure 4.Bode plot for Bougainvillea

Potentiodynamic polarization study :

The anodic and cathodic current potential curves were extrapolated up to their intersection at the point where corrosion current density (I_{corr}) and corrosion potential (E_{corr}) were obtained.

The presence of inhibitor causes a marked decrease in corrosion rate, shifts the anodic curves to more positive potentials. This may be ascribed to the adsorption of inhibitor over the surface. The tafel plot for sea water was illustrated in Figure 5.

The Tafel plot of *Cocos nucifera* shows an anodic corrosion which is very small was represented in Figure 6. In Bougain *villea* shift in anodic potential is high which was shown in Figure 7. This result implies that the flower extract compounds suppresses both cathodic and anodic corrosion depending upon their nature and thereby inhibiting corrosion.

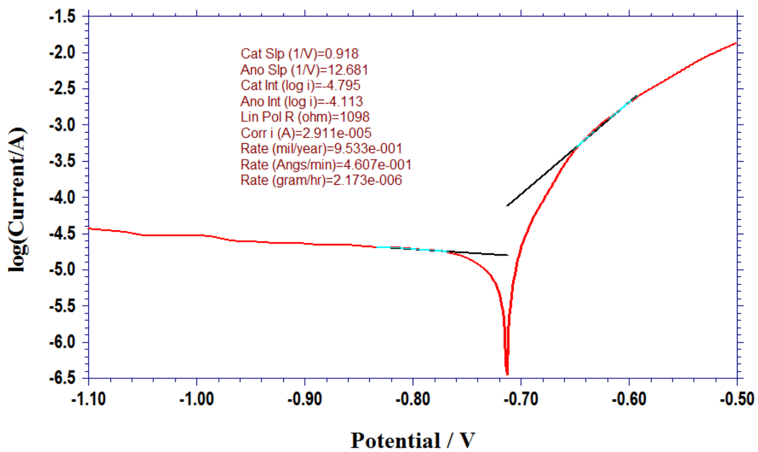

Figure 5.Tafel plot for Sea water

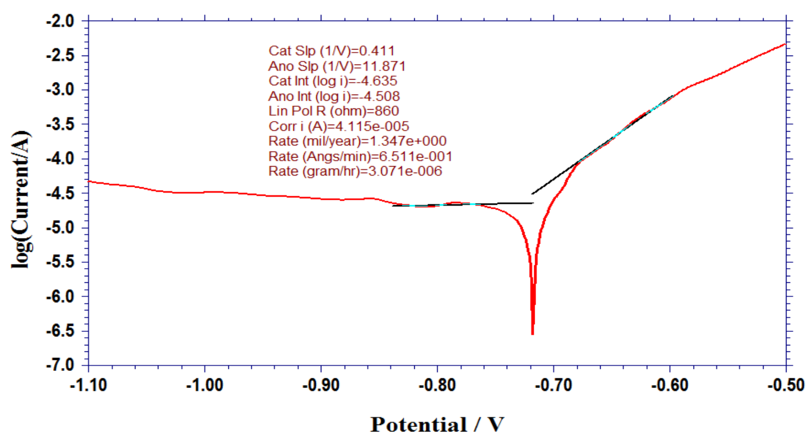

Figure 6.Tafel plot for Cocosnucifera

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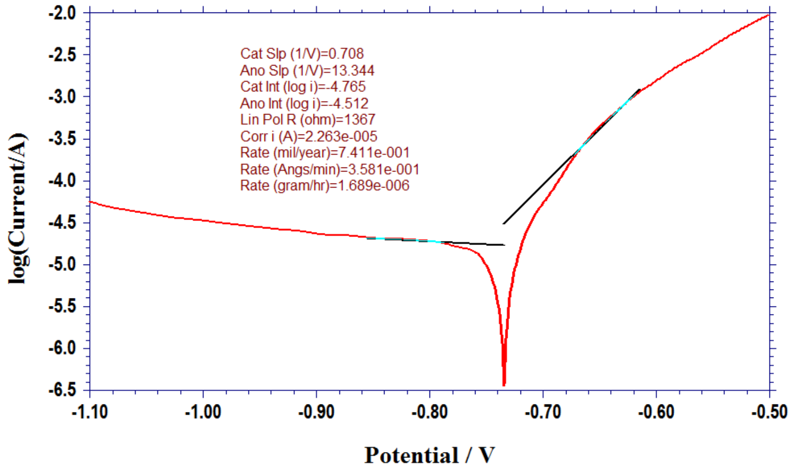

Figure 7.Tafel plot for Bougainvillea

Fourier-transform infrared spectroscopy

The FTIR Analysis method uses infrared light to scan test samples and observe chemical properties.The Peaks observed for the flower extracts show the presence of C-H, Alkynes and C=O group. Figure 8 shows the FTIR results of Cocos nucifera. FTIR results of Bougain villea was depicted in Figure 9.

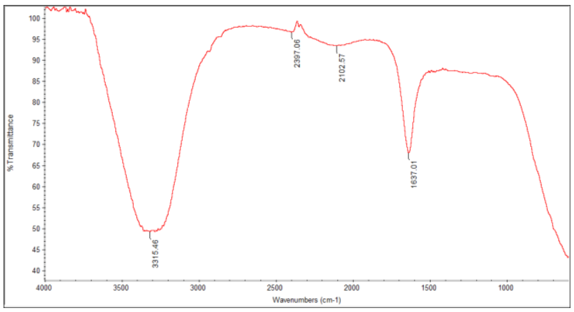

Fig 8. FTIR Spectrum for Cocosnucifera

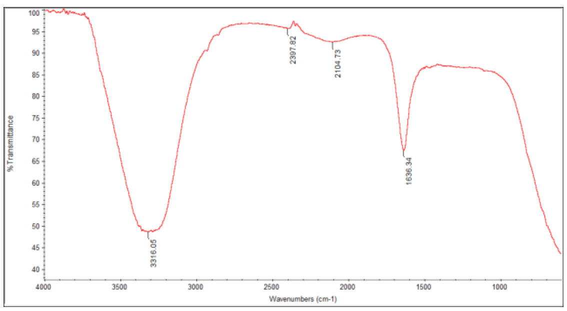

Fig 9. FTIR Spectrum for Bougainvillea

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Conclusion:

The effectiveness of the plant extract was evaluated using weight loss measurements. The highest efficiency was observed at 40 ppm in sea water.The corrosion inhibition decreases with increase in temperature due to the fact that the inhibitor adsorption on metal surface is physisorption.The corrosion inhibition process follows Langmuir and Tempkin isotherm which suggest that one molecule of the inhibitor occupying one active site.All the inhibitors are of low cost, non-toxic and ecofriendly as well as having good inhibition efficiency.From the impedance polarization, C_{dl} values it is concluded that all the flower extracts are very good corrosion inhibitors for mild steel. From the tafel plot, the electrochemical nature of corrosion inhibition is examined.The current investigation shows that the choosen inhibitors are very effective in inhibiting corrosion of mild steel in sea water.

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