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Anti-corrosive effect of Lantana camara fruit peel on mild steel in acid medium

KEYWORDS: Mild steel, Corrosion, Lantana camara fruit peel, Polarisation, EIS

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ABSTRACT *The inhibition efficacy of Lantana camara fruit peel (LCFP) extract on the corrosion of mild steel in 1.0N Hydrochloric acid is carried out by potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) measurements. The inhibition efficiency is increased with increase of inhibitor concentration and achieved maximum inhibition efficiency of 85% for both polarization as well as impedance studies. The observed value shows that the corrosion current moderately decreased with increase of inhibitor concentration by polarisation studies. The parameters of electrochemical impedance studies also agreed and confirmed with the above results.*

1.Introduction

Mild steel and its alloy have wide applications and hence are used in many environments because of their excellent corrosion resistance, which is coupled with combination of other desirable properties, such as superior electrical and thermal conductivity, ease of fabricating and joining, wide range of attainable mechanical properties and resistance to bio fouling. It is widely used for all kinds of field work in world viz used in industries, acid cleaning, pickling, fabrication of various reaction vessels such as cooling tower tanks, pipelines automobiles, engineering, submarine, nuts, screws, bolts etc. However this metal suffers from severe corrosion when it comes in contact with acid solutions during acid cleaning, transportation of acid, de-scaling, storage of acids and other chemical processes. In order to overcome this problem, the use of inhibitor is one of the best methods to protect the metal against corrosion. [1]. Recently many researchers have used green plant leaves, flowers and fruit extract as corrosion inhibitor for metal and its alloy in various environment *Prunus cerasus* [2], *Uncaria gambir* [3], *Raphia hookeri* [4], Black Pepper [5], *Lebbeck* Seed [6], *Eugenia Jambolana* seed [7], *Cassia alata* leaves[8] *Jatropha curcas* [9], *Pyrus pyrifolia* fruit peel[10]. The present investigation deals with the study of the dissolution and the inhibitive efficiency of mild steel in 1.0N Hydrochloric acid environment by electrochemical method using *Lantana camara* fruit peelat various exposure time and temperature.

2. Materials and method

2.1. Chemical properties of Lantana camara fruit extract

Lantana camara is a species of *flowering plant* in the *verbena* family, *Verbenaceae*. The common names are large leaf lantana, wild sage, red sage, yellow sage, white sage, and shrub verbena [11]. The fruit has anti-*ulcer* activity in rats in laboratory studies [12]. Phytochemical analysis of *Lantana camara* reported that the presence of saponin, steroids, alkaloids, tannins, polyphenols, terpenoids and flavonoids [13].

2.2. Specimen preparation

2.2.1. Potentiodynamic polarisation studies

The electrodes of 1 cm^2 area with stem were cut from the respective metal sheets and one side of the electrode and stem was masked with araldite. The electrodes were polished with emery papers and degreased with trichloroethylene. Accurately 100 ml of the test solution was taken in three-electrode cell. The electrode was introduced into the test solutions in the polarisation cell and it was allowed to attain a steady potential value for about 20minutes. Then the electrode potential was fixed at ±200 mV to the open circuit potential (OCP). Polarisation measurements were carried out potentio-dynamically at a sweep rate of 1mV/sec using electrochemical analyser Princeton applied research Model: PARSTAT 2273 (Advanced electrochemical system) The potential of the working electrode was measured with respect to a saturated calomel electrode (SCE) and the platinum electrode was used as an auxillary electrode. The corrosion current (I_{corr}) as well as b_a and b_c values were obtained from the polarisation curves by extrapolation of anodic and cathodic curves back to the corrosion potential. The corrosion potential (E_{corr}) value taken as mV and I_{corr} values A/cm^2 was taken and all the experiments were carried out at room temperature. The experiments were performed with and without the addition of inhibitor.

2.2.2. Electrochemical impedance spectroscopy measurement

The well-polished electrode was introduced into 100 ml of test solution and allowed to attain a steady state potentialvalue. A.C. signal of amplitude 10 mV was impressed to thesystem with frequencies ranging from 100 mHz to 10 kHz using electrochemical analyser Princeton applied researchModel: PARSTAT 2273 (Advanced electrochemical system).

3. Results and discussion

3.1. Polarisation studies

The Fig.1 shows that the potentiodynamic polarisation behaviour of mild steel in 1.0N Hydrochloric acid containing different concentration of LCFP inhibitor and the observed values are placed in the Table- 1. It was clear that the I_{corr} decreased from 3828 to 571 mA/cm^2 with increase of inhibitor concentration (from 0 to 500ppm) and the corrosion potential (E_{corr}) was shifted to negative direction from -507 to -484mV. Thus this inhibitor behaved as mixed type. The inhibition efficiency calculated from the extrapolation of the anodic (b_a) and cathodic (b_c) Tafel slopes were in good agreement with those observed from the previous studies (mass loss).

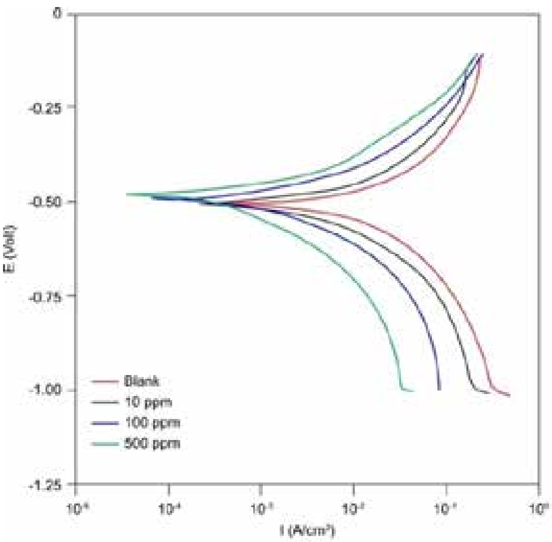


Fig. 1 Polarisation curves for mild steel in 1.0N Hydrochloric acid containing various concentration of LCFP inhibitor.

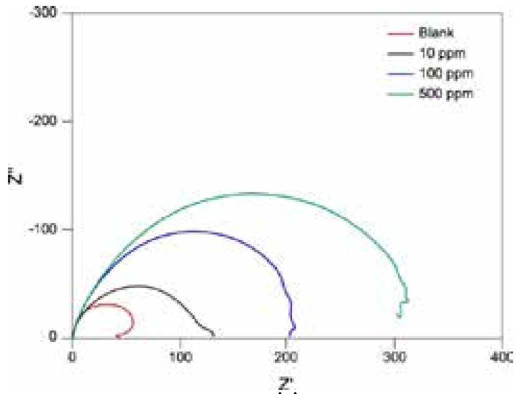
3.2. Electrochemical impedance (EIS) studies

Fig.2 (a-c) shows that typical set of complex plane plots of mild steel in 1.0N Hydrochloric acid in the absence and presence of various concentration of LCFP inhibitor at room temperature. It was obvious that the addition of inhibitor results in an increase of the diameter of the semicircle capacitive loop (Fig.2(a)), increase the double layer capacitance (Cdl) (Fig. 2(b)) and the maximum phase angle (Fig.2(c)). Careful inspection of this data revealed that the value of charge transfer resistance (Rct) increased from 84.15 to 303.77Ω of mild steel in acid with increase of inhibitor concentrations. The inhibition efficiency increased from 59.97 to 83.49% with increase of inhibitor concentration. It ensures that the formation of protective film on the metal surface. The double layer capacitance (Cdl) decreased as the increase of inhibitor concentration may be due to the adsorption of the active compounds on the metal surface leading to a film formation. It can be noticed, that the perfect semi-circles clearly indicates that the charge transfer process may controlling the dissolution of the metal. This data was also fitted with the values obtained from the mass loss data as described earlier.

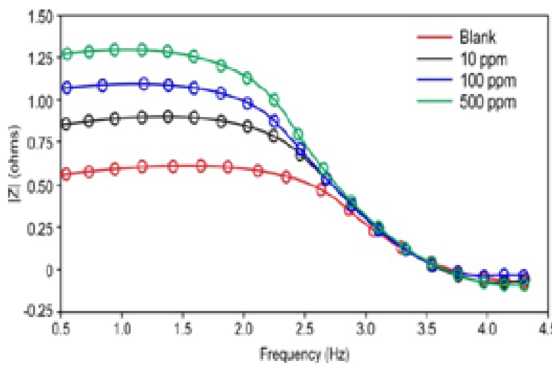
Table- 1 Parameters derived from electrochemical measurements of mild steel in 1.0N Hydrochloric acid containing various concentration of LCFP inhibitor.

	Polarisation studies					Impedance studies		
Conc. (ppm)	$-E_{corr}$ V/dec	b_a (mV/decade)	b_c (mV/decade)	I_{corr} mA cm^{-2}	I.E (%)	R_{ct} (Ω cm^2)	C_{dl} x10^{-4} Fcm^2	I.E (%)
Blank	507	182.48	121.11	3828	---	50.14	1.456	---
10	498	151.30	110.71	1242	67.55	125.28	0.612	59.97
100	491	146.24	95.04	1056	72.41	208.53	0.424	75.95
500	484	144.63	89.69	571	85.08	303.77	0.287	83.49

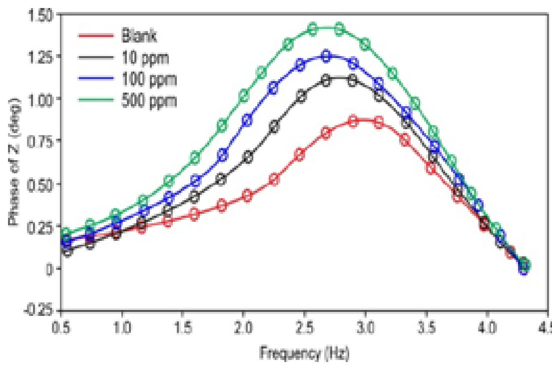
The Bode plots (Fig.2(b)) reflected that the value of charge transfer resistance (R_{ct}) increased with increase of inhibitor concentration and suggested that the protective film formed on the metal surface was more stable. Since it was able to withstand the attack of aggressive corrosive environment. In Bode phase plots (Fig.2(c)) the phase angle at higher frequencies attributed to anticorrosion performance. The depression of phase angle at relaxation frequency with the decrease in the inhibitor concentration indicates that the decrease of capacitive response with the decrease of inhibitor concentration. Such a phenomenon reflects that the higher corrosion activity at low concentrations of the inhibitor.



(a)



(b)



(c)

Fig.2(a-c). Electrochemical impedance plots, (a) Nyquist, (b) Bode impedance plot, (c) phase angle plot for mild steel in 1.0N Hydrochloric acid containing various concentration of LCFP inhibitor.

4. Conclusion

From our present study the following conclusions can be drawn.

The *Lantana camara* fruit peel (LCFP) is used as good inhibitor for mild steel in 1.0N Hydrochloric acid environment. The observed values clearly indicates that the adherent film formed on the surface of mild steel in acid media and achieved more than 85% inhibition efficiency. The corrosion potential shifted to passive direction in-

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dicates that the inhibitor was mixed type and the inhibitor was effective in controlling the dissolution rate of mild steel. The electrochemical impedance studies also revealed that the value of R_{ct} increased from 50.14 to 303.77Ω and maximum of 83.49% of inhibition efficiency was attained in the presence of inhibitor. Bode phase plot may suggests that the increasing concentration of inhibitor in acid solution results in more values of phase angle at high frequencies, indicating that there was greater surface coverage and charge transfer resistance.

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