Journal of Advanced Scientific Research

Available online through http://www.sciensage.info/jasr

ISSN
0976-9595
Research Article

STUDY OF CARBON STEEL CORROSION IN 1.0N HCL MEDIUM BY *MIMUSOPS ELENGI* LEAVES EXTRACT BY ELECTRO CHEMICAL STUDIES

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ABSTRACT

The inhibitive effect of Mimusops Elengi Leaves extract on Carbon steel corrosion in 1.0 N HCl solution was studied using electro chemical techniques. Observed result indicates that the corrosion inhibition efficiency was increased with increase of inhibitor concentration. The corrosion current (I_{corr}) decreased with increase of inhibitor concentration (from 189.9 to 57 μA/cm^2) studied by potentio dynamic polaraisation. By using impedance spectroscopy the charge transfer Resistance (R_{ct}) value increased from 5.7602 to 30.95 Ωcm^2. These results are in very good agreement with the non electro chemical studies.

Keywords: Acid, Mimusops Elengi Leaves, Carbon steel, Polarization, Impedance spectra

1. INTRODUCTION

Carbon steel is most familiar material widely employed almost all the field in world wide. But the facing main problem of using this material undergoes dissolution in acidic environments. In industry, for cleaning processes, mostly acid solutions are commonly used for the removal of rust and scale. Use of inhibitor is one of the best method to prevent metal dissolution is very common. Corrosion of materials is a natural phenomenon that is a cause of concern as it has incurred a total damage of billions of dollars to many industries. Many ways of overcoming the corrosion problem such as inhibitors, anodic protections, Cathodic protections and coatings are developed. Among all the methods, corrosion inhibitors are popular due to the ease in application and the advantage of in situ application without disruption of the process. Corrosion inhibitors are substances which when added in small concentrations to the corrosive environment will reduce the rate of corrosion [1]. The heterocyclic organic compounds and their derivatives have been successful as corrosion inhibitors, although their toxicity is an important disadvantage, for it limits their application due to environmental impact reason [2, 3]. The use of corrosion inhibitors as a means of protection is necessary in many industrial cases: surface preparation, transport and storage of metals, cooling circuits, rehabilitation of reinforced concrete, painting and Cathodic protection [4-6]. The adsorption characteristics mild steel of corrosion inhibitors depend upon the chemical moiety of the molecule, type of functional groups and the electron density at the donor atoms. Organic compounds, containing hetero atom's (N, O, S and P), electronegative functional groups, π-electrons and aromatic rings as electron density rich centers which are considered as good adsorptive centre [7-9]. These heterocyclic organic inhibitors get adsorb onto the steel surface or form protective insoluble layer and block corrosion sites, which reduces contact of corroding material with the corrosive medium/steel [10]. Recent studies using plants containing heteroatom such as oxygen, nitrogen and sulphur like *Cnidoscolus chayamans, Solanum Torvum, Pisonia Grandis, mimusops elengi, Sauropus Androgynus, Kingiodendron pinnatum, Wrightia Tinctoria, Lagenaria Siceraria* Peel, *Tephrosia Purpurea* [11-19] have also been used for inhibition of corrosion. In the present study, *Mimusops Elengi* Leaves extracts was investigated for its corrosion inhibition potential by using potentio dynamic measurement, electrochemical impedance spectroscopy.

2. MATERIALS AND METHODS

2.1. Mimusops Elengi Leaves Is Used As Corrosion Inhibitor

2.1.1. Electrochmical measurements

Electrochemical measurements were carried out using CH Instruments **660E** with three electrode system, Carbon steel specimen with an exposure area 1cm^2 was used as working electrode, platinum electrode (pt) as the auxiliary electrode while the saturated calomel electrode (SCE) was used as the reference electrode. All the electrochemical studies were carried out at room temperature (27±3°C). The open circuit potential (OCP) was recorded as a function of time up to 30 minutes.

2.2. Polarisation Method

The corrosion rates in the presence [I_{corr}(I)] and in the absence [I_{corr}] of the inhibitors were determined by Tafel (extrapolation) method. The inhibition efficiency (I.E) was determined by the following relationship.

$$\text{I.E }(\%) = \frac{[I_{corr} - I_{corr}(I)]}{I_{corr}} \times 100 \quad \text{.......... (1)}$$

2.3. Impedance Measurements

Inhibition efficiencies were also determined from R_{ct} values with and without inhibitors by using the following relationships.

$$\text{I.E }(\%) = \frac{[R_{ct}\text{ with (I) --- }R_{ct}]}{R_{ct}\text{ with (I)}} \times 100 \quad \text{......... (2)}$$

where,

R_{ct} with(I)=charge transfer resistance with inhibitor

R_{ct} = charge transfer resistance without inhibitor

3. RESULTS AND DISCUSSION

3.1. Electrochemical Studies

3.1.1. Polarisation Studies

Polarisation experiment has been used to study the protective film formed on the metal surface. The Potentiodynamic polarisation curves of carbon steel immersed in 1.0N HCl acid environment in the absence and presence of inhibitor are shown in fig.1. The corrosion parameters viz, corrosion potential (E_{Corr}), Corrosion current density (I_{Corr}), Tafel slopes (b_a & b_c) and percentage of inhibition efficiency (%IE) are given table 1. E_{corr} values shifted to positive potential with increase in concentrations of MEL extract. The corrosion current densities reduced from 189.9 to 57**μA**/cm^2 with increase in concentrations of the inhibitor. It is evident from Table 5.5 that the addition of MEL shows a positive shift in the E_{corr} value shift in corrosion potential exceeds ±85mv with respect to corrosion potential of the uninhibited solution, the inhibitor acts as either anodic (or) Cathodic type. In the present case the maximum displacement in E_{corr} is found to be within ±35mv, which indicates that MEL acts as mixed type of inhibitor by showing its inhibitory action on both hydrogen evolution and metal dissolution.

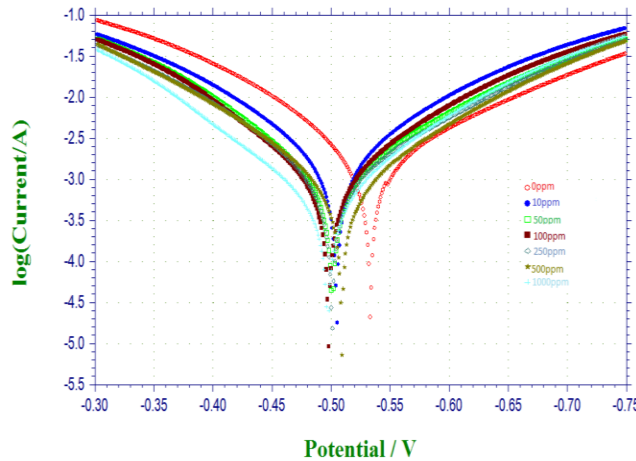


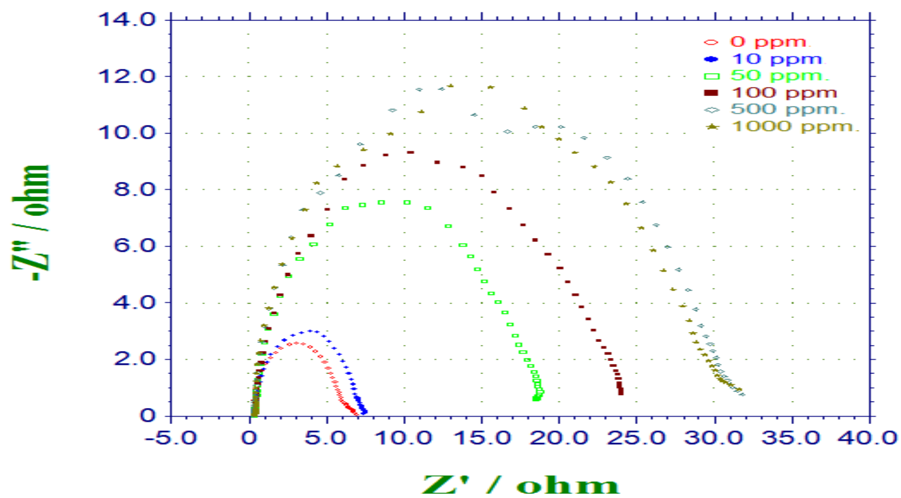
Fig.1: Polarisation curves for Carbon steel in 1.0N HCl in the presence and absence of different concentration of MEL

3.1.2. Electrochemical Impedance (EIS) Studies

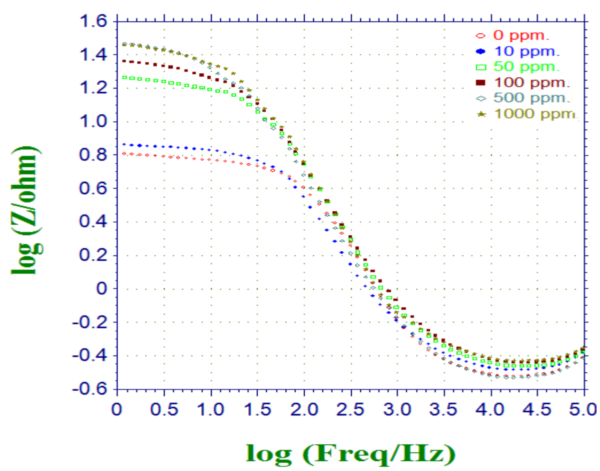
Fig.2. shows that typical set of complex planes plot of carbon steel in 1.0N Hydrochloric acid in the absence and presence of various concentration of MEL inhibitor at room temperature. It was obvious that the addition of inhibitor results in an increase of the diameter of the semicircle capacitive loop Fig.2 (a), bode impedance plot Fig. 2 (b) and the maximum phase angle Fig.2 (c). Careful inspection of this data revealed that the value of charge transfer resistance (R_{ct}) increased from **5.76** to 30.95 **Ωcm^2** of carbon steel in acid with increase of inhibitor concentrations. The inhibition efficiency increased from **14.83** to 81.39% with increase of inhibitor concentration. It ensures that the formation of protective film on the metal surface. The double layer capacitance (C_{dl}) 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 indicated 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 carbon steel in 1.0 N Hydrochloric acid containing various concentration of MEL inhibitor

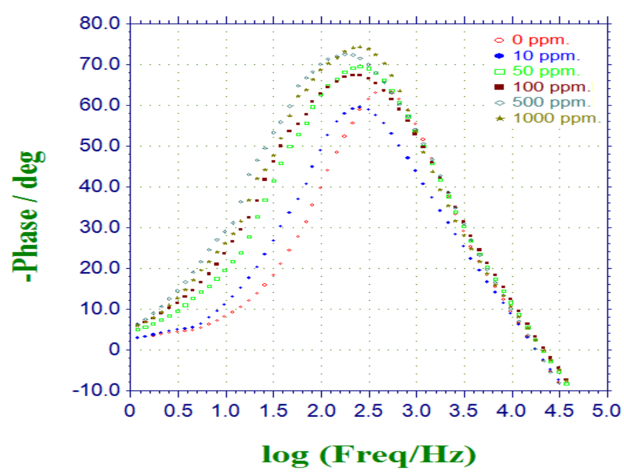
Conc. (ppm)	Polarisation studies					Impedance studies		
	$-E_{corr}$ mV	b_a (mV/decade)	b_c (mV/decade)	I_{corr} µA cm^{-2}	I.E (%)	R_{ct} (Ω cm^2)	C_{dl} x10^{-4} Fcm^2	I.E (%)
Blank	533.2	113.46	143.53	189.9	---	5.7602	0.0887	---
10	505.5	112.00	121.46	175.4	7.63	6.7632	0.0068	14.83
50	501.9	98.74	122.80	107.7	43.28	17.8623	0.0010	67.75
100	498.8	94.61	114.22	92.49	51.29	23.45	0.0006	75.43
500	509.2	108.90	114.46	90.87	52.14	30.46	0.0004	81.09
1000	497.5	93.52	105.90	57	69.98	30.95	0.0003	81.39



(a)



(b)



(c)

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

The Bode impedance 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 reflected that the higher corrosion activity at low concentrations of the inhibitor.

4. CONCLUSION

The corrosion behavior of Carbon steel in 1.0N Hydrochloric acid was studied in the presence and absence of an eco-friendly inhibitor. The inhibition efficiency was found to be 81.39% by impedance studies and 69.98% of polarisation studies. The study also showed that MEL functioned as a mixed-type corrosion inhibitor in the acid environments studied and therefore presents it as a long-term inhibitor for the corrosion of Carbon steel.

5. REFERENCES

1. Riggs JOL, et al. *Nat. Asso. Corros. Eng*, 1973.
2. Guzman- Lucero D, Olivares-Xometl O, Martinez-palou R, Likhanova NV, et al. *Ind Eng Chem Res,* 2011; **50:**7129.
3. Manahan SE, *Env. Che*, 6th ed., Lewis, Boca Raton, 1994.
4. Salghi R, Jodeh S, Ebenso EE, et al. *Int.J. Electrochem. Sci.,* 2017; **12:**3309.
5. Laabaissi T, Lgaz H, Oudda H, et al. *J. Mater. Environ. Sci.,* 2017; **8:**1054.
6. El Aoufir Y, Sebhaoui J, .Lgaz H, El Bakri Y, Zarrouk A, Bentiss F, Guenbour A, Essassi EM, et al. *J. Mater. Environ. Sci.,* 2017; **8:**2161.
7. Lgaz H, Salghi R, Jodeh S, Hammouti B, et al. *J. Mol. Liq.,* 2017; **225:**271.
8. Messali M, Lgaz H, Dassanayake R, Salghi R, Jodeh S, Abidi N, Hamed O, et al. *J. Mol. Struct.,* 2017; **1445:**43.
9. Salghi R, Jodeh S, Ebenso EE, Lgaz H, Ben Hmamou D, BelKhaouda M, Ali IH, Messali M, Hammouti B, Fattouch S, et al, *Int. J. Electrochem. Sci.,* 2017; **12:**3283.
10. Lgaz H, Subramanya Bhat K, Salghi R, Shubhalaxmi, Jodeh S, Algarra M, Hammouti B, et al, *J. Mol. Liq.,* 2017; **238:**71.
11. Bright A, Michlin Ruphina Maragatham S, Malar vizhi I, Dr. Kalirajan K, Dr. Selvaraj S, et al. *Int. J. Inno Res Sci Eng & Techno,* 2015; **4(10):**10181-10191.
12. Bright A, Michlin Ruphina Maragatham S, Malar Vizhi I, Kalirajan K, Selvaraj S, et al. *Res. J. Chem Sci,* 2015; **5(11):**31-39.
13. Bright A, Michlin Ruphina Maragatham S, Malar Vizhi I, Kalirajan K, Selvaraj S, et al. *Int. J. Curr Res,* 2015; **7(9):**20566-20573.
14. Deivanayagam P, Malarvizhi I, Selvaraj S, Deeparani P, et al. *Int. J. Multidiscip Res and Develop*, 2015; **2(4):**100-107.
15. Deivanayagam P, Malarvizhi I, Selvaraj S, Deeparani P, et al. *Int. J. Adv Pharm Bio & Che.*, 2015; **4(3):**574-583.
16. Deivanayagam P, Malarvizhi I, Selvaraj S, et al. *Int. J. Eng Res & General Science*. 2015; **3(6):**52-61.
17. Deivanayagam P, Malarvizhi I, Selvaraj S, et al. *Inter. J. Eng Sci & Res Technol*, 2016; **5(4):**93-101.
18. Malarvizhi I, Selvaraj S, et al. *Journal Emerg Technol & Inno Res*, 2018; **5(7):**158-168.
19. Malar vizhi. I, Selvaraj S, Kalirajan K, et al. Inter *J. Res & Anal Reviews*, 2018; **5(4):**164-174.