International Journal of Applied Science-Research and Review www.ijas.org.uk

Original Article

Electrochemical Investigation of *Manilkara zapota f*ruit Peel Extract on Mild Steel in Acid Medium

A. Petchiammal*, S. Selvaraj and K. Kalirajan

Post graduate and Research Department of chemistry,
Sri Paramakalyani College, Alwarkurichi-627412, Tamil Nadu, India

A R T I C L E I N F O

Received 05 Nov. 2014
Received in revised form 18 Nov. 2014
Accepted 20 Nov. 2014

***Keywords*:**
Mild steel,
Corrosion,
Manilkara zapota fruit peel,
Mass loss,
Adsorption isotherm.

Corresponding author: Post graduate and Research Department of chemistry, Sri Paramakalyani College, Alwarkurichi-627412, Tamil Nadu, India.
E-mail address: ap_mscchem@yahoo.in

A B S T R A C T

The inhibition efficacy of *Manilkara zapota* fruit peel (MZFP) extract on the corrosion of mild steel in 1.0N hydrochloric acid has been studied by potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) measurements. The inhibition efficiency was increased with increase of inhibitor concentration and achieved maximum of more than 93% for both methods. The charge transfer resistance increased with increase of inhibitor concentration which was confirmed by impedance studies. In bode phase plot, the increasing concentration of MZFP inhibitor in hydrochloric acid solution resulted in more values of phase angle at high frequencies also suggested that, there was greater surface coverage and charge transfer resistance. The inhibitor acted as a mixed type. ie, it protected both cathodic and anodic corrosion.

INTRODUCTION

Mild steel and its alloy have many applications and hence are used in most of the environments because of their excellent anti-corrosive properties, which is coupled with combination of superior thermal and electrical conductivity, ease of fabricating, joining, mechanical properties and bio fouling resistance. It is widely used for all kinds of field work in worldwide namely used in industries, pickling, acid cleaning, fabrication of various reaction vessels such as pipelines, cooling tower tanks, automobiles, submarine, engineering, nuts, bolts, screws etc. However this metal attacks from severe corrosion when it comes in contact with acid solutions during acid cleaning, acid storage, de-scaling, transportation of acid 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]. But the use of chemical inhibitor has been found to be toxic, expensive, harmful to living things and non bio-degradable. Hence there is a search to need the eco-friendly, non-toxic corrosion inhibitors. Recent years, several green inhibitors have been used for the hindrance of corrosion by most of the researchers. Few examples are *Gossipium hirsutum L*[2], Red Onion Skin[3], Guar Gum[4], Beet Root[5], *Tridax procumbens L*[6], *Isertia coccinea*[7], *Ocimum tenuiflorum*[8], Amla[9], *Cucumis sativus* peel[10], *Cassia alata* leaves[11], *Eugenia Jambolana*[12], *Pyrus pyrifolia*[13], *Jatropha curcas*[14]. The present investigation deals with the study of the dissolution and the inhibitive efficiency of mild steel in 1.0N hydrochloric acid environment by electro-chemical method using *Manilkara zapota* fruit peel at various exposure time.

MATERIALS AND METHODS

Chemical properties of *Manilkara zapota* fruit extract

Manilkara zapota, is a medicinal plant and belongs to Sapotaceae family. The fruit has important medicinal properties of shielding lung and oral cavity cancers, anti-inflammatory, antiviral, anti-bacterial, and anti-parasitic effects, search the harmful free radicals[15]. Peel extracts of sapota showed radical scavenging potential and high antioxidant activity compared to pulp extracts. The main active photochemical present in the fruit peels are tannin, flavonoid and phenol[16,17].

Specimen preparation

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 state 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[18]. 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. The corrosion potential (E_{corr}) values as mV and I_{corr} values as $\mu A/cm^2$ were taken and all the experiments were carried out at room temperature.

Electrochemical impedance spectroscopy measurement

The well-polished electrode was introduced into 100 ml of test solution and allowed to attain a steady state potential value. A.C. signal of amplitude 10 mV was impressed to the system of frequencies ranging from 100 mHz to 10 kHz using electrochemical analyser Princeton applied research Model: PARSTAT 2273 (Advanced electrochemical system)[18].

RESULTS AND DISCUSSION

Polarisation studies

The anodic and cathodic polarisation curves of mild steel in the presence and absence of MZFP extract in 1.0N hydrochloric acid environment is shown in Fig.1. The corrosion potential was shifted to noble or passive direction i.e., from -477 to -457mV, indicating an adherent film on the metal surface in acid medium (Table-1). The value of I_{corr} decreased from 501.01 to 34.21$\mu A/cm^2$ and the inhibition efficiency was found to be in the range of 83 to 93% with increase of inhibitor concentration from 10 to 1000ppm. The corrosion potential was shifted to nobler or passive direction indicating that the inhibitor was mixed type and the inhibitor were effective in controlling the dissolution rate of metal. In MZFP extract, the O^{2-} was act as reaction centres through which it formed the complex with the metal ions. This active group formed the complex mainly with metal ions and this complex film was able to prevent the corrosion of metal.

Electrochemical impedance (EIS) studies

The electrochemical impedance parameters such as charge transfer resistance (R_{ct}), anodic and cathodic Tafel slopes (b_a and b_c) and % inhibition efficiency (IE) for the corrosion of mild steel in 1.0N hydrochloric acid at room temperature in the absence and presence of different concentrations of extract are given in Table-1 and its related curves are shown in Fig.2(a). Nyquist plot clearly indicates that the R_{ct} values increased from 28.38 to 707.42Ω with increase of inhibitor concentration from 0 to 1000ppm. The double layer capacitance (C_{dl}) values decreased with increase of inhibitor concentration. These results agree with the previous result.

Bode impedance plots as shown in Fig.2 (b), reflect that the impedance value in the presence of inhibitor was larger than the blank solution. This means that the corrosion rate is significantly reduced in the presence of inhibitor. Bode phase plot (Fig. 2(c)), it was only one time constant, which indicates that the increasing concentration of MZFP extract in 1.0N hydrochloric acid solution as a results in more values of phase angle at high frequencies clearly suggests that there was greater surface coverage (θ) and charge transfer resistance (R_{ct}).

CONCLUSION

From our present study the following conclusions can be drawn.

1. The *Manilkara zapota* fruit peel (MZFP) was used as good inhibitor for mild steel in 1.0N hydrochloric acid environment.

2. The inhibition efficiency of more than 93% was achieved in both potentiodynamic polarisation and impedance studies.

3. The inhibitor acted as mixed type and was effective in controlling the dissolution rate of mild steel.

ACKNOWLEDGEMENT

I would express our heartful thanks to the management of Sri Paramakalyani College, Alwarkurichi, for providing the lab facilities.

REFERENCES

1. Anand B, Balasubramanian V, "Corrosion Behaviour of Mild Steel in Acidic Medium in Presence of Aqueous Extract of Allamanda Blanchetii", *E-J. of Chem*, vol. 8, 226-230, 2011
2. Olusegun K. Abiola , J.O.E. Otaigbe , O.J. Kio, "*Gossipium hirsutum* L. extracts as green corrosion inhibitor for aluminium in NaOH solution", *Corrosion Science*, vol 51, 1879–1881, 2009.
3. James A. O, Akaranta O, "Inhibition of Corrosion of Zinc in Hydrochloric Acid Solution by Red Onion Skin Acetone Extract", *Res. J. Chem. Sci*, Vol. 1, no. 1, 2011.
4. M. Abdallah, "Guar Gum as Corrosion Inhibitor for Carbon Steel in Sulfuric Acid Solutions", *Portugaliae Electrochimica Acta*, vol. 22, 161-175, 2004.
5. J. Arockia Selvi, Susai Rajendran, V. Ganga Sri, A. John Amalraj, B. Narayanasamy, "Corrosion Inhibition by Beet Root Extract", *Portugaliae Electrochimica Acta*, vol.27, no. 1, 1-11, 2009.
6. G. Ilayaraja, A.R. Sasieekhumar, P. Dhanakodi, "Inhibition of Mild Steel Corrosion in Acidic Medium by Aqueous Extract of *Tridax procumbens*" L, *E-Journal of Chemistry*, vol. 8, no.2, 685-688, 2011.
7. M. Lebrini, F. Robert, P.A. Blandinières, C. Roos, "Corrosion Inhibition by *Isertia coccinea* Plant Extract in Hydrochloric Acid Solution", *Int. J. Electrochem. Sci,* vol.6, 2443 – 2460, 2011.
8. Deepa Rani P and Selvaraj S. "Influence of *Ocimum tenuiflorum* extract on mild steel in acid environment", *Asian. J. Research Chem*. vol.4, 211- 216, 2011.
9. Deepa Rani. P, S.Sathya, S. Selvaraj, "Inhibitive Efficacy of Amla as Green Inhibitor for Brass in Natural Sea Water Environment," *International Journal of Chemical and Pharmaceutical Sciences*, vol.3, no. 1, 2012.
10. Petchiammal A, Selvaraj S and Kalirajan K. "*Cucumis sativus* peel as effective corrosion inhibitor for zinc in acid media", *Annalen der chemischen Forschung*, vol.1, No. 2, 37-45, 2013.
11. A. Petchiammal, P. Deepa Rani, S. Seetha lakshmi and S. Selvaraj, "Anti-corrosive effect of Cassia alata leaves extract on Mild steel in 1.0N Hydrochloric acid", *Journal of Advances in Chemistry*, vol 2, No. 2, 2013.
12. P. Deepa rani, A. Petchiammal, M. Pirammarajeswari, C. Rajeswari and S. Selvaraj, "*Eugenia Jambolana* used as corrosion inhibitor on mild steel in 1N hydrochloric acid medium", *American Journal of Phytomedicine and Clinical Therapeutics*, vol.1, no.2, 1-11, 2013.
13. Petchiammal A, Selvaraj S and Kalirajan K,"Corrosion control of mild steel in 1.0N Hydrochloric acid medium using *Pyrus pyrifolia* fruit peel extract", *Biointerface research in applied chemistry*, vol. 4, no. 2, 685-693, 2014.
14. P. Deepa Rani, S. Selvaraj, "Inhibitive efficacy of *Jatropha curcas* plant extract on brass in sea water environment", *International Journal of Advanced Scientific and Technical Research*, vol 2, no. 4, 2014.
15. http://www.nutrition-and-you.com/sapodilla.html.
16. http://www.nutrition-and-you.com/fruit-peel.html
17. Kannan Gomathy, Ramakrishnan Baskar, Kuppamuthu Kumaresan, "Comparison of antioxidant potential in pulp and peel extracts of *Manilkara zapota* (L.)", *African Journal of Biotechnology*, vol.12, no. 31, 4936-4943, 2013.
18. Xiumei Wang, Huaiyu Yang, Fuhui Wanga, A cationic gemini-surfactant as effective inhibitor for mild steel in HCl solutions, *Corrosion Science*, vol 52, 1268–1276, 2010.

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

Conc. (ppm)	Polarisation studies					Impedance studies		
	E_{corr} (mV vs SCE)	b_a (mV/decade)	$-b_c$ (mV/decade)	I_{corr} (μA/cm^2)	I.E (%)	R_{ct} (Ω)	C_{dl} (μF/cm^2)	I.E (%)
Blank	- 477.0	60.30	113.40	501.01	---	28.38	3.20	---
10	- 472.0	76.40	184.80	85.62	83.0 %	227.31	1.50	87.53
500	- 456.0	74.80	171.80	45.29	91.0%	353.39	2.70	91.97
1000	-457.0	98.50	198.80	34.21	93.0 %	707.42	2.00	95.98

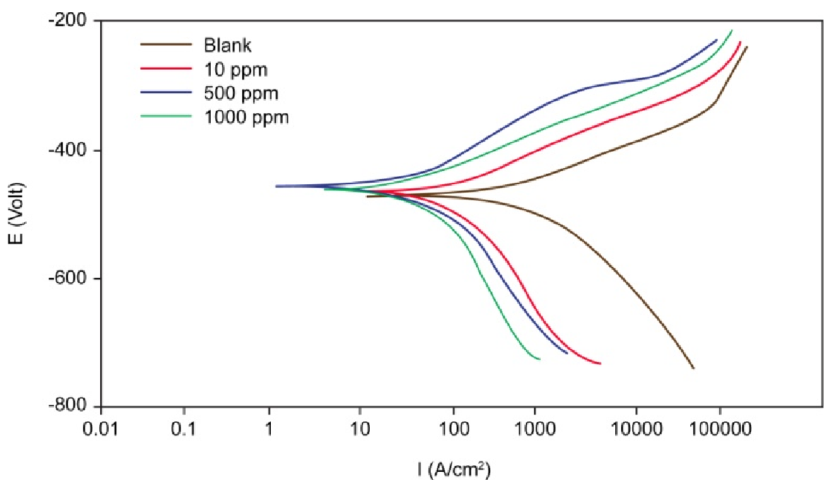

Figure 1. Polarisation curves for mild steel in 1.0N Hydrochloric acid containing various concentration of MZFP inhibitor

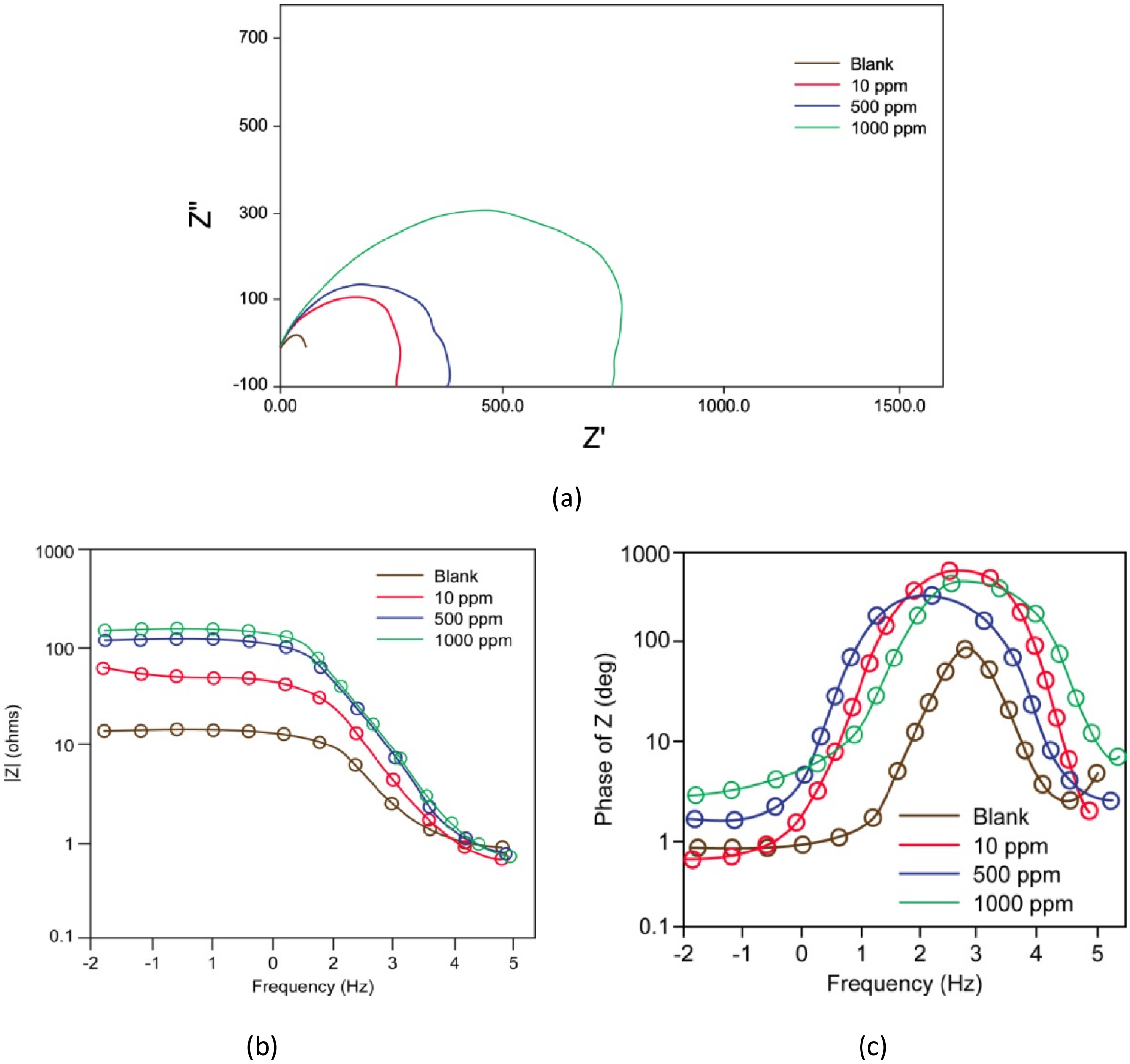

Figure 2. **(a-c).** Electrochemical impedance plots, Nyquist **(a)** Bode impedance plot **(b),** phase angle plot **(c),** for mild steel in 1.0N Hydrochloric acid containing various concentration of MZFP inhibitor