Volume : 2 | Issue : 2 | Feb 2013 • ISSN No 2277 - 8160

Research Paper | Chemistry

Study on the Corrosion Inhibition of Mild Steel by Phosphono and Benzotriazole Derivative in Ground Water Media

Dr. V. Manivannan Professor & Head, Department of Chemistry, Paavai College of Engineering, Pachal, Namakkal, Tamilnadu, India

ABSTRACT *Corrosion inhibition by benzotriazole derivative 1-(2- pyrrolecarbonyl)benzotriazole (PCBT) and phosphono derivative 2-Phosphonoacetic acid (2-PAA) on mild steel in ground water media has been investigated by weight loss method, potentiodynamic polarization, electrochemical impedance spectroscopy (EIS) and atomic absorption spectroscopy(AAS) method. The experimental results obtained reveal that among the two inhibitors PCBT is the best effective inhibitor than 2-PAA. The variation in inhibitive efficiency mainly depends on the type and nature of the substituent present in the inhibitor molecule. Inhibition efficiency (IE %) values obtained from various methods used are in good agreement.*

KEYWORDS: Mild steel, Benzotriazole, Phosphonic acid, Corrosion, Potentiodynamic polarization, Inhibition.

1. INTRODUCTION

Corrosion control of metals is an important activity of technical, economical, environmental and aesthetical importance. Thus, the search for new and efficient corrosion inhibitors has become a necessity to secure metallic materials against corrosion. Over the years, considerable efforts have been deployed to find suitable compounds of organic origin to be used as corrosion inhibitors in various corrosive media, to either stop or delay to the maximum the attack of a metal [1-10]. The adsorption of corrosion inhibitor depends mainly on physico-chemical properties of the molecule such as functional groups, steric factor, molecular size, molecular weight, molecular structure, aromaticity, electron density of the donor atoms and p- orbital character of donating electrons [11-12] and also on the electronic structure of the molecules. The aim of the present study is to determine the inhibition efficiency of benzotriazole with Zn2+ and 2-phosphonoacetic acid.

2. EXPERIMENTAL

Mild steel samples with the composition C-0.13%, P-0.032%, Si-0.014%, S-0.025%, Mn-0.48% and balance Fe were used and the standard electrode preparation was followed. For weight loss measurements metal specimens of 4.0 cm x 2.0 cm x 0.2 cm dimension were used. For each electrochemical study, specimens of size 1.0 cm 9 1.0 cm 9 0.3 cm were cut, embedded in epoxy resin and mechanically polished with silicon carbide papers. All the electrochemical measurements were performed using an Electrochemical Workstation (Model No: CHI 760, CH Instruments, USA). The potentiodynamic polarization studies were carried out from -1200 to 0 mV at a scan rate of 0.1 mV s-1. Electrochemical impedance studies were carried out with the same setup used for potentiodynamic polarization studies. The applied ac perturbation signal was about 10 mV within the frequency range 100 kHz to 1Hz. The amount of iron leached-out to the solution after carrying out potentiodynamic polarization measurement of mild steel in ground water in the absence and presence of inhibitors was estimated by AAS technique.

3. RESULTS AND DISCUSSION

3.1 Weight loss measurements

The results of weight loss measurements for mild steel in ground water in the absence and presence of optimum concentrations of benzotriazole, phosphono derivatives are listed in Table 1. According to these results, among the benzotriazole derivatives PCBT had shown the maximum inhibition efficiency of 74.4 % at the optimum concentration of 12 ppm and the phosphono derivative 2-PAA had shown the maximum inhibition efficiency of 61.96 % at the optimum concentration of 12 ppm.

3.2 Electrochemical Studies

The potentiodynamic polarization curves of mild steel in ground water without and with the presence of various concentrations of PCBT and 2-PAA are shown in Fig. 1 & 2. It is evident from the figure that the anodic and cathodic curves for mild steel with benzotriazole derivative was shifted towards negative potential region compared to the blank and at the same time in the presence of phosphono derivative, the anodic and cathodic curves for mild steel were shifted towards positive potential region compared to the blank. The values of the electrochemical parameters like Ecorr and its corresponding corrosion current density are obtained from the polarization curves and are summarized in Table 2.With the aid of Tafel extrapolation the corrosion inhibition efficiency of PCBT was found to be 75.5% for optimum concentrations of 12 ppm. In the case of phosphono derivative, the corrosion inhibition efficiency of 2-PAA is found to be 62.6%. Impedance measurements of the mild steel electrode at its open circuit potential after 1 hr of immersion in ground water alone and in the presence of various optimum inhibitor combinations were performed over the frequency range from 100 kHz to 1 Hz. represents the capacitance of the inhibitor film on the metal surface due to adsorption. Typical Nyquist plots obtained in the absence and presence of optimum concentration of all the studied inhibitors are shown in Fig. 3. The impedance diagrams obtained are not perfect semicircles and this difference has been attributed to frequency dispersion. The values of the different elements present in the equivalent circuit were evaluated using a fitting procedure and the parameters obtained are shown in Table 3. From the impedance plots of the individual inhibitors, it is evident that the values of charge transfer resistance of PCBT found to be 0.5728 ×104 Ω and 2-PAA found to be 0.3168 ×104 Ω All the ac measurements show the same trend as those observed from dc polarization.

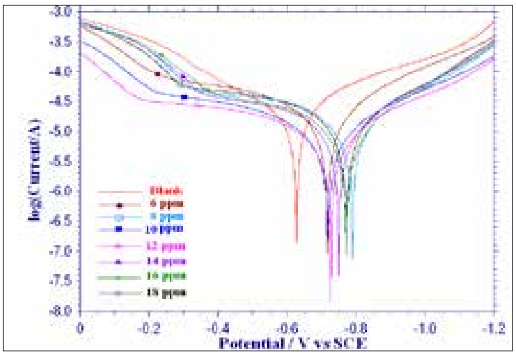

Fig. 1. Potentiodynamic polarization curves of mild steel in ground water in the absence and presence of various concentrations of PCBT at 30 °C.

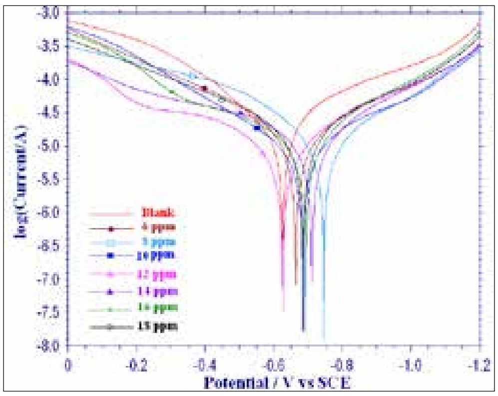

Fig. 2. Potentiodynamic polarization curves of mild steel in ground water in the absence and presence of various concentrations of 2-PAA at 30 °C

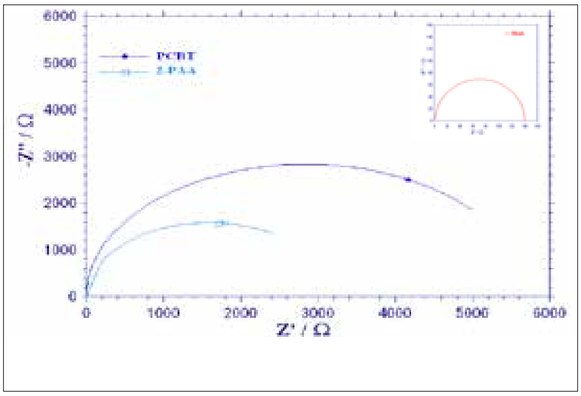

Fig. 3. Nyquist plots of mild steel in ground water without and with the presence of optimum concentration of triazole, phosphono derivatives at 30 °C

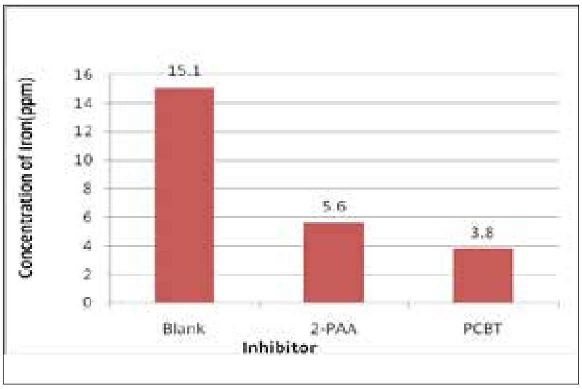

Fig.4. Estimation of leached-out iron present in the ground water in the absence and presence of optimum concentration of 2-PAA and PCBT by AAS method.

Table 1. Weight loss measurements of mild steel in ground water in the absence and presence of various concentration of benzotriazole and Phosphono derivative at 30° C.

Inhibitor	Inhibitor conc. (ppm)	Corrosion rate (mpy)	Inhibition efficiency (%)
Blank	-	6.6	-
PCBT	6	3.71	43.78
	8	3.39	48.64
	10	3.10	53.00
	12	1.70	74.40
	14	2.19	66.80
	16	3.02	54.24
	18	3.68	44.24
2-PAA	6	3.85	42.27
	8	3.43	48.03
	10	2.75	58.33
	12	2.51	61.96
	14	2.90	56.06
	16	3.37	48.93
	18	4.01	39.24

WWTRTable 2. Potentiodynamic polarization parameters of mild steel in ground water in the absence and presence of various concentrations of PCBT and 2-PAA at 30 °C

Inhibitor	Inhibitor conc. (ppm)	E_{corr} (mV)	i_{corr} (µA cm^{-2})	Corrosion rate (mpy)	Inhibition efficiency (%)
Blank	-	-640	12.59	5.75	-
PCBT	6	-715	7.08	3.23	43.8
	8	-785	6.30	2.87	50.0
	10	-715	5.82	2.66	53.8
	12	-720	3.09	1.41	75.5
	14	-748	4.16	1.90	66.9
	16	-770	5.71	2.61	54.6
	18	-774	6.96	3.18	44.7
2-PAA	6	-669	7.23	3.30	42.5
	8	-744	6.38	2.91	49.3
	10	-681	5.15	2.35	59.0
	12	-627	4.71	2.15	62.6
	14	-714	6.07	2.77	57.7
	16	-713	6.42	2.93	49.0
	18	-684	7.50	3.42	40.4

Table 3. Electrochemical impedance parameters for mild steel in ground water in the absence and presence of optimum concentration of benzotriazole and phosphono derivative at 30° C

Inhibitor	Inhibitor conc. (ppm)	R_{ct} x 10^4 (W)	C_{dl} (mF)
Blank	-	0.0130	15.03
PCBT	12	0.5728	6.49
2-PAA	12	0.3168	7.83

3.3. AAS Studies

Figure 4 depicts the estimation of leached-out iron present in the ground water in the absence and presence of optimum concentration of individual inhibitors. In the absence of inhibitor, the leached-out iron present in the solution was found to be 15.1 ppm. While, in the presence of inhibitor the leaching of iron was significantly decreased, it may be due to the adsorption of inhibitor molecules on the surface of mild steel and it prevents the dissolution of iron in the electrolyte. Among the studied individual inhibitor systems, PCBT was found to be very low dissolution of iron in the electrolyte (3.8 ppm).

4. CONCLUSIONS

1. All the examined benzotriazole derivative, phosphono derivative were found to be good corrosion inhibitors for mild steel in ground water medium.
2. Studied phosphono derivative were acting as mixed-type inhibitors with anodic predominance, benzotriazole derivative act as mixed-type inhibitors with cathodic predominance.
3. PCBT act as better inhibitor than 2-PAA and a good agreement was observed between weight loss measurements coupled with electrochemical and AAS measurements. A., Boulkamh, & Djebbar, K. (2007). Investigations of the inhibition of copper corrosion in nitric acid solutions by ketene dithioacetal derivatives: Appl. Surf. Sci. 253, 9347. doi.org/10.1016/j.apsusc.2007.05.066.

REFERENCES

1. Bentiss, F., Traisnel. M & Lagrene`e. (2000). The substituted 1,3,4-oxadiazoles: a new class of corrosion inhibitors of mild steel in acidic media: Corros. Sci. 42, 127.doi.org/10.1016/S0010-938x(99)00049-9. | 2. Bouklah, M. Hammouti, B., Benkaddour M.,& Benhadda. (2005). Thiophene derivatives as effective inhibitors for the corrosion of steel in 0.5 M H2SO4: J. Appl. Electrochem. 35, 1095. doi:10.1007/S10800-005-9004-z. | 3. Elkad, L., Mernari B., Traisnel, M., Bentiss, M., & Lagrene`e, M. (2000). The inhibition action of 3,6-bis(2-methoxyphenyl)-1,2-dihydro-1,2,4,5-tetrazine on the corrosion of mild steel in acidic media: Corros. Sci. 42, 703.doi ;org/10.1016/soo10-938x(99)00101-8. | 4. Wang, H.L., Liu, R.B., & Xin, J. (2004). Inhibiting effects of some mercapto-triazole derivatives on the corrosion of mild steel in 1.0 M HCl medium: Corros. Sci. 46, 2455.doi.org/10.1016/j.corsci.2004.01.023. | 5. Mahmoud, S.S. (2007). Corrosion inhibition of iron by amphoteric surfactants in hydrochloric acid solutions: J. Mater. Sci. 42, 989. doi: 10.1007/s10853-006-1389-5. | 6. Fouda, A.S., Mostafa, H.A., Ghazy, S.E., & El-Farah, S.A. (2007). Use of Hydrazone Derivates as Inhibitors for the Corrosion of Nickel in Hydrochloric Acid Solution): Int. J. Electrochem. Sci. 2, 182. | 7. Villamizar, W., Casales, M., & Gonzalez-Rodriguez , J.G. (2007). CO2 corrosion inhibition by hydroxyethyl, aminoethyl, and amidoethyl imidazolines in water–oil mixtures: J. Solid State Electrochem. 11, 619. Doi: 10.1007/s10008-006-0208-x. | 8. Fiala, A., Chibani, A., Darchen, A., Boulkamh, & Djebbar, K. (2007). Investigations | of the inhibition of copper corrosion in nitric acid solutions by ketene dithioacetal derivatives: Appl. Surf. Sci. 253, 9347. doi.org/10.1016/j.apsusc.2007.05.066. | 9. Fouda, A.S., Abd El-Aal, A., & Kandil, A.B. (2006). The effect of some phthalimide derivatives on corrosion behavior of copper in nitric acid: Desalination 201, 216. | 10. Bockris, JO'M & Yang, B. (1991). The Mechanism of Corrosion Inhibition of Iron in Acid Solution by Acetylenic Alcohols: J. Electrochem. Soc. 138, 2237. doi: 0.1149/1.2085956. | 11. Khamis, E., (1990). The Effect of Temperature on the Acidic Dissolution of Steel in the Presence of Inhibitors: Corrosion. 46, 476 doi.org/10.5006/1.358535. | 12. Stupnisek Lisac, E.,& Podbrscek, S. (1994). Non-toxic organic zinc corrosion inhibitors in hydrochloric acid: J. Appl. Electrochem. 24, 779.