 doi:10.20944/preprints201801.0053.v1

Short Note

Corrosion Inhibition Effect of 1,10-Phenanthroline-5,6-diamine on Mild Steel in Hydrochloric Acid Solution

Ahmed A. Al-Amiery

Energy and Renewable Energies Technology Centre, University of Technology, Baghdad, Iraq;
* Correspondence dr.ahmed1975@gmail.com.

Abstract: The inhibition impacts of 1,10-Phenanthroline-5,6-diamine (PTDA) on mild steel in 1 M HCl solution were investigated through weight loss method. The inhibition efficiencies of PTDA increase with increase in PTDA concentration at the temperature 303. Weight loss method indicate that PTDA is an excellent inhibitor the inhibition efficiency of 81.5% at the maximum PTDA concentration of 0.5 g/L at the temperature 303K.

Keywords: 1,10-Phenanthroline-5,6-diamine; corrosion inhibitor; weight loss method

1. Introduction

The employ of inhibitors to impedance and control the corrosion become the most common techniques [1–3]. Organic and natural compounds are widely utilized as efficient corrosion inhibitors [4–9]. They show excellent corrosion inhibitions due to multiple adsorption sites in addition to hetro-atoms that may bonded coordinating with the surface of mild steel [10]. The coated layers on the mild steel surface act as barriers and protectors for the surface of mild steel against acid or base solutions. Recently, novel synthesized corrosion inhibitors that are built structurally with some hetro-atoms such as nitrogen, oxygen, sulfur and/or phosphorous that have the ability to coordinate with the metal through unshared electrons that will block the active sites and prevent the corrosion from corrosive environment [11,12]. Moreover, these motivating inhibitors may have also double or triple bonds that have the ability to be adsorbed on the surface of inhibitor and from the acid or base environments and impedance the corrosion damage [13–14]. Corrosion inhibitor has the efficiency to produce a stable complex through coordination bonds between the inhibitor molecules and the surface of the metal which being a film that protect the metal surface acids or bases solutions [15-21]. The aim of this work is to study the corrosion inhibition behavior of 1,10-Phenanthroline-5,6-diamine (PTDA) on mild steel in corrosive solution employing weight loss method.

2. Materials and Methods

Corrosion technique: Mild steel samples that applied in this work as an electrode have been purchase via Company of metal samples. The iron percentage was 99.21; carbon percentage was 0.21; the silicon percentage was 0.38; the sulfur percentage was 0.09; the manganese percentage was 0.05 and the aluminum percentage 0.01. The inhibition performance for the studied compound PTDA for mild steel surface of with aria of 4.5 cm2 and they cleaned based on reference [22,23]. The samples of mild steel were suspended in 200mL of I M of hydrochloric acid solution without the inhibitor PTDA and with the inhibitor PTDA at the concentrations of 0.001, 0.05, 0.10, 0.15, 0.2.0, 0.25 and 0.50 g/L for (1, 2, 5 and 10 h). The inhibition performance was estimated based on equation 1:

$$\mathrm{IE}(\%) = \left(1 - \frac{W_2}{W_1}\right) \times 100 \qquad \mathbf{1}$$

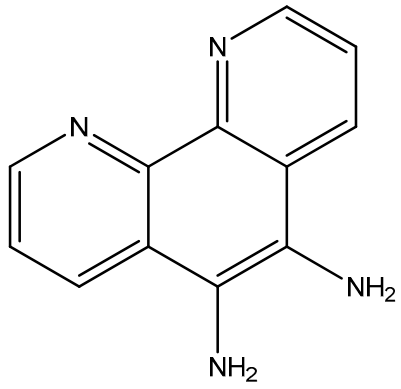
where W1 and W2 represent the weights of the studied samples in presence and absence PTDA.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 January 2018 doi:10.20944/preprints201801.0053.v1

3. Results and discussion

The chemical structure of the utilized inhibitor namely 1,10-Phenanthroline-5,6-diamine (PTDA) was posted in Figure 1.

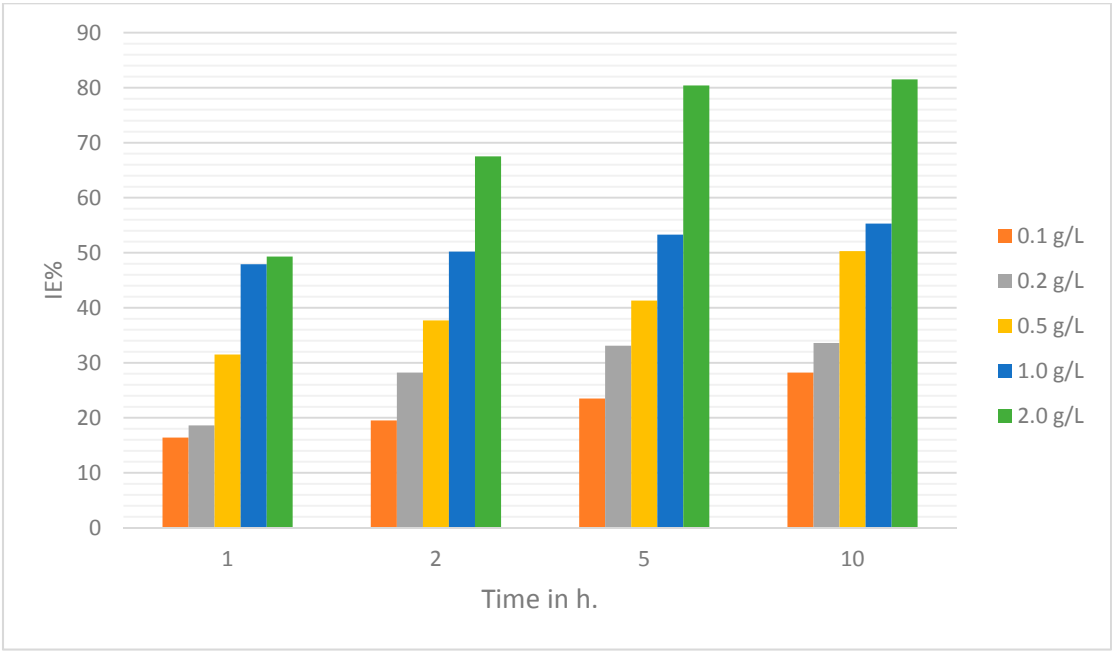
Figure 1: 1,10-Phenanthroline-5,6-diamine (PTDA) structure



3.1. Results of weight loss technique: The employing of inhibitors in industries turn in to considerable economic case due to prevention the surface of mild steel against hydrochloric acid [24]. Organic inhibitors have the priority as inhibitors that used in oil manufactures and gas manufactures in order to form a protected barrier for alloys surfaces. The significance of applying corrosion inhibitors that have hetro-atoms such as nitrogen and/or oxygen and/or sulfur were the capability of them to bonding in coordination bonds with surface of metal and forming stable barrier [25-28].

3.2. Concentration effect: Weight loss procedure which utilized to compute the performance of inhibition PTDA with the concentrations of 0.05-0.5 g/L for times 1, 2, 5 and 10 h and steady temperature degree 303K in corrosive medium for surface of mild steel. The PTDA results that were exhibit in Figure 2, point to the impact of PTDA to reduce the corrosion that place of mild steel surface in corrosive solution with highest impedance efficiency 81.5% at the concentration of 0.5 g/L of PTDA.

Figure 2. The impact of time and concentrations on inhibition efficiencies.

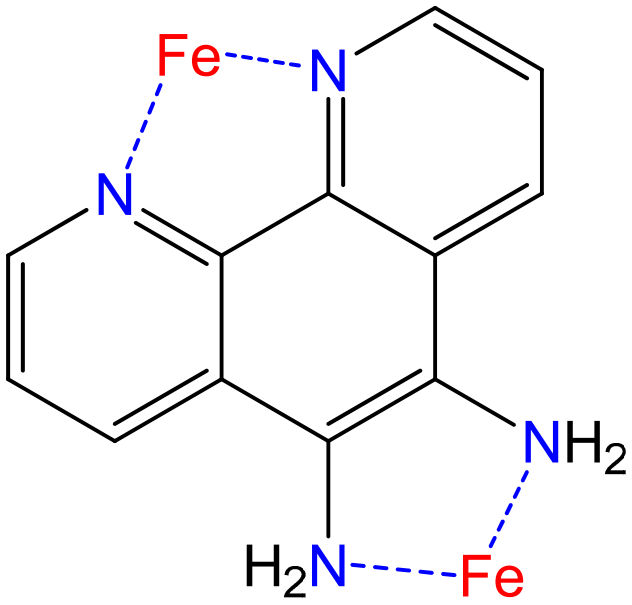


Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 January 2018 doi:10.20944/preprints201801.0053.v1

3.3. Suggested inhibition mechanism

PTDA was adsorb on the surface of mild steel and form a barrier as a thin film that protect the surface. The coordination bonds which formed via the reaction of active sites of PTDA with the iron atoms on the surface of alloy will protect the surface of the metal. The mechanism of PTDA may conduct via 1 of 3 tracks. The track, was PTDA molecules charges and attraction to the metal surface electrostatically. 2nd track was the nitrogen unshared electrons which interaction with surface of metal. Third 3rd track was the π-electrons of double bonds of PTDA and the interaction with metal surface. PTDA can protect the surface of alloy through blocking anodic and/or cathodic to form metal-complex. Inhibition performance of PTDA as inhibitor for surface of alloy in corrosive environment may be due to the adsorption sites, molecular charge, size of PTDA molecules and capability of metal to coordinate with inhibitor molecules as shown in Figure 3.

Figure 3. The postulated inhibition mechanism



4. Conclusions

1,10-Phenanthroline-5,6-diamine (PTDA) act as an inhibitor for the surface of alloy such as mild steel as in this work. The inhibition efficiency of the PTDA in 1 M of hydrochloric acid solution for MS was investigated. PTDA, showed a moderate action as an inhibitor with performance of 81.5 at the highest studied concentrations of PTDA.

References

1. Sherif, E.S.M. Electrochemical investigations on the corrosion inhibition of aluminum by 3-amino-1,2,4-triazole-5-thiol in naturally aerated stagnant seawater, J. Ind. Eng. Chem. 19 (2013) 1884–1889.
2. Chaussemier, M. Pourmohtasham, E. Gelus, D. Pécoul, N. Perrot, H. Lédion, J. Cheap-Charpentier, H. Horner, O. State of art of natural inhibitors of calcium carbonate scaling. A review article, Desalination 356 (2015) 47–55.
3. Rahmani, K. Jadidian, R. Haghtalab, S. Evaluation of inhibitors and biocides on the corrosion, scaling and biofouling control of mild steel and copper–nickel alloys in a power plant cooling water system, Desalination 393 (2016) 174–185.

4. Migahed, M.A. Rashwan, S.M. Kamel, M.M. Habib, R.E. Synthesis, characterization of polyaspartic acid-glycine adduct and evaluation of their performance as scale and corrosion inhibitor in desalination water plants, J. Mol. Liq. 224 (2016) 849–858.
5. Karthikaiselvi, R. Subhashini, S. The water soluble composite poly(vinylpyrrolidone-methylaniline): a new class of corrosion inhibitors of mild steel in hydrochloric acid media, Arab. J. Chem. 10 (2017) S627–S635.
6. Biswas, A. Pal, S. Udayabhanu, G. Experimental and theoretical studies of xanthan gum and its graft co-polymer as corrosion inhibitor for mild steel in 15% HCl, Appl. Surf. Sci. 353 (2015) 173–183.
7. Gu, T. Liu, X. Chai, W. Li, B. Sun, H. A preliminary research on polyvinyl alcohol hydrogel: a slowly-released anti-corrosion and scale inhibitor, J. Pet. Sci. Eng. 122 (2014) 453–457.
8. Benchikh, R. Aitout, L. Makhloufi, L. Benhaddad, B. Saidani, Soluble conducting poly(aniline-co-orthotoluidine) copolymer as corrosion inhibitor for mild steel in 3% NaCl solution, Desalination 249 (2009) 466–474.
9. Al-Sabagh, M. Migahed, M.A. Abd-El-Raouf, M. Corrosion inhibition of mild steel during acid cleaning process by a new synthesized polyamide based on thiourea, Chem. Eng. Commun. 199 (2012) 737–750.
10. Montemor, M.F. Snihirova, D.V. Taryba, M.G. Lamaka, S.V. Kartsonakis, I.A. Balaskas, I.A.C. Kordas, G.C. Tedim, J. Kuznetsova, A. Zheludkevich, M.L. Ferreira, M.G.S. Evaluation of self-healing ability in protective coatings modified with combinations of layered double hydroxides and cerium molibdate. Electrochim. Acta 60 (2012) 31–40.
11. Shchukin, D. Lamaka, S.V. Yasakau, K.A. Zheludkevich, M.L. Ferreira, M.G.S. Möhwald, H. Mechanism of corrosion inhibition of AA2024 by rare-earth compounds. J. Phys. Chem. C 112 (2008) 958–964.
12. Montemor, M.F. Functional and Smart Coatings for Corrosion Protection: A Review of Recent Advances. Surf. Coat. Technol. 258 (2014) 17–37.
13. Achary, G. Naik, Y.A. Kumar, S.V. Venkatesha, T.V. Sherigara, B.S. An electroactive co-polymer as corrosion inhibitor for steel in sulphuric acid medium, Appl. Surf. Sci. 254 (2008) 5569–5573.
14. Tedim, J. Zheludkevich, M.L. Salak, A.N. Linsekov, A. Ferreira, M.G.S. Nanostructured LDH-container layer with active protection functionality. J. Mater. Chem. 21 (2011) 15464–16687.
15. Al-Amiery AA, Al-Majedy YKA, Kadhum AAH, Mohamad AB. New coumarin derivative as an eco-friendly inhibitor of corrosion of mild steel in acid medium. Molecules 2015;20(1):366-383.
16. Al-Amiery AA, Kadhum AAH, Mohamad AB, Musa AY, Li CJ. Electrochemical study on newly synthesized chlorocurcumin as an inhibitor for mild steel corrosion in hydrochloric acid. Mater 2013;6(12):5466-5477.
17. Junaedi S, Al-Amiery AA, Kadihum A, Kadhum AAH, Mohamad AB. Inhibition effects of a synthesized novel 4-aminoantipyrine derivative on the corrosion of mild steel in hydrochloric acid solution together with quantum chemical studies. Int J Mol Sci 2013;14(6):11915-11928.
18. Obayes HR, Al-Amiery AA, Alwan GH, Abdullah TA, Kadhum AAH, Mohamad AB. Sulphonamides as corrosion inhibitor: Experimental and DFT studies. J Mol Struct 2017;1138:27-34.
19. Kadhum AAH, Mohamad AB, Hammed LA, Al-Amiery AA, San NH, Musa AY. Inhibition of mild steel corrosion in hydrochloric acid solution by new coumarin. Mater 2014;7(6):4335-4348.
20. Obayes HR, Alwan GH, Alobaidy AHMJ, Al-Amiery AA, Kadhum AAH, Mohamad AB. Quantum chemical assessment of benzimidazole derivatives as corrosion inhibitors. Chem Cent J 2014;8(1).

21. Al-Azawi KF, Al-Baghdadi SB, Mohamed AZ, Al-Amiery AA, Abed TK, Mohammed SA, et al. Synthesis, inhibition effects and quantum chemical studies of a novel coumarin derivative on the corrosion of mild steel in a hydrochloric acid solution. Chem Cent J 2016;10(1).
22. Issa AY, Rida KS, Salam AQ, Al-Amiery AA. Acetamidocoumarin as a based eco-friendly corrosion inhibitor. Int J ChemTech Res 2016;9(11):39-47.
23. Al-Amiery AA, Binti Kassim FA, Kadhum AAH, Mohamad AB. Synthesis and characterization of a novel eco-friendly corrosion inhibition for mild steel in 1 M hydrochloric acid. Sci Rep 2016;6.
24. Alobaidy AH, Kadhum A, Al-Baghdadi SB, Al-Amiery AA, Kadhum AAH, Yousif E, et al. Eco-friendly corrosion inhibitor: Experimental studies on the corrosion inhibition performance of creatinine for mild steel in HCl complemented with quantum chemical calculations. Int J Electrochem Sci 2014;10(5):3961-3972
25. Mohamad AB, Kadhum AAH, Al-Amiery AA, Ying LC, Musa AY. Synergistic of a coumarin derivative with potassium iodide on the corrosion inhibition of aluminum alloy in 1.0 M H2SO4. Met Mater Int 2014;20(3):459-467.
26. Al-Amiery AA, Kadhum AAH, Alobaidy AHM, Mohamad AB, Hoon PS. Novel corrosion inhibitor for mild steel in HCL. Mater 2014;7(2):662-672.
27. Kadhum AAH, Mohamad AB, Jaffar HD, Yan SS, Naama JH, Al-Tamimi AA, et al. Corrosion of Nickel-Aluminum-Bronze alloy in aerated 0.1 M sodium chloride solutions under hydrodynamic condition. Int J Electrochem Sci 2013;8(4):4571-4582.
28. Junaedi S, Kadhum AAH, Al-Amiery AA, Mohamad AB, Takriff MS. Synthesis and characterization of novel corrosion inhibitor derived from oleic acid: 2-Amino 5-Oleyl-1,3,4-Thiadiazol (AOT). Int J Electrochem Sci 2012;7(4):3543-3554.