INTERNATIONAL JASIN MULTIMEDIA & COMPUTER SCIENCE INVENTION & INNOVATION EXHIBITION
i-JaMCSIIX 2020

Schiff Base As A Corrosion Inhibitor

Nur Hasniza Abu Hassan, Nur Natasha Mohd Zulkamal Punnia and Nur Nadia Dzulkifli
School of Chemistry and Environment, Faculty of Applied Sciences
University of Technology Mara, Negeri Sembilan Branch, Kuala Pilah Campus, 72000 Kuala Pilah, Negeri Sembilan, Malaysia
nurnadia@uitm.edu.my

ABSTRACT

Mild steel metal plays an important role as a construction material in many industries due to its low cost and excellent mechanical properties. However, acid solution that is widely used for pickling, descaling and oil-well cleaning contributes to severe corrosion problems, mostly in maintenance cost. Schiff base as a corrosion inhibitor is used to reduce the corrosion rate of the metal in this acidic medium. A thiosemicarbazone ligand, DiMMATSC acts as a corrosion inhibitor due to the presence of nitrogen and oxygen as electronegative atoms, where the interactions form a protective layer on the metal surface and block the active corrosion sites. Different concentrations of the inhibitor at 1, 2, 3, 4, and 5 mM were studied at room temperature in 1M HCl. The results showed that as the inhibitor concentration increased, the corrosion rate decreased but the inhibition efficiency increased. Langmuir isotherm was implemented to determine the type of interaction and adsorption between DiMMATSC as an inhibitor with the mild steel surface. A strong correlation from the Langmuir isotherm graph recommends that the adsorbed inhibitors occupy only one site and there are no interactions between the adsorbed species. The value of standard free energy (ΔG) from the calculation is -17.96 kJ mol^{-1}, which indicates spontaneous physisorption of inhibitors onto the mild steel surface by forming a protective film through electrostatic interaction between charged metal surface and charged inhibitor molecules.

KEYWORDS: Corrosion Inhibitor, Schiff Base, Mild Steel

1 INTRODUCTION

Corrosion is a process where metal is corroded when exposed to the environment that consists of moisture. It brings many consequences, especially in industrial applications and daily lives, such as plant shutdown, waste of valuable resources, loss or contamination of products, costly maintenance, and expensive overdesign [1]. Corrosion problems that usually happen in many industries contribute to huge financial losses in terms of repairing and replacing. The use of inhibitors is one of the most practical methods for corrosion protection of metallic objects, particularly in acidic media, which act as a protective barrier against corrosive agents [2]. Corrosion inhibitors are effective agents that minimize corrosion as they can protect metal against corrosion by the adsorption of inhibitor on the metal surface through the formation of a coordinate covalent bond (chemisorption) or the electrostatic interaction between the metallic object and inhibitor (physisorption) [3].

2 OBJECTIVE

There are many studies about thiosemicarbazone applications such as antibacterial, antimalarial, and antitumor but it is very rarely used in anti-corrosion studies. The objective of the study is to determine the anti-corrosion activity of thiosemicarbazone in hydrochloric acid (HCl). The Schiff base (DiMMATSC) can contribute as a new corrosion inhibitor in technological, manufacturing, and industry facilities based on further research with mild steel in acidic conditions.

3 SIGNIFICANCE (S)

The study of corrosion inhibitor is a way to provide knowledge and understanding on how corrosion inhibition operates. The corrosion inhibitor is suggested as the most effective method to inhibit corrosion. Raja (2007) stated that corrosion inhibitors are substances that, when added in small concentrations to the corrosive media, will decrease or prevent the reaction of the metal with the media [4]. Besides, an organic inhibitor is effective and efficient in protecting the metal from corrosion by forming a film on the metal surface which provides a barrier to the metal dissolution. Mostly, organic compounds contain nitrogen, sulfur, oxygen atoms and functional groups such as C=N and conjugated π-bond which will form covalent bonds. These good properties of inhibitor can adsorb well on the surface of mild steel and block the active sites, which reduce the rate of corrosion [5].

4 METHODOLOGY/TECHNIQUE

4.1 Preparation of Solution

The acid used to study the corrosion inhibition of DiMMATSC was HCl. In this study, 1 M HCl was prepared by dilution process using the formula $M_1V_1=M_2V_2$. After that, approximately 8 mL of concentrated HCl was diluted with distilled water in a 100 mL volumetric flask up until the calibration mark. Then, 0.132 g of DiMMATSC was weighed and dissolved in the diluted acidic solution to obtain different solution concentrations. Five different concentrations of inhibitor used were 1, 2, 3, 4, and 5 mM.

4.2 Gravimetric Method

For weight loss study, mild steels were cut to the dimensions of 2 cm × 2 cm. Then, emery papers were used to polish the surface of metal steels in order to remove all dust and impurities. Next, ethanol was used to rinse mild steels, which were then dried with clean tissue papers. The initial weights of the mild steels were taken using an analytical balance before being immersed in 20 mL of 1 M HCl with different concentrations of inhibitor (1, 2, 3, 4, and 5 mM), including a blank (1 M HCl) at room temperature for 24 h. After 24 h, the mild steels were rinsed with acetone and dried in a desiccator. The final weights of mild steels were measured and recorded.

5 RESULT

5.1 Corrosion Inhibition Study

Fig. 1 shows the effect of different concentrations of inhibitor on corrosion rates and inhibition efficiency in 1 M HCl. This is probably due to the coordination by the donor-acceptor interactions between the lone pair of electrons of donor atoms of the ligand [6]. The ligand contains sulfur and nitrogen that have greater polarizability of electron clouds and the presence of electron pairs [7]. The corrosion rate of mild steels decreased as the concentration of inhibitors increased. The inhibition efficiency was better at higher concentration for the metal complex compared to the ligand. The presence of an inhibitor provided a large surface coverage on the mild steel surface, thus blocking available reaction sites. Metal dissolution was inhibited as well, thus retarding hydrogen evolution. Therefore, the mild steels were protected from corrosion. The adsorption provides a uniform film that prevents the interaction of the metal surface with aggressive medium, thus consequently reduces corrosion [8].

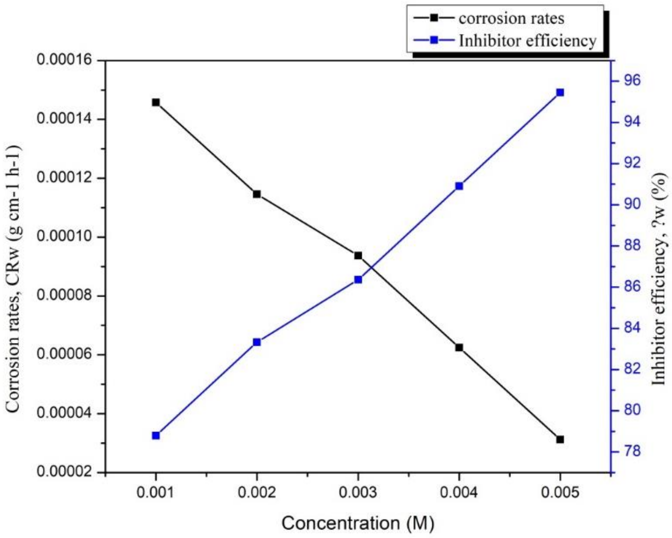

Fig. 1: Corrosion rate and inhibitor efficiency in different concentration of HCl

5.2 Adsorption Isotherm Study

Langmuir adsorption isotherm was implemented to deduce the type of interaction and adsorption between DiMMTSC as an inhibitor with the mild steel surface. Langmuir isotherm calculation was well-suited with the corrosion rate values obtained from the weight loss study. The degree of surface coverage (ϴ) attained from the weight loss study was used to classify the best type of adsorption isotherm that fitted into the corrosion rate values obtained. A fitted straight line was obtained with the correlation, $R^2 = 0.9959$. The strong correlation recommends that the adsorbed inhibitors occupied only one site and there were no interactions between the adsorbed species.

5.3 Standard Free Energy (ΔGads)

Standard free energy (ΔG_{ads}) can be calculated using the following equation:

$$\Delta Gads = -RT\ln(K_{ads} \times A)$$

Where R = gas constant (8.314 $JK^{-1}mol^{-1}$), A = water density (1000 g/L), T = Temperature (K) and K_{ads} = adsorption equilibrium constant. The value of ΔG_{ads} obtained from the calculation was -17.96 $kJmol^{-1}$. This implies spontaneous physisorption of inhibitors onto the mild steel surface by forming a protective film through electrostatic interaction between charged metal surface and charged inhibitor molecules [9]. The values of ΔG_{ads} lower than -20 kJ mol^{-1} were in line with the electric charges between the inhibitor molecules and the mild steel surface (physisorption) and the values lower than -40 kJ mol^{-1} involved sharing of electrons from the inhibitor to the mild steel surface to form a chemical bonding (chemisorption) [10].

6 CONCLUSION

The Schiff base showed a better inhibition efficiency against corrosion of mild steel when using different concentrations of inhibitor in HCl. This was due to the large surface area of the steel surrounded by higher molecular weight of inhibitor ligand, which caused more inhibitor molecules to adsorb on the metal surface. Since the corrosion process was inhibited by the adsorption of this inhibitor on the mild steel surface, it followed Langmuir's adsorption isotherm. The negative value of ΔG_{ads} obtained indicated that the ligand was spontaneously adsorbed on the mild steel surface.

REFERENCES

[1] B. W Allcock, and P. A. Lavin, "Novel composite coating technology in primary and conversion industry applications," Surface & Coatings Technology., vol. 163-164, p. 62–66, 2003.

[2] Y. Meng, W. Ning, B. Xu, W. Yang, K. Zhang, Y. Chen, L. Li, X. Liu, J. Zheng, and Y. Zhang, "Inhibition of mild steel corrosion in hydrochloric acid using two novel pyridine schiff base derivatives: A comparative study of experimental and theoretical results," RSC Advances, vol. 7(68), p. 43014–43029, 2017

[3] F. M. Mahgoub, and S. M. Al-Rashdi, "Investigate the corrosion inhibition of mild steel in sulfuric acid solution by thiosemicarbazide," Open Journal of Physical Chemistry, vol. 6, p. 54–66, 2016.

[4] P. B. Raja, and M. G. Sethuraman, "Natural products as corrosion inhibitor for metals in corrosive media," Materials Letters, vol. 62, p. 113-116, 2008.

[5] P. Rajeev, A. O. Surendranathan, and C. S. N. Murthy, "Corrosion mitigation of the oil well steels using organic inhibitors," Journal Material Environment Science, vol. 3(5), p. 856-869, 2012.

[6] Y. B. Zemede, and A. S. Kumar, "Synthesis, characterization, corrosion inhibition and biological evaluation of schiff bases," International Journal of ChemTech Research, vol. 7(01), p. 279–286, 2015.

[7] T. Poornima, J. Nayak, and S. A. Nityananda, "Effect of 4-(*N*,*N*-diethylamino)benzaldehyde thiosemicarbazone on the corrosion of aged 18 Ni 250 grade maraging steel in phosphoric acid solution," Corrosion Science, vol. 53(11), p. 3688–3696, 2011.

[8] S. John, R. Jeevana, K. K. Aravindakshan, and A. Joseph, "Corrosion inhibition of mild steel by *N*(4)-substituted thiosemicarbazone in hydrochloric acid media," Egyptian Journal of Petroleum, vol. 26(2), p. 405–412, 2017.

[9] H. Ekemini, A. Onyewuchi, and J. Abosede, "Evaluation of performance of corrosion inhibitors using adsorption isotherm models: An overview," Chemical Science International Journal, vol. 18(1), p. 1-34, 2017.

[10] S. A. X. Stango, and U. Vijayalakshmi, "Studies on corrosion inhibitory effect and adsorption behaviour of waste materials on mild steel in acidic medium," Journal of Asian Ceramic Societies, vol. 6(1), p. 20-29, 2018.