



Study of Corrosion Inhibition of Mild Steel in 3% NaCl Solution Using Weight Loss Method

¹*Pritee Raotole, ²R. S. Khadayte, ¹Vishnu Huse

¹Mahatma Gandhi Shikshan Mandal's Arts Science and Commerce College, Chopda, 425 107, Maharashtra, INDIA.

²G. D. M. Arts, K.R.N. Commerce and M. D. Science College, Jamner, Dist-Jalgaon, Maharashtra, INDIA

Abstract: This study employed a quantitative analysis method to determining the corrosion rate based on weight loss method. It involved exposing the mild steel substrate samples to the corrosive media i.e. 3 % NaCl for different exposure time. The measurement of specimen weight done before and after exposure and measuring the loss of weight of sample to find the corrosion rate as function of time.

Then inhibitive effect of o-anisidine with different concentration on corrosion of mild steel in 3% NaCl was investigated. The inhibition performance of o-anisidine results illustrate that o-anisidine act as effective corrosion inhibitor for mild steel in 3% NaCl. It was observed that corrosion inhibition efficiency and corrosion rate obtained from weight loss method increases with increase in concentration of o-anisidine. The Langmuir adsorption plot illustrate the strong adsorption of o-anisidine molecules on the mild steel surface.

Keywords - corrosion inhibitor, conducting polymer, mild steel, NaCl

I. INTRODUCTION

A corrosion inhibitor is a chemical additive which when added to a corrosive aqueous environment reduces the rate of metal corrosion. Conducting polymers, due to their inherent nature, offer better inhibition efficiency than organic compounds because of conjugated systems which possess alternate single and double bonds. Rich in electrons it gets effectively adsorbed on metallic surface. It acts as protective film and prevents corrosion. Polymers have the ability to control the corrosion process of various metals such as mild steel, [1-10]. Mild steel is the substance of choice in oil manufactures for its ability to work mechanical and low cost [11,12]. Polymers function as corrosion inhibitors because of their ability to form complexes through their functional groups with metal ions which occupy large area and by so doing blanket the metal surface from aggressive anions present in solution [13]. In general, the cyclic organic compounds containing heteroatoms reported have an excellent inhibition efficiency, but they are limited to use due to the following: (1) high production cost, (2) Toxicity of the secondary compounds which formed during their production or via side reactions resulting in ecological concern and (3) the specificity of work related with the utilize of individual organic corrosion inhibitors [14]. Thus, inhibitors must be active, not expensive and eco-friendly [15,16].

Mild steel possessed good tensile strength and it has low cost. It is easy to fabricate and hence readily available. These account for its being widely used in many industries. However, it suffers severe corrosion when it comes in contact with acid solutions during acid cleaning, transportation of acid, de-scaling, storage of acids and other chemical processes. Corrosion is a natural phenomenon, which degrades the metallic properties

of metals and alloys. Corrosion of metals is a major industrial problem that has attracted much investigations and researches, in some cases corrosion inhibitors are introduced to reduce the menace of corrosion [17]. A corrosion inhibitor is a chemical additive which when added to a corrosive aqueous environment reduces the rate of metal wastage. It is widely accepted that inhibitors especially the organic ones work by an adsorption mechanism. The resultant film of chemisorbed inhibitor is then responsible for protection either by physically blocking the surface from the corrosion environment or by retarding the electrochemical processes. The main functional groups capable of forming chemisorbed bonds with metal surfaces are amino (-NH₂), carboxyl (-COOH) and phosphate (-PO₃H₂) although other functional groups or atoms can form coordinate bonds with metal surfaces[13]. The use of polymers as corrosion inhibitors has attracted considerable attention recently. Polymers are used as corrosion inhibitors because, through their functional groups they form complexes with metal ions and on the metal surface these complexes occupy a large surface area, thereby blanketing the surface and protecting the metal from corrosive agents present in the solution [18].

In the present work inhibitive effect of conducting polymer with different concentration on corrosion of mild steel in 3% aqueous NaCl corrosive environment was investigated with weight loss method.

II. EXPERIMENTAL

2.1. Materials

All chemicals were of analytical grade. The monomers, o-anisidine were procured from Fluka and were doubly distilled prior to being used. Sodium chloride (NaCl) was procured from Merck and used as-received without further purification. Bi-distilled water was used to prepare all the solutions.

2.2. Substrate preparation

The mild steel substrates were polished with a series of emery papers. After polishing, the substrates were cleaned with acetone and double distilled water and dried in air. Prior to any experiment, the substrates were treated as described and freshly used with no further storage. Steps adopted during substrate preparation are as follows

- a) The mild steel sample were cleaned before dipping in distilled water for 5 minutes
- b) After which the mild steel samples were soaked in acetone for 5 minutes
- c) Then the sample is allowed to dry in sun, followed by obtaining the initial weight (W₁) of individual mild steel sample using a digital weighing balance.
- d) The size of sample measured to ascertain the area of the sample
- e) The weighted mild steel samples were there after put back inside the solution
- f) After completion of immersion time, each of mild steel samples are brought out and thoroughly cleaned by same procedure as above and weighted again. And note down the final weight (W₂)
- g) Then evaluate the weight loss
- h) Then find the corrosion rate by given formula.

2.3. Solution preparation

Initially the solution of corrosive media i.e. 3% NaCl was prepared in 100 ml distilled water enough to dissolve the solid NaCl salt. The inhibitor solutions were prepared by adding different concentration i.e. 0.05M, 0.001M, 0.005M, 0.01M and 0.05M of o-anisidine in 3% NaCl solution.

2.4. Weight loss measurement

The weight loss measurements were performed using cleaned and dry mild steel sample and its initial weight was recorded before immersion in solution. These samples were immersed in corrosive environment i.e. 3% NaCl and inhibitive solutions with presence of o-anisidine of different concentration after every two hours the samples were brought out washed, dried and then weighted. After that the loss in weight was calculated through by the variation in mild steel sample weights before and after immersion. Then Corrosion rate (CR), inhibition efficiency (IE%), and mild steel surface coverage (θ) were measured via Equations (1)–(3).

$$CR = \frac{w}{A t} \quad \text{----- (1)}$$

$$IE \% = \frac{CR_0 - CR}{CR_0} \times 100 \quad \text{----- (2)}$$

$$\theta = \frac{CR_0 - CR}{CR_0} \quad \text{----- (3)}$$

where W is the loss in weight of the mild steel sample in gram, A represent the area in cm^2 , t is the immersion time in hours and CR_0 is the corrosion rate in absence of *o*-anisidine and CR is the corrosion rate in presence of *o*-anisidine. Determination of weight loss was repeated at least three times and result shows good repeatability.

III. RESULTS AND DISCUSSIONS

3.1 Weight loss measurement

The experimental work conducted for 8 hours. At this stage, simulated laboratory work was carried out to measure the metal loss rate due to corrosion. When mild steel samples are exposed to various concentrations of salt solutions. The solutions and samples were placed into a glass container, washed dried and reweighed on electronic weighing balance after dipping. Sample retrieval was carried out periodically for 2 Hrs. as such, in order to get a time function data of metal loss, every sample is assumed uniform in terms of strength, thickness and corrosion resistance. Hence, metal loss measurements from respective retrieval at different time within 8 Hrs. period are considered correlated with each other.

The weight loss measurement results for mild steel sample in the 3% NaCl environment with and without of *o*-anisidine as corrosion inhibitor were for different immersion time was demonstrated in Table 3.1 and Fig 1. The excellent inhibition efficiency of new synthesized corrosion inhibitor for mild steel samples in 3% NaCl corrosive environment was attributed to the existence of a number of heteroatoms, aromatic rings and carbonyl compound in *o*-anisidine molecule in addition to big molecular structure of *o*-anisidine.

3.2. Adsorption Isotherms

The values obtained for surface coverage (θ) or Inhibition Efficiency (IE %) were used by weight loss calculations to find the best and most suitable adsorption isotherm shown in Fig-2. The adsorption isotherm helps to realize the bonding between the *o*-anisidine molecules and the sample surface. The *o*-anisidine molecules on the sample surface are absorbed chemically or physically. To realize the adsorption phenomenon, isothermal adsorption was utilized to methodological results. It was noted that the adsorption isotherm of Langmuir was very well constructed, with the regression coefficient (R_2) value of *o*-anisidine, indicating a good fit. The obtained slope was and intercept value obtained for the Langmuir isotherm was tabulated in table 3.2. The Langmuir isotherm plot between $\log(\theta/1 - \theta)$ versus $\log C$ yielded a straight line (Fig. 2), where C is the inhibitor concentration, proving that the inhibition is due to the adsorption of the active compounds onto the metal surface and obeys the Langmuir isotherm. It is significant to note that this plots is linear and gave a positive average value of slope equal to 23.08, which indicates a strong adherence to the Langmuir adsorption isotherm.

Table 3.1: Weight loss measurement results for mild steel sample in the 3% NaCl environment with and without of o-anisidine as corrosion inhibitor were for different immersion time

Immersion Time 2 Hours						
Type of solution	W ₁	W ₂	Weight Loss	Corrosion Rate	Surface Coverage θ	Inhibition efficiency (IE %)
Blank	1.2567	1.255	0.0017	0.000425	--	--
0.001	1.158	1.1571	0.0009	0.000225	0.4705	47.05%
0.005M	0.9376	0.9373	0.0003	0.000075	0.8235	82.35%
0.01M	1.0044	1.0042	0.0002	0.00005	0.8823	88.23%
0.05M	0.7388	0.7387	0.0001	0.000025	0.9411	94.11%
Immersion Time 4 Hours						
Blank	1.2115	1.2023	0.0092	0.00115	--	--
0.001	1.355	1.350	0.005	0.00062	0.4505	45.05%
0.005M	0.8784	0.8775	0.0009	0.000112	0.9021	90.21%
0.01M	1.1665	1.166	0.0005	0.000062	0.9456	94.56%
0.05M	1.0169	1.0166	0.0003	0.0000375	0.9673	96.73%
Immersion Time 6 Hours						
Blank	1.8583	1.8037	0.0546	0.00455	--	--
0.001	1.307	1.297	0.01	0.000833	0.8169	81.69%
0.005M	1.8179	1.8164	0.0015	0.000125	0.9725	97.25%
0.01M	1.1149	1.1137	0.0012	0.00001	0.978	97.80%
0.05M	1.1725	1.1720	0.0005	0.0000041	0.9901	99.01%
Immersion Time 8 Hours						
Blank	1.1111	1.0326	0.0785	0.00049	--	--
0.001	1.1144	1.0759	0.0385	0.00024	0.5105	51.05%
0.005M	0.9635	0.9453	0.0182	0.000113	0.7693	76.93%
0.01M	1.0984	1.0916	0.0068	0.000042	0.9142	91.42%
0.05M	1.3442	1.3434	0.0008	0.000005	0.9847	98.47%

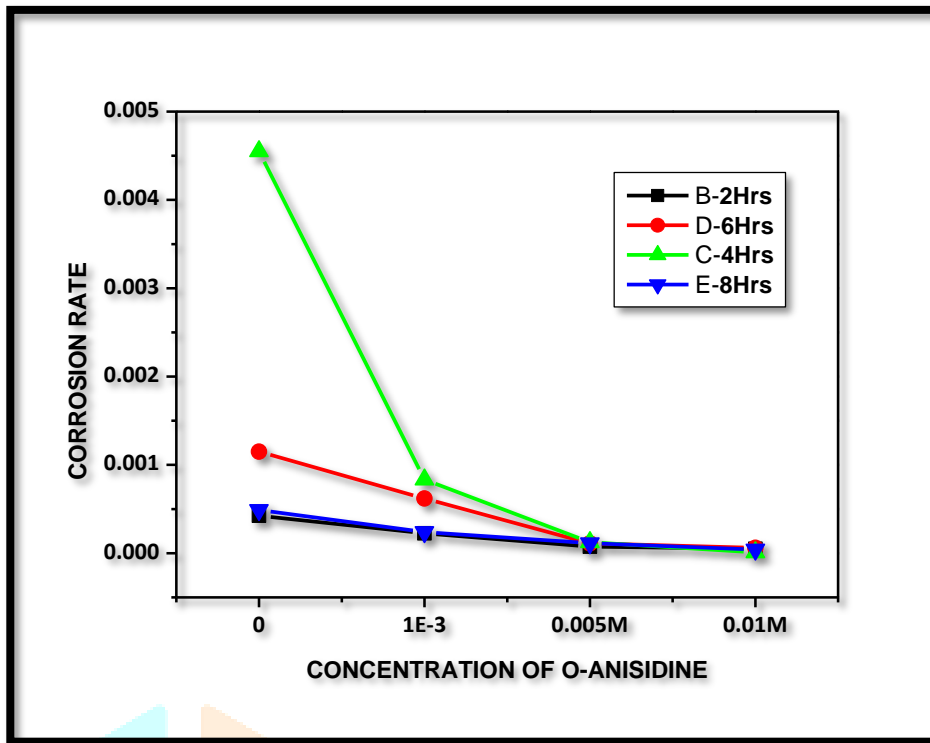


Figure 1. Plot of Concentrations of o-anisidine Vs Corrosion Rate for mild steel samples in 3% NaCl for different immersion time

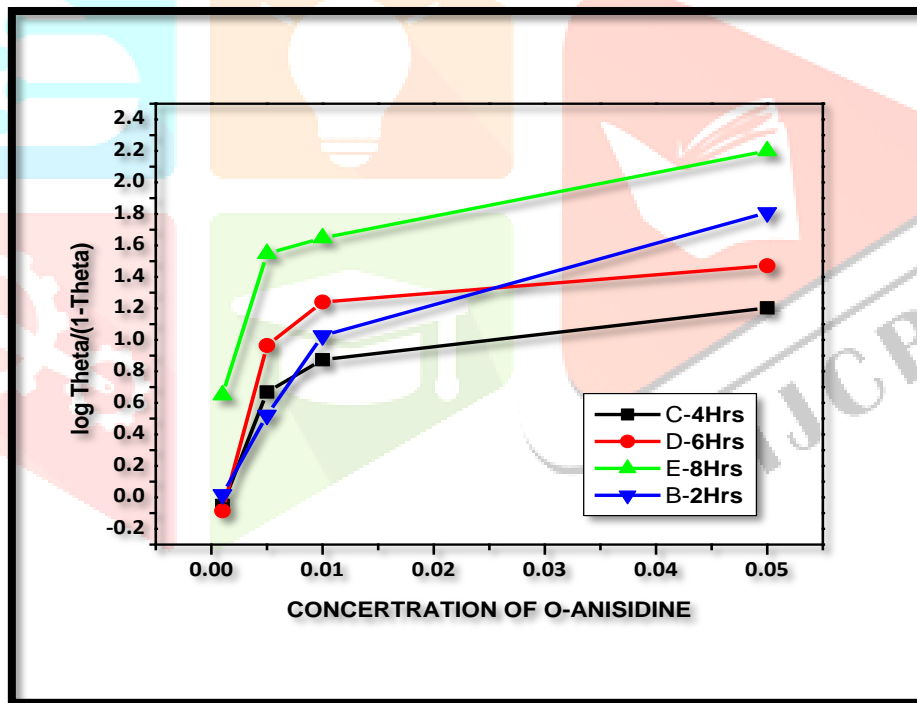


Figure 2. Effect of various concentrations of o-anisidine on the inhibition efficiency for mild steel samples in 3% NaCl at 300° K for different immersion time.

Table 3.2: The obtained slope was and intercept value obtained for the Langmuir isotherm

Dipping Duration	Slope	Intercept
2Hrs	18.047	0.356
4Hrs	20.47	0.599
6Hrs	22.84	1.134
8Hrs	30.97	0.333

4. Conclusions

1. The o-anisidine acts as excellent corrosion inhibitor for mild steel in 3% NaCl solution.
2. Inhibition performance increased with increasing o-anisidine concentration
3. Evaluation of adsorption isotherm parameters implies the formation of protective layer at the mild steel/corrosive environment interface.

IV. ACKNOWLEDGMENT

The financial support from Kavayitri Bahinabai Chaudhari, North Maharashtra University, Jalgaon under VCRMS scheme. Authors would like to acknowledge UGC for the financial support via minor research project.

V. REFERENCES

- [1] Banumathi, N., Subhashini, S., Rajalakshmi, R., E-J. Chem., 2010, 7, S67
- [2] Wang, S., Wylde, J.J., NACE-Int. Corros. Conf. Series., 2009.
- [3] Achary, A.G., Naik, Y.A., Kumar, S.V., Venkatesha, T.V., Appl. Surf. Sci., 2008, 254, 5569.
- [4] P Pawar, AB Gaikwad, PP Patil, Electrochimica Acta 52 (19), 5958-5967, 2007
- [5] P Pawar, AB Gaikwad, PP Patil, Science and Technology of Advanced Materials 7 (7), 732-744, 2006
- [6] P Pawar, SR Sainkar, PP Patil, Journal of applied polymer science 103 (3), 1868-1878, 2007
- [7] PM Raotole, P Koinkar, B Joshi, SR Patil, Journal of Coatings Technology and Research 12 (4), 757-766, 2015.
- [8] P Raotole, M Raotole, VT Patil, VR Huse, AL Chaudhari, AIP Conference Proceedings 1728 (1), 020123, 2016
- [9] P .M. Raotole, VT Patil, VR Huse, Journal of Engineering Sciences (JES) 11 (4), 1323-1325, 2020.
- [10] Pritee Raotole^{1*}, M. L. Raotole, V.T. Patil, ALC V.R. Huse, A.Z. Shaikh,, International Journal of Innovative Research in Science, Engineering and ..., 2017
- [11] Adewuyi, A.; Göpfert, A.; Wolf, T. Succinyl amide gemini surfactant from Adenopus breviflorus seed oil: A potential corrosion inhibitor of mild steel in acidic medium. Ind. Crops Prod. 2014, 52, 439–449.
- [12] Anupama, K.K.; Ramya, K.; Joseph, A. Electrochemical measurements and theoretical calculations on the inhibitive interaction of Plectranthusamboinicus leaf extract with mild steel in hydrochloric acid. Measurement 2017, 95, 297–305
- [13] S.A. Umoren, The Open Corrosion Journal, 2009, 2, 175-188 a review.
- [14] Fanar Hashim 1, Khalida Al-Azawi 1, Shaimaa B. Al-Bghdadi 2, Lina M. Shaker 2 and Ahmed Al-Amiery, MDPI Proceedings 2019, 41, 15;
- [15] Morad, M.S. Inhibition of iron corrosion in acid solutions by Cefatrexyl: Behaviour near and at the corrosion potential. Corros. Sci. 2008, 50, 436–448.
- [16] Abiola, O.K.; James, A.O. Te Effects of Aloe Vera Extract on Corrosion and Kinetics of Corrosion Process of Zinc in HCl Solution. Corros. Sci. 2010, 52, 661–664.
- [17] David Ebuka Arthur¹ · Stephen Eyije Abechi, SN Applied Sciences (2019) 1:1089 research article
- [18] Rajendran S, Sridevi SP, Anthony N, John Amalraj A, Sundearavadivelu M. Corrosion behaviour of carbon steel in polyvinyl alcohol. Anti-Corrosion Methods Mater