Nigerian Research Journal of Chemical Sciences **(ISSN: 2682-6054)**
Volume 8, Issue 2, 2020

SYNTHESIS OF SCHIFF BASE DERIVED FROM ANTHRANILIC ACID AND ITS POTENTIALS ON OIL AND GAS PIPELINE CORROSION INHIBITION

Ibrahim I.A., Mahmud S.D., *Sani S. and Almustapha, M.N.

Department of Pure and Applied Chemistry, Usmanu Danfodiyo University, Sokoto, Nigeria.

*Correspondence author: salihusani016@gmail.com

ABSTRACT

The corrosion inhibition of zinc sheet in 2 M H_2SO_4 by 2-[(4-Hydroxy-benzylidene)-amino]-benzoic acid Schiff base derived from condensation reaction of 4-hydroxybenzaldehyde and 2-aminobenzoic acid has been studied at room temperature using weight loss measurements. Determination of corrosion rate at 1 h immersion time with varying concentrations of the inhibitor at room temperature was also studied. The weight loss obtained for sample A (blank sample) with initial and final weight of 3.1900 and 2.061 g respectively was 1.1294 g while for samples B, C, D and E were in the range of 0.504 – 0.076 g. The results obtained from the calculated data showed that inhibition efficiency increased when the inhibition concentration increased. The synthesized Schiff base showed maximum inhibition efficiency of 96.3% at 0.1 M concentration of the inhibitor and as such the Schiff base can be used as a corrosion inhibitor.

Keywords: Anthranilic acid, Inhibitor, Oil and Gas, Pipeline corrosion, Schiff base.

INTRODUCTION

Corrosion is the destructive attack of a substance by reaction with its environment [1] and a potential natural hazard associated with oil and gas production and transportation facilities [2]. Nearly any aqueous environment may promote corrosion, which occurs in oil and gas production, processing, and pipeline systems under various complex condition [3]. The corrosion process is composed of three components: a cathode, an anode and an electrolyte. The cathode forms the electrical conductor in the cell that is not consumed in the corrosion process. The anode is the site of the corroding metal, and the electrolyte is the corrosive medium that enables the transfer of electrons from the anode to the cathode [4]. Crude oil and natural gas can carry various high-impurity products which are inherently corrosive.

Inhibitors are chemicals that are normally used to protect the surface of metals used in oil and gas industries to prevent corrosion. They protect the surface of metals either by merging with them or by reacting with some impurities in the surrounding environment that may cause pollution [5]. A corrosion inhibitor may work in a number of ways: It may limit the rate of the anodic process or the cathodic process by simply blocking active sites on the metal surface. Alternatively, it may act by increasing the metal surface potential so that the metal reaches the area of passivation where a natural oxide film forms. Further mode of action of some inhibitors is that the inhibiting compound leads to the formation of a thin layer on the surface which stifles the corrosion process [6].

Plating is a finishing process that is used to add a protective coating to a metal part's surface. Zinc plating was primarily used to take advantage of the protective properties of zinc against strong corrosion. Lots of goods in oil and gas sector need zinc-coated or zinc-electroplated materials to provide protection against corrosion in harsh conditions. Usually electroplated zinc coatings are applied at thicknesses ranging from only a few microns for less costly materials to 15 microns or more for highly expensive iron and steel parts. Depending on environmental and atmospheric conditions and other factors a zinc coating can delay the onset of corrosion by 10 to 100 times. When first exposed to the atmosphere a freshly plated zinc surface is extremely reactive. However, a thin protective film is forming rapidly, which greatly reduces the corrosion risk of the zinc-plated substrate [7].

Schiff base compounds are condensation products of primary amines and carbonyl compounds [8]. They possess functional group containing carbon-nitrogen double bond with the nitrogen atom linked to an aryl or alkyl group, with the exception of hydrogen. Schiff bases of aliphatic aldehydes are relatively unstable which readily undergo polymerization while those of aromatic aldehydes having an effective conjugation system are found to be more stable. Schiff bases of aliphatic aldehydes are relatively unstable and are readily polymerizable while those of aromatic aldehydes, having an effective conjugation system, are more stable.

Recent publications show increased concern for these compounds as corrosion inhibitors for various metal such as steel, aluminum, zinc and copper in especially acidic medium [9-12].

Previously, various researchers have studied steel corrosion inhibition by acids using different organic compounds [13-16]. In general, these compounds are adsorbed onto the metal surface that blocks the active corrosion sites. Several Schiff bases in acidic media have been investigated as corrosion inhibitors for different metals and alloys [17-18].

Zinc is used as a protective coating against corrosion in oil and gas pipelines. Therefore, the aim of the present study is to investigate the corrosion behavior of zinc metal sheet in 2 M H_2SO_4 solution in the presence and absence of Schiff base compound using weight loss technique.

The objectives of the research are to synthesize Schiff base derived from condensation reaction of 4-hydroxybenzaldehyde and 2-aminobenzoic; to partially characterize the Schiff base using IR, melting point and solubility test; to also investigate the corrosion behaviour of zinc metal in 2 M H_2SO_4 solution in the absence and presence of Schiff base as corrosion inhibitor at different concentrations.

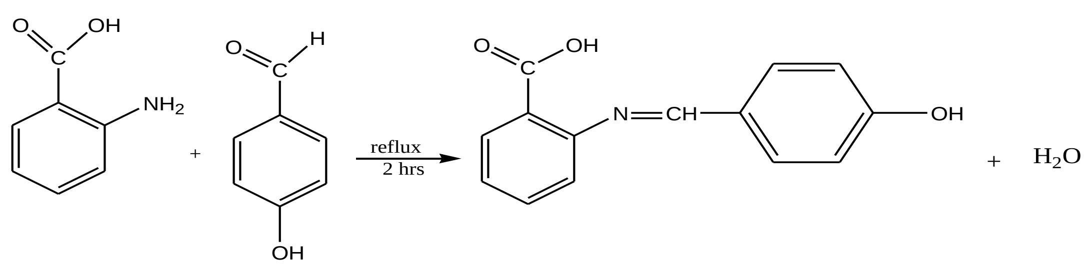
The synthesized Schiff base was assessed for its inhibition potential.

MATERIALS AND METHODS

Reagents used in this study were obtained from Sigma Aldrich UK and were used as obtained without further purification. FT-IR spectra were performed on a Perkin-Elmer FT-IR Spectrum-400 (USA). Melting points were determined using digital melting point MPA100.

Synthesis of the Schiff base

2-aminobenzoic acid (10.00 g, 7.29 mmol) was dissolved in 50 cm^3 hot absolute ethanol and 4–hydroxybenzaldehyde (7.09 g, 7.29 mmol) in 50 cm^3 hot absolute ethanol was added drop wise with stirring. The resulting solution was refluxed for 2 h. An orange precipitate formed upon cooling, which was filtered and washed with cold ethanol and allowed to dry in air. The product was recrystallized from hot ethanol and dried on silica gel. The mass of the Schiff base product was weighed as 10.70 g [19].



Scheme 1: Synthetic Reaction of the Schiff base

Weight Loss Measurement

This is a preliminary assessment of the synthesized Schiff base for corrosion inhibition potentials.

Preparation of Zinc metal sheet

The zinc metal sheet used for the study was cut into 3 x 5 cm size for weight loss measurement. The sheets were polished using sand-paper, then soaked in ethanol solution for 10 min for de-greasing, rinsed with distilled water, kept in a desiccator. This is necessary to prevent contamination before usage for corrosion studies.

Weight loss Measurements

Weight loss experiment was carried out by weighing the sample before and after immersion of the sample in the corrosion inhibition medium. The specimens were immersed in (50 cm^3) 2 M H_2SO_4 solution without and with various concentrations of the studied inhibitors for a period of 1 h at room temperature. The specimens were taken out, washed with distilled water, ethanol and dried. The weight loss values were taken as the difference between the initial weight and the final weight of the test specimens [20].

The corrosion rate and percentage inhibition efficiency are calculated using equation 1 and 2 respectively.

$$\text{Corrosion rate in millimeter per year (MM/P)} = 87.6 \text{ X } (W / DAT) \quad (1)$$

Where

W = weight loss in milligrams

D = metal density in g/cm^3

A = area of the sample in cm^3

T = time of exposure of the metal sample (1 h)

Furthermore, the inhibition efficiency (IE) of each sample was calculated by using equation 2

$$IE = (V_0 – V_1) / V_0 \quad (2)$$

Where

V_0 = corrosion rate before treatment

V_1 = corrosion rate after treatment at different concentrations

RESULTS AND DISCUSSION

The Schiff base was a non-hygroscopic orange crystalline solid with melting point range of 103 – 107 ^{o}C and yield of 82.5% (Table 1). The synthesized Schiff base was soluble in polar solvents, methanol, ethanol, and liquid ammonia, but insoluble in non-polar solvents, benzene and hexane. The solubility of the synthesized compound in some common polar solvents was due to the polar nature the compound (Table 2).

Table 1: Physical properties of the Schiff Base

Compound	Molecular formula	Colour	Yield (%)	Melting point (°C)
(H_2L')	$C_{14}H_{11}NO_3$	Orange	72.5	105

Table 2: Solubility Test of Schiff Base

Compound	Methanol	Ethanol	Liquid ammonia	Benzene	Hexane
(H_2L')	S	S	S	IS	IS

FT-IR spectrum of the synthesized Schiff base was compared with the spectra of the reactants. The preliminary identification of the Schiff base was observed from the absence of IR bands characteristics of the amino and carbonyl groups.

This was further confirmed by the presence of new bands at 1643 cm^{-1}due to -C=N- of azomethine (Table 3). Strong peak at 3520 cm^{-1} was also observed which was assigned to O-H stretching vibration. The band observed at 1510 cm^{-1} in the IR spectrum of (H_2L') Schiff base are characteristics of C=C symmetric stretching of aromatic ring [21]. The spectra of Schiff base also show band corresponding to aromatic C-H stretching at 3050 cm^{-1}[22].

Table 3: Infrared spectral data of Schiff Base (cm^{-1})

Compound	ν(C=N)	ν(O–H)	ν(C=C)	ν(C–H)
(H_2L')	1643	3520	1510	2750

Table 4 shows results obtained from the weight loss measurement which indicated a decrease in weight loss of zinc metal with increase in concentration of the inhibitor, which were in agreement with what was reported by James et al., [23]. The results show an increase in inhibition efficiency (IE), but decrease in corrosion rate with increase in concentrations of inhibitors in 2 M H_2SO_4 at room temperature. The results also indicated that the maximum efficiency of 93% at 0.1 molar concentration of the Schiff base, while the least efficiency of 55% was obtained at 0.0001 molar concentration of the Schiff base (Fig. 1). The obtained results were in agreement with what was reported by Bentiss et al. [24]. This behavior could be due to the strong interaction of the compound with metal and resulted in the adsorption of the inhibitor molecules on metal surface, there by blocking the active site of the metal surface [23]. It may also be due to the presence of lone pair of electrons on nitrogen atom which it can donate to metal surface to increase adsorption and enhance inhibition [25]. At high concentration of inhibitor, a coherent and compact film is formed on the metal surface which reduces the chances of attack of chemical on metal.

Table 4: Corrosion Rate, Weight loss, Concentration of the inhibitor, and Inhibition Efficiency of the zinc metal at 1-hour immersion time

Sample	Inhibitor Conc. (M)	Weight loss (gram)	Inhibitor Efficiency (%)	Corrosion rate (mmpY')
A (Blank)	-	1.129	-	1.533
B	0.0001	0.504	75.6	0.374
C	0.001	0.368	85.1	0.229
D	0.01	0.110	94.7	0.081
E	0.1	0.076	96.3	0.056

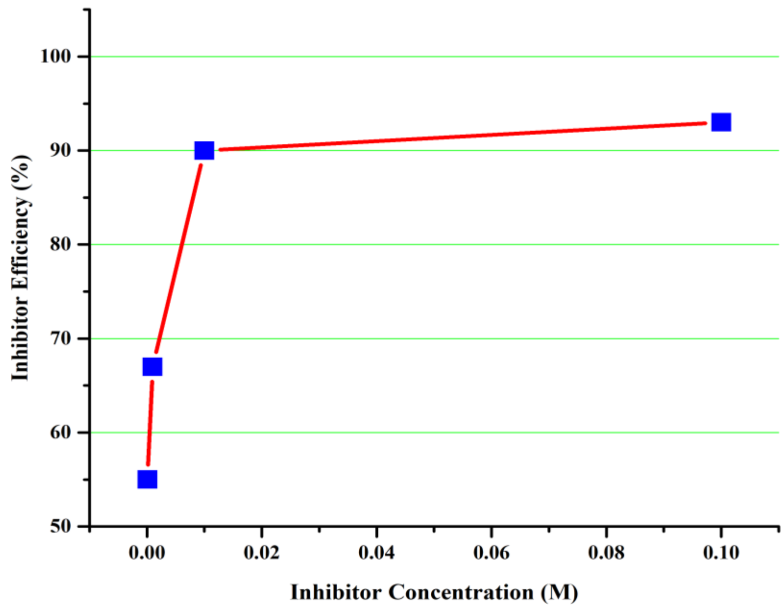


Fig 1: Showing Relationship between Inhibitor efficiency (%) and Inhibitor Concentration (M)

CONCLUSION

Based on the results obtained from the present study, the percentage inhibition efficiency was seen to increase with increasing inhibitor concentration. The Inhibition was as a result of the adsorption of the Schiff base compound on zinc sheet surface and blocking of the active sites. Corrosion is a phenomenon requiring interdisciplinary approach. The damage caused by corrosion occurs not only in the oil and gas industries but also in other major areas such as construction, manufacturing, transportation etc. Corrosion is thus a global problem that everybody must find a solution to because it affects many fields.

REFERENCES

[1] Roberge, P.R. (2000). Handbook of Corrosion Engineering Mcgraw-Hill. *New York, NY*

[2] Kermani, M. B. & Smith, L. M. (1997). CO~ 2 Corrosion Control in Oil and Gas Production Design Considerations. *Book-Institute of Materials*, 688

[3] Al-izzi, T. Y. (2018). Corrosion protection of copper pipes in cooling systems using poly styrene solution in North oil Company/Baba Gorge. *Journal of Petroleum Research & Studies*, E188–E197.

[4] Corbin, D. & Willson, E. (2007). In New technology for real-time corrosion

detection.*Proceedings Title: Tri-service Corrosion Conference, USA.*

[5] Rajeev, P., Surendranathan, A. O., & Murthy, C. S. (2012). Corrosion mitigation of the oil well steels using organic inhibitors–a review. *Journal of Materials and Environmental Science*, 3, 856–869.

[6] Jisha, M., Hukuman, N.Z., Leena, P., & Abdussalam, A.K. (2019). Electrochemical, computational and adsorption studies of leaf and floral extracts of Pogostemon quadrifolius (Benth.) as corrosion inhibitor for mild steel in hydrochloric acid. *Journal of Materials and Environmental Science*, 10(9), 840-853

[7] Kavitha, B., Santhosh, P., Renukadevi, M., Kalpana, A., Shakkthivel, P., & Vasudevan, T. (2006). Role of organic additives on zinc plating. *Surface and Coatings Technology*, 201, 3438–3442.

[8] Ashraf, M.A., Mahmood, K., Wajid, A., Maah, M.J., & Yusoff, I. (2011). Synthesis, characterization and biological activity of Schiff bases. *IPCBEE* 10, 1–7.

[9] Emregül, K.C. & Atakol, O. (2004). Corrosion inhibition of iron in 1 M HCl solution with Schiff base compounds and derivatives. *Materials Chemistry and Physics*, 83, 373–379.

[10] Shokry, H., Yuasa, M., Sekine, I., Issa, R. M., El-Baradie, H.Y., & Gomma, G.K. (1998). Corrosion inhibition of mild steel by Schiff base compounds in various aqueous solutions: part 1. *Corrosion science*, 40, 2173–2186.

[11] Ma, H., Chen, S., Niu, L., Shang, S., Li, S., Zhao, S., & Quan, Z. (2001). Studies on electrochemical behavior of copper in aerated NaBr solutions with Schiff base, N, N′ o-phenylen-bis (3-methoxysalicylidenimine). *Journal of the Electrochemical Society*, 148, B208–B216.

[12] Emregül, K.C., Kurtaran, R., & Atakol, O. (2003). An investigation of chloride-substituted Schiff bases as corrosion inhibitors for steel. *Corrosion Science*, 45, 2803–2817.

[13] El-Rehim, S.A., Ibrahim, M.A., & Khaled, K.F. (1999). 4-Aminoantipyrine as an inhibitor of mild steel corrosion in HCl solution. *Journal of Applied Electrochemistry*, 29, 593–599.

[14] Sykes, J.M. (1990). Silver Jubilee review 25 years of progress in electrochemical methods. *British Corrosion Journal*, 25, 175–183.

[15] Rengamani, S., Muralidharan, S., Kulandainathan, M. A., & Iyer, S.V. (1994). Inhibiting and accelerating effects of aminophenols on the corrosion and permeation of hydrogen

through mild steel in acidic solutions. *Journal of applied electrochemistry*, 24, 355–360.

[16] Ajmal, M., Mideen, A.S., & Quraishi, M.A. (1994). 2-Hydrazino-6-methyl-benzothiazole as an effective inhibitor for the corrosion of mild steel in acidic solutions. *Corrosion Science*, 36, 79–84.

[17] Desai, M.N., Desai, M.B., Shah, C.B., & Desai, S.M. (1986). Schiff bases as corrosion inhibitors for mild steel in hydrochloric acid solutions.*Corrosion science*, 26, 827–837.

[18] Li, S.L., Wang, Y.G., Chen, S.H., Yu, R., Lei, S.B., Ma, H.Y., & Liu, D.X. (1999). Some aspects of quantum chemical calculations for the study of Schiff base corrosion inhibitors on copper in NaCl solutions. *Corrosion Science*, 41, 1769–1782.

[19] Ejidike, I.P. & Ajibade, P.A. (2015). Synthesis, characterization, antioxidant, and antibacterial studies of some metal (II) complexes of tetradentate schiff base ligand:(4E)-4-[(2-(E)-[1-(2, 4-dihydroxyphenyl) ethylidene] aminoethyl) imino] pentan-2-one. *Bioinorganicchemistry and applications*, Article ID 890734.

[20] Echem, O.G., Oforka, N.C., & Abosode, J. (2014). Synthesis and characterization of 4-[(E)-(-2, 5-dimethoxybenzylidene) amino] benzoic acid Schiff base and evaluation as corrosion inhibitor of steel in 2.0 MH 2 SO 4. *Journal of Applied Sciences and Environmental Management*, 18, 63–69.

[21] Vadivel, T. & Dhamodaran, M. (2016). Synthesis, characterization and antibacterial studies of ruthenium (III) complexes derived from chitosan Schiff base. *International journal of biological macromolecules*, 90, 44–52.

[22] Mapari, A.K. & Mangaonkar, K.V. (2011). Synthesis, characterization and antimicrobial activity of mixed Schiff base ligand complexes of transition metal (II) ions. *International Journal of ChemTech Research*, 3, 477–482.

[23] James, A.O., Oforka, N. C., & Abiola, O.K. (2007). Inhibition of acid corrosion of mild steel by pyridoxal and pyridoxol hydrochlorides. *International Journal of Electrochemical Science*, 2, 278–284.

[24] Bentiss, F., Traisnel, M., & Lagrenee, M. (2000). The substituted 1, 3, 4-oxadiazoles: a new class of corrosion inhibitors of mild steel in acidic media. *Corrosion science*, 42, 127–146.

[25] Adams, K.E. & Rans, T.S. (2013). Adverse reactions to alcohol and alcoholic beverages. *Annals of Allergy, Asthma & Immunology*, 111, 439–445.