*Research Journal of Chemical Sciences* ISSN 2231-606X
Vol. **16(2),** 64-67, June **(2026)** *Res. J. Chem. Sci.*

# Analysis of Corrosion inhibition Efficacy of novel Nitrogen containing Ligands on Aluminium in acid mixture

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**Available online at: www.isca.in, www.isca.me**
Received 20th April 2026, revised 25th May 2026, accepted 15th June 2026

## Abstract

*The mass loss method was used to analyze the corrosion inhibition of Aluminum in an acid mixture (HCl+ $H_2SO_4$) by novel nitrogen-containing ligands (Schiff's bases), namely, N(vanillidine)-4-methyl-1-phenylimine ($SB_1$), N(vanillidine)-4-methoxy-1-phenylimine ($SB_2$), and N(anisidine)-1-napthylimine($SB_3$ ).The inhibition efficacy values extracted from the two methods are in good agreement and based on the concentration from the mass loss data. The maximum inhibition efficacy was 91.97% for Aluminum in a mixture of acids (HCl+$H_2SO_4$). The outcome show that the inhibition efficacy increases with increasing concentration of the inhibitor.*

**Keywords:** Corrosion inhibition, mass loss method, inhibition efficacy.

## Introduction

Aluminum is an industrially significant metal. It has extraordinary economic consequences because of its inexpensive, weightless, and high thermal and electrical conductivities. Aluminum is a valuable metal owing to its good spectral reflectivity, sanitation, and innocuous qualities. Aluminum alloys suggested for building reasons have good resistivity to concrete mortars, plasters, asbestos, and cement materials[1-3]. Aluminum is also universally used as a structural substance in many industries and highly contaminated areas, as even gases such as $SO_2$ and $CO_2$ do not increase the corrosiveness of the atmosphere towards it. Aluminum has a face-centered cubic crystal structure, which makes it resistant to brittle cleavage fracture at low temperatures, enabling its use for making tanks and vessels to hold reactants and products at very low temperatures.

The cause of the achievement of Aluminum is transparent. It has good corrosion resistance, which allows it to sustain a non-tarnished and alluring natural surface in the atmosphere with minimal treatment. Due to low density, relative economy and excellent fabricating properties it is widely used in every dwelling. Many researchers have analyzed the corrosion of Aluminum in various aqueous atmospheres. Aluminum is defenseless against pure water but dissolves in hydrous acids. Acids, such as hydrochloric acid solutions, are used for cleaning Aluminum or for its electrochemical etching. The presence of inhibitors decreases the rate of dissolution of metals in such solutions[4-6].

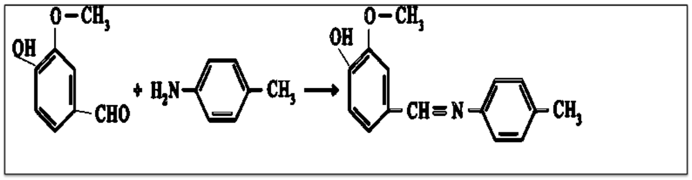
Generally, heterocyclic compounds with heteroatoms such as nitrogen, oxygen, and sulpher offer effective corrosion resistance by adsorbing on the metal surface through the lone pair of electrons present on these atoms[7-9]. This action may block the active site and hence decreases the corrosion rate. The efficacy of heterocyclic compounds depends on the electron density of the heteroatom[10-15]. Novel nitrogen containing ligands (Schiff's bases) derived from aromatic amine and aldehyde act as a corrosion inhibitor for Aluminium have been evaluated[16-20].

In the present study, three novel nitrogen-containing ligands (Schiff's bases), namely, N(vanillidine)-4-methyl-1-phenylimine ($SB_1$), N(vanillidine)-4-methoxy-1-phenylimine ($SB_2$), and N(anisidine)-1-napthylimine($SB_3$), were tested for their corrosion-inhibitive properties for Aluminium 0.1N in mixture of both acids (HCl+ $H_2SO_4$) by employing mass loss and thermometric methods.

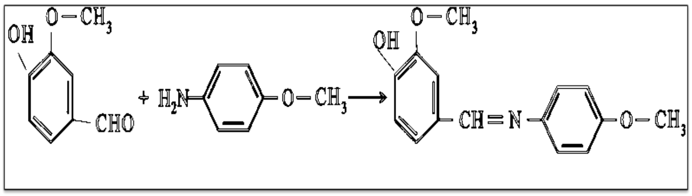
## Materials and Methods

Rectangular specimens of Aluminum with dimensions of 2.50 × 1.55 × 0.02 cm with a small hole of approximately 2 mm diameter near the upper edge were used for the mass loss measurement. The specimens were cleaned by buffing to produce a glass like finish using emery paper and then reduced with acetone. Each specimen was hung using a glass hook and dipped in a beaker containing 50 ml of the test solution at room temperature and left exposed to air evaporation. Similar experiments were carried out in each case, and the mean values of the mass losses were measured.

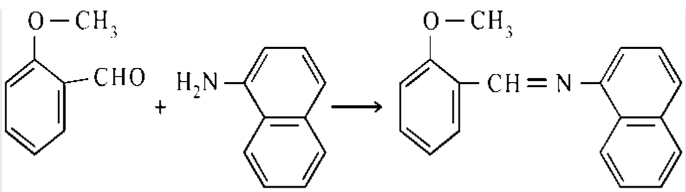
**Preparation of Test Solution:** Hydrochloric and sulphuric acids and mixtures of both acids at different concentrations were prepared. The specific solutions of novel nitrogen-containing ligands (Schiff's bases) were prepared using ethanol as the solvent.



**Scheme-1:** Preparation of N (vanillidine)-4-methyl-1-phenylimine ($SB_1$) from vanillin and p-toluidine.



**Scheme-2:** Preparation of N (vanillidine)-4-methoxy-1-phenylimine ($SB_2$) from vanillin and p-anisidine.



**Scheme-3:** Preparation of N (anisidine)-1-napthylimine ($SB_3$) from anisaldehyde and α-napthylamine.

To monitor the impact of various variables, such as inhibitor concentration, acid concentration, and time, the corrosion inhibition efficacy ($\eta$%) of the compounds was calculated using the mass loss method, applying the following equation[20]:
Inhibition Efficacy ($\eta$%) =100 ($\Delta M_u$ - $\Delta M_i$) / $\Delta M_u$
Where: $\Delta M_u$ is the mass loss in uninhibited solution. $\Delta M_i$ is the mass loss in the inhibited solution.

The degree of surface coverage ($\theta$) can be calculated as –
$\theta = (\Delta M_u - \Delta M_i) / \Delta M_u$
Where: $\Delta M_u$ is the mass loss in the uninhibited solution. $\Delta M_i$ is the mass loss in the inhibited solution.

The corrosion rate in mmpy (mm per year) was obtained by the following equation
Corrosion rate= $\Delta M \times 87.6 / A\, T\, D$
Where: $\Delta M$ is expressed in mg. A is expressed in square centimeters, and T is the time of exposure in hours. D is metal density in $gcm^{-3}$.

## Results and Discussion

The mass loss and percentage inhibition efficacy for 0.1N concentrations of the mixture of acids (HCl+ $H_2SO_4$) and inhibitors are shown in Table-1. The inhibition efficacy increased with increasing concentration of inhibitors.

**Table-1:** Corrosion data for different concentrations of novel nitrogen-containing ligands (Schiff's bases) for Aluminum in a 0.1 N (HCl +$H_2SO_4$) mixture of acids *at* 298 ± 0.1 K. Area of exposure – 7.75 $cm^2$, Time of exposure – 24 hrs.

| S. No. | | Inhibitor concentration (%) | Mass Loss $\Delta M$ (mg) | Inhibition efficacy ($\eta$ %) | Corrosion rate (mmpy) | Surface coverage ($\theta$) | Log ($\theta/1-\theta$) |
|---|---|---|---|---|---|---|---|
| $SB_1$ | 1 | Blank | 548 | - | 32.8745 | - | |
| | 2 | 0.12 | 248 | 57.75 | 14.8775 | 0.5774 | 1.3328 |
| | 3 | 0.24 | 195 | 64.41 | 11.6980 | 0.6441 | 1.3757 |
| | 4 | 0.36 | 145 | 73.54 | 8.6985 | 0.7354 | 1.4240 |
| | 5 | 0.48 | 96 | 82.48 | 5.7590 | 0.8248 | 1.5357 |
| | 6 | 0.60 | 44 | 91.97 | 2.6395 | 0.9197 | 1.6055 |
| $SB_2$ | 1 | Blank | 548 | - | 32.8745 | - | |
| | 2 | 0.12 | 231 | 57.84 | 13.8576 | 0.5784 | 0.756 |
| | 3 | 0.24 | 191 | 65.14 | 11.4580 | 0.6514 | 0.9699 |
| | 4 | 0.36 | 139 | 74.63 | 8.3386 | 0.7463 | 1.1911 |
| | 5 | 0.48 | 121 | 77.91 | 7.2587 | 0.7791 | 1.2564 |
| | 6 | 0.60 | 87 | 84.12 | 5.2191 | 0.8412 | 1.6055 |
| $SB_3$ | 1 | Blank | 548 | - | 32.8745 | - | |
| | 2 | 0.12 | 219 | 60.03 | 13.1378 | 0.6003 | 1.0805 |
| | 3 | 0.24 | 189 | 65.51 | 11.3381 | 0.6551 | 1.2936 |
| | 4 | 0.36 | 178 | 67.51 | 10.6782 | 0.6751 | 1.3757 |
| | 5 | 0.48 | 155 | 71.71 | 9.2984 | 0.7171 | 1.4765 |
| | 6 | 0.60 | 135 | 75.36 | 8.0986 | 0.7536 | 1.6857 |

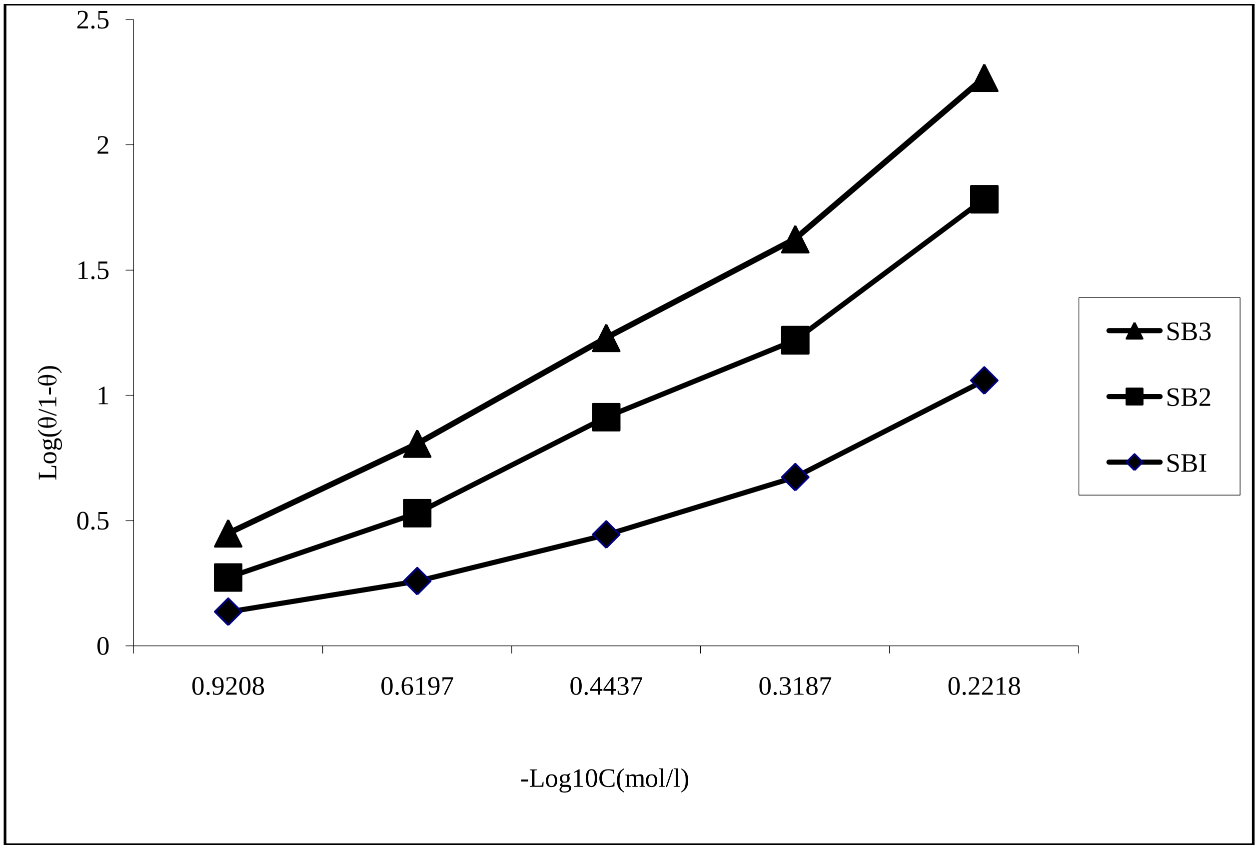



**Figure-1:** Langmuir adsorption isotherm for Aluminum in a 0.1N mixture of both acids containing novel nitrogen-containing ligands (Schiff's bases).

The maximum inhibition efficacy was observed for N (vanillidine)-4-methyl-1-phenylimine (SB1) at an inhibitor concentration of 0.6% in a 0.1 N mixture of acids (HCl+ $H_2SO_4$). The mass loss data indicate that the novel nitrogen-containing ligands (Schiff's bases) effectively reduce the corrosion rate of Al in an acid mixture and can be safely used without hydrogen destruction, toxicity, or environmental damage.

**Adsorption isotherm:** Langmuir adsorption isotherm.

$\text{Log}(\theta / (1-\theta)) = \log A + \log C - Q / 2.303\ RT$

Where: θ = Surface coverage, A = Temperature-dependent constant, C = Inhibitor concentration and Q = Heat liberated in reaction.

Figures-1 shows the Langmuir adsorption isotherm for the adsorption of novel nitrogen-containing ligands (Schiff's bases) on the Aluminum surface. The valves of adsorption parameters deduced from the isotherm are given in Table-1. From the results obtained, it is significant to note that these plots (Log (θ/ (1- θ) versus log C) are linear with the slopes equal to the unity, which indicates a strong adherence of the adsorption data to the assumption establishing Langmuir adsorption isotherm. As we can see from Figure-1, the inhibitor was found to obey the Langmuir adsorption isotherm.

## Conclusion

The novel nitrogen-containing ligands (Schiff's bases) viz, N(vanillidine)-4-methyl-1-phenylimine ($SB_1$) from vanillin and p-toluidine, N(vanillidine)-4-methoxy-1-phenylimine ($SB_2$) from vanillin and p-anisidine, N(anisidine)-1-napthylimine ($SB_3$) from anisaldehyde and α-napthylamine, are more effective corrosion inhibitors than the parent aldehyde and amines. In general, the order of corrosion inhibition efficiency of the three Schiff's bases has been found as - $SB_1 > SB_2 > SB_3$

The inhibition efficacy of all the Schiff's bases increases with the increase in the concentrations of the inhibitor, thus:

Inhibition Efficacy $\alpha$ Inhibitor Concentration

The inhibitors from a protective layer through chemisorption on the metallic surface thus retard the corrosion rate according to Langmuir's isotherm.

Overall, the results indicate that this Schiff's base compound has the potential to be an effective corrosion inhibitor for aluminum in acidic environments. Its adsorption behavior and inhibition efficacy demonstrate its ability to protect the aluminum surface and reduce corrosion.

## References


**1.** Desai, M.N. and Desai, M.B. (1984). Carbonyl compounds as corrosion inhibitors for Mild steel in HCl solutions. *Corrosion Science*, 24(8), 649-660.

**2.** Serpil, Ş., Duran, B., Yurt, A. and Türkoğlu, G. (2012). Schiff bases as corrosion inhibitor for aluminium in HCl solution. *Corrosion Science*, 54, 251-259.

**3.** Rajalakshmi, K. and Jayendran, T. (2010). Inhibition of Corrosion of Aluminium in 1N Sodium Hydroxide by Salicylic Acid in Conjunction with Calcium Acetate. *Asian J. Research Chem*, 3(2), 351-354.

**4.** Kobotiatis, L., Pebere, N. and Koutsou Kos, P.G. (1999). Study of the electrochemical behavior of the 7075 aluminum alloy in the presence of sodium oxalate. *Corr. Science*, 41(5), 941-957.

**5.** Desai, M. N., Desai, Y. B., Shah, C. B., Desai, S. M. and Gandhi, M. H. (1970). Influence of the combined effect of cathodic polarization and inhibitors on the corrosion of Al in HCl. *Corrosion Science*, 10 (11), 831-836.

**6.** Sharma, A., Arora, S., Batra, M. K. and Khandelwal, R. (2023). Corrosion inhibition and Adsorption characteristics of 3, 4, 5-trihydroxy-n-(3,4-dimethoxy benzylidene) benzo hydrazide schiff base on aluminium in different concentration of Hydrochloric acid environment. *Research J. Science and Tech*, 15 (4), 175-182.

**7.** Yadav, M., Kumar, S., Nasar, A. and Kumar, S. (2010). Inhibition of Corrosion of Copper by 4-Amino-3-Phenyl-5-Mercapto-1,2,4-Triazolein 3.5% Sodium Chloride Solution. *Asian J. Research Chem*., 3(4), 938-942.

**8.** Amaal, S. S. and Entesar, O. A.T. (2021). Synthesis and Characterization of New poly β-Lactam from poly acrolein and Study Corrosion Inhibition for Stainless steel in Hydrochloric Acid Solution. *Research Journal of Pharmacy and Technology*, 14(6), 3039-3044.

**9.** Beccaria, A. M. and Chiaruttini, L. (1999). The inhibitive action of metacryloxypropylmethoxysilane (MAOS) on aluminium corrosion in NaCl solutions. *Corrosion science*, 41(5), 885-899.

**10.** Zheludkevich, M.L., Yasakau, K.A., Poznyak, S.K. and Ferreira, M.G.S. (2005). Triazole and thiazole derivatives as corrosion inhibitors for AA2024 aluminum alloy. *Corrosion Science*, 47(12), 3368-3383.

**11.** Bhawsar, J. and Jain, P. (2018). Investigation of Mentha spicata extract as Green Corrosion Inhibitor for Mild Steel in 2M Sulphuric Acid Medium. *Research J. Pharm. and Tech*, 11 (10), 4627-4634.

**12.** Blanc, C. and Gastand, S. (2003). Electrochemical Behavior of Aluminum in aqueous solutions containing Chloride and Sulfate Ions. *Electrochemical Acta*, 150, 396.

**13.** Jain, T., Chaudhary, R. and Mathur, S. P. (2006). Electrochemical behavior of aluminium in acdic media. *Material and corrosion*,57(5),1-5.

**14.** Sharma, M. K., Kumar, S., Ratnani, R. and Mathur, S. P. (2006). Corrosion inhibition of aluminium by extracts of Prosopis cineraria in acdic media. *Bulletin of Electrochemistry*, 22(2), 69-73.

**15.** Arora, P., Kumar, S., Sharma., M. K. and Mathur, S. P. (2007). Corrosion inhibition of aluminium by capparis decidua in acdic media. *E-Journal of Chemistry*, 4(4), 450-456.

**16.** Sethi, T., Chaturvedi, A., Upadhyay, R. K. and Mathur, S. P. (2007). Corrosion inhibitory effects of some Schif" S bases on mild steel in acid media. *J. Chil. Chem. Soc*, 52(3), 1206-1213.

**17.** Sethi,T., Chaturvedi, A., Upadhyay, R. K. and Mathur, S. P. (2008). Inhibition effect of nitrogen containing ligands on corrosion of aluminium in acid media with and without KCl. *Polish J. Chem*, 82,591-598.

**18.** Khandelwal, R., Sahu, S. and Arora, S. K. (2018). Comparative Study of Schiff's Bases and Plant Extract as Corrosion Inhibitors. *Advanced science Engg. and Medicine*, 10, 1023-1028.

**19.** Emregül, K. C., Düzgün, E. and Atakol, O. (2006). The application of some polydentate Schiff base compounds containing aminic nitrogens as corrosion inhibitors for mild steel in acidic media. *Corrosion Science*, 48, (10), 3243–3260.

**20.** Tang, L., Li, X., Li, L., Mu, G. and Liu, G. (2006). Interfacial behavior of 4-(2-pyridylazo) resorcin between steel and hydrochloric acid. *Surface and Coatings Technology*, 201(1), 384–388.