

“A role of Schiff base and their metal complexes used as corrosion inhibitor in different corrosive medium”

Suraj B. Ade*, Balasaheb U. Jadhav¹, Subhash M. Lonkar², Nana V. Shitole³

P.G. Department of Chemistry, Shri Shivaji College, Parbhani, India.

ABSTRACT

The inhibition effect of Schiff base and their metal complexes, on the corrosion of carbon steel in an acidic medium were studied by the weight loss method at room temperature. The study revealed that the action of Schiff base and their metal complexes have an inhibitory action on the corrosion of carbon steel in the investigated different acid medium. This paper presents use of Schiff base 2-[(1H-indol-3-ylmethylene)-amino]-4-methyl-phenol and their metal complexes [Ti(IV)AMPIA], [Zr(IV)AMPIA], [Cd(II)AMPIA], [Hg(II)AMPIA] as corrosion inhibitors for carbon steel in 0.1N, 0.01N and 0.001N (HCl, HNO₃ and H₂SO₄) acidic medium. Thus, inhibition efficiency was obtained from Further chelating agent and metal chelates were used to study their effect on mild steel corrosion

KEYWORDS: Corrosion, Inhibition, carbon steel, Weight loss, Schiff base and their metal complexes.

I. INTRODUCTION

Corrosion is an afflicting problem associated with every use of metals. The damage by corrosion results in highly cost for maintenance and protection of materials used. It is a constant and continuous problem, often difficult to eliminate completely because Metals generally tend to move to its original state by corrosion process. Prevention would be more practical and achievable than complete elimination¹⁻⁴. Studies report that the adsorption of the organic inhibitors mainly depends on some physico-chemical properties of the molecule related to its functional group, to the possible steric effects and electronic density of donor atoms; adsorption is also supposed to depend on the possible interaction of π -orbital's of the inhibitor with d-orbital's of the surface atoms, which induce greater adsorption of the inhibitor molecules onto the surface of C-steel, leading to the formation of corrosion protecting film^{5,6}. The organic molecules adsorb on the metal surface through heteroatom, such as nitrogen, oxygen and Sulphur, blocking the active sites and generating a physical barrier to reduce the transport of corrosive species to the metal surface⁷⁻¹¹. Other researches revealed that the adsorption is influenced not only by the nature and surface charge of the metal, but also by the chemical structure of inhibitors. Schiff base compounds and their metal complexes have been extensively investigated due to their wide range of applications including catalysts^{12,13}, medicine^{14,15} crystal engineering¹⁶, anti-corrosion agent^{17,18}. Schiff bases had been reported to show a variety of biological activities and are potential corrosion inhibitors for mild steel in acidic media^{19, 20}. The azomethine linkage and the donor atoms in the back bone of the Schiff bases are responsible for their biological activity and corrosion inhibition²¹. In most cases the biological activity and inhibition efficiency of the Schiff bases increases up on coordination with metal ions. The corrosion behaviour of iron and its passivation processes have been studied extensively over the last few decades²²⁻²⁷. Some Schiff base compounds have recently been reported as effective corrosion inhibitors for mild steels^{28, 29} in various aqueous solutions. The effects of Schiff base-metal complexes³⁰ on the corrosion of mild steel were investigated by corrosion weight loss. Literature survey reveals that studies about the effect of Schiff bases and their metal complexes as corrosion inhibitor for steel in acid solution are extremely limited³¹⁻³³. The synthesis and characterization of Schiff base Ligand and their metal complexes were published in the research paper. The aim of this research work is to investigate the inhibitive effect of a Schiff base 2-[(1H-indol-3-ylmethylene)-amino]-4-methyl-phenol and their metal complexes [Ti(IV)AMPIA], [Zr(IV)AMPIA], [Cd(II)AMPIA], [Hg(II)AMPIA] on mild steel in (0.1N, 0.01N, 0.001N) HNO₃, H₂SO₄ and HCl acid solution.

II. EXPERIMENTAL SECTION

To analysis the inhibition efficiency of Schiff base and their metal chelates. The simple experiments were carried out steel binding wire were cleaned first by regmal paper and wash with water and it was dried. After drying it was cutted in small 5cm pieces and its weight were determined on analytical balance as initial weight. In this experiment beakers were labeled from 1-54 and in beakers having labeled 1-6 20ml 0.1N HCl, 7-12 20ml 0.01N HCl, 13-18 20ml 0.001N HCl, in beakers 19-24 20ml 0.1N HNO₃, 25-30 20ml 0.01N HNO₃ and in beaker 31-36 20ml 0.001N HNO₃ and In beakers 37-42 20ml 0.1N H₂SO₄, 43-48 20ml 0.01N H₂SO₄, 49-54 20ml 0.001N H₂SO₄ were added. After the preparation of the mixture solution in different labeled beaker, dipped binding wire pieces in each beaker for 48 hours. After 48 hours the wire pieces were taken out from the beaker. They were washed with water and dried at room temperature. Its weight was determined on analytical balance as final weight.

The loss in mass was determined using the relation.

$$I.E. = \frac{W_u - W_i}{\text{---}} \times 100$$

W_i

Where,

I.E. = Inhibition efficiency.

W_i = Weight loss of metal in inhibitor solution

W_u = weight loss of metal in control solution

III. RESULT AND DISCUSSION

Table no. 1

Effect of Schiff base (AMPIA) and their metal complexes [Ti (IV), Zr (IV), Cd (II), Hg (II)] on corrosion in 0.1N HCl

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.511	0.443	0.068	13.30	-
AMPIA	0.492	0.453	0.039	79.27	42.64
[Ti(IV)AMPIA]	0.514	0.456	0.055	10.7	19.11
[Zr(IV)AMPIA]	0.490	0.432	0.058	11.83	14.70
[Cd(II)AMPIA]	0.483	0.471	0.012	24.84	82.35
[Hg(II)AMPIA]	0.495	0.477	0.018	36.36	73.52

Fig: Variation of weight loss of mild steel in 0.1N HCl solution containing Schiff base and their metal complexes. (Graph no.1)

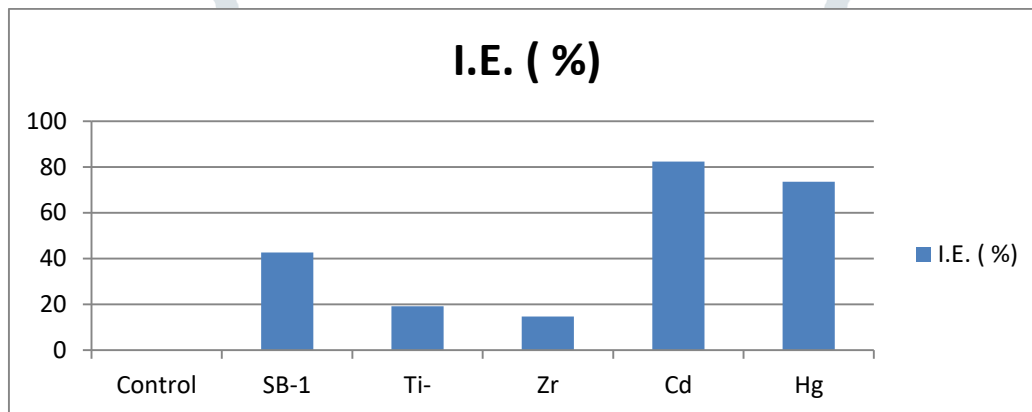


Table no. 2

Effect of Schiff base (AMPIA) and their metal complexes [Ti (IV), Zr(IV), Cd(II), Hg(II)] on corrosion in 0.01N HCl

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.487	0.470	0.017	3.49	-
AMPIA	0.492	0.490	0.002	0.40	88.23
[Ti(IV)AMPIA]	0.494	0.479	0.015	3.03	11.76
[Zr(IV)AMPIA]	0.482	0.476	0.006	1.24	64.70
[Cd(II)AMPIA]	0.485	0.482	0.003	0.61	82.35
[Hg(II)AMPIA]	0.498	0.492	0.004	0.80	76.47

Fig: Variation of weight loss of mild steel in 0.01N HCl solution containing Schiff base and their metal complexes. (Graph No. 2)

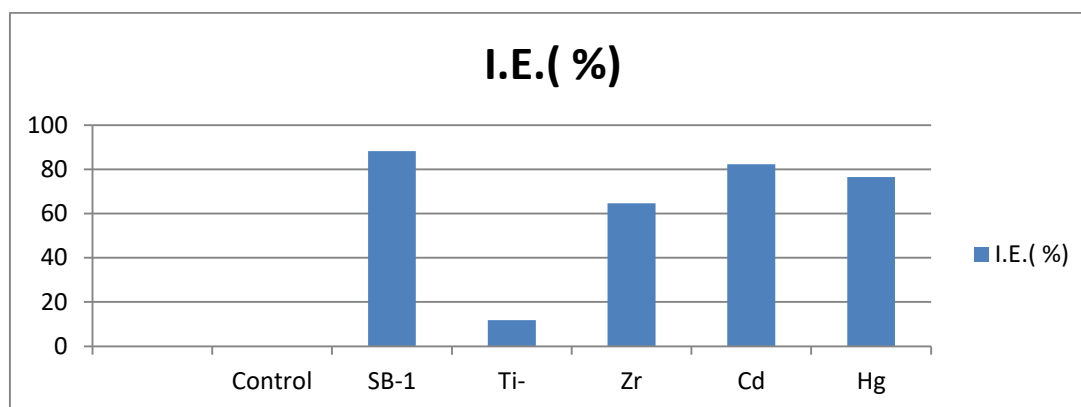


Table no. 3
Effect of Schiff base (AMPIA) and their metal complexes [Ti (IV), Zr (IV), Cd (II), Hg (II)] on corrosion in 0.001N HCl

Compound	Initial weight (W ₁)	Final Weight (W ₂)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.510	0.498	0.012	2.35	-
AMPIA	0.500	0.494	0.006	1.2	50
[Ti(IV)AMPIA]	0.494	0.492	0.002	0.40	83.3
[Zr(IV)AMPIA]	0.479	0.476	0.003	0.62	75
[Cd(II)AMPIA]	0.476	0.473	0.003	0.63	75
[Hg(II)AMPIA]	0.495	0.493	0.002	0.40	83.3

Fig: Variation of weight loss of mild steel in 0.001N HCl solution containing Schiff base and their metal complexes. (Graph No. 3)

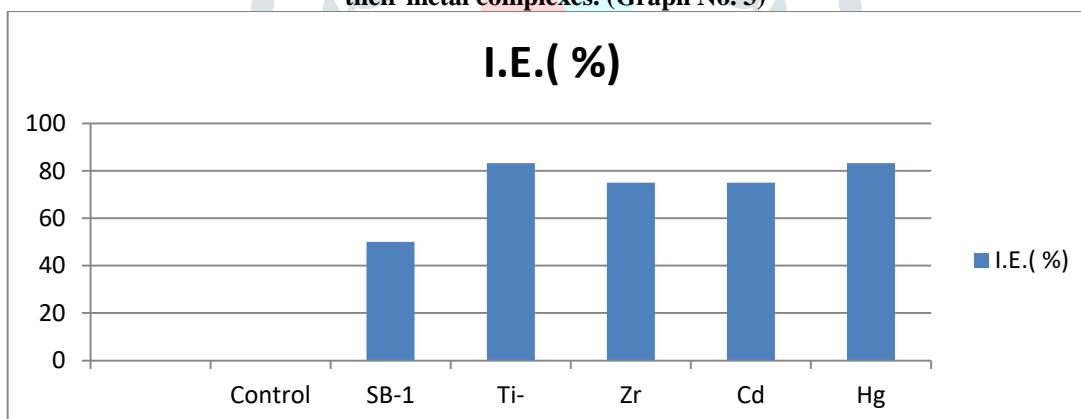


Table no. 4
Effect of 2-[(1H-indol-3-ylmethylene)-amino]-4-methyl-phenol [AMPIA] and their metal complexes in 0.1N HNO₃

Sample	Initial weight (W ₁)	Final Weight (W ₂)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.498	0.467	0.031	6.22	-
AMPIA	0.513	0.491	0.022	4.28	29.03
[Ti(IV)AMPIA]	0.495	0.468	0.027	5.45	12.90
[Zr(IV)AMPIA]	0.473	0.447	0.026	5.49	16.12
[Cd(II)AMPIA]	0.517	0.500	0.017	3.28	45.16
[Hg(II)AMPIA]	0.483	0.459	0.024	4.96	22.58

Fig: Variation of weight loss of mild steel in 0.1N HNO₃ solution containing Schiff base (AMPIA) and their [Ti (IV), Zr(IV), Cd(II), Hg(II)] metal complexes.(Graph No.4)

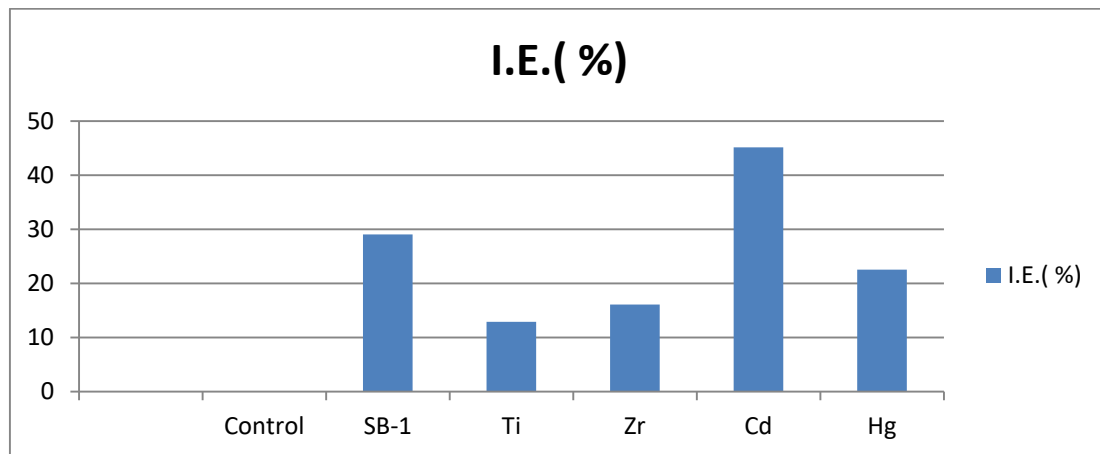


Table no. 5
Effect of 2-[(1H-indol-3-ylmethylene)-amino]-4-methyl-phenol [AMPIA] and their metal complexes in 0.01N HNO₃

Sample	Initial weight (W ₁)	Final Weight (W ₂)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.518	0.506	0.012	2.31	-
AMPIA	0.509	0.503	0.006	1.17	50
[Ti(IV)AMPIA]	0.497	0.491	0.006	1.20	50
[Zr(IV)AMPIA]	0.478	0.471	0.007	1.46	41.66
[Cd(II)AMPIA]	0.501	0.498	0.003	0.59	75
[Hg(II)AMPIA]	0.492	0.488	0.004	0.81	66.66

Fig: Variation of weight loss of mild steel in 0.01N HNO₃ solution containing Schiff base (AMPIA) and their[Ti (IV), Zr (IV), Cd (II), Hg (II)] metal complexes. (Graph No. 5)

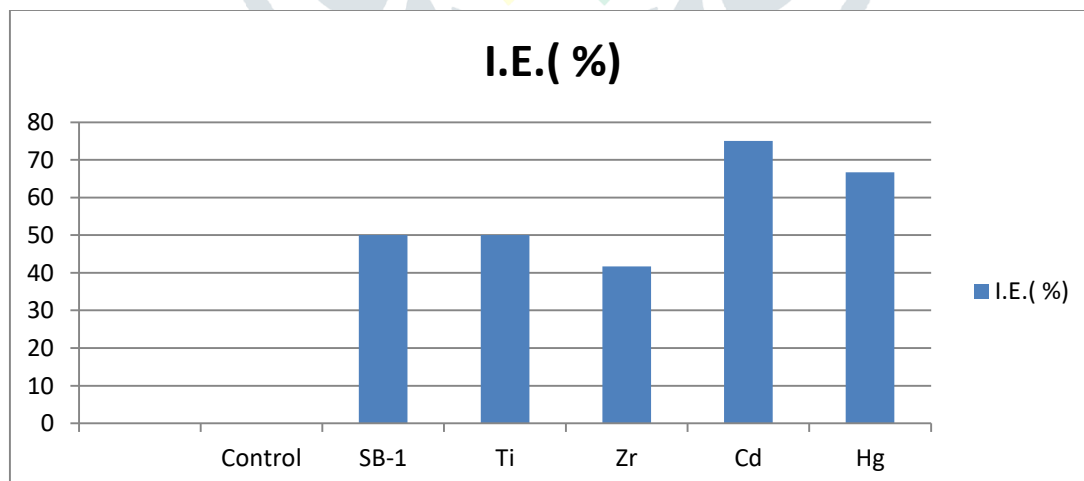


Table no. 6
Effect of 2-[(1H-indol-3-ylmethylene)-amino]-4-methyl-phenol [AMPIA] and their metal complexes in 0.001N HNO₃

Sample	Initial weight (W ₁)	Final Weight (W ₂)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.489	0.484	0.005	1.02	-
AMPIA	0.486	0.484	0.002	0.41	60
[Ti(IV)AMPIA]	0.515	0.512	0.003	0.58	40
[Zr(IV)AMPIA]	0.516	0.512	0.004	0.77	20
[Cd(II)AMPIA]	0.488	0.486	0.002	0.41	60
[Hg(II)AMPIA]	0.507	0.504	0.003	0.59	40

Fig: Variation of weight loss of mild steel in 0.001N HNO₃ solution containing Schiff base (AMPIA) and their [Ti (IV), Zr (IV), Cd (II), Hg (II)] metal complexes. (Graph No. 6)

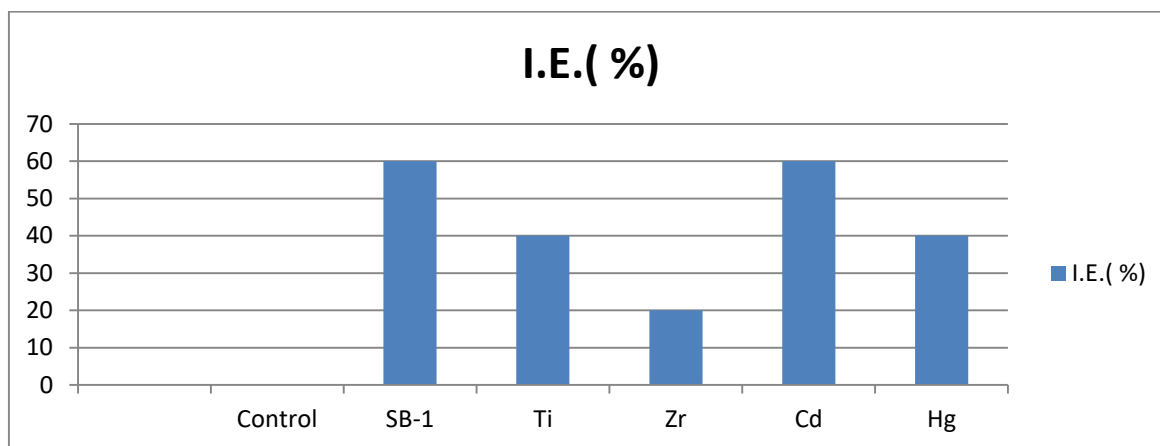


Table no. 7
Effect of Schiff base and their metal complexes on corrosion in 0.1N H₂SO₄

Compound	Initial weight (W ₁)	Final Weight (W ₂)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.491	0.437	0.054	10.99	-
AMPIA	0.486	0.465	0.021	4.32	61.11
[Ti(IV)AMPIA]	0.492	0.442	0.050	10.16	7.40
[Zr(IV)AMPIA]	0.494	0.446	0.048	9.71	11.11
[Cd(II)AMPIA]	0.487	0.474	0.013	2.66	75.92
[Hg(II)AMPIA]	0.491	0.481	0.010	2.03	81.48

Fig: Variation of weight loss of mild steel in 0.1N H₂SO₄ solution containing Schiff base (AMPIA) and their [Ti(IV), Zr(IV), Cd(II), Hg(II)] complexes.(Graph No. 7)

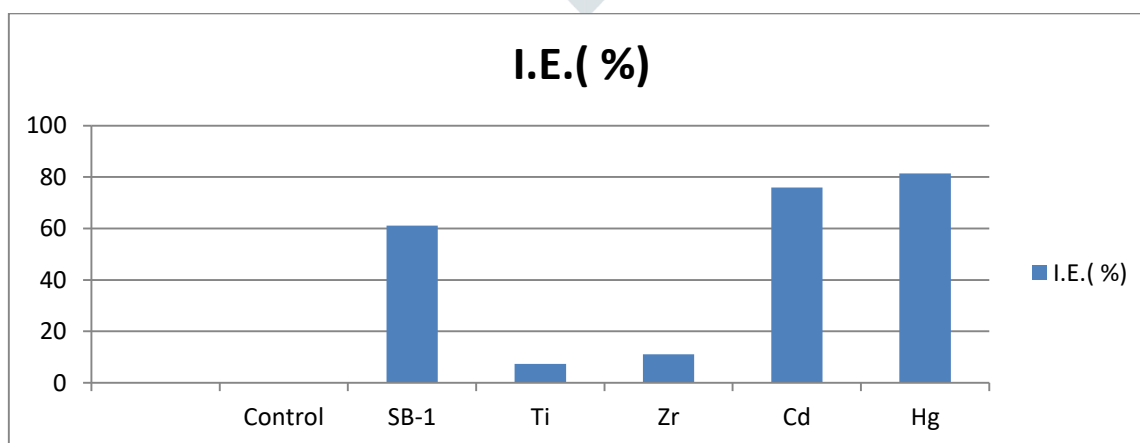


Table no. 8
Effect of Schiff base and their metal complexes on corrosion in 0.01N H₂SO₄

Compound	Initial weight (W ₁)	Final Weight (W ₂)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.494	0.486	0.008	1.61	-
AMPIA	0.491	0.486	0.005	1.01	37.5
[Ti(IV)AMPIA]	0.478	0.473	0.005	1.04	37.5
[Zr(IV)AMPIA]	0.483	0.477	0.006	1.24	25
[Cd(II)AMPIA]	0.486	0.481	0.005	1.02	37.5
[Hg(II)AMPIA]	0.492	0.485	0.007	1.42	12.5

Fig: Variation of weight loss of mild steel in 0.01N H₂SO₄ Solution containing Schiff base (AMPIA) and their [Ti (IV), Zr (IV), Cd (II), Hg (II)] Complexes. (Graph No. 8)

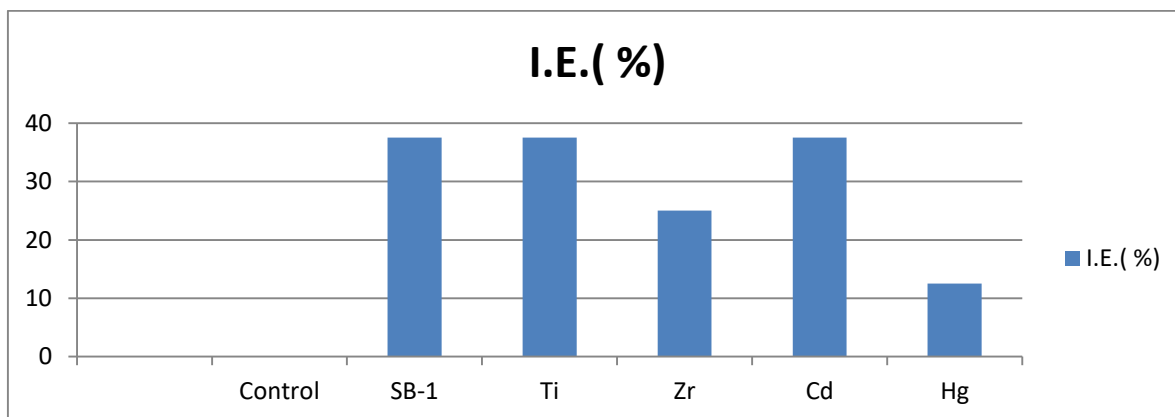
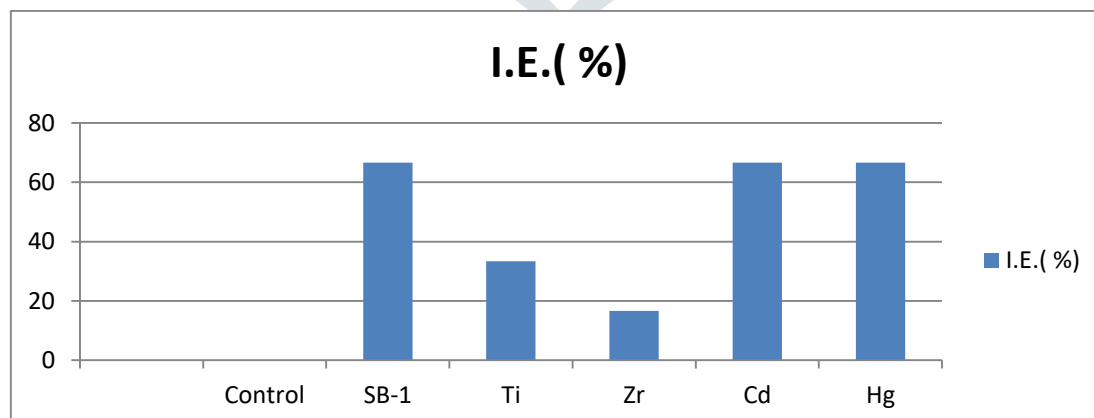


Table no. 9
Effect various Schiff base and their metal complexes on corrosion in 0.001N H₂SO₄

Compound	Initial weight (W ₁)	Final Weight (W ₂)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.488	0.482	0.006	1.22	-
AMPIA	0.480	0.478	0.002	0.41	66.66
[Ti(IV)AMPIA]	0.487	0.483	0.004	0.82	33.33
[Zr(IV)AMPIA]	0.490	0.485	0.005	1.02	16.66
[Cd(II)AMPIA]	0.491	0.489	0.002	0.40	66.66
[Hg(II)AMPIA]	0.495	0.493	0.002	0.40	66.66

Fig: Variation of weight loss of mild steel in 0.001N H₂SO₄ solution containing Schiff base (AMPIA) and their [Ti(IV), Zr(IV), Cd(II), Hg(II)] complexes.(Graph No. 9)



The experimental result regarding inhibition efficiency of Schiff base 2-[(1H-indol-3-ylmethylene)-amino]-4-methyl-phenol and their metal complexes [Ti (IV) AMPIA], [Zr (IV) AMPIA], [Cd (II) AMPIA], [Hg (II) AMPIA]. Under reveals that the compounds have inhibition property. They inhibit oxidation of metal in various mineral acid medium. We conclude that the inhibition efficiency is also depending on the oxidizing medium. In experimental process we have to used three types of acidic medium namely 0.1, 0.01, 0.001 N, HCl, HNO₃ and H₂SO₄. Nitric acid is strong oxidizing agent as compare to other two mineral acids. After the analysis of Schiff base AMPIA and their Ti (IV), Zr (IV), Cd (II), Hg (II) metal complexes used to study inhibition efficiency. Effect of Ligand and their metal ion complexes are recorded in table

and also represented in a graph. From the observation table we conclude that in 0.1N HCL [Cd (II) AMPIA] complex shows inhibition efficiency 82.35% and [Hg (II) AMPIA] complex exhibit 73.52%. Schiff base shows (Ligand) inhibition efficiency 42.64%. [Ti (IV) AMPIA] and [Zr (IV) AMPIA] shows less inhibition efficiency. In 0.01N HCl solution Schiff base Ligand AMPIA shows maximum inhibition efficiency 88.23% and their [Ti (IV) AMPIA] and [Zr (IV) AMPIA] shows 60% inhibition efficiency. Simultaneously [Cd (II) AMPIA] and [Hg (II) AMPIA] exhibits 82.35% and 76.46%.

In 0.001N HCl the inhibition efficiency of Schiff base is 50%. [Zr(IV)AMPIA] and [Cd(II)AMPIA] metal complexes shows 75% inhibition efficiency, [Ti(IV)AMPIA] and [Hg(II)AMPIA] exhibits the maximum inhibition efficiency is 83.3%. In the nitric acid medium the inhibition efficiency of Schiff base 2-[(1H-indol-3-ylmethylene)-amino]-4- methyl-phenol is 29.03% and their various metal complexes shows less inhibition efficiency. In 0.01N HNO₃ And 0.001N HNO₃ The inhibition efficiency of Schiff base (AMPIA) Ligand shows inhibition efficiency in the range 50-60% and their metal complexes Ti (IV), Zr(IV), Cd(II), Hg(II) shows the inhibition efficiency in the range 40-60%. By graphical representation in sulphuric acid medium, in 0.1N H₂SO₄ the inhibition efficiency of Schiff base is 61.11%, 0.01N H₂SO₄inhibition efficiency is 37.5% and also inhibition efficiency of Schiff base in 0.001N H₂SO₄ is 66.66%. From the observation table the inhibition efficiency of [Cd (II) AMPIA] and [Hg(II)AMPIA] shows maximum inhibition efficiency 75.92% and 81.48%. The Schiff base and their metal complexes shows less inhibition efficiency 0.01N H₂SO₄. The [Cd (II) AMPIA] and [Hg (II) AMPIA] shows inhibition efficiency in the range of nearly same 66.66%. From all above study of Schiff base and their various metal complexes, inhibition efficiency of [Cd (II) AMPIA] and [Hg (II) AMPIA] have found to be good inhibitors for mild steel in various acid medium. The Schiff base 2-[(1H-indol-3-ylmethylene)-amino]-4- methyl-phenol also exhibit good inhibition efficiency, it can be shown by graphical interpretation data. The active groups which is responsible to inhibit corrosion of mild steel in a different acid medium. The inhibitor property of AMPIA Schiff base and their metal complexes Ti (IV), Zr (IV), Cd (II), Hg (II) accounts for blanket preventing mild steel from coming in contact with acidic and corrosive environment.

IV. CONCLUSION

From the experimental data and graphical representation results regarding inhibition efficiency of Schiff base and their metal complexes Ti (IV), Zr(IV), Cd(II), Hg(II) under study reveals that, the Schiff base 2-[(1H-indol-3-ylmethylene)-amino]-4- methyl-phenol exhibit good inhibition property. The Schiff base Ligand inhibit the oxidation of metal in different acid medium and also the metal complexes Ti(IV), Zr(IV), Cd(II), Hg(II) also exhibit good inhibition efficiency. Inhibition efficiency is related to concentration, temperature and chemical structure of the Schiff base compound. Interesting result come out from the experiment that in HCl acid medium, Schiff base and their metal complexes shows good inhibition efficiency than HNO₃ and H₂SO₄ acid medium.

V. ACKNOWLEDGEMENT

The authors are thankful to the principal of shri Shivaji College, Parbhani for providing research facilities. Authors are also thankful to Head Department of chemistry providing necessary facilities and interpretation of corrosion activities.

REFERENCES

1. Abdel Hameed R. S., (2011), *Advances in Applied Science Research*, 2(3), pp 483-499.
2. Abd El Hameed, R.S., AlShafey, H.I., Soliman, S.A., Metwally, M.S., (2008), *Al-Azhar Bull.Sci*, 19, 283.
3. Abd el Hameed, R.S., Al Shafey, H.I., Ismail, E.A., (2009), *Al-Azhar Bull.Sci.*, 20(1), pp 185-19.
4. Shehata, H.A., Abdelbary, H.M., Soliman, S.A., Salem, A.M., Atta, A.M., Reda S. Abdel Hameed, (2012) *Materials Science*, 8(7), pp 289-302.
5. Bentiss, F., Lagrenee, M., Traisnel, M., (2000), *J. Corros.*, 56, pp 733-742.
6. Bentiss, F., Traisnel, M., Lagrenee, M., (2001), *J. Appl. Electrochem.*, 31, pp 41-48.
7. Wang, H. L., Liu, R. B., Xin, (2004), *J. Corros. Sci.*, 46, 2455-2466.
8. Solmaz, R., Kardas, G., Yazici, B., Erbil, M., (2005), *Prot. Met.*, 41, pp 581-585.
9. Emregul, K. C., Kurtaran, R., Atakol, O., (2003), *Corros. Sci.*, 45, pp 2803-2817.
10. Liu, F. G., Du, M., Zhang, J., Qiu, M., (2009), *Corros. Sci.* 51, pp 102-109.
11. Khaled, K. F., Amin, M. A., (2009), *Corros. Sci.* 51, pp 1964-1975.
12. K. C. Gupta and A. K. Sutar, (2008), *Coordination Chemistry Reviews*, 252(12-14), pp 1420-1450.
13. Cozzi, P. G., (2004), *Chemical Society Reviews*, 33(7), pp 140-421.
14. Turkkan, B., Sariboga, B., Sariboga, N., (2011), *Transition Metal Chemistry*, 36, 6, pp 679-684.
15. Siji, V. L., M. R., Sundarsanakumar and S. Suma, (2011), *Transition Metal Chemistry*, 36, 4, 417-424.
16. C. V. Krishnamohan Sharma, (2002), *Crystal Growth & Design*, 2(6), pp 465-474.
17. I. Ahamad, R. Prasad and M. A. Quraishi, (2010), *Corrosion Science*, 52, pp 933- 942.
18. M. Antonijevic and M. Petrovic, (2008), *International Journal of Electrochemical Science*, 3(1), pp 1-28.
19. K. S. Jacob and G. Parameswaran, (2010), *Corros. Sci.*, 52, pp 224-228.
20. Shokry, H., Yuasa, M., Sekine, I., Issa, R. M., El-Baradie, H. Y., Gomma, G. K., (1998), *Corros. Sci.*, 39, pp 2173-2186.
21. G. G. Mohamed and Z. H. Abd El-Wahab, (2003), *J. Therm. Anal. Calorim.*, 73, pp 347-359.
22. K. K. Al-Neami, A. K. Mohamed, I. M. Kenafiy, and A. S. Fouda, (1995), *Monatsh Chem.*, 126, 369.
23. H. Zhang, and S. M. Park, (1994), *Electrochem. Soc.*, 141(3), 718.
24. E. B. Castro, (1994), *Electrochim. Acta.*, 39(14), 117.
25. D. You, N. Pebere and F. Dabosi, (1993), *Corros. Sci.*, 34(1), 5.
26. U. Rammelt, and G. Reinhard, (1994), *Electrochim. Acta.*, 40(4), 505.
27. S. H. Zhang, and S. B. Lyon, (1994), *Corros. Sci.*, 36(8), 309.
28. Desai, M. N., Desai, M. B., Shah, C. B., Desai, S. M., (1986), *Corros. Sci.*, 26, 827.
29. H. Shokry, M. Yuasa, I. Sekine, R. M. Issa, H. Y. El-Baradie, and O. K. Comma, (1998), *Corro. Sci.*, 40(12), 2173.

- 30.H. Shokry, I.Sekine, M. Yuasa, H.Y. El- Baradie, G. K. Comma, and R.M. Issa,(1997),Zairyo to Kankyo, 47(7), 447.
- 31.M. Mahdavian, and M. M. Attar,(2009),Corros. Sci., 51, pp409–414.
- 32.P. V. Singh, P. Singh and A.K. Singh,(2011),Inorg. Chim. Acta, 379, pp56–63.
- 33.P. Singh, A.K. Singh and V.P. Singh,(2013),Polyhedron, 65, pp73–81.
34. S. Aprael, Yaro, AneesA.Khadom, Rafalk.Wael, “Apricot juice as green corrosion inhibitor of mild steel in phosphoric acid,”(2013), Alexandria Engineering Journal,52(1), pp129-135.
- 35.V. Gentil, Corrosao, 4th ed., Rio de Janeiro; LTC,2003.
- 36.Ali, S.A., Al-Muallem,H. A.,Rahman,S. U.,Saeed,M.T., (2008),Corro.Sci.,50,pp3070-3077.

