International Journal of Recent Advances in Multidisciplinary Topics
Volume 7, Issue 6, June 2026
www.ijramt.com | E-ISSN: 2582-7839 | RESAIM Publishing | www.resaim.com

Evaluation of the Corrosion Behaviour of Copper in Different Corrosive Media Using Weight Loss Measurements

Parineeta Singh Shekhawat[1*], Harish Kumar[1]
[1]*Department of Chemistry, Tantia University, Sri Ganganagar, Rajasthan, India*

***Abstract*: Copper is different from most other metals because it combines corrosion resistance with high electrical and thermal conductivity. It also has good formability and machinability and its strength can be improved by alloying, although copper alloys generally lose strength at high temperatures. Copper exhibits good resistance to urban, marine, and industrial atmospheres, as well as to water. It is considered a noble metal, and hydrogen evolution is usually not part of its corrosion process, which contributes to its good corrosion resistance in many environments. Copper is not attacked by non-oxidizing acids in the absence of oxygen or other oxidizing agents. However, when oxidizing agents such as nitric acid are present, corrosion can occur. For example, the reaction between copper and dilute sulphuric acid is not thermodynamically favourable under normal conditions. In the presence of dissolved oxygen, however, corrosion proceeds and copper sulphate and water are formed. In such cases, the main cathodic reaction is the reduction of oxygen to hydroxide ions. This corrosion behaviour is applicable to both copper and its alloys.**

***Keywords*: Corrosion, copper, weight loss method, concentration, metals, time.**

1. Introduction

Copper exhibits excellent corrosion resistance in many environments because of its ability to form a thin, adherent, and protective oxide film on its surface [1]. The corrosion behaviour of copper depends on environmental factors such as oxygen concentration, humidity, pH, temperature, and the presence of aggressive ions like chlorides and sulphides. In atmospheric conditions, copper initially forms cuprous oxide (Cu_2O), which gradually transforms into a stable patina consisting of basic copper carbonate and sulphate compounds [2], [3]. This patina acts as a barrier against further corrosion and contributes to the long service life of copper structures [4]. However, in marine and chloride-containing environments, localized attack such as pitting corrosion may occur due to the breakdown of the protective film. Acidic media generally accelerate copper dissolution, whereas alkaline solutions promote passivation and improve corrosion resistance [5], [6]. Industrial pollutants, particularly sulphur dioxide, can increase corrosion rates and alter the composition of corrosion products. Electrochemical studies have shown that copper corrosion proceeds through oxidation to Cu^+ and Cu^{2+} ions, followed by the formation of oxide or hydroxide layers [7], [8]. Understanding the corrosion behaviour of copper is important for its applications in electrical systems, heat exchangers, plumbing, marine equipment, and architectural structures, where durability and reliability are essential [9], [10]. Antonijevic and Petrovic investigated the corrosion behaviour of copper in acidic media using weight loss and electrochemical techniques and reported that corrosion rates increased with acid concentration while inhibitors significantly reduced metal dissolution [3]. Otmacic and Stupnisek-Lisac studied copper corrosion in near-neutral solutions through weight loss measurements and found that organic inhibitors effectively enhanced corrosion resistance by forming protective surface films [1]. Kear et al. evaluated the corrosion of copper in chloride-containing environments and observed that chloride ions accelerated metal loss, leading to localized corrosion and increased weight loss [6]. Sherif and Erasmus examined copper corrosion in sodium chloride solutions and demonstrated that corrosion rates obtained from weight loss studies increased with chloride concentration and immersion time [2]. Zhang et al. investigated the inhibition of copper corrosion in acidic media using weight loss methods and reported significant reductions in corrosion rate due to adsorption of inhibitor molecules on the copper surface [5].

2. Materials and Methods: Corrosion study of Copper by Weight Loss Method

The weight loss method is one of the simplest and most widely used techniques for studying the corrosion behaviour of iron. In this method, a clean and accurately weighed copper specimen is immersed in a corrosive medium, such as acidic, alkaline, or saline solution, for a specified period. Before immersion, the surface of the copper specimen is polished, degreased, washed with distilled water, dried and weighed accurately. After exposure to the corrosive environment, the specimen is removed, cleaned to remove corrosion products, washed, dried and reweighed. The difference between the initial and final weight represents the amount of metal lost due to corrosion. The corrosion rate is calculated using the weight loss data and is generally expressed in mils per year (mpy). The corrosion rate can be determined using the formula:

*Corresponding author: kewalpreet983@gmail.com

$$Corrossion\ Rate = \frac{87.6 \times W}{D \times A \times T}$$

where,

W = Weight loss (mg)

D = Density of copper (g/cm³)

A = Surface area exposed (cm²)

T = Exposure time (hours)

The weight loss method provides valuable information about the effect of factors such as concentration of corrosive medium, temperature, pH, and immersion time and corrosion inhibitors on the corrosion behaviour of iron. It is inexpensive, easy to perform, and suitable for long-term corrosion studies. The weight loss method remains a standard and reliable technique for evaluating the corrosion resistance of iron and other metals. The corrosion of copper has been studied in different environments like acids, bases, and organic solvents. The results were compared with existing research. Copper plates of dimension 8 cm x 6 cm being used for the experiment. Solutions of different strengths viz 0.1, 0.5, 1N and 4N being prepared. The copper plates were dipped in these effective solutions for 1 to 5 hours and the corrosion study is measured in the form of weight loss basis. Corrosion was measured by weighing the plates before and after.

3. Result and Discussion

The experimental outcome led to several conclusions, which are given below: Copper corrodes less in acidic solutions than iron because copper is nobler (less reactive). In alkaline solutions (NaOH, KOH), copper corrodes more than iron. The low potential readings support copper's noble nature. Copper corrodes significantly in 4N nitric acid (HNO_3). Corrosion rates in acids: HNO_3 > H_2SO_4 > H_3PO_4 > HCl. In alkalis: KOH > NaOH > NH_4OH. Corrosion is high in potassium dichromate due to a redox reaction. Corrosion is similar in neutral solvents (like water, aniline, chloroform) for both copper and iron, but slightly higher for copper. The difference in corrosion is linked to copper's lower reactivity compared to iron. The findings are given in tables 1-2 and figures 1-8. The potentials have been measured using Copper electrode and Calomel electrode as the reference electrode.

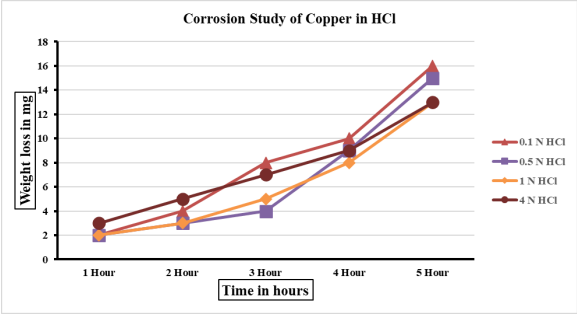

Fig. 1. Corrosion study of copper in HCl

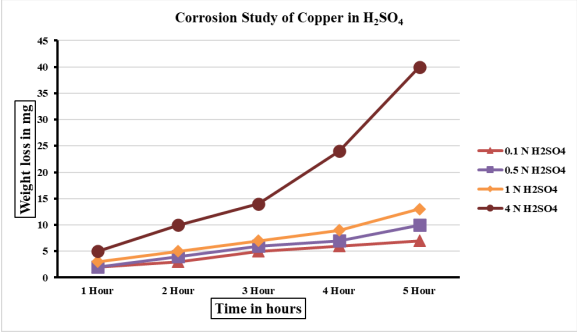

Fig. 2. Corrosion of copper in H_2SO_4

Table 1
Weight loss study of copper in different medium in (mg)

S.No.	Medium	0.1N	0.5N	1N	4N	Saturated Solution	Natural Solution
1	HCl	16	17	19	21	…..	……
2	H_2SO_4	7	10	13	45	….	….
3	HNO_3	8	12	18	75	….	…..
4	H_3PO_4	8	19	22	42	…..	…..
5	CH_3COOH	5	7	8	10	…..	….
6	NaOH	7	11	13	19	…..	…..
7	KOH	11	14	18	29	…..	……
8	NH_4OH	15	21	26	17	…..	…..
9	NaCl	….	….	….	…..	168	…..
10	KCl	….	….	….	…..	28	…..
11	Sea Water	….	….	….	….	….	13
12	Water	….	….	….	…..	…..	20

Table 2
Potential study of copper in different medium in terms of EMF (V)

S.No.	Medium	0.1N	0.5N	1N	4N	Saturated Solution	Natural Solution
1	HCl	0.071	0.137	0.243	0.350	…..	……
2	H_2SO_4	0.014	0.034	0.02	0.054	….	….
3	HNO_3	0.015	0.08	0.019	0.046	….	…..
4	H_3PO_4	0.082	0.091	0.099	0.477	…..	…..
5	CH_3COOH	0.01	0.012	0.017	0.019	…..	….
6	NaOH	0.195	0.293	0.351	0.579	…..	…..
7	KOH	0.062	0.288	0.335	0.621	…..	……
8	NH_4OH	0.029	0.097	0.371	0.553	…..	…..
9	NaCl	….	….	….	…..	0.353	…..
10	KCl	….	….	….	…..	0.341	…..
11	Sea Water	….	….	….	….	….	0.265
12	Water	….	….	….	…..	…..	0.053

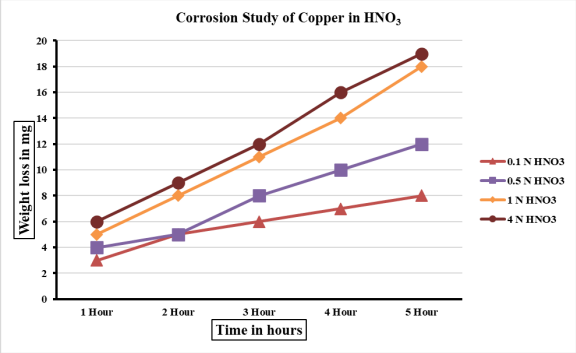

Fig. 3. Corrosion study of copper in HNO_3

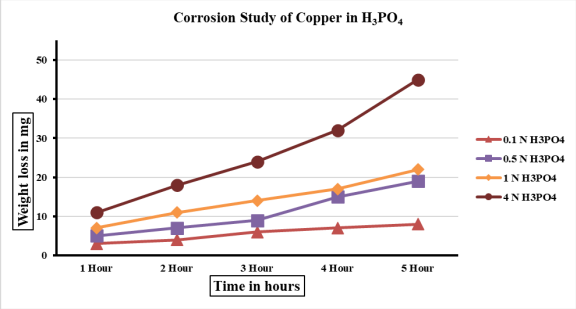

Fig. 4. Corrosion study of copper in H_3PO_4

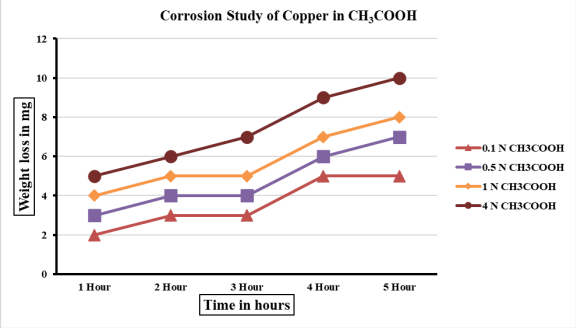

Fig. 5. Corrosion study of copper in acetic acid

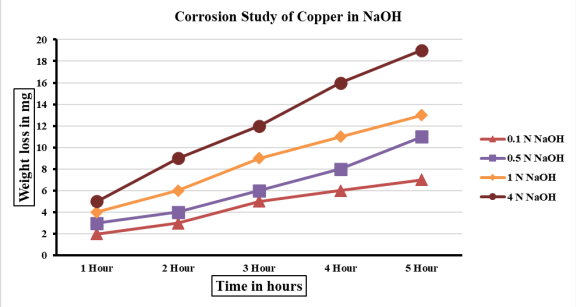

Fig. 6. Corrosion study of copper in NaOH

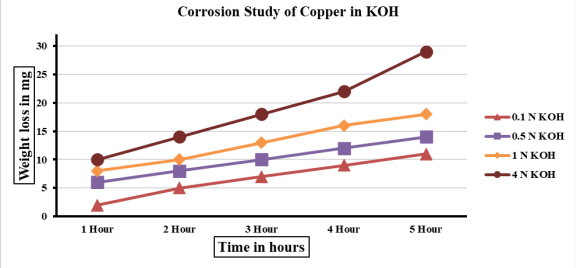

Fig. 7. Corrosion study of copper in KOH

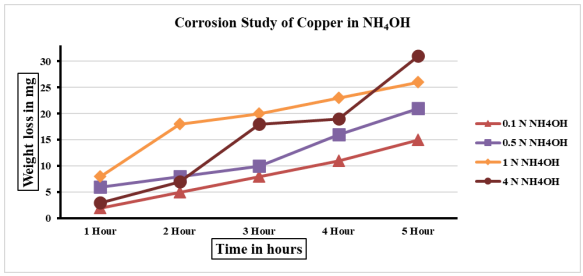

Fig. 8. Corrosion study of copper in NH_4OH

4. Conclusion

The present study demonstrates that the corrosion behaviour of copper varies significantly with the nature and concentration of the corrosive medium. Copper exhibits lower corrosion rates than iron in acidic solutions due to its noble character and lower chemical reactivity. However, in alkaline media, copper shows comparatively higher corrosion rates, indicating its susceptibility under such conditions. Among the acids studied, nitric acid (HNO_3) was found to be the most aggressive towards copper, followed by sulfuric acid, phosphoric acid, and hydrochloric acid. In alkaline solutions, the corrosion rate followed the order KOH > NaOH > NH_4OH. Significant corrosion was also observed in potassium dichromate solution owing to redox reactions occurring at the metal surface. In neutral media such as water, aniline, and chloroform, both copper and iron exhibited relatively low corrosion rates, although copper showed slightly higher weight loss. Overall, the results confirm that the corrosion resistance of copper is strongly dependent on the surrounding environment, and its lower reactivity compared to iron plays a key role in determining its corrosion behaviour.

Acknowledgement

The Authors are thankful to Head, Department of Chemistry for providing necessary facilities.

References

[1] H. Otmacic and E. Stupnisek-Lisac, “Copper corrosion inhibitors in near neutral media,” *Electrochimica Acta*, vol. 48, no. 8, pp. 985–991, 2003.

[2] E. M. Sherif and R. M. Erasmus, “Effects of chloride ions on copper corrosion,” *Electrochimica Acta*, vol. 53, no. 17, pp. 5359–5365, 2008.

[3] M. M. Antonijevic and M. B. Petrovic, “Copper corrosion inhibitors: A review,” *International Journal of Electrochemical Science*, vol. 3, no. 1, pp. 1–28, 2008.

[4] C. Fiaud and E. M. M. Sutter, “Corrosion behaviour of copper in aqueous solutions,” *Corrosion Science*, vol. 24, no. 5, pp. 375–389, 1984.

[5] D. Q. Zhang, L. X. Gao, and G. D. Zhou, “Inhibition of copper corrosion in acidic solutions,” *Corrosion Science*, vol. 46, no. 12, pp. 3031–3040, 2004.

[6] G. Kear, B. D. Barker, and F. C. Walsh, “Electrochemical corrosion of copper in chloride media,” *Corrosion Science*, vol. 46, no. 1, pp. 109–135, 2004.

[7] J. M. Costa and A. D. Mercer, “The corrosion of copper and its alloys,” *British Corrosion Journal*, vol. 20, no. 3, pp. 127–135, 1985.

[8] J. M. Bastidas, E. Cano, and E. M. Mora, “Atmospheric corrosion of copper,” *Corrosion Science*, vol. 47, no. 3, pp. 795–814, 2005.

[9] L. Robbiola, T. T. M. Tran, P. Dubot, O. Majerus, and K. Rahmouni, “Characterization of copper patinas,” *Corrosion Science*, vol. 50, no. 8, pp. 2205–2215, 2008.

[10] F. King, C. D. Litke, and M. J. Quinn, “Corrosion of copper under environmental conditions,” *Corrosion*, vol. 51, no. 2, pp. 104–115, 1995.