International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Comparative Study of Corrosion in Metals in Acidic media

Dr. Bhagyashree Chari
Xavier Institute of Engineering, Mumbai 400 016, Maharashtra, India
Email: bhagyashree.c@xavier.ac.in

ABSTRACT

Metallic corrosion is of immense importance in industry. Present study involves a comparison on corrosion reaction between iron, copper and zinc in various acidic media at constant room temperature for a given period of time exposure. Nitric acid is found to be more corrosive than sulphuric acid under similar conditions of temperature and exposure time. Also, the severity of corrosion depends upon the position of metal in galvanic series. The weight loss method was used to check the severity of corrosion.

Keywords: corrosion, exposure time, galvanic series, weight loss

INTRODUCTION

Metal industries extensively work with different types of metals in various conditions and these find enormous applications in engineering field. Corrosion Science is of interest since many years due to its impact on the environment.[1][2][3] It is not only confined to metals and alloys but also to the nanomaterials and microscopic materials. Corrosion is a kind of man – made destruction that can be prevented to some extent unlike natural hazards like volcanoes, earthquakes, etc. Most of the modern day industrial as well as domestic applications involves the use of metals and alloys and corrosion causes a heavy loss to industries and impairs the economic status of a society in general. Several industries such as automobile industry, petroleum industry, electroplating industry, paper and pulp industry, alloy manufacturing industry and chemical industry largely contribute to the phenomena of corrosion. Degradation of metals results in the reduction of their useful properties such as ductility and malleability and causes loss of cross sectional area and increase in the roughness of the surface. Corrosion is exactly reverse of metallurgy, a process of extraction of metals[4]. Some d – block elements including Iron, Copper, Cobalt, Zinc, Chromium are extensively used in industry for the engineering purposes[5][6][7]. It is essential to predict the corrosion behavior of these metals to prevent from any type of severe hazard[8].

Present paper describes a comparative study on the corrosion reaction of three metals, viz, iron, copper and zinc in acidic media. To avoid any ambiguity, the procedures are done under similar experimental condition such as temperature, exposure time and concentration and volumes of acids. The surface areas of metals under investigation are also uniform. Previously, enormous research[9][10][11] is being conducted on behavior of metals when exposed to different corroding media. Weight loss method[12] is used for analyzing the behavior of the three metals. Profoundly, nitric acid is observed as more corrosive than sulphuric acid in all

the three cases. Further, rate of corrosion also depends upon position of zinc (on the top side), iron (medial position) and copper (towards the bottom side) in the galvanic series[13][14]. The corrosion tendency amongst the three follows the order Zn > Fe > Cu.

METHODS AND MATERIAL

The metal sheets were procured from Jindal Company. Sulphuric acid and nitric acid were of analytical grade Merck make. All the glasswares used were made of borosilicate glass. Distilled water was obtained from water distillation plant used in lab. Acetone, used for washing was obtained from SD Fine Chemicals. Thermostatic water bath from LABPRO was used to maintain the constant temperature. All diluted acid samples were prepared as per standard procedure[15].

Iron metal specimen 3cm X 3cm was cleaned with acetone and its initial weight was noted. Then it was immersed for 20 min. in 0.5 N sulphuric acid solution. Then, it was washed with distilled water, dried and cleaned with acetone and final weight noted. The procedure was repeated using the same iron specimen with three other sulphuric acid samples with concentrations 1.0 N, 1.5 N and 2 N respectively at room temperature 23.5°C. The weight loss was calculated after each exposure.

In another set – up, copper specimen 3cm X 3cm was immersed in 0.5 N sulphuric acid at room temperature and weight loss was noted after 20 minutes. The process was repeated by using Sulphuric acids of various concentrations, 1.0 N, 1.5 N and 2 N respectively at room temperature.

Similarly, Zinc specimen was also tested for corrosion in these acidic media.

To have a comparative study, the whole procedure was repeated by using 0.5 N, 1N, 1.5 N and 2 N Nitric acid solutions on the three metals.

RESULTS AND DISCUSSION

According to the corrosion theory, metals have a strong tendency to displace hydrogen in acidic medium. Their electropositive nature is responsible for oxidation tendency. In the present study, when the three metals were investigated for corrosion behavior, it was observed that, zinc undergoes faster reaction as compared to iron and copper. This may be due to its higher position in galvanic series owing to its higher standard oxidation potential 0.76 V than the other two metals iron and copper with S. O. P values, 0.44 V and – 0.34 V respectively. As shown in the table 1, the weight loss is significant in zinc when exposed to nitric acid of higher concentration. Similarly, table II and III depicts the corrosion behavior in iron and copper respectively. In general, the weight loss is maximum in higher in nitric acid than in sulphuric acid as shown in the Fig 1 and Fig. 2. Nitric acid has strong oxidizing power than sulphuric acid. Therefore, rate of corrosion is maximum in the former than the latter. Corrosion continues till all the metal is oxidized, there occurs the formation of corrosion products on the surface, which make the surface rough and brownish deposits are observed as shown in Fig. 3.

TABLE I

CORROSION IN ZINC

Concentration of Acid	Initial Weight (g)	Final weight (g) after dipping in Sulphuric acid	Final weight (g) after dipping in Nitric acid
0.5 N	2.5	2.2	1.7
1 N	2.5	1.8	1.5
1.5 N	2.5	1.5	0.9
2 N	2.5	1.1	0.8

TABLE II

CORROSION IN IRON

Concentration of Acid	Initial Weight (g)	Final weight (g) after dipping in Sulphuric acid	Final weight (g) after dipping in Nitric acid
0.5 N	2.5	2.4	2.2
1 N	2.5	2.2	2.0
1.5 N	2.5	2.1	1.9
2 N	2.5	1.9	1.0

TABLE III

CORROSION IN COPPER

Concentration of Acid	Initial Weight (g)	Final weight (g) after dipping in Sulphuric acid	Final weight (g) after dipping in Nitric acid
0.5 N	2.5	2.3	2.2
1 N	2.5	2.2	1.9
1.5 N	2.5	1.7	1.5
2 N	2.5	1.1	1.0

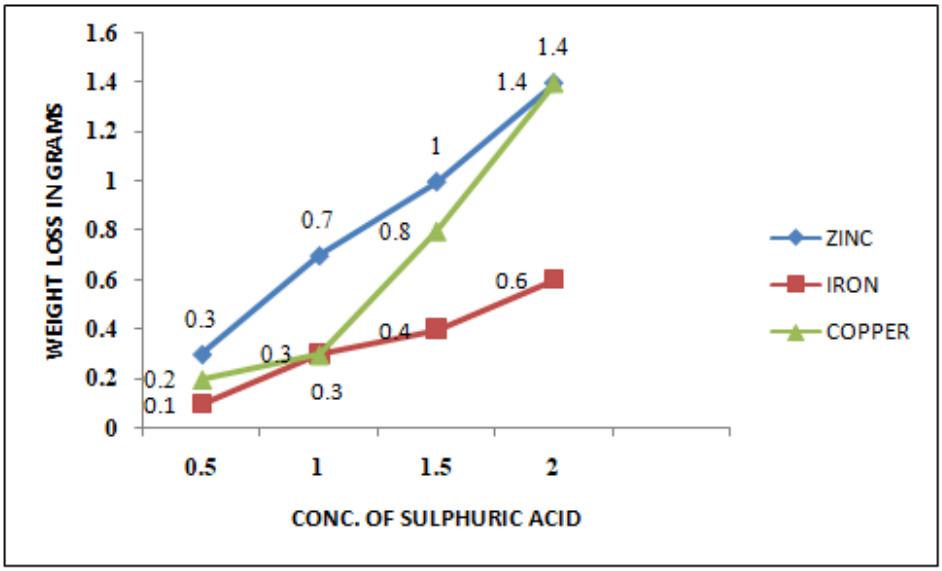

FIG 1: Effect of sulphuric acid concentrations on weight loss of metals

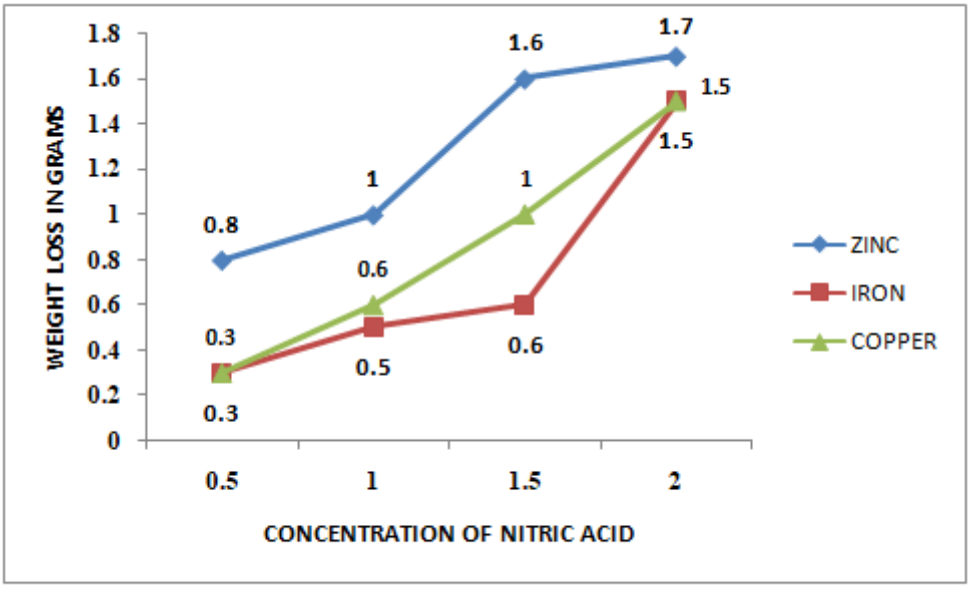

FIG 2: Effect of Nitric Acid concentrations on weight loss of metals

Fig 3. Appearance of Metal coupons after corrosion

CONCLUSION

The metals under investigation are of enormous importance in engineering purposes such as in metallurgy, electrical industry, electroplating industry and many more. It is essential to examine the corrosion of these metals prior to use, so that, necessary measures can be adopted to prevent from any type of industrial hazard. Their corrosion behavior is in accordance with the positions in galvanic series. Higher the electrode potential value, higher is the tendency of the metal to undergo corrosion. In present study, corrosion is clearly visible in the form of blisters, and it is basically oxidation of the metal by the respective acid. The research can be further conducted to pursue chemical kinetic study of the reactions at various temperatures and time exposure.

REFERENCES

[1] P. R. Roberge, Handbook of Corrosion Engineering, Mc-Graw Hill Publishers, 1999.
[2] M. G. Fontana, Corrosion Engineering, New York, Mc – Graw Hill Publishers, 1986.
[3] W. H. Ailor, Handbook on Corrosion Testing and Evaluation, New York, John Wiley and sons 1971, pp 697.
[4] B. Sivasankar, Engineering Chemistry, Tata McGraw Hill publishing company, New Delhi, 2008, pp 467.
[5] Edwin C. Constable. 2019. Royal Society of Chemistry, March 2019, DOI: 10.1039/c9dt00765B
[6] P. Pal, J. M. Ting et. al. 2021. Reactions. , September 2021, https://doi.org/10.3390/reactions2030022
[7] M. Weller, J. Rourke, T. Overton and F. Armstrong, "The d-block elements", in the book Inorganic Chemistry, (August 2023) DOI:10.1093/hesc/9780198768128.003.0021
[8] D. A. Jones, Principles and Prevention of Corrosion, 2nd edition, Prentice Hall, Upper Saddle River, NJ.
[9] S. A. Farooq, A. Raina, M. I. Ul Haq and Ankush Anand. 2022. Journal of the Institution of Engineers (India): Series D, Review Paper, June 2022, Volume 103, pages 639 – 661.
[10] Ming Liu. 2023. Materials, Jan 2023, https://doi.org/10.3390/ma16030973.
[11] D. B. Patil and A. Sharma, "Study on Corrosion Kinetics of Iron in Acid and Base medium", E – Journal of Chemistry, April 2011, page 358 – 362.
[12] Brahim El Ibrahimi and Elyor B., "Weight Loss Technique for Corrosion Measurements", in Electrochemical and Analytical Technique for Sustainable Corrosion Monitoring: Advances, Challenges & Opportunities, Elsevier, Saudi Arabia, 2023, pages 81 – 90. https://doi.org/10.1016/C2021-0-03502-1
[13] S. S. Dara and S. S. Umare, "Corrosion" in Text Book of Engineering Chemistry, S. Chand, New Delhi, 12th Edition, page 198 – 199.
[14] P. Jain and M. Jain, T. B. of Engineering Chemistry, 16th Edition, Dhanpat Rai Publishing Co., New Delhi, 2016.
[15] P. B. Joshi, Experiments in Engineering Chemistry, I. K. International Publishing House Ltd., New Delhi, 2016.