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Studies in Corrosion Performance of Iron in Presence of Variable Acidic Concentration Medium

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ABSTRACT

Iron is one of the most common materials used in the construction of industry for its relatively low cost paired with an acceptable corrosion resistance. Nevertheless, the early failure of a number of structures around the world that use iron as reinforcement has raised some controversy on the understanding of the corrosion behaviour of iron. The purpose of this paper was to study the effect of variable H_2SO_4, HCI and HNO_3 concentration on the corrosion performance of iron and to study the investigates the influence and mechanism of SO_4^{2-},CI^- and NO_3^-. Ion, investigated passivity of iron by the potentiodynamic polarization method in acidic solution and the weight loss method. Furthermore, the corrosion strength of Iron that exposed to acidic solutions for a specific duration of time. The surfaces were analyzed using photographs of iron plate.

Keywords: Iron Corrosion, Weight loss, Potentiodynamic curve, Acidic solutions.

INTRODUCTION

Iron is best known as the metal that gave us weapons and tools, and whose ability by means of alloys and heat treatment to suit itself to every application makes it the primary metal of technology. Iron is an excellent and versatile material of construction[1-2] , strong, tough, easily formed and worked, and, very importantly, cheap compared to the alternatives .Iron has many industrial application because of its easy availability , low cost , uncomplicated fabrication of it into water pipe line , cooling water system,[3-4] During industrial process such as pickling, etching, acid cleaning, acid de-scaling, iron is often made to come in contact with aggressive solutions such as acidic solutions.[5-6] the spontaneous reactions occurring in galvanic cells generate electric potential. Non-spontaneous reactions which we can force to occur in plating or other electrolytic cells also have their utility. But by far the most significant and undesirable spontaneous electrochemical process is corrosion.[7-8] The most common example is the rusting of iron metal or iron alloys such as ordinary carbon steel.[9-10] Corrosion costs this country billions of dollars each year in replacement and maintenance costs. From a purely economic point of view, then, it would be helpful to understand corrosion processes. This study assesses the corrosion of iron in sulphuric acid, nitric acid and hydrochloric acid medium using weight loss method. Comparative corroding behavior, kinetics and activating parameters are explained.

MATERIALS AND METHODS

Materials: Iron sheet (Jindal Iron Limited, India) were purchased from local market

Weight loss method: Iron,1 cm × 1cm plates were used to determine the corrosion rates using the weight loss method. The surfaces of the plates were cleaned by a chemical process, including a $3HNO_3$:$1H_2SO_4$:$1H_2O$ mixed solution, followed by pure water and CCl_4. The cleaned specimens were held in a furnace to a fixed mass. Masses of the fixed mass specimens were determined and recorded. The specimens were immersed in 2N H_2SO_4, 2N HCl, and 2N HNO_3 solutions. The specimens were taken from each solution at specified times (24, 48, 72, 96,h). Specimens were taken and then rinsed with pure water. These specimens were later dried again at 110 ^{o}C in a furnace and weighed. Using this process, weight losses were determined and corrosion rates were calculated (tables 1,2) using the following formula:

$$\text{Corrosion rate} = \frac{\text{weight loss}}{\text{Surface area of metal} \times \text{time}}$$

Solutions: All the chemicals used in the present investigation, for the preparation of solutions were of analytical grade. Glass doubly distilled water was for the preparation of all the solutions.

Table 1 . Weight Loss (g) in Acidic solution (2N HCI, 2N H_2SO_4, 2N HNO_3) at Room Temperature

Acidic Solution	Time in Hours 24 h	48 h.	72 h.	96 h.
2 N HCI	0.47	0.50	o.52	o.54
2 N H_2SO_4	0.56	0.60	0.62	0.64
2 N HNO_3	0.22	0.23	0.25	0.30

Table 2 . Corrosion Rate in Acidic solution (2N HCI, 2N H_2SO_4, 2N HNO_3) at Room Temperature

Acidic Solution	Time in Hours 24 h.	48 h.	72 h.	96 h.
2 N HCI	11280	24000	37440	51840
2 N H2SO4	13440	28800	44640	61440
2 N HNO3	5280	11040	18000	28800

Electrochemical method: Electrochemical measurements were made by PAR 263 A, potentiostat/Galvanostat. In the electrochemical measurements, platinum was used as the counter electrode, saturated calomel electrode (SCE), as the reference electrode, and Iron as the working electrode. The surfaces of the working electrode were covered with polyester, except for the parts connected to the solutions. Before measuring, the surface of the working electrode was polished to a mirror finish with a polishing device using, 800 and 1200 mesh sandpaper. Polarization curves were obtained between −1.00 and +1.00 Vat a 1 mV/s scan rate. During the measurement, the solutions were mixed with a magnetic mixer. All the above experiments were carried out using freshly polished specimens in aerated solutions.

Surface analysis: The surfaces of the Iron plates that were exposed to acidic solutions 2N H_2SO_4, 2N HCl, and 2N HNO_3 for were investigated by digital photos.

RESULTS AND DISCUSSION

Weight loss test results: The variance of the corrosion rate as a function of time for Iron in 2N H_2SO_4, 2N HCI and 2N HNO_3. Acidic solution (fig1,2).

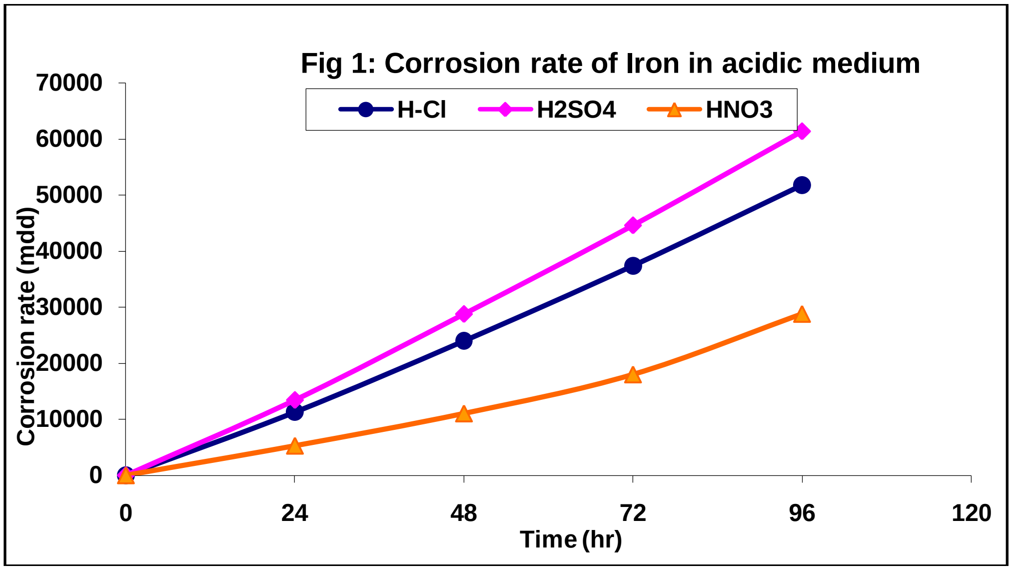

Fig.1. Varying of corrosion rate according to time for Iron in 2N H_2SO_4, 2N HCl and 2N HNO_3 solutions.

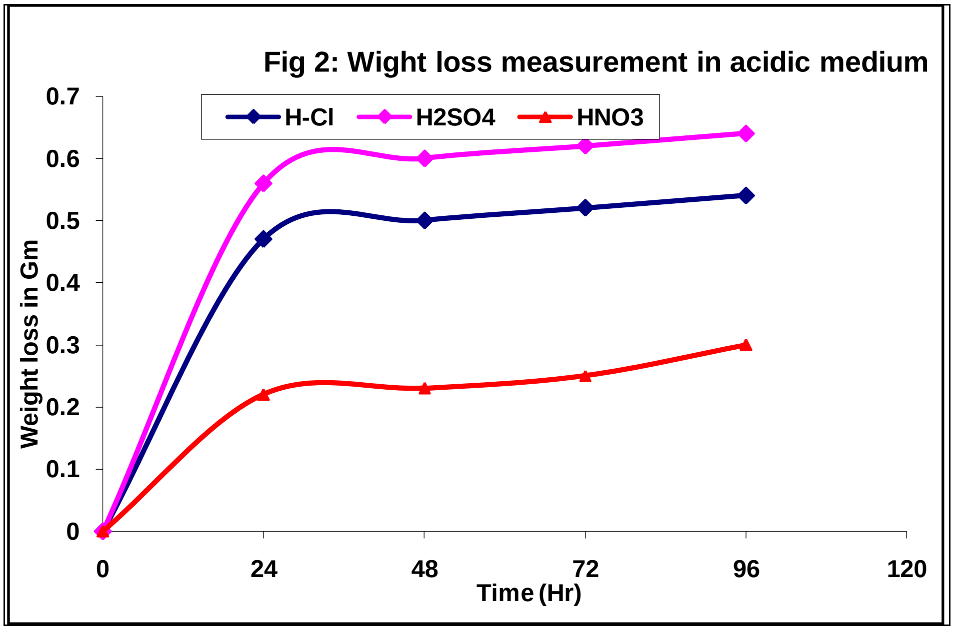

Fig.2.Varying of weight loss according to time for Iron in 2N H_2SO_4, 2N HCl and 2N HNO_3 solutions.

According to fig. 1, the corrosion rates of Iron in a 2N H_2SO_4 and 2N HCl solution was observed to increasing, while the 2N $HN0_3$ solutions indicated no clear increased corrosion through the protective oxide passivation. Corrosion rates of specimens immersed in a 2N H2SO4 solution were observed to increase by approximately 10 times, reaching 60000 mdd at the end of 96 h. While the corrosion rates of plates in the 2N HCl solution were observed to increase for the first 20 h, the rates oscillate up to 96 h due to the cyclical protective oxide layer formation and degradation on the metal surface. After 96 h, the corrosion rates increased due to a breakdown of the protective oxide layer, ultimately reaching 50000 mdd at the end of 96 h. The corrosion rate of iron in a nitric acid solution became constant at the end of 20 h due to the formation of a protective oxide layer. The corrosion rates of iron in a 2N H_2SOS_4 solution were observed to be the greatest due to SO_4^{2-} ions, followed by 2N HCI acidic solutions, respectively (Fig. 1).

Electrochemical method results :

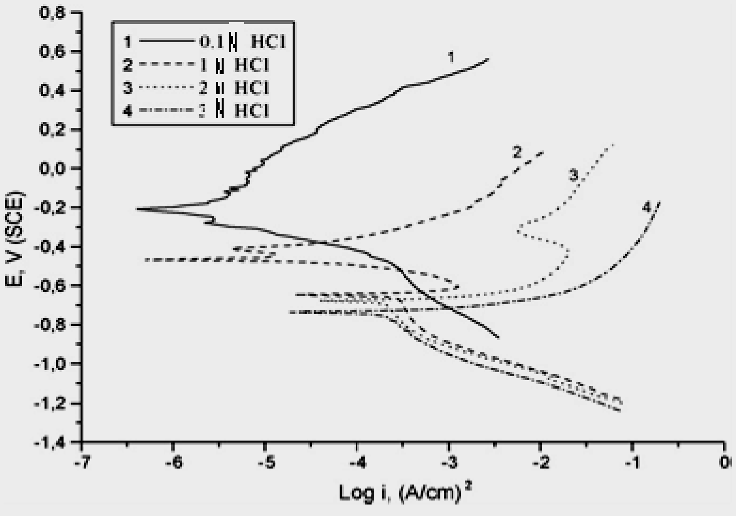

Fig. 3. Potantiodynamic polarization curves Iron in HCl.

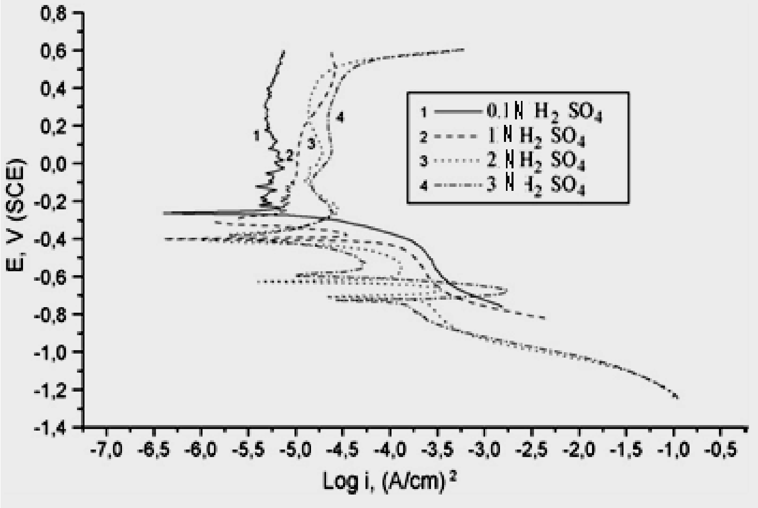

Fig. 4. Potentiodynamic polarization curves of Iron in H_2SO_4.

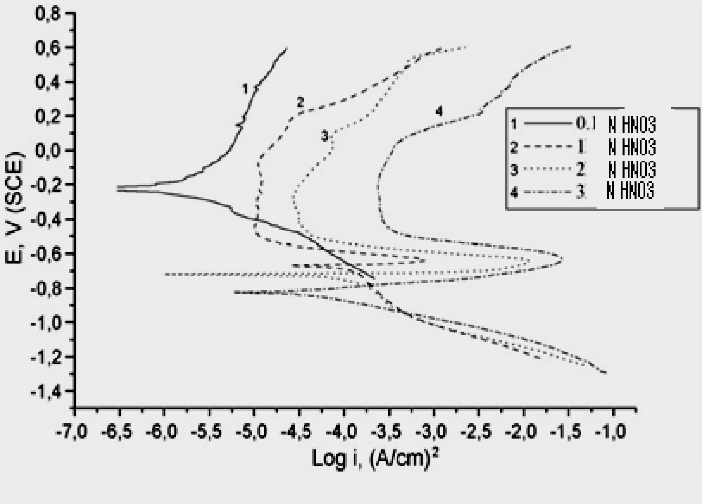

Fig. 5. Potantiodynamic polarization curves of Iron in HNO_3.

Potentiodynamic polarization curves of Iron in HCl, H_2SO_4 and HNO_3 acidic solutions with different concentrations (0.1, 1, 2, and 3N) are given in Figs. 3–5. As shown in the polarization curves in fig. 3, increasing the acid concentration iron HCl immersion solution was observed to increase the corrosion current density from 38.19A cm^{-2} (0.1N HCl) to 4505A cm^{-2} (3N HCl). In this case, Cl^- ions penetrate into the metal surface and increase the concentration of the metal. This effect is also increased with increasing chloride concentration. Furthermore, passivity was not observed for specimens immersed in HCl solutions, Cl^- and SO_4^{2-} ions obstruct the oxide at the metal surface (fig.3 and 4). The corrosion potential increases as a function of HCl and H_2SO_4 concentration, which is shown as more negative values. Fig. 4 Potentiodynamic polarization curves of iron in H_2SO_4. tial region was observed to be −0.22–0.55V in 0.1 and 1N H_2SO_4, −0.25–0.52V in 2N H_2SO_4 and −0.26–0.5V in 3N H_2SO_4, Furthermore, passivity was not observed for specimens immersed in H_2SO_4 solutions, Fig. 5 depicts the polarization curves of iron in 0.1, 1, 2, and 3N HNO_3 solutions. Passivity was observed in all of these curves due to the occurrence of oxide on the metal surfaces. The cathodic reactions in the acidic solutions are hydrogen reductions.

Surface analysis: Fig. 6 depicts photographs of iron specimens immersed in different acidic solutions for 1 to 4 days. The metal surfaces exposed to any acidic solutions were not appreciably abraded at the end of 4 days, the surfaces were observed have increased corrosion on the metal surfaces were observed for specimens immersed in 2N H_2SO_4 ,2N HCl and 2N HNO_3 solutions due to the corrosive effect of SO_4^{2-} , Cl^- and NO_3^- ions. The most corrosive effect was caused by H_2SO_4 solutions.

96 Hours in H_2SO_4

96 Hours in HCL

96 Hours in HNO_3

APPLICATIONS

This study on the effect of variable different acid concentration on the corrosion performance of iron and to study the influence and mechanism of SO_4^{2-},CI^- and NO_3^-.

CONCLUSIONS

The corrosion rate of iron was increased according to the weight loss method. The greatest increase was observed in 3N H_2SO_4 solution.

Full passivity in H_2SO_4 and HCl solutions was not observed in the potentiodynamic polarization measurements.

The occurrence of pitting corrosion on metal surfaces was determined from photographic films.

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