



CORROSION BEHAVIOR of LOW CARBON STEEL (SHEET METALS) in SELECTED ACIDIC MEDIUM

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Abstract— Low carbon sheet metals are one of the widely used materials in the industrial sector, it will have a frequent contact with different chemicals, due to relative availability, its cost and the like. The main drawback of this metal is it corrodes easily when exposed to different environment. The research aims at investigating the corrosion rate of low carbon steel, specifically sheet metals in the acidic medium (Nitric Acid, sulphuric acid and hydrochloric Acids each with concentration of 1.0M, 1.5M and 2.0M). The sample coupons with known weight were immersed in the sample media (Nitric Acid, Sulphuric acid and Hydrochloric Acids) for five days and the weight loss measurement were taken with the interval of 24hrs. Different research revealed that the presence of corrosion of low carbon sheet metals in HCl, HNO₃ and H₂SO₄ solutions are credited to the presence of water, air and H⁺ which accelerated the corrosion processes. To fulfil the aim of this research weight loss was calculated from the measured weight values. And the calculated value shows, the rate of attack increases with increase in time and molar concentration of the acids, the weight loss and corrosion rate becomes high in Nitric acid and the least in hydrochloric acids. Finally, corrosion in Nitric acid exhibits colourful appearance due to the evolution of Nitrogen (II) oxide gas.

Keywords— Low Carbon sheet metals, Acidic Medium, Corrosion rate, Weight loss, Molar Concentration

I. INTRODUCTION

Low carbon steel is one of the most important materials that meet the strength requirements because most of its properties like its optimal strength to weight ratio, good cost to weight ratio, availability, ability to be readily supplied at relatively cheap price in range of different product forms with useful range of materials properties, possibility of enhancing desired mechanical properties by heat treatment, worldwide existence of abundant quantities of iron ore with in earth crust from which steel originates and possibility to produce the alloy from the ore using relatively economical extraction, refining alloying and fabrication, make the steel to be selective for structural works [1]. Corrosion of low carbon steel especially on sheet metals and the formation of corrosion products like iron oxides is one of the factors that obstruct the wide range in usage. Corrosion is believed to be an abiotic process of chemical reactions. It was generally agreed by most of the researches that carbon steels are generally attacked by uniform corrosion or general corrosion. Corrosion can be arise on low carbon due to a number of variables and complicate the course of corrosion in different ways such as chloride, sulphate, humidity and temperature [2]. So on time monitoring and inspection is required to alleviate the wide range of destruction and to propose the mechanisms as well as to take an on time action. This work aims at examining the corrosion rate of low carbon sheet metals in the acidic medium using gravimetric method.

II. MATERIALS AND METHODS

Materials used for this work were low carbon steel prepared in the mechanical workshop of Hawassa University in Hawassa Ethiopia. The chemical compositions of these materials are as shown in Table 1. The samples are sheet of metals with 1 mm thickness was mechanically press-cut into 5 × 5 cm coupons and perforated at the center with holes to allow the passage of threads.

The specimens' surfaces were cleaned gently using emery paper, ethanol and tap water, and then dried. Nitric acid, hydrochloric acid and Sulphuric acid solutions were prepared with molarities listed using standard procedures 1.0M, 1.5M and 2.0. All reagents were prepared using distilled water. Three sets of experiments were performed. Each set consisting of 42 x 500 ml beakers in which the coupons were suspended in it.

TABLE I. CHEMICAL COMPOSITION OF LOW CARBON SHEET METAL

No	METAL TYPE	PERCENTAGE CHEMICAL COMPOSITION BY WEIGHT											AVERAGE DIMENSION	
		C	SI	MN	S	P	Ni	CR	MO	CU	AL	FE	LENGHT (DIMENSION)	THICKNESS (MM)
1	SHEET METALS	0.156	0.11	0.14	0.005	0.3	0.138	---	---	---	0.054	Bal.	5cmx5cm	0.06mm

Prepared samples were weighted and suspended in the beaker each containing selected chemical environment with concentrations stated above. The specimen's exposure time were five days with five measurements taken with time intervals of twenty four hours (1 day). Finally, the corrosion rate of each sample was determined using corrosion rate formula [3].

$$\text{Corrosion Rate} = \frac{534W}{\rho AT}$$

Where, Corrosion is in millimeter per year, W- is the weight loss in mg, ρ - is metal density in mg/m^3 , A – is area of metal coupon exposed in m^2 , T- Exposure time in hours.

III. RESULT AND DISCUSSION

A. WEIGHT LOSS

The sample coupons weight was measured before immersed in to the beakers containing chemicals with different concentration at room temperature.

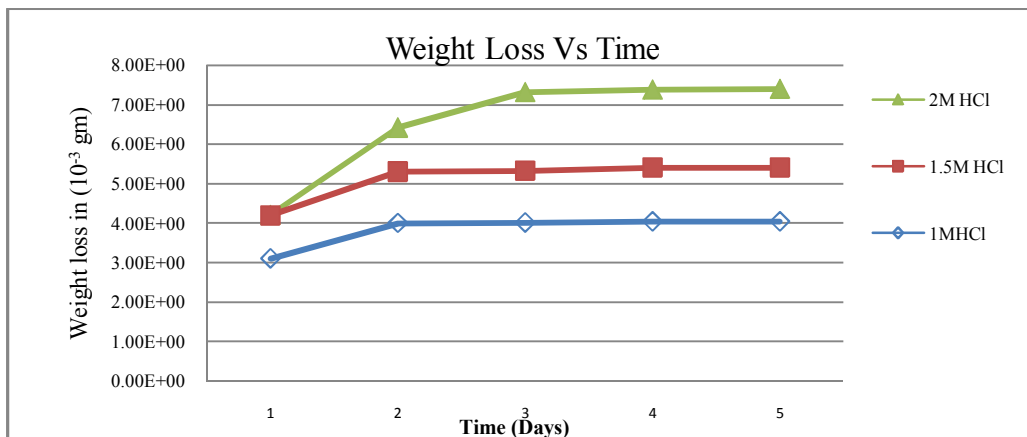


Figure 1. Variation of Weight loss (10^{-3} gm) with time for Low Carbon Sheet metals in Different Concentration of HCl Solution.

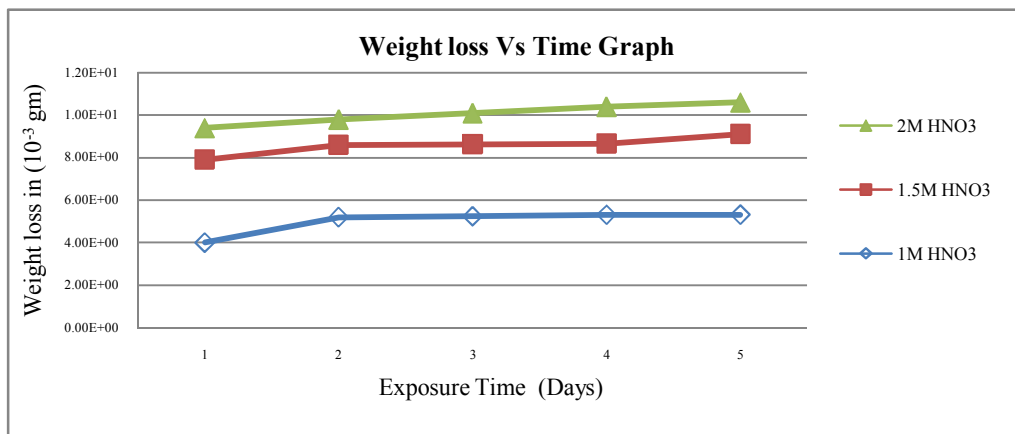


Figure 2. Weight loss (10^{-3} gm) with time for Low Carbon Sheet metal in Different Concentration of HNO_3 Solution.

Then samples weight were measured and recorded with every 24hrs(1day). For consecutive five days. Finally using the date collected before after exposure to the sample environment, the weight loss were calculated. Figure 1, Figure 2 and Figure 3 shows the results of weight loss of the sample in the three acids with different concentration with time.

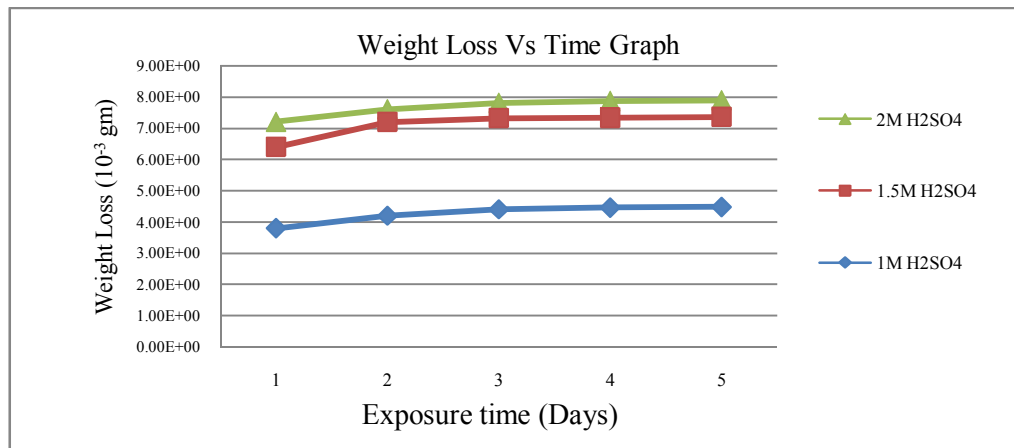


Figure 3. Weight loss (10^{-3} gm) with time in Days for Low Carbon Sheet metal in Different Concentration of H_2SO_4 Solution

The rate of weight loss measured within five days with different concentration of acidic environments. The corrosion of low carbon sheet metals in HCl, HNO₃ and H₂SO₄ solutions are credited to the presence of water, air and H⁺ which accelerated the corrosion processes. From Figure 1 up to 3 also shows the weight in loss of low carbon sheet metals increased with time and molar concentration of the acids [4]. This observation is attributable to the fact that the rate of chemical reaction increases with increasing concentration. At the same fashion low carbon in the nitric acid lose more mass and the least mass was lost in the Hydrochloric acid.

B. CORROSION RATE CALCULATION

The corrosion rates of the samples immersed in the acidic environment were determined using the standard mathematical relation stated above and the results are listed in table 2. The results show that the corrosion rate is notably larger in nitric acid because nitric acid is known to be a strong oxidizing agent, and the least in hydrochloric acid (HCl). The primary displacement of hydrogen ion (H⁺) from the solutions is followed by nitric acid reduction rather than hydrogen evolution since the acid reduction leads to a marked decrease in the free energy [5].

The chemical reaction involved when the low carbon immersed in Nitric acid becomes



This reaction leads to the evolution of Nitrogen (II) oxide and production of Fe(NO₃)₂ which forms brown in colour due to the color gas that is Nitrogen(II) oxide[6]. Figure 4, Figure 5 and Figure 6 also indicates that, the rate of corrosion of low carbon sheet metals also higher with high molar concentration of the respective acids, which is similar to the weight loss activity. Moreover the rate of corrosion is faster for the first two days and then slows down. This may be due to the formation of passive layer [7].

IV. CONCLUSION

- This research proved that low carbon sheet metals are corrosive in Acidic environments due to the evolution of hydrogen gas.
- Corrosion of low carbon sheet metal is significant in varying the concentrations of hydrochloric acid, nitric acid and sulphuric acids with more corrosive in nitric acids and least in hydrochloric acid.
- Corrosion in Nitric acid environment shows brown in color due to the evolution of Nitrogen (II) oxides.
- The concept of passivity were introduced as a means of corrosion resistance for low carbon sheet metals

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TABLE 2 CORROSION RATE OF LOW CARBON SHEET METAL IN DIFFERENT CONCENTRATION OF

Time in Days.	Corrosion Rate (10 ⁻³ mm/yr)								
	Hydrochloric Acid (HCl)			Nitric Acids (HNO ₃)			Sulphuric Acid (H ₂ SO ₄)		
	1M	1.5M	2M	1M	1.5M	2M	1M	1.5M	2M
1	0.351	0.476	0.477	0.454	0.896	1.066	0.431	0.726	0.816
2	0.227	0.3	0.364	0.295	0.488	0.556	0.238	0.408	0.431
3	0.152	0.201	0.277	0.198	0.325	0.382	0.166	0.277	0.295
4	0.115	0.153	0.209	0.151	0.245	0.295	0.126	0.208	0.223
5	0.0916	0.122	0.168	0.121	0.206	0.24	0.102	0.167	0.179

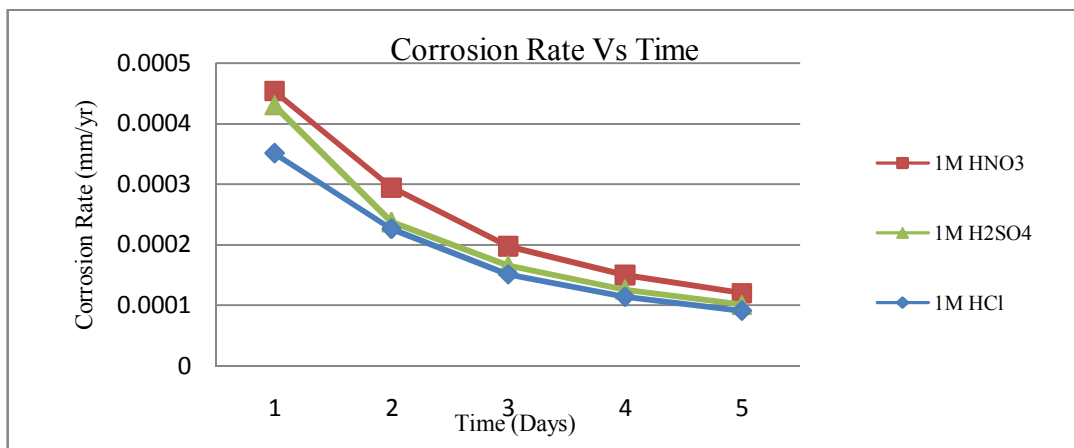


Figure 4. Corrosion Rate of low carbon sheet metal in 1M HCl, HNO₃ and H₂SO₄

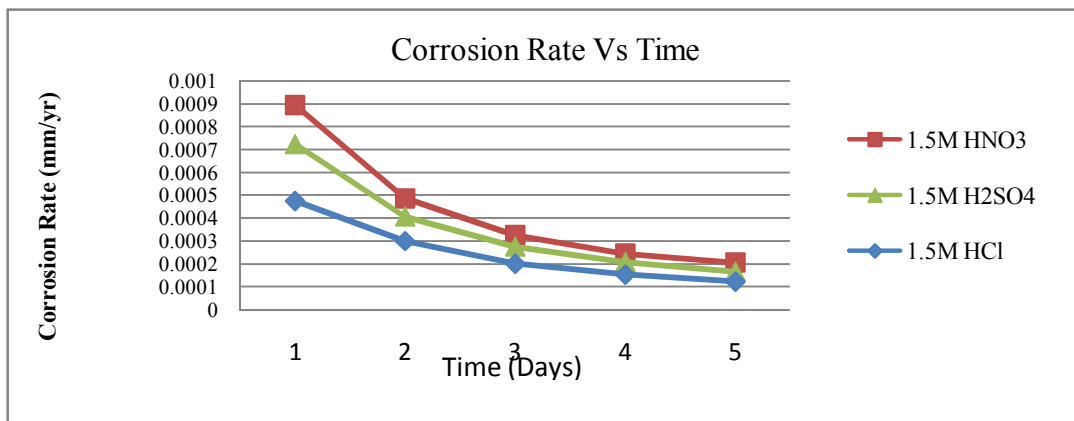


Figure 5. Corrosion Rate of low carbon sheet metal in 1.5 M HCl, HNO₃ and H₂SO₄

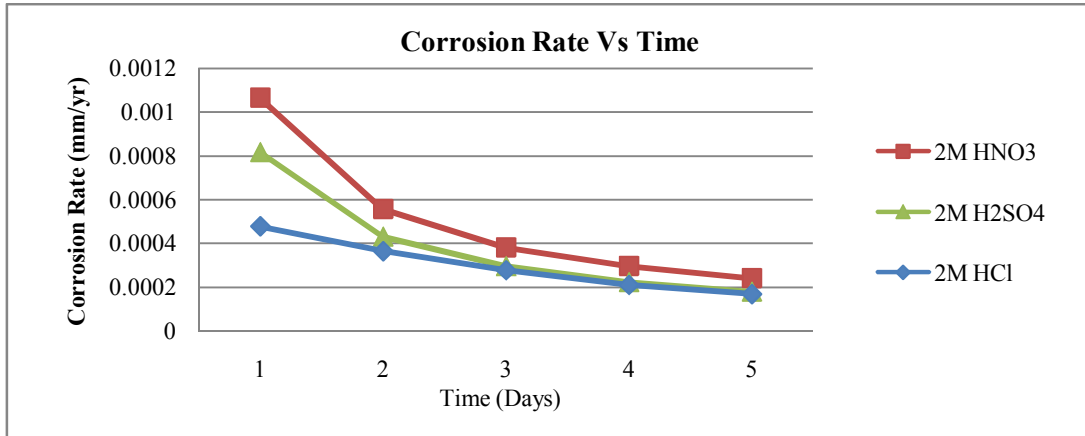


Figure 6. Corrosion Rate of low carbon sheet metal in 2 M HCl, HNO₃ and H₂SO₄