



## CORROSION EVALUATION ON MILD STEEL IN ACIDIC MEDIA

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### ABSTRACT:

Corrosion of mild steel has threatened global industrial growth globally. In this research work, an assessment of corrosion of locally produced mild steel in tetraoxosulphate (VI) acid (H<sub>2</sub>SO<sub>4</sub>) and hydrochloric acid (HCl) were done. The collected samples from Ilorin, Kwara State, Nigeria after chemical analysis were machined to the same sizes. Each of the samples was immersed in equal volumes of the selected media. The assessment of effect of corrosion on the mild steel samples used was carried out via weight loss at various exposure times which lasted for duration of 45 days. The results obtained indicated that tetraoxosulphate (VI) acid was most aggressive environment. The average weight loss are 5.04g (H<sub>2</sub>SO<sub>4</sub>) and 1.20g (HCL) with corresponding corrosion rate of values 0.066 and 0.017 (mm/yr). The follow up statistical analysis output showed that loss in weight is significant for tetraoxosulphate (VI) acid when compared with hydrochloric acid (HCl). Thus, it can be concluded that of the two media examined, tetraoxosulphate (VI) acid is the most corrosive, followed by hydrochloric acid degree of corrosiveness. Therefore, facilities and equipment made of mild steel should not be used in an environment containing traces of acidic ions due to the hazardous effect it has on mild steel material.

### KEYWORDS:

ACIDIC MEDIA, CORROSION, ENVIRONMENT, METAL AND STEEL.

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### INTRODUCTION

All over the globe, mild steel is a valuable material and generally use in most engineering applications for the production of some automobile components, structural shapes and sheets that are used in plants, Engineering facilities, pipelines, building bridges (Callister, 1997). The usage of carbon steel material is noticeable in various facets of human life such as in manufacturing, oil and gas, construction, medical, textile, transport and aviation industries to mention a few. Despite the versatile usage of mild steel materials, the failure of parts and components of engineering materials produced from such materials in different industries environment by corrosion is one of the major problems facing mankind (Oyejide, Orhorhoro, Ogie, and Idi, 2017). As a result of man activities in our ecosystem, the environment is increasing becoming corrosive thereby causing significant impact in the degradation of metals (Oluwole, Atanda, Odekunbi, and Adegbaaju, 2009), (Qiang, Zhang, Guo, Zheng, Xiang, Chen, 2017) and (Orhorhoro, Erameh, and Adingwupu, 2018). Most metals such carbon steels are prone to corrosion irrespective of their area of application be it power generation, paper industries, oil and gas etc.

Corrosion is a prevailing destructive phenomenon in science and technology. In industries such as pulp and paper industry, power generation, underground

structures, chemical and oil industries, metals are used in over 90% of construction process (Osarolube, et al., 2004). Iron and steel are the most commonly used materials in the fabrication and manufacturing of oil field operating platforms because of their availability, low cost, ease of fabrication, and high strength. Most industrial media are usually rich in elemental gases, inorganic salts, and acidic solutions most of which influence corrosion rates, and mechanisms (Abiola and Oforika, 2005). Metals are usually exposed to the action of bases or acids in the industries. Processes in which acids play a very important role are acid pickling, industrial acid cleaning, cleaning of oil refinery equipment, oil well acidizing and acid descaling (Farina et al., 2004). The exposures can be severe to the properties of the metals and thus lead to sudden failure of materials in service. There is therefore the need to study the corrosion behaviour of metals when exposed to various environments, as this is an important factor in material selection that determines the service life of the material. Mild steel and high carbon steels are classified as ferrous metals (they contain a large percentage of iron).

Carbon steels are essentially iron-carbon alloys. They are sometimes subdivided by the broad range of carbon content, which include: (a) mild or low carbon steel (0.08 – 0.30% carbon) (b) medium carbon steel (0.3 – 0.5%

carbon) and (c) high carbon steel (0.55 – 1.40 carbon). For many years, mild steel plates and rod-sections have been used as structural members in bridges, buildings, pipelines, heavy vehicles, in welded plate form for the construction of ships storage vessels and numerous other application.. High carbon steel (having a higher carbon content than mild steel) is harder and stronger, and yet least ductile of all the carbon steels. It is mainly used for the manufacture of metal cutting tools like hammers, saws, forging die blocks, axes, knives, drills and wood. This work examines the corrosion behaviour of mild steel and high carbon steel when exposed to various concentrations of nitric acid, hydrochloric acid, and perchloric acid. The corrosion rates in these media are also calculated to study their stability when similar industrial environments are encountered.

Metals corrode because they are used in environment where they are chemically unstable. Apart from copper and the other precious metals such as gold, silver, platinum etc., which are found in nature in their free metallic state. Every other metal are processed from minerals or ores into metals which are inherently unstable in their environments hence, they tend to revert to their

more stable state, a phenomenon termed as reversed extractive metallurgy (Roberge, 2008), (Senthilkumar, and Ajiboye, 2012) and (Fontana, 2001). Corrosion which has existed over the years and regarded as a gradual deterioration of materials, usually metals, by chemical reaction with its environment (Kamachi, 2009), (Onyekpe, 2002), (Afolabi, 2007) and (Aramide, Olorunniwo, Atanda, and Borode, 2010) is a menace to the existence of man and his environment (Orhorhoro, Oyiboruona, and Ikpe, 2017), Corrosion is said to be a destructive phenomenon of which its economics effects is detrimental to the appearance of metal and some cases can cause equipment failure (Chinwko, Odio, Chukwuneke and Sinebe, 2014).

## MATERIALS AND METHODS

### A. MATERIALS SELECTION

The material used for the experimental study were locally produced mild steel premium steel and Ilorin, Kwara State. The element composition of the mild steel was conducted via Minipal 4 spectrometer, having a chemical composition as follow;

**TABLE 1: COMPOSITION OF MILD STEEL**

Element	Percentage Composition (%)
C	0.14
Mn	0.49
P	0.018
Si	0.19
S	0.005
Cu	0.05
N	0.008
Cr	0.79
Fe	98.44

The collected samples were machined using a lathe and cutting machine into rectangular shape of dimension of 5mm by 3mm by 0.5mm thickness. The samples were then taken through grinding, polishing and etching preparation in order to eliminate the effect of surface impurity. The samples were finally rinsed in distilled water before drying.

### B. PREPARATION OF TEST MEDIA

The media in which the experiment was conducted consist of 2M tetraoxosulphate (VI) acid and 2M hydrochloric acid. Both acids were obtained from the industrial market, Ilorin, Kwara State. Other media are readily available in the environment.

### C. SHAPES AND SIZE OF SAMPLES

The samples used in this research work are rectangular in shape.

Length=5mm=50cm

Breath=3mm=30cm

Thickness = 0.5mm=5cm

Area of flat Sides =  $2(L \times B) = 2(50 \times 30) = 3000\text{cm}^2$

Area of Edges =  $2(\text{Length} \times \text{Thickness}) + 2(\text{Length} \times \text{Thickness})$

$= 2(50 \times 5) + 2(30 \times 5) = 500 + 300 = 800\text{cm}^2$

Therefore,

Total Area = Area of flat sides+ Area of edges =  $3000 + 800 = 3800\text{cm}^2$

### D. DETERMINATION OF CORROSION RATE

Twenty (20) samples of properly machined mild steel to shape and dimension were used for the weight loss and corrosion rate experiment and analysis. The initial weight

of each samples was measured with a weighing balance and recorded (all samples have equal weight). Each of the samples was immersed in each of the media for initial period of 5 days and the investigation was continue for a period 10 days intervals and this lasted for a duration of 45 days. Equation (1) was used to determined the weight loss (Free man, Silverman, 1992).

$$C_R = \frac{K \times \Delta W}{A \times T \times \beta}$$

where,

$C_R$  = Penetration (Corrosion) rate in (mm/wk.)

$\Delta w$  = Weight loss in gram

A = Exposed Surface area of sample= $3.8 \times 10^2 \text{cm}^2$

P = Density of mild steel (g/cm<sup>3</sup>) =7.86 g/cm<sup>3</sup>

T = Time of exposure in hours

K = Constant for unit conversion= $8.76 \times 10^4$

Also, to provide minimum uncertainty in the corrosion rate, this method implicitly assumes that;

- i. The corrosion rate does not vary with exposure time
- ii. The area does not change as mass is lost to corrosion
- iii. The projected and actual surface areas are the same
- iv. The penetration rate is uniform over the entire surface
- v. The weight is unaffected by corrosion product removal, and even assuming that the above criteria are fulfilled, errors can still be propagated because of the uncertainty in the measurement of time, mass and dimension.

**EXPERIMENT AND RESULT**

The weight loss and the corrosion rate of the different mild steel samples were calculated and tabulated as shown in Table 2-Table

**TABLE 2: WEIGHT LOSS OF SAMPLE IN 2M H2SO4 DAYS**

Days	Initial Weight(g)	Final Weight(g)	Weight Loss(g)	Corrosion Rate (mm/yr)
5	78.50	70.90	7.60	0.1856
15	70.90	64.70	6.20	0.0758
25	64.70	60.10	4.60	0.3748
35	60.10	56.30	3.80	0.0232
45	56.30	53.40	2.90	0.0142

**TABLE 3: WEIGHT LOSS OF SAMPLE IN 2M HCL**

Days	Initial Weight(g)	Final Weight(g)	Weight Loss (g)	Corrosion Rate (mm/yr)
5	78.50	76.33	2.30	0.0538
15	76.33	74.73	1.60	0.0196
25	74.73	73.63	1.10	0.0090
35	73.63	72.93	0.70	0.0043
45	72.93	72.53	0.40	0.0020

From the result analyzed, the average weight loss are 5.04g (H2SO4) and 1.20g (HCL) with corresponding corrosion rate of values 0.066 and 0.017 (mm/yr). The sample in Tetraoxosulphate (VI) acid shows a more severe level of corrosion rate and this was due to the aggressiveness of the sulphate (SO4<sup>2-</sup>) ion in the solution. Also the sample in hydrochloric acid experienced what is considered in Engineer literature as chloride aggressiveness. The presence of halide ions breakdown any passive films available and sometimes prevent passive films from forming on the mild steel. However sample exposed to tetraoxosulphate (VI) acid environment show a sharp increase in corrosion rate, this might be attributed to high oxidizing nature of the corrodent.

**CONCLUSION**

From the foregoing, it was concluded that mild carbon steel samples experienced fast corrosion rate at the early stage of exposure period to the different media used in this research work. However, as exposure time prolongs, there was a continuous decreased in corrosion rate. Besides, among the media used in this research work, tetraoxosulphate (VI) acid showed more aggressiveness in terms of corrosion and weight loss when compared to hydrochloric acid

**RECOMMENDATION**

Mild steel should not be used in an environment with traces of acidic contents.

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