Global Journal of Environmental Science and Technology: ISSN-2360-7955, Vol. 9(8): pp: 121-139, August, 2021.

Full Length Paper

Assessing the Corrosion Behavior of Low Carbon and Alloy Steel in Acidic Media

[*1]Atadious D, [1]Ogie N.A., [1]Dennar O.T.

[1]Department of Mechanical Engineering, Petroleum Training Institute, Effurun, Delta State, Nigeria

Corresponding Author's Email: atadious_d@pti.edu.ng

Abstract

The corrosion behavior of mild steel and stainless steel in five different concentrations of Nitric acid (HNO), Hydrochloric acid (HCl), Hydrogen tetraoxosulphate VI acid (H_2SO_4), Acetic acid (CH_3COOH), Hydrogen tetraoxophosphate V acid (H_2PO_4) has been studied. Specimen were exposed in the acidic media for seven days (168hours) and corrosion rates evaluated, using the weight loss method. It was observed that nitric acid environment was most corrosive because of its oxidizing nature, followed by hydrogen tetraoxosulphate VI acid, Hydrochloric acid, hydrogen tetraoxophosphate V acid and lastly acetic acid for the mild steel. While for the stainless steel, it was observed that hydrochloric acid was most corrosive, followed by hydrogen tetraoxosulphate VI acid. Also, the stainless steel was immune to Nitric acid, phosphoric acid and Acetic acid solutions. The rate of metal dissolution increased with increasing concentration of the corrosion media and the exposure time. Corrosion rates of mild steel in all the acidic media studied were found to be higher than that of the stainless steel.

Keywords: *Corrosion, Carbon steel, Alloy Steel, Acidic Media*

1.0 INTRODUCTION

Corrosion is a prevailing destructive phenomenon in science and technology (Ita and offiong 1999). In industries such as pulp and paper, power generation, chemical and oil industries, steels are used in over 90% of construction process. Steels are the most commonly used materials in the fabrication and manufacturing of oil field operating platforms because of their availability , cost, ease of fabrication and high strength. Most industrial environment are usually rich in elemental gases, inorganic salts and acidic solutions, most of which influence corrosion rates and mechanisms (Abu and Owate, 2003; Abiola and Oforka, 2005) steels are usually exposed to the action of bases or acids in the industries. The exposure can be severe to the properties of the metal and thus leads to sudden failure of materials in service. There is the need to study the corrosion behavior of steels when exposed to various environments, as this is an important factor in material selection that determines the service of the material. Corrosion can be defined in many ways, some deterioration are very narrow and deal with a specification form of corrosion. While other quite broad and cover forms of deterioration. The word corrode is derived from the Latin word corrodere, which means "to gnaw to pieces" (Osarolube etal, 2004, Abiola and Oforka, 20005, Oforka etal 2005). The general definition of corrode is to eat into or wear away gradually, as if by gnawing.

When corrosion is discussed, it is important to think of a combination of a material and the environment . The corrosion behavior of material cannot be described unless the environment in which the material is to be exposed is identified. Similarly, the corrosively or aggressiveness of an environment cannot be described unless the material that is to be exposed to that environment is identified. It is useful to identify both combinations and unnatural combinations. In corrosion examples of natural or desirable combinations of material and environment include nickel in caustic environment, lead in water aluminium in the atmosphere exposure. In these environments, the interaction between the metal and the environment does not usually result in detrimental or costly corrosion problems. Unnatural combinations, on the other hand, are those that result in severe corrosion damage to the metal because of exposure to an undesirable environments. Examples of unnatural combination include copper in ammonia solutions, stainless steel in chloride containing environments and iron in water.

CORROSION RATE EXPRESSION

Corrosion rate have being expressed in vanity of ways in literatures, such as percent weight loss, milligram per square inch per hour. However, the most desirable way of expressing corrosion rate according to (Fontana, 1987, 13) is the milligram per year. This expression is the most readily used and corrosion rate is calculated from the weight loss of the metal specimen during the corrosion test.

CORROSION ENVIRONMENT

Corrosive environment include the atmosphere, aqueous solutions, soils, acid bases, inorganic solvents, molten salts. Atmospheric corrosion accounts to greater losses. Moisture containing dissolved oxygen is the primary corrosive agent, but other substances, including sulphur compound and sodium chloride may also contribute. This is especially true for marine atmospheres, which are highly corrosive because of the presence of sodium chloride.

This research is aimed at examining the corrosion behavior of mild steel and stainless steel, when exposed to concentrations of Nitric acid and hydrochloric acid. The corrosion rates in these media are calculated to the study their stability when similar industrial environmental are encountered. The objectives entailed the measurement of corrosion rate in mild steel and stainless steel when subjected at five acidic environments of five concentrations using the weight loss method.

METHODOLGY

The basic method used in this research is weight loss measurement (that is the differences recorded between the initial weight of the coupon and final weight of the coupon when immersed in the various acidic environments with respect to time intervals. The acid medium was maintained a various concentration of 0.5m, 1.0m, 1,5m, 2.0m and 2.5 mole of acids at 24hours to 18hours (7 days)

CHEMICALS USED

Five chemicals of different analytical grade, distilled water were used for the experimental research of this project. Chemical were obtained from 'Light house petroleum Engineering Company', Effurun, Delta State

.

Table 1: The chemicals used

Chemical Name	**Hydrochloric Acid**	**Acetic acid**	**1.004g/mol**	**Hydrogen Tetraoxosulphate vi acid**	**Hydrogen Tetraoxosulphate v acid**
Percentage Purity	36%	99.7%	68%	98%	85%
Relative Density	1.17g/mol	1.04g/mol	1.42g/mol	1.8305g/mol	1.685g/mol
Molar	36.5g/mol	60.05g/mol	63.05g/mol	98g/mol	98g/mol
Molecula Formula	HCL	CH3COOH	HNO3	H2SO4	H3PO4

3.2 EQUIPTMENT/APPARATUS USED

The following equipment and apparatus were used during the experimental research of this project. They include flasxk, beakers, nylon thread, measurement tape, PMII sensitivity digital weighing balance, hacksaw, volumetric flask, venier caliper, PH paper, scriber, vice and clothe

3.3 SPECIMEN PREPARATION

In carrying out this project, two types of steels of different thickness was obtained and prepared as follows;

Mild steel of 2.5mm thickness was cut using hacksaw into 25 pieces to size 50mm x 19.5mm, and drilled a hole of 4mm diameter on each coupon with the aid of drilling machine . this is to enable the suspension of the specimen in the solution by the aid of nylon thread tied on a plain rod of 0.5mm thickness. The mild steel specimen was then washed wish distilled water and dried with clothe before immersed into the solution.

For the stainless steel(0.5mm thickness), the same step was taken above for the specimen preparation of 25 pieces.

3.4 PREPARATION OF STANDARD SOLUTION

The procedure below where followed to prepare the various standard solution.

3.4.4 HYDROCHLORIC ACID SOLUTION

The stock solution of hydrochloric acid was prepared to the following concentration 0.5m,1.0m,1.5m,2.0m and 2.5mole as follow below

Molar mass of HCL = 36.5 g/mol
Relative density = 1.17 g/mol = 1.17 x 100 = 1170 g/litre
Percentage purity = 36%
Amount in grams/litre of stock = 36/100 x 1170 = 421.2 g/l
Amount of stock in mol/dm^3 = 421.2/36.5 = 11.54 mole
This means that the undiluted HCL solution is 11.54 mole concentrated.
Using the dilution formular,

$M_1 V_1 = M_f V_f$

Where

M_1 = molarity of bulk solution, M_f = molarity of stock solution,V_1 = volume of acid required to make stock solution, V_f = final total volume of stock solution.

That is

M_1= 11.54m, M_f = 0.5m, V_1 = ?, V_f = 200ml

$$V_1 = \frac{M_f x V_f}{M_1}$$

V_1 = (0.5x200) / 11.54 = 8.7ml

This means that 9ml of the concentrated acid was diluted on 191ml of distilled water to make 200ml solution to 0.05m.

Subsequent steps above, where followed to prepare 1.0m,1.5m,2.0m,2.5mole of solution.

The result was obtained as shown in Table below.

Table 2: Preparation of Standard Solution Hcl

Concentration	1.0m	1.5m	2.0m	2.5m
Volume of acid	17ml	27ml	35ml	42ml
Volume of distilled H2O	183ml	173ml	165ml	158ml
Total amount of solution	200ml	200ml	200ml	200ml

3.4.2 HYDROGEN TETRAOXOSULPHATE VI ACID SOLUTION

The solution of H2SO4 acid was prepared to the following concentration, 0.5m,1.0m,1.5m,2.0m and 2.5mole as shown below:

Molar mass= 98g/mol
Relative density= 1.8305g/mol=1830.5g/l
Percentage purity=98%
Amount of stock in grams/l stock=98/100x1830.5/1=179.89g/l
Amount of stock in mol/dm3 = 1793.88/98=18.31mole

This means that the undiluted H2SO4 is (18.31 mole concentrated.
Using dilution formula
$M_1 V_1 = M_f V_f$
Where
M_1=18.31 mole, M_f = 0.5m, V_1= ?, V_f= 200ml
. V_1= 0.5*200 / 18.31= 5.46ml

This means 6ml of the concentrated acid was diluted in 194ml of the distilled water to make 200ml solution of 0.5m.
Subsequent steps above, where followed to prepare 10m, 1.5m, 2.0 ands 2.5 mole of acid solution.
The following result are obtained as shown on the table.

Table 3: Preparation of standard solution H_2SO_4

Concentration of acid	1.0ml	1.5ml	2.0ml	2.5ml
Volume of acid	11ml	17ml	22ml	27ml
Volume of distilled H_2O	189ml	183ml	178ml	173ml
Total amount of solution	200ml	200ml	200ml	200ml

NITRIC ACID SOLUTION

The stock solution of nitric acid was prepared to the following concentration 0.5ml, 1.0ml, 1.5ml, 2.0ml and 2.5mole as followed below.
Molar mass 63.01glmol
Relative density = 1.42glmol = 1420g/l
Percentage purity = 68%
Amount in gram/litre of stock =68/100 * 1420 = 965.6g/l
Amount of stock in mol/dm^3 = 965.6/63.1 = 15.3 mole
This means that the undiluted HNO^3 is 15.3m concentrated. Using dilution formula

$M_1 V_1 = M_f V_f$
Where
M_l= 15.3m, V_l= ?, M_f= 0.5m, Vf= 200ml
V_1 = 0.5 *200/ 15.30= 6.53ml
This means 7ml of the concentrated acid was diluted in 194ml of distilled water to make 200ml solution of 0.5 mole.
Subsequent steps above, where followed to prepare 1.0m, 1.5m, 2.0m and 2.5mole of solution.
The results were obtained as shown on the table below

Table 4: Preparation of standard solution HNO3

Concentration of acid	1.0ml	1.5ml	2.0ml	2.5ml
Volume of acid	13ml	20ml	26ml	33ml
Volume of distilled H_2O	7ml	180ml	174ml	164ml
Total amount of solution	200ml	200ml	200ml	200ml

ACETIC ACID SOLUTION

The stock solution of acetic acid was prepared to the following concentration 0.5ml, 1.0ml, 2.0ml and 2.5mole of solution as follow below
Molar mass= 60.05g/mol
Relative purity= 99.7%
Amount in gram/litre of stock = 99.7/100*1040 = 1036.88g/l
Amount of stock solution on mol/dm3=1036.88/60.05=17.26m
This means the concentration of the undiluted acid was 17.26m using dilution formulae

$M_l V_l = M_f v_f$
Where: M_l=17.26M, Mf=0.5m, Vl=?, Vf=200ml, Vl=0.5 * 200/ 17.26=5.79ml
This means that 6ml of the concentrated acid was diluted in 194ml of distilled water to make 200ml of solution to 0.5mole.
Subsequent steps above were followed to prepare 1.0m, 1.5m, 1.0m, 2.0male and 2.5mole
The results was obtained as shown below in the table below

Table 5: preparation of standard solution CH3COOH

Concentration of acid	1.0ml	1.5ml	2.0ml	2.5ml
Volume of acid	12ml	17ml	23ml	29ml
Volume of distilled H_2O	188ml	183ml	177ml	171ml
Total amount of solution	200ml	200ml	200ml	200ml

The solution of h3po4 was prepared to the following concentration 0.5m, 1.0m, 1.5m, 2.0m and 2.5mole of solution as follow below.
Molar mass = 98.00g/mol, Relative density = 1.685g/ml = 1685g/l, Amount in grams/litre of stock = 85/100 * 1685/1 = 1425.25/1, Amount of stock in mol/dm2 1432.25/98.00 = 14.61m
This means the concentration of the undiluted acid is 14.61 mole.
Using dilution formular: MIVI=MfVf
Where
MI=14.61m, Mf= 0.5m, VI= ?, Vf= 200ml, VI = 0.5* 200/14.61 = 6.84ml
This means that 7ml of the concentrated was diluted in 194ml of distilled water to make 200ml of solution to 0.5 mole.
This means that 7ml of the concentrated acid was diluted in 194ml of distilled water to make 200ml of solution to 0.5mole.
Subsequent steps above were followed to prepare 1.0m, 1.5m, 2.0m, 2.5mole solution.
The results were obtained as shown in the table below.

Table 6: Preparation of standard solution H3PO4

Concentration of acid	1.0ml	1.5ml	2.0ml	2.5ml
Volume of acid	14ml	21ml	27ml	34ml
Volume of distilled H_2O	186ml	179ml	17ml	166ml
Total amount of solution	200ml	200ml	200ml	200ml

EXPERIMENTAL PROCEDURE/SPECIMEN IMMERSION

For the mild steel, the acid solutions was prepared to the following concentrations(0.5m, 1.0m, 2.0m, and 2.5mole) as stated in table 1to table 6, on a 250ml beaker. Then, the beakers were tagged accordingly in sets of five. For example HCL acid was tagged steel A0.5m to steel A2.5mole. Same was done for the other acid solution. This was to enable differentiate the concentration of the solution and the different metal. Steel A means (mild steel). After which, the PH value of each solution was taken according and recording, using a PH paper (colour indication that was approximated in whole numbers) prior to immersion. The specimen were the washed, dried and the initial weight was measured and the recorded with the aid of PMII sensitive digital weight balance scale at PAL LAB, Petroleum Training Institute Effurun

Thereafter, the coupons (specimen) were immersed unto the acidic solution without making any contact with the beaker. This was done by help of the nylon thread. In which the nylon thread was tied through the hole drilled on the coupon. The nylon was also tied to a rod that was flatten for stability which was suspended on each beaker. This was to aid in the experimental set-up.

For the stainless steel, the following steps above was followed accordingly.

4.0 RESULT AND DISCUSION

4.1 MATERIAL USED

The experimental materials used for this project was 2.5mm thick mild steel flat bar, and 0.5mm austenitic stainless steel materials.

4.2 CHEMICAL COMPOSITION OF THE STEELS

The above mentioned steels were analyzed via spark text at delta steel company limited ovwian aladja delta state, and the following results were obtained as shown in the table 7.

Table 7 elemental composition

Element	c	Si	Mn	p	S	Cr	Ni	Mo	Cu	v	Al	Sn	N	Ti
Elemental % (mild steel)	0.15	0.22	0.50	0.06	0.057	0.25	0.10	0.02	0.26	0.009	0.001	0.021	T	0.01
Elemental % (stainless steel)	0.08	0.54	1.32	0.04	0.012	18.96	8.66	0.18	0.003	0.003	0.02	0.015	0.08	0.06

RESULTS

The Table below shows the initial weight of mild steel and stainless steel in grams(g) obtained by the weight measuring scale, and the weight loss at 24hrs(twenty four) interval to 168hrs (7days). Initial weight of mild steel and weight loss shown in table 8-12

Table8: Initial weight and weight loss measurement in HCL Acid Recorded at Different Time Interval

CONC	ORIGINAL WEIGHT	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	17.6014	17.23	16.8997	16.5695	16.1707	15.7708	15.2641	14.8591
1	17.803	17.3057	16.8856	16.4425	15.948	15.4434	14.8292	14.3232
1.5	18.2046	17.5575	16.9226	16.2287	15.5066	14.7744	13.856	13.139
2	17.6196	16.7955	16.0787	15.3206	14.5089	13.6871	12.6559	11.7653
2.5	17.7595	16.8618	16.1175	15.2962	14.4045	13.5117	12.3167	11.3047

Table 9: Initial Weight and weight loss Measurement in HNO3 Acid Recorded at different time interval

CONC	ORIGINAL WEIGHT	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	18.2548	14.0191	13.7663	13.4281	13.299	13.148	13.0513	12.9513
1	18.9689	14.3682	13.5369	12.7738	12.5422	12.2905	11.9095	11.4895
1.5	18.1992	11.9928	11.6862	11.1964	10.4331	10.4331	10.0123	9.4915
2	17.9586	9.237	8.7118	8.1775	7.3834	7.3834	6.8601	6.3318
2.5	18.1222	8.1681	7.8678	7.531	7.0947	6.6384	6.1884	5.7274

Table10: Initial Weight and Weight loss measurement in H2SO4 Acid Recorded at different time interval

CONC	ORIGINAL WEIGHT	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	17.6906	17.0903	16.5145	15.9772	15.3985	14.8097	14.1647	13.5647
1	17.8021	17.0794	16.3902	15.7339	15.0757	14.4075	13.656	12.9545
1.5	17.9273	17.0718	16.2378	15.4742	14.5954	13.7166	12.7249	11.8232
2	18.347	17.3123	16.2981	15.3828	14.3828	13.3727	12.3084	11.3042
2.5	18.4009	17.192	16.1501	15.2709	14.0932	12.9156	11.5644	10.4132

Table11: Initial Weight and Weight loss measurement in H3PO4 acid recorded at different time interval

CONC	ORIGINAL WEIGHT	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	17.8045	17.363	17.032	16.7466	16.4552	16.1437	15.7508	15.2985
1	18.6327	18.159	17.7405	17.378	16.9808	16.5636	16.0621	15.5006
1.5	18.0872	17.4909	17.0172	16.5874	16.1052	15.6029	15.051	14.4131
2	17.6196	17.03	16.5093	16.0262	15.513	14.9799	14.3224	13.6349
2.5	17.5799	16.967	16.3944	15.8808	15.0637	14.7205	14.0927	13.4149

Table 12: Initial weight and loss measurement in Ch_3cooh Acid recorded nat different time interval

Conc	Original Weight	24HRS	48HRS	72hrs	96HRS	120HRS	144HRS	168HRS
0.5	18.2548	18.0792	18.0597	18.0114	17.9507	17.8799	17.8024	17.7235
1	18.4434	18.2803	18.2499	18.2104	18.1654	18.1244	18.0537	17.9801
1.5	18.0103	17.8623	17.8251	17.744	17.7443	17.7041	17.6366	17.5681
2	17.6483	17.5055	17.4699	17.435	17.3997	17.3572	17.2923	17.2354
2.5	18.6625	18.5221	18.4844	18.4411	18.4025	18.3639	18.2109	18.3051

Initial weight stainless steel and weight loss. Shown in table 13-17

Table 13: Initial Weight Loss Measurement in Hcl Acid Recorded at Different Time Interval

Conc	Original Weight	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	16HRS
O.5	4.8452	4.8446	4.8436	4.8421	4.8411	4.84	4.8382	4.8358
1	4.3386	4.3377	4.3368	4.335	4.3339	4.339	4.3307	4.329
1.5	4.2786	4.2727	4.2755	4.274	4.2729	4.2714	4.27	4.2664
2	4.0086	4.0066	4.0045	4.0022	4.0008	3.9997	3.9983	3.9962
2.5	4.5782	4.556	4.55	4.5407	4.532	4.5257	4.5142	4.5008

Table 13: Initial Weight Loss Measurement in Hcl Acid Recorded At Different Time Interval

Conc	Original Weight	24hrs	48hrs	72hrs	96hrs	120hrs	144hrs	168hrs
0.5	4.6086	4.603	4.5984	4.5889	4.5814	4.5736	4.5725	4.5705
1	4.3853	4.3726	4.3644	4.3504	4.3344	4.3276	4.3132	4.3107
1.5	4.1505	4.137	4.1189	4.1074	4.0939	4.0734	4.0679	4.0629
2	4.1303	4.113	4.0912	4.0804	4.0649	4.0475	4.031	4.0278
2.5	4.8098	4.7677	4.7396	4.7166	4.695	4.6729	4.6516	4.6479

Table 14: Initial Weight and weight loss measurement in H_2SO_4 Acid recorded at different time interval

Conc	Original Weight	24hrs	48hrs	72hrs	96hrs	120hrs	144hrs	168hrs
0.5	4.6086	4.603	4.5984	4.5889	4.5814	4.5736	4.5725	4.5705
1	4.3853	4.3726	4.3644	4.3504	4.3344	4.3276	4.3132	4.3107
1.5	4.1505	4.137	4.1189	4.1074	4.0939	4.0734	4.0679	4.0629
2	4.1303	4.113	4.0912	4.0804	4.0649	4.0475	4.031	4.0278
2.5	4.8098	4.7677	4.7396	4.7166	4.695	4.6729	4.6516	4.6479

Table 15: Initial Weight and Weight Loss Measurement in CH3COOH Acid Recorded At Different Time Interval

CONC	ORIGINAL WEIGHT	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	4.0146	4.0146	4.0146	4.0146	4.0146	4.0146	4.0146	4.0146
1	4.5143	4.5143	4.5143	4.5143	4.5142	4.5142	4.5142	4.5142
1.5	4.6842	4.6842	4.6842	4.6842	4.6842	4.6842	4.6842	4.6842
2	4.7756	4.7756	4.7756	4.7756	4.7756	4.7756	4.7756	4.7756
2.5	4.1456	4.1456	4.1456	4.1456	4.1456	4.1456	4.1456	4.1456

Table 16: Initial Weight And Weight Loss Measurement in H3PO4 Acid Recorded At Different Time Interval

CONC	ORIGINAL WEIGHT	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	4.1606	4.1606	4.1606	4.1606	4.1606	4.1606	4.1606	4.1606
1	4.0413	4.0413	4.0413	4.0413	4.0413	4.0413	4.0413	4.0413
1.5	4.3602	4.3602	4.3602	4.3602	4.3602	4.3602	4.3602	4.3602
2	4.3912	4.3912	4.3912	4.3912	4.3912	4.3912	4.3912	4.3912
2.5	4.8475	4.8475	4.8475	4.8475	4.8475	4.8475	4.8475	4.8475

Table 17: INITIAL Weight and Weight Loss Measurement in HNO3 ACID Recorded At Different Time Interval

CONC	ORIGINAL WEIGHT	24HRS	72HRS	96HRS	96HRS	120HRS	14HRS	168HRS
0.5	4.6063	4.6063	4.6063	4.6063	4.6063	4.6063	4.6063	4.6063
1	4.5385	4.5385	4.5385	4.5385	4.5385	4.5385	4.5385	4.5385
1.5	4.511	4.511	4.511	4.511	4.511	4.511	4.511	4.511
2	4.3652	4.3652	4.3652	4.3652	4.3652	4.3652	4.3652	4.3652
2.5	4.1553	4.1553	4.1553	4.1553	4.1553	4.1553	4.1553	4.1553

4.4 NORMALISATION

This is the ratio of the initial weight to the final weight. It can be expressed
Mathematically as shown below.
Normalization=W0/WF

Where: Wo= initial weight, Wf=final weight at each 24 hour
The below show normalization table, for mild steel acid stainless Steel coupons.
Normalize table for mild steel, shown in table 18-22

Table 18: Normalization Table for Hcl

MILD STEEL HOL							
CONC.	24	48	72	96	120	144	168
0.5	0.9789	0.9601	0.9414	0.9187	0.896	0.8672	0.8442
1	0.9721	0.9485	0.9236	0.8958	0.8675	0.833	0.8442
1.5	0.9645	0.9296	0.8915	0.8518	0.8116	0.7611	0.7217
2	0.9532	0.9126	0.8675	0.8235	0.7768	0.7182	0.6677
2.5	0.9495	0.9075	0.8613	0.811	0.7608	0.6935	0.6365

Table 19 Normalization Table for HNO3

MILD STEEL HNO3							
CONC.	24	48	72	96	120	144	168
0.5	0.768	0.7541	0.7356	0.7356	0.7202	0.715	0.7094
1	0.7575	0.7136	0.6734	0.6612	0.6479	0.6278	0.6057
1.5	0.659	0.6421	0.6152	0.5948	0.4057	0.3769	0.3479
2	0.5143	0.4851	0.4554	0.4338	0.4113	0.382	0.3526
2.5	0.4507	0.4342	0.4156	0.3915	0.3663	0.3413	

Table 20: Normalization Table for H2SO4

MILD STEEL H2SO4							
	24	48	72	96	120	144	168
0.5	0.9661	0.9207	0.9031	0.8704	0.8372	0.8007	0.7668
1	0.9594	0.9207	0.8838	0.8469	0.8093	0.7671	0.7277
1.5	0.9523	0.9058	0.8632	0.8141	0.7651	0.7098	0.6595
2	0.9436	0.8883	0.8384	0.7839	0.7289	0.6709	0.6161
2.5	0.9343	0.8778	0.8299	0.7659	0.7019	0.6285	0.5659

Table 21: Normalization table for H3 PO4

MILD STEEL H3PO4							
	24	48	72	96	120	144	168
0.5	0.9752	0.9566	0.9406	0.9242	0.9067	0.8847	0.8592
1	0.9746	0.9521	0.9327	0.9113	0.889	0.862	0.8319
1.5	0.967	0.9408	0.9171	0.8904	0.8627	0.8321	0.7969
2	0.9665	0.9369	0.9097	0.8804	0.8502	0.8129	0.7738
2.5	0.9651	0.9033	0.8569	0.8373	0.8373	0.8016	0.7631

Table 22: Normalization Table for CH3 OOOH

MILD STEEL CH3 COOH							
	24	48	72	96	120	144	168
0.5	0.9924	0.9904	0.9881	0.9861	0.984	0.9812	0.9808
1	0.9924	0.9904	0.9879	0.9855	0.9835	0.9798	0.9766
1.5	0.9919	0.9897	0.9875	0.9852	0.983	0.9793	0.9755
2	0.9911	0.9895	0.9873	0.9849	0.9827	0.9789	0.9749
2.5	0.9904	0.9893	0.9867	0.9833	0.9795	0.9752	0.9709

Normalize table for stainless shown in table 23-24

Table 23: Normalization Table for HCL

STAINLESS STEEL HCL							
	24	48	72	96	120	144	168
0.5	0.9988	0.9978	0.9957	0.9941	0.9924	0.9922	0.9917
1	0.9971	0.9952	0.992	0.9883	0.9868	0.9836	0.983
1.5	0.9968	0.9924	0.9896	0.9864	0.983	0.98	0.9789
2	0.9958	0.9905	0.9879	0.9842	0.9799	0.976	0.9752
2.5	0.9854	0.9854	0.9806	0.9761	0.9715	0.9671	0.9663

Table 24: Normalization Table for H2SO4

STAINLESS STEEL H2SO4							
	24	48	72	96	120	144	168
0.5	0.9999	0.9996	0.9994	0.9992	0.9989	0.9986	0.9981
1	0.9998	0.9994	0.9993	0.9989	0.9985	0.9982	0.9979
1.5	0.9997	0.9993	0.9989	0.99087	0.9983	0.998	0.9972
2	0.9995	0.9989	0.9984	0.9981	0.9978	0.9974	0.9969
2.5	0.9952	0.9938	0.9918	0.9899	0.9885	0.986	0.9831

4.5 WEIGHT LOSS

Weight loss is the different between initial weight of the metal and the final
Weight of the metal. This can be expressed mathematically as shown below.
Wo = W1-W2

Where: Wo = weight loss in gram (g), W1=initial weight of the metal before immersion (g)
W2=final weight after immersion in grams(g)

Table 25-31 hours the weight loss of mild steel and stainless in the various acidic Environment.
Weight loss table for mild steel show in table 25-29

Table 25: weight loss for HCL Acid

	24HRS	48HRS	72HRS	96HES	120HRS	144HRS	168HRS
0.5	0.3714	0.7017	1.0319	1.4307	1.8306	2.3373	2.7423
1	0.4973	0.9174	0.3605	1.855	2.3596	2.9738	3.4798
1.5	0.6471	1.282	1.9758	2.698	3.4302	4.9639	5.8543
2	0.8241	1.5409	2.2299	3.1107	3.9325	4.9639	5.8543
2.5	0.8977	1.642	2.4633	3.355	4.2478	5.4428	6.4553

Table 26: weight loss for HNO3 Acid

	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	4.2356	4.885	4.8267	4.9558	5.1068	5.205	5.3035
1	0.4973	0.9174	1.3605	1.855	2.3596	2.9738	3.4798
1.5	0.4973	0.9174	1.3605	1.855	2.3596	2.9738	3.4798
2	0.8241	1.5409	2.2299	3.1107	3.9325	4.9639	5.8543
2.5	0.8977	1.642	2.4633	3.355	4.2478	5.4428	6.4533

Table 27: WEIGHT LOSS FOR H_3PO_4

	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	0.6003	1.1763	1.7134	2.2921	2.8809	3.5259	4.1253
1	0.7227	1.4119	2.0682	2.4036	3.3946	4.1461	4.8476
1.5	0.8555	1.6895	2.5446	3.3319	4.2107	5.2024	6.1041
2	1.0378	2.0489	2.9642	3.9642	4.9743	6.0386	7.0428
2.5	1.2109	2.2508	3.13	4.3077	5.4855	6.8365	7.9877

Table 28: WEIGHT LOSS DOR H_3PO_4 ACID

	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	0.4415	0.7725	1.0578	1.3493	1.6608	2.0537	2.506
1	0.4737	0.8922	1.2547	1.6519	2.0691	2.5706	3.1321
1.5	0.5963	1.07	1.4998	1.982	2.4843	3.0362	3.6741
2	0.5896	101103	1.5934	2.1066	2.6397	3.2972	3.9847
2.5	0.6128	1.855	1.6991	2.5162	2.8594	3.4872	4.165

Table 29: WEIGHT LOSS FOR CH_3COOH ACID

	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	0.4104	0.1781	0.2214	0.26	0.2986	0.3516	.3584
1	0.1428	0.183	0.2233	0.2632	0.3011	0.356	0.1429
1.5	0.144	0.1852	0.2259	0.266	0.306	0.3737	0.4422
2	0.1631	0.1935	0.233	0.268	0.309	0.3797	0.4533
2.5	0.1756	0.1951	0.2434	0.3041	0.3749	0.4524	0.5313

Weight Loss for stainless steel shown in table 30-31

Table 30: WEIGHT LOSS FOR HCL ACID

	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	0.0056	0.0102	0.0197	0.0272	0.035	0.6361	0.0381
1	0.0127	0.0209	0.6349	0.0509	0.0577	0.6721	0.0746
1.5	0.0135	0.0316	0.0431	0.0566	0.0705	0.0826	0.0876
2	0.0173	0.0391	0.0499	0.0654	0.0828	0.0993	0.1025
2.5	0.0421	0.0702	0.0932	0.1148	0.1369	0.1582	0.1619

Table 31: WEIIGHT LOSS FOR H_2S0_4 ACID

	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	0.0006	0.0016	0.0031	0.0041	0.0052	0.007	0.0094
1	0.0009	0.0081	0.0036	0.0047	0.0066	0.0079	0.0096
1.5	0.0014	0.0031	0.0046	0.0057	0.0072	0.0086	0.0122
2	0.002	0.0041	0.0064	0.0078	0.0089	0.103	0.0124
2.5	0.0222	0.0282	0.06375	0.0462	0.0525	0.034	0.0774

4.6 CORROSION RATE

From the weight loss table the corrosion rate was calculated using the Equation below.
Corrosion rate = 534w/DAT, mpy
Where
W = weight loss in milligram (m)
D = density of coupon in g/cm^3
A = surface areas of coupon in square inch
T = Exposure time in hours

4.6.1 TOTAL SURFACE AREA

The total surface area for mild steel was calculated using the formula
The total surface area for mild steel was calculated using the formula
A_t 2(LW+WT+LT) = DT- D^2/2

Where,
A_t = total surface area in inch^2
L = length in mm, W = Width in mm, T = thickness in mm, D = hole diameter in mm
In calculating the corrosion rate(CR) for mild steel and stainless steel coupon in the various acidic Environment, the following steps below was used
For mild steel,
To calculate for the HCL acid environment let say at 24hrs
Density of mild steel = 7.85g/cm, Weight loss for 24hrs m= 0.3715g = 371.4milligram(mg)
Surface area for mild steel = 3.569inch^2
Therefore
CR=534 w
CR = 294.95MPY
Subsequently, the above formula procedure was use to calculate the
Corrosion rate for mild steel in the various acidic environment at 24hrs to
168hrs respectively
Table 32 -36 shown below the corrosion rate calculated for mild steel coupons

Table 32: Corrosion Rate for HCL Acid

	24hrs	48hrs	72hrs	96hrs	120hrs	144hrs	168hrs
0.5	294.95	278.63	273.16	284.05	290.76	309.36	311.12
1	394.94	364.29	360.15	368.3	374.78	393.62	394.79
1.5	513.91	509.06	523.04	535.67	544.83	575.59	574.71
2	654.48	611.87	590.3	617.61	624.62	657.03	664.19
2.5	712.93	652	697.02	666.11	674.7	720.42	732.37

Table 33: Corrosion Rate for HNO_3 Acid

	24hrs	48hrs	72hrs	96hrs	120hrs	144hrs	168hrs
0.5	3363.79	1782.32	1277.41	983.94	811.13	688.74	601.7
1	3653.74	2156.97	1640.15	1275.97	1060.75	934.39	848.45
1.5	4971.82	2586.22	1853.81	1464.13	1233.52	1083.6	987.91
2	7335.75	3671.77	2589.29	2018.8	1679.7	1469	1318.4
2.5	7905.25	4071.87	2803.74	2189.43	1824.02	1580	1406.2

Table 34: Corrosion Rate for H_2SO_4 Acid

	24hrs	48hrs	72hrs	96hrs	120hrs	144hrs	168hrs
0.5	476.74	467.09	453.58	455.68	457.59	466.69	468.02
1	573.95	560.64	547.5	477.22	539.18	548.79	549.97
1.5	679.19	670.88	673.67	661.52	668.8	688.6	692.53
2	824.19	813.59	784.69	787.06	790.09	799.28	799.03
2.5	961.66	893.76	828.58	855.26	871.28	904.89	906.23

Table 35: CORROSION RATE FOR H_3PO_4 ACID

	24hrs	48hrs	72hrs	96hrs	120hrs	144hrs	168hrs
0.5	350.63	306.75	280.89	267.89	263.79	271.83	284.31
1	376.2	354.28	332.15	327.97	328.64	340.25	355.35
1.5	473.56	424.88	397.03	393.51	394.59	401.88	461.84
2	468.24	440.88	421.81	418.25	419.27	436.42	452.08
2.5	486.67	470.75	449.79	499.57	454.14	461.57	472.53

Table 36: CORROSION RATE FOR CH_3COOH ACID

	24hrs	48hrs	72hrs	96hrs	120hrs	144hrs	168hrs
0.5							
1							
1.5							
2							
2.5							

Subsequent steps above, where followed to prepare 1.0m, 1.5m, 2.0m and 2.5mole of solution.

The results were obtained as shown on the table 4.

Table 4 preparation of standard Solution HNO_3

Concentration of acid	1.0m	1.5m	2.0m	2.5m
Volume of acid	13ml	20ml	26ml	33ml
Volume of distilled H2O	7ml	180ml	174ml	164ml
Total amount of solution	200ml	200ml	200ml	200ml

3.4.4 ACETIC ACID SOLUTION

The stock solution of acetic acid was prepared to the following concentration 0.5m, 1.0m, 1.5m, 2.0m and 2.5mole of solution.
Molar mass=60.05g/mol, Relative purity = 99.7%, Amount in grams/litre of stock=99.7/100 x 1040=1036.88g/l, Amount of stock solution on mol/dm^3 = 1036.88/60.05 = 17.26m
The means the concentration of the undiluted acid was 17.26m using dilution formula

$M_1V_1 = M_fV_f$
Where M_1 = 17.26m, V_1 =?, V_f = 200ml, V_1= 0.5 x 200/17.26 = 5.79ml
This means that 6ml of the concentration acid was diluted in 194ml of distilled water to make 200ml of a solution to 0.5mole. Subsequent steps above were followed to prepare 1.0m, 1.5m, 1.0m, 2.0mole and 2.5mole. The results were obtained as shown below in the table 5.

Table 5: preparation of Standard solution CH_3COOH

Concentration of acid	1.0m	1.5m	2.0m	2.5m
Volume of acid	12ml	17ml	23ml	29ml
Volume of distilled H2O	188ml	183ml	177ml	171ml
Total amount of solution	200ml	200ml	200ml	200ml

The solution of H3PO4 was prepared to the following concentration 0.5m, 1.0m, 1.5m, 2.0m and 2.5mole of solution.
Molar mass = 98.00g/mol, Relative density = 1.685g/ml = 1685g/l, Percentage purity = 85%
Amount in grams/litre of stock = 85/100 x 1685/1 = 1425.25g/l, Amount of stock in mol/dm^3 1432.25/98.00 = 14.61m.
This means the concentration of the undiluted acid is 14.61 moles
Using Dilution formula: $M_1V_1 = M_fV_f$. Where: M_1 = 14.61m, M_f = 0.5m, V_l = ?, V_f = 200ml, V_1 = 0.5 x 200/14.61 = 6.84ml
This means that 7ml of the concentrated acid was diluted in 194ml of distilled water to make 200ml of solution to 0.5mole. Subsequent steps above were followed to prepare 1.0m, 1.5m, 2.0m, and 2.5mole solution. The results were obtained as shown in the table 6.

Table 6: Preparation of Standard Solution H_3PO_4

Concentration of acid	1.0m	1.5m	2.0m	2.5m
Volume of acid	14ml	21ml	27ml	34ml
Volume of distilled H20	186ml	179ml	17ml	166ml
Total amount of solution	200ml	200ml	200ml	200ml

3.5 EXPERIMENTAL PROCEDURE/SPECIMEN IMMERSION

For the mild steel, the acid solutions was prepared to the following concentrations (0.5m, 1.0m, 1.5, 2.0 and 2.5mole) as stated in Table 1 to Table 6, on a 250ml beaker. Then, the beakers were tagged accordingly in sets of five. For example HCL acid was tagged steel A 0.5M to steel A 2.5 mole. Same was done for the other acid solution. This was to enable differentiate the concentration of the solution and the different metal. Steel a means (mild steel). After which, the PH value of each solution was taken according and recorded, using a PH paper (color indication that was approximated in whole numbers) prior to immersion. The specimens were washed, dried and the initial weight was measured and recorded with the aid of PM II sensitive digital weight balance scale at PAL LAB, Petroleum

Training Institute Effurun. Thereafter, the coupons (specimen) were immersed into the acidic solution without making any contact with the beaker. This was done by the help of the nylon thread. In which the nylon thread was tied through the hole drilled on the coupon. The nylon was also tied to a rod that was flattening for stability which was suspended on each beaker. This was to aid in the experiment al set-up. For the stainless steel, the following steps above were followed accordingly.

4. RESULTS AND DISCUSSION

4.1 MATERIAL AND METHODS

The experiment material used for this project was 2.5mm thick mild steel flat bar and 0.5mm thick austenitic stainless steel materials.

4.2 CHEMICAL COMPOSITION OF THE STEELS

The above mentioned steels were analyzed via spark text at delta steel company limited Ovwian Aladja Delta State, and the following results were obtained as shown in the table below

.Table 7 elemental composition

Element	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	V	Al	Sn	N	Ti
Elemental % (mild steel	0.15	0.22	0.50	0.06	0.057	0.25	0.10	0.02	0.26	0.009	0.001	0.021	T	0.01
Elemental % (stainless steel)	0.08	0.54	1032	0.04	0.012	18.96	8.66	0.18	0.003	0.003	0.02	0.015	0.08	0.06

RESULTS

The table below shows the initial weight of mild steel and stainless steel in grams(g) obtained by the weight measuring scale, and the weight loss at 24hr (twenty hour) interval to 168 hrs(7 days)

Initial weight of mild steel and weight loss shown in table 8-12

Table 8: Initial weight and weight loss measurement in Hcl Acid recorded At Different time Interval

Conc	ORIGINAL WEIGHT	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	17.6014	17.23	16.8997	16.5695	16.1707	15.7708	15.2641	14.8591
1	17.803	17.3057	16.8856	16.4425	15.948	15.4434	14.8292	14.3232
1.5	18.2046	17.5575	16.9226	16.2287	15.5066	14.7744	13.856	13.139
2	17.6196	16.7955	16.0787	15.3206	14.5089	13.6871	12.6559	11.7653
2.5	17.7595	16.8618	16.1175	15.2962	14.4045	13.5117	12.3167	11.3047

TABLE 9: Initial Weight and Weight loss Measurement in Hno3 Acid Recorded At Different time Interval

Conc	Original weight	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	18.2548	14.0191	13.7663	13.4281	13.299	13.148	13.0513	12.9513
1	18.9689	14.3682	13.5369	12.7738	12.5422	12.2905	11.9095	11.4895
1.5	18.1992	11.9928	11.6862	11.1964	10.8248	10.4331	10.0123	9.4915
2	17.9586	9.237	8.7118	8.1775	7.7905	7.3834	6.8601	6.3318
2.5	18.1222	8.1681	7.8678	7.531	7.0947	6.6384	6.1884	5.7274

Table 10: Initial Weight and Weight Loss Measurement in H_2so_4 Acid Recorded At Different Time Interval

Conc	Original weight	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	17.6906	17.0903	16.5145	15.9772	15.3985	14.8097	14.1647	13.5647
1	17.8021	17.0794	16.3902	15.7339	15.0757	14.4075	13.656	12.9545
1.5	17.9273	17.0718	16.2378	15.4742	14.5954	13.7166	12.7249	11.8232
2	18.347	17.3123	16.2981	14.3828	13.3727	13.3727	12.3084	11.3042
2.5	18.4009	17.192	16.1501	15.2709	14.0932	12.9156	11.5644	10.4132

Table 11: Initial Weight and Weight Loss Measurement in H_3po_4 Acid Recorded At Different Time Interval

Conc.	Original Weight	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	17.8045	17.363	17.032	16.7466	16.4552	16.1437	15.7508	15.2985
1	18.6327	18.159	17.7405	17.378	16.9808	16.5636	16.0621	15.5006
1.5	18.0872	17.4909	17.0172	16.5874	16.1052	15.6029	15.051	14.4131
2	17.6196	17.03	16.5093	16.0262	15.513	14.9799	14.3224	13.6349
2.5	17.5799	16.967	16.3944	15.8808	15.0637	14.7205	14.0927	13.4149

Table 12: initial Weight Loss Measurement in CH_3cooh Acid Recorded at Different Time Interval

Conc.	Original Weight	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	18.2548	18.0792	18.0597	18.0114	17.9507	17.8799	17.8024	17.7235
1	18.4434	18.2803	18.2499	18.2104	18.1654	18.1244	18.0537	17.9801
1.5	18.0103	17.8623	17.8251	17.7144	17.7443	17.7041	17.6366	17.5681
2	17.6483	17.5055	17.4699	17.435	17.3997	17.3572	17.2923	17.2354
2.5	18.6625	18.5221	18.4844	18.4411	18.4025	18.3639	18.3109	18.3051

Initial Weight of stainless steel and Weight loss, shown in table 13-17

Table 13: Initial Weight and Weight loss Measurement in Hcl Acid Recorded At Different Time Interval

Conc.	Original weight	24HRS	48HRS	72HRS	96Hrs	120HRS	144HRS	168HRS
0.5	4.8452	4.8446	4.8436	4.8421	4.8411	4.84	4.8382	4.8358
1	4.3386	4.3377	4.3368	4.335	4.3339	4.339	4.3307	4.329
1.5	4.2786	4.2727	4.2755	4.274	4.2729	4.2714	4.27	4.2664
2	4.0086	4.0066	4.0045	4.0022	4.0008	3.9997	3.9983	3.9962
2.5	4.5782	4.556	4.55	4.5407	4.532	4.5257	4.5142	4.5008

Table 15: Initial Weight and Weight Loss Measurement in CH_3COOH Acid Recorded At Different Time Interval

Conc.	Original Weight	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	4.0146	4.0146	4.0146	4.0146	4.0146	4.0146	4.0146	4.0146
1	4.5143	4.5143	4.5143	4.5143	4.5142	4.5142	4.5142	4.5142
1.5	4.6842	4.6842	4.6842	4.6842	4.6842	4.6842	4.6842	4.6842
2	4.7756	4.7756	4.7756	4.7756	4.7756	4.7756	4.7756	4.7756
2.5	4.1456	4.1456	4.1456	4.1456	4.1456	4.1456	4.1456	4.1456

Table 16: Initial Weight and Weight Loss Measurement in H_3PO_4 Acid Recorded At Different Time Interval

Conc.	Original Weight	24HRS	48HRS	72HRS	96HRS	120HRS	144HRS	168HRS
0.5	4.1606	4.1606	4.1606	4.1606	4.1606	4.1606	4.1606	4.1606
1	4.1413	4.1413	4.1413	4.1413	4.1413	4.1413	4.1413	4.1413
1.5	4.3602	4.3602	4.3602	4.3602	4.3602	4.3602	4.3602	4.3602
2	4.3912	4.3912	4.3912	4.3912	4.3912	4.3912	4.3912	4.3912
2.5	4.8475	4.8475	4.8475	4.8475	4.8475	4.8475	4.8475	4.8475

Subsequently, the above formula/procedure was used to calculate the corrosion rate for stainless steel in the various acidic medium at 24hr to 168hr respectively.

Table 37-38 shown below the corrosion rate calculated for stainless steel coupons

Table 38: Corrosion Rate for H_2SO_4 Acid

	24hrs	48hrs	72hrs	96hrs	120hrs	144hrs	168hrs
0.5	0.438	0.5839	0.7543	0.7482	07591	0.8516	0.9802
1	0.6569	0.6659	0.8759	0.8577	0.9635	0.9611	1.001
1.5	1.0219	1.1314	1.1192	1.0402	1.0511	1.0462	1.2722
2	1.4598	1.4964	1.5572	1.4234	1.2992	1.253	1.293
2.5	16.2	10.292	9.1241	8.4307	7.6642	7.7859	8.0709

Table 37: Corrosion rate for HCL Acid

	24hrs	48hrs	72hrs	96hrs	120hrs	144hrs	168hrs
0.5	4.09	3.72	4.79	4.96	5.11	4.39	3.97
1	9.27	7.63	8.49	9.29	8.42	8.77	7.78
1.5	9.85	11.53	10.49	10.33	10.29	10.05	9.13
2	12.63	14.27	12.14	11.93	12.09	12.08	10.69
2.5	30.73	25.62	22.67	20.94	19.99	19.25	16.88

GRAPHICAL REPRESENTATION AND COUPONS REPRESENTATION COUPONS REPRESENTATION

The coupons below shows the initial phase of the mild steel and stainless steel, and corrosion damage on the steels when exposed to the five acidic media after 168 hours

4.7.2 **NORMALIZATION GRAPH**

The graph below shows the graphical representation for normalized ration with respect to time for mild steel coupon and stainless steel coupon that was plotted from Table 18-24. The table below shows the graphical representation of the highest corrosion rate i.e. at 2.5mole for the various acidic environments for mild steel and stainless steel with respect to time

Table 39: CORROSION RATE AT 2.5MOLE FOR MILD STEEL IN FIVE ACIDIC ENVIRONMENTS

	Hcl	Hno3	H2so4	H3po4	Ch3c00h
24	712	7905.25	961.66	486.67	139.46
48	652	4071.87	893.76	470.75	77.47
72	697.02	2803.74	828.58	449.79	64.43
96	666.11	2189.43	855.26	499.59	60.37
120	674.7	1824.02	871.28	454.17	59.55
144	720.42	1579.98	904.89	461.57	59.88
168	732.37	1406.23	906.23	472.53	60.28

CURVE FIT

EXPONENTIAL		POLYNOMIAL
HCL	$Y=668.4e^{0.009x}$	$y=5.264x^2-35.84x+731.6$
HNO3	$y= 7591e^{-0.26x}$	$y=284.7x^2-3187x+10165$
H2SO4	$y=901.1e^{-0.00x}$	$y=9.748x^2-81.60x+1020$
H3PO4	$y=478.4e^{-0.00x}$	$y=1.021x^2-10.18x+491.0$
CH3COOH	$y=110.6e^{-0.11x}$	$y=4.586x^2-46.60x+169.1$

Table 40: CORROSION RATE AT 2.5MOLE FOR STAINLESS STEEL IN TWO ACIDIC ENVIRONMENT

	HCL	**H2SO4**
24	**30.73**	**16.2**
48	**25.62**	**10.29**
72	**22.67**	**9.124**
96	**20.94**	**8.431**
120	**19.97**	**7.664**
144	**19.25**	**7.786**
168	**16.88**	**8.071**

CURVE FIT

EXPONENTIAL		POLYNOMIAL
HCL	$Y=31.29e^{-0.08x}$	y=0.313x2-4.546x+34.20
H2SO4	$y=13.97e^{-0.01x}$	y=0.443x2-4.651x+19.38

4.8 DISCUSSION OF RESULT

Mild steel coupons (specimen) were found to corrode in different concentrations of HNO3, HCL, H2SO4, H3PO4 and CH3COOH solution. This was evidenced by the decrease in the original weight of the metal coupons. HNO3 was found to be more corrosive followed by H2SO4, HCL, and H3PO4 and lastly CH3COOH was the least corrosive environment. The findings are shown in the graph of behavior of the acids reveal that the weight loss of the steel samples increased with time and concentration. This observation is attributed to the fact that the rate of a chemical reaction increases with increasing condensation (ita and offiong, 1999)

For the stainless steel, the experimental research shows that only two environment were able to corrode the steel coupons in different concentration of HCL, H2SO4. This was evidenced by the decrease in the original weight of the metal coupon. Also it was observed from the graph that HCL was more corrosive, followed by the H2SO4.

From the weight loss table of stainless steel, HNO3, H3PO4, CH3COOH were behaving immune in the solution. I.e. there was no corrosion rate within the 168hours of exposure.

CONCLUSION

The scope of this project work is limited to weight loss measurement of two type of steels (mild steel and stain less steel) that are subjected to five different corrosive environment namely, nitric acid, Acetic acid, hydro tetraoxophosphate vii hydrogen tetra oxosulpahte(vi) acid and hydrochloric acid, of five concentration (0.5m, 1.0m, 1.5m 2.0m and 2.5m); and the corrosion rate of the two steels in milligram per year. The relevance of this study is to know how much corrosion damages can cause to the usefulness of metals, and to help in material selection that determines the suitability of the service life in various acidic environments. Corrosion of mild steel and stainless is significant in varying concentrations of nitric acid, hydrochloric acid, hydrogen tetraoxosulphate VI acid, hydrogen tetraoxosulphate VII acid and acetic acid, being that nitric acid is most corrosive for mild steel, and hydrochloric acid for the stainless steel. The corrosion rate obtained for mild steel support the fact that carbon content in itself has little if any effect on the general corrosion resistances of steels, as they were higher than that of the stainless steel. That stainless steels e.g. austenic stainless steel corrode very slowly in certain type of acidic environment and can gradually destroyed under some types of condition. That the more corrosion resistant stainless steels, the corrosion rate decreases with time due to the formation of a protective layer on the surface of the alloy. The protective layer adds to the corrosion resistance of the alloy. Conclusively, this research study have reviewed that both mild steel and stainless steel corrodes at least to some some extent; therefore the need to select the right material for the right environment is a basic factor towards the life span of the material when subjected to corrosive environment.

REFERENCES

Abiola O.K,Oforka N.C (2005).”Organic Inhibitors For Steel and Aluminium in Acid System”J.Corr.Sci.Tech.3.

Akusoba E.U and Ewelukwa G.O(1996): Calculation in chemistry for Secondary School, Onitsha,Africa.Feb Publishers Limited.

Britannica Encyclopedia(2008):Steel, Volume ii,page 230(3a).

Clark D.S,varney W.R(1987):Physical Metallurgy for Engineer”.Van Nostrand and Reinhold Ltd.Canada.

Enteram A.N,Aisha H.A(2008):Corrosion behavior of Mild Steel in Hydrochloric Acid Solutions,www.electrochemsci.org.

Fadeyi J., Okwu M.O.,Mgbemena C.O., Ezekiel K.C. (2016)Pareto Principle and Hazard Model as Tools for Apporpriate Scheduled Maintenance in a Manufacturing Firm. African Journal of Science and Technology , Innovation and Technology, Taylor and Francis.

Fontana M.G,(1987):Corrosion Engineering,Singapore,Mcgraw-Hill International.

Ita B.I,offiong O.E (2001).”Analytical Assessment of the Corrosion Product in Automobile Cooling System: The Effect of Antirust Agent”Material Chemistry and Physics,70:330-335.

Nwoha T.C., Garrick Ombor, Modestus Okwu(2016) A Combined Algorithm Approach to Fuel Consumption Rate Analysis and Prediction of Sea-Worthy Diesel Engine Powered Marine Vessels. Journal of Engineering for the Maritime Environment, SAGE. DOI: 10.1177/1475090216663946

Osarolube E,Owate I.O, Oforka N.C (2004).” The Influence of Acidic Concentrations on Corrosion of Copper and Zinc”J.Corr.Sci.Tech.1.1,pp.66-69.

Thaddeus C. Nwaoha, Jasper Agbakwuru, (2016): Facilitating Hazard Analysis of LNG Carrier Operations via Risk Matrix Approach. *International Journal of Scinece and Technology, (IJST), United Kingdom.* Vol 5. (4). 156-162.