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Corrosion Inhibition of Mild Steel in Different Acid Medium by Using Various Acidic Groups of Organic Compounds

Suraj B. Ade
Associate Professor, P.G. Department of Chemistry, Shri Shivaji College, Parbhani, India

Abstract: ***Benzoic acid, salicylic acid, Anthranilic acid, 2- Nitro benzoic acid, 2- Chlorobenzoic acid compounds containing acidic group as a corrosion inhibitor for carbon steel was investigated. The study revealed that the various group such as (-COOH, OH, Cl and –NO_2) containing in organic compounds has an inhibitory action on the corrosion of carbon steel in the investigated medium. Corrosion rate of mild steel was studied using chemical weight loss method at room temperature. This research paper presents use of carboxylic group organic compounds as corrosion inhibitors for metals in 0.1N, 0.01N and 0.001N (HCl, HNO_3 and H_2SO_4) acidic medium. A common mechanism for inhibiting corrosion involves formation of a coating, often a passivation layer, which prevents access of the corrosive substance to the metal. Organic corrosion inhibitors adsorb on the surface to form protective film, which displace water and protect it against deteriorating. Effective organic corrosion inhibitors contain nitrogen, oxygen, sulphur and phosphorus with lone electron pairs as well can contain structural moieties with π-electrons that interact with metal favouring the adsorption process. This review presents mechanisms and monitoring of corrosion, laboratory methods for corrosion study, relationship between structure and efficacy of corrosion inhibitions, theoretical approach to design new inhibitors and some aspects of corrosion.***

Keywords: Corrosion, Inhibition, carbon steel, Weight loss and acidic group (-COOH, OH, -Cl and –NO_2) group containing organic compounds.

I. INTRODUCTION

Corrosion is the loss of useful properties of a material as result of chemical or electrochemical reaction with its environment. The consequence of corrosion are quite many and are considered a serious problem in industry, Constructions and civil services such as electricity, water and sewage system to prevent or minimize internal corrosion in this system, inhibitors are used especially in flow and closed system, such as fresh water distribution system. Corrosion problems have received a considerable amount of attention because of their attack on materials. The use of inhibitors is one of the most practical methods for protection against corrosion. Several works have studied the influence of organic compounds containing nitrogen on the corrosion of steel in acidic media[1-4], most organic inhibitors act by adsorption on the metal surface[5]. Most of the well-known acid inhibitors are organic compounds a containing nitrogen, oxygen, phosphorus, sulfur and aromatic ring or triple bonds. It was reported before that the inhibition efficiency decreases in the order: O<N<S<P[6-9]. Among the various methods to avoid or prevent destructions or degradation of metal surface, the corrosion inhibitor is one of the best known methods of corrosion protection and one of the most useful on the industry, this method is following stand up due to low cost and practice method[10-13]. Historically, inhibitors and great acceptance in the industries due to the excellent anti-corrosive properties. However, many showed up as a secondary effect, damage the environment. Thus the scientific community began searching for friendly environmentally inhibitors, like the organic inhibitors[14-15]. The aim of this research work is to investigate the inhibitive effect of mild steel in different acid medium by (-COOH, OH, -Cl and –NO_2) group containing organic compounds.

II. EXPERIMENTAL SECTION

Corrosion inhibition of mild steel in various acidic medium by (-COOH, OH, -Cl and –NO_2) group containing organic compounds. Steel binding wire was purchased from the local market. First, all wire cleaned by sand paper, and then it was washed by cleaning solution later on by distilled water. After cleaning the wire, it was dried by keeping at room temperature. After the preparation of the mixture solution in different labeled beaker 1-54, the previously weighed steel wire was dipped for 48 hours. After 48 hours the wire pieces were taken out from the beaker, pieces were washed with distilled water and dried. The weight of each wire was determined by using electronic balance in mg and they were recording tables.

In this experiment beakers were labeled as 1-54 and beakers labeled as 1-6, 20 ml 0.1N HCl, 7-12, 20 ml 0.01N HCl, 13-18, 20 ml 0.001N HCl, in beakers 19-24, 20 ml 0.1N HNO_3, 25-30, 20 ml 0.01N HNO_3, 31-36 ,20 ml 0.001N HNO_3, 37-42, 20 ml 0.1N H_2SO_4, 43-48, 20 ml 0.01N H_2SO_4 and in 49-54, 20 ml 0.001N H_2SO_4 were added 20 mg Benzoic acid, salicylic acid, Anthranilic acid, 2- Nitro benzoic acid, 2- Chlorobenzoic acid added to various beakers. The (-COOH, OH, -Cl and $–NO_2$) group containing organic compounds labeled as, Compound (A) Benzoic Acid, Compound (B) Salicylic Acid, Compound(C) Anthranilic Acid, Compound (D) 2- Nitro Benzoic Acid, Compound (E) 2- Chloro Benzoic Acid. Weight of metal wire pieces before and after dipping in corrosion solution, loss in weight, % loss weight was calculated by usual method. The % inhibition efficiency was calculated by using following formula

Where,

$$\text{I.E} = \frac{Wu - Wi}{Wu} \times 100$$

I.E. = Inhibition efficiency.

W_i= Weight loss of metal in inhibitor solution

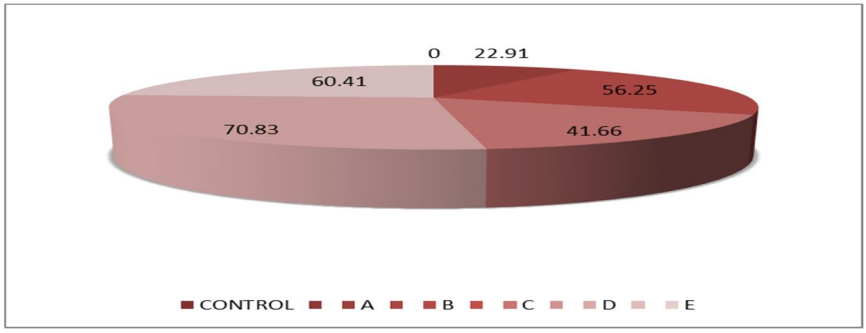
W_u = weight loss of metal in control solution

III. RESULT AND DISCUSSION

Effect of various Acidic group of organic compounds on corrosion in 0.1N HCl
(Table no. 1)

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (△W)	% Loss in weight	I.E. (%)
Control	0.281	0.233	0.048	17.08	-
A	0.309	0.272	0.037	11.97	22.91
B	0.278	0.257	0.021	7.55	56.25
C	0.315	0.290	0.025	7.93	41.66
D	0.322	0.308	0.014	4.34	70.83
E	0.295	0.276	0.019	6.44	60.41

Fig: Variation of weight loss of mild steel in 0.1N HCl solution contain in different acidic group of organic compounds (Graph no.1)



E

ffect of various Acidic group of organic compounds on corrosion in 0.01N HCl (Table no. 2)

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight(△W)	% Loss in weight	I.E.(%)
Control	0.274	0.240	0.034	12.40	-
A	0.344	0.316	0.028	8.13	17.64
B	0.341	0.323	0.018	5.27	47.05
C	0.275	0.255	0.020	7.27	41.17
D	0.282	0.270	0.012	4.25	64.70
E	0.286	0.277	0.009	3.14	73.52

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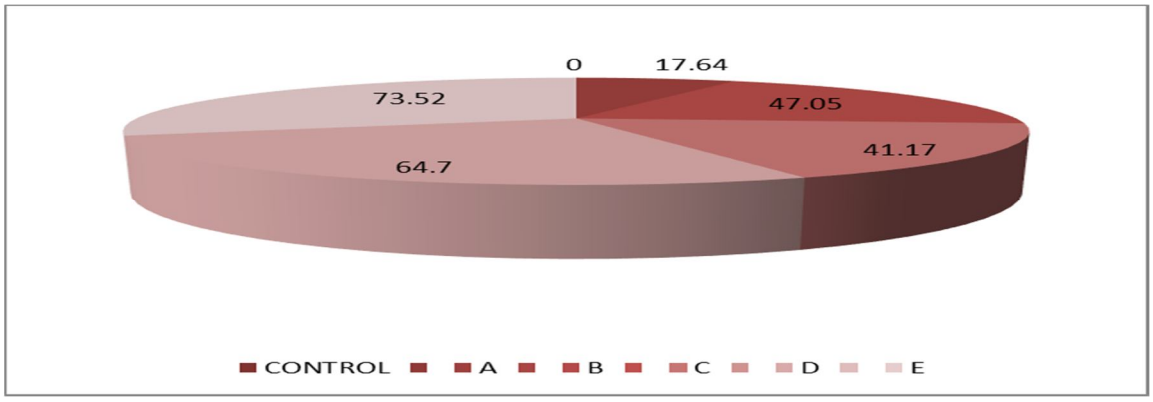
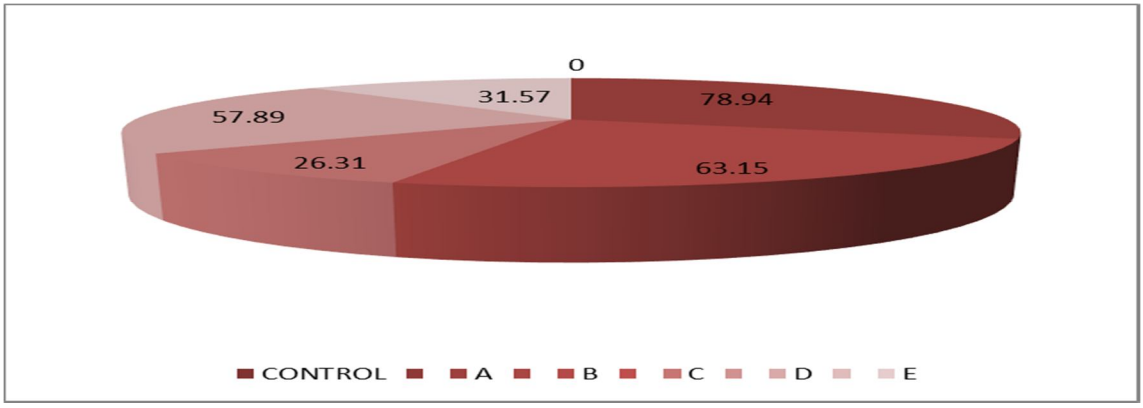
Fig: Variation of weight loss of mild steel in 0.01N HCl solution containing different acidic group (Graph no.2)



Effect of various Acidic group of organic compounds on corrosion in 0.001N HCl
(Table no. 3)

Compound	Initial weight(W_1)	Final Weight(W_2)	Loss in weight($\triangle W$)	% Loss in weight	I.E.(%)
Control	0.293	0.274	0.019	6.48	-
A	0.298	0.294	0.004	1.34	78.94
B	0.290	0.283	0.007	2.41	63.15
C	0.334	0.320	0.014	4.19	26.31
D	0.342	0.334	0.008	2.33	57.89
E	0.301	0.288	0.013	4.31	31.57

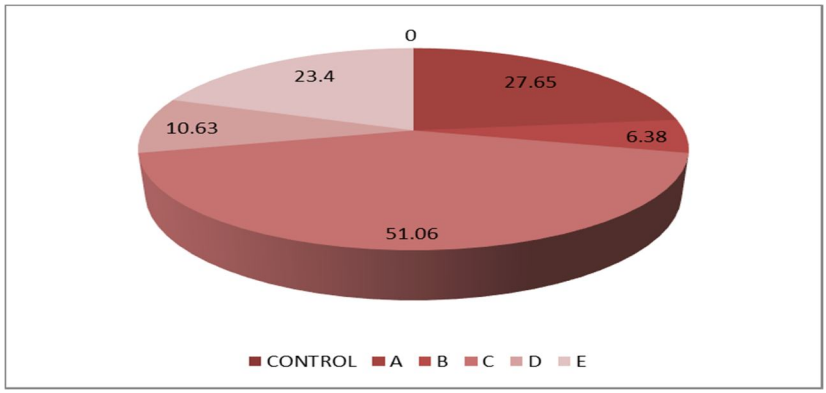
Fig: Variation of weight loss of mild steel in 0.001N HCl solution containing different acidic group (Graph no. 3)



Effect of various Acidic group of organic compounds on corrosion in 0.1N HNO_3
(Table no. 4)

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight ($\triangle W$)	% Loss in weight	I.E.(%)
Control	0.277	0.230	0.047	16.96	-
A	0.261	0.227	0.034	13.02	27.65
B	0.274	0.230	0.044	16.05	6.38
C	0.254	0.231	0.023	9.05	51.06
D	0.266	0.224	0.042	15.78	10.63
E	0.261	0.225	0.036	13.79	23.40

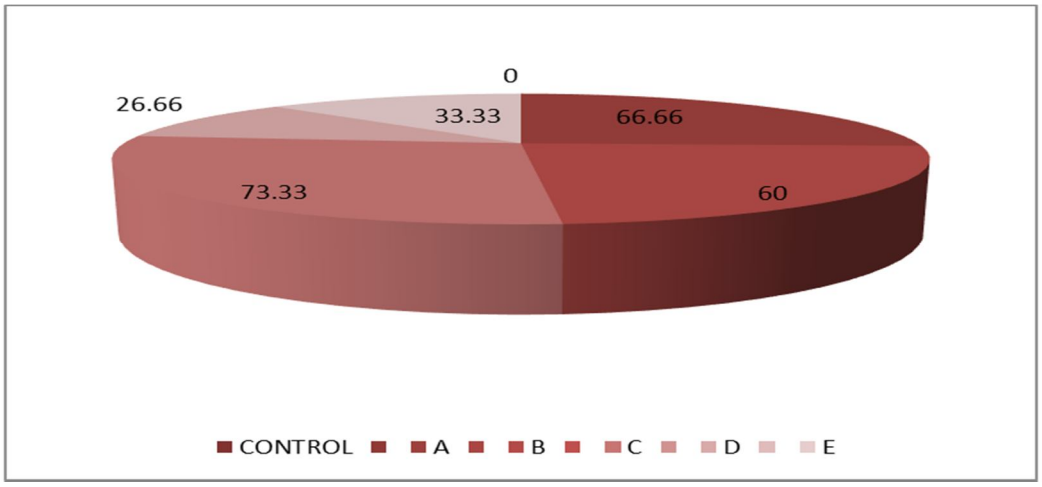
Fig: Variation of weight loss of mild steel in 0.1N HNO_3 solution containing different acidic group (Graph no. 4)



Effect of various Acidic group of organic compounds on corrosion in 0.01N HNO_3 (Table no. 5)

Compound	Initial weight(W_1)	Final Weight(W_2)	Loss in weight($\triangle W$)	% Loss in weight	I.E.(%)
Control	0.286	0.271	0.015	5.55	-
A	0.266	0.261	0.005	1.87	66.66
B	0.264	0.258	0.006	2.27	60.00
C	0.268	0.264	0.004	1.49	73.33
D	0.248	0.237	0.011	4.43	26.66
E	0.260	0.250	0.010	3.84	33.33

Fig: Variation of weight loss of mild steel in 0.01N HNO3 solution containing different acidic group (Graph no. 5)



Effect of various Acidic group of organic compounds on corrosion in 0.001N HNO_3 (Table no. 6)

Compound	Initial weight(W_1)	Final Weight(W_2)	Loss in weight($\triangle W$)	% Loss in weight	I.E.(%)
Control	0.281	0.268	0.013	4.62	-
A	0.253	0.249	0.004	1.58	69.23
B	0.267	0.262	0.005	1.87	61.63
C	0.261	0.258	0.003	1.14	66.66
D	0.269	0.261	0.008	2.97	38.46
E	0.246	0.240	0.006	2.43	53.84

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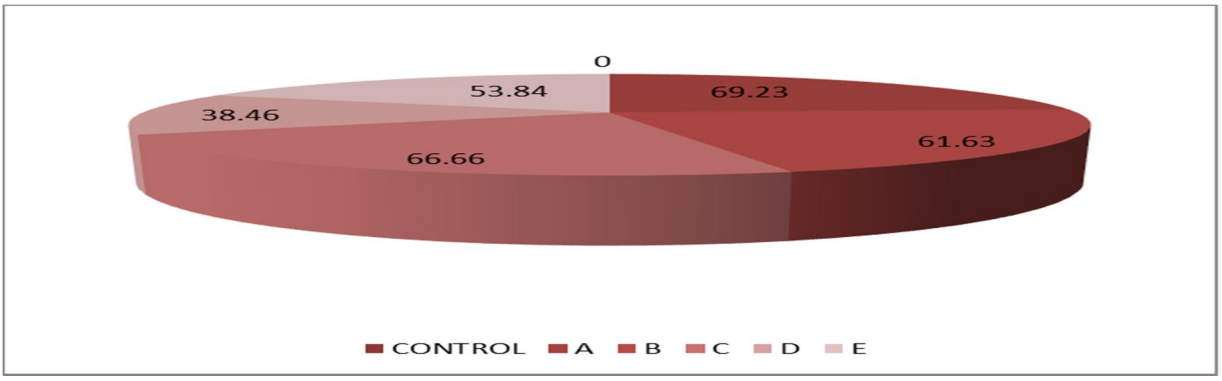
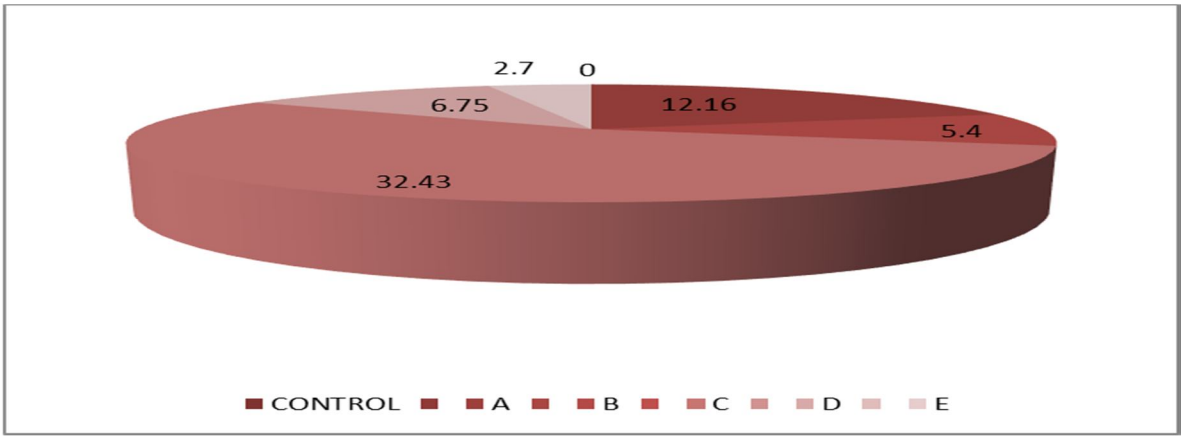
Fig: Variation of weight loss of mild steel in 0.001N HNO_3 solution containing different acidic group (Graph no. 6)



Effect of various Acidic group of organic compounds on corrosion in 0.1N H2SO4
(Table no. 7)

Compound	Initial weight(W_1)	Final Weight(W_2)	Loss in weight($\triangle W$)	% Loss in weight	I.E.(%)
Control	0.304	0.230	0.074	24.34	-
A	0.288	0.223	0.065	22.56	12.16
B	0.283	0.213	0.070	24.73	5.40
C	0.273	0.223	0.050	18.31	32.43
D	0.286	0.217	0.069	24.12	6.75
E	0.270	0.198	0.072	26.66	2.70

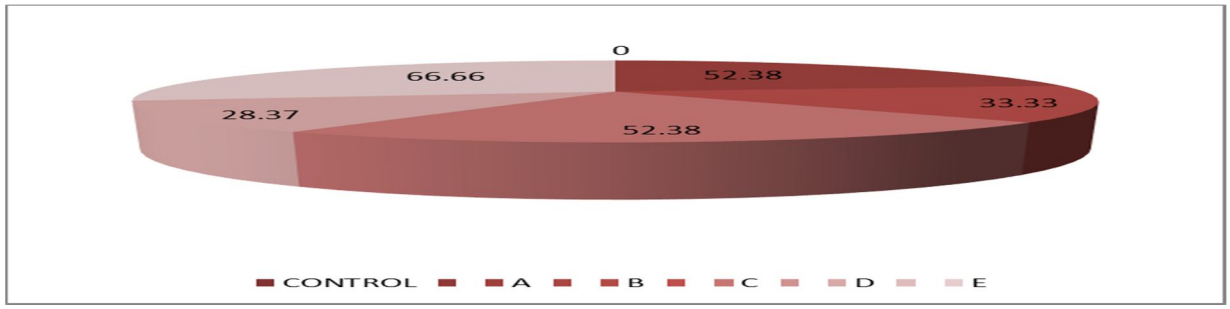
Fig: Variation of weight loss of mild steel in 0.1N H_2SO_4 solution containing different acidic group (Graph no. 7)



Effect of various Acidic group of organic compounds on corrosion in 0.01N H_2SO_4 (Table no. 8)

Compound	Initial weight(W_1)	Final Weight(W_2)	Loss in weight($\triangle W$)	% Loss in weight	I.E.(%)
Control	0.281	0.260	0.021	7.47	-
A	0.290	0.280	0.010	3.44	52.38
B	0.298	0.284	0.014	4.69	33.33
C	0.297	0.287	0.010	3.36	52.38
D	0.301	0.286	0.015	4.98	28.37
E	0.268	0.261	0.007	2.61	66.66

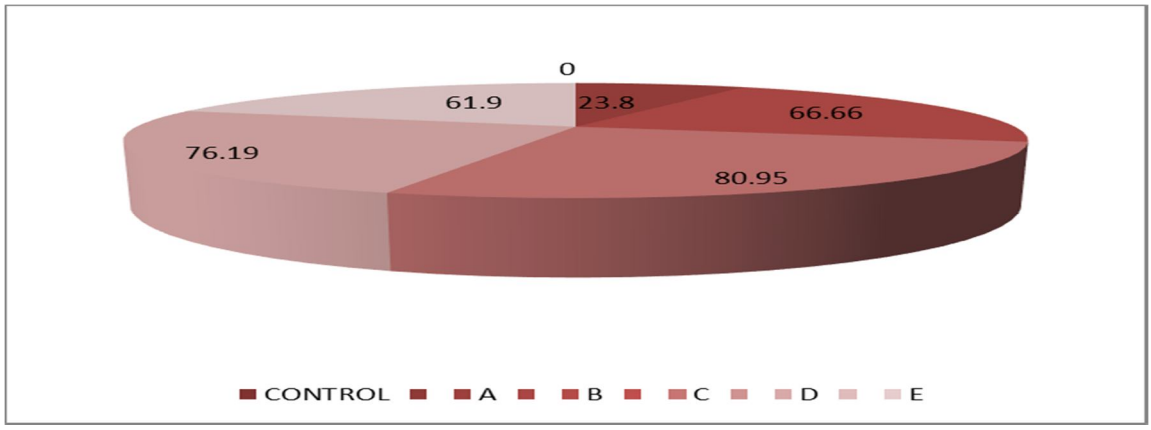
Fig: Variation of weight loss of mild steel in 0.01N H_2SO_4 solution containing different acidic group (Graph no. 8)



Effect of various Acidic group of organic compounds on corrosion in 0.001N H_2SO_4 (Table no.9)

Compound	Initial weight(W_1)	Final Weight(W_2)	Loss in weight($\triangle W$)	% Loss in weight	I.E.(%)
Control	0.290	0.269	0.021	7.24	-
A	0.305	0.289	0.016	5.24	23.80
B	0.306	0.299	0.007	2.28	66.66
C	0.297	0.293	0.004	1.34	80.95
D	0.275	0.270	0.005	1.81	76.19
E	0.295	0.287	0.008	2.71	61.90

Fig: Variation of weight loss of mild steel in 0.001N H_2SO_4 solution containing different acidic group (Graph no.9)



In the present study, different acidic group compounds were used as corrosion inhibitor & their inhibition efficiency in acidic medium was investigated. Benzoic acid (A), Salicylic acid (B), Anthranilic acid (C), 2- nitro benzoic acid (D), & 2- chloro benzoic acid were found to be effective inhibitors in acid environment. The inhibition action of these various acidic compounds was attributed to blocking the surface via formation of layer on the metal surface. The objective of this study to investigate the corrosion behavior of the mild steel in various acid concentration at room temperature. In the presence of organic compounds using weight loss measurements. From observation table, we conclude that benzoic acid act as good inhibitor for the corrosion of mild steel in HCl & HNO_3 by weight loss studies. The inhibition efficiency values exhibits, that the benzoic acid has excellent inhibition properties, against the mild steel corrosion in 0.001N HNO_3.Compound (B) salicylic acid shows I.E. in 0.001N HCl, 0.01N HNO_3, 0.001N HNO_3, & 0.001N H_2SO_4 solution having range nearly about 60 – 66% & lover I.E. in 0.1N H_2SO_4 about 5.40 %.Inhibition efficiency, value of compound (C) Anthranilic acid exhibits, higher I.E. in 0.01N HNO_3 & 0.001N H_2SO_4 solution and having I.E. 73.33% & 80.95% while in other acid concentration exhibits low inhibition effect. Compound (D) 2- nitro benzoic acid shows higher I.E. in 0.1N HCl & 0.001N H_2SO_4 solution having I.E. is 70.83% and 76.19% while 0.1N H_2SO_4 solution shows lower I.E. is about 6.75% which less inhibition efficiency. Inhibition efficiency figure indicate that the compound (E) 2- Chlorobenzoic acid shows higher I.E. in 0.01N HCl solution having I.E. 73.52% and also this compounds shows less inhibition efficiency in 0.1N H_2SO_4 solution. Further other variable acid concentration it shows medium inhibition efficiency.

IV. CONCLUSION

The weight loss study reveals that inhibition efficiency of mild steel in different mineral acidic medium by using various acidic group compound. In order to explain the above observations, the following result of corrosion inhibition is explained. Benzoic acid exhibits inhibition efficiency is 89.23 in 0.001N HNO_3. Compound (C) Anthranilic acid 80.95% I.E. in 0.001N H_2SO_4 also compound (B) shows 47-66% range in various acid concentration. In further compound 2- nitro benzoic acid 70.83% in 0.1N HCl & 76.19% in 0.001N H_2SO_4. Compound (A) 2- Chlorobenzoic acid exhibits very low 2.70% I.E. value in 0.1N H_2SO_4.

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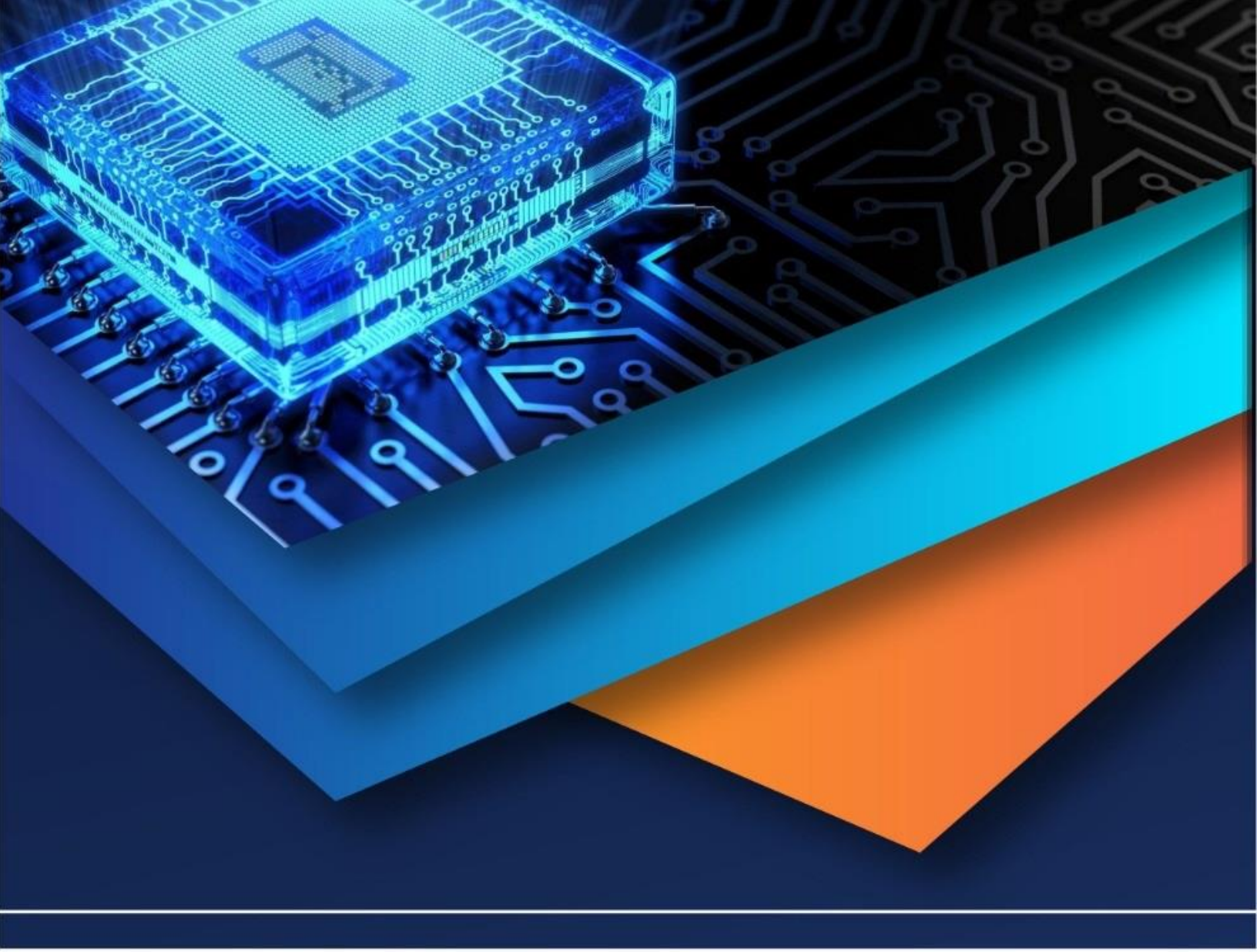

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