WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.084
Volume 11, Issue 3, 1525-1535. Research Article ISSN 2277– 7105

CORRUSION INHIBITION ANALYSIS OF MILD STEEL IN VARIOUS ACID MEDIUM BY AMIDE (-$CONH_2$) GROUP OF ORGANIC COMPOUNDS

Suraj B. Ade*

P. G. Department of Chemistry, Shri Shivaji College, Parbhani, India.

Article Received on
29 Dec. 2021,

Revised on 19 January 2022,
Accepted on 09 Feb. 2022

DOI: 10.20959/wjpr20223-23254

***Corresponding Author**
Dr. Suraj B. Ade
P. G. Department of Chemistry, Shri Shivaji College, Parbhani, India.

ABSTRACT

Acetamide, Benzamide, Thioacetamide, Urea, Thiourea compounds containing amide (-$CONH_2$) group as a corrosion inhibitor for carbon steel was investigated. The study revealed that the amide group 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 amide 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. Studied report that the adsorption of the organic inhibitors mainly depends on the some physicochemical properties of the molecule to the possible steric effects and electronic density of donor atoms; adsorption is suppose also to depend on the possible interaction of p-orbitals of the inhibitor with d-orbital of the surface atoms, which induce greater adsorption of the inhibitor molecule on to the surface of the metal alloy, leading to the formation of a corrosion protecting film.

KEYWORDS: Corrosion, Inhibition, Carbon steel, Weight loss and amide (-$CONH_2$) group containing organic compounds.

INTRODUCTION

A corrosion inhibitor is a chemical substance which when added is small concentration to an environment, minimizes or prevents corrosion.[1] Corrosion inhibitors are used to protect metals from corrosion, including temporary protection during storage or transport as well as localized protection, required, for example, to prevent corrosion that may result from accumulation of small amount of an aggressive phase. Corrosion is an electrochemical process by which metallic structure are destroyed gradually through anodic dissolution[2]

Stainless steel is covered with a highly protective film of chromium oxyhydroxide and is resistant to corrosion in many aggressive environment; however, acidic solution are aggressive environments; acidic solution are aggressive to this film layer and results in severe pitting formation[3-5] Several mineral acid solutions are widely used for various treatments of materials in industry such as pickling, descaling, acid cleaning and oil-well acidizing, thus the presence of corrosion inhibitors is very important to keep the surface of steel intact and reduce their corrosion rates[6,7] The use of inhibitors is one of the most practical method to protect the metal from corrosion[8, 9] Most of the effective inhibitors are organic compounds containing in their structures, nitrogen, phosphorus and sulphur. Heteroatoms such as nitrogen, phosphorus and sulphur are capable of forming coordinate covalent bond with metal owing to their free electron pairs and thus acting as inhibitors[10-12] Mostly, sulphuric and hydrochloric acids are employed for such purposes.[13] The main problem concerning carbon steel applications is its relatively low corrosion resistance in acidic solutions. Several methods are currently used to prevent corrosion of carbon steel. One such method is the use of an organic inhibitors.[14,15] Amides are organic molecules that contain atoms with high electron levels, Such as N, O, and S, in their molecule structures.

Relationship between molecular structures of these amides and their inhibition efficiencies have studied in several research reports.[16-19] Organic compounds used as inhibitors, occasionally they act as cathodic, anodic or together, as cathodic and anodic inhibitors, nevertheless, as a general rule, act through a process of absorption, designated as a film forming. Naturally the occurrence of molecules exhibiting a strong affinity for metal surfaces compounds showing good inhibition efficiency and low environmental risk.[20] These inhibitors build up protective hydrophobic film absorbed molecules on the metal surface, which provides the barrier to the dissolution of the metal in the electrolytes. They must be soluble or dispersible in the medium surrounding the metal.[21] The use of organic compounds to inhibit corrosion has assumed great significance due to their application in preventing corrosion under the various corrosive environments.[22].The aim of this research work is to investigate the inhibitive effect of mild steel in different acid medium by amide (-$CONH_2$) organic compounds.

Experimental section

Corrosion inhibition of mild steel in various acidic medium by organic compounds containing amide (-$CONH_2$) group. 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 from 1-54 and in beakers having labeled 1-6 20ml 0.1N HCl, 7-12 20ml 0.01N HCl, 13-18 20ml 0.001N HCl, in beakers 19-24 20ml 0.1N HNO_3, 25-30 20ml 0.01N HNO_3 and in beaker 31-36 20ml0.001N HNO_3 and in beakers 37-42 20ml 0.1N H_2SO_4, 43-48 20ml 0.01N H_2SO_4, 49-54 20ml 0.001N H_2SO_4 were added 20 mg of Acetamide, Benzamide, Thioacetamide, Urea, Thiourea of were added to beakers. The amide group of different organic compounds used are labeled as, Compound (A) Acetamide, Compound (B) Benzamide, Compound(C) Thioacetamide, Compound (D) Urea, Compound (E) Thiourea. 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, $$I.E = \frac{Wu - Wi}{Wu} \times 100$$

I.E. = Inhibition efficiency.

W_i= Weight loss of metal in inhibitor solution

W_u = weight loss of metal in control solution

RESULT AND DISCUSSION

Table no. 1: Effect of various amide group of organic compounds on corrosion in 0.1N HCl.

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.311	0.271	0.060	19.29	-
A	0.290	0.242	0.048	16.55	6.00
B	0.305	0.255	0.050	16.39	16.66
C	0.292	0.263	0.029	9.93	51.66
D	0.299	0.251	0.048	16.05	20.00
E	0.282	0.258	0.024	8.51	60.00

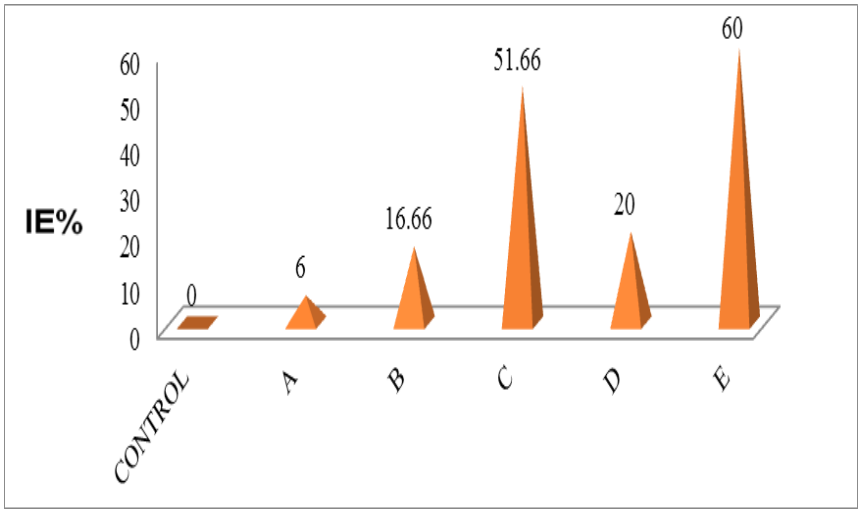

Fig. 1: Variation of weight loss of mild steel in 0.1N HCl solution containing different amide group. (Graph no. 1)

Table no. 2: Effect of various amide group of organic compounds on corrosion in 0.01N HCl.

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.294	0.270	0.024	8.16	-
A	0.284	0.276	0.008	2.81	66.66
B	0.308	0.288	0.020	6.49	16.66
C	0.294	0.287	0.007	2.38	70.83
D	0.289	0.279	0.010	3.46	58.33
E	0.306	0.302	0.004	1.30	83.33

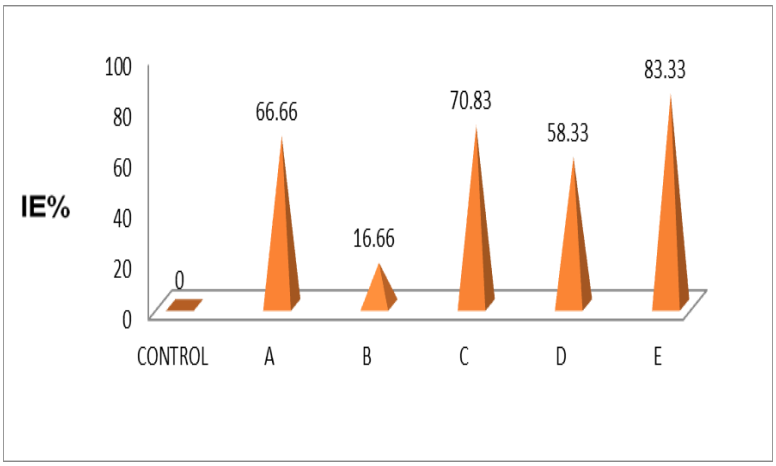

Fig. 2: Variation of weight loss of mild steel in 0.01N HCl solution containing different amide group. (Graph No. 2)

Table no. 3: Effect of various amide group of organic compounds on corrosion in 0.001N HCl.

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E.(%)
Control	0.293	0.270	0.023	7.84	-
A	0.305	0.284	0.021	6.88	8.69
B	0.294	0.276	0.018	6.12	21.73
C	0.293	0.287	0.006	2.04	73.91
D	0.296	0.286	0.010	3.37	56.52
E	0.275	0.264	0.011	4.0	52.17

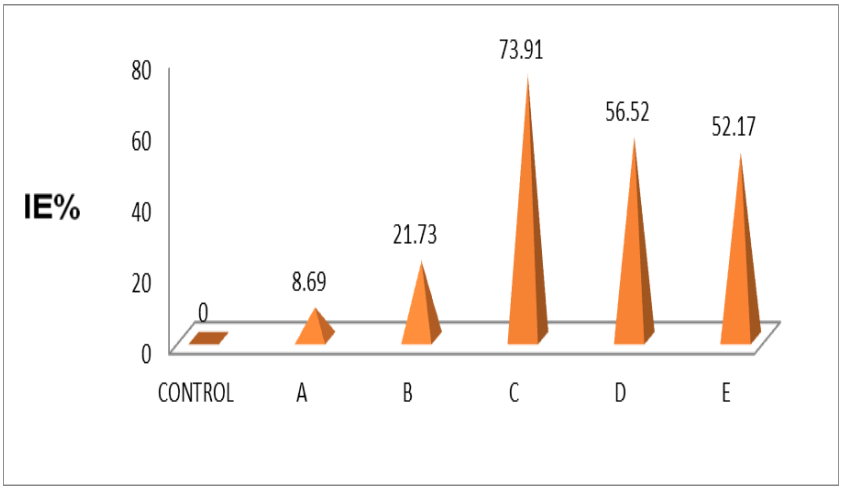

Fig. 3: Variation of weight loss of mild steel in 0.001N HCl solution containing different amide group. (Graph No. 3)

Table no. 4: Effect of various amide group of organic compounds on corrosion in 0.1N HNO_3.

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E. (%)
Control	0.253	0.207	0.046	18.18	-
A	0.282	0.247	0.035	12.41	23.91
B	0.275	0.237	0.038	13.81	17.39
C	0.265	0.258	0.007	2.64	84.78
D	0.281	0.247	0.034	12.09	26.08
E	0.278	0.269	0.009	3.23	80.43

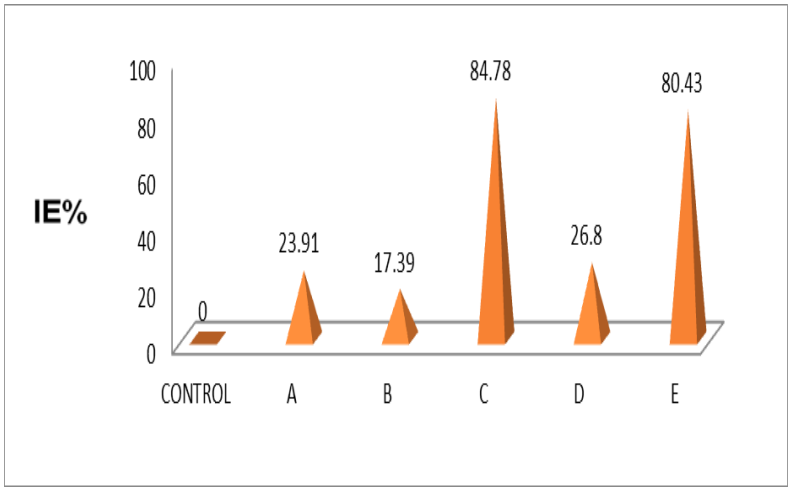

Fig. 4: Variation of weight loss of mild steel in 0.1N HNO_3 solution containing different amide group. (Graph No.4)

Table no. 5: Effect of various amide group of organic compounds on corrosion in 0.01N HNO_3.

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E.(%)
Control	0.258	0.244	0.014	5.42	-
A	0.259	0.255	0.004	1.54	71.42
B	0.263	0.257	0.006	2.28	57.14
C	0.281	0.271	0.010	3.55	28.57
D	0.272	0.263	0.009	3.30	35.71
E	0.275	0.262	0.013	4.72	7.14

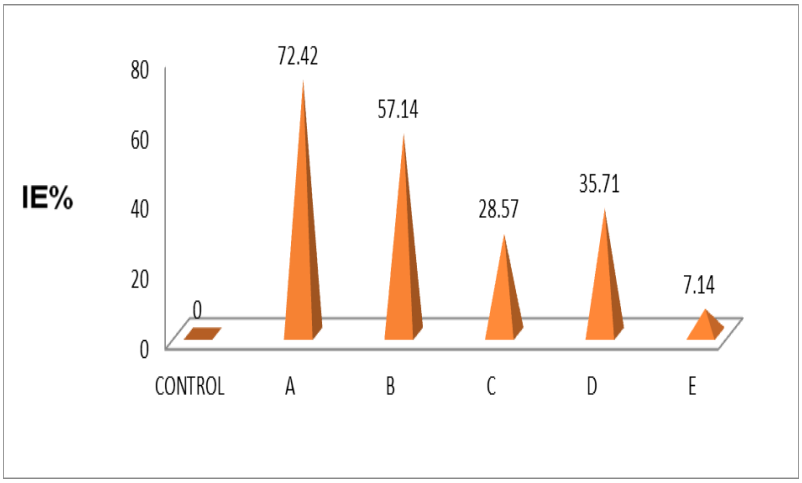

Fig. 5: Variation of weight loss of mild steel in 0.01N HNO3 solution containing different amide group. (Graph No. 5)

Table no. 6: Effect of various amide group of organic compounds on corrosion in 0.001N HNO_3.

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E.(%)
Control	0.261	0.242	0.019	6.89	-
A	0.274	0.260	0.014	5.10	26.31
B	0.250	0.246	0.004	1.60	78.94
C	0.276	0.271	0.005	1.81	73.68
D	0.266	0.253	0.013	4.88	31.57
E	0.278	0.273	0.005	1.79	73.68

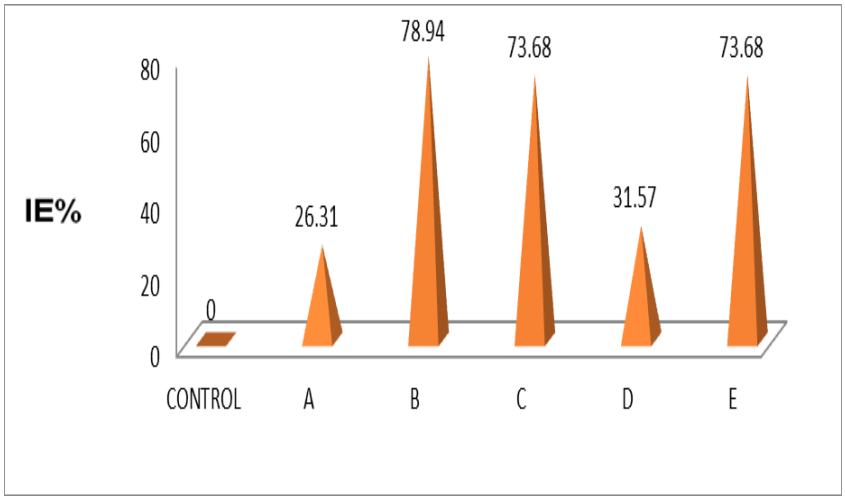

Fig. 6: Variation of weight loss of mild steel in 0.001N HNO_3 solution containing different amide group. (Graph No. 6)

Table no. 7: Effect of various amide group of organic compounds on corrosion in 0.1N H_2SO_4.

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E.(%)
Control	0.287	0.216	0.071	24.73	-
A	0.299	0.232	0.067	22.40	5.63
B	0.283	0.218	0.065	22.96	8.45
C	0.288	0.280	0.008	2.77	88.73
D	0.289	0.226	0.063	21.79	11.26
E	0.295	0.286	0.009	3.05	87.32

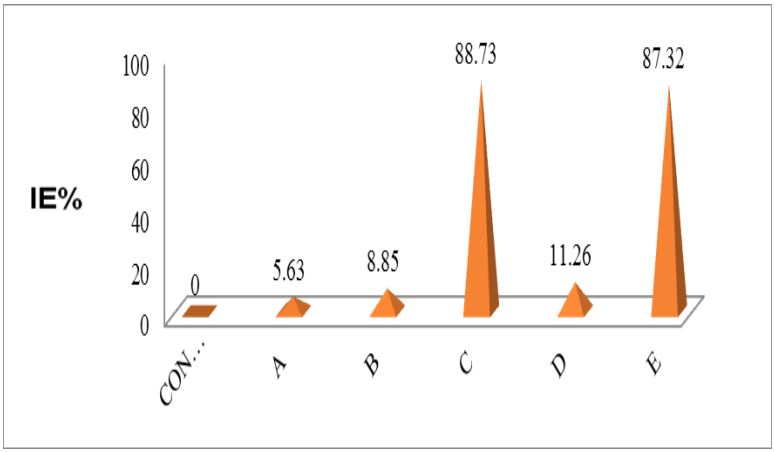

Fig. 7: Variation of weight loss of mild steel in 0.1N H_2SO_4 solution containing different amide group. (Graph No. 7)

Table no. 8: Effect of various amide group of organic compounds on corrosion in 0.01N H_2SO_4.

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E.(%)
Control	0.317	0.301	0.016	5.04	-
A	0.291	0.277	0.014	4.81	12.50
B	0.279	0.268	0.011	3.94	31.25
C	0.275	0.265	0.010	3.63	37.50
D	0.286	0.278	0.008	2.79	50.00
E	0.310	0.301	0.009	2.90	43.75

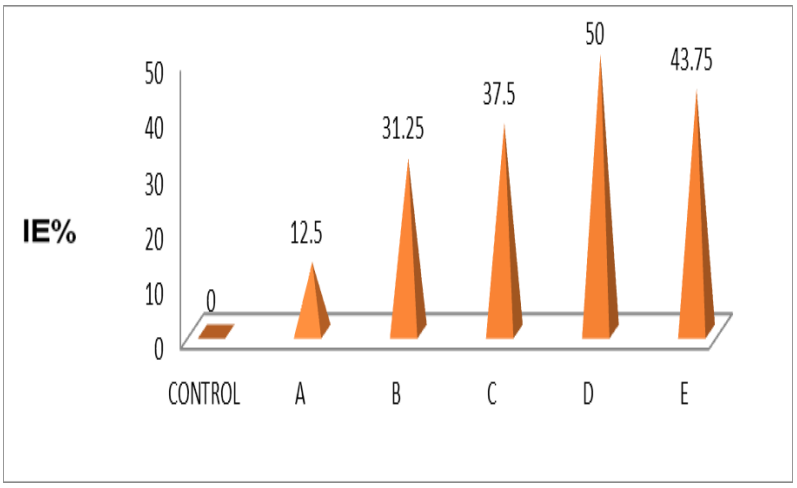

Fig. 8: Variation of weight loss of mild steel in 0.01N H_2SO_4 Solution containing different amide group. (Graph No. 8)

Table no. 9: Effect of various amide group of organic compounds on corrosion in 0.001N H_2SO_4.

Compound	Initial weight (W_1)	Final Weight (W_2)	Loss in weight (ΔW)	% Loss in weight	I.E.(%)
Control	0.277	0.262	0.015	19.54	-
A	0.295	0.291	0.004	1.35	73.33
B	0.288	0.283	0.005	1.73	66.66
C	0.276	0.270	0.006	2.17	60.00
D	0.284	0.280	0.004	1.40	73.33
E	0.291	0.288	0.003	1.03	80.00

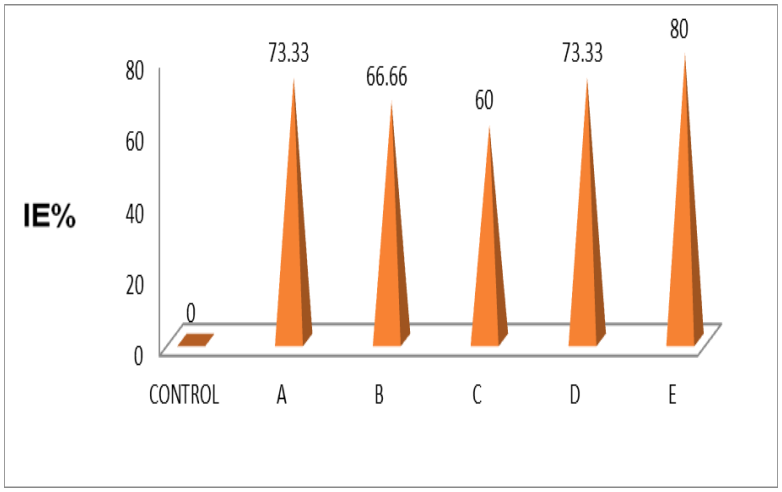

Fig. 9: Variation of weight loss of mild steel in 0.001N H_2SO_4 solution containing different amide group. (Graph No. 9)

The experimental result regarding inhibition efficiency of various amide (-$CONH_2$) group organic compounds under reveals that, the compounds have inhibition property. They inhibits of oxidation of metal in various mineral acid medium. We conclude that the inhibition efficiency are also depends on the oxidizing medium. In experimental process, we have to used three types of acidic medium namely 0.1, 0.01, 0.001 N HCl, HNO_3 and H_2SO_4.Nitric acid is strong oxidizing agent as compared to other two mineral acids.

After the analysis of various amide groups in organic compound, that is amide group of organic compound (A) Acetamide having higher inhibition efficiency in 0.01 N HNO_3 is 71.42% and in 0.001 N H_2SO_4 is 73.33%.Inhibition efficiency of Acetamide compound is less in dilution of other acids. In compound (B) Benzamide it can shows in the range of inhibition efficiency 16.66% to 31.25% in 0.1N, 0.01N HCl, HNO_3 and H_2SO_4 acid solutions. Inhibition efficiency of Benzamide compound in 0.001N HNO3 is 78.94%.Thioacetamide

(C) can exhibits good inhibition efficiency in 0.1N H_2SO_4 is 88.73%. And 73.0% efficiency in 0.001N HCl and HNO_3 acid medium. Certain compound (D) Urea having higher inhibition efficiency except in 0.001 N H_2SO_4 acid solution that is IE 73.33%.In other concentration of acids it shows less inhibition efficiency. Thiourea (E) is shows inhibition efficiency in the range of nearly 80.0% to 87.0% in 0.01N HCl, 0.1N, 0.001N HNO_3 and H_2SO_4 acidic medium.

Form all above study of amide group organic compounds, inhibition efficiency of Thioacetamide and Thiourea have found to be good inhibitors for mild steel in various acid medium. The other amide group compounds also exhibits inhibition efficiency also it can be shown by graphical interpretation data. The inhibition efficiency increased with the efficiency in the concentration of acids. The inhibition efficiency (IE %) of these compounds followed the sequence C > E > B > A > D. The corrosion process is inhibited by the adsorption of these molecules on steel binding wire. The various amide group organic compound containing active groups which is responsible to inhibits corrosion of mild steel in different acidic medium.

CONCLUSION

The amide (-$CONH_2$) group organic compounds shows good corrosion inhibition property against carbon steel corrosion in various corrosive acidic medium. Inhibition efficiencies are related to concentration, temperature and chemical structures of the organic compounds. Generally, inhibition efficiencies increase when concentration increases. All organic compound affected both anodic and cathodic reactions. Result obtained from the experimental data shows. Thioacetamide and Thiourea inhibits good inhibition efficiency. Also, Benzamide, Acetamide and Urea shows inhibition efficiency and act as corrosion inhibitor.

ACKNOWLEDGEMENT

The authors are thankful to the principal of shri Shivaji College, Parbhani for providing research facilities. Authors are also thankful to Head Department of chemistry providing necessary facilities and interpretation of corrosion activities.

REFERENCES

1. Riggs, OL, Jr., in C.C. Nathan (Ed), corrosion Inhibitors, NACE, Houston, TX, 1973; 11.
2. Roberge, PR, Handbook of corrosion Engineering, McGraw-Hill, 2000.

3. Merner BH, El Attari, Traisnet, M., Bentics, F., Lagrenee, M. Corr. Sci, 1998; 40: 391-399.
4. Chetouani A, Medjahed K, Benabadji. KE, Hammouti B, Kertit S, Mansri A, Prog. org. Coat, 2003; 46: 312.
5. Sekine I, Nakahata Y, Tanabe H, Corros. Sci, 1988; 28: 987.
6. Sinko J, Prog. org. Coat, 2001; 42: 267.
7. Manahan SE, Environmental Chemistry, Lewis, Boca Rato, 1994; 6.
8. Hackerman N, "The theory and practice of corrosion and its control in industry", Langmuir, 1987; 3(6): 922-924.
9. Nestle A, "Corrosion inhibitors in petroleum production primary'', in corrosion inhibitors, C. C., Nathan, Ed., NAC, Houston, Tex, USA, 1973.
10. Flick FW, corrosion inhibitors: As industrial guide, William Andrew, 1993; 2.
11. Bilgic S, Askut AA, "Effect of amino acid on corrosion of cobalt on H_2SO_4, British corrosion Journal, 1993; 28(1): 59-62.
12. Moretti G, Guide F, Tryptophan as copper corrosion inhibitor in 0.5m aerated sulphuric acid Corros. Sci, 2002; 44(9): 1995-2001.
13. Migahed MA, Nassar IF, Electrochem. Act, 2008; 53: 2877-2882.
14. Avci G, Colloids Surf. A, 2008; 317: 730-736.
15. Benali O, Larabi Traisnel M, Gengembra L, Harek Y, Appl. Surf. Sci, 27: 253, 6130-6139.
16. Fang J, and Li J, Journal of molecular Structure (Theo-Chem), 2002; 593: 179.
17. Ebenso K, Fekpe UJ, Ha, BI, etal. Materials Chemistry and physics, 1999; 60: 79.
18. Kandemirli F, Sagdinc S, Corrosion Sci., 2007; 49: 2118.
19. Zhang DQ, Cai QR, He XM, et al, Materials chemistry and physics, 2008; 112: 353.
20. Aprael S, Yaro, Anees A, Khadom, Rafal k,Wael, "Apricot juice as green corrosion inhibitor of mild steel in phosphoric acid," Alexandria Engineering Journal, 2013; 52(1): 129-135.
21. Gentil V, Corrosions, Rio de Janeiro; LTC, 2003; 2.
22. Ali SA, Al-Muallem HA, Rahman SU, Saeed MT, Corros. Sci, 2008; 50: 3070-3077.