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Study of Corrosion Inhibitors (Pennisetum Glaucum extracts) on Mild Steel used in Building Construction

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Abstract

Corrosion of Mild steel IS: 432 (Part I)-1982 in various concentrations of hydrochloric acid and sulphuric acid are studied by Mass Loss method in the absence and presence of the extracts of seeds plant *Pennisetum glaucum* (Pearl Millet). Corrosion relates effects the technologies. Water plays an important role in enhancing corrosion. In this paper the mass loss equation, concludes that corrosion inhibition increased to proportionate concentration of the extract. It has been found that seed extract of plant *Pennisetum glaucum* is the effective and have high corrosion inhibition efficacy. It was also observed that mild steel is more susceptible in acid like HCl and H_2SO_4 solution.

Keywords: Corrosion inhibitor, *Pennisetum glaucum*, mild steel, mass loss method.

Introduction

Mild steel finds a variety of applications due to its properties such as strength, low cost, susceptibility. It is widely used for many mechanical, structural and other engineering purposes such as wire, automobiles, ships, girders, bridge structures, structural reactors, boilers plates, steam engines and many parts and automobile. Applications of mild steel are also for the fabrication of number reaction vessels, tanks, pipelines and underground structures [1]. Mild steel with the surroundings tend to corrode, and is affected by numbers of factors such as humidity[2], metal composition, temperature, presence of gases like sulphur dioxide, hydrogen chloride, chlorine and other corrosive gases, for structure. Water plays an important role in the process of destruction and deterioration of various metals and alloys.

Metallic corrosion is a very common but serious problem, causing considerable economic losses throughout the whole world. To reduce the corrosion requires the application of various corrosion protective techniques and scientific knowledge to allow metals to decrease the corrosion losses. Number of methods are employed in which one of that is the application of the film forming inhibitors [3].

Corrosion inhibitors, prevents the corrosion and are coated over substrate forming a barrier to oxygen and moisture by complexing with metal ions or with forming of passivating film or nano coating on the metal or alloys surface [4-5].

A great deal of study has been devoted to corrosion in the multidiscipline area of different, engineering and technology. With the help of certain materials, including eco-friendly seed extracts a number of organic compounds have been used as potent corrosion inhibitors [6-10].

There are numerous naturally occurring substances like Tannin, beet root[11-12], Saponin[13], Tamarind, Tea leaves, Pomegranate juice and *Capparis decidua*[14], *Embellica officinalis*, *Terminalia bellerica*, *Sapindus trifoliatus* and *Acacia concinna*, *Swertia angustifolia*, *Adhatoda-vasica*, *Vinca-rosea*, *Citrullus colocynthis*[15], *Argenmone mexicana*[16], *Calotropis giganta*, *Eugenia jambolans*, *Prosopis juliflora*[17], *Ficus relgeosa*(*peepal*) [18], which have been evaluated as effective corrosion inhibitors.

Tobacco products such as dried tobacco leaves, stems and dust are added to cementations concrete and mortar to inhibit corrosion.

The tobacco addition protects steel embedded in Portland cement from corrosive attack. Tobacco is renewable, potentially inexpensive bio-product that provides excellent corrosion protection with little or no environmental concerns [19].

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Imasawa patented an aqueous styrene-butadiene co-polymer emulsion corrosion inhibitor for reinforcing steel for autoclaved light weight concrete [20]. A 50:50 combination sodium benzoate and alkali metal sebasate was used as a migrating inhibitor in the polymer fibre, in post-tensioning cables [21].

Problem formulation

Acid solutions are commonly used for removal of undesirable scale and rust in metal furnishing industries, cleaning of boilers, and heat exchangers. Among these, hydrochloric acid is one of the most widely used agents in the process of pickling of metals and alloys.

Use of inhibitors and passivators are one of the most practical materials used for protection against corrosion in acid solution and prevent unexpected metal dissolution [22].

A mild steel corrosion phenomenon has become important particularly in acidic media because of the increased industrial applications [23] of acid solution.

The importance of the study lies in the fact that the naturally occurring plant extracts are of environmentally compatible, non-polluting, less toxic, easily available and bio-degradable and are economically viable corrosion inhibitors.

A large number of corrosion inh ibitors have been developed and used for application to various systems depending on the medium treated, and the type of surface that is susceptible to corrosion, and the medium exposed [24]. The efficiency and usefulness of a corrosion inhibitor under one set of circumstances often does not imply the same for another set of circumstances. In many applications like industrial water treatment systems, a combination of more than one corrosion inhibitors along with other additives such as anti-scalents, biocides and polymeric dispersants are used. According, corrosion inhibitors work synchronously with coating and cathodic protection. Further, highly efficient and durable inhibitors that can completely protect and low carbon steel in aggressive environments such as high Cl electrolyte for longer duration is yet to be realized.

In this paper an attempt has been evaluated the influence of different concentration of extract of seeds of Pennisetum glaucum (Pearl Millet) as corrosion inhibition on mild steel in the presence of hydrochloric acid and sulphuric acid. For this study Mass Loss method has been employed.

Experimental observation/theoretical modelling

Theoretical details

Corrosion inhibition efficacy (η %) of the extracts have been calculated by mass loss measurements method using following equation:-

$$\eta\% = \frac{\Delta Mu - \Delta Mi}{Mu} \times 100 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where ΔM_U and ΔM_i are the mass loss of the metal in uninhibited acid and inhibited solution respectively.

The corrosion rates in mmpy (milli miles per year) can be calculated by following equations:

$$\text{Corrosion Rate (mmpy)} = \frac{Mass\ loss\ X\ 87.6}{Area\ X\ Time\ X\ Metal\ density} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Where mass loss is expressed in mg, area is expressed in square cm of metal surface exposed, time is expressed in hours of exposure, metal density is expressed in gm/cm^3 and 87.6 is conversion factor.

Materials & method

Preparation of seed extract

Seeds of *Pennisetum glaucum* were air dried for 5 to 6 days in the present environment. This was finely grounded into coarse material. Grinded powder passes through sieve of 100 mesh. 250gms of this material treated with 300ml ethanol in conical flask to cover the powder completely. Afterwards, the resulting paste was refluxed about 3 hours. Solution left for cooling. Then it was filtered. The reaction procedure was repeated to obtained the maximum extracts quantity. After the solution get cooled, the solution was made 100ml using distilled water. Then the solution was filtered and filtrate kept to dry.

Figure-1 Seeds Powder of *P.glaucum*

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Figure-2 Seeds Extract of *P.glaucum*

ii) Preparation of specimen

Rectangular pieces of mild steel of fixed dimensions 2.50 x 1.55 x 0.016 cm were saw cut from the sheet were employed for the mass loss measurements. Specimens were cleaned by buffing to produce mirror finish with the help of emery paper. Then the mass of the each specimen has to be taken by the use of weighing balance. Each specimen immersed in a beaker containing 100 ml of test solution and left expose to air. Duration of exposure was kept up to 24hours. After 24hours, the specimen take out from the beaker and left for dry. As the specimen get dry, further its mass has to be taken by using a weighing balance.

Experimental design

`Mass loss and percentage inhibition efficacy (η) for the different concentration of acid and inhibitor are given in table 1-6. The inhibition efficacy (I.E.) has been calculated from the mass loss for different concentration of hydrochloric acid (HCl) and sulphuric acid (H_2SO_4) solution. The results revealed that the inhibition efficacy increases with the increase in inhibitors concentration of seeds extracts from 0.12% to 0.60% for naturally occurring plant *Pennisetum glaucum*.

Table-1 Mass loss data presentation for mild steel in 0.5N HCl (24hours) with given inhibitor i.e., extracts of seeds of plant Pennisetum glaucum(Pearl Millet)

Inhibitor concentration (%)	Mass loss (ΔM) in mg	Inhibition efficacy (η%)	Corrosion Rate (mmpy)
Seeds Extract			
Uninhibited	152	-	20.2609
0.12%	32	78.94	4.3257
0.24%	29	80.92	4.0201
0.36%	25	83.55	3.4017
0.48%	23	84.86	3.2949
0.60%	16	89.47	2.2238

Table-2 Mass loss data presentation for mild steel in 1N HCl (24hours) with given inhibitor i.e., extracts of seeds of plant Pennisetum glaucum(Pearl Millet)

Inhibitor concentration (%)	Mass loss (ΔM) in mg	Inhibition efficacy (η%)	Corrosion Rate (mmpy)
Seeds Extract			
Uninhibited	35	-	19.2422
0.12%	28	20	18.3065
0.24%	20	42.85	15.2231
0.36%	10	71.42	9.7247
0.48%	7	80	4.2806
0.60%	3	91.42	1.1389

Table-3 Mass loss data presentation for mild steel in 2N HCl (24hours) with given inhibitor i.e., extracts of seeds of plant Pennisetum glaucum(Pearl Millet)

Inhibitor concentration (%)	Mass loss (ΔM) in mg	Inhibition efficacy (η%)	Corrosion Rate (mmpy)
Seeds Extract			
Uninhibited	45	-	8.0903
0.12%	21	53.33	3.9975
0.24%	13	71.11	2.5763
0.36%	9	80	1.9107
0.48%	8	82.22	1.5910
0.60%	5	88.88	1.0167

Table-4 Mass loss data presentation for mild steel in 0.5N H_2SO_4 (24hours) with given inhibitor i.e., extracts of seeds of plant Pennisetum glaucum(Pearl Millet)

Inhibitor concentration (%)	Mass loss (ΔM) in mg	Inhibition efficacy (η%)	Corrosion Rate (mmpy)
Seeds Extract			
Uninhibited	418	-	33.5516
0.12%	88	78.94	7.1901
0.24%	78	81.33	6.3778
0.36%	62	85.16	4.9517
0.48%	59	85.88	3.6917
0.60%	57	86.36	2.5216

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Table-5 Mass loss data presentation for mild steel in 1N H_2SO_4 (24hours) with given inhibitor i.e., extracts of seeds of plant Pennisetum glaucum(Pearl Millet)

Inhibitor concentration (%)	Mass loss (ΔM) in mg	Inhibition efficacy (η%)	Corrosion Rate (mmpy)
Seeds Extract			
Uninhibited	34	-	18.1830
0.12%	26	23.52	17.0001
0.24%	17	50	12.9407
0.36%	8	76.47	7.7805
0.48%	7	79.41	4.2815
0.60%	3	91.17	1.1383

Table-6 Mass loss data presentation for mild steel in 2N H_2SO_4 (24hours) with given inhibitor i.e., extracts of seeds of plant Pennisetum glaucum(Pearl Millet)

Inhibitor concentration (%)	Mass loss (ΔM) in mg	Inhibition efficacy (η%)	Corrosion Rate (mmpy)
Seeds Extract			
Uninhibited	51	-	8.7446
0.12%	22	56.86	4.1825
0.24%	14	72.54	2.7302
0.36%	9	82.35	1.9110
0.48%	8	84.31	1.5944
0.60%	6	88.23	1.2227

Results and discussions

The inhibitors have shown the efficiency in the range:

Pennisetum glaucum seeds extract show minimum 78.94% inhibition efficiency and maximum 89.47% for 0.5N HCl solution but 1N HCl solution show minimum efficiency 20% and maximum 91.42% and 2N HCl solution show minimum efficiency 53.19% and maximum efficiency 88.88%.

Pennisetum glaucum seeds extract shows minimum inhibition efficiency 78.94% and maximum 86.36% for 0.5N H_2SO_4 solution but for 1N H_2SO_4 solution show minimum 23.52% and maximum 91.17% and for 2N H_2SO_4 solution show minimum 56.86% and maximum 88.23%.

Figure 3 Variation of Corrosion Rate for Mild Steel in 0.5N, 1N and 2N HCl (24Hours) with Inhibitor Concentration of P.glaucum

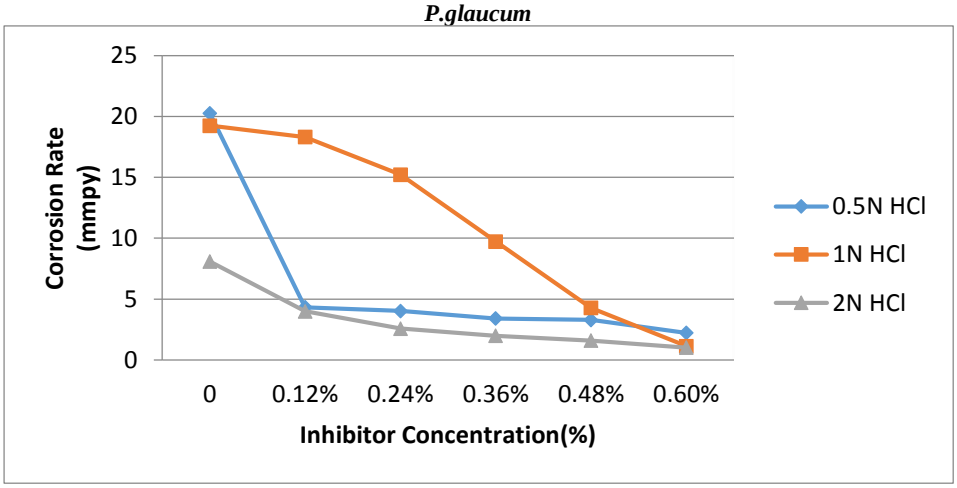

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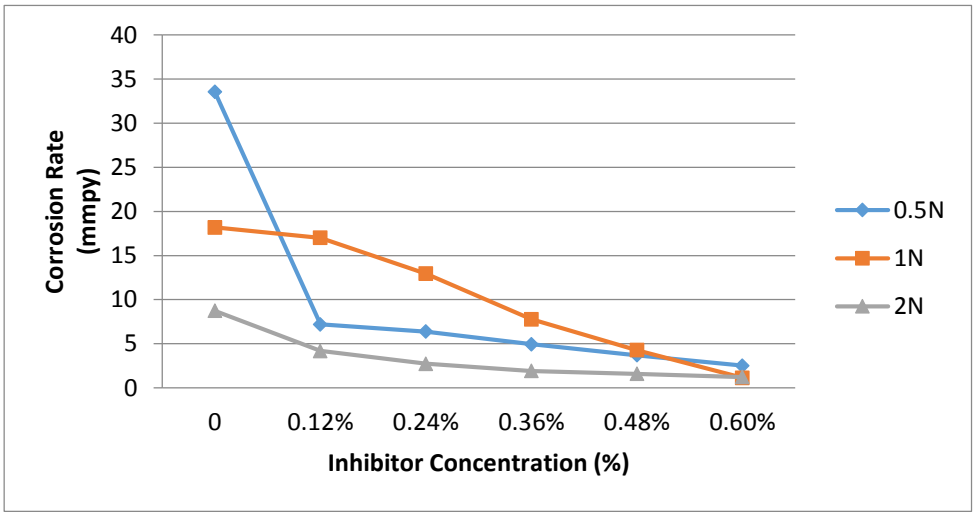
Figure 4 Variation of Corrosion Rate for Mild Steel in 0.5N, 1N and 2N H_2SO_4 (24Hours) with Inhibitor Concentration of P.glaucum



The acidic extracts of the plant *Pennisetum glaucum* is effective corrosion inhibitors. The seeds extract of *Pennisetum glaucum* are the most potent corrosion inhibitors..

Thus from this experimental results it shown that as the concentration of acid increased, the inhibition efficacy decreases. This is due to the fact that with the increases in acid concentration more hydrogen ions reaches at the cathodic sites which increases the cathodic reaction rate hence inhibition efficacy decreases.

Conclusion and scope of future work

From the above analytical, experimentally precise research works following points are inferred after successful completion and observations from variety of experimental data obtained:

1. Mild steel is highly prone to corrosion in acidic media like hydrochloric acid and sulphuric acid.
2. The acidic extract are much effective for Mild steel in 1.0N concentration of hydrochloric acid than in sulphuric acid.
3. The inhibition efficacy of all extracts increases with increases in its concentration. Thus,

Inhibition efficacy α Concentration of inhibitor

4. The corrosion rate is governed by number of complex reactions taking place and also on the nature of the protective film.
5. The inhibition efficacy of the extracts of Pennisetum glaucum decreases with the increase in the concentration of acid. Thus,

Inhibition efficacy $\alpha \frac{1}{Concentration\ of\ acid}$

Corrosion importance lies in the fact that corrosion causes great loss to our economy and is a major threat for human health. This loss to the US economy is more than the entire cost of floods and fires in the U.S.A. In fact 45% of the country steel production goes to replace corroded parts and products. A survey carried out by Central Electrochemical Research Institute, Karaikudi, estimated the annual cost of corrosion in India at rest 1500million [25]. According to recent estimates by the Satellite institute, corrosion costs in U.S.A. almost $350 billion per year [26].

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References

1. *Rittu Chowdhary & Tripti Jain "Effect of temperature in Corrosion Rate of Mild Steel", J.Electrochemical Soc. India, Vol.53(1), pg.33-38, 2004.*
2. *K.Barton, "Atmospheric Corrosion Of Metals-A Symposium Issue 767",1974.*
3. *Anand Vishal, J. Prasanna Kumar, TS Mukherje, "Metallic Corrosion And Its Control Using Surface Modification Techniques", Bulletin Of Electrochemistry, Vol.15, pg.148-151, 1999.*
4. *OM. K. Sharma, P. Arora, S. Kumar, S. P. Mathur, and R. Ratnani, "Inhibitive effect of Prosopis cineraria on mild steel in acidic media," Corrosion Engineering Science and Technology, Vol.43, No 3, pg.213-218, 2008.*
5. *G.Carbajal, A.Martinez, J.G.Gonzalez-Rodriguez, V.M.Castano, "Corrosion-resistant coatings: a nanotechnology approach", Anti-Corrosion Methods and Materials, Vol.48, Iss:4, pg.241-245, 2001.*
6. *I.Ahamed; S.Khan; K.R.Ansari and M.A.Quarishi, "Primaquine: A pharmaceutically active compound as corrosion inhibitor for mild steel in hydrochloric acid solution", Journal of Chemical and Pharmaceutical Research, Vol.3, pg.703-717, 2011.*
7. *P.D.Reena Kumari, Jaganath Nayak, A.Nityananda Setty, "3-Methyl-4-amino-5-mercapto-1,2,4-triazole (MAMT) as Corrosion Inhibitor for Aluminium alloy" Journal of Coating Technology and Research, Vol.8(6), pg.685-695, 2011.*
8. *M.A.Quarishi and Ambrish Singh, "Piper longum and Bacopa monnieri extracts as green corrosion inhibitors for Aluminium", Journal of Chemical and Pharmaceutical Research, Vol.4(1), pg.322-325, 2012.*
9. *O.A.Paul, M.Ladan, and S.Takuma, "Corrosion inhibition and adsorption behaviour for mild steel by Ficus glumosa gum in sulphuric solution", African Journal of Pure and Applied Chemistry, 6,100,2012.*
10. *T.Sethi, A.Chaturvedi, R.K.Upadhyay and S.P.Mathur, "Corrosion Inhibitory Effects of Some Schiff's Bases On Mild Steel In Acidic Media", Journal Chilean Chemistry Society, No.3, pg.1206-1213, 2007.*
11. *G.Trabanelli and V.Carassiti, "Advances in Corrosion Science and Technology", Eds.-M.G. Fontana and R.W.Stachle, Plenum Press, New York, 6, 1976.*
12. *A.A.El-Hossary, M.M.Garwish and R.M.Saleh, "Proc. 2nd Intl. Symp. Indl and Oriented Basic Electrochemical Tech", Madras Prepr SAEST, CECRI Karaikudi, India,Vol.6, pg.81, 1980.*
13. *"The Useful Plants of India" CSIR New Delhi "The Wealth of India-Raw Materials" CSIR New Delhi, 1986.*
14. *P.Arora, S.Kumar, M.K.Sharma and S.P.Mathur, "Corrosion Inhibition of Aluminium by Capparis Decidua in Acidic media", E-Journal of Chemistry, Vol.4, pg.450-456, 2007.*
15. *R.Chauhan , U.Garg and R.K.Tak , "Corrosion inhibition of aluminiumin acid media by Citrullus Colocynthis extract" ,E-Journal of Chemistry, Vol.8(1), pg. 85-90, 2011.*
16. *P. Sharma, R. K. Upadhyay, A. Chaturvedi and R. Parashar, "Study of Corrosion Inhibition Efficiency of Naturally Occurring Argenmone mexicana on Al in HCl Solution," Journal of Technical and Research in Chemistry, Vol.5, No.1, pg.21-27, 2008.*
17. *Rittu Chowdhary, Tripti Jain, Mahendra Kumar Rathoria and S.P.Mathur "Corrosion Inhibition Of Mild Steel By Acid Extracts Of Prosopis Juliflora", Bulletin of Electrochemistry, Vol.20(2), pg.67-75, 2004.*
18. *Tripti Jain, Rittu Chowdhary and S.P.Mathur "Effect of Temperature in Corrosion rate of Mild Steel in hydrochloric and sulphuric acid in presence of Ficus Relgeosa ", Bulletin of Electrochemistry Society, India, Vol.53, pg.33-38, 2004.*
19. *Von Fraunhofer JA, Langan T, Davis GD "Cementitious concrete and mortar with tobacco products as corrosion inhibitors" US patent 163796, 2008*
20. *Imasawa K. "Aqueous SBR emulsion corrosion inhibitor for reinforcing steel for autoclaved lightweight concrete", JP patent 102700, 2009.*
21. *BA Miksic, A Furman, M Kharshan, J.Jackson "Composition and method for preserving post-tensioning cables in metal-reinforced concrete structures" US patent 7541089, 2009.*

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Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

22. *H. Ashassi-Sorkhabi, D.Seifzadeh and M.G.Hosseini, "EN, EIS and polarization studies to evaluate the inhibition effect on Mild Steel Corrosion", Vol.50, pg.3363-3370, 2008.*
23. *A.K.Satapathy, G.Gunasekaran, S.C.Sahoo, K.Amit and P.V.Rodrigues, "Corrosion inhibition by Justicia gendarussa plant extract in HCl solution" ,Vol.51, pg.2848-2856, 2009.*
24. *Vedula S. Sastri , "Corrosion Inhibitors, Principles and Applications", New York: John Wiley and Sons, ISBN-13:978-0471976080, 1998.*
25. *R. Bhaskaran, N.S. Rengaswamy, and N.Palaniswamy, "Impact of Metallic Corrosion, Part II: Economic Impact, Corrosion Update", No.60, pg2–4, May-June 2001.*
26. *J.R.Davis, "The Effects and Economic Impacts of Corrosion", Corrosion: Understanding the Basics, Chapter-1, pg.-10, 2000.*