PREVENTION OF STEEL CORROSION IN CONCRETE BY USING "ALLIUM SATIVUM"

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ABSTRACT:

Reinforced concrete is the one of the versatile and economical material which is used in the world wide. Steel is used as reinforcement material in the concrete. Reinforcement embedded in the brittle concrete imparts tensile strength. Corrosion of these steel is a main factor that affects both durability and strength when subjected to the sever environment conditions. The concrete who's PH below 10 will destroy passivity of reinforcing steel bars and leads for corrosion. This paper includes the experimental analysis on prevention of steel corrosion in concrete by using natural inhibitor allium sativum. As corrosion is longer process solution of HCL and water is used to increase rate of corrosion in in varying proportion 30% and 50% of total weight of solution. Artificial inhibitor epoxy resin is used for result comparison. Results of weight loss test and electrical resistance were showed that allium sativum is a good inhibitor and having inhibition efficiency between 90%- 95%.

Keywords: *Corrosion, Eight Loss Test, Electrical Resistance, Allium Sativum etc*

INTRODUCTION

Reinforced concrete is one of the most extensively used construction materials in the world. It is a versatile and economical material that generally performs its proposed use well over its service life. Reinforced concrete is used in numerous ways, some of the larger and better known uses including roadways, bridges, car parks, residential buildings and in industry; it is widely used in nuclear power plant. It is an excellent construction material. Concrete alone is good in compression, but reinforced concrete greatly escalations the scope for making structures required to withstand other forms of mechanical force. Corrosion of steel bars is the main factor influencing both the concrete durability and strength. The corrosion of the steel reinforcement expand up to seven times the original size, developing high pressures within the concrete, which cause cracking and spalling of the concrete cover and expose the bar to further corrosion activity. Researchers are looking for finding several solutions to avoid corrosion of steel use of corrosion inhibitors is one of them. Use of synthetic inhibitors is leading to discarding problems, health threats and many more. So it is essential to overcome such wicked consequences by emerging natural corrosion inhibitors which are inexpensive, non-toxic, and environmentally friendly. The known hazardous effects of most synthetic corrosion inhibitors are the inspiration for the use of some natural products. In chemical industries corrosion of metals is serious problem to prevent or minimize corrosion, inhibitor normally used especially in flow cooling system.

B Shyamala Marko Chigondo, et al (2016) [2] did overview on the application of natural plant

extracts as corrosion inhibitors for mild steel. Miroslav Brodoan et al (2016) [6]did determination of reinforcement corrosion using the electrical resistance method of embedded bars in the concrete beams in laboratory conditions. In this work they measured the changes of electrical resistance of a metal sample. This was a method that can be applied for the non-destructive monitoring of the corrosion of steel reinforcement in concrete. Principle of this method was based on the fundamental theory regarding the relation of electrical resistance change onto the cross section size of each conductor.

Cleophas A.Loto, et al (2016) [5] focused on the inhibition performance in most cases concentration was sensitive as all the result parameters in this work respond positively. The best inhabitation was achieved by researchers with the 100% garlic extract concentration.

A.M. Al- Fakih, ET al (2015) [1] was used turmeric and ginger as green inhibitors for mild steel corrosion in acidic medium in experimental work. Efficiency of corrosion inhibition was investigated using weight loss method and potentiodynamic polarization measurements. Results showed that efficiency increases with the increase in the inhibitors concentrations which attains92% and 91% at 10 g/L of turmeric and ginger, respectively. Results indicated that the turmeric acts as a better corrosion inhibitor compared to ginger.

Pallav Shah et al (2014) [5] discussed the effect of aloe Vera as green inhibitor on galvanized iron in HCl and H2SO4 solution. Inhibitor Mannose-6- phosphate was the main constituent of the aqueous extract of aloe Vera. Results were indicates that aloe Vera has excellent inhibition efficiency in controlling corrosion of galvanized iron in H2SO4 and HCl solution.

E.Rodriguez clemente, et al (2014) [10] experimental work was focused on the use of aluminum sativum as a corrosion inhibitor for carbon steel in 0.5M .H2SO4 had been carried out by using weight loss measurements. Results were proved that aluminum sativum is a good inhibitor with its efficiency increased as concentration increased up to 400ppm

Aprael S. Yaro , et al (2013) [11]was used apricot juice as green corrosion inhibitor of mild steel in phosphoric acid. The corrosion protection of mild steel in 1 M H3PO4 solution by apricot juice was studied at different temperatures by weight loss technique. Observations noted that apricot juice acts as a corrosion inhibitor of mild steel with maximum inhibition efficiency of 75% by forming a monolayer on metal surface.

Taleb H.Ibrahim, et al (2013) [12]in experimental work used potato peel extract for corrosion of mild steel in 2M HCL solution has been investigated by weight loss and electrochemical techniques. Results showed that maximum efficiency of potato peel extract of 70% obtained at concentration of 50ppm

This paper includes the experimental analysis on prevention of steel corrosion in concrete by using natural inhibitor allium sativum. As corrosion is longer process solution of HCL and water is used to

increase rate of corrosion in in varying proportion 30% and 50% of total weight of solution. Artificial inhibitor epoxy resin is used for result comparison Results of weight loss test and electrical resistance were showed that allium sativum is a good inhibitor and having inhibition efficiency between 90%-95%.

EXPERIMENTAL WORK

Selection of inhibitor

Natural Inhibitor

Use of inhibitor is important task in the protection of metals from corrosion. Choice of the inhibitor Allium Sativum (Garlic) for experimental work is based on following considerations like-

Less expensive Non Toxic
Possess no heat to environment Easy availability

Allium Sativum (Garlic) is a natural inhibitor. It contains 0.1-0.36% of a volatile oil and 33 sulphur compounds like aliin, allicin, ajoene, allylpropl, diallyl trisulphide, s-allylcysteine, vinyldithiines, S-allylmercaptocystein. It also contains 17 amino acids and their glycosides, arginine. Garlic contains a higher concentration of sulphur compounds than any other Allium species. Compounds responsible for corrosion inhibition are Allicin, s-allylcysteine and arginin. The reduction in the corrosion rate was due to the formation of S-containing film present in the extract which was adsorbed physically on the steel surface It contains sulphur compounds that gets adsorb on the surface of steel surface protecting steel from corrosion.

Preparation of Garlic extract

Garlic extract can be prepared by grinding and filtering garlic bulbs and collecting the concentrated liquid extract in glass container. This solution is used as inhibitor.

Artificial inhibitor

Epoxy resin is an artificial corrosion inhibitor used to compare the results of corrosion inhibition efficiency of natural corrosion inhibitor (Allium Sativum) and artificial corrosion inhibitor. 2.1.2. Preparation of test specimen and solution

For experimental work TMT bars of 12mm diameter and 100mm length are selected. Number of specimens taken was 18, 9 for natural inhibitor and remaining 9 for artificial inhibitor. Clean the specimen to remove dirt and oil by using distilled water. Weight of each specimen with the precision is 0.0001 ± 0.1 mg and noted down as initial weight.

As corrosion is a long process solution of concentrated HCL and water was used to increase rate of corrosion. Concentration of HCl was taken in varying proportion 30% and 50% of total weight of solution to change the rate of corrosion. Garlic extract concentration was taken in proportion as 20% of total weight of solution to see the effect on inhibition efficiency. Epoxy resin selected as an artificial inhibitor to compare the corrosion inhibition efficiency between artificial and natural inhibitor. The methods used for experimental analysis were Weight loss method and Electrical resistance method.

Weight loss method

Weight loss percentage and percentage inhibitor efficiency were obtained from weight loss measurement in absence and presence of inhibitors. Results from use of natural and artificial inhibitor were compared in this method.

TMT bars of 12mm diameter and 100 mm length are selected 9 among these 3 were coated with artificial inhibitor epoxy resin and 3 coated with garlic extract coating. Remaining 3 were kept without coating. Clean the specimen to remove dirt and oil by using distilled water. Weight of each specimen with the precision is 0.0001 ± 0.1 mg and noted down as initial weight. For increasing corrosion rate HCL and water solution used as corrosive medium. Concentration of HCL was taken as 30% and 50% of total volume of solution. Coated specimens were looked as shown in figure.1.Specimens coated with Epoxy Resin shown in figure.2

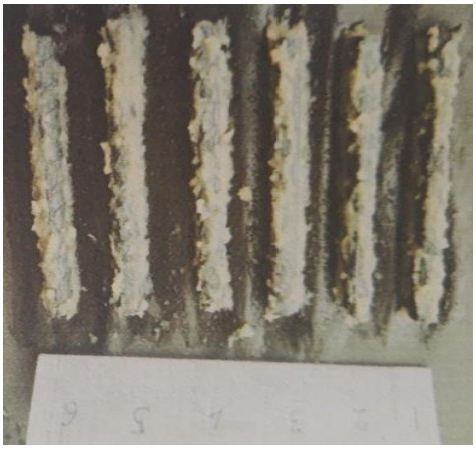

Figure.1.Allium Sativum coated bars

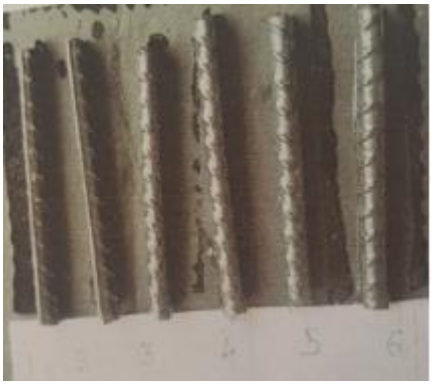

Figure.2. Epoxy Resin coated bars

These test specimens were immersed in the corrosive solution for 48 hours. After 48 hours all corrosive test specimens kept in open atmosphere for 7 day to increase rate of corrosion. After 7 days drying weight of each specimen was measured. The percentage weight loss was calculated based on the weight loss measurement by the following equation

( ) ……..(1)

Where,

Wo and W1 are the initial and final weight of the TMT bars.

Inhibition efficiency was calculated by using formula given below:

( ) ……..(2)

Where
ΔWa= Weight loss without inhibitor
Δ Wb= Weight loss with inhibitor

Electrical resistance method

Specimen preparation and number of specimens are as same as weight loss method. After 48 hours all corrosive test specimens kept in open atmosphere for 7 day to increase rate of corrosion. Measuring the changes of electrical resistance of a metal sample is a method that can be applied for the non- destructive monitoring of the corrosion of steel reinforcement in concrete. Figure .3 demonstrates the device used for measurement of resistance. Principal of this method was based on the theory regarding the relation of electrical resistance and the cross section size of each specimen bar. Resistance offered by test specimen was analyzed by using following equation (3)

…….(3) ‾

Where,
R=Resistance offered by test specimen
V=Applied voltage
I=Current corresponding to applied voltage

After performing weight loss method, measured the electrical resistance of test specimen using digital multi-meter. The value displayed on millimeter was the indication of resistance. The efficiency was calculated by using following formula

( ) …….(4)

Where,
Ro=Initial Resistance
R1=Final Resistance

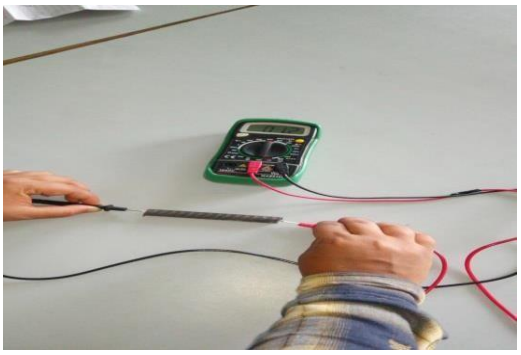

Figure.3 Measurement of Resistance

RESULT AND DISCUSSION

Results of Weight loss test is as indicated in the following tables. Table.1. indicates average weight loss for without coating, With Allium Sativum is coating and Epoxy Resin coating steel bars for 30% HCL corrosive medium. Table.2. Shows the average weight loss for same coatings but corrosive medium is contain high concentration of HCL solution Bars without any coating showed more weight loss than bars coated with Allium Sativum and Epoxy resin. The corrosion inhibition efficiency of Allium Sativum was found to be between 90-95% percent for different concentrations of HCI. The corrosion inhibition efficiency of Epoxy Resin was found to be between 77-95% percent for different concentrations of HCl.

Table.1.Average weight loss of bars in 30% HCL corrosive medium

Specimen No.	Steel bar type	(gm)	Average weight loss(gm)
1	Without coating	5.626	5.642
2		5.095	
3		6.206	
1	With Allium Sativum coating	0.349	0.339
2		0.323	
3		0.347	
1	With Epoxy Resin coating	0.702	0.656
2		0.670	
3		0.598	

Table no.2 Inhibitors efficiency in 30% HCL corrosive medium

Sr.No	Inhibitor	Inhibitors efficiency (%)
1	Allium Sativum	93.99
2	Epoxy Resin	88.37

Table.3.Average weight loss of bars in 50% HCL corrosive medium

Specimen No.	Steel bar type	(gm)	Average weight loss(gm)
1	Without coating	8.368	8.270
2		8.628	
3		7.816	
1	With Allium Sativum coating	0.573	0.583
2		0.626	
3		0.550	
1	With Epoxy Resin coating	1.063	1.066
2		0.935	
3		1.200	

Table no.4 Inhibitors efficiency in 50% HCL corrosive medium

Sr.No	Inhibitor	Inhibitors efficiency (%)
1	Allium Sativum	92.95
2	Epoxy Resin	87.11

Table.5. Inhibitors efficiency in 30% HCL corrosive medium

Specimen No.	Steel bar type	Initial resistance Ω (Ro)	Final resistance Ω (R1)	Efficiency (%)
1	Without coating	1.5	2.3	65.21
2		1.5	2.2	68.18
3		1.5	2.3	65.21
1	With Allium Sativum coating	1.5	1.6	93.75
2		1.5	1.6	93.75
3		1.6	1.7	94.11
1	With Epoxy Resin coating	1.6	1.8	88.88
2		1.5	1.9	78.94
3		1.5	1.8	83.33

Table no.6 Inhibitors efficiency in 30% HCL corrosive medium

Sr.No	Inhibitor	Inhibitors efficiency (%)
1	Allium Sativum	93.87
2	Epoxy Resin	83.71

Table no.7 Inhibitors efficiency in 50% HCL corrosive medium

ecimen No.	Steel bar type	Initial resistance Ω (Ro)	Final resistance Ω (R1)	iciency (%)
1	Without coating	1.5	2.5	60.00
2		1.6	2.5	64.00
3		1.5	2.4	62.50
1	With Allium Sativum coating	1.5	1.6	93.75
2		1.5	1.7	88.23
3		1.5	1.7	88.23
1	Epoxy Resin coating	1.5	2.0	75.00
2		1.6	2.0	80.00
3		1.5	1.9	78.94

Table no.8 Inhibitors efficiency in 30% HCL corrosive medium

Sr.No	Inhibitor	Inhibitors efficiency (%)
1	Allium Sativum	97.07
2	Epoxy Resin	77.78

The increase in electrical resistance of test bars without any coating was more. The increase in electrical resistance of test bars coated with Allium Sativum was found to be least. The increase in electrical resistance of test bars coated with Epoxy Resin was found to be in between that of bars without any coating and bars coated with Allium Sativum.

CONCLUSION

1. Natural extract of Allium Sativum was found to be effective inhibitor in the acidic medium which has given corrosion inhibition efficiency between 90%-95% for different concentration of acid HCL.
2. The corrosion inhibition efficiency of Epoxy Resin was found to be between 77- 95% percent for different concentrations of HCL. This indicates effectiveness Allium Sativum over the Epoxy resin. With the increase in corrosion there is increase in the electrical resistance.

3. After performing weight loss method, the increase in electrical resistance of test bars without any coating was found to be higher and the increase in electrical resistance of test bars coated with Allium Sativum was found to be least.
4. Allium Sativum gel coating increases the corrosion inhibition efficiency .The natural inhibitor Allium, Sativurn (Garlic) is proved to be effective to protect metals from corrosion and to maintain the efficiency of steel. Allium Sativum is proved to be a good, efficient and eco- friendly corrosion inhibitor.
5. The problem with Allium Sativum is that the paste applied on bars does not sustain for long time in water. In future, emphasis must be given on the formation of Album Sativum coating which will sustain in water and which may contain some adhesives or water repellent's which will make it water insoluble. There is need to increase the adhesive and binding property of Allium Sativum which will increase its corrosion inhibition efficiency and will effectively protect steel reinforcement from corrosion for longer time.

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