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Effect of Corrosion Inhibitor in Mild Steel Bar

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ABSTRACT: The explorative study made on corrosion of mild steel by accelerating corrosion by galvanostatic method. Different corrosion inhibitors as such paint coated, mortar coated, slurry coated and green corrosion inhibitor was used. This project intended to move our community towards green corrosion inhibitor. In view of this green corrosion inhibitor was developed from Azadirachta indica (Neem) and Crossandra infundibuliformis (Kanagamaram) plants leaves. The experimental results show that, the corrosion process alters the external surface by pitting. The rate of corrosion has been calculated by mass loss rate. The study clearly shows that the bar coated with slurry is efficient than other coating. The inhibition efficiency of the selected plant material on the mild steel dissolution in acidic media is assessed and found to be best replacement of inorganic with organic corrosion inhibitor, environmentally safe materials for corrosion resistance. Investigation results that corrosion rate is proportional to temperature and inversely proportional to pH medium. The present investigation is evident for the application and development of green corrosion inhibitor.

KEYWORDS: Galvanostatic method, Slurry coated, Weight loss, Mass loss rate, Inhibition efficiency, Green corrosion inhibitor.

I. INTRODUCTION

Since twentieth century, the use of reinforced cement concrete (RCC) has become common practice due to its excellent properties compared to other construction materials like steel structures, bamboo, clay, bark, mammoth ribs etc. RCC is relatively cheap and easy to maintain. This has led to the widespread use of reinforced and pre-stressed concrete in the construction of structures and infrastructure due to its strength, fire resistance, durability etc. In spite of its advantages, there are some drawbacks with reinforced concrete; one among them is degradation of the reinforced concrete structures due to corrosion of reinforcement. Corrosion degradation of steel reinforcement in concrete is due to aggressive agents present in the surrounding environment, which affects the durability of the structure and leads to the premature failure. Some of the reasons for the degradation of reinforced concrete are chloride attack, acid and sulphate attack, reaction of alkaline pore solution with the carbon dioxide present in the atmosphere. These break down the thin oxide protective layer which surrounds the reinforcement and makes the steel reinforcement susceptible to corrosion. As the process of corrosion sets in, the products of corrosion in the form of rust expand within the structure and leads to cracks, spalling and low structural bearing strength of the structure.

The use of inhibitors is simple and economical with good inhibiting effect. The effectiveness of inhibitors depends mainly on the concentration of inhibitor, more the concentration more is the inhibitor effect on corrosion. The application requires transport of inhibitor to the reinforcement where it has to reach sufficiently on the surface of reinforcement to protect the steel against corrosion or to reduce the rate of ongoing corrosion. The application of inhibitor does not require any skill it only depends on adding of inhibitor in proper proportion.

II. METHODOLOGY

Concrete structures are subjected to chloride attack. In order to protect concrete structures from chloride attack in aggressive environment, it is necessary that protective coatings are applied to steel to prevent ingress of chlorides. We made a study on cement based inhibited reinforcement bar by application of mortar and slurry coating in addition to it

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paint coating were also studied for two different diameter mild steel bars of 8 mm and 12 mm. The corrosion of the bar was induced by galvanostatic method and corrosion rate was measured by weight loss.

Corrosion is a slow process in a natural environment, thus; the nature of the oxidation reaction is simulated by the galvanostatic method to accelerate the corrosion process in an artificially controlled environment. The method is impressed current technique for accelerating steel bar corrosion inside or outside the concrete. Hence, an electrochemical technique was adopted to accelerate the corrosion process of reinforcement, in order to achieve a significant degree of corrosion within a reasonable period of time and the easy control of the corrosion degree desired. As shown in Fig. 2.3, the circuit of corrosion resulting by applying the electrical potential (DC) using direct electric current impressed on a steel bar as the anode (+) and a Copper strip as the cathode (-), both immersed in 5% sodium chloride solution.



Fig 2.1 Image of Copper Plate



Fig 2.2 Image of Electrolyte Solution



Fig 2.3 The DC power supply used in corrosion process

Fig 2.1 shows the copper strip which used as cathode and Fig 2.2 shows the image of electrolyte solution which is used in galvanostatic method i.e, 5% sodium chloride solution.

III. PREPARATION OF ORGANIC EXTRACT

The leave of Azadirachta indica and Crossandra infundibuliformis were dried at 80°C and made into fine powder. About 10 g of Powder was weighed and added to 100 ml of prepared 1 M HCl, 2 M HCl and 3 M HCl solutions in separate reagent bottles. The mixtures were boiled for 30 minutes with continuous stirring and allowed to cool overnight. The mixtures were then filtered to obtain the extract.

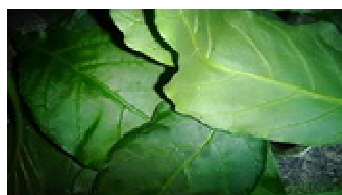


Fig 2.4 Image of Crossandra infundibuliformis leaves



Fig 2.5 Image of Azadirachta indica leaves



Fig 2.6 Drying of Crossandra infundibuliformis leaves



Fig 2.7 Oven dried Azadirachta indica leaves

Image of Crossandra infundibuliformis and Azadirachta indica leaves was shown in Fig 2.4 and Fig 2.5. These leaves kept for oven drying it is clearly shown in Fig 2.6 and Fig 2.7 shows the image of oven dried Azadirachta indica leaves.

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Fig 2.8 Azadirachta indica Concentration



Fig 2.9 Crossandra Concentration



Fig 2.10 Boiling of extract

Fig 2.8 and Fig 2.9 shows the concentration of Azadirachta indica and Crossandra infundibuliformis inhibitor. Fig 2.10 shows the boiling of extract. Table 2.1 show the amount of concentric HCl in ml for different concentration.

Table 2.1 Amount of HCl for different concentration

Concentration of HCl	Amount of conc. HCl
1 N	8.985
2 N	17.97
3 N	26.96

IV. EXPERIMENTAL SETUP

Corrosion behaviour of mild steel has been investigated for organic inhibitors. The organic inhibitors were extracted from Azadirachta indica (Neem) and Crossandra infundibuliformis (Kanagamaram) plants leaves. The corrosion behaviour mild steel for organic inhibitor was studied by 16 specimens of mild steel plates (23 mm x 23 mm), and its inhibiting action on the corrosion of mild steel in acidic bath of HCl at different concentrations has been investigated by monitoring the corrosion. Prior to immersion, specimens are cleaned with the help of sandpaper. The pH of the green corrosion inhibitors was determined. To accelerate the corrosion of the mild steel in the green corrosion inhibitor (Azadirachta indica and Crossandra infundibuliformis) they were mixed with the HCl at different concentration. The pH of the aggressive solution and weight of rectangular specimen has been measured. The continuous monitoring of weight, pH and temperature of specimen and solution has been studied.



Fig 2.11 Different concentration of inhibitors

Fig 2.11 shows the concentration of inhibitors at different corrosion inhibitor medium and corrosion environment of specimen.

V. EXPERIMENTAL RESULTS

Study made on cement based inhibited reinforcement bar by application of mortar and slurry coating in addition to it paint coating were also studied for two different diameter mild steel bars of 8 mm and 12 mm. The corrosion of the bar was induced by galvanostatic method and corrosion rate was measured by weight loss. Table 3.1 gives the details of

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corrosion of 8 mm and 12 mm mild steel bar for different coating. Rate of corrosion of bar was determined by weight loss method and their percentage variation is clearly compared in following data. The rate of corrosion of bar is given by ratio of Weight loss and product of area and duration.

Table 3.1 Details of rate of corrosion for different coating

Coating	% of corrosion	Accelerated Corrosion result					
		8 mm dia bar			12 mm dia bar		
		Duration (h)	Loss in weight (g)	Rate of corrosion $\text{g mm}^{-2} \text{h}^{-1}$	Duration (h)	Loss in weight (g)	Rate of corrosion $\text{g mm}^{-2} \text{h}^{-1}$
Non	10	3	7	0.046	5	16.4	0.029
Paint	10	7.5	9.2	0.024	9.5	17	0.0158
Mortar	10	6.5	8	0.024	8	18.16	0.0205
Slurry	10	10.5	6.6	0.013	12	4.2	0.0031

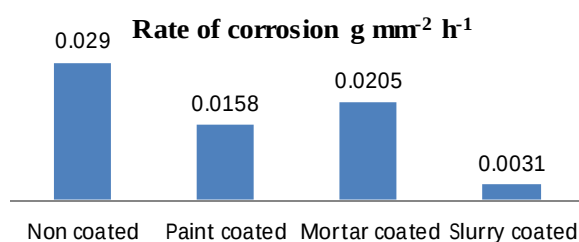
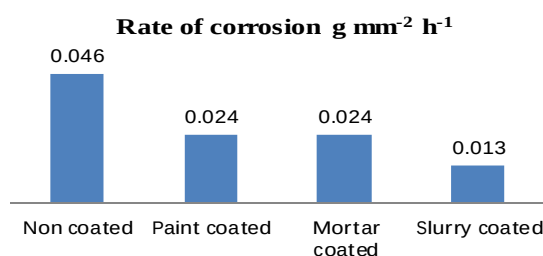


Fig 3.1 Rate of corrosion for 8 mm bar

Fig 3.2 Rate of corrosion for 12 mm bar

Fig 3.1 and Fig 3.2 show the weight loss comparison of 8mm and 12 mm dia mild steel bar for different coating. It clearly shows that for 12mm dia bar coated with slurry has less weight loss and to achieve 10% of corrosion it took maximum time. Fig 3.2 shows the rate of corrosion of 12 mm dia bar, it shows that rate of corrosion maximum for non-coated bar and for bar coated with slurry the corrosion rate was decreased about 55.17%, where as to mortar coated and paint coated percent of reduction in corrosion is 36.59% and 17.72% when compare with slurry coated. We observed that weighted coated in mortar coated is due to removal of mortar layer. The level of corrosion of the bar was measured at different length by measuring the decrease in diameter using Vernier calliper. The diameters are measured at five places i.e., top end, L/3, L/2, 2L/3 and L. Table 3.2 shows the variation in corrosion level for 8 mm and 12 mm dia bar.

Table 3.2 Variation of diameter for 8 mm and 12mm bar

Coating	8 mm dia bar					12 mm dia bar				
	Diameter of bar at									
	top end	L/3	L/2	2L/3	L	top end	L/3	L/2	2L/3	L
Non	8	7	7	6.5	5.5	12	11	11	11	10.5
Paint	8.5	8	8	7	6.5	12	11.5	11	11	10
Mortar	9.5	8.5	8	7	6.5	12	12	11	10.5	9
Slurry	10	7	6.5	6.5	6	12	12	11.5	11	10

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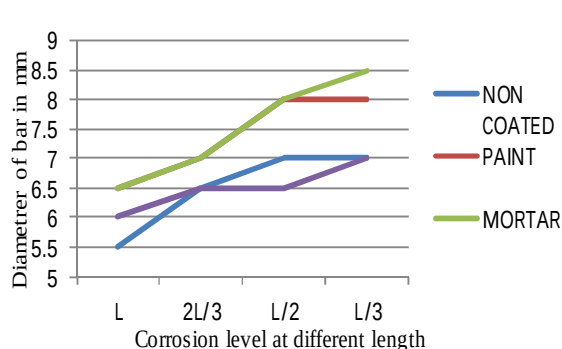


Fig 3.3 Level of corrosion of 8mm dia bar

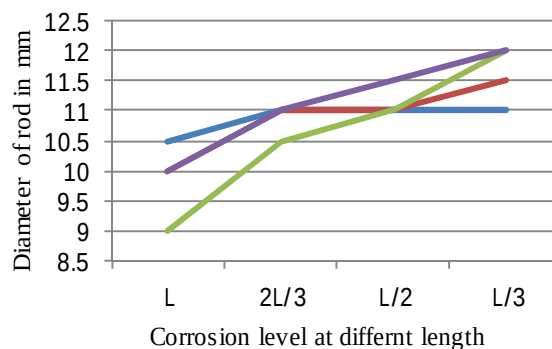


Fig 3.4 Level of corrosion of 12 mm dia bar

The above table 3.2 and Fig 3.3 and Fig 3.4 clearly shows that the maximum decrease in diameter of bar is at the end, it indicates that anion cation exchange took place maximum at the end and with respect to the coating the decrease in diameter is reduced.

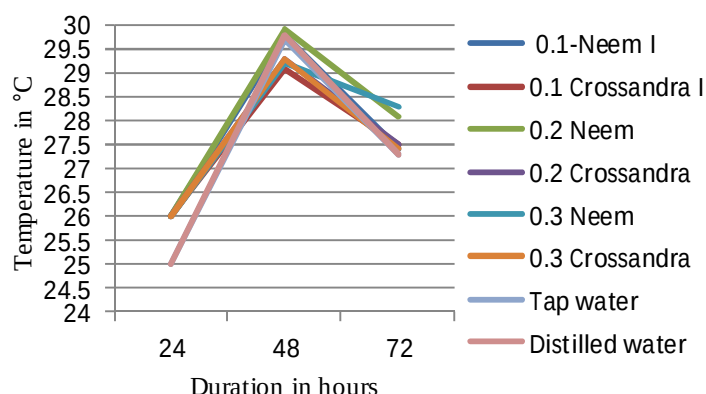


Fig 3.5 Variation of Temp vs Duration

The temperature of the inhibitor increases as the pH increases and there is decrease in temperature when pH falls. It shows that temperature and pH is directly propositional. Fig 3.5 shows the temperature variation of inhibitor with respect to duration in hours. Table 3.3 gives the details of Influence of rate pH and temp in Rate of corrosion for different environment and different medium for both green corrosion inhibitors. **ble 4.6 Influence of rate pH and temp in Rate of corrosion**

VI. CONCLUSION

This study investigated the properties of corrosion inhibition of extract of on mild steel in 1 M HCl, 2 M HCl and 3 M HCl using the weight loss measurements and efficiency of protective coating. From the investigation following conclusion are made,

1. The rate of corrosion of slurry coated bar decreased about 71.74% for 8 mm bar and 55.17% for 12 mm bar.
2. From the corrosion acceleration it observed that bar coated with slurry takes maximum duration.
3. Experimental results that in case of mortar coating there is poor bonding due to presence of sand it shows removal of mortar.
4. The analyses of the results showed that the inhibition efficiency increased with increase in concentration of the inhibitor.
5. It is observed that the inhibition efficiency decreases with increase in temperature for both acidic media.
6. It results that and Azadirachtaindica (Neem) extract is efficient then compare with Crossandrainfundibuliformis (Kanagamaram)

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