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Relative Study of Biodiesel & Calcium Palmitate in Reducing the Rate of Corrosion

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Abstract: *In the present research, we have employed biodiesel & calcium palmitate, as an inhibitor to corrosion on steel structures while inspected their effects as an inhibitor. The main reason behind the selection of these two materials is to have sustainable and eco-friendly construction. Biodiesel is a renewable source, obtained from vegetable oil and calcium palmitate acts as an eco-friendly inhibitor. The impact of both on various important properties i.e. consistency, setting times, the compressive strength of cement and concrete & soundness was also investigated. The end results signify that calcium palmitate is a profitable and potent inhibitor. Samples Z3 and Z4 displayed 88 % and 91% IE (Inhibitor Efficiency) respectively, after 90 days with 3.5% NaCl solution without seesawing the strength of cement and concrete. However, Z3 exhibits 69.30% IE after 90 days with 3.5% NaCl solution. Present investigation showed that biodiesel is an effective inhibitor, but calcium palmitate is better and effective than biodiesel.*
***Key Words**: Biodiesel, Inhibitor, Corrosion, Calcium Palmitate, Concrete, Efficiency etc.*

I. Introduction

The modern world is changing with time, as more and more non-renewable sources are used up, we are forced to find new technologies and materials based upon renewable sources and eco-friendly. In the present research, we tried to examine the properties of the environment-friendly material. The two materials we used are; Biodiesel & Calcium Palmitate. The choice of biodiesel is based on the fact that it's a renewable source, as it's synthesized from vegetable oil. The calcium palmitate is an eco-friendly corrosion inhibitor as it does not have such adverse effects on surrounding which other methods of corrosion inhibition posses.

In the modern era, the application of reinforced concrete structures is rather common & widespread. The factors behind their enormous use are their durability, better tensile strength, thermal compatibility, high strength and their capacity to withstand adverse conditions. However, failures in reinforced structures do still occur by the action of corrosion in steel [1]. Reinforced structures consist of steel bars, to provide tensile strength to structure (as concrete is vulnerable in tension). Corrosion influences those steel bars and as a result, the durability of the structure got affected. The protective coating formed (in an alkaline environment), sustains the steel reinforcement in the static condition [2 & 3]. However, this static condition could be invaded by two possibilities, either by the decline in the pH value or by the introduction of chlorides. At certain times, it has been observed that both the ways can strike simultaneously [4 & 5]. Additionally, nasty artistry and several other reasons may cause corrosion rapidly. On the account of corrosion, the forecasted life of subjected structure is often not accomplished. Due to corrosion of reinforcement, a large number of structures are required to be repaired around the world [6]. On account of corrosion, the repair work expense for reinforced structures rises up to gigantic amounts and thus, it turned into a genuine global issue.

A chemical compound being added as an admixture, in liquid or solid form, that retards the reinforcement corrosion in solidified state is classified as the corrosion inhibitor or suppressor [7]. It can likewise be depicted as a compound, which when added to the system decreases the rate of metal wastage. Due to the economy & simple application, the use of corrosion inhibitors is viewed as most effective and best among all other available methods for suppressing corrosion [8]. In the present work, we have synthesized Biodiesel & Calcium Palmitate in the laboratory and investigated the suppressing action of both (compare).

II. Experimental Procedure

2.1 Experiment Material

Ordinary Portland Cement (OPC) Conforming to IS: 456-2000; Fine aggregate (FA) with fineness modulus 2.017; Course aggregate (CA): 10 mm size with fineness modulus 6.145, 20 mm size: with fineness modulus 7.0434; Tap water was used in preparation of mortar; TMT (Thermo Mechanical Treatment) steel bars was utilized for preparing steel embedded concrete cubes; Chemical admixtures: Biodiesel and Calcium Palmitate.

2.2 Inhibitor Synthesis- Calcium Palmitate & Biodiesel

In the process of obtaining calcium palmitate, the first ingredient we required was palmitic acid. It was added to warm water and mixed. NaOH, about 35 grams was added to it and mixed properly. The mix was kept to cool. After cooling, the entire mix was added to an aqueous solution of $CaCl_2$ (68 grams) and mixed. A white precipitate was acquired which was initially washed, then filtered and finally dried to obtain the required calcium palmitate. Synthesis of biodiesel involves transesterification process. It is a process that involves the transformation of a kind of ester in some other kind.

Biodiesel is formed from vegetable oil (soyabean oil) synthesis. In order to obtain biodiesel in the laboratory, the most important ingredient was finely grounded NaOH. NaOH was added to pure methanol (25 ml) in a conical flask (250 ml) and mixed firmly. The pure soyabean oil (110 ml) was heated up to 40 Degree Celsius, in a laboratory beaker (250 ml). As soon as, the warm soyabean oil mixed into methoxide solution, the solution gets separated into distinctive layers. The whole mix was whipped for 20 minutes. The mix, then transferred to a sep funnel (250 ml). Two different layers were clearly visible, with glycerol in the bottom and methyl esters (biodiesel) floating at the top. After an hour or so, stop cock was opened and glycerol was allowed to drain out, leaving biodiesel as our required product.

2.3 Consistency

It is used to determine the initial & final setting time, strength and soundness. The standard consistency of cement paste can be explained as that consistency or water content, which allows a vertical penetration for a Vicat plunger (having 10 mm diameter and 50 mm length) to a depth of 33-35 mm from the top. The tests were directed according to IS: 4031 (Part 4)-1988.

2.4 Setting Time

Initial and final setting times were examined, using Vicat apparatus. Experiments are conducted according to Indian standard specification (IS: 269-1989).

2.5 Soundness

Soundness is examined using Le-Chatelier's apparatus. The test was performed according to Indian standard specification (IS: 4031(Part 3) 1988).

2.6 Compressive Strength

According to the Indian standard specification (IS: 650-1991), the standard sand was utilized for preparing the mortar. The ratio of cement and sand was taken as 1:3 and the measure of water added in % of combined weight of cement and sand and it was computed by the formula $Q/4 + 3$. Where Q is the percentage of water needed to prepare the cement paste of standard consistency. The test was conducted, as specified with IS: 4031(Part 6)-1988.

2.7 Corrosion or Rust Test

Cubes of 100 × 100 × 100 mm size were cast, having TMT steel bars (10 mm diameter and 45 mm length) embedded in it. 20 mm cover is provided on each side of the cube (lengthwise). The weight of each TMT bar was calculated, by using a digital weighing machine (in grams, up to 3 digits). After 24 hours, the cast specimens were demolded and then placed in simulated NaCl solution of 3.5% concentration first 7 days and then placed in the dry environment for next 7 days and so on up to 90 days. Later on, all samples were taken out of the solution and dried. The dried cubes were broken and the inserted bars took out and cleaned in Clarke's solution and finally cleaned with distilled water. After that, the bars were kept to dry and then weighed again. By calculating the weight loss, the efficiency of inhibitor was calculated by using the eq. (I).

Efficiency of inhibitor or suppressor (percentage) = $[(T_0 – T) / T_0] \times 100$ (I)

Where, T_0 = Final average weight (in mg) of steel embedded in control sample T = Final average weight (in mg) of steel embedded in inhibited samples.

2.8 Concrete Cube Specimen for testing

Concrete cubes of 150x150x150 mm size were cast for testing. The water cement proportion was taken as 0.46 in all the cubes. Mixing of all samples of concrete carried out in the Civil Engineering Structural Laboratory by utilizing tilting drum blender. In order to prepare the inhibited concrete, first the inhibitor with respective percentage was added to the cement, and then fine and course aggregates were added to that cement paste prepared earlier. The cast specimens were demoulded after a day and cured for respective periods of days.

III. Result

Table I. Notation used for different samples

Description of Sample	Notation
Cement (Pure)	Z1
Cement + 1.5% Biodiesel (by cement weight)	Z2
Cement + 2% Calcium Palmitate (by cement weight)	Z3
Cement + 4% Calcium Palmitate (by cement weight)	Z4

Table II. Consistency of different samples

Sample	Consistency (%)
Z1	30.50
Z2	30.00
Z3	33.20
Z4	38.00

The outcome of the test demonstrates that the % of the water required to attain standard consistency is slightly more in the case of in inhibited cement samples in comparison to controlled samples. The sample with Calcium palmitate has more consistency than the sample with Biodiesel.

Table III. Soundness of different samples

Sample	Distance between indicator points (in mm)		Expansion (in mm)
	Before Boiling	After Boiling	
Z1	44	45	1
Z2	29	30	1
Z3	35	36	1
Z4	15	16	1

The outcomes reveal that addition of admixtures does not influence the soundness, as in all cases the expansion is same.

Table IV. Setting time

Sample	Initial Setting time in minutes	Final Setting time in minutes
Z1	78	180
Z2	90	191
Z3	84	190
Z4	80	185

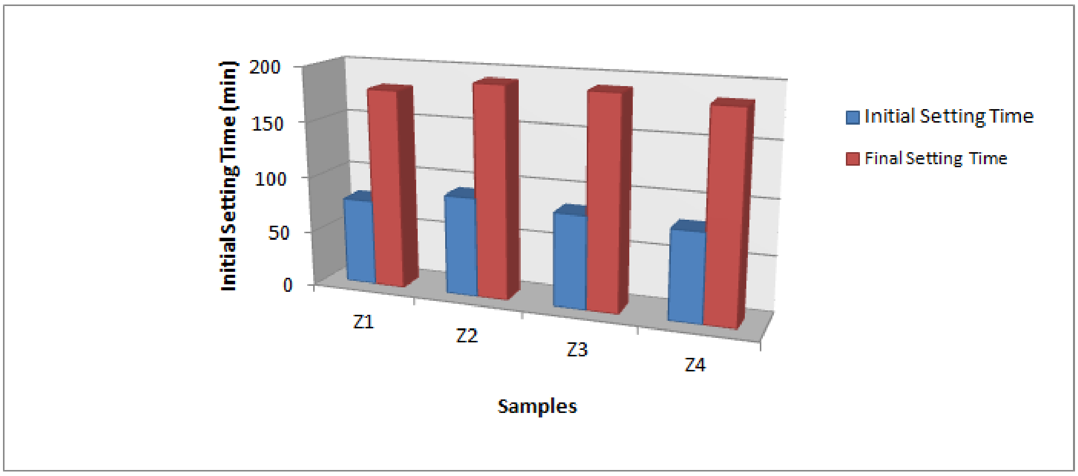

Fig 1. Comparision of Initial and Final Setting Time

Table IV shows the variation of setting times for different systems. It has been observed that, in the presence of inhibitors, both the initial and final setting time increases. Thus it acts as a checker. The addition of Calcium Palmitate and Biodiesel act as an accelerator for the final setting time but do not show any regular trend in variation of initial setting times.

Table V (I). Compressive strength of Pure Cement and inhibited Cement

Sample	Avg. 3 days	Avg. 7 days	Avg. 28 days
Z1	26.44	32.11	41.15
Z2	26.77	27.28	33.77
Z3	20.70	26.66	36.72
Z4	17.33	20.46	26.26

Table V (II). Compressive strength of concrete

Sample	Avg. 7 days	Avg. 28 days	Avg. 90 days
Z1	34.26	43.47	41.70
Z2	23.40	32.51	36.71
Z3	18.51	27.47	37.30
Z4	16.46	25.32	36.78

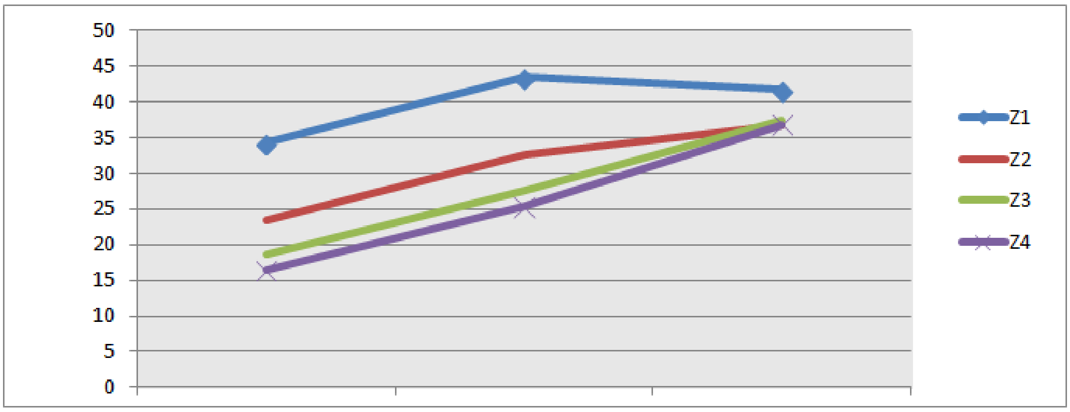

Fig 2. Compressive strength of concrete

The compressive strength of concrete with samples having biodiesel and calcium palmitate and also the controlled samples are examined and cured for 7, 28 and 90 days respectively. It was seen that addition of biodiesel & calcium palmitate reduces compressive strength of all the samples, up to 28 days. After 90 days of curing significant gain in strength was observed, however, it remained slightly less than controlled sample.

Table VI. Weight Loss of Steel bars in different samples after 30 and 90 days

Sample	Avg. weight loss in gram		I.E. (%)	
	30 days	90 days	30 days	90 days
Z1	0.096	0.178		
Z2	0.022	0.040	77.44	69.30
Z3	0.018	0.023	93.43	88.09
Z4	0.013	0.017	94.12	91.00

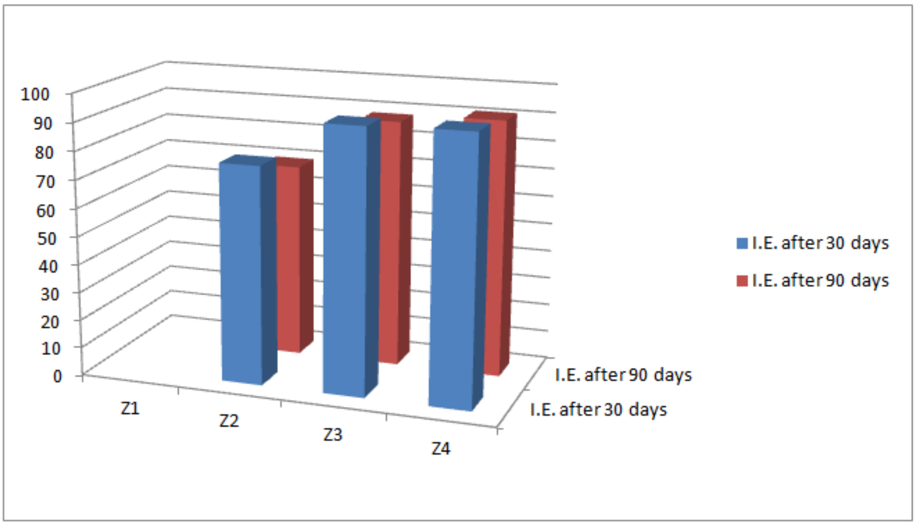

Fig 3. Inhibition Efficiency after 30 and 90 days respectively

The results of corrosion tests are conferred in Table VI. All the samples having inhibitors showed inhibition of corrosion of steel. The sample Z3 and Z4 showed 88.09 % and 91.00 % IE respectively after 90 days of cyclic immersion with 3.5 % NaCl solution.

IV. Conclusion

1) There is a gain in consistency of cement with a gain in the percentage of Calcium Palmitate. However, it stays the same for Biodiesel.
2) Both the setting times increases in the presence of Calcium Palmitate.
3) From the present investigation, it can be surmised that Calcium Palmitate has inhibitor efficiency (IE) of 91.0% whereas in Biodiesel it is 69.30%. But being a renewable source of energy, Biodiesel might be preferred as sustainable construction material.
4) Calcium Palmitate is preferably advantageous as a corrosion inhibitor.

Scope & Future

1) There is great scope in the present research. The present result proves that Biodiesel is good inhibitor & with further more research and with different combination it might serve better.

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