Study on Corrosion Resistance of Metals by Using Chemical Inhibitors in Concrete

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Abstract: ***Hydrozincite, Zn5 (CO3)2 (OH) 6, was recently found to play a key role in reducing corrosion product flaking on Cu-Zn alloys. A fundamental study was undertaken to explore the underlying mechanisms, in particular why hydrozincite can suppress the interaction between chloride and the alloy surface. Hydrozincite could be formed by exposure of Cu40Zn to air at 70% relative humidity and 1000 ppm of CO2 resulting in a surface of decreased wettability. It presents reduces the initial spreading ability of NaCl-containing droplets and lower the overall initial corrosion rate when the alloy is exposed to pre-deposited NaCl and wet / dry cycles***.

Keywords: corrosion, chemical inhibitors, corrosion evaluation, weight loss.

1. Introduction

Corrosion is the deterioration of a material due to interaction with its environment. It is the process in which metallic atoms leave the metal or form compounds in the presence of water and gases. Metal atoms are removed from a structural element until it fails, or oxides build up inside a pipe until it is plugged. Most metals are not thermodynamically stable in the metallic form. Corrosion occurs in every metal subjected to it. Even though this corrosion cannot be eliminated, it can be controlled. Corrosion results in reduction in metal thickness followed by weight loss and reduction in mechanical strength. All small group of metals, called the Noble Metals, are much less reactive than others. As a result, they corrode rarely. They are, in fact, the only metals that can be found in nature in their pure form. The Noble Metals, not surprisingly, are often very valuable. They include copper, palladium, silver, platinum, and gold.

2. Materials Used

a) Cement
b) Coarse aggregate
c) Fine aggregate
d) Water
e) Metal alloys
- Aluminium
- Mild Steel

f) Chemicals
- HCl -Hydrochloric acid
- NaCl -Sodium chloride
- Cleaning agent –Ethanal

g)Chemical inhibitors
Hydrozincite: Hydrozincite, also known as zinc bloom or marionite, is a white carbonate mineral consisting of Zn5(CO3)2(OH)6. It is usually found in massive rather than crystalline form. It occurs as an oxidation product of zinc ores and as post mine incrustations. It occurs associated with smithsonite, calcite and limonite.

3. Corrosion Evaluation by Weight loss method

The weight loss experiments were carried out under total immersion conditions in test solution maintained at room temperature. The experiments were carried out in a beaker containing 250ml solutions. After exposure, the specimens were removed, washed initially under running tap water, to remove the loosely adhering corrosion product and finally cleaned as per the recommendation of ASTM. Then the weight loss was determined by a sensitive analytical balance (0.1mg). Similar experiments were conducted with different inhibitor concentrations to find out the effect of inhibitor concentration on corrosion rate and inhibition efficiency. In each case duplicate experiments were conducted and showed that the second results were within + 1% of the first. Whenever the variations were very large, the data were confirmed by a third test. The percentage inhibition efficiency, % IE was calculated using the relation:

%IE=W0-W/W0 X100

Where W0 and W are the weight losses in the uninhibited and inhibited solutions respectively.

Weight loss due to corrosion of steel rebar can be calculated as the loss in weight over the initial weight.

Weight loss (%)=[(W1–W2)/W1] × 100

Where,
W1=Initial weight of rebar.
W2=Weight rebar after removal of corrosion products

4. Corrosion Determination of Metals

Initially the metals aluminium and steel rods are taken with pre mentioned dimensions. Then the metals are scrapped with emery sheet to remove the dust particles and then cleaned with ethanol cleaning agent. And the weight of the two metals are taken in gram and mentioned as W1. Few metal samples are coated with the inhibitor with various normalities as 0.1N and 0.5N. The weight of the metal samples are taken and noted as W2 and W3 for the metals coated with inhibitor of 0.1N and 0.5N respectively. The ingredients of the concrete like cement, coarse aggregate, fine aggregate and water are tested for its standards. The concrete cubes of size 150mm×150mm×150mm are casted as follows: In one concrete cube, a layer of concrete is poured, compacted and few normal metal samples are placed and then the cube is casted.

Table 1: Metal Sample Dimensions

Sl.No	Metal	Length	Breadth	Thickness
1	Aluminium	5.3cm	2.8cm	1.55mm
2	Steel rod	8mm diameter		

Figure 1: Metal Samples coated with corrosion inhibitor

Similarly, in the other cube, after pouring and compacting a layer of concrete. The metal samples coated with 0.1N hydrozincite are placed in the cube and then casted. In the other cube, after pouring and compacting a layer of concrete. The metal samples coated with 0.5N hydrozincite are placed in the cube and then casted.

Figure 2: Concrete cube casting

The casted cubes are allowed to remain inside the mould for 24 hours and then the cubes are remolded. The concrete cubes are then cured with water for 28 days by immersing them into a water pool. The cubes are checked for its compressive strength on7th day, 14th day and 28th day using UTM and the results are noted down.

Figure 3: Test for compressive strength using UTM

After 28 days of curing,the metal samples from the concrete cubes are taken out safely.The metal samples are then immersed in test solution maintained at room temperature in a beaker containing 250ml solutions of HCl. After exposure, the metal samples are removed, washed initially under running tap water, to remove the loosely adhering corrosion product and finally cleaned as per the recommendation of ASTM.

Figure 4: Metal samples taken out of the concrete

Then the weight of the samples is taken and noted asW4 and W5 for metals coated with 0.1N and 0.5N hydrozincite solution respectively. The corrosion rate of the metals is determined using the formula in weight loss method. The efficiency of the corrosion inhibitor used is calculated for various concentrations and then conclusion is made.

Figure 5: Metal samples in acidic solution

5. Observation

The following observations are made from the samples

Table 2: Initial weight of metal sample

Sl.No	Metal Sample 1	Weight W1 (g)
1	Aluminium	20
2	Steel rod	30

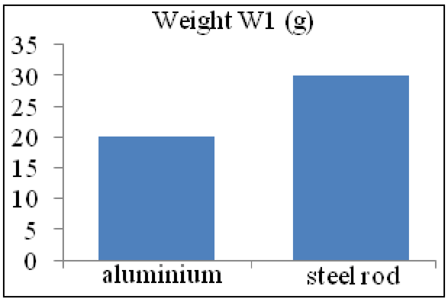

Figure 6: Initial weight of metal sample

Table 3: Weight of metal samples coated with 0.1N inhibitor

S.No	Metal Sample 1	Weight W2 for 0.1N(g)
1	Aluminium	20.19
2	Steel rod	30.04

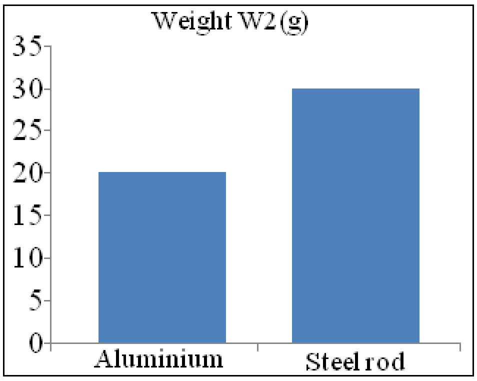

Figure 7: Weight of metal samples coated with 0.1N inhibitor

Table 4: Weight of metal samples coated with 0.5N inhibitor

Sl.No	Metal Sample 1	Weight W3 for 0.5N(g)
1	Aluminium	20.25
2	Steel rod	30.09

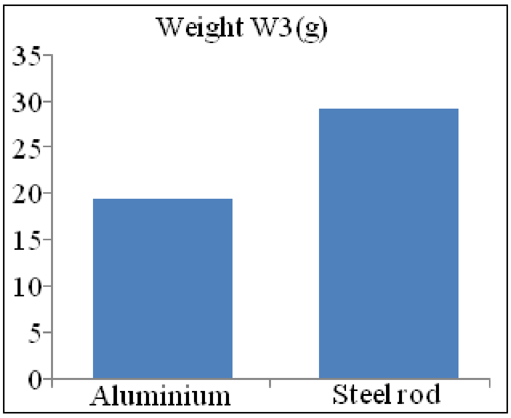

Figure 8: Weight of metal coated with 0.5N inhibitor

Table 5: Weight of metal samples used in concrete

S. No	Metal Sample 2	Weight in normal concrete W4(g)
1	Aluminium	18.2
2	Steel rod	27.3

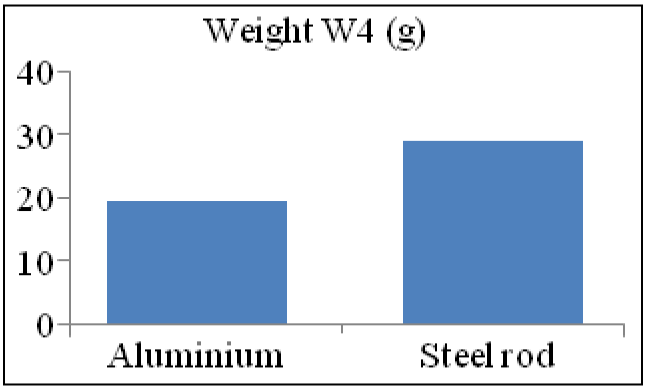

Figure 9: Weight of metal samples used in concrete

Table 6: Weight of metal samples coated with 0.1N inhibitor used in concrete

Sl.No	Metal Sample 2	Weight for 0.1 N W5(g)
1	Aluminium	18.9
2	Steel rod	28.1

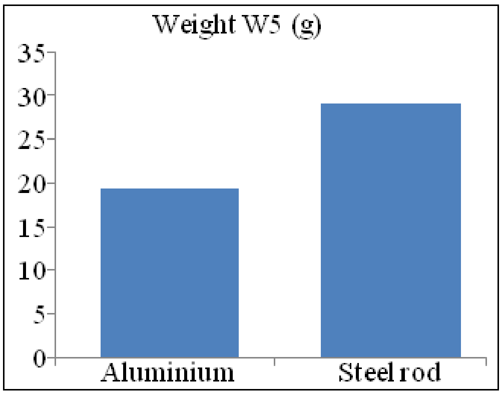

Figure 10: Weight of metal samples coated with 0.1N inhibitor used in concrete

Table 7: Weight of metal samples coated with 0.5N inhibitor used in Concrete

Sl.No	Metal Sample 2	Weight for 0.5N W6(g)
1	Aluminium	19.4
2	Steel rod	29.1

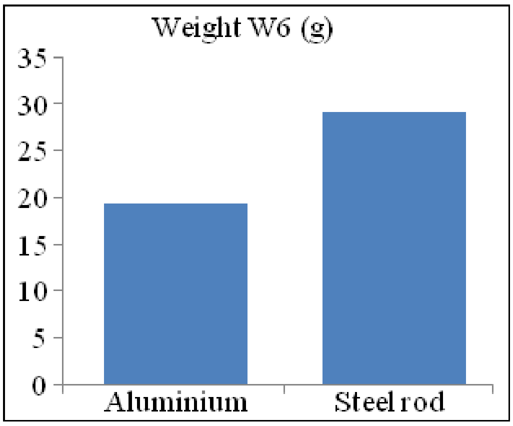

Figure 11: Weight of metal samples coated with 0.5N inhibitor used in concrete

5.1 Calculation

5.1.1 Corrosion for metals in concrete without corrosion inhibitor

Formula for Rate of corrosion = 534× (W1-W2)/DAT

- Aluminium

Rate of corrosion =534× (20-18.2)/ (2712 ×10.6 ×1)
=0.033inch/yr

- Steel

Rate of corrosion =534× (30-27.3)/ (7850 ×50.26 ×1)
=0.0036inch/yr

4.2.2 Corrosion for metals in concrete with 0.1N corrosion inhibitor

Rate of corrosion = 534× (W1-W2)/DAT

- Aluminium

Rate of corrosion =534× (20.19-18.9)/ (2712 ×10.6×1)
=0.023inch/yr

- Steel

Rate of corrosion =534× (30.4-28.1)/ (7850 ×50.26 ×1)
=0.0026inch/yr

5.1.2 Corrosion for metals in concrete with 0.5N corrosion inhibitor

Rate of corrosion = 534× (W1-W2)/DAT

- **Aluminium**

Rate of corrosion =534× (20.25-19.4) /(2712 ×10.6 ×1) =0.015inch/yr

- **Steel**

Rate of corrosion =534× (30.09-29.1)/ (7850 ×50.26 ×1) =0.0013inch/yr

5.1.3 Efficiency Calculation

- **Aluminium**

For 0.1N hydrozincite,
Efficiency = (0.033-0.023)/0.033×100
=30%

For 0.5N hydrozincite,
Efficiency = (0.033-0.015)/0.033×100
= 54%

- **Steel**

For 0.1N hydrozincite,
Efficiency = (0.0036-0.0026)/0.0036×100
=27%

For 0.5N hydrozincite,
Efficiency = (0.0036-0.0013)/0.0036×100
=63%

6. Conclusion

Corrosion degrades the useful properties of materials. Weight loss, electrochemical methods, SEM, EDX and FTIR were employed in the present investigation. Corrosion inhibition efficiencies of the plant extracts have been compared with that of commercial inhibitor, hydrozincite. To find the industrial applicability of the inhibitor, the plant extracts were tested in the local industry. Corrosion rate of the metals has been reduced by the corrosion inhibitor, Hydrozincite, to a certain extent. 0.1N solution of hydrozincite can reduce the corrosion rate of steel rod by 27% and that of aluminium by 30%.Whereas 0.5Nsolution of hydrozincite can reduce the corrosion rate of steel rod by 63% and that of aluminium by 54%.

References

[1] R.D.Armstrong and V.J.Braham ”The mechanism of aluminium corrosion in alkaline solutions” in September 1996.
[2] George batis ”Production system for reinforced concrete with corrosion inhibitor” in 1998
[3] T.A.Soylev and M.G.Richardson “Corrosion inhibitor for steel in concrete:state of the art report” 2008.
[4] Azharbadaoul “Carbonic gas randomness effect on reinforced concrete carbonation” 2012.
[5] KalaiSelvi “Corrosion inhibitor properties for mild steel ” June 2013.
[6] P.C.S. Hayfield “Cathodic protection of steel reinforced bars in concrete” 2014.
[7] Kishanrao M Godbole and Priyadarshi H. Sawantin “Reinforcement Corrosion Assessment Through Half – Cell in Concrete Structure Exposed in Marine Environment” 2014.
[8] Karolina Hajkova “Mechanism of reinforcement corrosion” 2015.
[9] JsRuzankina and OsVasiliev “Study on possibility for the improvement of corrosion resistance of metals using laser formed oxide surface structure” 2016.
[10] Deepak Dwivedi , Katerina Lepkova and Thomas Becker “Carbon of steel corrosion: a review of surface properties and characterization methods” in 2017 by.