Use of Vapor Phase Corrosion Inhibitors for Galvanized Steel Protection

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Introduction

- Cost of corrosion (~$276 billion)
  - food processing industry at 2.1 billion
  - pulp & paper industry at 6 billion
  - chemical, petrochemical and pharmaceutical at 1.7 billion
- Galvanizing-The coating of zinc onto steel
- Vapor Phase Corrosion Inhibitors (VpCI)
  - biodegradable, low toxic products which can be incorporated into conventional water-treatment programs to provide effective corrosion protection to different metals.
  - The studied VpCI additive is a synergistic blend of salts of carboxylic acids and alkalinity builders.

Evaluation of Corrosion Protection Provided by VpCI Additive to Galvanized Steel

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Protection Ability Tested With Tafel Plots

Test Equipment

- Potentiostat/Galvanostat "Versastat" with corrosion software model 352/252 SoftCorr™
- Zinc working electrode
- Graphite counter electrode
- SSCE reference electrode

Test Parameters

- Tap water: pH = TDS = ppm, Conductivity = μS
- $CaCO_3$ in Tap water: pH = TDS = ppm, Conductivity = μS
- Polarization was applied 20 minutes after the working electrode was immersed in electrolyte

Sample	Corrosion Rate in Tap Water, mpy	Protection Ability, %	Corrosion Rate in 1000ppm $CaCO_3$ Solution, mpy	Protection Ability, %
100ppm VpCI additive	1.06	86.5	0.24	87.2
Control	7.8	-	1.8	-

Linear Polarization Resistance (LPR) Study

Test Parameters

1000ppm VpCI was added into two different types of water

90:10 Deionized : Tap water, pH 6.63; Conductivity 183μS			Tap water, pH 7.44; Conductivity 356μS		
Sample	Corrosion Rate, mpy	Protection Ability, %	Sample	Corrosion Rate, mpy	Protection Ability, %
Water with VpCI	0.2242	89	Water with VpCI	0.3924	98
Control Water	2.061	-	Control Water	17.74	-

Immersion Corrosion Test

Test Parameters

Immersion at 40°C for 10 days

Test Solutions

VpCI was added at 25wt% to two different water treatment program formulas (TF 1 and TF 2) both containing a blend of antiscalants (phosphates, maleates, phosphonates, acrylates) and azoles. These mixtures were then added to tap water at 2000ppm

Material	Protection Ability, %
TF 1 + VpCI additive	94.3
TF 2 + VpCI additive	94
TF 1	74
TF 2	31
Control (tap water)	-

Testing In Pilot Cooling Tower

Test Equipment

RSD Towers, Model 005 Cooling Tower

16 GPM recirculation rate, 1.5 inch inlet and outlet diameter

Test Parameters

45-50°C tap water with 2.3-2.5 cycles of concentration

pH = 8.6-8.8, TDS = 1250-1300ppm, Conductivity = 1850-2000μS

Continuously treatment of 250ppm for 1 week, 100ppm for 1 week and then 50ppm during the following 6 weeks

Solution Tested	Corrosion Rate, mpy	Protection Ability, %
TF 1 + VpCI additive	0.59	89
TF 1	4.49	-

Toxicity Testing

Aquatic Toxicity Test: VpCI was also tested for aquatic toxicity with several species.

Species	NOEC	LOEC	LC_{50}	IC_{25}
M. Beryllina	1000ppm	2500ppm	-	-
M. Bahia	600ppm	1000ppm	-	-
Fathead minnow	-	-	1700ppm	140ppm
C. dubia	-	-	1100ppm	90ppm

Toxicity Testing

- Primary Skin Irritation Test: VpCI additive was applied at 4000ppm to skin of rabbits. The final Primary Irritation Index (PII) was 0, the best score possible in this test.
- Theoretical LD-50 (rat): >4000ppm

CONCLUSION

- VpCI additive is safe for handling and use in cooling water treatment programs. At concentration of use it remains safe for many species allowing discharge according to local authorities.

Conclusion

The advantage of using a VpCI additive in cooling water was tested with various methods including immersion tests, pilot cooling tower tests and electrochemical analysis.

These tests all show the effectiveness of a vapor phase corrosion inhibitor based additive (VpCI additive) to protect galvanized steel against corrosion.

VpCIs which are safe and environmentally acceptable for use can be added to traditional water-treatment programs to significantly improve corrosion protection of galvanized steel.

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