Diacid Corrosion Inhibitors for Water-Based Systems

Ivanhoe Industries inc.
Tullytown PA
www.ivanhoeindustries.com

February 2015

Rust 101

- Oxidation of Iron and Its Alloys

$$4Fe + 3O_2 \longrightarrow 2Fe_2O_3$$

- Contributing Factors
  - pH Excursions
  - Agitation (Oxygen Entrainment)
  - Microbial Contamination

Diacid Corrosion Inhibitors

- Used as amine salt for solubility and pH control.
- Protection by forming a molecular film.
- May be used in conjunction with borates and/or triazoles.

Uses For Diacid Inhibitors

- Water-based metalworking fluids.
- Water-based hydraulic fluids.
- Long-life antifreeze. (Aluminum and alloys)

Established Technology

- US 3,981,780 (9/21/76); UOP/CFR – Distillation Columns
- US 4,382,008 (5/3/83); ICI – Antifreeze
- US 4.390,440 (6/28/83); BASF – Hydraulic Fluids
- US 4,426,208 (1/17/84); Ethyl Corp. – Gasoline/Alcohol Blends
- US 4,533,481 (8/6/85); Lubrizol – Aqueous Systems
- US 4,647,392 (3/3/87); Texaco - Antifreeze

Scope of Study

Compare diacid corrosion inhibitors, specifically two new grades of azelaic acid with enhanced undecanedioic acid (C_{11}) using the iron-chip corrosion test ASTM D4627.

Diacids Studied & Compositions

Diacid (Wt%)	Azelaic Acid Tech Grade	Azelaic Acid CI Grade	Azelaic Acid CI+	Sebacic Acid	Corfree® M1
>C_9	3	2	1		
C_9	85	70	45		<10 (C_4-C_9)
C_{10}				>98	5-10
C_{11}		15	40+		30-45
C_{12}					30-45
Others	13 (>C_9)	30 (Total >C_9)	50(Total>C_9)		<6

Previous Studies

Earlier work has shown that the efficacy of long chain diacids as corrosion inhibitors follows the order:

$$C_{11} > C_{10} \approx C_{12} > C_9$$

ASTM D4627

An aqueous solution of the corrosion inhibitor is prepared. Standard iron chips (4g) are placed on a piece of clean filter paper in a petri dish and covered with 5g of the solution.

Cover the dish and allow it to stand for 20-24 hrs. After standing, the solution And chips are removed, the filter paper rinsed and examined for evidence of discoloration due to corrosion products. A clean filter paper is a "pass."

ASTM D4627 Continued

A stepped series of inhibitor concentrations is run and the lowest concentration to pass is determined. Lower "pass" concentrations are indicative of more effective inhibition.

Stock Solution

94% Hard Water (304 mg/L $CaCl_2$ + 139 mg/L $MgCl_2 \cdot 6H_2O$ in distilled water)

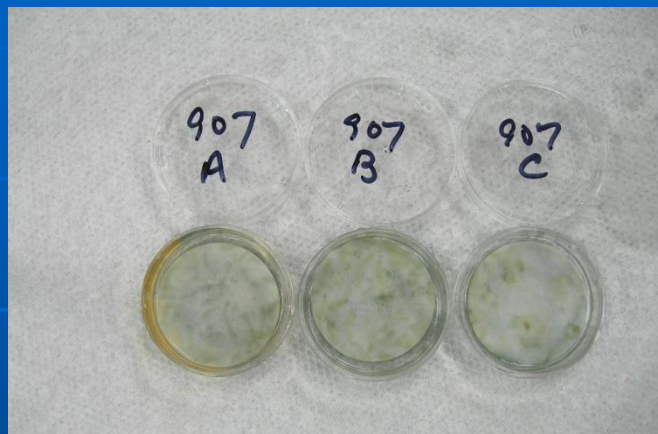
2% MEA (Monoethanolamine)

2% TEA (Triethanolamine)

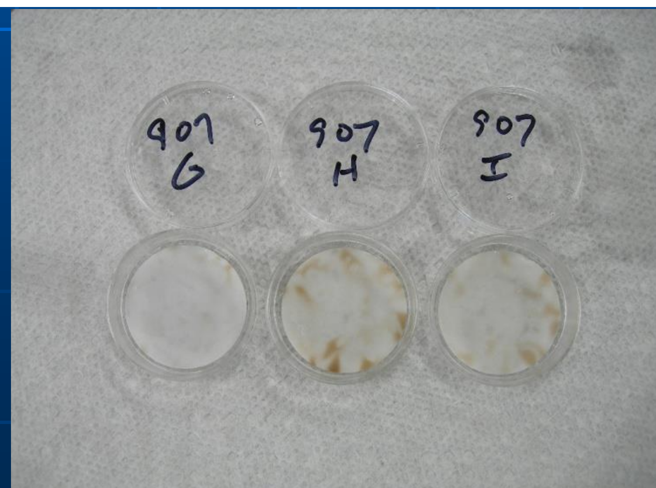
2% Diacid Inhibitor

Dilutions were prepared from the 2% inhibitor stock by adding hard water as above.

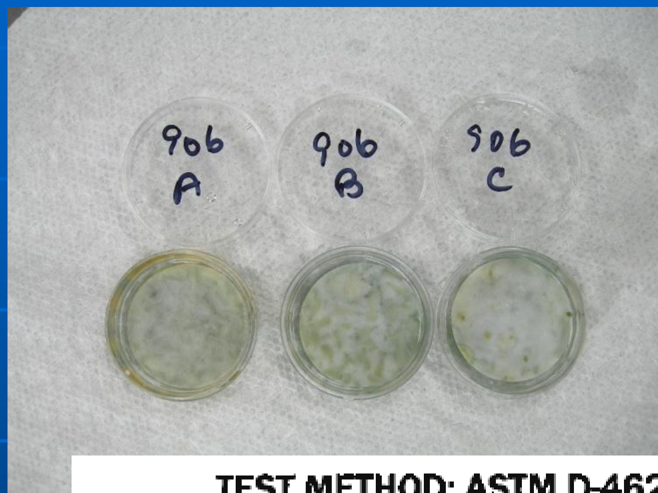
Azelaic Acid – Emerox® 1112

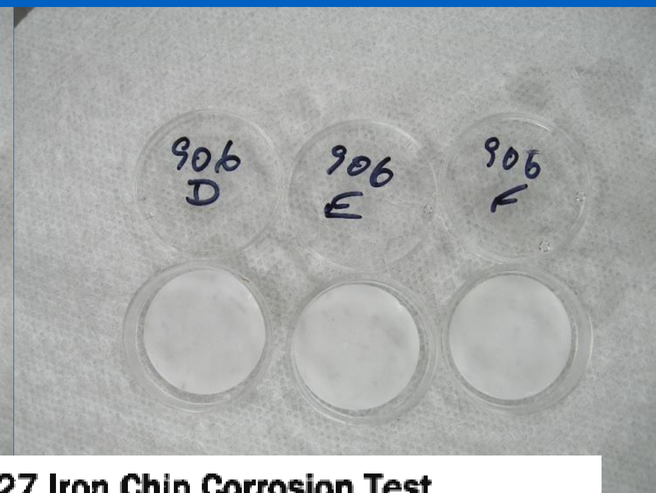


TEST METHOD: ASTM D-4627 Iron Chip Corrosion Test
2%, 1.5%, 1%, 0.7%, 0.5%, 0.4%, 0.3%, 0.2%, 0.1% and 0.05% diacid

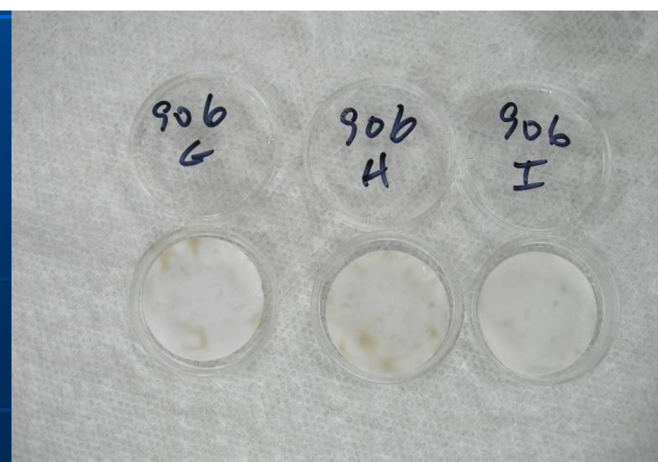


Azelaic Acid – Emerox® 1175

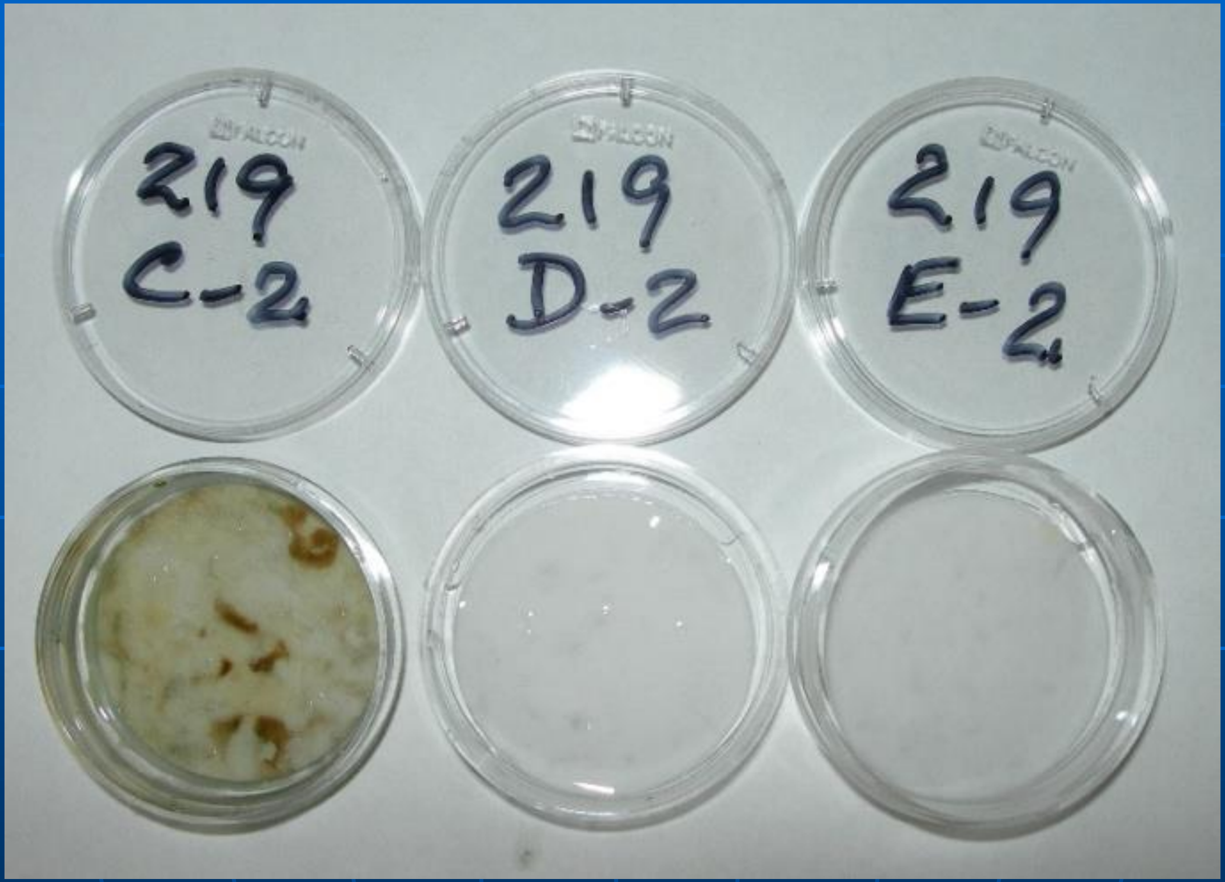




TEST METHOD: ASTM D-4627 Iron Chip Corrosion Test
2%, 1.5%, 1%, 0.7%, 0.5%, 0.4%, 0.3%, 0.2%, 0.1% and 0.05% diacid

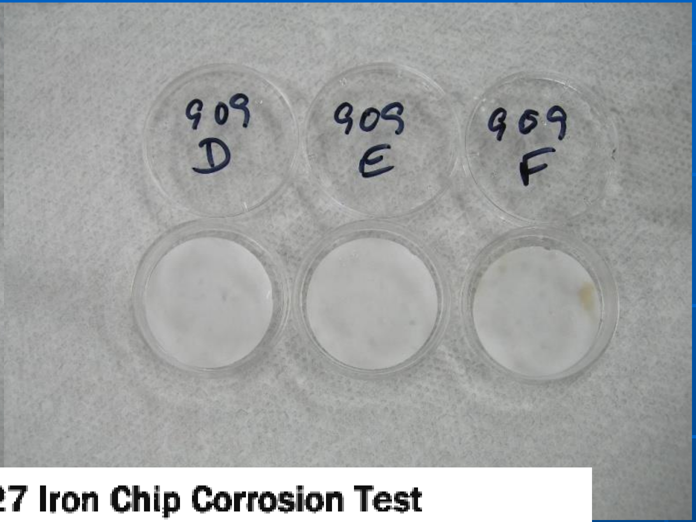


Azelaic Acid – Emerox® 1185



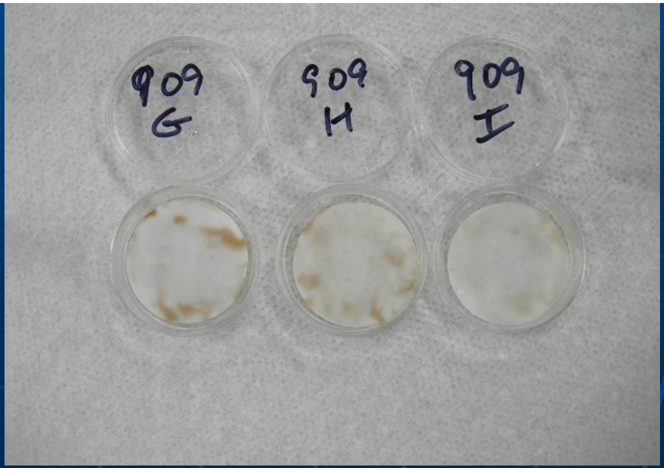
Test Method ASTM D-4627 Iron Chip Corrosion Test
0.14%, 0.16%, 0.18% Diacid Concentrations

Sebacic Acid

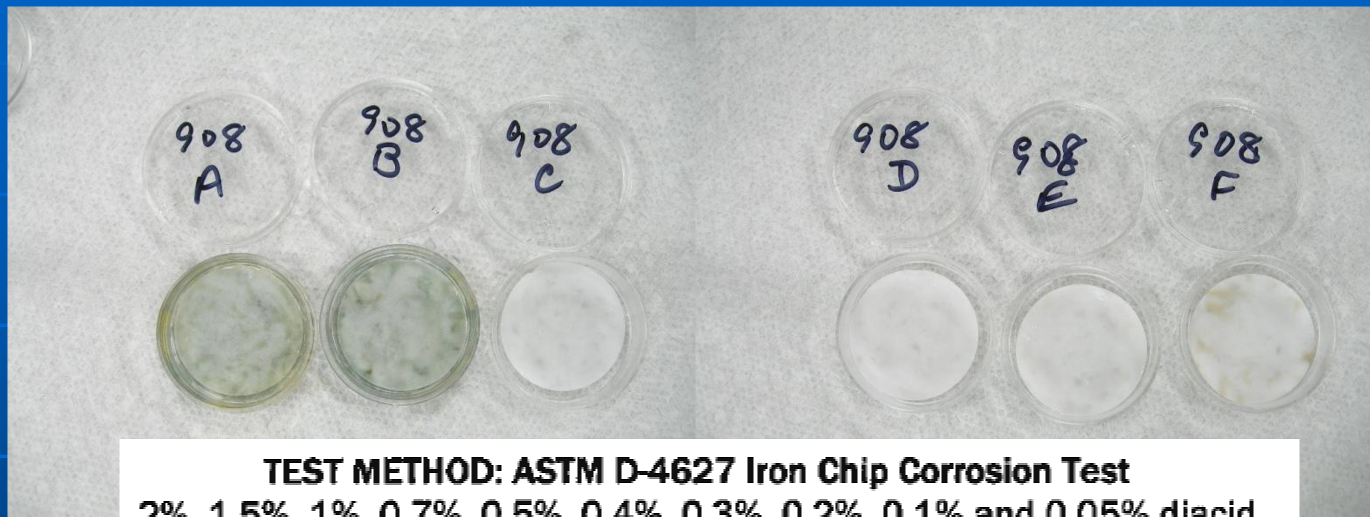


TEST METHOD: ASTM D-4627 Iron Chip Corrosion Test

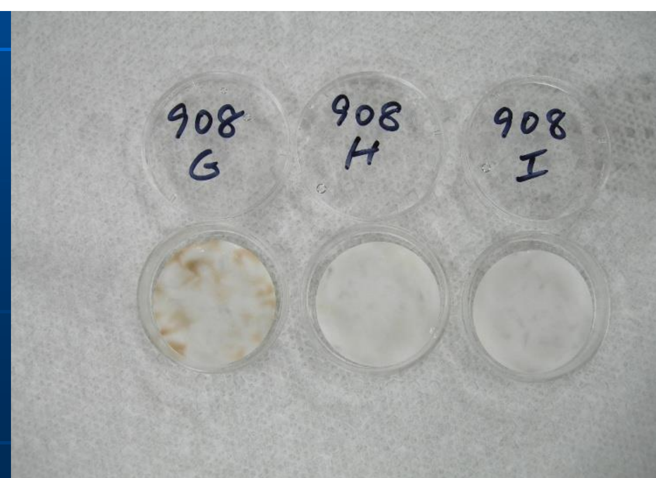
2%, 1.5%, 1%, 0.7%, 0.5%, 0.4%, 0.3%, 0.2%, 0.1% and 0.05% diacid



Corfree® M1



TEST METHOD: ASTM D-4627 Iron Chip Corrosion Test
2%, 1.5%, 1%, 0.7%, 0.5%, 0.4%, 0.3%, 0.2%, 0.1% and 0.05% diacid



Summary of Results

Diacid (Wt%)	Azelaic Acid Emerox 1112	Azelaic Acid Emerox 1175	Azelaic Acid Emerox 1185	Sebacic Acid	Corfree® M1
0.05 (A)	Rust	Rust	Rust	Rust	Rust
0.1 (B)	Rust	Rust	Rust	Rust	Rust
0.2 (C)	Rust	Rust	Pass	Rust	Pass
0.3 (D)	Rust	Pass	Pass	Pass	Pass
0.5 (E)	Pass	Pass	Pass	Pass	Pass
0.7 (F)	Pass	Pass	Pass	Pass	Pass
1.0 (G)	Pass	Pass	Pass	Pass	Pass
1.5 (H)	Pass	Pass	Pass	Pass	Pass
2.0 (I)	Pass	Pass	Pass	Pass	Pass

Conclusion

As expected, each of the diacids studied proved to be an effective corrosion inhibitor at concentrations ≥0.5% wt. Enhancing the C_{11} content of azelaic acid to 15% improves its corrosion-inhibiting properties to be comparable to sebacic acid. Raising the C_{11} level to 45% improves the performance to be equivalent to Corfree® M1.