High-Performance Corrosion Inhibitors for Aluminum and Its Alloys

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Business Manager, Industrial Lubricants & Corrosion Inhibitors

June 23, 2021
About Aluminum

- A very reactive metal
- Generally viewed as corrosion-resistant metal
  - Resistant to conc. nitric acid
  - Naturally protected from corrosion by a clear, stable oxide layer
    - 2 ~ 10 nm thick in a hydrated form
    - Impermeable by oxygen
    - Stable at pH 4 ~ 8.5
    - Naturally self-renewing upon abrasion or other mechanical damage

*Also spelled aluminium.
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Why Aluminum Corrosion/Staining Still Occurs?

• **Corrosive Ions**
  - Chlorides & sulfates present in water
  - Can penetrate the protective layer leading to pitting.

• **Galvanic Corrosion**
  - Al comes in direct contact with the cast iron/steel bed of the machine tool in an aqueous environment in the machining process

• **Dissolution of Aluminum Oxides**
  - At high pH, the protective oxide layer is etched away by the metalworking fluid causing staining
Chemical Approaches to Protect Aluminum from Staining or Corroding

**Inorganic**
- Create a chemically bonded physical barrier
- Require additional processing and changes of surface profiling
- Enabling Chemistry
  - Silicates

**Organic**
- Produce a hydrophobic film that promotes water repellency
- Can be applied simply
- Intended to be temporary at best
- Enabling Chemistry
  - Carboxylic acid/amine salts
  - Phosphate Esters
  - Sulfonates
  - Polymers
  - Triazoles/Thiadiazoles

To form a transient, organized protective layer of inhibitors on the metal surface to exclude out water and/or oxygen
Overview: Colonial's Aluminum Corrosion Inhibitors

• Film-forming, organic corrosion inhibitors

• Core Enabling Chemistry

  - Carboxylic acid/amine salts
    • Based on acylamidocarboxylic acids
      - ColaCor 186
      - ColaCor 372
      - ColaCor 215

  - Phosphate Esters
    • ColaCor ACI
Cola®Cor 186

Physiochemical Characteristics

• An acylamidocarboxylic acid

• Neat, free acid

• Liquid to solid
  - Melting point: ~ 50°C

• Insoluble in water

• Water-soluble upon neutralization with alkanolamines or alkali hydroxides

<table>
<thead>
<tr>
<th>Cola®Cor 186</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance* @ 50°C</td>
<td>Clear Liquid</td>
</tr>
<tr>
<td>Color, GARDNER BYK @ 50°C</td>
<td>4 MAX</td>
</tr>
<tr>
<td>% NaCl</td>
<td>0.1 MAX</td>
</tr>
<tr>
<td>Acid Value, mg KOH/g</td>
<td>180 – 205</td>
</tr>
<tr>
<td>% Moisture, K.F.</td>
<td>3.0 – 9.0</td>
</tr>
<tr>
<td>Solubility</td>
<td>Clear Liquid</td>
</tr>
</tbody>
</table>
  (2 GRAMS OF PRODUCT, 2 GRAMS OF TEA, AND 96 GRAMS OF DI Water)
Cola®Cor 186

Key Performance Attributes
• Stable in hard water (up to 1000 ppm hardness)
• Capable of multi-metal protection
• Low-foaming
• Reduced cobalt & copper leaching
• Offers formulation flexibility

Applications
• Suitable for all water dilutable metalworking fluids
• Applicable to MWF for all metalworking processes
• Mild alkaline metal cleaner
• Fire-resistant hydraulic fluids (HFAE, HFAS)
• General corrosion protection

• Globally registered
Cola®Cor 372

General Features

• Liquified ColaCor 186

• Partially neutralized Cola®Cor 186 with cyclohexylamine

• Insoluble in water

• Needs to be neutralized with alkanolamines or alkali hydroxides to become water soluble

• Broad global registration

<table>
<thead>
<tr>
<th>Cola®Cor 372</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance, 25°C</td>
<td>Clear Liquid</td>
</tr>
<tr>
<td>Color, Gardner BYK</td>
<td>6.0 Max</td>
</tr>
<tr>
<td>Alkali Value</td>
<td>50.0 – 67.0</td>
</tr>
<tr>
<td>Acid Value</td>
<td>165.0 – 180.0</td>
</tr>
<tr>
<td>% Moisture</td>
<td>9.0 – 12.0</td>
</tr>
<tr>
<td>Solubility (Neutralized)</td>
<td>Clear Liquid</td>
</tr>
</tbody>
</table>
Cola®Cor 372

Key Performance Attributes

- Multi-metal corrosion inhibitor
  - Ferrous
  - Non-ferrous: Al, etc.
- Suitable for aqueous systems including those with heavy amounts of chlorides
- Low foaming
- High hard water tolerance (up to 1000 ppm)

<table>
<thead>
<tr>
<th>Test Summary</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cast Iron Chip Test</strong></td>
<td></td>
</tr>
<tr>
<td>1% active solution in tap water</td>
<td>Pass</td>
</tr>
<tr>
<td><strong>Chip Stack Corrosion Test</strong></td>
<td></td>
</tr>
<tr>
<td>- 48 hrs, 25°C</td>
<td>No corrosion at either concentration</td>
</tr>
<tr>
<td><strong>Aluminum Block Stain Test</strong></td>
<td></td>
</tr>
<tr>
<td>- 72 hrs, 25°C</td>
<td>No staining on 2024, 3003, H14 or 6061 alloys at either concentration</td>
</tr>
<tr>
<td><strong>Aluminum Block, Dried Residue Test</strong></td>
<td></td>
</tr>
<tr>
<td>- 72 hrs, 25°C</td>
<td>No staining at either concentration, 6061 alloy</td>
</tr>
<tr>
<td><strong>Stack-Stain Corrosion Test, 1.0% only</strong></td>
<td></td>
</tr>
<tr>
<td>- 7 days, 25°C</td>
<td>No rust on 1010 cold rolled steel, no staining on 3003 H14 Al alloy</td>
</tr>
</tbody>
</table>

Samples neutralized to pH 8.5, tested at 0.5 and 1.0% concentration
Cola®Cor 372 Applications

- Metalworking fluids
  - Semisynthetic
  - Synthetic
  - Rolling emulsions

- Alkaline metal cleaners

- Fire-resistant hydraulic fluids (HFAE, HFAS)

- Other general corrosion protection purpose

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Cola®Cor 215

**Chemistry**

- An optimized blend of a variety of carboxylic acids including acylamidocarboxylic acids
- Pre-neutralized with optimized combinations of alkanolamines
- Water soluble

<table>
<thead>
<tr>
<th>Cola®Cor 215 Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>APPEARANCE, 25°C</strong></td>
</tr>
<tr>
<td><strong>COLOR, GARDNER BYK</strong></td>
</tr>
<tr>
<td><strong>ALKALI VALUE</strong></td>
</tr>
<tr>
<td><strong>ACID VALUE</strong></td>
</tr>
<tr>
<td><strong>%MOISTURE</strong></td>
</tr>
</tbody>
</table>
Cola®Cor 215

Key Performance Attributes

• Effective for ferrous and aluminum protection
• Used as short-term indoor corrosion inhibitor
• Hard water stable @ 300 – 400 ppm

Cast Iron Chip Test

Result: Stain-free @ 1.5 wt% (tapwater, 120 ppm hardness)

Al Immersion test

Al 6061 Stress test (@ 60 °C for 15 days)
No stain & no discoloration
Cola®Cor 215

Applications

• Metalworking fluids
  - Synthetic
  - Semi-synthetic
  - Soluble oil

• Machining Coolants

• General Machining
  - Threading
  - Tapping
  - Cutting
  - Grinding
### ColaCor 186 vs. ColaCor 372 vs. ColaCor 215

<table>
<thead>
<tr>
<th></th>
<th>ColaCor 186</th>
<th>ColaCor 372</th>
<th>ColaCor 215</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Form</td>
<td>Low MP solid</td>
<td>Liquid</td>
<td>Liquid</td>
</tr>
<tr>
<td>Chemical Form</td>
<td>Free Acid</td>
<td>Solubilized/partially neutralized</td>
<td>Fully neutralized</td>
</tr>
<tr>
<td>How to Use</td>
<td>Neutralize with amines</td>
<td>Neutralize with amines</td>
<td>Use as is</td>
</tr>
<tr>
<td>MWF</td>
<td>Water-dilutable</td>
<td>Water-dilutable</td>
<td>Water-dilutable</td>
</tr>
<tr>
<td>Fire Resistant HF</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>(HFAE/HFAS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleaner</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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The Acylamidocarboxylic Acid Corrosion Inhibitor Family

ColaCor 186
- Free acid
- Neutralize as you wish
- For ferrous & non-ferrous

ColaCor 372
- Solubilized ColaCor 186
- For ferrous & non-ferrous
- For metalworking & metal cleaning

ColaCor 215
- Mixed carboxylic acids
- Fully neutralized
- Good for ferrous & aluminum

ColaCor IT
- Amine neutralized ColaCor 186
- For ferrous
- Improved GHS profile

ColaCor 298
- Mixed carboxylic acids
- Fully neutralized
- For ferrous
Cola®Cor ACI

Chemistry

- Alkoxylate-based mono-phosphate esters

- Water soluble (in the acid form)

- Completely water-soluble upon neutralization with alkanolamines and alkali hydroxides.

- Compatible with other corrosion inhibitors

<table>
<thead>
<tr>
<th>Appearance</th>
<th>Clear Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (1% aqueous)</td>
<td>3 Max.</td>
</tr>
<tr>
<td>% Moisture</td>
<td>16.0 – 20.0</td>
</tr>
<tr>
<td>Color, Gardner BYK</td>
<td>2 Max.</td>
</tr>
<tr>
<td>Acid Value</td>
<td>385 – 410</td>
</tr>
</tbody>
</table>

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Cola®Cor ACI

Key Performance Attributes

• Effective & efficacious corrosion inhibitor for aluminum and ferrous metals

• Low foam or inhibit foam formation

• Prevents aluminum staining at a pH up to 9.3

• Reduces staining at higher pH

• Provides sufficient ferrous protection at 0.2 wt%

Applications

- Synthetic
- Semi-synthetic
- Soluble oil
ColaCor KAT & ColaCor KAT-B & ColaCor 910

• Based on the blended phosphate esters

• To be introduced in a dedicated session soon
Be Aware of the (Negative) Impact of Other Components

• Amines
  - Essential to other performance: alkalinity boost for fluid longevity
  - All amines cause Al staining
  - Need to balance the good and bad
Summary

• Variety of Al corrosion inhibitors including
  - Carboxylic acid/amine salts: ColaCor 186, ColaCor 372, & ColaCor 215
  - Phosphate esters: ColaCor ACI

• Classified as film-forming, organic corrosion inhibitors

• High-performance

• Low foaming

• Suitable for metalworking, alkali cleaners, and other industrial applications
Thank You!

For samples and inquiries, please visit

colonialchem.com

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