High-Performance Corrosion Inhibitors for Aluminum and Its Alloys

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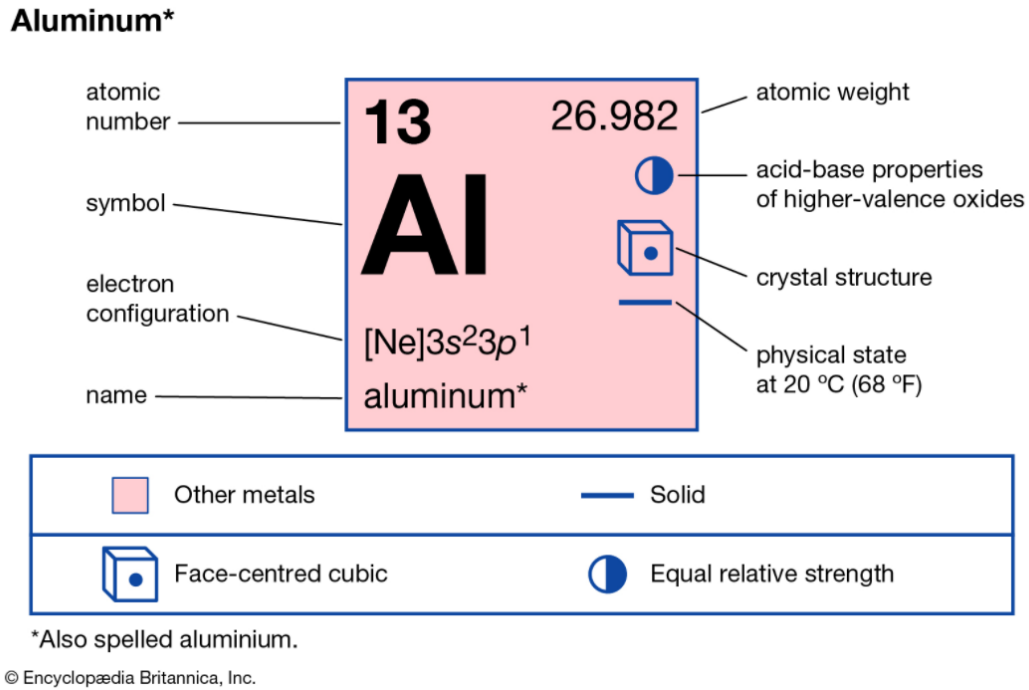
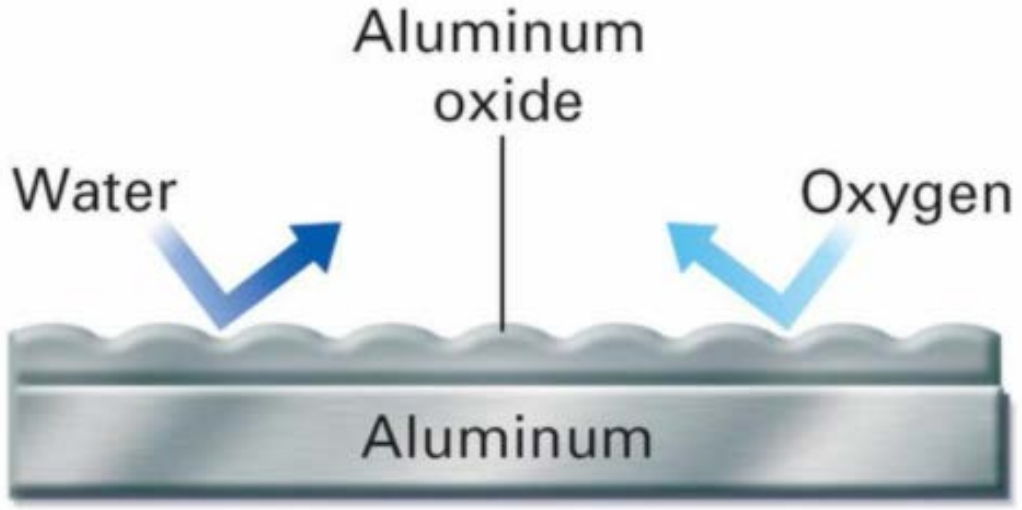
About Aluminum

- 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





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

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

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*

- Globally registered

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

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

Cola®Cor 372	Specifications
Appearance, 25°C	Clear Liquid
Color, Gardner BYK	6.0 Max
Alkali Value	50.0 – 67.0
Acid Value	165.0 – 180.0
% Moisture	9.0 – 12.0
Solubility (Neutralized)	Clear Liquid

Cola®Cor 372

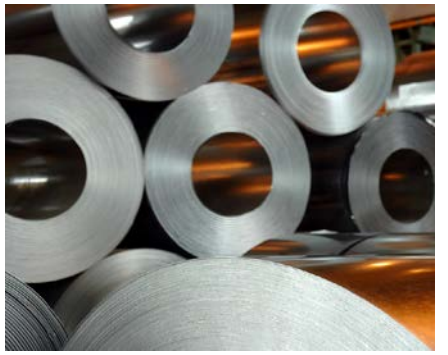
Key Performance Attributes

- 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)

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

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

Cola®Cor 215	Specifications
APPEARANCE, 25°C	CLEAR LIQUID
COLOR, GARDNER BYK	REPORT
ALKALI VALUE	200.3 – 227.8
ACID VALUE	128.0 – 222.0
%MOISTURE	3.6 MAX

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

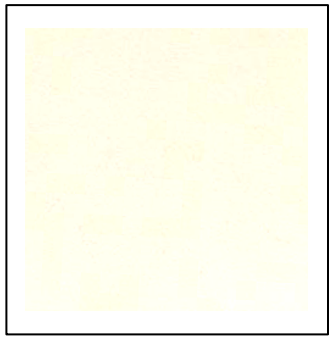
Al Immersion test

Al 6061

Al 7075

(1.5 wt% in tapwater, 120 ppm hardness)

Cast Iron Chip Test



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

Al 6061 Stress test (@ 60 °C for 15 days)

No stain & no discoloration

Cola®Cor 215

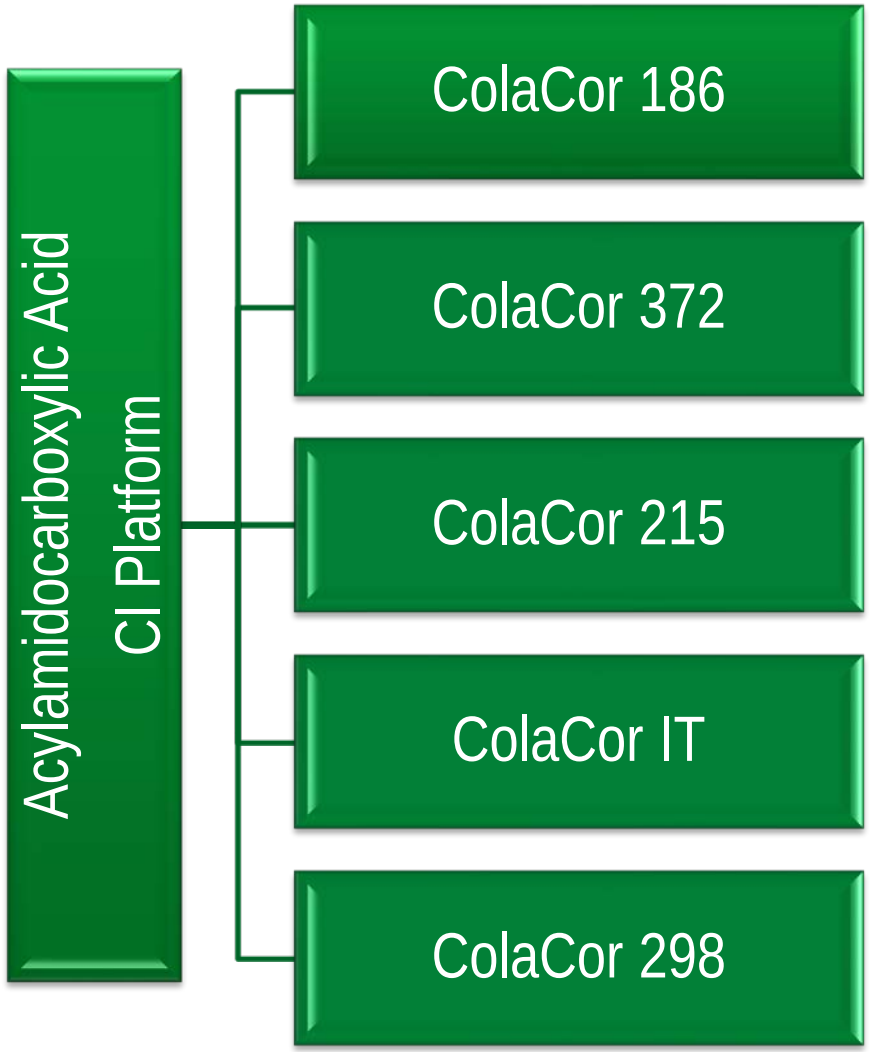
Applications

- Metalworking fluids
  - Synthetic
  - Semi-synthetic
  - Soluble oil
- Machining Coolants
- General Machining
  - Threading
  - Tapping
  - Cutting
  - Grinding

ColaCor 186 *vs.* ColaCor 372 *vs.* ColaCor 215

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

The Acylamidocarboxylic Acid Corrosion Inhibitor Family



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

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

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

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

- 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

Appearance	Clear Liquid
pH (1% aqueous)	3 Max.
% Moisture	16.0 – 20.0
Color, Gardner BYK	2 Max.
Acid Value	385 – 410

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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