Vanderbilt Worldwide Ltd
A Wholly Owned Subsidiary of R.T. Vanderbilt Holding Company, Inc.

VANDERBILT CORROSION INHIBITOR ADDITIVES

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DQS Inc.
VANDERBILT CHEMICALS, LLC
CERTIFIED TO ISO 9001:2015
10002461

DISCLAIMER

Vanderbilt Chemicals, LLC sells a wide variety of Corrosion Inhibitors (CI) that are used in a wide number of Industrial Oils available around the globe. Corrosion inhibitors are selected based upon what metal composition needs protection. Vanderbilt Chemicals, LLC has an extensive line of corrosion inhibitors designed for use with copper and its alloys (brass, bronze). The use of "yellow metal" (copper, and its alloys - brass, bronze) require special corrosion inhibitors (CI) that form a passivation layer on the metal surface. This layer protects the surface by inhibiting corrosive access to the metal surface. This prevents the cathodic corrosion that can occur on copper surfaces. Because of the usefulness of these "yellow metal" alloys and copper, this type of corrosion inhibitor is effective in a variety of lubricant and grease applications. Vanderbilt Chemicals, LLC supplies a wide variety of heterocyclic corrosion inhibitors as derivatives of thiadiazole, mercaptobenzothiazole, and various triazole compounds. These three chemical classes represent the primary types of corrosion inhibitors used to protect "yellow metal" and copper, especially in the lubricant industry (see Figure 1).

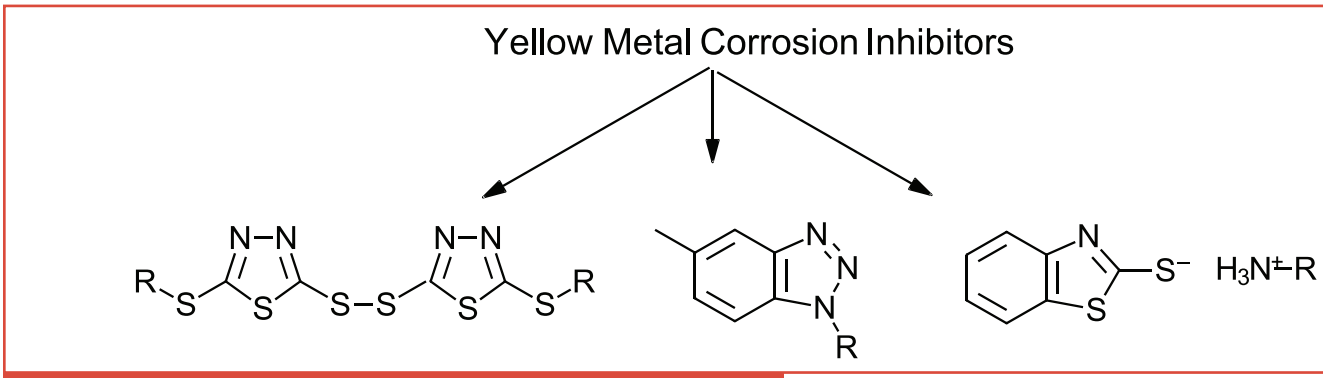


FIGURE 1: CORROSION INHIBITORS FOR COPPER, BRASS, AND BRONZE

MODE OF ACTION (FILM FORMATION)

The corrosion inhibitor is generally used in small amounts in a mineral oil to prevent the corrosion of the metal by adhering to and deactivating the metal surface. Due to this mode of action, these types of corrosion inhibitors are often referred to as metal deactivators (MD). Figure 2 shows that the CI mode of action occurs by forming a film on the copper surface. This occurs when the lone pair of the electrons from the nitrogen and/or sulfur atoms are inserted into the open "d" orbitals in the copper oxide electron shell. This protective film inhibits further corrosion of the metal.

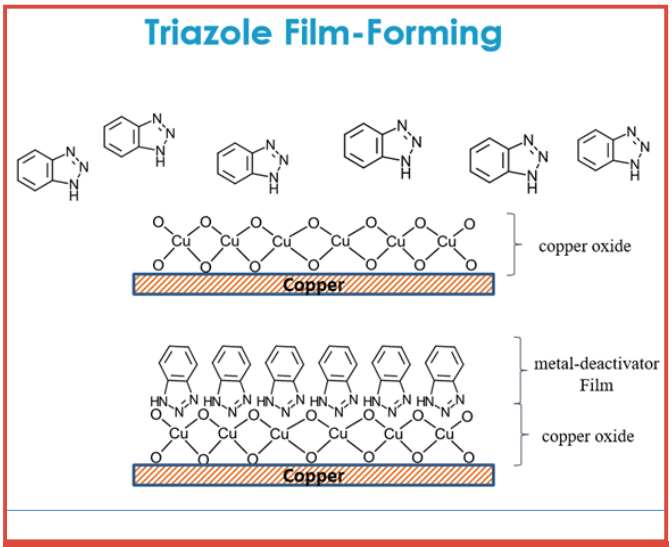
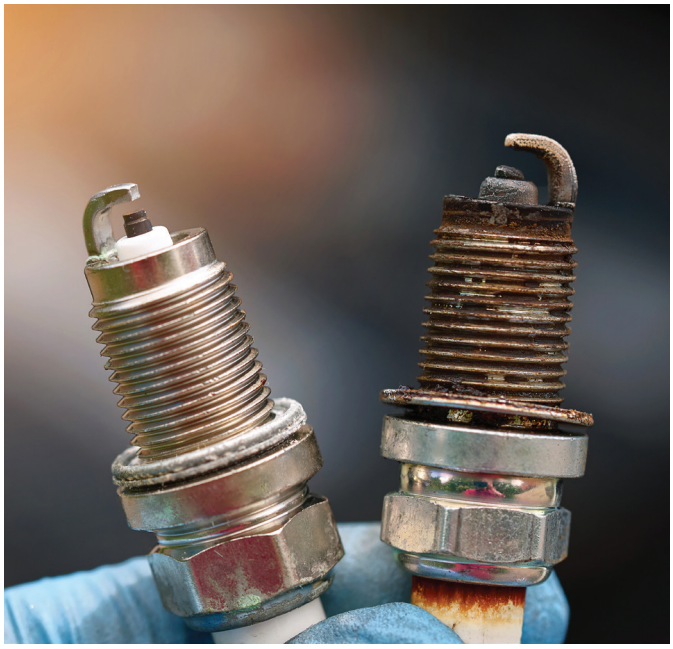


FIGURE 2: TRIAZOLE CI FORMING A METAL DEACTIVATING FILM ON A COPPER SURFACE



COMPARISON OF VANDERBILT CORROSION INHIBITORS IN THE COPPER STRIP CORROSION TEST (ASTM D130 & MODIFIED D130)

The standard test for copper corrosion by the lubricant industry is referred to by its American Society for the Testing of Materials (ASTM) as the Copper Strip or D130 method. The ASTM D130 corrosion test is an important part of many industrial oil specifications , such as turbine oils, hydraulic fluids, gear oils, and grease. The corresponding industrial machinery is often manufactured using copper and other yellow metals for internal parts such as gears, liners, bearings, and bearing races. The use of metal deactivating additives to inhibit corrosion of these "yellow metals" is an important property of lubricants and greases.

The ASTM D130 test is an important part in industrial oil specifications by ASTM, DIN, and ISO (the three primary societies that develop lubrication specifications). The ASTM D130 method utilizes copper strips (or coupons) and immerses them in a lubricant for specified period and at a specified temperature. The standard ASTM D130 is run at 100 °C for 3 hours. These conditions are not severe enough for some industrial applications so a modified ASTM D130 version can be run, which increases the test time to 24 hours and the temperature to 121 °C. The copper coupons are then removed from the liquid at the end of the test and manually rated according to a reference guide provided by ASTM (Figure 3).

FIGURE 3: ASTM RATING SYSTEM FOR THE D130 COPPER CORROSION TEST

Vanderbilt Chemicals tested our various MD in an API Group I base oil that was fortified with a high level (4 wt.%) of sulfur-containing compounds. These compounds are known for their excellent extreme pressure and antioxidant properties, but have a tendency to be corrosive to copper. The sulfur-containing compounds were **VANLUBE® SB**, a sulfurized isobutylene containing active sulfur, blended at 2 wt.%, and **VANLUBE 7723**, an ashless dithiocarbamate containing inactive sulfur, blended at 2 wt.%. These sulfur-containing compounds will corrode and discolor the copper strip, while various MD additives, when used at 0.1 wt.% individually and blended into the sulfur-fortified Group I base oil, should prevent this corrosion from occurring. The test results Vanderbilt Chemicals and other competitive additives can be seen in Tables 1, 2 & 3.

TABLE 1. RATINGS OF VANDERBILT ADDITIVES IN THE ASTM D130 COPPER STRIPS TEST (3 & 24H)

	GROUP 1 OIL (REFERENCE)	CUVAN® 303	CUVAN 313	CUVAN 484	CUVAN 826	VANLUBE 887 (50% ACTIVE)
D130 @ 100 °C 3 hours	1b	1b	1a	1a	1a	1b
D130 @ 100 °C 24 hours	3b/4a	3a	1a	1b	1b	3a

PICTURE 1: ASTM D130 RESULTS 24H @ 100 °C CORROSION TEST

D130 Rating	Base	303	313	484	826	887
	3b/4a	3a	1a	1b	1b	3a

TABLE 2. RATINGS OF VANDERBILT ADDITIVES IN THE ASTM D130 COPPER STRIPS TEST (3H)

	GROUP 1 OIL (REFERENCE)	CUVAN® 303	CUVAN 313	CUVAN 484	CUVAN 826	VANLUBE 887 (50% ACTIVE)
D130 @ 121 °C 3 hours	3b	3a	1a	1b	1b dark	1b dark

PICTURE 2: D130 RESULTS 3H @ 121 °C CORROSION TEST

D130 Rating	Base	303	313	484	826	887
	3b	3a	1a	1b	1b Dark	1b Dark

TABLE 3. RATINGS OF VANDERBILT ADDITIVES IN THE ASTM D130 COPPER STRIPS TEST (24H)

	GROUP 1 OIL (REFERENCE)	CUVAN® 303	CUVAN 313	CUVAN 484	CUVAN 826	VANLUBE 887 (50% ACTIVE)
D130 @ 121 °C 24 hours	4c	3a	1a	1b dark	1b	1b

PICTURE 3: D130 RESULTS 24H @ 121 °C CORROSION TEST

D130 Rating	Base	303	313	484	826	887
	4c	3a	1a	1b Dark	1b	1b

VANDERBILT CHEMICALS, LLC CORROSION INHIBITORS

Dimercaptothiadiazole (DMTD) Derivatives

CUVAN® 484

CUVAN 826

VANLUBE® 829

VANLUBE 972M

VANLUBE 972 NT

VANCHEM® DMTD

VANCHEM NATD

- Sulfur-Based Corrosion Inhibitors
- Liquid and Solid Versions
- Water-Soluble and Oil-Based Versions
- Secondary Effects - Antioxidant, Extreme Pressure, and Antiwear Benefits
- **VANLUBE® 829** has NSF Food Grade Approvals
- **VANLUBE 972M** and **VANLUBE 972 NT** are Not Soluble in Oil are Recommended for Grease and are Not Soluble in Mineral Oil
- **VANCHEM™ DMTD** and **VANCHEM NATD** are Water Soluble

Mercaptobenzothiazole Derivatives

NACAP®

VANLUBE® 601

VANLUBE 601E

- Nitrogen and Sulfur based Copper Corrosion Inhibitors
- Water-Soluble and Oil-Based Version Available
- Color Stabilizing Properties
- Synergistic with Dithiocarbamates
- Liquid and Solid (MBT) Versions Available
- **NACAP®** Water Soluble (50% Aqueous Solution)
- ROKON® = 2-Mercaptobenzothiazole (powder)

Triazole Derivatives

CUVAN® 303

CUVAN 313

VANLUBE® 887

VANLUBE 887 FG

VANLUBE 887E

- Ashless Nitrogen Based Copper Corrosion Inhibitors
- Liquids with High Solubility in Petroleum Based Mineral Oils
- Provides Supplemental Oxidation Protection
- Optimized Blends Available for both Corrosion and Oxidation Protection
- Food Grade Versions Available
- LuSC Listed Additives Available for Formulating Environmentally Acceptable Lubricants (EAL)

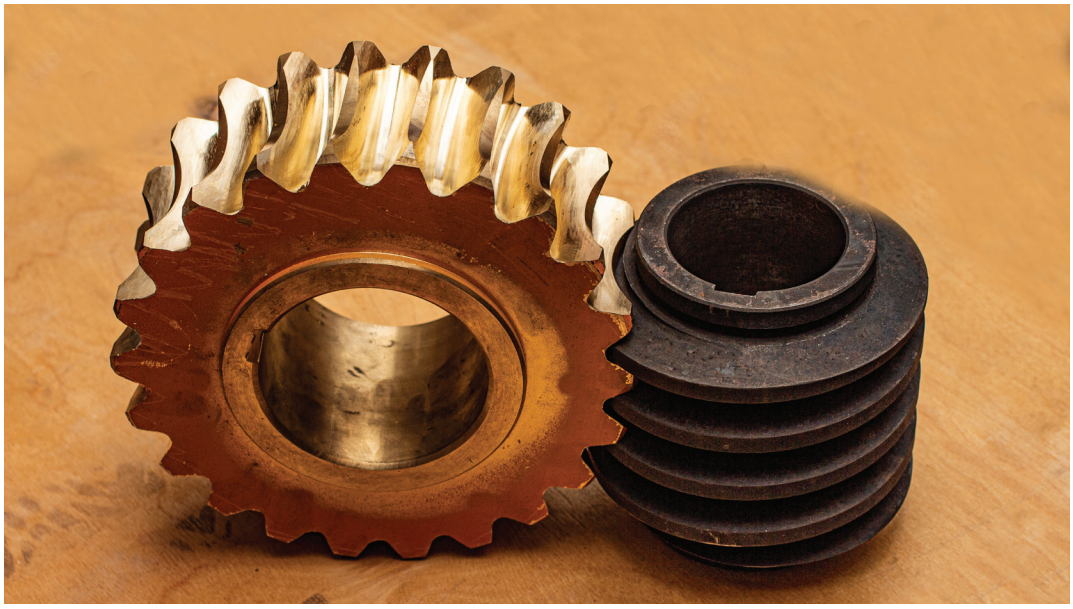
Vanderbilt Chemicals offers a wide variety of CI and MD components for use in lubricant and grease formulations, especially in "yellow metal" and copper metal protection.

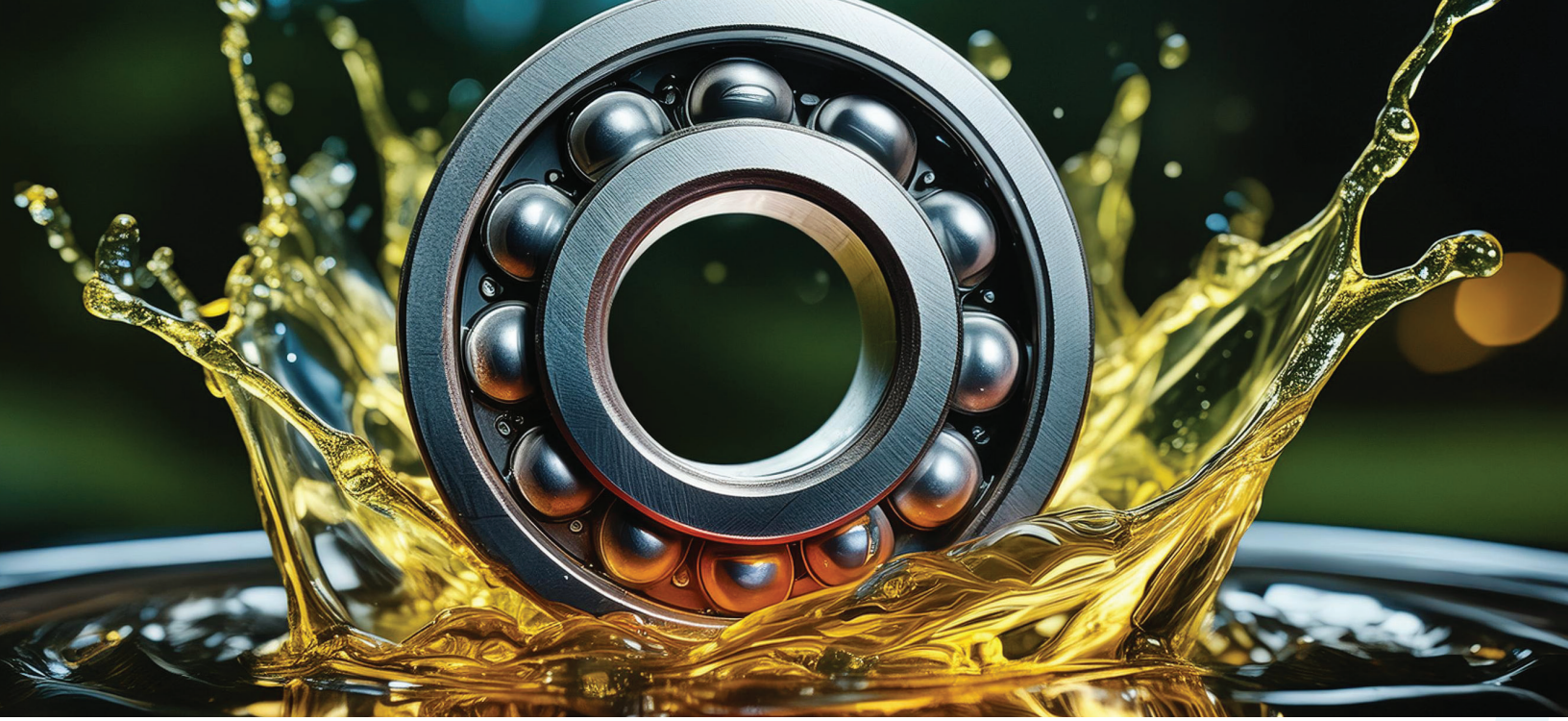
CUVAN® 303 & **CUVAN 313** are ashless and non-sulfur based for general "yellow metal" corrosion protection. **CUVAN 484** & **CUVAN 826** are sulfur/nitrogen based, but also offer good "yellow metal" and copper corrosion protection.

- Low levels can be used to as SH (sulfide) scavengers
- May also add AW and EP protection

VANLUBE® 887 series will provide general corrosion protection, plus synergistic oxidation control, especially when used with **VANLUBE 7723**. There are also Food Grade Options available (**VANLUBE 887 FG**). Vanderbilt also has a broad range of LuSC Listed additives for EU EAL (EcoLabel) applications, including MD additives.

NOTES:





NOTES:

FOR SAMPLES, PRODUCT INFORMATION AND/OR TECHNICAL SERVICE PLEASE CONTACT VANDERBILT CHEMICALS, LLC, OR THE VANDERBILT REPRESENTATIVE IN YOUR AREA:

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