As coolants, corrosion inhibitors, and cleaners, NORKOOL® and NORCHEM™ Products set the standards in quality and performance, in unmatched technical expertise, and in industry-leading service.

With over 60 years experience in ethylene glycol, Union Carbide has an unparalleled record of meeting customer needs. In fact, NORKOOL Products are endorsed by many equipment manufacturers because of our continued dedication to solving coolant and cleaning needs in the field.

A total service package includes free sample analyses for trouble-free system performance. Our state-of-the-art automated laboratory provides the fastest, most accurate and comprehensive test program for heat transfer fluids available today. Our broad distribution network in the U.S. and Canada means product when and where you want it.

NORKOOL Coolants and NORCHEM Inhibitors—products that perform and save you money!

Environmental Fate and Effects of NORKOOL® Industrial Coolants and Ethylene Glycol

Introduction

As concern for the environment increases and environmental regulations become more stringent, the need heightens for additional information about the environmental effects of the chemicals in use in your equipment and at your facilities. This review details the in-depth studies done by Union Carbide to assess the potential effects of its ethylene glycol-based industrial coolant, NORKOOL® Industrial Coolant, on the environment.

Summary

Regardless of whether ethylene or propylene glycol is used, all handling and processing must be done in compliance with federal, state, and local environmental regulations. NORKOOL Coolant and other ethylene glycol-based fluids can have a lower environmental impact for routine or accidental discharges.

NORKOOL Coolant has a 20-day biooxidation of nearly 100% in water, indicating that it will completely and readily biodegrade. It is also practically non-toxic to aquatic life. Compared to propylene glycol-based coolants, it is more readily biodegraded, as evident from the 20-day biooxidation rates of ethylene glycol (96%) versus propylene glycol (79%). Furthermore, propylene glycol has a higher chemical oxygen demand of 1.68 mg/O₂ versus 1.34 mg/O₂ for ethylene glycol. Thus, a propylene glycol-based fluid will deplete the available oxygen in a stream or other water supply to a greater extent than an ethylene glycol-based fluid, which can cause violations of permit limits.

The accidental discharge of large amounts of ethylene glycol, propylene glycol, or other degrading organics directly into water systems can cause a localized loss of dissolved oxygen. Background information concerning the broad, basic principles, definitions and analyses related to water quality are presented in the Appendix.

The data demonstrate that ethylene glycol-based coolants are environmentally acceptable fluids that meet your heat transfer needs. More readily biodegradable than similar propylene glycol-based fluids, they also have a significantly lower chemical oxygen demand. The superior heat transfer characteristics of ethylene glycol-based fluids coupled with environmental acceptability make NORKOOL Industrial Coolants the clear choice for your cooling system needs.

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Ecological Fate and Effects Data

Biodegradation in Water Systems

The following biooxidation data\(^{(1,2,10)}\) show rapid and virtually complete biooxidation of NORKOOL\(^{®}\) Coolants and ethylene glycol during Biochemical Oxygen Demand (BOD) tests.

<table>
<thead>
<tr>
<th>Product Tested</th>
<th>Chemical Oxygen Demand, mg/mg</th>
<th>Biooxidation, % (BOD/ThOD x 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theoretical, (ThOD)</td>
<td>Measured</td>
</tr>
<tr>
<td>NORKOOL(^{®}) Coolant</td>
<td>1.22</td>
<td>1.14</td>
</tr>
<tr>
<td>NORKOOL SLH Coolant</td>
<td>1.22</td>
<td>1.17</td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>1.29</td>
<td>1.39</td>
</tr>
</tbody>
</table>

The BOD test simulates river conditions and, consequently, is a very dilute biological system. In wastewater treatment plants, where concentrations of microorganisms are far higher, biodegradation can take place in a matter of hours. Pitter has demonstrated excellent removal of ethylene glycol in activated sludge systems.\(^{(12)}\) Thus, NORKOOL Coolants are as readily amenable to biological waste treatment as ethylene glycol.

However, because these materials are biodegradable, large quantities could represent a significant oxygen demand in receiving streams.\(^{(3)}\) The rate of oxygen depletion of the stream is related to biodegradability. The extent of oxygen depletion is related to molecular structure.

EG exerts a slightly lower short-term oxygen demand and lower ultimate oxygen demand than PG. Based on 20-day BOD data, 1.29 mg of oxygen are depleted in 20 days for every mg of EG (99% depletion). 1.34 mg of oxygen would be depleted by 1 mg of PG (79% degradation in 20 days). However, 1.69 mg of oxygen would ultimately be depleted by each mg of PG.

The lower oxygen demand of EG is an advantage in the treatment of spent fluids. EG will have less impact on receiving streams in the event of an accident, as well.

Biodegradation in Soil

Laboratory tests conducted in topsoil at 20 °C showed rapid biodegradation of ethylene glycol at concentrations of 1000 and 5000 milligrams of EG per kilogram of soil (mg/kg or ppm).\(^{(4)}\) The half-life at 1000 mg/kg was about 30 hours as monitored by gas chromatographic and organic carbon procedures. Tests at 5000 mg/kg showed a similar biodegradation rate after an initial lag period of about 35 hours. Winter temperatures, inadequate nutrients and increased soil penetration would be expected to reduce this rate of biodegradation.
**Effect on Aquatic Life**

As indicated below, NORKOOL® Coolant and ethylene glycol are relatively nontoxic to aquatic life.

<table>
<thead>
<tr>
<th>Product</th>
<th>Test Procedure</th>
<th>Test Organism</th>
<th>Toxicity, 24 hr</th>
<th>48 hr</th>
<th>96 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORKOOL® Coolant</td>
<td>Static acute</td>
<td>Fathead minnows</td>
<td>—</td>
<td>—</td>
<td>&gt;10,000(10)</td>
</tr>
<tr>
<td>NORKOOL SLH Coolant</td>
<td>Static acute</td>
<td>Fathead minnows</td>
<td>—</td>
<td>—</td>
<td>&gt;10,000(10)</td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>Static acute</td>
<td>Fathead minnows</td>
<td>&gt;10,000</td>
<td>&gt;10,000</td>
<td>&gt;10,000(2)</td>
</tr>
<tr>
<td></td>
<td>Daphnia magna</td>
<td></td>
<td>&gt;10,000</td>
<td>&gt;10,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brine shrimp</td>
<td></td>
<td>&gt;20,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Effect on Biological Treatment Systems**

The adverse effect level of NORKOOL Coolants and ethylene glycol on activated sludge microorganisms or the IC₅₀ (concentration that inhibited growth to 50% of the growth in a control system) was determined to be greater than 5000 mg/L (greater than 0.5%) and greater than 10,000 mg/L (greater than 1%), respectively(1,10).

Consequently, neither product should have any adverse effect on biological treatment systems at normal discharge levels (less than 0.5%).

**Effect on Plant Life**

Since higher concentrations of organic liquids can have herbicidal properties, the reported impact of ethylene glycol solutions (1 to 3%) on selected plants is not surprising(5). Natural dilution during disposal would minimize this problem. The greatest risk of impact would occur when undiluted run off may flow into planted areas.

**Product Safety**

When considering the use of any Union Carbide products in a particular application, you should review our latest Material Safety Data Sheets and ensure that the use you intend can be accomplished safely. For Material Safety Data Sheets and other product safety information, contact the Union Carbide Sales Office nearest you. Before handling any other products mentioned in the text, you should obtain available product safety information and take necessary steps to ensure safety of use.

No chemical should be used as or in a food, drug, medical device, or cosmetic, or in a product or process in which it may contact a food, drug, medical device, or cosmetic until the user has determined the suitability and legality of the use. Since government regulations and use conditions are subject to change, it is the user’s responsibility to determine that this information is appropriate and suitable under current, applicable laws and regulations.

Union Carbide requests that the customer read, understand, and comply with the information contained in this publication and the current Material Safety Data Sheet(s). The customer should furnish the information in this publication to its employees, contractors, and customers, or any other users of the product(s), and request that they do the same.
Appendix

Biodegradability

In its simplest terms, biodegradability expresses the degree to which a compound is reduced in complexity by the action of microorganisms. A committee of the Water Pollution Control Federation has suggested three criteria of biodegradability.

- **Primary Biodegradation**: Biodegradation to the minimum extent necessary to change the identity of the compound.

- **Environmentally Acceptable Biodegradation**: Biodegradation to the minimum extent necessary to remove undesirable properties of the compound such as foaminess and/or toxicity.

- **Ultimate Biodegradation**: Biodegradation to inorganic end products.

According to Busch, biodegradable carbon is “...that organic carbon converted to microbial cells or carbon dioxide by biological metabolism, due to the microbial species present, in the time interval allowed under specific test conditions. In some cases, partial degradation, or conversion, removes an undesirable characteristic of a compound or ‘destroys’ the substance in terms of a specific test.” Thus, to state simply that a material is “biodegradable,” without indicating the conditions of the test or the degree of degradation, is of limited value.

Aerobic bacteria oxidize the organic matter in wastewater and each reaction step is performed by a specific enzyme. A compound containing carbon, hydrogen, and oxygen (such as ethylene glycol) will ultimately be decomposed into carbon dioxide and water. Small amounts of mineral supplements are required for this activity. Phosphate, for example, plays an important role in the metabolism of any organism, with the resultant release of energy; the phosphate acts as a catalyst, so only a trace is required. A nitrogen supplement such as an ammonium salt is also required.

**Biochemical Oxygen Demand**

When aerobic bacteria oxidize organic matter, oxygen is consumed during the process and the amount required is proportional to the amount of organic material present. As long as oxygen is available, aerobic microbial decomposition of the organics will continue until the oxygen demand is satisfied—that is, until the aerobic microorganisms have oxidized all of the organic material they are capable of oxidizing. The amount of oxygen used during this process is the biochemical oxygen demand (BOD).

**Chemical Oxygen Demand**

The amount of oxygen required to completely oxidize an organic material to carbon dioxide and water is known as the Theoretical Oxygen Demand (ThOD). ThOD can be calculated if the organic structure is known. Chemical Oxygen Demand (COD) uses a strong oxidant, potassium dichromate, to measure the amount of oxygen needed for complete oxidation. COD and ThOD are nearly identical for simple organics such as glycols.
**BOD Test Procedure**

For measurement purposes, BOD is considered to be the quantity of oxygen required for aerobic biological stabilization of waterborne substances under a specific set of test conditions. The most common test condition is the 5-day BOD. A sample of the material to be tested is incubated at 20°C for 5 days in the presence of a selected biota consisting principally of bacteria. Comparison of the dissolved oxygen content of the sample at the beginning and end of the incubation period provides a measure of the BOD. Because the solubility of oxygen in water is very low, about 9.2 ppm at 20°C, the material to be tested has to be diluted to the low ppm range in order to avoid completely depleting the dissolved oxygen during the 5-day test.

Few, if any, materials are completely degraded during the 5-day test. When the test is continued beyond 5 days, until the material is oxidized as completely as possible, the result is termed an ultimate BOD. Determination of ultimate BOD has been observed to require approximately 20 days for many materials at the dilutions normally employed in the test.

The oxygen consumed during the test is used by the microorganisms to oxidize carbonaceous matter to carbon dioxide and water and to oxidize nitrogenous matter to nitrite ions and/or nitrate ions. The oxidation of nitrogen can become particularly important in the longer-term BOD tests but generally does not occur during the 5-day test.

The most commonly employed source of microorganisms for use in the BOD test is domestic sewage. When an organic material is not commonly found in nature, as is the case with many petrochemicals, sewage microorganisms can be slow to attack the material, and the BOD test results may be lower than experienced in nature. Adaptation (termed “acclimation”) of microorganisms to the organic material normally results in an increased rate and extent of oxidation of the material. Acclimation refers to the process of contacting a microbial culture with a material in such a way as to permit an increase in the number of those organisms in the culture which have the ability to oxidize and utilize the material, as well as permitting the organisms to “gear-up” enzymatically for the oxidation and utilization of the material.

The BOD test can be highly variable and is very dependent on the degrees of acclimation of the seed organisms. An average of 20 BOD tests for ethylene glycol showed an average of 51% oxidation after 5 days with a range from 34-68% oxidation.

In general, a biological waste treatment facility that has been receiving a material for a long period of time is acclimated to the material. Acclimation can be lost if the material only intermittently enters the biological waste treatment facility.

The concentrations of organic material and microorganisms are much higher in a biological waste treatment system than in the BOD tests. These higher concentrations result in a much more rapid rate of BOD exertion. For example, a conventional activated sludge biological waste treatment system can remove as much as 95-99% of a compound in 6 to 12 hours, where a BOD test might achieve only a 50% removal in 5 days.
Measurement of Biodegradability

Biodegradability can be measured through several different means—for example, through the disappearance of foam-producing properties, as in detergents, or a change in some other physical property. One quantitative method of expressing biodegradability is to compare the amount of oxygen consumed in the standard BOD test with the amount of oxygen required to completely oxidize the material to carbon dioxide and water on a theoretical basis. For example, the Theoretical Oxygen Demand of ethylene glycol is calculated as indicated below:

\[
2 \text{HOCH}_2\text{-CH}_2\text{OH} + 5 \text{O}_2 \rightarrow 4 \text{CO}_2 + \text{H}_2\text{O}
\]

Ethylene Glycol  
Molecular Weight = 62  
Oxygen  
Molecular Weight = 32

2 moles of ethylene glycol can be completely oxidized by 5 moles of oxygen. When converting to mass units, we find 124 mg of ethylene glycol are oxidized by 160 mg of oxygen.

\[
\frac{\text{mg EG}}{2 \times 62} = \frac{X \text{ mg O}_2}{5 \times 32}
\]

Theoretical Oxygen Demand = \(\frac{5 \times 32}{2 \times 62} = \frac{1.29 \text{ mg O}_2}{\text{mg EG}}\)

For example, if the measured 5-day BOD of ethylene glycol is 0.50 mg O\(_2\)/mg EG, or 36% of the theoretical oxygen demand. Similarly, the measured 20-day BOD might be 1.32 mg O\(_2\)/mg EG, which is over 100% of the theoretical oxygen demand (some nitrogen in the dilution water likely was oxidized after the glycol was depleted). In a biological system, some of the organic material is incorporated into new microbial cells rather than being completely oxidized to carbon dioxide and water; and, thus, oxygen consumption equal to 100% of the theoretical oxygen demand is only approached in the 20-day period. Therefore, in making a judgment concerning whether or not a material is biodegradable, some arbitrary percentage of the theoretical oxygen demand must be selected as the break point between biodegradable and non-biodegradable materials.

The Organization of Economic Cooperation and Development (OECD) utilizes several tests for biodegradability. If 60% of the Theoretical Oxygen Demand is removed in 28 days in a closed-bottle test (which is similar to the BOD test), the compound is said to be readily degradable. Readily degradable compounds require very little acclimation periods. Ethylene glycol is considered readily degradable.

It should be noted that the extent of removal of a material in a biological waste treatment system cannot be easily predicted from BOD test data. In general, however, the higher the percent oxidation in 5- and 20-day BOD tests, the greater would be the removal in a biological waste treatment plant. The importance of acclimating a biological waste treatment system to a given waste or waste constituent cannot be overemphasized. Acclimation can increase the rate and extent of biooxidation as well as aiding in overcoming inhibitory or toxic effects of an organic material. Discharges to the environment of any chemical product, including NORKOOL\textsuperscript{®} Coolants and ethylene glycol, can require federal, state, and local environmental permits. Contact the appropriate regulatory authorities for details.
References


4. Recent internal R/D laboratory studies, not formally reported to date.


Support Services

For product information or customer service, contact:
Union Carbide Corporation
Houston Customer Center
10235 West Little York Road, Suite 300
Houston, TX 77040
800-568-4000 or 713-849-7000

For technical assistance, contact:
Union Carbide Heat Transfer Laboratory
3200 Kanawah Turnpike, Building 770
South Charleston, WV 25303
800-UCC-HTFS or 800-822-4837
**Emergency Service**

Union Carbide maintains a 24-hour emergency service for its products. The Chemical Manufacturers Association (CHEMTREC), Transport Canada (CANUTEC), and the National Chemical Emergency Center also maintain 24-hour emergency service:

<table>
<thead>
<tr>
<th>Location</th>
<th>Union Carbide Products</th>
<th>All Chemical Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainland, United States and Puerto Rico</td>
<td>Phone Union Carbide HELP: (800) UCC-HELP (toll-free), i.e., (800) 822-4357</td>
<td>Phone CHEMTREC: (800) 424-9300 (toll-free)</td>
</tr>
<tr>
<td>Alaska and Hawaii</td>
<td>Phone Mainland United States: (304) 744-3487 (collect)</td>
<td>Phone CHEMTREC: (800) 424-9300 (toll-free)</td>
</tr>
<tr>
<td>Canada</td>
<td>Phone Union Carbide: (514) 640-6400 (collect)</td>
<td>Phone CANUTEC: (613) 996-6666 (collect)</td>
</tr>
<tr>
<td>Continental Europe, Ireland, Middle East, North and Central Africa</td>
<td>Phone BIG (Geel-Belgium): (32)(0) 14 58-45-45</td>
<td>Phone CHEMTREC (United States): (703) 527-3887 (collect)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Phone National Chemical Emergency Center (Culham–UK): (44)(0) 1865-407-333</td>
<td>Phone CHEMTREC (United States): (703) 527-3887 (collect)</td>
</tr>
<tr>
<td>Latin America, Asia/Pacific, South Africa, and any other location worldwide</td>
<td>Phone United States: (304) 744-3487 (collect)</td>
<td>Phone CHEMTREC (United States): (703) 527-3887 (collect)</td>
</tr>
</tbody>
</table>

At sea, radio U.S. Coast Guard, who can directly contact Union Carbide HELP. . . (800) 822-4357 (toll-free) or CHEMTREC. . .(800) 424-9300 (toll-free).

DO NOT WAIT. Phone if in doubt. You will be referred to a specialist for advice.