Rhodia Water

Performance Biocides in Industrial Applications
Rhodia

Rhodia is a global specialty chemicals manufacturer with a streamlined organization focused around nine Enterprises, holding strong technological positions in applications chemistry, specialty materials and services as well as fine chemicals. Rhodia subscribes to the principles of sustainable development.

As a strategic partner to the world’s leading companies in the automotive, electronics, fibers, pharmaceuticals, agrochemicals, food, consumer care, tires, paint and coating markets, Rhodia combines molecules and innovative technologies to deliver custom solutions tailored to its customers’ unique challenges.

Rhodia’s Phosphorus and Performance Derivatives (PPD) enterprise is dedicated to bringing quality products based on phosphorus technology to our customers. Our extensive product portfolio is organised around three business units; Rhodia Water, Performance Products and Industrial Intermediates.

Further details on Rhodia’s vision, identity and strategy can be found on our web site:

http://www.rhodia.com

Rhodia Water

Rhodia Water specialises in the marketing of technologies to solve problems of water clarity, scale formation, corrosion and microbiological fouling in the industrial and waste water markets. Our customers enjoy the benefits of improved process efficiency and have the solutions to comply with the ever increasing legislative demands for environmental protection, conservation and improved human health in the use of water. Our extensive product range is targeted at a wide range of applications including:

- Oilfield
- Process Water
- Waste Water

This brochure illustrates our premier technology Tolcide® PS, the high performance solution for industrial biocide applications.
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Key Features

- Exceptionally rapid acting, potent microbiocide
- Favourable environmental profile
- Biodegradable and non-bioaccumulative
- On discharge, rapidly breaks down to environmentally benign products
- Water soluble, insoluble in oils
- Non-foaming
- Effective over pH range
- Halogen free
- Easily analysed using a simple field test method
- Extensive formulation options

In summary, Tolcide\(^{\circledR}\) PS presents industrial users with a rapid acting, broad spectrum, flexible and environmentally sensitive solution to microbiological problems.

Tolcide\(^{\circledR}\) PS contains the active ingredient tetrakishydroxymethyl phosphonium sulphate.
<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Rapid acting, powerful microbiocide</td>
<td>• Effective control over a wide range of micro-organisms</td>
</tr>
<tr>
<td>• Concurrently dissolves iron sulphide</td>
<td>• Simultaneously protects systems from microbiological activity and iron sulphide problems in industrial water applications</td>
</tr>
<tr>
<td>• Particularly effective against troublesome micro-organisms such as</td>
<td>• Improves system efficiency, safety and operational integrity</td>
</tr>
<tr>
<td>- sulphate reducing bacteria (SRB)</td>
<td></td>
</tr>
<tr>
<td>- <em>Legionella pneumophila</em></td>
<td></td>
</tr>
<tr>
<td>- algae (unicellular and filamentous)</td>
<td></td>
</tr>
<tr>
<td>- aerobic and anaerobic bacteria</td>
<td></td>
</tr>
<tr>
<td>• Effective at low dose rates</td>
<td>• Economical in use</td>
</tr>
<tr>
<td>• Low aquatic toxicity</td>
<td>• Ideal for use in environmentally sensitive applications</td>
</tr>
<tr>
<td>• Degrades to virtually inert components</td>
<td>• Reduced risk to people and the environment</td>
</tr>
<tr>
<td>• Flexible formulation options</td>
<td>• Tailor made solutions to fit a variety of applications and requirements</td>
</tr>
<tr>
<td>• Comprehensively supported by a growing number of registrations</td>
<td>• Applicable to an increasing number of global markets</td>
</tr>
<tr>
<td>• Simple field test</td>
<td>• On-site monitoring, tracking and control</td>
</tr>
<tr>
<td>• Manufactured to ISO 9002</td>
<td>• Quality assurance</td>
</tr>
</tbody>
</table>

These benefits, together with Rhodia’s ongoing technical development, ensure there is no better choice for the oilfield, industrial water and paper industries.
Oilfield Applications and End User Benefits

Tolcide® PS has become firmly established as the product of choice in the oilfield industry, where its multifunctional behaviour in controlling sulphate reducing bacteria and dissolving iron sulphide has delivered significant operational, cost and environmental benefits:

Applications
- Water injection systems
- Top-side separation
- Transmission lines
- Fracturing and stimulation fluids
- Hydrostatic testing

Iron Sulphide Dissolution

Field experience has shown substantial operational savings can be achieved through the control of iron sulphide (FeS) deposits. Tolcide® PS combines with FeS to form a soluble and stable complex without the release of H₂S gas or colloidal sulphur:

Benefits include:
- Improved productivity and injectivity
- Enhanced water/oil separator performance
- Reduced formation plugging and lower operational costs
- Reduced corrosion
- Extended filter life on water re-injection systems

Microbiological control

Tolcide® PS is highly effective in controlling sulphate reducing bacteria (SRB) that contribute toward downhole souring and the generation of hydrogen sulphide - a flammable, corrosive and toxic gas. Tolcide® PS also has low environmental impact and can be de-activated prior to discharge when necessary.
Industrial Water Applications and End User Benefits

The Tolcide® PS range is particularly suitable for industrial water treatment applications in the control of micro-organisms which can reduce system efficiency, damage equipment and create health risks.

Applications

- Open evaporative cooling towers
- Re-circulating water systems
- Process water treatment

Microbiological control

Tolcide® PS provides effective and efficient control over a wide range of aerobic and anaerobic bacteria found in industrial water systems. Importantly, Tolcide® PS has been widely recognised as being effective against bacteria of the *Legionella sp.* through extensive independent tests.

Before

![Before](image1)

After

![After](image2)

Algae

Tolcide® PS has been successfully deployed to clean up fouled systems such as this process water lagoon at a textile mill contaminated with algae.

Benefits include:

- Improved plant efficiency and cleanliness
- Product optimisation through a simple field test method
- Compatible with most other water treatment chemicals at use concentrations
- Can be formulated with biodispersants to aid penetration and dispersion of biofilms
Pulp and Paper Applications and End User Benefits

The increasing trend toward water re-cycling and the drive toward environmentally friendly technologies has placed greater focus on the selection of biocides in the Pulp and Paper industry. Tolcide® PS provides important applications benefits and is fully supported by recent US FDA and German BgVV product registrations.

Applications

- Paper stock and broke
- Whitewater slimicide
- Odour control
- Short term preservation of paper additives
- Catalase control in de-inking plants

Benefits include:

- Enhanced protection of stock and paper additives from spoilage
- Reduced risk to man and the environment
- Improved efficiency in de-inking plants
- Improved mill environment compliance through the control of malodours (H₂S and volatile fatty acids)
- Product performance unaffected by the presence of H₂S
- Improved environmental performance through control of malodours
- Compliant with the requirements of Nordic White Swan approval
- Greater production flexibility

Microbiological control

Tolcide® PS delivers outstanding performance over a wide range of micro-organisms and is particularly effective against slime-forming bacteria, yeast and moulds, which give rise to significant operational difficulties in the mill environment.
Environmental Profile

Low Ecotoxicity to Aquatic Species

<table>
<thead>
<tr>
<th>Freshwater Species</th>
<th>Result (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainbow trout</td>
<td>119 (96hr LC50)</td>
</tr>
<tr>
<td>Bluegill sunfish</td>
<td>93 (96hr LC50)</td>
</tr>
<tr>
<td>Daphnia magna</td>
<td>19 (48hr EC50)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Marine Species</th>
<th>Result (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheepshead minnow</td>
<td>94 (96hr LC50)</td>
</tr>
<tr>
<td>Juvenile plaice</td>
<td>86 (96hr LC50)</td>
</tr>
<tr>
<td>Brown shrimp</td>
<td>340 (96hr LC50)</td>
</tr>
<tr>
<td>Mysid shrimp</td>
<td>9.5 (96hr LC50)</td>
</tr>
</tbody>
</table>

Waste water management | Result (mg/l) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated sludge</td>
<td>24 (3 hr EC50)</td>
</tr>
</tbody>
</table>

Tolcide® PS is typically applied at concentrations below the product level toxic to fish.

Readily Biodegradable

- As Defined by US EPA, FIFRA 40 CFR, Part 158, Subdivision N, Series 162-4, the active ingredient in Tolcide® PS is considered to be readily biodegradable

Does Not Bioaccumulate

- Negative octanol-water partition co-efficient

Halogen Free

- No contribution to adsorbable organic halide (AOX), Trihalomethanes (THM) or dioxins

A key advantage of Tolcide® PS is its positive environmental profile, making this technology an excellent choice for systems located in or near ecologically sensitive areas. Rhodia has chosen to invest in the future of this core technology in line with the company’s commitment to sustainable development. Abstracts from our comprehensive data library are illustrated opposite.
Degradation in the Environment

Tolcide® PS degrades in the environment to by products that pose minimal risk to ecological life making this technology ideally suited for environmentally sensitive applications.

At Tolcide® PS concentrations of less than 1 ppm, degradation occurs in a matter of minutes.

Degradation occurs by a combination of hydrolysis, oxidation, photodegradation and biodegradation.

De-activation prior to discharge

Several applications such as hydrostatic testing in the oilfield industry require complete de-activation of biocides prior to discharge into the environment. In the case of Tolcide® PS, a number of processes are effective in facilitating this degradation including de-activation with hydrogen peroxide.

THPO Toxicity

<table>
<thead>
<tr>
<th>Species</th>
<th>Test</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainbow trout</td>
<td>96 hr. LC50</td>
<td>&gt;5000 mg/l</td>
</tr>
<tr>
<td>Daphnia magna</td>
<td>48 hr. EC50</td>
<td>&gt;1000 mg/l</td>
</tr>
<tr>
<td>Skeletonema costatum</td>
<td>72 hr. EC50</td>
<td>2090 mg/l</td>
</tr>
</tbody>
</table>
Investing for the Future

Since Rhodia first discovered and patented the unique properties of the Tolcide® PS range of products, we have made significant investments in new manufacturing capacity, product quality, data support and applications know-how in order to better meet the needs of our customers.

Today, Rhodia has established a global leadership position and continues to invest in the future of this strategically important technology.

Manufacturing and Product Quality

Rhodia leads the way in the manufacture and marketing of phosphorus and performance derivatives, with production sites located in Europe and Asia. Tolcide® PS is manufactured to the highest quality assurance standards critical to support product registrations in an increasing number of global markets.

Patents

Rhodia holds and vigorously supports a number of world-wide patents for the use of Tolcide® PS in water treatment applications which extend until 2020, including several patents pending. Potential customers should contact the nearest Rhodia Water location in case of questions.

Future

In line with a leadership position in phosphorus derivatives, Rhodia plans to commit resources to the development of the Tolcide® PS range of products to secure the long term future of this important technology.

Applications Development

Research into new applications for Tolcide® PS such as waste water treatment and other industrial uses is an important driver for future growth. Accelerating the pace of innovation through customer partnerships is a primary focus within Rhodia.
Rhodia has achieved registrations for the Tolcide® PS product line and active ingredient across a wide range of markets and applications.

Rhodia is the sole registrant for Tolcide® PS products with the US EPA (under FIFRA) and Biocidal Products Directive (BPD) in Europe.

- U.S. Presidential Green Chemistry challenge award
- U.S. Environmental Protection Agency Registration
- Satisfies Criteria for Nordic Region
  - White Swan Approval
- U.K. Department of Environment Off-shore Chemical Notification Scheme
- Approved western Australian Environmental Protection Agency
- U.S. FDA (listed for use as a slimicide in the manufacture of paper and paperboard that comes into contact with food)
  - German BgVV Approval
Product Range

Rhodia has developed several novel Tolcide® PS formulations designed to enhance performance and assist in the disruption and dispersion of biofilms. This expertise has produced a number of patented synergistic formulations based on blends with surfactants, polymers, quaternary and polyquaternary ammonium salts.

Customised formulations to solve specific customer problems can be made available using Rhodia’s asset capabilities.

Full details of the Tolcide® PS range are available from Rhodia (please see back page for contact details).

Technical Support

Rhodia’s technical support is focused on a unique combination of industry expertise, application know-how and an extensive library of product technical data.

- Extensive operational experience across a broad industrial spectrum
- Highly skilled team capable of handling field trial support for new applications
- Off-shore support capabilities
- Formulation development and technical support
- Fully fitted and accredited Category 2 Microbiological Laboratory
- Regionally based team of industry experts in the US, Europe and Asia
Appendix 1

Mode of Action

Extensive research into the mechanism of Tolcide® PS has conclusively shown the product causes rapid and severe damage to the cell membrane of target micro-organisms.

In addition, Tolcide® PS is a potent inhibitor of lactate dehydrogenase which is a crucial enzyme in the metabolic pathway for SRB.

Extensive field experience and laboratory studies has shown no evidence of resistance to SRB.

Significant disruption to the structural integrity of the bacterial cell has occurred. Analysis of the surrounding water phase has detected components lost from the cell which are essential to its vital activities. These include:

- Nucleic acids needed for replication and protein synthesis
- Adenosine nucleotides required for maintaining the energy balance in the cell

In conclusion, Tolcide® PS is an excellent choice for systems requiring rapid control of microbiological activity.
Appendix 2

Performance Data

Tolcide® PS is extremely effective against a wide range of micro-organisms including algae and bacteria. Data below generated from laboratory quantitative suspension tests, show the concentrations of Tolcide® PS and contact times required to achieve a 4 log reduction in surviving bacteria. Algal data refers to concentrations required to achieve 100% control.

Quantitative Suspension Test Data (QST)

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Ref No</th>
<th>Contact time (Hours)</th>
<th>THPS conc mg/litre (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacillus cereus</td>
<td>ATCC 11778</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Desulfovibrio vulgaris</td>
<td>NCTC 8306</td>
<td>2</td>
<td>80</td>
</tr>
<tr>
<td>Enterobacter aerogenes</td>
<td>NCTC 10006</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>NCTC 8196</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>ATCC 9027</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Pseudomonas cepecia</td>
<td>Wild Strain</td>
<td>6</td>
<td>25</td>
</tr>
</tbody>
</table>

Algae

<table>
<thead>
<tr>
<th>Algal Species</th>
<th>Ref No</th>
<th>Contact time (Hours)</th>
<th>THPS conc mg/litre (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anacystis nidulans</td>
<td>Wild Strain</td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td>Chlorella emersonii</td>
<td>Wild Strain</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>Phormidium laminosum</td>
<td>Wild Strain</td>
<td>4</td>
<td>27</td>
</tr>
</tbody>
</table>

More performance data against other micro-organisms is available on request.

Microbiological Screening

Customers are advised to use the QST or Minimum Biocide Concentration (MBC) methods for the screening of Tolcide® PS products in lab tests. Minimum Inhibitory Concentration (MIC) methods are not suitable for this technology.

Technical bulletins advising on the preferred test methods and generation of stock solutions are available to customers.
DISCLAIMER

The information contained in this document is, to the best of Rhodia’s knowledge and belief, correct based on general industrial experience. Customers must satisfy themselves the product is suitable for their purposes and conditions of use and their facilities are suitable for handling or using the product. Accordingly Rhodia disclaims any liability for loss, injury or damage which may result from use of the product, or from information contained in this brochure, save as may be expressly agreed under its terms of sale. Customers must take account of the product label and any associated material safety data sheet and are reminded there may be uses or applications for the product which are protected by Rhodia’s or third parties’ patent rights and nothing herein may be construed as an authority to use or apply the product in contravention of such rights.