Metal Ion Control for Hard Surface Cleaners
VERSENE™ Chelating Agents Control Reactive Metal Ions and Improve Cleaning Performance
Water hardness ions (primarily calcium and magnesium) as well as iron, copper, and manganese ions pose a significant threat to the cleaning performance of hard surface cleaners. That’s why VERSENE™ chelating agents are an essential component of these formulations.

Chelating agents such as VERSENE products, often referred to as “sequestering agents,” “builders,” “co-builders,” or “water conditioners,” are designed to provide effective control of trace metal ions, the source of which can be local water supplies, soils, and raw materials in the formulation. By controlling undesirable metals, VERSENE chelating agents may perform several critical functions in cleaning products. First, VERSENE chelating agents promote dissolution of scale, stone, and scum from hard surfaces. Hard water scales can be effectively cleaned with the use of VERSENE chelating agents in your formulation. They will even dissolve hard water precipitates of soaps. Second, they provide water conditioning—control of the water hardness, which affects detergency, clarity and rinsability. Third, VERSENE chelating agents control trace metal ions which may lead to degradation of the product’s fragrance and color. Fourth, VERSENE chelating agents can stabilize peroxygen bleaches in specialty formulations.

The three Dow chelating agents most commonly used in cleaning formulations are VERSENE 100 (EDTA—tetrasodium ethylenediaminetetraacetic acid), VERSENOL™ 120 (HEDTA—trisodium N-[hydroxyethyl] ethylenediaminetriacetate), and VERSENEX™ 80 (DTPA—pentasodium diethylenetriaminedipentacetic acid) chelating agents. Their structures can be seen in Figure 1.

The family of VERSENE chelating agents includes products designed for liquid or dry formulations. Among cleaning products whose performance is enhanced by VERSENE chelating agents are bathroom cleaners, dishwashing liquids, bar soaps, glass cleaners, disinfectant cleaners, automotive cleaners, floor cleaners, metal cleaners, and other household and institutional cleaners.

Why Metal Ions are a Threat to Cleaning Product Effectiveness

Metal ions are a pervasive threat to cleaning product effectiveness. These contaminants are commonly present in water sources, formulation raw materials, soils, and on the substrate to be cleaned. What’s more, metal ions react readily with many formulation ingredients.

Left unchecked, metal ions can hinder the effectiveness of cleaning products in several ways. Metal ions can reduce the effectiveness of anionic surfactants by forming salts that are often insoluble. Metal ions can also combine with various soils—such as lipid residues and clays—to form less dispersible residues that adhere strongly to host surfaces. Metal ions also comprise a large portion of many soils.

Low levels (ppm) of metal ions can cause rapid decomposition of peroxygen bleaches, resulting in reduced bleaching power. These ions also contribute to product discoloration and clouding.

How VERSENE Chelating Agents can Help

By deactivating metal ions, VERSENE chelating agents improve detergency, clarity, rinsability, and bleach stability. This high degree of metal ion control is particularly important in areas with hard water. VERSENE chelating agents form strong, soluble complexes with metal ions on an equimolar basis.

While controlling metal ions, VERSENE chelating agents provide builder properties to improve the performance of other system components. For example, VERSENE chelating agents increase the efficiency of anionic surfactants and prevent spotting problems by effectively tying up metal ions and preventing precipitation or redeposition. Formulation foaming characteristics and clarity of liquid products can also be enhanced when VERSENE products are incorporated.

VERSENE chelating agents contribute to improved rinsability by preventing hardness ions in water from combining with soils and forming hard-to-remove residues, thus enhancing the ability of the formulation to remove soils and stains. Figure 2 shows that EDTA controls calcium ions more effectively than citrates and pyrophosphates over a broad pH range.

In addition to controlling hardness ions in water, use of VERSENE chelating agents in soap or cleaner formulations containing phenolic or quaternary germicides improves hard water germicidal performance—especially important for institutional cleaners.

Figure 1: Structures of EDTA, DTPA, and HEDTA

Ethylenediaminetetraacetic acid (EDTA)

\[
\text{HO-C-CH}_2 \xrightarrow{N} \text{CH}_2\text{CH}_2\text{N} \xrightarrow{CH}_2\text{C-OH}
\]

Diethylenetriaminepentaacetic acid (DTPA)

\[
\text{HO-C-CH}_2 \xrightarrow{N} \text{CH}_2\text{CH}_2\text{N} \xrightarrow{CH}_2\text{C-OH}
\]

N (Hydroxyethyl) ethylenediaminetriacetic acid (HEDTA)

\[
\text{HO-C-CH}_2 \xrightarrow{N} \text{CH}_2\text{CH}_2\text{N} \xrightarrow{CH}_2\text{C-OH}
\]

Structures of EDTA, DTPA, and HEDTA
Why VERSENE™ Products are the Best Choice for Metal Ion Control

VERSENE chelating agents can offer more effective control of harmful metal ions than phosphates, citric acid, and other alternatives available to cleaning product formulators.

VERSENE chelating agents are very selective and highly efficient at very low concentrations and over a wide pH range. This means that, compared to other metal ion control agents, less material is required to meet your formulation needs.

Better pH and Heat Stability for System Compatibility, Plus More Reliable Protection

The complexes formed by some chelating agents can break down during processing and storage of cleaning products, as well as during end use, releasing metal ions to react with soils or with the surfactant or other components of the cleaning product system. Common phosphates such as STPP tend to hydrolyze and break down in aqueous systems at elevated temperatures, while citric acid forms relatively weak bonds with metals. In contrast, VERSENE chelating agents are stable up to 400°F and bond strongly with metals.

An important measure of the efficiency of metal ion control agents is the stability constant of the complexes they form with the metal ions.

The higher the stability constant, the stronger the complex formed and the more efficiently the metal ions are controlled. Figure 3 shows that EDTA complexes of iron and copper are much more stable than pyrophosphate and citric acid complexes. In addition, the EDTA complexes retain their stability over a wider pH range.

In practical terms, the higher stability of VERSENE chelating agent and metal complexes means better protection for the performance, clarity (in the case of liquid cleaners), quality, shelf life, and value of your products. This higher stability translates into more effective removal of scales and soils, too.

Effectiveness of VERSENE Products

Results from Basic Chemistry

Soluble trace metals are introduced into cleaning formulations by water and soils as positively charged ions.
Copper, iron, calcium, magnesium, and manganese ions have from four to six reactive sites that can react with formulation raw materials, leading to problems. VERSENE™ chelating agents form strong, water-soluble complexes with metal ions.

Figure 4 illustrates how an EDTA molecule can block up to six reactive sites on a metal ion, deactivating the ion (HEDTA and DTPA molecules perform similarly). VERSENE chelating agents produce more stable complexes than other materials because they form strong five-membered ring structures – even at higher temperatures and over a wide pH range. In cleaning products, this can translate into better shelf life or improved cleaning under use conditions. In comparison, other metal ion control agents used in cleaning products may form relatively weak or unstable complexes, or they may precipitate out of liquid systems over time.

Better Binding Strength for More Effective Cleaning

Figure 5 shows the relative binding strength of VERSENE chelating agents and other chelants vs. five common soils. Tripolyphosphate, and citrate do not have the strength to remove all of the soils shown, but VERSENE chelating agents (EDTA) are far superior to even the strong calcium stearate precipitate. Experienced formulators know that an effective cleaner needs EDTA for effective product performance with gentle surface care.

Selecting the Right VERSENE Product

Figure 6 provides basic formulation guidelines for using VERSENE chelating agents to control specific metals-related problems in cleaning applications.

Formulation Notes

VERSENE chelating agents are highly soluble in neutral to basic solutions, but solubility is poor in highly acid solutions. Solubility of the acid form in water is approximately 0.05%. The acid product must be neutralized with base to make it soluble in aqueous solutions.

Improved solubility can be achieved at slightly acid pH by using ammonium salts of VERSENE chelants rather than the sodium salts. Diammonium and tetraammonium products are available. VERSENE chelating agents are not soluble in organic solutions.

The Complete Package of Support from Dow

When you choose a VERSENE chelating agent, you get much more than just a quality product. You get the extra support you need – where and when you need it. Included are:

The Exclusive PIMIC™ Computer Modeling Service

When it comes to identifying the optimum solution to your metals problem, only Dow can call on the sophisticated PIMIC computer modeling service for help. This exclusive Dow service is based on a powerful proprietary computer program that constructs a model of your system, then applies the principles of solution equilibrium chemistry to
predict and help optimize the behavior of various chelating agents in it. The program draws on a database of more than 2,700 equilibrium reactions and can model the behavior of 45 metals with multiple oxidation states, 26 anions, and 96 different chelating agents.

**Dow’s Unmatched Technical Service and Support**

With more than 30 years experience providing metal ion control solutions, we’re equipped to help you identify, implement, and maintain the most cost-effective answer to your metals problem. Our team of chelant experts is prepared to work with you each step of the way to:

- Help you decide if metals should be investigated in your system.
- Employ our PIMIC service to define the problem, then help identify the best solution.
- Establish optimum chelant addition points and use levels for your system.
- Fine-tune your chelant program to achieve cost-effectiveness.
- Provide the ongoing support you need, including enhanced product stewardship services.

**Comprehensive Technical and Application Literature**

For detailed information on safety and handling considerations for VERSENE™ products, we provide Material Safety Data Sheets (MSDS) for each product. Call 1 (800) 447-4369 to obtain copies of the current MSDS or visit www.versene.com.

**High Quality VERSENE Chelating Agents and Dow Support set us Apart**

VERSENE (EDTA), VERSENEX™ (DTPA), and VERSENOL™ (HEDTA) chelating agents, together with our comprehensive supporting services, represent a complete package of value that sets VERSENE products apart from all the rest.

### Specifications and Properties of VERSENE Products

<table>
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<tr>
<th>Specifications</th>
<th>VERSENE 100&lt;sup&gt;1&lt;/sup&gt;</th>
<th>VERSENE 220</th>
<th>VERSENOL 120</th>
<th>VERSENEX 80</th>
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<tbody>
<tr>
<td>Chelation value&lt;sup&gt;2&lt;/sup&gt;, min. (mg CaCO&lt;sub&gt;3&lt;/sub&gt;/g)</td>
<td>102</td>
<td>219&lt;sup&gt;4&lt;/sup&gt;</td>
<td>120</td>
<td>80</td>
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<tr>
<td>Active ingredients, min.</td>
<td>39%</td>
<td>99%&lt;sup&gt;3&lt;/sup&gt;</td>
<td>41.3%</td>
<td>40.2%</td>
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<tr>
<td>Specific gravity (at 25/25 °C)</td>
<td>1.290-1.325</td>
<td>---</td>
<td>1.26-1.31</td>
<td>1.28-1.32</td>
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<tr>
<td>APHA color, max.</td>
<td>200</td>
<td>200&lt;sup&gt;6&lt;/sup&gt;</td>
<td>300</td>
<td>250</td>
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<tr>
<td>pH</td>
<td>11.0-11.8</td>
<td>10.5-11.5</td>
<td>11.0-11.8</td>
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<table>
<thead>
<tr>
<th>Properties</th>
<th>VERSENE 100&lt;sup&gt;1&lt;/sup&gt;</th>
<th>VERSENE 220</th>
<th>VERSENOL 120</th>
<th>VERSENEX 80</th>
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<tbody>
<tr>
<td>Appearance</td>
<td>light straw-colored liquid</td>
<td>white crystal-line powder</td>
<td>light straw-colored liquid</td>
<td>light straw-colored liquid</td>
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<tr>
<td>Molecular wt. of active ingredient</td>
<td>380.2</td>
<td>452.2</td>
<td>344.2</td>
<td>503.1</td>
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<td>Freeze pt. (°C)</td>
<td>&lt; -30&lt;sup&gt;7&lt;/sup&gt;</td>
<td>---</td>
<td>&lt; -30</td>
<td>&lt; -30</td>
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<tr>
<td>Bulk density (lb./gal.)</td>
<td>10.9</td>
<td>45&lt;sup&gt;8&lt;/sup&gt;</td>
<td>10.7</td>
<td>10.8</td>
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<tr>
<td>Sol. in water (wt. % at 25 °C)</td>
<td>100</td>
<td>48-50</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Phys. form</td>
<td>Aqueous solution</td>
<td>Dry crystals</td>
<td>Aqueous solution</td>
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<sup>1</sup> Typical properties, not to be construed as product specifications

<sup>2</sup> Also available is VERSENE 100 XL chelating agent, a high-purity alternative to VERSENE 100 chelating agent containing low levels of NTA

<sup>3</sup> Determined by oxalate titration

<sup>4</sup> As Na<sub>4</sub>EDTA•4H<sub>2</sub>O

<sup>5</sup> At 30% aqueous solution

<sup>6</sup> At pH 11

<sup>7</sup> Precipitation of Na<sub>4</sub>EDTA•4H<sub>2</sub>O

<sup>8</sup> lb./ft.³
Interested in Learning More?

To learn more about VERSENE™ chelating agents and our supporting services, call us toll-free at +1 (800) 447-4369 or visit www.versene.com. We’ll be happy to answer your questions, provide additional literature, and send samples of VERSENE products for your evaluation.

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<th>The Dow Chemical Company</th>
<th>U.S.</th>
<th><a href="http://www.versene.com">www.versene.com</a></th>
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