



Chelating Agents

VERSENE™, VERSENEX™, AND VERSENOL™

Effective, Economical Metal Ion Control

Product Overview and Selection Guide





Almost any aqueous system can be affected by uncontrolled metal ions

Uncontrolled metal ions in your product or process can eat away profits by causing scaling, chemical degradation, discoloration, precipitation, emulsion instability, rancidity, and a host of other problems. In products, soluble metal ions accelerate chemical reactions which reduce quality, consumer appeal, shelf-life, and ultimate value. In processes, uncontrolled metal ions hamper process efficiency and increase equipment downtime.

Since trace amounts of soluble iron, copper, manganese, calcium, and other metals occur naturally in many raw materials, the potential for scaling

and undesirable metal-catalyzed reactions is widespread. These metal ions are normally found in processing water, and can also be introduced during processing.

Food and beverage products are vulnerable to metal-catalyzed spoilage and discoloration

Even in concentrations as low as 0.05 ppm, metal ions can cause spoilage, rancidity, discoloration, off-odors, off-flavors, and shortened shelf-life in foods. Metal ions also catalyze the oxidative degradation of fats and oils. Emulsified products are particularly sensitive. In products such as salad dressings, mayonnaise, sauces, and

spreads, as little as 0.5 to 1.0 ppm copper or iron can lead to color changes, off-flavors, and emulsion instability.

Another familiar example is the discoloration of white potatoes which begins when iron in the potato reacts with phenolic compounds during cooking. In canned seafood, naturally high levels of copper, zinc, tin, and iron combine with organics to cause discoloration, off-flavors, and off-odors. Uncontrolled metal ions also lead to problems in food processing equipment by causing scaling.

Cleaning and laundering products can be rendered ineffective by metal ions in hard water

Metal ions have long plagued formulators of soaps, detergents, and cleaning formulations. One of the major challenges is producing formulations that provide good cleaning performance and rinsability when used with hard water. Metal ions can also reduce shelf-life and cause cloudiness in liquid cleaning products and detergents. In combined detergent and disinfectant formulations, metal ions can inhibit germicidal performance.

Applications where metal ions cause problems

- Agriculture
- Cleaning products and detergents
- Food and beverage
- Metalworking
- Oilfield applications
- Personal care products
- Pharmaceuticals
- Polymerization
- Pulp and paper
- Scale removal and prevention
- Textiles and fabric care
- Water treatment

Metal ions shorten shelf-life and hamper performance in personal care products

Metal ion reactions can seriously affect the quality, performance, consumer appeal, and shelf-life of personal care formulations. Oil-in-water emulsions such as creams, lotions, deodorants, and ointments are subject to metal-catalyzed oxidation and rancidity. In shampoos and soaps, metal ions can cause turbidity and reduce shelf-life.

Without provisions to control metal ions, these products can also exhibit poor detergency and lathering characteristics when used with hard water.

In pulp and paper processing, metal ions reduce bleaching efficiency and cause brightness reversion

Traces of heavy metals, which occur naturally in wood fibers and processing water, work against the best efforts of pulp and paper mills to produce brighter, whiter papers. Uncontrolled, these metal ions reduce the effectiveness of hydrosulfite and hydrogen peroxide bleaches used to brighten pulps. As a result, it takes more bleach to achieve and maintain the desired level of brightness. Because bleach chemicals are relatively expensive, pulp and paper mills have long worked to control metal ions through chelation chemistry.

Metal ions cause scaling and sludge deposits in water systems

Wherever water is used as a processing or heat exchange medium, metal ion reactions can lead to problems – boilers, heat exchangers, wood pulp digesters, processing equipment and evaporators are just a few examples. Scaling on interior surfaces of equipment is the major problem. Scaling can reduce heat exchange efficiency and increase equipment downtime. Scaling caused by soluble calcium, magnesium, or iron is the most common problem.

Dow chelating agents provide an effective, economical solution to metal ion problems

Chelating agents (also known as sequestering agents) can inhibit undesirable metal-catalyzed reactions by forming complexes with the metal ions. The resulting structure, called a chelate, deactivates the metal ion and prevents it from reacting with other components of the system.

Of the different types of metal ion control agents in use today, Dow chelating agents produce the most stable complexes with metal ions and generally provide the most effective control of metal ion problems. Dow products are aminopolycarboxylic acids available as VERSENE™ EDTA, VERSENOL™ HEDTA, and VERSENEX™ DTPA chelating agents (generically referred to as EDTA, HEDTA, and DTPA). Although often more expensive than other materials on a per-pound basis, Dow chelating agents are frequently the least costly option for metal ion control due to their effectiveness at remarkably low concentrations. Unique advantages of Dow chelating agents include predictable performance, high thermal stability, chemical stability, pH stability, and resistance to bacterial or mold breakdown.



Whenever water is used as a heat transfer or processing medium, salts can deposit to form scale. Dow chelating agents are used successfully to remove calcium and other types of scale and also to prevent scale formation.



Precipitation or cloudiness in liquid products can degrade the consumer appeal, shelf-life, and ultimate value of the product. As shown in the bottle on the right, small amounts of Dow chelating agents prevent these problems by complexing with the metal ions responsible.

How Dow chelating agents control troublesome metal ions

Dow locks problem ions in a highly stable complex

Soluble trace metals in aqueous systems exist as positively charged ions. Each of these ions has a fixed number of reactive sites. Most metal ions have either four or six reactive sites. EDTA, DTPA, and HEDTA have six, eight, and six metal-complexing sites respectively, enabling one molecule to interact with all the reactive centers of a metal ion. NTA has four metal complexing sites, enabling one molecule to interact with the majority of the reactive centers of a metal ion.

Figure 1 illustrates how VERSENE™ EDTA can block up to six reactive sites on a metal ion, completely deactivating the ion. Equally important, the intrinsically strong, five-membered ring structures in this complex are highly stable even under heat, light, and pH extremes. This can translate into trouble-free processing and better protection for products, even in adverse conditions. By comparison, other metal ion control agents, such as phosphates and citrates, may form relatively weak complexes with metal ions and can't always provide the protection you need.

Effective at remarkably low concentrations, Dow chelating agents can help you reduce operating and material costs

Because they are so efficient, Dow chelating agents can often provide the protection you need at much lower concentrations than citric acid, phosphates, or other competitive metal ion control agents. A dramatic example is in treating frozen potatoes to inhibit after-cooking darkening. In this application, 20 times less VERSENE EDTA is required for protection than sodium acid pyrophosphate (SAPP).



Excellent heat and pH stability make Dow chelating agents compatible with most aqueous systems and processes

The complexes formed by many other types of chelating agents can break down during processing and storage of products, releasing metal ions to cause undesirable reactions. Long-chain phosphate molecules also tend to hydrolyze and break down in aqueous systems, particularly at elevated temperatures. In contrast, Dow chelating agents are stable up to, and beyond, 400°F (204°C).

In addition, many chelating agents function within a restricted pH range. Figures 2 and 3 show that EDTA complexes of iron and copper retain their stability over a wider pH range than citric acid and pyrophosphate complexes, making Dow chelating agents compatible over a wide range of processing, storage, and use conditions.

Higher stability means more reliable protection for your product or process

One measure of the efficiency of metal ion control agents is the conditional stability constant of the complex they form with a metal ion. The higher the stability constant, the stronger the complex formed and the more efficiently the metal ions are controlled. Figures 2 and 3 compare the conditional stability constants of complexes formed by VERSENE EDTA, citric acid, and pyrophosphate with iron and copper ions. In each case, EDTA forms the most stable complex. In practical terms, the higher stability of EDTA complexes means better protection for your product or process.

Figure 1: VERSENE EDTA surrounds and immobilizes problem ions in a stable ring structure called a "chelate"

This illustration shows how the EDTA molecule can block up to six reactive sites on a metal ion, completely deactivating the ion. The highly stable ring structures contribute excellent pH, heat, and light stability to these complexes.

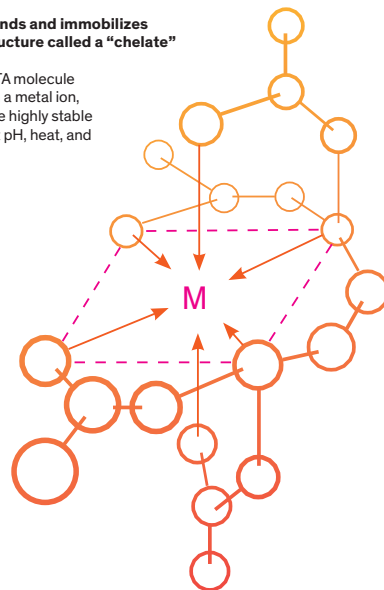


Figure 2: Conditional stability constants for iron with EDTA, citric acid, and pyrophosphate versus pH

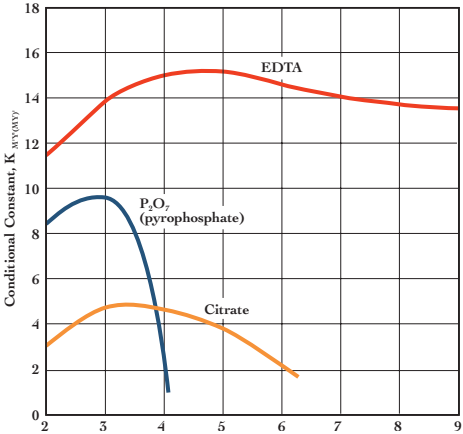
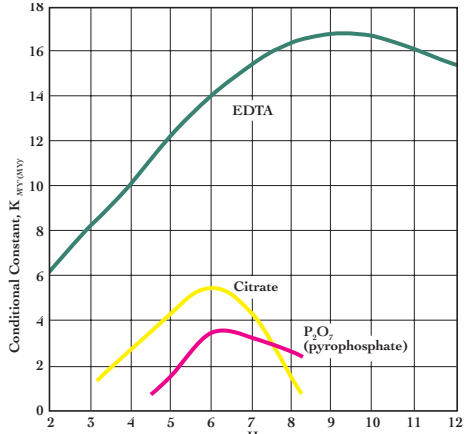


Figure 3: Conditional stability constants for copper with EDTA, citric acid, and pyrophosphate versus pH



These graphs show the EDTA complexes of iron and copper remain stable at high pH levels and are much more stable than citric acid and pyrophosphate complexes. In addition, the EDTA complexes retain their stability over a wider pH range.



Table 1: Common Symptoms of Undesirable Trace-Metal Reactions In Your Product or Process

	APPLICATION	TYPICAL SYMPTOMS	BENEFITS OF USING DOW CHELATING AGENTS
Food & Beverage	Canned seafood products Dressings, sauces, spreads Canned beans Beverages Potato products Pickled vegetables	Discoloration Rancidity Off-odors/off-flavors Precipitation Loss of clarity Deterioration of texture Crystal formation Shortened shelf-life	Protects the natural flavor, color, texture, and nutritive value of your food products Improves shelf-life and consumer appeal Effective at low concentrations, VERSENE™ food-grade EDTA is frequently more economical than citrates or phosphates
Cleaning Products	Heavy-duty laundry detergents Hard surface cleaners	Poor performance in hard water Poor foaming characteristics Poor rinsability Haze formation or precipitation Poor shelf-life Discoloration Rancidity Need to reduce phosphate levels Poor performance of germicides Hard water stains Bathtub ring Dishwater spots	Better foaming, detergency, and rinsing in hard water Helps remove metal oxides and salts from fabrics Enhances shelf-life by inhibiting rancidity, clouding, and discoloration Improved consumer appeal and product value Improved germicidal action USDA approved for many indirect food uses (e.g., sanitizing solutions)
Personal Care Products	Creams, lotions Oils Bar and liquid soaps Shampoos Hair preparations	Poor performance in hard water Poor rinsability Haze formation or precipitation Oxidation, rancidity, or off-odors Viscosity shifts Poor shelf-life Degradation of texture or appearance	Better lathering in shampoos and soaps, particularly in the presence of hard water Improves shelf-life and consumer appeal Prevents softening, brown spotting, and cracking in bar soaps Improves stability of fragrances, fats, oils, and other water-soluble ingredients
Pharmaceuticals	Drug stabilization Antimicrobial booster Antioxidant Preservative	Poor drug performance in presence of hard water	Deactivates metal ions that interfere with drug performance VERSENE food- and pharmaceutical-grade EDTA products comply with USP/NF/FCC requirements
Pulp & Paper	Mechanical pulp bleaching Chemical pulping Reduction of brightness reversion Chemithermomechanical pulping	Poor performance of hydrogen peroxide or hydrosulfite bleaches Problems meeting brightness needs Excessive bleach usage Process scaling Brightness reversion in finished paper	Enhanced effectiveness of sodium sulfite Enhanced effectiveness of hydrogen peroxide and hydrosulfite bleach Higher brightness and/or lower bleaching costs Less need to overbleach to ensure specified brightness level Controls scaling and reduces costly downtime Water-soluble Dow chelating agents are ideal for pulping since water is the processing medium Dow offers a unique system-approach to silicate-free peroxide bleaching—Ask your Dow Sales Representative for more information Dow chelating agents are approved for many indirect food uses (e.g., food wrap paper)
Water Treatment	Boilers Heat exchangers Evaporators Filter cloths Glass-lined kettles	Scale deposits Frequent shut-downs for cleaning Reduced heat transfer efficiency	Dissolves common types of scale during normal operation Effective in off-line and on-line scale removal Improves process efficiency and reduces downtime Works over a wide range of temperatures, pH levels, and pressures

	APPLICATION	TYPICAL SYMPTOMS	BENEFITS OF USING DOW CHELATING AGENTS
Metalworking	Surface preparation Metal cleaning Metal finishing and plating	Drag-in and contamination of succeeding plating baths Poor rinse solution performance at elevated temperatures Oxidation of cleaned iron or steel during storage Streaking after pickling Rough deposits, reduced efficiency, dulling, and unsuitable metal deposition during plating	Improved product performance in hard water Improved rinsability More consistent performance Improved high-temperature performance
Textiles	Preparation Desizing Scouring Bleaching Dyeing	Poor performance of hydrogen peroxide bleach Fabric contaminated with deleterious materials Dye shade change	Deactivates metal ions that interfere with hydrogen peroxide performance Less need to overbleach to ensure specified brightness level Water soluble Dow chelating agents are ideal for metal ion control in textile processes Dye shade stability
Agriculture	Chelated micronutrients Herbicides	Poor performance of herbicides in hard water Plant problems associated with micronutrient deficiencies Micronutrient deficiencies in animal feeds	VERSENOL™ AG Fe is a ready-to-use micronutrient that supplies the trace metal iron, which is vital to the metabolism of plants and animals Excellent water solubility makes metal chelants more readily utilized by plants than the inorganic forms of metals Stabilizes herbicides when formulated or mixed with hard water
Polymerization	Styrene-butadiene polymerization PVC polymerization Stabilization of polymer systems	Poor uniformity in polymerization rates Polymer buildup on reactor walls Coarse, off-grade polymer Polymer breakdown and discoloration Heat and light instability in polymer systems	Stable polymerization rates Reduced polymer buildup in reactors Improved suspending agent performance Better polymer stability and shelf-life
Photography	Developers Bleaches	Scaling in photoprocessors Deposits or scratches on film Silver retention	Reduced scaling Less downtime for scale removal Higher quality prints and negatives Enhanced silver recovery Increased longevity of prints and negatives
Oilfield Applications	Drilling Production Recovery	Formation plugging due to iron precipitation during acidizing and fracturing processes Scaling on well casings from brines normally coproduced with oil Scale buildup, precipitation, and plugging in enhanced oil recovery operations	Prevents plugging, sealing, precipitation by deactivating metal ions Effective over wide temperature and pH range
Scale Removal & Prevention	Boilers Evaporators Heat exchangers Filter cloths Glass-lined kettles	Scale deposits Reduced heat transfer efficiency Reduced flow rates	Removes existing scale deposits Works in combination with other materials to prevent scale formation

Choose from many different VERSENE™, VERSENOL™, and VERSENEX™ products to meet your needs

Dow offers a broad range of Dow chelating agents to meet specific needs. These products include general purpose and specialty VERSENE EDTA products as well as VERSENOL HEDTA products and VERSENEX DTPA products.

Unsurpassed quality and consistency

Quality is the standard achieved by products that give you exactly what you want, every time. That's the standard set by top management for Dow chelating agents. It serves as the driving force behind the people who make and distribute Dow products.

At the heart of this program is a dedicated quality assurance plan that helps us maintain the highest possible quality and consistency for Dow chelating agents. Every aspect of production and distribution is carried out according to a formalized quality control plan which documents each action that must be taken to meet predetermined product specifications.



In textile manufacturing, Dow chelating agents are used to improve hydrogen peroxide bleach performance and to provide dye shade stability.

PRODUCT	PRODUCT AVAILABILITY ²	COMPOSITION	APPEARANCE
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Table 2: Typical Properties¹ of EDTA (ethylenediaminetetraacetic acid)-Based Chelating Agents

VERSENE 100 chelating agent	NLPEIMA	Tetrasodium ethylene-diaminetetraacetate	Amber, light
VERSENE 100 XL	NLPEIMA	Tetrasodium ethylene-diaminetetraacetate	Amber, light
VERSENE 100 LN	NLPE	Tetrasodium ethylene-diaminetetraacetate	Amber, light
VERSENE Diammonium EDTA chelating agent	NLP	Diammonium ethylene-diaminetetraacetate	Light, straw-colored liquid
VERSENE Tetraammonium EDTA chelating agent	NLP	Tetrasodium ethylene-diaminetetraacetate	Light, straw-colored liquid
VERSENE 220 Crystals chelating agent	NLPEIMA	Tetrasodium ethylene-diaminetetraacetate tetrahydrate	White crystalline powder
VERSENE Na ₂ Crystals chelating agent	NLPEIMA	Disodium ethylene-diaminetetraacetate tetrahydrate	White to off-white powder
VERSENE Acid chelating agent	NLPEIMA	Ethylenediaminetetraacetic acid	White powder
VERSENE NA Disodium EDTA chelating agent	NLPEIMA	Disodium ethylene-diaminetetraacetate dihydrate	White to off-white powder
VERSENE CA chelating agent	NLPEIMA	Calcium disodium ethylene-diaminetetraacetate dihydrate	White to off-white powder

EDTA (ethylenediaminetetraacetic acid)-Based Chelating Agents

Our EDTA (ethylenediaminetetraacetic acid)-based chelating agents are the workhorses of our chelating agent product line. The leading product in this lineup is VERSENE™ 100 chelating agent, a general purpose product that is widely used to control common multivalent metal ions to pH 12, iron to pH 8, and water hardness ions above pH 4.

Other products in this series make the basic EDTA chemistry available in diammonium, tetra-ammonium, disodium, and acid forms. Physical forms include liquids, powder, and crystal forms. VERSENE NA Disodium EDTA and VERSENE CA chelating agents are food and pharmaceutical grade EDTA products.

¹ The data provided for these properties are typical values, intended only as guides, and should not be construed as sales specifications.

² N = North America; L = Latin America; P = Pacific; E = Europe; I = India; M = Middle East; A = Africa

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CHELATION VALUE	% ASSAY	MOLECULAR WEIGHT	SPECIFIC GRAVITY (@25/25° C)	BULK DENSITY	pH (1 WT% AQUEOUS SOLUTION)
102 (mg as CaCO ₃ per g)	39 wt% as Na ₄ EDTA	380.2	1.3	10.6 lb/U.S. gal 1270 kg/m ³	11 - 12
102 (mg as CaCO ₃ per g)	38 wt% as Na ₄ EDTA	380.2	1.27	10.5 lb/U.S. gal 1260 kg/m ³	11 - 12
102 (mg as CaCO ₃ per g)	39 wt% as Na ₄ EDTA	380.2	1.3	10.6 lb/U.S. gal 1270 kg/m ³	11 - 12
137 (mg as CaCO ₃ per g)	40 wt% as (NH ₄) ₂ EDTA	328.2	1.2	10 lb/U.S. gal 1200 kg/m ³	4.6 - 5.3
130 (mg as CaCO ₃ per g)	38 wt% as (NH ₄) ₄ EDTA	362.2	1.17	9.8 lb/U.S. gal 1170 kg/m ³	9.0 - 9.5
219 (mg as CaCO ₃ per g)	99.0 wt% as Na ₂ EDTA·4H ₂ O 83.2 wt% as Na ₄ EDTA 64.0 wt% as H ₄ EDTA	452.2	—	45 lb/cu ft 720 kg/m ³	10.5 - 11.5
267 (mg as CaCO ₃ per g)	99.0 wt% as Na ₄ H ₂ EDTA·2H ₂ O 89.4 wt% as Na ₂ H ₂ EDTA 77.7 wt% as H ₄ EDTA	372.2	—	61 lb/cu ft 977 kg/m ³	4.3 - 4.7 4.0 - 6.0 (5 wt% solution)
339 (mg as CaCO ₃ per g)	99 wt% as H ₄ EDTA	292.24	—	54 lb/cu ft 870 kg/m ³	2.5 - 3.0 (saturated solution)
267 (mg as CaCO ₃ per g)	99.0 wt% as Na ₄ H ₂ EDTA·2H ₂ O 89.4 wt% as Na ₂ H ₂ EDTA 77.7 wt% as H ₄ EDTA	372.24	—	61 lb/cu ft 980 kg/m ³	4.3 - 4.7 4.0 - 6.0 (5 wt% solution)
Already a calcium chelate of EDTA	97.0 – 102.0 wt% as CaNa ₂ EDTA·2H ₂ O 91.2 wt% as CaNa ₂ EDTA	410.26	—	40 lb/cu ft 640 kg/m ³	6.5 - 7.5

DTPA (diethylenetriaminepentaacetic acid)-Based Chelating Agents

We offer DTPA (diethylenetriaminepentaacetic acid)-based chelating agents under the trademark VERSENEX™. These products should be considered for use when: 1) the chelant will be used in the presence of oxidizers such as peroxide; 2) when metal chelates of greater stability or solubility are sought; or 3) when VERSENE™ 100 chelating agent has shown limited utility.

HEDTA (N-(hydroxyethyl)-ethylenediaminetriacetic acid)-Based Chelating Agents

VERSENOL™ 120 and VERSENOL 120E chelating agents are the trisodium salts of N-(hydroxyethyl)-ethylenediaminetriacetic acid. They have some unique properties that make them worth considering for use: 1) to control iron at pH 8 – 10; and 2) under more acidic conditions (i.e. low pH) where other chelants are less soluble.

Agricultural Micronutrients

VERSENOL AG micronutrient is a chelated micronutrient that is more readily utilized by plants than are inorganic forms of metals; therefore, less metal is required in the chelate form. This chelating agent is designed to provide trace amounts of iron. VERSENE Acid is a base chelant for micronutrient formulation.

PRODUCT	PRODUCT AVAILABILITY ²	COMPOSITION	APPEARANCE
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Table 3: Typical Properties¹ of DTPA (diethylenetriaminepentaacetic acid)-Based Chelating Agents

VERSENEX 50 chelating agent	NL	Pentasodium diethylenetriaminepentaacetate	Light straw-colored liquid
VERSENEX 80 chelating agent	NLPEIMA	Pentasodium diethylene-triaminepentaacetate	Light straw-colored liquid

Table 4: Typical Properties¹ of HEDTA (N-(hydroxyethyl)-ethylenediaminetriacetic acid)-Based Chelating Agents

VERSENOL 120 chelating agent	NLPEIMA	Trisodium N-(hydroxyethyl)-ethylenediaminetriacetate	Light straw-colored liquid
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Table 5: Typical Properties¹ of Agricultural Micronutrients

VERSENOL AG Fe Chelate fully chelated micronutrient	NLEIMA	Iron disodium N-(hydroxyethyl)-ethylenediaminetriacetate	Dark red-brown liquid
VERSENE Acid chelating agent	NLPEIMA	Ethylenediaminetetraacetic acid	White powder

¹ The data provided for these properties are typical values, intended only as guides, and should not be construed as sales specifications.

² N = North America; L = Latin America; P = Pacific; E = Europe; I = India; M = Middle East; A = Africa

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CHELATION VALUE	% ASSAY	MOLECULAR WEIGHT	SPECIFIC GRAVITY (@25/25° C)	BULK DENSITY	pH (1 WT% AQUEOUS SOLUTION)
97 (mg as CaCO ₃ per g)	40.9 wt% as Na ₅ DTPA	503.1	1.3	11.5 lb./U.S. gal 1376 kg/m ³	11.0-12.0
80 (mg as CaCO ₃ per g)	40.2 wt% as Na ₅ DTPA	503.1	1.3	10.9 lb./U.S. gal 1310 kg/m ³	11.0 -11.8
120 (mg as CaCO ₃ per g)	41 wt% as Na ₃ HEDTA	344.2	1.28	10.7 lb./U.S. gal 1280 kg/m ³	11.0-11.8
—	4.5 wt% as Iron	334.0	1.4	11.6 lb./U.S. gal 1390 kg/m ³	6
339 (mg as CaCO ₃ per g)	99 wt% as H ₄ EDTA	292.24	—	54 lb/cu ft 870 kg/m ³	2.5-3.0 (saturated solution)

Selecting the correct Dow chelating agent

The three-step method discussed below should be a fast and useful technique to determine chelating agents requirements for controlling polyvalent metal ions. It should also be helpful in making quantitative estimates which can be converted into initial process economic estimates. However, unless you are experienced in making the choice of a Dow chelating agent and in determining chelating agent requirements for commercial use, consultation with Dow Technical Service and Development personnel is recommended.

Three-Step Method

Use of the method requires first determining:

- Problem metal ion or ions
- Other metal ions present
- pH of solution
- Concentration of metal ion or ions

Step One: Select Chelating Agent

Using the Metal Ion Control Chart (Figure 4), select the most suitable material. In most applications, VERSENE™ 100 chelating agent should be considered first. Note: Since calcium and magnesium (hardness metal ions) are not chelated below a pH of 4.0, no chelating agents are specified. Above pH 4.0, VERSENE 100 is usually the chelant of choice, although NTA should be considered as an alternative for chelation of hardness ions above pH 9. For ferric (Fe⁺³) ion control above a pH of 8.0, refer to VERSENO™ 120 and/or Triethanolamine 99.

Step Two: Determine Metal Ion(s) to Be Chelated

Using the Metal Chelate Selectivity Displacement Series (Table 6), determine the metals to be chelated. The metal ions are listed in order of chelation: Fe⁺³ before Cu⁺²; Cu⁺² before Ni⁺², etc. Note: If Ca⁺² is the problem metal ion and Cu⁺² is present, Cu⁺² must be inactivated first.

Step Three: Determine Quantity Required

From Table 7 (Parts of Chelating Agent Required to Chelate One Part of Metal), determine the amount of chelating agent needed to control a unit weight of metal [4.7 grams VERSENE 100 for 1 gram Pb⁺²].

Table 8 (Conversion Factors, Chelating Agent Equivalents, page 14), will then be useful to estimate the amount of Dow chelating agent required.

Answers obtained by the three steps should be checked on a limited or laboratory basis. Final adjustments can then be made so the optimum quantity of chelating agent will be used in commercial processes.

Figure 4: Metal Ion Control Chart

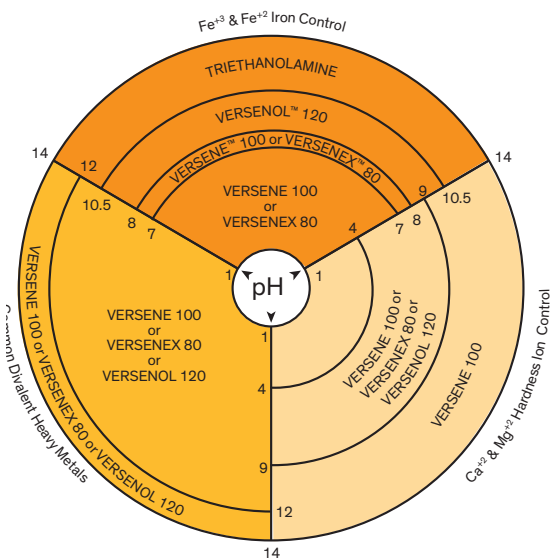


Table 6: Metal Chelate Selectivity (Displacement) Series

V ⁺³	Vanadium	25
Fe ⁺³	Iron (Ferric)	24
In ⁺³	Indium	23
Th ⁺⁴	Thorium	22
Sc ⁺³	Scandium	21
Hg ⁺²	Mercury	20
Ti ⁺³	Titanium	19
Ga ⁺³	Gallium	18
Cu ⁺²	Copper	17
VO ⁺²	Vanadium Oxide	16
Ni ⁺²	Nickel	15
Pd ⁺²	Palladium	14
Y ⁺³	Yttrium	13
Pb ⁺²	Lead	12
TiO ⁺²	Titanium Oxide	11
Zn ⁺²	Zinc	10
Cd ⁺²	Cadmium	9
Co ⁺²	Cobalt	8
Al ⁺³	Aluminum	7
Fe ⁺²	Iron (Ferrous)	6
Mn ⁺²	Manganese	5
V ⁺²	Vanadium	4
Ca ⁺²	Calcium	3
Mg ⁺²	Magnesium	2
Sr ⁺²	Strontium	1
Ba ⁺²	Barium	0



METAL	NAME	VERSENE™ 100	VERSENEX™ 80	VERSENOL™ 120	DIAMMONIUM EDTA	TETRAAMMONIUM EDTA
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Table 7: Parts of Chelating Agent Required to Chelate One Part of Metal

Al ⁺³	Aluminum	36.1	46.4	30.9	27.1	28.5
Ba ⁺²	Barium	7.1	9.1	6.1	5.3	5.6
Cd ⁺²	Cadmium	8.7	11.1	7.4	6.5	6.8
Ca ⁺²	Calcium	24.3	31.2	20.8	18.2	19.2
Co ⁺²	Cobalt	16.5	21.2	14.1	12.4	13.1
Cu ⁺²	Copper	15.3	19.7	13.1	11.5	12.1
Fe ⁺³	Iron (Ferric)	17.5	22.4	14.9	13.1	13.8
Fe ⁺²	Iron (Ferrous)	17.5	22.4	14.9	13.1	13.8
Ga ⁺³	Gallium	14.0	18.0	12.0	10.5	11.0
In ⁺³	Indium	8.5	10.9	7.3	6.4	6.7
Pb ⁺²	Lead	4.7	6.0	4.0	3.5	3.7
Mg ⁺²	Magnesium	40.1	51.5	34.3	30.1	31.6
Mn ⁺²	Manganese	17.7	22.8	15.2	13.3	14.0
Hg ⁺²	Mercury	4.9	6.2	4.2	3.6	3.8
Ni ⁺²	Nickel	12.2	21.3	14.2	12.4	13.1
Pd ⁺²	Palladium	9.2	11.8	7.8	6.9	7.2
Sc ⁺³	Scandium	21.7	27.8	18.5	16.3	17.1
Sr ⁺²	Strontium	11.1	14.3	9.5	8.3	8.8
Th ⁺⁴	Thorium	4.2	5.4	3.6	3.2	3.3
Ti ⁺³	Titanium	20.4	26.1	17.4	15.3	16.1
TiO ⁺²	Titanium Oxide	15.3	19.6	13.0	11.4	12.0
V ⁺³	Vanadium	19.1	24.6	16.4	14.3	15.1
V ⁺²	Vanadium	19.1	24.6	16.4	14.3	15.1
VO ⁺³	Vanadium Oxide	14.6	18.7	12.5	10.9	11.5
Y ⁺³	Yttrium	11.0	14.1	9.4	8.2	8.7
Zn ⁺²	Zinc	14.9	19.1	12.8	11.2	11.8

Typical Use of Three-Step Method

Problem

Both calcium and copper ions have been identified to be problems in a textile processing step. There are 3 ppm of copper and 20 ppm of calcium in the system. The questions: Which Dow chelating agent should be used...and how much?

Solution

Because Ca and Cu ions must be controlled and system pH in the textile plant is 8, use of the Metal Ion Control Chart (Figure 4, page 12) suggests VERSENE™ 100 chelating agent as the product of choice.

Because Ca and Cu ions must be chelated, use of Table 6 (page 12) indicates that the Cu ion must be inactivated first, and then the Ca ion.

By use of Table 7 (page 13), it is apparent that 15.3 parts of VERSENE 100 product are required to chelate one part of the Cu ion, and 24.3 parts of VERSENE 100 are required to chelate one part of the Ca ion. Therefore, 15.3 times 3 ppm of copper = 45.9 ppm VERSENE 100 required to chelate the copper, and 24.3 times 20 ppm of calcium = 486 ppm of VERSENE 100 required to chelate the calcium: a total of 531.9 ppm of VERSENE 100. Often a 10% excess is used to account for fluctuations in the system.

Judgement on volume requirement for a process is dependent on volume throughput of the system to be treated. Assistance in determining specific amounts of chelating agent required for a particular system is available from Dow. For further information, please contact The Dow Chemical Company.

Use of Table 8 suggests that 248 ppm of VERSENE 220 Crystals could be utilized in replacement of the 532 ppm of VERSENE 100 product, if that were desirable.

TO REPLACE ONE POUND OF:	VERSENE 100	VERSENE 220 CRYSTALS	VERSENE ACID	VERSENEX™ 80	VERSENOL™ 120	VERSENE Na ₂ CRYSTALS
Table 8: Conversion Factors, Chelating Agent Equivalents						
VERSENE 100	—	0.466	0.301	1.28	0.880	0.395
VERSENE 220 Crystals	2.15	—	0.646	2.73	1.83	0.849
VERSENE Acid	3.32	1.55	—	4.24	2.83	1.31
VERSENEX 80	0.784	0.365	0.236	—	0.667	0.310
VERSENOL 120	1.18	0.548	0.354	1.50	—	0.465
VERSENE Na ₂ Crystals	2.53	1.18	0.761	3.23	2.15	—

How Dow helps you get the most out of Dow chelating agents

METAL SIGNATURE™ analytical service

The METAL SIGNATURE analytical service from Dow is an exclusive lab service that provides you with a detailed profile of the metal ions present in your product or process. You'll also get the results of lab studies which determine the type, amount, and addition point for Dow chelating agents to achieve optimum effectiveness and economy. All you need to do to initiate the service is provide us with basic information about your process, plus samples of your product or process water at key points in your process.

The sophisticated PIMIC™ modeling service

Another unique service available from Dow is the PIMIC modeling service using the predictive and interpretive metal ion control computer program. With specific data about your system, this computer model helps us predict and optimize the behavior of different chelating agents in the system. The result is a valuable data package that can minimize your laboratory work and help you determine the best route to take to solve your problem. The powerful PIMIC modeling service was developed by Dow researchers and is available only from Dow.

Expert technical support

In addition to valuable lab services, we also provide dedicated technical service support for Dow chelating agents. Qualified technical specialists who understand your process technology and can quickly help you find the best solution to metal ion problems are just a phone call away. Our more than 50 years of experience in metal ion control have provided us with a large data base of information covering almost every conceivable application. Don't hesitate to take advantage of this significant resource.



Our excellent distributor network

Our network of national and independent distributors offers the advantages of local inventories, convenient quantities, and individual service tailored to your needs. The Dow Chemical Company has a fundamental concern for all who make, distribute, and use our family of chelant products, and the environment we share. This concern is the basis for our Product Stewardship philosophy, by which we assess all available information on our products and then take appropriate steps to protect employee and public health and the environment. In addition, Dow is committed to implementing the guiding principles and management practices of the chemical industry's Responsible Care® Initiative, which includes Product Stewardship as one of the Management Practices. As part of our Product Stewardship effort, information such as Material Safety Data Sheets and this brochure are provided to assist our customers in handling our chelant products in a safe and responsible manner.

Contact Dow for up-to-date information and samples of Dow chelating agents

Contact Dow for more information on our chelating agents as well as samples for your developmental work. Contact information for your region is on the back cover of this brochure. If you have questions, a technical representative will be glad to assist you.

For detailed information on safety and handling considerations for Dow chelating agents, we provide Material Safety Data Sheets (MSDS) for each product. MSDS are available on request, and are included with each product order.

We also offer brochures and technical data sheets on the complete range of applications for Dow chelating agents. These include materials on foods and beverages, cleaning products, personal care products, pharmaceuticals, pulp and paper processing, water treatment, metalworking solutions, textile processing solutions, agricultural micronutrients, polymerization, oilfield applications and scale removal and prevention.

Chelating Agents

Why Dow chelating agents should be your first choice for metal ion control

- Provide reliable protection for the quality, shelf-life, and value of your products
- Improve processing efficiency
- Reduce scale formation
- Effectively dissolve inorganic scales
- Improve bleach performance
- Prevent metals from reacting with your process or product
- Improve product performance in hard water
- Soften process water
- Keep metal ions in solution
- Form more stable complexes than other metal ion control agents
- Offer unique thermal, light, and pH stability
- Effective at low concentrations, helping you reduce ingredient costs
- A long history of success in a broad range of applications

Why Dow is your best source for metal ion control solutions

- Unsurpassed quality and consistency in every Dow product
- Different product chemistries and many physical forms for formulating versatility
- The exclusive METAL SIGNATURE™ analytical service
- The sophisticated PIMIC™ computer modeling service
- Expert technical support
- Comprehensive technical and application literature
- Complete metal ion control systems tailored to your needs
- Global production facilities and our excellent distributor network

Why not find out more about how Dow chelating agents can help you protect the value of your products and/or the efficiency of your processing? We'll be happy to answer your questions, provide additional literature, and send samples of Dow chelating agents for your evaluation. Call today. The sooner you get started formulating with Dow chelating agents, the sooner you'll start getting more reliable, cost-effective protection against detrimental metal ion reactions.

For more information, complete literature, and product samples you can reach a Dow representative at the following numbers:

U.S., Canada, Mexico:	1-800-447-4369	www.versene.com
Latin America:	+55 11 5188 9222	
Europe:	+31 11567 2626	
	Toll-free +800 3 694 6367*	
Asia-Pacific	+60 3 7965 5392	
	Toll-free +800 7776 7666*	

*(Toll-free service not available in all countries.)

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