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## Technical Information

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# Trilon® M types

Trilon M Liquid  
Trilon M Powder  
Trilon M Granules

**Organic chelating agents used to control the concentration of metal ions in aqueous systems**

## Contents

	Page
<b>Introduction</b>	3
<b>Properties</b>	3
Chemical nature	3
Chemical and physical data	4
Complex formation	5
Chemical stability	8
pH stability	8
Corrosion	8
<b>Applications</b>	9
Inorganic scale	10
Dissolving calcium carbonate scale	10
Inhibiting calcium carbonate scale	11
Dissolving calcium phosphate scale	12
Organic scale	12
Bleaching	13
<b>Safety</b>	13
Handling	13
Storage	13
Ecology and toxicology	13
Labelling	13
<b>Note</b>	14

## Introduction

BASF is one of the world's largest producer of complexing agents. In addition to the Trilon M types (MGDA, methylglycinediacetic acid), the range also comprises traditional products such as the Trilon A types (NTA, nitrilotriacetic acid), Trilon B types (EDTA, ethylenediaminetetraacetic acid), Trilon C types (DTPA, diethylenetriaminepentaacetic acid) and Trilon D Liquid (HEDTA, hydroxyethylethylenediaminetriacetic acid).

MGDA is a strong complexing agent. BASF does not supply weak complexing agents such as citrates or succinates. The performance of the Trilon M types is higher, and the advantage for customers is that they are more cost-effective.

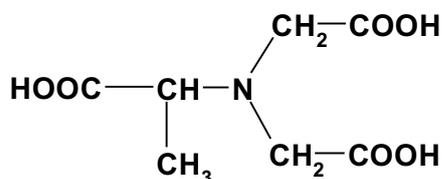
The excellent ecological and toxicological properties of the Trilon M types have regularly been confirmed in a wide variety of studies. BASF therefore recommends the Trilon M types as replacements for other, less environmentally friendly complexing agents such as phosphates, phosphonates, zeolites and silicates, etc. BASF's team of experts is always pleased to give advice on adapting formulations.

## Properties

### Chemical nature

The active ingredient contained in the Trilon M types is the trisodium salt of methylglycinediacetic acid (MGDA- $\text{Na}_3$ ). Methylglycinediacetic acid is also referred to as  $\alpha$ -alaninediacetic acid.

Methylglycinediacetic acid,  $\text{C}_7\text{H}_{11}\text{NO}_6$ , is an aminocarboxylic acid with four functional groups.



Trilon M Liquid

Aqueous solution of the trisodium salt of methylglycinediacetic acid (MGDA- $\text{Na}_3$ )  
CAS No. 164462-16-2

Trilon M Powder

Trisodium salt of methylglycinediacetic acid (MGDA- $\text{Na}_3$ ) in solid form  
CAS No. 164462-16-2

Trilon M Granules

Trisodium salt of methylglycinediacetic acid (MGDA- $\text{Na}_3$ ) in solid form  
CAS No. 164462-16-2

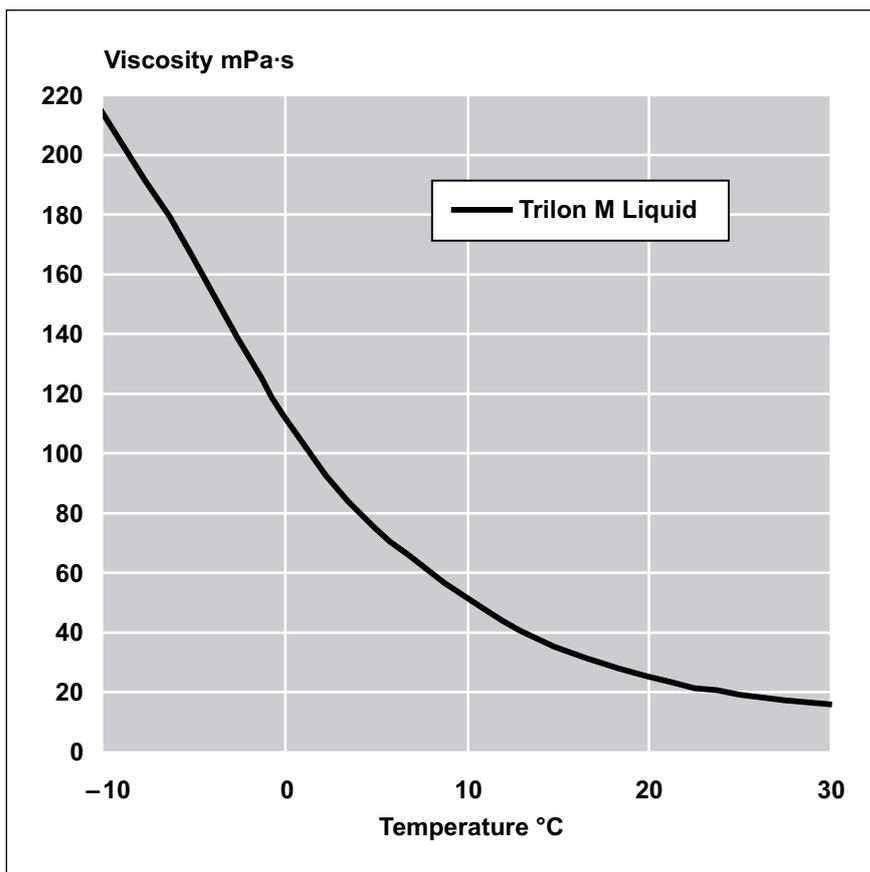
**Chemical and physical data**

		<b>Trilon M Liquid</b>	<b>Trilon M Powder</b>	<b>Trilon M Granules</b>
Physical form (visual)		Clear, yellowish or yellow liquid	Fine, yellowish powder	Coarse, yellowish granules
Molar mass (DIN 32625)	g/mol	271	271	271
Concentration (BASF method)* expressed as trisodium salt (MGDA-Na <sub>3</sub> )	%	approx. 40	approx. 84	approx. 78
expressed as free acid (MGDA-H <sub>3</sub> )	%	approx. 30	approx. 64	approx. 59
Density (DIN 51757, 20 °C, U-tube densitometer)	g/cm <sup>3</sup>	approx. 1.31	–	–
pH (DIN 19268, 23 °C, 1 % in water)		approx. 11.0	approx. 11.5	approx. 11.5
Bulk density (ISO 697, 40 mm diam.)	g/l	–	approx. 690	approx. 850
Hazen colour (DIN EN 1557)		max. 250	max. 150 (40 % solution)	max. 150 (40 % solution)
Volatile NH <sub>3</sub> (BASF method)	ppm	max. 80	max. 80	max. 80
Calcium binding capacity (BASF method, pH 11)	mg CaCO <sub>3</sub> /g t. q.	approx. 160	approx. 325	approx. 310
Water content (EN 13268)	%	approx. 57	approx. 8	approx. 14
Viscosity (DIN 53018, 23 °C)	mPa · s	approx. 25	–	–
Freezing point (ISO 3013)	°C	< –20	–	–
Melting point (ISO 3146)	°C	–	> 300 (decomposes)	> 300 (decomposes)
Solubility in water (BASF method, 25 °C)	g/l	Miscible in all proportions	approx. 590	approx. 550

The above information is correct at the time of going to press. It does not necessarily form part of the product specification.

A detailed product specification is available from your local BASF representative.

*\*Determined by potentiometric titration against iron(III)chloride.*



Viscosity as a function of temperature

### Complex formation

The most important property of the Trilon M types is their ability to form water-soluble complexes with polyvalent ions (eg. calcium, magnesium, lead, copper, zinc, cadmium, mercury, manganese, iron) over a wide pH range from 2 to 13.5. MGDA usually forms 1 : 1 complexes, i.e. 1 mol of MGDA chelates binds to 1 mol of metal ions. These complexes remain stable, especially in alkaline media and even at temperatures of up to 100 °C.

From the law of mass action, the equation for the stability constant K for 1 : 1 complexes can be written as follows.

$$K = \frac{[\text{MeZ}^{(m-n)-}]}{[\text{Me}^{n+}] [\text{Z}^{m-}]}$$

where

$[\text{MeZ}^{(m-n)-}]$  is the concentration of the chelate that is formed

$[\text{Me}^{n+}]$  is the concentration of free, positively charged metal ions

$[\text{Z}^{m-}]$  is the concentration of the ligand anion, in this case MGDA

K is the stability constant for the chelate.

Logarithmic stability constants (log K) for complexes of MGDA and selected metal ions

Metal ion	log K
Fe <sup>3+</sup>	16.5
Cu <sup>2+</sup>	13.9
Pb <sup>2+</sup>	12.1
Ni <sup>2+</sup>	12.0
Co <sup>2+</sup>	11.1
Zn <sup>2+</sup>	10.9
Cd <sup>2+</sup>	10.6
Fe <sup>2+</sup>	8.1
Mn <sup>2+</sup>	8.4
Ca <sup>2+</sup>	7.0
Mg <sup>2+</sup>	5.8
Sr <sup>2+</sup>	5.2
Ba <sup>2+</sup>	4.9

→ **A high value for log K indicates that the chelating agent has a high affinity for that particular metal ion, and it provides a preliminary indication of whether the chelating agent is suitable for the specific application.**

MGDA-H<sub>3</sub> is a tribasic acid that dissociates in three steps. The acid dissociation constants pK<sub>a</sub> are as follows.

MGDA-H <sub>3</sub>	pK <sub>a</sub> 1	1.6
MGDA-H <sub>2</sub> <sup>-</sup>	pK <sub>a</sub> 2	2.5
MGDA-H <sup>2-</sup>	pK <sub>a</sub> 3	10.5

In aqueous solutions, MGDA competes for metal ions with other anions such as hydroxide, sulphate, sulphide, carbonate and oxalate that form sparingly soluble metal salts. The formation of chelates reduces the concentration of free metal ions [Me<sup>n+</sup>] to such an extent that the solubility products of many sparingly soluble metal salts are no longer exceeded. The result is that the salts no longer precipitate or may even redissolve.

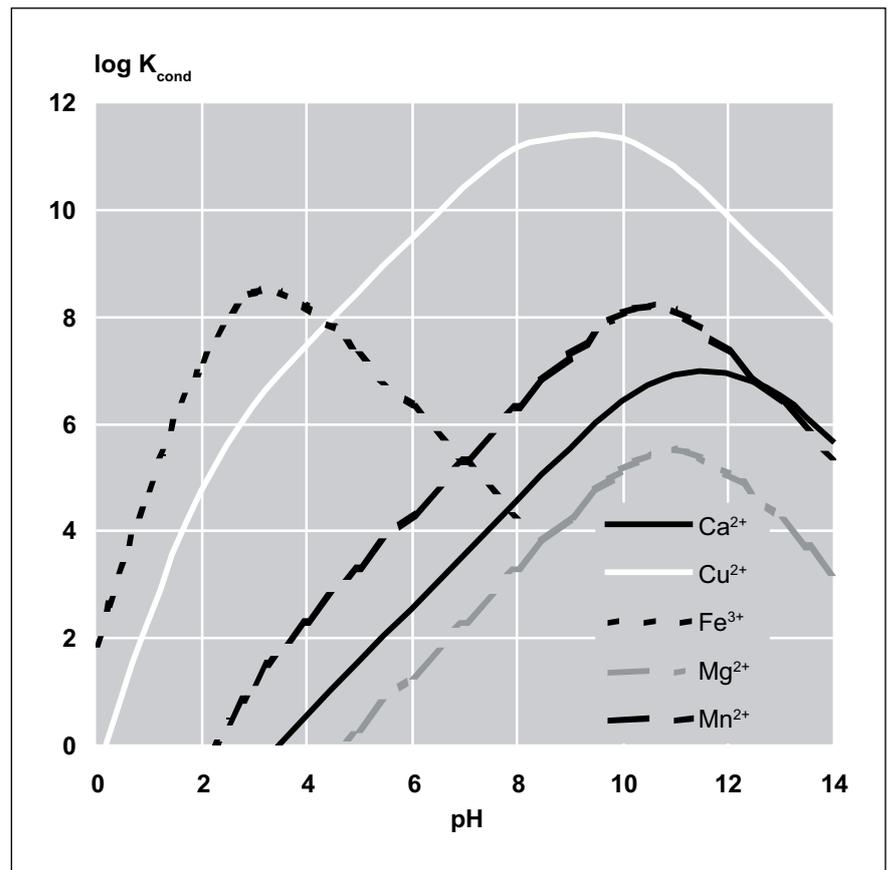
→ **The Trilon M types reduce the concentrations of free metal ions in aqueous systems.**

→ **The Trilon M types prevent scale from forming and can be used to redissolve even stubborn scale.**

The high stability of these complexes prevents metal ions from participating in typical chemical reactions. For instance, manganese, iron and copper are no longer able to catalyse the decomposition of peroxide bleach.

→ **The Trilon M types modify the reactivity of metal ions in water.**

Conditional stability constants [log K<sub>cond</sub>] can be used along with the log K values to help select the best complexing agent for a specific application. Conditional stability constants differ from the stability constants referred to above [log K] in that they also take the acid-base dissociation equilibria – i.e. the influence of the pH on the formation of complexes – into account.



Conditional stability constants for selected MGDA chelates

- The stability of complexes depends on the pH. Complexing agents need to be selected according to the nature of the metal ions that are present and the prevailing pH.
- The Trilon M types are very effective complexing agents for calcium in the alkaline pH range. This is an advantage in many detergent and cleaner applications.
- The Trilon M types are less likely to crystallise in the acidic pH range than other aminocarboxylic acids, and they are still capable of complexing iron ions effectively in the pH 2 – 3 range.

#### Comparison with weak complexing agents:

Weak complexing agents are incapable of reducing the concentration of free metal ions in aqueous systems to the same extent as the Trilon M types, and the result is that they are unable to prevent metal ions from playing a disruptive role in chemical processes.

- If weak complexing agents are used, there is a greater risk that formulations will not fulfil the standards of performance that are expected of them.
- Very large quantities of weak complexing agents are often required to reduce the concentration of metal ions to the required level. The result is that formulations are less cost-effective.

## Chemical stability

The Trilon M types are chemically very stable.

The Trilon M types have been shown to be very stable compared to other organic complexing agents such as citric acid, tartaric acid and gluconates, especially at high temperatures.

Whereas inorganic sequestering agents (eg. phosphates) may hydrolyse at high temperatures, Trilon M types are stable – even when heated to 200 °C under pressure.

Trilon M Powder and Trilon M Granules begin to decompose at approx. 300 °C.

The Trilon M types are resistant to strong acids and strong bases. They are gradually broken down by chromic acid, potassium permanganate and other strong oxidizing agents. Stability in the presence of hydrogen peroxide, percarbonate and perborate is sufficient for joint application. Nevertheless, we do not recommend combining Trilon M types and peroxides in liquid formulations.

Sodium hypochlorite and other substances that release chlorine cause the Trilon M types to decompose. Alkaline earth and heavy metal complexes are broken down.

→ **Formulations that contain complexing agents have to remain chemically unchanged in storage and during transport in order to be able to unfold their full action. Many readily biodegradable complexing agents such as iminodisuccinates (IDS) and citrates are not sufficiently stable. The Trilon M types have excellent chemical stability under a wide range of conditions, and this ensures that formulations that contain Trilon M types remain effective over long periods.**

## pH stability

The Trilon M types are resistant to being broken down across the whole pH 2–14 range, even at elevated temperatures. For instance, formulations that contain Trilon M types and high concentrations of sodium hydroxide remain stable and do not precipitate. Other readily biodegradable complexing agents such as iminodisuccinate precipitate in alkaline media, and these weak complexing agents are then no longer able to keep metal ions in solution.

The miscibility and stability of the Trilon M types are excellent, even in highly acidic solutions. Many complexing agents cannot be employed in acidic formulations because they precipitate in the form of their sparingly soluble free acids. The Trilon M types have the advantage that they remain soluble and chemically stable, even in the acidic pH range.

→ **The Trilon M types boost the performance of highly alkaline formulations.**

→ **The Trilon M types can also be employed in acidic formulations.**

→ **The Trilon M types do not decompose even at an extreme pH.**

## Corrosion

The Trilon M types stabilize polyvalent metal ions, which means that they can increase the rate at which metals dissolve. Nevertheless, with the exception of aluminium, an oxidizing agent such as air always has to be present for corrosion to take place. Unalloyed steel is prone to corrosion in media that contain air, but corrosion can be reduced substantially if the pH is in the alkaline range and can be eliminated almost completely if oxygen and other oxidizing agents are excluded. Steel cleaned with the Trilon M types in the slightly alkaline range, which is the optimum pH range for the Trilon M types, is much less prone to corrosion than if it is cleaned with acids.

The only type of corrosion that has been observed with the Trilon M types is uniform corrosion: pitting or stress cracking have not been observed in media with a low chloride content. One of the advantages of the Trilon M types is that they can be supplied with a very low chloride content (< 20 mg/kg).

The following information on materials is of a very general nature, because corrosion depends on many different factors such as exposure to air, galvanic corrosion caused by the presence of different metals and by the flow patterns of liquids. The compatibility of Trilon M types with different materials needs to be tested in each individual case.

Austenitic stainless steels such as AISI/SAE 304, 316 Ti and 321 are very effective for vessels used to store and transport Trilon M Liquid.

The corrosion resistance of ferritic carbon steel such as ASTM A201 Grade B (European Material No. P265GH) is limited. A rate of corrosion of 0.01 mm/a has been measured at 50 °C and air exclusion. Crevice corrosion has also occasionally been observed on welded joints, and so we would not recommend storing the Trilon M types in vessels made from unalloyed carbon steel for any prolonged length of time. The rate of corrosion can be reduced by removing the air from the system.

Aluminium and aluminium alloys such as AL 7075 T6 (European Material No. 3.4365) are not resistant to Trilon M Liquid, because Trilon M Liquid is alkaline and aluminium is quickly corroded by strong bases. Solutions that contain Trilon M types are much less corrosive to aluminium if their pH is adjusted to 5–7.

## Applications

Complexing agents can be employed in a very wide range of different applications. They are used to control the concentration of metal ions in aqueous systems.

Complexing agents are recommended for the following applications:

Application	Mode of action
Removing scale	Displaces the equilibrium by sequestering metal cations
Preventing scale formation	Reduces the concentration of free metal ions to below the solubility product
Stabilising bleach and other chemicals	Sequesters reactive metal ions (iron, manganese, copper) and reduces the reactivity of these ions in the presence of chemicals such as peroxide
Preparing concentrated solutions of metal ions, modifying the reactivity of metal ions in the presence of reducing agents (e. g. in electroplating applications)	Displaces the equilibrium by sequestering metal cations

### **When should complexing agents be used instead of dispersing agents?**

Dispersing agents can be used to temporarily prevent solids from precipitating. A problem that is commonly encountered in cleaning applications is that organic and inorganic scale has to be removed from surfaces. Polymeric dispersing agents are incapable of dissolving scale effectively, and complexing agents are recommended for use in this type of application.

Dispersing agents can be very effective for preventing the build-up of scale, but complexing agents need to be employed in situations in which the performance of dispersing agents is not sufficient to prevent the formation of scale by very sparingly soluble solids such as barium sulphate.

### **Inorganic scale**

Alkali earth cations such as calcium and magnesium and inorganic anions such as carbonate and phosphate are present in virtually all aqueous systems. Their sparingly salts form scale that can disrupt many industrial processes. The Trilon M types can be used to redissolve precipitated metal salts and hydroxides. Traces of free metal ions are always present in equilibrium even with very sparingly soluble salts. If these free ions are chelated, the equilibrium is gradually displaced in favour of the soluble chelates.

The rate at which precipitates dissolve depends on their crystal structure and age and on the temperature. The rate at which they dissolve can be increased by raising the temperature. Old, dried-on scale has to be treated with Trilon M types over a longer period, and we would recommend applying 1 g/l more than the stoichiometric amount in this case.

### **Dissolving calcium carbonate scale**

The equilibrium of the reaction by which scale forms has to be displaced in favour of the soluble species in order for the scale to dissolve. This can be achieved by

a) Removing the carbonate anions

or

b) Sequestering the calcium cations.

Carbon dioxide is formed when carbonate anions react with acids.  $\text{CO}_2$  does not dissolve easily in water, and the release of gas from the solution causes the equilibrium to be displaced. Acids such as hydrochloric acid or citric acid are used in many applications to remove calcium carbonate scale. The speed with which the reaction takes place is an advantage in many applications, but the drawback of this method is, that it is difficult to use in closed systems owing to the generation of gas.

**→ 10 kg of calcium carbonate generates 2.2 m<sup>3</sup> of CO<sub>2</sub> gas when it is dissolved with a strong acid.**

**→ Acids such as hydrochloric acid and citric acid are corrosive to many materials.**

The Trilon M types have a very high calcium binding power, which enables them to dissolve existing calcium scale and to prevent new scale from forming. They displace the equilibrium of the precipitation reaction by sequestering the calcium cations. MGDA has a very high affinity for calcium compared to weak complexing agents such as iminodisuccinate (IDS), as can be seen from the following example.



*Dissolving calcium carbonate scale with MGDA (left) and IDS (right)*

In the experiment shown above, the calcium carbonate scale on the plate on the left was removed by dipping it in a solution of MGDA. It is much cleaner than the plate on the right, which was dipped in a solution of IDS.

The following points need to be taken into account when comparing the performance of the Trilon M types with weaker complexing agents.

- **The quantity of complexing agent that is required to sequester a given concentration of calcium ions depends on the strength of the complexing agent. The Trilon M types have a more effective complexing action, and much smaller quantities are required to obtain the same effect as with IDS.**
- **The quantities of complexing agents that need to be applied also depend on their active content. The Trilon M types have a higher active content than many competitors' products because they contain fewer by-products.**

#### **Inhibiting calcium carbonate scale**

Phosphonates and water-soluble polymers are often used to prevent calcium carbonate from precipitating and forming scale. These substances act by temporarily delaying the onset of crystallisation. Chelating agents such as the Trilon M types act differently, because they prevent salts from precipitating and forming scale by sequestering the calcium ions.

Scale can form if phosphonates or water-soluble polymers are used, depending on the concentrations of calcium ions and polymer or phosphonates, because the calcium ions do not form permanent bonds.

- **The Trilon M types can be used to boost the action of polyacrylates and phosphonates in inhibiting scale formation. They can enhance the overall performance of scale inhibitor formulations.**

There is a need for phosphonates to be replaced in many applications because of issues concerning the effects of phosphorus compounds on aquatic life and water quality. Aminocarboxylates often perform better at a high pH, but phosphonates perform better at a low pH because they are more soluble than many aminocarboxylates. The solubility of the Trilon M types at a low pH is very good and they are quite capable of competing with phosphonates.

### **Dissolving calcium phosphate scale**

Calcium phosphate also forms scale that is difficult to dissolve. This type of scale is often encountered in applications in which high concentrations of phosphate are present. Scale often gives rise to problems in dairies, because milk contains high concentrations of calcium phosphate and this sparingly soluble salt precipitates when milk is processed.

The Trilon B types (EDTA) are very effective products for dissolving calcium phosphate scale and they are usually used in preference to other complexing agents in this type of application. Nevertheless, some local restrictions on the use of EDTA still apply despite the positive findings of the EU Risk Assessment.

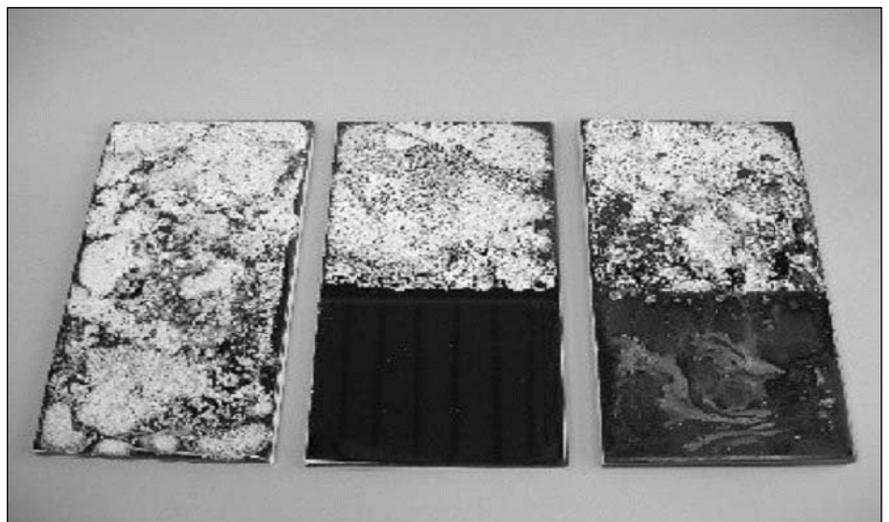
The Trilon M types are an effective alternative to EDTA for removing calcium phosphate scale. The high performance of EDTA remains unsurpassed, but the performance of the Trilon M types is by far the best of all of the readily biodegradable complexing agents. Weak complexing agents such as imino-disuccinate (IDS), ethylenediaminedisuccinate (EDDS), hydroxyethyliminodiacetate (HEIDA) and citrate are completely ineffective for dissolving stubborn calcium phosphate scale.

**→ The Trilon M types are the best choice when it comes to finding a readily biodegradable complexing agent for dissolving calcium phosphate scale.**

### **Organic scale**

#### **Calcium stearate and calcium oleate (lime soaps)**

Fatty acids and soaps also react with calcium ions to form sparingly soluble deposits in the kitchen, in the bathroom and on textiles. Lime, magnesium and heavy metals can form soaps that precipitate and give rise to spots and stains, dull surfaces, a rancid odour and poor wettability. They can also cause uneven dyeing, turbidity and changes in colour and cause rubber to perish. The Trilon M types are very effective for dissolving the scale formed by lime soaps and preventing scale from building up, and they are much more effective than weak complexing agents such as IDS or HEIDA.



*Dissolving calcium soaps with Trilon M types (centre) and a weak complexing agent (right)*

**→ The Trilon M types prevent the deposition of lime soaps and can be used to dissolve the scale formed by lime soaps.**

#### **Calcium oxalate**

Calcium oxalate forms sparingly soluble deposits in milk-processing plants and pulp mills. The Trilon M types can be used in these and other applications as an effective but gentle means of removing calcium oxalate scale. Acids and weak complexing agents such as IDS or HEIDA cannot be used to remove calcium oxalate.

**Bleaching**

The Trilon M types can be used to stabilise bleach. They prevent hydrogen peroxide decomposing too quickly by sequestering iron, manganese and copper ions. The Trilon M types are an effective alternative to established bleach stabilisers such as EDTA, but the performance of EDTA is still unsurpassed.

- We would generally recommend our customers to use the Trilon B types (EDTA) to stabilise bleach. DTPA is often used here but it has the disadvantage that its biodegradability is very low, whereas EDTA has been given a favourable verdict in the EU Risk Assessment. The data that are available on EDTA are much more extensive and positive than the data on phosphonates and DTPA.
- If local restrictions prevent EDTA from being used, the Trilon M types and Trilon P Liquid supplied by BASF are effective alternatives for stabilising bleach. Trilon P Liquid is an inherently bioeliminable complexing agent that can also be used in combination with the Trilon M types to sequester iron, manganese and copper ions.

**Safety****Handling**

We know of no ill effects that could have resulted from using the Trilon M types for the purpose for which they are intended and from processing them in accordance with current practice.

According to the experience we have gained over many years and other information at our disposal, the Trilon M types do not exert any harmful effects on health, provided that they are used properly, due attention is given to the precautions necessary for handling chemicals, and the information and advice given in our Safety Data Sheets are observed.

**Storage**

Trilon M Liquid should not be stored at temperatures below 0 °C, because this can cause them to precipitate. It can be reconstituted by heating it briefly to 40–50 °C and stirring.

Trilon M Powder is hygroscopic, and so it should be kept in tightly sealed containers.

The Trilon M types have a shelf life of one year in their tightly sealed original packaging.

We would recommend storing Trilon M Liquid in tanks made from AISI 316 Ti or AISI 321 stainless steel.

**Ecology and toxicology**

The Trilon M types have an excellent ecological and toxicological profile and there are no restrictions on their use in many applications. The active ingredient contained in the Trilon M types, MGDA, is classified as being readily biodegradable according to the OECD criteria. In these tests, the test substance is broken down by bacteria under standardised conditions.

→ **The Trilon M types are classified as being readily biodegradable.**

The products supplied by BASF conform to ecological and toxicological stringent standards in order to protect the environment.

BASF has submitted the Trilon M types to a thorough programme of tests and possesses a very extensive collection of data on the Trilon M types.

**Labelling**

Please refer to the latest Safety Data Sheets for detailed, up-to-date information on classification, labelling and product safety.

**Note**

The data contained in this publication are based on our current knowledge and experience. In view of the many factors that may affect processing and application of our product, these data do not relieve processors from carrying out their own investigations and tests; neither do these data imply any guarantee of certain properties, nor the suitability of the product for a specific purpose. Any descriptions, drawings, photographs, data, proportions, weights etc. given herein may change without prior information and do not constitute the agreed contractual quality of the product. It is the responsibility of the recipient of our products to ensure that any proprietary rights and existing laws and legislation are observed.

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