Technical Information

December 2013
Supersedes issue dated April 2011

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WF-No. 3160

Trilon® M types

® = Registered trademark of BASF

Trilon® M Liquid
Trilon® M Powder
Trilon® M Granules SG
Trilon® M Compactate

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

BASF
The Chemical Company

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.

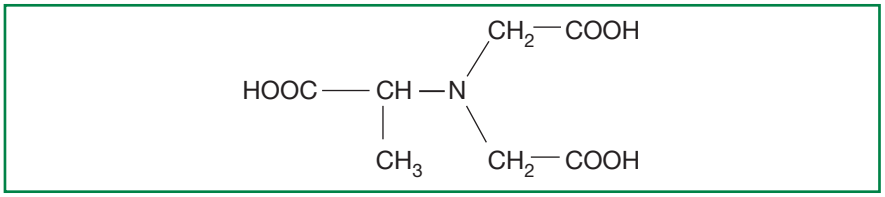
The excellent ecological and toxicological properties of the Trilon® M types have regularly been confirmed in a wide variety of studies. BASF therefore recommends the Trilon® M types as replacements for other, less environmentally friendly complexing agents. So, for example, phosphates contribute to eutrophication in waters. 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-Na_3). Methylglycinediacetic acid is also referred to as α-alaninediacetic acid.

Methylglycinediacetic acid, $C_7H_{11}NO_6$, is an aminocarboxylic acid with four functional groups.



Trilon® M Liquid

Aqueous solution of the trisodium salt of methylglycinediacetic acid (MGDA-Na_3)
CAS-No. 164462-16-2

Trilon® M Powder

Trisodium salt of methylglycinediacetic acid (MGDA-Na_3) in solid form
CAS-No. 164462-16-2

Trilon® M Granules SG

Trisodium salt of methylglycinediacetic acid (MGDA-Na_3) in solid form
CAS-No. 164462-16-2

Trilon® M Compactate

Trisodium salt of methylglycinediacetic acid (MGDA-Na_3) in solid form
CAS-No. 164462-16-2

PRD-Nos.*

30043459	Trilon® M Liquid
30215074	Trilon® M Powder
30513095	Trilon® M Granules SG
30442699	Trilon® M Compactate

* BASF's commercial product numbers.

Chemical and physical data

Trilon® M		Liquid	Powder	Granules SG	Compactate
Physical form (visual)		Clear, yellowish or yellow liquid	Fine, yellowish powder	Coarse, yellowish granules	Coarse, yellowish granules
Molar mass	g/mol	271	271	271	271
Concentration (BASF method)*					
calculated as trisodium salt (MGDA-Na_3)	%	approx. 40	approx. 87	approx. 78	approx. 85
calculated as free acid (MGDA-H_3)	%	approx. 30	approx. 66	approx. 59	approx. 64
Density (DIN 51757, 20 °C, U-tube densitometer)	g/cm^3	approx. 1.31	–	–	–
pH value (DIN 19268, 23 °C, 1% in dist. water)		approx. 11.0	approx. 11.5	approx. 11.5	approx. 11.5
Bulk density (DIN ISO 697, 40 mm diam.)	g/l	–	approx. 690	approx. 775	approx. 750
Hazen color (DIN EN 1557)		max. 350	–	–	–
Volatile NH_3 (BASF method)	ppm	max. 80	max. 80	–	–
Calcium binding capacity (BASF method, pH 11)	mg $CaCO_3$/g t.q.	approx. 160	approx. 330	approx. 300	approx. 330
Water content (EN 13267)	%	approx. 56	approx. 8	approx. 13	approx. 7
Viscosity (DIN EN 12092, 23 °C)	mPa·s	approx. 25	–	–	–
Freezing point (DIN 3013)	°C	< -20	–	–	–
Melting point (DIN EN ISO 3146)	°C	–	>300 (decomposes)	>300 (decomposes)	>300 (decomposes)
Solubility in water (BASF method, 25 °C)	g in 1 liter	Miscible in all proportions	approx. 900	approx. 950	approx. 900

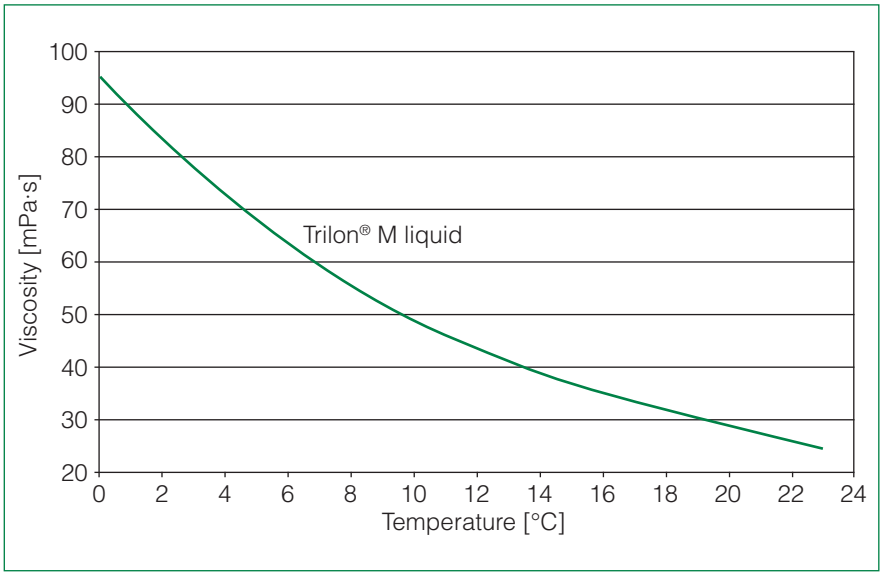
The above information is correct at the time of going to press. It does not necessarily form part of the product specification.

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

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

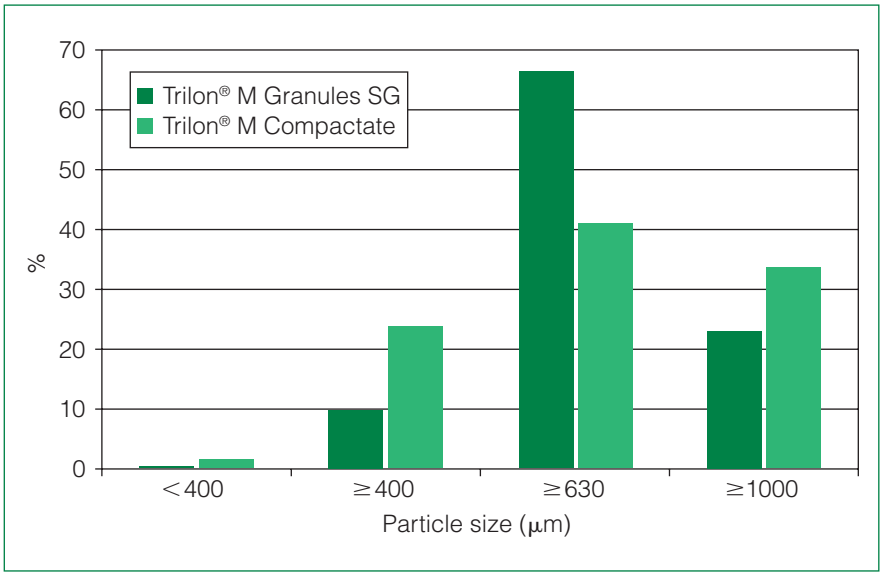
Viscosity

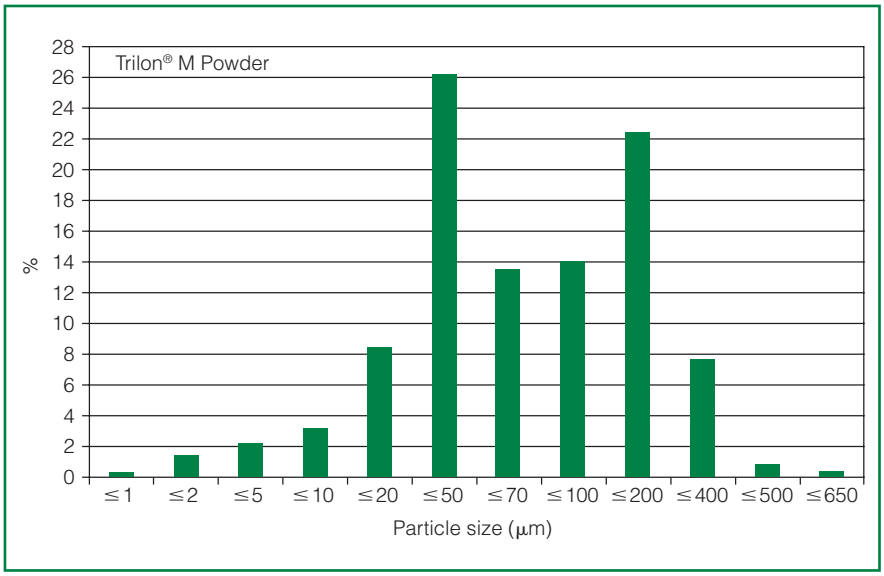
The relationship between viscosity and temperature is always an important point to consider when Trilon® M liquid is to be delivered or put into storage. The following curve shows the viscosity of Trilon® M liquid as a function of temperature (all values are approximate; mPa·s, Brookfield LVT):



Distribution of particles

The following curves show the distribution of particles of Trilon® M solid types (all values are approximate):





Complex formation

The most important property of the Trilon® M types is their ability to form water-soluble complexes with polyvalent ions (e. g. 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.

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

where

$[MeZ^{(m-n)-}]$	is the concentration of the chelate that is formed
$[Me^{n+}]$	is the concentration of free, positively charged metal ions
$[Z^{m-}]$	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^{3+}	16.5
Cu^{2+}	13.9
Pb^{2+}	12.1
Ni^{2+}	12.0
Co^{2+}	11.1
Zn^{2+}	10.9
Cd^{2+}	10.6
Fe^{2+}	8.1
Mn^{2+}	8.4
Ca^{2+}	7.0
Mg^{2+}	5.8
Sr^{2+}	5.2
Ba^{2+}	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.

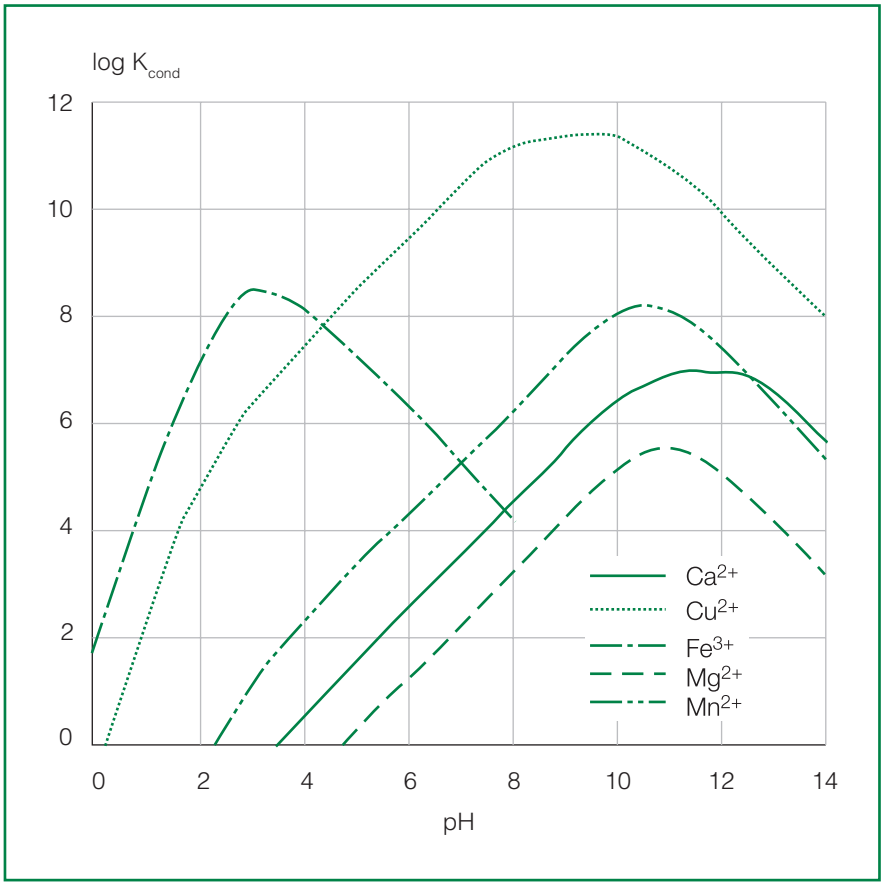
MGDA-H_3 is a tribasic acid that dissociates in three steps. The acid dissociation constants pK_a are as follows:

MGDA-H_3	pK_a1	1.6
MGDA-H_2^-	pK_a2	2.5
MGDA-H^{2-}	pK_a3	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 $[Me^{n+}]$ 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 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.

Conditional stability constants [log $K_{cond.}$] 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.

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 sequestring agents (e. g. phosphates) may hydrolyse at high temperatures, Trilon® M types are stable – even when heated to 200 °C under pressure.

Trilon® M Powder, Granules SG and Trilon® M Compactate begins to decompose at approx. 300 °C, whereas at approx. 140 °C release of bound water is possible.

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.

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.

Safety

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

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

b) Trilon® M Powder and Trilon® M Compactate are hygroscopic and soluble in water, with the result that they absorb moisture very quickly. Drums should be tightly resealed each time material is taken from them.

Materials

The following materials can be used for tanks and drums:

a) AISI 321 stainless steel (X6 CrNiTi 1810)
b) AISI 316 Ti stainless steel (X6 CrNiMoTi 17122)

Shelf life

Trilon® M Powder has a shelf life of one year, provided it is stored in its original packaging and kept tightly sealed.

Trilon® M Liquid has a shelf life of two years, provided it is stored in its original packaging and kept tightly sealed.

Trilon® M Granules SG and Trilon® M Compactate have a shelf life of three years, provided they are stored in their original packaging and kept tightly sealed.

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 to a thorough programme of tests and possesses a very extensive collection of data on the Trilon® M.

Labelling

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

Note

December 2013