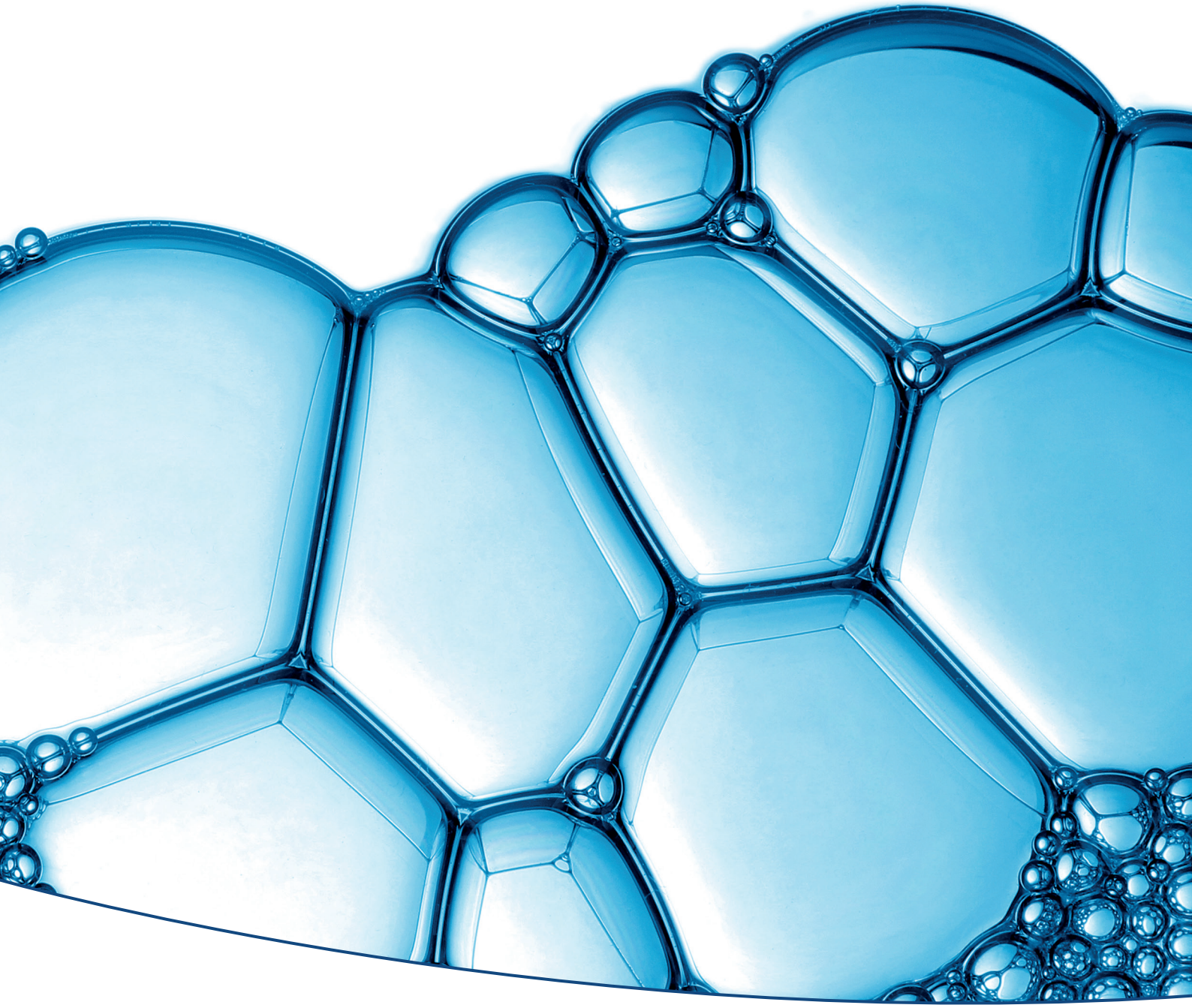


MGDA technical brochure
Dissolvine® M-40
Dissolvine® M-X

Dissolvine®
master the elements

Nouryon

Introducing Dissolvine®

Dissolvine® aminopolycarboxylate-based chelating agents are used in countless applications to control metal ions in water-based systems. They are highly effective for controlling water hardness ions as well as for cleaning surfaces, descaling boilers, processing textiles and preventing scale formation.

When it comes to controlling metal ion reactivity, Dissolvine® chelating agents are an important tool for reducing the detrimental effect of metal catalysts in peroxide cleaners and in pulp bleaching for paper manufacturing. Other applications include improving personal care formulations and stabilizing the bleaching process in textile.

Finally, Dissolvine® chelating agents are also used extensively to enhance the chemical and physical properties of metal ions, ranging from metal plating, providing essential elements to growing plants and supplying iron for H_2S gas scrubbing.

Innovating and supplying high performing products with a low environmental impact is important for Nouryon. In our search for a product that delivers excellent chelating performance with readily biodegradable properties, Nouryon introduced Dissolvine® M-40. The active component is MGDA, a chelating agent that has a proven track record in many different institutional and household cleaners. Today, in addition to Dissolvine® M-40, another MGDA product is offered to the market; Dissolvine® M-X, a free flowing granule.

MGDA is a fast-working, strong builder with excellent ecological properties, being readily biodegradable and not labelled as dangerous. This makes MGDA an ideal replacement for ingredients under regulatory pressure, such as phosphates (which are banned in various regions due to water eutrophication) in automatic dish washing (ADW), in car care and laundry. It is a drop-in replacement for NTA in industrial and institutional cleaners. In cleaning applications, Dissolvine® M-40, as well as Dissolvine® M-X, will outperform widely used builders like phosphates, citrates, gluconates and zeolites due to their stronger bonds with hard water ions.

Dissolvine® M-40 is a 40 weight percent solution of Methylglycine N,N-diacetic acid trisodium salt (MGDA) in water (**figure 1**) with typicals listed in **table 1a**. The IUPAC name for MGDA is 2-Aminopropionic acid, N,N-dicarboxymethyl-, trisodium salt. MGDA is also known as Alanine N,N-bis(carboxymethyl) trisodium salt.

The Dissolvine® chelate product portfolio is ready for tomorrow's requirements by covering a full range of applications

Product description and chemical structure

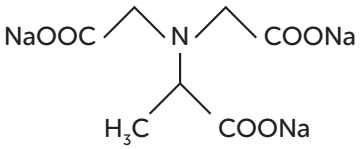
Dissolvine® M-X is the solid version of Dissolvine® M-40 having an assay of min. 81 weight percent. The typicals of Dissolvine® M-X are listed in **table 1b**.

MGDA has three carboxylic groups and, together with the central nitrogen atom, these carboxylic groups provide strong multiple bonds with di- and trivalent metal ions. The small molecular size enables rapid action at low temperatures and short contact time. The MGDA trisodium salt is fully REACH registered.

The excellent low toxicity and low eco-toxicological profile allow for non-dangerous labelling. MGDA-Na_3 is listed on EPA's Safer Chemical Ingredients List in the United States.

MDGA is a strong chelate for hard water and transition metal ions. Using MGDA as an ingredient in cleaning formulations improves the descaling and cleaning capabilities. This includes whiteness and color care benefits in laundry and stain removal abilities in automatic dish washing (ADW). Since MGDA is also a strong chelating agent for heavy metal ions, such as Fe and Cu, it enhances product stability and prevents negative effects of transition metals.

Figure 1: Chemical formula



Dissolvine® M-40 is a trisodium salt of methylglycine diacetic acid (MGDA-Na_3) in water and Dissolvine® M-X the solid.

Chemical name:	Methylglycine N,N-diacetic acid, trisodium salt
Chemical formula:	MGDA-Na_3 ($C_7H_8NO_6Na_3$)
CAS No:	164462-16-2
EC Number:	423-270-5
Molecular weight:	271.1 g/mol
INCI name:	Trisodium Dicarboxymethyl Alaninate

Table 1a: Dissolvine® M-40 product typicals

Dissolvine® M-40	
Chemical abbreviation	MGDA-Na_3
Physical form	liquid
Appearance	clear colorless to light yellow liquid
NTA-Na_3	< 0.10 wt.%
Active ingredient*	39 – 41 wt.%
pH	10.0 – 12.0 (1 w/v% aqueous solution)
Liquid density	1280 – 1320 kg/m³
Viscosity	25mPa.s (20°C) / 55mPa.s (5°C)
Freezing point	< –15°C
Solubility in water	miscible in all ratios
COD	290 mg/g

* Based on Fe-sequestering capacity

Table 1b: Dissolvine® M-X product typicals

Dissolvine® M-X	
Chemical abbreviation	MGDA-Na_3
Physical form	crystalline solid
Appearance	white free flowing granules
NTA-Na_3	< 0.20 wt.%
Active ingredient*	min 81 wt.%
pH	10.5 – 12.5 (1 w/v% aqueous solution)
Density	> 700 kg/m³
Auto ignition temperature	> 400°C
Solubility in water	1100 g/l

* Based on Fe-sequestering capacity

Physical and functional features of Dissolvine® M-40 and Dissolvine® M-X

Solubility

The solubility of MGDA as a function of pH is shown in **figure 2**. Like most aminocarboxylic chelates, the solubility is greatest for the fully ionized form that is present at high pH, quite similar to that of NTA. The solubility of MGDA is surpassed by the extraordinary high solubility of GLDA (Dissolvine® GL) across the entire pH range.

Table 2 lists the solubility of several chelates in various media. Here too the solubility of MGDA is similar to NTA, which may enable Dissolvine® M-40 to be used as a direct replacement for NTA in many formulations. Unlike NTA, Dissolvine® M carries no hazard warnings and may also qualify for eco labelling.

Table 2: Solubility of several chelates in various media at 25°C

	MGDA	NTA	EDTA	GLDA
NaOH, 15 %	~ 20	~ 23	~ 20	~ 60
NaOH, 28 %	~ 3	~ 7	~ 6	~ 53
Acetic acid, 28 %	~ 7	~ 1	< 1	> 50
HCl, 28 %	~ 6	~ 13	< 1	> 50
Ethylene glycol	~ 26	low	low	~ 45

Density

The density of the liquid can be used as a quick reference for checking the concentration of the material (**figure 3**). The density of the solid is important for packaging and plays a role in tableting the granules.

Chemical stability

Like all the Dissolvine® chelating agents, Dissolvine® M-40 is chemically stable under both acid and alkaline conditions. This is a prerequisite for stable formulations that are based on Dissolvine® M-40. The thermal stability of Dissolvine® M-X has been determined using Thermal Gravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC). MGDA-Na3 crystals will lose all crystal water at temperatures around 200°C and start to decompose at temperatures above 300°C.

Solutions of MGDA-Na_3 are fully stable at temperatures of up to 170°C for six hours, or at 150°C for one week. This means that MGDA can be a useful biodegradable alternative

Figure 2: Solubility of chelating agents, expressed as their sodium salt, in water at various pH levels.

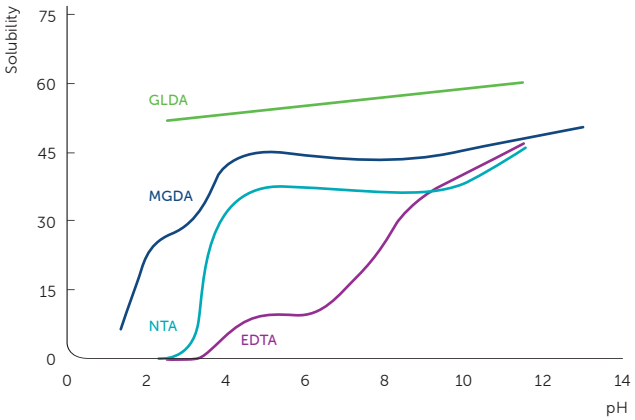
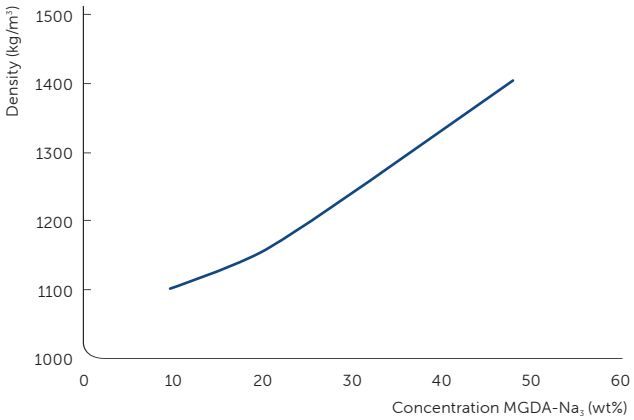


Figure 3: Density of a solution of MGDA-Na_3 plotted against concentration.



to EDTA when used for scale prevention or for cleaning boilers.

Acid/base dissociation constants

Dissolvine® chelating agents are amino polycarboxylic acids that ionize in water to multiple charged species depending on pH.
The ionization constants, or pKa values, for MGDA are shown in **table 3**. Again we see a close similarity to NTA. The ion species distribution of the MGDA molecule as a function of the pH can be calculated from the pKa values (**figure 4**).

Chelating power

Chelating agents are added to products or processes to control the properties of metal ions. For example, chelating agents are used in cleaning and personal care to complex with cations (e.g. Calcium, Magnesium, Fe, etc.) and prevent reactions with other ingredients that often lead to precipitation. In other applications, chelates are used to remove unwanted scale by complexing the scale metal ions.

Chelates are used in copper and nickel plating to deliver metal ions in the ideal form for the plating process. For each application, it is important to select a chelating agent that is sufficiently strong to do the job.
An indication of the chelates' strength or affinity for a certain metal ion can be derived from the dissociation constants, stability constants and conditional stability constants.

The stability or equilibrium constant (K), generally expressed as log K, is an indication of the strength of the complex formed between the metal ion and the chelating agent. The higher the log K value, the tighter the bond between the metal ion and the chelating agent, which in turn increases the likelihood that a complex will be formed (**table 4**).

Figure 4: Ionized forms of MGDA as a function of pH.

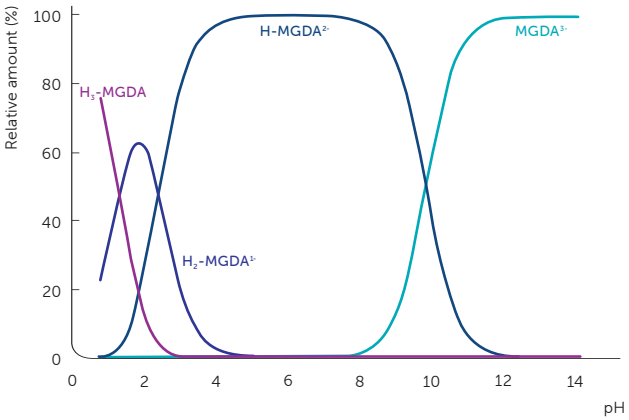


Table 3: The acid dissociation constants (pKa)* for MGDA, NTA and EDTA

	MGDA	NTA	EDTA
pK_{a1}	9.9	9.7	10.2
pK_{a2}	2.6	2.5	6.2
pK_{a3}	1.5	1.8	2.7
pK_{a4}	not available	1.0	2.0
pK_{a5}	not applicable	not applicable	1.5
pK_{a6}	not applicable	not applicable	0.0

*A.E. Martell, R.M. Smith, NIST Critically selected stability constants of metal complexes (NIST standard reference database 46, Version 7.0, 2003). pKa values: as determined at an ionic strength of 0.1M and at a temperature of 25°C, or if not available at 20°C.

The pH of the system and the oxidizing nature of the environment can affect the stability and effectiveness of the chelating system. For each metal complex, there is an optimum pH and an active pH range in which the metal complex is stable. The conditional stability constant is an indication of the stability of the complex as a function of the pH (**figure 5**).

Chelating capacity

Chelates generally form 1:1 complexes with metal ions. The quantity of chelating agent needed depends both on the concentration of metal ion to be chelated and the molecular weight of the chelate. In general, while a chelate with a high molecular weight will complex a metal ion more strongly than a chelate with a low molecular weight, a larger quantity will be needed. The chelating capacity of Dissolvine® M-40 and Dissolvine® M-X expressed as mg chelate/g MGDA product are compared to NTA and EDTA products in **table 5**.

The experimentally determined $CaCO_3$ chelating value (CaCV) of Dissolvine® M-40 is 147 mg/g and 297 mg/g Dissolvine® M-X. These measurements were performed using Ca^{2+} as a titrant and with two different means to detect the endpoint: one with a Ca^{2+} ion selective electrode and another using carbonate as a precipitation indicator. The found values correspond well with the theoretical CaCV.

Unlike very strong chelates like EDTA and DTPA, the 'chelating ability' of MGDA is dependent on the testing conditions (the indicator, temperature and concentration). Besides the theoretical chelating capacity, there is also a practical 'chelating capacity'. For example, when using Ca ions this practical chelating capacity is often called Ca dispersing power. The value of the Ca dispersing power of Dissolvine® M-40 can range from 160 to 195 mg $CaCO_3$/g [1], which is substantially higher than the theoretical value.

To illustrate the strong calcium binding strength of MGDA, experiments have been performed with various chelating agents and the calcium ion indicator Hydroxy Naphthol Blue (HNB), which is used in this experiment as a competitive chelating agent. HNB has a relatively high affinity for calcium and shifts color from blue to red when fully complexed to calcium. As a result, the color of a solution containing calcium ions, HNB and the tested chelate gives a measure for the calcium binding efficiency of the chelate vs. the HNB.

In **figure 6** the calcium affinity at pH 11–12 for a number of chelates is compared. The key

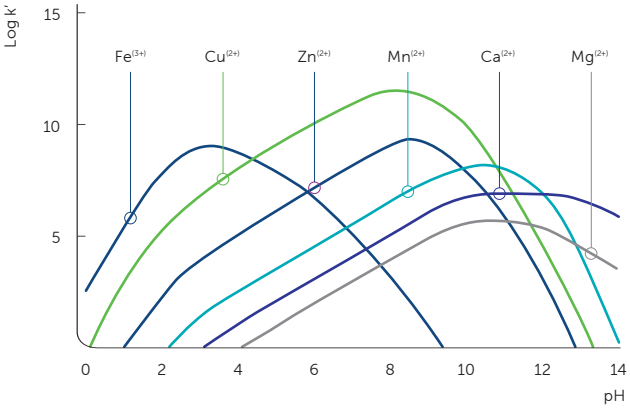
Table 4: Stability constants (log K values1) and active pH range for Dissolvine® M-40 / Dissolvine® M-X (MGDA)

Metal ion	Ca^{2+}	Cu^{2+}	Fe^{3+}	Mg^{2+}	Mn^{2+}	Zn^{2+}
Log K	7.0	13.9	16.5	5.8	8.4	11.0
Active pH range[2]	6 - 14	1 - 11	0 - 8	7 - 11	4 - 11	2 - 11

[1] A.E. Martell, R.M. Smith, NIST Critically selected stability constants of metal complexes (NIST standard reference database 46, Version 7.0, 2003); Log K values as determined at an ionic strength of 0.1M and at a temperature of 25°C or 20°C. Log K for Fe^{3+} and Mn^{2+} the figure was extracted from P.T. Anastas, Green Processes, Volume 9: Designing Safer Chemicals.

[2] Active pH range: calculated for demineralized water at 0.1 mol/l. Lower pH limit: the conditional stability constant logK' ≥ 3. Upper pH limit is based on the precipitation of the metal hydroxide; at upper pH limit the fraction chelated ≥ 95%.

Figure 5: Theoretical curves of the conditional stability constant (log K') of MGDA for various metal ions as a function of pH (1:1 metal:chelate complex).



finding is that Dissolvine® M-40 / M-X as well as Dissolvine® GL are very effective for complexing hard water ions.

Another measure of the ability to complex the calcium and magnesium hard water ions, and thus to soften water, is presented in **figure 7**. It shows a calculated plot of water hardness versus the strength of a builder (log K) in the presence of an equal molar amount of Ca ions and chelates. MGDA is capable of achieving low water hardness levels, while citrate is only capable of providing a medium hardness unless a significantly higher amount is used vs. Ca ion present. The ideal wetting conditions for a fast cleaning process appear only at a low water hardness; a few ppm of Ca.

[1]The details of such a test are available on request. Please contact us.

Table 5: Theoretical chelating capacity expressed as mg of chelated substance /g Dissolvine® M-40, Dissolvine® M-X, EDTA and NTA for several metal ions and $CaCO_3$

Product	Assay wt. %	$CaCO_3$	Ca^{2+}	Cu^{2+}	Fe^{3+}	Mg^{2+}	Mn^{2+}	Zn^{2+}
Dissolvine® M-40	40	147	59	93	82	36	81	97
Dissolvine® M-X	80	297	120	190	167	73	164	195
NTA-Na_3 as 40 % solution	40	156	62	99	87	38	85	102
EDTA Na_4 (Dissolvine® E-39)	39	103	41	65	57	25	56	67

Figure 6: The calcium complexing efficiency of various chelating agents in competition with Hydroxy Naphthol Blue (HNB) at pH 11–12.

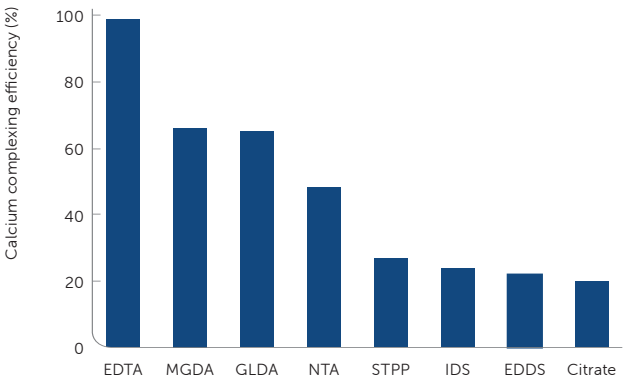
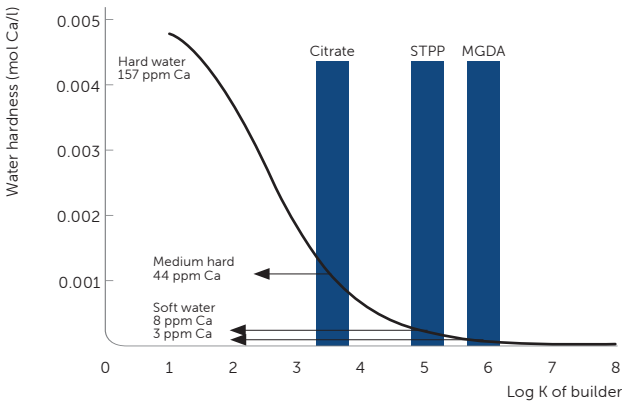


Figure 7: Water hardness reduction in the presence of various chelates versus Log K of the Ca-chelate stability constant.



Features Dissolvine® M-X

Dissolvine M-X granules are free-flowing, odorless and have good storage stability at 65% Relative Humidity and 40°C. The fact that MGDA granules are crystalline contributes to storage stability. In a storage test for 6 months at 40°C and 65% relative humidity, no ammonia like smell was noticed. Caking of Dissolvine® M-X under these conditions is negligible when the relative humidity is 65% or lower. Dissolvine® M-X when mixed with bleaching agents will remain color stable even after several months' time.

The bulk-density of the granules (min 700 kg/m^3) ensures that tablet size and pods containing MGDA have a good size or volume. The particle size distribution of the Dissolvine® M-X granules provides non-dusting behavior. The particle size distribution makes MGDA granules easily compatible with other ADW ingredients and tableting when needed can take place with little effort. The low friability of Dissolvine® M-X is another positive aspect in handling this product.

These functionalities of Dissolvine® M-X in combination with the high assay / high chelation capacity are favoring MGDA as the chelate of choice.

The thermal stability of Dissolvine® M-X is excellent; this is reflected by the auto ignition temperature being > 400°C. In handling solids like Dissolvine® M-X dust explosion properties are also important to know. The Lower Explosion Limit (LEL) of MGDA-Na_3 solid according to test standard EN 14034-3 was measured at our safety laboratory and the result of 250g/m^3 shows a rather high value for a dust explosion due to combustion.

Applications that are hindered by too much water sometimes can't handle Dissolvine® M-40. In that case the Dissolvine® M-X is the logical alternative.

Figure 8: Thermographic analysis Dissolvine® M-X, 0.2°C/min heating.

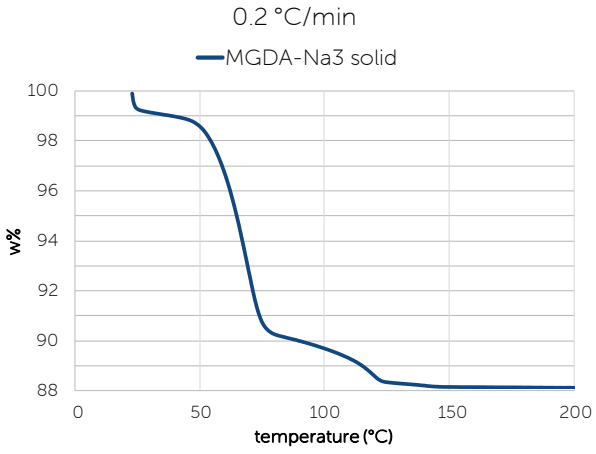


Figure 9: Dissolvine® M-X granules.

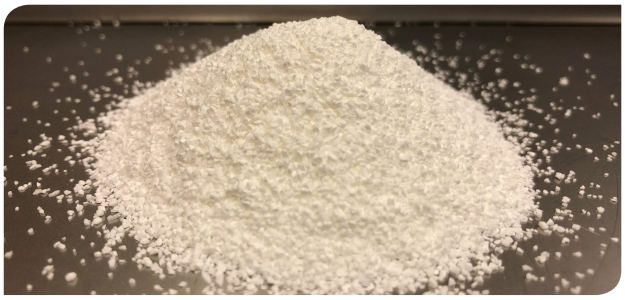


Figure 10: Petri-dish in vertical position with non-sticking Dissolvine® M-X after storage at 65% Relative Humidity at 40°C

A wide range of applications

As we see it, cleaning is probably the main application for MGDA, but it is also used in other applications, for example: polymer production, textile industry, gas sweetening, membrane cleaning, metal plating and electronics.

For cleaning the sub-application areas are:

Household cleaning
- Automatic dish wash
- Laundry detergents
- Surface cleaning

Industrial and institutional cleaning
- Mechanical dish washing
- Cleaning in place
- Transport cleaning
- Hard surface cleaning
- Laundry detergents
- Biocidal detergents
- Metal cleaning

The next chapter describes in detail why Dissolvine® M-40 and Dissolvine® M-X should be considered as ingredients.

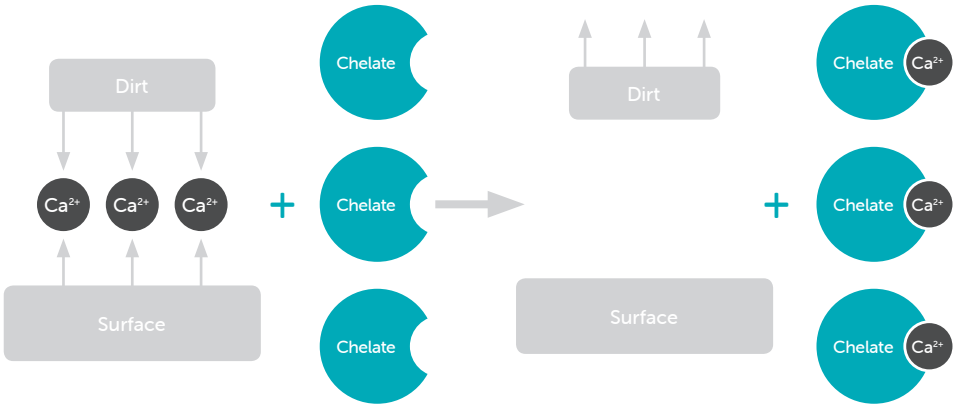
MGDA in cleaning

One of the main tasks of a builder/chelating agent in a cleaner is to complex Ca^{2+} ions that are part of the dirt. Ca^{2+} ions act as a 'glue' that can hold dirt and stains onto the surface. Chelates can 'de-glue' this debris by chelating and solubilizing the Ca^{2+} from the surface as depicted in **figure 11**.

In order to achieve a fast release of dirt and scale, the builder molecule needs to be rather small and have strong chelating capabilities. This is even more valid for low temperatures and short contact times. Once the dirt is free from the surface, surfactants can effectively disperse the dirt particles.

The ability of MGDA to bind to hard water ions also prevents the inactivation/precipitation of anionic surfactants. Anionic surfactants will be

Figure 11: Dirt and stains are bound to surfaces by Ca^{2+} ion bridges that act like a glue. Chelates can complex the Ca^{2+} ions, which helps to release the dirt/stain.



deactivated in the presence of medium hard water because their Ca-salts are not suited to act as a surface active ingredient and to form micelles. Soaps will even form scum with hard water ions and precipitate, as seen in **figure 12**. The addition of a weaker chelate like citrate has no real benefit in preventing the anionic surfactant's deactivation, but using a chelating agent with the strength of MGDA provides adequate protection and detergency.

Household cleaning

In household detergents, phosphate containing builders like STPP (sodium tripolyphosphate) must be reduced due to their negative environmental impact, which includes widespread eutrophication of rivers and lakes. Phosphates have been restricted/banned for household cleaning purposes across multiple regions, including the United States and the EU. The alternative is to use biodegradable builders like Dissolvine® M-40, Dissolvine® M-X and Dissolvine® GL-47-S. Since cleaners may also include enzymes, the calcium binding strength

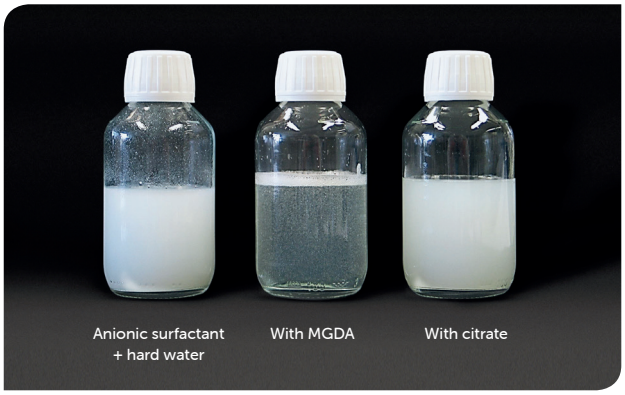
Enhanced cleaning by complexing hard water ions in a quick and seamless way!

of chelates must have the right strength. Dissolvine® M-40 / M-X are compatible with common amylase and protease enzymes used in cleaners. Formulas containing Dissolvine® M-40 may also be suitable for eco labelling.

Household automatic dish wash (ADW)

Strong chelates are required in household automatic dish washing formulations because of the limited mechanical action in the cleaning

Figure 12: Ca soap scum formation of a liquid anionic soap in the presence of Ca^{2+} ions and with MGDA or citrate addition.



process. Stains, especially from tea, are firmly glued to hydrophilic surfaces of cups and dishes by hard water (or iron) cations. Dish washing tests have shown that significant amounts of a strong chelate like MGDA are effective for removing the most severe stains, even without the aid of bleaching agents. To achieve the best results, the amount of chelate must be approximately equal to the amount of hard water ions that are channeled into the dish washer. Filming and spotting tests demonstrate that both MGDA and GLDA based formulations outperform formulations based on citrate, as illustrated in **figure 13**.

The use of MGDA in ADW may provoke some glass corrosion. This means that formulas containing Dissolvine® M-40 or Dissolvine® M-X require the addition of a glass corrosion inhibitor (e.g. zinc or bismuth salts). For all-in-one ADW products, addition of crystal growth inhibitors, like Alcoguard, are also required in order to reduce spotting and filming caused by the rinsing process.

Household laundry detergents

Since the mechanical action in this application is larger than that in ADW, less chelate than a 1:1 ratio with hard water ions is required for providing adequate cleaning conditions.

Small amounts of chelate like MGDA can enhance the shelf life stability of liquid products by reducing the catalytic activity of transition metal ions that can cause rancidity and can decompose fragrances and colorants. On the shelf haze formation from these and hard water metal ions can also be prevented. At higher levels, chelates will ensure anionic surfactants remain active.

Figure 13: Anti-spotting and filming performance of several formulas based on citrate, MGDA and GLDA after 10 washing cycles.

The main benefit of using a strong chelate for cleaning laundry is that it generally leads to better stain removal and color protection. Transition metal ions are known to contribute to stains (e.g. from the sunscreen ingredient Avobenzone with iron ions). Since Dissolvine® M-40 and Dissolvine® M-X bind directly to these ions, it will enable the removal of such stains. The color of the fabric will also be better protected when the heavy metals in the washing process are chelated. The Ca-glue, which binds the dirt, will be better removed at a faster pace and the surfactants will be more active. Higher levels will lead to less greying/improved whiteness and softer garments due to a descaling action on the textile. The heat-exchanger of the laundry machine will also be protected and the typical lime scale and soap scum deposits that reduce the machines energy efficiency will be removed. With the addition of more powerful builders like Dissolvine® M-40 and Dissolvine® M-X, cleaning can be done at lower temperatures, which in turn contributes to energy savings.

Household surface cleaning

The advantages of using a strong chelate like Dissolvine® M-40 / Dissolvine® M-X in hard surface cleaners are that it will speed up the cleaning process and make it easier since less mechanical force (scrubbing) is needed.

In low dosages, Dissolvine® M-40 will help to stabilize the liquid recipe (as described under Household laundry detergents paragraph). At higher concentrations, it will actively contribute to cleaning process and also dissolve soap scum and lime scale. By solubilizing Ca salts, it allows them to be thoroughly washed away, enhancing glass and shine.

Industrial and institutional cleaning

Industrial and institutional cleaning presents special challenges, such as the need for quick and efficient cleaning of highly soiled items. Chemical cleaning plays a larger role in this area and high concentrations of chelates like EDTA, NTA and phosphates are often required. MGDA is a good drop-in replacement for NTA. Replacing phosphate with MGDA will boost the cleaning power of these formulas.

Mechanical dish washing (MDW)

Typical mechanical dish washing formulas often contain the chelating agent NTA or EDTA combined with caustic and a non-ionic surfactant. The use of these chelates often eliminates the potential for eco-labeling and may require hazard label with the GHS08 'exploding chest' pictogram. MGDA can readily replace EDTA, NTA and phosphates in MDW. Dissolvine® M-40 and Dissolvine® M-X do not require the GHS08 symbol.

Figure 14: The molar efficiency dissolution of $CaCO_3$ by various chelating agents at pH 8 after 10 minutes.

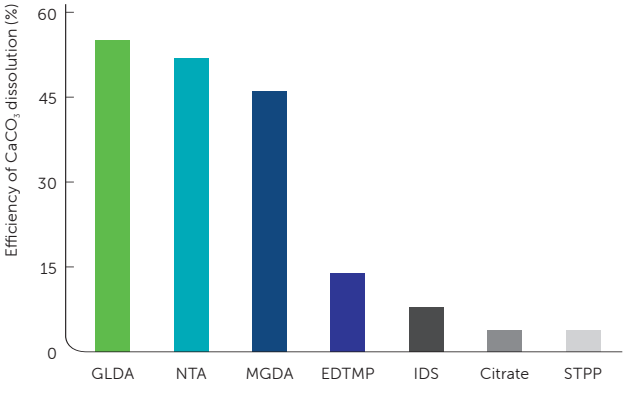
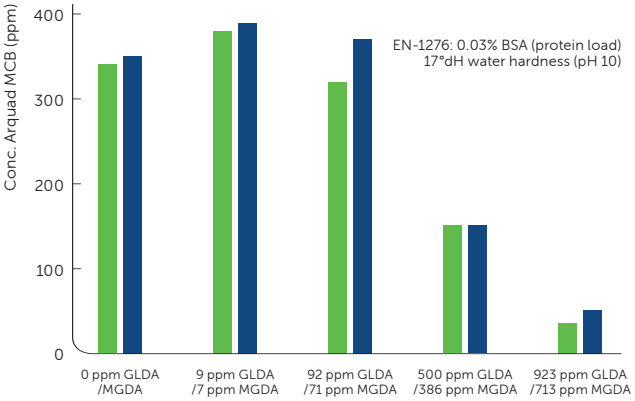


Figure 15: The influence of MGDA and GLDA on biocidal activity of Arquad® MCB-50 against gram negative bacteria Pseudomonas Aeruginosa (EN1276).



MGDA is soluble and quite tolerant towards most non-ionic surfactants. It is listed on the French positive list for cleaning food contact surfaces and it is also compliant with the Swan and the Euro flower legislation for professional dish washing.

Cleaning in place (CIP)

In addition to preventing precipitation of scale, Dissolvine® chelating agents are used to remove scale from surfaces. The most frequently encountered scales have calcium, magnesium and iron as their carbonate, oxalate, sulfate or oxide. The advantage of descaling with a chelate like Dissolvine® M-40 over an acid cleaner is that most scales can be removed in one step, thus saving time without concern for corrision or treatment of the spent solution. MGDA is approved by Safer Choice and for Direct Release in the United States.

In **figure 14** the $CaCO_3$ dissolving efficiency is compared for a variety of chelating agents. In comparison with other aminopolycarboxylates, phosphonates and succinates, MDGA is a good readily biodegradable chelate for the removal of $CaCO_3$ scale.

Biocidal detergents

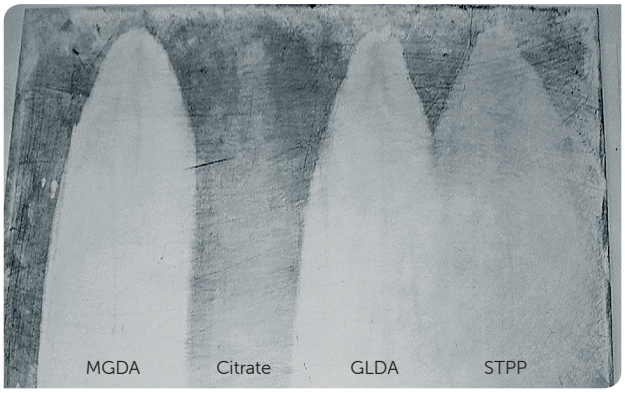
Biocidal detergents, which contain the readily biodegradable chelating agents Dissolvine® M-40 or Dissolvine® GL series, will combat microorganisms more efficiently than detergents without these ingredients. Chelates are well known for boosting the biocidal and preservative action. They enhance the permeability of bacteria and mold cell membranes, making them more susceptible to biocidal attacks. Test results depicted in **figure 15** show less biocidal agent is needed when chelating agents are added. Dissolvine® M and Dissolvine® GL series are readily biodegradable and inert to active biocidal and preservative ingredients; approved by the U.S. EPA for non food contact use.

Transport cleaning

Removal of dirt, debris and grime from vehicles requires a combination of capable active ingredients since the cleaning may be performed at low temperatures with low mechanical action and short cleaning times. To compensate for this, high levels of chelate and other ingredients are often needed to reach an efficient cleaning result.

In **figure 16** the results from a touchless automative dirt removal test are depicted; these were performed with a non-ionic surfactant and several different chelates.

Figure 16: Touchless removal of automotive dirt at room temperature with Berol® ENV226 and various builders.



High levels of ionic active ingredients, such as NaOH, MDGA-Na_3 or GLDA-Na_4, can lower the cloud point of non-ionic surfactants. This results in phase separation of the formulation and reduced cleaning performance. These problems can often be eliminated by adding a suitable co-surfactant or hydrotrope, such as Berol R648 PO, to the formulation in order to maintain the solubility of all ingredients.

Highly soluble ingredients such as Dissolvine® M-40 and Dissolvine® GL-47-S enable preparation of highly concentrated cleaning formulations that may reduce costs for production, packaging and transports.

Hard surface cleaning

Time is often of essence in industrial and institutional hard surface cleaning and cleaners must perform rapidly. The use of strong chelates like Dissolvine® M-40 / Dissolvine® M-X is essential for fast dirt removal without the need of extensive mechanical action. A strong chelate will detach the calcium bound dirt from the surface (as described under Cleaning chapter above). A non-ionic surfactant cannot achieve this by itself. The strong chelate softens the water and protects anionic surfactants from inactivation when used in the recipe. MDGA also descales surfaces from organic and inorganic residues of Calcium and Magnesium salts from anionic surfactants, oxalates, sulfates and carbonates.

Laundry detergents

In institutional laundry, it is crucial that all spots are removed in order to avoid rewashing. This means that high amounts of strong chelates are needed for an efficient cleaning also in this area. The high strength of Dissolvine® M-40 and Dissolvine® M-X enables lower wash temperatures and less mechanical action (thus less abrasion) in shorter wash cycles. A combination of Dissolvine® M-40 and Dissolvine® CSA (glucoheptonate) or Dissolvine® H-40 (HEDTA) is advised for solving problems with iron spots or iron stains, which are tough to remove.

The high cleaning power and the good solubility of Dissolvine® M-40, and particularly of Dissolvine® GL, enable production of compact liquid detergents that will reduce costs for production, packaging and transports.

Safe for humans and the environment

Ecotox and toxicological data

The excellent properties regarding human toxicity and environmental acceptability are major advantages of MGDA. Dissolvine® M-40 / M-X are completely safe for humans and the environment. This is demonstrated in **table 6**, which displays some of the test results for MGDA. All toxic and eco-toxic studies were carried out according to GLP as well as to official test methods. An overview of all tests and results can be found on https://echa.europa.eu/.

Biodegradability

One of the basic requirements for a chelate to be considered environmentally friendly is that it must be fully and promptly degradable under a wide range of environmental conditions. MGDA meets this requirement. It is has also proven to be biodegradable under anaerobic conditions (OECD 311) that can occur in septic tanks of private households. This finding is important since anaerobic degradability is a requirement for complying with the European Eco labelling legislation (http://ec.europa.eu/environment/ecolabel/).

Biodegradability studies performed under the wide range of conditions are shown in **table 7**.

Eco Labelling

MGDA's safe nature and its low environmental impact is recognized around the world, both by private and governmental agencies. MGDA has no negative safety issues and does not require any dangerous labelling. Use the following link to access ECHA details: https://echa.europa.eu/registration-dossier/-/registered-dossier/15592/2/1.

After extensive review in the United States, the Environmental Protection Agency (EPA) has recognized MGDA as a safe chemical ingredient. Alanine, N,N-bis(carboxymethyl)-, sodium salt (also called MGDA) is placed on the Safer Chemical Ingredients List with a full green circle. See the following link under chelating agents for more details: https://www.epa.gov/saferchoice/safer-ingredients.

Consumer and industrial products formulated with Dissolvine® M-40 or Dissolvine® M-X may qualify for displaying the Safer Choice logo on their product's packaging. Consumers, purchasing agents and workers can be assured that Safer Choice products are safe to use and that they are safe for the environment.

In Europe, MGDA is listed on the French positive list, which means that it is approved for institutional dish washing and (food contact) hard surface cleaning.

Dissolvine® M-40 is fully compliant with the Nordic Swan detergent Ecolabel legislation. See the following link under product groups: http://www.nordic-ecolabel.org/product-groups/
It also complies with the EU Ecolabel legislation, which can be found in the criteria documents on https://ec.europa.eu/environment/ecolabel/products-groups-and-criteria.html.

MGDA is listed in the the European Detergent Ingredient Database (DID list) under line 2608 (Tri-sodium methylglycine diacetate). For details see: https://www.svanen.se/en/how-to-apply/criteria-application/did-list/. MGDA is also compliant with the European Regulation on Cosmetic products EC 1223/2009.

Chemical registrations

The following are countries that have included MGDA-Na_3, CAS 164462-16-22 in their registrations and/or national inventories:

- European Union
- United States of America
- Canada
- China
- Japan
- Korea
- Taiwan
- New Zealand
- Australia
- Turkey

Handling and Storage

Dissolvine® M-40 and Dissolvine® M-X are stable products under normal and recommended storage conditions. There are no decomposition or dangerous reactions known under normal conditions.
Due to its high pH, Dissolvine® M-40 should be stored in containers made of corrosion-resistant material (e.g. stainless steel or plastic containers).

Materials to avoid in storage containers: Aluminum, Zinc, Copper alloys, Copper, Nickel. Don't combine MGDA with hypochlorite bleach. More information on handling and safety issues can be found in the safety data sheet of Dissolvine® M-40 and Dissolvine® M-X.

[2] Containing <1% NaOH, CAS 1310-73-2.

Table 6: (Eco)-toxicological test data for MGDA

	Method	MGDA-Na_3
Physical chemical properties		
Partition coefficient (n-octanol/water) HPLC	EU method A.8	Log Pow < –4
Water Solubility	EU method A.6	Solubility > 500 g/L
Effects on biotic systems		
Algae, growth inhibition (Scenedesmus subspicatus)	EU method C.3	72-h – EC50 > 100 mg/L
Daphnia sp. acute immobilization (Daphnia magna)	EU method C.2	48-h – EC50 > 100 mg/L
Daphnia magna long term toxicity and reproduction	EU method C.20	21-day – NOEC ≥ 100 mg/L
Fish, short term toxicity (Zebra fish)	EU method C.1	96-h – LC50 > 110 mg/L
Fish, prolonged toxicity test (Rainbow trout)	OECD 204	28-day – NOEC = 100 mg/L
Health effects		
Acute oral toxicity (rat)	EU Method B.1	LD50 > 2000 mg/kg bw
Acute dermal toxicity (rat)	OECD 402	LD50 > 2000 mg/kg bw
Acute dermal irritation/corrosion (rabbit)	OECD 404	not irritating
Acute eye irritation/corrosion (rabbit)	OECD 405	not irritating
Skin sensitization (guinea pig)	OECD 406	not sensitizing
Repeated dose 90-day oral toxicity (rat)	OECD 408	NOAEL = 170 mg/kg bw /day
Combined Chronic Toxicity/Carcinogenicity Studies	OECD 453	NOAEL = 262 mg/kg bw/day
Developmental toxicity (rat)	OECD 414	NOAEL ≥ 1000 mg/kg bw /day
Reproduction/Developmental Toxicity Screening Test (rat)	OECD 421	NOAEL for reproductive performance and fertility ≥ 1000 mg/kg bw/day NOAEL for general systemic toxicity = 200 mg/kg bw/day NOAEL for developmental toxicity for the F1 progeny ≥ 1000 mg/kg bw/day
Bacterial reverse mutation (Ames test)	OECD 471/472	not mutagenic
In vitro mammalian chromosome aberration test	OECD 473	ambiguous results due to chelating properties of MGDA-Na_3
In vitro mammalian cell gene mutation test	OECD 476	not genotoxic
In vivo micronucleus test (mouse)	OECD 474	not genotoxic

NOAEL = No Observed Adverse Effect Level
NOEC = No Observed Effect Concentration
bw = bodyweight

Table 7: Biodegradability test data for Dissolvine® M-40

Biodegradability studies	OECD Method	Result
Ready Biodegradability DOC die away test	301A	after 14d 90–100% biodegraded Interpretation: readily biodegradable
Ready Biodegradability CO_2 evaluation test	301 B	after 10d 77% biodegraded after 28d 90–100% biodegraded Interpretation: readily biodegradable
Ready Biodegradability modified MITI test	301 C	after 37d 90–100% DOC removal and O2 consumption Interpretation: readily biodegradable
Ready Biodegradability manometric respirometry test	301 F	after 28d 88% biodegradability Interpretation: readily biodegradable
Inherent biodegradability/Zahn-Wellens test	302 B	DOC removal in excess of 90% after 8 days
Anaerobic Biodegradability test	311	after 14d 7%, after 21d 48%, after 35d 82% and after 61d 87% biodegradable Interpretation: anaerobic biodegradable

Our sustainability approach

We have long been an industry leader in sustainability and our commitment to sustainability remains unchanged going forward. We take pride in improving our environmental impact and maximizing our positive societal impact. We work in alignment with the UN Paris Climate Agreement and we contribute to the UN Sustainable Development Goals through our operations, supply chain, products, and initiatives.

On a daily basis we strive to do more with less, reducing carbon emissions through a combination of improved energy efficiency, increased use of renewable energy, and higher use of bio-based raw materials in production. Downstream, we focus on expanding our portfolio of eco-premium products, which have a significant sustainability benefit over common alternatives. We see sustainability not just as the right thing to do, but as a true business opportunity that delivers value to everyone involved.

Our Dissolvine® MGDA product line shows our sustainability commitment. Due to its readily biodegradable properties it is marked as an Eco-Premium Solution and it provides a key environmental aspect as replacement for traditional and more pollutant ingredients, such as phosphates.

Dissolvine® M-40 is an everyday essential ingredient with well-recognized benefits in a wide range of applications; mainly used in Household as well as Industrial and Institutional cleaning applications. Dissolvine® M-40 and Dissolvine® M-X strengthens our biodegradable chelate portfolio as well as demonstrates our strong commitment to contribute in protecting and improving our urban environments.

Dissolvine® M-40 / M-X contain 43% renewable C-atoms (ASTM method D6866), which underlines the sustainability approach taken by Nouryon.

*Dissolvine® is a registered trademark in many countries.

Contact us directly for detailed product information and sample request
website | nouryon.com/markets/cleaning
email | cleaning@nouryon.com

Nouryon

Nouryon is a global, specialty chemicals leader. Markets and consumers worldwide rely on our essential solutions to manufacture everyday products, such as personal care, cleaning goods, paints and coatings, agriculture and food, pharmaceuticals, and building products. Furthermore, the dedication of more than 7,900 employees with a shared commitment to our customers, business growth, safety, sustainability and innovation has resulted in a consistently strong financial performance. We operate in over 80 countries around the world with a portfolio of industry-leading brands. Visit our website and follow us @Nouryon and on LinkedIn.

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