# Dissolvine® GL
# technical brochure

**AkzoNobel Chelates & Micronutrients**

AkzoNobel

Dissolvine® GL
The greener chelate

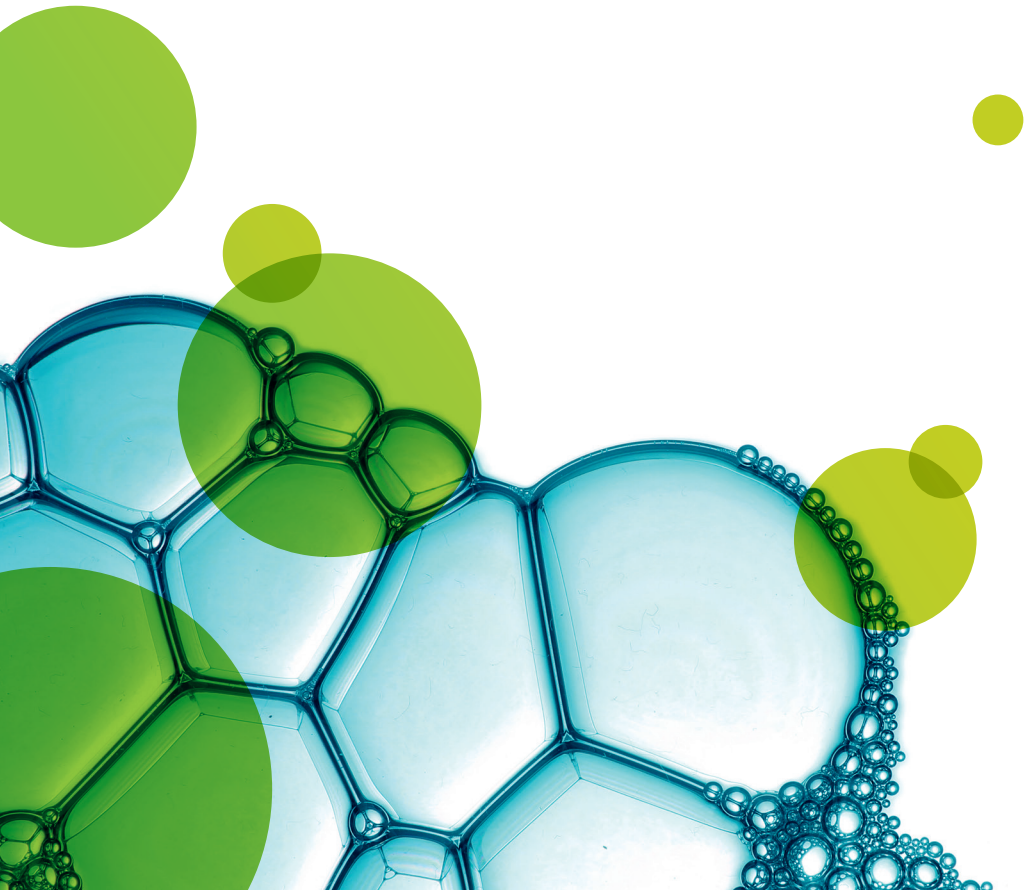
# Dissolvine makes a difference

Dissolvine® aminopolycarboxylate-based chelating agents (examples of classic ones are EDTA and DTPA) are used extensively to control metal ions in water-based systems for countless applications. They are highly effective in the control of water hardness ions and find wide application in cleaning surfaces, descaling boilers, processing textiles and preventing scale formation. For control of metal ion reactivity, they are an important tool for reducing the detrimental effect of metal catalysts in peroxide cleaners and in pulp bleaching for paper manufacturing, improving personal care formulations, stabilizing food products and for pharmaceutical formulations. Finally, they 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.

While classical aminopolycarboxylates provide outstanding performance in terms of cost effectiveness and versatility, they may not always fulfill all the needs of the customer in terms of performance, properties and health, safety and environmental considerations. Recognizing this, AkzoNobel is constantly seeking to develop innovative and more environmentally friendly products with excellent chelating performance to complement our existing product range.

Dissolvine® GL is an outcome of our continuing effort to develop new and improved products. Produced from monosodium L-glutamic acid (MSG) which is a biobased naturally occurring amino acid, GLDA is readily biodegradable and offers a high solubility over a wide pH range. It does not sensitize human skin, provides enhanced biocidal boosting power and improved biodegradability properties. Compared to phosphates, GLDA is a far more effective chelating agent and does not contribute to eutrophication.

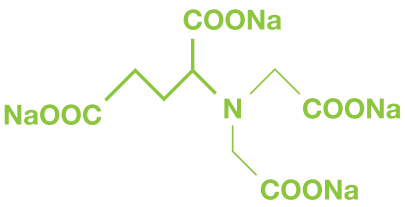
The sheer diversity of application demonstrates the versatility of the Dissolvine® chelate product range.



# Product description and chemical structure

Dissolvine® GL is glutamic acid diacetic acid, tetra sodium salt (GLDA-$Na_4$). GLDA has four carboxylic acid groups and combined with a centralized nitrogen atom these carboxylate groups provide strong multiple bonds with di- and trivalent metals ions.

The chemical structure of GLDA highlighting the natural amino acid structure of MSG:




Chemical name: L-glutamic acid N,N-diacetic acid, tetrasodium salt; GLDA-$Na_4$

CAS No: 51981-21-6
Chemical formula: $C_9H_9NO_8Na_4$
Molecular weight: 351.1 g/mol

INCI name: Tetrasodium Glutamate Diacetate

**Overview**
Dissolvine® GL is based on the food-approved natural amino acid salt, monosodium L-glutamate (MSG). Manufacture with this biobased raw material allows for more than half of the carbons in GLDA to be biobased. We believe that this natural amino acid structure in the GLDA molecule allows it to be readily recognized as food by bacteria and thus for GLDA to be readily biodegradable.

Dissolvine GL has excellent low toxicity and low ecotox profiles and does not require dangerous labeling. Significantly, Dissolvine GL-47-S meets the requirement as a safer chemical by the U.S. EPA's Design for the Environment program as well as being recognized as safe by numerous international institutions.

Dissolvine GL is a strong chelate for hard water metal ions – like $Ca^{2+}$ – and cleaning formulations containing it benefit from enhanced water softening, cleaning and stability.

Dissolvine® GL is a shining example of a sustainable, innovative material that can add value to your product. It offers added value from an economic and ecological perspective and should therefore be considered a cost effective, safe and greener chelating product.

**Table 1: Dissolvine® GL Product Offerings and Characteristics**

| Product name | Dissolvine® GL-38 | Dissolvine® GL-47-S | Dissolvine® GL-PD-S |
|---|---|---|---|
| **Chemical formula** | GLDA-$Na_4$ | GLDA-$Na_4$ | GLDA-$Na_4$ |
| **Physical form** | liquid | liquid | solid |
| **Appearance** | clear liquid | clear liquid | white to off white powder |
| **Odor** | slightly ammonia like | slightly ammonia like | odorless |
| **NTA** (wt%) | ~ 2.5 | < 0.10 | < 0.20 |
| **Assay** (wt%)* | 38.0 min | 47.4 min | 80.0 min |
| **pH** (1% wv aqueous solution) | 11.0 – 12.0 | 11.0 – 12.0 | 11.0 – 12.0 |
| **Liquid density**** (kg/$m^3$) | approx. 1330 | approx. 1400 | – |
| **Poured bulk density** (kg/$m^3$) | – | – | approx. 650 |
| **Viscosity**** (mPa.s) | approx. 41 | 90 – 150 | – |
| **Freezing point** (°C) | < –15 | < –15 | – |
| **Solubility in water**** (g/l water) | miscible in all ratios | miscible in all ratios | approx. 1000 |
| **Solubility in water at low pH**** (wt%) | miscible in all ratios | miscible in all ratios | > 25 |
| **Solubility in Ethylene Glycol**** (wt%) | miscible in all ratios | miscible in all ratios | approx. 45 |
| **Solubility in 5M NaOH**** (wt%) | miscible in all ratios | miscible in all ratios | approx. 60 |
| **COD** (mg/g) | 280 – 310 | 345 – 385 | 590 – 655 |

* Based on Fe-sequestering capacity ** at 20°C Dissolvine GL-PD-S is a spray dried equivalent of the liquid product Dissolvine GL-47-S

# Functional features

**Chemical and physical properties**
**Table 1** lists the Dissolvine® GL product range including various chemical and physical properties. Dissolvine® GL-38 (offered in EMEA) and Dissolvine® GL-47-S (offered worldwide) are standard multi-purpose liquid chelating agents. The primary difference in these products is the active ingredient content (38 % vrs 47%) and also that the 'S' version is high purity (NTA free). Dissolvine® GL-PD-S is a spray dried equivalent of the liquid product, Dissolvine® GL-47-S, is convenient for the preparation of highly concentrated formulations (solid or liquid). This solid product readily dissolves in water to yield a clear, slightly yellow liquid, is hygroscopic and should be stored in closed bags or containers until it is used.

**Liquid density**
The density of the liquid can be used as a quick reference to check the concentration of the material. See **Figure 2**.

**Viscosity**
Viscosity is an important parameter for handling products and is dependent on concentration and temperature. **Figure 3** shows the viscosity of various concentrations of GLDA-$Na_4$ solutions as a function of temperature.

**Figure 2**
Density of Dissolvine® GL plotted against GLDA-$Na_4$ concentration based on GL-38 or high purity GL-47-S.

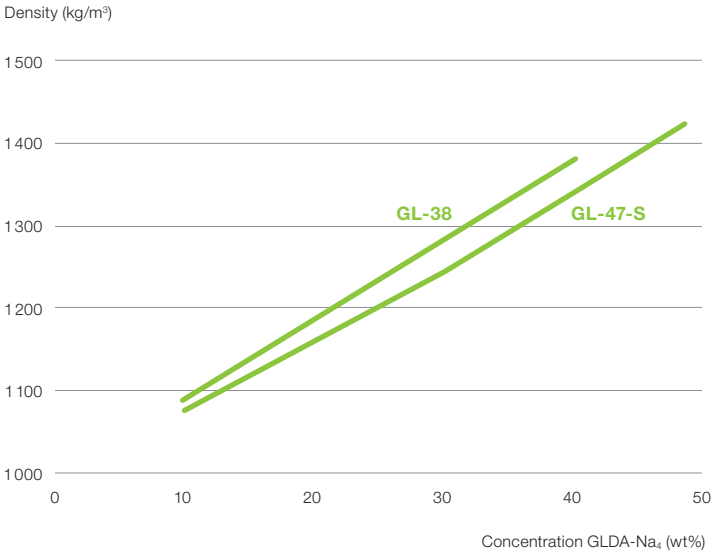
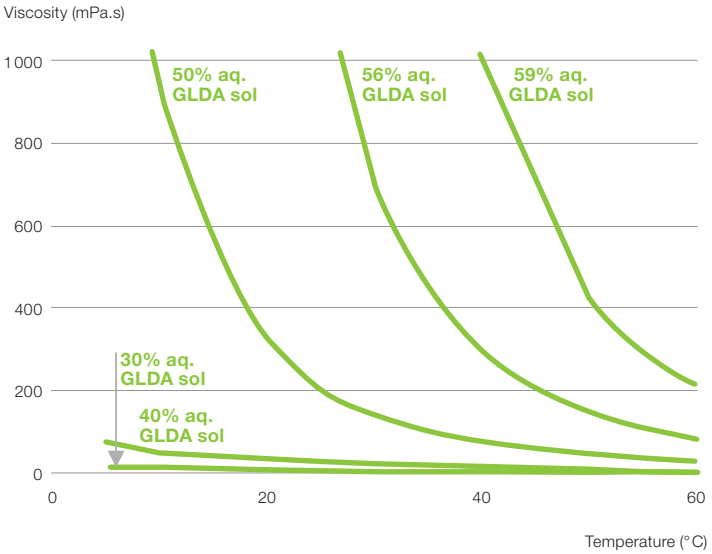



**Figure 3**
Graph of the viscosity of various concentrations of Dissolvine® GL at different temperatures, using GL-PD-S as starting material.



# Enhanced solubility

**Solubility**
A special feature of GL is its extremely high solubility under a wide range of conditions – from strongly acidic to high caustic conditions and in between. For strong chelating agents this property is unique to GL and allows the preparation of formulated products with a high active ingredient and low water content. Besides sparking creative ideas on developing innovative formulations with GL – this also has a beneficial impact on our environment. Higher assay mixtures means less inert water is present and therefore less packaging is needed and less packaging waste is generated. High assay products also reduce the shipping and storage of water present in formulated products – important especially to stores who have limited display space on their shelves. Ultimately the environment and we as consumers benefit the most.

**Figure 4** has plotted the solubility of GLDA, EDTA and NTA over the range of pH 2 – 12. Not only does GLDA offer greater solubility at high pH, but it is the only strong chelate allowing highly concentrated solutions to be stable at low pH. **Table 2** shows the exceptional solubility that GLDA exhibits in weak acids like acetic acid, to strong acids like HCl and even concentrated NaOH.

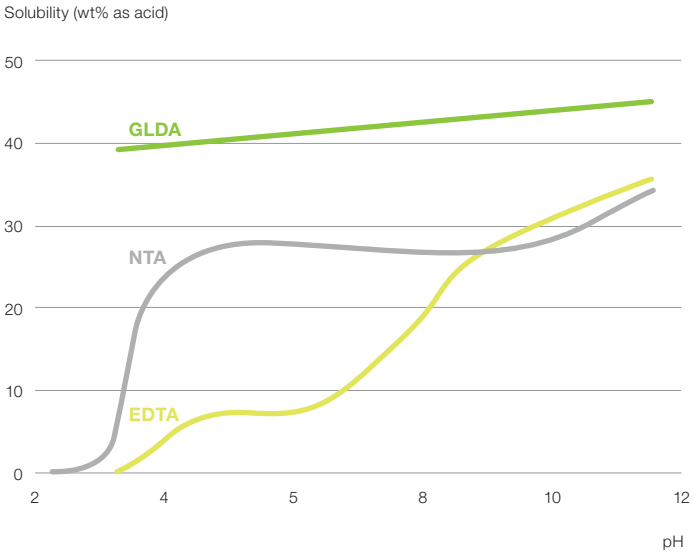
Formulating with highly soluble GLDA reduces the water that needs to be used to maintain clarity of a cleaning formulation and may allow for a greater variety and concentration of other additives to be used.

**Table 2: Weight % solubility of chelates in acid, caustic and ethylene glycol**

| | GLDA | EDTA | NTA |
|---|---|---|---|
| **NaOH, 15%** | ~ 60 | ~ 20 | ~ 23 |
| **NaOH, 28%** | ~ 53 | ~ 6 | ~ 7 |
| **Acetic acid, 28%** | > 50 | < 1 | ~ 1 |
| **HCl, 15%** | > 50 | < 1 | ~ 4 |
| **HCl, 28%** | > 50 | < 1 | ~ 13 |
| **Ethylene glycol** | ~ 45 | low | low |

GLDA's high solubility allows you to make more concentrated products.

**Figure 4**
Solubility of chelating agents, expressed as their acids, in water at various pH levels.




# Stability and chelating power

**Thermal stability**
Like all the Dissolvine® chelating agents, Dissolvine® GL is chemically stable under both acid and alkaline conditions. This is a prerequisite for stable formulations based on Dissolvine® GL.

The thermal stability of the GLDA-$Na_4$ powder has been determined using Thermal Gravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC). Dissolvine® GL solid loses all its water (10-15%) at temperatures around 200° C and starts to decompose at temperatures above 300° C.

Testing of aqueous GLDA solutions at temperatures of up to 170° C for 6 hours, or one week at 150° C show that GLDA is extremely stable especially under alkaline conditions. GLDA can therefore be a useful biodegradable alternative to EDTA when used for scale prevention or in cleaning boilers for example at high pH.

In aqueous solutions at pH 7 and below, GLDA shows some degradation occurs after 24 hours at temperatures of 140° C and above.

**Acid/base dissociation constants**
Dissolvine chelating agents are weak poly acidic chemicals which can ionize in water to a multiply charged chelate anion depending upon pH. The strength of these acid groups is expressed as the acid dissociation equilibrium constant or pKa. The theoretical values for GLDA are shown in **Table 3**. From the pKa values the ion species distribution of the GLDA molecule as function of the pH can be calculated, see **Figure 6**.

**Table 3: The acid dissociation constants ($pK_a$)* for GLDA, NTA and EDTA**

| | GLDA | NTA | EDTA |
|---|---|---|---|
| $pK_{a1}$ | 9.4 | 9.7 | 10.2 |
| $pK_{a2}$ | 5.0 | 2.5 | 6.2 |
| $pK_{a3}$ | 3.5 | 1.8 | 2.7 |
| $pK_{a4}$ | 2.6 | 1.0 | 2.0 |
| $pK_{a5}$ | not available | 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)
$pK_a$ values: as determined at an ionic strength of 0.1M and at a temperature of 25° C, or if not available at 20° C.

GLDA builds cleaning power.

**Figure 6**
The ion species distribution for GLDA.

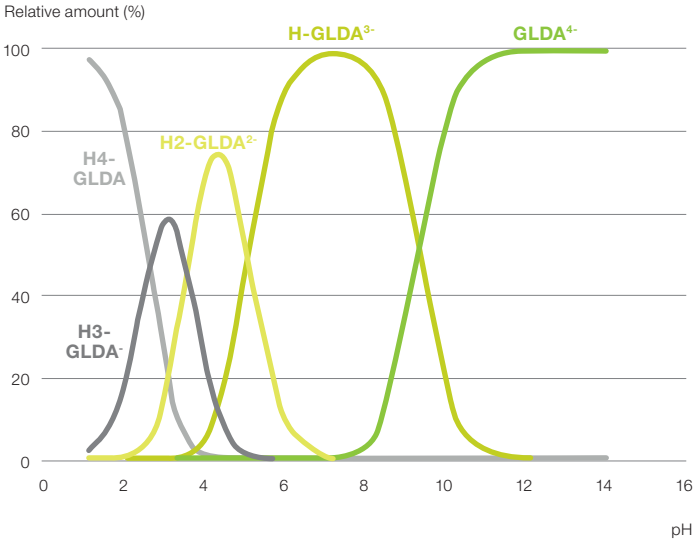
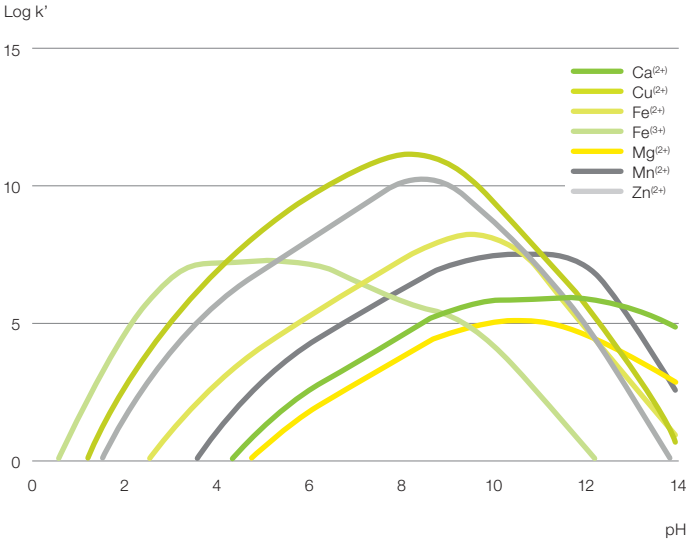



**Figure 7**
Theoretical curves of the conditional stability constant (log K') of GLDA for various metal ions as a function of pH (1:1 metal:chelate complex).



**Chelating power**
Chelating agents are added to products or processes to control the properties of metal ions. For example, in cleaning and personal care chelating agents are used to complex calcium and magnesium ions and prevent their reaction with other ingredients that often lead to precipitation. In other applications chelates are used to remove unwanted scale by complexing the scale metal ions. In copper and nickel plating chelates are used to deliver the metal ions in the ideal form for the plating process. For every application, it is important to select a chelating agent that is sufficiently strong to be able to do the job. An indication of the strength or affinity a chelate has for a certain metal 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 values, the more tightly the metal ion will be bound to the chelating agent and the more likely it is that the complex will be formed, see **Table 4**.

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 (log K') is an indication of the stability of the complex as a function of the pH, see **Figure 7**.

Experimental data show that the $Ca^{2+}$ affinity of GLDA in practical applications is much higher than would be expected based on the calculated conditional stability constant (as is clearly shown in the section Main functionalities in applications, **Figure 9**). A separate application leaflet (AL 291) on calcium affinity of chelates is available on request.

Chelates generally form 1:1 complexes with metal ions, and the quantity of chelating agent needed depends 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 lower molecular weight, more of it will be needed. The chelating capacity of Dissolvine® GL-38 and GL-47-S as mg metal/g GLDA product are compared to NTA and EDTA products in **Table 5**.

**Table 4: Stability constants (log K values)[1] and active pH range for GLDA**

| Metal ion | $Ca^{2+}$ | $Cu^{2+}$ | $Fe^{3+}$ | $Mg^{2+}$ | $Mn^{2+}$ | $Zn^{2+}$ |
|---|---|---|---|---|---|---|
| **Log K** | 5.9 | 13.1 | 15.35 | 5.2 | 7.6[2] | 11.5[2] |
| **Active pH range[3]** | 6 – 14 | 2 – 12[4] | 2 – 8[4] | 7 – 10 | 5 – 10[4] | 3 – 12[4] |

[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.

[2] As determined by AkzoNobel; Log K values as determined at an ionic strength of 0.1M and at a temperature of 25°C.

[3] Active pH range: calculated for a hydroxide environment in 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%.

[4] Upper pH limit is determined experimentally.

[5] Z.A. Begun, I.M.M. Rahman, H. Sawai, Y. Tate, H. Hasegawa, Journal of Chemical & Engineering Data (2012), 57(10), 2723 – 2732.

**Table 5: Chelating capacity as mg metal/g Dissolvine® GL (GLDA), Dissolvine® E-39 (EDTA) and $NTANa_3$ 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® GL-38** | 38 | 108 | 43 | 69 | 60 | 26 | 59 | 71 |
| **Dissolvine® GL-47-S** | 47 | 134 | 54 | 85 | 75 | 33 | 73 | 88 |
| **Dissolvine® GL-PD-S** | 80 | 227 | 91 | 145 | 125 | 55 | 125 | 150 |
| **$NTANa_3$ 40%** | 40 | 156 | 62 | 99 | 87 | 38 | 85 | 102 |
| **Dissolvine® E-39** | 39 | 103 | 41 | 65 | 57 | 25 | 56 | 67 |

# Environmental and toxicological data

**Ecotox and toxicological data**

A major advantage of Dissolvine® GL is its excellent properties with regard to human toxicity and environmental acceptability. Dissolvine® GL is completely safe for man and the environment. This can be seen in **Table 6**, which shows test results for solid Dissolvine® GL. The entire data set on GLDA was determined under Good Laboratory Practice and according to OECD (Organization of Economic Cooperation and Development, www.oecd.org/) guidelines. The latest OECD guidelines on acute toxicity (i.e. OECD 201-203) adopted a limit test at 100 mg/l of test substance. Above this limit a substance is considered to have no toxic effects.

An Eco-Efficiency Analysis (EEA) conducted on a variety of alternative chelating agents concluded that GLDA is one of the most environmentally benign chelating agents. The EEA assessed the ecological and economic profiles of alternative systems delivering the same customer benefits. The references to external publications for the EEA analysis are SOFW (10-2009).

Table 6: Ecotox and toxicological test data for Dissolvine® GL

| | Method | Dissolvine® GL |
|---|---|---|
| **Physical chemical properties** | | |
| Partition coefficient (n-octanol/water) HPLC | OECD 117 | Log $P_{ow}$ < 0 |
| **Effects on biotic systems** | | |
| Algae, growth inhibition (green algae) | OECD 201 | 72h – NOEC ≥100 mg/l |
| Daphnia sp. acute immobilization (daphnia magna) | OECD 202 | 48h – NOEC ≥100 mg/l |
| Fish, acute toxicity (rainbow trout) | OECD 203 | 96h – NOEC ≥ 100 mg/l |
| Fish, short term toxicity on embryo and sac-fry stages under flow through conditions (zebrafish) | OECD 212 | NOEC = 103 mg/l |
| Daphnia magna reproduction (chronic toxicity) | OECD 211 | NOEC ≥ 265.7 mg/l |
| **Health effects** | | |
| Acute oral toxicity (rat) | OECD 425 | $LD_{50}$ > 2000 mg/kg bw |
| Acute dermal toxicity (rat) | OECD 402 | $LD_{50}$ > 2000 mg/kg bw |
| Acute inhalation toxicity (rat) | OECD 403 | 4h-$LC_{50}$ > 4.2 g/$m^3$ (highest attainable concentration) |
| 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 = 300 mg/kg bw/day |
| Prenatal developmental toxicity (rabbit) | OECD 414 | NOAEL ≥ 300 mg/kg bw/day |
| Two-generation reproduction toxicity (rat) | OECD 416 | NOAEL = 5000 ppm for parental toxicity (corresponding to ca. 300-400 mg/kg bw/day); NOAEL ≥ 15000 ppm for both reproduction and developmental toxicity (corresponding to ca. 900-1200 mg/kg bw/day; highest dose tested) |
| Bacterial reverse mutation (Ames test) | OECD 471 | not mutagenic |
| In vitro mammalian chromosome aberration test (CHL cells) | OECD 473 | weakly clastogenic to CHL cells in vitro |
| In vitro mammalian cell gene mutation test (HGPRT; CHO cells) | OECD 476 | not mutagenic |
| In vivo mammalian erythrocyte micronucleus test (mouse) | OECD 474 | not genotoxic |

NOAEL = No Observed Adverse Effect Level
NOEC = No Observed Effect Concentration
bw = body weight

**Biodegradability**
One of the basic requirements for a chelate to be considered environmentally friendly is it needs to be degradable under a wide range of environmental conditions – and GLDA readily meets this requirement. In fact GLDA is the only safe chelate where it has been demonstrated to be readily biodegradable using inoculum from over a dozen municipal waste treatment plants in the U.S. (June 2012 ACS Green Chemistry Conference, How a New Builder in ADW Detergent Became Readily Biodegradable: Widespread Microbial Adaption in the Field).

Dissolvine GL is manufactured with L-glutamic acid – a naturally occurring amino acid that itself is readily biodegradable. This amino acid structure may well account for the relative ease that micro-organisms feed on and degrade it. Indeed, this is confirmed by the results obtained in biodegradability studies performed under the wide range of conditions shown below.

At the top of **Table 7**, the conventional test for biodegradability (OECD 301D) shows consistent degradation well in excess of the 60% degradation required to be considered readily biodegradable. This high level of biodegradation coupled with the virtual disappearance of GLDA following the OECD 303A test also demonstrates that GL is ultimately biodegradable, which means complete conversion to $CO_2$, $H_2O$, biomass and mineral salts, even at temperatures as low as 10° C.

GLDA is also found to be biodegradable under anaerobic conditions OECD 311 as may be found in private household septic tanks. This finding is important as anaerobic degradability is a requirement to be compliant with European Eco labelling legislation www.ec.europa.eu/environment/ecolabel/. GLDA is also found to biodegrade in sea water (OECD 306).

Due to this high level of biodegradation and low toxicity to aquatic organisms, GLDA is listed as 'Approved for Direct Release' to the environment on the U.S. EPA sponsored CleanGredients web site: www.cleangredients.org/home.

**Official recognition as a safe ingredient and certified as 58% biobased**
GLDA's safe nature and low environmental impact is recognised around the world by both private and government agencies. GLDA has no negative safety issues and does not require any dangerous labelling.

In the U.S., after extensive review, the Environmental Protection Agency has recognized GLDA as a safer chemical ingredient with full Design for the Environment (DfE) status (see: www.epa.gov/dfe/). Formulated consumer and industrial products containing GL may then qualify to show the DfE logo on their product's packaging. Consumers, purchasing agents and workers can be assured DfE recognized products are safe to use and are safe for the environment.

In Europe, GLDA is listed on the French positive list, which means that it is approved for institutional dish washing and rinsing. The Dissolvine GL-S types are fully compliant with Nordic Swan detergent Ecolabel legislation (see www.nordic-ecolabel.org/criteria) and with EU Ecolabel legislation (as can be found on www.ec.europa.eu/environment/ecolabel/). GLDA is listed in the 2014.1 version of the European Detergent Ingredient Database (DID list) under line 2510. Also GLDA is compliant with the European Regulation on Cosmetic products EC 1223/2009. Around the world private organizations have approved GLDA to be used in products they endorse, including:

For Ecocert, GLDA is the only chelate on the positive list of authorized synthetic ingredients that can be used in natural and organic cosmetics (see www.ecocert.com/en)

For Bioform, GLDA has an authorization for use in Ecogarantie certified cleaning products. For COSMOS, GLDA is an authorized chelating agent for use in soaps (COSMOS = COSMetic Organic Standard) as of 2013 of BDIH (Germany), Cosmebio (France), Ecocert (France), ICEA (Italy) and the Soil Association (UK) (see www.cosmos-standard.org)

Also from the U.S., after careful review, Green Seal Inc. has approved several consumer products that contain Dissolvine GL-47-S as an ingredient. Additionally, in an effort to promote the development and use of renewable raw materials, the U.S. Department of Agriculture (USDA) initiated a program to not only certify the biobased content of products but to then encourage the procurement of goods made from these renewable resources. The program – USDA Biopreferred Procurement Program (www.biopreferred.gov/) has certified Dissolvine GL-47-S as an Intermediate with 58% biobased content. GLDA is the only strong chelate in this category certified as biobased.

For companies who wish to qualify and promote their products as USDA biobased, formulating with Dissolvine GL-47-S offers enhanced marketing and sales opportunities not afforded with other chelating agents.

In Europe following the Bra Miljöval protocol of Swedish Society for Nature Conservation, GLDA is 86% based on non-fossil / renewable resources.

**Figure 8**
GLDA-$Na_4$ fossil and green character, according to the Bra Miljöval protocol

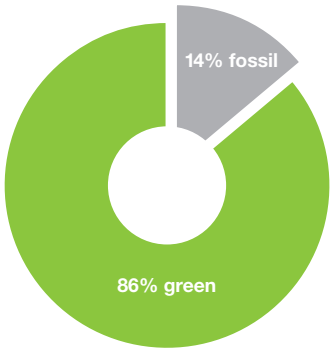



**Table 7: Biodegradability test data for Dissolvine® GL**

| Biodegradability studies / OECD Method | Result |
|---|---|
| Ready biodegradability / 301D<br>Closed bottle test with inoculum from 13 waste water treatment plants | All > 60% at day 28 |
| Ready biodegradability 301D<br>Standard closed bottle test with river water | 83% at day 28 |
| Biodegradability in sea water / 306 | 83% at day 60 |
| Inherent biodegradability / 302B<br>Zahn-Wellens | >98% after 10 days |
| Simulation test-aerobic sewage treatment / 303A<br>A activated sludge units | >95% disappearance |
| Anaerobic biodegradability / 311 | 67% at day 75 |

**Summary**

| | Strong chelate? | Readily biodegradable? | Safe for man and environment? | Biobased? |
|---|---|---|---|---|
| **GLDA** | + | + | + | + |
| **EDTA** | + | – | – | – |
| **NTA** | + | + | – | – |
| **Citrate** | – | + | + | + |
| **Phosphates*** | + | inorganic | –** | – |
| **Phosphonates** | + | – | + | – |

* such as STPP (sodium tripolyphosphate) ** causes eutrophication

# Main functionalities in applications

**Enhanced cleaning – complexing hard water ions**

One of the main reasons why chelates are added to a wide variety of products and processes is to complex the hard water ions $Ca^{2+}$ and $Mg^{2+}$. These ions need to be complexed to prevent their precipitation as unwanted scale or turbidity and to allow other chemicals in the formulation, such as surfactants, to do their job properly. Most formulations or process streams contain other components that compete for the hard water ions so the chelate should have a higher affinity for these ions than the other components.

**Figure 9** illustrates the significant impact metal ion control has in cleaning. Addition of chelates – like GLDA – to control metal ion interactions that occur with soil and surfactants and even bacteria can greatly enhance the cleaning and preserving/sanitizing property of the cleaning formulation.

To illustrate the calcium binding efficiency of GLDA, experiments have been performed with various chelating agents and the $Ca^{2+}$ ion indicator Hydroxy Naphtol Blue (HNB) that is used here as a competitive chelating agent. HNB has a relatively high affinity for calcium and colors from blue to red when fully complexed to calcium. As a result, the color of a solution containing $Ca^{2+}$ ions, HNB and the chelate to be tested gives a measure for the calcium binding efficiency of the chelate vs. the HNB. **Figure 10** compares the $Ca^{2+}$ affinity at pH11-12 of a number of chelates. The finding here is that Dissolvine® GL is the most effective biodegradable chelating agent for the complexation of hard water ions.

Another measure of the ability to soften water is shown in **Figure 11** which is a plot of water hardness vs. log K in the presence of an equal molar concentration of GLDA and other common chelates. As seen GLDA is capable of achieving low water hardness levels due to its strong binding with $Ca^{2+}$ ions.

The ability of GLDA to soften water and prevent $Ca^{2+}$ precipitation with an anionic surfactant is shown in **Figure 12**. In the presence of medium hard water the liquid anionic soap readily forms 'soap scum' and deactivates the surfactant. Addition of the weaker chelate citrate has limited benefit in preventing this deactivation – but addition of GLDA shows adequate softening ability.

Addition of small quantities of GLDA to a formulation can help stabilize the product and prevent discoloration or formation of turbidity from reaction of trace metal ions that may be present or contaminate the product during use. Addition of larger quantities of GLDA will lead to enhanced cleaning ability and prevent deactivation of active ingredients during use.

**Figure 9**
Competition for metal ions – like $Ca^{2+}$ or $Fe^{3+}$ – between GLDA chelate and various substrates that may form a reaction or precipitate with the metal ion.

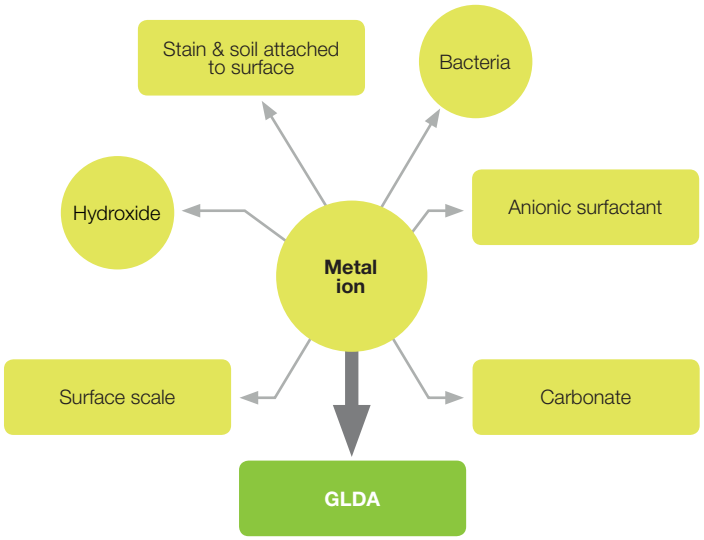
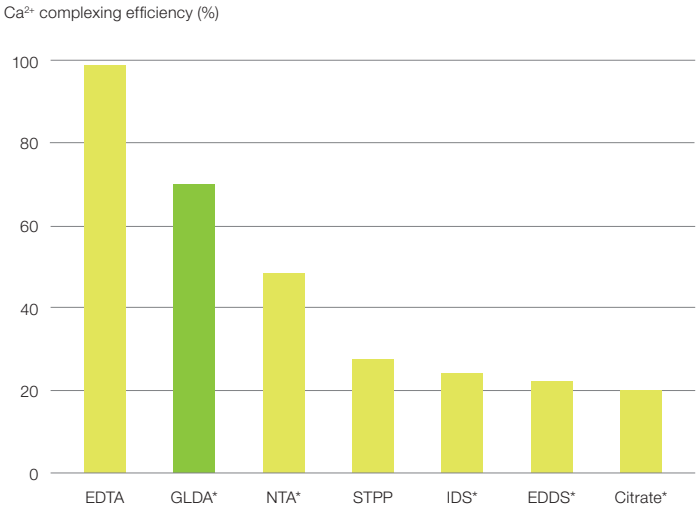



**Figure 10**
The $Ca^{2+}$ complexing efficiency of various chelating agents in competition with Hydroxy Naphthol Blue at pH 11-12.
* Readily biodegradable chelating agents.



**Dissolving scales**
In addition to preventing precipitation of scale, Dissolvine® chelating agents are used to remove unwanted scale. The most frequently encountered scales consist of calcium, barium and iron as their carbonate, sulfate or oxide. **Figure 13** compares the $CaCO_3$ dissolving capability of a variety of chelating agents. Compared to other aminopolycarboxylates, phosphonates and succinates, Dissolvine® GL is the best readily biodegradable chelate for the removal of $CaCO_3$ scale.

**Removing tea stains in institutional machine and household automatic dishwashing (ADW)**
Tea stains are particularly difficult to remove in automatic dishwashing cleaning without the aid of chlorine based bleaching agents that whiten the stain by oxidation and were commonly mixed directly with STPP based ADWs. Without bleaching agents the tea stain, which strongly adheres to the surface of cups and dishes by $Ca^{2+}$ ion linkages that act like glue, must be dissolved from the surface by removal of these underlying $Ca^{2+}$ ions, see **Figure 14**.

Institutional machine dishwashing tests have shown that GLDA is particularly effective at removing tea stains, when compared to alternative chelating agents at the same concentration in a formulation based on 7% NaOH and 11.4% chelate in demineralized water. The test results shown in **Figure 11** reveal that GLDA is superior in institutional dishwashing cleaning to phosphates and citrates on a weight basis. GLDA performs better than EDTA and equal to NTA on a weight basis.

In comparing readily biodegradable chelates for the removal of various dish deposits and stains in a household dish washer cleaner, it was found that GLDA scores slightly better in ADW than the alternative products on an equal weight basis. The formulations had a neutral pH and contained 5wt% of the listed chelating agent. The result is given in **Figure 16**.

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

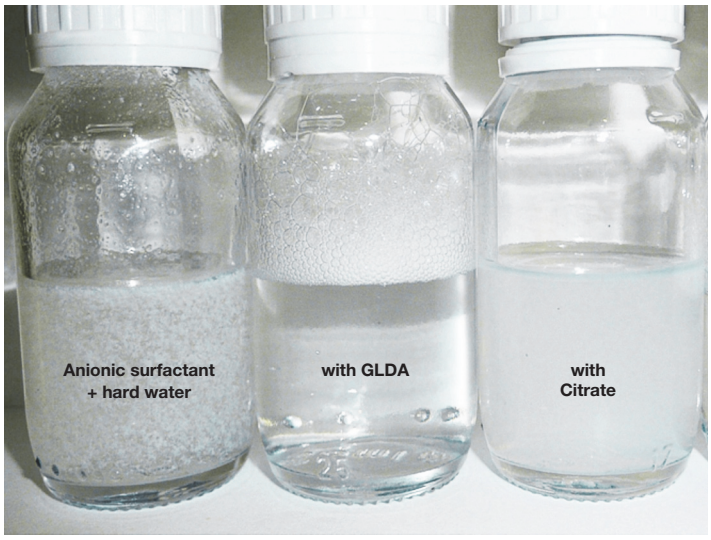



**Figure 11**
Water hardness reduction in the presence of various chelates vs. Log K of the Ca-chelate stability constant.

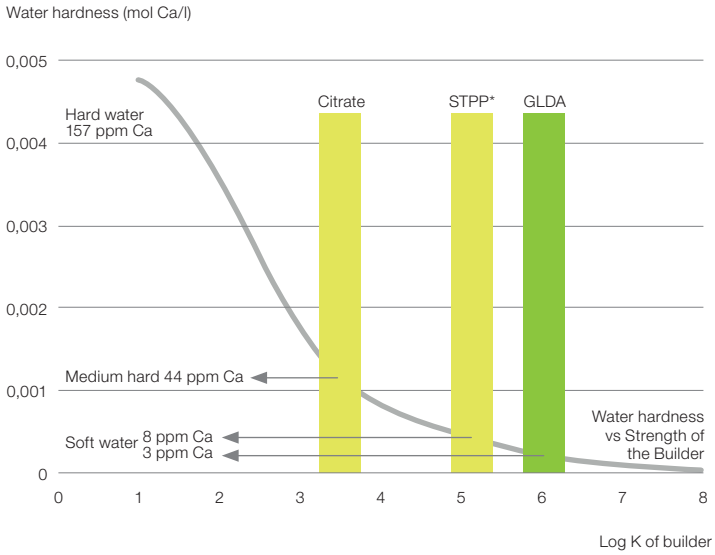
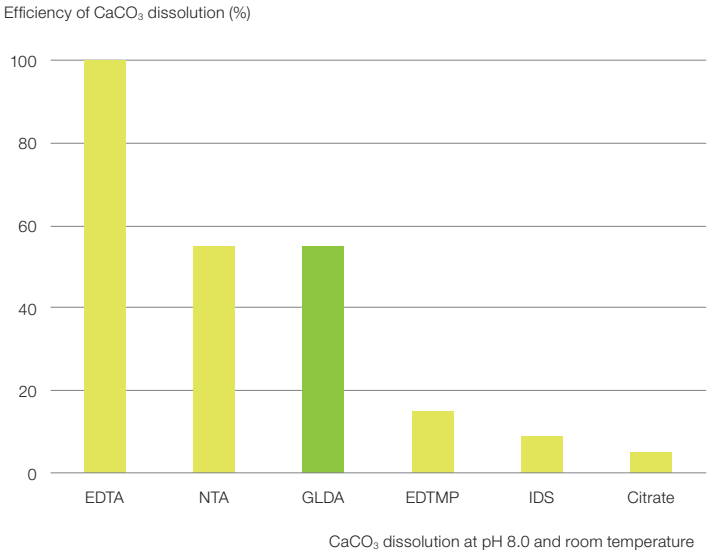



**Figure 13**
The dissolution of $CaCO_3$ by various chelating agents at pH 8.



As shown in **Figure 17**, GLDA also offers excellent anti-filming/deposition in phosphorous free 'All in One' ADW cleaners when combined with co-builders such as AkzoNobel's Alcoguard 4160-G product. The combination is a shining example of the effectiveness of AkzoNobel's products for cleaners.

Due to GLDA's high solubility in water it is ideally suited for bulk gel ADW cleaners and also in single dose gels packaged in dissolvable PVOH pouches. The low water content possible with GLDA containing gels allows for the gel's compatibility with the PVOH. While GLDA solid by itself is hygroscopic, it can be favorably formulated in single dose pouches when sealed in water resistant packaging.

**Hard surface and fabric cleaning**

Low foam is a prerequisite for ADW cleaning as it is for many other surface cleaning formulations – like car wash and home surface cleaning products. For touchless cleaning of cars or home surfaces – GLDA combined with an AkzoNobel Berol® (alcohol ethoxylate) product make cleaning easy and surfaces shine. While non-ionic surfactants do not react with hard water ions like anionic surfactants do, they benefit from addition of chelates like GLDA to remove the $Ca^{2+}$ bridges that hold dirt to the surface. **Figure 18** clearly shows the benefit of using a strong chelate like GLDA in combination with a non-ionic low foaming surfactant.

But when high foaming cleaners are needed – such as in carpet cleaners and hand laundry and hand dish detergents – GLDA can deliver. As evident in Fig. 12, when combined with anionic surfactants GLDA can greatly enhance the foaming and hence cleaning action when it is needed.

**Enhancing personal care products and improving the effectiveness of preservatives and biocides**

As in cleaning, chelates are often added to personal care products to complex hard water metal ions to maintain the effectiveness of surfactants present. Chelates are also added to personal care products to improve shelf life and product appearance. Trace amounts of certain transition metal ions can combine with oxygen in the air and can cause product degradation and rancidity. What's more, chelates are known to enhance the effectiveness of biological preservatives that protect products against bacteria contamination and growth. Chelates like GLDA act by weakening bacteria cell wall membranes by complexing/extracting $Ca^{2+}$ ions from the cell's surface. The weakened cell wall is then more susceptible to the action of preservatives. Such preserving action is critical to prevent against gram negative bac-

**Figure 14**
Dirt and stains are bound to the surface of dishware by $Ca^{2+}$ ion bridges that act like glue. Chelates can complex the $Ca^{2+}$ ions which helps to release the dirt/stain.

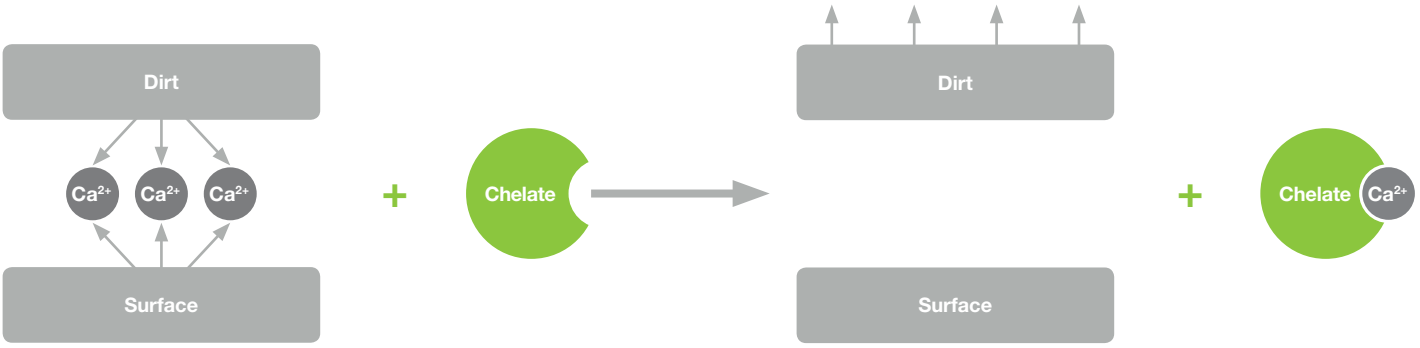



**Figure 15**
GLDA's ability to remove tea stains compared to alternative alkaline builders. KTPP = Potassium tri polyphosphate; TKPP = Tetrapotassium pyrophosphate. * Readily biodegradable chelating agent.

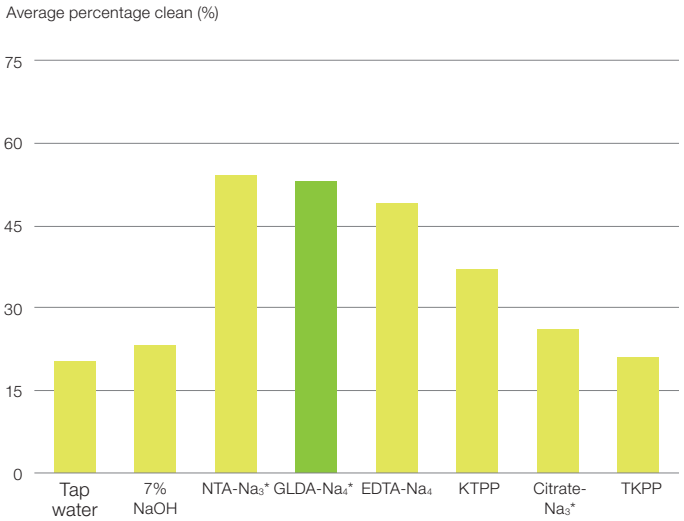
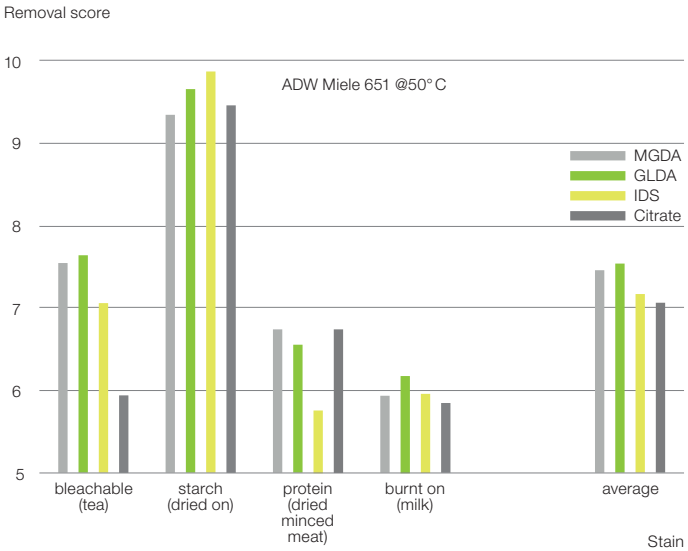



**Figure 16**
Stain removal performance of GLDA compared to other biodegradable chelates. (From WO2007/052064).



teria that can cause blindness. All Dissolvine® GL products are fully compliant with the European Cosmetics Directive.

To demonstrate the effectiveness of a chelate to enhance the effect of a preservative, a series of solutions containing varying quantities of preservatives, chelate and water hardness were prepared and were 'challenged' with various bacteria. This so-called challenge test then measures the number of bacteria that survive.

The results of a challenge test using sodium benzoate as a preservative against gram negative bacteria Pseudomonas aeruginosa at pH 4.5 is shown in **Figure 19**. By itself Dissolvine® GLDA has no biocidal properties, but boosts the effectiveness of benzoate, and many other preservatives tested. By enhancing the effectiveness of the preservative, the amount of preservative needed to achieve the desired effect can be reduced. The ability for GLDA to boost the effectiveness of various preservatives has been documented for gram negative bacteria, gram positive bacteria and mold (see W. Siegert in SOFW Jour. 2008, vol 1/2, p 22; 2011, vol 5; and 2014, vol 1/2 p 104).

**Enhancing the effect of biocides**

Dissolvine® GL is particularly suited for this application as it is more effective than EDTA when measured by the European Standard 1276 test for bactericidal activity. As a formulation it meets the criteria for designation as a green label. The criterion to pass the test is a log 6 reduction in bacterial activity within 5 minutes. The results for the gram negative bacteria Pseudomonas aeruginosa in a hard water environment (17° dH) are presented in **Figure 20**. By comparison, a smaller quantity of GLDA is required to obtain the equivalent biocidal activity.

Similar positive effects of GLDA on the activity of biocides against gram negative bacteria, gram positive bacteria and fungi are described in several publications. Chelates appear to remove calcium and magnesium ions present in the membrane of the bacterial cells, thereby increasing the permeability of the membrane to biocides. In multiple tests we find GLDA is more effective than EDTA in its ability to enhance the effectiveness of biocides.

We've demonstrated the multiple benefits of using chelates and Dissolvine GL in particular for various cleaning jobs – dissolving scale, cleaning dishes and hard surfaces, making surfactants and preservatives work harder. Don't hesitate to contact us with your cleaning or personal care challenges.

**Figure 17**
Anti-filming performance of a GLDA based ADW cleaner (2nd from left) containing AkzoNobel's Alcoguard 4160-G polymeric co-builder after 30 washing cycles.

**Figure 18**
Touchless removal of automotive dirt at room temperature with Berol® ENV226 with various builders.

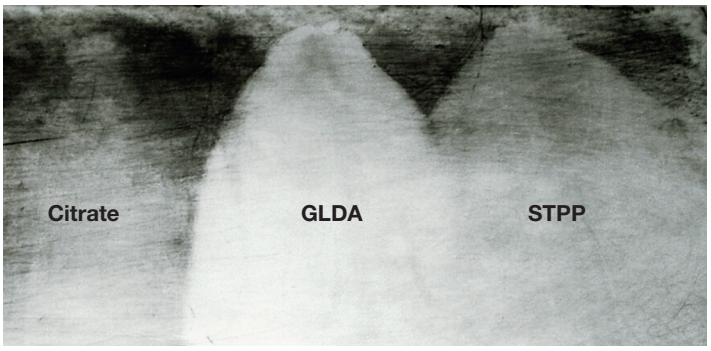



**Figure 19**
The influence of GLDA with Benzoic acid on Pseudomonas aeruginosa at pH 4.5. The yellow bar areas indicate conditions with germ growth, whereas the green bars represent conditions with germ reduction.

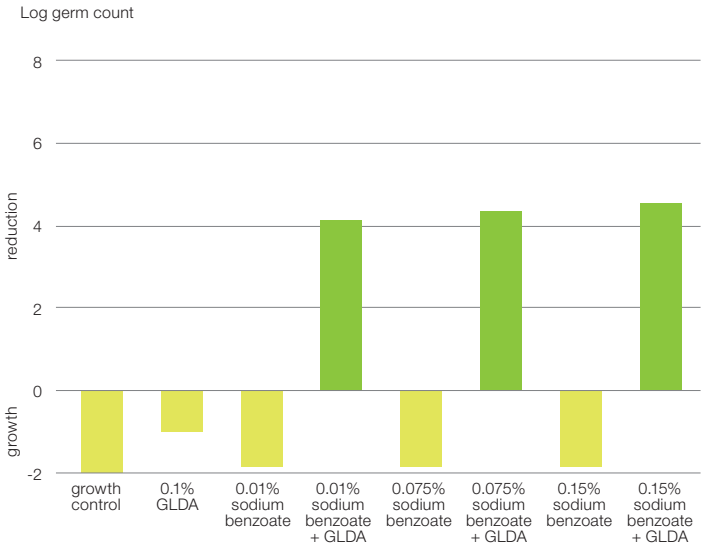
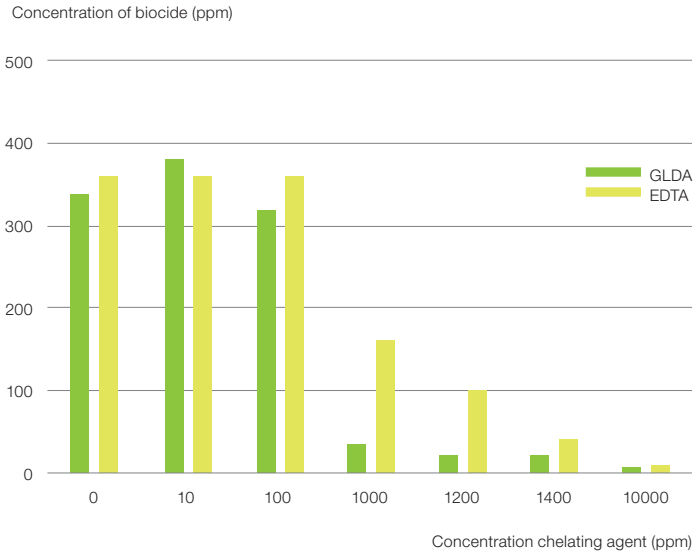



**Figure 20**
The influence of EDTA and GLDA on the biocidal activity of Arquad® MCB-50 against gram negative bacteria Pseudomonas aeruginosa.



# Commited to develop sustainable products for our environment

AkzoNobel is the largest global paints and coatings company and a major producer of specialty chemicals. We supply industries and consumers worldwide with innovative products and are passionate about developing sustainable products and answers for our customers.

From 2006 – 2014 AkzoNobel has ranked #1 or #2 in the Chemical Materials Group of the Dow Jones Sustainability Index Review.

**GLDA – Globally Registered**
GLDA is available everywhere – it is registered and allowed for use in all countries where a chemical registration is required, including:

U.S.A. – TSCA inventory

E.U. – EINECS/ELINCS inventory and full REACh registration since 2010.

China – AkzoNobel has obtained the license according to Chinese Measures on Environment Management of New Chemical Substances for GLDA. GLDA is in compliance with the Chinese New Chemical Management Regulation and approved for importation and production.

Canada – DSL inventory
Japan – ENCS inventory
Korea – KECI inventory
Australia – AICS inventory
New Zealand – NZIoC inventory
Philippines – PICCS inventory

In addition, GLDA-$Na_4$ is registered/listed in several specialty use areas, for example:
in cosmetics the INCI name is Tetrasodium Glutamate Diacetate. Please request the application leaflet 'Dissolvine in Cosmetics' for more specific information on GLDA's status.

FIFRA – the U.S. Environmental Protection Agency (EPA) has approved GLDA-$Na_4$ at concentrations of up to 5% by weight to be used in non-food use pesticide products applied as hard surface sanitizers and disinfectants for indoor non-food contact surfaces.

At this writing, Akzo Nobel is actively seeking to register GLDA-$Na_4$ with the U.S. Food and Drug Administration (FDA) for food contact use (21 CFR). Please contact us for the current status on these approvals.

## Application areas

**Household cleaning**
- Automatic dishwashing
- Laundry detergents
- Hand dishwashing
- Surface cleaning

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

**Personal care & cosmetics**
- The INCI names is:
  – Tetrasodium glutamate diacetate

**Polymer production**

**Pulp and paper**

**Textiles**

**Gas sweetening**

**Metal plating and electronics**

**Oil industry**

**For the 3rd consecutive year:
AkzoNobel ranked #1
in the Chemical Materials Group**

**2014 Dow Jones Sustainability Index Review**

**Sustainable raw materials**
**Eco-premium solutions**
**Greenhouse gas emissions**
**Sustainable fresh water management**
**Product Stewardship**
**Bio-based products**

**Further information**
For more detailed product information please refer to the separate product leaflets. For samples, technical service and further information, please contact your nearest AkzoNobel Office or agent, or visit our website at www.dissolvinegl.com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AkzoNobel

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AkzoNobel is a leading global paints and coatings company and a major producer of specialty chemicals. We supply industries and consumers worldwide with innovative products and are passionate about developing sustainable answers for our customers. Our portfolio includes well-known brands such as Dulux, Sikkens, International and Eka. Headquartered in Amsterdam, the Netherlands, we are consistently ranked as one of the leaders in the area of sustainability. With operations in more than 80 countries, our 50,000 people around the world are committed to delivering leading products and technologies to meet the growing demands of our fast-changing world.



Dissolvine® GL
The greener chelate


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