

The logo for 'innospec' is located in the top left corner. It consists of the word 'innospec' in a white, lowercase, sans-serif font, followed by a white icon of a stylized leaf or arrow pointing to the right. The background of the entire image is a close-up photograph of a plant with green leaves and small white flowers, with a bee on one of the flowers.

innospec

ENVIOMET[®] C

effective biodegradable chelating agent
for micronutrient application

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SUSTAINABILITY
at Innospec

Innospec is a global supplier of specialty chemicals to the agrochemical market.

Our adjuvants, emulsifiers, specialty solvents and wetting agents are used widely in agrochemical formulations.

Our mission is to develop high performing products for use in Agriculture, with a low environmental impact.

In our research for a product that delivers excellent chelating performance with readily biodegradable properties, we developed ENVIOMET® C.

Chelated micronutrients

In plant nutrition, there are a number of metallic elements such as copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn), which are considered essential as micronutrients. Nutrient deficiencies caused by lack of these vital elements is a condition that causes many serious problems in agriculture.

Nutrient	Deficiency symptoms
Manganese	Manganese deficiency causes interveinal chlorosis with necrotic spots and stunted root development.
Zinc	The leaf is narrow and small. Lamina is often chlorotic, veins remain green. Necrotic spots develop randomly all over the leaf.
Iron	Younger leaves are affected with interveinal chlorosis (also known as lime induced iron chlorosis), with main veins remaining green; in severe cases, the entire leaf may become bleached.
Copper	Interveinal chlorosis. Resetting and permanent wilting of leaves. The leaf detaches easily from the stem. Copper deficiency causes pollen sterility, yellowing and curling of leaves and lower density of ear production in cereals.

All for a good harvest: Addressing micronutrient deficiencies. September 2019 – PWC and International Zinc Association

Chelated micronutrients are a group of products in which the micronutrient element is bound to an organic ligand. In this form, the cations are protected from reaction with other elements, improving its availability to plants. These metal-containing chelate compounds can be used as fertilisers for soil, foliar treatments and seed dressings.

Properties of ENVIOMET[®] C chelating agents

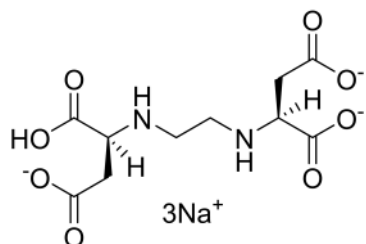
The ENVIOMET[®] C are high-performance chelating agents with the following characteristics:

- Based on aminocarboxylic acid - [S,S]-ethylenediamine-disuccinic acid (EDDS);
- Single isomer: optical purity >99% [S,S] form;
- Readily biodegradable according to OECD 301;
- Available as 37% aqueous solution of trisodium salt (ENVIOMET[®] C 140) or solid free acid (ENVIOMET[®] C 265);
- Classified as non hazardous.

ENVIOMET[®] C140

aqueous solution trisodium salt of EDDS

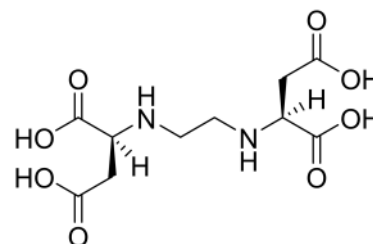
- Liquid, 37% w/w, as trisodium salt
- Appearance - Clear liquid, free of foreign matter
- pH 9.5 +/-0.5
- Total salts <1% w/w (sodium bromide and sodium chloride)
- Soluble in all proportions in water



ENVIOMET[®] C265

solid free acid form of EDDS

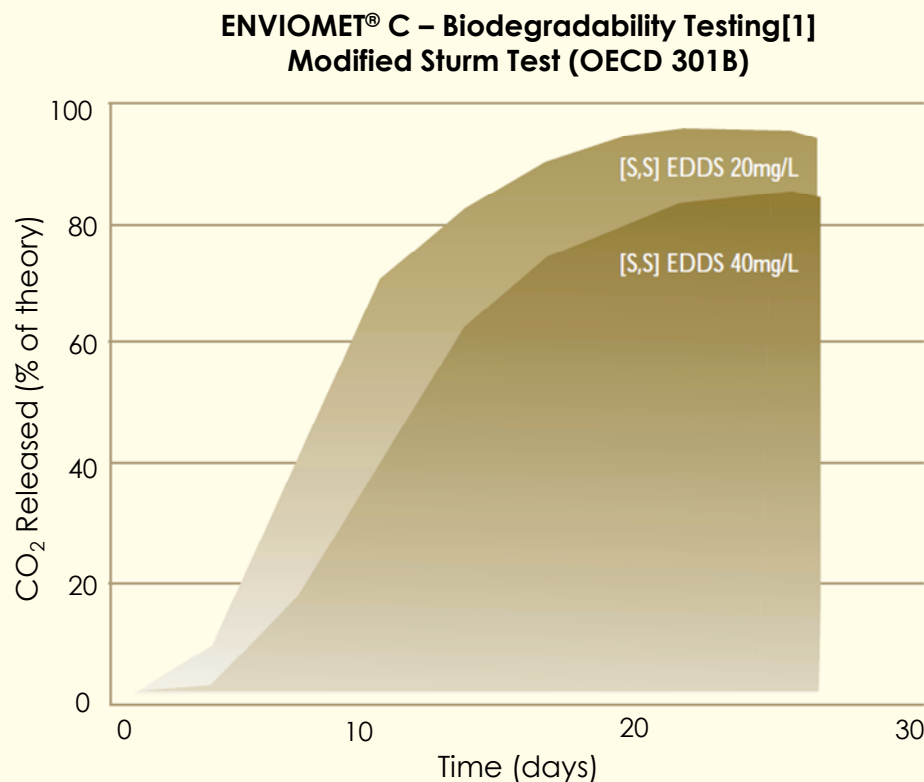
- Solid, fully protonated, with 10-20%w/w water
- White crystalline free flowing powder
- Water solubility at 20°C is 150 mg/L



ENVIOMET[®] C biodegradability

ENVIOMET[®] C chelating agents are readily biodegradable in accordance with OECD 301B test protocols:

- Extensive (>80%) mineralization to CO₂ after 28d;
- 10-60% degradation was 5 days for US sludge and 9 days for EU sludge (i.e. within 10d window).



Mineralisation of ENVIOMET[®] C in an unacclimatised CO₂ production Sturm test

After 28 days, the degree of degradation was in the range of 85-95%

A lag phase of 3-5 days occurred before the degradation started

When released into the environment, ENVIOMET[®] C chelating agents will rapidly biodegrade reducing the possibility to form persistent organic chelates with heavy metals such as lead (Pb). This will result in less risk in soil accumulation and underground water pollution.

ENVIOMET[®] C toxicity

Human Health Toxicology

- Human health safety of ENVIOMET[®] C chelating agents has been comprehensively assessed and the available data shows:
 - It is poorly absorbed and rapidly excreted from the body;
 - It exhibits low acute and systemic toxicity;
 - It is not a carcinogenic, mutagenic or reproductive (CMR) toxicant.
- ENVIOMET[®] C chelating agents are not classified for any human health hazards according to EU CLP.

Environmental Aquatic Toxicology

- Aquatic toxicology of ENVIOMET[®] C chelating agents has been comprehensively studied and the available data shows:
 - It exhibits very low acute and chronic toxicity to fish and invertebrates;
 - It exhibits moderate toxicity to algae (indirect toxicity via chelation of essential trace nutrient metals in static laboratory test systems).
- ENVIOMET[®] C chelating agents are not classified for adverse effects on aquatic environment according to EU CLP.

ENVIOMET[®] C toxicity

Environmental Terrestrial Toxicology

Terrestrial toxicity of ENVIOMET[®] C chelating agents has been comprehensively studied and the available data shows:

- It exhibits low toxicity to earthworms;
- It exhibits low toxicity to plants in seedling emergence tests (with oat, lettuce and tomato);
- It exhibits no detrimental toxic effects on microflora.

Impact on soil ecosystems

When applied to soil, ENVIOMET[®] C chelating agents are less toxic to the soil microbial community and will be rapidly degraded. As a result, the ENVIOMET[®] C chelating agents will not accumulate over time and are less likely to have a negative impact on the soil ecosystem functions.

Regulatory Status

- ENVIOMET® C is listed on all major global chemical inventories (Europe, US, Canada, China, Australia, New Zealand, Korea, Japan, Philippines and Taiwan).
- ENVIOMET® C is registered and fully compliant with EU Regulation 1907/2006 concerning the Registration, Evaluation Authorisation and Restriction of Chemicals (EU REACH).
 - Hazard data does not warrant warnings on product labels for adverse (eco)toxicological effects;
 - Safe use has been demonstrated according to standardized risk assessment methodology.
- ENVIOMET® C is included in the list of authorised organic chelating agent for micro-nutrients by Commission Regulation (EU) 2016/1618 amending Regulation (EC) No 2003/2003 which designs EU fertilisers.
- ENVIOMET® C140 and ENVIOMET® C265 are approved inert ingredients, exempted from the requirement of a tolerance in accordance with US EPA 40 CFR § 180.
- ENVIOMET® C chelating agents meet all criteria and qualify as raw material ingredient under the EU Ecolabel and the US EPA Safer Choice schemes.



ENVIOMET® C in organic farming

- The use of ENVIOMET® C as chelating agent for micro-nutrient is **consistent with the principles of sustainable agriculture**. Thanks to its **biodegradability**, it is particularly recommended for organic certified products.
- To this regard, the Research Institute of Organic Agriculture (FiBL), one of the World's leading institutes in the field of organic agriculture, recommends EDDS as chelating agent in its European Input List for fertilizers, soil conditioners and crop management tools.

ENVIOMET[®] C chelating capacity

Chelation is a process in which free metal ions combine with ligands to form metal complexes. The ability of a chelant to bind metal ion is determined by stability constants. The larger the stability constant, the stronger the chelation effect and the free metal ion in solution become lesser.

Table 1: Stability constants

	Biodegradable chelants		Conventional chelants		
	EDDS ¹	IDHA ³	EDTA ¹	DTPA ¹	o-o EDDHA ²
Ca ²⁺	4.6	6.0	10.6	10.7	7.3
Cu ²⁺	18.4	14.6	18.8	21.5	25.1
Fe ³⁺	22.0	16.4	25.0	28.6	35.1
Mg ²⁺	6.0	7.2	8.7	9.3	9.8
Mn ²⁺	8.6	9.0	13.8	15.6	9.6 ⁴
Zn ²⁺	13.4	12.0	16.5	18.7	

IDHA = Imidodisuccinic acid / EDTA = Ethylenediaminetetraacetic acid / DTPA = Diethylenetriaminepentaacetic acid
o-o EDDHA = o-o ethylenediamine-N,N'-bis(2-hydroxyphenylacetic acid)

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 if not available at 20°C.
2. Isabel S. S. Pinto, et al., Environ Sci Pollut Res (2014) 21:11893–11906.
3. Miguel A Sierra, et al., Dalton Trans. 2004 Nov 7;(21):3741-7.
4. Sandra López-Rayó, et al., Chemical Speciation and Bioavailability (2012), 24(3).

ENVIOMET[®] C chelating agents have a low affinity with calcium and magnesium that will result in more stable chelated micronutrient when diluted in hard water and/ or applied to calcareous soils.

ENVIOMET[®] C and pH

pH plays an important role in the formation of metal complexes and this is a crucial parameter for the chelates efficacy for application in agriculture. We have compiled below the pH range, calculated by chemical simulations, for which at least 80% of the metal cation is chelated.

Table 2 pH range, calculated by chemical simulations, for which there is at least 80% of metal complexed by EDDS and IDHA, in a medium with Ca and Mg in excess.

Cation	Biodegradable chelating agent	
	EDDS	IDHA
Fe	2 – 7	2 – 4.2
Cu	1 – 14	2.3 – 11.3
Mn	6 – 12	7 – 13
Zn	3.8 – 12.8	3.8 – 10.8

Calculated from: Isabel S S Pinto, et al., Environ Sci Pollut Res (2014) 21:11893–11906

In general, ENVIOMET[®] C chelating agents show better pH stability compared to the IDHA chelating agent.

ENVIOMET[®] C applications

Chelated micronutrients are less reactive, less subject to precipitation and remain water soluble for longer time, increasing the overall bioavailability compared to inorganic sources of nutrient metal ions.

ENVIOMET[®] C are effective chelating agents for copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) with the added advantage of readily biodegradability.

We present in the following paragraphs agronomical testing showing the performance of iron EDDS chelate in foliar and soil application.

Foliar application

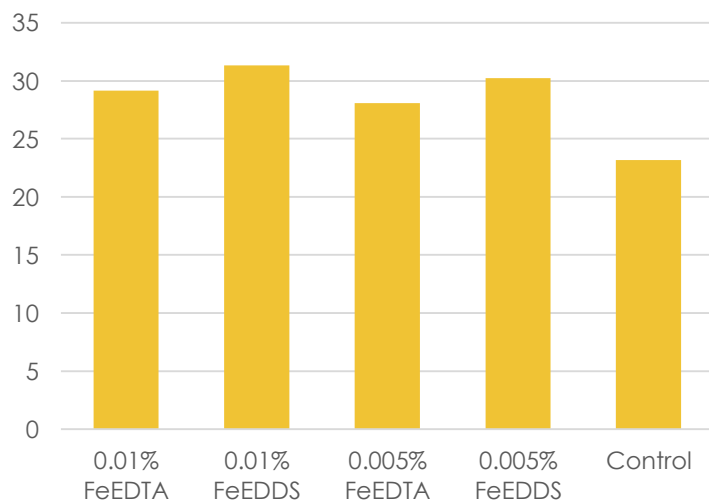
The efficacy of Fe-EDDS in comparison to Fe-EDTA chelates was tested on Maize and Soybean. Growth trials (80 plants) have indicated that EDDS is as effective as EDTA in delivering iron metal to soyabean and maize plants in foliar feeding applications.

- Plants grown in calcareous soil were each treated with 0.01% and 0.005% of Fe(EDDS) and Fe(EDTA) as foliar sprays in order to compare their effectiveness in alleviating Fe deficiency symptoms.
- The results obtained suggest that 0.01% Fe(EDDS) was the better foliar treatment for soyabean and maize deficient in iron. The work also suggests that application of iron as Fe(EDDS) may be a safer source because it does not produce the leaf scorching associated with higher levels of Fe(EDTA). The results showed a very good response of all plants to EDDS application, superior in comparison to EDTA.

ENVIOMET[®] C Foliar application

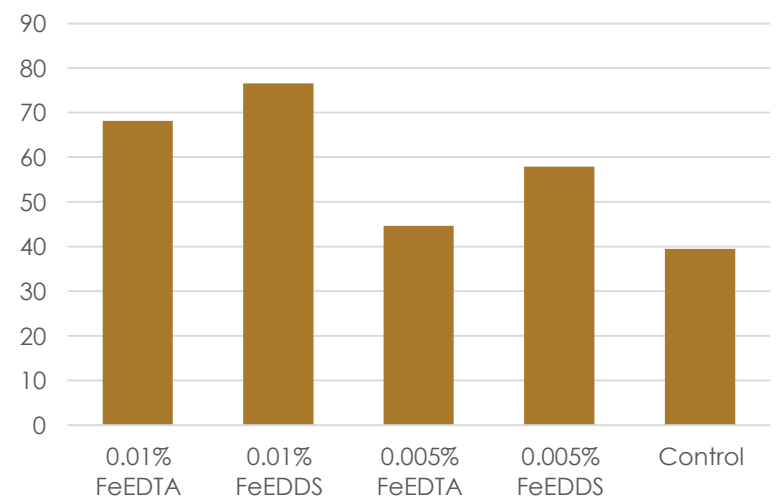
Maize

Maize (Zea Mays L.)
Relative Chlorophyll Content*



*determined using Minolta SPAD-502 Chlorophyll meter

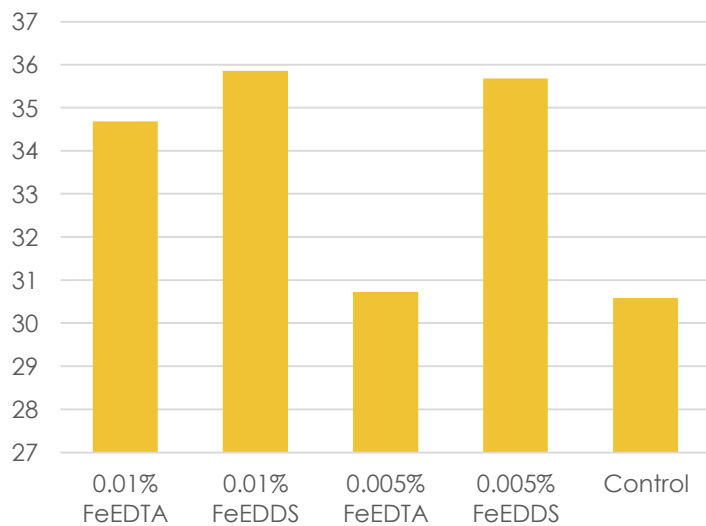
Fe mg/kg



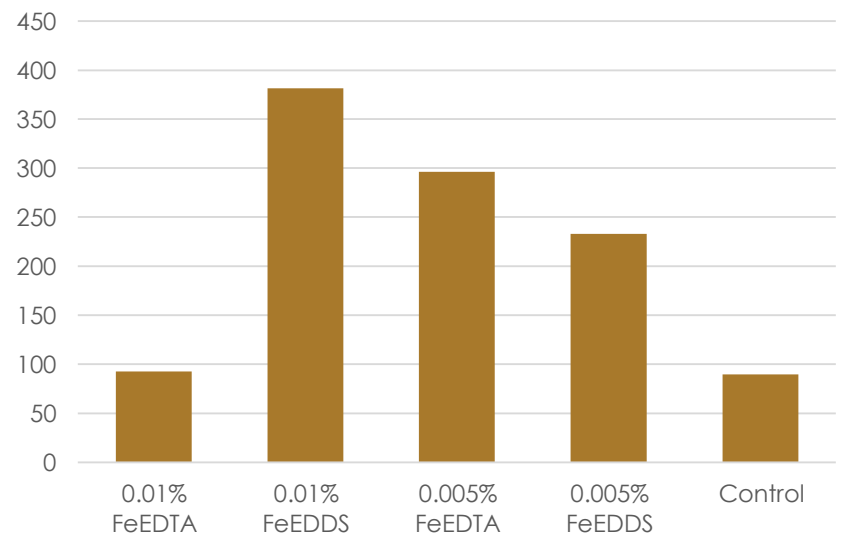
ENVIOMET[®] C Foliar application

Soyabean

Soyabean (Glycine max L.)
Relative Chlorophyll Content*



Fe mg/kg



*determined using Minolta SPAD-502 Chlorophyll meter

ENVIOMET[®] C Soil application

Sandra López-Rayó et al. (*Science of the Total Environment* 647/2019, 1508–1517) demonstrated by experiments on soyabean that [S,S]-EDDS/Fe was sufficiently stable when applied to calcareous soil to allow an efficient root uptake and in improving the iron translocation to shoots. ENVIOMET[®] C chelating agents can be considered as an environmentally sustainable alternative to traditional synthetic chelating agents for curing Fe chlorosis in soil application.

In summary, **ENVIOMET[®] C are readily biodegradable, environmentally friendly chelating agents, able to form water-soluble complexes with polyvalent metal ions such as copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) over a wide pH range. Some agronomic tests show that chelated micronutrients prepared from ENVIOMET[®] C are effective alternative to traditional chelating agents and can be recommended for foliar and soil application in many cropping situations including arable crops, horticulture, orchards, ornamental gardens and seed dressing.**

Sustainability at Innospec

We are committed to using resources as efficiently as possible and minimizing the impact of our operations on the environment. We continuously review advancing technologies and processes so that we can actively seek out opportunities to improve our performance. We also look to improve the sustainability of our products and help our customers respond to environmental challenges through innovation and improved product performance.

We have been monitoring and publicly reporting on our environmental performance since 2006. Each year, we report on our impact across the four key areas of Greenhouse Gas (GHG):

- emissions,
- energy use,
- water use,
- hazardous waste.

Since this time, significant reductions have been made in our GHG emissions, energy and water usage.



For the second consecutive year, we achieved the EcoVadis Gold Medal for our sustainability management system and performance. During 2020 we worked hard to improve our management systems, policies and practices. Achieving gold puts us in the top 5% of all companies rated in our sector globally. EcoVadis is a Corporate Social Responsibility (CSR) platform for supply chain sustainability. It independently evaluates and benchmarks the sustainability performance of over 65,000 companies across environmental, labor and fair business practices.



Connect with us

innospec.com

Email: agrochemicals@innospecinc.com

