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AgChem Additives by BASF

Emulsifiable Concentrates (EC)

April 2024

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3 | EC testing

4 | Solvent system for EC

5 | Available test formulations

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Formulation types:

Active ingredient physchem properties define formulation type

a.i. is water-soluble

→ **SL – Soluble Concentrate**
a.i. dissolved in water (clear to opalescent liquid) e.g. Glyphosate


a.i. is water-insoluble

→ **EC – Emulsifiable Concentrate**
a.i. is water-insoluble and dissolved in hydrophobic solvents. Emulsifiers enable spontaneous emulsification upon dilution in water

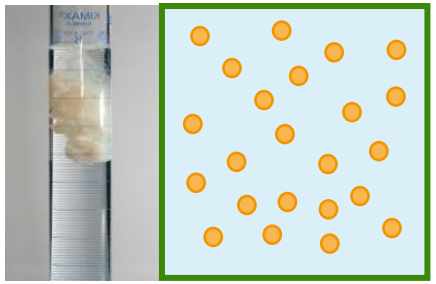

→ **SC – Suspension Concentrate**
A high concentration, stable suspension of finely dispersed a.i.(s) particles in water.


→ **OD – Oil Dispersion**
a.i. is insoluble in both oil and water and dispersed as small particles in oil. In the spray tank mix, a suspo-emulsion is formed.


Emulsifiable concentrate
Definition

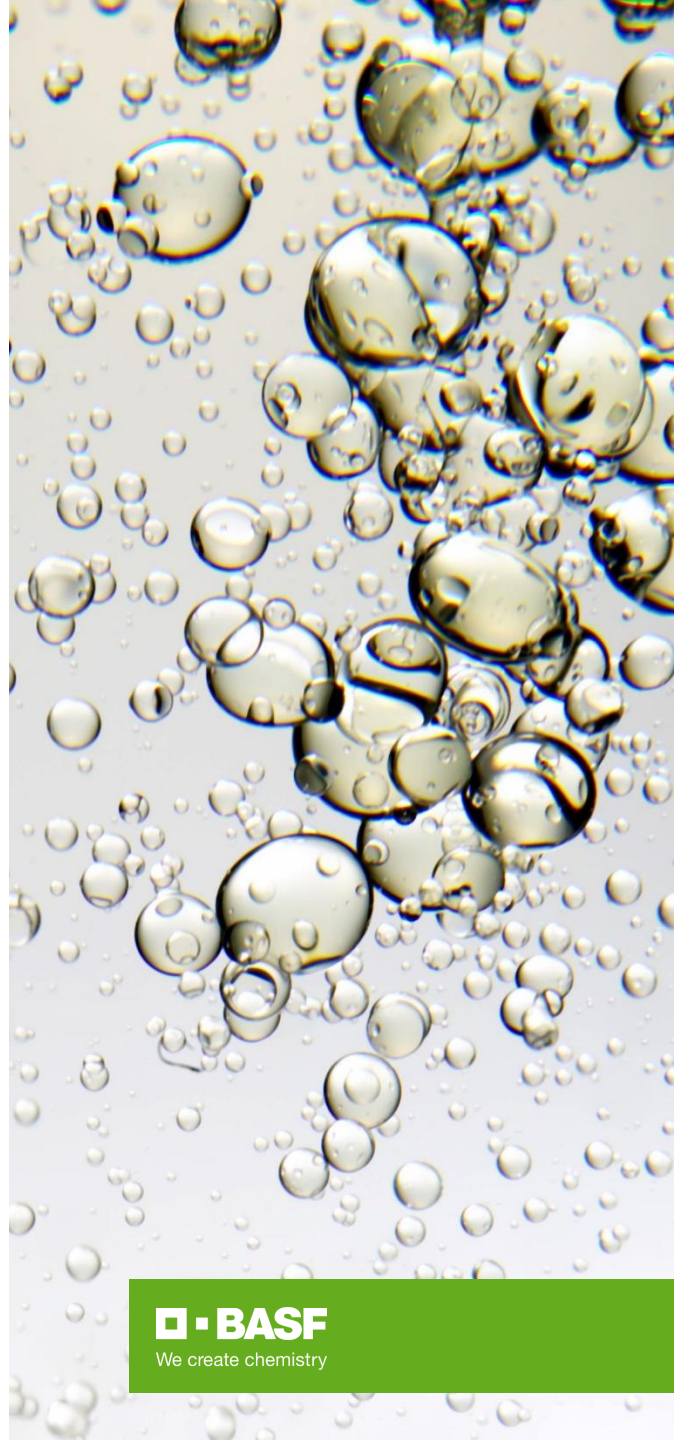
- Emulsifiable concentrate (EC)
  - a.i. and emulsifiers dissolved in hydrophobic solvents
  - Water-free
  - EC spontaneously emulsifies upon preparation of spray tank mix
    - Resulting emulsion is stable and a.i. remains in the solvent/oil emulsion droplets
- Requirements:
  - a.i. has good solubility in the solvent/oil phase
  - Solvents do not degrade a.i.
  - a.i. does not crystalize during storage of the EC or in the aqueous spray mix

Dilution



Generic emulsifiable concentrate formulation

Function	Content, (g/l)	Comment
Active	50 – 500	1 – 3 actives are typical
Solvents	200 – 800	Water-insoluble, polar
Co-solvent	20 – 100	Either water-soluble or insoluble solvents
Non-ionic emulsifier	60 – 80	Preferably only non-ionics to minimize interactions. Recommendation: 6% Agnique® CSO-35 / 6% Pluronic® PE 9400
Anionic emulsifier	20 – 50	In combination with non-ionics (if required) Recommendation: 8% Agnique® CSO-35 / 4% Agnique® ABS 70 C
Adjuvant	0 – 200	Depends on formulation and a.i. mode of action



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Formulation additives selection for EC

Solvents

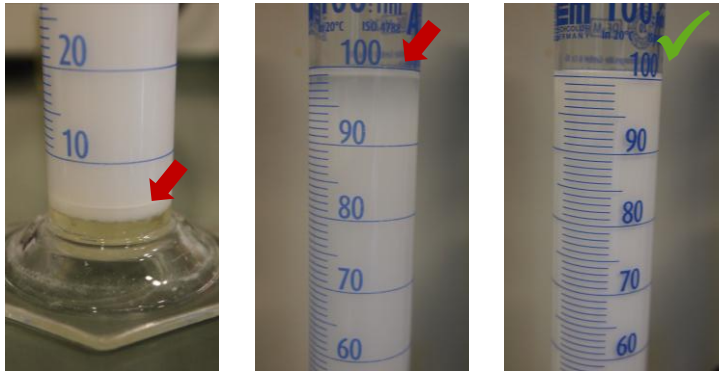
- Hydrophobic solvents required, stay 5% below max. concentration to avoid a.i. crystallisation at low temperatures
- Co-solvents can increase a.i. concentration

Emulsifiers

- Spontaneous blooming in water at r.t. and at cold conditions e.g. 4 °C
- Emulsification in both hard and soft water
- Reversible creaming can be tolerated
- Oil separation must me avoided
- Emulsion should be stable under shear forces to avoid a.i. crystallization in spray solution

Adjuvants

- Some EC solvents (e.g. Agnique® AMD 10) provide good adjuvancy by boosting uptake of systemic actives
- Suitable adjuvant needs sufficient solvency in selected EC solvents



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Product portfolio overview

Solvents and base oils

Dimethyl amides

Alkyl & methyl esters

Carbonates

Adjuvants

Alkoxylated alcohols

Alkyl polyglucosides

Alkyl ether sulfate

Sulfosuccinate

Dispersants

EO-PO-EO copolymers

Polycarboxylates

Sulfonic acid condensates

We offer products from a **broad technology base** using both petrochemical and renewable raw materials

Non-ionic emulsifiers

Castor oil ethoxylates

EO-PO-EO copolymers

Sorbitol ester ethoxylates

Ionic emulsifier

Alkyl benzene sulfonates

Alkyl ether sulfates

Alkyl sulfates

Stickers and thickeners

Epoxidised oils

Polyvinylpyrrolidone homo- and copolymers

Micronutrients and Chelating agents

EDDHA- and EDTA-based micronutrients

EDTA

Sustainability drivers

Products with bio-based content

Product classification[a]	Bio-based carbon [X% of total C]	Icon
Wholly bio-based	X ≥ 95	
Majority bio-based	95 > X >50	
Minority bio-based	50 ≥ X >5	
Non bio-based	X ≤ 5	

RSPO-certified products

Products available with RSPO mass balance certification

Readily biodegradable products

Readily biodegradable according to OECD 301[b]

Label-free according GHS EU criteria[c]

Product with negative PCF

Product Carbon Footprint (cradle-to-gate)[d]

[a] According to the EN17035 surfactants classification
[b] In case of mixture all organic components are readily biodegradable
[c] Status of October 2023. Please check the latest MSDS
[d] The PCF calculations follow the requirements and guidance given by ISO 14067:2018.

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Additives for EC formulations
Solvents

Product	Sustainability profile	Chemistry	Function
Agnique® AMD 810		C_8/C_{10} N,N-dimethyl amide	Hydrophobic solvents allow penetration, however, >300 ml/ha, phytotox may occur depending on crop
Agnique® AMD 10		C_{10} N,N-dimethyl amide	
Agnique® AMD 12		C_{12} N,N-dimethyl amide	
Agnique® AE 3-2 EH		2-Ethylhexyl lactate ester	Hydrophobic solvent provides adjuvancy
Agnique® ME 1218		C_{12}-C_{18} fatty acid methyl esters	Hydrophobic solvent with adjuvant properties
Propylene Carbonate S		Propylene carbonate	Water miscible solvent
Agnique® AMD 3 L		N,N-dimethyl lactamide	Water soluble solvent

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Additives for EC formulations
Solvents

Product	Chemistry	Hansen solubility parameter, (MPas$^{1/2}$)		
		δ_d	δ_p	δ_h
Agnique® AMD 810	C_8/C_{10} N,N-dimethyl amide	15.8	5.3	6.0
Agnique® AMD 10	C_{10} N,N-dimethyl amide	15.9	4.8	5.7
Agnique® AMD 12	C_{12} N,N-dimethyl amide	15.9	4.5	4.7
Agnique® AE 3-2 EH	2-Ethylhexyl lactate ester	16.0	4.0	11.0
Agnique® ME 1218	C_{12}-C_{18} fatty acid methyl esters	15.9	3.4	4.2
Propylene Carbonate S	Propylene carbonate	16.5	17.0	5.2
Agnique® AMD 3 L	N,N-dimethyl lactamide	16.5	11.9	14.2

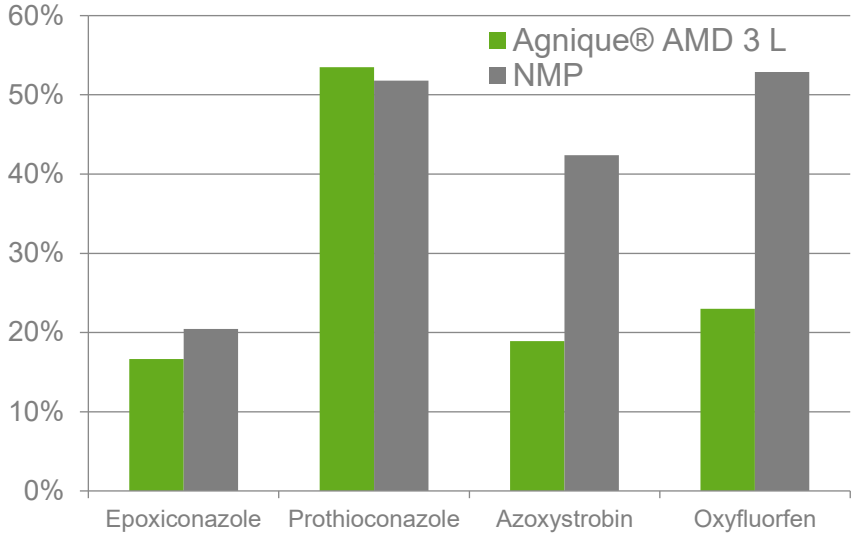
Agnique® AMD 3 L

Powerful, **label-free, water-micible solvent**, NMP alternative

Phys.-chem. properties

Chemical structure	**N,N-Dimethyl lactamide**
Hansen solubility parameter: δ_d / δ_p / δ_h (MPas$^{1/2}$)	16.5 / 11.9 / 14.2
Boiling point (°C)	223
Flash point (°C)	103
Pour point (°C)	~-60
Density (g/ml) (20°C, 1013 hPa)	1.046
Solvent into water (g/L)	miscible
Log Kow	1.56

Powerful solvent for low soluble a.i.s



Very selective on plants

Test conditions:

- Soya: 4-5 leaf stage
- EC:
  - 90% solvent
  - 10% emulsifier
- Dose rate: 2 L/ha
- Spray rate: 200 L/ha
- Rating: 14 DAT

Agnique® AMD 3 L
No phytotox

Sustainability

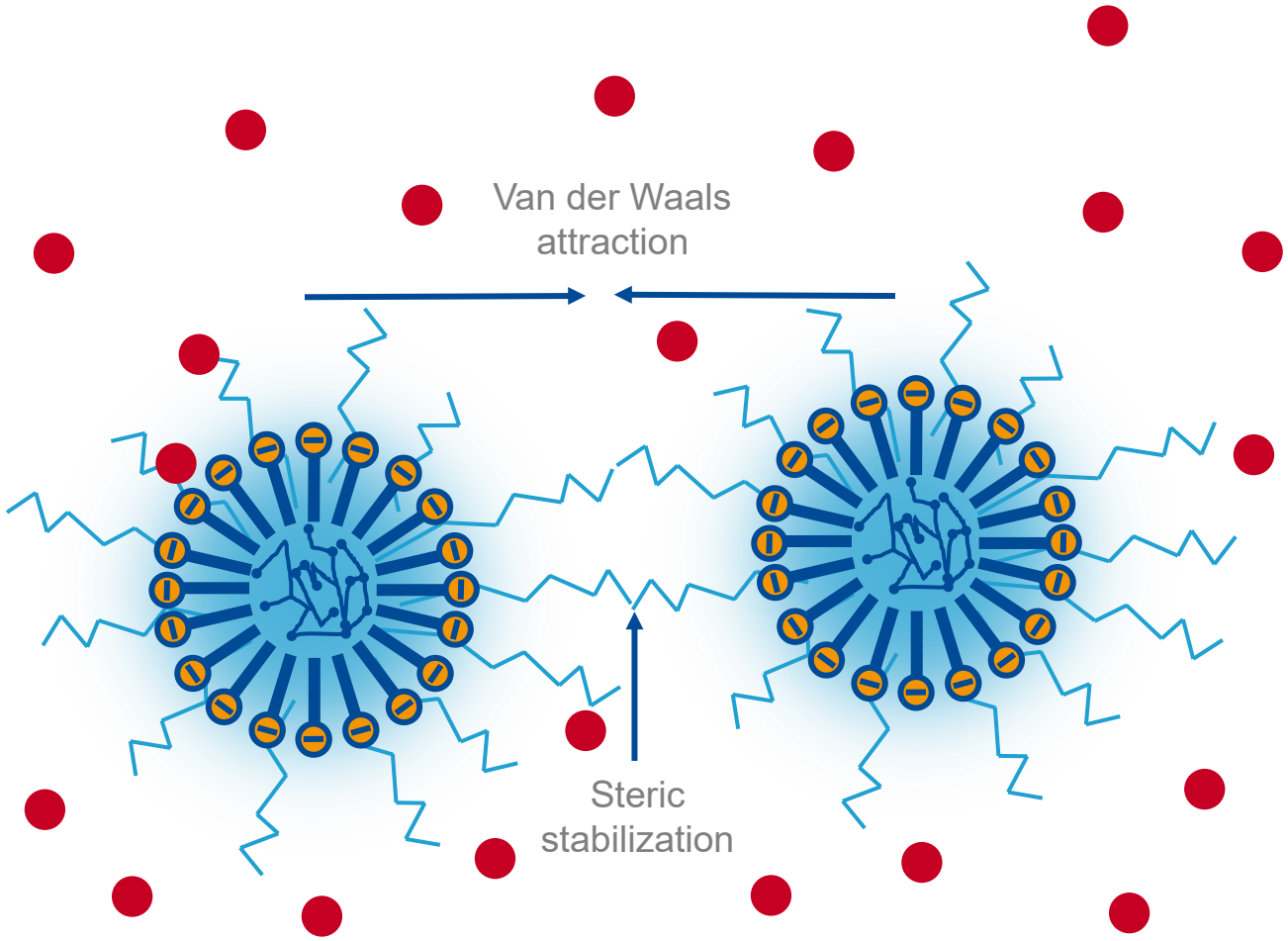
- Label-free according to GHS criteria[a)]
- Majority bio-based product[b)]
  ➔ bio-based carbon content between 50-95%
- Readily biodegradable according to OECD 301

Test formulation available

ECK-T13: Prothioconazole 18.8%, Fenpropimorph 8.8%

[a)] Status as of June 2023. Please check the latest MSDS
[b)] According to the EN17035 surfactants classification

Emulsifier selection for EC



Combination of ionic and non-ionic surfactants

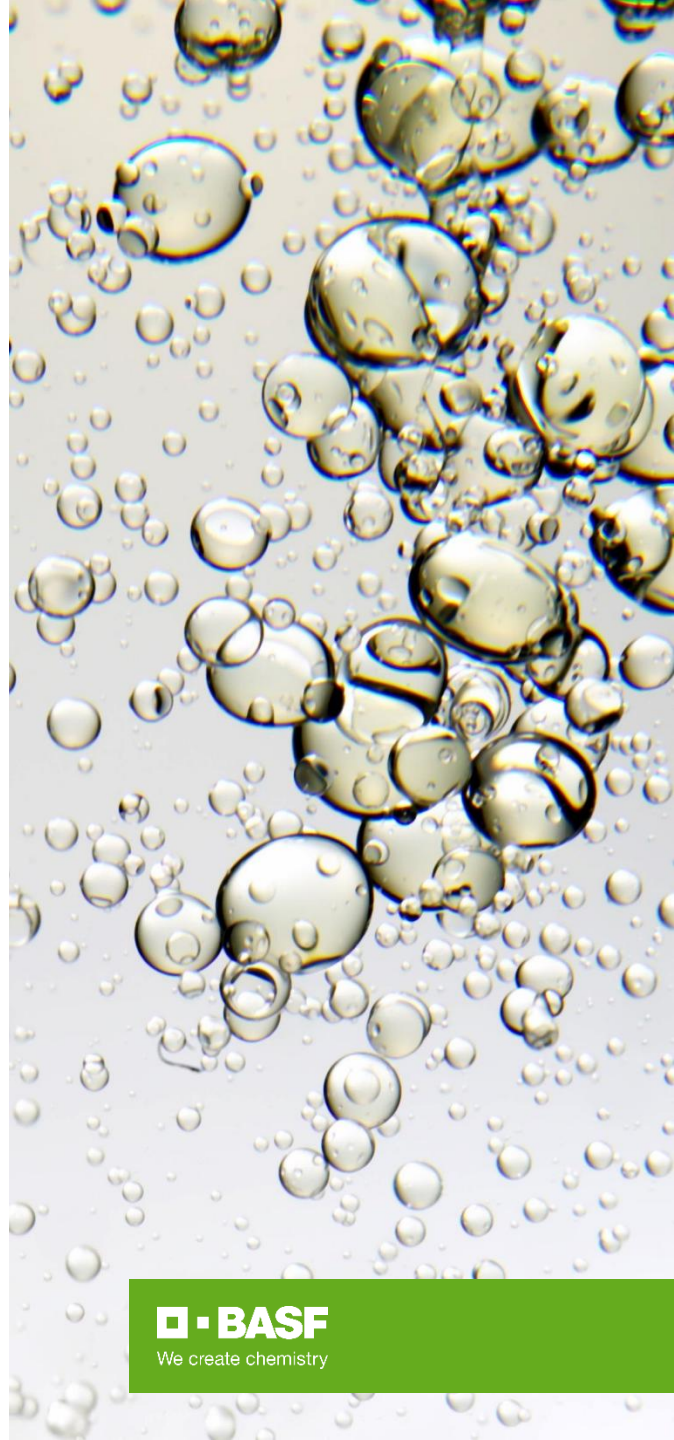
Non-ionic surfactants are generally compatible with a wide range of solvents, making them versatile tool

Non-ionic polymeric surfactants stabilize emulsions additionally by steric repulsion

When combined with non-ionics, anionic surfactants give electrostatic stabilization

Additives for EC formulations
Non-ionic emulsifiers

Product	Sustainability profile	Chemistry	Function
Agnique® CSO-30		Castor oil ethoxylates	Efficient general-purpose non-ionic emulsifier. Can be combined with Pluronic® PE 9400, Agnique® ABS 70 C or 60 C-EH
Agnique® CSO-35			
Agnique® CSO-40			
Pluronic® PE 9400		EO-PO-EO blockcopolymer (~40% EO content)	Non-ionic co-emulsifier. Can be combined with Agnique® CSO types
Pluronic® PE 6400			
Agnique® SPO 40		Sorbitol hexaoleate ethoxylate (40 EO)	Good general-purpose label-free emulsifier



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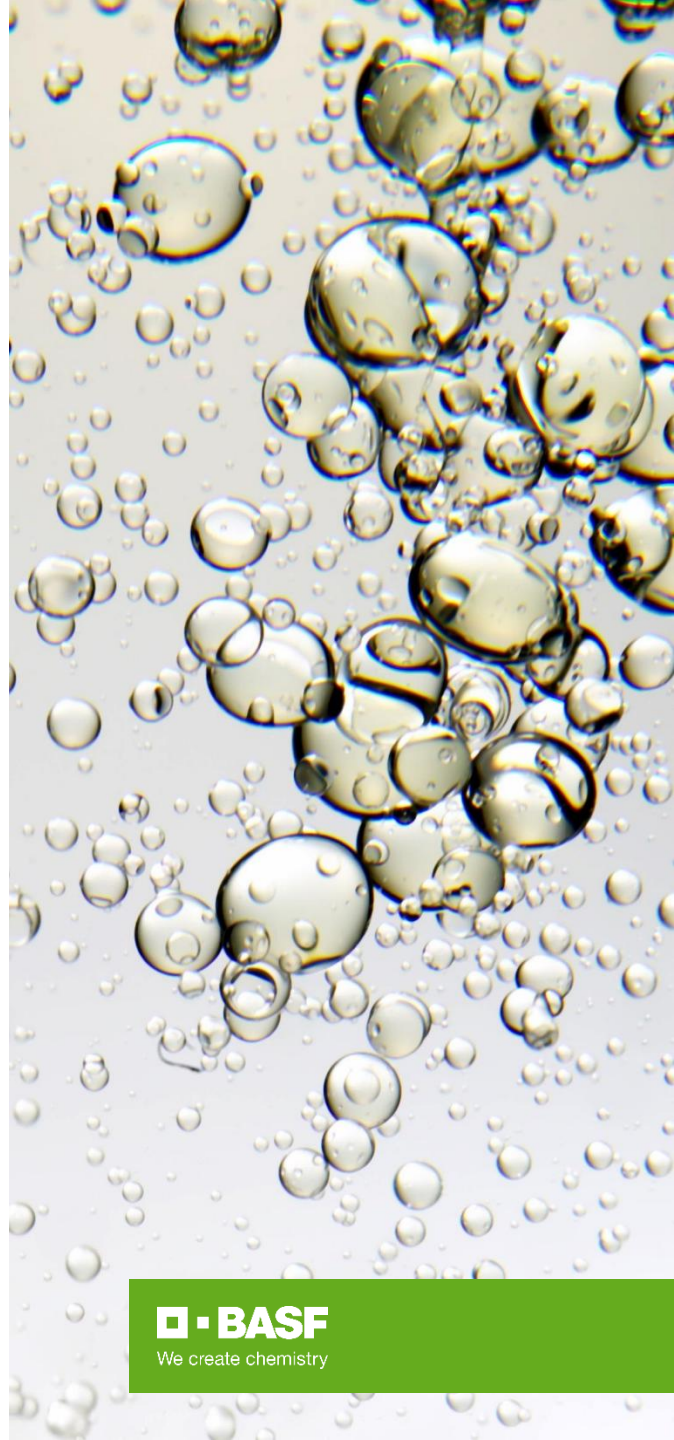
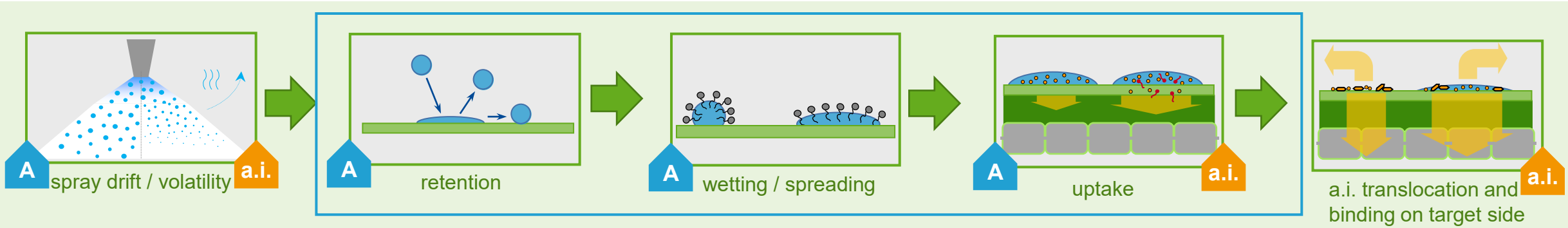
Agrochemical additives
Anionic emulsifiers

Product	Sustainability profile	Chemistry	Function
Agnique® ABS 70 C		Alkyl benzene sulfonate 70% in iso-butanol 58% or 60% in 2-ethylhexanol	Anionic emulsifiers, typically combined with castor oil ethoxylates
Agnique® ABS 58 C-EH			
Agnique® ABS 60 C-EH			



Delivery chain

Adjuvants can not substitute a.i.s or change their mode of action



A step affected by adjuvants

a.i. step affected by phys.-chem. properties of a.i.

Additives for EC formulations

Recommended adjuvants by mode of action

Product	Sustain. profile	Chemistry	Retention	Wetting	Uptake
Agnique® FOH 9 OC-3		Oleyl alcohol ethoxylate			✓
Agnique® KE 3551		Guerbet alcohol alkoxylate	✓	✓	✓
Agnique® SBO 10		Soybean oil ethoxylate			✓
Dehypon® 2574		Fatty alcohol alkoxylate	✓	✓	✓
Dehypon® LS 54		Fatty alcohol alkoxylate	✓	✓	✓
Lutensol® ON 50		C_{10} oxo alcohol ethoxylate		✓	
Lutensol® TO 6		Oxo alcohol ethoxylate		✓	✓
Lutensol® TO 8		Oxo alcohol ethoxylate	✓	✓	✓
Lutensol® XL 50		Guerbet alcohol alkoxylate	✓	✓	✓
Lutensol® XP 30		Guerbet alcohol ethoxylate	✓		
Lutensol® XP 80		Guerbet alcohol ethoxylate	✓	✓	✓
Plurafac® LF 224		Oxo alcohol ethoxylate		✓	
Plurafac® LF 300		Oxo alcohol alkoxylate		✓	
Plurafac® LF 431		Guerbet alcohol alkoxylate			✓
Plurafac® LF 901		Guerbet alcohol alkoxylate	✓		
Plurafac® LF 1300		Fatty alcohol ethoxylate			✓
Pluronic® PE 6100		EO/PO block copolymer	✓		

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EC testing and results
Overview

- FAO[1] defines standard CIPAC[2] tests to characterize phys-chem properties

- Additional tests are also used to further validate formulation quality/stability
  - Stability against crystallisation is tested by storing the concentrate at low temperatures (down to -10°C), typically for 1 week
  - Circulation pump test to mimic spray tank conditions to ensure no crystal growth

[1] Food and Agricultural Organisation of the United Nations
[2] Collaborative International Pesticides Analytical Council

Test EC assessment

FAO required CIPAC tests

Property	Comment	CIPAC Method
Appearance	Visual check	
Density (20°C)		CIPAC MT 3.2
Water content	Determine aqueous content	CIPAC MT 30.5
Acidity and/or Alkalinity or pH range	In de-ionized water	CIPAC MT 191 or 75.3
Emulsion stability and re-emulsification	Blooming, spontaneous emulsification in hard and soft water	CIPAC MT 36.3
Persistent foam	Foam after 1 minute	CIPAC MT 47.2
Stability at 0°C	Check for crystallisation, separation	CIPAC MT 39.3
Stability at elevated temperature	14 d at 54°C, or 28 d at 50°C, or 8 weeks at 40°C. Recheck for by-products, acidity/alkalinity, emulsification	CIPAC MT 46.3

EC Testing – emulsion stability
Method: CIPAC MT 36.3

- CIPAC defines emulsion stability at 5% aqueous dilution in a measuring cylinder
  - However, farmer commonly dilutles 1 l EC into 200 l spray mix (0.5%)
  - Emulsion stability is therefore assessed at both 0.5 and 5 %
  - Hard and soft water dilutions are assessed
  - Low temperature emulsion stability is also required
- Emulsion stability assessed by measuring the following parameters:
  - ‚Cream' which can be re-emulsified (reversible)
  - ‚Oil' which has separated (irreversible)
  - Precipitation at the bottom of the cylinder
  - „ease" of re-emulsifciation after 24 h storage

EC Testing – emulsion stability

Blooming and spray mix storage

Emulsion stability: CIPAC MT 36.3

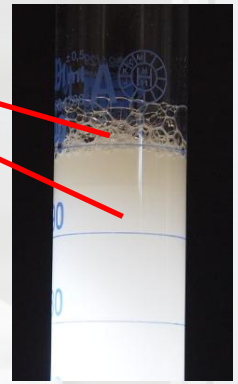
instant blooming

after 1h

after 2h

after 4h

Emulsion instability.
Herein, phase separation has occurred



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Example EC formulation:
Tebuconazole EC 280, ECK-T02

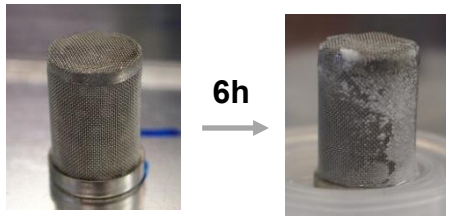
Component	Function	% w/w
Tebuconazole	Active	28.5
Agnique® AMD 10	Solvent	61.5
Agnique® CSO-35	Non-ionic emulsifier	10.0

Stability Emulsion (5% EC) Water quality: CIPAC D	
t= 0	1 (milky)
t = 1h	stable
t = 2h	stable
t = 4 h	stable
t = 24h	2 ml cream
Re-emulsification	stable

EC Testing – emulsion shear stability

Circulation pump test

- Emulsions can become unstable under shear forces
  - Emulsions formed in the spray tank are circulated under shear until application to crops
  - Any crystallisation/precipitation during circulation will block the spray nozzles
  - This must be avoided!
- Method
  - Lab-based circulation equipment (next slide)
  - Testing under harsh conditions: e.g. 0.5% dilution, hard water, 5°C
  - Control pressure and flow rate
  - Assess precipitate collected on 140 µ filter after 6 h
- Monitor crystal formation
  - Filter must not be clogged after 6 h
  - Determine residues by weighing filter



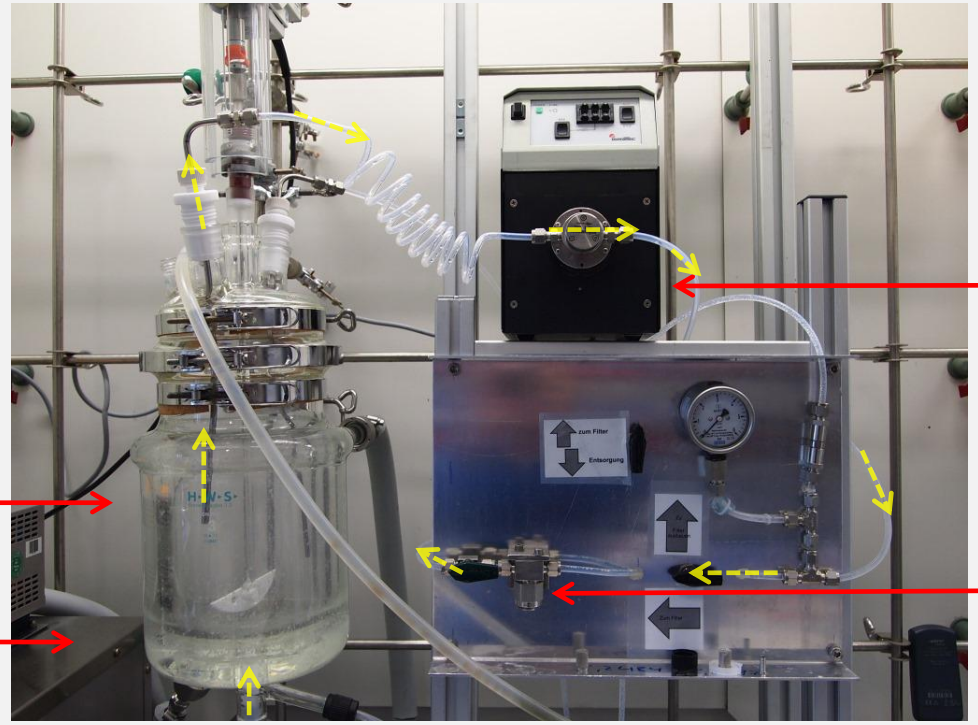
EC Testing – emulsion shear stability

Circulation pump test equipment

Target: 0.5% emulsion (e.g. in CIPAC D water) circulated through filter over 6 h

Technical data:

Mesh size:	140 µm
Pressure limit:	4.5 bar
Flow rate:	1 l/min



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4 | **Solvent system for EC**

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Fatty acid dimethyl amides for EC formulations

- Agnique® AMD 810 or AMD 10 are excellent solvents
  - Proven record for more than two decades in Tebuconazole EC and EW
  - Prothioconazole & Difenoconazole EC in combination with co-solvents
  - Propiconazole, Cyproconazole EC with water miscible co-solvent
  - In another EC, Epoxiconazole is combined with strobilurin
  - Corresponding EC test formulations available

- Agnique® AMD 12 is an alternative for EC formulations
  - Pour point of Agnique® AMD 12 at +8 °C
  - Co-solvents are required

Limited Availability of C_8/C_{10} Dimethylamides
Raw materials extracted from fatty acids

Carbon fraction split in different vegetable oils

- C_{12} fraction in palm kernel and coconut oil is significaltly higher
- **Agnique® AMD 12 → N,N-dimethyl dodecanamide**

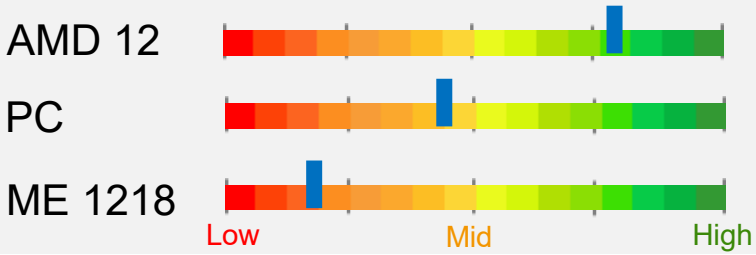
EC Formulations with Fatty Acid Amides like Agnique® AMD 12

- **Advantages:**
  - Based on lauric acid, Agnique® AMD 12 has better availability
  - Agnique® AMD 12 shows good solvency
- **Challenges:**
  - But has a high pour point → Tm = 8°C
  - Emulsification can be a challenge without co-solvent
- **Solution:**
  - Fine-tuning of solvents mixture in formulation to increase cold stability and improve emulsion stability

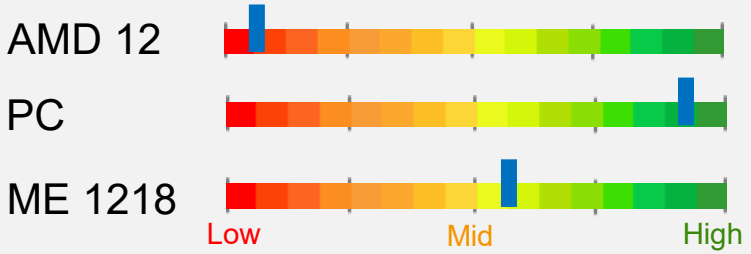
Example Formulations with Agnique® AMD 12, ME 1218 and PC

Fine-tuning of solvents mixture to achieve target formulation

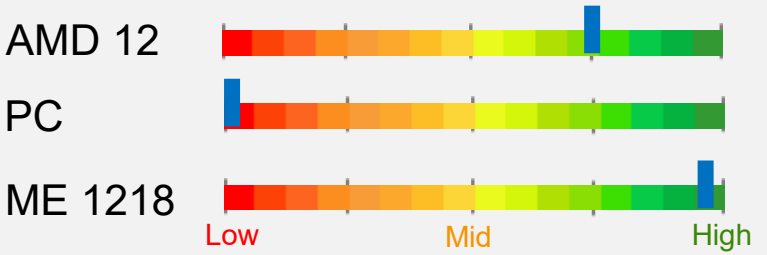
Active Ingredient Solvency



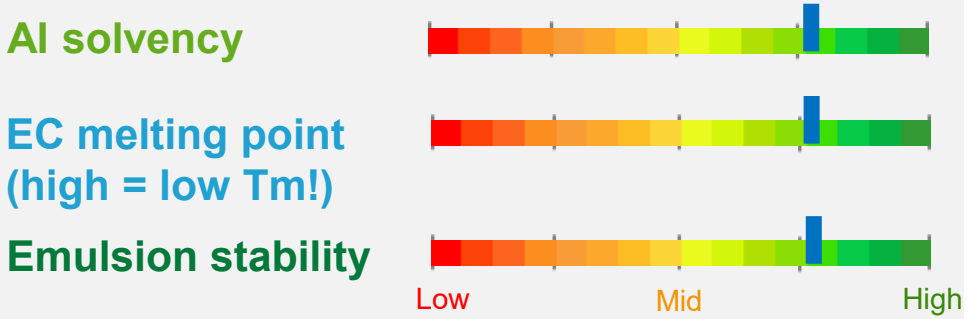
Solvent Melting Point



Emulsion Stability* (water sol)



Solvent Mixture ??



*Emulsion stability linked to solvent water solubility

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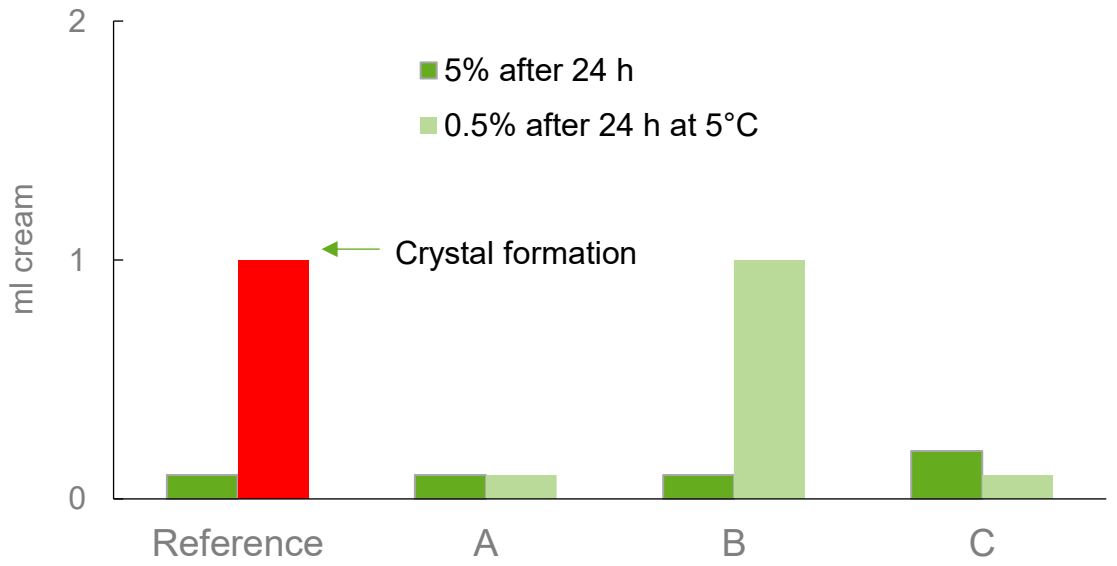
Good Emulsification of Agnique® AMD 12 with co-solvents

Examples: Oxyfluorfen EC with different hydrophobic co-solvents

Components (% w/w)	Reference	A	B	C
Oxyfluorfen	20	20	20	20
Agnique® AMD 12	32.5	27.5	27.5	27.5
Agnique® ME 1218		10		
Agnique® ME 610			10	
Cetiol® B				10
Propylene Carbonate S	32.5	27.5	27.5	27.5
Agnique® CSO-40	10	10	10	10
Pluronic® PE 6400	5	5	5	5
Re-circulation test	✗	✓	n.d.	n.d.

Emulsion stability (CIPAC MT 36.3), EC diluted in CIPAC D water



Various hydrophobic esters can be used as co-solvents

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Easier Emulsification of Hydrophobic Solvents

Triangle approach offers high flexibility

- Tested formulations are stable and liquid at -5 °C
  - Elevated concentrations of Agnique® AMD 12 lead to solid EC formulations below -5°C
  - Higher levels of propylene carbonate lead to emulsion instability and a.i. crystallization
- Formulation a.i. concentration can be fine-tuned by careful selection of FADMA, fatty acid ester and hydrophilic solvent contents
- Fatty acid amides and fatty acid esters can enhance uptake of systemics

- Corresponding patent filed

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Available Test Formulations

Please contact us for the further information

Fungicides

ECK-T01 / T02	Tebuconazole 300 & 285
ECK-T03 / T04	Tebuconazole 200
ECK-T09 / T14	Difenoconazole 200
ECK-T10	Cyproconazole 200
ECK-T13	Prothioconazole 190/ Fenpropimorph 90
ECK-T17	Prochloraz 225/ Tebuconazole 125/ Fenpropimorph 190
ECP-H20	Tebuconazole 200 / Propiconazole 200
ECP-H21	Epoxiconazole 60 / Pyraclostrobin 60

Fungicides

ECC-S27	Pyraclostrobin 200
ECC-S28	Propiconazole 250 / Cyproconazole 160
ECC-S29	Prothioconazole 175 / Difenoconazole 125
ECP-H30	Epoxiconazole 60 / Pyraclostrobin 60
ECP-H34	Tebuconazole 250

Insecticides

ECK-T18	Abamectin 18

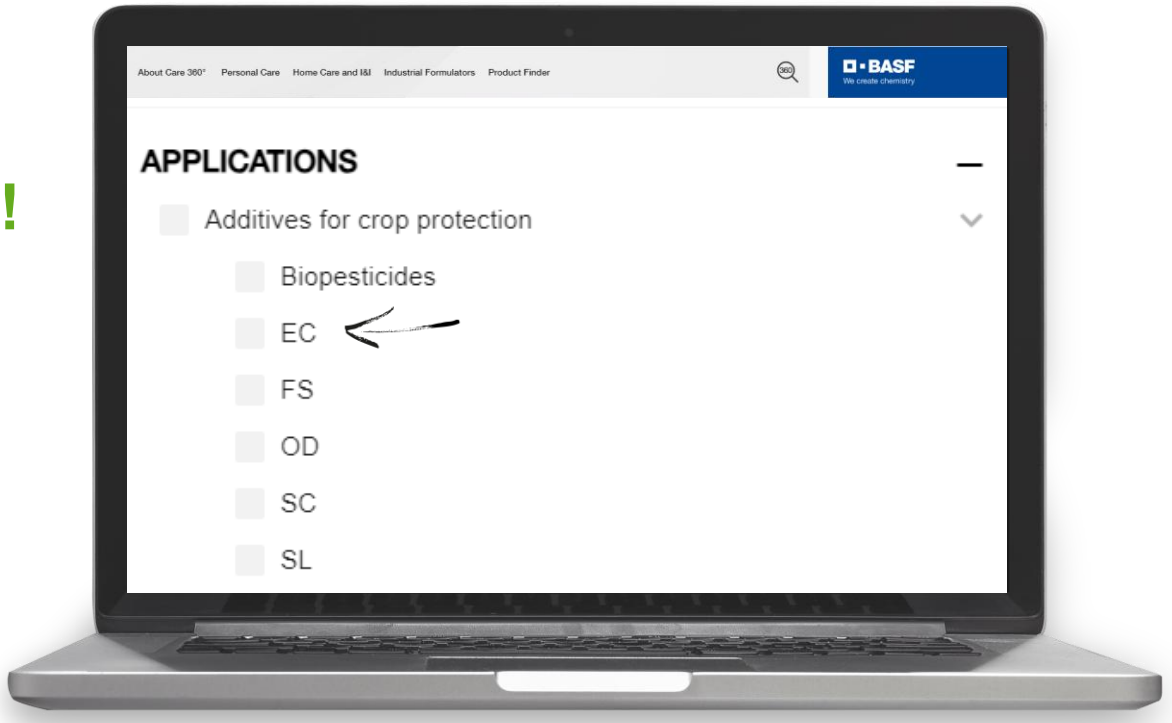
Herbicides

ECK-T05 / T06	Oxyfluorfen 250
ECK-T07	Oxyfluorfen 230
ECK-T11 / T12	Fluroxypyr-meptyl 400
ECK-T16	Flufenacet 200
ECC-S25	Pinoxaden 50 / Cloquintocet 10
ECC-S26	Fenoxaprop-p-ethyl 100/ Mefenpyr-diethyl 270

Our top recommendations

Register and explore our new product finder!

Product Finder at
www.care360.basf.com



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