Crop Protection

Enhancing delivery of biologicals

Smart science to improve lives™

Biologicals classes

A mass-produced agent manufactured from a living microorganism or a natural product and sold for the control of plant pests

Biochemical
Pheromones
Plant extracts

Microbial
Bacteria
Fungi
Virus

Biomolecules
Proteins
Peptides

Nucleic acids
DNA
RNA

Benefits of biologicals

As part of Integrated Pest Management (IPM) programs, the use of biologicals offer multiple benefits:

Sustainability

Crop yield and quality

Residue management

Resistance management

Challenges in biological formulations

- Biologics show intrinsic complexity and variability due to their biological nature
- Biological formulations often incorporate living materials that are more sensitive in comparison to chemical active ingredients
- Some biopesticides require the preservation of viability alongside the expected physical and chemical stabilities of traditional pesticides
- Biopesticides can be susceptible to degradation over a relatively short period, influenced by factors such as air, light, and temperature exposure
- Possibility for lower intrinsic activity levels

Expertise at Croda

Microbes

Natural extracts

Peptides & Proteins

RNAi

- Development of formulations with long shelf-life stability
- Extensive selection of sustainable surfactants that do not harm biological viability
- Efficacy boosting with tailored adjuvant selection

Expertise at Croda

Microbes

Natural extracts

Peptides & Proteins

RNAi

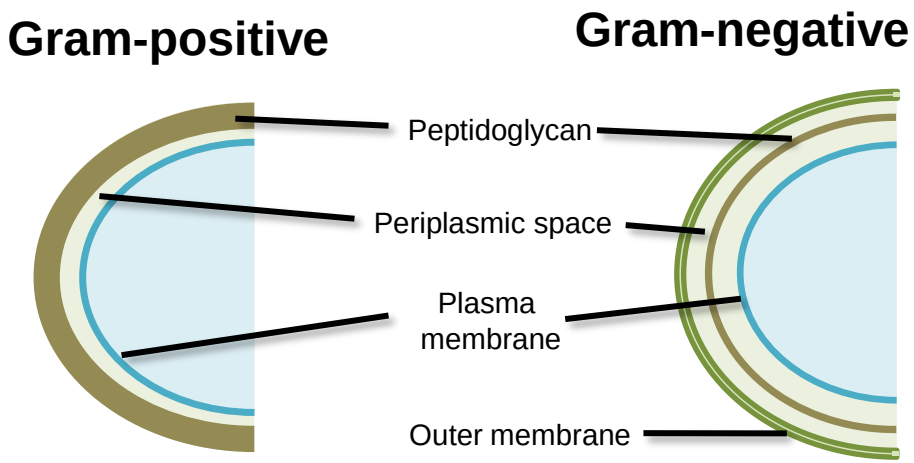
- Development of formulations with long shelf-life stability
- Extensive selection of sustainable surfactants that do not harm biological viability
- Efficacy boosting with tailored adjuvant selection

Microbes

- Beneficial microorganisms are utilised for their role in biocontrol, biofertilisation and biostimulation

Bacteria

- Bacteria, such as *Rhizobium*, fix atmospheric nitrogen, making it available to plants and reducing the need for synthetic nitrogen fertilizers

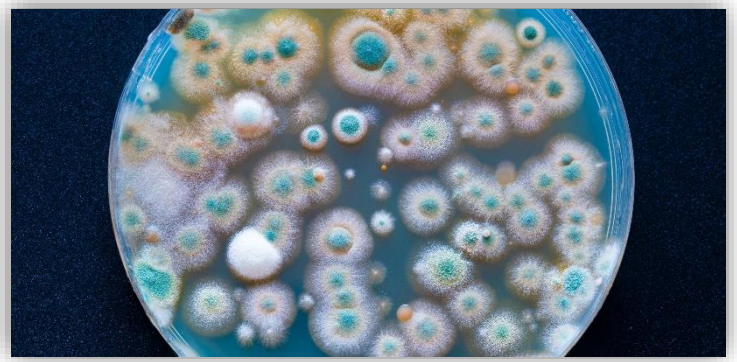


Fungi

- Fungi like *Trichoderma* help control plant pathogens and pests, promoting plant health and reducing reliance on chemical pesticides

Formulation considerations

What are you formulating – living microbes, metabolites, entire broth, by-products of fermentation?



Know your microbe!

The physical properties of a microorganism means they must be formulated.

- Microbes can be highly hydrophobic and low density
- Tank mix compatibility can be challenging
- Bioavailability of a microbe when on a leaf

The intrinsic properties of a microorganism dictates the most suitable formulation type.

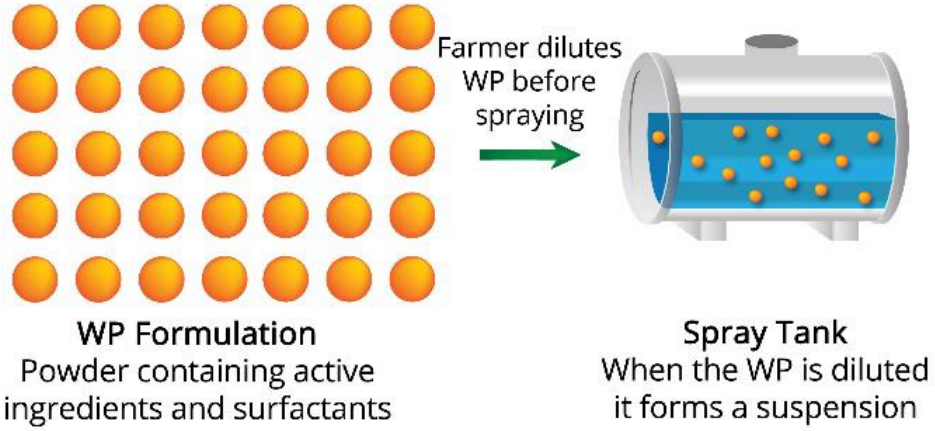
- Spore forming or non-spore forming
- Shelf-life of the microbe
- Sensitivity to external stresses such as UV or high temperature

Formulation development can provide:

- ✓ Delayed viability loss
- ✓ Improved useability
- ✓ Enhanced dilution properties
- ✓ Protection from external factors

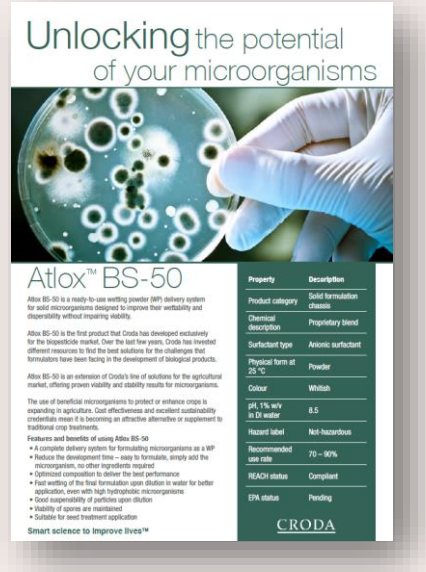
Solid microbe formulations

Wettable powder (WP)



Benefits

- Water-free systems
- Provide a uniform distribution of active ingredients
- Simple and easy to be formulated
- No storage sedimentation issues
- High loading of active ingredient is possible



Challenges

- Poor water dispersibility
- Low wettability
- Slow disintegration in the tank mix

Atlox™ BS-50

- Complete WP delivery system for spore forming microbes
- Designed to improve wettability and dispersibility without affecting spore viability

Atlox BS-50 wettability

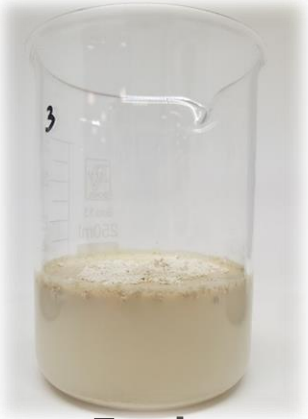
Beauveria bassiana and Atlox BS-50

Metarhizium anisopliae and Atlox BS-50



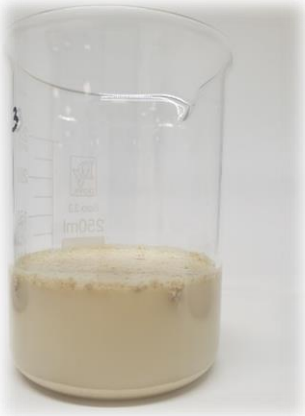



Very good wettability

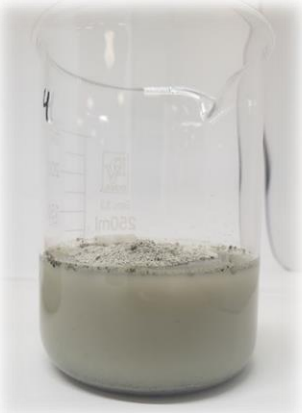


5 min

10 min

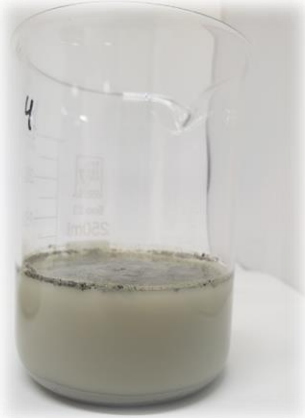


15 min



5 min

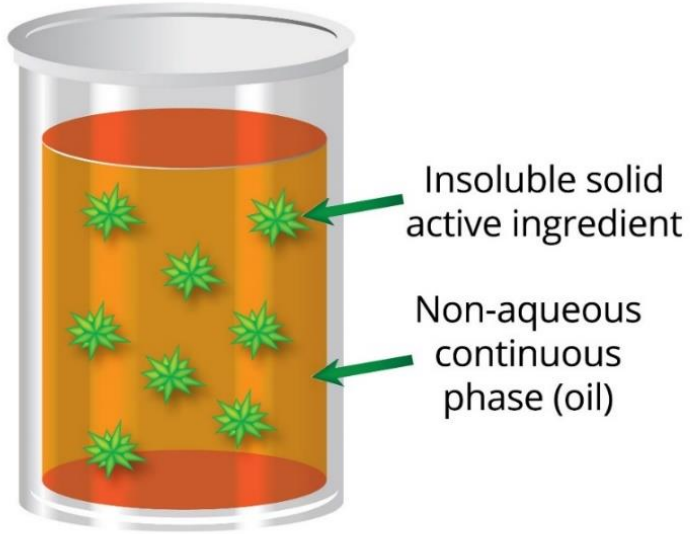
10 min



15 min

Non-aqueous, liquid microbe formulations

Oil dispersion (OD)



On dilution in the spray tank the oil phase is emulsified and the solids are dispersed

Benefits

- Liquid formulation option to improve useability
- Water-free system
- Oil continuous phase acts as a built-in adjuvant
- No additional preservatives required

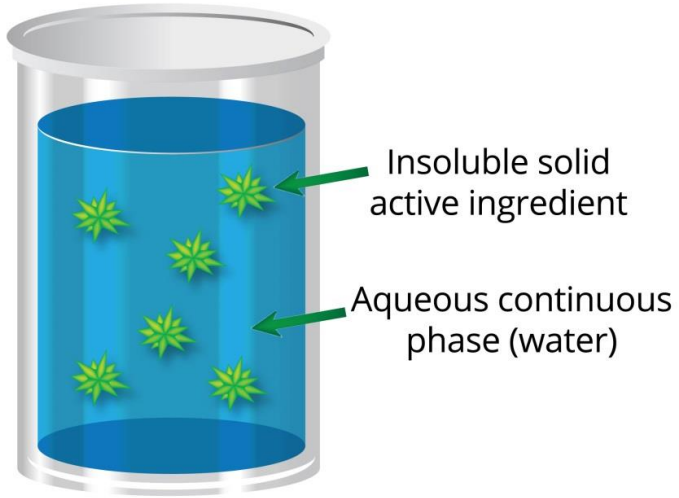
Challenges

- Complex development process
- Many surfactants required to stabilise
- Prone to sedimentation issues

Microbial OD chassis recipes

Aqueous, liquid microbe formulations

Suspension concentrate (SC)



On dilution in the spray tank the SC is further diluted

Benefits

- Simple, low-cost formulation type
- An option when formulating the entire fermentation broth
- Good for formulations using fermentation metabolites
- Suitable for some spore forming microorganisms

Challenges

- Need for a preservative in formulation
- Activity of microbe in presence of water
- Shelf-life compromised

Aqueous dispersants
Atlox 4913
Atlox 4917
Atlox Metasperse 500L

Wetting agents
Atlas G5002L
Atlas G5004LD

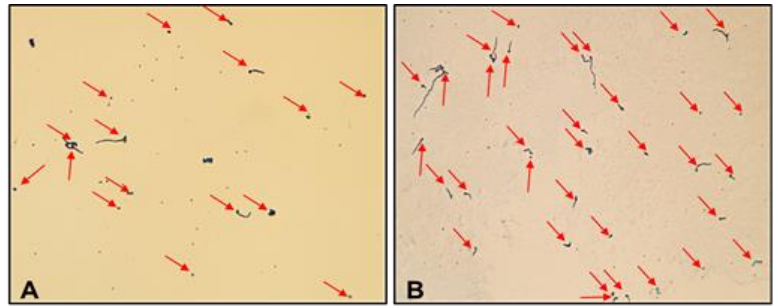
Rheology modifier
Atlox Rheostrux 300A

Tested with *Bacillus thuringiensis,* 2 % & 5 % dilutions, 6 months CFU

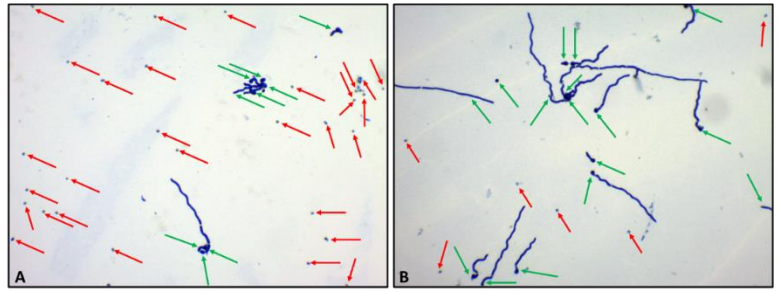
Other formulation considerations

- Impurities found in formulation aids can reduce shelf life of microbial products
- Removal of such impurities provides a wider selection of formulation aids for the most challenging microbes
- Table identifies some of the ways we can further purify our Tween chemistry range:

Added	Oxidation products	Unreacted
▪ Residual catalyst ▪ Water ▪ Bleach	▪ Peroxides ▪ Aldehydes, e.g. formaldehyde and acetaldehyde ▪ Organic acids, e.g. formic acid and acetic acid	▪ Free fatty acid ▪ Fatty acid soaps (sodium and/or potassium salt)



- Surfactant A and surfactant B on Trichoderma sp. formulation after 135 days
- Surfactant B shows more conidia have formed but there is no improvement on germination



- Standard surfactant (A) and high purity surfactant (B) with *Trichoderma* sp. formulation after 135 days
- Surfactant A produces few conidia able to germinate
- Surfactant B shows increased level of germination from the conidia

Compatibility data

Microbe compatibility screening has been completed on a selection of Croda's product offering from each functionality to give an initial indication as to suitability with different microbes

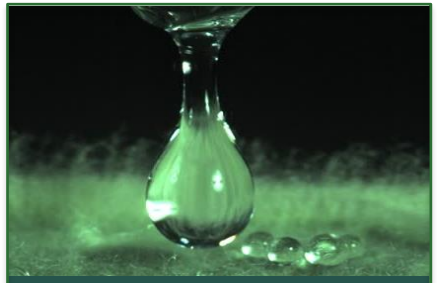
Product name / Microbe	Dispersants										Rheology modifiers		Adjuvants/emulsifiers												Emulsifiers								Adjuvants						Wetting agents		WP chassis
	Atlox 4912	Atlox 4913	Atlox 4914	Atlox 4915	Atlox 4916	Atlox 4917	Atlox 4921	Atlox Metasperse 500L	Atlox Metasperse 550S	Atlox Metasperse 650S	Atlox Rheostrux 100	Atlox Rheostrux 200	Tween 20	Tween 22	Tween 23	Tween 24	Tween 28	Tween 40	Tween 60	Tween 80	Tween L-0515	Tween L-1010	Tween L-1505	Atlas G-5000	Atlas G-5002L	Atlas G-5004 LD	Atlas G-1086	Etocas 29	Etocas 30	Etocas 35	Etocas 40	Atlox AL-2575	Atlox AL-2559	Synperonic PE/F 127	Atplus DRT-EPS	Atplus UEP-100	Atplus DRT-100	Crodasinic CS-30	Crodateric LIDP	Atlox BS-50
Bacillus thuringiensis																																							
Bacillus firmus																																							
Bacillus amyloliquefaciens																																							
Pseudomonas fluorescens																																							
Clonostachys rosea																																							
Aureobasidium pullulans																																							
Trichoderma harzianum																																							
Beauveria bassiana																																							
Metarhizium anisopliae																																							
Gliocadium catelatum																																							

- High confidence in compatibility
- Moderate confidence in compatibility
- Lower confidence in compatibility
- No test data avaliable

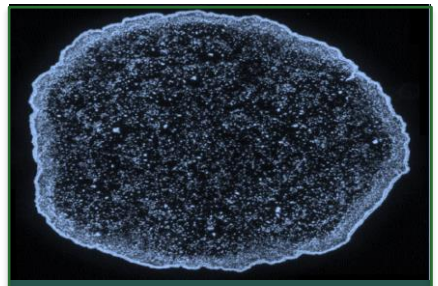
Results determined through multiple test methods at a representative surfactant inclusion of approximately 5%. Microbes tested in spore or vegetative state.

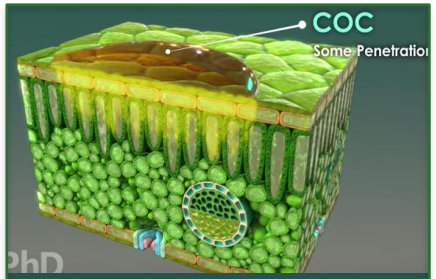
Boosting biological efficacy


Spray quality


Spray retention


Wetting

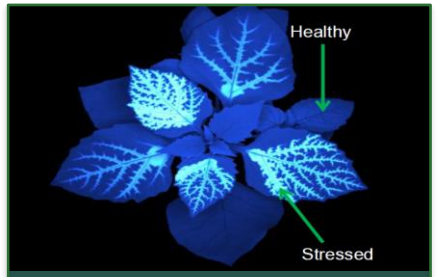

Deposit formation



Active mobility


Rainfastness


UV protection



Crop injury

Sustainable solutions

- Increasing demand for **low carbon** ingredients to support de-carbonisation goals
- Regulations driving **biodegradable** products to be used (such as the European microplastic and fertiliser legislation)
- Drive to utilise **bio-based** surfactants in the place of hazardous chemistries
- Expectation for biological formulations to be suitable for **organic farming**

Eco range of products

- 100% bio-based
- 100% renewable

Product carbon footprint calculations

- Statements available on most of our product portfolio
- Product level information
- Each Croda site has a 2030 roadmap for reducing carbon footprint

OMRI listed surfactants

- Identification of Croda products on NOP list
- OMRI certification of a selection of Croda products

Our capabilities at Croda

Global microbiology laboratories

Biodegradability testing

Customisable chemistries

Adjuvancy screening facilities

Efficacy testing

Encapsulation screening

Bespoke / tailored solutions

Stronger together

Partnering with our customers and external parties to achieve the highest performing products

Face to face support

Request to meet with our marketing, sales or technical teams

Laboratory support

We can work on your developments in our lab. Bespoke training in-house or at your site.

Fit-for-purpose products

We can specifically design ingredients that are:

- De-mineralised
- Low moisture
- High purity

Crop Protection

Formulating a sustainable future together

09/24 CCMP400v1 EN

CRODA