Improve Biopesticide Performance through Formulation Science and Technology

Dr David Calvert
iFormulate Limited
Biopesticide Summit
Swansea 3rd July 2019
Agenda

• Introductions
• Formulation
• Biopesticide Formulations
  – Past
  – Present
  – Future
• Summary
A Little About iFormulate

Founded in 2012 by two experienced industry professionals

Diverse experiences, knowledge and wide range of contacts

Complementary Network of Associates

Polymers, materials science, chemistry, imaging, dyes, pigments, emulsion polymerisation, biocides, pharma, agrochem, FMCG, food, anti-counterfeiting, environmental, formulation etc...

Consultancy, innovation, marketing, business development, strategy, regulatory, training, events, R&D

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Our Services

iFormulate
- Consult

iFormulate
- Strategic

iFormulate
- Skills

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Some Ways We Can Help You

Technology Profiling Assignments

– “we need some new ideas for our development programme”
– “we want to know about the pros and cons of technology x, and who we should talk to”
– “what markets could/should we enter with our technology?”

Problem Solving assignments

– “we want some help solving a problem with our formulation”
– “we want some help developing a new formulation”

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Some of our Agrochemical Activities

Individual client projects

- Supporting formulation development and trouble shooting
- Scouting for novel formulation technologies
- Positioning new technologies in the market

Training

- Introduction to Agrochemical Formulation Strategies – in-person and online training via ATI (Informa)
- Applying Design Principles to Agrochemical Formulation via ATI (Informa)

Reports

- Agrow Formulations Report 2016 (Informa Agrow)
- Sustainability in Agrochemicals 2018 (Informa Agrow)
- Formulation of Biopesticides 2019 (complete at end of year, publication early 2020 Informa Agrow)
What is Formulation?

• A **composition or recipe** comprising an active ingredient (chemical, biochemical or biological) and other ingredients (often called formulants, co-formulants or inerts).

• A **process of combining** the active ingredient with the other ingredients to create a useable product. In most cases good formulation requires not only combining the various ingredients but also creating within the product a suitable microscopic physical structure (microstructure) which gives the product many of its desired properties.

• The finished (formulated) **end-use product** itself may be called a formulation.
<table>
<thead>
<tr>
<th>Formulation Type</th>
<th>Physical Form of Product</th>
<th>Active Soluble in Water?</th>
<th>Solid or Liquid Active?</th>
<th>Suitable for Water Sensitive Active?</th>
<th>Suitable for Living Actives?</th>
<th>Suitable for Bio-Extracts etc</th>
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<td>No</td>
<td>Either</td>
<td>Yes</td>
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<tr>
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<td>Yes</td>
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<tr>
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<td>Yes/No</td>
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<td>Yes</td>
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<td>Yes</td>
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<tr>
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</tbody>
</table>

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Category of Biopesticides*

*BCPC online Manual of Biocontrol Agents 2019
Microorganism Formulation Past*

**Solids (88)**
- WP: 52%
- WG: 25%
- GR: 19%
- Other: 4%

**Liquids (44)**
- SL: 64%
- SC: 20%
- EC: 11%
- Other: 5%

* © iFormulate Limited 2019
Microorganism Formulation Present

- 29 products based on microorganisms launched in last four years based on new actives
  - Biopesticides 2018 Agrow report
- 17 liquid formulation products
  - Dominated by SC (13 products)
- 12 solid formulation products
  - Still dominated by WP (8 products)
Components of an SC Formulation

• Active
• Surfactant(s)
• Viscosity Modifier
• Freeze/Thaw Additive
• Bactericide
• Foam Control Agent
• Water
• Adjuvant?
Wettable Powder (WP) Formulations

- Powder which is applied as a suspension after dispersion in water
- Many particles <5µm, all < 45µm (BS 350 Mesh)
- Typical application: Spray
- Low cost and low phytotoxicity but difficult spray tank mixing and dust issues.

- Active Ingredient
- Wetting Agent
- Dispersing Agent
- Antifoam
- Powder Flow Aid
- Filler
- Adjuvant?
UV resistance of Biopesticides

- Lignin spray dried to form granules
- Added to spray mixture with calcium chloride (crosslinker)
- Original Activity Remaining (OAR) measured two days after application
- Two Baculoviruses and commercial Bt product
Future

- New formulation types will be used to solve problems/provide new products
  - Combination products
  - More stable products
  - More cost-effective treatments
Combination Products

• Different pesticides with different Modes of Action (MoA) needed to prevent development of resistance
• Often biopesticides are rotated with conventional pesticides as part of Integrated Pest Management (IPM)
• Can you combine in one treatment?
Combination Products

Regev™
- STK Group Tea Tree Oil combined with chemical pesticides
- Initially Difenoconazole
  - Many more claimed in patent WO2013068961
- Oil in Water emulsion
- Different emulsifiers claimed

PONCHO®/VOTiVO®
- Seed Treatment from BASF
- Bacillus firmus and Clothianidin
  - PONCHO alone contains 8% glycerine and 2.25% Fatty alcohol ethoxylate (Liquid Suspension)
- Other Ingredients >50%
- Applied as a water based slurry with dye to seed
- 2.0 contains two strains of Bt
PONCHO®/VOTiVO® 2.0*

*https://agriculture.basf.com/us/en/Crop-Protection/Poncho-VOTiVO-2-0.html
Pickering Emulsions/Encapsulation*

*Bashir et al. (2016), Controlled-release of Bacillus thurigiensis formulations encapsulated in light-resistant colloidosomal microcapsules for the management of lepidopteran pests of Brassica crops. PeerJ 4:e2524; DOI 10.7717/peerj.2524
Results*

*Bashir et al. (2016), Controlled-release of Bacillus thurigiensis formulations encapsulated in light-resistant colloidosomal microcapsules for the management of lepidopteran pests of Brassica crops. PeerJ 4:e2524; DOI 10.7717/peerj.2524
Encapsulated Bt*

Persistance

Field Trial Efficacy

Bashir et al. (2016), Controlled-release of Bacillus thurigiensis formulations encapsulated in light-resistant colloidosomal microcapsules for the management of lepidopteran pests of Brassica crops. PeerJ 4:e2524; DOI 10.7717/peerj.2524
Future Formulation Possibilities

[0045] The substances set forth above used in the compositions and methods disclosed herein can be formulated in any manner. Non-limiting formulation examples include but are not limited to Emulsifiable concentrates (EC), Wettable powders (WP), soluble liquids (SL), Aerosols, Ultra-low volume concentrate solutions (ULV), Soluble powders (SP), Microencapsulation, Water dispersed Granules, Flowables (FL), Microemulsions (ME), Nano-emulsions (NE), and Seed treatments etc. In any formulation described herein, percent of the active ingredient is within a range of 0.01% to 99.99%.

Applicant: Marrone Bio Innovations Inc.

[0046] The compositions can be in the form of a liquid, gel or solid. Liquid compositions comprise pesticidal compounds derived from a Burkholderia sp strain, e.g. a strain having the identifying characteristics of Burkholderia A396 (NRRL Accession No. B-50319).
Summary

• Biopesticide formulations are at an early stage
• Standard formulation types being used mainly
• Performance advantages will come from formulation
• Combination products will rely upon formulation science
• Oh and what about adjuvants?
  – Another time and another place...
Interested in learning more?

- **CIR Barcelona**
- **Beginners Guide to Agrochemical Formulation Strategies**
  - In-person 5th-6th November London
  - ATI On-line academy
    - [http://www.ati-global.co.uk/event/agrochemical-formulationoa](http://www.ati-global.co.uk/event/agrochemical-formulationoa)
- **Applying Design Principles to Agrochemical Formulations**
  - ATI On-Line academy
    - [http://www.ati-global.co.uk/event/applying-design-principles-to-agrochemical-formulations](http://www.ati-global.co.uk/event/applying-design-principles-to-agrochemical-formulations)
- **Formulation of Biopesticides Agrow Report**
  - Early 2020, contact Alan Bullion (Alan.Bullion@informa.com)
- **Formulation – The Basics**
  - Alderley Park 24th September 2019
- **Design of Experiments for Formulators**
  - East Midlands December 3rd and 4th 2019
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