Formulation of chemical (and biological) pesticides

Biology-based Chemical Control Methods 2012

Why formulate?

- Make pesticide easy to use
- optimise performance
- increase stability in storage

A household example of a formulation

Shampoo

• sodium lauryl sulphate	anionic surfactant
• cocamidopropyl betaine	neutral surfactant
• sodium chloride	ionic strength adjuster
• citric acid	pH adjuster
• sodium EDTA	complexer (shelf life)
• formaldehyde	bacteriostat
• dye CI 15935	colouring agent
• water	filler

>40 standard pesticide Formulations …

Terminology (*CropLife International**)

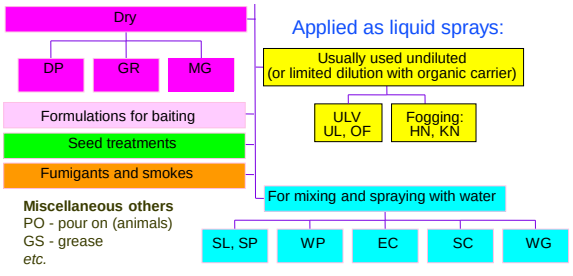
2-letter convention: *e.g.* EC, WP

… starting with:
AI - Active Ingredient
TC - Technical material

* formerly GIFAP then GCPF
go to Catalogue of Pesticide Formulation Types (Monograph 2): http://www.croplife.org/monographs.aspx

Some common formulations

Formulation types by use



Formulation components

The active ingredient (a.i.)

For activity:
- solvents
- compatibility agents
- anti-evaporants
- humectants
- anti-oxidants
- UV screens
- wetters
- stickers
- herbicide absorption
- herbicide enhancers
- other synergists
- bacteriostats

For safety:
- warning colours
- stenches
- bittering agents
- emetics

Water miscible formulations

Older formulations:

Emulsifiable concentrate	EC
Wettable powder	WP
Soluble (liquid) concentrate	SL
Soluble powder	SP

Reducing hazards (and use of solvents), improved stability:

Suspension concentrate	SC
Capsule suspensions	CS
Water dispersible granules	WG
Micro-emulsions	ME

Solutions

water-miscible concentrate SL

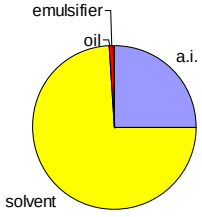
active ingredient (e.g. glyphosate ester herbicide)	250 g/L
cationic surfactant	20 g/L
ethylene glycol	100 g/L
anti-oxidant	5 g/L
water	to 1 L

Suspensions and Emulsions

emulsifiable concentrate	EC
micro-emulsion	ME

[smaller oil globules: improved suspensibility]

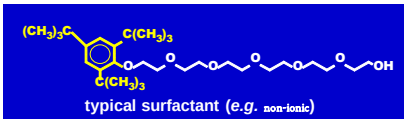
Composition of a basic EC



Formulation compounds - Examples of solvents

	water miscible	phyto -toxic	user hazard	flash point	dissolving power (a.i)
Alcohols (e.g. methanol)	yes	low	low	low	low
glycols	yes	low	low	high	mid
Aromatics (xylene, iranolin)	no	low -high	high	low -mid	high
Ideal solvent	**yes**	**low**	**low**	**high**	**high**

Emulsification



Polar Hydrophilic end

Lipophilic end

High shear blender

Oil globules in water

Water-miscible Powders

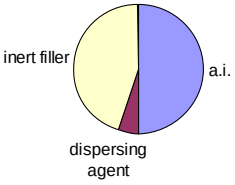
wettable powders	WP
water soluble powder	SP
water-dispersible granules	WG

[easy to handle / no dust / free-flowing … but more expensive]

Water-soluble sachets

Safety advantages of sachets: reduced contact between operator and formulation

Composition of a typical WP



Suspension concentrate SC

no dust, easier handling than WP

For example:

active ingredient *	600 g/L
non-ionic surfactant	50 g/L
bentonite (gelling agent)	8 g/L
ethylene glycol	50 g/L
benzoic acid (bacteriostat)	0.5 g/L
water	to 1 L

* milled to a fine particle size - suspensibility

Maintaining particles in suspension

Stokes' Law (spherical particles):

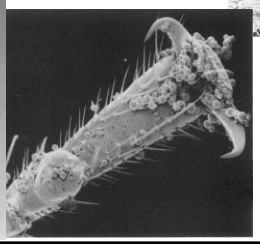
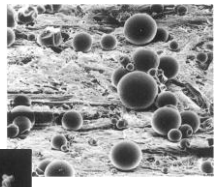
$$u \text{ (terminal velocity of particle)} = \frac{g d^2 \partial\rho}{18\,\eta}$$

where:

- g is 9.81 m s^{-1}
- d is the inclusion diameter [m]
- $\partial\rho$ is the difference in densities between the ambient liquid and the particle [kg m^{-3}], and
- η is the liquid viscosity [N s m^{-2}]

Capsule suspension CS

Micro-encapsulation:
Can separate reactive components
reduced volatility/flamability
reduced iritant handling hazards…..

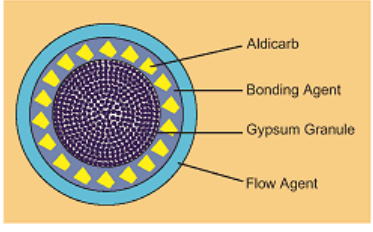

Seed treatments

Flowable concentrate for seed treatment	FS
Emulsion for seed treatment	ES
Solution for seed treatment	LS

Granules and Dusts

dustable powder	DP
micro-granules	MG
granules [easy to handle/ no dust/ slow release]	GR


Toxic granule formulation ('Temik' GR)



see: http://www.bayercropscience.co.uk/output.aspx?sec=414&con=391

Formulations for small droplets…

Hot fogging concentrate HN

Cold fogging concentrate KN

Aerosol dispenser AE

Smokes

Smoke cartridge FP
[also smoke candles etc.]

- warehouses
- greenhouses
- grain silos

Baits

bait (ready for use) RB
block bait BB
etc…

… also Contact (tracking) powder CP

Spreading oil SO

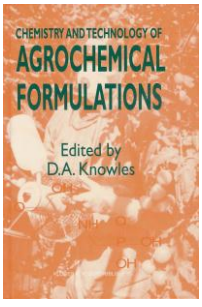
Adjuvants

… not active themselves,
but enhance pesticidal action
acting as …

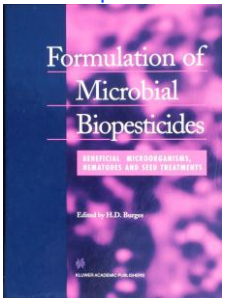
- anti-evaporants
- stickers
- compatibility agents
- herbicide absorption enhancers
- humectants
- wetters
- synergists

References on Formulations

General



For biopesticides



Both: Kluwer (1998)

Biopesticides
Bacillus thuringiensis (*B.t.*) products

- Most important sector of biopesticide market
- Products often similar to chemicals …
- … but are bacteria alive?

Biopesticide formulation issues:

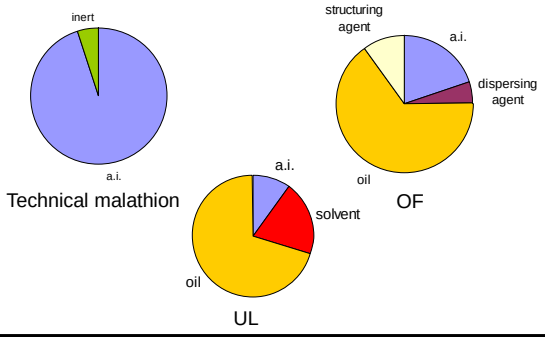
- Maintaining biological activity in hostile environments …
- …mitigating the effects of solar radiation
- Interactions with production systems
- Stability and quality control
- … maintaining viability of agent

Ultra-low volume (ULV) application

oil-based solution for ULV UL
suspension for ULV SU

oil-miscible flowable concentrate OF
- dimilin (an insect growth regulator)
- mycoinsecticides

UL and OF formulations



Summary

Wide range (>40) of pesticide formulations
Main issues for formulator:
- method of application
- properties of a.i.
- biological activity
- mode of action
- safety in use
- formulation costs
- market preference

Q: what type of formulation would you develop for...

- a rodenticide for use on farms?
- an irritating compound for spraying?
- an insecticide for disinfestation of glasshouses at end of season?
- high volume treatment of a cereal crop with a non-soluble pesticide?
- an aerially applied locust insecticide?