Formulation and Delivery of Actives:
Technology Promises Delivered and Renewed

Scott Hutchins and Ray Boucher

Dow AgroSciences

9330 Zionsville Road

Indianapolis, Indiana

Outline of Topics

- Premise of IPM
- Formulation Science and Technology
  - Definitions & Formulation Design Considerations
  - "Older" vs. "Newer" Formulation Technologies
- Delivery Systems
- Future Innovation Space
- The role of technology in IPM

Premise of IPM

- PEST MANAGEMENT IS all about using technology to reduce pest-induced injury
- INTEGRATED PEST MANAGEMENT IS all about the rational and cost-effective use of technology
- IPM does/should NOT advocate avoidance of technology
- The future Promise of IPM is BETTER TECHNOLOGY !!

Definitions

- Active Ingredient – any substance that will prevent, destroy, repel or mitigate any pest or that functions as a plant regulator, desiccant or defoliant
- Formulation – the active ingredient combined with co-formulants to create a product with good handling, efficacy and stability properties
- Co-formulant – any substance other than the active ingredient that is intentionally added to a pesticide product
- Delivery System – the formulation, package and application equipment

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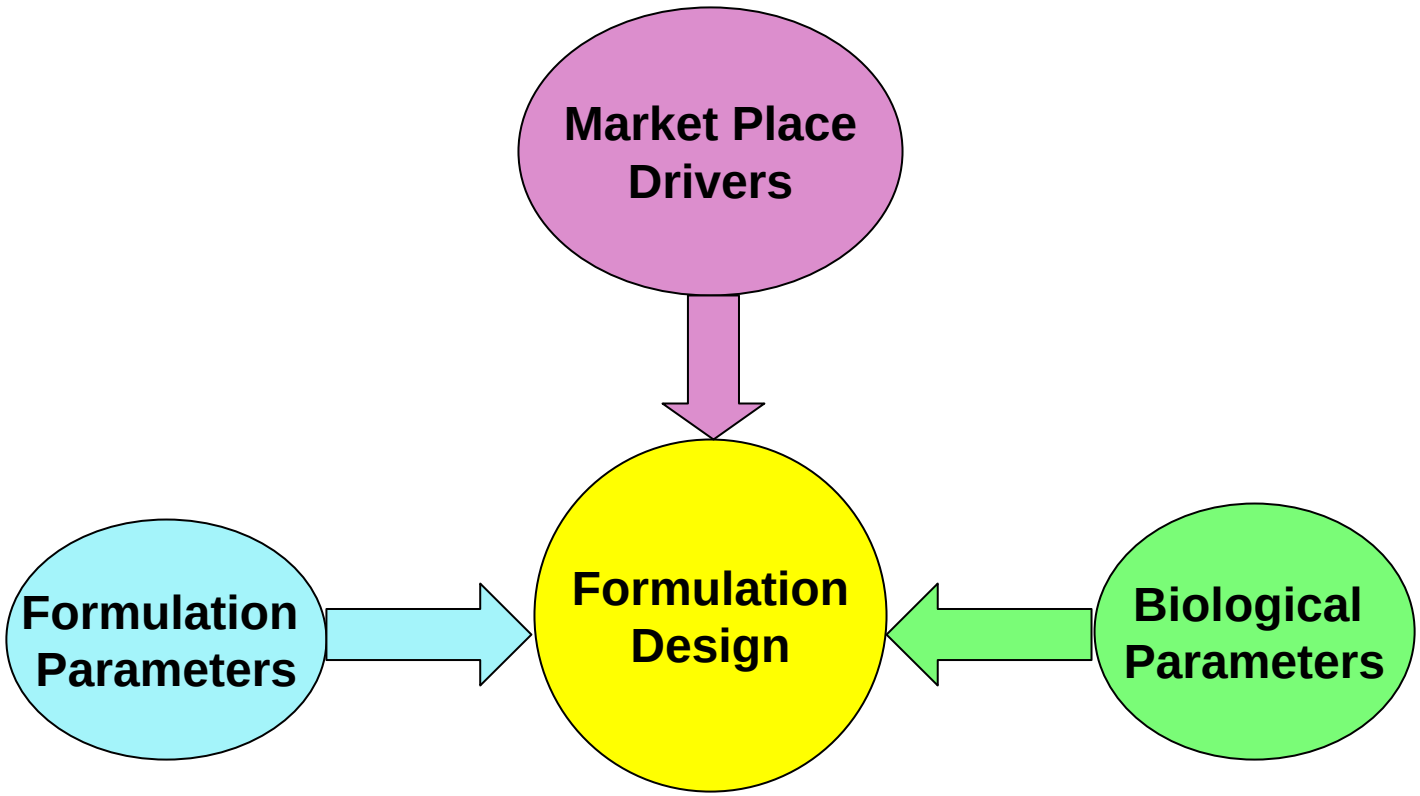
Formulation Design



Market Place Drivers

- Cost
  - Economical control of pest
  - Gross Margin to the Company
- Handling Properties
  - Ease of use – liquids generally preferred
  - Safety – protective equipment required by user
- Tank mix compatible with other formulations
- Application equipment compatible

Formulation Parameters

- Active Ingredient physical properties drive the formulation type selection process
  - Low melt point – dry product difficult, liquid product preferred
  - High melt point, low solubility – dry product
  - High melt point, good solubility – liquid or dry product possible
    - Choice based on efficacy, customer needs

Biological Parameters

	Herbicide A applied at 512 g/ha % Control 19 Days after Application		
	Ivyleaf Morningglory	Velvetleaf	Prickly Sida
EC	63%	100%	65%
Dry Flowable	40%	80%	40%

- Conclusion – 25-50% more active required to achieve same level of pest control

Older vs. Newer Technologies

- Older Formulation Technologies:
  - Emulsifiable Concentrates, Soluble Liquids, Wettable Powders
- Older Co-Formulants:
  - Nonyl phenol ethoxylates (NPE), toluene, xylene, chlorinated solvents
- Implications and Issues:
  - Worker exposure to co-formulants with potential toxicology issues
  - Environmental exposure to co-formulants with potential issues

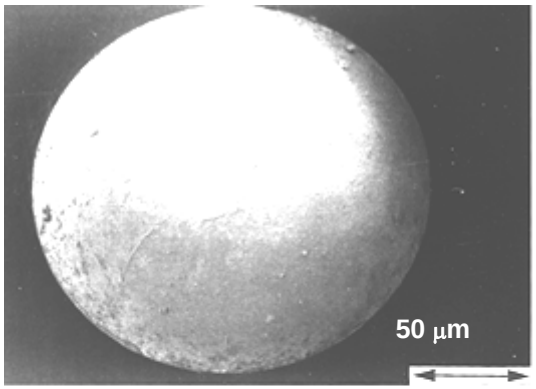
Older vs. Newer Technologies

- Newer Formulation Technologies:
  - Capsule Suspensions, Suspo emulsions, Invert emulsions
- Newer Co-Formulants:
  - New surfactant chemistries, biodegradable solvents, natural materials
- Implications and Benefits:
  - Less worker and environmental exposure to toxic co-formulants
  - Improved efficacy, flexibility and handling properties

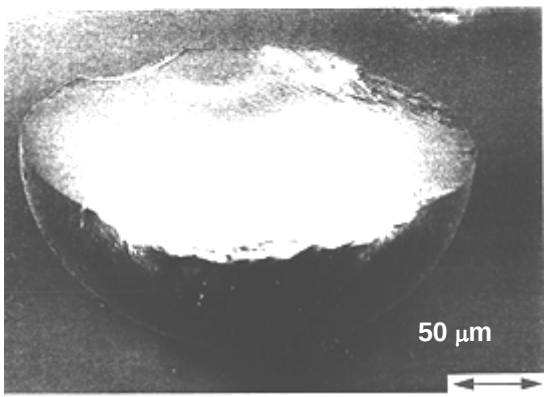
Older vs. Newer: Case Studies

Chlorpyrifos Formulations:

$\underline{LD_{50}(rat)\ mg/Kg}$:



Chlorpyrifos CS >5000



Chlorpyrifos EC 350

Older vs. Newer: Case Studies

Glyphosate Formulations:

Original DAS Formulation

- Rainbow Trout LD50 >200 mg/L
- Green Algae LD50 >100 mg/L
- Daphnia EC50 >200 mg/L

New DAS Formulation

- Rainbow Trout LD50 <100 mg/L
- Green Algae LD50 < 1.0 mg/L
- Daphnia EC50 < 100 mg/L

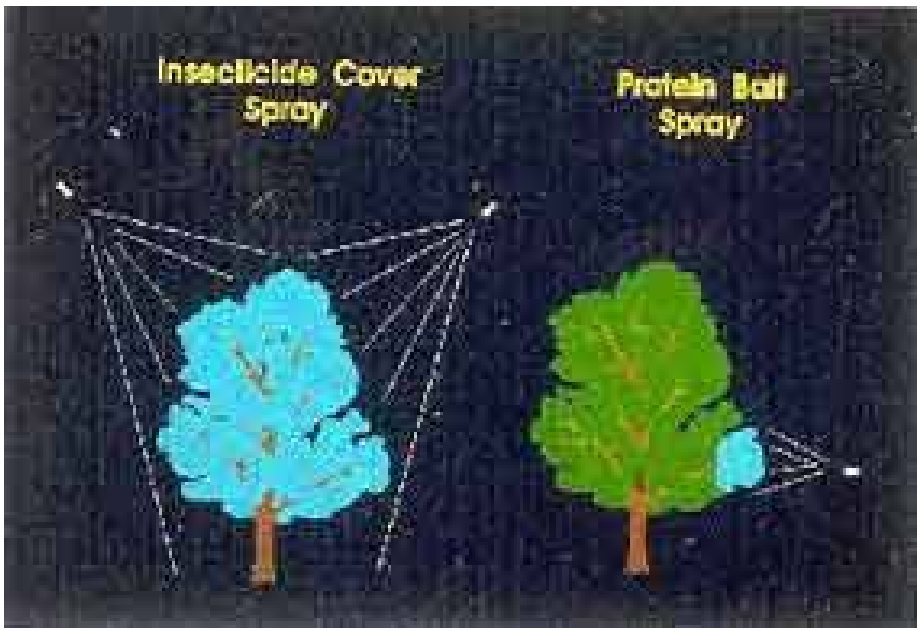
Delivery Systems: Baits

- Past:
  - Cost Driven, Reduced Efficacy, Broad Spectrum Toxicant, Poor Selectivity
- Innovations:
  - Use of attractants
  - Sprayable Bait Formulations
  - Increased spectrum
- Result:
  - Efficacy equal or better than commercial standards
  - Selectivity Controlled (non-target species considered)
  - Food Chain Friendly
  - Integral component of IPM system

Delivery Systems: Case Study

Fruit Fly Control:

Cover Spray - Malathion (500 g/acre)
Protein + Malathion (5 g/acre)



GF-120*NF (Spinosad 0.4g/acre)

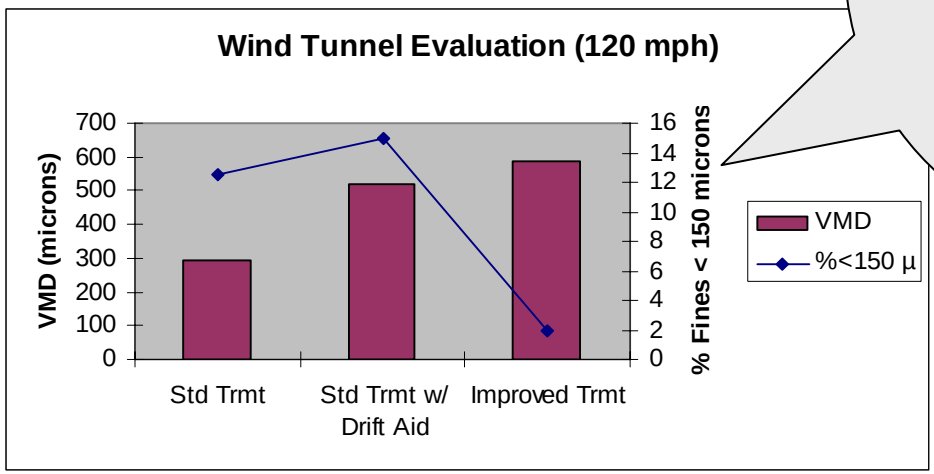
- Organic, Safe to Beneficials, Safe to Cars!

Delivery Systems: Drift Control

- Past:
  - Drift Agents managed as tank mix additives, Nozzle Configuration driven by efficacy only, General solutions
- Innovations
  - Use of Wind Tunnels for Experimental Design
  - Emphasis on entire tank mixture
  - In-the-can Formulations
- Result:
  - Registrants increasingly engaged in spray drift
  - Efficacy/Spray Drift optimized
  - More specific labeling and/or built in drift control

Delivery Systems: Case Study

Non-Target Drift Control:



Drift is Significantly Reduced via Reduction in % of Small Droplets

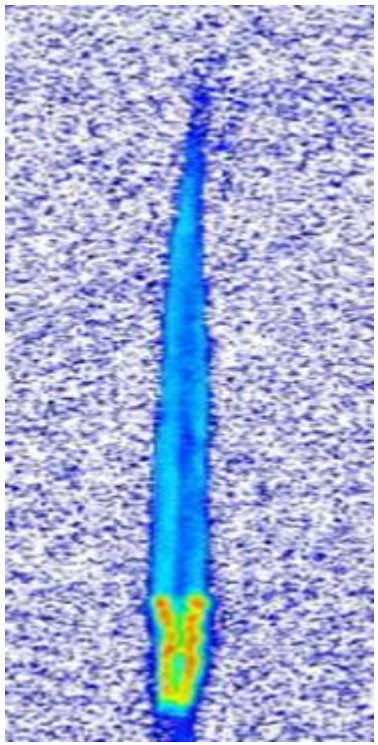
Delivery Systems: Seed Coatings

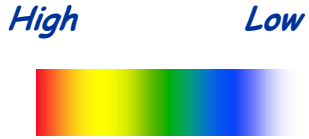
- Past:
  - Seed Protection, Stand Improvement
- Innovations
  - Improved Coating Techniques
  - Discovery Goals Targeting Seed
- Result:
  - Seed is an ideal delivery system
  - Systemic insecticides/fungicides will be selected based on this characteristic
  - Coating technologies will open up new concepts

Delivery Systems: Case Study

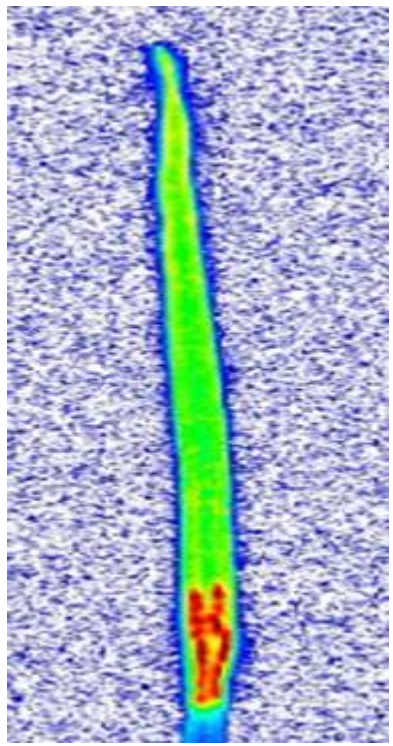
Fungicidal Protection via Seed Coating:

(Older System)





(Newer System)



Future Innovation Space

- Remote Sensing and Pest Detection
  - Sentricon™ ESP Remote Sensing
- Precise selection and mixing of actives
  - On-Demand Creation of specific products (combination of required actives in preferred formulation)
- Use of Chemical Taxis techniques
  - Attractants/Repellants matched with real actives

Older vs. Newer Technologies

- The future Promise of IPM:

BETTER TECHNOLOGY through Innovation !!

- New Preventive Technologies
- New Curative Technologies

AND

ADVANCED FORMULATIONS

NOVEL / TARGETED DELIVERY SYSTEMS

The IPM Community must be … "Obsessed with Progress"

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Steve Wilson