Chapter 7

Formulations

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An active ingredient can rarely be sold as originally discovered and manufactured. Formulation is the science, or "art" as the case may be, that transforms a biologically active ingredient into a form that is suitable for commercial use. Other ingredients—collectively called inerts—are added to the formulation to help the product take on required physical characteristics, such as the ability to mix, disperse, and flow.

A formulation may be diluted with water or other carriers and then applied onto the target, which is the topic of Chapter 8. A formulation must be physically and chemically stable. It must provide optimum biological activity under a variety of concentrations, temperatures, and water quality. It should be compatible with many other insecticides, fungicides, and other tank mix partners. When used, it must not corrode application or mixing equipment, storage, or applicator facilities.

Use properties are very important for pesticide formulations. When the formulation is placed in a sprayer or mix tank, there should be no toxic dust or objectionable odor. The material should disperse rapidly, form a stable dispersion, and not foam, form sediment, or plug nozzles.

The formulation composition and type must be tailored to fit the particular physical and chemical properties of the candidate active ingredient. It is not unusual for the companies to prepare and test numerous compositions to find the one(s) best suited for the active ingredient. Candidate formulations then undergo extensive testing by chemists and biologists before the compositions are submitted for approval by regulatory bodies. Important functions the formulation of a crop protection chemical product should deliver include

- Optimized biological activity
- Product safety and handling equal to or better than technical material
- Good chemical and physical stability
- Ease of handling and application
- Robustness (capable of performing under a wide range of conditions)

Formulation Ingredients

The active ingredient is the agent (or agents) in a formulation that has a specific effect on a target organism or complex. A bewildering number of approved materials can be used as inerts for formulating these agents. In the United States, inert ingredients are governed by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and approved by the Environmental Protection Agency (EPA) listing 40CFR180.1001 (c, d, and e). Regulatory agencies throughout the world follow a similar practice. This means that all inert products must be selected from an approved list of materials.

Inert ingredients can be described by their functionality or the properties they lend to the overall formulation. The EPA divides the inerts along functional lines. Some examples of inert ingredient classes are listed in Table 1. Each category may contain 1,000 or more separate materials and/or manufacturers from which to choose for evaluation with the active ingredient. Considering that many formulations contain as many as six ingredients, it is easy to see why statistically designed experiments are often necessary during optimization studies to minimize the number of experiments necessary to choose a specific composition.

A formulation chemist begins by selecting the inerts thought necessary to fit the quality criteria listed earlier. Finding the proper mixture is often a difficult task. A brief functional description of some of the most frequently used classes follows.

Diluents. Diluents affect the handling properties of formulations during manufacture as well as during application. A diluent (carrier) may serve to improve ease of

Table 1. Inert ingredients commonly used in agricultural formulations

Diluents	Buffering agents
Surfactants:	Dyes
Wetting agents	Antifreeze
Dispersing agents	Antidrift agents
Emulsifiers	Grinding aids
Suspending agents	Binding agents
Anticaking agents	Antimicrobials
Antifoaming agents	Preservatives