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IN THIS ISSUE

- Pesticide Formulations (Part 2 of 2) Pages 1-5
- Blast From the Past: El Vampiro Hand Duster Page 5
- Program Updates Pages 5-6



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Pesticide Formulations (Part 2 of a 2 Part Series)

Kathleen Miller and Stephanie Blevins Wycoff – Extension Associates

Introduction

In part 1 of the "Pesticide Formulations" series, we discussed why pesticides are formulated, examined the major types of formulations, and took a deeper dive into dry pesticide formulations. In part 2 of the series, we will take a closer look at liquid (and other) pesticide formulations, proper measuring techniques, and factors to consider when selecting a pesticide formulation.

Liquid Pesticide Formulations

Liquid pesticides are formulated in a variety of ways to meet different application needs. The following are some of the most common types.

Emulsifiable Concentrates (EC or E) — Pesticide products formulated as emulsifiable concentrates contain an oil-soluble liquid active ingredient, one or more petroleum-based solvents, and a mixing agent (fig. 1). This mixing agent (or emulsifying agent) allows the formulation to be mixed with water to form an emulsion that can then be applied as a spray. ECs are versatile because they can be used in a variety of agricultural and urban settings and are adaptable to many types of application equipment.

- Pros: Easy to pour and measure, not abrasive to application equipment, and do not clog screens or nozzles.
- Cons: Can be hazardous to the applicator through dermal exposure, difficult to clean up when splashed or spilled, and can cause phytotoxicity. Petroleum-based solvents can damage rubber or plastic sprayer parts.



Figure 1. An example of an emulsifiable concentrate before dilution (left) and after dilution (right). ECs develop a milky appearance when mixed with water.

Solutions (S) — A solution is a pesticide formulation in which the active ingredient dissolves completely in a liquid solvent and forms a true solution when mixed. Because this formulation remains fully dissolved, it does not require agitation after mixing. Solutions are easy on equipment and will not clog strainers or screens. The two main types of solutions are ready-to-use formulations and concentrates.

Ready-to-Use (RTU) — A ready-to-use solution is a liquid formulation that is pre-diluted and requires no further mixing before use. RTUs generally contain a small amount of active ingredient and are often sold in an application device (fig. 2).

- Pros: Require no measuring or mixing. Pose a lower risk of personal exposure due to reduced toxicity and handling.
- Cons: Availability may be limited and they are often more expensive than concentrated formulations.

Concentrates (C) / Liquid Concentrates (LC) — A concentrate / liquid concentrate solution is a type of formulation that must be diluted before use (fig. 2). The label will specify the appropriate carrier (most often water), and when mixed, the concentrate will form a true solution.

- Pros: Easy handling and easy to pour and measure. Do not require agitation and are easy on equipment.
- Cons: Can be difficult to clean up splashes or spills.



Figure 2. Example of a ready-to-use insecticide (left) and an herbicide concentrate (right).

Liquid Baits — Some pesticides are formulated as liquid baits (fig. 3). Common examples include insecticide baits for ant control and rodenticide baits for rodent control. Many liquid baits are ready-to-use or sold with specialized bait stations.

- Pros: Very targeted pest control and many are ready-to-use.
- Cons: Pests may not feed on the bait if alternative food and water resources are readily available. Baits may also require frequent replacement to maintain control.

Aerosols (A) — There are two types of aerosols: ready-to-use aerosols/foggers and smoke or fog generators (used for pest control in greenhouses or warehouses, and for outdoor mosquito control). Here we will discuss ready-to-use aerosols/foggers, which are sold in pressurized, sealed containers (fig. 3). These aerosols release a fine-droplet pesticide spray when the nozzle valve is triggered.

- Pros: Ready-to-use, portable, easily stored, and a convenient way to purchase a small amount of pesticide.
- Cons: Limited to specialized uses, pose an inhalation risk to the applicator, and can be difficult to apply precisely without contaminating nearby surfaces or drifting from the intended target site or pest.



Figure 3. Example of a liquid ant bait (left) and two ready-to-use aerosol formulations (middle and right).

Ultra-Low Volume (ULV) — Ultra-low volume formulations are highly concentrated, with some products approaching 100% active ingredient. They are often applied undiluted. ULVs are intended for special purpose applications, such as mosquito control programs. They are applied at very low rates as very fine droplets.

- Pros: Relatively easy to handle, need little to no agitation, and provide excellent coverage.
- Cons: Pose a high drift hazard, high dermal and inhalation exposure risk, and require specialized equipment.

Invert Emulsions — Pesticide products formulated as invert emulsions contain a water-soluble pesticide dispersed in an oil carrier (fig. 4). They are thick mixtures, with a consistency resembling mayonnaise. Invert emulsions are a low drift option due to their properties and the fact that they are applied in very large droplets. Invert emulsions are relatively uncommon, but they are often used for managing weeds in rights-of-way.

- Pros: Low drift risk, increased surface coverage and penetration, and reduced runoff.
- Cons: Limited availability.

Flowables (F) / Liquids (L) — This formulation type is produced by impregnating a pesticide onto a dry carrier such as clay. It is then ground into a fine powder and suspended in a very small amount of liquid (fig. 5). The resulting product is a thick liquid suspension that can be mixed with water and applied as a spray.

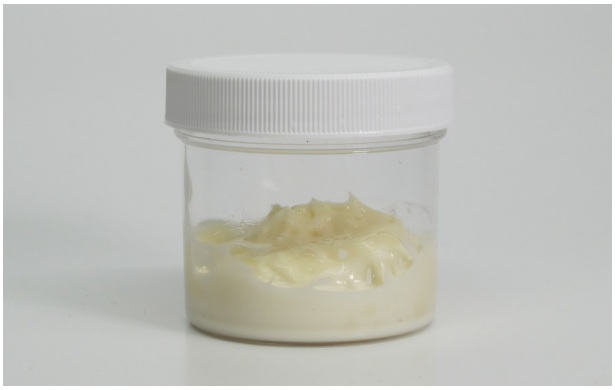


Figure 4. An example of an invert emulsion formulation.

- Pros: Easy to handle and apply, do not splash like other liquid formulations, and rarely clog nozzles.
- Cons: May settle in the product container (which can be difficult to rinse), require some agitation, can be abrasive to spray equipment, and spills may be difficult to clean up.



Figure 5. An example of a flowable formulation.

Other Formulations

Fumigants — Pesticide products formulated as fumigants deliver the active ingredient to the target site in a gaseous state. Fumigants may be formulated as solids, volatile liquids, or highly pressurized liquids. Fumigants are used in agricultural pest control to manage soil-borne pests and pests in stored food and grain. They are also used for structural pest control and in regulatory pest control at ports of entry.

- Pros: Penetrate hard-to-reach areas, such as cracks, crevices, wood, and tightly packed areas (e.g., soil or grains).
- Cons: High risk of inhalation exposure and high toxicity to humans and other non-target organisms. Require specific application equipment, personal protective equipment, and training.

Microencapsulated Pesticides (M) — Microencapsulated pesticides are comprised of the active ingredient surrounded by a coating (e.g., plastic or starch). This formulation type is mixed with water and applied with a sprayer. After application, the coating gradually degrades, releasing the active ingredient over time. In addition to agricultural settings, microencapsulated pesticides are typically used in residential and industrial structural applications due to their reduced odor and increased human safety.

- Pros: Capsule coating offers increased applicator safety and a slow release of the active ingredient for increased efficacy.
- Cons: Longer restricted-entry or preharvest intervals, require constant agitation, and are hazardous to bees because they look similar to pollen grains.

Water-Soluble Packaging (WSP) — Some pesticide products are formulated in water-soluble packaging by encasing a premeasured amount of active ingredient within a water-soluble film (fig. 6). The active ingredient within the film is typically formulated as a wettable powder, soluble powder, or gel. When added to water in a spray tank, the water-soluble packaging dissolves and releases the contents. Water-soluble packaging is predominantly used in large-scale agricultural applications.

- Pros: Increased handler safety, lower risk of spills, and no need to measure the pesticide product.
- Cons: Premeasured contents may not match the exact amount needed for a specific application.



Figure 6. An example of water-soluble packaging.

Impregnates — Impregnated pesticide products consist of an active ingredient incorporated into a solid material (e.g., livestock ear tags, pet collars, clothing, and bed nets) (fig. 7). Over time, the pesticide is released from the treated material, providing protection against nearby pests.

- Pros: Long-term, passive protection.
- Cons: Continuous dermal and/or inhalation exposure and a higher risk for pest resistance.

Animal Systemics — Pesticide products formulated as animal systemics are absorbed and distributed throughout the treated animal, providing full-body protection against both internal and external parasites. Animal systemics are typically applied orally (e.g., food additives, capsules, pastes, and liquids) (fig. 7) or externally (e.g., pour-on liquids, sprays, and dusts).

- Pros: Effective, long-lasting control of both internal and external pests.
- Cons: Risk of adverse reactions in susceptible animals.



Figure 7. Example of an impregnate (left) and animal systemic (right).

Proper Measuring Techniques

Before handling any pesticide product, read the pesticide product label for dosage information, mixing and loading instructions, and application procedures. The label will also list the personal protective equipment (PPE) that is required for each pesticide-handling task.

Select a location for mixing and loading that is outdoors or in a well-ventilated area that protects other people, animals, and the environment. Use clean water for your pesticide applications. When measuring pesticides, you will need an assortment of glass or plastic containers to measure liquid formulations and a scale and some pans for weighing dry formulations. Some products come with their own measuring device. Use this device ONLY for the specific container of product it came with and NEVER

use it for another pesticide. Mark all measuring devices clearly so they cannot be used for another purpose and clean them after each use.

Factors to Consider When Selecting a Formulation

Many pesticide active ingredients are available in more than one formulation type. If you find that there are multiple types to choose from, it is important to select the best one for the job by considering the following factors:

- **Target Site** — Consider only products that are labeled for the site you intend to treat.
- **Applicator Safety** — Choose formulations with lower toxicity and reduced potential for applicator exposure. Refer to the signal word on the front panel of the pesticide label to assess relative acute toxicity.
- **Protection of Sensitive Areas** — Assess the application site and surrounding area to identify risks of off-target movement through runoff, leaching, or drift. Select formulations that minimize these risks.
- **Pest Biology** — Understand key biological features of the target pest, such as feeding habits, damaging life stage(s), habitat, and mobility. For example, soil-dwelling pests are often managed more effectively with granules or pellets than with foliar sprays.
- **Equipment Type** — Refer to the product label for equipment requirements. Some formulation types require specialized application equipment or devices for safe and effective application. If you do not have the necessary equipment, and do not want to purchase it, select a different formulation. For example, if your equipment cannot provide continuous agitation, do not use a wettable powder formulation.

For further information on pesticide formulations, please see Purdue Pesticide Programs Publications: https://ag.purdue.edu/department/extension/ppp/resources/ppp-publications/publications-archive/_docs/ppp-31.pdf

Blast From the Past

Stephanie Blevins Wycoff – Extension Associate

El Vampiro Hand Duster

Since Halloween is just around the corner, I thought this antique was rather fitting for the occasion. The El Vampiro hand duster (which translates to The Vampire) was manufactured by Allaire Woodward & Co. in 1912 (fig. 8). This company was founded in the early 1870s and primarily specialized in pharmaceutical preparations. However, they began to branch into other markets in the early 1900s.

The El Vampiro hand duster was advertised to control several blood feeding insects such as mosquitoes, flies, bed bugs, lice, and fleas, and a few other insects such as moths, cockroaches, and ants. It contained 75% pyrethrum as the active ingredient, which is derived from chrysanthemum flowers. It was applied by removing the nail at the bottom of the container and squeezing the center of the container, causing billows of dust to exit the nail hole. Today, this active ingredient is known as pyrethrin, and is still used in several pesticide products.



Figure 8. The El Vampiro Hand Duster, 1912.

Program Updates

VTPP Updates

For the 2026-27 Private Applicator Recertification (PAR) season, VTPP will offer two online recertification courses for Virginia private pesticide applicators: one in English and one in Spanish. Completion of either course provides full recertification credit in Categories 90 and 91.

Each participant must register using their own unique email address. Recertification credit may only be awarded to the individual registered under

that email address; therefore, only one registrant is permitted per email address. Following registration and enrollment confirmation, participants will receive a VCE Canvas guest account invitation via email to access the course.

Enrollment Information:

- 2026/2027 Online Private Pesticide Applicator Recertification **(English)**: tinyurl.com/VCE-VTPP-PAR-90-91.
- 2026/2027 Recertificación en línea de aplicador privado de pesticidas **(Spanish)**: tinyurl.com/VCE-VTPP-PAR-ES.
- Cost: $35.
- Enrollment Period: October 1, 2026, through February 28, 2027.
- Course Completion Deadline: February 28, 2027.
- Email Dana Watson if you would like a QR code for either enrollment link.

Applicators whose certificates expire on December 31, 2026, must complete an approved recertification course before March 1, 2027, or they will be required to retest. No extensions will be granted.

Registration information is also available at register.ext.vt.edu/ by selecting Programs and then Agriculture or Natural Resources, or by searching keywords (e.g., pesticide, applicator, private, recertification, PAR, private applicator, VTPP, Category 90, or Category 91). For guest account issues, contact the VCE Help Desk at vceprograms@mail.ext.vt.edu. For questions regarding course content, contact Rachel Parson (rparson@vt.edu) or Dana Watson (danaew@vt.edu).

Editors: Dana Beegle and Daniel Frank • Layout and Design: Whitney Weaver Wright