Pesticide Formulation Demonstration Kit For Pesticide Applicators

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Learning Objectives

The purpose of this demonstration is to model different pesticide formulations and mixture protocols using household materials. This allows the audience to gain practical experience observing how formulations behave without exposure to hazardous pesticides.

Materials Included:

Setup Protocol:

Set up materials in order of demonstration on a flat surface. Place **display materials** in front of any mixing containers so the audience can see them clearly.

- Prepare a **display jar** (containing the dry or unmixed material) and a **mixing jar** (containing water, to be used for demonstration) for the following demonstrations:
    - **Solution/soluble powders (SP or WSP)**: sugar or lemonade drink powder
    - **Suspension/wettable powder (WP)**: cocoa powder
    - **Emulsion/emulsifiable concentrate (EC)**: vegetable oil or oil soap
    - **Water-dispersible granule (WDG)/Dry flowable (DF):** dry milk
- For **RTU, ULV, and Aerosol demonstrations**, lay out the following:
    - Plastic clear spray bottle
    - Aluminum canister spray bottle
    - Food dye
- Lay out **display materials** (no mixing needed) for the following demonstrations:
    - **Bait (B):** guinea pig food/pet pellets
    - **Paste (P)/Gel (GL):** toothpaste
    - **Dust (D):** Clubman’s classic powder
    - **Granule (G):** pet litter
    - **Microencapsulated:** water beads

    - **Water-soluble packet:** laundry detergent packet/pod
    - **Fumigant:** air freshener
- Prepare an empty jar for the **incompatibility** demonstration, alongside **display jars** for baking soda and vinegar

(It is recommended to have a tablecloth or other cover, as well as plastic spoons or other scooping utensils to minimize cleanup.)

Demonstration Protocol:

Part 1: Solutions, Suspensions, and Emulsions

Materials: three mixing jars, water, sugar, cocoa powder, and vegetable oil/soap

Purpose: this demonstration shows how ingredients in pesticide formulations may have different solubilities and how solubility affects mixtures.

Note: these mixtures will be reused for specific formulation examples. Make note of how the “active ingredient” material remains dissolved or separates from a suspension after a few minutes without agitation.

1. **Solution**

   Instructions: mix sugar with water to produce a **true solution**

   Summary: Sugar models an active ingredient that is **fully soluble**. When it is stirred into water, the sugar dissolves and produces a **true solution** that is clear and cannot be mechanically separated back into distinct sugar and water. There are soluble liquid products (which you can model with pre-mixed lemonade) and soluble dry powder products (sugar). After initial mixing in a spray tank with water, agitation is no longer necessary to keep the active ingredient uniformly distributed.

2. **Suspension**

   Instructions: mix cocoa powder with water to produce a **suspension** mixture

   Summary: Cocoa powder models an active ingredient that is **insoluble** and does not dissolve. Formulations like **wettable powders** require frequent agitation to make sure that the active ingredient remains in **suspension**, meaning that the particles are uniformly mixed in with the water carrier. Unlike solutions, the cocoa powder in this suspension will separate from the water over time and clump at the bottom.

3. **Emulsion**

Instructions: mix vegetable oil or oil soap with water to produce an **emulsion**

Summary: An **emulsion** is a mixture of liquids that retain their original identity. In emulsion pesticides, the active ingredient is dissolved into an oil-based solvent, which is then mixed with water. The refraction of light in oil droplets often gives emulsions a cloudy or murky appearance. A common example of an emulsion is milk; discuss the difference in consistency between full milk and skim milk based on fat content.

Part 2: Liquid Formulations

4. Emulsifiable Concentrate (EC)

Instructions: use mixture from "**Demonstration #3: Emulsion**."

Summary: **Emulsifiable concentrates** are liquid pesticide formulations that contain an active ingredient that does not dissolve in water and instead is dissolved in an oil (usually petroleum-based) solvent and mixed with water before spray application. Emulsions require agitation to keep from separating, and product formulations frequently include an **emulsifying agent** or **emulsifier** to slow separation. ECs are versatile and used for control pests in agricultural, ornamental and turf, food processing, structural, livestock, and public health settings.

Advantages: ECs require minimal agitation to mix, are non-abrasive on equipment, typically don't clog nozzles or screens, and leave little residue on treated surfaces.

Disadvantages: Since they are oil-based, ECs are easily absorbed by skin and are especially hazardous to the eyes. They also may cause damage to sensitive plants (**phytotoxicity**), degrade plastic or rubber equipment components, leave visible residue, and are corrosive and flammable.

5. Ready-to-Use Low Concentrate Solution (RTU)

Instructions: pre-fill clear plastic spray bottle with water and add a couple drops of food coloring.

Summary: A **Ready-to-Use Low Concentrate Solution** is a solution that has a low concentration of active ingredients (1% or less of total volume) dissolved in an organic solvent and requires no additional dilution before application. In this demonstration, the water models an RTU solution that requires no additional mixing

before application. Including only one or two drops of food coloring models a low concentration of active ingredient.

Advantages: RTUs are easy and safe to handle due to requiring no additional dilution. They have minimal staining and odor, making them useful for structural, institutional, and household pesticide applications.

Disadvantages: RTUs are relatively costly per unit of active ingredient and availability may be limited. Since they use an organic solvent, there is risk of damaging sensitive plant tissues.

6. Ultra-Low-Volume Formulation (ULV)

Instructions: using the same bottle and mixture from "**Demonstration #5: RTU,"** add food coloring until the water is distinctly colorful.

Summary: An **ultra-low-volume formulation** is a liquid formulation that may include up to 100% active ingredient with very small amounts of carrier or without any dilution, in contrast to the low active ingredient concentration of RTUs. These products tend to be spray-applied at very low rates (less than ½ gallon per acre) due to their high concentration and are most common for outdoor applications.

Advantages: ULVs are relatively easy to transport and store due to being concentrated, remain in solution with no agitation required, and generally leave minimal residue on surfaces. They are not abrasive to equipment and will not plug screens or nozzles.

Disadvantages: ULVs must be carefully applied to avoid over- or underapplication due to the high active ingredient concentration. They require specialized equipment and the organic solvents result in rapid wear and degradation of plastic and rubber parts of application equipment. ULV also are easily absorbed into skin because they use an oil-based solvent, making careful handling especially important.

7. Aerosol (A)

Instructions: pre-fill aluminum canister with water. You may add food dye to help with visualization of spray patterns.

Aerosols contain a very low percentage of active ingredient(s) and a solvent. This demonstration shows a "ready-to-use" type like bug sprays, which contain an inert gas under pressure. When the trigger is released, the formulation is dispersed in very fine droplets. Note how much the water drifts when it is sprayed and ask the

audience to consider whether large and heavy water particles, like those of the clear spray bottle, or small and light water particles, like those in the aluminum canister are more likely to drift further. These products are used in greenhouses, small areas inside of buildings, or localized outdoor spaces.

Advantages: Aerosol formulations are convenient, easily transported and stored, and retain potency over time, making them ideal for small-scale applications.

Disadvantages: Aerosol formulations pose a high risk of inhalation exposure, are difficult to confine to target areas, and are hazardous if punctured, overheated, or used near open flames.

Part 3: Dry Formulations

8. Bait (B)

Instructions: display only.

Summary: **Bait formulations** are dry or liquid pesticides that are combined with food or other attractants to lure target pests. Most bait formulations contain a relatively low active ingredient concentration (less than 5%). The bait either attracts pests or is placed where a pest will find it. Main target pests include insects like ants and roaches, invertebrates like snails and slugs, and vertebrates like rodents. The pest is killed by consuming the bait. In this demonstration, the hay represents a food source that has been treated with pesticide. An alternative is using pet food pellets.

Advantages: Baits are typically ready-to-use and come in both dry and liquid forms, with liquid baits being especially effective in dry environments. They offer the advantage of controlling pests that move in and out of an area without requiring full coverage.

Disadvantages: Baits pose risks to children, pets, livestock, and non-target wildlife. Pests may ignore bait in favor of crops, and poisoned pests can harm predators or cause odor issues if they die in inaccessible areas. To ensure safety and effectiveness, bait stations should be placed carefully, kept out of reach of children and animals, and regularly replenished and maintained.

9. Paste (L) or Gel (GL)

Instructions: display only.

Summary: A **paste** or **gel bait** is mainly used in the pest control industry for ants and cockroaches. These insecticides are applied using a syringe or bait gun by placing a “bead” or “dot” inside cracks and crevices, where insect pests hide or travel.

Advantages: Paste/gel baits are odorless, produce no vapors, pose minimal risk to applicators, and provide long-term, targeted control with low human toxicity.

Disadvantages: Paste/gel baits can melt in high temperatures, may stain porous surfaces, and can become contaminated by other chemicals. Repeated applications may also lead to unsightly buildup. Compare this to the buildup in a bathroom sink when brushing your teeth.

10. Dust (D)

Instructions: display only.

- *Optional*: mixing with water will show that the dust does not remain in solution and tends to quickly separate and float, making spray application impractical

Summary: A **dust** formulation pesticide is commonly sold as a ready-to-use product. The inert ingredients in the formula are very fine, dry particles such as talc, chalk, clay, or volcanic ash that have the active ingredient stuck to the outside of the particle. Dust pesticides have a low percentage of active ingredient and are spread around the treatment area. Dusts are always applied as dry formulations and are used in seed treatments, for ant and cockroach control in structures, and on pets and livestock for flea, lice, and other parasite control.

Advantages: Dusts are effective in hard-to-reach areas like cracks and crevices.

Disadvantages: While convenient, dusts pose a high drift hazard and carry significant risks of exposure through inhalation, skin contact, and even accidental ingestion, especially when opening and scooping. Compare this to when you open flour and it billows upwards towards you.

11. Granule (G)

Instructions: display only.

Summary: A **granule** formulation is similar to dust formulations but have larger and heavier particles. Each particle is comprised of an inert ingredient such as clay, corn cobs, or walnut shells, as well as the active ingredient either coating the outside or absorbed into the particle. Granules have relatively low amounts of active ingredient by weight (1 to 15%). They are usually used for soil treatments to control weeds,

nematodes, or soil-dwelling insects and provide slow-acting and long-lasting protection. Keep granules away from birds and other non-target wildlife that may mistake them for food.

Advantages: Granule formulations offer long-lasting, slow-release protection and are ready-to-use with minimal drift and low applicator risk.

Disadvantages: Granules can be difficult to apply uniformly, may not adhere to foliage or uneven surfaces, and often require moisture to activate. Additionally, granules may be attractive to non-target wildlife such as seed-feeding birds.

Part 4: Dry Formulations + Water

12. Wettable Powder (WP)

Instructions: use suspension mixture from "**Demonstration #2: Suspension**."

Summary: Wettable powders are dry, finely ground formulations that are similar to dusts but are mixed with water and applied as a spray. Wettable powders are usually concentrated and contain at least 50% active ingredient by weight, though products can range (5 to 95%). Note how the suspension has separated in the time since you first mixed it, similarly to if you were to mix dirt and water. For this reason, WPs usually include an emulsifying agent to aid in tank mixing.

Advantages: WPs are easy to store, measure, and mix, and pose less risk of skin and eye absorption than oil-based formulations. They are also less likely to harm non-target organisms or surfaces.

Disadvantages: WPs pose a high risk of inhalation during handling, can be abrasive to equipment, may clog nozzles, and are difficult to mix in hard or alkaline water. Staining may also occur on treated surfaces.

13. Dry Flowable (DF) or Water-dispensible Granule (WDG)

Instructions: mix dry milk with water to produce a suspension.

Summary: Dry flowables and water-dispersible granules are similar to wettable powders but come as granule-sized bead-like particles rather than powder. When mixed with water, they produce a suspension that can be used for sprays.

Advantages: Since the particles are larger and heavier, there is less risk to applicators during handling and mixing compared to dusts.

Disadvantages: Once mixed with water, DF/WDG require constant agitation to stay suspended and can be abrasive to equipment, leading to wear on pumps and nozzles. Treated surfaces may also show visible residues.

14. Microencapsulated

Instructions: display only.

Summary: A **microencapsulated** formulation includes a liquid or dry pesticide particle that is coated in plastic. When the particles are mixed with water in the spray tank, the plastic coating breaks down and releases the active ingredient.

Advantages: The plastic coating reduces exposure risk to applicators and the breakdown of the coating also results in delayed or slow release that prolongs the pesticide's effect allowing for fewer and less precisely timed applications.

Disadvantages: Microcapsules are very hazardous to bees because the microcapsules are a similar size to pollen grains and foraging bees may bring them back and poison the entire hive.

15. Water-soluble Packet

Instructions: display only.

Summary: Water-soluble packets are packets that contain a precise amount wettable powders or soluble powder formulations. When mixed with water in the spray tank, the packet dissolves and releases the pesticide. There is no risk of exposure with the concentrated product as long as you do not open the packets.

16. Fumigant

Instructions: display only.

Summary: Fumigants are non-selective pesticides that are active as highly toxic gases which enter through the lungs. Fumigants are applied to enclosed areas because the gas quickly penetrates cracks, crevices, and stored commodities. Products may be sold as solids or liquids that change to gases when exposed to humidity or released from pressurized containers.

Advantages: Fumigation effective against a wide range of pests and typically requires only one treatment.

Disadvantages: Fumigants are extremely hazardous to humans and non-target organisms, require specialized protective equipment (especially respirators), and are only effective in sealed environments. Strict safety protocols are essential when using fumigants.

Part 4: Mixing Pesticides and the Jar Test

Tank mixing pesticides can save time, labor, and reduce equipment and application costs. However, it's essential to carefully review each product label before mixing to ensure compatibility and legal use for the specific crop, site, and application method. Pesticide mixtures may react negatively, so conducting a **jar test** is a critical step to check for compatibility. Physical incompatibility can result in clumping, separation, or precipitate formation, while chemical incompatibility may alter the effectiveness of one or more ingredients—leading to under- or overdosing. Always test mixtures in a small jar before full-scale application to avoid costly mistakes and ensure safe, effective pest control.

17. **Jar Test (Incompatibility)**

    Instructions: Consider using a tablecloth or cover to protect surfaces. Fill a mixing jar up to 1/5 volume with vinegar and then add baking soda to produce a vigorous bubbling reaction.

Resources:

Penn State Formulation demonstration

University of Florida Formulation demonstration

Purdue Formulation Calibration demonstration

Pesticide Formulation Demonstration Penn State University