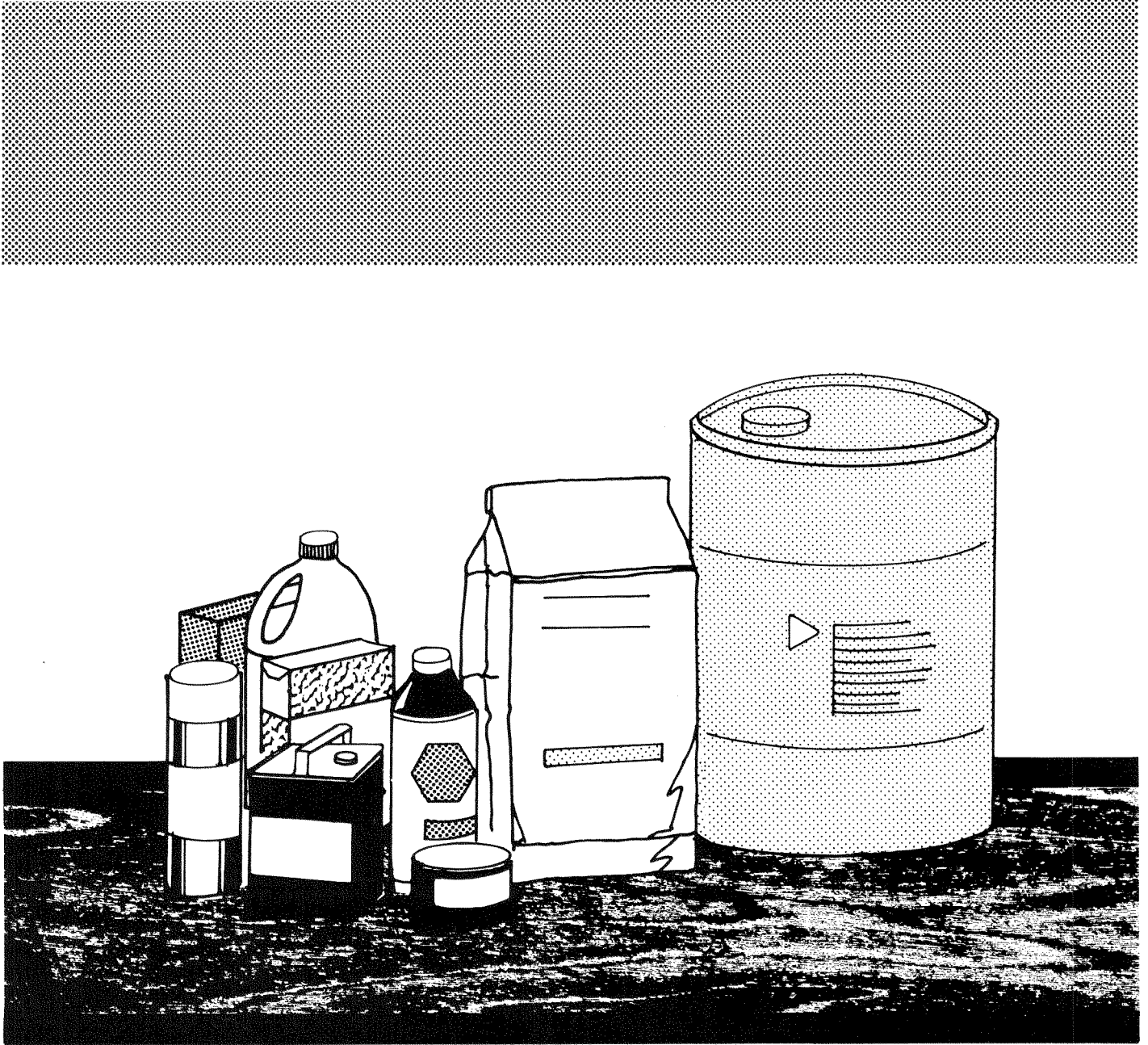
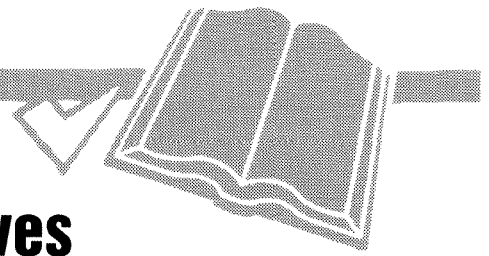
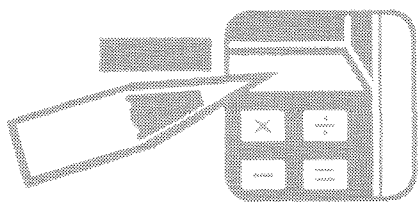


Formulations





Learning Objectives

After you complete your study of this unit, you should be able to:

- Explain what a pesticide formulation is.
- Distinguish between “active” and “inert” ingredients.
- Identify factors to consider when choosing a formulation.
- Use your knowledge of the characteristics, advantages, and disadvantages of different types of pesticide formulations to select appropriate formulations for specific purposes.
- Recognize the purpose of adjuvants and list several types.

Terms To Know

Abrasive — Capable of wearing away or grinding down another object.

Agitation — The process of stirring or mixing.

Alkaline — The opposite of acidic; having a pH greater than 7.

Carrier — The primary material used to allow a pesticide to be dispersed effectively; for example, the talc in a dust formulation, the water mixed with a wettable powder before a spray application, or the air that disperses the pesticide in an air blast application.

Dilute — To make less concentrated.

Emulsion — A mixture of two or more liquids that are not soluble in one another. One is suspended as small droplets in the other.

Insoluble — Does not dissolve in liquid.

Nontarget — Any site or organism other than the site or pest toward which the control measures are being directed.

Pesticide handler — Person who directly works with pesticides, such as during mixing, loading, transporting, storing, disposing, and applying, or working on pesticide equipment.

Petroleum-based — Made from petroleum products. Examples are: xylene, refined oil, and kerosene.

Soluble — Able to be dissolved in another substance, usually a liquid.

Solvent — A liquid, such as water, kerosene, xylene, or alcohol, that will dissolve a pesticide (or other substance) to form a solution.

Suspension — A substance that contains undissolved particles mixed throughout a liquid.

Target pest — The pest toward which control measures are being directed.

Volatile — Evaporating rapidly; turning easily into a gas or vapor.

The active ingredients in a pesticide are the chemicals that control the target pest. Most pesticide products you buy also have other ingredients, called inert (inactive) ingredients. They are used to dilute the pesticide or to make it safer, more effective, easier to measure, mix, and apply, and more convenient to handle.

Usually the pesticide is diluted in water, a petroleum-based solvent, or another diluent. Other chemicals in the product may include wetting agents, spreaders, stickers, or extenders. This mixture of active and inert ingredients is called a pesticide formulation.

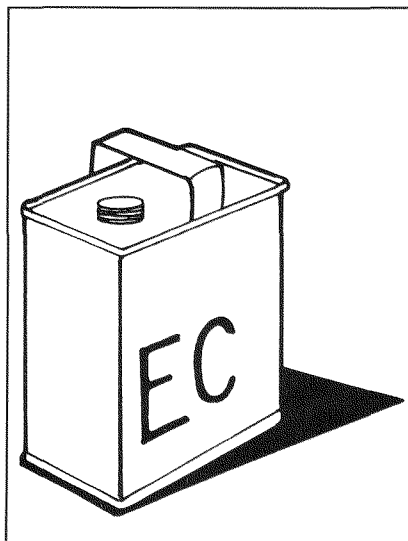
Some formulations are ready for use. Others must be further diluted with water, a petroleum-based solvent, or air (as in airblast or ULV applications) by the user before they are applied.

A single active ingredient often is sold in several different kinds of formulations. If you find that more than one formulation is available for your pest control situation, you must choose the best one for the job. Before you make the choice, ask yourself several questions

about each formulation. For example:

- Do you have the necessary application equipment?
- Can the formulation be applied safely under the conditions in the application area?
- Will the formulation reach your target and stay in place long enough to control the pest?
- Is the formulation likely to harm the surface to which you will apply it?

To answer these kinds of questions, you need to know something about the characteristics of different types of formulations and the general advantages and disadvantages of each type.



Liquid Formulations

Emulsifiable Concentrates (EC or E)

An emulsifiable concentrate formulation usually contains liquid active ingredient, one or more petroleum-based solvents, and an agent that allows the formulation to be mixed with water to form an emulsion. Each gallon of EC usually contains 25 to 75 percent (2 to 8 pounds) active ingredient. EC's are among the most versatile formulations. They are used against agricultural, ornamental and turf, forestry, structural, food processing, livestock, and public health pests. They are adaptable to many types of application equipment, from small, portable sprayers to hydraulic sprayers, low-volume ground sprayers, mist blowers, and low-volume aircraft sprayers.

Advantages:

- Relatively easy to handle, transport, and store,
- Little agitation required — will not settle out or separate when equipment is running,
- Not abrasive,
- Do not plug screens or nozzles,
- Little visible residue on treated surfaces.

Disadvantages:

- High concentration makes it easy to overdose or underdose through mixing or calibration errors,
- May cause unwanted harm to plants,
- Easily absorbed through skin of humans or animals,
- Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate,
- May cause pitting or discoloration of painted finishes,
- Flammable—should be used and stored away from heat or open flame,
- May be corrosive.

Solutions (S)

Some pesticide active ingredients dissolve readily in a liquid solvent, such as water or a petroleum-based solvent. When mixed with the solvent, they form a solution that will not settle out or separate. Formulations of these pesticides usually contain the active ingredient, the solvent, and one or more other ingredients. Solutions may be used in any type of sprayer indoors or outdoors.

Ready-to-use (RTU)

Some solutions are products that contain the correct amount of solvent when you buy them. No further dilution is required before application. These formulations, usually solutions in petroleum based solvents, contain small amounts (often 1 percent or less) of active ingredient per gallon.

Concentrate solutions (C or LC)

Other solutions are sold as concentrates that must be further diluted with a liquid solvent before you apply them. Occasionally the solvent is water, but more often the solvent is a specially refined oil or

Abbreviations for Formulations

A	= Aerosol
AF	= Aqueous Flowable
AS	= Aqueous Solution or Aqueous Suspension
B	= Bait
C	= Concentrate
CM	= Concentrate Mixture
CG	= Concentrate Granules
D	= Dust
DF	= Dry Flowable
DS	= Soluble Dust
E	= Emulsifiable Concentrate
EC	= Emulsifiable Concentrate
F	= Flowable
G	= Granules
H/A	= Harvest Aid
L	= Flowable
LC	= Liquid Concentrate or Low Concentrate
LV	= Low Volatile
M	= Microencapsulated
MTF	= Multiple Temperature Formulation
P	= Pellets
PS	= Pellets
RTU	= Ready to Use
S	= Solution
SD	= Soluble Dust
SG	= Soluble Granule
SP	= Soluble Powder
ULV	= Ultra Low Volume
ULW	= Ultra Low Weight or Ultra Low Wettable
WS	= Water Soluble
WSG	= Water-Soluble Granules
WSL	= Water-Soluble Liquid
W	= Wettable Powder
WDG	= Water-Dispersible Granules
WP	= Wettable Powder
WSP	= Soluble Powder

petroleum-based solvent.

Some uses of solutions are:

- structural and institutional pest control,
- control of some household pests,
- livestock and poultry pest control,
- space sprays in barns and warehouses,
- shade tree pest control,
- mosquito control.

Advantages:

- No agitation necessary.

Disadvantages:

- Limited number of formulations of this type available.

The other advantages and disadvantages of solutions vary depending on the solvent used, the concentration of the active ingredient, and the type of application involved.

Ultra-Low-Volume (ULV)

These concentrates may approach 100 percent active ingredient. They are designed to be used as is or to be diluted with only small quantities of specified solvents. These special-purpose formulations are used mostly in outdoor applications, such as in agricultural, forestry, ornamental, and mosquito control programs.

Advantages:

- Relatively easy to handle, transport, and store,
- Little agitation required,
- Not abrasive to equipment,
- No plugging of screens and nozzles,
- Little visible residue on treated surfaces.

Disadvantages:

- Difficult to keep pesticide in the target site — high drift hazard,
- Specialized equipment required,
- Easily absorbed through skin of humans or animals,
- Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate.

Flowables (F or L)

Some active ingredients are insoluble solids. These may be formulated as flowables in which the finely ground active ingredients are mixed with a liquid, along with inert ingredients, to form a suspension. Flowables are mixed with water for application and are similar to EC or wettable powder formulations in ease of handling and use. They are used in the same types of pest control operations for which EC's are used.

Advantages:

- Seldom clog nozzles,
- Easy to handle and apply.

Disadvantages:

- Require moderate agitation,
- May leave a visible residue.

Aerosols (A)

These formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredient. There are two types of aerosol formulations — the ready-to-use type, and those made for use in smoke or fog generators.

Ready-to-use aerosols

These aerosol formulations are usually small, self-contained units that release the pesticide when the nozzle valve is triggered. The pesticide is driven through a fine opening by an inert gas under pressure, creating fine droplets. These products are used in greenhouses, in small areas inside buildings, or in localized outdoor areas. Commercial models, which hold 5 to 10 pounds of pesticide, are usually refillable.

Advantages:

- Ready to use,
- Easily stored,
- Convenient way to buy small amount of a pesticide,
- Retain potency over fairly long time.

Disadvantages:

- Practical for very limited uses,
- Risk of inhalation injury,
- Hazardous if punctured, overheated, or used near an open flame,
- Difficult to confine to target site or pest.

Formulations for smoke or fog generators

These aerosol formulations are not under pressure. They are used in machines that break the liquid formulation into a fine mist or fog (aerosol) using a rapidly whirling disk or heated surface. These formulations are used mainly for insect control in structures such as greenhouses and warehouses and

for mosquito and biting fly control outdoors.

Advantages:

- Easy way to fill entire space with pesticide.

Disadvantages:

- Highly specialized use and equipment,
- Difficult to confine to target site or pest,
- May require respiratory protection to prevent risk of inhalation injury.

Invert Emulsions

This mixture contains a water-soluble pesticide dispersed in an oil carrier. Invert emulsions require a special kind of emulsifier that allows the pesticide to be mixed with a large volume of petroleum-based carrier, usually fuel oil. When applied, invert emulsions form large droplets that do not drift easily. Invert emulsions are most commonly used in vegetation control along rights-of-way where drift to susceptible nontarget plants is a problem.

Dry Formulations

Dusts (D)

Most dust formulations are ready to use and contain a low percentage of active ingredient (usually 1/2 to 10 percent), plus a very fine dry inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash. The size of individual dust particles is variable.

A few dust formulations are concentrates and contain a high percentage of active ingredient. These must be mixed with dry inert carriers before they can be applied.

Dusts are always used dry, and they easily drift into nontarget sites. They sometimes are used for agricultural applications. In structures, dust formulations are

used in cracks and crevices and for spot treatments. They are widely used in seed treatment. Dusts also are used to control lice, fleas, and other parasites on pets and live-stock.

Advantages:

- Usually ready to use, with no mixing,
- Effective where moisture from a spray might cause damage,
- Require simple equipment,
- Effective in hard-to-reach indoor areas.

Disadvantages:

- Easily drift off target during application,
- Residue easily moved off target by air movement or water,
- May irritate eyes, nose, throat, and skin,
- Do not stick to surfaces as well as liquids,
- Difficult to get an even distribution of particles on surfaces.

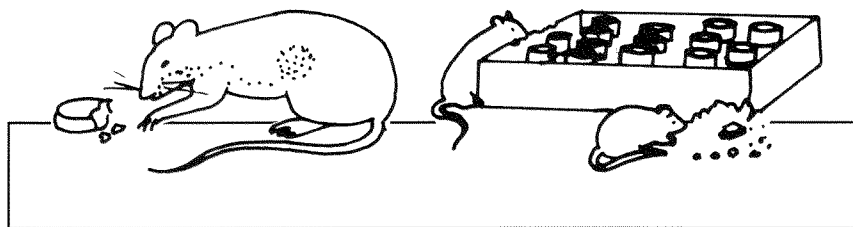
Baits (B)

A bait formulation is an active ingredient mixed with food or another attractive substance. The bait either attracts the pests or is placed where the pests will find it. Pests are killed by eating the pesticide the bait contains. The amount of active ingredient in most bait formulations is quite low, usually less than 5 percent.

Baits are used inside buildings to control ants, roaches, flies, and other insects and for rodent control. Outdoors they sometimes are used to control snails, slugs, and some insects, but their main use is for control of vertebrate pests such as rodents, other mammals, and birds.

Advantages:

- Ready to use,
- Entire area need not be covered, because pest goes to bait,
- Control pests that move in and out of an area.



Disadvantages:

- Can be attractive to children and pets,
- May kill domestic animals and nontarget wildlife outdoors,
- Pest may prefer the crop or other food to the bait,
- Dead pests may cause odor problem,
- Other animals may be poisoned as a result of feeding on the poisoned pests.
- If baits are not removed when the pesticide becomes ineffective, they may serve as a food supply for the target pest or other pests.

Granules (G)

Granular formulations are similar to dust formulations except that granular particles are larger and heavier. The coarse particles are made from an absorptive material such as clay, corn cobs, or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from 1 to 15 percent.

Granular pesticides are most often used to apply chemicals to the soil to control weeds, nematodes, and insects living in the soil. Granular formulations are sometimes used in airplane or helicopter applications to minimize drift or to penetrate dense vegetation.

Granular formulations also are used to control larval mosquitoes

and other aquatic pests. Granules are used in agricultural, structural, ornamental, turf, aquatic, right-of-way, and public health (biting insect) pest control operations.

Advantages:

- Ready to use — no mixing,
- Drift hazard is low, and particles settle quickly,
- Little hazard to applicator — no spray, little dust,
- Weight carries the formulation through foliage to soil or water target,
- Simple application equipment, such as seeders or fertilizer spreaders,
- May break down more slowly than WP's or EC's through a slow-release coating.

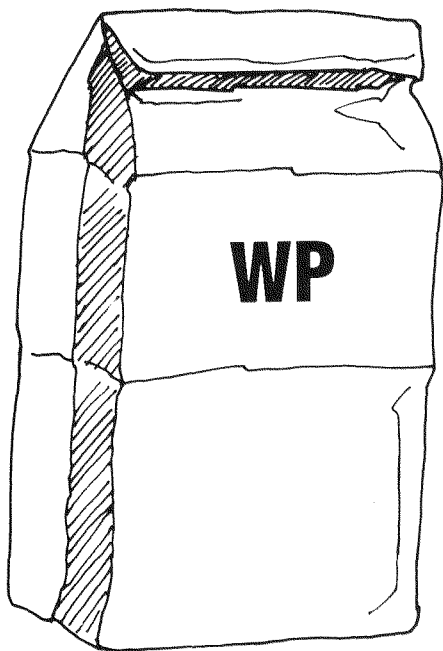
Disadvantages:

- Do not stick to foliage or other nonlevel surfaces,
- May need to be incorporated into soil or planting medium,
- May need moisture to start pesticidal action,
- May be hazardous to nontarget species, especially waterfowl and other birds that mistakenly feed on the grain- or seed-like granules.

Pellets (P or PS)

Most pellet formulations are very similar to granular formulations; the terms often are used interchangeably. In a pellet formulation, however, all the particles are the same weight and shape. The uniformity of the particles allows them to be applied by precision applicators such as

those being used for precision planting of pelleted seed. A few fumigants are formulated as pellets; however, these will be clearly labeled as fumigants and should not be confused with nonfumigant, granule-like pellets.



Wettable Powders (WP or W)

Wettable powders are dry, finely ground formulations that look like dusts. They usually must be mixed with water for application as a spray. A few products, however, may be applied either as a dust or as a wettable powder — the choice is left to the applicator.

Wettable powders contain 5 to 95 percent active ingredient, usually 50 percent or more. Wettable powder particles do not dissolve in water. They settle out quickly unless constant agitation is used to keep them suspended.

Wettable powders are one of the most widely used pesticide formulations. They can be used for most pest problems and in most types of spray equipment where agitation is possible.

Advantages:

- Easy to store, transport, and handle,
- Less likely than EC's and other petroleum-based pesticides to cause unwanted harm to treated plants, animals, and surfaces,
- Easily measured and mixed,
- Less skin and eye absorption than EC's and other liquid formulations.

Disadvantages:

- Inhalation hazard to applicator while pouring and mixing the concentrated powder,
- Require good and constant agitation (usually mechanical) in the spray tank and quickly settle out if agitation is turned off,
- Abrasive to many pumps and nozzles, causing them to wear out quickly,
- Difficult to mix in very hard or very alkaline water,
- Often clog nozzles and screens,
- Residues may be visible.

Soluble powders (SP or WSP)

Soluble powder formulations look like wettable powders. However, when mixed with water, soluble powders dissolve readily and form a true solution. After they are mixed thoroughly, no additional agitation is necessary. The amount of active ingredient in soluble powders ranges from 15 to 95 percent; it usually is over 50 percent. Soluble powders have all the advantages of wettable powders and none of the disadvantages except the inhalation hazard during mixing. Few pesticides are available in this formulation, because few active ingredients are soluble in water.

Microencapsulated Pesticides (M)

Microencapsulated formulations are particles of pesticides (liquid or dry) surrounded by a plastic coating. The formulated product is mixed with water and applied as a spray. Once applied, the capsule slowly releases the pesticide. The encapsulation process can prolong the active life of the pesticide by providing a timed release of the active ingredient.

Advantages:

- Increased safety to applicator,
- Easy to mix, handle, and apply,
- Releases pesticide over a period of time.

Disadvantages:

- Constant agitation necessary in tank,
- Some bees may pick up the capsules and carry them back to their hive where the released pesticide may poison the entire hive.

Water-Dispersible Granules (Dry Flowables) (WDG or DF)

Water-dispersible granular formulations are like wettable powder formulations, except the active ingredient is prepared as granule-sized particles. Water-dispersible granules must be mixed with water to be applied. Once in water, the granules break apart into fine powder. The formulation requires constant agitation to keep it suspended in water. Water-dispersible granules share the advantages and disadvantages of wettable powders except:

- They are more easily measured and mixed,
- They cause less inhalation hazard to the applicator during pouring and mixing.

Fumigants

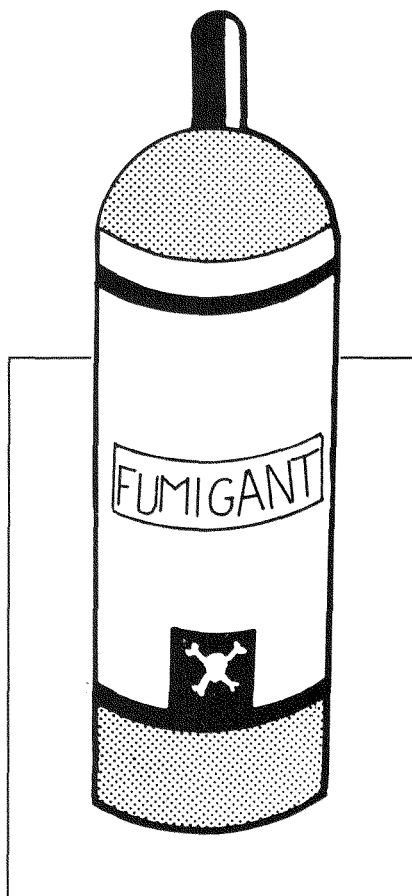
Fumigants are pesticides that form poisonous gases when applied. Some active ingredients are liquids when packaged under high pressure but change to gases when they are released. Other active ingredients are volatile liquids when enclosed in an ordinary container and so are not formulated under pressure. Others are solids that release gases when applied under conditions of high humidity or in the presence of water vapor. Fumigants are used for structural pest control, in food and grain storage facilities, and in regulatory pest control at ports of entry and at State and national borders. In agricultural pest control, fumigants are used in soil and in greenhouses, granaries, and grain bins.

Advantages:

- Toxic to a wide range of pests,
- Can penetrate cracks, crevices, wood, and tightly packed areas such as soil or grains,
- Single treatment usually will kill most pests in treated area.

Disadvantages:

- The target site must be enclosed or covered to prevent the gas from escaping,
- Highly toxic to humans and all other living organisms,
- Require the use of specialized protective equipment, including respirators,



- Require the use of specialized application equipment.

Adjuvants

An adjuvant is a chemical added to a pesticide formulation or tank mix to increase its effectiveness or safety. Most pesticide formulations contain at least a small percentage of adjuvants. Some of the most common adjuvants are **surfactants** — “**surface active ingredients**” that

alter the dispersing, spreading, and wetting properties of spray droplets.

Common adjuvants are:

- Wetting agents — allow wettable powders to mix with water.
- Emulsifiers — allow petroleum-based pesticides (EC's) to mix with water.
- Invert emulsifiers — allow water-based pesticides to mix with petroleum carrier.
- Spreaders — allow pesticide to form a uniform coating layer over the treated surface.
- Stickers — allow pesticide to stay on the treated surface.
- Penetrants — allow the pesticide to get through the outer surface to the inside of the treated area.
- Foaming agents — reduce drift.
- Thickeners — reduce drift by increasing droplet size.
- Safeners — reduce the toxicity of a pesticide formulation to the pesticide handler or to the treated surface.
- Compatibility agents — aid in combining pesticides effectively.
- Buffers — allow pesticides to be mixed with diluents or other pesticides of different acidity or alkalinity.
- Anti-foaming agents — reduce foaming of spray mixtures that require vigorous agitation.



Test Your Knowledge

Q. What is a pesticide formulation?

A. A pesticide formulation is the mixture of active and inert (inactive) ingredients that forms a pesticide product.

Q. What is the difference between active ingredients and inert ingredients?

A. Active ingredients are the chemicals in a pesticide product that control pests. Inert ingredients are the chemicals in a pesticide product that are added to make the product safer, more effective, easier to measure, mix, and apply, and more convenient to handle.

Q. What types of factors should you consider when you have a choice of formulations for a pest control task?

A. You should think about the characteristics of each formulation, and you should consider which of the formulation's advantages and disadvantages are important in your application situation. Also consider the following: Do you have the right

application equipment? Can you apply the formulation safely? Will the formulation reach the target and stay in place long enough to control the pest? Might the formulation harm the target site?

Q. If you had a choice of either a wettable powder formulation or a granular formulation for a particular pest control task, which would be best if drift were a major concern? Which would be best if you need the pesticide to stay on a surface that is not level, such as foliage?

A. The granular formulation would be the best choice in the first situation, because granules have a much lower drift hazard than wettable powders. Granules do not stick to nonlevel surfaces, so the wettable powder would be the best choice in the second situation.

Q. If you had a choice of either a wettable powder or an emulsifiable concentrate for a particular pest control task, which would be better if you were concerned about harming the treated surface? Which would be best if you were diluting with very hard or alkaline water?

A. The wettable powder would be the best choice in the first situation, because EC's are corrosive and may cause pitting, discoloration, or other damage to treated surfaces. Wettable powders are difficult to mix in very hard or very alkaline water, so the EC formulation would be the best choice in the second situation.

Q. Why are adjuvants sometimes added to pesticide formulations?

A. Adjuvants are added to a pesticide formulation or tank mix to increase its effectiveness or safety.

Q. What type(s) of adjuvants should you consider for reducing drift? for coating a surface evenly? when you wish to combine two or more pesticides for one application?

A. Foaming agents and thickeners help to reduce drift. Spreaders help to coat the treated surface with an even layer of pesticide. Compatibility agents aid in combining pesticides effectively.