CYPERMETHRIN

Cypermethrin is a synthetic pyrethroid insecticide used to kill insects on cotton and lettuce, and to kill cockroaches, fleas, and termites in houses and other buildings.

Cypermethrin is toxic to the nervous system. Symptoms of exposure include dizziness, nausea, headaches, and seizures. It also suppresses the immune system, inhibiting the formation of antibodies to disease-producing microbes.

If exposed to cypermethrin during pregnancy, rats give birth to offspring with developmental delays. In male rats exposed to cypermethrin, the proportion of abnormal sperm increases. It causes genetic damage: chromosome abnormalities increased in bone marrow and spleen cells when mice were exposed to cypermethrin. Cypermethrin is classified as a possible human carcinogen because it causes an increase in the frequency of lung tumors in female mice.

Among structural pest control operators in California, cypermethrin is the fourth most common cause of pesticide-related illness.

After household treatments, it persists in the air and on walls and furniture for about three months.

Cypermethrin is toxic to bees, other beneficial insects, earthworms, fish, and shrimp. Birds in cypermethrin-treated areas are less successful at raising nestlings because their insect food sources are killed.

By Caroline Cox

C ypermethrin is an insecticide in the synthetic pyrethroid family. It was first marketed in 1977.1 The primary manufacturers in the U.S. are Zeneca Inc., FMC Corp., and American Cyanamid Co. Common brand names are Demon, Cymbush, Ammo, and Cynoff.2

All of the insecticides in this family have chemical structures that are loosely based on pyrethrins, insecticidal compounds found in chrysanthemum flowers. (See Figure 1.) Most synthetic pyrethroids are complex molecules; cypermethrin is no exception. Because of its complexity, there are eight different ways that the atoms that make up the cypermethrin molecule can arrange themselves in three dimensions. These are called isomers. Cypermethrin is a mixture of all eight isomers.1

Over ninety percent of the cypermethrin manufactured worldwide is used to kill insects on cotton.1 In the U.S., use on cotton is important in 5 states.3 (See Figure 2.) It is also used on lettuce and pecans, to kill cockroaches (and other indoor pests) in buildings, and to kill termites. In California, where pesticide use reporting is more comprehensive than other states, use of cypermethrin in homes and other buildings is the predominant use.4 (See Figure 3.)

Mode of Action

![Figure 1: Cypermethrin and Related Naturally-Occurring Insecticidal Chemicals](image-url)
Cypermethrin, like all synthetic pyrethroids, kills insects by disrupting normal functioning of the nervous system. In insects, as well as all other animals including humans, nerve impulses travel along nerves when the nerves become momentarily permeable to sodium atoms, allowing sodium to flow into the nerve. Pyrethroids delay the closing of the “gate” that allows the sodium flow.5 This results in multiple nerve impulses instead of the usual single one. In turn, these impulses cause the nerve to release the neurotransmitter acetylcholine and stimulate other nerves.6

Cypermethrin has other effects on the nervous system. It inhibits the γ-aminobutyric acid receptor, causing excitability and convulsions.7 In addition, it inhibits calcium uptake by nerves8 and inhibits monoamine oxidase,9 an enzyme that breaks down neurotransmitters.

Cypermethrin also affects an enzyme not directly involved with the nervous system, adenosine triphosphatase. It is involved in cellular energy production, transport of metal atoms, and muscle contractions.10

Acute Toxicity

Humans: Symptoms of cypermethrin poisoning in humans include facial burning and tingling (called paraesthesia), dizziness, headaches, nausea, anorexia, fatigue,11 and loss of bladder control.12 With greater exposure, symptoms include muscle twitching, drowsiness, coma, and seizures.11

Laboratory Animals: Symptoms of cypermethrin toxicity in laboratory animals include pawing, burrowing, salivation, tremors, writhing, and seizures.13

The median oral lethal dose (the dose that kills 50 percent of a population of test animals; LD50) is variable. In rats the LD50 can vary from 250 to over 4,000 milligrams per kilogram (mg/kg) of body weight. This variability is partly due to the solvents used in the test, and partly due to variability in the proportions of cypermethrin’s isomers. In mice, it can vary from 80 to almost 800 mg/kg.12 The U.S. Environmental Protection Agency (EPA) uses LD50s of 250-300 mg/kg.14 This puts cypermethrin in toxicity category II (“Warning”).2

Juvenile rats are almost twenty times more susceptible to cypermethrin than adults. This is probably due to incomplete development of detoxification enzymes.15

Synergy: Pyrethroid insecticides, including cypermethrin, are broken down by enzymes called esterases. The same enzymes are inhibited by organophosphate insecticides. If the two kinds of insecticides are used together, cypermethrin will not be broken down as fast as it normally is. The result is that the two kinds of insecticides are synergistic: the toxicity of cypermethrin in combination with an organophosphate insecticide is greater than the toxicity of either insecticide alone.16

Skin and Eye Irritation: Cypermethrin and some cypermethrin-containing products are skin sensitizers. This means that when cypermethrin is applied to skin several times, later applications will have a more serious response than the first application.17

Cypermethrin has caused the cornea of laboratory animals to become opaque.17

Effects on the Immune System

In both rabbits and rats, cypermethrin has been shown to suppress immune system function. Rats fed cypermethrin produced fewer antibodies to a Salmonella bacterium than did unexposed animals. They also produced a smaller reaction to a tuberculin skin test. Some effects were significant at doses of 1/40 of the LD50.18 (See Figure 4.)

Rats fed cypermethrin produced fewer antibodies to foreign blood cells and foreign proteins. Effects were significant at doses of 1/10 of the LD50.18
Effects on Reproduction

Exposure of pregnant laboratory animals to cypermethrin can affect their offspring. Feeding pregnant rabbits cypermethrin resulted in a small increase in the number of organ and skeletal abnormalities in their offspring. Rats exposed prenatally showed developmental delays: events such as the emergence of a tooth, opening of eyes, and development of particular reflexes occurred up to three days later in exposed rats than in unexposed rats.

Male reproduction is also affected by cypermethrin. In mice, the proportion of abnormal sperm increased with increasing dose of cypermethrin.

Other research has shown that a receptor protein found in high concentration in the testes is inhibited by cypermethrin. This indicates that cypermethrin could disrupt the normal functioning of sex hormones.

Mutagenicity

Tests on mice have shown that cypermethrin damages genetic material. Injection of cypermethrin caused an increase in the number of cells with abnormal chromosomes in both bone marrow and spleen. Similar results were also found in bone marrow cells following ingestion, and when exposure occurred over a five day period rather than all at once.

The first study also found an increase in sister chromatid exchanges in bone marrow cells (sister chromatid exchanges are exchanges of genetic material during cell division between members of a chromosome pair. They result from point mutations.) Similar results were found with both cypermethrin and a cypermethrin-containing product in a third study.

Ingestion of, or dermal exposure to, cypermethrin caused an increase in the number of micronuclei in bone marrow cells in mice. Micronuclei are chromosomes or fragments that get left behind during cell division. A similar increase in micronuclei was found in human blood cells.

Carcinogenicity

EPA has classified cypermethrin as a possible human carcinogen (a chemical that causes cancer) because it causes lung tumors in female mice.

Two recent studies have demonstrated molecular mechanisms by which cypermethrin might be involved in causing cancer. One study looked at “gap junctional intercellular communication.” This process plays “important roles in maintenance, growth, and differentiation of cells” and is inhibited by many carcinogenic agents. The study showed that cypermethrin, four other synthetic pyrethroid insecticides, and the organochlorine insecticide DDT all were inhibitory. A second study showed that, in addition to inhibiting intercellular communication, cypermethrin also increased the number of “altered foci” in rat livers. Both are characteristics of tumor promoters.

In rats that were fed increasing amounts of cypermethrin over the course of their lives, tumors developed in the thymus, liver, adrenal glands, lungs, and skin.

Occupational Exposure

In the U.S., most occupational exposure to cypermethrin comes from its use to kill home and building pests. Structural pest control operators are exposed to cypermethrin; in California, where reporting of pesticide-related illnesses is more complete than in other states, cypermethrin was the fourth most common cause of pesticide-related illnesses among this group.

Employees can also be exposed if the building in which they work is treated with cypermethrin. For example, nine employees at a California business where cypermethrin was applied as a termicide were exposed when they entered the building two days after treatment. Employees immediately experienced dizziness, headaches, and nausea. Six days after treatment, employees noticed a return of their symptoms when they returned the building. Some symptoms persisted seven months.

In countries where agriculture is labor intensive, agricultural workers are exposed to cypermethrin. For example, over 25 percent of the workers in Chinese cotton fields exhibited symptoms of pyrethroid (including cypermethrin) poisoning.

Concerns about occupational exposure are increased because laundering is not completely successful in removing cypermethrin from clothing. Experiments found that up to 19 percent of residues remained after hand washing, and up to 27 percent remained after machine washing.

Exposure from Household Pest Control Uses

Cypermethrin is commonly used to kill household insect pests. In California, it is the fourth most commonly-used insecticide only chlorpyrifos, pyrethrins, and diazinon have more reported applications.

Potential exposure to cypermethrin following household treatments has been studied by making applications that simulate commercial “crack and crevice” cockroach treatments in vacant dormitory rooms. This study showed that residues persisted for 84 days (the end of the study) in the air, and on the walls, floor, and furniture. Cypermethrin moved to rooms adjacent to those treated by the

Figure 4

Effects of Cypermethrin on the Immune System of Rabbits

![Graph showing the effects of cypermethrin on the immune system of rabbits.](Image)

Cypermethrin inhibits the production of antibodies that fight disease-causing microbes. Experiments found that up to 19 percent of residues remained after hand washing, and up to 27 percent remained after machine washing.
seventh day after treatment and persisted for 84 days.

Termiticide cypermethrin treatments are typically made to soil around or under houses. Persistence is longer than for other household applications, at least three years.35

**Exposure through Food**

Cypermethrin residues have been found in lettuce,36 and in the milk from cows wearing cypermethrin-impregnated ear tags (as a horn fly control measure).37

**Effects on Beneficial Insects, Spiders, and Mites**

Cypermethrin is a broad-spectrum insecticide. In addition to killing the insects that are the target of a particular treatment, it can also reduce populations of insects and other arthropods that are economically desirable because they prey on unwanted insects or are useful pollinators.

**Bees:** Cypermethrin kills honey bees as well as leaf cutter bees (used to pollinate seed alfalfa crops). Residues on leaf surfaces are toxic (killing at least 25 percent of bees tested) for more than 3 days following treatment.38 In addition, bees exposed to cypermethrin learned more slowly and less successfully than untreated bees.39

**Spiders:** Spiders are desirable predators in many agricultural systems because of their appetite for insects that would otherwise be agricultural pests. For example, treatment of rice with cypermethrin caused a decrease in the number of spiders and an increase in the number of whitebacked planthoppers, a pest in- sect. Because of the “resurgence” of the pest, cypermethrin caused a decrease in the population of predatory beetles in fava beans40 and high mortality of of two predators and a parasitoid important in the control of the pecan aphid.41

**Aquatic Insects:** While not usually considered beneficial insects in an economic sense, many aquatic insects are important components of aquatic ecosystems. Cypermethrin is toxic to caddisflies, mayflies, damselflies, and diving beetles.42 Sublethal effects (abnormal swimming, etc.) have also been documented. Effects occur at low concentrations, much less than one part per billion (ppb) in some species.43

**Effects on Other Animals**

**Fish:** Fish are particularly susceptible to cypermethrin.1 The median lethal concentration (the concentration that kills 50 percent of a population of test animals LC50) for most fish is less than 5 ppb.1 This is partly because fish are unable to break down pyrethroids as efficiently as mammals and birds and partly because fish nervous systems are particularly sensitive to pyrethroids.42

Cypermethrin also causes sublethal effects in fish. These include an increase in cholesterol at 1/5 of the LC5013 and abnormal levels of blood sugars44 at concentrations as low as 1/10 of the LC50.55

Cypermethrin bioconcentrates in fish. Bioconcentration factors (the ratio between the concentration in fish tissue and the concentration in the water in which the fish is living) in rainbow trout range from 180 to 438 depending on water type.56 Values up to 1200 have been reported.14

**Other Aquatic Animals:** Cypermethrin kills shrimp,58,59 crabs,60 crayfish,61 and lobsters62 at concentrations between 5 and 70 parts per trillion; water fleas are killed by concentrations of 5 ppb;59 and oysters are killed by 2.3 parts per million.59

**Effects on Plants**

Since cypermethrin is an insecticide, it is surprising that it also negatively impacts plants. The growth of a green algae (Scenedesmus bijugatus) is inhibited by concentrations as low as 5 parts per million.52 In addition, nitrogen fixation (the conversion of atmospheric nitrogen into a form that can be used by plants) is decreased for 6 weeks in soybean root nodules by cypermethrin.63 For nitrogen-fixing soil microbes, the cypermethrin product Ripcord was inhibitory.64

Cypermethrin also affects plant cells. In both onion and chili roots, cypermethrin inhibited cell division and increased the number of chromosome abnormalities.65,66

**Persistence in Soil**

The half-life (the amount of time required for half of what was originally applied to break down or move away from the test site) for cypermethrin in soil is between 4 and 12 days.14 However, it can be significantly more persistent. In agricultural soil in Ontario, Canada, cypermethrin per-
sisted for between 4 and 12 months. Persistence was less in sandy soil than in a "muck" soil. In surface layers of the soil, persistence was somewhat less (4 to 6 months). 67

Water Contamination

Crystalline silica has been found in groundwater in France 68 and in river water and sediment in the United Kingdom. 69

Resistance

Resistance to cypermethrin has developed quickly in insects exposed frequently. Both agricultural and household pest species have developed resistance. The degree of resistance is usually measured with a resistance ratio, the ratio between the amount of a pesticide required to kill a resistant insect and the amount required to kill average (non-resistant) insects. Resistance ratios from 6 to 32 have been measured in agricultural pests. 70-72 Among household pests, resistance ratios have ranged from 5 to 100. 73, 74 (The resistance ratio of 5 was enough to render synthetic pyrethroids ineffective.)

Secret "Inert" Ingredients

Virtually all cypermethrin-containing insecticide products contain ingredients that are called trade secrets by their manufacturers and classified as "inert" ingredients by EPA. However, these ingredients are neither biologically, toxicologically, or chemically inert. The following "inert" ingredients have been identified on the material safety data sheets produced for at least one cypermethrin-containing product. 75 (For molecular diagrams of some of these "inerts", see Figure 5.)

Figure 5

Some of the "Inert" Ingredients Used in Cypermethrin-containing Products

- CH₃
- CH₂CH₃
- CH₃
- CH₃
- CH₃
- CH₃
- CH₃
- CH₃
- CH₃
- CH₃
- CH₂CH₃

Xylenes are solvents. They cause nose, throat, and eye irritation, labored breathing, lung inflammation, nausea, vomiting, mild liver toxicity, impaired short-term memory, and hearing loss in exposed humans and/or laboratory animals. In laboratory tests, xylene exposure has also caused reduced fertility, increased number of fetal resorptions, increased incidence of cleft palate, and decreased fetal weight. Xylene inhalation has been associated with increased frequency of leukemia in solvent-exposed workers. It may be a cocarcinogen, exposure to xylene has increased the number of skin cancers caused by other carcinogens. It "has the potential for bio-accumulation" in human fat tissue. 77

Trimethylbenzenes are highly volatile solvents that cause skin and eye irritation, nervousness, tension, bronchitis, disruptions of blood clotting, headaches, fatigue, dizziness, and loss of consciousness. 76

References

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