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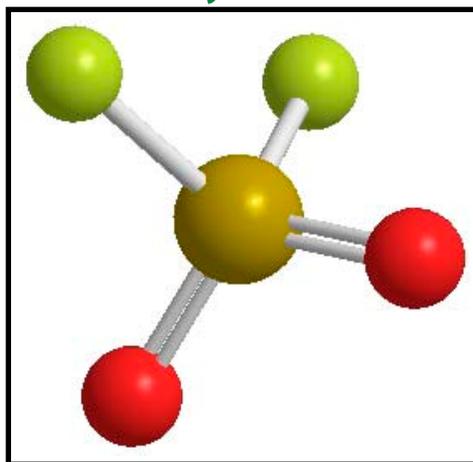
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### **Molecular Structure - Sulfuryl Fluoride**



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NPTN Technical Fact Sheets are designed to provide information that is technical in nature for individuals with a scientific background or familiarity with the regulation of pesticides by the U.S. Environmental Protection Agency (US EPA). This document is intended to be helpful to professionals and to the general public for making decisions about pesticide use.

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# Sulfuryl Fluoride

## (Technical Fact Sheet)

For less technical information please refer to the General Fact Sheet

**The Pesticide Label:** Labels provide directions for the proper use of a pesticide product. *Be sure to read the entire label before using any product.* A signal word on each product label indicates the product's short-term toxicity.

**CAUTION - low toxicity**

**WARNING - moderate toxicity**

**DANGER - high toxicity**

## What is sulfuryl fluoride?

- Sulfuryl fluoride is an insecticide and rodenticide first registered in the United States in 1959. After meeting current health, safety, and product labeling requirements sulfuryl fluoride was eligible for re-registration in 1993 by the U.S. Environmental Protection Agency (EPA) (1).
- Sulfuryl fluoride is a gas used to fumigate closed structures and their contents for drywood and Formosan termites, wood infesting beetles, bedbugs, carpet beetles, clothes moths, cockroaches, and rodents.
- Sulfuryl fluoride is an odorless, colorless gas (2). It is non-flammable, non-corrosive, and does not react with materials to produce odors or residues (3,4). In addition, sulfuryl fluoride has a very low boiling point (-55.2 °C at 760 mm Hg) and a very high vapor pressure (17.7 mm Hg @ 25 °C) (1).
- As a result of the knowledge required to use fumigants appropriately EPA has classified sulfuryl fluoride as a "Restricted Use Pesticide," i.e., one that may be purchased and used only by certified applicators (1,5). Although sulfuryl fluoride is only slightly toxic via inhalation an acute hazard is associated with this chemical because it is an odorless, colorless gas (1). Therefore, product labels contain the signal word "DANGER," EPA's highest toxicity category because of the chemical's acute inhalation hazard (6). See the *Pesticide Label* box above.

## How does sulfuryl fluoride work?

- Sulfuryl fluoride is introduced into structures as a gas intended to fill all air spaces in the enclosed area and penetrate cracks, crevices, and pores in the wood (7). It penetrates materials quickly and rapidly dissipates during the ventilation process (3,4). To be effective, sulfuryl fluoride must be contained for a sufficient period of time; therefore, workers place a tent around the structure during the fumigation (7).

- Sulfuryl fluoride breaks down to fluoride and sulfate inside the insect's body (8,9). Fluoride, the primary toxin, interferes with the metabolism of stored fats and carbohydrates that the insect needs to maintain a sufficient source of energy (disrupts glycolysis and the citric acid cycle). The insect then uses protein and amino acids as an alternative source of energy; however, the metabolic rate does not increase sufficiently, and the insect dies (8). Mortality may not occur for several days (8,10).
- Sulfuryl fluoride reduces the amount of oxygen taken up by insect eggs (11). Eggs, however, tend to be less susceptible than adults primarily because the egg shell limits the passage of sulfuryl fluoride (3,11). Control of insect eggs may require an increased exposure time or, increased concentration of sulfuryl fluoride (3,11,12). Larvae of social insects (ants and termites) are unable to survive without adult care; therefore, additional control measures may not be necessary (12).

## What are some products that contain sulfuryl fluoride?

- Vikane®
- Termafume®

## Will I be exposed to sulfuryl fluoride?

- Sulfuryl fluoride is a biocide, a substance that will kill all living organisms including people, animals, and plants if exposed for a sufficient period of time and at a high enough concentration. For this reason, occupants must leave the structure before the fumigation begins and remain absent until the gas is removed from the structure.
- Sulfuryl fluoride is an odorless, colorless gas that does not cause skin or eye irritation at the concentrations used by applicators (2,5,13). Therefore, prior to the fumigation, applicators introduce trace amounts of a warning agent, *chloropicrin*, into the structure (13,14).
 

**Chloropicrin** has a strong odor and will cause respiratory and eye irritation. Symptoms include tears, burning eyes, difficulty breathing, coughing, headaches, and nausea (13,15). Structures should be completely aired before re-entry is allowed because chloropicrin dissipates more slowly from structures than sulfuryl fluoride (13,14).
- Residues do not remain following a proper ventilation process. Although the uptake (sorption) of sulfuryl fluoride by materials within the structure is low, the fumigant needs sufficient time to diffuse (desorb) during aeration (7,14). When applicators remove the tent, the gas quickly dissipates to very low levels within 24 hours and escapes to areas of lower concentration according to gas laws and principles of diffusion (1,7).
- Initial concentrations in single family homes range from 1440 to 3850 parts per million (ppm) (13). The EPA requires that prior to re-entry, applicators must continue to ventilate the structure until the concentration of sulfuryl fluoride is measured at 5 ppm (or less). Exposure to remaining levels, following the required ventilation period, are expected to be very low (1,6).
- Dietary exposure is unlikely because sulfuryl fluoride is not registered for use on food (1). Refer to the last section for *necessary preparations prior to fumigation*.

## What is the toxicity of sulfuryl fluoride?

### Animals

- Sulfuryl fluoride is moderately toxic when “fed” to rats and guinea pigs. See box on *Laboratory Testing*. The acute oral LD<sub>50</sub> is 100 milligrams per kilogram of body weight or mg/kg (1). See boxes on *Toxicity Categories and LD50*.

**Toxicity Category (Signal Word) (16)**

	<b>High Toxicity (Danger)</b>	<b>Moderate Toxicity (Warning)</b>	<b>Low Toxicity (Caution)</b>	<b>Very Low Toxicity (Caution)</b>
<b>Oral LD50</b>	Less than 50 mg/kg	50 - 500 mg/kg	500 - 5000 mg/kg	Greater than 5000 mg/kg
<b>Inhalation LC50</b>	Less than 0.2 mg/l	0.2 - 2 mg/l	2 - 20 mg/l	Greater than 20 mg/l
<b>Dermal LD50</b>	Less than 200 mg/kg	200 - 2000 mg/kg	2000 - 5000 mg/kg	Greater than 5000 mg/kg
<b>Eye Effects</b>	Corrosive	Irritation persisting for 7 days	Irritation reversible within 7 days	No irritation
<b>Skin Effects</b>	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours

**LD50/LC50:** A common measure of toxicity is the lethal dose (LD50) or lethal concentration (LC50) that causes death (resulting from a single or limited exposure) in 50 percent of the treated animals. LD50 is generally expressed as the dose in milligrams (mg) of chemical per kilogram (kg) of body weight. LC50 is often expressed as mg of chemical per volume (e.g., liter (l)) of medium (i.e., air or water) the organism is exposed to. Chemicals are considered highly toxic when the LD50/LC50 is small and practically non-toxic when the value is large. However, the LD50/LC50 does not reflect any effects from long-term exposure (i.e., cancer, birth defects, or reproductive toxicity), that may occur at doses below those used in short-term studies.

- Sulfuryl fluoride is slightly toxic to rats and mice in short term inhalation studies (1 hr LC<sub>50</sub> (rat) = 17.5 milligrams per liter or mg/L and 4 hr LC<sub>50</sub> (mice) = 2.5 mg/L) (1).
- In subchronic inhalation studies, researchers exposed rats and rabbits to sulfuryl fluoride 6 hours a day for 90 days at concentrations of 0, 30, 100, or 300 ppm (Male Rats - 0, 29, 97, or 290 mg/kg/day; Female Rats - 0, 33, 109, or 326 mg/kg/day; Rabbits - 0, 11, 38, or 114 mg/kg/day). The following effects were observed at 100 and 300 ppm: decreased body weights, mottled teeth, and injury to the brain, nervous system, liver, kidney, lung, and nasal tissues (1). In another study, animals died when exposed to concentrations of 600 ppm (17).
- Dogs exposed to sulfuryl fluoride for the same time period at concentrations of 0, 30, 100, or 200 ppm resulted in a NOEL (no observable effects level) of 100 ppm (2.5 mg/kg/day). At 200 ppm (5.0 mg/kg/day) dogs showed decreased body weight and body weight gain, nervous system effects and changes in the brain (1).
- Rats did not exhibit adverse effects during a two day inhalation neurotoxicity study when exposed to concentrations of 0, 100, or 300 ppm (M - 0, 97, or 290 mg/kg/day; F - 0, 109, or 326 mg/kg/day). However, researchers observed some effects in the animals following chronic exposures (1).
- An inhalation study demonstrated that rats exposed to higher concentrations of sulfuryl fluoride were incapacitated and died within a shorter period of time than rats exposed to lower concentrations. For example, it took 6 minutes at 40,000 ppm to become incapacitated versus 45 minutes at 4000 ppm (18).

**Laboratory Testing:** Before the U.S. EPA registers pesticides, they must undergo laboratory testing for short-term and long-term health effects. Laboratory animals are purposely exposed to high enough doses to cause toxic effects. These tests help scientists judge how these chemicals might affect humans, domestic animals, and wildlife in cases of overexposure. When pesticide products are used according to the label directions, toxic effects are not likely to occur because the amount of pesticide that people and pets may be exposed to is low compared to the doses laboratory animals are exposed to.

**Humans**

- Symptoms of sulfuryl fluoride poisoning include nose, eye, throat, and respiratory irritation, shortness of breath, numbness, weakness, nausea, abdominal pain, and slowed speech or movements (5,13,19).

- Sulfuryl fluoride is a central nervous system depressant. Signs of sulfuryl fluoride poisoning include coughing, vomiting, restlessness, muscle twitching, seizures, and pulmonary edema (5,19). Repeated exposures to high concentrations of sulfuryl fluoride may cause lung and kidney damage (5).
- People have died when they entered structures during the fumigation process or when sulfuryl fluoride had not dissipated to appropriate levels (5 ppm or less) prior to re-entry (1,5,20).

Effects of **sulfuryl fluoride** on human health and the environment depend on how much sulfuryl fluoride is present and the length and frequency of exposure. Effects also depend on a person's health or the condition of the environment when exposure occurs.

## Does sulfuryl fluoride cause reproductive or teratogenic effects?

### Animals

- Researchers exposed pregnant rats on gestation days 6-15 and rabbits on gestation days 6-18 to air concentrations of 0, 25, 75 or 225 ppm (Rats - 0, 27, 81, or 244 mg/kg/day; Rabbits - 0, 10, 28, or 85 mg/kg/day) for 6 hours a day. Inhalation of sulfuryl fluoride was not teratogenic. Developmental and maternal toxicity were not observed in rats, however, a reduction in the fetal body weights and crown rump length of rabbits were observed at levels that produced a decrease in the maternal body weight gain (225 ppm) (1,21).
- Scientists exposed rats to air concentrations of 0, 5, 20 or 150 ppm (M - 0, 4, 17, or 130 mg/kg/day; F - 0, 5, 20 or 152 mg/kg/day) for six hours a day, five days a week during a two-generation reproductive study. Lung and brain effects were observed in the parent animals at 20 and 150 ppm. Scientists also noted decreased pup weights at the highest dose (150 ppm) (1).

### Humans

- Data is not available from work-related exposures, accidental poisonings, or other human studies to indicate whether sulfuryl fluoride is likely to cause reproductive or developmental effects in humans.

## Is sulfuryl fluoride a carcinogen?

### Animals

- Based on the current use pattern of sulfuryl fluoride, EPA did not require carcinogenicity tests. Therefore, the EPA has not classified the potential for sulfuryl fluoride to cause cancer. See the *Cancer* box.
- Researchers often screen potential carcinogens using studies designed to test the chemical's ability to cause mutations. Sulfuryl fluoride was negative in three mutagenicity studies (1).

**Cancer:** The U.S. EPA has strict guidelines that require testing of pesticides for their potential to cause cancer. These studies involve feeding laboratory animals large *daily* doses of the pesticide over most of the lifetime of the animal. Based on these tests, and any other available information, EPA gives the pesticide a rating for its potential to cause cancer in humans. For example, if a pesticide does not cause cancer in animal tests, then the EPA considers it unlikely the pesticide will cause cancer in humans. Testing for cancer has not been done on human subjects.

### Humans

- Data is not available from work-related exposures, accidental poisonings, or epidemiological studies to indicate whether sulfuryl fluoride is likely to cause cancer in humans.

## Does sulfuryl fluoride accumulate?

### Animals

- Data regarding the biochemical effects of sulfuryl fluoride in mammals is limited; however, when researchers exposed termites to sub-lethal concentrations of sulfuryl fluoride, inorganic sulfate was excreted (an indication that sulfuryl fluoride was broken down inside the insect's body to fluoride and sulfate) (8,9).
- Researchers exposed rats and rabbits to sulfuryl fluoride 6 hrs/day, 5 days a week for 13-weeks at concentrations of 0, 100, or 300 ppm and 0, 100, or 337 ppm, respectively. Serum fluoride levels in rats exposed to the highest concentration were slightly elevated. Rabbits, however, exhibited a significant increase in serum fluoride levels at all test concentrations compared to control values. Serum fluoride levels were also significantly increased in another study when scientists exposed rats to concentrations of 4,000 or 10,000 ppm until the time of incapacitation. Although additional factors may be involved, the toxicity of sulfuryl fluoride is due, in part, to the increased fluoride levels. For example, fluoride inhibits metabolism and decreases calcium, magnesium, and serum cholinesterase levels in mammals: Cholinesterase is an enzyme needed for the proper functioning of the nervous system (17,18).
- Animal studies show that fluoride binds to teeth and bones following long term exposures, resulting in mottled teeth (13,17).

### Humans

- A serum fluoride level of 0.5 mg/l was measured in one fatality 6 days after the home was fumigated with sulfuryl fluoride (background levels have been reported to be approximately 0.01 mg/l). Air samples were taken in the home; however, the gas had dissipated and the previous levels of sulfuryl fluoride were no longer detectable (1,19,20).

## What is the environmental fate and behavior of sulfuryl fluoride?

- Sulfuryl fluoride quickly dissipates in the atmosphere once the gas moves outside the structure during the ventilation process (12).
- Sulfuryl fluoride does not contribute to local ozone formation or stratospheric ozone depletion, nor does it contribute significantly to acid rain (13).
- Sulfuryl fluoride is broken down by hydrolysis into fluoride and sulfide ions (1,13). It is also broken down by ultraviolet radiation and reactions with solid particles in the atmosphere (13).
- Groundwater contamination is unlikely based on the present use pattern and volatility of sulfuryl fluoride (1).

## How does sulfuryl fluoride affect fish and wildlife?

- Exposure to non-target organisms is unlikely based on the present use pattern of sulfuryl fluoride (1).
- Wildlife may be exposed to low concentrations of sulfuryl fluoride for a short period of time during the ventilation process. Adverse effects are unexpected based on mammalian inhalation toxicity data (22).

## What preparations are necessary prior to fumigation?

- The pesticide label requires that pest control companies provide an information sheet to an adult occupant of the structure, prior to a fumigation. The pesticide fact sheet contains important information on health risks, safety precautions, and preparations (1,6). A product label may also be available from the applicator.
- People, animals, plants, water proof covers, and items covered with plastic (plastic can slow down the aeration process) should be removed from the structure. In addition, food, feed, and medicines that no longer have the manufacturer's air-tight seal intact should also be removed or double bagged in special bags (available from your pest control company). Don't forget to remove items in refrigerators and freezers. Turn off all flames: e.g., pilot lights and electric heating elements (6).
- As a result of sulfuryl fluoride's low water solubility, wetting the soil around the perimeter of the structure will help prevent loss of the fumigant near the base of the tent and reduce exposure to plant roots (3,13,14). Sulfuryl fluoride is phytotoxic (2,3,4).
- Please check with your *Pest Control Company* for additional preparations that may be required.

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