

SULFURYL FLUORIDE

TECHNICAL FACT SHEET

NPIC Technical Fact Sheets provide information that is complex and intended for individuals with a scientific background and/or familiarity with toxicology and risk assessment. This document is intended to promote informed decision-making. Please refer to the General Fact Sheet for less technical information.

What is sulfuryl fluoride?

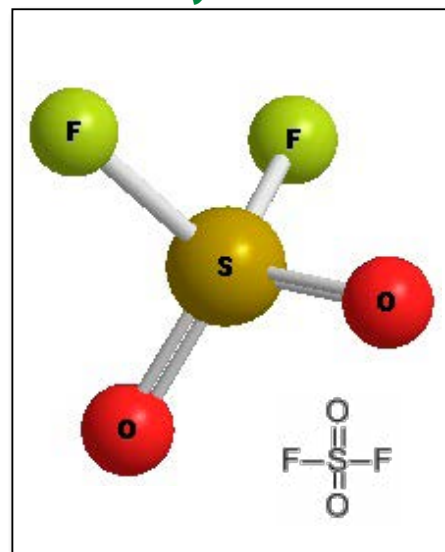
- Sulfuryl fluoride is an insecticide and rodenticide first registered 1959. After complying with current health, safety, and product labeling requirements sulfuryl fluoride was eligible for re-registration in 1993 by the U.S. Environmental Protection Agency (U.S. EPA).¹ See the text box on **Laboratory Testing**.
- 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 of -55.2 °C at 760 mm Hg, and a very high vapor pressure of 17 x 103 kPa at 21 °C (13,000 mm Hg).²
- As a result of the knowledge required to use fumigants appropriately, the U.S. 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

Laboratory Testing: Before pesticides are registered by the U.S. EPA, they must undergo laboratory testing for short-term (acute) and long-term (chronic) health effects. Laboratory animals are purposely given 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.

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.⁹ Mortality may not occur for several days.^{9,10}
- 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

Molecular Structure - Sulfuryl Fluoride



SULFURYL FLUORIDE

TECHNICAL FACT SHEET

What are some products that contain sulfuryl fluoride?

- Vikane®
- Termafume®
- Signal words for products containing sulfuryl fluoride may range from Caution to Danger. The signal word reflects the combined toxicity of the active ingredient and other ingredients in the product. See the pesticide label on the product and refer to the NPIC fact sheets on [Signal Words](#) and [Inert or "Other" Ingredients](#).
- To find a list of products containing sulfuryl fluoride which are registered in your state, visit the website http://npic.orst.edu/reg/state_agencies.html select your state then click on the link for "State Products."

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.^{2,8,11} 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}
- During fumigation, concentrations in single-family homes range from 1440 to 3850 parts per million (ppm).¹³
- Before occupants are allowed back into a treated structure, the U.S. EPA requires that sulfuryl fluoride levels are measured and those levels must be very low.¹⁶ Labels of registered products containing sulfuryl fluoride indicate that those levels must be less than 1 ppm.
- Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to discuss an incident with the National Pesticide Information Center, please call 1-800-858-7378.

What is the toxicity of sulfuryl fluoride?

Animals

- Sulfuryl fluoride is moderately toxic when "fed" to rats and guinea pigs. The acute oral LD₅₀ is 100 milligrams per kilogram of body weight or mg/kg.¹
- Sulfuryl fluoride is highly toxic to rats and mice in short term inhalation studies.¹ See the text boxes on **Toxicity Classification** and **LD₅₀/LC₅₀**.

LD₅₀/LC₅₀: A common measure of acute 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 levels below those that cause death.

SULFURYL FLUORIDE

TECHNICAL FACT SHEET

- In subchronic inhalation studies, researchers exposed rats and rabbits to sulfuryl fluoride six 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 See the text box on **NOAEL, NOEL, LOAEL**, and **LOEL**.
- 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

NOAEL: No Observable Adverse Effect Level
NOEL: No Observed Effect Level
LOAEL: Lowest Observable Adverse Effect Level
LOEL: Lowest Observed Effect Level

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
- Fatalities have occurred when people have entered structures during the fumigation process, or when sulfuryl fluoride had not dissipated to appropriate levels prior to re-entry as required by the product label.^{1,5,20}

TOXICITY CLASSIFICATION - SULFURYL FLUORIDE

	High Toxicity	Moderate Toxicity	Low Toxicity	Very Low Toxicity
Acute Oral LD ₅₀	Up to and including 50 mg/kg (≤ 50 mg/kg)	Greater than 50 through 500 mg/kg (> 50 – 500 mg/kg)	Greater than 500 through 5000 mg/kg (> 500 – 5000 mg/kg)	Greater than 5000 mg/kg (> 5000 mg/kg)
Inhalation LC ₅₀	Up to and including 0.05 mg/L (≤ 0.05 mg/L) (aerosol)	Greater than 0.05 through 0.5 mg/L (>0.05 – 0.5 mg/L)	Greater than 0.5 through 2.0 mg/L (> 0.5 – 2.0 mg/L)	Greater than 2.0 mg/L (> 2.0 mg/L) (dust)
Dermal LD ₅₀	Up to and including 200 mg/kg (≤ 200 mg/kg)	Greater than 200 through 2000 mg/kg (> 200 – 2000 mg/kg)	Greater than 2000 through 5000 mg/kg (>2000 – 5000 mg/kg)	Greater than 5000 mg/kg (> 5000 mg/kg)
Primary Eye Irritation	Corrosive (irreversible destruction of ocular tissue) or corneal involvement or irritation persisting for more than 21 days	Corneal involvement or other eye irritation clearing in 8 – 21 days	Corneal involvement or other eye irritation clearing in 7 days or less	Minimal effects clearing in less than 24 hours
Primary Skin Irritation	Corrosive (tissue destruction into the dermis and/or scarring)	Severe irritation at 72 hours (severe erythema or edema)	Moderate irritation at 72 hours (moderate erythema)	Mild or slight irritation at 72 hours (no irritation or erythema)

The highlighted boxes reflect the values in the “Acute Toxicity” section of this fact sheet. Modeled after the U.S. EPA, Office of Pesticide Programs, Label Review Manual, Chapter 7: Precautionary Labeling. <http://www.epa.gov/oppfead1/labeling/lrm/hap-07.pdf>

SULFURYL FLUORIDE

TECHNICAL FACT SHEET

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 (male - 0, 4, 17, or 130 mg/kg/day; female - 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, the US EPA did not require carcinogenicity tests. Therefore, the U.S. EPA has not classified the potential for sulfuryl fluoride to cause cancer. See the text box on **Cancer**.

Cancer: Government agencies in the United States and abroad have developed programs to evaluate the potential for a chemical to cause cancer. Testing guidelines and classification systems vary. To learn more about the meaning of various cancer classification descriptors listed in this fact sheet, please visit the appropriate reference, or call NPIC.

- 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

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 in the body?

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 six hours a day, five 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}

SULFURYL FLUORIDE

TECHNICAL FACT SHEET

- 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 dissipates in the atmosphere once the gas moves outside the structure during the ventilation process.¹²
- Recent research has demonstrated that sulfuryl fluoride is longer lived than previously believed. Researchers determined that the atmospheric lifetime of sulfuryl fluoride is 30-40 years.²² Between 1978 and 2007, global tropospheric sulfuryl fluoride concentrations rose $5 \pm 1\%$.²²
- Researchers have determined that sulfuryl fluoride has significant potential to contribute to global warming. However, the extent of its global warming potential is uncertain.^{23,24}
- 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.²⁵

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 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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SULFURYL FLUORIDE

TECHNICAL FACT SHEET



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SULFURYL FLUORIDE

TECHNICAL FACT SHEET

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