CHARACTERISTICS AND GLOBAL POTENTIAL OF THE INSECTICIDAL FUMIGANT, SULFURYL FLUORIDE

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Abstract—Global potential of sulfuryl fluoride (SF), SO_2F_2, the active ingredient in Vikane* Gas Fumigant is being reexamined in light of recent regulatory pressures on competitive fumigants. Researchers in Europe and Japan are investigating the utility of SF as an alternative to Methyl Bromide for control of wood-infesting insects in imported lumber and structures. Presently, SF is the primary structural fumigant in the United States of America for eliminating Drywood termites (Kalotermitidae). Wood-infesting beetles such as Anobiidae and Lyctidae and common household pests such as Carpenter ants (*Camponotus* spp.) and cockroaches (Dictyoptera) also are target pests. SF is not an appropriate alternative for some MB uses such as soil and food commodity fumigations. SF is odorless and colorless, has a high vapor pressure and low boiling point, does not react with household items, is only slightly soluble in water. It rapidly desorbs from materials and aerates from structures. SF is highly toxic to both plants and animals. Insect eggs are less susceptible to SF than are the more active larval and adult stages. SF is not considered to be an ozone depletor or to significantly impact any global environmental processes. Lethal dosages are species specific, and for insects, are temperature dependent. Dosages are calculated using the formula: concentration of fumigant x exposure time. Length of exposure and quantity of fumigant introduced into a structure can be varied by the fumigator to satisfy economic and practical considerations.

INTRODUCTION

The global potential of sulfuryl fluoride (SF), SO_2F_2, the active ingredient in VIKANE Gas Fumigant, is being re-examined in response to recent regulatory pressures on methyl bromide (MB). SF is presently used in these insect fumigation market segments:

1) Above-ground termite control; mainly Drywood termites (Kalotermitidae) but including above ground nests of Formosan subterranean termites, *Coptotermes formosanus Shiraki.*
2) Wood-infesting beetles; (Anobiidae, Cerambycidae, Lyctidae, etc.).
3) Household pests; such as Carpenter ants (*Camponotus* spp.); cockroaches, mainly the German cockroach, *Blattella germanica* (L.),

The major use for SF has been Drywood termite control in the southern coastal regions of the USA due to the fumigant's effectiveness, nonreactive characteristics, and manufacturer support. SF has been widely used in the USA in beetle fumigations of expensive art objects and other valuable materials that can be damaged by MB. Also, SF use for control of Drywood termites is growing in the USA and Caribbean Islands where MB and SF have traditionally competed in the Drywood termite market segments. DowElanco is pursuing SF use only in selected markets in which it provides unique benefits to the fumigator. SF is not an appropriate alternative for some MB uses such as soil and food commodity fumigations.

Stimulated by the present regulatory pressure to reduce MB use in markets where alternative fumigants are available, fumigators are investigating the use of SF to control wood infesting beetles in structures in Europe, and in imported lumber in Japan. MB has been the dominant fumigant in these market segments due to its greater toxicity to beetle eggs.

Fumigation with SF requires a professional attitude and thorough education. DowElanco is enforcing a strict product stewardship policy to augment the training and certification required by government regulatory agencies. SF, like any fumigant, has unique hazards that require full understanding and proper execution of application and safety measures to ensure insect control with minimal hazard to fumigators and the public.

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History of sulfuryl fluoride

In the 1950's, The Dow Chemical Company developed SF to meet the structural fumigator's need for a fumigant that did not cause mercaptan odors, was not flammable, and rapidly aerated from structures. Several early scientific papers describe the research to develop this product and initially define its characteristics and efficacy (Kenaga, 1957, Meikle et al., 1963, Stewart, 1957, Stewart, 1966).

SF was first marketed by The Dow Chemical Company in 1961 in the USA for structural insect control. The Dow Chemical Co. and now DowElanco have been the only marketers of SF.

SF has never been used for soil or stored grain fumigations due to limited efficacy, cost competitiveness of other fumigants, and the potential for residues. DowElanco is not pursuing any registrations for these uses.

Sulfuryl fluoride characteristics

SF is an inorganic chemical composed of 99% SO_2F_2 and 1% inert ingredients (DowElanco, 1992a). SF is inorganic, and is essentially nonreactive with materials generally found in structures. SF is not combustible and has no flash point, but in temperatures exceeding 400°C (752°F) SF will degrade to form hydrogen fluoride (HF) and sulfur dioxide. These chemicals, when combined with water vapor, can form weak acids that can tarnish smooth surfaces such as metal, glass, and ceramics.

SF is odorless and colorless and thus small quantities of chloropicrin are generally introduced into the fumigant atmosphere to warn humans and animals of potential hazard (DowElanco, 1992a). A slight sulfur odor may be detected at high SF concentrations due to inert ingredients.

The vapor density of SF is 3.52, but SF will remain in equilibrium once it is mixed with the ambient air (DowElanco, 1992a). SF has a vapor pressure of 13,442 mm Hg at 25°C (77°F)(MB = 1,610 mm Hg). SF rapidly reaches equilibrium in the fumigant atmosphere and rapidly aerates from structures. SF has a boiling point of −55.2°C (−67°F) at 760 mm Hg, and thus is a gas under all practical fumigation conditions. SF is relatively insoluble in water, 750 ppm at 25°C and 1 ATM (DowElanco, 1992a).

SF is packaged only in steel cylinders 4 feet long and 10 inches in diameter. Each cylinder contains 125 lbs. of SF as a liquid under pressure.

Environment fate

When SF is aerated from a structure it rapidly dissipates into the atmosphere because of its high vapor pressure. SF is broken down mainly through hydrolysis in water to release fluoride and fluorosulfate ions. Ultraviolet radiation and reaction with solid particles in the atmosphere may also catalyze the breakdown of SF (Bailey, 1992).

The relatively small amounts of SF released are calculated to have virtually no impact on the global atmosphere and environment. SF is fully oxidized and thus will not interact with ozone. The relative contribution of SF to acid rain is infinitely small compared to the massive amount of sulfur released into the atmosphere from industry (Bailey, 1992).

Toxicity

Inhalation Toxicity

Inhalation is the critical route of exposure to SF. The acute inhalation hazard of SF is shown below (DowElanco, 1992b).

	Acute Inhalation (Rats)	
Gender	*Exposure time (hr)*	*LC_{50} (ppm)*
Male	4	1122
Female	4	991
Male	1	3730
Female	1	3021