Dow AgroSciences

General Information On Vikane Gas Fumigant

INTRODUCTION

Drywood termites and other wood-destroying insects can cause significant damage as they feed on materials containing cellulose found in structures, such as wood, paper, textiles, furnishings, and works of art. Because these insects live most of their life cycle within their food source, the exact distribution and extent of infestation is often difficult to determine. Therefore, localized treatments using physical methods or conventional insecticides may not eradicate all wood-destroying insects infesting a structure. To solve this problem The Dow Chemical Company developed sulfuryl fluoride, the active ingredient of Vikane* gas fumigant, to be used exclusively by professional fumigators (DowElanco 1992).†

Research conducted during the development of sulfuryl fluoride demonstrated that this fumigant possesses highly desirable characteristics for the eradication of structure-infesting insects (Derrick et al. 1990). Sulfuryl fluoride is nonflammable, non-corrosive, and does not cause undesirable odors. It quickly penetrates structural materials, is effective against a variety of structural pests, and dissipates rapidly during aeration (Kenaga 1957; Stewart 1957). Since first marketed as Vikane in 1961, sulfuryl fluoride has been used to fumigate more than one million buildings, including museums; historical landmarks, such as the Hearst Castle in California (Pest Control 1977) and the Flagler Museum in Florida (Moon 1981), rare book libraries, government archives, scientific and medical research laboratories, and food-handling facilities.

EFFICACY

Vikane has been demonstrated to reduce oxygen uptake in insect eggs (Outram 1970). Vikane also prevents insects from metabolizing the stored fats they need to maintain a sufficient source of energy for survival by disrupting the glycolysis cycle (Meikle et al. 1963). This metabolic imbalance may delay mortality of insects for several days or more following fumigation (Osbrink et al. 1987). For this reason, insects that have received a lethal exposure to Vikane may still be alive immediately following fumigation.

The activity of Vikane depends on the concentration reaching the target pest and the duration of exposure. Therefore, the dosage of Vikane required for a specific target pest is calculated in "ounce-hours," ounces of Vikane multiplied by hours of exposure. Insect eggs require a higher ounce-hour dosage of Vikane compared to later life stages. Control of the egg stage of social insects, such as termites and ants, is not necessary because newly hatched termites and ants cannot survive without adult care.

Higher dosages required to control eggs of insects, such as wood-boring beetles, can be obtained by increasing the exposure time, increasing the concentration of Vikane, or a combination of both. Fumigators use the Fumiguide* calculation system, which was developed specifically for Vikane, to determine the amount of Vikane required for specific pests and fumigation conditions.

Vikane has also been successfully used since 1961 to control a wide variety of household pests, including cockroaches, clothes moths, rodents, bedbugs and carpet beetles. The eradication of eggs of carpet beetles requires very high dosages of Vikane (Su and Scheffrahn 1990) which are not economically practical. Therefore, two fumigations are required to eradicate carpet beetles using Vikane. The second fumigation is conducted after all beetle larvae have hatched from eggs surviving the first fumigation.

FORMULATION AND PROPERTIES

Sulfuryl fluoride, the active ingredient of Vikane, is a gas at temperatures above -67°F. Vikane is packaged in white cylinders as a liquid under pressure, containing 99.5% sulfuryl fluoride with no other pesticides, solvents or additives. Vikane has a high vapor pressure; it evaporates 20,000 times more readily than mothballs and therefore disperses rapidly from structures.

Vikane does not react with common household furnishings. This is why fumigation with Vikane is an established method used to eradicate pests infesting delicate and rare biological and historical museum artifacts. Food must be protected from exposure to Vikane during fumigation because no residue tolerances have been set for any food product (see PREPARATION). Vikane does not form toxic surface residues in household items, and thus dishes, clothes, and other items do not need to be washed following fumigation with Vikane.

Watering soil around exterior perimeter building foundations is recommended to reduce both loss of fumigant through the soil and exposure of plant roots to Vikane during fumigation. The solubility of sulfuryl fluoride in water is very low, 0.075% by weight at 77°F (Meikle and Stewart 1962).

Vikane is nonflammable and relatively stable; however, it will react to form hydrogen fluoride at extremely high temperatures exceeding 752°F. This acid can etch metals, glass, ceramic tile, or china near the heat source. Thus, prior to structural fumigation, all open flames and glowing heat filaments are turned off or disconnected.

Vikane is odorless at concentrations used to fumigate structures and is not irritating as a gas to the eyes or skin. For these reasons, a trace amount of the warning agent, chloropicrin, is introduced in the structure prior to fumigation to warn people and animals that the structure is being fumigated. Chloropicrin acts as a warning by causing irritation of the eyes, tears, discomfort, and has a noticeable disagreeable pungent odor even at very low concentrations, less than 1 part per million (ppm).

Chloropicrin diffuses from structures more slowly than Vikane. Thus, occupants may experience some eye irritation after all of the Vikane has aerated from the structure. The fumigator should be contacted to take remedial measures if this occurs. A trained fumigator will use an approved clearance device, such as an Interscan[1] or Miran[2], to determine that the concentration of Vikane within the structure is 5 ppm or less prior to allowing anyone to reoccupy the structure.

†DowElanco is now known as Dow AgroSciences LLC

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FUMIGATION PREPARATION

The label for Vikane requires that the following preparations be completed prior to releasing the fumigant into the structure.

1. All animals (including fish) and plants must be removed from the structure to be fumigated.
2. Mattresses and pillows completely enveloped in water-proof covers (not including waterbeds) must be removed from the area to be fumigated if the covers can not be removed. The water-proof covers restrict dispersion of fumigant during aeration.
3. All flames such as pilot lights and electric heating elements must be turned off for reasons previously described[3].
4. The following should be opened prior to fumigation: internal doors, internal openings to attics and sub-areas, storage chests, cabinets, drawers, closets, and appliances such as washers, dryers and ovens. In tarpaulin fumigations, operable windows are opened. These procedures assist in rapid dispersion of Vikane during fumigation and aeration.
5. Food, feed, drugs and medicinals, including items in refrigerators and freezers, must be removed from the fumigation site or sealed in highly resistant containers such as glass, metal or plastic or enclosed in special bags according to label directions.

   This is required because exposure of unprotected foodstuffs to Vikane may result in the formation of temporary sulfuryl fluoride residues and permanent fluoride residues. However, experimental exposure of food commodities protected in two nylon bags to 10x dosages of Vikane resulted in no detectable sulfuryl fluoride or added fluoride residues. Two nylon bags reduced the exposure of protected foodstuffs to Vikane by 99.99% (Scheffrahn et al. 1990). Excessive exposure to fluoride can have toxicologically significant effects, although longterm human intake of water containing up to 1 mg/l (1 ppm) fluoride is generally considered not to result in adverse effects. (National Research Council 1977).

DOSAGE DETERMINATION

Because of a multitude of structural, environmental, and fumigation variations, there are no two fumigation jobs that are identical. The required dosage of Vikane is influenced by the temperature at the site of the pest, the length of the exposure period and the susceptibility of the pest to be controlled. Consequently, the dosages vary, but the typical single family home fumigation involves the use of 6-16 ounces/1000 cubic ft (1440-3850 ppm). The length of the exposure period is critical to accumulate sufficient ounce-hours[4] required for the temperature at the site of the pest. The ounce-hours required to control target insect pests have been determined from laboratory and field testing.

RELEASING VIKANE

Five to ten minutes prior to introducing Vikane into the structure, the fumigator will place a warning agent, chloropicrin, in the structure. This warning agent is required to warn any person or animal that may have entered the structure after the final inspection by the fumigator. Once the building is determined to be cleared of all people and animals, the fumigator will release the Vikane into the structure.

Vikane is packaged in 125 lb. cylinders that fumigators transport on their vehicles. The fumigator introduces Vikane through tubing into the air stream of a fan that helps disperse the fumigant throughout the structure. Once the appropriate amount of Vikane is introduced, the fumigator turns off the cylinder valve and removes the tubing from the cylinder.

FUMIGATION PERIOD

Vikane is usually held in the structure for approximately 16-30 hours. Fumigation time is dependent upon the factors mentioned previously[5]. When the fumigation exposure period is complete, the fumigator will return to the structure to conduct the aeration procedure.

AERATION

Aeration is the final step of a fumigation. Aeration involves proper ventilation and clearance of Vikane and the warning agent, chloropicrin, from a structure.

The Occupational, Safety & Health Administration (OSHA) established a Permissible Exposure Level (PEL) of 5 parts per million (ppm) for Vikane. A PEL is the Time Weighted Average (TWA) exposure to which it is believed that most members of a healthy working population can be exposed 40 hours/week for a working lifetime.

The fumigator must aerate a structure so that the concentration of Vikane in the air is 5 ppm or less prior to allowing reentry. This 5 ppm PEL is substantially lower than the level that may affect people and pets following even long-term exposure.

Unlike liquid and solid insecticides, Vikane is a gas possessing a very high vapor pressure (potential to escape from an area) and low boiling point (it is a gas above -67°F). During aeration of the fumigated structure, Vikane will quickly diffuse from high concentrations within a structure to the outside air where it rapidly dissipates to nondetectable levels.

Degassing is the process of fumigant diffusing out of materials when the concentration of gas is less around the object than within the object. Required aeration procedures allow the fumigant time to diffuse from structural voids and household materials and be ventilated out of the structure. The fumigator will use powerful fans and open cabinets, doors, and windows to speed the process of aeration.

Many structures have been tested by university researchers and DowElanco[†] scientists with the goal of developing new aeration procedures. The aeration procedures have been vigorously tested to ensure that even under poor ventilation conditions concentrations of Vikane will not increase after occupants return.

Only specially trained and state-licensed/certified professionals can determine that a structure can be reoccupied. Unique equipment, such as the Interscan and Miran, must be used to test the concentrations of Vikane within structures. The Interscan is specially designed to detect levels of Vikane down to 1 ppm.

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ENVIRONMENT

When Vikane is aerated from a structure it rapidly dissipates into the atmosphere because of its high vapor pressure. Vikane is broken down mainly through hydrolysis to release fluoride and fluorosulphate ions. Ultraviolet radiation and reactions with solid particles in the atmosphere may also catalyze the breakdown of Vikane.

The relatively small amounts of Vikane released are calculated to have virtually no impact on global atmosphere/environment. Sulfuryl fluoride is fully oxidized, and thus is not expected to interact or contribute to local ozone formation (such as Los Angeles smog) because of its low reactivity in the atmosphere. The relative contribution of Vikane to acid rain is infinitely small compared to the massive amount of sulfur released into the atmosphere from industry. Vikane contains no chlorine or bromine and thus can not react to deplete stratospheric ozone by the known mechanisms (Bailey 1992).

VIKANE

Mode of Action, Symptoms of Overexposure

The severity of toxicological effects is dependent on the exposure concentration and exposure duration. The mode of action by which Vikane produces its toxicity in humans depends on the exposure concentration. In general, the effects of overexposure to high concentrations are central nervous system depression and respiratory irritation followed by pulmonary edema, which is the accumulation of fluids in the lungs and can result in death. Humans exposed to high concentrations of Vikane may expect to experience symptoms similar to drunkenness. Speech and movements may be slowed, and fingers, hands, and toes may become numb.

Animal studies may indicate that some sulfuryl fluoride is converted to fluoride ion in the body. Chronic exposure may result in fluoride binding to the teeth and bones, causing fluorosis, which is manifested as mottled teeth.

Applicators who work with Vikane can have their urine checked for fluoride. However, high fluoride levels in the urine could be due to chemicals other than sulfuryl fluoride, for example, fluorides in drinking water, fluorinated tooth paste, and some medicines.

Time to Incapacitation

Another factor to be considered in the safe use of Vikane is the length of time in which a person might have "escape capability" during exposure to high levels of Vikane. Researchers have investigated this by determining the length of time that rats are able to maintain coordinated activity when exposed to very high concentrations of Vikane. The time to incapacitation of laboratory rats for various exposure concentrations were (Nitschke et al. 1986):

42 minutes at 4,000 ppm
16 minutes at 10,000 ppm
10 minutes at 20,000 ppm
6 minutes at 40,000 ppm

Exposures were terminated when incapacitation occurred. All rats died or were moribund within 3 hours following the end of exposure. Therefore, the above exposures can be considered to produce 100% mortality in rats. For comparison, typical initial concentrations in single family homes are 1440-3850 ppm and must be reduced to 5 ppm or less before humans can enter dwellings without respiratory protection.

[1] Manufactured by Interscan Corporation, Chatsworth, CA 91311

[2] Manufactured by The Foxboro Company, East Bridgewater, MA 02333

[3] See the section on FORMULATION AND PROPERTIES

[4] See the section on EFFICACY

[5] See the section on Vikane FUMIGANT DOSAGE DETERMINATION

Repeated Exposure Toxicity Studies

Rats, rabbits, and dogs have been studied following daily repeated exposures to Vikane. Exposures of 30 ppm 6 hours/day, 5 days/week for 13 weeks had no effects on rats or rabbits, while dogs showed no effects from 100 ppm in a similar exposure regimen. Rats exposed to 300 ppm had decreased body weights, mottled teeth, and microscopic evidence of brain and kidney injury and respiratory irritation. Rabbits exposed to 100 or 300 ppm showed decreased body weights and microscopic changes in brain and nasal tissues. Dogs exposed to 200 ppm showed nervous system effects, including microscopic changes in the brain.

Studies For Effects On Reproduction And Development Of Offspring

The results of the studies described here indicate that Vikane is not likely to have any effects on reproduction or development of offspring. Groups of pregnant rats and rabbits were exposed to Vikane at three different concentrations: 25, 75, or 225 ppm for 6 hours/day during the majority of the gestation period. Although the highest level of 225 ppm was toxic to the maternal animals (as would be expected), there was no evidence that Vikane was teratogenic (causing birth defects in offspring of exposed females). The only effects on the fetus were reduced body weights in the rabbits at the highest level, probably associated with the maternal weight loss. In a reproduction study, male and female rats were exposed to concentrations of 5, 20, or 150 ppm throughout two generations.

The highest level of 150 ppm was toxic to the parent animals, producing effects similar to those seen in the 13-week study described in the preceding section. Parent animals exposed to 5 ppm were without evidence of effects. Decreased weights of the offspring were observed at 150 ppm that may have been secondary to decreased maternal growth. The only effect observed at 20 ppm was mild lung irritation in parental rats, with no evidence of toxicity in offspring. There were no effects on reproductive performance in any exposure group.

Carcinogenicity And Mutagenicity Studies

Vikane has been tested in a battery of mutagenicity tests that serve as a screen for identifying chemicals that affect genetic mechanisms. All test results have been negative, indicating that Vikane is not mutagenic in standard testing. Lifetime studies in which rats and mice were exposed to Vikane to assess whether or not the chemical has potential to cause cancer were also negative.

Neurological Effects

Rats exposed for 6 hours a day for 2 days to 100 ppm and 300 ppm showed no signs of neurotoxicity.

Other Routes Of Exposure To Vikane

Inhalation is the primary route of exposure to Vikane. Ingestion is highly unlikely since the material is a gas at temperatures higher than -67°F. Laboratory animals maintained for 66 days on feed directly fumigated at 2 lb/1000 cubic ft (7700 ppm) showed no adverse effects. Typical structural fumigation concentrations are 1 lb/1000 cubic ft (3850 ppm) or less. Feed exposed to abnormally high application rates (10-200 lb/1000 cubic ft; 38,500 to 770,000 ppm) and fed to test animals caused decreased body weight gains and fluorosis of the teeth. The gas is not absorbed through the skin in acutely toxic amounts; rats exposed dermally for 4 hours to concentrations of 9599 ppm did not show evidence of toxicity.

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