Vikane* and its Use as a Fumigant for Artifacts in Europe

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Introduction

During the last few decades Methyl bromide has been used to eradicate pests in artifacts in museums and churches. However, it is an ozone depletor and will be banned in the future. Stimulated by the need to identify alternatives to Methyl bromide we investigated Vikane* as a substitute to control wood infesting beetles in structures in Europe. This article describes the progress of our research and new developments in Vikane fumigations in museums and churches.

History of Sulfuryl fluoride

The Dow Chemical Company patented Sulfuryl fluoride (=SF) in 1957 to meet the market needs for a fumigant that did not cause rotten egg smell, was inflammable and rapidly aerated from structures without leaving residues (Kenaga, 1957). It was initially marketed in 1961 under the tradename “Vikane”. The primary target market is structure fumigation to control Drywood termites and other wood infesting insects. Recently, Dow AgroSciences has been developing SF for food commodity and mill fumigation. Vikane is currently used in the USA, Europe, Caribbean Islands and Japan.

*Trademark of Dow AgroSciences

Sulfuryl fluoride Characteristics

SF is an inflammable, noncombustible, odorless and colorless inorganic compound composed of 99.8% SO_2F_2 and 0.2% impurities. These impurities, like Hydrogen fluoride (HF) and Sulfur dioxide (SO_2) may affect certain sensitive surfaces and tarnish metals under some environmental conditions and very high rates of fumigant introduction. Purified SF is essentially nonreactive with materials generally found in museums and churches. An on-site purification system was developed by Binker.

Fig. 1 Vikane is released from steel cylinders

Vikane is packaged in white steel cylinders containing 56.7 kg or 125 lbs of SF as a liquid under pressure.

The relative vapor density of SF is 3.52 and the vapor pressure is 18.2 bar at 26.9 ^{o}C. SF is relatively insoluble in water (750 ppm @ 25 ^{o}C), rapidly aerates from fumigated structures and objects leaving no breakdown residues. SF is broken down in the atmosphere through hydrolysis in water. Fluoride and Fluorosulfate are formed. The breakdown is catalyzed by ultraviolet radiation and reactions with solid particles (Bailey, 1992). SF contains fully oxidized sulfur and thus will not react with ozone. The relative contribution of SF to acid rain and the impact on the environment are infinitely small.

Toxicity and Efficacy

SF causes no teratological and genotoxicological effects. Laboratory studies have demonstrated no effects on reproductive or fertility indices and no ill effects in animals through dermal exposure. Inhalation is the critical route of exposure to SF. The acute inhalation hazard of SF is: LC_{50} 991 ppm female rats and 1122 ppm male rats (4 hrs exposure time). The Permissible Exposure Limit (PEL) for SF is 5 ppm. There is no known antidote for SF (Schneider, 1993).

SF kills insects by disrupting the glycolysis cycle, depriving the insect of necessary metabolic cell energy. Sometimes a delayed mortality is observed. The efficacy of SF is mainly governed by 1) temperature at the insect site, 2) the initial concentration of SF, 3) SF loss rate and 4) exposure time. The required dosage and the initial concentration of SF are calculated by Binker Materialschutz in Germany using a computer calculator system called Altarion® Dosy, whereas other fumigators use the Dow AgroSciences Fumiguide* Calculator. Both indicate the proper amount of Vikane to minimize fumigant costs while achieving successful pest eradication. The active life stages of insect pests, larval, pupal, and adult stages, are more susceptible to SF than the egg stage. The egg stage of some insects, for example carpet beetles, may require 10x or more the drywood termite dosage to achieve 100% control.

Fig. 2 Tarping of a woodborer-infested castle using a form fitting tarpaulin

Sealing and Pressure Testing

The quality of the seal has a great influence on the effectivity of the fumigation. There are two main approaches to the challenges of confining SF:

1. Tarps: The structure is covered with a tarpaulin which envelopes all components susceptible to pest infestation. Experience has shown that Laminated Polyethylene

or PVC-coated materials are able to adequately confine Vikane gas fumigant. However, it is difficult to tarp large and steep structures like churches.

2. "Tape and Seal"-Techniques: Most of the Vikane church fumigations in Europe are carried out using this technique. Buildings are sealed by poly-sheeting and tapeing the cracks at windows, doors and other small openings with paper strips and adhesives.

Fig. 3 “Tape and Seal”-Technique: windows of a church are sealed with poly sheeting

The quality of the sealing is checked prior to fumigation by pressure testing. In this test, a pressure difference between the interior and exterior of the structure is generated by using a fan. When a pressure difference is changed to +/-20 Pascal (Pa) the fan opening is sealed. The pressure difference is allowed to fall by natural leakage to +/-10 Pa. The time to fall from +/-

20 to +/-10 Pa is then a measure of the degree of sealing. If the structure fails the test it is necessary to improve sealing and search for leaks.

Fig. 4 Set up for the Pressure Test of a church

In large structures air-inflated balloons are installed to minimize the fumigation volume in order to save fumigant. Stationary cultural property can be fumigated by compartment fumigations. For this, objects like altars or pulpits are covered in foil sheeting and sealed to floor and/or wall sections.

Fig. 5 Air inflated balloons help to save Vikane fumigant

Shooting and Monitoring

Binker Materialschutz releases SF from cylinders and passes it through a patented filtering system, called Viklean® System, which removes the acid impurities like Hydrogen fluoride and Sulfur dioxide to zero. Highly purified Vikane is introduced into the structure as another precaution Binker Materialschutz takes to help avoid altering or tarnishing surfaces of artifacts such as highly sensitive pipe organs. Also no warning agent, such as chloropicrin is introduced into the churches in order to avoid altering the artifacts.

The introduction rate of Vikane is controlled largely by the inside diameter and by the length of the suitable leakproof shooting hose. Vikane is introduced in a manner to achieve rapid equilibrium, avoid excessive loss due to stratification and with safety to the fumigator and materials. Usually this can be accomplished by directing the SF outlet into the air stream of a powerful fan. Continuous circulation by fans offers assurance that the fumigant is evenly distributed during the exposure period.

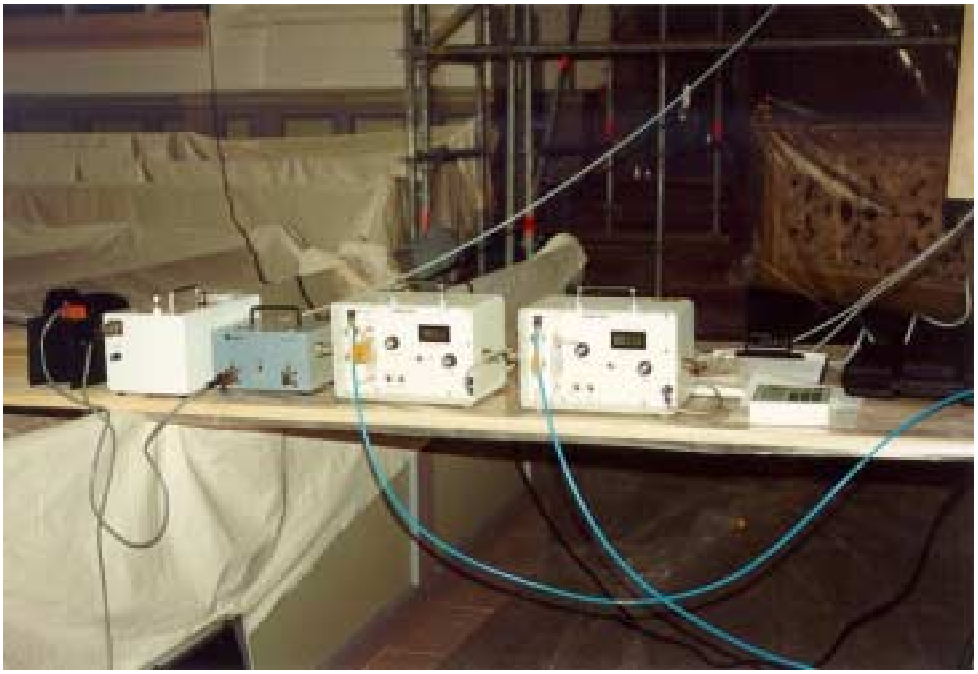

Fig. 6 Fumiscopes are measuring the Vikane concentration

It is a general practice of Binker Materialschutz to monitor all Vikane- fumigations to insure efficiency of the fumigation and achieve 100% mortality of the target insects. The measurements are made by an air pump equipped thermal conductivity unit, called the Fumiscope® via monitoring lines running into the open space of the structure. The instrument has to be calibrated for accuracy. The readings are transferred to a computer (Dosy software) calculating the actual half-loss time, additional amounts of Vikane for topping up the fumigant concentration if necessary and the current accumulated ct-product. It also allows for the determination of the exact aeration time and the estimation of the final concentration remaining in the structure for aeration.

Aeration

When the required ct product is accumulated, assuming all target pests are eradicated, aeration is carried out. When first preparing the fumigation the aeration period is planned and steps are taken to aid in aeration by strategic placement of fans and aeration vents. An optimum seal may require the removal, by aeration, of high remnant concentrations of SF.

Fig. 7 Recapture of Vikane using a mobile filter unit

The aeration procedure must not allow the SF concentration to exceed the allowable SF concentration limit (= MIK limit = 1 ppm) near dwelling houses outside of fumigated structures for Germany. Thus, for SF aeration, we have developed a modified aeration procedure to ensure the German Sulfuryl fluoride-MIK-value is not exceeded. We use a fan and ducting with a valve to aerate SF from the structure following fumigation. The ducting is raised by scaffolding or placement through the steeple to serve as a chimney, venting fumigant where it will diffuse distant from adjacent structures. During aeration periods with no wind the valve attached to the fan can be shut or ventilation rate controlled by a throttle valve. In doing so the vacuum or flow rate is adjusted to the exhaust height.

Recently, Binker Materialschutz has been working on a prototype filtering system to remove SF from air during aeration to minimize atmospheric emissions. Although SF is not classified as an ozone depletor and does not present any appreciable risk to the atmospheric environment, removing atmospheric contaminants is now very common in Europe. A second benefit of a filtering system is to reduce or eliminate non-target exposure during aeration. A developed, large scale filtration system is able to remove significant amounts of SF from the air being exhausted from the structure.

Clearance

The low sorption and non-reactivity of Vikane gas fumigant with structural components and artifacts are extremely favorable properties for rapid aeration.

Fig. 8 Detection of Vikane traces for clearance of a fumigation bubble

Most of the Vikane will be aerated during the initial part of the aeration period in response to the lower concentration inside the structure when the aeration fan is switched on. Research has shown, however, that fumigant aeration must usually be extended to allow for diffusion of the fumigant from the structure and its furnishing, interior objects, artifacts etc. as well as diffuse from internal voids, such as wall voids. Aeration continues until the fumigant has aerated from throughout the structure, which generally takes a few additional hours. At the conclusion of the aeration period, the structure must be tested with an approved detection device of sufficient sensitivity, such as a Miran or Vikane monitor, to confirm in Germany a concentration of

Vikane of 1 ppm or less in the breathing zone. The structure is still considered under fumigation and appropriate precautions are to be taken until the final clearance is obtained.

Summary

Binker Materialschutz has developed an enhanced application and monitoring system for SF which has proven to be effective in controlling insect pests infesting valuable and sensitive cultural property without damaging these materials. Dow AgroSciences' strong product stewardship policy, careful sealing checked by pressure testing prior to fumigation, and concentration monitoring and fumigant scrubbing methods during aeration ensure a high standard of safety and an outstanding reputation of Vikane. As the ozone depletor Methyl bromide is phased out of this market segment, further developments of sophisticated SF fumigation procedures are expected.

Literature

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