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Vikane® and its use as a fumigant for artefacts in Europe

Abstract - Stimulated by regulatory pressure we investigated Vikane as a fumigant to control wood infesting beetles in structures and museum pests in museums in Europe. This article describes the progress of our research and new developments in Vikane fumigations in museums and churches. The required dosage and the initial concentration of Sulfuryl difluoride = SF are calculated by a computer calculator system. The SF is released from cylinders and passed through a patented filtering system, which removes the acid impurities almost to zero to make sure not to alter or tarnish materials and surfaces of artefacts. When the required ct-product is accumulated, assuming all target pests are eradicated, aeration is carried out. A filtering system was developed to remove SF from air during aeration to minimize atmospheric emissions. The low sorption and non-reactivity of Vikane gas fumigant with structural components and artefacts are extremely favourable properties for rapid aeration.

Key words: fumigant, museum pests, Sulfuryl difluoride, woodborers.

INTRODUCTION

During the last few decades Methyl bromide (=MB) and Hydrogen Cyanide (=HCN) have been used to eradicate pests in artefacts in museums and churches. However, MB is an ozone depletor and is banned in Europe. HCN is too reactive and can cause damage to the fumigated materials. Stimulated by the need to identify alternatives we investigated Vikane* (*Trademark of Dow AgroSciences, active ingredient Sulfuryl difluoride) as a substitute to control wood infesting beetles in structures and museum pests in museums in Europe. This article describes the progress of our research and new developments in Vikane fumigations in museums and churches.

MATERIALS AND METHODS

SF is an inflammable, non-combustible, odourless and colourless 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. Vikane is packaged in steel cylinders containing 56.7 kg or 125 lbs of SF as a liquid under pressure.

The relative vapour density of SF is 3.52 and the vapour pressure is 18.2 bar at 26.9°C. SF is relatively insoluble in water (750 ppm/ 25°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. 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 (MAK or now AGW) for SF is 2.5 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.

Fig. 1 - Tarping of a woodborer-infested structure (40000 m3) using a form fitting tarpaulin.

Sometimes a delayed mortality is observed.

RESULTS

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 calculator. It indicates 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. The quality of the seal has a great influence on the effectiveness of the fumigation. There are two main approaches to the challenges of confining SF (Figs 1 and 2):

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 taping the cracks at windows, doors and other small openings with paper strips and adhesives.

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. In large structures air-inflated balloons are installed to minimize the fumigation volume in order to save fumigant (Fig. 3). 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. The fumigant SF is released from cylinders and passed through a patented filtering system, called Viklean® System, which removes the acid impurities like Hydrogen fluoride and Sulfur dioxide almost to zero. Highly purified Vikane is introduced into the structure as another precaution we take to help avoid altering or tarnishing surfaces of artefacts such as highly sensitive pipe organs. Also no warning agent, such as chloropicrin is introduced into the churches in order to avoid altering the artefacts. The introduction rate of Vikane is controlled largely by the inside diameter and by the length of the suitable leak-proof 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. It is our general practice to monitor all Vikane-fumigations to insure efficiency

Fig. 2 - “Tape and Seal”-Technique: windows of a church are sealed with poly sheeting.

Fig. 3 - Air inflated balloons help to save Vikane fumigant.

of the fumigation and achieve 100% mortality of the target insects. The measurements are made by an air pump equipped infrared unit, called the PROcheck Gas Monitor 2240 (http://www.ppm-mt.com) 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. 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. 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 fumiga-

Fig. 4 - Recapture of Vikane using a mobile filter unit.

tion. 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. We also have been working on a prototype filtering system to remove SF from air during aeration to minimize atmospheric emissions (Fig 4). 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. The low sorption and non-reactivity of Vikane gas fumigant with structural components and artefacts are extremely favourable properties for rapid aeration. 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, artefacts etc. as well as to 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 the CLEARcheck 2240 (http://www.ppm-mt.com), 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.

DISCUSSION AND CONCLUSION

We have 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 market for fumigations is increasing further developments of sophisticated SF fumigation procedures are expected.

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