DOUGLAS PRODUCTS

ProFume®

COMPARISON OF PROFUME® FUMIGANT (SULFURYL FLUORIDE) AND HYDROGEN CYANIDE FOR STORED PRODUCT PEST CONTROL

FUMIGANT

Hydrogen cyanide was used extensively as a fumigant from about 1886 through the early 1900's. Its usage declined in part due to the advent of newer fumigants that were easier to use, most notably methyl bromide. Much of our understanding of its use as a fumigant comes from research conducted prior to 1950. Currently hydrogen cyanide is being marketed commercially in Europe for fumigation purposes under the tradename of BLUEFUME® (trademark of Draslovka). The following chart provides a comparison between ProFume® fumigant and hydrogen cyanide for desirable attributes for fumigants.

Attribute	ProFume® fumigant (99.8% sulfuryl fluoride)	Hydrogen Cyanide (HCN)
Concentration x time (CT) dosages established for a broad range of key pests	**Yes.** Extensive laboratory efficacy studies have been conducted in cooperation with the USDA-ARS, DFA of California, Food and Environmental Research Agency in the UK, Julius Kuehn Institute in Germany, the University of Milan in Italy, and Laboratoire National des Denrées Stockées in France to define the dosages required to control all the life stages of target pests under a range of fumigation conditions (Thoms et al. 2008). These studies, such as Bell et al. 2003; Drinkall et al. 2003; Ducom et al. 2003; Reichmuth et al. 2003; Thoms and Scheffrahn 1999, confirmed the effectiveness of sulfuryl fluoride on all life stages of a wide range of postharvest insect pests.	**No.** Data on the efficacy of HCN as a fumigant is outdated and cannot be correlated with the present concept of the CT dosage (Aulicky et al. 2015; Rambeau et al. 2000).
Calculation tool is used to accurately determine and verify the dosage required to control target pest(s)	**Yes.** Data from extensive research has been used to develop the dosage calculations for the Fumiguide™ program. The Fumiguide integrates factors such as target pest, temperature, half loss time (HLT) and exposure period to accurately determine the fumigant dose and accumulated concentration x time (CT) dosage required for the space or commodity. When monitoring data is entered into the Fumiguide, the program will calculate the actual HLT and accumulated CT dosage, predict the CT dosage outcome for the planned exposure period, and update instructions on exposure time ("on target", "shorten" or "lengthen") and fumigant concentration ("on target" or "add more") (Thoms et al. 2008).	**No** dosage calculation tool is available for HCN.
Documented pest resistance	**No** documented resistance to sulfuryl fluoride of field strains of stored product insects has been observed. In addition, sulfuryl fluoride effectively controls stored product insects resistant to phosphine (Bell et al. 2003; Jagadeesan et al. 2015; Opit et al. 2016; Nayak et al. 2016).	HCN resistance in agricultural insects is well documented and could develop in stored product insects. Historically, 1.7 to 3-fold higher dosage of HCN was required to control field-collected compared to laboratory strains of stored product insects (Gough 1939; Lindgren and Vincent 1965). Recently, a 4-fold higher dosage of HCN was required to control a field strain of confused flour beetle from a flour mill where HCN had been repeatedly used compared to that of the lab strain (Aulicky et al. 2015).
Low water solubility	**Yes.**	**No.** High water solubility can result in sorption to commodities (FAO 1965).
Flammable or combustible	**No.**	**Yes.** Flammable at 6% by volume (FAO 1965).
Penetrates deeply into commodities	**Yes.** Research has verified sulfuryl fluoride penetration through 30 cm of flour (Bell et al. 2003) and through 2 cm flour deposits to kill all life stages of red flour beetles (Hartzer et al. 2010).	**Variable.** Penetration affected by grain moisture content, temperature, and dockage (presence of weed seeds, stems, chaff) (Kunz et al. 1964).
Has PPP and biocide registrations in EU	**Yes.**	**No.** Does not have PPP registration.
Dermal absorption as a route of human exposure	**No.**	**Yes.** Dermal absorption may be significant through open wounds and moist skin (Böye and Mück 2011, 2017) and when airborne concentrations are very high during fumigation operations (Simeonova and Fishbein 2004).
Toxicology data up to date	**Yes.** More than $5 million spent in last 10 years to update toxicology data specific to sulfuryl fluoride for current registration reviews in EU and the United States.	Toxicology data based primarily on cyanide research and not specifically on hydrogen cyanide. Not registered in the United States.

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Attribute	ProFume® fumigant (99.8% sulfuryl fluoride)	Hydrogen Cyanide (HCN)
Antidote available	**No.**	**Yes.** Requires amyl nitrate (inhaled), sodium nitrate (IV), and sodium thiosulfate (IV).
Adverse effects on food commodities	**No.** (Thoms et al. 2008).	Cereal grains take up hydrogen cyanide during fumigation and small amounts of gas remain associated with the grains for long periods. Unreacted HCN adversely affects baking quality of flour (FAO 1965).
Adverse effects on computers, sensors and food processing equipment	**No** documented effects on equipment and sensors in food processing facilities (Thoms et al. 2008), or on computers when fumigated at 10-fold the maximum label dosage at 50ºC.	Effects on computers, sensors and other food processing equipment are unknown due to limited use as a fumigant in recent decades.
Inert gas required during and after fumigant introduction	**No.** An inert gas is not used as a propellent during introduction or to clean introduction hoses after application of ProFume.	**Yes.** Nitrogen is used as a propellent during introduction and to clean introduction hoses of liquid HCN after application of BLUEFUME® (Draslovka).
Spray nozzles at end of introduction hoses required to aerosolize fumigant	**No.** Spray nozzles are not used at the end of introduction hoses for ProFume.	Spray nozzles are needed at the end of introduction hoses to aerosolize liquid HCN in BLUEFUME (Draslovka). Liquid HCN can corrode several types of plastic, rubber and finishes such as epoxy resin floors (Böye and Mück 2011, 2017).
Rapid aeration	**Yes.** Requires less than 24 hours to aerate.	**No.** Requires at least 24 hours to aerate. Readily sorbs into porous materials including walls, ceilings, floors, and furnishings, especially at cold temperatures, which can hinder aeration (Böye and Mück 2011).

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