MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

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INTEROFFICE COMMUNICATION

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TO: File for Ethyl mercaptan (CAS # 75-08-1)

FROM: Doreen Lehner, Toxics Unit, Air Quality Division

DATE: May 22, 2017

SUBJECT: Screening Level for Ethyl mercaptan (CAS # 75-08-1)

The initial threshold screening level (ITSL) for ethyl mercaptan (CAS # 75-08-1) is 13 µg/m^3 with a 1-hour averaging time.

Ethyl mercaptan (CAS# 75-08-1) also known as ethanethiol, mercaptoethane, and ethyl sulfhydrate has a molecular weight of 62.13 g/mol. Ethyl mercaptan is a highly flammable clear liquid with an overpowering pungent cabbage or skunk-like odor having an odor threshold of 0.00076 ppm [1.9 µg/m^3] (ACGIH, 2004). The vapor may irritate the nose and throat. The vapor is heavier than air (vapor density = 2.14 [air = 1]) and may travel along the ground. Ethyl mercaptan occurs naturally in some vegetables such as cabbage and as a minor component of petroleum, and is used: as an additive in liquefied petroleum gas, butane, and propane to warn of gas leaks; as a flavoring agent; as a stabilizer for adhesives; and in mining as “stench gas” to alert mine workers during an emergency.

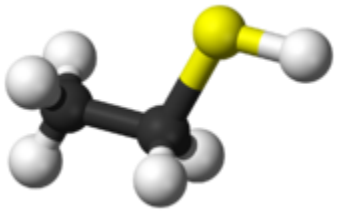

Figure 1. Structure of ethyl mercaptan.

A literature review was conducted to determine an Initial Threshold Screening Level (ITSL) for ethyl mercaptan. The following references and databases were searched to derive the above screening level: CCD, United States Environmental Protection Agency (US EPA) Integrated Risk Information System (IRIS), National Institute for Occupational Safety and Health (NIOSH), American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values and Biological Exposure Indices (TLV/BEI) 2017 guide, National Toxicology Program (NTP) Study Database, International Agency for Research on Cancer (IARC), European Chemicals Agency (ECHA), Acute Database, Chemical Abstract Service (CAS) Online using SciFinder portal (searched 4/24/2017), National Library of Medicine (NLM)-online, EPA Aggregated Computational Toxicology Resource (ACToR) Database, US EPA TSCATS database, and Hazardous Substances Data Bank (HSDB).

ACGIH has an occupational exposure limit for ethyl mercaptan. The threshold limit value – time weighted average (TLV-TWA) is 0.5 ppm (1 mg/m^3) with a TLV basis listed as irritation of the mucous membranes and CNS effects. ACGIH derived its value "from human information from the 1910s and 1960s that is more experience-based than experimentally derived, but it reflects the undesirable properties of ethyl mercaptan. Animal data suggest that 40 ppm is the threshold effect concentration (cardiovascular and organ weight changes). Because ethyl mercaptan is extremely malodorous, it may be necessary to control exposure below the TLV to prevent complaints of odor" (ACGIH, 2004).

ACGIH based their TLV on two human studies. One, a study by Blinova EA (1965), where human "volunteers exposed to ethyl mercaptan at 10 mg/m^3 (4 ppm) 3 hours daily during 5 to 10 days produced effects that included a rise in olfactory threshold and altered taste reaction to bitter and sweet substances; periodic nausea; irritation of mucous membranes of the lips, mouth, and nose; and a sensation of fatigue. Exposure at 1 mg/m^3 (0.5 ppm) produced no unpleasant symptoms" (ACGIH, 2004). Blinova EA (1965) also performed subchronic "inhalation studies, in which rabbits, rats, and mice were exposed to ethyl mercaptan for a period of 5 months at a concentration of 100 mg/m^3 (approximately 40 ppm), showed minimal deviations in cardiovascular system regulation and organ weights. Forty ppm was considered to be the threshold effect concentration" (ACGIH, 2004).

The second study utilized by ACGIH (2004), Pichler K, et al., (1918), reported an "accidental exposure of 28 students to approximately 4 ppm ethyl mercaptan for several hours caused headaches and nausea, which resolved within 24 hours [after] removal from the contaminated area. One student showed some liver involvement with epithelial cells, protein, and erythrocytes in the excretion fluids. These effects subsided and the patient was considered normal within 6 weeks" (ACGIH, 2004).

Even though ACGIH set a TLV-TWA of 0.5 ppm, based on irritation of the mucous membranes, lacrimation, and CNS effects seen at 4 ppm, they admit that, "because the TLV-TWA of 0.5 ppm exceeds the odor threshold by perhaps a thousand-fold, it is doubtful that this concentration can be maintained in a workplace without causing a nuisance, if appreciable quantities are involved" (ACGIH, 2004).

"In summary, all thiols behave as weak acids, their chemical reactivity being due essentially to the -SH group. The predominant biologic effect of exposure to thiol vapors is on the CNS. Toxicity via inhalation route of administration is of importance in the case of the C_1-C_6 group of alkane thiols and the dermal route in the case of C_7-C_{12}, C_{16}, and C_{18} alkane thiols and cyclohexanethiol, the former group being more volatile than the latter" (NIOSH, 1978). "It is pertinent to recognize that all the thiols have strong odor that constitute a nuisance at concentrations far lower than those at which they cause signs and symptoms of toxicity. In general, the low molecular weight thiols have a more obnoxious odor than the high molecular weight thiols at comparable concentrations" (NIOSH, 1978). "Sensitive individuals may experience adverse reactions to thiols and related materials at lower concentrations than those tolerated by most other employees" (NIOSH, 1978).

NIOSH (1978, 1988) established a recommended exposure limit (REL) of 0.5 ppm (1.3 mg/m^3) [15-minute ceiling level] to be protective against acute effects such as headache, nausea, weakness, fatigue, incoordination, and mucous membrane irritation which appear to be the most sensitive endpoints identified in the available data. NIOSH derived their REL based on (Fairchild et al, 1958) inhalation LC_{50} studies on rats and mice. "Both the human and animal toxicity data show adverse effects resulting from relatively short-term inhalation exposure to thiols at 50 ppm.

These findings indicate that workplace concentrations of thiols should be kept well below this concentration. The minimal effects of olfactory fatigue and mucosal irritation observed when individuals were exposed to 4 ppm ethanethiol ceased when the inhalation exposure was stopped, and no effects were observed at 0.4 ppm exposure. Because there is no evidence that adherence to the TLV of 0.5 ppm has resulted in any cases of toxicity, NIOSH recommends that the concentration of C_1-C_{12}, C_{16}, C_{18} alkane thiols or cyclohexanethiol, or any combination of these thiols, in the workplace air should not exceed 0.5 ppm as a ceiling concentration for any 15-minute period. Since the toxic action of thiols, on short term-exposure, is expressed largely by reversible mucosal irritation, a ceiling limit is deemed more appropriate than a TWA concentration limit. The use of a ceiling concentration instead of a TWA has the effect of increasing the protection provided to the worker about twofold. NIOSH believes that adherence to the proposed ceiling concentration would prevent both irritative and systemic effects arising from occupational exposure to the aliphatic thiols" (NIOSH, 1978).

Fairchild, et. al., (1958) exposed male Wistar rats via whole body to ethyl mercaptan vapor, "for 4 hours at analytical concentrations of 2600, 3150, 3573, 4438, 4832, 4868, 5100, [or] 5125 ppm. Maximal sublethal and lethal concentrations induced characteristic symptoms of toxicity, i.e., increased respiration and restlessness, uncoordinated movement and staggering gait, muscular weakness, partial skeletal muscle paralysis beginning in hind limbs, light to severe cyanosis, tolerance of prone position, and mild to heavy sedation. Fatal responses usually followed one of two patterns: (1) animals exposed to maximal lethal concentrations died from respiratory arrest while in shortly after removal from the chamber, and (2) those animals exposed to minimal lethal concentrations died while in a semiconscious condition of long duration. Animals very often remained in a semi-conscious condition of sedation and lethargy 4 to 6 hours post-exposure before showing signs of recovery. Occasionally a period of deep lethargy of 18 to 28 hours intervened before visible signs of recovery occurred. Irritation to the mucous membranes within approximately 15 minutes after exposure of animals to high concentrations was evidenced by their rubbing of the eyes and nose, eye closure, occasional sneezing, watering of the eyes, and retracting of the head" (OECD, 2010). All animals survived exposure at 3,573 ppm. At 4,868 ppm, 2 of the 5 animals died by day 15. The 4-hour LC_{50} was 4,420 ppm [11.2 mg/L] (OECD, 2010).

Fairchild, et al., (1958) exposed male Swiss mice (10/group) "to ethyl mercaptan vapor via whole body inhalation for 4 hours at analytical concentrations of 2600, 3150, 3573, 4438, [or] 4832 ppm" (OECD,2010). The clinical signs of exposure in the mice were the same as listed above for rats. At 2,600 ppm, 4 of the 10 mice died by day 15. The 4-hour LC_{50} was 2770 ppm [7.0 mg/L] (OECD, 2010).

The Fairchild et al., (1958) study does not address the irritancy effects of this compound. NIOSH has established a recommended exposure limit (REL) of 0.5 ppm (1.3 mg/m^3) [15-minute ceiling level] to be protective against acute irritation effects which appear to be the most sensitive endpoints identified by available data. According to Rule 232(1)(c) an ITSL can be derived from an occupational exposure level (OEL). Both NIOSH and ACGIH have established OELs for ethyl mercaptan at 0.5 ppm (1.3 mg/m^3); however, the NIOSH REL is a ceiling level and the ACGIH OEL is a TLV-TWA. The NIOSH ceiling level is more protective from sensitive acute effects due to the shorter averaging time, and is selected as the ITSL basis.

$$ITSL = \frac{occupational\ exposure\ level}{100} = \frac{1.3\ {}^{mg}/_{m^3}}{100} = 0.013\ {}^{mg}/_{m^3} = 13\ {}^{\mu g}/_{m^3}$$

The Initial Threshold Screening Level for ethyl mercaptan is 13 µg/m^3 with a 1-hour averaging time. It should be noted that the odor threshold for this compound is 0.00076 ppm (1.9 µg/m^3) (ACGIH, 2004).

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