MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

INTEROFFICE COMMUNICATION

TO: File for Silicon tetrachloride (CAS #10026-04-7)

FROM: Doreen Lehner, Toxics Unit, Air Quality Division

DATE: December 19, 2022

SUBJECT: Screening Level for Silicon tetrachloride (CAS #10026-04-7)

Summary

The initial threshold screening level (ITSL) for silicon tetrachloride (CAS #10026-04-7) is 20 µg/m^3 based on an annual averaging time. A second acute ITSL for silicon tetrachloride of 2,000 µg/m^3 based on a 1-hour averaging time. The acute ITSL is derived as a short-term exposure and will be used in conjunction with the more chronic ITSL. Footnote #36 should be used. Footnote #36 states: "The ***combined*** ambient impact of these chloro-silanes must be evaluated together so that their hazard index (HI) does not exceed a value of one (1)".

Uses and Physical Chemical Properties

Silicon tetrachloride is quickly decomposed by water to hydrochloric acid with the generation of heat. It is corrosive to metals and tissue in the presence of moisture. Silicon tetrachloride is used in smoke screens; to make various silicon containing chemicals; in chemical analysis; and as chemical intermediates in the production of silicone and silicone containing materials.

Table 1. Physical/Chemical Properties of Silicon tetrachloride

Structure	
CAS Number	10026-04-7
Synonyms	Tetrachlorosilane; Silicon chloride; Tetrachlorosilicon; Perchlorosilane
Appearance/Odor	Colorless, fuming liquid with a pungent, suffocating odor
Molecular Weight	169.9 g/mol

Melting Point	-70 °C
Boiling Point	59 °C
Relative Density (water =1)	1.48
Relative Vapor Density (air = 1)	5.9
Vapor Pressure	236 mm Hg at 25°C
Heat of Vaporization	29.7 kJ/mol at 25°C

Literature Search

The literature was searched to find relevant data to assess the toxicity of silicon tetrachloride. The following references or databases were searched: U.S. Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS), Registry for Toxic Effects of Chemical Substances (RTECS), American Conference of Governmental and Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Levels (RELs), International Agency for Research on Cancer (IARC) Monographs, Chemical Abstract Service (CAS) SciFinder (searched 12/1/2022), U.S. EPA ChemView, California Office of Environmental Health Hazard Assessment (OEHHA), the U.S. Department of Health and Human Services Agency for Toxic Substances and Disease Registry (ATSDR), European Chemical Agency (ECHA), and the U.S. National Toxicology Program (NTP).

Discussion

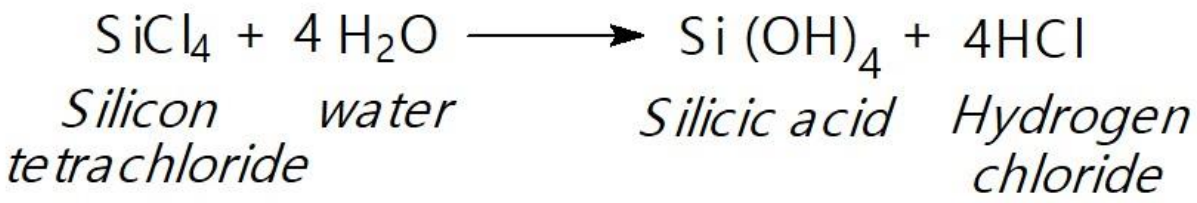
The previous ITSL for silicon tetrachloride was derived in 1988 and was set at 1,100 µg/m^3. The ITSL was based on a rat lethal concentration (50 percent kill) on rats. The justification that was written stated that the available toxicity information is quite poor. After a thorough review of the available toxicity information, the U.S. Environmental Protection Agency established an Acute Exposure Guideline Level (AEGL) for a group of 26 chlorosilanes, including silicon tetrachloride. The AEGLs for these selected chlorosilanes were based on the molar equivalent of hydrochloric acid released when chlorosilanes are exposed to the air. “Chlorosilanes are corrosive, and inhalation exposure might cause nasal, throat, or lung irritation, coughing, wheezing, and shortness of breath. Chlorosilanes react rapidly with water, steam, or moisture; hydrolysis yields hydrogen chloride (HCl) gas along with silanols and other condensation products” (NRC, 2012). “These data suggest that the acute toxicity of chlorosilanes is largely explained by the HCl hydrolysis product; acute toxicity of these chlorosilanes is qualitatively (based on clinical signs) and quantitatively (based on molar equivalents of HCl) similar to HCl” (NRC, 2012). “On the bases of these data, and in the absence of appropriate chemical specific data for chlorosilanes…the AEGLs for HCl were used to derive AEGLs for chlorosilanes. For each class of chlorosilanes (mono-, di-, tri-, and tetra-chlorosilanes), the molar ratio (moles of HCl released per mole of chlorosilane assuming complete hydrolysis) was used to adjust the AEGL values for HCl to the equivalent concentration of chlorosilane” (NRC, 2012).

ITSL Derivation

Due to the rapid decomposition of silicon tetrachloride to hydrogen chloride in the presence of any moisture. It is appropriate to consider that environmental emissions of silicon tetrachloride should be based on the acute and chronic ITSLs for hydrogen chloride.

The MDEQ (2014) ITSLs for hydrogen chloride are an acute ITSL is 2,100 µg/m^3 (1-hour averaging time) and a chronic ITSL is 20 µg/m^3 (annual averaging time).

The ITSLs for silicon tetrachloride were derived based on the following equation:



One mole of silicon tetrachloride produces four moles of hydrogen chloride. The molecular weight of hydrogen chloride is 36.5 g/mol.

The ITSL for silicon tetrachloride = ITSL for hydrogen chloride x $\frac{1\ mole\ silicon\ tetrachloride}{4\ moles\ hydrogen\ chloride}$

Acute ITSL for silicon tetrachloride = $2{,}100\ {}^{\mu g}/_{m^3} \times \frac{169.89\ g}{4 \times 36.5\ g} = 2{,}443.62\ {}^{\mu g}/_{m^3} \approx 2{,}000\ {}^{\mu g}/_{m^3}$ (1-hour averaging time)

Chronic ITSL for silicon tetrachloride = $20\ {}^{\mu g}/_{m^3} \times \frac{169.89\ g}{4 \times 36.5\ g} = 23.2726\ {}^{\mu g}/_{m^3} \approx 20\ {}^{\mu g}/_{m^3}$ (annual averaging time)

References:

Act 451 of 1994, Natural Resources and Environmental Protection Act and Air Pollution Control Rules, Michigan Department of Environment, Great Lakes, and Energy.

MDEQ. 2014. File for Hydrogen Chloride (CAS No. 7647-01-0). Development of the Screening Level. Interoffice communication. By Michael Depa, Toxics Unit, Air Quality Division. April 8, 2014. Available online at:
Toxic Screening Level Justification for 7647-01-0 (state.mi.us)

NRC. 2012. Selected Chlorosilanes. Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 11. Committee on Acute Exposure Guideline Levels; Committee on Toxicology; National Research Council. ISBN 978-0-309-25481-6, 356 pages.

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