Occidental Chemical Corporation
A subsidiary of Occidental Petroleum Corporation

Product Stewardship Summary
Vinyl Chloride Monomer

Summary

Vinyl Chloride Monomer (VCM) is a colorless, flammable gas at room temperature. Its chemical formula is C_2H_3Cl. It is primarily used to manufacture polyvinyl chloride (PVC), a very stable, non-flammable, lightweight and durable plastic. PVC is used in a variety of applications. For example, it is found in common building products such as PVC pipe and window frames.

1. Chemical Identity

Name: Vinyl Chloride Monomer
Synonyms: VCM, Vinyl Chloride, Chloroethene, Chloroethylene
Chemical Abstracts Service (CAS) number: 75-01-4
Chemical Formula: C_2H_3Cl
Molecular Weight: 62.5

Vinyl Chloride Monomer (VCM) is a colorless, flammable gas at room temperature. At concentrations of about 3.6 percent VCM in air, VCM can be an explosion hazard. VCM is often stored as a liquid under pressure. The liquid evaporates readily at ambient temperatures. At high concentrations, it has a sweet odor typical of chlorinated hydrocarbons. VCM vapors are heavier than air and tend to sink to low areas.

2. Production

VCM is manufactured using a series of chemical reactions. The initial feedstocks are ethylene and chlorine. Ethylene is made by processing natural gas or petroleum. Chlorine is derived from brine.

The first reaction steps produce ethylene dichloride (EDC). EDC is manufactured by OxyChem by two different reactions. Direct chlorination is the reaction of ethylene and chlorine:

$$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$$

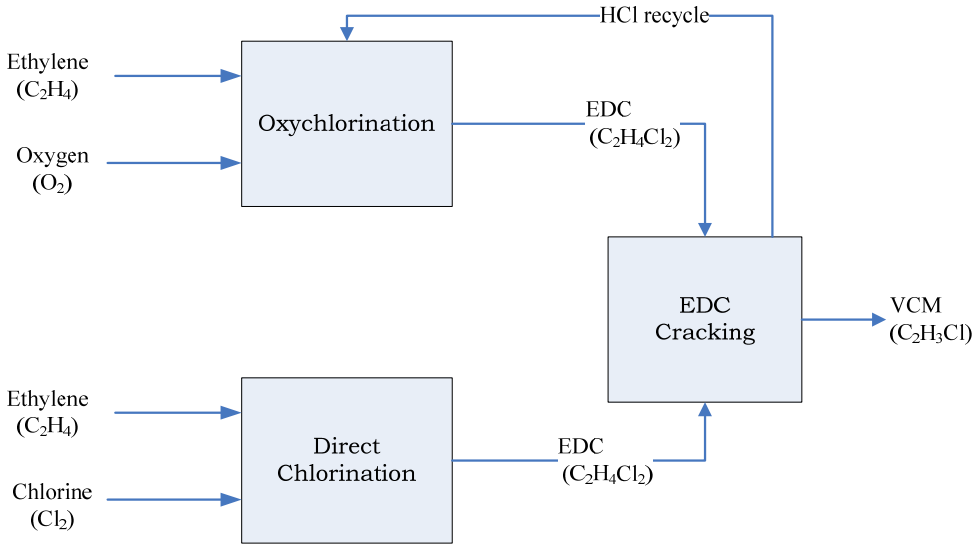
Oxychlorination is the reaction of oxygen, ethylene and hydrogen chloride:

$$½O_2 + C_2H_4 + 2HCl \rightarrow C_2H_4Cl_2 + H_2O$$

The next reaction occurs when the temperature and pressure of EDC is raised. The EDC molecule is "cracked" to produce VCM and hydrogen chloride. The reaction is:

$$C_2H_4Cl_2 \rightarrow C_2H_3Cl + HCl$$

The following is a schematic of the process:



OxyChem is a leading manufacturer of VCM and operates facilities in Deer Park, Texas; Ingleside, Texas; and LaPorte, Texas.

3. Uses

OxyChem does not sell VCM to household consumers. VCM is used primarily as a raw material in industrial operations that manufacture polyvinyl chloride (PVC). The polyvinyl chloride, in turn, is used in products such as:

- Building materials – siding, roofing, water distribution, irrigation, sewer and sprinkler pipe, fencing; wire and cable insulation; electrical conduit; floor and wall coverings, window frames, gutters and downspouts
- Industrial processes - landfill liners, piping used in food processing, chemical processing and other manufacturing
- Medical devices - for blood and intravenous bags, kidney dialysis and blood transfusions, cardiac catheters, endotracheal tubes, artificial heart valves and many others
- Automotive components - for body side moldings, interior upholstery, under-the hood wiring, under-the-car abrasion coatings, floor mats, dashboards and arm rests
- Electronics – components in air conditioners, floppy disks, components, housings, keyboards, phone systems, computers, power tools, electrical cords, refrigerators, fiber optics, washers
- Toys - for rigid and flexible parts
- Packaging materials - for flexible food wrap, shrink wrap, jar lids and can linings; and for rigid blister and clamshell packaging, and bottles to store household, personal care products, and automotive lubricants

VCM is consumed and converted into PVC during the manufacture of PVC resin. OxyChem's industrial customers further process PVC resin to manufacture finished articles.

4. Physical and Chemical Properties

Flammability
VCM is extremely flammable. At concentrations of about 3.6 percent VCM in air, VCM can be an explosion hazard. Direct contact with open flames or a high energy heat source will result in combustion and corrosive, noxious gases. If combustion occurs, extinguish fires using dry chemical, foam, or carbon dioxide. Water may be ineffective, but should be used to keep fire-exposed containers cool.

Reactivity
VCM will polymerize if exposed to air, elevated temperatures or other activating substances. Inhibitors are often added to VCM to prevent polymerization during storage. VCM can be stored in vessels made of common materials of construction. VCM is stable with common metals other than aluminum and aluminum alloys and copper and copper alloys (including brass). When moisture is present, VCM can corrode iron and steel. Avoid VCM contact with moisture, pure oxygen, strong alkalis, alkali metals, open flames and welding arcs, and other high temperature sources, which induce thermal decomposition to irritating and corrosive hydrochloric acid.

5. Health Effects

Inhalation
Several minutes of exposure to high, but attainable concentrations (over 1000 ppm) may cause central nervous system depression with effects such as dizziness, drowsiness, disorientation, tingling, numbness or burning sensation of the hands and feet, impaired vision, nausea, headache, difficulty breathing, cardiac arrhythmias, unconsciousness, or even death.

Eye and Skin Contact
Contact with rapidly evaporating liquid VCM can cause frostbite.

Ingestion
Ingestion is not a likely route of exposure because VCM is a vapor at normal temperature.

Chronic effects
VCM is a known human carcinogen. Occupational overexposure has produced a specific cancer (angiosarcoma of the liver) and is associated with hepatocellular and cholangiocellular cancer. Occupational exposure has also resulted in changes in bones and skin, especially in the extremities such as the fingers (acroosteolysis). Additionally, repeated exposure may result in dose-related sensory disorders, nervous system effects, blood system damage, lymphatic system changes, liver malfunction, pulmonary insufficiency, and dermatitis.

Developmental/Reproductive Studies
VCM did not cause birth defects when tested in rats, mice, or rabbits. Studies in rats show that inhalation produces fetal toxicity only at exposure levels that also produce maternal toxicity.

6. Environmental Effects

If released to soil, VCM is expected to have high mobility. Volatilization from moist soil surfaces is expected to be an important fate process based on its vapor pressure.

If VCM is released into water, it is not expected to adsorb to suspended solids and sediment in the water. The biodegradation half-life of vinyl chloride in aerobic and anaerobic waters was reported as 28 and 110

days, respectively. Volatilization from water surfaces is expected to be an important fate process. The estimated volatilization half-lives for a model river and model lake are 1 hour and 3 days, respectively. VCM is practically non-toxic to fish on an acute basis.

If released to air, VCM will exist solely as a gas in the ambient atmosphere. It will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 55 hours.

7. Exposure

The most likely ways exposures could occur are:

- Worker exposure – Exposure could occur in the manufacturing facility or in industrial facilities that use VCM. Exposures could occur by inhalation of vapors or by contact to the skin or eye. VCM is used in closed systems in manufacturing processes to minimize exposures. In the U.S., the Occupational Safety and Health Administration regulates VCM. The standard is in 29 CFR 1910.1017. It contains requirements for personal protective equipment, medical surveillance, and training.
- Consumer exposure – OxyChem does not sell VCM for use directly in consumer products.
- Releases – If a spill occurs, emergency personnel should wear protective equipment to minimize exposures. The leak should be stopped if it is possible to do so without personal risk. Any ignition sources in the area should be removed, and closed spaces must be ventilated before they are entered.

8. Recommended Risk Management Measures

VCM is flammable and can react with certain materials of construction. In addition, personnel exposure must be controlled. Prior to using VCM, carefully read and comprehend the Material Safety Data Sheet. Users in the U.S. must comply with OSHA regulations at 20 CFR 1910.1017. The following are some risk management measures that are effecting against these hazards:

- Work areas where VCM is used should be fire resistant. VCM must be stored in a National Fire Prevention Association (NFPA) Class I area. During VCM transfers from one container to another, equipment should be properly grounded and bonded to prevent the build up of static electricity. If discharged, this build up could create an igniting spark.
- Work areas where VCM is used should be well ventilated to limit solvent vapors to below exposure limits and to limit the concentration of potentially flammable vapors.
- The odor threshold of VCM is approximately 3,000 ppm. This odor threshold is much greater than exposure limits. To avoid overexposure to VCM vapors, monitor the VCM vapor concentration in the work place. If vapors are above exposure limits, install additional engineering controls (such as localized ventilation) to reduce VCM vapor concentrations to safe operating levels.
- To prevent eye contact, protective eye wear (such as splash goggles, a full face shield, or safety glasses with side shields) must be worn.
- To prevent skin contact, wear protective clothing (including gloves) when working with VCM.
- Equipment used for VCM storage or processing should be constructed of the proper materials. For example, bulk storage containers should be constructed of either mild, carbon,

or stainless steel. Do not use aluminum, copper or copper alloys as materials of construction for any wetted metal parts.

- Personnel involved with VCM manufacturing operations should be properly trained.

9. Regulatory Compliance Information

The following is a summary of regulations and guidelines that may pertain to VCM (additional regulations and guidelines may apply):

U.S. Environmental Protections Agency:

- Clean Air Act: VCM is included on the Clean Air Act, Section 112(b) list of Hazardous Air Pollutants.
- Clean Water Act – Water Quality Criteria:
  - Based on fish/shellfish and water consumption = 2.0 μg/L
  - Based on fish/shellfish consumption only = 530 μg/L
- Comprehensive Environmental Response, Compensation, and Liability Act: Releases of VCM in excess of the Reportable Quantity of 1 pound must be reported.
- Emergency Planning and Community Right-to-know Act: VCM is a listed substance that is subject to reporting requirements under Section 313 of the act. These reports are often called Toxic Release Inventory (TRI) Reports.
- Resource Conservation and Recovery Act:
  - Characteristic Toxic Hazardous Waste code D043. The code applies if waste contains 0.2 mg/L or more VCM as determined by the Toxicity Characteristic Leaching Procedure.
  - Listed Hazardous Waste Codes in which listing is based wholly or partly on VCM include U043, K019, K020, K028, and K029.
- Safe Drinking Water Act – Maximum Contaminant Level (MCL) = 0.002 mg/L

Food and Drug Administration:

- Maximum permissible level in bottled water = 0.002 ppm

Occupational Safety and Health Administration - The U.S. OSHA standard, 29 CFR 1910.1017, outlines occupational requirements, including personal protective equipment, medical surveillance, and training. The Permissible Exposure Limits established by the standard are:

- 8 hour time weighted average: 1 ppm
- Short-term exposure limit (15 minutes): 5 ppm

10. Sources for Additional Information

Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Vinyl Chloride, July 2006.

HSDB, Hazardous Substances Databank Number: 169, Last Revision Date: 20050624.

IARC, Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, Supplement 7, Vol 71, (1999).

NTP, Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program.

Organization for Economic Cooperation and Development (OECD) SIDS Initial Assessment Report for SIAM 13: Vinyl Chloride, UNEP Publications, November 2001.
(www.chem.unep.ch/irptc/sids/OECDSIDS/VINYLCHL.pdf)

OxyChem Material Safety Data Sheet web site: http://msds.oxy.com/

Reprotox, Reprotox Record Number: 1364, Last Revision Date: August 1, 2003.

RTECS, RTECS Number: KU9625000, Review Date: 200802.

The Vinyl Institute (http://www.vinylinfo.org)

11. Contact Information: For additional information, call 1-800-752-5151 or 1-972-404-3700.

12. Preparation Date: 12/12/2008 **Revised**: 02/13/2013

This Product Stewardship Summary is intended to give general information about the product discussed above. It is not intended to provide an in-depth discussion of all health and safety information about the product or to replace any required regulatory communications.