ChemFacts

Ethylene Oxide (EtO)
CAS 75-21-8

Physical Hazards

Ethylene Oxide (EtO) is an extremely flammable and reactive material which is a gas at room temperature. It has a flash point of -0.4^{o}F and an extremely large flammable range of 3 to 100%. It is very water soluble and solutions of as little as 4% in water are flammable. In closed systems, such as sewers, dilutions of 1:100 are required to produce a mixture that will not support combustion.

Violent self polymerization of the material can occur with exposure to heat, acids, or bases. It also reacts violently with exposure to copper, copper alloys, and rust. Liquids can accumulate a static charge by splashing or agitation. The gas can be ignited by a static charge. The gas is heavier than air and can travel long distances to a source of ignition and flash back to a leaking or open container.

The heat of a fire may cause spontaneous polymerization, causing containers to rupture violently. EtO can also ignite and decompose explosively at pressures less than one atmosphere. Once the decomposition reaction has been initiated, it can be propagated from the ignition source through the gas phase as a flame and, under certain conditions, may be explosive. This reaction can occur in the absence of air or oxygen.

Warning Properties and Exposure Limits

EtO has a sweet odor with an odor threshold of 200 ppm (perception) but is not distinguishable from other organics until 500-700 ppm. Odor cannot be relied on to determine safe conditions, however: The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) and the Occupational Health and Safety Administration (OSHA) Permissible Exposure Limit for EtO is 1 ppm. This is the level of EtO to which a worker can be exposed for up to eight hours a day, forty hours per week, for a working lifetime without adverse health effects.) OSHA also has set a 15 minute excursion level for EtO at 5 ppm and an action level of 0.5 ppm. The National Institutes of Occupational Safety and Health (NIOSH) Immediately Dangerous to Life and Health Level (IDLH) for EtO is 800 ppm. This is the level to which a worker can be exposed for up to 30 minutes while escaping from a hazardous atmosphere without serious permanent injury.

Toxicity Data

Ethylene oxide is generally classified as genotoxic, mutagenic and carcinogenic. EtO toxicity is based on its ability to bind to nucleophilic biopolymers such as RNA, DNA, and proteins. The primary enzyme for EtO detoxification is microsomal epoxide hydrolase (EH). To a lesser degree, the cytoplasmic enzyme glutathione-S-transferase (GST) is also involved. Levels of these enzymes vary widely between species, for example, mice have a much lower level of EH than do humans. This is reflected in the differences seen in the literature in $LD_{50's}$ and $LC_{50's,}$ not

just between studies, but also between species.[1] Given orally in water or corn oil, EtO is only slightly toxic with an LD_{50} of 250-350 mg/kg, (rats and mice). By inhalation, EtO is moderately toxic with an LC_{50} (1 hr) of 1460 ppm in rats and 835 ppm in mice.

The species differences in detoxification pathways makes assessing risk to humans based on animal testing somewhat more complicated for EtO than with other chemicals. Evaluating human studies is also difficult because the human data is confounded by the fact that EtO is found in cigarette smoke. In one study, EtO associated genetic markers were more prevalent in smokers than in occupationally exposed non-smokers. In the case of EtO, however, we have the advantage of a large body of data, much of it from hospital workers and other people who had little or no exposures to other chemicals that might confound test results.

Health Effects/ Signs and Symptoms of Exposure

Acute Exposures

- Eyes- irritation including corneal injury
- Skin- effects go from irritation to blistering with the possibility of frostbite from exposure to the rapidly evaporating liquid
- Inhalation
    - Central Nervous System (CNS) effects have been reported from human exposures including headache, nausea and coma.
    - Lung damage/pulmonary edema

Chronic Exposures

- Eyes- cataracts have been reported in people working at the 1 ppm (TLV) level with no protection.
- Skin- contact dermatitis has been reported. Sensitization has been reported as well but the data is equivocal and may be species related
- Inhalation-chronic exposures to several hundred ppm in humans have resulted in CNS effects: ataxia (muscle incoordination) and slurred speech.
- Reproductive-
    - Increased frequency of spontaneous abortions have been reported in women who worked in hospitals or dental clinics around EtO sterilizers.
    - Damage to the testes and ovaries have been reported from animal studies but may be species related and not directly applicable to human exposures
- Carcinogenicity
    - IARC: classified as carcinogenic to humans (Group 1), based to a great degree, on studies done on hospital workers who have very few other chemical exposures.
    - ACGIH: classified a possible human carcinogen (A2).

[1] LD_{50} = Lethal Dose, 50%, or the dose that killed 50% of the test animals, usually within 1-2 hours;
LC_{50} = Lethal Concentration, 50%, or the concentration of airborne contaminant that killed 50% of the test animals, within a specified time.

Emergency Procedures:

Areas around ethylene oxide sterilizers are required to be equipped with monitors set to alarm at 0.5 ppm. In the event of an alarm, exit the building immediately, pulling the fire alarm on your way out. Be sure to stay in the area to inform emergency responders of the nature of the emergency.

In the event of an inhalation exposure to EtO, move victim outdoor to fresh air. Exposure victims should rest in half upright position and seek medical attention.

In the event of a skin exposure- Remove contaminated clothes. Rinse with tepid water for 15 minutes.

For frostbite: rinse with plenty of water, do NOT remove clothes. Rinse skin with plenty of water or shower. Seek medical attention.

Methods of Determining EtO Exposures

Biological monitoring to determine whether a person has been over-exposed to EtO by testing their blood or urine is possible, but not standard practice unless workplace exposures exceed ½ the TLV (0.5 ppm). A much more direct method to assess exposure is to take air samples in the worker's breathing zone. This can be done by a number of methods, some involve monitoring badges (passive sampling) while others involve using a small air pump worn by the worker to pull air through a tube of chemically treated sampling media, specific for EtO (active sampling). Area monitoring for EtO is also possible by direct reading devices. Many such devices are available and can be set to alarm if levels exceed a pre-set level.

Protecting Against Ethylene Oxide Exposure

The best protection against inhalation of EtO is making sure that all personnel using EtO follow a Standard Operating Procedure (SOP) which has been checked by personal sampling and has been proven to keep worker exposures below the action level of 0.5 PPM. In addition, areas with ethylene oxide sterilizers are required to be equipped with monitors set to alarm at 0.5 ppm.

Personal protective equipment for working with EtO includes appropriate lab attire, safety glasses, lab coat and nitrile gloves. Respirators will not be issued at Georgia Tech for people working with EtO; the only acceptable methods of respiratory protection against EtO are a military style gas mask (not available at GT) or a Self Contained Breathing Apparatus (SCBA). An air purifying respirator with an organic vapor cartridge is not sufficient to protect against EtO.

The Ethylene Oxide Training Competency Evaluation is attached. See also the GT Program for the Safe Use of Ethylene Oxide Sterilizers

Ethylene Oxide (EtO) Training Competency Evaluation

Name_____ e-mail _____

Department_____ date_____

Supervisor _____

lab location: Building_____ Room_____

1) Ethylene oxide is:
   a) Extremely flammable
   b) Extremely reactive
   c) Smells bad at low concentrations
   d) A & B
   e) All of the Above

2) Solutions of EtO in water are:
   a) Non-flammable
   b) Flammable as low as 4% v/v
   c) Reactive with plastic
   d) Combustible in sewer systems unless diluted more than 1:100
   e) B&D

3) EtO may self polymerize- violently, especially when heated
   a) True
   b) False

4) The ACGIH TLV (8 hour exposure limit) for ethylene oxide is:
   a) 1 ppb
   b) 5 ppm
   c) 1 ppm
   d) 200 ppm

5) The odor threshold for EtO is
   a) 1 ppb
   b) 200 ppm
   c) 5 ppm
   d) 5 mg/m^3
   e) EtO does not have an odor

6) Chronic exposures of EtO have been associated with
   a) Cataracts
   b) Dermatitis
   c) Spontaneous abortions
   d) Cancer
   e) All of the above

7) Inhalation of EtO in acute exposure situations (short duration, high dose) has been associated with which of the following:
   a) Eye irritation and injury
   b) Headache
   c) Lung Damage
   d) Coma
   e) All of the above

8) A person who has inhaled EtO should be:
   a) Moved outside to fresh air
   b) Allowed to rest in a semi-upright position
   c) Given O_2 if needed
   d) Encouraged to seek medical attention
   e) All of the above

9) In the event of a spill/release of EtO all persons working in the area should:
   a) Clean it up
   b) Put on a respirator and then clean it up
   c) Evacuate the building and pull the fire alarm on the way out
   d) Evacuate the lab and call EH&S

10) All labs with EtO sterilizers are required to
   a) Write a Standard Operating Procedure for its use
   b) Train everyone in the area on what the alarms sound like
   c) Teach everyone in the area how to mute the alarms
   d) A & B
   e) B &C

11) If the EtO alarm sounds you should:
   a) Call EH&S
   b) Call your adviser
   c) Call your mother
   d) Evacuate, pull the fire alarm, and call GT Police

12) The number of the GT Police Department is:
   a) 911
   b) 404-894-2500
   c) Programmed into my cell phone (or will be after taking this test)
   d) B& C