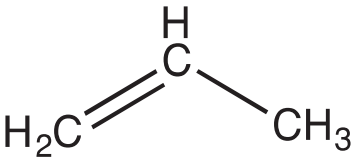
Toxic tips: Propylene



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INTRODUCTION

Chemical Description

Propylene, CH_2:$CHCH_3$, also known as propene, methylethene, 1-propylene, 1-propene, or methylethylene, is an unsaturated, aliphatic hydrocarbon with the double bond between the first and second carbons. It commonly exists as a colorless gas but can also be a liquid under pressure.[1] It has a slight aromatic odor, however a stenchant is often added.[2] "Propylene is obtained from petroleum oils during refining of gasoline."[3] It is highly flammable, "explosive in the form of vapor when exposed to heat, flame," or oxidizers,[4] and "burns with a yellow sooty flame."[3] The lower explosion limit is 32 g/m^3 and the upper explosion limit is 200 g/m^3.[5] It is a simple asphyxiant.[4] The CAS Registry number is 115-07-1. Its molecular weight is 42.08.[3]

Uses and Typical Exposure Situations

"Propylene is used in the production of many organic chemicals including resins, plastics, synthetic rubber and gasoline."[1] "Propylene is also expected to be released to the environment in the combustion gases of hydrocarbon fuels, wood, cigarettes, and synthetic polymers such as polyethylene, polyamides, and polyacrylonitrile. It occurs naturally in fruits, such as bananas and apples, but also in ocean sediments as a microbiological degradation product. Occupational exposure to propylene may occur through inhalation at workplaces where propylene is produced or used, such as an oil refinery. Monitoring data indicate that the general population may be exposed to propylene via inhalation of ambient air, since propylene has been found in air samples collected along roadways, city streets, and restaurants."[6] An incident of uncontrolled release of propylene occurred in a polypropylene plant in Norway. The exit valves became plugged with the polymer. "After shutting down the factory, propylene was boiled off, and the reactor was purged with nitrogen. Propylene leaked into the control room around cable ducts. After three hours of filling the reactor with water, a concentrated release of propylene and nitrogen occurred with a bang. The gaseous mixture that was released was attributed to the presence of gaseous and liquid propylene pockets in a high volume of the polymer powder, lower temperatures in the reactor, and malfunctioning of the ventilator system."[7]

Metabolism and Pharmacokinetics

"The main route of exposure for propylene is via the respiratory tract."[5] "Accumulation of propylene is impossible because of rapid removal from the body"[8] through unaltered exhalation. "It is expected to have low bioaccumulation potential."[9] "Propylene oxide is produced during the first step of propylene metabolism. Epoxidation is catalyzed by cytochrome P450 reductase. Propylene is expected to undergo various addition reactions, such as hydration to alcohol, and excretion in the urine as the conjugated alcohol or propionic acid. Most propylene inhaled into the lungs is exhaled again and does not reach the blood to become systemically available. At a steady state, about 58% of systemically available propylene is eliminated metabolically and 42% is eliminated by exhalation as the unchanged substance."[10] "For low exposure concentrations, the rate of uptake into blood by inhalation is limited by the blood flow through the lungs and the rate of metabolism is limited by the blood flow through the metabolizing organs."[11]

PATHOPHYSIOLOGY

Determinants of Toxicity

The airborne concentration of propylene, the respiratory rate of the individual, and the time of exposure to the contaminated air will determine the amount of toxicant in contact with the respiratory system.

DOIs of original article: http://dx.doi.org/10.1016/j.jchas.2016.02.005, http://dx.doi.org/10.1016/j.jchas.2016.05.007

1871-5532
http://dx.doi.org/10.1016/j.jchas.2016.05.009

Mechanism(s) of Action

Propylene has low toxicity in general, but it is a simple asphyxiant that induces its effect by crowding out oxygen in the lungs after direct inhalation of the gaseous form.[12] "The gas is heavier than air and may accumulate in lowered spaces causing a deficiency in oxygen."[13]

CLINICAL PRESENTATION

Effects Following Inhalation

"On loss of containment this substance can cause suffocation by lowering the oxygen content of the air in confined areas."[13] Drowsiness, unconsciousness, and eventually asphyxia follow exposure through inhalation.[14] In humans, "concentrations of propylene gas at 24%–33% led to unconsciousness within three minutes; at 35%–40% vomiting occurred in two patients. The patients woke up rapidly after termination of the exposure and did not exhibit any substantial clinical symptoms."[5]

Effects Following Skin and Eye Exposure

"Eye and skin contact with the liquefied propylene causes local frostbite as a result of the extreme evaporation coldness." At low concentrations the gas is non-irritating to the skin. However, a skin-irritating potential of the gas was observed in humans after exposure to extreme concentrations. "40%–75% concentration of propylene gas caused reddening of the eyelids in a few minutes." This concentration can later affect the whole face, cause "lacrimation, coughing, and narcotic unconsciousness."[5]

Carcinogenicity

Propylene is not classifiable as a human carcinogen[15] and has been given the A4 category by the American Conference of Governmental Industrial Hygienists (ACGIH). "Data presently available, particularly from the chronic studies performed on rats and mice, indicate that 'inadequate evidence' exists with regard to the carcinogenic effects of the substance on humans and animals."[5] However, in an experiment on propylene gas exposure to rats at various concentrations for 6 hours/day, 5 days/week, for 103 weeks, "histopathological examinations revealed portal-of-entry effects based on an increased incidence of squamous metaplasia and inflammation at the continuation of 10,000 ppm in the nasal cavities."[9]

Reproductive Effects

There are no known reproductive effects in animals or humans. In a study with "inhalation exposure of pregnant Wistar rats to propylene gas from implantation to one day before parturition, there were no maternal toxicity, prenatal or developmental toxicity, or teratogenicity at all concentrations of propylene up to 10,000 ppm."[16]

FIRST AID AND CLINICAL MANAGEMENT

In case of high exposure by inhalation, move individuals to fresh air and monitor for breathing difficulty. Supplemental oxygen is the mainstay of treatment, and most patients recover rapidly once exposure ceases and oxygen is administered. Following exposure to propylene, "avoid benzodiazepines or other respiratory depressants. Patients who do not recover rapidly have likely sustained organ damage due to hypoxia, which may be irreversible. In case of eye exposure, irrigate the exposed eye(s) with copious amounts of room temperature water for at least fifteen minutes."[17] Remove contact lenses.[13] "In cases of frostbite due to direct contact with liquefied propylene, clothes frozen in place should not be quickly removed, but instead defrosted with water.[5] Rewarming and a variety of topical treatments are indicated for frostbite injury."[17]

HANDLING AND STORAGE

Accidental Release Measures

If a spill occurs, eliminate all ignition sources and evacuate the contaminated area. "Prevent the spill from entering sewers, basements and work pits, or any place where its accumulation can be dangerous. Wear a self-contained breathing apparatus when entering the contaminated area unless the atmosphere is proven to be safe."[2] Ensure adequate ventilation of the atmosphere and the floor area.[5] Stop the leak, if it is safe to do so.

Storage Guidelines

Propylene should be stored in upright and firmly secured compressed gas cylinders away from temperatures that exceed 52°C and direct sunlight. "Full and empty containers should be stored separately and a first-in, first-out inventory system should be implemented to prevent storing full containers for long periods of time."[2] Cylinders should be isolated from oxygen and other oxidizers. "Avoid cylinder exposure to areas where salt or other corrosive chemicals are present."[18] "Metal containers