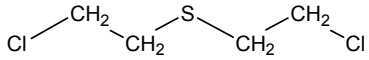
MUSTARD GAS
CAS No. 505-60-2
First Listed in the *First Annual Report on Carcinogens*



CARCINOGENICITY

Mustard gas is *known to be a human carcinogen* based on sufficient evidence of carcinogenicity in humans (IARC 1975, 1982, 1987). Several studies have shown an increased mortality from respiratory tract cancer among individuals exposed to mustard gas. This mortality was greater in those individuals with long-term occupational exposure than in those with sporadic exposure.

An IARC Working Group reported that there is limited evidence of carcinogenicity of mustard gas in experimental animals (IARC 1975, 1982, 1987). When administered by inhalation or intravenous injection, mustard gas caused increased incidences of lung tumors in mice of both sexes. Subcutaneous administration of mustard gas induced local fibrosarcomas or sarcomas in mice of both sexes.

ADDITIONAL INFORMATION RELEVANT TO CARCINOGENESIS OR POSSIBLE MECHANISMS OF CARCINOGENESIS

Evidence of covalent binding to cellular DNA, RNA, and protein *in vivo* was obtained in mice injected intraperitoneally with ^{35}S-labelled mustard gas. Chromosomal aberrations and DNA damage in rodent cells *in vitro* and mutation in mouse lymphoma cells *in vitro* and in a host-mediated assay were induced by mustard gas. Aneuploidy, heritable translocations, dominant lethal mutations, and sex-linked recessive lethal mutations in *Drosophila* were also induced. Mustard gas was mutagenic to fungi and also induced DNA damage in bacteria (IARC 1987).

PROPERTIES

Mustard gas [bis(2-chloroethyl) sulfide] is a colorless, oily liquid or yellow prisms with a weak, sweet, agreeable, or garlic-like odor. It is sparingly soluble in water and soluble in fat, fat solvents, and other common organic solvents. Mustard gas volatilizes in steam. It is combustible when exposed to heat or flame. Products of its hydrolysis are thiodiglycol and hydrochloric acid. Commercial production results in the formation of a mixture containing approximately 70% mustard gas and 30% high molecular weigh polysulfides (HSDB 2001).

USE

Mustard gas is used primarily as a model compound in biological studies of alkylating agents. Researchers have tested mustard gas as an antineoplastic agent, but its clinical use as a tumor inhibitor has been minimal. Use of mustard gas in chemical warfare occurred mainly during World War I (IARC 1975, HSDB 2001). It was also formerly used in the topical treatment of psoriasis (HSDB 2001).

PRODUCTION

There was no indication that mustard gas is manufactured or used in the United States at the present time (HSDB 2001). Two U.S. suppliers were identified in 2001 (Chem Sources 2001). U.S. companies produced and stockpiled the chemical during World War II, and stocks may have existed in the United States as recently as 1974; however, no volumes have been reported (IARC 1975).

EXPOSURE

The primary routes of potential human exposure to mustard gas are inhalation and dermal contact. From the 1987 Survey of Veterans conducted by the Census Bureau of Veterans Affairs, World War II (WWII) veterans had the highest percentage reporting health problems and disability (43%). The effects of mustard gas are of concern not only for this group but also for World War I (WWI) veterans. During the first World War, as many as 28,000 of the American Expeditionary Forces were exposed to the chemical vesicant, but seldom to lethal concentrations due to dispersion of the gas on the battlefield. Although mustard gas was not used in WWII, the United States produced and stockpiled the chemical for possible use. Aware of the same strategy occurring in other countries, particularly Germany and Japan, the U.S. military launched a secret research program to prepare against the threat of such an attack. Using military volunteers, top secret experiments of protective equipment, clothing, and antivesicant ointments were conducted. They involved patch or drop tests, chamber tests, and field tests. The patch or drop tests, employed to assess the strength of protective ointments, exposed 15,000 to 60,000 soldiers and sailors to mustard gas. In chamber tests, protective masks and clothing were evaluated by exposing volunteers to the chemical in a gas chamber for an hour or more every day or every other day until penetration was observed, evidenced by moderate to intense chemical burns on the skin. The same outcome was sought in field tests, which required soldiers to cross tropical or subtropical lands where the gas was dropped to check the quality of masks, protective clothing, and ointments. In the latter two experiments, at least 4,000 servicemen were exposed to mustard gas. Occupational exposure was found to have also occurred during the manufacture of the gas during WWII (Bullman and Kang 1994).

Although the greatest risk of exposure to date has been for military personnel, there is also some small risk for persons living near military installations that stockpile mustard gas. The average and maximum atmospheric concentrations likely to have been produced under military conditions have been estimated to be 3 and 5 ppm, respectively (IARC 1975).

Occupational exposure to mustard gas may occur through inhalation and dermal contact at workplaces where this compound is produced or used. People may be exposed as a result of accidental release or chemical warfare attack. Additionally people may be exposed to residues that had been disposed of in bulk quantities years or even decades ago if these disposal sites are disturbed (HSDB 2001).

Additional human exposure information may be found in the ATSDR Toxicological Profile for Mustard Gas (ATSDR 2001).

REGULATIONS

EPA regulates mustard gas under the Emergency Planning and Community Right to Know Act (EPCRA) subjecting it to reporting requirements. Emergency response plans are required under EPCRA if the threshold planning quantity of 500 lb is exceeded. EPA also regulates mustard gas as a hazardous constituent of waste under the Resource Conservation and Recovery Act (RCRA).

OSHA regulates mustard gas under the Hazard Communication Standard and as a chemical hazard in laboratories. Regulations are summarized in Volume II, Table 116.

REFERENCES

ATSDR. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Mustard 'Gas'. (Update). (Draft for Public Comment). Atlanta, GA: ATSDR, Public Health Service, U.S. Department of Health and Human Services. 2001. 218 pp.

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