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# Chemical Terrorism Fact Sheet

## Methyl Isocyanate

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### Protective Equipment/Detection

Positive-pressure, self-contained breathing apparatus (SCBA) and chemical-protective clothing are recommended in response situations with potentially unsafe levels of methyl isocyanate.

### Decontamination

For eye exposure, irrigate exposed eyes with copious amounts of tepid water for at least 15 minutes. For dermal contact, remove contaminated clothing and wash exposed area thoroughly with soap and water. With acute inhalation, remove the victim from the exposure area as quickly as possible and administer 100% oxygen.

### Signs and Symptoms

The early effects of acute gaseous exposure to methyl isocyanate are respiratory tract and mucous membrane irritation. With eye exposure, the victim will have intense burning of the eyes, photophobia, blepharospasm, profuse lacrimation, lid edema, and superficial corneal ulceration with a resulting reversible blindness. As the exposure continues, respiratory symptoms -- difficulty breathing and cough -- will develop and can progress to acute pulmonary edema and even acute respiratory distress syndrome, with damage noted to the alveolar septa. Other systemic symptoms include nausea, gastritis, sweating, fever, and chills. In the Bhopal accident, burning eyes was the most frequently reported first symptom, followed by coughing, watering of the eyes, and vomiting in that order. Cough was significantly associated with a poor prognosis. Among less frequently mentioned symptoms, diarrhea was also strongly associated with mortality, while shortness of breath was strongly, inversely related to death. Many of the Bhopal deaths resulted from secondary respiratory infections such as bronchitis and bronchial pneumonia. Severe changes in lung function, renal tubular necrosis and reduced liver function have been reported as well.

Methyl isocyanate is also a skin irritant causing a burning sensation. It can be absorbed through the skin, although little is known about this route of exposure.

The chemical is highly toxic with oral exposure, and once absorbed it reaches various organs in its active form. In animal studies, the systemic effects include a dose-dependent hypotension, hemoconcentration, hyperglycemia, clinical lactic acidosis and uremia. These will also be evident with inhalation.

### Chemical Overview

**Methyl isocyanate** --  $C_2H_3NO$  -- is a colorless liquid that has a sharp odor with an odor threshold of 2.1 ppm. Its vapor pressure is 348 mm Hg at 20° C and it is highly flammable with a low flash point. Methyl isocyanate is a chemical intermediate in the production of carbamate insecticides and herbicides, and is extremely toxic to humans from acute (short-term) exposure. In 1984, in Bhopal, India, an accidental acute inhalation exposure to the gas, estimated at 13 to 100 ppm, resulted in the deaths of more than 2,000 people within 5 days and adverse health effects in greater than 170,000 survivors. However, the main source of potential exposure is an occupational one in those workers who use insecticides and herbicides produced from methyl isocyanate. It has also been found in cigarette smoke (about 4 µg per cigarette).

Methyl isocyanate diffuses through polyethylene and attacks most elastomers (fluorocarbon resins are resistant). It is dangerous to use materials other than stainless steel, nickel, or glass/ceramic in contact with methyl isocyanate. In particular, do not use iron, steel, zinc, tin, copper, or their alloys.

Acute animal tests in rats have shown methyl isocyanate to be extremely toxic from inhalation exposure ( $LD_{50} < 200$  mg/m<sup>3</sup>), as well as being highly toxic from oral exposure ( $LD_{50}$  of 50-500 mg/kg). Acute exposure to concentrations of methyl isocyanate of 23 mg/m<sup>3</sup> is irritating to the eyes, nose, and throat; 68 mg/m<sup>3</sup> results in a risk of severe injuries; and 225 mg/m<sup>3</sup> may result in death. While the EPA has not established a Reference Concentration (RfC) or a Reference Dose (RfD) for methyl isocyanate, the California EPA has calculated a chronic inhalation reference exposure level of 0.001 mg/m<sup>3</sup> based on lung and body weight effects in rats. This reference exposure level is a

## Treatment

Treatment is primarily supportive, with attention directed to treating pulmonary irritation and maintaining adequate ventilation and oxygenation.

For oral exposures, administer activated charcoal as a slurry (240 mL water/30 gm charcoal) at a dose of 25 to 100gm in adults and adolescents, 25 to 50gm in children ages 1 to 12 years, and 1 gm/kg in infants less than 1 year old. The use of a cathartic may be beneficial, but such benefits are not proven.

Eye contact with liquid methyl isocyanate is extremely irritating and may cause permanent damage. Gaseous exposure, while irritating, does not tend to result in permanent injury. Mydriatics, systemic analgesics, and topical ophthalmic antibiotics may be used for corneal abrasions. Severe iritis may be treated with topical atropine or homatropine.

Dermal exposure is extremely irritating and should be treated topically as indicated. Patients who develop dermal hypersensitivity reactions may require treatment with systemic or topical corticosteroids or antihistamines.

Following inhalation, markedly symptomatic patients should receive oxygen, ventilatory support, and an intravenous (IV) line. If bronchospasm is evident, consider inhaled sympathomimetics, IV theophylline, parenteral sympathomimetics (epinephrine, terbutaline) and steroids. All patients displaying pulmonary symptoms should be hospitalized and observed for 72 hours in order to detect a delayed onset of pulmonary edema. For pulmonary edema, maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Hypoxia may be controlled by O<sub>2</sub> supplementation, and the early use of positive airway pressure intermittent positive pressure breathing (IPPB), a positive end-expiratory pressure (PEEP) mask or, if necessary, intubation (with or without a ventilator) may delay and/or minimize the pulmonary edema and reduce the degree of hypoxia.

Monitor ECG, chest x-ray, pulse oximetry, peak air flows, arterial blood gases, serum electrolytes, and renal and hepatic function in symptomatic patients.

## Chemical Overview (Continued)

concentration at or below which adverse health effects are not likely to occur. An experiment on human exposure revealed no irritation at levels of 0.4 ppm, while exposure at 2 ppm produced bronchial irritation and lacrimation, and exposure at 21 ppm was unbearable. Based on these and other data, an 8-hour threshold limit value of 0.02 ppm (46 µg/m<sup>3</sup>) has been set.

## Long-term Medical Sequelae

The long term effects of acute methyl isocyanate exposure are being followed after the Bhopal accident. Survivors there are showing chronic eye (loss of vision, loss of visual acuity, and cataracts) and pulmonary (bronchoalveolar lesions and decreased lung function) damage; and reproductive effects, with an increased number of stillbirths, spontaneous abortions and low birth weight babies, have been noted. The EPA has classified methyl isocyanate in Group D, not classifiable as to human carcinogenicity. Its teratogenicity has not been defined.

## Environmental Sequelae

If **methyl isocyanate** is released to moist soil or to water, it will rapidly hydrolyze to N-carboxymethylamine, methylamine, carbon dioxide, and N,N'-dimethylurea. Based upon methyl isocyanate's measured vapor pressure, volatilization from dry near-surface soil or surfaces is likely. Since it rapidly hydrolyzes, bioconcentration, volatilization, and adsorption to sediment and suspended solids are not expected to be significant processes.

## Disclaimer

Information contained in this fact sheet was current as of October 2002, and was designed for educational purposes only. Medication information should always be researched and verified before initiation of patient treatment.

Additional information and references available at <http://www.bioterrorism.slu.edu>