



Arsenic

Substance Technical Guidelines

UCSC Laboratory Safety Services
Providing a little slug of information on . . .

Chemical Information Overview

GENERAL OVERVIEW

Nearly all forms of arsenic are toxic. Certain arsenic compounds are known human carcinogens. Chronic exposure in either occupational settings or through drinking of contaminated groundwater can cause poisoning and carries an increased risk of skin, lung, and bladder cancers. Systemic effects may occur with chronic arsenic poisoning, regardless of the route of exposure. Acute arsenic ingestion generally produces signs and symptoms within 30 minutes but may be delayed in onset for several hours if ingested with food. Initial signs and symptoms of arsenic ingestion include burning lips, throat constriction, and dysphagia (difficulty swallowing) followed by excruciating abdominal pain, severe nausea, projectile vomiting, and profuse "rice water-like" diarrhea. A garlic-like odor of the breath and feces may occur. Many arsenic compounds are skin, eye, and mucous membrane irritants. Ulceration of nasal septum, Dermatitis, Gastrointestinal disturbances, Peripheral neuropathy, Respiratory Irritation, Hyperpigmentation of skin, Potential occupational carcinogen

USES/FORMS/SOURCES

- A. Arsenic is found to a small extent as the element, mostly as an arsenide of true metals. It is usually produced as the trioxide when smelting ores for those metals.
- B. Arsenic is used: in metallurgy for hardening copper, lead, and alloys; in the manufacture of certain types of glass; in pigment production; in insecticides, fungicides, and rodenticides; as a by-product in the smelting of copper ores; as a radioactive tracer (an artificial isotope, As) in toxicology.
- C. Arsenic is used as a dopant material in semiconductor manufacture.
- D. Most likely, arsenic occurs throughout the universe. Meteorites contain from 0.0005 to 0.1% arsenic. The occurrence of this compound in the earth's crust is 1.8 ppm.

ACUTE CLINICAL EFFECTS

- A. Arsenic can cause severe gastrointestinal damage, including vomiting, diarrhea, and shock, following ingestion. Facial swelling, muscle cramps, cardiac abnormalities, anemia, decreased white blood cell count, and enlargement of the liver have also been noted in acute ingestions (ILO, 1983). These effects can be immediate or delayed in onset
- B. Arsenic trioxide is generally the most commonly arsenic compound encountered by the inhalation exposure route, unless arsine gas is a hazard in a particular industrial setting. The toxicity of arsine is quite different than that of other arsenic compounds. Inhalation of arsine gas causes HEMOLYSIS and results in anemia, jaundice, and kidney failure from deposition of red blood cell breakdown products in the renal tubules.
- C. Inorganic arsenic compounds are absorbed through intact skin, with trivalent compounds being more rapidly absorbed than pentavalent compounds. The effects of acute exposure solely to the skin are not well described in the literature, but would presumably include severe skin irritation followed by the possibility of developing any or all the effects described above.

CHRONIC CLINICAL EFFECTS

- A. Ulceration of nasal septum, Dermatitis, Gastrointestinal disturbances, Peripheral neuropathy, Respiratory Irritation, Hyperpigmentation of skin, cancer
- B. As little as 3 to 4 mg of arsenic per day can cause chronic poisoning. The trivalent form is eliminated less rapidly than the pentavalent form, and can cause cumulative toxicity (HSDB).

Chronic arsenic poisoning appears to be more common from non-industrial exposures; cases of poisoning from ingestion of arsenic-based herbicides are still common

- C. Evidence for chronic effects from ingestion of arsenic comes from its use in human medicine for the treatment of psoriasis. A peculiar hyperpigmentation of the skin occurs, particularly on the palms of the hands and soles of the feet (Friberg et al, 1986). So-called blackfoot disease (gangrene), anemia, and cirrhosis of the liver (perhaps complicated by alcohol intake in winery workers) have also been reported with chronic arsenic ingestion.
- D. Similar systemic effects may occur with chronic arsenic poisoning, regardless of the route of exposure. The major target organs for arsenic toxicity are the nerves, heart, blood/bone marrow, and liver. Nervous damage can be both central (encephalopathy) and peripheral (peripheral polyneuropathy) (HSDB). Early symptoms of peripheral nerve damage include pain, numbness, tingling, a pins-and-needles sensation in the extremities, loss of touch sensation, foot or wrist drop, and muscle cramps.
- E. Arsenic may be a rare example of a chemical carcinogen that is also a co-promoter. An NIH study showed arsenic enhances the development of skin neoplasms via the chronic stimulation of keratinocyte-derived growth factors.

MINIMUM LETHAL EXPOSURE

- A. ACUTE
 - 1. As little as 20 mg of arsenic may produce life-threatening toxicity
 - 2. 200 mg of arsenic trioxide ingested acutely by an adult may be lethal.
 - 3. One mg/kg of ingested arsenic may be lethal in a child.

WORKPLACE STANDARDS

- A. **ACGIH-TLV:** Listed (elemental and inorganic compounds, as As): 0.01 mg/m³ TWA; no STEL
Other isomers: 500 ppm TWA; 1000 ppm STEL
 - 1. Notation(s):
 - a. Skin Notation: Listed
 - b. Carcinogenicity: Confirmed Human Carcinogen
 - 4. TLV Basis - Critical Effect(s): Cancer (lung, skin); lung
- B. **OSHA PEL:** Listed (OSHA, 1997a) The PELs are 8-hour TWAs unless otherwise noted; a (CEILING) designation denotes a ceiling limit. They are to be determined from breathing-zone air samples.
 - 1. Limit(s) for Air Contaminant (Table Z-1):
 - a. organic compounds, as As: 0.5 mg/m³.
- C. **NIOSH VALUES:** (NIOSH, 1998)
 - 1. REL 0.002 mg/m³ (STEL) Ceiling
 - a. A Ceiling value should not be exceeded at any time.
 - 2. **IDLH VALUE** (as As): 5 mg/m³

TOXICOLOGIC MECHANISM

- A. Arsenic inactivates sulfhydryl-containing enzymes such as lactic dehydrogenase in heart muscle, thereby producing toxicity (Gorby, 1988). Similar effects occur in the gastrointestinal tract and in neurologic tissues leading to the observed clinical toxicity.
- B. The severe gastroenteritis may not be due to a direct corrosive effect but secondary to the effects of absorbed arsenic on the vascular beds.
- C. Competition for sulfhydryl binding by 2,3 dimercaprol (BAL) or D-penicillamine has resulted in successful reversal of arsenic poisoning.
- D. Pentavalent arsenic acts as an uncoupler of both oxidative phosphorylation and the phosphorylation associated with glycolysis. It is incorporated into key high energy

intermediates by imitating the phosphate ion. This blocks fat and tissues rich in oxidative systems, mainly the gastrointestinal tract, kidney, liver, lung, and epidermis are most affected.

CHEMICAL AND PHYSICAL PROPERTIES

Appearance/Odor/Taste A silver-grey brittle, crystalline, metallic-looking substance

Odorless

Nearly tasteless

Cas Registry Number 7440-38-2

Molecular Weight: 74.92

Boiling Point: Sublimes

Solubility in Water: Insoluble

Flash Point: -None

Ionization Potential: NA

Specific Gravity: 5.73

Flammability Class: Metal: Noncombustible Solid in bulk form, but a slight explosion hazard in the form of dust when exposed to flame

Vapor Pressure: 0 mmHg @ 68°F

Melting Point: - 817 DEG C @ 28 ATM

Upper Explosive Limit in air (% by volume): NA

Lower Explosive Limit in air (% by volume): NA%

Emergency and First Aid Procedures

Ingestion (Swallowing): Rinse mouth with water. Do not induce vomiting. If the victim is conscious, give water. Keep affected person warm and at rest. Get medical attention immediately.

Inhalation (Breathing): Remove the victim from the exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep the affected person warm and at rest. Qualified first-aid or medical personnel should administer care until the victim can be transported to a medical facility.

Skin Contact. Remove contaminated clothing (including shoes) immediately. Wash the affected area of body with soap or mild detergent and large amounts of water until no evidence of the chemical remains (at least 10 to 20 minutes). Get medical attention.

Eye Contact: Wash the eyes immediately with large amounts of water occasionally lifting lower and upper lids, until no evidence of chemical remains (at least 15 to 20 minutes). Remove contact lenses if they are not rinsed by eyewash. Get medical attention immediately.

Emergency Procedures

Emergencies: If a spill of appreciable quantity occurs, leave the area quickly unless you are a designated person who has been given specific emergency response training and duty assignments. Do not touch spilled material. Designated persons should isolate the hazard area and deny entry except for necessary people protected by suitable protective clothing and respirators adequate for the exposure.