Massachusetts Chemical Fact Sheet

Arsenic and Arsenic Compounds

Inorganic arsenic is a known human carcinogen. An element in the earth's crust, inorganic arsenic enters production primarily in the form of arsenic trioxide or "white arsenic." It is also used as a pure metal and in the form of arsine gas. The most common end-use for arsenic in the U.S. and Massachusetts is as a wood preservative. Massachusetts firms also use arsenic as an intermediary in the manufacture of electronic products. Following the national trend, arsenic use in Massachusetts is growing, with total use up 13% between 1990 and 1996.

ARSENIC FACTS

CAS Number:	7440-38-2
Chemical Symbol:	As
Water Solubility:	None

ARSENIC TRIOXIDE FACTS

Common Names:	White Arsenic
Chemical Formula:	As_2O_3
CAS Number:	1327-53-3
Water Solubility:	Slightly soluble

ARSINE GAS FACTS

Chemical formula:	AsH_3 (gas)
CAS Number:	7784-42-1
Flammability:	Flammable gas

Hazards

Acute (Short-Term) Health Effects

- Acute inhalation of arsenic can cause nausea, vomiting, diarrhea, and abdominal pain and/or irritation of the nose and throat.
- Skin and eye contact can cause irritation and burning.
- Arsine gas is lethal to humans between 25 and 50 ppm (parts per million).

Chronic (Long-Term) Health Effects

- Inorganic arsenic is a known carcinogen. The U.S. EPA (Environmental Protection Agency) classifies inorganic arsenic as a Group A carcinogen, a human carcinogen of high carcinogenic hazard. The inhalation of inorganic arsenic is strongly associated with lung cancer and its ingestion has been linked to skin, bladder, liver, and lung cancers. The International Agency for Research on Cancer (IARC), classifies arsenic as a Group 1 carcinogen; it is carcinogenic to humans.
- Human and animal data suggest that inorganic arsenic is a reproductive hazard. The data are insufficient for developing a definitive causal relationship, especially due to the chance that other chemicals and risk factors were involved in analyses of human exposure.
- Chronic human inhalation of inorganic arsenic is associated with irritation of the skin and mucous membranes (dermatitis, conjunctivitis, pharyngitis, and rhinitis).
- Chronic oral exposure has resulted in kidney, liver, or stomach damage, as well as anemia, skin lesions, and holes or ulcers in the "bone" dividing the inner nose.

Exposure Routes

Worker Health

Facilities using arsenic or any of its compounds must minimize worker exposure.

- Ideally, arsenic should be used in closed systems, where it is automatically transferred from storage to process containers.
- If a closed production system is infeasible, facilities need to enclose operations and use local exhaust ventilation.
- Facilities must implement precautions to avoid contact with skin and eyes. For example, workers should not bring clothes home.

While arsenic is not flammable, contact with fire will produce poisonous gases.

Workers in metal smelters and wood preserving businesses are most likely to be exposed to above average levels of arsenic. Most industrial accidents involving arsenic occur when it is converted into arsine gas.

Public Health

Found naturally in the environment and used in industry and agriculture, people are exposed to arsenic on a daily basis.

- For most people food is the primary source of inorganic arsenic exposure, with daily exposure levels ranging from 25-50 micrograms (µg) per day. Lower level exposures result from drinking water and breathing air.

- Residents living near metal smelters or facilities that burn plywood or other arsenic-treated wood products may be exposed to elevated levels of inorganic arsenic.

Use Nationally and in Massachusetts

In the U.S, arsenic production ended in 1985 when ASARCO closed its smelter in Tacoma, Washington. Now solely a consumer of arsenic, the U.S. used 22,300 metric tons in 1995 to produce industrial and agricultural chemicals, ceramics and glass products, electronics, and other products[1].

- Industrial chemicals, primarily wood preservatives, accounted for 88% of U.S. arsenic consumption.

- Agricultural chemicals accounted for 4.5% of U.S. arsenic consumption. Today agricultural use of arsenic is limited to the herbicides disodium methanearsonate and monosodium methanearsonate, for weed control in cotton fields. With the discovery of the hazards of arsenic and the development of organic-based herbicides and pesticides, arsenic use in agriculture has declined steadily since the 1930s and 1940s, when an estimated 45,000 metric tons of arsenic-based insecticides were used annually. As late as 1975, agricultural chemicals accounted for over 80% of total arsenic consumption in the U.S.

- Ceramics and glass products accounted for 3% of U.S. arsenic consumption. Arsenic compounds remove dispersed air bubbles and color in glass manufacturing and control the rate of crystal growth in the glass ceramics industry.

- Electronics and nonferrous alloys accounted for 2.7% of U.S. arsenic consumption. Arsenic serves a variety of functions in the electronics industry: it is used in the processing of gallium arsenic crystal, as a dopant in silicon wafers, and to manufacture arsine gas, which is used to make superlattice materials, lightwave devices, and high performance integrated circuits. Arsenic metal also increases corrosion resistance and tensile strength in copper alloys and strengthens posts and grids in lead-acid batteries.

- The manufacture of pharmaceuticals and feed additives accounted for 1.8% of U.S. arsenic consumption.

Between 1990 and 1995 U.S. consumption of arsenic grew

Table 1. Massachusetts Arsenic & Arsenic Compounds Data: Inputs and Outputs for 1990 and 1996

Input Data -- MA TURA	Inputs (pounds) 1990	1996	Change in Inputs (pounds)	% Change
Manufactured or Processed	505,447	572,277	66,830	13%
Otherwise Used	0	0	0	N/A
Total TURA Inputs	505,447	572,277	66,830	13%

Output Data -- MA TURA	Outputs (pounds) 1990	1996	Change In Outputs (pounds)	% Change
Byproduct	1,364	4,519	3,155	231%
Shipped In/As Product	504,083	504,466	383	0%
Total TURA Outputs	505,447	508,985	3,538	1%

Releases and Transfers (R&T) Date -- EPA	R&T (pounds) 1990	1996	Change in R&T (pounds)	% Change
Environmental Releases	15	0	-15	-100%
Off-site Transfers	529	4,221	3,692	698%
Total EPA R&T	544	4,221	3,677	676%

Sources: MA TURA -- Massachusetts Toxics Use Reduction Act data, 1998; and U.S. EPA, TRI -- U.S. Environmental Protection Agency, Toxics Release Inventory data, 1998.

from 20,500 metric tons to 22,300 metric tons.[2] Driving the national expansion of arsenic consumption is its use in industrial chemicals/wood preservatives, which increased from 14,400 metric tons in 1990 to 19,600 metric tons in 1995.

Table 2. Massachusetts Arsenic and Arsenic Compounds Use by Use Categories for 1990 and 1996

Use Categories [1]	Facility Name	Use (pounds) 1990	Use (pounds) 1996	Percent Change
Wood Preservative	North American Wood Preserving	66,871	0	-100%
	Notheast Treaters, Inc.	307,429	322,834	5%
	Universal Forest Products	131,147	176,799	35%
	Total	505,447	499,633	-1%
Electronics	Matheson Gas Products, Inc.	0	21,300	N/A [2]
	M/A Com, Inc.	0	51,344	N/A
	Total	0	72,644	N/A
Total Arsenic and Arsenic Compounds		**505,447**	**572,277**	**13%**

[1] Use Categories were assigned based on the Institute's examination of TURA data and in some cases may not represent the actual use; [2] N/A = not applicable; Source: Massachusetts Toxics Use Reduction Act data, 1998.

In Massachusetts, arsenic consumption increased 13% between 1990 and 1996 (see Table 1). Driving the increase in use was the electronics industry, which did not report any use of arsenic in 1990, but reported almost 73,000 pounds in 1996 (see Table 2).

- Matheson Gas Products, Inc., reported 21,300 pounds of arsenic used to manufacture arsine gas for use in the electronics industry including: the manufacture of superlattice materials, lightwave devices, and high performance integrated circuits.

- M/A Com reported 51,000 pounds of arsenic used: to produce arsine gas, to produce gallium arsenide crystal for use in semiconductor wafers, and as a dopant for manufacturing silicon wafers.

Similar to the nation, the primary use of arsenic in Massachusetts is as a wood preservative; it accounted for 100% of arsenic use in 1990 and 87% in 1996. Overall, the use of arsenic as a wood preservative in Massachusetts declined by 1% between 1990 and 1996. This reduction is a combination of one facility closing, and two larger facilities increasing their use of arsenic by almost 40%.

Table 1 includes two sources of "output" data: Massachusetts Toxics Use Reduction Act (MA TURA) and U.S. Environmental Protection Agency (EPA), Toxics Release Inventory (TRI) data. The MA TURA database includes all non-product material created by a process line prior to release, on-site treatment, or transfer ("byproduct") and the amount of toxic chemical incorporated into a product ("shipped in or as product"). The U.S. EPA, TRI database includes information on the waste materials generated by a facility after on-site treatment including: releases to air, land, and water ("environmental releases") and transfers off-site for treatment or disposal ("off-site transfers").

- Total MA TURA outputs of arsenic and its compounds increased by only 1% between 1990 and 1996. In the electronics industry, arsenic is commonly used as an intermediary chemical and is transformed into new products like arsine gas and gallium arsenide crystal. Therefore, little TURA-reportable byproduct results from these uses.

- Total EPA releases and transfers for Massachusetts increased between 1990 and 1996, rising from 544 pounds to 4,221 pounds. EPA off-site transfers increased because M/A Com reported almost 4,000 pounds of waste arsenic that was not generated in 1990.

Alternatives

Chromated copper arsenate (CCA) is a popular wood preserving chemical, replacing creosote and pentachlorophenol, two previously popular wood preservatives. CCA consists of chromium (a bactericide), copper (a fungicide) and arsenic (an insecticide) and is one of the chemical compounds used to produce what is commonly called pressure-treated wood. This wood is used for decks, fences, boat docks, playground equipment, utility posts, wherever wood must be protected from decay. In an effort to reduce their use of both arsenic and chromium,

some European companies have developed alternatives. These include copper acetate, copper carbonate, copper citrate, cupric oxide and zinc chloride. A consumer can avoid the use of pressure-treated wood by choosing steel, plastic, concrete or aluminum depending on the application. However these materials have their own environmental and/or energy use concerns.

Regulatory Context

Nationally, the Occupational Safety and Health Administration (OSHA) and the EPA both regulate arsenic.

- Reflecting its extreme toxicity, the OSHA permissible exposure limit (PEL) is set at the very low level of 0.01 milligrams per cubic meter, averaged over an 8-hour workshift.

The EPA regulates arsenic under the authority of six environmental statutes. Under the:

- Clean Air Act arsenic is a "hazardous air pollutant."
- Clean Water Act arsenic is a "priority pollutant."
- Comprehensive Environmental Responsibility, Compensation and Liability Act (popularly known as "Superfund"), arsenic is a "hazardous substance."
- Emergency Planning and Community Right-to-Know Act, TRI program, all large quantity users of arsenic must submit data on arsenic releases and transfers.
- Resource Conservation and Recovery Act arsenic is a "hazardous constituent."
- Safe Drinking Water Act a "maximum contaminant level" (MCL) is set for arsenic at 0.05 milligram per liter. The MCL is the maximum permissible level of a contaminant in drinking water from a public water system.

Arsenic has also been identified by the Swedish government as a "sunset" chemical — a chemical whose use should be phased-out due to extreme potential for environmental and human health damage. In particular, Sweden is concerned with its use as a wood preservative and in lead alloys.

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Endnotes

1 All national data are from SRI, 1996.

2 This short time period masks wide fluctuations in U.S. arsenic consumption. Since 1973 (when 22,000 metric tons were consumed), consumption varied between a low of 9,700 metric tons in 1976 to a high of 23,900 metric tons in 1992. Between 1973 and 1995, consumption increased by only one percent (SRI, 1996).

This is one in a series of Massachusetts Chemical Fact Sheets prepared for each of the chemicals in significant use on the Toxics Use Reduction Science Advisory Board's 'more hazardous chemicals' list. For more information on the Chemical Categorization Project, consult the Institute's Technical Report #47.