



2012 Minerals Yearbook

ARSENIC

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In 2012, the United States produced no arsenic and relied mainly on Morocco and China, the leading and second ranked import sources, respectively, for arsenic trioxide and on China for arsenic metal. In 2012, estimated world production of arsenic trioxide was 46,700 metric tons (t). Production figures were not available for arsenic metal in 2012. No arsenic trioxide or commercial-grade arsenic metal has been produced domestically since 1985 following the closure of the ASARCO Inc. copper smelter in Tacoma, WA. Arsenic trioxide was used mostly for the production of arsenic acid used in the formulation of chromated copper arsenate (CCA), a pesticide and preservative used to treat wood products for nonresidential applications such as utility poles, posts, guard rails, pilings, and railroad ties. Arsenic metal was used for electronics applications and in nonferrous alloys.

Legislation and Government Programs

In 1975, the Safe Drinking Water Act mandated that the U.S. Environmental Protection Agency identify and regulate drinking water contaminants, including arsenic, that may have adverse effects on human health. The maximum contaminant level (MCL) for arsenic was established at 50 parts per billion (ppb) and in 2001, was revised to 10 ppb.

In May, Maryland enacted legislation prohibiting the sale and use of roxarsone, or any other additive that contained arsenic, for use as a poultry feed additive. Roxarsone, an organic arsenic compound produced by Pfizer, Inc., and marketed as 3-Nitro® was known for its ability to kill parasites and promote growth in chickens. Pfizer suspended the sale of roxarsone in the United States in July 2011 in response to a finding by the Food and Drug Administration (FDA) that chickens that ate feed treated with roxarsone had high levels of arsenic in their livers. The Maryland law took effect on January 1, 2013 (U.S. Food and Drug Administration, 2011; Larsen, 2012).

Environmental and Human Health Issues

Arsenic is a naturally occurring element that may be present in drinking water as a result of weathering of arsenic-containing minerals exposed by natural processes or released by mining and smelting; as runoff from arsenic-containing pesticides used in orchards; in wastewater runoff from glass and electronics production; as arsenic released from coal-fired powerplants or underground coal fires; or from volcanic eruptions. In humans, some of the noncancerous effects of arsenic exposure include blindness, diarrhea, discoloration and thickening of the skin, nausea, stomach pain, and vomiting. Prolonged arsenic exposure has been linked to cancer of the bladder, kidney, liver, lungs, and prostate (Agency for Toxic Substances and Disease Registry, 2007, p. 1–30).

In February, the FDA announced the results of data collection on the arsenic content in pear juice. From 2005 to 2011, the FDA analyzed 142 samples of pear juice and pear juice concentrate. Of those samples, 23 had levels of inorganic arsenic at or above 23 ppb, the level of concern for inorganic arsenic in pear juice. In each of these cases, the product was either recalled, refused entry into the United States, or the FDA sent a warning letter to the producer of the juice. The FDA was considering setting a guidance level for arsenic in pear juice and pear juice concentrate (U.S. Food and Drug Administration, 2012a).

In September, the FDA released the analytical results of nearly 200 samples of rice and rice products that were analyzed for arsenic content. Based on available data and scientific literature, the FDA did not recommend consumers change their consumption of rice and rice products. The FDA planned to collect and analyze more than 1,000 additional rice and rice product samples and post the data as results became available (U.S. Food and Drug Administration, 2012b).

Several U.S. Geological Survey (USGS) Scientific Investigation Reports issued in 2012 addressed the occurrence of arsenic in drinking water. USGS Scientific Investigation Report 2011–5220 outlined a comprehensive analysis of drinking water well samples in New England, New Jersey, and New York. USGS Scientific Investigation Reports 2012–5065 and 2012–5156 addressed the construction of data models to predict concentrations of arsenic in aquifers and wells (Flanagan and others, 2011, p. 45; Anning and others, 2012, p. 1, 73; Ayotte and others, 2012, p. 2, 13).

Consumption

Apparent domestic consumption for arsenic, based on net imports, was about 6,180 metric tons (t) in 2012, a 26% increase from 4,910 t in 2011. The estimated value of arsenic compounds and metal consumed domestically in 2012 was approximately \$6.5 million.

Domestic consumers of arsenic trioxide to produce CCA were Arch Chemicals, Inc. (Norwalk, CT), Osmose Wood Preserving, Inc. (Buffalo, NY), and Viance LLC (Charlotte, NC).

Arsenic metal was used, along with antimony, to harden ammunition, in solders, and in other applications. Grids and posts in lead-acid storage batteries are strengthened by the addition of arsenic metal. Arsenic is one of several metals used as an antifriction additive in babbitt metals (alloys that are used for bearings).

High-purity (99.9999%) arsenic metal was used to produce gallium-arsenide (GaAs), indium-arsenide (InAs), and indium-gallium-arsenide semiconductors that were widely used in biomedical, communications, computer, electronics, and photovoltaic applications. Arsenic may be used for germanium-

arsenide-selenide or GaAs specialty optical materials. Based on the reported consumption of gallium, about 25 t of arsenic was consumed domestically to produce GaAs integrated circuits in 2011. The value of worldwide GaAs device consumption was \$5.3 billion in 2012, a slight increase from \$5.2 billion in 2011 (Higham, 2013).

Prices

There was little change in the overall arsenic market throughout 2012 compared with that in 2011. According to U.S. Census Bureau data, the value of arsenic trioxide originating from Morocco ranged from \$0.43 to \$0.57 per kilogram in 2012. Global prices for 99%-pure arsenic metal in 2012 ranged from \$0.68 to \$0.78 per pound in January, increasing slightly to a range of \$0.75 to \$0.85 per pound by February, and increasing to a range of \$0.78 to \$0.95 per pound in November where they remained through yearend (Metal-Pages, 2013).

Foreign Trade

In 2012, domestic imports of arsenic compounds were 5,740 t contained arsenic, an overall increase of approximately 15% compared with the 4,990 t imported in 2012. Arsenic trioxide contains about 76% arsenic. In 2012, Morocco was the source of 62% of the arsenic trioxide imported into the United States, China was the source of 25%, and Belgium was the source of 10%.

In 2012, the United States imported 883 t of arsenic metal, a 41% increase compared with the 628 t of arsenic metal imported in 2011. China was the leading source of arsenic metal in 2012, accounting for 86% of U.S. metal imports.

Exports of arsenic metal from the United States in 2012 decreased to 439 t from 705 t in 2011. Export destinations included Honduras (31%), France (21%), Guatemala (15%), and Colombia (9%). Because the United States did not produce arsenic metal, it was thought that much of the material reported as metal under the Harmonized Tariff Schedule code 24808 was arsenic-containing compounds and waste. The exports also may have included arsenic-containing electronic waste, such as circuit boards and other electronic components destined for reclamation and recycling. Therefore, actual exports of arsenic metal may be significantly less than reported.

World Review

In 2012, commercial-grade arsenic trioxide was thought to have been recovered from processing of nonferrous ores or concentrates in eight countries. Reduction of arsenic trioxide to arsenic metal accounted for all world output of commercial-grade (99%-pure) arsenic metal. Arsenic-containing residues and smelter dusts recovered from nonferrous metals plants in several countries may not have been processed to recover commercial-grade arsenic trioxide in 2012 and may have been stockpiled for future treatment. Production data for most countries were estimated.

In 2012, China produced approximately 26,000 t of arsenic trioxide and remained the world's leading producer followed by Chile (10,000 t) and Morocco (8,000 t). In China, in addition to reclaiming arsenic as a byproduct of nonferrous smelting, arsenic was recovered as a byproduct of gold mining from

orpiment (As_2S_3) and realgar (AsS), the more common ore minerals of arsenic (Peters and others, 2002, p. 182).

Outlook

The voluntary decision by the wood preservative industry at yearend 2003 to eliminate CCA as a wood preservative for certain wood products led to an overall decline in U.S. consumption of arsenic trioxide. The use of alternative wood preservatives and wood alternatives, such as concrete, plastic, or wood composites, will continue to reduce use of CCA wood preservatives. Specific industrial applications, such as marine timber, plywood roofing, and utility poles, are expected to continue to use CCA-treated wood.

The use of GaAs components in cellular handsets and increased penetration of GaAs-based light-emitting diodes in general and automotive lighting applications are expected to increase arsenic metal consumption.

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TABLE 1
 SALIENT ARSENIC STATISTICS¹

(Metric tons of arsenic content)

	2008	2009	2010	2011	2012
Imports:					
Metal ²	376	438	769	628	883
Compounds	4,810	4,660	4,530	4,990	5,740
Total	5,180	5,100	5,300	5,620	6,620
Exports:					
Metal ²	1,050	354	481	705	439
Apparent Consumption	4,130	4,740	4,820	4,910	6,180
Price, cents per pound, average³					
Metal (China)	125	121	72	74	75
Trioxide (Morocco)	19	20	20	22	24

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Listed as metal only, but may include alloys, waste, and compounds.

³Landed duty-paid unit based on U.S. imports for consumption.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF ARSENIC PRODUCTS¹

Class and country	2011		2012	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Arsenic trioxide:				
Belgium	794	\$458	731	\$489
China	1,080	486	1,900	855
Germany	(2)	3	--	--
Hong Kong	--	--	240	108
Japan	(2)	4	--	--
Morocco	4,690	2,290	4,680	2,460
Spain	--	--	(2)	2
Total	6,570	3,240	7,550	3,910
Arsenic acid:				
Japan	4	26	4	40
Taiwan	20	17	--	--
Total	24	42	4	40
Arsenic sulfide, Russia	2	28	(2)	30
Arsenic metal:				
China	611	999	758	1,260
Finland	(2)	10	--	--
France	--	--	(2)	4
Germany	2	407	6	454
Japan	15	697	112	804
United Kingdom	(2)	17	7	28
Total	628	2,130	883	2,550

-- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
ARSENIC TRIOXIDE: ESTIMATED WORLD PRODUCTION, BY COUNTRY^{1, 2, 3}

(Metric tons)

Country ⁴	2008	2009	2010	2011	2012
Belgium	1,000	1,000	1,000	1,000	1,000
Bolivia	74 ⁵	115 ⁵	155 ⁵	99 ^{r, 5}	100
Chile	10,000	11,000	11,000	10,000	10,000
China	25,000	25,000	25,000	25,000	26,000
Japan	40	40	40	40	40
Mexico	-- ^r	--	--	--	--
Morocco	8,000 ^r	8,655 ^{r, 5}	13,731 ^{r, 5}	8,154 ^{r, 5}	8,000
Peru ⁶	4,822 ⁵	301 ⁵	-- ⁵	-- ⁵	--
Portugal	15	15	15	15	15
Russia	1,500	1,500	1,500	1,500	1,500
Total	50,500^r	47,600^r	52,400^r	45,800^r	46,700

^rRevised. -- Zero.

¹Includes calculated arsenic trioxide equivalent of output of elemental arsenic compounds other than arsenic trioxide, inclusion of such materials would not duplicate reported arsenic trioxide production.

²World totals and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

³Table includes data available through July 2, 2013.

⁴Austria, Hungary, Iran, the Republic of Korea, Serbia and Montenegro, South Africa, Ukraine, the United Kingdom, and Zimbabwe have produced arsenic and (or) arsenic compounds in previous years, but information is inadequate to make estimates of output levels, if any.

⁵Reported figure.

⁶Output of Empresa Minera del Centro del Perú (Centromín Perú) as reported by the Ministerio de Energía y Minas.