



2015 Minerals Yearbook

ARSENIC [ADVANCE RELEASE]

ARSENIC

By Mark Brininstool

Domestic tables were prepared by Samir Hakim, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2015, the United States produced no arsenic and relied mainly on Morocco and China for arsenic trioxide and China for arsenic metal. No arsenic trioxide or commercial-grade arsenic metal has been produced domestically since 1985 following the closure of the ASARCO Incorporated 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 guard rails, pilings, posts, railroad ties, and utility poles. Arsenic compounds were also used in fertilizers, fireworks, glassmaking, and pesticides. Arsenic metal was used for electronics applications and in nonferrous alloys. In 2015, estimated world production of arsenic trioxide was 36,500 metric tons (t). Production data for arsenic metal were not available.

Environmental and Human Health Issues

In March, Exide Technologies, Inc. announced that it would permanently close its lead-acid battery recycling plant in Vernon, CA, as part of an agreement between Exide and the U.S. Department of Justice (DOJ). The agreement allowed Exide to avoid criminal prosecution for exposing the land on which the plant was located and surrounding areas to lead, arsenic, and other dangerous pollutants. As part of the agreement, Exide agreed to pay \$50 million dollars for the remediation of the affected areas. A press release issued by the DOJ stated that the U.S. Attorney's Office was concerned that criminal prosecution would result in the liquidation of Exide and agreed not to prosecute so that the company and its other assets would survive to fund the remediation efforts (Barboza, 2015; U.S. Department of Justice, 2015).

Consumption

In 2015, domestic apparent consumption of arsenic, based on the estimated arsenic content of imports, was 6,430 t, an increase of 8% from the 5,940 t imported in 2014. The value of arsenic compounds and metal imported in 2015 was approximately \$5.9 million. Domestic consumers of arsenic trioxide to produce CCA were Arch Wood Protection, Inc. (Norwalk, CT), Koppers Inc. (Pittsburgh, PA), and Viance LLC (Charlotte, NC).

Arsenic metal was used 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, 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. The value of worldwide GaAs device sales was reportedly \$6.9 billion in 2014, an increase of 16% from that in 2013 and, in 2015, the value was estimated to have exceeded \$7 billion (Higham, 2015a, b). Based on preliminary data for reported domestic consumption of gallium, an estimated 24 t of arsenic metal was consumed domestically in the production of GaAs integrated circuits and optoelectronic devices (Edelstein, 2016). (More information on GaAs use can be found in the Gallium chapter of the 2015 Minerals Yearbook, volume I, Metals and Minerals.)

Prices

According to U.S. Census Bureau data, the value of arsenic trioxide originating from Morocco averaged 29 cents per pound, a decrease of 3% from that in 2014. Prices for arsenic metal from China averaged 84 cents per pound, an increase of 12% from that in 2014.

Foreign Trade

In 2015, domestic imports of arsenic compounds were estimated to contain about 5,920 t of contained arsenic, an increase of 13% compared with the 5,260 t imported in 2014 (table 1). Arsenic trioxide contains about 76% arsenic. In 2015, Morocco was the source of 57% of the arsenic trioxide imported into the United States; China, 42%; and Belgium, 1% (table 2).

In 2015, the United States imported 514 t of arsenic metal, a 25% decrease compared with the 688 t of arsenic metal imported in 2014. China was the leading source of arsenic metal in 2015, accounting for 98% of U.S. metal imports (table 2).

According to U.S. Census Bureau data, exports of arsenic metal from the United States in 2015 decreased to 1,670 t from 2,950 t in 2014. Export destinations included Honduras (59%), Guatemala (16%), Jamaica (13%), Peru (3%), and Ecuador (3%). Because the United States did not produce arsenic metal, it was thought that much of the material reported as exports of metal under the Harmonized Tariff Schedule code 2804.80.0000 was arsenic-containing compounds and waste, as well as nonferrous alloys containing relatively minor quantities of arsenic. 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 2015, commercial-grade arsenic trioxide was thought to have been recovered from the processing of nonferrous ores or

concentrates. Reduction of arsenic trioxide to arsenic metal is believed to have 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 2015 and may have been stockpiled for future treatment or disposed. Production data for most countries were estimated.

In 2015, China produced an estimated 25,000 t of arsenic trioxide and remained the world's leading producer, followed by Morocco with 6,900 t. In China, based on historical information, in addition to reclaiming arsenic as a byproduct of nonferrous smelting, arsenic was believed to have been recovered as a byproduct of smelting gold ores containing orpiment (As_2S_3) and realgar (AsS), the more common ore minerals of arsenic (Peters and others, 2002, p. 182).

Outlook

Specific industrial applications, such as marine timber, plywood roofing, and utility poles, are expected to continue to use CCA-treated wood. High-purity arsenic is used in military, solar cells, space, and telecommunications applications. 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.

References Cited

- Barboza, Tony, 2015, How a battery recycler contaminated L.A.-area homes for decades: The Los Angeles [CA] Times, December 21. (Accessed June 21, 2016, at <http://www.latimes.com/local/lanow/la-me-exide-cleanup-story-so-far-20151121-story.html>.)
- Edelstein, D.L., 2016, Arsenic: U.S. Geological Survey Mineral Commodity Summaries 2016, p. 26–27.
- Higham, Eric, 2015a, GaAs RF device revenue reaches record levels in 2014: Strategy Analytics, October 7. (Accessed July 18, 2016, at <https://www.strategyanalytics.com/strategy-analytics/news/strategy-analytics-press-releases/strategy-analytics-press-release/2015/10/07/gaas-rf-device-revenue-reaches-record-levels-in-2014>.)
- Higham, Eric, 2015b, Wireless applications push GaAs device revenues to record levels in 2014—Report summary: Strategy Analytics, April 24, 6 p. (Accessed May 5, 2015, at <http://www.strategyanalytics.com/default.aspx?mod=reportabstractviewer&a0=10828>.)
- Peters, S.G., Jiazhan, Huang, and Chenggui, Jing, 2002, Geology and geochemistry of sedimentary-rock-hosted Au deposits of the Qinling fold belt (Chuan-Shan-Gan) area, Shaanxi, Sichuan, and Gansu Provinces, P.R. China, chap. 4 of Peters, S.G., ed., Geology, geochemistry, and geophysics of sedimentary rock-hosted Au deposits in P.R. China: U.S. Geological Survey Open-File Report 02–131, p. 168–254.
- U.S. Department of Justice, 2015, Exide Technologies admits role in major hazardous waste case and agrees to permanently close battery recycling facility in Vernon: U.S. Department of Justice, U.S. Attorney's Office, Central District of California, March 12. (Accessed June 21, 2016, at <https://www.justice.gov/usao-cdca/pr/exide-technologies-admits-role-major-hazardous-waste-case-and-agrees-permanently-close>.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Arsenic. Ch. in Mineral Commodity Summaries, annual.
- Arsenic. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
- Arsenic (As). Ch. in Metal Prices in the United States Through 2010, Scientific Investigations Report 2012–5188, 2013.
- Arsenic in Minnesota Groundwater. U.S. Geological Survey, 2014 (<https://www2.usgs.gov/envirohealth/headlines/2014-10-03-arsenic.html>).
- Effectiveness of Water-Treatment Systems for Arsenic Used in 11 Homes in Southwestern and Central Ohio, 2013, The. Scientific Investigations Report 2015–5156, 2016.
- Gallium. Ch. in Minerals Yearbook, annual.
- Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.
- Public Perception Impedes Prevention of Arsenic Exposure. U.S. Geological Survey, 2015 (https://www2.usgs.gov/envirohealth/headlines/2015-08-11-understanding_arsenic.html).

Other

- American Wood Protection Association.
- Arsenic. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
- Arsenic (8th ed.). Roskill Information Services Ltd., 1992.
- Arsenic and Old Waste, A report of the U.S. Interagency Working Group on Industrial Ecology, Material and Energy Flows. U.S. Environmental Protection Agency, 1998.
- Gallium and Gallium Arsenide—Supply, Technology, and Uses. U.S. Bureau of Mines Information Circular 9208, 1988.
- Materials Flow of Arsenic in the United States. U.S. Bureau of Mines Information Circular 9382, 1994.

TABLE 1
SALIENT ARSENIC STATISTICS¹

(Metric tons of contained arsenic unless otherwise specified)

	2011	2012	2013	2014	2015
Imports:					
Metal ²	628	883	514	688	514
Compounds	4,990	5,720 ^r	6,290	5,260	5,920
Total	5,620	6,600 ^r	6,810	5,940	6,430
Exports, metal ²	705	444 ^r	1,630	2,970 ^r	1,670
Apparent consumption ³	5,620	6,620	6,810	5,940	6,430
Price, average, cents per pound: ⁴					
Metal (China)	74	75	72	75	84
Trioxide (Morocco)	22	24	27	30	29

^rRevised.

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.

³Estimated to be the same as imports.

⁴Landed duty-paid unit based on U.S. imports for consumption.

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

Class and country	2014		2015	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Arsenic trioxide:				
Belgium	696	\$438	118	\$86
China	2,770	1,250	3,280	1,480
Germany	--	--	(2)	65
Japan	(2)	6	--	--
Morocco	3,470	2,310	4,420	2,830
Total	6,940	4,000	7,810	4,470
Arsenic metal:				
China	618	1,020	502	931
Germany	8	639	1	298
Japan	62	547	10	164
United Kingdom	(2)	5	(2)	5
Total	688	2,210	514	1,400

-- 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	2011	2012	2013	2014	2015
Belgium	1,000	1,000	1,000	1,000	1,000
Bolivia	99 ⁴	104 ⁴	120 ⁴	52 ⁴	50
China	25,000	26,000	25,000	25,000	25,000
Japan	45	45	45	45	45
Morocco	8,154 ⁴	8,820 ⁴	8,968 ⁴	6,860 ^{r,4}	6,900
Namibia	1,750	1,590	1,520	1,980	1,960
Portugal	15	15	--	--	--
Russia	1,500	1,500	1,500	1,500	1,500
Total	37,600	39,100	38,200	36,400	36,500

^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.

³Includes data available through March 15, 2016.

⁴Reported figure.