



2016 Minerals Yearbook

ARSENIC [ADVANCE RELEASE]

ARSENIC

By Micheal W. George

Domestic tables were prepared by Samir Hakim, statistical assistant.

In 2016, 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, but shipments from the remaining stockpile continued until 1994. 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 2016, estimated world production of arsenic trioxide was 37,100 metric tons (t). Production data for arsenic metal were not available.

Environmental and Human Health Issues

In April, the U.S. Food and Drug Administration (FDA) took steps to reduce arsenic in infant rice cereal, a leading source of arsenic exposure in infants. Through draft guidance to the industry, the FDA proposed a limit of 100 parts per billion for inorganic arsenic in infant rice cereal, the same as the limit set in the European Union (U.S. Food and Drug Administration, 2016).

Consumption

In 2016, domestic apparent consumption of arsenic, based on the estimated arsenic content of imports, was 6,120 t, a decrease of 5% from the 6,430 t imported in 2015. The value of arsenic compounds and metal imported in 2016 was approximately \$6.3 million. Domestic consumers of arsenic trioxide that produced CCA were Arch Wood Protection, Inc. (Atlanta, GA), a subsidiary of Lonza Group Ltd. (Switzerland); 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 revenues was reportedly \$8.2 billion in 2016, a slight increase from that in 2015 (Higham, 2016, 2017). More information on GaAs use can be found in the Gallium chapter of the 2016 U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

Prices

According to U.S. Census Bureau data, the value of arsenic trioxide originating from Morocco averaged 31 cents per pound, an increase of 2 cents per pound from that in 2015. Prices for arsenic metal from China averaged 86 cents per pound, a slight increase from that in 2015 (table 1).

Foreign Trade

In 2016, domestic imports of arsenic compounds were estimated to contain about 5,330 t of contained arsenic, a decrease of 10% compared with the 5,920 t imported in 2015 (table 1). Arsenic trioxide, which accounted for more than 99% of the gross weight of compound imports in 2016, contains about 76% arsenic. In 2016, China was the source of 50% of the arsenic trioxide imported into the United States; Morocco was the source of 49% (table 2).

In 2016, the United States imported 793 t of arsenic metal, a 54% increase compared with the 514 t of arsenic metal imported in 2015. China was the leading source of arsenic metal in 2016, accounting for 92% of United States metal imports (table 2).

According to U.S. Census Bureau data, exports of arsenic metal from the United States in 2016 increased to 1,760 t from 1,670 t in 2015. Export destinations included Honduras (54%), Jamaica (17%), Guatemala (10%), Chile (9%), and Belize, Dominican Republic, and Peru (2% each). 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 of the United States 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 2016, 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 was 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 2016 and may have been stockpiled for future treatment or disposed. Production data for most countries were estimated.

In 2016, China produced an estimated 25,000 t of arsenic trioxide and remained the world's leading producer, followed by

Morocco with 7,600 t. In China, based on historical information, 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, in addition to reclaiming arsenic as a byproduct of nonferrous smelting (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

- Higham, Eric, 2016, RF GaAs device revenue reaches a new high in 2015—Report summary: Strategy Analytics, April 8. (Accessed April 4, 2017, at <https://www.strategyanalytics.com/access-services/components/advanced-semiconductors/reports/report-detail/rf-gaas-device-revenue-reaches-a-new-high-in-2015?slid=129476&spg=67>.)
- Higham, Eric, 2017, RF GaAs device revenue hits record level in 2016—Report summary: Strategy Analytics, March 15. (Accessed April 4, 2017, at <https://www.strategyanalytics.com/access-services/components/advanced-semiconductors/reports/report-detail/rf-gaas-device-revenue-hits-record-level-in-2016?slid=129457&spg=3>.)
- 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. Food and Drug Administration, 2016, FDA proposes limit for inorganic arsenic in infant rice cereal: U.S. Food and Drug Administration news release, April 1. (Accessed April 10, 2017, at <https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm493740.htm>.)

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/geohealth/articles/2014-10-03-arsenic.html>).
- 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/geohealth/articles/2015-08-11-understanding_arsenic.html).
- The Effectiveness of Water-Treatment Systems for Arsenic Used in 11 Homes in Southwestern and Central Ohio, 2013. Scientific Investigations Report 2015–5156, 2016.

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 arsenic content unless otherwise specified)

	2012	2013	2014	2015	2016
Imports:					
Metal ²	883	514	688	514	793
Compounds ³	5,720	6,290	5,260	5,920	5,330
Total	6,600	6,810	5,940	6,430	6,120
Exports, metal ²	444	1,630	2,970	1,670	1,760
Apparent consumption ⁴	6,600 ^r	6,810	5,940	6,430	6,120
Price, average: ⁵					
Metal, China cents per pound	75	72	75	84	86
Trioxide, Morocco do.	24	27	30	29	31

^rRevised.

¹Includes data available through May 1, 2017. Data 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.

³Includes arsenic acid, arsenic sulfides, and arsenic trioxide. Arsenic content estimated from the reported gross weight of imports; arsenic trioxide contains nearly 76% arsenic by weight and accounts for nearly all imports.

⁴Estimated to be the same as imports.

⁵Landed duty-paid unit value based on U.S. imports for consumption.

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

Class and country	2015		2016	
	Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Arsenic trioxide:				
Belgium	118	\$86	2	\$8
China	3,280	1,480	3,540	1,640
Germany	(2)	65	(2)	19
Morocco	4,420	2,830	3,470	2,340
Total	7,810	4,470	7,000	4,000
Arsenic sulfides, Italy	--	--	35	98
Arsenic metal:				
China	502	931	728	1,380
France	--	--	(2)	3
Germany	1	298	6	543
Hong Kong	--	--	20	30
Japan	10	164	39	300
United Kingdom	(2)	5	(2)	11
Total	514	1,400	793	2,260

-- Zero.

¹Includes data available through May 1, 2017. Data 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: WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons)

Country ³	2012	2013	2014	2015	2016
Belgium ^e	1,000	1,000	1,000	1,000	1,000
Bolivia	104	120	52	38 ^r	40 ^e
China ^e	26,000	25,000	25,000	25,000	25,000
Iran ^e	100 ^r	100 ^r	100 ^r	-- ^r	--
Japan ^e	45	45	45	45	45
Morocco	8,820	8,970	6,860	7,570	7,600 ^e
Namibia ^e	1,590	1,520	1,980	1,960	1,900
Portugal ^e	15	--	--	--	--
Russia ^e	1,500	1,500	1,500	1,500	1,500
Total	39,200 ^r	38,300 ^r	36,500 ^r	37,100 ^r	37,100

^eEstimated. ^rRevised. -- Zero.

¹Includes data available through May 1, 2017. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to total shown.

²Includes 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.

³In addition to the countries listed, other countries may have produced arsenic, but available information was inadequate to make reliable estimates of output.