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2021 Minerals Yearbook

ARSENIC [ADVANCE RELEASE]

U.S. Department of the Interior
U.S. Geological Survey

April 2025

U.S. Geological Survey, Reston, Virginia: 2025

Arsenic

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In 2021, the United States produced no arsenic and relied mainly on China and Morocco for arsenic trioxide (As_2O_3) and China and Japan for arsenic metal (table 2). No As_2O_3 or commercial-grade arsenic metal had been produced domestically since 1985, following the closure of the ASARCO Inc. copper smelter in Tacoma, WA, but shipments from the remaining stockpile continued until 1994. In 2021, estimated world production of As_2O_3 was 60,000 metric tons (t), slightly less than production in 2020 (revised) (table 3). Production data for arsenic metal were not available.

As_2O_3 was used primarily to produce 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 (arsenic acids, sulfides, and As_2O_3) also were used in fertilizers, fireworks, glassmaking, and pesticides. Arsenic metal was used in nonferrous alloys. High-purity arsenic metal was used for semiconductors in a wide variety of applications for the defense, electronics, energy, and telecommunications sectors.

Government Actions and Legislation

Executive Order 13817, "A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals," was issued on December 20, 2017. Pursuant to the Executive order, the Secretary of the Interior, in coordination with the Secretary of Defense, and in coordination with other executive branch agencies, was tasked with developing and submitting to the Federal Register a list of minerals defined as critical minerals. On May 18, 2018, arsenic was included in the 35 minerals or mineral material groups identified as critical. On June 4, 2019, the White House released "A Federal Strategy To Ensure a Reliable Supply of Critical Minerals," which directed the U.S. Department of the Interior to assist in locating domestic sources of critical minerals, provide information for the study and production of the minerals, and expedite permitting for mineral projects (Trump, 2017; U.S. Department of the Interior, 2018, 2019; Nassar and others, 2020).

Consumption

In 2021, domestic apparent consumption of arsenic, based on the estimated arsenic content of imports, was 5,600 t, a decrease of 32% from the 8,270 t consumed in 2020 (table 1). The value of arsenic compounds and metal imported in 2021 was $6.82 million, a 13% decrease from that in 2020 (table 2). The value of imports of arsenic metal increased by 10% to $2.08 million, but the value of As_2O_3 decreased by 23% to $4.44 million.

Much of the consumption of As_2O_3 was in the production of CCA. Known domestic consumers of CCA were Arch Wood Protection, Inc. (Atlanta, GA), a subsidiary of Lonza Group A.G. (Switzerland); A Meredith Schneider Co. (East Point, GA); Brown Wood Preserving Co., Inc. (Louisville, KY); Koppers Inc. (Pittsburgh, PA); Stella-Jones Corp. (Pittsburgh, PA); Thomasson Co. (Philadelphia, MS); and Viance, LLC (Charlotte, NC). As_2O_3 also was used in the treatment of acute promyelocytic leukemia (National Cancer Institute, 2019).

Arsenic metal was used in nonferrous alloys. Arsenic metal was used to harden ammunition, in solders, and in other applications. The addition of arsenic metal strengthens grids and posts in lead-acid storage batteries. Arsenic was one of several metals used as an antifriction additive in babbitt metals (alloys 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, infrared light-emitting diodes (LEDs), integrated circuits, microwave frequency integrated circuits, monolithic microwave integrated circuits, optical windows, other LEDs, and photovoltaic applications. GaAs devices generate less signal noise than other semiconductor materials; as a result, GaAs semiconductors were useful in weak-signal amplification applications such as wireless communications. Despite the closures, shipping constraints, and the shortage of semiconductor production related to the global coronavirus disease 2019 (COVID-19) pandemic, total revenues from GaAs devices increased in 2021 because of increases in implementation of fifth-generation (5G) technology standards for broadband cellular networks and consumer devices. A variety of GaAs wafer manufacturers ranging from large multinational corporations to small privately owned companies competed in this industry globally, but the top six producing companies—AXT Inc. (Freemont, CA); China Crystal Technologies Co. Ltd. (Beijing, China); DOWA Electronics Materials Co., Ltd. (Tokyo, Japan); Freiberger Compound Materials GmbH (Freiberger, Germany); Sumitomo Electric Industries, Ltd. (Osaka, Japan); and Wafer Technology Ltd. (Milton Keynes, United Kingdom)—accounted for more than 75% of the market. China and Japan each accounted for about 30% of the production of GaAs, followed by Europe (20%), North America (15%), and rest of the world (5%) (Maia Research Co., Ltd., 2019, p. 1, 17; Higham, 2020, 2021, 2022). More information on GaAs use can be found in the Gallium chapter of the 2021 U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

Prices

In 2021, the annual average price for 99%-pure arsenic (in U.S. warehouse), as reported by Argus Metals International, was $1.11 per pound, 3% more than the annual average price in 2020 (table 1). The price began the year at a range of $1.05 to $1.13 per pound, where it remained until late July

when the range increased to $1.05 to $1.20 per pound, where it remained for the rest of the year.

According to U.S. Census Bureau unrounded data, the annual average unit value of As_2O_3 originating from Morocco averaged 83 cents per kilogram in 2021, and from China averaged 43 cents per kilogram; both were unchanged from 2020. The unit value of arsenic metal imported from China averaged $1.38 per kilogram, a decrease of 9% from that in 2020 (table 2).

Foreign Trade

In 2021, domestic imports of arsenic compounds were estimated to contain about 4,760 t of arsenic, a decrease of 39% compared with 7,750 t (revised) imported in 2020 (table 1). As_2O_3, which contains about 76% arsenic by weight, accounted for 98% of the arsenic content of compound imports in 2021. Morocco was the source of 52% of the As_2O_3 imported into the United States; China was the source of 39% (table 2).

In 2021, the United States imported 835 t of arsenic metal, a 60% increase compared with the 522 t of arsenic metal imported in 2020. The leading source of arsenic metal in 2021 was China, which accounted for 94% of United States arsenic metal imports (table 2).

According to U.S. Census Bureau data, exports of arsenic metal (under the Schedule B number 2804.80.0000) from the United States in 2021 increased by 4% to 31 t from 29 t in 2020. Export destinations included France (53%), Ecuador (14%), Argentina (13%), Germany (9%), and Canada (7%). Because the United States did not produce arsenic metal, much of the material reported as exports of metal was arsenic-containing compounds and waste, as well as nonferrous alloys containing relatively minor quantities of arsenic.

World Review

In 2021, As_2O_3 was thought to have been recovered from the processing of nonferrous ores or concentrates, such as copper, gold, and lead. Reduction of As_2O_3 to arsenic metal was thought 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 As_2O_3 in 2021 and may have been stockpiled for future treatment or disposal. Production data for most countries were estimated.

In 2021, Peru produced an estimated 27,000 t of As_2O_3 and was the world's leading producer; China produced 24,000 t, and Morocco produced 6,883 t (table 3). Output from these countries accounted for an estimated 96% of total estimated world production. In China, based on historical information, arsenic was thought 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).

In Morocco, production was from the Managem S.A.'s Bou-Azzer cobalt mine. In 2021, the mine produced 6,883 t of arsenic, an 11% decrease from production in 2020. The decrease was caused by supply disruptions that limited the production of cobalt cathodes (Managem S.A., 2022, p. 115–116).

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 metal is expected to be increasingly used in military, space, and telecommunications applications, and in solar cells. Despite the COVID-19 pandemic that constrained global economies, increased geopolitical tensions, and a global semiconductor shortage, the use of GaAs components increased in 2021 and is expected to increase in 2022. The increase will be mostly in 5G devices and networks (Higham, 2021).

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TABLE 1
SALIENT ARSENIC STATISTICS[1]

(Metric tons, arsenic content)

		2017	2018	2019	2020	2021
Imports:						
Metal[2]		942	929	391	522	835
Compounds[3]		5,980	5,540	7,050 r	7,750 r	4,760
Total		6,920	6,470	7,440 r	8,270 r	5,600
Exports, metal[2]		698	107	56	29	31
Apparent consumption[4]		6,920	6,470	7,440 r	8,270 r	5,600
Price, annual average:[5]						
Rotterdam	dollars per pound	1.08	1.10	1.03	0.94	1.34
U.S. warehouse	do.	0.88	0.97	1.01	1.08	1.11

rRevised. do. Ditto.
[1]Table includes data available through April 29, 2022. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Listed as metal only, but may include alloys, compounds, and waste.
[3]Includes 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.
[4]Estimated to be the same as imports.
[5]Minimum 99% arsenic. Source Argus Media group, Argus Metals International.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF ARSENIC PRODUCTS[1, 2]

Class and country or locality	2020 Gross weight (metric tons)	2020 Value (thousands)	2021 Gross weight (metric tons)	2021 Value (thousands)
Arsenic trioxide:				
Belgium	544	$121	336	$88
China	5,820	2,490	2,380	1,020
Germany	47	179	181	661
Morocco	3,460	2,860	3,220	2,660
Russia	144	100	18	14
Total	10,000	5,750	6,140	4,440
Arsenic sulfide, Germany	2	15	1	4
Arsenic acid:				
Hungary	--	--	66	201
Japan	--	--	(3)	2
Malaysia	210 r	224 r	83	92
Total	210 r	224 r	149	295
Arsenic metal:				
China	466	706	786	1,080
Germany	4	814	9	538
Hong Kong	40	44	--	--
Japan	11	326	40	455
Korea, Republic of	--	--	(3)	7
Total	522	1,890	835	2,080

rRevised. -- Zero.
[1]Table includes data available through April 29, 2022. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Imports calculated from Harmonized Tariff Schedule of the United States codes 2811.29.1000, 2813.90.1000, 2811.19.1000, and 2804.80.0000.
[3]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
ARSENIC TRIOXIDE: WORLD PRODUCTION, BY COUNTRY OR LOCALITY[1, 2]

(Metric tons, gross weight)

Country or locality[3]	2017	2018	2019	2020	2021
Belgium[e]	1,000	1,000	1,000	1,000	1,000
Bolivia	20	238	120	100 e	120 e
China[e]	24,000	24,000	24,000	24,000	24,000
Iran[e]	400	--	--	--	--
Japan[e]	45	45	40	40	40
Morocco	6,879	5,578	5,055	7,694 r	6,883
Namibia	700 e	--	--	--	--
Peru	32,000	29,000	35,000	27,000	27,000 e
Russia	1,500 e	--	2,226	500 r	1,000 e
Total	66,500	59,900	67,400	60,300 r	60,000

eEstimated. rRevised. -- Zero.
[1]Table includes data available through April 29, 2022. All data are reported unless otherwise noted; totals may include estimated data. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes 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.
[3]In addition to the countries and (or) localities listed, other countries or localities may have produced arsenic, but available information was inadequate to make reliable estimates of output.