

ARSENIC

(Data in metric tons of arsenic content¹ unless otherwise noted)

Domestic Production and Use: Arsenic trioxide and primary arsenic metal have not been produced in the United States since 1985. The principal use for arsenic trioxide was for the production of arsenic acid used in the formulation of chromated copper arsenide (CCA) preservatives for the pressure treating of lumber used primarily in nonresidential applications. Three companies produced CCA preservatives in the United States in 2018. The grids in lead-acid storage batteries were strengthened by the addition of arsenic metal. Arsenic metal was also used as an antifriction additive for bearings, to harden lead shot, and in clip-on wheel weights. Arsenic compounds were used in herbicides and insecticides. High-purity arsenic (99.9999%) was used to produce gallium-arsenide (GaAs) semiconductors for solar cells, space research, and telecommunications. Arsenic also was used for germanium-arsenide-selenide specialty optical materials. Indium-gallium-arsenide (InGaAs) was used for short-wave infrared technology. The value of arsenic compounds and metal imported domestically in 2018 was estimated to be about \$5.8 million. Given that arsenic metal has not been produced domestically since 1985, it is likely that only a small portion of the material reported by the U.S. Census Bureau as arsenic exports was pure arsenic metal, and most of the material that has been reported under this category reflects the gross weight of alloys, compounds, residues, scrap, and waste containing arsenic. Therefore, the estimated consumption reported under salient U.S. statistics reflects only imports of arsenic products.

| Salient Statistics—United States: | 2014 | 2015 | 2016 | 2017 | 2018^e |
|---|-------------|-------------|-------------|-------------|-------------------------|
| Imports for consumption: | | | | | |
| Arsenic metal | 688 | 514 | 793 | 942 | 630 |
| Compounds | 5,260 | 5,920 | 5,320 | 5,980 | 4,900 |
| Exports, arsenic ² | 2,970 | 1,670 | 1,760 | 698 | 60 |
| Estimated consumption ³ | 5,940 | 6,430 | 6,120 | 6,920 | 5,500 |
| Value, dollars per kilogram, average ⁴ | | | | | |
| Arsenic metal (China) | 1.64 | 1.85 | 1.89 | 1.56 | 1.40 |
| Trioxide (China) | 0.45 | 0.45 | 0.46 | 0.45 | 0.42 |
| Trioxide (Morocco) | 0.66 | 0.64 | 0.68 | 0.68 | 0.75 |
| Net import reliance ⁵ as a percentage of estimated consumption | 100 | 100 | 100 | 100 | 100 |

Recycling: Arsenic metal was contained in new scrap recycled during GaAs semiconductor manufacturing. Arsenic-containing process water was internally recycled at wood treatment plants where CCA was used. Although scrap electronic circuit boards, relays, and switches may contain arsenic, no arsenic was known to have been recovered during the recycling process to recover other contained metals. No arsenic was recovered domestically from arsenic-containing residues and dusts generated at nonferrous smelters in the United States.

Import Sources (2014–17): Arsenic metal: China, 91%; Japan, 5%; Hong Kong, 3%, and other, 1%. Arsenic trioxide: Morocco, 50%; China, 47%; Belgium, 3%; and other, <1%.

| Tariff: Item | Number | Normal Trade Relations 12–31–18 |
|---------------------|---------------|--|
| Arsenic | 2804.80.0000 | Free. |
| Arsenic acid | 2811.19.1000 | 2.3% ad val. |
| Arsenic trioxide | 2811.29.1000 | Free. |
| Arsenic sulfide | 2813.90.1000 | Free. |

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

ARSENIC

Events, Trends, and Issues: China and Morocco continued to be the leading global producers of arsenic trioxide, accounting for about 85% of estimated world production and supplied almost all of United States imports of arsenic trioxide in 2018. China was the leading world producer of arsenic metal and supplied about 90% of United States arsenic metal imports in 2018.

In May 2018, the U.S. Department of the Interior, in coordination with other executive branch agencies, published a list of 35 critical minerals (83 FR 23295), including arsenic. This list was developed to serve as an initial focus, pursuant to Executive Order 13817, "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals" (82 FR 60835).

High-purity (99.9999%) arsenic metal was used to produce GaAs, indium-arsenide, and InGaAs semiconductors that were used in biomedical, communications, computer, electronics, and photovoltaic applications. Global GaAs wafer revenue was estimated to be \$278 million in 2018, and almost one-half of GaAs wafer production took place in China. See the Gallium chapter for additional details.

World Production and Reserves:

| | Production ⁶ (arsenic trioxide) | | Reserves ⁷ |
|-----------------------|---|-------------------------|--|
| | <u>2017^e</u> | <u>2018^e</u> | |
| United States | — | — | World reserves data are unavailable but are thought to be more than 20 times world production. |
| Belgium | 1,000 | 1,000 | |
| Bolivia | 40 | 40 | |
| China | 24,000 | 24,000 | |
| Iran | 110 | 110 | |
| Japan | 45 | 45 | |
| Morocco | 6,000 | 6,000 | |
| Namibia | 1,900 | 1,900 | |
| Russia | <u>1,500</u> | <u>1,500</u> | |
| World total (rounded) | 34,600 | 35,000 | |

World Resources: Arsenic may be obtained from copper, gold, and lead smelter flue dust, as well as from roasting arsenopyrite, the most abundant ore mineral of arsenic. Arsenic has been recovered from orpiment and realgar in China, Peru, and the Philippines; has been recovered from copper-gold ores in Chile; and was associated with gold occurrences in Canada. Orpiment and realgar from gold mines in Sichuan Province, China, were stockpiled for later recovery of arsenic. Arsenic also may be recovered from enargite, a copper mineral. Arsenic trioxide was produced at the hydrometallurgical complex of Guemassa, near Marrakech, Morocco, from cobalt arsenide ore from the Bou-Azzer Mine.

Substitutes: Substitutes for CCA in wood treatment include alkaline copper quaternary, ammoniacal copper quaternary, ammoniacal copper zinc arsenate, alkaline copper quaternary boron-based preservatives, copper azole, copper citrate, and copper naphthenate. Treated wood substitutes include concrete, plastic composite material, plasticized wood scrap, or steel. Silicon-based complementary metal-oxide semiconductor power amplifiers compete with GaAs power amplifiers in midtier third generation cellular handsets. Indium phosphide components can be substituted for GaAs-based infrared laser diodes in some specific-wavelength applications, and helium-neon lasers compete with GaAs in visible laser diode applications. Silicon is the principal competitor with GaAs in solar-cell applications. GaAs-based integrated circuits are used in many defense-related applications because of their unique properties, and no effective substitutes exist for GaAs in these applications. GaAs in heterojunction bipolar transistors is being replaced in some applications by silicon-germanium.

^eEstimated. — Zero.

¹Arsenic content of arsenic metal is 100%; arsenic content of arsenic compounds is calculated at 75.71%.

²Most of the materials reported to the U.S. Census Bureau as arsenic exports are thought to be arsenic-containing compounds or residues.

³Estimated to be the same as imports.

⁴Calculated from U.S. Census Bureau import data.

⁵Defined as imports.

⁶Chile, Mexico, and Peru were believed to be significant producers of commercial-grade arsenic trioxide but have reported no production in recent years.

⁷See Appendix C for resource and reserve definitions and information concerning data sources.