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ARSENIC

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ARSENIC

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There has been no domestic production of arsenic trioxide (As_2O_3) or arsenic metal since 1985, and the United States was import dependent for all of its supply. In 2005, domestic imports of As_2O_3 increased to 8,330 metric tons (t), an approximate increase of 35% compared with the 6,150 t of As_2O_3 imported in 2004. Owing to a voluntary phaseout of arsenical wood preservatives for nonindustrial uses at yearend 2003, this was still about 60% less than the amount of As_2O_3 imported in 2003. The United States remained the world's leading consumer of arsenic, as As_2O_3, primarily as a component of chromated copper arsenate (CCA), a pesticide-preservative for pressure-treated wood products in commercial applications. Arsenic metal and As_2O_3 were also used for agricultural chemicals, electronics, and nonferrous alloys. China was the source of 51% of the As_2O_3 imported into the United States, Morocco was the source of 30%, and Hong Kong, 10%. Imports of arsenic metal have generally declined since 2001, and in 2005, the United States imported 812 t of arsenic metal, down from 872 t in 2004. China was the leading source, accounting for 718 t, down from 730 t in 2004.

Legislation and Government Programs

In response to health concerns over arsenic contamination in public water systems, the U.S. Environmental Protection Agency (EPA) has set the arsenic standard for drinking water at 10 micrograms per liter (µg/l). Municipal water suppliers were to comply with this standard by January 2006 (U.S. Environmental Protection Agency, 2006§[1]). Arsenic is a common, naturally occurring element that may be a drinking water contaminant. Rural communities have complained that they cannot afford to purchase the systems needed to reduce the arsenic content of water to 10 µg/l. Especially in the southwestern United States, such systems may need to lower the pH of the water by using carbon dioxide or sulfuric acid. Therefore, the EPA has proposed to make it permissible for water systems serving 10,000 or fewer residents to have up to 30 µg/l arsenic in their water (Eilperin, 2006a). In 2004, the U.S. Food and Drug Administration proposed a rule that would insure that the amount of arsenic in bottled water would be comparable with the quality of public drinking water (U.S. Food and Drug Administration, 2004).

Under current U.S. law, aging coal-fired powerplants, chemical plants, and incinerators that emit 10 metric tons per year (t/yr) or more of a single toxin or 25 t/yr or more of a combination of toxins, including arsenic, mercury, and lead, must install maximum achievable control technology to cut the emissions by 95%. A draft proposal by the EPA would lift that requirement from plants that have reduced emissions to below 25 t/yr. Critics argued that if the draft rule were to be implemented, polluters could emit many more tons of arsenic, mercury, and lead by running pollution controls at half-speed (Eilperin, 2006b).

At yearend 2003, domestic manufacturers of arsenic-containing wood preservatives began a voluntary cutback in use of such preservatives after consulting with the EPA. The voluntary phaseout of CCA applied to wood used for boardwalks, decks, fencing, gazebos, picnic tables, and play structures. Wood treated prior to December 31, 2003, could still be used, and glue-laminated beams, marine timbers, plywood flooring and roofing, and utility poles could still be treated with CCA (American Wood Preservers Institute, 2003§).

Environmental Issues

Following the International Conference on Arsenic in 1995 in Calcutta, India, sponsored by the School of Environmental Studies, Jadavpur University, the problem of arsenic in ground water became more widely known by scientists outside of India and an increasing health concern. A study in one district in Bangladesh, for example, found that more than 90% of the water wells had arsenic levels higher than 50 µg/l (Meharg, 2005, p. 16). In Bangladesh, the problem is exacerbated because rice that is grown in ground-water-flooded fields bioaccumulates arsenic, and then the rice may be cooked in arsenic-laden water, which drives the arsenic load even higher (Mehard, 2005, p. 18). In rural and urban water supplies in Peru, arsenic contamination is blamed on mining waste and pesticide use (Luna, 2005).

Arsenic is one of several hazardous elements contained in many electronic products, specifically in the circuit boards of computers, relays, and switches (Ohio Department of Natural Resources, 2005§). In celebration of Earth Day, some organizations posted the locations of dropsites for safe disposal and recycling, or "e-cycling," of computer electronics which may contain arsenic or other hazardous elements (Washington Post, The, 2006). Of global concern was that these electronics, which include used computers and televisions, were being exported and became part of uncontrolled hazardous waste in China or Nigeria (Grossman, 2005).

In the aftermath of Hurricane Katrina, arsenic was one of several contaminants deposited in sludge across New Orleans, LA. Maps have been produced that show several high arsenic areas in the city, and removal of the sludge has been discussed (Hsu and Eilperin, 2006).

Consumption

In 2005, the United States was again the world's leading consumer of arsenic, mainly for CCA. In response to the voluntary ban on CCA at yearend 2003, the global arsenic market declined sharply. Apparent domestic demand was 8,800 t in 2005, up by almost 30% from 6,800 t in 2004, yet far less

[1]References that include a section mark (§) are found in the Internet References Cited section.

than the 21,600 t of arsenic in 2003. The estimated value of arsenic compounds and metal consumed domestically in 2005 was approximately $7 million.

In 2005, about 65% of the arsenic, as As_2O_3, was used in the wood preservative industry for nondomestic use, down from about 90% prior to 2004; the remainder was used in agricultural chemicals, either directly or after conversion to arsenic acid, such as desiccants, glass manufacturing applications., herbicides, and insecticides. Major U.S. producers of CCA included Arch Wood Protection, Inc., Smyrna, GA; Chemical Specialties, Inc., Charlotte, NC; and Osmose Wood Preserving, Inc., Buffalo, NY. Arsenic acid is also used as a bubble dispersant or decoloring agent in glassmaking.

Arsenic metal, used as a hardener, is alloyed with lead and antimony for ammunition, solders, and other applications. Arsenic is one of several metals used as an antifriction additive to metals (babbitts) used for bearings. Grids and posts in lead-acid storage batteries are strengthened by the addition of arsenic metal. Arsenic is used in lead shot, and in addition to lead and antimony, minor amounts of arsenic are used in clip-on wheel weights (Los Angeles Silhouette Club, 2006§).

Gallium arsenide (GaAs) semiconductors are used in lasers, light emitting diodes, and solar cells. Gallium-arsenide and indium-arsenide semiconductors for use in computers and electronic devices require high-purity (99.9999%-pure) arsenic metal. Arsenic is also an important component of GaAs wafers for electronics applications. Indium-gallium-arsenide is used for Short Wave Infrared technology (Metal-Pages, 2005§). Arsenic may be used for germanium-arsenide-selenide or GaAs specialty optical materials (Harrick Optical Materials, 2006§). Domestic demand for gallium and arsenic in wafer production declined significantly in 2002 owing to the buildup of the domestic GaAs inventory, closure of several domestic plants, and increased wafer manufacturing in China. Based on reported consumption of gallium, domestic consumption of arsenic metal in GaAs semiconductors declined to approximately 15 t in 2005 from a peak of about 40 t in 2000 (D.A. Kramer, gallium commodity specialist, U.S. Geological Survey, written commun., April 28, 2006).

Imports into the United States of As_2O_3 from China rose to 5,620 t in 2005 and were significantly higher than the 3,040 t imported in 2004. However, the total amounts of As_2O_3 imported in 2005 and 2004 were dramatically lower than the 20,600 t of As_2O_3 imported in 2003.

World Review

Reduction of As_2O_3 to arsenic metal accounted for all world output of commercial-grade (99%-pure) arsenic metal (Roskill Information Services Ltd., 1992, p. 2). China continued to be the leading world producer of commercial-grade arsenic metal, and the U.S. imported 700 t from China, followed by 90 t from Japan, in 2005.

In 2005, as in previous years, As_2O_3 was obtained from the treatment of nonferrous ores, or concentrates in 14 countries. In China, arsenic is also obtained as a byproduct of gold mining. Orpiment and realgar, the more common ore minerals of arsenic, are routinely stockpiled near the Qiaoqiaoshang gold mine, northern Sichuan Province, for transport and processing in Guizhou Province (Peters and others, 2002, p. 182).

Arsenic-containing residues and smelter dusts recovered from nonferrous plants in several countries were not processed to commercial grade As_2O_3 in 2005 and may have been stockpiled for future treatment. As in previous years, China remained the world's leading producer of As_2O_3, followed by Chile and Peru. Country data are estimated and subject to revision because As_2O_3 production may not be accurately reported.

Outlook

The use of alternative wood preservatives or wood alternatives, such as concrete, plastic, or wood composites, will continue to increase because of environmental and health concerns over the use of CCA as a wood preservative. The voluntary decision by the wood preservative industry to eliminate CCA as a wood preservative for specified wood products at yearend 2003 has led to a decline in U.S. demand and has affected As_2O_3 production in China. CCA-treated wood, however, will continue to be used for specific industrial applications such as marine timber, plywood roofing, and utility poles. High-purity arsenic will continue to be used by the electronics industry for GaAs semiconductors for automotive uses, military and space applications, solar cells, and telecommunications. World sources of arsenic, as As_2O_3 and arsenic metal available from nonferrous metal processing in 14 countries, are sufficient to meet projected needs.

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TABLE 1
ARSENIC SUPPLY-DEMAND RELATIONS[1]

(Metric tons of arsenic content)

	2001	2002	2003	2004	2005
U.S. supply:					
Imports:					
Metal	1,030	879	990	872	812
Compounds	23,900	18,800	20,800	6,150	8,330
Total	25,000	19,700	21,700	7,020	9,150
Distribution of U.S. supply:					
Exports[2]	57	100	173	220	327
Apparent demand	24,900	19,600	21,600	6,800	8,820
Estimated U.S. use:					
Agricultural chemicals	1,000	750	860	850	1,000
Glass	750	700	660	650	700
Wood preservatives	21,900	17,300	19,200	4,450	5,760
Nonferrous alloys and electronics	1,000	650	660	650	1,100
Other	250	200	200	200	250
Total	24,900	19,600	21,600	6,800	8,810

[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Metal only.

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

	2004		2005	
Class and country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Arsenic trioxide:				
Belgium	292	$202	307	$209
Bolivia	180	101	120	64
Chile	104	44	78	33
China	3,040	1,340	5,620	2,680
Germany	54	107	(2)	4
Hong Kong	464	230	1,140	606
Japan	--	--	--	--
Mexico	927	558	344	234
Morocco	2,950	1,450	3,350	1,450
Spain	91	43	(2)	3
Total	8,090	4,080	11,000	5,280

See footnotes at end of table.

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

Class and country	2004 Quantity (metric tons)	2004 Value (thousands)	2005 Quantity (metric tons)	2005 Value (thousands)
Arsenic acid:				
China	20	$20	--	--
France	2	12	9	$50
Total	22	32	9	50
Arsenic sulfide:				
Canada	(3)	(3)	--	--
Russia	(2)	2	--	--
Total	(2)	2	--	--
Arsenic metal:				
China	730	1,300	718	1,790
Germany	6	847	5	758
Hong Kong	20	20	--	--
Japan	116	862	90	860
United Kingdom	(2)	6	--	--
Total	872	3,030	812	3,410

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Less than ½ unit.
[3]Revised to zero.

Source: U.S. Census Bureau.

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

(Metric tons)

Country[4]	2001	2002	2003	2004	2005
Belgium	1,000	1,000	1,000	1,000	1,000
Bolivia	846 [5]	237 [5]	276 [5]	168 [r, 5]	150
Canada	250	250	250	250	250
Chile	11,500 [r]	11,400 [r]	11,600 [r]	11,600 [r]	11,500
China	39,500	40,000	40,000	30,000	30,000
France	1,000	1,000	1,000	1,000	1,000
Germany	200	200	200	200	200
Iran	400	400	275 [r, 5]	89 [r, 5]	100
Japan	40	40	40	40	40
Kazakhstan	1,500	1,500	1,500	1,500	1,500
Mexico	2,381 [5]	1,946 [5]	1,729 [r, 5]	1,829 [r, 5]	1,650
Peru[6]	2,800 [5]	2,970 [5]	3,000 [5]	3,500	3,600
Portugal	50	50	50	50	50
Russia	1,500	1,500	1,500	1,500	1,500
Total	63,000 [r]	62,500 [r]	62,400 [r]	52,700 [r]	52,500

[r]Revised.
[1]Including calculated arsenic trioxide equivalent of output of elemental arsenic compounds other than arsenic trioxide where inclusion of such materials would not duplicate reported arsenic trioxide production.
[2]World totals and estimated data have been rounded to no more than three significant digits; may not add to totals shown.
[3]Table includes data available through April 1, 2006.
[4]Austria, Hungary, the Republic of Korea, Serbia and Montenegro, South Africa, Spain, 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.
[5]Reported figure.
[6]Output of Empresa Minera del Centro del Perú (Centromín Perú) as reported by the Ministerio de Energía y Minas.