



2009 Minerals Yearbook

IODINE

IODINE

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Iodine production and apparent consumption in the United States decreased in 2009 compared with that of 2008. Data for production and apparent consumption were withheld to avoid disclosing company proprietary data. Reported consumption by producers and consuming industries was 4,550 metric tons (t) in 2009 compared with 4,590 t in 2008. Crude and sublimed iodine exports increased to 1,160 t valued at \$22.9 million in 2009 compared with 950 t valued at \$17.4 million in 2008. Imports of crude iodine decreased to 5,190 t valued at \$133 million in 2009 compared with 6,300 t valued at \$144 million in 2008. World production, excluding United States production, was estimated to be 28,500 t in 2009 compared with 26,500 t in 2008.

Legislation and Government Programs

After a 1-year trial period and extensive study of health effects, the U.S. Environmental Protection Agency (EPA) approved the restricted use of the soil fumigant iodomethane (methyl iodide) as an alternative to the ozone depleting methyl bromide. In May, the EPA concluded its reevaluation of the fumigant and mandated regulations on all users. Under the regulations effective September 2008, companies must provide training for employees and satisfy risk mitigation requirements set by the EPA. Respirators or ducted fan and blower systems must be used by workers applying the fumigant. Tarps must be placed over treated fields, and buffer zones must be established around fields where the fumigant will be applied. Use of the fumigant is prohibited within a specified distance from such sites as day care facilities, nursing homes, prisons, and schools. Methyl iodide can be used to control insects, nematodes, plant pathogens, and weeds and may be used on crops and plants such as ornamentals, peppers, strawberries, tomatoes, trees, turf, and vines. Field tests were underway in Washington to determine if the climate—weak sunlight intensity and cooler temperatures—reduced the dissipation of the fumigant, leading to a risk of overexposure (Chemical and Engineering News, 2008; U.S. Environmental Protection Agency, 2009).

Production

The U.S. Geological Survey derived domestic production data for iodine from a voluntary canvass of two U.S. operations (table 1). U.S. production decreased slightly in 2009 from that of 2008. Data were withheld to avoid disclosing company proprietary data.

IOCHEM Corp. (a subsidiary of Toyota Tsusho America, Inc.) produced iodine near Vici, Dewey County, OK. Woodward Iodine Corp. (owned by Ise Chemical Corporation of Japan) produced iodine near Woodward, Woodward County, OK.

Iofina plc (United Kingdom) completed development of its Atlantis prospect in northern Montana, which included

drilling its first production well, construction of iodine and gas separation buildings, and laying a 9-mile long gas pipeline extension. Iofina commenced continuous iodine production in late July. The prospect consists of sodium chloride brine with high concentrations of iodine, located between two major biogenic gas fields. The company was also considering development of its Triton prospect, a 30,000-acre site located in southern Montana (Iofina plc, 2008a; 2009a, p. 1). By implementing its Wellhead Extraction Technology (WET), a method that is expected to reduce operating costs and capital expenditures, Iofina contended that both locations would prove to be economically successful (Iofina plc, 2008b; 2009a, p. 3). In August 2009, Iofina acquired Kentucky-based H&S Chemical with the intent to produce and sell iodine derivatives based on its iodine production (ICIS Chemical Business, 2009).

Consumption

U.S. apparent consumption of iodine, which is withheld to avoid disclosing company proprietary data, decreased by 20% in 2009 from that of 2008. Reported consumption by consuming industries was 4,550 t in 2009 compared with 4,590 t in 2008. Accurate end-use statistics are difficult to gather since domestic and imported iodine were used to produce many intermediate iodine compounds, usually by downstream manufacturers. However, 18 of the 22 companies to which a survey form was sent responded to the annual or preliminary surveys, representing 81% of the total consumption by major domestic users of iodine (tables 1, 2).

Uses for iodine in manufacturing decreased by 1% in 2009 compared with those of 2008 (table 2). Production of crude iodine and iodophors decreased by 27% and 31%, respectively, and potassium iodide (KI) production decreased by about 59%. Increased use of crude iodine was reported by several companies. Two companies accounted for the bulk of the decrease in use of iodine for iodophors. One company accounted for the decrease in use of iodine for KI. Other inorganic and organic iodine compounds increased in tonnage.

Specifications

Commercial crude iodine normally has a minimum purity of 99.5% to 99.8%, depending on the supplier. Impurities, in order of quantity, are primarily insoluble materials, iron, sulfuric acid, and water. The U.S. Pharmacopeia specifies an iodine content of not less than 99.8% for commercial iodine. The Committee on Analytical Reagents of the American Chemical Society allows a maximum of 0.005% total bromine and chlorine and 0.010% nonvolatile matter in its specifications for iodine.

Biocides and Disinfectants.—Since iodine is one of the most effective medical antiseptics available, it was used in biocides

and disinfecting chemicals. Iodophors, chemical complexes designed to carry large amounts of iodine which are highly water soluble, were incorporated into disinfectants for use in dairies, food processing plants, hospitals, and laboratories. The iodophor, polyvinyl pyrrolidinone-iodine (PVP), was used owing to its bactericidal, fungicidal, germicidal, and general disinfecting properties. The National Aeronautics and Space Administration (NASA) uses iodine in its water disinfection process on all manned space flights and in the international space station. Iodine is a cost-efficient, effective, and simple means of water disinfection.

Catalyst.—Iodine catalysts were used to manufacture acetic acid and synthetic rubbers. Acetic acid was used in the manufacture of certain adhesives, dyes, pharmaceuticals, plastics, surface coating, and vinegar. Iodine is employed in the production of acetic acid using the Monsanto process. Catalysts were generally recycled and reused in new processes.

Chemicals.—Iodine is used as a stabilizer in the manufacture of nylon for tire cord and carpets and for converting resins, tall oil, and other wood products to a more stable form.

Nutrition.—Iodine was an essential component of thyroid hormones, which directly affect processes in the brain, muscles, heart, pituitary gland, and kidneys. Iodine deficiency causes goiter in adults, increased mortality and impaired cognitive development in children, and reproductive failure. Iodine deficiency disorder can be prevented by consuming about 150 milligrams of iodine per day for a human adult (Institute of Medicine of the National Sciences, 2006).

Owing to expanded salt iodization campaigns to reduce iodine deficiency, 70% of households in the developing world consumed iodized salt in 2009, compared with only 20% in 1990 (Micronutrient Initiative, 2009). Iodized salt is table salt mixed with a minute amount of iodate, KI, or sodium iodide. Bakers in Australia and Belgium are mandated by law to only use iodized salt in their bread to fight iodine deficiency in their countries (Drake, 2009; Expatica, 2009).

Pharmaceuticals.—Radiopaque agents, drugs that absorb x rays, are used to help diagnose certain medical ailments and may contain iodine. Radiopaque-diagnosed medical problems include brain disorders, cardiac disease, central nervous system disorders, cerebrospinal fluid, disk disease, gastrointestinal (gall bladder) disorders, peritoneal disorders, splenic and portal vein disorders, urinary track disorders, and vascular disease. Potassium iodide was used as an expectorant in cough medicines. Hydriodic acid and KI were used in the synthesis of amphetamine, ethylamphetamine, and methamphetamine, which are regulated stimulants. The isotope I-131 was used to treat thyroid cancer and hyperthyroidism.

Other Uses.—Developments in digital imaging have produced electronic prints and overhead transparencies without the need for wet processing film. The majority of current feature films, however, were reliant on printed film for shooting since film provides higher image resolution. In the next decade, uses of iodine in films and processing may be limited to specialty film imaging as digital imagery technology for motion pictures improves and digital equipment and printers become more affordable.

Using iodine as a radiocontrast agent in x-ray imaging has been found to increase the risk of kidney failure and should be used with caution on patients with impaired kidney function (Tung, 2006). Barium sulphate, which was used primarily in digestive system imaging, can be used as an iodine substitute but is also known to cause complications. Many elements have higher atomic numbers than iodine; however, no other element has the chemical characteristics that allow iodine to form soluble compounds with low toxicity. It is these latter properties which make iodine-containing contrast media suitable for radiography.

Iodine is used for manufacturing iodine-adsorbed polyvinyl alcohol polarizing films for liquid crystal displays (LCD) for electronic equipment, including appliances, computers, digital cameras, personal handheld devices, and televisions. Polarizers are added to LCDs to enhance the light contrast between the screen and the liquid crystals, making the LCD more visible. These polarizers are usually made from stretched polyvinyl alcohol films that contain iodine.

Prices

Prices for iodine and its derivatives continued to increase in 2009. The average free alongside ship (f.a.s.) value for exported crude iodine in 2009 was \$19.74 per kilogram, an increase from \$18.30 per kilogram in 2008. The average declared cost, insurance, and freight (c.i.f.) value for imported crude iodine was \$25.54 per kilogram in 2009, an increase from \$22.90 per kilogram in 2008. The average declared c.i.f. value for iodine imported from Chile, the major source of imported iodine for the United States, was \$26.59 per kilogram in 2009 compared with \$23.57 per kilogram in 2008. The average declared c.i.f. value for imported crude iodine from Japan was \$19.90 per kilogram in 2009, an increase from \$19.40 per kilogram in 2008.

The price of crude crystal iodine, 99.5% minimum purity, in 50-kilogram drums delivered to the United Kingdom ranged from \$28.50 to \$30 per kilogram in January. In December, the price increased to \$30.80 to \$31.80 per kilogram (Industrial Minerals, 2009d, e).

Actual prices for iodine are negotiated on long- and short-term contracts between buyers and sellers.

Foreign Trade

Net trade is not easily defined since iodine was exported and imported in many forms other than elemental iodine and KI. Exports of crude iodine increased to 1,160 t with an f.a.s. value of \$22.9 million in 2009 compared with 950 t valued at \$17.4 million in 2008 (table 3). Exports of KI decreased to 126 t with an f.a.s. value of \$2.7 million in 2009 compared with 568 t valued at \$11.3 million in 2008. Imports of crude iodine decreased to 5,190 t with a c.i.f. value of \$133 million in 2009 compared with 6,300 t valued at \$144 million in 2008 (table 4). Imports of KI decreased to 259 t with a c.i.f. value of \$6.0 million in 2009 compared with a total of 564 t valued at \$12.1 million in 2008.

World Review

World production of iodine, excluding the United States, was estimated to be 28,500 t in 2009 compared with 26,500 t in 2008 (table 5). Chile was the world's leading producer of iodine, followed by Japan and the United States.

World consumption of iodine and its derivatives was estimated to be 25,500 t in 2009, a 13% decrease from 29,200 t in 2008. Production from Chile accounted for 53% of that tonnage; Japan accounted for 25%; and the United States accounted for 5%. Other producing countries accounted for 3% of the iodine supply, and iodine recycled in the manufacturing process accounted for 14% (Sociedad Química y Minera de Chile S.A., 2010a, p. 12). Human and animal health and nutrition represented 55% of iodine consumption in 2009, with x-ray contrast media, disinfectants, and LCD screen manufacture representing the other major end uses (Sociedad Química y Minera de Chile S.A., 2009, p. 16; 2010a, p. 12). Under the category for other or unknown applications, an estimated 16% of iodine consumption may be in industrial catalysts (Kanto Natural Gas Development Co., Ltd., undated).

The leading consuming region was Western Europe, with 39% of world consumption, followed by the North America with 24% of world consumption, China with 8%, Japan with 7%, and India with 6%. A breakout was not available for the remaining 16% of world consumption (Iofina plc, 2009b).

European Union.—The European Union announced that the 27 member countries are prohibited from using or selling iodine for the purpose of disinfecting drinking water after October 10, 2009 (Paddling Instructor, 2009). Iodinating water is considered a safe means of disinfection if consumed during short periods. However, according to the U.S. Center for Disease Control, chronic exposure to iodinated water may result in adverse health effects, and ingestion is not recommended by persons with thyroid disease or known iodine allergy or by pregnant women.

Chile.—Sociedad Química y Minera de Chile S.A. (SQM), the largest iodine producer in Chile, reported sales of 7,200 t of iodine and iodine derivatives valued at \$190 million in 2009 compared with 10,500 t valued at \$247 million in 2008. The decrease in sales was attributed to the global economic downturn, which adversely affected sales of biocides used in the automotive industries and construction (Sociedad Química y Minera de Chile S.A., 2010b). In response to the downturn, SQM announced the suspension of operations at its El Toco and Pampa Blanca mining facilities. In the event of a faster than expected recovery in the iodine market in the coming years, the company thinks its available inventory and installed capacity would allow it to respond rapidly (Sociedad Química y Minera de Chile S.A., 2010c). SQM estimated that it held 25% of the world market for iodine and its derivatives (Sociedad Química y Minera de Chile S.A., 2010a).

ACF Minera, the third leading iodine producer in Chile, started a new project at Algorta, Region II which was expected to replace its current operation at Lagunas, Region I (Industrial Minerals, 2009c).

Atacama Minerals Corp., a publicly held Canadian company operating the Aguas Blancas mine in northern Chile, commissioned an agitated leaching processing plant in late 2008 with the intent to increase production to 1,500 metric

tons per year (t/yr) of iodine from 1,000 t/yr. The \$26.5 million plant was expected to increase recovery of iodine to more than 75% from 55%, reduce processing time from several months to less than 24 hours (reducing the need for new heap-leach pad construction), and reduce water consumption by 25%. However, full startup had been delayed since the crushing and grinding section of the plant was inadequate to handle the higher than expected sodium sulfate levels found in the mine. In late 2009, the company announced plans to reconfigure the crushing and grinding circuit to adequately handle the various ore types and have the plant fully operational in 2011. To mitigate any loss of production during this transition, the company increased the amount of ore delivered to its heap-leach operations (Atacama Minerals Corp., 2008, 2009).

Turkmenistan.—Two new iodine operations were expected to become operational in Balkan Welayaty. A plant in Hazar, formerly Cheleken, was expected to produce 350 t/yr of iodine and a plant in Khazar Boyadag was expected to produce 300 t/yr of iodine (News Central Asia, 2009).

Outlook

The Chilean producers, which produced 53% of the global iodine supply in 2009, were operating near capacity and were expected to expand production in response to changes in demand. Prices continued to increase owing to an imbalance between supply and demand observed in 2008 and 2009 (Industrial Minerals, 2009b).

The economic slowdown experienced in most countries directly affected nylon production for the automotive industry, biocides in paints for construction, and polarizing films for LCDs. Demand in the health and human nutrition sectors remained steady during the economic downturn and were expected to remain steady throughout 2010. New applications in agrochemicals were expected to increase demand for iodine. SQM projected overall demand in these markets to normalize by the end of 2010 (Industrial Minerals, 2009a; Sociedad Química y Minera de Chile S.A., 2010a).

Demand in other segments of the iodine market was likely to be maintained. The water treatment market was expected to increase, with more growth anticipated in Asian areas. Expanding treatment of municipal water supplies could increase the demand for biocides and disinfectants in the future.

As more countries implement legislation mandating salt iodization, the global demand for iodized salt is expected to increase.

Use of x-ray contrast media, which contain as much as 60% iodine, was expected to increase. More medical tests on an aging population could possibly result in increased demand for iodine-containing x-ray contrast media.

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TABLE 1
SALIENT IODINE STATISTICS¹

(Metric tons and dollars)

	2005	2006	2007	2008	2009
United States:					
Production	1,570	W	W	W	W
Imports:					
Quantity, for consumption ²	6,250	5,640	6,060	6,300	5,190
Price, average ³ dollars per kilogram	16.75	19.34	21.01	21.52	25.55
Exports ²	2,430	1,580	1,060	950	1,160
Consumption:					
Reported ⁴	4,680	4,570	4,470	4,590	4,550
Apparent ⁵	5,600	W	W	W	W
World, production ⁶	26,500	26,700	26,300	26,500	28,500

⁶Estimated. W Withheld to avoid disclosing company proprietary data.

¹Data are rounded to no more than three significant digits, except prices.

²Source: U.S. Census Bureau information reported by Harmonized Tariff Schedule of the United States code 2801.20.0000.

³Cost, insurance, and freight valuation.

⁴Reported by voluntary response to the U.S. Geological Survey from a survey of domestic establishments.

⁵Calculated using domestic production plus imports minus exports plus adjustments for government and domestic industry stock changes.

TABLE 2
DOMESTIC CONSUMPTION OF IODINE, BY PRODUCT¹

Product	2008		2009	
	Number of plants	Quantity (metric tons)	Number of plants	Quantity (metric tons)
Inorganic compounds:				
Crude iodine	7 ^r	688	7	505
Resublimed iodine	7 ^r	45	7	62
Potassium iodide	4 ^r	410	4	167
Sodium iodide	5	112	5	193
Hydriodic acid	3	78	3	195
Potassium iodate	3	28	3	17
Miscellaneous iodate, and iodides ²	2	38	2	37
Other inorganic compounds	5	439	5	510
Total	XX ³	1,840	XX ³	1,690
Organic compounds:				
Ethylenediamine dihydroiodide	2	211	2	231
Povidine-iodine (iodophors)	2	468	2	321
Other organic compounds ⁴	9	2,070	7	2,310
Total	XX ³	2,750	XX ³	2,860
Grand total ⁵	XX	4,590	XX	4,550

^rRevised. XX Not applicable.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes ammonium iodide, calcium iodate, and cuprous iodide.

³Nonadditive because some plants produce more than one product concurrently.

⁴Includes methyl and (or) ethyl iodide and other unspecified products.

⁵Reported by voluntary response to the U.S. Geological Survey in a survey of domestic establishments.

TABLE 3
U.S. EXPORTS OF CRUDE IODINE AND POTASSIUM IODIDE, BY COUNTRY OF ORIGIN¹

Type and country of origin ³	2008		2009	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Iodine, crude/resublimed:				
Argentina	2	\$22	8	\$76
Belgium	6	143	1	23
Canada	137	2,990	154	3,570
Costa Rica	(4)	4	8	8
Egypt	--	--	5	144
El Salvador	--	--	6	42
France	12	92	1	29
Germany	667	11,800	779	15,300
Italy	35	788	90	2,180
Japan	11	168	14	222
Malaysia	11	53	2	13
Mexico	52	964	67	854
Other ⁵	22	241	25	425
Total	950	17,400	1,160	22,900
Potassium iodide:⁶				
Australia	30	578	6	164
Brazil	(4)	4	3	37
Chile	98	1,940	--	--
France	327	6,840	29	792
Guatemala			5	100
Korea, Republic of	11	133	12	108
Kuwait	23	140	(4)	8
Malaysia	6	184	1	32
Mexico	14	301	10	297
Netherlands	6	183	1	15
Taiwan	47	607	40	610
Turkey	6	155	8	245
Other ⁷	1	71	11	310
Total	568	11,300	126	2,720

-- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Declared free alongside ship valuation.

³Export information for crude and resublimed iodine and potassium iodide are reported by Harmonized Tariff Schedule of the United States codes 2801.20.0000 and 2827.60.2000, respectively.

⁴Less than ½ unit.

⁵Includes countries with quantities less than 10 metric tons.

⁶Potassium iodide contains 76% crude iodine.

⁷Includes countries with quantities less than 3 metric tons.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS OF CRUDE IODINE AND POTASSIUM IODIDE FOR
CONSUMPTION, BY COUNTRY OF ORIGIN¹

Type and country of origin ³	2008		2009	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Iodine, crude:				
Chile	5,290	\$125,000	4,290	\$114,000
France	46	833	7	187
India	--	--	19	615
Japan	963	18,700	871	17,300
Other ⁴	(5)	21	2	25
Total	6,300	144,000	5,190	133,000
Potassium iodide:^{4, 6}				
Brazil	165	2,610	22	632
Canada	258	5,730	183	4,560
Chile	112	3,500	35	471
United Kingdom	23	163	8	188
Other ⁴	7	141	11	144
Total	564	12,100	259	6,000

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Declared cost, insurance, and freight valuation.

³Import information for crude iodine and potassium iodide are reported by Harmonized Tariff Schedule of the United States codes 2801.20.0000 and 2827.60.2000, respectively.

⁴Includes countries with quantities less than 10 metric tons.

⁵Less than ½ unit.

⁶Gross potassium iodide contains 76% crude iodine.

Source: U.S. Census Bureau.

TABLE 5
CRUDE IODINE: ESTIMATED WORLD PRODUCTION, BY COUNTRY^{1, 2}

(Metric tons)

Country	2005	2006	2007	2008	2009
Azerbaijan	300	300	300	300	300
Chile ³	15,346 ⁴	16,494 ⁴	15,473 ⁴	15,503 ⁴	17,399 ⁴
China	550	560	570	570	580
Indonesia	75	75	75	75	75
Japan	8,095 ⁴	8,724 ⁴	9,282 ⁴	9,500	9,600
Russia	300	300	300	300	300
Turkmenistan	270	270	270	270	270
United States	1,574 ⁴	W	W	W	W
Uzbekistan	2	2	2	2	2
Total	26,500	26,700	26,300	26,500	28,500

W Withheld to avoid disclosing company proprietary data; not included in total.

¹World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Table includes data available through June 24, 2010.

³Includes iodine production reported by Servicio Nacional de Geología y Minería.