

# 2008 Minerals Yearbook

**IODINE** 

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Iodine production in the United States increased slightly in 2008 compared with that of 2007. The two U.S. producers supplied about 24% of U.S. apparent consumption. Data for production and apparent consumption were withheld to avoid disclosing company proprietary data. Reported consumption by producers and consuming industries was 4,680 t in 2008 compared with 4,540 t in 2007. Crude and sublimed iodine exports decreased to 950 metric tons (t) valued at \$17.4 million in 2008 compared with 1,060 t valued at \$19.3 million in 2007. Imports of crude iodine increased to 6,300 t valued at \$143 million in 2008 compared with 6,060 t valued at \$128 million in 2007. World production, excluding United States production, was estimated to be 26,500 t in 2008 compared with 26,300 t in 2007.

### **Legislation and Government Programs**

In October, the U.S. Environmental Protection Agency (EPA) approved the continued use of the soil fumigant iodomethane (methyl iodide). The approval was made after a 1-year trial period and extensive study of the health effects of the fumigant. Companies must provide training for employees and satisfy data and risk mitigation requirements of 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 such plants as ornamentals, peppers, strawberries, tomatoes, trees, turf, and vines (Chemical and Engineering News, 2008; U.S. Environmental Protection Agency, 2008).

# **Production**

The U.S. Geological Survey derived domestic production data for iodine from a voluntary canvass of U.S. operations (table 1). IOCHEM Corp. (a subsidiary of Toyota Tsusho America, Inc.) produced iodine near Vici, in Dewey County, OK. Woodward Iodine Corp. (owned by Ise Chemical Corporation of Japan) produced iodine near Woodward, in Woodward County, OK. U.S. production increased slightly in 2008 from that of 2007. Data were withheld to avoid disclosing company proprietary

Iofina plc continued work on its Atlantis Prospect in Montana. The company completed drilling its first production well, constructing iodine and gas separation buildings, and laying a 9-mile long gas pipeline extension. Iofina also continued to improve its iodine extraction technology process. The company anticipated initial gas and iodine production to begin in 2009 (Iofina plc, 2008b).

# Consumption

U.S. apparent consumption of iodine, which is withheld to avoid disclosing company proprietary data, increased in 2008 from that of 2007. Reported consumption by consuming industries was 4,680 t in 2008 compared with 4,540 t in 2007. Domestic and imported iodine were used to produce a multitude of intermediate iodine compounds, usually by downstream manufacturers, making it difficult to gather accurate end-use statistics. However, 19 of the 23 companies to which a survey form was sent responded to the annual or preliminary surveys, representing 86% of the total consumption by major domestic users of iodine (tables 1, 2).

Uses for iodine in manufacturing did not change significantly between 2007 and 2008 (table 2). Production of crude iodine and iodophors increased by 10% and 13%, respectively, and potassium iodide (KI) decreased by about 9%. Increased use of crude iodine was reported by several companies. One company accounted for the bulk of the increase in use of iodine for iodophors. Three companies accounted for the decrease in use of iodine for KI. Other inorganic and organic iodine compounds increased or decreased slightly in tonnage.

Commercial crude iodine normally has a minimum purity of 99.5% to 99.8%, depending on the supplier. Impurities, in order of quantity, are chiefly insoluble materials, iron, sulfuric acid, and water. The U.S. Pharmacopeia specifies an iodine content of not less than 99.8%. 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.

Biocides and Disinfectants.—Iodine is used in biocides and disinfecting chemicals. Iodine is one of the most effective medical antiseptics available. Iodine was used with iodophors in disinfectants for use in dairies, food processing plants, hospitals, and laboratories. Polyvinyl pyrrolidinone-iodine (PVP) complexes were used owing to 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 is employed in the production of acetic acid using the Monsanto process. The process involves methanol carbonylation with an iodide-promoted rhodium complex as the catalyst. Iodide catalysts, such as titanium tetraiodide and aluminum iodide, are used in the production of butane, in the conversion of butane to butadiene, and in the preparation of stereoregular polymers.

*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 deficiency causes goiter, increased child mortality, irreversible mental retardation, and reproductive failure. Iodine deficiency disorder can be prevented by consuming about 150 milligrams of iodine per day for a human adult.

About 31% of households in developing countries do not consume iodized salt. Iodized salt is table salt mixed with a minute amount of iodate, KI, or sodium iodide. It was estimated that about \$19 million per year would be required to increase iodized salt use and provide iron fortification in South Asia, sub-Saharan Africa, central and eastern Europe, and the Commonwealth of Independent States (Copenhagen Consensus Center, 2008).

Pharmaceuticals.—Radiopaque agents are drugs used to help diagnose certain medical problems and may contain iodine, which absorbs x rays. 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 are used in the synthesis of amphetamine, ethylamphetamine, and methamphetamine, which are regulated stimulants.

Other Uses.—Developments in digital imaging have produced electronic prints and overhead transparencies without the need for wet processing film. Despite this, a large percentage of all televised programs seen during prime time are still recorded on 35-millimeter motion picture film and then transferred to videotape or laser disc for display. Furthermore, the majority of feature films for movie theater presentations are shot and printed on film because 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.

Performing x-ray imaging using iodine contrast media has been found to increase risk of kidney failure and is used with caution on patients with impaired kidney function (Tung, 2006). Barium sulphate can also be used as contrast media but can cause complications as well. 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. To make LCDs more visible, polarizers are added. These polarizers are usually made from stretched polyvinyl alcohol films that contain iodine.

Iodine and its derivatives were used principally in animal feed, catalysts, colorants, inks, pharmaceutical and medical applications, photographic equipment, sanitation or disinfectants, and resin stabilizers.

World consumption of iodine and its derivatives was estimated to be about 20% for x-ray contrast media, 13% for

pharmaceuticals, 10% for LCD screen manufacture, 9% each for animal nutrition and iodophors, 5% each for biocides and nylon manufacture, 3% for human nutrition, and 26% for other applications (Sociedad Química y Minera de Chile S.A., 2009a). Under the category for other or unknown applications, an estimated 16% may be used as industrial catalysts (Kanto Natural Gas Development Co., Ltd., 2008).

The leading consuming region was Western Europe with 39% of world consumption, followed by the United States with 24%, China with 8%, Japan with 7%, and India with 6%. A breakout was not available for the remaining 16% (Iofina plc, 2008a).

#### **Prices**

Prices for iodine and its derivatives continued to increase in 2008. Sociedad Química y Minera de Chile S.A. (SQM) announced price increases of 25% in the fourth quarter of 2008 (Sociedad Química y Minera de Chile S.A., 2009b).

The average free alongside ship (f.a.s.) value for exported crude iodine in 2008 was \$18.30 per kilogram, an increase from \$18.16 per kilogram in 2007. The average declared cost, insurance, and freight (c.i.f.) value for imported crude iodine was \$22.90 per kilogram in 2008, an increase from \$21.32 per kilogram in 2007. The average declared c.i.f. value for iodine imported from Chile, the major source of imported iodine for the United States, was \$23.58 per kilogram in 2008 compared with \$22.03 per kilogram in 2007. The average declared c.i.f. value for imported crude iodine from Japan was \$19.40 per kilogram in 2008, an increase from \$18.31 per kilogram in 2007.

The price of crude crystal iodine, 99.5% minimum purity, in 50-kilogram drums delivered to the United Kingdom ranged from \$25.50 to \$26.50 per kilogram in January. In December, the price range was \$28.50 to \$30.00 per kilogram (Industrial Minerals, 2008a, b).

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

#### **Foreign Trade**

Exports of crude iodine decreased to 950 t with an f.a.s. value of \$17.4 million in 2008 compared with 1,060 t valued at \$19.3 million in 2007 (table 3). Exports of KI decreased to 568 t with an f.a.s. value of \$11.3 million in 2008 compared with 136 t valued at \$2.62 million in 2007. Iodine also was exported and imported in many forms other than elemental iodine and KI, so net trade is not easily defined. Imports of crude iodine increased to 6,300 t with a c.i.f. value of \$144 million in 2008 compared with 6,060 t valued at \$129 million in 2007 (table 4). Imports of KI decreased to 564 t with a c.i.f. value of \$12.1 million in 2008 compared with 649 t valued at \$13.6 million in 2007.

# **World Review**

World production of iodine, excluding the United States, was estimated to be 26,500 t in 2008 compared with 26,300 t in 2007 (table 5). Chile was the leading world producer of iodine, followed by Japan and the United States.

SQM estimated that 29,200 t of iodine was used worldwide in 2008, with production from Chile accounting for 57% of

that tonnage, Japan accounting for 21%, and the United States accounting for 5%. Other producing countries accounted for 2% of the iodine supply, and iodine recycled in the manufacturing process accounted for 15% (Sociedad Química y Minera de Chile S.A., 2009a).

Azerbaijan.—Azeryod LLC (a subsidiary of ISR Holding) continued expansion of its Neftchala iodine plant. The expansion was supported by a \$15 million loan from the European Bank for Reconstruction and Development (European Bank for Reconstruction and Development, 2008). The company planned to expand plant capacity to 500 metric tons per year (t/yr) through the purchase of new equipment, addition of a new production line, and repair of extraction wells (Association for Civil Society Development in Azerbaijan, 2008; Today.az, 2008).

*Chile.*—SQM announced a \$1 billion production capacity expansion plan for iodine, nitrates, lithium carbonate, and potassium-base products. SQM planned to increase capacity for iodine and nitrate production by 25% by 2012 at its Nueva Victoria and Pampa Blanca facilities (Chemical Week, 2008).

SQM indicated that it sold 10,500 t of iodine and iodine derivatives valued at \$247 million in 2008 compared with 9,100 t valued at \$215 million in 2007. Sales increased primarily because of market growth (Sociedad Química y Minera de Chile S.A., 2009b). SQM estimated that it held 33% of the world market for iodine and its derivatives (Sociedad Química y Minera de Chile S.A., 2009a).

Atacama Minerals Corp. commissioned a continuous-agitated leach processing plant. However, full startup had been delayed until problems with ore preparation caused by higher than expected sodium sulphate levels were resolved. A \$1.5 million modified scrubber system was expected to resolve the problem. Full startup of the plant was expected in the first half of 2009 (Atacama Minerals Corp., 2008d, p. 1, 6). The plant will allow the company to increase iodine production to 1,500 t/yr from 1,000 t/yr. The \$26.5 million plant will increase recovery of iodine to more than 75% from 55%, reduce processing time to less than 24 hours from several months (reducing the need for new heap leach pad construction) and reduce water consumption by 25%. The company also completed its \$8.6 million upgrade to its power supply system. Atacama connected its plant to a local power grid through a 28-mile-long transmission line and replaced its diesel-powered generators (Atacama Minerals Corp., 2008a, b).

Atacama determined through an ongoing drilling program that proven and probable reserves of iodine, sulfates, and nitrates at the Aguas Blancas Mine were 37.7 million metric tons (Mt), an increase of 53% from an estimate made in 2007 (Atacama Minerals Corp., 2008c). Through September 30, the company produced 641 t of iodine and sold 656 t. A decline in production from 2007 was attributed mainly to the anticipated changeover in the company's ore processing (Atacama Minerals Corp., 2008b).

*Iran.*—The country's first iodine production plant was commissioned in the northern province of Golestan. The \$2.7 million plant has a production capacity of 65 t/yr of iodine with plans underway to expand capacity to 130 t/yr (Zawya Ltd., 2008).

#### Outlook

Most of the iodine producers were operating near capacity, with capacity increases planned by several producers. Prices continued to increase owing to tight supplies worldwide.

The economic slowdown experienced in most countries began to affect the automotive and electronics segments of the iodine market by the end of 2008. SQM reported slowing of sales for the manufacture of polarizing films for LCD applications and for the manufacture of nylon for automotive applications (Sociedad Química y Minera de Chile S.A., 2009b).

Demand in other segments of the iodine market is likely to be maintained. The water treatment market is expected to increase with more growth anticipated in Asian areas. Expanding treatment of municipal water supplies will probably increase the demand for biocides and disinfectants in the future. Use of iodine derivatives as biocides in paint and wood treatment products also has increased in recent years.

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

Demand for KI pills as a preventative of cancer of the thyroid in the event of a nuclear accident continued to influence sales of pills to government and private individuals. More countries are providing these pills to individuals, and the demand for this compound remained strong.

Use of x-ray contrast media, which contain as much as 60% iodine, may continue to increase despite the decline in most world economies. More medical tests on an aging population are likely to result in increased demand for iodine-containing x-ray contrast media.

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TABLE 1
SALIENT IODINE STATISTICS<sup>1</sup>

(Metric tons and dollars)

2004	2005	2006	2007	2008
1,130	1,570	W	W	W
5,700	6,250	5,640	6,060	6,300
13.38	16.75	19.34	21.01 r	21.52
1,060	2,430	1,580	1,060	950
4,070	4,680	4,570	4,470 <sup>r</sup>	4,590
5,560	5,600	W	W	W
24,800	26,500	26,700	26,300 <sup>r</sup>	26,500
	1,130 5,700 13.38 1,060 4,070 5,560	1,130 1,570  5,700 6,250  13.38 16.75  1,060 2,430  4,070 4,680  5,560 5,600	1,130 1,570 W  5,700 6,250 5,640  13.38 16.75 19.34  1,060 2,430 1,580  4,070 4,680 4,570  5,560 5,600 W	1,130     1,570     W     W       5,700     6,250     5,640     6,060       13.38     16.75     19.34     21.01 °       1,060     2,430     1,580     1,060       4,070     4,680     4,570     4,470 °       5,560     5,600     W     W

<sup>&</sup>lt;sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits, except prices.

<sup>&</sup>lt;sup>2</sup>Source: U.S. Census Bureau information reported by Harmonized Tariff Schedule of the United States code 2801.20.0000.

<sup>&</sup>lt;sup>3</sup>Cost, insurance, and freight valuation.

<sup>&</sup>lt;sup>4</sup>Reported by voluntary response to the U.S. Geological Survey from a survey of domestic establishments.

<sup>&</sup>lt;sup>5</sup>Calculated using domestic production plus imports minus exports plus adjustments for government and domestic industry stock changes.

 $\label{eq:table 2} \mbox{Domestic consumption of iodine, By Product}^1$ 

		2007		2008	
	Number	Quantity	Number	Quantity	
Product	of plants	(metric tons)	of plants	(metric tons)	
Inorganic compounds:					
Crude iodine	8	626	8	688	
Resublimed iodine	7 <sup>r</sup>	45 <sup>r</sup>	5	45	
Potassium iodide	4	450	3	410	
Sodium iodide	5	116 <sup>r</sup>	5	112	
Hydriodic acid	2	69 <sup>r</sup>	3	78	
Potassium iodate	4	27 <sup>r</sup>	3	28	
Miscellaneous iodate, and iodides <sup>2</sup>	2	38 <sup>r</sup>	2	38	
Other inorganic compounds	5	471 <sup>r</sup>	5	439	
Total	XX <sup>3</sup>	1,840 <sup>r</sup>	XX <sup>3</sup>	1,840	
Organic compounds:					
Ethylenediamine dihydroiodide	2	195 <sup>r</sup>	2	211	
Povidine-iodine (iodophors)	2 r	414 <sup>r</sup>	2	468	
Other organic compounds <sup>4</sup>	9	2,020 r	9	2,070	
Total	XX <sup>3</sup>	2,630 r	XX <sup>3</sup>	2,750	
Grand total reported consumption <sup>5</sup>	XX	4,470 <sup>r</sup>	XX	4,590	

<sup>&</sup>lt;sup>r</sup>Revised. XX Not applicable.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Includes ammonium iodide, calcium iodate, and cuprous iodide.

<sup>&</sup>lt;sup>3</sup>Nonadditive because some plants produce more than one product concurrently.

<sup>&</sup>lt;sup>4</sup>Includes methyl and/or ethyl iodide and other unspecified products.

<sup>&</sup>lt;sup>5</sup>Reported by voluntary response to the U.S. Geological Survey in a survey of domestic establishments.

 $\label{eq:table 3} \textbf{U.S. EXPORTS OF CRUDE IODINE AND POTASSIUM IODIDE, BY COUNTRY OF ORIGIN }^1$ 

	2007		2008	
	Quantity	Value <sup>2</sup>	Quantity	Value <sup>2</sup>
Type and country of origin <sup>3</sup>	(metric tons)	(thousands)	(metric tons)	(thousands
Iodine, crude/resublimed:				
Argentina			2	\$22
Australia	2	\$38	(4)	3
Belgium	131	2,970	6	143
Canada	180	4,020	137	2,990
Germany	510	8,780	667	11,800
India	81	1,340	4	133
Italy			35	788
Japan	5	80	11	168
Malaysia			11	53
Mexico	90	1,610	52	964
Taiwan			(4)	15
United Kingdom			3	42
Venezuela	10	138	(4)	g
Other	51	280	22	241
Total	1,060	19,300	950	17,400
Potassium iodide: <sup>5</sup>	(			
Australia	5	87	30	578
Chile			98	1,940
China	(4)	10	1	17
France	37 <sup>r</sup>	809 r	327	6,840
Germany	2	29 r		-
Ireland			3	68
Korea, Republic of	18 <sup>r</sup>	279 <sup>r</sup>	11	133
Kuwait			14	140
Malaysia	11	200	6	184
Mexico	13 <sup>r</sup>		14	301
Netherlands	7 <sup>r</sup>	149 <sup>r</sup>	6	183
Singapore	(4)	10	1	32
Taiwan	37 <sup>r</sup>	607 <sup>r</sup>	47	607
Thailand	(4)	5	2	3
Turkey	r	r	6	155
United Kingdom	(4)	19	1	30
Other	6 <sup>r</sup>	129 <sup>r</sup>	1	7
Total	136 <sup>r</sup>	2,620 r	568	11,300

<sup>&</sup>lt;sup>r</sup>Revised. --Zero.

Source: U.S. Census Bureau.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Declared free alongside ship valuation.

<sup>&</sup>lt;sup>3</sup>Export 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.

<sup>&</sup>lt;sup>4</sup>Less than ½ unit.

<sup>&</sup>lt;sup>5</sup>Potassium iodide contains 76% crude iodine.

TABLE 4  $\mbox{U.s. IMPORTS OF CRUDE IODINE AND POTASSIUM IODIDE FOR } \\ \mbox{CONSUMPTION, BY COUNTRY OF ORIGIN}^1$ 

	2007		2008	
	Quantity	Value <sup>r, 2</sup>	Quantity	Value <sup>2</sup>
Type and country of origin <sup>3</sup>	(metric tons)	(thousands)	(metric tons)	(thousands)
Iodine, crude:				
Chile	4,890	\$108,000	5,290	\$125,000
France	62	1,200	46	833
Japan	1,110	20,200	963	18,700
Other	(4)	18	(4)	21
Total	6,060	129,000	6,300	144,000
Potassium iodide: <sup>5</sup>				
Brazil	276	5,730	165	3,500
Canada	299	6,310	258	5,730
Chile	68	1,480	112	2,610
Other		112	30	304
Total	649	13,600	564	12,100

rRevised.

Source: U.S. Census Bureau.

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

# (Metric tons)

Country	2004	2005	2006	2007	2008
Azerbaijan	300	300	300	300	300
Chile <sup>3</sup>	14,931 4	15,346 4	16,494 4	15,473 4	15,503 4
China	550	550	560	570	570
Indonesia	75	75	75	75	75
Japan	7,264 4	8,095 4	8,724 4	9,282 <sup>r, 4</sup>	9,500
Russia	300	300	300	300	300
Turkmenistan	250	270	270	270	270
United States	1,130 4	1,570 4	W	W	W
Uzbekistan	2	2	2	2	2
Total	24,800	26,500	26,700	26,300 r	26,500

<sup>&</sup>lt;sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data; not included in total.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Declared cost, insurance, and freight valuation.

<sup>&</sup>lt;sup>3</sup>Import 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.

<sup>&</sup>lt;sup>4</sup>Less than ½ unit.

<sup>&</sup>lt;sup>5</sup>Gross potassium iodide contains 76% crude iodine.

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

<sup>&</sup>lt;sup>2</sup>Table includes data available through June 2, 2009.

<sup>&</sup>lt;sup>3</sup>Includes iodine production reported by Servicio Nacional de Geologia y Minería.

<sup>&</sup>lt;sup>4</sup>Reported figure.