



2011 Minerals Yearbook

IODINE [ADVANCE RELEASE]

IODINE

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Iodine production and apparent consumption in the United States increased in 2011 compared with that of 2010. Data for production and apparent consumption were withheld to avoid disclosing company proprietary data. Reported consumption by producers and consuming industries was 4,740 metric tons (t) in 2011 compared with the revised 4,640 t in 2010. Crude and sublimed iodine exports decreased to 900 t valued at \$19.2 million in 2011 compared with 1,070 t valued at \$22.3 million in 2010. Imports of crude iodine increased to 6,590 t valued at \$251 million in 2011 compared with 5,710 t valued at \$139 million in 2010. World production, excluding U.S. production, was estimated to be 26,800 t in 2011 compared with the revised 26,500 t in 2010.

Legislation and Government Programs

In 2008, the U.S. Environmental Protection Agency (EPA) approved the restricted use of the soil fumigant iodomethane (commonly known as methyl iodide) as an alternative to the ozone-depleting methyl bromide. To use the compound, 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 was 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 on crops, turf, and plants such as ornamentals, peppers, strawberries, tomatoes, trees, and vines. The EPA concluded three field studies conducted in Georgia, Florida, and Michigan consisting of human health risk assessments and emission studies of methyl iodide applied to fields using impermeable tarps, and found that emissions were significantly reduced compared to typical practices, which were quantified in previous emissions studies (U.S. Environmental Protection Agency, 2011). Arysta LifeScience Corp., a Japanese manufacturer of methyl iodide, suspended sales, marketing, and production of all formulations of its fumigant MIDAS®, or methyl iodide, in the United States. MIDAS® had come under harsh criticism from environmentalists and farm workers who claimed the chemical was toxic and may cause cancer (Arysta LifeScience Corp., 2012).

Production

The U.S. Geological Survey obtained domestic production data for iodine from a voluntary canvass of three U.S. operations (table 1). U.S. production increased slightly in 2011 from that of 2010. Data were withheld to avoid disclosing company proprietary data.

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

In March, Iofina entered an agreement with water treatment company, Anticline Disposal, LLC (a subsidiary of High Sierra Energy, LP) to increase throughput of iodine-rich brines to produce 3.5 t of iodine per month. Iofina was expected to pay 100% of the cost to install and operate a compact iodine recovery unit and was expected to start production in 2012. This was expected to be the first commercial iodine extraction to take place in Wyoming (Iofina plc, 2011). The company used a proprietary wellhead extraction technology, which was comparable to that used in the iodine-gas fields in Mobarra, Japan. Iofina was expected to offer the technology to third-party producers on a contract basis, allowing the company to expand production without acquiring further properties.

Consumption

U.S. apparent consumption of iodine, which is withheld to avoid disclosing company proprietary data, increased by 17% in 2011 from that of 2010. Reported consumption by producers and consuming industries increased to 4,740 t in 2011 compared with 4,640 t (revised) in 2010. Accurate end-use statistics are difficult to gather because domestic and imported iodine were used to produce many intermediate iodine compounds, usually by downstream manufacturers. However, 17 of the 21 companies to which a survey form was sent responded to the annual or preliminary surveys, representing 95% of the total consumption by major domestic users of iodine (tables 1, 2).

Use of iodine in manufacturing decreased slightly in 2011 compared with that of 2010 (table 2). Consumption of crude iodine increased slightly and production of potassium iodide (KI) was about four times that of 2010. Consumption of miscellaneous and other inorganic iodine products, which includes cuprous iodide and potassium iodate, decreased slightly. Consumption of organic iodine compounds increased by 18%.

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, water-soluble chemical complexes designed to carry large amounts of iodine, were incorporated into disinfectants for use in dairies, food processing plants, hospitals, and laboratories. 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 coatings, and vinegar. Most acetic acid is produced using the methanol carbonylation process, which uses methyl iodide at an intermediate step. Catalysts were generally recycled and reused in new processes.

Chemicals.—Iodine was 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 more stable forms.

Medical.—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 disorders, 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.

Using iodine as a radiocontrast agent in x-ray imaging has been found to increase the risk of kidney failure and was used with caution on patients with impaired kidney function (Tung, 2006). Barium sulfate, 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 this latter property which makes iodine-containing contrast media suitable for radiography.

Nutrition.—Iodine is an essential component of thyroid hormones, which directly affect processes in the brain, heart, kidneys, muscles, and pituitary gland. Iodine deficiency can cause 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 Academies, 2006).

Other Uses.—Developments in digital imaging have allowed electronic prints and overhead transparencies to be produced without the need for wet processing film. The majority of current feature films, however, relied on printed film for shooting 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.

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 2011. The average free alongside ship (f.a.s.) value for exported crude iodine in 2011 was \$21.29 per kilogram, an increase from \$20.81 per kilogram in 2010. The average declared cost, insurance, and freight (c.i.f.) value for imported crude iodine was \$38.13 per kilogram in 2011, an increase from \$24.39 per kilogram in 2010. The average declared c.i.f. value for iodine imported from Chile, the leading source country of imported iodine for the United States, was \$40.40 per kilogram in 2011 compared with \$25.19 per kilogram in 2010. The average declared c.i.f. value for imported crude iodine from Japan was \$21.73 per kilogram in 2011, an increase from \$20.42 per kilogram in 2010.

The spot price of crude crystal iodine, 99.5% minimum purity, in 50-kilogram drums delivered to the United Kingdom ranged from \$31 to \$33 per kilogram in January 2011. Prices continued to increase each month in 2011, and in June, prices ranged from \$55 to \$60 per kilogram. In December, prices ranged from \$80 to \$95 per kilogram (Industrial Minerals, 2011b–d). The substantial price increases resulted from the closure of several plants in Japan after the March earthquake and tsunami. 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 decreased to 900 t with an f.a.s. value of \$19.2 million in 2011 compared with 1,070 t valued at \$22.3 million in 2010 (table 3). Exports of KI decreased to 344 t with an f.a.s. value of \$7.3 million in 2011 compared with 442 t valued at \$9.3 million in 2010. Exports of crude iodine to Canada and Germany represented 85% of total crude iodine exports in 2011.

Imports of crude iodine increased to 6,590 t with a c.i.f. value of \$251 million in 2011 compared with 5,710 t valued at \$139 million in 2010 (table 4). Imports of KI decreased to 366 t with a c.i.f. value of \$5.4 million in 2011 compared with a total of 423 t valued at \$9.7 million in 2010. Imports of crude iodine from Chile and Japan represented more than 99% of total crude iodine imports in 2011.

World Review

World production of iodine, excluding the United States, was estimated to be 26,800 t in 2011 compared with 26,500 t in 2010 (table 5). Chile was the world's leading producer of iodine, followed by Japan and the United States.

Azerbaijan.—In October, Azeryod, LLC (a subsidiary of ISR Holding) announced that production began at the third line of its Azer-Iod's Neftchalinsky iodide plant, which was expected to raise the plant's capacity to 500 metric tons per year (t/yr) of iodine (ISR Holding, 2011).

Chile.—Chilean producers, which produced 60% of the global iodine supply in 2011, were operating near capacity. Sociedad Química y Minera de Chile S.A. (SQM), the leading iodine producer worldwide, reported sales of 12,200 t of iodine and iodine derivatives valued at \$455 million in 2011, compared with 11,900 t of iodine valued at \$316 million in 2010 (Sociedad Química y Minera de Chile S.A., 2011b, p. 2). Other Chilean producers were ACF Minera S.A., Atacama Chemical S.A., and Cosayach Nitratos S.A.

SQM operated four operations in Chile that produced iodine and nitrates from caliche ore—Pedro Valdivia, Maria Elena, Nueva Victoria, and Pampa Blanca. In February 2010, production at Pampa Blanca and a mine within Maria Elena was suspended owing to decreased global demand. According to SQM, both operations were restarted by the first quarter of 2011, owing to recovery in demand. SQM was operating at full capacity in 2011. The company planned to increase capacity to 14,000 t/yr from 12,000 t/yr by 2014. SQM's iodine and iodine derivatives division increased sales in 2011 by 35% to \$117.2 million compared with sales in 2010 (Industrial Minerals, 2011a).

ACF Minera was developing a new mining operation, the Algorta Norte project, in the Antofagasta Region of Chile (Sociedad Química y Minera de Chile S.A., 2011a, p. 28). ACF Minera had an expansion project through a joint venture with Japan trading group, Toyota Tsusho Corp. The companies jointly invested in the Algorta Norte project to produce 4,000 t/yr of iodine (Industrial Minerals, 2011a).

Atacama Minerals Corp., a publicly held Canadian company operating the Aguas Blancas Mine in northern Chile, hired a new management team in October to expand its capacity (Industrial Minerals, 2011a). The company changed its name to Sirocco Mining Inc. on January 24, 2012. The Aguas Blanca Mine produced 1,256 t of iodine in 2010 and produced 1,122 t in 2011. Increased iodine prices during 2011 contributed to 33% higher revenues than in 2010. Higher revenues were partially offset by increased production costs as the company experienced higher power and personnel costs in 2011. The company was expected to increase iodine production to between 1,350 t and 1,450 t of iodine in 2012 (Sirocco Mining Inc., 2012).

Cosayach has a capacity of 7,500 t/yr of iodine from its three operations—Negreiros (40%), Soledad (40%), and Cala Cala (20%). The operations produce an iodine solution, which is brought by trucks to the Cala Cala refinery to produce prilled iodine, iodine flakes, as well as byproduct nitrates. In 2011, the company produced only 4,000 t of iodine, owing to long-term water shortage problems. More than 20 alleged illegal water wells installed near the Cala Cala operation were shut down in September. The company was working with local authorities to find a solution to the problem, including purchasing more water rights and building a seawater pipeline. The seawater pipeline

was expected to be in operation by the beginning of 2013 (Industrial Minerals, 2011a).

Japan.—In March, the damage caused by the earthquake and tsunami at the Fukushima Daiichi nuclear powerplant in northern Honshu caused radioactive iodine to leak into Japanese food and water supplies. This triggered worldwide panic buying of potassium iodide tablets, which were used to reduce the ability of the thyroid gland to absorb and retain radioactive iodine. The potassium iodide tablet supply shortfall was exacerbated further because of the damage of the earthquake, which disrupted iodine production and supply within Japan itself. Japanese production was disrupted for at least 3 months after the earthquake, according to some analysts (Industrial Minerals, 2011a).

Outlook

According to Roskill Information Services Ltd., during 2010 to 2014, world consumption of iodine is forecast to rise by an average of 3.5% per year and was expected to reach 30,500 t (Roskill Information Services Ltd., 2010, p. 5). The water treatment market is expected to increase, with higher growth anticipated in Asia. Expanding treatment of municipal water supplies could increase the demand for biocides and disinfectants in the future. Use of x-ray contrast media, which contain as much as 60% iodine, is expected to increase. More medical tests on an aging population could also result in increased demand for iodine-containing x-ray contrast media.

Another major application expected to heavily influence iodine demand, mainly in Asia, is optical polarizing film (OPF) for LCD screens. According to some analysts, LCDs are expected to remain the most commonly used technology for at least the next 5 years after which they are expected to receive increased competition from technologies that do not use OPF. The most likely competition is expected to be from organic light emitting diode products and plasma televisions (Industrial Minerals, 2011a).

Iodine recycling continued to increase in 2011. Several Japanese producers have recycling facilities where they recover iodine and iodine derivatives from iodine waste streams, which were estimated to represent 70% to 75% of world recycling. Iodine recycling, mainly related to LCD consumption, has increased during the past few years and represents approximately 15% of world iodine sales (Sociedad Química y Minera de Chile S.A., 2011a, p. 28).

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GENERAL SOURCES OF INFORMATION

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Other

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TABLE 1
SALIENT IODINE STATISTICS¹

(Metric tons and dollars)

	2007	2008	2009	2010	2011
United States:					
Production	W	W	W	W	W
Imports:					
Quantity, for consumption ²	6,060	6,300	5,190	5,710	6,590
Price, average ³ dollars per kilogram	21.01	21.52	25.55	24.39 ^r	38.13
Exports ²	1,060	950	1,160	1,070	900
Consumption:					
Reported ⁴	4,540 ^r	4,580 ^r	4,550	4,640 ^r	4,740
Apparent	W	W	W	W	W
World, production ^c	26,300	26,500	27,200 ^r	26,500 ^r	26,800

^cEstimated. ^rRevised. 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.

TABLE 2
DOMESTIC CONSUMPTION OF IODINE, BY PRODUCT^{1,2}

Product	2010		2011	
	Number of plants	Quantity (metric tons)	Number of plants	Quantity (metric tons)
Inorganic compounds:				
Crude iodine	3	170 [†]	1	171
Resublimed iodine	7	699	6	108
Potassium iodide	4	122	3	527
Sodium iodide	1	10	3	145
Ammonium iodide	--	--	1	(3)
Hydriodic acid	3	181	3	124
Potassium iodate	3	34	3	40
Miscellaneous iodate and iodides ⁴	1	93	1	87
Other inorganic compounds	4	752	4	494
Total	XX ⁵	2,060 [†]	XX ⁵	1,700
Organic compounds:				
Ethylenediamine dihydroiodide	2	256	2	226
Povidine-iodine (iodophors)	--	--	3	443
Other organic compounds ⁶	9	2,320	9	2,370
Total	XX ⁵	2,580	XX ⁵	3,040
Grand total	XX	4,640 [†]	XX	4,740

[†]Revised. XX Not applicable. -- Zero.

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

²Reported by voluntary response to the U.S. Geological Survey in a survey of domestic establishments.

³Less than ½ unit.

⁴Includes ammonium iodide, calcium iodate, and cuprous iodide.

⁵Nonadditive because some plants produce more than one product concurrently.

⁶Includes methyl and (or) ethyl iodide and other unspecified products.

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

Type and country of origin ³	2010		2011	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Iodine, crude/resublimed:				
Belgium	--	--	19	\$526
Canada	203	\$4,920	124	2,630
Germany	661	14,000	643	14,000
Italy	35	940	18	485
Japan	28	509	16	305
Malaysia	9	64	11	90
Mexico	55	319	3	57
Netherlands	10	221	--	--
South Africa	33	551	47	769
Other ⁴	39 ^r	783 ^r	20	336
Total	1,070	22,300	900	19,200
Potassium iodide:⁵				
Australia	14	338	3	52
Chile	82	1,730	19	444
China	3	77	16	476
France	119	2,600	1	24
Germany	35	862	4	64
Japan	1	10	24	408
Korea, Republic of	25	452	20	349
Mexico	13	370	11	271
Netherlands	--	--	28	486
Russia	5	125	--	--
Saudi Arabia	31	702	58	1,530
Singapore	5	82	11	188
Taiwan	73	1,030	89	1,540
Turkey	16	451	38	906
Other ⁶	20 ^r	505 ^r	23	512
Total	442	9,330	344	7,250

^rRevised. -- 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.

⁴Includes countries with quantities less than 10 metric tons.

⁵Potassium iodide contains 76% crude iodine.

⁶Includes countries with quantities less than 5 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	2010		2011	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Iodine, crude:				
Chile	4,770	\$120,000 ^r	5,790	\$234,000
France	1	13	6	188
India	--	--	13	245
Japan	937	19,100 ^r	777	16,900
Other ⁴	4	43 ^r	5	95
Total	5,710	139,000^r	6,590	251,000
Potassium iodide:⁵				
Brazil	19	412 ^r	--	--
Canada	315	7,980 ^r	233	3,310
Chile	26	330 ^r	--	--
Germany	9	107 ^r	6	90
India	35	646 ^r	78	1,370
United Kingdom	15	151 ^r	41	486
Other ⁴	3	79 ^r	8	151
Total	423	9,700^r	366	5,400

^rRevised. -- Zero.

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 5 metric tons.

⁵Gross 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	2007	2008	2009	2010	2011
Azerbaijan	300	300	300	300	300
Chile ³	15,473 ⁴	15,503 ⁴	17,399 ⁴	15,793 ^{r,4}	16,000
China	570	570	580	590	590
Indonesia	75	75	75	75	75
Japan	9,282 ⁴	9,500	8,232 ^{r,4}	9,216 ^{r,4}	9,300
Russia	300	300	300	300	300
Turkmenistan	270	270	270	270	270
United States	W	W	W	W	W
Uzbekistan	2	2	2	2	2
Total	26,300	26,500	27,200^r	26,500^r	26,800

^rRevised. 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 May 31, 2012.

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

⁴Reported figure.