



2014 Minerals Yearbook

IODINE [ADVANCE RELEASE]

IODINE

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In 2014, there were three domestic producers of crude iodine. Reported consumption by producers and consuming industries was 3,900 metric tons (t) in 2014, which was a 4% decrease from that in 2013 (table 2). Crude iodine exports increased to 1,240 t valued at \$36.2 million in 2014 compared with 1,150 t valued at \$33.2 million in 2013 (table 3). Imports of crude iodine decreased to 5,360 t valued at \$198 million in 2014 compared with 5,960 t valued at \$255 million in 2013 (table 4). World production, excluding U.S. production, was estimated to be 30,300 t in 2014 compared with the revised 30,800 t in 2013 (table 5). Chile was the world's leading producer of iodine, followed by Japan and the United States.

Iodine and its compounds are primarily used in x-ray contrast media (XRCM), pharmaceuticals, liquid-crystal-display (LCD) screens, and iodophors, in descending order. Iodine is also used in animal feed, antiseptics, catalysts, food supplements, halogen lights, starch detection, and water purification. Globally, XRCM was the largest single market for iodine in 2014, accounting for approximately 22% of consumption (Sociedad Química y Minera de Chile S.A., 2015, p. 20).

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 in 2014 from that of 2013; data were withheld to avoid disclosing company proprietary data.

IOCHEM Corp. produced iodine near Vici, in Dewey County, OK, from 16 production wells that extract brine from a sandstone layer approximately 2 miles below the surface. The brines contained between 300 and 400 parts per million (ppm) of iodine. According to the company, IOCHEM was the largest producer of iodine in North America with an estimated 1,200 metric tons per year (t/yr) of iodine manufactured. Iodine produced by IOCHEM has a minimum specification of 99.5% iodine content (IOCHEM Corp., undated).

Woodward Iodine Corp. (owned by Ise Chemicals Corp. of Japan) produced iodine near Woodward, in Woodward County, OK, with 22 production and 10 injection wells. Woodward produced iodine from brines and also recycled iodine from other sources. The associated plant has an estimated capacity of 900 t/yr (Roskill Information Services Ltd., 2013, p. 151).

Iofina plc (United Kingdom) had iodine production operations in Kentucky, Montana, Oklahoma, and Texas. In 2014, the company produced 328 t of crystallized iodine, a 91% increase compared with the 171 t produced in 2013 (Iofina plc, 2015, p. 1). The company also completed construction and commissioning of its IO#4, IO#5, and IO#6 iodine extraction plants, yielding a total of six iodine production facilities by the end of 2014. The extraction plants were expected to use

the company's Wellhead Extraction Technology® (WET®) and WET® IOsorb™ method to process saltwater waste brines from shale-oil production. According to the company, WET® IOsorb™ plants are capable of producing between 50 and 450 t/yr of iodine, depending on the location's flow and iodine concentrations (Iofina plc, undated).

Consumption

The U.S. Geological Survey obtained domestic consumption data for iodine from a voluntary canvass of 20 U.S. operations (table 1). Reported consumption by producers and consuming industries decreased to 3,900 t in 2014 compared with a revised 4,070 t in 2013. Of the 20 companies to which a survey form was sent, 13 responded to the annual or preliminary surveys. Accurate end-use statistics were difficult to gather because domestic and imported iodine were used to produce many intermediate iodine compounds, typically by downstream manufacturers.

Reported consumption of inorganic compounds decreased slightly in 2014 from that of 2013 (table 2). In particular, consumption of hydriodic acid and potassium iodate decreased by 21% and 31%, respectively. Reported consumption of organic compounds decreased 6% in 2014 from the revised number of 2013, although consumption of Ethylenediamine dihydroiodide (EDDI) increased by 50%. EDDI is most commonly used as an additive in pet food to prevent iodine deficiency.

Commercial crude iodine typically 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.—Because iodine is one of the most effective medical antiseptics available, it is used in biocides and disinfecting chemicals. Iodine is a cost-efficient, effective, and simple means of water disinfection. 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 most popular iodophor for surgical scrub and gargle is povidone-iodine, which contains about 10% iodine. These forms have almost completely replaced tincture of iodine as they do not cause any burning sensation when applied to human tissue.

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 conditions and may contain iodine. Problems diagnosed using radiopaque agents 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 medicine, and hydriodic acid and potassium iodide were used in the synthesis of amphetamine, ethylamphetamine, and methamphetamine, which are regulated stimulants.

Radioactive iodine, the isotope ^{131}I , is a major constituent of both nuclear power plants and nuclear bombs. The ingestion of a very small amount of radioactive iodine can cause thyroid cancer. Potassium iodide tablets can be taken to prevent radioactive iodine from accumulating in the thyroid gland. Iodine prophylaxis is especially important for children under the age of 18 and pregnant women. The World Health Organization recommends the stockpiling of potassium iodide tablets near any nuclear powerplant (World Health Organization, 1999, p. 2).

XRCM are substances that cause soft tissues to become visible during x-ray examination. The media are typically injected or swallowed by the patient and block the ability of x rays to pass through, temporarily changing the appearance of body tissue, blood vessels, and organs. All XRCM in use today are organic iodine derivatives. Although many elements have higher atomic numbers than iodine, no other element has the chemical characteristics that allow iodine to form soluble compounds with low toxicity. It is this latter property that makes iodine-containing contrast media suitable for radiography.

Nutrition.—Iodine is an essential component of thyroid hormones, which directly affect processes in the brain, muscles, heart, pituitary gland, and kidneys. Iodine deficiency, a world health problem affecting approximately 2 billion people, can cause goiter in adults, increased mortality and impaired cognitive development in children, and reproductive failure (World Health Organization, undated). Since the 1920s, iodized salt has been the primary source of supplemental dietary iodine in the western world. Iodine deficiency disorder can be prevented by consuming about 150 milligrams per day of iodine for a human adult (Institute of Medicine of the National Academies, 2006).

Other Uses.—Developments in digital imaging have allowed electronic prints to be produced without the need for wet processing film. The majority of current feature films, however, continue to rely 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 was also used for manufacturing iodine-adsorbed polyvinyl alcohol polarizing films for LCDs 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

The spot price of crude crystal iodine, 99.5% minimum purity, in 50-kilogram drums, as reported by Industrial Minerals, ranged from \$45 to \$55 per kilogram in January 2014. This is a decrease in price compared to January 2013 prices which ranged from \$65 to \$85 per kilogram. Prices continued to decrease slowly throughout the year. In April, May, and June prices ranged from \$39 to \$48 per kilogram. This also was less than 2013 prices which ranged from \$59 to \$65 per kilogram in April and May 2013. In September and October, prices ranged from \$35 to \$40 per kilogram. At yearend 2014, prices ranged from \$31 to \$35 per kilogram compared to 2013 year end prices of \$45 to \$55 per kilogram. Actual prices for iodine are negotiated on long- and short-term contracts between buyers and sellers.

Foreign Trade

Net trade was not easily defined because iodine was exported and imported in many forms other than elemental iodine and potassium iodide. Exports of crude iodine increased by 8% to 1,240 t, and the free alongside ship (f.a.s.) value of those exports increased by 9% to \$36.2 million compared with those in 2013. Exports of crude iodine to Canada and Germany represented 71% of total crude iodine exports in 2014. The quantity of exported potassium iodide decreased by 8% to 255 t but the value of those exports increased by 5% to \$5.6 million compared those in 2013. The leading destination for exported potassium iodide was Taiwan, which received 40% of the total potassium iodide exported in 2014 (table 3).

Imports of crude iodine decreased by 10% to 5,360 t, and the value of those imports decreased by 22% compared with those in 2013. Imports of crude iodine from Chile and Japan represented 99% of total crude iodine imports in 2014. Imports of potassium iodide decreased by 17% to 283 t and the cost, insurance, and freight (c.i.f.) value of those imports decreased by 16% compared with those in 2013. Imports of potassium iodide from Canada represented 52% of total potassium iodide imported in 2014 (table 4).

World Review

World production of iodine, excluding U.S. production, was estimated to be 30,300 t in 2014 compared with the revised 30,800 t in 2013 (table 5). Chile was the world's leading producer of iodine, followed by Japan and the United States.

Azerbaijan.—Azer-Yod, LLC (a subsidiary of ISR Holding) was the sole iodine producer in Azerbaijan. Its Neftchalinsky plant has a production capacity of 500 t/yr with output in the form of 90.1% and 99.5% crystalline iodine (ISR Holding, undated).

Chile.—Sociedad Química y Minera de Chile S.A. (SQM), the world's leading iodine producer with a total production capacity of approximately 13,300 t/yr, reported 2014 production for iodine and its derivatives of 8,800 t of contained iodine valued at \$335 million. This was a 5% decrease in quantity compared with the 9,300 t of contained iodine valued at \$461 million reported in 2013. According to SQM, their average price in 2014 was \$38 per kilogram, approximately 23% less than the 2013 reported price (Sociedad Química y Minera de Chile S.A., 2015, p. 21, 54). SQM owned four operations in Chile that produced iodine and nitrates from caliche ore, only two of which were operational in 2014—Nueva Victoria and Pedro de Valdivia. Operations at their other facilities, Maria Elena and Pampa Blanca, were suspended in 2013 and 2010, respectively. In 2014, SQM completed an expansion of the production facility at Nueva Victoria, increasing its capacity to approximately 6,500 t/yr of iodine (Sociedad Química y Minera de Chile S.A., 2015, p. 5, 39).

RB Energy Inc. (Vancouver, British Columbia, Canada) became the owner of the Aguas Blanca Mine, located approximately 75 kilometers (km) southeast of Antofagasta, following the acquisition and merger of Sirocco Mining Inc. and Canadian Lithium Corp. in January (RB Energy Inc., 2014a). In September, RB Energy announced it was accepting offers for the sale of Aguas Blanca (RB Energy Inc., 2014b). Production for the first three quarters of 2014 was 913 t of iodine. Data were not available for the final three months of 2014 (RB Energy Inc., 2014c, d, e).

Compañía de Salitre y Yodo (Cosayach) produced iodine from caliche ore at its three Chilean operations, Cala Cala, Negreiros, and Soledad, with a total capacity of 6,000 t/yr of iodine (Compañía de Salitre y Yodo, undated a). In May, the company was found guilty of the illegal use of groundwater for its iodine and nitrate production at the Cala Cala and Negreiros facilities and was ordered to close 38 wells. The wells had been illegally extracting water since 2003 in a region with an average rainfall of less than 20 milliliters a year, depleting aquifers and potentially causing considerable damage to the environment (Syrett, 2014). With the intention of bringing production to full capacity at the Negreiros facility, the company was constructing a 26-km pipeline that would deliver 4 million cubic meters per year of seawater to the site. The pipeline was expected to be fully operational in 2015 (Compañía de Salitre y Yodo, undated b).

China.—Almost all crude iodine produced in China was as a coproduct of sodium alginate extraction from seaweed rather than from brines or nitrate deposits. Therefore, China's iodine industry was located mainly in the coastal Provinces of Shandong and Jiangsu. There were more than 30 producers of iodine in China, though their capacities were relatively small compared with producers in most other countries (Roskill Information Services Ltd., 2013, p. 77–78).

Japan.—Japan's estimated production included both crude iodine production and secondary iodine production. Crude iodine capacity has remained between 6,000 and 6,500 t/yr; however, secondary iodine production has continued to increase. Crude iodine production was produced from underground brines associated with wet natural gas deposits. An estimated

80% of output was from Chiba Prefecture, from the Southern Kanto gasfield, and the remainder from Niigata and Miyazaki Prefectures. Japanese crude iodine producers have historically high production costs, owing to the expense of brine extraction. However, high production costs are typically offset by the high price of natural gas (Roskill Information Services Ltd., 2013, p. 107).

In 2014, iodine producers in Japan included Godo Shigen Co. Ltd., Inpex Co., Ise Chemical Co., Kanto Natural Gas Development Co. Ltd. (KNG), Nihon Tennen Gas Co. Ltd., Nippoh Chemicals Co., Ltd., and Toho Earthtec Inc.

Outlook

Future growth in iodine consumption likely will be driven by applications for LCD screens and XRCM, especially in developing countries. According to some analysts, LCDs are expected to remain the most commonly used technology for at least the next few years, after which they are expected to experience increased competition from technologies that do not use optical polarizing film. The most likely competition is expected to be from organic light emitting diode products (Industrial Minerals, 2011).

In addition, demand for XRCM, which contain as much as 60% iodine, has increased significantly. More medical testing of an aging population in developing countries could also result in increased demand for iodine-containing XRCM.

The water treatment market is also 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. World demand for iodine is forecast to rise by an average of about 3.45% per year to 36,300 t by 2017 (Roskill Information Services Ltd., 2013, p. 190).

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Other

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TABLE 1
SALIENT IODINE STATISTICS¹

(Metric tons and dollars)

	2010	2011	2012	2013	2014
United States:					
Production	W	W	W	W	W
Imports:					
Quantity, for consumption ²	5,710	6,620 ^r	5,960	5,960	5,360
Price, average dollars per kilogram ³	24.71 ^r	38.35 ^r	42.28 ^r	42.77 ^r	37.04
Exports ²	1,080 ^r	902 ^r	1,040	1,150	1,240
Consumption:					
Reported	4,670 ^r	4,780 ^r	4,930 ^r	4,070 ^r	3,900
Apparent	W	W	W	W	W
World, production ^c	26,000 ^r	26,200 ^r	27,800 ^r	30,800 ^r	30,300

^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.

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

Product	2013		2014	
	Number of plants	Quantity (metric tons)	Number of plants	Quantity (metric tons)
Inorganic compounds:				
Ammonium iodide	--	--	1	(3)
Crude iodine	1	147	1	147
Hydriodic acid	2	160	3	126
Potassium iodate	3	51	3	35
Potassium iodide	3	638	3	567
Resublimed iodine	5	43	6	80
Sodium iodide	3	60	3	79
Miscellaneous iodate and iodides ⁴	1	88	1	78
Other inorganic compounds	4	537	5	587
Total	XX ⁵	1,720	XX ⁵	1,700
Organic compounds:				
Ethylenediamine dihydroiodide	1	150	1	225
Povidine-iodine (iodophors)	-- ^r	-- ^r	--	--
Other organic compounds ⁶	7 ^r	2,190 ^r	9	1,980
Total	XX ⁵	2,340 ^r	XX ⁵	2,210
Grand total	XX	4,070 ^r	XX	3,900

^rRevised. 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 from a survey of domestic establishments.

³Less than ½ unit.

⁴Includes 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 ²	2013		2014	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Iodine, crude:				
Belgium	41	\$675	38	\$552
Canada	255	3,460	199	3,310
Germany	630	24,500	687	25,800
Italy	(4)	7	18	644
Japan	6	87	58	2,080
Malaysia	10	119	9	126
Mexico	26	475	28	147
New Zealand	50	828	56	926
South Africa	24	402	24	403
Spain	--	--	(4)	4
Thailand	1	26	10	175
Other ⁵	107	2,600	114	2,050
Total	1,150	33,200	1,240	36,200
Potassium iodide:⁶				
Australia	8	127	--	--
Belgium	1	18	--	--
China	8	137	(4)	33
Korea, Republic of	17	392	20	409
Mexico	34	649	27	653
Peru	5	70	--	--
Saudi Arabia	18	344	46	1,260
Singapore	1	79	2	100
Taiwan	110	2,110	103	1,940
Turkey	19	330	19	499
United Arab Emirates	25	421	--	--
United Kingdom	4	64	3	54
Venezuela	11	187	--	--
Other ⁷	15	397	35	662
Total	276	5,320	255	5,610

-- Zero.

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

²Export 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.

³Declared free alongside ship valuation.

⁴Less than ½ unit.

⁵Includes countries with quantities less than 10 metric tons.

⁶Contains 76% iodine.

⁷Includes 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 ²	2013		2014	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Iodine, crude:				
Brazil	--	--	39	\$1,630
Chile	5,300	\$233,000 ^r	4,670	175,000
Hungary	44	844 ^r	--	--
India	1	25 ^r	(4)	9
Japan	617	21,100 ^r	642	21,600
Other ⁵	2	105 ^r	3	110
Total	5,960	255,000^r	5,360	198,000
Potassium iodide:⁶				
Brazil	53	2,420 ^r	30	1,130
Canada	200	2,440 ^r	148	2,600
China	9	104 ^r	20	207
Germany	11	154 ^r	33	445
India	34	466 ^r	27	368
Japan	(4)	6 ^r	1	12
Netherlands	3	31	--	--
Switzerland	--	--	1	18
United Kingdom	30	524 ^r	23	407
Other ⁵	2	57 ^r	(4)	13
Total	341^r	6,200^r	283	5,200

^rRevised. -- Zero.

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

²Import 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.

³Declared cost, insurance, and freight valuation.

⁴Less than ½ unit.

⁵Includes countries with quantities less than 5 metric tons.

⁶Contains 76% iodine.

Source: U.S. Census Bureau.

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

(Metric tons)

Country ³	2010	2011	2012	2013	2014
Azerbaijan	223 ^r	230 ^r	240 ^r	249 ^r	221
Chile ⁴	15,793 ⁵	16,000 ⁵	17,494 ⁵	20,656 ⁵	20,000
Indonesia	56 ^r	61 ^r	44 ^r	43 ^r	50
Japan	9,216 ⁵	9,277 ⁵	9,315 ⁵	9,334 ⁵	9,500
Russia	230	210	200	-- ^r	--
Turkmenistan	470 ^r	470 ^r	480	500	500
United States	W	W	W	W	W
Total⁶	26,000^r	26,200^r	27,800^r	30,800^r	30,300

^rRevised. W Withheld to avoid disclosing company proprietary data; not included in total. -- Zero.

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

²Includes data available through June 4, 2015.

³In addition to the countries listed, China and Iran also produce crude iodine, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.

⁴Includes iodine production reported by Servicio Nacional de Geología y Minería.

⁵Reported figure.

⁶Does not include U.S. production.