



2013 Minerals Yearbook

IODINE [ADVANCE RELEASE]

IODINE

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In 2013, iodine production and apparent consumption in the United States increased. There were three domestic producers of crude iodine. Reported consumption by producers and consuming industries was 4,020 metric tons (t) in 2013 compared with 4,880 t in 2012 (table 2). Crude iodine exports increased to 1,150 t valued at \$33.2 million in 2013 compared with 1,040 t valued at \$27.8 million in 2012 (table 3). Imports of crude iodine remained the same at 5,960 t valued at \$254 million in 2013 compared with 5,960 t valued at \$250 million in 2012 (table 4). World production, excluding U.S. production, was estimated to be 31,300 t in 2013 compared with the revised 27,900 t in 2012 (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, biocides, pharmaceuticals, and photography, in descending order. Iodine is also used in animal feed, antiseptics, catalysts, food supplements, halogen lights, starch detection, and water purification. Globally, x-ray contrast media was the largest single market for iodine in 2012, accounting for an estimated 6,725 t (Roskill Information Services Ltd., 2013, p. 194).

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 2013 from that of 2012; data were withheld to avoid disclosing company proprietary data.

IOCHEM Corp. produced iodine from brines near Vici, in Dewey County, OK. In 2012, IOCHEM became a 100% subsidiary of Toyota Tsusho America, Inc. According to the company, IOCHEM has the largest capacity of the three U.S. producers, estimated at 1,500 metric tons per year (t/yr). Iodine produced by IOCHEM has a minimum specification of 99.5% iodine content (Roskill Information Services Ltd., 2013, p. 151).

Woodward Iodine Corp. (owned by Ise Chemical Corp. of Japan) produced iodine near Woodward, in Woodward County, OK, and has 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. The company produced a record 171 t of crystallized iodine in 2013. The company also reported that it completed construction and commissioning of its IO#2 and IO#3 iodine extraction plants, achieving a tenfold increase in production capacity compared with yearend 2012, when it only had IO#1 in production. The extraction plants were expected to use the company's WET[®]

IOsorb[™] technology to process saltwater waste brine from shale-oil production. The shale waste brine was piped by shale-oil producers to saltwater disposal sites. Iofina's plants were expected to be located at these disposal sites. The company was not expected to release information on the exact location of any of its extraction facilities. The company expected to complete construction of IO#4, IO#5, and IO#6 in 2014, which would result in total annual production of approximately 400 t of crystallized iodine (Iofina plc, 2014, p. 1–2.)

Consumption

The U.S. Geological Survey obtained domestic consumption data for iodine from a voluntary canvass of 21 U.S. operations (table 1). Reported consumption by producers and consuming industries decreased to 4,020 t in 2013 compared with 4,880 t in 2012. Of the 21 companies to which a survey form was sent, 12 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.

U.S. apparent consumption of iodine, which was withheld to avoid disclosing company proprietary data, increased in 2013 from that of 2012. Consumption of potassium iodide (KI) decreased slightly and consumption of resublimed iodine decreased by 51% compared with 2012. The large decrease in consumption of resublimed iodine was attributed to one consumer. Consumption of miscellaneous and other inorganic iodine products, which include ammonium iodide, calcium iodate, and cuprous iodide, decreased by 8%. Consumption of organic iodine compounds decreased by 24% (table 2).

Commercial crude iodine normally has a minimum purity of 99.5% to 99.8%, depending on the supplier. Impurities, in decreasing 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 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. Iodine is a cost-efficient, effective, and simple means of water disinfection.

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. 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 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 I^{131} , is a major constituent of both nuclear powerplants 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. The World Health Organization recommends the stockpiling of potassium iodide tablets near any nuclear powerplant (Roskill Information Services Ltd., 2013, p. 210–211).

X-ray contrast media (XRCM) are substances that cause soft tissues to become visible during x-ray examination. 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 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 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. Consumption of iodine in photography is expected to

decrease and by 2017 is expected to be as little as 50 t (Roskill Information Services Ltd., 2013, p. 258).

Iodine was used for manufacturing iodine-adsorbed polyvinyl alcohol polarizing films for liquid crystal displays (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 \$65 to \$85 per kilogram in January 2013. Prices continued to decrease slowly throughout the year. In April and May, prices ranged from \$59 to \$65 per kilogram. In August and September, prices ranged from \$55 to \$59 per kilogram. At yearend 2013, prices ranged from \$45 to \$55 per kilogram. Actual prices for iodine are negotiated on long- and short-term contracts between buyers and sellers.

Iodine prices were largely stable in 2010 and at the beginning of 2011. However, prices began a dramatic increase in March 2011 following the earthquake and tsunami in Japan. Gasfields were damaged by the tsunami and iodine production declined. South American producers also experienced a seasonal decrease in iodine production owing to severe weather conditions in 2011. Worldwide consumption of iodine, specifically KI tablets for radioactivity protection, dramatically increased owing to the fear associated with the Fukushima Daiichi nuclear disaster. In 2012, both Japanese and South American producers recovered to normal rates of iodine production causing prices to slowly decline. Prices in 2013 continued to decline owing to a surplus of iodine in the market (Roskill Information Services Ltd., 2013, p. 261).

Foreign Trade

Net trade was not easily defined because iodine was exported and imported in many forms other than elemental iodine and KI. Exports of crude iodine increased to 1,150 t with a free alongside ship (f.a.s.) value of \$33.2 million in 2013 compared with 1,040 t valued at \$27.8 million in 2012. Exports of crude iodine to Canada and Germany represented 77% of total crude iodine exports in 2013. Exports of KI decreased to 276 t with an f.a.s. value of \$5.3 million in 2013 compared with 336 t valued at \$6.8 million in 2012 (table 3).

Imports of crude iodine remained the same at 5,960 t valued at \$254 million in 2013 compared with 5,960 t valued at \$250 million in 2012. Imports of KI decreased to 340 t with a cost, insurance, and freight (c.i.f.) value of \$6.1 million in 2013 compared with a total of 431 t valued at \$6.2 million in 2012. Imports of crude iodine from Chile and Japan represented 99% of total crude iodine imports in 2013. Imports of KI from Brazil and Canada represented 74% of total KI imports in 2013 (table 4).

World Review

World production of iodine, excluding the United States, was estimated to be 31,300 t in 2013 compared with the revised 27,900 t in 2012 (table 5). In 2013, 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) produced approximately 350 t of iodine in 2013 at its Neftchalinsky plant, which has a capacity of 500 t/yr of iodine. Output was 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 leading iodine producer worldwide, reported 2013 production for iodine and its derivatives of 9,300 t of contained iodine valued at \$461 million, a 15% decrease in quantity compared with the 11,000 t of contained iodine valued at \$578 million reported in 2012. According to SQM, the average price for 2013 was just under \$50 per kilogram, almost 6% less than the price reported during 2012 (Sociedad Química y Minera de Chile S.A., 2014, p. 2–3). SQM owned four operations in Chile that produced iodine and nitrates from caliche ore—Pedro de Valdivia, Maria Elena, Nueva Victoria, and Pampa Blanca. According to the company, its Nueva Victoria plant was the largest iodine plant in the world and has an estimated capacity of 5,500 t/yr. SQM also produced a small amount of secondary iodine by recycling imported wastes.

Sirocco Mining Inc. (Toronto, Ontario, Canada) announced that its Aguas Blanca Mine, located approximately 75 kilometers southeast of Antofagasta, produced approximately 1,400 t of iodine in 2013 and was expected to produce approximately 1,000 t in 2014. Annual capacity was expected to increase to over 2,000 t/yr upon completion of the installation of a semi-autogenous grinding (SAG) mill (RB Energy Inc., 2013).

Compañía de Salitre y Yodo (Cosayach) had a capacity of 7,500 t/yr of iodine from its three Chilean operations—Negreiros (40%), Soledad (40%), and Cala Cala (20%). Negreiros and Soledad only produced iodine-rich solutions, which were sent to a purification and melting plant at Cala Cala to produce iodine flakes, prilled iodine, and byproduct nitrates (Industrial Minerals, 2011).

China.—Almost all crude iodine produced in China was as a coproduct of sodium alginate extraction from seaweed rather than based on 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, and 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 some 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 2013, iodine producers in Japan included GodoShigen Sangyo Co. Ltd., Inpex, Co., Ise Chemical Co. Ltd., Kanto Natural Gas Development Co. Ltd. (KNG), Nihon Tennen Gas Co. Ltd., Nippon Chemicals Co., and Toho Earthtec Inc.

Outlook

During the past decade, the iodine market has evolved significantly. New technological applications have been developed, including LCDs, stimulating growth in demand. 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 experience increased competition from technologies that do not use optical polarizing film. The most likely competition was expected to be from organic light-emitting diode products (Industrial Minerals, 2011). LCD televisions represent the largest market for polarizers in terms of surface area, but tablet PCs and smartphones are the fastest growing applications. Notebooks, global positioning systems, and portable media devices are also a growing market for polarizers, but at a lower rate (Roskill Information Services Ltd., 2013, p. 219).

In addition, demand for x-ray contrast media, which contain as much as 60% iodine, has increased significantly. The water treatment market also was 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. More medical tests on an aging population in developing countries could also result in increased demand for iodine-containing x-ray contrast media. World consumption of iodine was forecast to rise by an average of 3.45% per year to 36,300 t by 2017 (Roskill Information Services Ltd., 2013, p. 190).

References Cited

- Industrial Minerals, 2011, Inside iodine: Industrial Minerals, no. 531, December, p. 35–39.
- Institute of Medicine of the National Academies, 2006, Iodine, *in* Otten, J.J., Hellwig, J.P., and Meyers, L.D., eds., DRI, dietary reference intakes—The essential guide to nutrient requirements: Washington, DC, Institute of Medicine of the National Academies, p. 321–327.
- Iofina plc, 2014, Audited final results: London, United Kingdom, April 25, 55 p. (Accessed May 12, 2014, at <http://www.iofina.com/perch/resources/25april20142013-final-results.pdf>.)
- ISR Holding, undated, Azer Yod: Baku, Azerbaijan, ISR Holding. (Accessed April 24, 2014, at <http://isrholding.com/production/info/93/>.)
- RB Energy Inc., 2013, Sirocco and Canada Lithium combining to form strategic international competitor in growth-oriented industrial minerals sector: Toronto, Ontario, Canada, RB Energy Inc., Dec. 4. (Accessed June 16, 2014, via <http://www.rb-e.com/s/home.asp>.)
- Roskill Information Services Ltd., 2013, Global industry markets and outlook (11th ed.): London, United Kingdom, Roskill Information Services Ltd., 271 p.
- Sociedad Química y Minera de Chile S.A., 2014, SQM reports earnings for the fourth quarter of 2013: Santiago, Chile, Sociedad Química y Minera de Chile S.A., March 4, 9 p. (Accessed April 24, 2014, at http://ir.sqm.com/files/doc_news/2014/new/SQM_4Q_Earnings_press_release_v_ing_FINAL.pdf.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140. Iodine. Ch. in Mineral Commodity Summaries, annual.

Other

Roskill Information Services Ltd. [last reported on iodine in 2013].

TABLE 1
SALIENT IODINE STATISTICS¹

(Metric tons and dollars)

	2009	2010	2011	2012	2013
United States:					
Production	W	W	W	W	W
Imports:					
Quantity, for consumption ²	5,190	5,710	6,590	5,960	5,960
Price, average ³ dollars per kilogram	25.55	24.39	38.13	41.97	42.51
Exports ²	1,160	1,070	900	1,040	1,150
Consumption:					
Reported	4,550	4,640	4,740	4,880	4,020
Apparent	W	W	W	W	W
World, production ^c	26,500 ^r	25,900 ^r	26,100 ^r	27,900 ^r	31,300

^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	2012		2013	
	Number of plants	Quantity (metric tons)	Number of plants	Quantity (metric tons)
Inorganic compounds:				
Ammonium iodide	1	--	--	--
Crude iodine	1	171	1	147
Hydriodic acid	3	201	2	160
Potassium iodate	3	45	3	51
Potassium iodide	3	648	3	638
Resublimed iodine	6	87	5	43
Sodium iodide	3	40	3	60
Miscellaneous iodate and iodides ³	1	96	1	88
Other inorganic compounds	4	592	4	537
Total	XX ⁴	1,880	XX ⁴	1,720
Organic compounds:				
Ethylenediamine dihydroiodide	2	192	1	150
Povidine-iodine (iodophors)	3	386	3	179
Other organic compounds ⁵	9	2,430	6	1,970
Total	XX ⁴	3,000	XX ⁴	2,300
Grand total	XX	4,880	XX	4,020

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.

³Includes ammonium iodide, calcium iodate, and cuprous iodide.

⁴Nonadditive because some plants produce more than one product concurrently.

⁵Includes 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	2012		2013	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Iodine, crude:				
Belgium	3	\$55	41	\$675
Canada	196	3,050	255	3,460
Germany	630	19,800	630	24,500
Italy	(4)	9	(4)	7
Japan	44	935	6	87
Malaysia	5	62	10	119
Mexico	15	290	26	475
New Zealand	22	515	50	828
Norway	36	1,410	--	--
South Africa	38	625	24	402
Spain	18	397	--	--
Thailand	15	380	1	26
Other ⁵	16	301	107	2,610
Total	1,040	27,800	1,150	33,200
Potassium iodide:⁶				
Australia	16	268	8	127
Belgium	4	64	1	18
China	33	580	8	137
Korea, Republic of	23	357	17	392
Mexico	36	692	34	649
Peru	3	56	5	70
Saudi Arabia	40	1,160	18	344
Singapore	2	66	1	79
Taiwan	113	2,330	110	2,110
Turkey	22	367	19	330
United Arab Emirates	11	189	25	421
United Kingdom	21	350	4	64
Venezuela	--	--	11	187
Other ⁷	12 ^r	287 ^r	15	397
Total	336	6,760	276	5,320

^rRevised. -- 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	2012		2013	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Iodine, crude:				
Chile	5,180	\$228,000	5,300	\$232,000
Hungary	85	1,710	44	831
India	(4)	12	1	23
Japan	689	20,000	617	20,900
Other ⁵	6	134	2	89
Total	5,960	250,000	5,960	254,000
Potassium iodide:⁶				
Brazil	31	1,280	53	2,410
Canada	295	3,640	200	2,420
China	8	94	9	102
Germany	3	66	11	150
India	67	805	34	452
Japan	5	64	(4)	5
Netherlands	--	--	3	31
Switzerland	5	61	--	--
United Kingdom	17	209	30	504
Other ⁵	(4)	31	2	55
Total	431	6,250	340	6,130

-- 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	2009	2010	2011	2012	2013
Azerbaijan	300	300	300	350	350
Chile ^{4,5}	17,399	15,793	16,000	17,494 ^r	20,656
Indonesia	75	75	75	75	75
Japan	8,232 ⁵	9,216 ⁵	9,277 ⁵	9,315 ^{r,5}	9,500
Russia	250 ^r	230 ^r	210 ^r	200 ^r	200
Turkmenistan	270	270	270	480	500
United States	W	W	W	W	W
Uzbekistan	-- ^r	-- ^r	-- ^r	-- ^r	--
Total	26,500 ^r	25,900 ^r	26,100 ^r	27,900 ^r	31,300

^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 17, 2014.

³In addition to the countries listed, China also produces 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.