



2012 Minerals Yearbook

IODINE

IODINE

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Iodine production and apparent consumption in the United States increased in 2012 compared with that of 2011. Data for production and apparent consumption were withheld to avoid disclosing company proprietary data. Reported consumption by producers and consuming industries was 4,880 metric tons (t) in 2012 compared with 4,740 t in 2011. Crude and sublimed iodine exports increased to 1,040 t valued at \$27.8 million in 2012 compared with 900 t valued at \$19.2 million in 2011. Imports of crude iodine decreased to 5,960 t valued at \$250 million in 2012 compared with 6,590 t valued at \$251 million in 2011. World production, excluding U.S. production, was estimated to be 28,000 t in 2012 compared with the revised 26,200 t in 2011.

Legislation and Government Programs

The U.S. Environmental Protection Agency (EPA) and Arysta LifeScience North America LLC entered into a memorandum of agreement to formally terminate all agricultural use of its fumigant MIDAS[®], also known as iodomethane and methyl iodide, in the United States by yearend 2012, and ultimately remove all methyl iodide products from the U.S. market completely. Arysta was the only supplier of iodomethane to U.S. markets. 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; U.S. Environmental Protection Agency, 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 2012 from that of 2011. 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 Oklahoma.

In August, Iofina commissioned its first U.S. iodine extraction plant, IO#1, which, by December, was producing 1 t per week of high-grade iodine. The company announced that production at IO#1 was limited by both a shortfall of brine, which must be trucked to the plant, lower than expected disposal rates for the processed brine, and issues with lower than anticipated iodine content of the supplied brines. The extraction plant was 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 salt water disposal sites. Iofina's plants were expected to be located on

these disposal sites. The company was not expected to release information on the exact location of any of its extraction facilities. Construction of IO#2, located in Oklahoma, was complete. IO#3 was being fabricated and was expected to receive equipment by early 2013. The company continued to discuss options for IO#4, IO#5, and IO#6. Iofina expected to produce approximately 300 t of iodine in 2013 from its two operating plants (IO#1 and IO#2) (Iofina plc, 2012a; Syrett, 2012).

Iofina also announced that it has successfully entered into the iodine recycling business to manage waste streams from chemical, electronics, nylon, and pharmaceuticals manufacturing. The iodine was processed at the Iofina Chemical, Inc. location in Covington, KY (Iofina plc., 2012b).

Consumption

U.S. apparent consumption of iodine, which is withheld to avoid disclosing company proprietary data, decreased in 2012 from that of 2011. Reported consumption by producers and consuming industries increased to 4,880 t in 2012 compared with 4,740 t in 2011. Of the 21 companies to which a survey form was sent, 17 responded to the annual or preliminary surveys, representing 95% of the total consumption by major domestic users of iodine (tables 1, 2). Accurate end-use statistics were difficult to gather because domestic and imported iodine were used to produce many intermediate iodine compounds, usually by downstream manufacturers.

Consumption of potassium iodide (KI) increased by 23% and consumption of resublimed iodine decreased by 19% compared with that in 2011. Consumption of miscellaneous and other inorganic iodine products, which include ammonium iodide, calcium iodate, and cuprous iodide, increased by 10%. Consumption of organic iodine compounds increased slightly (table 2).

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.—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 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.

X-ray contrast media (XRCM) are substances which 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 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, 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 and overhead transparencies to be produced without the need for wet processing film. The majority of current feature films, however, continued 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 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 2012. The average free alongside ship (f.a.s.) value for exported crude iodine in 2012 was \$26.75 per kilogram, an increase from \$21.29 per kilogram in 2011. The average declared cost, insurance, and freight (c.i.f.) value for imported crude iodine was \$41.97 per kilogram in 2012, an increase from \$38.13 per kilogram in 2011. The average declared c.i.f. value for iodine imported from Chile, the leading source country of imported iodine for the United States, was \$44.07 per kilogram in 2012 compared with \$40.40 per kilogram in 2011. The average declared c.i.f. value for imported crude iodine from Japan was \$29.07 per kilogram in 2012, an increase from \$21.75 per kilogram in 2011.

The spot price of crude crystal iodine, 99.5% minimum purity, in 50-kilogram drums delivered to the United Kingdom, as reported by Metal Bulletin, ranged from \$55 to \$80 per kilogram in March 2012. Prices continued to increase in April, and in May, prices ranged from \$65 to \$90 per kilogram. In December, prices ranged from \$65 to \$85 per kilogram. Actual prices for iodine are negotiated on long- and short-term contracts between buyers and sellers.

Foreign Trade

Net trade is not easily defined since iodine was exported and imported in many forms other than elemental iodine and KI. Exports of crude iodine increased to 1,040 t with an f.a.s. value of \$27.8 million in 2012 compared with 900 t valued at \$19.2 million in 2011. Exports of KI decreased to 336 t with an f.a.s. value of \$6.8 million in 2012 compared with 344 t valued at \$7.3 million in 2011. Exports of crude iodine to Canada and Germany represented 80% of total crude iodine exports in 2012 (table 3).

Imports of crude iodine decreased to 5,960 t with a c.i.f. value of \$250 million in 2012 compared with 6,590 t valued at \$251 million in 2011. Imports of KI increased to 431 t with a c.i.f. value of \$6.2 million in 2012 compared with a total of 366 t valued at \$5.4 million in 2011. Imports of crude iodine from Chile and Japan represented 98% of total crude iodine imports in 2012. Imports of KI from Canada and India represented 84% of total KI imports in 2012 (table 4).

World Review

World production of iodine, excluding the United States, was estimated to be 28,000 t in 2012 compared with 26,200 t in 2011 (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) produced 350 t of iodine in 2012 at its Neftchalinsky plant, which has a capacity of 500 metric tons per year (t/yr) of iodine (ISR Holding, 2013).

Chile.—Sociedad Química y Minera de Chile S.A. (SQM), the leading iodine producer worldwide, reported 2012 production for iodine and its derivatives of 11,000 t of contained

iodine valued at \$578 million, a 10% decrease in quantity compared with the 12,200 t of contained iodine valued at \$455 million reported in 2011. However, the decreased quantity was more than offset by prices that were more than 40% higher than average prices seen in 2011, increasing SQM's gross profit in its iodine segment by more than 38% (Sociedad Química y Minera de Chile S.A., 2012, p. 66). SQM owned four operations in Chile that produced iodine and nitrates from caliche ore—Pedro de Valdivia, Maria Elena, Nueva Victoria, and Pampa Blanca.

Atacama Minerals Corp., a publicly held Canadian company operating the Aguas Blancas Mine in northern Chile, changed its name to Sirocco Mining Inc. on January 24, 2012. The Aguas Blanca Mine, located approximately 75 kilometers southeast of Antofagasta, produced 1,223 t of iodine in 2012 compared with 1,122 t of iodine in 2011. Increased iodine prices during 2012 contributed to 66% higher revenues than in 2011. Sirocco exported all of its iodine production to Asia and Europe. The iodine was packaged in containers which were shipped from Chilean ports (Sirocco Mining Inc., 2013, p. 7).

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%). The operations produced an iodine solution, which was brought by trucks to the Cala Cala refinery to produce prilled iodine, iodine flakes, and byproduct nitrates (Industrial Minerals, 2011).

Japan.—Production of crude iodine is based on underground brines associated with some wet natural gas deposits. An estimated 80% of output takes place in Chiba Prefecture from the Southern Kanto gas field, and the remainder in Niigata and Miyazaki Prefectures. Japanese crude iodine producers have historically high production costs, owing to the expense of brine extraction. However, the cost of production is typically offset by the high price of domestically produced natural gas (Roskill Information Services Ltd., 2010, p. 105).

In 2012, Japanese iodine producers included: Ise Chemical Co. Ltd., GodoShigen Sangyo Co. Ltd., Kanto Natural Gas Development Co. Ltd. (KNG), Nippoh Chemicals Co., and Toyota Tsusho Corp.

KNG employed two methods in the manufacture of iodine. The blowing out method takes advantage of the easy vaporization property of iodine and is ideal for processing large amounts of iodine or for processing brine at high temperature. The ion exchange resin method uses resin that adsorbs iodine and it is suitable for both small and large plants. KNG has an estimated production capacity of 1,200 t/yr of iodine from its operations (Roskill Information Services Ltd., 2010, p. 110–111).

Outlook

During 2010 to 2014, world consumption for iodine is forecast to rise by an average of 3.5% per year and is expected to reach 30,500 t (Roskill Information Services Ltd., 2010, p. 185).

During the last 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 is expected to be from organic light emitting diode products (Industrial Minerals, 2011).

In addition, demand for x-ray contrast media, which contain as much as 60% iodine, has increased significantly. The water treatment market also 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. More medical tests on an aging population could also result in increased demand for iodine-containing x-ray contrast media. According to SQM, total iodine demand in 2012 is estimated between 30,500 and 31,000 t (Sociedad Química y Minera de Chile S.A., 2012, p. 44).

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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 2010].

TABLE 1
SALIENT IODINE STATISTICS¹

(Metric tons and dollars)

	2008	2009	2010	2011	2012
United States:					
Production	W	W	W	W	W
Imports:					
Quantity, for consumption ²	6,300	5,190	5,710	6,590	5,960
Price, average ³ dollars per kilogram	21.52	25.55	24.39	38.13	41.97
Exports ²	950	1,160	1,070	900	1,040
Consumption:					
Reported	4,580	4,550	4,640	4,740	4,880
Apparent	W	W	W	W	W
World, production ^c	26,000 ^r	26,600 ^r	26,000 ^r	26,200 ^r	28,000

^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	2011		2012	
	Number of plants	Quantity (metric tons)	Number of plants	Quantity (metric tons)
Inorganic compounds:				
Crude iodine	1	171	1	171
Resublimed iodine	6	108	6	87
Potassium iodide	3	527	3	648
Sodium iodide	3	145	3	40
Ammonium iodide	1	(3)	1	--
Hydriodic acid	3	124	3	201
Potassium iodate	3	40	3	45
Miscellaneous iodate, and iodides ⁴	1	87	1	96
Other inorganic compounds	4	494	4	592
Total	XX ⁵	1,700	XX ⁵	1,880
Organic compounds:				
Ethylenediamine dihydroiodide	2	226	2	192
Povidine-iodine (iodophors)	3	443	3	386
Other organic compounds ⁶	9	2,370	9	2,430
Total	XX ⁵	3,040	XX ⁵	3,000
Grand total	XX	4,740	XX	4,880

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 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	2011		2012	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Iodine, crude/resublimed:				
Belgium	19	\$526	3	\$55
Canada	124	2,630	196	3,050
Germany	643	14,000	630	19,800
Italy	18	485	⁽⁴⁾	9
Japan	16	305	44	935
Malaysia	11	90	5	62
Mexico	3	57	15	290
New Zealand	--	--	22	515
Norway	--	--	36	1,410
South Africa	47	769	38	625
Spain	--	--	18	397
Thailand	2	42	15	380
Other ⁵	18 ^r	294 ^r	16	301
Total	900	19,200	1,040	27,800
Potassium iodide:⁶				
Australia	3	52	16	268
Chile	19	444	--	--
China	16	476	33	580
Japan	24	408	--	--
Korea, Republic of	20	349	23	357
Mexico	11	271	36	692
Netherlands	28	486	--	--
Saudi Arabia	58	1,530	40	1,160
Singapore	11	188	2	66
Taiwan	89	1,540	113	2,330
Turkey	38	906	22	367
United Arab Emirates	--	--	11	189
United Kingdom	1	19	21	350
Other ⁷	27 ^r	581 ^r	19	406
Total	344	7,250	336	6,760

¹Revised. -- Zero.

²Data are rounded to no more than three significant digits; may not add to totals shown.

³Declared free alongside ship valuation.

⁴Export 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.

⁵Less than ½ unit.

⁶Includes countries with quantities less than 10 metric tons.

⁷Potassium iodide contains 76% iodine.

⁸Includes 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	2011		2012	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Iodine, crude:				
Chile	5,790	\$234,000	5,180	\$228,000
France	6	188	--	--
Hungary	--	--	85	1,710
India	13	245	(4)	12
Japan	777	16,900	689	20,000
Other ⁵	5	95	6	134
Total	6,590	251,000	5,960	250,000
Potassium iodide:⁶				
Brazil	--	--	31	1,280
Canada	233	3,310	295	3,640
China	4	62	8	94
Germany	6	90	3	66
India	78	1,370	67	805
Japan	(4)	33	5	64
Switzerland	(4)	48	5	61
United Kingdom	41	486	17	209
Other ⁵	4 ^r	8 ^r	(4)	31
Total	366	5,400	431	6,250

^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.

⁴Less than ½ unit.

⁵Includes countries with quantities less than 5 metric tons.

⁶Gross potassium iodide contains 76% iodine.

Source: U.S. Census Bureau.

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

(Metric tons)

Country ³	2008	2009	2010	2011	2012
Azerbaijan	300	300	300	300	350
Chile ⁴	15,503 ⁵	17,399 ⁵	15,793 ⁵	16,000	17,500
China	NA ^r	NA ^r	NA ^r	NA ^r	NA
Indonesia	75	75	75	75	75
Japan	9,500	8,232 ⁵	9,216 ⁵	9,277 ^{r,5}	9,300
Russia	300	300	300	300	300
Turkmenistan	270	270	270	270	480
United States	W	W	W	W	W
Uzbekistan	2	2	2	2	2
Total	26,000 ^r	26,600 ^r	26,000 ^r	26,200 ^r	28,000

^rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in total.

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

²Table includes data available through June 17, 2013.

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.