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2019 Minerals Yearbook

IODINE [ADVANCE RELEASE]

U.S. Department of the Interior
U.S. Geological Survey

September 2023

Iodine

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In 2019, three companies produced crude iodine in United States. Reported consumption of iodine compounds by producers and consuming industries was 4,000 metric tons (t) in 2019, which was a 13% decrease from that in 2018 (table 1). Crude iodine exports increased by 3% to 1,230 t and the value increased by 22% to $28.7 million in 2019 compared with 1,190 t valued at $23.6 million in 2018 (table 2). Imports of crude iodine decreased by 13% to 4,300 t valued at $114 million compared with 4,930 t valued at $111 million in 2018 (table 3). World production, excluding U.S. production, was 30,100 t in 2019, essentially unchanged from that in 2018 (revised) (tables 1, 4). Chile was the world's leading producer of iodine, followed by Japan and the United States.

Iodine and its compounds were primarily used in X-ray contrast media (XRCM), pharmaceuticals, liquid crystal displays (LCDs), and iodophors, in descending order of quantity consumed. Other applications of iodine included animal feed, biocides, fluoride derivatives, food supplements, and nylon. Globally, XRCM was the largest single market for iodine in 2019, accounting for approximately 24% of demand (Sociedad Química y Minera de Chile S.A., 2020, p. 33).

Production

The U.S. Geological Survey obtained domestic production data for iodine from a voluntary canvass of three U.S. producers. U.S. production increased in 2019 from that in 2018; data were withheld to avoid disclosing company proprietary data.

IOCHEM Corp. (Oklahoma City, OK) produced iodine near Vici, in Dewey County, OK, from 16 production wells that extracted brine from a sandstone layer approximately 3 kilometers (km) below the surface. The brines contained between 300 and 400 parts per million iodine, primarily as sodium iodide. According to the company, IOCHEM was the leading producer of iodine in North America with an estimated 1,200 metric tons per year (t/yr) of iodine manufactured. Iodine produced by IOCHEM had a minimum specification of 99.5% iodine content but typically exceeded 99.8% (IOCHEM Corp., undated a).

Iofina plc (United Kingdom) operated four extraction plants in northwest Oklahoma, which used the company's Wellhead Extraction Technology® (WET®) and WET® IOsorb® method to process saltwater waste brines from oil and gas production. According to the company, WET® IOsorb® plants were capable of producing between 50 and 450 t/yr of iodine, depending on the location's flow and iodine concentrations. In 2019, the company produced 603 t of crystallized iodine, slightly more than the 589 t produced in 2018 (Iofina plc, 2020, p. 7, 12; undated).

Woodward Iodine Corp. (owned by Ise Chemicals Corp. of Japan) produced iodine near Woodward, in Woodward County, OK, from brines and also recycled iodine from other sources. The associated plant had an estimated capacity of 800 t/yr (Krukowski, 2017, p. 36).

Recycling

Some iodine-containing byproducts were recycled (recovered) to obtain crude iodine. The iodine was separated from the product as a gas, passed through and concentrated in a recovery system, and then processed into crude iodine (IOCHEM Corp., undated b). In 2019, an estimated 17% of the world's iodine supply came from recycled iodine (Sociedad Química y Minera de Chile S.A., 2020, p. 35).

Consumption

The U.S. Geological Survey obtained domestic consumption data for iodine from a voluntary canvass of 17 U.S. operations. Reported consumption by producers and consuming industries decreased by 13% to 4,000 t in 2019 compared with 4,600 t reported in 2018 (table 1). The 4,000 t included 2,950 t of inorganic iodine compounds and 1,050 t of organic iodine compounds. Accurate end-use statistics were difficult to collect because domestic and imported iodine were used to produce many intermediate iodine compounds, typically by downstream manufacturers.

Commercial crude iodine typically was sold with a minimum purity of 99.5% to 99.8%, depending on the supplier. The primary impurities, in order of quantity, were insoluble materials, iron, sulfuric acid, and water. The Committee on Analytical Reagents of the American Chemical Society allowed a maximum of 0.005% total bromine and chlorine and 0.010% nonvolatile matter in its specifications for iodine (American Chemical Society, 2016).

Biocides and Disinfectants.—Because iodine is one of the most effective medical antiseptics available, it was used in biocides and disinfecting chemicals. Iodine is a cost-effective, efficient, 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.

Catalysts.—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 was produced using the methanol carbonylation process, which used 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 used to help diagnose certain medical conditions, may contain iodine. These agents, typically referred to as XRCM, are substances that cause soft tissues to become visible during X-ray examination. The media were typically injected or swallowed by the patient and blocked the ability of X-rays to pass through, temporarily changing the appearance of body tissue, blood vessels, and organs. XRCM in use were primarily organic iodine derivatives. Although many elements have higher atomic numbers than iodine, no other element has the chemical characteristics to form soluble compounds with low toxicity. It is this latter property that makes iodine-containing contrast media suitable for radiography. Problems diagnosed using radiopaque agents included 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.

Radioactive iodine, the isotope ^{131}I, is a major fission product of nuclear reactions. The ingestion or inhalation 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 (U.S. Department of Health and Human Services, undated). Iodine prophylaxis is especially important for children under the age of 18 and pregnant women. The World Health Organization recommended the stockpiling of potassium iodide tablets near any nuclear powerplant (World Health Organization, 1999). In 2001, the U.S. Nuclear Regulatory Commission encouraged, but did not require, States to stockpile a supply of potassium iodide for anyone within a 50-mile (80-km) radius of a nuclear reactor (U.S. Nuclear Regulatory Commission, 2001, p. 5432).

Potassium iodide was used as an expectorant in cough medicine; hydriodic acid and potassium iodide were used in the synthesis of amphetamine, ethylamphetamine, and methamphetamine. Because controlled substances such as amphetamines and methamphetamines are produced from iodine, iodine was regulated under the U.S. Controlled Substances Act (U.S. Department of Justice, 2020, p. 91). These regulatory controls applied to iodine crystals and iodine chemical mixtures containing greater than 2.2% iodine (U.S. Department of Justice, 2007).

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 goiters in adults, increased mortality and impaired cognitive development in children, and reproductive failure (World Health Organization, undated). Since the 1920s, iodized salt had been the primary source of supplemental dietary iodine in the western world. Iodine deficiency disorder could be prevented by consuming about 150 micrograms per day of iodine for a human adult (Institute of Medicine of the National Academies, 2006). The iodization of salt and the addition of iodine to infant formulas and food is regulated in the United States by the U.S. Food and Drug Administration (Trumbo, 2016).

Other Uses.—Iodine was 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 were added to LCDs to enhance the light contrast between the screen and the liquid crystals, making the LCD more visible. These polarizers usually were made from stretched polyvinyl alcohol films that contained iodine.

Prices

Most iodine prices were negotiated on long- and short-term contracts between buyers and sellers. The January 2019 spot price of crude crystal iodine (99.5% minimum purity, in 50-kilogram drums) ranged from an average low of $26.05 per kilogram to an average high of $28.20 per kilogram. Spot prices steadily increased over the course of 2019. By December 2019, the average low spot price was $32.00 per kilogram and the average high was $36.50 per kilogram (Fastmarkets IM, 2020). This price range was about one-third of the peak price range of $80 to $95 per kilogram reached in December 2011 following the Tohoku earthquake and subsequent tsunami in Japan that resulted in the Fukushima nuclear reactor meltdown; these events disrupted Japanese iodine production and increased demand for prophylactic potassium iodide. The price increases over the course of 2019 were attributed to continued strong global demand for iodine combined with an undersupply in the market (Iofina plc, 2020, p. 5).

Foreign Trade

Net iodine trade was not easily defined because it was exported and imported in many forms other than elemental iodine and potassium iodide. In 2019, exports of crude iodine (1,230 t) increased by 3% and the free alongside ship (f.a.s.) value of those exports ($28.7 million) increased by 22% compared with that in 2018. The annual average unit value of crude iodine exports increased by 18% to $23.34 per kilogram in 2019, from $19.83 per kilogram in 2018. Exports of crude iodine to India, Belgium, and Germany, in descending order of quantity, represented 55% of total crude iodine exported in 2019. The quantity of exported potassium iodide (203 t) decreased by 17% and the value decreased by 18% compared with that in 2018. The average annual unit value of exported potassium iodide was $17.22 per kilogram in 2019, a slight decrease compared with the average annual unit value of $17.40 per kilogram in 2018. The leading destinations for exported potassium iodide were, in descending order of quantity Singapore, Saudi Arabia, and Taiwan, which received 72% of the total potassium iodide exported in 2019 (table 2).

Imports of crude iodine in 2019 (4,300 t) decreased by 13% and value increased slightly compared with that in 2018. The average annual unit value of imported crude iodine increased by 17% to $26.38 per kilogram from $22.46 per kilogram in 2018. Imports of crude iodine from Chile represented 90% of total crude iodine imported in 2019. Imports of potassium iodide (325 t) decreased by 3% and the cost, insurance, and freight (c.i.f.) unit value of those imports decreased by 5% compared with those in 2018. The annual average unit value of imported potassium iodide decreased slightly to $15.15 per kilogram in 2019 from $15.40 per kilogram in 2018. Imports of potassium

iodide from Canada represented 47% of total potassium iodide imported in 2019 (table 3).

World Review

World production of iodine, excluding U.S. production, was 30,100 t in 2019, essentially unchanged from that in 2018 (table 4). Chile was the world's leading producer of iodine, followed by Japan and the United States.

Chile.—Sociedad Química y Minera de Chile S.A. (SQM), the world's leading iodine producer, produced 12,082 t of iodine in 2019 with reported sales for iodine and its derivatives of 12,700 t of contained iodine valued at $371 million. This was a 7% increase in production but more than a 4% decrease in quantity sold compared with the 11,255 t produced and 13,300 t sold in 2018. Although the amount of iodine sold in 2019 decreased by more than 4%, revenues increased by approximately 14% compared with 2018 revenues of $325 million owing to an increase in the average sales price of iodine. According to SQM, its average iodine sales price in 2019 was approximately $29 per kilogram, more than 19% higher than the 2018 average price. SQM's 2019 production of 12,082 t was divided among three facilities: Nueva Victoria (9,558 t), Iris (1,174 t), and Pedro de Valdivia (1,351 t). The total iodine production capacity of these facilities was 14,800 t/yr (Sociedad Química y Minera de Chile S.A., 2019, p. 45; 2020, p. 34–35, 45).

Compañía de Salitre y Yodo (Cosayach) had a production capacity of 6,000 t/yr of iodine extracted from caliche ore at its three operations: Cala Cala, Negreiros, and Soledad (Compañía de Salitre y Yodo, undated). Other iodine producers in Chile included ACF Minera S.A., which produced iodine at its Lagunas Mine, and Algorta Notre S.A., which operated northwest of Baquedano in the Antofagasta Region, and had a capacity of 4,000 t/yr (Algorta Norte S.A., undated; Independent Iodine, undated).

Japan.—Crude iodine was produced from underground brines associated with wet natural gas deposits at depths of less than 2,000 meters. An estimated 90% of iodine production in Japan came from the Minami-Kanto gasfield, most of which is in the Chiba Prefecture. Iodine also was produced at the Niigata gasfield and Nakajo oilfield and gasfield, both in the Niigata Prefecture, and the Sadowara gasfield in the Miyazaki Prefecture (Kaneko and Kaiho, 2015, p. 231–232).

In 2019, iodine producers in Japan included Godo Shigen Co. Ltd., Inpex Co., Ise Chemicals Co., Kanto Natural Gas Development Co. Ltd., Nihon Tennen Gas Co. Ltd., Nippoh Chemicals Co., Ltd., and Toho Earthtech Inc.

Outlook

The global consumption of iodine is expected to increase at a compound annual growth rate of 3.4% from 2020 through 2027 (Business Wire, 2020). Demand for iodine will depend on general levels of economic activity and demand from the leading iodine-consuming industrial, medical, and pharmaceutical markets (Sociedad Química y Minera de Chile S.A., 2020, p. 35).

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TABLE 1
SALIENT IODINE STATISTICS[1]

(Metric tons)

	2015	2016	2017	2018	2019
United States:					
Production	W	W	W	W	W
Imports:[2]					
Quantity, for consumption	5,630	4,320	4,170	4,930	4,300
Price, average, dollars per kilogram[3]	27.74	22.71	19.55	22.46	26.38
Exports[2]	1,210	1,050	1,230	1,190	1,230
Consumption:[4]					
Reported, inorganic compounds	2,510	3,020	2,870	3,350	2,950
Reported, organic compounds	1,290	1,590	1,630	1,260	1,050
Total, reported	3,800	4,610	4,500	4,620	4,000
Apparent	W	W	W	W	W
World, production	32,600	29,200	27,600	30,100 r	30,100

rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through June 9, 2020. Data are rounded to no more than three significant digits, except prices; may not add to totals shown.
[2]Source: U.S. Census Bureau information reported by Harmonized Tariff Schedule of the United States code 2801.20.0000 for crude iodine.
[3]Cost, insurance, and freight valuation.
[4]Includes U.S. Geological Survey estimates.

TABLE 2
U.S. EXPORTS OF CRUDE IODINE AND POTASSIUM IODIDE, BY COUNTRY OR LOCALITY[1]

Type and country or locality[2]	2018 Quantity (metric tons)	2018 Value[3] (thousands)	2019 Quantity (metric tons)	2019 Value[3] (thousands)
Iodine, crude:				
Belarus	43	$85	--	--
Belgium	108	2,630	217	$5,180
Brazil	50	796	77	1,880
Canada	135	1,610	135	2,780
Germany	415	9,110	202	4,320
India	197	3,960	257	5,750
Japan	75	1,510	90	2,480
Korea, Republic of	37	898	1	31
Netherlands	90	2,120	198	5,210
New Zealand	20	428	29	860
Other[4]	21 r	445 r	23	198
Total	1,190	23,600	1,230	28,700
Potassium iodide:[5]				
Korea, Republic of	53	612	29	349
Mexico	15	332	15	371
Saudi Arabia	47	937	40	1,130
Singapore	32	633	69	698
Taiwan	71	1,060	38	635
Other[4]	27 r	687 r	12	309
Total	245	4,260	203	3,490

rRevised. -- Zero.

[1]Table includes data available through June 9, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Export information for crude iodine and potassium iodide are reported by Schedule B numbers 2801.20.0000 and 2827.60.2000, respectively.

[3]Declared free alongside ship valuation.

[4]Includes countries with quantities less than 10 metric tons.

[5]Contains 76% iodine.

Source: U.S. Census Bureau.

TABLE 3
U.S. IMPORTS OF CRUDE IODINE AND POTASSIUM IODIDE FOR CONSUMPTION, BY COUNTRY OR LOCALITY[1]

Type and country or locality[2]	2018 Quantity (metric tons)	2018 Value[3] (thousands)	2019 Quantity (metric tons)	2019 Value[3] (thousands)
Iodine, crude:				
Chile	4,340	$98,100	3,870	$103,000
Japan	556	11,900	429	10,800
Switzerland	36	756	--	--
Other[4]	1	47	2	81
Total	4,930	111,000	4,300	114,000
Potassium iodide:[5]				
Brazil	32	469	38	673
Canada	135	2,070	154	1,910
Chile	2	18	70	1,390
Germany	5	66	17	261
India	141	2,220	18	275
Singapore	12	174	18	247
Other[4]	9 r	151 r	10	165
Total	336	5,170	325	4,930

rRevised. -- Zero.

[1]Table includes data available through June 9, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Import information for crude iodine and potassium iodide are reported by Harmonized Tariff Schedule of the United States codes 2801.20.0000 and 2827.60.2000, respectively.

[3]Declared cost, insurance, and freight valuation.

[4]Includes countries with quantities less than 10 metric tons.

[5]Contains 76% iodine.

Source: U.S. Census Bureau.

TABLE 4
CRUDE IODINE: WORLD PRODUCTION, BY COUNTRY OR LOCALITY[1]

(Metric tons)

Country or locality[2]	2015	2016	2017	2018	2019e
Azerbaijan	210	208	198	185 r	190
Chile	21,179	18,444	17,976	20,216 r	20,200
Indonesia	45	35	34	38	40
Japan	10,610	9,993	8,839	9,136 r	9,100
Russia	14	3	8	8	2
Turkmenistan	500 e	500 e	544	540 e	600
United States	W	W	W	W	W
Total[3]	32,600	29,200	27,600	30,100 r	30,100

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data; not included in total.

[1]Table includes data available through June 1, 2020. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]In addition to the countries and (or) localities listed, China and Iran may have produced crude iodine, but available information was inadequate to make reliable estimates of output.

[3]Does not include U.S. production.