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IODINE [ADVANCE RELEASE]

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Iodine

By Emily K. Schnebele

Domestic survey data and tables were prepared by Darlene V. Thompson, statistical assistant.

In 2016, there were four domestic producers of crude iodine. Reported consumption of iodine compounds by producers and consuming industries was 4,530 metric tons (t) in 2016, which was a 25% increase from that in 2015 but still 8% less than the amount consumed in 2012 (table 1). Crude iodine exports decreased to 1,050 t valued at $23.3 million in 2016 compared with 1,210 t valued at $29.4 million in 2015 (table 2). Imports of crude iodine decreased to 4,320 t valued at $98.0 million compared with 5,630 t valued at $156 million in 2015 (table 3). World production, excluding U.S. production, was estimated to be 32,500 t in 2016 compared with the revised 32,600 t in 2015 (table 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, food supplements, and nylon. Globally, XRCM was the largest single market for iodine in 2016, accounting for approximately 23% of demand (Sociedad Química y Minera de Chile S.A., 2017, p. 20).

Production

The U.S. Geological Survey obtained domestic production data for iodine from a voluntary canvass of four U.S. producers. U.S. production increased in 2016 from that of 2015; data were withheld to avoid disclosing company proprietary data (table 1).

IOCHEM Corp. produced iodine near Vici, in Dewey County, OK, from 16 production wells that extract brine from a sandstone layer approximately 3 kilometers (km) below the surface. IOCHEM's 17th production well was drilled at the end of 2016 (IOCHEM Corp., 2016). The brines contained between 300 and 400 parts per million (ppm) iodine. 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 has a minimum specification of 99.5% iodine content (IOCHEM Corp., undated).

Iofina plc (United Kingdom) operated five extraction plants in Oklahoma, which used 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 were capable of producing between 50 and 450 t/yr of iodine, depending on the location's flow and iodine concentrations (Iofina plc, undated). In 2016, the company produced 474 t of crystallized iodine, 17% less than the 569 t produced in 2015 (Iofina plc, 2016a, p. 1; 2017a, p. 1). Production slowed in late 2016 owing to water quality issues as well as water from suppliers being diverted to hydraulic fracturing operations (Iofina plc, 2016b). Salt water disposal well injection restrictions imposed by the State of Oklahoma also affected brine supply and thus production output (Iofina plc, 2017b).

Kiva Holding Inc. (Leedey, OK) began operating its new iodine production facility in late 2015 with a full year of production achieved in 2016. The company produced iodine with a minimum specification of 99.6% iodine content based on produced water from oil and gas fields (Kiva Holding, Inc., undated).

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

Consumption

The U.S. Geological Survey obtained domestic consumption data for iodine from a voluntary canvass of 19 U.S. operations. Reported consumption by producers and consuming industries increased by 25% to 4,530 t in 2016 compared with the 3,620 t reported in 2015. This included consumption of 1,990 t of inorganic iodine compounds and 2,540 t of organic iodine compounds (table 1). 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.

Commercial crude iodine typically had 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 U.S. Pharmacopeia specified an iodine content of no less than 99.8% for commercial iodine. 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.

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.

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 that absorb X-rays, were used to help diagnose certain medical conditions and may contain iodine. 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. These agents, or XRCM, were 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 today are frequently 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 was this latter property that made iodine-containing contrast media suitable for radiography.

Radioactive iodine, the isotope ^{131}I, is a major fission product of both nuclear powerplants and nuclear bombs. 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 (Roskill Information Services Ltd., 2013, p. 210). 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).

Potassium iodide was also used as an expectorant in cough medicine, and hydriodic acid and potassium iodide were used in the synthesis of amphetamine, ethylamphetamine, and methamphetamine. Because controlled substances are produced from iodine, such as amphetamines and methamphetamines, iodine was regulated under the U.S. Controlled Substances Act (U.S. Department of Justice, 2017, p. 83).

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 has been the primary source of supplemental dietary iodine in the western world. Iodine deficiency disorder can be prevented by consuming about 150 micrograms per day of iodine for a human adult (Institute of Medicine of the National Academies, 2006).

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

Prices

Iodine prices continued to decline throughout 2016. Most prices for iodine were negotiated on long- and short-term contracts between buyers and sellers; the spot price of crude crystal iodine (99.5% minimum purity, in 50-kilogram (kg) drums, as reported by Industrial Minerals) ranged from $27.50 to $32 per kilogram in January 2016. This was a decrease compared to January 2015 prices, which ranged from $31 to $35 per kilogram. By December 2016, prices ranged from $18.50 to $21 per kilogram. This was less than one-third of the peak price range of $60 to $95 per kilogram reached in 2011 following the Tohoku earthquake and subsequent tsunami in Japan that resulted in a meltdown at a nuclear powerplant, increasing demand for prophylactic potassium iodide. Oversupply in the market and competition for market share contributed to the decline in the global price of iodine (McCormick, 2016).

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 decreased by 13% to 1,050 t, and the free alongside ship (f.a.s.) value of those exports decreased by 21% to $23.3 million compared with that in 2015. Exports of crude iodine to Canada, Germany, and India represented 75% of total crude iodine exported in 2016. The average unit value of crude iodine exports in 2016 decreased by 9% from that in 2015 to $22.29 per kilogram. The quantity of exported potassium iodide decreased by 13% to 246 t with a 29% decrease in value compared with that in 2015. The leading destinations for exported potassium iodide were Singapore and Taiwan, which received 51% of the total potassium iodide exported in 2016 (table 2).

Imports of crude iodine decreased by 23% to 4,320 t, and the value of those imports decreased by 37% compared with that in 2015. The average price of imported crude iodine decreased by 18% to $22.71 per kilogram from $27.74 per kilogram in 2015. Imports of crude iodine from Chile represented 88% of total crude iodine imported in 2016. Imports of potassium iodide decreased by 23% to 202 t, and the cost, insurance, and freight (c.i.f.) value of those imports decreased by 21% compared with those in 2015. Imports of potassium iodide from Brazil, Canada, and India represented 95% of total potassium iodide imported in 2016 (table 3). The decrease in unit value for both exported and imported crude iodine, 9% and 18% respectively, illustrated the continued global decline of iodine prices in 2016.

World Review

World production of iodine, excluding U.S. production, was estimated to be 32,500 t in 2016 compared with the revised 32,600 t in 2015 (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 8,542 t of iodine in 2016 with reported sales of iodine and its derivatives of 10,200 t of contained iodine valued at $231 million. This was a 17% decrease in production but a 10% increase in quantity sold compared with the 10,309 t produced and 9,300 t sold in 2015 (Sociedad Química y Minera de Chile S.A., 2016, p. 21, 33; 2017, p. 20, 31). Although the amount of iodine sold in 2016 increased, revenues decreased by approximately 12% compared with 2015 revenues of $263 million (Sociedad Química y Minera de Chile S.A., 2017, p. 20). The decrease in revenue was largely attributed to the decrease in global iodine prices in 2016. According to SQM, its average iodine sales price in 2016 was $23 per kilogram, approximately 18% less than the average 2015 reported price of $28 per kilogram (Sociedad Química y Minera de Chile S.A., 2016, p. 23; 2017, p. 22). In 2016, SQM produced iodine and nitrates from caliche ore deposits in northern Chile at the Nueva Victoria Mine and activated a new mining sector 15 km northwest of Nueva Victoria named Tente en el Aire. Iodine solutions were also produced by leaching the mine tailings at the Pedro de Valdivia and María Elena sites. SQM's 2016 production of 8,542 t was divided among Nueva Victoria (7,744 t), Pedro de Valdivia (610 t), and María Elena (188 t). Total iodine production capacity of the three sites was 10,000 t/yr (Sociedad Química y Minera de Chile S.A., 2017, p. 29–31).

Compañía de Salitre y Yodo (Cosayach) produced iodine from caliche ore at its three operations, Cala Cala, Negreiros, and Soledad, with a total capacity of 6,000 t/yr of iodine (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, with 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 gas field, most of which is in the Chiba Prefecture (Kaneko and Kaiho, 2015, p. 232). Iodine was also produced at the Niigata gas field and Nakajo oil and gas field, both in the Niigata Prefecture, and the Sadowara gas field in the Miyazaki Prefecture (Kaneko and Kaiho, 2015, p. 231, 232).

In 2016, 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

Although prices continued to decline in 2016, the global consumption of iodine and iodine derivatives was estimated to have increased by between 2% to 3%, primarily owing to applications for XRCM and LCDs (Iofina plc, 2017a, p. 4). Iodine consumption will likely follow market demand for medical applications and LCDs as these are the primary consuming markets of iodine and iodine derivatives.

Japan was the world's leading iodine recycler, responsible for approximately 75% of the total iodine recycled worldwide. Iodine recycling has increased in recent years, with about 18% of world iodine sales attributed to recycled iodine (Sociedad Química y Minera de Chile S.A., 2017, p. 22). Future increases in iodine recycling will likely be dependent upon available iodine supply and global prices.

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TABLE 1
SALIENT IODINE STATISTICS[1]

(Metric tons)

	2012	2013	2014	2015	2016
United States:					
Production	W	W	W	W	W
Imports:					
Quantity, for consumption[2]	5,960	5,960	5,360	5,630	4,320
Price, average dollars per kilogram[3]	42.28	42.77	37.04	27.74	22.71
Exports[2]	1,040	1,130 r	1,240	1,210 r	1,050
Consumption:[4]					
Reported:					
Inorganic compounds	1,880	2,000	1,860	1,390	1,990
Organic compounds	3,040	2,050	1,880	2,240	2,540
Total	4,920	4,050	3,740	3,620 r	4,530
Apparent	W	W	W	W	W
World, production[e, 5]	27,800	30,800	29,600	32,600 r	32,500

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through July 6, 2017. 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.
[3]Cost, insurance, and freight valuation.
[4]Includes U.S. Geological Survey estimates.
[5]Does not include U.S. production.

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

Type and country or locality of origin[2]	2015 Quantity (metric tons)	2015 Value[3] (thousands)	2016 Quantity (metric tons)	2016 Value[3] (thousands)
Iodine, crude:				
Belgium	31	$507	25	$414
Brazil	2	36	72	1,320
Canada	141 r	2,900 r	113	1,650
China	7	158	42	373
Germany	649 r	18,600 r	523	14,300
India	73	1,570	144	2,640
Italy	73	1,970 r	--	--
Japan	74	2,010 r	5	85
Korea, Republic of	(4)	6	39	897
Latvia	65	128	--	--
New Zealand	25	500	15	383
Norway	--	--	18	378
South Africa	23	372	16	267
Other[5]	44 r	699 r	33	617
Total	1,210 r	29,400 r	1,050	23,300
Potassium iodide:[6]				
China	6 r	108 r	36	895
Korea, Republic of	36	709	30	433
Mexico	17	492	23	562
Saudi Arabia	85	1,730	12	212
Singapore	1	79	75	608
Taiwan	100	1,770	50	812
Other[5]	37 r	751 r	19	493
Total	282	5,640 r	246	4,020

rRevised. -- Zero.
[1]Table includes data available through July 6, 2017. 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 Harmonized Tariff Schedule of the United States codes 2801.20.0000 and 2827.60.2000, respectively.
[3]Declared free alongside ship valuation.
[4]Less than ½ unit.
[5]Includes countries with quantities less than 10 metric tons.
[6]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 OF ORIGIN[1]

Type and country or locality of origin[2]	2015 Quantity (metric tons)	2015 Value[3] (thousands)	2016 Quantity (metric tons)	2016 Value[3] (thousands)
Iodine, crude:				
Azerbaijan	--	--	10	$218
Canada	11	$341	1	28
Chile	5,080	141,000	3,790	86,000
Japan	538	15,100	511	11,800
Other[4]	1	39	1	32
Total	5,630	156,000	4,320	98,000
Potassium iodide:[5]				
Brazil	82	1,400	43	877
Canada	67	1,820	119	2,040
China	10	65	1	20
Germany	79	981	1	27
India	22	405	30	622
Other[4]	2	49 r	8	146
Total	262	4,720	202	3,730

rRevised. -- Zero.
[1]Table includes data available through July 6, 2017. 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]	2012	2013	2014	2015	2016
Azerbaijan	240	249	263	247	210 e
Chile	17,494	20,656	18,989	21,179 r	21,200 e
Indonesia	44	43	56	45	15
Japan	9,315	9,334	9,814	10,610 r	10,600 e
Russia[e]	200	--	--	--	--
Turkmenistan[e]	480	500	500	500 r	500
United States	W	W	W	W	W
Total[e, 3]	27,800	30,800	29,600	32,600 r	32,500

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.
[1]Table includes data available through May 1, 2017. All data are reported unless otherwise noted. Totals and estimated data are rounded to three significant digits; may not add to totals shown.
[2]In addition to the countries 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.