



2017 Minerals Yearbook

IODINE [ADVANCE RELEASE]

IODINE

By Emily K. Schnebele

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

In 2017, three companies produced crude iodine in United States. Reported consumption of iodine compounds by producers and consuming industries was 4,500 metric tons (t) in 2017, which was a slight decrease from that in 2016. Crude iodine exports increased to 1,230 t, but the value decreased to \$22.7 million in 2017 compared with 1,050 t valued at \$23.3 million in 2016 (table 2). Imports of crude iodine decreased to 4,180 t valued at \$81.7 million compared with 4,320 t valued at \$98.0 million in 2016 (table 3). World production, excluding U.S. production, was estimated to be 29,200 t in 2017, essentially unchanged from that in 2016 (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, fluoride derivatives, food supplements, and nylon. Globally, XRCM was the largest single market for iodine in 2017, accounting for approximately 23% of consumption (Sociedad Química y Minera de Chile S.A., 2018, p. 19).

Production

The U.S. Geological Survey obtained domestic production data for iodine from a voluntary canvass of three U.S. producers. U.S. production decreased in 2017 from that of 2016; data were withheld to avoid disclosing company proprietary data.

IOCHEM Corp. produced iodine near Vici, in Dewey County, OK, from 17 production wells that extract brine from a sandstone layer approximately 3 kilometers below the surface. The brines contained between 300 and 400 parts per million 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., 2016, 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 2017, the company produced 503 t of crystallized iodine, 6% more than the 474 t produced in 2016 (Iofina plc, 2018, p. 3). Iofina closed one of its locations and repurposed its WET® IOSorb® plant at a new location. The new plant had higher production capacity and was expected to come online in the first quarter of 2018 (Iofina plc, 2018, p. 3).

Kiva Holding, Inc. (Leedey, OK) is an iodine producer and halogen-production consulting company. Owing to

ongoing legal disputes between Kiva and Iofina regarding a misappropriation of Iofina's trade secrets, it is believed that Kiva did not produce iodine in 2017 (Lexis Legal News, 2017; Kiva Holding, Inc., 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).

Consumption

The U.S. Geological Survey obtained domestic consumption data for iodine from a voluntary canvass of 18 U.S. operations. Reported consumption by producers and consuming industries decreased slightly to 4,500 t in 2017 compared with the revised 4,610 t reported in 2016. This included consumption of 1,930 t of inorganic iodine compounds and 2,570 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 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 (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, 2018, p. 86).

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

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 drums, as reported by Industrial Minerals) ranged from \$18.50 to \$21 per kilogram in January 2017. This was a

decrease compared with January 2016 prices, which ranged from \$27.50 to \$32 per kilogram. By December 2017, prices ranged from \$22 to \$24 per kilogram. This was about 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. In response to low prices, some producers in Chile decreased production in early 2017; the decrease in supply led to a small increase in prices in late 2017 (Lismore-Scott, 2018, p. 44).

Foreign Trade

Net trade was not easily defined because iodine was exported and imported in many forms other than elemental iodine and potassium iodide. In 2017, exports of crude iodine (1,230 t) increased by 18%; however, the free alongside ship value of those exports (\$22.7 million) decreased by 3% to compared with that in 2016. The average price of crude iodine exports decreased by 17% to \$18.43 per kilogram from \$22.30 per kilogram in 2016. Exports of crude iodine to Canada, Germany, India, and the Republic of Korea represented 81% of total crude iodine exported in 2017. The quantity of exported potassium iodide (311 t) increased by 26% with a 50% increase in value compared with that in 2016. The average price of exported potassium iodide increased by 19% to \$19.41 per kilogram from \$16.34 per kilogram in 2016. The leading destinations for exported potassium iodide were Saudi Arabia and Taiwan, which together received 37% of the total potassium iodide exported in 2017 (table 2).

Imports of crude iodine in 2017 (4,180 t) decreased by 3% with a 17% decrease in value compared with that in 2016. The average price of imported crude iodine decreased by 14% to \$19.55 per kilogram from \$22.71 per kilogram in 2016. Imports of crude iodine from Chile represented 87% of total crude iodine imported in 2017. Imports of potassium iodide (227 t) increased by 12%, and the cost, insurance, and freight value of those imports increased by 7% compared with that in 2016. The average value of imported potassium iodide decreased by 5% to \$17.58 per kilogram from \$18.44 per kilogram in 2016. Imports of potassium iodide from Brazil, Canada, and India represented 89% of total potassium iodide imported in 2017 (table 3).

World Review

World production of iodine, excluding U.S. production, was estimated to be 29,200 t in 2017, essentially unchanged from that in 2016 (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 9,696 t of iodine in 2017 with reported sales for iodine and its derivatives of 12,700 t of contained iodine valued at \$252 million. This was a 14% increase in production and a 25% increase in quantity sold compared with the 8,542 t produced and 10,200 t sold in 2016 (Sociedad Química y Minera de Chile S.A., 2017, p. 31; 2018, p. 19, 31). Although the amount of iodine sold in 2017 increased by 25%, revenues increased by only 9% compared with 2016 revenues of \$231 million owing to a decrease in the average

sales price of iodine. According to SQM, its average iodine sales price in 2017 was \$20 per kilogram, approximately 13% less than the average 2016 reported price of \$23 per kilogram (Sociedad Química y Minera de Chile S.A., 2017, p. 22; 2018, p. 19, 21). SQM's 2017 production of 9,696 t was from Nueva Victoria (7,476 t), Iris (1,328), Pedro de Valdivia (851 t), and María Elena (41 t). Total iodine production capacity of the four facilities was 11,000 t/yr (Sociedad Química y Minera de Chile S.A., 2018, p. 31).

Compañía de Salitre y Yodo (Cosayach) had a production capacity of 6,000 t/yr of iodine, which was 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 Norte 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).

Iodine supply from Chile was less than the previous year owing to decreases in production by Cosayach and ACF Minera SA. In early 2017, ACF Minera laid off 200 employees from its Lagunas operation and Cosayach decreased production by 40% to 250 metric tons per month (t/mo) from the previous 400 t/mo (Lismore-Scott, 2017, p. 6).

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 (Kaneko and Kaiho, 2015, p. 232). Iodine was also produced at the Niigata gasfield and Nakajo oil and gas field, both in the Niigata Prefecture, and the Sadowara gasfield in the Miyazaki Prefecture (Kaneko and Kaiho, 2015, p. 231).

In 2017, iodine producers in Japan included Godo Shigen Co. Ltd., Inpex Corp., Ise Chemicals Co., Kanto Natural Gas Development Co. Ltd., Nihon Tennen Gas Co. Ltd., Nippon Chemicals Co., Ltd., and Toho Earthtech Inc.

Outlook

Global consumption of iodine and iodine derivatives was estimated to have increased by approximately 3% in 2017, primarily owing to applications for XRCM and LCDs (Iofina plc, 2018, p. 5). 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 70% of the total iodine recycled worldwide in 2017. Although iodine recycling is a growing trend, recycling decreased in the past year, with about 17% of world iodine sales attributed to recycled iodine compared with 18% in 2016 (Sociedad Química y Minera de Chile S.A., 2017, p. 22; 2018, p. 21).

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TABLE 1
SALIENT IODINE STATISTICS¹

(Metric tons unless otherwise specified)

| | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|--------------------|--------------------|---------------------|---------------------|--------|
| United States: | | | | | |
| Production | W | W | W | W | W |
| Imports: | | | | | |
| Quantity, for consumption ² | 5,960 | 5,360 | 5,630 | 4,320 | 4,180 |
| Price, average, dollars per kilogram ³ | 42.77 | 37.04 | 27.74 | 22.71 | 19.55 |
| Exports ² | 1,130 | 1,240 | 1,210 | 1,050 | 1,230 |
| Consumption: ⁴ | | | | | |
| Reported: | | | | | |
| Inorganic compounds | 2,120 ^r | 2,030 ^r | 1,570 ^r | 2,080 ^r | 1,930 |
| Organic compounds | 2,050 | 1,880 | 2,240 | 2,540 | 2,570 |
| Total reported | 4,170 ^r | 3,910 ^r | 3,800 ^r | 4,610 ^r | 4,500 |
| Apparent | W | W | W | W | W |
| World, production ^{e, 5} | 30,800 | 29,600 | 32,500 ^r | 29,200 ^r | 29,200 |

^eEstimated. ^rRevised. W Withheld to avoid disclosing company proprietary data.

¹Table includes data available through July 10, 2018. Data 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.

⁴Includes U.S. Geological survey estimates.

⁵Does not include U.S. production.

TABLE 2
U.S. EXPORTS OF CRUDE IODINE AND POTASSIUM IODIDE, BY COUNTRY OR LOCALITY¹

| Type and country or locality ² | 2016 | | 2017 | |
|---|---------------------------|-----------------------------------|---------------------------|-----------------------------------|
| | Quantity (metric tons) | Value ³ (thousands) | Quantity (metric tons) | Value ³ (thousands) |
| Iodine, crude: | | | | |
| Belgium | 25 | \$414 | 3 | \$56 |
| Brazil | 72 | 1,320 | 47 | 798 |
| Canada | 113 | 1,650 | 280 | 4,060 |
| China | 42 | 373 | 51 | 1,060 |
| Germany | 523 | 14,300 | 606 | 12,100 |
| India | 144 | 2,640 | 57 | 997 |
| Japan | 5 | 85 | 39 | 778 |
| Korea, Republic of | 39 | 897 | 56 | 1,110 |
| Malaysia | 5 | 50 | 12 | 122 |
| New Zealand | 15 | 383 | 15 | 381 |
| Norway | 18 | 378 | -- | -- |
| South Africa | 16 | 267 | 9 | 220 |
| Spain | -- | -- | 36 | 768 |
| Other ⁴ | 28 ^r | 567 ^r | 21 | 290 |
| Total | 1,050 | 23,300 | 1,230 | 22,700 |
| Potassium iodide:⁵ | | | | |
| China | 36 | 895 | 35 | 1,010 |
| France | 4 | 119 | 26 | 744 |
| Korea, Republic of | 30 | 433 | 43 | 521 |
| Mexico | 23 | 562 | 12 | 243 |
| Netherlands | (6) | 4 | 14 | 241 |
| Saudi Arabia | 12 | 212 | 52 | 889 |
| Singapore | 75 | 608 | 40 | 868 |
| Taiwan | 50 | 812 | 64 | 960 |
| Other ⁴ | 15 ^r | 371 ^r | 26 | 569 |
| Total | 246 | 4,020 | 311 | 6,040 |

^rRevised. -- Zero.

¹Table includes data available through July 10, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Export 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 free alongside ship valuation.

⁴Includes countries and (or) localities with quantities less than 10 metric tons.

⁵Contains 76% iodine.

⁶Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
U.S. IMPORTS OF CRUDE IODINE AND POTASSIUM IODIDE FOR
CONSUMPTION, BY COUNTRY OR LOCALITY¹

| Type and country or locality ² | 2016 | | 2017 | |
|---|---------------------------|-----------------------------------|---------------------------|-----------------------------------|
| | Quantity (metric tons) | Value ³ (thousands) | Quantity (metric tons) | Value ³ (thousands) |
| Iodine, crude: | | | | |
| Azerbaijan | 10 | \$218 | -- | -- |
| Chile | 3,790 | 86,000 | 3,640 | \$71,400 |
| Japan | 511 | 11,800 | 537 | 10,200 |
| Other ⁴ | 2 ^r | 63 ^r | 2 | 56 |
| Total | 4,320 | 98,000 | 4,180 | 81,700 |
| Potassium iodide:⁵ | | | | |
| Brazil | 43 | 877 | 62 | 1,160 |
| Canada | 119 | 2,040 | 99 | 1,640 |
| India | 30 | 622 | 40 | 793 |
| Other ⁴ | 10 ^r | 193 ^r | 26 | 392 |
| Total | 202 | 3,730 | 227 | 3,990 |

^rRevised. -- Zero.

¹Table includes data available through July 10, 2018. Data 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.

⁴Includes countries and (or) localities with quantities less than 10 metric tons.

⁵Contains 76% iodine.

Source: U.S. Census Bureau.

TABLE 4
CRUDE IODINE: WORLD PRODUCTION, BY COUNTRY OR LOCALITY¹

(Metric tons)

| Country or locality ² | 2013 | 2014 | 2015 | 2016 | 2017 |
|----------------------------------|------------------|------------------|---------------------------|---------------------------|---------------------|
| Azerbaijan | 249 | 221 ^r | 210 ^r | 208 ^r | 199 |
| Chile | 20,656 | 18,989 | 21,179 | 18,444 ^r | 18,400 ^e |
| Indonesia | 43 | 56 | 45 | 35 ^r | 39 |
| Japan | 9,334 | 9,814 | 10,610 | 9,993 ^r | 10,000 ^e |
| Turkmenistan | 500 ^e | 500 ^e | 500 ^e | 500 ^e | 544 |
| United States | W | W | W | W | W |
| Total³ | 30,800 | 29,600 | 32,500^r | 29,200^r | 29,200 |

^eEstimated. ^rRevised. W Withheld to avoid disclosing company proprietary data.

¹Table includes data available through May 14, 2018. All data are reported unless otherwise noted. Totals and estimated data are rounded to three significant digits; may not add to totals shown.

²In 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.

³Does not include U.S. production.