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IODINE

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IODINE

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Iodine production and apparent consumption in the United States increased in 2010 compared with that of 2009. Data for production and apparent consumption were withheld to avoid disclosing company proprietary data. Reported consumption by producers and consuming industries was 4,670 metric tons (t) in 2010 compared with 4,550 t in 2009. Crude and sublimed iodine exports decreased to 1,070 t valued at $22.3 million in 2010 compared with 1,160 t valued at $22.9 million in 2009. Imports of crude iodine increased to 5,710 t valued at $141 million in 2010 compared with 5,190 t valued at $133 million in 2009. World production, excluding United States production, was estimated to be 28,700 t in 2010 compared with 28,500 t in 2009.

Legislation and Government Programs

In 2008, the U.S. Environmental Protection Agency (EPA) approved the restricted use of the soil fumigant iodomethane (methyl iodide) as an alternative to the ozone depleting methyl bromide. Companies must provide training for employees and satisfy risk mitigation requirements set by the EPA. Respirators or ducted fan and blower systems must be used by workers applying the fumigant. Tarps must be placed over treated fields, and buffer zones must be established around fields where the fumigant will be applied. Use of the fumigant is prohibited within a specified distance from such sites as day care facilities, nursing homes, prisons, and schools. Methyl iodide can be used to control insects, nematodes, plant pathogens, and weeds and may be used on crops, turf, and plants such as ornamentals, peppers, strawberries, tomatoes, trees, and vines. The EPA concluded three field studies conducted in Georgia, Florida, and Michigan, consisting of human health risk assessments and emission studies of iodomethane applied to fields using impermeable tarps, and found that emission were significantly reduced compared to typical processes. Once an evaluation of data from these field studies is concluded, changes to iodomethane labels will likely be made (U.S. Environmental Protection Agency, 2011).

Production

The U.S. Geological Survey obtained domestic production data for iodine from a voluntary canvass of two U.S. operations (table 1). U.S. production increased slightly in 2010 from that of 2009. 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 Corporation of Japan) produced iodine near Woodward, in Woodward County, OK.

Iofina plc (United Kingdom) completed development of its Atlantis prospect in northern Montana, which included drilling its first production well, construction of iodine and gas separation buildings, and laying a 14.5-kilometer (km)-long gas pipeline extension. The prospect consists of sodium chloride brine with high concentrations of iodine, located between two major biogenic gas fields. After several delays owing to mechanical issues, collection of gas and iodine at the prospect began in March (Iofina plc, 2008, 2010).

Consumption

U.S. apparent consumption of iodine, which is withheld to avoid disclosing company proprietary data, increased by 12% in 2010 from that of 2009. Reported consumption by consuming industries was 4,670 t in 2010 compared with 4,550 t in 2009. Accurate end-use statistics are difficult to gather since domestic and imported iodine were used to produce many intermediate iodine compounds, usually by downstream manufacturers. However, 16 of the 22 companies to which a survey form was sent responded to the annual or preliminary surveys, representing 74% of the total consumption by major domestic users of iodine (tables 1, 2).

Use of iodine in manufacturing increased by 3% in 2010 compared with that of 2009 (table 2). Production of crude iodine and potassium iodide (KI) decreased by about 59% and 27%, respectively. Two companies accounted for the bulk of the decrease in use of crude iodine and KI. Production of miscellaneous and other inorganic iodine products, which includes cuprous iodide and potassium iodate, increased by 12%. Production of organic iodine compounds decreased by 10%.

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.—Since 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. The National Aeronautics and Space Administration (NASA) uses iodine in its water disinfection process on all manned space flights and in the international space station. Iodine is a cost-efficient, effective, and simple means of water disinfection.

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 coating, and vinegar. Most acetic acid is produced using the methanol carbonylation process, which uses iodomethane at an intermediate step. Catalysts were generally recycled and reused in new processes.

A research team from Japan developed a metal-free way to create the compound 2,3-dihydrobenzofuran, used in a variety of biologically active drugs, by employing iodine as a way to sidestep the use of toxic heavy metals. This catalytic process was considered environmentally friendly since no heavy metal waste products were produced (Everts, 2010).

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 a more stable form.

Nutrition.—Iodine is an essential component of thyroid hormones, which directly affect processes in the brain, muscles, heart, pituitary gland, and kidneys. Iodine deficiency causes 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 of iodine per day for a human adult (Institute of Medicine of the National Academies, 2006).

Pharmaceuticals.—Radiopaque agents, drugs that absorbs 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, 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.

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, relied on printed film for shooting since 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.

Using iodine as a radiocontrast agent in x-ray imaging has been found to increase the risk of kidney failure and should be used with caution on patients with impaired kidney function (Tung, 2006). Barium sulfate, which was used primarily in digestive system imaging, can be used as an iodine substitute but is also known to cause complications. Many elements have higher atomic numbers than iodine; however, 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.

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 2010. The average free alongside ship (f.a.s.) value for exported crude iodine in 2010 was $20.81 per kilogram, an increase from $19.75 per kilogram in 2009. The average declared cost, insurance, and freight (c.i.f.) value for imported crude iodine was $24.71 per kilogram in 2010, a decrease from $25.54 per kilogram in 2009. The average declared c.i.f. value for iodine imported from Chile, the leading source country of imported iodine for the United States, was $25.45 per kilogram in 2010 compared with $26.66 per kilogram in 2009. The average declared c.i.f. value for imported crude iodine from Japan was $21.06 per kilogram in 2010, an increase from $19.90 per kilogram in 2009.

The spot price of crude crystal iodine, 99.5% minimum purity, in 50-kilogram drums delivered to the United Kingdom ranged from $30.80 to $31.80 per kilogram in January 2010. In December, the price increased to $31 to $33 per kilogram (Industrial Minerals, 2010a, b). 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 decreased to 1,070 t with an f.a.s. value of $22.3 million in 2010 compared with 1,160 t valued at $22.9 million in 2009 (table 3). Exports of KI increased to 442 t with an f.a.s. value of $9.3 million in 2010 compared with 128 t valued at $2.7 million in 2009. Exports of crude iodine to Canada, Germany, and Mexico represented 86% of total crude iodine exports in 2010.

Imports of crude iodine increased to 5,710 t with a c.i.f. value of $141 million in 2010 compared with 5,190 t valued at $133 million in 2009 (table 4). Imports of KI increased to 423 t with a c.i.f. value of $9.8 million in 2010 compared with a total of 259 t valued at $6 million in 2009. Imports of crude iodine from Chile and Japan represented more than 99% of total crude iodine imports in 2010.

World Review

World production of iodine, excluding the United States, was estimated to be 28,700 t in 2010 compared with 28,500 t in 2009 (table 5). Chile was the world's leading producer of iodine, followed by Japan and the United States.

World consumption of iodine and its derivatives was estimated to be 30,000 t in 2010, a 17% increase from 25,500 t

in 2009. Production from Chile accounted for 58% of that tonnage; Japan accounted for 21%; and the United States accounted for 5%. Other producing countries accounted for 2% of the iodine supply, and iodine recycled in the manufacturing process accounted for 14%. X-ray contrast media represented 20%, iodophors represented 13%, pharmaceuticals represented 13%, and LCD represented 11% of iodine consumption in 2010 (Sociedad Química y Minera de Chile S.A., 2011a, p. 11). An estimated 16% of iodine may be consumed in manufacturing industrial catalysts (Kanto Natural Gas Development Co., Ltd., undated).

Azerbaijan.—Azeryod LLC (a subsidiary of ISR Holding) continued expansion of its Neftchala iodine plant, supported by a $15 million loan from the European Bank for Reconstruction and Development (European Bank for Reconstruction and Development, 2010). In late 2009, construction was completed on a 10-km-long collector linking the Khilly field with the Azeryod plant, and two 15,000-cubic-meter reservoirs were repaired (ISR Holding, 2010). In 2010, the company received warnings from the Ministry of Ecological and Natural Resources in connection with environmental pollution at the Neftchala plant. After an examination, it was determined that a leak existed in a tank which received iodine from the wells, and the Ministry instructed the company to resolve the deficiencies (Today.az, 2010).

Chile.—Sociedad Química y Minera de Chile S.A. (SQM), the leading iodine producer in Chile, reported sales of 11,900 t of iodine and iodine derivatives valued at $316 million in 2010 compared with 7,200 t valued at $191 million in 2009. The increase in sales was attributed to increased demand in industrial applications, such as LCD screens and biocides (Sociedad Química y Minera de Chile S.A., 2011b). SQM estimated that it held 36% of the world market for iodine and its derivatives (Sociedad Química y Minera de Chile S.A., 2011a).

Atacama Minerals Corp., a publicly held Canadian company operating the Aguas Blancas mine in northern Chile, commissioned an agitated leaching processing plant in late 2008 with the intent of increasing production to 1,500 metric tons per year (t/yr) of iodine from 1,000 t/yr. The $26.5 million plant was expected to increase recovery of iodine to more than 75% from 55%, reduce processing time from several months to less than 24 hours (reducing the need for new heap-leach pad construction), and reduce water consumption by 25%. However, full startup was delayed since the crushing and grinding section of the plant was inadequate to handle the higher than expected sodium sulfate levels found in the mine. In late 2009, the company announced plans to reconfigure the crushing and grinding circuit to adequately handle the various ore types. In the second quarter of 2010, design details were finalized, and construction was expected to be completed in January 2011 (Atacama Minerals Corp., 2008, 2009, 2010).

Outlook

The Chilean producers, which produced 58% of the global iodine supply in 2010, were operating near capacity and were expected to expand production in response to changes in demand and to capitalize on expected increases in iodine prices. SQM projected global demand to increase to 31,000 t and prices to increase to $34 per metric ton in 2011 (Sociedad Química y Minera de Chile S.A., 2011a). The water treatment market was expected to increase, with more growth anticipated in Asia. Expanding treatment of municipal water supplies could increase the demand for biocides and disinfectants in the future. Use of x-ray contrast media, which contain as much as 60% iodine, was expected to increase. More medical tests on an aging population could result in increased demand for iodine-containing x-ray contrast media.

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Other

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TABLE 1
SALIENT IODINE STATISTICS[1]

(Metric tons and dollars)

	2006	2007	2008	2009	2010
United States:					
Production	W	W	W	W	W
Imports:					
Quantity, for consumption[2]	5,640	6,060	6,300	5,190	5,710
Price, average[3] dollars per kilogram	19.34	21.01	21.52	25.55	24.71
Exports[2]	1,580	1,060	950	1,160	1,070
Consumption:					
Reported[4]	4,570	4,470	4,590	4,550	4,670
Apparent[5]	W	W	W	W	W
World, production[e]	26,700	26,300	26,500	28,500	28,700

[e]Estimated. W Withheld to avoid disclosing company proprietary data.

[1]Data are rounded to no more than three significant digits, except prices.

[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]Reported by voluntary response to the U.S. Geological Survey from a survey of domestic establishments.

[5]Calculated using domestic production plus imports minus exports plus adjustments for government and domestic industry stock changes.

TABLE 2
DOMESTIC CONSUMPTION OF IODINE, BY PRODUCT [1, 2]

	2009		2010	
Product	Number of plants	Quantity (metric tons)	Number of plants	Quantity (metric tons)
Inorganic compounds:				
Crude iodine	7	505	3	207
Resublimed iodine	7	62	7	699
Potassium iodide	4	167	4	122
Sodium iodide	5	193	1	10
Hydriodic acid	3	195	3	181
Potassium iodate	3	17	3	34
Miscellaneous iodate, and iodides[3]	2	37	1	93
Other inorganic compounds	5	510	4	752
Total	XX [4]	1,690	XX [4]	2,100
Organic compounds:				
Ethylenediamine dihydroiodide	2	231	2	256
Povidine-iodine (iodophors)	2	321	--	--
Other organic compounds[5]	7	2,310	9	2,320
Total	XX [4]	2,860	XX [4]	2,580
Grand total	XX	4,550	XX	4,670

XX Not applicable. -- Zero.

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

[2]Reported by voluntary response to the U.S. Geological Survey in a survey of domestic establishments.

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

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

[5]Includes methyl and (or) ethyl iodide and other unspecified products.

TABLE 3

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

Type and country of origin[3]	2009 Quantity (metric tons)	2009 Value[2] (thousands)	2010 Quantity (metric tons)	2010 Value[2] (thousands)
Iodine, crude/resublimed:				
Argentina	8	$76	2	$24
Canada	154	3,570	203	4,920
Costa Rica	8	8	--	--
Egypt	5	144	4	104
El Salvador	6	42	--	--
Germany	779	15,300	661	14,000
Italy	90	2,180	35	940
Japan	14	222	28	509
Malaysia	2	13	9	64
Mexico	67	854	55	319
Netherlands	--	--	10	221
South Africa	(4)	6	33	551
United Arab Emirates	--	--	9	235
Other[5]	26 r	471 r	24	420
Total	1,160	22,900	1,070	22,300
Potassium iodide:[6]				
Australia	6	164	14	338
Chile	--	--	82	1,730
France	29	792	119	2,600
Germany	(4)	3	35	862
Korea, Republic of	12	108	25	452
Mexico	10	297	13	370
Russia	--	--	5	125
Saudi Arabia	--	--	31	702
Taiwan	40	610	73	1,030
Turkey	8	245	16	451
Other[7]	23 r	497 r	30	673
Total	128 r	2,720 r	442	9,330

rRevised. -- Zero.

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

[2]Declared free alongside ship valuation.

[3]Export 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.

[4]Less than ½ unit.

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

[6]Potassium iodide contains 76% crude iodine.

[7]Includes 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 ORIGIN[1]

Type and country of origin[3]	2009 Quantity (metric tons)	2009 Value[2] (thousands)	2010 Quantity (metric tons)	2010 Value[2] (thousands)
Iodine, crude:				
Chile	4,290	$114,000	4,770	$121,000
France	7	187	1	13
India	19	615	--	--
Japan	871	17,300	937	19,700
Other[4]	2	25	4	45
Total	5,190	133,000	5,710	141,000
Potassium iodide:[5]				
Brazil	22	471 r	19	415
Canada	183	4,560	315	8,000
Chile	35	632 r	26	337
Germany	3	47	9	110
India	8	188	35	663
United Kingdom	8	95	15	166
Other[4]	(6) r	2 r	3	82
Total	259	6,000	423	9,770

rRevised. -- Zero.

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

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

[3]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.

[4]Includes countries with quantities less than 5 metric tons.

[5]Gross potassium iodide contains 76% crude iodine.

[6]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5
CRUDE IODINE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Azerbaijan	300	300	300	300	300
Chile[3]	16,494 4	15,473 4	15,503 4	17,399 4	17,500
China	560	570	570	580	590
Indonesia	75	75	75	75	75
Japan	8,724 4	9,282 4	9,500	9,600	9,700
Russia	300	300	300	300	300
Turkmenistan	270	270	270	270	270
United States	W	W	W	W	W
Uzbekistan	2	2	2	2	2
Total	26,700	26,300	26,500	28,500	28,700

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

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

[2]Table includes data available through June 23, 2011.

[3]Includes iodine production reported by Servicio Nacional de Geologia y Minería.

[4]Reported figure.