

# IODINE

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Three producers of crude iodine supplied about 27% of domestic demand (table 1). Domestic and imported iodine was consumed in intermediate products prior to being sold to consumers (table 2). Iodine and derivatives find principal uses in pharmaceutical and medical applications, sanitation or disinfectants, animal feed, catalysts, inks, colorants, photographic equipment, and stabilizers. Published prices for crude iodine were unchanged from 1999 (table 3). Imports of crude iodine decreased by 7% and imports of potassium iodide increased by 65% (table 4). End uses for domestic consumption in 2000 were reported in potassium iodide, which decreased by 26%, and sodium iodide, which decreased by 27%. Exports of crude iodine and potassium iodide were at 1999 levels during 2000 (table 5). Because some exports and imports are in product categories rather than crude products, net imports are not clearly distinguished. In Chile, iodine is a coproduct of sodium nitrate production. Japan produced iodine from brines associated with natural gas production (table 6).

## Legislation and Government Programs

The annual materials plan of the U.S. Department of Defense proposed the sale of 453,593 kilograms (kg) (1 million pounds) of iodine for fiscal year 2000. The National Defense Authorization Act for Fiscal Year 2000 (Public Law 106-65), signed on October 5, 1999, did not change the previous

authorization for disposal of all stock of crude iodine in excess of the national defense stockpile (NDS) goal. The law authorized the transfers of no more than \$150 million from the NDS transaction fund equally to the operation and maintenance accounts of the Army, Navy, and Air Force, no more than \$50 million each (section 304). Public Law 106-65 also obligated no more than \$78.7 million of the NDS transaction fund for the operation of the NDS program. The law required the sale of authorized commodities that would result in receipts of \$10 million by the end of fiscal year 2000; \$100 million during the fiscal year ending September 30, 2004; and \$300 million during the fiscal year ending September 30, 2009. On October 17, 2000, the Defense National Stockpile Center (DNSC) issued "Amendment No. 003" to Solicitation of Offers for DLA-Iodine-003 that changed the dates for offerings to February 21, May 16, and August 15, 2001. On October 29, 1999, "Amendment No. 002 to the Solicitation" changed the sale of the 453,593 kg to quarterly sales of 113,398 kg (250,000 pounds) and set subsequent offering dates for 1999 and 2000. On January 13, 2000, the DNSC announced the award of 19,050 kg (42,000 pounds) at a value of \$270,000 (\$14.17 per kilogram or \$6.42 per pound). On March 8, 2000, the DNSC announced the sale of 2,270 kg (5,000 pounds) at a value of \$31,000 (\$13.67 per kilogram or \$6.20 per pound). On June 7, 2000, the DNSC announced the sale of 2,260 kilograms (5,000 pounds) at a value of \$30,000 (\$13.23 kilogram or \$6.00 per

## Iodine in the 20th Century

Iodine was first produced in the United States between 1917 and 1921 at an experimental station at Summerland in Santa Barbara County, CA. Large quantities of seaweed were harvested and used to produce acetic acid, potash fertilizers, and iodine. Iodine was first exploited commercially in 1916 in the form of potassium iodide as a remedy for goiter. In 1916, tincture of iodine was used as a disinfectant for cuts and abrasions and for sanitation. In 1939, Louis Daguerre published details of his method for making photographs on plated silver by using iodine vapor to form a thin coating of light sensitive silver iodide crystals.

Iodine production from underground brines began in the United States on August 2, 1928, near Shreveport, LA, using a process developed by Dow Chemical Co. The General Salt Co. began extracting iodine in 1928 from oilfield brines in the Signal Hill district in Long Beach, CA, using a charcoal process. The Louisiana plant closed in 1932 and the operation moved to California and was renamed the Jones Chemical Co. Deepwater Chemical Co. produced iodine in California from 1932 until 1960 by the silver iodide process. Domestic

production in 1937 was reported to be 136,000 kilograms. In 1938, the Jones plant was incorporated as the Io-Dow Chemical Co. Production in 1940 was 564,000 kilograms. In 1961, Dow closed its plant in California and opened an iodine plant in Midland, MI, using underground brines associated with bromine production. Dow closed its Michigan plant in 1986.

In 1977, Woodward Iodine Corp. began production of iodine in Oklahoma. This plant was purchased by Ise Chemical Industries Co. Ltd. of Japan in 1994. In 1983, North American Brine Resources completed two miniplants in Kingfisher County, OK. In 1987, IOCHEM Corp. opened an iodine plant in Vici, OK. All production in Oklahoma was from gas brines.

In 2000, iodine was consumed in animal feed (45%), pharmaceuticals (27%), catalysts (10%), heat stabilizers (5%), and other applications (5%). About 27% of the iodine consumed during 2000 was from domestic production, which was about 1.5 million kilograms.

pound). On August 31, 2000, the DNSC announced the sale of (USA), Inc. (10%), began operating a miniplant at Dover in 14,300 kg (31,500 pounds) at a value of \$188,000 (\$13.21 per kilogram or \$5.97 per pound). On December 5, 2000, the DNSC announced the sale of 11,200 kg (25,000 pounds) at a value of \$150,00 (\$13.23 per kilogram or \$6.00 per pound). At year end, 949,215 kg (108,500 pounds) was sold valued at \$670,000, and the excess iodine was 1.7 million kilograms (Mkg) (3.8 million pounds) valued at \$28 million (\$16.44 per kilogram or \$7.46 per pound).

In 1906, the Food and Drug Act was passed to ensure the safety and effectiveness of drugs and to set standards to determine which drugs can be sold over the counter and which ones require a prescription. During 1997 and 1998, online pharmacies were selling drugs to consumers without a valid prescription. Iodine and many of the products made from iodine are controlled substances. To protect consumers from illegal sales of drugs over the Internet, the Executive Office of the President unveiled an initiative in December that would require all online pharmacies to demonstrate that they comply with State and Federal laws and are licensed by the Food and Drug Administration (FDA). The maximum civil penalty would be raised to \$500,000 from \$1,000. The proposal would give the FDA subpoena power to investigate online pharmacies and provide \$10 million to set up a rapid-response team to go after illicit drugs (Hileman, 2000).

One of the standards that is used for iodine is set by U.S. Pharmacopeia (USP). USP is an organization whose work is largely unknown, unrecognized, or overlooked by the public. USP sets and disseminates standards that ensure high-quality drugs for human and animal use, and it is a major element in drug regulation. The very foundation of drug regulation is delegated by statute to this private organization. USP was created in 1820 to bring some rational order to the pharmaceutical industry. At the first national convention, physicians made a list of safe and effective drugs and published this in what is now the USP. The USP was first revised in 1830 and every 10 years thereafter until 1970, when it was updated every 5 years; after 2002, it will be revised annually. In 1973, USP purchased the "National Formulary" (NF) from the American Pharmaceutical Association and combined the NF with the USP. The latest volume (USP24-NF19) was published in 2000 and included officially recognized standards for drugs and health care technologies (Ember, 2001).

## Production

Domestic production data for iodine were derived from a voluntary survey of U.S. operations by the U.S. Geological Survey. The three companies to which a survey request was sent responded, representing 100% of the total production (tables 1, 6).

In 1987, IOCHEM Corp. began producing iodine by the blowing-out process at a plant 1.2 kilometers (km) east of Vici, Dewey County, OK. IOCHEM, the largest U.S. plant, was owned by the Kita family and Tomen Corp. The majority of the production was shipped to Schering AG of Germany under a long-term contract. IOCHEM reported having nine production wells and four injection wells with a total production capacity of 1,400 metric tons per year (t/yr) at Vici.

North American Brine Resources, owned by Beard Oil Co. (40%), Godoe Shigen (USA) Inc. (50%), and Mitsui & Co.

Kingfisher County, OK, in 1983. In 2000, the company operated one plant at an oilfield injection-disposal site that obtained brines from about 50 wells in the Oswego Formation. Iodine concentrations were as much as 1,200 parts per million (ppm). Its large plant in Woodward, OK, remained closed pending price increases.

Woodward Iodine Corp., which began production in 1977, was purchased by Asahi Glass Co. of Japan in 1984 and sold to Ise Chemical Industries Co. Ltd. of Japan in 1994. Woodward's plant in Woodward County, OK, produced iodine from 22 brine production wells, which used the blowing-out process, and injected waste through 10 injection wells. Mical Specialty Chemicals, Inc., a subsidiary of Mitsubishi International Corp., was the exclusive distributor for iodine produced by Woodward.

## Consumption

Estimated end uses, by percentage, for iodine in 2000 were as follows: sanitation, 45%; animal feed, 27%; pharmaceuticals, 10%; catalysts, 8%; heat stabilizers, 5%; and other, 5%. Other smaller uses included inks and colorants, photographic chemicals, laboratory reagents, production of batteries, high-purity metals, motor fuels, and lubricants (table 2).

Commercial crude iodine normally has a minimum purity of 99.5%. Impurities are chiefly water, sulfuric acid, iron, and insoluble materials. The USP specifies an iodine content of not less than 99.8%. 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.

Recommended daily allowances of iodine were as follows: infants, 40 to 40 micrograms (mg); children age 1 to 3 years, 70 mg, age 4 to 6 years, 90 mg, age 7 to 10 years, 120 mg, and age 11 and up, 150 mg; pregnant women, 175 mg; and lactating women, 200 mg. A quarter teaspoon of iodized table salt provides 95 mg of iodine. A 170 gram (6-ounce) portion of ocean fish provides 650 mg of iodine. Most people are able to meet their iodine requirements by eating iodized salt, plants grown in iodine-rich soil, seafood, and seaweed (Yahoo! Health, 2000, Iodine in diet, accessed October 30, 2000, at URL [http://health.yahoo.com/health/diseases\\_and\\_conditions/disease\\_feed\\_data/iodine\\_in\\_diet](http://health.yahoo.com/health/diseases_and_conditions/disease_feed_data/iodine_in_diet)).

In the human fetus, thyroid hormone is essential for the development of the central nervous system. The lack of thyroid hormone causes cretinism, which results in severe mental retardation and somatic growth. Until the 12th week of life, the sole source of thyroid hormone supply is maternal thyroid hormone. Recently, it was reported that the mild deficiency of thyroxine in maternal blood in the first or the second trimester of pregnancy would cause the impairment of cognitive capabilities of the offspring measured at 4 to 7 years after birth (Shishiba, 2000).

Arizona Chemical Division, which is a subsidiary company of International Paper Co., is a leading producer of pine chemicals that include tall oil and rosins, which use iodine as a stabilizer. These pine products were used globally for a variety of end uses, including adhesives, chewing gum, inks and coating, lubricants, rubber, plastics soaps and cleaners, and other markets (Arizona Chemical, July 26, 2000, Arizona Chemical











TABLE 1  
SALIENT IODINE STATISTICS 1/

(Thousand kilograms, unless otherwise specified)

	1996	1997	1998	1999	2000
United States:					
Production	1,270	1,320	1,490	1,620	1,470
Imports for domestic consumption 2/ 3/	4860	6380	5960	5430	4790
Exports 2/ 3/	2410	2760	2790	1130	886
Consumption:					
Reported 4/	3,920	4,500	4,100	4,540	3,990
Apparent 5/	3,700	5,140	4,950	5,990	5,420
Price, imports, average c.i.f. value, dollars per kilogram 2/	\$12.82	\$14.74	\$16.45	\$16.15	\$14.59
World, production	14,100 r/	15,700 r/	18,600 r/	18,400 r/	18,000 e/

e/ Estimated. r/ Revised.

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

2/ U.S. Census Bureau.

3/ Only the crude iodine "content" of the potassium iodide as declared by tables 4 and 5 is incorporated in data or calculations for this table.

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

5/ Calculated by using domestic production plus imports minus exports plus adjustments for Government and domestic industry stock changes.

TABLE 2  
DOMESTIC CONSUMPTION OF CRUDE IODINE, BY PRODUCT 1/

(Thousand kilograms)

Product	1999		2000	
	Number of plants	Quantity	Number of plants	Quantity
Inorganic compounds:				
Resublimed iodine	9	196	11	205
Potassium iodide	9	676	9	496
Sodium iodide	7	373	7	403
Ammonium iodide	1	W	1	W
Calcium iodate	2	W	1	W
Cuprous iodide	2	W	2	W
Hydriodic acid	4	177	3	175
Potassium iodate	3	70	3	94
Other inorganic compounds	6	367	7	799
Total	(2/)	1,860	(2/)	2,170
Organic compounds:				
Ethylenediamine dihydroiodide	4	877	3	176
Methyl and/or ethyl iodide	3	68	2	W
Povidone-iodine (idophors)	4	645	--	--
Other organic compounds	8	1,090	7	1,640
Total	(2/)	2,680	(2/)	1,820
Grand total:				
Reported consumption 3/	(2/)	4,540	(2/)	3,990
Apparent consumption 4/	(2/)	5,990	(2/)	5,420

W Withheld to avoid disclosing company proprietary data; included with "Other inorganic compounds" and "Other organic compounds." -- Zero.

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

2/ Nonadditive because some plants produce more than one product concurrently.

3/ Reported by voluntary response to the U.S. Geological Survey in a survey of domestic establishments.

4/ Calculated by using domestic production plus imports minus exports plus adjustments for Government and domestic industry stock changes.

TABLE 3  
YEAREND 2000 PRICES OF ELEMENTAL IODINE AND SELECTED COMPOUNDS

(Dollars)

Elemental iodine/compounds	Value 1/	
	Per kilogram	Per pound
Calcium iodate, FCC drums, f.o.b. works	16.42	7.45
Calcium iodide, 50-kilogram drums, f.o.b. works	30.00	13.61
Iodine, crude, drums	19.00-21.00	8.62-9.53
Potassium iodide, U.S.P., drums, 5,000-pound lots, delivered	26.48	12.01
Sodium iodide, U.S.P., crystals, 5,000-pound lots, drums, freight-equalized	36.38	16.50

1/ Conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiations and/or somewhat different price quotations.

Source: Chemical Market Reporter. Current Prices of Chemicals and Related Materials; v. 258, no. 25, December 18, 2000, p. 23-28.

TABLE 4  
U.S. IMPORTS OF CRUDE IODINE AND POTASSIUM IODIDE FOR  
DOMESTIC CONSUMPTION, BY COUNTRY OF ORIGIN 1/

(Thousand kilograms and thousand dollars)

Material type and country of origin 2/	1999		2000	
	Quantity	Value 3/	Quantity	Value 3/
<b>Iodine, crude:</b>				
Canada	4	33	--	--
Cayman Islands	--	--	18	234
Chile	3,490	54,800	3,450	49,100
China	--	--	5	47
Germany	3	52	--	--
Japan	1,480	25,300	1,220	18,600
Russia	109	1,880	87	1,260
Switzerland	36	540	--	--
Other 4/	21	365	7	68
<b>Total</b>	<b>5,140</b>	<b>83,000</b>	<b>4,790</b>	<b>69,400</b>
<b>Iodide, potassium: 5/</b>				
Canada	247	4,310	222	3,720
Chile	36	622	37	590
Japan	1	9	1	20
Other 6/	9	154	223	3,330
<b>Total</b>	<b>293</b>	<b>5,090</b>	<b>483</b>	<b>7,660</b>
<b>Grand total</b>	<b>5,430</b>	<b>88,100</b>	<b>5,270</b>	<b>77,000</b>

-- Zero.

1/ 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 HTS numbers 2801.20.0000 and 2827.60.2000, respectively.

3/ Declared c.i.f. valuation.

4/ Includes Georgia (1999), India, Mexico (2000), and the Netherlands (1999).

5/ Gross potassium iodide contains 76% crude iodine.

6/ Includes Denmark (1999), France (2000), Germany, India (1999), Israel, and the Netherlands (2000).

Source: U.S. Census Bureau.

TABLE 5  
U.S. EXPORTS OF CRUDE IODINE AND POTASSIUM IODIDE,  
BY COUNTRY OF DESTINATION 1/

(Thousand kilograms and thousand dollars)

Material type and country of origin 2/	1999		2000	
	Quantity	Value 3/	Quantity	Value 3/
<b>Iodine, crude/resublimed:</b>				
Canada	28	551	69	1160
France	34	564	45	716
Germany	686	10,800	597	8,330
India	22	375	(4/)	5
Mexico	166	2,170	120	1,630
Netherlands	34	630	--	--
United Kingdom	--	--	68	978
Other 5/	138	2,340	109	1,780
Total	1,110	17,400	1,010	14,600
<b>Iodide, potassium: 6/</b>				
Australia	1	20	--	--
Mexico	7	120	8	141
Netherlands	2	50	3	49
Thailand	(4/)	9	--	--
Turkey	10	205	--	--
Other 7/	5	126	11	198
Total	25	530	22	388
Grand total	1,130	18,000	1,130	15,000

-- Zero.

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

2/ Export information for iodine, crude/resublimed and potassium iodide are reported by HTS numbers 2801.20.0000 and 2827.60.2000, respectively.

3/ Declared "free alongside ship" (f.a.s.) valuation.

4/ Less than 1/2 unit.

5/ Includes Belgium, Columbia (2000), Costa Rica (1999), the Dominican Republic (2000), Denmark (2000), El Salvador (2000), Italy (1999), Japan, the Republic of Korea (1999), Norway (2000), Portugal (1999), Spain (1999), Taiwan (2000), Thailand, and Venezuela.

6/ Gross potassium iodide contains 76% crude iodine.

7/ Includes Denmark (1999), France (1999), Germany (2000), Indonesia (1999), Jamaica (1999), Malaysia (1999), Singapore (1999), Switzerland (2000), Taiwan (2000), the United Kingdom (1999), and Vietnam (1999).

Source: U.S. Census Bureau.

TABLE 6  
CRUDE IODINE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand kilograms)

Country	1996	1997	1998	1999	2000 e/
Azerbaijan e/	300	300	300	300	300
Chile 3/	5,514	7,154	9,722	9,317 r/	9,100
China e/	500	500	500	500	500
Indonesia e/	75	83	66	70	70
Japan	6,178	6,036	6,142	6,152 r/	6,100
Russia e/	250 r/	250 r/	280 r/	300 r/	300
Turkmenistan	35	87	90 e/	150 e/	150
United States	1,270	1,320	1,490	1,620	1,470 4/
Uzbekistan e/	--	--	1	2	2
Total	14,100 r/	15,700 r/	18,600 r/	18,400 r/	18,000

e/ Estimated. r/ Revised. -- Zero.

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 8, 2001.

3/ Includes iodine production reported by Servicio Nacional de Geología y Minería.

4/ Reported figure.