ANNUAL REPORT

IODINE

By Phyllis A. Lyday

1993

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

BIBLIOGRAPHIC INFORMATION

PB94-215662

Report Nos:

Title: Minerals Yearbook, 1993: Iodine.

Date: Sep 94

Authors: P. A. Lyday.

Performing Organization: Bureau of Mines, Washington, DC.

Type of Report and Period Covered: Annual rept.

Supplemental Notes: See also report for 1991, PB93-209716.

NTIS Field/Group Codes: 48A (Mineral Industries), 96A (Domestic Commerce, Marketing, & Economics)

Price: PC A03/MF A01

Availability: Available from the National Technical Information Service, Springfield, VA. 22161

Number of Pages: 14p

Keywords: *Iodine, *Mineral economics, Geology, Production, Consumption, International trade, Imports, Exports, Tables(Data).

Abstract: Three producers of crude iodine supplied approximately 55% of domestic demand; the remainder was imported. Because some exports and imports are in product categories rather than crude products, net imports are not clearly developed. The major world producer, Japan, produced iodine from brines associated with gas production. The second largest producer, Chile, produced iodine as a coproduct of sodium nitrate.

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IODINE

U.S.
DEPARTMENT
OF THE
INTERIOR

Bruce Babbitt
Secretary

BUREAU
OF
MINES

September 1994

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COVER PHOTO:
The photograph shows a chemical research assistant working in fluoroiodocarbon (FIC) analysis. These compounds show promise as chlorofluorocarbon (CFC) and halon replacements in refrigeration, foam blowing, solvents, and fire fighting and could account for significant increases in worldwide iodine utilization. For more information, see Current Research section. (Photo courtesy of Ajar Chemicals, Inc.)

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PB94-215662

IODINE

By Phyllis A. Lyday

Mrs. Lyday, a physical scientist with the U.S. Bureau of Mines, has been the commodity specialist for iodine for 15 years. Domestic survey data were prepared by Gail Mason, statistical assistant; and international data tables were prepared by Amy Durham, international data coordinator.

Three producers of crude iodine supplied approximately 55% of domestic demand; the remainder was imported. Because some exports and imports are in product categories rather than crude products, net imports are not clearly developed. The major world producer, Japan, produced iodine from brines associated with gas production. The second largest producer, Chile, produced iodine as a coproduct of sodium nitrate.

DOMESTIC DATA COVERAGE

Domestic production data for iodine are developed by the U.S. Bureau of Mines from a voluntary survey of U.S. operations. Of the four operations to which a survey request was sent, four responded, representing an estimated 100% of the total production shown in tables 1 and 6. *(See tables 1 and 6.)*

BACKGROUND

Definitions, Grades, and Specifications

Commercial crude iodine normally has a minimum purity of 99.5%. Resublimed iodine is usually 99.9% pure. Most iodine is converted for industrial use to potassium iodide, sodium iodide, and other inorganic compounds, as well as numerous organic compounds.

Geology-Resources

Iodine occurs in rocks and soils, surface and underground brines, and caliche ores. Michigan brines contain about 30 parts per million (ppm) of iodine in the Sylvania Formation of Devonian age. California brines contain 30 to 70 ppm of iodine in brines associated with oilfields in the middle Miocene age, Monterey Formation, and the lower Pliocene age Repetto Formation. Louisiana brines contain about 35 ppm of iodine. In Oklahoma, iodine concentrations associated with oil and gas range between 150 and 1,200 ppm. In Woodward County, OK, iodine occurs in the Morrowan Formation of Pennsylvania age. The iodine concentration averages about 300 to 350 milligrams per liter; 22 barrels of brines are required for each kilogram of iodine.

Extensive iodine-bearing nitrate ores occur in caliche deposits in a belt several hundred kilometers long in the Atacama Desert of northern Chile. The ore layers are 1 to 3 meters thick, usually flat or gently dipping and near the surface. Evaporate minerals such as lautarite (CaI_2O_6) and dietzeite ($2CaO{\cdot}I_2O_5{\cdot}CrO_3$) occur as cementing material in unconsolidated surface material or as veins and impregnations in bedrock.

Japanese brines contain 50 to 135 ppm of iodine in the Kiwada, Otadai, and Umegase Formations of the Kazusa Group of Pliocene age. The major iodine-producing area was the southern Kanto Gasfield, which extends over Chiba, Tokyo, and Kanagawa Prefectures. Iodine was produced in the Niigata and Nakojo Gasfields in Niigata Prefecture, on the Sea of Japan side of central Japan, and the Sadowara Gasfield in Miyazaki Prefecture, southern Kyushu.

In Indonesia, iodine occurs with trace amounts of bromine in brines associated with oil. The most important iodine-producing area is the Gujangon anticline of sandstone and diatomaceous marls of the Upper Pliocene, Kailiberg Formation.

On Okinawa, iodine occurs in concentrations of about 85 ppm in the Tomigusuku Formation of the Shimajiri Group of late Miocene-early Pleistocene age.

Technology

Processing.—In Japan and the United States, iodine is removed from brines by processes that separate the brines from any associated hydrocarbons. In the blowing-out process, brine is acidified and iodine is liberated by reducing the pH to about 3. A countercurrent stream of air transports the liberated iodine to a second tower where the iodine is absorbed by a solution of hydriodic acid. The iodine settles, is filtered, and is melted under concentrated acid. Brine stripped of iodine is treated and then injected into its subsurface formation of origin.

In the absorption process, brine is passed through an absorber, and the waste brine is neutralized and sent to a disposal well. The absorbent laden with iodine is treated with an alkaline solution to regenerate the absorbent and eludes iodine as sodium iodide. Iodide is precipitated under acid.

Japanese plants also use an ion-exchange resin. Upon saturation, the iodine is eluted using a caustic solution that regenerates the resin. Iodine is then processed with a sodium chloride solution and melted under acid.

Chilean caliche deposits are mined by open pit methods. The ore is leached with an alkaline solution to dissolve the

iodine as sodium iodate, which is converted to sodium iodide. Iodine is precipitated by reacting with additional alkaline solution. The precipitated iodine is filtered in bag filters, and the iodine free-leach solution is returned to the nitrate-leaching cycle.

Recycling.—The removal of ionic silver from photographic processing solutions, such as developer, fixer, bleach fixers, and wash waters, can be accomplished with halogens such as iodine and an adsorbent. Photographic silver is commonly recovered by electrolytic methods if the concentration is greater than 500 ppm. Adsorbents such as natural and synthetic zeolites, activated alumina, activated silica, Fuller's earth, and ion exchange resins are used to recover low concentrations of silver from a stream.

Economic Factors

Prices.—Changes in the official price of crude iodine have in the past been initiated during shortages. Because iodine cannot be substituted readily in radiopaque media, animal feeds, catalysts, and stabilizers shortages tend to cause the accumulation of inventories to ensure an adequate supply. An adequate supply tends to lower and stabilize the price.

Costs.—One typical iodine brine well costs about $2 million to complete and is between 1,800 and 3,000 meters deep. Electrical costs for maintaining the pumps to bring the brine to the surface, for air-blowing the iodine, and for injecting the brine are major components of maintenance costs. Capital costs have been estimated at $20 per pound of annual iodine production. These costs include high-quality stainless steels because iodine is highly corrosive. In addition, the brine must be leased from private landowners over large acreage for many years. The principal material cost is for chlorine because 1 pound is required for every 1.4 to 1.8 pounds of iodine produced.

Tariffs.—Crude and resublimed iodine enters the United States duty free. Calcium and cuprous iodine has a 25% ad valorem duty for non-most-favored-nation (MFN) status. Potassium iodide has duties of 2.8% ad valorem for MFN status and 7.5% ad valorem for non-MFN status.

Depletion Provisions.—The domestic and foreign depletion allowances for mined iodine are 14% of gross income, and they may not exceed 50% of net income without the depletion deduction. The domestic and foreign depletion allowances for minerals from brine wells are 5%. The domestic and foreign depletion allowances for solid minerals are 14%.

Operating Factors

Environmental Requirements.—The injection of waste brine is a limiting factor to the production of iodine. During 1982, the Environmental Protection Agency (EPA) reclassified disposal wells for spent brine after halogen extraction as Class 5 wells. All of the injection wells for iodine in Oklahoma were drilled for the injection of waste associated with brine production or oil and gas effluent. Woodward Iodine Corp. operated 22 production wells and injected the waste brine through 10 injections wells. Brine-production and injections wells are 2,130 to 2,290 meters deep. IoChem Corp. had nine production wells and four injection wells. North American Brine Resources operated iodine production facilities at the site of two injection wells for waste brines associated with oil production.[1]

Toxicity.—Iodine is absorbed by the body and concentrated in the thyroid. Iodine is essential to higher animals and humans. A normal person requires about 75 milligrams of iodine per year, which is usually consumed as iodized salt that contains one part sodium or potassium iodide to 100,000 parts of sodium chloride. Iodine deficiency is a major cause of goiter.

The maximum safe concentration of iodine for short-term air environment exposure of up to 1 hour is 1.0 ppm. Exposure of the lungs and eyes can be irritating at concentrations of 0.1 ppm and should be avoided. Greater exposure can cause severe irritations to the eyes and the respiratory tract and may lead to pulmonary edema.

In 1979 and 1986, nuclear accidents caused the release of radioactive iodine, I^{131}, into the atmosphere. A dosage of potassium iodide (KI) administered before or shortly after exposure to radioactive iodine can block the intake of radiation to the thyroid. The dosage must be repeated if exposure continues. Replenishing the thyroid with KI prevents the thyroid from using radioactive I^{131} for normal metabolic needs.

During the 1940's and 1950's, civilians living near the Hanford nuclear weapons plant in Washington were deliberately exposed to high levels of radiation in the form of radioactive iodine. The iodine was deposited on grass that was eaten by cows and conveyed to humans through milk. More than 800,000 people in a 194,000-square-kilometer area of eastern Washington and parts of Idaho and Oregon and some children may have been exposed to as much as 870 rads and adults may have absorbed 350 rads to their thyroid. Federal guidelines call for evacuation if the dose to the thyroid reaches between 5 and 25 rads.[2]

The Joint Food and Agriculture Organization of the United Nations/World Health Organization (FAO/WHO) Expert Committee on Food Additives and No. 832 in the WHO Technical Report Series released its 40th report. The report is an evaluation of certain veterinary drug residues in food. Closantel, an anthelmintic containing 38% iodine by weight, was one of five anthelmintics examined for acceptable daily intakes and maximum residue limits in food-producing animals. The report identifies deficiencies in the available data and specifies the further information required for reevaluation.[3]

ANNUAL REVIEW

Legislation and Government Programs

The U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), proposed in the Federal Register June 12, 1992, to amend its existing air contaminant standards that set permissible exposure limits (PEL's) for the maritime, construction, and agriculture industry sectors. Only employees of farms with more than 10 employees are covered under OSHA standards. Included in the proposed PEL's are iodoform and methyl iodide.

The EPA announced that the use of Iprodione will not be used in processed foods. EPA announced that the pesticide posed only a negligible risk to public health, but was seeking to comply with a 1992 Federal court decision. The action, announced jointly with the Food and Drug Administration and the U.S. Department of Agriculture, was expected to increase the need for a workable alternative to the "Delaney clause" risk standard. The clause required the Federal Government to ban from processed foods any substance found to cause cancer in animals. Although there is a need for a standard for assessing potential harm to human health, there is little consensus on a proposal to replace the clause.[4]

Strategic Considerations

The National Defense Stockpile contained 2,631,292 kilograms of crude iodine. The stockpile goal for iodine was reduced to zero with the passage of Public Law 102-484 on October 23, 1992. A meeting for prospective offers was held on June 3 at the Defense National Stockpile Center in Arlington, VA. On May 12, a draft Invitation for Bids for Iodine was circulated. The Defense Logistics Agency (DLA) of the U.S. Department of Defense sold 45 kilograms (kg) of excess iodine valued at $275 ($2.75 per pound) during fiscal year 1993.

Production

IoChem began production in 1987, 1.2 kilometers east of Vici, Dewey County, OK, by the blowing-out process. The majority of production was shipped to Schering AG, Germany, under a long-term contract. IoChem was reported to have nine production wells and four injection wells with a total production capacity of 1,400 kg per year.

North American began operating a miniplant at Dover in Kingfisher County, OK, in 1983. Two plants are at an oilfield injection disposal site that obtains brines from about 50 wells in the Oswego Formation. Iodine concentrations ranged up to 1,200 ppm. The company closed a plant in 1992 that began operating in 1991 because of the low-market prices for iodine.

Woodward Iodine began production in 1977 and was purchased by Asahi Glass Co. of Japan in 1984. Woodward operated a plant in Woodward County that produced iodine from 22 brine production wells using the blowing-out process and injected waste through 10 injection wells.

Consumption and Uses

Iodine was used primarily in animal feed supplements, catalysts, inks and colorants, pharmaceutical, photographic equipment, sanitary and industrial disinfectants, stabilizers, and radiopaque medium. Other smaller uses included production of batteries, high-purity metals, motor fuels, iodized salt, and lubricants.

Iodine deficiency is the largest preventable cause of mental impairment in the world. Disorders stemming from a lack of iodine range from simple goiter to the severe cluster of mental and physical handicaps known as cretinism. In between are mental retardation, learning disabilities, apathy and lack of motivation in adults, and increased rates of stillbirths and miscarriages. By simply adding iodine to salt the deficiency disorders could be eradicated within a few years.[5]

Excessive levels of iodine, which may cause thyroid cancer, were found in cat foods by scientists at the University of Missouri. Iodine is an essential nutrient in the diet, so high doses were thought to be healthy.[6]

The lithium-iodine battery was the first commercially successful lithium battery and is unusual because of its in situ growth of electrolytes. Superior charge transfer is achieved using an iodine compound with powdered iodine. Layers of lithium iodide act as both electrolyte and separator and are self-sealing in the event of a crack. Thus, the batteries are intrinsically reliable and withstand abuse.

Producers sold iodophors for medical, veterinary, and food-processing applications. The two main classes of iodophors are povidone iodine, manufactured from polyvinylpyrrolidone and utilized in human skin disinfectants, and the nonionic detergent-iodine combinations, utilizing primarily nonoxynol and the poloxamers. Iodophors are highly self-stable, substantially free of the corrosive effects of noncomplexed-iodine concentrations, and relatively nonirritating to human skin. One of the world's largest producers of nonionic detergent iodines is West Agro, Inc.[7]

Tall oil was produced using iodine as a stabilizer by Arizona Chemical Co., a division of International Paper Co., Hercules, Inc., and Westvaco, Inc. Modest reductions in supply were attributed to the limited availability of wood rosin. Tall oil fatty acid inventories declined during 1993 in the United States and Europe.[8]

Eastman Chemical Co. was spun off from the Eastman Kodak Co. Eastman became one of Tennessee's leading employers and joined the ranks of a public company headquartered in Kingsport, TN. The company manufactures chemicals, fibers, and plastics.[9] Acetic anhydride manufactured uses methyl iodide as a catalyst to produce acetic acid.[10]

Kodak planned to concentrate on photography and imaging and its health sciences division. Kodak manufactures its own film and paper supports, as well

as photographic-grade gelatin and processing chemicals and equipment. In the photographic business, a thin gelatin of imaging layers containing light-sensitive silver halide crystals or auxiliary layers help to regulate the photographic or physical performance.

A regenerable biocide delivery unit is an extension of technology developed by Umpqua Research Co. for the space shuttle program in the late 1970's and currently used on the shuttle to purify drinking water. Water is passed through an anion exchange bed that has been treated with iodine. An improvement in the unit regenerates the resin bed in situ using small amounts of elemental iodine. The improved unit has been licensed for water purification of between 9 to 68 liters (2 to 15 gallons) per minute of water for community applications.[11] *(See table 2.)*

Prices

The average declared c.i.f. value for imported crude iodine was $7.90 per kg ($3.58 per pound). The average declared c.i.f. value for imported crude iodine from Japan averaged $7.82 per kg ($3.55 per pound). The average declared c.i.f. value for iodine imported from Chile was $8.01 per kg ($3.63 per pound). The average producer price was $7.98 per kilogram ($3.62 per pound). Quoted yearend U.S. prices for iodine and its primary compounds are shown in table 3. *(See table 3.)*

Foreign Trade

The U.S. Government adopted the Harmonized Commodity Description and Coding System (Harmonized System) as the basis for its export and import tariff and statistical classification systems. The system is intended for multinational use as a basis for classifying commodities in international trade for tariff, statistical, and transportation purposes. The Harmonized System, as proposed, includes resublimed and crude iodine under the same code, and the duty rate is free. Values that differ significantly could be a result of items being placed in the wrong category. *(See tables 4 and 5.)*

World Review

Canada.—In 1976, research was begun to selectively leach amorphous manganese dioxide from the coatings on mineral grains to enhance geochemical anomaly in soils. In recent soil analysis studies on iodine, an anomaly with a contrast of 100-times-background was found at the Sleeper and Rabbit Creek gold mines in Nevada. Trace elements released by oxidation of sulfide-mineral deposits in the bedrock migrate up through overburden by ground water flow, capillary action, or diffusion of volatile compounds. The iodine anomaly was found at a point where the Rabbit Creek deposit was buried by 183 meters (600 feet) of basin fill.[12]

Chile.—Sociedad Química y Minera de Chile (SQM, formerly known as SOQUIMICH) was the largest producer of iodine in Chile. SQM planned to expand potash with a $57.5 million share offer in the United States. On July 8, 1993, SQM issued a prospectus that advertised American Depositary Shares, backed by Series B shares in the company. The money would enable SQM to embark on a $229.7 million expenditure between 1993 and 1997 that includes $7 million to extract nitrates and iodine from fines at the Pedro de Valdivia ore crushing facility. A supplemental amount of $7 million during 1994 and 1995 was to be spent on the construction of a new iodine facility at Lagunas, northern Chile.[13]

Cominac S.A., a subsidiary of Inversiones Errazuriz S.A. Enterprises, began production at two of three reserve areas of the Pozo Almonte Project. The site is in a valley where the natural gravity flow is utilized to collect the iodine-rich solutions. A third reserve area was undergoing a third step in a civil process to determine ownership. The two areas under development are not involved in the civil processing and are under development by a subsidiary company, Compania de Salitre y Yodo de Chile (Cosayach). Cosayach has a plant to recover 600 tons of iodine per year by heap leaching. Plans to expand capacity were being developed.

ACF Minera Ltda. is a Chilean company with a 50% joint venture with DSM N.V. of the Netherlands. The company maintains three production facilities that have a nameplate capacity of 1,200 tons that are in the first region of Chile at La Granja, Lagunas, and Iris. The facilities are about 161 kilometers (100 miles) southeast of the port city of Iquique. The production capacity was reported to be 810 tons of 99.5% to 100.5% iodine, with mineral reserves of 48,000 tons of iodine in situ. The company also owns mineral rights at other locations in the first and second regions of Chile.

Mineral Yolanda, Yumbres, Chile, planned to produce 1.7 million tons per year of nitrate ore that includes iodine with a $78 million investment. The project is wholly owned by Kap Resources Ltd., Vancouver, Canada. The mineral salts or caliche will be leached with seawater to dissolve the salts. The solution will be processed to extract the iodine. The remaining solution will be evaporated in solar ponds to concentrate the nitrate salts.[14]

Indonesia.—The only producer of crude iodine was the state-owned pharmaceutical firm, P. T. Kimia Farma, that operated a plant at Watudakon near Mojokerto, East Java.

Japan.—Japan was the world's leading producer of iodine in 1993. Six companies operated 17 plants with a total production capacity of 9 million kg per year. Plans were announced to close two small plants by midyear 1994. Production of iodine was from underground brines associated with natural gas.

Russia.—Authorities in the Tyumen region will hold open bidding to extract iodine from a deposit near the city of Tobolsk. The Tyumen region was reported to contain one-half of Russia's known iodine reserves. The iodine

deposit was discovered in the 1960's but remained unexploited because of the region's oil boom. Preliminary studies indicate that the deposit could produce from 1,000 to 2,000 tons of iodine annually. Russia consumes 1,600 tons of iodine per year and imports 85% of that amount.[15] *(See table 6.)*

Switzerland.—The Nuclear Medicine division of Mallinckrodt Medical Inc. acquired Oryx Pharmaceutica AG, Zurich, Switzerland. Oryx, which sells more than one-half of the radiopharmaceuticals in Switzerland, had distributed nuclear medicine products manufactured by Mallinckrodt since the 1970's.[16]

Current Research

Trifluoromethyl iodide (CF_3I), an FIC, can replace the common CFC's used in household refrigerants. An FIC is a molecule that contains fluorine, iodine, and carbon and in some cases hydrogen. FIC's have advantages as CFC replacements because they are about the same cost as the replacements now used, HFC-134a, have low toxicity, and do not damage the ozone layer. FIC's break down rapidly on exposure to sunlight; therefore, they have an ozone depletion potential of about zero. FIC's are nonflammable and noncorrosive. FIC's will have higher refrigeration capacities and energy efficiencies will be essentially unchanged. The U.S. Air Force began testing the toxicity of CF_3I as a potential substitute for Halon 1301.[17] Scientists at E.I. du Pont de Nemours & Co. Inc. have produced nonprotonated material by heating C_{60} and excessive trifluoromethyl iodide. The compounds are more volatile but display surface properties of perfluoroalkylated materials, such as Teflon.[18]

Pennsylvania State University studied new methods of producing acetic acid from methane using rhodium trichloride as a catalyst. The yield of acetic acid was increased by adding a source of iodine ions. The new process is similar to the Monsanto process used commercially for carbonylation of methanol to acetic acid using a rhodium-base catalyst. In the new method the methane is hydrolyzed to acetic acid. This reduces the steps from three to one, thereby making the process more economical.[19]

Chemists at the University of Salford and the ICI Runcorn Technical Center prepared thermoplastic hydrogels from linear copolymers of vinyl pyrrolidone and methyl methacrylate. The hydrogels demonstrated favorable properties such as film-forming capacity, melt processability, fluid retention, and biocompatability.[20]

OUTLOOK

Iodine production capacity in the United States and Chile has doubled during the past decade, ensuring an adequate world supply. Uses for iodine in specialty chemicals have remained stable. Recent developments in digital images using computers can produce electronic prints and overhead transparencies without using processing. Using a digital camera or scanning the film and converting to digital, the images are produced and stored on hard drives, disks, tape, or optical storage.

The trend to digital imaging is used for recording most sporting events, game shows, and some situation comedies for broadcasts. However, 75% to 85% of all televised shows seen during prime time are recorded on 35-millimeter (mm) motion picture film and then transferred to videotape or laser disc for display. Furthermore, just about all feature films for movie theater presentation are shot and printed on film. The main reason is the image quality. A frame of 35-mm color negative film contains about 6.6 million pixels or about 15 times that of the best current high-definition television system and 4 times that of the digital systems now in development. Most popular home video rentals have been box office movie hits. Future use of iodine in films and processing could be limited to specialty imaging in the next decade.[21]

New uses of IFC's as halogen replacements could cause an increased demand for iodine. More tests need to be completed on the IFC's before they are acceptable, but preliminary tests are promising.

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TABLE 1
SALIENT IODINE STATISTICS

(Thousand kilograms and thousand dollars)

	1989	1990	1991	1992	1993
United States:					
Production	1,508	1,973	1,999	1,995	1,935
Imports for consumption[1]	3,326	3,168	3,555	3,745	3,615
Exports[1]	NA	2,100	1,317	1,807	1,219
Consumption:[2]					
Apparent	4,834	3,041	4,327	3,933	4,331
Reported	2,900	3,100	3,200	3,400	3,547
Price, average c.i.f. value, dollars per kilogram	$19.50	$13.78	$10.16	$9.03	$7.98
World: Production	r16,259	r17,113	r17,448	r16,581	e16,625

eEstimated. rRevised. NA Not available.
[1]Bureau of the Census.
[2]Calculated by production plus imports minus exports.

TABLE 2
U.S. CONSUMPTION OF CRUDE IODINE, BY PRODUCT

Product	1992		1993	
	Number of plants	Consumption (thousand kilograms)	Number of plants	Consumption (thousand kilograms)
Reported consumption:				
Resublimed iodine	9	148	8	170
Hydriodic acid	3	107	3	289
Calcium iodate	(1)	(1)	(1)	(1)
Calcium iodide	3	125	3	121
Cuprous iodide	3	62	3	81
Potassium iodide	4	530	5	650
Potassium iodate	3	40	3	49
Sodium iodide	6	94	4	62
Other inorganic compounds	14	1,219	9	525
Ethylenediamine dihydroiodide	4	559	3	654
Povidone iodine	—	—	3	361
Other organic compounds	8	516	7	585
Total	[2]27	3,400	[2]27	3,547
Apparent consumption	XX	4,000	XX	4,400

XX Not applicable.
[1]Included with calcium iodide.
[2]Nonadditive total because some plants produce more than one product.

TABLE 3

YEAREND 1993 PUBLISHED PRICES OF ELEMENTAL IODINE AND SELECTED COMPOUNDS

	Dollars per kilogram[1]	Dollars per pound[1]
Calcium iodate, FCC drums, f.o.b. works	16.42	7.45
Calcium iodide, 50-kilogram drums, f.o.b. works	23.65-25.65	11.62-12.07
Iodine, crude, drums	10.00-11.00	4.75- 5.21
Potassium iodide, U.S.P., drums, 5,000-pound lots, delivered	26.48	12.01
Iodine, U.S.P.	17.00	7.70
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 Marketing Reporter. V. 245, No. 1, Jan. 3, 1994, pp. 31-37.

TABLE 4

U.S. IMPORTS FOR CONSUMPTION OF CRUDE IODINE, BY TYPE AND COUNTRY

(Thousand kilograms and thousand dollars)

Country	1992		1993	
	Quantity	Value[1]	Quantity	Value[1]
Iodine, crude:				
Chile	1,963	16,723	1,621	12,977
Japan	1,689	16,188	1,880	14,696
Total	3,652	32,911	3,501	27,673
Iodide, potassium:				
Canada	15	166	17	184
Chile	6	58	14	123
India	40	389	49	452
Japan	—	—	34	238
Other[2]	30	279	—	—
Total[3]	93	891	114	997
Grand total	3,745	33,802	3,615	28,670

[1]Declared c.i.f. valuation.
[2]Includes Germany, Mexico, Sweden, Switzerland, and the United Kingdom.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census, as adjusted by the U.S. Bureau of Mines.

TABLE 5

U.S. EXPORTS OF CRUDE IODINE, BY TYPE AND COUNTRY

(Thousand kilograms and thousand dollars)

Country	1992		1993	
	Quantity	Value[1]	Quantity	Value[1]
Iodine, crude/resublimed:				
Belgium	13	52	—	—
Canada	94	966	28	312
Germany	567	4,925	573	5,078
Hong Kong	15	175	—	—
Japan	428	4,664	—	—
Mexico	350	2,819	380	2,865
Philippines	—	—	16	33
Taiwan	59	106	—	—
United Kingdom	67	889	—	—
Other[2]	32	543	19	269
Total	1,625	15,139	1,016	8,557
Iodide, potassium:				
Canada	76	67	23	360
China	18	58	148	479
Colombia	36	42	—	—
Germany	—	—	5	50
Mexico	1	2	—	—
Spain	11	55	—	—
Sweden	18	20	—	—
Turkey	—	—	14	186
Other[3]	24	159	13	103
Total[4]	182	402	203	1,178
Grand total	1,807	15,541	1,219	9,735

[1]Declared f.a.s. valuation.

[2]Includes Australia, The Bahamas, Ecuador (1992), El Salvador (1992), France (1992), Ghana, Indonesia (1992), Ireland (1992), Italy, the Republic of Korea (1992), Kuwait (1992), New Zealand (1992), Panama (1992), Peru, the Philippines (1992), Spain (1992), Turkey (1992), and the United Arab Emirates (1992).

[3]Includes Belgium (1992), Brazil (1992), Chile, Finland (1992), Hong Kong, Ireland (1992), the Republic of Korea, Mexico (1992), Norway (1992), Saudi Arabia, the Republic of South Africa (1992), and Thailand (1992).

[4]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

TABLE 6

CRUDE IODINE: WORLD PRODUCTION, BY COUNTRY[1]

(Thousand kilograms)

Country	1989	1990	1991	1992	1993e
Azerbaijan[2]	—	—	—	e600	600
Chile	r4,645	r5,099	r5,621	r5,887	5,550
China e	500	500	500	500	500
Indonesia	14	60	36	e35	40
Japan	7,592	7,581	r7,492	r6,764	7,200
Russia[2]	—	—	—	e200	200
Turkmenistan[2]	—	—	—	e600	600
U.S.S.R. e [3]	2,000	1,900	1,800	—	—
United States	1,508	1,973	1,999	1,995	[4]1,935
Total	r16,259	r17,113	r17,448	r16,581	16,625

eEstimated. rRevised.

[1]Table includes data available through June 24, 1994.

[2]Formerly part of the U.S.S.R.; data were not reported separately until 1992.

[3]Dissolved in Dec. 1991.

[4]Reported figure.