IODINE

By Phyllis A. Lyday

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.

Legislation and Government Programs

On January 12, 1994, The Environmental Protection Agency (EPA) published in the Federal Register, Vol. 59, No. 8, a temporary tolerance for the combined residues of the fungicide Iprodione, its isomer and its metabolite in or on the raw agricultural commodity cotton seed. The temporary tolerance expires January 1, 1996.

EPA halted reviews of 60 pesticide registrations that may violate the zero-risk Delaney clause and plans to revoke 25 of 80 existing pesticide registrations on the same basis. The Delaney clause bans cancer-causing chemicals from processed foods.[1]

The EPA planned to add 313 chemicals and chemical categories to the list of toxic chemicals required to be reported under the Toxic Release Inventory (TRI). The proposal published in the January 12 Federal Register, Vol. 59, No. 8. p. 1794 included two iodine compounds. The Defense National Stockpile contained 2,501,732 kilograms (kg) of crude iodine. The stockpile goal for iodine was reduced to zero with the passage of Public Law 102-484 on October 23, 1992.

On September 28, 1994, The Defense National Stockpile Center awarded 116,120 kg (256,000 pounds) of crude iodine to West Agro, Inc., and Chemland, Inc. The total value of the awards was $1,009,397.49 or $8.69 per kg.

In December, 102,386 kg (225,723 pounds) of crude iodine was awarded to West Agro and IOCHEM Corp. The total value of the awards was $941,594.91, or $9.20 per kg.

Production

Domestic production data for iodine are developed by the U.S. Bureau of Mines from a voluntary survey of U.S. operations. Of the three operations to which a survey request was sent, two responded, representing an estimated 51% of the total production shown in tables 1 and 6. *(See tables 1 and 6.)*

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 Chemical Co. 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 parts per million. 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

Iodine deficiency is the world's leading cause of mental defects in the form of severe retardation, deaf-mutism, and partial paralysis and more subtle problems such as clumsiness, lethargy, and reduced learning capacity. Iodine is an essential part of thyroid hormone, a substance that contributes to brain development during fetal life and metabolism thereafter. A worldwide effort is underway to eliminate iodine-deficiency disorders by fortifying the world's salt supply. The international salt iodization campaign will pay for simple machinery that adds iodate to crystallized salt, and for the quality control and education necessary to ensure the transformation is permanent.[2]

Tall oil rosin (TOR) is used as a "paper size," and in ink resins and tackifying resins for adhesives. The main competition for TOR is hydrocarbons resins made from byproducts of ethylene production.[3] Three U.S. companies use iodine to stabilize TOR. Deepwater Iodide Inc., agreed in April 1994 to sell 80% of the company to LSB Chemical Corp., a division of Oklahoma City based LSB Industries Inc. LSB Chemical has businesses in nitric acid and ammonium nitrate and in air conditioning products. Deepwater has $12 million in annual sales and production of a fire extinguishing replacement for Halon 1301 that used iodine and fluorine. The new plant that was to go on-stream in mid-1994 in Woodward, OK, will triple the iodine capacity of the previous plant located in California.

Iodotrifluoromethane (CF_3I) can replace Halon 1301 for total flooding and streaming applications as a fire extinguishing agent. Test conducted by the U.S. Air Force have shown that CF_3I performs at least as well as Halon 1211. The ozone depletion potential (ODP) of CF_3I is zero. CF_3I has been found to be "nontoxic." Flow test shows that CF_3I works well in existing Halon 1301 distribution systems with little or no hardware modifications.[4]

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. *(See table 2.)*

Prices

Tall oil rosin (TOR) prices increased in August, which responded to a rosin resin increase effective January 1, 1995. Pricing for all TOR derivatives will increase 5% to 12%.[5]

The averaged declared c.i.f. value for imported crude iodine was $7.56 per kg. The average declared c.i.f. value for imported crude iodine from Japan was $7.41 per kg. The average declared c.i.f. value for iodine imported from Chile was $7.82 per kg. The average producer price was $7.98 per kg. 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

Chile.—Sociedad Quimica y Minera de Chile (SQM, formerly known as SOQUIMICH) closed two satellite plants late in 1994 to maintain stability in the marketplace. A 100,000-ton-per-year potassium nitrate plant opened at Coya Sur, in northern Chile. Iodine is produced as a byproduct of nitrate production. SQM had invested $1.5 to $2.0 million in a project that boosted productivity by 65% and cut production costs by 30% in the last 5 years. All facilities were International Standards Organization (ISO) certified. SQM holds a patent on prilled iodine, which is preferred by some consumers because of its ease in pouring and lack of dust. SQM is producing iodine derivatives through a subsidiary Inquim, and marketing the derivites to South America and Asia.[6] SQM announced the construction of a new plant in the Salar de Lagunas to produce sodium nitrate.[7]

Compania Salitre Y Yodo de Chile, COSAYACH, part of a multisectorial Inverraz S.A., mines raw material in the form of boron, chlorides, iodine, magnesium from caliche, nitrates, and sulfates. COSAYACH has assets of 190,000 acres of mining claims located in the Atacama and Antofagasta deserts. Reserves are estimated as 356,000 tons of iodine, 46,000,000 tons of sodium nitrate, and 80,000,000 tons of sodium sulfate. Present capacity exceeds 340 tons of iodine per year. Planned capacity increases in Cala-Cala and construction of an additional plant at Chinquiquiray are planned to reach a production level of 1,000 tons per year by 1997.[8]

Haifa Chemicals, Israel, and DSM N.V., Netherlands, have agreed to build a sodium and potassium nitrate plant in the Salare de Lagunas of northern Chile. Haifa agreed to purchase 15% of DSM's shares in the company. DMS has a 75% share in ACF Minera Ltda. The plant would use the waste nitrates from ACF Minera's iodine production to produce 40,000 tons per year of nitrates. Haifa will market all the nitrates produced.[9]

KAP Resources Ltd., Vancouver, Canada, has secured financing for a potassium nitrate project in northern Chile. The nitrates are reported to also contain high concentration of iodides. New investors are members of Canpotex, the Canadian potash export firm. The Canadian interest received a 19% in KAP in exchange for a $5 million investment. KAP plans to raise $41 million for the project that will produce 250,000 tons per year of potassium nitrate and iodine as a coproduct.[10]

The Sierra de Tarapaca's iodine plant and ore reserves were auctioned in March 1994.[11]

Japan.—Japan was the world's leading producer of iodine in 1994. Six companies operated 17 plants with a total production capacity of 9 million kg per year. Two small plants closed in midyear 1994. Production of iodine was from underground brines associated with natural gas.

Russia.—Tyumen Oblast administration and the West Siberian regional geological center are inviting bids for the right to complete surveying and to extract iodine at the Cherkashinskoye deposit. Project development will require $3.8 million. Commercial iodine extraction is from two deposits in Russia in Krasnodar Kray and perm Oblast.[12] *(See table 6.)*

Current Research and Technology

Every photograph is created by light rays that make marks on photosensitive material such as silver salts, usually silver iodide. Silver's chemical properties make it the best photomaterial for everything from beach scenes to X-rays. Photograph companies are trying to revolutionize everyday photography by producing a "smart film." Five of the world's largest film and camera companies formed a partnership to develop a new technology to revolutionize 35 mm photography. The film is "smart" because it has magnetic strips, which can record data that will later be read and translated onto prints by compatible photo-finishing equipment. Additionally, the film can be shot in three different formats, perhaps even on the same roll. The new film may be polyester-based instead of the traditional cellulose triacetate, translating into a stronger film than can be stretched thinner. A polyester-based film would not require methylene chloride needed for acetate based films. Methylene chloride has been labeled as a carcinogen by the EPA.[13]

Iodine may be part of a new scenario as a facilitator in ozone depletion. Some scientists believe, based on a number of assumptions, that iodine reaches the stratosphere and is a facilitator to make chlorine and bromine more potent. The huge volume of natural iodocarbons produced by marine life dwarfs potential industrial emissions. Iodocarbons usually break down when exposed to sunlight. Concern is for methyl iodide in thunderclouds that form in the tropics where idocarbons could reach the ozone layer in just a few hours.[14]

A group of researchers at the University of Utah, Salt Lake City, has synthesized a family of molecular squares. A postdoctoral fellow produced hybrid squares with iodides occupying opposite corners and platinum or palladium at the other corners. The compounds are soluble in organic solvents. The self-assembling molecular squares could eventually prove useful as a hosts for anions.[15]

Chemists at Emory University in Atlanta created a "smart" molecular catalyst that both self-assembles and catalyzes a reaction using idosylbenzene.[16]

Mercury iodide crystals intended for use as X-ray detectors must be coated for protection against moisture and other contaminants. The coatings are thermoplastic polymers derived from paraxylene that are used to make pore-free coatings and thin dielectric films in capacitors. To improve the quality of the polymeric deposit, the pyrolysis temperature was increased and barriers or baffles were added to the pyrolysis tube. The resulting coating was of better quality, including greater transparency and more uniformity of appearance.[17]

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 video tape 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.[18]

New uses of fluoroiodocarbon as halogen replacements may 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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[1]Begley, R. EPA Intensifies Its Crackdown on Pesticides Covered by Delaney. Chem. Week, v. 154. No. 14, 1994, p. 9.

[2]Brown, D. Science Nutriation: Lack of Simmple Element Puts Millions at Risk. The Washington Post. Mar. 13, 1994, p. A3.

[3]Santos, W. Oils, Fats & Waxes: Tall Oil Rosin Hikes Spur Price Movement for Resins. Chem. Mark. Rep., v. 246, No. 26, 1994, p. 10.

[4]Written communication with M. Angela Ludena, Marketing Analyst. Available by request from Pacific Scientific, 1800 Highland Avenue, Duarte, CA 91010.

[5]Work cited in footnote 3.

[6]Chemical Marketing Reporter. Iodine Makers are Satisfied With Pricing. V. 247, No. 12, 1994, pp. 5, 18.

[7]Crozier, R. D. Chile. Mining Annual Review 1994 (London). June 1994, p. 80.

[8]Written Communication available from Tamaya Chemical Corp. 1062 Laskin Road, Virginia Beach, VA 23451

[9]Phosphorus & Potassium. DSM/Haifa Plan Nitrates Plant in Chile. No. 194, 1994, p. 4.

[10]Chemical Week. Projects: Chilean Nitrate Project Proceeds. V. 156, No. 1, 1994, p. 26.

[11]Work cited in footnote 7.

[12]Industrial Minerals (London). Mineral Notes: Russian Iodine Project Out to Tender. No. 323. 1994, p. 49

[13]Bounds, W. Technology: Photography Companies Hope People Smile Over "Smart Film." Wall St. J. V. 264, No. 16, 1994. pp. B1, B7.

[14]Zurer, P. Iodine May Be a Missing Link in Ozone Depletion. V. 72, No. 46, 1994, p. 8,9

[15]Baum, R. Chemists Create Family of "Molecular Squares" Based on Iodine or Metals. Chem. & Eng. News, v. 73, No. 7, 1995, pp. 37, 38.

[16]———."Smart" Catalyst Self Assembles, Self-repairs. Chem. & Eng. News. V. 73, No. 5, 1995, p. 7.

[17]NASA Tech Briefs. Furnace Tubes for Depositing Parylene-N on HgI_2 crystals. V. 18, No. 11, 1994, p. 105.

[18]Kraus, P. Silver Consumption in the Photographic Industry. BuMines OFR 76-92, 1992, 71 pp.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Iodine. Ch. in Mineral Facts and Problems, 1985.

Iodine. Ch. in Minerals Yearbook, annual.

TABLE 1
SALIENT IODINE STATISTICS 1/

(Thousand kilograms and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Production	1,970	2,000	2,000	1,940	1,630
Imports for consumption 2/	3,170	3,560	3,750	3,620	4,390
Exports 2/	2,100	1,320	1,810	1,220	1,250
Consumption: 3/					
Apparent	3,040	4,330	3,930	4,330	4,770
Reported	3,100	3,200	3,400	3,550	3,600
Price, average c.i.f. value, dollars per kilogram	$13.78	$10.16	$9.03	$7.98	$8.02
World: Production	16,000 r/	17,300 r/	16,500 r/	15,700 r/	14,800 e/

e/ Estimated. r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.
2/ Bureau of the Census.
3/ Calculated by production plus imports minus exports.

TABLE 2
U.S. CONSUMPTION OF CRUDE IODINE, BY PRODUCT 1/

Product	1993		1994	
	Number of plants	Consumption (thousand kilograms)	Number of plants	Consumption (thousand kilograms)
Reported consumption:				
Resublimed iodine	8	170	9	205
Hydriodic acid	3	289	3	30
Calcium iodate	(2/)	(2/)	2	94
Calcium iodide	3	121	--	--
Cuprous iodide	3	81	3	79
Potassium iodide	5	650	8	668
Potassium iodate	3	49	3	40
Sodium iodide	4	62	6	93
Other inorganic compounds	9	525	10	664
Ethylenediamine dihydroiodide	3	654	3	671
Povidone iodine	3	361	--	--
Other organic compounds	7	585	7	1,060
Total	27 3/	3,550	25 3/	3,600
Apparent consumption	XX	4,330 r/	XX	4,770

r/ Revised. XX Not applicable.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown
2/ Included with calcium iodide.
3/ Nonadditive total because some plants produce more than one product.

TABLE 3
YEAREND 1994 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	30.00	13.61
Iodine, crude, drums	9.00-10.00	4.08-4.54
Potassium iodide, U.S.P., drums, 5,000-pound lots, delivered	26.48	12.01
Iodine, U.S.P.	37.48	17.00
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. 247, No. 1, Jan. 2, 1995, pp. 27-32.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF CRUDE IODINE, BY TYPE AND COUNTRY 1/

(Thousand kilograms and thousand dollars)

	1993		1994	
Country	Quantity	Value 2/	Quantity	Value 2/
Iodine, crude:				
Canada	--	--	3	52
Chile	1,620	13,000	1,560	12,200
Germany	--	--	7	262
Russia	--	--	18	130
Japan	1,880	14,700	2,670	19,800
Total	3,500	27,700	4,260	32,400
Iodide, potassium:				
Brazil	--	--	3	11
Canada	17	184	45	437
Chile	14	123	13	133
India	49	452	14	123
Italy	--	--	7	29
Japan	34	238	52	422
Total	114	997	134	1,160
Grand total	3,620	28,700	4,390	33,600

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Declared c.i.f. valuation.

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 1/

(Thousand kilograms and thousand dollars)

Country	1993		1994	
	Quantity	Value 2/	Quantity	Value 2/
Iodine, crude/resublimed:				
Brazil	--	--	19	153
Canada	28	312	80	736
Costa Rica	--	--	1	86
Egypt	--	--	2	25
Germany	573	5,080	518	3,770
Ghana	--	--	3	58
India	--	--	17	123
Italy	--	--	1	14
Jamaica	--	--	8	18
Mexico	380	2,870	491	3,920
Netherlands	--	--	2	45
Philippines	16	33	--	--
Saudi Arabia	--	--	9	6
Turkey	--	--	1	22
United Kingdom	--	--	11	69
Other 3/	19	269	1	26
Total	1,020	8,560	1,160	9,070
Iodide, potassium:				
Australia	--	--	3	55
Belgium	--	--	19	185
Canada	23	360	29	450
China	148	479	--	--
Germany	5	50	--	--
Mexico	--	--	3	61
Panama	--	--	2	6
Thailand	--	--	19	45
Turkey	14	186	15	173
Other 4/	13	103	(5/)	15
Total	203	1,180	90	990
Grand total	1,220	9,740	1,250	10,100

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Declared f.a.s. valuation.
3/ Includes Australia, The Bahamas (1993), Colombia, Ghana (1993), Italy (1993), Peru (1993), and Sweden.
4/ Includes Chile (1993), Colombia, Hong Kong, The Republic of Korea (1993), Peru, Saudi Arabia (1993), and Spain.
5/ Less than 1/2 unit.

Source: Bureau of the Census.

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

(Thousand kilograms)

Country	1990	1991	1992	1993	1994 e/
Azerbaijan e/	XX	XX	600	500 r/	400
Chile	3,980 r/	5,450 r/	5,840 r/	5,550 e/	5,600
China e/	500	500	500	500	500
Indonesia	60	36	35 e/	14 r/	15
Japan	7,580	7,490	6,760	6,490 r/	6,400
Russia e/	XX	XX	200	180 r/	160
Turkmenistan e/	XX	XX	600	500 r/	251
U.S.S.R. e/ 3/	1,900	1800	XX	XX	XX
United States	1,970	2,000	2,000	1940	1,430
Total	16,000 r/	17,300 r/	16,500 r/	15,700 r/	14,800

e/ Estimated. r/ Revised. XX Not applicable.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Table includes data available through June 9, 1995.
3/ Dissolved in Dec. 1991.