

Iodine production and industrial applications

Katja Hora World Iodine Association (WIA)

Leading manufacturers, formulators, and distributors of iodine recently established the World Iodine Association (WIA), whose role is to promote the use of iodine and provide relevant and accurate information about its applications and benefits. The WIA members involved in the production of iodine and its derivatives (Iofina, Calibre Chemicals, SQM, and Ajay-SQM Group) explain where iodine comes from and where it is used.

1. How common is iodine in nature?

No less than 99.6% of the earth's mass can be accounted for by only thirty-two chemical elements, and the remaining 0.4% is apportioned among sixty-four elements in trace quantities. Iodine is number 61 on this list, making it one of the least abundant non-metallic elements in earth's composition. Although not abundant in quantity, iodine is distributed almost everywhere. It is present in rocks, soils, waters, plants, animal tissues, and our daily food. Seawater contains the world's largest iodine reserve (approx. 34.5 million tons), but its direct extraction is not economically feasible because of its extremely low concentration: less than 0.05 ppm. Organisms that naturally accumulate iodine include seaweeds, sponges, and corals. Arable soils vary in iodine content, but it is generally low, with a global average of 3 ppm.

TABLE 1 Iodine sources and concentrations

Origin	Chemical form	Typical concentration
Underground brines	Sodium iodide: NaI	30–150 ppm
Caliche ore	Calcium iodate: (CaI03)2	400 ppm

TABLE 2 Estimated iodine reserves per region

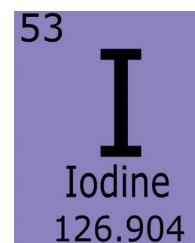
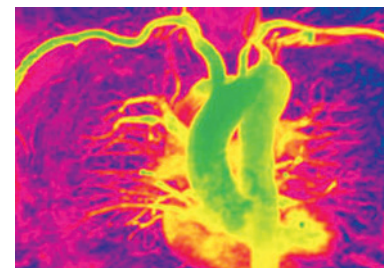
Origin	Region	Reserves x 1000 ton
Underground brines	Japan	5,000
	USA	250
	Indonesia	100
	Turkmenistan, Azerbaijan, Russia	360
	Caliche ore	Chile
Seaweed	China	4
Total estimated reserves		7,514

Source: 2016 USGS Mineral Commodity Summary

2. Where does most iodine come from?

Due to unique events in geological history, iodine is found in higher concentrations in mineral deposits in underground brines and in caliche ore (Table 1). It is from these deposits that iodine is extracted for production. The global demand for iodine is on the rise and currently exceeds 33 thousand metric tons per year. The bulk of iodine for production (>95% of the demand) is derived from brines in Japan, USA, Turkmenistan, Azerbaijan, Indonesia, and from caliche ore in Chile.

In Chile, iodine is produced from caliche ore found in the Atacama Desert in northern Chile and west of the Andes Mountains. Most current commercial production of iodine in the United States comes from deep well brines in northern Oklahoma. Japan's iodine is found in brines associated with gas wells. Production in Azerbaijan and Turkmenistan is not associated with oil extraction; their wells have been drilled specifically for brine to produce iodine. Iran is also reported to produce iodine from brine. In Indonesia, iodine brine deposits are located in Mojokerto, East Java, but production is limited and mainly consumed domestically (Table 2).



A scan made with the help of x-ray contrast media and potassium iodide tablets (100 mg I) to protect the thyroid during nuclear accidents.

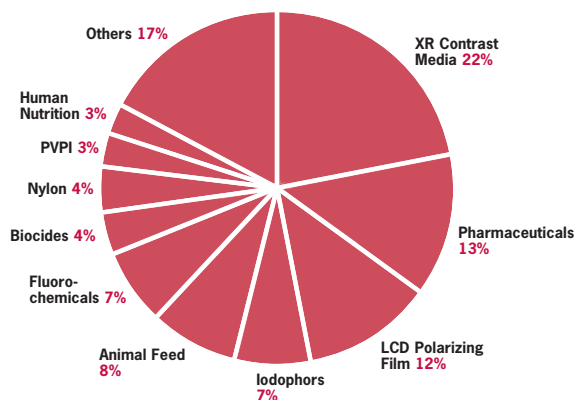
3. Will we ever run out of iodine?

It is estimated that the existing global reserves of iodine will support iodine production for at least the next two centuries. Their lifespan is likely to be further extended by developments in production efficiency and iodine recycling from industrial uses. Japanese iodine producers play a major role



Transport of caliche ore from its mining site

FIGURE 1 Global estimated demand for iodine in 2016 according to its application



in iodine recycling, leading in iodine recovery worldwide. Other producers of iodine and iodine derivatives in Europe, India, and America are active recyclers as well. Around 6 thousand metric tons of iodine are being recycled annually and sold back to the merchant market as fresh product, mostly to the same companies which originated the recyclable iodine stream. This amount corresponds to approximately 18% of the total world iodine demand and is additional to the iodine recovered and recycled internally by many industrial users. The main drivers of recycling include savings in costs as well as environmental and regulatory considerations.

4. What are the most common uses of iodine?

Only around 3% of the global iodine production is destined for human consumption. As an animal feed additive, iodine is only slightly more in demand, at 8%. In addition to nutrition products, iodine and iodine derivatives are used in a wide range of medical, agricultural, and industrial applications. The leading application is in the production of X-ray contrast media (22%) (Figure 1). Iodine's high atomic number and density make it ideally suited for this application, as its presence in the body can help to increase contrast between tissues, organs, and blood vessels with similar X-ray densities. Another application driving the demand for iodine is in polarizing film in liquid-crystal display (LCD) screens, where iodine is incorporated as polyiodide (I_3^- or I_5^-). Potassium iodide is used in iodine tablets to be taken during nuclear accidents to protect the thyroid against exposure to radioactive

iodine. Iodine based biocides are often used in paints as an in-can preservative as well as to prevent mold growth after application. Other applications include pharmaceuticals, disinfectant iodophors and povidone-iodine, fluoride derivatives, heat stabilization of nylon, or as process enabler in polymerization of plastics or other processes requiring chemical synthesis.

5. What are the different types of iodine derivatives?

Most iodine producers deliver their product on the market as solid, prilled, elemental iodine (I_2), which is then used to produce a wide range of organic and inorganic derivatives.

Inorganic derivatives

Typically iodine is introduced into the human food chain as an inorganic compound: iodide or iodate of potassium, calcium or sodium. Iodides range from completely ionic structures, like potassium iodide, to covalent structures such as titanium tetraiodide. They are produced by reduction of iodine.

Iodates are stable at room temperature, but they lose oxygen on heating. Iodates can be prepared by strong oxidation of iodine to iodic acid, followed by neutralization with an oxide or hydroxide or by electrolytic oxidation of an iodide solution.

Organic derivatives

Iodine-containing organic compounds include a wide range of aliphatic or aromatic iodine derivatives. Compounds such as ethyl- or methyl iodide and hydriodic acid are used in organic chemistry or for

pharmaceutical purposes. Ethylenediamine dihydroiodide (EDDI) is used as an additive in pet food and cattle feed with high bio-availability.

Sources

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Kaiho T. Iodine Chemistry and Applications John Wiley & Sons, 2014; 656 pp

2016 USGS Mineral Commodity Summary Iodine statistics and information <http://minerals.usgs.gov/minerals/pubs/commodity/iodine/>



Katja Hora (PhD) is a member of the WIA Technical Committee in the Scientific Advisory Board. Katja's scientific interest is optimization of crop production. She is Research Manager for SQM Europe N.V., working on the development of Specialty Plant Nutrition.

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