Health Physics Society

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Polonium-210 Information Sheet

General

Polonium is a radioactive element that occurs naturally in very low concentrations in the earth's crust. Marie and Pierre Curie discovered polonium in 1898 while they were seeking the cause of the radioactivity of pitchblende ore that contained uranium.

Polonium in its pure form is a low-melting, fairly volatile metal. Over 25 isotopes of polonium are known, with atomic masses ranging from 192 to 218 (isotopes are different forms of an element that have the same number of protons in the nucleus but a different number of neutrons).

All polonium isotopes are radioactive, but most are very short lived and decay rapidly. Only three polonium isotopes last for any appreciable amount of time. Put another way, they have relatively long half-lives. Those isotopes are polonium-208, polonium-209, and polonium-210. Polonium-210 is the predominant naturally occurring isotope of polonium and the one most widely used.

Polonium-210 has a half-life of 138 days, and it decays to stable lead-206 by emitting an alpha particle (an alpha particle has two protons and two neutrons). With a specific activity of 166 TBq/g, it would take about a microgram to deliver a 50 Gy (5,000 rad) whole-body radiation dose. The quantity of polonium-210 that the International Atomic Energy Agency (IAEA) regards as dangerous if uncontrolled is 60 GBq (1.6 Ci) or 0.3 milligrams.

Origins

Polonium-210 exists naturally; there are tiny amounts in our bodies and small quantities in the soil and air. Although it can be produced by the chemical processing of uranium ores or minerals, uranium ores contain less than 0.1 milligram of polonium-210 per ton.

Polonium-210 is usually produced artificially in a nuclear reactor by bombarding bismuth-209 (a stable isotope) with neutrons. This forms radioactive bismuth-210, which has a half-life of five days. Bismuth-210 decays to polonium-210 through beta decay. Milligram amounts of polonium-210 have been produced by this method. The longer-lived isotopes polonium-209 (half-life 103 years) and polonium-208 (half-life 2.9 years) are also produced in reactors or particle accelerators, but this is very expensive.

Uses

Polonium-210 is used mainly in static eliminators, which are devices designed to eliminate static electricity in machinery where it can be caused by processes such as paper rolling, manufacturing sheet plastics, and spinning synthetic fibers. The polonium-210 is generally electroplated onto a backing foil and inserted into a brush, tube, or other holder. Alpha particles from the polonium ionize adjacent air, and the air ions then neutralize static electricity on the surfaces in contact with the air.

The Health Physics Society is a nonprofit scientific professional organization whose mission is excellence in the science and practice of radiation safety. Formed in 1956, the Society has approximately 5,500 scientists, physicians, engineers, lawyers, and other professionals. Activities include encouraging research in radiation science, developing standards, and disseminating radiation safety information. The Society may be contacted at 1313 Dolley Madison Blvd., Suite 402, McLean, VA 22101; phone: 703-790-1745; fax: 703-790-2672; email: HPS@BurkInc.com. The Society's Media Liaison can be contacted at 507-284-4407 (office) or 507-254-8444 (cell); email: media@hps.org.

Polonium-210 is also used in brushes to remove dust from photographic films and camera lenses. Static eliminators typically contain from one to tens of GBq (hundreths to tenths of curies) of radioactivity. Polonium-210 can also be combined with beryllium to produce neutron sources. Other alpha emitters are occasionally, but not frequently, used in medicine and academic research.

Health Effects

Polonium-210 is a health hazard only if it is taken into the body. External exposure is not a concern because polonium is an alpha emitter. Alpha emitters can be very biologically effective internally but are hardly able to pass through a few centimeters of air outside the body.

Polonium can be taken into the body through eating, drinking, or breathing. Between 50 percent and 90 percent of the polonium taken in by ingestion will promptly appear in the gastrointestinal (GI) tract and leave the body in feces. The fraction remaining in the body enters the bloodstream and will decrease with a half-life of 50 days. Substantial radiation doses from polonium can be expected in many tissues of the body; it supplies a more nearly whole-body dose than almost all other alpha emitters. In general, the spleen and kidneys concentrate polonium more than other tissues except for temporary deposition in the lung after inhalation of an insoluble form. Effects are more common in the kidney than the spleen, despite a higher dose in the spleen. It is estimated that approximately 45 percent of ingested polonium will be deposited in the spleen, kidneys, and liver, with 10 percent deposited in bone marrow and the remainder distributed throughout the body, including in the lymph nodes and on the mucous lining of the respiratory tract.

Alpha particles emitted from polonium-210 can disrupt cell structures, fragment nuclei, damage DNA, and cause cell death. When administered in relatively “large” amounts—such as a microgram or two—it can cause high radiation doses of approximately 12.5 Gy (1,250 rad) per microgram.

With ingestion of several micrograms of polonium-210, GI symptoms begin to appear within a day or so. GI symptoms will mimic food poisoning—nausea, diarrhea, vomiting, and general tiredness. This is followed by a “latent” phase and then a further decline, including the loss of all hair and a massive depletion in white blood cells.

Bone marrow depression will occur with a 5 Gy (500 rad) whole-body single radiation dose. The intestinal lining has rapidly proliferating cells which are sensitive to radiation—GI syndrome will occur with acute doses of 5-15 Gy (500-1,500 rad), and necrosis and ulcerations will occur at 40-50 Gy (4,000-5,000 rad). Within the lining of the GI tract, the alpha particles will irradiate the mucosa; this will cause sloughing of the disrupted cells and will affect the inner lining, leading to GI bleeding.

Polonium-210 inside someone’s body is not detectable with standard radiation instrumentation used outside that person’s body. Testing the individual’s urine or feces for alpha radiation would be the method of detection. For someone to be poisoned with polonium-210, a big radiation dose would be needed—a dose not possible with naturally occurring polonium-210, but possible with man-made polonium-210.

A median survival time of 20 days has been associated with a median dose of about 1.6 MBq (0.04 mCi; 0.0096 micrograms) per kilogram of polonium-210. For a 70-kilogram person, this would only be about 111 MBq (3 mCi; about 0.7 microgram).

Isotope	**Half-Life**	**Specific Activity (TBq/g)**	**Decay Mode**	**Alpha (α) Energy (MeV)**
Polonium-208	2.9 yr	21.8	α	5.1
Polonium-209	103 yr	0.63	α	4.9
Polonium-210	138 days	166	α	5.3

g = gram, and MeV = million electron volts;

Glossary

Alpha Particle

A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and an electric charge of +2. It has low penetrating power and a short range (a few centimeters in air). The most energetic alpha particle will generally fail to penetrate the dead layers of cells covering the skin and can be easily stopped by a sheet of paper. Alpha particles represent much more of a health risk when emitted by radionuclides deposited inside the body.

Bq or Becquerel

The unit of radioactive decay equal to one disintegration per second. The becquerel is the basic unit of radioactivity used in the international system of radiation units, referred to as the “SI” units. Thirty-seven billion (3.7×10^{10}) becquerels = 1 curie (Ci). (A megabecquerel or MBq is 10^6 Bq. A gigabecquerel or GBq is 10^9 Bq. A terabecquerel or TBq is 10^{12} Bq.) (1 millicurie or 1,000 microcuries equals 37 MBq.)

Curie or Ci

The original unit used to express the decay rate of a sample of radioactive material. The curie is equal to that quantity of radioactive material in which the number of atoms decaying per second is equal to 37 billion (3.7×10^{10}). It was based on the rate of decay of atoms within one gram of radium. It is named for Marie and Pierre Curie, who discovered radium in 1898. The curie is the basic unit of radioactivity used in the system of radiation units in the United States, referred to as “traditional” units.

DNA

Deoxyribonucleic acid (DNA) is a nucleic acid that contains the genetic instructions for the biological development of a cellular form of life or a virus. All known cellular life and some viruses have DNA. DNA is a long polymer of nucleotides (a polynucleotide) that encodes the sequence of amino acid residues in proteins, using the genetic code.

Dose

A general term used to refer to the effect on a material that is exposed to radiation. It is used to refer either to the amount of energy absorbed by a material exposed to radiation (absorbed dose) or to the potential biological effect in tissue exposed to radiation (equivalent dose).

Geiger-Mueller Counter

A radiation detection and measuring instrument. It consists of a gas-filled tube containing electrodes, between which there is an electrical voltage, but no current flowing. When ionizing radiation passes through and ionizes the gas within the tube a short, intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses per second is an indication of the rate at which ionizing events are occurring within the tube. The Geiger-Mueller counter was named for Hans Geiger and W. Mueller, who invented it in the 1920s. Sometimes called simply a Geiger counter or a G-M counter, it is the most commonly used portable radiation instrument.

Gy or Gray:

The international system (SI) unit of radiation dose in terms of absorbed energy per unit mass of tissue. The gray is the unit of absorbed dose and has replaced the rad. 1 gray = 1 Joule/kilogram and also equals 100 rad.

Half-Life

The time in which one-half of the activity of a particular radioactive substance is lost due to radioactive decay. Measured half-lives vary from millionths of a second to billions of years. Also called physical or radiological half-life. The biological half-life is the time required for the body to eliminate, by biological processes, one-half of the material originally taken in. The effective half-life is the time required for the combined action of the physical and biological half-lives to reduce the activity by 50 percent.

Radioactive Decay

The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation.

Radiation Dose Comparisons

The radiation doses described in this document include:

"With a specific activity of 166 TBq/g, it would take only approximately 4 micrograms to deliver a **50 Gy (5,000 rad)** whole-body radiation dose."

"Bone marrow depression will occur with a **5 Gy (500 rad)** whole body-single radiation dose."

"The intestinal lining has rapidly proliferating cells which are sensitive to radiation—GI syndrome will occur with acute doses of **5-15 Gy (500-1,500 rad),** and necrosis and ulcerations will occur at **40-50 Gy (4,000-5,000 rad)**."

Average radiation doses delivered to patients undergoing common medical procedures range in dose from fractions of a Gy to hundreths of a Gy (roughly 0.01 rad to a few rad)

Average annual individual background radiation dose = 0.0036 Sv (0.36 rem or 360 mrem)