Health Physics Society
Specialists in Radiation Safety

Fact Sheet
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Polonium-210

General

Polonium is a radioactive substance that can be found throughout our natural environment. Polonium was discovered in the late 1800s when Marie and Pierre Curie were trying to determine why something they were studying was still radioactive even after they had extracted some of the radioactive contents.

When it is purified, polonium melts at a low temperature and can be volatile. There are different types of polonium due to a varying number of neutrons in the nucleus of the isotopes. We are aware of 25 isotopes of polonium; polonium-210 is one of them.

The polonium isotopes that are known are radioactive, but most are very short-lived and decay rapidly. Of the 25 known isotopes, there are three that have longer half-lives. Those isotopes are polonium-208, polonium-209, and polonium-210. The most widely used and the one occurring most in nature is polonium-210.

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 T*Bq*/g, one microgram of ingested polonium would deliver a *committed effective dose equivalent* of approximately 40 *Sv* (4,000 rem). This value is based on human and animal studies conducted in the 1950s that showed that approximately 10 percent of ingested polonium is absorbed by blood (Harrison et al. 2007).

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.

Although it exists naturally, to generate useful quantities polonium-210 needs to be made in a nuclear reactor by bombarding a stable product with neutrons. The stable product becomes radioactive and decays according to a certain half-life, and polonium-210 is left. This method can produce gram amounts of polonium-210.

Uses

Polonium-210 has many uses, but is most well known for its use in static eliminators. These devices, which have a very small amount of the radioactive material mixed in a matrix and put on a foil, are used in manufacturing environments to get rid of static that can be generated by routine processes like making tape, rolling paper, and smoothing metals. It can also be used to remove dust particles in environments that need to be "clean," like computer-chip manufacturing and photographic-film processing.

Static eliminators typically range from a few MBq (hundreds of *microcuries*) of radioactivity to tens of GBq (tenths of *curies*) for certain industrial applications. Polonium-210 can also be combined with beryllium to produce neutron sources.

Health Effects

If a source of polonium-210 is outside of the body, it is not a health hazard. It can be a health hazard if it is taken inside the body. The alpha particles emitted by polonium-210 do not travel far and deposit their energy in a very small area. This is why they cannot penetrate the layer of skin on our bodies, but do damage internal structures by killing or injuring nearby cells.

The most common ways to get radioactivity, including polonium-210, inside the body are by eating it, breathing it, or drinking it. If polonium is taken orally (by

*Words in italics are defined in the Glossary on page 3.

mouth), excretion is largely via the feces (Stannard 1988). What is left will travel throughout the body via the bloodstream, with much of it finally ending up in the spleen and kidneys.

If polonium is inhaled, some of it will stay in the lungs. Almost half of the polonium that stays in the body can be found in the spleen, kidneys, and liver. A small portion will go to the bone marrow while the rest is distributed throughout the body, mainly in the blood, 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.

The extent of biological damage caused from alpha emitters like polonium-210 in the gastrointestinal (GI) tract is not well known. Some data gathered from animal studies during the 1960s indicated that alpha emitters actually deliver less *dose* to the mucosal lining per Bq than beta or gamma emitters. This may be due to the short range of the alpha particle.

As food traverses through the GI tract, it moves through by muscular contractions in clusters that are referred to as a bolus of food. As a bolus containing alpha emitters traverses the GI tract, only alphas that are on the edge of the bolus are close enough to the epithelial cells of the GI tract to result in radiation dose to the intestinal lining.

Bone marrow depression will occur with 5 *Gy* (500 rad) whole-body single radiation dose and is likely to be the principal biological effect for acutely lethal intakes.

Polonium-210 inside someone's body is not detectable with standard radiation survey instruments 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 large radiation dose would be needed—a dose not possible with naturally occurring polonium-210, but possible with man-made polonium-210.

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 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.)

Ci or Curie

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 is 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. A *microcurie* is 10^{-6} curie.

Committed Effective Dose Equivalent (CEDE)

CEDE is the sum of the radiation dose to each of the body organs or tissues, considering their sensitivity to radiation, that is received from an intake of radioactive material by an individual during the 50-year period following the intake.

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 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).

Gy or Gray

The International System of Units (SI) unit of radiation absorbed dose in terms of energy deposited per unit mass of material, e.g., 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

Also called physical or radiological 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. 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.

Sv or Sievert

The International System of Units (SI) unit for dose equivalent equal to 1 joule/kilogram. The sievert has replaced the rem; one sievert is equal to 100 rem.

Radiation Dose Comparisons

Listed below are radiation doses from common life activities, medical procedures, and types of radiation exposure that can cause acute (prompt) effects.

Item	***Dose (Gy)***	***Dose (mrad)***
Flying Roundtrip from New York to California	*0.00005*	*5*
Chest X Ray	*0.00010*	*10*
One-View Abdominal X Ray	*0.0006*	*60*
Average Annual Background Radiation Dose	*0.0036*	*360*
Abdominal CT Scan	*0.01*	*1,000*
NRC Occupational Worker Annual Limit	*0.05*	*5,000*
Acute Dose Causing Decreased White Blood Cell Count	*1*	*~ 100,000*
Lethal Dose to 50 Percent of the Exposed Individuals Without Medical Intervention ($LD_{50/60}$)	*4.5*	*~ 450,000*

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Resources for more information

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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.