Health Physics Society
Fact Sheet
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Health Physics Society
Specialists in Radiation Safety

Polonium-210

General

In 1898, Marie and Pierre Curie discovered their first *radioactive*[*] element. It was later named polonium in honor of Marie Sklodowska Curie's native Poland. Polonium, a naturally occurring element that can be found throughout our environment, results from the *radioactive decay* of radon-222 gas—a part of the uranium-238 decay chain. There are over 30 known *isotopes* of polonium, and all are radioactive, but the one occurring most in nature—and the one most widely used—is polonium-210 (^{210}Po). With a *half-life* of 138 days, it decays to stable lead-206 by the emission of an *alpha particle* (an alpha particle has two protons and two neutrons).

Radioactive materials are quantified by activity, or the number of disintegrations that occur over a period of time. A *terabecquerel* (TBq), for instance, is equal to 1 x 10^{12} disintegrations per second. Polonium-210 has a very high *specific activity*—activity per unit mass—of about 166 TBq per gram (4,490 *curies*, *Ci*, per gram). In other words, it doesn't take a large physical amount to be very radioactive. Because of the high specific activity and the large associated thermal cross section, according to a human health fact sheet for ^{210}Po produced by Argonne National Laboratory, a capsule containing about 0.5 grams (83 TBq) of ^{210}Po can reach temperatures exceeding 500° C (ANL 2005). When it is purified, polonium melts at a low temperature and can be quite volatile.

Origins

Polonium-210 exists throughout our environment, from the air that we breathe to the foods that we eat. There are tiny amounts in our bodies and small quantities in the soil and air. Deposition of ^{210}Po onto the broad leaves of the tobacco plant results in an elevated concentration of ^{210}Po in tobacco smoke, therefore resulting in a higher internal radiation *dose* directly to the lungs for smokers vs. nonsmokers.

Although it can be produced by the chemical processing of uranium ores or minerals, uranium ores contain less than 0.1 mg of ^{210}Po per ton. According to the Nuclear Regulatory Commission, ^{210}Po can be produced in milligram amounts in nuclear reactors, and only about 100 grams is believed to be produced each year (NRC 2019). This is accomplished by bombarding stable bismuth-209 with neutrons in the reactor, creating bismuth-210 (^{210}Bi). The radioactive ^{210}Bi decays with a half-life of five days to ^{210}Po via the emission of a *beta particle*.

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. The activities associated with static eliminators typically range from a few MBq of radioactivity to tens of GBq for certain industrial applications. Due to the relatively short half-life of ^{210}Po, they have to be

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

replaced periodically. In addition to industrial static eliminators, ^{210}Po is also used to reduce static electricity and facilitate the removal of dust from objects such as camera lenses or vinyl records.

Polonium-210 has had other uses, as well. It has been used as the heat source for radioisotope thermal generators and can also be combined with beryllium to produce neutron sources. However, other materials more suitable to these applications have taken its place.

Health Effects

Polonium-210 entered the modern public's consciousness in 2006 with the poisoning of Alexander Litvinenko. For someone to be poisoned with ^{210}Po, a large radiation dose would be needed. John Harrison and colleagues estimated Litvinenko ingested about 4 GBq of ^{210}Po, which delivered a dose in the range of 20 *gray, Gy*, to 100 Gy (Harrison et al. 2017). It's not possible to get this quantity from naturally occurring means. However, industrialized ^{210}Po production methods are capable of producing the necessary amount to deliver a fatal radiation dose.

Static eliminator: polonium-210 on bar at the base of the brush. Notice the results of the alpha interactions on the lid of the box after close and continuous exposure.
Photo courtesy of Steve Sugarman

Alpha particles travel only a very short distance in air and cannot penetrate the skin. Therefore, alpha-emitting materials such as ^{210}Po do not pose an external radiation hazard. The most common ways to get radioactive materials, including ^{210}Po, inside the body are by ingestion or inhalation. Once inside the body, the alpha particles emitted from the internalized ^{210}Po can disrupt cell structures, fragment nuclei, damage *DNA*, and cause cell death. Unlike most alpha-emitters, the internal dose delivered by ^{210}Po is more of a whole-body dose than dose to one specific organ or tissue. The dose to the spleen can be quite high. Doses to the kidney, liver, and lymph nodes may also be of concern since almost half of the polonium that stays in the body can be found in those organs/tissues. Effects to all of these organs should be considered, with particular attention paid to potential kidney effects.

If ingestion of polonium occurs, 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 previously mentioned organs and tissues. The extent of biological damage caused from alpha emitters like ^{210}Po 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 an alpha-emitter such as ^{210}Po 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.

If polonium is inhaled, it is deposited on the mucosal lining along the respiratory tract. Some of it will deposit and stay in the lungs. This results in a dose to the cells of the lungs, potentially causing damage resulting in an increased risk for lung cancer or other diseases. Some of the inhaled material will be trapped and removed from the respiratory tract via mucociliary clearance (that is, the coughing up and swallowing of phlegm) into the digestive tract.

Detection

Because ^{210}Po is an almost pure alpha emitter, deposition of ^{210}Po inside someone's body is not detectable with standard radiation survey instruments and is quite difficult to detect with more sensitive detectors such as those used for whole-body or lung counting. Testing the individual's urine or feces for alpha radiation would be the preferred method of detection and can only be done in specialized laboratories.

Glossary

Alpha Particle

A positively charged particle ejected spontaneously from the nucleus 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.

Beta Particle

A type of radiation, identical to an electron, emitted from the nucleus of an atom during the process of radioactive beta decay.

Becquerel or Bq

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.)

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 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.

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).

Gray or Gy

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

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%.

Isotope

A form of a chemical element that has a different number of neutrons. Carbon-12 and carbon-14 are two isotopes of carbon and each has 6 protons, but carbon-12 has 6 neutrons and carbon-14 has 8 neutrons.

Radioactive

A property of material that tends to undergo spontaneous decay resulting in the emission of ionizing radiation.

Radioactive Decay
The process by which an unstable atomic nucleus emits radiation and transforms into a different element or into a lower-energy state of the same element.

Specific Activity
The radioactivity per unit mass of any sample of radioactive material.

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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 3,500 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 950 Herndon Parkway, Suite 450, Herndon, VA 20170; phone: 703-790-1745; fax: 703-790-2672; email: HPS@BurkInc.com.