PLUTONIUM

Overview

Plutonium (chemical symbol Pu) is a radioactive metal with Atomic Number 94. Plutonium is considered a man-made element, although scientists have found trace amounts of naturally occurring plutonium produced under highly unusual geologic circumstances. The most common radioisotopes of plutonium are plutonium-238, plutonium-239, and plutonium-240.

Chemical Description

Plutonium is a rare transuranic radioactive chemical element. It is an actinide metal of silvery-white appearance that tarnishes when exposed to air, forming a dull coating when oxidized. Plutonium has at least 15 different isotopes, all of which are radioactive.

All isotopes of plutonium undergo radioactive decay. As plutonium decays, it releases radiation and forms other radioactive isotopes. For example, Pu-238 emits an alpha particle and becomes uranium-234; Pu-239 emits an alpha particle and becomes uranium-235. This process happens slowly since the half-lives of plutonium isotopes tend to be relatively long: Pu-238 has a half-life of 87.7 years; Pu-239 has a half-life is 24,100 years, and Pu-240 has a half-life of 6,560 years. The decay process continues until a stable, non-radioactive element is formed.

The most important isotope of plutonium is plutonium-239, with a half-life of 24,100 years. Plutonium-239 and 241 are fissile, meaning the nuclei of their atoms can break apart by being bombarded by slow moving thermal neutrons, releasing energy, gamma radiation and more neutrons. It can therefore sustain a nuclear chain reaction, leading to applications in nuclear weapons and nuclear reactors. The most stable isotope of plutonium is plutonium-244, with a half-life of about 80 million years, long enough to be

found in trace quantities in nature. Plutonium-238 has a half-life of 88 years and emits alpha particles. It is a heat source in radioisotope thermoelectric generators, which are used to power some spacecraft.

Production

Plutonium is created from uranium in nuclear reactors. When uranium-238 absorbs a neutron, it becomes uranium-239 which ultimately decays to plutonium-239. Different isotopes of uranium and different combinations of neutron absorptions and radioactive decay, create different isotopes of plutonium.

Some of the plutonium-239 in the fuel rods burns (fissions) along with uranium and helps produce heat, which is converted into electricity. As fission continues, the reaction products remain in the fuel pellets and absorb neutrons, slowing ("poisoning") the fission process. Finally, the ratio of poisons to fissional materials reaches a point at which the fuel is said to be "spent" and must be replaced. However, even spent fuel contains some plutonium.

In the US, the majority of plutonium was produced for nuclear weapons in several government reactors designed to maximize the production of plutonium. Between 1944 and 1988, the U.S. built and operated these "production reactors" at high-security government facilities. In all, the US produced about 100 metric tons of plutonium.

The reactors made plutonium by bombarding special fuel rods containing uranium with neutrons. Once the maximum amount of plutonium was produced, workers removed the fuel rods from the reactor. The spent fuel rods were extremely radioactive, and the process for recovering the plutonium used only remote-controlled equipment. This processing left behind over 100 million gallons of exceedingly hazardous mixed wastes of acids and radioactive fission products.

Routes of Exposure and Metabolism

Residual plutonium from atmospheric nuclear weapons testing is dispersed widely in the environment. As a result, virtually everyone comes into contact with extremely small amounts of plutonium.

People who live near nuclear weapons production or testing sites may have increased exposure to plutonium, primarily through particles in the air, but possibly from water as well. Plants growing in contaminated soil can absorb small amounts of plutonium.

The stomach does not absorb plutonium very well, and most plutonium swallowed with food or water passes from the body through the feces. When inhaled, plutonium can remain in the lungs depending upon its particle size and how well the particular chemical form dissolves. The chemical forms that dissolve less easily may lodge in the lungs or move out with phlegm, and either be swallowed or spit out. But, the lungs may absorb chemical forms that dissolve more easily and pass them into the bloodstream.

Once in the bloodstream, plutonium moves throughout the body and into the bones, liver, or other body organs. Plutonium that reaches body organs generally stays in the body for decades and continues to expose the surrounding tissue to radiation.

Health Effects

People may inhale plutonium as a contaminant in dust. It can also be ingested with food or water. Most people have extremely low ingestion and inhalation of plutonium. However, people who live near government weapons production or testing facilities may have increased exposure.

Internal exposure to plutonium is an extremely serious health hazard. It generally stays in the body for decades, exposing organs and tissues to radiation, and increasing the risk of cancer. Plutonium is also a toxic metal, and may cause damage to the kidneys.

History

Element 94 was first synthesized in 1940 by a team led by Glenn T. Seaborg and Edwin McMillan at the University of California, Berkeley laboratory by bombarding uranium-238 with deuterons. McMillan named the new element after Pluto, and Seaborg suggested the symbol Pu as a joke. Trace amounts of plutonium were subsequently discovered in nature. Discovery of plutonium became a classified part of the Manhattan Project to develop an atomic bomb during World War II. The first nuclear test, "Trinity" (July 1945), and the second atomic bomb used to destroy a city (Nagasaki, Japan, in August 1945), "Fat Man", both had cores of plutonium-239. Human radiation experiments studying plutonium were conducted without informed consent, and a number of criticality

accidents, some lethal, occurred during and after the war. Disposal of plutonium waste from nuclear power plants and dismantled nuclear weapons built during the Cold War is a major nuclear-proliferation, health, and environmental concern.

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