Plutonium

(Pu)

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Fact Sheet 320-080

Division of Environmental Health
Office of Radiation Protection

WHO DISCOVERED PLUTONIUM?

Plutonium was first produced by Glenn T. Seaborg, Joseph W. Kennedy, Edward M. McMillan and Arthur C. Wohl by bombarding an isotope of uranium, uranium-238, with deuterons that had been accelerated in a device called a cyclotron. This created neptunium-238 and two free neutrons. Neptunium-238 has a half-life of 2.1 days and decays into plutonium -238 through beta decay. Although they conducted their work at the University of California in 1941, their discovery was not revealed to the rest of the scientific community until 1946 because of wartime security concerns.

Plutonium was the second transuranic element of the actinide series to be discovered. By far of greatest importance is the isotope ^{239}Pu, which has a half-life of more than 20,000 years. The complete detonation of a kilogram of plutonium produces an explosion equal to about 20,000 tons of chemical explosive. The isotope ^{238}Pu was used in the American Apollo lunar missions to power seismic and other equipment on the lunar surface.

WHAT IS PLUTONIUM USED FOR?

Only two of plutonium's isotopes, plutonium-238 and plutonium-239, have found uses outside of basic research. Plutonium-238 is used in radioisotope thermoelectric generators to provide electricity for space probes that venture too far from the sun to use solar power, such as the Cassini and Galileo probes. It also provides the electricity source in implanted cardiac pacemakers, space satellites, and navigation beacons.

Plutonium-239 will undergo a fission chain reaction if enough of it is concentrated in one place, so it is used at the heart of modern day nuclear weapons and as a fuel for some nuclear power plants. The United State does not currently operate nuclear power plants that use this type of fuel.

For weapons use, Pu-240 is considered a serious contaminant and it is not feasible to separate Pu-240 from Pu-239. An explosived device could be made from plutonium extracted from low burn-up enriched uranium fuel (i.e., if the fuel had only been used for a short time), from a nuclear power plant, but any significant proportion of Pu-240 in it would make it hazardous to the bomb makers, as well as unreliable and unpredictable.

WHERE DOES PLUTONIUM COME FROM AND WHERE IS IT FOUND?

Plutonium-238 is artificially produced by neutron bombardment. Plutonium-239 is a by-product of the fission process in nuclear reactors. When operating, a typical nuclear reactor contains within its uranium fuel load about 325 kilograms of plutonium, with plutonium-239 being the most common isotope. Plutonium is created when non-fissionable uranium (U-238) absorbs a neutron released by the fission process.

Through neutron capture, Pu-239 becomes Pu-240 (and then neutron capture Pu-241). Pu-241 was once found naturally, but due to the short half-life of ^{241}Pu (14 years) the original, naturally formed supply has not survived.

In addition to the great destructive power of fission bombs, highly radioactive fission byproducts are released into the atmosphere and spread over a wide area. Radioactive fallout in the form of fine particulate matter is particularly dangerous because it can be ingested, bringing alpha emitters into the body where they can do much more damage. Both U-238 and Pu-239 are found in the environment from weapons testing fallout.

IS PLUTONIUM HAZARDOUS?

There are three principal routes by which plutonium can reach human beings:

- Ingestion
- Contamination of Open Wounds
- Inhalation

Ingestion is not a significant hazard, because plutonium passing through the gastro-intestinal tract is poorly absorbed and is expelled from the body before it can do harm. Contamination of wounds has rarely occurred although thousands of people have worked with plutonium. Their health has been protected by the use of remote handling, protective clothing and extensive health monitoring procedures.

The main threat to humans comes from inhalation. While it is very difficult to create airborne dispersion of a heavy metal like plutonium, certain forms, including the insoluble plutonium oxide at a particle size less than 10 microns are a hazard. If inhaled, much of the material is immediately exhaled or is expelled by mucous flow from the bronchial system into the gastro-intestinal tract, as with any particulate matter.

Some however, will be trapped and readily transferred, first to the blood or lymph system and later to other parts of the body, notably the liver and bones. It is here that the deposited plutonium's alpha radiation may eventually cause cancer.

Plutonium is toxic if ingested but the problems associated with the toxicity of plutonium are no different in type from those presented by a whole range of heavy metals. There are other substances found in nature, which are more toxic than plutonium, and there are many well-known substances in everyday use that, like plutonium, that are very toxic if they are not handled properly.

Despite being toxic both chemically and radiologically, plutonium is far from being 'the most toxic substance on earth' or so hazardous that 'a speck can kill'.

PROPERTIES OF PLUTONIUM-238 (^{238}Pu)

Half-Life:

Physical: 87.7 years

Biological: Bone, 50 years; liver, 20 years; gonads, considered permanent

Principal Modes of Decay (MeV):

Alpha 5.50 (70.9%), 5.46 (29%)X

X-ray 0.0136 (11.7%)

Special Chemical and Biological Characteristics:

General forms are insoluble fluorides, hydroxides, and oxides. Solubility in water depends on redox, pH, and organic ligands present.

PROPERTIES OF PLUTONIUM-239 (^{239}Pu)

Half-Life:

Physical: 2.41×10^4 years

Biological: Bone, 50 years; liver, 20 years; gonads, considered permanent

Principal Modes of Decay (MeV):

Alpha 5.16 (73.3%)

Special Chemical and Biological Characteristics:

General forms are insoluble fluorides, hydroxides, and oxides. Solubility in water depends on redox, pH, and organic ligands present.

Amount of Element in Body:

Trace

Sources

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