History and proerties of plutonium

“ PU!” might be the first thing you hear when you skip taking a shower… Either that or your chemistry professor (and every chemistry professor ever) mentions plutonium and they believe it’s a real knee slapper. Despite its stinky reputation, Plutonium doesn’t have a foul smell. In fact, not many people have the opportunity to smell it. That’s because plutonium is so poisonous that if you inhaled it its radiation would have you dead, give you cancer, or both. So, sorry if you had to remove that from your bucket list.

In all seriousness though, plutonium holds a lot of interesting information as well as being a big part of history. Plutonium was named after the shunned dwarf planet Pluto back when it was considered the ninth planet in our solar system. The people who decided to name it just wanted to follow the previous scheme of Uranium, which was also named after a planet (Uranus). Nearly all of plutonium is man-made (technically a very, very, small amount exists naturally), and its discovery dates back to late 1940 at the University of California in Berkeley, CA. At this institution, three scientists by the name of Glenn T. Seaborg, Edwin McMillan, Joseph W. Kennedy, and Arthur Wahl isolated the newly found element for the first time in history. They did so by using a device called a cyclotron. A cyclotron is a really cool machine whose design is based on a special magnet to create an electromagnetic field. This magnetic field is used to hurl charged particles in a spiral at extremely fast speeds. The particle they used was called a Deuteron, and they collided it with Uranium-238, which created something else that went through beta decay and became Plutonium-238! Prior to this, though, the team of researchers were eager to publish their discovery to the public in 1941, but they were stopped when another isotope (Uranium-239) was found. That’s

because Uranium-239 was highly fissile, which means the atom is easily capable of splitting in a chain reaction by neutrons. Thus, during World War II, plutonium became the perfect candidate for trying to create an atomic bomb and had to be kept as a secret during the work of the Manhattan Project.

Not long after, production reactors were built to obtain more radioactive plutonium. Then in 1945, codenamed as the " Trinity," the scientists produced a big enough sample of plutonium to successfully test the first atomic bomb ever. This happened in a desert in New Mexico and it produced the energy (Joules) equivalent to about 20, 000 tons of TNT (that's 40 million pounds of TNT)! Later in 1945, Germany surrendered to the allied powers but Japan was in no mood to do the same. A few short months after, under President Truman, two more atomic bombs, Hiroshima and Nagasaki, were dropped on the respective cities of Japan. However, Nagasaki, which was also called " Fat Man," used a plutonium core whereas Hiroshima (or " Little Boy") used a uranium core. Nagasaki itself ended up killing 80, 000 people of Japan, and that's not even including the lethal radioactivity after the fact. It also produced a larger explosion or " mushroom cloud" than its son, Little Boy. Albert Einstein, one of the greatest minds ever, once said, " It is easier to denature [To take away or alter the natural qualities of] plutonium than to denature the evil spirit of man." Einstein commented on how humans were capable of turning a fascinating new element into a lethal weapon of mass destruction by manipulating its properties for their selfish and reckless benefits. Although he never directly participated in the Manhattan Project, he did (somewhat) indirectly let the project takeaway. Indeed, plutonium

has some grim history under its belt, but it really shows the potential of the element and its crazy but extraordinary properties.

Speaking of properties, we have not yet discussed the other physical and chemical properties of plutonium. Not many people have seen or wondered what it looks like. With atomic number 94 and a mass number of 244, the most common form of plutonium is a hard, brittle, silvery metal (like many metals) that loses its shimmer when exposed to the air through oxidation. As part of the actinide metals, plutonium shares its spot with 14 other elements on the Periodic Table, such as Uranium and Americium. Most of the actinides were synthetically made, but what they all share in common are their metallic appearances and nuclear instability that makes them highly reactive and optimal for nuclear reactions.

In addition, despite being a metal, plutonium is a poor conductor of electricity and heat. Plutonium is also very dense, varying from densities of 16. 00g/cm ^{3} to 19. 86g/cm ^{3} , depending on its allotrope. In fact, plutonium has up to seven different allotropes that come in a variety of structures. Nuclear Engineering International Magazine broke it down nicely, explaining, “ At room temperature plute is in its alpha phase, strong but very brittle, more like a ceramic than a metal, with a density of 19. 8g/cm3. Warm it to 112°C, and it flips to beta phase, 10% bulkier with a density of only 17. 8g/cm3. At 185°C it changes to gamma phase, expanding another 3. 5%. At 310°C it becomes delta phase, expanding another 7% to become ductile. Then at 450°C it changes to a variant of the delta phase, delta prime, and shrinks 0. 5%. Slightly hotter, 475°C, it changes again, to the epsilon phase, shrinking more dramatically by 3%,” (Fishlock, David). Relating to crystal

structures, plutonium is also one of the few substances whose density increases when melted.

Continuing on plutonium’s grim history, the United States actually performed numerous experiments on individuals during the World War II era. In 1942, because of how little was known of the element, the head-honchos of the Manhattan Project were responsible for the establishment of a health division that did these experiments on people to find out what kind of health effects plutonium has on the body. In 1944, Doctor Stafford Warren was hired as the Chief Medical Officer of the project. Initially, radiation experiments were performed on just workers within the Manhattan Project who were actually exposed to or working with the plutonium samples directly. Despite this, and some tests on animals as well, many scientists felt not enough data was being collected to fully understand the adverse effects of plutonium. Thus, with Warren’s leadership, he set into motion the idea that controlled experiments on people was ideal if not necessary. The plan consisted of subjects in multiple different hospitals around the country who were injected with plutonium. The goal was to determine its toxicity and how waste (urine and feces) can approximate the amount of the radioactive element in the body of the patient.

Approximately 30 people were subjected to these kind of tests. Besides the fact that researchers injected civilians with plutonium (knowing very well how dangerous it can be despite not being fully understood), all but one were unaware of the type of injections they were receiving and did not get any type of consent form. Even the one person documented to have signed a consent form was still misconstrued from the actual nature of the tests

anyway. Of course, the experiments were held under a high level of secrecy because of reasons such as the fear of nuclear war with Soviet Russia during the Cold War, as well as obvious controversy among the open public if they found out. Now here are some interesting examples of specific people injected by plutonium.

The first recorded test subject went by the name of Ebb Cade and was Code-named HP-12 (meaning Human Product). Cade was a middle-aged African American male who worked for in construction as a cement mixer until he got in an automobile accident that caused fractures in his limbs. He was injected with a dose of 4. 7 micrograms of plutonium. Doctors thought 5 micrograms was the limit for the human body based on research from radium. Sadly, radium doesn’t remain in the bones for as long as plutonium and animal experimentation estimated the limit to actually be 1 microgram, which was more than five times over the dosage given to Cade. Anyways, nothing bad seemed to happen right away, but he died about eight years later of heart failure.

Another case involved a four-year old child by the name of Simeon Shaw who was code-named CAL-2 (from California). Diagnosed with terminal bone cancer, he came from Australia with his mother urgently to the hospital at the University of California in San Francisco in hopes of better and more advanced treatment. Unknowingly, after some time, he was injected with plutonium. He was released from the hospital about a month later and went back to Australia, but then also died eight months later.

It is easy to see how unethical these experiments were. Most subjects, if not all, had no clear idea what exactly was happening to them. Some scientists tried to justify their experiments by arguing that they were terminally ill anyway. However, they failed to account for the many subjects that were misdiagnosed or the very young children like Shaw who didn't really have a say in the matter or a chance to life. In 1986, the Congressional Subcommittee on Energy Conservation and Power wrote, " Although these experiments did provide information on the retention and absorption of radioactive material by the human body, the experiments are nonetheless repugnant because human subjects were essentially used as guinea pigs and calibration devices," (Atomic).

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