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Arafat may have been poisoned, but what is polonium?

November 7 2013, by Martin Boland

Nine years after his death, Yasser Arafat's remains have produced even more questions. Credit: Magh

A Swiss forensic report of the exhumed remains of ex-Palestinian leader Yasser Arafat today suggests polonium poisoning may have been the cause of death – but what is polonium, and why is it so deadly?

First, we need to understand the basics of radioactivity.

Radioactivity is the (term given to the) emission of certain particles or electromagnetic waves caused by the breakdown of nuclei in atoms. Elements can vary so they have different numbers of neutrons within their nuclei; these are called isotopes.

An isotope's half-life is the time that it takes for half of the starting material in a sample to be converted, or decayed, into another product (after this time half of the starting material is gone). The radioactivity of a material is inversely proportional to the material's half-life (if something has a long half-life, the amount of radiation it releases per second is lower).

High radioactivity, high lethality

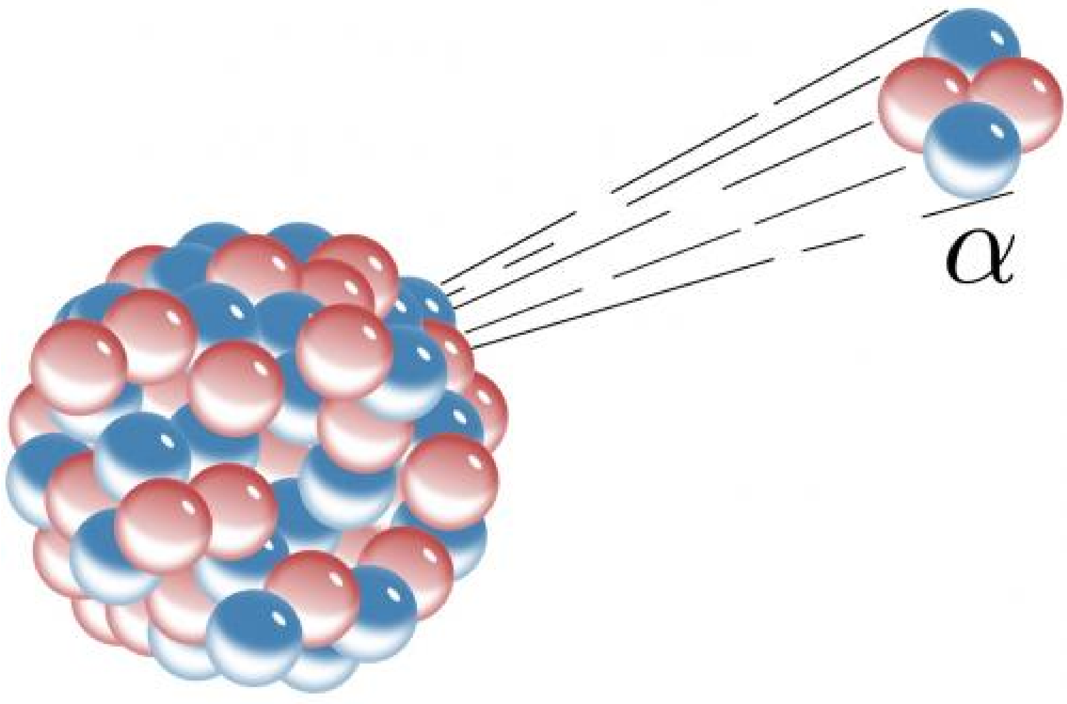
Polonium is a highly radioactive heavy metal. It is arguably the most lethal known material. Although it has some minor industrial uses it is best known for links with possible assassinations. It is also used to produce neutrons in the core of nuclear weapons.

Discovered by Marie Curie, the element was named after her home country of Poland. Polonium is element 84 in the periodic table, and all of its isotopes are radioactive. Their half-lives vary between a few millionths of a second to 103 years.

When polonium is discussed in the media, it is usually in the context of the polonium-210 isotope (210Po). This isotope has a half-life of 138 days, so while the material has very high radioactivity, it is stable enough to be transported (usually from a location with nuclear reactors or other high level scientific equipment).

210Po has been suggested as a method of assassination. The two most famous suspected cases being KGB-agent-turned-journalist Alexander Litvinenko in 2006 and – as mentioned above – Yasser Arafat.

As air reacts with alpha particles, the polonium must be ingested (or be injected) into the assassination target. In the case of Litvinenko it is alleged that was given to him in a cup of tea.



Alpha decay. Credit: Wikimedia Commons

The 138-day half-life of 210Po is short, so the element is very radioactive. While it has a melting point of 254°C, it is so radioactive that if you made 1g piece of 210Po it would create so much heat it would melt itself. The liquid would appear to glow blue due to the interaction of the alpha particles with the surrounding air.

Polonium's effects

The toxicity of radioactive materials is usually measured in terms of the radiation emitted and/or absorbed. However, to compare with more conventional toxins, the median lethal dose (LD50) for 210Po that is usually quoted is about 1μg, or one millionth of a gram.

That is one ten thousandth the dose of VX – the most potent nerve gas.

Contamination is treated in the same way as other heavy metal poisoning, with chelating agents that bind to the metal and make it more likely to be excreted. However, once a victim shows the symptoms of 210Po poisoning, the effects are likely to be fatal.

The type of radiation is also a factor in how dangerous a material is. The radiation released by 210Po is called an alpha particle.

The alpha particle is a helium nucleus (two protons and two neutrons). This relatively large particle will not travel far through air and is stopped by a piece of paper. However, it pulls electrons out of other elements (ionising them). In turn, the ionised elements are highly reactive and able to undergo reactions that would not normally occur in a human body.

So unlike the image of radiation damaging DNA and causing cancer, alpha particles act more like a normal poison, but damaging many different biological systems rather than targeting one type of molecule.

The effects of polonium poisoning are effectively those of acute radiation poisoning. These occur within one day of exposure to a large dose of ionising radiation. The effects include are all based on damage occurring to the body's fast-growing cells:

Credit: Benjamin Deutsch

- bone marrow – a drop in number of blood cells causing tiredness
- gastrointestial cells – causing vomiting and nausea
- follicular cells – causing hair loss.
- Detecting polonium

Due to polonium's high radioactivity, it is usual to detect it by making use of the way it decays. The speed (energy) of alpha particles produced by radiation is specific to the isotope that emits them and leaves a kind of signature, with which the original isotope can be identified.

A sample of fluid suspected of containing polonium is dried onto a surface and the energy of the emitted particles is measured. The number of particles with a particular energy is directly proportional to the amount of that isotope in the sample.

The short half-life makes 210Po very hard to study. It is particularly hard to look for the remains of 210Po contamination once a significant amount of time has passed.

Measurement of ratios of stable breakdown products of the various isotopes of polonium could give some insight into if poisoning has occurred, but this depends on the initial composition of the polonium sample and it is susceptible to contamination.

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