**University of Pennsylvania**
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# The Murder/Assassination of Alexander Litvinenko by $^{210}$Po Poisoning.

## Introduction

The most toxic natural materials in the environment are radioactive elements that emit harmful radiation. Most of these substances are located deep in the ground and pose no threat. However, in the past 100 years or so, scientists have discovered the immense power and danger nuclear radioactive elements can cause. From the atom bomb to nuclear power reactors, there is a new danger emerging that is widely unknown; intentional radioactive poisoning. It is well known that some radiological terrorist attacks are more effective than others. Typically, inhalation attacks were thought of as the most effective way to spread radioactive contaminates to the masses. A new form of attack recently occurred: ingestion. Not until this past November, 2006, have scientists seen this new way of poisoning others radioactively. Alexander Litvinenko, a former KGB agent, was given a dose of $^{210}$Po that ended in death approximately three weeks later. Many questions concerning this fatal assassination remain: Many wonder how this substance could have been made and how it was distributed to Litvinenko.

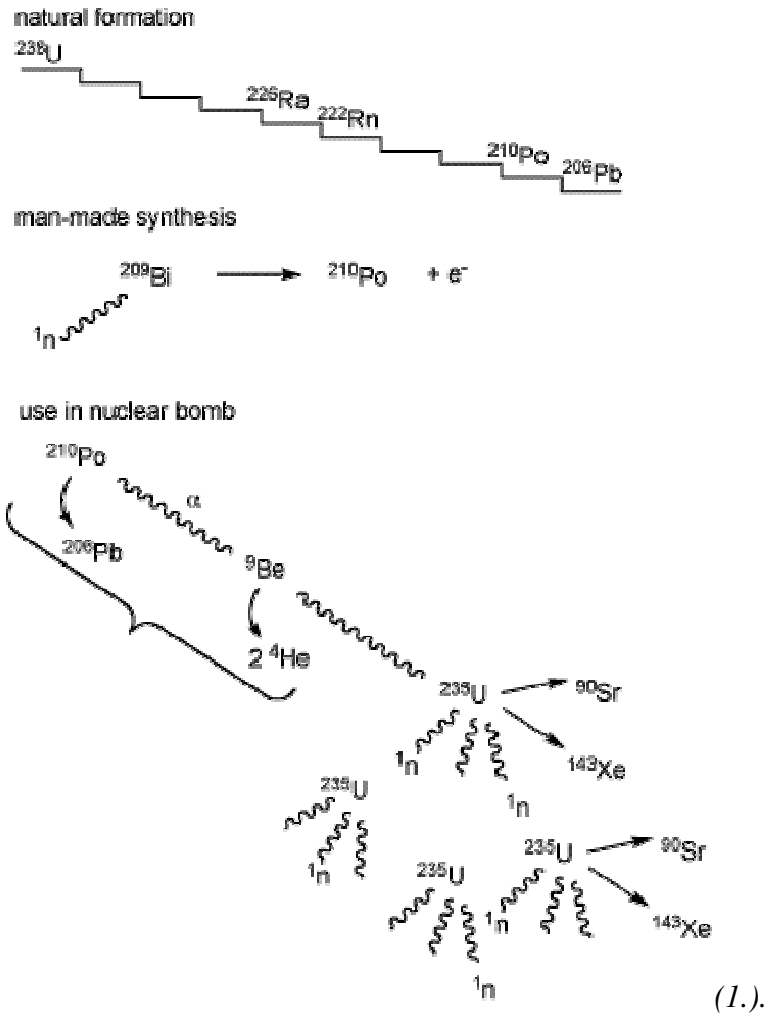
The events surrounding the death of Litvinenko are not completely clear, but authorities do know that he visited a diner, among other places, the day he was poisoned. Tests taken in the hospital have shown that he was poisoned by ingestion on two separate occasions *(1)*.

## Sources of Polonium-210

Polonium-210 can occur naturally in fish, vegetables, mushrooms, herbs, flowers, and wheat *(2)*. In addition higher levels have been found in the tissues and organs of mussels collected off the coast of England *(3)*. However, the concentration levels in natural agricultural products (around 1.9 Bq/day) and organisms in the environment are no where near the levels necessary to kill a person in three weeks *(1)*. A lethal dose of $^{210}$Po is around 1 µg. This amount would be nearly impossible to see with the human eye.

There are at least three ways to make polonium-210. It can be extracted from rocks containing radioactive uranium, produced in a nuclear research reactor, or separated chemically from the substance radium-226 (4). Figure 1 shows some of these options:

Figure 1




*(1.).*

**History of Polonium-210**

The history of $^{210}$Po extents back to the late 1800's. Noble Prize winner Marie and Pierre Curie discovered the radioactive elements radium and polonium. (Only uranium and thorium were the only known radioactive elements at the time). Using the extraction method, Marie Curie separated a new substance, which she named polonium after her native country of Poland *(4).* She discovered that $^{210}$Po was 400 times more radioactive than uranium *(1).* Her research led to the discovery of radioactivity.

In 1939, polonium was used in the Manhattan Project to build an atomic bomb. The radioactive element was important because it provided a neutron source to carry out a chain reaction. Furthermore, scientists in 1949, working on the Dayton Project, discovered that they could bombard natural bismuth with neutrons and obtain polonium-210 *(1).* This method would require the use of high neutron fluxes of nuclear reactors

**Chemistry of Polonium-210**

Naturally, polonium is formed through the decay of radioactive uranium and thorium. Uranium contains about 100 micrograms of polonium per ton *(1)*. Dangerous to handle in even very small amounts, polonium-210 is a low melting, volatile metal, 50% of which is vaporized in air within two days. "It is an alpha emitting element with a half life of 138.39 days and a milligram emits as many alpha particles as 5 g of radium" *(1)*. If one had a microgram of polonium, like the amount that killed Litvinenko, it would produce a blue glow, caused by the excitation of the surrounding gas *(1)*.

Because of polonium's lightweight properties of emitting energy and generating heat, it has been used for thermoelectric power in space satellites. It has also been used in eliminating static charges in textile mills and used on brushes for removing dust from photographic films *(1)*.

Although Marie Curie used the extraction method to obtain polonium, Dr. Nick Priest, professor and part of United Kingdom's National Radiological Protection Board, notes that "to produce the amounts required (to kill Litvinenko) you would need to use a nuclear (research) reactor" (5). This method, as noted above in Figure 1, would require the use of bismuth. Another method to produce polonium is suggested by Klaus Luetzenkirchen, director of nuclear chemistry at the Institute for Transuranium Elements in Karlsruhe, Germeny. He notes that polonium could be chemically separated from radium-226 (5). This would need sophisticated lab facilities because of the byproducts releasing penetrating radiation.

**An Unusual Death**

All previously known deaths from Polonium poisoning, including daughter of Marie and Pierre Curie, were accidental *(6)*. Polonium-210 can either kill by radiation poisoning or by causing cancer. Since Litvinenko died within three weeks of being poisoned, cancer is easily ruled out.

Radiation poisoning is also known as acute radiation syndrome (ARS). People who have ARS usually have some skin damage within a few hours after exposure, which can include swelling, itching, hair loss, and redness of the skin. The cause of death (usually within a few months of exposure) in most cases is the destruction of the person's bone marrow, which is results in infections and internal bleeding *(7)*.

There are three classic ARS scenarios: *(7)*.

1. Bone marrow syndrome-
    - " The survival rate of patients with this syndrome decreases with increasing dose. The primary cause of death is the destruction of the bone marrow, resulting in infection and hemorrhage."

2. Gastrointestinal (GI) syndrome-
    - "Survival is extremely unlikely with this syndrome. Destructive and irreparable changes in the GI tract and bone marrow usually cause infection, dehydration, and electrolyte imbalance. Death usually occurs within 2 weeks."

3. Cardiovascular (CV)/Central Nervous System (CNS) syndrome.
    - "Death occurs within 3 days. Death likely is due to collapse of the circulatory system as well as increased pressure in the confining cranial vault as the result of increased fluid content caused by edema, vasculitis, and meningitis."

Based on the above descriptions and the evidence from Litvinenko's death, scenario one and/or two are the most likely cause of death.

Studies have been completed on baboons, dogs, and rats, ingesting them with polonium-210. Dogs poisoned with polonium-210 and irradiated with γ-rays had a decreased oxidative function toward the terminal phases of radiation sickness (8). In another study, rats were injected at 14-day intervals with 2μc. of Po per kg. of body wt. Blood and excreta of living rats were examined for polonium. The greatest concentration of polonium was found in the spleen, kidney, lymph nodes, and small intestine. Death occurred from 170 to 290 days after injections had been carried out for 20 weeks (9). Other literature sources indicated that Cm, Am, Pm, Ce, La, Th, Pu4+, and U4+ accumulate in the liver mainly, while Po, Cs, Te, Ru, and Nb give rather uniform body distribution (10).

After a further investigation of why ARS causes death, one can agree that damage arises form the complete absorption of the energy of the alpha particle into tissue. As stated earlier, Litvinenko was reportedly given 0.000 000 1 g. One source indicates that the maximum amount of polonium the body can withstand if ingested is only 0.03 microcuries *(1).* This corresponds to a polonium particle weighting only 0.000 000 000 068 g. "Weight for weight, it is about *250 billion times* as toxic as hydrocyanic acid"*(1)* (emphasis added).

**Conclusion**

Most individuals focus on the thick plot that surrounds the events of Alexander Litvinenko's death. It is a bizarre tale of a fatal assassination that was unlike any other murder. Even more interesting was the method in which Litvinenko died. It is difficult to conclude on the method in which a dangerously radioactive substance like polonium-210 was artificially made, transported, and distributed. Many questions still are unanswered surrounding how polonium-210 was given to Litvinenko. Polonium-210, an extremely toxic radioactive substance, irradiated throughout the ex-KGB's body and left him dead within three weeks from acute radiation syndrome. This terribly painful death left the world stunned because this method of death that had not been seen before.

**Literature Cited**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