What should be done to reduce the amount of high-level radioactive waste?

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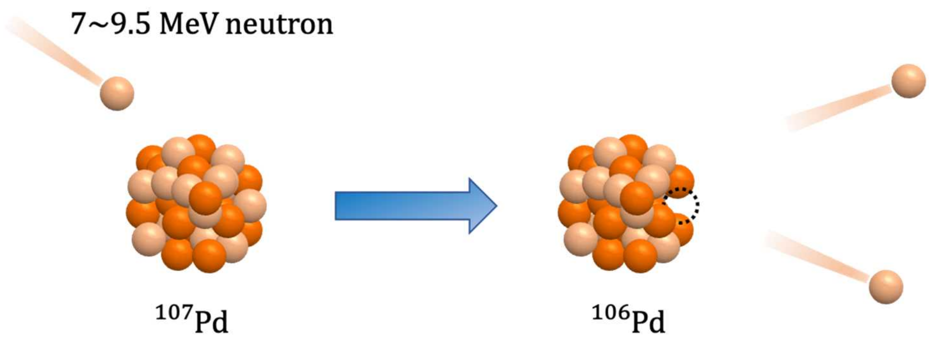
Electricity is essential to us in modern society, and a part of the electricity is generated in nuclear power plants. However, nuclear power generation leaves high-level radioactive waste. I'm not willing to discuss in this essay the rights and wrongs of nuclear power generation but we have a responsibility to run a sustainable society. "Responsible consumption and production" is one of the Sustainable Development Goals (SDGs). We have been using nuclear power, but a method for disposal of radioactive waste has not been decided yet. We must responsibly dispose of the waste for future generations. Recent developments in accelerator technology and a discovery of a new electronic state may enable the reduction of radioactive waste. In this essay, I would like to introduce the method which is expected to reduce radioactive waste.

In a nuclear power plant, Uranium235, which is easy to be divided into another atom, collides with a neutron, and the energy released in this process is used for power generation. Uranium235 is one of the isotopes of Uranium. Nuclear power generation uses nuclear fission reaction, so spent nuclear fuel contains high-level radioactive waste. High-level radioactive waste can be classified into two groups, minor actinoid (MA) and fission product (FP). MA is a group of elements that are heavier than Uranium. Uranium238, which is difficult to fission, in a nuclear fuel catches neutrons and changes to MA. MA attacked by low energy neutrons is converted to another atom easily, thus MA has been researched in relation to the nuclear fuel cycle. On the other hand, FP is a product of the nuclear fission of Uranium235. Especially, FP whose half-valued period is long is called long-lived fission product (LLFP). Selenium79, Zirconium93, Caesium135, and Palladium107 are examples of LLFP. LLFP is one of the rare metals, so LLFP is useful if it is stabilized. However, LLFP is difficult to be divided by low energy neutrons, so research on LLFP has not been popular. Despite this, improvements in the technology of an accelerator have made efficient data acquisition about nuclear transformation possible. I'm going to explain the method to reduce the amount of LLFP.

Separation and transformation are important to reduce LLFP. Spent nuclear fuel contains many kinds of atoms, so we should separate LLFP from other atoms. A nuclide whose mass number is odd has a long half-valued period, on the other hand, a nuclide whose mass number is even has a short half-valued period. We can separate them with a polarized laser. Only an odd nuclear is ionized by a polarized laser. The research members in Professor Fujita's group discovered a new electron state [1]. The method using this electron state can increase the ionizing efficiency, thus the discovery is important from a practical application perspective. We can use the phenomenon for the separation. For example, high-level radioactive waste contains Palladium104, Palladium105, Palladium106 and Palladium107. Palladium104, Palladium105 and Palladium106 are stable, but Palladium107 is radioactive isotopes. The half-valued period of Palladium107 is 6,500,000 years. We can separate Palladium105 and Palladium107 from Palladium104 and Palladium106 with a polarized laser. The usefulness of this method of separation has been demonstrated, but the method has not yet been commercialized because the ion yield is still low. Therefore, an improvement of the method is desired. After the separation, we should convert Palladium107 into a stable atom. It is irradiated with neutrons accelerated to 7 to 9.5 MeV in an accelerator. The neutron whose energy is higher than 8 MeV is required for this reaction to occur, so the researchers need to use an accelerator. We can change the energy of the neutrons by adjusting the parameters of the accelerator. A thermal neutron, which is a low-energy neutron made in an atomic reactor, was used previously, but we had to separate one kind of radioisotope from radioactive waste in the method. On the other hand, we can deal with some kinds of isotopes at the same time in the method using an accelerator. Therefore, we don't have to separate Palladium105 from Palladium107. The accelerated neutron picks out a neutron in the atomic nucleus, and the atom is transmuted into an atom that has one less neutron than an original one, so Palladium105 and Palladium107 are converted into Palladium104 and Palladium106 respectively by an accelerated neutron. Palladium104 and Palladium106 are stable, and they can be used as a catalyst in a car. Palladium105 and Palladium107 can be also used as a catalyst. But Palladium107 has radioactivity, so we couldn't use it practically because we could be exposed to radiation. However, we got to be able to convert Palladium105 and Palladium107 into Palladium104 and Palladium106 in the method, so we can use radioactive waste beneficially.

We must take responsibility for the disposal of radioactive waste for future generations. The method I introduced in this essay can reduce radioactive waste, but there are some points to be improved, thus the research should be continued. To run a sustainable society, it is necessary to promote basic research. You may think an accelerator has nothing to do with non-scientists. But the technology of an accelerator helps us to solve the problem of radioactive waste from nuclear power plants, so I hope that basic research will be more active in Japan.



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