PRESS RELEASE

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Subject line: A fast reactor system to shorten the lifetime of long-lived fission products

(Tokyo, November 14) Researchers in Japan have proposed a more efficient method to reduce radioactive waste. The study involves converting radioactive material into short-lived nuclides by absorbing surplus neutrons in the core peripheral portion of a small fast reactor faster than they are generated in the core, thus providing an effective way to lessen the burden of nuclear waste on future generations.

A team of scientists at Tokyo Institute of Technology (Tokyo Tech) working in collaboration with Tohoku University, Tokyo City University and the Japan Atomic Energy Agency has proposed a novel approach to tackle the problem of radioactive waste disposal.

The new method, published in *Scientific Reports*, could dramatically reduce the effective half-life (an indicator of the amount of time it takes to bring radioactive materials down to safe levels) of long-lived fission products[1] (LLFPs) from hundreds of thousands of years to within a hundred years.

How to dispose of nuclear waste is one of the biggest dilemmas facing the world today. The issue concerns what to do with radioactive waste after uranium and plutonium have been recovered from spent nuclear fuel using reprocessing methods such as Plutonium Uranium Redox EXtraction (PUREX).

Although burying waste deep underground is widely viewed as the most viable option, a number of strategies are being explored to reduce the stockpile of depleted fuel. One of the most promising is the partitioning and transmutation (P&T) strategy. This involves separating fuel into minor actinides[2] (MAs) and LLFPs followed by the transmutation[3] of MAs and LLFPs into shorter-lived nuclides.

So far, the P&T strategy has been limited by the costly and cumbersome need to separate LLFP isotopes before they can undergo transmutation. Also, some LLFPs, owing to their small neutron capture cross sections, are not able to capture enough neutrons for effective transmutation to occur.

The new study led by Satoshi Chiba at Tokyo Tech shows that effective transmutation of LLFPs can be achieved in fast spectrum reactors without the need for isotope separation. By adding a moderator (or slowing-down material) called yttrium deuteride (YD_2), the team found that LLFP transmutation efficiency increased in the radial blanket and shield regions of the reactor. The researchers say that this is due to the moderator's ability "to soften the neutron spectrum leaking from the core".

Chiba and his co-workers focused on six LLFPs: selenium-79, zirconium-93, technetium-99, palladium-107, iodine-129 and caesium-135. Calculations showed that the effective half-lives of these LLFPs could be drastically reduced so that total radiotoxicity at long cooling time domain will be efficiently reduced (see Figure 1).

In experiments of this kind, the support ratio (that is, the ratio of the transmutation rate to the production rate) is an important indicator of transmutation efficiency. The team showed that support ratios of over 1.0 were achieved for all six LLFPs tested, representing a vast improvement on previous findings.

Using their method, the researchers say that the 17,000 tons of LLFPs now in storage in Japan could potentially be disposed of using ten fast spectrum reactors. Their method also has the advantage of contributing to electricity generation and supporting efforts towards nuclear non-proliferation.

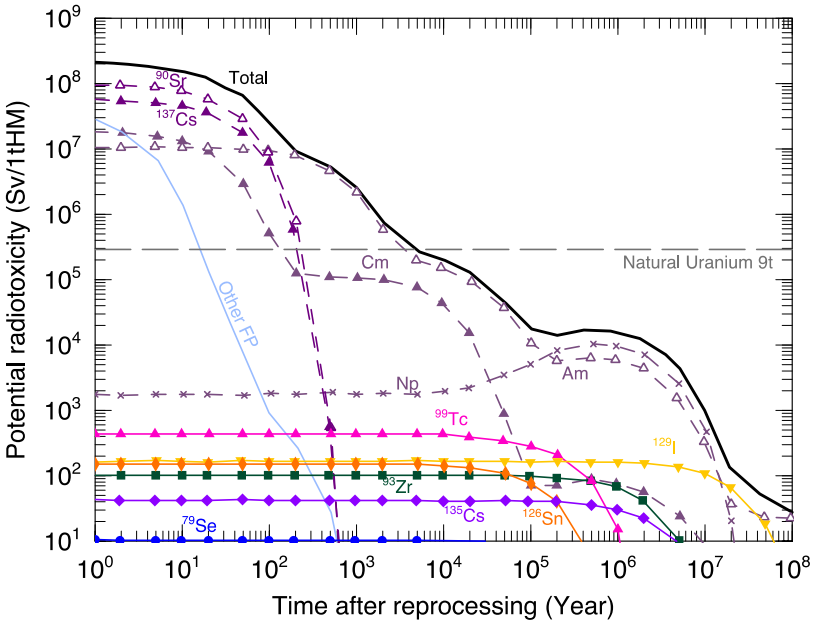

Figure. Representation of the dramatically reduced half-lives of LLFPs

Technical terms

[1]Long-lived fission products (LLFPs): Radioactive materials with long half-lives produced by nuclear fission. This study concerns the LLFPs selenium-79, zirconium-93, technetium-99, palladium-107, iodine-129 and caesium-135.

[2]Minor actinides (MAs): Elements synthesized in nuclear fuel other than uranium and plutonium, such as neptunium, americium and curium.

[3]Transmutation: A change induced by neutron capture that results in the conversion of LLFPs to short-lived or non-radioactive nuclides.

Reference

Satoshi Chiba[1,*], Toshio Wakabayashi[2], Yoshiaki Tachi[3], Naoyuki Takaki[4], Atsunori Terashima[1], Shin Okumura[1], and Tadashi Yoshida[1], Method to Reduce Long-lived Fission Products by Nuclear Transmutations with Fast Spectrum Reactors, *Scientific Reports,* DOI:10.1038/s41598-017-14319-7

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About Tokyo Institute of Technology

Tokyo Institute of Technology stands at the forefront of research and higher education as the leading university for science and technology in Japan. Tokyo Tech researchers excel in a variety of fields, such as material science, biology, computer science and physics. Founded in 1881, Tokyo Tech has grown to host 10,000 undergraduate and graduate students who become principled leaders of their fields and some of the most sought-after scientists and engineers at top companies. Embodying the Japanese philosophy of "monotsukuri," meaning technical ingenuity and innovation, the Tokyo Tech community strives to make significant contributions to society through high-impact research. https://www.titech.ac.jp/english/

Tohoku University

Tohoku University was established in 1907 as Japan's third national university, and is proud to be recently ranked No.2 on the Times Higher Education 2017 list of top universities in Japan.

Tohoku University has a history of innovation and continues to lead in traditional fields of research, is committed to contributing to its local and global communities, and encourages academic-industry-government cooperation to help strengthen and develop new areas of research. https://www.tohoku.ac.jp/en/

About Tokyo City University

Tokyo City University's predecessor, Musashi Insitute of Technology was founded in 1929, by students seeking an ideal engineering education. The university promotes high-level engineering education and research, and educates engineers that contribute to society.

The university was renamed to Tokyo City University in 2009. In April 2013, the Faculty of Environmental and Information Science was split into the Faculty of Environmental Studies and the Faculty of Informatics, and now has six faculties and eighteen schools. Building on traditions of high quality specialist engineering education, we continue to educate graduates that will be sought after by society.

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