Desorption of ^{88}Zr from soil with artificial digestive juices

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Some fission products in high-level radioactive waste are planned to be recovered for reusing of valuable materials and reducing waste volume. Zirconium is one of such materials; however, the reuse of radioactive nuclides in public requires safety assessment, clearance level, and internal exposure assessment because ^{93}Zr including fission products has a long half-life (1.61×10^6 y). The careful and reasonable evaluation of the internal exposure, in particular, is of importance for reuse in public.

Internal-exposure experiments on animals should be conducted with materials that provide an easy measurement and have no chemical toxicity. Zirconium-88 is the one of suitable zirconium isotopes for the experiments because it is a gamma-emitting nuclide with an adequately long half-life (83.4 d) and can be produced as carrier-free isotopes from yttrium.

Although internal exposure is evaluated from the migration of radio isotopes inside a living body, as a preliminary experiment in this report, we have investigated the desorption property of ^{88}Zr from contaminated soil samples with digestive juices in vitro before using animals.

Zirconium-88 was produced by the bombardment of yttrium metal with deuterons at the RIKEN AVF cyclotron and then purified by solvent extraction at Kyoto University Research Reactor Institute (KURRI).[1] The resulting solution of c.HCl was evaporated once and prepared in 1 M HNO_3 with a specific activity of 9.8×10^4 Bq/mL as the initial solution.

Contaminated soil samples were prepared by the following methods. Soil collected from a farm field in KURRI was dried at room temperature, ground to pieces, and then sieved through 0.25 mm. An aliquot of 1 g of the soil was immersed into a zirconium solution, which was prepared by mixing 0.2 mL of the initial ^{88}Zr solution and ultra-pure water immediately before immersion at a solid-to-solution ratio of 0.1 g/mL and shaking reciprocally at 120 rpm for 48 h. Subsequently, the soil was completely dried at 40°C to obtain the initial contaminated soil.

The desorption of ^{88}Zr from soil was investigated based on methods described elsewhere.[2,3] The contaminated soil was treated with the following four eluent solutions: ultra-pure water, simple artificial gastric acid (pH 1),[4] artificial gastric juice (pH 1),[3] and artificial gastrointestinal juice (pH 8).[3] An aliquot of 0.2 g of contaminated soil was added into 20 mL of each eluent, except artificial gastrointestinal juice, and the mixture was agitated at 120 rpm at 37°C for 2 h. As artificial gastrointestinal juice, an aliquot of 0.2 g of contaminated soil first added into 5.45 mL of artificial gastric juice was agitated at 120 rpm at 37°C for 2 h, following which the mixture was added with 14.55 mL of artificial gastrointestinal juice and agitated under the same condition. After agitation, the mixture was centrifuged at 3000 rpm for 10 min. The comparison of the specific activity to the initial activity yielded the desorption ratio of ^{88}Zr from contaminated soil.

Table 1. Desorption ratio of ^{88}Zr from soil samples.

Eluent	Desorption ratio
Ultra-pure water	0.09 ± 0.02
Simple artificial gastric juice	0.17 ± 0.02
Artificial gastric juice	0.17 ± 0.02
Artificial gastrointestinal juice	0.22 ± 0.02

The results of the desorption of ^{88}Zr are listed in Table 1. The desorption ratios were relatively low with every eluent, and the difference between gastric and gastrointestinal juices was almost negligible, which showed that the adsorption of zirconium was strong and independent of pH. Most of zirconium adsorbed onto soil was directly excreted without desorption. Furthermore, taking account of the history of soil in the environment, soil washed out by rain, for example, would provide lesser desorption and, consequently, lower inner exposure. Based on these results, internal exposure experiments using animals will be conducted in future work.

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References

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