

Research Group for Interfacial Reaction Field Chemistry

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Our research objectives are to explore novel chemical reactions of aqueous species of elements at liquid-solid and liquid-liquid interfaces to contribute to environmental chemistry, actinide chemistry, and waste treatment & disposal. More concretely, we focus our research on elucidation of environmental radionuclide migration and radioactive waste treatment. The research on elucidation on environmental radionuclide migration has two research fields, Fukushima and Ningyo-toge. Research on the environmental aspects of the Fukushima issues includes circulation of radiocesium (Cs) in Fukushima forest and decontamination of contaminated substances. Research on Ningyo-toge includes chemistry of uranium and radium in soil, rock, and groundwater in the context of environmental safety. Research and development on radioactive waste treatment includes development of breakthrough technologies particularly for difficult-to-treat elements.

Research on radiocesium migration in the terrestrial environment

Since the Fukushima Daiichi nuclear power plant (1F) accident, our group has been investigating Cs migration in the terrestrial environment, particularly in the forest environment. The forest environment is a very complex system, where physicochemical characteristics of inorganic substances (minerals, ions) are influenced by numerous living substances (microorganisms including mushrooms, insects, plants, and so on) and organic substances originated from those living substances. This complexity makes the elucidation of Cs migration in the forest environment difficult. Mushroom generally has a high Cs accumulating capacity. However, the Cs accumulation mechanisms, such as why mushroom accumulates Cs and what will become of the accumulated Cs after the death of mushroom, have not been clarified. We investigated accumulation of Cs by shiitake mushroom and leach of the accumulated Cs after the death of shiitake fruit bodies [1]. We revealed that Cs is present at a constant ratio to potassium, which is an essential element and has a chemical nature similar to Cs, in any part of the fruit body. After the death of the shiitake fruit body, most of the Cs accumulated in the fruit bodies were leached into water. Our results strongly suggest that shiitake has no tissues (organic substances) that strongly bind to Cs and that by being exposed to rain after the death of the fruit body Cs is leached out of the cells and returns to soil. These results are consistent with our result published in 2020 that the binding between the Cs accumulated in some trees and their tissues (organic substances) is weak [2]. It is generally considered that when Cs ions reach to soil the Cs is tightly fixed to clay minerals in soil and becomes immobile. On the other hand, plants and mushrooms absorb Cs from soil. This inconsistency has not received attention. We investigated reaction of a clay mineral and siderophore, which is an organic iron chelating substance and produced by many of soil bacteria, in terms of Cs behavior in soil [2]. The siderophore, which was produced by an endophytic bacteria isolated from the root of

clover, selectively dissolved the biotite crystals and the Cs from the broken edge of the biotite. Our findings suggest that Cs circulates in the forest environment as soil microorganisms dissolve the Cs little by little but constantly from clay minerals, plants and mushrooms absorb the dissolved Cs, the absorbed Cs is released from the plants and mushrooms after their death, and the released Cs is fixed to the soil.

As for the research on Ningyo-toge, a synchrotron radiation analysis of hydrated barium ion, which has similar chemical characteristics to radium, was performed as a preliminary study to evaluate the applicability of our approach to radium analysis. The analytical results matched the *ab initio* molecular dynamics simulation result for hydrated barium ion [4]. Following this success, we started planning of radium analysis. The iron plaque (deposit) formed on the root of *Phragmites australis* that grows in a mill tailing pond of the Ningyo-toge environmental engineering center accumulated uranium [5]. The iron plaque, probably formed by microbial activity of root-endophytic bacteria of *P. australis*, may prevent accumulation of uranium in the upper part of the plant because uranium is not detected there.

Research and development of radioactive waste treatment

The main objective radionuclides of this research are anionic radionuclides with long half-lives (^{79}Se , ^{99}Tc , and ^{129}I) because of their difficulty in stable confinement in waste forms and high mobility in the environment. In the contaminated water treatment facilities of 1F, the ^{129}I in the contaminated water is believed to be mainly removed by activated carbon (AC). Groundwater is flowing into 1F, and groundwater generally contains organic substances such as fulvic acid. We revealed that a fraction of the iodate (IO_3^-) adsorbed on AC changes to iodide (I^-) by fulvic acid [6]. The adsorptivity of I^- to AC is lower than that of IO_3^- . Our results suggest that during the storage of spent AC a fraction of the IO_3^- on AC changes to I^- and a fraction of I^- desorbs from the AC.

We also reported that alkaline geopolymer is superior to conventional Portland cement as solidification method for the sewage sludge ash contaminated with Cs [7] and revealed that the metal organic framework (MOF) that is easily synthesized using terbium oxalate has a high selectivity and adsorption capacity for Pb^{2+} (see Highlight) [8].

References

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