7–5 Safety Study of Extraction Chromatography Technology for a Partitioning Process
— Behavior of Heat, Hydrogen Gas, and Degradation Products in a Separation Column —

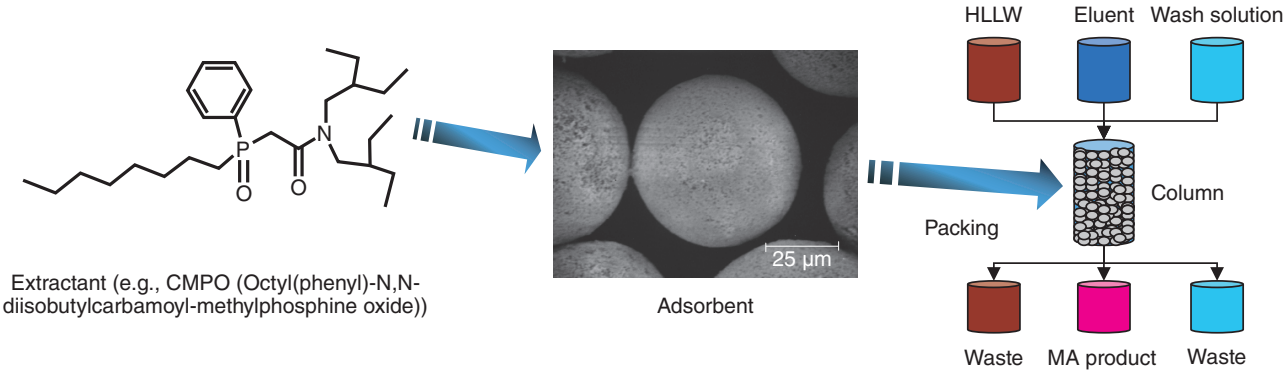

Fig.7-14 Extraction chromatography technology for MA partitioning
MAs in high-level liquid waste are extracted by an extractant impregnated into adsorbents. MAs are recovered through adsorption/elution reactions inside the packed column.

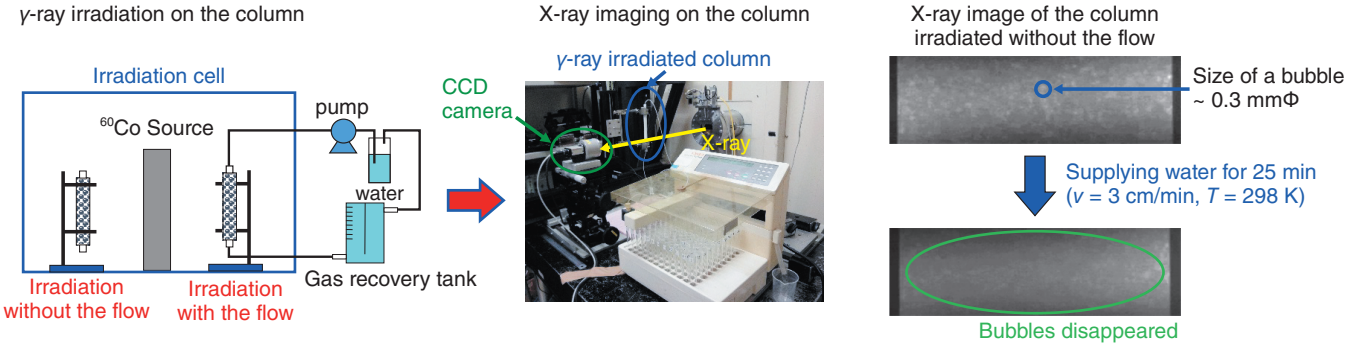

Fig.7-15 *γ*-ray irradiation and X-ray imaging of the column
X-ray imaging experiments on a *γ*-ray irradiated column reveal the distribution of bubbles generated inside the column by irradiation.

Partitioning and transmutation technology, which is used for the recovery process of actinides or long-lived fission products from spent nuclear fuel and transmutation processes of those nuclides by neutron irradiation, is expected to reduce the volume and potential hazard of nuclear waste. We are developing extraction chromatography technology for the recovery of minor actinides (MAs).

This technology employs silica-based adsorbents, and MAs in high-level liquid waste are selectively recovered in a product solution using a chromatographic operation (Fig.7-14).

Since the radioactive elements are treated by adsorbents containing organic compounds, generation and accumulation of decay heat, hydrogen gas, and degradation products of the organic compounds inside the packed column may be unavoidable. Those phenomena cause a potential risk of lead fire or explosion; thus, we have been focusing on the safety of the extraction chromatography system to prevent hazardous accidents.

The behavior of gas inside the extraction chromatography column was investigated through X-ray imaging on the *γ*-ray irradiated column and computational fluid dynamics (CFD) simulation. Although gas is generated by radiolysis and accumulated inside the packed column after the operation is ceased, the supply of a coolant has been revealed to be an effective means of discharging this gas (Fig.7-15). CFD simulation shows that decay heat accumulating due to the stopping of the flow was simultaneously discharged with the gas. Continuous flow is essential for preventing the accumulation of heat and hydrogen gas, and the equipment for feeding coolant must be effective in the case of irregular stoppages of the operation caused by accidents with the pumps.

Degradation products produced by the radiolysis of organic compounds were analyzed in the irradiated adsorbents using *γ*-rays or He^{2+} ion beams by the GC/MS, NMR, and FT-IR methods. Chemical species with low flash or ignition points were not confirmed. It was found that the radiolysis of the organic compounds should not cause fire or explosions. Further investigations of the degradation mechanism of the adsorbents should be undertaken to secure the safety of the extraction chromatography technology.

Reference

Watanabe, S. et al., Safety Operation of Chromatography Column System with Discharging Hydrogen Radiolytically Generated, Proceedings of 2015 International Congress on Advances in Nuclear Power Plants (ICAPP 2015), Nice, France, 2015, paper 15241, 8p., in CD-ROM.