Universal 3D-printed device for the separation of radio isotope and target metal[†]

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The separation of short-lived radio isotopes (RI) from target required rapidity, and high recovery and purity for RI. Previously we developed new separation method for metal RI with ethylenediaminetetraacetic acid (EDTA) as selective chelator to switch the polarity of RI ion followed by cation-exchange resin trapping of target metal ion.[1)] The separated RI is released from EDTA-complex by UV radiation to decompose EDTA.[2)] In the present study, we developed newly designed 3D-printed device for the RI separation of a practical-scale (∼10 mL) solution with EDTA method. Furthermore, the developed method was applied for the separation of RI/target combination of ^{67}Ga/Zn, and ^{89}Zr/^{89}Y.

The newly designed 3D-printed device consisted with sample reservoir, cation-exchange resin column, and UV radiation reactor (Fig. 1). One of the merits of 3D-printing device is tunnel-like solution channel which dramatically decreases the dead volume. The device was also designed as disposable. The sample solution which contains RI and target metal ions into the sample reservoir followed by capping with the tube connected plug. The HNO_3 solution was flowed into the reservoir to push the sample solution into the cation exchange resin column. The effluent of the column was kept in UV reactor to decompose metal EDTA complex.

After the decomposition, the solution (Ga fraction) was collected from the bottom of the reactor. The total recovery and UV decomposition efficiency were obtained with NaI (Tl) scintillator and HPLC separation followed by the fraction collection and quantitation with NaI (Tl) scintillator. HPLC separation performance was initially evaluated with flow through detector. The chromatograms with Ga^{3+} and Ga-EDTA complex standard solutions were respectively shown by blue and magenta filled graph in Fig. 2.

The recovery achieved with the separation of ^{67}Ga and Zn was greater than > 91% of the ^{67}Ga in Ga fraction against the sample. Furthermore, the UV-decomposition efficiency, which was evaluated with radio-HPLC (Fig. 2(a)), was >99%. Similarly, the separation performances were evaluated with ^{89}Zr and Y. The recovery and UV-decomposition efficiency were 98 and 99% respectively. The present separation system can be used on many kinds of RI/target if the formation constants with EDTA are enough difference. The separation also requires only ∼30 min. Also, the process is fully automated. The multi-functional and cost-effective separation device is suitable for a wide range of RI applications.

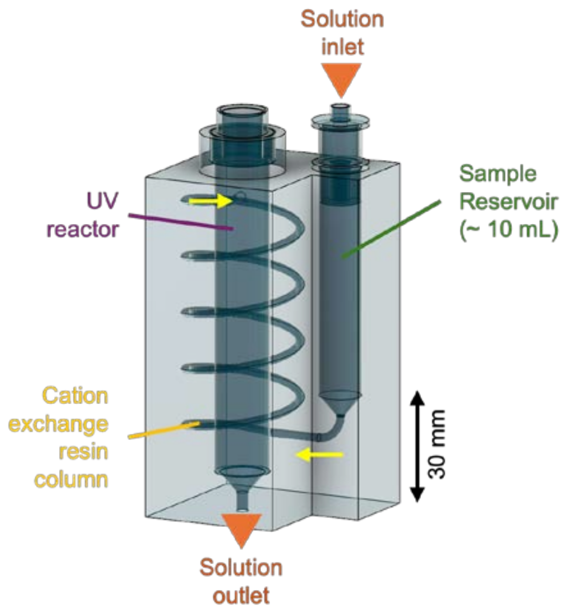

Fig. 1. Schematic illustration of newly designed 3D-printed device for the separation of RI and target metal ions.

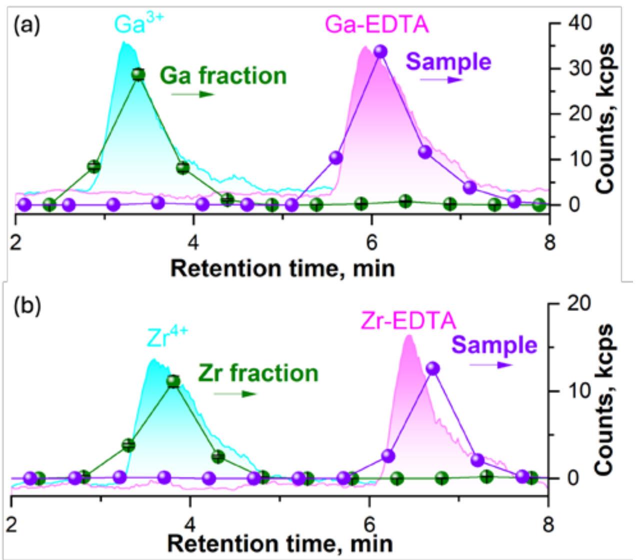

Fig. 2. Chromatograms for the sample and device effluent of (a) Ga/Zn and (b) Zr/Y.

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