Simultaneous imaging of Na^+/K^+ by semiconductor Compton camera GREI†

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Various metal elements exist in a living body and are used as essential factors for maintaining life. For example, sodium (Na) and potassium (K) are homologous alkali metals that are clearly distinguished by some biomolecules and used for forming a membrane potential required for nerve activity. Since various metal elements in a living body are controlled by specific biomolecules, it is expected that the behavior of these metal elements changes in diseased tissues.

We are exploring the possibility of a new concept of diagnostic imaging that diagnoses the function of a living organism by non-invasive visualization of the dynamics of associated metal elements in vivo. In particular, a nuclear medicine imaging technique, which takes the images of the radioisotopes (RIs) of the metal elements to be traced, enables the visualization of the dynamics of a deep part of a living body by administering a small amount of RIs. As for Na and K, ^{24}Na, ^{42}K, and ^{43}K have suitable half-lives for administration to a living body: 15, 12, and 22 h, respectively. However, since these are not positron-emitting nuclides, they cannot be imaged by PET, and the gamma-ray energies of the nuclides are too high for use in SPECT.

Therefore, we are studying the imaging of ^{24}Na, ^{42}K, and ^{43}K using a semiconductor Compton camera called GREI[1,2] to visualize the dynamics of Na^+ and K^+ in a living body. We have already obtained various results in the simultaneous imaging of multiple nuclides that emit gamma rays from about 200 KeV to 2 MeV by using GREI equipped with germanium semiconductor detectors as gamma-ray sensors. In addition, it is possible to create three-dimensional images simply by taking an image from one direction with a single imaging head without arranging a large number of sensors around the imaging target or rotating the imaging head.

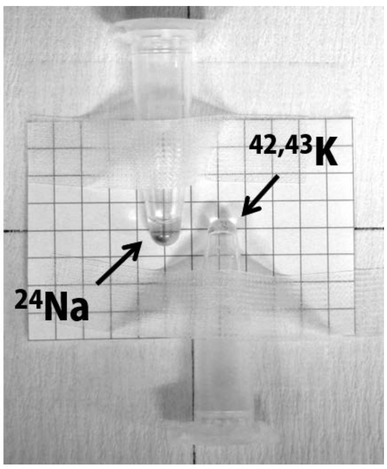

Fig. 1. RI solutions of ^{24}Na and ^{42,43}K collected in micro tubes. The gap between the tips of the micro tubes was 1 cm.

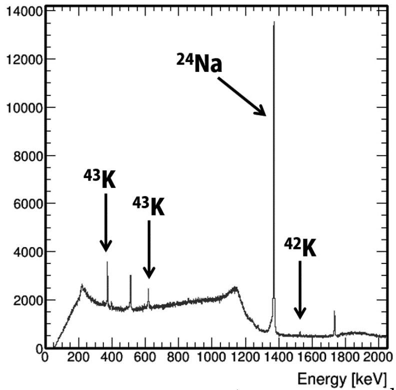

Fig. 2. Gamma-ray energy spectrum measured by GREI.

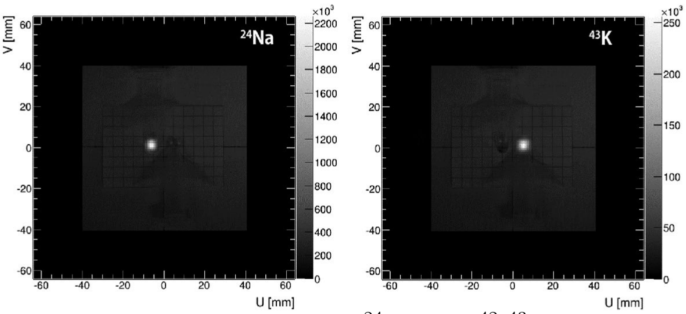

Fig. 3. Gamma-ray images of ^{24}Na and ^{42,43}K simultaneously measured by GREI.

Since FY2018, the use of these nuclides has been made possible at the Molecular Imaging Facility at RIKEN Kobe campus, and a series of protocols for manufacturing and preparing ^{24}Na, ^{42}K, and ^{43}K in-house and conducting GREI imaging experiments have been established. To demonstrate the feasibility of simultaneous imaging of these nuclides by GREI, we performed a test imaging experiment by using RI solutions.

RI solutions of ^{24}Na and ^{42,43}K were collected at the tips of two micro tubes separately (Fig. 1). ^{42}K and ^{43}K were not separated, because they are chemically identical. The radio-activities of ^{24}Na, ^{42}K, and ^{43}K were 2.1 MBq, 910 kBq, and 76 kBq, respectively. The tubes were placed under the GREI imaging head 3.5 cm away from the front detector. The GREI imaging was performed for 1 h.

Figure 2 shows the gamma-ray spectrum obtained in the GREI imaging experiment. We were able to clearly identify the gamma-ray peaks of each nuclide. By setting energy windows on the peaks of each nuclide, we performed three-dimensional image reconstruction on the recorded data. As a result, we succeeded in taking the images of ^{24}Na and ^{42,43}K simultaneously.

References
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