

Real-time alpha-particle trajectory imaging using a thin GAGG(Ce) scintillator for targeted radionuclide therapy

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Actinium-225 (Ac-225) and lead-212 (Pb-212) are widely regarded as radionuclides with exceptional potential for targeted alpha therapy, spurring extensive research into the development of novel radiopharmaceuticals. For accurate detection of alpha-emitting radionuclides in cells and small organs, high-resolution imaging of alpha-particle trajectories is crucial to identify the accumulation sites of the radionuclides. However, real-time visualization of alpha-particle tracks emitted from Ac-225, Pb-212, and their daughter nuclides had not been achieved prior to this study. To overcome this limitation, we developed a real-time imaging system capable of visualizing alpha-particle trajectories.

The system comprises a magnification module, a cooled electron-multiplying charge-coupled device (EM-CCD) camera, and a 100–200 μm thick GAGG(Ce) scintillator, as shown in Fig. 1(A) [1]. The scintillation trajectories generated in the GAGG(Ce) scintillator were optically magnified and detected by the EM-CCD camera, then displayed and stored on a desktop computer. Using this setup, we successfully imaged alpha-particle tracks with varying lengths and intensities, achieving a spatial resolution of 1.0 μm .

In imaging of Ac-225 and its daughter radionuclides, we captured alpha particles in real time with four distinct types of trajectories corresponding to four different alpha-particle energies, as shown in Fig. 1(B). Sequential alpha-particle emissions arising from the short-lived decay of Fr-221 to At-217 were also successfully visualized. In imaging of Pb-212 and its daughter radionuclides, two types of trajectories corresponding to alpha particles with two different energies were observed, including extended trajectories produced by high-energy alpha particles emitted from Po-212, as shown in Fig. 1(C).

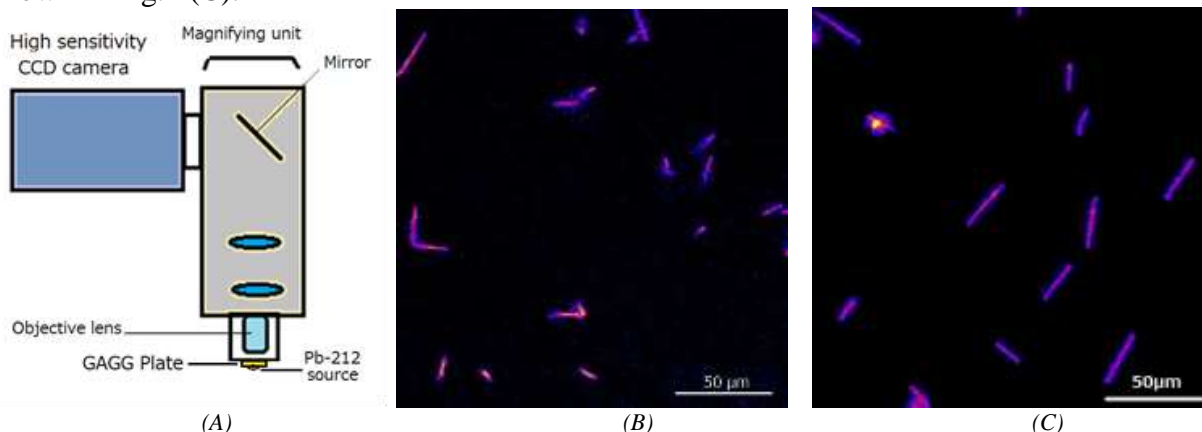


Fig. 1 Schematic drawing of real-time alpha particle trajectory imaging system (A), trajectory images of Ac-225(B) and Pb-212 (C)

This work establishes a high-resolution imaging platform that simultaneously provides spatial, temporal, and energy information on alpha-particle emissions. The developed method offers valuable insights into the microscale emission behavior of Ac-225 and Pb-212, advancing the understanding and development of targeted alpha therapy and related applications.

1. S. Yamamoto, et al., “Development of an ultrahigh resolution real-time alpha particle imaging system for observing the trajectories of alpha particles in a scintillator” *Sci Rep* 13:4955 (2023)