Plastic Scintillators With Bismuth Nanoparticles For Low Energy Gamma Spectroscopy Using Subtraction Method

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Abstract

- Normally, gamma radionuclides are identified using inorganic scintillators despite the high cost. In this study, we made an organic scintillator for low-energy gamma radionuclides using bismuth nanoparticles, which increase both the effective atomic number and density of the scintillator. We find the energy peak of Co-57 gamma-ray source by subtracting the count of photopeak of bismuth and ordinary scintillators.

Introduction & Experimental Setup

- Nowadays, gamma spectroscopy using a multichannel analyzer (MCA) with a scintillator is the most widely used method to identify gamma-emitted radioactive nuclides by finding the photoelectric peaks in the gamma energy spectrum. When the gamma-ray enters the scintillator, it generate the scintillating light and the types of nuclides, which are determined by analyzing the spectrum of scintillating light.
- In most cases, inorganic scintillators are used to identify gamma-emitted nuclides due to high density and effective atomic number. However, inorganic scintillators are inappropriate to make large sensors for portal monitoring because of their high cost and difficult fabrication process. On the other hand, plastic scintillators generally need a much lower production cost and are easy to make in large sizes. But they have poor light yield, low effective atomic number to occur enough photoelectric effects
- For ordinary plastic scintillators without high z material, energy peaks due to photoelectric effects cannot be found in gamma spectra. Thus, an energy peak can be found in a positive value by subtracting the gamma spectrum of Co-57 measured with a plastic scintillator using bismuth from the gamma spectrum of Co-57 measured without bismuth. Before experiments, an energy spectrum was obtained through MCNP simulation for comparison with the experimental values.
- We use Co-57 gamma-ray source (122 keV). Two cylindrical plastic scintillators of which size is 5 cm in diameter and 1 cm in thickness, are prepared. Nineteen cylindrical holes of 0.5 cm diameter and depth are drilled in one of them and filled with bismuth nanoparticles. The scintillator and experimental composition can be seen in figure 1. The gamma-ray of Co-57 is measured using the photomultiplier tube (R6231-100, Hamamatsu), the scintillation preamplifier (2007B, Mirion), and the digitizer (DT5725, Caen).

Fig 1. The scintillator with nineteen holes (left) and the experimental composition (right)

Experimental results

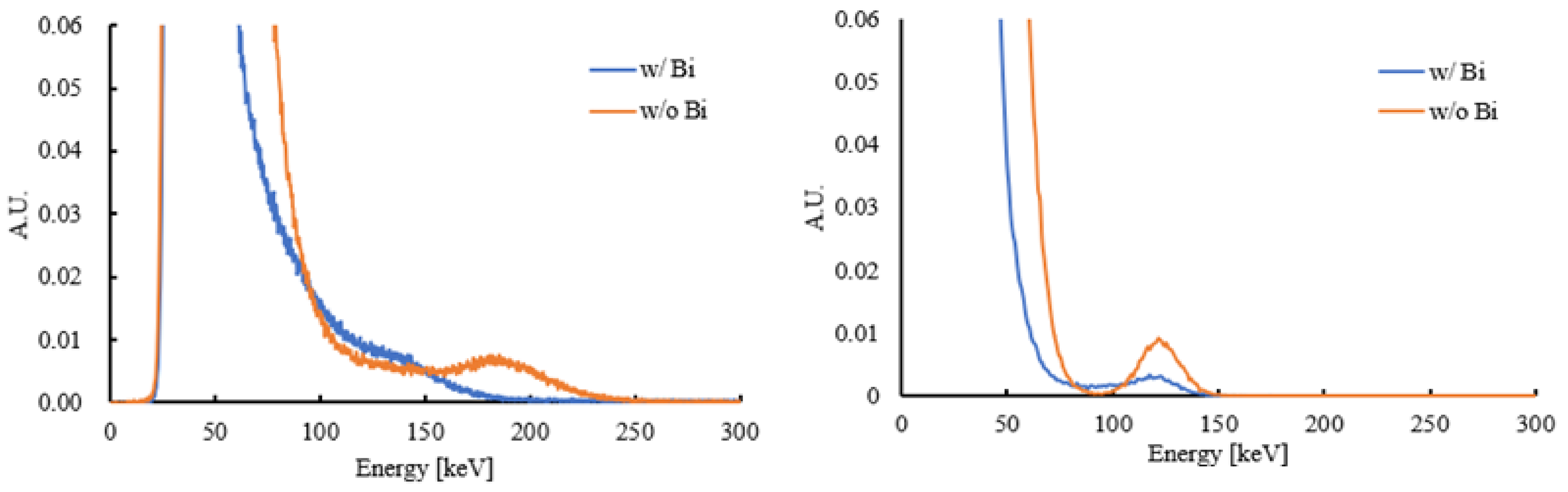

Fig 2. The spectra of MCNP simulations (left) and experiments (right) using the plastic scintillator with (blue line) and without (orange line) bismuth

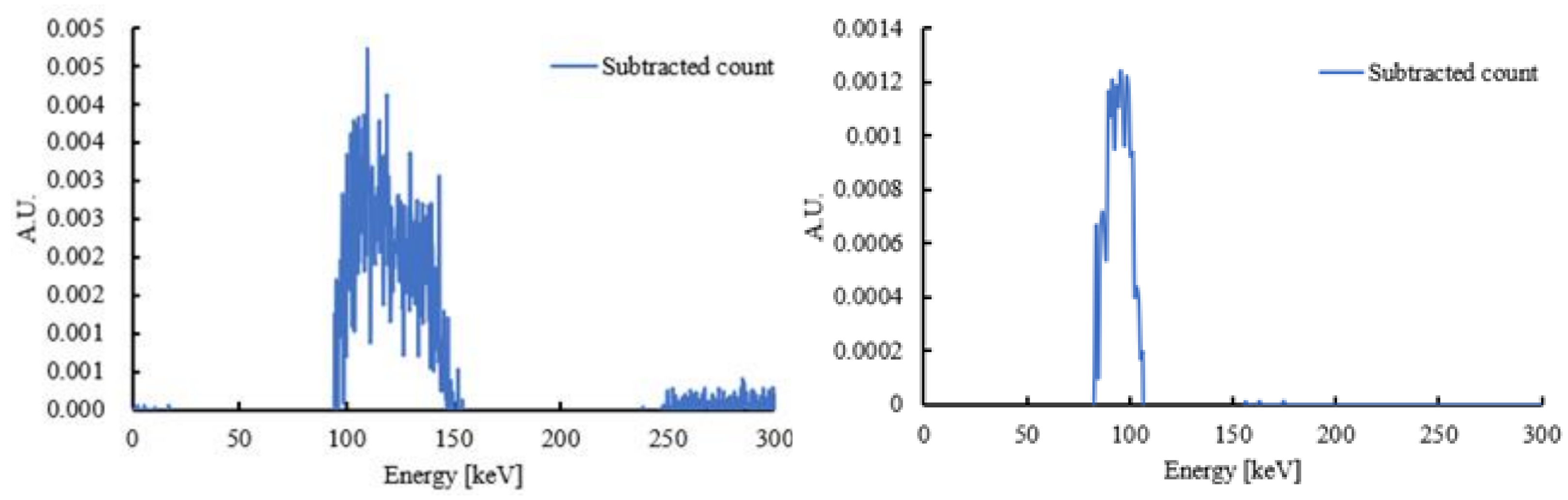

Fig 3. The positive parts of spectra of MCNP simulations (left) and experiments (right) subtracted the result of the bismuth scintillator from the ordinary scintillator

	FWHM (keV)	Energy resolution (%)
MCNP simulation	30.35	24.88
Experiments	38.64	31.67

Table 1. FWHM and energy resolution of photopeak measured by MCNP simulation and experiments

- As shown in figure 2 and 3, the energy peak due to the photoelectric effect is identified when the results without bismuth are subtracted from the spectrum obtained using bismuth. We tabulate full width and half maximum and energy resolution of the photopeak of Co-57. As shown in table I, the energy resolution of experiment is differed from MCNP simulation by 6.79 percent.

Conclusions

- In this study, we find a clear energy peak of Co-57 by subtracting the MCA result of ordinary plastic scintillator from the result of scintillator with bismuth nanoparticles. The results demonstrate the possibility of gamma-ray sources identification using plastic scintillators with high z materials. Further studies will be carried out to measure gamma-ray spectra with the same system using variable gamma-ray sources.

Acknowledgements

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