Transactions of the Korean Nuclear Society Autumn Meeting
Changwon, Korea, October 30-31, 2025

Drop-casting of $CsPbX_3$ Quantum Dots on LuAG:Ce Bulk for Gamma Spectroscopy

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Keywords : $CsPbX_3$, drop-casting, LuAG:Ce, gamma spectroscopy, channel shifting

1. Introduction

Halide perovskite $CsPbX_3$ (X = Cl/Br/I) quantum dots (QDs) have emerged as versatile photonic enhancement layers for light yield improvement, owing to their high PLQY, narrow emission bandwidths, and composition tunable visible emission [1-3]. Related studies show that perovskite coatings/films can strengthen scintillation signals via wavelength conversion, near-field interfacial energy transfer, and improved light extraction (index matching) [4-6]. However, most prior work has focused on thin scintillator wafers (sub-mm to a few mm) and time-of-flight (TOF) metrics, with relatively limited gamma spectroscopy evidence. In this work, by contrast, we drop-cast $CsPbX_3$ QDs onto the polished end face of thicker bulk cylindrical scintillator—LuAG:Ce with 10 mm diameter × 10 mm thickness—and evaluate the effect via gamma spectroscopy, focusing on ADC channel shifts and changes in energy resolution.

2. Materials and methods

The scintillator used in this study was a cylindrical LuAG:Ce crystal (Ø10 mm × L 10 mm) manufactured by Epic Crystal. To maximize light collection, all faces except one end face were wrapped with a PTFE diffuse reflector sheet (PMR10P1, Thorlabs). Two perovskite QD solutions were evaluated: $CsPb(Cl/Br)_3$ and $CsPbBr_3$ (QDot ABX-450 and ABX-510, Quantum Solutions), both dispersed in toluene and capped with oleic acid and oleylamine.

Prior to coating, the crystal was preheated at 50°C for 10 min in a drying oven. 10 μL of the perovskite solution was then drop-cast onto the unwrapped end face and baked in the oven at 60°C for 10 min and followed by 80°C for 10 min. The sample was removed and air-dried at room temperature for 10 min, then baked at 100°C for 10 min, and finally air-dried at room temperature for 10 min to complete the perovskite coating.

An optical pad (EJ-560, Eljen Technology) was applied to the perovskite-coated end face to couple the scintillator to a photomultiplier tube (PMT, H10828, Hamamatsu). The PMT-scintillator assembly was enclosed in a black acetal housing to block ambient light and ensure rigid coupling. The PMT output was fed to a charge-sensitive preamplifier (CR-113, Cremat) and digitized with a digitizer (DT5725, Caen). All measurements were performed in a dark room for 1800 sec with the PMT biased at -1000 V.

3. Experimental results

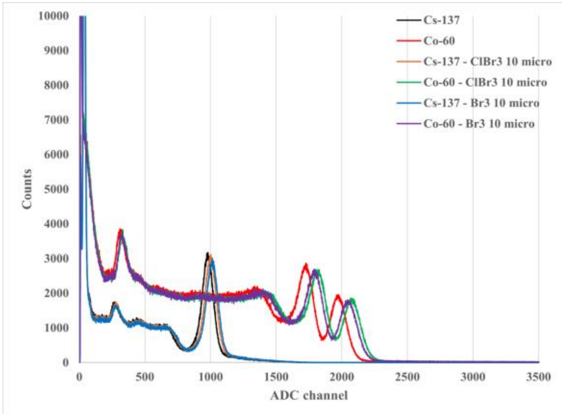
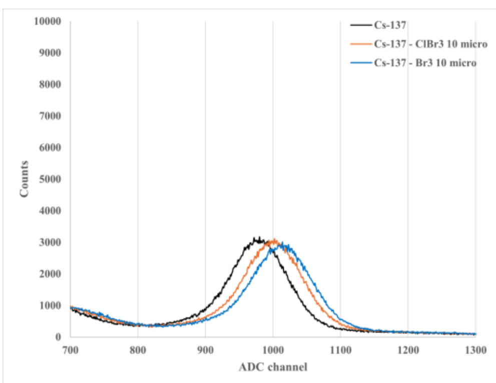


Fig. 1. Pulse height spectra of Cs-137 and Co-60 before and after perovskite drop-casting.

Figure 1 shows pulse height spectra of Cs-137 and Co-60 measured with the LuAG:Ce scintillator before and after perovskite drop-casting. The source activities were 0.233 μCi and 0.668 μCi respectively. Each source was positioned on axis, 2 mm from the scintillator.

Figure 2 shows enlarged views of the Cs-137 661.657 keV peak and the Co-60 1173.228 keV and 1332.492 keV peaks. After perovskite drop-casting, the centroid ADC channels of all peaks shift to higher values.

As summarized in Table 1, the perovskite-dependent changes show that the increase in ADC channel is accompanied by a modest improvement in energy resolution.



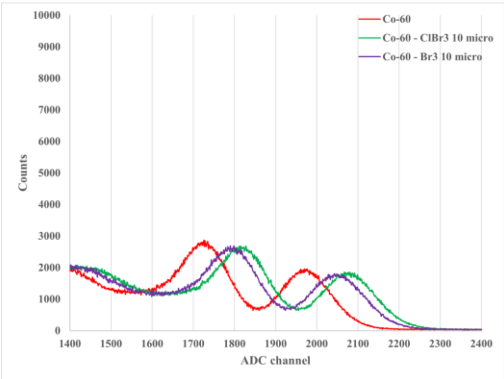


Fig. 2. Enlarged views of Cs-137 and Co-60 peaks.

Table 1. Perovskite-dependent changes in ADC channel and energy resolution.

661.657	**bare**	**$CsPb(Cl/Br)_3$**	**$CsPbBr_3$**
centroid channel	976.47	998.36 (+ 2.2%)	1010.77 (+ 3.5%)
resolution	11.59%	11.49%	11.31%
1173.228	**bare**	**$CsPb(Cl/Br)_3$**	**$CsPbBr_3$**
centroid channel	1725.97	1816.35 (+ 5.2%)	1792.83 (+ 3.9%)
resolution	6.56%	6.43%	6.51%
1332.492	**bare**	**$CsPb(Cl/Br)_3$**	**$CsPbBr_3$**
centroid channel	1982.49	2088.19 (+ 5.3%)	2059.85 (+ 3.9%)
resolution	6.00%	5.73%	5.92%

4. Conclusion

This study shows that even a simple drop-casting process can yield perovskite-induced enhancement of scintillation signals and that the approach is applicable to thick, bulk scintillators. However, because the observed gains are smaller than in prior reports and vary with radionuclide, we plan follow-up work to develop low-thermal-budget coating procedures that better preserve QD photoluminescence efficiency and to systematically investigate energy-dependent response differences.

ACKNOWLEDGMENTS

This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No. RS-2024-00414355), and the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIT) (No. 2020M2D2A2062457).

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