STUDY OF LANTHANUM BASED SCINTILLATORS FOR NUCLEAR MEDICINE IMAGING INSTRUMENTATION

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Introduction

In Nuclear Medicine Imaging instrumentation, the scintillator is an important component for the accurate detection of γ-rays. It should exhibit high detection efficiency, high light output and a fast decay time. Most widely used detectors in nuclear medicine are NaI(Tl), Bi4Ge3O12 (BGO), Gd2SiO5(Ce) (GSO) and Lu2SiO5(Ce) (LSO). In recent years, other materials with Ce as an activator may be prominent for γ-ray detection.

The aim of this study is to evaluate the efficiency of crystalline scintillators LaCl3(Ce) and LaBr3(Ce), within the energy range used in nuclear medicine applications. Both LaCl3(Ce) and LaBr3(Ce) are characterized by high light output (49.000 photons/MeV and 63.000 photons/MeV respectively) and a small decay times (28 ns and 25 ns respectively), providing excellent energy resolution performance.

Methods

The suitability of the scintillators has been determined by the Spectral Matching Factor (SMF) and the Quantum Detection Efficiency (QDE) for various crystal thicknesses and energies corresponding to Tl-201, Tc-99m, In-111, Ga-67, I-131 and I-123 radiopharmaceuticals used in Nuclear Medicine.

The efficiency of a scintillator to detect photons is described by the QDE, which is defined as the fraction of incident photons interacting with the scintillator mass. SMF expresses the degree of coincidence between the spectrum of light emitted by the scintillator and the spectral sensitivity of a photoreceptor [Kalivas N. et al, "Optical Gain Signal-to-Noise Ratio Transfer Efficiency as an index for ranking of phosphor-photodetector combinations used in X-ray medical imaging". Applied Physics A 78:915-919, 2004].

The photon attenuation coefficients used for QDE calculation were extracted from XMuDat software, while the scintillator optical photon spectra where obtained from Advantech UK Limited. [www.advatech-uk.co.uk]. In Figure 1 the scintillators emission spectra are shown

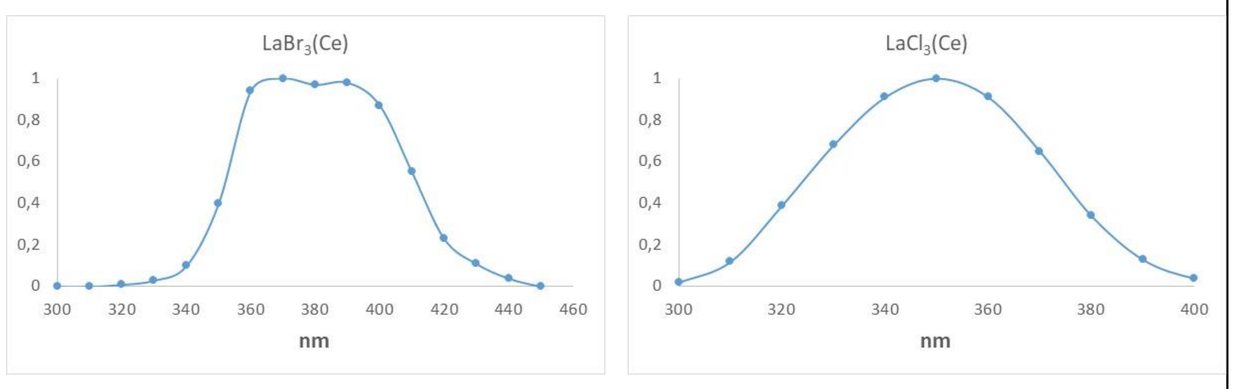

Figure 1: $LaBr_3(Ce)$ and $LaCl_3(Ce)$ scintillators emission spectra.

Results

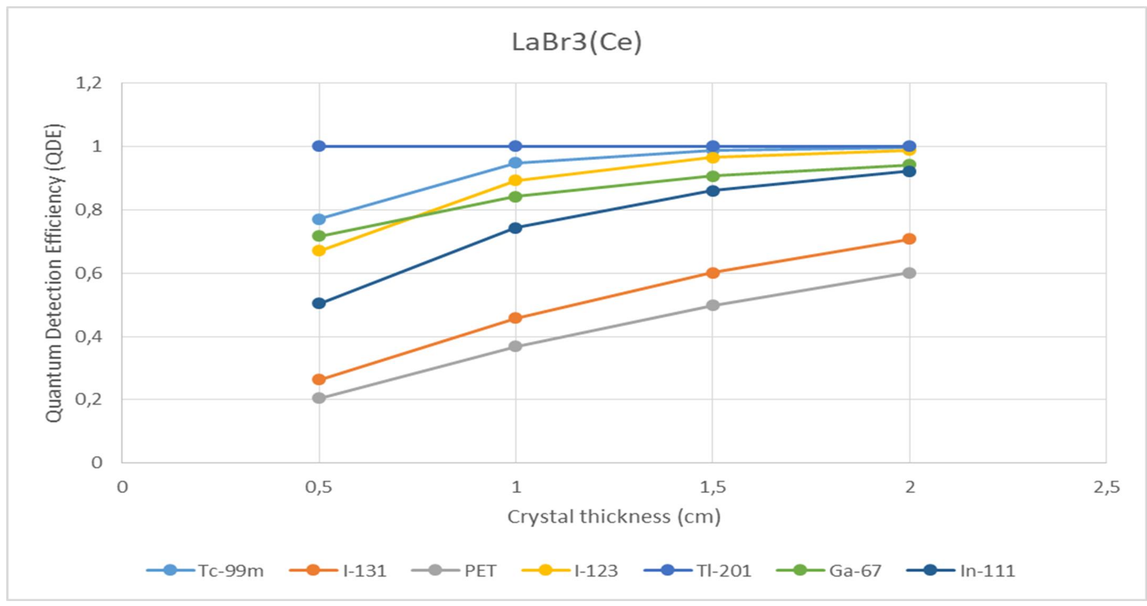

Figure 2,3: Quantum Detection Efficiency (QDE) of LaBr3(Ce) and LaCl3(Ce) for various crystal thicknesses and energies.

Optical detectors	LaCl3(Ce)	LaBr3(Ce)
GaAs photocathode	0.90	0.91
Si photocathode	0.85	0.17
E/S-20 photocathode	0.83	0.94
S-9 photocathode	0.72	0.81

Table 1: LaCl3(Ce) and LaBr3(Ce) Spectral matching factors with commercially available detectors.

In figure 2 and figure 3 the QDE of $LaBr_3(Ce)$ and $LaBr_3(Ce)$ are shown respectively. In Table 1 the calculated SMF are also presented

- The lower QDE value was 16% at 511 keV (PET) for 0.5 cm LaCl3(Ce).
- The highest QDE values were 99.9% at 75 keV (Tl-201) for both crystals at all thicknesses.
- The best SMF value equals to 91% was calculated for LaBr3(Ce)/GaAs combination.

Conclusions

LaBr3(Ce) and LaCl3(Ce) scintillators' QDE performance, as well as the corresponding SMF values with various photodetectors, may categorize them as suitable for Nuclear Medicine Imaging instrumentation.

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