

Cs₂TeCl₆ as a Promising Scintillating Detector for the Rare Decay of ¹²³Te

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Anti-fluorite A₂BX₆ materials have become a focus of interest due to their optoelectronic properties and structural versatility. Materials such as Cs₂TeCl₆ (CTC) microcrystals (MCs) have been studied for their luminescence properties since 1984 [1], and over the past 10 years, have received interest as a thin-film scintillator detector [2]. Furthermore, Te-based crystals can find their application as an effective detector for a rare process that can occur in Te isotopes, namely the electron capture of ¹²³Te with a transition energy of just 53 keV [3]. However, a detailed characterization of the bulk CTC crystal has not yet been reported.

In the present study, two CTC single crystal ingots with dimensions Ø10 × 40 mm have been grown by the Bridgman-Stockbarger method, using powdered CTC precursors produced by a solution synthesis method yielding more than 95%. The dynamics of chemical impurities at each stage of the CTC crystal production were controlled by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The purity of the synthesized powder increases to 99.995% compared to the low-purity starting materials of 99%, with the grown crystal maintaining similar purity to the synthesized powder. ICP-MS also revealed segregation of elemental impurities like Fe, Ag, Tl and Pb to the heel of the crystal at a level of 5 – 31 ppm. and a low concentration of U and Th radioactive contaminants (< 1 × 10⁻⁹ g g⁻¹). The intrinsic radiopurity of a 4.5 g CTC crystal sample was measured over 400 hours via gamma-ray spectrometry using a low-background high-purity Ge (HPGe) detector, with the major contamination originating from cosmogenic ¹³⁴Cs isotope (50 mBq kg⁻¹) and no evidence of contribution from U/Th decay chains, with upper limits set at hundreds of mBq kg⁻¹. A modified Bollinger-Thomas method was used to evaluate the decay constants of CTC's scintillating pulse induced by gamma quanta of ²²Na (93.6 ± 1.6 ns), and alpha particles of ²⁴¹Am (82.9 ± 1.3 ns). The scintillation measurements were performed using both PMT and SiPM light detectors, and better energy resolution was obtained with SiPM, corresponding to FWHM = 38% and 26% for 662 keV of ¹³⁷Cs and 5.3 MeV alpha particles of ²⁴¹Am, respectively. The light yield (LY) of the CTC crystal was evaluated to be about 1000 ± 100 photons/MeV, along with a quenching factor for alpha particles estimated to be 0.33 ± 0.03. Based on preliminary photoluminescence measurements, future measurements are planned to be taken at low-temperatures using the SiPM to improve the LY and FWHM of CTC.

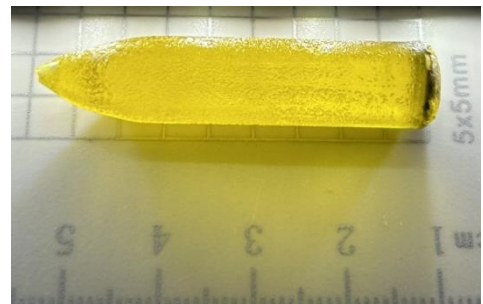


Figure 1. Cs₂TeCl₆ (CTC) single-crystal ingot.

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2. J. Lai, et al., Enhanced Performance in Cesium Tellurium Chlorine by Hafnium Alloying for X-Ray Computed Tomography Imaging. *Adv. Optical Materials*, **12**, 2303297 (2024).
3. A. Alessandrello et al., New limits on naturally occurring electron capture of ¹²³Te, *Phys. Rev. C*, **67**, 014323 (2003).