

Photoluminescence and Scintillation Properties of Copper Iodide Clusters with K- and Rb- Benzo-15-crown-5 Complexes

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Scintillators are luminescent materials which emit many photons when they are exposed to ionizing radiation, such as X-rays, γ -rays, and α -rays. They are widely used for ionizing-radiation detection across diverse fields such as medical diagnosis, security screening, and high-energy physics. For security-inspection systems (e.g., baggage X-ray scanners), scintillators are required to possess high density (ρ) and large effective atomic number (Z_{eff}), high light yield (LY), and low afterglow level (AL), to achieve efficient X-ray absorption, high signal-to-noise ratio, and suppressed noise in transmission imaging, respectively. A representative material used in the application is CdWO_4 (CWO) crystals, which shows $\rho = 7.9 \text{ g/cm}^3$, $Z_{\text{eff}} = 64$, suppressed $AL = 10\text{ppm}$, and high $LY = 15,800$ photons/MeV [1-3]. However, the use of CWO is subject to regulatory limitations due to its composition, which includes Cd, a toxic element regulated under the RoHS directive. The necessity for alternative scintillators that are both environmentally friendly and suitable for practical use has been increased by these restrictions.

Recently, organometallic compounds have attracted great attention as promising candidates for X-ray detection owing to their high LY and photoluminescence quantum yield (QY). In our previous work, organometallic single crystals composed of CuI clusters and 18-crown-6-alkali metal complexes were systematically investigated. Among the compounds, $(18\text{-crown-6})_2\text{Na}_2(\text{H}_2\text{O})_3\text{Cu}_4\text{I}_6$, showed the best scintillation properties, with a high LY value of 59,000 photons/MeV, high QY of 99%, well-suppressed AL of 3 ppm, and medium Z_{eff} of 44 [4]. In this study, we synthesized CuI clusters with K- and Rb- Benzo-15-crown-5 ($\text{C}_6\text{H}_4(\text{OCH}_2\text{CH}_2)_4\text{O}$) complexes, and evaluated their photoluminescence and scintillation properties. As a representative example, three-dimensional crystal structure and scintillation spectrum of $(\text{Benzo-15-crown-5})_4\text{K}_2\text{Cu}_2\text{I}_4$ are shown in Figure 1. The sample consists of $[\text{Cu}_2\text{I}_4]^{2-}$ cluster anions and $[\text{K}(\text{Benzo-15-crown-5})_2]^+$ cations, and it showed emission peaks and subpeaks at around respectively 500nm and 600 nm. The detailed results are introduced in the presentation.

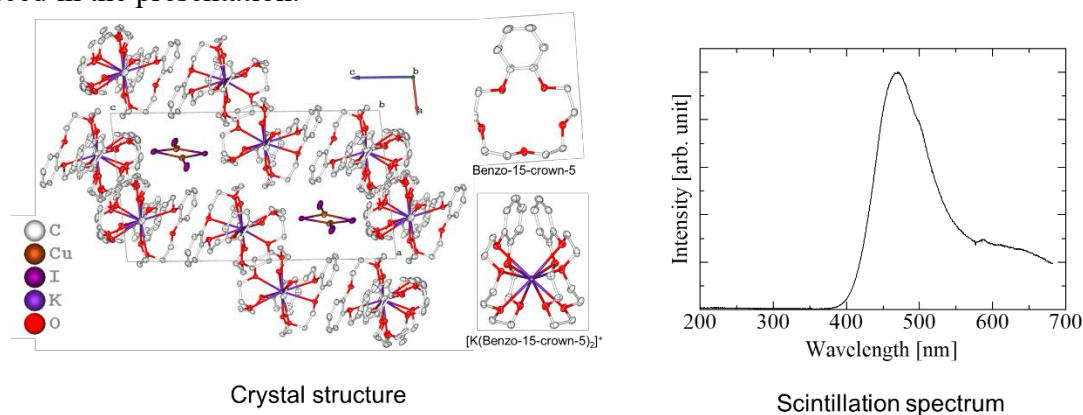


Fig. 1. Crystal structure and scintillation spectrum of $(\text{Benzo-15-crown-5})_4\text{K}_2\text{Cu}_2\text{I}_4$.

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