

Supporting Information

Rare earth-based Cs₂NaRECl₆ (RE = Tb, Eu) halide double perovskite nanocrystals with multicolor emissions for anticounterfeiting and LED applications

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Keywords: Halide double perovskite, Rare earth, Multicolor emissions, Anticounterfeiting, Light-emitting diodes

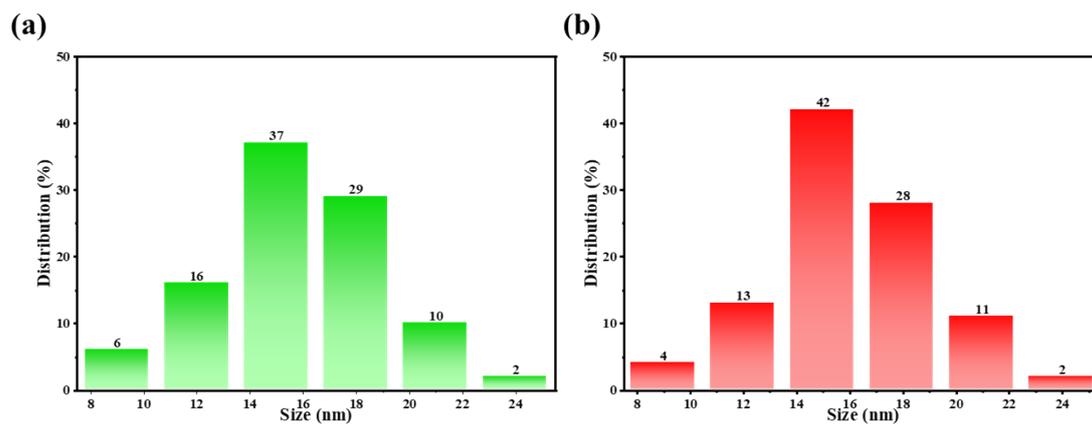


Fig. S1 The size distribution histograms of $\text{Cs}_2\text{NaTbCl}_6$ and $\text{Cs}_2\text{NaEuCl}_6$ NCs.

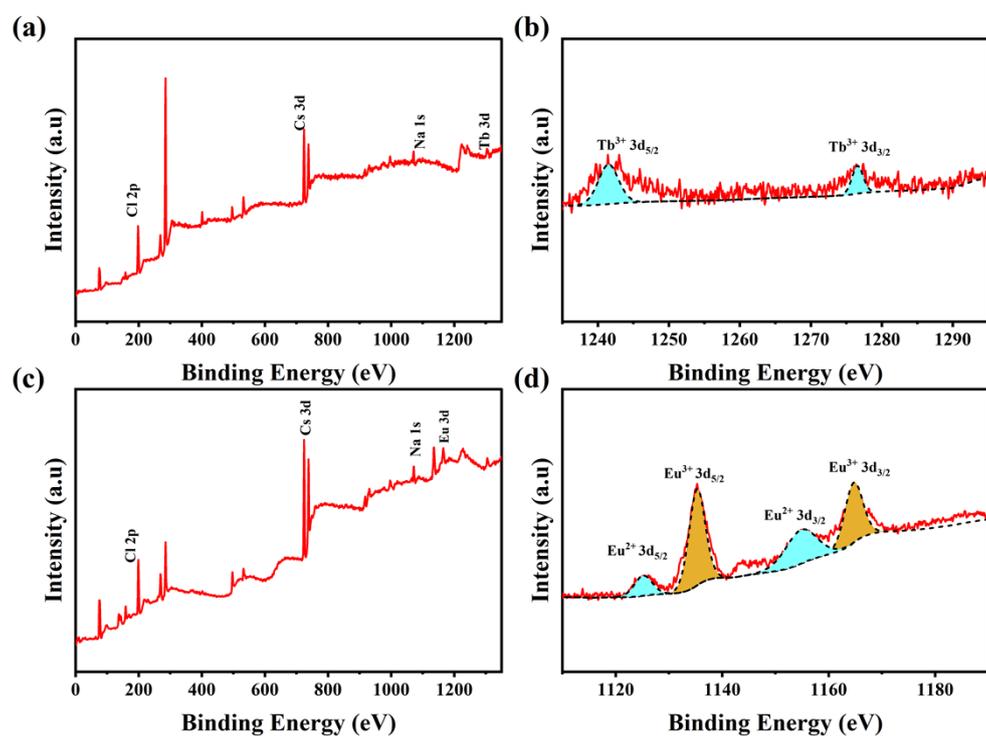


Fig. S2 Survey XPS spectra of $\text{Cs}_2\text{NaTbCl}_6$ (a) and $\text{Cs}_2\text{NaEuCl}_6$ (c). High-resolution XPS spectra of $\text{Cs}_2\text{NaTbCl}_6$ (b) and $\text{Cs}_2\text{NaEuCl}_6$ (d).

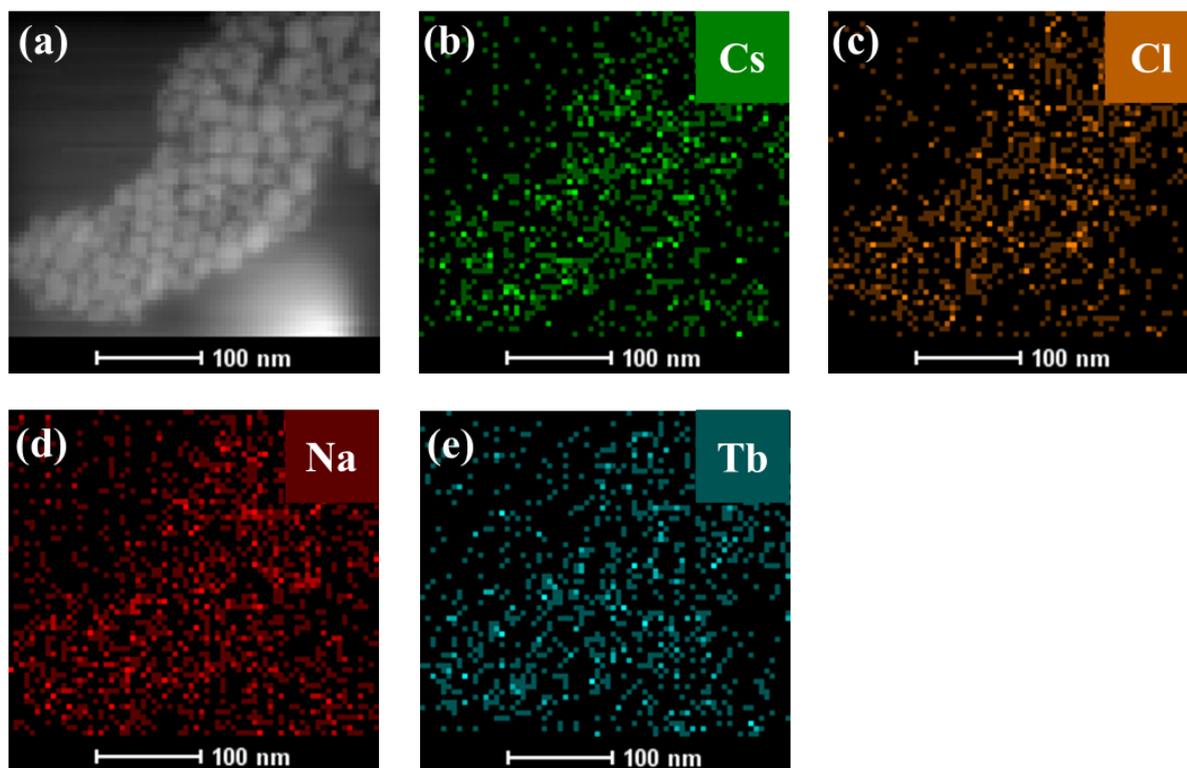


Fig. S3 (a) High-angle annular dark-field (HAADF) image of $\text{Cs}_2\text{NaTbCl}_6$ NCs. (b-e) STEM-EDS elemental mappings of Cs, Na, Tb and Cl elements colocalized in $\text{Cs}_2\text{NaTbCl}_6$ NCs.

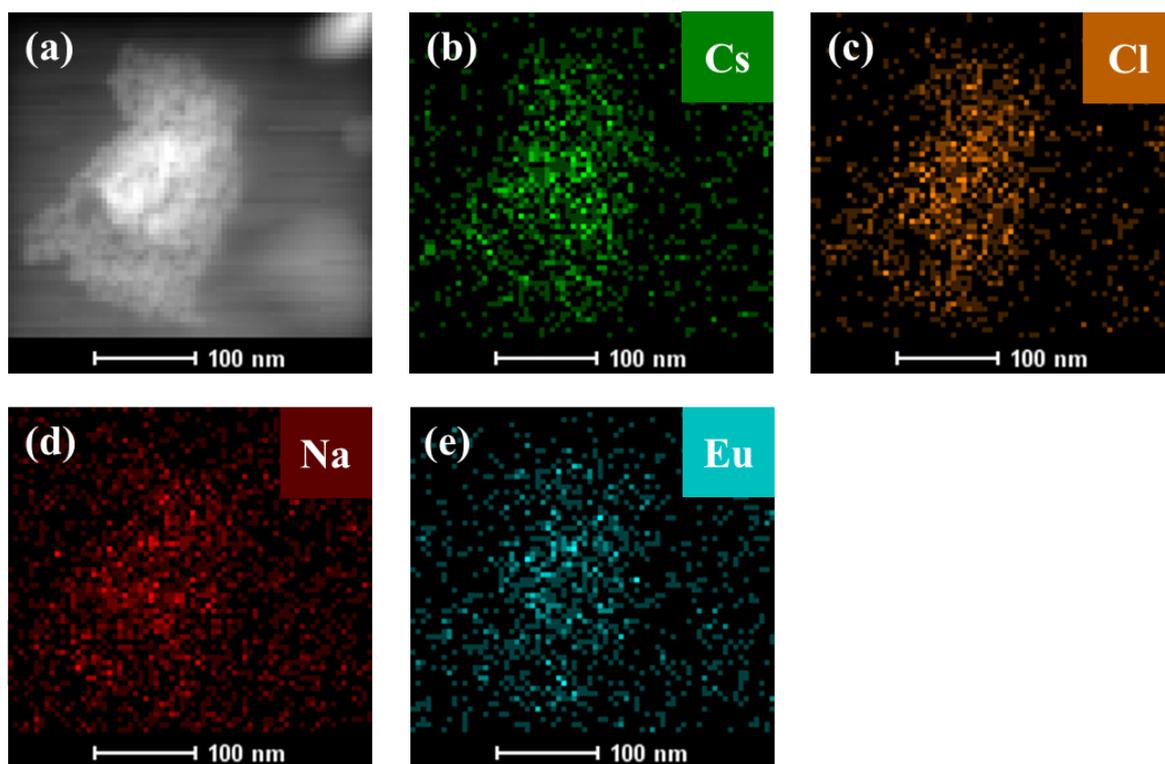


Fig. S4 (a) High-angle annular dark-field (HAADF) image of $\text{Cs}_2\text{NaEuCl}_6$ NCs. (b-e) STEM-EDS elemental mappings of Cs, Na, Eu, and Cl elements colocalized in $\text{Cs}_2\text{NaEuCl}_6$ NCs.

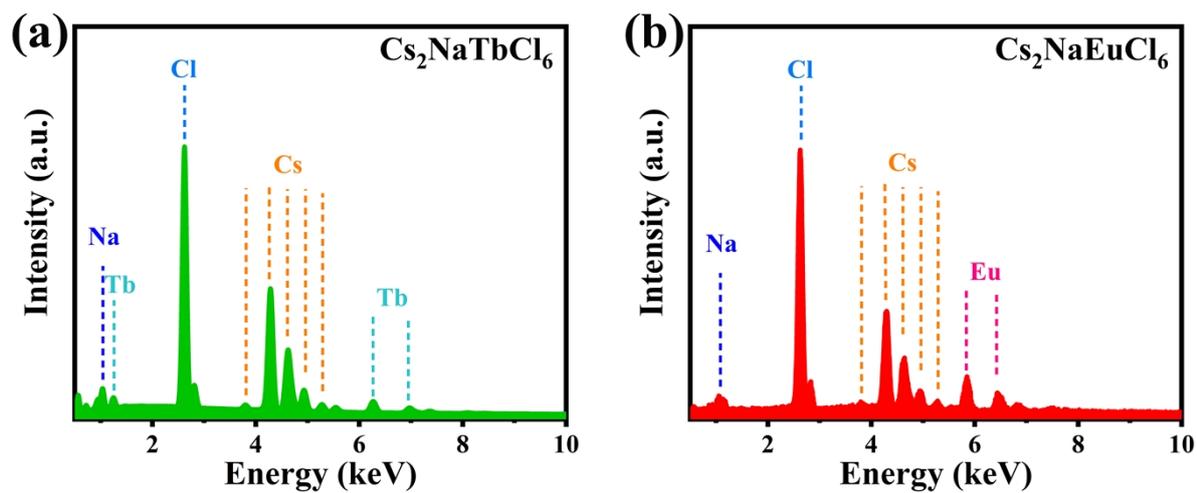


Fig. S5 EDX spectra of (a) $\text{Cs}_2\text{NaTbCl}_6$ and (b) $\text{Cs}_2\text{NaEuCl}_6$ NCs.

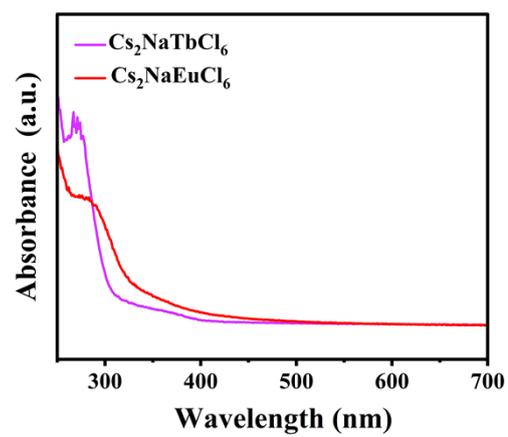


Fig. S6 UV-vis absorption spectra of Cs₂NaTbCl₆ and Cs₂NaEuCl₆ NCs.

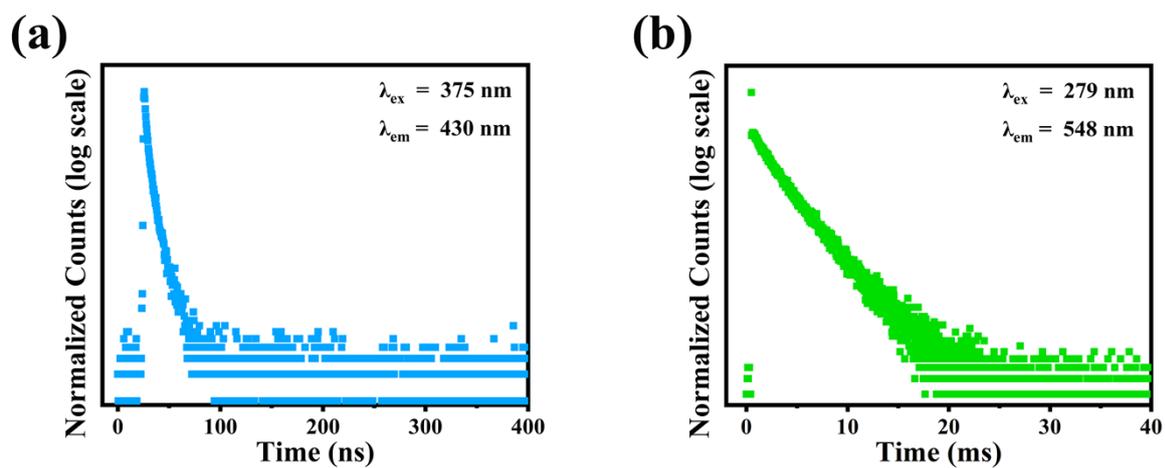


Fig. S7 The PL decay curves of $\text{Cs}_2\text{NaTbCl}_6$ NCs monitored at (a) 430 nm ($\lambda_{\text{ex}} = 375 \text{ nm}$) and (b) 548 nm ($\lambda_{\text{ex}} = 279 \text{ nm}$).

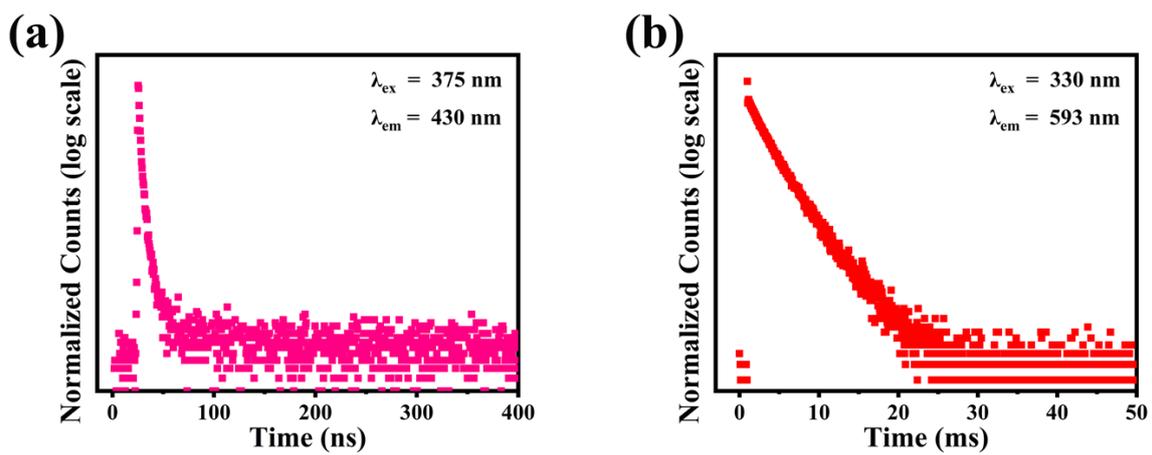


Fig. S8 The PL decay curves of $\text{Cs}_2\text{NaEuCl}_6$ NCs monitored at (a) 430 nm ($\lambda_{\text{ex}} = 375 \text{ nm}$) and (b) 593 nm ($\lambda_{\text{ex}} = 330 \text{ nm}$).

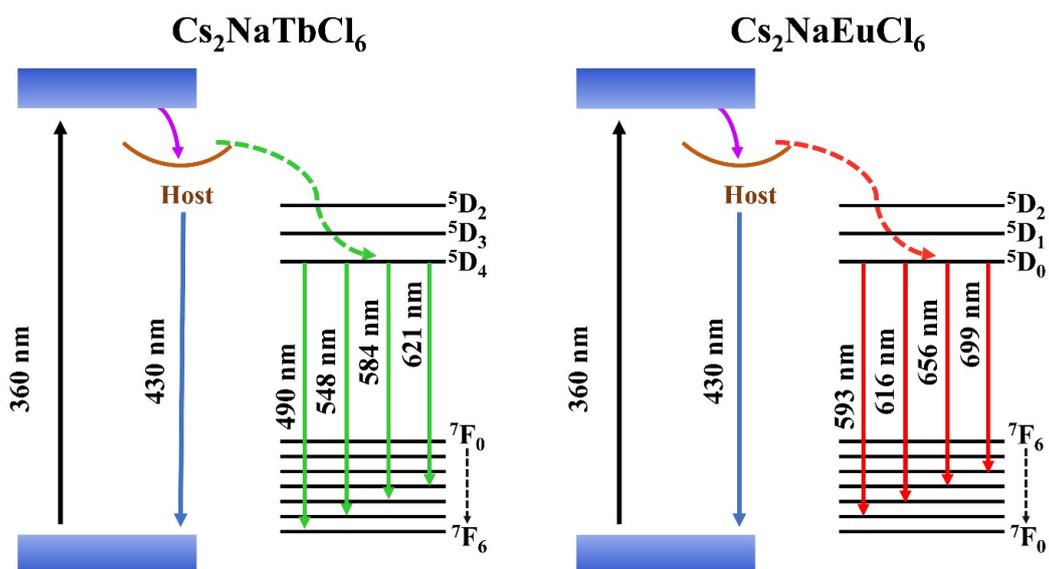


Fig. S9 Schematic diagram of the possible luminescence mechanism of $\text{Cs}_2\text{NaRECl}_6$ (RE = Tb, Eu) NCs.

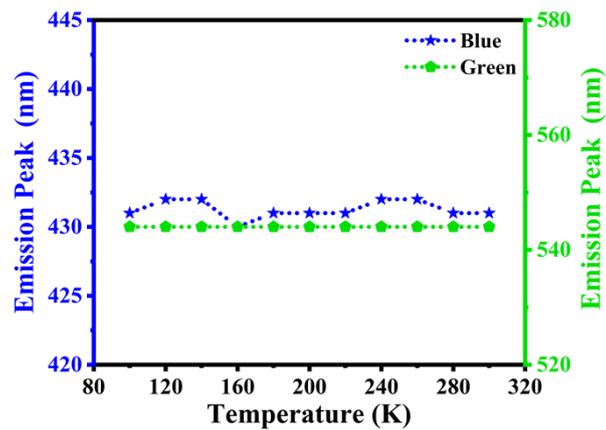


Fig. S10 PL peak changes of Cs₂NaTbCl₆ NCs under 360 nm excitation from 100-300 K (blue line: host emission, green line: Tb³⁺ ions emission).

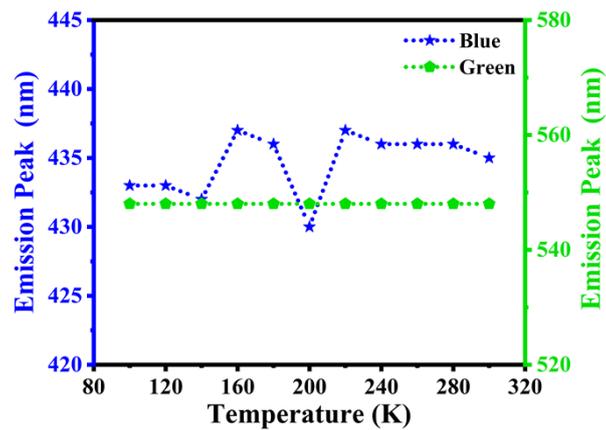


Fig. S11 PL peak changes of Cs₂NaTbCl₆ NCs under 279 nm excitation from 100-300 K (blue line: host emission, green line: Tb³⁺ ions emission).

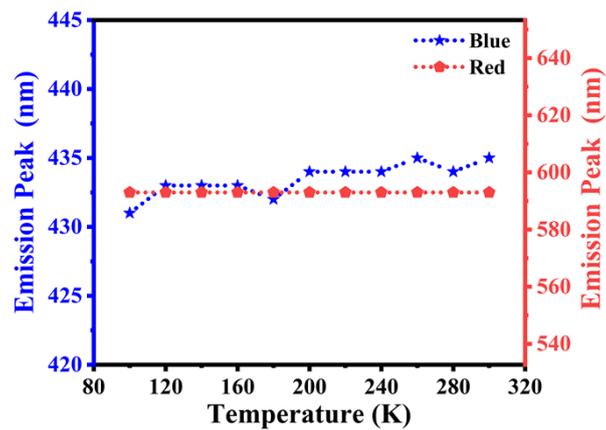


Fig. S12 PL peak changes of Cs₂NaEuCl₆ NCs under 360 nm excitation from 100-300 K (blue line: host emission, red line: Eu³⁺ ions emission).

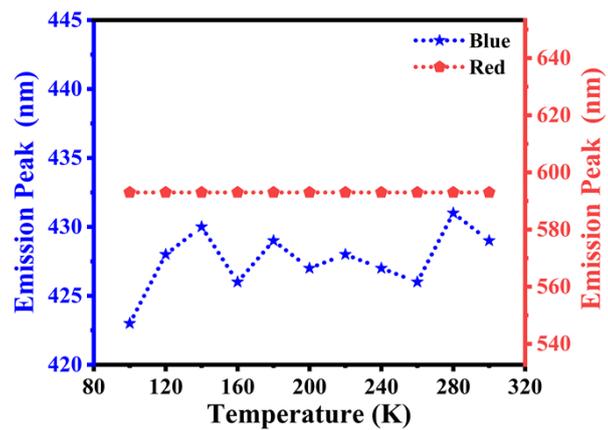


Fig. S13 PL peak changes of Cs₂NaEuCl₆ NCs under 330 nm excitation from 100-300 K (blue line: host emission, red line: Eu³⁺ ions emission).

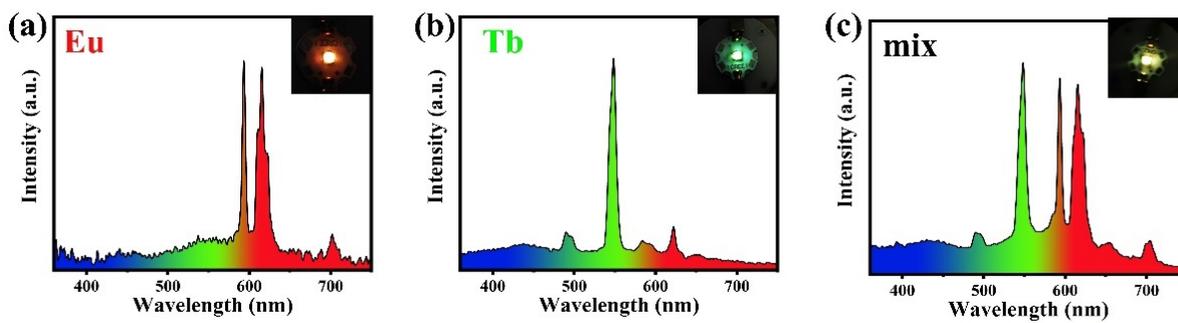


Fig. S14 Electroluminescence spectra of the LED devices based on (a) $\text{Cs}_2\text{NaEuCl}_6$ NCs, (b) $\text{Cs}_2\text{NaTbCl}_6$ NCs, and (c) $\text{Cs}_2\text{NaEuCl}_6$ and $\text{Cs}_2\text{NaTbCl}_6$ NCs. The insets show the corresponding photographs of LED devices driven by 20 mA forward current.