Supplementary Information

Dual-emissive $CsPbBr_3$@$NaGdF_4$:Eu^{3+} nanocomposites for ratiometric temperature sensing and anti-counterfeiting applications

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Due to the energy transfer process and the presence of two distinct luminescent centers in the CPB@NGF:40%Eu^{3+} nanocomposite, the measured fluorescence decay curves typically no longer follow a single-exponential decay law. Therefore, a double-exponential function must be used to fit the decay curves, and its form can be described by the following equation:

$$I(t) = A_1 \exp(-\frac{t}{\tau_1}) + A_2 \exp(-\frac{t}{\tau_2})$$

The average lifetime value is calculated using the following formula:

$$\tau_{avg} = \frac{A_1\tau_1^2 + A_2\tau_2^2}{A_1\tau_1 + A_2\tau_2}$$

τ_1 and τ_2 are the lifetimes of two different fluorescence emission pathways, radiative transition and non-radiative transition, while A_1 and A_2 represent their respective relative weights at t=0. Detailed fitting data are shown in Table S1 and S2.

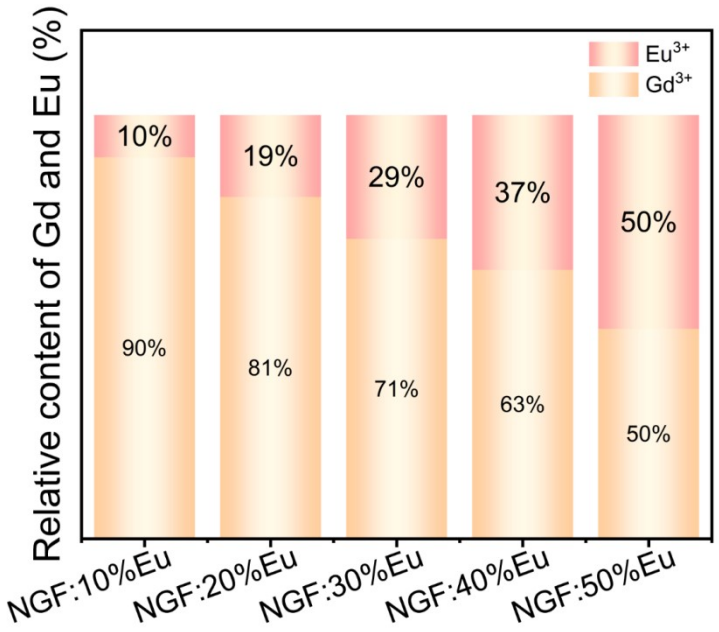

Fig. S1 ICP-OES test results for NGF:x%Eu^{3+}.

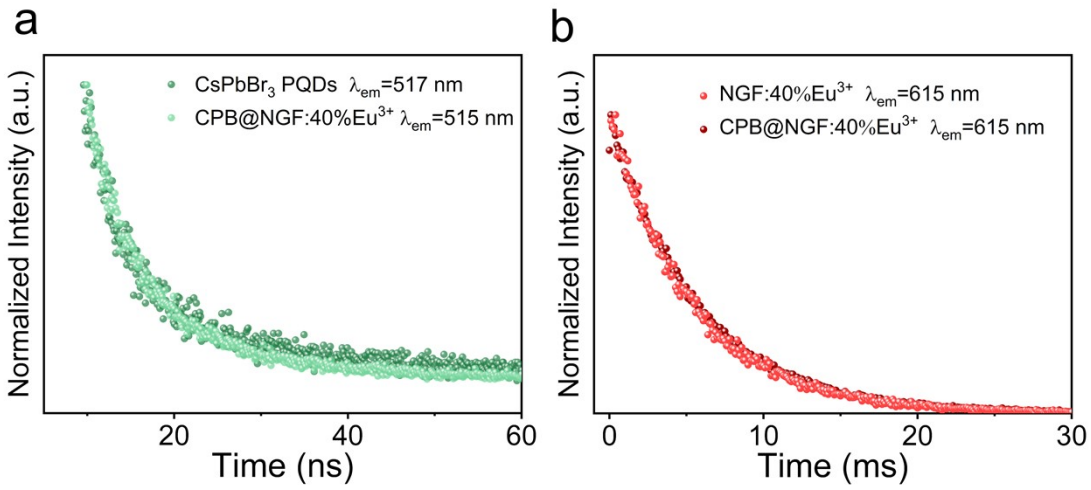

Fig. S2 (a) Fluorescence lifetimes of $CsPbBr_3$ PQDs before and after encapsulation; (b) fluorescence lifetimes of Eu^{3+} before and after encapsulation.

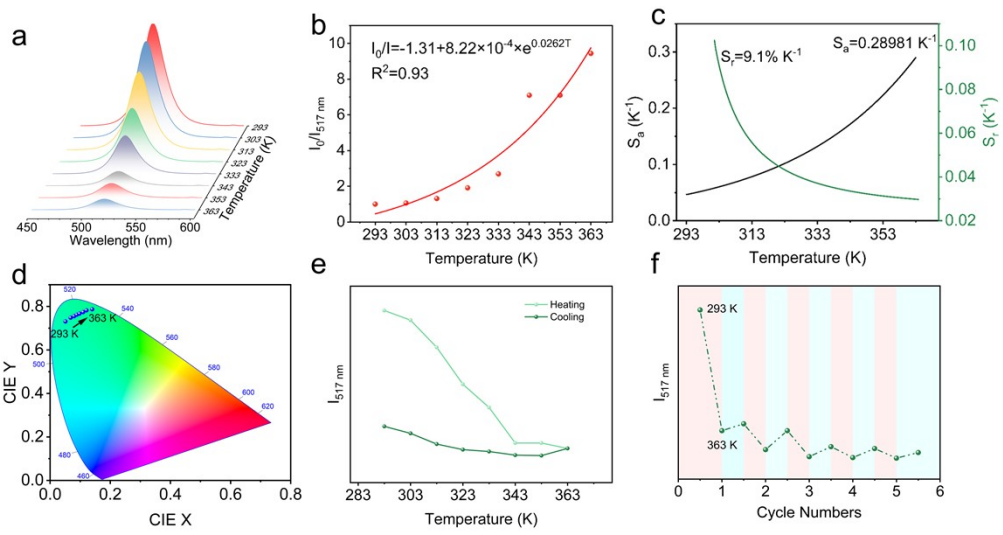

Fig. S3 (a) Temperature-dependent steady-state emission spectra of pure $CsPbBr_3$ PQDs over the temperature range of 293 K-363 K; (b) Exponential fitting curves of $I_0/I_{517\ nm}$ versus temperature at 293 K-363 K; (c) S_a and S_r of pure $CsPbBr_3$ PQDs versus temperature;(d) Corresponding CIE chromaticity diagram at different temperatures; (e) PL intensity changes of pure $CsPbBr_3$ PQDs. (f) pure $CsPbBr_3$ PQDs under heating and cooling cycles from 293 K to 363 K.

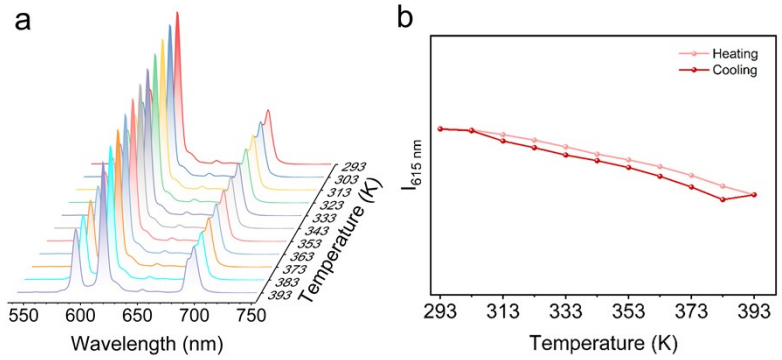

Fig. S4 (a) Temperature-dependent steady-state emission spectra of NGF:40%Eu^{3+} over the temperature range of 293 K-393 K; (b) PL intensity changes of NGF:40%Eu^{3+}.

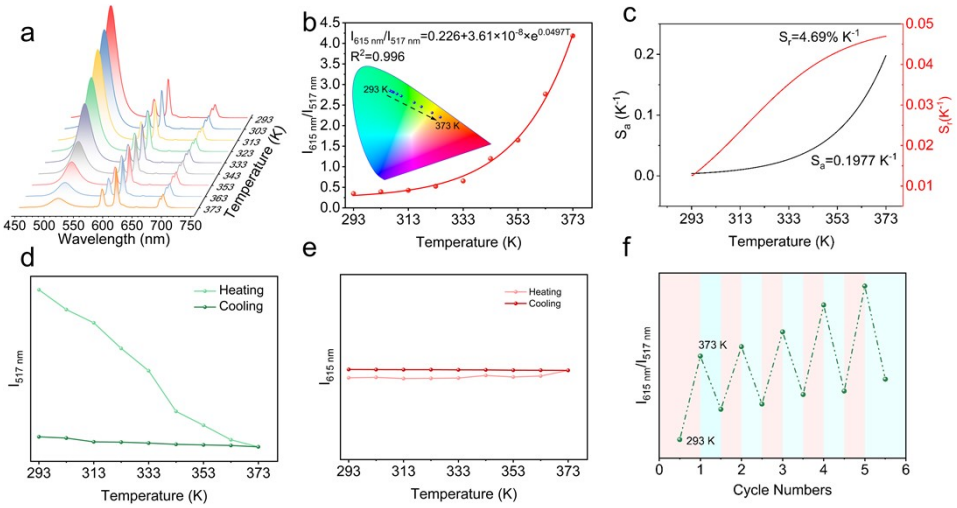

Fig. S5 (a) Temperature-dependent steady-state emission spectra of mixture of $CsPbBr_3$ PQDs and NGF:40%Eu^{3+} over the temperature range of 293 K-373 K; (b) Exponential fitting curves of $I_{615\ nm}/I_{517\ nm}$ versus temperature at 293 K-373 K (Inset:Corresponding CIE chromaticity diagram at different temperatures); (c) S_a and S_r of mixture of $CsPbBr_3$ PQDs and NGF:40%Eu^{3+} versus temperature; PL intensity changes in 517 nm (g) and 615 nm (h) during heating-cooling processes; (f) Mixture of $CsPbBr_3$ PQDs and NGF:40%Eu^{3+} under heating and cooling cycles.

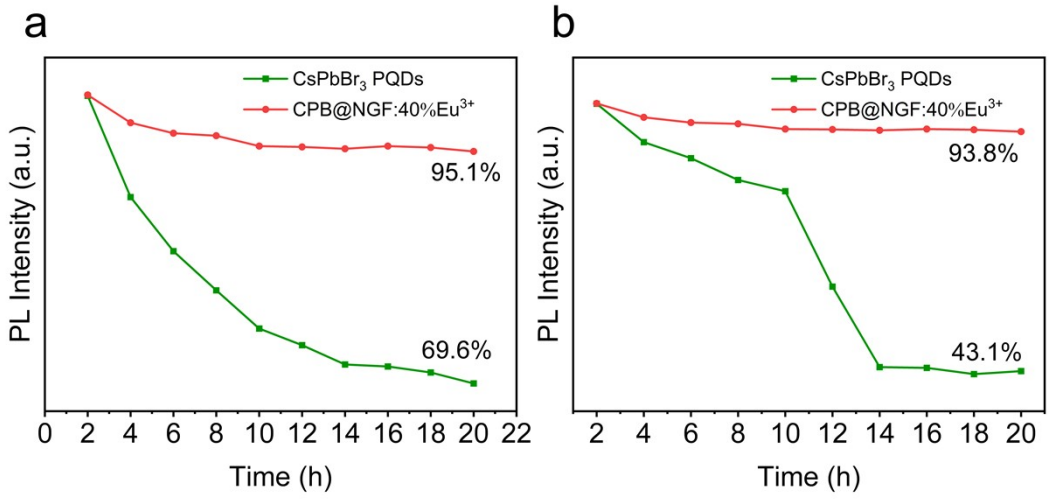

Fig. S6 (a) Relative fluorescence intensities of pure $CsPbBr_3$ PQDs and CPB@NGF:40% Eu^{3+} nanocomposites measured at room temperature at different time intervals; (b) Relative fluorescence intensities of pure $CsPbBr_3$ PQDs and CPB@NGF:40% Eu^{3+} nanocomposites measured at different time intervals under intense UV irradiation.

Table S1. PL decay parameters of $CsPbBr_3$ PQDs before and after encapsulation at an excitation wavelength of 395 nm

Samples	t_1 (ns)	t_2 (ns)	A_1	A_2	τ (ns)
$CsPbBr_3$ PQDs	4.30	19.82	6.21	0.44	8.13
CPB@NGF:40%Eu^{3+}	4.52	14.30	5.61	0.65	7.14

Table S2. PL decay parameters of Eu^{3+} before and after encapsulation at an excitation wavelength of 395 nm

Samples	t_1 (ms)	t_2 (ms)	A_1	A_2	τ (ms)
NGF:40%Eu^{3+}	4.88	6.93	0.50	0.23	5.69
CPB@NGF:40%Eu^{3+}	5.70	5.70	0.50	0.49	5.70