Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting Information for

Nanohybrids with switchable multicolor emission for anticounterfeiting

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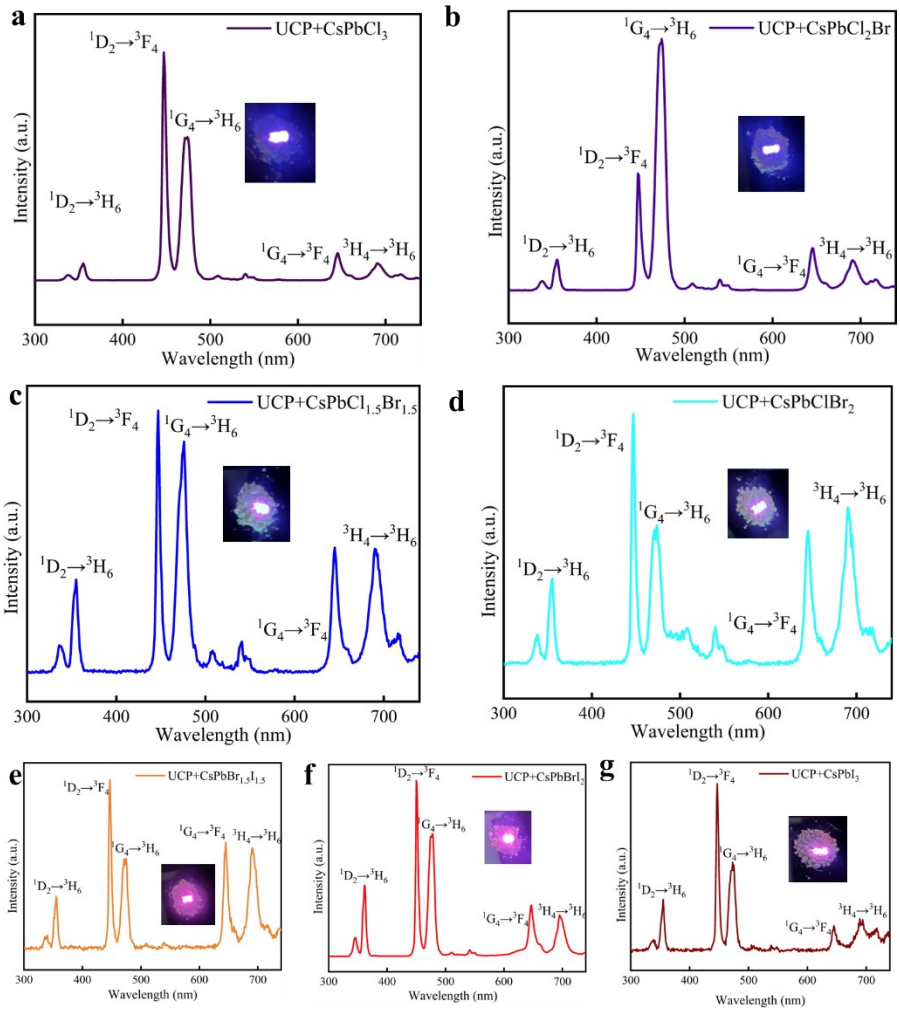

Figure S1. (a-g) UCL spectra of different samples. Inset of (b-k): Digital photographs of different samples under 980 nm laser diode.

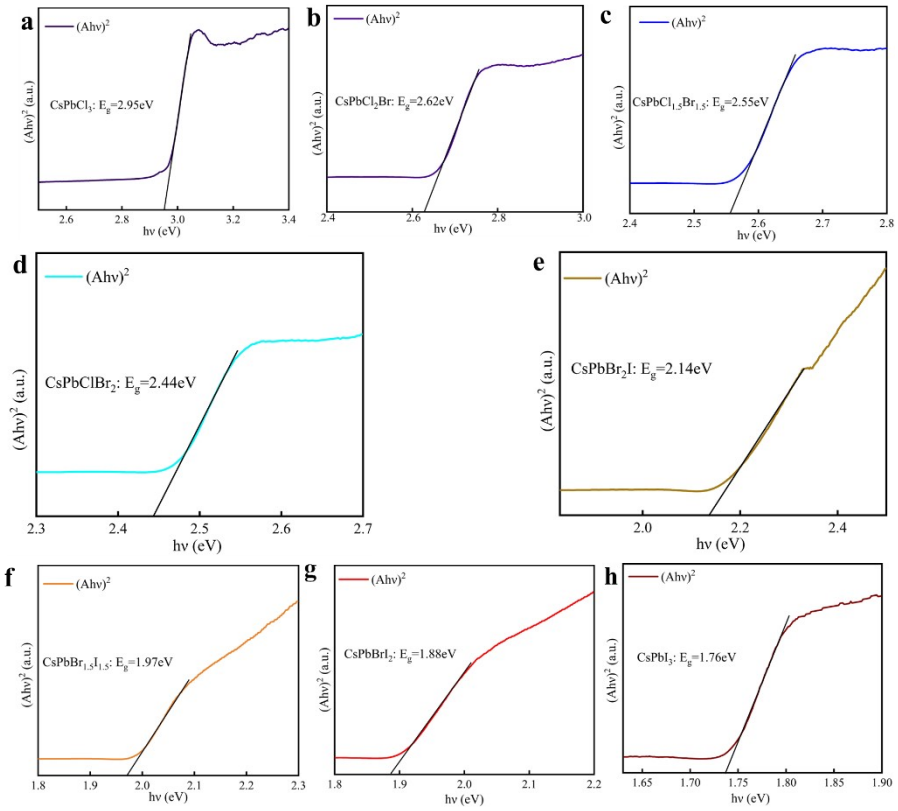

Figure S2. (a-h) $(Ahv)^2$-hv plot of different $CsPbX_3$ QDs glasses: the oblique line is the fitted curve to estimate the E_g.

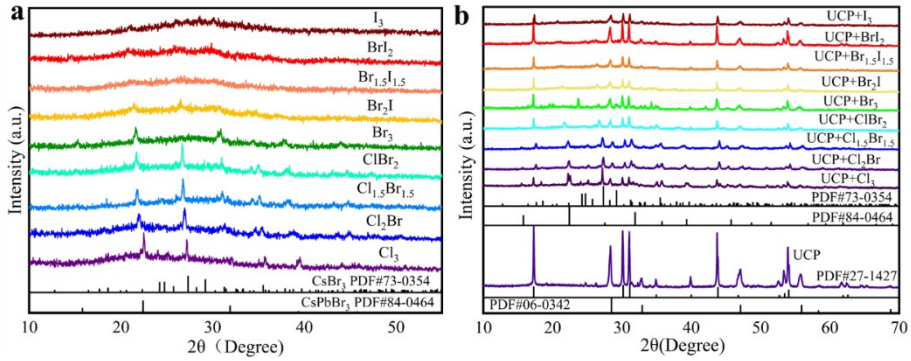

Figure S3. (a, b) XRD patterns of different $CsPbX_3$ QDs glasses and nanohybrids, respectively.

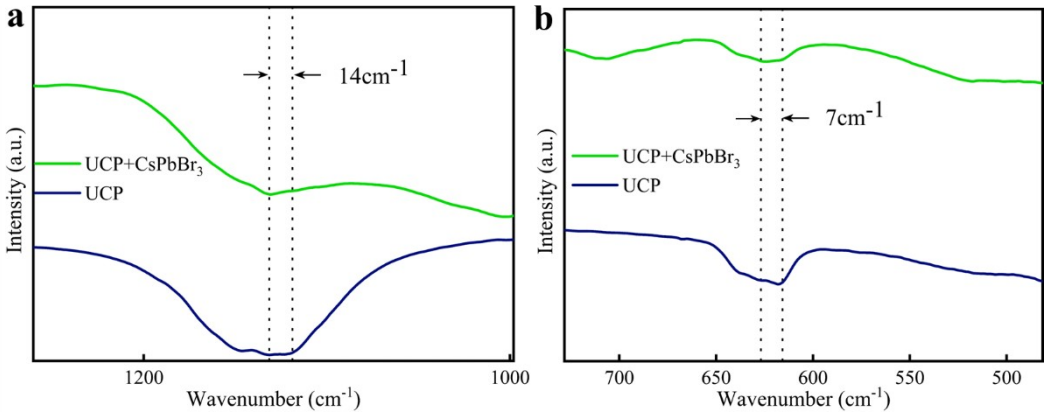

Figure S4. The partial magnification spectroscopy of the FTIR peaks shift.

Table S1 The fitting parameters of UCL decays lifetime for Tm/Yb: $NaYF_4$ UCP+$CsPbBr_3$ QDs glasses nanohybrids at different emission bands excited by 980 nm.

	362 nm		**450 nm**		**478 nm**		**524 nm**	
UCP/QDs	**A**	**τ(μs)**	**A**	**τ(μs)**	**A**	**τ(μs)**	**A**	**τ(μs)**
UCP	1.07	430.28	1.07	426.55	1.17	983.20	--	--
8:1	1.07	427.35	1.07	424.40	1.16	920.21	1.05	490.19
2:1	1.07	424.19	1.06	420.69	1.15	895.57	1.05	504.63
1:2	1.07	420.74	1.07	419.84	1.16	883.90	1.05	533.77
1:8	1.07	417.01	1.05	414.34	1.14	851.28	1.05	551.04

Both Tm^{3+} ions and $CsPbBr_3$ QDs UCL lifetimes in **nanohybrids V** are obtained by singe exponential decay [1]:

$$I = A\exp(-t/\tau) \qquad \textbf{(S1)}$$

Where I is the luminescence intensity of Tm^{3+} ions or $CsPbB_3$ QDs; t is the time; A is fitting constants; τ is fluorescence lifetimes for the exponential components.

The DCL lifetime of $CsPbBr_3$ QDs glasses are obtained by double exponential decay [1]:

$$I = A_1\exp(-t/\tau_1)+A_2\exp(-t/\tau_2) \qquad \textbf{(S2)}$$

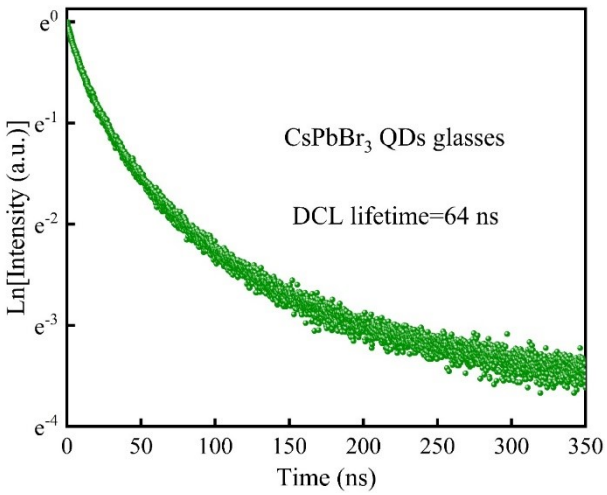

Figure S5. DCL decay curve of $CsPbBr_3$ QDs glasses.

Note 1: Förster radius (R_0)

Förster radius R_0 is the distance between donor and acceptor when the energy transfer efficiency is 50%, the equation is defined as [2]:

$$R_0^6 = \left[\frac{9(\ln 10)\kappa^2\eta_D}{128\pi^5 N_A n^4} J\right] \quad \textbf{(S3)}$$

Known from the **Equation S3** that Förster radius R_0 is proportional to the orientation factor of the interacting dipoles (κ^2), the donor's UCL fluorescence quantum yield in the absence of acceptor (η_D), spectral overlap integral (M^{-1} cm^{-1} nm^4) (J), and is inversely proportional to the Avogadro constant (N_A), and the average refractive index of the medium (n). The spectral overlap integral J is calculated as [2]:

$$J(\lambda) = \int F_D(\lambda)\varepsilon_A\lambda^4 d\lambda \quad \textbf{(S4)}$$

Where F_D (λ) is the UCL spectrum of the donor normalized to unit area, which is $5.4*10^{16}$, ε_A is the molar extinction coefficient (M^{-1} cm^{-1}) of quantum dots, which is $5*10^6$ $M^{-1}cm^{-1}$, λ is the wavelength range of spectral overlap of donner and acceptor (300~600 nm). Herein, assuming that interacting dipoles κ^2 is a random orientation of donor and acceptor, thus the value of κ^2 is 2/3 (the most used value in the literature), the value of η_D is 0.01%, the average refractive index of the medium (glass and UCP) is assumed as 1.5.

Note 2 Determination of the slope of the double logarithmic plots of the UCL intensity vs. excitation power density.

The relationship between UCL intensity and the laser power densities of 980 nm is defined as [3],

$$I_{UCL} \propto (I_{NIR})^n \qquad (\mathbf{S5})$$

Where n refers to the number of photons.

References

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2. R. Marin, L. Labrador-Páez, A. Skripka, P.H. González, A. Benayas, P. Canton, D. Jaque, F. Vetrone, ACS Photonics. 2018, **5**, 2261-2270.
3. Z. Chen, Q. Zhou, H.T. Du, Y. Yu, C. Zhang, S.H. Han, Z.Y. Pang, Photonics. Res, 2021, **9**, 865-872.