Supporting Information for

2D/3D Heterostructure Derived from Phase Transformation of 0D Perovskite for Random Lasing Applications with Remarkably improved Water Resistance

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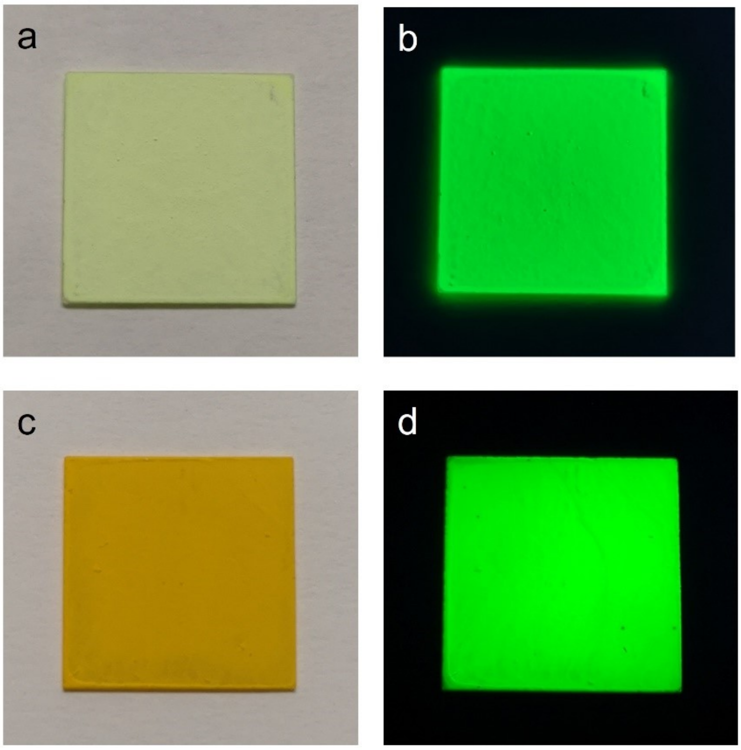

Figure S1. Photographs of perovskite films fabricated by drop casting Cs_4PbBr_6 NCs (a, b) and $CsPb_2Br_5/CsPbBr_3$ NCs (c, d) on glass substrates: illuminated by room lamp (a, c) and UV lamp (b, d) at 365 nm.

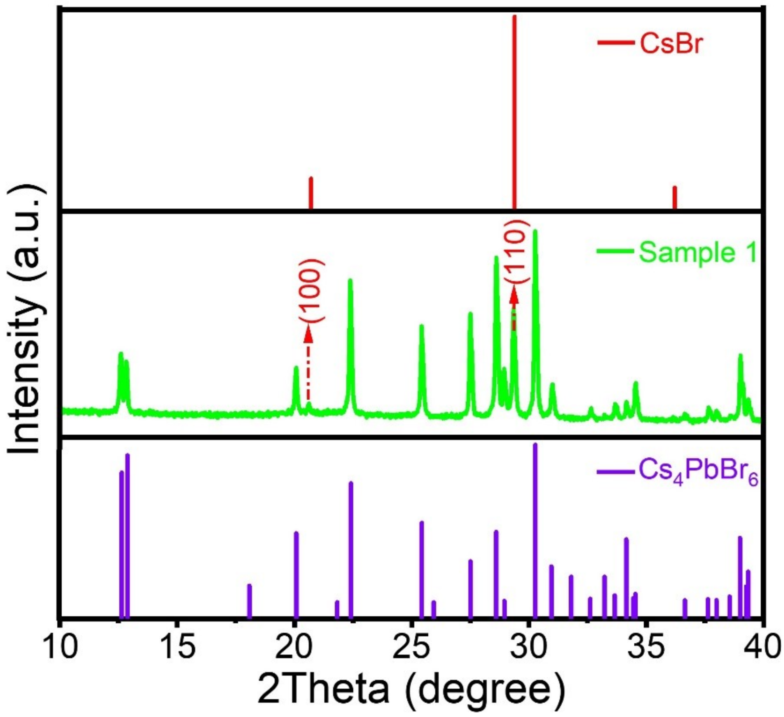

Figure S2. XRD patters of Cs_4PbBr_6 NCs. The standard patterns of CsBr and Cs_4PbBr_6 are introduced for comparison. Residual phase of CsBr can be clearly identified in the developed Cs_4PbBr_6 NCs.

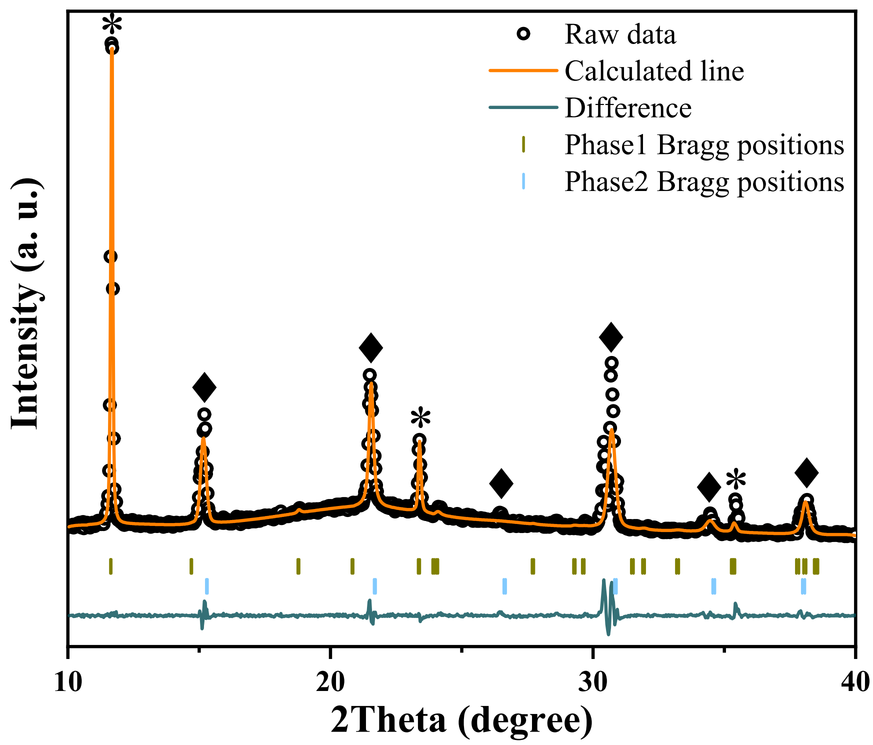

Figure S3. XRD refinement of the XRD pattern of the developed 2D/3D heterostructure. The results are fitted with the GSAS software, indicating that the molar ratio of $CsPb_2Br_5$ to $CsPbBr_3$ is approximately 3:7. The $CsPbBr_3$ phase is marked with the stars, while the $CsPb_2Br_5$ phase is marked with diamonds.

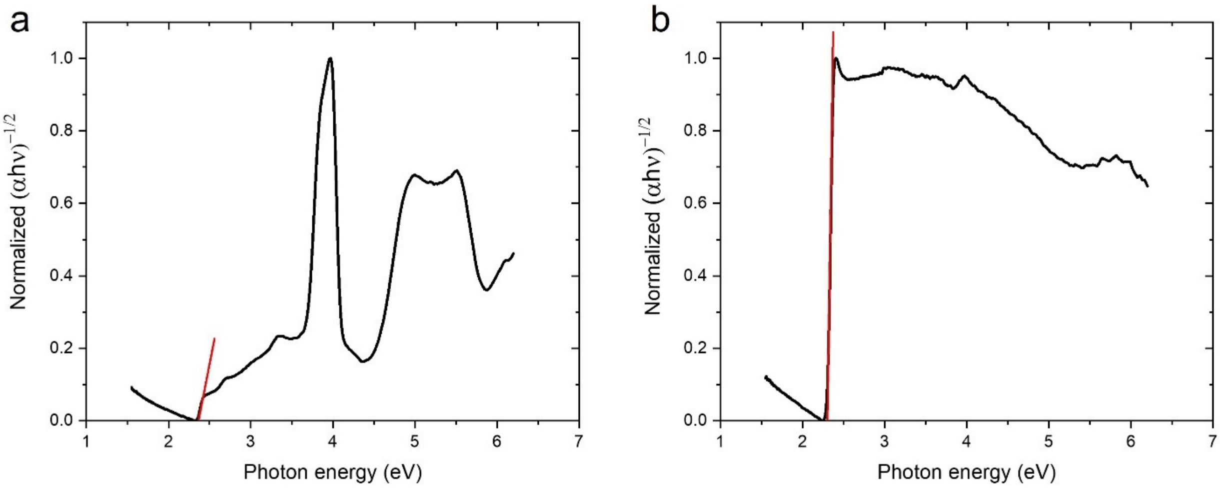

Figure S4. Determine optical bandgap via Tauc plot of Cs_4PbBr_6 (a) and $CsPb_2Br_5/CsPbBr_3$ (b). The Tauc relation is described with $(\varepsilon h\nu)^{1/n} = C(h\nu - E_g)$, where ε is the molar extinction coefficient, h is the Plank constant, ν is the frequency, C is a constant, E_g is the bandgap. Here, n = 2 is taken for Cs_4PbBr_6 since Cs_4PbBr_6 is usually viewed as indirect allowed transition, while n = 1 is taken for $CsPb_2Br_5/CsPbBr_3$ since $CsPbBr_3$ is generally thought as direct bandgap semiconductor. The black curves are experimental data, while the red lines are tangents. The crossover of the tangents with the x axis determines the optical bandgap.

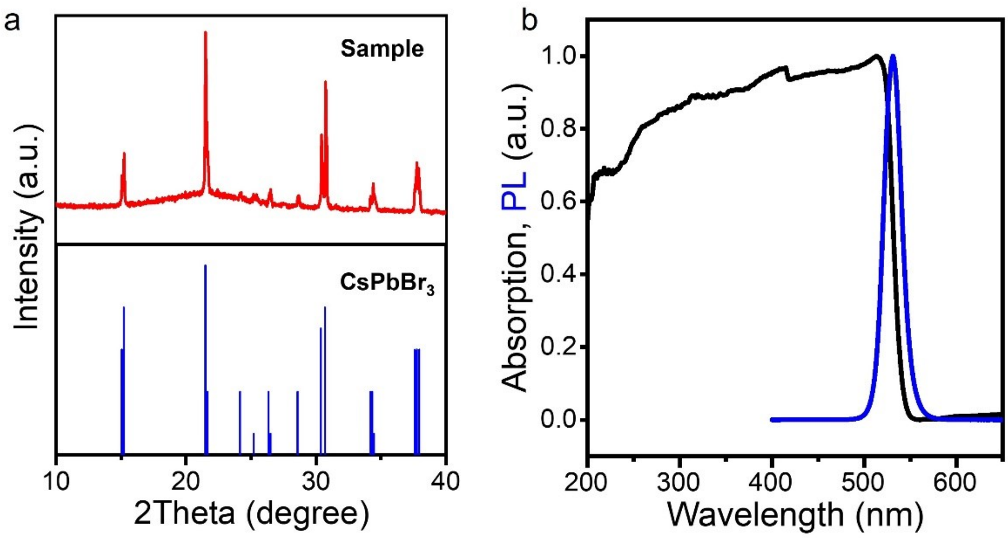

Figure S5. (a) XRD pattern of the obtained $CsPbBr_3$ product upon phase transformation Cs_4PbBr_6 when exposed to methanol. The standard pattern of $CsPbBr_3$ is presented for comparison. (b) Optical absorption (black) and photoluminescence (red) spectra of the obtained $CsPbBr_3$ product.

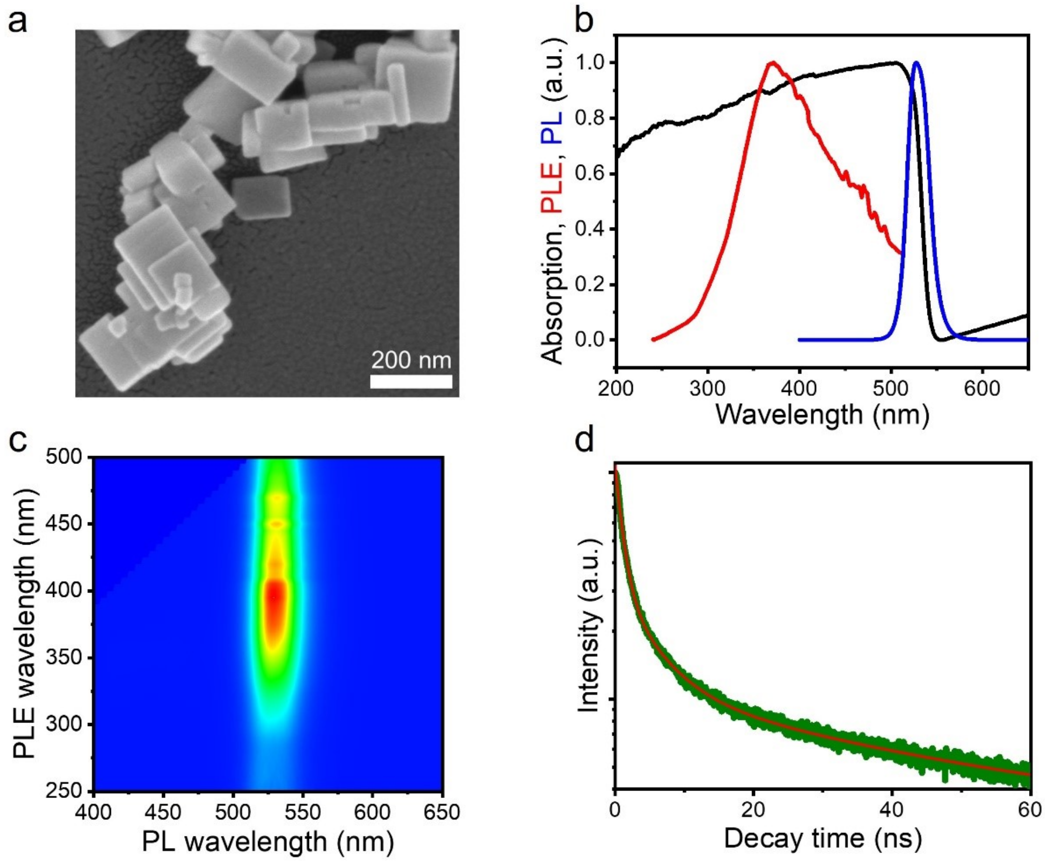

Figure S6. Structural and optical characterizations of $CsPbBr_3$ NCs: (a) SEM image; (b) Optical absorption (black curve), PLE (red curve), and PL (blue curve) spectra; (c) 2D PLE-PL mapping; and (d) Transient-state PL spectrum: experimental (green) and triple exponential fit (red).

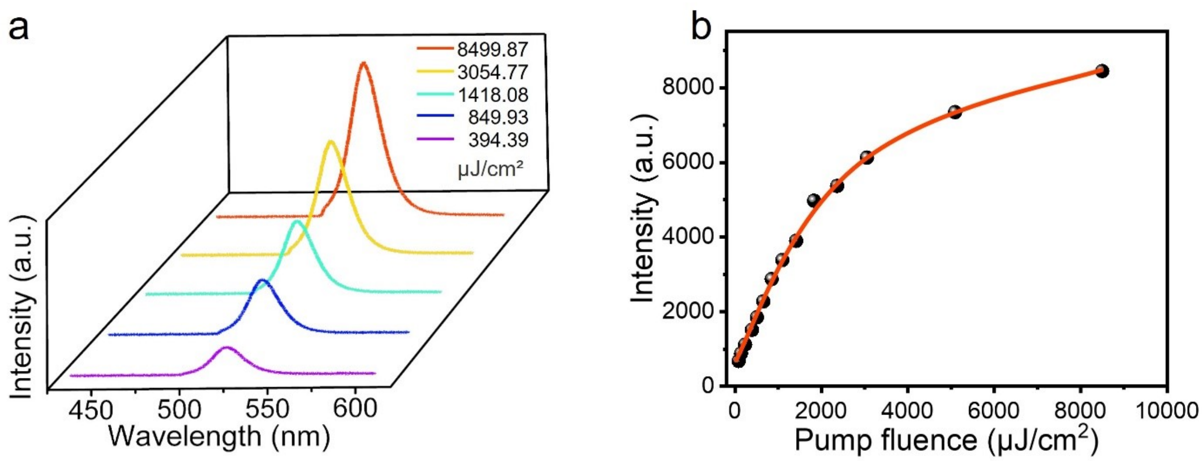

Figure S7. PL properties of Cs_4PbBr_6 NC film upon optical pumping. (a) Evolution of the PL spectral profile with the pump fluence. (b) Plot of the PL intensity with the pump fluence. No spectral indicative of light amplification is observed.

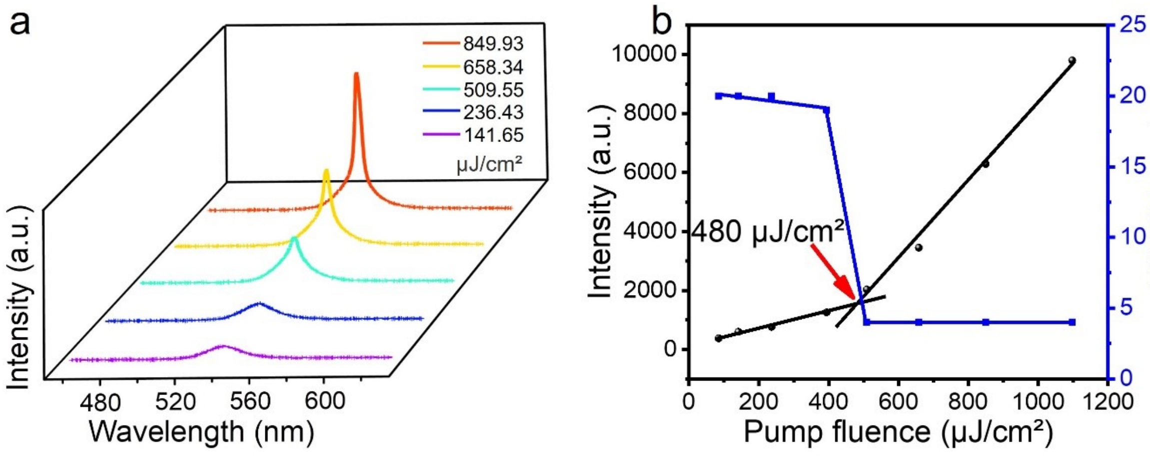

Figure S8. PL properties of the $CsPb_2Br_5/CsPbBr_3$ NC film after the first time water soaking. (a) Evolution of the PL spectral profile with the pump fluence. (b) Plot of the PL intensity with the pump fluence. The pump threshold is ~480 μJ/cm^2.

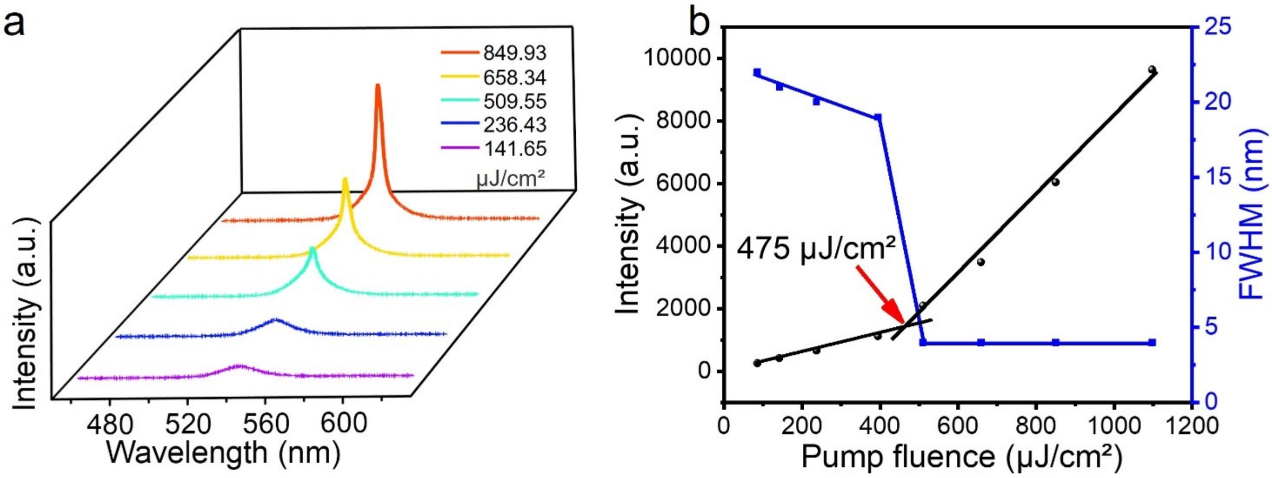

Figure S9. PL properties of the $CsPb_2Br_5/CsPbBr_3$ NC film after the second time water soaking. (a) Evolution of the PL spectral profile with the pump fluence. (b) Plot of the PL intensity with the pump fluence. The pump threshold is ~475 μJ/cm^2.

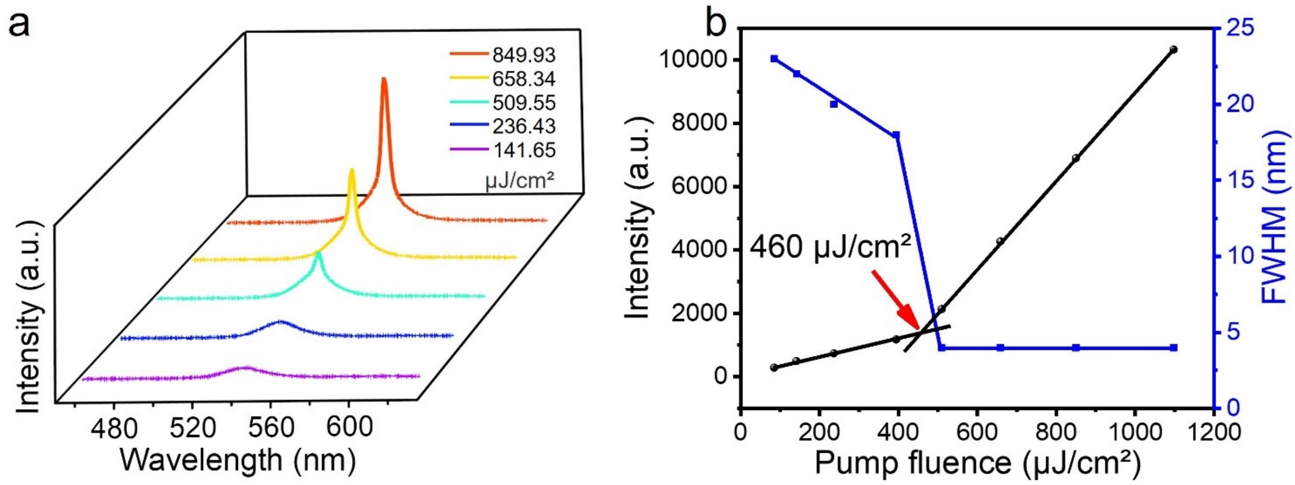

Figure S10. PL properties of the $CsPb_2Br_5/CsPbBr_3$ NC film after the third time water soaking. (a) Evolution of the PL spectral profile with the pump fluence. (b) Plot of the PL intensity with the pump fluence. The pump threshold is ~460 μJ/cm^2.

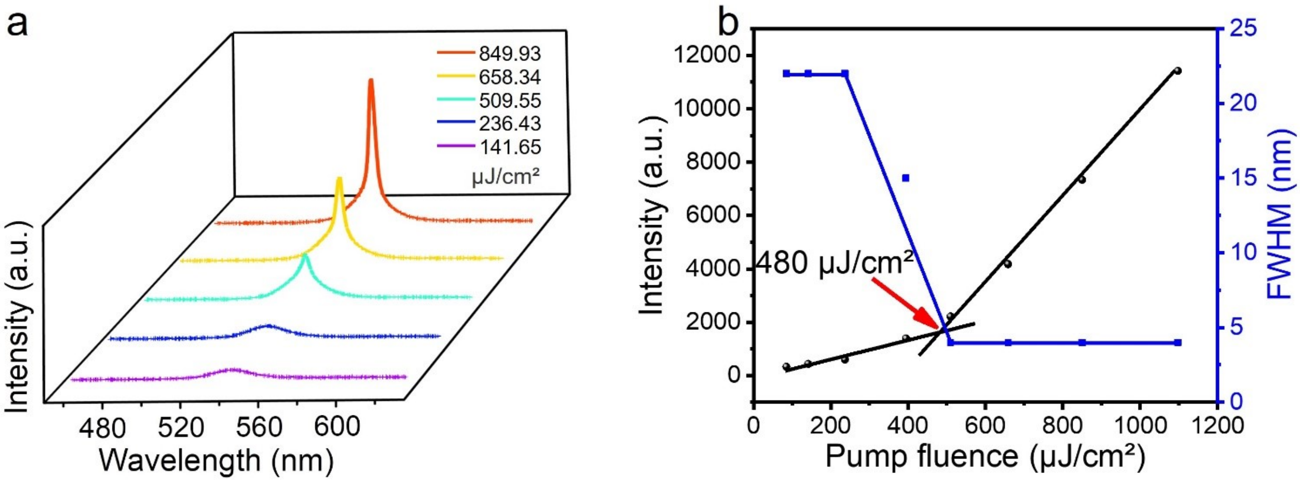

Figure S11. PL properties of the $CsPb_2Br_5/CsPbBr_3$ NC film after the fourth time water soaking. (a) Evolution of the PL spectral profile with the pump fluence. (b) Plot of the PL intensity with the pump fluence. The pump threshold is ~480 μJ/cm^2.

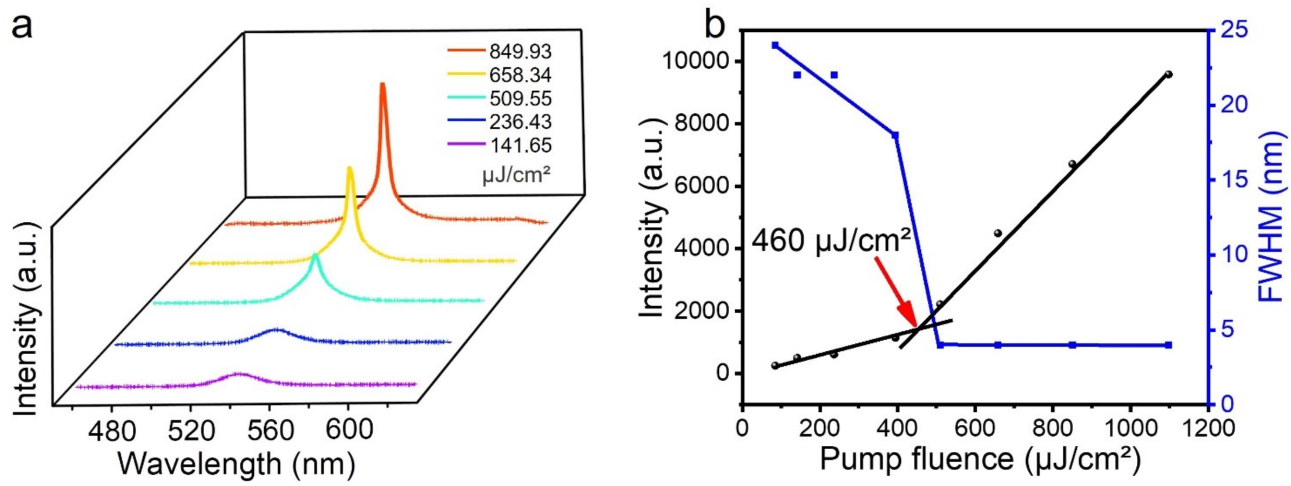

Figure S12. PL properties of the $CsPb_2Br_5/CsPbBr_3$ NC film after the fifth time water soaking. (a) Evolution of the PL spectral profile with the pump fluence. (b) Plot of the PL intensity with the pump fluence. The pump threshold is ~460 μJ/cm^2.