Supporting Information

# Ice-Confined Synthesis of Lecithin-Protected Perovskite Microcrystals for Stable Optical Synapse

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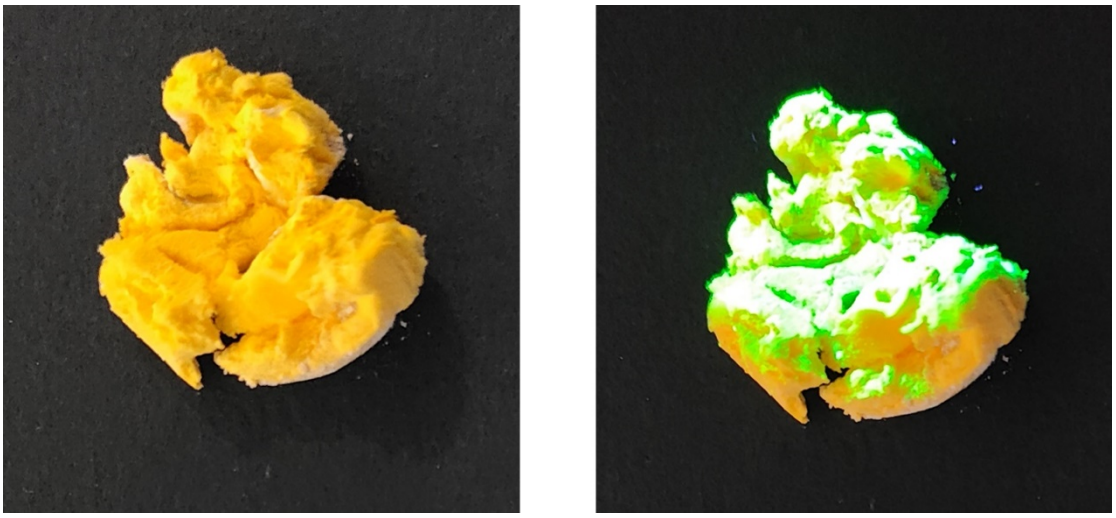

**Fig. S1.** Optical photographs of PeMCs synthesized by the ice-confined strategy (left: under fluorescent light, right: under UV light).

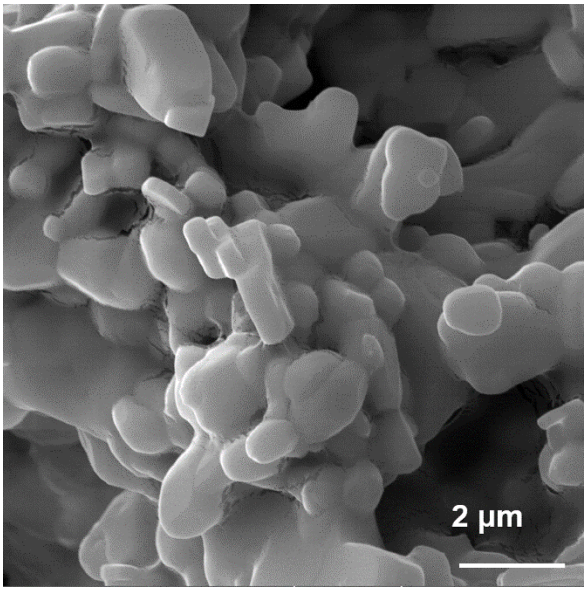


**Fig. S2.** SEM image of ligand-free synthesized perovskite material by ice-confined strategy.

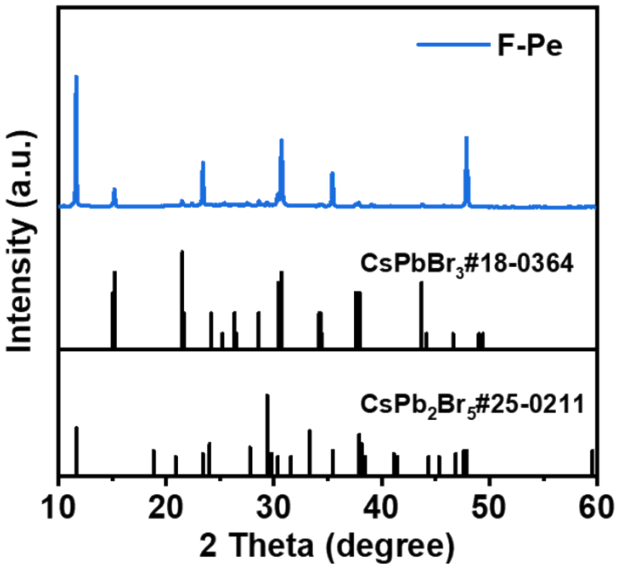


**Fig. S3.** XRD pattern of perovskite material without ligand.

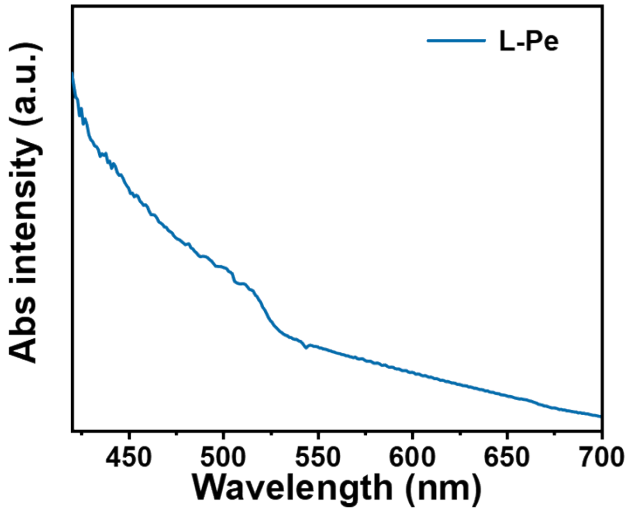


**Fig. S4.** The Abs spectra of lecithin-protected PeMCs.

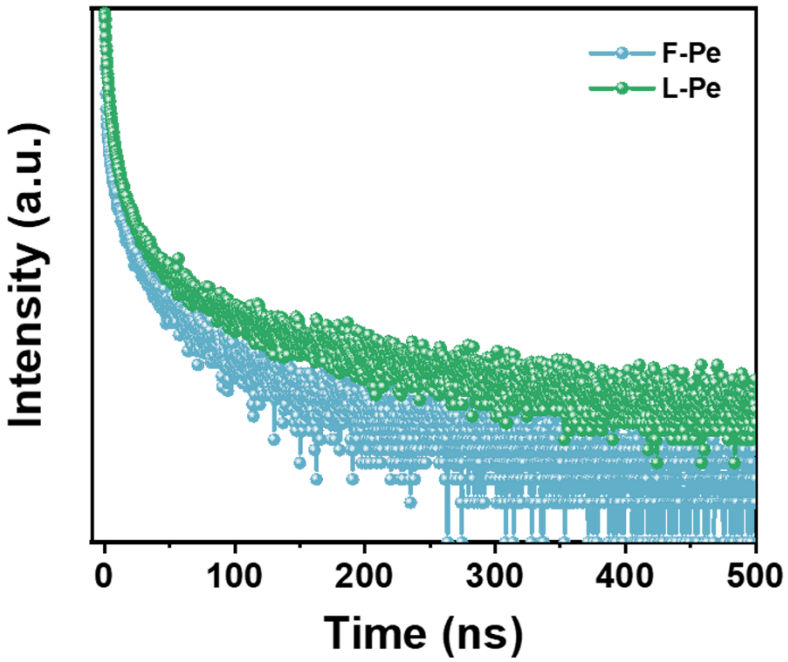


**Fig. S5.** Time-resolved PL decay spectra of perovskite materials.

Decay curves were fitted using the following double exponential function equations, respectively, and the average lifetime ($\tau_{avg}$) of the entire fluorescence decay process was calculated:

$$I = A_1 e^{-\frac{\tau}{\tau 1}} + A_2 e^{-\frac{\tau}{\tau 2}}$$

where $\tau_1$ and $\tau_2$ are the decay lifetimes, and $A_1$ and $A_2$ are the finger-forward factors of $\tau_1$ and $\tau_2$. The TRPL spectrogram of the perovskite material is shown in **Figure S4**. The results of fitting the two perovskite materials using the double-exponential formula are shown in **Table 1**, where $\tau_1$ = 15.44 ns in 38.08% and $\tau_2$ = 124.74 ns in 61.92% of the fitting results for the lecithin-protected PeMCs; As for the ligand-free perovskite material, its $\tau_1$=8.85 ns with a percentage of 49.39% and $\tau_2$=77 ns with a percentage of 50.61%.

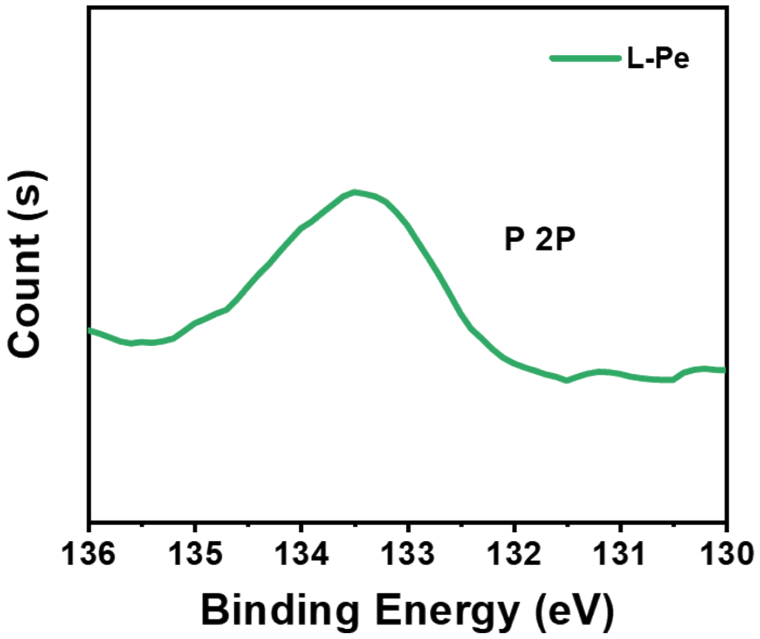


**Fig. S6.** High-resolution XPS spectra corresponding to P 2p of lecithin-protected PeMCs.

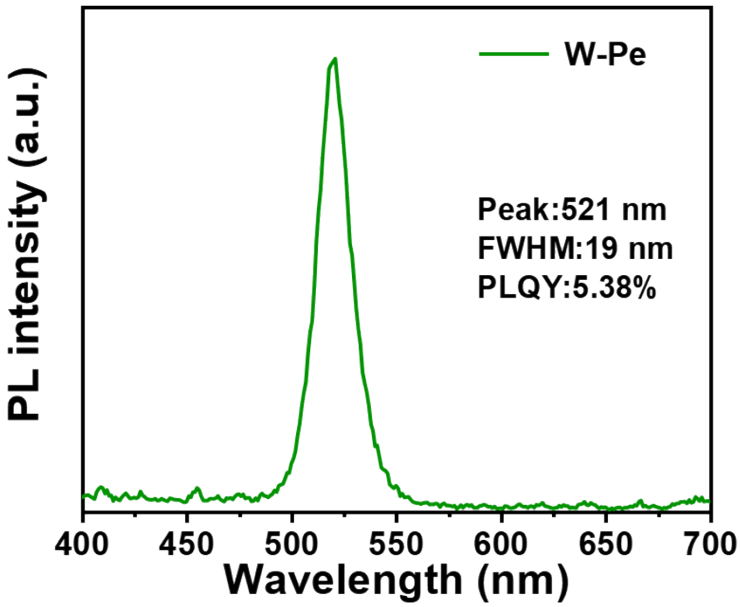


**Fig. S7.** PL spectra of $CsPbBr_3$ PeMCs dispersed in water.

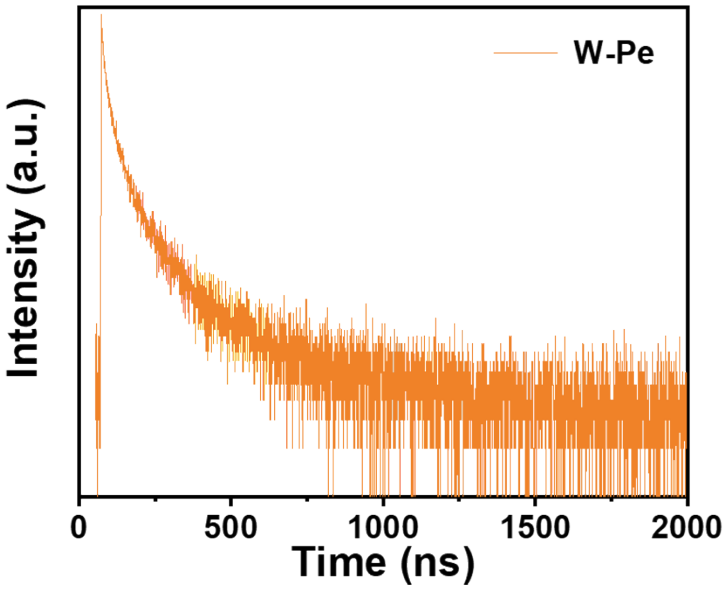


**Fig. S8.** Time-resolved PL decay spectra of $CsPbBr_3$ PeMCs dispersed in water.

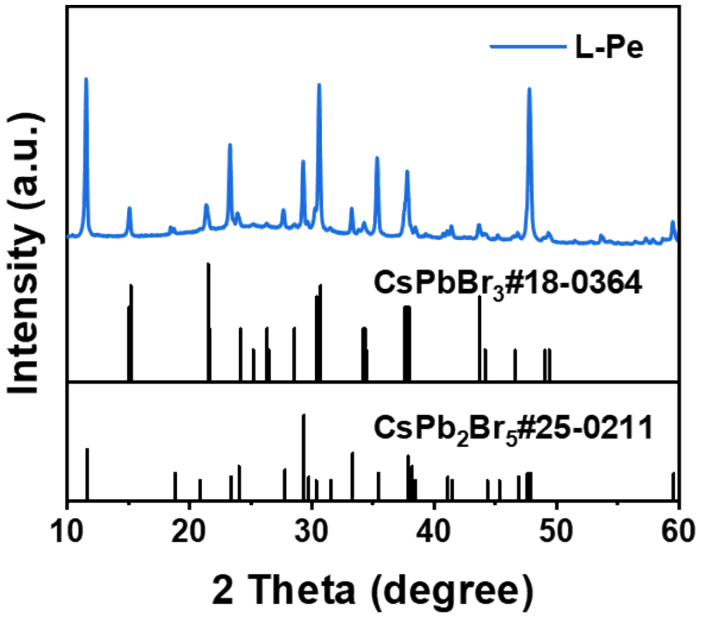


**Fig. S9.** XRD pattern of PeMCs in aqueous solution.

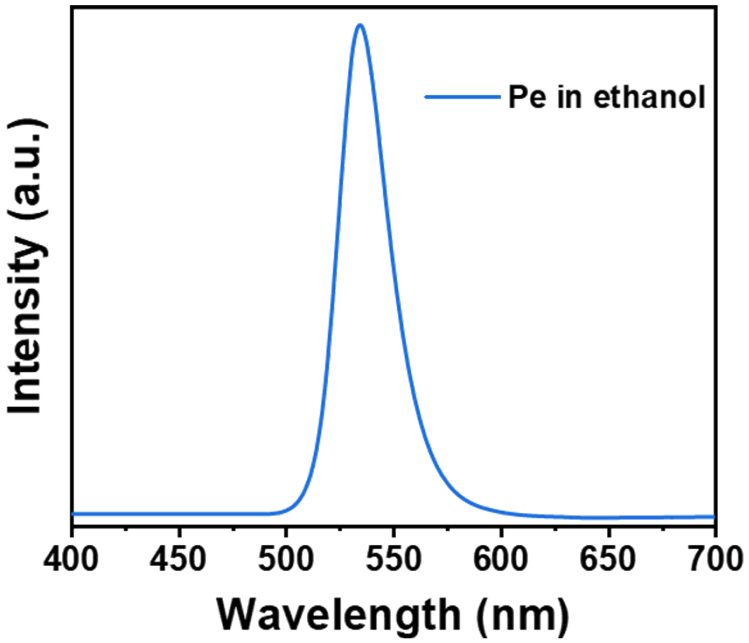


**Fig. S10.** PL spectra of PeMCs in ethanol solvents.

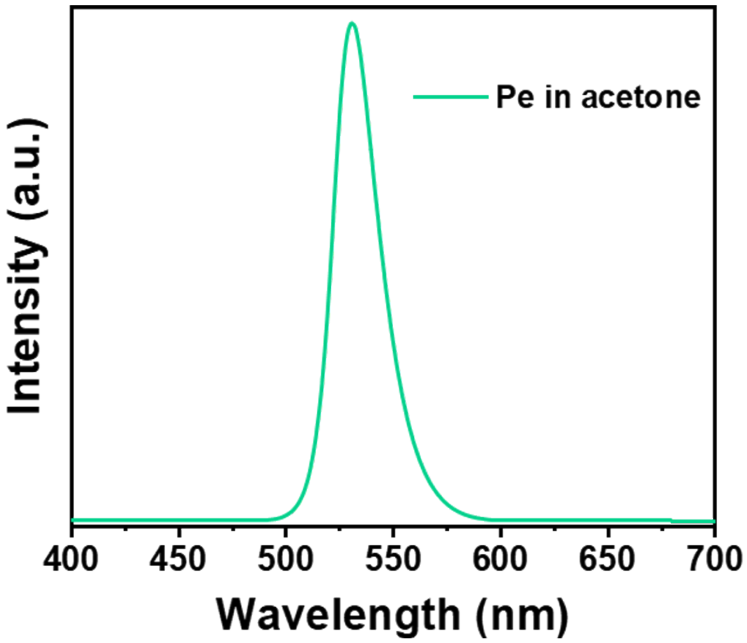


**Fig. S11.** PL spectra of PeMCs in acetone solvent.

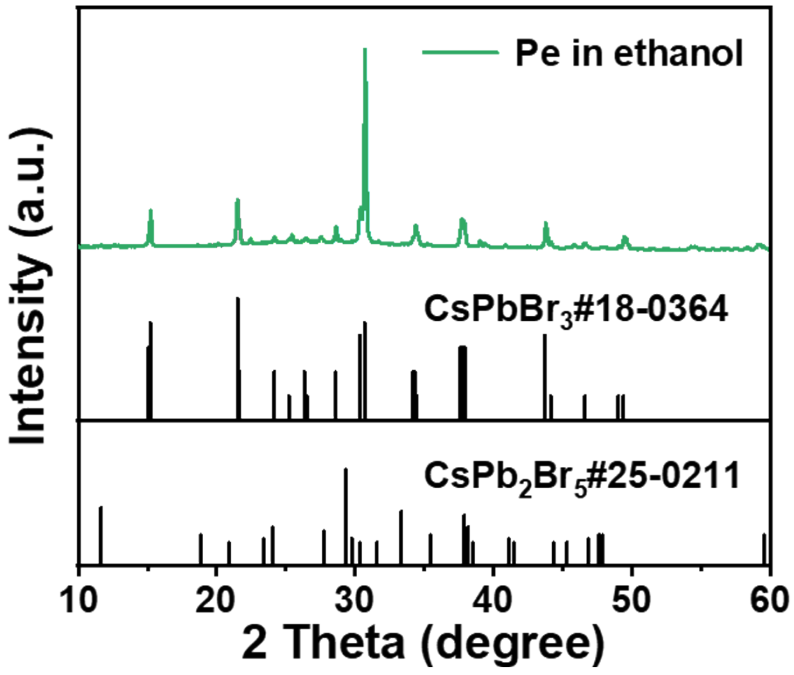


**Fig. S12.** XRD pattern of PeMCs in ethanol.

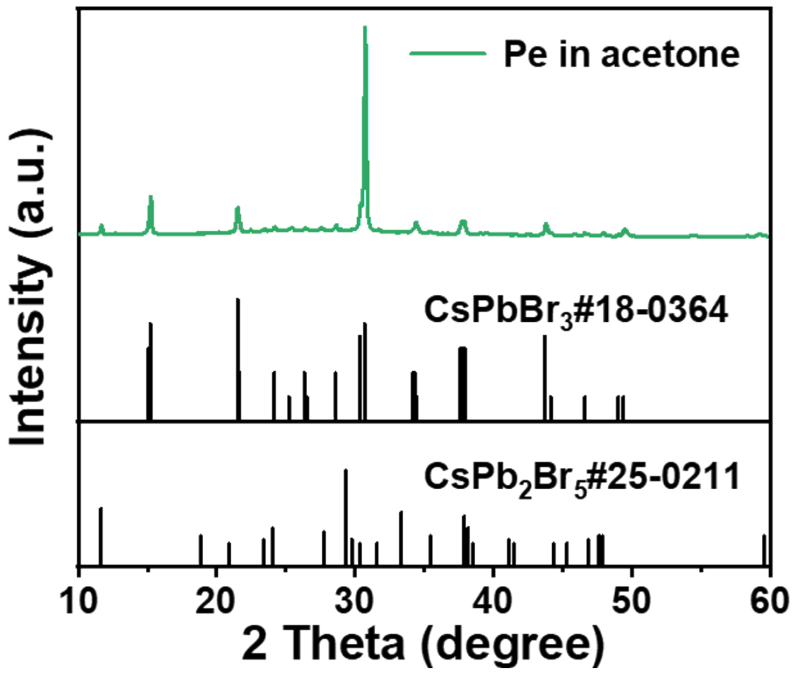


**Fig. S13.** XRD pattern of PeMCs in acetone.

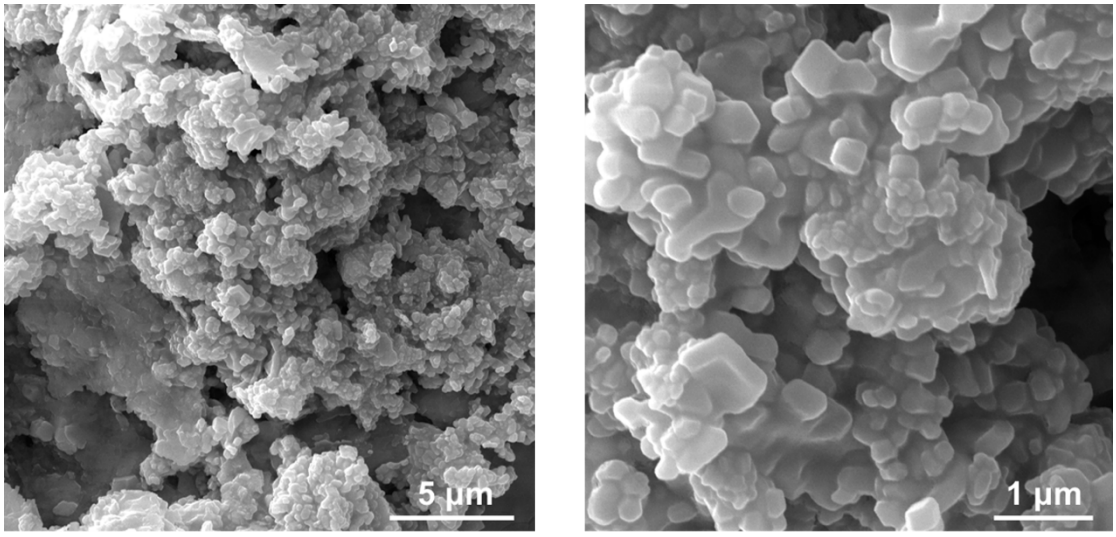


**Fig. S14.** SEM images of PeMCs in ethanol.

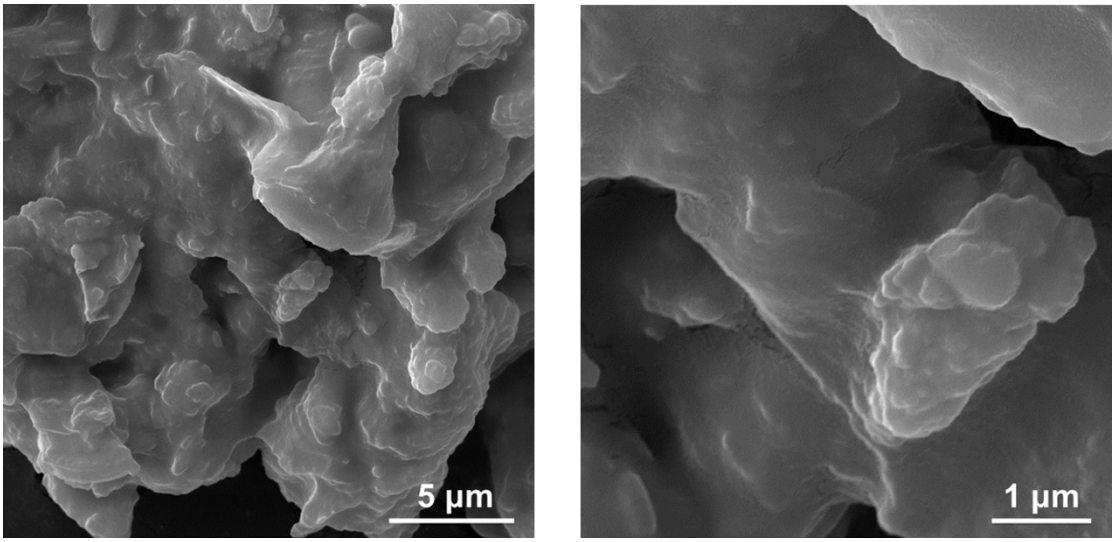


**Fig. S15.** SEM images of PeMCs in acetone.

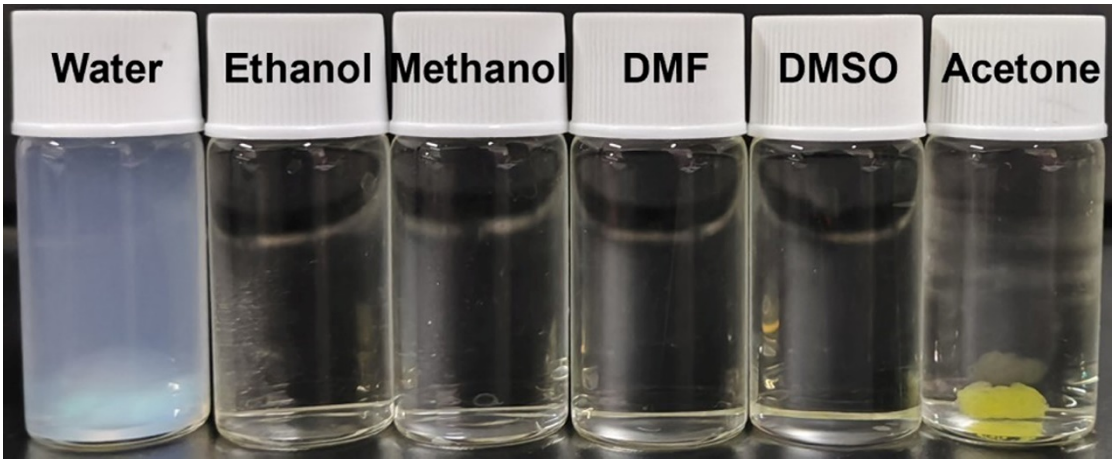


**Fig. S16.** Dispersion images of lecithin ligands dispersed in aqueous, ethanol, methanol, DMF, DMSO and acetone polar solutions.

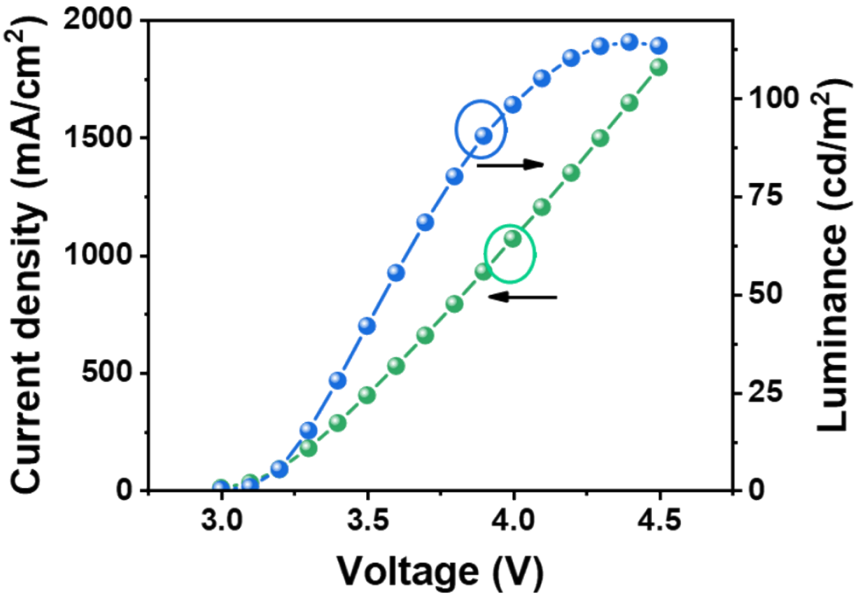


**Fig. S17.** The J-L-V curve of the PeMCs-based LED.

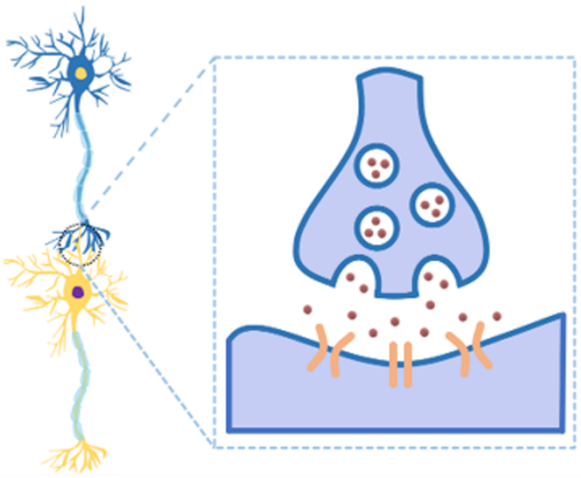

**Fig. S18.** Schematic of a biological synapse.

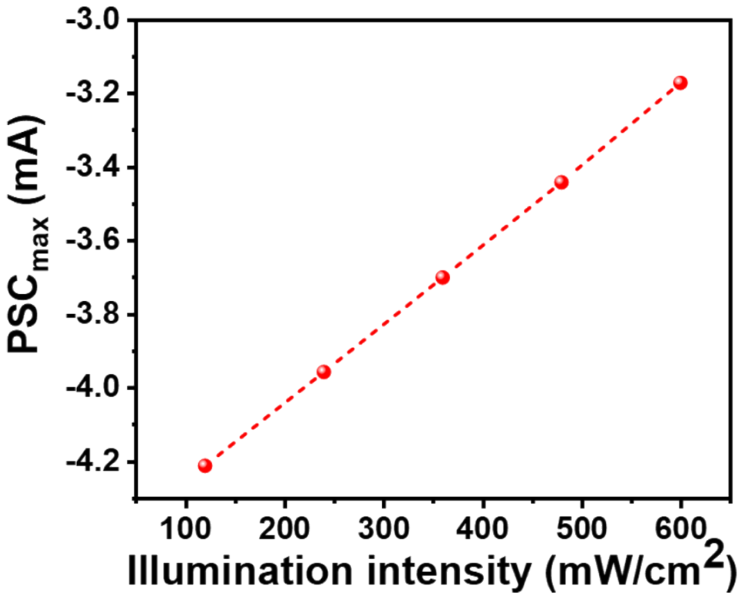


**Fig. S19.** Curve of maximum photocurrent as a function of light intensity.

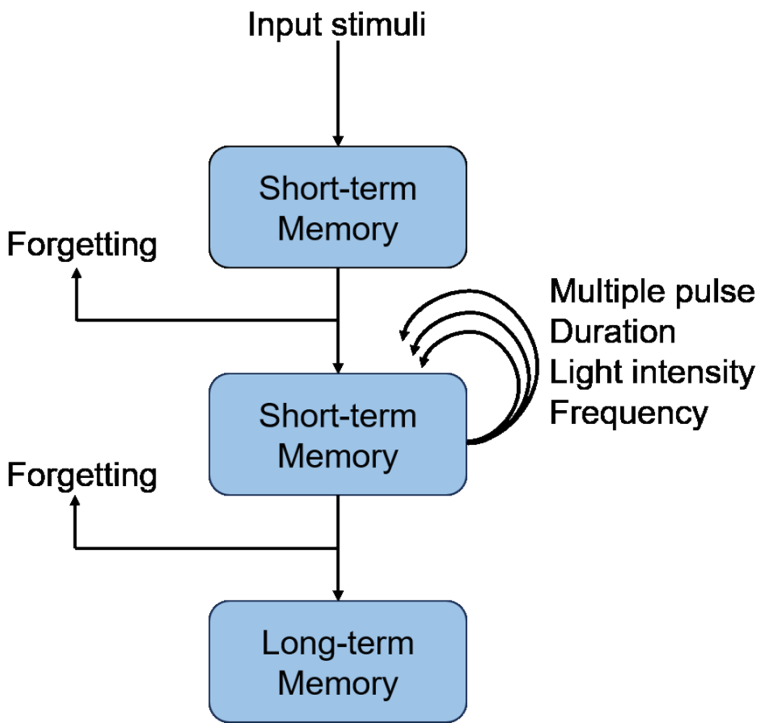


**Fig. S20.** Psychological learning and forgetting model of the human brain.

**Table 1** Summary of biexponential fitting parameters for time-resolved PL spectroscopy of perovskite materials：

| Perovskite | $\tau_1$ (ns) | $A_1$ (%) | $\tau_2$ (ns) | $A_2$ (%) | $\tau_{avg}$ (ns) |
|---|---|---|---|---|---|
| Free-ligands-Pe | 8.85 | 49.39 | 77 | 50.61 | 43.34 |
| Lecithin-Pe | 15.44 | 38.08 | 124.74 | 61.92 | 83.11 |

**Table 2** Comparative analysis of optical properties of PeMCs reported in recent literatures:

| Structure | FWHM | TRPL | Ref |
|---|---|---|---|
| $CsPbBr_3$ microcrystals | 26.6 nm | 14 ns | 1 |
| pNE-$CsPbBr_3$ microcrystals | - | 6.7 ns | 2 |
| Gold-coated $CsPbBr_3$ microcrystals | - | 0.67 ns | 3 |
| $CsPbBr_3$ microcrystals | 24 nm | 63.59 ns | 4 |
| $CsPbBr_3$ microcrystals | 21 nm | - | 5 |
| $CsPbBr_3$ microcrystals | 21.9 nm | 83.11 ns | This work |

**Table 3** Comparative stability analysis of perovskite materials recently reported in the literatures:

| Structure | Stability in ethanol | Stability in acetone | Thermal stability | Ref |
|---|---|---|---|---|
| $CsPbX_3/PbSO_4$ | 150 min/75% | 90 min/90% | - | 6 |
| α -ZrP/$CsPbBr_3$ | - | - | 100℃/35% | 7 |
| A3D-LDH/$CsPbBr_3$ | - | - | 110℃/60% | 8 |
| $CsPbBr_3$@$SiO_2$ | - | - | 105℃/37.2% | 9 |
| $CsPbBr_3/SiO_2$ | - | - | 100℃/65% | 10 |
| $CsPbBr_3$ | 5 days/41% | 5 days/11% | - | 11 |
| $CsPbBr_3$@AlO(OH) | 1 h/0 | - | - | 12 |
| $CsPbBr_3$ | 90 days/95% | 90 days/95% | 150℃/80% | This work |

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