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

Supporting Information

A-site FA^+ Engineering Boosting Photoluminescence Efficiency and Stability of Cesium Copper Iodine ($Cs_3Cu_2I_5$) Perovskites

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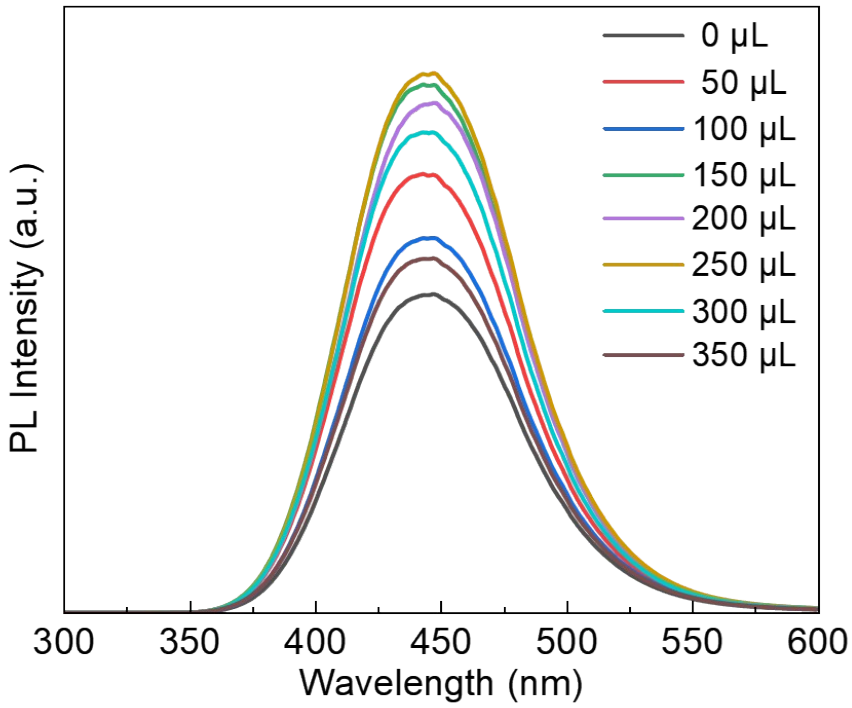

Figure. S1 PL spectra of $Cs_3Cu_2I_5$ samples treated by different quantities of OA.

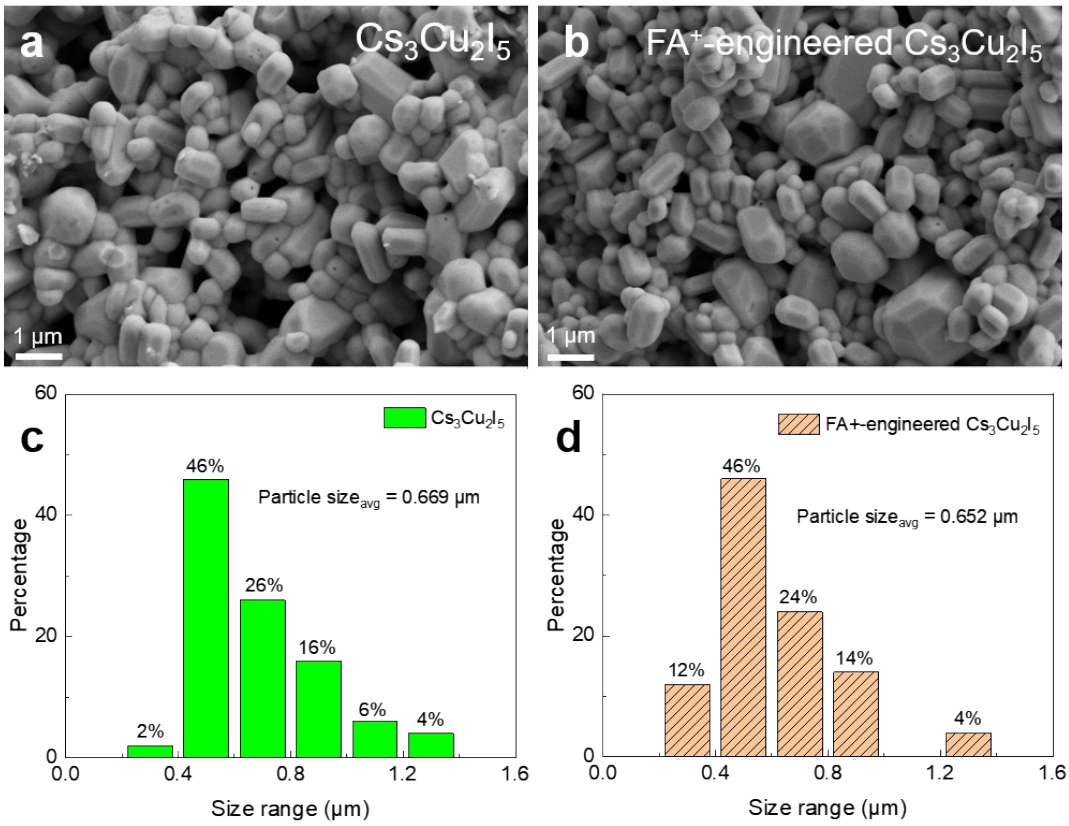

Figure S2. The SEM images of pure and FA^+-engineered $Cs_3Cu_2I_5$ (a-b) and particle size distribution histograms (c-d).

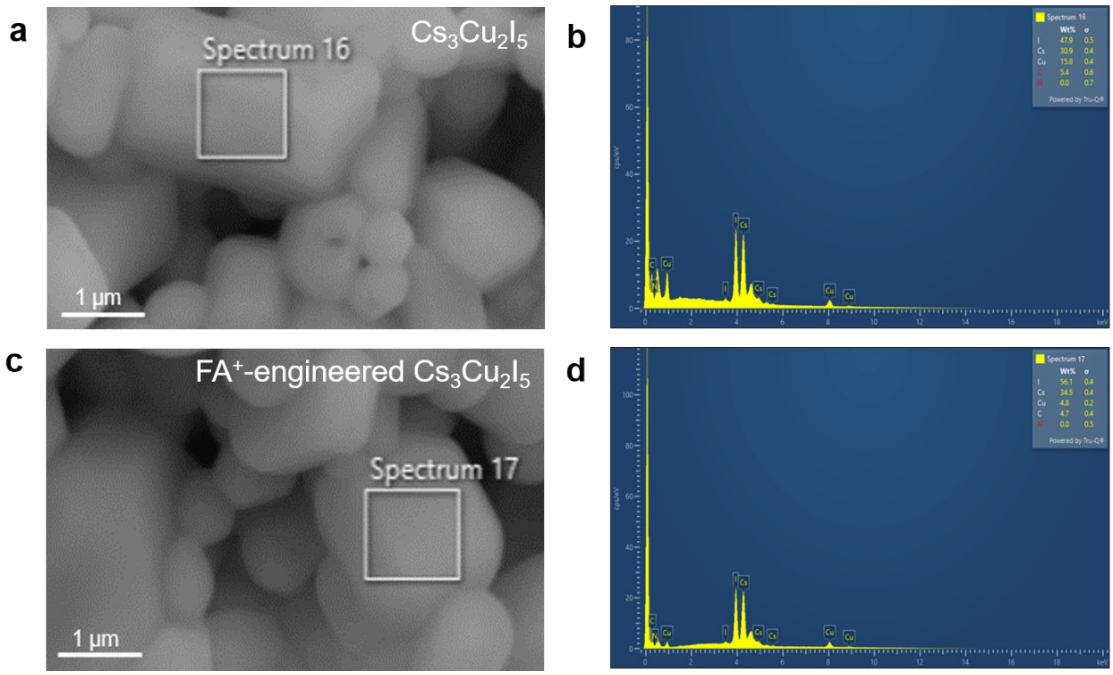

Figure. S3 The EDS spectrum of $Cs_3Cu_2I_5$ (a) and 5% FA^+-engineered $Cs_3Cu_2I_5$ (b).

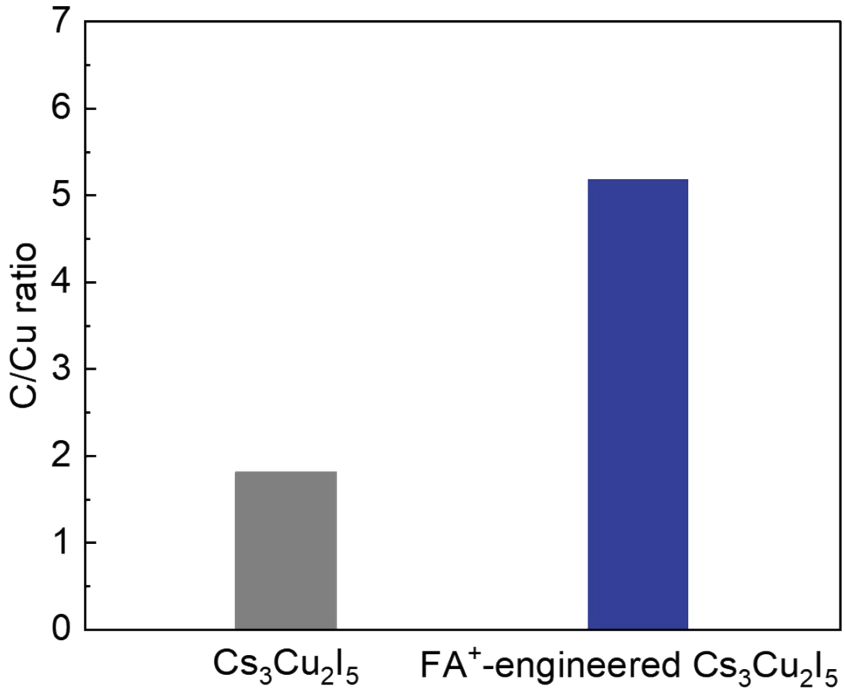

Figure. S4 The C/Cu ration of $Cs_3Cu_2I_5$ and 5% FA^+-engineered $Cs_3Cu_2I_5$ obtained from EDS result.

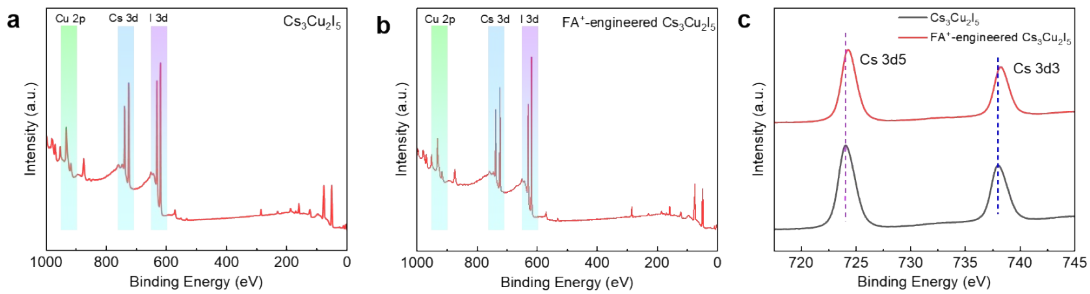

Figure. S5 X-ray photoelectron spectra (XPS) of (a) $Cs_3Cu_2I_5$, (b) 5% FA^+-engineered $Cs_3Cu_2I_5$, (c) Cs 3d.

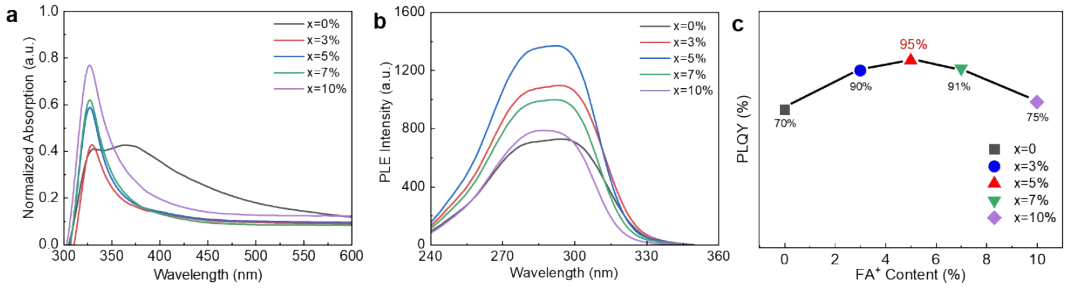

Figure. S6 The Normalized Absorption spectra (a) and PLE spectra (b) of $Cs_3Cu_2I_5$ with different FA^+ content. (c) PLQY of pure and different proportions FA^+-engineered $Cs_3Cu_2I_5$ samples.

The PLQY was tested by integrating sphere method. The excitation wavelength is 290 nm (Scatter Range: 279 to 302 nm and Emission Range: 306 to 803 nm). The PLQY can be calculated from the equation:

$$\Phi = \frac{E_c - E_a}{L_a - L_c}$$

Φ is the absolute PLQY; E_c and L_c are the fluorescence emission and the scatter of the sample and L_a and E_a are also the emission and scatter of a blank.

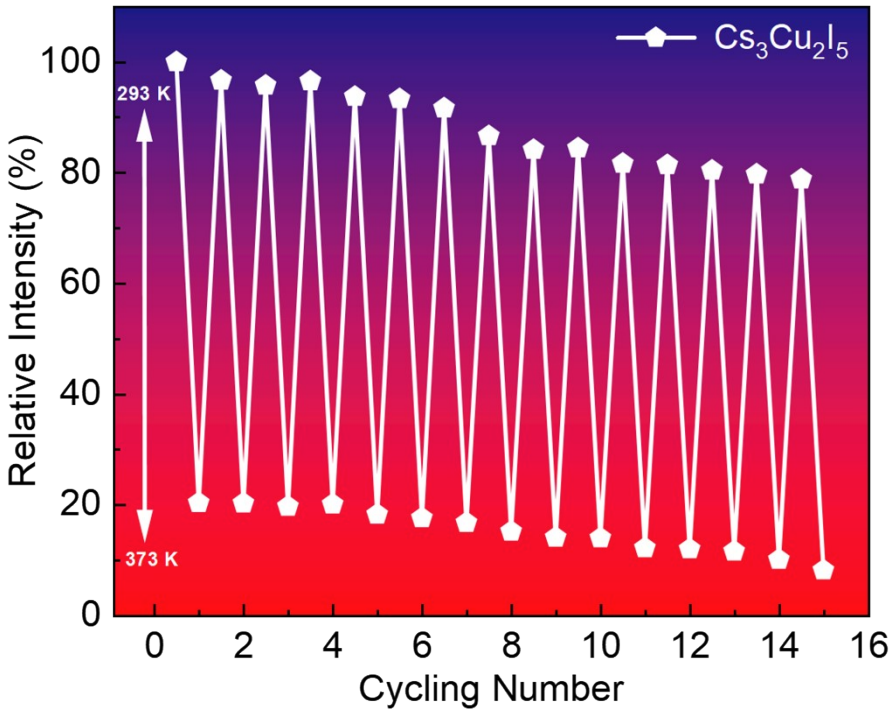

Figure. S7 Heat-cooling cycles stability test of pure $Cs_3Cu_2I_5$ powder.

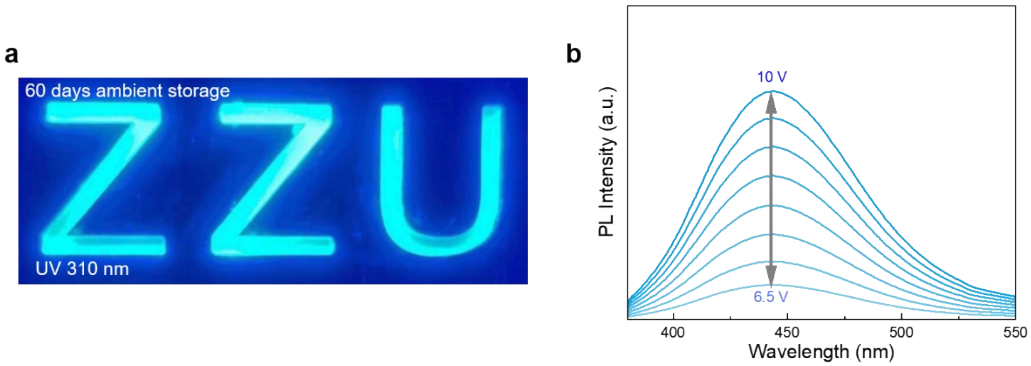

Figure. S8 (a) The picture of 5% FA^+-engineered $Cs_3Cu_2I_5$ powder in polydimethylsiloxane (PDMS) gel after 60 days ambient storage under UV light (310 nm). (b) The PL spectra of 5% FA^+-engineered $Cs_3Cu_2I_5$-LED device under different driving voltage.

Table S1. Time-resolved PL decay curves of the pure and different proportions FA^+-engineered $Cs_3Cu_2I_5$ samples.

FA (%)	A_1	τ_1 (ns)	A_2	τ_2 (ns)	T_{avg} (ns)
0	462	414	2528	1109	1064
3	341	361	2619	1123	1092
5	500	658	2416	1229	1172
7	617	963	2298	1162	1126
10	602	608	2416	1169	1104

The decay curves of the pure and FA^+-engineered $Cs_3Cu_2I_5$ sample which collected at the emission wavelength of 443 nm were fitted by a double exponential attenuation equation: $I(t) = A_1 \exp(-t/\tau_1) + A_2 \exp(-t/\tau_2)$. The correlation index of the fitted curve is 0.9990, 0.9987, respectively.

The average PL lifetime is calculated by a weighted averaging equation:

$$\tau_{avg} = (A_1\tau_1^2 + A_2\tau_2^2) / (A_1\tau_1 + A_2\tau_2).$$

τ_1 and τ_2 are time constants representing radiative and non-radiative transition process respectively; A_1 and A_2 are corresponding weight factor for the τ_1 and τ_2 respectively.