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

Supporting Information

Efficient ambient-air-stable HTM-free carbon-based perovskite solar cells with hybrid 2D-3D lead halide photoabsorber

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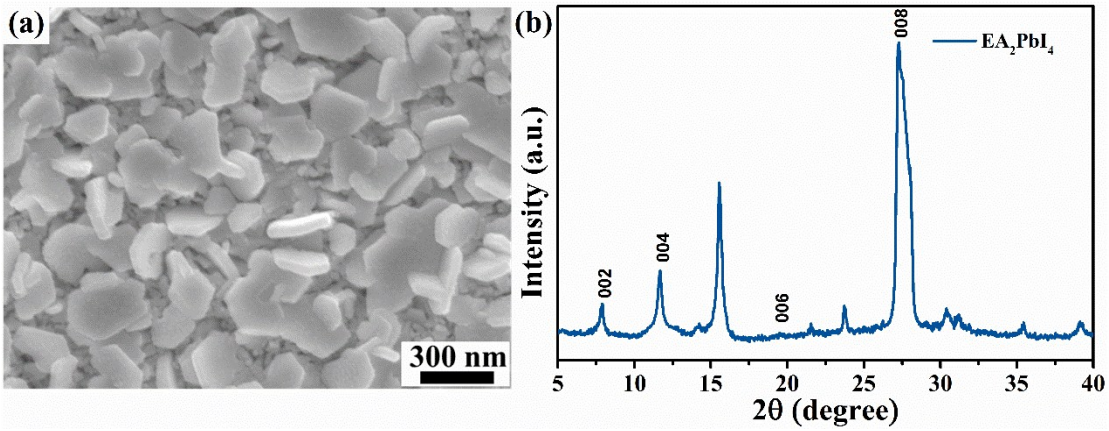

Fig. S1 (a) Top view SEM image and (b) XRD pattern of fresh EA_2PbI_4 film.

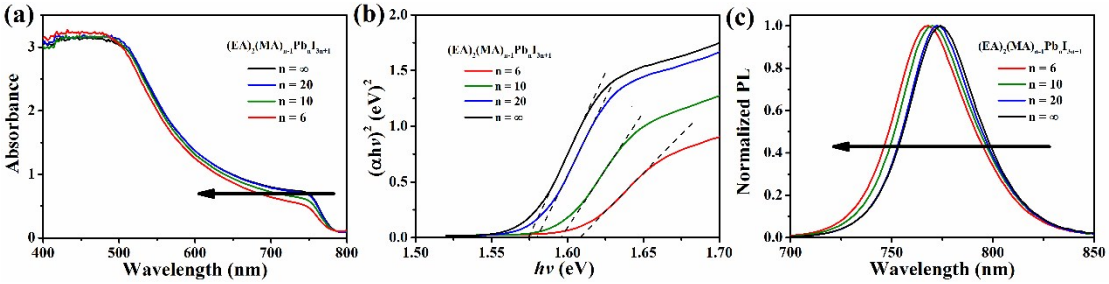

Fig. S2 Photovoltaic characterization of $(EA)_2(MA)_{n-1}Pb_nI_{3n+1}$ films. (a) Absorption spectra of the $(EA)_2(MA)_{n-1}Pb_nI_{3n+1}$ films, (b) Band gap energy (Eg) of $(EA)_2(MA)_{n-1}Pb_nI_{3n+1}$ films corresponding to UV-Vis absorption spectra, and (c) Normalized steady-state PL spectra of $(EA)_2(MA)_{n-1}Pb_nI_{3n+1}$ films illuminated from the front side of the films on silica glass.

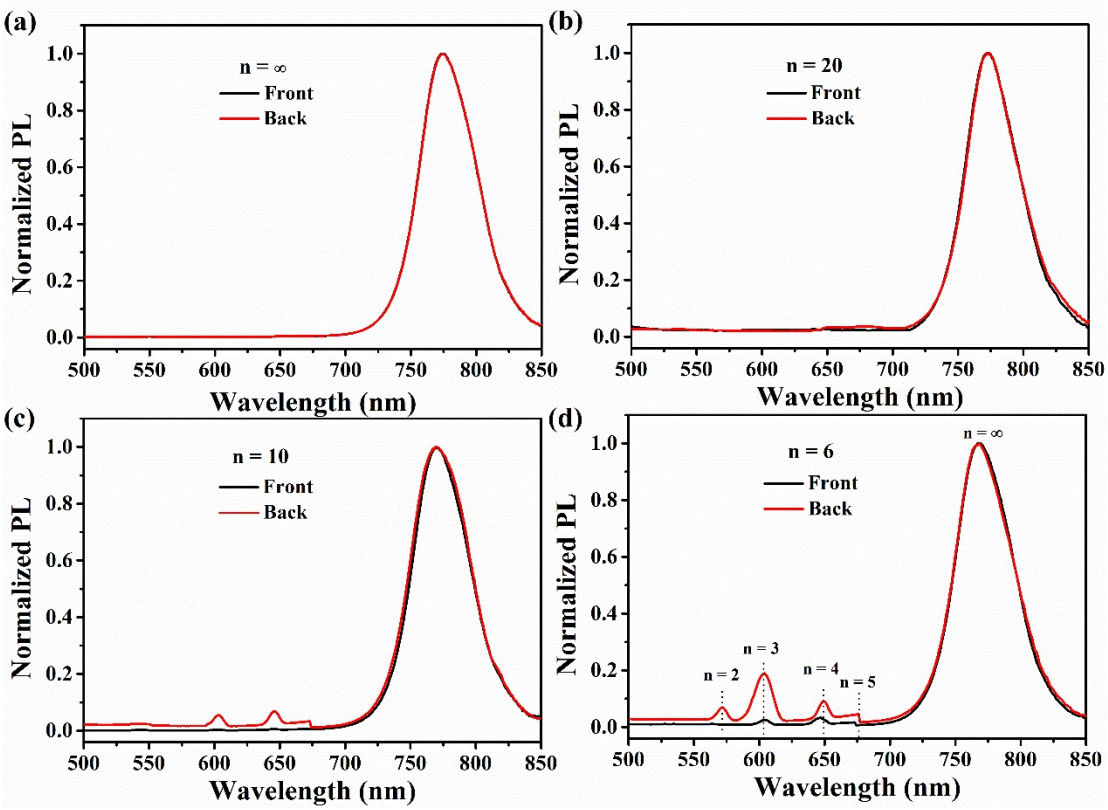

Fig. S3 Steady-state PL spectra of $(EA)_2(MA)_{n-1}Pb_nI_{3n+1}$ films illuminated from the front and back sides of the films on silica glass. (a) n = 6, (b) n = 10, (c) n = 20, and (d) n = ∞.

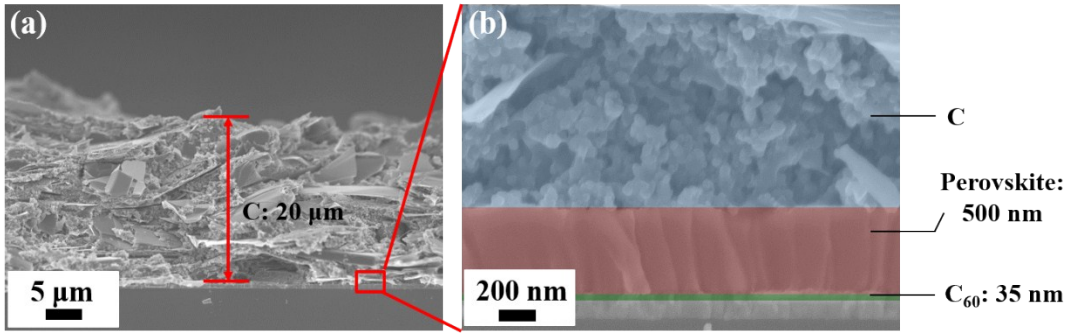

Fig. S4 (a, b) Cross-sectional SEM images of ITO/C_{60}/perovskite/C device.

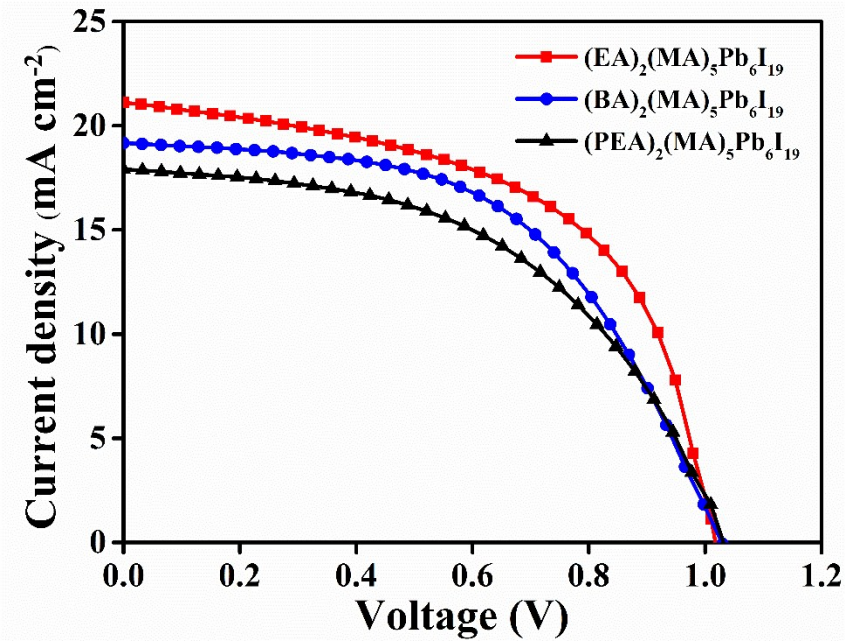

Fig. S5 *J-V* curves of the champion C-PSCs with different 2D-3D hybrid perovskites (n = 6) measured with reverse scans.

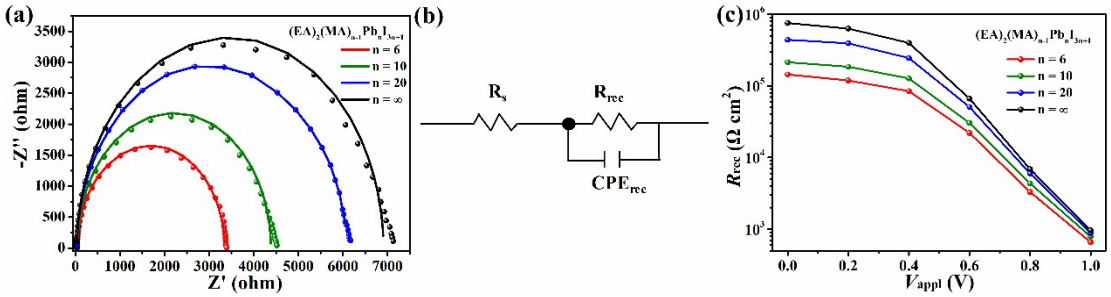

Fig. S6 Electrochemcal propertyies. (a) Nyquist plots of the C-PSCs with $(EA)_2(MA)_{n-1}Pb_nI_{3n+1}$ measured at 0.8 V in dark condition measured with frequency ranging from 10^6 to 1 Hz, (b) the equivalent circuit model for C-PSCs in EIS, and (c) variation of R_{rec} under different bias voltages from 0 to 1.0 V.

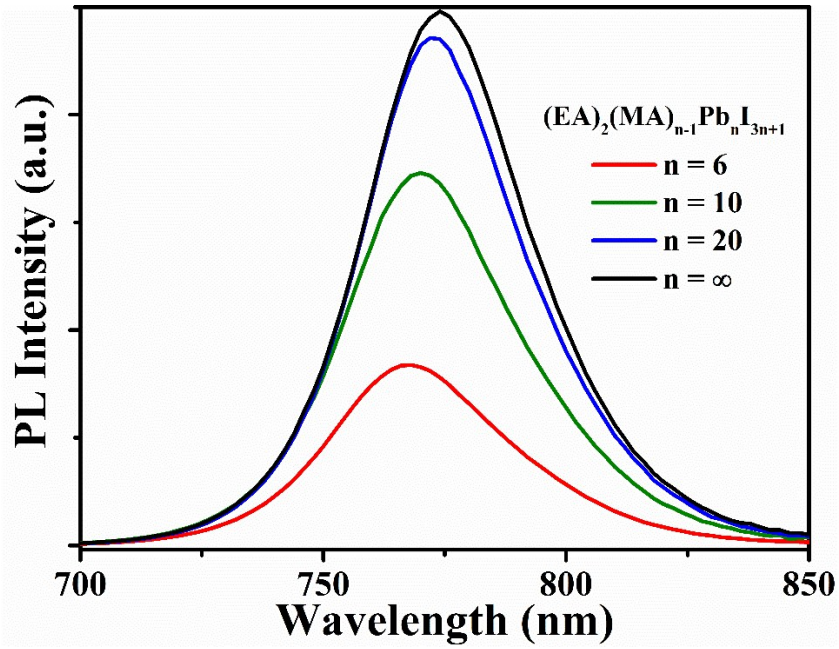

Fig. S7 Steady-state PL spectra of $(EA)_2(MA)_{n-1}Pb_nI_{3n+1}$ films illuminated from the front side of the films on silica glass.

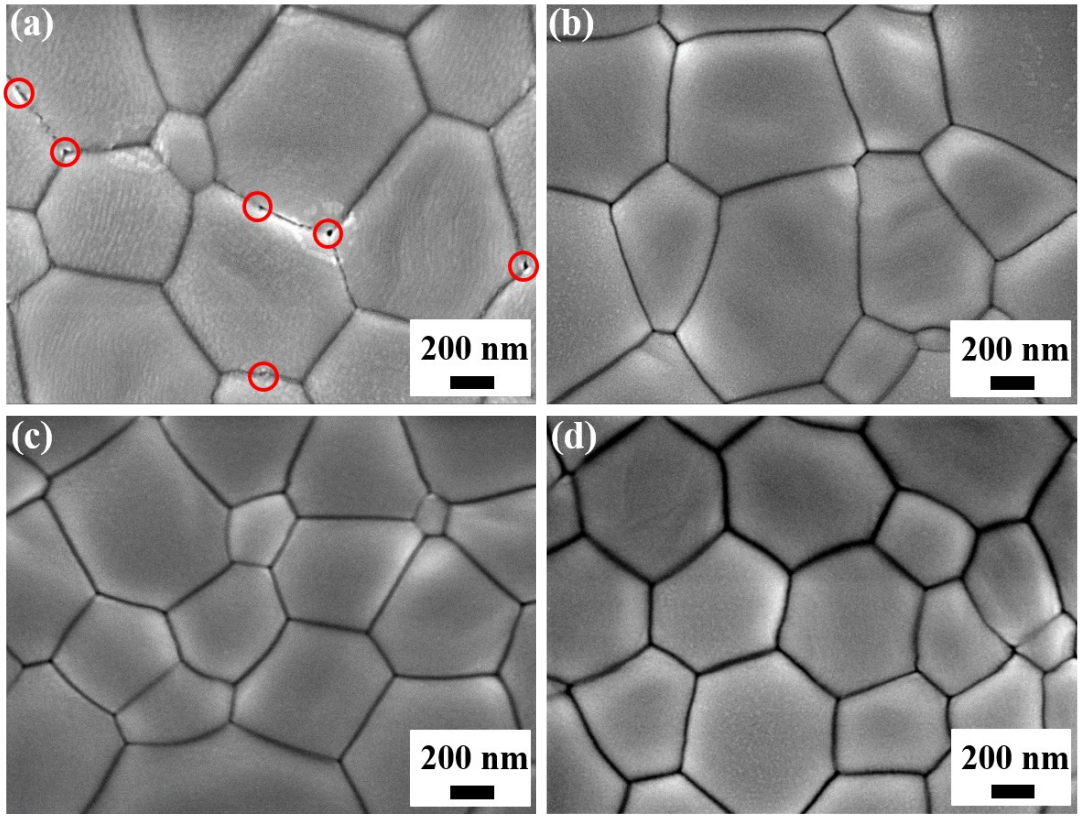

Fig. S8 Top view SEM images of $(EA)_2(MA)_{n-1}Pb_nI_{3n+1}$ films: (a) $n = \infty$, (b) n = 20, (c) n = 10, and (d) n = 6. Pin-holes are labeled in red circles.

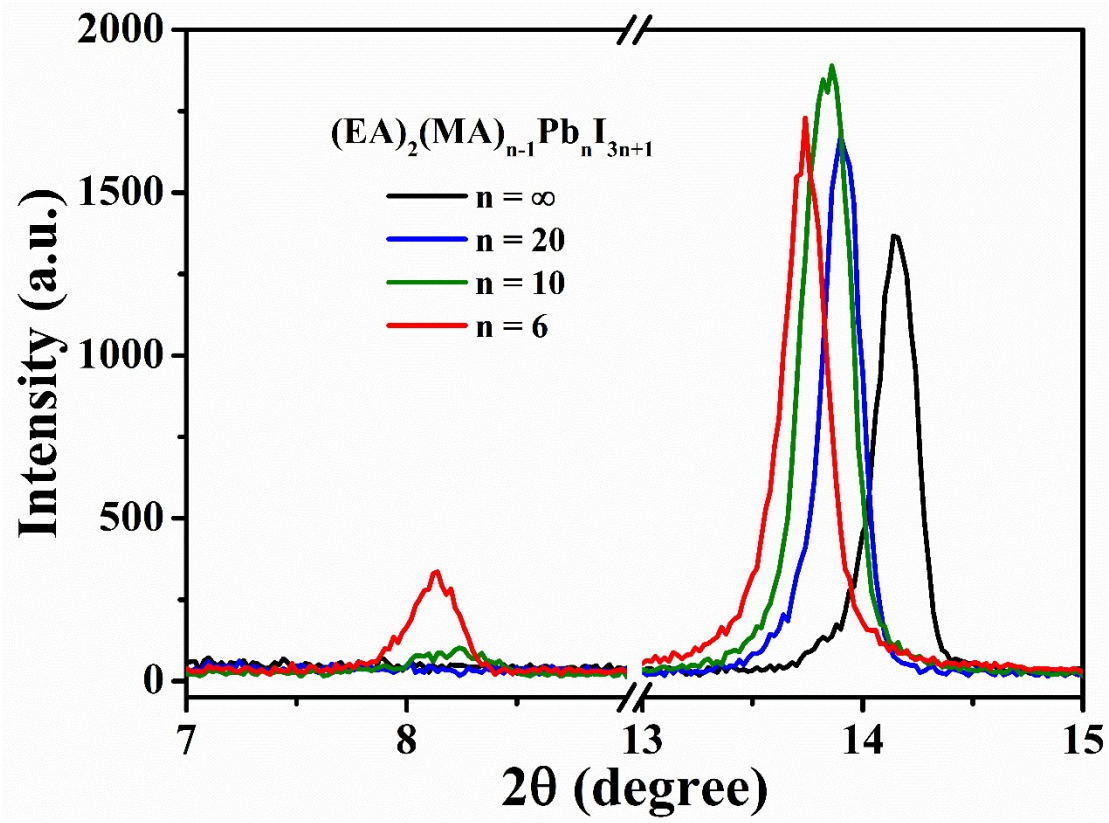

Fig. S9 Zoomed-in XRD patterns of $(EA)_2(MA)_{n-1}Pb_nI_{3n+1}$ films on ITO substrate in the region of 7° – 15°.

Table S1 Photovoltaic parameters of the best-performing C-PSCs with different 2D-3D hybrid perovskites (n = 6) measured with reverse scans.

Samples	V_{OC} (V)	J_{SC} (mA cm^{-2})	FF (%)	PCE (%)
$(EA)_2(MA)_5Pb_6I_{19}$	1.018	21.14	55.21	11.88
$(BA)_2(MA)_5Pb_6I_{19}$	1.025	19.26	53.38	10.54
$(PEA)_2(MA)_5Pb_6I_{19}$	1.031	18.21	50.40	9.46