Supporting Information for

Stable and Conductive Perovskites Materials Facilitated by X-type Ligands

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Figure S1. (A) (C) (E) and (G) Scanning electron microscopy (SEM) images of CPB-SH, CPB-SH-Pb, CPB-SH-Pb-SH and CPB large nanocrystal, respectively; (B) (D) (F) and (H) Statistical distribution histogram of CPB-SH, CPB-SH-Pb, CPB-SH-Pb-SH and large nanocrystal CPB, respectively.



Figure S2. (A) UV–Vis absorption and photoluminescence (PL) spectra of CPB and CPB-SH-Pb-SH; (B) UV–Vis absorption spectra of CPB and CPB-SH-Pb-SH in the wavelength range from 300 to 490 nm; (C) The diffuse reflection spectrum of CPB and CPB-SH-Pb-SH nanocrystals.

Sample	СРВ	CPB-SH-Pb-SH
A ₁	7247.3	15154.5
τ_1 (ns)	2.0 (21%)	4.0 (34%)
A ₂	2853.5	2737.1
τ_2 (ns)	9.9 (41%)	21.8 (34%)
A3	531.0	619.2
τ_3 (ns)	50.5 (38%)	92.0 (32%)
Average(ns)	23.9	38.4

Table.S1 Triexponential fitting results of the CPB and CPB-SH-Pb-SH

Time-resolved PL decay curves were fitted by a triexponential (see eqs 1 and 2) function: A(t) =A₀ + A₁exp-(t-t₀)/ τ_1 + A₂exp-(t-t₀)/ τ_2 + A₃exp-(t-t₀)/ τ_3 (eqs 1); The average lifetimes were calculated using $\tau_{avg} = (A_1\tau_1^2 + A_2\tau_2^2 + A_3\tau_3^2)/(A_1\tau_1 + A_2\tau_2 + A_3\tau_3)$ (eqs 2).



Figure S3. Photoluminescence (PL) spectra and relative PL intensity of the CPB with 13 nm (A, B), CPB-SH (C, D), CPB-SH-Pb (E, F), CPB-SH-Pb-SH (G, H) and CPB with 238 nm (I, J), in a mixed solvent (the volume ratio of toluene and ethanol is 9:1).

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Sample	Percentage	
CPB-13 nm	7.2 %	
CPB-SH	28.5 %	
CPB-SH-Pb	14.3 %	
CPB-SH-Pb-SH	108.5 %	
CPB-238 nm	20.5 %	

Table.S2 Relative PL intensity after 30 min in a mixed solvent (the volume ratio of toluene and

ethanol is 9:1).



Figure S4. Monitoring the stability of CPB-SH-Pb-SH in ethanol by PL spectra: (A) 0 h; (B) 1 h; (C) 2 h; (B) 3 h; (D) 4 h; (F) 5 h; (G) 6 h; (H) Time depended PL intensity of CPB-SH-Pb-SH in ethanol.

TIME	Peak area
0 h	43942775
1 h	53901580
2 h	54945419
3 h	56948401
4 h	51006333
5 h	51457357
6 h	59860124

Table.S3 Time depended PL intensity of CPB-SH-Pb-SH in ethanol.