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Supporting information

Phosphatidylcholine-Mediated Regulation of Growth Kinetics for Colloidal Synthesis of Cesium Tin Halide Nanocrystals

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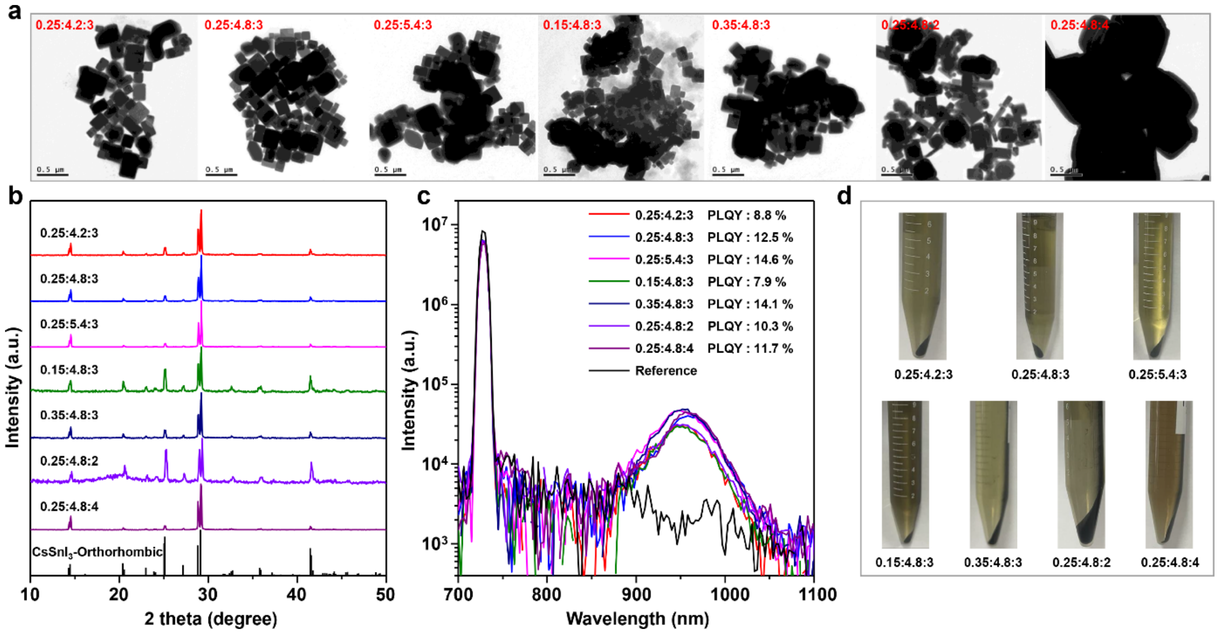

Figure S1. a-c) TEM images (a), XRD patterns (b), and PLQY measurements (c) of large-sized $CsSnI_3$ synthesized with different Cs:Sn:I precursor ratios. All samples are large-sized precipitates obtained after the first centrifugation of the crude solution. d) Photographs of the $CsSnI_3$ solution with different Cs:Sn:I precursor ratios after the first centrifugation. The detailed synthetic parameters are shown in **Table S1**.

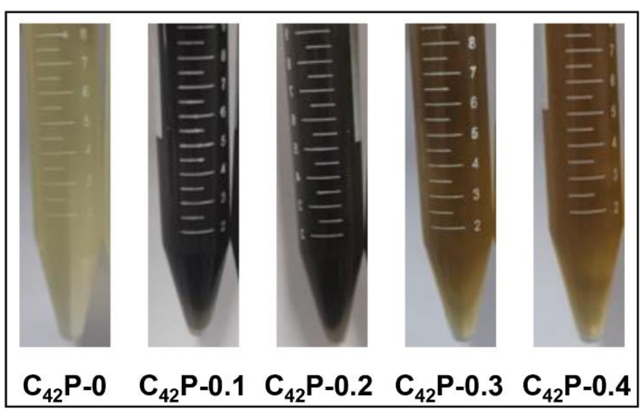

Figure S2. Photographs of the $CsSnI_3$ NCs supernatant obtained after the first centrifugation. The samples were synthesized with different ratios of $C_{42}P$ to Cs.

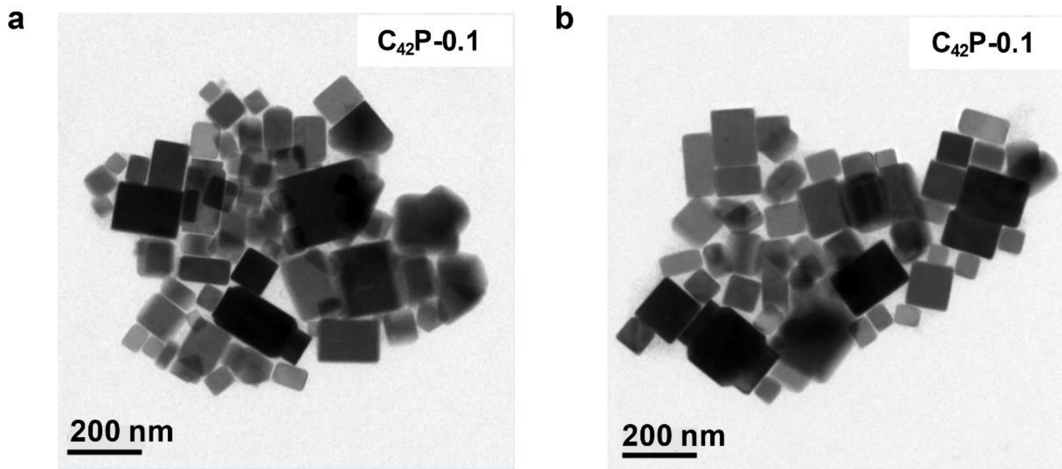

Figure S3. Additional TEM images of C_{42}P-0.1.

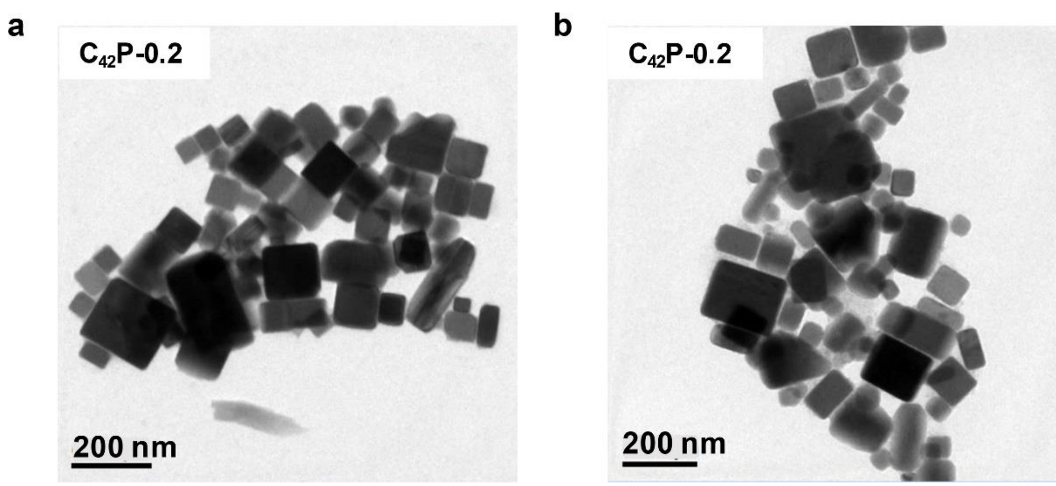

Figure S4. Additional TEM images of C_{42}P-0.2.

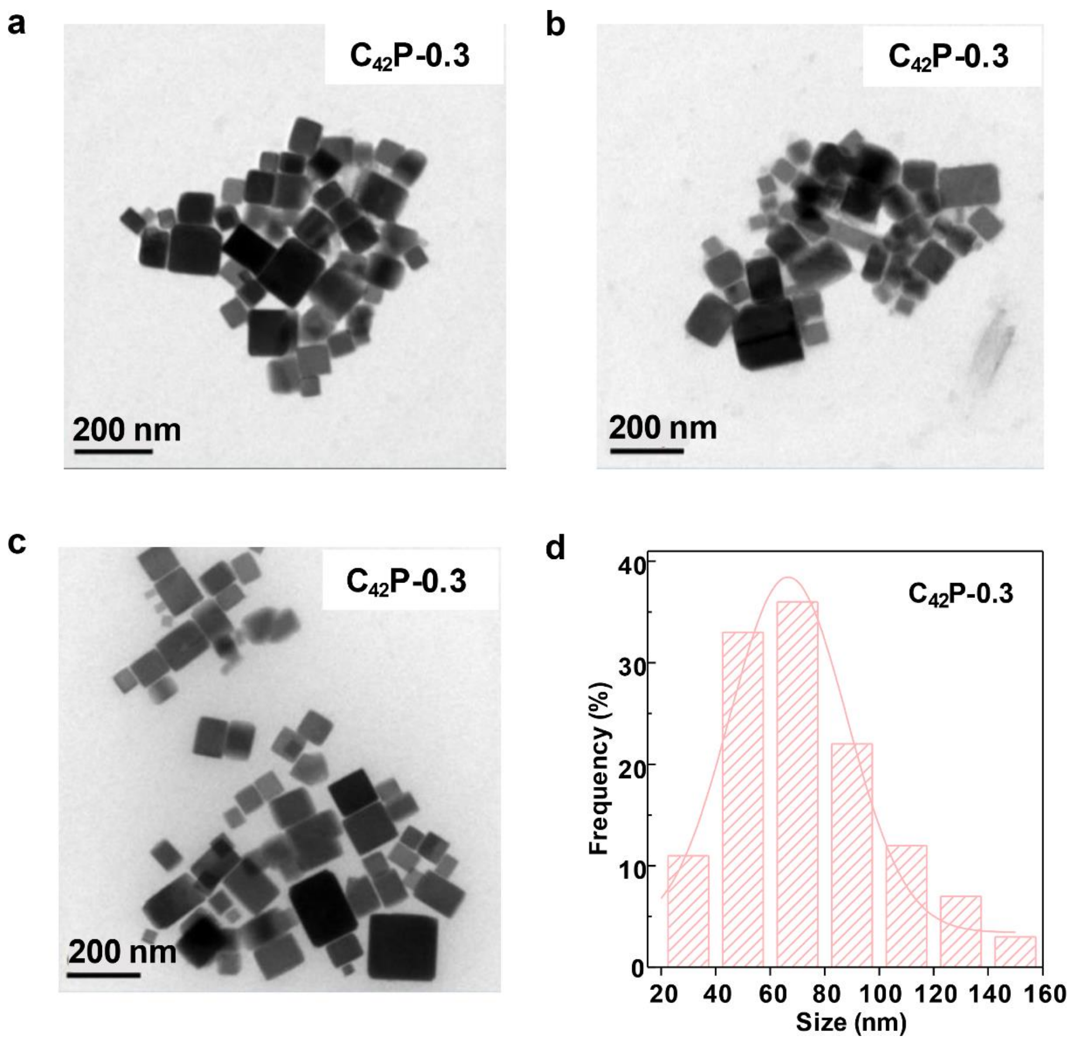

Figure S5. (a-c) Multiple TEM images of $C_{42}P$-0.3. (d) Size-distribution histogram of $C_{42}P$-0.3 based on multiple TEM images.

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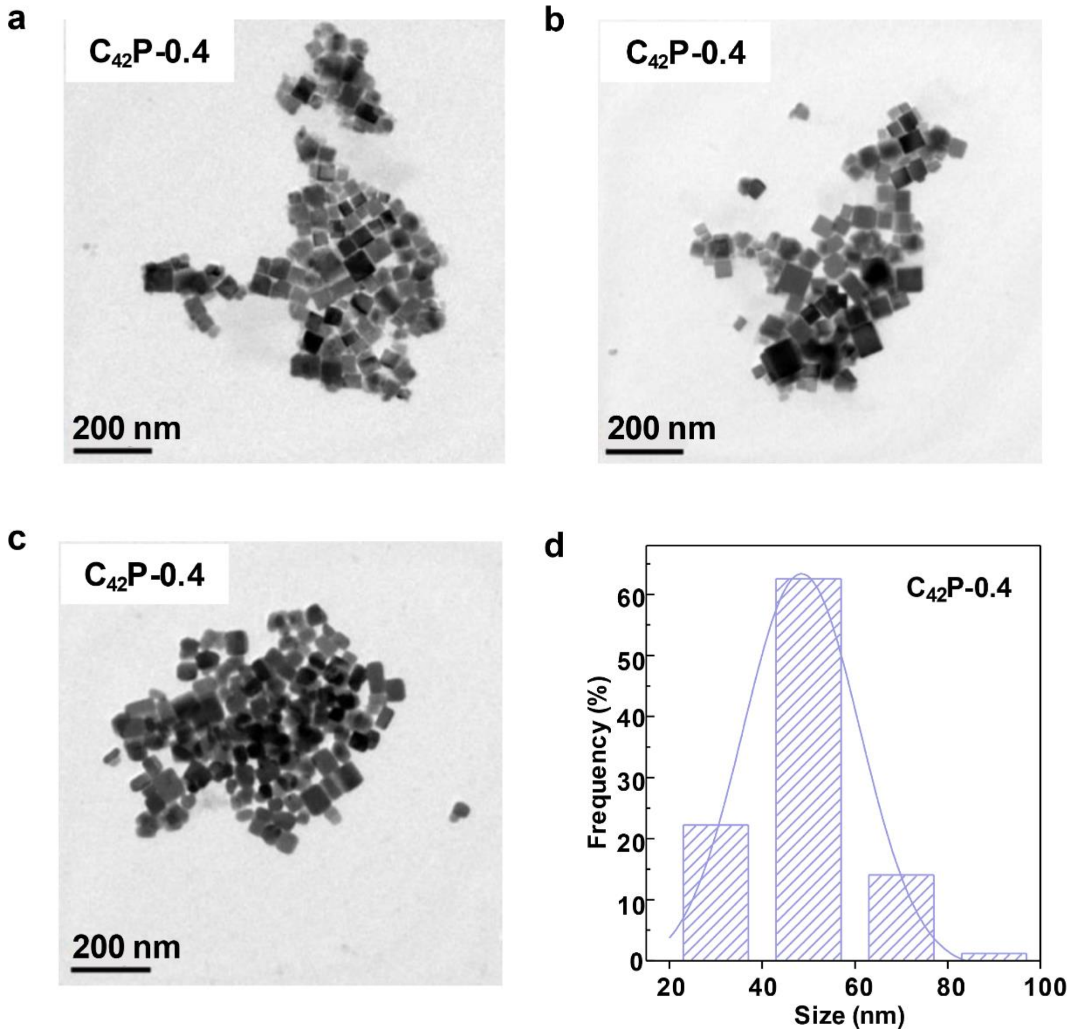

Figure S6. (a-c) Multiple TEM images of C_{42}P-0.4. (d) Size-distribution histogram of C_{42}P-0.4 based on multiple TEM images.

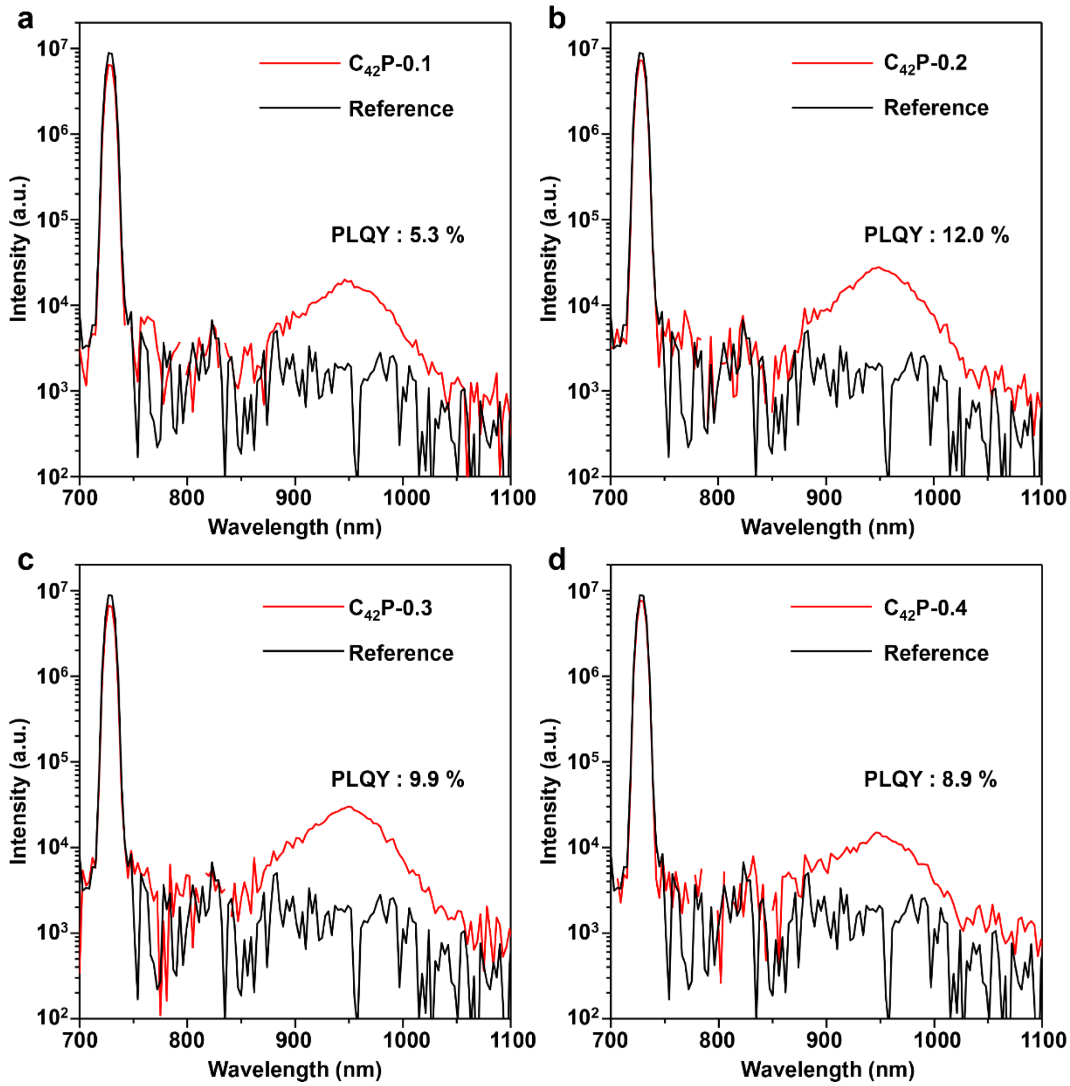

Figure S7. PLQY measurements of (a) $C_{42}P$-0.1, (b) $C_{42}P$-0.2, (c) $C_{42}P$-0.3, and (d) $C_{42}P$-0.4.

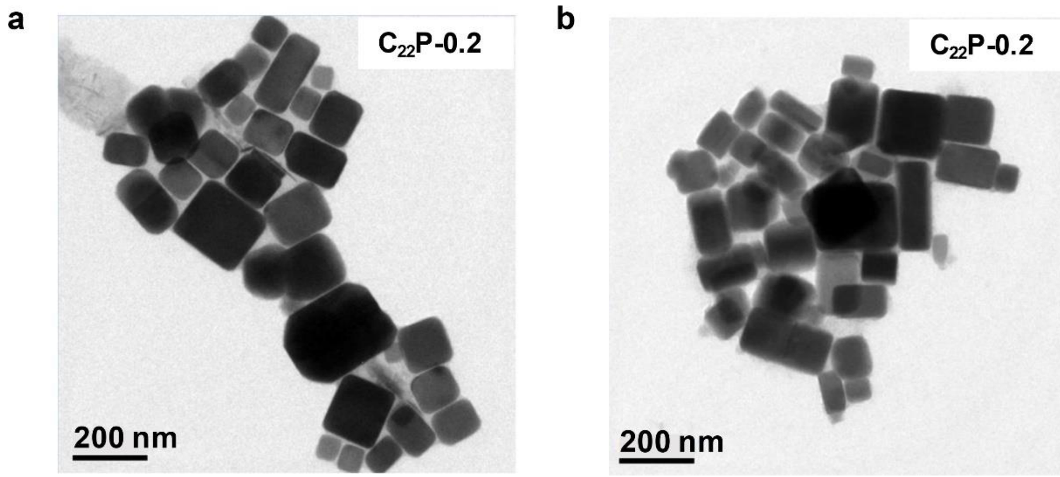

Figure S8. Additional TEM images of C_{22}P-0.2.

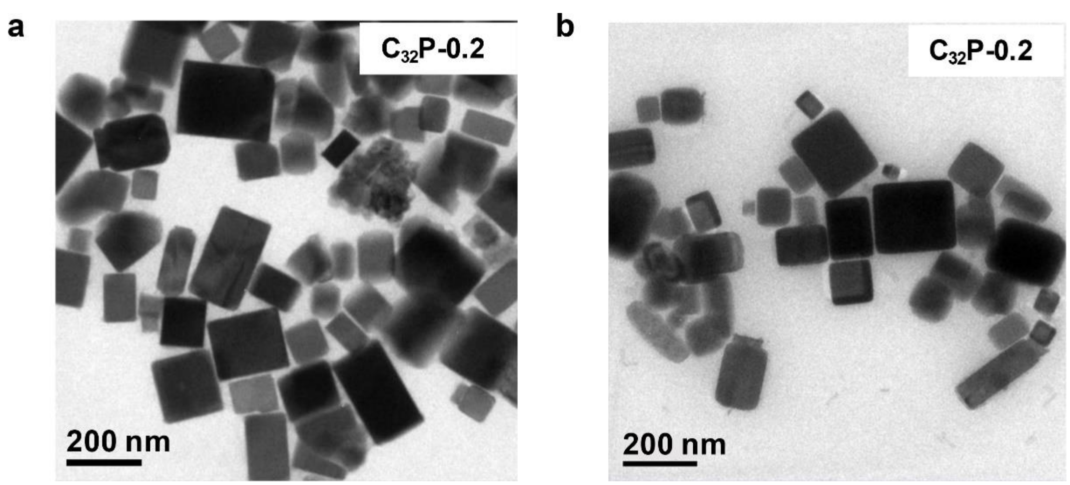

Figure S9. Additional supplementary TEM images of C_{32}P-0.2.

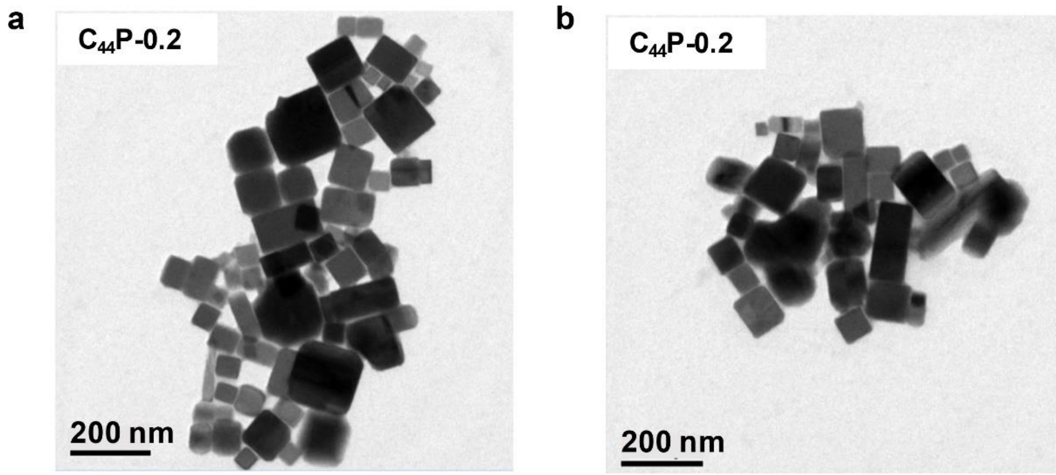

Figure S10. Additional supplementary TEM images of C_{44}P-0.2.

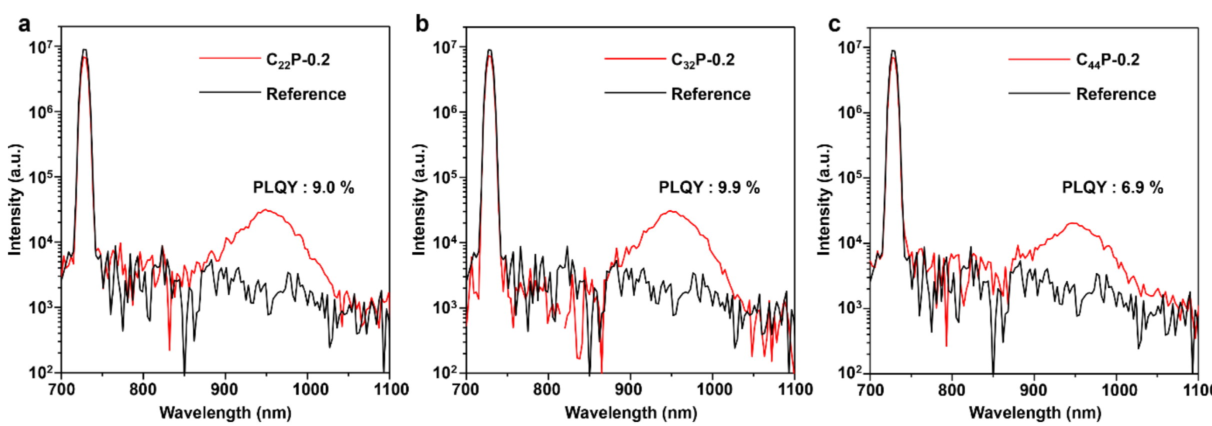

Figure S11. PLQY measurements of (a) C_{22}P-0.2, (b) C_{32}P-0.2, and (c) C_{44}P-0.2.

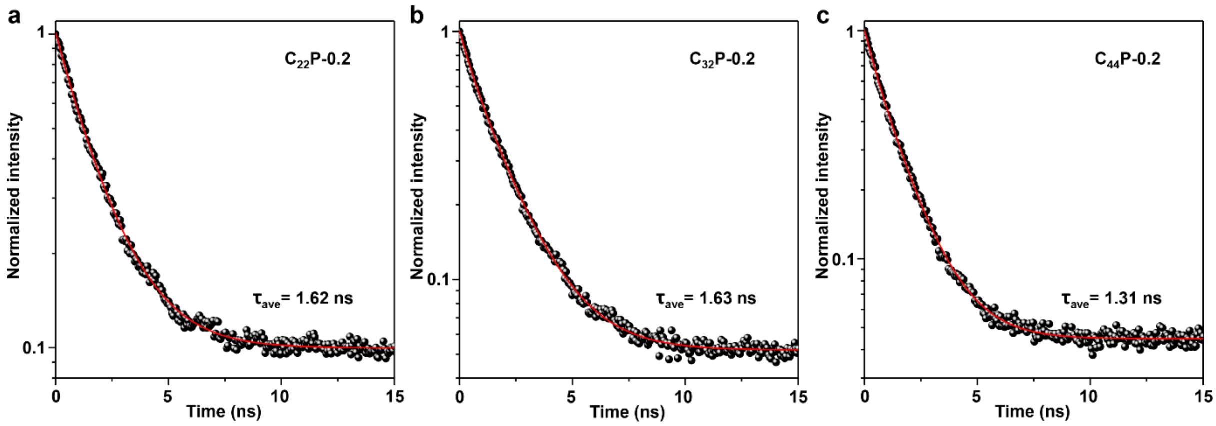

Figure S12. PL decay traces (black dots) and fitted curves (red lines) of (a) $C_{22}P$-0.2, (b) $C_{32}P$-0.2, and (c) $C_{44}P$-0.2.

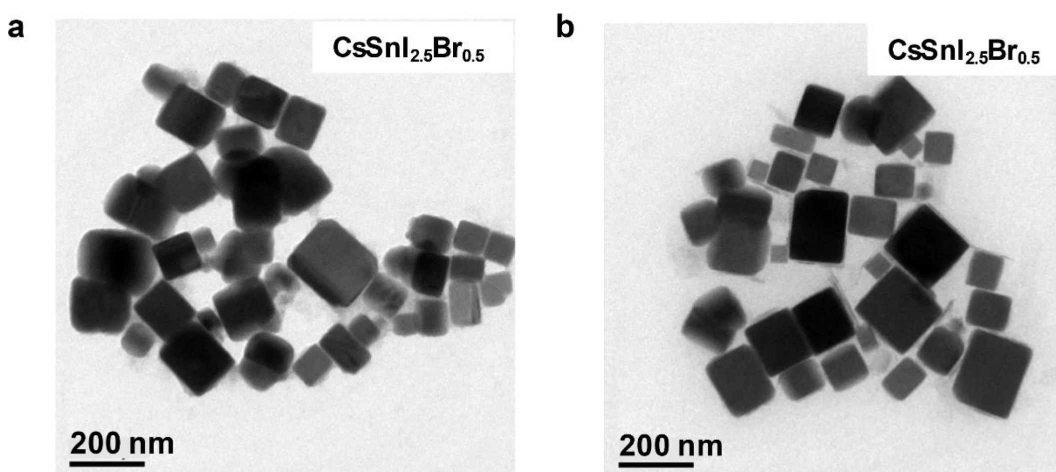

Figure S13. Additional TEM images of $CsSnI_{2.5}Br_{0.5}$.

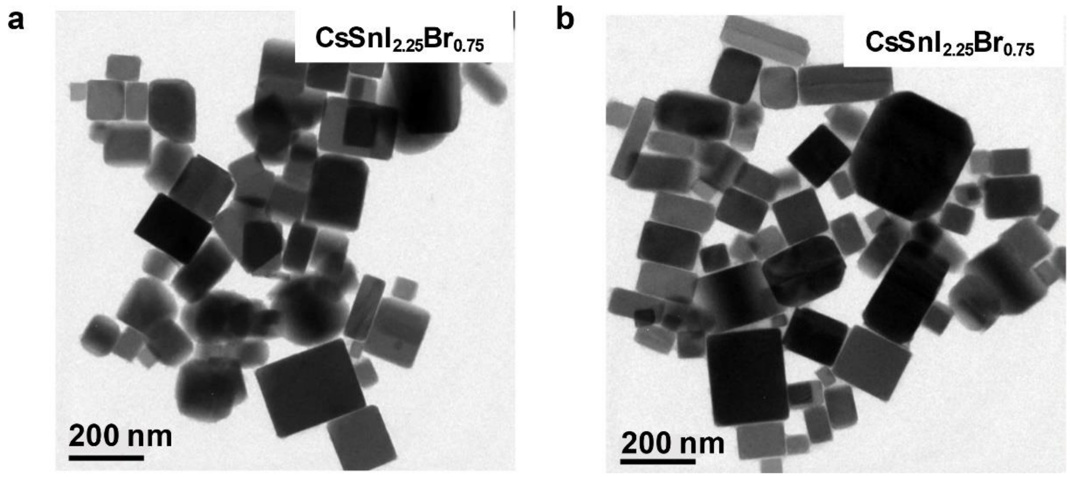

Figure S14. Additional TEM images of $CsSnI_{2.25}Br_{0.75}$.

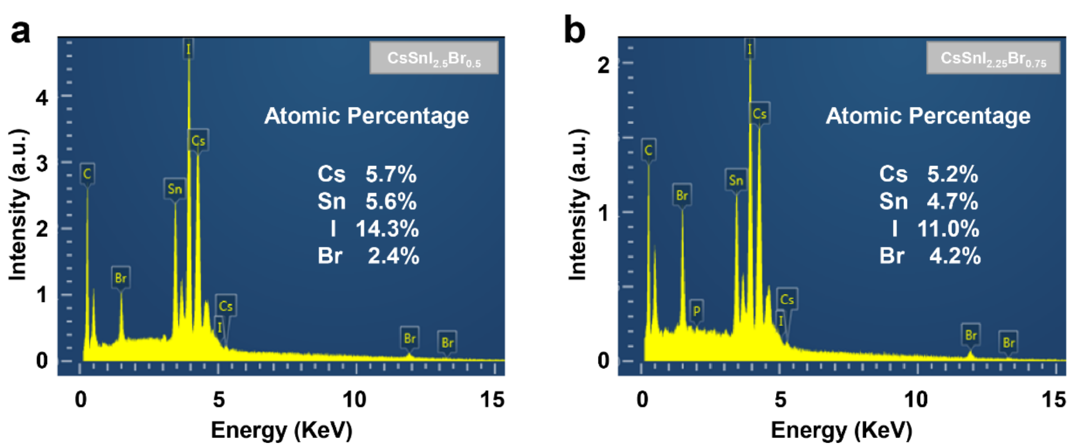

Figure S15. EDS spectra of (a) $CsSnI_{2.5}Br_{0.5}$ and (b) $CsSnI_{2.25}Br_{0.75}$ NCs synthesized with $C_{42}P$. Note that we used the nominal compositions for denoting the products.

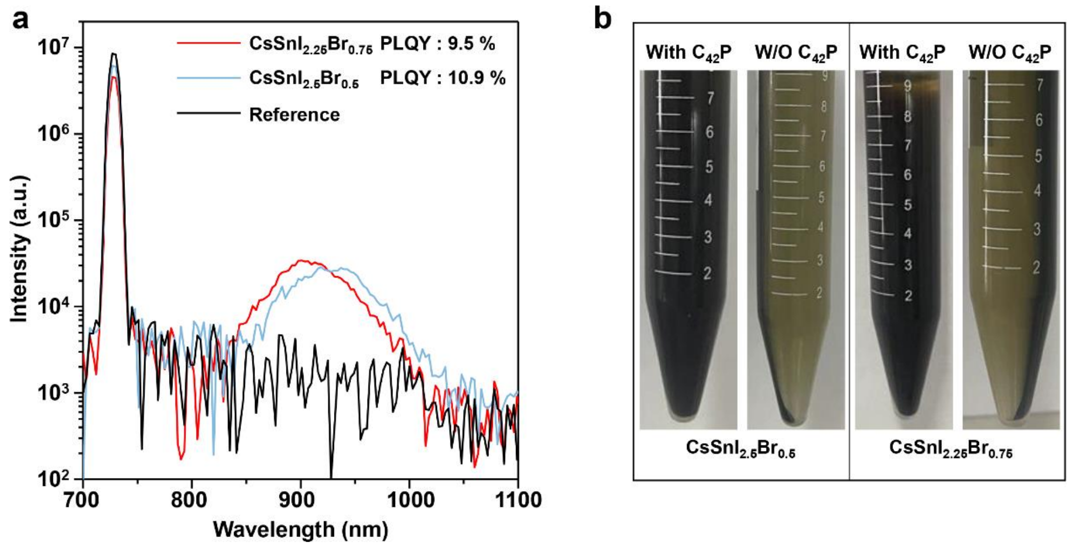

Figure S16. (a) PLQY measurements of $CsSnI_{2.5}Br_{0.5}$ and $CsSnI_{2.25}Br_{0.75}$ NCs synthesized with $C_{42}P$. (b) Photographs of $CsSnI_{2.5}Br_{0.5}$ and $CsSnI_{2.25}Br_{0.75}$ crude solution after the first centrifugation. The samples were synthesized with and without (W/O) $C_{42}P$. We note that NCs cannot be obtained in the absence of $C_{42}P$.

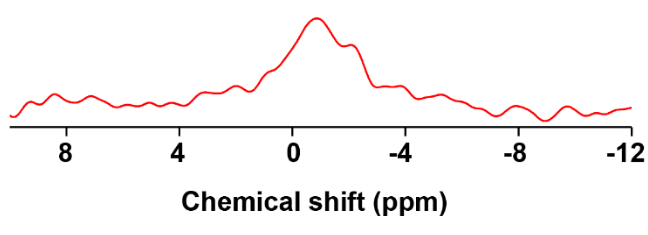

Figure S17. ^{31}P NMR spectrum of diluted $C_{42}P$ solution.

Table S1. Synthetic parameters used for the synthesis of large-sized $CsSnX_3$ powders and NCs. We denote the samples synthesized without using phosphatidylcholines by the molar ratio of Cs, Sn, and I precursors, and the mixed halide products by their nominal compositions. \`With\` and \`W/O\` stand for with and without using $C_{42}P$ in the synthesis, respectively.

Sample	Cs-Oleate (mL)	$Sn(Oct)_2$ (mL)	NH_4I (g)	$C_{42}H_{80}NO_8P$ (g)	$C_{22}H_{44}NO_8P$ (g)	$C_{32}H_{64}NO_8P$ (g)	$C_{44}H_{84}NO_8P$ (g)	NH_4Br (g)	OA (mL)	OAm (mL)	Temperature (°C)
0.25:4.2:3	0.5	1.12	0.3436						3	3.5	250
0.25:4.8:3	0.5	1.28	0.3436						3	3.5	250
0.25:5.2:3	0.5	1.44	0.3436						3	3.5	250
0.15:4.8:3	0.3	1.28	0.3436						3	3.5	250
0.35:4.8:3	0.7	1.28	0.3436						3	3.5	250
0.25:4.8:2	0.5	1.28	0.2291						3	3.5	250
0.25:4.8:4	0.5	1.28	0.4581						3	3.5	250
$CsSnI_{2.25}Br_{0.75}$(W/O)	0.5	1.28	0.2577					0.0574	3	3.5	250
$CsSnI_{2.5}Br_{0.5}$(W/O)	0.5	1.28	0.2863					0.0383	3	3.5	250
$C_{42}P$-0.1	0.5	1.28	0.3436	0.0155				/	3	3.5	250
$C_{42}P$-0.2	0.5	1.28	0.3436	0.0309				/	3	3.5	250
$C_{42}P$-0.3	0.5	1.28	0.3436	0.0464				/	3	3.5	250
$C_{42}P$-0.4	0.5	1.28	0.3436	0.0618				/	3	3.5	250
$C_{22}P$-0.2	0.5	1.28	0.3436		0.0194			/	3	3.5	250
$C_{32}P$-0.2	0.5	1.28	0.3436			0.0251		/	3	3.5	250
$C_{44}P$-0.2	0.5	1.28	0.3436				0.0318	/	3	3.5	250
$CsSnI_{2.25}Br_{0.75}$(With)	0.5	1.28	0.2577	0.0309				0.0574	3	3.5	250
$CsSnI_{2.5}Br_{0.5}$(With)	0.5	1.28	0.2863	0.0309				0.0383	3	3.5	250

Table S2. Fitting results of PL decay curves, adjusted R-square, and τ_{ave}.

Sample	A_1	τ_1 (ns)	A_2	τ_2 (ns)	A_0	Adjusted R-square	τ_{ave} (ns)
C_{42}P-0.1	0.26	0.27	0.65	0.78	0.0802	0.9978	0.72
C_{42}P-0.2	0.06	0.36	0.79	1.97	0.1367	0.9969	1.95
C_{42}P-0.3	0.29	2.26	0.69	1.25	0.0422	0.9992	1.69
C_{42}P-0.4	0.12	0.41	0.83	1.64	0.0521	0.9992	1.59
C_{22}P-0.2	0.06	0.20	0.83	1.63	0.1240	0.9984	1.62
C_{32}P-0.2	0.16	0.52	0.80	1.70	0.0519	0.9994	1.63
C_{44}P-0.2	0.15	0.49	0.81	1.36	0.0446	0.9993	1.31
$CsSnI_{2.25}Br_{0.75}$(With)	0.62	1.06	0.29	0.36	0.1058	0.9959	0.96
$CsSnI_{2.5}Br_{0.5}$(With)	0.09	0.15	0.88	1.33	0.0342	0.9988	1.32

Table S3. Optical properties of the tin halide perovskite NCs ever reported.

Formula	Emission peak (nm)	PLQY (%)	Reference
$CsSnI_3$	ca. 945	0.06	1
$CsSnBr_3$	ca. 660	0.14	1
$CsSn(Br_{0.5}I_{0.5})_3$	ca. 730	0.05	1
$CsSnCl_3$	ca. 490	≤0.14	1
BA_2SnI_4[a]	628.2	0.5	2
$BA_2[FASnI_3]SnI_4$	689	2.6	2
$CsSnBr_3$	682	2.1	3
$CsSnI_3$	780	<1	4
$CsSnI_3$	849	0.35	5
$CsSnBr_3$	677	0.60	5
$CsSnCl_3$	475	0.17	5
$CsSnI_3$	944	18.4	6
$CsSnI_{2.5}Br_{0.5}$	925	7.7	6
$CsSnI_{2.25}Br_{0.75}$	896	7.1	6
$FASnI_3$	ca. 663-763	0.3	7
$CsSnI_3$	944	12.0	This work
$CsSnI_{2.5}Br_{0.5}$	926	10.9	This work
$CsSnI_{2.25}Br_{0.75}$	902	9.5	This work

[a]BA is the abbreviation of butylammonium.

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