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

Supporting Information

Reverse Synthesis of $CsPb_xMn_{1-x}(Cl/Br)_3$ Perovskite Quantum Dots from $CsMnCl_3$ Precursor through Cation Exchange

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Table S1 Tabulation of Cs, Pb, Mn and Cl mole contents from EDX data for $CsMnCl_3$ precursor NCs and the prepared PQDs with Mn-to-Pb feeding ratio of 1:4 for different reaction times.

Element / Sample	Cs	Pb	Mn	Cl
$CsMnCl_3$	0.333		0.284	1.143
5 min	0.313	0.106	0.109	0.856
10 min	0.345	0.233	0.071	1.099
30 min	0.322	0.256	0.018	0.979
60 min	0.339	0.277	0.004	0.993

Table S2 Tabulation of Mn: Pb mole ratio from ICP data for $CsMnCl_3$ precursor NCs and the prepared PQDs with Mn-to-Pb feeding ratio of 1:4 for different reaction times.

Element / Sample	Mn (mmol/L)	Pb (mmol/L)	Mn: Pb
$CsMnCl_3$	0.556		
5 min	0.413	0.159	0.72:0.28
10 min	0.251	0.313	0.45:0.55
30 min	0.021	0.527	0.04:0.96
60 min	0.007	0.559	0.01:0.99

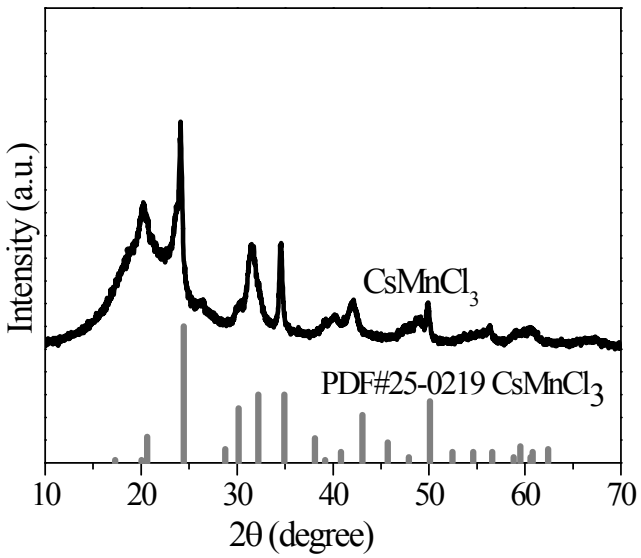


Figure S1 XRD pattern of $CsMnCl_3$ precursor nanocrystals via a hot injection method.

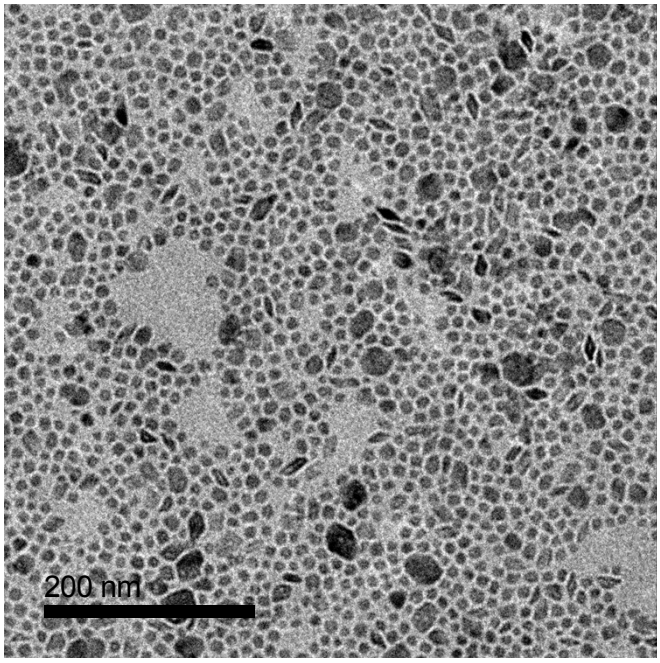
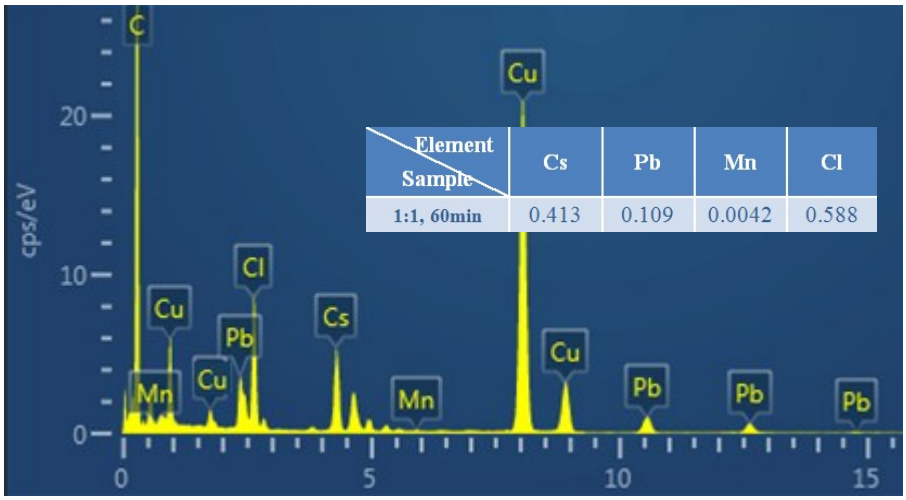


Figure S2 TEM image of $CsMnCl_3$ precursor nanocrystals via a hot injection method.



Element / Sample	Cs	Pb	Mn	Cl
1:1, 60min	0.413	0.109	0.0042	0.588

Figure S3 EDX spectrum of $Cs_4Pb_xMn_{1-x}Cl_6$ sample with reaction time of 60 min, showing the existence of Cs, Pb, Cl and Mn elemental signals. Inset is the calculated elemental contents with Cs: (Pb+Mn): Cl ratio being close to 4:1:6.

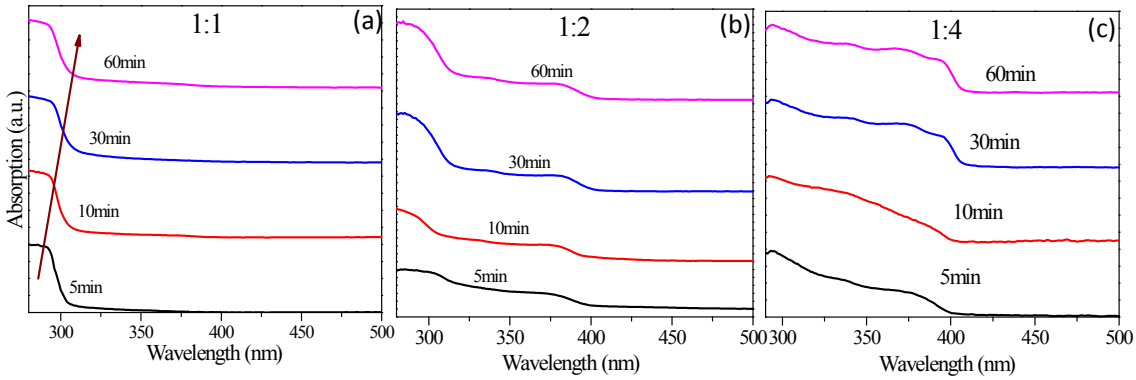


Figure S4 Absorption spectra of the as-prepared products with different Mn-to-Pb feeding ratios for reaction time of 5, 10, 30, 60 min using $PbCl_2$ as the source for cation exchange: (a) 1:1, (b) 1:2 and (c) 1:4.

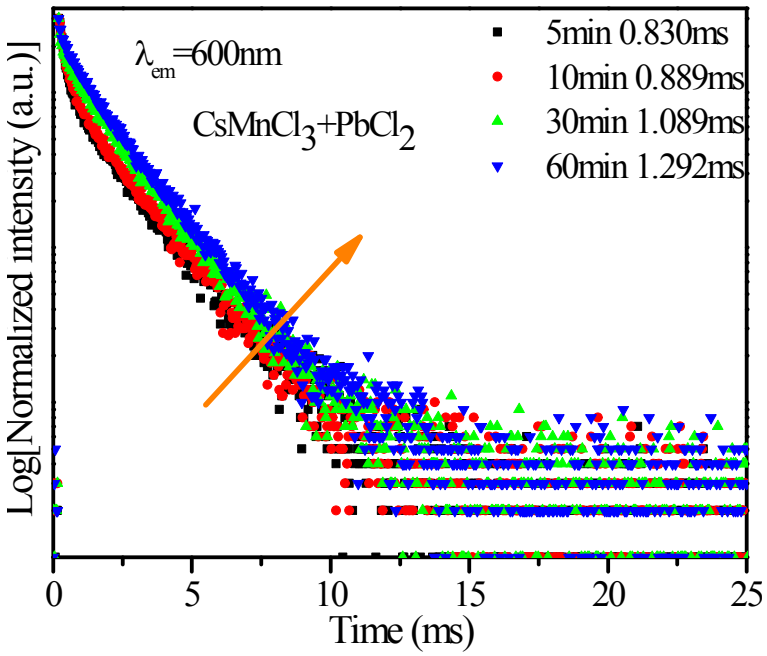


Figure S5 PL decay curves of Mn^{2+} luminescence (λ_{em}=600 nm, assigned to Mn^{2+}: $^4T_1 \rightarrow {}^6A_1$ transition) in the $CsPb_xMn_{1-x}Cl_3$ PQDs synthesized with Mn-to-Pb feeding ratio of 1:2. Evidently, with increase of reaction time, the lifetime of Mn^{2+}: $^4T_1$ emitting state increases from 0.830 ms to 1.292 ms.

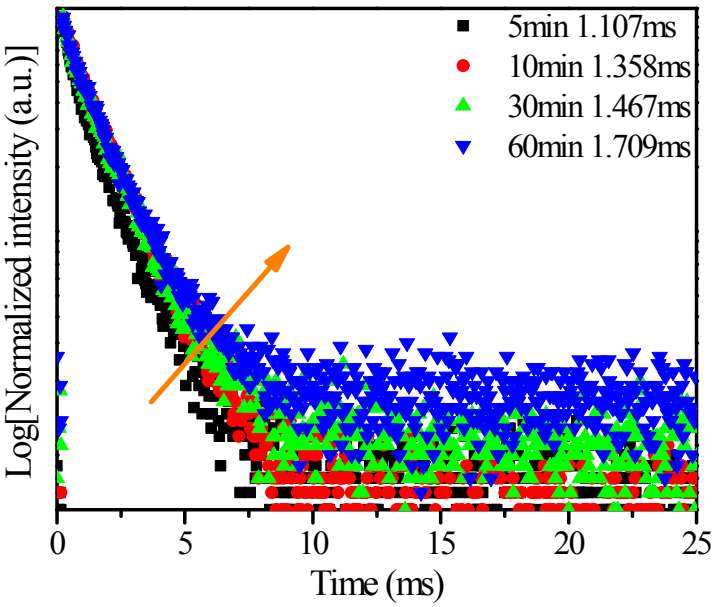


Figure S6 PL decay curves of Mn^{2+} luminescence (λ_{em}=600 nm, assigned to Mn^{2+}: $^4T_1 \rightarrow {}^6A_1$ transition) in the $CsPb_xMn_{1-x}Cl_3$ PQDs synthesized with Mn-to-Pb feeding ratio of 1:4. Evidently, with increase of reaction time, the lifetime of Mn^{2+}: $^4T_1$ emitting state increases from 1.107 ms to 1.709 ms.

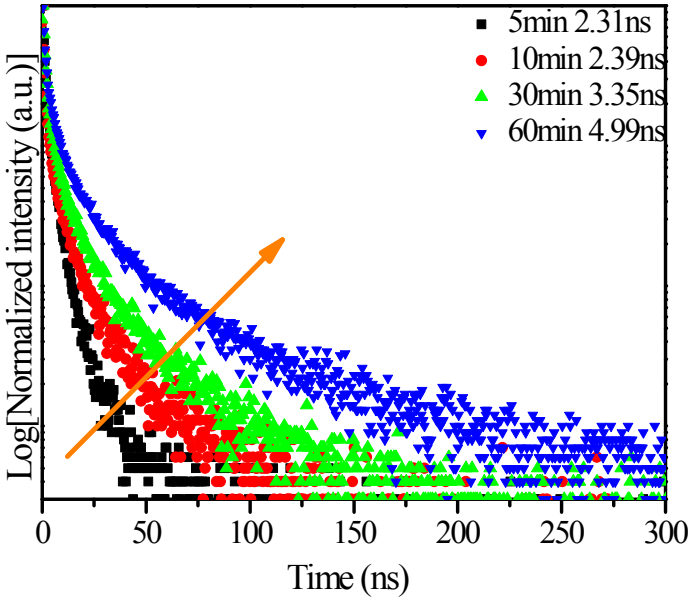


Figure S7 PL decay curves of exciton recombination for $CsPb_xMn_{1-x}Cl_3$ PQDs synthesized with Mn-to-Pb feeding ratio of 1:4, showing gradual increase of lifetime for PQDs with increase of cation exchange time.

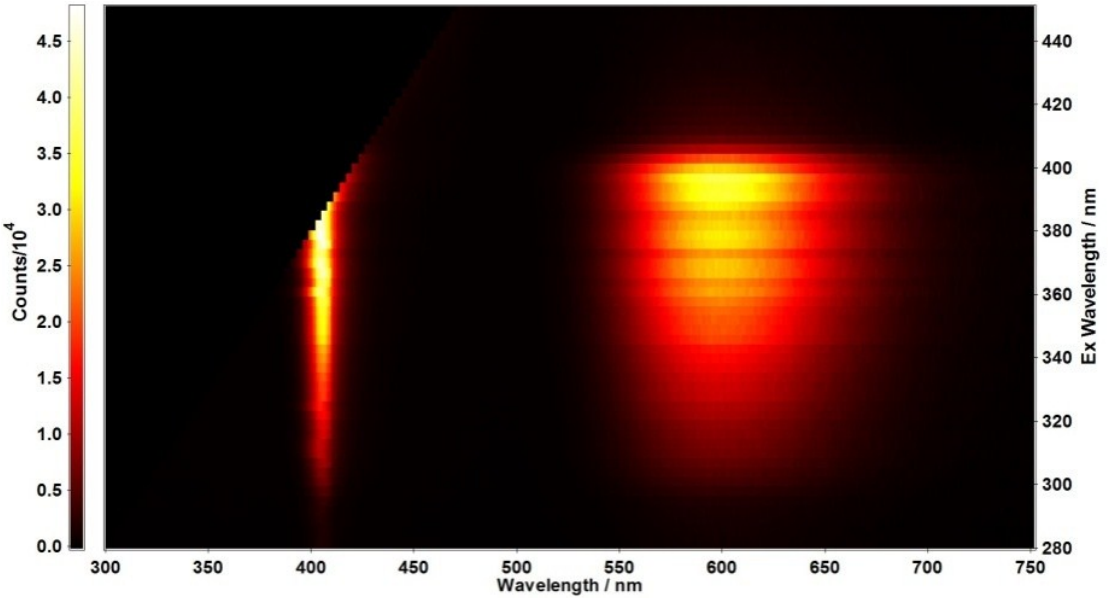


Figure S8 Excitation-emission mapping for the as-prepared $CsPb_xMn_{1-x}Cl_3$ PQDs with Mn-to-Pb feeding ratio of 1:4 and reaction time of 60 min, showing the excitation wavelength independent emissions for both $CsPbCl_3$ QDs and Mn^{2+} ions.

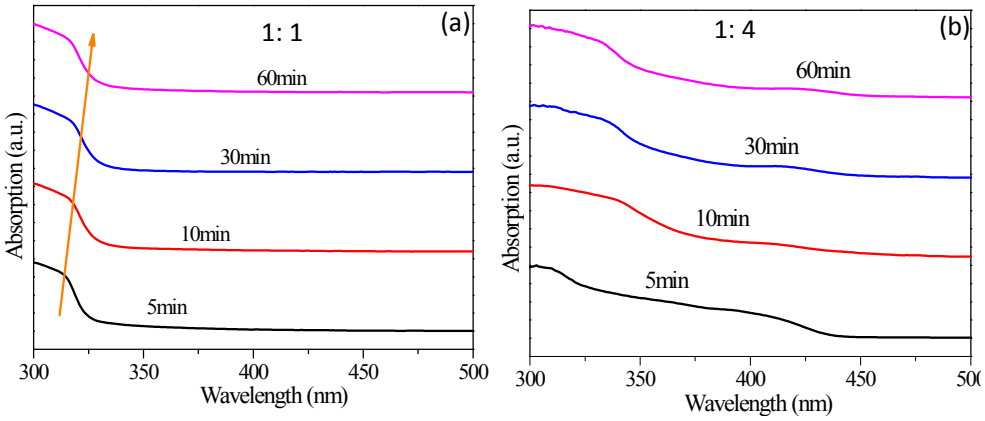


Figure S9 Absorption spectra of the as-prepared products with different Mn-to-Pb feeding ratios for reaction time of 5, 10, 30, 60 min using $PbBr_2$ as the source for cation exchange: (a) 1:1, (b) 1:4.

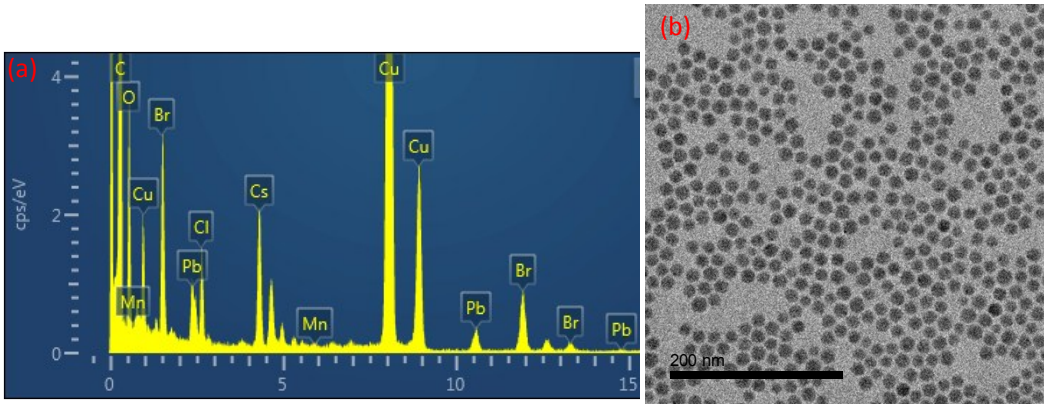


Figure S10 (a) EDX spectrum of $Cs_4Pb_xMn_{1-x}(Cl/Br)_6$ sample with Mn-to-Pb feeding ratio of 1:1, Cl-to-Br ratio of 3:2 and reaction time of 60 min, showing the existence of Cs, Pb, Cl, Br and Mn elemental signals. (b) TEM image of $Cs_4Pb_xMn_{1-x}(Cl/Br)_6$ sample, exhibiting spherical shape with homogeneous size distribution.

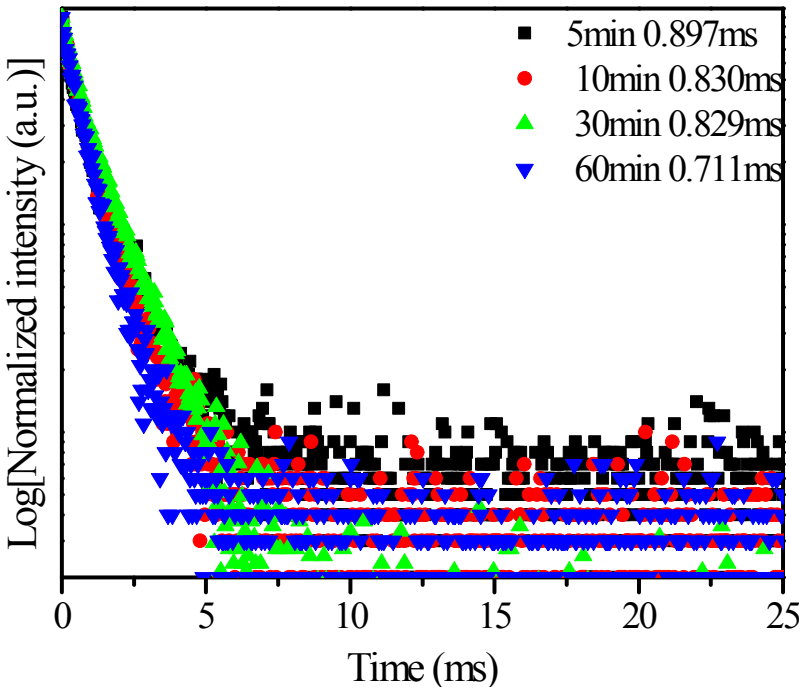


Figure S11 PL decay curves of Mn^{2+} luminescence (λ_{em}=600 nm, assigned to Mn^{2+}: $^4T_1 \rightarrow {}^6A_1$ transition) in the $CsPb_xMn_{1-x}(Cl/Br)_3$ PQDs synthesized with Mn-to-Pb feeding ratio of 1:4 using $PbBr_2$ as the source for cation exchange. Evidently, with increase of reaction time, the lifetime of Mn^{2+}: $^4T_1$ emitting state decreases from 0.897 ms to 0.711 ms ascribing to gradual change of Mn^{2+} ligand-field from Cl^- octahedron to Br^- dominant one.