Supporting Information

Enhancing Orange-red Emission by Doping/codoping $CsPb_2Br_5$ with Cations through a Room-temperature Aqueous-phase Synthesis

Yuwei Zhong[a], Xinran Li[a], Hao Zhang[a], Rong Zhang[a], Kaiwen Hu [a,*], Xuedong Zhou[a], Yi Xie[a,*]

[a] *State Key Laboratory of Silicate Materials for Architectures, Wuhan University of Technology, No. 122, Luoshi Road, Wuhan 430070, P. R. China.*

Email: xiey@whut.edu.cn

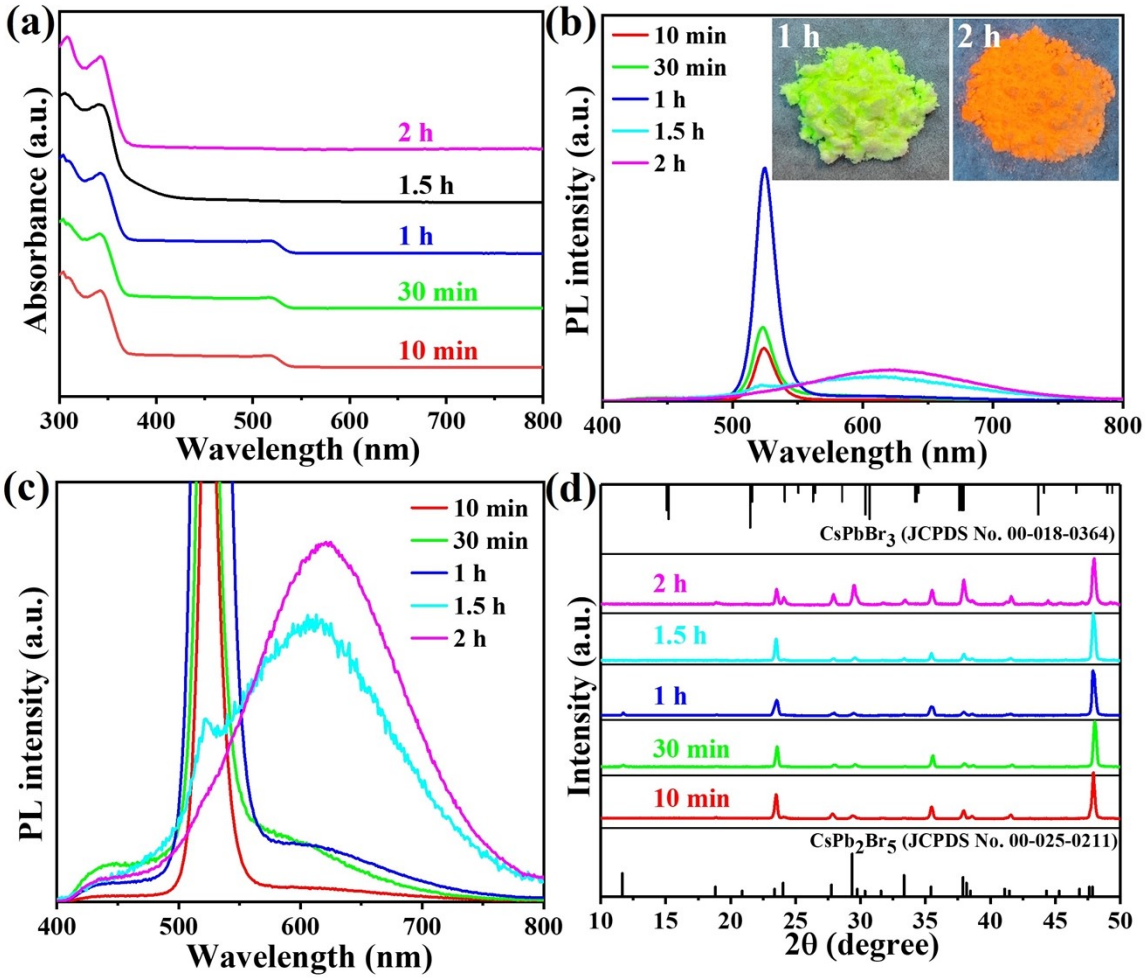

Fig. S1 (a) UV-visible diffuse reflectance spectra, (b) PL spectra and (c) corresponding magnified view of the PL spectra, and (d) XRD patterns of the undoped Cs-Pb-Br samples achieved at different reaction time. Insets in panel b) provide the digital photographs of the related powder samples under UV irradiation.

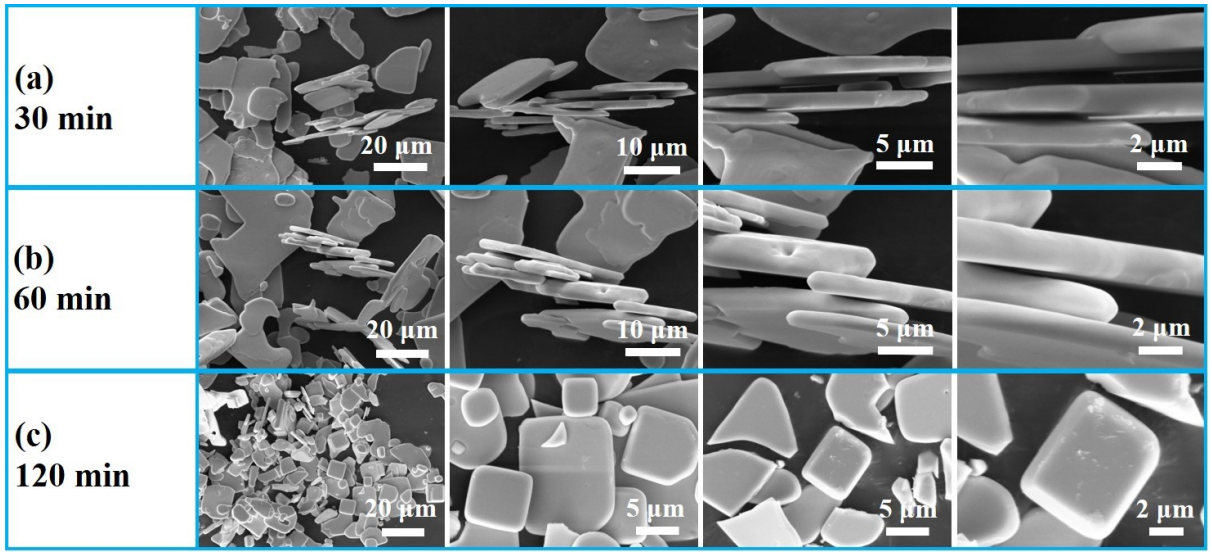

Fig. S2 SEM images with different magnifications of the typical undoped $CsPb_2Br_5$ achieved by room-temperature aqueous phase reaction for different time as dictated.

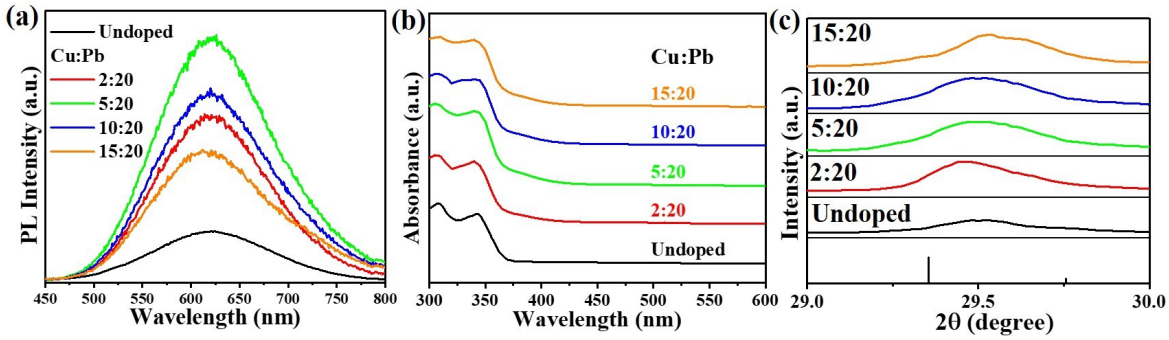

Fig. S3 (a) PL spectra, (b) UV-visible diffuse reflectance spectra, and (c) enlarged XRD patterns of the typical undoped $CsPb_2Br_5$ and various Cu-doped $CsPb_2Br_5$ samples collected in the presence of different amounts of Cu-precursor (denoted as precursor molar ratio of Cu:Pb). For comparison, PL and UV-visible diffuse reflectance spectra of the undoped $CsPb_2Br_5$ (i.e., 0% Cu) are also provided.

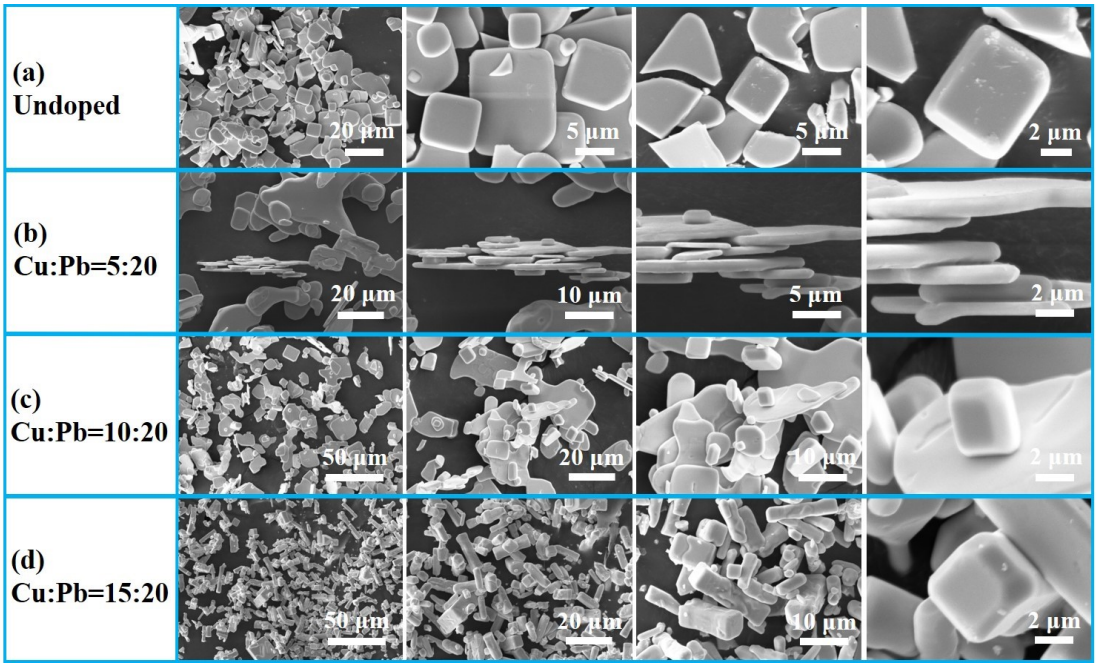

Fig. S4 SEM with different magnifications of the representative Cu-doped $CsPb_2Br_5$ collected in the presence of different amounts of Cu-precursors (denoted as precursor molar ratio of Cu:Pb). For comparison, SEM images of the undoped $CsPb_2Br_5$ (i.e., 0% Cu) are also provided.

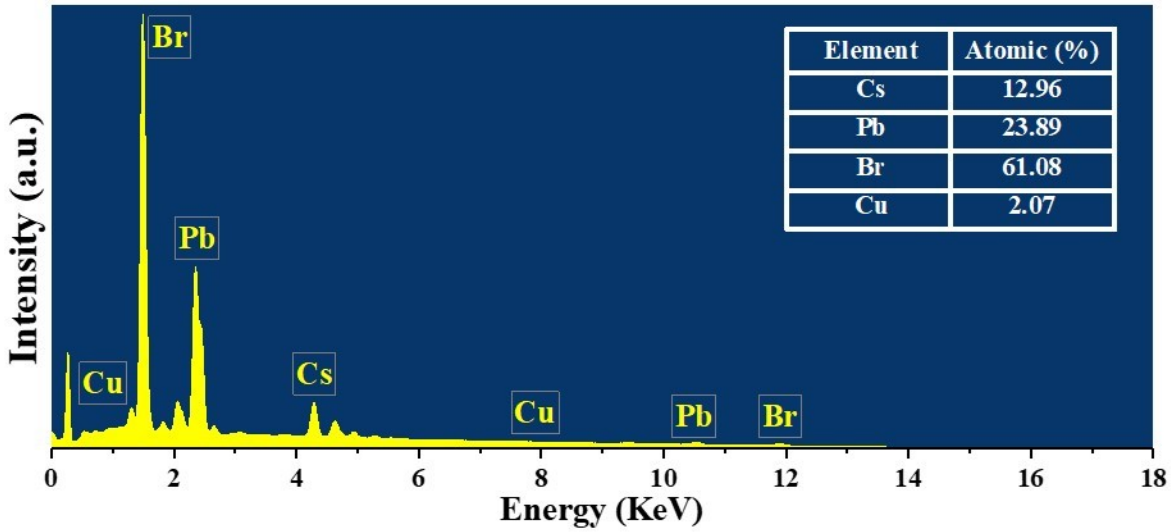

Fig. S5 EDS spectrum and element analysis on the typical Cu-doped $CsPb_2Br_5$.

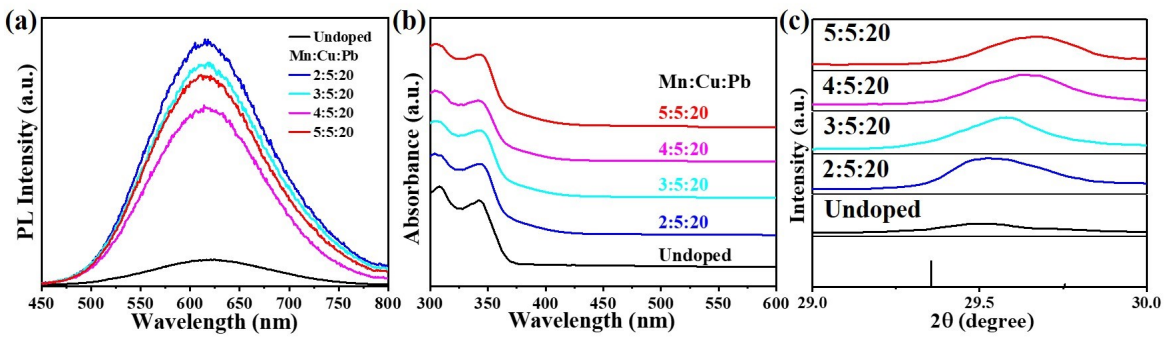

Fig. S6 PL spectra (a), UV-visible diffuse reflectance spectra (b), and enlarged view of the XRD patterns (c) of the Cu-Mn-codoped $CsPb_2Br_5$ collected in the presence of different amounts of Mn-precursors (denoted as precursor molar ratio of Mn:Cu:Pb).

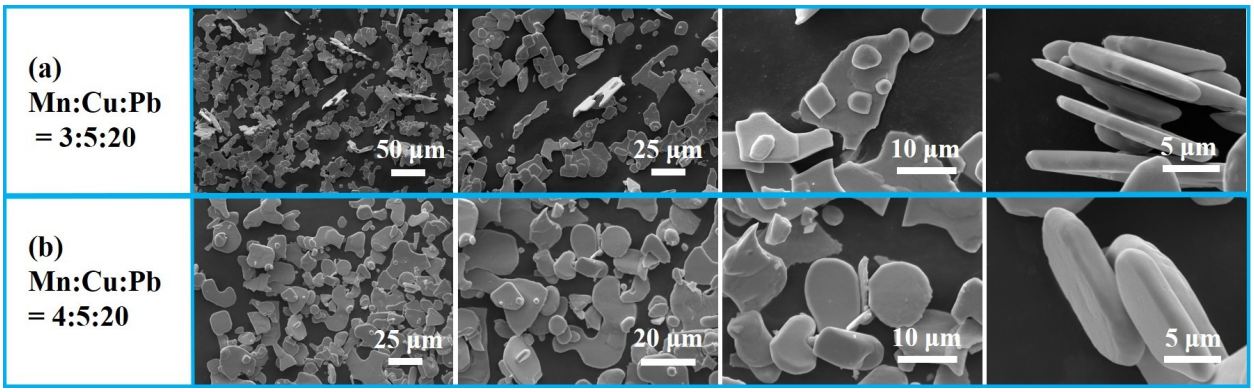

Fig. S7 SEM images with different magnifications of the Cu-Mn-codoped $CsPb_2Br_5$ collected in the presence of different amounts of Mn-precursors (denoted as precursor molar ratio of Mn:Cu:Pb).

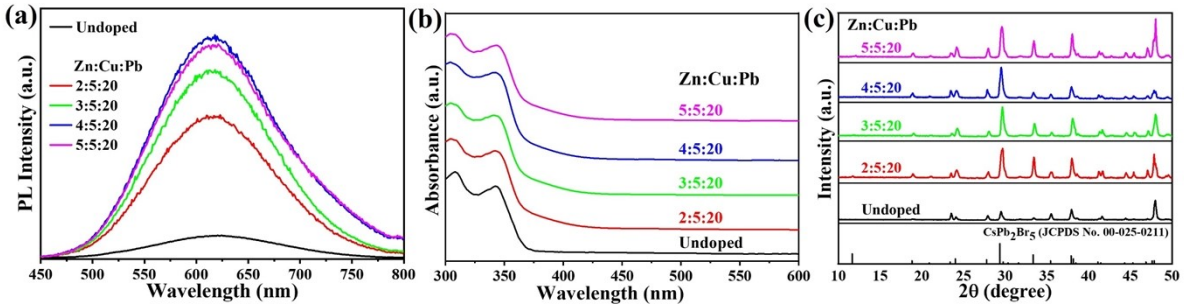

Fig. S8 PL spectra (a), UV-visible diffuse reflectance spectra (b), and XRD patterns (c) of the Cu-Zn-codoped $CsPb_2Br_5$ collected in the presence of different amounts of Zn-precursors (denoted as precursor molar ratio of Zn:Cu:Pb).

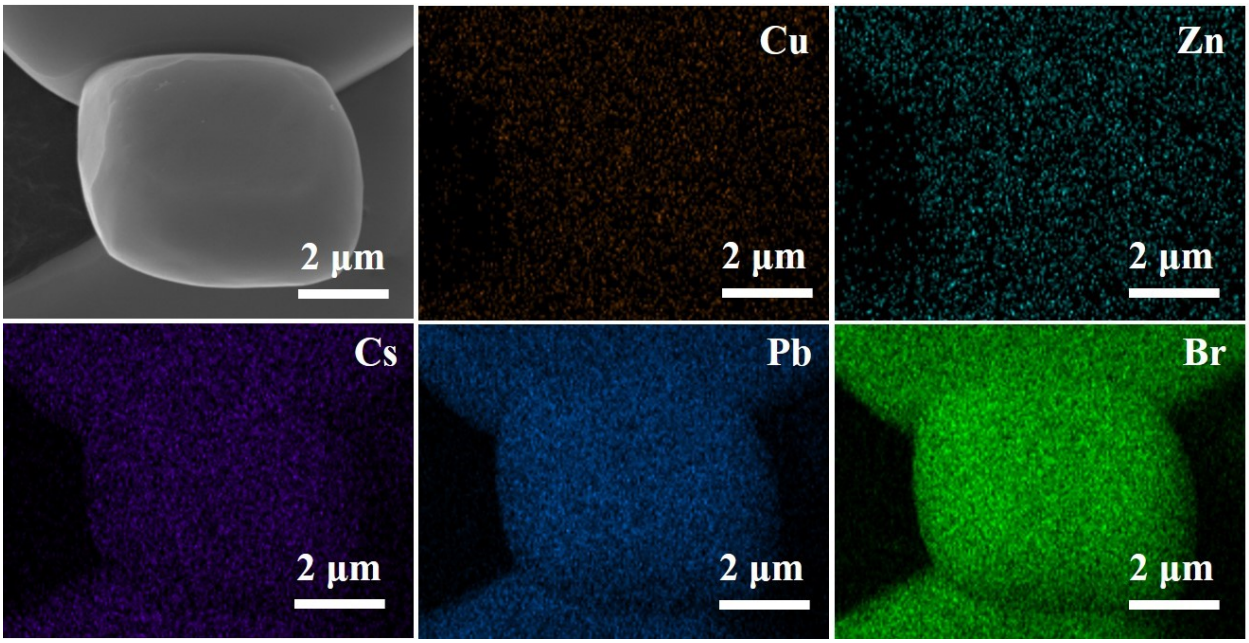

Fig. S9 Elemental mapping of the representative Cu-Zn-codoped $CsPb_2Br_5$ sample.

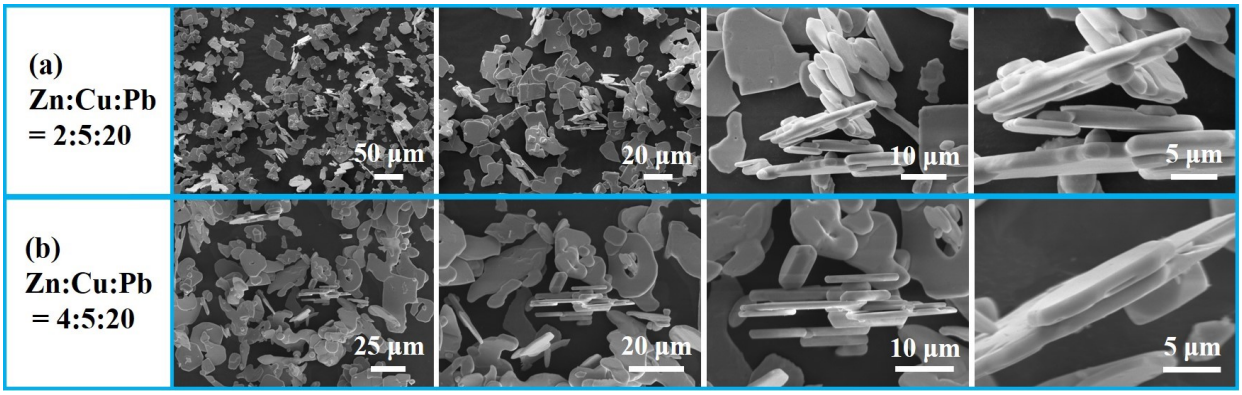

Fig. S10 SEM images with different magnifications of the Cu-Zn-codoped $CsPb_2Br_5$ collected in the presence of different amounts of Zn-precursors (denoted as precursor molar ratio of Zn:Cu:Pb).

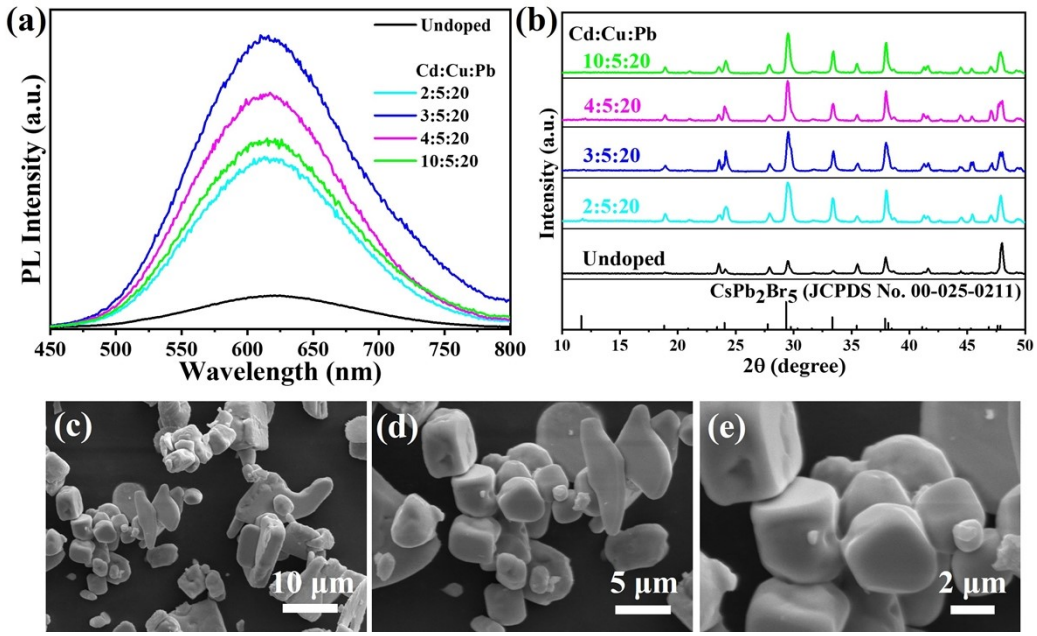

Fig. S11 (a-b) PL spectra (a) and XRD patterns (b) of the Cu-Cd-codoped $CsPb_2Br_5$ collected in the presence of different amounts of Cd-precursors (denoted as precursor molar ratio of Cd:Cu:Pb). (c-e) SEM images with different magnifications of the typical Cu-Cd-codoped $CsPb_2Br_5$ sample.

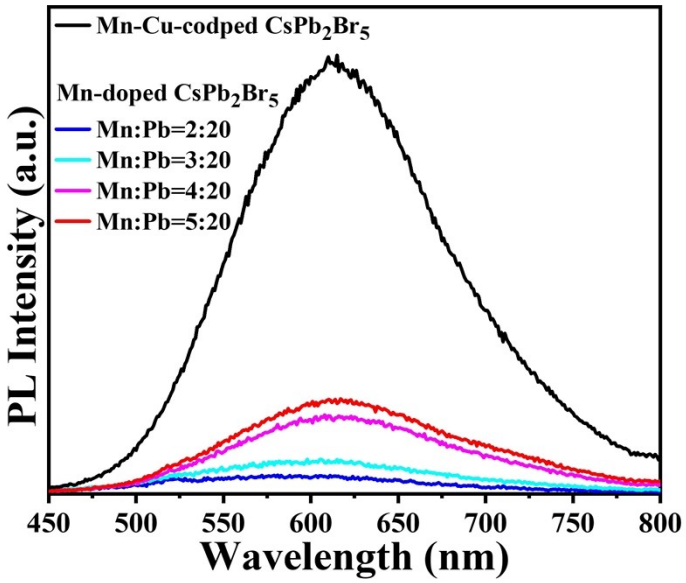

Fig. S12 PL spectra the Cu-Mn-codoped $CsPb_2Br_5$ (black curve) and Mn-doped $CsPb_2Br_5$ collected in the presence of different Mn amounts in the precursors (denoted as precursor molar ratio of Mn:Pb).

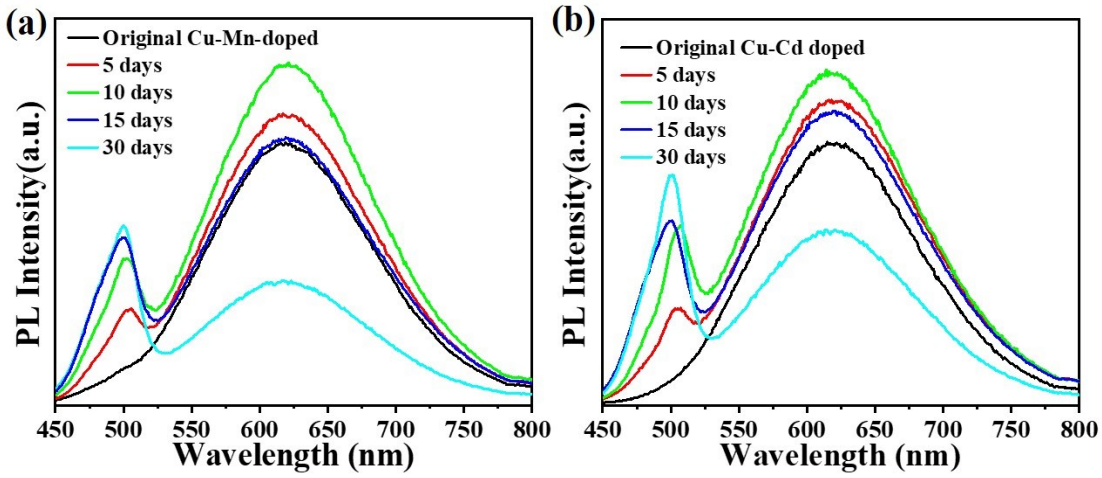

Fig. S13 PL spectra of the representative Cu-Mn-codoped $CsPb_2Br_5$ (a), and Cu-Cd-codoped $CsPb_2Br_5$ (b) collected after immersing in water for different time.

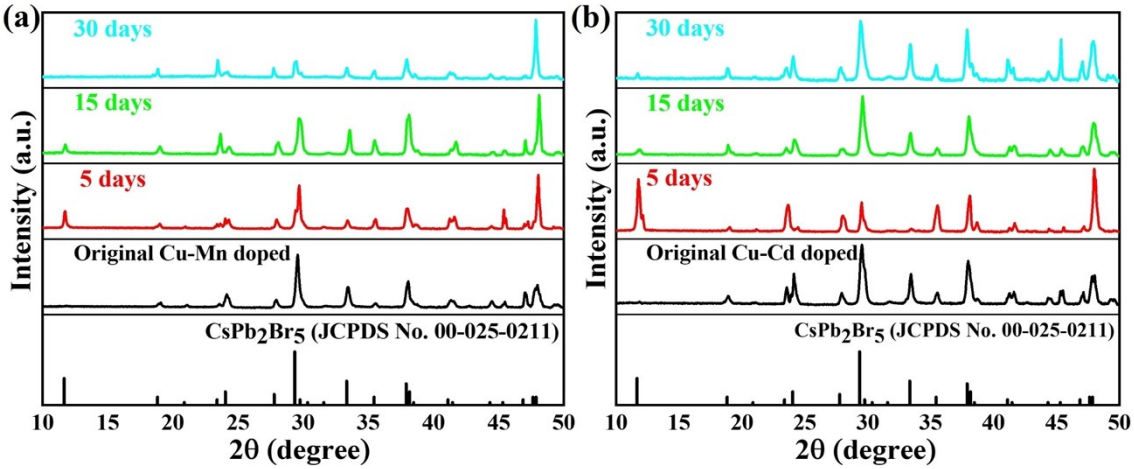

Fig. S14 (a-c) Evolution of XRD patterns of the representative Cu-Mn-codoped $CsPb_2Br_5$ (a), and Cu-Cd-codoped $CsPb_2Br_5$ (b) before immersing and after immersing in water for different time.

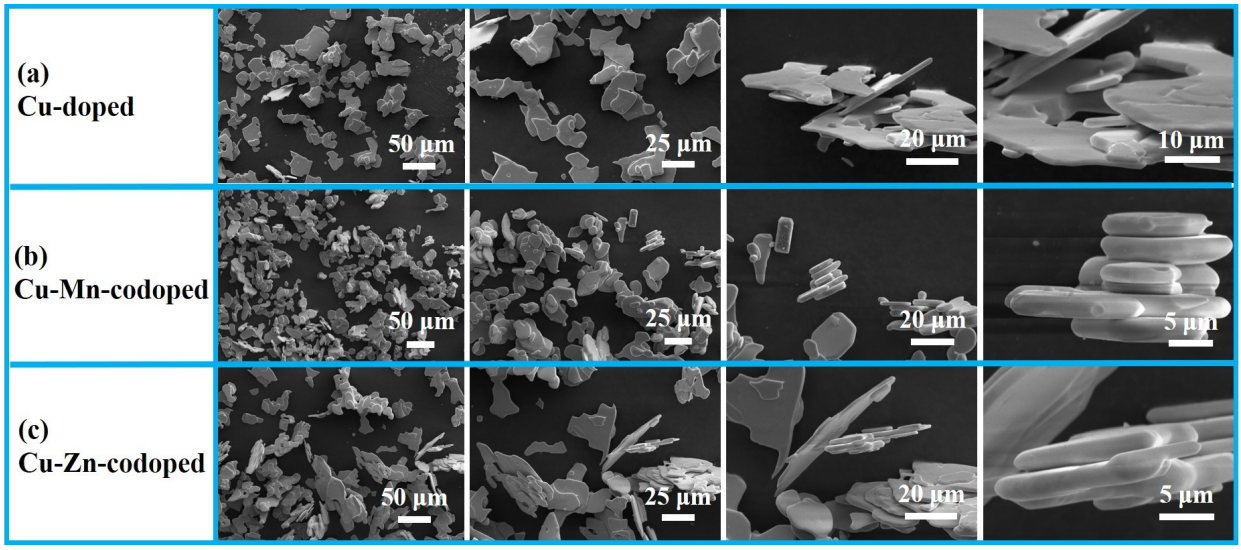

Fig. S15 SEM images with different magnifications of the Cu-doped $CsPb_2Br_5$ (a), and Cu-Mn-codoped $CsPb_2Br_5$ (b), and Cu-Zn-codoped $CsPb_2Br_5$ (c) immersed in water for 5 days.

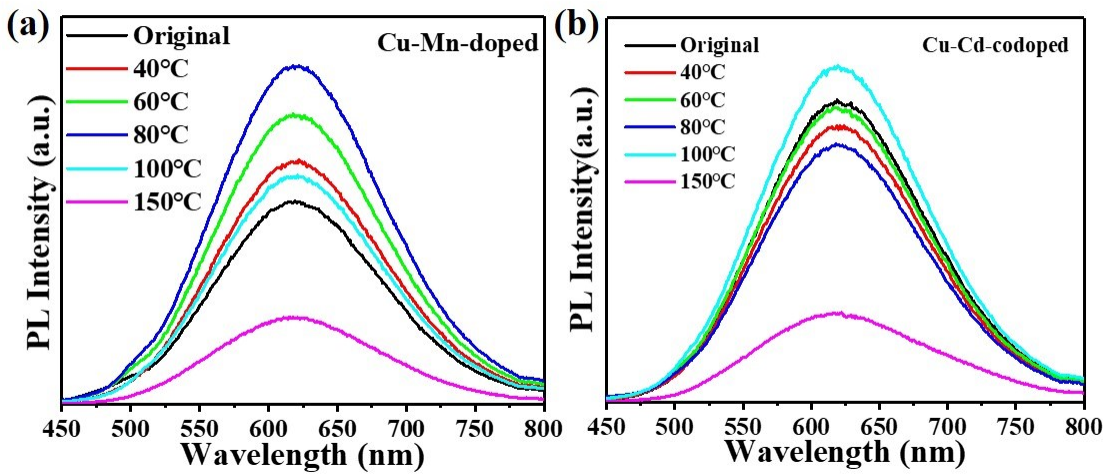

Fig. S16 Evolution of PL spectra of the representative Cu-Mn-codoped $CsPb_2Br_5$ (a), and Cu-Cd-codoped $CsPb_2Br_5$ (b) treated at different temperatures for 2 h.

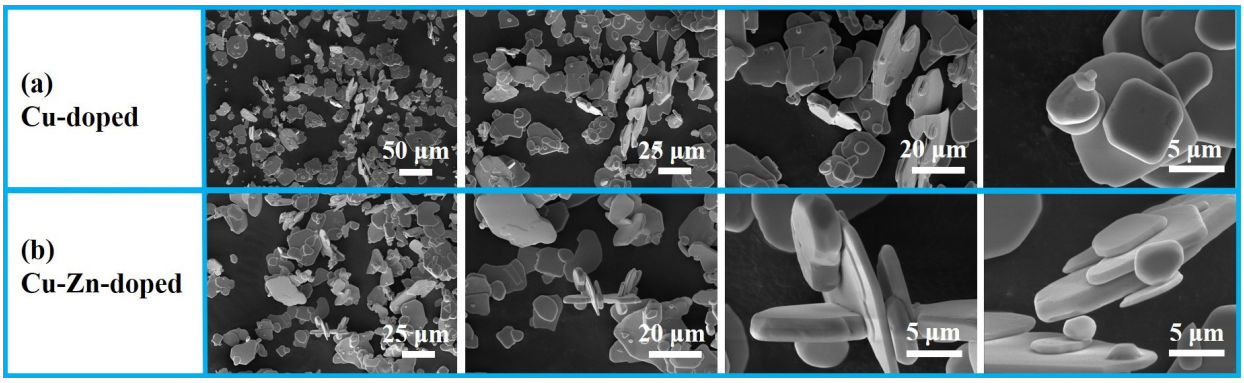

Fig. S17 SEM images with different magnifications of the Cu-doped $CsPb_2Br_5$ and Cu-Zn-codoped $CsPb_2Br_5$ annealed at 60°C for 2 h.

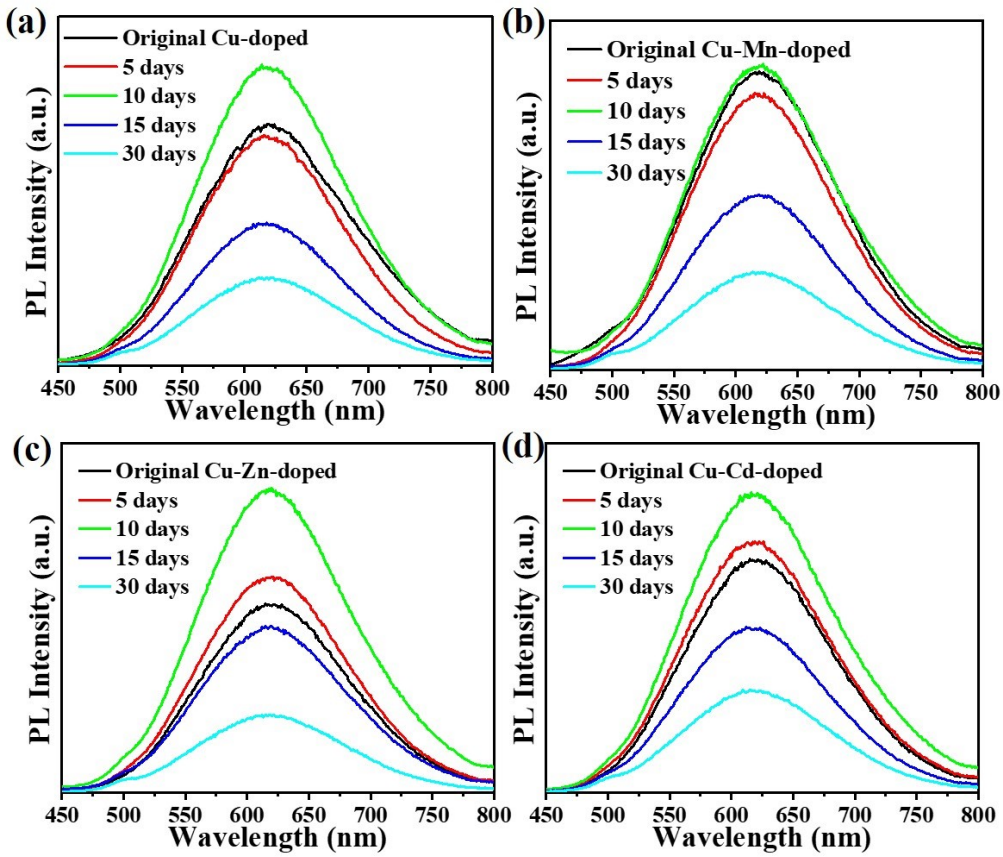

Fig. S18 Evolution of PL spectra of the representative Cu-doped $CsPb_2Br_5$ (a), and Cu-Mn-codoped $CsPb_2Br_5$ (b), Cu-Zn-codoped $CsPb_2Br_5$ (c), and Cu-Cd-codoped $CsPb_2Br_5$ (d) over exposing time under ambient condition.