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# The Formation Process of Five-Component Cu-In-Zn-Se-S Nanocrystals from Ternary Cu-In-S and Quaternary Cu-In-Se-S Nanocrystals via Gradually Induced Synthesis

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**Table S1.** Summary of the fluorescence decay lifetime data of Cu-In-Se-S NCs obtained by the one-pot method.

| | $\alpha_1$ (%) | $\tau_1$ (ns) | $\alpha_2$ (%) | $\tau_2$ (ns) | $\alpha_3$ (%) | $\tau_3$ (ns) | $\tau_{ave}$ (ns) |
|---|---|---|---|---|---|---|---|
| 120 °C | 49.9 | 9.2 | 37.7 | 32.6 | 12.4 | 154.5 | 36.0 |
| 150 °C | 16.8 | 13.9 | 45.4 | 64.5 | 37.8 | 274.5 | 135.4 |
| 180 °C | 12.7 | 15.7 | 45.7 | 73.9 | 41.6 | 314.6 | 166.6 |

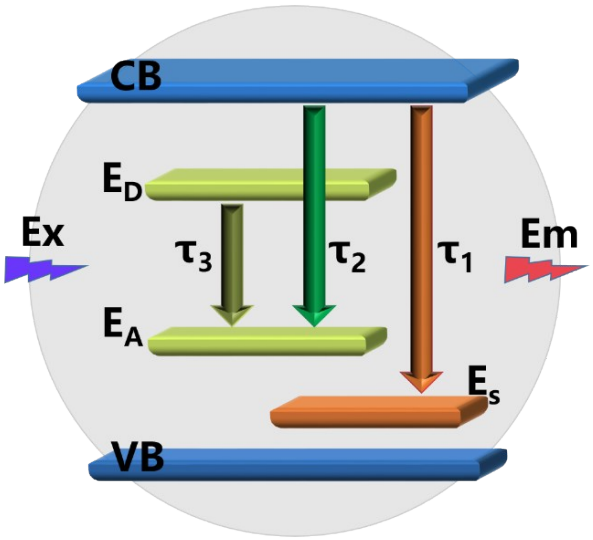


**Figure S1.** The schematic diagram of the radiation recombination mechanism of Cu-In-S NCs.

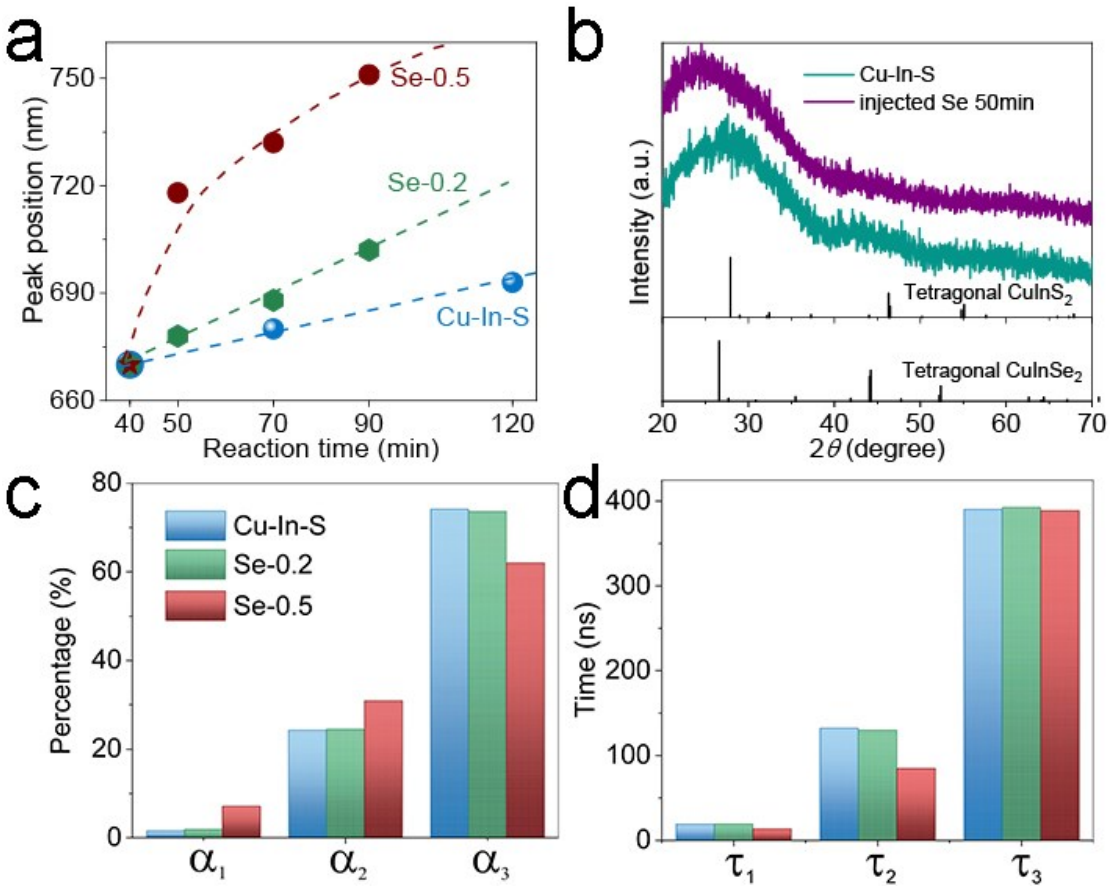


**Figure S2.** The summary of the Cu-In-S NCs before and after Se powder injected (0.2 mmol and 0.5 mmol): (a) emission peak position; (b) XRD of Cu-In-S obtained in 220 $^{o}$C 40 min and the Cu-In-Se-S NCs prepared 50 min later after 0.2 mmol Se was injected. (c) The percentage of $\alpha_1$, $\alpha_2$ and $\alpha_3$; (d) the time of $\tau_1$, $\tau_2$ and $\tau_3$.

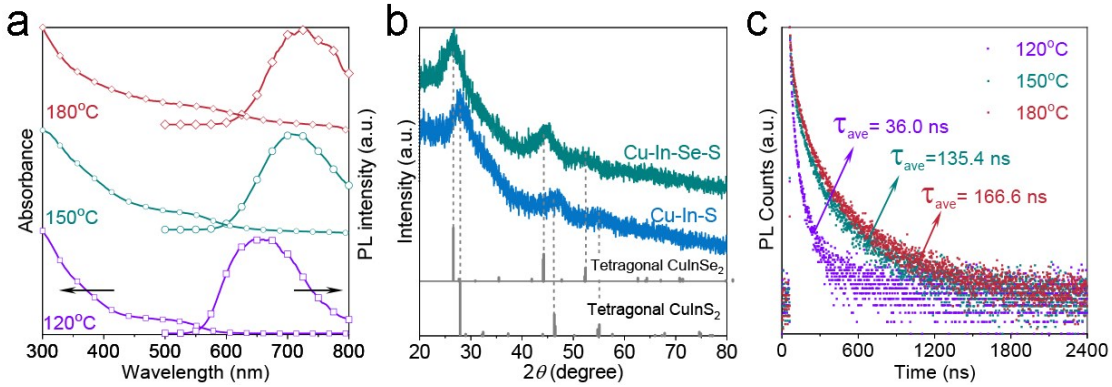


**Figure S3**. (a) Absorption and PL spectra of Cu-In-Se-S NCs in different temperatures. (b) Comparison of XRD patterns of Cu-In-S NCs obtained at 220 °C 40 min and Cu-In-Se-S NCs prepared at 150 °C, both of them are obtained in one-pot method. (c) Decay curves of Cu-In-Se-S NCs in different temperatures.

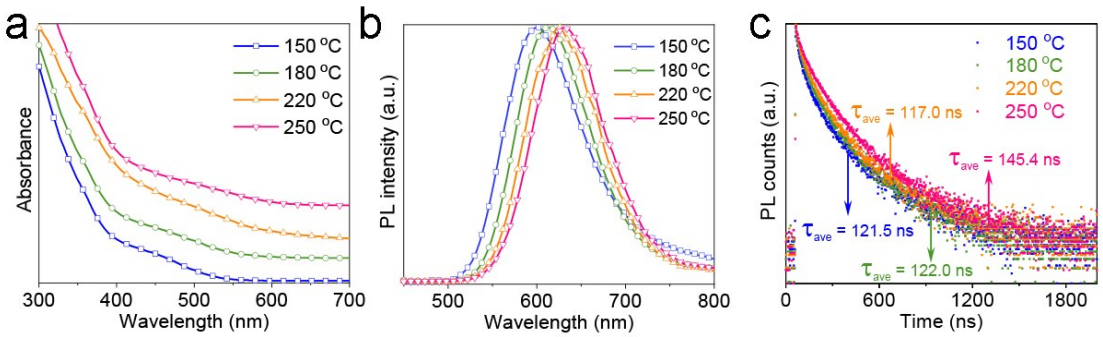


**Figure S4.** (a) Absorption and (b) emission spectra and (c) fluorescence decay curve of Cu-In-Zn-Se-S NCs via the one-pot method with 0.5 mmol Zn precursor (Zn-0.5).

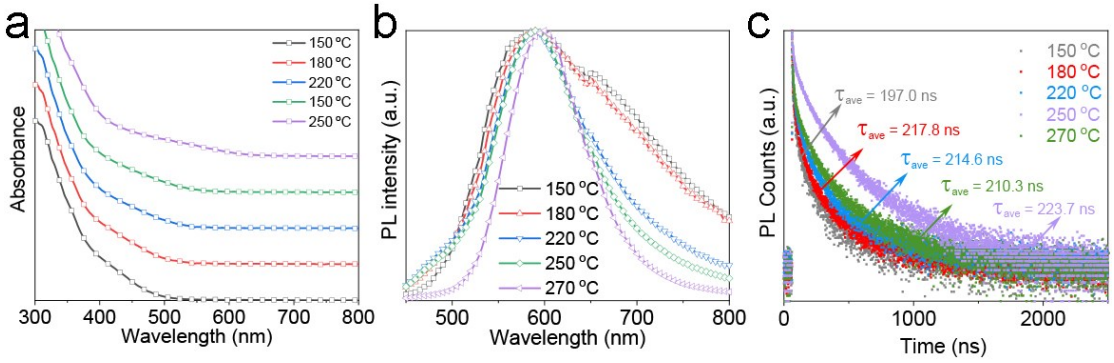


**Figure S5.** (a) Absorption and (b) emission spectra and (c) fluorescence decay curve of Cu-In-Zn-Se-S NCs via the one-pot method with 1 mmol Zn precursor (Zn-1).

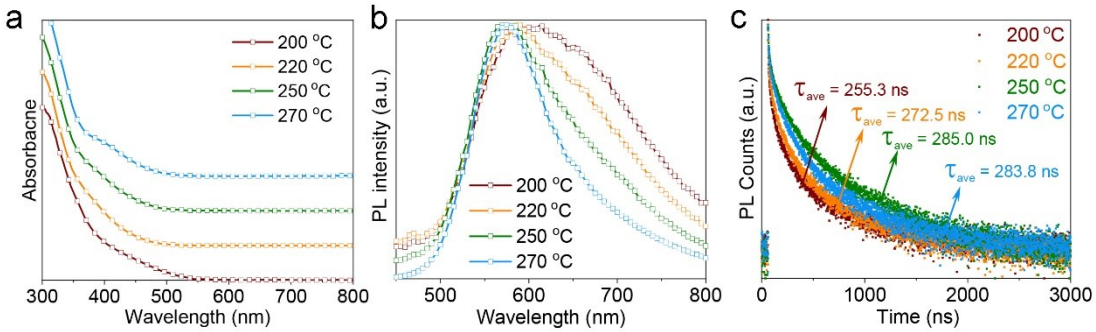


**Figure S6**. (a) Absorption and (b) emission spectra and (c) fluorescence decay curve of Cu-In-Zn-Se-S NCs via the one-pot method with 1.5 mmol Zn precursor (Zn-1.5).

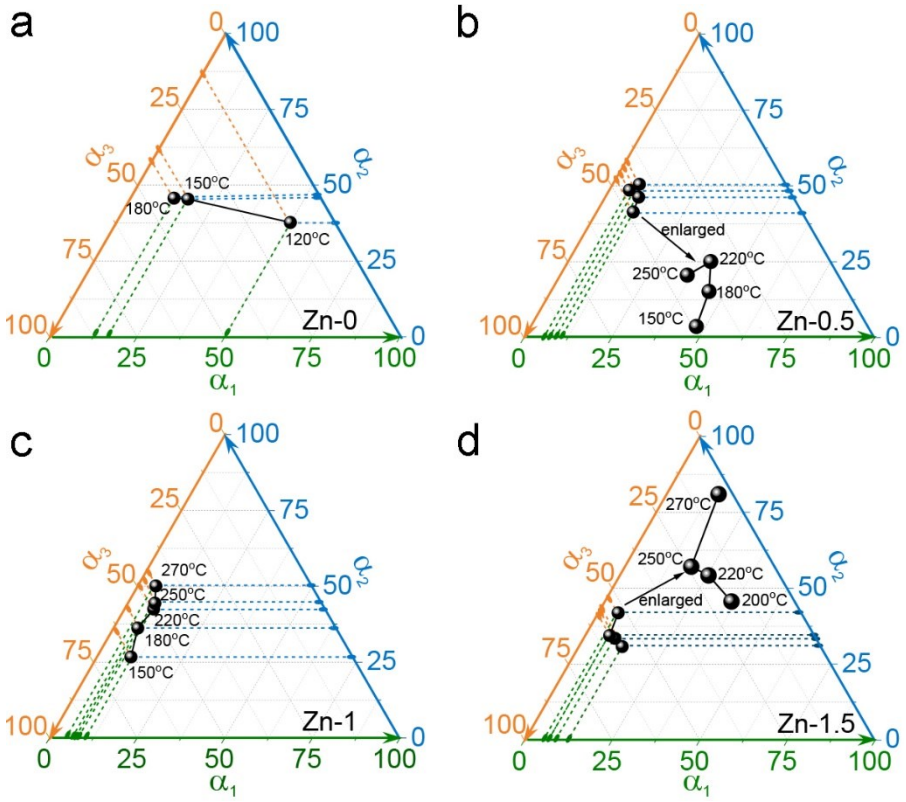


**Figure S7**. The change percentage of different combinations ($\alpha_1$, $\alpha_2$ and $\alpha_3$) upon the temperature increasing under altering dosages of Zn precursor: (a) Zn-0, (b) Zn-0.5, (c) Zn-1, (d) Zn-1.5.

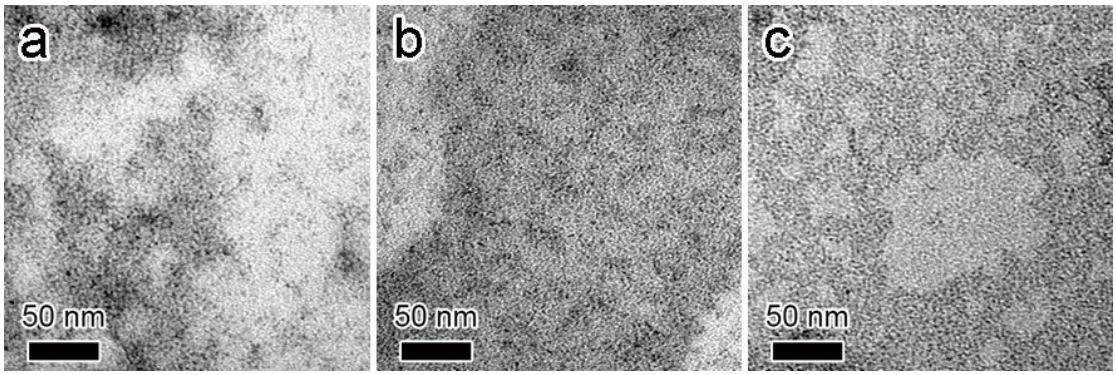


**Figure S8**. The TEM of (a) Zn-0 (150 $^{o}$C), (b) Zn-0.5 (250 $^{o}$C) and (c) Zn-1 (250 $^{o}$C), and these samples were obtained by one-pot method.

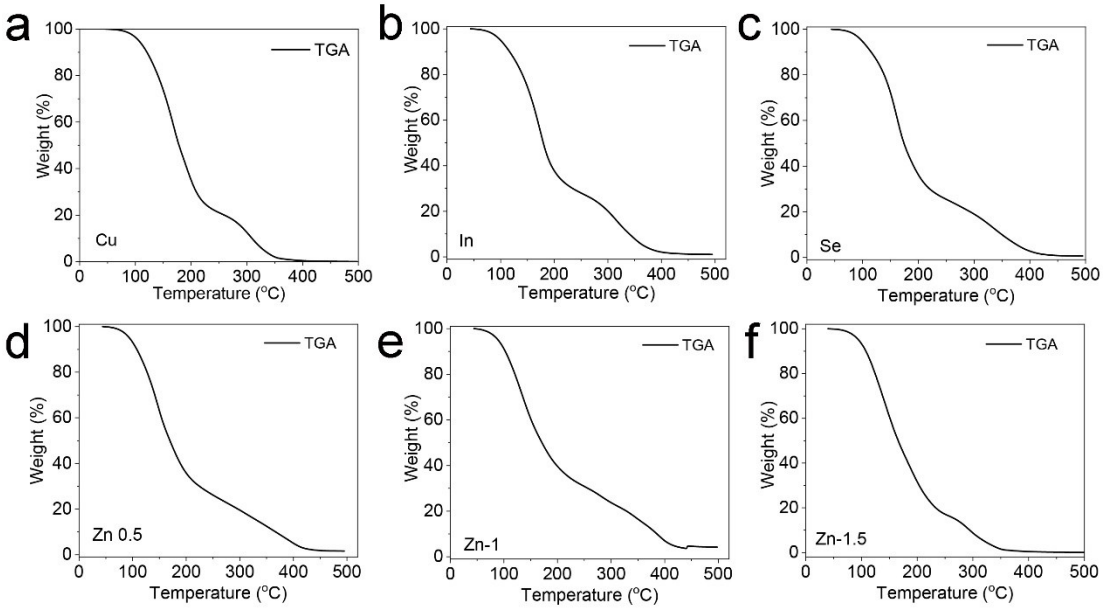


**Figure S9**. The thermogravimetric analysis data (TGA) of each ion mixed with organic matter respectively: (a) Cu, (b) In, (c) Se, (d) Zn-0.5, (e) Zn-1, (f) Zn-1.5.

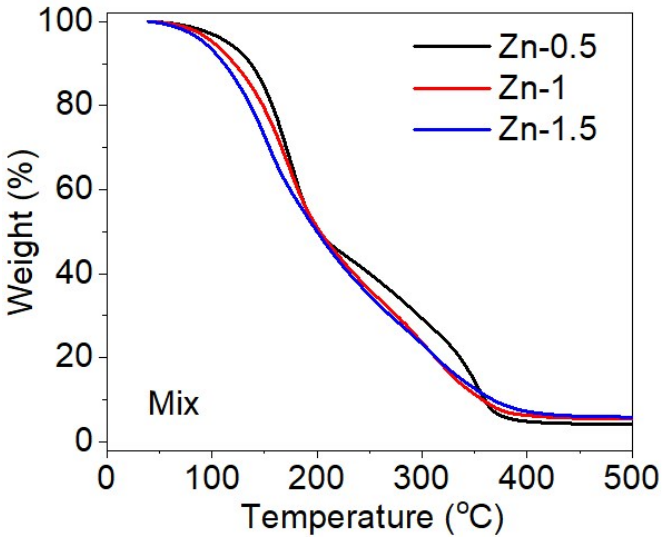


**Figure S10**. The thermogravimetric analysis (TGA) curves of all the precursors mixed with organic matters under different dosages of Zn, while other amounts kept constant.

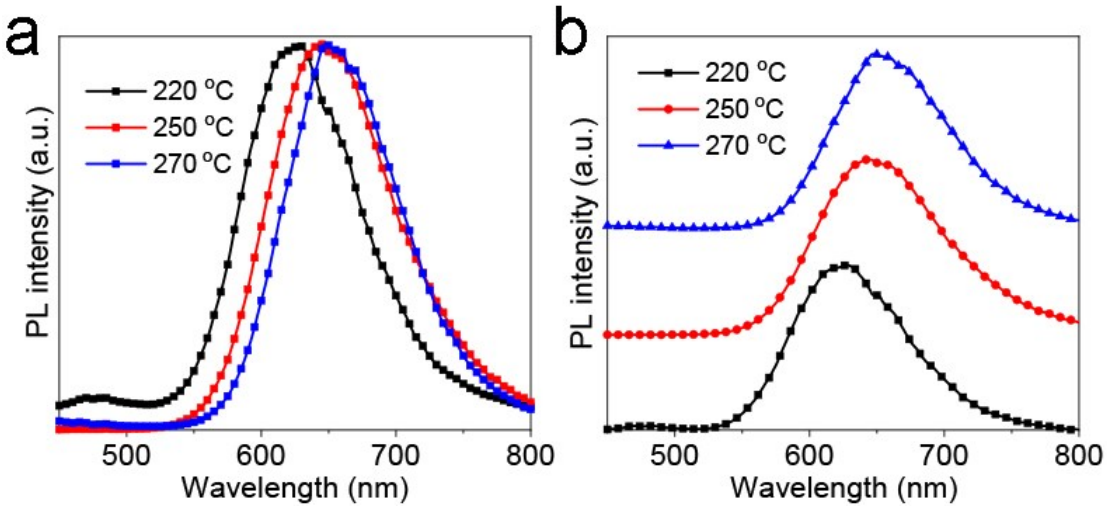


**Figure S11**. The emission spectra of Cu-In-Zn-Se-S NCs obtained by Cu precursor injected method and the dosage of Zn precursor is 0.5 mmol (Zn-0.5): (a) Normalized and (b) non-normalized.

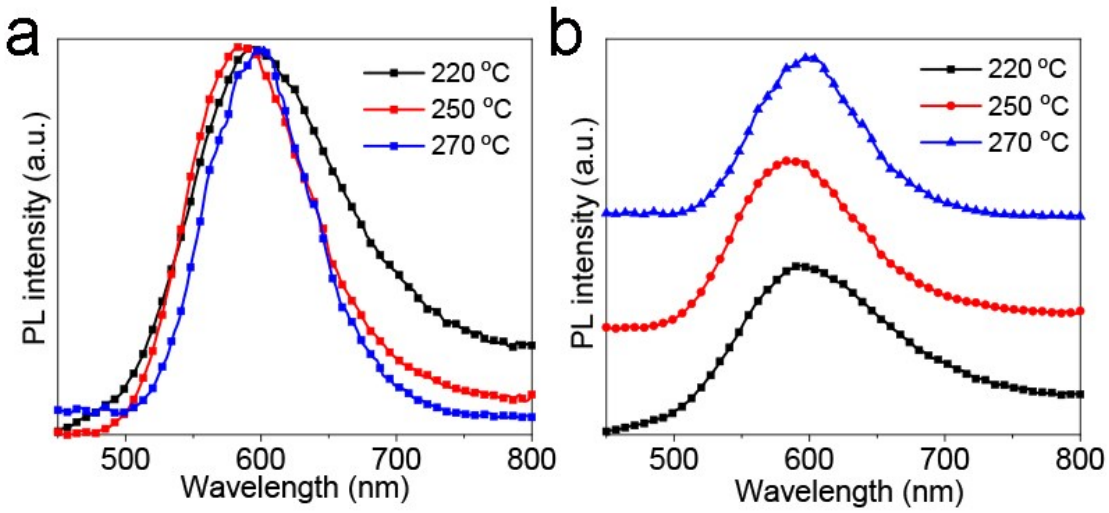


**Figure S12**. The emission spectra of Cu-In-Zn-Se-S NCs obtained by Cu precursor injected method and the dosage of Zn precursor is 1 mmol (Zn-1): (a) Normalized and (b) non-normalized.

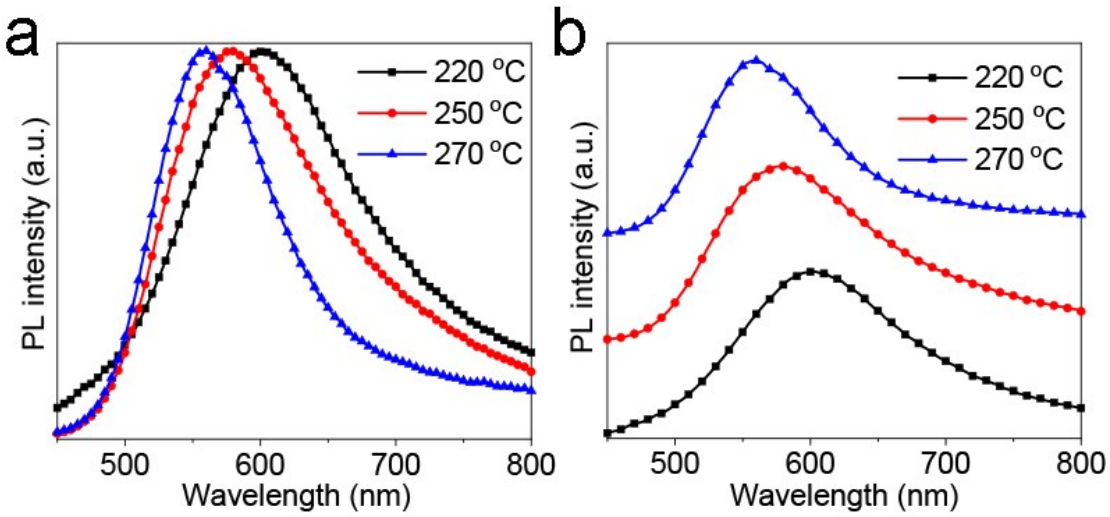


**Figure S13**. The emission spectra of Cu-In-Zn-Se-S NCs obtained by Cu precursor injected method and the dosage of Zn precursor is 1.5 mmol (Zn-1.5): (a) Normalized and (b) non-normalized.

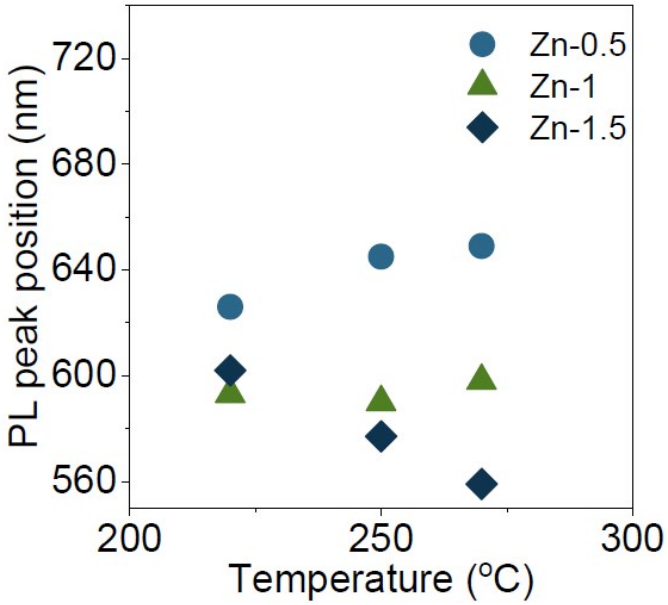


**Figure S14.** The summary of the emission peak position of Cu-In-Zn-Se-S NCs in different temperatures obtained by Cu precursor injected method with varying dosages of Zn precursor (Zn-0.5, Zn-1, Zn-1.5).