

Supporting Information

Cation Exchange on Colloidal Copper Selenide Nanosheets: A Route to Two-Dimensional Metal Selenide Nanomaterials

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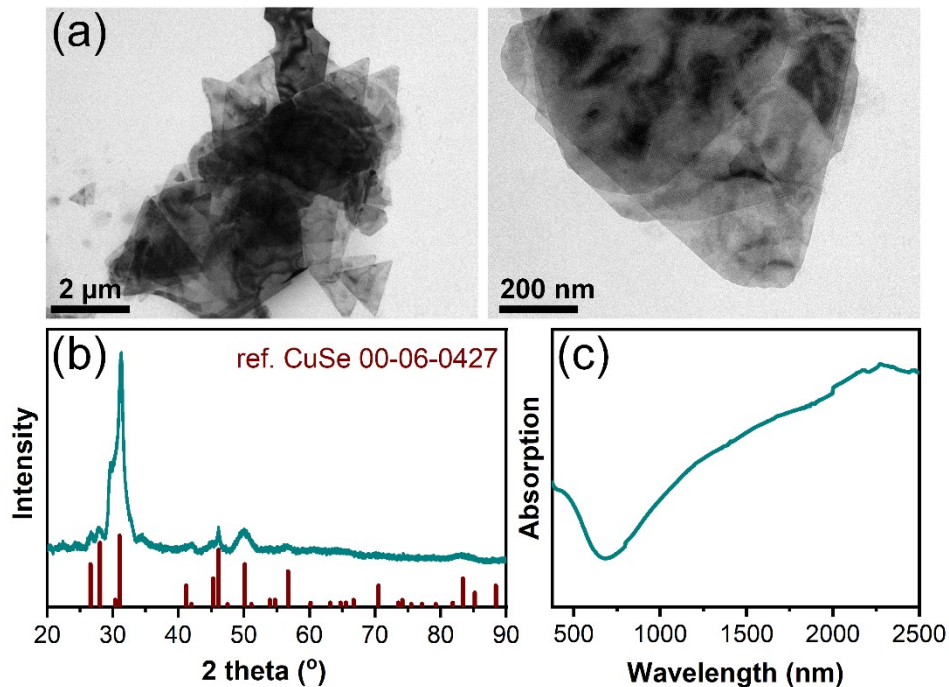


Figure S1. (a) TEM images showing a stack of CuSe NSs of different sizes. (b) XRD pattern of CuSe NSs with the corresponding bulk reference. (c) Absorption spectrum of CuSe NSs dispersed in TCE.

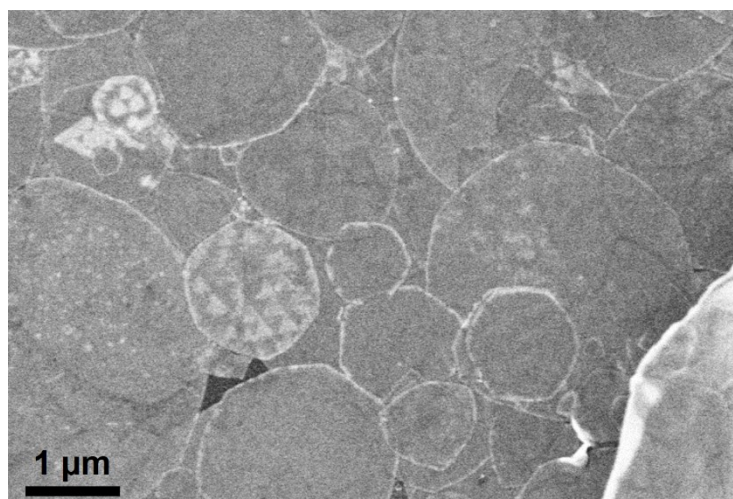


Figure S2. SEM image of CZTSe NSs showing their horizontal orientation in the film.

Table S1. Sizes of cations used in the synthesis, bond dissociation energies, and solubility product constants of the corresponding compounds in water.

Compound	Cation	Cation radius (pm)	Bond dissociation energy (kJ/mol)	Solubility product
CuSe	Cu ⁺ / Cu ²⁺	60 / 72	293	2·10 ⁻⁴⁰
PbSe	Pb ²⁺	119	303	1·10 ⁻³⁷
HgSe	Hg ²⁺	96	167	4·10 ⁻⁵⁹
ZnSe	Zn ²⁺	60	136	3.6·10 ⁻²⁶
SnSe	Sn ²⁺ / Sn ⁴⁺	118 / 55	401	5·10 ⁻³⁴

Table S2. Initial Cu:Zn:Sn feed ratios, reaction times, and compositions of the final CZTSe NSs determined by ICP-OES analysis.

Initial Cu:Zn:Sn molar ratio	Reaction time (hours)	Composition	Total oxidation number balance between cations and anion, Sn ²⁺ (Sn ⁴⁺)
1:1:1	0.5	Cu _{1.54} Zn _{0.54} Sn _{0.23} Se	+3.08 (3.54) -2
	1	Cu _{0.77} Zn _{0.50} Sn _{0.27} Se	+2.31 (2.85) -2
	2	Cu _{0.67} Zn _{0.57} Sn _{0.27} Se	+2.35 (2.89) -2
	3	Cu _{0.57} Zn _{0.54} Sn _{0.26} Se	+2.17 (2.69) -2
	4	Cu _{0.40} Zn _{0.40} Sn _{0.22} Se	+1.64 (2.08) -2
1:1:2	4	Zn _{0.33} Sn _{0.47} Se	+1.60 (2.54) -2
1:1:3	4	Zn _{0.23} Sn _{0.77} Se	+2.00 (3.54) -2
1:0.5:2	4	Zn _{0.11} Sn _{0.71} Se	+1.64 (3.06) -2
1:0.5:3	4	Zn _{0.06} Sn _{0.5} Se	+1.12 (2.12) -2

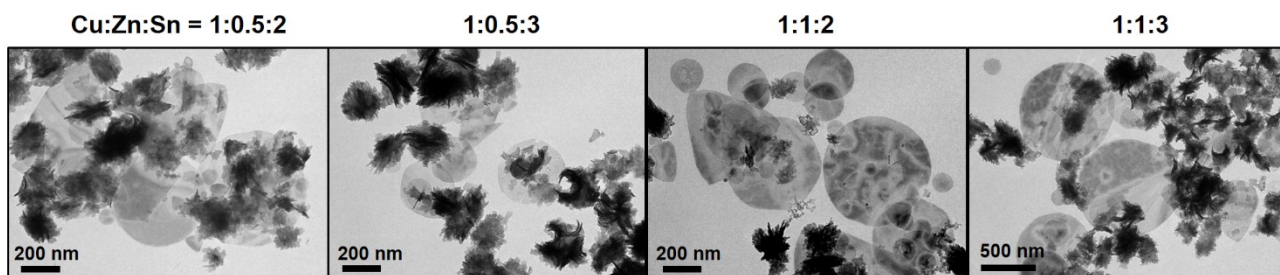


Figure S3. TEM images of the products of Cu⁺-to-Zn²⁺/Sn⁴⁺ CE with different feed ratios between host and guest cations.

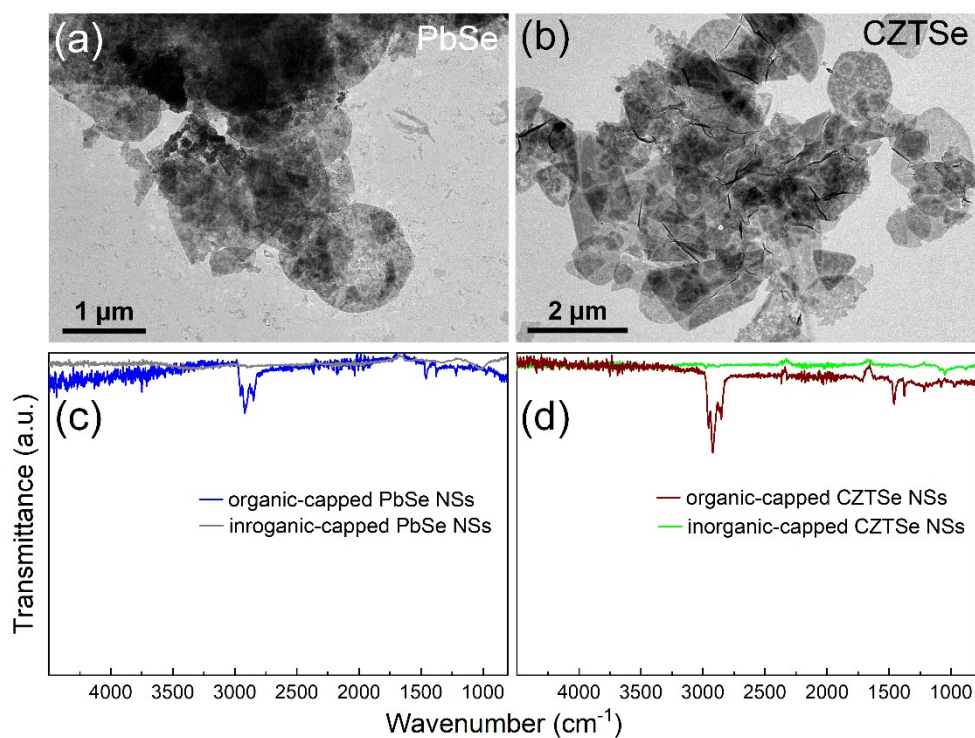


Figure S4. TEM images of PbSe (a) and CZTSe (b) NSs after ligand exchange. FTIR spectra of PbSe (c) and CZTSe (d) NSs after ligand exchange.