Supporting Information

Efficient Electrosynthesis of Urea Using CO_2 and Nitrate over a Bifunctional In_4SnS_8 Catalyst

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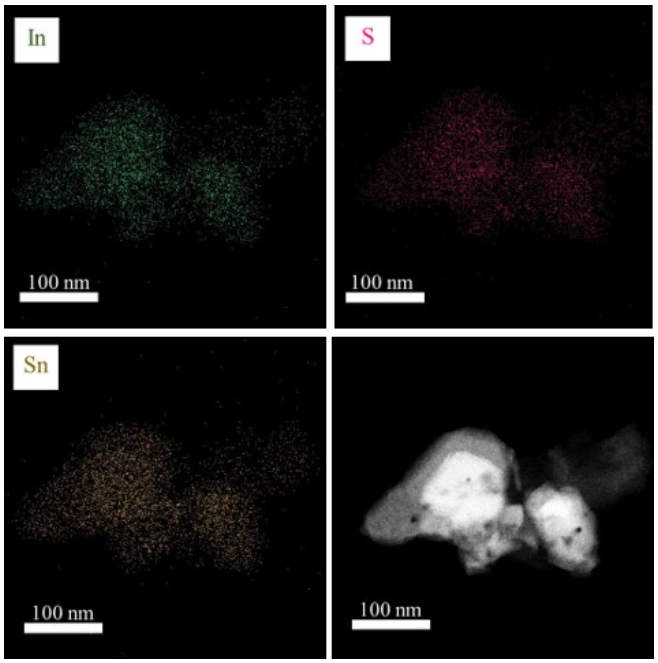

Fig. S1 Element mapping of In_4SnS_8.

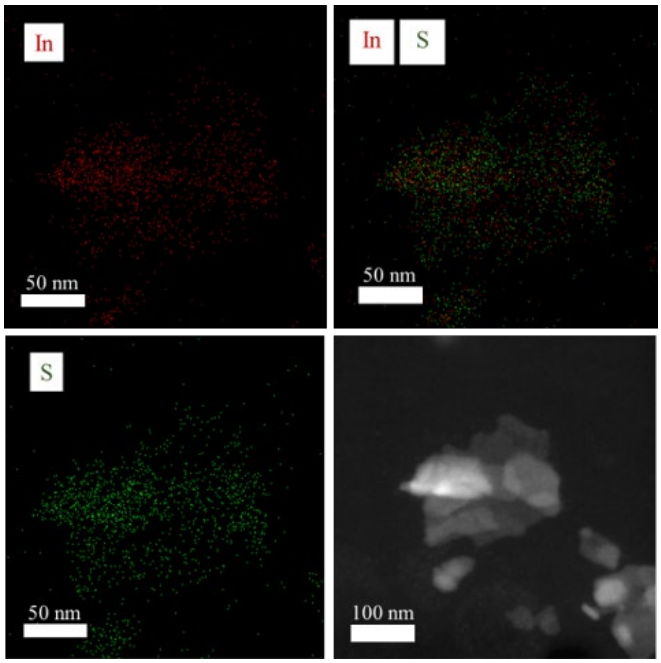

Fig. S2 Element mapping of In_2S_3.

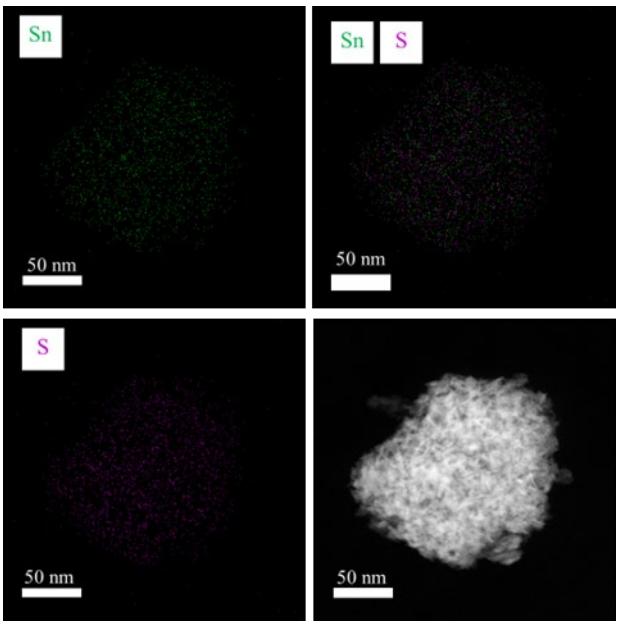

Fig. S3 Element mapping of SnS_2.

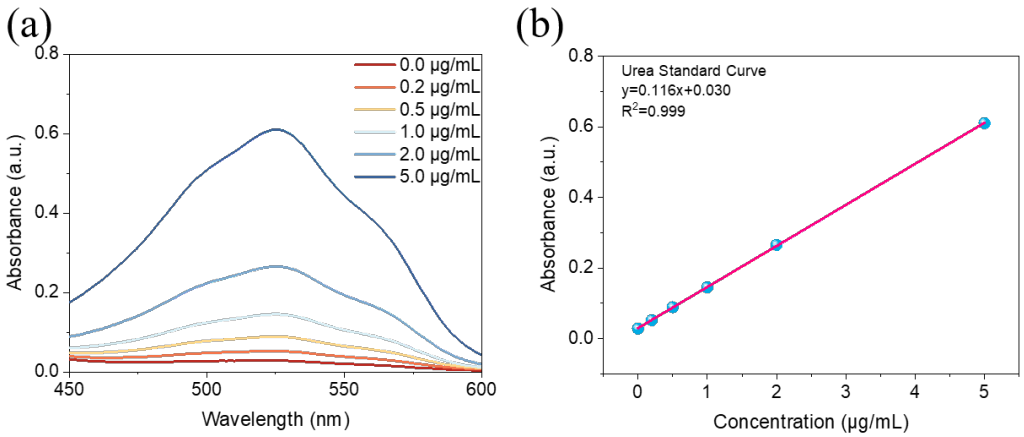

Fig. S4 (a) UV-Vis absorption spectra of urea standard solutions with different concentrations. (b) Calibration curve for quantitative analysis of urea concentration.

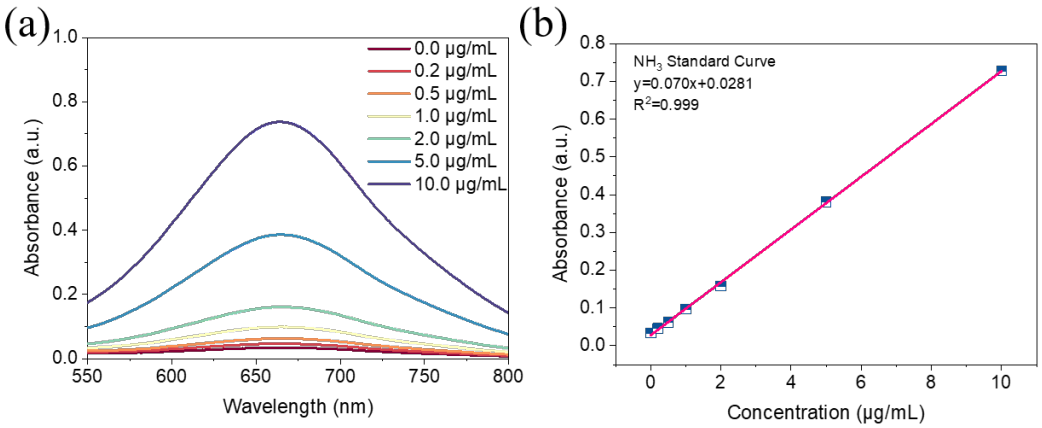

Fig. S5 (a) UV-Vis absorption spectra of NH_3 standard solutions with different concentrations. (b) Calibration curve for quantitative analysis of NH_3 concentration.

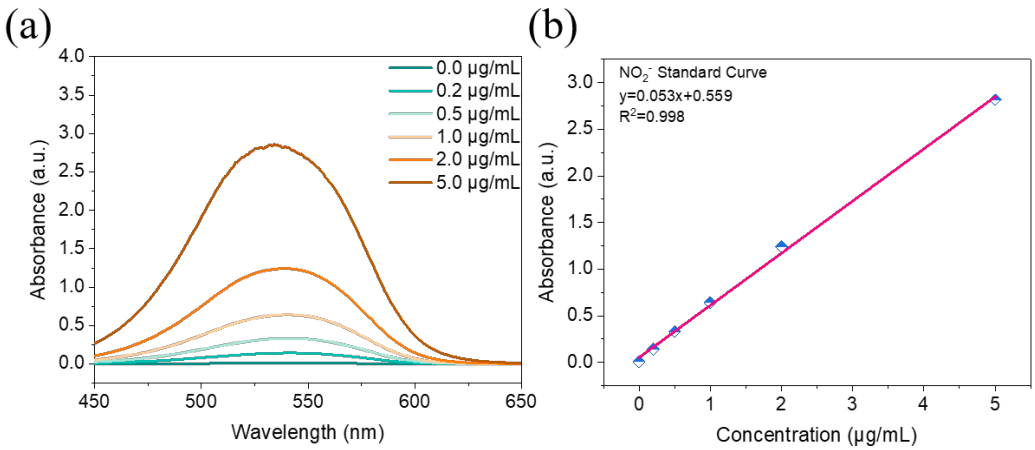

Fig. S6 (a) UV-Vis absorption spectra of NO_2^- standard solutions with different concentrations. (b) Calibration curve for quantitative analysis of NO_2^- concentration.

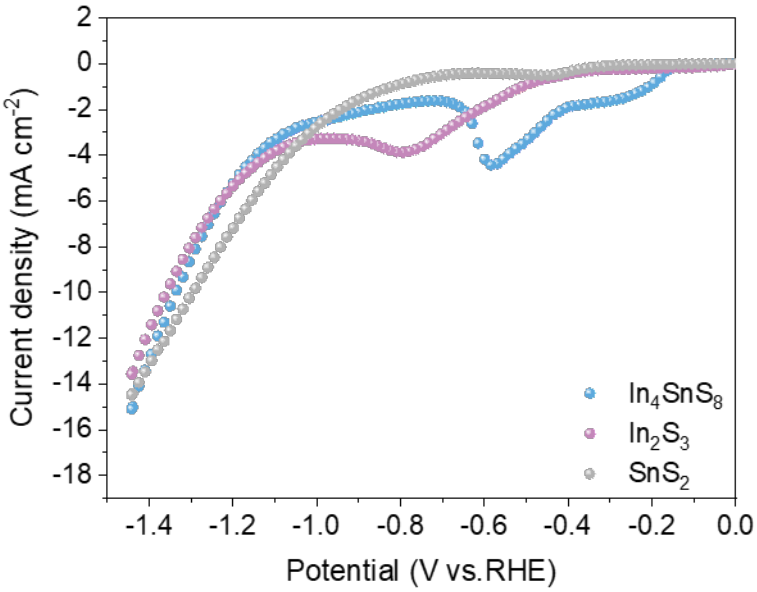

Fig. S7 LSV curves of In_4SnS_8, In_2S_3, SnS_2 in 0.1 M KNO_3 electrolyte with CO_2.

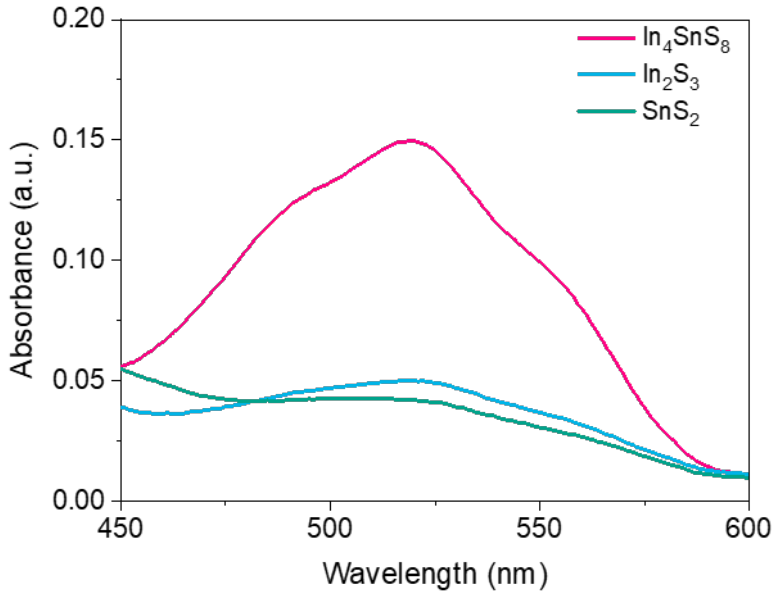

Fig. S8 UV-vis absorption spectra of urea formed by In_4SnS_8, In_2S_3, SnS_2 at -0.65 V(vs.RHE).

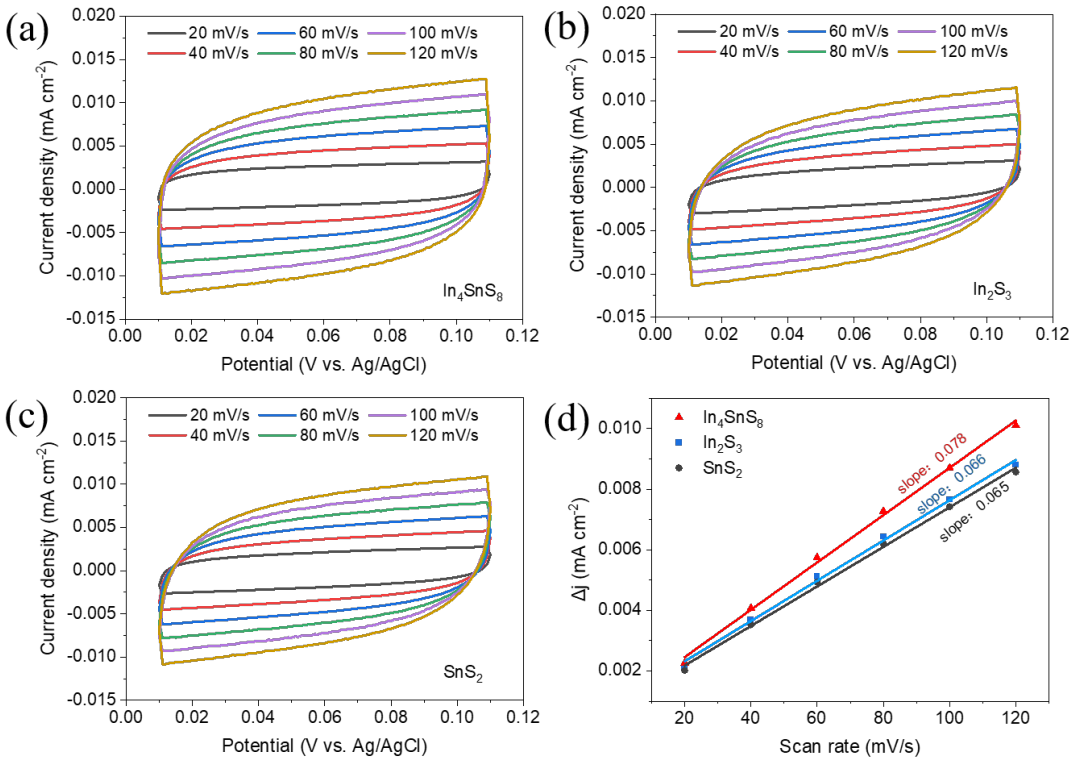

Fig. S9 Cyclic voltammograms diagrams at different scan rates of (a) In_4SnS_8; (b) In_2S_3; (c) SnS_2; (d) Functional relationship of different scanning speeds and current density.

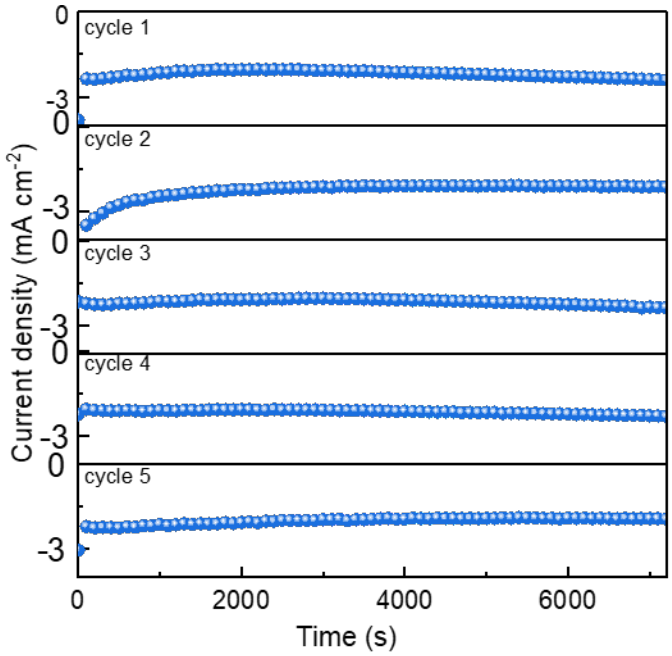

Fig. S10 The chronoamperometric curves in the five-cycle test over In_4SnS_8.

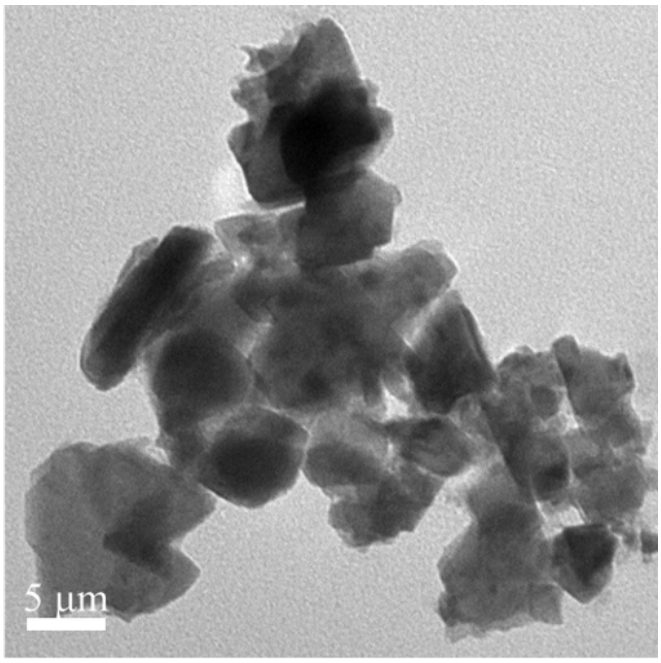

Fig. S11 TEM image of In_4SnS_8 after 2 h reaction.

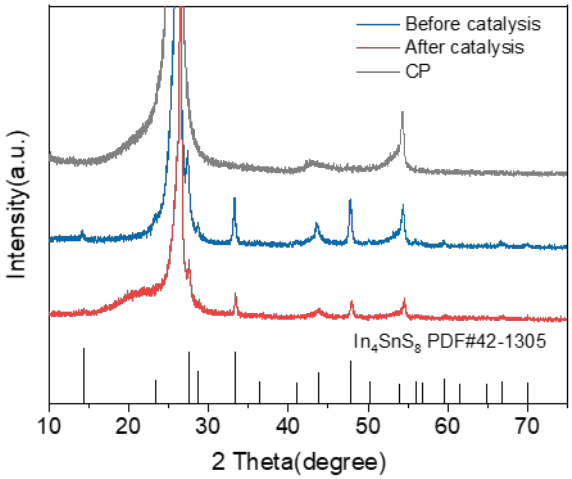

Fig. S12 XRD pattern of In_4SnS_8 after 2 h reaction.

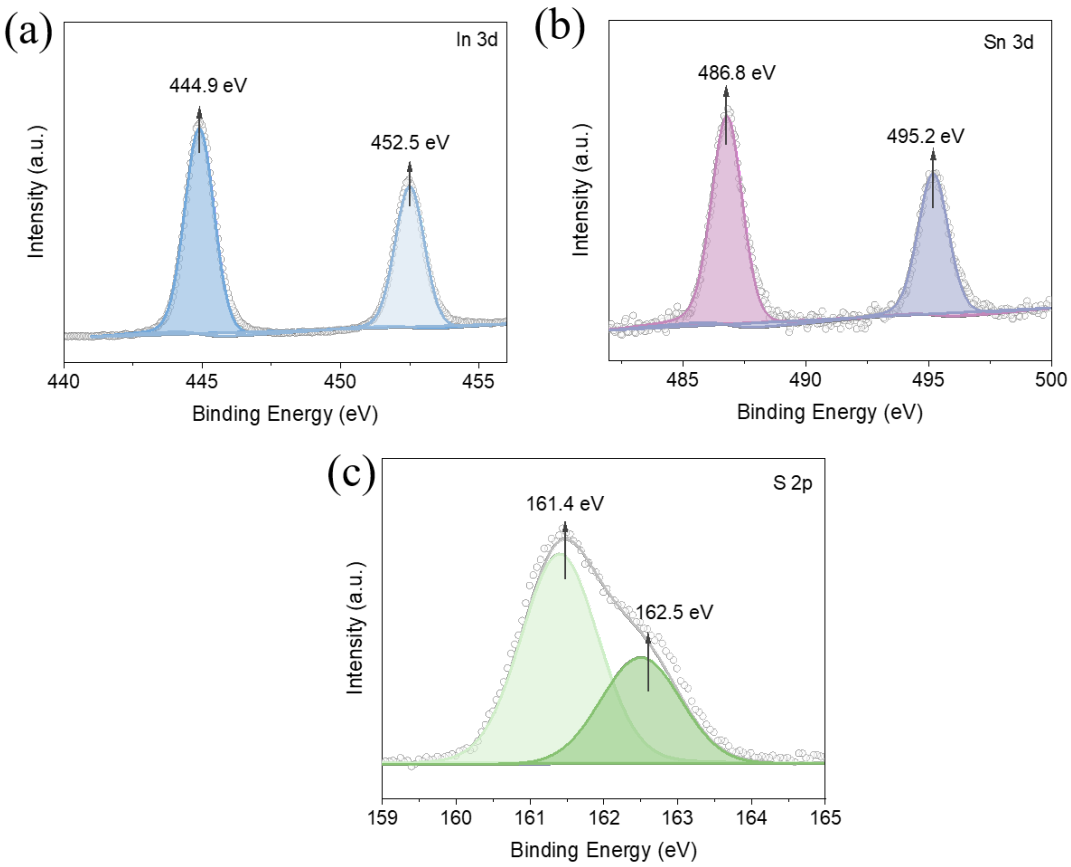

Fig. S13 (a) In 3d;(b) Sn 3d and (c) S 2p spectrum of In_4SnS_8 after 2 h reaction.

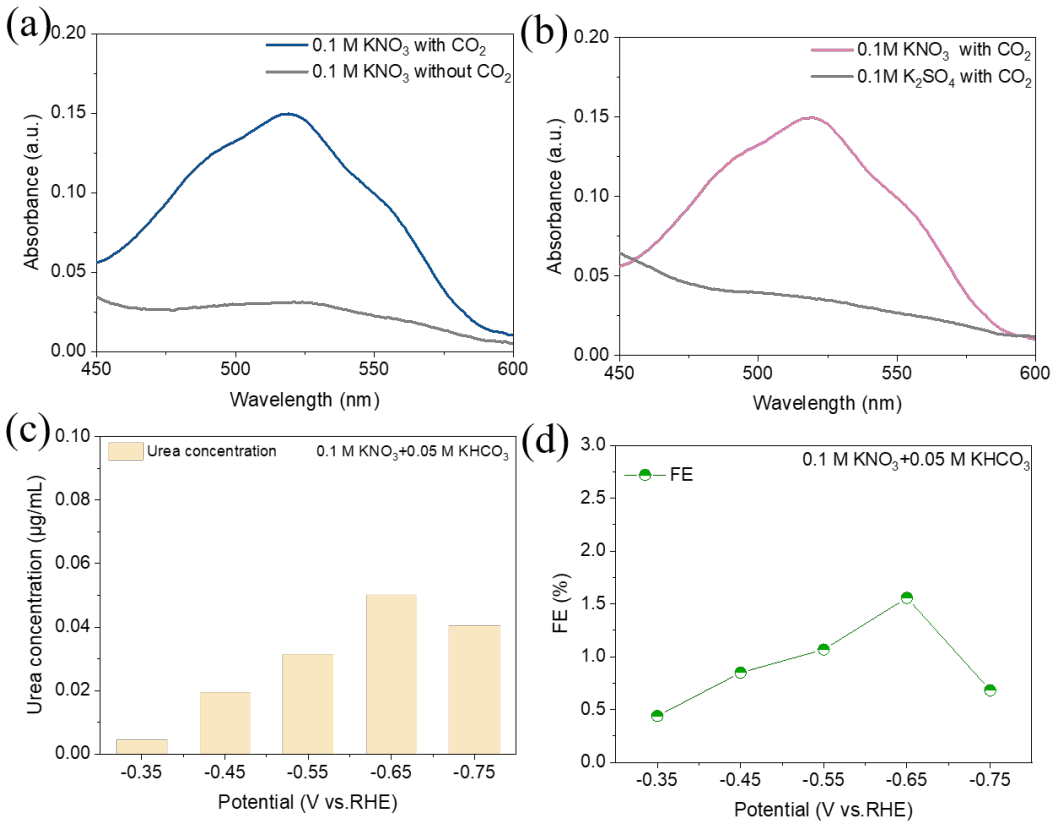

Fig. S14 UV-vis absorption spectra of (a) 0.1 M KNO_3 with and without CO_2 over In_4SnS_8 after 2 h reaction at -0.65 V versus RHE; (b) 0.1 M K_2SO_4 with and without CO_2 over In_4SnS_8 after 2 h reaction at -0.65 V versus RHE; Electrocatalytic performance of urea synthesis over In_4SnS_8 at different potentials in 0.1 M KNO_3 + 0.05 M $KHCO_3$ electrolyte without CO_2: (c) Urea concentration (d) Faraday efficiency.

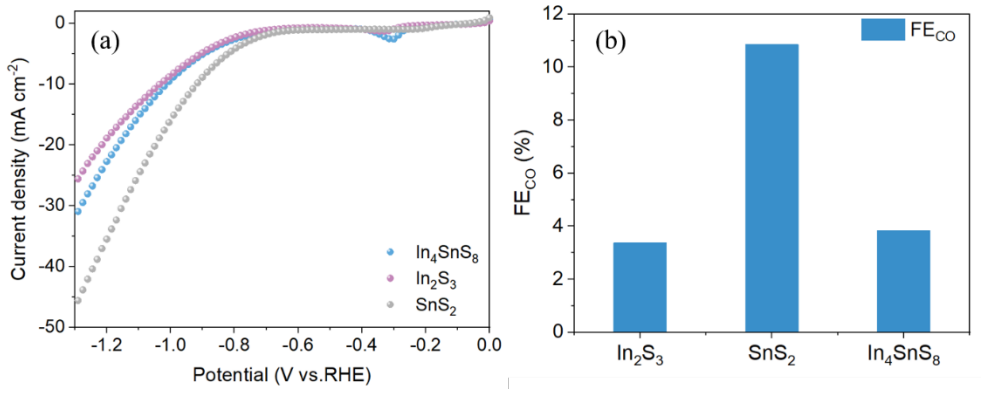

Fig. S15 (a) LSV curves of In_4SnS_8, In_2S_3 and SnS_2 in 0.1 M $KHCO_3$ electrolyte with CO_2; (b) Faradaic efficiency of CO for In_4SnS_8, In_2S_3 and SnS_2 at -1.0 V (vs.RHE).

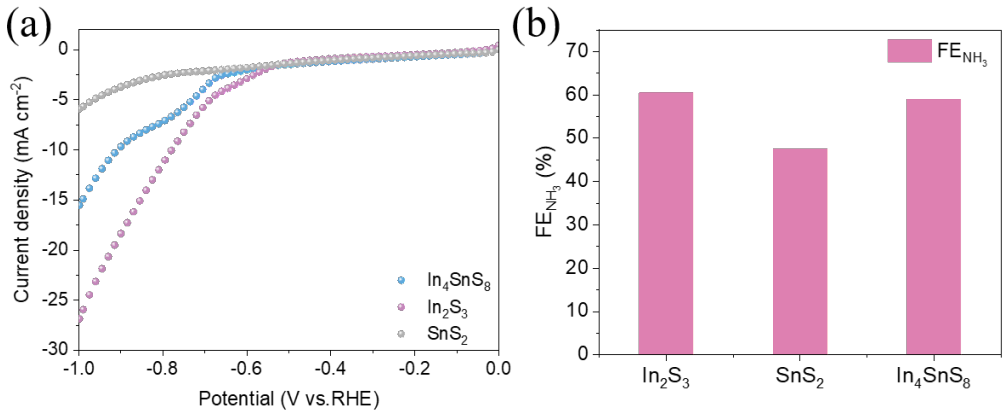

Fig. S16 (a) LSV curves of In_4SnS_8, In_2S_3 and SnS_2 in 0.1 M KNO_3 electrolyte; (b) Faradaic efficiency of NH_3 for In_4SnS_8, In_2S_3 and SnS_2 at -1.0 V(vs.RHE).

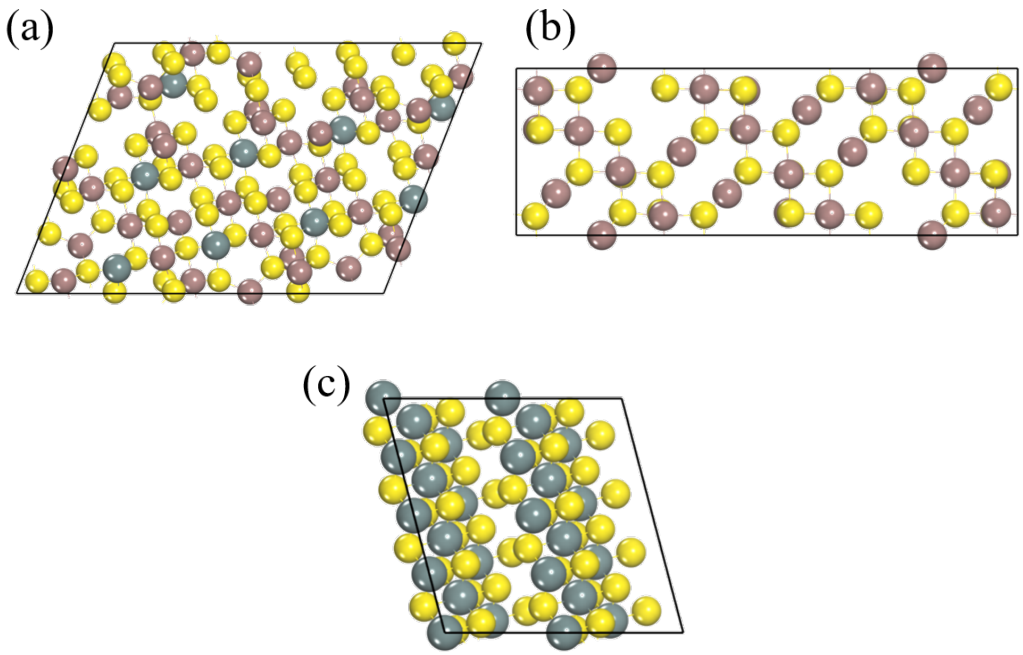

Fig. S17 DFT calculation models of (a) In_4SnS_8;(b) In_2S_3; (c) SnS_2.

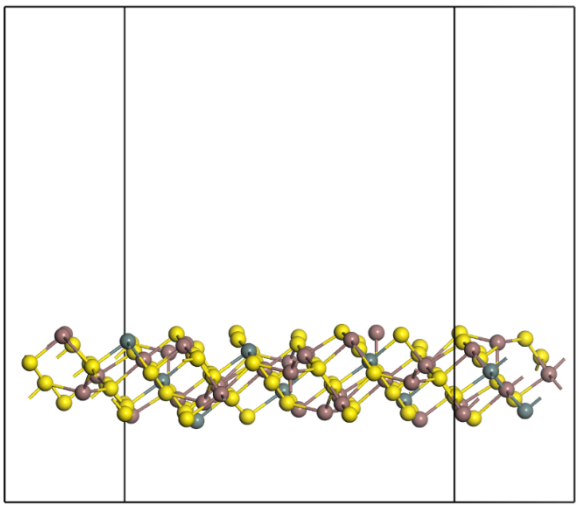

Fig. S18 The side view of the In_4SnS_8(311) surface.

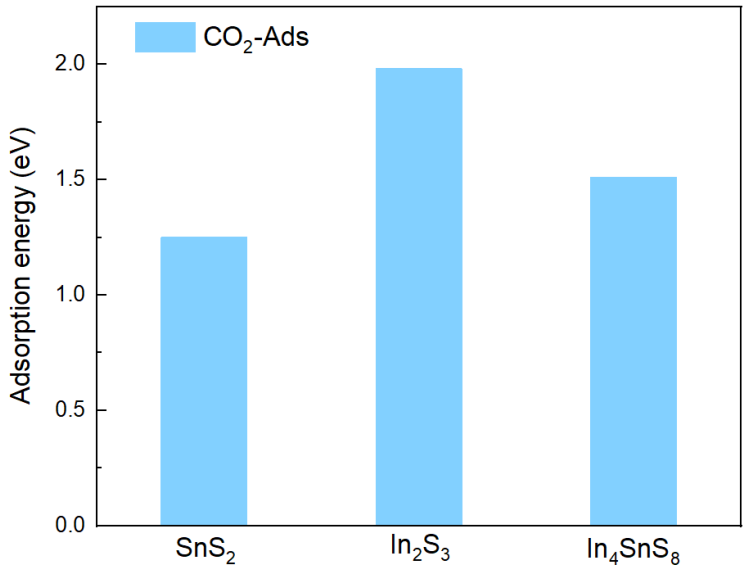

Fig. S19 The adsorption energy of CO_2 on SnS_2(101), In_2S_3(440) and In_4SnS_8(311) surface.

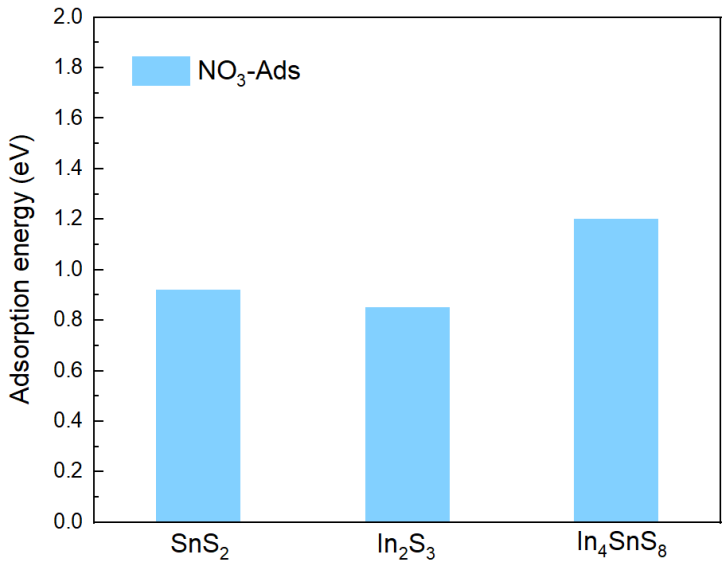

Fig. S20 The adsorption energy of nitrate on SnS_2(101), In_2S_3(440) and In_4SnS_8(311) surface.

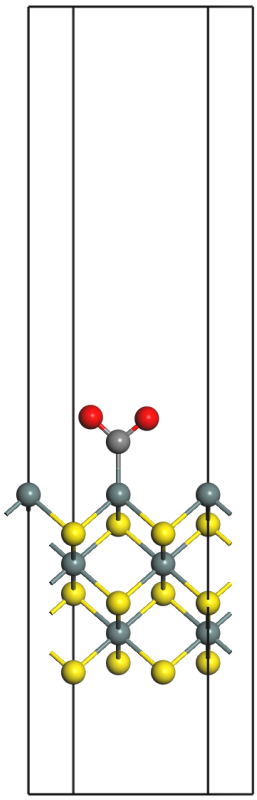

Fig. S21 The CO_2 adsorption model on SnS_2(101) surface.

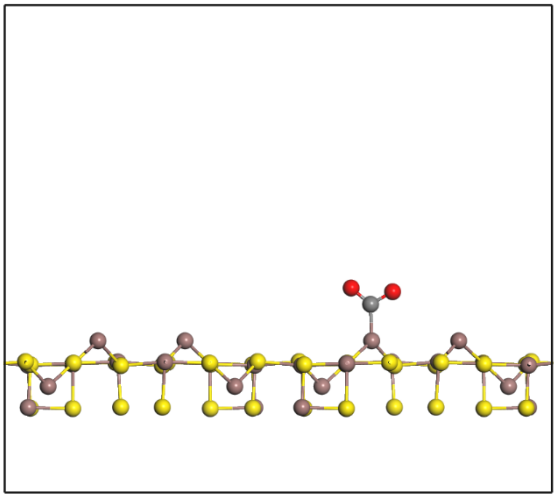

Fig. S22 The CO_2 adsorption model on In_2S_3(440) surface.

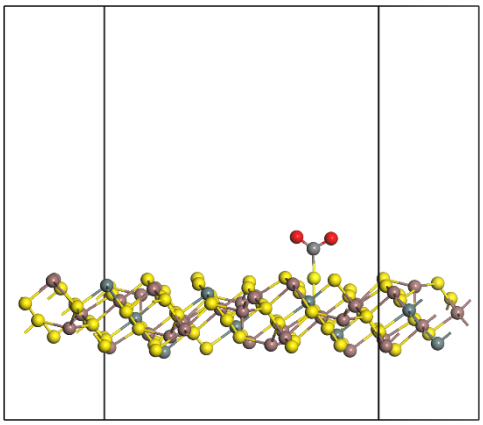

Fig. S23 The CO_2 adsorption model on In_4SnS_8(311) surface.

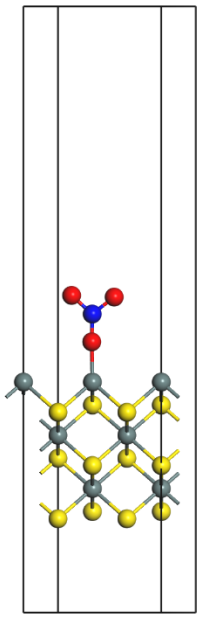

Fig. S24 The nitrate adsorption model on SnS_2(101) surface.

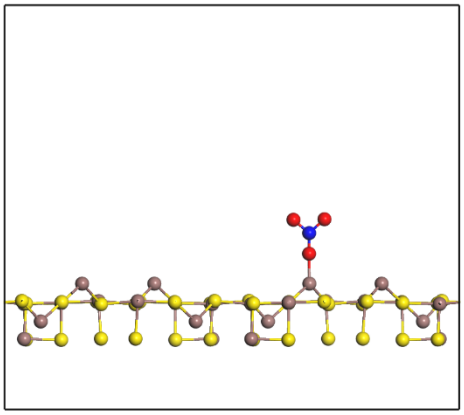

Fig. S25 The nitrate adsorption model on In_2S_3(440) surface.

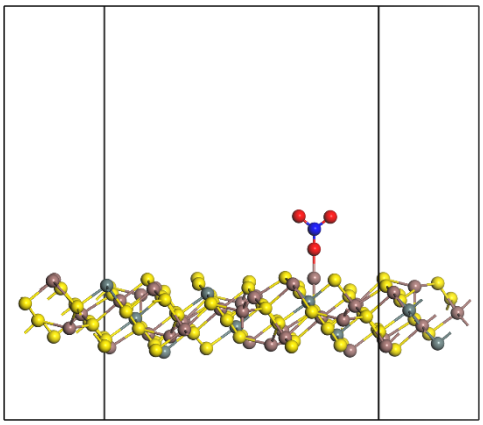

Fig. S26 The nitrate adsorption model on In_4SnS_8(311) surface.

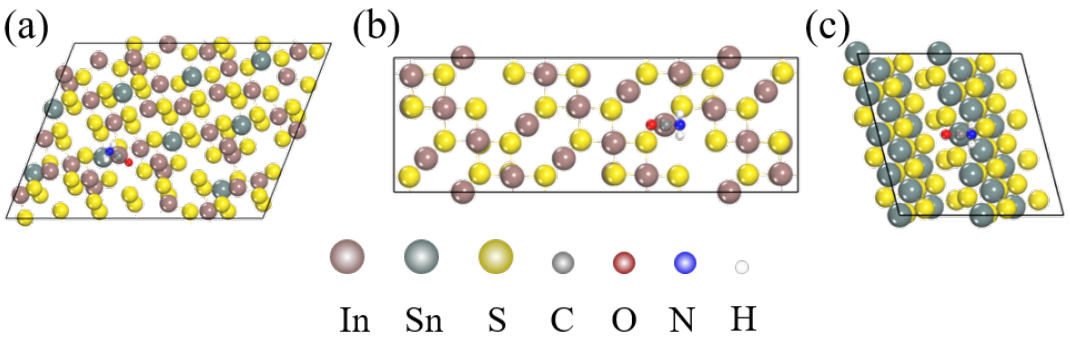

Fig. S27 DFT calculation models of *$CONH_2$ intermediate on the (a) In_4SnS_8(311), (b) In_2S_3(440) and (c) SnS_2(101) surface, respectively.