Creation of $Sn_xNb_{1-x}O_2$ solid solution through heavy Nb-doping in SnO_2 to enhance its photocatalytic CO_2 reduction to C_{2+} products under simulated solar illumination

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Table S1 Element analysis result of Sn and Nb in the $Sn_xNb_{1-x}O_2$ solid solution sample.

Element	wt.%	at.%
Sn	24.44	31.55
Nb	75.56	68.45

Table S2 The photocatalytic CO_2 reduction product types and amounts at different reaction time by the $Sn_xNb_{1-x}O_2$ solid solution sample under simulated solar illumination.

Time (h)	Acetaldehyde ($\mu mol \cdot g^{-1}$)	Methanol ($\mu mol \cdot g^{-1}$)	Ethanol ($\mu mol \cdot g^{-1}$)
1	12.0	19.7	33.3
2	23.6	53.0	72.8
4	27.7	67.0	158.0
8	106.0	42.0	1043.0

Table S3 The photocatalytic CO_2 reduction product types and amounts at different reaction time by the pristine SnO_2 sample under simulated solar illumination.

Time (h)	Acetaldehyde ($\mu mol \cdot g^{-1}$)	Methanol ($\mu mol \cdot g^{-1}$)	Ethanol ($\mu mol \cdot g^{-1}$)
1	0.0	15.0	37.5
2	0.0	16.2	45.0
4	0.0	109.0	21.6
8	13.7	52.8	21.5

Table S4 Photocatalytic CO_2 reduction performances of SnO_2-based photocatalysts without usage of sacrificial agents reported in literature, compared with $Sn_xNb_{1-x}O_2$ solid solution and pristine SnO_2 samples.

Photocatalyst	Products	R_{max} ($\mu mol \cdot g^{-1} \cdot h^{-1}$)	Total Reduction Efficiency ($\mu mol \cdot g^{-1} \cdot h^{-1}$)	Light Source	Reference
SnO_2	CH_4 CO C2H4	3.41 2.74 0.03	6.21	18 W mercury lamp	[33]
SnO_2-C_3N_4	CH_4 CO	0.62 0.72	1.34	300 W Xe lamp	[34]
SnO_{2-x}/g-C_3N_4	CH_4 CO CH_3OH	1.03 18.52 3.25	22.70	500 W Xe lamp	[35]
SnO_2/Fe_2O_3	CH_4 CO	5.00 11.25	16.25	300 W Xe lamp $\lambda \geq$ 420 nm	[36]
SnO_2/$BiVO_4$	CH_4	3.30	3.30	300 W Xe lamp $\lambda \geq$ 420 nm	[37]
SnO_2/Ag/MoS_2	CH_4 CO	25.00 11.25	36.25	300 W Xe lamp $\lambda \geq$ 420 nm	[38]
Pristine SnO_2	CH_3OH CH_3CHO C_2H_5OH	6.60 1.71 2.69	15.40	300 W Xe lamp 200 mW/cm^2	This work
$Sn_xNb_{1-x}O_2$ solid solution	CH_3OH CH_3CHO C_2H_5OH	5.25 13.25 130.36	292.47	300 W Xe lamp 200 mW/cm^2	This work

Table S5 The photocatalytic CO_2 reduction product types and amounts at 8 h reaction time by the $Sn_xNb_{1-x}O_2$ solid solution sample under simulated solar illumination for four consecutive runs.

Time (h)	Acetaldehyde (μmol·g^{-1})	Methanol (μmol·g^{-1})	Ethanol (μmol·g^{-1})	Total Reduction Efficiency (μmol·g^{-1}·h^{-1})
Run 1	102	40	944	266.5
Run 2	154	28	896	266.0
Run 3	163	27	790	241.6
Run 4	176	10	713	223.5

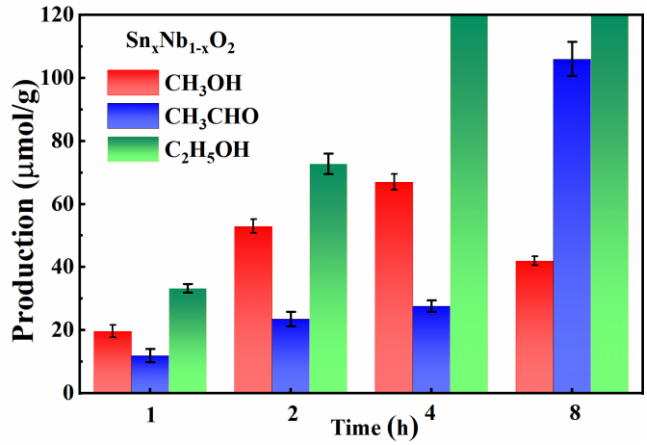

Fig. S1 Magnification of the product evolution image (Fig. 6b) of the photocatalytic CO_2 reduction by the $Sn_xNb_{1-x}O_2$ solid solution sample under simulated solar illumination for a series of reaction time from 1 h to 8 h, respectively, to show the evolution of different products more clearly especially in the earlier stage of the process.

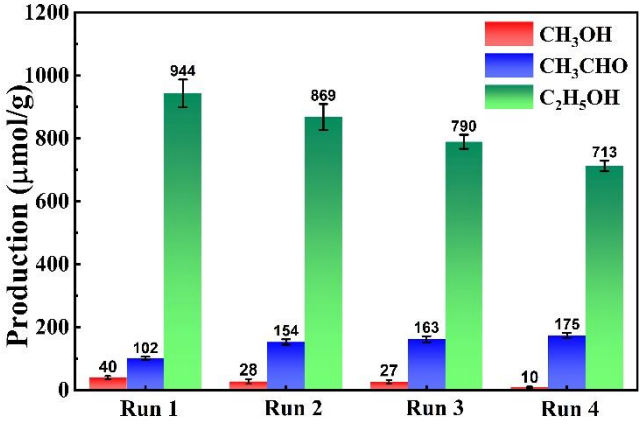

Fig. S2 The product evolution of photocatalytic CO_2 reduction by the $Sn_xNb_{1-x}O_2$ solid solution sample under simulated solar illumination with the reaction time of 8 h for four consecutive runs.

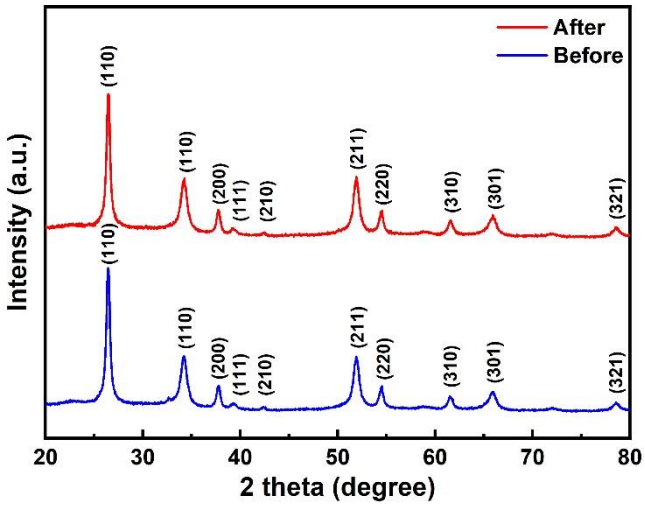

Fig. S3 XRD patterns of the $Sn_xNb_{1-x}O_2$ solid solution sample before and after the photocatalytic CO_2 reduction experiment, respectively.