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Electronic Supplementary Material

Self-standing SnS nanosheet array: A bifunctional binder-free thin film catalyst for electrochemical hydrogen generation and waste-water treatment

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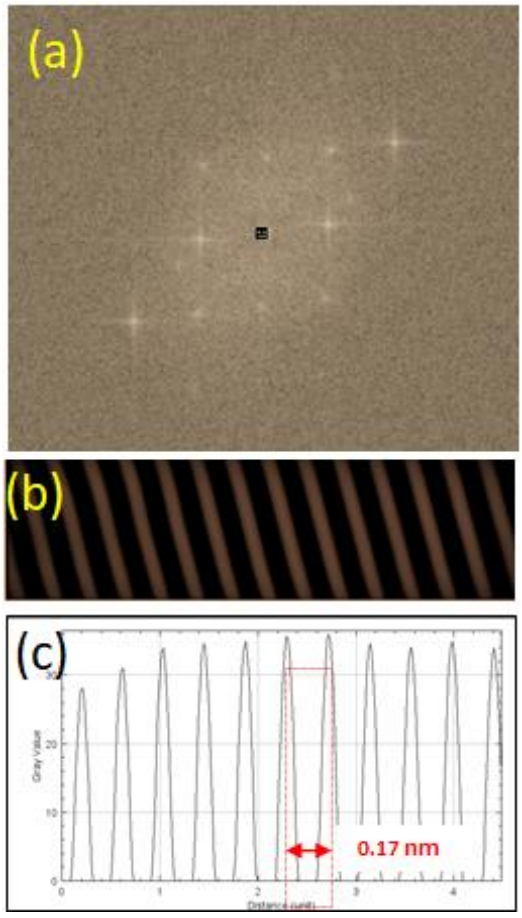


Figure S1. (a) Fast Fourier transform (FFT) of the selected region of the HRTEM image of SnS film (b) inverse FFT of the selected region of the HRTEM image, and (c) line profile for the selected line in its inverse FFT image indicating the d spacing as 0.17 nm.

Element	Weight%	Atomic%
S K	19.14	46.70
Sn L	80.86	53.30

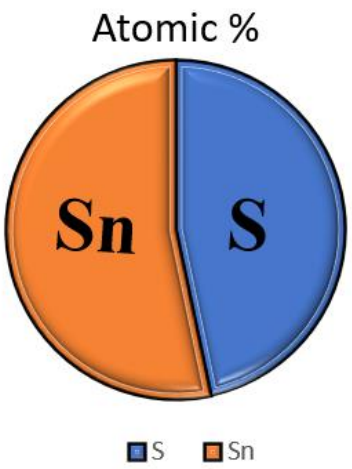


Figure S2. (a) Percentage *vs*. elements plotted figure calculated from energy-dispersive X-ray spectroscopy (EDX) analysis spectrum showed a stoichiometric ratio of Sn:S is 1:1.

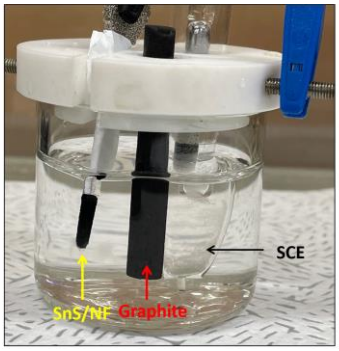


Figure S3. Photograph of an electrolyzer with graphite cathode, SnS/NF anode and SCE reference electrode in aqueous 1 M KOH + 0.33 M urea electrolyte.

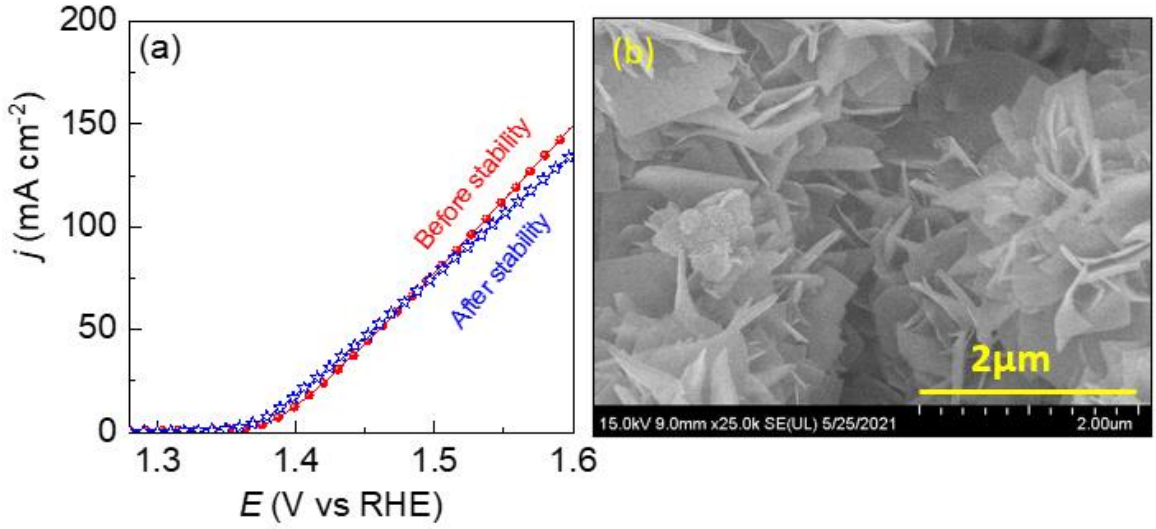


Figure S4. (a) Linear sweep voltammograms of the 1 M aqueous KOH electrolyzer consisting of the SnS/NF (+)||Graphite (−) assembly with a reference SCE before and after the long-term electrochemical durability test. (b) SEM image of the SnS film after the stability analysis.

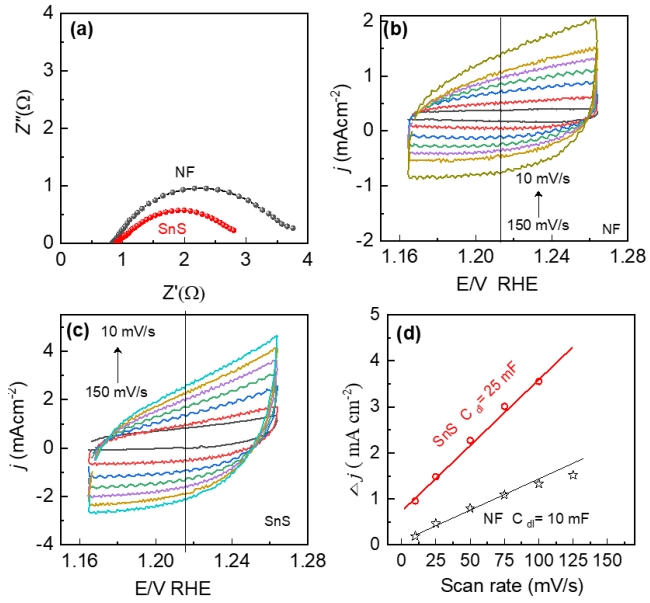


Figure S5. Electrochemical impedance spectroscopy and C_{dl} of the SnS and NF electrodes in 1 M KOH + 0.33 M urea: (a) Nyquist plots showing the improved electron transport. (b, c) CV plots of electrodes in a non-faradaic region at various scan rates ranging from 10 to 150 mV s^{-1}. (d) Plot

showing the SnS/NF catalyst having a considerably larger C_{dl} value (25mF) as compared to the bare NF-substrate (10 mF).

Table S1. Comparison of OER performance of the SnS catalyst with the recently reported transition metal-based metal catalysts.

No	Catalyst	η (mV)@ *j* (mAcm^{-2})	Substrate	Electrolyte (Molar of KOH)	Reference
	SnS	280@10	NF	1M	This work
	SnS	340 @50	NF	1M	This work
1	$(Ni_{0.33}Co_{0.6})$ S_2 NW	295@100	CC	1M	[1]
2	MoS_2-NiS_2	249@10	NF	1M	[2]
3	Co_3S_4@MoS_2	310@10	GC	1M	[3]
4	3D porous graphene film@$NiCo_2S_4$	264@10	Graphene film	1M	[4]
5	$NiCoMnS_4$/rGO	410@10	Reduced graphene oxide	1M	[5]
6	$NiCo_2S_4$	340@10	NF	1M	[6]
7	$CuCo_2S_4$	310@10	NA	1M	[7]
8	NiFeS	286@10	Graphene framework	0.1 M	[8]
9	Mn-Cd-S@amorphpus-Ni_3S_2	333@10	Reduced graphene oxide	1 M	[9]
10	Ultrathin Co_3S_4 nanosheet	280@onset potential	na	0.1 M	[10]
11	$NiCo_2S_4$/N-CNT	370@10	Carbon nanotubes	0.1M	[11]

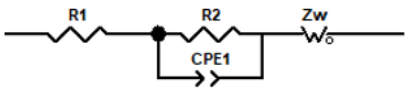
Table S2. Comparison of HER performance of the SnS catalyst with the recently reported transition metal-based metal catalysts.

No	Catalyst	η_{10}(mV)	Substrate	Electrolyte (Molar of KOH)	Reference
	SnS	214	NF	1M	This work
1	Ni_3S_2/NF	223	NF	1M	[12]
2	NiFeS/Ni	180@10	NF	1M	[13]
3	$Ni_xCo_{3-x}S_4/Ni_3S_2$	136@10	NF	1M	[14]
4	Graphene/Ni_3Se_2/Co_9S_8	170@20	exfoliated graphene	1M	[15]

5	$Ni(OH)_2/Ni_3S_2$	211@20	NF	1M	[16]
6	3D Se-$(NiCo)S_x/(OH)_x$	103@10	NF	1M	[17]
7	Mn-Ni_3S_2/NF	152@10	NF	1M	[18]
8	CoS_2	~255@10	Ti	1M	[19]
9	MoS_2	187@10	Graphite	1M	[20]
10	$NiCo_2S_4$ NW/NF	210@10	NF	1M	[6]
11	Ni/NiS	230@10	NF	1M	[21]
12	Sn-Ni_3S_2/NF	137@10	NF	1M	[22]
13	$Fe_{0.1}$-NiS_2 NA/Ti	~200@10	Ti foil	1M	[23]

Table S3. Comparison of UOR performance of the SnS catalyst with the recently reported transition metal-based metal catalysts.

No	**Catalyst**	**E** (V *vs* RHE) **@ *j* (mAcm^{-2})**	**Substrate**	**Electrolyte (Molar of KOH/Urea)**	**Reference**
	SnS	1.37 @10	NF	1/0.33	This work
	SnS	1.43 @50	NF	1/0.33	This work
1	$NiCo_2S_4$ NS/Carbon cloth	1.47@10	CC	1/0.33	[24]
2	Ni_3S_2/NF	1.44@100	NF	1/0.2	[25]
3	Ni_3S_2@NF	1.35@10	NF	1/0.5	[25]
4	Ni**Ir**-MOF/NF	1.32@10	NF	1/0.5	[26]
5	NiFeCo LDH/NF	~1.35@10	NF	1/0.33	[27]
6	$NiSe_2$	1.35@10	NF	1/0.33	[28,]
7	NiMo /NF	1.36@10	NF	1/0.1	[29]
8	(Ni–Bi)/GC	1.42 @50	GC	1/0.33	[30]



Element	SnS	NF
R_s (Ω)	0.9091	0.8504
R_{ct} (Ω)	2.291	2.943
CPE(μF)	0.5806	0.5933
Z_w(Ω)	0.3420	0.2562

Table S4. Fitted EIS parameters extracted from Nyquist plots of the SnS_2 and NF samples. The electrical circuit above the Table shows the equivalent circuit used to fit the experimentally obtained EIS spectra.

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