Electronic Supplementary Material (ESI) for New Journal of Chemistry.
This journal is © The Royal Society of Chemistry and the Centre National de la Recherche Scientifique 2023

Supporting Information

Controlled growth of Sb_2S_3 nanorods on phosphorous doped reduced graphene oxide for enhanced overall water splitting

A. Gowrisankar, K. Selvadharshini, Krishnendu M. Nair, T. Selvaraju*

Department of Chemistry, Bharathiar University-641046, Coimbatore, India

Email id: veluselvaraju@gmail.com

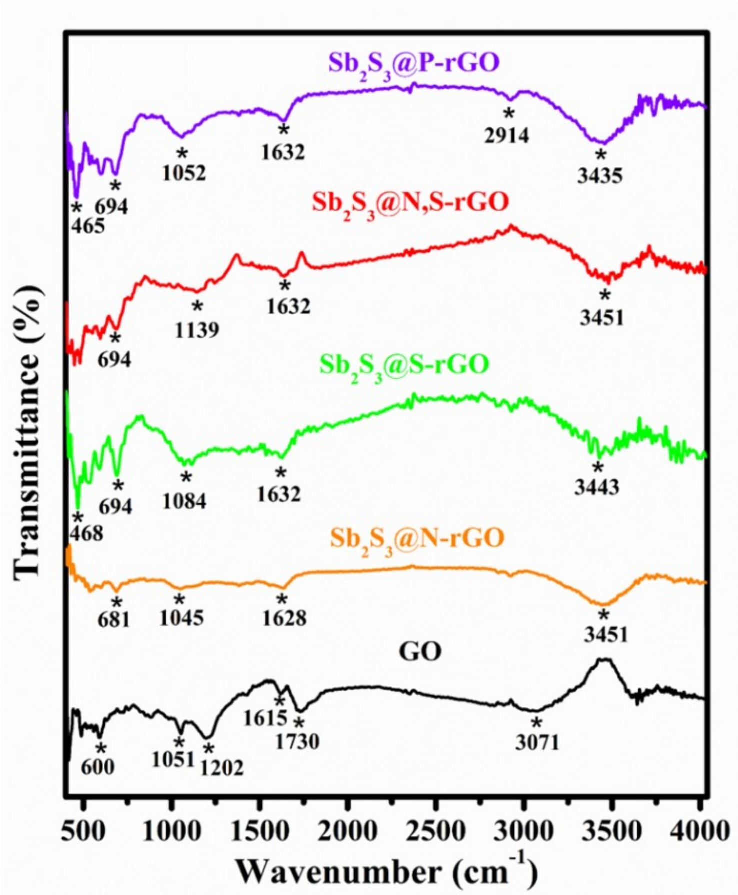

Fig. S1. FT-IR analysis of as-synthesized electrocatalysts.

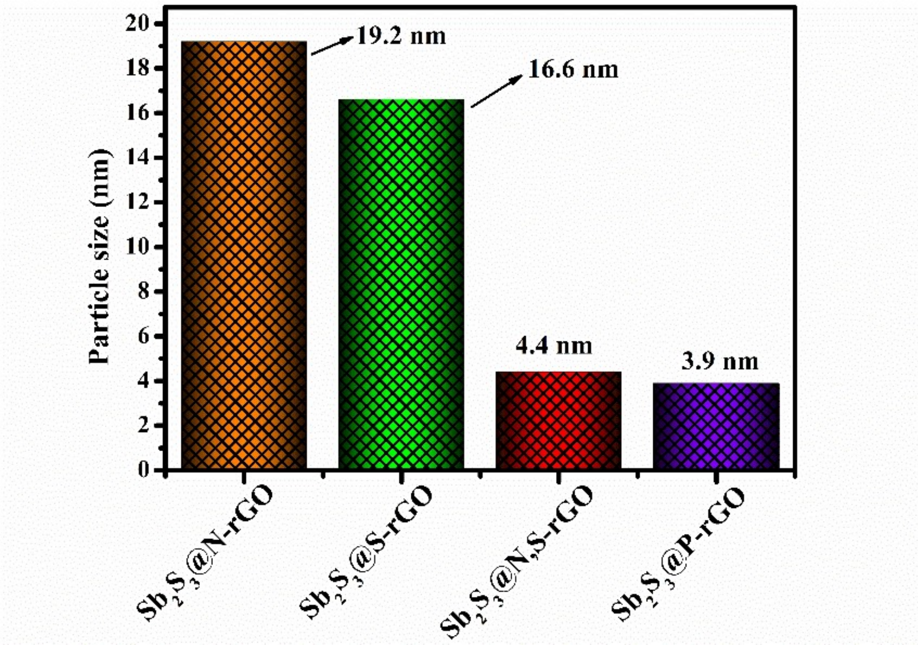

Fig. S2. Particle size distribution plot of as-synthesized electrocatalysts.

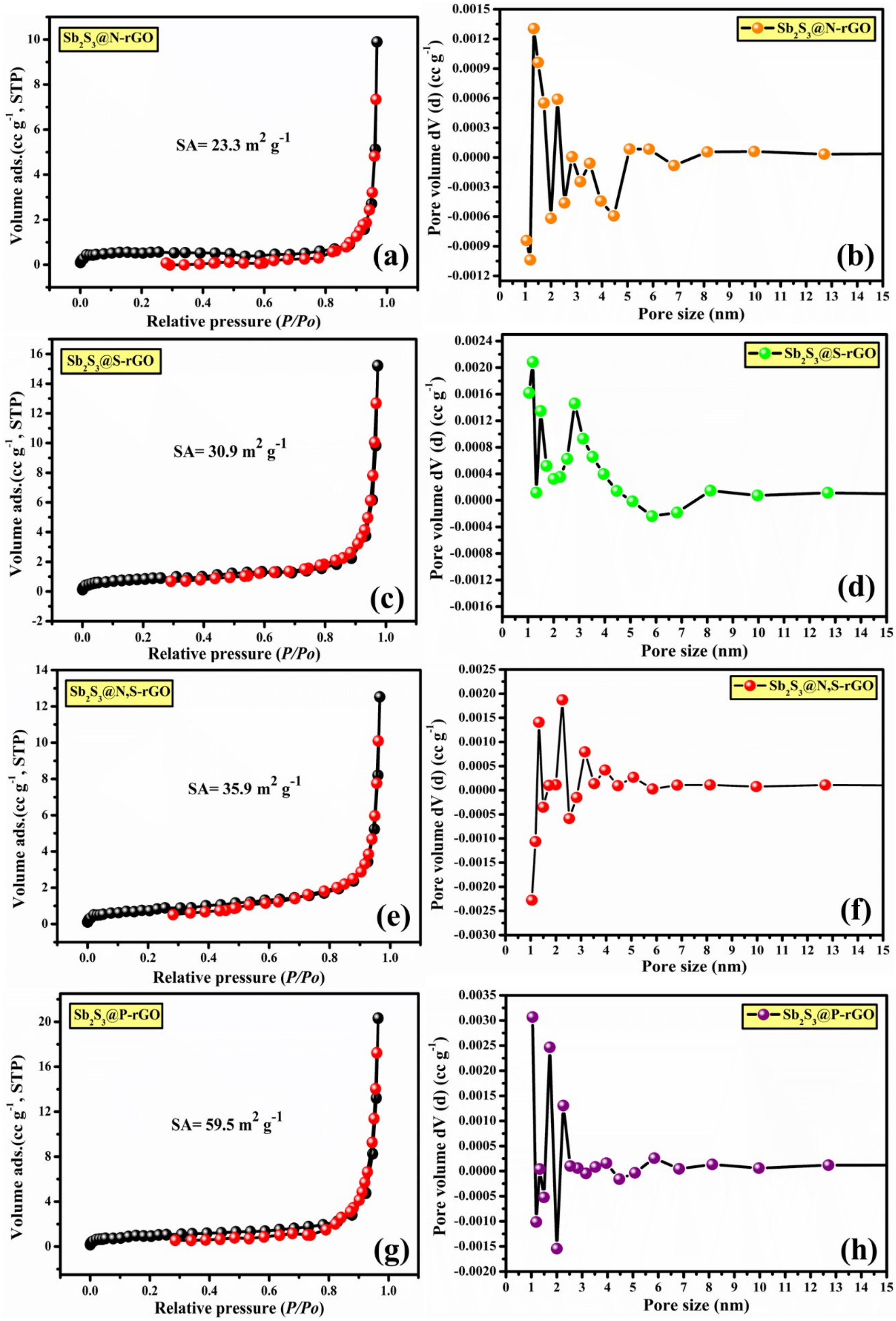

Fig. S3. N_2 adsorption-desorption curves and pore size analysis of Sb_2S_3@N-rGO (a, b), Sb_2S_3@S-rGO (c, d), Sb_2S_3@N,S-rGO (e, f) and Sb_2S_3@P-rGO (g, h) electrocatalysts, respectively.

Table S1. Electrochemical activities of different heteroatom doped rGO supported Sb_2S_3 composite materials at the GCE electrode for the HER and OER.

Electrocatalyst	η (mV) at 10 mA cm^{-2}		j (mA cm^{-2}) at 300 mV	Tafel Slope (mV dec^{-1})		EIS plot (Ω)		TOF (ms^{-1})	
	HER	OER	OER	HER	OER	R_s	R_{ct}	HER	OER
SSNG	238.6	310.7	10.16	128.4	200.5	9.97	-	714.3	254.3
SSSG	206.5	290.8	12.45	125.3	192.3	18.87	-	521.5	327.8
SSNSG	195.6	272.2	15.49	88.7	181.5	19.23	-	252.1	155.9
SSPG	**186.6**	**160**	**56.63**	**88.1**	**141.8**	**6.43**	**-**	**922.2**	**955.6**

Table S2. Comparative electrocatalytic performances of as prepared electrocatalysts with similar state-of-the-art materials.

S. No.	Electrocatalyst	Electrolyte	OER , η (mV) @ 10 mA cm^{-2}	HER , η (mV) @ 10 mA cm^{-2}	Cell voltage (V)
1	NCS/NS-rGO	1 M KOH	253.4	92.7	1.58
2	PrGO/NiCoP	1 M KOH	281.3	106	1.56
3	SNG@GF	1 M KOH	330	247	1.75
4	Ni_2P@NSG	1 M KOH	240	110	1.572
5	CoP/GO-400	1 M KOH	340	105	1.70
6	Al, Fe-codoped CoP/RGO	1 M KOH	280	145	1.66
7	NiVB/rGO	1 M KOH	267	151	1.56
8	Ir/N-rGO	1 M KOH	260	76	1.74
9	rGO/Co_2P-800	1 M KOH	378	134	1.78
10	Co–SCN/RGO	1 M KOH	250	150	1.63
11	FeS_2-MoS_2@CoS_2-MOF	1 M KOH	211 at 20 mA cm^{-2}	92	1.51
12	G-Mo-Ni_3S_2	1 M KOH	326 at 20 mA cm^{-2}	68	1.58
13	S-(Co, Fe)OOH	1 M KOH	240	186	1.64
14	S, N-Co_9S_8	1 M KOH	244	92	1.54
15	Co_3S_4@MoS_2-Ni_3S_2	1 M KOH	270 at 50 mA cm^{-2}	136	1.72 at 50 mA cm^{-2}
16	**Sb_2S_3@P-rGO**	**3 M KOH**	**160**	**186.6**	**1.57**

Abbreviations:

(NCS/NS-rGO) - $NiCo_2S_4$/N, S co-doped reduced graphene oxide,[1] **(PrGO/NiCoP) -** Ni-Co phosphides encapsulated in P-doped reduced graphene oxide,[2] **(SNG@GF) -** Nitrogen and sulfur co-doped graphene on graphite foam,[3] **(Ni_2P@NSG) -** Ni_2P nanocrystals encapsulated in N- and S-doped graphene,[4] **(CoP/rGO-400) -** CoP/reduced graphene oxide at 400 °C,[5] **(Al, Fe-codoped CoP/RGO) -** Al, Fe- codoped CoP nanoparticles/reduced graphene oxide,[6] **(NiVB/rGO) -** Nickel/vanadium boride nanoparticles/reduced graphene oxide,[7] **(Ir/N-rGO) -**

N-doped graphene anchored Ir nanoparticles,[8] **(rGO/Co_2P) -** Cobalt phosphide loaded reduced graphene oxide,[9] **(Co−SCN/RGO) -** Cobalt-coordinated sulfur-doped graphitic carbon nitride and reduced graphene oxide,[10] (**FeS_2-MoS_2@CoS_2-MOF) -** Metal-organic framework (MOF)-derived mesoporous CoS_2 nanoarrays coupled with FeS_2@MoS_2 layers,[11] **(G-Mo-Ni_3S_2)** - Graphene-Quantum-Dots (GQDs) loaded and molybdenum doped porous Ni_3S_2 hybrid,[12] **(S-(Co,Fe)OOH)** – Sulfur-incorporated cobalt–iron (oxy) hydroxide nanosheets,[13] **(S, N-Co_9S_8)** - Sulfur-enriched N-Co_9S_8,[14] **(Co_3S_4@MoS_2-Ni_3S_2)** - Zeolitic imidazolate framework derived Co_3S_4 hybridized MoS_2-Ni_3S_2 heterointerface.[15]

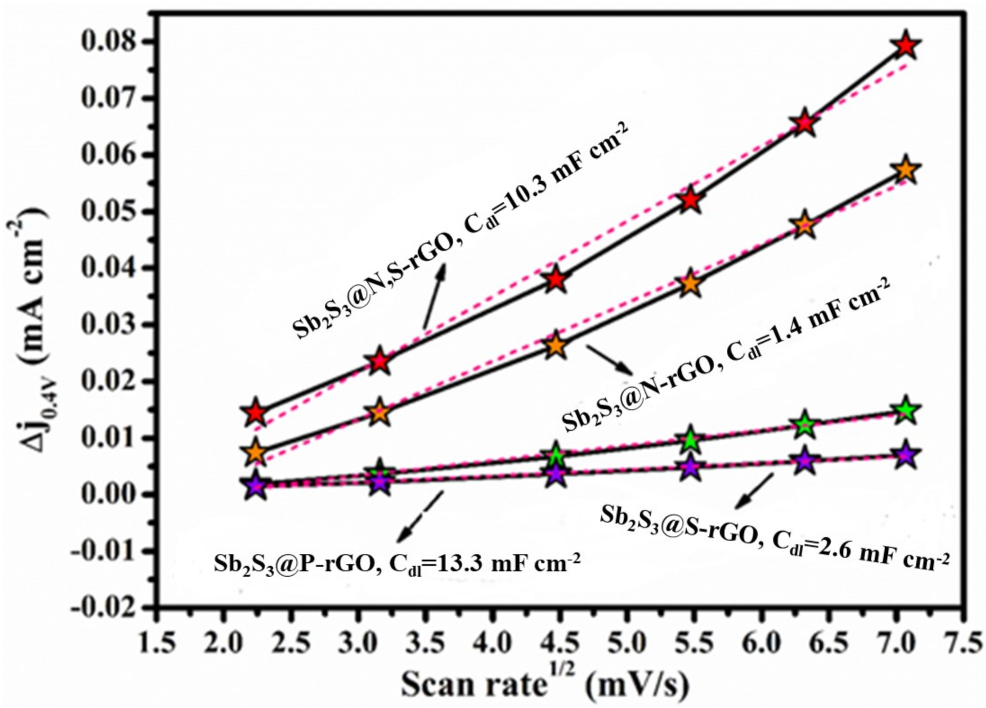

Fig. S4. ECSA measurements of Sb_2S_3@N-rGO, Sb_2S_3@S-rGO, Sb_2S_3@N,S-rGO and Sb_2S_3@P-rGO electrocatalysts. Plot between current density vs. square route of scan rates for measuring double layer capacitance (C_{dl}).

References

1 H. Li, L. Chen, P. Jin, Y. Li, J. Pang, J. Hou, S. Peng, G. Wang and Y. Shi, *Nano Res.*, 2022, **15**, 950–958.

2 T. Dong, X. Zhang, P. Wang, H. S. Chen and P. Yang, *Carbon N. Y.*, 2019, **149**, 222–233.

3 X. Guo, X. Duan, J. Ji, X. Fan, Y. Li, F. Zhang, G. Zhang, Y. A. Zhu, W. Peng and S. Wang, *J. Colloid Interface Sci.*, 2021, **583**, 139–148.

4 U. P. Suryawanshi, U. V. Ghorpade, D. M. Lee, M. He, S. W. Shin, P. V. Kumar, J. S. Jang, H. R. Jung, M. P. Suryawanshi and J. H. Kim, *Chem. Mater.*, 2021, **33**, 234–245.

5 L. Jiao, Y. X. Zhou and H. L. Jiang, *Chem. Sci.*, 2016, **7**, 1690–1695.

6 S. F. Zai, Y. T. Zhou, C. C. Yang and Q. Jiang, *Chem. Eng. J.*, 2021, **421**, 127856.

7 M. Arif, G. Yasin, M. Shakeel, M. A. Mushtaq, W. Ye, X. Fang, S. Ji and D. Yan, *J. Energy Chem.*, 2021, **58**, 237–246.

8 W. Yao, X. Jiang, Y. Li, C. Zhao, L. Ding, D. Sun and Y. Tang, *Green Energy Environ.*, 2021, 1–8.

9 X. Zhao, Y. Fan, H. Wang, C. Gao, Z. Liu, B. Li, Z. Peng, J. H. Yang and B. Liu, *ACS Omega*, 2020, **5**, 6516–6522.

10 W. K. Jo, S. Moru and S. Tonda, *ACS Sustain. Chem. Eng.*, 2019, **7**, 15373–15384.

11 K. Chhetri, A. Muthurasu, B. Dahal, T. Kim, T. Mukhiya, S. H. Chae, T. H. Ko, Y. C. Choi and H. Y. Kim, *Mater. Today Nano*, 2022, **17**, 100146.

12 J. Li, X. Zhang, Z. Zhang, Z. Li, M. Gao, H. Wei and H. Chu, *Electrochim. Acta*, 2019, **304**, 487–494.

13 C. Kim, S. Lee, S. H. Kim, I. Kwon, J. Park, S. Kim, J. H. Lee, Y. S. Park and Y. Kim, *Nanoscale Adv.*, 2021, **3**, 6386–6394.

14 A. Talha, A. Ahmed, J. Han, G. Shin, S. Park, S. Yeon, Y. Park, H. Kim and H. Im, 2023, **2023**, 14.

15 A. Muthurasu, G. P. Ojha, M. Lee and H. Y. Kim, *Electrochim. Acta*, 2020, **334**, 135537.