Electronic Supplementary Material (ESI) for Dalton Transactions.

Supporting Information

VS_2: An efficient Catalyst for Electrochemical Hydrogen Evolution Reaction in Acid Medium

Jiban K. Das[a,b], Aneeya K. Samantara[a,b], Arpan K. Nayak[c], Debabrata Pradhan[c] and J. N. Behera[a,b,*]

[a] *School of Chemical Sciences, National Institute of Science Education and Research (NISER), P.O. Jatni, Khurda 752050, Odisha, India.*
[b]*HomiBhabha National Institute, Mumbai, India*
[c]*Materials Science Centre, Indian Institute of Technology, Kharagpur 721302, West Bengal, India.*

e-mail: jnbehera@niser.ac.in

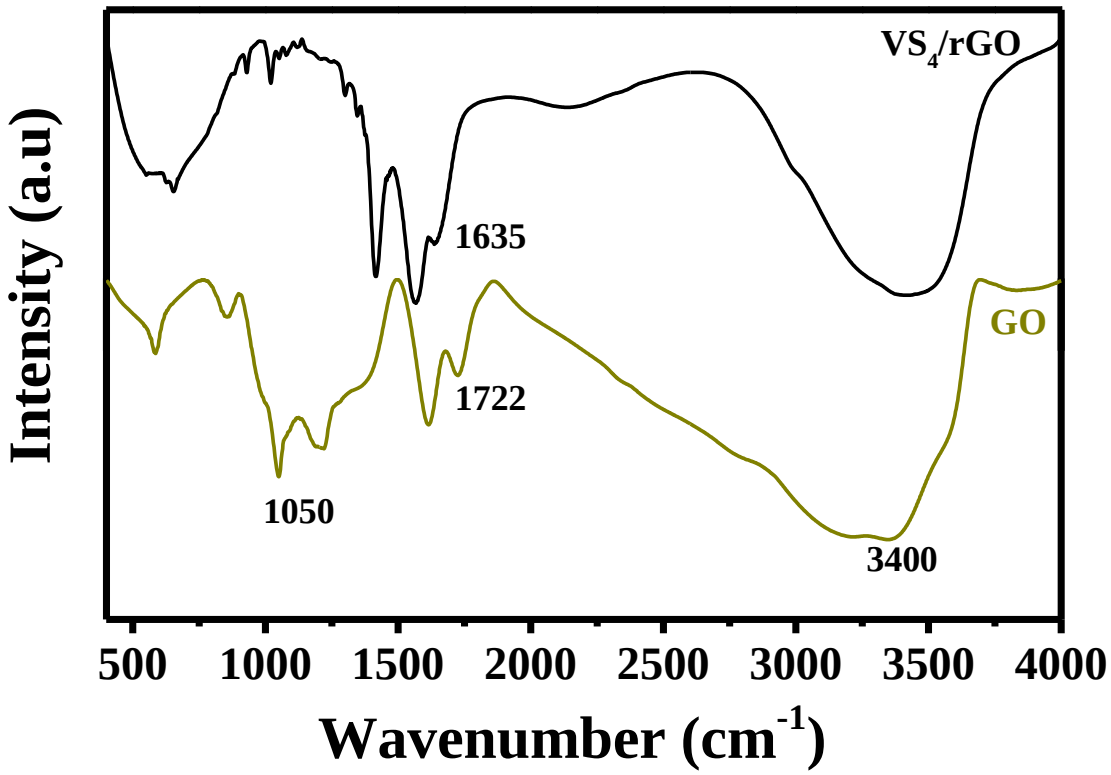

Figure S1 Fourier transform infrared spectrum for graphene oxide and VS_4/rGO composite

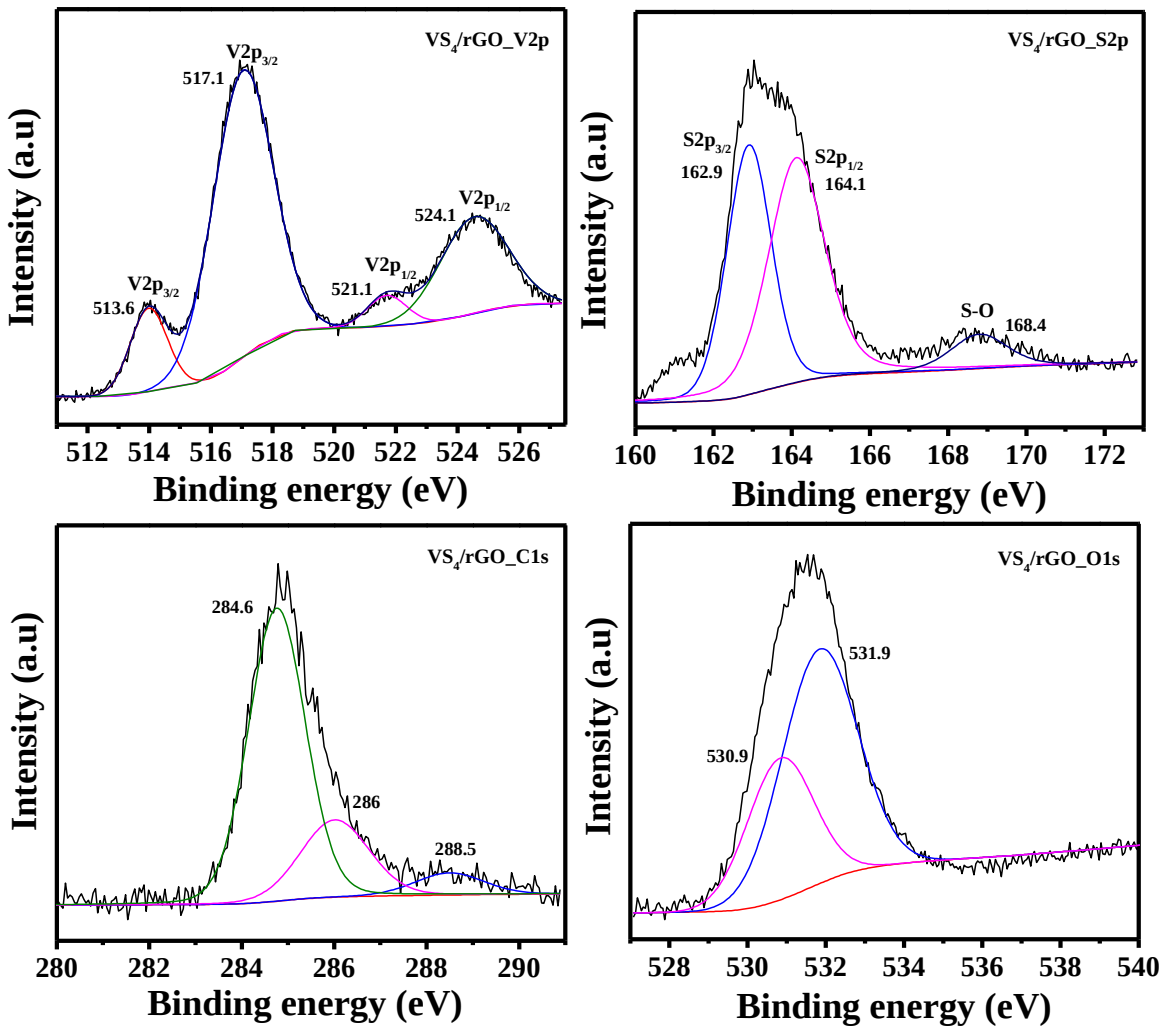

Figure S2 High resolution XPS of V2p, S2p, O1s and C1s of VS_4/rGO composite.

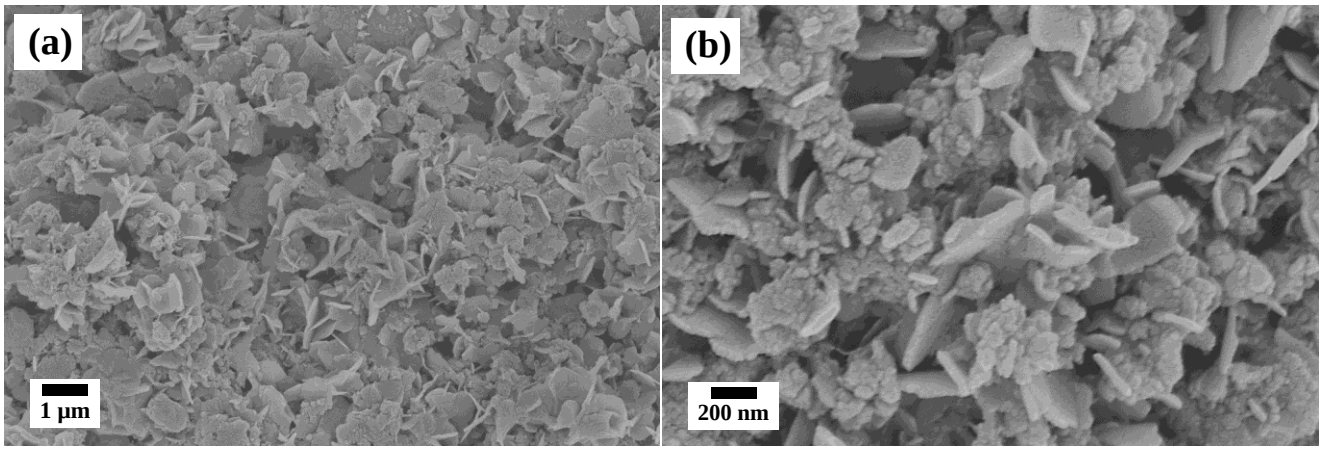

Figure S3 Field emission scanning electron microscopic images for VS_4/rGO at low (a) and higher (b) magnifications.

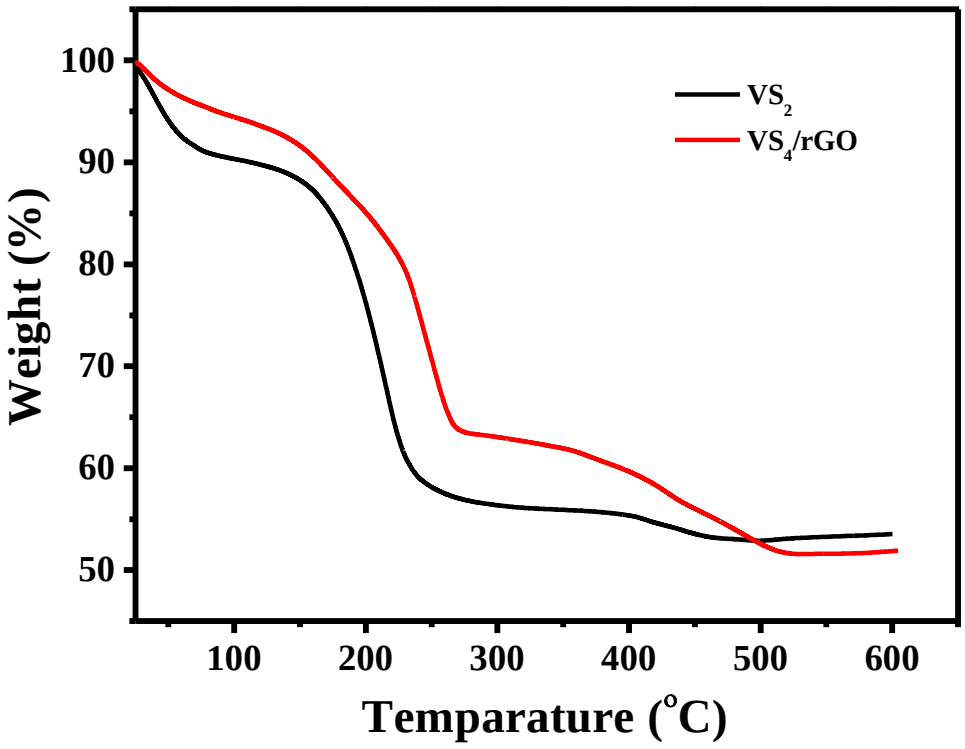

Figure S4 Thermo gravimetric analysis for VS_2 and VS_4/rGO

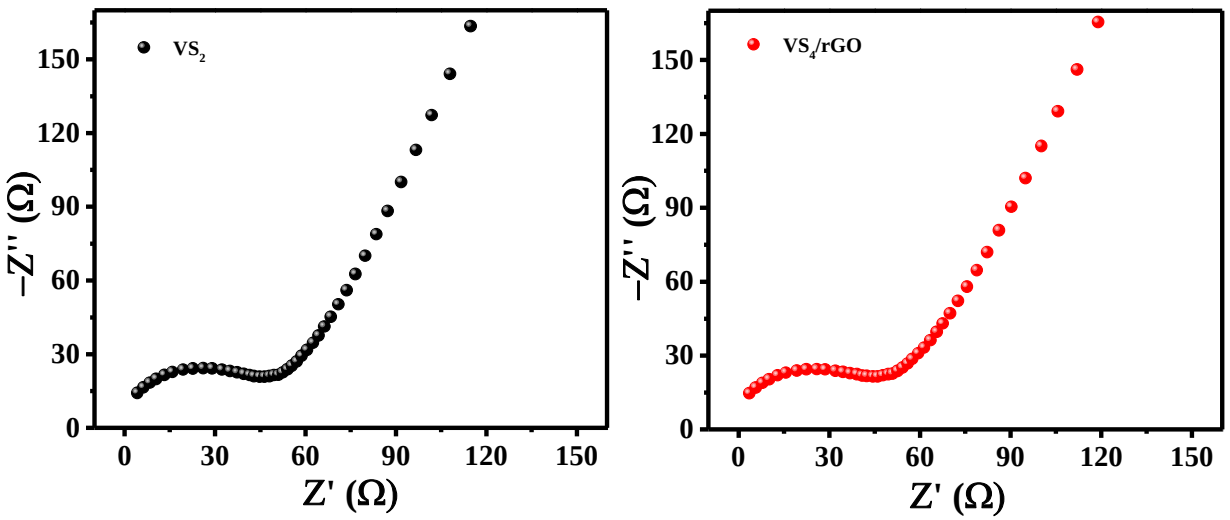

Figure S5 Nyquist impedance spectrum for the VS_2 and VS_4/rGO composites.

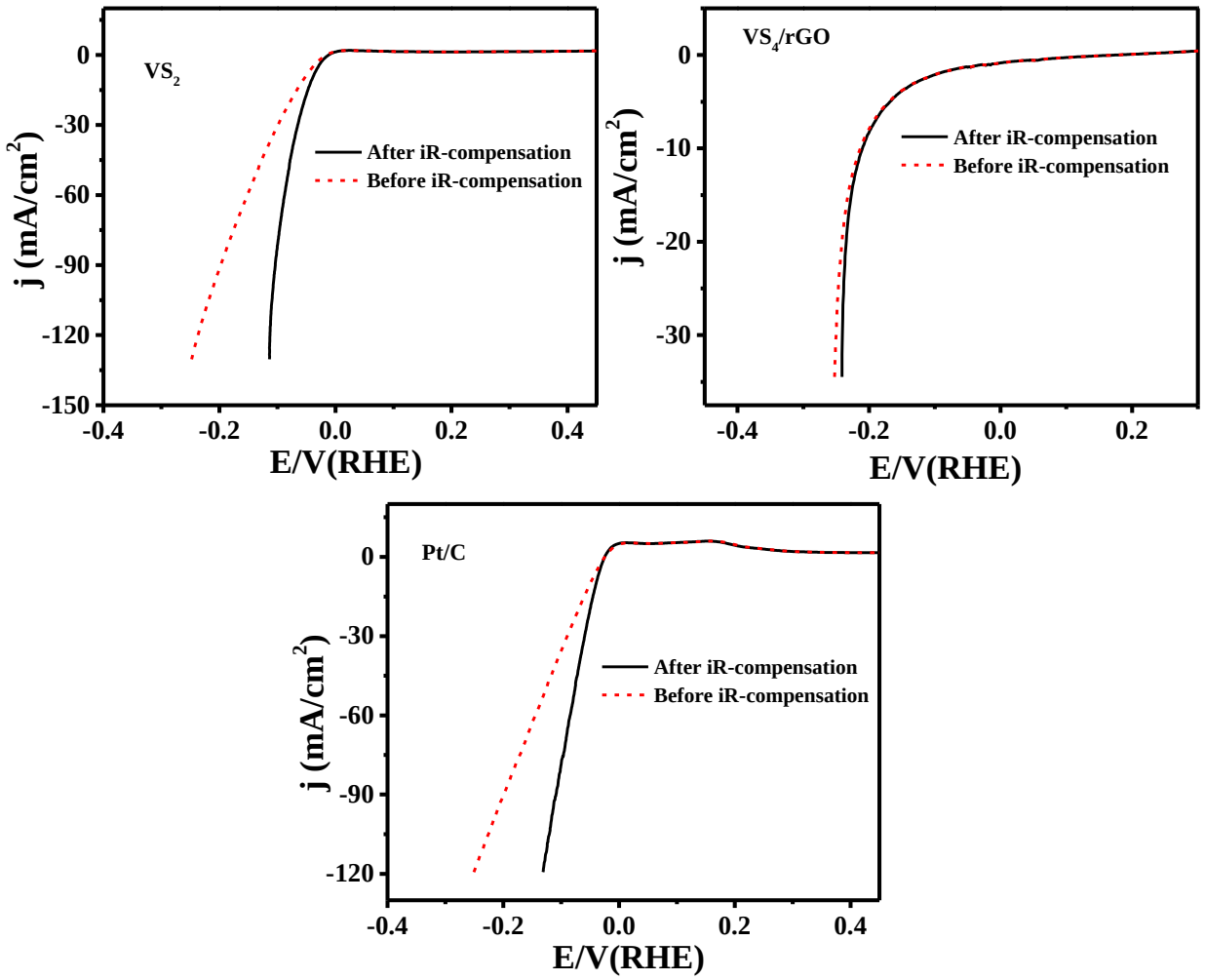

Figure S6 Linear sweep voltamograms for VS_2, VS_4/rGO and Pt/C before and after iR compensation in 0.1M H_2SO_4 electrolyte. The LSVs are recorded at a sweep rate of 5 mV/s.

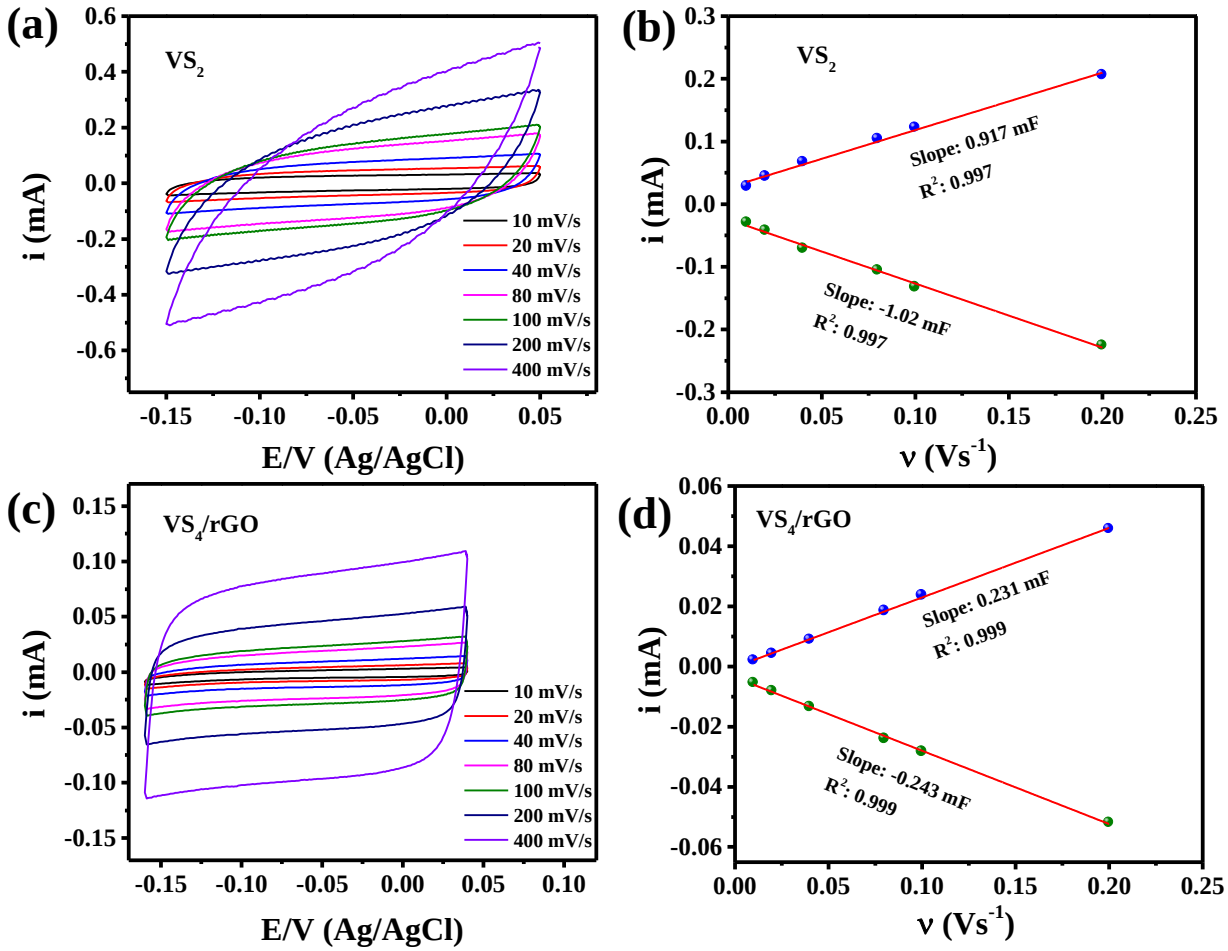

Figure S7 (a, c) are the cyclic voltammograms in 0.1M H_2SO_4 at different scan rates (10 to 400 mV/s) and (b, d) are the plot of scan rate vs. cathodic and anodic current at -0.05 V for VS_2 and VS_4/rGO.

Table S1. A brief literature survey on metal sulphide catalysts for HER

Sl. No.	Sample	Electrolyte H_2SO_4 (M)	Over potential 10mA/cm^2 (mV)	Tafel slope (mV/dec)	Reference
1	1T MoS_2	0.5	100	40	Nano Lett. 2013, 13, 6222
2	1T-VS_2	0.5	68	34	Adv. Mater. 2015, 27, 5605
3	CoS_2/rGO	0.5	150	48	Nano Convergence, 2016, 3:5.
4	NiS_2/rGO	0.5	200	52	Catalysis Communications, 2016, 85, 26
5	2H-MoS_2 triangle, Mo edge	0.5	201	68	Adv. Mater. 2017, 1701955
6	2H-MoS_2basal plane	0.5	425	109	Adv. Mater. 2017, 1701955
7	1T′-MoS_2 basal plane	0.5	356	84	Adv. Mater. 2017, 1701955
8	H-Co/MoS_2	0.5	156	58	Nano Energy, 2017, 39, 409
9	WS_2	0.5	337	80	Nanoscale, 2017, 9, 13515
10	Fe-MoS_2	0.5	136	82	Electrochemica Acta, 2017, 20, 72
11	3D WS_2/graphene /Ni	0.5	87	79	Int. journal of hydrogen energy, 2017, 7811.
12	rGO/WS_2	0.5	229	73	Nanoscale, 2015, 7, 14760
13	Annealed WS_2/CC	0.5	250 mv at 15 mA/cm^2	50	J. Mater. Chem. A, 2015, 3, 131
14	Freeze-dried WS_2/rGO after annealing	0.5	300 mv at 23 mA/cm^2	58	Angew. Chem. Int. Ed., 2013, 52, 13751
15	3D WS_2/Ni	0.5	115	98	International journal of hydrogen energy, 2017, 42, 7811
16	WS_2/3DG sheet	0.5	137 mv at 300 mA/cm^2	131	J. Mater. Chem. A, 2015, 3, 24128
17	MoS_2	0.5	214	74	ACS Appl. Mater. Interfaces, 2016, 8, 5517
18	WC−CNTs	0.5	145	72	ACS Nano, 2015, 9, 5125
19	VS_2 Nano flower	0.5	58	34	J. Mater. Chem. A, 2017, 5, 15080
20	VS_2 Nano plate	0.5	42	36	Chem. Mater. 2016, 28, 5587
21	**Vs_2**	**0.1**	**41**	**36**	**This Work**
22	**Vs_4/rGO**	**0.1**	**210**	**73**	**This Work**

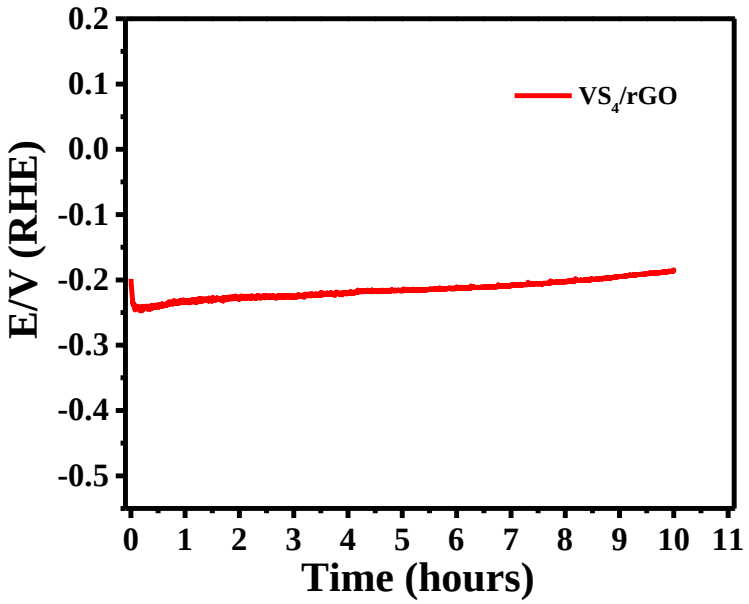

Figure S8 The long term stability test for HER by the VS_4/rGO modified GCE in 0.1 M H_2SO_4 electrolyte. Here the stability test was carried out by using the Chrono potentiometric technique at a state of art current density of 10 mA/cm^2.

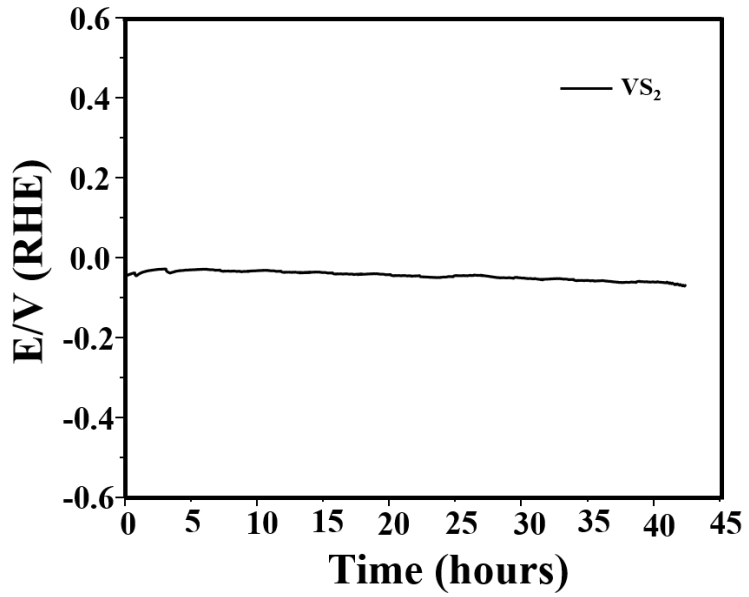

Figure S9 The long term stability test for HER by the VS_2 modified GCE in 0.1 M H_2SO_4 electrolyte at a current density of 30 mA/cm^2.

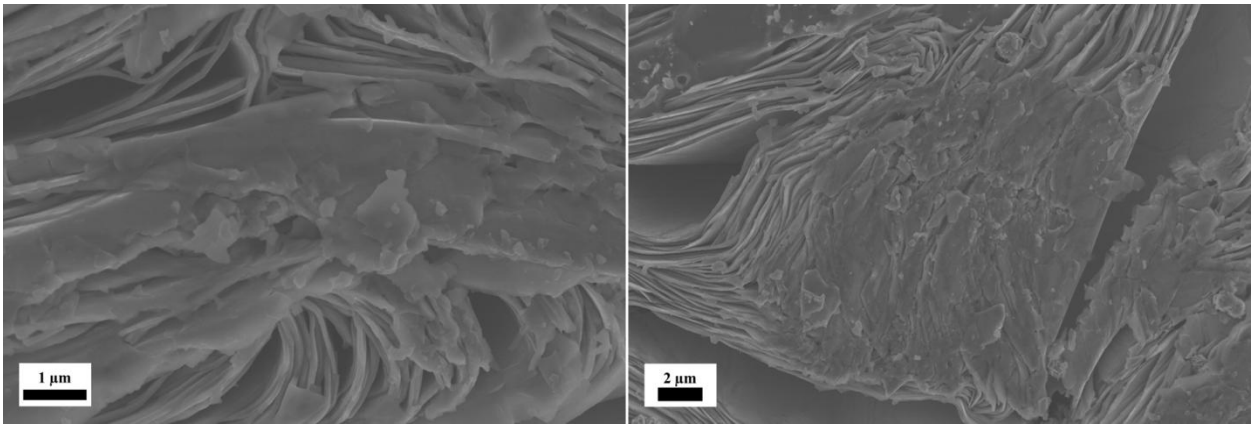

Figure S10 FESEM images for the VS_2 after the Chronopotentiometric measurement at 10 mA/cm^2.

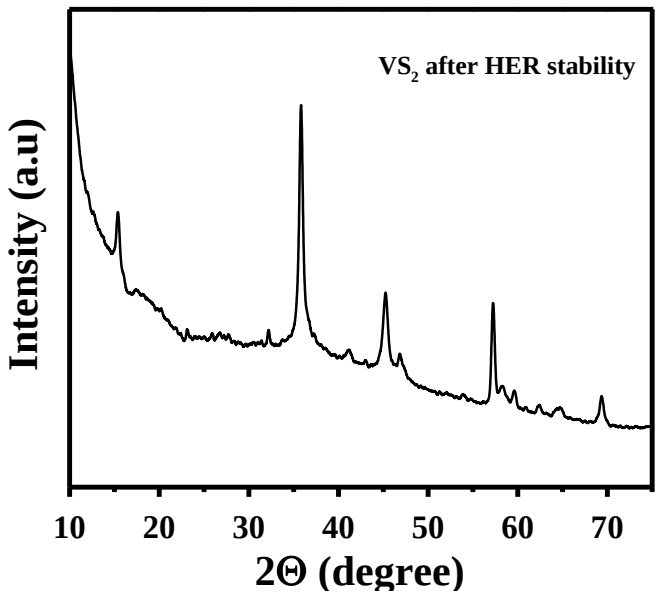

Figure S11 XRD for the VS_2 after the Chronopotentiometric measurement at current density of 10 mA/cm^2.

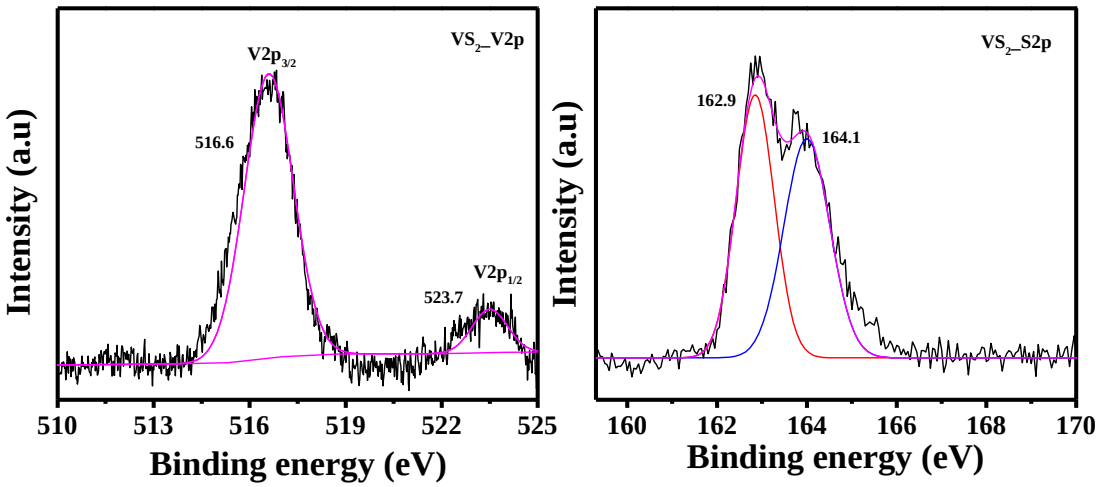

Figure S12 High resolution XPS spectrum for V2p and S2p of VS_2 after the long Chronopotentiometric measurement at 10 mA/cm^2.