Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Supporting Information

Three-Dimensional Annealed WO_3 Nanowire/Graphene Foam as an Electrocatalytic Material for an All Vanadium Redox Flow Battery

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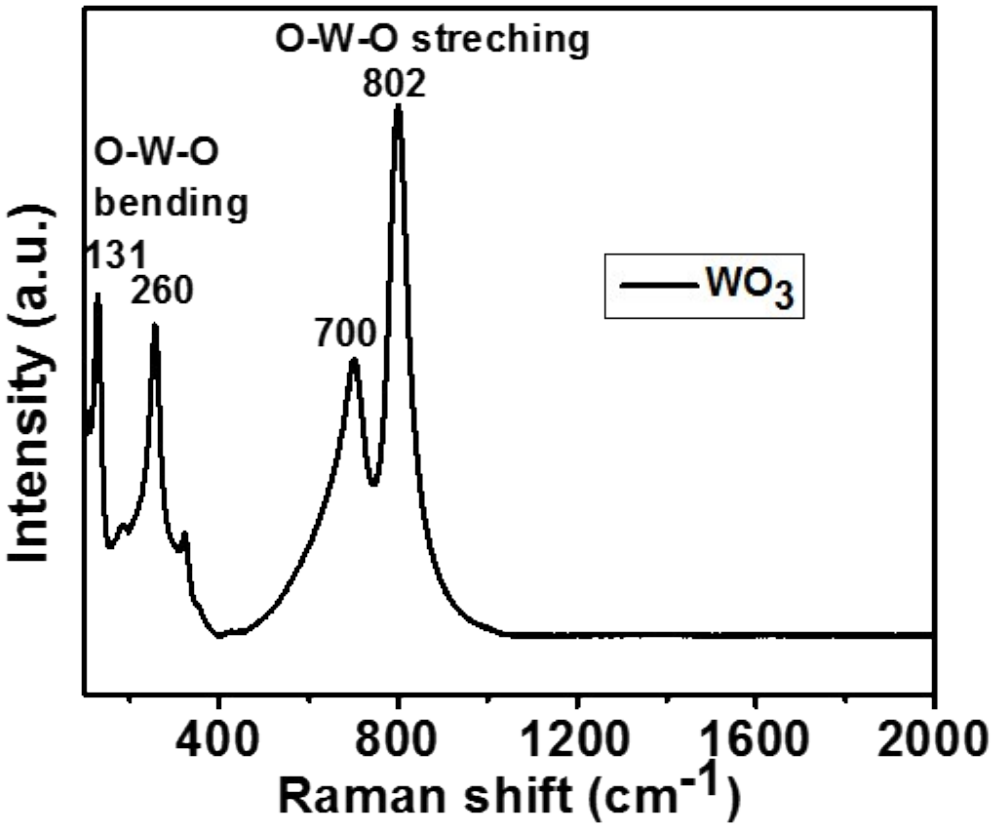

Fig. S1 Raman spectra of WO_3 NWs.

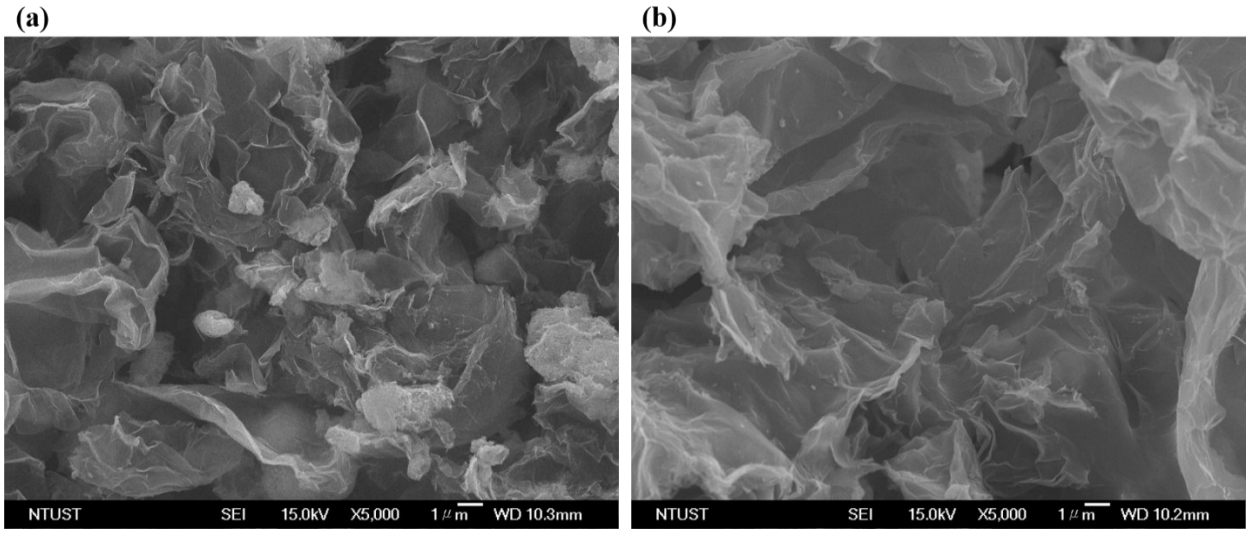

Fig. S2 Low magnification SEM images of (a) 3D WO_3 NWs/GS foam and (d) 3D annealed WO_3 NWs/GS foam.

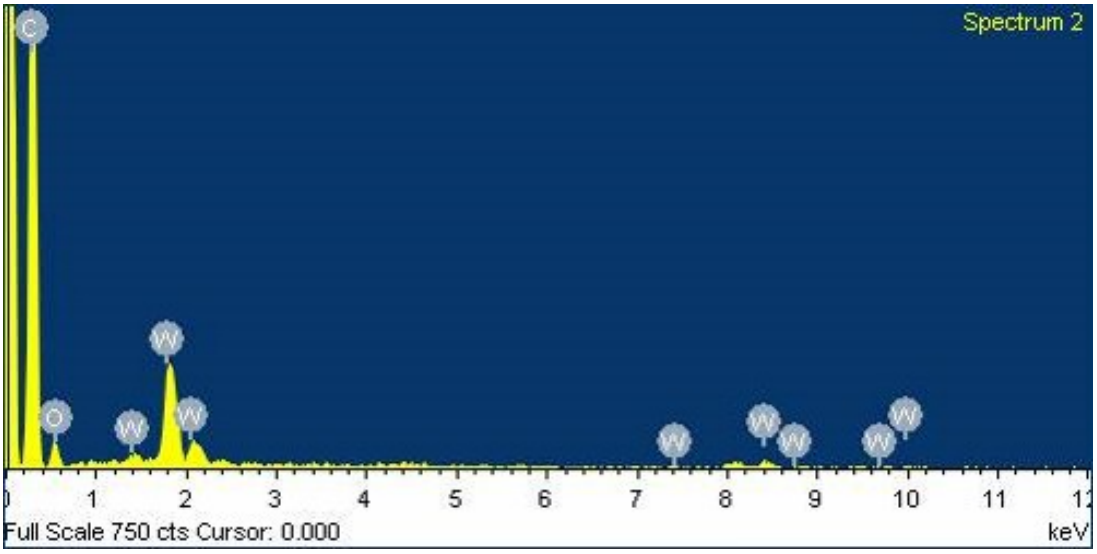

Fig. S3 EDX images 3D annealed WO_3 NWs/GS foam.

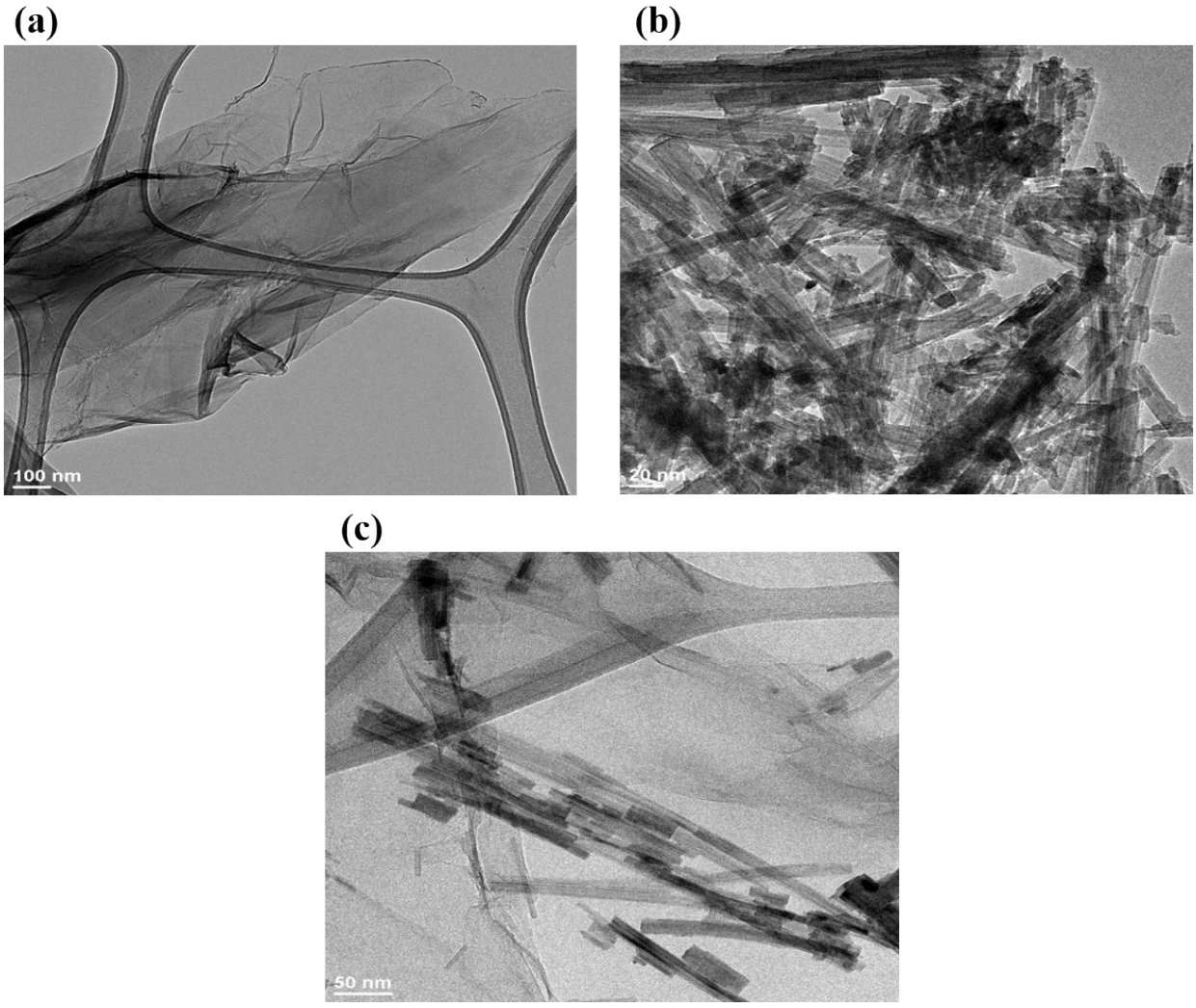

Fig. S4 TEM images of (a) GO, (b) WO_3 NWs, and (c) 3D WO_3 NWs/GS foam.

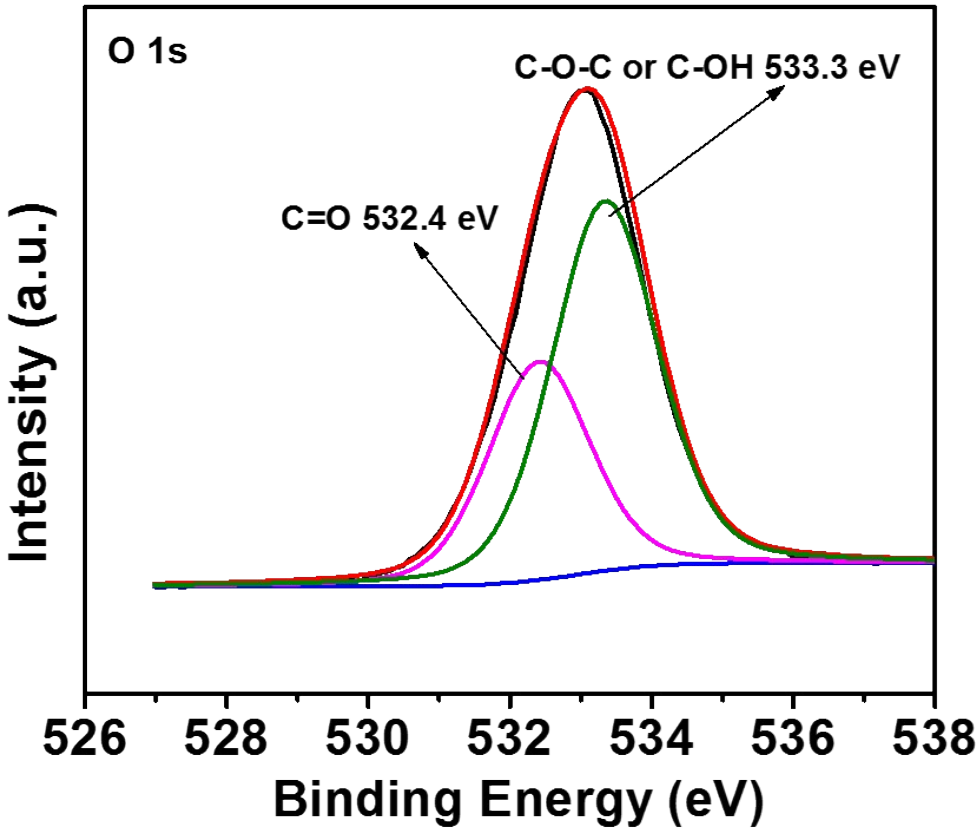

Fig. S5 Narrow-scan O 1s XPS spectra of the GO.

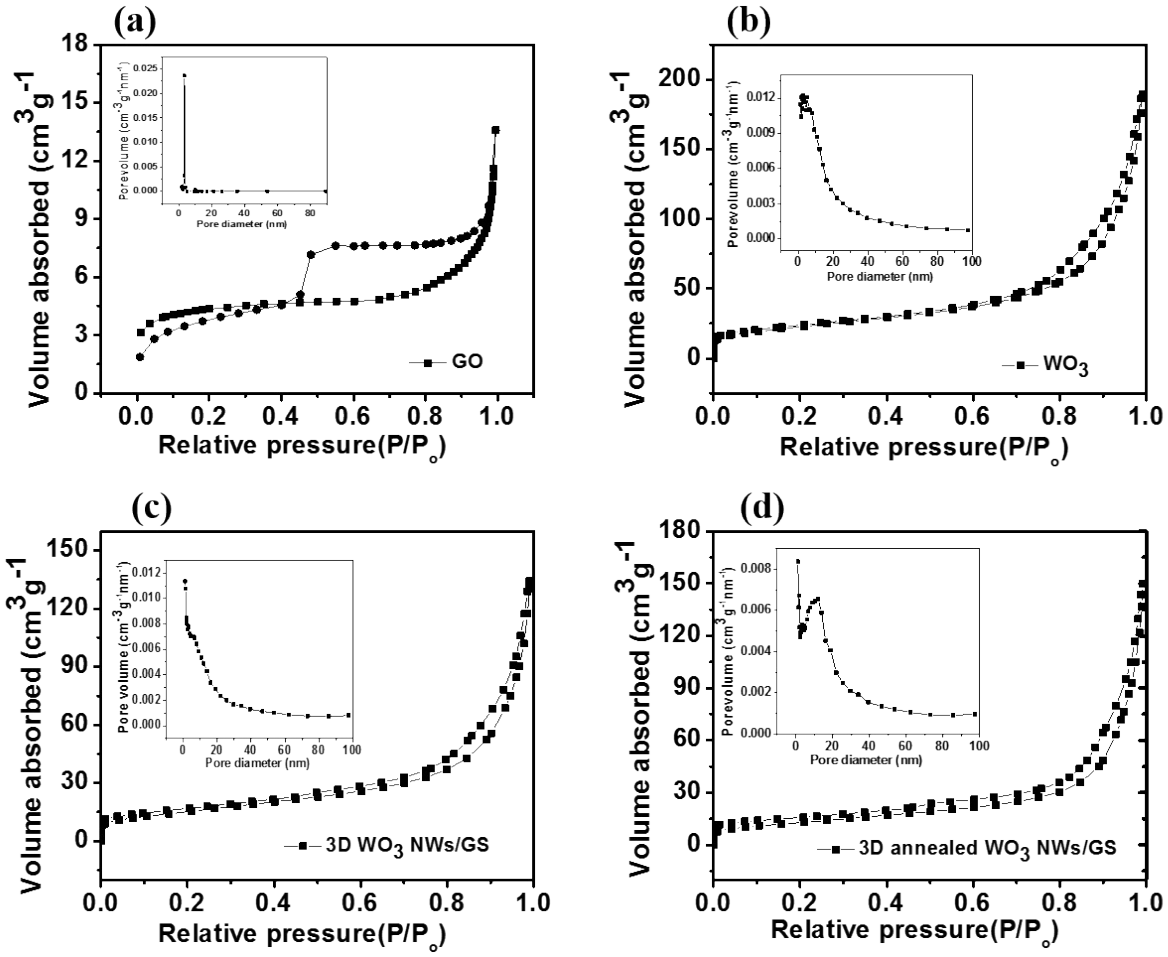

Fig. S6 Nitrogen adsorption and desorption isotherms and the corresponding pore size distribution curves of (a) GO, (b) WO_3 NWs, (c) 3D WO_3 NWs/GS foam, and (d) 3D annealed WO_3 NWs/GS foam.

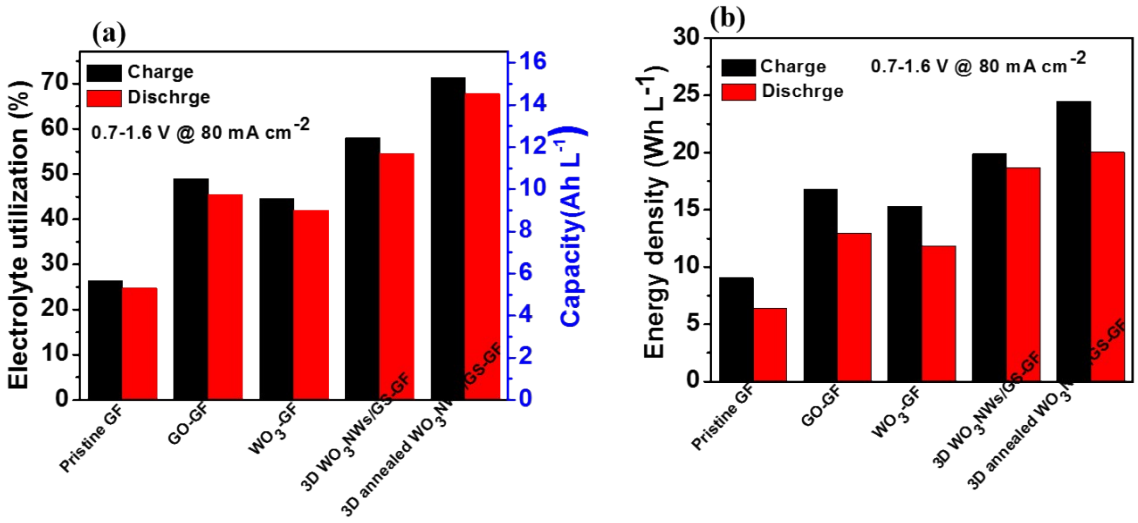

Fig. S7 Comparison of (a) electrolyte utilization ratio and charge–discharge capacity, (b) charge–discharge energy density of pristine GF, GO-modified GF, WO_3 NWs-modified GF, 3D WO_3 NWs/GS foam-modified GF, and 3D annealed WO_3 NWs/GS foam-modified GF at the current density of 80 mA cm^{-2}.

Table S1. Comparison of the CE, VE and EE of 3D annealed WO_3 NWs/GS foam-modified GF with previously reported Composite materials as electrode for VRFB Application.

Materials	Electrolyte	Current density (mA cm^{-2})	CE (%)	VE (%)	EE (%)	Ref.
3D annealed WO_3 NWs/GS foam	1.6 M $VOSO_4$ + 2.5 M H_2SO_4	160	98.18	68.85	67.6	This work
N-doped CNT	1 M $VOSO_4$ + 2 M H_2SO_4	10	81.3	94.7	77.0	[1]
Mn_3O_4/MWCNTs	1.2 M $VOSO_4$ + 3 M H_2SO_4	20	93.50	90.53	84.65	[2]
MoO_2/MSU-F-C	1 M $VOSO_4$ + 1 M H_2SO_4	40	87.6	89.0	78.0	[3]
SWCNT	1.5 M $VOSO_4$ + 2 M H_2SO_4	20	92.2	96.8	89.3	[4]
corn-protein-derived N-doped carbon	2 M $VOSO_4$ + 3 M H_2SO_4	150	98.0	70.0	68.6	[5]
WO_3/SAC	1.5 M $VOSO_4$ + 3 M H_2SO_4	50	94.5	85.2	80.5	[6]
Pt/MWNTs	1 M $VOSO_4$ + 1 M H_2SO_4	20	83.88	27.55	23.11	[7]
Ti/:IrO_2:Ta_2O_5	1.7 M $VOSO_4$ + 4 M H_2SO_4	40	90	90	81.0	[8]
polyol Pt/C	1 M $VOSO_4$ + 1 M H_2SO_4	40	87.0	81.6	71.0	[9]
TiO_2/C	3 M $VOSO_4$ + 2 M H_2SO_4	200	90	73	65.4	[10]
CNF/CNT	2 M $VOSO_4$ + 3 M H_2SO_4	100	97.7	67.5	66.0	[11]

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