Supporting Information

1D-$CoSe_2$ nanoarray: A designed structure for efficient hydrogen evolution and symmetric supercapacitor characteristics

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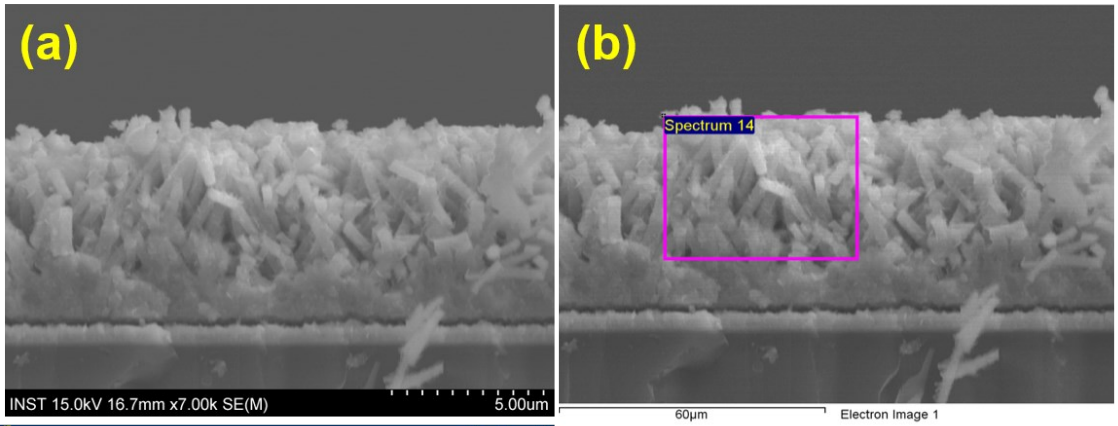
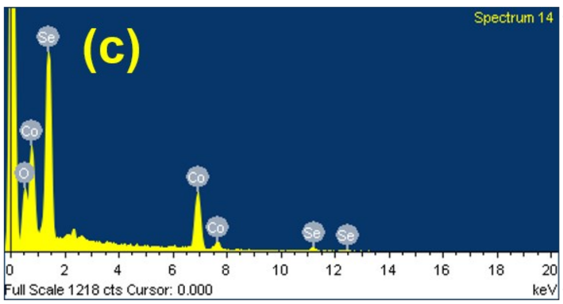
S1. Characterization details of 1D-Co_3O_4 and 1D-$CoSe_2$ nanoarrays

The crystallinity of synthesized nanoarrays structures were analyzed by Raman spectroscopy (Renishaw invia RE04, 512 nm Ar laser) with a spot size of 1 µm and a scan speed of 30 seconds. X-ray photoelectron spectroscopy (PHI 5000 Versa Probe, 25W Al Kα, 6.7×10^{-8} Pa) was used to characterize the surface binding energy and composition. field emission-scanning electron microscopy (HITACHI S-4700) was used to examine the morphology and microstructure of the films. The atomic structure of 1D-$CoSe_2$ nanoarray was captured by a JEOL-2010F high resolution-transmission electron microscopy with an accelerating voltage of 200 keV. The 1D-Co_3O_4 and 1D-$CoSe_2$ nanoarray structures were analyzed by in-plane X-ray diffraction (Rigaku) with Cu-Kα(λ= 1.5406 Å) radiation operated at 50 KV and 300mA.





(d)

Element	Weight%	Atomic%
O K	18.60	49.37
Co K	37.52	27.03
Se L	43.88	23.60
Totals	100.00	

Figure S1. (a-b) FE-SEM cross-sectional images and (c-d) EDS spectrum of 1D-$CoSe_2$ (t_{ex}-48h) nanoarrays with their composition ratio.

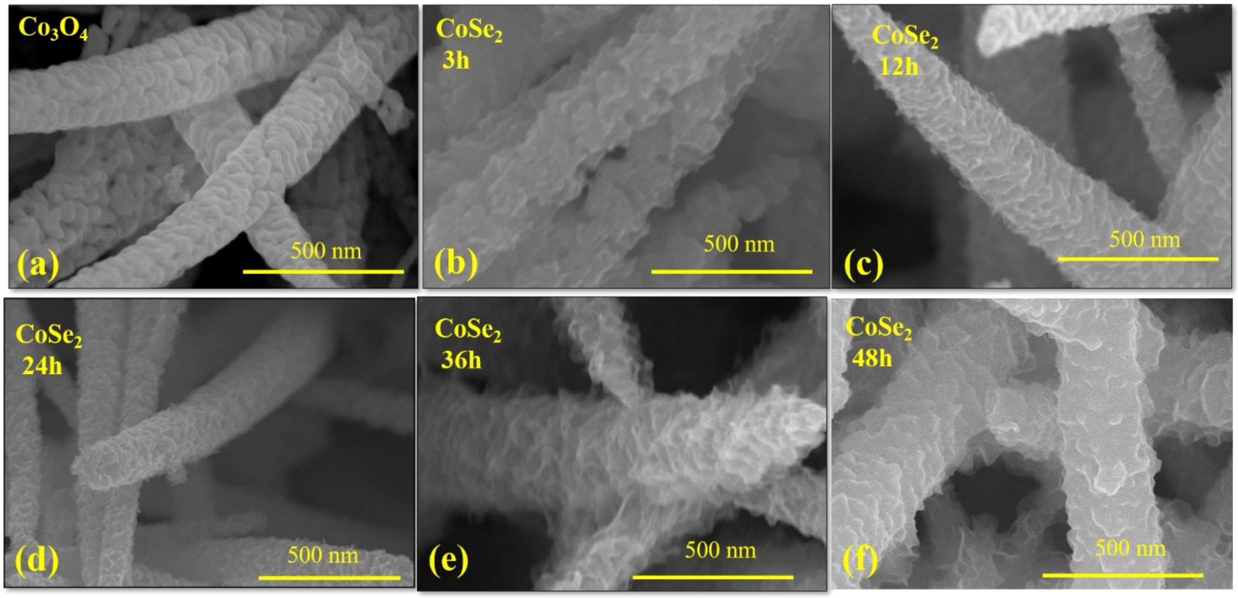


Figure S2. High magnification FESEM images of (a) 1D-Co_3O_4 and (b-f) 1D-$CoSe_2$ with different ion exchange time (b) 3, (c) 12, (d) 24, (e) 36 and (f) 48 h.

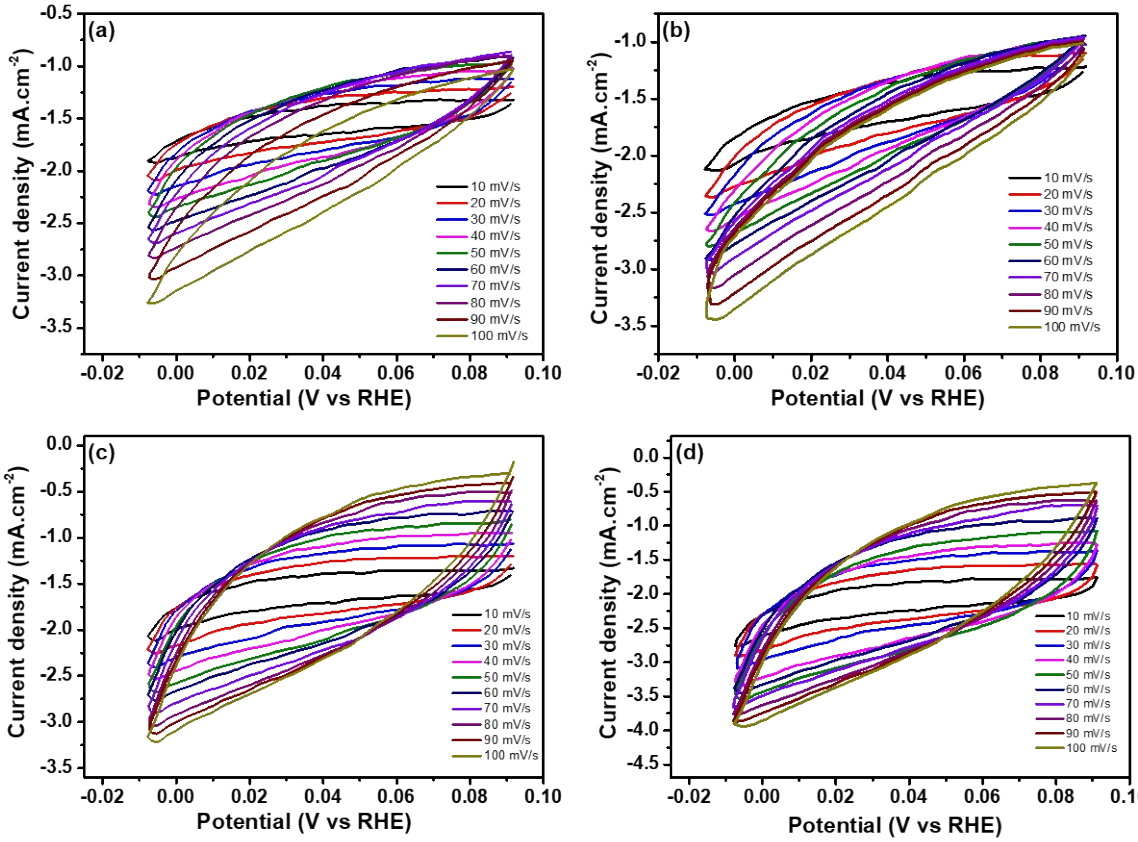


Figure S3. The CV profiles acquired at various scan rates in the non-Faradaic region of acidic medium for (a) 1D-$CoSe_2$(t_{ex}-12h), (b) 1D-$CoSe_2$(t_{ex}-24h), (c) 1D-$CoSe_2$(t_{ex}-36h) and (d) 1D-$CoSe_2$(t_{ex}-48h) nanoarrays electrocatalysts.

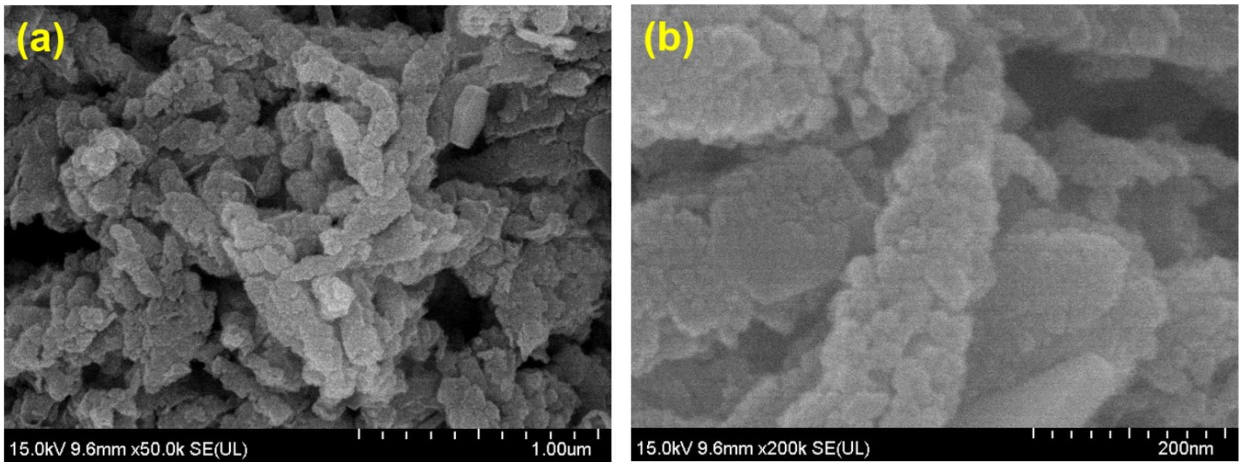


Figure S4. FESEM images of 1D-$CoSe_2$(t_{ex}-48h) electrocatalyst after 25h HER performance in acidic medium.

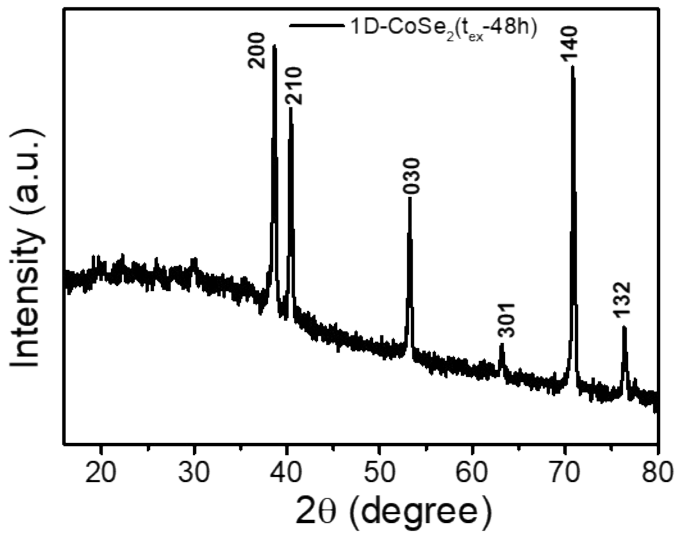


Figure S5. XRD spectrum for 1D-$CoSe_2$(t_{ex}-48h) electrocatalyst after 25h HER performance in acidic medium.

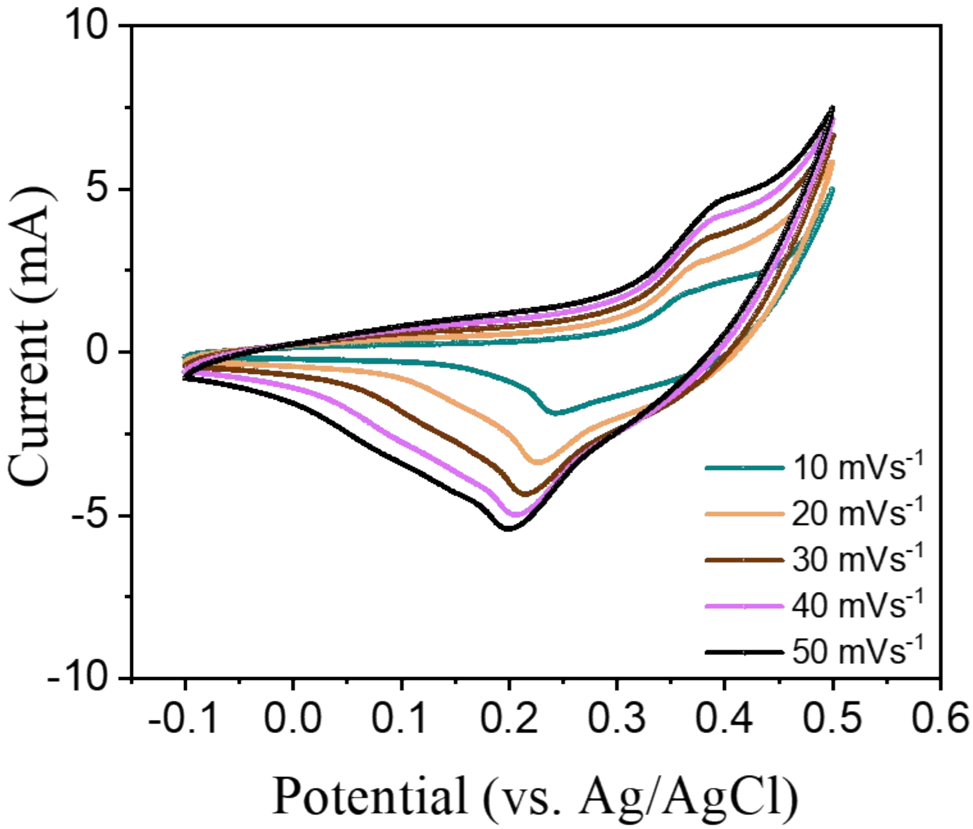


Figure S6. Cyclic voltammograms of 1D-Co_3O_4 electrode at different scan rates.

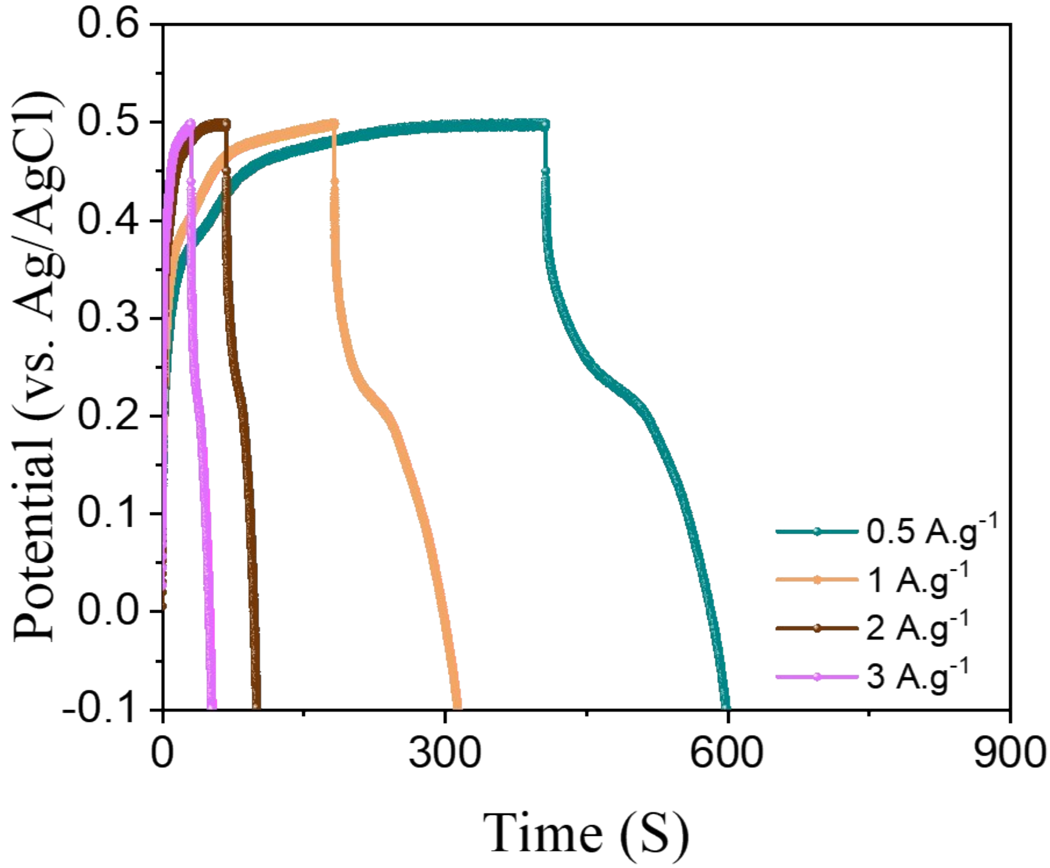


Figure S7. Galvanostatic charge-discharge profiles for 1D-Co_3O_4 electrode at various current densities.

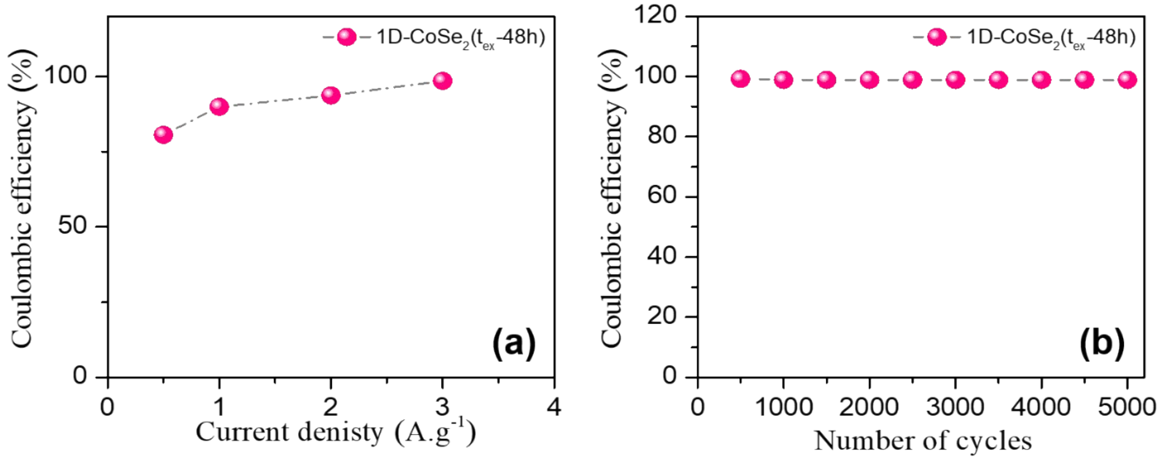


Figure S8. Coulombic efficiency of SSC device (a) different current densities and (b) 5000 cycles at current density 3 $A.g^{-1}$.

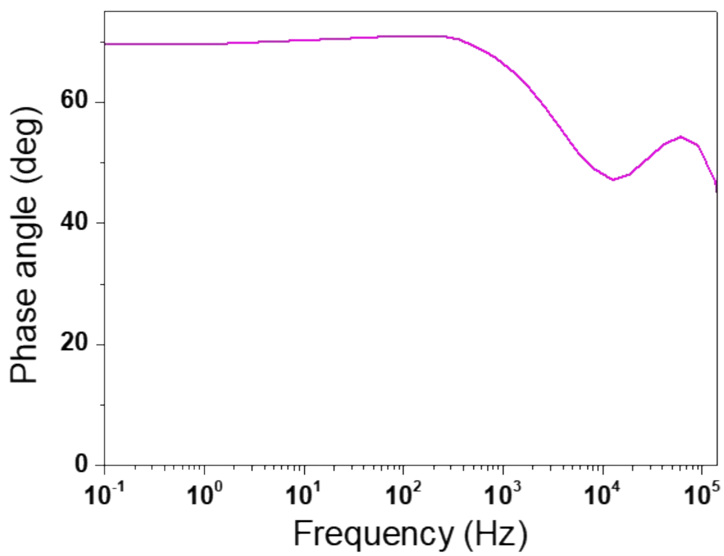


Figure S9. Bode phase plot for 1D-$CoSe_2$(t_{ex}-48h) SSC electrode.

Table S1 Comparison of catalytic parameters of different HER catalysts

Catalyst	**Onset potential (mV vs RHE) @10 mA cm^{-2}**	**Tafel slope (mV dec^{-1})**	**Exchange current density (j_0, mA cm^{-2})**
1D-Co_3O_4	377	98	1.25×10^{-3}
1D-$CoSe_2$(t_{ex}-3h)	314	88	7.07×10^{-3}
1D-$CoSe_2$(t_{ex}-12h)	265	78	1.62×10^{-2}
1D-$CoSe_2$(t_{ex}-24h)	254	78	3.25×10^{-2}
1D-$CoSe_2$(t_{ex}-36h)	241	73	4.57×10^{-2}
1D-$CoSe_2$(t_{ex}-48h)	216	72	5.62×10^{-2}
Pt	135	57	1.02×10^{-1}

Table S2. HER catalytic performances TMDs-based electrocatalysts

Electrocatalyst	**Electrolyte**	**η (mV)**	**Tafel Slope ($mV\cdot dec^{-1}$)**	**j_0 ($mA\cdot cm^{-2}$)**	**Ref.**
1D-$CoSe_2$(t_{ex}-48h) nanoarray	0.5 M H_2SO_4	41 and 216 @ 1 and 10 mA/cm^2	78	5.62×10^{-2}	This work
$CoS_2/CoSe_2$ hybrid	0.5 M H_2SO_4	80 @ 10 mA/cm^2	33.6	$37.8 \mu A.cm^{-1}$	1
$CoSe_2$ NW/CC	0.5 M H_2SO_4	130 @ 10 mA/cm^2	32	-	2
$CoSe_2$ nanorods	0.5 M H_2SO_4	205 @ 100 mA/cm^2	35	-	3
$CoSe_2$ Nanocrystals	0.5 M H_2SO_4	160 @ 10 mA/cm^2	40	-	4
CoS_2/CoSe@C	0.5 M H_2SO_4	164 @ 10 mA/cm^2	42	-	5
$CoSe_2$ nanoparticles	0.5 M H_2SO_4	137 @ 10 mA/cm^2	40	-	6
CoP nanowire arrays	1.0 M KOH	209 @ 10 mA/cm^2	129	-	7
$CoSe_2$@GO	0.5 M H_2SO_4	210 @ 10 mA/cm^2	42	-	8
Cubic pyrite-type $CoSe_2$	0.5 M H_2SO_4	193 @ 10 mA/cm^2	40	-	9
Co_3O_4@Ni	0.5 M H_2SO_4	220 @ 10 mA/cm^2	53	-	10
$WS_2/CoSe_2$ heterostructure	0.5 M H_2SO_4	160 @ 10 mA/cm^2	44	$1.44\times10^{-2} mA\ cm^{-2}$	11

Table S3. Solid-state supercapacitors performances of TMDs-based electrodes

Electrode materials	**Electrolyte**	**Specific capacitance**	**Energy density**	**Power density**	**Capacitance retention (%)/cycles**	**Ref.**
1D-$CoSe_2$(t_{ex}-48h) nanoarray	PVA/KOH	152 $F·g^{-1}$ @ 0.5 $A·g^{-1}$	21.1 Wh kg^{-1}	0.5 kW kg^{-1}	95.8/5000	In this study
MoS_2/CNS	1 M Na_2SO_4	108 F g^{-1} at 1 A g^{-1}	74 Wh/kg	3700 W/Kg	-	12
Co_3O_4/VAGN /carbon	PVA/KOH	580 F g^{-1} @1 A g^{-1}	80 Wh/kg	27 Wh/kg	86.2/20000	13
$Ni_{0.85}Se$@$MoSe_2$/ graphene	2 M KOH		25.5 Wh/kg	420 W/kg	95/20000	14
PEDOT/CNTs	PVA/H_2SO_4/ H_2O	147 F. g^{-1} at 0.5 A. g^{-1}	12.6 Wh. kg^{-1}	1 kW. Kg^{-1}	95/3000	15
WS_2 nanosheets	PVA/LiCl	0.93 F cm^{-2}	0.97 m Wh cm^{-3}	0.7 W cm^{-3}	82/10000	16
MoS_2-NH_2/PANI nanosheets	1 M H_2SO_4	58.6 F g^{-1}	4.0 Wh/kg	175W/kg	96.5/10000	17
$Ni_{0.6}Co_{0.4}Se_2$	PVA-KOH	402 F g^{-1} at 0.5 A g^{-1}	42.1 Wh/kg		91.0/ 5000	18
(Mo_2C/NCF)	PVA-KOH	75 F g^{-1} @0.5 A g^{-1}	54 Wh/kg	1080 W/Kg	100/ 5000	19
WTe_2 Nanosheets	H_3PO_4/PVA	74 F cm^{-3}	0.01 Wh cm^{-3}	83.6 W cm^{-3}	91/5500	20
VSL-MoS2@3D-Ni foam	Na_2SO_4/PVA	34.1 F g^{-1}@ 1.3 A g^{-1}	4.7 W h/kg	650 W/kg	82.5/10000	21
MoS_2/G nanobelts	1 M Na_2SO_4	278.2 F g^{-1} @ 0.8 A g^{-1}	38.6 Wh/kg	0.4 kW/Kg	-	22
MoS_2 NSs @PANI nanoneedle arrays	0.5 M H_2SO_4	853 F g-1 @1 A g-1	106 Wh/kg	106 KW/kg	91/4000	23

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