Supporting Information

Facilitating the redox conversion of $CoSe_2$ nanorods by $Ti_3C_2T_x$ to improve the electrode durability as anodes for sodium-ion batteries

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1. The calculation of $Ti_3C_2T_x$ in $CoSe_2/Ti_3C_2T_x$

According to the TG curves of all samples, assuming that the actual content of $Ti_3C_2T_x$ is X, then the actual content of TiO_2 and Co_3O_4 are 93%X and (1-X)×35%, respectively.

At this time, the content of $Ti_3C_2T_x$ in $CoSe_2/Ti_3C_2T_x$-10 can be calculated by

(1-X)×35%+93X=39% (S1)

The content of $Ti_3C_2T_x$ $CoSe_2/Ti_3C_2T_x$-25 can be calculated by

(1-X)×35%+93%X=48% (S2)

2. The calculation of D_{Na^+}.

$$D_{Na^+}=\frac{R^2T^2}{2A^2n^4F^4C^2\sigma^2} \quad \text{(S3)}$$

$$Z'=R_f+R_{ct}+\sigma\omega^{-1/2} \quad \text{(S4)}$$

R is gas constant, T is the absolute temperature, F is the Faraday constant, n is the number of electrons, A is the active surface area of the electrode and C is the

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concentration of sodium ions in the electrolyte. σ is the Warburg factor, ω is the angular frequency, which is related to Z' and can be attained from the slope of the fitting line of the EIS data.

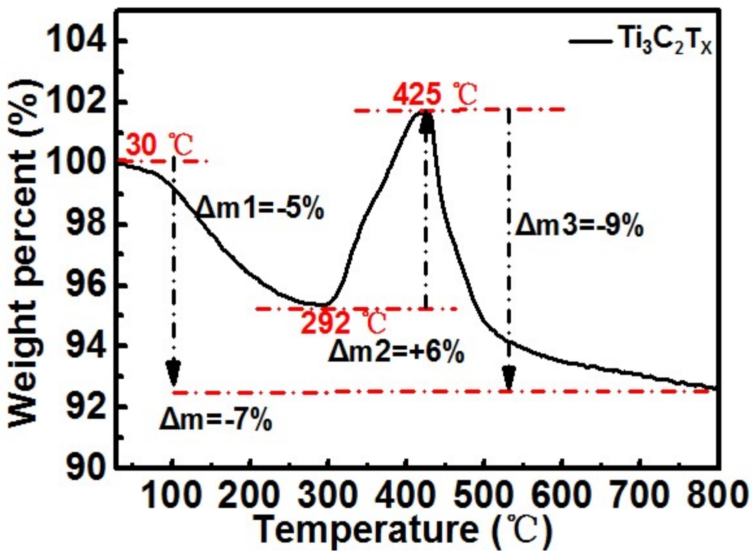

Figure S1. TG curves of $Ti_3C_2T_x$.

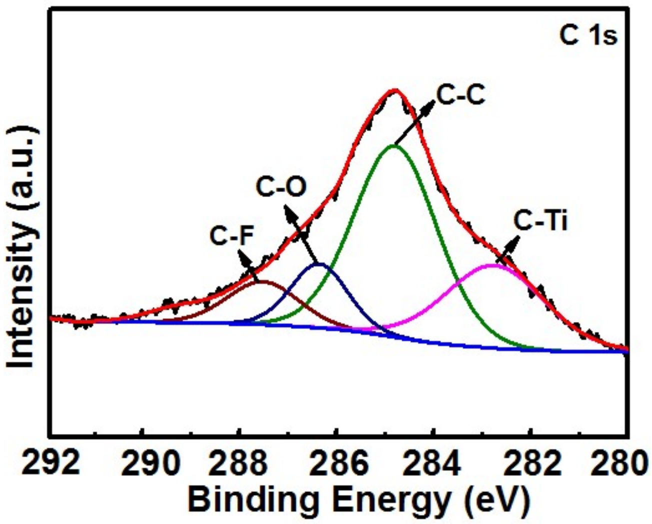

Figure S2. The C 1s spectra of $CoSe_2/Ti_3C_2T_x$-10

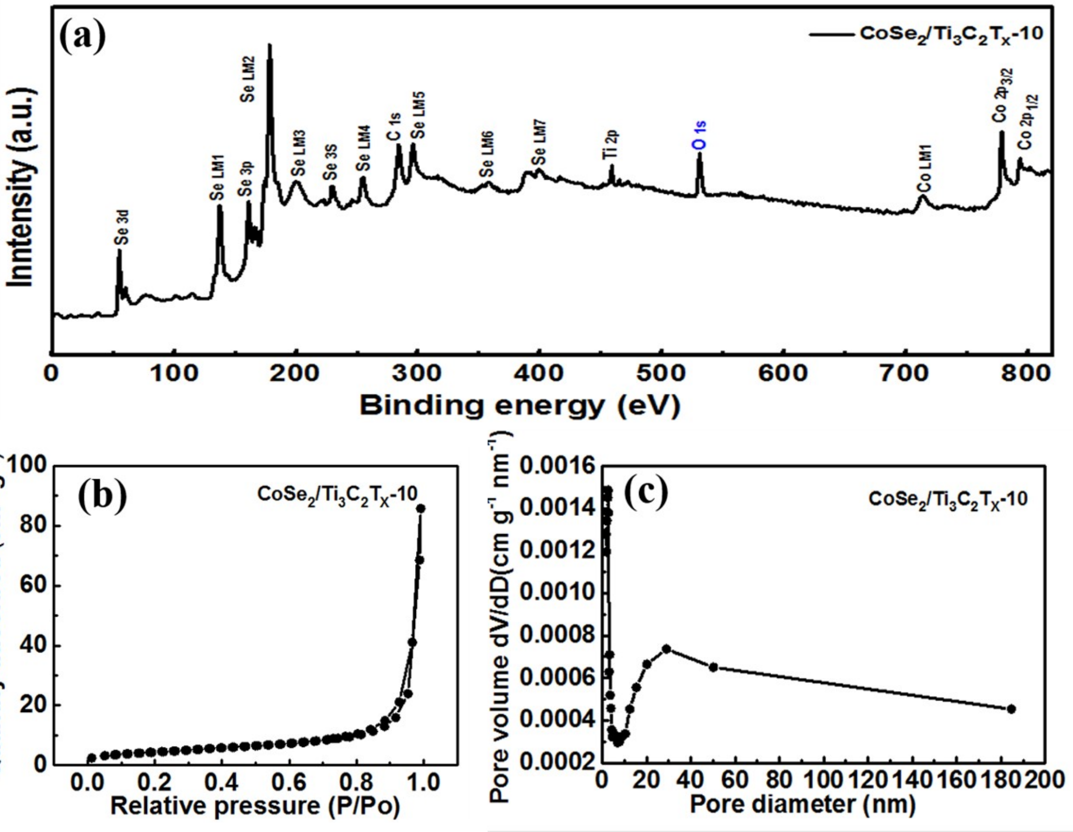

Figure S3. (a) The survey scan spectrum of $CoSe_2/Ti_3C_2T_x$-10; (b) N_2 adsorption–desorption isotherms and (c) pore size distributions of $CoSe_2/Ti_3C_2T_x$-10.

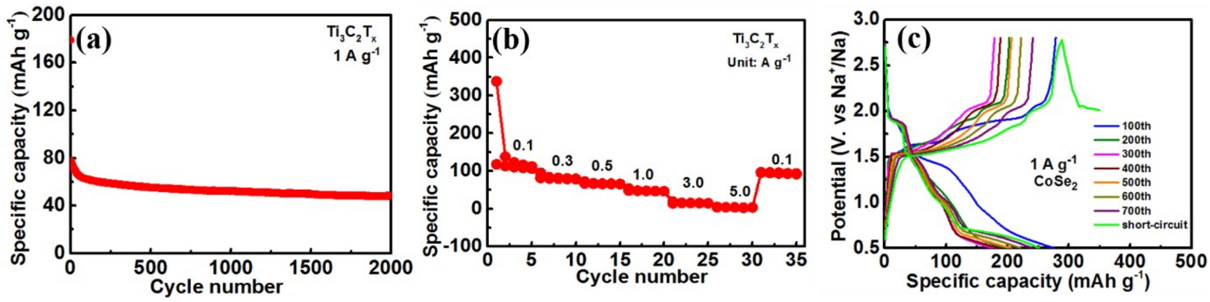

Figure S4. (a) Cycling performance of $Ti_3C_2T_x$ at 1.0 A g^{-1}; (b) Rate performance of $Ti_3C_2T_x$; (c) Different cycles charge/discharge curves of $CoSe_2$ at 1.0 A g^{-1}.

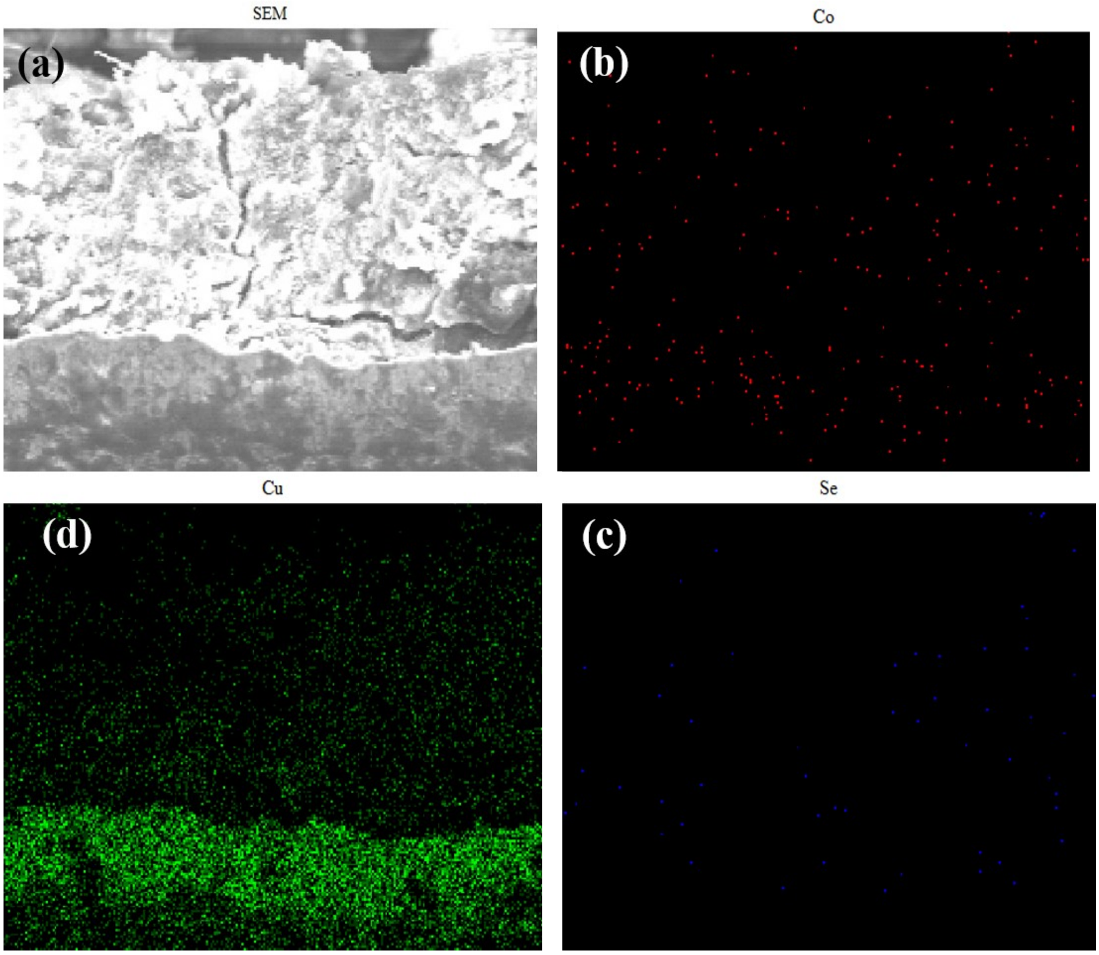

Figure S5. EDS mapping of $CoSe_2/Ti_3C_2T_x$-10 after 1000 cycles at 1 A g^{-1}.

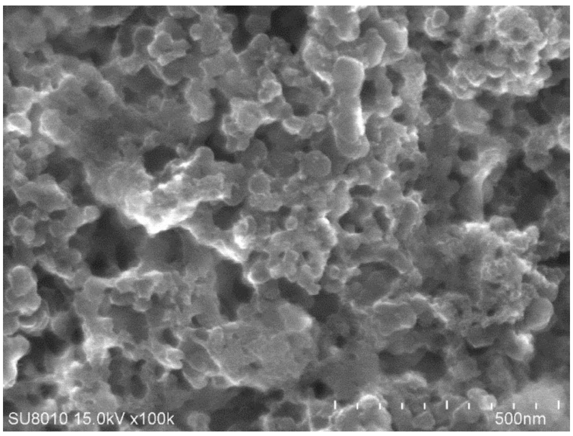

Figure S6. SEM image of $CoSe_2/Ti_3C_2T_x$-10 after 1000 cycles

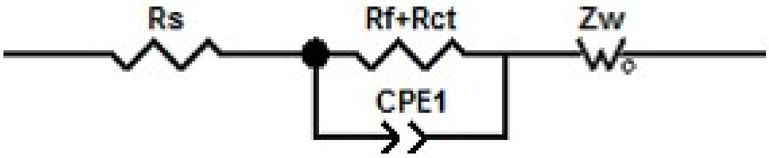

Figure S7. Equivalent circuit of the all electrode.

Table S1. The atomic content in survey scan spectrum of $CoSe_2/Ti_3C_2T_x$-10

$CoSe_2/Ti_3C_2T_x$-10	Peak BE	Atomic %
Co2s	925.08	2.61
Co2p1	794.03	2.21
Co2p3	779.08	2.66
F1s	684.84	0.19
Ti2s	565.12	0.77
O1s	531.2	5.37
Ti2p1	465.01	0.17
C1s	284.33	14.96
Se3s	230.08	6.68
Cl2p1	201.85	0.56
Cl2p3	199.41	0.19
Se3p1	166.64	1.39
Se3p3	160.82	3.09
Co3s	101.38	2.06
Co3p1	55.31	7.69
Co3p3	55.31	3.99
Ti3s	55.16	36.81
Se3d	54.94	6.15
Ti3p	37.2	1.34
O2s	22.95	0.87
Cl3s	15.77	0.23
total		100%

Table S2. Comparison of $CoSe_2$-based anode in sodium-ion storage

electrode	Rate performance (current density, specific capacity)	Long cycles performance (current density, specific capacity, cycles)	Ref
This work	0.1 A g^{-1}, 450 mAh g^{-1}; 1 A g^{-1}, 350 mAh g^{-1}	0.3 A g^{-1},350 mAh g^{-1}, 1200 cycles 10.0 A g^{-1},200 mAh g^{-1}, 1400 cycles	
$CoSe_x$–rGO	0.2 A g^{-1},443 mAh g^{-1}; 1 A g^{-1},357 mAh g^{-1}	0.3 A g^{-1}, 420 mAh g^{-1}, 50 cycles	1
$CoSe_2$-Gc	0.1 A g^{-1},526 mAh g^{-1}; 1 A g^{-1}, 451 mAh g^{-1}	0.2 A g^{-1},399 mAh g^{-1}, 100 cycles	2
$CoSe_2$ @N-PGC/CNTs	0.2 A g^{-1}, 482 mAh g^{-1}; 5 A g^{-1}, 368 mAh g^{-1}	1 A g^{-1}, 300 mAh g^{-1}, 400 cycles	3
$CoSe_2$-(NiCo)Se_2	0.2 A g^{-1}, 554 mAh g^{-1}; 5 A g^{-1}, 456 mAh g^{-1}	1 A g^{-1},410 mAh g^{-1}, 100 cycles	4
$Co_{0.85}$ Se@rGO	0.5 A g^{-1}, 448 mAh g^{-1}; 6 A g^{-1}, 280 mAh g^{-1}	1 A g^{-1},382 mAh g^{-1}, 800 cycles	5
$CoSe_2$/N-CNFs	0.2 A g^{-1}, 323 mAh g^{-1}; 2 A g^{-1}, 299 mAh g^{-1}	2 A g^{-1},308 mAh g^{-1}, 1000 cycles	6
$CoSe_2$-$MoSe_2$/C	0.2 A g^{-1}, 483 mAh g^{-1}; 5 A g^{-1}, 317 mAh g^{-1}	0.2 A g^{-1},399 mAh g^{-1}, 100 cycles	7
$CoSe_2$	0.2 A g^{-1}, 483 mAh g^{-1}; 5 A g^{-1}, 317 mAh g^{-1}	1 A g^{-1},220 mAh g^{-1}, 1690 cycles	8
$CoSe_2$@$MoSe_2$/C	0.1 A g^{-1}, 460 mAh g^{-1}; 3 A g^{-1}, 379 mAh g^{-1}	1 A g^{-1},305 mAh g^{-1}, 200 cycles	9
$Ni_{1.8}Co_{1.2}Se_4$ @NDDC	0.1 A g^{-1}, 427 mAh g^{-1}; 50 A g^{-1}, 153 mAh g^{-1}	0.5 A g^{-1},379.3 mAh g^{-1}, 100 cycles	10
$CoMSe_2$@NC, M = Ni, Cu, Zn	0.1 A g^{-1}, 511 mAh g^{-1}; 2 A g^{-1}, 291 mAh g^{-1}	0.5 A g^{-1},474 mAh g^{-1}, 80 cycles	11
$CoSe_2$@C∩NC	0.1 A g^{-1}, 366 mAh g^{-1}; 25 A g^{-1}, 291 mAh g^{-1}	5 A g^{-1},234 mAh g^{-1}, 2000 cycles	12
$Ni_xCo_{1-x}Se_2$	0.1 A g^{-1}, 525 mAh g^{-1}; 5 A g^{-1}, 346 mAh g^{-1}	2 A g^{-1},321 mAh g^{-1}, 2000 cycles	13
CNT/$CoSe_2$@NC	0.2 A g^{-1}, 480 mAh g^{-1}; 5 A g^{-1}, 364 mAh g^{-1}	0.2 A g^{-1},404 mAh g^{-1}, 120 cycles	14

$Co0_{.85}Se$/N-HMCNs/CNTs	0.1 A g^{-1}, 361 mAh g^{-1}; 5 A g^{-1}, 132 mAh g^{-1}	1 A g^{-1},102 mAh g^{-1}, 1000 cycles	15
$CoSe_2$@NC@TiO_2	0.1 A g^{-1}, 500 mAh g^{-1}; 6.4 A g^{-1}, 300 mAh g^{-1}	0.1 A g^{-1},364 mAh g^{-1}, 200 cycles	16
$NiCoSe_4$@NC@rGO	0.1 A g^{-1}, 503 mAh g^{-1}; 10 A g^{-1}, 439 mAh g^{-1}	1 A g^{-1},293 mAh g^{-1}, 1500 cycles	17
CNT/$CoSe_2$/C	0.1 A g^{-1}, 609 mAh g^{-1}; 2.4 A g^{-1}, 224 mAh g^{-1}	0.5 A g^{-1},396 mAh g^{-1}, 300 cycles	18
$CoSe_2$@BCN	0.1 A g^{-1}, 632 mAh g^{-1}; 2 A g^{-1}, 338 mAh g^{-1}	8.0 A g^{-1},300 mAh g^{-1}, 4000 cycles	19
DCC-$CoSe_2$	0.1 A g^{-1}, 609 mAh g^{-1}; 2.4 A g^{-1}, 224 mAh g^{-1}	5 A g^{-1},430 mAh g^{-1}, 2000 cycles	20
(Ni,Co)Se_2/CNT	0.5 A g^{-1}, 444 mAh g^{-1}; 20 A g^{-1}, 163 mAh g^{-1}	3 A g^{-1},336 mAh g^{-1}, 10000 cycles	21

Table S3. Electrochemical resistances of $CoSe_2$, $CoSe_2/Ti_3C_2T_x$ -10 an $CoSe_2/Ti_3C_2T_x$ -25 fresh state, after 200th and 500th cycles

Sample	Fresh $R_s/(R_f+R_{ct})$	After 200 cycles $R_s/(R_f+R_{ct})$	After 500 cycles $R_s/(R_f+R_{ct})$
$CoSe_2$	2.4/739.6 Ω	11.3/36.5 Ω	8.9/5.9 Ω
$CoSe_2/Ti_3C_2T_x$-10	1.2/307.1 Ω	10.4/8.9 Ω	9.8/4.1 Ω
$CoSe_2/Ti_3C_2T_x$-25	1.4/472.5 Ω	9.9/12.3 Ω	9.8/5.7 Ω

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