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Supporting Information

Layered Tin Sulfide and Selenide Anode Materials for Li- and Na-ion Batteries

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Table S1. Summary of the Li-storage performance of typical SnS.

Type of materials	Current density [mA g^{-1}]	Cycle number	Cut-off voltage [V]	Specific capacity [mAh g^{-1}]	Mass loading [mg cm^{-2}]	References
SnS nanorods	150	20	0.01–2.0	422	/	[1]
SnS nanosheets	782	50	0.01–1.3	560	/	[2]
SnS nanoflowers	50	30	0.01–1.1	580	/	[3]
3D hierarchical SnS *(hollow microflowers)*	50	50	0.02–1.5	520	~2	[4]
Yolk-shell SnS	1000	150	0.001–1.0	672	/	[5]
SnS NPs@C (700 °C)	40	40	0.02–1.2	484	/	[6]
Net-like SnS/C film *(spin-coated, 650 °C)*	40	40	0.02–1.2	542	/	[7]
Porous SnS nanorods/C	50	50	0.01–2.0	696	/	[8]
Hollow yolk-shell SnS@C	100 (500)	50 (300)	0.01–2.5	936 (830)	~1.1	[9]
Flower-like SnS@C	5000	1550	0.01–3.0	530	/	[10]
SnS NPs@CNFs	200	100	0.01–2.2	530	1.34	[11]
Se-doped SnS NPs@CNFs *($SnS_{0.9}Se_{0.1}$)*	200	50/100	0.01–2.2	742/693	1.34	[11]
Porous interconnected SnS/C	1000	200/300	0.01–3.0	607/535	~0.6–0.8	[12]
SnS/rGO	500	50	0–3	575	~1.1	[13]
SnS NPs/rGO	200	70	0.01–3.0	559	~0.7	[14]
SnS NPs/rGO	50	50	0.01–3.0	535	/	[15]
SnS NPs/N-rGO	50	60	0.01–3.0	466	/	[16]
SnS nanorods/rGO	160	50	0.01–2.5	602	/	[17]
SnS nanorods /graphene	500 (100)	1000/1500 (200)	0.1–3.0	600/550 (~850)	~2.1	[18]
SnS nanosheet /graphene	100	100	0.05–1.5	560	~1.5	[19]
SnS/spherical graphene framework	100 (1000)	100 (300)	0.01–3.0	800 (527)	~1.0	[20]
Prelithiated SnS/graphene	100	100	0.01–3.0	1016	1.0	[21]
SnS/MoS_2-C	200 (2000)	60 (700)	0.01–3.0	990 (718)	/	[22]
Sandwich-like SnS/PPy	100 (1000)	50 (300)	0.01–3.0	967 (703)	1.5–2.0	[23]
SnS@PPy-nanobelt/CNTs paper	100 (1000)	100 (500)	0.01–3.0	887 (757)	/	[24]

SnS-SnSe nanocomposite	150	50	0.01–3.0	613	/	[25]

Note: The theoretical capacity of SnS (reversible) is 782 mAh g^{-1} for LIBs.[18]

Table S2. Summary of the Na-storage performance of typical SnS.

Type of materials	Current density [mA g^{-1}]	Cycle number	Cut-off voltage [V]	Specific capacity [mAh g^{-1}]	Mass loading [mg cm^{-2}]	References
SnS nanotablets	125	30	0.1–2.0	~370	/	[26]
SnS 3D flowers	150 (800)	50 (50)	0.01–2.0	275 (180)	2–3	[27]
SnS/C particles	100	50	0.01–2.0	415	~2.9	[28]
SnS@C microplates	1000	50	0.01–2.0	445	/	[29]
5nm-SnS NPs/C nanospheres	1000	200	0.01–2.9	518	/	[30]
SnS-C nanocomposite	100	80	0.01–2.0	532	~2.0	[31]
SnS@C nanotubes	200	100	0.01–3.0	440	~1.0	[32]
Porous interconnected SnS/C	1000	100/200/300	0.01–3.0	282/270/266	~0.6–0.8	[12]
Cubic-like SnS/C microspheres	500	50	0.001–2.0	433	~1.2	[33]
Sn-SnS-C	100	150	0.01–2.0	407	/	[34]
SnS NPs/CNTs	50 (500)	50 (100)	0.01–2.0	356 (210)	/	[35]
Flower-like SnS/CNTs	50	100	0.01–2.5	364	1.0±0.2	[36]
SnS nanoflakes/S-doped N-rich C NSs	1000	100	0.01–3.0	474	1.0±0.1	[37]
SnS NPs/N-doped C nanosheet networks	100 1000 (5000)	50 1000	0.01–2.5	853 484 (322) */428/331*	1.5 */2.8/4.3*	[38]
SnS/rGO	30 (810/7290)	50 (250)	0.01–3.0	940 (492/308)	1.0±0.2	[39]
SnS/rGO	100	100	0.01–2.0	386	~3	[40]
SnS/rGO	50	30	0.01–2.0	500	~2.0	[41]
SnS NPs/3D N-doped graphene	2000	1000	0.01–2.5	510	~1.1–1.3	[42]
SnS NS arrays /graphene foam	100	200	0.01–3.0	1010	~1.0	[43]
Free-standing tetrahedral SnS/MWCNTs	300	50/250	0.01–2.7/0.01–0.5	946/~500	~2.2	[44]
C-coated SnS NSs /carbon fiber paper	100 (3000)	100 (500)	0.01–2.0	792 (345)	/	[45]
SnS NPs/Mxene	500	50	0.01–3.0	~320	/	[46]

C@SnS/SnO_2 @graphene Heterostructures	30 (810/2430)	50/300 (500)	0.01–2.0	715/618 (409/360)	1.0±0.2	[47]
Yolk-shell SnS-MoS_2 mircrospheres	500/7000	100	0.001–2.5	396/238	~1.4	[48]

Note: The theoretical capacity of SnS (reversible) is 667 mAh g^{-1} for NIBs.[49]

Table S3. Summary of the Li-storage performance of typical SnS_2.

Type of materials	Current density [mA g^{-1}]	Cycle number	Cut-off voltage [V]	Specific capacity [mAh g^{-1}]	Mass loading [mg cm^{-2}]	References
SnS_2 nanoplates	323	30	0.001–1.1	583	/	[50]
SnS_2 nanoplates	100	50	0.05–1.2	332	/	[51]
SnS_2 nanoplates	100	50	0.05–1.2	521	/	[52]
SnS_2 nanoplates	200	30	0.0–3.0	935	/	[53]
SnS_2 nanosheets	323	50	0–1.15	~500	/	[54]
SnS_2 nanosheets	100	100	0.01–1.5	437	/	[55]
SnS_2 nanosheets	100	50	0.005–1.15	513	/	[56]
SnS_2 nanoplates	100/500	50/80	0.005–1.1	515/470	/	[57]
Plate-like SnS_2 *(stacked/individual)*	100	30	0.05–1.2	390/540	/	[58]
Flower-like SnS_2	100	50	0.05–1.2	387	/	[51]
Flower-like SnS_2	100	50	0.01–2.0	~458	/	[59]
Flow-like SnS_2 microspheres	80	50	0.05–2.0	475	/	[60]
SnS_2 nanoflowers	100	100	0.01–1.5	542	/	[55]
3D hierarchical SnS_2 mcirospheres	645/3225/6450	100	0.001–1.3	570/486/264	/	[61]
3D SnS_2 hierarchitectures	100	100	0.01–2.0	550	/	[62]
SnS_2 hollow microspheres	64.5	60	0.001–1.2	430	/	[63]
SnS_2 3D nanoflake-based hollow microspheres	64.5	60	0.001–1.2	532	/	[63]
SnS_2 nanoflowers /acetylene black	400	100	0.01–1.3 /0.01–2.5	456 /~700	/	[64]
SnS_2 NPs/CNTs arrays	100 (1000)	50 (100)	0.01–2.5	551 (~300)	/	[65]
SnS_2 nanosheet arrays on Sn foil	645	10	0.5–2.0	1050	/	[66]
SnS_2-SnO_2 nanorods	200	25	0.01–1.15	536	/	[67]
SnS_2 NPs@C	50	50	0.0–1.2	668	/	[68]
SnS_2 NSs@MWCNTs coaxial nanocables	100	50	0.01–1.15	~450	/	[69]
SnS_2 NSs@MWCNTs	645	100	0.2–1.3	432	0.3–0.4	[70]
SnS_2 NPs/SWCNTs	1000	100	0.01–3.0	509	/	[71]
SnS_2 nanoflakes /CNTs	100	50	0.01–1.2	373	~1.4	[72]
SnS_2 nanoflakes /MWCNTs	100	50	0.005–1.15	~510	/	[73]
SnS_2 nanoplates /graphene nanoribbons	400	800	0.01–3.0	823	~1.0	[74]
SnS_2 NPs/rGO *(nanoplates and ultrafine NCs)*	100	200	0.05–3.0	1005	/	[75]

SnS_2 NPs@rGO	120	60	0.01–3.0	564	/	[76]
SnS_2 NPs@graphene	322.5 (1290)	80	0.001–2.0	405 (304)	/	[77]
SnS_2@rGO	58.4	50	0.001–3.0	577	/	[78]
Ultrasmall SnS_2 nanocrystals@rGO	64.5/645 (645/1935/3225)	200 (450)	0.001–2.5	1034/737 (773/570/415)	/	[79]
$SnS_{x(1<x<2)}$ nanocrystal /graphene	0.2C	150	0.02–2.5	860	~0.8	[80]
SnS_2 nanotablets @graphene	0.5C	200	0.005–1.0	504	/	[81]
SnS_2 nanosheets /graphene	100	30	0.01–3.0	1114	/	[82]
Orientated SnS_2 nanoplates/graphene	50	100	0.005–3.0	704	~2	[83]
SnS_2 NSs/rGO	66/660	40	0.005–3.0	896/657	~1.5	[84]
Few-layer SnS_2/graphene	100	50	0.01–1.5	920	/	[85]
SnS_2 nanoplates /graphene	50	30	0.005–1.3	~650	~2–3	[86]
SnS_2/N-doped rGO	200	200	0.01–1.3	562	0.8–1.0	[87]
Ultrasmall SnS_2/N-doped graphene	200 (800)	120 (150)	0.01–3.0	1407 (914)	1.6±0.2	[88]
SnS_2/S-doped graphene	1000 (5000)	200 (600)	0.005–3.0	947 (532)	/	[89]
SnS_2@graphene nanocable network	200	350	0.01–3.0	720	/	[90]
SnS_2/graphene aerogels	50	30	0.01–3.0	656	/	[91]
SnS_2 NS/graphene foam	1000	50	0.01–2.0	451	~1.4–1.6	[92]
SnS_2 nanoflakes /graphene foam	1000	500	0.01–2.5	818	/	[93]
SnS_2/MoS_2/graphene foam	200	50	0.01–3.0	~800	~1.75–1.8	[94]
CC-VN@SnS_2 *(carbon cloth supported vanadium nitride/SnS_2 NS)*	650 (13000)	100 (70/650)	0.01–3.0	791 (349/231)	3.1	[95]
Flexible SnS_2 NSs /Gr-CNTs paper	100	100	0.01–3.0	1018	/	[96]
SnS_2/MoS_2/graphene	80	100	0.01–3.0	743	/	[97]
SnS_2/MoS_2/graphene	150/750	190/200	0.01–3.0	1244/772	~1.3	[98]
SnS_2@TiO_2 layer	100	50	0.01–1.2	324	/	[99]
SnS_2/TiO_2/rGO	50	200	0.05–3.0	485	~1	[100]
SnO_2@SnS_2@rGO	200 (500)	100	0.01–2.0	583 (487)	/	[101]
SnS_2/SnO_2/C heterostructures	100	300	0.05–3.0	712	0.59	[102]
SnS_2@PANi nanoplates	100	80	0.01–3.0	731	/	[103]

Note: The theoretical capacity of SnS_2 (reversible) is 645 mAh g^{-1} for LIBs.[74]

Table S4. Summary of the Na-storage performance of typical SnS_2.

Type of materials	Current density [mA g^{-1}]	Cycle number	Cut-off voltage [V]	Specific capacity [mAh g^{-1}]	Mass loading [mg cm^{-2}]	References
SnS_2 nanoplates	100	50	0.005–2.0	242/187	/	[57]
Ultrathin SnS_2 nanosheets *(3-4 nm)*	100	50	0.005–3.0	647	/	[104]
SnS_2 nanoarrays	200	200	0.01–3.0	~810	3.98	[105]
SnS_2 nanowall arrays on stainless steel	500	100	0.01–2.5	510	~0.3	[106]
SnS_2/CNTs	1000	100/200/300	0.01–2.5	625/602/556	/	[107]
SnS_2/Mxene	100	200	0.01–2.5	322	/	[108]
SnS_2/MoS_2/graphene	80	100	0.01–3.0	100	/	[97]
SnS_2/SnO_2/CNTs	50	100	0.01–2.5	355	~1.2	[109]
Flower-like SnS_2	20	10 (20)	0–3	448 (255)	/	[110]
Flower-like SnS_2/CNTs	20	10 (20)	0–3	485 (333)	/	[110]
Flower-like SnS_2/rGO	50	100	0.01–3.0	509	/	[111]
SnS_2/rGO	200 (1000)	100 (400)	0.01–2.5	628 (500)	0.8–1.0	[112]
SnS_2@rGO	200 (800)	300 (1000)	0.005–3.0	509 (300)	/	[113]
SnS_2/graphene	200	100	0.01–2.5	619	1.0–1.5	[114]
SnS_2/rGO	200	100	0.01–2.5	627	~2	[115]
SnS_2 nanoplatelet @graphene	20	60	0.01–3.0	670	~1.0	[116]
Ultrathin SnS_2/rGO	2500	150	0–3	~338	1.5	[117]
SnS_2 nanoplates/rGO	200/1000/2000	100	0.01–3.0	615/542/437	~1.6	[118]
Ultrasmall SnS_2/N-doped graphene	200	100	0.01–3.0	450	1.6±0.2	[88]
Sandwiched SnS_2 NSs/rGO	100 (200/840)	100 (200)	0.01–2.5	826 (~760/~570) *(based on SnS_2 mass only)*	1.27 (~0.8)	[119]
SnS_2/S-doped graphene	100 (2000)	85 (400)	0.01–3.0	530 (~300)	/	[89]
SnS_2/C nanospheres	50	100	0.005–2.5	570	/	[120]
SnS_2 nanosheets@C hollow structures	200	100	0.01–3.0	525/588/631	~1.0	[121]
SnS_2/EDA-rGO	200 (1000)	100 (1000)	0.01–3.0	680 (480)	1±0.15	[122]
SnS_2 nanocrystalline @rGO	50 (500)	50 (150)	0–2	~600 (450)	/	[123]
Flexible 2nm-SnS_2 nanocrystals/graphene	1000/5000	1500	0.01–3.0	334/255	0.78	[124]

nanoribbons paper						
SnS_2@graphene nanosheet arrays on carbon cloth	200 (1200)	100 (200)	0.01–1.0	548 (378)	1.93	[125]
SnS_2 NCs@N,S-doped graphene aerogels	20	50	0.01–3.0	527	0.55	[126]
SnS_2/MoS_2/graphene	150/750/1500	100/150/150	0.01–3.0	655/612/546	~1.3	[98]

Note: The theoretical capacity of SnS_2 (reversible) is 584 mAh g^{-1} for NIBs.[127]

Table S5. Summary of the Li-storage performance of typical SnSe and $SnSe_2$.

Type of materials	Current density [mA g^{-1}]	Cycle number	Cut-off voltage [V]	Specific capacity [mAh g^{-1}]	Mass loading [mg cm^{-2}]	References
SnSe nanocrystals	0.1C	1/30	0.01–2.5	~425/~180	~4	[128]
SnSe nanosheets	50	2/20	0.01–3.0	~410/73	10	[129]
Ultrathin SnSe nanoplates	200	300	0.01–3.0	788	~1	[130]
SnSe thin film	130 (10 μA cm^{-2})	40	0.01–2.5	~400	/	[131]
SnSe-SnS nanocomposite thin film	150 (3 μA cm^{-2})	50	0.01–3.0	613	/	[25]
$SnSe_{0.5}S_{0.5}$ nanoplates	100/500	100/200	0.01–3.0	1144/681	~1.0	[132]
SnSe/C nanocomposite *(carbon black)*	500	100	0.01–3.0	633	0.8–1.2	[133]
SnSe/C (Super P)	100	200	0.0–2.5	626	~3.1	[134]
$SnSe_x$-MWCNT	40	50	0.01–3.0	651	~2	[135]
SnSe@CNFs	200	100	0.01–2.5	840	/	[136]
$SnSe_{0.5}S_{0.5}$/C nanocomposite *(glucose-derived C)*	1000	500	0.01–3.0	625	~1.0	[137]
SnSe NCs/rGO	100	100	0.01–3.0	764	/	[138]
$SnSe_2$ nanodots/rGO	150	50	0.05–3.0	659	/	[139]
$SnSe_2$ quantum dots/rGO	200/2000	500/3000	0.01–3.0	746/410	/	[140]
$SnSe_2$ nanoplate/rGO	40	30	0.001–3.0	640	0.95	[141]
Flexible SnSe NCs/carbon fabric	200	80	0.01–3.0	676	2–3	[142]
Free-standing SnSe/SnO_x@CNFs membrane	200/1000	70/1000	0–3	741/345	/	[143]

Note: The theoretical capacity of SnSe and $SnSe_2$ (reversible) is 847 and 800 (426) mAh g^{-1} for LIBs.[134, 140, 141]

Table S6. Summary of the Na-storage performance of typical SnSe and $SnSe_2$.

Type of materials	Current density [mA g^{-1}]	Cycle number	Cut-off voltage [V]	Specific capacity [mAh g^{-1}]	Mass loading [mg cm^{-2}]	References
SnSe nanoplates	300	50	0.001–3.0	558	~0.2	[144]
Ultrathin SnSe nanoplates (2D ladder-like cluster)	50	300	0.01–3.0	393	~1	[130]
3D SnSe nanosheet clusters	25 (200/2000/5000)	30 (100)	0.0–3.0	730 (271/183/70)	~0.8	[145]
$SnSe_x$ flowerlike composite ($SnSe/SnSe_2$)	200	50	0.01–3.0	272	/	[146]
SnSe/C *(Super P)*	143	50	0.0–2.0	707	~1–2	[147]
SnSe/C nanocomposite *(carbon black)*	500	200	0.01–2.0	325	0.8–1.2	[133]
$SnSe_{0.5}S_{0.5}$/C nanocomposite *(glucose-derived C)*	200	100	0.01–3.0	430	~1.0	[137]
SnSe/rGO	100/1000	50/115	0.01–2.0	570/385	1±0.1	[148]
$SnSe_2$ NSs/rGO nanocomposite	100	100	0.005–2.5	515	~1.2	[149]

Note: The theoretical capacity of SnSe and $SnSe_2$ is 780 and 756 mAh g^{-1} for NIBs.[145, 147, 149]

Table S7. Summary of the Li-storage performance of typical SnTe.

Type of materials	Current density [mA g^{-1}]	Cycle number	Cut-off voltage [V]	Specific capacity [mAh g^{-1}]	Mass loading [mg cm^{-2}]	References
SnTe/C nanocomposite	100	100	0.0–2.5	647 (1308 mAh cm^{-3})	4.43	[150]
SnTe-TiC-C composite	100	100/400	0.0–2.5	398/~408 (652 mAh cm^{-3})	1.3–1.7	[151]
SnTe-rGO composite	100	100	0.05-2.5	690 (3015 mAh cm^{-3})	~1.5	[152]

Note: The theoretical capacity of SnTe is 680 (696) mAh g^{-1} for LIBs.[150, 152]

Table S8. Summary of the Na-storage performance of typical SnTe.

Type of materials	Current density [mA g^{-1}]	Cycle number	Cut-off voltage [V]	Specific capacity [mAh g^{-1}]	Mass loading [mg cm^{-2}]	References
SnTe/C nanocomposite	100	100	0.0–2.5	647 (1308 mAh cm^{-3})	4.43	[150]
SnTe-rGO composite	100	100	0.05–2.5	288 (1260 mAh cm^{-3})	~1.5	[152]

Note: The theoretical capacity of SnTe is 626 mAh g^{-1} for NIBs.[150]

Abbreviations

NPs: Nanoparticles

NRs: Nanorods

Nanowires: NWs

NSs: Nanosheets

NCs: Nanocrystals

CNTs: Carbon nanotubes

SWCNTs: Single-walled carbon nanotubes

MWCNTs: Multi-walled carbon nanotubes

Gr: Graphene

rGO: Reduced graphene oxide

N-rGO: N-doped rGO

N-Gr: N-doped graphene

GF: Graphene foam

CNFs: Carbon nanofibers

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