Supplementary Information

Revitalising Sodium-Sulfur Batteries for Non-High-Temperature Operation: A Crucial Review

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Table S1. General characteristics of different Na-S battery systems.

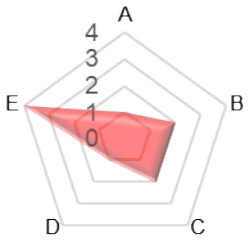
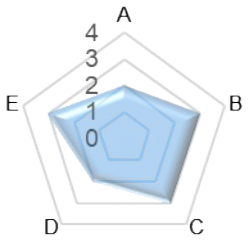
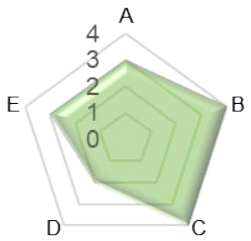
Battery system	**Working temperature**	**Battery configuration**	**Comparison on safety (A), energy density (B), low-cost advantage (C), voltage (D), and lifespan (E). (Number 4 represent the best, while number 0 represents the worst).**
HT Na-S battery	300~350 °C	Tubular cell Planar cell	
IMT Na-S battery	120~300 °C	Tubular cell Planar cell	
RT Na-S battery	Ambient temperature	Coin cell Pouch cell	

Table S2. Performances of typical solid-state and quasi-solid-state electrolytes for RT Na-S batteries.

State	Electrolyte material	Plasticiser	Cathode active material	Anode	Cycle number	Current density	Voltage range (V)	Specific capacity after cycling (mAh g^{-1}), based on the mass of.	Ref.
Solid	Na_3PS_4	-	Na_2S-Na_3PS_4-CMK-3	Na-Sn-C	50	50 mA g^{-1}	0.5~3	650, Na_2S	[S1]
Solid	Na_3PS_4	-	Na_3PS_4-nanosized Na_2S-carbon	Na-Sn-C	50	50 mA g^{-1}	0.5~3	438.4, Na_2S	[S2]
Solid	Na_3SbS_4	-	Sulfur-Na_3SbS_4-carbon	Na metal	100	1000 mA g^{-1}	1~2.8	468.1, sulfur	[S3]
Solid	Na-β″-Al_2O_3	-	Na_2S_8	Na-BP-TEGDME	3500	1100 mA g^{-1}	1.8~2.5	≈150, Na_2S_8	[S4]
Solid	Na-β″-Al_2O_3	-	Sulfur@carbon	Na metal	104	1/64 C	1~3	521, sulfur	[S5]
Solid	PIN-coated $Na_3Zr_2Si_2PO_{12}$	-	Sulfur@carbon	Na metal	100	0.2 C	1.2~2.8	≈550, sulfur	[S6]
Solid	PEO-NaFSI-1% TiO_2	-	S-pPAN	Na metal	100	100 mA g^{-1}	0.8~2.8	251, S-pPAN	[S7]
Quasi-solid	PETEA-THEICTA	1 M NaTFSI in PC: FEC	Poly(S-PETEA)@carbon	Na metal	100	0.1 C	0.5~2.8	736, sulfur	[S8]
Quasi-solid	PVDF-HFP	0.5 M $NaCF_3SO_3$ in EMITf	Sulfur	Na-Hg	10	-	-	≈150, sulfur	[S9]

Abbreviations in this table: BP: biphenyl; TEGDME: tetraethylene glycol dimethyl ether; PIN: polymer with intrinsic nanoporosity; PEO: poly(ethylene oxide); S-pPAN: sulfurised-pyrolysed polyacrylonitrile; PETEA: pentaerythritoltetraacrylate; THEICTA: tris[2-(acryloyloxy)ethyl] isocyanurate; PC: propylene carbonate; FEC: Fluoroethylene carbonate; PVDF-HFP: poly(vinylidinefluorideco-hexafluoropropyline); EMITf: 1-ethyl 3-methyl imidazolium trifluoro-methane sulfonate.

References

[S1] X. Fan, J. Yue, F. Han, J. Chen, T. Deng, X. Zhou, S. Hou and C. Wang, *ACS Nano*, 2018, **12**, 3360-3368.

[S2] J. Yue, F. Han, X. Fan, X. Zhu, Z. Ma, J. Yang and C. Wang, *ACS Nano*, 2017, **11**, 4885-4891.

[S3] H. Wan, W. Weng, F. Han, L. Cai, C. Wang and X. Yao, *Nano Today*, 2020, **33**, 100860.

[S4] J. Yu, Y.-S. Hu, F. Pan, Z. Zhang, Q. Wang, H. Li, X. Huang and L. Chen, *Nat. Commun.*, 2017, **8**, 14629.

[S5] I. Kim, J.-Y. Park, C. H. Kim, J.-W. Park, J.-P. Ahn, J.-H. Ahn, K.-W. Kim and H.-J. Ahn, *J. Power Sources*, 2016, **301**, 332-337.

[S6] X. Yu and A. Manthiram, *Matter*, 2019, **1**, 439-451.

[S7] T. Zhu, X. Dong, Y. Liu, Y.-G. Wang, C. Wang and Y.-Y. Xia, *ACS Appl. Energy Mater.*, 2019, **2**, 5263-5271.

[S8] D. Zhou, Y. Chen, B. Li, H. Fan, F. Cheng, D. Shanmukaraj, T. Rojo, M. Armand and G. Wang, *Angew. Chem., Int. Edit.*, 2018, **57**, 10168-10172.

[S9] D. Kumar and D.K. Kanchan, *J. Energy Storage*, 2019, **22**, 44-49.