Electronic Supplementary Information

Synergy of phase and interface engineering of manganese difluoride enable high-efficiency potassium-ion batteries

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Experimental Section

Materials. Manganese (II) acetylacetonate ($Mn(acac)_2$), manganese (III) acetylacetonate ($Mn(acac)_3$), manganese acetate tetrahydrate ($Mn(Ac)_2 \cdot 4H_2O$), NH_4F , *N*,*N*-dimethylformamide (DMF), polyvinylidene fluoride (PVDF, $M_w = 534,000$), and polyacrylonitrile (PAN, $M_w = 150,000$) were all purchased from Aladdin. All chemicals were analytical grade reagents and used without further purification.

Synthesis of rutile-MnF₂@carbon nanofibers (R-MnF₂@CNFs). 3 mmol of Mn(acac)₃ and 1 g of PVDF were dissolved in 10 mL of DMF and stirred vigorously at 50 °C for 6 h. The obtained solution was drawn into a 10 mL syringe fitted with a 20-gauge blunt-tip needle and used as the precursor fluid for electrospinning. Then, a direct-current power supply was employed to provide a voltage of 20 kV between the Al foil and the needle tip, with the distance adjusted to 15 cm. The flow rate was controlled at 0.5 mL h⁻¹ by a syringe pump. Subsequently, the resulting membranes were heated in an electric oven at 150 °C for 2 h and carbonized in a tube furnace at 450 °C for 2 h under an argon environment at a heating rate of 10 °C min⁻¹ to obtain R-MnF₂@CNFs.

Synthesis of fluorite-MnF₂@CNFs (F-MnF₂@CNFs). 3 mmol of Mn(acac)₂ and 1 g of PVDF were dissolved in 10 mL of DMF and stirred vigorously at 50 °C for 6 h to obtain the precursor solution. The electrospinning and pyrolysis processes are the same as those for R-MnF₂@CNFs, except that the carbonization temperature is 550 °C.

Synthesis of MnO@CNFs. 5 mmol of Mn(acac)₃ and 1 g of PAN were dissolved in 10 mL of DMF and stirred vigorously at 50 °C for 6 h to obtain the precursor solution. The subsequent electrospinning and pyrolysis processes are the same as those for R-MnF₂@CNFs.

Synthesis of bulk R-MnF₂. Solution A: 6 mmol of $Mn(Ac)_2 \cdot 4H_2O$ was dissolved in 25 mL of water and ethanol (volume ratio 1:1). Solution B: 18 mmol of NH₄F was dissolved in 10 mL of deionized water. Solution B was added dropwise to solution A with continuous stirring for 30 min, and then aged at 40 °C for 12 h. The resultant white product was harvested by centrifugation, washed once with ethanol in the wake of three times with deionized water, and then vacuum dried at 60 °C overnight to obtain NH₄MnF₃. Finally, bulk R-MnF₂ was obtained by annealing NH₄MnF₃ at 450 °C for 2 h under an argon atmosphere.

Material Characterization. The crystal structure was studied by X-ray diffraction (XRD; Rigaku, SmartLab). Scans were conducted over the range of 20-80° with a 20 step size of 0.01°. The Rietveld method was used to refine the dataset using the GSAS package combined with the EXPGUI interface.¹ Thermogravimetric (TG) analysis was performed on a NETZSCH STA 449 F3 thermogravimetric analyzer under an air or argon atmosphere at a heating rate of 10 °C min⁻¹. Raman spectra were recorded using a HORIBA LabRAM HR Evolution instrument with a 532 nm laser as the excitation source. Elemental information and valence were obtained by X-ray photoelectron spectroscopy (XPS, ESCALAB Xi⁺ electron spectrometer). The morphology and microstructure were observed using a scanning electron microscope (SEM, JSM-7600F) and a transmission electron microscope (TEM, FEI Talos F200X). Elemental mapping and energydispersive X-ray spectroscopy (EDX) spectra were acquired on the FEI Talos F200X field-emission transmission electron microscope, equipped with a high-brightness field emission gun (X-FEG) and a Super-X G2 EDX detector. The specific surface area and pore size distribution were evaluated by N₂ adsorption/desorption (ASAP 3020). In situ XRD patterns were collected using an X'Pert Pro MPD X-ray diffractometer (D8 Bruker Advance, Germany) equipped with Cu K α radiation (λ = 1.5406 Å) at 40 kV and 40 mA. Cryogenic transmission electron microscopy (cryo-TEM) images were obtained using a JEOL JEM F200 microscope at cryogenic temperatures (~100 K) and 200 kV. The active material was first scraped from the cycled R-MnF₂@CNFs or MnO@CNFs electrode in an Ar-filled glovebox and ultrasonically dispersed in dimethyl carbonate. It was then deposited onto the lacey carbon TEM grid. The TEM grid was subsequently transferred into a cryogenic vacuum transfer holder (Fischione 2550), which is equipped with sealed shutters to ensure a completely argon environment, preventing the samples from contacting with air. The holder was finally inserted into the TEM chamber, and liquid nitrogen was added to the holder's Dewar flask to cool the internal temperature to approximately 100 K.

Electrochemical Measurements. The electrochemical performance of half-cells was tested using CR2032 coin cells. The anode was prepared by mixing the active material (R-MnF₂@CNFs, F-MnF₂@CNFs, or MnO@CNFs; 80 wt%), Super-P carbon black (10 wt%), and carboxymethyl cellulose binder (10 wt%) in deionized water to form a homogeneous slurry, which was then coated onto Cu foil and dried in a vacuum oven at 80 °C for 12 h. The typical loading mass of the active

material is approximately 2.5 mg cm⁻². The electrolyte was 3 M potassium bis(fluorosulfonyl) imide (KFSI) in 1,2-dimethoxyethane (DME). All batteries were assembled in an argon-filled glovebox (MBRAUN) with water and oxygen levels less than 0.1 ppm. Galvanostatic charge/discharge tests were carried out on a Land CT2001A battery test system. All the specific capacities were calculated based on the total mass of active material. Cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and galvanostatic intermittent titration technique (GITT) examinations were performed on a PARSTAT 4000 electrochemical workstation. The EIS investigation was conducted in the frequency range of 100 kHz to 0.01 Hz. The GITT test used a pulse current of 0.05 A g^{-1} for 10 min with a relaxation time of 20 min to evaluate the diffusion coefficient of K⁺. The potassium diffusion coefficient ($D_{\rm K}^+$) can be calculated based on the simplified Fick's second law:²

$$D_{\mathrm{K}^{+}} = \frac{4}{\pi\tau} \left(\frac{m_{\mathrm{B}} V_{\mathrm{M}}}{M_{\mathrm{B}} S} \right)^{2} \left(\frac{\Delta E_{\mathrm{s}}}{\Delta E_{\mathrm{t}}} \right)^{2} \quad \left(\tau << L^{2} / D_{\mathrm{K}^{+}} \right) \tag{1}$$

where τ stands for the duration time of current pulse; $m_{\rm B}$, $V_{\rm M}$, and $M_{\rm B}$ are the mass, molar volume, and molar mass of the electrode materials, respectively; *S* is the area of the electrode/electrolyte interface; $\Delta E_{\rm s}$ and $\Delta E_{\rm t}$ refer to the potential difference between adjacent steady states and the potential variation during the constant current pulse in a single GITT period, respectively.

То construct potassium-ion full batteries, potassium iron hexacyanoferrate (K_{1.92}Fe[Fe(CN)₆]_{0.94}·0.5H₂O, denoted as KFeHCF) and carbon coated KVPO₄F (KVPF/C) were selected as the cathode materials, as reported in our previous studies.^{3,4} The loading mass of the active materials for KFeHCF and KVPF/C were approximately 3.5 and 4.5 mg cm⁻², respectively. The electrodes were cut into a rectangular shape of 6 cm \times 4 cm, corresponding to an absolute capacity of about 10 mAh for each pouch cell. Before assembling the full cells, the R-MnF₂@CNFs electrodes were pre-cycled between 0.01 and 3.0 V in half-cells to eliminate the irreversible capacities in the initial cycles. For KFeHCF||R-MnF2@CNFs, the electrolyte was 1 M KPF6 dissolved in DME; for KVPF/C||R-MnF₂@CNFs, the electrolyte was 1 M KPF₆ dissolved in a 1:1 volume ratio mixture of ethylene carbonate and propylene carbonate (PC). The electrolyte injection volume for each pouch cell was 200 µL. The voltage window was set to 1.0-4.2 V for the KFeHCF||R-MnF2@CNFs full cell and 1.5-4.9 V for the KVPF/C||R-MnF2@CNFs full cell. To achieve optimal energy density and power density of the full battery, the capacity ratio of the cathode to anode is around 0.90. The performance of full batteries was tested in pouch cells. Note that the capacity of the full cell is calculated based on the mass of the cathode material, while the energy density of the full cell is computed based on the total mass of both the cathode and anode materials.

Theoretical Calculations. First-principles simulation calculations for R-MnF₂ and F-MnF₂ were performed using the Vienna Ab initio Simulation Package (VASP) and the projector-augmented wave (PAW) method. The electron exchange-correlation interaction effect was described using the generalized gradient approximation (GGA) and the Perdew–Burke–Ernzerhof (PBE) exchange-correlation function.⁵ The kinetic energy cutoff for the plane wave basis set was set to 500 eV to optimize the model structure. The electron energy convergence condition was set to be smaller than 10^{-6} eV, with a force relaxation of 0.02 eV Å⁻¹ applied. During geometry optimization, all atomic positions were allowed to relax. When calculating the density of states, the effective U_{eff} value ($U_{eff} = U - J$) for the *d* orbitals of Mn atoms was determined to be 3.5 eV.

The formation energy of $R-MnF_2$ and $F-MnF_2$ bulks was calculated using the following equation:

$$E_{\text{formation}} = E_{\text{MnF}_2} - E_{\text{Mn}} - 2E_{\text{F}}$$
(2)

where $E_{\text{formation}}$ represents the bulk energy of R-MnF₂ and F-MnF₂ and E_{Mn} and E_{F} indicate the energy of a free single Mn and F atom in a 10 × 10 × 10 cell, respectively.



Fig. S1 SEM images of Mn(acac)₃/PVDF electrospun nanofibers without carbonization.



Fig. S2 Rietveld refinement on XRD patterns of (a) R-MnF₂@CNFs and (b) F-MnF₂@CNFs.



Fig. S3 (a) TG curve of PVDF in flowing Ar. (b) XRD patterns of the samples after annealing temperature exchange for R-MnF₂@CNFs and F-MnF₂@CNFs.



Fig. S4 Crystal structure of (a) rutile-type and (b) fluorite-type MnF_2 .



Fig. S5 (a) XPS survey scans and (b) high-resolution F 1s XPS spectra of R-MnF₂@CNFs and F-MnF₂@CNFs.



Fig. S6 (a) XRD patterns of the R-MnF₂@CNFs after annealing at 500 °C in air. (b) TG curves of R-MnF₂@CNFs and F-MnF₂@CNFs measured in air.

It is worth noting that the XRD patterns of $R-MnF_2@CNFs$ and $F-MnF_2@CNFs$ after annealing at 500 °C in air are identical. Therefore, we only present the XRD pattern of $R-MnF_2@CNFs$ annealed in air in Fig. S6a. Additionally, based on the TG results in Fig. 6b and the following formula:

$$MnF_{2} \text{ (wt\%)} = \frac{3 \times \text{molecular weight of } MnF_{2}}{\text{molecular weight of } Mn_{3}O_{4}} \times \frac{\text{weight of } Mn_{3}O_{4}}{\text{weight of } MnF_{2}@CNFs} \times 100\%$$
(3)

we calculated that the content of R-MnF₂ in R-MnF₂@CNFs is 65.2 wt% and the content of F-MnF₂ in F-MnF₂@CNFs is 64.6 wt%.



Fig. S7 (a, b) SEM images, (c, d) TEM images, and (e) elemental mapping images of F- $MnF_2@CNFs$.



Fig. S8 EDX spectra of (a) $R-MnF_2@CNFs$ and (b) $F-MnF_2@CNFs$.



Fig. S9 (a) N_2 adsorption/desorption isotherms and (b) the corresponding pore size distribution of R-MnF₂@CNFs and F-MnF₂@CNFs.



Fig. S10 (a, b) SEM images and (c, d) TEM images of $R-MnF_2@CNFs$ synthesized with a higher dosage of 4 mmol $Mn(acac)_3$.



Fig. S11 (a, b) SEM images, (c) TEM image, and (d) XRD pattern of MnO@CNFs.



Fig. S12 (a) SEM image and (b) XRD pattern of bulk R-MnF₂.



Fig. S13 Initial three charge/discharge curves of (a) R-MnF₂@CNFs, (b) F-MnF₂@CNFs, (c) MnO@CNFs, and (d) bulk R-MnF₂ at 0.1 A g^{-1} .



Fig. S14 (a) Initial three charge–discharge profiles at 0.1 A g^{-1} of CNFs obtained from R-MnF₂@CNFs treated with 1 M HCl and (b) Super-P carbon black. Inset in (a): TEM image of CNFs.

As shown in Fig. S6, the CNFs content in R-MnF₂@CNFs is 34.8%. To clarify the intrinsic contribution of R-MnF₂, we calculated the contributions of all components: (1) the contribution of CNFs is 136.5 mAh $g^{-1} \times 34.8\% = 47.5$ mAh g^{-1} ; (2) Super-P (accounting for 10 wt% in the electrode) contributes 150.1 mAh $g^{-1} \times (10\%/80\%) = 18.8$ mAh g^{-1} relative to the active material. After subtracting these contributions, the capacity of R-MnF₂ is calculated as (407.4 - 47.5 - 18.8)/0.652 \approx 523 mAh g^{-1} , which is very close to its theoretical capacity 577 mAh g^{-1} .



Fig. S15 In situ XRD patterns gathered during the first discharge/charge of R-MnF₂@CNFs at 100 mA g^{-1} and a voltage range of 0.01–3.0 V. Note that Al/SS means aluminum or stainless steel.



Fig. S16 Schematic illustration of the conversion reaction of MnF_2 during discharge/charge.



Fig. S17 (a) *Ex situ* XRD patterns of F-MnF₂@CNFs collected during the first discharge/charge process. (b) TEM image, (c) selected area electron diffraction (SAED) pattern, and (d) high-resolution TEM (HRTEM) image of the F-MnF₂@CNFs electrode after the first cycle.

As shown in Fig. S17a, the diffraction peaks of F-MnF₂ weaken during discharge, while new diffraction peaks corresponding to R-MnF₂ appear during charge. This indicates that Mn and KF are more likely to transform into R-MnF₂ rather than F-MnF₂ due to the lower formation energy of the rutile phase (Fig. 1e). Furthermore, to gain a deeper understanding of this phenomenon, the TEM image, SAED pattern, and HRTEM image of F-MnF₂@CNFs after the initial cycle were analyzed, as illustrated in Fig. S17b–d. The SAED pattern shows polycrystalline diffraction rings corresponding to both R-MnF₂ and F-MnF₂, indicating the coexistence of these two phases within

the CNFs (Fig. 17c). The HRTEM image reveals that $F-MnF_2$ nanoparticles with a particle size of 5–20 nm are aggregated in the inner region, while R-MnF₂ nanoparticles with a particle size of 2–3 nm are distributed in the outer region (Fig. S17d). Therefore, during cycling, part of the F-MnF₂ can transform into R-MnF₂, whereas the remaining aggregated portion is electrochemically inactive, consistent with its lower capacity.



Fig. S18 (a, b) TEM images, (c) SAED pattern, and (d) elemental mappings of the R-MnF₂@CNFs electrode material after cycling.



Fig. S19 (a) Cryo-TEM image and (b) cryo-scanning TEM dark field image with the concerned elemental mappings of R-MnF₂@CNFs cycled in 0.1 M KClO₄/PC electrolyte.



Fig. S20 Characterization of KFeHCF: (a) SEM image and (b) XRD pattern.



Fig. S21 Electrochemical characterization of KFeHCF: (a) charge/discharge profiles at 20 mA g^{-1} in the voltage range of 2.0–4.3 V and (b) cycling performance at 100 mA g^{-1} .



Fig. S22 Characterization of KVPF/C: (a) SEM image and (b) XRD pattern.



Fig. S23 Electrochemical characterization of KVPF/C: (a) charge/discharge curves at 50 mA g^{-1} in the voltage window of 2.5–5.0 V and (b) cycling property at 100 mA g^{-1} .



Fig. S24 Digital image of a KFeHCF||R-MnF₂@CNFs pouch cell.



Fig. S25 Galvanostatic charge/discharge profiles of (a) $KFeHCF||R-MnF_2@CNFs$ and (b) $KVPF/C||R-MnF_2@CNFs$ full cells at varied current rates.

Substance	$\Delta_{\rm f} G_{\rm m} ({\rm kJ}{\cdot}{ m mol}^{-1})$
MnF ₂	-749
MnO	-362.9
Mn	0
KF	-537.8
K_2O	-322.1
K	0
LiF	-587.7
Li ₂ O	-561.2
Li	0

Table S1. Standard molar Gibbs free energy of formation.⁶

Reaction	$\Delta_{\rm r}G_{\rm m}({\rm kJ}{\rm \cdot mol}^{-1})$	Voltage (V vs. A ⁺ /A)*
$MnF_2 + 2K \leftrightarrow 2KF + Mn$	-326.6	1.692
$MnO + 2K \leftrightarrow K_2O + Mn$	40.8	-0.211
$MnF_2 + 2Li \leftrightarrow 2LiF + Mn$	-426.4	2.210
$MnO + 2Li \leftrightarrow Li_2O + Mn$	-198.3	1.028

Table S2. Standard molar Gibbs free energy and calculated voltage of the conversion reaction.

*The voltage was calculated based on $\Delta_r G_m = -nFE$, where *n* is the number of transferred electron (*n*=2), *F* is the Faraday constant (96485 C mol⁻¹), and *E* is the voltage of cell.

Sample	R-MnF ₂ @CNFs	F-MnF ₂ @CNFs	
Space group	P4 ₂ /mnm	$P4^2m$	
<i>a</i> , Å	4.874(6)	5.124(5)	
<i>c</i> , Å	3.310(5)	5.251(7)	
V, Å ³	78.63(9)	137.87(8)	
Z	2	4	
χ^2	1.02	1.61	
R _{wp} , R _p	8.5%, 5.8%	8.8%, 5.9%	
	X-ray, Cu Kα		
Radiation	$\lambda_1 = 1.54051 \text{ Å}, \lambda_2$	= 1.54433 Å	
2θ range, step, deg.	20–80, 0	.01	

Table S3. Crystallographic data and parameters of the Rietveld refinement for R-MnF₂@CNFs and F-MnF₂@CNFs.

Atom	Position	Occupancy	Х	У	Z
Mn	2a	1	0.3048	0.3048	0
F	4f	1	0	0	0

 $\label{eq:stable} \textbf{Table S4.} Fractional atomic coordinates and atomic displacement parameters for R-MnF_2@CNFs.$

Atom	Position	Occupancy	Х	у	Z
Mn1	1a	1	0	0	0
Mn2	1d	1	0.5	0.5	0
Mn3	2f	1	0.5	0	0.5
F1	4n	1	0.25	0.25	0.25
F2	4n	1	0.25	0.25	0.75

 Table S5. Fractional atomic coordinates and atomic displacement parameters for F-MnF2@CNFs.

	R-MnF ₂	F-MnF ₂
Mn	-5.15466	-5.15466
F	-0.43585	-0.43585
$E_{\rm MnF2}$	-34.0132	-64.6643
$E_{\rm f}$ per unit cell	-21.9605	-40.5588
$E_{\rm f}$ per formula	-10.9803	-10.1397

Table S6. Calculated formation energy ($E_{\rm f}/{\rm eV}$) for R-MnF₂ and F-MnF₂.

Anode material	Reversible capacity $(mAh g^{-1}/A g^{-1})$	Cycles/capacity/current density (mAh g ⁻¹ /A g ⁻¹)	Rate capability (mAh g ⁻¹ /A g ⁻¹)	Reference
O-Sb-N SA@NC	638/0.05	1000/194.5/2	166/4	[7]
nano-BiOBr/rGO	320/0.125	1000/255.6/2.5	278/5	[8]
Sn-SCs@MCNF	459/0.05	5000/165/2	125/5	[9]
I-P@BPC	622/0.1	1200/358/1	200/10	[10]
TQBQ-COF	423/0.3	2000/147/3	185/3	[11]
MoSe ₂ -on-NC	393/0.2	4800/247/1	171/5	[12]
FCNC-500	439.3/0.02	200/200/0.5	202.3/1	[13]
H–NiSe/SnSe@NC	462.5/0.1	1000/226.3/2	298.9/2	[14]
CoSe ₂ –FeSe ₂ @C	401.1/0.1	300/271.4/2	275/2	[15]
Hard carbon	250/0.025	Not reported	160/0.5	[16]
Graphite	275/0.1	2400/233/0.1	Not reported	[17]
on-CZL	421/0.1	10000/184/5	250/5	[18]
СМРТО	132.9/0.1	7000/54.2/0.5	55/2	[19]
$Ti_2Nb_2O_9$	205/0.05	10000/155/1	133/8	[20]
R-MnF ₂ @CNFs	407.4/0.1	5000/279.8/1	252.1/5	This work

Table S7. Comparison of electrochemical performance of the R-MnF₂@CNF electrode with previously reported potassium-ion battery anodes.

O–Sb–N SA@NC: $O_2Sb_1N_4$ in nitrogen-doped micropore carbon nanosheets; Sn-SCs@MCNF: Sn subnanoclusters encapsulated in nitrogen-doped multichannel carbon matrix; I-P@BPC: P/C composites with I₂ catalyst; TQBQ-COF: triquinoxalinylene and benzoquinone covalent organic framework; MoSe₂-on-NC: twodimensional (2D) MoSe₂ on 2D nitrogen-doped carbon; FCNC-500: F-doped carbon-skeleton@NiS₂@carbon with fluorination temperature of 500 °C; H–NiSe/SnSe@NC: hollow NiSe/SnSe nanocubes within nitrogen-doped carbon nanofibers; *on*-CZL: zinc-assisted lignin-derived O,N co-doped carbon; CMPTO: Mo-doped and carboncoated lead titanate.

	Composition	Volume per formula (Å ³)	Volume change*
	R-MnF ₂	39.32	221%
Sample	F-MnF ₂	34.47	252%
	MnO	21.91	352%
	KF	38.15	/
Conversion product	Mn	10.53	/
	K ₂ O	66.65	/
he Volume variation	as of MnE2 and MnO	were calculated based on $\frac{2V_{KF}}{2}$	$-V_{Mn}$ and $V_{K_2O} + V_{Mn}$

Table S8. Volume change of R-MnF $_2$, F-MnF $_2$, and MnO before and after potassiation.

The Volume variations of MnF₂ and MnO were calculated based on $\frac{2V_{\text{KF}} + V_{\text{Mn}}}{V_{\text{MnF}_2}}$ and $\frac{K_2 O - Mn}{V_{\text{MnO}}}$,

respectively.

Full cell	Working voltage (V)	Energy density (Wh kg ⁻¹)*	Cycling stability (retention/cycles/ A g ⁻¹)	Rate capability (retention/A g ⁻¹)	Reference
KFeHCF O–Sb–N SA@NC	~2.4	45.3	81.0%/1200/5	38.7%/5	[7]
PTCDA I-P@BPC	~1.5	142.7	69.5%/300/1	41.7%/10	[10]
KFeHCF H– NiSe/SnSe@NC	~1.8	84.0	68.9%/1200/1	51.5%/1	[14]
K ₂ PTCDA Hard Carbon	~1.6	115.7	Not reported	49.4%/2.5	[16]
KFeHCF CNS-1000	~2.75	166.6	85.7%/140/0.1	Not reported	[17]
KFeHCF on-CZL	~2.5	129.4	63.7%/4000/1	20.9%/5	[18]
PTCDA BiSb-HTR	~1.8	198.2	41.7%/100/1	23.4%/10	[21]
PTCDA@450 SC-Fe _{1-x} S	~1.25	145.6	74.8%/100/0.1	Not reported	[22]
PTCDA@450 TpPa- COF@CNT nanocables	~1.7	110.2	91.4%/500/0.5	39.8%/1	[23]
$KV_{0.95}Cr_{0.05}PO_4F \ graphite$	3.49	155.1	83.7%/500/0.0655	68.5%/2.62	[24]
KVPF G@PSC	3.46	247.0	67%/200/0.1	35.7%/1	[25]
KFeHCF R-MnF ₂ @CNFs	2.58	243.0	75.0%/500/0.1	54.6%/1	This work
KVPF/C R-MnF2@CNFs	3.27	250.1	78.3%/2000/0.5	78.6%/1	This work

Table S9. Electrochemical performance comparison of the KFeHCF||R-MnF2@CNFs andKVPF/C||R-MnF2@CNFs full cells with previously reported potassium-ion full cells.

*Note that the energy density is calculated based on the total mass of cathode and anode materials. PTCDA: perylene-3,4,9,10-tetracarboxylic dianhydride; K₂PTCDA: pre-potassiated PTCDA; BiSb-HTR: BiSb fabricated by a high-temperature radiation method; SC-Fe_{1-x}S: skin-inspired carbon-coated Fe_{1-x}S; PTCDA@450: PTCDA heat-treated at 450 °C; TpPa-COF: 2,4,6-triformylphloroglucinol (TP) and p-phenylenediamine (PA) covalent organic framework.

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