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Supporting Information

Layered Sodium Vanadate (NaV_8O_{20}) nanobelts: A New High-Performing Pseudocapacitive Material for Sodium-Ion Storage Applications

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S1. (a) Chemicals and Reagents

Vanadium pentoxide (V_2O_5), sodium sulfate (Na_2SO_4), sodium perchlorate ($NaClO_4$), polyvinylidene difluoride (PVDF), and activated carbon (AC) were procured from Sigma-Aldrich, India; N-Methyl-2-Pyrrolidone (NMP) was obtained from HPLC, India. All the solutions were prepared in double distilled water (DDW). The torey carbon fibre substrate was purchased from Global Nanotech, Mumbai.

S1. (b) Formulae to calculate the C_{sp} of working electrode and ASC device

The C_{sp} values of the SC working electrodes and SC device from the CV and GCD measurements were calculated using the following equations:

From the CV measurements:

$$C_{sp} = \frac{\int IV\, dV}{m \times \vartheta \times \Delta V} \qquad \text{(E1)}$$

Where, *I* is the current density (A), m is the active mass (g) on the electrode, ϑ is the applied scan rate (V), and ΔV is the voltage window during CV measurements.

From the GCD measurements:

$$C_{sp} = \frac{I \times \Delta t}{m \times \Delta V} \qquad \text{(E2)}$$

Where, *I* is the current density (A), Δt is the discharging time (s), m is the active mass (g) on the electrode, and ΔV is the voltage window during GCD measurements.

S1. (c) Characterization Techniques

The V_2O_5 and Na–V_8O_{20} samples were characterized using the following characterization techniques. The X-ray diffraction (XRD) studies were carried out with the help of CuK_α X-ray radiations $(\lambda_\alpha = 1.5405\ \text{Å})$ using Bruker D8 advanced X-ray diffractometer. X-ray photoelectron spectroscopy (XPS) measurements were performed with Al Kα X-ray, on the PHI Versaprobe III instrument. All binding energies in XPS spectra were calibrated to C1s peak at 284.5 eV arising from adventitious carbon. The morphology of samples was studied using field emission scanning electron microscopy (FESEM), recorded on JEOL- JSM-6360A. JEOL JEM – 2200 FS (field electron emission gun), high-resolution transmission electron microscope (HRTEM), Japan, was used for detailed structural and morphological studies.

S2. XPS studies

XPS characterization was conducted to examine the oxidation states and surface chemical composition of Na, V, and O elements in the NaV_8O_{20} sample. The XPS survey spectrum of the NaV_8O_{20} sample, presented in **Fig. S1a**, confirms the presence of Na, C, V, and O elements. Prior to detailed analysis, the binding energies were calibrated using the C 1s peak **(Fig. S1b)** at 284.5 eV.

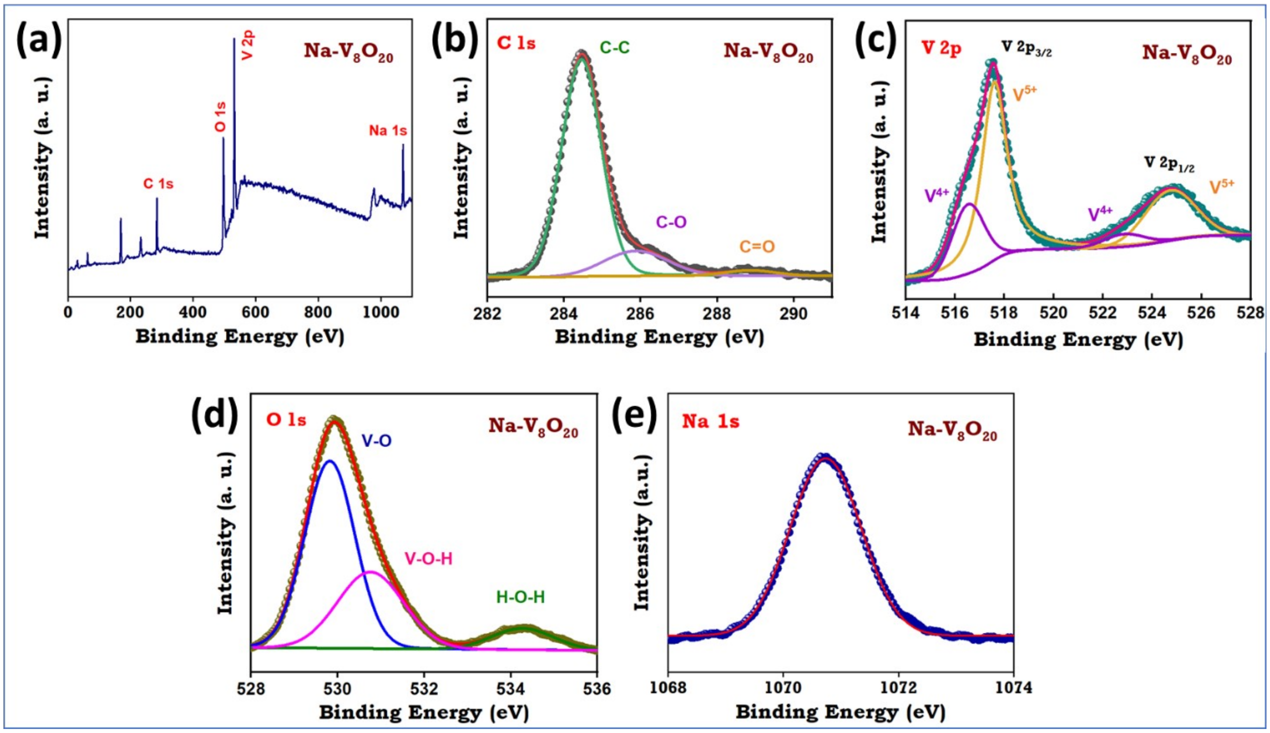

Fig. S2: (a) Survey, (b) C 1s, (c) V 2p, (d) O 1s, and (e) Na 1s core XPS spectra of the NaV_8O_{20} nanobelts sample.

In the C 1s core-level spectrum, the peak at 284.5 eV corresponds to adventitious carbon (C–C), while additional peaks at 285.9 and 288.9 eV are associated with C–O and C=O bonds, respectively.[1] **Fig. S1c** shows the deconvoluted high-resolution V 2p core spectrum for the NaV_8O_{20} nanobelts. Two prominent peaks at 517.6 eV and 524.7 eV are assigned to the V $2p_{3/2}$ and V $2p_{1/2}$ spin-orbit doublet of V^{5+}, while two minor peaks at 516.6 eV and 522.8 eV correspond to the V $2p_{3/2}$ and V $2p_{1/2}$ doublet of V^{4+}.[2, 3] **Fig. S1d** shows the deconvoluted core-level O 1s spectrum of the Na–V_8O_{20} sample. Here, three deconvoluted peaks at 529.8, 530.8, and 534.3 eV correspond to the V-O bonding, chemisorbed V-O-H, and crystalline water (H-O-H), respectively.[4-6] Additionally, the XPS core spectrum of Na 1s **(Fig. 4e)** demonstrates a broad peak (1070.7 eV), indicating the presence of Na inside the V_8O_{20} matrix.[7]

S3. Electrochemical measurements

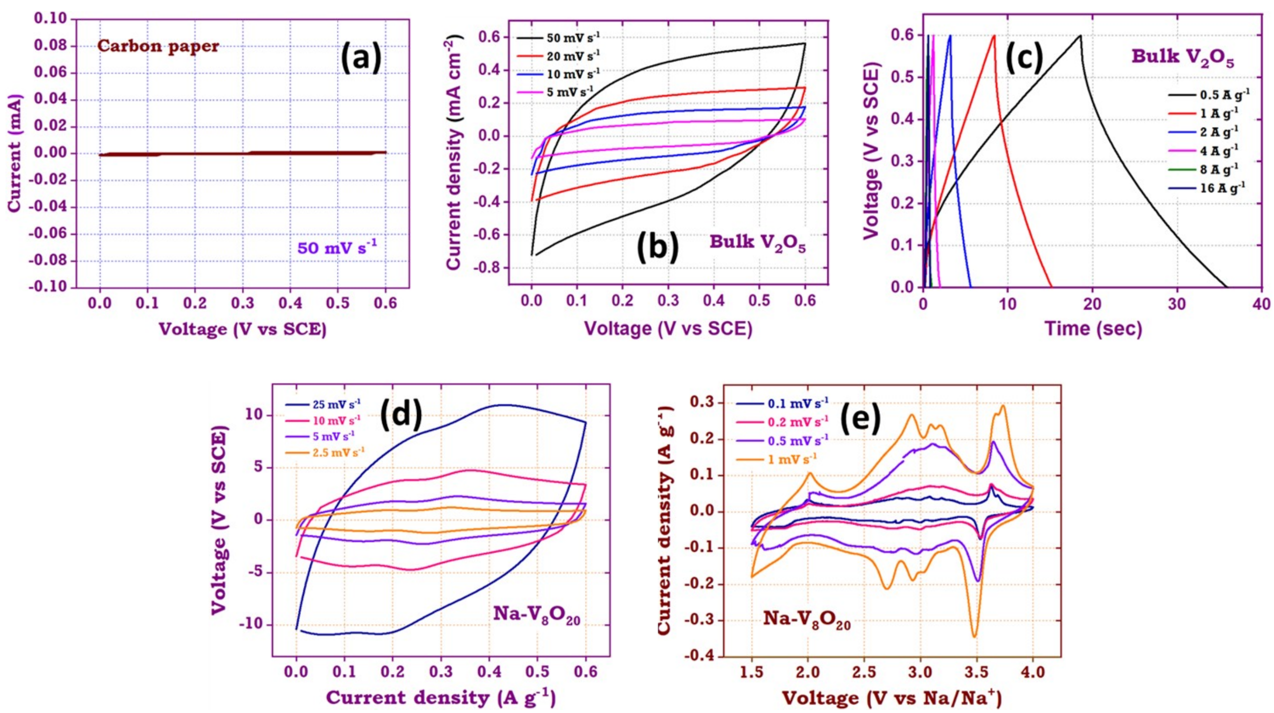

Fig. S3: CV curves of (a) carbon paper and (b) bulk V_2O_5 electrode at different scan rates; (c) GCD curves of bulk V_2O_5 electrode at different current densities; (d) CV curves of Na–V_8O_{20} electrode at 2.5 – 25 mV s^{-1} and (e) Na ion battery at different scan rates ranging from 0.1 to 1 mV s^{-1}.

Table S1: Crystallographic data of the NaV_8O_{20} powder obtained from Rietveld refinement

Space group *C2/m*	a= 11.74(2) b=3.66(6) c=11.117(5)	α= 90° β= 102.47° γ= 90°		R_{wp} (%) = 3.0353 R_p (%) = 1.2726 R_{exp} (%) = 0.6205 chi^2= 4.8913
Atom	x	z	U	Occupancy
Na1	-0.581	0.117	-0.01	0.138
Na2	-0.117	0.122	0.09	0.128
V1	-0.581	0.117	-0.01	0.948
V2	0.112	0.151	-0.01	0.957
O1	0.954	0.129	-0.02	1.003
O2	0.954	0.129	-0.02	1
O3	0.777	0.137	-0.01	1.029
O4	0.233	0.165	-0.02	1.013
O5	0.188	0.155	0.02	0.945

Table S2: Specific capacitance values at different scan rates from CV curves of the NaV_8O_{20} electrode.

Scan rates (mV s^{-1})	**Specific capacitance (F g^{-1})**	
	NaV_8O_{20} nanobelts electrode	**Bulk V_2O_5 electrode**
50	533.12	15
25	607.5	20
10	675.34	23
5	743.05	25
2.5	823.6	-

Table S3: Specific capacitance values at current densities from GCD curves for NaV_8O_{20} electrode.

Current densities (A g^{-1})	Specific capacitance (F g^{-1})	
	NaV_8O_{20} nanobelts electrode	**Bulk V_2O_5 electrode**
0.5	676	14
1	650	11
2	607	8
4	536	6
8	408	5
16	222	4
32	111	-

Table S4: Specific capacitance, energy and power density values at different current densities from GCD curves for AC// NaV_8O_{20} asymmetric supercapacitor coin cell device.

Current density (A g^{-1})	Specific capacitance (F g^{-1})	Energy density (Wh kg^{-1})	Power density (W kg^{-1})
0.5	126.76	45.07	163.26
1	119.94	42.64	326.53
2	109.69	39	653.06
4	93.46	33.23	1306.12
8	71.42	25.39	2612.24
16	41.63	14.80	5224.48

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