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Electronic Supplementary Information for

V_2O_5 Embedded in Vertically Aligned Carbon Nanotube Arrays as Free-standing Electrodes for Flexible Supercapacitors

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Calculations

The methods used to calculate the specific capacitances, energy density and power density are listed below.

The specific capacitance of single electrodes can be calculated from their CV curves according to the following equation 1:

$$C = \frac{\int idU}{2vm\Delta U}(F/g) \quad (1)$$

The capacitance can also be collected from the charge discharge curves in equation 2:

$$C = \frac{i \times \Delta t}{m \times \Delta U}\ (F/g) \quad (2)$$

Where *i* is the discharge current, ΔU is the potential window, v is the scan rate, m is the loading of active material, and Δt is the discharge time.

The total specific capacitance (C_c for cathode capacitance and C_a for anode capacitance) in the full cell was calculated according the equation 1 and 2 with being the total weight of cathode and anode active material. For full cells the positive charge and negative charge were balanced ($q^+=q^-$). The charge stored can be calculated from the equation 3:

$$q = C_c(C_a) \times m^+(m^-) \times \Delta U_a(\Delta U_c) \quad (3)$$

Where ΔUa is the potential window of cathode and ΔUc is the potential range for anode electrode.

The mass loading ratio of both electrodes is obtained from the equation 3 from the CP average specific capacitance:

$$\frac{m^+}{m^-} = \frac{C_a \times \Delta U_a}{C_c \times \Delta U_c} = \frac{1}{4.06} \quad (4)$$

The energy and power density of full cell were calculated from the following equation 5 and 6:

$$E = \frac{\int_{Umin}^{Umax} IdU}{3.6 \times m} = \frac{I\int_{t=0}^{t=t} U(t)dt}{3.6 \times m}(Wh/kg) \quad (5)$$

$$P = \frac{E}{t}(W/kg) \quad (6)$$

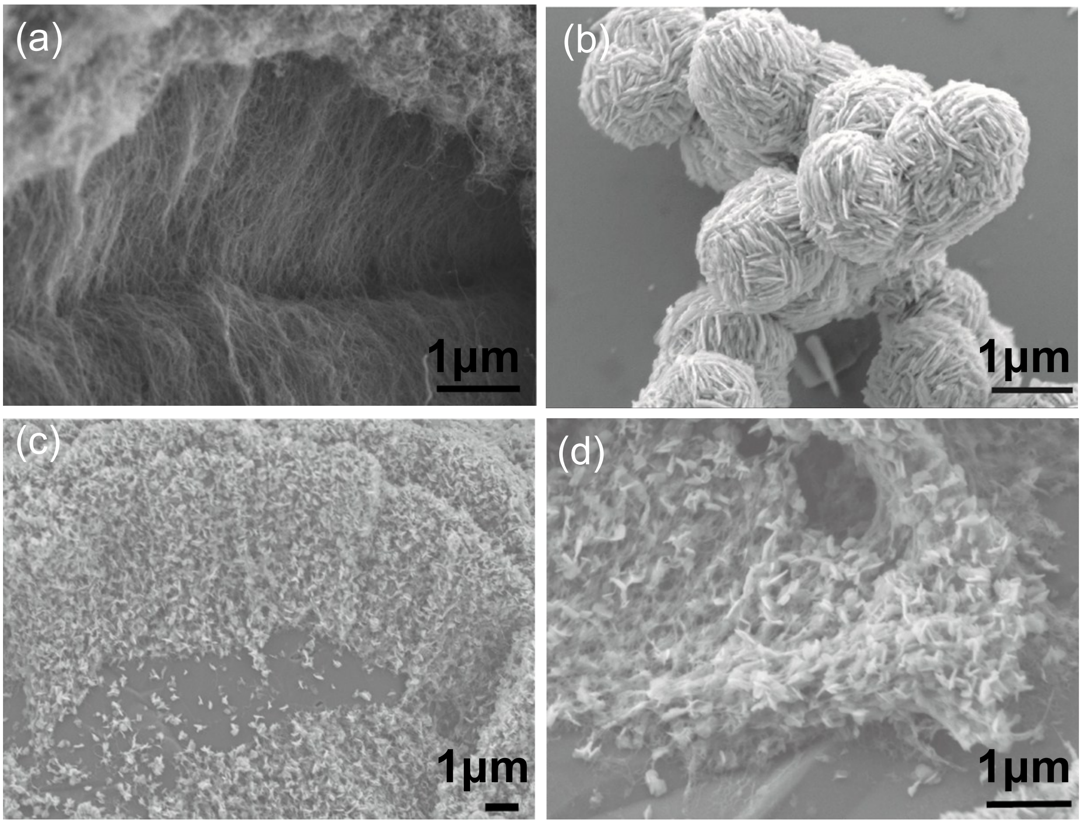

Fig. S 1 SEM image of (a) VA-CNT/GF (b) V_2O_5 powder without VA-CNTs/GF (c) V_2O_5-VA-CNTs /GF and (d) PEDOT-V_2O_5-VA-CNTs/GF

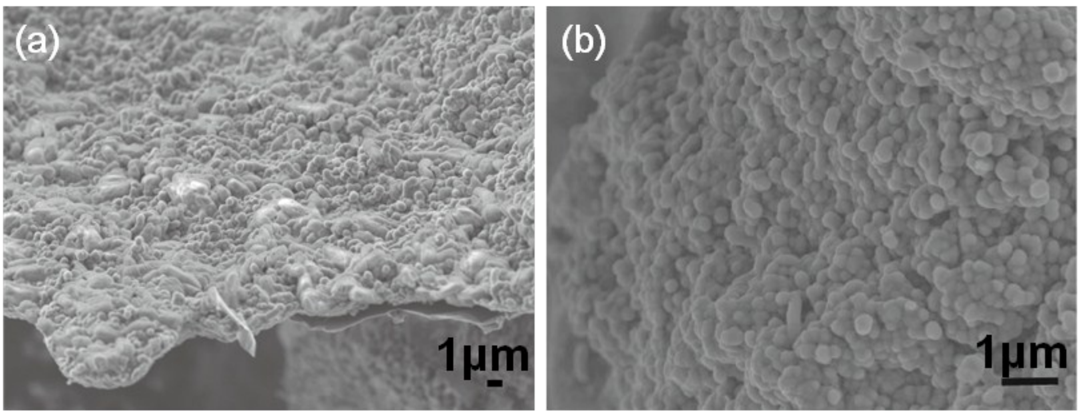

Fig. S 2 (a) and (b) SEM image of PPy-VA-CNTs/GF

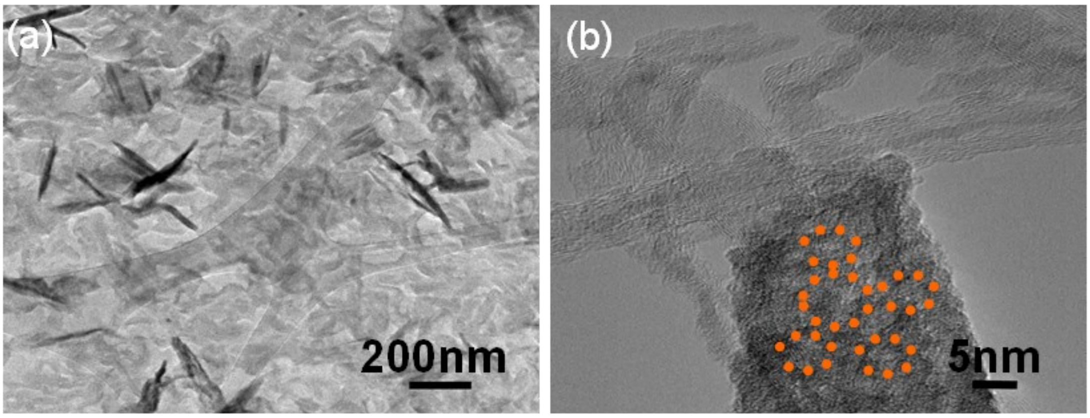

Fig. S 3 (a) TEM characterization of V_2O_5-VA-CNTs/GF and (b) HRTEM image of V_2O_5-VA-CNTs /GF

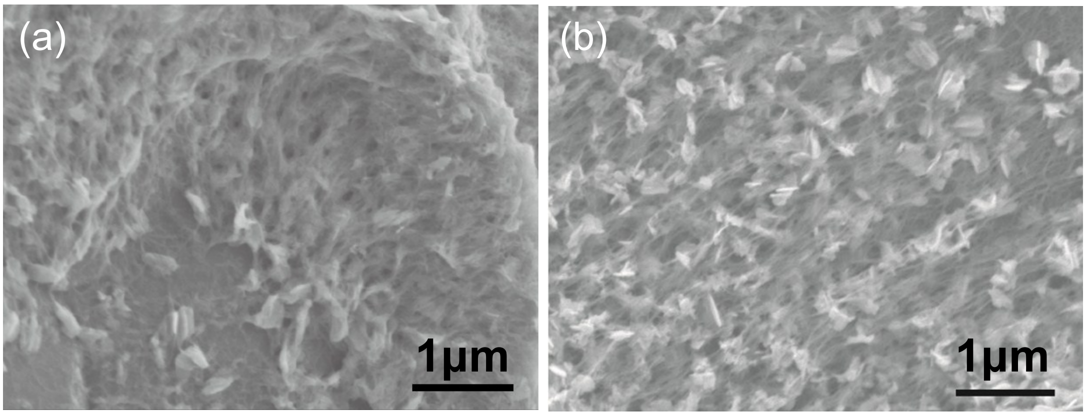

Fig. S 4 SEM image of (a) V_2O_5-VA-CNTs/GF (b) and PEDOT-V_2O_5-VA-CNTs/GF after cyclic voltammetry and chronopotentiometry

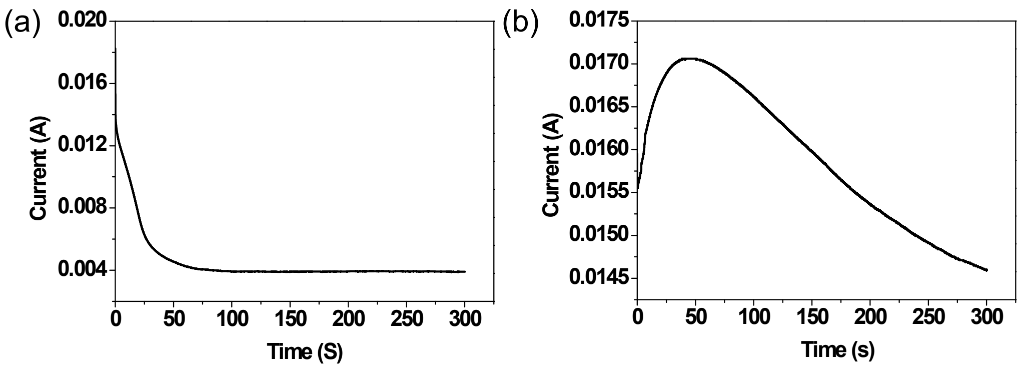

Fig. S 5 (a) PEDOT was coated onto the V_2O_5-VA-CNTs/GF by electrodeposition (b) PPy was electrochemically deposited on VA-CNTs/GF by chronoamperometry technique

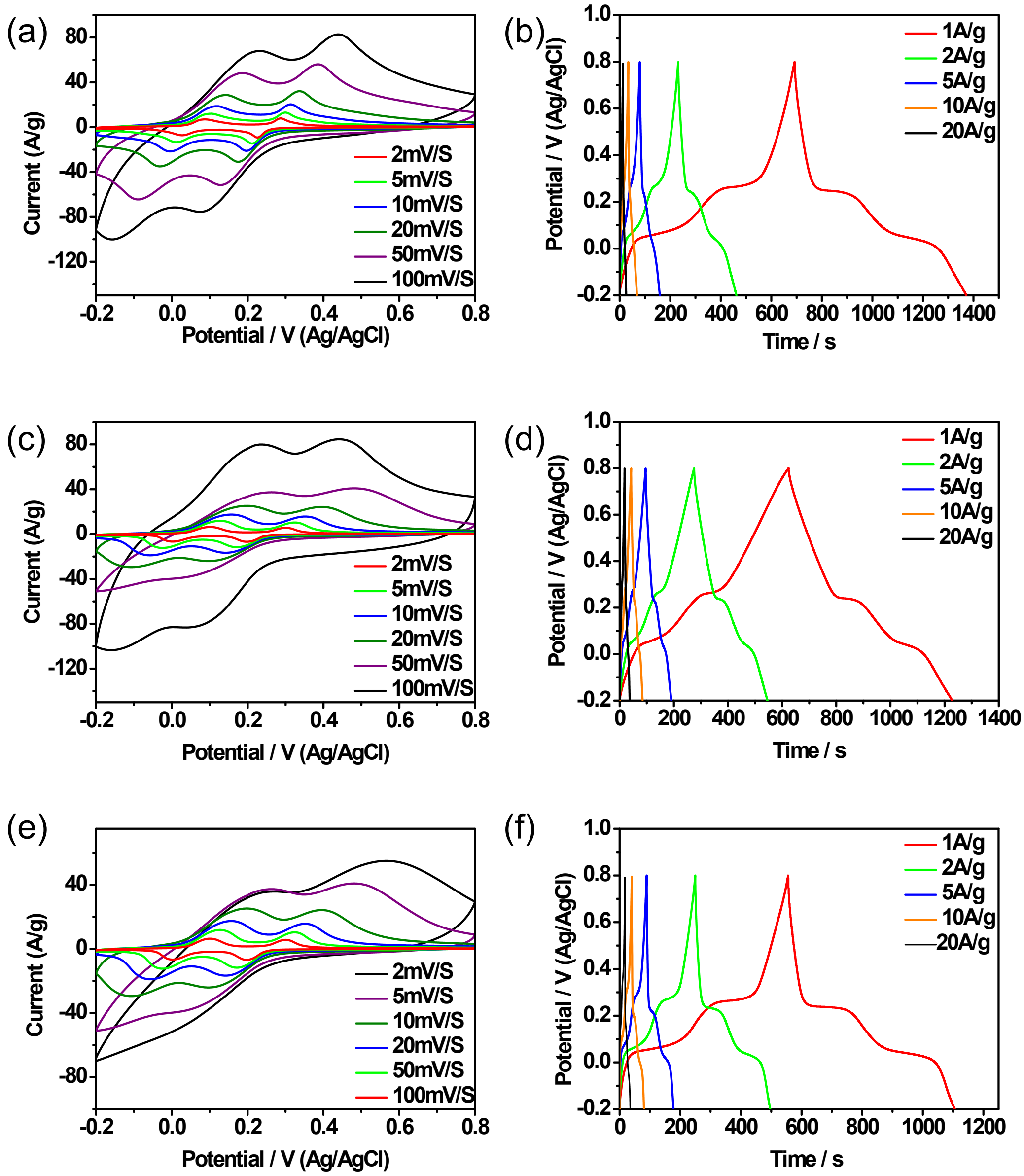

Fig. S 6 (a) (c) and (e) CV curve of V_2O_5-VA-CNTs/GF, PEDOT-V_2O_5 and V_2O_5 powder at different scan rates (b) (d) and (f) Charge-discharge curves of V_2O_5-VA-CNTs/GF, PEDOT-V_2O_5 and V_2O_5 powder at different current densities

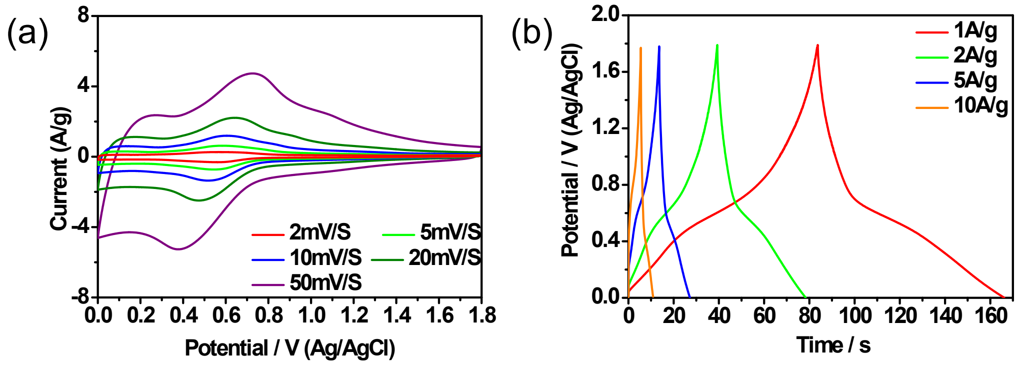

Fig. S 7 (a) CV curves of the device in 5 mol L^{-1} $LiNO_3$ aqueous solution at various scan rates from 2mV s^{-1} to 100mV s^{-1}. (b) Charge/discharge curves of the device in 5 mol L^{-1} $LiNO_3$ aqueous solution at different current densities from 1 A g^{-1} to 20 A g^{-1}

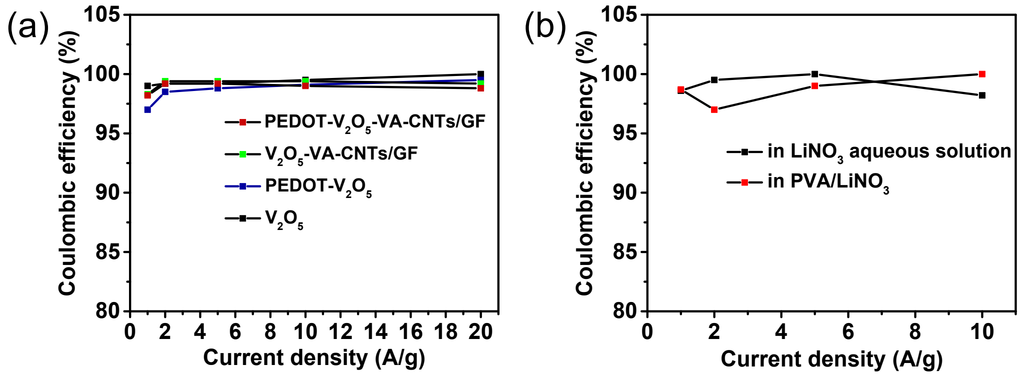

Fig. S 8 (a) The coulombic efficiency of PEDOT-V_2O_5-VA-CNTs/GF, V_2O_5-VA-CNTs/GF, PEDOT-V_2O_5 and V_2O_5 powder at different current densities (b) The corresponding coulombic efficiency of the device in 5 mol L^{-1} $LiNO_3$ aqueous solution and 5 mol L^{-1} PVA/$LiNO_3$ electrolyte from 1 A g^{-1} to 10 A g^{-1}

Table S1 a collected electrochemical performance of V_2O_5 for supercapacitor

Active materials	electrolyte	Specific capacitance	Devices' Energy density and powder density
PEDOT-V_2O_5-VA-CNT/GF flexible electrode (this work)	5 M $LiNO_3$/PVA	1016 F g^{-1} at 1 A g^{-1}	21.97 Wh kg-1 at 900 W kg-1
V_2O_5 nanowires/ GO flexible electrode[1]	1 M Lithium bis(tri-fluoromethanesulfonimide) (LiTFSi)in acetonitrile		38.8 Wh kg-1 at 465 W kg^{-1}
V_2O_5/polyaniline[2]	5M LiCl	443 F g^{-1} at 2 A g^{-1}	69.2 Wh kg-1 at 720 W kg^{-1}
V_2O_5/Ketjin black[3]	LiCl/PVA	3.9506 F•cm^{-2} at 5 mA•cm^{-2}	56.83 Wh kg-1 at 303W kg^{-1}
V_2O_5-rGO free-standing electrodes[4]	1 M $LiClO_4$ in PC	129.7 F g^{-1} at 0.1 A g^{-1}	13.3 Wh kg-1 at 12.5 W kg^{-1}
V_2O_5/PEDOT/MnO2[5]	1 M Na_2SO_4	266.4 F g^{-1} at 2 mV s^{-1}	21.7 Wh kg-1 at 2.2 KW kg^{-1}
VO_2/GF self-standing electrode[6]	K_2SO_4	485 F g^{-1} at 2 A g^{-1}	--
V_2O_5/polypyrrole[7]	5 M $LiNO_3$/PVA	448 F g^{-1} at 0.5 A g^{-1}	14.2 Wh kg-1 at 250 W kg^{-1}
V_2O_5/rGO[8]	1 M KCl	635 F g^{-1} at 1 A g^{-1}	39 Wh kg-1 at 900 W kg^{-1}
Flexible MWNT/V_2O_5[9]	$LiNO_3$/PVA	80 F cm^{-2} at 10 mV s^{-1}	6.8 mWh cm-3 at 80.0 W cm^{-3}
V_2O_5/MWCNT/GO[10]	2 M KCl/$LiClO_4$	2590 F g^{-1} at 1mV s^{-1}	96 Wh kg-1 at 800 W kg^{-1}
V_2O_5 nanofibre/ graphene[11]	1 M LiTFSi	218 F g^{-1} at 1 A g^{-1}	37.2 Wh kg-1 at 3743 W kg^{-1}
Spherical V_2O_5[12]	5 M $LiNO_3$	559 F g^{-1} at 3 A g^{-1}	--
VO_x nanowire[13]	LiCl/PVA	298.5 F g^{-1} at 10 mV s^{-1}	0.61 mWh cm-3 at 0.85 W cm^{-3}

V_2O_5/polyindole[14]	5 M $LiNO_3$	535.5 F g^{-1} at 1 A g^{-1}	38.7 Wh kg-^{1} at 900 W kg^{-1}
V_2O_5/ MWCNT[15]	0.5 M K_2SO_4	410 F g^{-1} at 0.5 A g^{-1}	57 Wh kg^{-1}at 250 W kg^{-1}
VO_2 nanoflake self-standing electrode[6]	K_2SO_4	485 F g-^{1} at 2 A g^{-1}	9.2 Wh kg^{-1} at 11.5 W kg^{-1}
MnO_2-GO/V_2O_5-GO[16]	1 M LiTFSI in acetonitrile	13 F g^{-1} at 500 mA g^{-1}	15.4 Wh kg^{-1} at 436.5 W kg^{-1}
Graphite mamoplatelets-V_2O_5[17]	1 M LiTFSI	226 F g^{-1} at 10 mV s^{-1}	28 Wh kg^{-1} at 303 W kg^{-1}
$V_2O_5.0.6H_2O$[18]	0.5 M K_2SO_4	180.7 F g^{-1} at 2C	20.3 Wh kg^{-1} at 2000 W kg^{-1}
Graphene/V_2O_5 xerogels[19]	0.5 M K_2SO_4	195.4 F g^{-1} at 1 A g^{-1}	---
3D V_2O_5/hydrogenated-WO_3[20]	LiCl/PVA	1101 F g^{-1} at 6.67 mA cm^{-2}	98 Wh kg^{-1} at 1538W kg^{-1}
V_2O_5 nanotube[21]	0.1 M LiTFSI	---	11.6 Wh kg^{-1} at 1200W kg^{-1}

Table S2 the specific capacitance of V_2O_5, PEDOT-V_2O_5, V_2O5-VA-CNT and PEDOT-V_2O_5-VA-CNT at differert scan rate

Scan rate [mV s^{-1}]	2	5	10	20	50	100
V_2O_5 (F g^{-1})	700.36	648.71)	602.18	551.85	428.56	297.00
PEDOT-V_2O_5 (F g^{-1})	836.88	747.45	688.76	631.53	553.56	475.24
V_2O_5-VA-CNTs/GF (F g^{-1})	891.45	777.05	705.38	632.39	517.06	417.84
PEDOT-V_2O_5-VA-CNTs/GF (F g^{-1})	1181.44	1041.09	907.88	777.13	630.47	524.70

Table S3 the capacitance of V_2O_5, PEDOT-V_2O_5, V_2O_5-VA-CNT/GF and PEDOT-V_2O_5-VA-CNT/GF at different current densities

Current densities[A g^{-1}]	1	2	5	10	20
V_2O_5 (F g^{-1})	550	494.8	442.5	400	350
PEDOT-V_2O_5 (F g^{-1})	604	541.8	474	421	368
V_2O_5-VA-CNTs/GF (F g^{-1})	627	545.2	480.5	435	376
PEDOT-V_2O_5-VA-CNTs/GF (F g^{-1})	1016	898	763.5	611	484

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