Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

SUPPLEMENTARY INFORMATION

Heterojunction of $VO(OH)_2$ nanorods onto hemp stem derived carbon for high voltage (1.5 V) symmetric supercapacitor

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Calculations

The equations used to evaluate specific capacitance of working electrodes were evaluated from the cyclic voltammograms curves using the following equation: [1]

$$C = \frac{1}{m\upsilon(V_a - V_c)} \int_{V_a}^{V_c} |i| dV \qquad (1)$$

Where, m is the mass of the working electrode material (g), υ is the scan rate (V s^{-1}), V_a indicates the initial voltage (V) while V_c represents the final voltage (V), i is the current density (A g^{-1}).

Supercapacitive performance of working electrode through charge discharge measurement was calculated using the following equation:

$$C_{sp} = \frac{I \times \Delta t}{m \times \Delta V} \qquad (2)$$

$$C_S = \frac{I \times \Delta t}{m \times 3.6} \quad (3)$$

Where, where, C_S is the specific capacity (mAh g^{-1}), C_{sp} is the specific capacitance (F g^{-1}), ΔV is the operational window (V) excluding IR drop, Δt is the discharging time (s), I is the applied current (A), m is the mass deposited on electrode (g).

Further, to evaluate the supercapacitive cell performance through GCD following equations were used: [2]

$$C_{sp} = \frac{I \times \Delta t}{m \times \Delta V} \quad (4)$$

$$E = \frac{0.5 \times C_m (\Delta V)^2}{3.6} \quad (5)$$

$$P = \frac{E \times 3600}{\Delta t} \quad (6)$$

Where, C_{sp} capacitance of cell in F g^{-1}, I is the current in mA, Δt is the discharge time in s, m is the active mass on two electrode in g, ΔV is the voltage after IR drop in V, E is the energy density in Wh Kg^{-1}, and P is the power density in W kg^{-1}.

To determine the mechanism behind charge storage power's law is implied using equation:[3]

$$i\,(V) = a\vartheta^b \quad (7)$$

Here, a and b are adjustable parameters and υ is the scan rate (V s^{-1}).

The following equation determines the contribution of current from capacitive and intercalation mechanism: [4]

$$i\,(V) = k_1(\vartheta) + k_2\,(\vartheta)^{1/2} \quad (8)$$

The value of $k_1(\upsilon)$ and $k_2(\upsilon)^{1/2}$ gives the current contribution from capacitive and diffusion controlled intercalation mechanism respectively.

Randles plot determines the diffusion coefficient of electrode material by equation: [5]

$$Z = R_s + R_{ct} + \sigma_w . \omega^{-0.5} \quad (9)$$

$$D_w = \left[\frac{RT}{\sqrt{2}\,AF^2\,\sigma\omega c}\right] \quad (10)$$

Where, ω is angular frequency' σ_w is the Warburg coefficient in Ω $s^{-1/2}$ and Rct and Rs are charge transfer resistance and solution resistance respectively. D_w is the diffusion ion coefficient in $m^2\, s^{-1}$, A is the area of the electrode in m^2, T is the absolute temperature in K, R is the gas constant in J K^{-1} mol^{-1}, F is the faraday constant in C mol^{-1} and Warburg impedance is used to describe the electrochemical process on electrodes and it represents the resistance to mass transfer.

Conductivity of $VO(OH)_2$, $VO(OH)_2$/AC-2 is determined by using the following equation:

$$R = \rho \frac{l}{a} \quad (11)$$

From the plot of I-V, the value of resistance (R) is determined and is used to calculate resistivity (ρ). Conductivity is reciprocal of resistivity.

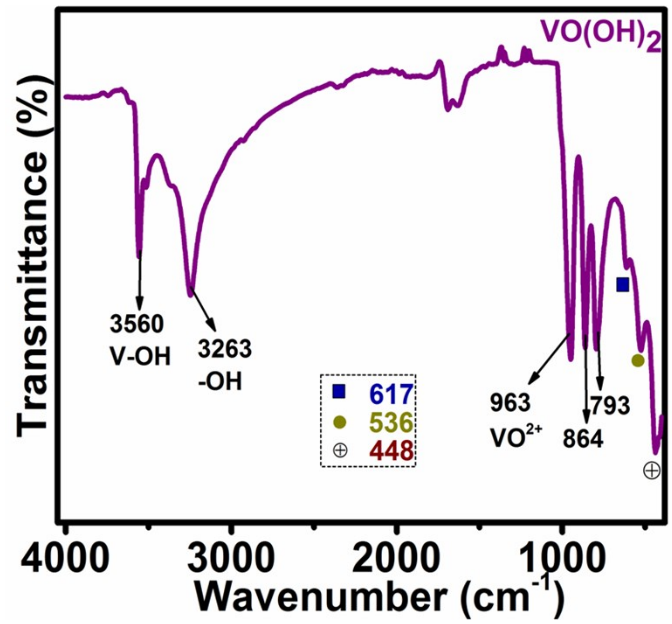

Fig. S1 FTIR spectra of $VO(OH)_2$.

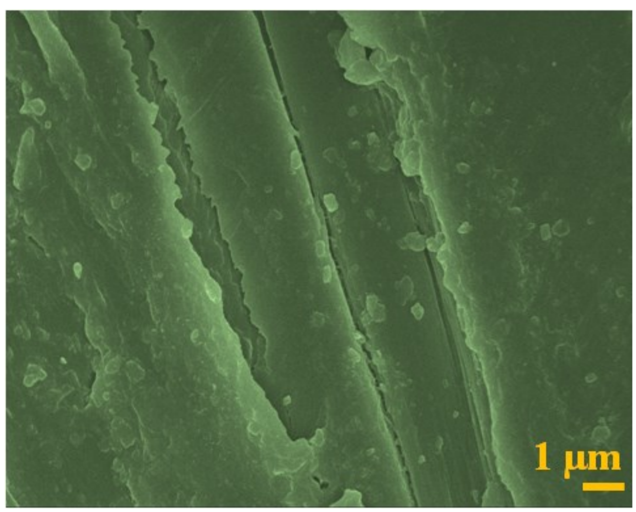

Fig. S2 FE-SEM image of raw hemp stem.

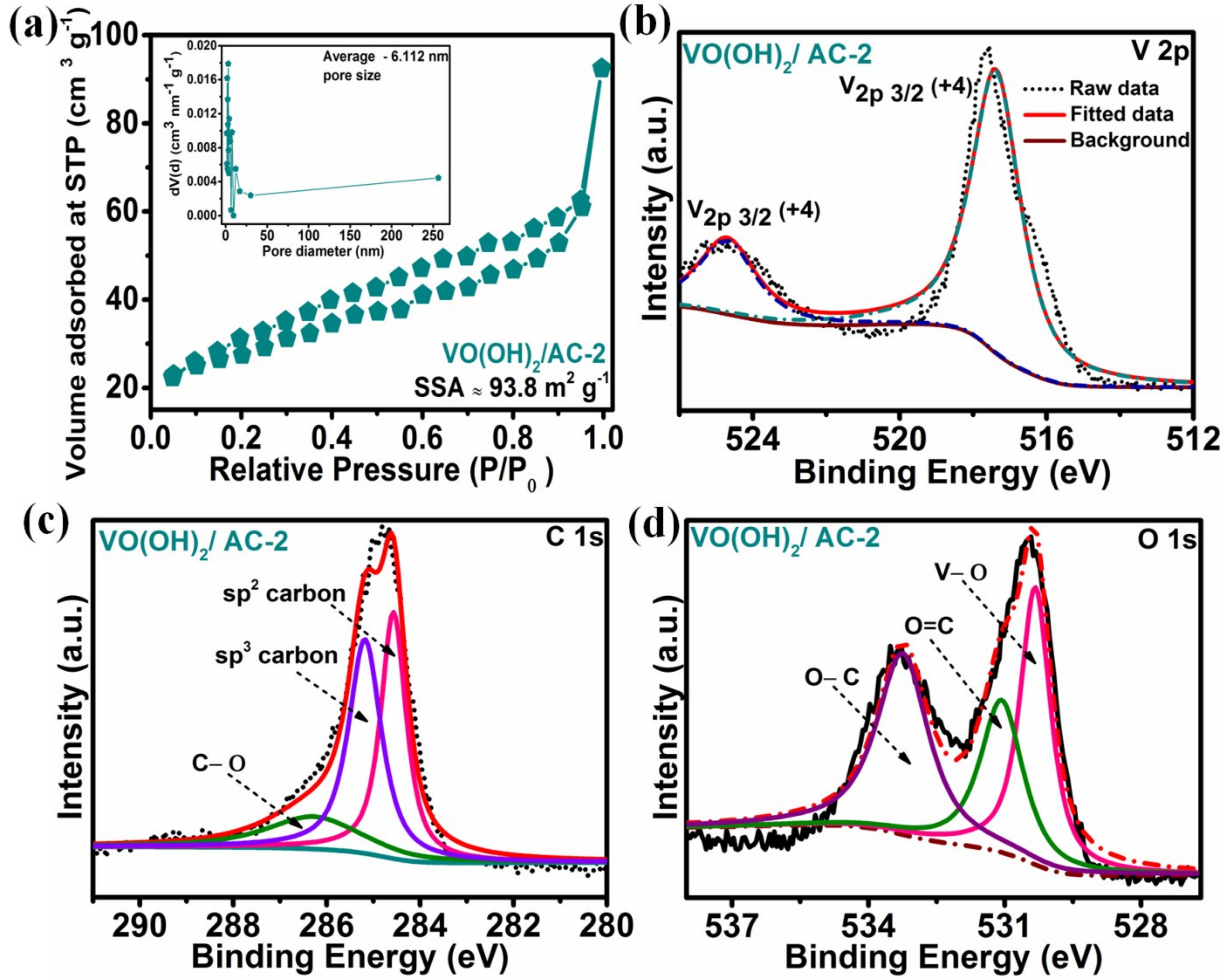

Fig. S3 (a) Nitrogen sorption isotherms [inset: Pore size distribution] XPS spectra of (b) V 2p (c) C 1s (d) O 1s of $VO(OH)_2$/AC-2.

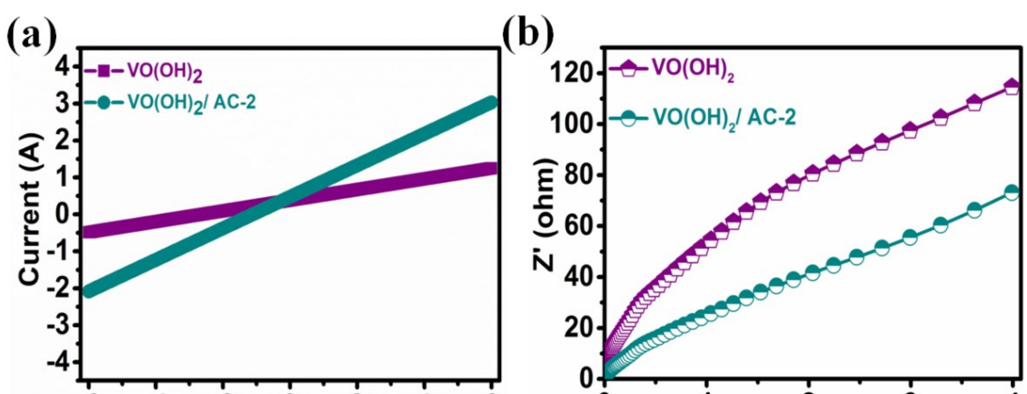

Fig. S4 (a) I-V measurement of $VO(OH)_2$, $VO(OH)_2$/AC-2 (b) Randles plot of $VO(OH)_2$, $VO(OH)_2$/AC-2.

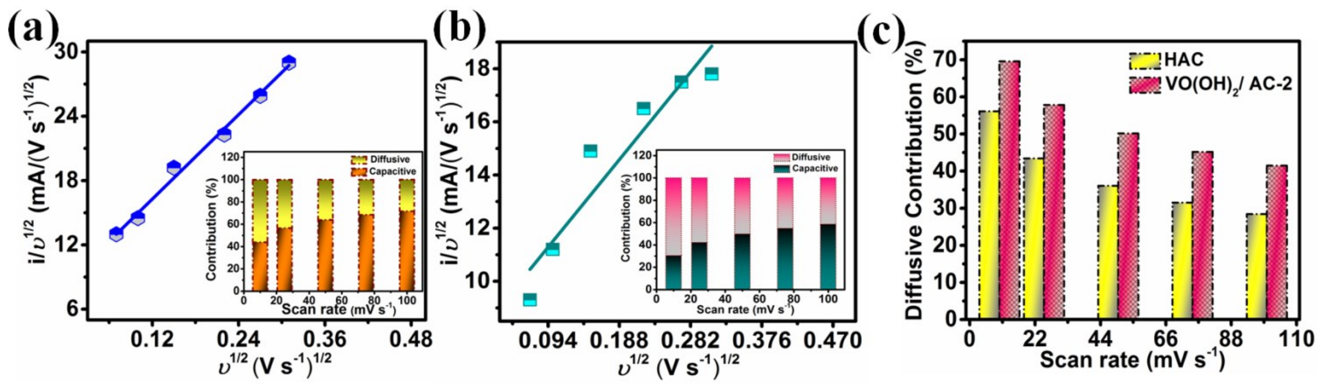

Fig. S5 Plot of $1/\upsilon^{1/2}$ versus $\upsilon^{1/2}$ for: (a) HAC (b) $VO(OH)_2$/AC-2 (c) Contibution of diffusive current at -0.2 V.

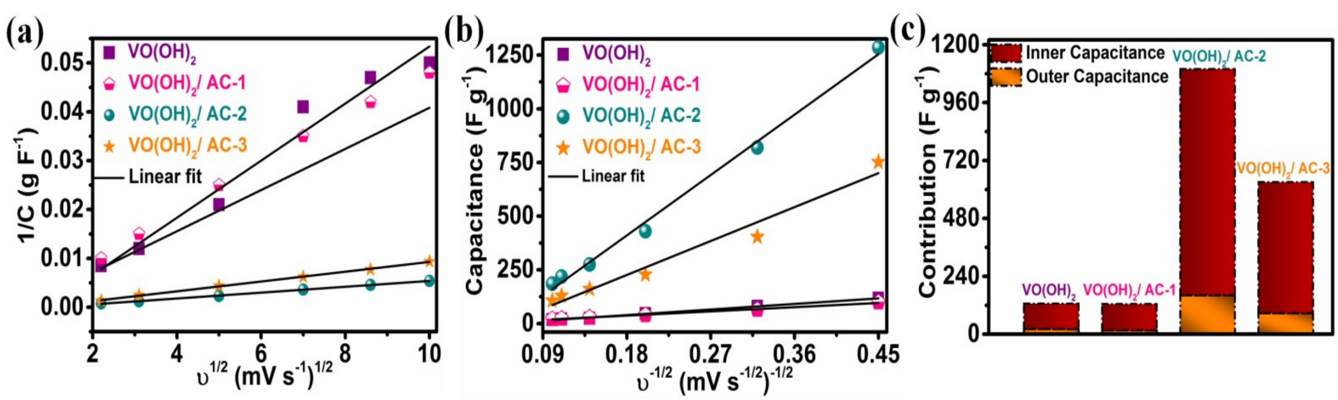

Fig. S6 (a, b, c) Trasatti plot for $VO(OH)_2$, $VO(OH)_2$/AC-1, $VO(OH)_2$/AC-2, $VO(OH)_2$/AC-3.

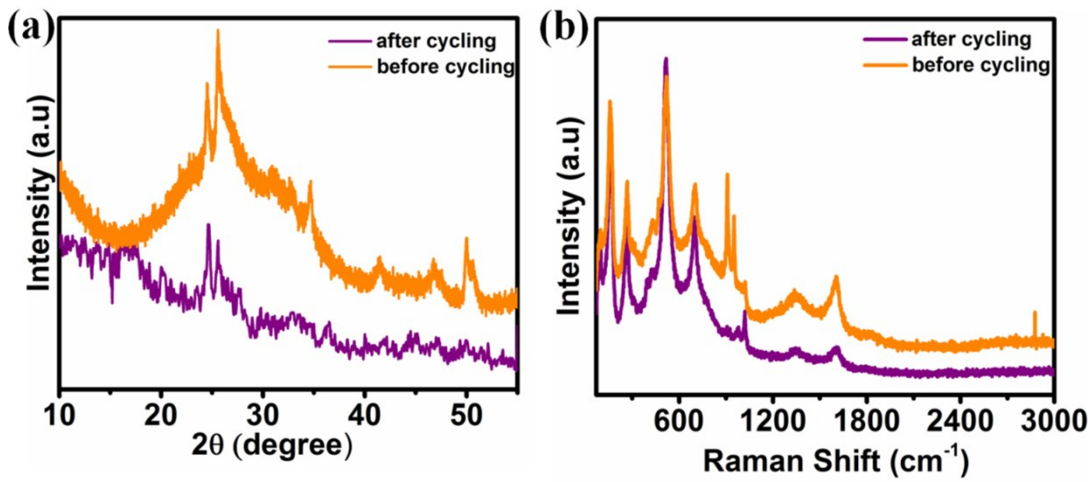

Fig. S7 (a) XRD, (b) Raman spectra of $VO(OH)_2$/AC-2 before and after cycling.

References:

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