Supporting Information

Tailorable and Wearable Textile Devices for Solar Energy Harvesting and Simultaneous Storage

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Supporting Discussions and Figures

Figure S1. Schematic illustrations of the weaving process of the energy textile.

Supporting Discussion S1

XRD patterns of samples are shown in Figure S2a. Diffraction peaks of the bottom curve are consistent with the $\text{H}_2\text{Ti}_2\text{O}_5$•H$_2$O phase according to the PDF card JCPDS 47-0124. Diffraction peaks of the top curve at $2\theta = 37.2^\circ$ and $43.5^\circ$ correspond to the (111) and (200) facets of TiN (JCPDS 38-1420), respectively, which indicates a valid nitridation process. To acquire deeper understanding of the element composition and chemical bonding of the as-prepared sample, X-ray photoelectron spectroscopy (XPS) studies are performed. High resolution Ti 2p and N 1s XPS spectra are shown in Figure S2. The core level Ti 2p spectrum (Figure S2b) can be divided into 6 peaks (three pairs of spin-orbit split doublets) after deconvolution, which are Ti–N (2p3/2 = 455.6 eV and 2p1/2 = 461.5 eV), Ti–N–O (2p3/2 =
457.2 eV and 2p1/2 = 463.2 eV), and Ti–O (2p3/2 = 458.7 eV and 2p1/2 = 464.5 eV). The N 1s spectrum is shown in Figure S2c, presenting a broad peak that can be split into three peaks at 396.3 eV (Ti–N), 397.1 eV (Ti–N–O) and 399.1 eV (the chemisorbed nitrogen).

Figure S2. (a) XRD patterns of the H₂Ti₂O₅•H₂O NWs and TiN NWs on Ti wire. Core level of XPS spectra of (b) Ti 2p and (c) N 1s for TiN NWs.

Figure S3. SEM images of (a) H₂TiO₅•H₂O NWs and (b) TiN NWs, insets show the corresponding magnified images. (c) TEM image of the porous TiN NWs, inset shows the SAED pattern. (d) TEM and HRTEM images of the TiN NW. (e) STEM image of an individual TiN NW and the corresponding EDS element mapping images.
Figure S4. (a) SEM image of TiN NWs with thin carbon shell, inset shows the corresponding magnified image. (b, c) TEM images of a TiN NW with thin carbon shell. (d) CV curves of the pure Ti wire, H$_2$Ti$_2$O$_5$•H$_2$O NWs, TiN NWs without carbon shell and TiN NWs with carbon shell electrodes. (e) Investigation of the cycle stability of FSC devices based on TiN NWs with and without carbon shell.

Table S1. Electrochemical performances of our TiN FSC and some previous FSCs.

<table>
<thead>
<tr>
<th>Electrode material</th>
<th>Device configuration</th>
<th>Electrolyte</th>
<th>Specific capacitance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MnO$_2$/ZnO NWs/Au–PMMA wire$^2$</td>
<td>Twisted</td>
<td>H$_3$PO$_4$/PVA</td>
<td>0.2 mF cm$^{-1}$ 2.4 mF cm$^{-2}$</td>
</tr>
<tr>
<td>CNT fiber$^3$</td>
<td>Twisted</td>
<td>H$_3$PO$_4$/PVA</td>
<td>0.006 mF cm$^{-1}$</td>
</tr>
<tr>
<td>MnO$_2$/rGO fiber$^4$</td>
<td>Twisted</td>
<td>H$_2$SO$_4$/PVA</td>
<td>0.14 mF cm$^{-1}$ 9.6 mF cm$^{-2}$</td>
</tr>
<tr>
<td>Chinese ink/stainless steel wire$^5$</td>
<td>Coaxial</td>
<td>H$_2$SO$_4$/PVA</td>
<td>0.1 mF cm$^{-1}$ 3.18 mF cm$^{-2}$</td>
</tr>
<tr>
<td>Pen ink/Ni wire$^6$</td>
<td>Parallel</td>
<td>1 M Na$_2$SO$_4$ aqueous solution</td>
<td>0.504 mF cm$^{-1}$ 19.5 mF cm$^{-2}$</td>
</tr>
<tr>
<td>rGO/Au wire$^7$</td>
<td>Parallel</td>
<td>H$_3$PO$_4$/PVA</td>
<td>0.1 mF cm$^{-1}$ 6.49 mF cm$^{-2}$</td>
</tr>
<tr>
<td>TiN NWs/Ti wire (Our work)</td>
<td>Parallel</td>
<td>KOH/PVA</td>
<td>0.36 mF cm$^{-1}$ 2.28 mF cm$^{-2}$ 0.37 F cm$^{-3}$</td>
</tr>
</tbody>
</table>
Figure S5. (a) Galvanostatic charge/discharge curves of the 4 cm-long TiN FSC. (b) Relationship of capacitance retention with scan rates from 0.1 V s\(^{-1}\) to 50 V s\(^{-1}\).

Supporting Discussion S2

The characteristic frequency \(f_0\) of -45° of the commercial electrolytic capacitor (CEC), TiN FSC and active carbon (AC) supercapacitor are about 630 Hz, 4.5 Hz and 0.4 Hz, respectively (Figure S6a). By calculating the relaxation time constant \(\tau_0=1/f_0\) (representing the minimum time for discharging its maximum energy of ≥50%), the FSC shows a rather short time of 0.22 s. Although much longer than that of the CEC (1.5 ms), it is still faster than that of the self-made AC supercapacitor (2.5 s), indicating very fast ion diffusion. The entire charge storage in supercapacitors is composed of the faradaic contribution, pseudocapacitance from the charge-transfer process, and the double electron layer effect. CV curves are analyzed according to the equation: \(i=a v^b\), where the current data \(i\) obeys power law relationship with the sweep rate \(v\).\(^9,10\) The rather important \(b\)-values can be determined from the slope for the graph \(log i vs. log v\). Theoretically, \(b\) takes defined values of 0.5 and 1 referring to diffusion controlled process and capacitive response, respectively. Figure S6b presents that the \(b\)-values at voltage from 0.2 V-1.0 V are all approaching 0.8, indicating the dominant capacitive effect. In this Trasatti’s analysis, the total stored charge \(Q\) and the capacitive contributed charge \(Q_c\) should obey the following equation: \(Q (v) = Q_c + k \times v^{-1/2}\).
where \( k \) (constant) \( \times v^{-1/2} \) represents the diffusion controlled charge. Based on Figure S6c, \( Q_c \) can be estimated to be around 1.4 C when the scan rate becomes infinite (y-intercept in Figure S6c). The capacitive contribution and diffusion controlled contribution in Figure S6d show that the capacitive charges are all over 70%, which further affirms that the capacitive contribution of this TiN FSC occupies the leading role in total stored charge.

**Figure S6.** (a) Impedance phase angle as a function of frequency of TiN FSC, electrolytic capacitor and AC supercapacitor. (b) b-values for TiN FSC plotted as a function of voltage for anodic scans. Inset is the power-law dependence of current on scan rate fitted at 0.2-1.0 V. (c) Capacity as a function of \( v^{-1/2} \), the y-intercept is 1.4 C. (d) Separation of contributions from capacitive and diffusion-controlled processes at different scan rates.
Figure S7. (a) CV curves of the TiN FSC at bending states of 0º, 180º, and 360º. (b) CV curves of a FSC before and after wrapping around a glass rod. Inset shows the photograph of the FSC under wrapping, demonstrating the excellent flexibility.

Figure S8. CV curves of the 4 cm and 20 cm-long FSCs at scan rates of (a) 0.1 V s⁻¹ and (b) 1 V s⁻¹. (c) A photograph of FSCs with different length.
**Figure S9.** Photoresponse curves varied with time duration of the DSSCs textile in dry condition.

**Figure S10.** A photograph of the as-fabricated DSSC-FSC textile mixed with colored wool wires.

**Figure S11.** Light-charging curves of the DSSC-FSC textile under different light intensity.
Figure S12. Light-charging curves of the DSSC-FSC textile for the DSSCs module connected in parallel with different unit length.

REFERENCES


