Polypyrrole-decorated 2D carbon nanosheet electrodes for supercapacitors with high areal capacitance

Jayesh Cherusseri and Kamal K. Kar

a Advanced Nanoengineering Materials Laboratory, Materials Science Programme, Indian Institute of Technology, Kanpur, Uttar Pradesh-208016, India.
b Advanced Nanoengineering Materials Laboratory Department of Mechanical Engineering, Indian Institute of Technology, Kanpur, Uttar Pradesh-208016, India.

*Corresponding Author. Tel: +91-512-2597687, E-mail: kamalkk@iitk.ac.in (Kamal K. Kar)

Electronic Supplementary Information

Supplementary Methods:
Method S1. Calculation of ionic conductivity of EGN/PPY nanocomposite electrodes.
Method S2. Calculation of the cell capacitance of EGN/PPY SC cell.
Method S3. Calculation of the area specific capacitance of EGN/PPY SC cell.
Method S4. Calculation of the area specific energy density of EGN/PPY SC cell.
Method S5. Calculation of the volumetric capacitance of EGN/PPY SC cell.
Method S6. Calculation of the volumetric energy density of EGN/PPY SC cell.
Method S7. Calculation of the volume specific capacitance of EGN/PPY SC cell.
Method S8. Calculation of the volume specific energy density of EGN/PPY SC cell.

Supplementary Figure:
Fig. S1. FTIR spectra of (a) pure PPY; (b) EGN$_{0.1}$PPY$_{0.9}$, (c) EGN$_{0.2}$PPY$_{0.8}$, (d) EGN$_{0.3}$PPY$_{0.7}$, (e) EGN$_{0.4}$PPY$_{0.6}$, (f) EGN$_{0.5}$PPY$_{0.5}$, (g) EGN$_{0.6}$PPY$_{0.4}$, (h) EGN$_{0.7}$PPY$_{0.3}$, (i) EGN$_{0.8}$PPY$_{0.2}$, (j) EGN$_{0.9}$PPY$_{0.1}$ nanocomposite; (k) EGN and (l) NFG.
Fig. S2. (a) N$_2$ sorption isotherms and (b) BJH pore-size distribution curve of EGN$_{0.5}$PPY$_{0.5}$ nanocomposite.

Method S1. Calculation of ionic conductivity of EGN/PPY nanocomposite electrodes.
The ionic conductivity of the SC electrodes is calculated by using the equation
\[
\sigma = \frac{T}{R_b \times A}
\]
Where $\sigma$ is the ionic conductivity in S/cm, $T$ is the total thickness of the SC cell (in cm), $R_b$ is the bulk electrolyte resistance (in $\Omega$), and $A$ is the geometrical area of electrodes (in cm$^2$).

Method S2. Calculation of the cell capacitance of EGN/PPY SC cell.
The cell capacitance of the SC is calculated by using equation
\[
C_{cell} = \frac{I_{dis}}{\Delta E}
\]
Where, $C_{cell}$ is the cell capacitance of the SC, $I$ is the charging current, $t_{dis}$ is the discharging time, and $\Delta E$ is the operating potential window.

Method S3. Calculation of the area specific capacitance of EGN/PPY SC cell.
The area specific capacitance of the SC is calculated by using the equation

1
\[ C_{cell,sp,A} = \frac{C_{cell}}{A_{ele}} \]

Where, \( C_{cell,sp,A} \) is the area specific capacitance of the SC and \( A_{ele} \) is the geometric area of the SC electrode.

**Method S4. Calculation of the area specific energy density of EGN/PPY SC cell.**
The area specific energy density \( (E_{cell,sp,A}) \) of the SC is calculated by using the equation

\[ E_{cell,sp,A} = \frac{C_{cell,sp,A} \times (\Delta E)^2}{2 \times 3600} \]

**Method S5. Calculation of the volumetric capacitance of EGN/PPY SC cell.**
The volumetric capacitance of the SC is calculated by using the equation

\[ C_{cell,V} = \frac{C_{cell}}{V_{cell}} \]

Where, \( C_{cell,V} \) is the volumetric capacitance of the SC and \( V_{cell} \) is the total volume of the SC.

**Method S6. Calculation of the volumetric energy density of EGN/PPY SC cell.**
The volumetric energy density \( (E_{cell,V}) \) of the SC is calculated by using the equation

\[ E_{cell,V} = \frac{C_{cell,V} \times (\Delta E)^2}{2 \times 3600} \]

**Method S7. Calculation of the volume specific capacitance of EGN/PPY SC cell.**
The volume specific capacitance of the SC is calculated by using the equation

\[ C_{cell,sp,V} = \frac{C_{cell}}{V_{ele}} \]

Where, \( C_{cell,sp,V} \) is the volume specific capacitance of the SC and \( V_{ele} \) is the total volume of the SC electrodes.

**Method S8. Calculation of the volume specific energy density of EGN/PPY SC cell.**
The volume specific energy density \( (E_{cell,sp,V}) \) of the SC is calculated by using the equation

\[ E_{cell,sp,V} = \frac{C_{cell,sp,V} \times (\Delta E)^2}{2 \times 3600} \]
Fig. S1. FTIR spectra of (a) pure PPY; (b) EGN\textsubscript{0.1}PPY\textsubscript{0.9}, (c) EGN\textsubscript{0.2}PPY\textsubscript{0.8}, (d) EGN\textsubscript{0.3}PPY\textsubscript{0.7}, (e) EGN\textsubscript{0.4}PPY\textsubscript{0.6}, (f) EGN\textsubscript{0.5}PPY\textsubscript{0.5}, (g) EGN\textsubscript{0.6}PPY\textsubscript{0.4}, (h) EGN\textsubscript{0.7}PPY\textsubscript{0.3}, (i) EGN\textsubscript{0.8}PPY\textsubscript{0.2}, (j) EGN\textsubscript{0.9}PPY\textsubscript{0.1} nanocomposite; (k) EGN and (l) NFG.
Fig. S2. (a) N₂ sorption isotherms and (b) BJH pore-size distribution curve of EGN₀.₅PPY₀.₅ nanocomposite.