Supporting Information

1. Preparation of graphene oxide

Graphene oxide (GO) was prepared by the Hummers’ method. Typically, 60 mL of concentrated sulfuric acid (98%) was added to 2 g graphite powder and 2 g of NaNO$_3$ in a flask. The mixture was stirred for 30 min in an ice bath. Subsequently, 10 g KMnO$_4$ was added slowly into the mixture and kept in the ice bath for 30 min. The mixture was continued to be stirred for 3 hours at 30 °C. 92 mL of deionized water was added drop by drop and then increase the temperature to 95 °C. After 15 min stirring, the suspension was further diluted with 350 mL of deionized water and treated with 10 mL 30% H$_2$O$_2$ at room temperature. Finally, the resulting mixture was centrifuged and washed repeatedly by 5% HCl aqueous and deionized water until the pH closes to 7.

The TEM image and XRD pattern of GO are shown in Fig. S1 and S2.

![Fig. S1 TEM image of GO.](image)
2. Configuration of the supercapacitor

A symmetrical two-electrode configuration is represented in the illustration (Fig. S3). For the supercapacitors of GP, the electrodes are the GP hydrogels (the inset of Fig. S3), and each of them is 2.8 mg in weight and 1 cm in diameter. For the supercapacitors of the pure PANI, PANI is first mixed with polystyrene (60 wt.% dispersion in water) and acetylene black in a mass ratio of 80:10:10 and then dispersed in ethanol. The suspension is drop-dried on the graphite paper as the electrodes. PANI as the active materials is in the range of 0.6 ~ 1.0 mg for a single electrode. The electrodes soaked used as electrodes are isolated by a separator (polystyrene (60 wt.% dispersion in water) and acetylene black in a mass ratio of 80:10:10 and then dispersed in ethanol). The graphite paper (Xinda sealing materials limited company, China) is used as the current collector and the electrolyte is 1 M H$_2$SO$_4$.

Fig. S2 XRD pattern of GO.

Fig. S3 Schematic illustration of the supercapacitor used in this paper and the inset
is the digital image of the GP hydrogel.

3. Calculation of specific capacitance, energy density and power density

The mass specific capacitances ($C_{sc}$) was calculated by using the formula (1): \[ C_{sc} = \frac{2I \Delta t}{m \Delta V} \] (1)

where $I$ is the discharge current, $\Delta t$ is the discharge time for a full discharge, $m$ is the single electrode weight and $\Delta V$ is the potential change for a full discharge. The energy density ($E$) and the power density ($P$) were estimated by using the equations (2) and (3):

\[ E = \frac{C_{sc} \Delta V^2}{8} \] (2)

\[ P = \frac{E}{\Delta t} \] (3)

where $C_{sc}$ is the specific capacitance, $\Delta V$ is the potential change for a full discharge, and $\Delta t$ is the change time for a full discharge.

4. Calculation of FTIR peak area

The peak area is calculated from the original data using peak area tool belonging to the OMNIC software (Thermo Fisher). The absorption range of the quinoid unit is from 1540 cm$^{-1}$ to 1620 cm$^{-1}$, and that of the benzenoid unit is 1394 cm$^{-1}$ to 1517 cm$^{-1}$.

5. BET surface area and BJH pore size distribution of GH and GP

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<th>Table S1 The BET surface area of GH and GP composites</th>
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<td>BET surface area (m$^2$/g)</td>
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6. Electrochemical properties of GH and PANI

The CV curves of GH and PANI doped with three acids are shown in Fig. S5. The CV curve of the GH presents a similar rectangular shape without faradaic current as a result of electrical double layer capacitive behavior. The PANI electrodes are deviated from idealized double-layer behavior due to a pair of broad and reversible faradaic surface redox reactions.

For the GCD curves (Fig. S6), the GH presents a symmetric triangular shape charge/discharge curve, indicating nearly ideal electric double layers capacitive characteristics. The curves of PANI doped with three acids are deviated from triangular shape, owing to the redox reactions. Based on the GCD curves, the specific capacitances of GH and PANI doped with HCl, H$_2$SO$_4$ and HClO$_4$ are 137.0 F g$^{-1}$, 228.4 F g$^{-1}$, 375.0 F g$^{-1}$ and 256.3 F g$^{-1}$ at a current density of 5 A g$^{-1}$, respectively.

The rate capabilities of GH and three types of PANI perform in Fig. S7. The capacitance retentions of GH and PANI doped with HCl, H$_2$SO$_4$ and HClO$_4$ are 76%, 23%, 44% and 32%, when the current density is increasing from 5 A g$^{-1}$ to 70 A g$^{-1}$. 

Fig. S4 BJH pore size distribution of GH (a), GP-HCl (b), GP-H$_2$SO$_4$ (c) and GP-HClO$_4$ (d).
Fig. S5 CV curves of GH and PANI at a scan rate of 20 mV s\(^{-1}\).

Fig. S6 GCD curves of GH and PANI at a current density of 5 A g\(^{-1}\).

Fig. S7 The specific capacitances of GH and PANI as a function of the current density.

7. The calculation of the specific capacitance of PANI against its own weight in GP
Taking GP-HCl composite as an example, the specific capacitance of GP-HCl against the total weight of PANI-HCl and GH is 303.8 F g\(^{-1}\) (Fig. 7) at a current density of 5 A g\(^{-1}\), and that of PANI-HCl is found to fall in between 526.2 F g\(^{-1}\) and 708.9 F g\(^{-1}\) (Fig. 6). The value of 526.2 F g\(^{-1}\) is obtained by assuming that GH provides its full capacitance (137.0 F g\(^{-1}\) from Fig. S7), while the contribution of GH to the capacitance is totally neglected for the value of 708.9 F g\(^{-1}\).

Supporting references