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基于混合溶剂有机电解液的超低温孔洞石墨烯超级电容

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Ultra-Low-Temperature Supercapacitor Based on Holey Graphene and Mixed-Solvent Organic Electrolyte

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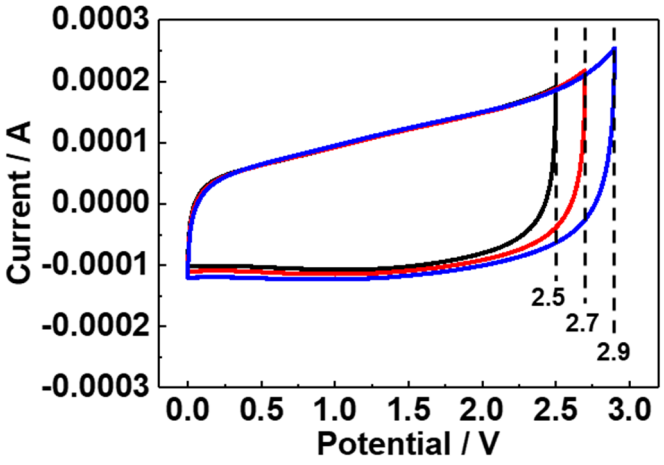

图 S1　25 °C 下 Swagelok 型双电极测试体系中 rHGO 电极在 10 mV·s^{-1} 扫速下的 CV 曲线，电压范围分别为 2.5、2.7 和 2.9 V

Fig. S1　CV curves of rHGO electrodes at a scan rate of 10 mV·s^{-1} in a Swagelok cell with potential ranges of 2.5, 2.7 and 2.9 V at 25 °C.

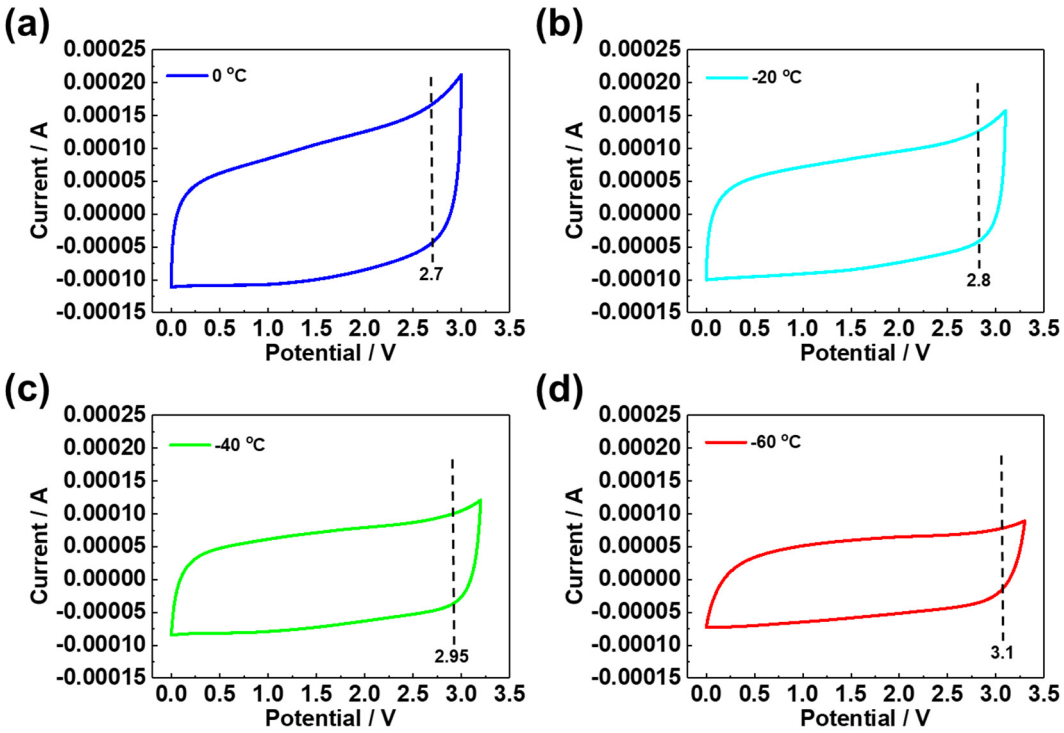

图 S2　(a) 0 °C、(b) −20 °C、(c) −40 °C 和(d) −60 °C 下 Swagelok 型双电极测试体系中 rHGO 电极 10 mV·s^{-1} 扫速下的 CV 曲线

Fig. S2　CV curves of rHGO electrodes at a scan rate of 10 mV·s^{-1} in a Swagelok cell at (a) 0, (b) −20, (c) −40, and (d) −60 °C.

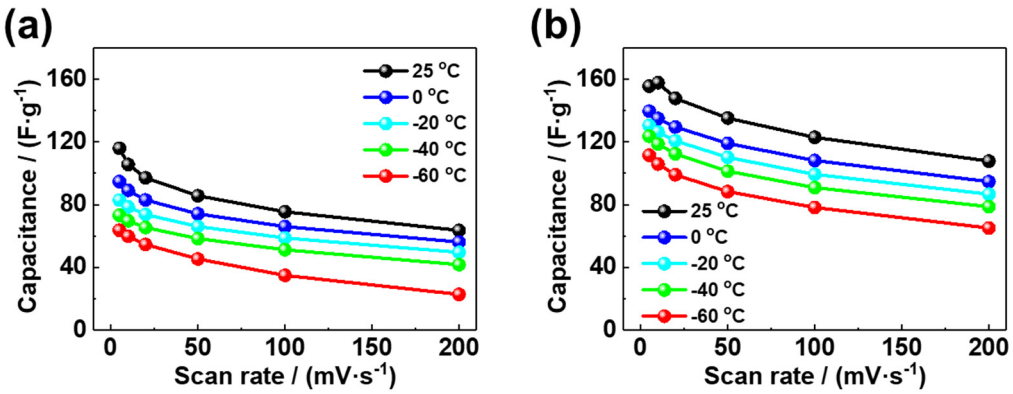

图 S3　(a) rGO 和(b) rHGO 超级电容在−60 至 25 °C 不同温度下和不同扫速下的单电极比电容

Fig. S3　Specific capacitance based on single electrode of (a) rGO and (b) rHGO supercapacitors at different scan rates within a temperature range of −60 to 25 °C.

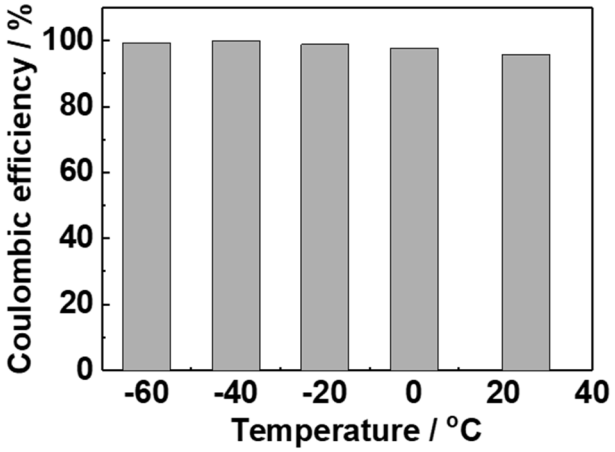

图 S4　−60 至 25 °C 范围内不同温度下 rHGO 超级电容在 1 A·g^{-1} 电流密度下的库伦效率

Fig. S4　Coulombic efficiency of rHGO supercapacitor at different temperatures from −60 to 25 °C with a current density of 1 A·g^{-1}.

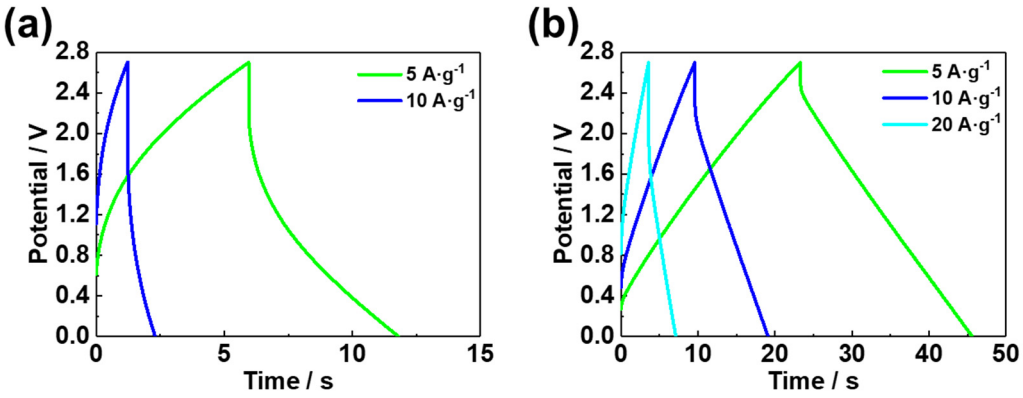

图 S5　−60 °C 时(a) rGO 超级电容在 5 和 10 A·g^{-1} 电流密度下的 GCD 曲线，
(b) rHGO 超级电容在 5、10 和 20 A·g^{-1} 电流密度下的 GCD 曲线

Fig. S5　(a) GCD curves of rGO supercapacitor at current densities of 5 and 10 A·g^{-1} at −60 °C.
(b) GCD curves of rHGO supercapacitor at current densities of 5, 10 and 20 A·g^{-1} at −60 °C.

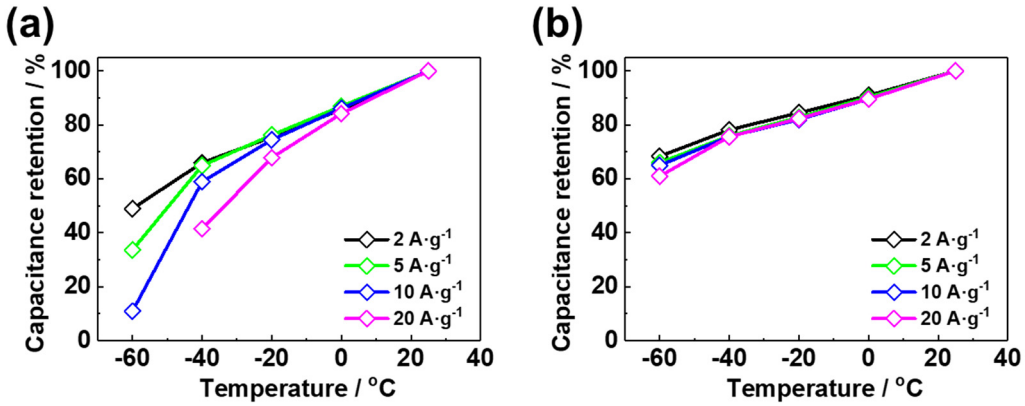

图 S6　2 至 20 A·g^{-1} 电流密度下(a) rGO 和(b) rHGO 超级电容在−60 至 25 °C 范围内不同温度下的电容保持率

Fig. S6　Capacitance retention of (a) rGO and (b) rHGO supercapacitors at different temperatures from −60 to 25 °C with current densities from 2 to 20 A·g^{-1}.

表 S1　rGO 电极的等效电路中的阻抗成分拟合值

Table S1　Fitting results for resistive elements in the equivalent circuit of rGO electrode.

Temperature/°C	R_s/Ω	R_{ct}/Ω	R_w/Ω
25	0.49	11.7	20.7
0	0.55	13.5	39.6
−20	0.89	15.3	69.5
−40	0.97	17.2	183
−60	2.29	22.6	665

表 S2　rHGO 电极的等效电路中的阻抗成分拟合值

Table S2　Fitting results for resistive elements in the equivalent circuit of rHGO electrode.

Temperature/°C	R_{st}/Ω	R_{ct}/Ω	R_w/Ω
25	0.28	9.9	8.9
0	0.25	11.8	13.9
−20	0.36	13.8	22.1
−40	0.62	16.5	36.1
−60	1.57	18.7	96.1