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Freestanding three-dimensional graphene and polyaniline nanowire arrays hybrid foams for high-performance flexible and lightweight supercapacitors

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The Preparation of Graphene Oxide

Graphite oxide was prepared from natural graphite powder by oxidation with $KMnO_4$ in concentrated H_2SO_4 according to Hummers' method.[1] Concentrated H_2SO_4 (46 mL) was poured into the 250 mL three neck flask and stirred in an ice bath until the temperature dropped to 0-3 ℃. Natural graphite (2 g) and $NaNO_3$ (1 g) were added and stirred uniformly. $KMnO_4$ (30 g) was gradually added with stirring and cooling in order to keep the temperature below 20 ℃. The solution was heated to 35±3 ℃and maintained for 30 min. Then, distilled water was slowly added, and the temperature was controlled lower than 100 ℃. After 15 min, this reaction was terminated by addition of a large amount of distilled water and 30% H_2O_2 solution (5 mL). The mixture was filtered and washed with 5% HCl aqueous solution and water. The sample of graphite oxide was obtained after drying. To prepare graphene oxide, 500 mg graphite oxide was dispersed in 100 mL of water, and the exfoliation of graphite oxide to graphene oxide was achieved by sonication with a cylindrical tip for 30 min.

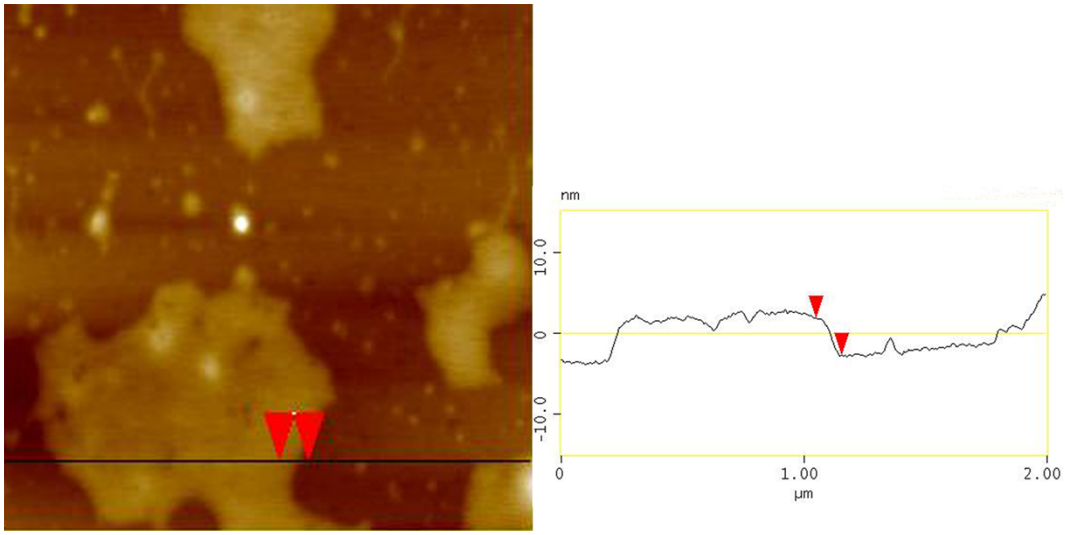

Figure S1. AFM image and cross-section analysis of RGO sheets. It shows that the height of RGO sheet is 4.52 nm. The thickness of a single graphene sheet obtained by AFM was reported to be ~0.8 nm,[2, 3] it suggest that the RGO sheet prepared in this study contained 6-8 layers.

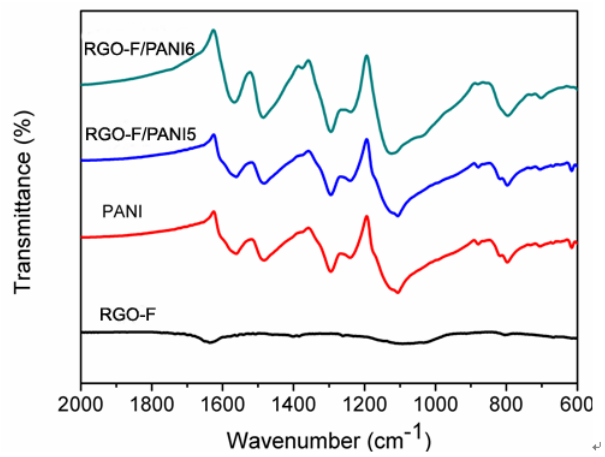

Figure S2. FTIR spectra of RGO-F, PANI, RGO-F/PANI5 and RGO-F/PANI6 composites. Compared to that of RGO-F, several typical bands can be observed for PANI, RGO-F/PANI5 and RGO-F/PANI6, indicating that PANI has been successfully synthesized in the composites as prepared. The bands at 1558 and 1431 cm^{-1} are assigned to C=C stretching vibrations of quinoid and benzenoid rings, respectively. The bands of aromatic C–N, C=N and C–H stretching vibration at 1298, 1240 and 1078 cm^{-1} also can be clearly recognized, respectively.[4] This result indicates that PANI is in the proton doped emeraldine salt state.

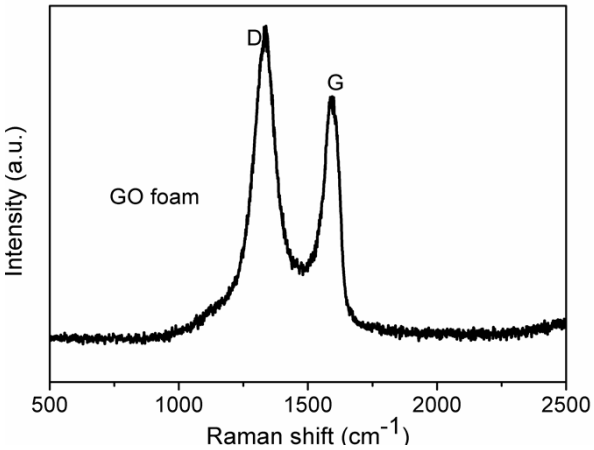

Figure S3. Raman spectrum of GO foam. The I_D/I_G ratio is 1.12 for GO foam higher than that of RGO-F foam (0.95), suggesting that RGO-F foam has less order structure after chemical reduced.

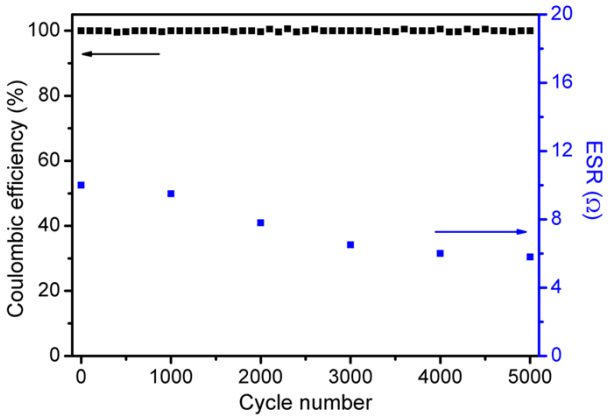

Figure S4. The plots of Coulombic efficiency (left axis) and ESR (right axis) for RGO-F/PANI5 electrode as a function of cycles.

Table S1. XPS data of RGO-F and RGO-F/PANI compsoites.

	C (atom%)	O (atom%)	N (atom%)
RGO-F	88.58	11.42	0
RGO-F/PANI5	86.78	11.64	1.58
RGO-F/PANI6	84.40	11.96	3.64

References:

(1) WILLIAM S. HUMMERS, J., OFFEMAN, R.E. Preparation of Graphitic Oxide. **1958**.

(2) Zhao, X., Zhang, Q., Hao, Y., Li, Y., Fang, Y., Chen, D. Alternate Multilayer Films of Poly(vinyl alcohol) and Exfoliated Graphene Oxide Fabricated via a Facial Layer-by-Layer Assembly. *Macromolecules.* **2010**, *43*, 9411-9416.

(3) Zhao, X., Zhang, Q., Chen, D., Lu, P. Enhanced mechanical properties of graphene-based poly(vinyl alcohol) composites. *Macromolecules.* **2010**, *43*, 2357-2363.

(4) Li, Y., Zhao, X., Xu, Q., Zhang, Q., Chen, D. Facile preparation and enhanced capacitance of the polyaniline/sodium alginate nanofiber network for supercapacitors. *Langmuir.* **2011**, *27*, 6458-6463.