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Supplementary Data

Synergistic effect of nitrogen doping and para-phenylenediamine functionalization on the physicochemical properties of reduced graphene oxide for electric double layer supercapacitor in organic electrolyte

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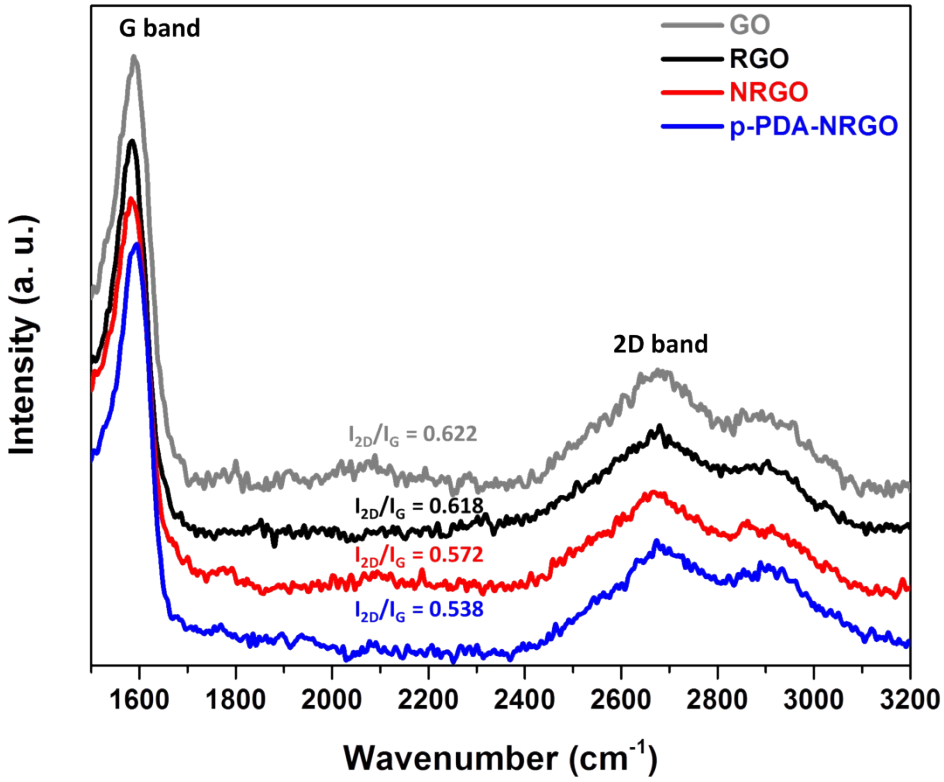

Fig. S1 G band and 2D band of Raman spectra and their I_{2D}/I_G values for GO, RGO, NRGO and p-PDA-NRGO.

Table S1. Atomic contents of GO, RGO, NRGO and p-PDA-NRGO for carbon, oxygen, nitrogen and sulfur and the calculated C/O ratio

Samples	C (at%)	O (at%)	N (at%)	S (at%)	C/O
GO	70.47	27.78	0.45	1.3	2.53
RGO	81.96	16.56	1.27	0.21	4.94
NRGO	79.66	15.46	4.02	0.86	5.15
p-PDA-NRGO	80.07	11.97	7.5	0.46	6.68

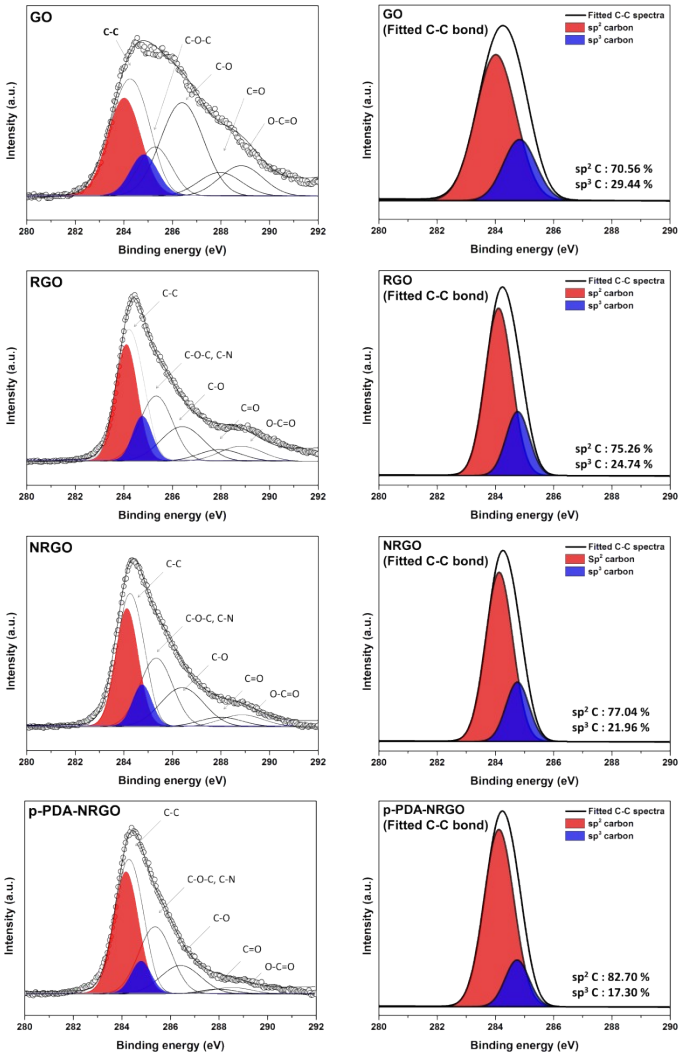

Fig. S2 Deconvoluted fitted C-C spectra into sp^2 and sp^3 carbon components in C1s spectra of GO, RGO, NRGO and p-PDA- NRGO.

Table S2. Relative ratio of nitrogen configuration in GO, RGO, NRGO and p-PDA-NRGO.

Samples	N-6 (%)	N-5 (%)	N-Q (%)	C-NH_4^+ (%)
GO	-	-	-	-
RGO	31.12	41.05	21.20	6.63
NRGO	44.26	30.73	16.80	8.2
	N-6/–N= (%)	N-5/-NH- (%)	N-Q/-N+- (%)	C-NH_4^+ (%)
p-PDA-NRGO	46.33	40.98	8.52	4.17

Table S3. Absolute ratio of nitrogen configuration in GO, RGO, NRGO and p-PDA-NRGO considering the atomic content of nitrogen in the corresponding materials.

Samples	N-6 (at%)	N-5 (at%)	N-Q (at%)	C-NH_4^+ (at%)
GO	-	-	-	-
RGO	0.3952	0.5213	0.2692	0.0842
NRGO	1.779	1.235	0.6753	0.3307
	N-6/–N= (at%)	N-5/-NH- (at%)	N-Q/-N+- (at%)	C-NH_4^+ (at%)
p-PDA-NRGO	3.474	3.0735	0.639	0.3135

Table S4. Calculated specific surface area and total pore volume values of GO, RGO, NRGO and p-PDA-NRGO.

Samples	Specific surface area (m^2/g)	Total pore volume (cm^3/g)
GO	124.64	0.2625
RGO	630.16	0.6361
NRGO	356.61	0.3288
p-PDA-NRGO	582.85	0.4696

Table S5. Measured resistance value of RGO and p-PDA-RGO by using 4-point probe measurements technique. (Unit : Ω/cm^2)

Samples	Measured resistance value
GO	-
RGO	24.3
NRGO	12.5
p-PDA-NRGO	13.1

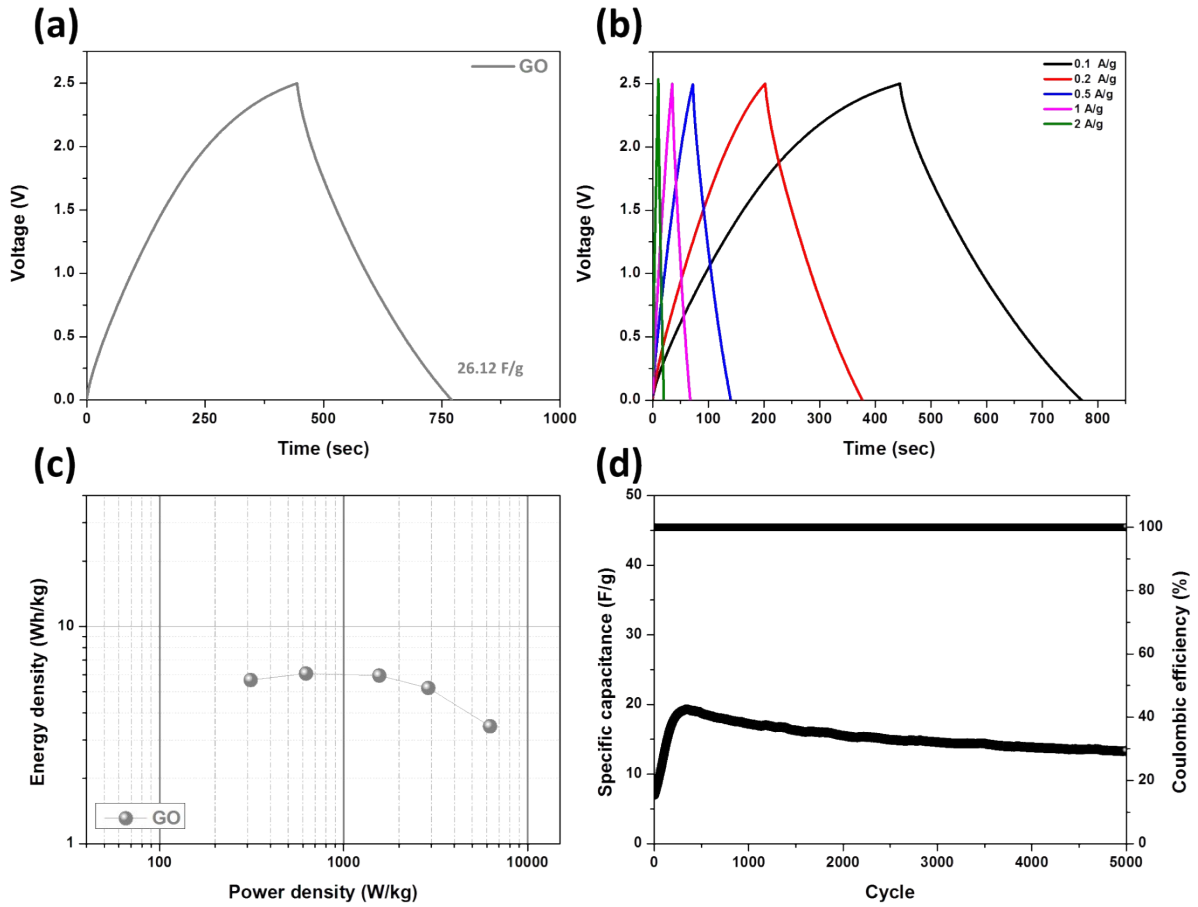

Fig. S3 Electrochemical performances of GO; (a) Galvanostatic charge/discharge curves at 0.1A/g, (b) galvanostatic charge/discharge curves at various current densities from 0.1A/g to 2A/g, (c) Ragone plots and (d) cycling performance measured at 1A/g up to 5000th cycle.

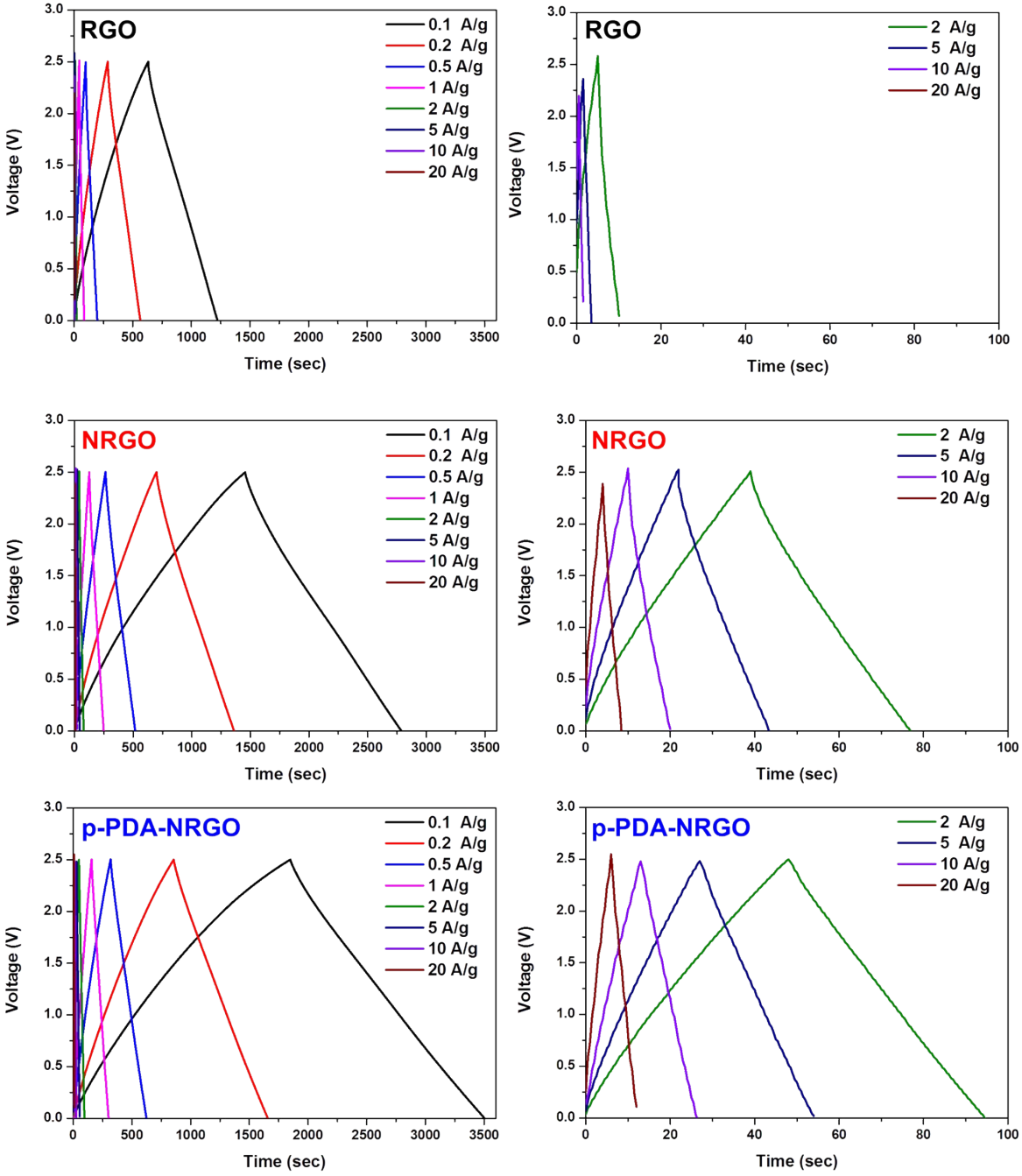

Fig. S4 Detailed galvanostatic charge-discharge curves of RGO, NRGO and p-PDA-NRGO obtained at various current densities from 0.1A/g to 20A/g

Table S6. Table for the comparison of specific capacitance value calculated in electrode and coin cell

Specific capacitance ($F/g_{electrode}$, F/g)								
Current density (A/g)	**0.1**	**0.2**	**0.5**	**1**	**2**	**5**	**10**	**20**
GO	26.12	28	27.4	24	16	-	-	-
RGO	47.4	44.6	39.44	33.84	24.2	20.92	18.04	15.28
NRGO	108.8	106.52	103.08	98.68	90.8	87.72	81	71.6
p-PDA-NRGO	133.48	128.72	122.64	115.2	111.28	107.96	105.2	98.4
Specific capacitance ($F/g_{coin\ cell}$, mF/g)								
Current density (A/g)	**0.1**	**0.2**	**0.5**	**1**	**2**	**5**	**10**	**20**
GO	6.79	7.28	7.12	6.24	4.16	-	-	-
RGO	12.3	11.6	10.3	8.80	6.29	5.44	4.69	3.97
NRGO	28.3	27.7	26.8	25.7	23.6	22.8	21.1	18.6
p-PDA-NRGO	34.7	33.5	31.9	30.0	28.9	28.1	27.4	25.6

Table S7. Table for the comparison of energy density and power density value calculated in electrode and coin cell

Energy density (E.D) & Power density (P.D) of electrode							
GO		RGO		NRGO		p-PDA-NRGO	
P.D (W/kg)	**E.D (Wh/kg)**	**P.D (W/kg)**	**E.D (Wh/kg)**	**P.D (W/kg)**	**E.D (Wh/kg)**	**P.D (W/kg)**	**E.D (Wh/kg)**
312.5	5.6684	62.71169	10.28646	62.5	23.61111	62.48128	28.96701
625	6.07639	125.5631	9.67882	124.8593	23.11632	125.0777	27.93403
1562.5	5.94618	312.8173	8.55903	316.4293	22.36979	312.602	26.61458
2884.615	5.20833	622.0588	7.34375	629.3367	21.41493	620.6897	25
6250	3.47222	1890.625	5.25174	1866.776	19.70486	1869.624	24.14931
		3268.75	4.53993	3115.057	19.03646	3123.843	23.42882
		5637.5	3.91493	6328.125	17.57813	6322.115	22.82986
		11937.5	3.31597	12430.56	15.53819	11826.92	21.35417
Energy density (E.D) & Power density (P.D) of coin cell							
GO		RGO		NRGO		p-PDA-NRGO	
P.D (W/kg)	**E.D (Wh/kg)**	**P.D (W/kg)**	**E.D (Wh/kg)**	**P.D (W/kg)**	**E.D (Wh/kg)**	**P.D (W/kg)**	**E.D (Wh/kg)**
0.08125	0.001474	0.0163	0.00267	0.01625	0.00614	0.01625	0.00753
0.1625	0.00158	0.03266	0.00252	0.03245	0.00601	0.03253	0.00727
0.40625	0.001546	0.08122	0.00222	0.08227	0.00582	0.08126	0.00692
0.75	0.001354	0.16176	0.00191	0.16352	0.00556	0.16142	0.0065
1.625	0.000903	0.49062	0.00136	0.4852	0.00512	0.48589	0.00628
		0.85	0.00118	0.80966	0.00495	0.8125	0.00609
		1.4625	0.00102	1.64375	0.00457	1.64423	0.00594
		3.10375	8.62E-04	3.22917	0.00404	3.07692	0.00556