Supplementary information

An ultra-effective pathway for fully removing the oxygen components of graphene oxide by a flame-assisted microwave process

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Experimental sections

Synthesis of graphite oxide (GtO). GtO was prepared by a typical modified Hummers' method, and the detailed processes were seen in our previous works.

Synthesis of FRGO. In detail, a fully dried GtO paper got closed to the epitaxial flame of an alcohol lamp by using a steel tweezer. Once the color of the brown paper turned into black, the reaction was terminated. The whole process only took 1 second. The obtained black products are FRGO (Seen in Video 1).

Synthesis of MFRGO. The obtained FRGO was placed into an 800 W household microwave oven. After < 3-seconds microwave pulse, the MFRGO was obtained (Seen in Video 2).

Physical measurements. Microstructure was observed by a FEI NanoSEM 450 field-emission scanning electron microscopy (FE-SEM) at a voltage of 10 kV and a TEM-2100F transmission electron microscopy (TEM) at a voltage of 200 kV. And energy dispersive X-ray (EDX) analysis was performed on the FEI NanoSEM 450. A Thermo Scientific K-Alpha X-ray photoelectron spectroscopy

(XPS) was employed to investigate the content of the obtained materials. X-ray diffraction (XRD) technology (PANalytical X'Pert powder) was used to identify the change of materials. Raman spectra were collected by a LabRAM HR Evolution spectrophotometer. A Quadrasorb 2MP analyzer was employed to investigate the pore distribution and specific surface area of the obtained materials.

Electrochemical measurements. A CHI760E electrochemical workstation (Shanghai Chenhua, China) was employed to perform all electrochemical measurements. The used electrolyte solution is 2M KOH aqueous solution. Pt sheet (2×2 cm) as counter electrode, saturated calomel electrode (SCE) as reference electrode, and working electrode fabricated by directly pressing ~ 2 mg MFRGO into two Ni foams with 1×2 cm at 8 Mpa for 10 min constituted the typical three-electrode system. The cyclic voltammetry (CV) process was carried out at the scan rate from 10 to 1000 mV s^{-1} in the voltage window of -1-0 V, respectively. Galvanostatic charge/discharge (GCD) process was performed within the potential window from -1 to 0 V at various current densities. Electrochemical resistance spectroscopy (EIS) was collected in the frequency range of 0.01-106 Hz.

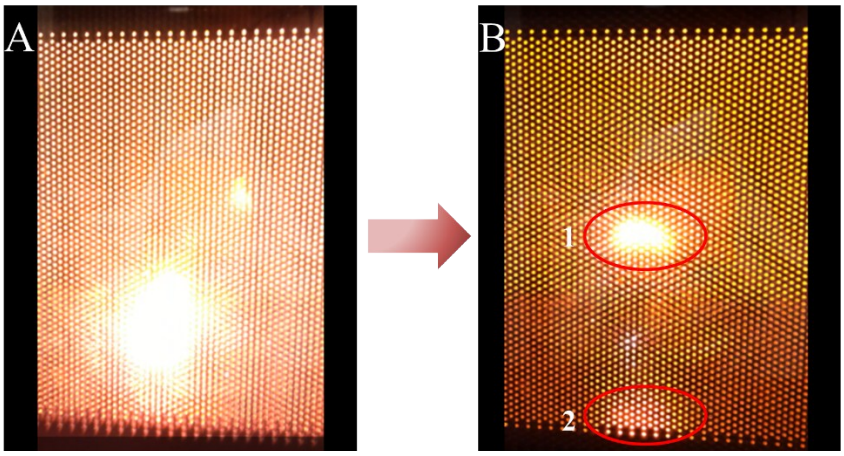

Figure S1. Flash and flame produced in the microwave process.

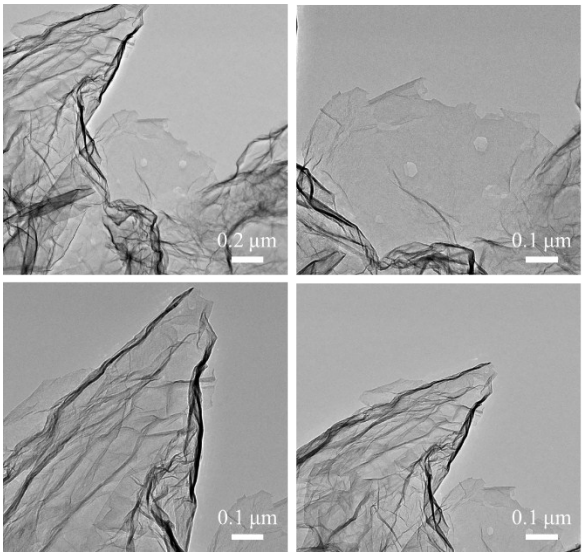

Figure S2. TEM images of MFRGO.

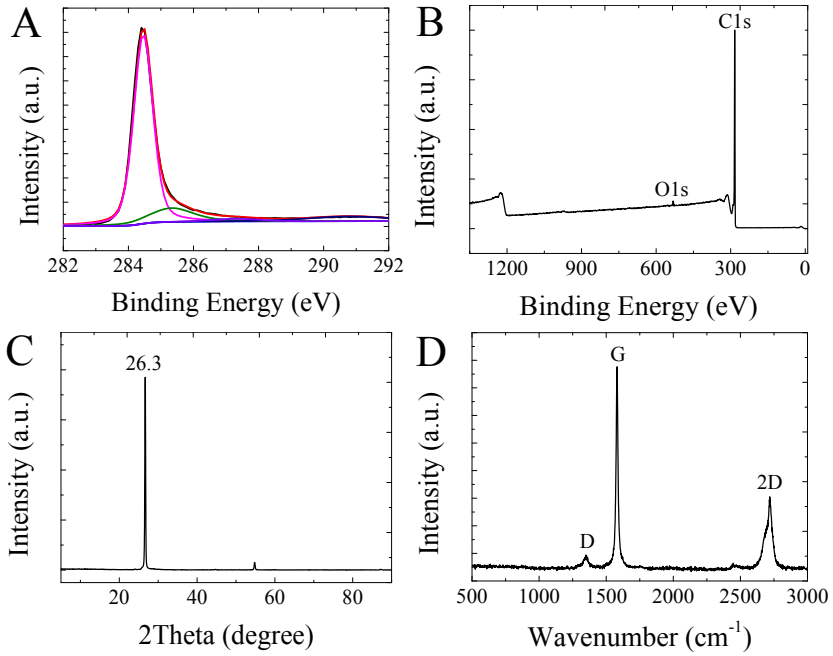

Figure S3. A) XRD pattern of graphite. B) Raman spectrum of graphite. C) C1s XPS spectrum of graphite. D) XPS survey spectrum of graphite.

Table S1. Analysis of components.

	C (at.%)	O (at.%)
MFRGO	96.88	3.12
graphite	98.37	1.63

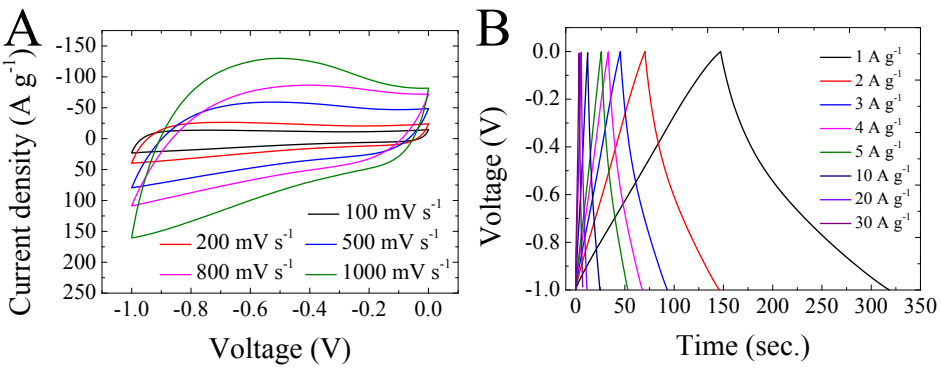

Figure S4. A) CV curves of MFRGO at various scan rates. B) GCD curves of MFRGO at different current densities.

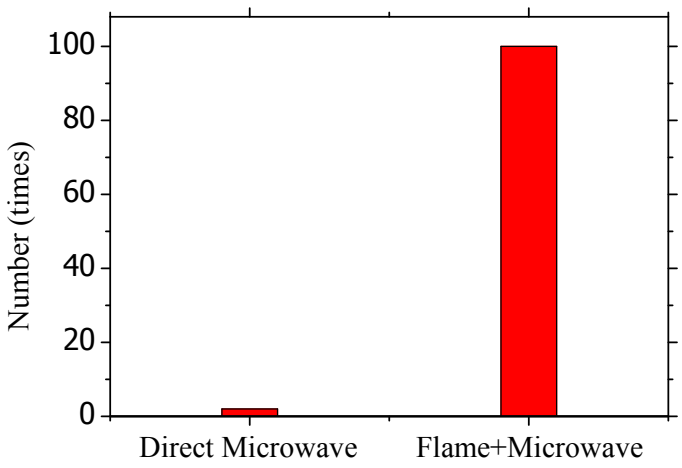

Figure S5. A comparative data of 100 tests between the direct microwave and flame-assisted microwave methods. In terms of the direct microwave method, the microwave process is the same as

the literature. The GO was directly handled by the microwave irradiation for 1 min.

Table S2. Comparison of typical as-reported reduction methods.

Method	Conditions	C/O atom	Reference
Chemical reduction	Hydrazine, 80 ℃, 12 h	10.2	*Carbon*, 2011, 49, 3019–3023
	55% hydrohalic acids, 100 ℃, 1 h	12	*Carbon*, 2010, 48, 4466–4474
	Sodium borohydride, 48 h	5.3	*Adv. Funct. Mater.*, 19, 2009, 1987–1992
	Benzyl alcohol, 100 ℃, 5 d	30	*J. Mater. Chem.*, 2011, 21, 3443–3447
	Lycium barbarum, 95 ℃, 30 min	6.5	*J. Solid State Chem.*, 2017, 246, 351–356
	Alanine, 85 ℃, 24 h		*Mater. Sci. Eng. C,* 2017, 72, 1-6.
	Chrysanthemum, 95 ℃, 24 h	4.96	*Mater. Chem. Phys.,* 2016, 183, 76-82.
	Vitamin C, 95 ℃, 2 h		*J. Mater. Chem. A,* 2018,6, 7777-7785
Hydrothermal/ solvothermal reduction	NMP, 180 ℃, 1 h	9.7	*J. Mater. Chem.*, 2011, 21, 3371–3377
	Water, 200 ℃, 16 h	21	*Carbon*, 2008, 46, 1994–1998
	Water, 180 ℃, 16 h	5.6	*Chem. Mater.*, 2009, 21, 2950–2956
	Methanol, vanadium chloride, 180 ℃, 6 h	11.9	*Mater. Chem. Phys.,* 2019, 229, 319-329.
	Water, 180 ℃, 24 h		*Phys. Lett. A,* 2019, 380(38), 3128-3132
Thermal annealing	1000 ℃, 1 h	18.3	*Adv. Funct. Mater.*, 2015, 25, 4664–4672
	Melamine, 800 ℃, 1 h	11.8	*ACS Nano*, 2011, 5, 4350–4358
	1050 ℃, 30 s	13.2	*J. Mater. Chem.*, 2011, 21, 5392–

			5397
	H_2, 800 ℃, 12 h	25.3	*Adv. Funct. Mater.*, 2010, 20, 1930–1936
	800 ℃, 2 h		*Mater. Chem. Phys.,* 2018, 204, 1-7.
	1700 ℃, 2 h		*Nanomaterials,* 2017, 7, 428-1
	1225 ℃, 250 ps		*Carbon,* 2016, 100, 90-98
Photothermal reduction	Camera flash, <1 s	4.23	*J. Am. Chem. Soc.*, 2009, 131, 11027–11032
	H_2, 500 W UV lamp, 2 h	4.5	ACS Appl. Mater. Interfaces, 2010, 2, 3461–3466
	Nd:YAG laser (355 nm), 10 ns	16.9	*Chem. Asian J.*, 2012, 7, 301–304
	Camera flash	15.6	*ACS Nano*, 2012, 6, 7867–7878
	IR irradiation, N_2, 26 s	8.3	*Nanoscale,* 2013, 5, 9040-9048
	Camera flash light, 1 h		*Front. Chem. Sci. Eng.,* 2018, 12(3), 376-382
	UV irradiation, 5 h	4.8	*New J. Chem.,* 2019, 43, 681-688
	IPL irradiation, 500 μs		*Applied Surface Science,* 2018, 459, 732-740
Microwave induction	700 W, 1 min	2.75	*Carbon*, 2010, 48, 2106–2122
	Pre-reduction at 300 ℃ for 1 h, 1000 W, < 2 s	24	*Science*, 2016, 353, 1413–1415
	Catalysis, 1000 W, < 5 s	19.4	*Angew. Chem. Int. Ed.*, 2017, 56, 15677–15682
	Intermittent Microwave, 400 s	19.0	*J. Colloid. Interf. Sci.,* 2020, 565, 288–294
Flame induction	Naked flame, < 5 s	6.1	*J. Power Sources*, 2013, 222, 52–58
	Naked flame, several seconds	7.9	*J. Mater. Chem. A*, 2014, 2, 5730–5737
	Freeze drying, naked flame, < 1 s	11.3	*J. Alloy. Compd.*, 2019, 782, 17–27

	Naked flame, <1 s	10.4	*J. Mater. Chem. C,*2015, 3,2788-2791
Plasma	Hydrogen plasma, 150 ℃	7.0	*J. Phys. Chem. Lett.*, 2012, 3, 772−777
	H_2/NH_3 plasma (500 W), 1 h	5.2	*J. Mater. Chem. A*, 2013, 1, 4431–4435
	Ar plasma, 15 min		*Light-Sci. Appl.*, 2016, 5, 16130-1
	H_2 plasma, 3 min		*Chem. Commun.,* 2016, 52, 10988-10991
Flame+microwave	**Naked flame induction, <1 s; microwave (800 W) irradiation, < 3 s**	**31.1**	**This work**