Supporting Information

Porous B-doped Graphene Inspired by Fried-Ice for Supercapacitors and Metal-Free Catalysts

Zicheng Zuo, Zhongqing Jiang, and Arumugam Manthiram *

Electrochemical Energy Laboratory & Materials Science and Engineering Program
University of Texas at Austin, Austin, TX 78712, USA;
* Address correspondence to

E-mail: manth@austin.utexas.edu,

Tel.: +1-512-471-1791; Fax: +1-512-471-7681.

The specific capacitance of these samples from galvanostatic charge/discharge curves are calculated as

$$Cs = \frac{I\Delta t}{m\Delta V}$$

where I is the constant current and m is the total mass for both carbon electrodes, Δt is the discharge time and ΔV is the voltage change during the discharge process.

The specific capacitance derived from cyclic voltammograms as

$$Cs = \frac{A}{f \bullet \Delta V \bullet m}$$

where A is the integral areas of the cyclic voltammogram loops, f is the scan rate, ΔV is the voltage window, and m is the mass of the electrode.

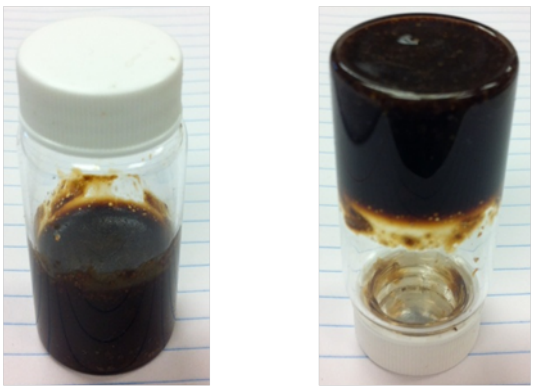
The electron transfer numbers at these three electrodes can be derived from the equation of Koutechy-Levich plot [1, 2] showing blow:

$$\frac{1}{j} = \frac{1}{j_k} + \frac{1}{B\omega^{0.5}} \qquad (1)$$

in which j is the current density at appointed voltage, j_k is the kinetic current and ω is the electrode rotating rate (rpm). The parameter B at different applied voltage could be obtained from the slope of the K-L plots in Figure S7. Meanwhile, the electron transfer number at different voltage is connected with parameter B according to the Levich equation as following in the alkaline aqueous solution [2]:

$$B = 0.2nF(D_{O2})^{2/3}v^{-1/6}C_{O2} \qquad (2)$$

where n represents the overall electron transfer number per oxygen molecule, F is the Faraday constant with the value of 96485 C mol $^{-1}$, D_{O2} is the diffusion coefficient of O_2 in 0.1 M KOH (1.9×10^{-5} cm ^{2} s $^{-1}$), ν is the kinetic viscosity (0.01 cm ^{2} s $^{-1}$), and C_{O2} is the bulk concentration of O_2 (1.2×10^{-6} mol cm $^{-3}$). The constant 0.2 is adopted when the rotation speed is expressed in rpm in alkaline aqueous solution.



a b

Figure S1. Photo image of the gel-like GO sediment before and after freezing.

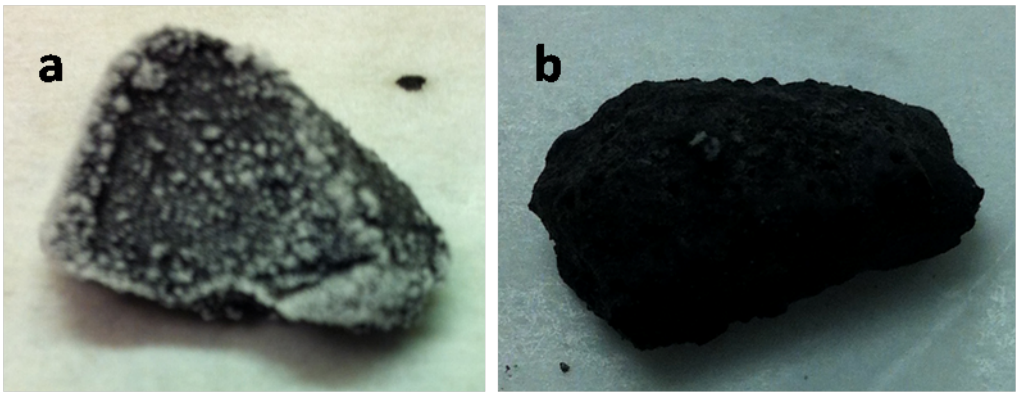


Figure S2. Photo image of the frozen GO monolith before thermal treatment (a) and the as-prepared porous graphene monolith after thermal treatment (b)

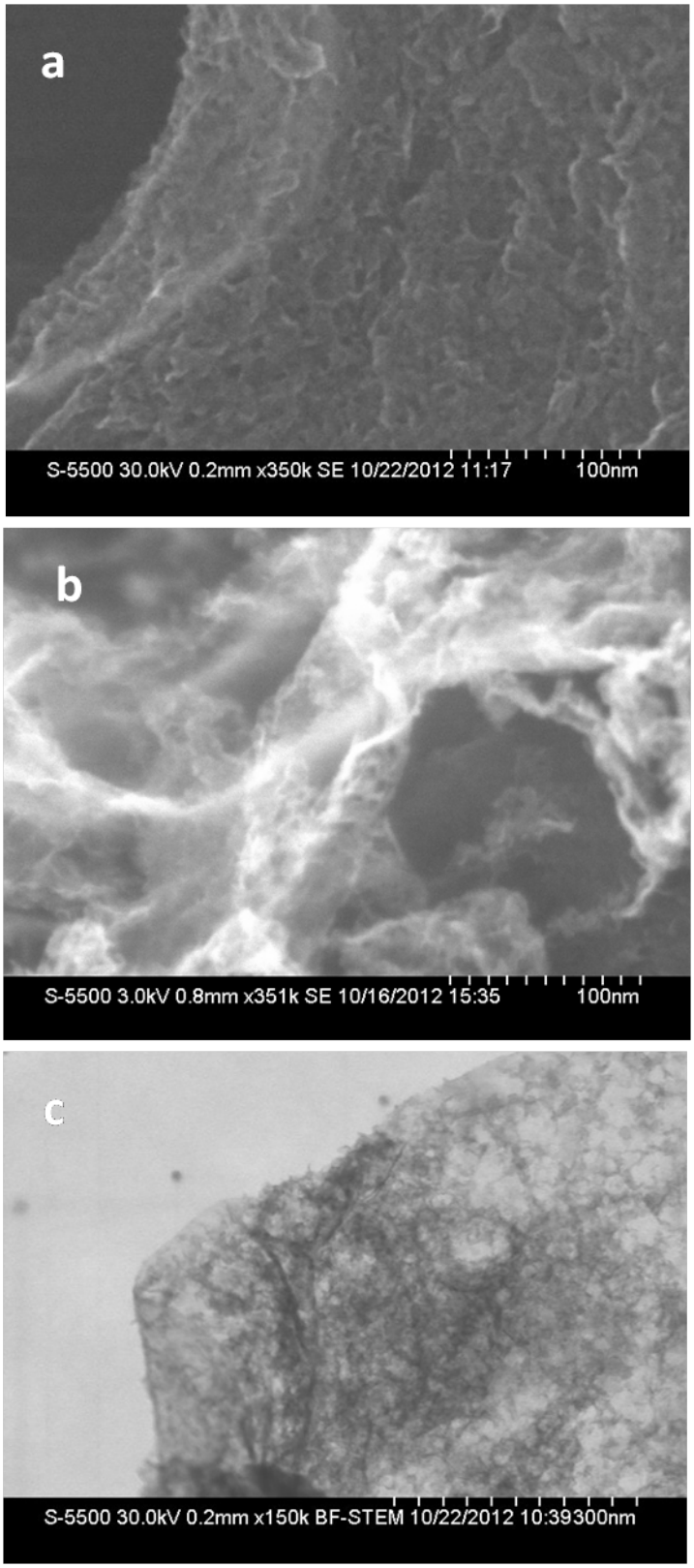


Figure S3. Magnified SEM images of B-G 600 (a), B-G 800 (b), and STEM image of B-G 800 (c).

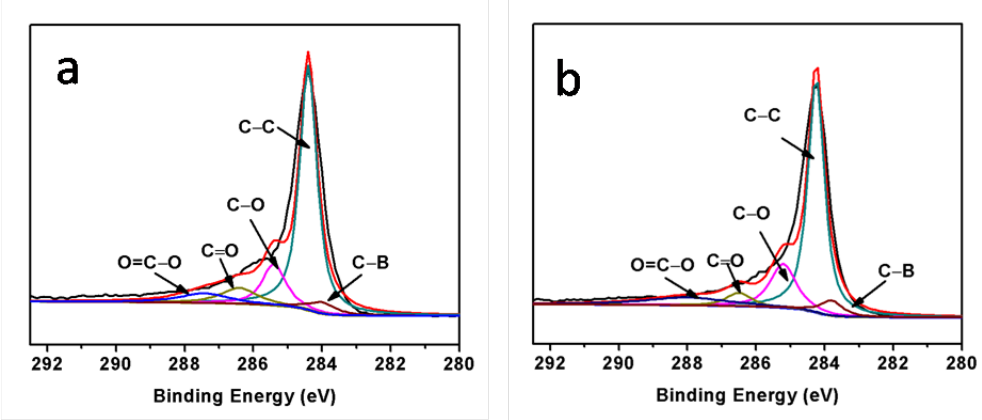


Figure S4. C1s spectrum of (a) B-G 600 and (b) B-G 800.

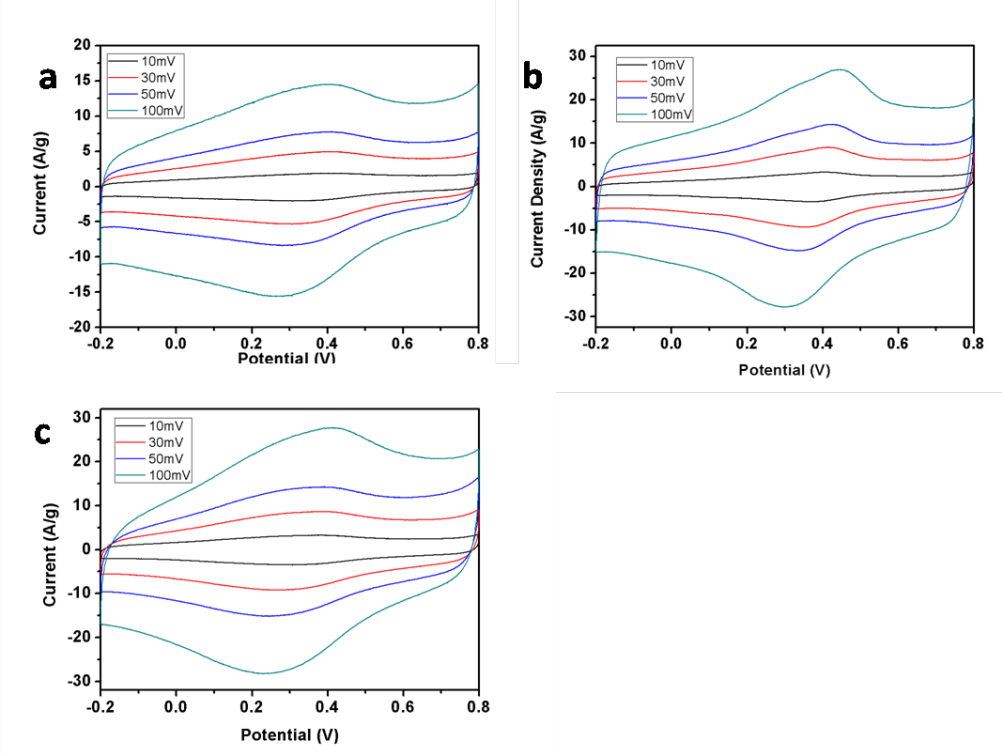


Figure S5. Cyclic voltammetry (CV) curves of 3-D porous graphene framework in a three electrode system in 2 M H_2SO_4 solution at the scan rate of 10, 30, 50, and 100 mV s^{-1}. (a) B-G 400, (b) B-G 600, and (c) B-G 800.

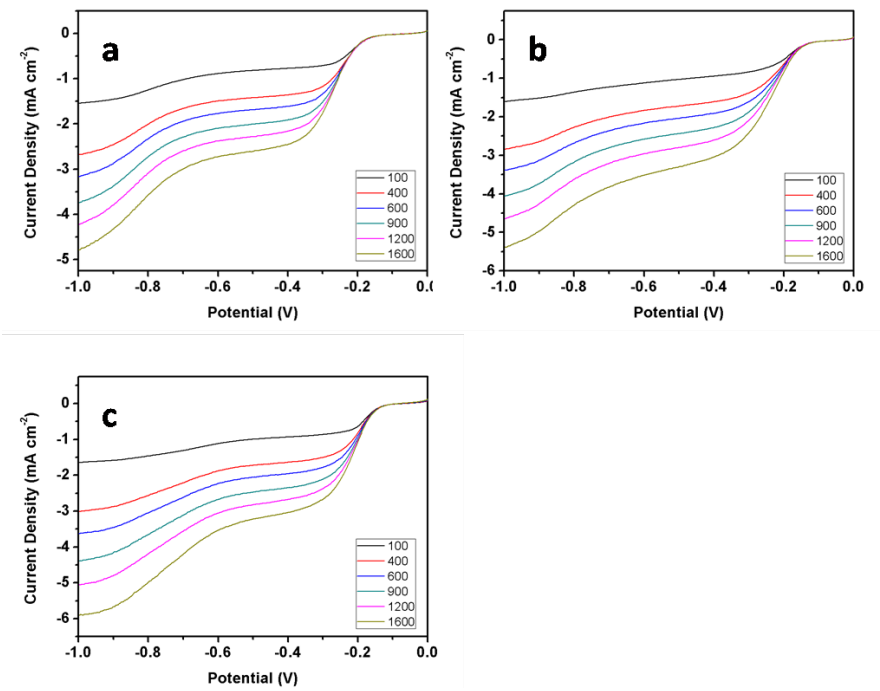


Figure S6. Linear sweep voltammetry curves of ORR at several designed rotation speed in the O_2-saturated 0.1 M KOH solution with the scan rate of 10 mV s^{-1}. a) B-G 400, (b) B-G 600, and (c) B-G 800.

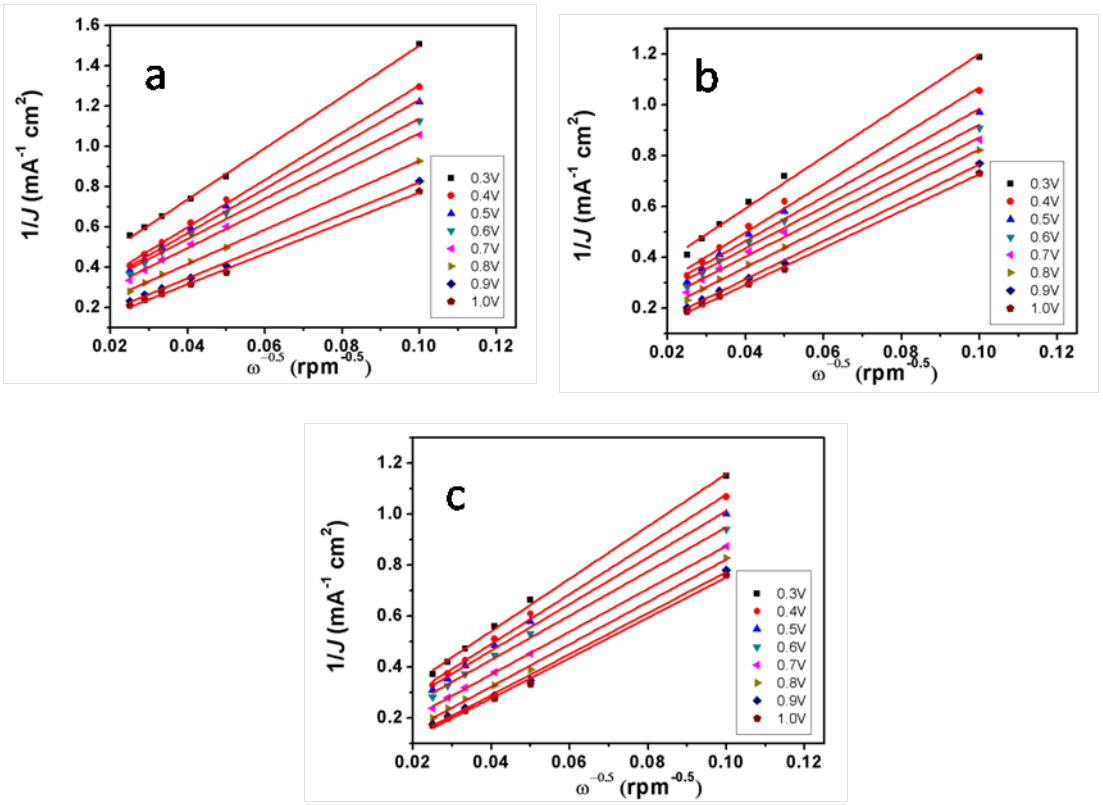


Figure S7. K-L plots of ORR at different applied potential of B-G 400 (a), B-G 600 (b), and B-G 800 (c).

References:

1. A. J. Bard, L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications.; Wiley: New York, 1980.

2. S. Wang, D. Yu, L. Dai, D. W. Chang and J.-B. Baek, Polyelectrolyte-Functionalized Graphene as Metal-Free Electrocatalysts for Oxygen Reduction. *ACS Nano* **2011,** *5*, 6202