Supporting Information

Three Dimensional Nanocomposite of Reduced Graphene Oxide and Hexagonal Boron Nitride as an Efficient Metal-Free Catalyst for Oxygen Electroreduction

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Experimental Details:

(a) Synthesis of Graphene Oxide (GO)

Graphene oxide was synthesized using a modified Hummer's method [49]. Briefly, 2.0 g graphite powder and 1.0 g $NaNO_3$ were mixed with 46 mL concentrated H_2SO_4. Afterwards, above mixture stirred together for 30 minutes and at vigorous condition 6.0 g $KMnO_4$ was slowly added under ice bath to prevent the temperature below the room temperature. Next, the mixtures was stirred and held at 35°C for 30 minute. Then 92 mL de-ionized water (DI) water was slowly added into system. Again stir the solution for 15 minute, after that 80 mL warm DI water was added. To reduce excess $KMnO_4$, a proper amount of 3% H_2O_2 aqueous solution was dropped into reaction until no bubbles were observed. The obtained mixture was centrifuged and the product was washed with 5% HCl to remove the residual metal impurities and finally with DI water up to neutral pH. As synthesized GO was collected by using freeze-drying.

Table S1. Comparison of experimental conditions, ORR activities and onset potentials for graphene based electrocatalysts

Catalyst	Preparation Method Used	Electrolyte	Reference electrode employed	Onset Potential (V vs RHE)[a]	Kinetic current density at 1600 rpm (mA cm^{-2})[a]	References
Cu_3N@CNT	Atomic layer deposition (ALD)	0.1 M KOH	Hg/HgO	0.66	N/A	15
CoP-nanocrystals	Hydrothermal	0.1 M KOH	RHE	0.80	N/A	16
Chemically drilled MWNT	Chemical drilling	0.1 M $HClO_4$	RHE	0.73	1.1 (@ 0.2 V)	17
TDMAC-reduced graphene oxide	Physiochemical process	0.1 M KOH	Ag/AgCl	0.76	2.7 (@ -0.2 V)	18
N, S co-doped carbon	CO impregnation	0.1 M KOH	Ag/AgCl	0.83	2.3 (@ 0.3 V)	19
N, P, S-tridoped graphene	Thermal annealing	0.1 M KOH	SCE	0.68	N/A	20
N doped-reduced graphene oxide	Ultrasonochemical	0.1 M KOH	NHE	0.87	2.0 (@ 0.2 V)	21
rGO/Co_3O_4	One-pot reaction	0.1 M KOH	Hg/HgO	0.72	N/A	22
Xerogel carbon/ PANFe	Pyrolysis	0.1 M H_2SO_4	NHE	0.67	N/A	23
C-N/ graphene compo.	Carbonization of polypyrrole	0.1 M KOH	Ag/AgCl	0.80	N/A	24
Py-N doped graphene	CVD	0.1 M KOH	Ag/AgCl	0.80	N/A	25
X-graph. nanoplatelets	Ball milling	0.1 M KOH	Ag/AgCl	0.83	N/A	26

N-doped graphene film	Organic synthesis route	0.1 M KOH	Ag/AgCl	0.86	1.1 (@ 0.2 V)	27
N-doped graphene oxide	Hydrothermal	0.1 M KOH	Ag/AgCl	0.79	N/A	28
N-doped graphene oxide	Hydrothermal	0.1 M KOH	SCE	0.80	N/A	29
B,N doped graphene quantum dots/graphene nanoplates	CVD	0.1 M KOH	Ag/AgCl	0.998	4.5 (@ 0.2 V)	30
B/N substituted carbon ribbons	Thermal reduction	0.1 M KOH	Ag/AgCl	1.00	3.5 (@ 0.2 V)	31
h-BN nanosheets supported on Au	Spin coating	0.5 M H_2SO_4	Ag/AgCl	0.70	1.6 (@ 0.2 V)	47
rGO/BN composite	**Hydrothermal method**	**0.1 M KOH**	**Ag/AgCl**	**0.798**	**3.0 (@ 0.2 V)**	**Present study**

[a] All potential have been mentioned against reversible hydrogen electrode (RHE) using standard conversion factor.

Figure S1. SEM image comparison of rGO/BN catalyst

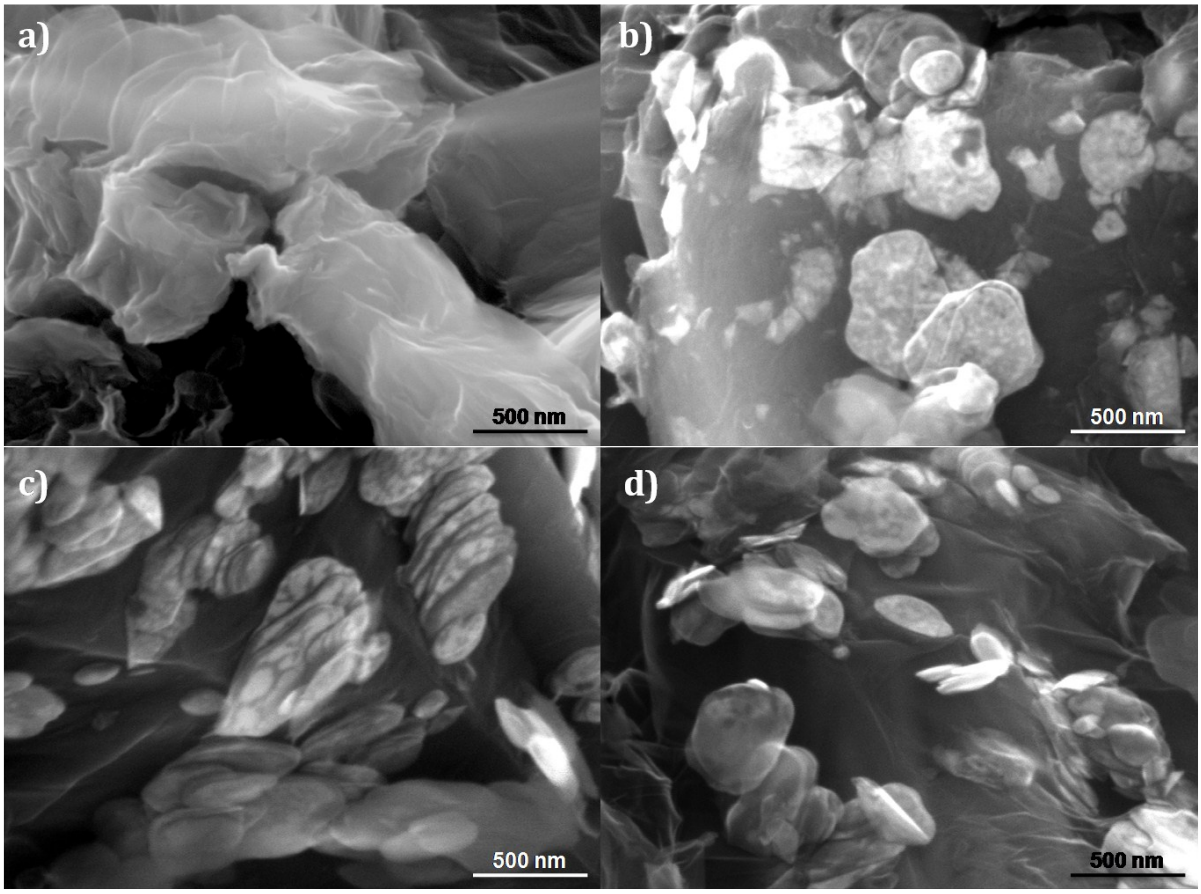

Figure S1. (a-d) A typical SEM images comparison of GO-750, GOBN3-750, GOBN7-750 and GOBN10-750 respectively**.**

Table S2. **Comparison of ORR activities of various electrocatalysts**

Catalyst	Onset (V vs RHE)	$E_{1/2}$ (V vs RHE)	Mass activity (mA/mg)
GO-750	0.73	0.57	40.12
GOBN3-750	0.725	0.52	48.98
GOBN5-750	**0.798**	**0.64**	**155.46**
GOBN7-750	0.72	0.51	39.9
GOBN10-750	0.74	0.59	60.79
Comm. Pt/C	1.0	0.88	227.4 (at 0.9 V)

Table S2. The onset potential, half wave potential (V vs RHE) and mass activity (mA/mg) comparison of various rGO/BN nanocomposite catalyst with commercial Pt/C (20 wt %).

Figure S2. SEM image of GOBN composite

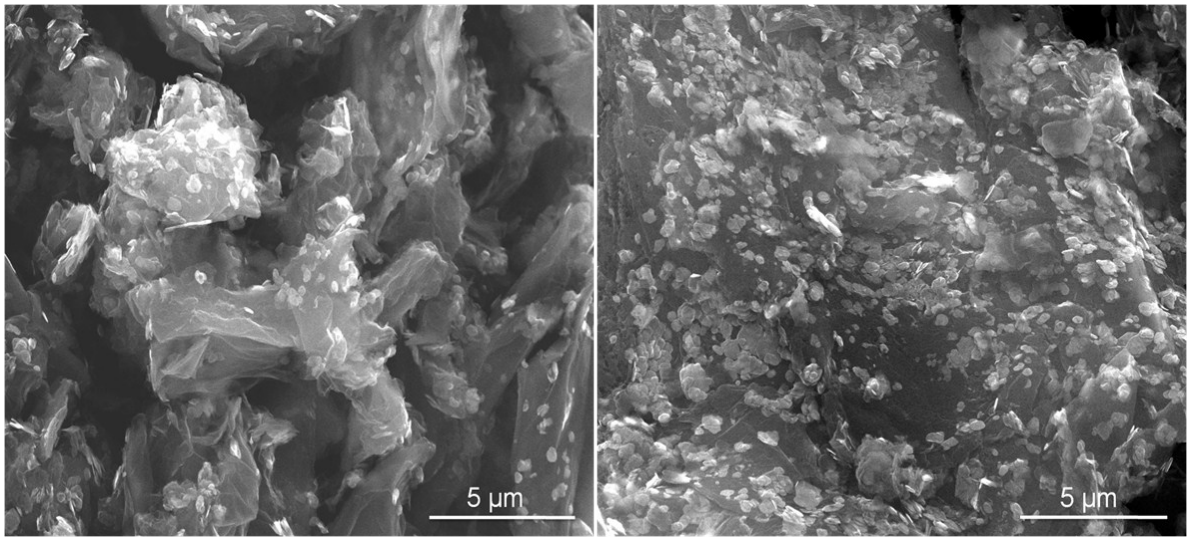

Figure S2. A low-magnification SEM image comparison of GOBN5 nanocomposite, before (left) and after (right) heat treatment at 750°C.

Figure S3. RRDE studies for GOBN5-750 catalyst

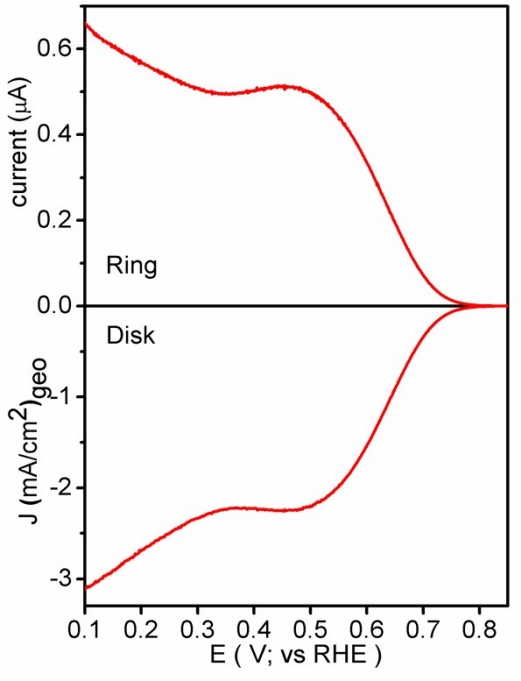

Figure S3. Disk current (bottom) and the corresponding ring current (top) for GOBN5-750 catalyst using RRDE at 1600 rpm in O_2-saturated 0.1 M KOH solution; (geo: geometric current density, sweep rate 10 mV/s).

Figure S4. **Comparative ORR polarization curves for different rGO/BN catalysts with at various rotating speed**

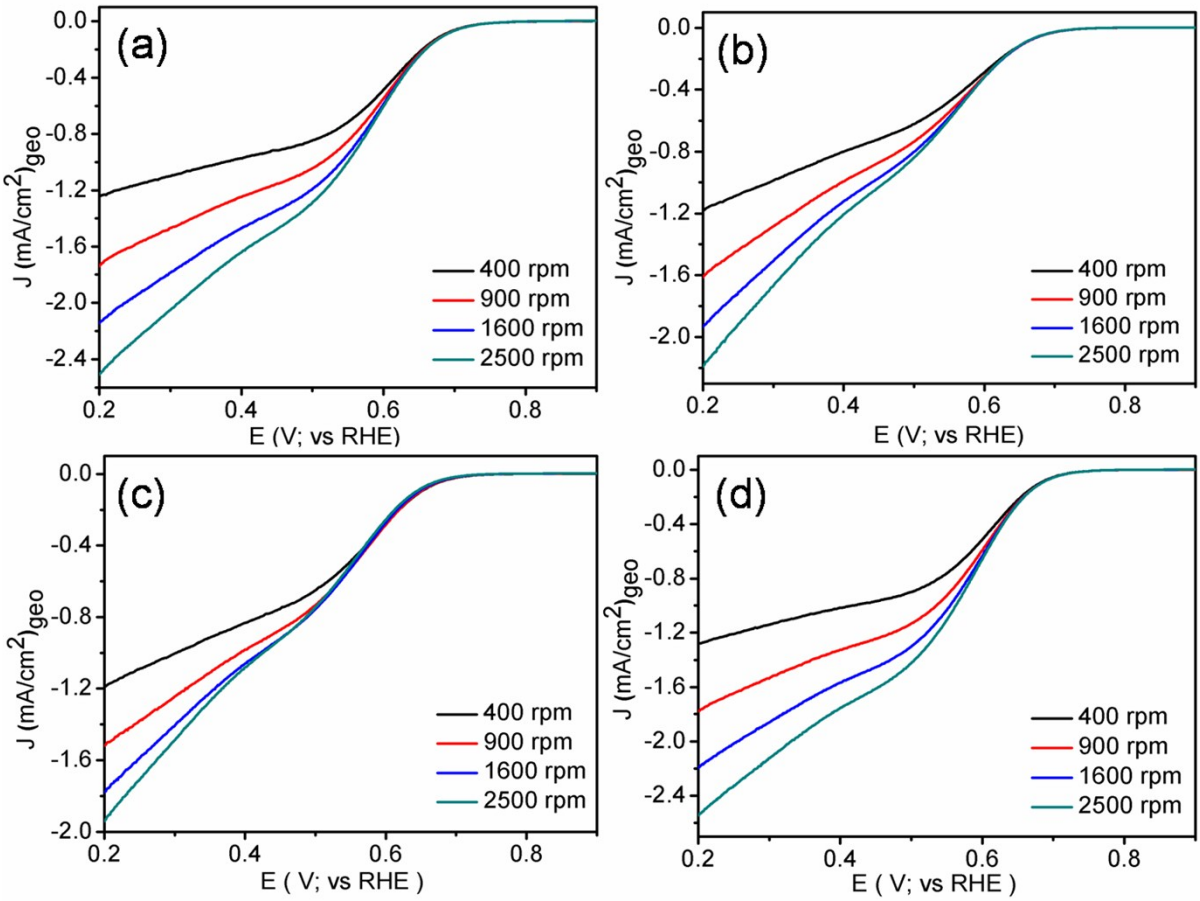

Figure S4. ORR polarization curves for (a) GO-750, (b) GOBN3-750, (c) GOBN7-750 and (d) GOBN10-750, in presence of O_2-saturated 0.1 M KOH at 25°C. (geo: geometric current density, sweep rate 10 mV/s).

Figure S5. Morphology comparison of GOBN5-750 catalyst after durability test

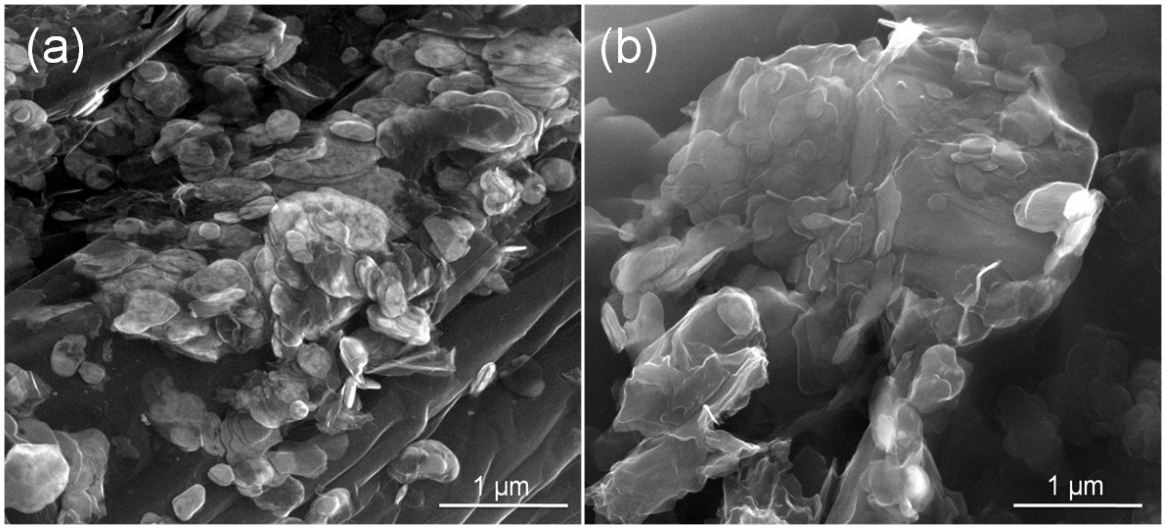

Figure S5. Comparative SEM images of GOBN5-750 electrocatalyst (a) before and (b) after durability test at 10000 cycles**.**