Electronic Supplementary Material (ESI) for Catalysis Science & Technology.

Supporting Information

For

Boron-doped Graphene as Electrocatalytic Support for Iridium Oxide for Oxygen Evolution Reaction

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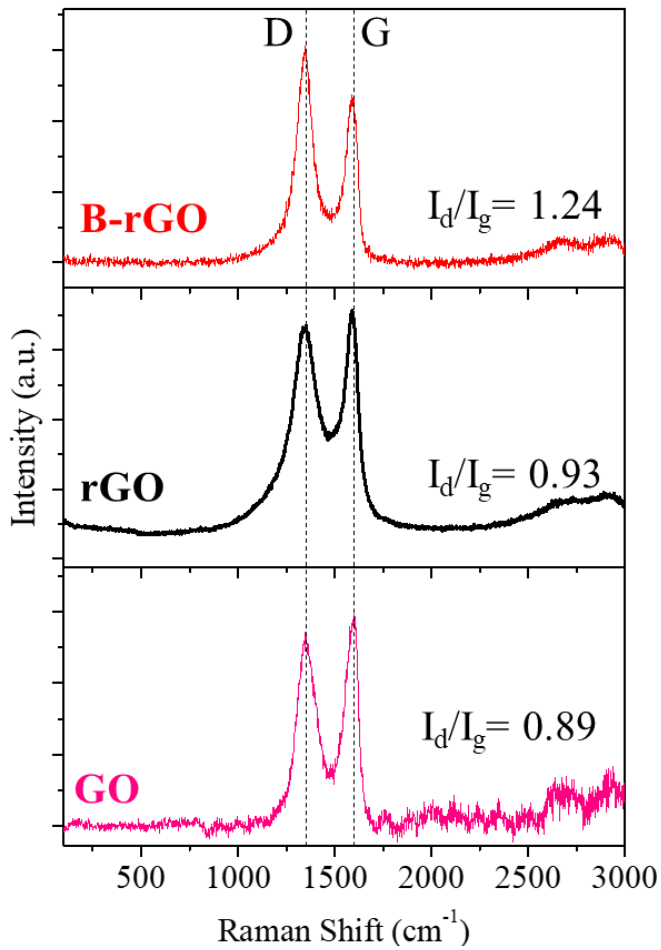

Figure S1 Comparison of Raman spectra for GO (red line), rGO (black line) and B-rGO (purple line) with I_d/I_g ratio

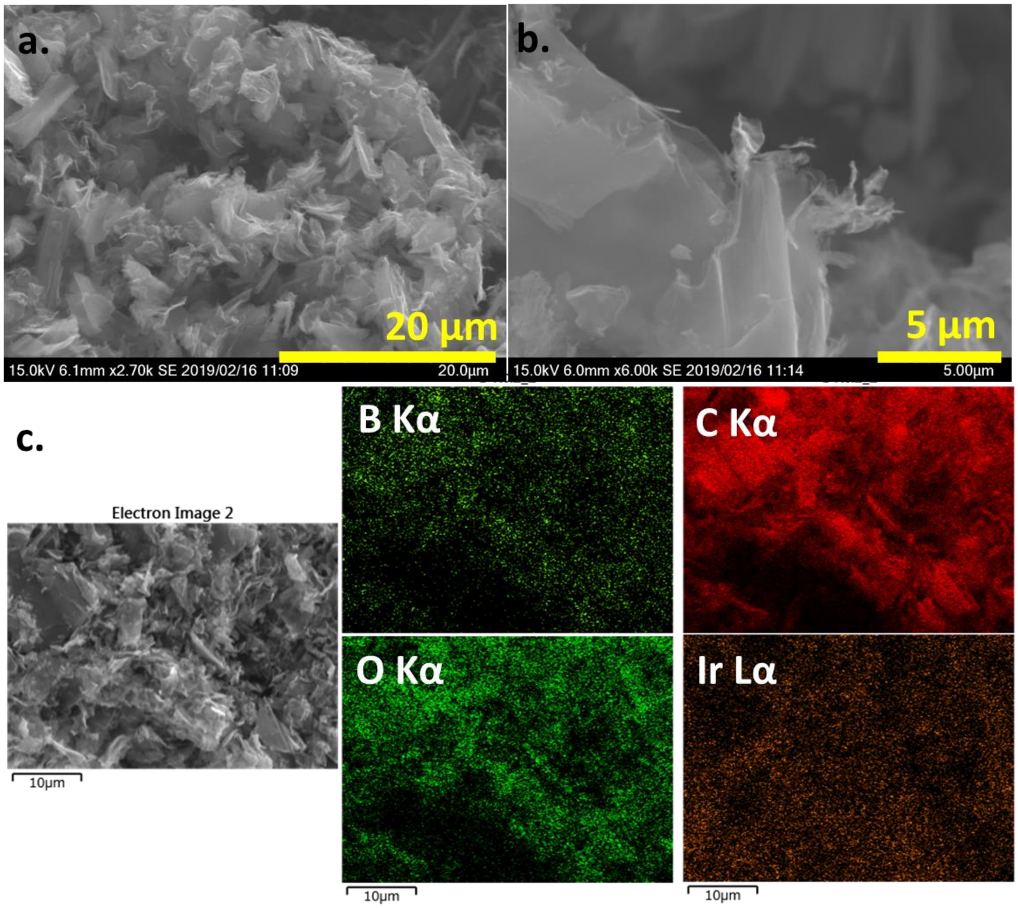

Figure S2 SEM images of B-rGO **a)** low magnification and **b)** high magnification. **c)** EDX elemental mapping of IrO_2-B-rGO at 20 kV

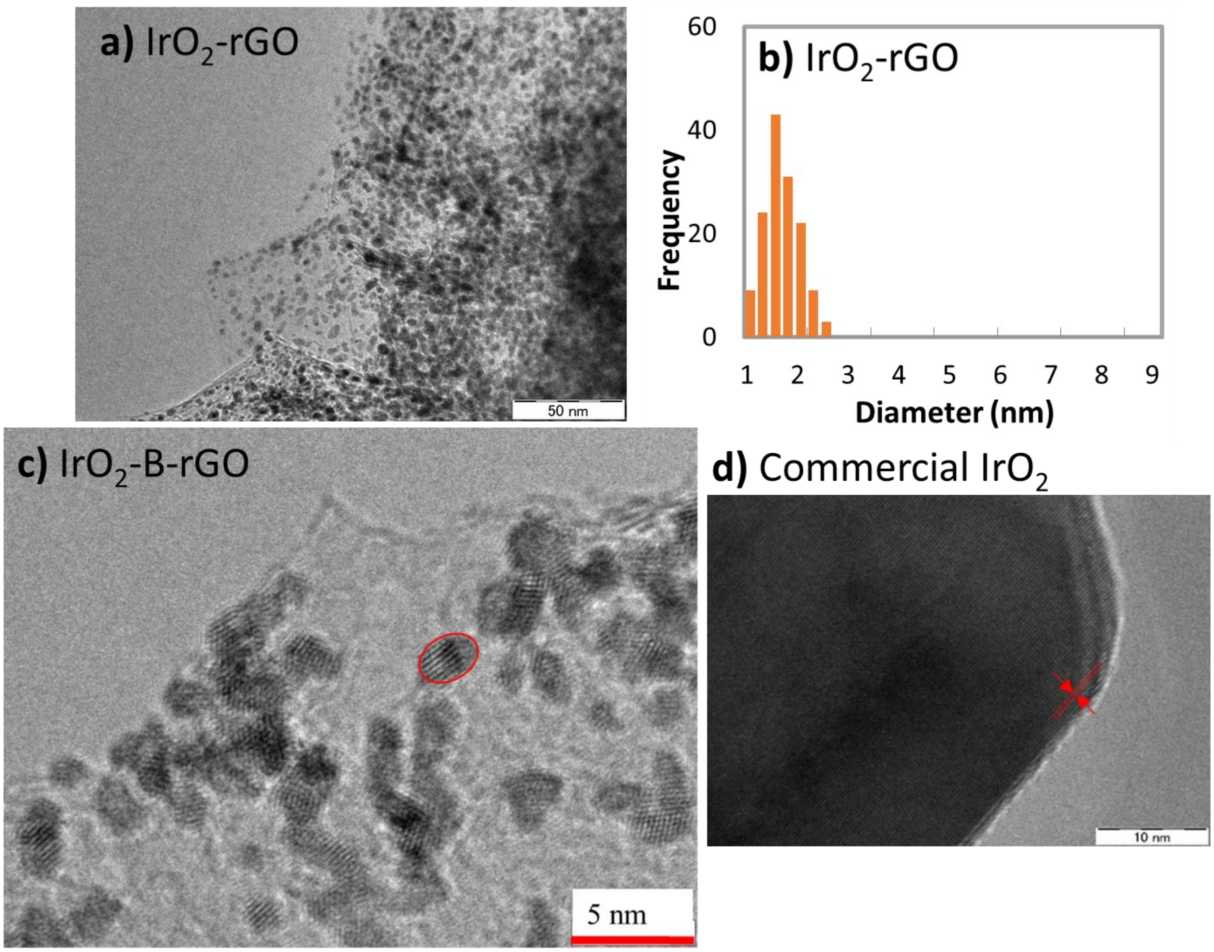

Figure S3 TEM images of **a)** IrO_2-rGO and **b)** size distribution of IrO_2 nps deposited on rGO sheets. **c)** TEM image of IrO_2-B-rGO (Enlarged image of IrO_2 nps showing lattice fringes of IrO_2). **d)** TEM image of comm. IrO_2

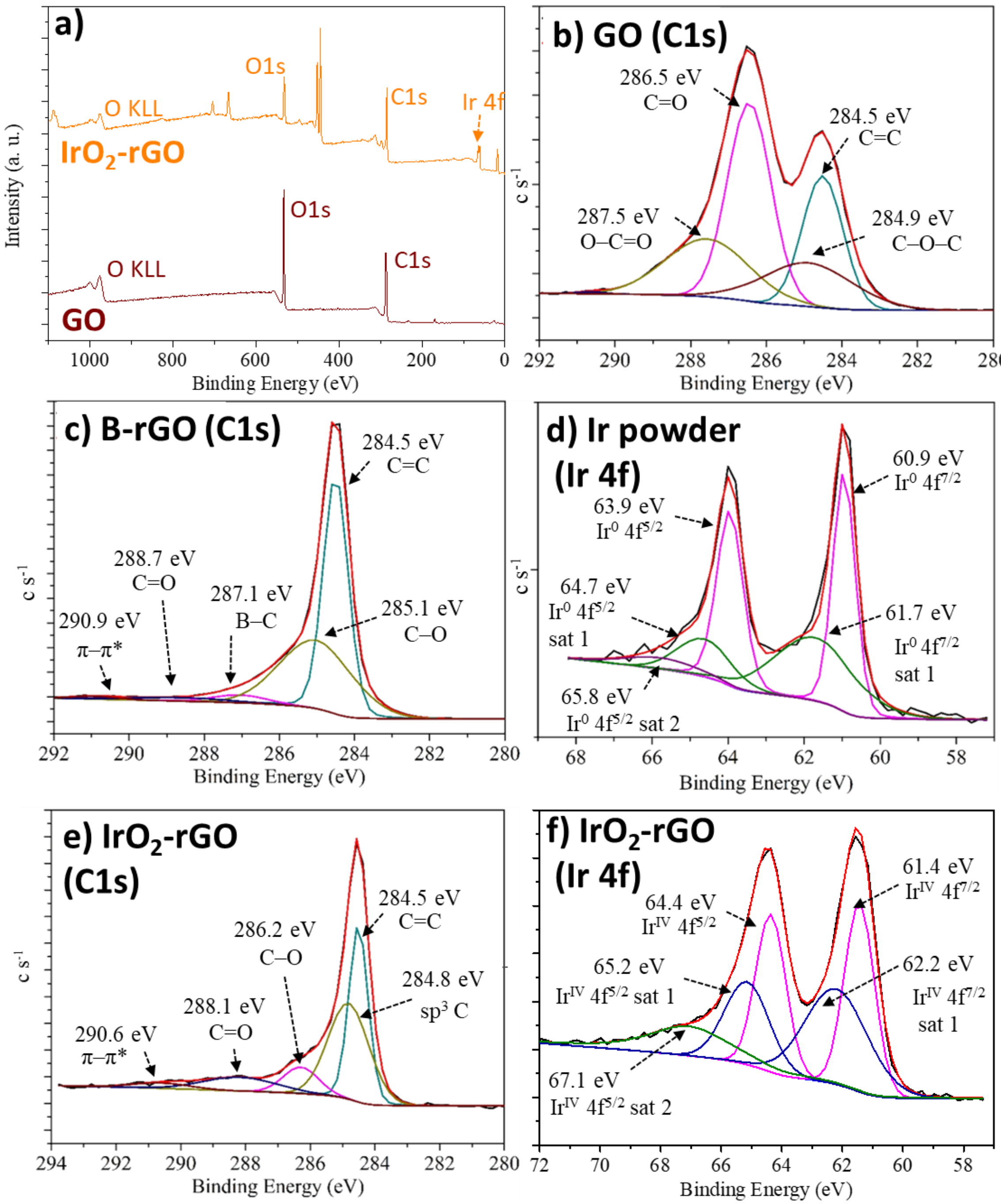

Figure S4 a) Survey scan of GO (brown line) and IrO_2-rGO (orange line), and XPS deconvoluted spectra for **b)** GO (C1s), **c)** B-rGO (C1s), **d)** Ir powder (Ir 4f), **e)** IrO_2-rGO (C 1s) and **f)** IrO_2-rGO (Ir 4f)

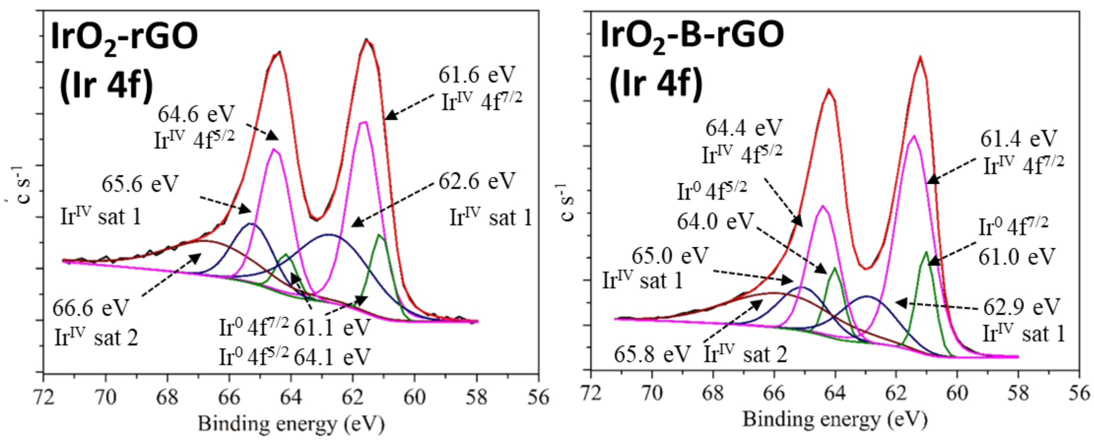

Figure S5 Deconvoluted Ir4f spectra for IrO_2-rGO and IrO_2-B-rGO with contribution of Ir^0

There is an additional way to deconvolute the Ir 4f peaks in IrO_2-B-rGO, i.e. inclusion of the contribution from metallic Ir, Ir^0. **Figure S5** shows the revised XPS deconvolution for IrO_2-B-rGO and IrO_2-rGO with inclusion of Ir metal peaks. Considering the reported XRD of Ir (111) plane in Ir^0, a high intensity sharp peak at 40.1° is reported [1], which is near IrO_2 (200) plane at 40.7 ° (**Figure S6**). This states the possibility of the presence of metallic Ir in the sample. However, bearing in mind the area ratio of the deconvoluted peaks, it can be deduced that Ir^{IV} is dominant.

Table S1 Elemental composition of IrO_2-B-rGO-19.6, estimated from XPS spectra

Elements	IrO_2-B-rGO (At. conc. from XPS)
B	1.94
C	36.93
O	44.82
Ir	16.10

Table S2 Ir 4f peak positions and peak shift obtained from XPS spectra

Sample	Ir 4f $^{7/2}$ / eV	Ir 4f $^{5/2}$ / eV	Peak Shift from Rutile type unsupported IrO_2 [2] / eV
Ir powder	60.9	63.9	0.9
IrO_2-rGO	61.4	64.4	0.4
IrO_2-B-rGO	61.2	64.2	0.6
Rutile type unsupported IrO_2	61.8	64.8	0.0

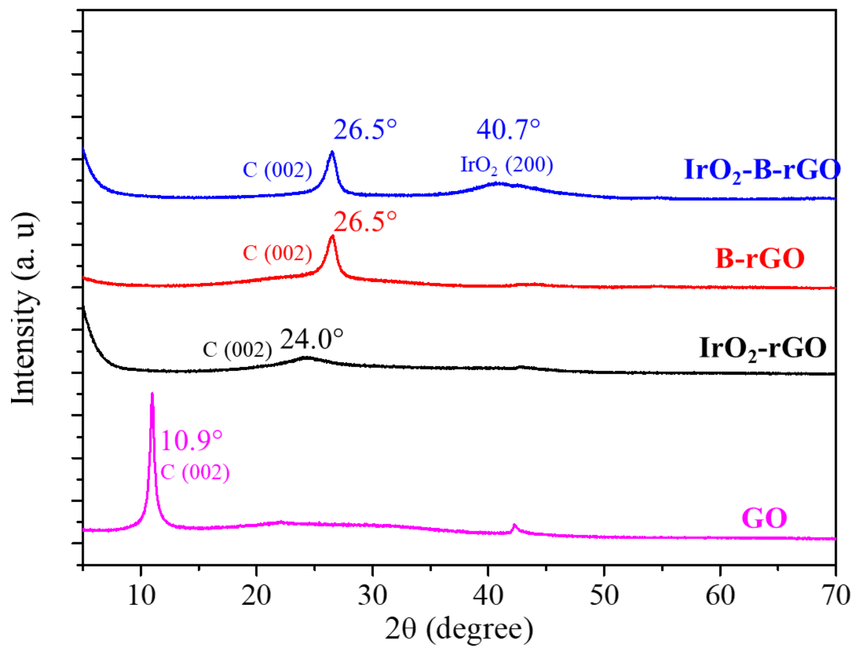

Figure S6 XRD patterns of the catalyst and the initial precursors, GO (purple line), IrO_2-rGO (black line), B-rGO (red line), IrO_2-B-rGO (blue line)

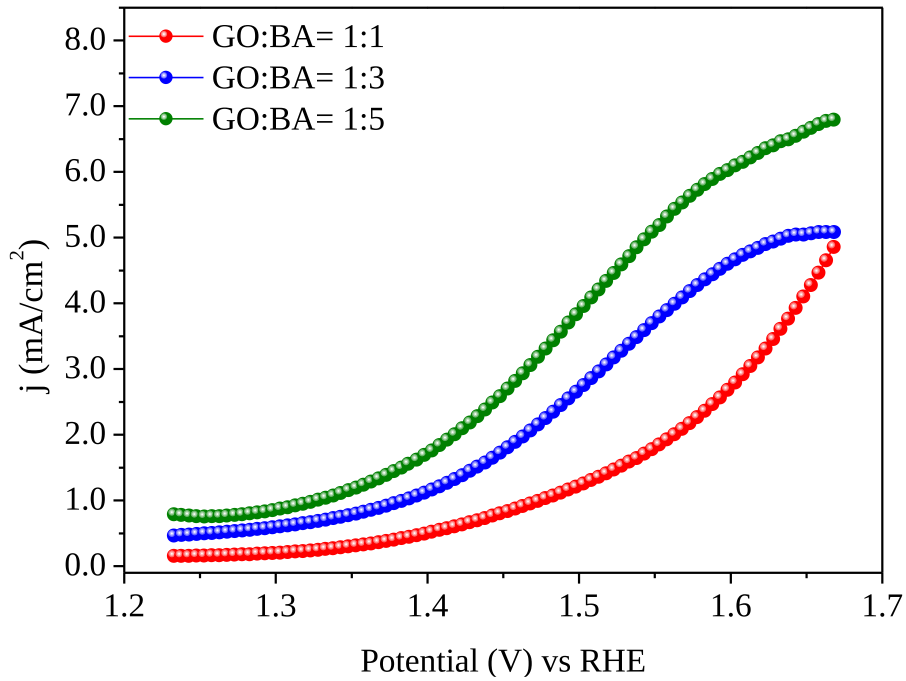

Figure S7 LSV profiles of B-rGO with various GO: BA weight ratio in 0.5 M H_2SO_4 electrolyte solution

Table S3 Elemental composition of B-rGO, estimated from SEM-EDX analysis

Elements	**GO : BA (wt./wt. %)**					
	1:1		**1:3**		**1:5**	
	At. %	**Wt. %**	**At. %**	**Wt. %**	**At. %**	**Wt. %**
B	2.82	2.33	2.69	2.34	2.14	1.87
C	88.92	86.66	85.92	82.86	84.58	80.37
O	8.14	10.57	10.77	13.84	11.96	15.15

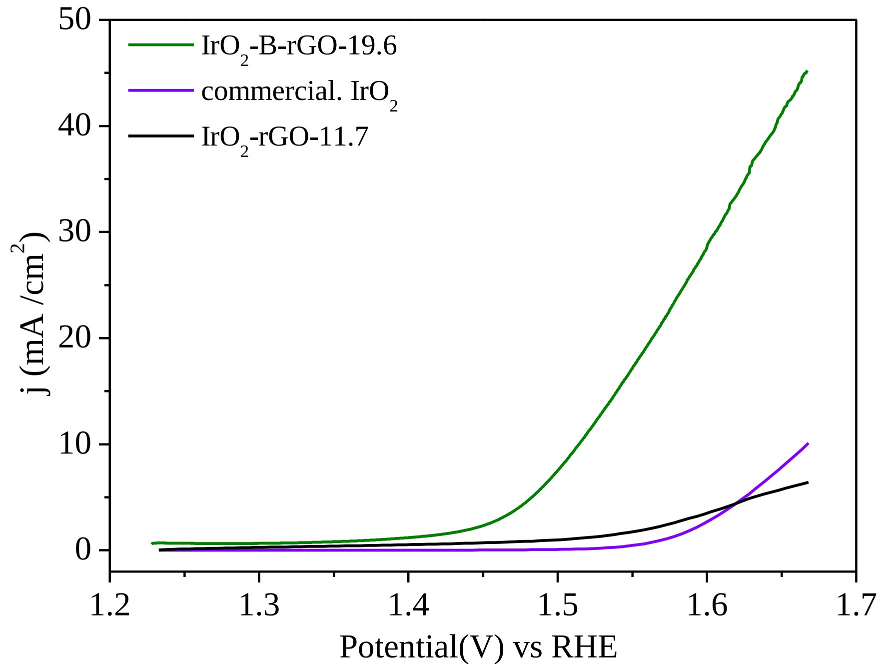

Figure S8 LSV curve of comm. IrO_2 (purple line) in 0.5 M H_2SO_4 solution between 1.20 to 1.65 V vs RHE (the Ir loading amount of comm. IrO_2 is 284 µg cm^{-2}) and its comparison with the synthesized catalyst IrO_2-B-rGO-19.6 (green line) and IrO_2-rGO-11.7 (black line)

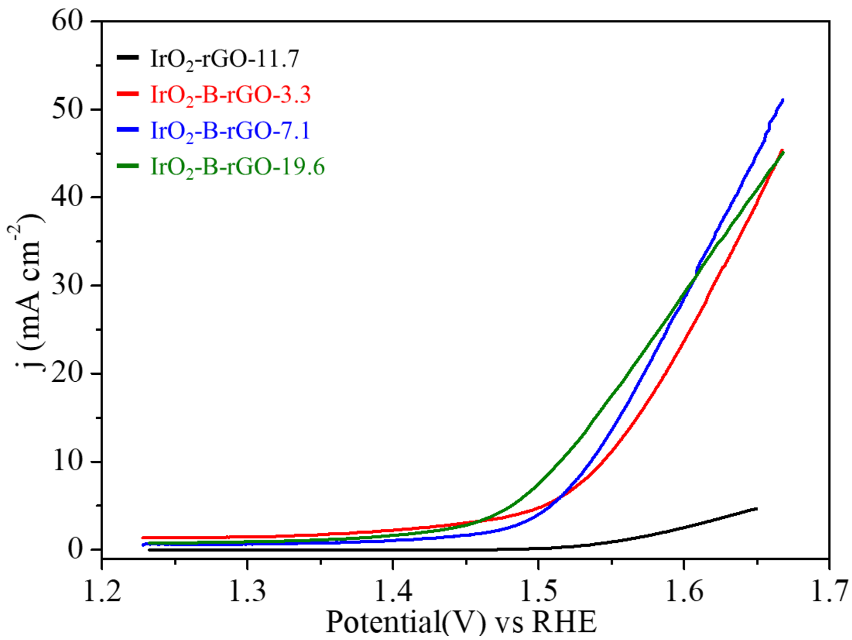

Figure S9 LSV profiles of IrO_2-rGO (with 11.7 wt.% Ir) and IrO_2-B-rGO with different Ir content (3.3, 7.1 and 19.6. wt. %)

Table S4 Particle size and active surface area (calculated from TEM image**)**

Catalyst	**Catalyst loading (wt. %)**	**Particle Size (nm) (by TEM)**	**Active Surface area ($m^2 g_{Ir}^{-1}$) (by TEM)**
IrO_2-B-rGO1	3.3	1.6 ± 0.3	10.6
IrO_2-B-rGO2	7.1	1.5 ± 0.3	24.4
IrO_2-B-rGO3	19.6	1.6 ± 0.4	63.1
IrO_2-rGO	11.7	1.5 ± 0.4	40.1

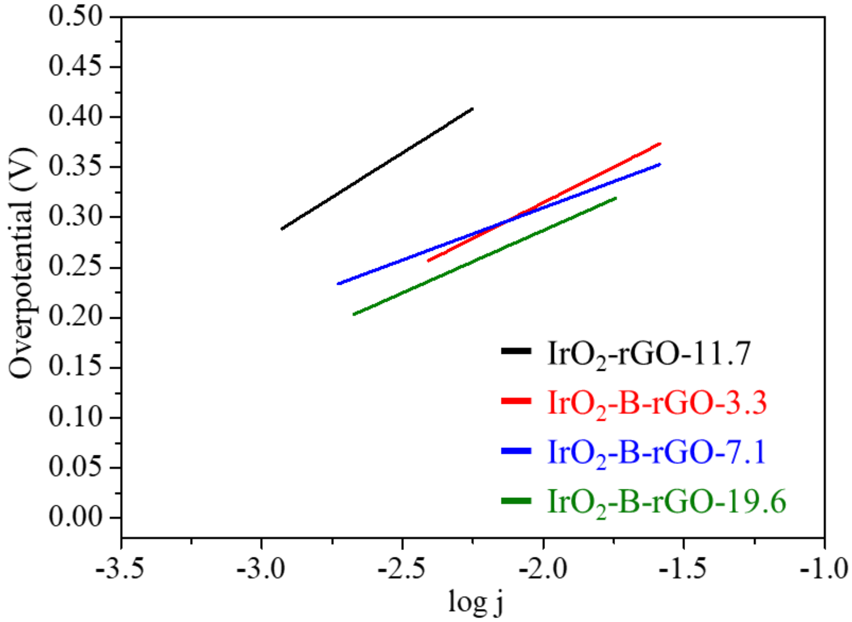

Figure S10 The calculated Tafel slopes for OER on the IrO_2 nps on the B-doped and undoped catalysts, calculated from their LSV profiles

Table S5 Calculated Tafel slopes for IrO_2-B-rGO with different Ir content

Catalyst (Ir wt. %)	**Tafel slope (mV dec^{-1})**
IrO_2-B-rGO-3.3	142.0
IrO_2-B-rGO-11.7	104.2
IrO_2-B-rGO-19.6	124.8
IrO_2- rGO -11.7	176.5

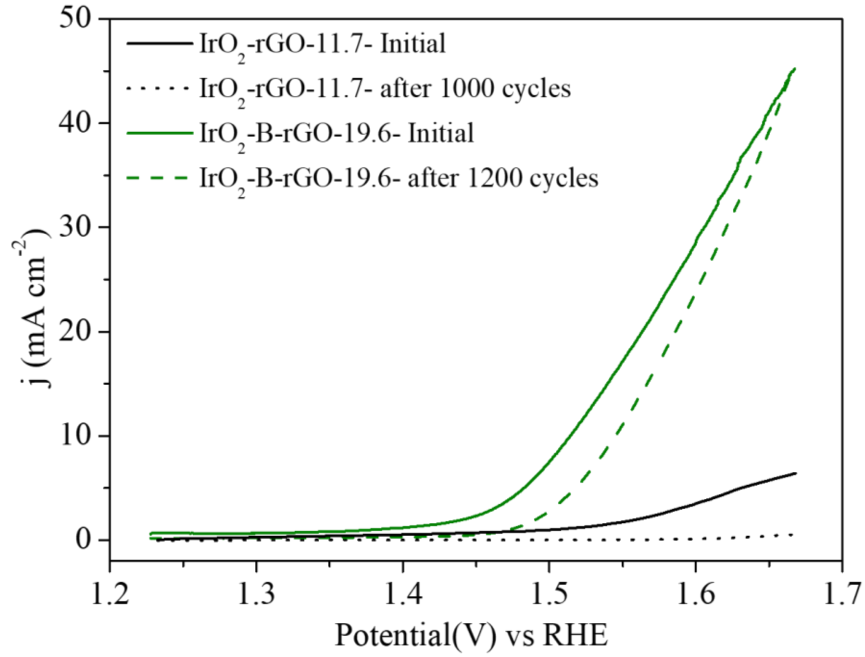

Figure S11 a) Accelerated durability test profiles for IrO_2-B-rGO-19.6 and IrO_2-rGO-11.7 (before (solid line) and after 1000 cycles (dashed line))

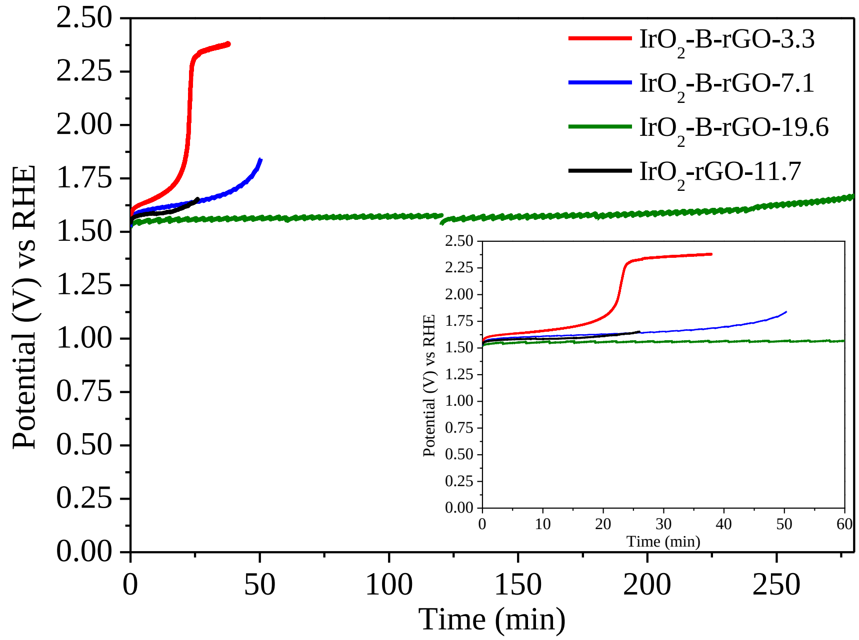

Figure S11 b) Chronopotentiometry profiles for IrO_2-B-rGO and IrO_2-rGO catalysts at 10 mA cm^{-2} (inset: magnified image at time scale of 60 min)

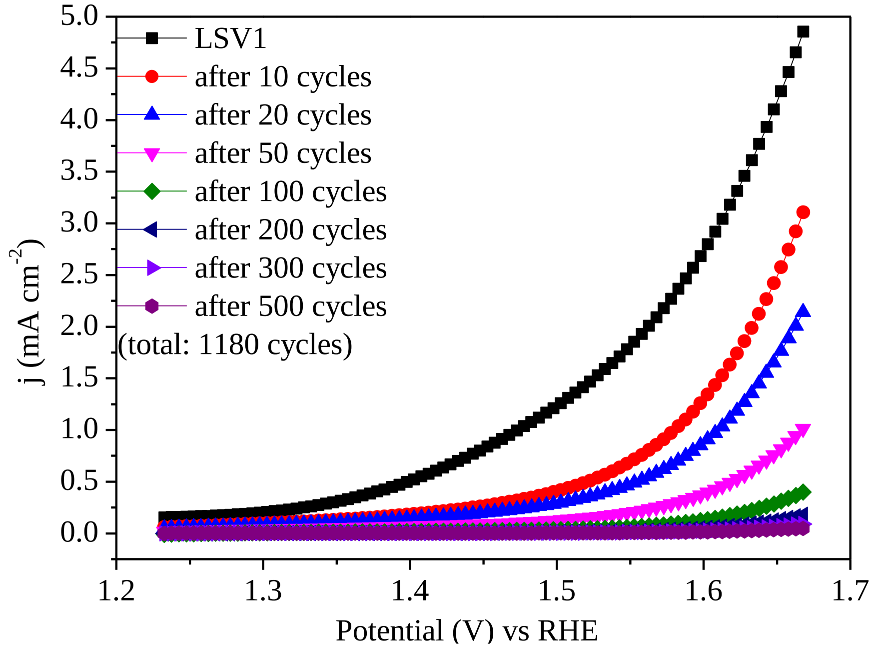

Figure S11 c) ADT studies of B-rGO in 0.5 M H_2SO_4 solution between 1.20 and 1.65 V vs RHE

References:

1 Y. Lee, J. Suntivich, K. J. May, E. E. Perry and Y. Shao-Horn, *J. Phys. Chem. Lett.*, 2012, **3**, 399−404.

2 V. Pfeifer, T. E. Jones, J. J. Velasco Vélez, C. Massué, M. T. Greiner, R. Arrigo, *et al.*, *Phys. Chem. Chem. Phys.*, 2016, **18**, 2292–2296.