Organic ligand-facilitated in situ exsolution of CoFe alloy over $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_3$ perovskite toward enhanced oxygen electrocatalysis for rechargeable Zn-air batteries

Yasir Arafat [a], Muhammad Rizwan Azhar [b], Yijun Zhong [a], Ryan O'Hayre[c], Moses O. Tadé [a] and Zongping Shao *[a]

[a]WA School of Mines: Minerals, Energy and Chemical Engineering (WASM-MECE), Curtin University, Perth, Western Australia 6102, Australia.

[b]School of Engineering, Edith Cowan University, 270 Joondalup Drive, Joondalup, Western Australia 6027, Australia.

[c]Department of Metallurgical and Materials Engineering, Colorado School of Mines, 1500 Illinois St., Golden, CO 80401, USA.

Supplementary information

Table S1- Surface area, pore diameter and pore volume of air cathodes

Electrocatalysts	BET surface Area ($m^2\ g^{-1}$)	Pore diameter (nm)	Pore volume ($cm^3\ g^{-1}$)
CoFe-Co-N-C-B1	144.9108	4.2661	0.098122
CoFe-Co-N-C-B2	130.2741	4.3074	0.092688
CoFe-Co-N-C-B3	55.0517	4.4489	0.060295

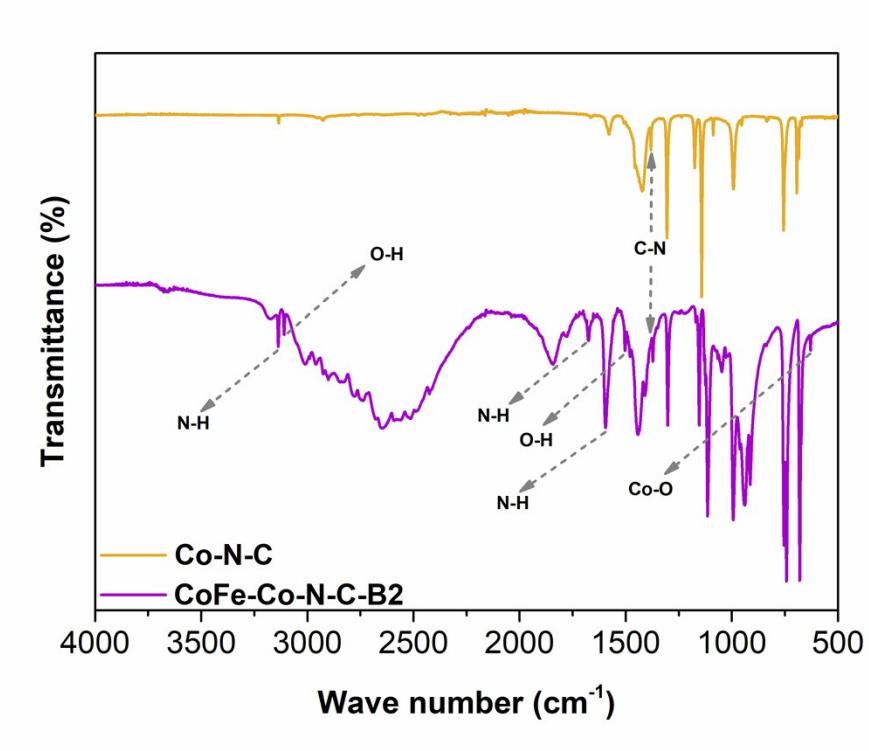

Fig. S1 FTIR of ZIF-67 and CoFe-Co-N-C-B2

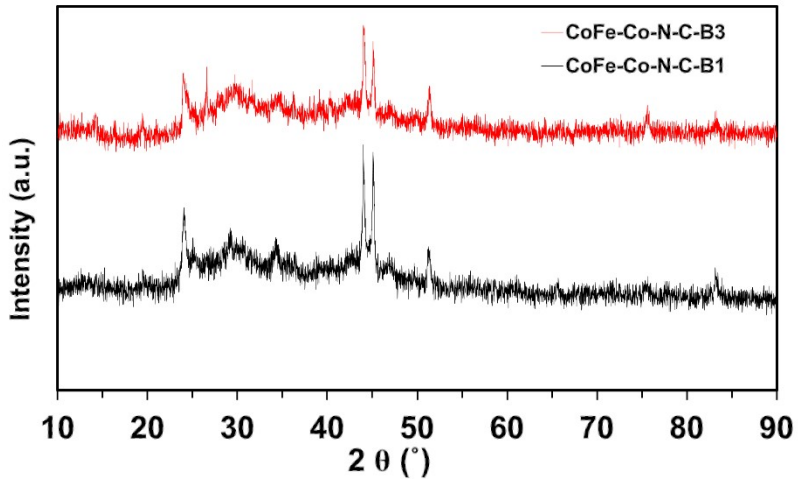

Fig. S2 XRD of CoFe-Co-N-C-B1 and CoFe-Co-N-C-B3

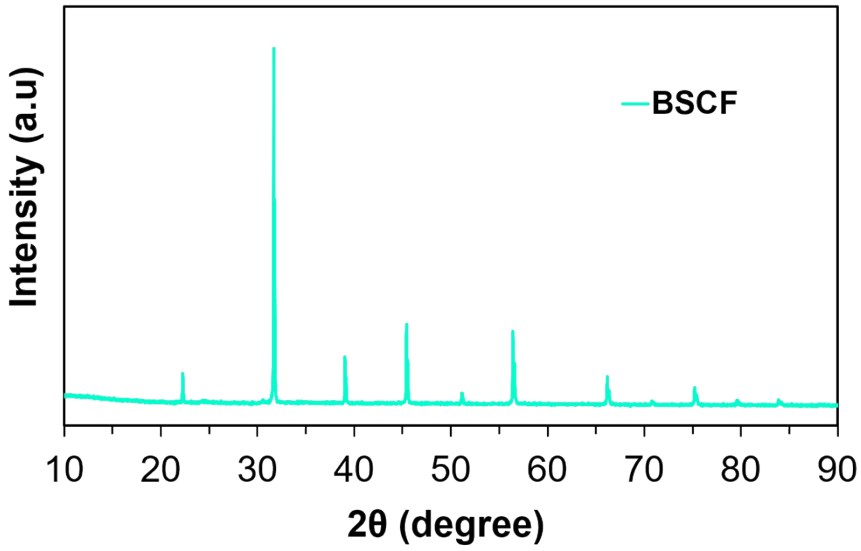

Fig. S3 XRD of pristine $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (BSCF)

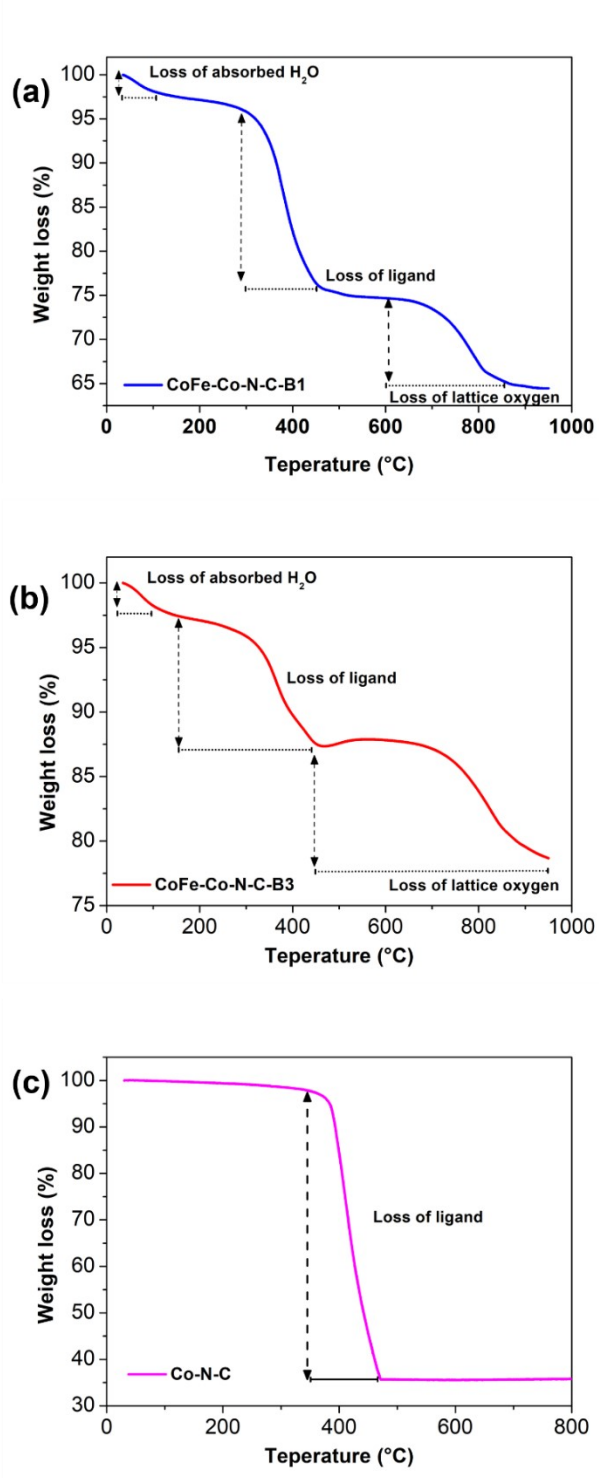

Fig. S4 TGA analysis of CoFe-Co-N-C-B1, CoFe-Co-N-C-B3 and ZIF-67

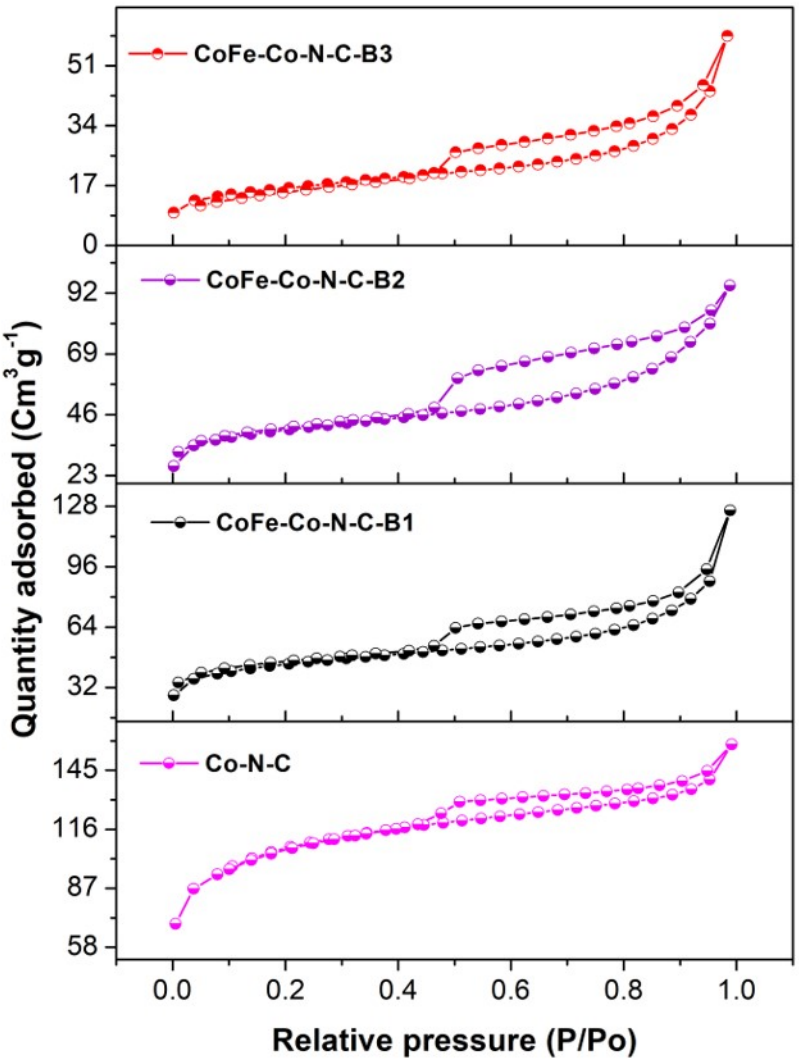

Fig. S 5 BET of CoFe-Co-N-C-B1, CoFe-Co-N-C-B2 and CoFe-Co-N-C-B3

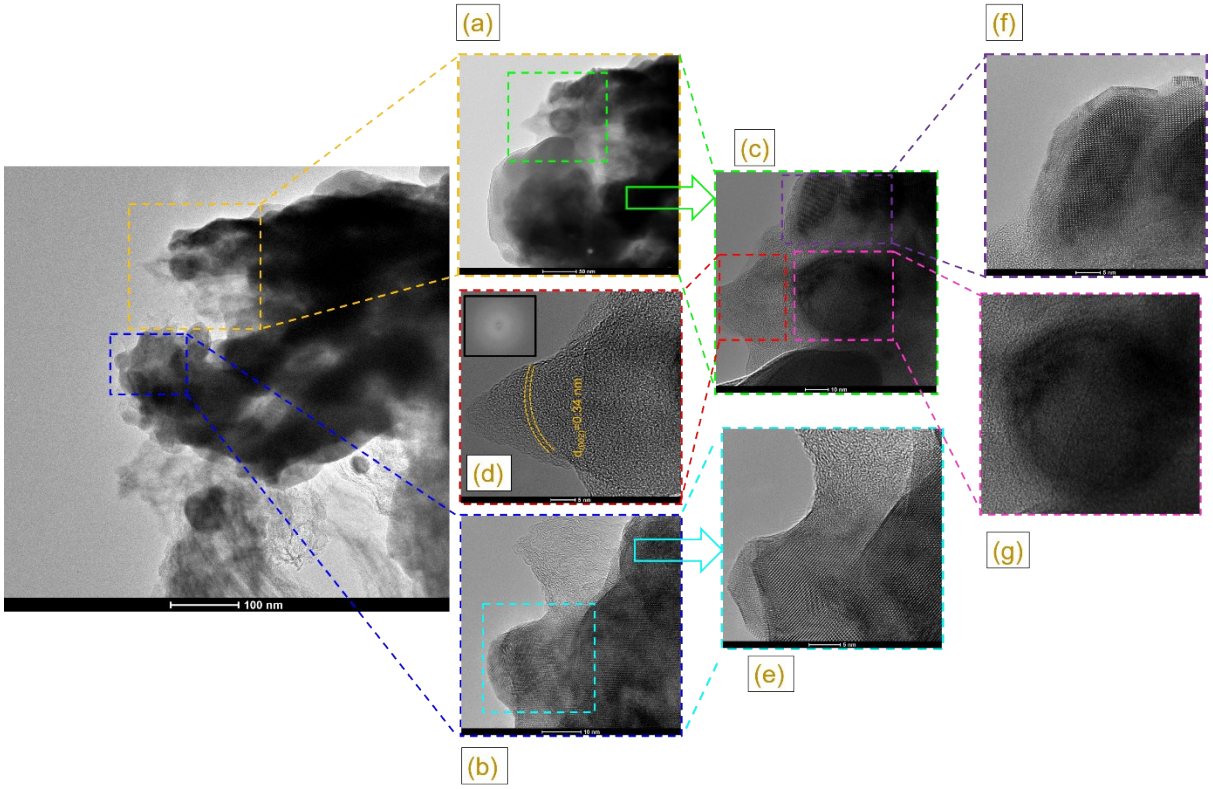

Fig. S6 TEM micrographs of CoFe-Co-N-C-B2 and corresponding HRTEM are illustrated in following Fig. 2

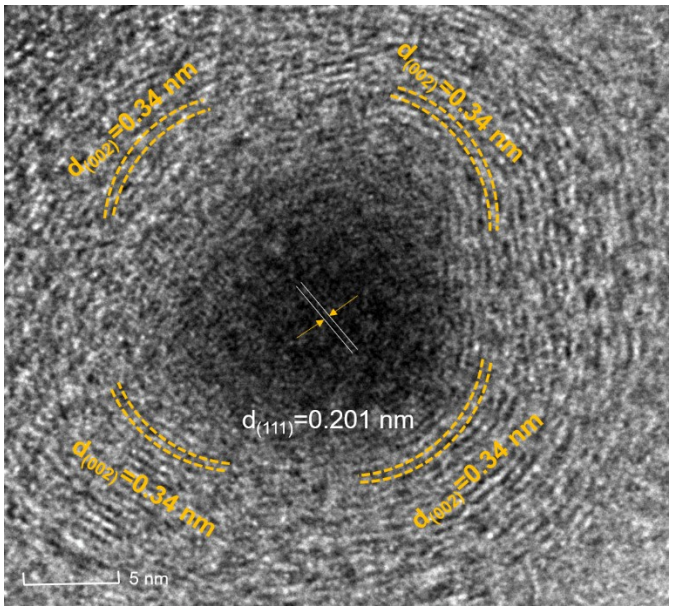

Fig. S7 HRTEM of Co encapsulated graphitic carbon

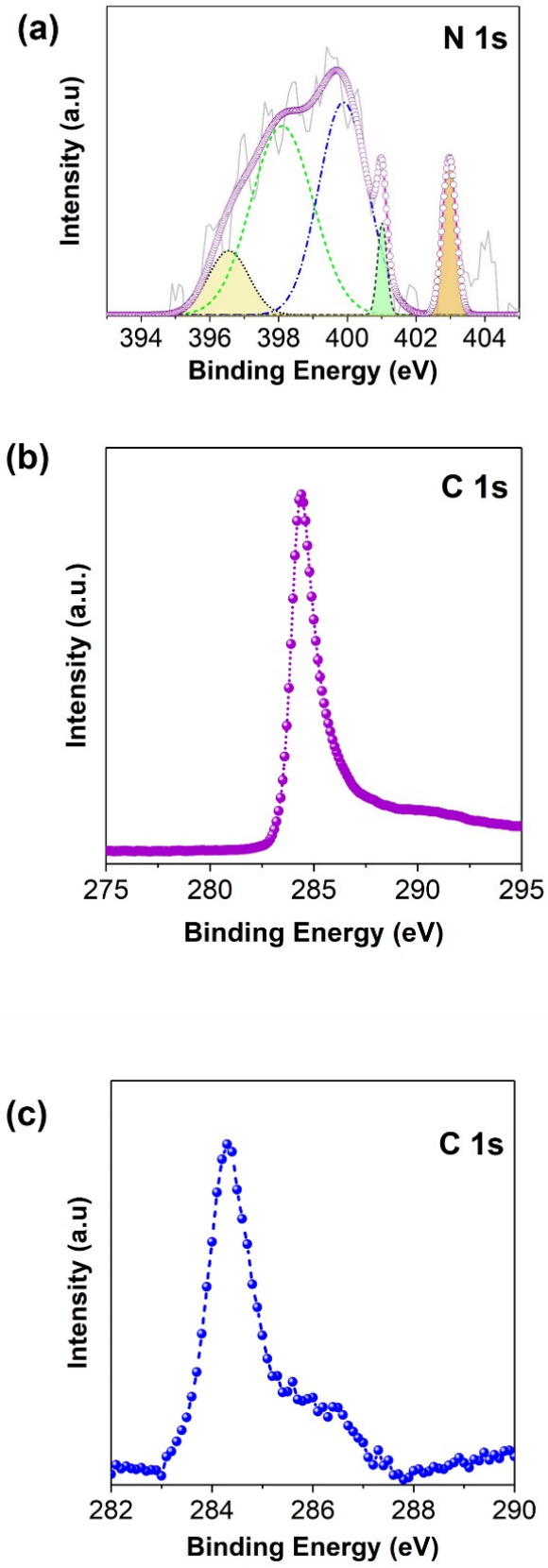

Fig. S8 **High resolution deconvoluted XPS spectrum of (a) N, ZiF-67 derived carbon and C and CoFe-C-N-C-B2-derived carbon**

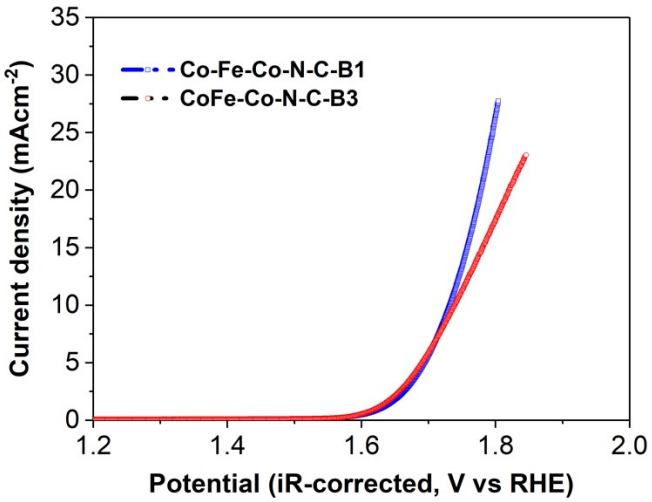

Fig. S9 (a) iR-corrected LSV OER curves of CoFe-Co-N-C-B1 and CoFe-Co-N-C-B3 in O_2-saturated 0.10 M KOH solution at 1600 rpm

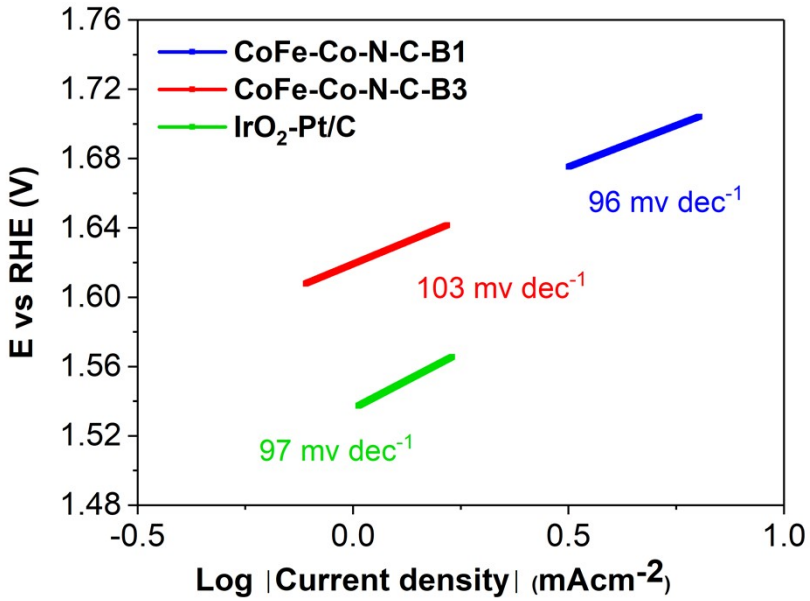

Fig. S10 The corresponding Tafel slopes

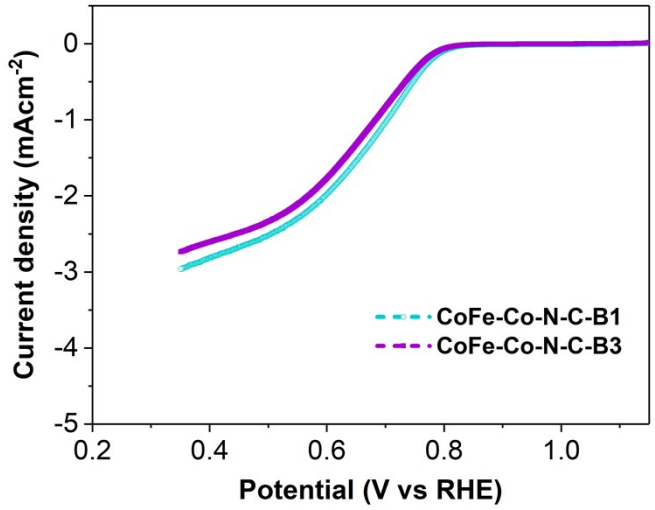

Fig. S11 LSV ORR scans of CoFe-Co-N-C-B1 and CoFe-Co-N-C-B3 in O_2-saturated 0.10 M KOH solution at 1600 rpm

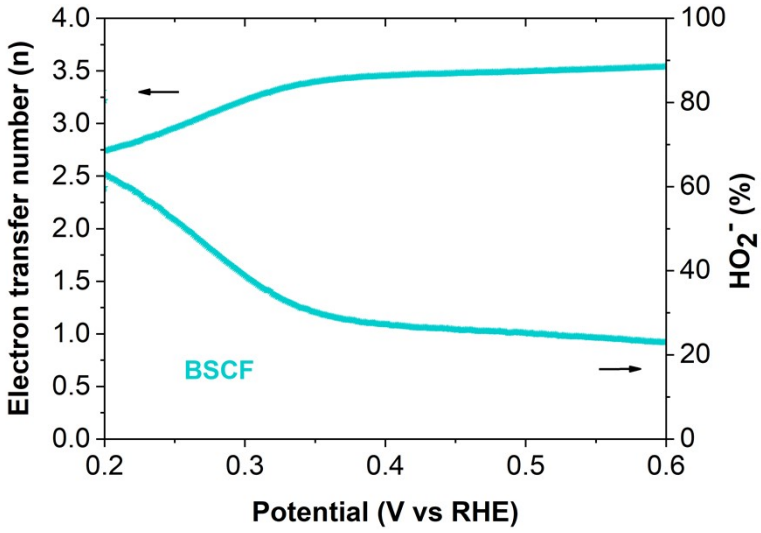

Fig. S12 Electron transfer number and percentage of HO_2^- of BSCF.

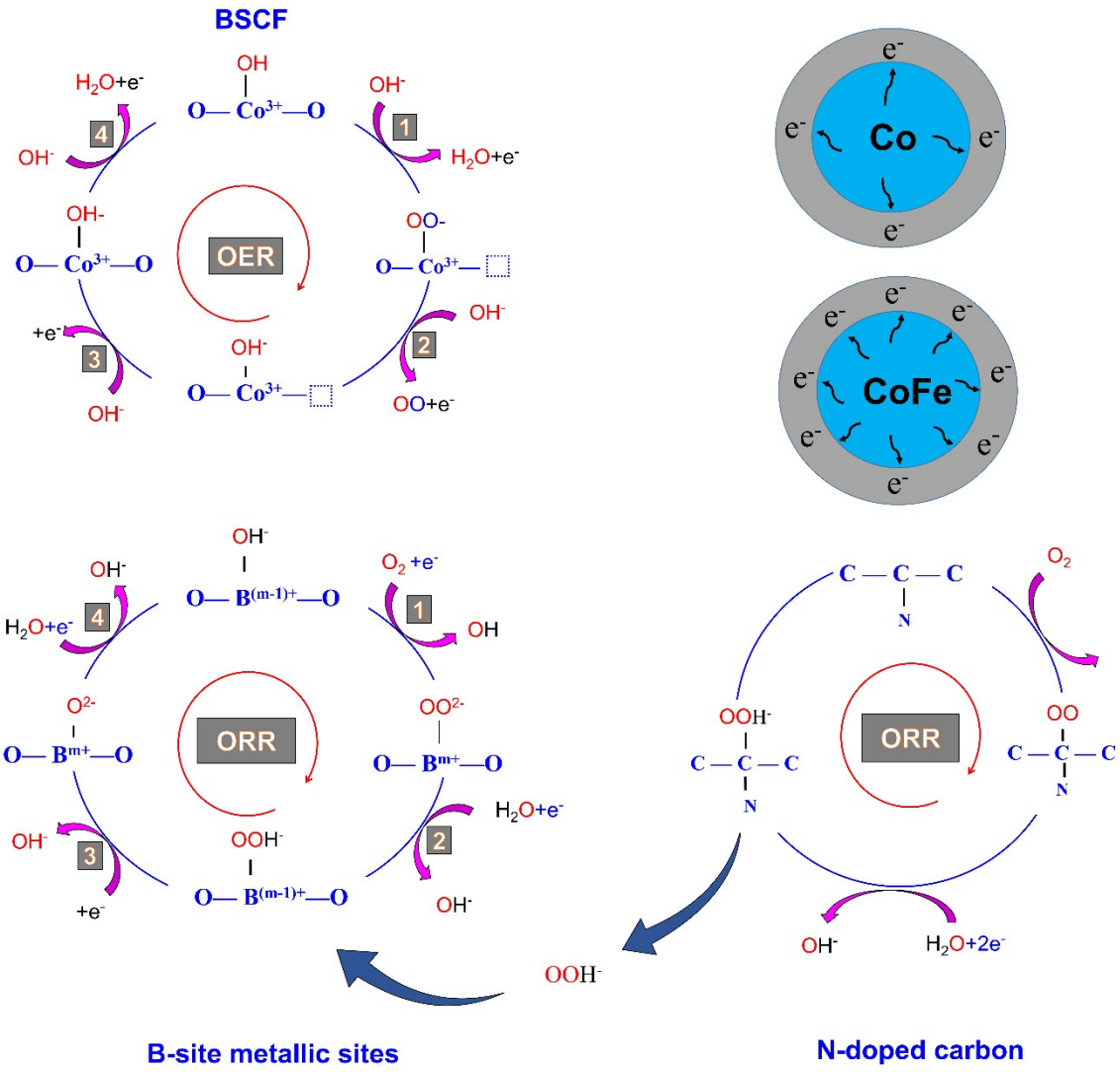

Fig. S13 An OER as well ORR reaction mechanisms involving different steps over CoFe exsolved BSCF and N-doped carbon surfaces.