

## Supplementary Information

### **High performance FeO<sub>x</sub>@CoO<sub>x</sub>/NC electrocatalyst for oxygen reduction reaction in alkaline media**

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#### **Determination of electron number**

For the determination of electron number, Koutechy-Levich plots were drawn at different potentials from which electron number was calculated according to the formula given below.<sup>1</sup>

$$\frac{1}{j} = \frac{1}{jd} + \frac{1}{jk}$$

$$\frac{1}{j} = \frac{1}{B\sqrt{W}} + \frac{1}{jk}$$

$$jd = 0.62nFC_0 (D_0)^{2/3} (V)^{-1/6}$$

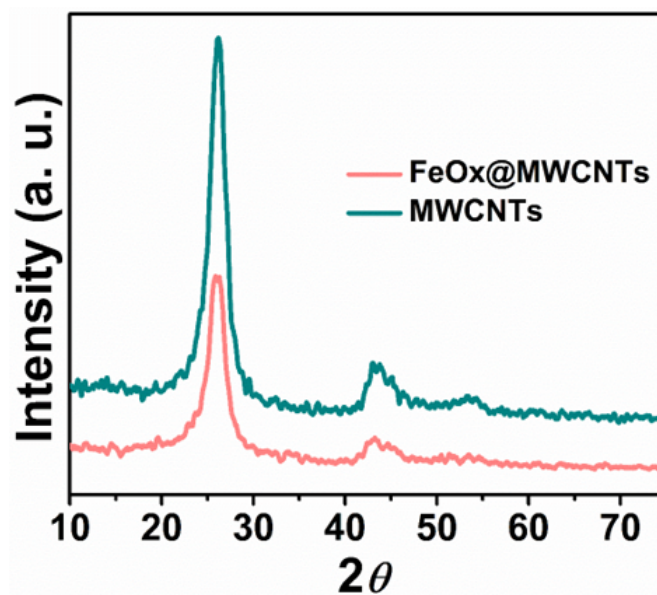


Figure 1. PXRD pattern of MWCNTs and FeOx@MWCNTs

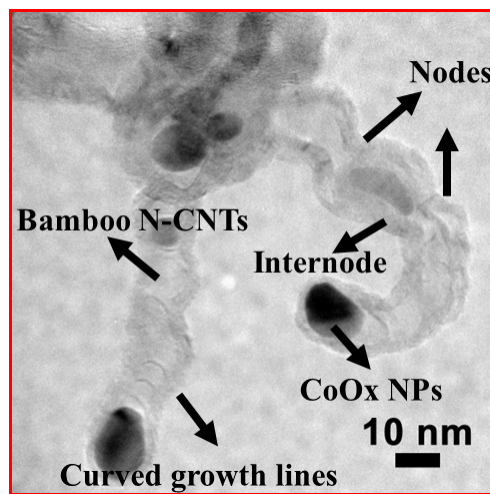
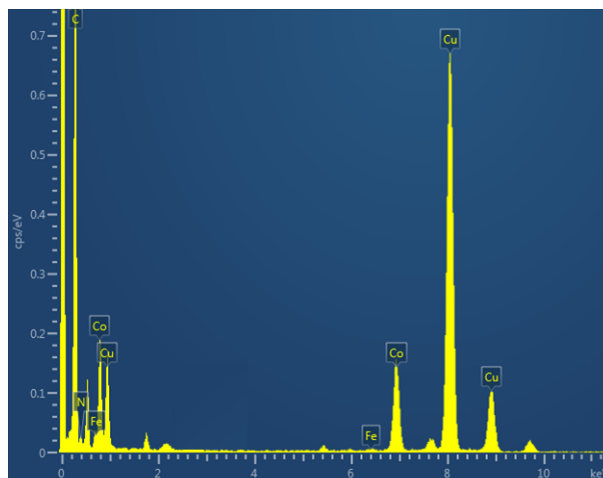
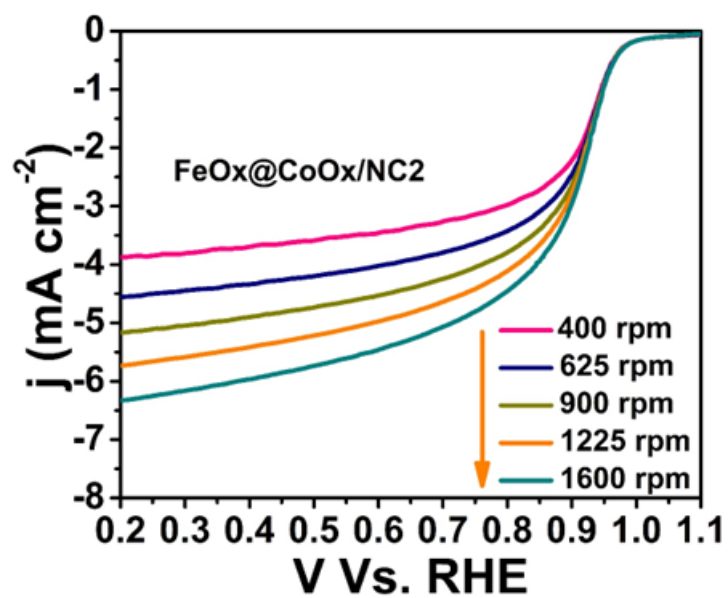


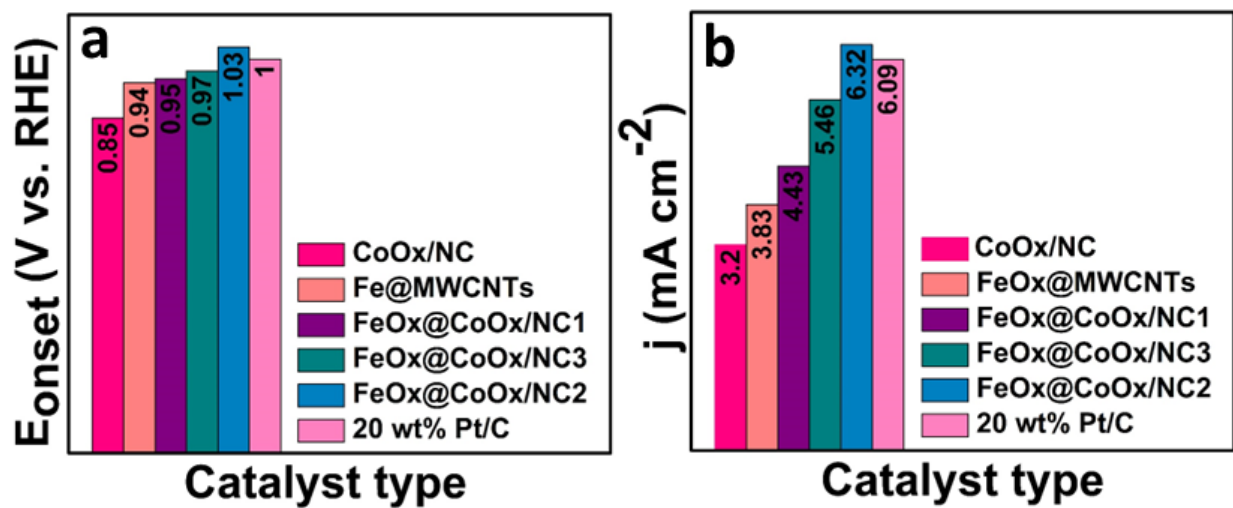
Figure S2. HRTEM image of CoOx/NC at 10nm



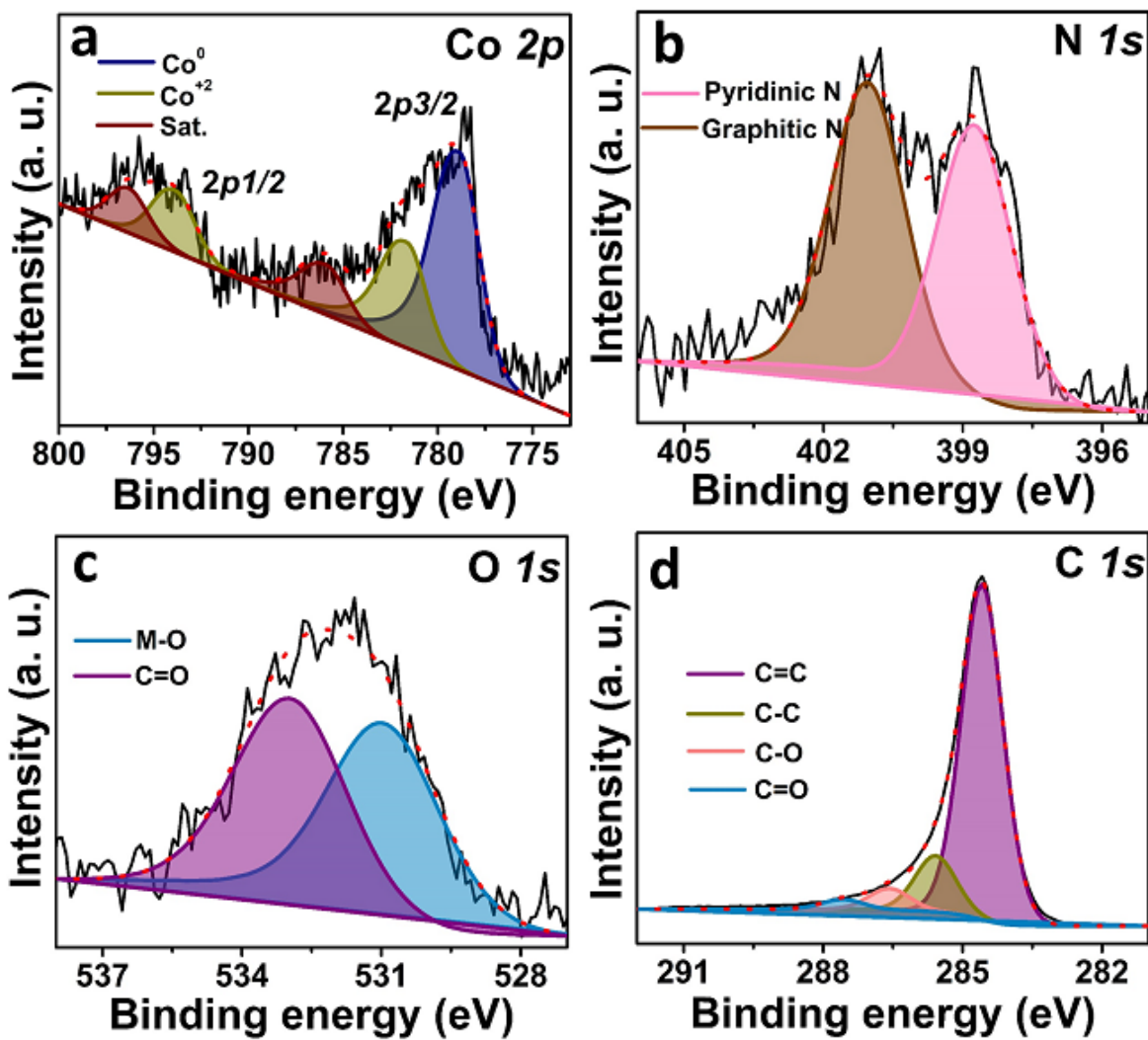
**Figure S3.** EDX analysis of FeOx@CoOx/NC2



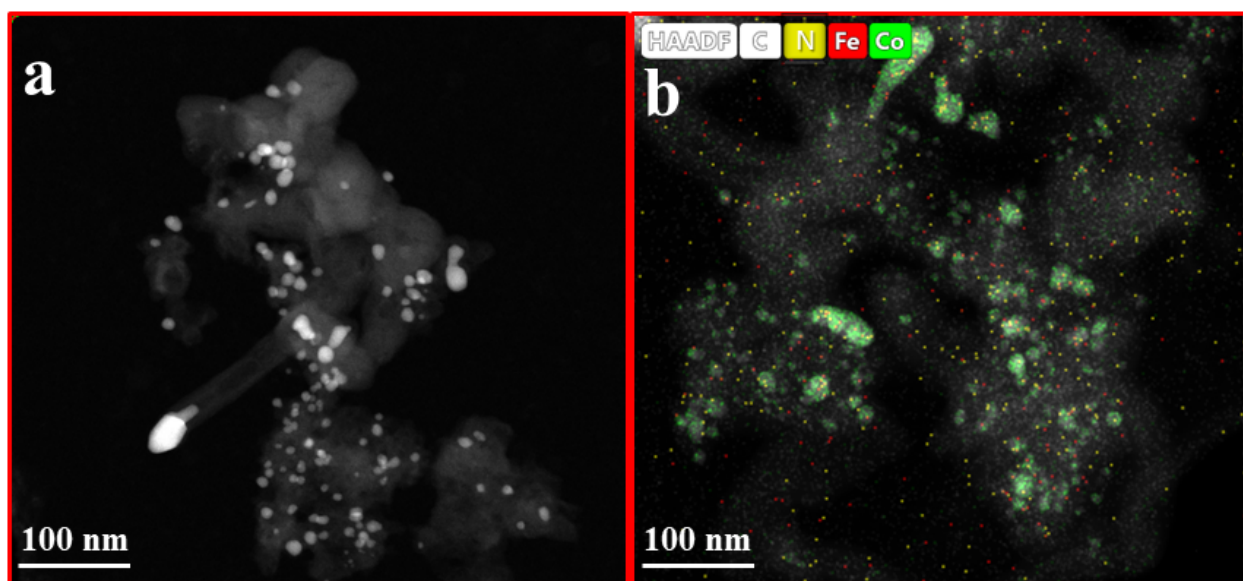
**Figure S4.** Rotation effect of FeOx@CoOx/NC2 at 10 mV s<sup>-1</sup> in 0.1 M KOH



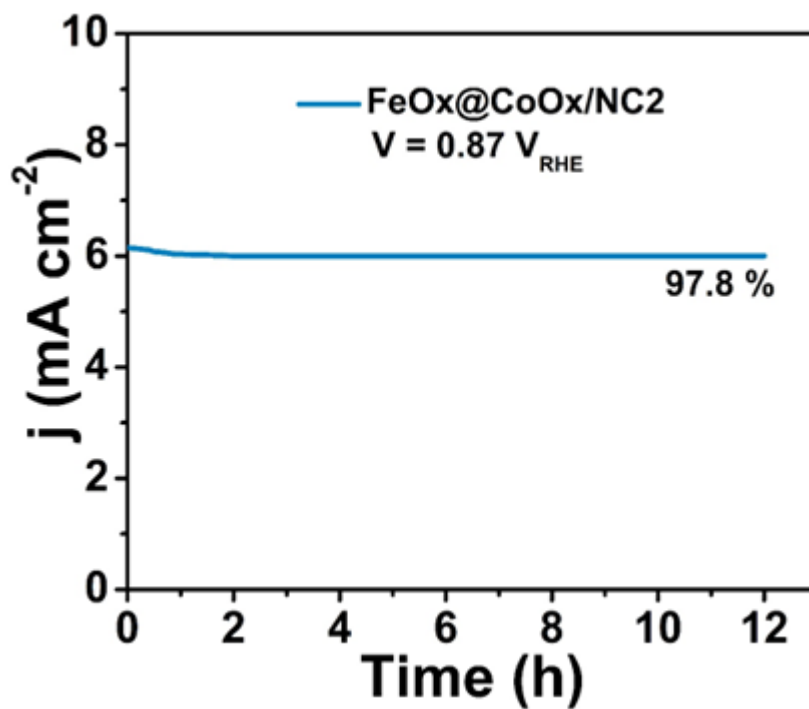
**Figure S5.** Comparison of ORR evaluating parameters of the synthesized materials with 20 wt% Pt/C (a) onset potential (b) current density



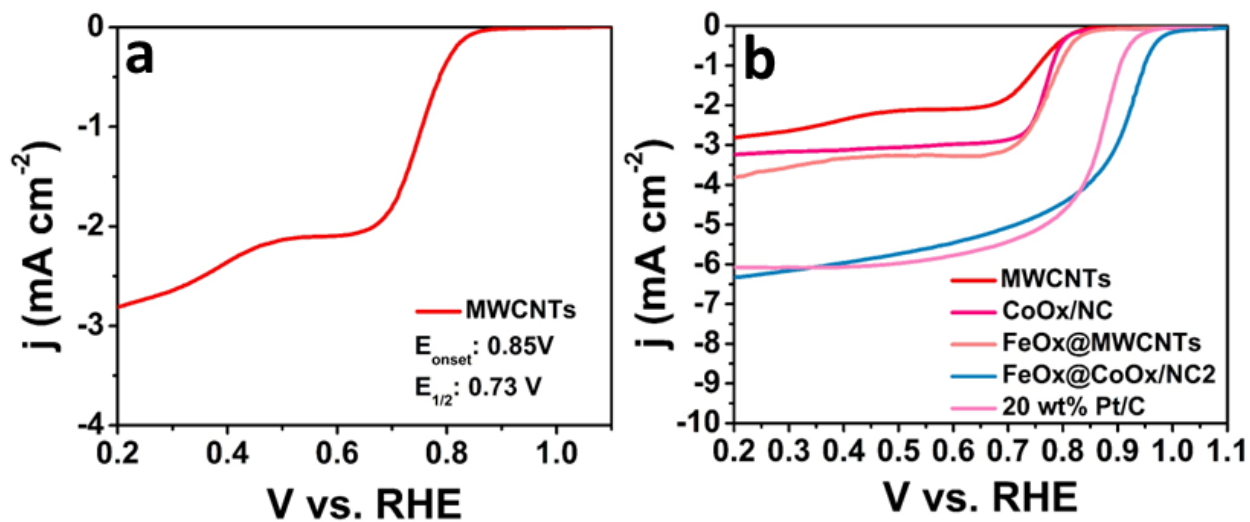
**Figure S6.** XPS spectrum of CoOx/NC (a) Co 2p (b) N 1s (c) O 1s (d) C 1s<sup>2</sup>



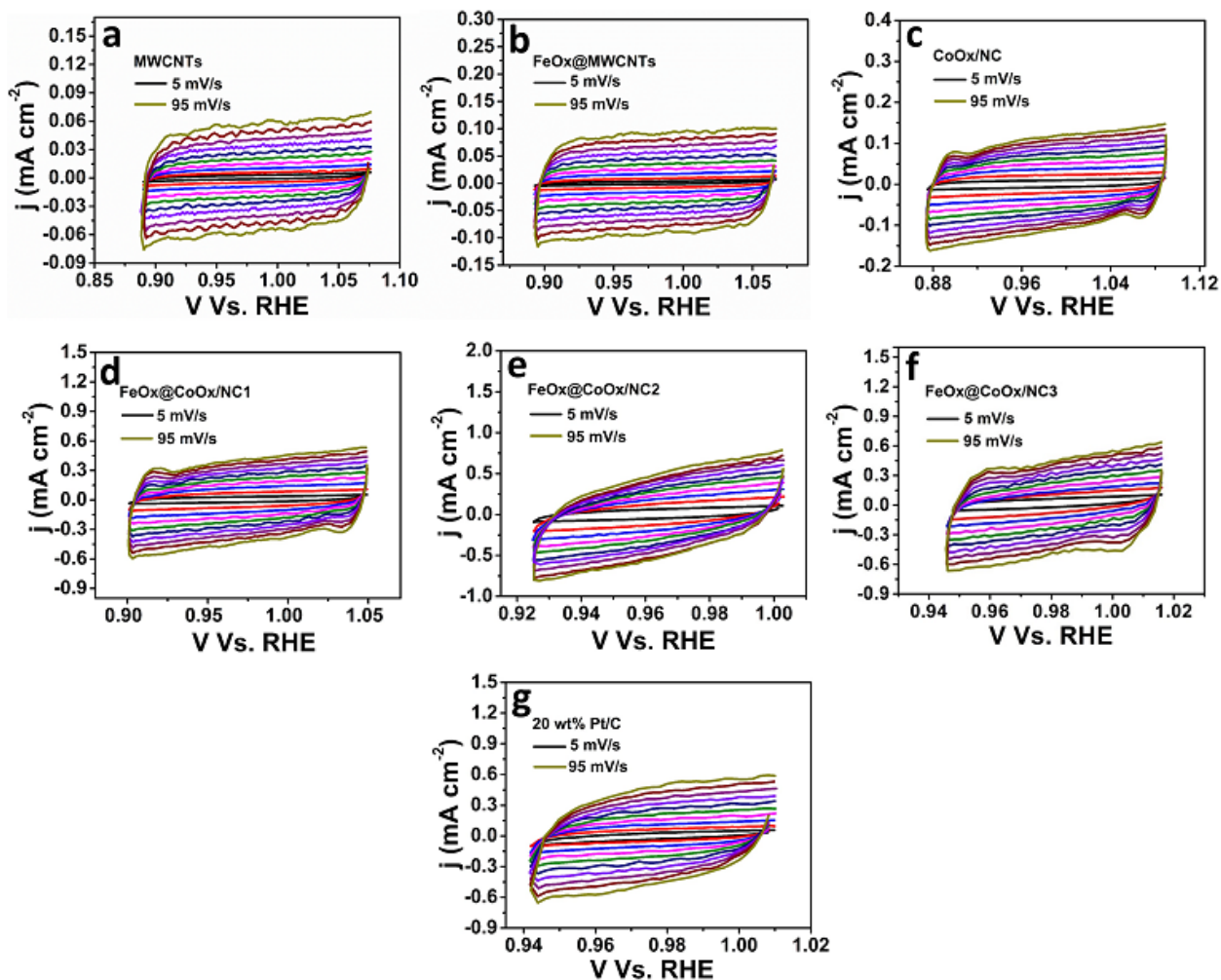
**Figure S7.** HAADF TEM analysis of FeOx@CoOx/NC2 at 100 nm



**Figure S8.** Chronoamperometric response of FeOx@CoOx/NC2 over 12 h in O<sub>2</sub> saturated environment at 1600 rpm



**Figure S9.** (a) LSV polarization curve of MWCNTs in O<sub>2</sub> saturated environment 0.1M KOH at 1600 rpm (b) comparison of ORR performance of MWCNTs and synthesized catalysts with 20 wt% Pt/C



**Figure S10.** Cyclic voltammograms of all the synthesized materials in the non-faradic region at different scan rates in Ar saturated environment

**Table S1.** Comparison of ECSA of all the synthesized materials

| S.No. | Catalysts     | Cdl (mF cm <sup>-2</sup> ) | ECSA (cm <sup>2</sup> ) |
|-------|---------------|----------------------------|-------------------------|
| 1     | MWCNTs        | 0.6                        | 15                      |
| 2     | FeOx@MWCNTs   | 1                          | 25                      |
| 3     | CoOx/NC       | 1.1                        | 27.5                    |
| 4     | FeOx@CoOx/NC1 | 4.3                        | 107.5                   |
| 5     | FeOx@CoOx/NC2 | 5                          | 125                     |
| 6     | FeOx@CoOx/NC3 | 4.4                        | 110                     |
| 7     | 20 wt% Pt/C   | 4.7                        | 117.5                   |



## References

1. Khan, I. A.; Qian, Y.; Badshah, A.; Nadeem, M. A.; Zhao, D., Highly porous carbon derived from MOF-5 as a support of ORR electrocatalysts for fuel cells. *ACS Appl. Mater. Interfaces* **2016**, *8* (27), 17268-17275.
2. Khan, I.; Nasim, F.; Choucair, M.; Ullah, S.; Badshah, A.; Nadeem, M., Cobalt oxide nanoparticle embedded N-CNTs: lithium ion battery applications. *RSC Adv.* **2016**, *6* (2), 1129-1135.