**Supplementary information**

# Pronounced effect of cobalt oxide on the electrocatalytic activity of palladium nanoparticles anchored on CoOx/NC towards ORR with increased MA and ECSA

## 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.[1]

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

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

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

## ECSA measurement

Electrochemical active surface area was calculated from palladium oxide layer reduction curve at potential limit of 1.4 $V_{RHE}$ according to the following formula.[2]

$$ECSA = \frac{Q_0}{q^o}$$

$$Q^0 = Charge\ contaimed\ in\ the\ CV\ curve$$

$$q^0 = standard\ value\ for\ Pd - based\ catalysts$$

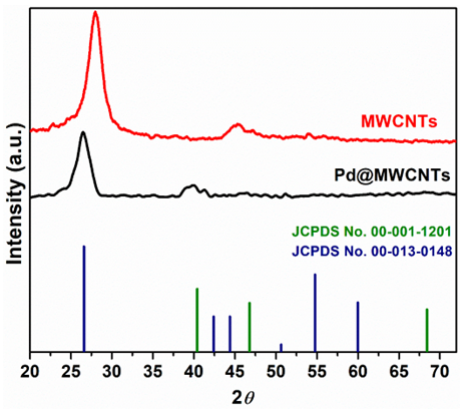


**Figure S1.** XRD pattern of MWCNTs and Pd@MWCNTs

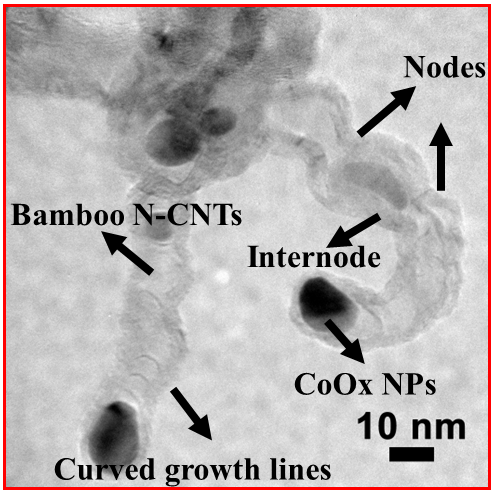


**Figure S2.** HRTEM image of CoOx/NC at 10nm

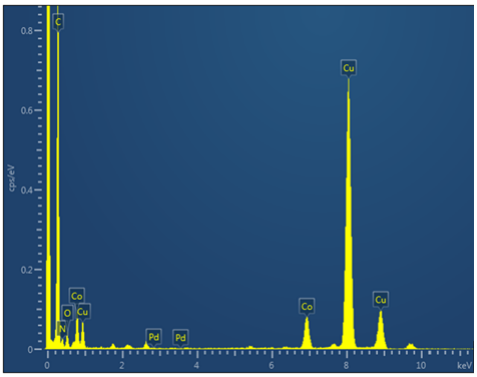

**Figure S3.** EDX analysis of Pd@CoOx/NC1

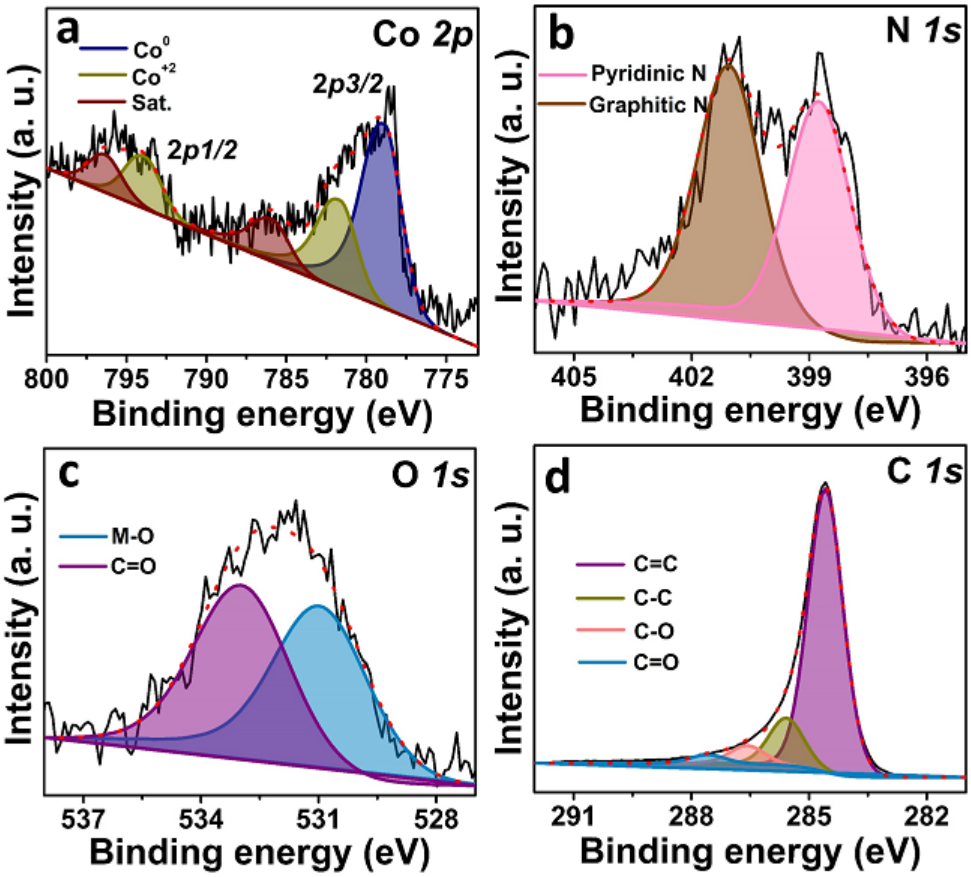


**Figure S4.** XPS spectrum of CoOx/NC (a) Co 2p (b) N 1s (c) O 1s (d) C 1s[3]

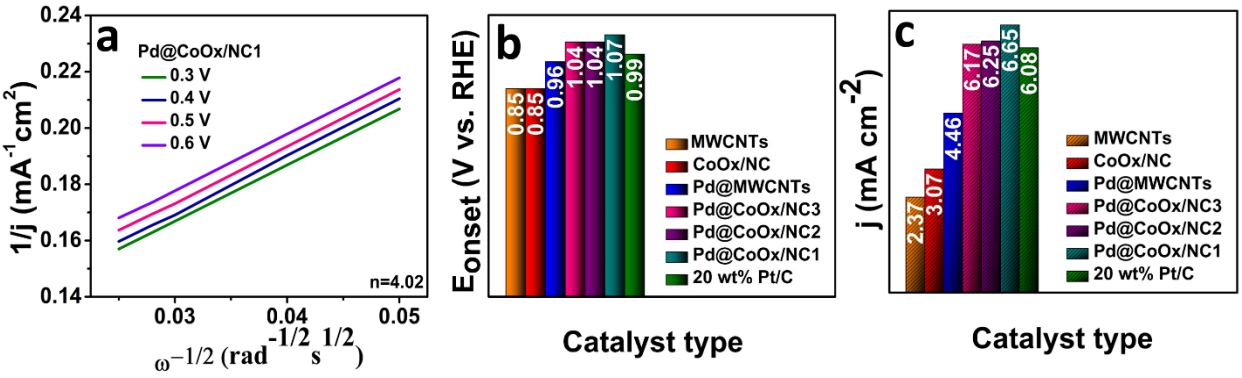


**Figure S5.** (a) K-L plot of Pd@CoOx/NC1 in 0.1M KOH (b) compariosn of $E_{onset}$ of the synthesized catalysts with 20 wt% Pt/C in 0.1M KOH (c) compariosn of $j_m$ of the synthesized catalysts with 20 wt% Pt/C in 0.1M KOH

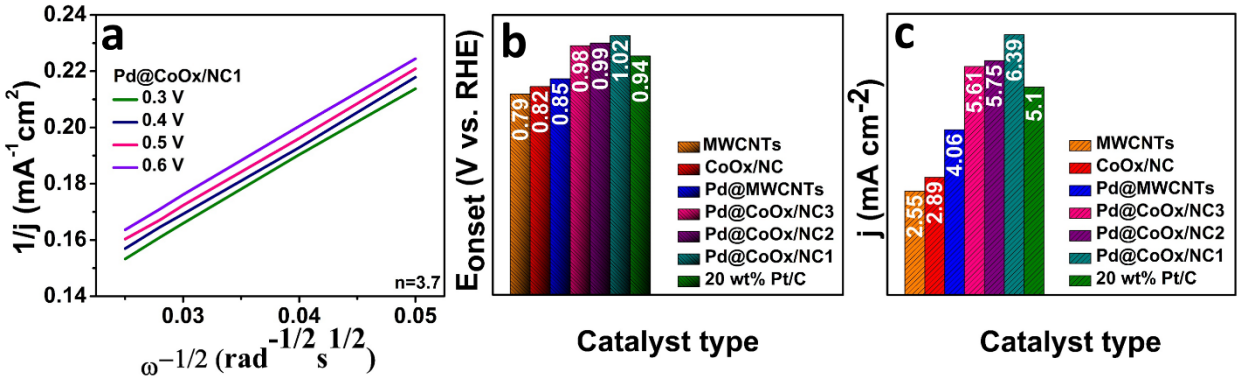


**Figure S6.** (a) K-L plot of Pd@CoOx/NC1 in 0.1M $HClO_4$ (b) compariosn of $E_{onset}$ of the synthesized catalysts with 20 wt% Pt/C in 0.1M $HClO_4$ (c) compariosn of $j_m$ of the synthesized catalysts with 20 wt% Pt/C in 0.1M $HClO_4$

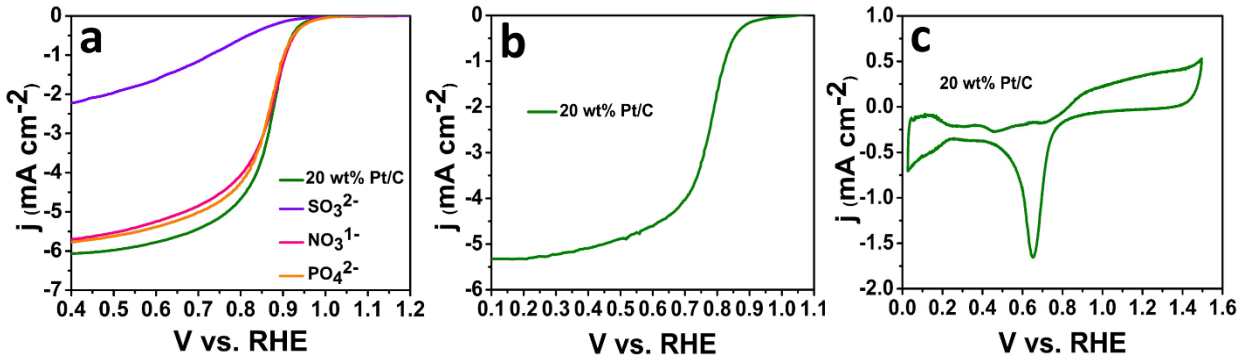


**Figure S7.** (b) ORR electrocatlytic performance of 20 wt% Pt/C in the presence of $SO_3^{-2}$, $NO_3^{-1}$, $HPO_4^{-2}$ anions in $O_2$ saturated 0.1M KOH at 10 $mVs^{-1}$ (b) LSV polarization curve of 20 wt% Pt/C in 0.1 M $HClO_4$ at 10 mV $s^{-1}$ (c) Pt-O layer reduction curve of 20 wt% Pt/C at 1.4 $V_{RHE}$ in 0.1 M $HClO_4$ at a scan rate of 50 mV $s^{-1}$ in Ar saturated environment

| Catalyst | Poisonous specie | $E_{onset}$ ($V_{RHE}$) | | $E_{1/2}$ ($V_{RHE}$) | | j (mA $cm^{-2}$) | |
|---|---|---|---|---|---|---|---|
| | 50 mM | before addition | after addition | before addition | after addition | before addition | after addition |
| Pd@CoOx/NC1 | $SO_3^{-2}$ | 1.07 | 1.06 | 0.95 | 0.941 | 6.65 | 6.19 |
| | $NO_3^{-1}$ | 1.07 | 1.06 | 0.95 | 0.948 | 6.65 | 6.27 |
| | $HPO_4^{-2}$ | 1.07 | 1.06 | 0.95 | 0.945 | 6.65 | 6.23 |
| 20 wt% Pt/C | $SO_3^{-2}$ | 0.99 | 0.96 | 0.865 | 0.679 | 6.08 | 2.25 |
| | $NO_3^{-1}$ | 0.99 | 0.99 | 0.865 | 0.854 | 6.08 | 5.72 |
| | $HPO_4^{-2}$ | 0.99 | 0.99 | 0.865 | 0.856 | 6.08 | 5.78 |

**Table S1.** ORR evaluating parameters of synthesized catalysts in the presence of toxic species

## References


1. I. A. Khan, Y. Qian, A. Badshah, M. A. Nadeem, and D. Zhao, ACS Appl. Mater. Interfaces, 2016, **8** (27), 17268-17275.
2. L.-I, Fang, Q. Tao, M.-f. Li, L.-w. Liao, D. Chen, and Y.-x. Chen, Chinese J. Chem. Phys., 2010, **23** (5),543-548.
3. I. Khan, F. Nasim, M. Choucair, s. Ullah, A. Badshah and M. Nadeem, RSC Adv. 2016, **6** (2), 1129-1135.