# Supporting Information

## Cobalt and Nitrogen Co-embedded Onion-like Mesoporous Carbon Vesicles as Efficient Catalysts for Oxygen Reduction Reaction in Alkaline Solution

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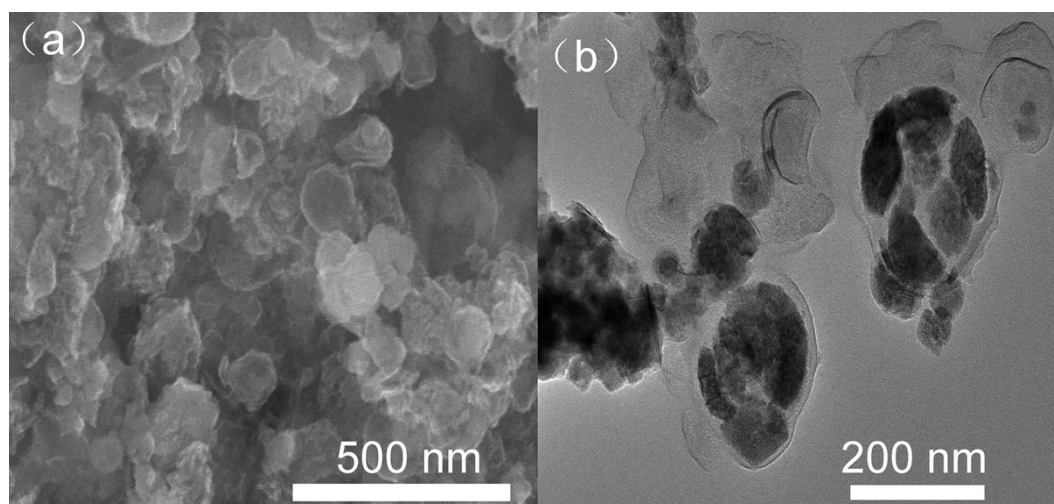
**Fig. S1.** (a) SEM and (b) TEM images of the Co20-NMCV sample.

**Table S1** Textural properties and atomic concentrations of the C, O, Co and N elements for the NMCV, Co5-NMCV, Co10-NMCV, and Co20-NMCV samples got from the $N_2$ physisorption isotherm curves and XPS analyses, respectively.

| Sample | $S_{BET}$ [a] $(m^2\ g^{-1})$ | $V_t$ [b] $(m^3\ g^{-1})$ | C [c] (at.%) | O [c] (at.%) | Co [c] (at.%) | N [c] (at.%) |
|---|---|---|---|---|---|---|
| NMCV | 569.05 | 0.69 | 84.20 | 14.68 | - | 1.13 |
| Co5-NMCV | 340.75 | 0.53 | 91.18 | 7.37 | 0.26 | 1.18 |
| Co10-NMCV | 308.44 | 0.52 | 84.66 | 13.70 | 0.41 | 1.23 |
| Co20-NMCV | 79.95 | 0.14 | 86.90 | 11.75 | 0.50 | 0.85 |

[a] Total BET surface area got from Fig. 2a;
[b] Total pore volume got from Fig. 2a;
[c] Getting from XPS analysis in Fig. 2c.

**Table S2.** The current density ($j$, mA cm$^{-2}$, read at -0.5 V vs. Ag/AgCl in the LSV curves), $E_{onset}$ value (V $vs.$ Ag/AgCl), the shift values of the $j$ ($\triangle j$) and $E_{onset}$ values ($\triangle E_{onset}$), and the % loss of the $j$ and $E_{onset}$ values for the Co10–NMCV and Pt/C catalysts before and after different potential cycles.

| Sample | Pulse potential cycles | $j$ (mA cm$^{-2}$) | $\triangle j$ (mA cm$^{-2}$) | % loss of $j$ | $E_{onset}$ (V) | $\triangle E_{onset}$ (mV) | % loss Of $\triangle E_{onset}$ |
|---|---|---|---|---|---|---|---|
| | 0 | -3.909 | - | - | -0.131 | - | - |
| Co10-NMCV | 2000 | -3.699 | 0.21 | -5.21 % | -0.141 | 10 | -7.61 % |
| | 4000 | -3.662 | 0.25 | -6.32 % | -0.149 | 18 | -13.74 % |
| | 6000 | -3.601 | 0.31 | -7.88 % | -0.153 | 24 | -18.32 % |
| | 0 | -4.106 | - | - | -0.078 | - | - |
| Pt/C | 2000 | -3.749 | 0.36 | -8.69 % | -0.090 | 12 | -15.38 % |
| | 4000 | -3.337 | 0.77 | -18.73 % | -0.106 | 28 | -35.89 % |
| | 6000 | -3.047 | 1.06 | -25.79 % | -0.118 | 40 | -51.28 % |
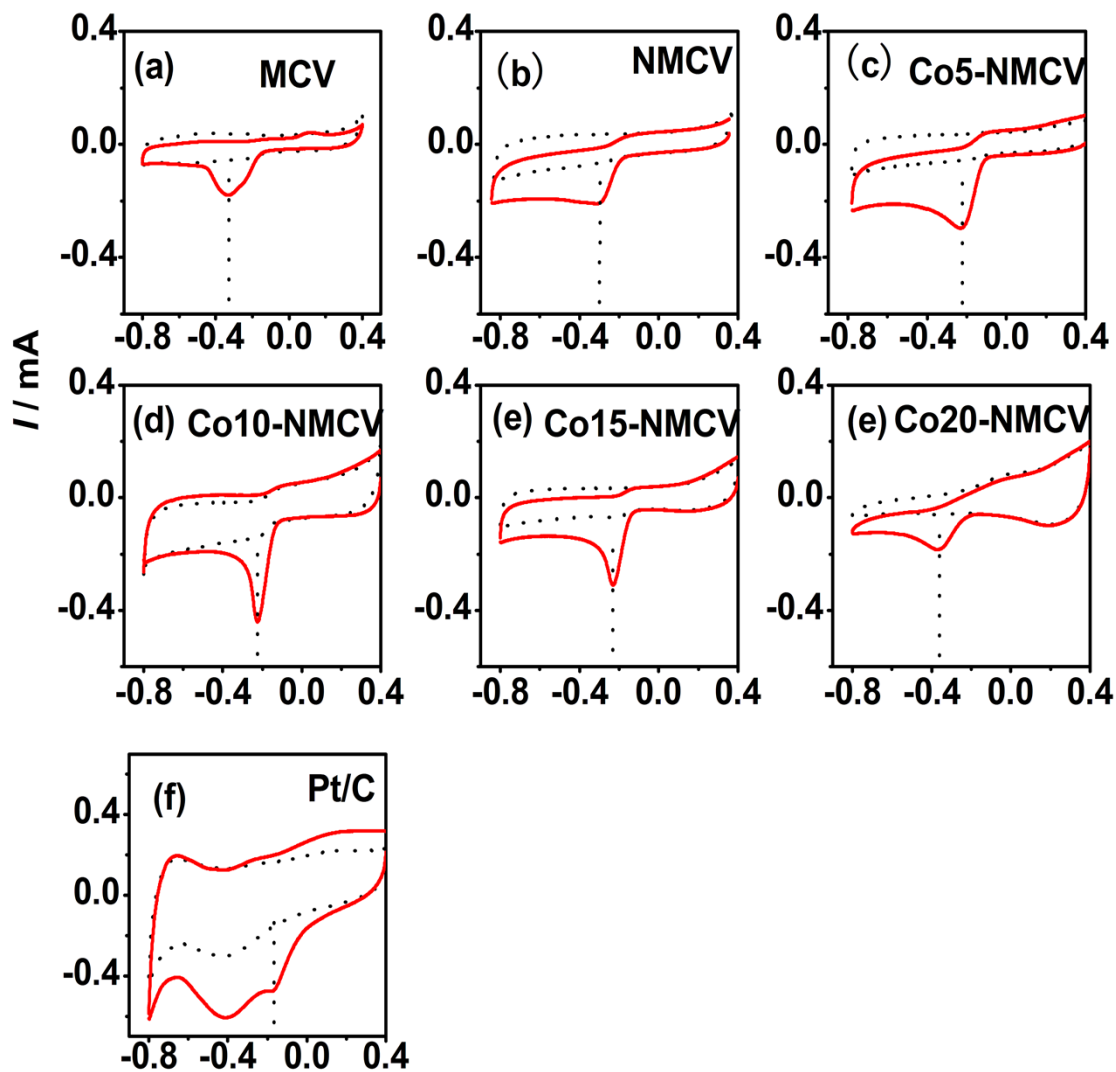
**Fig. S2.** Cyclic voltammograms (CVs) of the MCV, NMCV, Co5-NMCV, Co10-NMCV, Co10-NMCV, Co20-NMCV and Pt/C catalysts in 0.1 M KOH electrolyte (scan rate: 50 mV s$^{-1}$, catalyst loading: 152.9 mg cm$^{-2}$) saturated with N$_2$ (dot line) or O$_2$ (solid line).
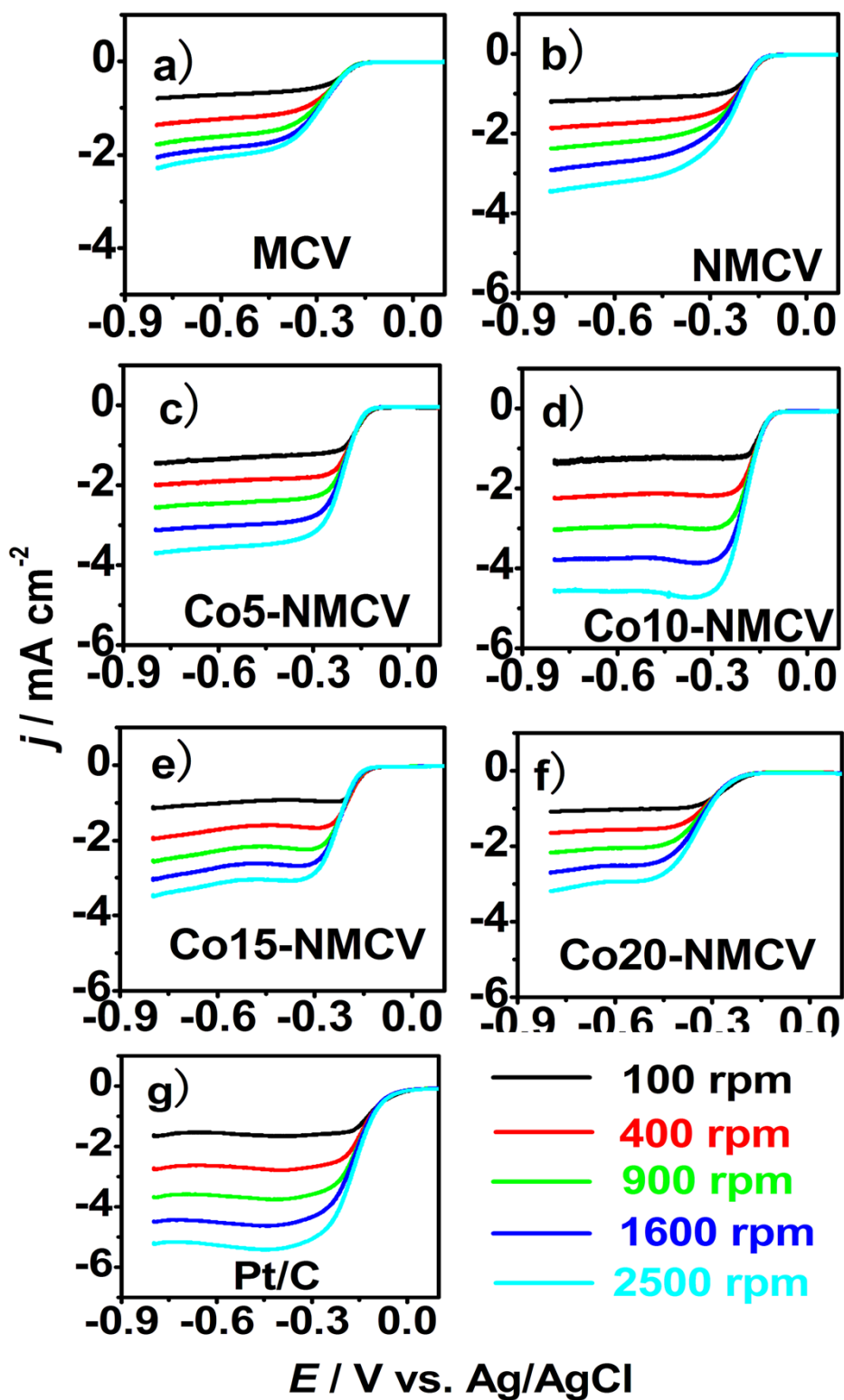
**Fig. S3.** RDE voltammograms of various catalysts in 0.1 M KOH electrolyte saturated with $O_2$ (scan rate 5 mV s$^{-1}$, catalyst loading 152.9 mg cm$^{-2}$) at different rotation rates from 100 to 2500 rpm.
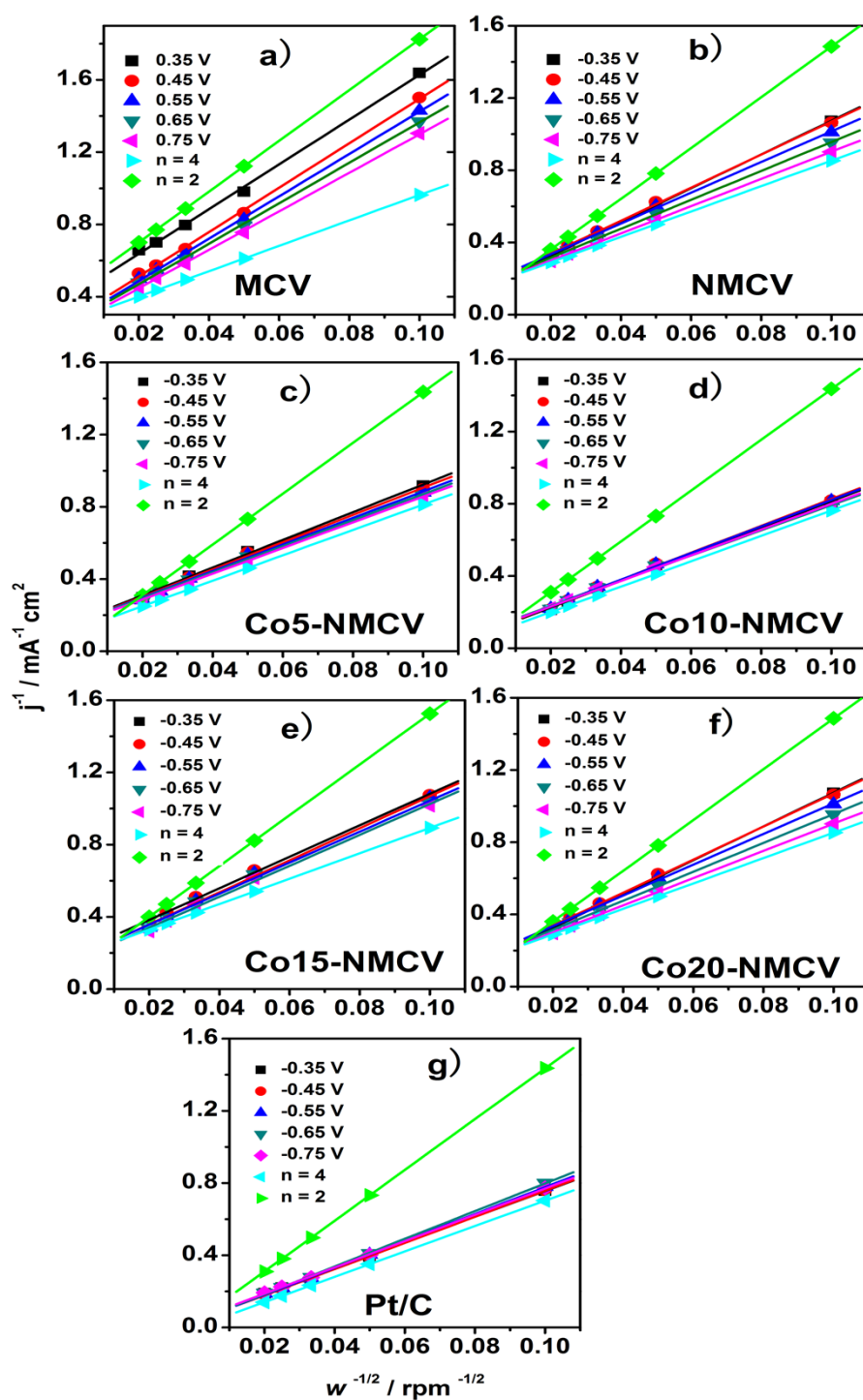
**Fig. S4.** K-L plots derived from the RDE voltammograms of various catalysts in 0.1 M KOH electrolyte saturated with $O_2$ (scan rate: 5 mV $s^{-1}$, catalyst loading: 152.9 mg $cm^{-2}$) at different potentials from -0.75 to -0.35 V vs. Ag/AgCl.

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**Table S3.** Heterocyclic C, N, and Co components of the NMCV, Co5-NMCV, Co10-NMCV, and Co20-NMCV samples recorded from the XPS C1s, N1s, and Co2p $_{3/2}$ spectra shown in Fig. 8.

| Peak | Component | Assignment | Binding Energy (eV) | Relative Quantity (at.%) | | | |
|---|---|---|---|---|---|---|---|
| | | | | NMCV | Co5-NMCV | Co10-NMCV | Co20-NMCV |
| C1s | C1 | C-C sp$^2$ | 284.5 | 33.14 | 46.89 | 33.54 | 41.66 |
| | C2 | C-C sp$^3$/ C-N sp$^2$ | 285.4 | 20.76 | 19.34 | 21.72 | 18.20 |
| | C3 | C-O | 286 | 9.31 | 9.78 | 8.20 | 11.22 |
| N1s | N1 | Pyridinic-N | 398.3 | 0.354 | 0.405 | 0.507 | 0.209 |
| | N2 | Pyrrolic-N | 400.4 | 0.352 | 0.202 | 0.199 | 0.366 |
| | N3 | Quaternary-N | 401.3 | 0.155 | 0.471 | 0.473 | 0.119 |
| | N4 | Oxidized-N | 402-405 | 0.166 | 0.079 | - | 0.054 |
| Co2p $_{3/2}$ | Co1 | Co (0) | 778.4 | - | 0.014 | 0.003 | 0.067 |
| | Co2 | Co$_x$O$_y$ | 779.6 | | 0.031 | 0.081 | 0.005 |
| | Co3 | Co-N-C | 780.3 | | 0.025 | 0.095 | 0.090 |
| | Co4 | Co-N | 781.5 | | 0.079 | 0.099 | 0.096 |
| | Co5 | Co (II) nitrate | 783.0 | | 0.036 | 0.070 | 0.113 |
| | Co6 | Satellites | 784-788 | | 0.066 | 0.068 | 0.132 |