**Supplementary Information**

**Phosphorous and Nitrogen Dual-Doped Carbon as a Highly Efficient Electrocatalyst for Sodium-Oxygen Batteries**

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**Supplementary Figures**



**Supplementary Fig. 1** (a) Low magnification SEM image of the polypyrrole; (b) high magnification SEM image of the polypyrrole; (c) STEM image of an individual polypyrrole tube.

 **Supplementary Fig. 2** (a) Low magnification SEM image of the NDC; (b) high magnification SEM image of the NDC; (c) STEM image of an individual NDC tube; (d) high-angle annular dark-field STEM image of an individual NDC tube; (e-f) corresponding element mappings.

 **Supplementary Fig. 3** (a) EDS spectrum of PNDC; (b) EDS spectrum of NDC.

 **Supplementary Fig. 4** (a) High resolution high-angle annular dark-field STEM image of PNDC; (b) high resolution high-angle annular bright-field STEM image of PNDC.



**Supplementary Fig. 5** (a) XPS survey spectrum and (b) high resolution C 1s XPS spectrum of PNDC.



**Supplementary Fig. 6** (a) XPS survey spectrum, (b) high resolution C 1s XPS spectrum and (c) high resolution N 1s XPS spectrum of NDC.



**Supplementary Fig. 7** Raman spectra of PNDC and NDC.

 **Supplementary Fig. 8** (a) Nyquist plot of PNDC, (b) Nyquist plot of NDC. Insert: equivalent circuit model.



**Supplementary Fig. 9** Discharge/recharge profiles of the PNDC and NDC in the voltage range of 1.5-4.0 V.



**Supplementary Fig. 10** (a) discharge/charge curves of the NDC at different current densities; (b) discharge/charge curves of the NDC for selected cycles at a current density of 200 mA g-1.



**Supplementary Fig. 11** XRD patterns of discharged and recharged NDC electrodes.



**Supplementary Fig. 12** SEM image of PNDC electrodes (a) a pristine, (b) discharged to 2.0 V, (c) discharged to 1.5 V, (d) recharged to 2.5 V, (e) recharged to 3.0 V; (f) schematic illustration of the ORR reaction on the PNDC electrodes. Scale bar, 1 μm.



**Supplementary Fig. 13** (a) the pristine NDC electrode; (b) the NDC electrode after discharged to 1.5 V; (c) the NDC electrode after recharged to 3.0 V.

**Supplementary Table**

**Supplementary Table 1** The adsorption energy (eV) of the PNDC and NDC for NaO2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *E*(carbon-NaO2) | *E*(carbon) | *E*(NaO2) | *ΔE*(Adsorption energy) |
| NDC | -2439.44 | -2426.81 | -10.83 | -1.80 |
| PNDC | -2392.68 | -2379.01 | -10.83 | -2.85 |