Supporting Information

N-doped onion-like carbon as efficient oxygen electrode for long-life

Li-O₂ battery

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Fig. S1 X-ray diffraction (XRD) pattern of OLC and N-OLC.



Fig. S2 Raman spectra of OLC and N-OLC.



Fig. S3 The discharge curves of the Ar-filled cells based on OLC and N-OLC electrodes at a current density of 500 mA g^{-1} .



Fig. S4 Plateau voltage vs. cycle number for Li-O₂ batteries with OLC at a current density of 0.15 mA cm⁻².



Fig. S5 Plateau voltage vs. cycle number for $Li-O_2$ batteries with Super P at a current density of 0.15 mA cm⁻².



Fig. S6 ¹H NMR spectra of the TEGDME electrolyte with 1 M LiTFSI before (a) and after 194 cycles (b) with the current density of 0.3 mA cm^{-1} .



Fig. S7 Electrochemical impedance spectra (EIS) of (a) OLC and (b) Super P cathodes in the pristine, discharged and recharged states.

Element	N-OLC Pristine	N-OLC Discharged	N-OLC Recharged	N-OLC 10 th	N-OLC 10 th
	Tistine	Dischargeu	Reenargeu	Discharge	Recharge
				d	d
Rs (Ω)	11.97	11.31	18.1	12.01	18.13
$Q_1 (\mu F)$	73.2	9.535	152	9.357	153.8
<i>a</i> 1	0.7587	0.8562	0.8312	0.8612	0.8297
Rct (Ω)	67.1	206.6	87.54	240.6	88.63
Q ₂ (mF)	13.97	16.65	19.09	16.32	19.22
<i>a</i> 2	0.9242	0.8597	0.8948	0.8653	0.8971

Table S1 Parameters for Figure 3, fitted by the equivalent circuit shown in the inset.

Table S2 Parameters for Figure S6a, fitted by the equivalent circuit shown in the inset.

Element	OLC-Pristine	OLC-Discharged	OLC-Recharged
Rs (Ω)	22.46	11.87	15.96
Q1 (µF)	117.8	9.401	99.32
<i>a</i> 1	0.7905	0.8595	0.8779
Rct (Ω)	107	234.1	148.6
Q ₂ (mF)	20.51	16.46	19.5
<i>a</i> 2	0.9356	0.8625	0.9311

Table S3 Parameters for Figure S6b, fitted by the equivalent circuit shown in the inset.

Element	Super P-	Super P-	Super P-Recharged
	Pristine	Discharged	
Rs (Ω)	18.09	12.26	11.68
$Q_{1}\left(\mu F\right)$	120.7	9.564	9.411

<i>a</i> 1	0.8654	0.8627	0.8586
Rct (Ω)	127.5	251.8	224.3
$Q_{2}\left(mF ight)$	19.2	16.37	16.46
<i>a</i> 2	0.9077	0.8722	0.8611

The equivalent circuit displayed above in Figure 3 and Figure S6 consists of an uncompensated ohmic resistance (Rs) in series with a constant phase element (Q_1) in parallel with the charge transfer resistance (Rct). At the end of the circuit is a second constant phase element (Q_2). The elements of Rs, Q_1 and Rct cause the depressed semi-circle shape in the Nyquist plots, while the element Q_2 is related to diffusion of active species to the surface of the electrode and gives rise to the linear tail following the semi-circle at low frequencies. The uncompensated resistance Rs is due to the electronic resistances of the electrodes, contacts, and electrolyte resistance and is roughly the same for each cell. The constant phase elements defines as Q and *a* represent the capacitive contributions of the each electrode, where the value of *a* can range between 0 and 1, with 0 being a pure resistor and 1 being a pure capacitor.





Fig. S8 SEM images of discharged N-OLC cathodes. It can be seen that Li_2O_2 toroids also deposited on glass fiber separator (insulator), indicates that toroid-like Li_2O_2 formed by nucleation of crystallites formed in solution.