

Supplementary Material

Cu/CuOx@C composite as a high-efficiency electrocatalyst for oxygen reduction reactions

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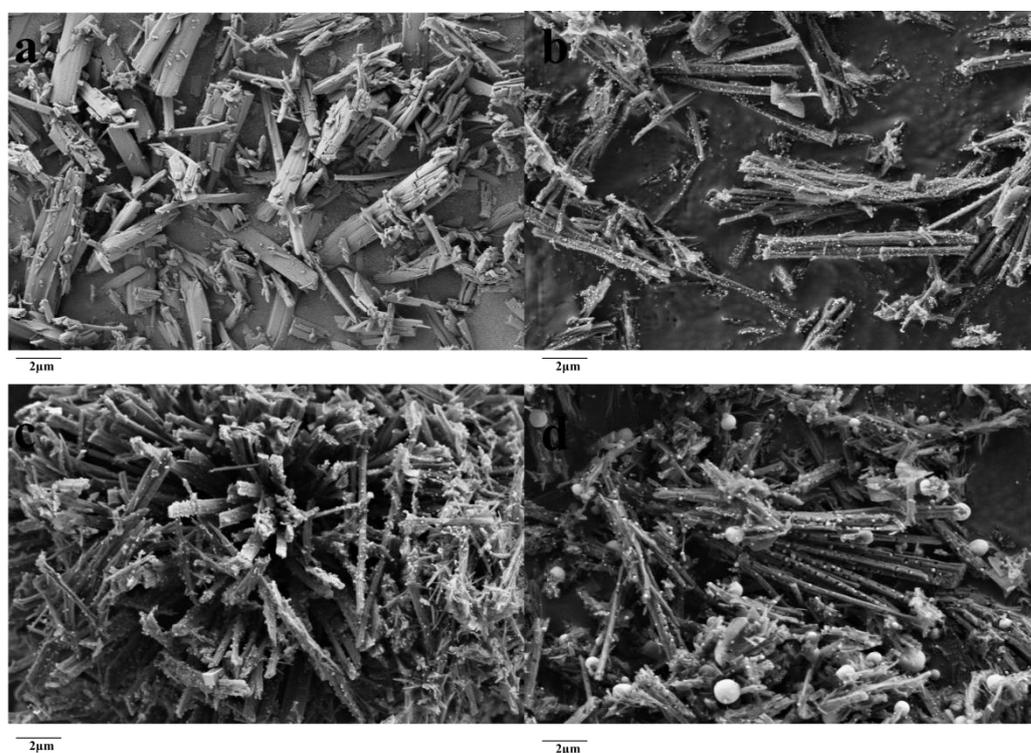


Figure S1. (a) Cu(OH)(Hsal)·H₂O (b) Cu@C (c) Cu@C-etching (d) SEM of Cu@C-800.

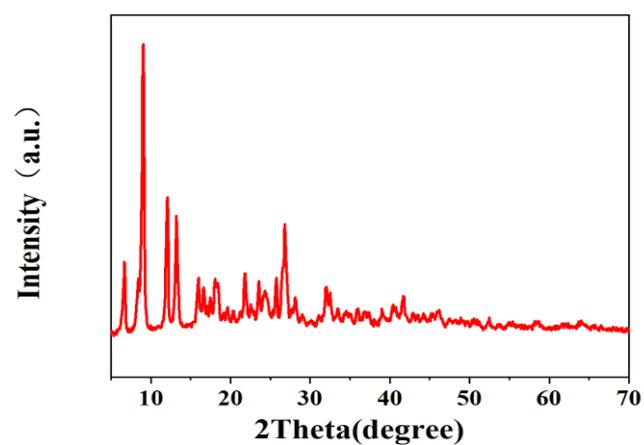
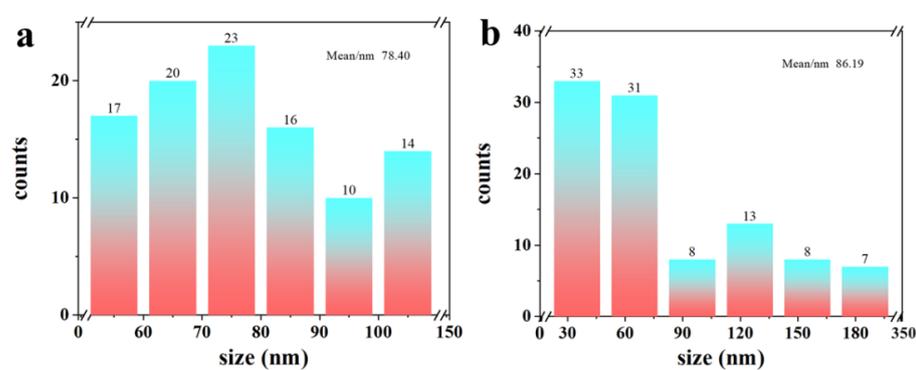
Figure S2. XRD of $\text{Cu(OH)(Hsal)·H}_2\text{O}$.

Figure S3. (a) Cu@C (b) Nanoparticle size distribution in Cu@C-800.

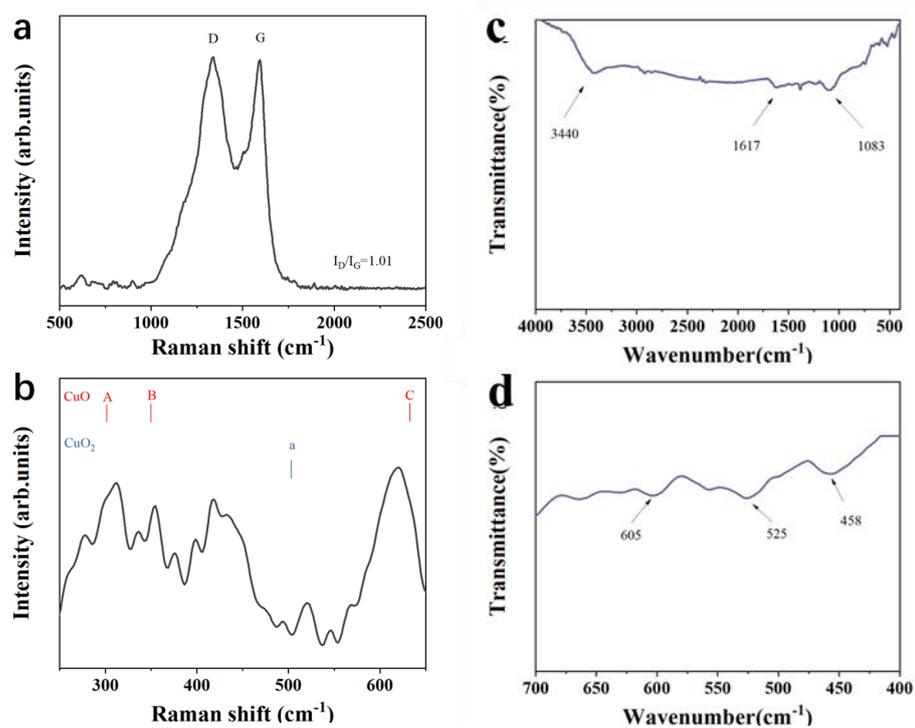


Figure S4. (a, b) Raman of Cu@C-800 (c, d) Infrared of Cu@C-800.

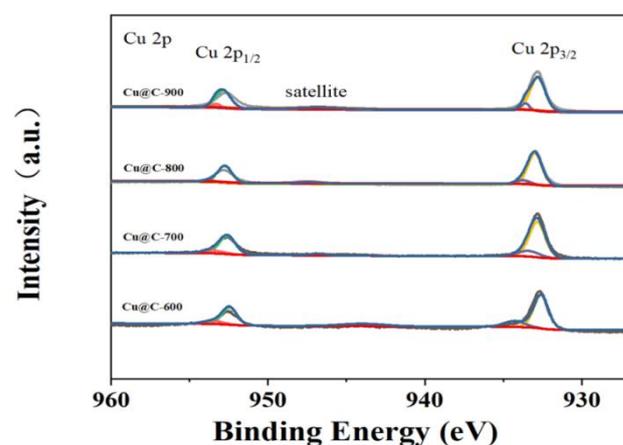


Figure S5. Cu@C-600, Cu@C-700, Cu@C-800, Cu@C-900's Cu XPS fine spectrum.

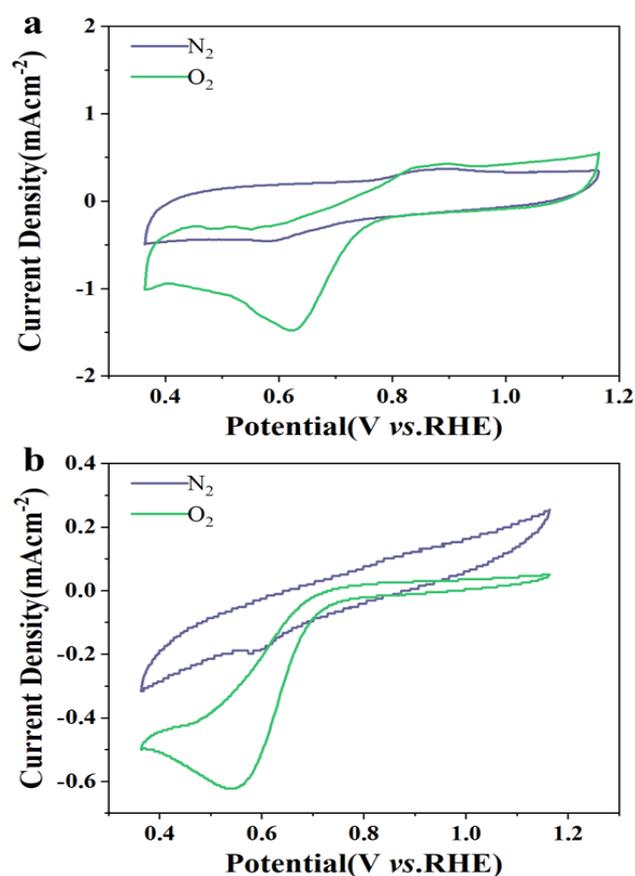


Figure S6. (a) Cu@C, (b) Cu@C-etching CV under N_2 , O_2 saturation.

Table S1. Cu@C-(600,700,800,900) Cu(111) XRD half-value width, particle size, O's XPS fine spectrum peak area, and the ratio of C-OH, O-Cu, Cu's XPS fine spectrum Peak area and the ratio of Cu(0)+Cu(I), Cu(II)

Samples	F.W.H.M.	Crystal-lite (\AA)	C-OH Area	O-Cu Area	O-Cu: C-OH	Cu(0)+Cu(I) Area	Cu(II) Area	Cu(II): Cu(0)+Cu(I)
Cu@C-600	0.322	279	27147	4171	0.15	13986	3471	0.25
Cu@C-700	0.306	296	37765	4128	0.11	31750	6831	0.22
Cu@C-800	0.146	800	24251	2238	0.11	51715	6852	0.13
Cu@C-900	0.144	825	29147	2593	0.09	56510	6368	0.11

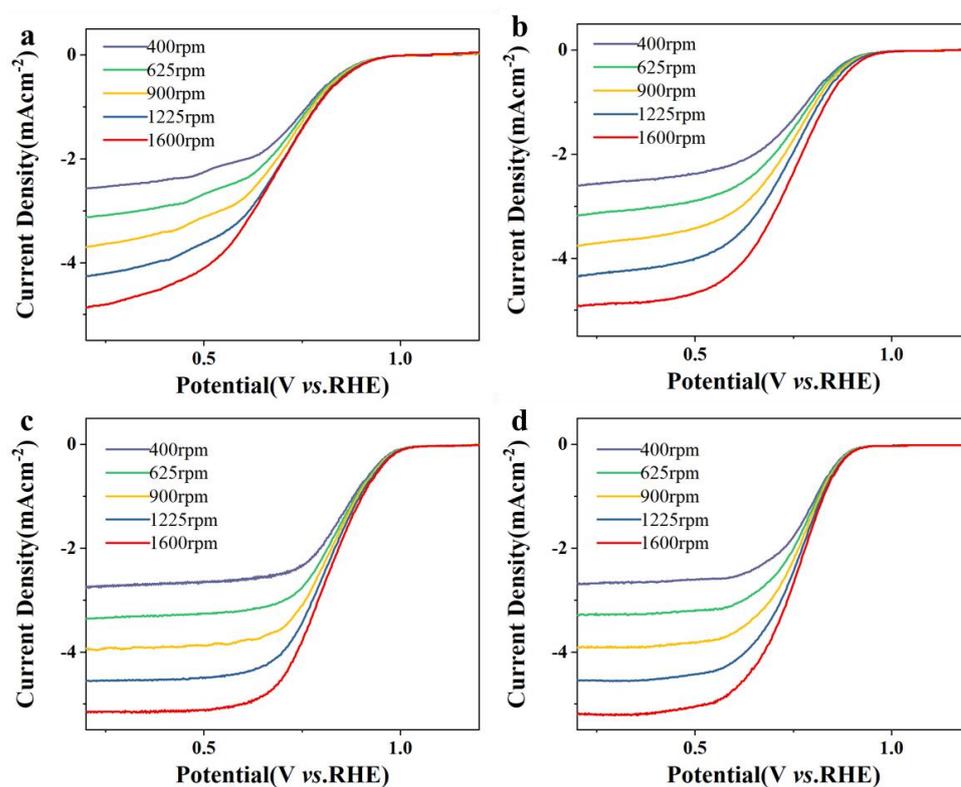


Figure S7. Cu@C-(600, 700, 800 and 900) LSV at 400, 625, 900.1225 and 1600rpm.

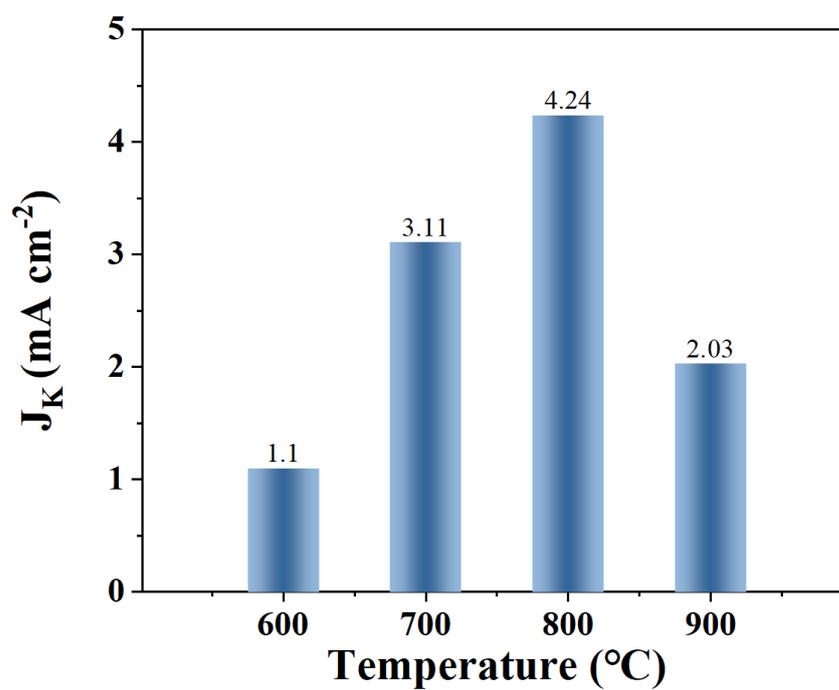


Figure S8. The dynamic current density at 0.81 V vs. RHE.

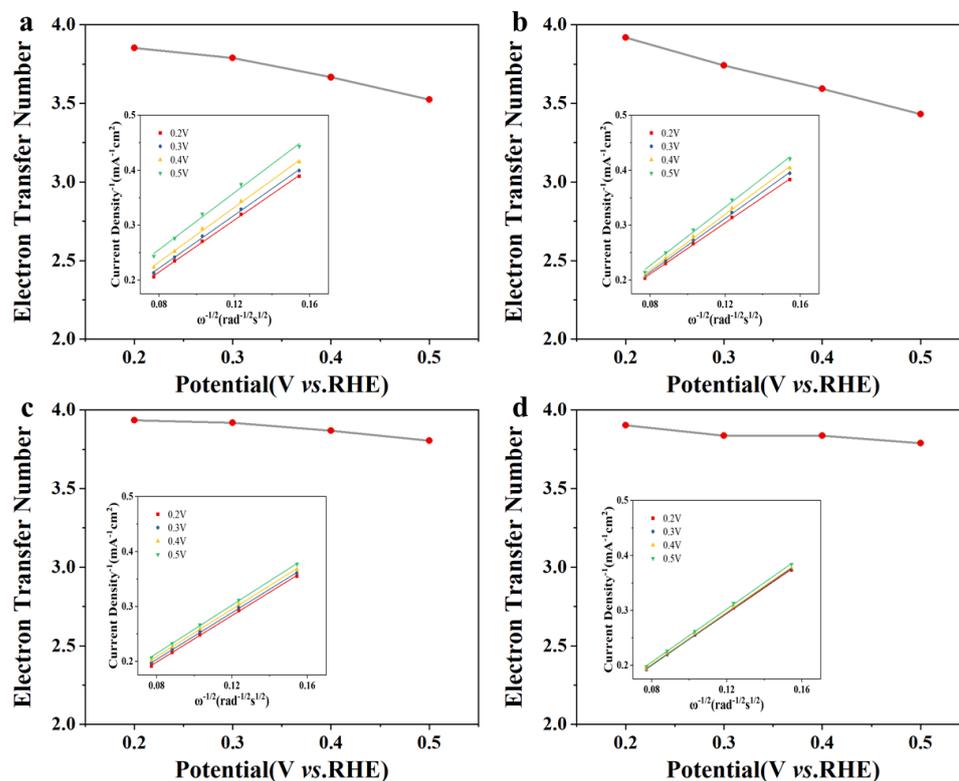


Figure S9 Cu@C- (600, 700, 800, and 900) electron transfer numbers at 0.2, 0.3, 0.4, and 0.5V.

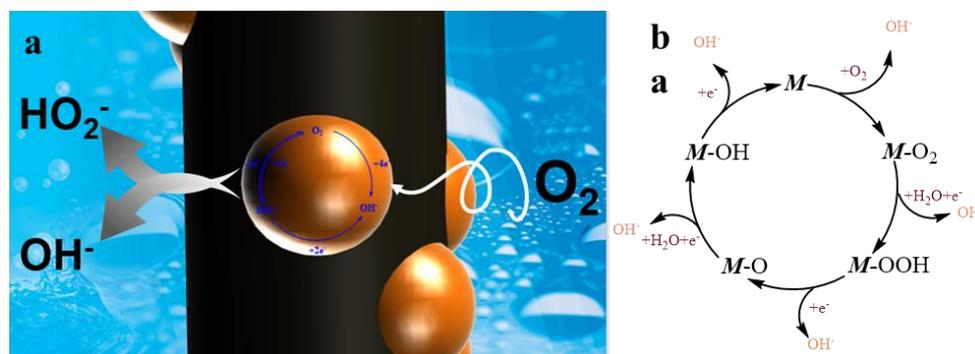


Figure S10. Cu@C-800 material surface (a) Simulation of ORR process (b) 4e-process.

Table S2. Comparison of the ORR activity of Cu@C-800 and Cu-based catalysts.

Samples	E_{onset}	$E_{1/2}$	References
Cu/Zn-NC	0.98	0.83	1
PPyCuPcTs(40:1)	0.92	0.81	2
PPy/CuPcTs	0.90	0.78	3
Cu-N/C	1.03	0.81	4
CuCo-600	0.95	0.84	5
Cu@Fe-N-C	1.01	0.89	6
Cu(15%)-MFC60	0.86	0.76	7
Cu-N-C NDs	0.97	0.85	8

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