

Supporting Information

Surface Engineering of MnO₂/Nitrogen-Doped Porous Carbon with a Protic Ionic Liquid toward Efficient Electrochemical Oxygen Reduction in Alkaline Solution

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Table S1. Kinetic parameters derived from RRDE analysis, including slope, intercept, k_1/k_2 (peroxide formation ratio), and k_3 (peroxide reduction rate constant), for MnO₂/NPC and PIL-modified catalysts at 0.57 and 0.67 V vs RHE.

0.57 V vs RHE				
Catalyst	Slope	Intercept	k_1/k_2	$k_3(\text{s}^{-1})$
MnO ₂ /NPC	-148.86	18.00	2.83	3.13×10^{-4}
MnO ₂ /NPC+PIL (1:2)	114.51	8.19	1.02	1.16×10^{-3}
MnO ₂ /NPC+PIL (1:1)	115.35	6.23	0.66	2.00×10^{-3}
MnO ₂ /NPC+PIL (2:1)	-186.41	19.63	3.13	3.31×10^{-4}
0.67 V vs RHE				
Catalyst	Slope	Intercept	k_1/k_2	$k_3(\text{s}^{-1})$
MnO ₂ /NPC	0	7.51	0.89	0
MnO ₂ /NPC+PIL (1:2)	31.14	8.17	1.01	3.20×10^{-4}
MnO ₂ /NPC+PIL (1:1)	11.17	6.58	0.71	1.78×10^{-4}
MnO ₂ /NPC+PIL (2:1)	70.52	5.94	0.60	1.36×10^{-3}

$$D_{\text{H}_2\text{O}_2} \approx 1.4 \times 10^{-5} \text{ cm}^2/\text{s}, \quad \nu \approx 0.01 \text{ cm}^2/\text{s}^{-1}$$

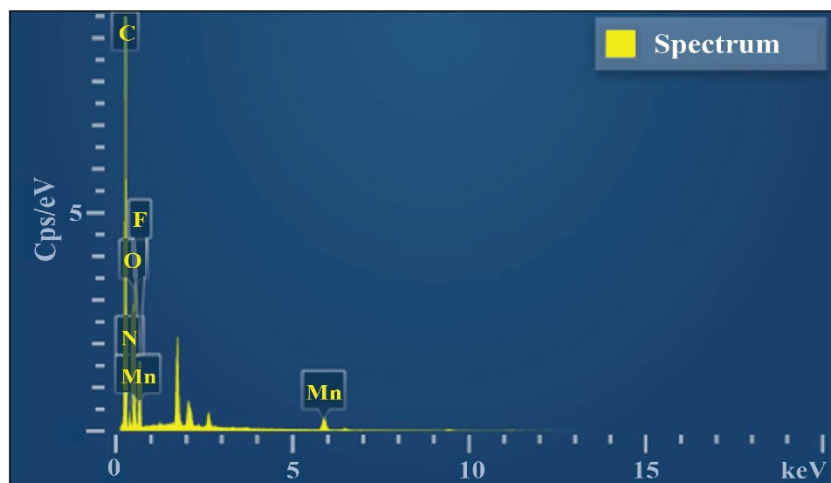


Figure S1. EDX spectrum of synthesized MnO₂/NPC-400+PIL (1:2).

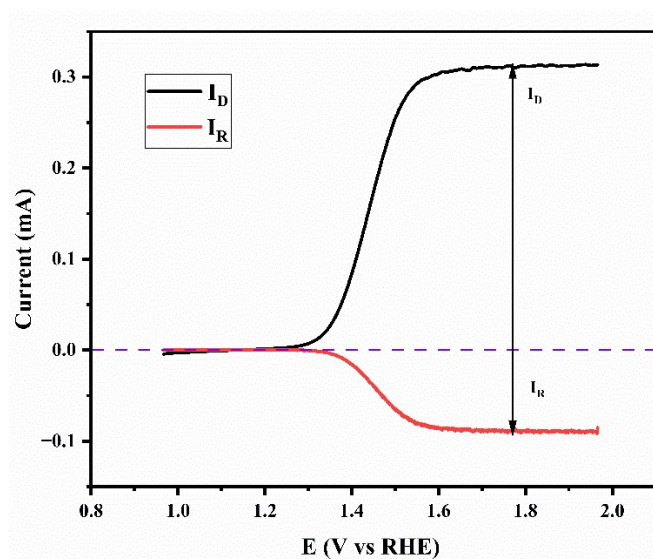


Figure S2. RRDE disk (top) and ring (bottom) currents for 1.0 mM K₄[Fe(CN)₆] in a 0.05 M H₂SO₄ supporting electrolyte. Rotation rate: 1600 rpm, scan rate: 50 mV s⁻¹.

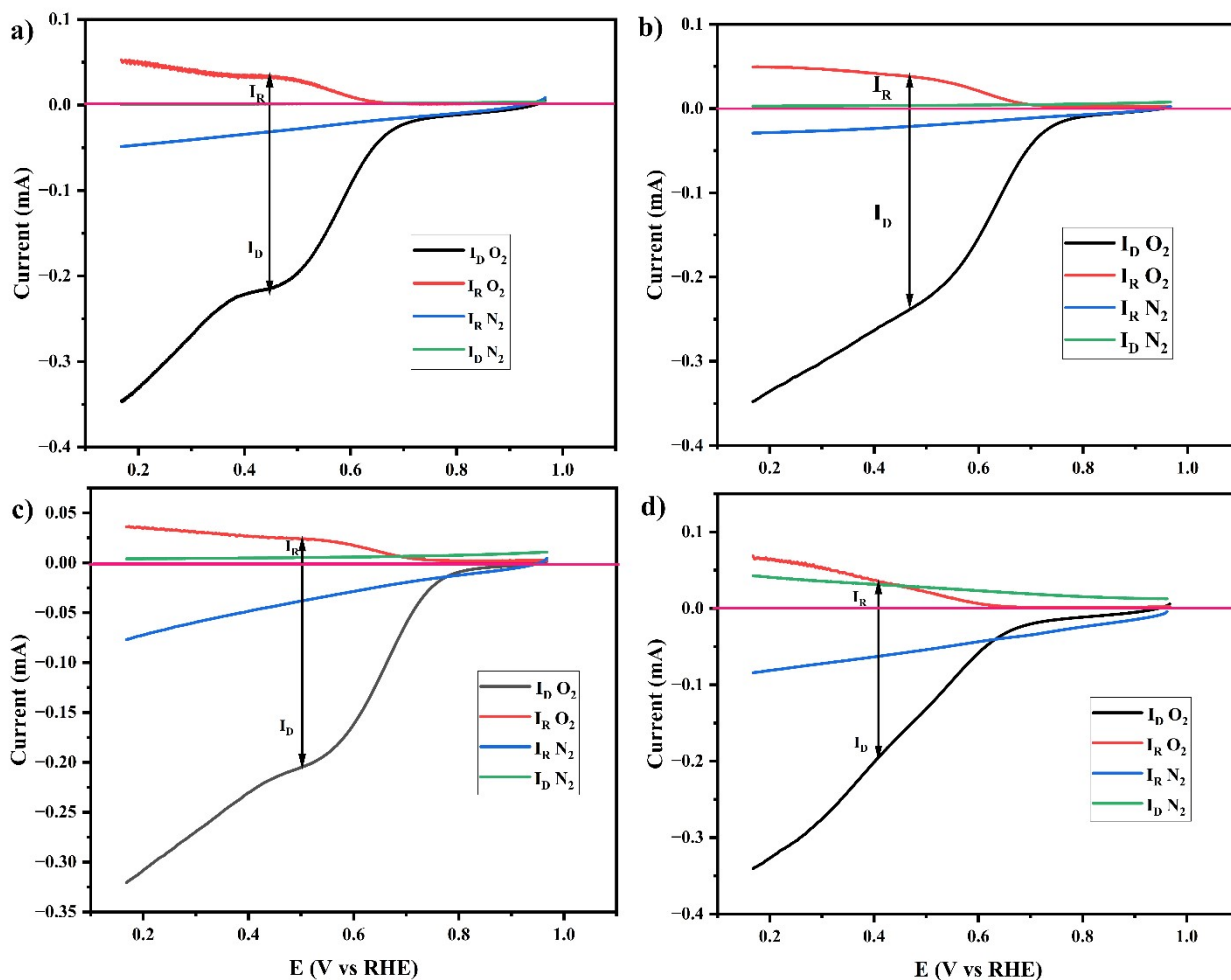


Figure S3. RRDE voltammograms showing disk (I_D) and ring (I_R) currents recorded in O_2 - and N_2 -saturated electrolyte for (a) MnO₂/NPC-400, (b) MnO₂/NPC-400+PIL (1:1), (c) MnO₂/NPC-400+PIL (1:2), and (d) MnO₂/NPC-400+PIL (2:1) catalysts, plotted as current vs potential (V vs RHE).

1. L. Zhang, H. Li and J. Zhang, *J. Power Sources*, 2014, **255**, 242–250, DOI: 10.1016/j.jpowsour.2014.01.042.