Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Efficient utilization of crude bio-oil: synthesizing of nitrogen-doped hierarchically porous carbons as electrocatalysts for oxygen reduction reaction

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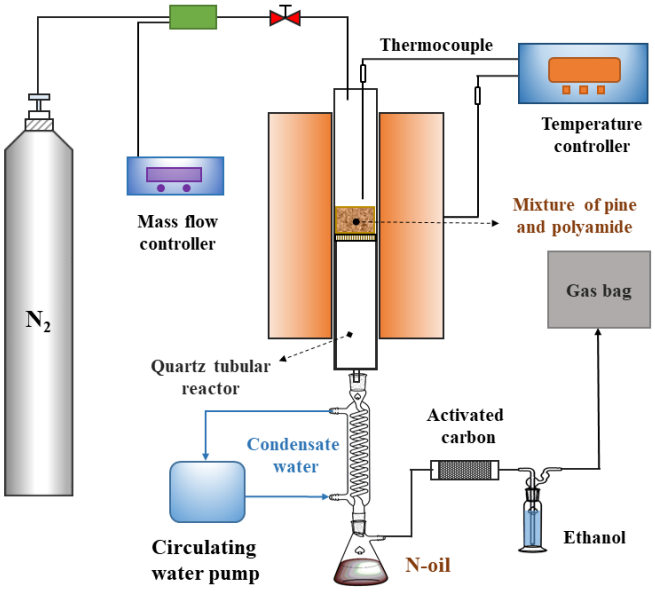

Fig. S1 Schematic diagram of the fixed bed for N-oil production

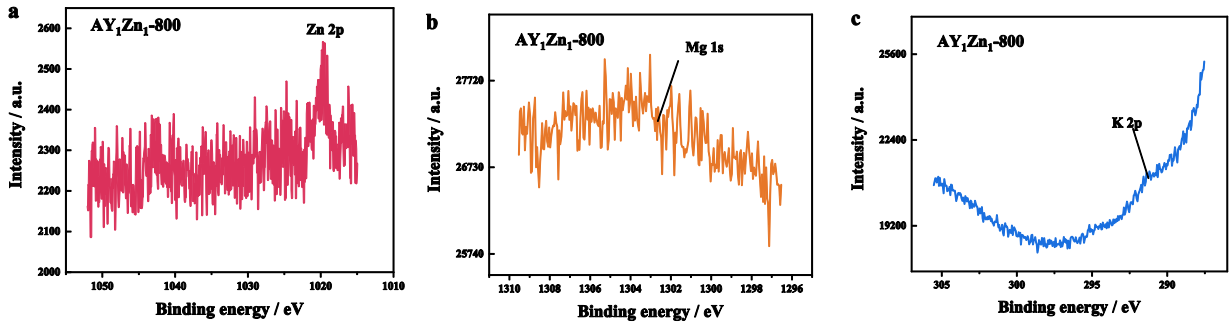

Fig. S2 (a) High-resolution Zn2p spectrum (b) High-resolution Mg1s spectrum (c) High-resolution K2p spectrum of AY_1Zn_1-800. The content of Zn, Mg, K were 0.33, 0.69 and 0.24 at%, respectively.

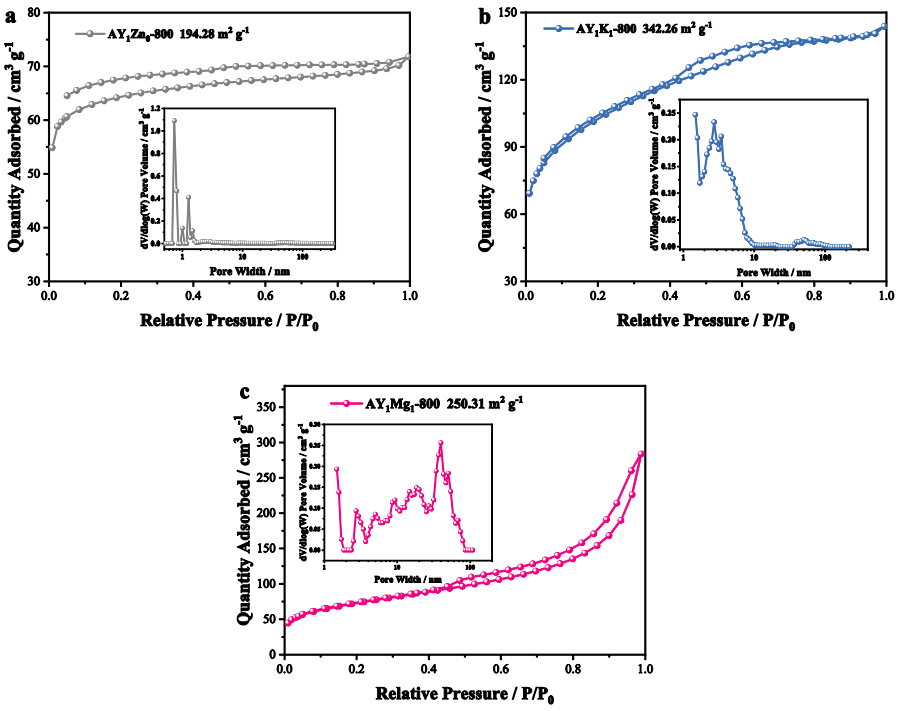

Fig. S3 N_2 adsorption-desorption isotherms of (a) AY_1Zn_0-800; (b) AY_1K_1-800 and (c) AY_1Mg_1-800.The insets are corresponding pore size distribution curves.

Table S1 Parameters from N_2 adsorption-desorption analysis

Sample	S_{BET}	S_{micro}[a]	S_{meso}	V_{total}[b]	V_{micro}[a]	V_{meso}	V_{meso}/V_{micro}	V_{meso}/V_{total}	$D_{average}$[c]	Porosity[d]
	$m^2\ g^{-1}$	$m^2\ g^{-1}$	$m^2\ g^{-1}$	$cm^3\ g^{-1}$	$cm^3\ g^{-1}$	$cm^3\ g^{-1}$		%	nm	%
AY_1Zn_0-800	194.28	155.93	38.35	0.110	0.082	0.028	0.34	25.45	2.84	66.92
AY_1K_1-800	343.26	108.20	235.06	0.222	0.055	0.167	3.05	75.30	3.17	78.46
AY_1Mg_1-800	250.31	41.43	208.88	0.439	0.021	0.418	19.90	95.22	8.42	88.28

[a] Surface area and pore volume of micropores determined by t-plot method; [b] Total pore volume of pores at P/P_0=0.99; [c] BJH desorption average pore diameter; [d] Porosity=$V_{total}/(V_{total}$+ Mass of tested sample/ Density of carbon), here the density of carbon is 1.99 g cm^{-3}.

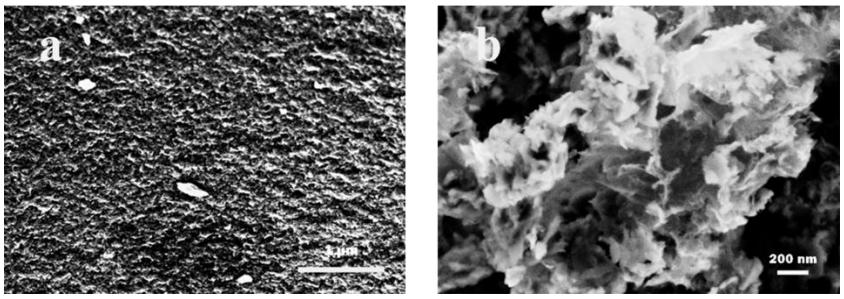

Fig. S4 The SEM images of (a) AY_1K_1-800 and (b) AY_1Mg_1-800.

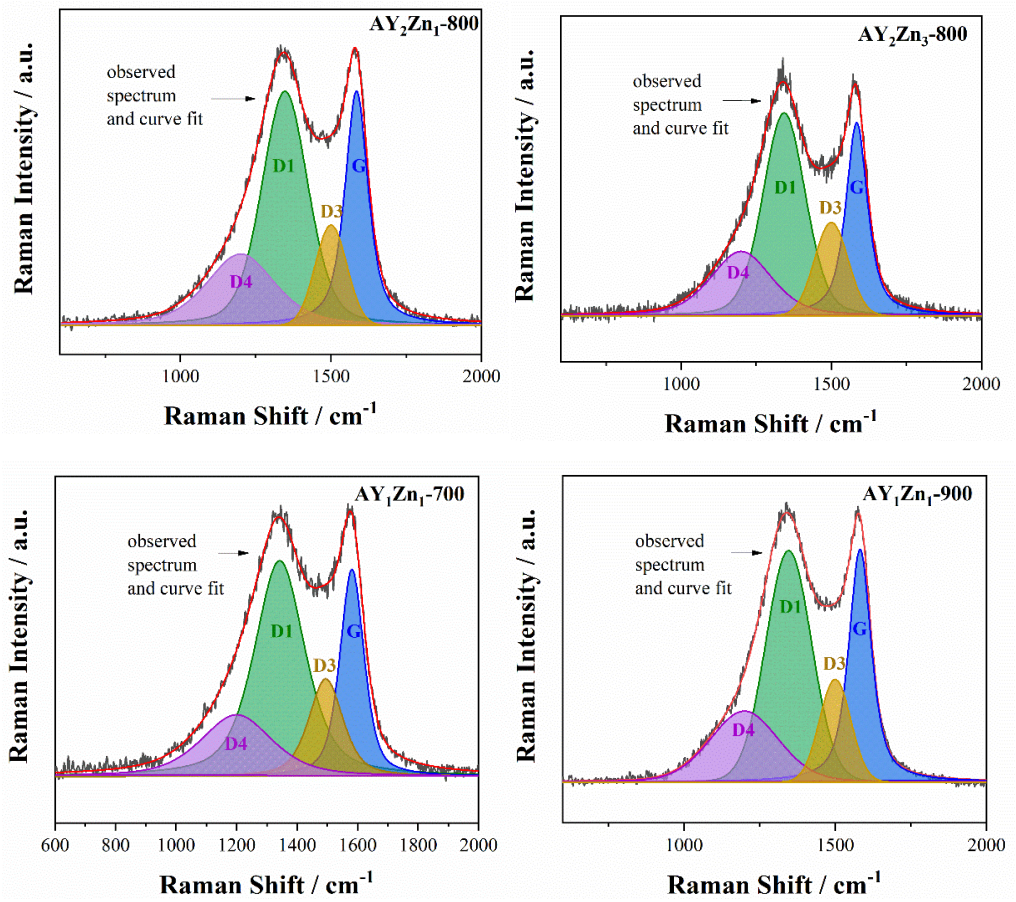

Fig. S5 Fitted Raman spectra of other samples

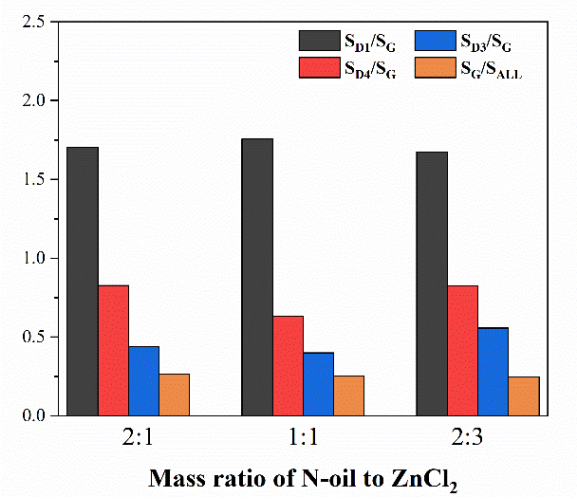

Fig. S6 The values of S_{D1}/S_G, S_{D3}/S_G, S_{D4}/S_G and S_G/S_{All} of samples prepared at different mass ratio of N-oil/$ZnCl_2$.

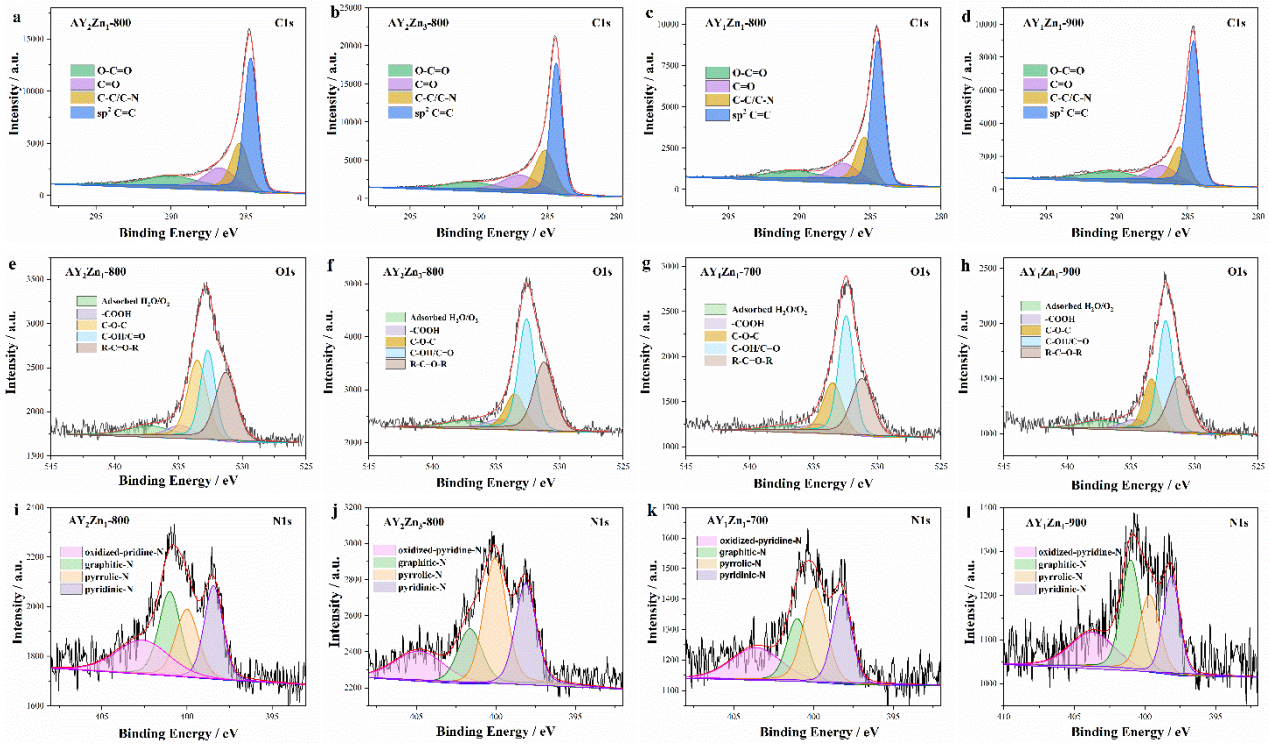

Fig. S7 (a-d) High-resolution C1s spectra of other samples; (e-h) High-resolution O1s spectra of other samples; (i-l) High-resolution N1s spectra of other samples.

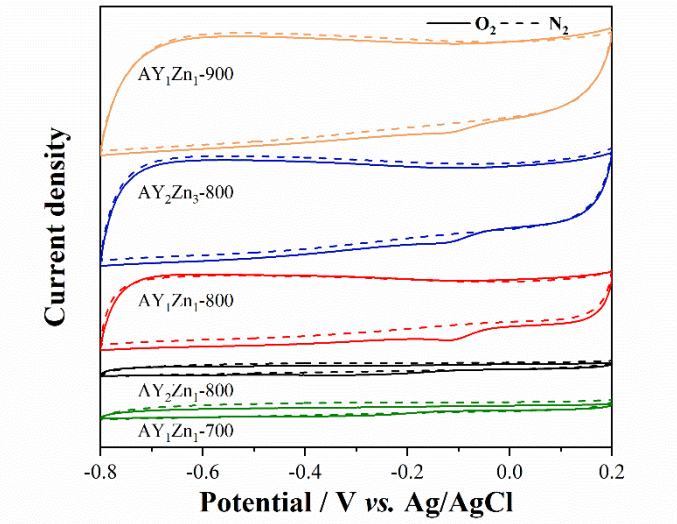

Fig. S8 CV curves of AY_xZn_y-T in O_2-saturated and N_2-saturated 0.1 M KOH electrolyte at a scan rate of 10 mV s^{-1}.

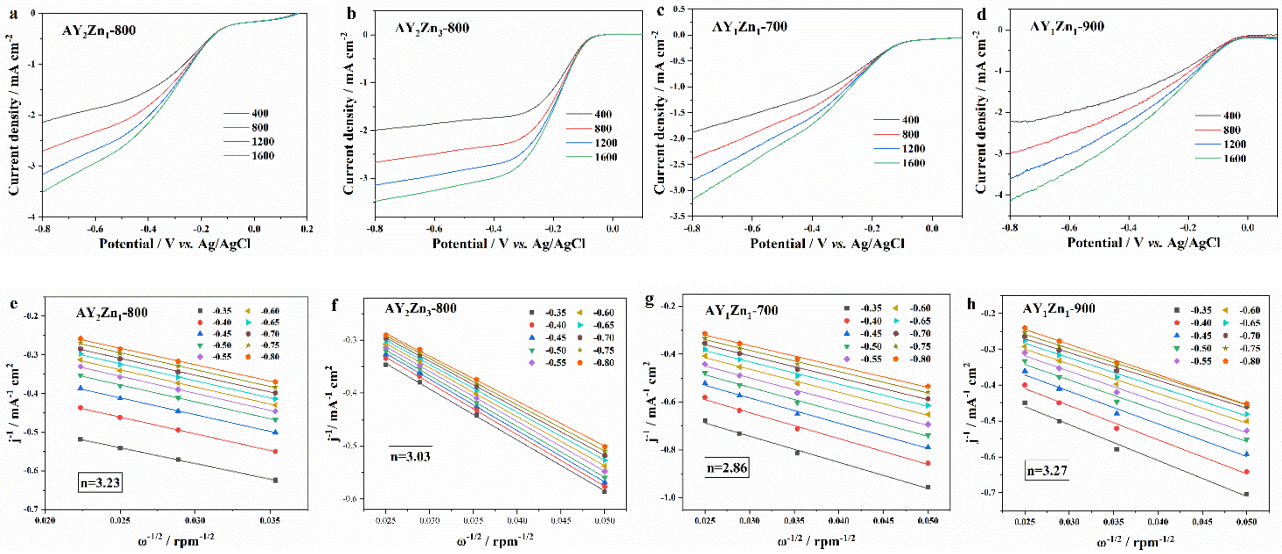

Fig. S9 (a-d) LSV curves for other samples in O_2-saturated 0.1 M KOH at various rotating speeds; (e-h) the corresponding K-L plots for ORR in O_2-saturated 0.1 M KOH.

Table S2 The LSV parameters for the carbons and commercial Pt/C catalyst tested by RDE

Sample	E_{onset} V *vs.*Ag/AgCl	$E_{1/2}$ V *vs.*Ag/AgCl	j_{lim} mA cm^{-2}	n[a]
AY_1Zn_1-800	**0.044**	**-0.174**	**5.91**	**3.75**
AY_2Zn_1-800	-0.054	-0.354	3.49	3.23
AY_2Zn_1-800	0	-0.214	3.47	3.03
AY_1Zn_1-700	-0.059	-0.38	3.17	2.86
AY_1Zn_1-900	0.016	-0.317	3.99	3.27
Pt/C (20 wt%)	0.048	-0.152	6.26	~4

[a] The electron transfer number calculated based on K-L plot method