

Giving a new life to waste cigarette butts: transformation into platinum group metal-free electrocatalysts for oxygen reduction reaction in acid, neutral and alkaline environment

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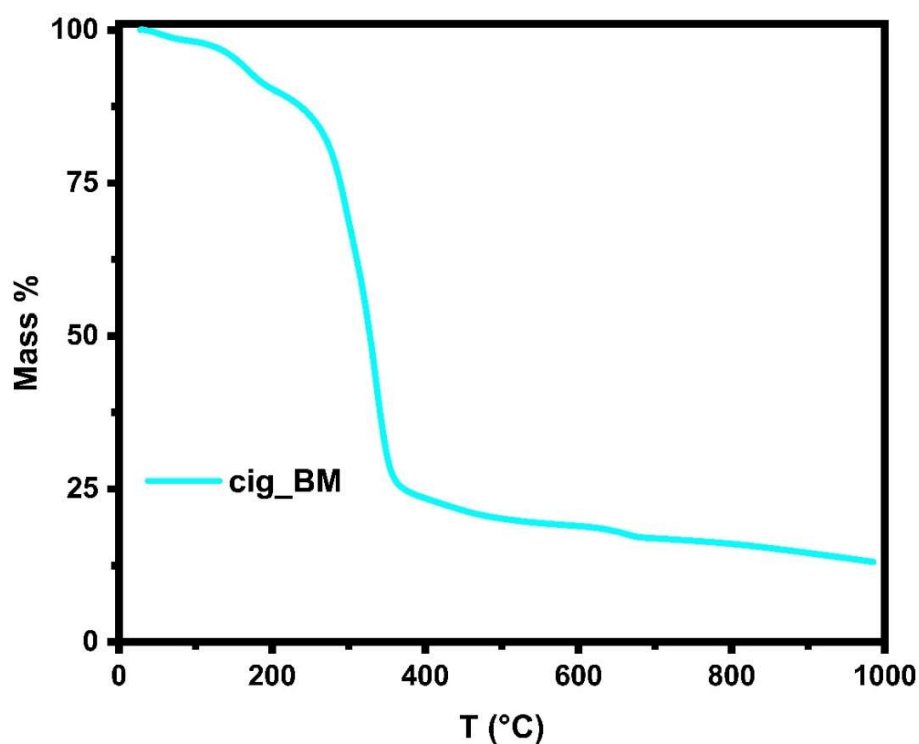


Figure S1. TGA of cig_BM performed under N₂ atmosphere.

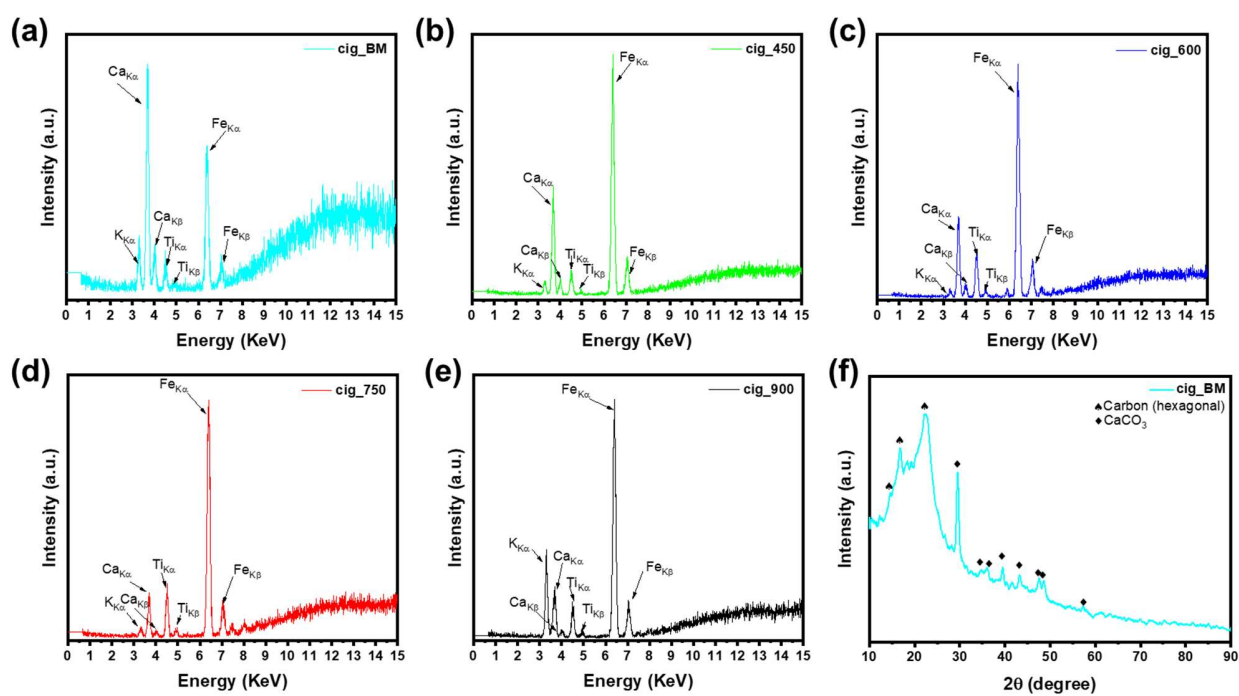


Figure S2. XRF spectra of as-synthesized samples (a-e) and XRD pattern of cig_BM (f).

Table S1. Fitting result of Raman bands as a sum of bands with Breit-Wigner-Fano line shape.

Sample	D band			G band			D' band		
	Peak intensity	Position	FWHM	Peak intensity	Position	FWHM	Peak intensity	Position	FWHM
cig_900	0.579	1338.990	82.507	0.421	1590.980	39.149			
cig_750	0.550	1334.580	85.334	0.450	1590.520	38.310			
cig_600	0.586	1344.680	124.736	0.414	1587.480	51.783			
cig_450	0.521	1333.720	45.996	0.345	1582.760	37.812	0.135	1616.680	6.645

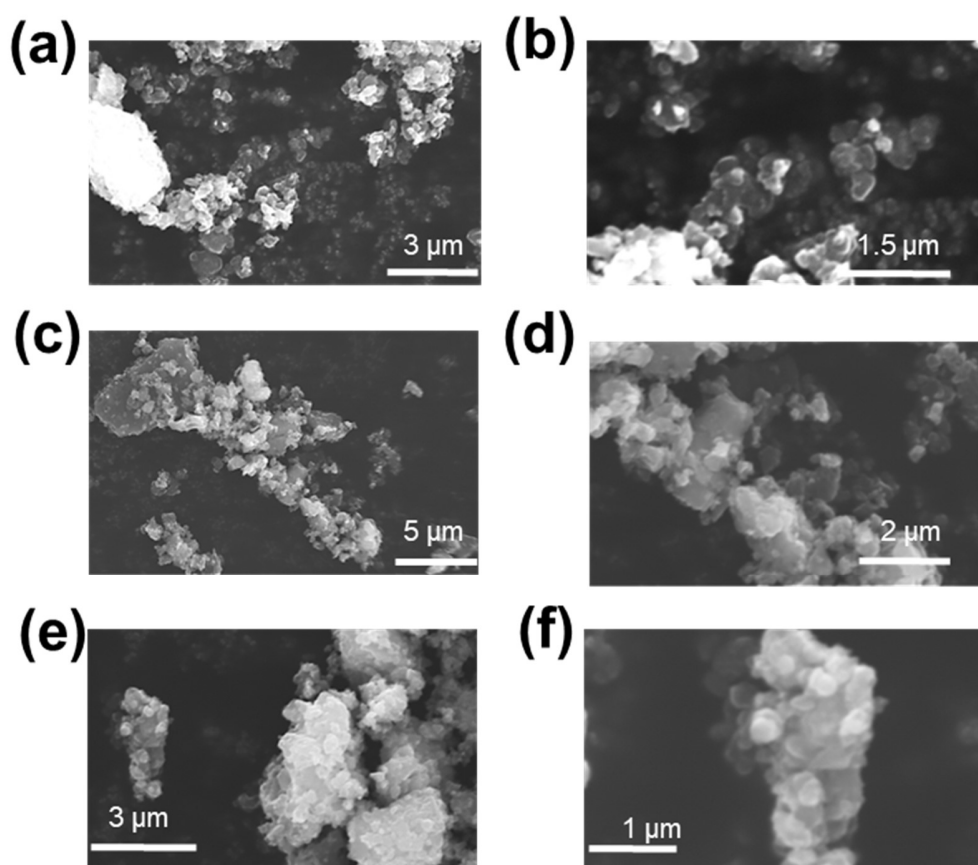


Figure S3. SEM micrographs of spectra of cig_450 (a, b), cig_600 (c,d) and cig_900 (e,f).

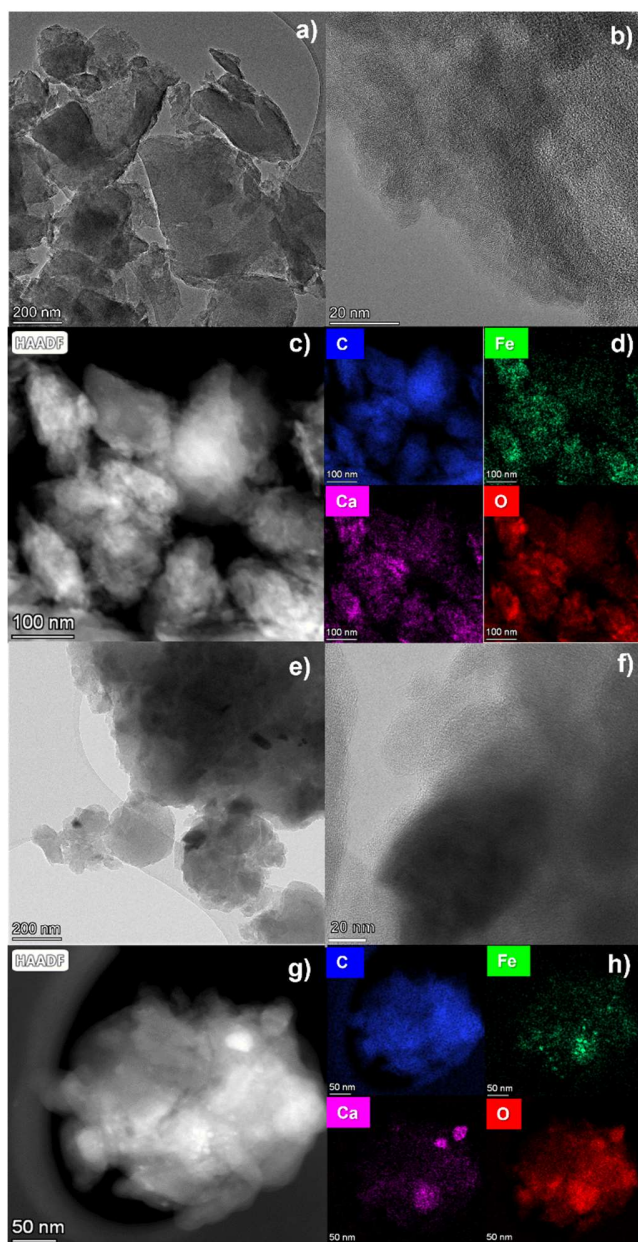


Figure S4. Electron microscopy investigation of cig_600 (a-d) and cig_900 (e-h). Low magnification HRTEM (a,e); high magnification HRTEM image (b,f); HAADF images (c,g); EDX maps of C, Fe, Ca and O (d,h).

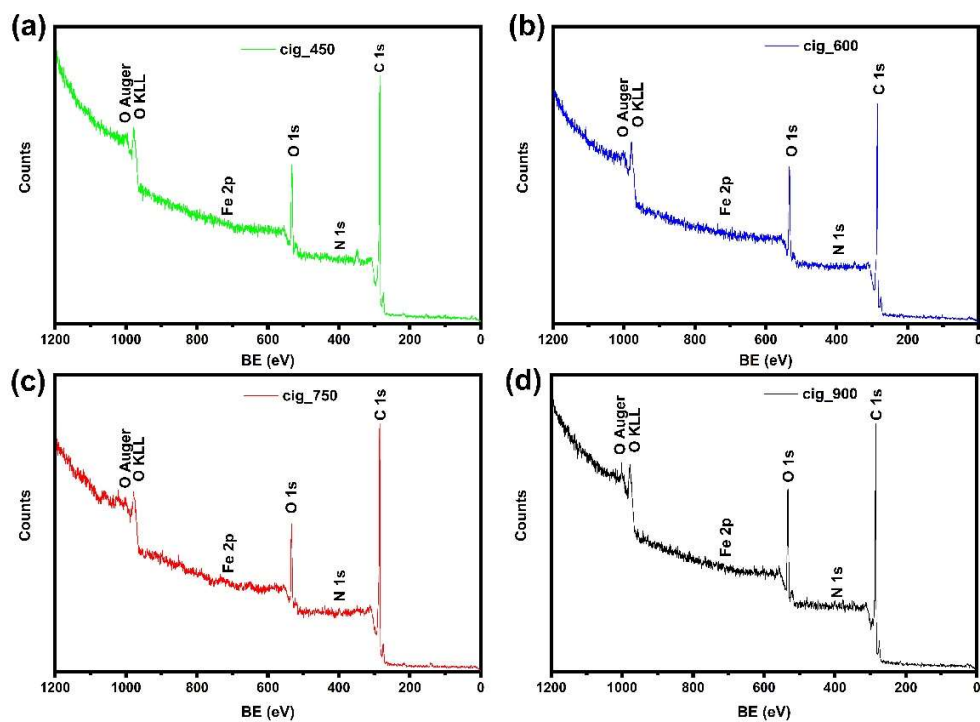


Figure S5. XPS survey spectra of (a) cig_450, (b) cig_600, (c) cig_750 and (d) cig_900.

Table S2. Percentage composition of the samples obtained by XPS analysis.

Sample	N1s	Fe2p
cig_450	1.6	0.3
cig_600	1.3	0.2
cig_750	2.0	0.2
cig_900	1.5	0.3

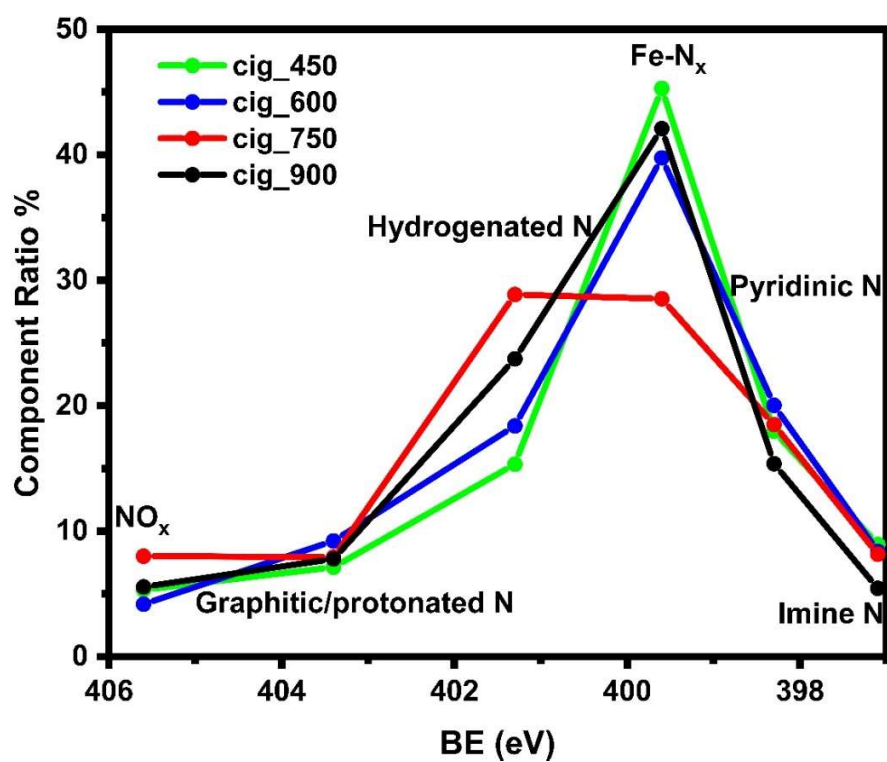


Figure S6. The component ratio of the nitrogen moieties detected by high-resolution N 1s spectra.

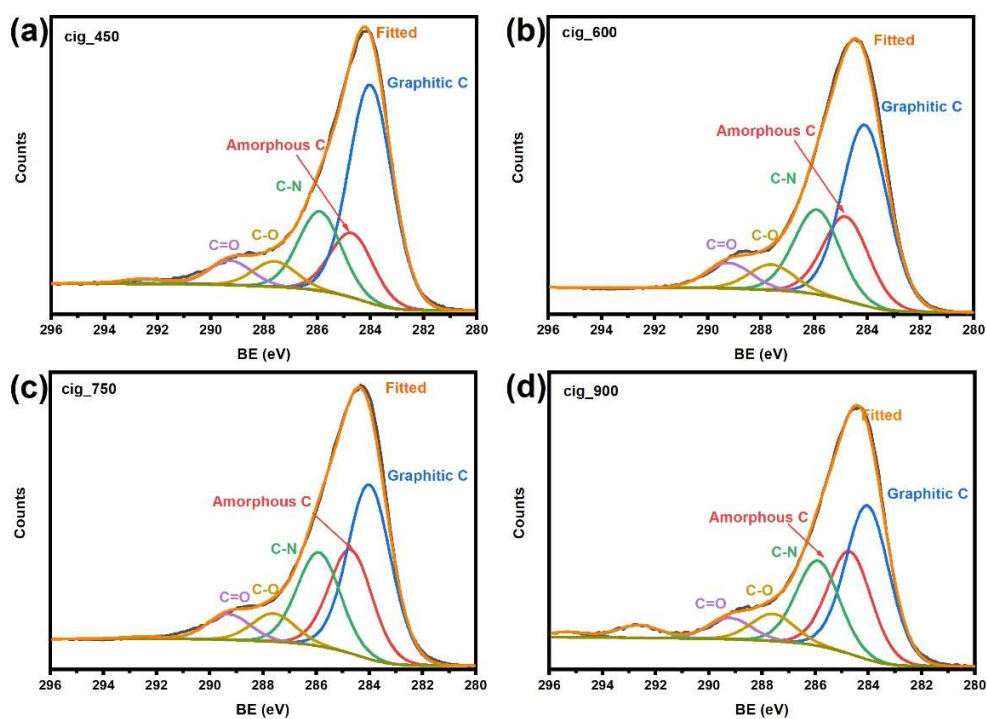


Figure S7. C 1s high resolution spectra of (a) cig_450, (b) cig_600, (c) cig_750 and (d) cig_900 with raw data.

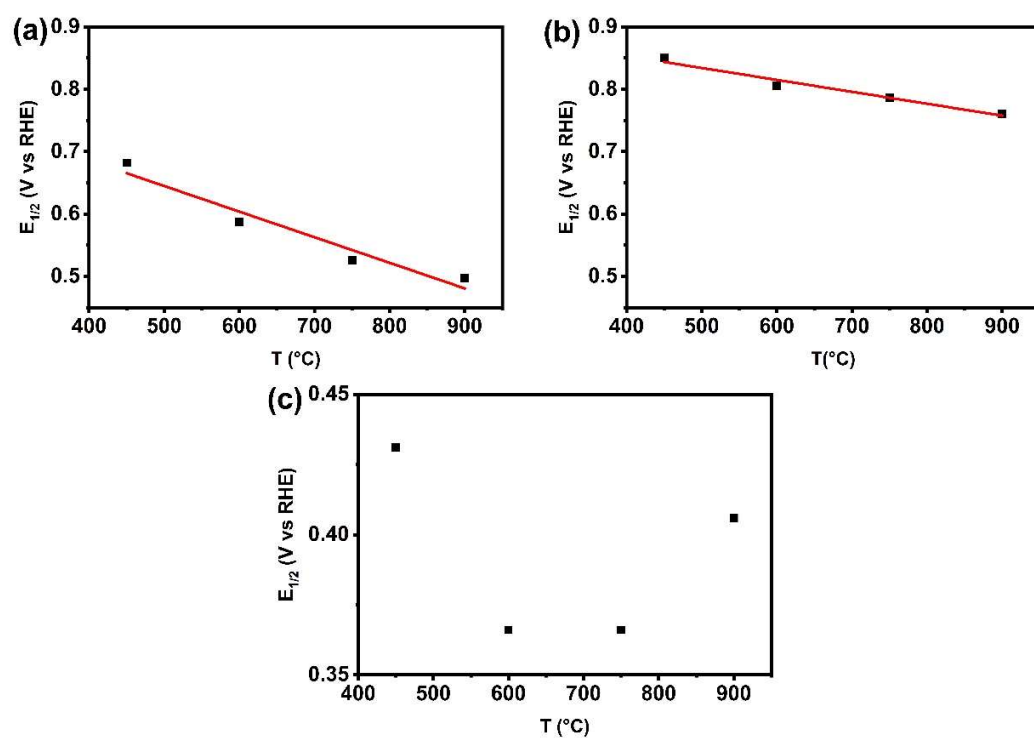


Figure S8. $E_{1/2}$ vs T plots obtained in (a) acidic, (b) alkaline and (c) neutral environments. The red line observed in graphs (a) and (b) refers to the linear fit of data.

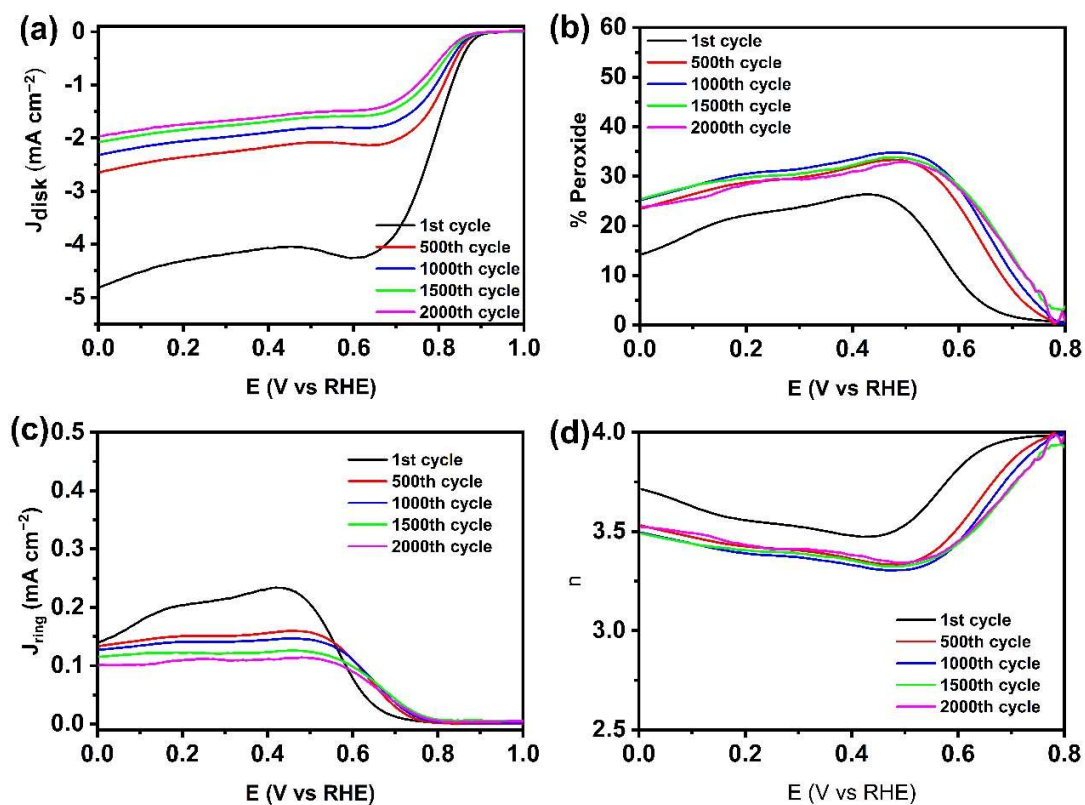


Figure S9. Accelerated stability tests of cig_450 conducted in 0.1 M PBS: (a) Disk current density (J_{disk}) and (c) Ring current density (J_{ring}) recorded at 1600 rpm and 5 mV s⁻¹, (b) % Peroxide yield and (d) the number of transferred electrons (n).

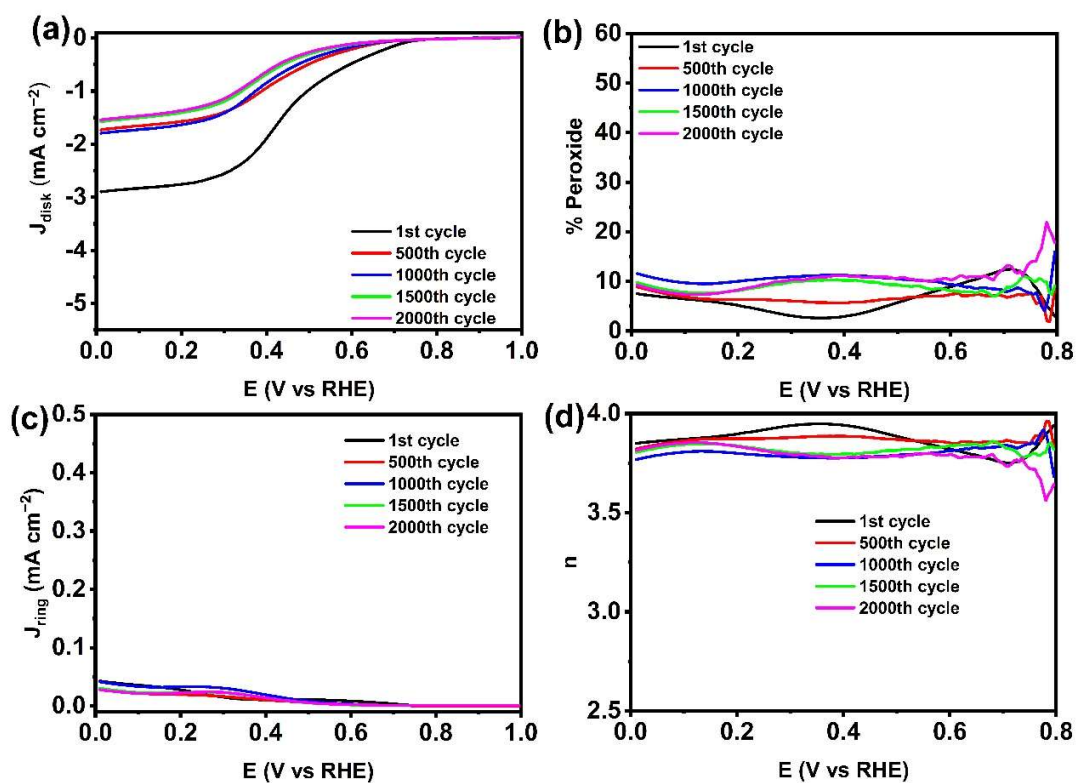


Figure S10. Accelerated stability tests of *cig_450* conducted in 0.1 KOH: (a) Disk current density (J_{disk}) and (c) Ring current density (J_{ring}) recorded at 1600 rpm and 5 mV s⁻¹, (b) % Peroxide yield and (d) the number of transferred electrons (n).