Supplementary Information

Electrochemical reduction of oxygen-functional-group-controlled graphene oxide for high carrier mobility

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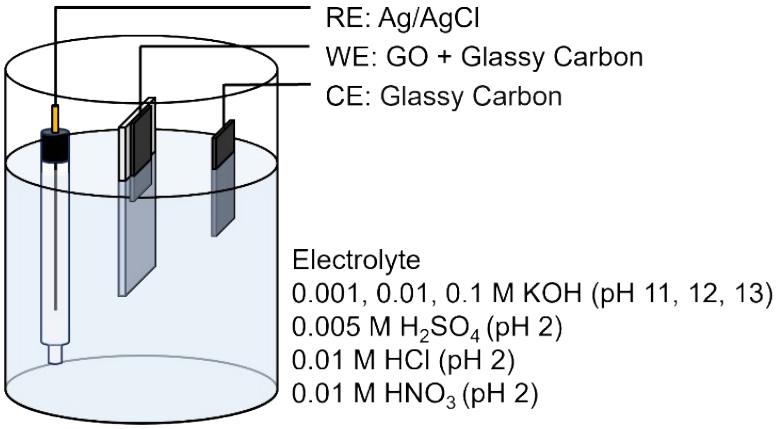

Fig. S1 Schematic diagram of the electrochemical reduction setup.

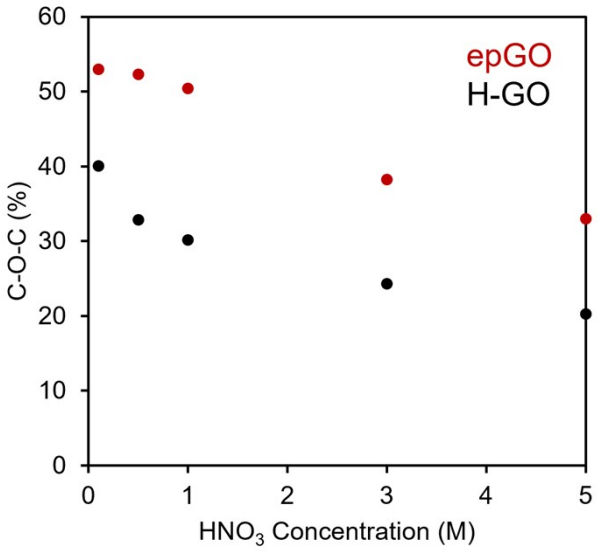

Fig. S2 Relationship between the HNO_3 concentration used for 1-hour immersion and the amount of epoxy groups.

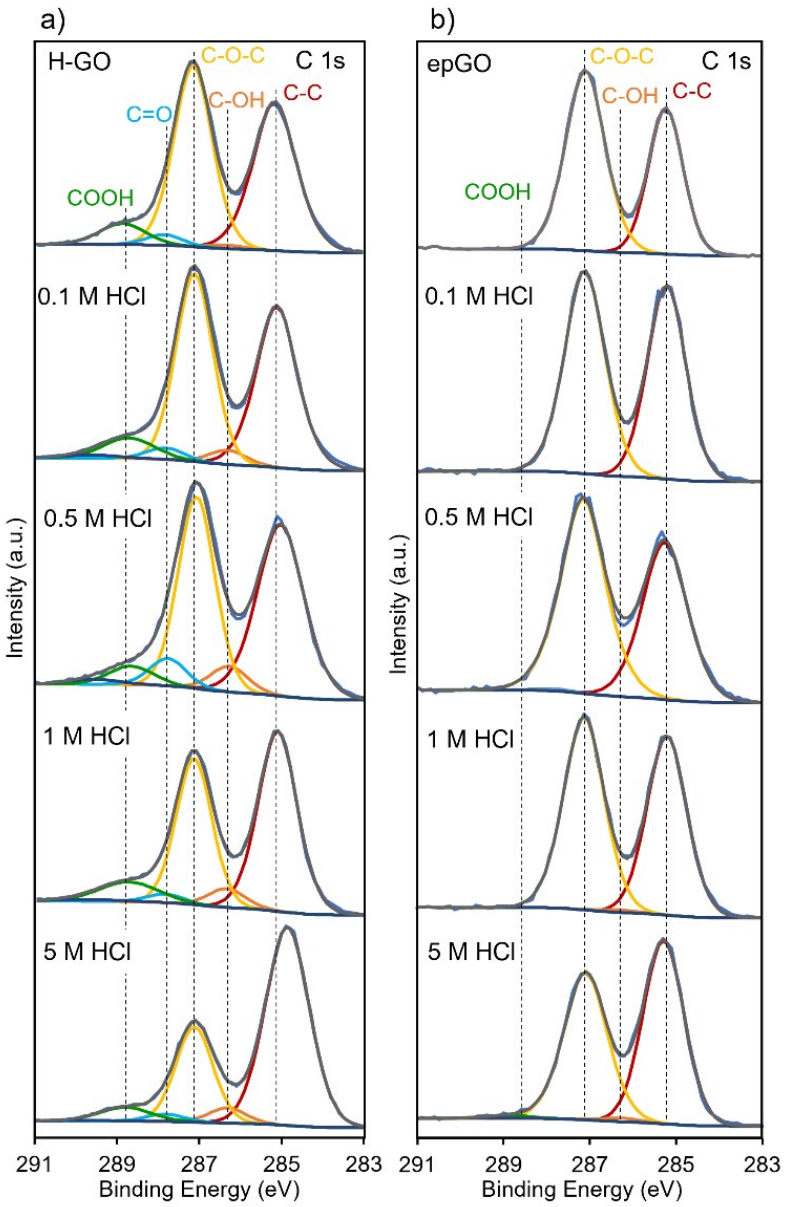

Fig. S3 C 1s XPS spectrum of (a) H-GO and (b) epGO films before treatment and after immersion in 0.1, 0.5, 1, 5 M HCl solution for 1 h, respectively.

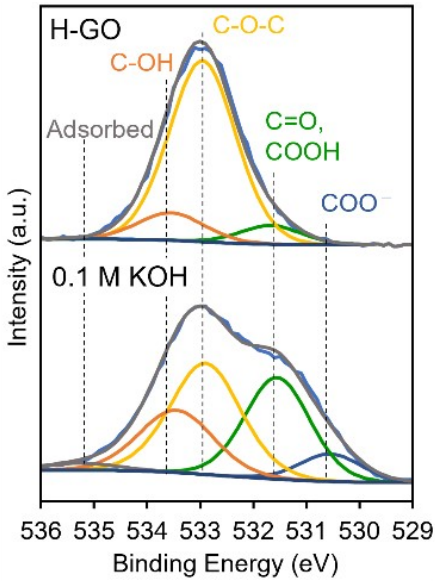

Fig. S4 O1s XPS spectra of H-GO film before treatment and after immersion in 0.1 M KOH solution for 3h.

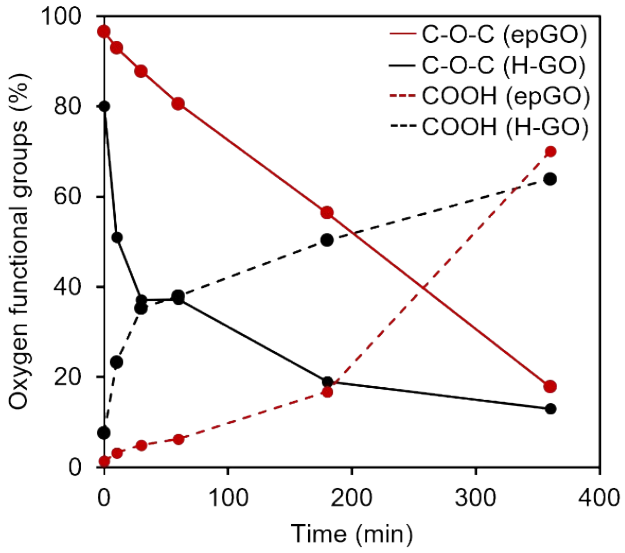

Fig. S5 Correlation between C–O–C and COOH groups after immersing HGO and epGO films in 1 M KOH solution for various durations.

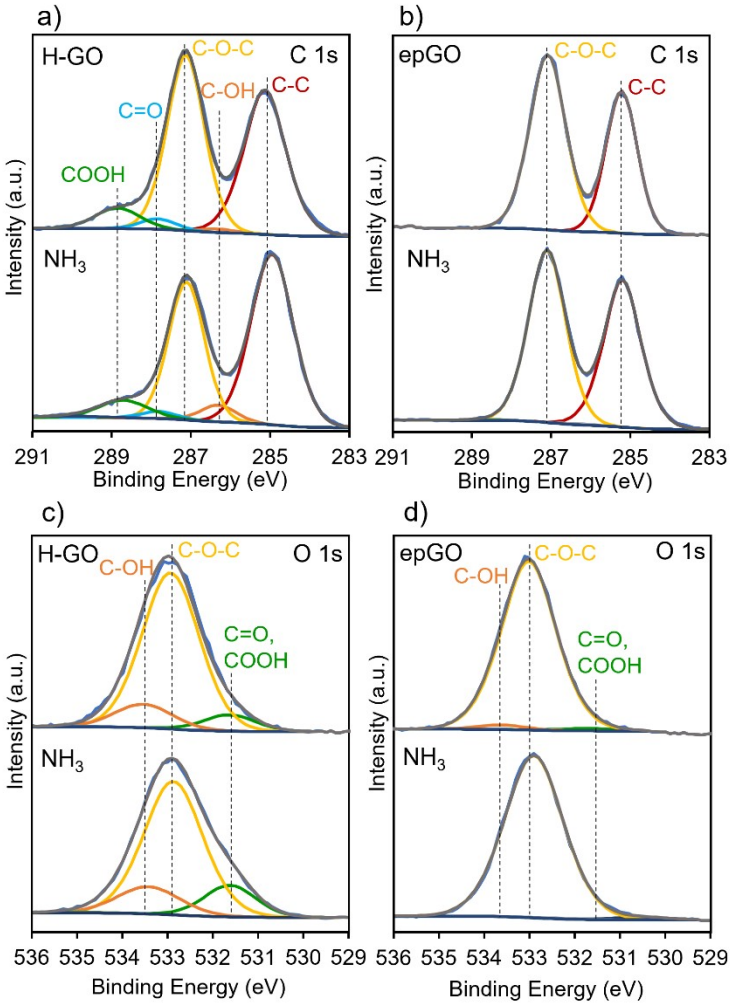

Fig. S6 C1s XPS spectrum of (a) H-GO and (b) epGO films, O 1s XPS spectrum of (c) H-GO and (d) epGO films before treatment and after immersion in 1 M NH_3 aqueous solution for 1 h.

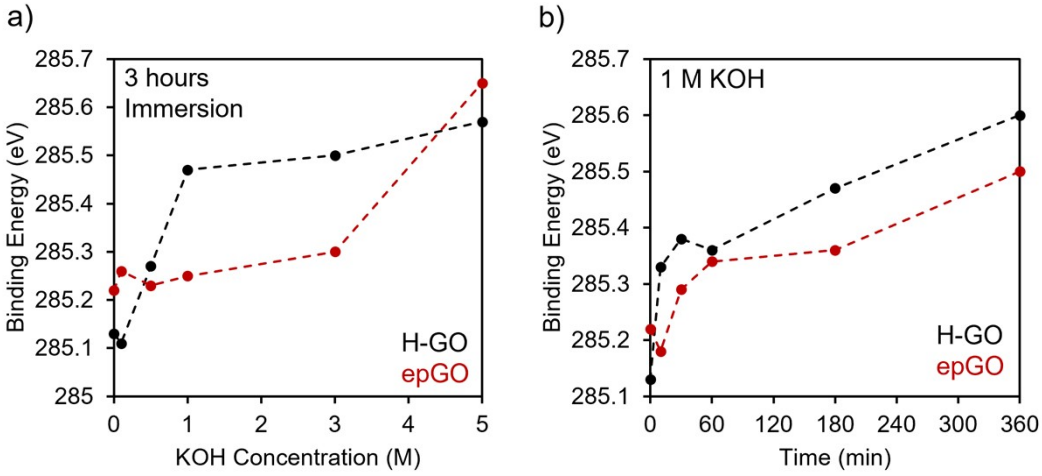

Fig. S7 Correlation plot of bond energy of peaks originating from C-C bonds versus (a) KOH

concentration and (b) immersion time in 1M KOH solution.

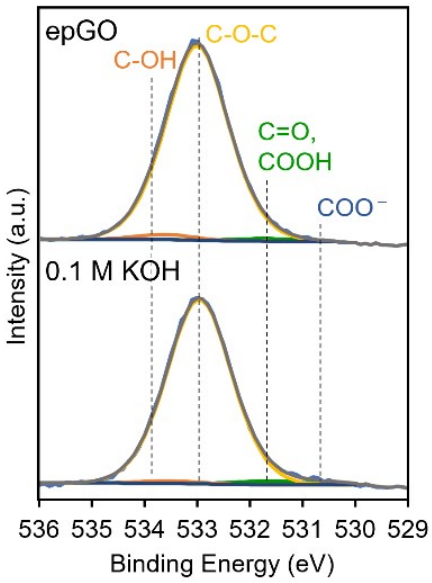

Fig. S8 O 1s XPS spectra of epGO film before treatment and after immersion in 0.1 M KOH solution for 3h.

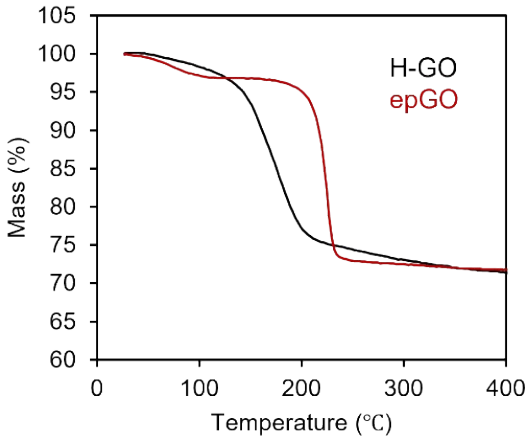

Fig. S9 TG profiles obtained by thermogravimetric analysis conducted under vacuum condition.

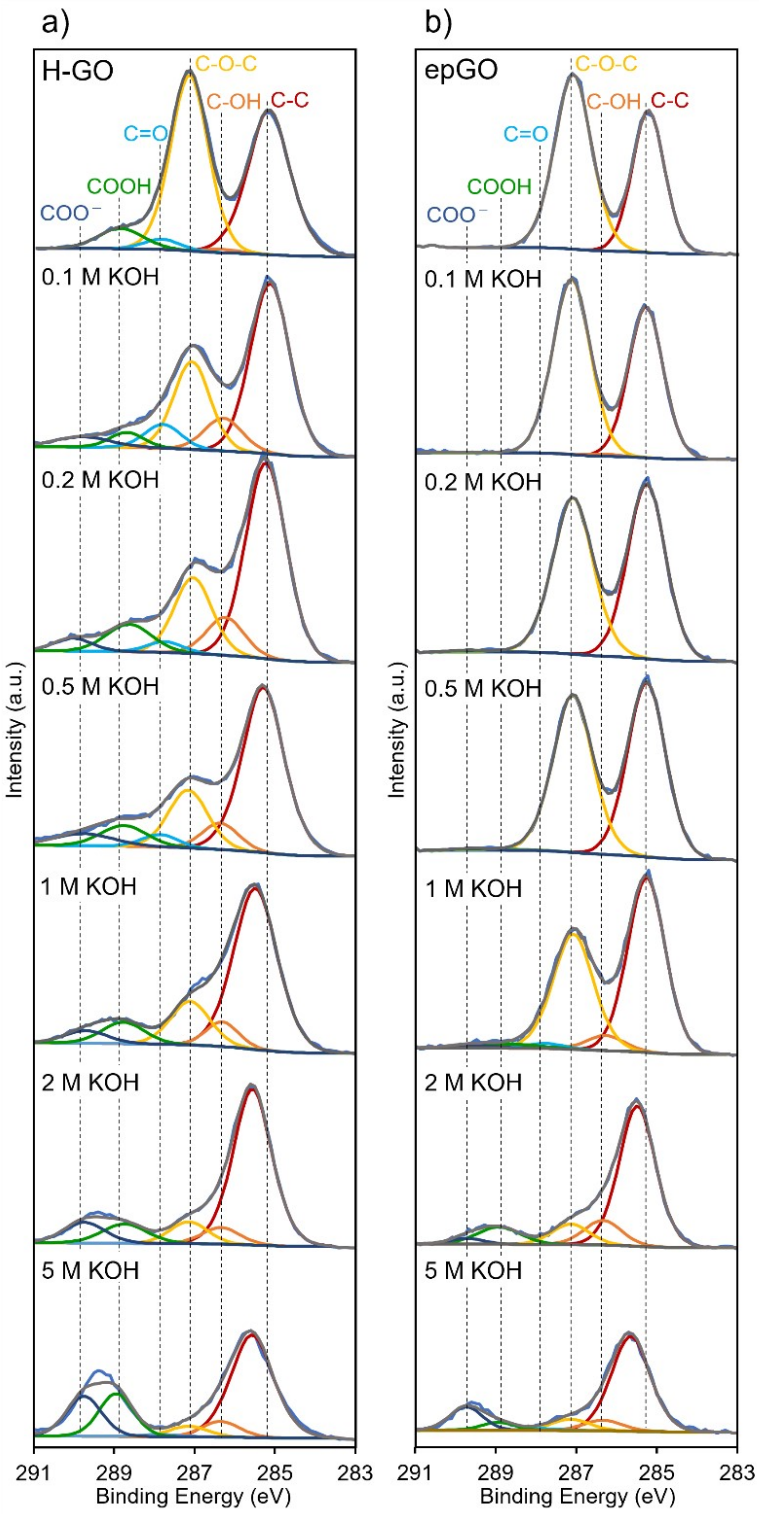

Fig. S10 C 1s XPS spectrum of (a) H-GO and (b) epGO films before treatment and after immersion in 0.1, 0.2, 0.5, 1, 2, 5 M KOH for 3 h, respectively.

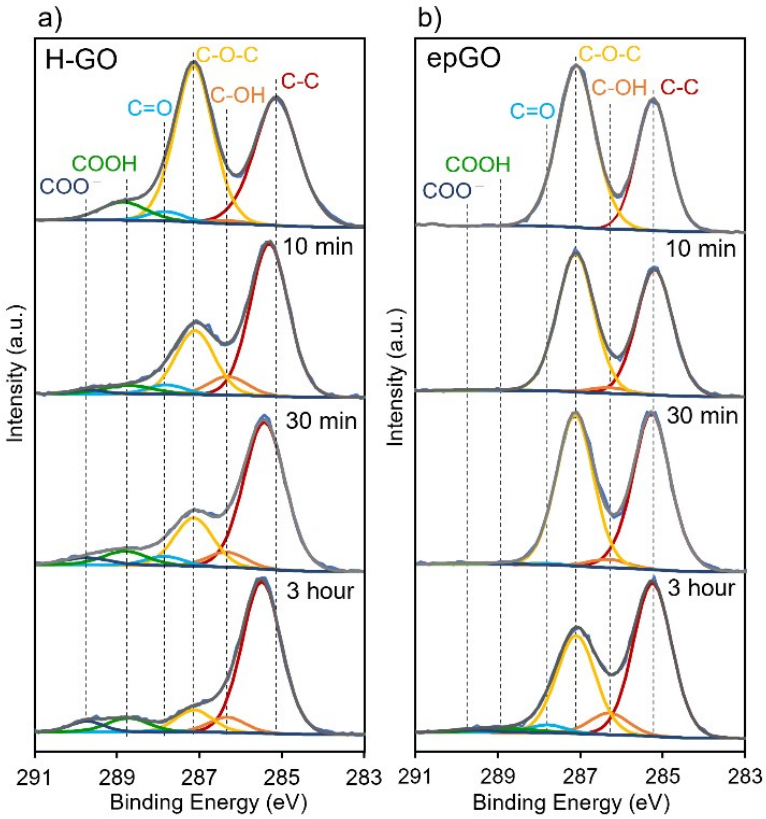

Fig. S11 C 1s XPS spectra of (a) H-GO and (b) epGO films before treatment and after immersion in 1 M KOH solution for 10 min, 30 min and 3 h, respectively.

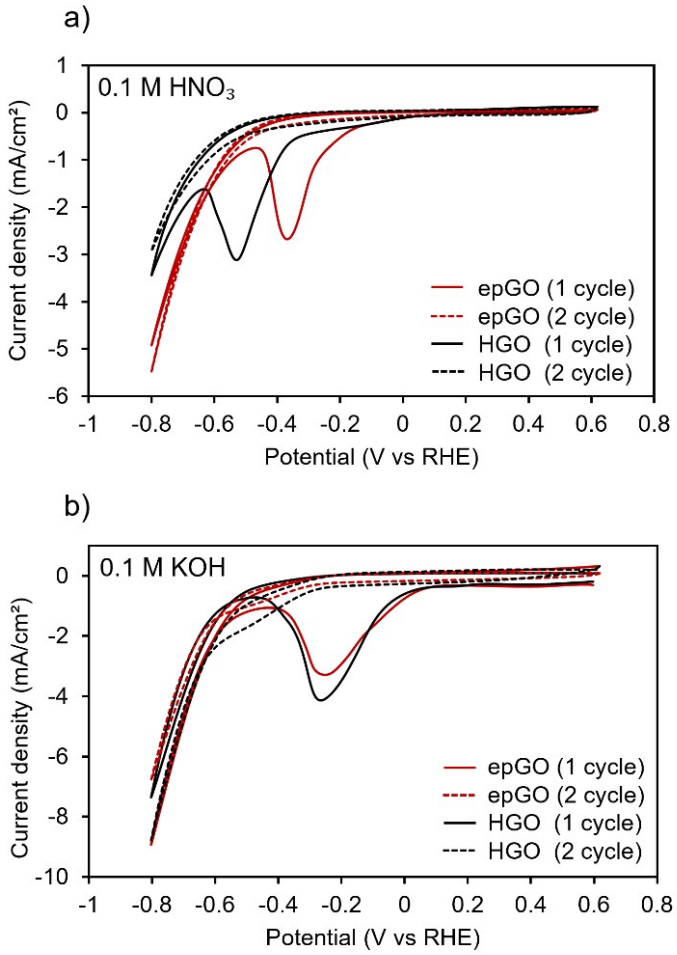

Fig. S12 Cyclic voltammograms of H-GO and epGO films in (a) 0.1 M HNO_3 and (b) 0.1 M KOH aqueous solution.

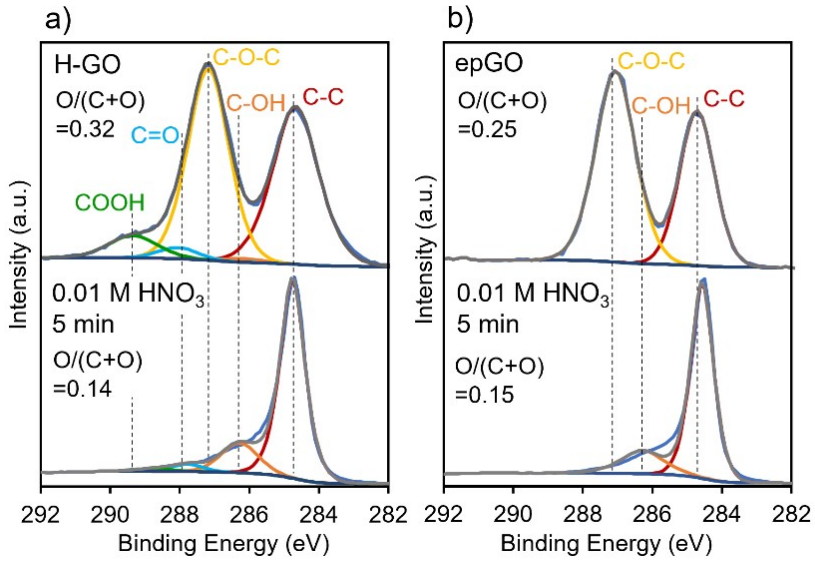

Fig. S13 XPS C 1s spectra and O/(C+O) ratios of H-GO and epGO films before and after electrochemical

reduction in 0.01 M HNO_3 for 5 min.

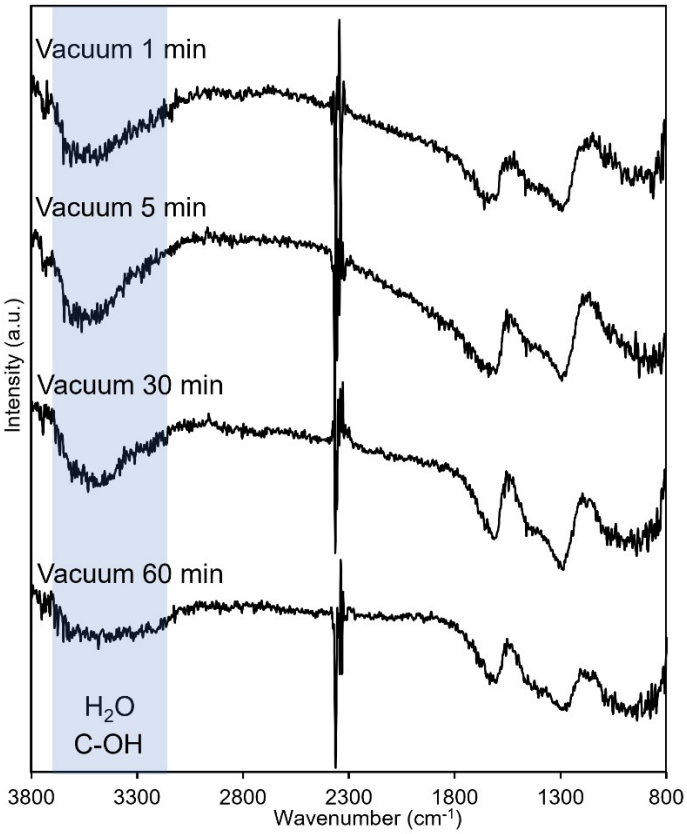

Fig. S14 FT-IR spectra of the electrochemically reduced epGO film obtained after electrochemical reduction of epGO in 0.005 M H_2SO_4 aqueous solution, measured under vacuum.

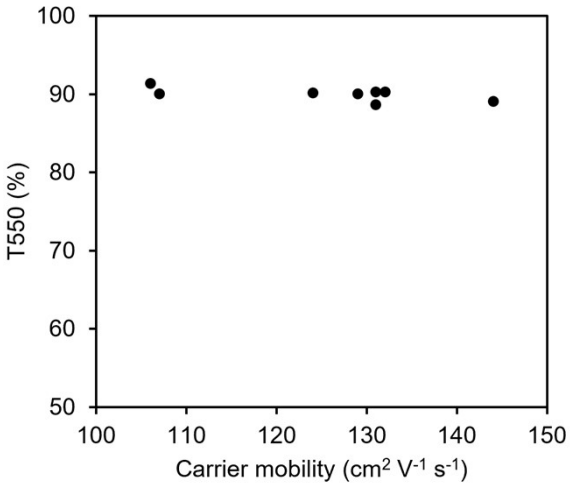

Fig. S15 Optical transmittance at 550 nm (T550) of rGO films used for mobility measurement.

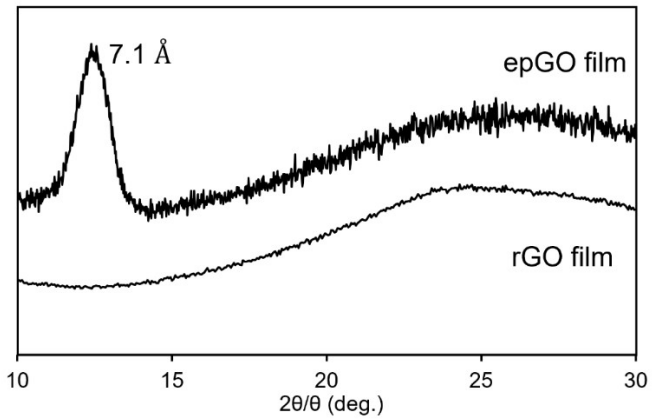

Fig. S16 XRD profiles of epGO thin films and electrochemically reduced epGO thin films on glass substrates after electrochemical reduction.

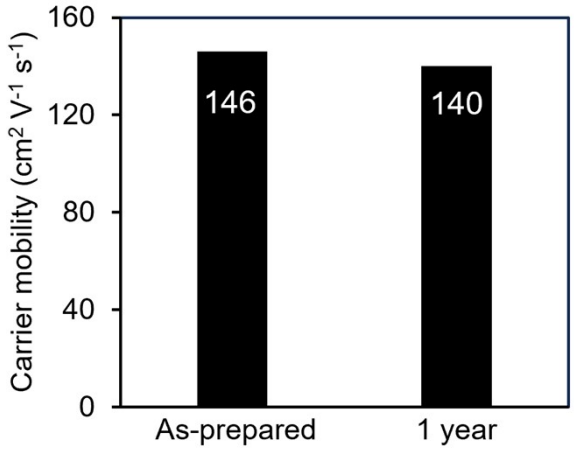

Fig. S17 The carrier mobility of rGO thin films prepared by electrochemical reduction in 0.005 M H_2SO_4 immediately after preparation and after 1 year.

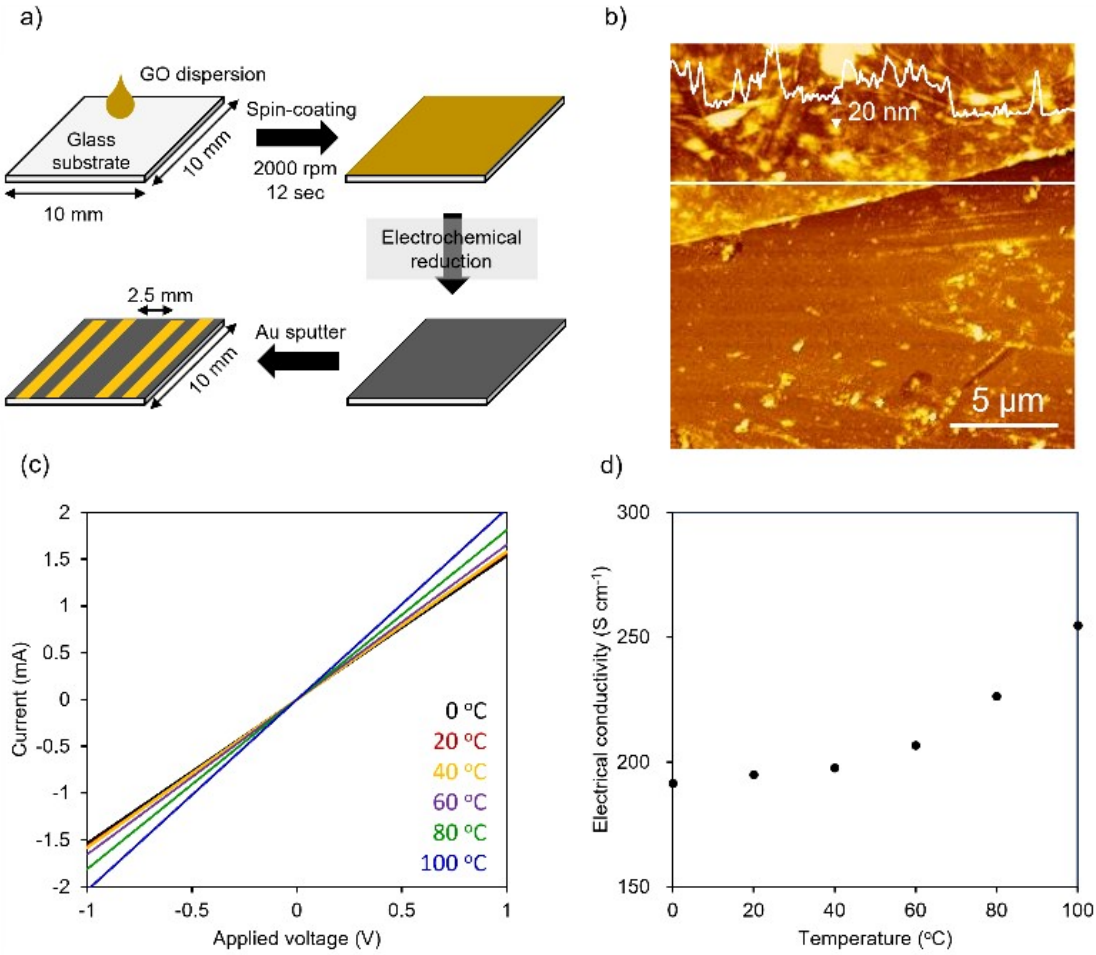

Fig. S18 (a) Fabrication flow of electrochemical reduced GO thin films for electrical conductivity measurement. (b) AFM image of rGO thin film, temperature dependence of (c) I–V characteristics and (d) electrical conductivities.

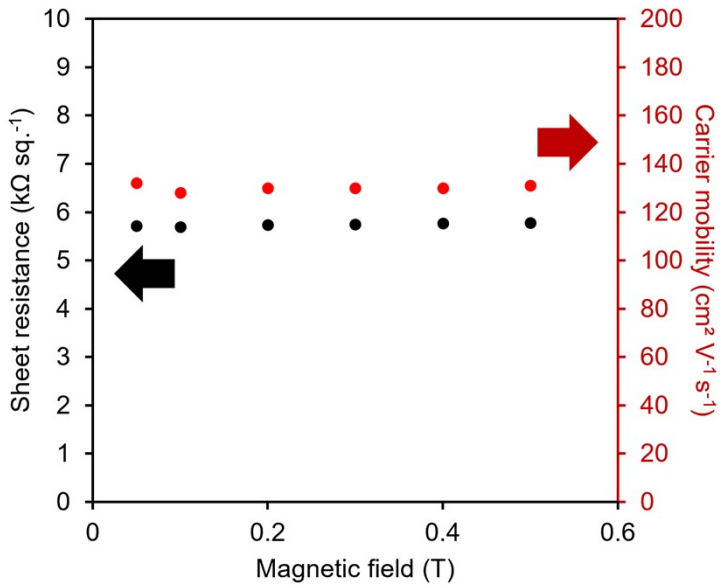

Fig. S19 Correlation between sheet resistance and carrier mobility as a function of magnetic field.

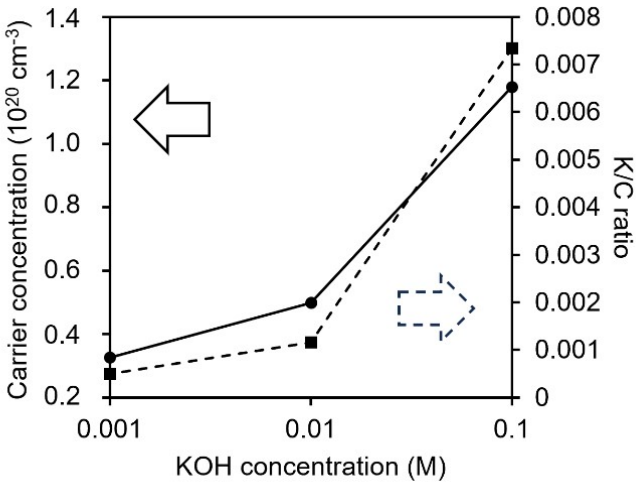

Fig. S20 Relationship diagram between KOH concentration and carrier concentration, and K/C ratio obtained by XPS analysis.

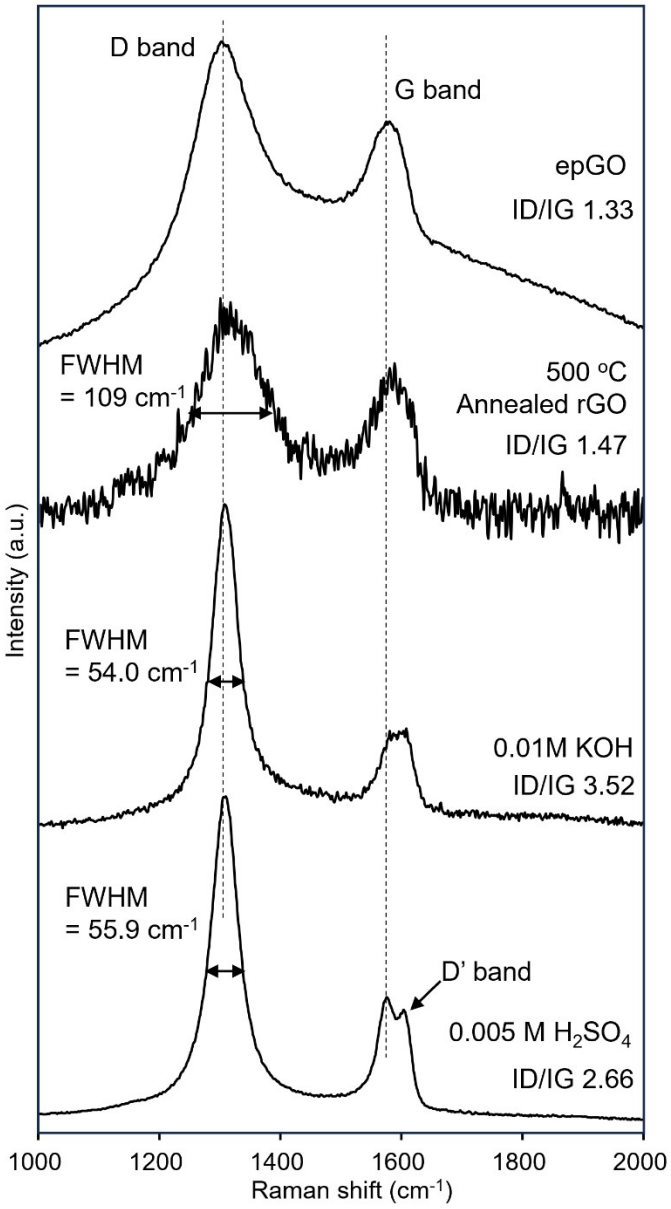

Fig. S21 Raman spectra of epGO thin film, 500 °C annealed-rGO thin film and rGO thin films electrochemically reduced in 0.005 M H_2SO_4 and 0.1 M KOH aqueous solution.

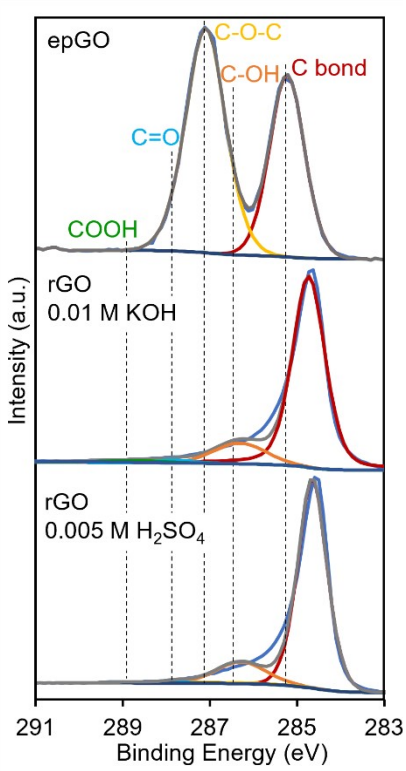

Fig. S22 C1s XPS spectra of pristine epGO and epGO films electrochemically reduced in 0.01 M KOH aqueous solution and 0.005 M H_2SO_4

Table S1. Summary of C-C bonds peak positions and full width at half maximum (FWHM) in the electrochemical reduction of H-GO and epGO in 0.1 M HNO_3 and KOH aqueous solution.

Samples	Peak top (eV)	FWHM (eV)
H-GO	285.1	1.4
Reduced H-GO (-0.44 V vs. RHE in 0.1 M HNO_3)	284.7	0.9
Reduced H-GO (-0.22 V vs. RHE in 0.1 M KOH)	285.0	1.0
epGO	285.2	1.1
Reduced epGO (-0.44 V vs. RHE in 0.1 M HNO_3)	284.6	0.7
Reduced epGO (-0.22 V vs. RHE in 0.1 M KOH)	284.6	0.9

Table S2 The carrier mobility and transmittance at 550 nm (T550) values of rGO thin films.

Sample	Carrier mobility ($cm^2 V^{-1} s^{-1}$)	T550 (%)
0.005 M H_2SO_4	146	75.0
0.005 M H_2SO_4	129	90.1
0.01 M HNO_3	144	89.1
0.01 M HCl	132	90.3
0.01 M KOH	61.5	87.2