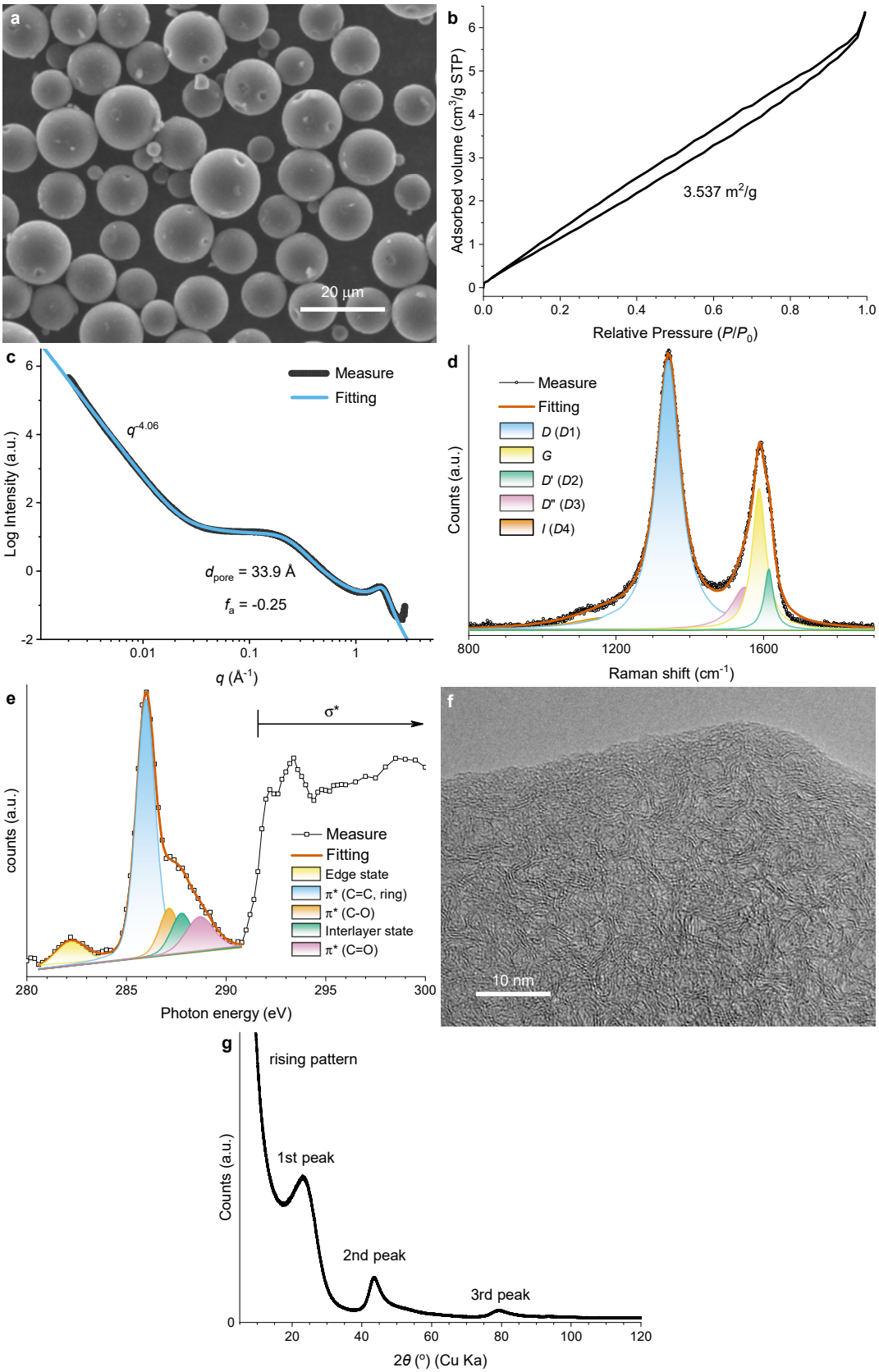
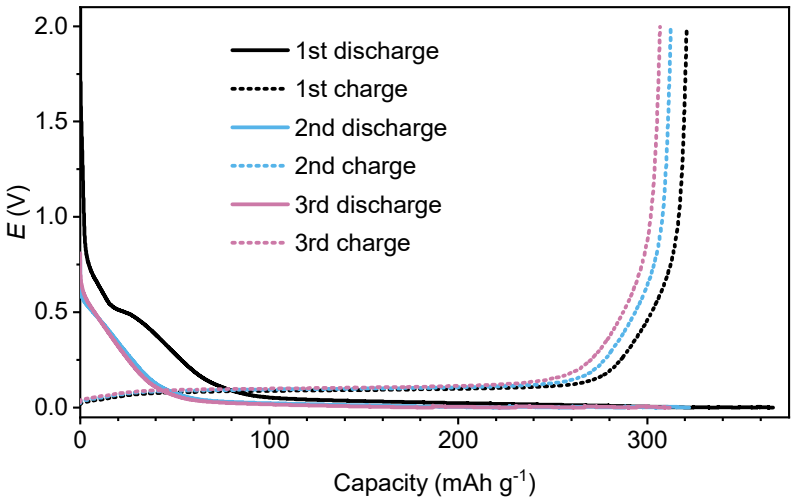
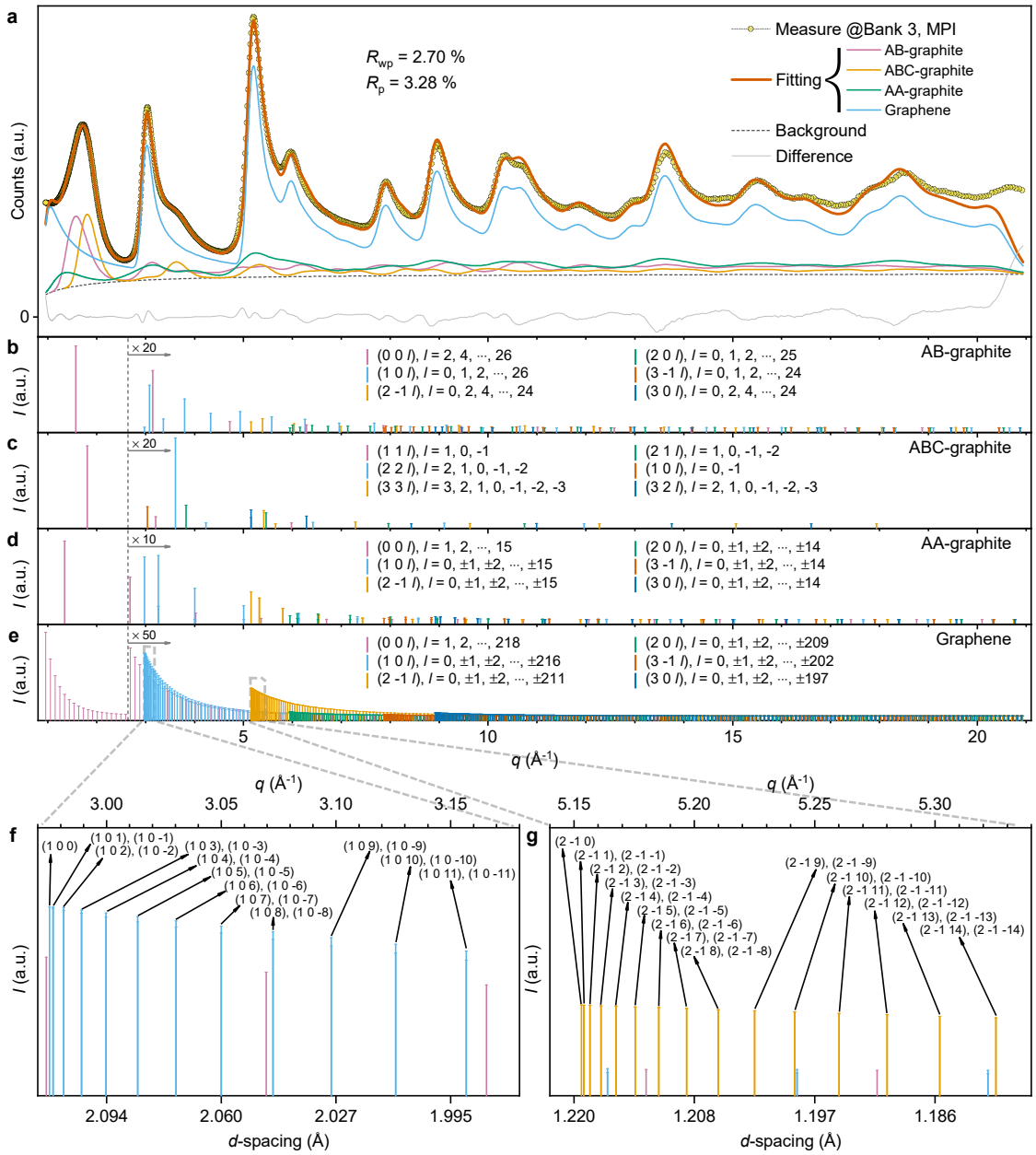
Extended Data Figures



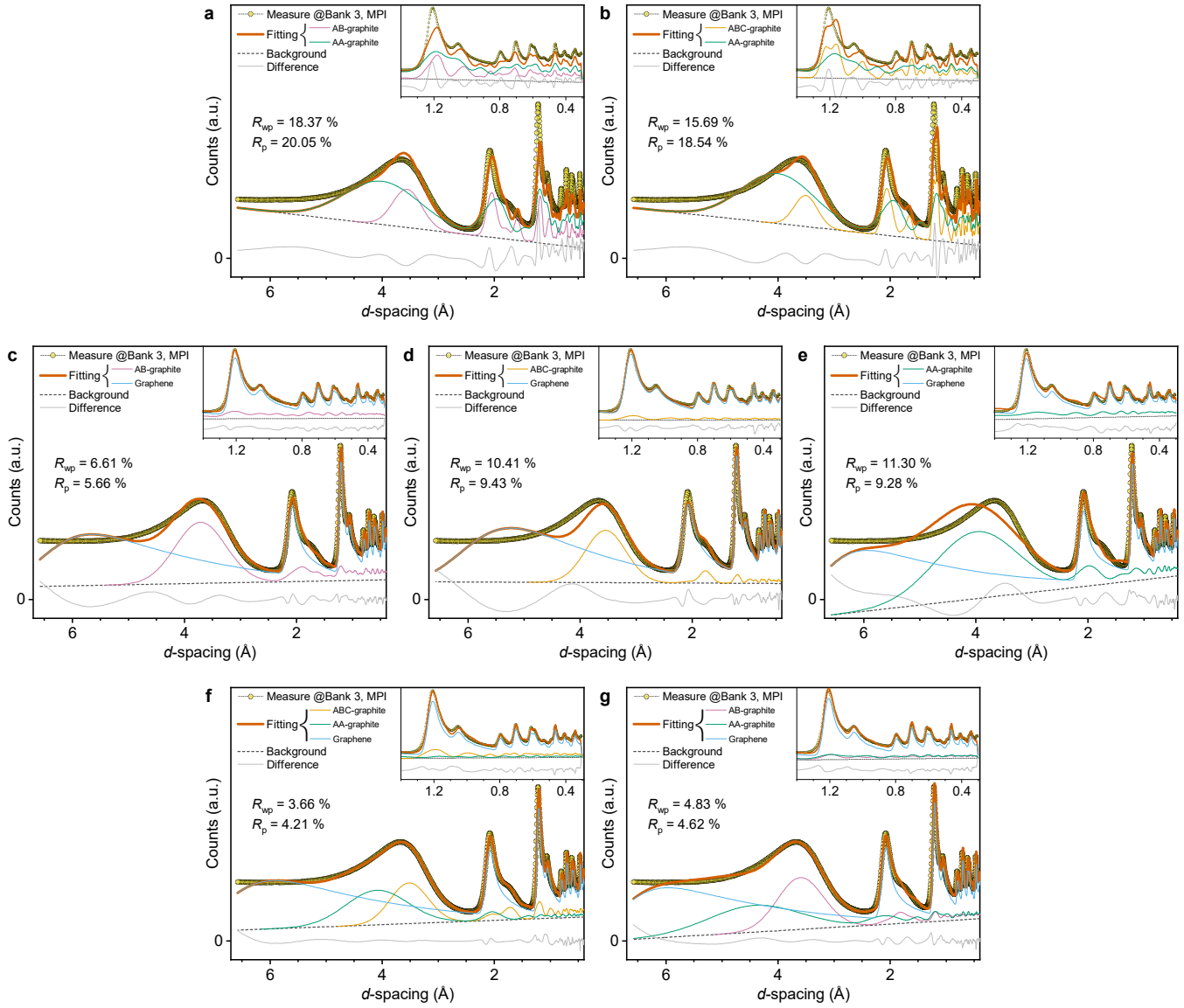
Extended Data Fig. 1 | General characterization of KC15. a, SEM, **b,** BET, **c,** SAXS and its fitting results, **d,** Raman spectra and its fitting results, **e,** XAS and its fitting results, **f,** TEM, and **g,** XRD.



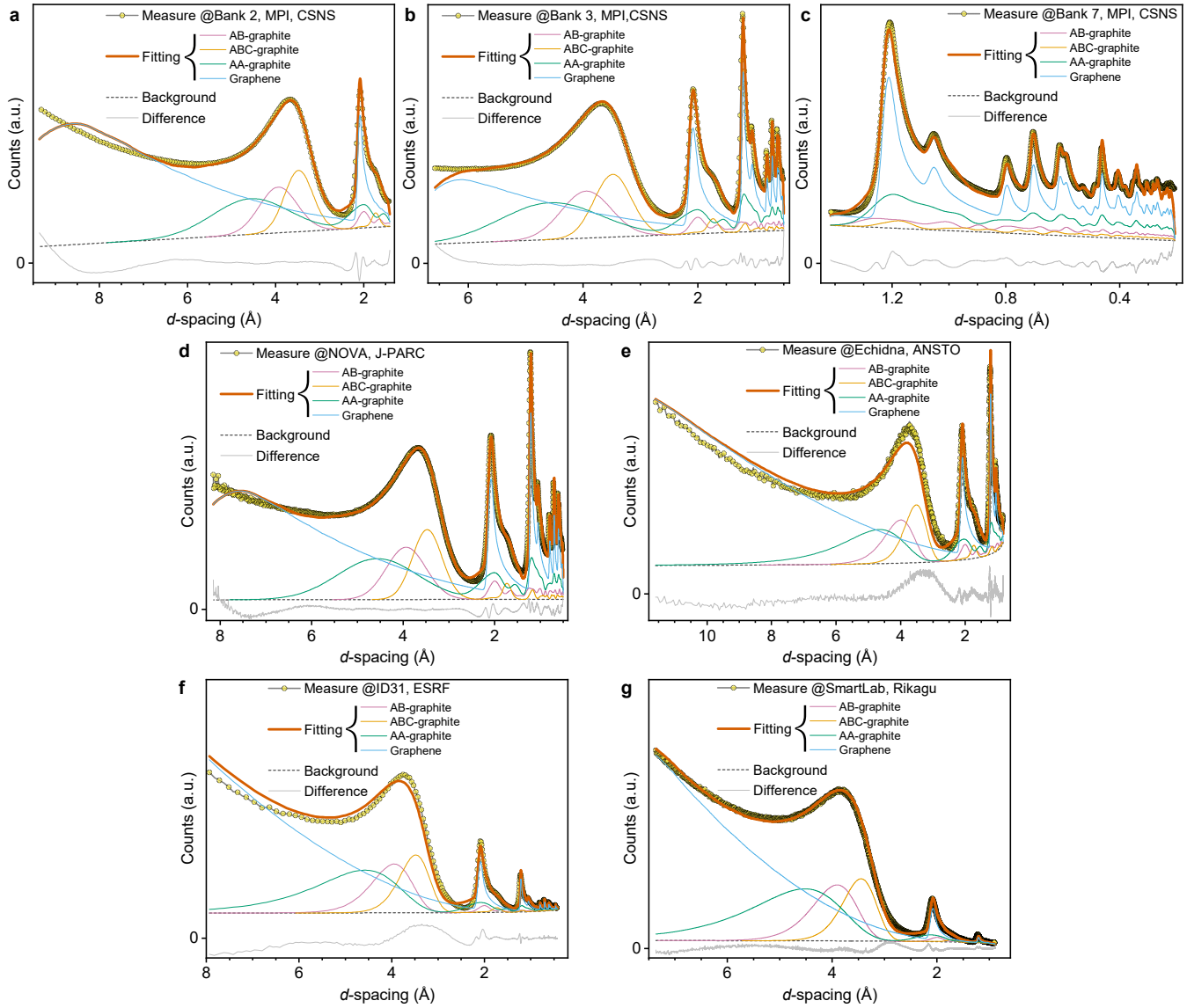
Extended Data Fig. 2 | Electrochemical test results of KC15.



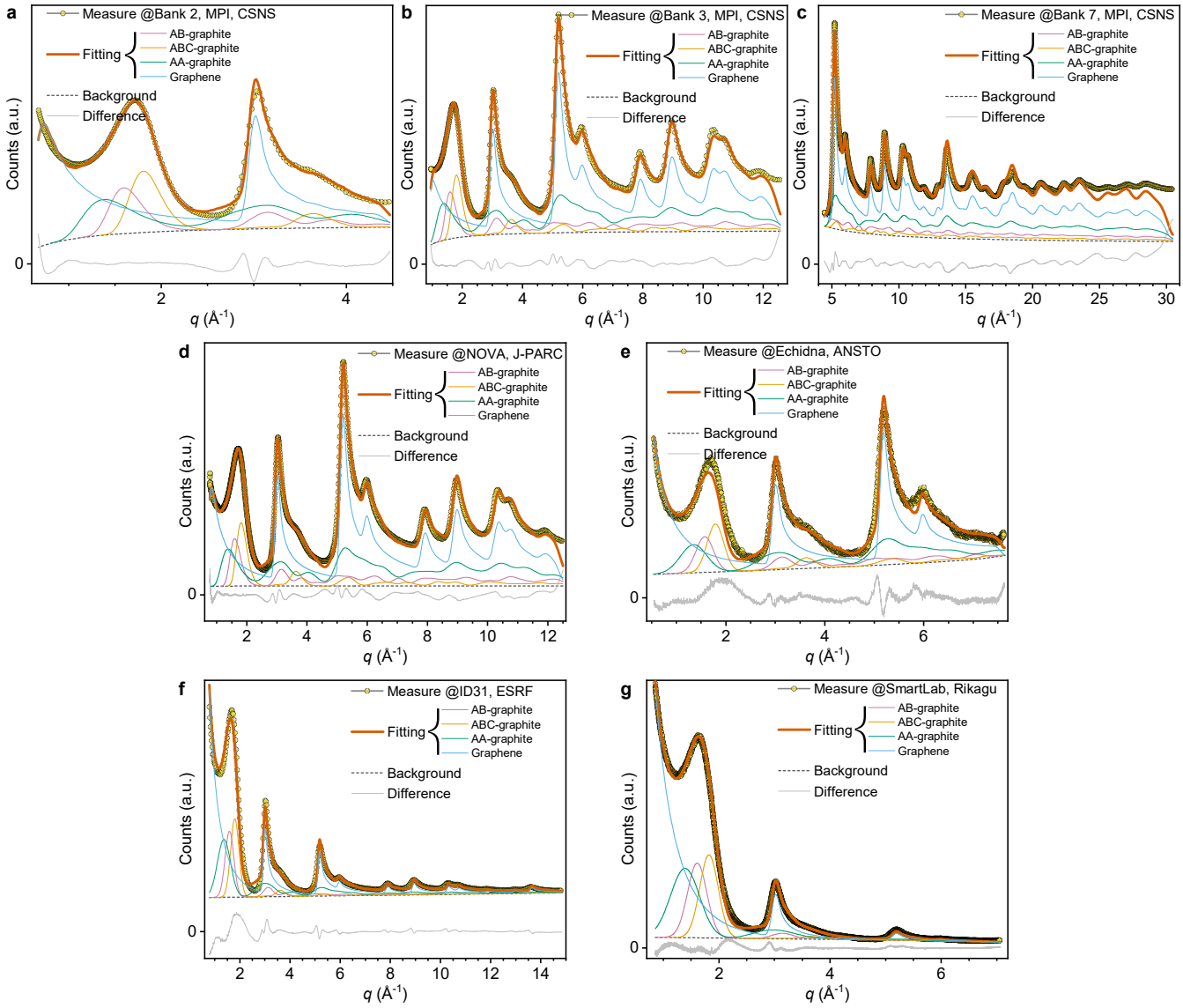
Extended Data Fig. 3 | Final Rietveld refinement solution for ND data of KC15 shown in *q*, as referenced to Fig. 1d-h. a, Rietveld refinement results and corresponding Miller indices for **b,** AB-graphite, **c,** ABC-graphite, **d,** AA-graphite, and **e,** graphene. Localized zooms of the Miller index series **f,** (1 0 *l*) and **g,** (2 -1 *l*) for the graphene phase shown in (**e**).



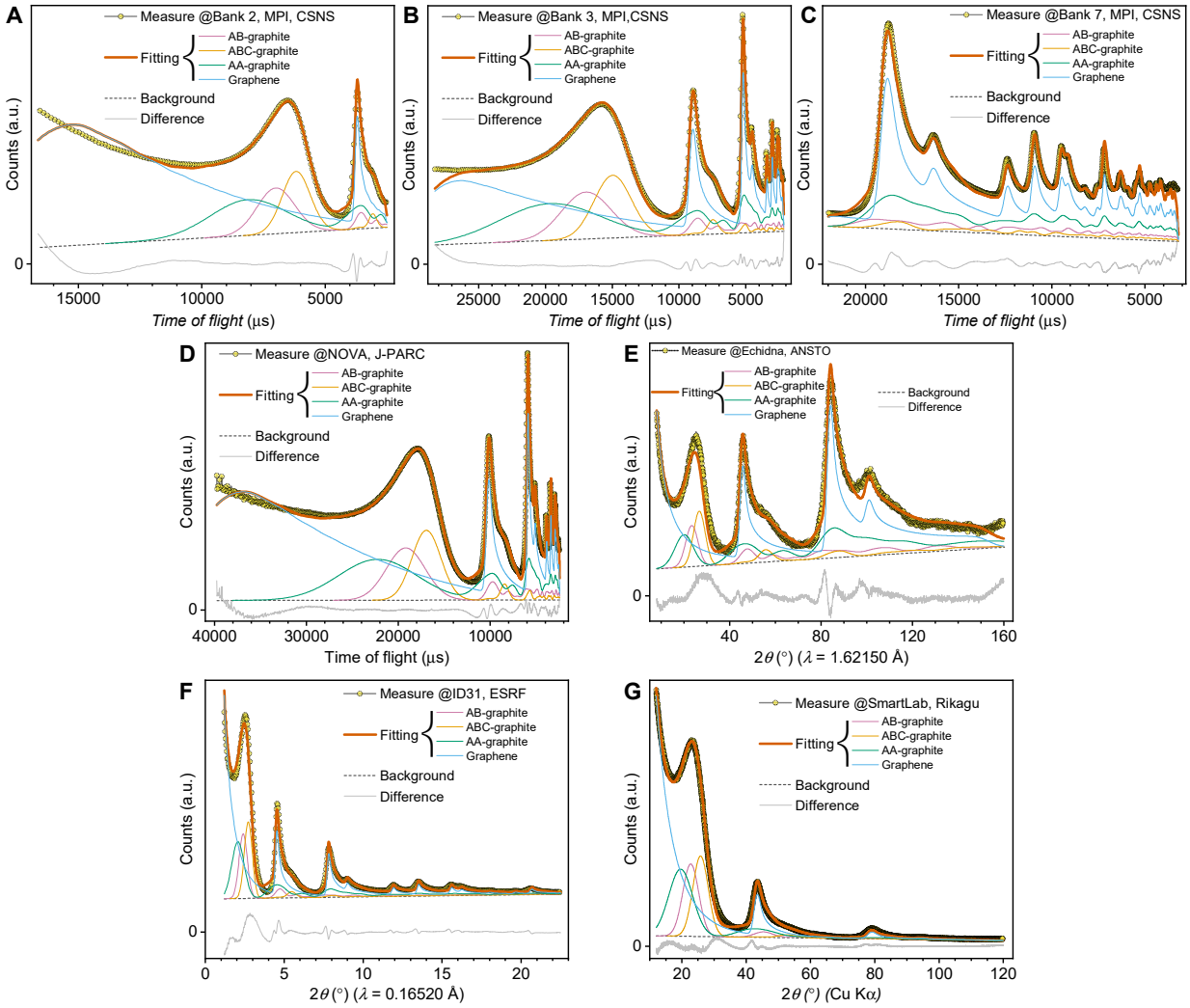
Extended Data Fig. 4 | Remaining phase combinations evaluated during initial Rietveld refinements of a single neutron diffraction dataset (Bank 3, MPI, CSNS) for KC15, supplementing those presented in Fig. 1.



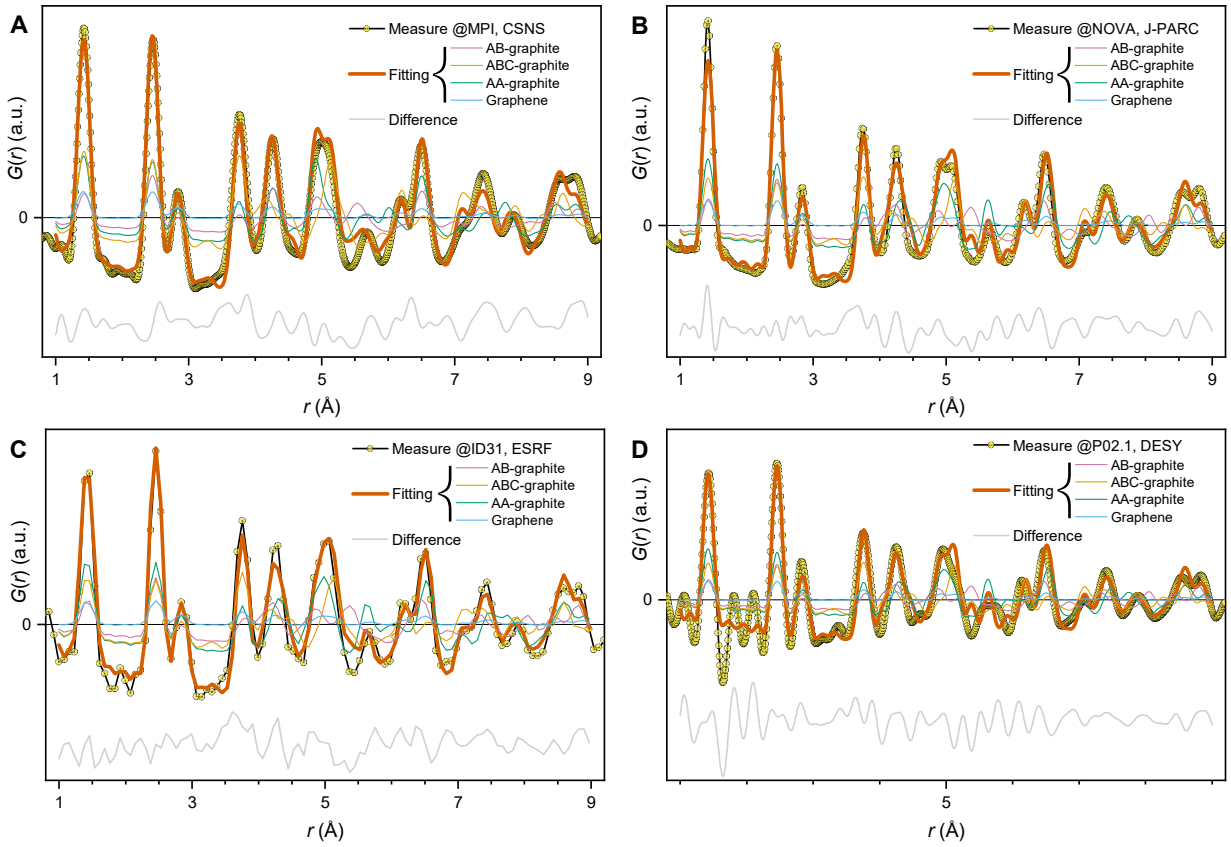
Extended Data Fig. 5 | Results of neutron/X-ray combined Rietveld refinement of KC15 shown in *d*-spacing. The diffraction patterns and their fitting results of **a,** Bank 2, **b,** Bank 3, and **c,** Bank 7 at MPI, CSNS (TOF-ND); **d,** NOVA at J-PARC (TOF-ND); **e,** Echidna at ANSTO (CW-ND); **f,** ID31 at ESRF (synchrotron-based XRD); and **g,** SmartLab of Rikagu (lab-based XRD).



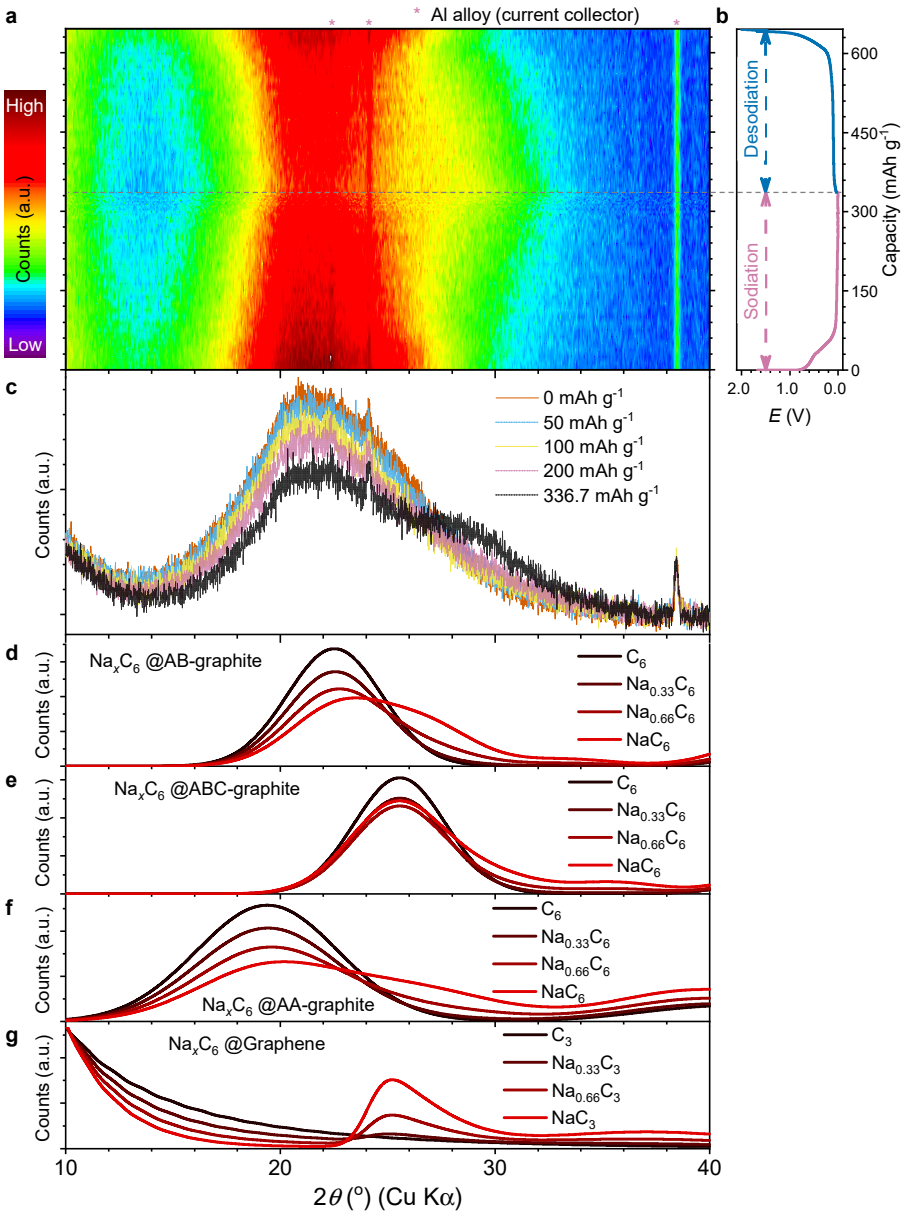
Extended Data Fig. 6 | Results of neutron/X-ray combined Rietveld refinement of KC15 shown in *q*. The diffraction patterns and their fitting results of **a,** Bank 2, **b,** Bank 3, and **c,** Bank 7 at MPI, CSNS (TOF-ND); **d,** NOVA at J-PARC (TOF-ND); **e,** Echidna at ANSTO (CW-ND); **f,** ID31 at ESRF (synchrotron-based XRD); and **g,** SmartLab of Rikagu (lab-based XRD).



Extended Data Fig. 7 | Results of neutron/X-ray combined Rietveld refinement of KC15 shown in TOF or 2*θ*. The diffraction patterns and their fitting results of **a,** Bank 2, **b,** Bank 3, and **c,** Bank 7 at MPI, CSNS (TOF-ND); **d,** NOVA at J-PARC (TOF-ND); **e,** Echidna at ANSTO (CW-ND); **f,** ID31 at ESRF (synchrotron-based XRD); and **g,** SmartLab of Rikagu (lab-based XRD).



Extended Data Fig. 8 | Neutron/X-ray combined PDF refinement for KC15. The PDF patterns and their fitting results of **a,** MPI at CSNS (TOF neutron), **b,** NOVA at J-PARC (TOF neutron), **c,** ID31 at ESRF (synchrotron-based X-ray), **d,** P02.1 at DESY (synchrotron-based X-ray).



Extended Data Fig. 9 | Structural evolution of KC15 during sodiation/desodiation characterised by *in situ* XRD. a, *In situ* XRD patterns of KC15 during the first sodiation/desodiation cycle, along with **b,** corresponding electrochemical profile and c, selected XRD patterns from (**a**) presented as counts versus *d*-spacing plots for clearer reference. Simulated XRD patterns of sodiated phases with varying sodiation concentrations, derived from the host phases of **d,** AB-graphite, **e,** ABC-graphite, **f,** AA-graphite, and **g,** graphene.