

Appendix A

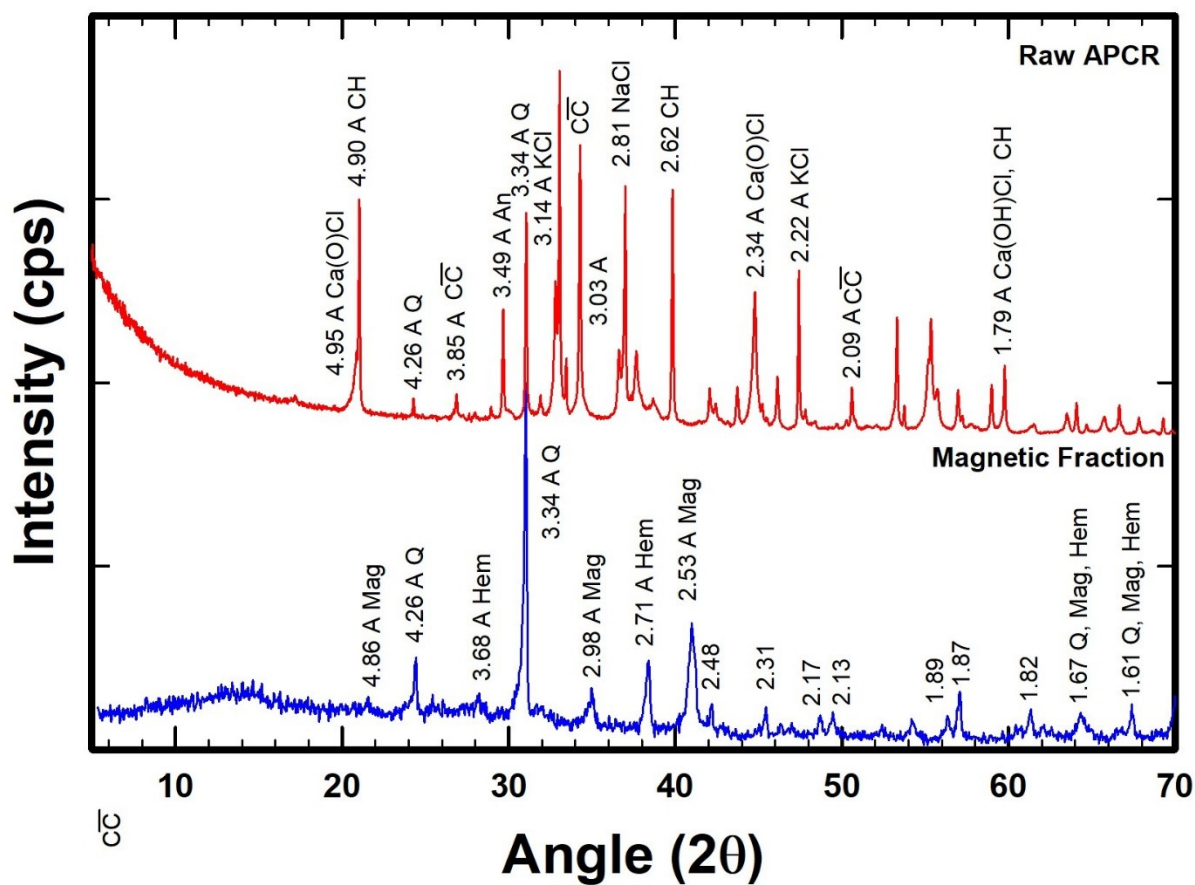


Figure A1 X-ray diffraction of raw APCR A3 and its magnetic fraction. Mag refers to magnetite, Hem represents hematite, Q refers to quartz, and the numbers correspond to d-values in Angstrom.

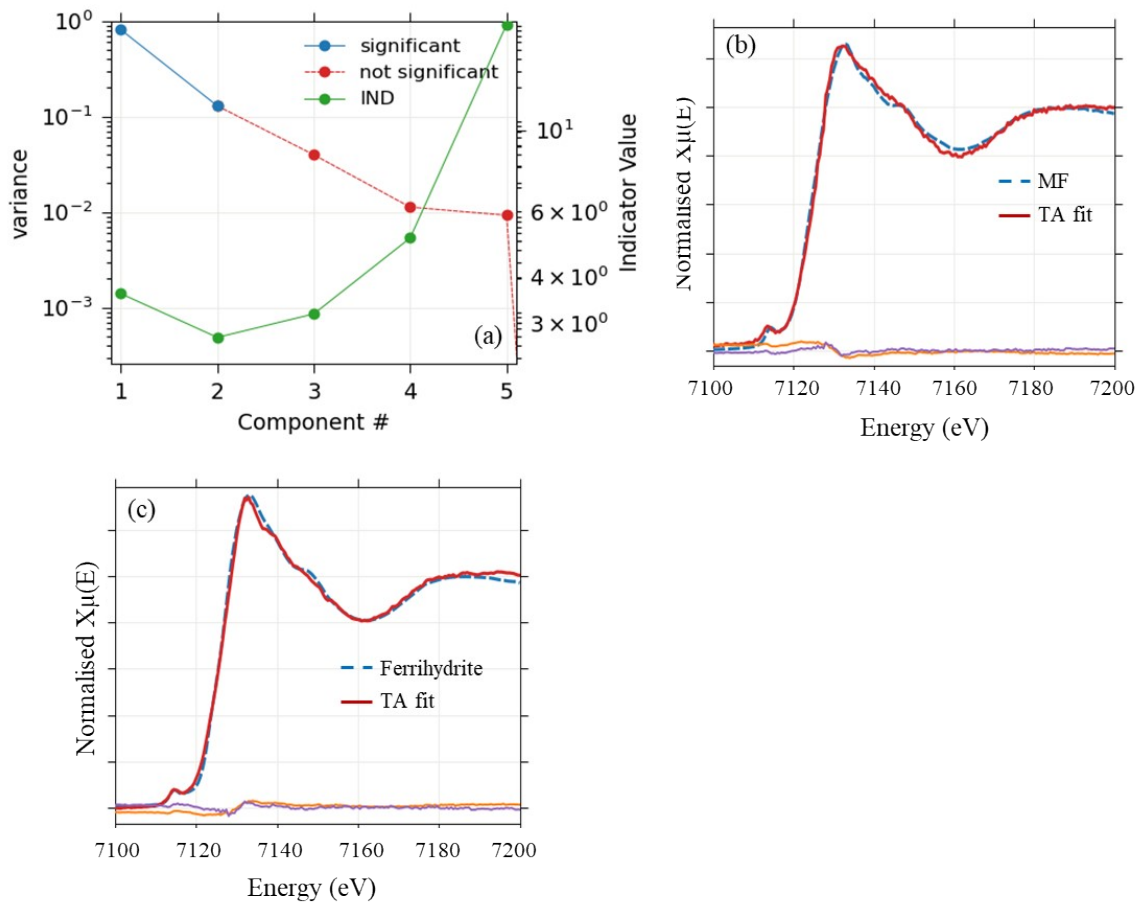


Figure A2 Factor indicator function (IND) values for all seven raw APCRs by Principal component analysis (PCA) (a); Target transform of magnetic fraction from APCR A3 spectrum (b) and ferrihydrate spectrum using the first two components generated from all seven raw APCRs (c).

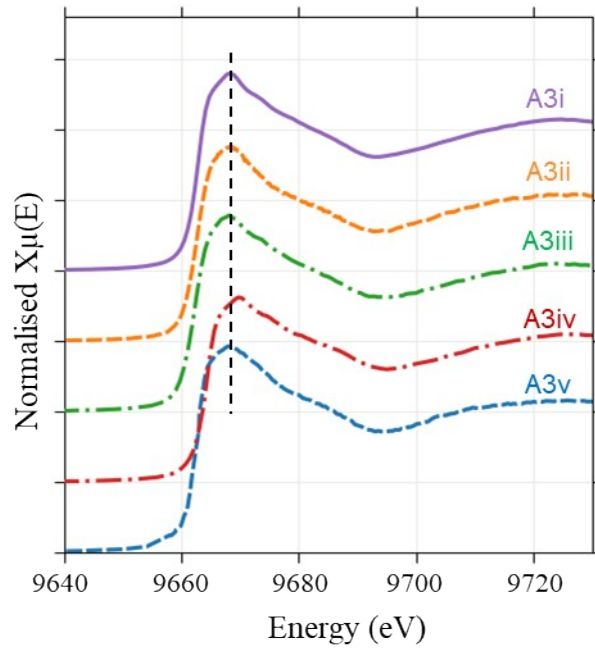


Figure A3 Zn K-edge X-ray XANES spectra for five A3 samples measured at various times.

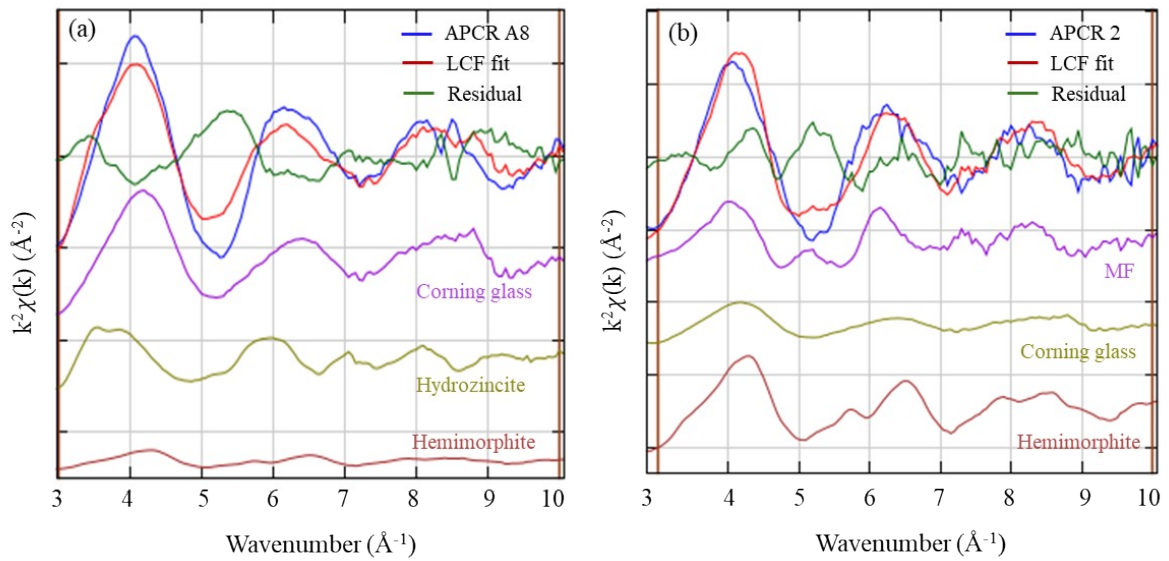
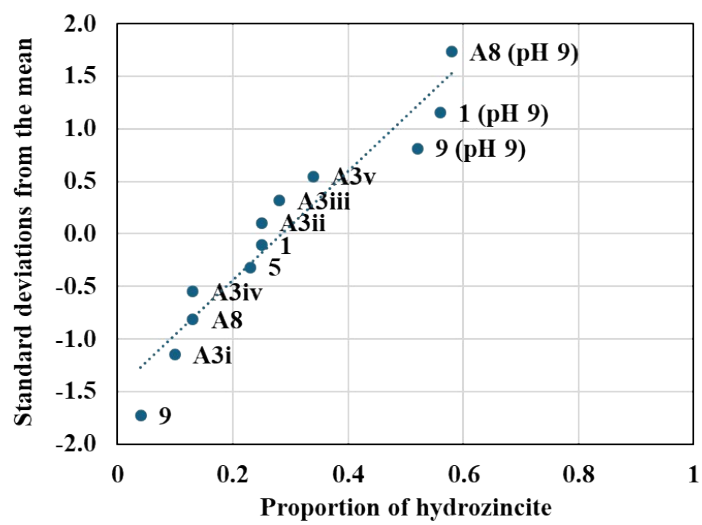
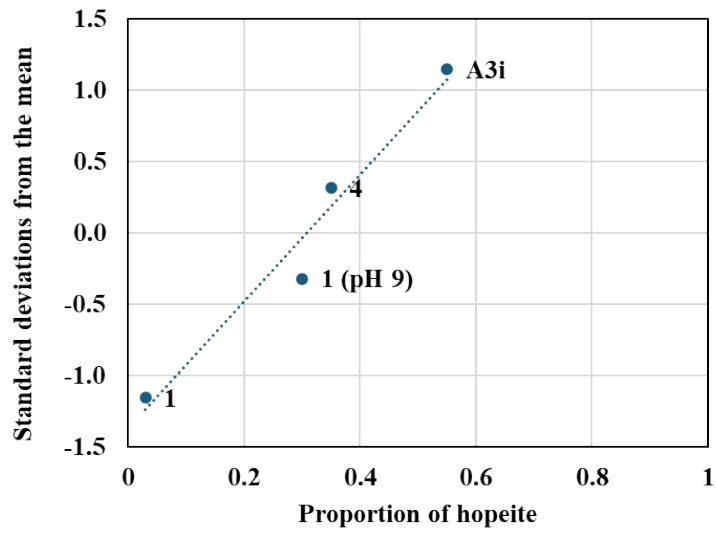
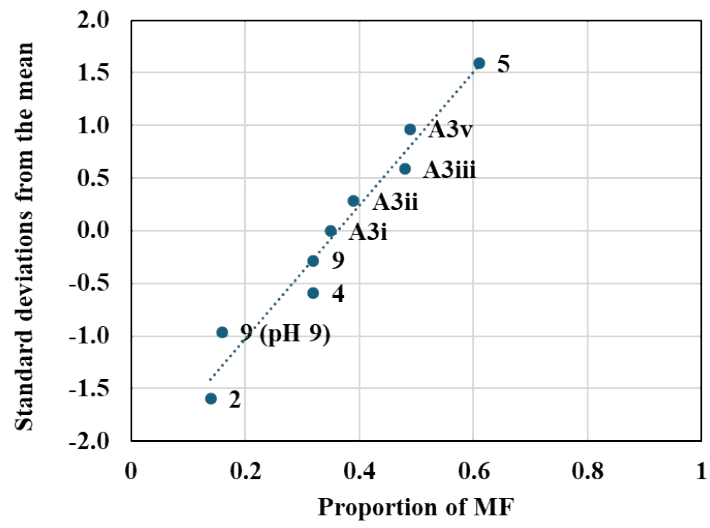


Figure A4 Linear combination fitting results of Zn K-edge EXAFS spectra for APCR A8 (a) and APCR 2 (b), with R-ranges from 3 to 10 \AA^{-1} for both samples.



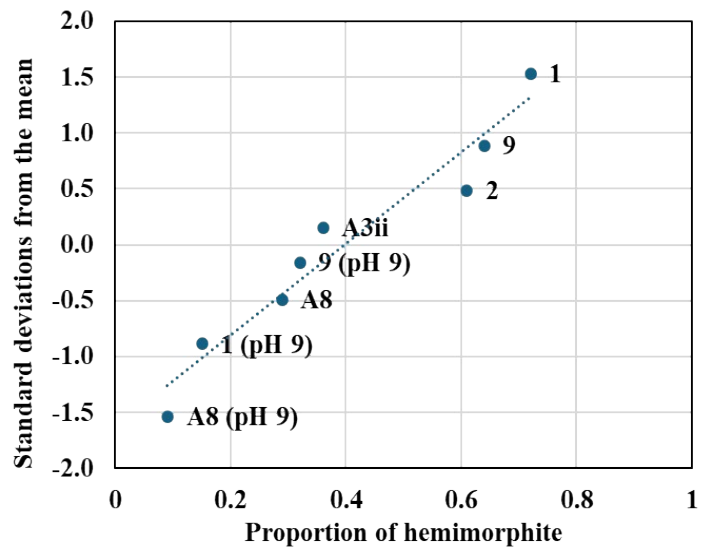
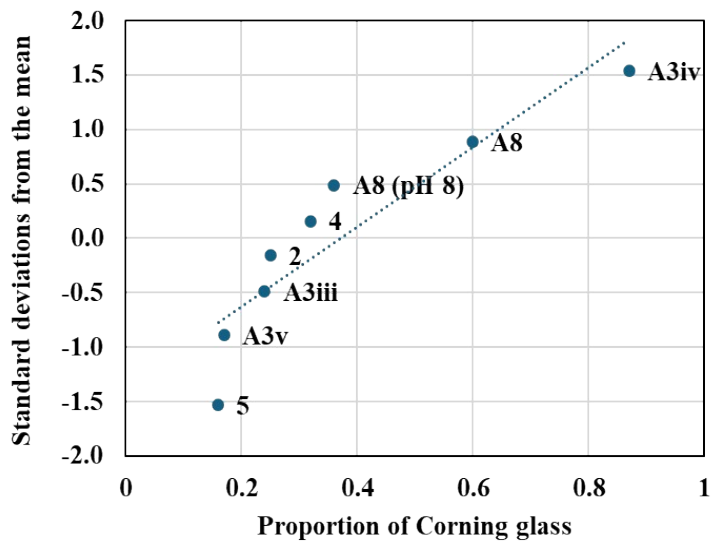


Figure A5 The cumulative normal distributions of proportions of APCR spinel (MF), hopeite, hydrozincite, Corning glass IR-X and hemimorphite in all raw APCR samples.

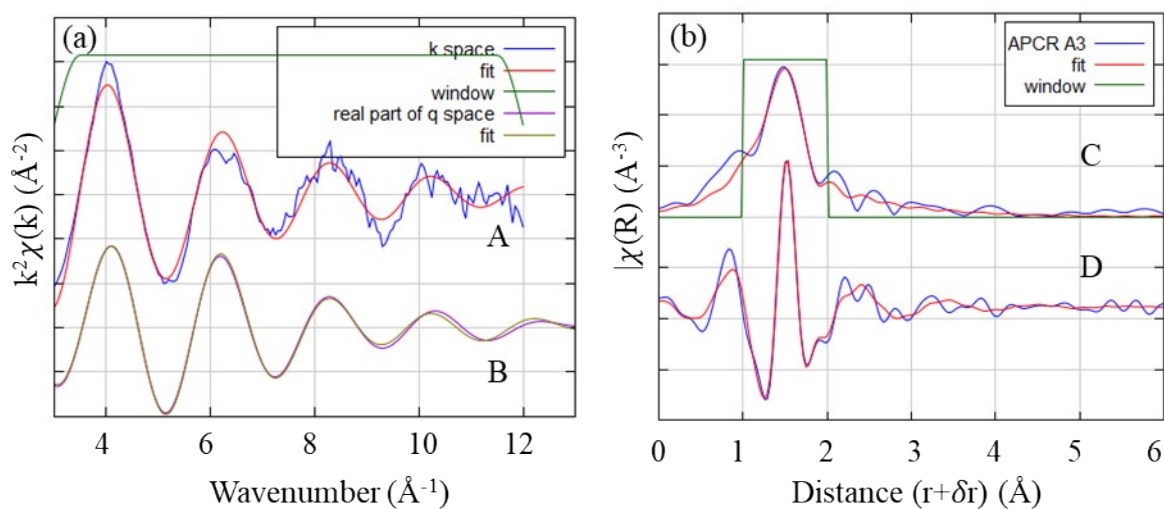


Figure A6 The $\chi(k)$ spectra of APCR A3 as measured (A) and fitted and filtered from the corresponding Fourier Transform spectrum by back Fourier Transformation (B) (a), using reference material ZnO. Spectrum B has been filtered from the 1.0-2.0 \AA region; Fourier Transform spectra of APCR A3 as measured and fitted in magnitude (C) and in real part (D) (b). Fourier Transform spectrum is uncorrected for phase shift. k-rang is 3.0-12.0 \AA^{-1} .

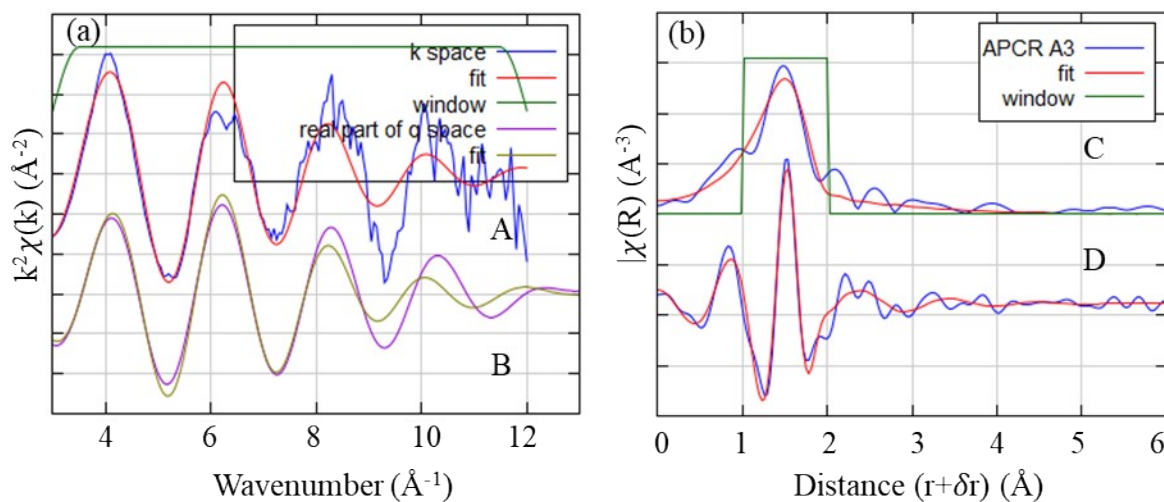


Figure A7 The $\chi(k)$ spectra of APCR A3 as measured (A) and fitted and filtered from the corresponding Fourier Transform spectrum by back Fourier Transformation (B) (a), using reference material ZnCl_2 . Spectrum B has been filtered from the 1.0-2.0 \AA region; Fourier Transform spectra of APCR A3 as measured and fitted in magnitude (C) and in real part (D) (b). Fourier Transform spectrum is uncorrected for phase shift. k-rang is 3.0-12.0 \AA^{-1} .

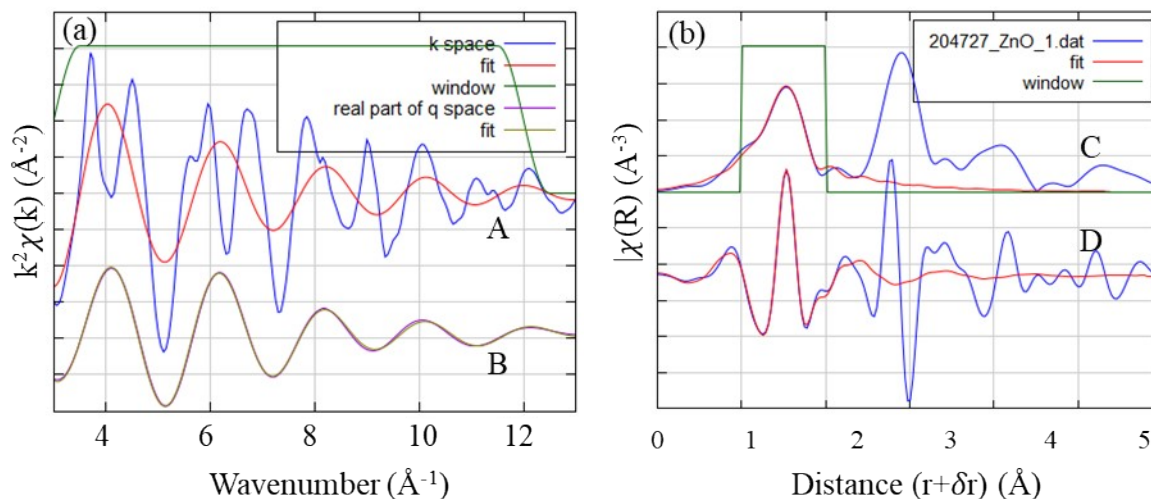


Figure A8 The $\chi(k)$ spectra of ZnO as measured (A) and fitted and filtered from the corresponding Fourier Transform spectrum by back Fourier Transformation (B) (a). Spectrum B has been filtered from the 1.0-2.0 Å region; Fourier Transform spectra of ZnO as measured and fitted in magnitude (C) and in real part (D) (b). Fourier Transform spectrum is uncorrected for phase shift. k-range is 3.0-12.0 Å⁻¹.

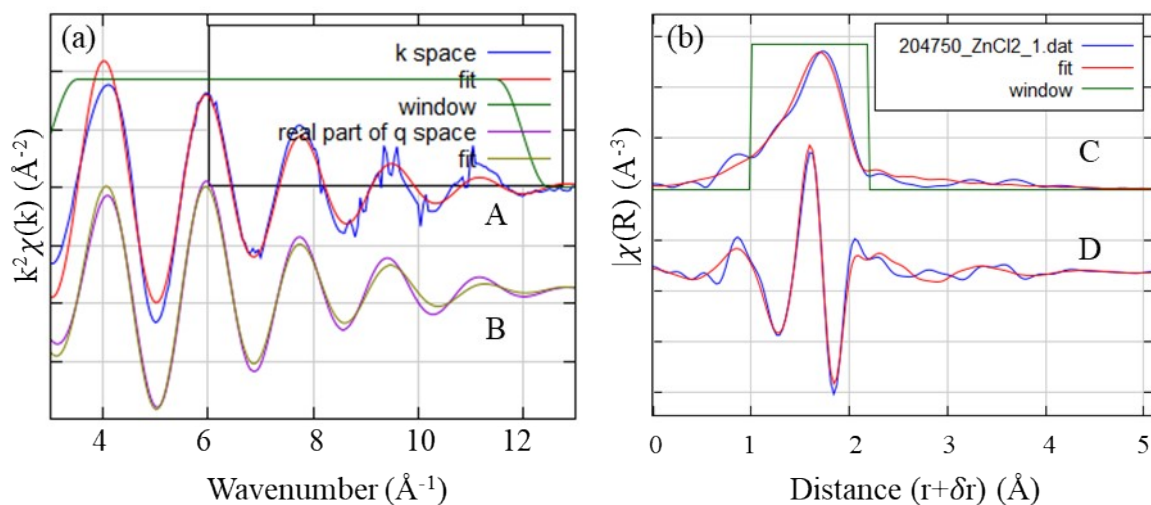


Figure A9 The $\chi(k)$ spectra of ZnCl₂ as measured (A) and fitted and filtered from the corresponding Fourier Transform spectrum by back Fourier Transformation (B) (a). Spectrum B has been filtered from the 1.0-2.2 Å region; Fourier Transform spectra of ZnCl₂ as measured and fitted in magnitude (C) and in real part (D) (b). Fourier Transform spectrum is uncorrected for phase shift. k-range is 3.0-12.0 Å⁻¹.

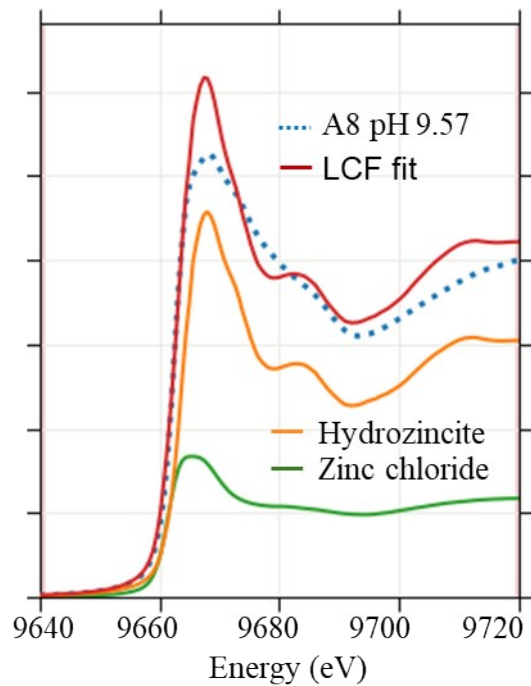


Figure A10. Best linear combination fit of Zn K-edge X-ray XANES spectrum for A8 pH 9.57, including zinc chloride as a reference compound, with a R-factor of 0.028.

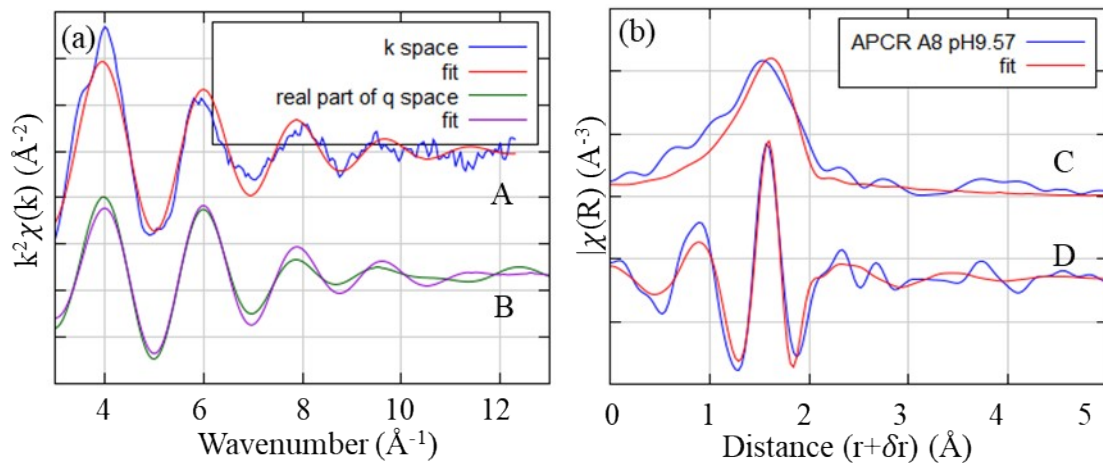


Figure A11 The $\chi(k)$ spectra of APCR A8 pH9.57 as measured (A) and fitted and filtered from the corresponding Fourier Transform spectrum by back Fourier Transformation (B) (a), using reference material ZnO. Spectrum B has been filtered from the 1.0-2.0 Å region; Fourier Transform spectra of APCR A8 pH9 as measured and fitted in magnitude (C) and in real part (D) (b). Fourier Transform spectrum is uncorrected for phase shift. k-rang is 3.0-12.0 Å⁻¹.

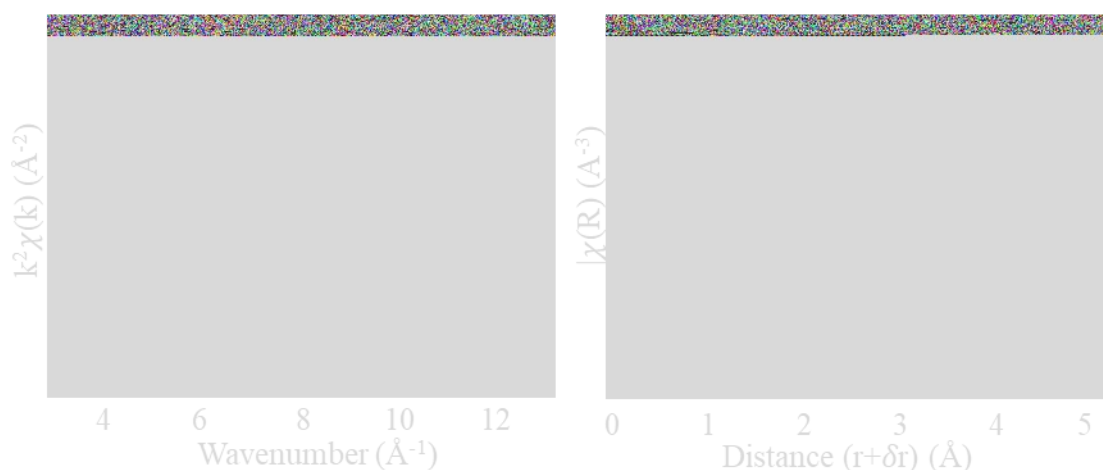


Figure A12 The $\chi(k)$ spectra of APCR A8 pH9.57 as measured (A) and fitted and filtered from the corresponding Fourier Transform spectrum by back Fourier Transformation (B) (a), using reference material ZnCl_2 . Spectrum B has been filtered from the 1.1-2.1 Å region; Fourier Transform spectra of APCR A8 pH9 as measured and fitted in magnitude (C) and in real part (D) (b). Fourier Transform spectrum is uncorrected for phase shift. k-rang is 3.0-12.0 Å⁻¹.

Table A1 Structural parameters derived from curve fitting to theoretical standards for Zn standards (ZnO and ZnCl_2) and APCR A3.

Fitted standards and samples	Filter (Å)	shell	CN	R (Å)	ΔR	$\sigma^2(\text{Å})$	$\Delta E_0(\text{eV})$	R-factor
ZnO	1.0-2.0	Zn-O	4.0*	1.964	-0.014	0.005	2.295	0.003
ZnCl_2	1.0-2.2	Zn-Cl	4.0*	2.198	-0.074	0.010	-7.142	0.022
APCR A3	1.0-2.0	Zn-O	4.1	1.943	-0.034	0.005	0.206	0.009
APCR A3	1.0-2.0	Zn-Cl	5.8	2.065	-0.207	0.014	-20.030	0.042
APCR A8 pH9.57	1.0-2.0	Zn-O	5.1	2.013	0.048	0.012	2.359	0.014
APCR A8 pH9.57	1.0-2.0	Zn-Cl	7.5	2.086	-0.187	0.020	-17.835	0.120

Amplitude reduction factor SO^2 is set as 0.93 by fitting ZnO standard ¹;

Fit range: 3-12 Å⁻¹ for ZnO, ZnCl_2 , APCR A3 and APCR A8 pH9;

'*' refers to a fixed parameter.

The best fit of APCR A3 or APCR A8 pH9.57 was highlighted in bold.

References:

1. D. T. Chen, UCL (University College London), 2024.