Swelling transition of a clay induced by heating


DOI
10.1038/srep00618

Publication date
2012

Document Version
Other version

Published in
Scientific Reports

Citation for published version (APA):
Swelling transition of a clay induced by heating

E. L. Hansen1,*, H. Hemmen1, D. M. Fonseca1,7, C. Coutant2,8, K. D. Knudsen3, T. S. Plivelic4,
D. Bonn5, J. O. Fossum1,6,*

1 Department of Physics, Norwegian University of Science and Technology – NTNU, Trondheim, Norway
2 UFR Structure et Propriétés de la Matière, Université de Rennes 1, Rennes, France
3 Physics Department, Institute for Energy Technology – IFE, Kjeller, Norway
4 MAX IV Laboratory, Lund University, Lund, Sweden
5 Van der Waals-Zeeman Institute, University of Amsterdam, Amsterdam, Netherlands
6 Centre for Advanced Study – CAS, Norwegian Academy of Science and Letters, Oslo, Norway

Fitting 001 peak profiles from clays with a Pseudo-Voigt function allows for extraction of parameters (such as the peak position and peak width), from which it is possible to deduce information about the scattering particles (such as interlayer distances and particle sizes). Fig. S1 shows the changes to the 001 peak position from Na-fluorohectorite intercalating two water layers as a function of temperature. The peak position shows a consistent shift towards lower $q$ and hence towards larger interlayer spacings with increasing temperature, similar to previous findings where the layer spacing gradually increased when the air humidity was raised within a given hydration state1,2. From the fitted Lorentzian width component $w_L$ of the 001 peak, we estimate an average crystal size of approximately $2\pi/w_L = 120$ nm at 320 K. Because the
repetition distance between layers is 1.51 nm, this means that approximately 100 such layers on average constitute a particle stack. The fact that the 001 peak width is not significantly affected by temperature (we estimate an average crystal size of 110 nm at 340 K), suggests that delamination does not progress by a gradual peeling off of layers from stacked particles, because this process would have caused peak broadening.

Fig. S1: The development of the 001 Bragg peak position with temperature in a dispersion of Na-fluorohectorite in 10 mM NaCl, showing a small but consistent increase in the interlayer spacing. The error bars reflect 95 % confidence intervals on the peak positions calculated from goodness-of-fit parameters. The position as well as the width of the peak was extracted by fitting peak profiles with the Pseudo-Voigt function\textsuperscript{3,4} plus a baseline of the form \( B = cq^{-x} + b \), attributable to small-angle scattering and the background signal. The solid line (–) is a linear fit to the peak position versus temperature up to about 320 K, providing a guide to the eye.

Fig. S2 shows x-ray diffraction profiles at low and high temperatures obtained with an extended \( q \)-range. The loss of intensity at the 001 position corresponding to two water layers is not accompanied by the appearance of 001 diffraction from other hydration states. The 20,13-band\textsuperscript{5} on the other hand is preserved, indicating that the lateral integrity of the crystalline structure of the platelets remains intact. The changes to the 20,13-band correspond to the loss of
sharp $l \neq 0$ reflections, as the band takes on the typical prism-reflection shape commonly encountered for clays with turbostratic disorder or delaminated clays.\textsuperscript{5}

Figure S2: Loss of 001 Bragg peak intensity with temperature (a) and simultaneous changes to the 20,13-band (b), for a Na-fluorohectorite dispersion in 10 mM NaCl. The changes to the 20,13-band correspond to the loss of sharp $l \neq 0$ reflections only. The signal from water scattering has been subtracted.


