Ionic co-crystal of barbituric acid and $CaCl_2$ pentahydrate: twin law and structure solution

Giulio I. Lampronti[1], Lucia Maini[2], Dario Braga[2], Fabrizia Grepioni[2], Davide Capucci[2], Alessandro Turrina[2]

[1] *Department of Earth Sciences, University of Cambridge*

[2] *Dipartimento di Chimica "G.Ciamician"*

Alma Mater Studiorum Università di Bologna- Italy

About Ionic Co-Crystals (ICC)

Ionic cocrystals (ICCs) are a recently introduced new class of compounds formed by an organic molecule and an inorganic salt, like an alkali or alkaline earth halide. In these compounds, the organic molecule, which is solid as a pure compound at ambient conditions, acts as a sort of solvating molecule toward the ions. As a matter of fact, ICCs are often hydrated, and water molecules compete with the organic component for ions coordination. ICCs can be obtained either by classic crystallization methods, i.e., by mixing components in solution in adequate stoichiometric ratios, or by solid-state reactions between solid components (grinding or kneading) with no or limited solvent involvement. The present investigation is included in Braga et al. (2011).

For further information:

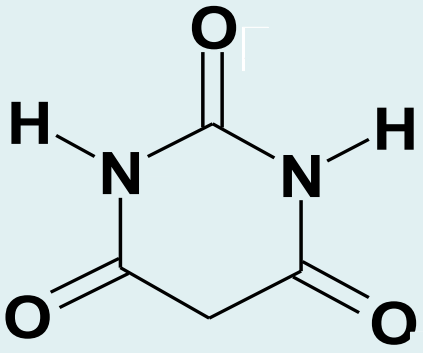
Braga D., Grepioni F., Maini L., Prosperi S., Gobetto R. Chierotti M.R.: "From unexpected reactions to a new family of ionic co-crystals: the case of barbituric acid with alkali bromides and caesium iodide", Chem. Commun., 2010, 46, 7715-7717

Braga D., Grepioni F., Lampronti G. I., Maini L..: "Ionic Co-crystals of Organic Molecules with Metal Halides: A New Prospect in the Solid Formulation of Active Pharmaceutical Ingredients", Cryst. Growth Des., 2011, 11 (12), pp 5621–5627

Braga D., Grepioni F., Maini L., Lampronti G.I., Capucci D., Cuocci C.: "Structure determination of novel ionic co-crystals from powder data: the use of rigid fragments in simulated annealing algorithms", CrystEngComm, 2012, 14, 3521-3527

Barbituric Acid·$CaCl_2$·$5H_2O$ synthesis

$CaCl_2$ (0.1 mmol) and 0.1 mmol of barbituric acid were dissolved in 20 mL of absolute ethanol; the solution was left to evaporate at room temperature, yielding crystalline barbituric acid·$CaCl_2$·$5H_2O$.



Barbituric Acid

Barbituric acid itself is not pharmacologically active, but substitution at C(5) results in the barbiturate family of hypnotic, sedative and anticonvulsant drugs, such as barbital and phenobarbital.

Single crystal XRD data collection and data analysis

Single-crystal X-ray diffraction data were collected at room temperature with an Oxford Diffraction Xcalibur diffractometer equipped with a CCD detector. Mo Ka radiation (λ = 0.71073 Å) was used. CrysAlis Pro software by Oxford diffraction and SHELX software were used for data reduction, and for structure solution and refinement respectively. Non-hydrogen atoms were refined anisotropically. Hydrogen atoms bound to carbon atoms were added in calculated positions. Hydrogen atoms bound to nitrogen and oxygen atoms were located from a Fourier map, and their positions were refined.

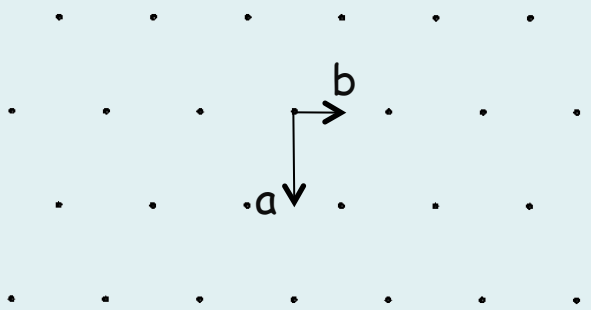
The diffraction pattern showed an orthorombic 2/m 2/m 2/m symmetry, and the data were first reduced using an orthorombic C-centered cell. Several space groups were tested but the data always lead to disorered solutions, which indicated a wrong cell choice.

The data were thus reduced again using a monoclinic primitive cell with $a = c$ (see next slide for more details). Systematic absences lead to space group n. 14. However the solution still showed disorder, R1 being over 20%. By inserting a twin matrix in SHELX the right twin law was found after a few attempts, and finally refined with R_{int} = 0.022, R_1(obsd) = 0.0318, wR_2(all) = 0.0715, GoF = 1.05

Twinning

XRD single crystal pattern indexing

Automatic cell search:

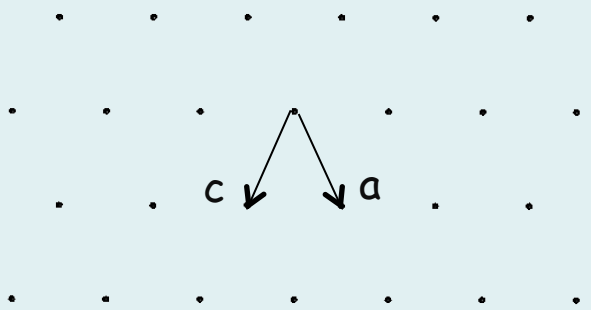


C centered orthorombic cell

transformation matrix

$$\begin{pmatrix} 0.5 & 0.5 & 0 \\ 0 & 0 & 1 \\ 0.5 & \overline{0.5} & 0 \end{pmatrix}$$

manual transformation:



primitive monoclinic cell

Twin law

individual space group: $P2_1/c$

twinning matrix

$$\begin{pmatrix} 0 & 0 & 1 \\ 0 & \overline{1} & 0 \\ 1 & 0 & 0 \end{pmatrix}$$

Twin point symmetry: orthorombic 2/m 2/m 2/m

Twin symmetry element is a 2-fold axis perpendicular to *b*: a case of crystal twinning by merohedry, class IIa.

(see Nespolo M., Ferraris G.: "Applied geminography – symmetry analysis of twinned crystals and definition of twinning by reticular polyholohedry", Acta Cryst. (2004). A60, 89-95, for twins classification)

Barbituric Acid·$CaCl_2$·$5H_2O$ Crystal Structure