Acta Crystallographica Section C
Crystal Structure Communications
ISSN 0108-2701

Lithium aspirinate hemihydrate

Jean-Baptiste Arlin,* Fiona Addison and Alan R. Kennedy

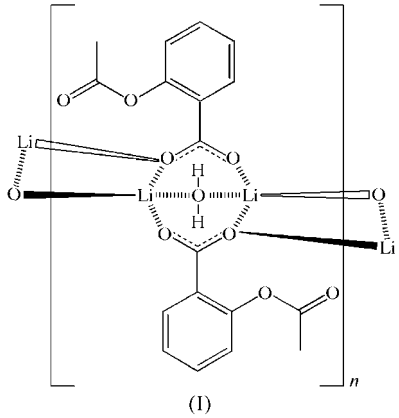
WestCHEM, Department of Pure and Applied Chemistry, University of Strathclyde, 295 Cathedral Street, Glasgow G1 1XL, Scotland
Correspondence e-mail: jeanbaptiste.arlin@strath.ac.uk

Received 5 September 2007
Accepted 16 October 2007
Online 14 November 2007

The title compound {systematic name: *catena*-poly[lithium(I)-μ_3-acetylsalicylato-hemi-μ_2-aqua]}, $\{[Li(C_9H_7O_4)]\cdot 0.5H_2O\}_n$, is the hemihydrate of the lithium salt of aspirin. The carboxylate groups and water molecules bridge between Li atoms to form a one-dimensional coordination chain composed of two distinct ring types. The water O atom lies on a twofold axis. Hydrogen bonding between water donors and carbonyl acceptors further links the coordination chains to form a sheet structure.

Comment

Aspirin (acetylsalicylic acid) and its salts are widely used pharmaceutically for their analgesic, antipyretic and anti-inflammatory properties. Aspirin itself is only sparingly soluble in water, and so its salt forms may be used to combat this and hence improve its bioavailability (Stahl & Wermuth, 2002; Barneoud & Curet, 1999). The most common counterions for pharmaceutical acids are sodium, potassium and calcium. Despite this, no structures of akaline metal salts of aspirin are known. This is not owing to lack of interest, as



(I)

highlighted by the recent debate on the structures of aspirin (Bond *et al.*, 2007) and the reported formation and characterization of calcium aspirinate by Ochsenbein *et al.* (2004). As well as difficulties with chemical instability, Ochsenbein and co-workers encountered problems with rapid phase changes. Indeed, the Ca salt was described as a furtive form, isolated only by microscopic examination of an evaporating droplet. Other relevant structural work on aspirin salts includes the isomorphic KH (Manojlovic & Speakman, 1967) and RbH (Grimvall & Wengelin, 1967) salts. The structures of numerous transition metal complexes of aspirin are also known [see Viossat *et al.* (2003) for a typical example]. As part of a study into structure/property correlations of *s*-block metal benzoate salts, we attempted the preparation of crystals of the alkaline metal salts of aspirin. We report here the structure of the hemihydrate of the lithium salt, (I).

The asymmetric unit of (I) is composed of one lithium cation, one acetylsalicylate anion and half a water molecule (Fig. 1), the O atom of which lies on a twofold axis. The Li1 coordination has a distorted tetrahedral geometry [angular range = 87.40 (14)–128.69 (19)°]. Of the carboxylate O atoms, atom O1 makes only one contact with Li and this is shorter than those formed by the bridging O2 atom (Table 1). The Li1 to bridging water distance is longer again, perhaps reflecting

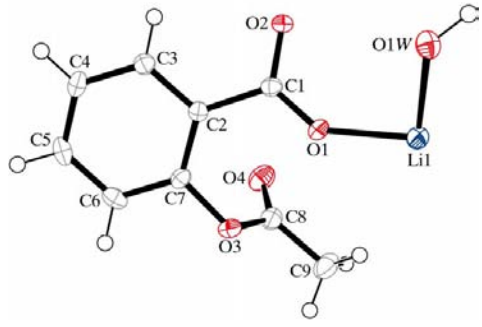


Figure 1
The contents of the asymmetric unit of (I), drawn with 50% probability displacement ellipsoids.

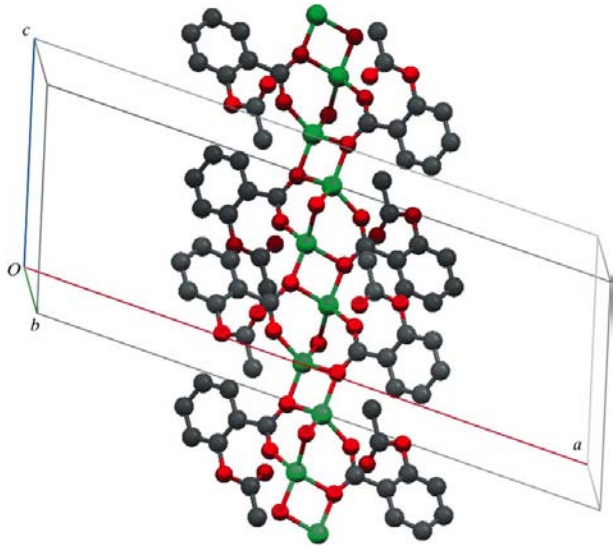


Figure 2
Part of the coordination chain that extends along the *c* direction. H atoms have been omitted for clarity. (Colour key in the electronic version of the paper: Li light green, O red and C grey.)

 DOI: 10.1107/S0108270107051104

the neutral nature of atom O1*W*. All bond lengths lie within the normal ranges found for similar bonds in the Cambridge Structural Database (CSD; Version 5.28 of May 2007; Allen, 2002). The ester group does not directly interact with the Li atom.

The interactions between Li and O atoms combine to form a one-dimensional coordination polymer propagating along the crystallographic *c* direction. This chain is composed of two different ring types, *viz*. four-membered (O2/Li1/O2/Li1) and six-membered (O1/Li1/O1*W*/Li1/O2/C1) rings (Fig. 2). Ten Li benzoate hydrate structures were found in a CSD search, and although one-dimensional chains were common, none had the same motif of alternating rings as (I). An alternative description of the larger ring is that it consists of a water molecule bridging over an eight-atom ring formed from two Li carboxylate groups in an $[LiOCO]_2$ arrangement, reminiscent of the classic hydrogen-bonded carboxylic acid dimer with Li replacing H. The two reported structures of aspirin have such dimeric arrangements in common (Wilson, 2002; Vishweshwar *et al.*, 2005; Bond *et al.*, 2007). The aspirin structures differ from one another in the detail of the C—H···O(carbonyl) interactions formed by the ester group. The presence of water in (I) replaces the weak C—H donors, and here the coordination chains link to each other through hydrogen bonding between the water molecule and atom O4 of the ester group, forming an $R_2^2(18)$ motif (see Table 2). This forms linkages in the *b*-axis direction (Fig. 3) to give an overall two-dimensional sheet structure with layers parallel to the *bc* plane. The sheets with their polar bonding modes are separated by a double hydrophobic layer formed by aromatic rings. The carboxylate group has lost its coplanarity with the aromatic ring [the dihedral angle between the plane of the aromatic ring and the CO_2 plane is 20.9 (2)°]. A similar twist is seen in the calcium aspirinate structure (Ochsenbein *et al.*, 2004) and other salt forms, and differs from the strict planarity found in aspirin itself.

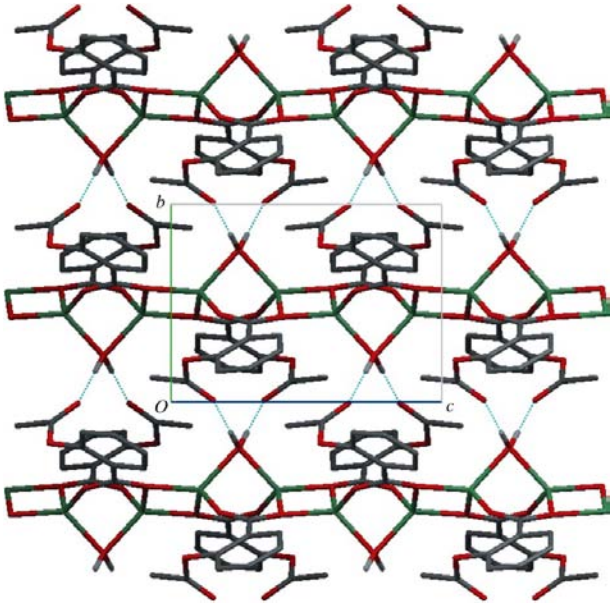


Figure 3
Part of the packing viewed down the *a* axis, showing the hydrogen bonds (dashed lines) between the chains. Only H atoms of water molecules are shown for clarity.

Experimental

The synthesis of the title compound was carried out by reaction of Li_2CO_3 with acetylsalicylic acid (molar ratio 1:2) in water. The solution was left to evaporate. The first crystals to appear were aspirin. These were removed and only then did crystals of (I) form. IR (KBr, cm^{-1}): 3429, 1745, 1728, 1614, 1590, 1561, 1400, 1232, 1195, 754. Differential scanning calorimetry (10 K per min) shows loss of the water molecule at 383 K.

Crystal data

$[Li(C_9H_7O_4)]\cdot 0.5H_2O$
M_r = 195.09
Monoclinic, $C2/c$
a = 26.262 (3) Å
b = 7.1677 (7) Å
c = 10.3351 (8) Å
β = 108.687 (3)°
V = 1842.9 (3) Å^3
Z = 8
Mo $K\alpha$ radiation
μ = 0.11 mm^{-1}
T = 123 (2) K
0.2 × 0.1 × 0.05 mm

Data collection

Nonius KappaCCD diffractometer
15207 measured reflections
1624 independent reflections
1110 reflections with $I > 2\sigma(I)$
R_{int} = 0.10

Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.040
$wR(F^2)$ = 0.095
S = 1.02
1624 reflections
137 parameters
H atoms treated by a mixture of independent and constrained refinement
$\Delta\rho_{max}$ = 0.20 e Å^{-3}
$\Delta\rho_{min}$ = −0.19 e Å^{-3}

Table 1
Selected geometric parameters (Å, °).

Li1—O1	1.918 (3)	Li1—O2^{ii}	1.971 (4)
Li1—O2^{i}	1.952 (3)	Li1—O1*W*	2.085 (4)
O1—Li1—O2^{i}	114.21 (18)	O1—Li1—O1*W*	94.85 (14)
O1—Li1—O2^{ii}	123.60 (19)	O2^{i}—Li1—O1*W*	128.69 (19)
O2^{i}—Li1—O2^{ii}	87.40 (14)	O2^{ii}—Li1—O1*W*	111.30 (16)
O2—C1—C2—C3	−20.2 (3)		

Symmetry codes: (i) $x, -y, z+\frac{1}{2}$; (ii) $-x, y, -z+\frac{3}{2}$.

Table 2
Hydrogen-bond geometry (Å, °).

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O1*W*—H1*W*···O4^{iii}	0.92 (3)	1.88 (3)	2.806 (2)	176 (3)

Symmetry code: (iii) $-x, y-1, -z+\frac{3}{2}$.

Data collection: *DENZO* (Otwinowski & Minor, 1997) and *COLLECT* (Hooft, 1998); cell refinement: *DENZO* and *COLLECT*; data reduction: *DENZO*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *ORTEPII* (Johnson, 1976) and *Mercury* (Macrae *et al.*, 2006); software used to prepare material for publication: *SHELXL97*.

We thank Westchem for funding a studentship (JBA) and AstraZenca for sponsoring a summer student (FA).

Supplementary data for this paper are available from the IUCr electronic archives (Reference: GZ3111). Services for accessing these data are described at the back of the journal.

References

Allen, F. H. (2002). *Acta Cryst.* B**58**, 380–388.

Barneoud, P. & Curet, O. (1999). *Exp. Neurol.* **155**, 243–251.

Bond, A. D., Boese, R. & Desiraju, G. R. (2007). *Angew. Chem. Int. Ed.* **46**, 618–622.

Grimvall, S. & Wengelin, R. F. (1967). *J. Chem. Soc. A*, pp. 968–970.

Hooft, R. (1998). *COLLECT*. Nonius BV, Delft, The Netherlands.

Johnson, C. K. (1976). *ORTEPII*. Report ORNL-5138. Oak Ridge National Laboratory, Tennessee, USA.

Macrae, C. F., Edgington, P. R., McCabe, P., Pidcock, E., Shields, G. P., Taylor, R., Towler, M. & van de Streek, J. (2006). *J. Appl. Cryst.* **39**, 453–457.

Manojlovic, L. & Speakman, J. C. (1967). *J. Chem. Soc. A*, pp. 971–979.

Ochsenbein, P., Bonin, M., Masson, O., Loyaux, D., Chapuis, G. & Schenk, K. J. (2004). *Angew. Chem. Int. Ed.* **43**, 2694–2697.

Otwinowski, Z. & Minor, W. (1997). *Methods in Enzymology*, Vol. 276, *Macromolecular Crystallography*, Part A, edited by C. W. Carter Jr & R. M. Sweet, pp. 307–326. New York: Academic Press.

Sheldrick, G. M. (1997). *SHELXS97* and *SHELXL97*. University of Göttingen, Germany.

Stahl, P. H. & Wermuth, C. G. (2002). *Handbook of Pharmaceutical Salts: Properties, Selection and Use*. Zurich: VHCA.

Viossat, B., Daran, J. C., Savouret, G., Morgant, G., Greenaway, F. T., Dung, N. H., Pham-Tran, V. A. & Sorenson, J. R. J. (2003). *J. Inorg. Biochem.* **96**, 375–385.

Vishweshwar, P., McMahon, J. A., Oliveira, M., Peterson, M. L. & Zaworotko, M. J. (2005). *J. Am. Chem. Soc.* **127**, 48, 16802–16803.

Wilson, C. C. (2002). *New J. Chem.* **26**, 1733–1739.