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*Acta Cryst.* (1997). **C53**, 1293–1295

### 4,12,16,24-Tetrahydroxycalix[4]arene–Methanol (1/2)

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(Received 6 February 1997; accepted 6 March 1997)

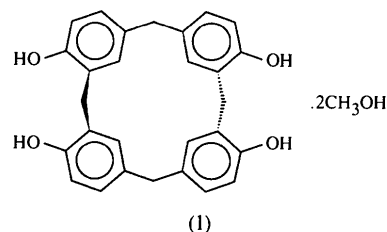
#### Abstract

The calixarene moiety in the title compound, 4,12,16,24-tetrahydroxypentacyclo[19.3.1.1<sup>3,7</sup>.1<sup>9,13</sup>.1<sup>15,19</sup>]octacosal(25),3,5,7(26),9,11,13(27),15,17,19(28),21,23-dodecane–methanol (1/2), C<sub>28</sub>H<sub>24</sub>O<sub>4</sub>·2CH<sub>3</sub>O, assumes a 1,2-alternate conformation in the crystalline state which allows two intramolecular O—H···O hydrogen bonds to be formed between pairs of adjacent phenolic OH groups. The molecules are arranged in the crystal to form infinite chains connected *via* intermolecular hydrogen bonds involving the two bridging methanol molecules. 12-Membered cyclic arrays of six hydrogen-bonded OH groups are formed with O···O 2.618(3)–2.742(2) Å.

#### Comment

Numerous single-crystal structures of calix[4]arenes with the hydroxy groups in *endo*-positions (25,26,27,28-tetrahydroxycalix[4]arenes) are known (see Böhmer, 1995, and references therein). Due to the cyclic array

of intramolecular hydrogen bonds, in all cases these calixarenes assume a more or less distorted cone conformation. We recently described the first X-ray structure of a *tert*-butyl-substituted calix[4]arene with four *exo*-hydroxy groups (Böhmer *et al.*, 1996), which somewhat surprisingly showed a cone conformation nearly identical to its *endo*-isomer. Such calix[4]arenes with four hydroxy groups in *exo*-positions have a still unexplored potential as building blocks, *e.g.* for the preparation of annelated calixarenes. We report here the crystal structure of the unsubstituted parent compound, (1).



Our X-ray analysis establishes that (1) has a 1,2-alternate conformation (Fig. 1) and reveals that two methanol molecules of solvation link the calix[4]arene molecules by O—H···O hydrogen bonds to form infinite rippled chains (Fig. 2) which extend along the *b* direction. In this way, 12-membered (···O—H···)<sub>6</sub> rings with graph-set notation R<sub>6</sub><sup>6</sup>(12) (Bernstein, Davis, Shimoni & Chang, 1995) are formed. The six O atoms of the (···O—H···)<sub>6</sub> rings are in a boat conformation. Hydrogen-bonding details are given in Table 2; the O···O distances are normal and in the range 2.618(2)–2.742(2) Å. There are only van der Waals interactions between the infinite chains.

A common method of describing calix[4]arene conformations is to quote the interplanar angles which the aromatic rings make with the plane of the four methyl-

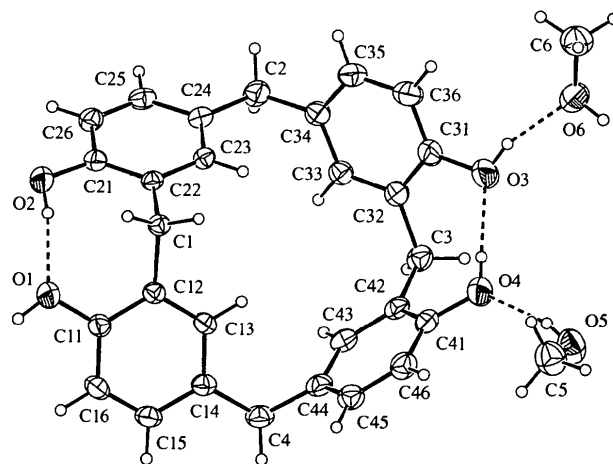


Fig. 1. A view of (1) with the crystallographic numbering scheme. Displacement ellipsoids are drawn at the 30% probability level.

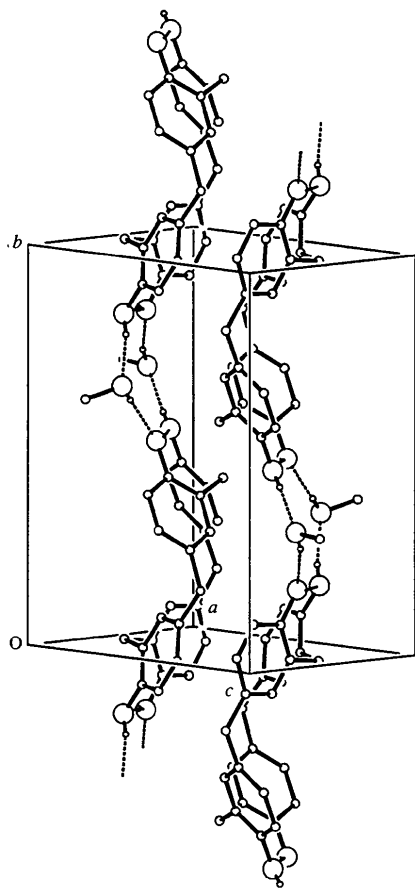


Fig. 2. A view of the hydrogen-bonded chains of molecules extending in the **b** direction. For clarity, non-hydroxy H atoms are not shown.

ene C atoms which link them. This is most effective when the four methylene C atoms are coplanar; such is not the case in (1) where the methylene C atoms show a folded conformation with deviations of  $-0.714(1)$  to  $+0.717(1)$  Å from their best plane [dihedral angle  $133.0(1)^\circ$  between the C2, C1, C4 and C2, C3, C4 planes]. To get around this general problem, Ugozzoli & Andreotti (1992) proposed an alternative conformation description based on signs and values of selected ring torsion angles  $\varphi$  and  $\chi$ ; the torsion-angle sign sequence (+-, +-, +-, --) values found for (1) (Table 1) are in accord with a distorted 1,2-alternate conformation, but this particular sequence [which is not mentioned in the Ugozzoli & Andreotti (1992) paper] arises because of the folding of the methylene carbon plane and some torsion angles being close to  $180^\circ$  (where the torsion-angle sign changes). An alternative conformation description is to quote the interplanar angles which the aromatic rings make with the C2, C1, C4 and C2, C3, C4 planes; these are  $134.7(1)$  (C11–C16/C2,C1,C4),  $120.8(1)$  (C21–C26/C2,C1,C4),  $130.9(1)$  (C31–C36/C2,C3,C4) and  $123.7(1)^\circ$  (C41–C46/C2,C3,C4).

Molecular dimensions are in the normal ranges. The C—C—C angles at C1 and C3 are slightly smaller than those at C2 and C4, presumably as a consequence of the intramolecular O—H...O bond formation. Examination of the structure with *PLATON* (Spek, 1996a) showed that there were no solvent-accessible voids in the crystal lattice.

## Experimental

The synthesis of (1) has been described by Böhmer, Dörrenbächer, Vogt & Zetta (1992) and Böhmer *et al.* (1996). Single crystals suitable for X-ray analysis were obtained by slow evaporation of a solution in acetone/methanol at room temperature.

### Crystal data

C<sub>28</sub>H<sub>24</sub>O<sub>4</sub>·2CH<sub>4</sub>O  
*M<sub>r</sub>* = 488.56  
 Triclinic  
*P* $\bar{1}$   
*a* = 8.1949 (8) Å  
*b* = 13.7540 (7) Å  
*c* = 11.350 (2) Å  
 $\alpha$  = 90.220 (7)°  
 $\beta$  = 93.333 (9)°  
 $\gamma$  = 90.082 (7)°  
*V* = 1277.1 (2) Å<sup>3</sup>  
*Z* = 2  
*D<sub>x</sub>* = 1.271 Mg m<sup>-3</sup>  
*D<sub>m</sub>* not measured

Mo *K*α radiation  
 $\lambda$  = 0.7107 Å  
 Cell parameters from 25 reflections  
 $\theta$  = 12.09–19.69°  
 $\mu$  = 0.088 mm<sup>-1</sup>  
*T* = 294 (1) K  
 Needle  
 0.42 × 0.28 × 0.21 mm  
 Orange-brown

### Data collection

Enraf–Nonius CAD-4 diffractometer  
 $\theta/2\theta$  scans  
 Absorption correction: none  
 5617 measured reflections  
 5617 independent reflections  
 3027 reflections with  $I > 2\sigma(I)$   
 $\theta_{\max}$  = 27.0°

*h* = -10 → 10  
*k* = 0 → 17  
*l* = -14 → 14  
 3 standard reflections  
 frequency: 120 min  
 intensity decay: no decay,  
 variation 0.9%

### Refinement

Refinement on *F*<sup>2</sup>  
 $R[F^2 > 2\sigma(F^2)] = 0.047$   
 $wR(F^2) = 0.149$   
*S* = 0.957  
 5617 reflections  
 334 parameters  
 H atoms constrained  
 $w = 1/[\sigma^2(F_o^2) + (0.0843P)^2]$   
 where  $P = (F_o^2 + 2F_c^2)/3$   
 $(\Delta/\sigma)_{\max} = 0.003$

$\Delta\rho_{\max} = 0.198$  e Å<sup>-3</sup>  
 $\Delta\rho_{\min} = -0.155$  e Å<sup>-3</sup>  
 Extinction correction: *SHELXL93*  
 Extinction coefficient: 0.005 (2)  
 Scattering factors from *International Tables for Crystallography* (Vol. C)

Table 1. Selected geometric parameters (Å, °)

O1—C11	1.385 (2)	O3—C31	1.376 (3)
O2—C21	1.379 (2)	O4—C41	1.380 (3)
C12—C1—C22	113.0 (2)	C32—C3—C42	113.4 (2)
C24—C2—C34	115.8 (2)	C14—C4—C44	114.5 (2)

C34—C2—C24—C25	176.9 (2)	C14—C4—C44—C45	84.3 (3)
C24—C2—C34—C35	−100.4 (3)	C44—C4—C14—C15	−161.5 (2)
C42—C3—C32—C31	93.0 (2)	C22—C1—C12—C11	−96.4 (2)
C32—C3—C42—C41	−86.2 (2)	C12—C1—C22—C21	85.2 (2)

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

D—H...A	D—H	H...A	D...A	D—H...A
O1—H1...O5 <sup>i</sup>	0.82	1.88	2.677 (2)	165
O2—H2...O1	0.82	1.93	2.742 (2)	171
O3—H3...O6	0.82	1.83	2.618 (3)	162
O4—H4...O3	0.82	1.87	2.681 (2)	171
O5—H5...O4	0.82	1.93	2.724 (2)	164
O6—H6...O2 <sup>ii</sup>	0.82	1.90	2.702 (2)	165

Symmetry codes: (i)  $x, y - 1, z$ ; (ii)  $x, l + y, z$ .

The calix[4]arene lies in a general position in the cell and it soon became apparent that there were also two independent methanol molecules in the asymmetric unit. All H atoms were visible in difference maps and were allowed for as riding atoms using appropriate *AFIX* controls in the *SHELXL93* (Sheldrick, 1993) refinement, with C—H 0.93–0.97 and O—H 0.82 Å.

Data collection: *CAD-4-PC* (Enraf–Nonius, 1992). Cell refinement: *SET4* and *CELDIM CAD-4-PC*. Data reduction: *DATRD2* in *NRCVAX96* (Gabe, Le Page, Charland, Lee & White, 1989). Program(s) used to solve structure: *SHELXS86* (Sheldrick, 1985). Program(s) used to refine structure: *NRCVAX96* and *SHELXL93*. Molecular graphics: *NRCVAX96*, *ORTEPII* (Johnson, 1976), *PLATON* (Spek, 1996a) and *PLUTON* (Spek 1996b). Software used to prepare material for publication: *NRCVAX96*, *SHELXL93* and WordPerfect macro *PREP-CIF97* (Ferguson, 1997).

GF thanks NSERC (Canada) for Research Grants. VB and MF are grateful to the German Israeli Foundation for Scientific Research & Development for financial support.

Supplementary data for this paper are available from the IUCr electronic archives (Reference: AB1469). Services for accessing these data are described at the back of the journal.

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*Acta Cryst.* (1997). **C53**, 1295–1299

## Trimethoprim–Sulfadimidine 1:2 Molecular Complex Monohydrate

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(Received 29 July 1996; accepted 10 January 1997)

## Abstract

In the title compound, C<sub>14</sub>H<sub>18</sub>N<sub>4</sub>O<sub>3</sub>·2C<sub>12</sub>H<sub>14</sub>N<sub>4</sub>O<sub>2</sub>S·H<sub>2</sub>O, trimethoprim [5-(3,4,5-trimethoxybenzyl)pyrimidine-2,4-diamine, TMP] interacts with one sulfadimidine [4-amino-*N*-(4,6-dimethyl-2-pyrimidinyl)benzenesulfonamide, SDMD] molecule through two N—H...N hydrogen bonds forming an eight-membered ring, as in the 1:1 methanolate complex, with no proton transfer from the imino sulfonamide N atom to the pyrimidine N atom of the partner. Association with the second sulfadimidine molecule (SDMD') occurs through an N—H...N interaction involving the same pyrimidine N atom of TMP (which therefore acts as a double acceptor) and the NH imino group of the sulfonamide. The water molecule bridges the sulfonamido O atom and the *p*-aminophenyl group of SDMD' of two molecular complex units.

## Comment

The previous paper on a 1:1 TMP–SDMD complex methanol solvate indicated (a) the absence of TMP protonation by the sulfonamide partner, unlike in the TMP complexes with sulfametrole and sulfamethoxazole, and (b) the very strong interaction between the methanol and the sulfonyl group without a direct contribution to crystal packing from the solvent (Bettinetti & Sardone, 1997). Since, in aqueous ethanolic solution, TMP and SDMD form a 1:2 molecular complex, the present study was undertaken to elucidate the nature of molecular association between TMP and SDMD in water