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Aromatic molecules included into and contacting the outer surface of cyclomaltohexaose (α-cyclodextrin): crystal structure of α-cyclodextrin–(benzyl alcohol)$_2$-hexahydrate [†]

Thomas Steiner *, Katrin Geßler

Institut für Kristallographie, Freie Universität Berlin, Takustraße 6, D-14159 Berlin, Germany

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Abstract

A single crystal X-ray diffraction study of the complex α-cyclodextrin (benzyl alcohol)$_2$ · $6H_2O$ was carried out at room temperature. Space group $P2_12_12$, cell constants $a = 22.189$ (18) $b = 16.602$ (6), $c = 8.265$ (4) Å, and $V = 3045$ (3) Å^3. The crystal packing is of the channel type with one benzyl alcohol molecule per αCD included in the channel formed by the αCD cavities, and one benzyl alcohol and six water molecules per αCD placed in wide interstitial channels. Both symmetry-independent benzyl alcohol molecules are engaged in short C–H · · · O contacts. The benzyl alcohol molecule placed in the interstitial channel forms close contacts with two αCD molecules such that C–H groups of the outer αCD surface point at the center of the aromatic moiety with H-center distances of 2.70 Å and angles at H of 167°, suggesting weak C–H · · · π interactions.

Key words: Crystal structure; α-Cyclodextrin–(benzyl alcohol)$_2$-hexahydrate; Cyclomaltohexaose (α-cyclodextrin); Inclusion complex

1. Introduction

The cyclodextrins (CDs, cyclomalto-oligosaccharides), which consist of six (αCD) to nine (δCD) α-D-glucose residues, form inclusion complexes with molecules of suitable size [1–3]. When crystallized from aqueous solution, guest molecules are generally included in the cyclodextrin cavities, and interstitial space between the

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* Corresponding author.

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CD molecules is filled by hydration water molecules. It is frequently observed that inclusion of a guest molecule is incomplete so that parts of it protrude from the cavity, but only in very rare cases [4–6], substrate molecules co-crystallize outside the CD cavities (in all these cases, the CD cavities are not empty or filled with only water, but they contain substrate as well). Consequently, only little structural information is available on the interaction of CDs with molecules other than water that are located 'outside' the CD cavity.

In this study, we report the crystal structure of the complex αCD–(benzyl alcohol)$_2 \cdot 6H_2O$, in which one molecule of benzyl alcohol is included within each αCD cavity, and one is in contact with the outside of the macrocycle.

2. Experimental

Crystallisation.—A hot (~ 70°C) satd aq solution of αCD was mixed with benzyl alcohol (which is only poorly soluble in water), stirred vigorously for several minutes and subsequently cooled in a Dewar flask. Crystals grew in the aqueous phase and at the phase boundary between the aqueous phase and the benzyl alcohol phase.

X-ray diffraction experiments.—X-ray experiments were performed at room temperature using a crystal of dimensions $0.5 \times 0.3 \times 0.2$ mm^3 sealed in a glass capillary together with some mother liquor (Enraf–Nonius Turbo-CAD4 diffractometer on a FR571 rotating anode generator, Ni-filtered CuK_α radiation with $\lambda = 1.542$ Å). The space group is orthorhombic $P2_12_12$ with cell constants $a = 22.189$ (18), $b = 16.602$ (6), $c = 8.265$ (4) Å, and $V = 3045$ (3) Å^3 (determined from the diffraction angles of 18 reflections), $Z = 4$, 1/2 formula unit per asymmetric crystal unit, $D_x = 1.42$ g$\cdot$cm^{-3}. 2612 reflection intensities were measured to a nominal resolution $\lambda/2 \sin \theta_{max} = 0.89$ Å ($2\theta_{max} = 120°$, ω-scan mode, ψ-scan absorption correction [7]).

Structure solution and refinement.—The atomic coordinates of the αCD molecule (1/2 molecule per asymmetric crystal unit; molecular axis coinciding with the crystallographic two-fold axis parallel c) in the structurally isomorphous crystal structure αCD–sodium benzenesulfonate [8] were used for initial phasing. Consecutive cycles of least-squares refinement and difference-Fourier calculations (program [9] SHELX76, function minimized $\Sigma w(|F_0| - |F_c|)^2$ with $w = 1.0$) revealed the positions of 1/2 benzyl alcohol molecule in the αCD cavity (per asymmetric crystal unit), and 1/2 benzyl alcohol and three water molecules (per asymmetric crystal unit) in interstices.

Both benzyl alcohol sites are placed on crystallographic two-fold axes, and were therefore refined as half-occupied with the covalent geometry fixed to ideal values (as the hydroxyl group may rotate around the C-1–C-7 bond, the corresponding torsion angle was allowed to vary freely). Two αCD primary hydroxyl groups exhibit positional disorder; the occupancy of the alternative sites was fixed to have a sum of 1.0. In the final stage of refinement, H atoms bonded to ordered C atoms were placed in their calculated [10] positions; hydroxyl and water H atoms could

Table 1
Fractional atomic coordinates [a] and equivalent isotropic temperture factors U_{eq} (Å^2) of the nonhydrogen atoms in α-cyclodextrin–(benzyl alcohol)$_2\cdot 6H_2O$. Occupancies are given if < 1.0

Atom	x/a	y/b	z/c	U_{eq} (Å^2)	Occupancy
C-1^1	0.6483 (5)	0.2475 (7)	0.368 (2)	0.05 (1)	
C-2^1	0.6196 (5)	0.2840 (7)	0.516 (2)	0.05 (1)	
C-3^1	0.5525 (5)	0.2559 (7)	0.538 (1)	0.05 (1)	
C-4^1	0.5191 (4)	0.2729 (7)	0.381 (1)	0.043 (9)	
C-5^1	0.5509 (5)	0.2364 (7)	0.235 (1)	0.041 (9)	
C-6^1	0.5221 (6)	0.2599 (9)	0.072 (1)	0.07 (1)	
O-2^1	0.6554 (4)	0.2659 (5)	0.656 (1)	0.062 (8)	
O-3^1	0.5254 (3)	0.2949 (5)	0.6702 (9)	0.052 (8)	
O-4^1	0.4619 (3)	0.2374 (4)	0.3983 (9)	0.041 (7)	
O-5^1	0.6130 (3)	0.2655 (5)	0.231 (1)	0.051 (8)	
O-6^1	0.5495 (5)	0.2142 (8)	−0.049 (1)	0.10 (1)	
C-1^2	0.7474 (5)	−0.0428 (7)	0.353 (2)	0.05 (1)	
C-2^2	0.7638 (5)	0.0088 (8)	0.494 (2)	0.05 (1)	
C-3^2	0.7157 (5)	0.0743 (7)	0.525 (2)	0.05 (1)	
C-4^2	0.7044 (5)	0.1215 (7)	0.366 (2)	0.04 (1)	
C-5^2	0.6956 (6)	0.0668 (8)	0.220 (1)	0.05 (1)	
C-6^2	0.6941 (8)	0.1114 (8)	0.066 (2)	0.07 (1)	
O-2^2	0.7694 (4)	−0.0434 (5)	0.633 (1)	0.069 (9)	
O-3^2	0.7323 (4)	0.1283 (5)	0.648 (1)	0.058 (8)	
O-4^2	0.6496 (3)	0.1635 (4)	0.391 (1)	0.044 (7)	
O-5^2	0.7426 (3)	0.0068 (5)	0.2128 (9)	0.053 (7)	
O-6^{2}A	0.6947 (6)	0.0609 (7)	−0.065 (1)	0.12 (1)	0.66
O-6^{2}B	0.746 (1)	0.143 (2)	0.019 (4)	0.22 (2)	0.34
C-1^3	0.5906 (5)	−0.2864 (7)	0.371 (2)	0.05 (1)	
C-2^3	0.6313 (5)	−0.2796 (7)	0.515 (2)	0.05 (1)	
C-3^3	0.6548 (5)	−0.1926 (7)	0.528 (2)	0.05 (1)	
C-4^3	0.6811 (5)	−0.1659 (7)	0.367 (2)	0.05 (1)	
C-5^3	0.6398 (6)	−0.1777 (8)	0.228 (1)	0.05 (1)	
C-6^3	0.6652 (8)	−0.155 (1)	0.070 (2)	0.08 (1)	
O-2^3	0.6000 (4)	−0.3036 (6)	0.656 (1)	0.068 (9)	
O-3^3	0.6978 (3)	−0.1866 (5)	0.655 (1)	0.058 (8)	
O-4^3	0.6898 (3)	−0.0795 (4)	0.385 (1)	0.044 (7)	
O-5^3	0.6198 (4)	−0.2621 (5)	0.227 (1)	0.053 (8)	
O-6^{3}A	0.6285 (7)	−0.172 (1)	−0.053 (2)	0.14 (1)	0.62
O-6^{3}B	0.705 (1)	−0.200 (2)	0.007 (3)	0.16 (2)	0.38
C-1^{B1}	0.5000 (−)	0.0000 (−)	0.766 (1)	0.08 (1)	0.50
C-2^{B1}[b]	0.5544 (2)	0.0000 (−)	0.682 (1)	0.11 (1)	
C-3^{B1}[b]	0.5544 (2)	0.0000 (−)	0.513 (1)	0.11 (1)	
C-4^{B1}	0.5000 (−)	0.0000 (−)	0.429 (1)	0.08 (1)	0.50
C-7^{B1}	0.5000 (−)	0.0000 (−)	0.953 (2)	0.16 (2)	0.50
O^{B1}	0.524 (1)	−0.078 (1)	1.006 (3)	0.16 (2)	0.50
C-1^{B2}	0.4858 (6)	0.5000 (−)	0.537 (2)	0.10 (2)	0.50
C-2^{B2}	0.5471 (6)	0.5000 (−)	0.500 (2)	0.09 (2)	0.50
C-3^{B2}	0.5659 (8)	0.5000 (−)	0.338 (2)	0.08 (2)	0.50
C-4^{B2}	0.523 (1)	0.5000 (−)	0.214 (2)	0.11 (2)	0.50
C-5^{B2}	0.462 (1)	0.5000 (−)	0.251 (2)	0.09 (2)	0.50

Table 1 (continued)

Atom	x/a	y/b	z/c	U_{eq} (Å^2)	Occupancy
C-6^{B2}	0.4432 (7)	0.5000 (−)	0.412 (2)	0.08 (2)	0.50
C-7^{B2}	0.465 (1)	0.5000 (−)	0.712 (2)	0.18 (2)	0.50
O^{B2}A	0.402 (2)	0.5000 (−)	0.746 (5)	0.27 (2)	0.32
O^{B2}B	0.477 (3)	0.560 (3)	0.805 (3)	0.16 (2)	0.18
W-1	0.8192 (4)	−0.0061 (6)	−0.080 (1)	0.082 (9)	
W-2	0.6661 (5)	0.3404 (6)	−0.050 (1)	0.11 (1)	
W-3	0.3701 (6)	0.3694 (6)	−0.051 (1)	0.12 (1)	

[a] Standard deviations are given in parentheses; coordinates with esd given as (−) were kept fixed in the refinement.

[b] The aromatic moiety is completed by the atoms C-2$'^{B1}$ and C-3$'^{B1}$, which are symmetry related with C-2^{B} and C-3^{B}, respectively, by the operation $1-x,\ -y,\ z$.

not be located. Anisotropic refinement converged with $R = 0.088$ for 2162 unique reflections with $F_0 > 1\sigma(F_0)$.

3. Results and discussion

General.—Fractional atomic coordinates and equivalent isotropic temperature factors are listed in Table 1; for partially occupied sites, occupation factors are given. Atom labelling is as in our previous contributions (refs. 11 and 12, and references therein), e.g., C-2^3 means atom C-2 of glucose residue 3 of the αCD molecule. Inter- and intra-molecular O $\cdots$ O contacts suggestive [11] of hydrogen bonding are listed in Table 2.

Crystal packing.—The αCD molecules are stacked along the crystallographic c-axis to form columns with infinite internal channels, which include one benzyl alcohol molecule per αCD. Unlike the densely packed hexagonal (or near-hexagonal) arrangements that are observed in many channel-type crystal structures of αCD [13], the columns form a rectangular arrangement with wide interstitial channels, Fig. 1, which accommodate one additional benzyl alcohol and six water molecules per αCD.

Within the stacks, the pattern of intermolecular hydrogen bonds is very regular and equivalent for all glucose residues (Table 2; Figs. 2 and 3): short O $\cdots$ O distances suggest [11] hydrogen bonds formed between O-3^n to O-6$^{n'}$, and bridges involving water molecules O-2^n $\cdots$ W $\cdots$ O-5$^{n'}$/O-6$^{n'}$, in which water molecules simultaneously form short contacts to O-5 and O-6 (A or B), indicating three-center hydrogen bonds [11,14].

This molecular packing mode has been reported for several crystal structures of αCD complexes [4,8,15–18] (including the first cyclodextrin crystal structure that was solved [15]). In most cases, however, it was obtained by crystallisation of αCD complexed with organic salts; then, the organic anions are included in the αCD channels whereas the cations and a number of water molecules are placed in the

Table 2
O ··· O separations suggestive [a] of hydrogen bonds

Contact	d (Å)	Symmetry
αCD intramolecular		
O-2^1 ··· O-3^2	2.85	
O-2^2 ··· O-3^3	2.87	
O-2^3 ··· O-3^1	2.79	
Intermolecular within the αCD stacks		
O-3^1 ··· O-6^1	2.73	$x, y, z-1$
O-3^2 ··· O-6^{2}A	2.76	$x, y, z-1$
O-3^2 ··· O-6^{2}B	3.09	$x, y, z-1$
O-3^3 ··· O-6^{3}A	2.87	$x, y, z-1$
O-3^3 ··· O-6^{3}B	2.92	$x, y, z-1$
Intermolecular between the αCD stacks		
O-6^{2}B ··· O-6^{3}B	2.83	$1.5-x, y-0.5, -z$
Involving benzyl alcohol		
O^{B_1} ··· O-6^1	2.82	$1-x, -y, z-1$
O^{B_1} ··· O-6^{3}A	2.84	$x, y, z-1$
O^{B_2}A ··· W-3	2.83	$x, y, z-1$
O^{B_2}B ··· O-3^1	2.66	$1-x, 1-y, z$
Involving water molecules		
W-1 ··· O-2^2	2.69	$x, y, z+1$
W-1 ··· O-5^2	2.96	x, y, z
W-1 ··· O-6^{2}A	2.98	x, y, z
W-1 ··· O-6^{2}B	3.07	x, y, z
W-1 ··· W-2	2.79	$1.5-x, y+0.5, -z$
W-1 ··· W-3	2.76	$x-0.5, 0.5-y, -z$
W-2 ··· O-2^1	2.73	$x, y, z+1$
W-2 ··· O-5^1	2.96	x, y, z
W-2 ··· O-6^1	3.33	x, y, z
W-2 ··· O-6^{3}B	2.95	$1.5-x, y-0.5, -z$
W-3 ··· O-2^3	2.74	$1-x, -y, z+1$
W-3 ··· O-5^3	2.92	$1-x, -y, z$
W-3 ··· O-6^{3}A	3.29	$1-x, -y, z$
W-3 ··· O-6^{3}B	3.31	$1-x, -y, z$
W-3 ··· O-6^{2}B	2.78	$x+0.5, 0.5-y, -z$
W-3 ··· O^{B2}A	2.83	$x, y, z+1$

[a] Method of analysis and reliability of assigning hydrogen bonds to O ··· O contacts: see ref 11.

interstitial channels [8,15–18]. As the only exception of an uncharged molecule, this packing mode was observed for the 1:2 complex of αCD with *m*-nitrophenol [4], where one *m*-nitrophenol molecule per αCD is included in the αCD channel and one substrate and six water molecules are placed in the interstitial channel (as in the present study).

Conformation of the αCD molecule.—The αCD molecule adopts an elliptically distorted conformation with two-fold symmetry (Fig. 1), thereby adjusting its shape

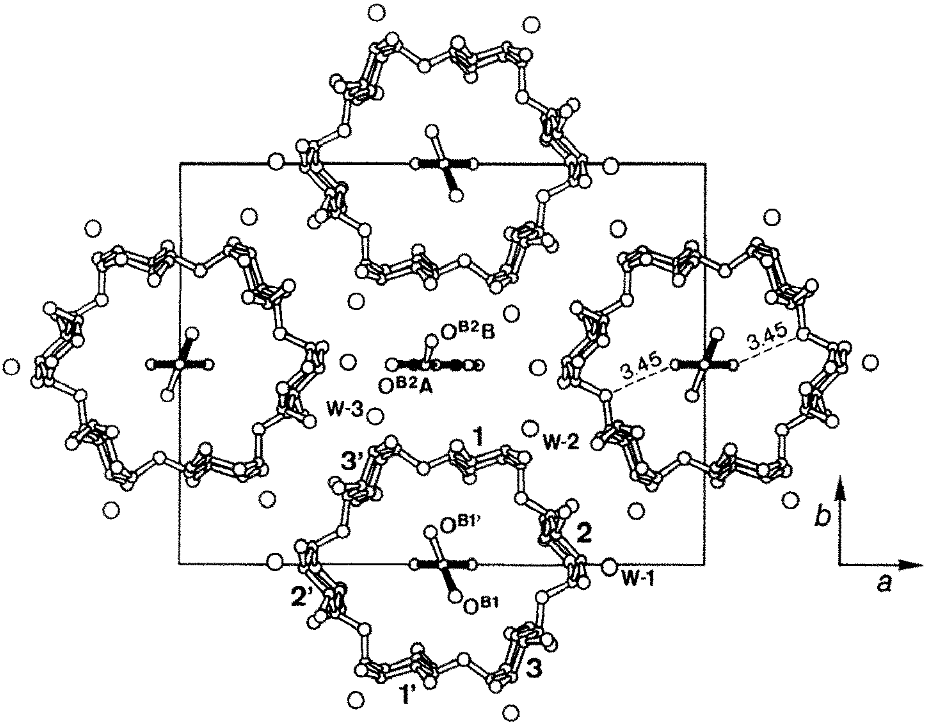

Fig. 1. Crystal packing of αCD–(benzyl alcohol)$_2$·6H$_2$O, viewed down the *c* axis. The aromatic moieties of the benzyl alcohol molecules are placed perpendicular to the *b* axis and are therefore only seen from the edges. For both symmetry-independent benzyl alcohol molecules, the hydroxyl group is two-fold disordered (one C–O bond is drawn filled and one is drawn open). *B*2 is placed on the two-fold crystallographic axis at $x/a = y/b = 1/2$ and two-fold disordered as a whole; for clarity, only one site of *B*2 is drawn.

to the shape of the guest molecule. The αCD conformation in this packing mode was described in detail in the earlier studies, but as an addition, the deviations of the individual glucose residues from ideal chair geometry are quantified according to Cremer and Pople [19] in Table 3; only residue 2, which forms the vertex of the αCD ellipse, Fig. 1, shows a significant distortion from ideal shape (the quantity of the distortion of residue 2, $\theta = 8°$, is not unusual for glucose residues in CDs). Two primary hydroxyl groups, C-6^2–O-6^2 and C-6^3–O-6^3 are two-fold disordered (Table 1).

The benzyl alcohol molecule enclosed in the αCD channel.—The central channel of the αCD columns contains one benzyl alcohol molecule per αCD. The aromatic moiety is inserted into the wide side of the αCD cavity, Fig. 3. The alcoholic CH$_2$OH group protrudes into the cavity of the next αCD molecule in the column, and forms hydrogen bonds with two αCD primary hydroxyl groups (Fig. 4a and Table 2). The benzyl alcohol hydroxyl group is rotated out of the aromatic plane with the torsion angle C-2–C-1–C-7–O = −68 (1)°, presumably to optimize hydro-

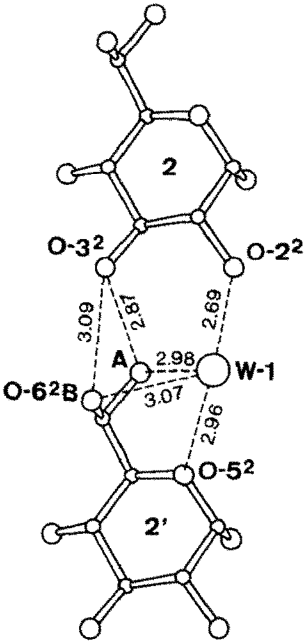

Fig. 2. The hydrogen bonding scheme within the stacks of αCD molecules as suggested by short O ··· O contacts. The pattern for glucose residues 1 and 3 (involving water molecules W-2 and W-3, respectively) is equivalent with variations only in the O ··· O separations, Table 2.

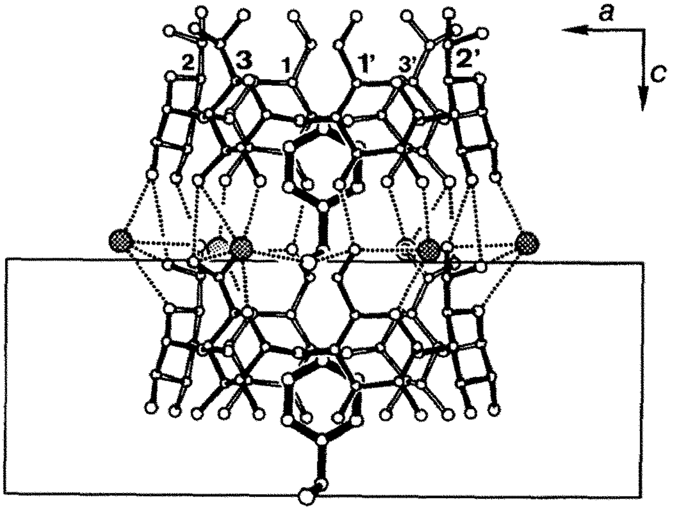

Fig. 3. Inclusion of benzyl alcohol in the αCD channel viewed along the b axis. Intermolecular O ··· O contacts suggestive of hydrogen bonds are indicated as dotted lines. Shaded spheres represent water molecules.

Table 3
Relevant ring puckering parameters [a] for the three symmetry-independent glucose residues in the αCD molecule

	Residue 1	Residue 2	Residue 3
Q (Å)	0.56 (1)	0.55 (1)	0.55 (1)
θ (°)	0 (1)	8 (1)	3 (1)

[a] Defined by Cremer and Pople [19]. Q, puckering amplitude. Increasing θ measures increasing deviation from ideal chair geometry. Atom sequence in the rings: O-5, C-1, C-2, C-3, C-4, C-5.

gen bond interactions. As the benzyl alcohol molecule is placed on a two-fold crystallographic axis, its hydroxyl group is inherently two-fold disordered with two equivalent sites (Fig. 1). This contrasts the crystal structure of βCD–benzyl alcohol, where full inclusion of a benzyl alcohol molecule in planar conformation was observed [20].

The benzyl alcohol aromatic moiety forms only weak C–H · · · O hydrogen bond interactions [21,22] with the host molecule. The shortest contacts, Fig. 4A, are directed to the glycosidic atoms O-4^3, (respectively O-$4^{3'}$) of the cavity wall:

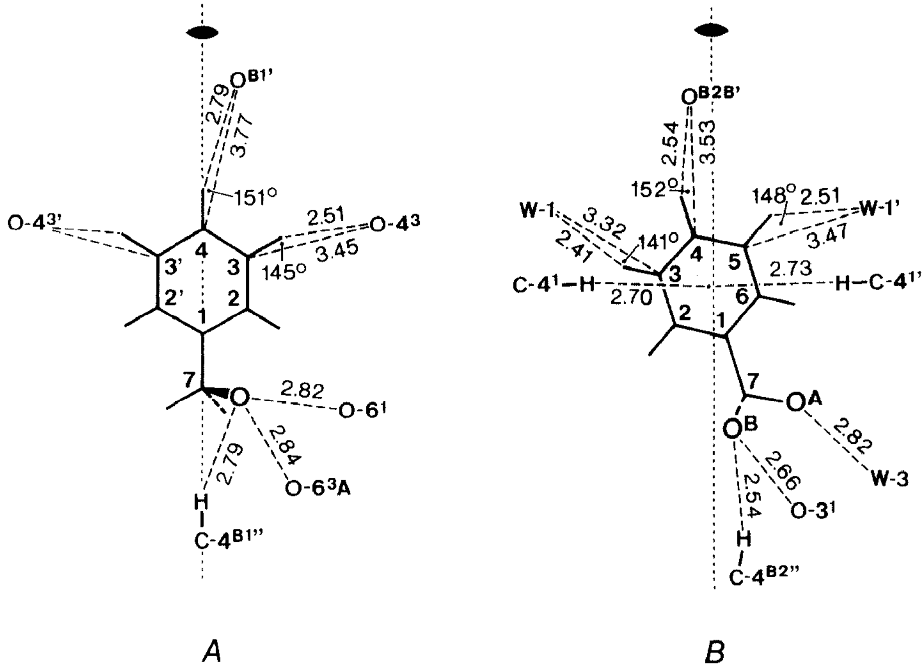

Fig. 4. Schematic representation of the shortest intermolecular O · · · O and C–H · · · O contacts of the two symmetry-independent benzyl alcohol molecules (numeric data for theoretical H positions based on a Csp^2–H bond length of 1.08 Å). Both molecules are placed on two-fold axes, which are indicated as thin dashed lines. (*A*) The benzyl alcohol molecule enclosed in the αCD channel. (*B*) The benzyl alcohol molecule in the interstitial channel. The C-4^1–H · · · π contacts are also shown schematically.

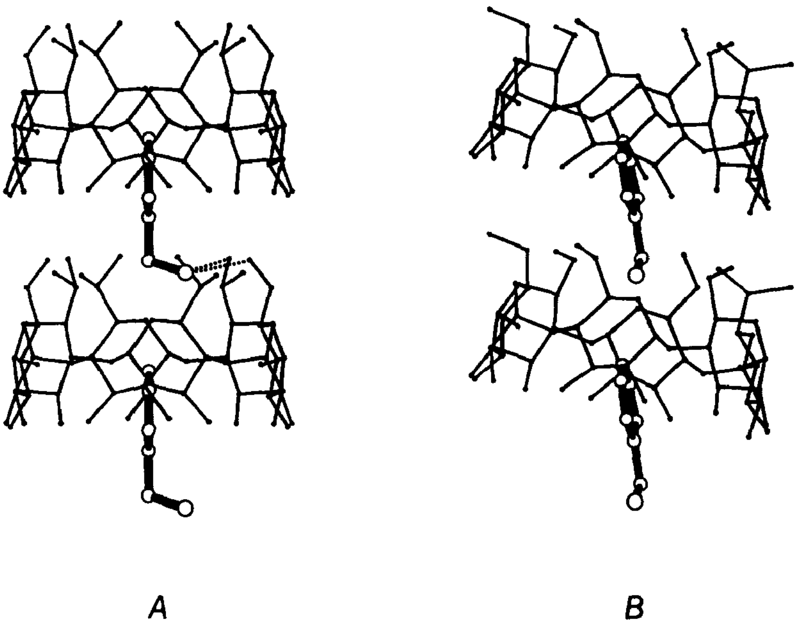

Fig. 5. Inclusion geometry in the crystal structures of (*A*) αCD–(benzyl alcohol)$_2 \cdot 6H_2O$ and (*B*) αCD-benzaldehyde$\cdot 6H_2O$ [23].

C-3^{B1} $\cdots$ O-4^3 = 3.45 Å (H $\cdots$ O = 2.51 Å for calculated H positions). The shortest contact between neighboring benzyl alcohol molecules in the channel is C-4^{B1} $\cdots$ O^{B1} = 3.77 Å (H $\cdots$ O = 2.79 Å for calculated H positions), Fig. 4A.

It is of interest to compare the inclusion geometry of benzyl alcohol in αCD with that of the related complex with benzaldehyde. The complex αCD–benzaldehyde-hexahydrate also crystallizes in a channel-type packing arrangement, but the space group is different ($P2_1$), and the equatorial planes of the αCD molecules are tilted by 11.5° against the channel axis [23], Fig. 5. The benzaldehyde molecule, which is in a planar conformation, is included into αCD in a similar way to benzyl alcohol: the aromatic moiety is inserted into the wider end of an αCD cavity and forms a relatively short C–H $\cdots$ O-4 contact [23] with the cavity wall (C-5^B $\cdots$ O-4^2 = 3.52 Å). The carbonyl group, however, does not form a hydrogen bond with αCD, but only a short C–H $\cdots$ O interaction [23] with the next benzaldehyde molecule in the channel (C-4^B $\cdots$ O^B = 3.36 Å; H-4^B $\cdots$ O^B = 2.44 Å).

The benzyl alcohol molecule in the interstitial channel.—The interstitial channel contains one benzyl alcohol and six water molecules per αCD. In the central part of the channel, the benzyl alcohol molecule is tightly sandwiched between two αCD molecules, Fig. 1.

This benzyl alcohol molecule is placed on a crystallographic two-fold axis with the molecular C-1–C-4 axis tilted by 17° against the symmetry axis, Fig. 4B. This

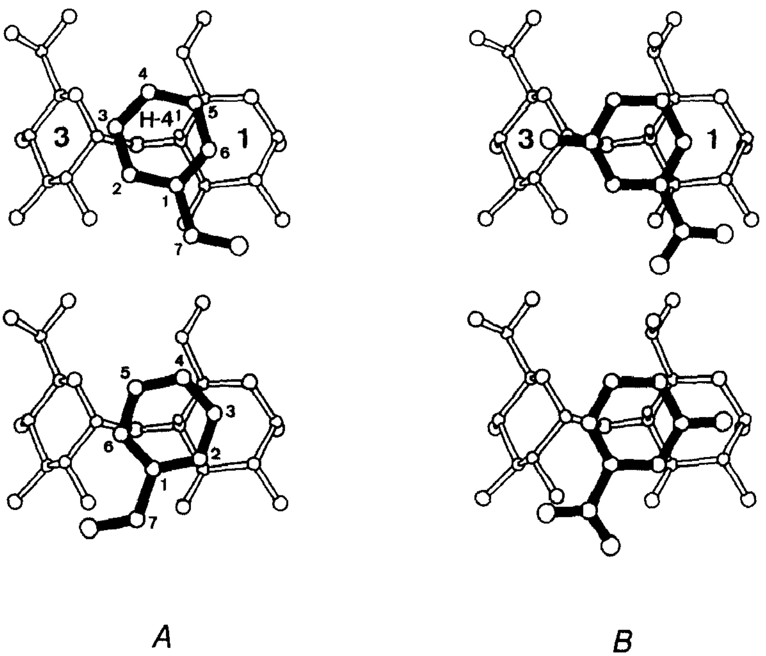

Fig. 6. (*A*) The contact of the benzyl alcohol molecule in the interstitial channel with the sandwiching αCD molecules (compare Fig. 1) seen for both sides of the disordered molecule in projections on the aromatic plane; for clarity, only one site of the two-fold disordered O atom is drawn. The shortest contact to the center of the aromatic ring is with atom H-4^1 which is drawn in its theoretical position (distance H-4^1-center = 2.73 and 2.70 Å, respectively; both angles at H = 167°). (*B*) The contact of *m*-nitrophenol with αCD in the related complex αCD-(*m*-nitrophenol)·$6H_2O$ [4]; distance H-4^1 $\cdots$ center = 2.68 Å, angle at H = 159°.

imposes disorder of the molecule as a whole with two equivalent sites. Furthermore, the hydroxyl group is two-fold disordered with C-2–C-1–C-7–O torsion angles 180° for $O^{B2}A$ (planar conformation) and 64 (3)° for $O^{B2}B$. In both conformations, the hydroxyl group forms only one short O $\cdots$ O contact suggestive of hydrogen bonding, Fig. 4B and Table 2, indicating unsatisfied hydrogen bond acceptor potentials. The aromatic moiety is engaged in three relatively short C–H $\cdots$ O contacts; two with water molecules and one with $O^{B2}B'$ of a symmetry related benzyl alcohol molecule, Fig. 4B.

The contacts with the αCD molecules are shown in projection onto the aromatic plane in Fig. 6A (because the center of the aromatic moiety is off the two-fold crystallographic axis, the two contacts are not equivalent, top and bottom). The aromatic moiety is at the height of the pyranose rings and almost directly faces the C-4–H hydrogen atom of glucose residue 1. If the midpoint of the aromatic moiety is called M, the resulting contact geometries are C-4^1 $\cdots$ M = 3.81 and 3.78 Å, respectively (top and bottom in Fig. 6a, respectively), H-4^1 $\cdots$ M = 2.73 and 2.70 Å, respectively (for calculated H positions with C–H = 1.10 Å), and both angles at H = 167°. The distances to the aromatic C atoms are significantly longer than the one to the midpoint. One can argue whether these contacts should be regarded as short van der Waals contacts or as examples of weak X–H $\cdots$ π interactions that are frequently observed in similar geometries for various types of X–H donors and aromatic π acceptors [24–28] (for stronger donors such as O–H [24–27] and HF [28], however, shorter H $\cdots$ M separations down to 2.2 Å are observed). For comparison, the contact with the external surface of αCD is also shown for the *m*-nitrophenol molecule in the related complex αCD–(*m*-nitrophenol)$_2$ hexahydrate [4], Fig. 6B. The contact is very similar as for αCD-benzyl alcohol: the aromatic moiety faces C-4^1-H with C-4^1 $\cdots$ M = 3.73 Å, H-4^1 $\cdots$ M = 2.68 Å and angle at H = 159° (theoretical H position; in this crystal structure, the contacts are equivalent on both sides).

Do benzyl alcohol molecules also contact the exterior of αCD in solution?—From the above results, the question arises whether exterior contacts such as shown in Fig. 6 also occur (in a more or less stable form) in solution. This could in fact be expected if an excess of benzyl alcohol is brought into aqueous solution together with αCD: if the available αCD cavities are already occupied, the outer jacket of the αCD molecules offers a relatively apolar contact area to the hydrophobic benzyl groups. The hydrophobic effect, probably assisted by C–H $\cdots$ π interactions, should therefore favour exterior αCD–benzyl alcohol contacts.

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