# The Solid State and Solution Conformational Behaviour of a Chiral 30-Crown-10 Derivative Synthesised from 1,4:3,6-Dianhydro-D-mannitol; *X*-Ray Crystal Structure

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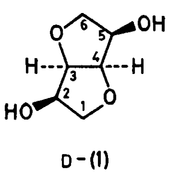
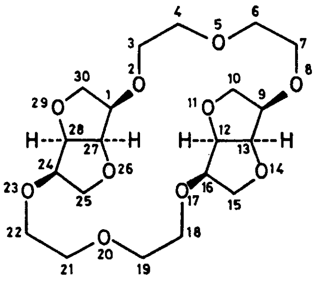
*Summary* A chiral 30-crown-10 derivative, DD-(**2**), has been prepared from 1,4:3,6-dianhydro-D-mannitol, D-(**1**), and shown by *X*-ray crystallography and dynamic $^{13}$C n.m.r. spectroscopy to adopt, in both the solid state and in solution, a 'face-to-back' conformation which must undergo substantial change in order to create the hydrophilic cavity necessary for the formation of complexes with $Li^+$, $Na^+$, $K^+$, $Rb^+$, $NH_4^+$, $MeNH_3^+$, and $Bu^tNH_3^+$ ions.

Previously we have drawn attention[1] to the attractions of 1,4:3,6-dianhydro-D-mannitol[2] D-(**1**) as a readily available and inexpensive precursor to chiral crown ethers. Not only does this diol serve as an ideal source of a 'chiral triethyleneglycol unit' (HO–$C^2$–$C^1$–O–$C^4$–$C^3$–O–$C^6$–$C^5$–OH) but it also has potential, on account of the *cis*-fused five-membered rings, to confer structural constraints upon receptor molecules incorporating it. The design and synthesis of both chiral[3] and achiral[4] host molecules of the crown ether type possessing potentially better three-dimensional complexing characteristics towards organic substrates than those provided by the complexes of 12-crown-4, 15-crown-5, and 18-crown-6 derivatives is recognised currently as an important objective in this area of biomimetic chemistry. Here, we (i) describe the preparation of a bisdianhydro-D-mannitolo-30-crown-10 derivative, DD-(**2**), (ii) discuss its conformational behaviour in the light of (a) the temperature dependence of its $^1$H-decoupled $^{13}$C n.m.r. spectrum in solution and (b) *X*-ray crystallographic data which establish its structural features in the solid state, and (iii) provide evidence that DD-(**2**) can act as a host molecule towards cationic species.



D-(**1**)



DD-(**2**)

Reaction of D-(**1**) with NaH and O(CH$_2$CH$_2$OTs)$_2$ in Me$_2$SO at 40 °C for 50 h afforded DD-(**2**) (14%), $M^+$, 432, m.p. 100—103 °C; $[\alpha]_D$ + 172° (*c* 1·98, CHCl$_3$); $^1$H n.m.r. (400 MHz) data (assignments and coupling constants supported by spin-decoupling experiments): $\delta$ (CDCl$_3$) 3·56—3·80 (16H, m, 4 × OCH$_2$CH$_2$O), 3·68 (4H, t, *J* 9 Hz, H-10, -15, -25, and -30), 3·78 (4H, q, *J* 7, 9 Hz, H'-10, -15, -25, and -30), 4·22 (4H, m, *J* 7, 9 Hz, H-1, -9, -16, and -24), and 4·66 (4H, m, H-12, -13, -27, and -28); $^{13}$C n.m.r. (100·6 MHz) data (partial assignments supported by selective decoupling of H-1, -9, -16, and -24 and H-12, -13, -27, and -28): $\delta$ (CD$_2$Cl$_2$) 70·1, 71·7, and 71·9 (methylene carbons), 80·8 (C-1, -9, -16, and -24), and 81·3 p.p.m. (C-12, -13, -27, and -28). On cooling this solution, the signals resonating at $\delta$ 71·9 and 81·3 exhibited gradual and *selective* line broadening until at − 110 °C the half-height linewidths were 44 and 38 Hz, respectively. Attempts to obtain spectra below − 110 °C in CD$_2$Cl$_2$–CHFCl$_2$ were frustrated by solubility problems. Nonetheless, sufficient qualitative spectral evidence exists to suggest that in solution (a) DD-(**2**) adopts a conformation with less than averaged $D_2$ symmetry, and (b) a slow conformational ring-inversion process is occurring at − 110 °C on the $^{13}$C n.m.r. time scale. Fortunately, crystals of DD-(**2**), obtained from EtOAc–light petroleum (b.p. 60—80 °C), were amenable to an $X$-ray structural analysis.† This revealed (Figure 1) that there are two non-symmetry-related molecules (A and B) in the asymmetric unit. Both conformations have the two *cis*-fused five-membered rings arranged in a 'face-to-back' manner. Although the gross conformational features are similar, significant differences are apparent on comparison of the conformations of molecules A and B. This is particularly noticeable from a comparison of the conformations of the linkages between the two *cis*-fused five-membered rings: *cf.* C(16) to C(24) with C(66) to C(74). The torsional angles associated with the C(69)–O(70) and C(71)–C(72) bonds in molecule B have opposite helicities from these associated with the C(19)–O(20) and C(21)–C(22) bonds respectively in molecule A. In addition, whilst the two

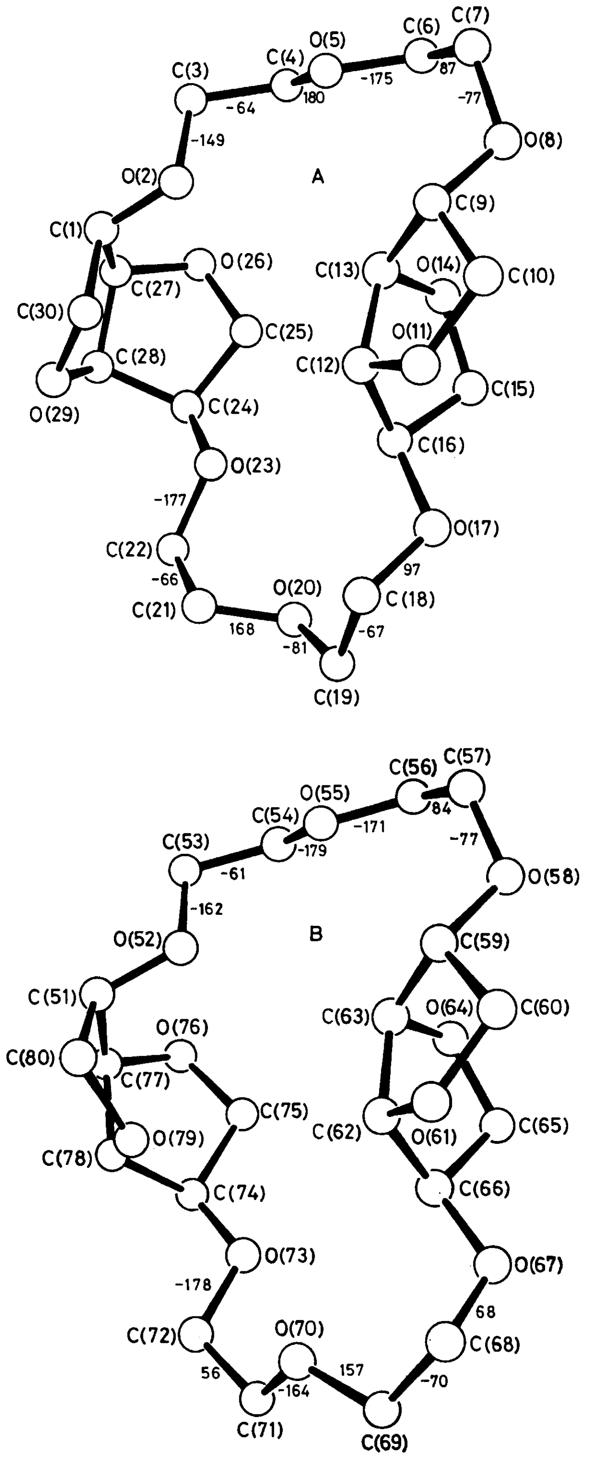


FIGURE 1. The conformations of molecules A (atoms numbered from 1 to 30) and B (atoms numbered from 51 to 80) of DD-(**2**) in the solid state. Torsion angles (°) for selected bonds are shown.

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† *Crystal data* for DD-(**2**): C$_{20}$H$_{32}$O$_{10}$, orthorhombic, space group $P2_12_12_1$, $a$ = 15·276(2), $b$ = 7·973(1), $c$ = 35·247(4) Å, $U$ = 4293 Å$^3$, $Z$ = 8, $D_c$ = 1·34 g cm$^{-3}$. Of the 4169 independent reflections ($\theta \leqslant 65°$) measured on a diffractometer using Cu-$K_\alpha$ radiation, 528 were classified as unobserved. The structure was solved by direct methods and refined to give $R$ = 0·060. The atomic co-ordinates for this work are available on request from the Director of the Cambridge Crystallographic Data Centre, University Chemical Laboratory, Lensfield Road, Cambridge CB2 1EW. Any request should be accompanied by the full literature citation for this communication.

dianhydromannitol residues in molecule A adopt similar conformations, they are different in molecule B. In the ring comprising atoms C(51), C(77), C(78), O(79), and C(80), the oxygen atom O(79) is oriented towards the face of the *cis*-fused five-membered rings whereas all, *i.e.* O(11), O(14), O(26), O(29), O(61), O(64), and O(76), the other oxygen atoms in molecules A and B are oriented towards the back.

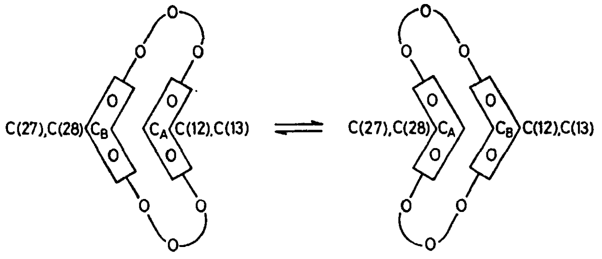

Figure 2. A diagrammatic representation of the equilibration in solution of the degenerate 'face-to-back' conformations of DD-(**2**).

The temperature dependence of the $^{13}$C n.m.r. spectrum of DD-(**2**) in $CD_2Cl_2$ can be interpreted in terms of equilibration (Figure 2) between degenerate 'face-to-back' conformations with averaged $C_2$ symmetry. Clearly, when DD-(**2**) forms 1 : 1 complexes ($K_a$ values, $\mathrm{l\,mol^{-1}}$)[5] in $CDCl_3$ with the picrates of $Li^+$ (7200), $Na^+$ (68,000), $K^+$ (120,000), $Rb^+$ (160,000), $NH_4^+$ (120,000), $MeNH_3^+$ (14,000), and $Bu^tNH_3^+$ (830), a wholesale conformational change must occur in order to generate a hydrophilic cavity capable of binding these cationic species. In this respect, DD-(**2**) resembles many of the naturally occurring polyether antibiotics.[6]

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