New Macromolecular Host Systems. Preparation and Structure of Certain Functionalized 2,6-Diaryl-*cis*-1,3,5,7-Tetraoxadecalin Podand Compounds and Macro-*m*-cyclophanes

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A series of new podands consisting of 2,6-*cis*-diaryl-1,3,5,7-tetraoxadecalin systems **2**–**7** have been prepared and fully characterized; the crystal structure of (2*R*,6*R*,9*S*; 9,10-*P*)-*cis*-2,6-di(*p*-nitrophenyl)-1,3,5,7-tetraoxadecalin **4** showed characteristic 'host–guest' packing and structural data which fitted well with the stereoelectronic features of the *cis*-1,3,5,7-tod system and a new class of macro-cyclophanes (**9**, **10**) was unravelled.

In our studies on novel host compounds, *i.e.* podands and macrocycles based on *cis*-1,3,5,7-tetraoxadecalin (*cis*-1,3,5,7-tod) in its 'O-inside' form (**1**, Ar = H), judiciously substituted in the 2 and 6 positions, we have aimed at using the cavity of the *cis*-tod system with its high electron lone pair concentration, as the 'core' of macrocyclic host systems with ion and neutral molecules inclusion ability. The *cis*-1,3,5,7-tod system has been thoroughly analysed in this framework, both in a structural[1] and computational study.[2]

cis-1,3,5,7-tod derivatives have been described, mainly in carbohydrate chemistry,[3,4] where they are known usually as 2,4 : 3,5-di-*O*-methylene or -di-*O*-benzylidene acetals of *threo*-tetrahydroxy moieties.[4] Their preparation was similar to that of the parent unsubstituted compound,[5] which involved the condensation of threitol with formaldehyde. Some other *cis*-1,3,5,7-tod derivatives have been reported[6–8] but for entirely different reasons than our own.

Our aim was to introduce aromatic substituents carrying reactive functions into the 2 and 6 positions of *cis*-1,3,5,7-tod. Thus, reaction of L-threitol (D- and racemic forms were also used) with the isomeric nitrobenzaldehydes gave the respective *cis*-1,3,5,7-tod products **2**, **3** and **4** (Scheme 1).† The structural and crystal packing details of (2*R*,6*R*,9*S*; 9,10-P)-*cis*-2,6-di(*p*-nitrophenyl)-1,3,5,7-tetraoxadecalin **4**‡ were examined by X-ray diffraction analysis (Fig. 1)§. The crystal packing details are of interest for topochemical reasons and for understanding the general behaviour of 1,3,5,7-tod system in the crystal. In this case, **4** occurs in a 'host-guest' packing arrangement (Fig. 2), characteristic of enantiopure tod molecules[1] and in contrast to racemic ones.[2] As to the structural parameters in the 1,3,5,7-tod 'core', they are largely similar to those previously measured and calculated,[2] accounting for the stereoelectronic (*anomeric* and *gauche*) effects operating within. The most sensitive structural parameters, *viz.* the C–O and C–C bond lengths are appreciably shortened (Fig. 1), as expected.[1]

The nitro compounds **2**, **3**, **4** were reduced to the reactive 2,6-di(aminophenyl) compounds **5**, **6** and **7**, respectively.† Using now the (2*S*,6*S*,9*R*; 9,10-M) configurations‡ (Scheme 2), the 2,6-di(*m*-aminophenyl) derivative **6** was converted to the diisocyanate **8** as shown. The first instances of macrocyclic ring formation by a *cis*-1,3,5,7-tod system were achieved by treating **8** with ethylene glycol or diethylene glycol, whereby

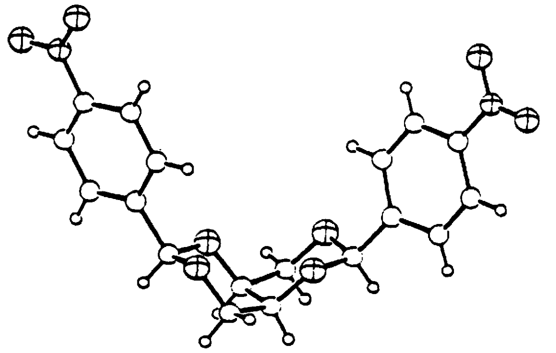


Fig. 1 ORTEP drawing of (2*R*,6*R*,9*S*; 9,10-P)-*cis*-2,6-di(*p*-nitrophenyl)-1,3,5,7-tetraoxadecalin **4** following the tod atom numbering shown in Scheme 1; selected bond lengths (Å): O(1)–C(2) 1.421, O(1)–C(9) 1.434(7), O(3)–C(2) 1.401(7), O(5)–C(6) 1.433(7), O(5)–C(10) 1.432(7), O(7)–C(6) 1.406(7), O(3)–C(4) 1.426(7), O(7)–C(8) 1.438(8), C(4)–C(10) 1.495(8), C(8)–C(9), 1.509(10), C(9)–C(10) 1.539(8)

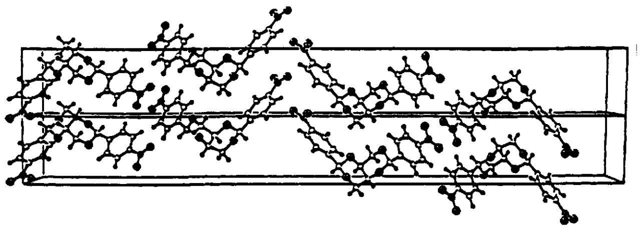
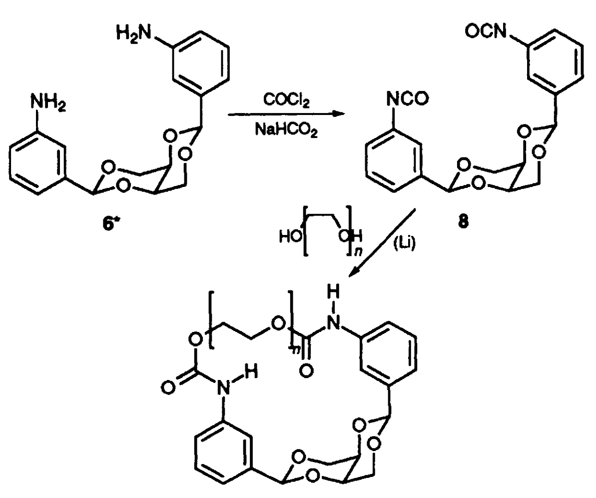
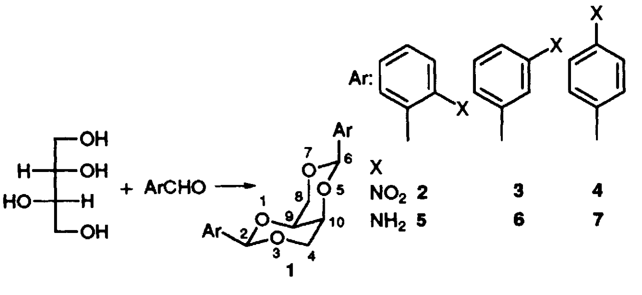


Fig. 2 Molecular packing diagram of **4** projected along the short axis



9 (*n* = 1); 10 (*n* = 2)

Scheme 2 Reaction sequence for the synthesis of the macrocycles **9** and **10**



Scheme 1 Reaction and products in the synthesis of (2*R*,6*R*,9*S*;-9,10-P)-*cis*-2,6-diaryl-1,3,5,7-tetraoxadecalins

the dicarbamate macro-*m*-cyclophanes **9** or **10** (Scheme 2)† were isolated in 17 and 10% yields, respectively.

The dicarbamate *m*-cyclophanes failed to show strong and specific alkali inclusion ability, but further studies in this and various other supramolecular contexts are being carried out presently.

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Footnotes

† All new compounds were fully characterized by spectrometric methods (IR, NMR, MS) and by elemental analysis and chemical correlation. All data will be provided in the full paper or, in the meantime, on request from the authors.

‡ Owing to a minor but basic omission in the CIP rules, the configurations for chiral *cis*-decalin (and similar) systems cannot be assigned, other than by 9.10-helicity specification. Thus, the diastereoconformers of type **1** ('O-inside') are (9*S*; 9,10-P)-*cis*-1,3,5,7-tetraoxadecalin forms.[2]

§ *Crystal data* for **4**: $C_{18}H_{16}N_2O_8$, $M_r = 388.3$, tetragonal space group $P4_1$, $a = b = 5.738(1)$, $c = 50.844(7)$ Å, $V = 1674.02$ Å^3, $Z = 4$, $D_c = 1.541$ g cm^{-3}, $F(000) = 808$, μ(Mo-Kα) = 1.15 cm^{-1}, 1793 unique reflections, 1645 observations with $I > 2\sigma(I)$, $R = 0.064$.[9] Atomic coordinates, bond lengths and angles, and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre. See Information for authors, Issue No. 1.

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