Novel Concave Building Block for the Synthesis of Organic Hosts

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Natural hosts frequently contain a cavity or cleft whose inner concave surface matches the convex surface of a guest. Recently, synthetic hosts that mimic this feature (cavitands) have been designed. If new and more elaborate host-guest systems are to be developed, versatile and readily accessible building blocks must be available. Here, we describe a novel building block, 2, that meets these requirements. Compound 2 contains two fused 2-imidazolidine rings, which are flanked by two o-xylene units. Its overall shape is concave and its convex side is shielded by two phenyl substituents. The use of 2 in the synthesis of three new cavitands is demonstrated. Diphenylglycoluril (1a) was treated with paraformaldehyde and NaOH in Me2SO to yield the tetrakis(hydroxymethyl) derivative (1b) (85%). Refluxing 1b in benzene with 4 equiv of p-toluene sulphonic acid gave 2a in 35% yield. Similarly, treatment of 1b with an excess of hydroquinone or 1,4-dimethoxybenzene in 1,2-dichloroethane gave 2b (75%) and 2c (50%), respectively. Molecular models indicate that the o-xylene units of 2 can have upward (u) or downward (d) orientations, leading to three possible conformers: uu, ud, or dd. Molecular mechanics calculations reveal that conformer uu has the lowest energy. For compound 2b an X-ray structure determination was performed. This structure determination (3) confirms the uu conformation of 2 in the solid state.

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(9) Crystal data for 2b: C73H58N8O6, m/e 1031 (M + H)+. Compound 5: IR (KBr) 3350, 2900, 1720, 1690, 1475, 1450 cm-1; 'H NMR (CDCl3) δ 7.05 (s, 10 H, Ar H), 6.65 (s, 4 H, Ar CH), 6.37 and 5.37 (2 d, 28 H, CH2), 3.5-4.0 (m, 28 H, CH2), 7.65 and 7.10 (2 m, 26 H, Ar H), 6.60 (s, 4 H, Ar CH). Fully acetylated 5: IR (KBr) 1715, 1450, 1400 cm-1; 'H NMR (CDCl3) δ 7.09 (s, 10 H, Ar H), 6.92 (s, 4 H, Ar H), 5.05 and 3.85 (2 d, 8 H, CH, CH), 4.24 (s, 10 H, CH2CO), FAB MS (triethyl citrate), m/e 571 (M+H)+. Compounds 4 and 5 (IR (KBr) 2960, 1780, 1715, 1450, 1450, 1130, 1070 cm-1; 'H NMR (CDCl3) δ 7.05, (10 H, Ar H), 6.65, (4 H, Ar H), 5.65 (d, 4 H, NCH2Ar, J = 16 Hz), 3.50-4.35 (m, 36 H, NCH2Ar and OCH2CH2), FAB MS (triethyl citrate), m/e 879 (M+H)+. Compound 5: FAB MS (glycoluril, H2SO4), m/e 905 (M+H)+. Fully acetylated 5: IR (KBr) 3605 and 3555 (bound H2O), 3940, 1760, 1630, 1465, 1465, 1430 cm-1; 'H NMR (CDCl3) δ 7.13 (20 H, Ar H), 4.93 and 3.82 (2 d, 16 H, CH, CH), 3.49 and 3.24 (2 d, 16 H, CH, CH), J = 2.54 (2 H, CH2CO), FAB MS (triethyl citrate), m/e 1073 (M+H)+. Compound 6: UV-vis (Me2SO) 413 nm (ε 223); 'H NMR (Me2SO-d6) δ 8.45 (4 H, NCH2CH2), 7.65 and 7.10 (2 m, 26 H, Ar H), 6.60 (4 H, Ar H), 3.40 (d, 4 H, NCH2Ar, J = 16 Hz), 4.40 (m, 8 H, NCH2Ar and OCH2CH2), FAB MS (glycoluril, H2SO4), m/e 1522 M+ (487 - M+H)+, 1452 (M+2Cl-H)+, 1418 (M - 3Cl-H)+, 1316 (M - RHCl + H)+, conductivity measurements (Me2SO, 10 M): 1:1 electrolyte, A 34 ft cm² mol⁻¹. All compounds gave C, H, and N analyses within 0.3% of theory.
contains two diphenylglycoluril and two hydroquinone rings linked through eight methylene bridges. The void in 5 (2.5 × 2.0 Å) is not large enough to hold an organic guest. However, higher homologues of 5, e.g., those containing additional diphenylglycoluril and hydroquinone rings, do have large enough voids.\(^2\)

Starting from 2, hosts that a metal center next to a cavity are readily accessible. As an example, we prepared 6 by reacting 2 with benzimidazole (Bz) to give: excess of Tos(OCH\(_2\)CH\(_2\))\(_2\)Cl and base in Me\(_2\)SO, excess of benzimidazole (Bz) and NaH in DMF, and 1 equiv of RhCl\(_3\) in Me\(_2\)SO (overall yield 70%). Compound 6 has two trans-coordinated Cl ligands, one being inside the cavity, the other outside. The binding and catalytic properties of hosts 4–6 are currently being investigated and will be published in forthcoming papers.

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**Observation of a Nonconcerted Double Proton Transfer in the Solid State by \(^{15}\text{N} CPMAS NMR**

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We present here for the first time NMR spectroscopic evidence of a nonconcerted double proton transfer. The double proton motion studied occurs along slightly asymmetric double-minimum potentials in solid TTAA\(^2\) according to Scheme I. For H-chelates of the malonaldehyde type like TTAA, it has been very difficult to establish the double-minimum character of the proton potential using different spectroscopic techniques\(^3\) including NMR.\(^4\)

Goedken et al.\(^5\) have performed an X-ray crystallographic analysis of solid TTAA, have postulated the "diagonal" tautomeration\(^6\) shown in Scheme I, and have further suggested that the degeneracy of this process is lifted due to a rhombic distortion of the unit cell. However, the X-ray method cannot reveal details such as the nonconcerted character of the double proton potential in solid TTAA or if the tautomeration is static or dynamic.

Since solid-state proton transfers between nitrogen atoms are most directly probed by \(^{15}\text{N} CPMAS NMR,\(^6\) we have performed

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(2) TTAA = 1,8-dihydrop-5,7,12,14-tetramethyldibenzo[a,d]-1,4,8,11-tetraazacyclotetradeca-4,6,11,13-tetraene-\(^{15}\text{N}\)\(_4\) (tetramethylbenzotetraaza[14]annulene).


