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AN EFFICIENT SYNTHESIS[†] OF HEXA-SUBSTITUTED BENZENES AND THE DISCOVERY OF A NOVEL HOST CONFORMATION FOR HEXAKIS(β-NAPHTHYLTHIO)BENZENE

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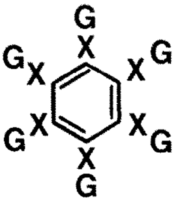
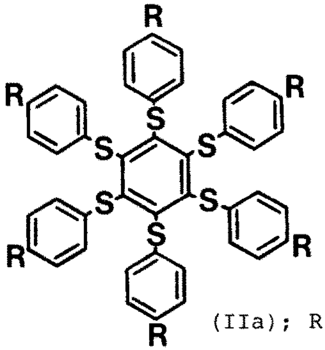
Summary. The title host molecule (III) has been synthesised by reaction of hexachlorobenzene with an excess of the sodium salt of β-mercaptonaphthalene in 1,3-dimethyl-2-imidazolidinone (DMEU) as solvent; other hexakis(arylthio)-benzenes, hexakis(phenoxy)benzene (IV), and hexakis(phenylseleno)benzene (V) were prepared analogously from hexahalobenzenes, HMPA being used as solvent in the last case. An X-ray analysis of the channel-type adduct of (III) with 1,4-dioxan as guest reveals a unique host conformation in which the side-chains are not situated alternately above and below the plane of the central benzene ring.

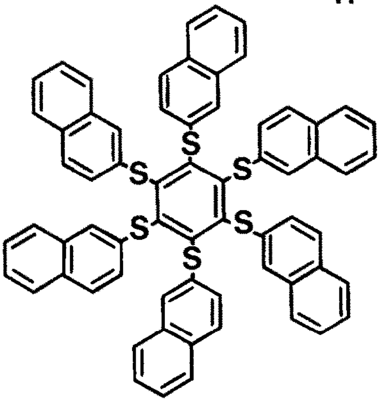
Although considerable attention has been focused on the study of hexa-host[1] molecules with a two or more atom link X joining the outer rings (G) to the central benzene ring, general formula (I), the important one-atom class has



(I)

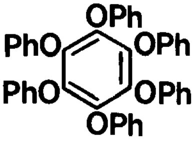


(IIa); R = H
(IIb); R = Me
(IIc); R = t-Bu

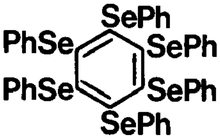


(III)

[†] Information protected by U.K. Patent application no. 8217510.



(IV)



(V)

been comparatively neglected due to synthetic difficulties.[2] This latter class is of particular interest owing to its close formal resemblance to the (OH...O) hydrogen-bonded hexameric unit found in the clathrates of phenol, hydroquinone, Dianin's compound and related systems.[5] Greatly encouraged by a recent report[6] by Tiecco and colleagues of complete substitution of C_6F_6 and C_6Cl_6 by i-PrSNa in HMPA, to give $C_6(SPr^i)_6$ in high yields, we investigated the action of the arenethiolate salt PhSNa on C_6Cl_6 and found remarkably facile displacement of all the chlorine atoms giving, after appropriate work-up, a 90% yield of pure $C_6(SPh)_6$, (IIa), entry 5 in Table. The first example of a hexakis(arylseleno)-benzene was prepared analogously, reaction of PhSeNa with C_6Cl_6 (Table, entry 6) furnishing a 51% yield of hexakis(phenylseleno)benzene (V), which on recrystallisation from pentachloroethane containing excess CBr_4, gave the CBr_4 adduct of (V) as beautiful orange rhombs, m.p. 195-196°C, (after apparent guest loss at ca. 100°C), a host/guest ratio of 1:2 being determined by microanalysis for halogen.[7]

Wishing to avoid prolonged use of the known[8] carcinogen HMPA, we sought an alternative solvent capable of promoting efficient aromatic halogen displacement. 1,3-Dimethyl-2-imidazolidinone, dimethylethyleneurea (DMEU), was found to be a remarkably effective, and probably much less toxic, substitute.[9] Reaction of C_6F_6, C_6Cl_6, or C_6Br_6 with PhSNa in DMEU gave in each case a high yield pure (IIa), entries 2-4 in Table; and the general nature of this substitution procedure is suggested by the analogous high yield synthesis, employing the sodium salt of the appropriate arenethiol, of hexakis(p-t-butylphenylthio)benzene (IIc), entry 7, and hexakis(β-naphthylthio)benzene (III), entry 1. The unique host molecule conformation of (III) in its 1,4-dioxan adduct is described below. To our knowledge no hexakis(aryloxy)benzene has yet been reported and hexakis-(phenyloxy)benzene (IV), an analogue of the hydrogen-bonded hexameric unit present in phenol clathrates,[10] appeared an attractive target. This hexaether, whose potential inclusion properties are currently being studied, was obtained as colourless needles, m.p. 277-280°C (with sublimation); in this case instead of the normal ambient conditions a temperature of 120°C was employed to effect complete substitution.

TABLE. Conditions for complete substitution of hexahalobenzenes

Entry No.	Product[c]	Solvent	Substrate, molar equivalents ArXNa	Time,[a] temperature	Yield[b]	m.p.
1	(III)	DMEU	C_6Cl_6, 12	5d, ambient	72%	194.5-195°C
2	(IIa)	DMEU	C_6F_6, 12	2d, ambient	86%	186.5-187°C (lit.[4] 186-186.5°C)
3	(IIa)	DMEU	C_6Cl_6, 12	3d, ambient	96%	
4	(IIa)	DMEU	C_6Br_6, 12	2d, ambient	90%	
5	(IIa)	HMPA	C_6Cl_6, 12	4d, ambient	90%	
6	(V)	HMPA	C_6Cl_6, 12	4d, ambient	51%	195-196°C
7	(IIc)	DMEU	C_6Cl_6, 12	3d, ambient	76%	242-243.5°C
8	(IV)	DMEU	C_6F_6, 18	4d, 120°C	73%	277-280°C

a. The minimum times required have not yet been established.
b. The yields are not optimised.
c. All new compounds gave a satisfactory microanalysis and had spectroscopic properties (i.r., ^{1}H n.m.r., and m.s.) concordant with their formulated structures.

Crystal structure of compound (III).[‡]

The host (III) forms a highly crystalline adduct with 1,4-dioxan, the host/guest ratio determined by ^{1}H n.m.r. being 1:1. The triclinic crystals have $a = 10.118(2)$, $b = 15.172(2)$, $c = 20.379(5)$ Å, $\alpha = 75.05(2)$, $\beta = 82.64(2)$, $\gamma = 68.45(1)°$, space group $P\bar{1}$, and $D_c = 1.32$ g cm^{-3} with two host and two guest molecules in the unit cell. A crystal measuring 0.1 x 0.15 x 0.05 mm, enclosed in a thin-walled glass capillary tube, was used for the measurement at 20°C of 9841 independent X-ray intensities (MoK_α radiation) by a θ-ω scan on a Nonius CAD4 diffractometer. The structure was solved by direct methods employing 5100 X-ray intensities with $F^2 > 2\sigma(F^2)$, and refinement by least squares methods gave a final R factor 0.048. During the course of the analysis all the host hydrogen atoms were located and included in subsequent refinement. The guest hydrogen atoms were not located.

Figure 1 shows a stereoview of the host molecule (III), which is located in a general position in the unit cell. In contrast with the trigonal conformation of $C_6(SPh)_6$ which is located on a point of $\bar{3}$ symmetry in its CCl_4 clathrate,[4] (III) is not constrained to have alternate disposition of side chains above and below the plane of the central ring: indeed, instead of having three-fold symmetry the molecule approximates to the point group C_2, adjacent 'legs' being found on the same side of the central ring, with a corresponding adjacent pair on the opposite side. The molecular conformation is reflected in a signif-

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[‡] The atomic co-ordinates for this work are available on request from the Director of the Cambridge Crystallographic Data Centre, University Chemical Laboratory, Cambridge CB2 1EW. Any request should be accompanied by the full literature citation for this communication.

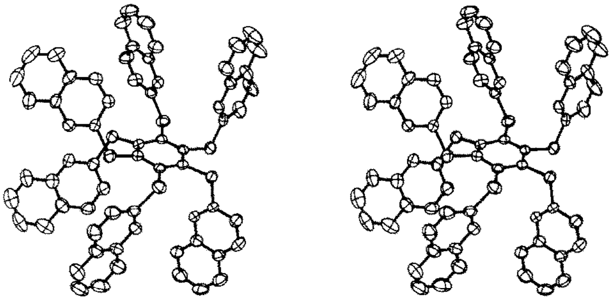

Figure 1. A stereoview showing the host molecule of hexakis(β-naphthylthio)benzene in its 1,4-dioxan channel-type inclusion compound. All hydrogen atoms have been omitted for clarity. The molecule has approximate $\underline{C}_2$ symmetry.

icant distortion of the central benzene ring, which has an approximate two-fold rotation axis. The retention of inclusion properties for (III), whose conformation corresponds to an interchange of two adjacent 'legs' away from a trigonal situation,[5] is of particular interest in view of the recent consideration by Huang and Mak[11] of the dominant role that two-fold molecular symmetry plays in the architecture of the lattices of many inclusion compounds. Figure 2 shows a stereoview of the host-guest packing; the host and guest molecules both occupy general positions in the centrosymmetric structure. The 1,4-dioxan guest molecules have a chair conformation and can be seen to be located in continuous voids running through the crystal.

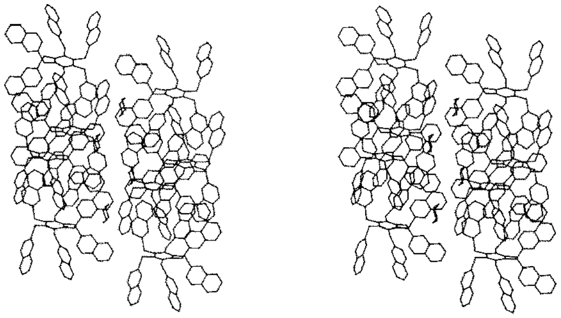

Figure 2. A stereoview showing the host-guest packing of the adduct of (III) with 1,4-dioxan as guest in the triclinic crystal. The chair-shaped 1,4-dioxan molecules can be seen to be located in continuous voids in the structure.

References and Notes

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