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SYNTHESIS, ^{1}H NMR, ^{13}C NMR SPECTRA AND CONFORMATIONAL PREFERENCE OF OPEN CHAIN LIGANDS ON LIPOPHILIC MACROCYCLES[1]

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Abstract—Several open chain ligands (polypodands) **3** and **4** have been synthesized introducing short oligoethylene glycol units $(-CH_2CH_2O)_mCH_3$, (m = 1,2) on lipophilic matrices represented by cyclic tetra- **1** and octa- **2** oligomers obtained from the base catalyzed reaction of p-butylphenol or p-octylphenol and formaldeyde. ^{1}H NMR and ^{13}C NMR spectral data have been used to establish the conformational freedom of the ligands, which is important for cation binding studies.

Open chain ligands (polypodands) have received attention in the last few years in connection with host-guest chemistry, transport phenomena and phase transfer catalysis.[2-4]

Although they usually show lower complexation ability and selectivity towards alkali, earth alkali or ammonium cations they offer certain advantages over cyclic crown ethers or cryptands. They are easier to synthesize in high yields and show higher complexation-decomplexation rates[5] which make them attractive for transport phenomena and separation techniques.

We have been interested to synthesize and test the complexing and transport properties of glyme-type short-chain oligoethers built on well shaped cyclic matrices, and we report in this paper preparative, spectral (^{1}H and ^{13}C NMR) data for the ligands.

RESULTS AND DISCUSSION

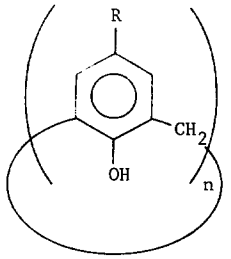
Cyclic oligomers derived from the base catalyzed condensation of p-t-butylphenol and p-octylphenol with formaldehyde (calix[n]arenes **1** and **2**) were chosen as "ordered building blocks" for these ligands.

Although many matrices of this type are now available in our laboratory, since we have undertaken a systematic study of the complexing ability of these macrocycles, we used in this work only cyclic oligomers for which the structure has been firmly established. Until recently, in fact, there has been much confusion in the literature about the nature of the products of the base catalyzed condensation of p-substituted phenols and formaldehyde. Most of the products synthesized by this method and considered to be tetramers[6-8] are actually a mixture of oligomers in which the octamer is the main component.

Only after the recent reports by Gutsche *et al.*[9-11] and our own work[12,13] which has benefitted from X-ray structural analysis to clarify the nature of these compounds, the problem has been clarified and the correct structure of the various products established.

Thus, through X-ray structure determination, compound **1a** which crystallizes as 1:1 complex with toluene as guest inside the cavity, was shown to be the true tetramer[12] and compound **2a** the cyclic octamer by resolving the structure of its octaacetate **4b**.[13]

The octameric nature of compound **2b**, which derives from p-octylphenol, has been proved on the basis of



1 and 2

MATRICES	n	R
1a	4	Bu^t
2a	8	Bu^t
2b	8	$-C(CH_3)_2CH_2C(CH_3)_3$ (octyl)
2c	8	H

molecular weight determination (osmometry) and indirect chemical evidence. In fact, the complete removal of the p-octyl group from **2b** gave quantitatively a compound which is insoluble in most organic solvents and is identical (IR, ^{13}C NMR) to the octamer **2c** obtained by de-t-butylating **2a** in the same conditions. Moreover, the octaacetyl derivatives of these two compounds, which are more suitable for comparison, show the same chromatographic (hplc, tlc) and spectrographic (IR, ^{1}H and ^{13}C NMR) behaviour (**4g**).

The matrices were attractive because of the many OH groups ordered in well shaped and cyclic arrays, which could be functionalized in several ways.

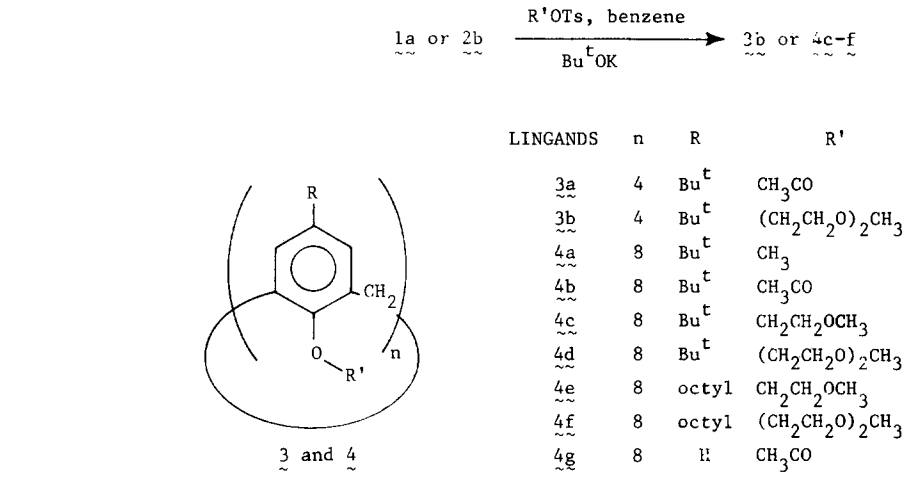
Except for the simple methyl and acetyl derivatives (**3a**, **4a**, **4b**, and **4g**) which were however synthesized through base-catalyzed reactions, the synthesis of the ligands **3** and **4** was performed according to the following reaction scheme:

^{13}C NMR spectra of the compounds are quite sensitive to the number of phenolic units in the macrocycle and to the substituents both on the aromatic nucleus and on the OH groups (see Table 3), therefore they are very useful in the characterization of the ligands.

Moreover, the ^{1}H and ^{13}C NMR spectra were valuable also in understanding preferred conformations.

The ^{1}H NMR spectra of the octameric derivatives are rather simple showing singlets for the alkyl groups on the nucleus and the bridging methylene $ArCH_2Ar$ (Fig. 1(b) and Table 2) indicating rotational freedom of the groups inside and outside the macroring at room temperature.

The mobility of the chains decreases with their length and the effect is greater for p-octylphenol derivatives. In fact, the ^{1}H NMR spectrum of compounds **4e** (R = octyl; R' = $CH_2CH_2OCH_3$), **4f** (R = octyl; R' = $-(CH_2CH_2O)_2CH_3$ and **3b** (R = Bu^t; R' = $-(CH_2CH_2O)_2CH_3$) are rather broad and unresolved at



LINGANDS	n	R	R'
3a	4	Bu^t	CH_3CO
3b	4	Bu^t	$(CH_2CH_2O)_2CH_3$
4a	8	Bu^t	CH_3
4b	8	Bu^t	CH_3CO
4c	8	Bu^t	$CH_2CH_2OCH_3$
4d	8	Bu^t	$(CH_2CH_2O)_2CH_3$
4e	8	octyl	$CH_2CH_2OCH_3$
4f	8	octyl	$(CH_2CH_2O)_2CH_3$
4g	8	H	CH_3CO

Scheme

Table 1. Analytical and physical data for compounds synthesized

Compd	n	R	R'	Yield %[a]	Melting point °C {Solvent}	Formula	Elemental analysis Required C	Required H	Found C	Found H
1a	4	Bu^t	H	20	343-345 {$C_6H_5CH_3$}[b]	$C_{44}H_{56}O_4 \cdot C_7H_8$	82.66	8.71	82.60	8.80
3a	4	Bu^t	CH_3CO	60	320dec {CH_3COOH}	$C_{52}H_{64}O_8 \cdot CH_3COOH$	73.97	7.76	73.60	7.60
3b	4	Bu^t	$(CH_2CH_2O)_2-CH_3$	80	57-59	$C_{64}H_{96}O_{12}$	72.69	9.16	72.09	8.88
2a	8	Bu^t	H	80	400 {$CHCl_3$}	$C_{88}H_{112}O_8$	81.44	8.70	81.40	8.80
4a	8	Bu^t	CH_3	95	286-287 {$CH_3COOC_2H_5$}	$C_{96}H_{128}O_8$	81.77	9.15	81.80	9.10
4b	8	Bu^t	CH_3CO	96	353dec {$(CH_3CO)_2O$}	$C_{104}H_{128}O_{16}$	76.44	7.89	76.20	7.60
4c	8	Bu^t	$CH_2CH_2OCH_3$	90	240-242 {CH_3CN}	$C_{112}H_{160}O_{16}$	76.33	9.15	75.85	9.45
4d	8	Bu^t	$(CH_2CH_2O)_2-CH_3$	80	196-197 {CH_3CN}	$C_{128}H_{192}O_{24}$	72.69	9.15	72.20	9.30
2b	8	octyl	H	30	343-345{C_6H_5/CH_3COCH_3}	$C_{120}H_{176}O_8$	82.51	10.16	82.35	9.95
4e	8	octyl	$CH_2CH_2OCH_3$	90	137-139{CH_3COCH_3/MeOH}	$C_{144}H_{224}O_{16}$	78.21	10.21	78.40	10.10
4f	8	octyl	$(CH_2CH_2O)_2-CH_3$	90	glass	$C_{160}H_{256}O_{24}$	74.96	10.07	74.40	10.30
2c	8	H	H	95	>360[c]	$C_{56}H_{48}O_8$	79.22	5.70	79.10	5.80
4g	8	H	CH_3CO	95	310-315dec {CH_3COOH}	$C_{72}H_{64}O_{16}$	72.96	5.44	72.65	5.60

[a] Yields of isolated products after crystallization.

[b] In ref. 12 we reported a m.p. = 328-329 °C for this compound. Further recristallizations (toluene) and determination of the melting point in capillars sealed *in vacuo* gave the present value.

[c] At this temperature the compound blackens without melting.

ambient temperature but become sharper and well resolved at 150–160° in DMSO.

On the contrary the ^{1}H and ^{13}C NMR spectra of compounds **3a** and **3b** derived from the tetramer **1a** are more complex indicating a dissymmetrical structure for these compounds. The spectra refer to products purified by preparative hplc, although the crude materials show impurities (<5%), probably not fully alkylated or acetylated compounds.

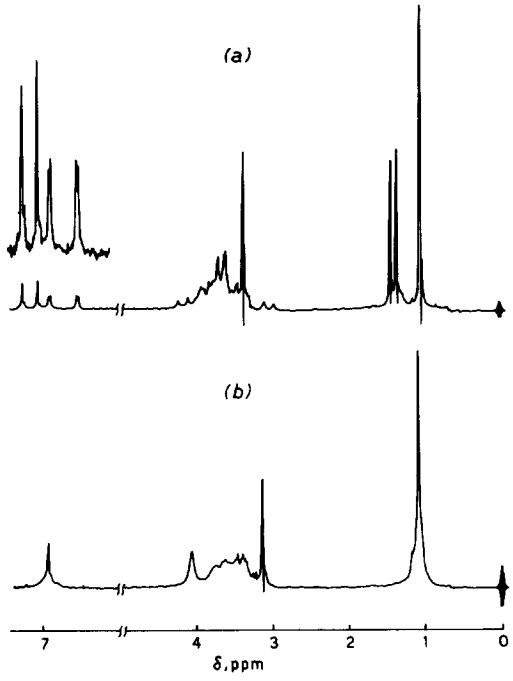


Fig. 1. ^{1}H NMR spectra in $CDCl_3$ at 25° of (a) podand **3b** and (b) podand **4d**

The ^{1}H NMR spectra of these compounds (Figs. 1(a) and 2) are very similar especially in the t-butyl group absorption region, indicating a similar arrangement of the R′ groups respect to an ideal plane containing the carbon atoms of the 16-membered metacyclophane ring. The similarities shown by the ^{13}C NMR spectra of these compounds support this hypothesis.

Therefore, the following discussion which refers to compound **3a** apply to **3b** as well.

In the ^{1}H NMR spectrum of **3a** the equivalence of t-butyl groups shown by the parent tetramer **1a** is removed and the signal is split into three singlets of intensity 2:1:1 at 1.08 (18H), 1.34 (9H), and 1.38 (19H) ppm. A similar splitting is experienced by the methyl groups of the CH_3CO– which absorb at 1.88 (3H), 1.92 (3H), and 2.28 (6H) ppm. The absorption of the bridging methylene $ArCH_2Ar$ in the same ^{1}H NMR spectrum consists of two doublets of equal intensity (2H) centred at 3.20 (H_B) and 3.48 (H_A) ppm (J_{AB} = 13 Hz) and in a 4H singlet at 3.85 ppm (H_C). Therefore, ^{1}H NMR data suggest the structure (I) for compounds **3a** and **3b** and ^{13}C NMR data (see Table 2) are in agreement.[14]

The parent calix[4]arene **1a** has shown in the solid state a symmetrical cage-like structure which is mainly determined by four intramolecular hydrogen bonds.[12]

The sharp and concentration independent OH absorption in the ^{1}H NMR and IR spectra of compound **1a** at ambient temperatures and the broad absorption showed by the bridging CH_2 which splits in two doublets (AB system) at −20° (J_{AB} = 13.6Hz) and coalesces to a singlet at T > 40°, suggest this symmetrical conformation is partially maintained also in solution (C_2Cl_4) but pseudorotation[15] is not hindered.

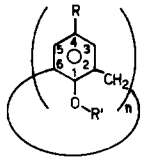
Table 2. ^{1}H NMR data for compounds synthesized. (δ_{CDCl_3} from TMS)

Compd[§]	n	R″	R′		Aromatics
1a	4	1.18,s,36H	10.0,s,4H (OH)	3.3-4.4,bs,8H	6.9,s,8H
3a	4	1.08,s,18H;1.34,s,9H;1.38,s,9H	1.88,s,3H;1.92,s,3H;2.28,s,6H (CH_3CO)	3.20,d,2H (J_{AB}= 13.Hz); 3.48,d,2H;3.58,s,4H	6.80,s,4H;7.20,s,4H
3b	4	1.02,s,18H;1.34,s,9H;1.42,s,9H	3.0-4.2,m,44H (CH_2CH_2O)-CH_3	3.0-4.2,m,8H	6.52,d,2H (J=2Hz);6.9,d,2H (J=2Hz);7.05,s,2H;7.26,s,2H
2a	8	1.24,s,72H	9.54,s,8H (OH)	3.3-4.8,bs,16H	7.16,s,16H
4a	8	1.00,s,72H	3.32,s,24H (OCH_3)	3.95,s,16H	6.83,s,16H
4b	8	1.18,s,72H	1.90,s,24H ($\underline{CH_3}CO$)	3.65,s,16H	7.0,s,16H
4c	8	1.10,s,72H	3.18,s,24H (OCH_3);3.4,bt,16H ($CH_2\underline{CH_2}OCH_3$);3.66,bt,16H($ArO\underline{CH_2}CH_2$)	4.08,s,16H;	6.94,s,16H
4d	8	1.06,s,72H	3.12,s,24H,(OCH_3);3.2-4.0,m,64H ($CH_2CH_2O)_2$-	4.06,s,16H	6.94,s,16H
2b	8	0.73,s,72H,1.30,s,48H; 1.70,s,16H	9.33,s,8H	3.2-4.8,bs,16H	7.02,s,16H
4e[ƒ]	8	0.70,s,72H;1.16,s,48H; 1.60,s,16H	3.08,s,24H (OCH_3);3.4,t,16H ($OCH_2\underline{CH_2}OCH_3$; $^3J_{CH_2CH_2}$=5Hz); 3.7,t, 16H ($ArO\underline{CH_2}CH_2$-)	3.97,s,16H	6.92,s,16H
4f[ƒ]	8	0.70,s,72H;1.14,s,48H; 1.60,s,16H	3.08,s,24H(OCH_3);3.2-3.9,m,64H ($CH_2CH_2O)_2$-	3.98,s,16H	6.92,s,16H
2c	8	-	4.0-4.4,bs,8H	3.2-4.3,bs,16H	6.5-7.2,m,24H
4g	8	-	2.0,s,24H ($\underline{CH_3}CO$)	3.65,s,16H	6.96,s,24H

[§] R = H for compounds 2c and 4g; octyl for 2b, 4e and 4f; Bu^t for all other compounds (1a-4d).

[ƒ] In DMSO-d_6 at 160°C. At lower temperature and in $CDCl_3$ the signals are broad.

Table 3. ^{13}C NMR data for compounds synthesized. (δ_{CDCl_3} from TMS)



Compd	n	R	R'	Ar-CH_2	C-1	C-2 + C-6	C-3 + C-5	C-4
1a[§]	4	31.34;32.72	–	33.80	159.60	120.26	125.59	127.31
3a	4	31.28;31.49;31.72; 34.00;34.35;34.44	21.21;21.90;22.35($\underline{CH_3}CO$); 168.27;168.75;170.04($CH_3\underline{CO}$)	38.00	146.89;146.97; 148.66	130.85;131.70; 132.99;133.78	125.31;125.39; 126.58;126.89	143.80;144.70
3b	4	31.44;31.70;33.70; 34.06	59.92(OCH_3);69.63;69.83; 70.75;71.96;72.36	37.28	152.95;153.64 154.63	131.78;131.97; 132.76;135.47	125.19;125.73; 127.57	143.03;143.52 144.81
2a	8	31.47;34.00	–	32.40	146.48	128.52	125.39	144.54
4a	8	30.26;33.07	59.38	29.07	153.17	131.83	124.64	144.73
4b	8	31.26;34.33	20.23($\underline{CH_3}CO$);168.33($CH_3\underline{CO}$)	31.85	148.18	131.16	125.89	145.05
4c	8	31.37;34.12	58.62(OCH_3);71.62(OCH_2CH_2O)	30.04	152.99	132.91	125.62	145.56
4d	8	31.38(J_{CH}=124Hz); 34.07	58.61(J_{CH}=142Hz,OCH_3);70.26 (CH_2CH_2O);74.76($ArO\underline{CH_2}CH_2$-)	29.83 (J_{CH}=128Hz)	152.80	132.90	125.54 (J_{CH}=159Hz)	145.60
2b	8	32.05;32.45;37.94 56.97($\equiv CCH_2C\equiv$)	–	31.58	146.35	128.10	126.08	143.53
4e	8	32.20;32.30;33.20; 38.50;57.30($\equiv CCH_2C\equiv$)	58.90(OCH_3);72.05(OCH_2CH_2O); 72.05	31.00	153.60	133.00	126.90	145.07
4f	8	31.87;32.34;38.00;	58.68(OCH_3);70.27(OCH_2CH_2O);	30.26	153.01	132.42	126.32	144.49
2c[f]	8	–	–	30.95	151.67	127.95	127.57	119.50
4g	8	–	20.23($\underline{CH_3}CO$);168.37($CH_3\underline{CO}$)	31.38	147.30	132.04	128.88	125.95

[§] In C_2Cl_4; lock on D_2O.

[f] In DMSO-d_6.

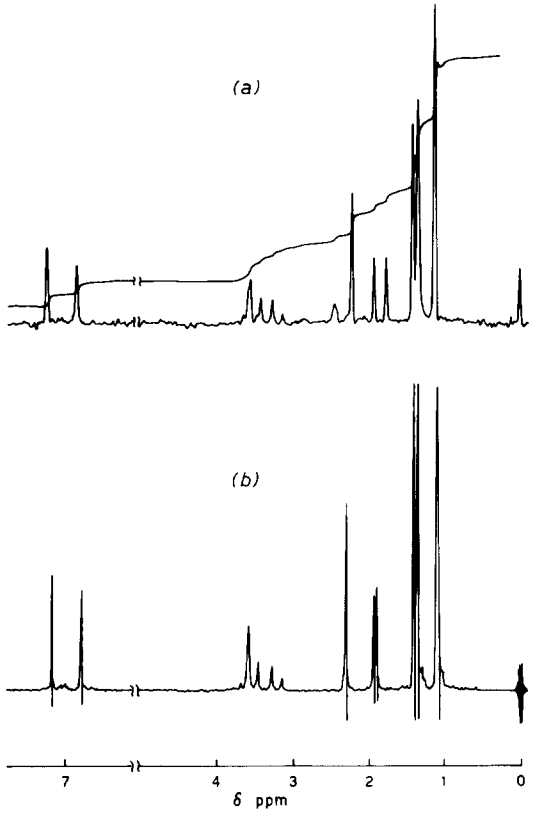


Fig. 2. ^1H NMR spectra of compound **3a**; (a) in DMSO d_6 at 160° (b) in $CDCl_3$ at 25°

Kämmerer and Coll[16] were able to determine $\Delta G^{\ddagger}$ = 66–67 kJ mol^{-1} for the pseudorotation process in tetranuclear cyclic compounds of the same type at 253 K.

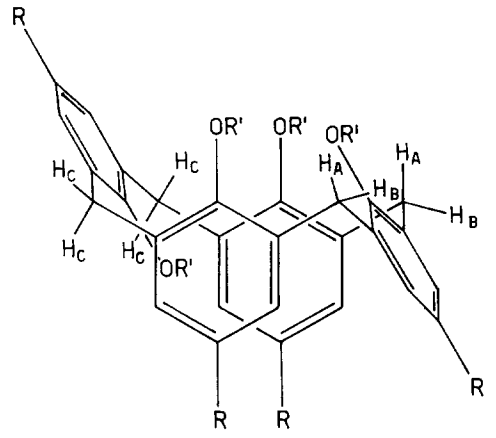
Munch[8] has reported a similar study on a presumed cyclic tetramer derived from the base-catalyzed reaction of p-octylphenol and formaldehyde calculating a barrier of inversion of 73.5 KJ/mol at 253 K. Nevertheless the few data he reported to characterize his compound do not agree with the true tetramer (Cornforth's LOC) whose X-Ray crystal structure has been solved by one of us.[17] From the ^1HNMR data of the acetyl derivative of the compound reported by Munch, which indicate a very simple spectrum composed of singlets only, it is conceivable that this author actually measured the conformational rotation of a higher molecular weight cyclic oligomer, probably the octamer **2b** (Cornforth's HOC).

On the contrary the ^1H NMR spectra of compounds **3a** remain unchanged up to 160° in DMSO-d_6 (Fig. 2(a)) indicating pseudorotation is hindered and structure (I) represents a stable configuration of the molecule. The same behaviour is shown by compound **3b**.

CONCLUSIONS

The results obtained show that in both cyclic matrices **1** and **2** all the phenolic OH groups can be functionalized with oligoethylene glycol units [$(CH_2CH_2O)_m$–CH_3; m = 1,2] to give podands of different geometries.

Analysis of the ^1H and ^{13}C NMR spectral data indicates that in the octameric ligands the ethereal chains are free to rotate at ambient temperature inside and outside the macroring and eventually converge to complex cations.



(I)

On the other hand ligands built on the tetramer **1a** prefer a configuration (I) where the ethereal chains are not convergent (three in one side, one in the other respect to the carbon macroring) and suffer severe steric crowding in the binding region. The arrangement of the binding sites around the cyclic array has a profound effect on the complexing ability of the two series of ligands synthesized.

Podand **3a** [n = 4, R' = $(CH_2CH_2O)_2$–CH_3], for example, shows no complexation toward guanidinium and cesium cations and very little towards Li^+, Na^+ and K^+ although podand **4d**, which derives from the octamer **2a** and has the same chain length, strongly complexes cations especially guanidinium and cesium. Work is in progress on the complexing and transport abilities of the ligands synthesized and the results will be reported later.

EXPERIMENTAL

Mass spectra were recorded on a Varian CH 5 spectrometer at 70 eV (EI). Infrared (IR) spectra were recorded on a Perkin Elmer Spectrometer. ^1H and ^{13}C (at 25.2 MHz) NMR spectra were determined on a Varian XL 100 instrument, with tetramethylsilane as internal standard. Melting points were determined in capillary tubes sealed *in vacuo* using a Büchi (for m.p. < 300°) and Electrothermal (London) (for m.p. > 300°) melting point apparatus. Osmometric molecular weight determinations were performed on a V.P.O. Hitachi Perkin Elmer Model 115 M.W. apparatus in $CHCl_3$ at 40°.[18] Microanalyses were carried out by Instituto di Chimica Farmaceutica -Università di Parma.

Thin layer chromatography analyses were performed on Carlo Erba Stratocrom SIF_{254} silica gel plates (0.2 mm thickness) using various eluting mixtures: hexane/CH_2Cl_2 3:2 or C_2Cl_4 for compounds **1a-c**; hexane/AcOEt 8:2 for compounds **2a-d** and **2i**; CH_2Cl_2/iPrOH 16:1 for all other ligands. HPLC analyses were performed using a Waters (Model 6000 A pump, U6K, injector and Model 440 UV detector, 254 and 280 nm) liquid-liquid Chromatograph on 30 cm × 3.9 mm i.d. high efficiency μ-Porasil or μ-Bondapak C_{18} colouns (Waters).

All solvents were distilled and dried over Linde Molecular Sieves 4A before use. Glycol monoether p-toluensulfonates have been synthesized according to general methods.[19]

Preparation of the cyclic matrices (**1** *and* **2**)[20]

Cyclo{tetra[(5-*t*-*butyl*-2-*hydroxy*-1,3-*phenylene*)*methylene*]} (**1a**). This compound was prepared in 20% yield following exactly Cornforth's procedure[6] and corresponds to the low melting compound (LBC) isolated by this author and coworkers. It easily crystallizes from toluene as tetragonal plates which include one mol of the solvent.[12] The compound shows a single peak in hplc (μ-Porasil; hexane/THF 95:5 flow rate 2.5 ml/min; Rt.time 2.65 min.) MS(EI, 70 eV): *m/e* (rel.%) 648(100) M^+; 649(49) $M+1^+$; 633(20); 592(33); 536(22); 92(75); 91(98). IR(KBr) cm^{-1}: 3150, 1600, 1500, 1205, 870, 820; 790, 740(toluene).

Cyclo{octa[5-*t*-*butyl*-2-*hydroxy*-1,3-*phenylene*)*methylene*]} (**2a**). This product we originally prepared in 40% yield through the Cornforth's method [6](HBC), has been obtained in 80% yield following the Munch's procedure recently reported by Gutsche *et al.*[10] It crystallizes from $CHCl_3$ in triclinic plates, which lose solvent very rapidly to give a powder. The compound shows a single peak in hplc (μ-Porasil; hexane/THF 95:5; flow rate 2.5 ml/min; Rt time 9.5 min). IR(KBr) cm^{-1}: 3200, 1600, 1480, 1220, 870, 820.

Cyclo {*octa*[(5-(1,1,3,3-*tetramethylbutyl*)-2-*hydroxy*-1,3-*phenylene*) *methylene*]} (**2b**). This compound, which corresponds to Cornforth's HOC was obtained in 30% yield following this author's procedure,[6] together with the corrispondent cyclic tetramer.[17] It crystallizes as a white powder from benzene/acetone 1:3 at 37°. Osmometric mol wt($CHCl_3$, 40°) 1770 (calc. for $C_{120}H_{176}O_8$, 1746). The compound shows a single peak in hplc (μ-Porasil;hexane/THF 95:5; flow rate 2.5 ml/min; Rt.time 3.2 min).

Cyclo{octa[(2-*hydroxy*-1,3-*phenylene*)*methylene*]} (**2c**). **2a** (2.6 g, 3 m mol) and $AlCl_3$(2.67 g, 20 m mol) are stirred in toluene (40 ml) at room temperature for 3 hr under a nitrogen atmosphere. Water (100 ml) was then slowly added and the organic phase in which the product was dispersed as a gelatinous suspension, was thoroughly washed with water in a separatory funnel. The toluene was removed by rotary evaporator and diethyl ether (100 cm^3) was added. The solid pink precipitate is filtered and washed several times with ethyl ether to give a white powder very insoluble in the most common organic solvents. The same compound can be obtained from the octamer **2b** in the same reaction conditions after 1.5 hr stirring. IR(KBr)cm^{-1}: 3500–3000 (br), 1590, 1470, 750.

Cyclo{octa[(5-*t*-*butyl*-2-*methoxy*-1,3-*phenylene*)*methylene*]} (**4a**). In a three necked flask **2a** (1.2 g, 1 m mol) and Bu^tOK(1.3 g, 12m mol) were stirred in anhydrous benzene under N_2, and the temperature raised at reflux. Dimethylsulphate (2.2 g; 18.0 m mol) was then slowly added in a period of ~1 hr and the reaction mixture refluxed for additional 1 hr then cooled at ambient temperature. After addition of water the benzene layer is separated and the aqueous phase extracted 3 times with CH_2Cl_2(50 ml portions). The combined organic extracts are dried over Linde Molecular Sieves 4A, then evaporated to give a solid residue which is crystallized from AcOEt giving pure **4a**. IR(KBr)cm^{-1}: 2900, 1600, 1500, 1100, 1020, 810. hplc(μ-Porasil; hexane/AcOEt 8:2; flow rate 2.5 ml/min; Rt.time 1.75 min.; μ-Bondapak C_{18}; THF/H_2O 3:1 + 1% AcOH; flow rate 1.5 ml/min; Ret time 6.30 min.)

Acetylation of the cyclic matrices **1** *and* **2**: *general procedure*

The cyclic matrix (1 m mol) is mixed with anhydrous sodium acetate (5 m mol), melted just before use, in a reaction flask dried *in vacuo* and protected from moisture with a $CaCl_2$ valve. Acetic anhydride (5 ml) is then added and the reaction mixture refluxed for 2 hr; most of the anhydride is removed *in vacuo* and the residue dissolved in CH_2Cl_2, washed with a saturated solution of $NaHCO_3$, then with water and finally the organic phase dried over Linde Molecular Sieves 4A.

Cyclo{tetra[(5-*t*-*butyl*-2-*acetoxy*-1,3-*phenylene*)*methylene*]} (**3a**). The compound crystallized from acetic acid in the form of triclinic prisms. IR (KBr) cm^{-1}: 29000, 1755, 1600, 1500, 1190. In hplc (μ-Porasil; hexane/AcOEt 8:2; flow rate 2.5 ml/min) the compound (Ret time 3.0 min) show impurities (~5%) at Ret time 2.0 and 2.6 min.

Cyclo{octa[(5-*t*-*butyl*-2-*acetoxy*-1,3-*phenylene*)*methylene*]} (**4b**). The compound crystallizes from acetic acid in the form of triclinic prisms. IR (KBr)cm^{-1}: 2960, 1760, 1370, 1210, 1180. In hplc (μ-Porasil hexane/THF 8:2; flow rate 3.0 ml/min; Rt.time 2.4 min.)

Cyclo{octa[(2-*acetoxy*-1,3-*phenylene*)*methylene*]} (**4g**). The

compound crystallized from acetic acid as a powder. IR(KBr)cm^{-1}: 2940, 1770, 1550, 1470, 1240, 1160. Hplc (μ-Porasil; hexane/THF 7:3; flow rate 3.0 ml/min; Ret time 3.35 min.

Preparation of podands **3b** *and* **4c–f**: *general procedure*

The cyclic matrix (1 m mol) was dissolved or suspended in anhydrous benzene in a flask protected from moisture with a $CaCl_2$ tube and under N_2. Bu^{t}OK (10 m mol) and glycol monoether p-toluensulphonates (10 m mol) are then added stepwise in 2 m mol aliquots. One aliquot of Bu^{t}OK was added first to the cold benzene solution which was then heated at reflux and one aliquot of tosylate (in benzene) added through a dropping funnel. After refluxing for 30 min the reaction mixture was cooled and a second aliquot of Bu^{t}OK is added, then the aliquot of tosylate was added and reflux continued for 30 min. These operations were repeated until all the tosylate has been added. A small sample was then withdrawn from the reaction mixture, quenched in H_2O, extracted with CH_2Cl_2 and checked by UV (EtOH + KOH)[6] for phenolic OH groups not yet alkylated. With short chain oligoethylene glycol tosylates used in this work the reaction was always complete at this stage and no further addition of reagents was necessary. However with tosylates of longer glymes (m > 3) the reaction may be incomplete[21] and in this case the solvent has to be distilled off under a nitrogen flux, new solvent has to be added to the residue and the reaction mixture refluxed until no phenolic OH group is detected in the UV spectrum. Water was then added, the two phases separated and the aqueous phase extracted with CH_2Cl_2. The combined organic extracts, washed with H_2O, are dried over Linde Molecular Sieves 4A, evaporated *in vacuo* to give a residue which is recrystallized from the proper solvent (see Table 1).

The ligands **4c-f** are strongly absorbed on both μ-Bondapak and μ-Porasil coloumns, which usually causes a large broadening of the chromatographic peak. Ligand **3b**, derived from the tetramer **1a**, shows a normal behaviour in hplc (μ-Porasil; hexane/AcOEt 8:2; flow rate 3.0 ml/min; Ret time 3.0 min.)

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[20]Systematic names: **1a**: 5, 11, 17, 23 - tetrakis(1, 1 - dimethylethyl) - pentacyclo[19.3.1.1^{3,7}.1^{9,13}.1^{15,19}.]octacosa - 1(25), 3, 5, 7(28), 9, 11, 13(27), 15, 17, 19(26), 21, 23 - dodecane 25, 26, 27, 28 - tetrol; **2c**: nonacyclo[43.3.1.1^{3,7}.1^{9,13}.1^{15,19}.1^{21,25}.1^{27,31}.1^{39,43}]hexapentaconta - 1(49), 3, 5, 7(56), 9, 11, 13(55), 15, 17, 19(54), 21, 23, 25(53), 27, 29, 31(52), 33, 35, 37(51), 39, 41, 43(50), 45, 47 - tetracosaene - 49, 50, 51, 52, 53, 54, 55, 56 - octol. **2a**: 5, 11, 17, 23, 29, 35, 41, 47 - octakis(1, 1 - dimethylethyl) - **2b**: 5, 11, 17, 23, 29, 35, 41, 47 - octakis(1, 1, 3, 3 - tetramethylbutyl - nonacyclo....

[21]Unpublished results from our laboratory.