for $C_{13}H_{18}SO_2$: C, 65.51; H, 7.61; S, 13.45. Found: C, 65.56; H, 7.52; S, 13.37.

Iodo Lactone 16. A 25-mL solution of saturated sodium bicarbonate was combined with a 2.5-mL solution of 102 mg of I_2 and 200 mg of KI. To this solution was added 60 mg (0.20 mmol) of acid **14a**, and the resulting mixture was stirred in the dark for 20 h. The crude reaction mixture was extracted three times with 10-mL portions of chloroform. The extracts were washed once with 10 mL of a 10% sodium bisulfite solution and dried over anhydrous magnesium sulfate. The dried solution was filtered through a pad of Celite with the aid of suction and concentrated to 92 mg of a brown solid. The crude product was triturated with a chloroform–ether mixture to afford 79 mg (93%) of material. An analytical sample was obtained by recrystallization from chloroform–ether: mp 152.5–154 °C; ^{1}H NMR ($CDCl_3$) δ 7.28 (5 H, s), 4.63 (1 H, br s), 1.8–3.2 (10 H, m), 1.73 (3 H, s); IR ($CDCl_3$) 2930, 1765, 1580, 1385, 1135, 965, 915 cm^{-1}; mass spectrum, m/e 426 (M^+), 299, 255 (100%), 145, 91, 77. Anal. Calcd for $C_{18}H_{19}SO_2I$: C, 50.71; H, 4.49; S, 7.52; I, 29.72. Found: C, 50.82; H, 4.51; S, 7.38; I, 29.77.

Keto Lactone 15. A solution comprised of 4.0 g of I_2 and 8.0 g of KI in 125 mL of water was added to a solution of 1.33 g (5.0 mmol) of acid **14c** in 100 mL of water. The reaction was stirred for 2 days at room temperature in the dark. The crude, dark reaction mixture was extracted three times with 50 mL chloroform. The extracts were washed once with 25 mL of 10% sodium bisulfite, dried over anhydrous sodium sulfate, and filtered through a Celite pad with the aid of suction. The crude material obtained by concentration of the dried chloroform extracts were chromatographed on 150 g of silica gel, using ether as the eluant, to yield 0.86 g (50%) of **15**, mp 167–169 °C. Compound **15** was also prepared from **14b** in 55% yield as described above: ^{1}H NMR ($CDCl_3$) δ 4.58 (1 H, br s), 1.60–3.10 (11 H, m), 1.75 (3 H, s); ^{13}C NMR ($CDCl_3$) 215.2, 180.2, 85.8, 56.2, 51.5, 40.8, 40.1, 36.1, 31.5, 30.5, 29.7, 22.5 ppm; IR ($CDCl_3$) 2975, 2940, 2860, 1765, 1740, 1225, 1150, 1130 cm^{-1}; mass spectrum, m/e (no M^+), 207, 179, 144, 130, 101, 91, 72 (100%); CI mass spectrum (CH_4), m/e 335 ($M^+ + 1$), 307, 207, 189, 171, 191, 129, 83, 41 (100%). Anal. Calcd for $C_{12}H_{15}IO_3$: C, 43.13; H, 4.53; I, 37.98. Found: C, 43.13; H, 4.50; I, 37.87.

Keto Ester 22. A solution of 0.65 g (2.0 mmol) of keto iodo lactone **15** in 50 mL of THF containing 0.50 g of zinc was refluxed for 3 h. The THF solution was filtered through a pad of Celite and concentrated to an oil which was partitioned between 25 mL each of chloroform and water. The chloroform layer was dried over anhydrous sodium sulfate, filtered through a Celite pad, and concentrated to an oil. The crude acid **21** so obtained was taken up in 50 mL of THF and was treated with 10 mL of diazomethane in ether (ca. 1 mmol/mL) at 0.5-h intervals three times. The reaction was stirred an additional 1 h after the third addition, filtered through a pad of Celite, and concentrated to 434 mg (100%) of an oil. The crude oil was chromatographed on 200 g of silica and was eluted with chloroform to yield 310 mg (90%) of **22**: mp 83–84.5 °C; ^{1}H NMR ($CDCl_3$) δ 5.42 (1 H, br t, J = 5 Hz), 3.63 (3 H, s), 3.07 (1 H, br t, J = 7 Hz), 2.62 (1 H, d of d, J = 15, 16 Hz), 2.25–2.45 (3 H, m), 1.95–2.15 (4 H, m), 1.85–1.95 (2 H, m), 1.70 (3 H, br s); ^{13}C NMR ($CDCl_3$) 217.8, 176.2, 134.1, 126.3, 55.1, 52.5, 52.0, 37.3, 35.4, 33.5, 26.5, 25.4, 23.5 ppm; IR ($CDCl_3$) 2925, 2850, 1740, 1732, 1210 cm^{-1}; mass spectrum, m/e 222 (M^+), 163, 141, 91, 82 (100%), 79, 68, 54. Anal. Calcd for $C_{13}H_{18}O_3$: C, 70.24; H, 8.16. Found: C, 70.15; H, 8.14.

Vinyl Sulfide 8. Sodium hydride (150 mg after washing three times each with 15 mL of ether, 6.2 mmol) was suspended in 50 mL of THF and 2.91 g (6.0 mmol) of **7** was added in one portion. The reaction was refluxed for 1 h and cooled and 0.64 mL of (96.3 mmol) of benzaldehyde in 10 mL of THF was added. The reaction was refluxed for 1 day, cooled, filtered through a pad of Celite with the aid of suction, and concentrated to 3 g of an oily brown solid. The crude material was triturated with petroleum ether to obtain 1.38 g of crude oil which was chromatographed on 40 g of silca, eluting with petroleum ether–ether (5:1). There was obtained 0.80 g (59%) of vinyl sulfide **8**, as a mixture of isomers: ^{1}H NMR (CCl_4) δ 7.1–7.5 (5 H, m), 6.5 and 6.2 (1 H, br s), 2.7 (4 H, br s), 2.23, 2.07, 2.02, 1.92 (6 H, s); mass spectrum, m/e 224 (M^+), 209, 194, 177, 160, 129, 115 (100%), 105, 91, 77.

Hydroxy Vinyl Sulfide 18. A solution of 210 mg (0.75 mmol) of vinyl sulfide **14c** 4 mL of ether was slowly added to 58 mg (1.6 mmol) of lithium aluminum hydride suspended in 5 mL of ether. The reaction was stirred for 2 h at room temperature, cooled to 0 °C, and excess hydride was decomposed by the careful addition of saturated sodium sulfate until no gray solid was apparent. The ether solution was filtered through a pad of Celite with the aid of suction and concentrated to 157 mg (83%) of an oil: ^{1}H NMR ($CDCl_3$) δ 5.7 (1 H, br t), 3.50 (2 H, s), 2.7–3.5 (1 H, heptet), 1.6–2.7 (11 H, m), 1.73 (3 H, br s), 1.22 (6 H, d, J = 6.5 Hz); IR ($CDCl_3$) 3400, 2955, 2920, 2850, 1480, 1380, 1365, 1240, 1030, 925, 815 cm^{-1}; mass spectrum, m/e 252 (M^+), 221 (100%), 209, 179, 145, 91, 79, 77.

Registry No. 3a, 58992-26-0; **3b**, 76757-63-6; **3c**, 76757-65-8; **5**, 76757-83-0; **7**, 76757-67-0; **8**, 76757-68-1; **9**, 76757-70-5; **10**, 76757-71-6; **11a**, 76773-01-8; **11b**, 76757-72-7; **11c**, 76757-73-8; **13**, 76757-74-9; **14a**, 76757-75-0; **14b**, 76757-76-1; **14c**, 76757-77-2; **15**, 76757-78-3; **16**, 76757-79-4; **18**, 76757-80-7; **22**, 76757-81-8; diisopropylamine, 108-18-9; *N*-(phenylthio)succinimide, 14204-24-1; methyl disulfide, 624-92-0; isopropyl disulfide, 4253-89-8.

Preparation and Characterization of 1,8,19,26-Tetraoxa[8.8](2,6)naphthalenophane-3,5,21,23-tetrayne and Related Donut-Shaped Cyclophanes

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The synthesis of two representative members of the little explored class of large donut-shaped molecules is described. Investigation of their NMR spectra shows them to possess large cavities.

We report here the preparation, characterization, and some initial studies of the donut-shaped macrocyclophanes **6** and **7** (Figure 1). Macrocyclophanes[1,2] of this general type are of some interest as they may serve as the structural basis for constructing large but conformationally well-defined molecular frameworks.[3-6] This is particularly

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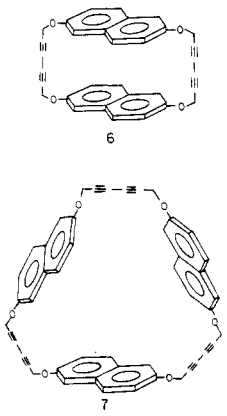
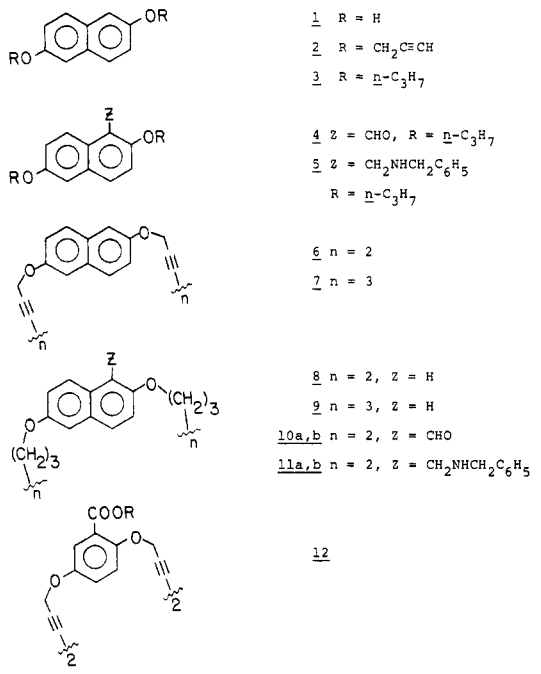


Figure 1. Structures of macrocyclophanes **6** and **7**.

Chart I



appealing in considering the construction of molecules capable of complexation in aqueous medium.[4-6] We have previously reported[7] the preparation and complexation properties of the 1,4-benzenophanes based on the network **12** (see Chart I). We were quite interested in the 2,6-naphthalene-based macrocyclophanes since they are or should be conformationally quite similar to the benzene series studied earlier. The major difference lies in the lateral dimensions of the cavities, approximately 4 Å in **12** vs. 6.5 Å for **6**. The effective size of a benzene ring clearly depends on the dimensions measured, but available crystallographic data permit one to calculate a maximum length of approximately 7.3 Å.[8] A more realistic "average" value[9] would seem to be approximately 6.3–6.6 Å. Thus the naphthalene-based macrocyclophanes should be capable of accommodating an aromatic ring but not the benzene series. Models suggest (and this is supported by our work) that macrocyclophanes of the size considered here should exhibit essentially free rotation about the 2,6-axis. This is in contrast with the situation found for the more compact and highly substituted 2,6-naphthalenophanes recently studied by Kemp and coworkers.[10]

Our findings may be summarized as follows. (1) Oxidative cyclization of 2,6-bis(propargyloxy)naphthalene affords in modest yield the 28- and 42-membered cyclophanes **6** and **7** without resorting to high-dilution conditions. (2) The rigid diyne spacers keep the aromatic rings well separated and permit effective free rotation of the naphthalene ring about the C2–C6 axis. (3) As was observed for the 1,4-benzenophane series[7] (**12**), hydrogenation leads to collapse of the molecule into a more compact conformation. This is *not* true, however, for **7**. (4) NMR solvent effects are consistent with the idea that **6** can accommodate an aromatic molecule inside its cavity.

Results and Discussion

Treating 2,6-bis(propargyloxy)naphthalene with cupric acetate in pyridine under Eglinton conditions[11] affords a difficultly soluble mixture which can be separated by a combination of trituration and fractional recrystallization into three components: an insoluble material (approximately 50%) assumed to be polymeric in nature, a difficultly soluble and infusible material (approximately 40%) which was shown to be **6**, and a material having similar properties which was shown to be **7** in 5–10% yield. Details of their isolation are presented in the Experimental Section.

A similar procedure has been applied to 1,4-bis(ω-alkynyl)benzene by Matsuoka et al.[12b] and earlier by Hubert and Dale.[12a] These workers and others[13] detected appreciable formation of cyclic monomers. We observe no cyclomonomers, and, in fact, would expect none, given the greater side-chain separation of the 2,6-disubstituted naphthalene. The proton NMR spectra of **6** and **7** are sufficiently well resolved at 270 MHz that they may be used as an analytical tool for semiquantitative analysis of crude **6**/**7** mixtures. Hydrogenation of the crude **6**/**7** mixture and isolation of **8** in good yield from the resulting product confirms the conclusion, based on NMR, that **6** and **7** are the principal low molecular weight products from this reaction.

Since satisfactory molecular weights could be obtained on neither **6** nor **7**, they were characterized as their perhydro derivatives **8** and **9**, respectively. Reduction (H_2, Pd/C) of pure **6** afforded **8** in high yield, while reduction of **7** afforded **9**. Both **8** and **9** possess molecular weights expected for dimer and trimer, respectively.

The proton NMR spectra of these molecules, **6** and **7** in particular, show no sign of restricted rotation[14,15] about the C2–C6 axis. The protons of the OCH_2 group are NMR equivalent under all conditions, confirming what is suggested by models that in cyclophanes of this size[16-18] at

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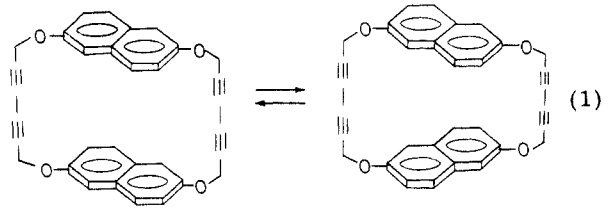
Table I. Cyclization Shifts[a] of Cyclophanes 6–9 and 12

entry	cyclophane	solvent	H1	H3	H4
1	6 (rigid dimer)	$CDCl_3$	−0.04	−0.05	−0.04
2	6	Me_2SO-d_6	−0.05	−0.03	−0.06
3	6	py-d_5 (29 °C)	−0.25	−0.28	−0.52
4	6	py-d_5 (72 °C)	−0.32	−0.31	−0.52
5	7 (rigid trimer)	$CDCl_3$	−0.05	−0.05	−0.04
6	7	Me_2SO-d_6	−0.02	−0.02	−0.06
7	7	py-d_5 (28 °C)	−0.09	−0.08	−0.14
8	8 (floppy dimer)	$CDCl_3$	−0.34	−0.29	−0.48
9	8	py-d_5 (28 °C)	−0.28	−0.26	−0.44
10	8	C_6D_6	−0.30	−0.28	?
11	9 (floppy trimer)	$CDCl_3$	−0.01	−0.03	−0.02
12	9	py-d_5 (29 °C)	−0.05	−0.04	−0.01
13	9	C_6D_6	−0.01	−0.04	−0.04
14	12 (rigid phenyl)	$CDCl_3$	−0.07[b]	−0.00[b]	−0.03[b]
15	12′ (floppy phenyl)[c]	$CDCl_3$	−0.30[b]	−0.31[b]	−0.17[b]

[a] Chemical shift in parts per million of cyclophane less the chemical shift of corresponding monomer (see Results and Discussion). [b] Data from ref 7; cyclization shifts are for protons H3, H4, and H6 of the substituted benzene. [c] Hexadecahydro 12; see ref 7.

least both[14] sides of the C2–C6 axis must bear bulky substituents to hinder rotation as in eq 1. Table I sum-



(1)

marizes the cyclization shifts of compounds 6–9. As before[7] we define the cyclization shift of a proton to be its chemical shift in the cyclophane less its chemical shift in the analogous "half molecule" 2 or 3: a negative value corresponds to an upfield shift on cyclization.

There is a striking parallel between the cyclization shifts of the naphthalenophanes 6 and 8 and our earlier studies on analogous benzophanes (12). The spectrum of 6 is characterized by small upfield cyclization shifts in nonaromatic solvents (Table I, entries 1 and 2). Similar small effects (entries 5 and 6) are seen for 7. These small effects are associated with the rigid diyne spacers keeping the aromatic rings well separated, as saturation of the bridging diynes results in collapse of the molecule with attendant upfield shifts (entry 8) of the aromatic protons of 8. This phenomenon has been observed earlier in the 12 series and is also observed in functionalized derivatives of 8 (e.g., 10, 11, and 3-carboalkoxy derivatives of 6[22]) and in 1,4-

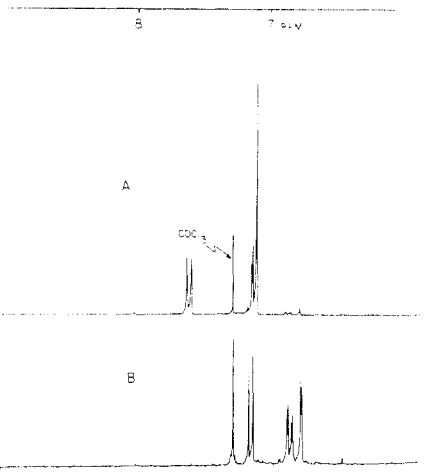


Figure 2. Aromatic region of ^1H NMR of reduced cyclophanes 9 (FA) and 8 (B) in $CDCl_3$. Shifts relative to 2,6-dipropoxynaphthalene are in Table I.

naphthalenophanes of the 6 type.[23] This accordion-like behavior seems to be characteristic of these macrocyclophanes, and it is striking in the extreme that it is *not* observed on reduction of 7 to 9. Here (Table I, entries 5 and 11) reduction leads to no significant changes in the NMR. The striking upfield cyclization shift of 8 relative to 9 is seen in Figure 2 which shows the aromatic region of 8 and 9. We can offer two explanations for this. Either the triangular shape of 7 and 9 cants the naphthalene rings relative to one another, thus diminishing the ring current effects, or, more likely, the flexibility[18,19] associated with the large 42-membered ring of 9 increases the average separation of the aromatic rings in 9 relative to that in 8.

Entry 4 of Table I is interesting in that substantial, upfield, aromatic, solvent-induced shifts (ASIS) are seen for 6 but for none of the other cyclophanes. Detailed interpretation of this requires data on a number of related structures.[16,20] This is possibly due to intercalation of the aromatic solvent into the cyclophane's cavity. Odashima et al. have observed related effects in other cyclophanes.[24]

We have carried out some initial work on the functionalization of 8. Vilsmeier-Haack formylation of 8 affords a separable mixture of two dialdehydes **10a** and **10b**. The higher melting isomer **10b** is tentatively assigned the C_2-symmetric structure on the basis of its NMR. Reductive amination of the more abundant lower melting isomer **10a** with benzylamine afforded the bis[(benzylamino)methyl] derivative 11. This diamine was insufficiently soluble in aqueous acid for NMR studies. Variable-temperature studies in organic solvents[21] afforded no indication of its existing in an "inside" conformation wherein the pendant phenyl groups are tucked into the cavity.[25]

Experimental Section

2,6-Bis(propargyloxy)naphthalene (2). A mixture of 5 g (0.026 mol) of 2,6-dihydroxynaphthalene dihydrate (1), 8.5 mL (0.08 mol) of propargyl bromide, and 12 g of potassium carbonate in 50 mL of acetone was heated under reflux with stirring for 12

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h. Workup afforded, on crystallization from methanol/acetone, 4.6 g (76% yield) of **2**: mp 134–136 °C; NMR ($CDCl_3$) δ 2.54 (2 H, t, J = 2.2 Hz), 4.8 (4 H, d, J = 2.2 Hz), 7.18 (2 H, dd, J = 8.8, 2.6 Hz, H3), 7.35 (2 H, d, J = 2.6 Hz, H1), 7.75 (2 H, d, J = 8.8 Hz, H4).

Anal. Calcd for $C_{16}H_{12}O_2$: C, 81.33; H, 5.12; m/e 236.0837. Found: C, 80.75; H, 5.36; m/e 236.0825.

2,6-Bis(1′-propyloxy)naphthalene (3) was prepared by hydrogenation of **2**: mp 134–135 °C ($MeOH/CHCl_3$); NMR ($CDCl_3$, 270 MHz) δ 1.07 (6 H, t, J = 7 Hz, CH_3), 1.86 (4 H, sextet, J = 6.6, 7.3 Hz), 4.00 (4 H, t, J = 6.6 Hz), 7.08 (2 H, d, J = 2.6 Hz, H1), 7.12 (2 H, dd, J = 2.6, 8.8 Hz, H3), 7.61 (2 H, d, J = 8.5 Hz, H4); UV (MeOH) λ_{max} 346 nm (ε 3700), 334 (3300), 268 (8200), 259 (9300).

2,6-Bis(1′-propyloxy)-1-naphthaldehyde (4). Phosphorus oxychloride (0.8 mL) was added to a solution of 303 mg (1.2 mmol) of **3** in 12 mL of DMF. The reaction mixture was heated (steam bath) with stirring for 1 h and then worked up to afford after chromatography 296 mg (88% yield) of aldehyde **4**: mp 74–76 °C; NMR ($CDCl_3$, 100 MHz) δ 1.1 (6 H, t, CH_3), 1.86 (4 H, m, CH_2CH_3), 4.03 (4 H, t, OCH_2), 7.04 (1 H, d, J = 2 Hz, H5), 7.16 (1 H, d, J = 9 Hz, H3), 7.32 (1 H, dd, J = 2, 9 Hz, H7), 7.85 (1 H, d, J = 9 Hz, H4), 9.26 (1 H, d, J = 9 Hz, H8).

Anal. Calcd for $C_{17}H_{20}O_3$: C, 74.97; H, 7.40; m/e 272.1407. Found: C, 75.01; H, 7.22; m/e 272.1413.

1-[(Benzylamino)methyl]-2,6-bis(1′-propoxy)naphthalene (5). A solution of aldehyde **4** (25 mg) in 1 mL of benzylamine was heated on a steam bath for 15 min. Solid sodium cyanoborohydride was added, and the mixture was heated overnight at 40 °C. Removal of excess benzylamine by distillation (100 °C, 0.2 mm) followed by workup afforded a light yellow oil (50 mg). Partitioning of this oil between 10% hydrochloric acid and chloroform followed by basification and chromatography of the chloroform-soluble fraction afforded **5** as a light yellow oil: 21 mg; mass spectrum, m/e 363.2171 (calcd for $C_{24}H_{29}NO_2$, 363.2191); NMR ($CDCl_3$, 270 MHz) δ 1.05 and 1.07 (3 H each, t, CH_3), 1.83 (4 H, m, CH_2CH_3), 4.02 (4 H, m, OCH_2), 3.87 and 4.23 (2 H each, s, CH_2NH), 7.08 (1 H, d, J = 2.6 Hz, H5), 7.15 (1 H, dd, J = 2.6, 9 Hz, H7), 7.21 (1 H, d, J = 9 Hz, H3), 7.63 (1 H, d, J = 9 Hz, H4), 7.86 (1 H, d, J = 9 Hz, H8), ca. 7.2 (5 H, m, C_6H_5).

Eglinton Dimerization of 2: Cyclodimer 6 and Cyclotrimer 7. To a stirred solution of 19 g (0.1 mol) of cupric acetate monohydrate in 540 mL of pyridine at 42 °C was added over 24 h a solution of 5 g (0.021 mol) of **2** in 250 mL of pyridine. The reaction mixture was poured over an ice–hydrochloric acid slurry and filtered. The precipitate was washed with cold acetone to afford 5.5 g of a tan solid (A).

This crude product is an approximately 1:1 mixture of polymeric (insoluble in dimethylformamide or warm pyridine) and organic-soluble material. The latter is typically a 4:1 mixture of cyclodimer **6** and cyclotrimer **7** with small and varying amounts of material containing free propargyl groups. Cyclomers **6** and **7** have indistinguishable chromatographic properties and are generally quite insoluble and difficult to work with. The following procedure does allow them to be isolated in a pure form.

The crude mixture (A) was stirred in 500 mL of acetone overnight to afford 0.55 g of acetone-soluble material. Recrystallization from acetone afforded first, as the less soluble fraction, pure cyclotrimer **7** (121 mg, 2.5% yield) and then cyclodimer **6** (106 mg, 2.1% yield).

Cyclodimer 6: colorless infusible needles; NMR (Me_2SO-d_6, 270 MHz) δ 5.101 (2 H, s), 7.155 (1 H, dd, J = 2.6, 8.8 Hz, H3), 7.315 (1 H, d, J = 2.6 Hz, H1), 7.699 (1 H, d, J = 8.8 Hz, H4).

Catalytic hydrogenation of **6** (10% Pd/C, atmospheric pressure) afforded **8**: mp 212–215 °C (EtOAc); NMR ($CDCl_3$, 270 MHz) δ 1.55 (8 H, m), 1.82 (8 H, m), 4.035 (8 H, t, J = 5.9 Hz, $OCH_2CH_2CH_2$), 6.739 (4 H, d, J = 2.7 Hz, H1), 6.828 (4 H, dd, J = 2.6, 8.6 Hz, H3), 7.124 (4 H, d, J = 8.8 Hz, H4); UV (MeOH) λ_{max} 346 nm (ε 2000), 334 (2000), 269 (4100), 259 (4500).

Anal. Calcd for $C_{32}H_{36}O_4$: C, 79.31; H, 7.49; m/e 484.2613. Found: C, 79.25; H, 7.31; m/e 484.2602.

Cyclotrimer 7: colorless and infusible powder; NMR (Me_2SO-d_6, 270 MHz) δ 5.041 (2 H, s), 7.158 (1 H, dd, J = 2.2, 8.8 Hz, H3), 7.330 (1 H, d, J = 2.2 Hz, H1), 7.700 (1 H, d, J = 8.8 Hz, H4). The structure of **7** follows from its hydrogenation (10% Pd/C, atmospheric pressure to its tris(octahydro) derivative **9**: mp 163–165 °C (EtOAc); NMR ($CDCl_3$, 270 MHz) δ 1.57 (12 H, m, $OCH_2CH_2CH_2$), 1.86 (12 H, m, $OCH_2CH_2CH_2$), 4.07 (12 H, t, J = 6.3 Hz, $OCH_2CH_2CH_2$), 7.07 (6 H, br s, H1), 7.08 (6 H, dd, J = 2.6, 8 Hz, H3), 7.58 (6 H, d, J = 9.4 Hz, H4).

Anal. Calcd for $C_{48}H_{54}O_6$: C, 79.31; H, 7.49; m/e 796.3920. Found: C, 78.97; H, 7.56; m/e 796.3906.

Vilsmeier–Haack Formylation of 8: 10a and 10b. A suspension of 192 mg (0.4 mmol) of **8** in 55 mL of DMF was heated to 70 °C to effect solution. When the mixture cooled to 55 °C, 6.6 mL of phosphorus oxychloride was added dropwise, and the resulting dark solution was heated overnight at 55 °C. Workup afforded 176 mg (82% yield) of a mixture of two aldehydes (δ 10.80 and 10.84 of equal intensity). Recrystallization (ethyl acetate) of this mixture afforded the two isomers in a substantially pure form.

Isomer 10a: mp 208–211 °C (EtOAc); NMR ($CDCl_3$, 270 MHz) δ 1.6–1.9 (8 H, m, $OCH_2CH_2CH_2$), 3.91 and 4.10 (4 H, t, J = 5 Hz, OCH_2CH_2), 6.32 (1 H, d, J = 3 Hz, H5), 6.77 (1 H, d, J = 9 Hz, H3), 7.10 (1 H, dd, J = 3, 9 Hz, H7), 7.19 (1 H, d, J = 9 Hz, H4), 8.88 (1 H, d, J = 9 Hz, H8), 10.77 (1 H, s, CHO); mass spectrum, m/e 540.2504 (calcd for $C_{34}H_{36}O_6$, 540.2502).

Isomer 10b: mp 218–230 °C dec (EtOAc); NMR ($CDCl_3$, 270 MHz) δ 3.97 and 4.07 (4 H, t, J = 5 Hz, $OCH_2CH_2CH_2$), 6.47 (1 H, d, J = 2.4 Hz, H5), 6.61 (1 H, d, J = 10 Hz, H3), 7.07 (1 H, dd, J = 2 and 9 Hz, H7), 7.11 (1 H, d, J = 10 Hz, H4), 8.92 (1 H, d, J = 10 Hz, H8), 10.83 (1 H, s, CHO).

Reductive amination of a mixture of **10a** and **10b** (20 mg), by using the procedure applied to **4**, gave after repeated chromatography a crystalline amine: 2.5 mg (17% yield; **11a** or **11b**); NMR ($CDCl_3$, 270 MHz) δ 1.5–1.9 (8 H, m, $OCH_2CH_2CH_2$), 3.80 (2 H, s, CH_2NH), 3.99 and 4.04 (4 H, t, J = 6 Hz, $OCH_2CH_2CH_2$), 4.12 (2 H, s, CH_2NH), 6.65 (1 H, d, J = 2.6 Hz, H5), 6.73 (1 H, d, J = 9.2 Hz, H3), 6.79 (1 H, d, J = 9.2 Hz, H4), 7.01 (1 H, dd, J = 2.6, 9.2 Hz, H7), 7.68 (1 H, d, J = 9.5, H8), 7.2–7.3 (5 H, m, C_6H_5); mass spectrum, m/e 722.4067 (calcd for $C_{48}H_{54}N_2O_4$, 722.4070).

Amine mixture **11a/b** was insoluble in aqueous acids (see **5**), and its NMR spectrum (270 MHz, $CDCl_3$) was temperature invariant to −51 °C.

Registry No. **1**, 581-43-1; **2**, 20009-43-2; **3**, 76630-84-7; **4**, 76630-85-8; **5**, 76630-86-9; **6**, 76648-68-5; **7**, 76630-87-0; **8**, 76630-88-1; **9**, 76630-89-2; **10a**, 76648-69-6; **10b**, 76630-90-5; **11a**, 76648-70-9; **11b**, 76630-91-6; propargyl bromide, 106-96-7; benzylamine, 100-46-9.