The Synthesis of Novel Oxa-Azamacrocycles

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Received 17 November 1998; revised 12 January 1999
Dedicated to the 75th birthday of Dr D.M. Brown, ScD, FRS

Abstract: Novel protected oxa-azamacrocycles **6a–f**, **7a**,**c–f** have been prepared by direct alkylation reaction between α,ω-bis[(2-mesitylsulfonyl)aminooxy]alkanes **2a–c** and α,ω-bis(tosyl)alkanediols **3a,b** in the presence of K_2CO_3 to give a mixture of the 1:1 (small macrocycles **6a–f**) and 2:2 (large macrocycles **7a**,**c–f**) adducts. Another method involved the reaction between bis (sulfonyl)amides **2a,b** and ω-bromoalkanols **4a,b** to give bis-alkanols **5a,b** which were subsequently condensed with **2a,b** under Mitsunobu conditions to give solely large macrocycles **7a,d** in high yields. Macrocycle **7d** was deprotected with HBr/HOAc to yield **8** as the tetrahydrobromide salt which was converted into its free base with methanolic KOH.

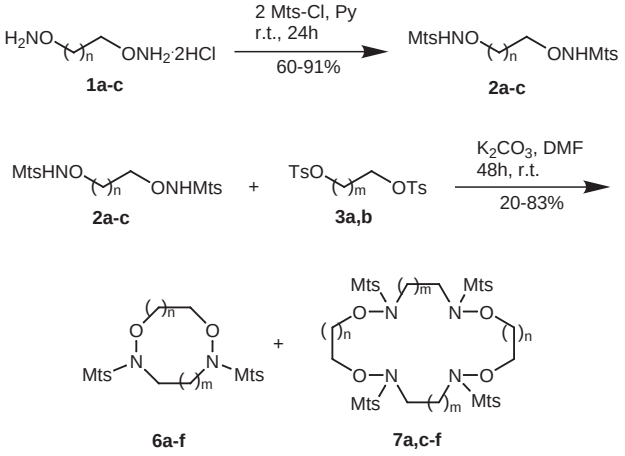
Key words: synthesis, oxa-azamacrocycles, oxyamines, alkylation, Mitsunobu reaction

Macrocycles with a heteroatom such as nitrogen and oxygen have for the last decade demonstrated wide application in many branches of science. For example azamacrocycles (cyclams) are important chelating agents for metal and organic cations, anions and neutral molecules.[1,2] One of the many medical uses of heterocyclic macrocycles is to sequester particle emitting radioisotopes for use with monoclonal antibody in radioimmunodiagnosis and radioimmunotherapy.[3,4] More recently, other workers have reported good anti-HIV activity for many azamacrocycles and their metal complexes.[5]

For a number of years we have been interested in the chemistry of oxyamino compounds[6,7] and their corresponding macrocyclic systems[8] such as **8**. We reason that such heterocyclic system can exhibit 'degenerate' properties in their binding with metal ions. These systems can in principle bind to alkali/alkali earth metals through the oxygen atoms (as shown by crown ethers) or the transition metals through the nitrogen atoms (as shown by cyclams). In this paper, we report the synthesis and characterisation of novel oxa-azamacrocyclic systems such as **6a-f**,**7a**,**c–f** containing N–O bonds. As far as we are aware it is the first time such heteromacrocyclic system has been reported.

In the alkylation reactions between α,ω-bis[(2-mesitylsulfonyl)aminooxy]alkanes **2a–c** and bis(tosyl)alkanediols **3a,b** in the presence of K_2CO_3 two products were formed, showing distinct spots on TLC (acetone: petroleum ether (bp 80–100 °C), (1:3)) with an approximate R_f values of 0.18 and 0.30. Recrystallisation of the mixture from a large volume of MeCN gave the slower running spot as a single product. Mass spectra of all these recrystallised products showed base peaks for large macrocycles **7a**,**c–f** (2:2 adducts) $[MH]^+$ with fragmentation ions at $[MH–Mts]^+$, $[MH–2Mts]^+$, $[MH–3Mts]^+$ and $[MH–4Mts]^+$. After evaporation of the filtrate the residue was crystallised from a small volume of MeCN to give the faster running spots as single products. The latter were deduced to be small macrocycles **6a–f** since they gave in their mass spectra base peaks corresponding to the 1:1 adducts $[MH]^+$ with the fragmentation pattern $[MH–Mts]^+$, and $[MH–2Mts]^+$. It is interesting to mention that the reaction between **2a** and **3b** gave only small macrocycle **6b** in 83% yield.

The two macrocyclic systems **6** and **7** were also differentiated by the examination of their NMR spectra. Generally, the chemical shifts of the hydrogen and carbon atoms situated at α-positions of the oxygen and nitrogen in large macrocyclic systems **7** were found to be in higher field compared with the corresponding hydrogens and carbons of **6**. For example, in the ^1H NMR spectrum of the small macrocycle **6d**, the α-hydrogens typically showed two triplets at δ = 3.66 and 3.47 while in the large macrocycle **7d** those α-hydrogens exhibit two signals which partially overlapped to appear as a multiplet at δ 3.44–3.66 ppm. Similarly, in the ^{13}C NMR spectra of compounds **6d** and **7d** the chemical shifts of the α-carbons were found to be δ = 73.6 (C–O), 48.2 (C–N) and 72.9 (C–O), 47.4 (C–N) respectively.



1,2a n=1, **b** n=2, **c** n=4; **3a** m=1, **b** m=2; **6,7a** n=m=1, **b** n=1 m=2, **c** n=2 m=1, **d** n=m=2, **e** n=4 m=1, **f** n=4 m=2

Scheme 1

X-ray crystallographic analysis of the compound with larger R_f value obtained from the reaction between **2b** and **3b,** confirmed the structure of 1:1 adduct **6d** (Figure 1). Selected bond lengths and angles for compound **6d** are presented in Table 2. During the course of our studies on the structure of oxa-azamacrocycle, we found that as the size of the ring increases, it becomes more difficult to grow single crystals since the degree of disorder increases. Due to disorder, the molecular shape of the ten-membered macrocycle **6d** in the crystalline state does not exhibit the internal symmetry found in analogous eight-membered ring system.[8] Eight of the atoms from **6d** are displaced alternately above and below the best plane through the ten atoms, with C8 and C11 on the plane.

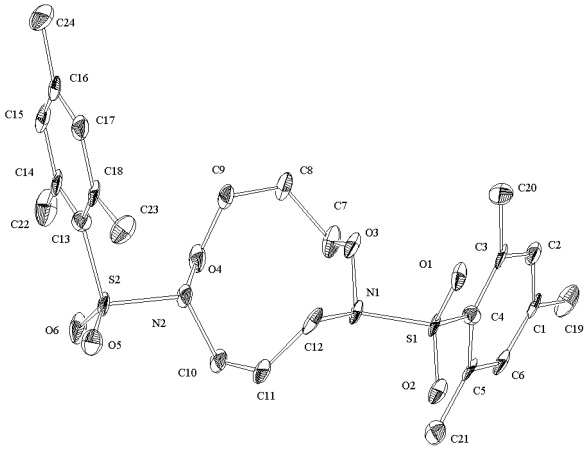
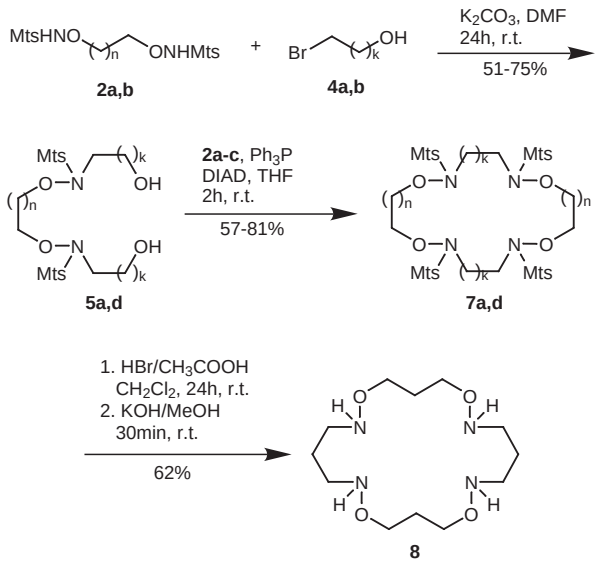


Figure 1. Crystal Structure of N^2,N^6-di(2-mesitylsulfonyl)-2,6-diaza-1,7-dioxacyclodecane **6d**. Hydrogen atoms are omitted for clarity.

Large oxa-azamacrocycle **7** is the system in which we are most interested. It was obtained as the sole product by the synthetic route outlined in Scheme 2. This involved first an alkylation reaction between α,ω-bis[(2-mesitylsulfonyl)aminooxy]alkanes **2a–c** and ω-bromoalkanols **4a,b** to give bis-alkanols **5a,d** which were subsequently condensed with another molecule of bis(sulfonyl)amides **2a,b** under Mitsunobu conditions. The products obtained showed identical spectral properties to the large macrocyles **7a,d** prepared via the alkylation reaction described above. Deprotection of the large macrocycle **7d** was performed with 30% HBr/HOAc to give the macroheterocycle **8** as the tetrahydrobromide salt. Hydrobromide salt of **8** was converted into its free base with methanolic KOH.

In this paper we report the synthesis and characterisation of novel oxa-azamacrocycles. Two synthetic routes leading to macrocycles **7** were applied. Alkylation reaction between bis(sulfonyl)amides **2a–c** and bis(tosyl)alkanediols **3a,b** gave mixtures of small (1:1 adduct) and large (2:2 adduct) macrocycles in approximately 1:1 ratio. To obtain the large macrocyclic systems such as **7**, we have introduced a new synthetic strategy which involved an alkylation of bis(sulfonyl)amides **2a,b** with ω-bromalkanols **4a,b** followed by ring closure under Mitsunobu conditions. We are currently investigating the complexing and chemical properties of the macrocycle **8**.



2a n=1, **b** n=2; **4a** k=1, **b** k=2; **5,7a** n=k=1, **d** n=k=2

Scheme 2

All reagents were purchased from Aldrich and Lancaster and used without further purification. Mps were determined on a Gallenkamp melting point apparatus in open capillaries and are uncorrected. TLC was performed on Kieselgel plates (Merck) 60 F_{254} in $CHCl_3$:MeOH (97:3 or 99:1) or acetone:petroleum ether (bp. 80–100 °C) (1:3) and visualised using UV-light or an iodine vapour bath. Silica gel Kieselgel 60 (230–400 mesh ASTM) was used for column chromatography. IR spectra were recorded on a Perkin-Elmer 781 IR spectrophotometer. ^1H and ^{13}C NMR spectra were recorded on a JEOL JNM-EX90 FT NMR spectrometer in $CDCl_3$ unless otherwise stated. FAB-MS were obtained on a VG Analytical AutoSpec (25kV) spectrometer (low resolution) or VG Analytical ZAB-E instrument (accurate mass). DMF was distilled prior to use. CH_2Cl_2 and THF were distilled over P_2O_5. α,ω-bis(aminooxy)alkane dihydrochlorides **1a–c** were prepared according to the described procedure.[7]

Crystal Structure Analysis of N^2,N^6-Bis(2-mesitylsulfonyl)-1,7-dioxa-2,6-diazacyclodecane (6d)

Crystal data: $C_{24}H_{34}N_2O_6S_2$, colourless, M=510.67, T=150 °K, monoclinic, space group $P2_1/n$, a=6.4161(12), b=26.751(6), c=14.5990(5) Å, β=92.95(3)°, V=2502.5(8) Å^3, Z=4, D_x=1.355gcm^{-3}; graphite monochromated Mo-*Kα* radiation, λ=0.71073 Å, μ=0.255mm^{-1}.

Data collection: The unit cell and intensity data were collected on a Delft Instruments Fast diffractometer. 8725 reflections were collected, of which 3574 were independent reflections,with 2θ range for data collection of 2.07 to 25.09°.

Structure Solution and Refinement: Structure solution and refinement were achieved using *SHELXS86*[9] and *SHELX93*.[10] Full-matrix least squares on F^2 of all data converged to R=0.1238 and wR=0.2742. Atomic coordinates, bond lengths, angles and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre, deposition number 102823.

α,ω-bis[(2-Mesitylsulfonyl)aminooxy]alkanes 2a–c

α,ω-bis(Aminooxy)alkane dihydrochloride **1** (20 mmol) was stirred in pyridine at r.t for 30 min and 2-mesitylsulfonyl chloride (40 mmol) was added portionwise to the mixture which was stirred at r.t. for 24h. Pyridine was removed under reduced pressure and residue was dissolved in $CHCl_3$ (50 mL), washed with 2M HCl (2x50 mL), H_2O (50 mL), sat. $NaHCO_3$ (50 mL) and dried (Na_2SO_4). Evaporation of solvent followed by crystallisation from toluene or EtOH afforded the title compound.

1,2-bis[(2-Mesitylsulfonyl)aminooxy]ethane (2a)[7]

Yield 91%; mp 116–117 °C (dec., toluene).

^{1}H NMR: δ = 7.32(s, 2H,N*H*), 7.04 (s, 4H), 4.00 (s, 4H); 2.65 (s, 12H), 2.49 (s, 6H).

^{13}C NMR: δ = 143.6, 140.8, 132.1, 130.8 (arom. *C*), 73.8, 22.9, 21.0.

IR (Nujol): ν = 3250, 1600 (N–H), 1350, 1160 (SO_2) cm^{-1}.

1,3-bis[(2-Mesitylsulfonyl)aminooxy]propane (2b)

Yield 79%; mp. 157–158 °C (EtOH).

^{1}H NMR: δ = 7.05 (s, 2H, N*H*), 6.95 (s, 4H), 3.75 (t, 4H), 2.58 (s, 12H), 2.29 (s, 6H), 1.73 (p, 2H).

^{13}C NMR: δ = 143.6, 140.7, 132.0, 130.8, 73.5, 26.8, 23.0, 21.0.

Table 1 *N*,*N*' -Bis(2-mesitylsulphonyl)dioxadiazacycloalkanes **6a-f** and *N*,*N*',*N*'',*N*'''-Tetra(2-mesitylsulfonyl)- tetraoxatetraazacycloalkanes **7a**, **c**–**f**

Compound	Yield %	mp. °C	^{1}H NMR δ, ppm	^{13}C NMR δ, ppm	MS-FAB m/z
6a	30	179–180	6.95 (s, 4H), 3.74 (s, 4H), 3.29 (s, 4H), 2.64 (s, 12H), 2.28 (s, 6H)	143.8, 141.5, 131.7, 129.2, 74.4, 48.3, 22.6, 20.7	Calcd for $C_{22}H_{30}N_2O_6S_2$ 482.6180 Found 482.1545, $[MH]^+$
6b	83	161–162	6.93 (s, 4H), 3.55 (s, 4H), 3.38 (t, 4H), 2.62 (s, 12H), 2.26 (s, 6H), 2.07 (p, 2H)	143.8, 141.9, 132.1, 129.2, 74.1, 48.7, 24.2, 23.2, 21.0	Calcd for $C_{23}H_{32}N_2O_6S_2$ 496.6449 Found 497.1542 $[MH]^+$
6c	26	165–166	6.97 (s, 4H), 3.66 (t, 4H), 3.49 (t, 4H), 2.65 (s, 12H), 2.29 (s, 6H), 1.56 (p, 2H)	143.9, 141.8, 131.9, 129.5, 73.5, 49.4, 27.7, 22.9, 20.9	Calcd for $C_{23}H_{32}N_2O_6S_2$ 496.6449 Found 497.1958 $[MH]^+$
6d	45	154–155	6.94 (s, 4H), 3.66 (t, 4H), 3.47 (t, 4H), 2.62 (s, 12H), 2.27 (s, 6H), 2.00 (p, 2H), 1.43 (p, 2H)	143.6, 141.5, 131.9, 129.9, 73.6, 48.2, 28.7, 27.7, 22.9, 20.9	Calcd for $C_{24}H_{34}N_2O_6S_2$ 510.6718 Found 511.1973 $[MH]^+$
6e	27	163–164	6.94 (s, 4H), 3.67 (s, 4H), 3.52 (t, 4H), 2.62 (s, 12H), 2.27 (s, 6H), 1.39-1.60 (m, 6H)	143.5, 141.4, 131.6, 129.2, 75.0, 47.9, 26.0, 22.6, 22.0, 20.5	Calcd for $C_{25}H_{36}N_2O_6S_2$ 524.6987 Found 525.2093 $[MH]^+$
6f	45	178–179	6.90 (s, 4H), 3.48 (t, 4H), 3.28 (2, 4H), 2.60 (s, 12H), 2.24 (s, 6H), 1.28-1.64 (m, 8H)	143.6, 141.6, 131.9, 129.7, 77.2, 47.6, 27.1, 22.9, 22.6, 21.4, 20.9	Calcd for $C_{26}H_{38}N_2O_6S_2$ 538.7255 Found 539.2250 $[MH]^+$
7a	28[a] 57[b]	245–246 (dec.)	6.95 (s, 4H), 3.57 (s, 4H), 3.37 (s, 4H), 2.58 (s, 12H), 2.29 (s, 6H)	144.1, 141.8, 132.2, 129.3, 74.1, 48.0, 23.1, 21.0	Calcd for $C_{44}H_{60}N_4O_{12}S_4$ 965.2360 Found 965.3169 $[MH]^+$
7c	27	229–230 (dec.)	6.97 (s, 8H), 3.50 (s, 8H), 3.34 (t, 8H), 2.61 (s, 12H), 2.31 (s, 6H), 1.38 (p, 4H)	144.1, 141.8, 132.0, 129.5, 72.5, 48.2, 27.0, 23.0, 21.0	Calcd for $C_{46}H_{64}N_4O_{12}S_4$ 993.2898 Found 993.3482 $[MH]^+$
7d	37[a] 82[b]	192–195 (dec.)	6.96 (s, 8H), 3.44-3.66 (m, 16H), 2.88 (s, 24H), 2.60 (s, 12H), 1.87 (p, 4H), 1.38 (p, 4H)	144.0, 141.8, 132.0, 129.6, 72.9, 47.4, 27.3, 24.0, 23.1, 21.0	Calcd for $C_{48}H_{68}N_4O_{12}S_4$ 1021.3435 Found 1021.2 $[MH]^+$
7e	20	238–239 (dec.)	6.95 (s, 8H), 3.55 (s, 8H), 3.36 (t, 8H), 2.63 (s, 24H), 2.29 (s, 12H), 1.05-1.32 (m, 12H)	143.9, 141.9, 132.0, 129.6, 75.6, 48.1, 28.0, 23.0, 22.5, 21.0	Calcd for $C_{50}H_{72}N_4O_{12}S_4$ 1049.3973 Found 1049.4108 $[MH]^+$
7f	37	188–191 (dec.)	6.93 (s, 8H), 3.11-3.40 (m, 16H), 2.59 (s, 24H), 2.26 (s, 12H), 2.10 (p, 4H), 0.95-1.40 (m, 12H)	143.7, 141.6, 131.8, 129.6, 75.6, 47.2, 27.9, 23.9, 22.9, 21.8, 20.9	Calcd for $C_{52}H_{76}N_4O_{12}S_4$ 1077.4510 Found 1077.4421 $[MH]^+$

[a] Alkylation reaction
[b] Mitsunobu reaction

IR (Nujol): ν = 3200, 1600 (N–H), 1330, 1155 (SO_2) cm^{-1}.

1,5-Bis[(2-mesitylsulfonyl)aminooxy]pentane (2c)
Yield 60%; mp. 110.5–111.5 °C (toluene).

^{1}H NMR: δ = 6.96 (s, 4H), 3.74 (t, 4H, *J* = 6.15 Hz)), 2.61 (s, 12H), 2.29 (s, 6H), 1.36 (m, 6H).

^{13}C NMR: δ = 143.3, 140.5, 131.8, 130.8, 76.4, 27.5, 22.8, 21.8, 20.8.

IR (Nujol): ν = 3210, 1600 (N–H), 1322, 1165 (SO_2) cm^{-1}.

N,N'-Bis(2-mesitylsulfonyl)dioxadiazacycloalkanes **6a–f** and *N*,*N*',*N*'',*N*'''-Tetra(2-mesitylsulfonyl)- tetraoxatetraazacycloalkanes **7a,c–f**; General Procedure (Alkylation Reaction)

A mixture of **3** (2.13 mmol), **4** (2.13 mmol), and K_2CO_3 (6.40 mmol) in anhyd DMF (60 mL) was stirred for 48 h at r.t. Solvent was removed in vacuo and the residue was dissolved in $CHCl_3$ (50 mL), washed with 2M HCl (2x50mL), H_2O (2x50 mL), brine (50 mL), and dried with Na_2SO_4. Solvent was then evaporated to dryness to give an oil which was dissolved in anhyd MeCN (3 mL) and cooled to –18 °C to give a mixture of macrocycles **6** and **7**. This solid was dissolved in boiling MeCN (150 mL), and left at 0 °C for 3 days. The precipitate formed was filtered off, washed with cold MeCN, and dried to give large macrocycle **7** as a white solid. The filtrate was reduced in volume and residue was recrystallised from MeCN to give small macrocycle **6** as a white solid (Table 1).

***N*,*N*'-Bis(ω'-hydroxyalkyl)-α,ω-bis[(2-mesitylsulfonyl)]aminooxy]alkanes 5a,d; General Procedure**
A mixture of **2** (4.72 mmol), ω-bromoalkanol **4** (9.44 mmol) and anhyd K_2CO_3 (11.72 mmol) in anhyd DMF (35 mL) was stirred at r.t. for 24 h. DMF was removed in vacuo, residue was dissolved in $CHCl_3$ (50 mL), washed with 1M HCl (2x50 mL), H_2O (50 mL), sat. $NaHCO_3$ (50 mL), and dried (Na_2SO_4). Solvent was removed in vacuo to give **5**.

***N*,*N*'-Bis(2-hydroxyethyl)-1,2-bis[(2-mesitylsulfonyl)]aminooxy]ethane (5a)**
Obtained as white solid in 51% yield, mp 90–93 °C (EtOH).

^{1}H NMR: δ = 6.94 (s, 4H), 3.82 (t, 4H), 3.44 (s, 4H), 3.40 (t, 4H), 2.58 (s, 12H), 2.29 (s, 6H), 2.09 (s, 2H, OH).

^{13}C NMR: δ = 143.9, 141.7, 131.9, 129.3, 73.0, 58.8, 52.0, 22.9, 20.9.

IR (Nujol): ν = 3330 (OH), 1610, 1570, 1340, 1180 (SO_2), 1090, 1060, 1040, 915, 860, 740 cm^{-1}.

LRMS-FAB: Calcd for $C_{24}H_{36}N_2O_8S_2$ 544.6864 Found 545.1 $[MH]^+$.

***N*,*N*'-Bis(3-hydroxypropyl)]-1,3-bis[(2-mesitylsulfonyl)]aminooxy]propane (5b)**
Obtained as yellow oil in 75% yield.

^{1}H NMR: δ = 6.93 (s, 4H), 3.68 (t, 4H), 3.21–3.40 (m, 8H), 2.60 (s, 12H), 2.28 (s, 6H), 1.85 (p, 4H), 1.35 (p, 2H).

^{13}C NMR: δ = 143.6, 141.3, 131.7, 129.4, 77.2, 72.2, 46.6, 29.6, 26.8, 22.7, 20.6.

IR (neat): ν = 3450 (OH), 2820, 2720, 1600, 1560, 1330, 1170 (SO_2), 850 cm^{-1}.

LRMS-FAB: Calcd for $C_{27}H_{42}N_2O_8S_2$ 586.7671 Found 587.2 $[MH]^+$.

***N*,*N*',*N*'',*N*'''-Tetra(2-mesitylsulfonyl) tetraoxatetraazacycloalkanes 7a,d; General Procedure (Mitsunobu reaction)**
To a stirred solution of **5** (3.30 mmol), **2** (3.30 mmol), and Ph_3P (1,79 g, 6.82 mmol) in anhyd THF (30 mL) DIAD (1.38 g, 6.82 mmol) was added dropwise at r.t. The mixture was allowed to stir for 2h at r.t. and THF was evaporated to dryness. The residue was dissolved in boiling EtOH (30 mL) and cooled to r.t. The precipitate formed was filtered off, washed with cold EtOH and dried to give macrocycle **7** as white solid, which was recrystallised from MeCN to give pure product with same spectral characteristics as those obtained via the alkylation reaction (Table 1).

1,7,11,17-Tetraoxa-2,6,12,16-tetraazacycloicosane (8)
1,7,11,17-Tetraoxa-2,6,12,16-tetraazacycloicosane Tetrahydrobromide
A mixture of protected macrocycle **7d** (1.44g, 1.41 mmol), 30% HBr/HOAc (6.20 g) in anhyd CH_2Cl_2 (30 mL) was stirred at r.t. for 24 h. The orange precipitate formed was filtered off, washed with CH_2Cl_2 (4x10 mL), EtOAc (2 x 10 mL), EtOH (2 x 10 mL), and dried in vacuo over P_2O_5 to afford the tetrahydrobromide salt of the macrocycle **8** as a white powder in 77% yield, mp 200–202 °C (dec).

^{1}H NMR (DMSO-d_6): δ = 7.70 (br s, 8H, ONH_2^+), 4.05 (t, 8H), 3.35 (t, 8H), 1.80–2.30 (m, 8H).

IR (KBr disk): ν = 2890, 2710, 2640, 2460, 2400, 1570, 1525, 1460, 1335, 1170, 1040, 1010, 990 cm^{-1}.

HRMS-FAB: Calcd for $[MH]^+$ $C_{12}H_{32}Br_4N_4O_4$ 616.0465 Found 293.2197 $[MH–4HBr]^+$.

1,7,11,17-Tetraoxa-2,6,12,16-tetraazacycloicosane (8)
To a suspension of the tetrahydrobromide salt of **8** (0.67g, 1.09 mmol) in MeOH (5 mL) a solution of KOH (0.36g, 6.06 mmol) in MeOH (5 mL) was added. The mixture was stirred at r.t. for 30 min, and filtered off. The filtrate was evaporated in vacuo and the residue was resuspended in $CHCl_3$ (2 x 10 mL), resulting solution was filtered and evaporation of the solvent gave macrocycle **8** (0.30 g, 80%) as viscous yellow oil.

^{1}H NMR: δ = 5.64 (br s, 4H, 4xON*H*), 3.73 (t, 16H, 4xCH_2O), 2.96 (t, 8H, 4xCH_2N), 1.56–1.94 (m, 8H, 4xCH_2).

^{13}C NMR: δ = 71.0 (C–O), 50.5 (C–N), 28.4, 25.4.

IR (neat): ν = 3250 (N–H), 2920, 2860 (C–H), 1480, 1435, 1370, 1060, 900 cm^{-1}.

Table 2 Selected bond lengths (Å) and angles (°) of N^2,N^6-Bis(2-mesitylsulfonyl)-1,7-dioxa-2,6-diazacyclodecane **6d**

Bond lengths, (Å)		Angles, (°)	
O(3)-N(1)	1.443(5)	N(1)-O(3)-C(7)	111.0(4)
O(3)-C(7)	1.446(6)	C(9)-O(4)-N(2)	110.4(4)
O(4)-C(9)	1.438(6)	O(4)-N(2)-C(10)	109.7(4)
O(4)-N(2)	1.444(5)	O(3)-N(1)-C(12)	108.8(3)
N(2)-C(10)	1.508(6)	N(1)-C(12)-C(11)	112.2(4)
N(1)-C(12)	1.500(6)	C(12)-C(11)-C(10)	116.9(4)
C(12)-C(11)	1.501(8)	C(11)-C(10)-N(2)	111.5(4)
C(11)-C(10)	1.507(8)	O(4)-C(9)-C(8)	108.0(4)
C(9)-C(8)	1.533(7)	C(7)-C(8)-C(9)	111.5(4)
C(8)-C(7)	1.509(7)	O(3)-C(7)-C(8)	107.8(4)

Acknowledgement

We would like to thank the Robert Gordon University and CVCP Award for financial support, the Centre of Mass Spectrometry at the University of Wales, Swansea, for mass spectroscopic analysis and the EPSRC X-ray data collection service based at the University of Cardiff. Thanks to Dr. M. Fraser for his comments on this paper and Mr. Yann Emzivat for his technical support.

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Article Identifier:
1437-210X,E;1999,0,06,1034,1038,ftx,en;P06198SS.pdf