Macroheterocycles. Part 42.[1] A Facile Synthesis of Dihydroxy Cryptands and their Dehydroxylation

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A facile synthesis of hydroxy cryptands by the reaction of diglycidyl ethers with a diazacrown ether is reported. The reaction results in a mixture of bi- and tri-cyclic cryptands which can be separated by chromatography. The yield of bicyclic cryptands is lowered with a decrease in the diazacrown ether cycle size and an increase in the number of oxyethylene moieties between the epoxy groups in the diglycidyl ether. The results are interpreted in terms of the intramolecular hydrogen bonding of epoxy groups promoting the steric fixation of the reaction centres. Dehydroxylation of the bicyclic dihydroxy cryptands has been performed by means of chlorination followed by reduction.

The presence of a hydroxy group in the side-chain of crown ethers allows them to immobilize readily on polymers[2] and modify their complexing properties *via* further chemical transformation.[3-5] The cryptands are the most interesting macrocyclic ligands. However, until now, only a few examples of hydroxy-containing cryptands,[6-9] prepared by multi-step syntheses, were known. The present paper reports a facile synthesis of novel hydroxy cryptands and their dehydroxylation.

Results and Discussion

The reaction of diazacrown ethers (**1**)—(**3**) with diglycidyl ethers (**4**)—(**6**) in a mixture of ethanol and tetrahydrofuran (THF) (1:1) resulted in a mixture of bi- (**9**)—(**17**) and tri-cyclic (**19**)—(**23**) cryptands in good yield which were separated by chromatography. We were unable to prepare tricyclic cryptands by the reaction of ethylene glycol diglycidyl ether (**5**) with diaza-15-crown-5 (**2**) and diethylene glycol diglycidyl ether (**6**) with diazacrown ethers (**2**) and (**3**). Cryptands (**9**)—(**17**) and (**19**)—(**24**) were isolated as mixtures of *meso*- and (±)-stereoisomers.

The yield of the tricyclic cryptands (**19**—(**24**) was 1—15%. The yield of the bicyclic cryptands (**9**)—(**17**) lowers as the size of the starting diazacrown ethers (**1**)—(**3**) cycle decreases and the distance between the epoxy cycles in the diglycidyl ethers (**4**)—(**6**) increases (Table 1). In most cases the yield of the cryptands (**9**)—(**17**) was quite good.

The yield of the cryptands was independent of the concentration of the starting reagents and their ratio as shown by cryptand (**15**) (Table 2). Taking this as well as the absence of cations in the reaction mixture, and their template effect promoting the cyclization into account, it was clear that formation of the cryptands (**9**)—(**17**) was being promoted by another factor. As was shown earlier,[10,11] during the interaction of piperazine with alkoxyglycidyl ether in methanol, C–O bond cleavage within the epoxy cycle occurs as a result of the effect of the nucleophilic and proton-donor agents which are polarizing this bond from the different sides. The reaction is consecutive-parallel resulting in the products of mono- and di-addition.

Evidently, the mechanism of diazacrown ether interaction with diglycidyl ether should be similar to the above process, in particular, at the addition *via* the first nitrogen atom. It is also evident that the yield of the cryptands (**9**)—(**17**) is determined by the ratio of the intra- and inter-molecular addition of the second epoxy group of the diglycidyl ether. The preferable intramolecular addition may be promoted by the steric fixation of the reaction centres.

The experimental results and CPK analysis of the models suggests that the formation of cryptands (**9**)—(**17**) should be realized *via* the monosubstituted azacrown ether (**18**), shown in the Scheme.

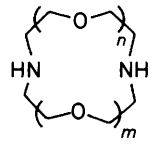
In the intermediate (**18**), intramolecular hydrogen bonding may provide a favourable steric position of the reaction centres for the bicycle formation. This suggestion is confirmed by the fact that the reaction of diaza-18-crown-6 (**3**) with the sterically hindered diglycidyl ether (**7**) results in the yield of the cryptand (**25**) being 37%, while the yield of its analogue (**16**) is 69%. On reaction of diaza-18-crown-6 (**3**) with hydroquinone diglycidyl ether (**8**), for which formation of the intermediate (**18**) is impossible for steric reasons, no cyclic products were obtained.

Table 1. Analytical data for the hydroxy cryptands (**9**)—(**17**) and (**19**)—(**24**)

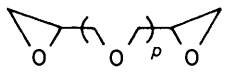
Compound (Formula)	Yield (%)	M.p. (°C)	Found (%) (Required) C	H	N
(**9**) ($C_{14}H_{28}N_2O_5$)	56	126—128	55.25 (55.24)	9.2 (9.27)	9.3 (9.21)
(**10**) ($C_{16}H_{32}N_2O_6$)	46	Oil	55.05 (55.15)	9.25 (9.26)	8.0 (8.04)
(**11**) ($C_{18}H_{36}N_2O_7$)	41	68—69	55.05 (55.08)	9.25 (9.25)	7.1 (7.14)
(**12**) ($C_{16}H_{32}N_2O_6$)	62	Oil	55.1 (55.15)	9.4 (9.26)	8.1 (8.04)
(**13**) ($C_{18}H_{36}N_2O_7$)	51	Oil	55.1 (55.08)	9.3 (9.25)	7.2 (7.14)
(**14**) ($C_{20}H_{40}N_2O_8$)	30	Oil	55.05 (55.02)	9.25 (9.24)	6.5 (6.42)
(**15**) ($C_{18}H_{36}N_2O_7$)	89	67—68	55.1 (55.08)	9.2 (9.25)	7.2 (7.14)
(**16**) ($C_{20}H_{40}N_2O_8$)	69	82—83	55.05 (55.02)	9.3 (9.24)	6.45 (6.42)
(**17**) ($C_{22}H_{44}N_2O_9$)	23	Oil	54.95 (54.98)	9.3 (9.23)	5.8 (5.83)
(**19**) ($C_{28}H_{56}N_4O_{10}$)	15	73—75	55.2 (55.24)	9.25 (9.27)	9.15 (9.21)
(**20**) ($C_{32}H_{64}N_4O_{12}$)	14	Oil	55.15 (55.15)	9.2 (9.26)	8.15 (8.04)
(**21**) ($C_{36}H_{72}N_4O_{14}$)	6	Oil	55.1 (55.08)	9.3 (9.25)	7.25 (7.14)
(**22**) ($C_{32}H_{64}N_4O_{12}$)	11	Oil	55.15 (55.15)	9.25 (9.26)	8.1 (8.04)
(**23**) ($C_{36}H_{72}N_4O_{14}$)	8	Oil	55.1 (55.08)	9.25 (9.25)	7.05 (7.14)
(**24**) ($C_{40}H_{80}N_4O_{16}$)	1	Oil	55.0 (55.02)	9.25 (9.24)	6.35 (6.42)

Table 2. The dependence of the yield of cryptand (**15**) on experimental conditions

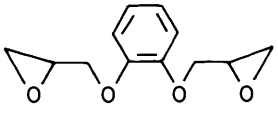
Concentration of diaza-18-crown-6, mol l^{-1}	Molar ratio of the starting reagents (**3**):(**4**)	Yield of cryptand (**15**) (%)
2×10^{-1}	1:1	88
1×10^{-1}	1:1	89
5×10^{-2}	1:1	94
2×10^{-2}	1:1	87
1×10^{-1}	1:2	77



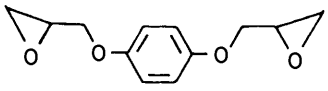
(**1**) $m = n = 1$
(**2**) $m = 1, n = 2$
(**3**) $m = n = 2$



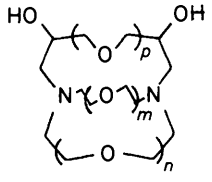
(**4**) $p = 1$
(**5**) $p = 2$
(**6**) $p = 3$



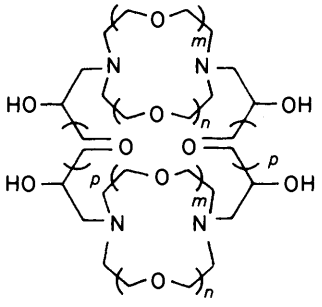
(**7**)



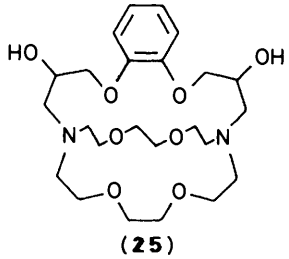
(**8**)



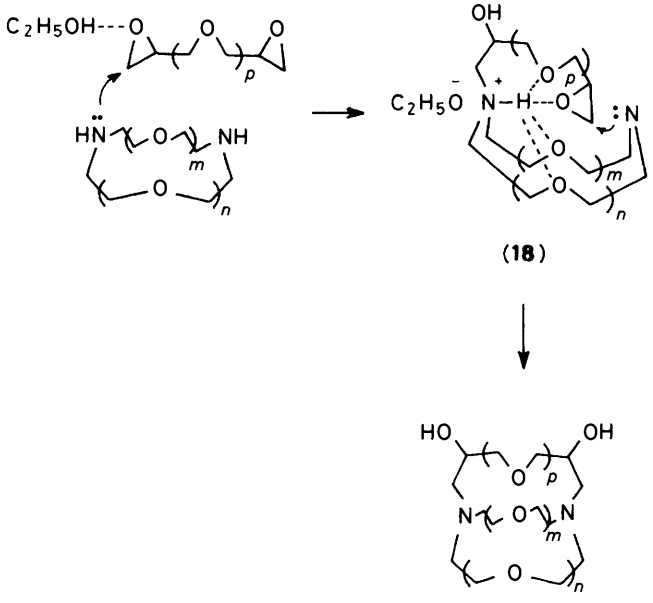
(**9**) $m = n = p = 1$
(**10**) $m = n = 1, p = 2$
(**11**) $m = p = 1, n = 3$
(**12**) $m = p = 1, n = 2$
(**13**) $m = p = 2, n = 1$
(**14**) $m = 1, n = 2, p = 3$
(**15**) $m = n = 2, p = 1$
(**16**) $m = n = p = 2$
(**17**) $m = n = 2, p = 3$



(**19**) $m = n = p = 1$
(**20**) $m = n = 1, p = 2$
(**21**) $m = n = 1, p = 3$
(**22**) $m = p = 1, n = 2$
(**23**) $m = n = 2, p = 1$
(**24**) $m = n = p = 2$



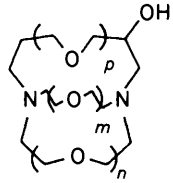
(**25**)



(**18**)

Scheme.

(**26**) $m = n = 1, p = 2$
(**27**) $m = n = 1, p = 3$
(**28**) $m = p = 1, n = 2$
(**29**) $m = 1, n = p = 2$
(**30**) $m = 1, n = 2, p = 3$
(**31**) $m = n = 2, p = 1$
(**32**) $m = n = p = 2$
(**33**) $m = n = 2, p = 3$



(**34**) $m = n = 1, p = 2$
(**35**) $m = 1, n = p = 2$
(**36**) $m = 1, n = 2, p = 3$

The reaction of cryptands (**10**)—(**17**) with thionyl chloride in chloroform followed by the reduction of the formed dichlorides (without any additional purification) with lithium aluminium hydride resulted in the cryptands (**26**)—(**31**). In some cases, in addition to cryptands (**26**)—(**33**), the monohydroxy cryptands (**34**)—(**36**) were obtained in a low yield; these probably result from the partial hydrolysis of the chlorination products. The facility of this procedure and the fair yield of the cryptands formed makes this a good alternative route to the classical methods of cryptands synthesis.

Experimental

General.—All m.p.s are uncorrected. ^{1}H N.m.r. (100 MHz) spectra were recorded on Tesla-BS-497 spectrometer in deuteriochloroform using HMDS as an internal standard. Mass spectra were recorded on a Varian MAT 112 instrument using electron impact ionization (at 70 eV). The purity of all the compounds was controlled by chromatography. T.l.c. was carried out with the glass plates coated with neutral alumina L 5/40 (Chemapol, Czechoslovakia). Gas liquid chromatography

was carried out on Chrom 5 instrument (Czechoslovakia), the column 3 × 1 500 mm, 5% SP2100 on Chromaton N-Super. Column chromatography was performed over neutral alumina L 40/250 (Chemapol, Czechoslovakia).

Materials. Commercial diglycidyl ether, hydroquinone diglycidyl ether, and diaza-18-crown-6 were used. Ethylene and diethylene glycol diglycidyl ether were prepared as described in ref. 12 and diaza-12-crown-4 and diaza-15-crown-5 as described in ref. 13. Ethanol, THF, and chloroform were purified and dried by general methods. The other solvents used were of the reagent grade.

Pyrocatechol Diglycidyl Ethers.—A 45% solution of sodium hydroxide (22.8 g) was added dropwise to the mixture of pyrocatechol (13.8 g, 0.12 mol), polyethylene glycol–2000 (Loba Chemie, 3 g), and epichlorohydrin (59.0 g, 0.64 mol) with vigorous stirring (the temperature of the reaction should not exceed 40—45 °C). Stirring was continued for 2 h, water (500 ml) and chloroform (250 ml) were added, and the organic layer was separated, and dried for 10—12 h (Na_2SO_4). The chloroform was evaporated under reduced pressure, and the residue was distilled under reduced pressure. The diglycidyl ether (**7**) was obtained as a colourless oil (15 g, 54%), b.p. 96—102 °C at 1 mmHg; δ 2.12—4.12 (10 H, m, CH_2–$CHCH_2O$) and 6.50—6.83 (4 H, m, ArH) (Found: C, 64.8; H, 6.35. Calc. for $C_{12}H_{14}O_4$: C, 64.84; H, 6.35%).

Reaction of Diazacrown Ethers (**1**)—(**3**) *with Diglycidyl Ethers* (**4**)—(**6**).—A typical experimental procedure is as follows. A solution of diaza-12-crown-4 (**1**) (0.9 g, 5 mmol) and diglycidyl ether (**4**) (0.7 g, 5 mmol) in a mixture of dry THF (25 ml) and ethanol (25 ml) was heated under reflux to complete conversion of the diazacrown ether (monitoring by t.l.c., g.l.c.; *ca.* 10 h). The oily residue after the solvents were evaporated off was extracted with hot hexane (5 × 100 ml). The colourless residue after hexane evaporation was subjected to column chromatography on neutral alumina using chloroform–benzene–methanol (8:3:1.5) as eluant. 3,7-Dihydroxy-5,12,17-trioxa-1,9-diazabicyclo[7.5.5]nonadecane (**9**), δ 2.30—2.81 (12 H, m, NCH_2) and 3.01—4.10 (16 H, m, OCH_2, $CHOH$, OH); *m/z* 304 (M^+) and 3,7,17,21-*tetrahydroxy*-5,12,19,26,31,36-*hexaoxa*-1,9,15,23-*tetra-azatricyclo*[21.5.5.5^{9,15}]*octatriacontane* (**19**), δ 2.38—2.77 (24 H, m, NCH_2), 3.31—3.57 (28 H, m, OCH_2, OH), and 3.56—3.95 (4 H, m, $CHOH$); *m/z* 608 (M^+) were isolated. The following compounds (**10**)—(**17**) and (**19**)—(**25**) were similarly prepared (see Table 1).

3,10-*Dihydroxy*-5,8,15,20-*tetraoxa*-1,12-*diazabicyclo*-[10.5.5]*docosane* (**10**), δ 2.41—2.90 (12 H, m, NCH_2) and 3.23—3.81 (20 H, m, OCH_2, $CHOH$, OH); *m/z* 348 (M^+) and 3,10,20,27-*tetrahydroxy* 5,8,15,22,25,32,37,42-*octaoxa*-1,12,18,29-*tetra-azatricyclo*[27.5.5.5^{12,18}]*tetratetracontane* (**20**), δ 2.43—2.92 (24 H, m, NCH_2) and 3.30—3.82 (40 H, m, OCH_2, $CHOH$, OH); *m/z* 696 (M^+); chloroform–benzene–methanol (8:3:0.4) as eluant.

3,13-*Dihydroxy*-5,8,11,18,23-*pentaoxa*-1,15-*diazabicyclo*-[13.5.5]*pentacosane* (**11**), δ 2.43—2.71 (12 H, m, NCH_2) and 3.25—3.93 (24 H, m, OCH_2, $CHOH$, OH); *m/z* 392 (M^+) and 3,13,23,33-*tetrahydroxy*-5,8,11,18,25,28,31,38,43,48-*decaoxa*-1,15,21,35-*tetra-azatricylo*[33.5.5.5^{15,21}]*pentacontane* (**21**), δ 2.40—2.71 (24 H, m, NCH_2) and 3.29—3.81 (48 H, m, OCH_2, $CHOH$, OH); *m/z* 784 (M^+); chloroform–benzene–methanol (8:3:0.1) as eluant.

12,16-*Dihydroxy*-4,7,14,20-*tetraoxa*-1,10-*diazabicyclo*-[8.7.5]*docosane* (**12**), δ 2.40—2.88 (12 H, m, NCH_2) and 2.25—3.91 (20 H, m, OCH_2, $CHOH$, OH); *m/z* 348 (M^+) and 3,7,20,24-*tetrahydroxy*-5,12,15,22,29,32,37,42-*octaoxa*-1,9,18,26-*tetra-azatricyclo*[24.8.5.5^{9,18}]*tetratetracontane* (**22**), δ 2.35—2.60 (8 H, m, NCH_2, CHOH), 2.63—2.88 (16 H, m, NCH_2CH_2O), 3.28—3.63 (36 H, OCH_2, OH), and 3.68—3.78 (4 H, m, $CHOH$); *m/z* 696 (M^+); chloroform–benzene–methanol (8:3:0.5) as eluant.

3,10-*Dihydroxy*-5,8,15,18,23-*pentaoxa*-1,12-*diazabicyclo*-[10.8.5]*pentacosane* (**13**), δ 2.34—2.82 (12 H, m, NCH_2) and 3.33—3.96 (24 H, m, OCH_2, $CHOH$, OH); *m/z* 392 (M^+); chloroform–benzene–methanol (8:3:0.4) as eluant.

3,13-*Dihydroxy*-5,8,11,18,21,26-*hexaoxa*-1,15-*diazabicyclo*-[13.8.5]*octacosane* (**14**), δ 2.31—2.52 (4 H, m, NCH_2, CHOH), 2.55—2.79 (8 H, m, NCH_2CH_2O), 2.75—3.10 (26 H, m, OCH_2, OH), and 3.69—3.93 (2 H, m, $CHOH$); *m/z* 436 (M^+); chloroform–benzene–methanol (8:3:0.5) as eluant.

20,24-*Dihydroxy*-4,7,13,16,22-*pentaoxa*-1,10-*diazabicyclo*-[8.8.7]*pentacosane* (**15**), δ 2.38—2.80 (12 H, m, NCH_2) and 3.43—3.75 (24 H, m, OCH_2, CHOH, OH); *m/z* 392 (M^+) and 12,16,29,33-*tetrahydroxy*-4,7,14,21,24,31,37,40,45,48-*decaoxa*-1,10,18,27-*tetra-azatricyclo*[24.8.8.8^{9,18}]*pentacontane* (**23**), δ 2.40—2.77 (24 H, m, NCH_2), 3.33—3.60 (44 H, m, CH_2O, OH), and 3.65—3.95 (4 H, m, $CHOH$), *m/z* 784 (M^+); chloroform–benzene–methanol (8:3:0.3) as eluant.

3,10-*Dihydroxy*-5,8,15,18,23,26-*hexaoxa*-1,12-*diazabicyclo*-[10.8.8]*octacosane* (**16**), δ 2.41—2.70 (12 H, m, NCH_2) and 3.38—3.85 (28 H, m, CH_2O, $CHOH$, OH); *m/z* 436 (M^+) and 3,10,23,29-*tetrahydroxy*-5,8,15,18,25,28,35,38,43,46,51,54-*dodecaoxa*-1,12,21,32-*tetra-azatricylo*[30.8.8.8^{12,21}]*hexapentacontane* (**24**), δ 2.45—2.60 (8 H, m, NCH_2CHOH), 2.73 (16 H, t, *J* 5 Hz, NCH_2CH_2O), and 3.37—3.83 (56 H, m, OCH_2, $CHOH$, OH); *m/z* 872 (M^+); chloroform–benzene–methanol (8:3:0.5) as eluant.

3,13-*Dihydroxy*-5,8,11,18,21,26,29-*heptaoxa*-1,15-*diazabicyclo*[13.8.8]*hentriacontane* (**17**), δ 2.32—2.55 (4 H, m, NCH_2CHOH), 2.60—2.78 (8 H, m, NCH_2CH_2O), 3.33—3.63 (30 H, m, OCH_2, OH), and 3.70—3.98 (2 H, m, $CHOH$); *m/z* 480 (M^+); chloroform–benzene–methanol (8:3:0.5) as eluant.

3,14-*Dihydroxy*-(*benz*[f]-5,8,15,18,23,26-*hexaoxa*-1,12-*diazabicyclo*[10.8.8]*octacosane*) (**25**) (37%) as an oil (Found: C, 59.45; H, 8.35; N, 5.85. $C_{24}H_{40}N_2O_8$ requires C, 59.48; H, 8.32; N, 5.78%); δ 2.38—2.82 (12 H, m, NCH_2), 3.30—3.72 (20 H, m, CH_2O, $CHOH$, OH), 4.05—4.23 (4 H, m, $CH_2OC_6H_4$), and 6.73—6.78 (4 H, m, ArH); *m/z* 484 (M^+).

Dehydroxylation of Cryptands (**10**)—(**17**).—A typical experimental procedure is as follows. The solution of thionyl chloride (1.25 g, 10.5 mmol) in anhydrous chloroform (3 ml) was added dropwise to a solution of the cryptand (**15**) (1.65 g, 4.2 mmol) in anhydrous chloroform (7 ml) cooled to −10 °C for 1 h. Stirring was carried out for 2 h without cooling and for a further 4 h at reflux. The reaction mixture was recooled to 0 °C and a 10% solution of sodium carbonate (*ca.* 5 ml) was slowly added to it. The organic layer was separated, and the aqueous layer was extracted with chloroform (2 × 20 ml). The combined extracts were dried (Na_2SO_4), and the chloroform was evaporated under reduced pressure. The brown oily residue (*ca.* 1.6 g) was dissolved in anhydrous THF (10 ml) and added dropwise to the cooled (−5 °C) suspension of lithium aluminium hydride (0.4 g, 10 mmol) in anhydrous THF (3 ml). The reaction mixture was stirred for 2 h at room temperature and for 6 h at boiling temperature, then recooled to −5 °C and the excess of lithium aluminium hydride decomposed with ice–water (*ca.* 1 ml). The mixture was filtered and the inorganic precipitate washed with chloroform (*ca.* 150 ml). The organic solutions were combined, dried (Na_2SO_4), and the colourless oily residue left after evaporation of the solvents was subjected to chromatography with chloroform–hexane–propan-2-ol (5:5:0.3) as eluant. The resultant colourless oil (0.66 g) was identified as 4,7,13,16,22-*pentaoxa*-1,10-*diazabicyclo*[8.8.7]*pentacosane* (**31**), overall yield 44%; δ 1.63 (4 H, quint., *J* 6.2 Hz, $NCH_2CH_2CH_2O$), 2.42 (4 H,

t, *J* 6.2 Hz, $NCH_2CH_2CH_2O$), 2.53 (8 H, t, *J* 5.2 Hz, NCH_2CH_2O), and 3.38—3.56 (20 H, m, OCH_2) (Found: C, 59.9; H, 10.05; N, 7.85. $C_{18}H_{36}N_2O_5$ requires C, 59.96; H, 10.07; N, 7.77%); *m/z* 360 (M^+). The following compounds (**26**)—(**36**) were similarly prepared.

5,8,15,20-*Tetraoxa*-1,12-*diazabicyclo*[10.5.5]*docosane* (**26**), overall yield 22%, as an oil; δ 1.65 (4 H, quint., *J* 6.4 Hz, $NCH_2CH_2CH_2O$), 2.47 (4 H, t, *J* 6.4 Hz, NCH_2CH_2O), 2.55 (8 H, t, *J* 5.3 Hz, NCH_2CH_2O), and 3.45—3.63 (16 H, m, OCH_2) (Found: C, 60.75; H, 10.2; N, 8.95. $C_{16}H_{32}N_2O_4$ requires C, 60.72; H, 10.19; N, 8.85%); *m/z* 316 (M^+) and 3-*hydroxy*-5,8,15,20-*tetraoxa*-1,12-*diazabicyclo*[10.5.5]*docosane* (**34**) (8%), as an oil; δ 1.67 (2 H, quint., *J* 6.0 Hz, $NCH_2CH_2CH_2O$), 2.30—2.84 (12 H, m, NCH_2), and 3.26—3.78 (18 H, m, OCH_2, CHOH, OH) (Found: C, 57.85; H, 9.7; N, 8.37. $C_{16}H_{32}N_2O_5$ requires C, 57.81; H, 9.70; N, 8.43%); *m/z* 332 (M^+); chloroform–hexane–propan-2-ol (5:5:0.5) as eluant.

5,8,11,18,23-*Pentaoxa*-1,15-*diazabicyclo*[13.5.5]*pentacosane* (**27**), overall yield 55%, as an oil; δ 1.60 (4 H, quint., *J* 6.5 Hz, $NCH_2CH_2CH_2O$), 2.48 (4 H, t, *J* 6.5 Hz, $NCH_2CH_2CH_2O$), 2.56 (8 H, t, *J* 5.0 Hz, NCH_2CH_2O), and 3.42—3.67 (20 H, m, OCH_2) (Found: C, 60.0; H, 10.1; N, 7.7. $C_{18}H_{36}N_2O_5$ requires C, 59.96; H, 10.07; N, 7.77%); *m/z* 360 (M^+); chloroform–hexane–propan-2-ol (8:3:0.5) as eluant.

4,7,14,20-*Tetraoxa*-1,10-*diazabicyclo*[8.7.5]*docosane* (**28**), overall yield 32%, as an oil; δ 1.64 (4 H, quint., *J* 6.0 Hz, $NCH_2CH_2CH_2O$), 2.45 (4 H, t, *J* 6.0 Hz, $NCH_2CH_2CH_2O$), 2.53 (8 H, t, *J* 4.0 Hz, NCH_2CH_2O), 3.43 (4 H, t, *J* 6.0 Hz, $NCH_2CH_2CH_2O$), and 3.47—3.64 (12 H, m, OCH_2) (Found: C, 60.75; H, 10.25; N, 8.9. $C_{16}H_{32}N_2O_4$ requires C, 60.72; H, 10.19; N, 8.85%); *m/z* 316 (M^+); chloroform–hexane–propan-2-ol (5:5:0.3) as eluant.

5,8,15,18,23-*Pentaoxa*-1,12-*diazabicyclo*[10.8.5]*pentacosane* (**29**), overall yield 49%, as an oil; δ 1.65 (4 H, quint., *J* 6.7 Hz, $NCH_2CH_2CH_2O$), 2.49 (4 H, t, *J* 6.7 Hz, $NCH_2CH_2CH_2O$), 2.56 (8 H, t, *J* 5.2 Hz, NCH_2CH_2O), and 3.40—3.63 (20 H, m, OCH_2) (Found: C, 60.0; H, 10.05; N, 7.8. $C_{18}H_{36}N_2O_5$ requires C, 59.96; H, 10.07; N, 7.77%); *m/z* 360 (M^+) and 3-*hydroxy*-5,8,15,18,23-*pentaoxa*-1,12-*diazabicyclo*[10.8.5]*pentacosane* (**35**) (3%), as an oil; δ 1.63 (2 H, quint., *J* 6.4 Hz, $NCH_2CH_2CH_2O$), 2.31—2.39 (12 H, m, NCH_2), and 3.28—3.81 (22 H, m, OCH_2, CHOH, OH) (Found: C, 57.45; H, 9.65; N, 7.4. $C_{18}H_{36}N_2O_6$ requires C, 57.42; H, 9.64; N, 7.44%); *m/z* 376 (M^+); chloroform–hexane–propan-2-ol (5:5:0.4) as eluant.

5,8,11,18,21,26-*Hexaoxa*-1,15-*diazabicyclo*[13.8.5]*octacosane* (**30**), overall yield 44%, as an oil; δ 1.63 (4 H, quint., *J* 6.2 Hz, $NCH_2CH_2CH_2O$), 2.42 (4 H, t, *J* 6.2 Hz, $NCH_2CH_2CH_2O$), 2.53 (8 H, t, *J* 5.2 Hz, NCH_2CH_2O), and 3.38—3.56 (20 H, m, OCH_2) (Found: C, 59.4; H, 10.0; N, 7.0. $C_{20}H_{40}N_2O_6$ requires C, 59.38; H, 9.97; N, 6.93%); *m/z* 404 (M^+) and 3-*hydroxy*-5,8,11,18,21,26-*hexaoxa*-1,15-*diazabicyclo*[13.8.5]*octacosane* (**36**) (5%), as an oil; δ 1.64 (2 H, quint., *J* 6.1 Hz, $NCH_2CH_2CH_2O$), 2.35—2.88 (12 H, m, NCH_2), and 3.25—3.82 (26 H, m, OCH_2, CHOH, OH) (Found: C, 57.15; H, 9.6; N, 6.55. $C_{20}H_{40}N_2O_7$ requires C, 57.12; H, 9.59; N, 6.66%); *m/z* 420 (M^+); chloroform–hexane–propan-2-ol (5:5:0.3) as eluant.

5,8,15,18,23,26-*Hexaoxa*-1,12-*diazabicyclo*[10.8.8]*octacosane* (**32**), overall yield 46%, m.p. 47—48 °C; δ 1.66 (4 H, quint., *J* 6.7 Hz, $NCH_2CH_2CH_2O$), 2.53 (4 H, t, $NCH_2CH_2CH_2O$), 2.61 (8 H, t, *J* 5.2 Hz, NCH_2CH_2O), and 3.46—3.65 (24 H, m, OCH_2) (Found: C, 59.4; H, 10.0; N, 7.0. $C_{20}H_{40}N_2O_6$ requires C, 59.38; H, 9.97; N, 6.93%); *m/z* 404 (M^+); chloroform–hexane–propan-2-ol (5:5:0.2) as eluant.

5,8,11,18,21,26,29-*Heptaoxa*-1,15-*diazabicyclo*[13.8.8]*hentriacontane* (**33**), overall yield 38%, as an oil; δ 1.65 (4 H, quint., *J* 6.4 Hz, $NCH_2CH_2CH_2O$), 2.55 (4 H, t, $NCH_2CH_2CH_2O$), 2.65 (8 H, t, *J* 5.6 Hz, NCH_2CH_2O), and 3.45—3.65 (28 H, m, OCH_2) (Found: C, 58.95; H, 9.9; N, 6.35. $C_{22}H_{44}N_2O_7$ requires C, 58.90; H, 9.89; N, 6.25%); *m/z* 448 (M^+); chloroform–hexane–propan-2-ol (5:5:0.2) as eluant.

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