Synthesis of Polyamine Macrocycles and Cryptands Incorporating Bipirydine and Phenanthroline Moieties

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Introduction

Polyamine macrocycles may constitute an excellent basis for the study of molecular recognition of different kind of substrates, such as inorganic or organic cations,[1−6] anionic species,[6−13] and neutral molecules.[14] Metal coordination by polyazamacrocycles have been widely investigated, to design selective complexing agents, ionophores, and catalysts. Furthermore, even without the involvement of metal cations, protonated species of polyazamacrocycles are effective receptors for negative substrates, such as carboxylate or phosphate anions, through charge−charge and hydrogen bonding interactions and can also catalyze hydrolytic reactions and syntheses of nucleotides, such as ATP.[7−12]

We have now synthesized a series of new macrocyclic receptors containing a bipirydine moiety as integral part of a polyamine macrocyclic structure. The insertion of a bipirydine unit can provide a further binding site for both metal cations and nucleotide anions. This unit is rigid and provides two aromatic nitrogens whose unshared electron pairs may act cooperatively in binding cations. At the same time, the heteroaromatic moiety may offer an optimal binding site for the coordination of nucleotide anions or nucleobases, through π-stacking and hydrophobic interactions. Incorporation of bipirydine into macrocyclic structures allows to combination within the same ligand the special complexation features of macrocycles with the versatile photoactivity displayed by the metal complexes of this heterocycle.[15,16] Actually, the photophysical properties of the Eu(III), Tb(III), and Ru(II) complexes with bipirydine-containing cryptands, such as **1**[15a,b] and **2**,[15f] have been extensively studied in the past few years.

An attractive perspective is the use of the ligands herein reported for simultaneously metal binding, through coordination of the metal to the heteroaromatic nitrogen atoms, and proton binding, through protonation of the more basic amine groups of the aliphatic chain giving rise to "pH-modulated" luminescent complexes. Such a behavior has been recently found for the Eu(III) complex with **3**.[17]

Results and Discussion

Macrocycles **13**−**15** were obtained by following the synthetic procedure depicted in Scheme 2. The disodium salts of the tosylated amine **7**,[18] **8**,[19] and **9**[20] were obtained according to the general procedure of Richman and Atkins.[21] Reaction of 6,6′-bis(bromomethyl)-2,2′-bipyri-

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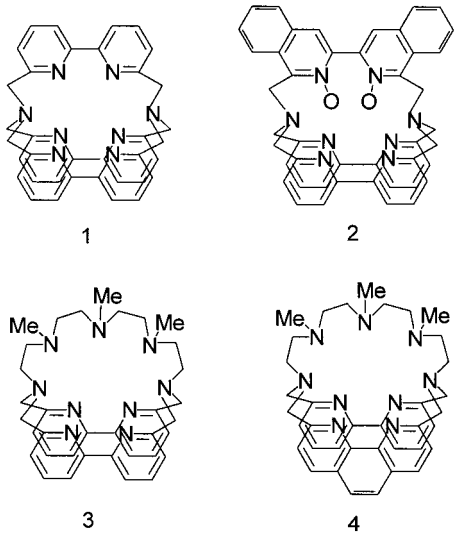
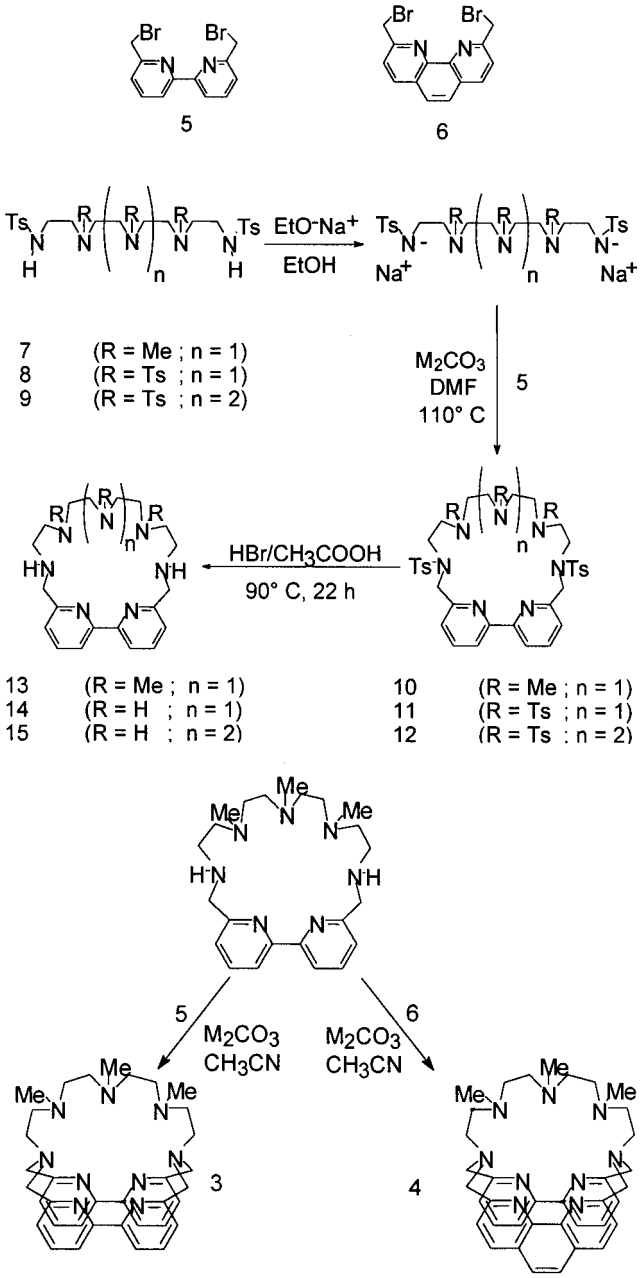
Scheme 1



Scheme 2



dine[22] **5** with the disodium salts of **7**−**9**, carried out in anhydrous DMF, afforded, after purification by column chromatography, the tosylated macrocycles **10**−**12** in rather satisfactory yields (**10**, 68%; **11**, 30%; **12**, 28%).

The most interesting finding is the remarkably higher yield for **10** with respect to **11** and **12**. This effect cannot be attributed to different "length" of the precursor polyamines **7**−**9**, since both **7** and **8** present two similar pentaaza chains. The higher yield for **10**, therefore, can be ascribed to the larger flexibility of precursor **7**, due to the presence of three *N*-methylated amine groups which replace the three tosylated ones in **8**. Most likely, the larger flexibility may allow **7** to easily achieve a better conformation in order to react with the two bromomethyl functions of **5**, which are instead separated by the rigid and smaller bipirydine moiety.

The tosylated compounds **10**−**12** were finally deprotected in 33% HBr/CH_3COOH mixture, according to a previously reported procedure,[5b] affording ligands **13**−**15** as hydrobromide salts. In the case of **13**, the formation of the hexahydrobromide salt implies a rather unusual protonation of a heteroaromatic nitrogen atoms. In the case of similar phenanthroline- or bipyridyl-containing polyamine ligands, in fact, protonation preferentially takes place on amine groups, at least in aqueous solution.[5b,11a] In the present case, protonation of the bipirydine moiety may be probably ascribed to the drastic acidic conditions used for ligand crystallization.

10 is a versatile precursor for the assembly of macropolycyclic structures, since it contains two secondary amine groups which can be connected by appropriate bridging moieties. Actually, reaction of **10** with 6,6′-bis-(bromomethyl)-2,2′-bipyridine **5** or 2,9-bis(bromomethyl)-1,10-phenanthroline[23] **6** gave the cryptands **3** and **4**, respectively (Scheme 1). The synthesis was carried out in CH_3CN in the presence of M_2CO_3 as base (M = Na or K). Separation by column chromatography (neutral alumina, $CHCl_3$) afforded the macrobicycles as their alkaline metal complexes ([M⊂**3**]Br and [M⊂**4**]Br), as shown by elemental analysis and FAB mass spectra. Although in similar cyclizations the simultaneous formation of macrotricyclic ligands, derived from 2:2 cyclizations, has been sometimes observed,[15g] in our case no macrotricyclic compound was isolated by using column cromatography. It is of interest that the yield of both cyclizations depends on the alkaline carbonate used. Both **3** and **4** were obtained in remarkably higher yields by using Na_2CO_3 as base ([Na⊂**3**]Br: 20.8%; [Na⊂**4**]Br: 24%). The formation of **3** and **4** was not observed by using Li_2CO_3, while minor amounts of the [K⊂**3**]Br (12%) and [K⊂**4**]Br (10%) complexes were isolated in the presence of K_2CO_3. On the other hand, the yield for the monocyclic ligands **10**, **11**, and **12** are not significantly affected by the alkaline metal carbonate used. A preliminary investigation on the metal coordination features of **3** and **4**, carried out by means of potentiometric measurements in aqueous solutions, show that both cryptands form more stable complexes with Na^+ with respect to Li^+ and K^+, probably due to a better dimensional matching between Na^+ and the

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macrobicyclic cavity.[24] At the same time, no interaction between **10**, **11**, or **12** and alkaline metals is found in aqueous solutions. These experimental observations strongly suggest that, in cryptand synthesis, the cyclizations are driven by a template effect, as already observed in other macrobicyclization procedures.[16] In all cases, however, the final products are collected as their alkaline metal salts. Further purification of the Na^+ complexes was performed by their precipitation as perchlorate salts, [Na⊂**3**]ClO_4 and [Na⊂**4**]ClO_4, which were obtained by treatment of aqueous solutions of [Na⊂**3**]$^+$ and [Na⊂**4**]$^+$ with $NaClO_4$ at alkaline pH's. Finally, simple addition of an ethanolic solution of $HClO_4$ to a ethanol solution of [Na⊂**3**]ClO_4 and [Na⊂**4**]ClO_4 at room-temperature allowed removal of the alkaline metal from the ligand cavity and recovery of **3** and **4** as their hydroperchlorate salts, **3**·5$HClO_4$ and **4**·5$HClO_4$, respectively. The corresponding "free" amine can be obtained by extraction with $CHCl_3$ of alkaline solutions containing **3**·5$HClO_4$ or **4**·5$HClO_4$. This seems to be a noticeable difference from previously reported cryptands, such as **1**, whose Na^+ complexes usually display a marked kinetic inertness. Actually removal of the metal from [Na⊂**1**]$^+$ takes place by using more drastic conditions, such as transmetalation with Ag^+ followed by precipitation of Ag_2S in order to obtain **1** as uncomplexed ligand.[15a] The much lower inertness of the present [Na⊂**3**]$^+$ and [Na⊂**4**]$^+$ complexes is probably due to the presence of the aliphatic pentaamine chain, which increases the ligand flexibility with respect to **1** and allows a prompt removal of the encapsulated alkaline metal cation. This allows to easy access to the free cryptands, as versatile precursors for different metal complexes.

Experimental Section

General. ^{1}H and ^{13}C NMR spectra were recorded on a 300-MHz instrument. CF-FAB mass spectra were performed with a VG−7070EQ mass spectrometer. The mass spectra of compounds **13**, **14**, **15**, **3**, and **4** were performed on the "free" amines obtained by extraction with $CHCl_3$ of alkaline solutions containing their hydrobromide or hydroperchlorate salts. Na and K elemental analyses were performed with a Varian AA-475 atomic absorption spectrophotometer.

5,8,11-Trimethyl-2,14-ditosyl-2,5,8,11,14-pentaaza[15]-[15](2,2′)[1,15]-bipyridylophane (10). A solution of sodium ethanolate, obtained by addition of small bits (ca. 200 mg each) of sodium (2.62 g, 0.11 mol) in dry ethanol (100 cm^3), was added to a suspension of **7**·3HCl (10.8 g, 0.02 mol) in ethanol (400 cm^3). The resulting mixture was refluxed for ca. 30 min, and the solvent was then removed under reduced pressure. The solid residue was dissolved in DMF (500 cm^3), and Na_2CO_3 (6 g, 0.057 mol) was added. To the resulting suspension, heated at 110 °C, was added **5** (7.0 g, 0.02 mol) in DMF (300 cm^3) over a period of ca. 6 h. The reaction mixture was kept at 115 °C for 2 h. After being cooled at room temperature, the suspension was filtered out, and the solvent was evaporated to dryness. The crude oil was chromatographied on neutral alumina eluting with $CHCl_3$. The eluted fractions were collected and evaporated to dryness affording **10** as a white solid. Yield 9.75 g (68%). ^{1}H NMR ($CDCl_3$): δ 1.70 (m, 4H), 1.86 (s, 3H), 2.03 (m, 4H), 2.11 (s, 6H), 2.16 (t, 4H), 2.46 (s, 6H), 3.22 (t, 4H), 4.49 (s, 4H), 7.35 (d, 4H), 7.60 (dd, 2H), 7.77 (d, 4H), 7.80 (m, 2H), 8.28 (dd, 2H) ppm. ^{13}C NMR ($CDCl_3$) δ 21.6, 42.1, 43.1, 47.3, 55.6, 55.7, 55.8, 56.0, 119.9, 123.8, 127.2, 129.9, 136.0, 137.7, 143.5, 154.8, 156.8 ppm. Anal. Calcd for $C_{37}H_{49}N_7S_2O_4$: C, 61.73; H, 6.86; N, 13.62. Found: C, 61.75; H, 6.90; N, 13.64.

5,8,11-Trimethyl-2,5,8,11,14-pentaaza[15]-[15](2,2′)[1,15]-bipyridylophane Hexahydrobromide (13·6HBr). Compound **10** (9.75 g, 0.014 mol) and phenol (70.0 g, 0.74 mol) were dissolved in 33% HBr/CH_3COOH (500 cm^3). The reaction mixture was kept under stirring at 90 °C for 22 h until a precipitate was formed. The solid was filtered out and washed several times with CH_2Cl_2. The hexahydrobromide salt was recrystallized from a EtOH/water 2:1 mixture. Yield 7.4 g (59%). ^{1}H NMR (D_2O pH = 11): δ(ppm) 1.97 (3H, s), 2.17 (6H, s), 2.19 (4H, t), 2.35 (4H, t), 2.38 (4H, t), 2.70 (4H, t), 3.93 (4H, s), 7.51 (2H, dd), 7.98 (2H, dd), 8.02 (2H, dd). ^{13}C NMR (D_2O pH = 11): δ(ppm) 42.26, 43.74, 45.51, 54.02, 54.66, 54.89, 56.54, 122.56, 125.49, 140.18, 156.54, 160.19 MS *m*/*z* 412 ([M +H]$^+$). Anal. Calcd for $C_{23}H_{43}N_7Br_6$: C, 30.80; H, 4.83; N, 10.93. Found: C, 30.78; H, 4.81; N, 10.91.

2,5,8,11,14-Pentatosyl-2,5,8,11,14-pentaaza[15]-[15](2,2′)-[1,15]-bipyridylophane (11). This compound was synthesized from **8** (9.6 g, 0.01 mol) and **5** (3.42 g, 0.01 mol) following the procedure reported for **10**. The crude solid was chromatographied on neutral alumina eluting with CH_2Cl_2:ethyl acetate (100:3). The eluted fractions were collected and evaporated to dryness, affording **11** as a colorless solid (3.46 g, 30.3%). ^{1}H NMR ($CDCl_3$): δ(ppm) 2.38 (s, 3H), 2.41 (s, 6H), 2.44 (s, 6H), 2.85 (m, 4H), 2.92 (m, 4H), 3.17 (m, 4H), 3.29 (m, 4H), 4.37 (s, 4H), 7.33 (m, 14H), 7.61 (d, 4H), 7.72 (d, 2H), 7.77 (d, 4H), 7.96 (d, 2H); ^{13}C NMR ($CDCl_3$) δ(ppm) 21.3, 47.1, 48.4, 49.0, 49.5, 54.7, 120.1, 123.9, 127.3, 127.6, 130.4, 134.4, 135.3, 135.5, 138.3, 143.2, 143.5, 155.0, 155.6. Anal. Calcd for $C_{55}H_{61}N_7O_{10}S_5$: C, 57.93; H, 5.39; N, 8.60. Found: C, 57.90; H, 5.37; N, 8.58.

2,5,8,11,14-Pentaaza[15]-[15](2,2′)[1,15]-bipyridylophane Pentahydrobromide (14·5HBr). This compound was synthesized from **11** (2.28 g, 2 mmol) following the procedure reported for **13** obtaining pure **14**·5HBr as a colorless solid (1.1 g, 71%). ^{1}H NMR (D_2O, pH = 11): δ (ppm) 3.52 (t, 4H), 3.54 (t, 4H), 3.72 (t, 4H), 3.73 (t, 4H), 4.77 (s, 4H), 7.82 (dd, 2H), 8.31 (dd, 2H), 8.36 (dd, 2H). ^{13}C NMR (D_2O pH = 11): δ (ppm) 44.7, 44.9, 45.1, 45.5, 52.2, 125.1, 127.1, 142.8, 150.9, 153.9. MS *m*/*z* 371 ([M + H]$^+$). Anal. Calcd for $C_{20}H_{36}N_7Br_5$: C, 31.03; H, 4.69; N, 12.67. Found: C, 31.3; H, 4.7; N, 12.8.

2,5,8,11,14,17-Hexatosyl-2,5,8,11,14,17-hexaaza[18]-[18]-(2,2′)[1,18]-bipyridylophane (12). This compound was synthesized from **9** (5.78 g, 5 mmol) and **5** (1.66 g, 5 mmol) following the procedure reported for **11** (1.87 g, 28%). ^{1}H NMR ($CDCl_3$): δ(ppm) 2.37 (s, 6H), 2.42 (s, 6H), 2.44 (s, 6H), 2.83 (s, 4H), 2.89 (m, 4H), 2.94 (m, 4H), 3.21 (m, 4H), 3.34 (m, 4H), 4.49 (s, 4H), 7.29 (m, 16H), 7.60 (d, 4H), 7.69 (d, 4H), 7.75 (d, 4H), 7.92 (d, 2H); ^{13}C NMR ($CDCl_3$): δ(ppm) 21.6, 47.5, 48.9, 49.5, 49.7, 49.9, 55.0, 120.2, 123.3, 127.5, 127.6, 127.7, 129.9, 134.8, 134.9, 135.3, 138.0, 143.4, 143.7, 154.9, 155.3. Anal.Calcd for $C_{64}H_{72}N_8O_{12}S_6$: C, 57.47; H, 5.43; N, 8.38. Found: C, 57.45; H, 5.40; N, 8.35

2,5,8,11,14,17-Hexaaza[18]-[18](2,2′)[1,18]-bipyridylophane Hexahydrobromide (15·6HBr). This compound was synthesized from **12** (1.87 g, 1.4 mmol) following the procedure reported for **13**, obtaining pure **15**·6HBr as a colorless solid (0.72 g, 57%). ^{1}H NMR (D_2O, pH = 11): δ(ppm) 3.29 (m, 8H), 3.42 (m, 8H), 3.57 (s, 4H), 4.66 (s, 4H), 7.65 (d, 2H), 8.13 (t, 2H), 8.34 (d, 2H). ^{13}C NMR (D_2O pH = 11): δ(ppm) 43.6, 43.8, 44.5, 44.9, 45.8, 52.3, 124.0, 126.9, 141.2, 150.8, 156.2. MS *m*/*z* 414 ([M + H]$^+$) Anal. Calcd for $C_{22}H_{42}N_8Br_6$: C, 29.42; H, 4.71; N, 12.48. Found: C, 29.40; H, 4.70; N, 12.46

Cryptand 3 ([Na⊂3]Br). A solution of **5** (2.84 g, 8.3 mmol) in dry CH_3CN (200 cm^3) was added over a period of 6 h to a refluxing and vigorously stirred suspension of **13**·6HBr (7.45 g, 8.3 mmol) and Na_2CO_3 (8.5 g, 0.08 mol) in CH_3CN (400 cm^3). After the addition was completed, the solution was refluxed for additional 2 h. The resulting suspension was filtered out, and the solution was vacuum evaporated to give a crude solid. The product was chromatographed on neutral alumina ($CHCl_3$). The eluted fractions were collected and vacuum evaporated to afford [Na⊂**3**]Br as a colorless solid, which was recrystallized from a $CHCl_3$:cyclohexane 1:1 mixture. Yield: 1.2 g (20.8%). ^{1}H NMR ($CDCl_3$): δ(ppm) 2.05 (s, 6H), 2.51 (b, 4H), 2.55 (s, 3H), 2.62 (m, 2H), 2.77 (t, 4H), 3.12 (b, 4H), 3.59 (b, 2H), 3.77 (d, 4H), 3.96 (d,

(24) Stability constants of the Li^+, Na^+, and K^+ complexes with **3** and **4**, determined by means of potentiometric measurements: [[Li⊂**3**]$^+$], log K = 3.4(1); [[Na⊂**3**]$^+$], log K = 7.0(1); [[K⊂**3**]$^+$], log K = 3.6(1); [[Li⊂**4**]$^+$], log K = 3.6(1); [[Na⊂**4**]$^+$], log K = 7.1(1); [[K⊂**4**]$^+$], log K = 4.0(1) (K = [[M⊂**L**]$^+$]/[M][**L**], **L** = **3** or **4**). The potentiometric measurements were performed at 298.1 K in 0.1 M NMe_4Cl by using the method and procedure from ref 5.

4H), 7.35 (m, 4H), 7.88 (m, 8H); ^{13}C NMR ($CDCl_3$): δ(ppm) 42.3, 42.9, 53.8, 53.9, 54.8, 55.0, 61.1, 120.5, 124.6, 138.8, 154.6, 158.9. MS *m*/*z* 614 ([M + Na]$^+$) Anal. Calcd for $C_{35}H_{45}N_9NaBr$: C, 60.51; H, 6.53; N, 18.15; Br, 11.38; Na, 3.31. Found: C, 60.73; H, 6.60; N, 18.25; Br, 11.22; Na, 3.24.

[Na⊂3]ClO$_4$. Addition of $NaClO_4 \cdot H_2O$ (5 g, 35 mmol) to an aqueous solution (10 cm^3, pH 11) of [Na⊂**3**]Br (1.0 g, 1.4 mmol) leads to the precipitation of [Na⊂**3**]ClO_4, as a white solid (0.93 g, 93%). ^{1}H NMR ($CDCl_3$): δ(ppm) 2.05 (s, 6H), 2.51 (m, 4H), 2.68 (m, 7H), 2.78 (t, 4H), 3.13 (m, 4H), 3.78 (d, 4H), 3.98 (d, 4H), 7.36 (dd, 4H), 7.85 (d, 4H), 7.94(dd, 4H); ^{13}C NMR ($CDCl_3$): δ(ppm) 42.26, 42.89, 53.84, 54.75, 61.06, 120.49, 124.59, 138.75, 154.61, 158.79. MS *m*/*z* 614 ([M + Na]$^+$) Anal. Calcd for $C_{35}H_{45}N_9NaClO_4$: C, 58.86; H, 6.35; N, 17.65. Found: C, 59.02; H, 6.42; N, 17.74

3·5HClO$_4$. Slow addition of a 20% ethanolic solution of $HClO_4$ to a solution of [Na⊂**3**]ClO_4 in ethanol leads to the formation, in almost quantitative yield, of the pentaperchlorate salt **3**·5$HClO_4$, as a white precipitate.^{1}H NMR (D_2O, pH = 2): δ(ppm) 2.39 (s, 3H), 3.04 (s, 6H), 3.07 (t, 4H), 3.56 (t, 4H), 3.62 (m, 4H), 3.74 (m, 4H), 4.30 (d, 4H), 4.55 (d, 4H), 7.57 (dd, 4H), 7.97 (m, 8H); ^{13}C NMR (D_2O pH = 2): δ(ppm) 40.9, 42.7, 51.8, 52.5, 52.8, 54.6, 61.0, 126.3, 128.8, 144.5, 146.9, 156.5. MS *m*/*z* 591 ([M + H]$^+$) Anal. Calcd for $C_{35}H_{50}N_9Cl_5O_{20}$: C, 38.42; H, 4.61; N, 11.52. Found: C, 38.41; H, 4.63; N, 11.50.

[K⊂3]Br. The K^+ complex with **3** was obtained as reported for [Na⊂**3**]Br, by performing the cyclization in the presence of K_2CO_3. Yield: 0.7 g (12.0%); MS *m*/*z* 630 ([M + K]$^+$). Anal. Calcd for $C_{35}H_{45}N_9KBr$: C, 59.14; H, 6.38; N,17.73; Br, 11.13; K, 5.50. Found: C, 59.30; H, 6.43; N, 17.83; Br, 10.95; K, 5.63.

Cryptand 4 ([Na⊂4]Br). This complex was synthesized from **13**·6HBr (7.45 g, 8.3 mmol) and **6** (3.0 g, 8.3 mmol) following the procedure reported for **3**. Yield: 1.43 g (24%). ^{1}H NMR ($CDCl_3$) δ 2.37 (s, 3H), 3.13 (s, 6H), 3.21 (t, 4H), 3.75 (t, 4H), 3.79 (m, 4H), 4.03 (m, 4H), 4.35 (d, 2H), 4.49 (d, 2H) 4.62 (d, 2H), 4.75 (d, 2H), 7.66 (d, 4H), 7.80 (d, 2H), 7.92 (m, 2H), 8.12 (s, 2H), 8.43 (d, 2H); ^{13}C NMR ($CDCl_3$) δ 42.4, 45.1, 50.7, 51.8, 52.5, 55.5, 62.2, 120.6, 125.3, 127.2, 128.9, 129.7, 144.0, 145.5, 146.1, 147.5, 156.1, 158.8. MS *m*/*z* 638 ([M + Na]$^+$). Anal. Calcd for $C_{37}H_{45}N_9NaBr$: C, 61.83; H, 6.31; N, 17.54; Br, 11.00. Na, 3.20. Found: C, 61.76; H, 6.25; N, 17.44; Br, 10.84; Na, 3.31.

[Na⊂4]ClO$_4$. The perchlorate Na^+ complex was obtained from [Na⊂**4**]Br as reported for [Na⊂**3**]ClO_4. Yield: 1.0 g (97%).^{1}H NMR ($CDCl_3$): δ 2.35 (s, 3H), 3.15 (s, 6H), 3.24 (t, 4H), 3.75 (m, 8H), 4.07 (m, 4H), 4.40 (d, 2H), 4.62 (d, 2H), 7.66 (d, 4H), 7.77 (d, 2H), 7.93 (m, 2H), 8.12 (s, 2H), 8.45 (d, 2H); ^{13}C NMR ($CDCl_3$) δ 42.7, 45.3, 50.6, 51.8, 52.5, 55.7, 62.0, 120.4, 125.1, 127.1, 129,1, 129.7, 144.3, 145.5, 146.0, 147.6, 156.0, 159.0. MS *m*/*z* 638 ([M+Na]$^+$). Anal. Calcd for $C_{37}H_{45}N_9NaClO_4$: C, 60.20; H, 6.14; N, 17.07. Found: C, 60.28; H, 6.21; N, 17.17.

4·5HClO$_4$. The hydroperchloric salt of **4** was obtained, in almost quantitative yield, as reported for **3**·5$HClO_4$. ^{1}H NMR (D_2O, pH = 2): δ(ppm) 2.49 (s, 3H), 3.11 (s, 6H), 3.18 (t, 4H), 3.64 (t, 4H), 3.76 (m, 4H), 3.94 (m, 4H), 4.40 (d, 2H), 4.56 (d, 2H), 4.63 (d, 2H), 4.67(d, 2H), 7.65 (d, 4H), 7.84 (d, 2H), 7.90 (m, 2H), 7.98 (s, 2H), 8.54 (d, 2H); ^{13}C NMR (D_2O pH = 2): δ(ppm) 40.7, 43.0, 52.0, 52.8, 52.9, 54.1, 61.5, 122.9, 126.6, 128.4, 128.8, 129.5, 143.0, 144.5, 146.2, 147.2, 155.1, 156.8. MS *m*/*z* 615 ([M + H]$^+$) Anal. Calcd for $C_{37}Cl_5H_{50}N_9O_{20}$: C, 39.75; H, 4.51; N, 11.27. Found: C, 39.76; H, 4.53; N, 11.29.

[K⊂4]Br. The K^+ complex with **4** was obtained as reported for [Na⊂**4**]Br, by performing the cyclization in the presence of K_2CO_3. Yield: 0.63 g (10.3%) MS *m*/*z* 654 ([M + K]$^+$). Anal. Calcd for $C_{37}H_{45}N_9KBr$: C, 60.48; H, 6.17; N, 17.15; Br, 10.86; K, 5.32. Found: C, 60.59; H, 6.23; N, 17.10; Br, 10.72; K, 5.25.

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