SYNTHESIS OF TRIS- AND TETRAKIS(TROPOCORONAND)S HAVING SHORT LINKER CHAINS[1]

Kimio Shindo,* Hidetsugu Wakabayashi, Luo-Cheng Zhang, Sumio Ishikawa, and Tetsuo Nozoe*†

Department of Chemistry, Faculty of Sciences, Josai University, Sakado, Saitama 350-02

†Tokyo Research Laboratories, Kao Corporation, 2-1-3 Bunka, Sumida-ku, Tokyo 131

Abstract - The syntheses of tris- and tetrakis(tropocoronand)s, a new kind of macrocycles derived from three or four aminotropone imine moieties bridged by three or four short methylene linker chains are described. These tropocoronands were prepared by the reaction of bis(2-methoxytropone imine)salts with α,ω-alkanediamine using a template or with tropopodand derived from benzo[*b*]cyclohepta[*e*][1,4]-oxazine with *N*-acetyl-1,2-ethanediamine by an intermolecular heterocycle exchange reaction.

Recently, we reported a very convenient, one pot synthesis of tetraazabis(tropocoronand)s (**1**)[2] and tropopodands (**2**) by the reaction of cyclohepta[*b*][1,4]oxazine (**3**)[3] with α,ω-alkanediamines (**4**) in high yields through an intermolecular heterocycle exchange reaction.[4] This method, however, gave bicyclic pyrazino or diazepino compounds (**5a,b**),[5] instead of the tropocoronand, when linker chains became short (n=2,3).[2] While one of us (T.N) and his co-workers previously sythesized **1** (n=2-6) from reactive troponoids and α,ω-alkanediamines (**4,** R=H, n=2-6) *via* bis(2-aminotropone) (**6,** R=H, n=2-6) and then the bis-2-alkoxytropone imine derivatives (**7**, n=2-6) under a high dilution condition.[6] Conversion of **6** (R=H, n=2) to the corresponding tropocoronand (**1**)(n=2) underwent in only 2% yield, but insted 2-phenyl-2-imidazol (**8**) was

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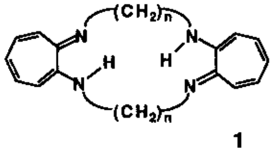
Dedicated to Dr. Arnold Brossi on the occasion of his 70th birthday.

obtained as the major product in 51% yield.

We wish to report here the synthesis of tris- and tetrakis(tropocoronand)s having short linker chains and related compounds.



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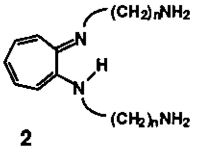

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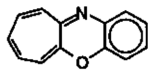

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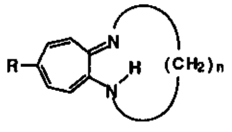
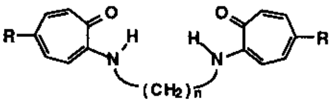
$H_2N-(CH_2)_n-NHR$

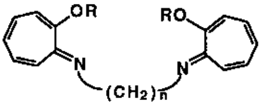
4a: R=H, n=2
4b: R=H, n=3
4c: R=Ac, n=2



5a-c **a**: R=H, n=2
b: R=H, n=3
c: R=iPr, n=2



6a-c **a**: R=H, n=2
b: R=H, n=3
c: R=iPr, n=2



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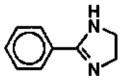

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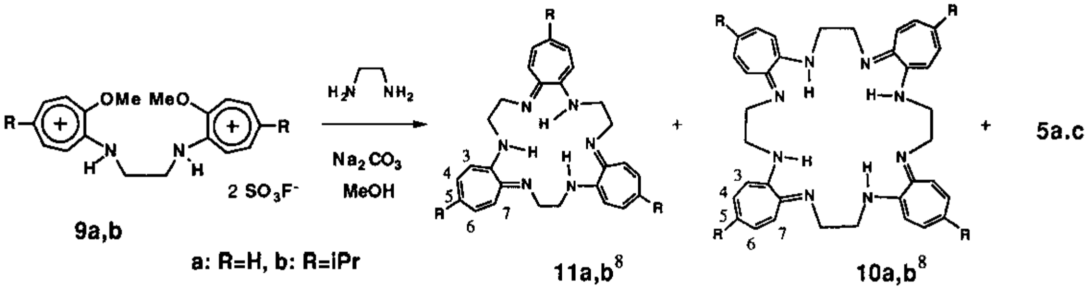
Results and Discussion

We first studied the reaction of *N,N'*-bis[2-methoxy-2,4,6-cycloheptatrienylium]-1,2-ethanediamine bisfluorosulfate (**9a**) with 1,2-ethanediamine (**4a**) to obtain bis(tropocoronand) (**1**, n=2) or tetrakis-(tropocoronand) (**10a**). Compound (**9a**) was prepared from **6a**[6] and methyl fluorosulfate in CH_2Cl_2. However, treatment of **9a** with **4a** in the presence of Et_3N (1:1.1:2.5 ratio) in absolute methanol at 20 °C for 30 h afforded, after column chromatography, bicyclic compound (**5a**) (69% yield) as the main product besides a small amount of **10a** (7%) and tris(tropocoronand) (**11a**, 13%).



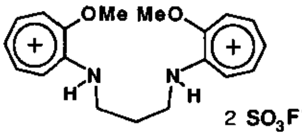
Then, in an attempt to increase the yields of coronands, Na_2CO_3 to a suspension of **9a** and **4a** in methanol, was added as a template, gradually depositing orange precipitates. The precipitates were collected and extracted with chloroform and, after chromatography, much higher yields of tetrakis(tropocoronand) (**10a**, mp > 300 °C, 32%) and tris(tropocoronand) (**11a**, mp 245-246 °C, 46%) were obtained. Compound (**10a**) showed uv absorption maxima at 262 (log ε 4.80), 345^{sh} (4.51), 362 (4.61), 414 (4.46), 438 (4.33), and 465 nm (3.99) which resemble those of **1**, and ^{1}H nmr signals at δ 3.67 (16H, s) due to methylene protons of symmetrical linker chains and at δ 6.18 (t), 6.37 (d), and 6.79 (dd), (4:8: ratio) due to five adjacent protons on the four seven-membered rings. FAB-ms spectrum of **10a** gave the molecular ion peak at m/z 585 (MH^+). These spectral data established the structure of **10a**. Compound (**11a**) showed uv absorption maxima and nmr signals which resemble those of **10a**. The mass spectrum [m/z 438 (M^+)], however, revealed the structure of tris(tropocoronand) for **11a**. Compound (**5a**) was also isolated from the filtrate in 15% yield. In a synthesis of **10a** and **11a** from the reaction of **9a** with **4a**, a template effect was found by the addition of some metals as shown in Table 1.

The same reaction of **9b** with **4a** in the presence of Na_2CO_3 afforded the corresponding tetrakis- and tris(tropocoronand)s (**10b**, **11b**) along with **5c**. The reaction of **9c** and **4b** with Na_2CO_3 in methanol gave tetrakis(tropocoronand) (**13**, 16%), bis-(tropocoronand) (**1**, n=3, 55%), and **5b** (25%).

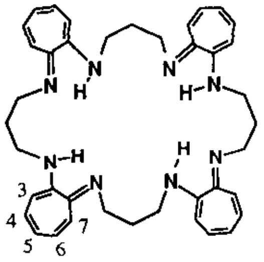
Table. 1. Template Effect of Some Alkaline Metals on Synthsis of Tris and Tetrakis(tropocoronand)s (**10a** and **11a**) by the Reaction of **9a** and **4a**.

Neutralization reagents		Yields (%) of products		
Metal source	amine	**10a**	**11a**	**5a**
Na_2CO_3	Et_3N	32	46	15
Na_2CO_3	---	29	45	19
K_2CO_3	Et_3N	16	28	47
Li_2CO_3	Et_3N	19	26	44
---	Et_3N	7	13	69

Next we studied the reaction of **9a** with podand (**2**, n=2) to obtain tris(coronand) (**11a**). Compound (**2**) was prepared by hydrolysis of the diacetyl derivative (**13**) which was available by treatment of **3** with *N*-acetyl-1,2-ethanediamine (**4c**) (1:4) in absolute ethanol at 80 °C for 30 h under an inert atmosphere.[7] Compound (**13**) (yellow needles, mp 170-171 °C) showed uv absorption maxima similar to the previously known tropopodands[2] and the structure was determined on the basis of nmr, ir, and mass spectra (see Experimental section). Upon heating in ethanol containing H_2SO_4 and H_2O, compound (**13**) gave sulfate (**14**) (yellow needles, mp 220-223 °C). Composition formula of **14** was determined by the elemental analysis, closely agreeable with $(C_{11}H_{18})_2 \cdot 5H_2SO_4 \cdot H_2O$. Compound (**2**) (n=2) was quantitatively obtained from **14** upon neutralization. The reaction of **9a** with **14** in methanol at 20 °C for 30 h was conducted likewise. The precipitates which formed were collected, extracted with chloroform, and recrystallized from chloroform-methanol to give **11a** in 67% yield. Compound (**5a**) was also obtained from the filtrate after chromatography.



9c



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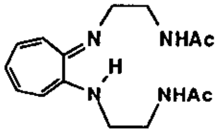

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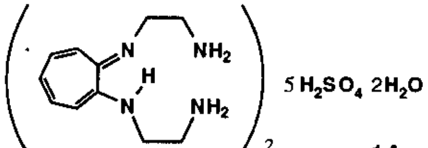

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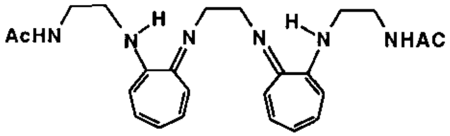
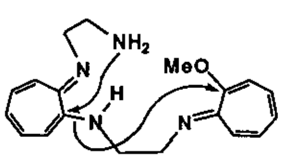


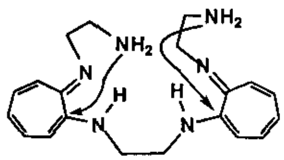
15b

The heterocycle exchange reaction of **3** with **2** (n=2, 1:1.2 ratio) gave **5a** (83%) and a small amount of **11a**[1] (4%) instead of bis(coronand) (**1**) (n=2). Although we attempted the synthesis of bis(aminotroponeimine) derivative (**15a**) from the reaction of **9a** and **4a** (1: excess), only **5a** was isolated.

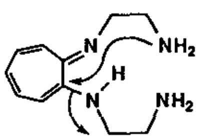
A similar reaction of **9a** with **4c**, however afforded diacetyl derivative (**15b**) in a high yield. Therefore, podand (**2**) (n=2) and the initially formed intermediate (**a**) or (**15a**) in the reaction of **9a** with **4a** are



a



15a



2 (n=2)

presumed to readily cyclize at the terminal amino group to give pyrazino derivative (**5a**) by extruding ethanediamine group as shown in the formulas below. The formation of bis(tropocoronand) (**1**, n=2) and 2-phenylimidazol (**8**) shown in the previous report[6] was not observed in all of the present experiments.

EXPERIMENTAL

The melting points were determined with a Yanagimoto MP-35 melting-point apparatus and were uncorrected. The ir and uv spectra were measured in $CDCl_3$ with a JEOL JNM-GX270 (100 or 270 MHz for ^1H and 67.8 MHz for ^{13}C) spectrometer using TMS as an internal standard. The assignments of all signals were made by employing a first-order analysis with the aid of a decoupling technique. The mass spectra were taken on a JEOL JMS-DX300 mass spectometer at 70 eV. The tlc analyses and column chromatoography were carried out with Merck Kieselgel 60F-254 plates and Wako gel C-200 using methanol-NaCl aq (1:1) as an eluent.

***N,N'*-Bis(2-methoxy-2,4,6-cycloheptatrienylidene)-1,2-ethanediammonium bis(fluorosulfate) (9a)**: A solution of **6a**[6a] (1.00 g, 3.73 mmol) and methyl fluorosulfate (1.70 g, 14.9 mmol) in CH_2Cl_2 (10 ml) was stirred for 24 h at room temperature. The precipitates were collected, washed with cold CH_2Cl_2 and dried in vacuo to give, upon recrystallization from methanol, **9a** (1.68 g, 91%) as pale yellow scales; mp 209 °C; uv λ max (MeOH) 248 (log ε 4.52), 338^{sh} (4.05), 372 nm (4.20); ^1H nmr (270 MHz, CD_3OD) δ 4.13 (4H, s, CH_2x2), 4.26 (6H, s, OCH_3x2), 7.65 (2H, t, J=9 Hz, H-5,5'), 7.80 (2H, d, J=11 Hz, H-7,7'), 7.90 (2H, dd, J=11 and 9 Hz, H-6,6'), 7.93 (2H, d, J=11 Hz, H-3,3'), 8.11 (2H, dd, J=11 and 9 Hz, H-4,4'). Anal. Calcd for $C_{18}H_{22}N_2O_8F_2S_2$: C, 43.54; H, 4.47; 5.68. Found: C, 43.83; H, 4.75; N, 5.37.

***N,N'*-Bis(5-isopropyl-1-oxo-2,4,6-cycloheptatrien-2-yl)-1,2-ethanediamine (6c)**: A solution of 5-isopropyl-2-methoxytropone (500 mg, 2.81 mmol) and **4a** (85 mg, 1.41 mmol) in ethanol (2 ml) was heated at 80 °C for 4 h and then the solution was set aside at room temperature, depositing crystals after several hours. The precipitates were filtered off, giving **6c** (430 mg, 87% yield) as yellow leaflets after recrystallization from ethanol; mp 219-222 °C; uv λ max ($CHCl_3$) 245 (log ε 3.77), 343 (3.55), 389^{sh} (3.27), 410 nm (3.42); ir (KBr) ν 3260, 2950, 1605, 1580, 1550, 1500, 1440, 1385, 1255, 1015, 845, 725, 635 cm^{-1}; ^1H nmr (270 MHz, $CDCl_3$) δ 1.22 (12H, d, J=7 Hz, CH_3x4), 2.80 (2H, septet, J=7 Hz, >CH- x2), 3.68 (4H, d, J=5.5 Hz, CH_2x2), 6.51 (2H, d, J=10.7 Hz, H-3,3'), 7.11 (2H, dd, J=10.7 and 2 Hz, H-4,4'), 7.22 (2H, dd, J=12.2 and 2 Hz, H-6,6'), and 7.24 (2H, br, NHx2); ^{13}C nmr (67.8 MHz, $CDCl_3$) δ 23.9, 37.2, 41.2, 109.1, 129.7, 133.3, 137.3, 143.6, 153.8, 176.2. Anal. Calcd. for $C_{22}H_{28}N_2O_2$: M. 352.2151 Found: m/z 352.2170

***N,N'*-Bis(5-isopropyl-2-methoxy-2,4,6-cycloheptatrienylidene)-1,2-ethanediammonium bis(fluorosulfate) (9b)**: A solution of **6c** (500 mg, 1.42 mmol) in CH_2Cl_2 (10 ml) was treated as above with methyl fluorosulfate (630 mg, 5.52 mmol) to give **9b** (758 mg, 92%): Pale yellow scales (from MeOH); mp 125-128 °C; uv λ max (MeOH) 248 (log ε 4.61), 335^{sh} (4.12), 374 nm (4.28); ^1H nmr (270 MHz, CD_3OD) δ 1.32 (12H, d, J=7 Hz, CH_3x4), 3.09 (2H, septet, J=7 Hz, >CH-x2), 4.15 (4H, s, CH_2x2), 4.25 (6H, s, OCH_3x2), 7.74 (2H, d, J=11 Hz, H-7,7'), 7.83 (2H, dd, J=11 and 2 Hz, H-6,6'), 7.99 (2H, d, J=12 Hz, H-3,3'), 8.13 (2H, dd, J=12 and 2 Hz, H-4,4'); ^{13}C nmr (67.8 MHz, CD_3OD) δ 23.7 (CH_3), 38.7, 42.6 (CH_2), 58.6 (OCH_3), 122.5, 124.7, 138.2, 146.3, 156.8, 158.3, 159.3. Anal. Calcd for $C_{24}H_{34}N_2O_8F_2S_2$: C, 49.64; H, 5.90; N, 4.82. Found: C, 49.39; H, 5.82; N, 4.61.

***N,N'*-Bis(2-methoxy-2,4,6-cycloheptatrienyldene)-1,3-propanediammonium bis(fluorosulfate) (9c):** Treatment of **6b**[6a] (900 mg, 3.19 mmol) with methyl fluorosulfate (1.45 g, 12.7 mmol) in CH_2Cl_2 (20 ml) similarly gave **9c** (1.49 g, 92%): Pale yellow crystals (from MeOH); mp 205-207 °C; uv λ max (MeOH) 246 (log ε 4.66), 333^{sh} (4.16), 364 nm (4.29); ^1H nmr (270 MHz, CD_3OD) δ 2.26 (2H, quintet, J=7 Hz, CH_2), 3.87 (4H, t, J=7 Hz, CH_2x2), 4.27 (6H, s, CH_3x2), 7.58 (2H, t, J=9 Hz, H-5,5'), 7.73 (2H, d, J=10 Hz, H-7,7'), 7.86 (2H, ddd, J=10, 9 and 1 Hz, H-6,6'), 7.88 (2H, d, J=11.5 Hz, H-3,3'), 8.01 (2H, ddd, J=11.5, 9, and 1 Hz, H-4,4'); ^{13}C nmr (67.8 MHz, CD_3OD) δ 26.8 (CH_2), 42.4 (N-CH_2), 58.8 (OCH_3), 121.6, 124.5, 134.1, 140.6, 146.0, 159.3, 160.8. Anal. Calcd for $C_{19}H_{24}N_2OF_2S_2$: C, 44.70; H, 4.73; N, 5.49. Found: C, 44.64; H, 5.03; N, 5.41.

Reaction of 9a with 4a.

(a): A suspension of **9a** (200 mg, 0.40 mmol), **4a** (27 mg, 0.45 mmol), and Et_3N (200 mg, 1.98 mmol) in methanol (5 ml) was stirred for 30 h at room temperature. The reaction mixture was concentrated in vacuo and the residue was extracted with chloroform. After concentration the desidue was passed through a silica gel column using methanol-NaCl aq (1:1) as eluent to give **5a** (81 mg, 69% yield), **10a** (8 mg, 7%) and **11a** (15 mg, 13%).

(b) The reaction in the presence of sodium carbonate: To a suspension of **9a** (200 mg, 0.40 mmol) and Na_2CO_3 (200 mg, 1.89 mmol) in methanol (10 ml) were added **4a** (27 mg, 0.45 mmol) and Et_3N (50 mg, 0.50 mmol), and the mixture was stirred for 30 h at room temperature. Precipitates were collected, and extracted with chloroform. The extracts were combined with the filtrate and concentrated in vacuo. The residue was disssolved in chloroform and chromatographed as described above to give **5a** (18 mg, 15%), **10a** (38 mg, 32%) and **11a** (54 mg, 46%). The reactions of **9a**, **4a** (mole ratio 1: 1.1), Et_3N and K_2CO_3 or Li_2CO_3 similarly gave **5a**, **10a** and **11a**, and the yields are given in Table 1.

7,8,16,17,25,26,34,35-Octahydro-6*H*,15*H*,24*H*,33*H*-tetracyclohepta[*b,h,n,t*][1,4,7,10,13,16,19,22]octaazacyclotetracosine (10a): Yellow needles (from $CHCl_3$); mp > 300 °C; uv λ max ($CHCl_3$) 262 (log ε 4.80), 345^{sh} (4.51), 362 (4.61), 414 (4.46), 438 (4.33), 465 nm (3.99); ir (KBr) ν 3210, 2900, 2845, 2825, 1605, 1588, 1548, 1535, 1530, 1510, 1500, 1493, 1470, 1450, 1425, 1414, 1380, 1350, 1270, 1205, 1115, 1055, 1005, 970, 928, 820, 745, 705, 620 cm^{-1}; ^{1}H nmr (270 MHz, $CDCl_3$) δ 3.67 (16H, s, CH_2x8), 6.18 (4H, t, J=9 Hz, H-5x4), 6.37 (8H, d, J=11 Hz, H-3,7 x4), 6.79 (8H, dd, J=11 and 9 Hz, H-4,6x4); FAB-ms m/z 585 (MH$^+$). Anal. Calcd for $C_{36}H_{40}N_8$: C, 73.94; H, 6.89; N, 19.16. Found: C, 73.65; H, 6.62; N,18.89.

7,8,16,17,25,26-Hexahydro-*6H*,*15H*,*24H*-tricyclohepta[*b*,*h*,*n*][1,4,7,10,13,16]hexaazacyclooctadecine (11a): Yellow needles (from $CHCl_3$-MeOH); mp 245-246 °C; uv λ max ($CHCl_3$) 264 (log ε 4.86), 345^{sh} (4.58), 362 (4.70), 411 (4.55), 436 (4.37), 465 nm (3.90); ir (KBr) ν 3250, 2850, 1585, 1505, 1460, 1260, 1120, 880, 740, 700, 620 cm^{-1}; ^{1}H nmr (270 MHz, $CDCl_3$) δ 3.66 (12H, s, CH_2x6), 6.17 (3H, t, J=9.5 Hz, H-5x3), 6.35 (6H, d, J=11.5 Hz, H-3,7 x3), 6.80 (6H, dd, J=11.5 and 9.5 Hz, H-4,6x3); ^{13}C nmr (67.8 MHz, $CDCl_3$) δ 46.1 (CH_2), 110.4 (C-3,7), 117.8 (C-5), 133.4 (C-4,6), 153.7 (C-1,2); ms (70 eV) m/z 438 (M$^+$, 39%), 409 (7), 305 (12), 279 (22), 159 (56), 147 (87), 131 (100). Anal. Calcd for $C_{27}H_{30}N_6$: C, 73.94; H, 6.889; N, 19.16. Found: C, 73.57; H, 6.72; N,19.15.

Reaction of 9b with 4a: A suspension of **9b** (200 mg, 0.34 mmol), **4a** (23 mg, 0.38 mmol), Et_3N (50 mg, 0.50 mmol) and Na_2CO_3 (200 mg, 1.89 mmol) in methanol (10 ml) was similarly treated as above to give **5c** (23 mg, 18%), **10b** (41 mg, 32%) and **11b** (56 mg, 43%).

7,8,16,17,25,26,34,35-Octahydro-*6H*,*15H*,*24H*,*33H*-3,12,21,30-*tetraisopropyltetracyclohepta*[*b*,*h*,*n*,*t*][1,4,7,10,13,16,19,22]octaazacyclotetracosine (10b): Yellow needles (from $CHCl_3$); mp > 300 °C; uv λ max ($CHCl_3$) 264 (log ε 5.31), 348^{sh} (5.05), 365 (5.12), 417 (4.95), 435 nm (4.86); ir (KBr) ν 3220, 2950, 2850, 1585, 1505, 1440, 1390, 1290, 1260, 815 cm^{-1}; ^{1}H nmr (500 MHz, $CDCl_3$) δ 1.17 (24H, d, J=7 Hz, CH_3x8), 2.63 (4H, septet, J=7 Hz, CHx4), 3.64 (16H, s, CH_2x8), 6.36 (8H, d, J=11.5 Hz, H-4,6x4), 6.70 (8H, d, J=11.5 Hz, H-3,7x4); FAB-ms m/z 753 (MH$^+$). Anal. Calcd for $C_{48}H_{64}N_8$: C, 76.56; H, 8.57; N, 14.88. Found: C, 76.28; H, 8.63; N, 14.61.

7,8,16,17,25,26-Hexahydro-*6H*,*15H*,*24H*-3,12,21-triisopropyltricyclohepta[*b*,*h*,*n*][1,4,7,-10,13,16]hexaazacyclooctadecine (11b): Yellow needles (from $CHCl_3$-MeOH); mp 235-236 °C; uv λ max ($CHCl_3$) 265 (log ε 4.64), 345^{sh} (4.41), 364 (4.51), 414 (4.32), 432 nm^{sh} (4.21); ir (KBr) ν 3250, 2950, 2800, 1580, 1505, 1445, 1390, 1300, 1260, 815, 635 cm^{-1}; ^{1}H nmr (270 MHz, $CDCl_3$) δ 1.16 (18H, d, J=7 Hz, CH_3x6), 2.63 (3H, septet, J=7 Hz, CHx3), 3.62 (12H, s, CH_2x6), 6.32 (6H, d, J=11.5 Hz, H-4,6x3), 6.70 (6H, d, J=11.5 Hz, H-3,7x3); ^{13}C nmr (67.8 MHz, $CDCl_3$) δ 24 (CH_3), 36.5 (CH), 46 (CH_2), 110 (C-3,7), 131.5 (C-4,6), 137 (C-5), 152 (C-1,2); ms (70 eV) m/z 564 (M$^+$, 28%), 549 (13), 535 (9), 375 (1), 363

(24), 189 (92), 173 (100). Anal. Calcd for $C_{36}H_{48}N_6$: C, 76.56; H, 8.57; N, 14.88. Found: C, 76.45; H, 8.74; N, 14.94.

1*H*-2,3-Dihydro-7-isopropylcyclohepta[*b*][1,4]pyrazine (5c): Yellow oil; uv λ max (MeOH) 252 (log ε 4.49), 368 (3.84), 428 nm (3.81); ^{1}H nmr (100 MHz, $CDCl_3$) δ 1.12 (6H, d, J=7 Hz, CH_3x2), 2.56 (1H, septet, J=7 Hz, >CH-x2), 3.48 (4H, s, CH_2x2), and 6.58 (4H, s, H-5,6,8,9). Found: m/z 188.1337. Calcd for $C_{12}H_{16}N_2$ M. 188.1313.

Reaction of 9c with 4b: Compound (**9c**) (200 mg, 0.39 mmol) similarly was treated with **4b** (32 mg, 0.43 mmol) in the presence of Et_3N (50 mg, 0.50 mmol) and Na_2CO_3 (200 mg, 1.89 mmol) in methanol (10 ml) gave **12** (25 mg, 16%), **1** (n=3) (101 mg, 65%) and **5c** (17 mg, 11%).

6,7,8,9,16,17,18,19,26,27,28,29,36,37,38,39-Hexadecahydrotetracyclohepta[*b*,*i*,*p*,*r*][1,4,-8,11,15,18,22,25]octaazacyclooctacosine (12): Yellow needles (from $CHCl_3$-MeOH); mp > 300 °C; uv λ max ($CHCl_3$) 261 (log ε 4.90), 346^{sh} (4.60), 360 (4.68), 415 (4.55), 441^{sh} (4.38), 465 nm^{sh} (3.87); ir (KBr) ν 3200, 2900, 2820, 1585, 1505, 1450, 1380, 1270, 1120, 740, 700, 620 cm^{-1}; ^{1}H nmr (270 MHz, $CDCl_3$) δ 2.25 (8H, quintet, J=7 Hz, CH_2x4), 3.44 (16H, t, J=7.3 Hz, CH_2x8), 6.14 (4H, t, J=9 Hz, H-5x4), 6.31 (8H, d, J=11 Hz, H-3,7 x4), 6.77 (8H, dd, J=11 and 9 Hz, H-4,6x4); ^{13}C nmr (67.8 MHz, $CDCl_3$) δ 30.1 (CH_2), 44.5 (CH_2), 110.4 (C-3,7), 117.7 (C-5), 133.4 (C-4,6), 153.7 (C-1,2); FAB-ms m/z 641 (MH^+). Anal. Calcd for $C_{40}H_{48}N_8$: C, 74.97; H, 7.55; N, 17.49. Found: C, 74.65; H, 7,63; N, 17.28.

***N*-Acetyl-*N'*-[2-[(2-acetamidoethyl)amino]-2,4,6-cycloheptatrienylidene]-1,2-ethanediamine (13):** A mixture of **3**[3] (500 mg, 2.56 mmol) and *N*-acetyl-1,2-ethanediamine (**4c**) (1.04 g, 10.2 mmol) in absolute ethanol (6 ml) was heated at 80 °C for 30 h under an argon atomosphere. After concentration in vacuo, the residue dissolved in chloroform was washed with 10% aqueous NaOH and water. The organic layer was concentrated and then passed through a silica gel column using benzene-methanol (20:1) as an eluent to give **13** (660 mg, 90%); Yellow needles (from $CHCl_3$); mp 170-171 °C ; uv λ max (MeOH) 260 (log ε 4.31), 327^{sh} (3.73), 347 (3.98), 357 (4.02), 396^{sh} (3.81), 415 (3.90), 436^{sh} (3.76), 463 nm (3.29); ir (KBr) ν 3450, 3300, 2920, 2850, 1640, 1590, 1560, 1540, 1510, 1490, 1450, 1395, 1370, 1265,1140, 1030, 960, 740, 700 cm^{-1}; ^{1}H nmr (270 MHz, $CDCl_3$) δ 2.06 (6H, s, CH_3x2), 3.36 (4H, m, CH_2x2), 3.68 (4H, m, CH_2x2), 6.18 (1H, t, J=10 Hz, H-5), 6.22 (2H, d, J=10 Hz, H-3,7), 6.76 (2H, t, J=10 Hz, H-4,6), 7.15 (2H, br, NH); ms (70 eV) m/z 290 (M^+, 7%), 218 (64), 204 (26), 159 (15), 133 (100), 86 (86). Found: m/z 290.1766. Calcd for $C_{15}H_{22}N_4O_2$: M, 290.1742.

Hydrolysis of 13. A solution of **13** (400 mg, 1.38 mmol), H_2O (0.5 ml) and H_2SO_4 (0.5 ml) in ethanol (10 ml) was heated at 80 °C for 20 h. After having been set aside overnight at room temperature, the pale yellow needles which formed was collected and washed with cold methanol to give sulfate (**14**) (362 mg, 56%). The filtrate was neutralized with 10% NaOH, extracted with chloroform. The extracts were concentrated in vacuo. The residue was dissolved in chloroform and passed through a silica-gel column using methanol-NaCl aq (1:1) as an eluent to give **5a** (23 mg, 11%) and unreacted **13** (107 mg, 27%). Sulfate (**14**) was neutralized to give, upon extraction with chloroform, **2** (n=2) quantitatively.

***N*-[2-(2-Aminoethyl)amino-2,4,6-cycloheptatrienylidene]-1,2-ethanediamine (2, n=2):** Yellow crystals; mp 110-112 °C; uv λ max ($CHCl_3$) 240^{sh}, 262, 348, 360, 418, 423, 465 nm^{sh}; ir (KBr) ν 3380, 3180, 2940, 2870, 1590, 1570, 1530, 1505, 1465, 1455, 1425, 1387, 1332, 1265, 1210, 1132, 980, 880, 815, 735, 703 cm^{-1}; ^1H nmr (270 MHz, $CDCl_3$) δ 1.76 (4H, br, NH_2x2), 3.06 (4H, t, J=6 Hz, CH_2x2), 3.38 (4H, t, J=6 Hz, CH_2x2), 6.18 (1H, t, J=9.5 Hz, H-5), 6.33 (2H, d, J=11 Hz, H-3,7), 6.77 (2H, dd, J=11 and 9.5 Hz, H-4,6); ^{13}C nmr (67.8 MHz, $CDCl_3$) δ 42.13 (t, CH_2), 49.30 (t, CH_2), 110.57 (d, C-3,7), 118.21 (d, C-5), 133.13 (d, C-4,5), 153.48 (s, C-1,2); ms (70 eV) m/z 206 (M^+, 10%), 176 (99), 145 (56), 133 (100). Found: m/z 206.1535. Calcd for $C_{11}H_{18}N_4$: M, 206.1531.

Sulfate **14**: $(C_{11}H_{18}N_4)_2 \cdot 5H_2SO_4 \cdot 2H_2O)$; mp 120-123 °C. Anal. Calcd for $C_{22}H_{50}N_8O_{22}S_5$: C, 28.14; H, 5.37; N, 11.93. Found: C, 28.14; H, 5.33; N, 11.73.

Reaction of 9a with 14: *Treatment of* **9a** *(200 mg, 0.40 mmol) with* **14** (206 mg, 0.22 mmol), Et_3N (50 mg, 0.50 mmol) and Na_2CO_3 (200 mg, 1.98 mmol) in methanol (10 ml) in a manner similar to that described above for **9a** with **4a** gave **11a** (117 mg, 67%) and **5a** (21 mg, 9%).

Reaction of 3 with 2 (n=2): A solution of **3** (200 mg, 1.02 mmol) and **2** (n=2) (250 mg, 1.21 mmol) in absolute ethanol (2 ml) was heated at 70 °C for 30 h under an argon atomosphere.[7] After concentration in vacuo, the residue dissolved in chloroform was washed with 10% aqueous NaOH and water, concentrated and then passed through a silica gel column using methanol-NaCl aq (1:1) solution as an eluent to give **11a** (16 mg, 4%) and **5a** (123 mg, 83%).

***N,N'*-Bis[2-(2-acetamidoethyl)amino-2,4,6-cycloheptatrienylidene]-1,2-ethanediamine (15b):** A suspension of **9a** (200 mg, 0.403 mmol), **4c** (150 mg, 1.47 mmol), and Na_2CO_3 (100 mg, 1.47 mmol) in methanol (10 ml) was treated as above to give, upon recrystallization from chloroform, **15b** as yellow needles (153 mg, 87%); mp 176-180 °C ; uv λ max (MeOH) 260 (log ε 4.53), 349 (4.21), 357 (4.23), 414 nm (4.16); ir (KBr) ν 3450, 3290, 2920, 2850, 1640, 1590, 1540, 1510, 1460, 1430, 1385, 1370, 1270, 1205, 1085, 880, 860, 740, 700, 605 cm^{-1}; ^1H nmr (270 MHz, $CDCl_3$) δ 1.95 (6H, s, CH_2x2), 2.18 (2H, t, J=6.7 Hz, N<u>H</u>Acx2), 3.48 (8H, m, CH_2x4), 3.62 (4H, m, CH_2x2), 6.10 (2H, s, NHx2), 6.22 (2H, t, J=10.5 Hz, H-5), 6.27 (2H, d, J=10 Hz, H-7 or 3), 6.33 (2H, d, J=11 Hz, H-3 or 7), 6.83 (4H, m, J=10.5 Hz, H-4,6); FAB-ms m/z 437 (MH^+). Anal. Calcd for $C_{24}H_{32}N_6O_2$: C, 66.03; H, 7.39; N, 19.25. Found: C, 66.23; H, 7.64; N, 18.96.

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RFERENCES

1. A part of the results have been preliminarily presented: a) T. Nozoe, K. Shindo, H. Wakabayashi, and S. Ishikawa, *Heterocycles*, 1992, **34**, 881; b) K. Shindo, H. Wakabayashi, L.C. Zhang, S. Ishikawa, and T. Nozoe, " 7th International Symposium on the Chemistry of Novel Aromatic Compounds" Victoria, Canada, July 1992, Abstr., P 106.
2. a) K. Shindo, H. Wakabayashi, S. Ishikawa, and T. Nozoe, *Bull Chem. Soc. Jpn.*, 1993, **66**, 2941; b) K. Shindo, H. Wakabayashi, S. Ishikawa, and T. Nozoe, *Heterocycles*, 1994, **37**, 943.
3. T. Nozoe, H. Okai, and T. Someya, *Bull. Chem. Soc. Jpn.*, 1978, **51** 2185.
4. a) T. Nozoe, H. Okai, H. Wakabayashi, and S. Ishikawa, *Chem. Lett.*, **1988**, 1589; b) T. Nozoe, K. Shindo, and S. Ishikawa, *Chem. Lett.*, **1988**, 1593.
5. T. Nozoe, S. Ishikawa, and K. Shindo, *Heterocycles*, 1989, **28**, 733.
6. a) S. Imajo, K. Nakanishi, M. Roberts, S. J. Lippard, and T. Nozoe, *J. Am. Chem. Soc.*, 1983, **105**, 2071; b) A. Zask, N. Gonnella, K. Nakanishi, C.J. Turner, S. Imajo, and T. Nozoe, *Inorg. Chem.*, 1986, **25**, 3400.
7. We used a small sealed tube under an argon atmosphere to avoid oxygen on refluxing. A stopped bottle can also be used more conveniently.
8. For convenience, numbering of the seven-memberd ring of **10**, **11**, and **12** on the nmr assignments are shown in the formulas.

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