Phosphate binding by a novel Zn(II) complex featuring a *trans*-1,2-diaminocyclohexane ligand. Effective anion recognition in water

Oscar Francesconi,[a] Matteo Gentili,[a] Francesco Bartoli,[a] Andrea Bencini,*[a] Luca Conti,[a] Claudia Giorgi,[a] and Stefano Roelens*[b]

[a] *Dipartimento di Chimica "Ugo Schiff", Università di Firenze, Polo Scientifico e Tecnologico, I-50019 Sesto Fiorentino, Firenze, Italy.*
E-mail: andrea.bencini@unifi.it
[b] *CNR, Istituto di Metodologie Chimiche (IMC), Università di Firenze, Polo Scientifico e Tecnologico, I-50019 Sesto Fiorentino, Firenze, Italy.*
E-mail: stefano.roelens@unifi.it

Supporting Information

Table of contents

General.

ESI-MS mass spectra were recorded on a LCQ-Fleet Ion Trap equipped with a standard Ionspray interface from Thermo Scientific. NMR spectra were recorded on Varian Gemini 200, Gemini 300, Mercury Plus 400 (all equipped with a direct detection probe), Inova 400, Bruker Avance 400 and 500 (all equipped with an indirect detection probe) instruments. For D_2O solutions, the spectra were recorded at different pH at 308 K. pD was adjusted by the addition of small amounts of 0.01 M NaOD and DCl. The pH was calculated by the measured pD values by using the following formula: pH = pD-0.40.[1] Chemical shifts are reported in part per million (δ) relative to TMS, using the residual solvent line as secondary internal reference (7.26 ppm for spectra run in $CDCl_3$, 1.96 ppm for spectra run in CD_3CN, 4.65 for spectra run in D_2O, 3.34 ppm for spectra run in CD_3OD and 2.54 ppm for spectra run in DMSO-d6). ^{13}C NMR spectra were obtained at 50, 75, 100 and 125 MHz. Chemical shifts are reported in δ relative to TMS, using the central solvent line as secondary internal reference at 77.0 ppm for spectra run in $CDCl_3$, 49.86 ppm for spectra run in CD_3OD and 40.45 ppm for spectra run in $DMSOd_6$. Elemental analyses were performed with a Perkin-Elmer series II CHNS/O 2400 Elementary Analyzer. $[\alpha]_D$ values were measured using a JASCO DIP-370 instrument. Melting points were measured with a Melting Point Büchi 510.

Potentiometric measurements.

Equilibrium constants for protonation and complexation reactions were determined by means of potentiometric measurements (pH = -log $[H^+]$), carried out in 0.1 M NMe_4Cl at 308 ± 0.1 K, in the pH range 2.5-10.5, by using the equipment that has been already described.[2] The reference electrode was an Ag/AgCl electrode in saturated KCl solution. The glass electrode was calibrated as a hydrogen concentration probe by titrating known amounts of HCl with CO_2-free NaOH solutions and determining the equivalent point by the Gran's method.[3] This allows one to determine the standard potential E^o, and the ionic product of water (pK_w = 13.40 ± 0.01). 1×10^{-3} M ligand concentrations was generally employed in the potentiometric measurements. In the study on metal complexation, the metal to ligand molar ratio was varied from 0.5:1 to 3:1, while in the measurements with anions, the anion to ligand molar ratio was varied from 1:1 to 4:1. The sodium salts Na_2HPO_4, $Na_4P_2O_7{\cdot}10H_2O$ and $Na_5P_3O_{10}{\cdot}6H_2O$, $Na_3HATP{\cdot}3H_2O$ and $Na_2HADP{\cdot}3H_2O$ were used in the titrations to evaluate the anion binding ability of the ligand or of its Zn(II)complex. The computer program HYPERQUAD[4] was used to calculate the stability

constants of the complexes from e.m.f. data. The analysis of the binding ability of the mononuclear Zn(II) complex towards phosphate anions was carried out by performing potentiometric titrations on solutions containing on solution containing Zn^{2+} and the ligand in 1 x 10^{-3} M concentrations and varying the anion to Zn(II) molar ratio from 1 to 4:1. At least three measurements (about 100 experimental points each one) were performed for each system. The titration curves for each system were treated either as a single set or as separated entities without significant variations in the values of the protonation or complexation constants.

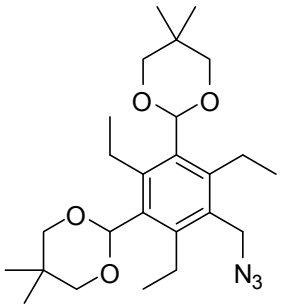
Materials.

Reagents were purchased from commercial suppliers and used without purification. 1-azidomethyl-3,5-diformyl-2,4,6-triethylbenzene (**2**),[5] pyrrole-2,5-dicarbaldehyde, (1*R*,2*R*)-*N*-*tert*-butoxycarbonyl-1,2-*trans*-diaminocyclohexane, were prepared according to known methods. Unless otherwise stated, all air and moisture sensitive reactions were performed under inert atmosphere.

Abbreviations.

BOC	*tert*-butoxycarbonyl
DAC	*trans*-1,2-diaminocyclohexane
DMF	N,N-dimethylformamide
EA	Ethyl acetate
Et	Ethyl
Me	Methyl
m.p.	Melting point
rt	room temperature
TFA	Trifluoroacetic acid
THF	Tetrahydrofurane
Ts	Toluenesulfonic
PE	Petroleum ether

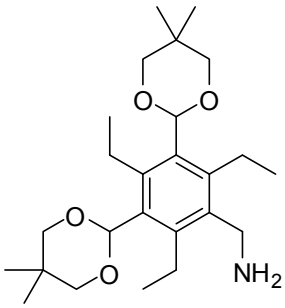
1,3-bis-(5,5-dimethyl-1,3-dioxane)-5-azidomethyl-2,4,6-triethylbenzene (3).



3

To a solution of **2** (16.3 g; 59.6 mmol) in toluene (200 mL), neopentylglycol (33.4 g; 320 mmol) and a catalitic amount of p-toluenesulfonic acid were added and the mixture was refluxed overnight while removing water from the reaction with a Dean-Stark apparatus. The solution was cooled to rt, diluted with toluene, washed three times with a saturated solution of $NaHCO_3$, twice with water then dried over anhydrous Na_2SO_4 and concentrated to give crude **3** that was purified by filtration over a pad of silica (EA 5% in PE) to afford pure **3** (23.2 g, 87%) as a colourless glass. ^{1}H-NMR (200 MHz, $CDCl_3$): δ= 5.77 (s, 2H; C*H* acetal), 4.49 (s, 2H; CH_2N_3), 3.83-3.78 (m, ^2J(H,H)=11.2 Hz, 4H; part A of an AB system, CH_2 acetal), 3.64-3.59 (m, ^2J(H,H)=11.2 Hz, 4H; part B of an AB system, CH_2 acetal), 3.31-3.20 (m, 2H; CH_2 ethyl), 3.15-3.03 (m, 4H; CH_2 ethyl), 1.35 (s, 3H; CH_3 acetal), 1.28-1.17 (m, 9H; CH_3 ethyl), 0.81 (s, 3H; CH_3 acetal); ^{13}C-NMR (50 MHz, $CDCl_3$): δ= 144.50, 143.57, 132.99, 130.57, 102.34, 78.85, 47.70, 30.29, 24.07, 22.96, 22.85, 22.32, 16.33, 16.10.

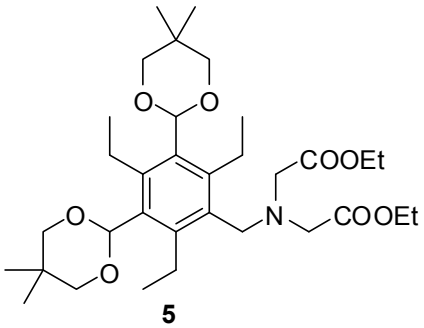
1,3-bis-(5,5-dimethyl-1,3-dioxane)-5-aminomethyl-2,4,6-triethylbenzene (4).



4

To a suspension of $LiAlH_4$ (4.23 g; 111.5 mmol) in freshly distilled dry THF (150 mL) at 0 °C, a solution of **3** (23.2 g; 52.1 mmol) in freshly distilled dry THF was added dropwise, followed by the evolution of gas. The suspension was vigorously stirred for 2.5 h, then cooled to 0 °C and quenched by the addition of H_2O (4.23 mL) then NaOH 15% w/w solution (4.23 mL) and finally H_2O (12.7 mL). The resulting precipitate was filtered and washed with CH_2Cl_2 three times, then the liquors were evaporated under reduced pressure to give crude **4** that was purified by flash column chromatography on silica gel (MeOH 20% in CH_2Cl_2) to afford pure **4** (20.2 g, 92%) as a white solid. m.p. = 64-65 °C; ^{1}H-NMR (200 MHz, $CDCl_3$): δ= 5.76 (s, 2H; C*H* acetal), 3.88 (s, 2H; CH_2NH$_2$), 3.81-3.75 (m, ^2J(H,H)=11.4 Hz, 4H; part A of an AB system, CH_2 acetal), 3.63-3.57 (m, ^2J(H,H)=11.4 Hz, 4H; part A of an AB system, CH_2 acetal), 3.29-3.18 (m, 2H; CH_2 ethyl), 3.12-3.01 (m, 4H; CH_2 ethyl), 1.77 (bs, 2H; NH_2), 1.34 (s, 3H; CH_3 acetal) 1.26-1.16 (m, 9H; CH_3 ethyl), 0.78 (s, 3H; CH_3 acetal); ^{13}C-NMR (50 MHz, $CDCl_3$): δ= 143.07, 141.81, 138.29, 132.78, 102.52, 78.84, 38.91, 30.28, 24.07, 22.82, 22.72, 22.31, 16.68, 16.48.

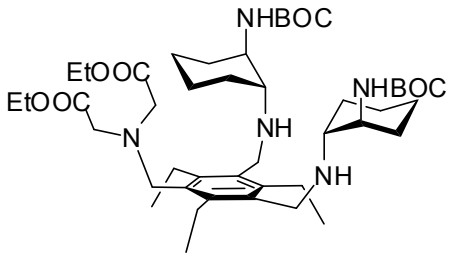
Compound (5).



5

To a solution of **4** (20.1 g; 47.9 mmol) in DMF (70 mL), $KHCO_3$ (19.2 g; 192 mmol) was added and the suspension was cooled to 0 °C followed by the addition of ethyl bromoacetate (32.0 g; 192 mmol). The mixture was stirred for 5 minutes, then it was allowed to warm to rt and stirred vigorously overnight. The suspension was poured on a saturated $NaHCO_3$ solution and extracted with CH_2Cl_2 three times. The combined organic layers were washed with water twice, dried over anhydrous Na_2SO_4 and concentrated to give crude **5** that was purified by flash column chromatography on silica gel (EA 20% in PE) to afford pure **5** (23.6 g, 83%) as a transparent oil. ^{1}H-NMR (200 MHz, $CDCl_3$): δ= 5.79 (s, 2H; C*H* acetal), 4.17-4.06 (m, 4H; CH_2 ethyl ester), 3.98 (s, 2H; CH_2N), 3.82-3.76 (m, ^2J(H,H)=11.4 Hz, 4H; part A of an AB system, CH_2 acetal), 3.63-3.57 (m, ^2J(H,H)=11.4 Hz, 4H; part B of an AB system, CH_2 acetal), 3.51 (s, 4H; CH_2COOEt), 3.35-3.24 (m, 2H; CH_2 ethyl), 3.19-3.08 (m, 4H; CH_2 ethyl), 1.34 (s, 3H; CH_3 acetal) 1.28-1.11 (m, 15H; CH_3 ethyl + CH_3 ethyl ester), 0.80 (s, 3H; CH_3 acetal); ^{13}C-NMR (50 MHz, $CDCl_3$): δ= 171.12, 145.21, 142.44, 132.39, 132.03, 102.20, 78.51, 59.96, 52.60, 50.29, 30.05, 23.82, 22.44, 22.09, 16.04, 13.91.

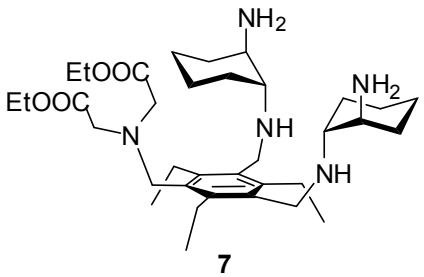
Compound (6).



6

To a solution of **5** (12.5 g; 21.1 mmol) in THF (600 mL) at 0 °C, HCl 1 M (390 mL) was added and the solution was then allowed to warm to rt overnight. The mixture was cooled to 0 °C and neutralized by the addition of solid $NaHCO_3$. THF was evaporated under reduced pressure while the aqueous residue was extracted with CH_2Cl_2 three times. The combined organic layers were washed twice with water, dried over anhydrous Na_2SO_4 and concentrated to give the intermediate dialdehyde that was used for the next reaction without any further purification. A solution of this dialdehyde (8.04 g; 19.2 mmol) and (1*R*,2*R*)-*N*-*tert*-butoxycarbonyl-1,2-*trans*-diaminocyclohexane (16.5 g, 76.8 mmol) in $CHCl_3$ (200 mL) was refluxed overnight, then cooled to rt. A suspension of $NaBH_4$ (2.91 mg, 76.8 mmol) in MeOH (200 mL) was added, the mixture was stirred for 1 h at rt, then poured on water and extracted with $CHCl_3$ three times. The combined organic layers were washed with water twice, dried over anhydrous Na_2SO_4 and concentrated to give crude **6**, that was purified by flash column chromatography on silica gel (starting EA 50% in CH_2Cl_2 then MeOH 10% in CH_2Cl_2) to obtain pure **6** (10.8 g, 62% over two steps) as a white solid. m.p. = dec.; ^{1}H-NMR (200 MHz, $CDCl_3$): δ= 4.73 (bs, 2H; N*H*BOC), 4.16-4.06 (m, 4H; CH_2 ethyl ester), 3.95 (s, 2H; CH_2N), 3.85-3.79 (m, 2H; CH_2NH), 3.60-3.55 (m, 2H; CH_2NH), 3.52 (s, 4H; CH_2COOEt), 3.33-3.13 (m, 2H; C*H*NHBOC), 2.96-2.71 (m, 6H; CH_2 ethyl), 2.51-2.31 (m, 2H; C*H*NH), 2.27-2.06 (m, 4H), 1.81-1.59 (m, 6H), 1.41 (s, 18H; CH_3 *t*Bu), 1.28-1.09 (m, 23H); ^{13}C-NMR (50 MHz, $CDCl_3$): δ= 171.46, 155.92, 143.81, 142.93, 134.21, 131.26, 79.02, 61.05, 60.25, 54.27, 53.19, 51.19, 44.33, 32.51, 31.20, 28.39, 24.55, 22.52, 22.40, 16.97, 16.60, 14.21.

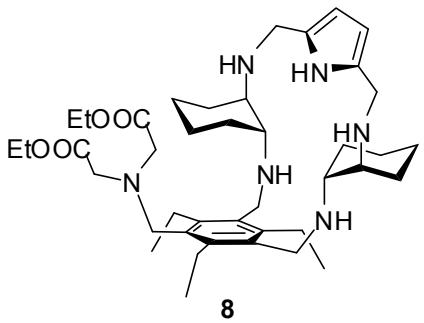
Compound (7).



7

To a solution of **6** (4.34 g; 5.32 mmol) in CH_2Cl_2 (25 mL) at 0 °C, trifluoroacetic acid (26.6 mL; 345 mmol) was added and the solution was stirred for 5 minutes. The mixture was allowed to warm to rt and stirred for 2 hours, then it was diluted with CH_2Cl_2 and poured on a mixture of 2 M NaOH solution and ice. The organic layer was collected and the aqueous phase was extracted with CH_2Cl_2 three times. The combined organic layers were washed with water twice, dried over anhydrous Na_2SO_4 and concentrated to give crude **7**, which was purified by flash column chromatography on silica gel (MeOH 10% in $CHCl_3$ + 1.3% NH_3 sol. 33%) to afford pure **7** (2.60 g, 79%) as a white wax. ^{1}H-NMR (200 MHz, $CDCl_3$): δ= 4.17-4.06 (m, 4H; C*H*$_2$ ethyl ester), 3.96-3.90 (m, 4H; C*H*$_2$N + C*H*$_2$NH), 3.52-3.48 (m, 6H; C*H*$_2$NH + C*H*$_2$COOEt), 3.01-2.70 (m, 6H; C*H*$_2$ ethyl), 2.42-2.26 (m, 4H), 2.19-2.07 (m, 2H), 1.92-1.68 (m, 6H), 1.59 (bs, 6H, N*H* + N*H*$_2$), 1.34-0.99 (m, 23H); ^{13}C-NMR (50 MHz, $CDCl_3$): δ= 171.58, 143.62, 142.80, 134.51, 131.20, 64.63, 60.29, 55.27, 53.20, 51.08, 44.92, 35.54, 31.29, 25.46, 25.15, 22.51, 22.26, 16.88, 16.56, 14.22.

Compound (8).

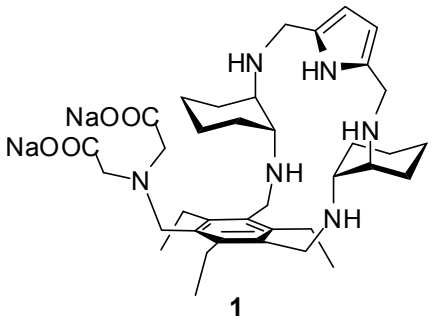


8

To a solution of **7** (2.48 g, 4.02 mmol) and pyrrole-2,5-dicarbaldehyde (495 mg, 4.02 mmol) in $CHCl_3$ (80 mL), a catalytic amount of acetic acid was added. The solution was stirred overnight at rt, then cooled to 0 °C. A suspension of $NaBH_4$ (1.72 g, 46.4 mmol) in

MeOH (80 mL) was added followed by a strong gas evolution. The solution was stirred for 1 h at rt, then it was poured on water/brine 1:1 and extracted with $CHCl_3$ three times. The combined organic layers were washed with water twice, dried over anhydrous Na_2SO_4 and concentrated to give crude **8**, which was purified by flash column chromatography on silica gel (MeOH 10% in $CHCl_3$ + 1% NH_3 sol. 33%) to afford pure **8** (2.20 mg, 70%) as a white glass. ^{1}H-NMR (200 MHz, $CDCl_3$): δ= 8.97 (bs, 1H; N*H* pyrr), 5.83 (m, 2H; C*H* pyrr), 4.16-4.08 (m, 4H; CH_2 ethyl ester), 3.99-3.91 (m, 5H), 3.75 (s, 2H), 3.55 (s, 4H), 3.51-3.44 (m, 2H), 3.40-3.37 (m, 1H), 3.18-2.96 (m, 3H), 2.88-2.74 (m, 3H), 2.59-2.50 (m, 1H), 2.35-2.14 (m, 8H), 2.12-1.70 (m, 6H), 1.46-1.40 (m, 2H), 1.35-1.11 (m, 20H), 1.00-0.92 (m, 2H); ^{13}C-NMR (50 MHz, $CDCl_3$): δ= 171.60 (2C), 143.94, 143.34, 142.39, 134.68, 134.25, 131.19, 130.92, 130.16, 105.32, 105.07, 63.84, 60.72, 60.34, 59.30, 58.36, 53.28, 51.25, 45.77, 45.74, 44.15, 43.83, 39.95, 39.93, 31.93, 31.81, 31.44, 30.72, 25.45, 25.41, 25.30, 25.24, 25.21, 24.87, 22.34, 22.25, 17.00, 16.42, 16.19, 14.21.

Receptor (1).



1

To a solution of **8** (514 mg, 0.727 mmol) in EtOH (5 mL), a solution of NaOH (495 mg; 12.4 mmol) in H_2O (5 mL) was added and the obtained suspension rapidly became a solution, which was stirred overnight at rt. The solvent was evaporated under reduced pressure and the residue was suspended in CH_2Cl_2, dried over anhydrous Na_2SO_4 and filtered on paper to afford pure **1** (411 mg, 81%) as a white solid. **1**: m.p. = >300 °C; $[\alpha]_D^{31}$ = -58.6 (c = 0.185, H_2O); ^{1}H-NMR (400 MHz, D_2O): δ= 5.81-5.78 (m, 2H, C*H* pyrr), 3.92-3.89 (m, 1H), 3.73-3.66 (m, 6H), 3.54-3.49 (m, 2H), 3.39-3.22 (m, 5H), 3.18-3.01 (m, 6H), 2.70-2.65 (m, 2H), 2.60-2.38 (m, 4H), 2.22-1.97 (m, 6H), 1.65 (bs, 4H), 1.43-1.29 (m, 1H), 1.24-1.10 (m, 4H), 1.06-0.93 (m, 12H); ^{13}C-NMR (100 MHz, D_2O): δ= 179.87 (2C), 144.97, 144.51, 143.20, 133.69, 132.82, 131.97, 130.93, 130.63, 106.12, 105.59, 62.40, 60.26, 57.98 (2C), 57.67, 57.13, 50.70, 44.59, 44.57, 42.82, 40.81, 39.33, 39.30, 30.41, 30.29,

29.79, 29.46, 24.69, 24.61, 24.40, 22.70, 22.28, 15.75 (2C), 15.71; ESI-MS *m/z* (%): 651.39 (100) $[M+H]^+$; HR-MS *m/z* (%): calcd. $[M+H]^+$ 651.4592, found $[M+H]^+$ 651.4589 (100); elemental analysis calcd. (%) for $C_{37}H_{56}N_6Na_2O_4$: C, 63.95; H, 8.12; N, 12.09; Na, 6.62; O, 9.21; found: C, 63.87; H, 8.18; N, 11.89; Na, 6.50.

References.

1 S. Bartoli, C. Bazzicalupi, S. Biagini, L. Borsari, A. Bencini, E. Faggi, C. Giorgi, C. Sangregorio, B. Valtancoli *Dalton Trans.* 2009, 1223.

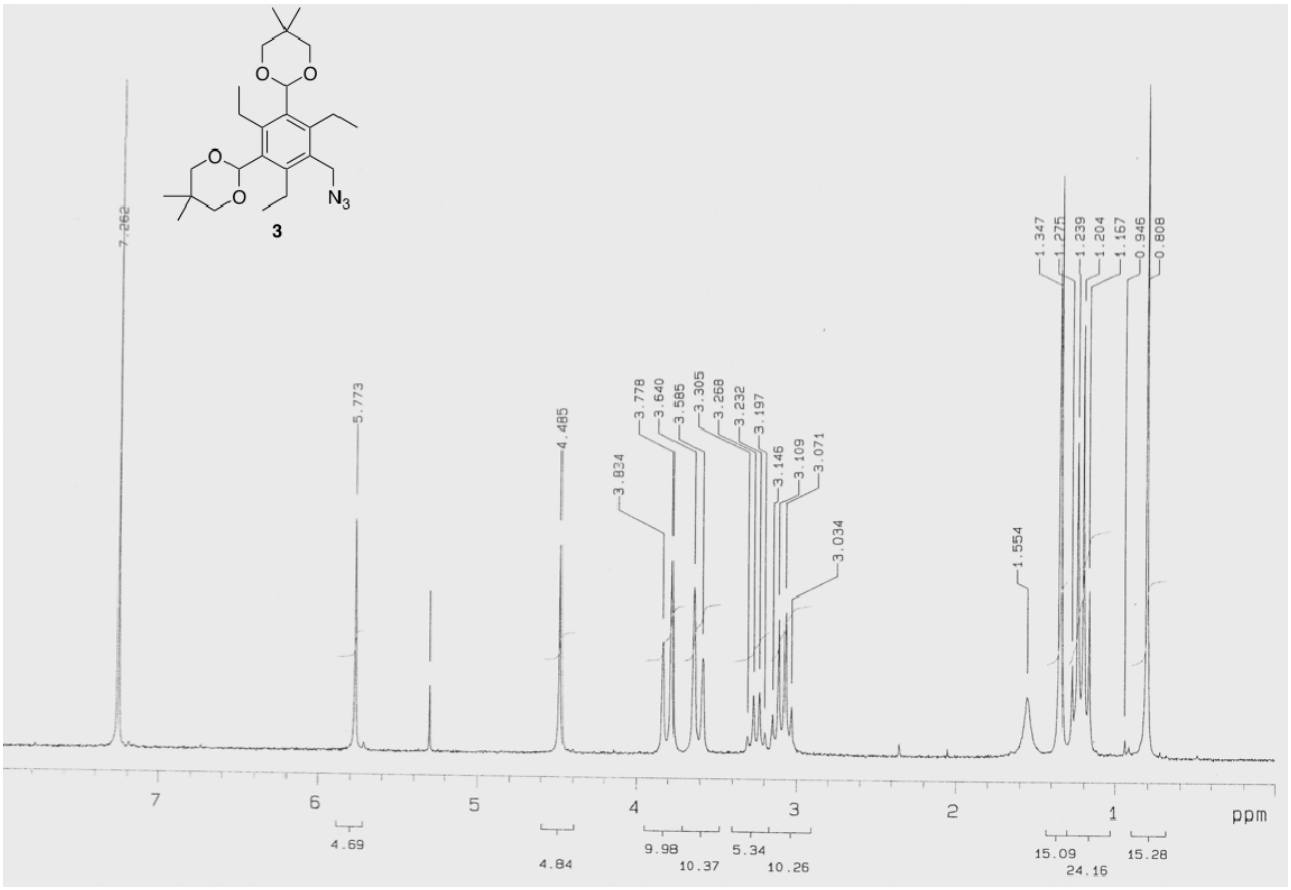
2 a) G. Gran, *Analyst* 1952, **77**, 661; b) F. J. Rossotti, H. Rossotti. *J. Chem. Educ.* 1965, **42**, 375

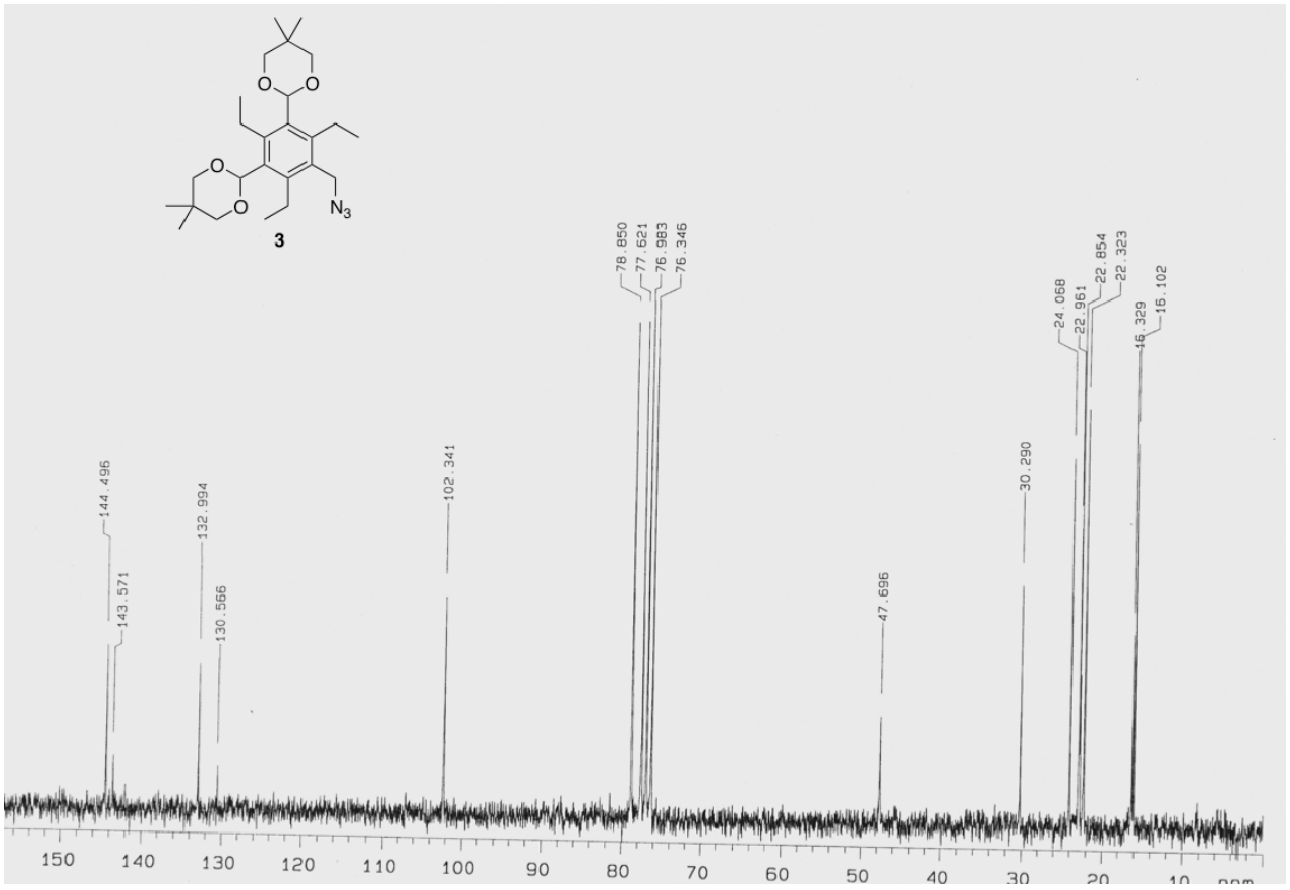
3 P. Gans, A. Sabatini, A. Vacca, *J. Chem. Soc., Dalton Trans.* 1985, 1195.

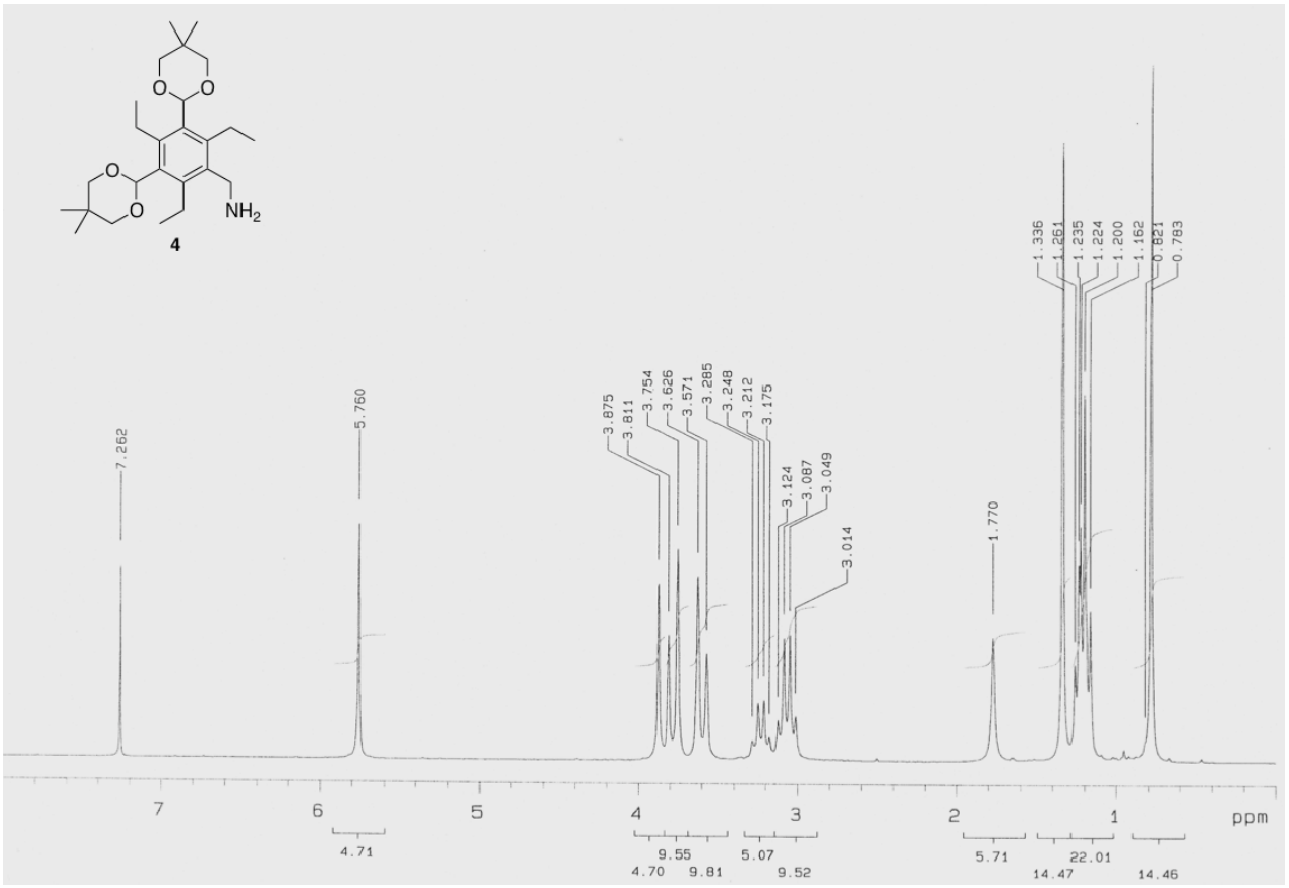
4 K. Covington, M. Paabo, R. A. Robinson, R. G. Bates *Anal. Chem.* 1968, **40***,* 700

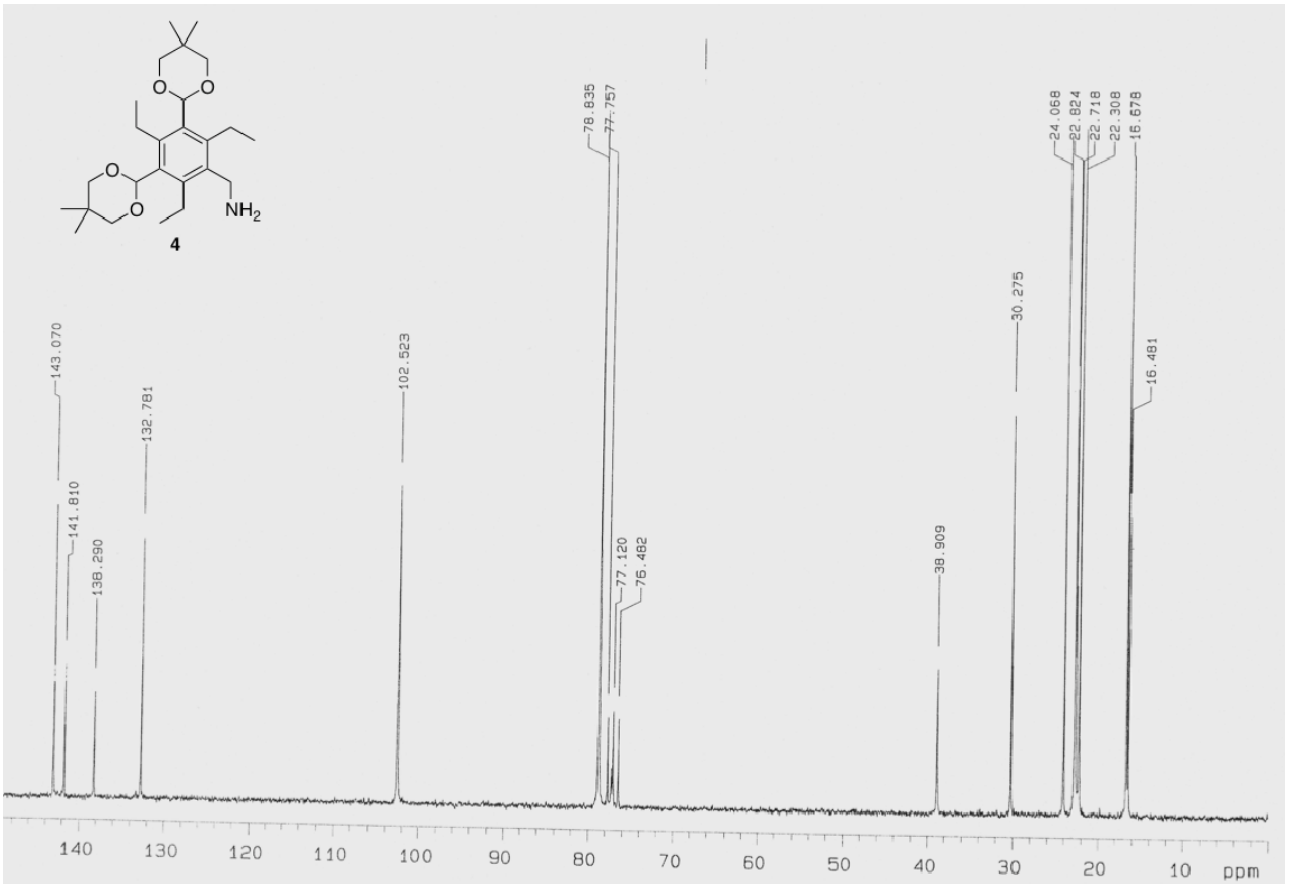
5 O. Francesconi, C. Nativi, G. Gabrielli, M. Gentili, M. Palchetti, B. Bonora, S. Roelens *Chem. Eur J.* 2013, **19**, 11742-11752.

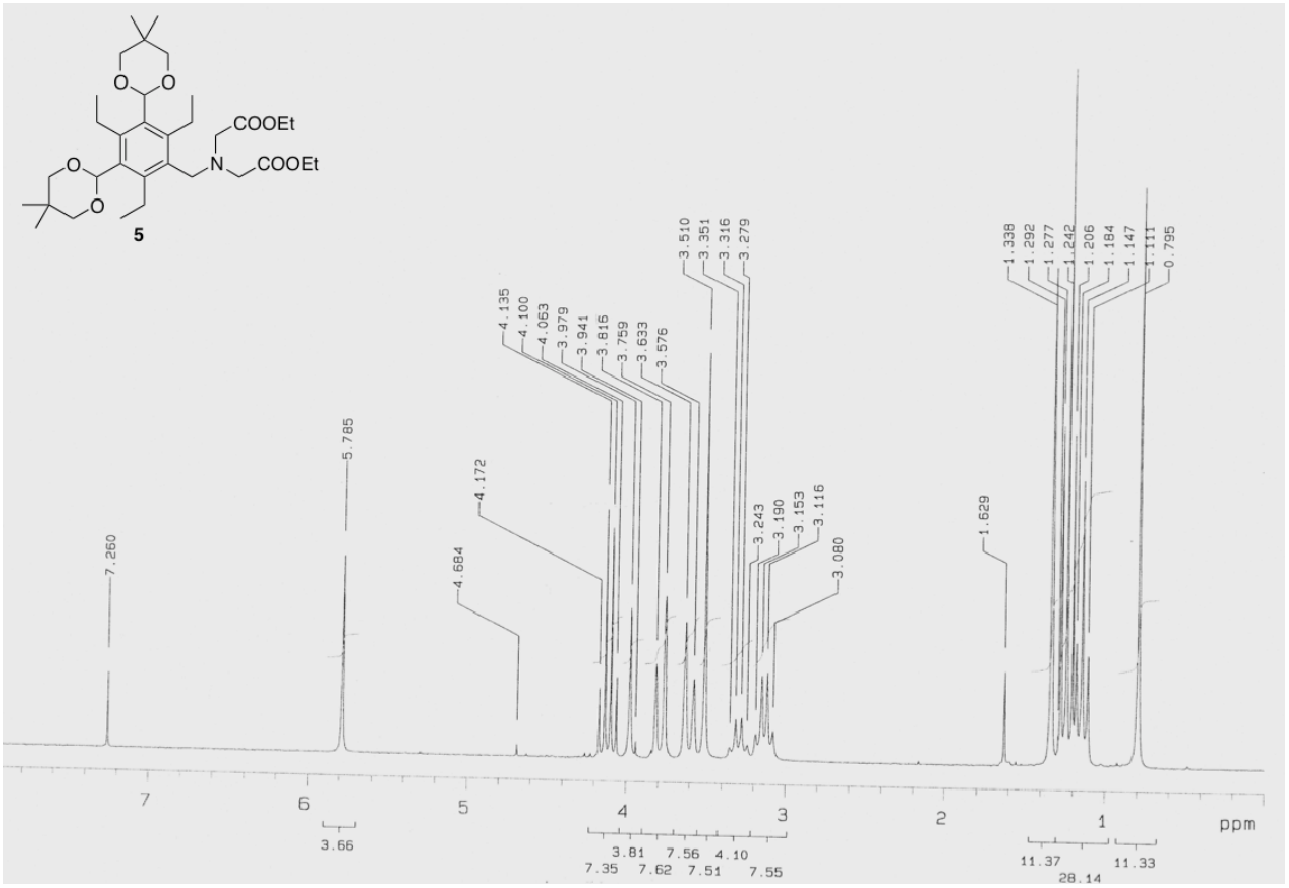
Copies of NMR spectra of the described compounds.

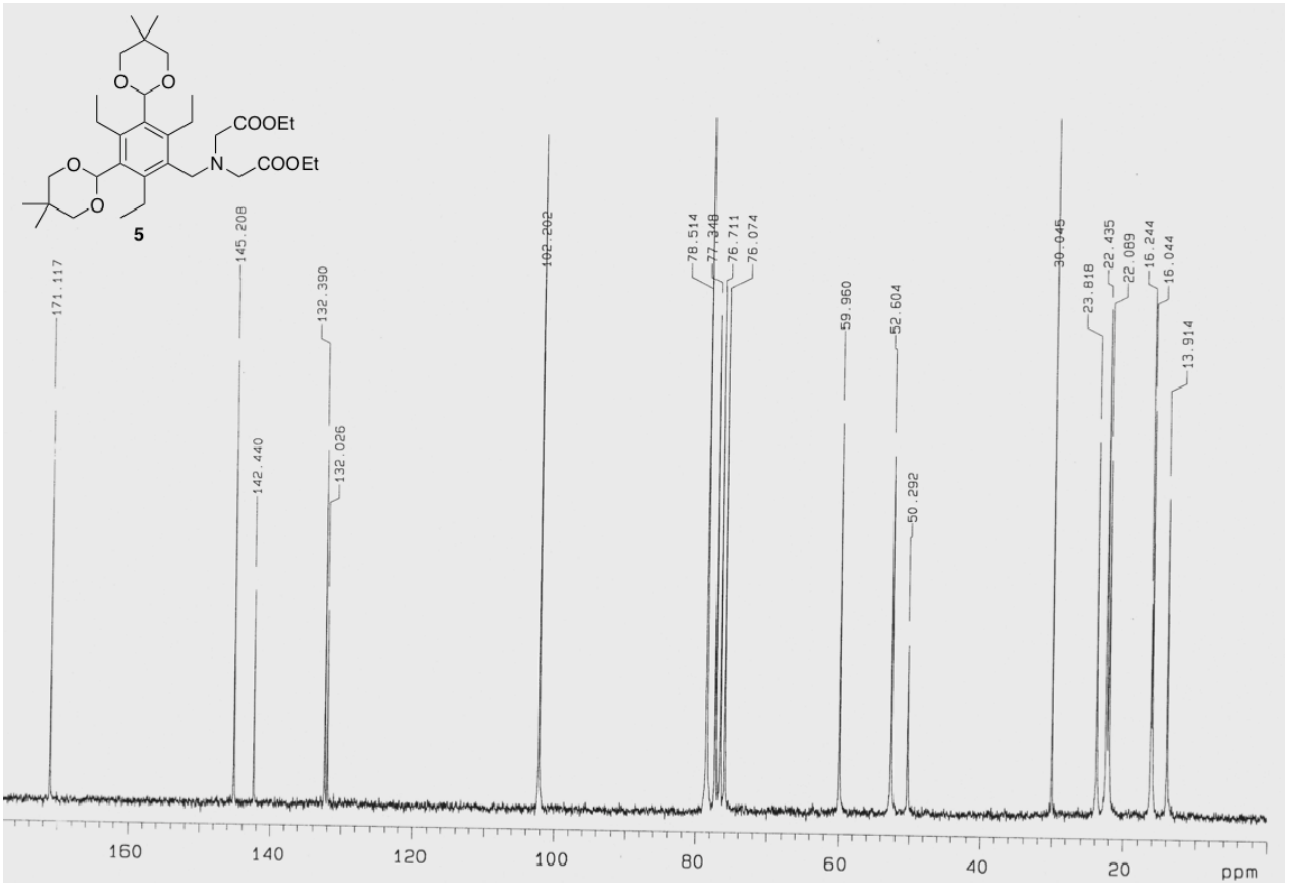


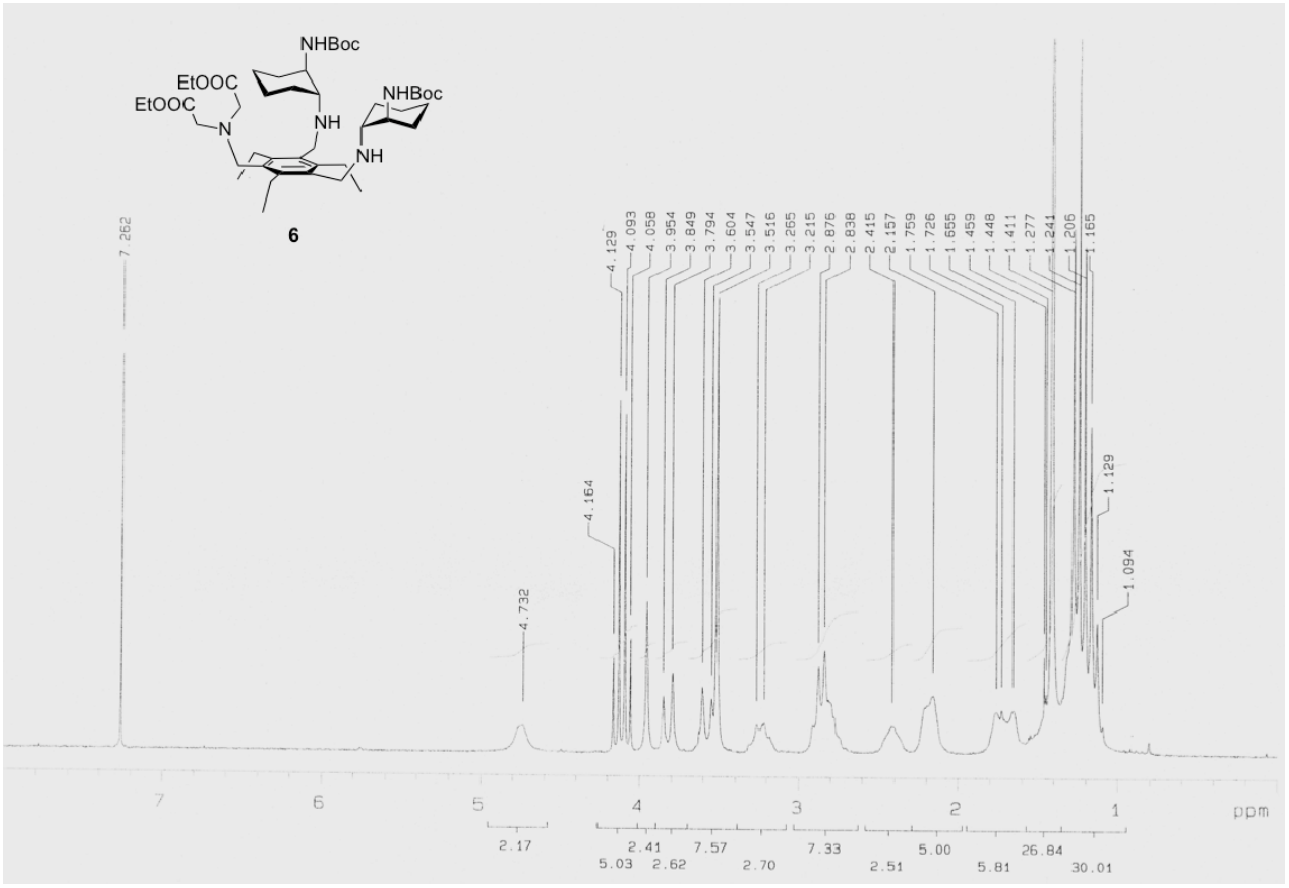


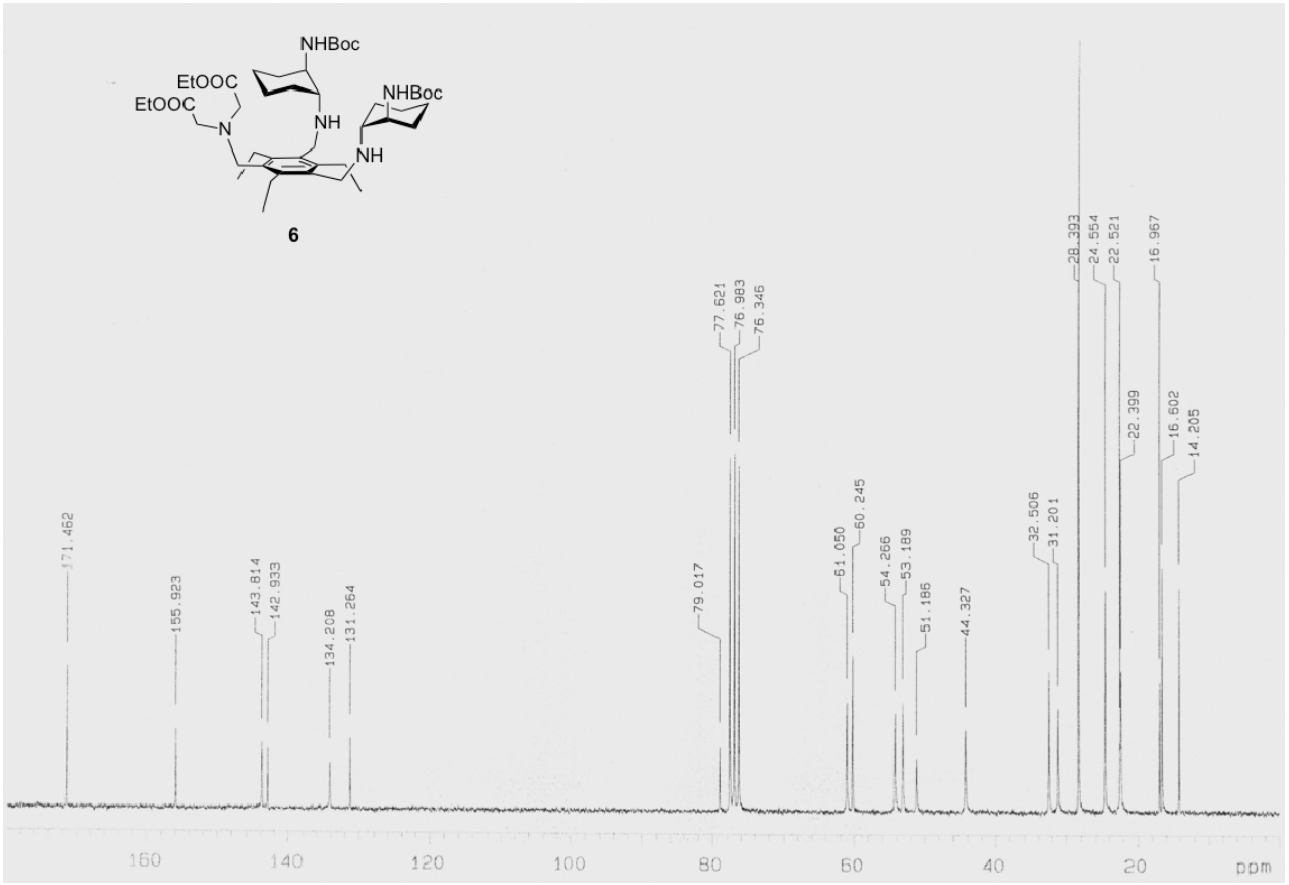

4
7.262
5.760
3.875
3.811
3.754
3.626
3.571
3.285
3.248
3.212
3.175
3.124
3.087
3.049
3.014
1.770
1.336
1.261
1.235
1.224
1.200
1.162
0.821
0.783
7
6
5
4
3
2
1
ppm
4.71
9.55
4.70
9.81
5.07
9.52
5.71
22.01
14.47
14.46

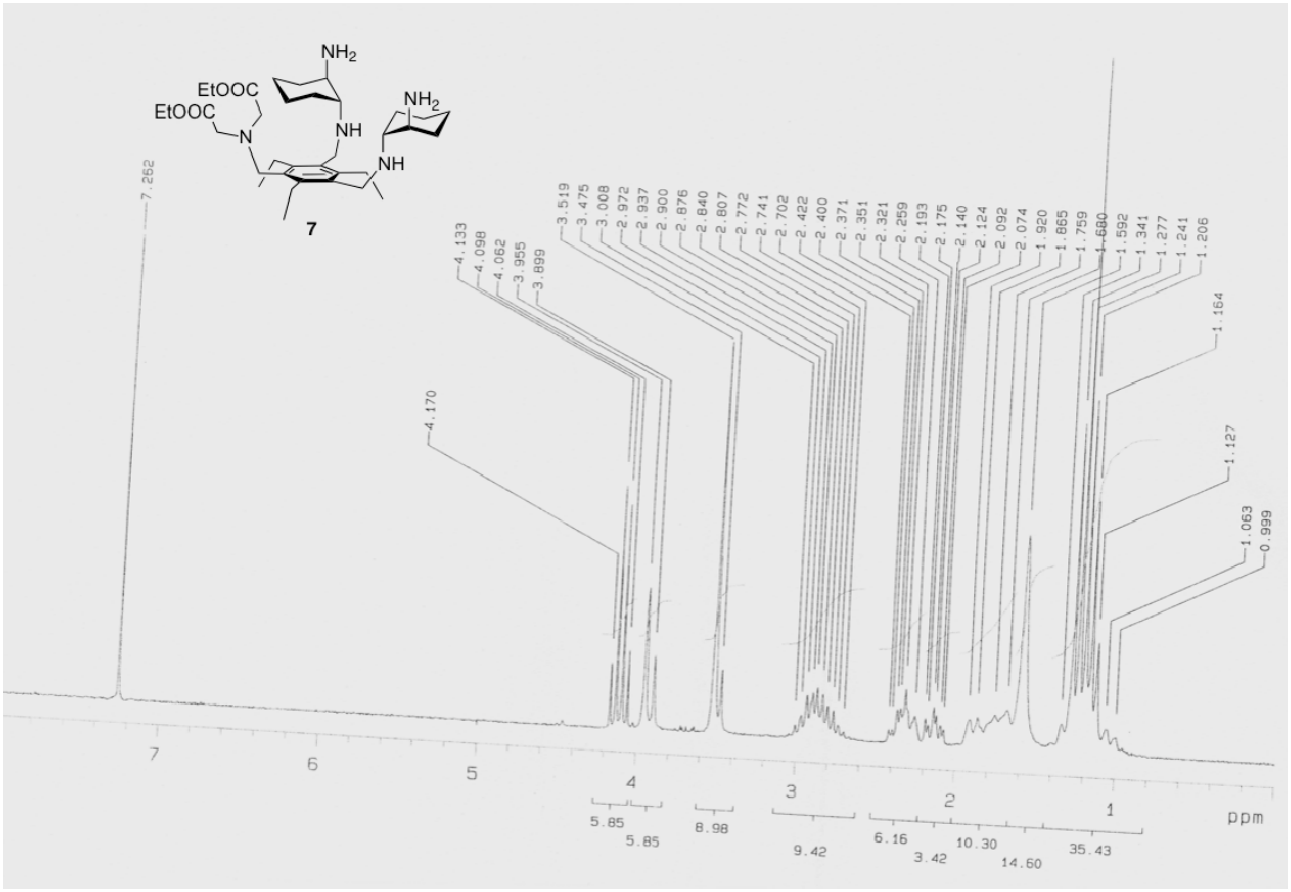

4
143.070
141.810
138.290
132.781
102.523
78.835
77.757
77.120
76.482
38.909
30.275
24.068
22.824
22.718
22.308
16.578
16.481
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

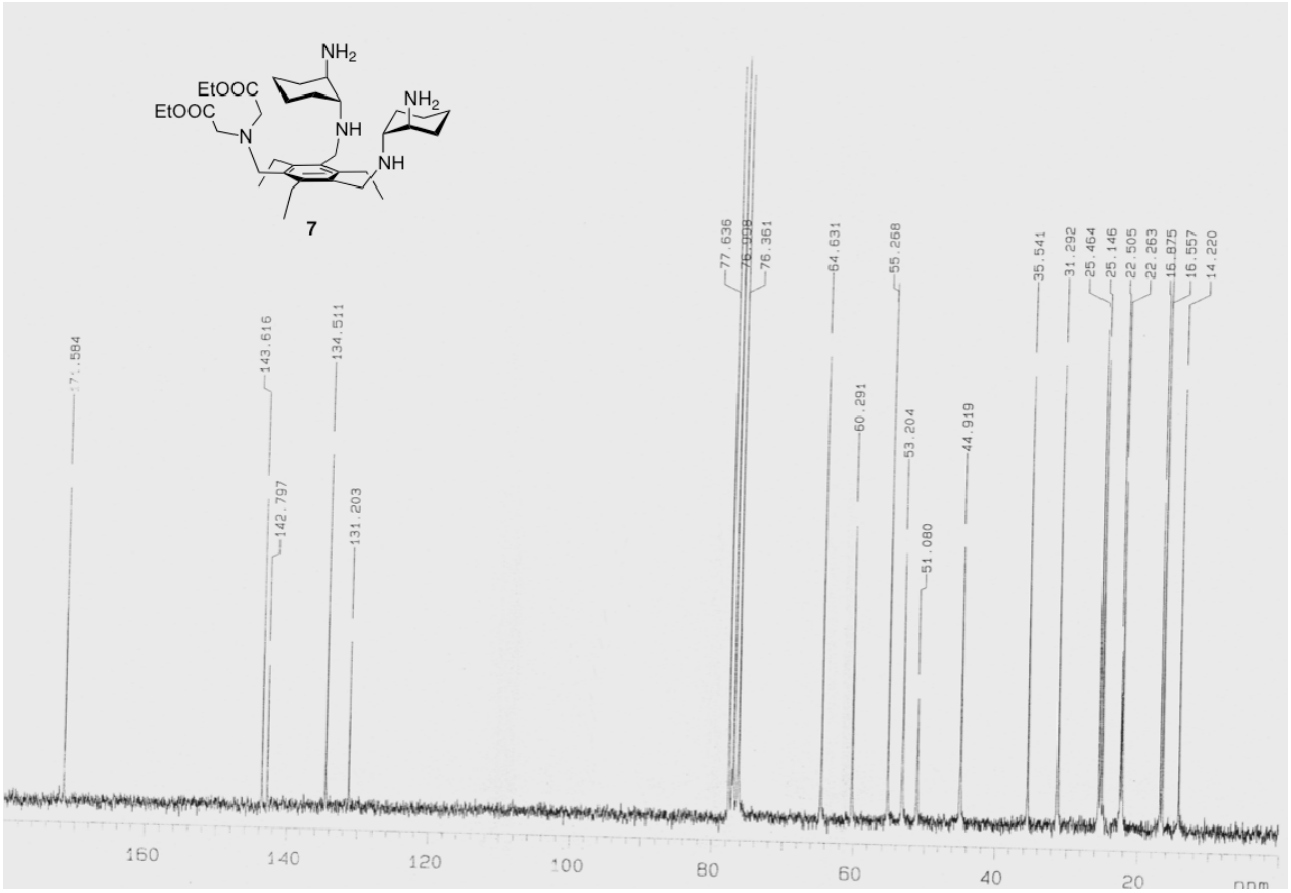

COOEt
N
COOEt
5
7.260
5.785
4.684
4.172
4.135
4.100
4.063
3.979
3.941
3.816
3.759
3.633
3.576
3.510
3.351
3.316
3.279
3.243
3.190
3.153
3.116
3.080
1.629
1.338
1.292
1.277
1.242
1.206
1.184
1.147
1.111
0.795
7
6
5
4
3
2
1
ppm
3.66
3.81
7.56
4.10
7.35
7.62
7.51
7.55
11.37
11.33
28.14

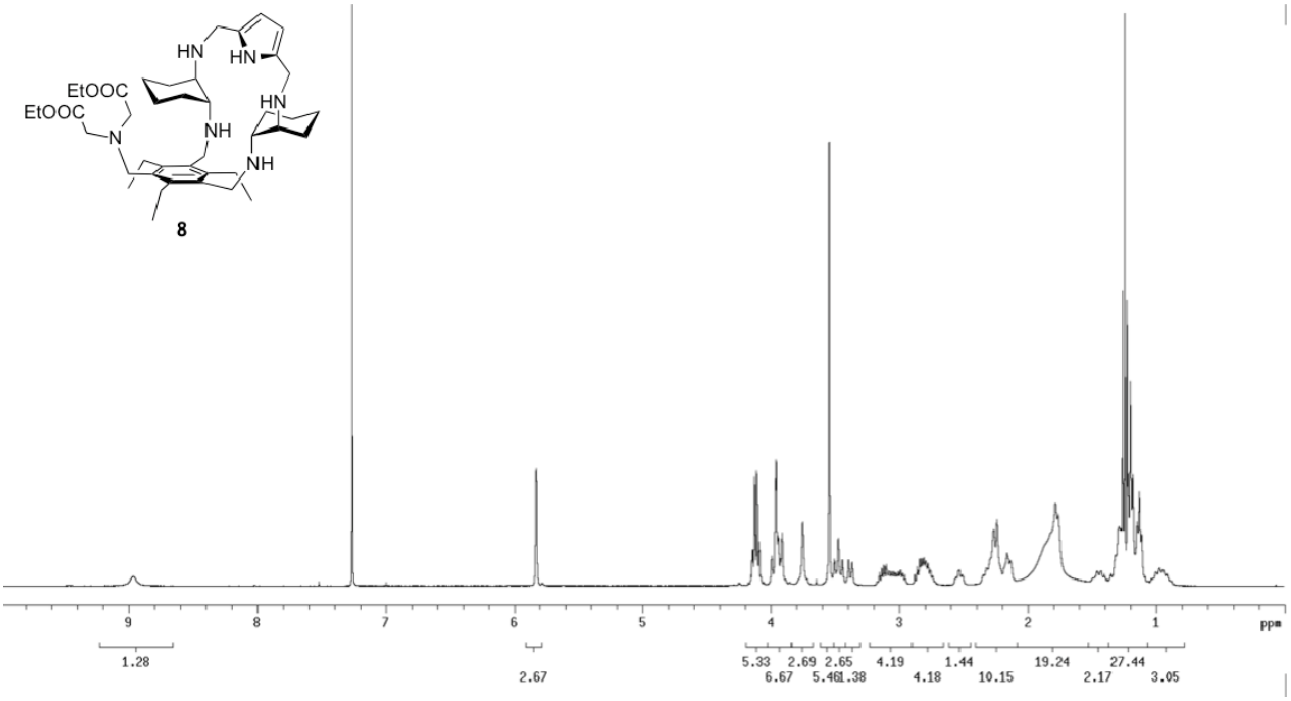

COOEt
N
COOEt
5
171.117
145.208
142.440
132.390
132.026
102.202
78.514
77.348
76.711
76.074
59.960
52.604
50.292
30.045
23.818
22.435
22.089
16.244
16.044
13.914
160
140
120
100
80
60
40
20
ppm

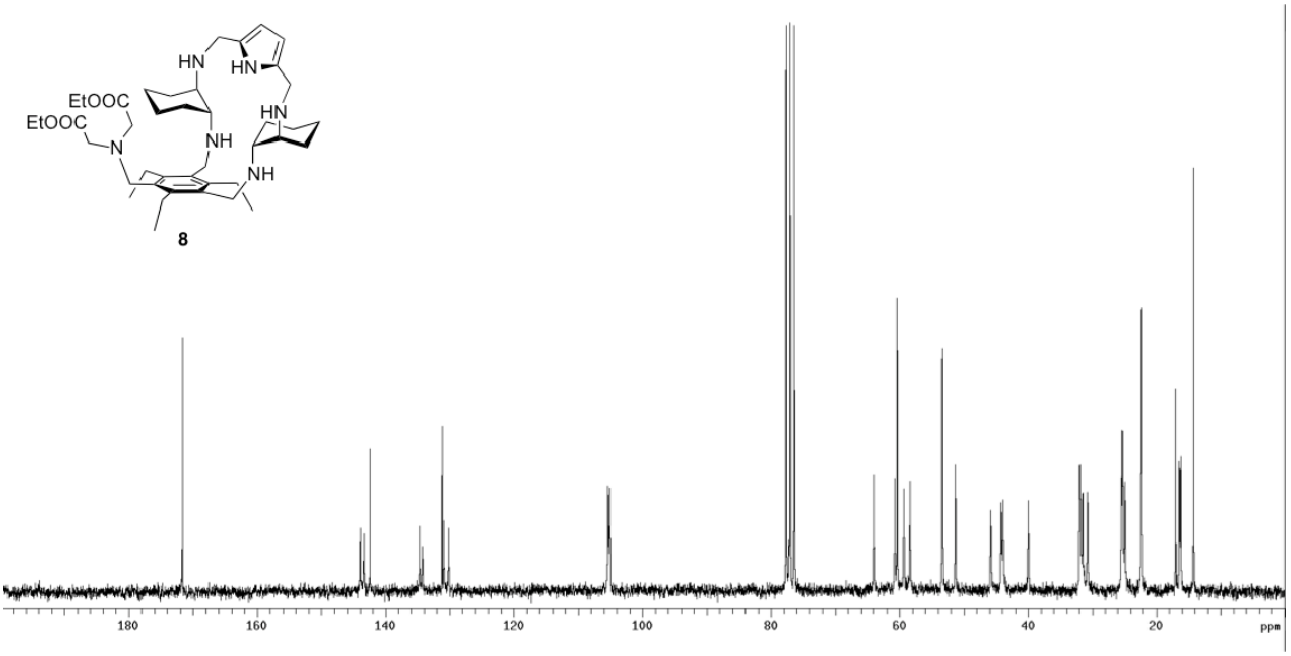

NHBoc
EtOOC
EtOOC
N
NH
NHBoc
NH
6
7.262
4.732
4.164
4.129
4.093
4.058
3.954
3.849
3.794
3.604
3.547
3.516
3.265
3.215
2.875
2.838
2.415
2.157
1.759
1.726
1.655
1.459
1.448
1.411
1.277
1.241
1.206
1.165
1.129
1.094
7
6
5
4
3
2
1
ppm
2.17
2.41
5.03
2.62
7.57
2.70
7.33
2.51
5.00
5.81
26.84
30.01

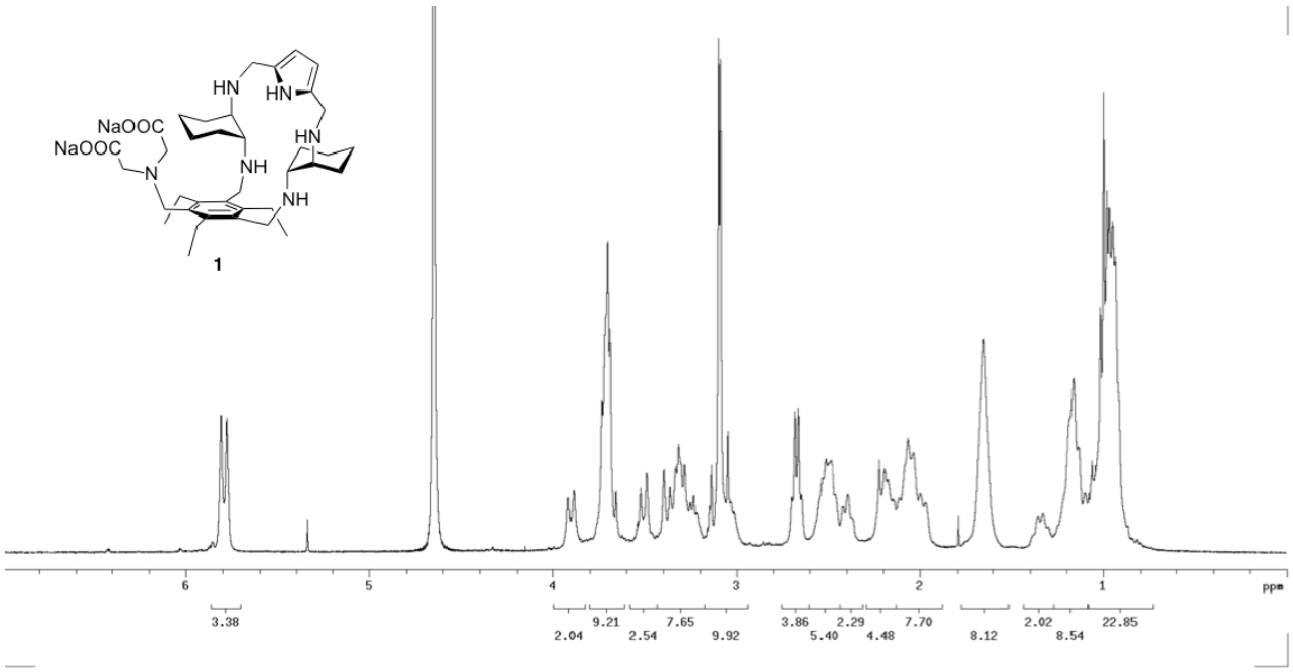

NHBoc
EtOOC
EtOOC
N
NH
NHBoc
NH
6
171.462
155.923
143.814
142.933
134.208
131.264
79.017
77.621
76.983
76.346
61.050
60.245
54.266
53.189
51.186
44.327
32.506
31.201
28.393
24.554
22.521
22.399
16.967
16.602
14.205
160
140
120
100
80
60
40
20
ppm


NH2
EtOOC
EtOOC
N
NH
NH2
NH
7
7.262
4.133
4.098
4.062
3.955
3.899
4.170
3.519
3.475
3.008
2.972
2.937
2.900
2.876
2.840
2.807
2.772
2.741
2.702
2.422
2.400
2.371
2.351
2.321
2.259
2.193
2.175
2.140
2.124
2.092
2.074
1.920
1.865
1.759
1.680
1.592
1.341
1.277
1.241
1.206
1.164
1.127
1.063
0.999
7
6
5
4
3
2
1
ppm
5.85
5.85
8.98
9.42
6.16
3.42
10.30
14.60
35.43


NH2
EtOOC
EtOOC
N
NH
NH2
NH
7
77.636
76.998
76.361
64.631
60.291
55.268
53.204
51.080
44.919
35.541
31.292
25.464
25.146
22.505
22.263
16.875
16.557
14.220
143.616
142.797
134.511
131.203
160
140
120
100
80
60
40
20
ppm


HN
HN
EtOOC
EtOOC
N
NH
HN
NH
8
9
8
7
6
5
4
3
2
1
ppm
1.28
2.67
5.33
2.69
2.65
4.19
1.44
19.24
27.44
6.67
5.46
1.38
4.18
10.15
2.17
3.05


HN
HN
EtOOC
EtOOC
N
NH
HN
NH
8
180
160
140
120
100
80
60
40
20
ppm


HN
HN
NaOOC
NaOOC
N
NH
HN
NH
1
6
5
4
3
2
1
ppm
3.38
2.04
9.21
2.54
7.65
9.92
3.86
5.40
2.29
4.48
7.70
8.12
2.02
8.54
22.85

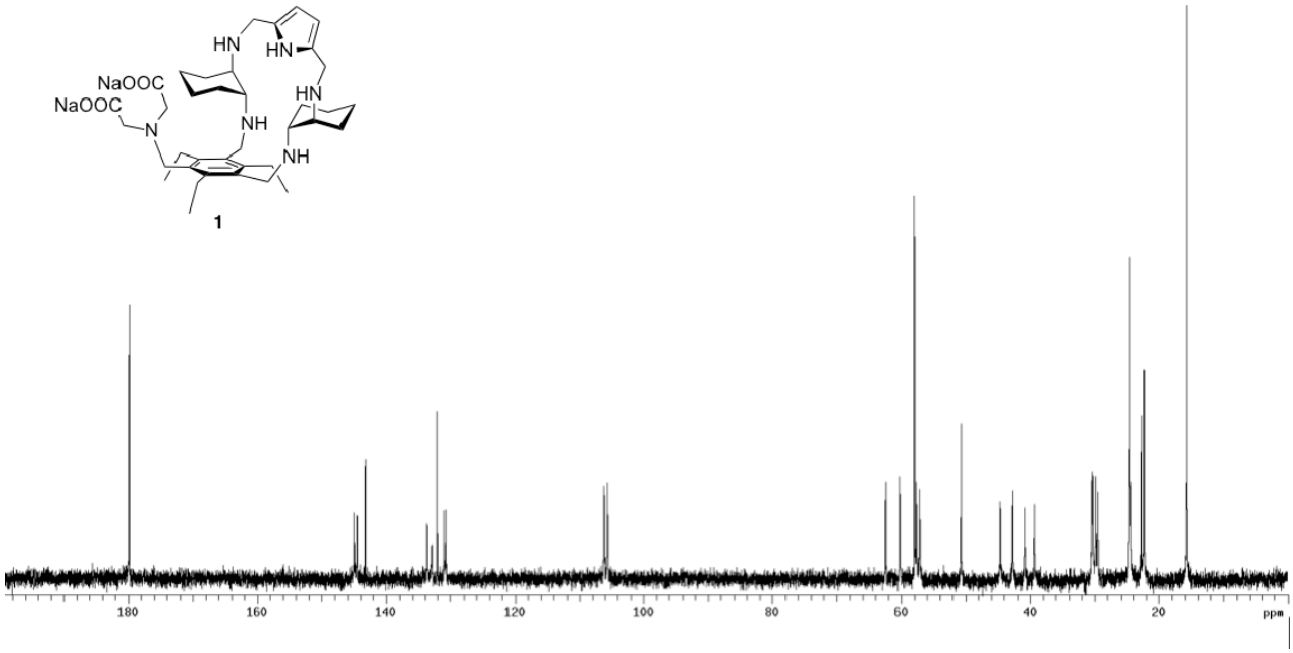

HN
HN
NaOOC
NaOOC
N
NH
HN
NH
1
180
160
140
120
100
80
60
40
20
ppm

Table S1. Protonation and Zn(II) binding constants of ligand MIDA (NMe_4Cl 0.1 M, 308 K; L^{2-} indicates the dianionic form of MIDA).

Equilibrium	LogK
$H^+ + L^{2-} = HL^-$	8.59 (5)
$H^+ + HL^- = H_2L$	2.40 (5)
$Zn^{2+} + L^{2-} = [ZnL]$	8.64(3)
$[ZnL] + OH^- = [ZnL(OH)]^-$	5.43(2)

Table S2. Addition constants of TP to the Zn(II) complex with MIDA (NMe_4Cl 0.1 M, 308 K; [ZnL] indicates the Zn^{2+} complex with the dianionic form of MIDA, L^{2-}).

Equilibrium	LogK
$[ZnL] + P_3O_{10}^{5-} = [ZnLP_3O_{10}]^{5-}$	4.45 (2)
$[ZnL] + HP_3O_{10}^{4-} = [ZnLHP_3O_{10}]^{4-}$	4.35(3)
$[ZnL] + H_2P_3O_{10}^{3-} = [ZnLH_2P_3O_{10}]^{3-}$	4.07 (4)

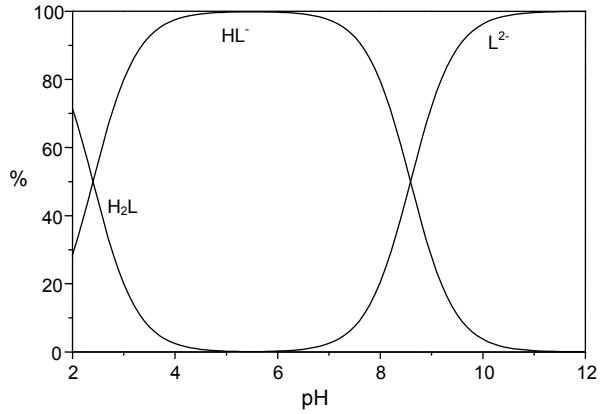


Figure S1. Distribution diagram of the species formed by MIDA as a function of pH (NMe_4Cl 0.1 M, 308 K: L^{2-} indicates the dianionic form of MIDA).

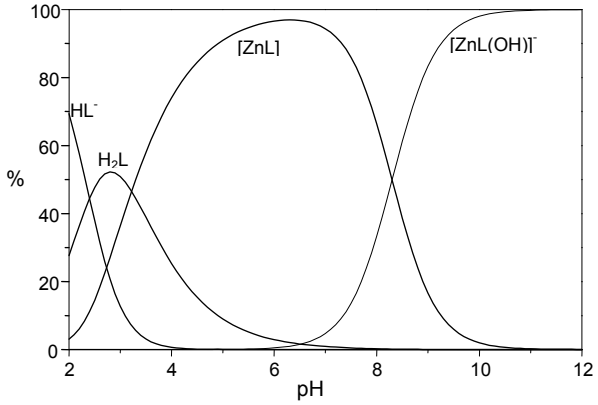


Figure S2. Distribution diagram of the complexes formed by MIDA as a function of pH (NMe_4Cl 0.1 M, 308 K; H_2L and HL^- indicate the neutral and the monoanionic forms of MIDA, respectively, while [ZnL] indicates the Zn^{2+} complex with the dianionic form of MIDA, L^{2-}).

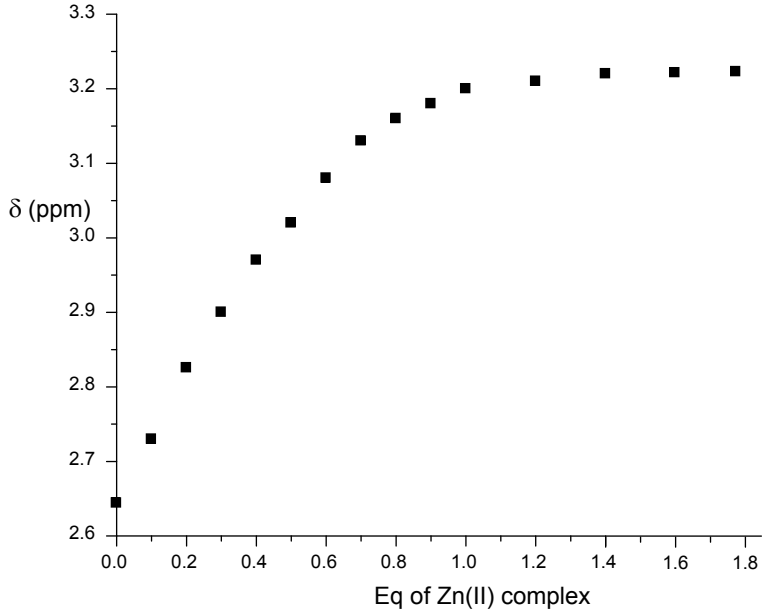


Fig. S3. Plot of the chemical shifts of the signal MP in the presence of increasing amount of the Zn(II) complex with receptor **1** at pH 7 and 308 K.

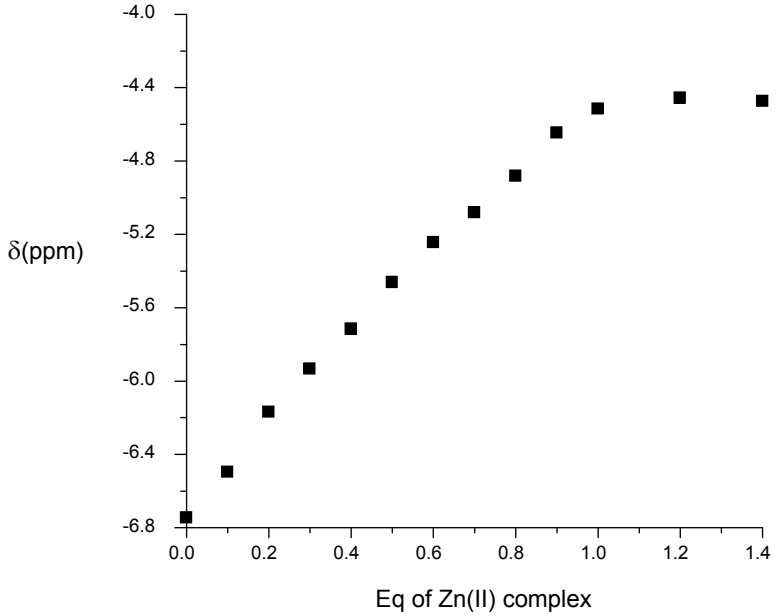


Fig. S4. Plot of the chemical shifts of the signal PP in the presence of increasing amount of the Zn(II) complex with receptor **1** at pH 7 and 308 K.

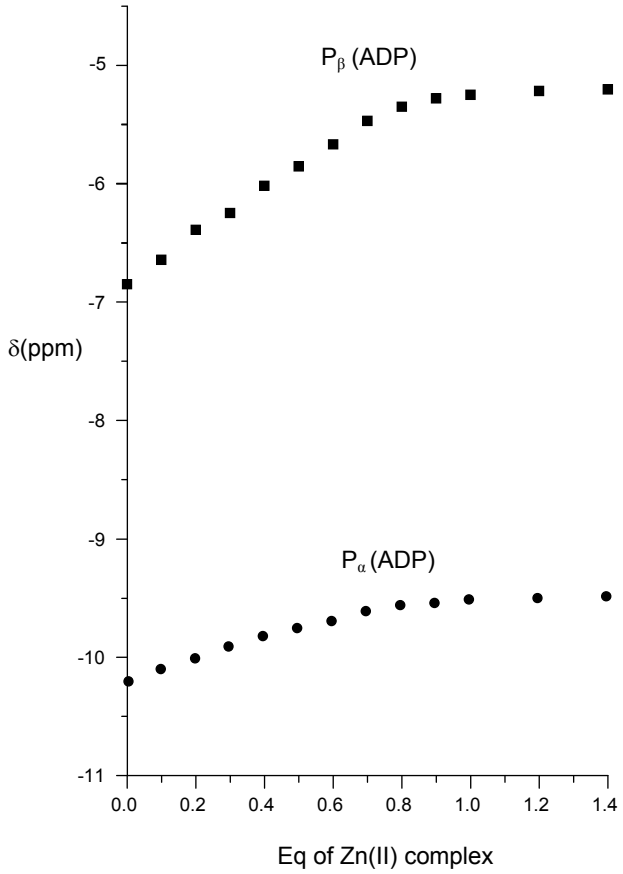


Fig. S5. Plot of the chemical shifts of the signals of the terminal (P_β) and central (P_α) phosphate groups of ADP in the presence of increasing amount of the Zn(II) complex with receptor **1** at pH 7 and 308 K.

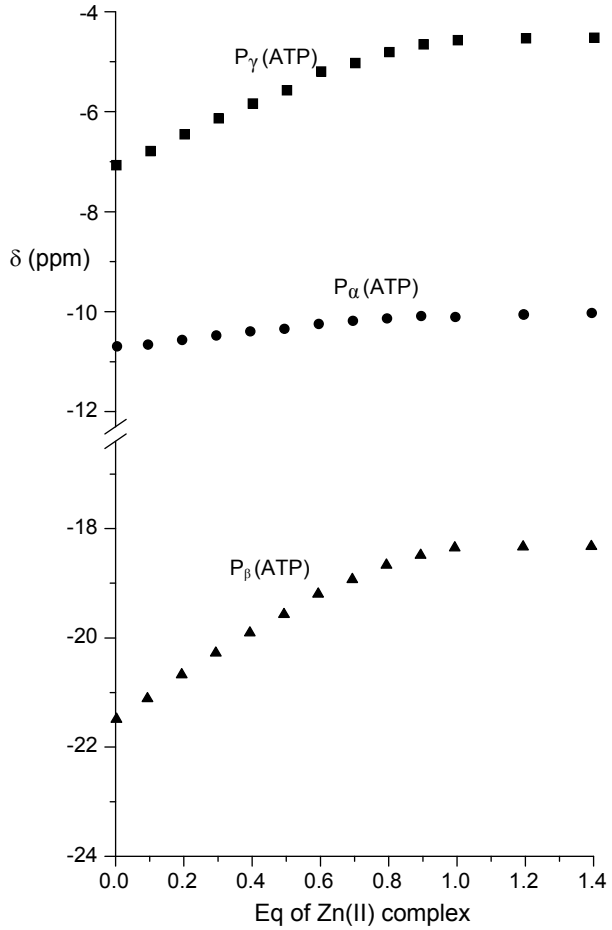


Fig. S6. Plot of the chemical shifts of the signals of the P_α, and P_β and P_γ phosphate groups of ATP in the presence of increasing amount of the Zn(II) complex with receptor **1** at pH 7 and 308 K.

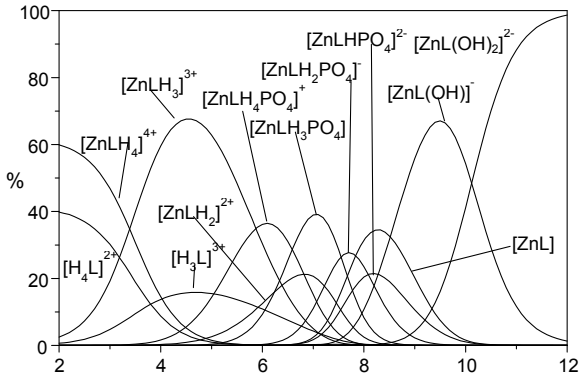


Fig. S7. Distribution diagrams of the complexes formed by MP with the Zn(II) complexes with receptor **1** (L^{2-} in the figure, [**1**] = [Zn^{2+}] = [MP] $1 \cdot 10^{-3}$ M, NMe_4Cl 0.1 M, 308 K).

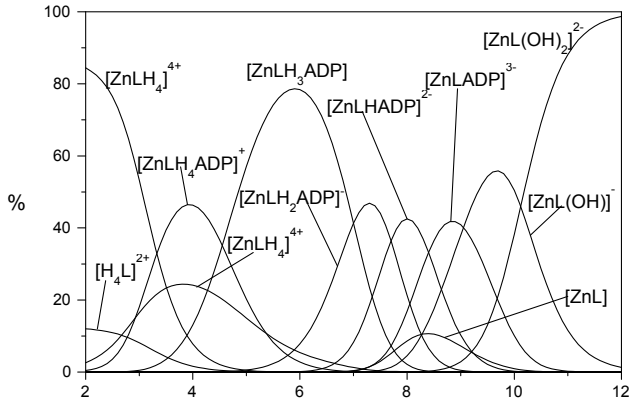


Fig. S8. Distribution diagrams of the complexes formed by ADP with the Zn(II) complexes with receptor **1** (L^{2-} in the figure, [**1**] = [Zn^{2+}] = [ADP] = $1 \cdot 10^{-3}$ M, NMe_4Cl 0.1 M, 308 K).

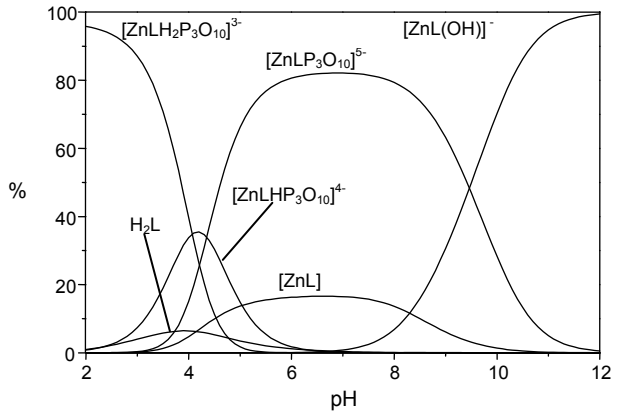


Fig. S9. Distribution diagrams of the complexes formed by TP with the Zn(II) complex with MIDA (indicated as H_2L in the figure, [MIDA] = $[Zn^{2+}]$ = [TP] = $1 \cdot 10^{-3}$ M, NMe_4Cl 0.1 M, 308 K).

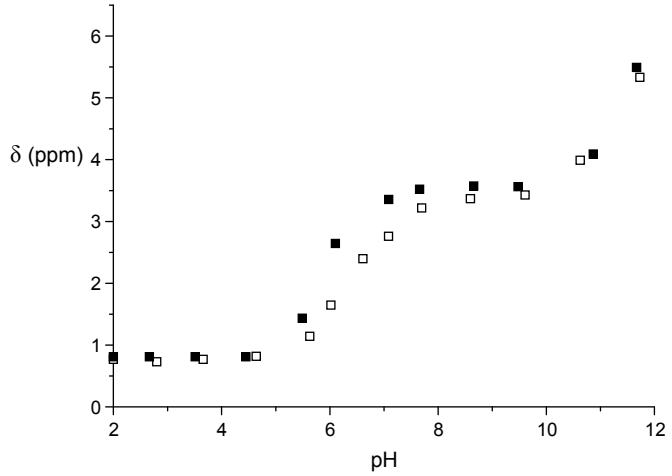


Fig. S10. pH dependence of the ^{31}P NMR signal of MP in the presence (filled symbols) and in the absence (empty symbols) of the Zn(II) complex with receptor **1** ([**1**] = [Zn^{2+}] = [MP] = 5 x 10^{-3} M, 308 K).

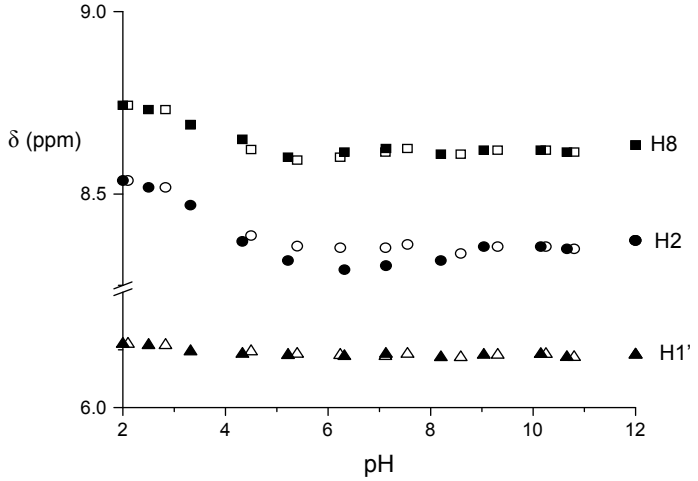


Fig. S11. pH dependence of the ^{1}H NMR signals of the H8 (top) and H2 (middle) adenine protons and of the anomeric H1' (bottom) proton of the sugar moiety of ADP in the presence (filled symbols) and in the absence (empty symbols) of the Zn(II) complex of **1**. Conditions: [**1**] = [Zn^{2+}] = [ATP] = 5 x 10^{-3} M, 308 K.