A Novel C_{3v}-Symmetrical Calix[6](aza)cryptand with a Remarkably High and Selective Affinity for Small Ammoniums

Ulrich Darbost, Michel Giorgi Olivia Reinaud and Ivan Jabin**

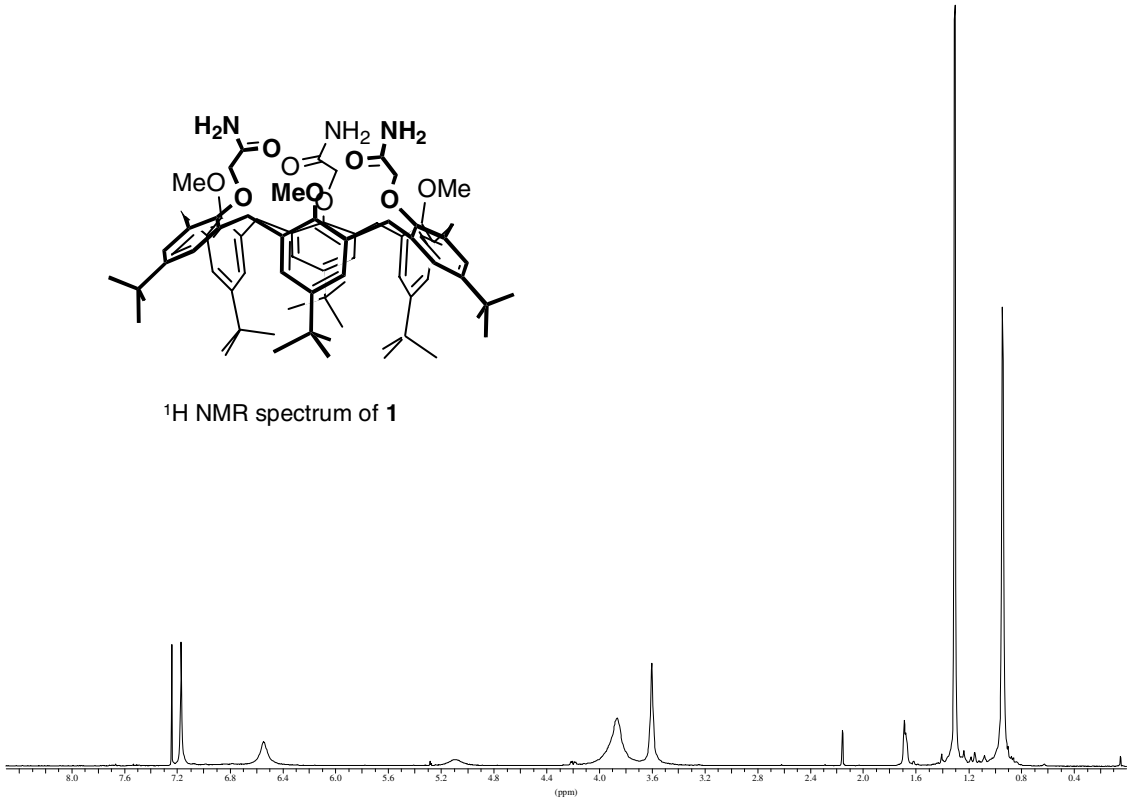
Supporting Information

i) Figures S1-S7: ^{1}H spectra of compounds **1**, **2**, **5** and ^{13}C NMR spectra of compounds **1**, **2**, **3**, **5** recorded at 200 MHz (^{1}H) and 50 MHz (^{13}C) in $CDCl_3$.

ii) Figures S8-S11: HMQC spectra of compounds **1**, **2**, **3** and DEPT 135 spectrum of **1** recorded in $CDCl_3$.

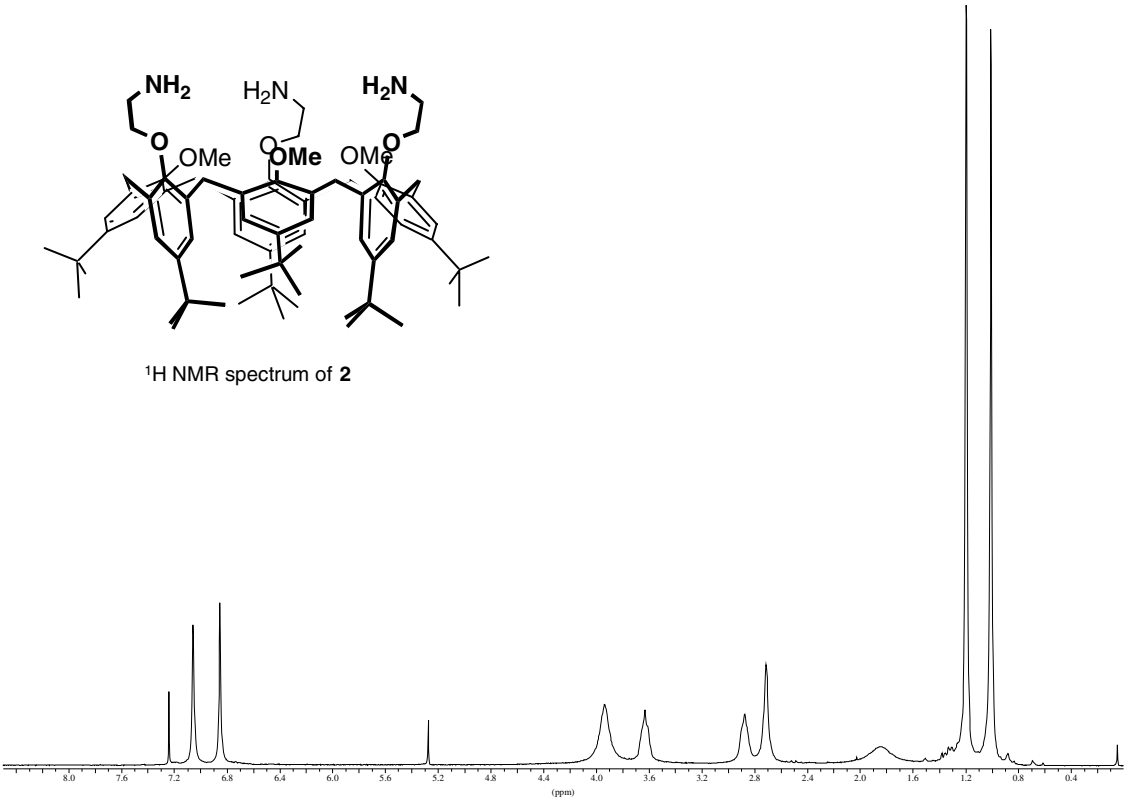
iii) Figure S12: X-ray structure of complex **3**⊃**4d** with a second conformation of the ammonium guest.

iv) General Experimental Methods (solid-liquid extraction of ammonium chloride salts by host **3**, percentage extraction measurements by the ultraviolet method, determination of association constant and free energy of binding).



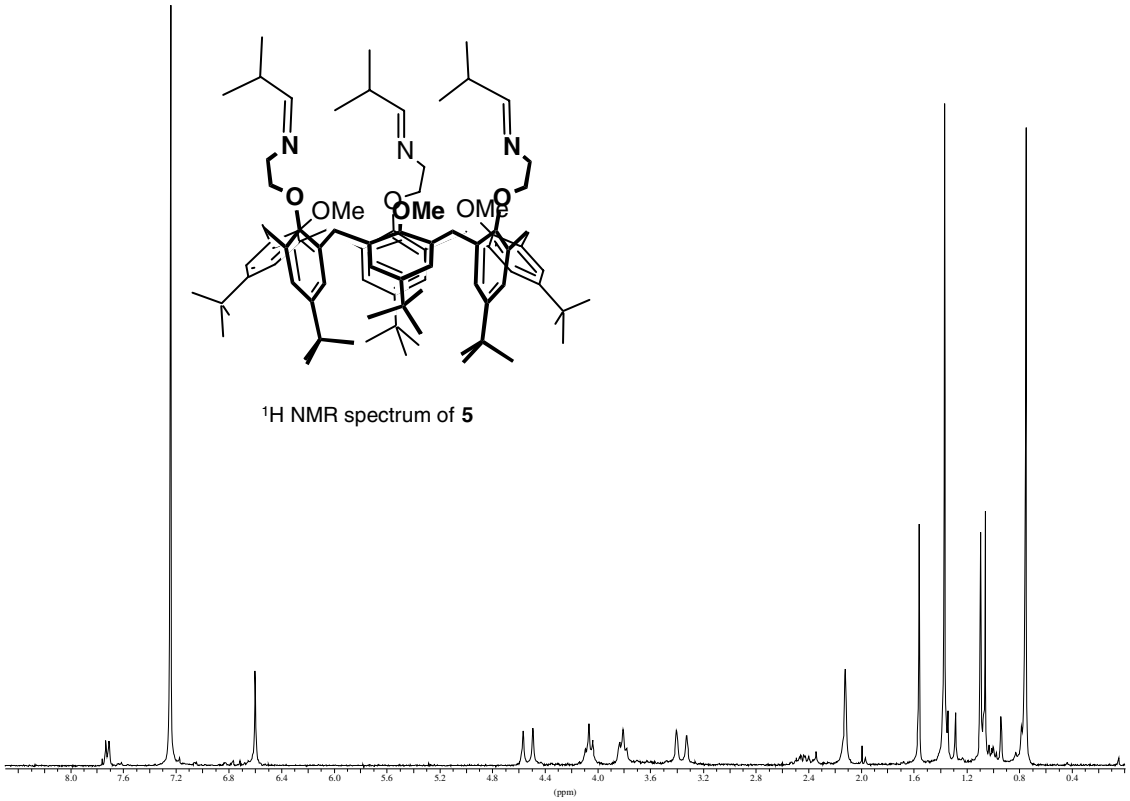
^{1}H NMR spectrum of **1**

Figure S1



^{1}H NMR spectrum of **2**

Figure S2



^{1}H NMR spectrum of **5**

Figure S3

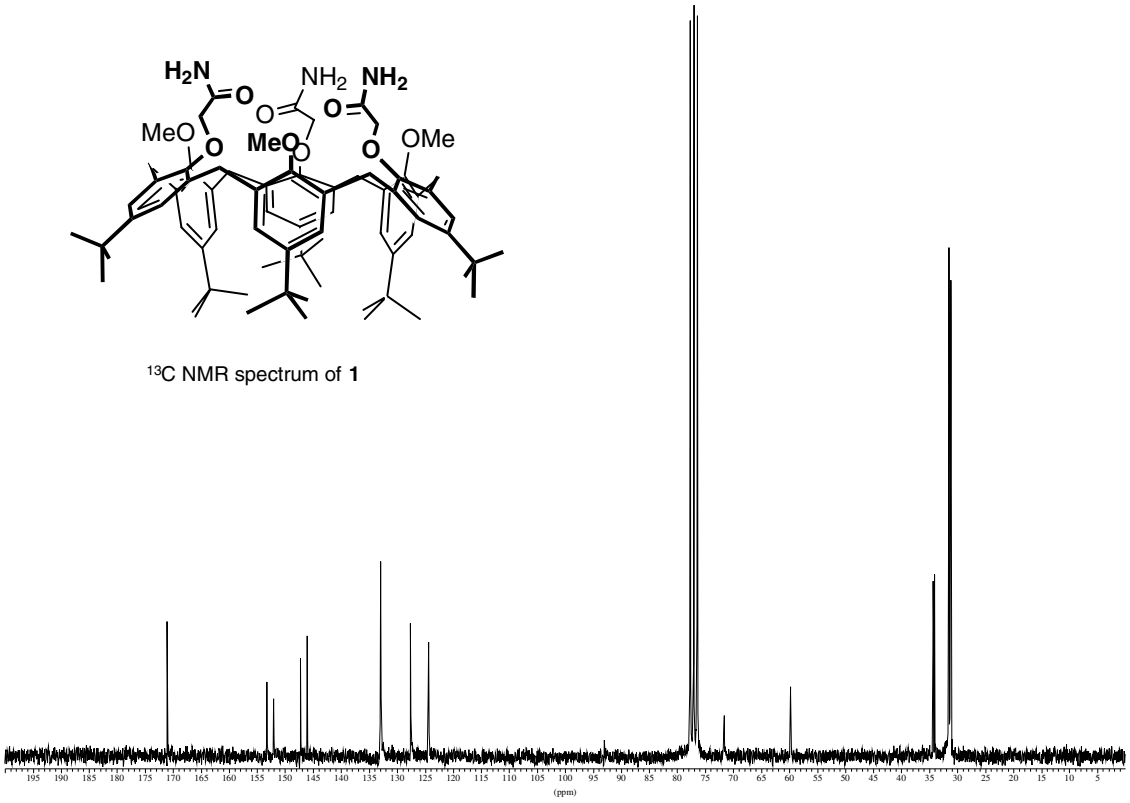


Figure S4

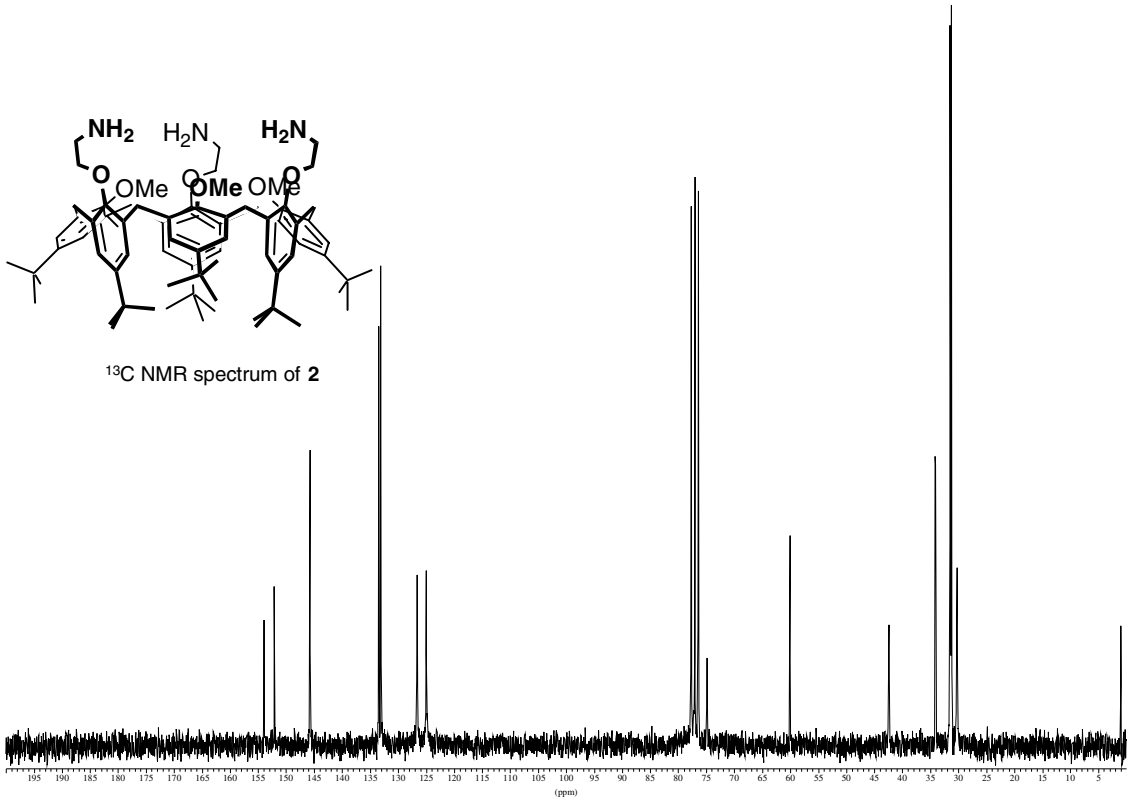

NH2
H2N
H2N
O
OMe
O
OMe
OMe
O
13C NMR spectrum of 2
195 190 185 180 175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5
(ppm)

Figure S5

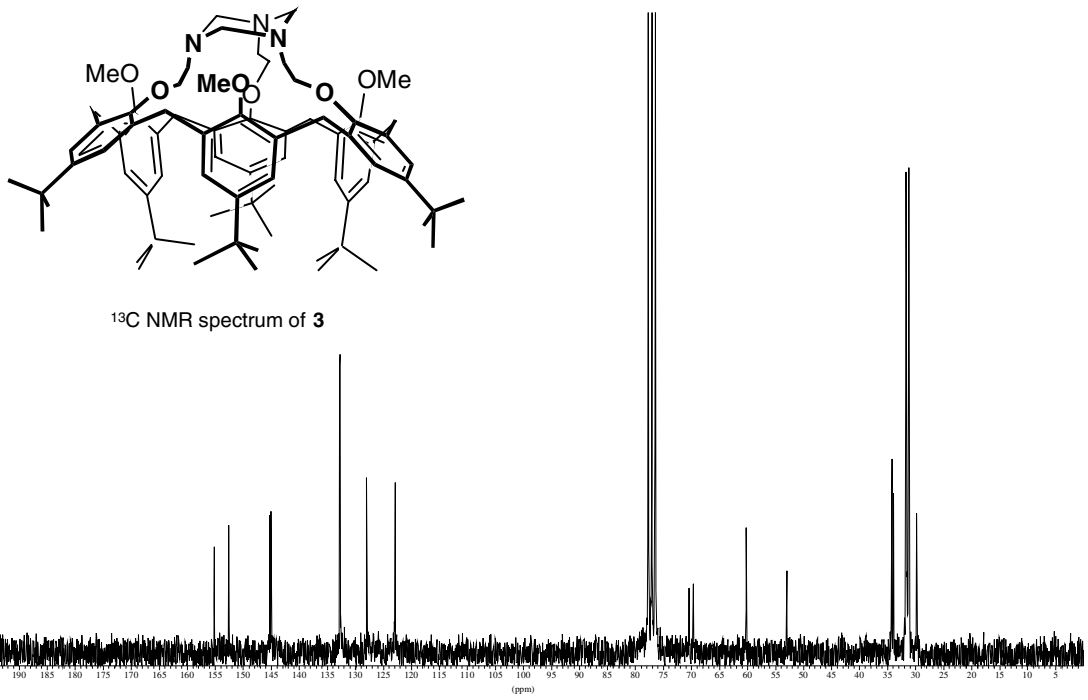

MeO
O
MeO
O
O
OMe
N
N
N
^{13}C NMR spectrum of **3**
195 190 185 180 175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5
(ppm)

Figure S6

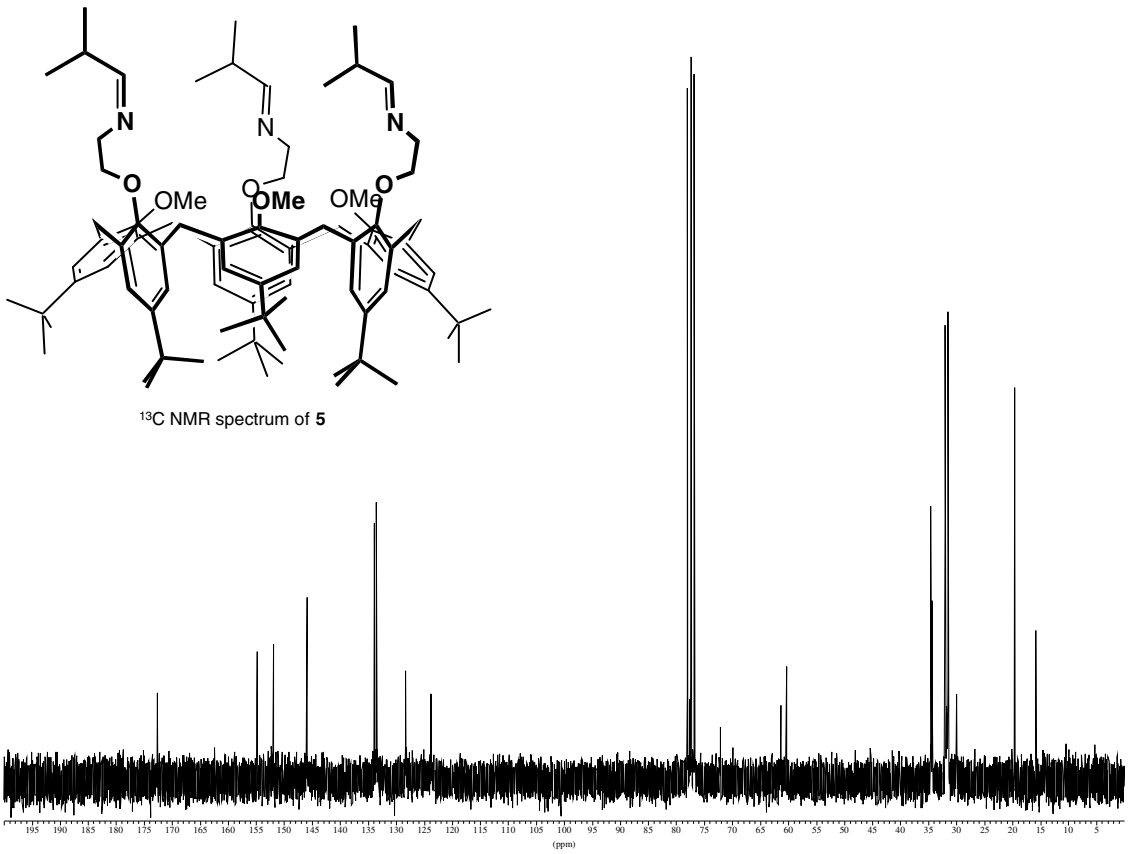
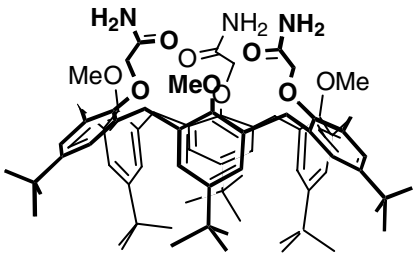


Figure S7



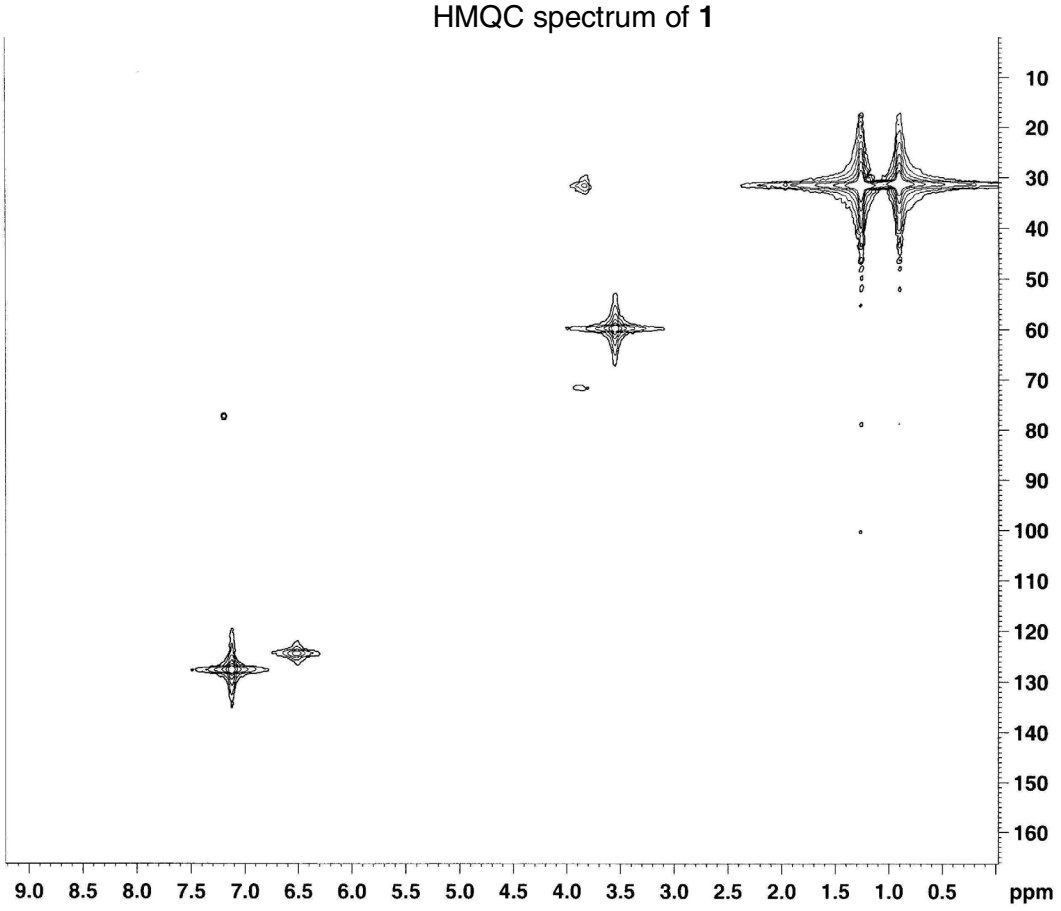
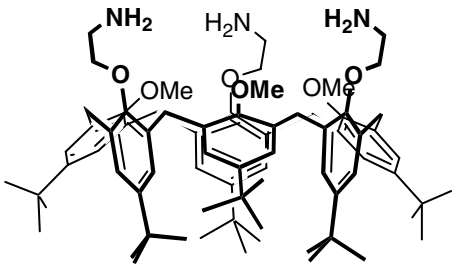


Figure S8. HMQC spectrum of 1.



HMQC spectrum of **2**

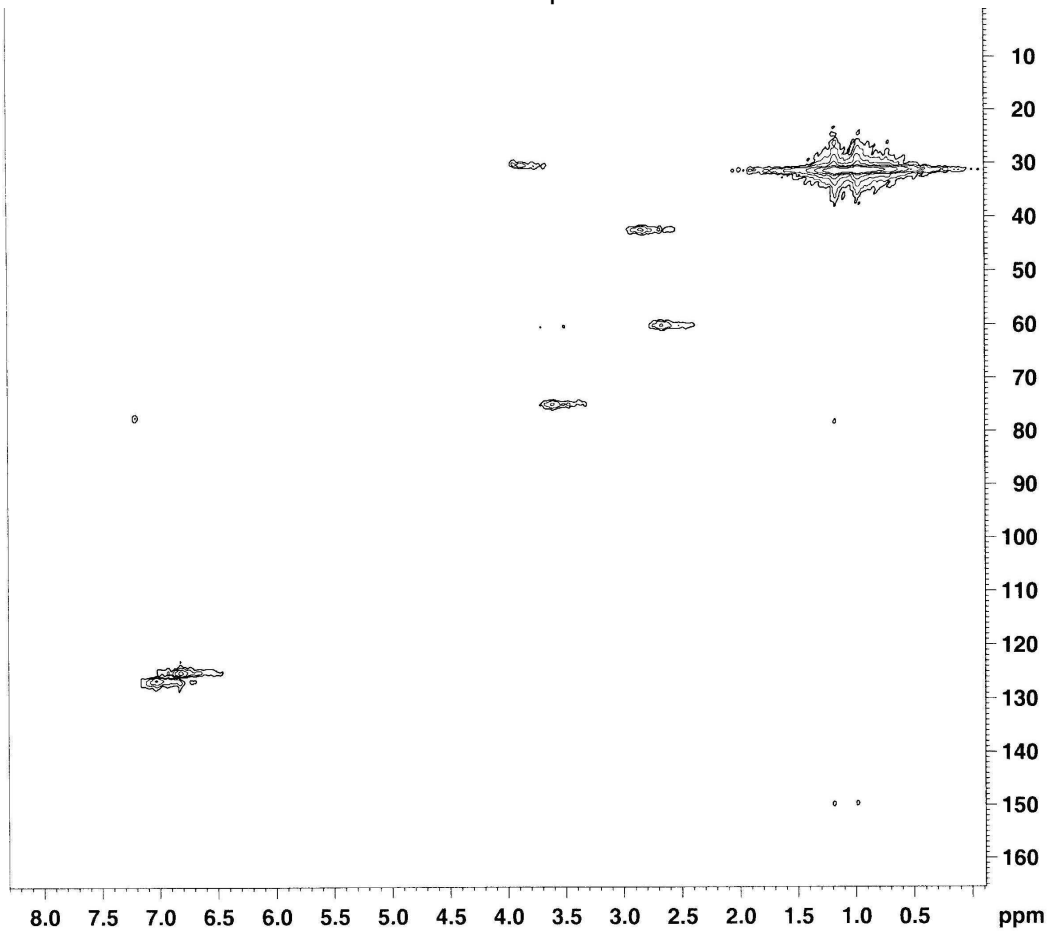
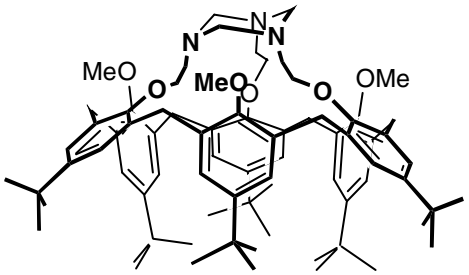


Figure S9. HMQC spectrum of 2.



HMQC spectrum of **3**

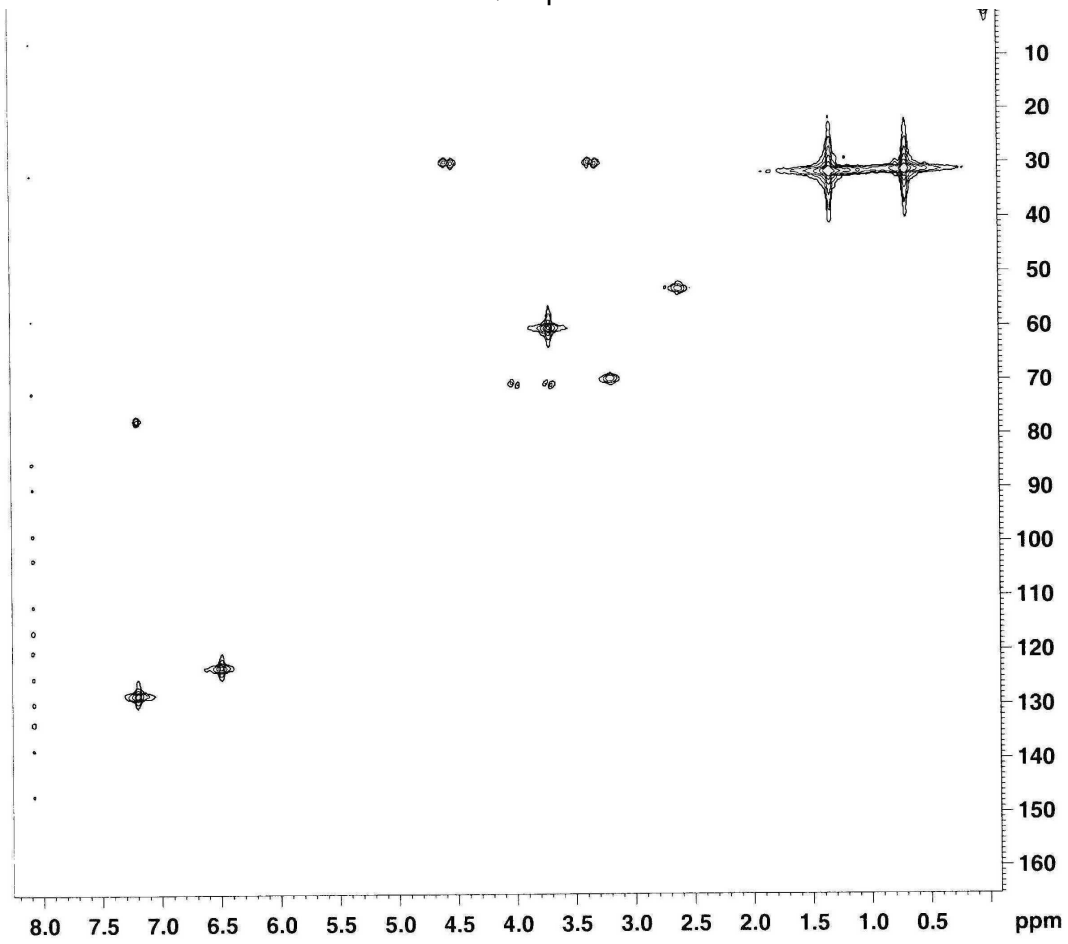
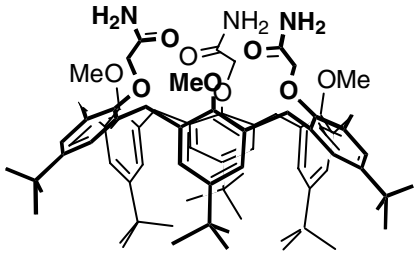


Figure S10. HMQC spectrum of 3.



DEPT 135 spectrum of **1**

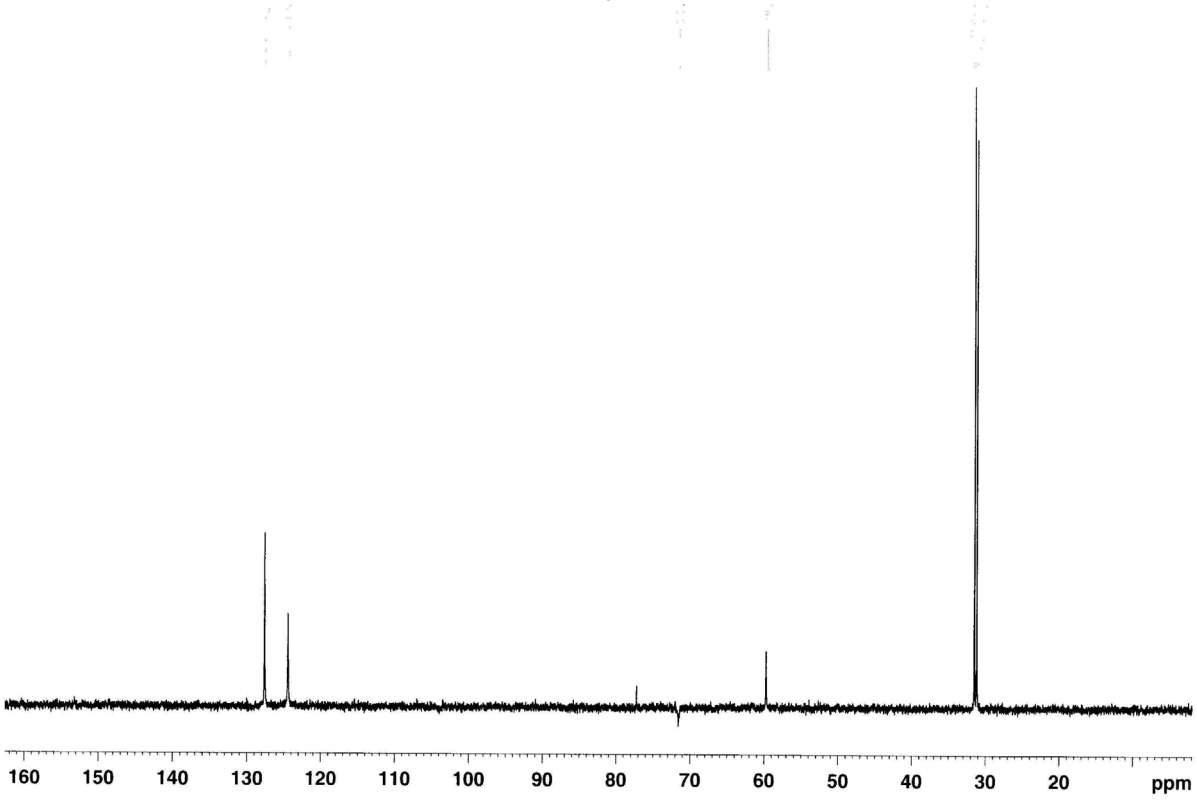
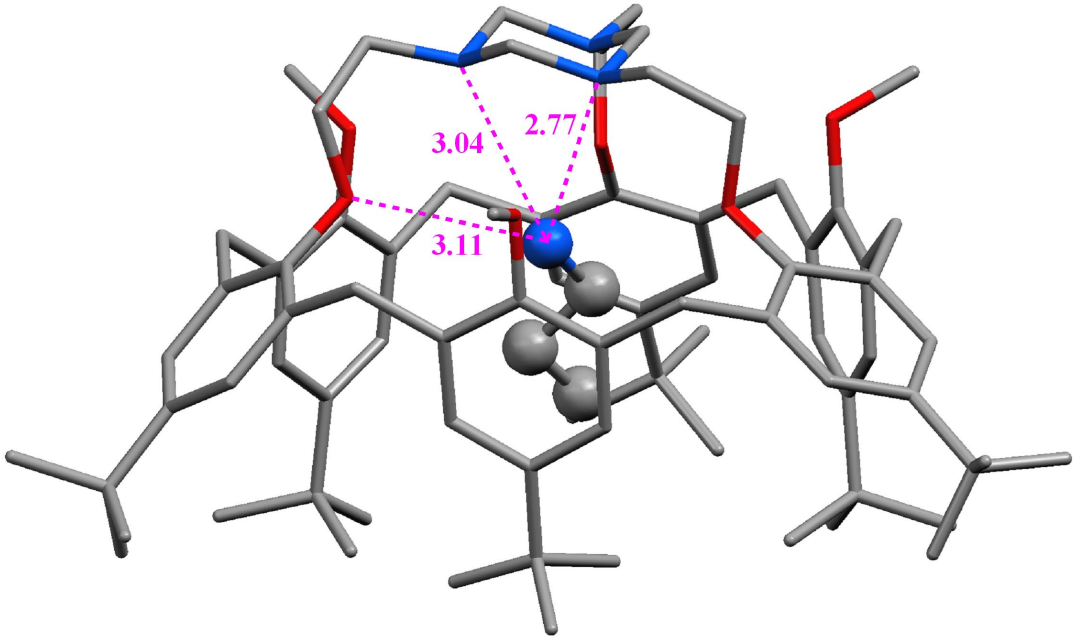


Figure S11. DEPT 135 spectrum of 1.



X-ray structure of complex **3⊃4d** with a second conformation for the ammonium guest. (Hydrogen atoms, picrate counter-ion and solvent of crystallization have been omitted for clarity).

Figure S12

General Experimental Methods

Solid-liquid extraction of ammonium chloride salts by host 3. An excess (ca. 4 equiv.) of solid $RNH_3^+Cl^-$ (with R = Me, Et or Pr) was added into an NMR tube containing calix[6]TAC **3** (5 mg, 4.2 µmol) in 0.6 mL of $CDCl_3$. After 15 min of sonication, a ^1H NMR spectrum recorded at 298 K revealed the presence of the complex **3**⊃**RNH$_3^+$** as the only product.

Percentage extraction (% E) measurements by the ultraviolet method. All UV measurements were made on a spectrometer at 298 K. Solutions (5×10^{-3} M) of picrate salts [**4a-d**] were prepared in distilled water in volumetric flasks. Solutions (5×10^{-3} M) of host **3** were prepared in $CHCl_3$ in volumetric flasks. Equal volumes (1.00 mL) of the two solutions were stirred vigorously for 36 hours at 298 K in stopped tubes. Then, the solutions were left standing until phase separation was complete. A sample (0.100 mL) of the aqueous layer was removed with a 0.25 mL syringe and diluted to 5.00 mL with distilled water into a volumetric flask. The absorbance (A) of the dilute solution was then recorded at 355 nm. At least two separate absorbance measurements were performed to ensure the values. The concentration of the picrate ion in the dilute solution was calculated according to the Lambert-Beer Law and the % E was then determined. Control experiments showed that the equilibrium was reached after 20 hours of stirring and that no picrate ion extraction occurred in the absence of host **3**.

Determination of association constant (Ka) and free energy of binding (ΔG°).

From the % E measurements. According to the literature,[17] association constant (Ka) and free energy of binding (ΔG°) between $NH_4^+Pic^-$ **4a** and host **3** were defined respectively as $Ka = [\mathbf{3}\supset\mathbf{4a}]_{CDCl_3} / [\mathbf{3}]_{CDCl_3} \times Kd \times [\mathbf{4a}]^2_{H_2O}$ (all the concentrations being those measured at equilibrium) and $\Delta G° = -RT \ln Ka$. Distribution constants Kd between water and $CHCl_3$ for **4a** ($Kd = 4.02 \times 10^{-3}$ M^{-1}) and for **4b** ($Kd = 14.5 \times 10^{-3}$ M^{-1}) have been previously reported by Cram.[16]

*From ^1H NMR competitive binding studies between calix[6]TAC **3** and ammonium picrates **4b-g**.* For a typical procedure: at room temperature, CD_3OD solutions (0.4 M) of ammonium picrates **4b** (29 µL, 11.6 µmoL) and **4c** (26 µL, 10.4 µmoL) were successively added with a 0.100 mL syringe in a $CDCl_3$ solution (0.600 mL) containing calix[6]TAC **3** (5 mg, 4.2 µmol). An ^1H NMR spectrum

recorded at room temperature showed the presence of both endo-complexes **3**⊃**4b** and **3**⊃**4c** besides the signals corresponding to the free ammonium picrates **4b** and **4c**. Thus, association constant for **4c** ($Ka_{(4c)}$) was defined as $Ka_{(4c)} = Ka_{(4b)} \times ([\mathbf{3}\supset\mathbf{4c}] \times [\mathbf{4b}_{(free)}]) / ([\mathbf{3}\supset\mathbf{4b}] \times [\mathbf{4c}_{(free)}])$. Free energy of binding ($\Delta G°$) were defined as $\Delta G° = -RT \ln Ka$.

Salts ratio used for other NMR competitive experiments ($CDCl_3$, CD_3OD; 92:8). **4c/4d**: 0.66, **4d/4e**: 0.31, **4b/4f**: 0.49, **4f/4g**: 0.12.