# Asymmetric Synthesis of Planar-chiral Metacyclophanes via Aromatic Amination enabled Enantioselective Desymmetrization

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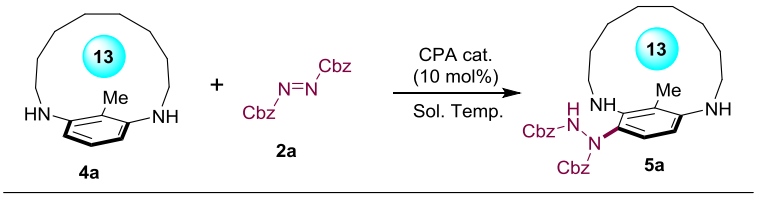
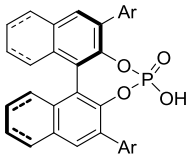
**General Information**

Unless otherwise noted, all commercial reagents were used without further purification. Dichloromethane, toluene, diethyl ether, THF were purified by passage through an activated alumina column under argon. Thin-layer chromatography (TLC) analysis of reaction mixtures were performed using Huanghai silica gel HSGF254 TLC plates, and visualized under UV or by staining with ceric ammonium molybdate or potassium permanganate. Flash column chromatography was carried out on Huanghai Silica Gel HHGJ-300, 300-400 mesh. Nuclear magnetic resonance (NMR) spectra were recorded using Bruker Avance III HD spectrometer (FT, 600 MHz for $^{1}$H, 151 MHz for $^{13}$C, 565 MHz for $^{19}$F, 500 MHz for $^{1}$H, 126 MHz for $^{13}$C, 471 MHz for $^{19}$F or 400 MHz for $^{1}$H, 101 MHz for $^{13}$C, 376 MHz for $^{19}$F). $^{1}$H and $^{13}$C chemical shifts are reported in ppm downfield of tetramethylsilane and referenced to residual solvent peak ($CDCl_3$; $\delta$H = 7.26 and $\delta$C = 77.16; toulene-$d_8$, δH = 2.08, 6.97, 7.01, 7.09 and δC = 20.43, 125.13, 127.96, 128.87, 137.48; acetone-$d_6$, δH = 2.05 and δC = 29.84, 206.26). Multiplicities are reported using the following abbreviations: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad resonance. Mass spectral data were obtained from the Thermo Fisher Scientific Q-Exactive Focus quadrupole orbital trap LC/MS spectrometer in electrospray ionization ($ESI^+$ or $ESI^-$) mode. Optical rotations were measured with an Autopol V Plus/VI digital polarimeter. X-Ray structure analyses were performed using a Bruker D8 Venture X-ray single crystal diffractometer. Enantiomeric excesses were determined on an Agilent 1260 Chiral HPLC using IA, IB, IC, ID columns under the detective wavelength of 210, 254 or 280 nm. The racemic products were synthesized by using diphenyl phosphate as catalyst.

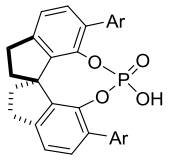
**Optimization of reaction conditions**

**Table S1.** Optimizations of reaction conditions of **5**.[a]




**A1**, BINOL, Ar = Ph
**A2**, BINOL, Ar = 2-naphthyl
**A3**, BINOL, Ar = 9-anthracenyl
**A4**, BINOL, Ar = 2,4,6-$(Me)_3C_6H_2$
**A13**, BINOL, Ar = 2,4,6-$(^iPr)_3C_6H_2$
**A5**, BINOL, Ar = 2,4,6-$(Cy)_3C_6H_2$
**A12**, BINOL, Ar = 2,6-$(^iPr)_2$-$C_6H_4$
**A14**, BINOL, Ar = 2,6-$(^iPr)_2$-4-tBu-$C_6H_2$
**A15**, H8-BINOL, Ar = 2,4,6-$(^iPr)_3C_6H_2$




**A16**, Ar = 2,4,6-$(iPr)_3C_6H_2$

| Entry | CPA | Sol. | Temp ($^o$C) | Yield (%)[b] | Er[c] |
|---|---|---|---|---|---|
| 1 | **A1** | Tol. | 20 | 23 | 53:47 |
| 2 | **A2** | Tol. | 20 | 21 | 51.5:48.5 |
| 3 | **A3** | Tol. | 20 | 65 | 87.5:12.5 |
| 4 | **A4** | Tol. | 20 | 37 | 53:47 |
| 5 | **A13** | Tol. | 20 | 46 | 87:13 |
| 6 | **A5** | Tol. | 20 | 45 | 74.5:25.5 |
| 7 | **A12** | Tol. | 20 | 72 | 91:9 |
| 8 | **A14** | Tol. | 20 | 51 | 76:24 |
| 9 | **A15** | Tol. | 20 | 75 | 82.5:17.5 |
| 10 | **A16** | Tol. | 20 | trace | N.D. |
| 11 | **A12** | DCM | 20 | 79 | 88.5:11.5 |
| 12 | **A12** | $Et_2O$ | 20 | 80 | 90.5:9.5 |
| 13 | **A12** | c-hexane | 20 | 76 | 93.5:6.5 |
| 14d | **A12** | Tol. | -20 | 85 | 94.5:5.5 |
| 15e | **A12** | Tol. | -40 | 86 | 95.5:4.5 |

a Reactions were performed with **4a** (0.05 mmol), **2a** (0.05 mmol), and the CPA catalyst (0.005 mmol, 10 mol%) in solvent (0.5 mL) at 20 $^o$C for 12 h.

b Isolated yield.

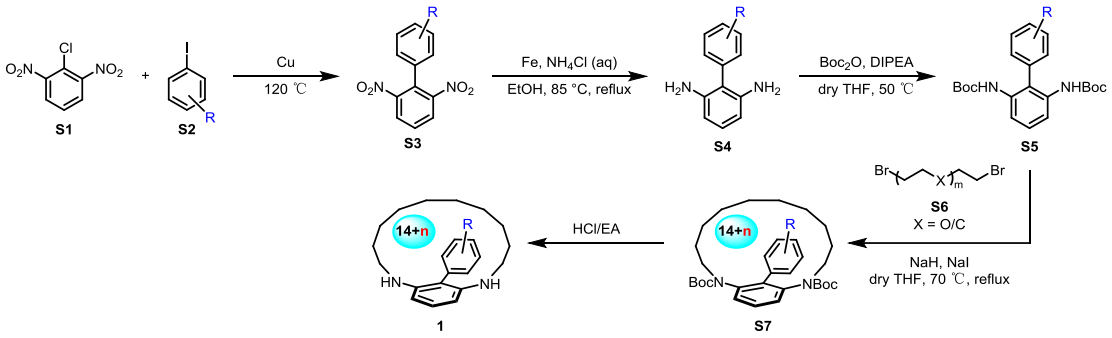
c The ee values were determined by HPLC analysis on a chiral stationary phase.

d The reaction was performed at -20 $^o$C for 48h.

e The reaction was performed at -40 $^o$C for 48h.

**Synthesis of substrates**

**1. Synthetic of Metacyclophane 1**




**General procedure**: To a Schlenk tube equipped with a stir bar were added **S1** (1.5 g, 7.5 mmol, 1.0 equiv), **S2** (15.0 mmol, 2.0 equiv) and Cu (2.0 g, 30.75 mmol, 4.1 equiv) sequentially at rt, and the mixture was stirred at 120 ℃ overnight under $N_2$ atmosphere. After completion of the reaction if indicated by TLC analysis, the mixture was cooled to room temperature and filtered over celite with DCM. The filtrate was concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **S3**.

To a solution of **S3** (4.0 mmol, 1.0 equiv) in EtOH (20 mL) and saturated $NH_4Cl$ solution (20 mL) was added Fe powder (2 g), and the mixture was allowed to stir overnight at 85 ℃. After the consumption of the starting materials as monitored by TLC, the reaction mixture was filtered over celite and extracted with ethyl acetate for 3 times. The combined organic phases were washed with water and brine, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **S4**.

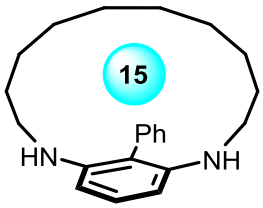
To a solution of **S4** (3.5 mmol, 1.0 equiv) in anhydrous THF (17.5 mL, c = 0.2 M) was added DIPEA (1.8 mL, 10.5 mmol, 3.0 equiv) and $Boc_2O$ (2.4 mL, 10.5 mmol, 3.0 equiv). Then the mixture was stirred at 50 ℃ for 24-48 h. After the consumption of the starting materials as monitored by TLC, the reaction mixture was extracted with ethyl acetate for 3 times. The combined organic phases were washed with water and brine, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **S5**.

To a suspension of sodium hydride (60% in mineral oil, 360 mg, 9 mmol, 3.0 equiv) in dry THF (150 mL) was added NaI (45.0 mg, 0.3 mmol, 0.1 equiv). Then the mixture was added with a solution of **S5** (3.0 mmol, 1.0 equiv) and **S6** (3.0 mmol, 1.0 equiv) in dry THF (50.0 mL) dropwise using syringe

pump (3.0 mL/h) over a 17 h period at 70 ℃. After stirring for another 12 h at this temperature, the reaction mixture was cooled to room temperature and quenched with saturated $NH_4Cl$ solution, and extracted with ethyl acetate for 3 times. The combined organic phases were washed with water and brine, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **S7**.

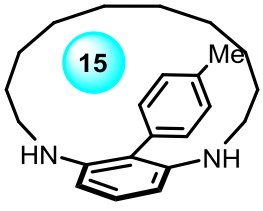
The solution of **S7** (0.3 mmol, 1.0 equiv) in HCl/EtOAc (8 mL, 2 mol/L in ethyl acetate) was allowed to stir for 5-8 h at room temperature. After the consumption of the starting materials as monitored by TLC, the reaction mixture was quenched with saturated $NaHCO_3$ solution, and extracted with ethyl acetate for 3 times. The combined organic phases were washed with water and brine, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **1**.

$1^2$-phenyl-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1a**)



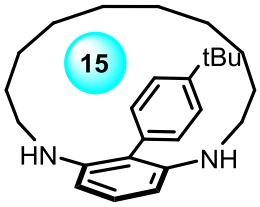

**1a** was prepared in 5.0 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: DCM: ethyl acetate = 100: 50: 1 to 20: 10: 3) as a yellow solid (206.8 mg, 13% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.2 (petroleum ether: DCM: ethyl acetate = 20: 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.60 – 7.47 (m, 3H), 7.42 (tt, *J* = 7.4, 1.4 Hz, 1H), 7.25 (d, *J* = 7.3 Hz, 1H), 7.10 (t, *J* = 8.1 Hz, 1H), 6.33 (d, *J* = 8.1 Hz, 2H), 3.44 (ddd, *J* = 14.8, 5.9, 3.5 Hz, 2H), 2.91 (ddd, *J* = 14.8, 9.0, 3.1 Hz, 2H), 1.80 – 1.72 (m, 2H), 1.27 – 1.00 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 146.6, 135.4, 133.3, 130.6, 129.6, 129.5, 128.5, 128.2, 117.1, 105.9, 45.2, 28.9, 28.8, 28.2, 25.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{22}H_{31}N_2^+$: 323.2482; found: 323.2478.

$1^2$-(*p*-tolyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1c**)



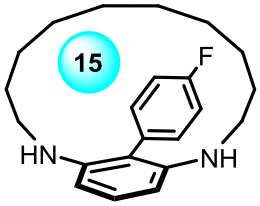
**1c** was prepared in 2.0 mmol scale (S5) and isolated by flash chromatography (petroleum ether: ethyl acetate = 30: 1 to 15: 1) as a yellow solid (69.6 mg, 10% yield for two steps from S5). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.43 – 7.34 (m, 2H), 7.31 (d, *J* = 7.8 Hz, 1H), 7.12 (dd, *J* = 7.8, 1.8 Hz, 1H), 7.08 (t, *J* = 8.1 Hz, 1H), 6.31 (d, *J* = 8.1 Hz, 2H), 3.44 (ddd, *J* = 14.8, 5.9, 3.4 Hz, 2H), 2.90 (ddd, *J* = 14.9, 9.1, 3.0 Hz, 2H), 2.42 (s, 3H), 1.80 – 1.70 (m, 2H), 1.26 – 0.98 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 146.9, 137.9, 133.1, 132.1, 131.3, 130.3, 129.3, 128.3, 117.0, 105.7, 45.2, 28.9, 28.8, 28.2, 25.4, 21.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{23}H_{33}N_2^+$: 337.2639; found: 337.2635.

$1^2$-(4-(*tert*-butyl)phenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1d**)




**1d** was prepared in 3.2 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: DCM: ethyl acetate = 100: 50: 1 to 20: 10: 1) as a yellow solid (151.1 mg, 13% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.4 (petroleum ether: DCM: ethyl acetate = 20: 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.58 – 7.48 (m, 2H), 7.44 – 7.38 (m, 1H), 7.19 – 7.13 (m, 1H), 7.08 (t, *J* = 8.1 Hz, 1H), 6.31 (d, *J* = 8.1 Hz, 2H), 3.45 (ddd, *J* = 14.8, 5.8, 3.5 Hz, 2H), 3.29 (s, 2H), 2.92 (ddd, *J* = 14.8, 9.2, 2.9 Hz, 2H), 1.81 – 1.72 (m, 2H), 1.38 (s, 9H), 1.28 – 0.98 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 150.9, 146.9, 132.8, 132.1, 129.0, 128.2, 127.6, 126.3, 117.0, 105.6, 45.1, 34.8, 31.5, 28.9, 28.8, 28.2, 25.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{26}H_{39}N_2^+$: 379.3108; found: 379.3104.

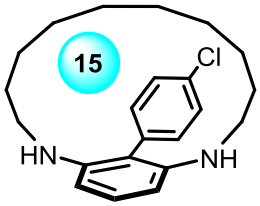
$1^2$-(4-fluorophenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1e**)




**1e** was prepared in 1.2 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: ethyl acetate = 20: 1 to 10: 1) as a yellow solid (37.8 mg, 9% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.54 – 7.41 (m, 1H), 7.30 –

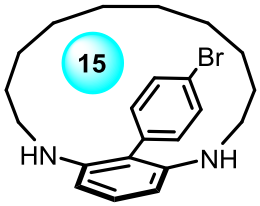
7.17 (m, 3H), 7.10 (t, *J* = 8.1 Hz, 1H), 6.31 (d, *J* = 8.1 Hz, 2H), 3.45 (ddd, *J* = 14.9, 5.9, 3.5 Hz, 2H), 3.17 (s, 2H), 2.92 (ddd, *J* = 14.9, 9.1, 3.1 Hz, 2H), 1.83 – 1.71 (m, 2H), 1.27 – 0.98 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 162.6 (d, *J* = 247.6 Hz), 146.9, 135.3, 131.2 (d, *J* = 3.6 Hz), 128.6, 117.7 (d, *J* = 20.8 Hz), 116.6 (d, *J* = 21.4 Hz), 115.7, 105.7, 45.1, 28.9, 28.8, 28.3, 25.4. **$^{19}$F NMR** (565 MHz, $CDCl_3$) δ -113.8. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{22}H_{30}FN_2^+$: 341.2388; found: 341.2384.

$1^2$-(4-chlorophenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1f**)




**1f** was prepared in 1.3 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: DCM: ethyl acetate = 50: 25: 1 to 20: 10: 1) as a yellow solid (60.7 mg, 12% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.4 (petroleum ether: DCM: ethyl acetate = 20: 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.55 (d, *J* = 8.2 Hz, 1H), 7.48 (d, *J* = 8.2 Hz, 1H), 7.44 (d, *J* = 8.1 Hz, 1H), 7.19 (d, 1H), 7.09 (t, *J* = 8.1 Hz, 1H), 6.31 (d, *J* = 8.1 Hz, 2H), 3.44 (ddd, *J* = 14.9, 5.9, 3.5 Hz, 2H), 3.12 (s, 2H), 2.91 (ddd, *J* = 14.9, 9.0, 3.0 Hz, 2H), 1.81 – 1.70 (m, 2H), 1.29 – 0.96 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 146.7, 134.9, 134.2, 133.9, 131.0, 130.8, 129.9, 128.8, 115.5, 105.8, 45.1, 28.9, 28.8, 28.3, 25.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{22}H_{30}ClN_2^+$: 357.2093; found: 357.2089.

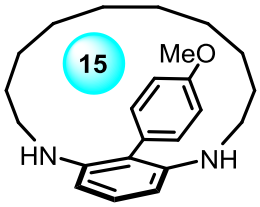
$1^2$-(4-bromophenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1g**)




**1g** was prepared in 4.4 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: ethyl acetate = 20: 1 to 10: 1) as a yellow solid (276.7 mg, 16% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.70 (d, *J* = 8.2 Hz, 1H), 7.64 (d, *J* = 8.2 Hz, 1H), 7.38 (d, *J* = 8.2 Hz, 1H), 7.14 (d, *J* = 8.2 Hz, 1H), 7.09 (t, *J* = 8.1 Hz, 1H), 6.31 (d, *J* = 8.1 Hz, 2H), 3.44 (ddd, *J* = 14.9, 5.9, 3.5 Hz, 2H), 3.15 (s, 2H), 2.91 (ddd, *J* = 14.8, 9.1, 3.1 Hz, 2H), 1.81 – 1.71 (m, 2H), 1.33 – 0.95 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 146.6, 135.2,

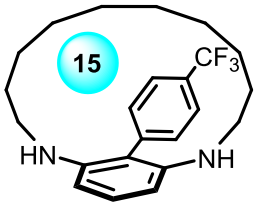
134.4, 133.8, 132.9, 131.3, 128.8, 122.4, 115.5, 105.8, 45.1, 28.9, 28.8, 28.3, 25.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{22}H_{30}BrN_2^+$: 401.1587; found: 401.1612.

$1^2$-(4-methoxyphenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1h**)



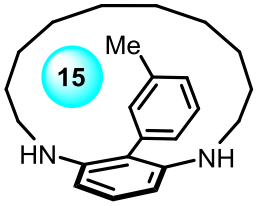

**1h** was prepared in 3.0 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: ethyl acetate = 20: 1 to 10: 1) as a yellow solid (151.2 mg, 14% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.2 (petroleum ether: ethyl acetate = 20: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.42 (dd, *J* = 8.5, 2.3 Hz, 1H), 7.16 (dd, *J* = 8.4, 2.2 Hz, 1H), 7.11 – 7.02 (m, 3H), 6.31 (d, *J* = 8.1 Hz, 2H), 3.87 (s, 3H), 3.45 (ddd, *J* = 14.8, 5.9, 3.4 Hz, 2H), 3.28 (s, 2H), 2.91 (ddd, *J* = 14.8, 9.1, 3.0 Hz, 2H), 1.81 – 1.68 (m, 2H), 1.29 – 0.97 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 159.4, 147.1, 134.5, 130.6, 128.3, 127.0, 116.6, 115.9, 115.1, 105.6, 55.4, 45.1, 28.9, 28.8, 28.2, 25.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{23}H_{33}N_2O^+$: 353.2588; found: 353.2583.

$1^2$-(4-(trifluoromethyl)phenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1i**)



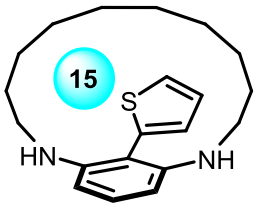

**1i** was prepared in 2.3 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: ethyl acetate = 20: 1 to 10: 1) as a yellow solid (178.9 mg, 20% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.81 (d, *J* = 34.0 Hz, 2H), 7.65 (s, 1H), 7.41 (s, 1H), 7.12 (t, *J* = 8.1 Hz, 1H), 6.33 (d, *J* = 8.1 Hz, 2H), 3.45 (ddd, *J* = 14.8, 6.0, 3.4 Hz, 2H), 3.09 (s, 2H), 2.92 (ddd, *J* = 14.9, 9.0, 3.1 Hz, 2H), 1.91 – 1.69 (m, 2H), 1.31 – 0.96 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 146.6, 139.8, 134.0, 130.4 (q, *J* = 32.6 Hz), 129.0, 127.4, 126.7, 124.2 (q, *J* = 272.2 Hz), 115.4, 105.9, 45.1, 28.9, 28.8, 28.3, 25.4. **$^{19}$F NMR** (565 MHz, $CDCl_3$) δ -62.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{23}H_{30}F_3N_2^+$: 391.2356; found: 391.2350.

$1^2$-(*m*-tolyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1j**)



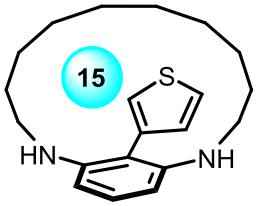

**1j** was prepared in 3.4 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: ethyl acetate = 20: 1 to 10: 1) as a yellow solid (137.5 mg, 12% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.44 (t, *J* = 7.6 Hz, 0.6H), 7.39 (t, *J* = 7.6 Hz, 0.4H), 7.34 – 7.28 (m, 1H), 7.22 (d, *J* = 7.7 Hz, 1H), 7.13 – 7.03 (m, 2H), 6.32 (d, *J* = 8.1 Hz, 2H), 3.51 – 3.38 (m, 2H), 2.91 (ddd, *J* = 14.9, 9.2, 2.9 Hz, 2H), 2.45 (s, 1.3H), 2.36 (s, 1.7H), 1.82 – 1.66 (m, 2H), 1.29 – 0.99 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 146.8, 146.7, 140.3, 139.1, 135.3, 135.2, 133.8, 130.4, 130.3, 130.1, 129.5, 128.9, 128.8, 128.3, 128.3, 126.4, 117.2, 105.7, 45.3, 45.1, 29.1, 29.1, 28.9, 28.7, 28.3, 28.2, 25.5, 25.4, 21.7, 21.5. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{23}H_{33}N_2^+$: 337.2639; found: 337.2634.

$1^2$-(thiophen-2-yl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1k**)



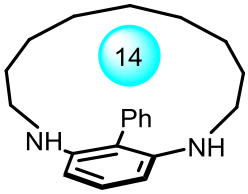

**1k** was prepared in 3.0 mmol (**S5**) scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 30: 1 to 10: 1) as a yellow solid (214.0 mg, 22% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.52 (dd, *J* = 5.2, 1.2 Hz, 1H), 7.21 (dd, *J* = 5.2, 3.4 Hz, 1H), 7.11 (t, *J* = 8.1 Hz, 1H), 7.06 (dd, *J* = 3.4, 1.1 Hz, 1H), 6.27 (d, *J* = 8.1 Hz, 2H), 3.58 (s, 2H), 3.47 (ddd, *J* = 14.7, 5.9, 3.4 Hz, 2H), 2.95 (ddd, *J* = 14.8, 9.1, 3.2 Hz, 2H), 1.80 – 1.69 (m, 2H), 1.36 – 0.82 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 148.6, 135.6, 129.8, 129.6, 128.4, 128.0, 108.4, 105.2, 45.0, 28.9, 28.4, 28.3, 25.3. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{20}H_{29}N_2S^+$: 329.2046; found: 329.2050.

$1^2$-(thiophen-3-yl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1l**)



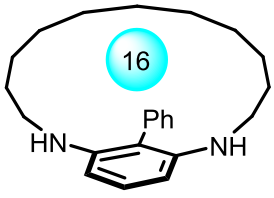

**1l** was prepared in 2.8 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: ethyl acetate = 20: 1 to 10: 1) as a yellow solid (137.3 mg, 15% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.56 (dd, *J* = 4.8, 2.9 Hz, 1H), 7.38 – 7.31 (m, 1H), 7.16 – 7.10 (m, 1H), 7.08 (t, *J* = 8.0 Hz, 1H), 6.29 (d, *J* = 8.1 Hz, 2H), 3.45 (ddd, *J* = 14.8, 5.7, 3.5 Hz, 2H), 2.93 (ddd, *J* = 14.6, 9.3, 3.0 Hz, 2H), 1.81 – 1.70 (m, 2H), 1.37 – 0.91 (m, 14H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 147.5, 135.2, 128.7, 127.7, 111.7, 105.5, 45.0, 28.8, 28.5, 28.2, 25.3. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{20}H_{29}N_2S^+$: 329.2046; found: 329.2046.

1$^2$-phenyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**1m**)



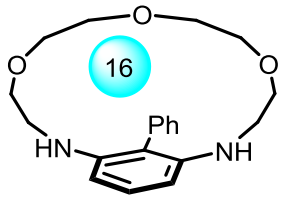

**1m** was prepared in 3.0 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: ethyl acetate = 20: 1 to 10: 1) as a pink solid (104.9 mg, 11% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.70 – 7.45 (m, 3H), 7.45 – 7.39 (m, 1H), 7.24 (s, 1H), 7.09 (t, *J* = 8.1 Hz, 1H), 6.43 (d, *J* = 8.1 Hz, 2H), 3.40 (ddd, *J* = 14.9, 8.4, 2.8 Hz, 2H), 3.10 (s, 2H), 3.00 (ddd, *J* = 14.8, 6.8, 2.8 Hz, 2H), 1.77 – 1.65 (m, 2H), 1.29 – 1.04 (m, 11H), 0.92 – 0.85 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 148.1, 135.2, 128.5, 128.2, 119.3, 107.8, 46.9, 31.7, 29.8, 27.4, 26.0. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{21}H_{29}N_2^+$: 309.2326; found: 309.2323.

1$^2$-phenyl-2,14-diaza-1(1,3)-benzenacyclotetradecaphane (**1n**)



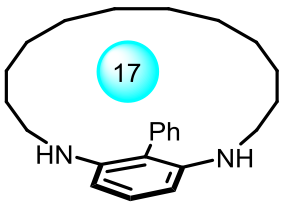
**1n** was prepared in 2.0 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: ethyl acetate = 20: 1 to 10: 1) as a white solid (124.1 mg, 18% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.55 (t, 1H), 7.51 (t, *J* = 1.5 Hz, 1H), 7.44 – 7.39 (m, 2H), 7.28 (d, *J* = 1.7 Hz, 1H), 7.09 (t, *J* = 8.1 Hz, 1H), 6.29 (d, *J* = 8.1 Hz, 2H), 3.53 (ddd, *J* = 14.8, 5.9, 3.3 Hz, 2H), 2.86 (ddd, *J* = 14.8, 9.4, 3.1 Hz, 2H), 1.93 – 1.81 (m, 2H), 1.32 – 1.12 (m, 11H), 1.08 – 0.98 (m, 4H), 0.87 – 0.77 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 146.1, 135.6, 133.2, 130.5, 129.9, 129.5, 128.5, 128.1, 115.7, 104.2, 44.3, 28.7, 27.9, 27.7, 27.7, 24.3. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{23}H_{33}N_2^+$: 337.2639; found: 337.2633.

1$^2$-phenyl-5,8,11-trioxa-2,14-diaza-1(1,3)-benzenacyclotetradecaphane (**1o**)




**1o** was prepared in 3.2 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 2: 1) as a yellow solid (60.7 mg, 12% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.6 (petroleum ether: ethyl acetate = 1: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.85 (dt, *J* = 7.8, 1.6 Hz, 1H), 7.53 (td, *J* = 7.5, 1.5 Hz, 1H), 7.45 (td, *J* = 7.5, 1.5 Hz, 1H), 7.37 (tt, *J* = 7.5, 1.3 Hz, 1H), 7.26 – 7.23 (m, 1H), 7.09 (t, *J* = 8.1 Hz, 1H), 6.33 (d, *J* = 8.1 Hz, 2H), 3.73 (ddd, *J* = 10.1, 8.0, 2.8 Hz, 2H), 3.64 (ddd, *J* = 11.9, 7.5, 2.4 Hz, 2H), 3.55 (ddd, *J* = 15.2, 5.2, 2.9 Hz, 2H), 3.48 – 3.30 (m, 7H), 3.11 – 3.02 (m, 4H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 146.5, 135.5, 132.2, 131.7, 129.7, 129.5, 128.0, 127.9, 119.0, 105.1, 70.7, 70.0, 68.5, 45.2. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{20}H_{27}N_2O_3^+$: 343.2017; found: 343.2013.

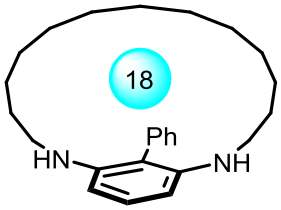
1$^2$-phenyl-2,15-diaza-1(1,3)-benzenacyclopentadecaphane (**1p**)




**1p** was prepared in 2.5 mmol scale (**S5**) and isolated by flash chromatography (DCM: ethyl acetate = 100: 1 to 30: 1) as a yellow solid (129.9 mg, 15% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.1 (DCM: ethyl

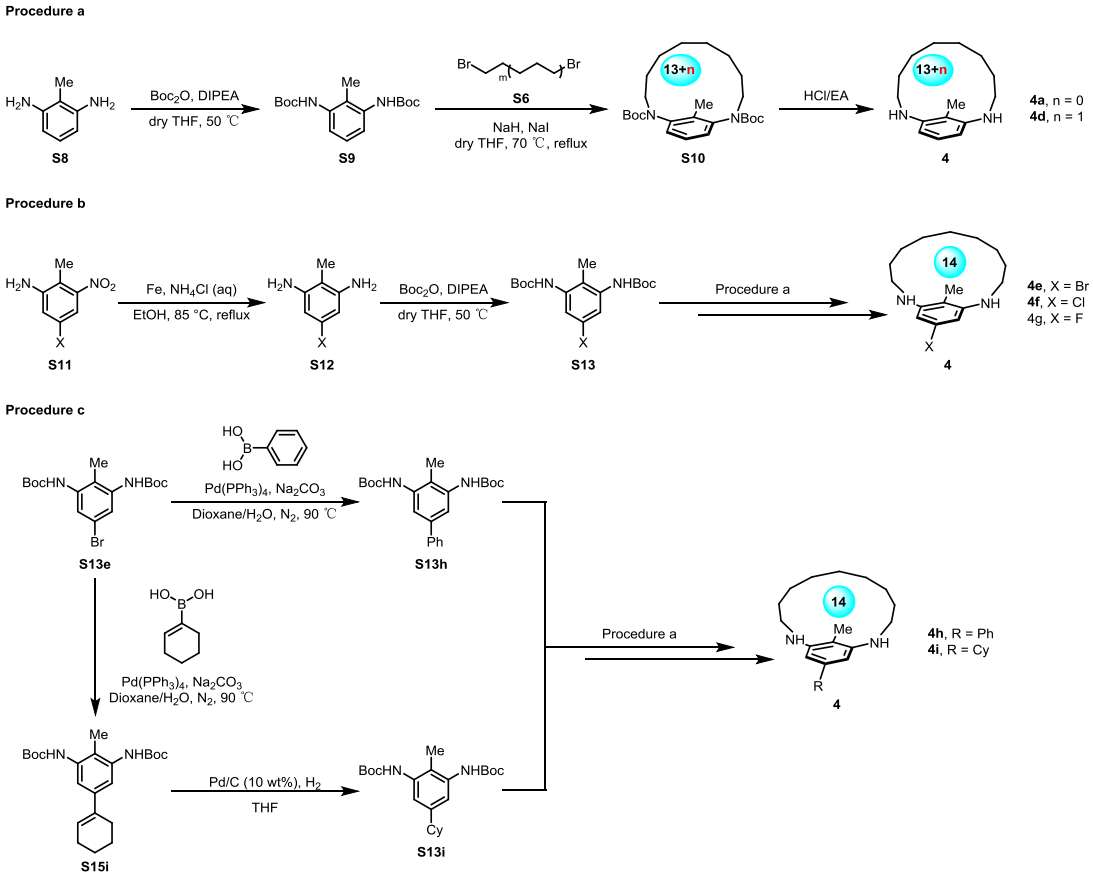
acetate = 50: 1, v/v). **$^{1}$H NMR** (600 MHz, $CDCl_3$) δ 7.58 – 7.49 (m, 2H), 7.41 (t, *J* = 1.4 Hz, 1H), 7.35 – 7.32 (m, 1H), 7.29 (d, *J* = 1.7 Hz, 1H), 7.09 (t, *J* = 8.1 Hz, 1H), 6.23 (d, *J* = 8.1 Hz, 2H), 3.50 – 3.39 (m, 2H), 3.21 (s, 2H), 2.94 – 2.86 (m, 2H), 1.83 – 1.73 (m, 2H), 1.28 – 1.03 (m, 18H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 146.0, 135.8, 132.9, 130.4, 130.3, 129.8, 128.8, 128.1, 114.4, 102.6, 43.8, 28.9, 28.5, 28.4, 28.3, 25.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{24}H_{35}N_2^+$: 351.2795; found: 351.2790.

1$^{2}$-phenyl-2,16-diaza-1(1,3)-benzenacyclohexadecaphane (**1q**)




**1q** was prepared in 2.5 mmol scale (**S5**) and isolated by flash chromatography (petroleum ether: ethyl acetate = 40: 1 to 10: 1) as a yellow solid (168.1 mg, 18% yield for two steps from **S5**). $\mathbf{R_f}$ = 0.7 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^{1}$H NMR** (600 MHz, $CDCl_3$) δ 7.58 – 7.49 (m, 2H), 7.41 (t, *J* = 1.4 Hz, 1H), 7.34 – 7.28 (m, 2H), 7.09 (t, *J* = 8.1 Hz, 1H), 6.20 (d, *J* = 8.1 Hz, 2H), 3.62 – 3.43 (m, 2H), 3.30 (s, 2H), 2.85 – 2.75 (m, 2H), 1.86 – 1.72 (m, 2H), 1.35 – 1.00 (m, 20H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 145.2, 135.9, 132.7, 130.6, 130.4, 129.8, 128.8, 128.1, 114.3, 102.0, 43.3, 28.9, 28.3, 27.9, 27.6, 26.6, 24.5.**HRMS** (ESI): $[M+H]^+$ calculated for $C_{25}H_{37}N_2^+$: 365.2952; found: 365.2943.

## 2. Synthetic of Metacyclophane 4.




**General Procedure a**: To a solution of **S8** (10.0 mmol, 1.0 equiv) in anhydrous THF (50 mL, c = 0.2 M) was added DIPEA (5.1 mL, 30.0 mmol, 3.0 equiv) and $Boc_2O$ (7.0 mL, 30.0 mmol, 3.0 equiv). Then, the mixture was stirred at 50 ℃ for 24-48 h. After the consumption of the starting materials as monitored by TLC, the reaction mixture was extracted with ethyl acetate for 3 times. The combined organic phases were washed with water and brine, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **S9**.

To a suspension of sodium hydride (60% in mineral oil, 360 mg, 9 mmol, 3.0 equiv) in dry THF (150 mL) was added NaI (45.0 mg, 0.3 mmol, 0.1 equiv). Then, the mixture was added with a solution of **S9** (3.0 mmol, 1.0 equiv) and **S6** (3.0 mmol, 1.0 equiv) in dry THF (50.0 mL) dropwise using syringe pump (3.0 mL/h) over a 17 h period at 70 ℃. After stirring for another 12 h at this temperature, the reaction mixture was cooled to room temperature and quenched with saturated $NH_4Cl$ solution, and extracted with ethyl acetate for 3 times. The combined organic phases were washed with water and brine, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **S10**.

The solution of **S10** (0.3 mmol, 1.0 equiv) in HCl/EA (8 mL, 2 mol/L in ethyl acetate) was allowed to stir for 5-8 h at room temperature. After the consumption of the starting materials as monitored by TLC, the reaction mixture quenched with saturated $NaHCO_3$ solution, and extracted with ethyl acetate for 3 times. The combined organic phases were washed with water and brine, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **4**.

**General procedure b**: To a solution of **S11** (5.0 mmol, 1.0 equiv) in EtOH (25 mL) and saturated $NH_4Cl$ solution (25 mL) was added Fe powder (1 g). Then the mixture was stirred at 85 ℃ overnight. After the consumption of the starting materials as monitored by TLC, the reaction mixture was filtered over celite and extracted with ethyl acetate for 3 times. The combined organic phases were washed with water and brine, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **S12**.

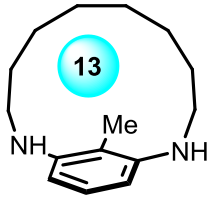
Through **general procedure a**, product **4** was prepared from **S12**.

**General procedure c**: To an oven dried round bottom flask equipped with a stir bar, **S13e**(2.3 mmol, 1.0 equiv), aryl boric acid (4.6 mmol, 2.0 equiv), $Pd(PPh_3)_4$ (0.2 mmol, 0.1 equiv), $Na_2CO_3$ (6.9 mmol, 3.0 equiv), dioxone (30 mL) and $H_2O$ (10 mL) were successively added at room temperature under $N_2$ atmosphere. Then, the mixture was heated to 90℃ and stirred overnight. After the consumption of the starting materials as monitored by TLC, the reaction mixture was filtered over celite and extracted with ethyl acetate for 3 times. The combined organic phases were washed with water and brine, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **S13h** and **S15i**.

To a solution of **S15i** (2.0 mmol, 1.0 equiv) in THF (20 mL) was added Pd/C (200 mg, 10 wt%). The reaction mixture was evacuated and purged with $H_2$ for three times, and then allowed to stir at room temperature under $H_2$ atmosphere (1 atm) overnight. After the consumption of the starting materials as monitored by TLC, the reaction mixture was filtered over celite and extracted with ethyl acetate for 3 times. The combined organic phases were washed with water and brine, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **S13i**.

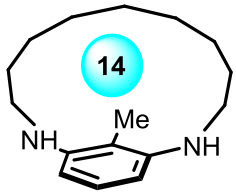
Through **general procedure a**, product **4h** and **4i** were synthesized from **S13h** and **S13i**.

$1^2$-methyl-2,11-diaza-1(1,3)-benzenacycloundecaphane (**4a**)



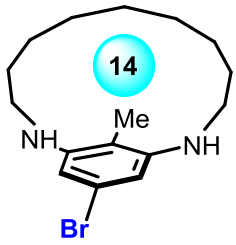

**4a** was prepared in 6.0 mmol scale (**S9**) according to the procedure a and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 2: 1) as a white solid (147.7 mg, 10% yield for two steps from **S9**). $\mathbf{R_f}$ = 0.2 (petroleum ether: ethyl acetate = 5: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 6.96 (t, *J* = 7.9 Hz, 1H), 6.46 (d, *J* = 7.9 Hz, 2H), 3.29 (ddd, *J* = 14.7, 5.7, 3.5 Hz, 2H), 3.24 – 3.03 (m, 4H), 2.18 (s, 3H), 1.49 – 1.40 (m, 2H), 1.29 – 1.21 (m, 2H), 1.12 – 1.03 (m, 2H), 0.94 – 0.74 (m, 6H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 148.5, 126.3, 116.9, 113.1, 47.1, 29.3, 27.1, 24.1, 12.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{15}H_{25}N_2^+$: 233.2013; found: 233.2008.

$1^2$-methyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4d**)



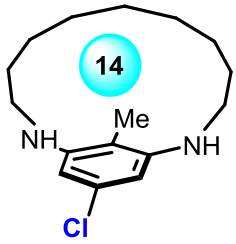

**4d** was prepared in 3.0 mmol scale (**S9**) according to the procedure a and isolated by flash chromatography (petroleum ether: ethyl acetate = 5: 1 to 2: 1) as a white solid (165.1 mg, 22% yield for two steps from **S9**). $\mathbf{R_f}$ = 0.2 (petroleum ether: ethyl acetate = 5: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 6.92 (t, *J* = 7.9 Hz, 1H), 6.37 (d, *J* = 7.9 Hz, 2H), 3.39 – 3.31 (m, 2H), 3.32 – 2.87 (m, 4H), 2.13 (s, 3H), 1.69 – 1.56 (m, 2H), 1.28 – 1.17 (m, 2H), 1.13 – 0.89 (m, 9H), 0.69 – 0.61 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 148.2, 126.2, 113.7, 110.6, 45.6, 28.6, 26.9, 26.5, 24.4, 12.3. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{16}H_{27}N_2^+$: 247.2169; found: 247.2165.

$1^5$-bromo-$1^2$-methyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4e**)



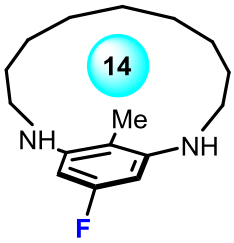

**4e** was prepared in 3.7 mmol scale (**S13**) according to the procedure b and isolated by flash chromatography (petroleum ether: ethyl acetate = 15: 1 to 5: 1) as a yellow solid (165.1 mg, 22% yield for two steps from **S13**). $\mathbf{R_f}$ = 0.1 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 6.50 (s, 2H), 3.37 – 3.29 (m, 2H), 3.15 – 3.06 (m, 2H), 2.05 (s, 3H), 1.69 – 1.60 (m, 2H), 1.27 – 1.18 (m, 2H), 1.13 – 0.92 (m, 9H), 0.73 – 0.64 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 149.4, 119.8, 112.9, 112.2, 45.5, 28.5, 27.0, 26.6, 24.4, 12.2. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{16}H_{26}BrN_2^+$: 325.1274; found: 325.1273.

$1^5$-chloro-$1^2$-methyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4f**)



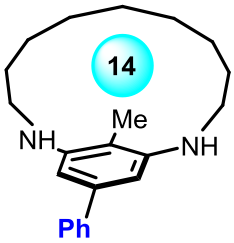

**4f** was prepared in 2.5 mmol scale (**S13**) according to the procedure b and isolated by flash chromatography (petroleum ether: ethyl acetate = 40: 1 to 5: 1) as a yellow solid (181.0 mg, 26% yield for two steps from **S13**). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 6.35 (s, 2H), 3.37 – 3.30 (m, 2H), 3.16 – 3.08 (m, 2H), 2.06 (s, 3H), 1.69 – 1.60 (m, 2H), 1.26 – 1.18 (m, 2H), 1.12 – 0.93 (m, 9H), 0.73 – 0.65 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 149.2, 131.8, 111.6, 109.9, 45.5, 28.5, 27.0, 26.6, 24.4, 12.1. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{16}H_{26}ClN_2^+$: 281.1780; found: 281.1775.

$1^5$-fluoro-$1^2$-methyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4g**)



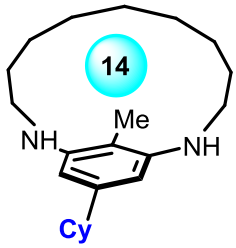

**4g** was prepared in 2.5 mmol scale (**S13**) according to the procedure b and isolated by flash chromatography (petroleum ether: ethyl acetate = 40: 1 to 5: 1) as a white solid (149.1 mg, 23% yield for two steps from **S13**). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 6.09 (d, *J* = 10.7 Hz, 2H), 3.34 (ddd, *J* = 14.7, 5.3, 4.0 Hz, 2H), 3.13 (ddd, *J* = 14.7, 9.7, 3.6 Hz, 2H), 2.05 (s, 3H), 1.71 – 1.62 (m, 2H), 1.25 – 1.17 (m, 2H), 1.14 – 0.90 (m, 9H), 0.74 – 0.66 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 162.4 (d, *J* = 238.7 Hz), 149.3 (d, *J* = 11.9 Hz), 108.47, 96.7 (d, *J* = 24.0 Hz), 45.7, 28.6, 27.1, 26.7, 24.5, 11.9. **$^{19}$F NMR** (565 MHz, $CDCl_3$) δ -117.2. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{16}H_{26}FN_2^+$: 265.2075; found: 265.2067.

$1^2$-methyl-$1^5$-phenyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4h**)



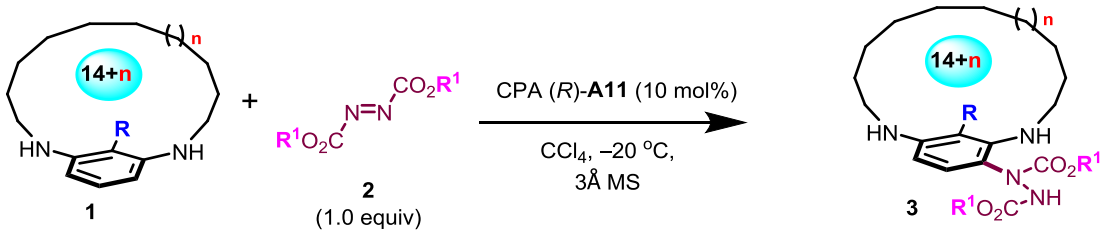

**4h** was prepared in 1.2 mmol scale (**S13h**) according to the procedure c and isolated by flash chromatography (petroleum ether: ethyl acetate = 5: 1 to 4: 1) as a white solid (75.6 mg, 19% yield for two steps from **S13h**). $\mathbf{R_f}$ = 0.2 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.61 – 7.54 (m, 2H), 7.41 (t, *J* = 7.6 Hz, 2H), 7.31 (t, *J* = 7.4 Hz, 1H), 6.61 (s, 2H), 3.46 – 3.40 (m, 2H), 3.17 (ddd, *J* = 14.3, 9.8, 3.8 Hz, 2H), 2.17 (s, 3H), 1.75 – 1.66 (m, 2H), 1.27 – 1.20 (m, 2H), 1.15 – 0.91 (m, 9H), 0.71 – 0.61 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 148.5, 142.1, 139.4, 128.7, 127.1, 127.0, 112.9, 109.4, 45.6, 28.6, 27.0, 26.6, 24.5, 12.2. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{22}H_{31}N_2^+$: 323.2482; found: 323.2478.

$1^5$-cyclohexyl-$1^2$-methyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4i**)




**4i** was prepared in 2.8 mmol scale (**S13i**) according to the procedure c and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 5: 1) as a white solid (197.8 mg, 21% yield for two steps from **S13i**). $\mathbf{R_f}$ = 0.1 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 6.23 (s, 2H), 3.39 – 3.34 (m, 2H), 3.31 – 2.80 (m, 4H), 2.38 – 2.29 (m, 1H), 2.08 (s, 3H), 1.87 – 1.78 (m, 4H), 1.75 – 1.61 (m, 3H), 1.42 – 1.31 (m, 4H), 1.29 – 1.15 (m, 3H), 1.12 – 0.87 (m, 9H), 0.64 – 0.53 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 147.8, 146.2, 111.1, 109.3, 77.4, 77.2, 76.9, 45.4, 44.7, 34.6, 28.7, 27.1, 26.9, 26.5, 26.4, 24.3, 12.0. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{22}H_{37}N_2^+$: 329.2952; found: 329.2946.

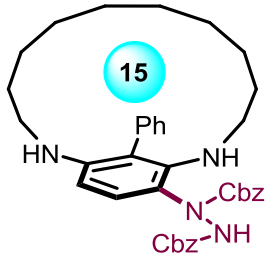
## Catalytic enantioselective synthesis of planar-chiral metacyclophanes 3




**Procedure**: To a precooled solution of **1** (0.1 mmol, 1.0 equiv.), CPA (*R*)-**A11** (0.01 mmol, 10 mol%) and 3Å MS (70 mg) in $CCl_4$ (2 mL, 0.05 M) was add **2** (0.1 mmol, 1.0 equiv.) at -20 °C. After stirring for 48-72 hours at this temperature, the reaction mixture was quenched with a solution of $Et_3N$ (0.2 mL, 1.0 M in DCM). Then the reaction mixture was then concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **3**.

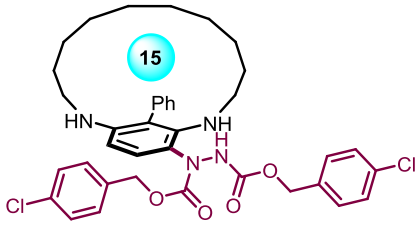
*Due to the presence of rotamers of the amide moieties in the products, the NMR spectra of the products appear complex at room temperature. However, their quality could be enhanced by performing the NMR analysis at elevated temperatures. (Unless otherwise noted, all NMR experiments of product 3 were recorded at 373 K in DMSO-$d_6$).*

**Metacyclophanes 3a**




**3a** was prepared in 0.1 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 4: 1) as a yellow solid (56.5 mg, 91% yield). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.59 (s, 1H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.43 – 7.24 (m, 13H), 7.07 (d, *J* = 8.6 Hz, 1H), 6.30 (d, *J* = 8.7 Hz, 1H), 5.30 – 5.00 (m, 4H), 4.34 (s, 1H), 4.01 – 3.81 (m, 1H), 3.50 – 3.38 (m, 1H), 2.48 – 2.42 (m, 1H), 2.42 – 2.32 (m, 1H), 1.83 – 1.71 (m, 1H), 1.46 – 1.20 (m, 5H), 1.16 – 0.85 (m, 10H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.1, 146.3, 144.8, 136.5, 135.9, 130.1, 128.6, 128.0, 127.7, 127.6, 127.3, 127.1, 127.1, 126.7, 126.4, 122.3, 116.3, 104.2, 66.8, 65.9, 44.0, 43.0, 29.0, 28.9, 28.0, 27.1, 26.7, 24.9, 24.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{38}H_{45}N_4O_4^+$: 621.3436; found: 621.3419. $[\boldsymbol{\alpha}]_{\mathbf{D}}^{\mathbf{25}}$ = -27.59 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/isopropanol = 85/15, 1 mL/min; $t_R$ = 12.2 min (minor), 13.2 min (major); 97:3 er.

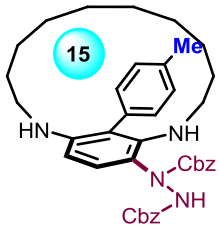
**Metacyclophanes 3b**




**3b** was prepared in 0.05 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 5: 1) as a yellow solid (28.0 mg, 81% yield). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.63 (s, 1H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.42 – 7.26 (m, 11H), 7.04 (d, *J* = 8.6 Hz, 1H), 6.30 (d, *J* = 8.7 Hz, 1H), 5.26 – 4.99 (m, 4H), 4.27 (s, 1H), 3.95 – 3.85 (m, 1H), 3.48 – 3.38 (m, 1H), 2.48 – 2.40 (m, 1H), 2.40 – 2.30 (m, 1H), 1.81 – 1.70 (m, 1H), 1.41 – 0.84 (m, 16H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.0, 146.3, 144.8, 136.4,

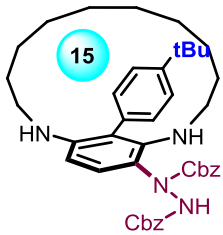
134.9, 132.3, 132.2, 130.1, 129.0, 128.6, 127.8, 127.7, 126.5, 122.2, 104.2, 66.1, 65.2, 44.0, 43.0, 29.0, 28.9, 28.0, 27.1, 26.7, 24.9, 24.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{38}H_{43}C_{l2}N_4O_4^+$: 689.2656; found: 689.2645. $[\alpha]_D^{25}$ = -19.08 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IC column, hexanes/isopropanol = 70/30, 1 mL/min; $t_R$ = 10.5 min (major), 18.5 min (minor); 95.5:4.5 er.

**Metacyclophanes 3c**




**3c** was prepared in 0.05 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 3: 1) as a yellow solid (25.3 mg, 80% yield). $\mathbf{R_f}$ = 0.1 (petroleum ether: ethyl acetate = 5: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.56 (s, 1H), 7.45 – 7.27 (m, 12H), 7.22 (d, *J* = 7.7 Hz, 2H), 7.04 (d, *J* = 8.6 Hz, 1H), 6.27 (d, *J* = 8.7 Hz, 1H), 5.26 – 5.01 (m, 4H), 4.27 (s, 1H), 3.92 – 3.82 (m, 1H), 3.46 – 3.37 (m, 1H), 2.48 – 2.38 (m, 2H), 2.37 (s, 3H), 1.81 – 1.75 (m, 1H), 1.43 – 1.20 (m, 5H), 1.13 – 0.85 (m, 10H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.8, 155.1, 146.3, 144.8, 135.9, 135.7, 133.3, 129.9, 129.2, 127.7, 127.6, 127.3, 127.1, 127.1, 126.7, 122.2, 116.2, 104.1, 66.7, 65.9, 44.0, 43.0, 29.0, 28.8, 27.9, 27.1, 26.7, 26.7, 24.9, 24.6, 20.1. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{39}H_{47}N_4O_4^+$: 635.3592; found: 635.3579. $[\alpha]_D^{25}$ = -16.26 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 75/25, 1 mL/min; $t_R$ = 7.3 min (major), 18.3 min (minor); 95.5:4.5 er.

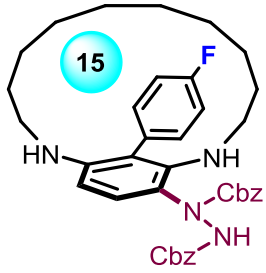
**Metacyclophanes 3d**




**3d** was prepared in 0.1 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 5: 1) as a yellow solid (62.5 mg, 92% yield). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.57 (s, 1H), 7.52 (d, *J* = 8.2 Hz, 2H), 7.44 – 7.22 (m, 13H), 7.06 (d, *J* = 8.7 Hz, 1H), 6.28 (d, *J* = 8.7 Hz, 1H), 5.26 – 5.03 (m, 4H), 4.31 (s, 1H),

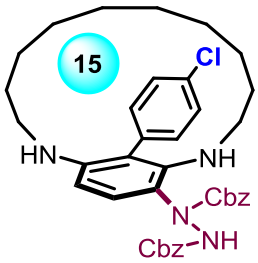
3.97 – 3.84 (m, 1H), 3.49 – 3.39 (m, 1H), 2.48 – 2.43 (m, 1H), 2.43 – 2.32 (m, 1H), 1.83 – 1.71 (m, 1H), 1.36 (s, 9H), 1.33 – 0.82 (m, 15H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.8, 155.1, 149.1, 146.3, 144.9, 135.9, 133.3, 129.7, 127.7, 127.6, 127.3, 127.1, 127.1, 126.6, 125.2, 122.2, 116.2, 104.0, 66.7, 65.9, 43.9, 43.0, 33.7, 30.6, 29.1, 28.7, 27.9, 27.1, 26.8, 26.7, 24.9, 24.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{42}H_{53}N_4O_4^+$: 677.4062; found: 677.4044. $[\alpha]_D^{25}$ = -27.27 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/isopropanol = 90/10, 1 mL/min; $t_R$ = 12.2 min (minor), 16.4 min (major); 95:5 er.

**Metacyclophanes 3e**



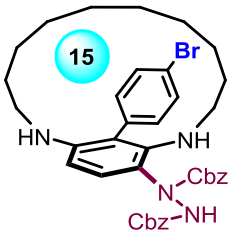

**3e** was prepared in 0.05 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 5: 1) as a yellow solid (27.7 mg, 87% yield). $\mathbf{R}_f$ = 0.4 (petroleum ether: ethyl acetate = 4: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.59 (s, 1H), 7.42 – 7.21 (m, 14H), 7.06 (d, *J* = 8.6 Hz, 1H), 6.30 (d, *J* = 8.7 Hz, 1H), 5.26 – 5.01 (m, 4H), 4.35 (s, 1H), 3.98 – 3.85 (m, 1H), 3.49 – 3.37 (m, 1H), 2.48 – 2.43 (m, 1H), 2.38 – 2.27 (m, 1H), 1.81 – 1.70 (m, 1H), 1.44 – 1.19 (m, 5H), 1.15 – 0.82 (m, 10H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 160.7 (d, *J* = 244.5 Hz), 155.8, 155.1, 146.4, 144.9, 135.9, 132.6, 132.1 (d, *J* = 7.8 Hz), 128.1, 127.7, 127.6, 127.3, 127.2, 127.1, 126.7, 122.3, 115.5 (d, *J* = 21.2 Hz), 104.2, 66.8, 65.9, 43.9, 42.9, 29.0, 28.8, 28.0, 27.1, 26.7, 26.7, 24.9, 24.6. **$^{19}$F NMR** (471 MHz, DMSO-*d6*, 373 K) δ -115.3. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{38}H_{44}FN_4O_4^+$: 639.3342; found: 639.3327. $[\alpha]_D^{25}$ = -35.44 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 70/30, 1 mL/min; $t_R$ = 8.5 min (major), 17.7 min (minor); 96:4 er.

**Metacyclophanes 3f**




**3f** was prepared in 0.05 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 7.5: 1 to 5: 1) as a yellow solid (23.3 mg, 71% yield). $\mathbf{R}_f$ = 0.4 (petroleum ether: ethyl acetate = 4: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.59 (s, 1H), 7.53 (d, *J* = 8.0 Hz, 2H), 7.39 – 7.16 (m, 12H), 7.06 (d, *J* = 8.7 Hz, 1H), 6.30 (d, *J* = 8.7 Hz, 1H), 5.26 – 4.99 (m, 4H), 4.38 (s, 1H), 4.02 – 3.92 (m, 1H), 3.48 – 3.37 (m, 1H), 3.12 – 2.99 (m, 1H), 2.40 – 2.27 (m, 1H), 1.80 – 1.70 (m, 1H), 1.43 – 1.19 (m, 5H), 1.14 – 0.82 (m, 10H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.0, 146.2, 144.9, 135.8, 135.4, 131.9, 131.2, 128.7, 128.3, 127.7, 127.6, 127.3, 127.2, 127.1, 126.7, 122.3, 109.6, 104.3, 66.8, 65.9, 44.0, 42.8, 28.9, 28.7, 28.0, 27.1, 26.7, 24.9, 24.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{38}H_{44}ClN_4O_4^+$: 655.3046; found: 655.3031. $[\alpha]_D^{25}$ = -18.96 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 80/20, 1 mL/min; $t_R$ = 9.6 min (minor), 12.5 min (major); 94:6 er.

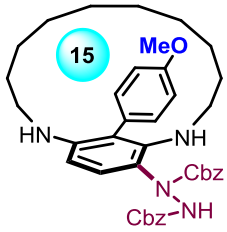
**Metacyclophanes 3g**




**3g** was prepared in 0.2 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 3: 1) as a yellow solid (107.4 mg, 77% yield). $\mathbf{R}_f$ = 0.6 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.62 (s, 1H), 7.67 (d, *J* = 8.2 Hz, 2H), 7.41 – 7.24 (m, 12H), 7.09 (d, *J* = 8.7 Hz, 1H), 6.31 (d, *J* = 8.7 Hz, 1H), 5.31 – 5.00 (m, 4H), 4.42 (s, 1H), 4.03 – 3.93 (m, 1H), 3.50 – 3.39 (m, 1H), 3.06 – 3.00 (m, 1H), 2.41 – 2.29 (m, 1H), 1.82 – 1.71 (m, 1H), 1.45 – 1.20 (m, 5H), 1.17 – 0.84 (m, 10H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.1, 146.2, 144.8, 135.9, 132.3, 131.6, 128.4, 127.7, 127.6, 127.3, 127.2, 127.1, 126.7, 122.4, 119.6, 114.9, 104.3, 66.8, 66.0, 44.1, 42.9, 29.0, 28.8, 28.0, 27.2, 26.7, 25.0, 24.6. **HRMS** (ESI): $[M+H]^+$

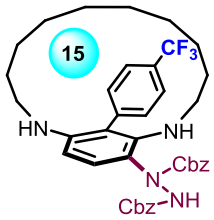
calculated for $C_{38}H_{44}BrN_4O_4^+$: 699.2541; found: 699.2529. $[\alpha]_D^{25}$ = -15.58 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 80/20, 1 mL/min; $t_R$ = 9.0 min (minor), 18.3 min (major); 90:10 er.

**Metacyclophanes 3h**




**3g** was prepared in 0.1 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 3: 1) as a yellow solid (58.1 mg, 89% yield). $\mathbf{R_f}$ = 0.2 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.56 (s, 1H), 7.43 – 7.28 (m, 10H), 7.26 (d, *J* = 8.2 Hz, 2H), 7.10 – 7.02 (m, 3H), 6.27 (d, *J* = 8.7 Hz, 1H), 5.26 – 5.02 (m, 4H), 3.92 – 3.85 (m, 1H), 3.83 (s, 3H), 3.47 – 3.40 (m, 1H), 2.47 – 2.37 (m, 1H), 1.83 – 1.70 (m, 1H), 1.41 – 1.20 (m, 5H), 1.14 – 0.85 (m, 10H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 157.9, 155.8, 155.1, 146.5, 144.9, 135.9, 131.2, 128.2, 127.7, 127.6, 127.3, 127.2, 127.1, 127.1, 127.0, 126.7, 122.2, 116.1, 114.4, 104.1, 66.8, 65.9, 54.7, 44.0, 43.0, 29.1, 28.8, 28.0, 27.1, 26.8, 26.7, 25.0, 24.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{39}H_{47}N_4O_5^+$: 651.3541; found: 651.3523. $[\alpha]_D^{25}$ = -13.82 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/isopropanol = 75/25, 1 mL/min; $t_R$ = 8.3 min (minor), 11.2 min (major); 91.5:8.5 er.

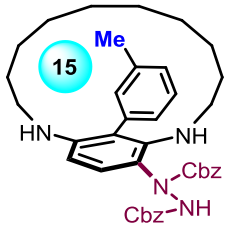
**Metacyclophanes 3i**




**3i** was prepared in 0.1 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 5: 1) as a yellow solid (56.5 mg, 91% yield). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.63 (s, 1H), 7.82 (d, *J* = 8.0 Hz, 2H), 7.56 (d, *J* = 7.9 Hz, 2H), 7.47 – 7.16 (m, 9H), 7.09 (d, *J* = 8.7 Hz, 1H), 6.33 (d, *J* = 8.8 Hz, 1H), 5.30 – 4.97 (m, 4H), 4.46 (s, 1H), 4.12 – 3.98 (m, 1H), 3.48 – 3.38 (m, 1H), 3.06 – 2.99 (m, 1H), 2.48 – 2.40 (m, 1H), 2.29 –

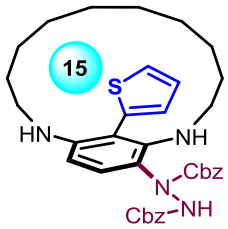
2.19 (m, 1H), 1.81 – 1.68 (m, 1H), 1.41 – 0.86 (m, 14H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.1, 146.2, 144.9, 141.3, 135.8, 131.0, 128.6, 127.7, 127.6, 127.4, 127.1 (q, *J* = 32.6 Hz), 127.1, 127.0, 126.7, 125.4, 123.8 (q, *J* = 271.9 Hz), 122.4, 104.4, 66.8, 66.0, 44.1, 42.8, 28.9, 28.7, 28.0, 27.2, 26.7, 26.7, 25.0, 24.6. **$^{19}$F NMR** (471 MHz, DMSO-*d6*, 373 K) δ -61.1.**HRMS** (ESI): $[M+H]^+$ calculated for $C_{39}H_{44}F_3N_4O_4^+$: 689.3310; found: 689.3291. $[\alpha]_D^{25}$ = -19.03 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/isopropanol = 75/25, 1 mL/min; $t_R$ = 6.6 min (minor), 8.4 min (major); 90:10 er.

**Metacyclophanes 3j**



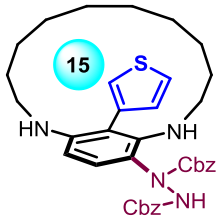

**3j** was prepared in 0.2 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 4: 1) as a yellow solid (90.8 mg, 72% yield). $\mathbf{R_f}$ = 0.6 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.59 (s, 1H), 7.48 – 7.25 (m, 11H), 7.21 – 7.12 (m, 3H), 7.09 (d, *J* = 8.6 Hz, 1H), 6.30 (d, *J* = 8.7 Hz, 1H), 5.33 – 5.01 (m, 4H), 3.89 (s, 1H), 3.49 – 3.34 (m, 1H), 3.01 – 2.95 (m, 1H), 2.46 – 2.38 (m, 1H), 2.36 (s, 3H), 1.82 – 1.70 (m, 1H), 1.48 – 0.85 (m, 16H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.1, 146.3, 144.7, 137.8, 136.3, 135.9, 130.7, 128.5, 128.0, 127.7, 127.6, 127.3, 127.1, 127.1, 127.0, 126.7, 122.4, 116.6, 104.2, 66.8, 66.0, 44.1, 43.2, 29.0, 27.9, 27.2, 26.7, 26.7, 24.9, 24.6, 20.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{39}H_{47}N_4O_4^+$: 635.3592; found: 635.3584. $[\alpha]_D^{25}$ = -32.28 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 80/20, 1 mL/min; $t_R$ = 8.4 min (major), 24.0 min (minor); 89.5:10.5 er.

**Metacyclophanes 3k**



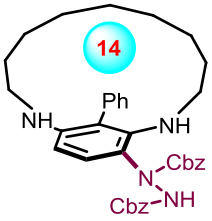
**3k** was prepared in 0.1 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 3: 1) as a yellow solid (58.0 mg, 93% yield). $\mathbf{R_f}$ = 0.6 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.59 (s, 1H), 7.64 (d, *J* = 5.1 Hz, 1H), 7.38 – 7.27 (m, 10H), 7.20 (dd, *J* = 5.2, 3.5 Hz, 1H), 7.14 – 7.04 (m, 2H), 6.26 (d, *J* = 8.7 Hz, 1H), 5.28 – 5.03 (m, 4H), 4.27 (s, 1H), 3.54 – 3.34 (m, 1H), 3.06 – 3.00 (m, 1H), 2.68 – 2.55 (m, 2H), 1.81 – 1.70 (m, 1H), 1.38 – 0.86 (m, 15H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.8, 155.0, 147.3, 146.2, 137.1, 135.9, 135.8, 129.1, 127.7, 127.6, 127.3, 127.1, 127.1, 126.8, 126.6, 126.5, 121.6, 108.1, 103.6, 66.8, 66.0, 43.8, 42.9, 29.4, 28.1, 28.0, 27.1, 26.9, 26.8, 25.0, 24.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{36}H_{43}N_4O_4S^+$: 627.3000; found: 627.2988. $[\alpha]_D^{25}$ = -20.08 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 80/20, 1 mL/min; $t_R$ = 10.1 min (major), 22.0 min (minor); 99:1 er.

**Metacyclophanes 3l**



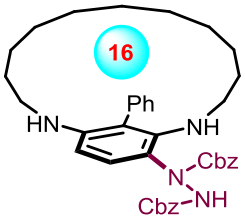

**3l** was prepared in 0.1 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 3: 1) as a yellow solid (51.9 mg, 83% yield). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.59 (s, 1H), 7.70 – 7.62 (m, 1H), 7.42 – 7.23 (m, 11H), 7.11 (d, *J* = 4.9 Hz, 1H), 7.03 (d, *J* = 8.6 Hz, 1H), 6.25 (d, *J* = 8.7 Hz, 1H), 5.28 – 4.94 (m, 4H), 4.42 (s, 1H), 4.15 – 4.03 (m, 1H), 3.49 – 3.38 (m, 1H), 2.56 – 2.50 (m, 1H), 2.42 – 2.33 (m, 1H), 1.81 – 1.68 (m, 1H), 1.44 – 0.84 (m, 15H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.1, 146.6, 145.4, 136.0, 135.9, 129.0, 128.1, 127.7, 127.6, 127.3, 127.1, 127.1, 126.7, 126.0, 123.2, 121.9, 111.2, 103.8, 66.8, 65.9, 43.7, 42.9, 29.2, 28.4, 28.0, 27.1, 26.8, 26.7, 25.0, 24.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{36}H_{43}N_4O_4S^+$: 627.3000; found: 627.2997. $[\alpha]_D^{25}$ = -22.77 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 80/20, 1 mL/min; $t_R$ = 10.7 min (major), 19.5 min (minor); 94:6 er.

**Metacyclophanes 3m**




**3m** was prepared in 0.2 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 3: 1) as a yellow solid (87.2 mg, 72% yield). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.61 (s, 1H), 7.49 (t, *J* = 7.6 Hz, 2H), 7.43 – 7.39 (m, 2H), 7.38 – 7.25 (m, 11H), 7.07 (d, *J* = 8.6 Hz, 1H), 6.28 (d, *J* = 8.6 Hz, 1H), 5.35 – 4.97 (m, 4H), 4.28 (s, 1H), 3.98 (s, 1H), 3.52 – 3.38 (m, 1H), 2.70 – 2.56 (m, 1H), 1.93 – 1.77 (m, 1H), 1.39 – 0.75 (m, 14H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.0, 146.1, 145.6, 136.7, 135.9, 135.8, 129.8, 128.6, 127.7, 127.6, 127.3, 127.2, 127.1, 126.7, 126.4, 122.5, 117.0, 105.9, 66.8, 65.9, 43.5, 43.4, 30.8, 27.6, 26.5, 26.5, 25.0, 23.5. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{37}H_{43}N_4O_4^+$: 607.3279; found: 607.3265. $[\alpha]_D^{25}$ = -15.01 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/ethanol = 80/20, 1 mL/min; $t_R$ = 10.1 min (minor), 13.4 min (major); 92.5:7.5 er.

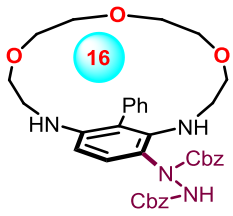
**Metacyclophanes 3n**




**3n** was prepared in 0.2 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 4: 1) as a yellow solid (95.3 mg, 77% yield). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.61 (s, 1H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.40 – 7.16 (m, 13H), 7.07 (d, *J* = 8.6 Hz, 1H), 6.23 (d, *J* = 8.7 Hz, 1H), 5.38 – 4.92 (m, 4H), 4.50 (s, 1H), 4.02 – 3.91 (m, 1H), 3.50 – 3.39 (m, 1H), 2.96 – 2.88 (m, 1H), 2.48 – 2.38 (m, 1H), 2.26 – 2.14 (m, 1H), 1.88 – 1.76 (m, 1H), 1.41 – 0.89 (m, 17H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.1, 145.1, 144.3, 136.6, 135.9, 135.9, 130.0, 128.7, 128.2, 127.7, 127.6, 127.3, 127.1, 126.6, 126.5, 121.8, 115.4, 102.6, 66.7, 65.9, 43.9, 41.8, 28.5, 27.2, 27.0, 26.9, 26.7, 26.2, 24.3, 24.1. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{39}H_{47}N_4O_4^+$: 635.3592; found: 635.3594. $[\alpha]_D^{25}$ = -30.39 (c = 1.0, $CHCl_3$).

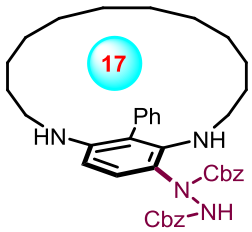
**HPLC:** Chiralpak IB column, hexanes/isopropanol = 80/20, 1 mL/min; $t_R$ = 8.1 min (major), 17.7 min (minor); 97.5:2.5 er.

**Metacyclophanes 3o**




**3o** was prepared in 0.1 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 3: 1 to 1: 1) as a yellow solid (66.3 mg, 99% yield). $\mathbf{R_f}$ = 0.3 (petroleum ether: ethyl acetate = 1: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.57 (s, 1H), 7.68 – 7.47 (m, 2H), 7.45 (t, *J* = 7.4 Hz, 2H), 7.40 – 7.26 (m, 11H), 7.05 (d, *J* = 8.6 Hz, 1H), 6.25 (d, *J* = 8.7 Hz, 1H), 5.23 – 5.07 (m, 4H), 4.49 (s, 1H), 3.94 – 3.84 (m, 1H), 3.75 – 3.68 (m, 1H), 3.67 – 3.59 (m, 1H), 3.53 – 3.43 (m, 2H), 3.40 – 3.21 (m, 7H), 3.08 – 3.00 (m, 3H), 2.65 – 2.54 (m, 1H), 2.33 – 2.23 (m, 1H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.1, 145.5, 143.2, 136.4, 136.0, 135.9, 130.8, 128.3, 127.8, 127.7, 127.5, 127.4, 127.2, 126.7, 126.4, 121.9, 117.8, 103.5, 70.6, 70.1, 69.5, 69.1, 68.8, 66.8, 66.7, 66.0, 43.6, 43.1. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{36}H_{41}N_4O_7^+$: 641.2970; found: 641.2952. $[\alpha]_D^{25}$ = -31.97 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/ethanol = 80/20, 1 mL/min; $t_R$ = 14.4 min (minor), 26.1 min (major); 97.5:2.5 er.

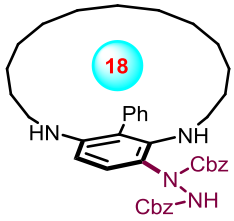
**Metacyclophanes 3p**




**3p** was prepared in 0.1 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 3: 1) as a yellow solid (56.5 mg, 87% yield). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.58 (s, 1H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.42 – 7.18 (m, 13H), 7.06 (d, *J* = 8.6 Hz, 1H), 6.18 (d, *J* = 8.7 Hz, 1H), 5.29 – 5.00 (m, 4H), 4.42 (s, 1H), 3.92 – 3.83 (m, 1H), 3.45 – 3.24 (m, 1H), 2.94 – 2.87 (m, 1H), 2.47 – 2.38 (m, 1H), 2.26 – 2.09 (m,

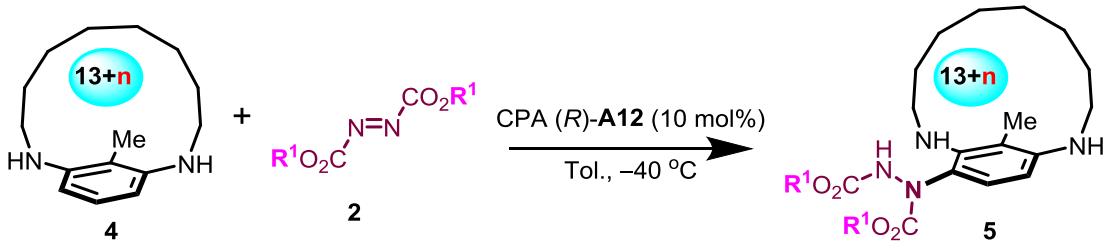
1H), 1.82 – 1.63 (m, 1H), 1.37 – 0.95 (m, 18H), 0.87 – 0.77 (m, 1H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.2, 145.2, 144.0, 136.6, 136.0, 135.9, 130.2, 128.6, 128.4, 127.7, 127.6, 127.4, 127.1, 126.6, 126.6, 121.2, 114.8, 101.3, 66.7, 66.0, 44.1, 41.8, 29.1, 27.8, 27.7, 27.5, 27.4, 27.3, 27.0, 25.3, 24.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{40}H_{49}N_4O_4^+$: 649.3749; found: 649.3738. $[\alpha]_D^{25}$ = -37.10 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 80/20, 1 mL/min; $t_R$ = 10.1 min (major), 21.2 min (minor); 92.5:7.5 er.

**Metacyclophanes 3q**




**3q** was prepared in 0.1 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 3: 1) as a yellow solid (65.9 mg, 99% yield). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.61 (s, 1H), 7.49 (t, *J* = 7.5 Hz, 2H), 7.43 – 7.17 (m, 13H), 7.06 (d, *J* = 8.6 Hz, 1H), 6.16 (d, *J* = 8.7 Hz, 1H), 5.27 – 4.97 (m, 4H), 4.61 (s, 1H), 3.85 – 3.74 (m, 1H), 3.36 – 3.24 (m, 1H), 2.96 – 2.85 (m, 1H), 2.43 – 2.30 (m, 1H), 2.07 – 1.93 (m, 1H), 1.76 – 1.63 (m, 1H), 1.38 – 0.91 (m, 20H), 0.81 – 0.70 (m, 1H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.1, 145.1, 143.5, 136.6, 136.0, 135.9, 130.1, 128.6, 127.7, 127.6, 127.4, 127.1, 127.1, 126.7, 126.5, 121.4, 114.8, 100.9, 66.7, 66.0, 44.1, 41.3, 27.7, 27.4, 27.2, 27.0, 26.8, 26.7, 24.5, 23.9. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{41}H_{51}N_4O_4^+$: 663.3905; found: 663.3893. $[\alpha]_D^{25}$ = --29.09 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 80/20, 1 mL/min; $t_R$ = 7.7 min (major), 9.8 min (minor); 86:14 er.

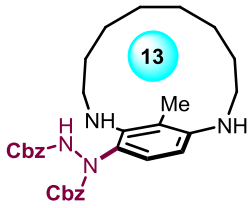
**Catalytic enantioselective synthesis of planar-chiral metacyclophanes 5**




**Procedure**: To a precooled solution of **4** (0.1 mmol, 1.0 equiv.) and CPA (*R*)-**A12** (0.01 mmol, 10 mol%) in toluene (1 mL, 0.1 M) was add **2** (0.1 mmol, 1.0 equiv.) at -40 °C. After stirring for 48-72 h at this temperature, the reaction mixture was quenched with $Et_3N$ (0.2 mL, 1 mol/L in DCM). Then the reaction mixture was concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product **5**.

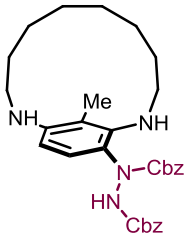
*Due to the presence of rotamers of the amide moieties in the products, the NMR spectra of the products appear complex at room temperature. However, their quality could be enhanced by performing the NMR analysis at elevated temperatures. (Unless otherwise noted, all NMR experiments of product 5 were recorded at 373 K in DMSO-$d_6$).*

**Metacyclophanes 5a**



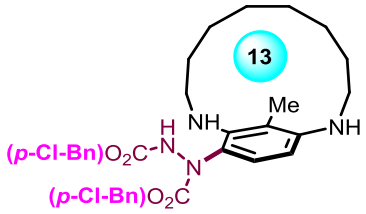

**5a** was prepared in 0.1 mmol scale and isolated by flash chromatography (DCM: ethyl acetate = 20: 1 to 5: 1) as a yellow solid (45.6 mg, 86% yield). $\mathbf{R_f}$ = 0.4 (DCM: ethyl acetate = 5: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.61 (s, 1H), 7.46 – 7.20 (m, 10H), 6.91 (d, *J* = 8.4 Hz, 1H), 6.34 (d, *J* = 8.4 Hz, 1H), 5.20 – 5.00 (m, 4H), 4.57 (s, 1H), 3.27 – 3.19 (m, 1H), 3.12 – 3.05 (m, 2H), 2.15 (s, 3H), 1.48 – 0.64 (m, 14H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.8, 155.1, 149.2, 145.5, 135.9, 135.8, 127.7, 127.6, 127.4, 127.1, 126.7, 125.5, 125.1, 115.9, 110.0, 66.8, 66.0, 44.8, 44.4, 28.5, 26.8, 26.0, 24.9, 22.9, 14.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{31}H_{39}N_4O_4^+$: 531.2966; found: 531.2963. $[\alpha]_D^{25}$ = 17.01 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/isopropanol = 70/30, 1 mL/min; $t_R$ = 11.5 min (major), 16.5 min (minor); 95.5:4.5 er.

**Metacyclophanes *ent*-5a**



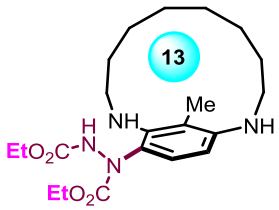

To a stirred solution of **3a** (0.1 mmol, 1.0 equiv.), CPA (*R*)- **A11** (0.01 mmol, 10 mol%) and 3 Å MS in $CCl_4$ (2 mL, 0.05 M) was add **2a** (0.1 mmol, 1.0 equiv.) and the reaction was stirred at -20 $^oC$. After stirring for 48 h, the reaction mixture quenched with $Et_3N$ (0.2 mL, 1 mol/L in DCM). Then the reaction mixture was concentrated under vacuum to give a residue, which was purified by flash column chromatography to give the product ***ent*-5a**. $[\alpha]_D^{25}$ = -14.57 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/isopropanol = 70/30, 1 mL/min; $t_R$ = 10.3 min (minor), 14.7 min (major); 11:89 er.

**Metacyclophanes 5b**



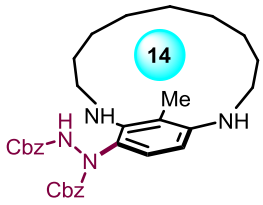

**5b** was prepared in 0.1 mmol scale and isolated by flash chromatography (DCM: ethyl acetate = 20: 1 to 5: 1) as a yellow solid (54.0 mg, 90% yield). $\mathbf{R_f}$ = 0.5 (DCM: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.65 (s, 1H), 7.42 – 7.23 (m, 8H), 6.89 (d, *J* = 8.4 Hz, 1H), 6.34 (d, *J* = 8.4 Hz, 1H), 5.17 – 4.99 (m, 4H), 3.27 – 3.20 (m, 1H), 3.11 – 3.03 (m, 2H), 2.14 (s, 3H), 1.49 – 1.15 (m, 5H), 1.08 – 0.68 (m, 9H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.6, 154.9, 149.2, 145.5, 134.9, 134.8, 134.6, 132.3, 132.1, 129.0, 128.8, 128.7, 128.6, 128.3, 127.8, 127.6, 125.4, 124.9, 116.0, 110.0, 66.0, 65.1, 44.8, 44.4, 28.5, 26.8, 26.0, 24.9, 22.9, 14.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{31}H_{37}Cl_2N_4O_4^+$: 599.2187; found: 599.2183. $[\alpha]_D^{25}$ = 21.17 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IC column, hexanes/isopropanol = 60/40, 1 mL/min; $t_R$ = 12.7 min (major), 18.1 min (minor); 93:7 er.

**Metacyclophanes 5c**



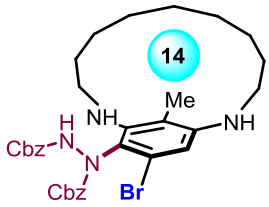

**5c** was prepared in 0.1 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 20: 1 to 3: 1) as a yellow solid (32.5 mg, 80% yield). $\mathbf{R_f}$ = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.30 (s, 1H), 6.88 (d, *J* = 8.4 Hz, 1H), 6.35 (d, *J* = 8.5 Hz, 1H), 4.67 (s, 1H), 4.16 – 4.02 (m, 4H), 3.29 – 3.19 (m, 1H), 3.14 – 3.00 (m, 3H), 2.16 (s, 3H), 1.51 – 1.41 (m, 1H), 1.34 – 1.26 (m, 3H), 1.21 (t, *J* = 7.1 Hz, 3H), 1.15 (t, *J* = 7.0 Hz, 3H), 1.13 – 0.75 (m, 9H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.9, 155.1, 149.1, 145.5, 125.5, 125.3, 115.8, 110.0, 61.2, 60.3, 44.8, 44.3, 28.5, 26.9, 26.0, 25.0, 22.9, 14.4, 13.8, 13.6. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{21}H_{35}N_4O_4^+$: 407.2653; found: 407.2650. $[\boldsymbol{\alpha}]_{\mathbf{D}}^{\mathbf{25}}$ = 9.97 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/isopropanol = 80/20, 1 mL/min; $t_R$ = 9.0 min (minor), 10.6 min (major); 88:12 er.

**Metacyclophanes 5d**



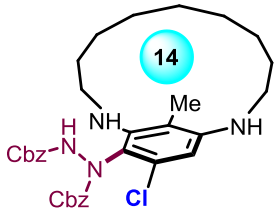

**5d** was prepared in 0.05 mmol scale and isolated by flash chromatography (DCM: ethyl acetate = 10: 1) as a yellow solid (25.9 mg, 96% yield). $\mathbf{R_f}$ = 0.5 (DCM: ethyl acetate = 5: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.60 (s, 1H), 7.45 – 7.17 (m, 10H), 6.90 (d, *J* = 8.5 Hz, 1H), 6.26 (d, *J* = 8.5 Hz, 1H), 5.22 – 5.01 (m, 4H), 4.63 (s, 1H), 3.39 – 3.30 (m, 1H), 3.18 – 3.00 (m, 3H), 2.09 (s, 3H), 1.59 – 1.46 (m, 1H), 1.26 – 0.99 (m, 8H), 0.94 – 0.79 (m, 4H), 0.77 – 0.66 (m, 1H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.8, 155.1, 148.0, 145.6, 135.9, 127.7, 127.6, 127.5, 127.4, 127.1, 127.1, 126.6, 125.6, 123.7, 113.6, 107.5, 66.7, 65.9, 43.9, 43.4, 28.2, 26.3, 25.3, 25.2, 25.2, 24.6, 22.7, 14.1. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{32}H_{41}N_4O_4^+$: 545.3123; found: 545.3120. $[\boldsymbol{\alpha}]_{\mathbf{D}}^{\mathbf{25}}$ = 20.89 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IC column, hexanes/isopropanol = 60/40, 1 mL/min; $t_R$ = 12.2 min (major), 19.1 min (minor); 80.5:19.5 er.

**Metacyclophanes 5e**




**5e** was prepared in 0.05 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 20: 1 to 5: 1) as a yellow solid (23.8 mg, 76% yield). $\mathbf{R_f}$ = 0.7 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.44 (s, 1H), 7.66 – 6.97 (m, 10H), 6.55 (s, 0.5H), 6.51 (s, 0.5H), 5.49 – 4.98 (m, 5H), 4.79 – 4.47 (m, 1H), 3.19 – 3.01 (m, 2H), 2.93 – 2.82 (m, 1H), 2.08 – 2.00 (m, 3H), 1.57 – 1.43 (m, 1H), 1.31 – 1.05 (m, 7H), 1.02 – 0.63 (m, 6H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 156.6, 154.6, 149.4, 149.1, 148.1, 135.7, 127.8, 127.7, 127.6, 127.5, 127.4, 127.4, 127.3, 127.2, 127.0, 126.7, 122.0, 121.0, 120.3, 113.1, 112.1, 110.9, 110.3, 67.1, 66.3, 43.9, 43.8, 43.4, 43.1, 28.6, 27.0, 26.2, 25.3, 25.3, 25.2, 25.0, 24.6, 24.6, 22.9, 22.9, 14.7, 14.5. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{32}H_{40}BrN_4O_4^+$: 623.2228; found: 623.2217. $[\boldsymbol{\alpha}]_{\mathbf{D}}^{\mathbf{25}}$ = 25.60 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/isopropanol = 90/10, 1 mL/min, >20:1 dr. 97:3 er, $t_R$ = 17.5 min (minor), 26.3 min (major);

**Metacyclophanes 5f**

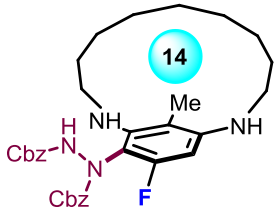



**5f** was prepared in 0.2 mmol scale and isolated by flash chromatography (petroleum ether: acetone = 10: 1 to 5: 1) as a yellow solid (89.5 mg, 77% yield). $\mathbf{R_f}$ = 0.4 (petroleum ether: acetone = 5: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.57 (s, 1H), 7.75 – 6.96 (m, 10H), 6.41 (s, 0.5H), 6.37 (s, 0.5H), 5.42 – 5.01 (m, 5H), 4.64 (d, *J* = 44.0 Hz, 1H), 3.33 (d, *J* = 20.0 Hz, 1H), 3.22 – 3.03 (m, 2H), 2.96 – 2.82 (m, 1H), 2.11 – 2.01 (m, 3H), 1.58 – 1.45 (m, 1H), 1.31 – 0.70 (m, 13H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 156.6, 154.9, 149.0, 148.7, 148.1, 148.0, 135.7, 129.8, 129.6, 127.8, 127.7, 127.6, 127.5, 127.4, 127.4, 127.3, 127.2, 126.9, 126.7, 120.8, 119.6, 112.4, 111.4, 107.7, 107.1, 67.4, 67.1, 66.2, 43.9, 43.8, 43.4, 43.2, 28.8, 27.1, 26.3, 25.4, 25.3, 25.2, 25.0, 24.7, 24.6, 24.5, 22.9, 22.9, 14.6,

14.3. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{32}H_{40}ClN_4O_4^+$: 579.2733; found: 579.2723. $[\alpha]_D^{25}$ = 45.06 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/EtOH = 90/10, 1 mL/min, 14:1 dr.

Major diastereomer: 91.5:8.5 er, $t_R$ = 12.6 min (major), 45.7 min (minor); Minor diastereomer: 83:17 er, $t_R$ = 11.6 min (minor), 23.8 min (major)

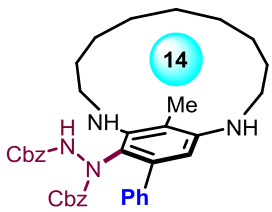
**Metacyclophanes 5g**




**5g** was prepared in 0.15 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 15: 1 to 2: 1) as a yellow solid (57.2 mg, 67% yield). $\mathbf{R_f}$ = 0.4 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.76 (s, 1H), 7.49 – 7.09 (m, 10H), 6.17 – 6.07 (m, 1H), 5.22 – 5.09 (m, 4H), 5.08 – 5.00 (m, 1H), 4.71 – 4.51 (m, 1H), 3.40 – 3.28 (m, 1H), 3.23 – 3.03 (m, 2H), 2.94 – 2.85 (m, 1H), 2.05 (s, 3H), 1.62 – 1.48 (m, 1H), 1.27 – 0.78 (m, 13H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 157.6, 156.2, 155.7, 154.8, 149.0, 148.9, 148.7, 148.6, 147.4, 135.8, 135.4, 127.7, 127.7, 127.6, 127.5, 127.4, 127.3, 127.2, 127.2, 127.1, 127.0, 126.8, 126.5, 111.48 (d, *J* = 14.6 Hz), 110.1, 108.6, 107.7, 94.22 (d, *J* = 23.4 Hz), 93.83 (d, *J* = 23.4 Hz), 67.1, 66.9, 66.0, 43.9, 43.8, 43.4, 43.2, 29.0, 27.5, 26.4, 26.4, 25.5, 25.4, 25.3, 25.2, 25.1, 24.7, 24.6, 22.8, 14.2, 13.6. **$^{19}$F NMR** (471 MHz, DMSO-*d6*, 373 K) δ -123.0, -124.2. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{32}H_{40}FN_4O_4^+$: 563.3029; found: 563.3025. $[\alpha]_D^{25}$ = 36.41 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 80/20, 1 mL/min, 1.8:1 dr.

Major diastereomer: 93.5:6.5 er, $t_R$ = 9.3 min (minor), 17.8 min (major); minor diastereomer: 94:6 er, $t_R$ = 11.7 min (major), 25.7 min (minor)

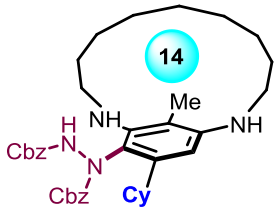
**Metacyclophanes 5h**



**5h** was prepared in 0.05 mmol scale and isolated by flash chromatography (petroleum ether: DCM: ethyl acetate = 20: 20: 1 to 10: 10: 1) as a yellow solid (30.6 mg, 99% yield). $\mathbf{R_f}$ = 0.7 (petroleum ether: DCM: ethyl acetate = 2: 2: 1, v/v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.20 – 8.02 (m, 1H), 7.51 – 7.16 (m, 14H), 7.13 – 7.06 (m, 1H), 6.16 (s, 0.6H), 6.15 (s, 0.4H), 5.30 – 5.06 (m, 3H), 5.04 – 4.67 (m, 2H), 4.50 – 4.23 (m, 1H), 3.45 – 3.25 (m, 1H), 3.21 – 3.06 (m, 2H), 2.92 – 2.81 (m, 1H), 2.18 – 2.03 (m, 3H), 1.72 – 1.55 (m, 1H), 1.31 – 0.79 (m, 13H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 156.3, 154.8, 147.7, 147.6, 146.5, 139.5, 137.8, 135.6, 135.5, 128.1, 127.9, 127.8, 127.7, 127.6, 127.5, 127.3, 127.3, 127.2, 126.9, 126.2, 126.0, 121.1, 120.2, 112.5, 112.3, 109.2, 109.0, 66.7, 66.4, 44.0, 43.9, 43.2, 43.1, 28.5, 27.0, 26.5, 26.3, 25.3, 25.3, 25.0, 24.7, 24.7, 24.5, 22.8, 14.6, 14.2. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{38}H_{45}N_4O_4^+$: 621.3436; found: 621.3423. $[\alpha]_D^{25}$ = 14.03 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/EtOH = 90/10, 1 mL/min, 1.2:1 dr.

Major diastereomer: 99:1 er, $t_R$ = 12.8 min (minor), 17.7 min (major); minor diastereomer: >99.5:0.5 er, $t_R$ = 14.1 min (major), 19.1 min (minor)

**Metacyclophanes 5i**




**5i** was prepared in 0.2 mmol scale and isolated by flash chromatography (DCM: ethyl acetate = 50: 1 to 5: 1) as a yellow solid (107.6 mg, 86% yield). $\mathbf{R_f}$ = 0.6 (DCM: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 10.35 – 9.88 (m, 1H), 8.15 – 7.60 (m, 10H), 6.71 (s, 0.6H), 6.69 (s, 0.4H), 5.78 – 5.45 (m, 5H), 3.91 – 3.80 (m, 1H), 3.65 – 3.53 (m, 2H), 3.45 – 3.33 (m, 1H), 3.13 – 3.03 (m, 1H), 2.58 (s, 3H), 2.32 – 1.33 (m, 25H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 156.8, 156.4, 155.4, 147.7, 147.4, 146.2, 145.5, 142.7, 142.5, 135.9, 135.8, 135.7, 127.7, 127.7, 127.6, 127.5, 127.5, 127.4, 127.3, 127.2, 126.9, 121.9, 120.6, 111.8, 110.6, 106.6, 105.7, 66.7, 66.2, 66.1, 59.1, 44.0, 44.0, 43.5, 43.2, 37.7, 37.5, 33.8, 33.5, 33.3, 33.0, 28.7, 27.2, 26.3, 26.3, 26.1, 26.0, 25.7, 25.5, 25.4, 25.3, 25.3, 25.3, 25.2, 24.8, 24.6, 22.9, 22.7, 20.0, 14.2, 14.0, 13.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{38}H_{51}N_4O_4^+$: 627.3905; found: 627.3896. $[\alpha]_D^{25}$ = 34.66 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak ID

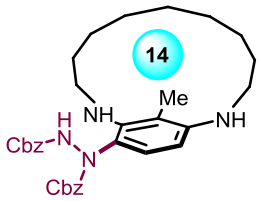
column, hexanes/EtOH = 95/05 35 min to 80/20 20 min, 1 mL/min; $t_R$ = 26.6 min, 30.2 min, 35.5 min, 41.3 min; 12:1 dr, 89:11 er (major), 92:8 er (minor). 12:1 dr.

Major diastereomer: 89:11 er, $t_R$ = 26.6 min (minor), 41.3 min (major); minor diastereomer: 92:8 er, $t_R$ = 30.2 min (minor), 35.5 min (major).

## Determination of $t_{1/2}^{rac}$ and racemization barrier

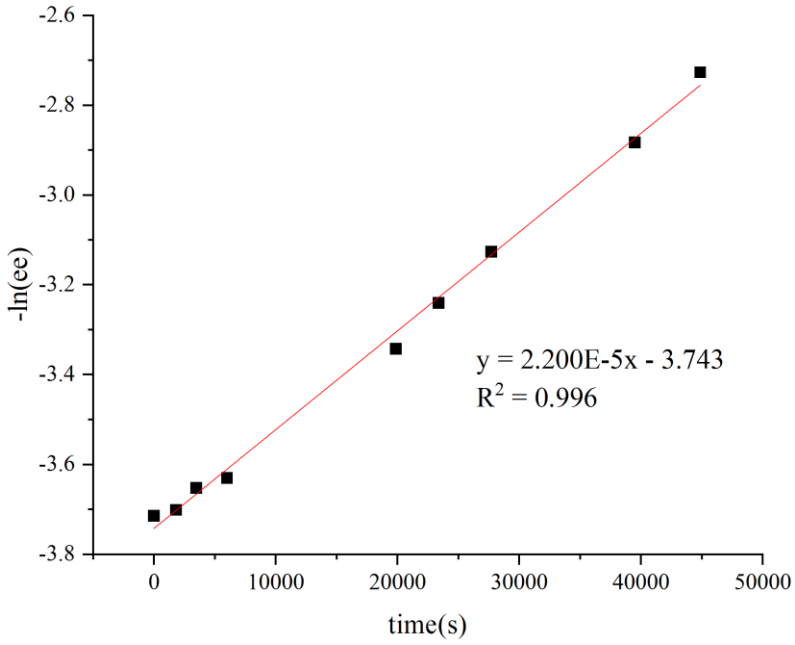
The configurational stability of the atropisomers was determined by measuring the energy barrier of rotation and the racemic half-life. Measurements were conducted at 1 mg/mL concentration. Enantiomeric excess values were determined by chiral HPLC.

**Metacyclophanes 5d**




Racemization of **5d** in diphenyl ether at 358 K

| Time (s) | ee (%) | -ln(ee) |
|---|---|---|
| 1740 | 41.0 | -3.7145 |
| 3540 | 40.5 | -3.7016 |
| 5220 | 38.6 | -3.6522 |
| 7740 | 37.7 | -3.6304 |
| 21600 | 28.3 | -3.3428 |
| 25140 | 25.5 | -3.2403 |
| 29460 | 22.8 | -3.1263 |
| 41220 | 17.9 | -2.8830 |
| 46620 | 15.3 | -2.7268 |




-ln(ee) = $2k_{ent}t + C$

Therefore, $k_{ent} = 1.100 \times 10^{-5}\ s^{-1}$

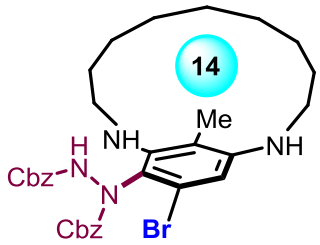
$$t_{1/2}{}^{358K}{}_{rac} = \frac{\ln(2)}{2k_{ent}} = 8.8\ h$$

Employing the Eyring equation:

$$\Delta G_{rac}{}^{\#} = -RTln\left(\frac{k_{ent} \times h}{k_B \times T}\right) = -8.314 \times 358 \times \ln\left(\frac{1.100 \times 10^{-5} \times 6.626 \times 10^{-34}}{1.381 \times 10^{-23} \times 358}\right)$$

= 122.2 kJ/mol = 29.2 kcal/mol

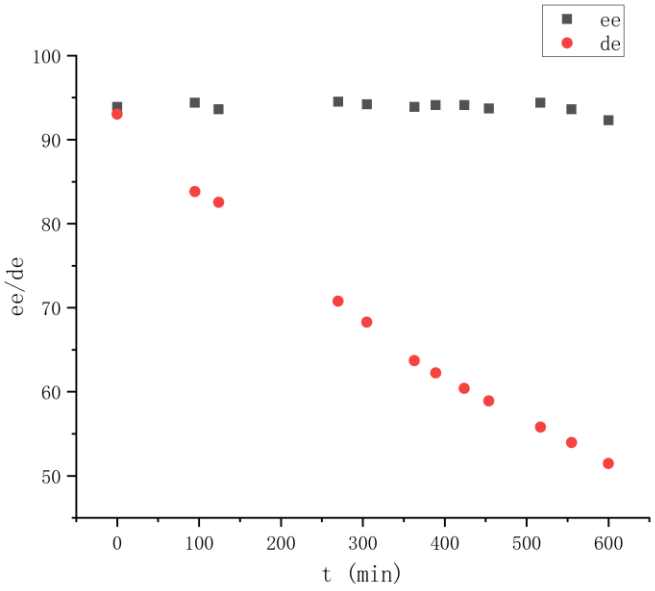
**Metacyclophanes 5e**

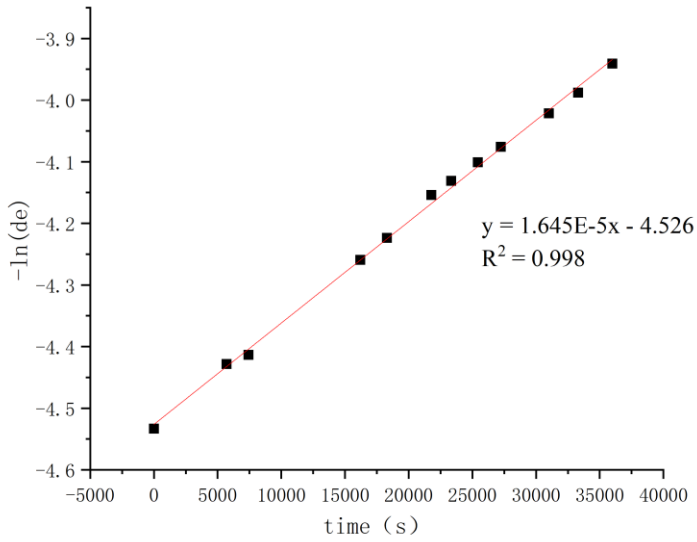



Racemization of **5e** in diphenyl ether at 323 K

| Time (s) | ee (%) | de(%) | -ln(de) |
|---|---|---|---|
| 0 | 93.9 | 93.0 | -4.5331 |
| 5700 | 94.4 | 83.8 | -4.4285 |
| 7440 | 93.6 | 82.6 | -4.4135 |
| 16200 | 94.5 | 70.8 | -4.2594 |
| 18300 | 94.2 | 68.3 | -4.2238 |

| | | | |
|---|---|---|---|
| 21780 | 93.9 | 63.7 | -4.1542 |
| 23340 | 94.1 | 62.2 | -4.1310 |
| 25440 | 94.1 | 60.4 | -4.1012 |
| 27240 | 93.7 | 58.9 | -4.0762 |
| 31020 | 94.4 | 55.8 | -4.0218 |
| 33300 | 93.6 | 54.0 | -3.9882 |
| 36000 | 92.3 | 51.5 | -3.9412 |




-ln(de) = $2k_{ent}t + C$

Therefore, $k_{ent} = 0.8225 \times 10^{-5}\ s^{-1}$

$$t_{1/2}{}^{323K}{}_{epi} = \frac{\ln(2)}{2k_{ent}} = 11.6\ h$$

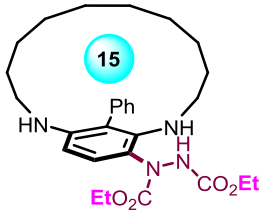
Employing the Eyring equation:

$$\Delta G_{epi}{}^{\#} = -RTln\left(\frac{k_{ent} \times h}{k_B \times T}\right) = -8.314 \times 323 \times \ln\left(\frac{0.8225 \times 10^{-5} \times 6.626 \times 10^{-34}}{1.381 \times 10^{-23} \times 323}\right)$$

= 108.4 kJ/mol = 25.9 kcal/mol

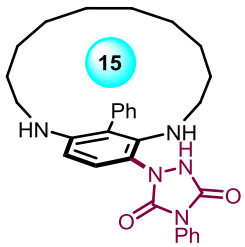
## Mechanistic studies through control experiments

### Metacyclophanes 3ac




**3ac** was prepared in 0.02 mmol scale and isolated by flash chromatography (petroleum ether: ethyl acetate = 10: 1 to 4: 1) as a yellow solid (6.9mg, 70% yield). $\mathbf{R_f}$ = 0.3 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K) δ 9.28 (s, 1H), 7.57 – 7.46 (m, 2H), 7.42 – 7.28 (m, 3H), 7.02 (d, *J* = 8.7 Hz, 1H), 6.30 (d, *J* = 8.7 Hz, 1H), 4.34 (s, 1H), 4.19 – 4.02 (m, 4H), 3.97 – 3.84 (m, 1H), 3.50 – 3.35 (m, 1H), 3.04 – 2.99 (m, 1H), 2.43 – 2.30 (m, 1H), 1.83 – 1.72 (m, 1H), 1.51 – 1.42 (m, 1H), 1.40 – 1.32 (m, 2H), 1.30 – 1.08 (m, 16H), 1.00 – 0.90 (m, 2H). **$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K) δ 155.8, 155.0, 146.0, 144.6, 136.4, 129.9, 128.4, 127.9, 126.2, 122.4, 104.0, 61.0, 60.1, 43.8, 42.9, 28.8, 27.8, 27.0, 26.6, 26.6, 24.8, 24.5, 13.6, 13.5. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{28}H_{41}N_4O_4^+$: 497.3123; found: 497.3118. **HPLC:** Chiralpak IA column, hexanes/isopropanol = 90/10, 1 mL/min; $t_R$ = 8.8 min (minor), 12.8 min (major); 66:34 er.

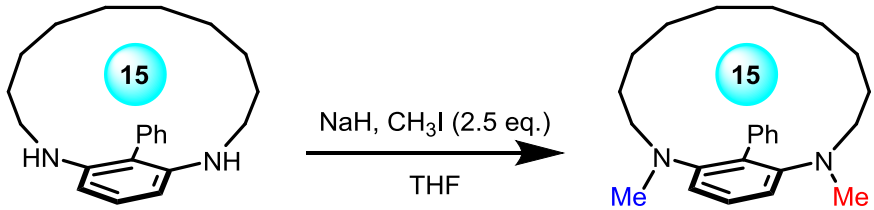
### Metacyclophanes 3ae




**3ae** was prepared in 0.05 mmol scale and isolated by flash chromatography (DCM: MeOH = 100: 1 to 20: 1) as a yellow solid (19.2 mg, 77% yield). $\mathbf{R_f}$ = 0.3 (DCM: MeOH = 20: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.66 – 7.59 (m, 3H), 7.58 – 7.52 (m, 3H), 7.51 – 7.46 (m, 3H), 7.40 – 7.35 (m, 1H),

7.16 (d, *J* = 7.5 Hz, 1H), 6.54 (d, *J* = 8.9 Hz, 1H), 3.60 – 3.51 (m, 1H), 2.99 – 2.90 (m, 2H), 2.90 – 2.82 (m, 1H), 1.95 – 1.88 (m, 1H), 1.41 – 1.36 (m, 2H), 1.29 – 1.22 (m, 6H), 1.16 – 1.09 (m, 5H), 1.02 – 0.97 (m, 2H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 152.6, 145.6, 134.0, 132.5, 131.8, 130.8, 129.9, 129.9, 129.2, 128.9, 128.1, 125.8, 125.2, 120.9, 116.8, 107.2, 46.8, 43.9, 28.5, 28.3, 27.7, 27.7, 26.9, 26.8, 26.0, 14.3. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{30}H_{36}N_5O_2^+$: 498.2864; found: 498.2858. **HPLC:** Chiralpak IB column, hexanes/isopropanol = 70/30, 1 mL/min; $t_R$ = 6.6 min (minor), 11.5 min (major); 56:44 er.

Synthesis of macrocyclic substrate **1a'**

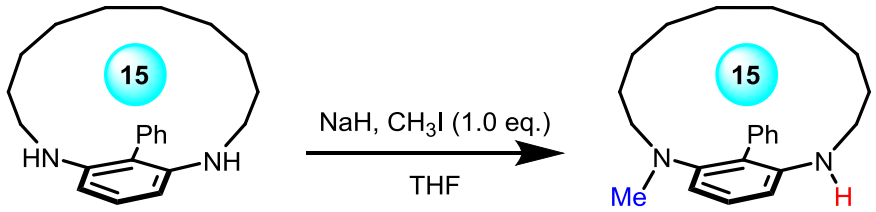



**1a** **1a'**

To a solution of sodium hydride (60% in mineral oil, 15.0 mg, 0.375 mmol, 2.5 equiv.) in THF (1.5 mL) was added **1a** (48.4 mg, 0.15 mmol, 1.0 equiv.) at 0 ℃. The reaction mixture was allowed to warm to rt and stirred for 30 minutes. Then methyl iodide (24.0 μL, 0.375 mmol, 2.5 equiv) was added. After stirring overnight, water was added carefully with ice-cooling and the resulting solution was extracted with ethyl acetate. The organic phases was washed with water for three times, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography (petroleum ether: ethyl acetate = 50:1) to give the product **1a'** as a brown solid (50.7 mg, 96% yield).

**$R_f$** = 0.7 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.56 – 7.43 (m, 2H), 7.36 (td, *J* = 7.3, 1.3 Hz, 2H), 7.25 – 7.22 (m, 1H), 7.20 (t, *J* = 8.0 Hz, 1H), 6.87 (d, *J* = 8.0 Hz, 2H), 2.82 – 2.71 (m, 4H), 2.43 (s, 6H), 1.42 – 1.34 (m, 4H), 1.24 – 1.06 (m, 8H), 1.00 – 0.93 (m, 2H), 0.90 – 0.83 (m, 2H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 151.6, 139.2, 132.5, 131.1, 127.6, 127.4, 125.8, 116.1, 53.5, 42.6, 27.4, 27.3, 25.8, 25.7. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{24}H_{35}N_2^+$: 351.2795; found: 351.2784.

Synthesis of macrocyclic substrate **1a''**

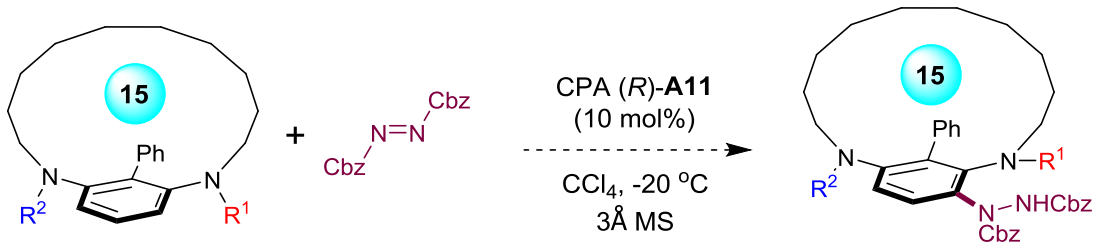



**1a** **1a''**

To a solution of sodium hydride (60% in mineral oil, 40.0 mg, 1.0 mmol, 5 equiv.) in THF (1.5 mL) was added **1a** (64.5 mg, 0.2 mmol, 1.0 equiv.) at 0 ℃. The reaction mixture was allowed to warm to rt and stirred for 30 minutes. Then a solution of methyl iodide (12.8 μL, 0.2 mmol, 1.0 equiv) in THF (0.5 mL) was added. After stirring overnight, water was added carefully with ice-cooling and the resulting solution was extracted with ethyl acetate. The organic phases was washed with water for three times, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography (petroleum ether: ethyl acetate = 50:1 to 40: 1) to give the product **1a''** as a brown solid (37.8 mg, 56% yield).

**$R_f$** = 0.5 (petroleum ether: ethyl acetate = 20: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.62 – 7.38 (m, 3H), 7.34 – 7.30 (m, 1H), 7.19 (s, 1H), 7.13 (t, *J* = 8.1 Hz, 1H), 6.62 – 6.56 (m, 1H), 6.54 – 6.50 (m, 1H), 3.52 – 3.43 (m, 1H), 3.07 – 2.99 (m, 1H), 2.91 – 2.80 (m, 1H), 2.63 (s, 3H), 2.45 – 2.35 (m, 1H), 1.80 – 1.71 (m, 1H), 1.66 – 1.54 (m, 2H), 1.45 – 1.37 (m, 2H), 1.34 – 1.14 (m, 6H), 1.10 – 0.88 (m, 5H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 151.1, 148.0, 138.0, 128.0, 126.9, 122.7, 110.6, 109.1, 52.8, 45.3, 40.2, 31.5, 28.2, 28.1, 27.0, 26.9, 25.7, 25.6, 23.0. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{23}H_{33}N_2^+$: 337.2639; found: 337.2627.

Asymmetric reactions of substrate **1a'** and **1a''**

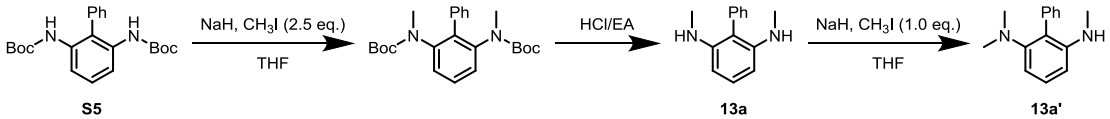



**1a'**, $R^1 = R^2$ = Me
**1a''**, $R^1$ = Me, $R^2$ = H

**3a',** $R^1 = R^2$ = Me, *N.D.*
**3a''**, $R^1$ = Me, $R^2$ = H, *N.D.*

To a precooled solution of **1a'** or **1a''** (0.05 mmol, 1.0 equiv.), CPA (*R*)- **A11** (0.005 mmol, 10 mol%) and 3Å MS in $CCl_4$ (1 mL, 0.05 M) was added **2a** (0.0.05 mmol, 1.0 equiv.) at -20 $^oC$. However, after stirring for 48 hours, no desired products **3a'** or **3a''** were isolated from the reaction mixture.

Synthesis of macrocyclic substrate **13a** and **13a'**




**S5** **13a** **13a'**

To a solution of sodium hydride (60% in mineral oil, 18.0 mg, 0.75 mmol, 2.5 equiv.) in THF (1.5 mL) was added **S5** (115.4 mg, 0.3 mmol, 1.0 equiv.) at 0 ℃. The reaction mixture was allowed to warm to rt and stirred for 30 minutes. Then a solution of methyl iodide (48.0 μL, 0.75 mmol, 2.5 equiv) in THF (1.5 mL) was added. After stirring overnight, water was added carefully with ice-cooling and the resulting solution was extracted with ethyl acetate. The organic phases was washed with water for three times, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, without further purification.

The residue was dissolved into HCl/EA (1.0 M) and stirred. After stirring overnight, NH4Cl (aq) was added carefully with ice-cooling and the resulting solution was extracted with ethyl acetate. The organic phases was washed with water for three times, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography (petroleum ether: ethyl acetate = 10:1 to 5: 1) to give the product **13a** as a brown solid (63.1 mg, 99% yield).

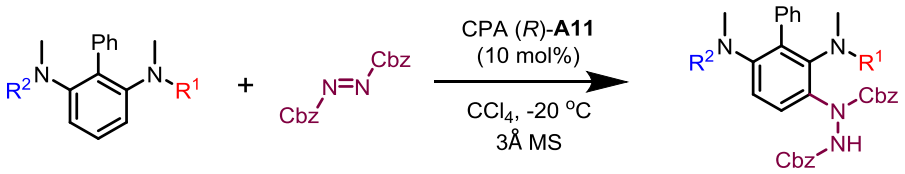
**13a**, **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.51 (dd, *J* = 8.4, 6.9 Hz, 2H), 7.43 – 7.36 (m, 1H), 7.31 – 7.27 (m, 2H), 7.21 (t, *J* = 8.1 Hz, 1H), 6.21 (d, *J* = 8.1 Hz, 2H), 3.31 (s, 2H), 2.73 (s, 6H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 147.0, 135.6, 131.5, 130.1, 129.5, 128.0, 112.5, 100.4, 31.1. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{14}H_{17}N_2^+$: 213.1387; found: 213.1384.

To a solution of sodium hydride (60% in mineral oil, 9.0 mg, 0.375 mmol, 2.5 equiv.) in THF (1.5 mL) was added **13a** (31.8 mg, 0.15 mmol, 1.0 equiv.) at 0 ℃. The reaction mixture was allowed to warm to rt and stirred for 30 minutes. Then a solution of methyl iodide (8.6 μL, 0.135 mmol, 0.9 equiv) in THF (1.5 mL) was added. After stirring overnight, water was added carefully with ice-cooling and the resulting solution was extracted with ethyl acetate. The organic phases was washed with water for three times, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by

flash column chromatography (petroleum ether: ethyl acetate = 50:1 to 20: 1) to give the product **13a'** as a yellow solid (14.1 mg, 42% yield)

**13a'**, **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.46 (t, *J* = 7.6 Hz, 2H), 7.38 – 7.30 (m, 3H), 7.23 (t, *J* = 8.1 Hz, 1H), 6.55 (d, *J* = 8.1 Hz, 1H), 6.42 (d, *J* = 8.1 Hz, 1H), 3.67 (s, 1H), 2.74 (s, 3H), 2.45 (s, 6H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 152.5, 147.6, 137.7, 131.2, 129.1, 128.9, 126.9, 120.8, 107.7, 104.5, 43.9, 31.2. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{15}H_{19}N_2^+$: 227.1543; found: 227.1538.

Asymmetric reactions of substrate **13a** and **13a'**




**13a**, $R^1 = R^2 = H$
**13a'**, $R^1$ = Me, $R^2 = H$

**14a**, $R^1 = R^2 = H$, 59 %
**14a'**, $R^1$ = Me, $R^2$ = H, 50 %

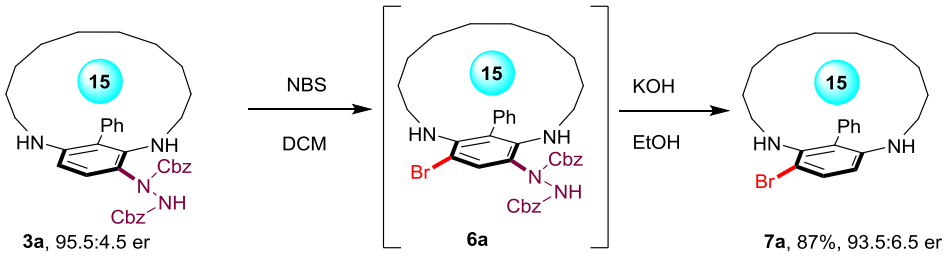
To a precooled solution of **13a** or **13a'** (0.05 mmol, 1.0 equiv.), CPA (*R*)- **A11** (0.005 mmol, 10 mol%) and 3Å MS in $CCl_4$ (1 mL, 0.05 M) was added **2a** (0.0.05 mmol, 1.0 equiv.) at -20 °C. After stirring 48h, water was added carefully with ice-cooling and the resulting solution was extracted with ethyl acetate. The organic phases was washed with water for three times, dried over $Na_2SO_4$, and concentrated under vacuum to give a residue, which was purified by flash column chromatography (petroleum ether: ethyl acetate = 20:1 to 10: 1) to give the product **14a** as a yellow oil (15.1 mg, 59% yield) or **14a'** as a yellow oil (13.1 mg, 50% yield).

**14a**, **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.58 – 7.27 (m, 16H), 6.33 – 6.07 (m, 1H), 5.34 – 5.01 (m, 4H), 3.56 – 3.39 (m, 1H), 2.72 (s, 3H), 2.45 – 2.16 (m, 3H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 156.2, 147.6, 145.2, 141.0, 136.3, 135.7, 131.4, 131.1, 129.7, 128.7, 128.7, 128.6, 128.5, 128.4, 128.3, 128.1, 127.9, 127.7, 127.1, 68.3, 67.9, 34.6, 30.8. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{30}H_{31}N_4O_4^+$: 511.2340; found: 511.2336.

**14a'**, **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.55 – 7.27 (m, 16H), 6.50 – 6.10 (m, 1H), 5.27 – 5.02 (m, 4H), 3.51 (s, 1H), 2.71 (s, 3H), 2.36 – 2.16 (m, 6H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 156.2, 147.9, 147.3, 136.6, 136.4, 135.9, 131.2, 130.3, 129.2, 129.0, 128.7, 128.7, 128.7, 128.6, 128.5, 128.4, 128.3, 128.1, 128.0, 127.8, 127.1, 125.5, 68.1, 67.7, 43.6, 30.9. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{31}H_{33}N_4O_4^+$**:** 525.2497; found: 525.2499.

## Derivatizations of the chiral products

### Metacyclophanes 7a



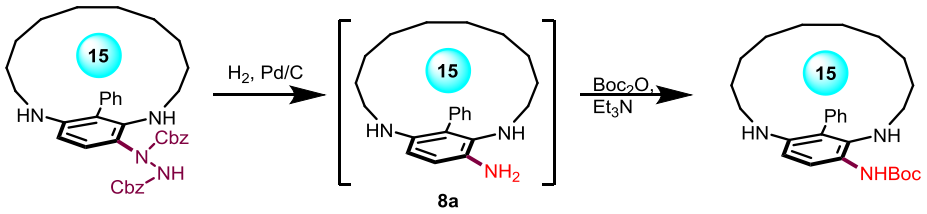

**3a**, 95.5:4.5 er　　**6a**　　**7a**, 87%, 93.5:6.5 er

To solution of **3a** (31.0 mg, 0.05 mmol, 1.0 equiv.) in DCM (2 mL) was added NBS (9 mg, 0.05 mmol, 1.0 equiv.) at -40 $^{o}$C. After stirring at -40 $^{o}$C for 4 h, the reaction mixture was warmed to room temperature, poured into water and extracted with EtOAc for 3 times. The combined organic layer was dried over $Na_2SO_4$, filtered and concentrated in vacuo to give a residue, which was purified by flash chromatography (petroleum ether/ethyl acetate = 5:1) to afford the product **6a** as yellow oil.

To solution of **6a** in EtOH (2 mL) was added KOH (22 mg, 0.4 mmol, 10 equiv.) and the mixture was warmed to 78 $^{o}$C and allowed to stir for 20 h. After completion of this reaction as monitored by TLC, the reaction mixture was cooled to room temperature, poured into water and extracted with EtOAc for 3 times. The combined organic layer was dried over $Na_2SO_4$, filtered and concentrated in vacuo to give a residue, which was purified by flash chromatography (petroleum ether/ethyl acetate = 50:1 to 20:1) to afford the product **7a** (17.5 mg, 87% for two steps) as a yellow solid.

**$R_f$** = 0.6 (petroleum ether: ethyl acetate = 10: 1, v/v). **$^{1}$H NMR** (600 MHz, $CDCl_3$) δ 7.60 – 7.41 (m, 3H), 7.38 (ddd, *J* = 8.7, 7.3, 1.5 Hz, 1H), 7.30 (d, *J* = 8.8 Hz, 1H), 7.16 (s, 1H), 6.39 (d, *J* = 8.8 Hz, 1H), 3.45 (ddd, *J* = 15.0, 8.0, 2.8 Hz, 1H), 3.00 (ddd, *J* = 14.9, 7.5, 3.1 Hz, 1H), 2.90 (ddd, *J* = 14.6, 6.6, 5.5 Hz, 1H), 2.64 (ddd, *J* = 14.6, 7.3, 5.5 Hz, 1H), 1.85 – 1.76 (m, 1H), 1.71 (s, 1H), 1.44 – 1.28 (m, 5H), 1.22 – 0.97 (m, 10H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 147.0, 145.7, 136.5, 132.1, 127.8, 120.6, 108.6, 104.8, 45.9, 44.8, 30.6, 30.3, 28.3, 27.9, 27.4, 27.2, 25.8, 25.7. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{22}H_{30}BrN_2^+$: 401.1587; found: 401.1576. $[\alpha]_D^{25}$ = 15.10 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IC column, hexanes/isopropanol = 98/02, 1 mL/min; $t_R$ = 5.2 min (minor), 6.9 min (minor); 93.5:6.5 er.

### Metacyclophanes 9a




**3a**, 95.5:4.5 er

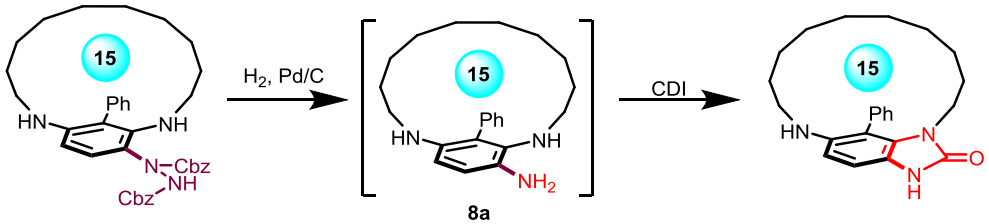
**8a**

**9a**, 85%, 95:5 er

To a solution of **3a** (18.1 mg, 0.05 mmol, 1.0 equiv.) in THF (2 mL) was added Pd/C (5 mg, 10 wt %), and the flask was evacuated and purged with $H_2$ fort 3 times. After stirring at room temperature under $H_2$ atmosphere (1 atm) for 4 hours, $Boc_2O$ (12.9 μL, 0.055 mmol, 1.1 equiv.), $NEt_3$ (20.8 μL, 0.15 mmol, 3.0 equiv.) was added under $H_2$, the mixture was allowed to stir for another 5 hours. After completion, the mixture was filtered through Celite and concentrated under vacuum to give a residue, which was purified by column chromatography (petroleum ether/ethyl acetate = 20:1 to 5:1) to give the product **9a** as a yellow solid (18.5 mg, 85 % yield).

**$R_f$** = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.66 (s, 1H), 7.61 – 7.47 (m, 3H), 7.46 – 7.39 (m, 1H), 7.13 (d, *J* = 7.6 Hz, 1H), 6.82 (s, 1H), 6.52 (d, *J* = 8.9 Hz, 1H), 3.50 (ddd, *J* = 14.9, 6.0, 3.1 Hz, 1H), 2.96 – 2.86 (m, 2H), 2.84 – 2.75 (m, 1H), 1.92 – 1.82 (m, 1H), 1.50 (s, 9H), 1.35 – 1.08 (m, 14H), 1.02 – 0.92 (m, 2H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 135.6, 132.4, 130.4, 129.9, 129.4, 128.2, 47.2, 44.6, 30.0, 29.8, 28.6, 28.3, 27.9, 27.6, 27.4, 26.7, 25.8. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{27}H_{40}N_3O_2^+$: 438.3116; found: 438.3103. $[\alpha]_D^{25}$ = -23.44 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/isopropanol = 98/02, 1 mL/min; $t_R$ = 9.5 min (minor), 14.4 min (major); 95: 5 er.

**Metacyclophanes 10a**




**3a**, 95.5:4.5 er

**8a**

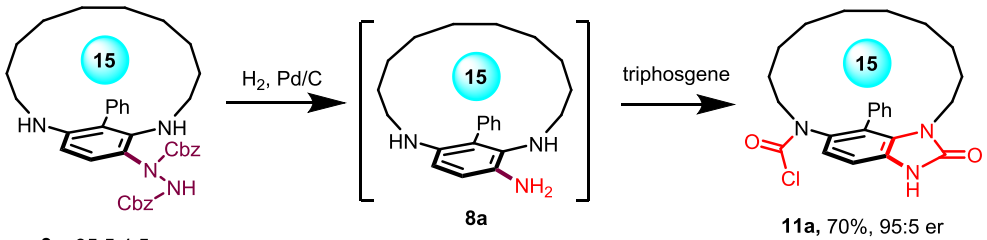
**10a**, 77%, 93.5:6.5 er

To a solution of **3a** (31.0 mg, 0.05 mmol, 1.0 equiv.) in THF (2 mL) was added Pd/C (5 mg, 10 wt %), and the flask was evacuated and purged with $H_2$ fort 3 times. After stirring at room temperature under $H_2$ atmosphere (1 atm) for 4 hours, the mixture was filtered through Celite under $N_2$ atmosphere and concentrated in vacuo to give a residue **8a**.

To solution of **8a** in THF (2 mL) was added CDI (16.2 mg, 0.1 mmol, 2 equiv.) and the mixture was stirred at room temperature for 24 h. After completion of this reaction as monitored by TLC, the mixture was poured into water and extracted with EtOAc for 3 times. The combined organic layer was dried over $Na_2SO_4$, filtered and concentrated in vacuo to give a residue, which was purified by flash chromatography (petroleum ether/ethyl acetate = 10:1 to 2:1) to afford the product **10a** (13.9 mg, 77% for two steps) as a yellow solid.

**$R_f$** = 0.2 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 9.41 (s, 1H), 7.80 (d, *J* = 7.6 Hz, 1H), 7.56 (t, *J* = 7.4 Hz, 1H), 7.51 – 7.40 (m, 2H), 7.15 (d, *J* = 7.4 Hz, 1H), 6.97 (dd, *J* = 8.5, 1.8 Hz, 1H), 6.61 (d, *J* = 8.5 Hz, 1H), 3.91 (ddd, *J* = 14.4, 10.2, 4.3 Hz, 1H), 3.56 (dt, *J* = 14.9, 4.1 Hz, 1H), 3.04 (ddd, *J* = 14.9, 10.3, 2.7 Hz, 1H), 2.70 (dt, *J* = 14.4, 4.7 Hz, 1H), 1.95 – 1.86 (m, 1H), 1.72 (s, 1H), 1.48 – 1.40 (m, 1H), 1.35 – 1.22 (m, 5H), 1.15 – 1.01 (m, 4H), 0.98 – 0.91 (m, 1H), 0.89 – 0.82 (m, 1H), 0.73 – 0.59 (m, 3H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 157.5, 134.6, 133.2, 129.8, 129.6, 128.8, 128.5, 128.4, 109.4, 45.3, 41.6, 29.8, 28.7, 27.9, 27.7, 27.2, 26.2, 24.4, 24.4. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{23}H_{30}N_3O^+$: 364.2384; found: 364.2380. $[\alpha]_D^{25}$ = -18.77 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IA column, hexanes/isopropanol = 90/10, 1 mL/min; $t_R$ = 9.9 min (major), 17.8 min (minor); 93.5:6.5 er.

**Metacyclophanes 11a**




**3a**, 95.5:4.5 er

**8a**

**11a,** 70%, 95:5 er

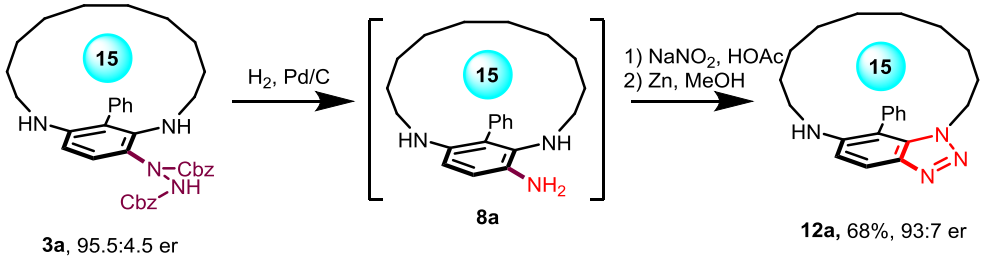
To a solution of **3a** (31.0 mg, 0.05 mmol, 1.0 equiv.) in THF (2 mL) was added Pd/C (5 mg, 10 wt %), and the flask was evacuated and purged with $H_2$ fort 3 times. After stirring at room temperature under $H_2$ atmosphere (1 atm) for 4 hours, the mixture was filtered through Celite under $N_2$ atmosphere and concentrated in vacuo to give a residue **8a**.

To solution of **8a** in DCM (2 mL) was added triphosgene (14.8 mg, 0.05 mmol, 1.0 equiv.), $NEt_3$ (34.7 μL, 0.25 mmol, 5.0 equiv.) at rt, and the mixture was stirred at room temperature for 3 h. After completion of this reaction as monitored by TLC, the mixture was poured into water and extracted with

EtOAc for 3 times. The combined organic layer was dried over $Na_2SO_4$, filtered and concentrated in vacuo to give a residue, which was purified by flash chromatography (petroleum ether/ethyl acetate = 10:1 to 2:1) to afford the product **11a** (14.9 mg, 70% for two steps) as a yellow solid.

**$R_f$** = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 10.66 (s, 1H), 7.60 – 7.36 (m, 4H), 7.21 – 7.12 (m, 2H), 6.95 (d, *J* = 8.0 Hz, 1H), 4.09 – 3.95 (m, 2H), 3.59 – 3.46 (m, 1H), 2.86 – 2.74 (m, 1H), 1.52 – 1.36 (m, 3H), 1.29 – 1.05 (m, 10H), 0.88 – 0.73 (m, 2H), 0.68 – 0.55 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 157.9, 149.4, 133.6, 132.7, 129.6, 129.5, 129.0, 128.6, 128.2, 127.6, 125.0, 124.5, 109.1, 52.0, 41.5, 29.8, 27.3, 26.8, 26.2, 25.2, 25.1, 24.9, 23.0. $[M+H]^+$ calculated for $C_{24}H_{29}ClN_3O_2^+$: 426.1943; found: 426.1941. **$[\alpha]_D^{25}$** = -9.21 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/EtOH = 95/05, 1 mL/min; $t_R$ = 18.3 min (major), 19.7 min (minor); 95:5 er.

**Metacyclophanes 12a**




**3a**, 95.5:4.5 er

**12a**, 68%, 93:7 er

To a solution of **3a** (31.0 mg, 0.05 mmol, 1.0 equiv.) in THF (2 mL) was added Pd/C (5 mg, 10 wt %), and the flask was evacuated and purged with $H_2$ fort 3 times. After stirring at room temperature under $H_2$ atmosphere (1 atm) for 4 hours, the mixture was filtered through Celite under $N_2$ atmosphere and concentrated in vacuo to give a residue **8a**.

To solution of **8a** in AcOH (0.5 mL) was added $NaNO_2$ (5.2 mg, 0.075 mmol, 1.5 equiv.). After stirring for 30 min, Zn powder (65 mg, 1.0 mmol, 20 equiv.) and MeOH (1 mL) was added, and the mixture was allowed to stir for 2h. After completion of this reaction as monitored by TLC, the mixture was quenched by adding saturation $Na_2CO_3$ solution and extracted with EtOAc for 3 times. The combined organic layer was dried over $Na_2SO_4$, filtered and concentrated in vacuo to give a residue, which was purified by flash chromatography (petroleum ether/ethyl acetate = 20:1 to 5:1) to afford the product **12a** (11.9 mg, 68%) as a yellow solid.

**$R_f$** = 0.5 (petroleum ether: ethyl acetate = 3: 1, v/v). **$^1$H NMR** (600 MHz, $CDCl_3$) δ 7.87 (d, *J* = 9.0 Hz, 2H), 7.66 – 7.50 (m, 2H), 7.47 (t, *J* = 7.5 Hz, 1H), 7.14 (s, 1H), 7.01 (d, *J* = 9.0 Hz, 1H), 4.47 (ddd,

*J* = 14.0, 9.6, 4.2 Hz, 1H), 3.72 – 3.55 (m, 2H), 3.09 (ddd, *J* = 14.5, 10.6, 3.2 Hz, 1H), 1.91 – 1.80 (m, 1H), 1.48 – 1.29 (m, 6H), 1.19 – 1.13 (m, 1H), 1.07 – 1.00 (m, 2H), 0.96 – 0.89 (m, 2H), 0.71 – 0.67 (m, 1H), 0.60 – 0.50 (m, 1H), 0.50 – 0.36 (m, 1H), -0.19 – -0.32 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 145.6, 141.5, 134.1, 134.1, 132.9, 130.2, 128.6, 128.2, 119.5, 115.5, 107.2, 49.2, 44.8, 28.8, 28.1, 28.1, 27.4, 27.1, 27.1, 25.0, 24.0. **HRMS** (ESI): $[M+H]^+$ calculated for $C_{22}H_{29}N_4^+$: 349.2387; found: 349.2367. $[\alpha]_D^{25}$ = -26.07 (c = 1.0, $CHCl_3$). **HPLC:** Chiralpak IB column, hexanes/isopropanol = 95/05, 1 mL/min; $t_R$ = 10.0 min (major), 11.9 min (minor); 93: 7 er.

**Supplementary References**

1. X. Zhang, D. Zhu, Y. Huo, L. Chen, and Z. Chen, Atroposelective Sulfenylation of Biaryl Anilines Catalyzed by Chiral SPINOL-Derived Selenide. *Organic Letters* **2023**, 25 (19), 3445-3450

2. H. Bao, Y. Chen, and X. Yang, Catalytic Asymmetric Synthesis of Axially Chiral Diaryl Ethers through Enantioselective Desymmetrization. *Angew. Chem. Int. Ed.* **2023**, 62, e202300481

3. Z. Ye, W. Xie, D. Wang, H. Liu, and X. Yang, Atroposelective Synthesis of Diarylamines via Organocatalyzed Electrophilic Amination, *ACS Catal*. **2024**, 14, 4958-4967.

**X-Ray structures**

The compound **5e** (5 mg) was dissolved in Tol. and MTBE (0.5 mL) at room temperature, which was filtered through the filter membrane into a vial. The single crystal of **5e** was obtained by slowly evaporating the solvent at room temperature.

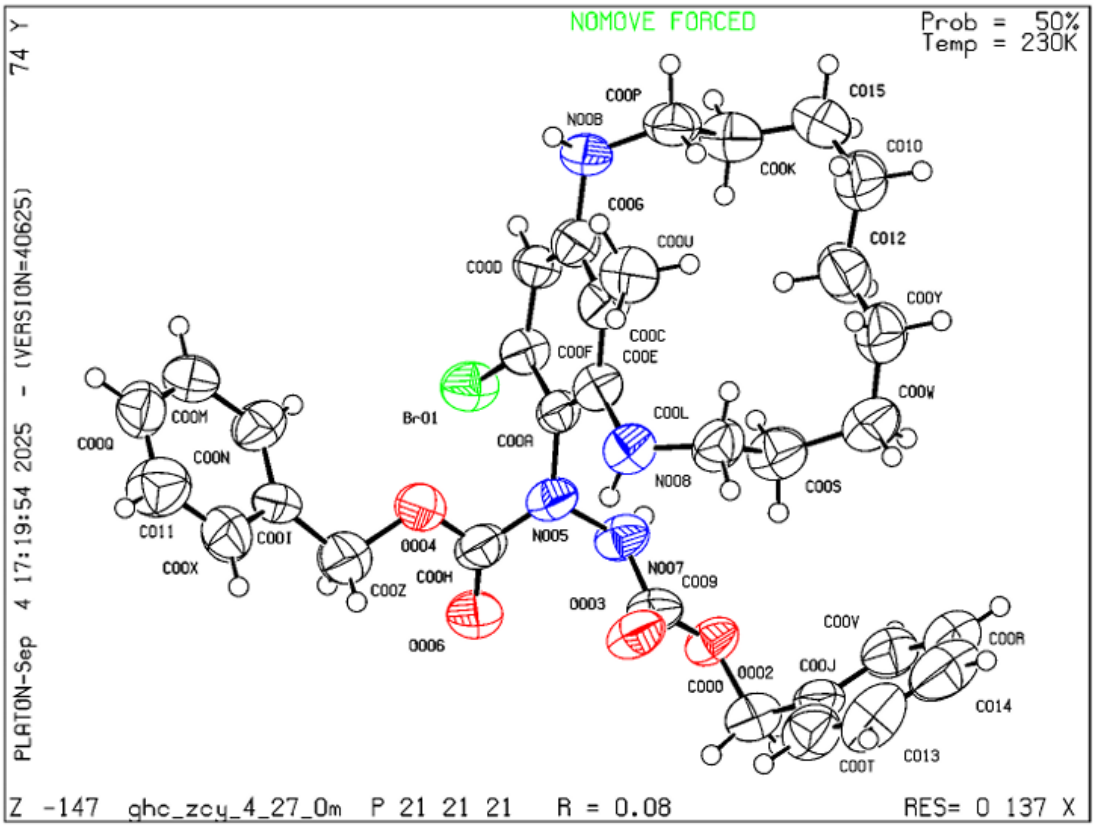



**Figure S1.** X-ray structure of **5e** (CCDC number 2500738)

**Table S2.** Crystal data and structure refinement for **5e**.

| Identification code | |
|---|---|
| Empirical formula | $C_{48}H_{59}F_6N_2O_7$ |
| Formula weight | 889.97 |
| Temperature/K | 299.0 |
| Crystal system | monoclinic |
| Space group | $P2_1/c$ |
| a/Å | 9.808(2) |
| b/Å | 30.241(6) |
| c/Å | 16.042(3) |
| α/° | 90 |
| β/° | 102.515(7) |
| γ/° | 90 |
| Volume/Å$^3$ | 4645.4(16) |
| Z | 4 |
| $\rho_{calc}$g/cm$^3$ | 1.273 |
| μ/mm$^{-1}$ | 0.539 |
| F(000) | 1884.0 |
| Crystal size/mm$^3$ | 0.1 × 0.1 × 0.1 |
| Radiation | GaKα (λ = 1.34138) |
| 2Θ range for data collection/° | 5.084 to 113.93 |
| Index ranges | $-12 \le h \le 12$, $-37 \le k \le 23$, $-19 \le l \le 20$ |
| Reflections collected | 46824 |
| Independent reflections | 9463 [$R_{int}$ = 0.0775, $R_{sigma}$ = 0.0687] |
| Data/restraints/parameters | 9463/0/582 |
| Goodness-of-fit on $F^2$ | 0.955 |
| Final R indexes [I>=2σ (I)] | $R_1$ = 0.0597, $wR_2$ = 0.1539 |
| Final R indexes [all data] | $R_1$ = 0.0927, $wR_2$ = 0.1723 |
| Largest diff. peak/hole / e Å$^{-3}$ | 0.53/-0.32 |
| Flack parameter | 0.06(4) |

The compound **11a** (5 mg) was dissolved in Tol. and MTBE(0.5 mL) at room temperature, which was filtered through the filter membrane into a vial. The single crystal of **11a** was obtained by slowly evaporating the solvent at room temperature.

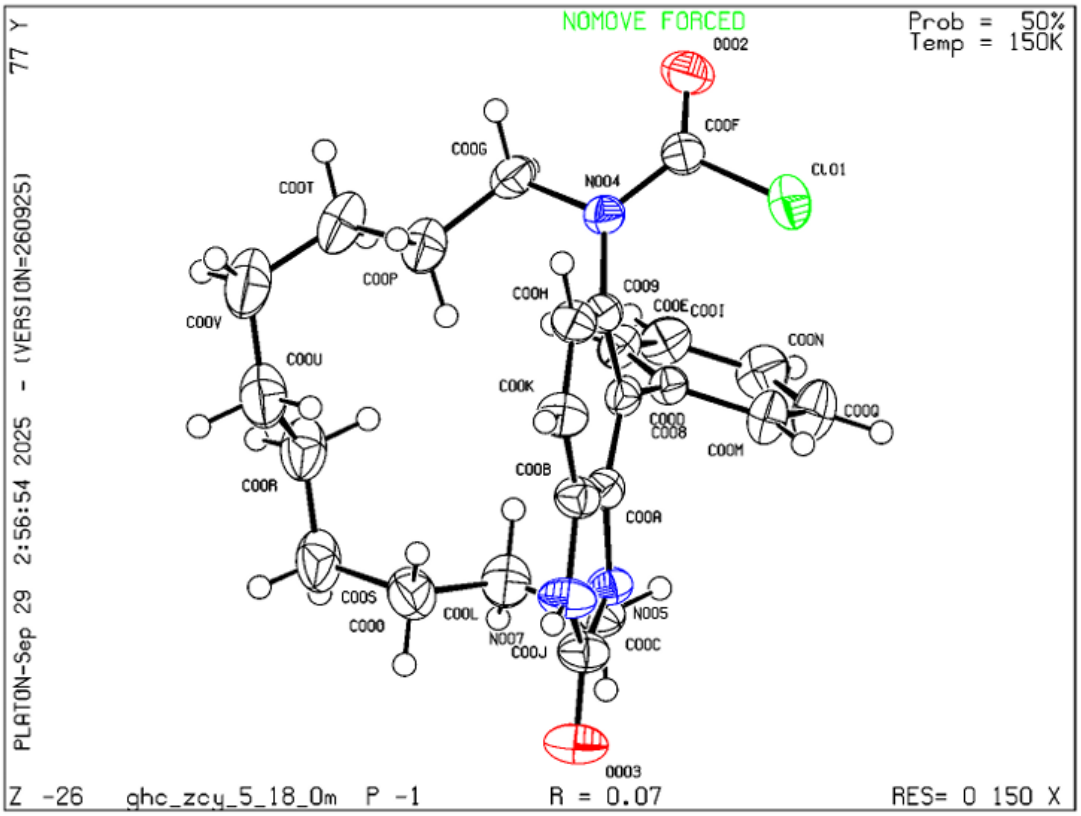


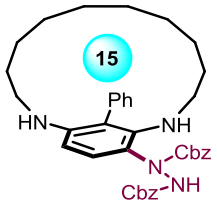

**Figure S12.** X-ray structure of **11a** (CCDC number 2500739)

**Table S3.** Crystal data and structure refinement for **11a**

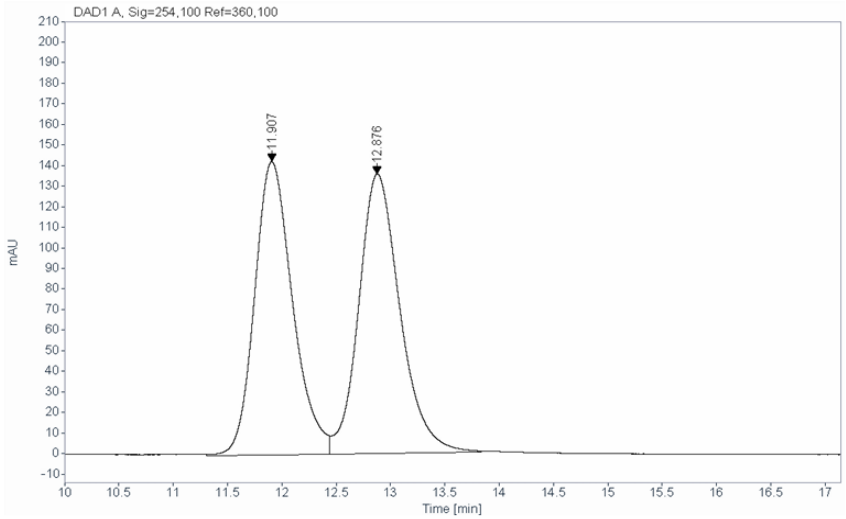
| Identification code | |
|---|---|
| Empirical formula | $C_{24}H_{28}ClN_3O_2$ |
| Formula weight | 425.94 |
| Temperature/K | 150.0 |
| Crystal system | triclinic |
| Space group | P-1 |
| a/Å | 8.6243(3) |
| b/Å | 9.9669(3) |
| c/Å | 16.1910(5) |
| α /° | 78.7430(10) |
| β /° | 82.7240(10) |
| γ /° | 82.149(2) |
| Volume/Å$^3$ | 1344.99(7) |
| Z | 2 |
| $\rho_{calc}$g/cm$^3$ | 1.052 |
| μ /mm$^{-1}$ | 0.932 |
| F(000) | 452.0 |
| Crystal size/mm$^3$ | 0.1 × 0.1 × 0.1 |
| Radiation | GaKα (λ = 1.34138) |
| 2Θ range for data collection/° | 4.868 to 107.798 |
| Index ranges | -10 ≤ h ≤ 9, -11 ≤ k ≤ 11, -19 ≤ l ≤ 19 |
| Reflections collected | 10406 |
| Independent reflections | 4762 [$R_{int}$ = 0.0573, $R_{sigma}$ = 0.0843] |
| Data/restraints/parameters | 4762/0/271 |
| Goodness-of-fit on F$^2$ | 1.057 |
| Final R indexes [I>=2σ (I)] | $R_1$ = 0.0656, w$R_2$ = 0.1955 |
| Final R indexes [all data] | $R_1$ = 0.0732, w$R_2$ = 0.2041 |
| Largest diff. peak/hole / e Å$^{-3}$ | 0.58/-0.47 |

## HPLC traces

### Metacyclophanes 3a

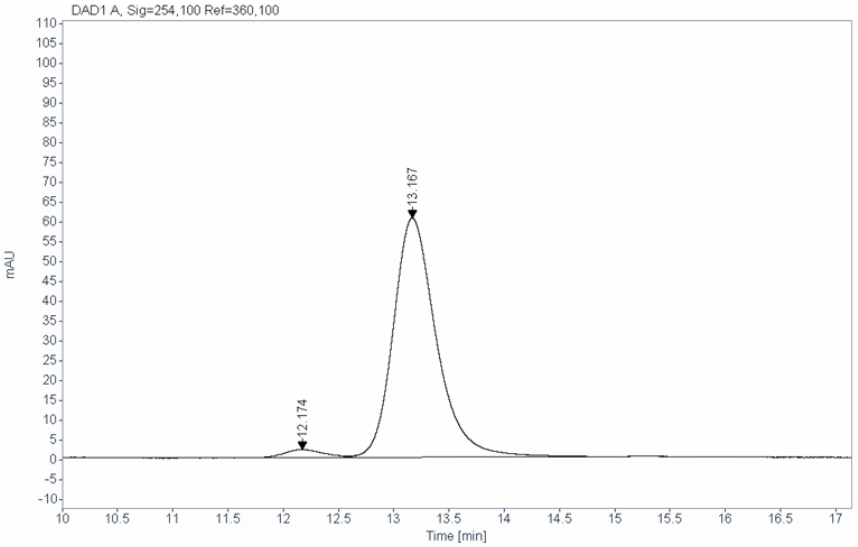



Chiral HPLC spectrum of *rac*-**3a**



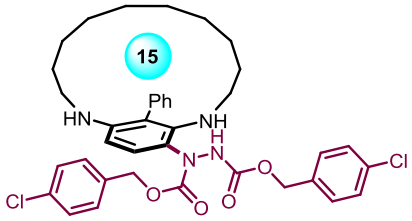

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 11.907 | 0.4035 | 3449.3264 | 142.4593 | 49.1289 |
| 12.876 | 0.4387 | 3571.6472 | 135.6884 | 50.8711 |

Chiral HPLC spectrum of **3a**

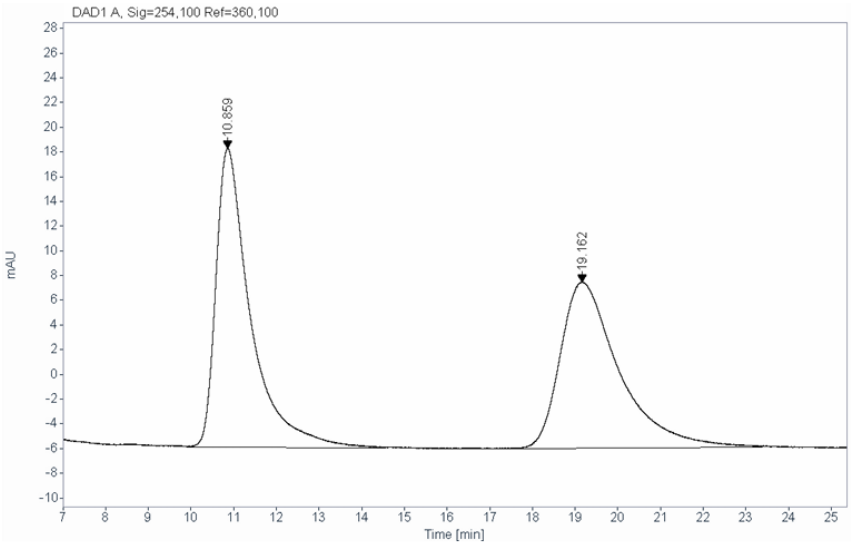



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 12.174 | 0.3040 | 51.5702 | 2.0393 | 3.0533 |
| 13.167 | 0.4041 | 1637.4069 | 60.4380 | 96.9467 |

**Metacyclophanes 3b**

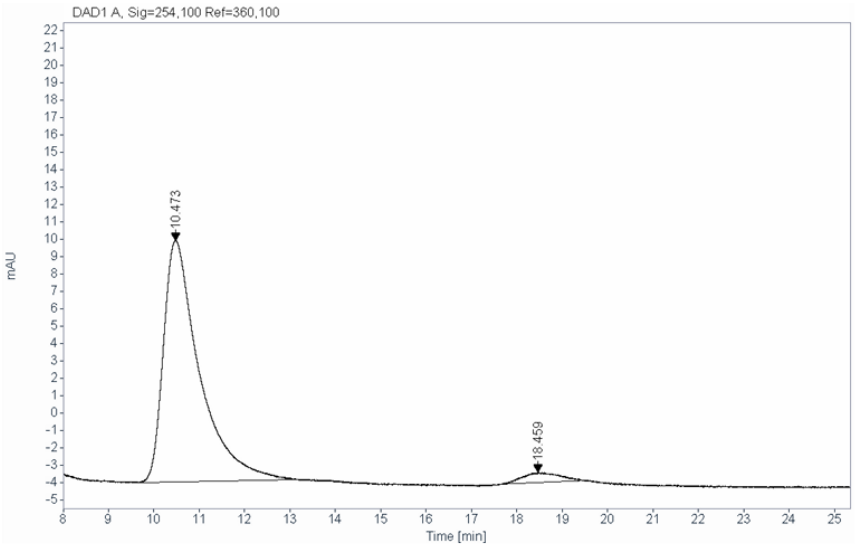



Chiral HPLC spectrum of *rac*-**3b**



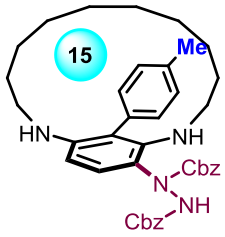

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.859 | 0.7974 | 1353.0159 | 24.1583 | 51.3009 |
| 19.162 | 1.1269 | 1284.3962 | 13.4406 | 48.6991 |

Chiral HPLC spectrum of **3b**

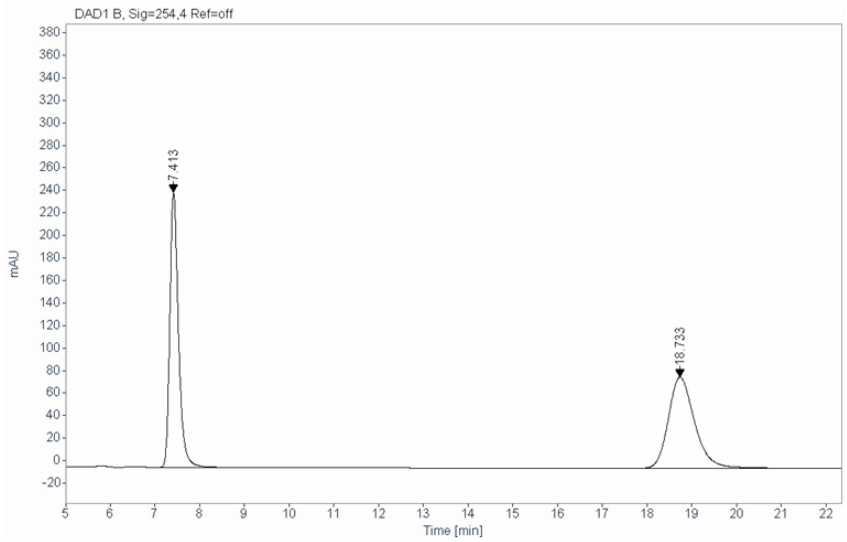



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.473 | 0.6654 | 766.9416 | 13.9076 | 96.2381 |
| 18.459 | 0.9127 | 29.9794 | 0.5474 | 3.7619 |

**Metacyclophanes 3c**

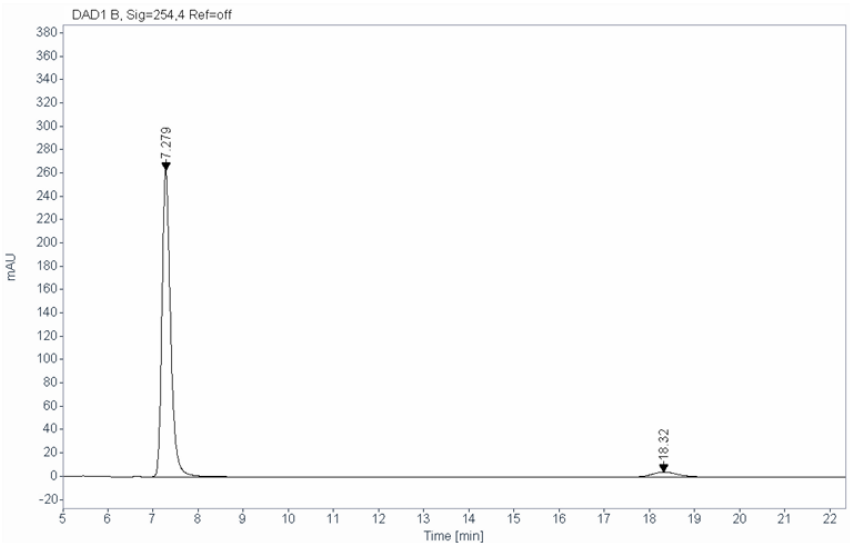



Chiral HPLC spectrum of *rac*-**3c**



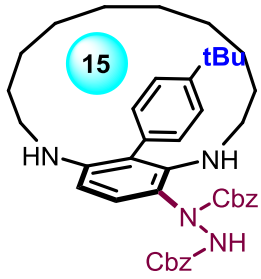

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 7.413 | 0.2047 | 3278.8667 | 244.1093 | 49.9322 |
| 18.733 | 0.6266 | 3287.7776 | 80.8259 | 50.0678 |

Chiral HPLC spectrum of **3c**

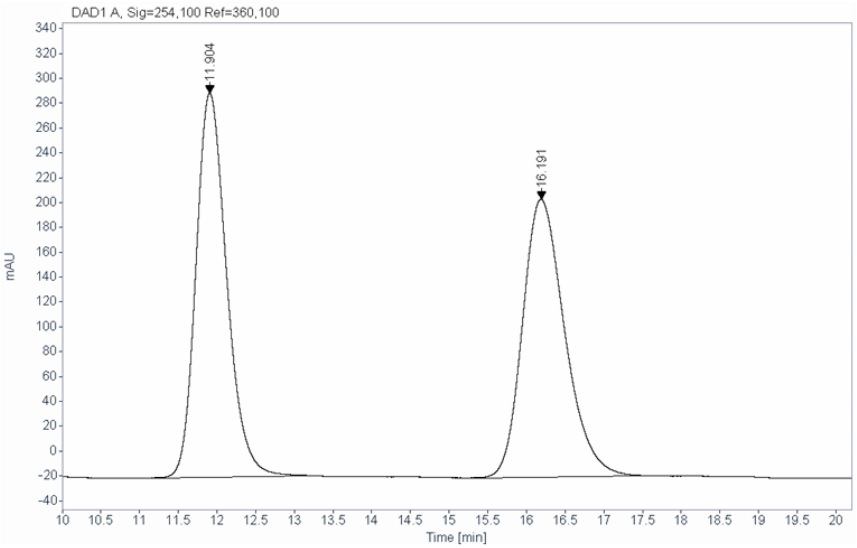



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 7.279 | 0.2010 | 3492.6609 | 262.8201 | 95.4477 |
| 18.320 | 0.5181 | 166.5793 | 4.2801 | 4.5523 |

**Metacyclophanes 3d**

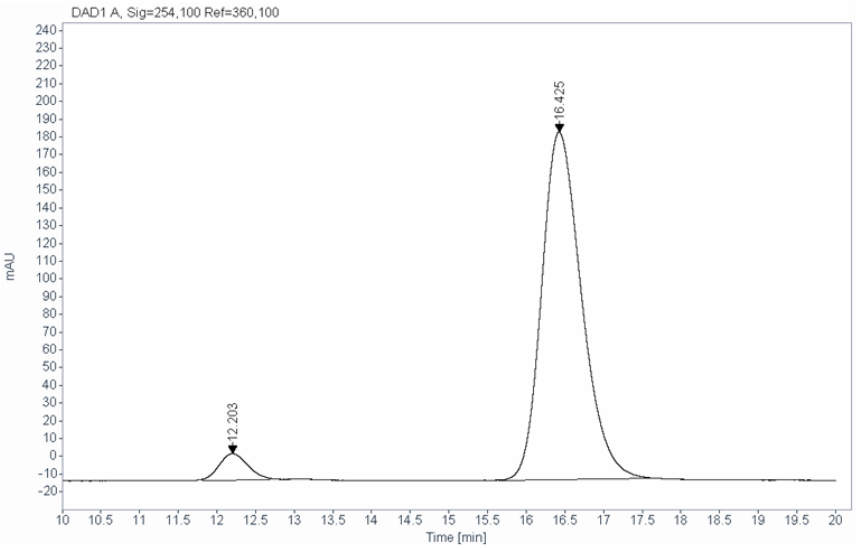



Chiral HPLC spectrum of *rac*-**3d**



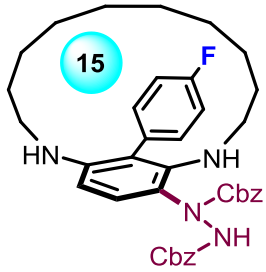

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 11.904 | 0.3265 | 8520.4688 | 309.1951 | 50.2354 |
| 16.191 | 0.4436 | 8440.6162 | 223.4819 | 49.7646 |

Chiral HPLC spectrum of **3d**

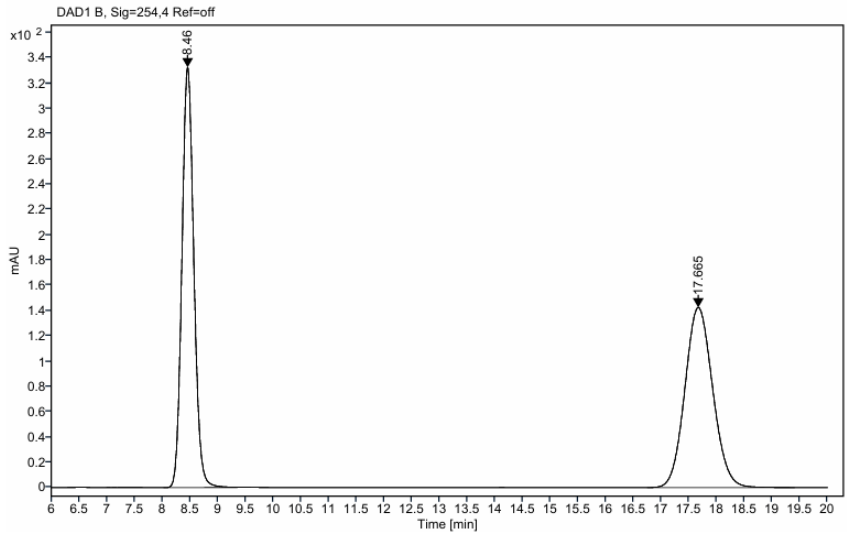



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 12.203 | 0.4239 | 377.8768 | 14.8566 | 5.1185 |
| 16.425 | 0.4199 | 7004.6348 | 195.7961 | 94.8815 |

**Metacyclophanes 3e**

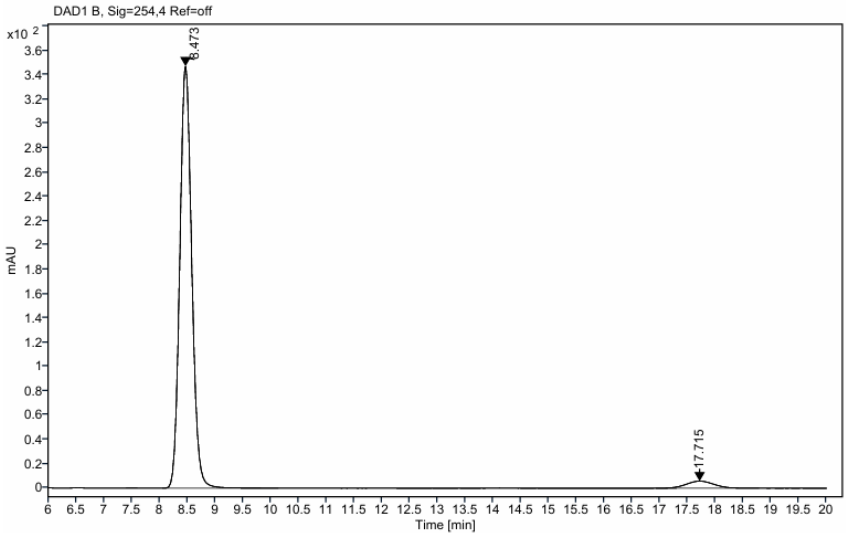



Chiral HPLC spectrum of *rac*-**3e**



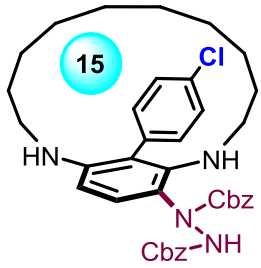

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.460 | 0.2325 | 4972.7520 | 332.4079 | 50.0154 |
| 17.665 | 0.5409 | 4969.6841 | 142.4897 | 49.9846 |

Chiral HPLC spectrum of **3e**

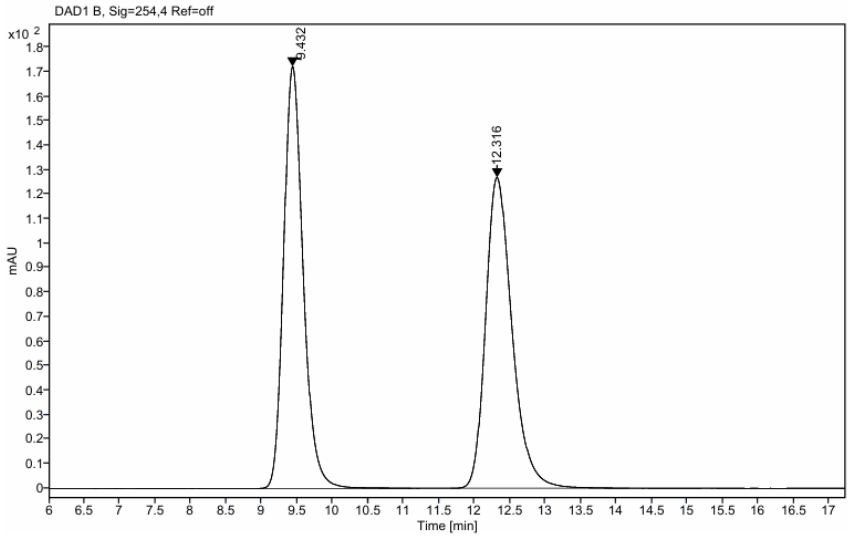



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.473 | 0.2308 | 5200.4927 | 347.1692 | 96.1957 |
| 17.715 | 0.5132 | 205.6664 | 5.8632 | 3.8043 |

**Metacyclophanes 3f**

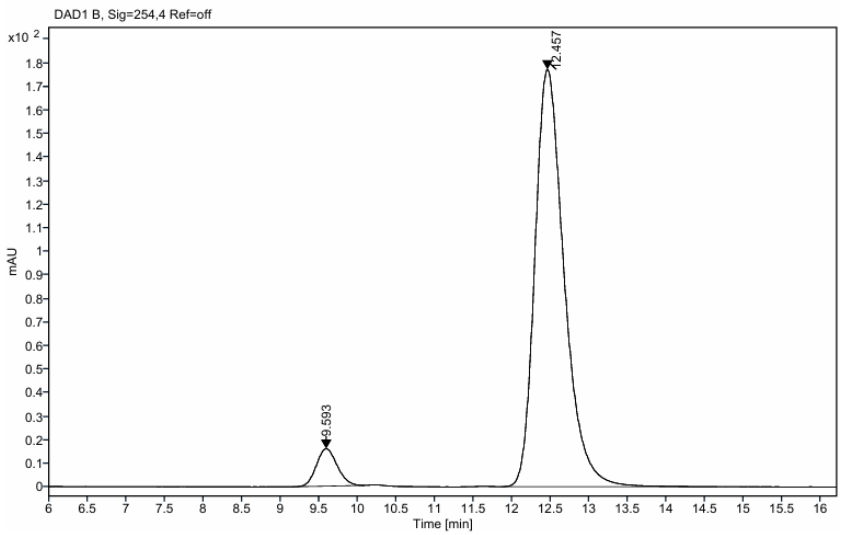



Chiral HPLC spectrum of *rac*-**3f**



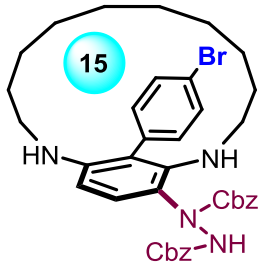

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 9.432 | 0.2939 | 3305.6104 | 172.2102 | 50.0827 |
| 12.316 | 0.3970 | 3294.6946 | 126.8561 | 49.9173 |

Chiral HPLC spectrum of **3f**

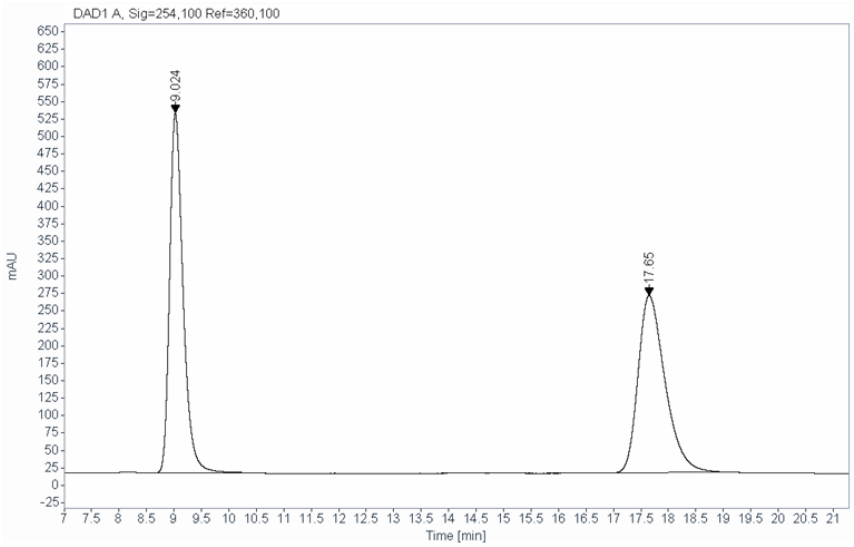



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 9.593 | 0.2929 | 297.7907 | 15.8747 | 6.0076 |
| 12.457 | 0.4010 | 4659.1094 | 177.0538 | 93.9924 |

**Metacyclophanes 3g**

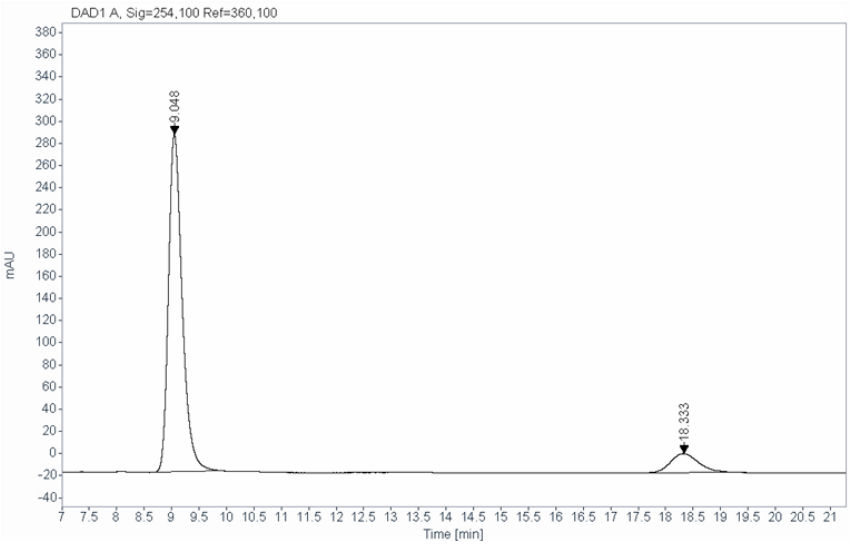



Chiral HPLC spectrum of *rac*-**3g**



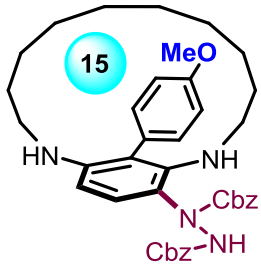

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 9.024 | 0.2101 | 8799.5752 | 516.8346 | 50.4360 |
| 17.650 | 0.4005 | 8647.4502 | 253.8306 | 49.5640 |

Chiral HPLC spectrum of **3g**

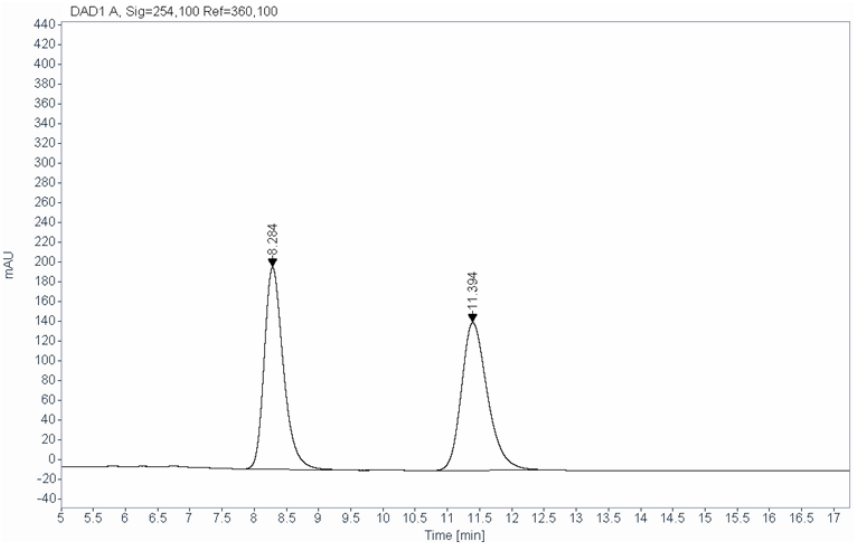



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 9.048 | 0.2272 | 5296.2275 | 305.5137 | 89.7823 |
| 18.333 | 0.4153 | 602.7365 | 17.0753 | 10.2177 |

**Metacyclophanes 3h**

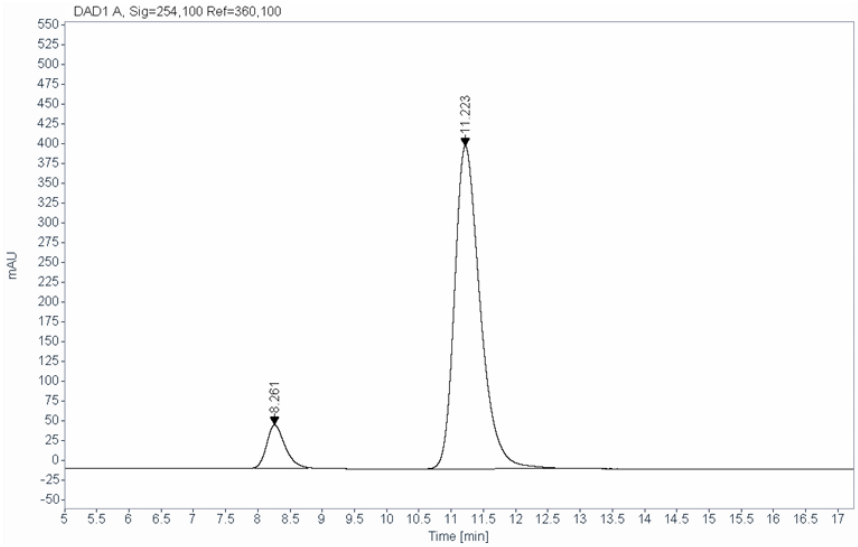



Chiral HPLC spectrum of *rac*-**3h**



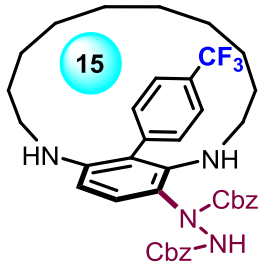

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.284 | 0.2459 | 4210.0132 | 205.1597 | 49.9542 |
| 11.394 | 0.3396 | 4217.7378 | 149.9837 | 50.0458 |

Chiral HPLC spectrum of **3h**

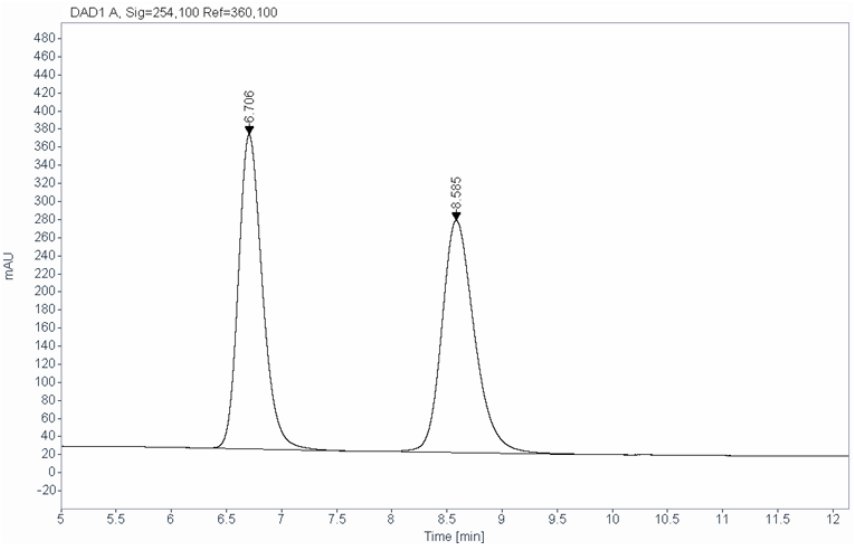



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.261 | 0.3273 | 1073.5323 | 54.6650 | 8.7086 |
| 11.223 | 0.3275 | 11253.7627 | 408.4196 | 91.2914 |

**Metacyclophanes 3i**

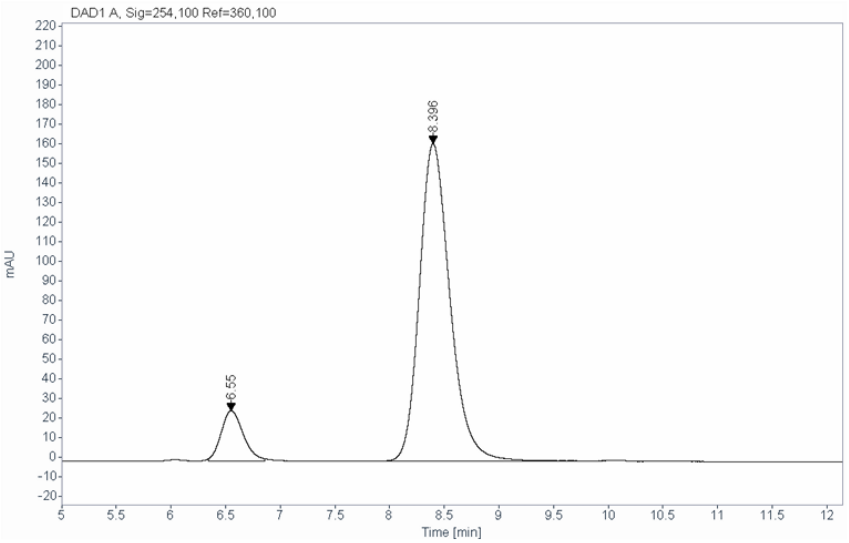



Chiral HPLC spectrum of *rac*-**3i**



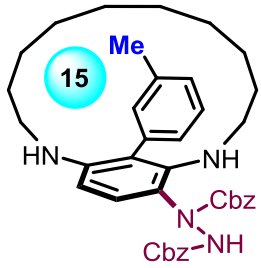

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 6.706 | 0.2152 | 5248.0200 | 347.5489 | 49.9052 |
| 8.585 | 0.2616 | 5267.9551 | 256.9937 | 50.0948 |

Chiral HPLC spectrum of **3i**

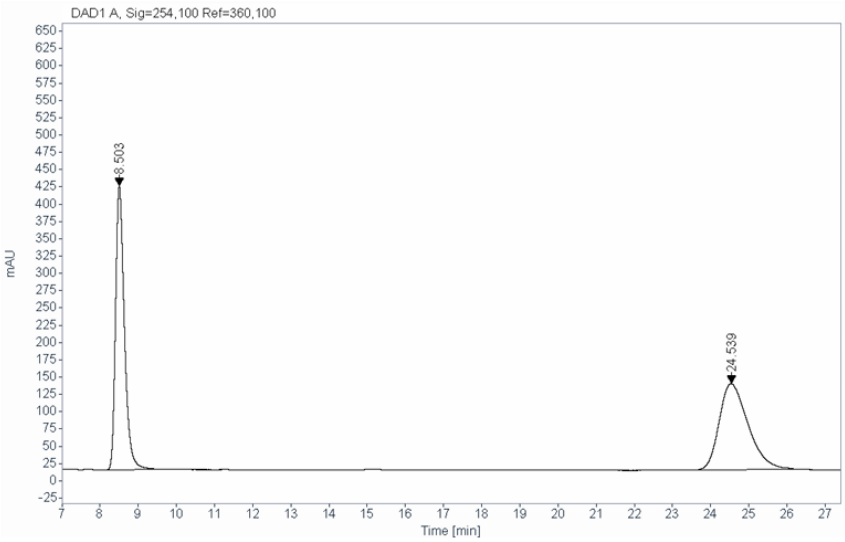



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 6.550 | 0.2335 | 360.8478 | 25.7563 | 10.2445 |
| 8.396 | 0.3245 | 3161.5188 | 162.3886 | 89.7555 |

**Metacyclophanes 3j**

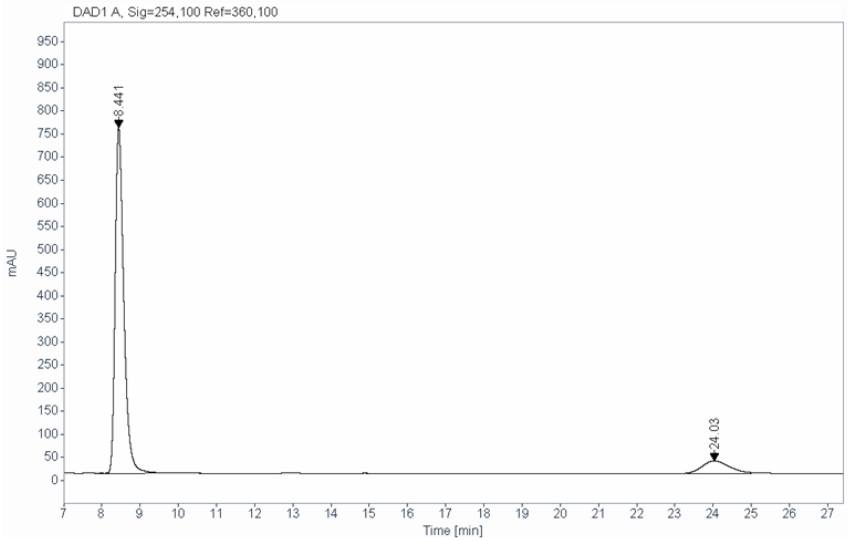



Chiral HPLC spectrum of *rac*-**3j**



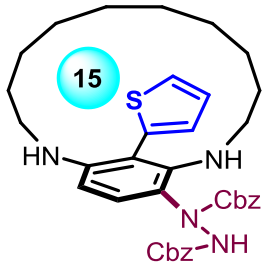

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.503 | 0.2420 | 6619.4463 | 410.8215 | 50.1305 |
| 24.539 | 0.6191 | 6584.9907 | 124.7032 | 49.8695 |

Chiral HPLC spectrum of **3j**

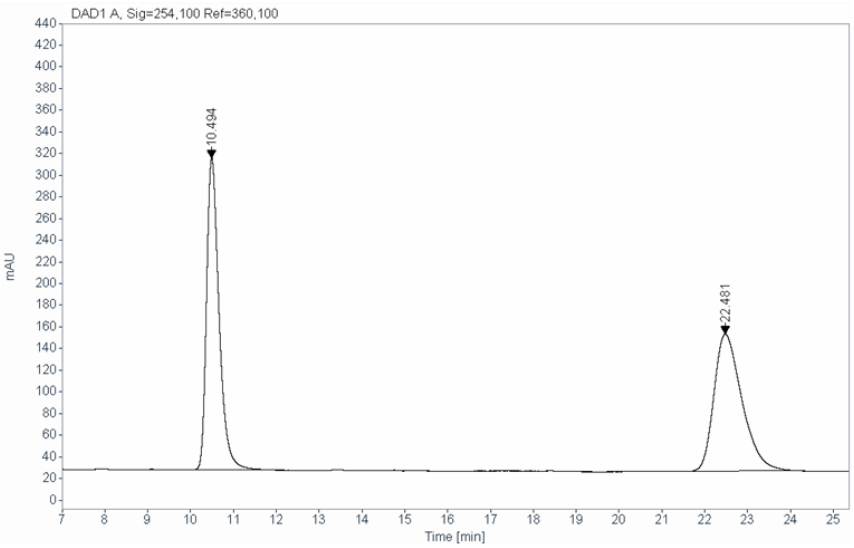



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.441 | 0.2399 | 11773.7012 | 747.1131 | 89.3309 |
| 24.030 | 0.8404 | 1406.1808 | 27.8886 | 10.6691 |

**Metacyclophanes 3k**

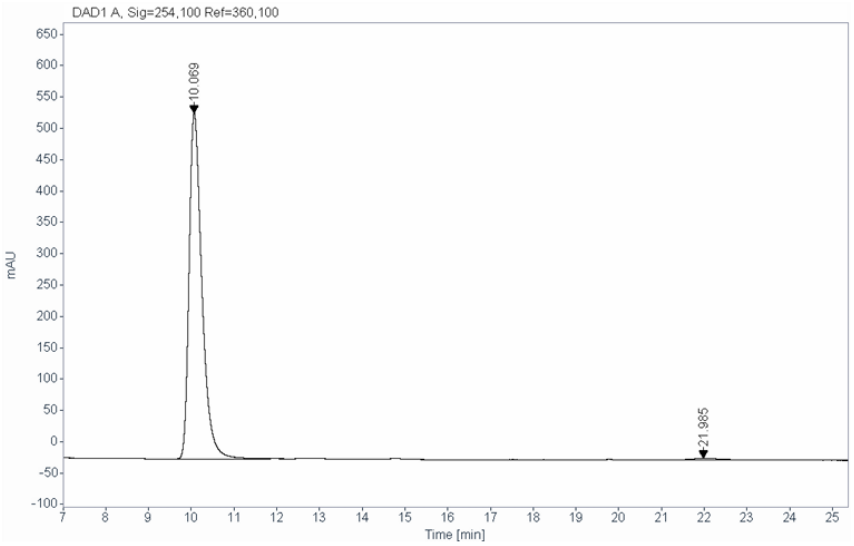



Chiral HPLC spectrum of *rac*-**3k**



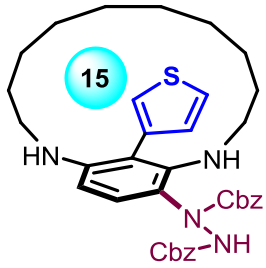

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.494 | 0.2531 | 5794.4956 | 287.5751 | 50.2897 |
| 22.481 | 0.5308 | 5727.7275 | 126.3762 | 49.7103 |

Chiral HPLC spectrum of **3k**

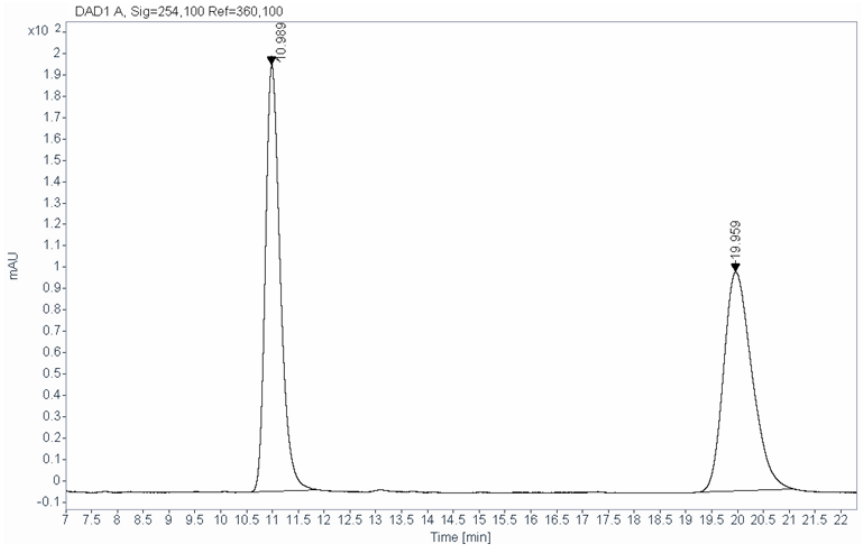



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.069 | 0.3478 | 11527.0400 | 552.3176 | 98.7740 |
| 21.985 | 0.8317 | 143.0754 | 2.8672 | 1.2260 |

**Metacyclophanes 3l**

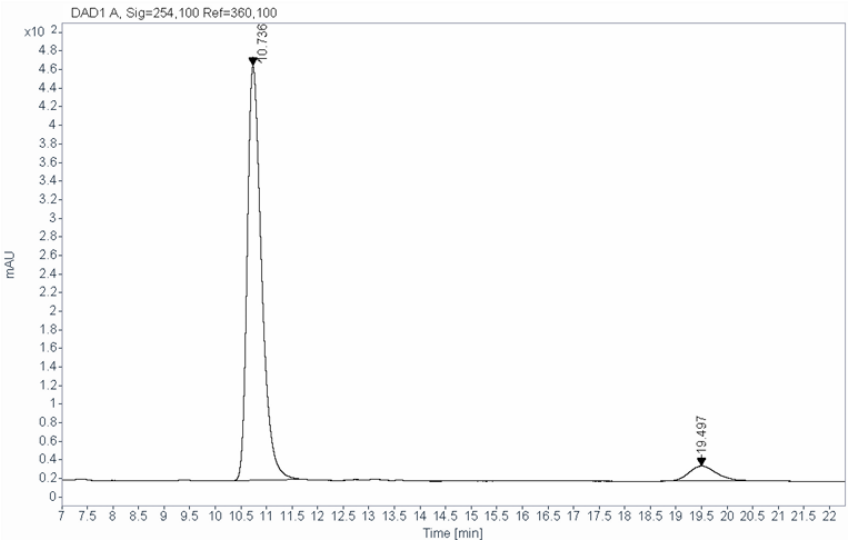



Chiral HPLC spectrum of *rac*-**3l**



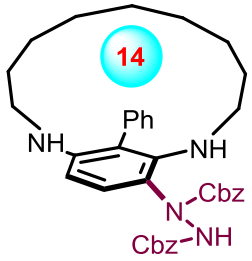

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.989 | 0.2526 | 3999.2754 | 199.7023 | 50.4760 |
| 19.959 | 0.4476 | 3923.8398 | 102.6243 | 49.5240 |

Chiral HPLC spectrum of **3l**

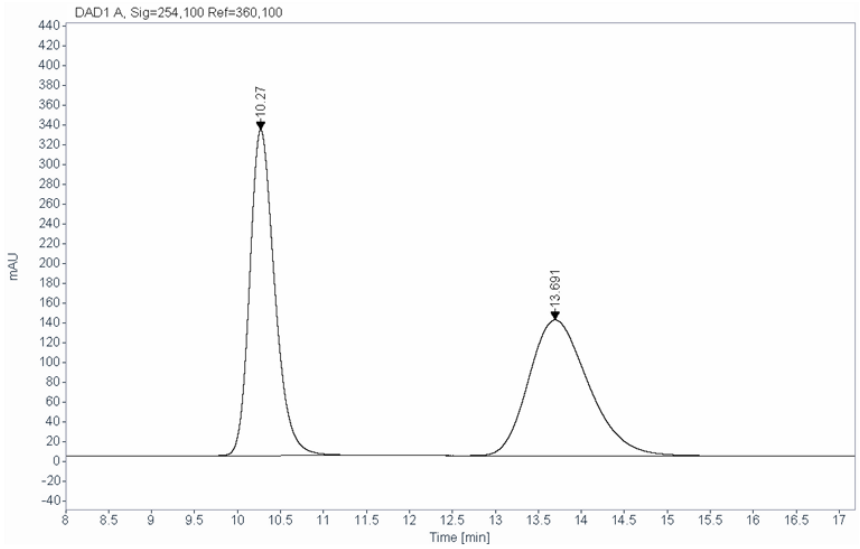



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.736 | 0.2299 | 8676.0830 | 446.0255 | 93.8215 |
| 19.497 | 0.4234 | 571.3498 | 15.7985 | 6.1785 |

**Metacyclophanes 3m**

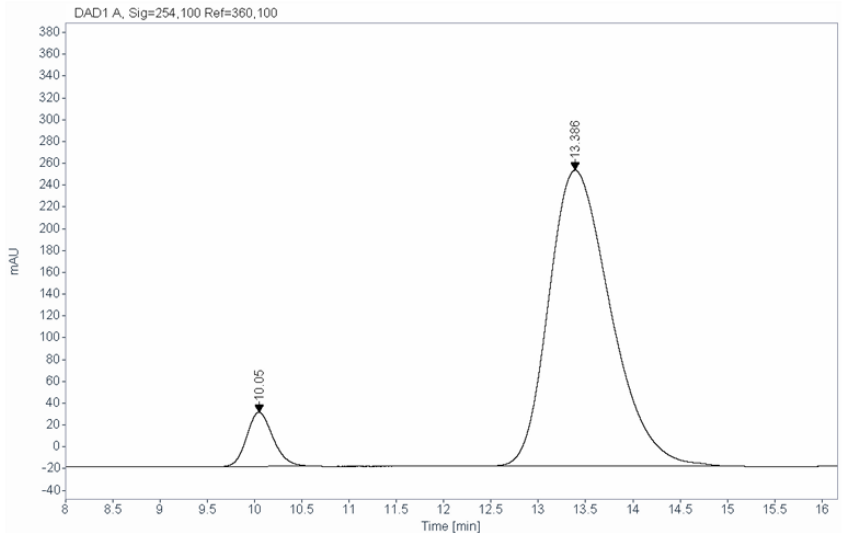



Chiral HPLC spectrum of *rac*-**3m**



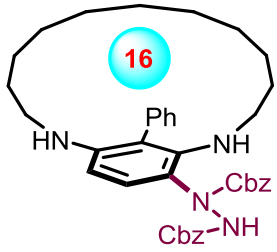

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.270 | 0.3003 | 6640.4873 | 329.9007 | 50.1458 |
| 13.691 | 0.5722 | 6601.8784 | 137.2400 | 49.8542 |

Chiral HPLC spectrum of **3m**

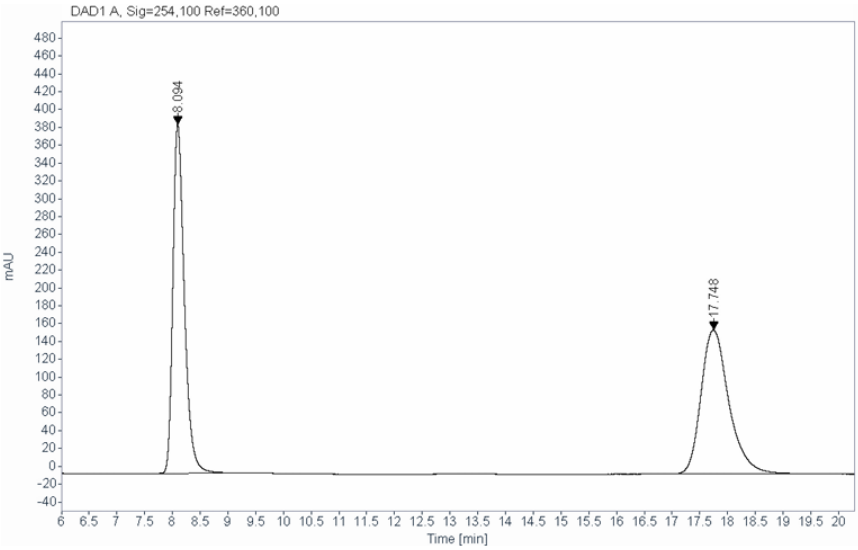



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.050 | 0.2366 | 966.8636 | 49.8798 | 7.2913 |
| 13.386 | 0.5312 | 12293.6260 | 271.2996 | 92.7087 |

**Metacyclophanes 3n**

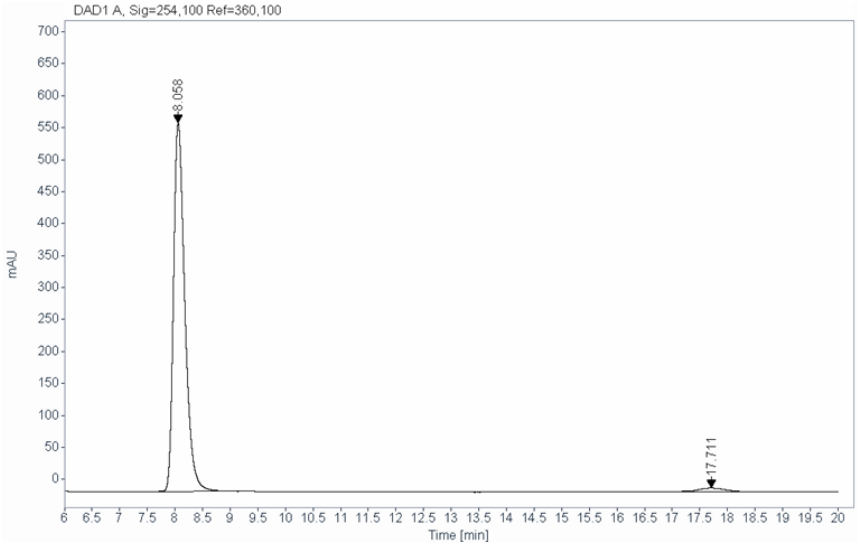



Chiral HPLC spectrum of *rac*-**3n**



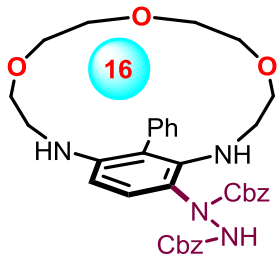

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.094 | 0.2076 | 5604.5791 | 391.2414 | 49.9956 |
| 17.748 | 0.4075 | 5605.5688 | 161.2935 | 50.0044 |

Chiral HPLC spectrum of **3n**

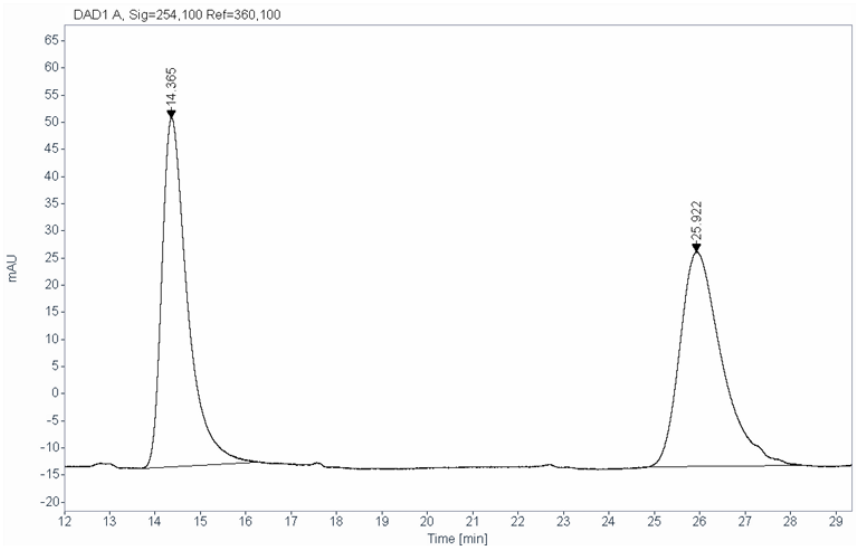



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.058 | 0.1925 | 8208.8174 | 576.9684 | 97.5526 |
| 17.711 | 0.4187 | 205.9443 | 5.8073 | 2.4474 |

**Metacyclophanes 3o**

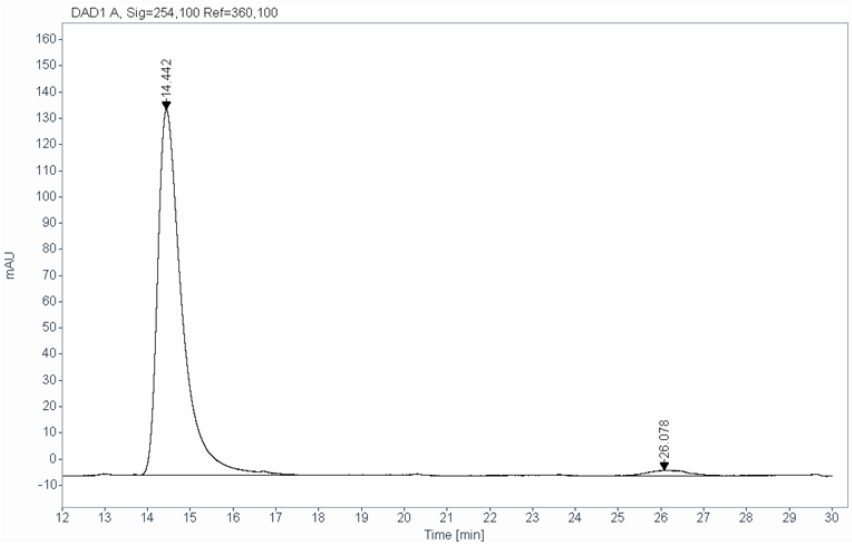



Chiral HPLC spectrum of *rac*-**3o**



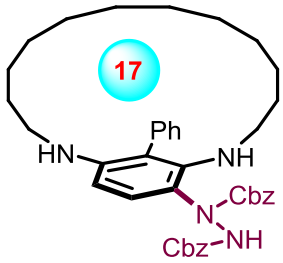

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 14.365 | 0.5412 | 2521.4146 | 64.3432 | 49.7677 |
| 25.922 | 0.7543 | 2544.9529 | 39.5735 | 50.2323 |

Chiral HPLC spectrum of **3o**

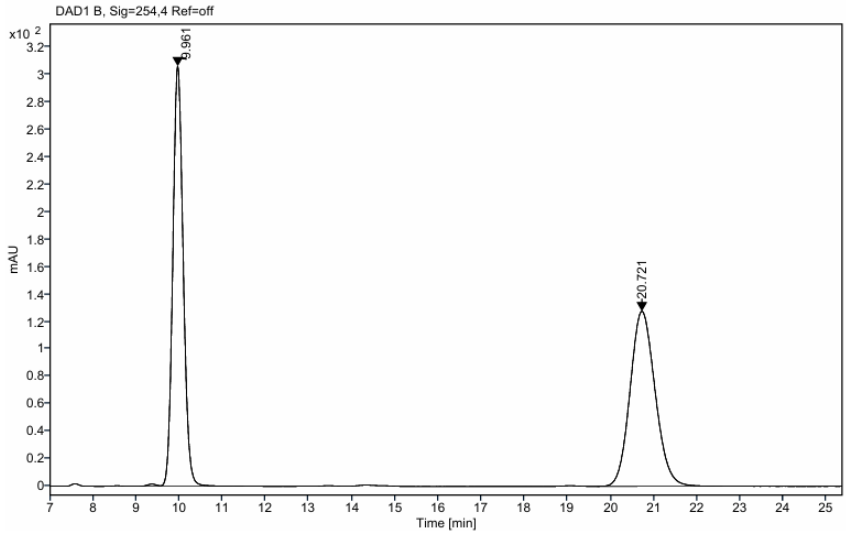



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 14.442 | 0.5807 | 5511.4536 | 139.5659 | 97.4557 |
| 26.078 | 0.8060 | 143.8878 | 2.1357 | 2.5443 |

**Metacyclophanes 3p**

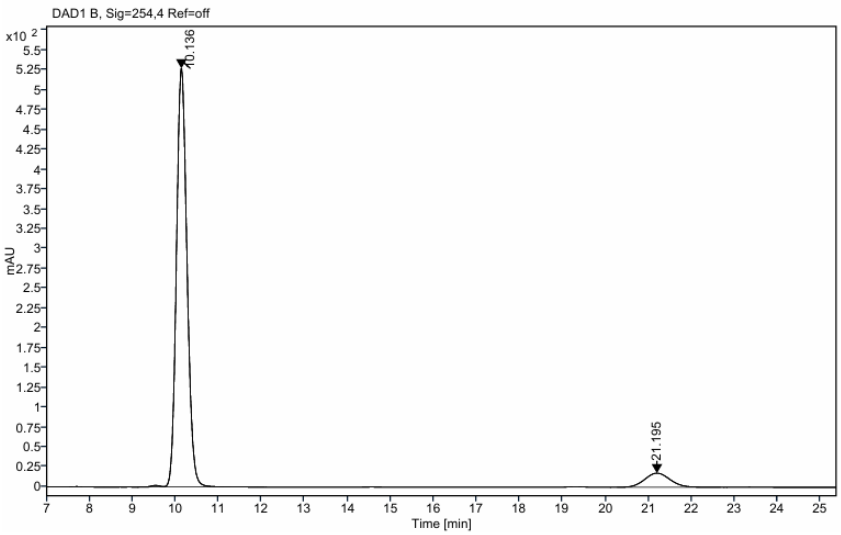



Chiral HPLC spectrum of *rac*-**3p**



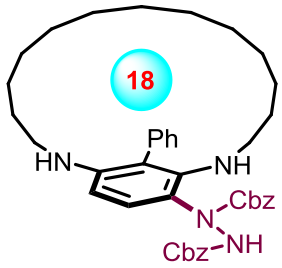

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 9.961 | 0.2615 | 5153.6362 | 306.2105 | 49.9776 |
| 20.721 | 0.6295 | 5158.2539 | 127.6317 | 50.0224 |

Chiral HPLC spectrum of **3p**

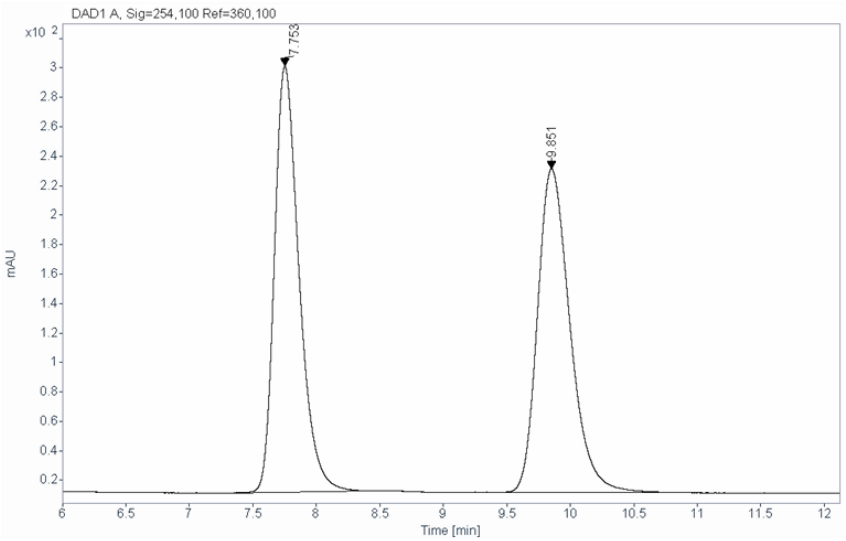



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.136 | 0.2648 | 9020.6709 | 527.4586 | 92.4437 |
| 21.195 | 0.6105 | 737.3474 | 17.8281 | 7.5563 |

**Metacyclophanes 3q**

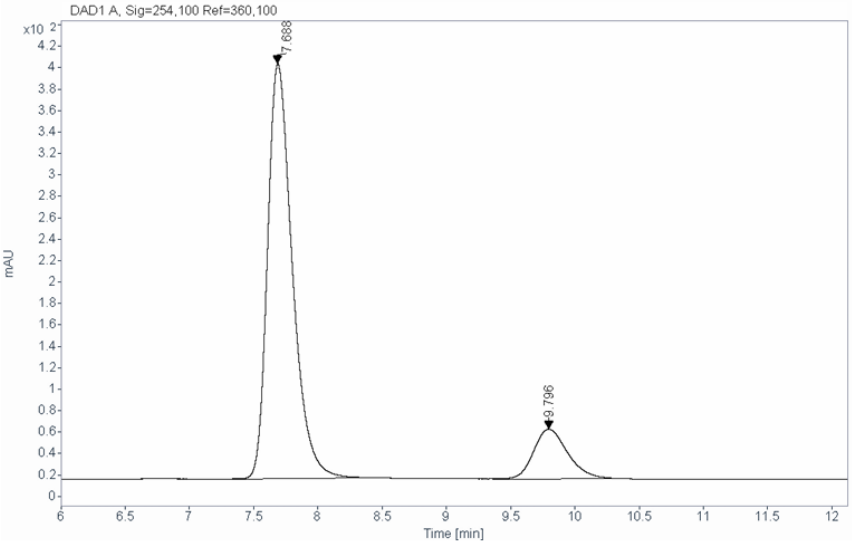



Chiral HPLC spectrum of *rac*-**3q**



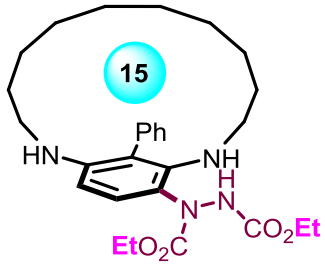

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 7.753 | 0.1864 | 3901.2979 | 289.1795 | 50.0028 |
| 9.851 | 0.2305 | 3900.8655 | 219.8122 | 49.9972 |

Chiral HPLC spectrum of **3q**

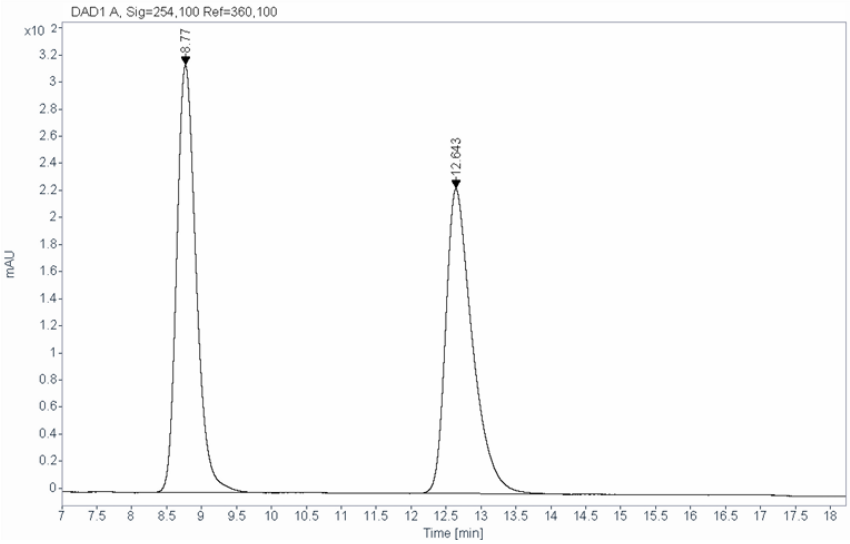



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 7.688 | 0.1791 | 5178.3091 | 387.0857 | 85.7742 |
| 9.796 | 0.2178 | 858.8307 | 46.4332 | 14.2258 |

**Metacyclophanes 3ac**

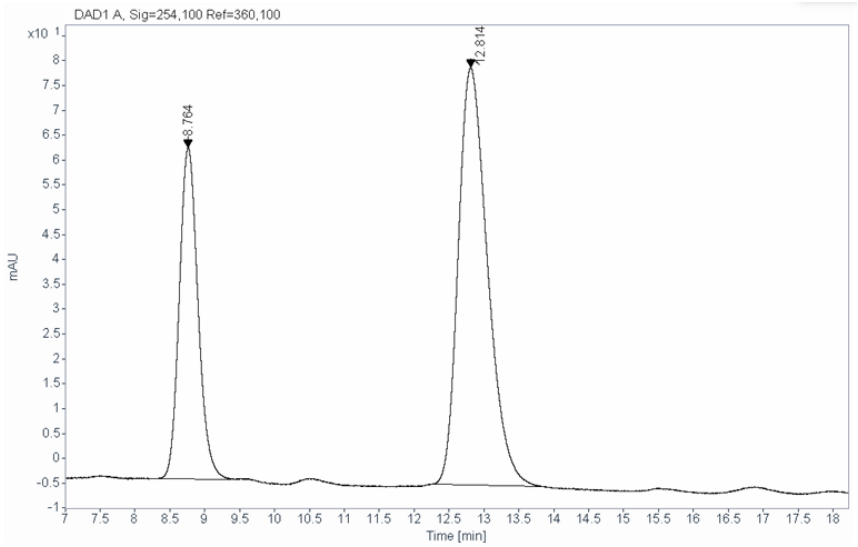



Chiral HPLC spectrum of *rac*-**3ac**



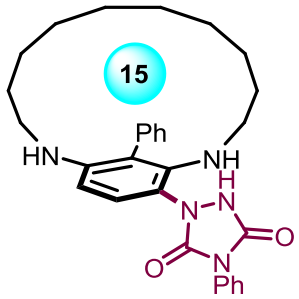

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.770 | 0.2421 | 6094.5415 | 315.8858 | 50.6750 |
| 12.643 | 0.3192 | 5932.1792 | 225.3058 | 49.3250 |

Chiral HPLC spectrum of **3ac**

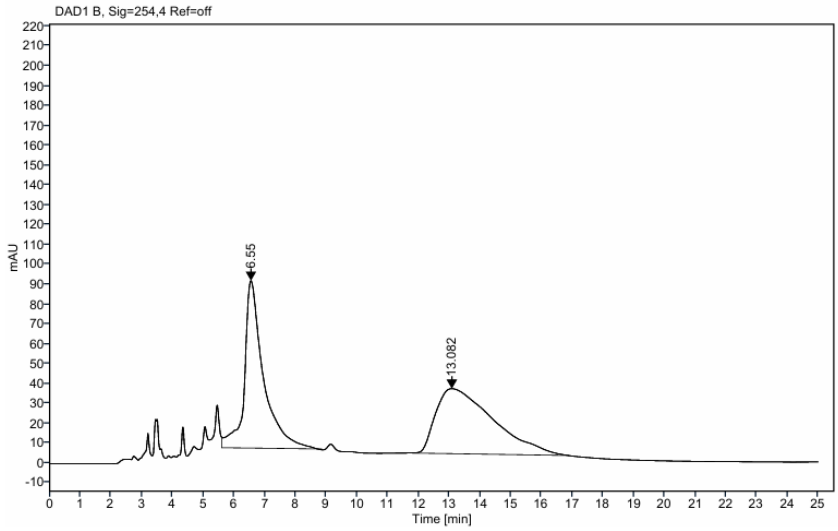



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.764 | 0.2192 | 1238.9028 | 66.7003 | 33.6183 |
| 12.814 | 0.3416 | 2446.2964 | 83.9072 | 66.3817 |

**Metacyclophanes 3ae**

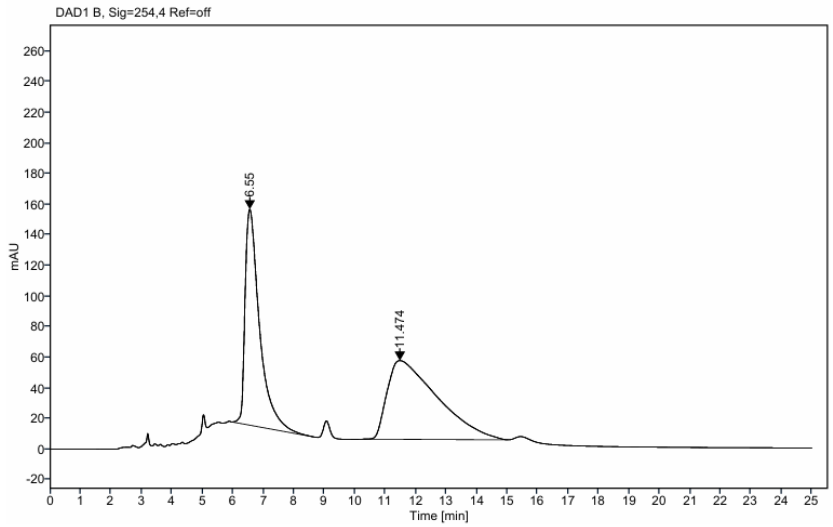



Chiral HPLC spectrum of *rac*-**3ae**



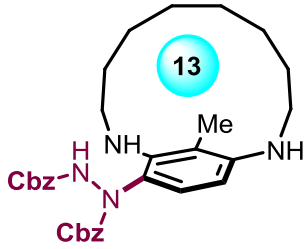

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 6.550 | 0.7185 | 3635.3884 | 84.3273 | 46.1854 |
| 13.082 | 2.1551 | 4235.9072 | 32.7581 | 53.8146 |

Chiral HPLC spectrum of **3ae**

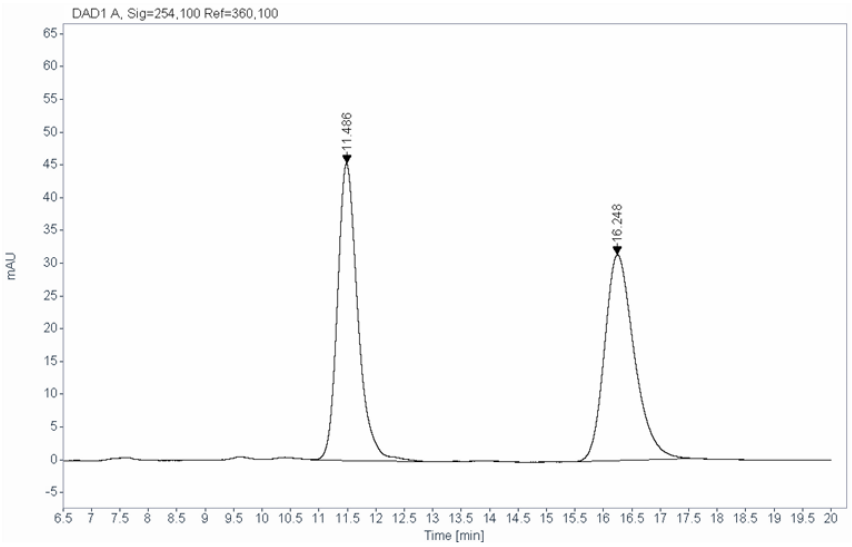



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 6.550 | 0.4924 | 4649.0972 | 141.0896 | 44.1243 |
| 11.474 | 1.5559 | 5887.2593 | 51.4150 | 55.8757 |

**Metacyclophanes 5a**

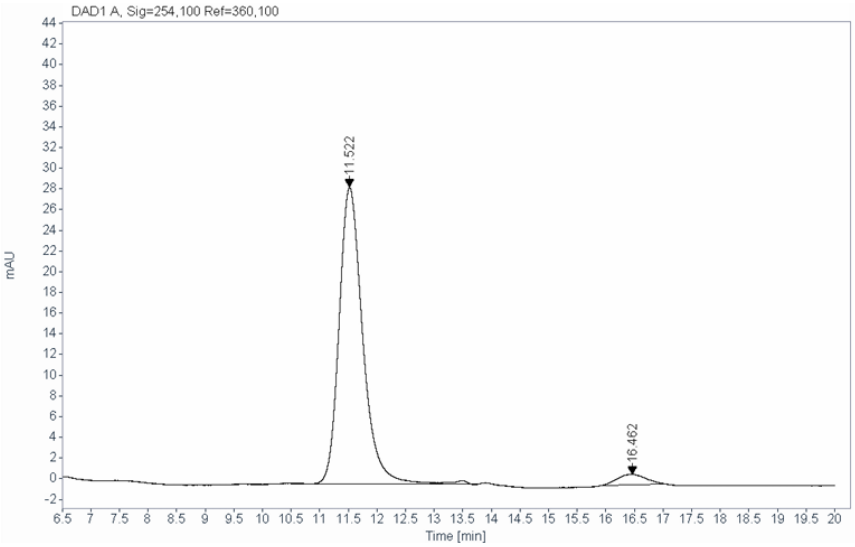



Chiral HPLC spectrum of *rac*-**5a**



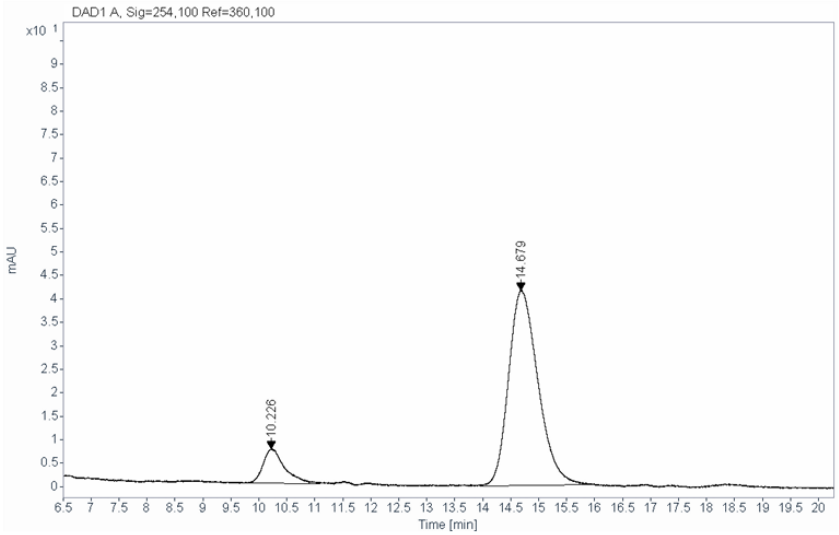

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 11.486 | 0.3561 | 1122.6080 | 45.2969 | 49.6766 |
| 16.248 | 0.4281 | 1137.2250 | 31.3930 | 50.3234 |

Chiral HPLC spectrum of **5a**



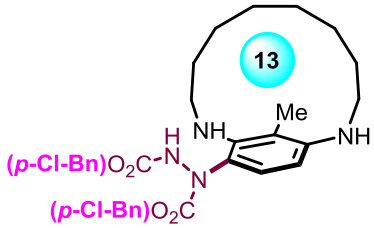

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 11.522 | 0.4827 | 831.1368 | 28.7004 | 95.8678 |
| 16.462 | 0.5780 | 35.8248 | 1.0330 | 4.1322 |

Chiral HPLC spectrum of *ent*-**5a**

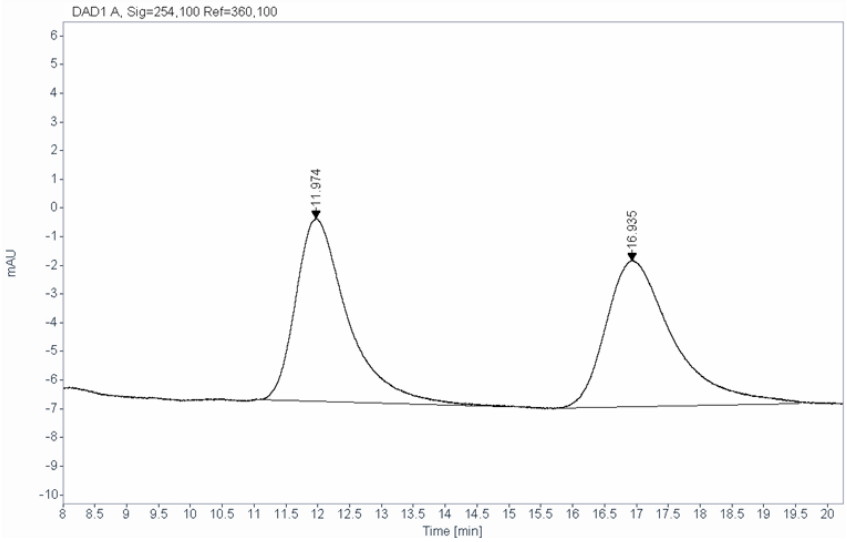



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.226 | 0.3151 | 193.2676 | 7.2722 | 11.2567 |
| 14.679 | 0.4527 | 1523.6492 | 41.5639 | 88.7433 |

**Metacyclophanes 5b**

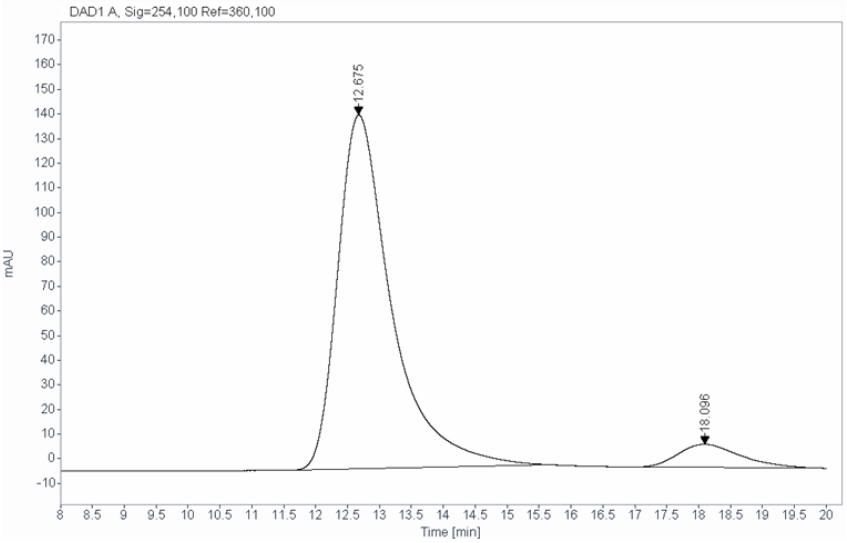



Chiral HPLC spectrum of *rac*-**5b**



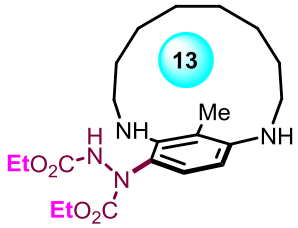

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 11.974 | 0.7644 | 362.7295 | 6.3693 | 49.3555 |
| 16.935 | 1.2174 | 372.2025 | 5.0955 | 50.6445 |

Chiral HPLC spectrum of **5b**

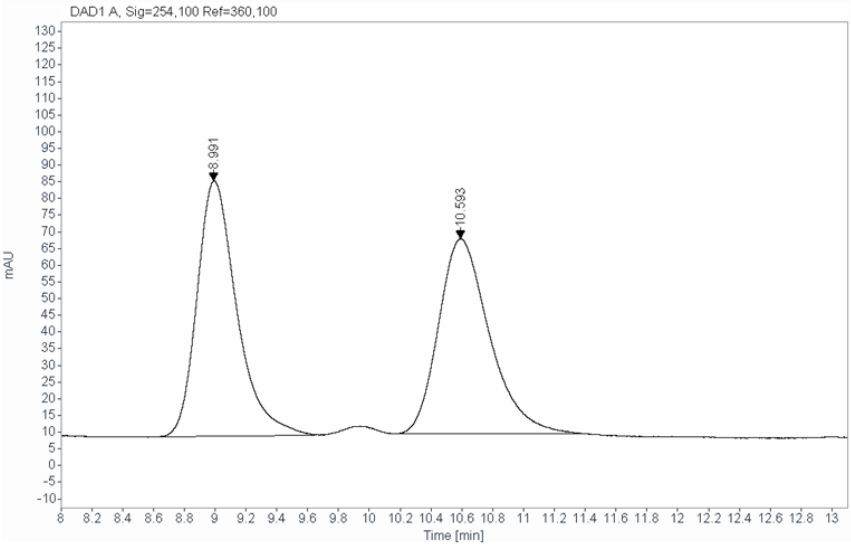



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 12.675 | 0.6900 | 8424.8828 | 143.6964 | 93.1610 |
| 18.096 | 0.7785 | 618.4733 | 9.2919 | 6.8390 |

**Metacyclophanes 5c**

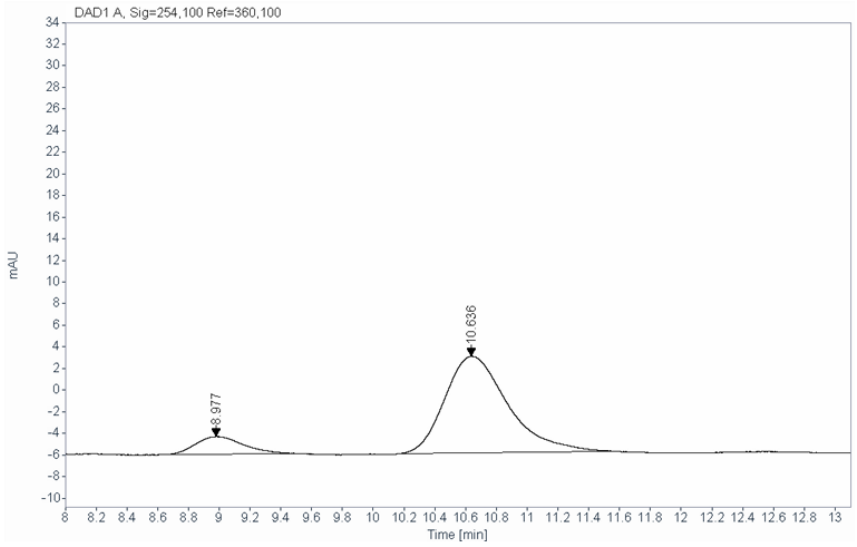



Chiral HPLC spectrum of *rac*-**5c**



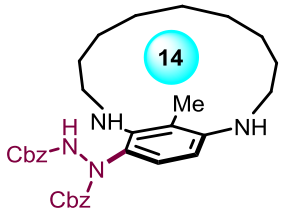

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.991 | 0.2113 | 1375.2261 | 76.6646 | 50.5139 |
| 10.593 | 0.2703 | 1347.2440 | 58.4728 | 49.4861 |

Chiral HPLC spectrum of **5c**

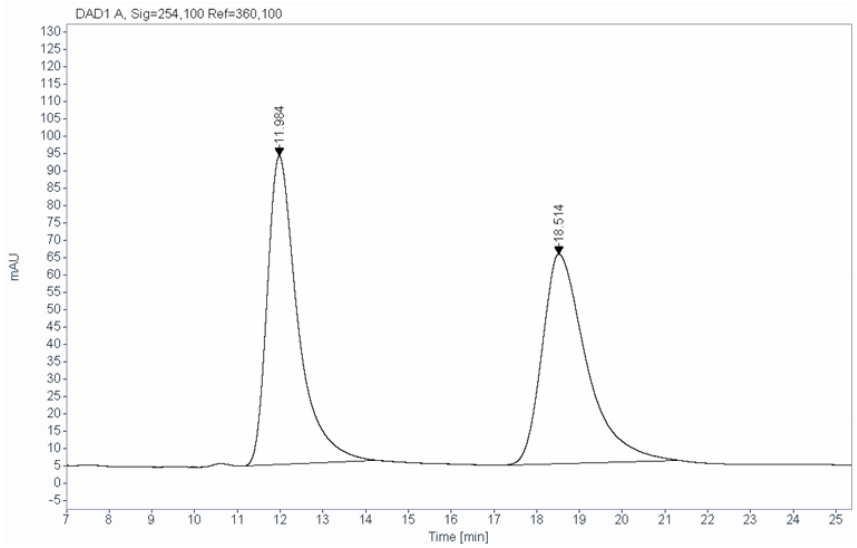



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 8.977 | 0.2527 | 35.3554 | 1.6419 | 12.2178 |
| 10.636 | 0.3330 | 254.0205 | 8.9412 | 87.7822 |

**Metacyclophanes 5d**

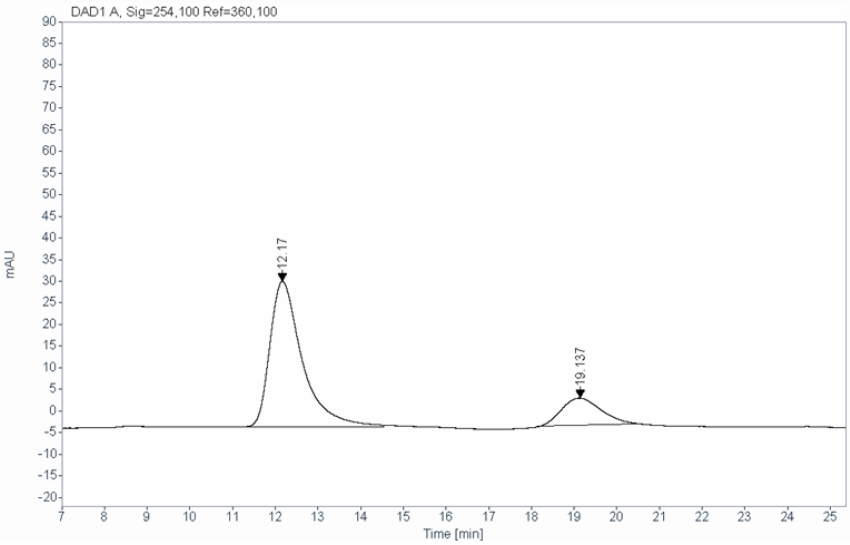



Chiral HPLC spectrum of *rac*-**5d**



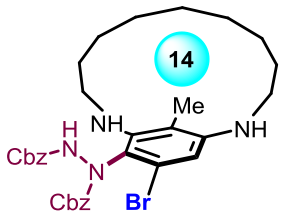

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 11.984 | 0.5840 | 4395.9014 | 88.9633 | 50.3960 |
| 18.514 | 0.8383 | 4326.8091 | 60.3278 | 49.6040 |

Chiral HPLC spectrum of **5d**

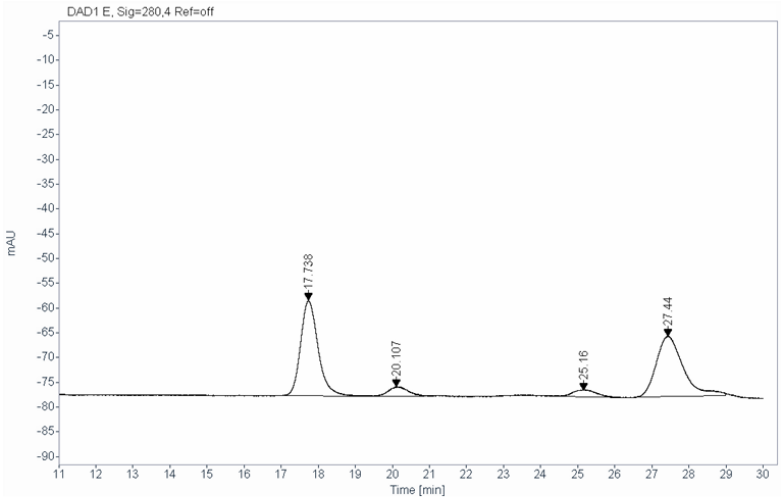



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 12.170 | 0.8777 | 1770.3427 | 33.6159 | 81.3892 |
| 19.137 | 1.0765 | 404.8153 | 6.2675 | 18.6108 |

**Metacyclophanes 5e**

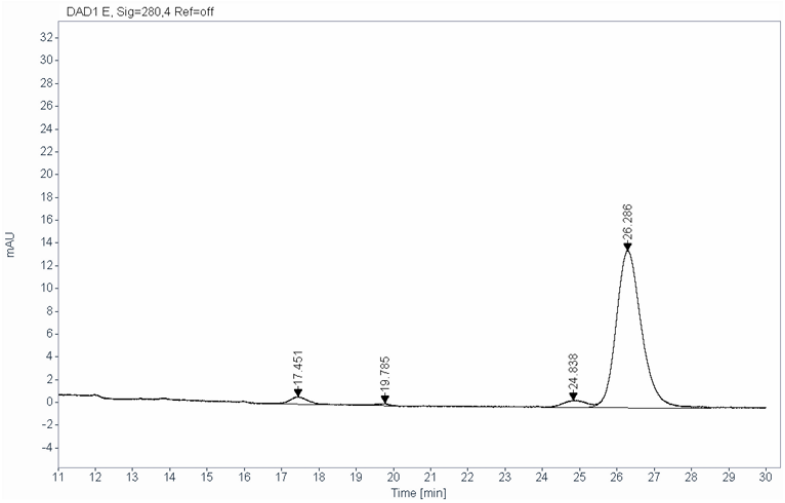



Chiral HPLC spectrum of *rac*-**5e**



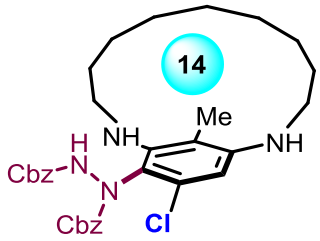

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 17.738 | 0.5056 | 635.5210 | 19.2293 | 45.6420 |
| 20.107 | 0.4546 | 71.8235 | 1.9103 | 5.1582 |
| 25.160 | 0.5722 | 68.1041 | 1.4388 | 4.8911 |
| 27.440 | 0.8447 | 616.9553 | 12.1724 | 44.3086 |

Chiral HPLC spectrum of **5e**

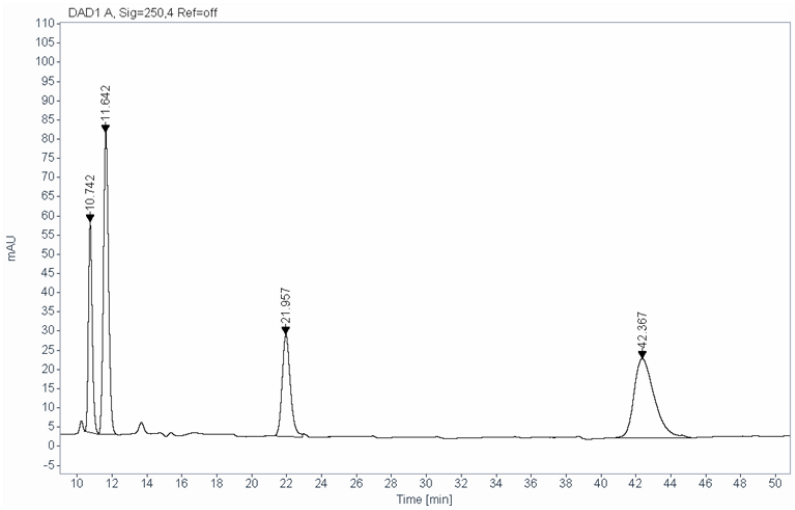



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 17.451 | 0.4389 | 24.0741 | 0.6548 | 3.4156 |
| 19.785 | 0.3897 | 3.6880 | 0.1908 | 0.5232 |
| 24.838 | 0.5208 | 27.9875 | 0.6343 | 3.9708 |
| 26.286 | 0.6872 | 649.0745 | 13.7877 | 92.0903 |

**Metacyclophanes 5f**

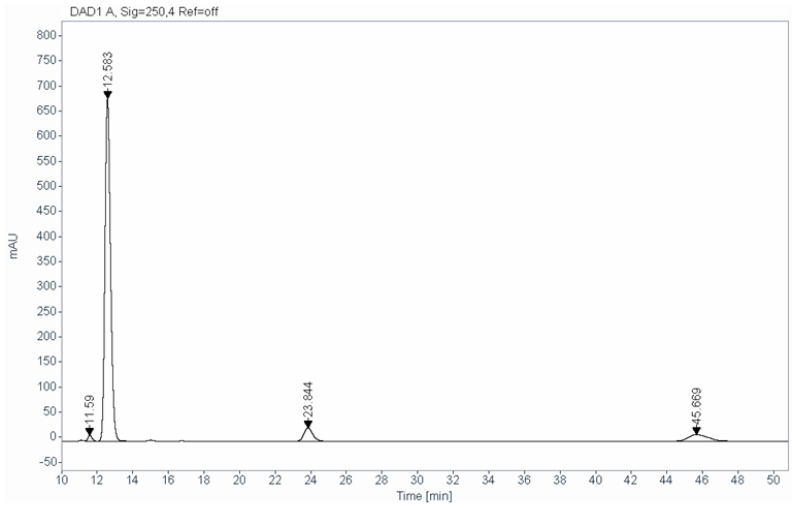



Chiral HPLC spectrum of *rac*-**5f**



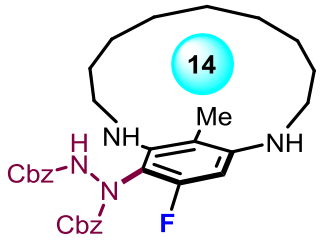

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.742 | 0.2521 | 829.1329 | 54.8156 | 16.7820 |
| 11.642 | 0.3347 | 1578.7542 | 78.6182 | 31.9547 |
| 21.957 | 0.5442 | 867.7822 | 26.5766 | 17.5643 |
| 42.367 | 1.2185 | 1664.9303 | 20.6101 | 33.6990 |

Chiral HPLC spectrum of **5f**

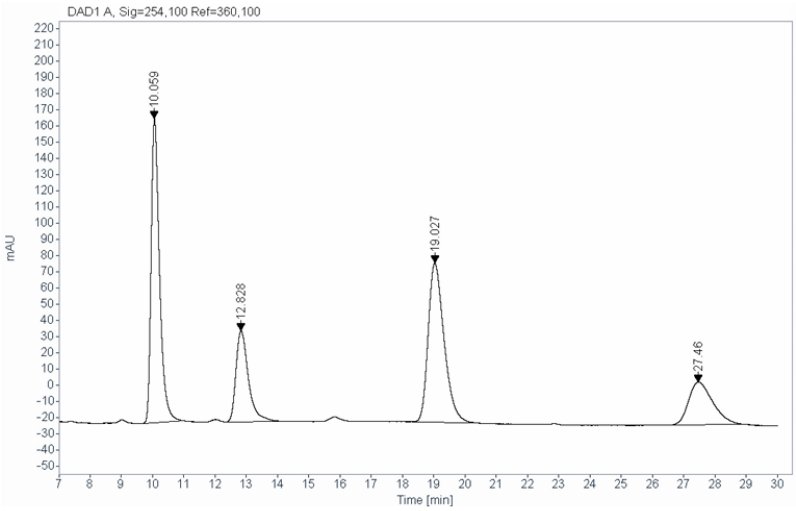



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 11.590 | 0.2679 | 194.0603 | 12.0751 | 1.1439 |
| 12.583 | 0.3372 | 14822.9795 | 682.9173 | 87.3720 |
| 23.844 | 0.5374 | 930.6942 | 26.6513 | 5.4858 |
| 45.669 | 0.9467 | 1017.6378 | 13.1523 | 5.9983 |

**Metacyclophanes 5g**

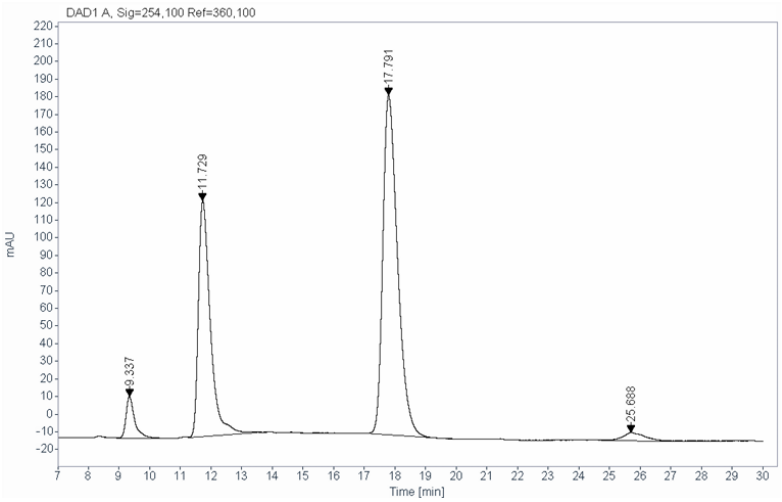



Chiral HPLC spectrum of *rac*-**5g**



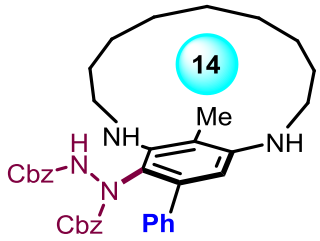

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.059 | 0.2626 | 3502.1770 | 187.7545 | 35.2659 |
| 12.828 | 0.3241 | 1552.9438 | 56.2411 | 15.6377 |
| 19.027 | 0.4127 | 3463.3335 | 98.3879 | 34.8748 |
| 27.460 | 0.6271 | 1412.3077 | 26.3580 | 14.2215 |

Chiral HPLC spectrum of **5g**

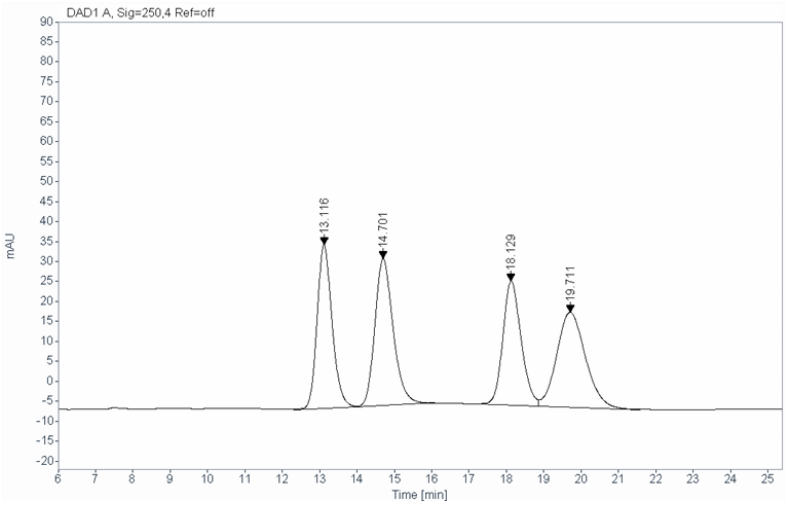



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 9.337 | 0.2903 | 463.9851 | 23.5034 | 4.3340 |
| 11.729 | 0.4061 | 3580.7393 | 133.8378 | 33.4467 |
| 17.791 | 0.5078 | 6440.1162 | 192.7327 | 60.1553 |
| 25.688 | 0.6155 | 220.9756 | 4.5750 | 2.0641 |

**Metacyclophanes 5h**

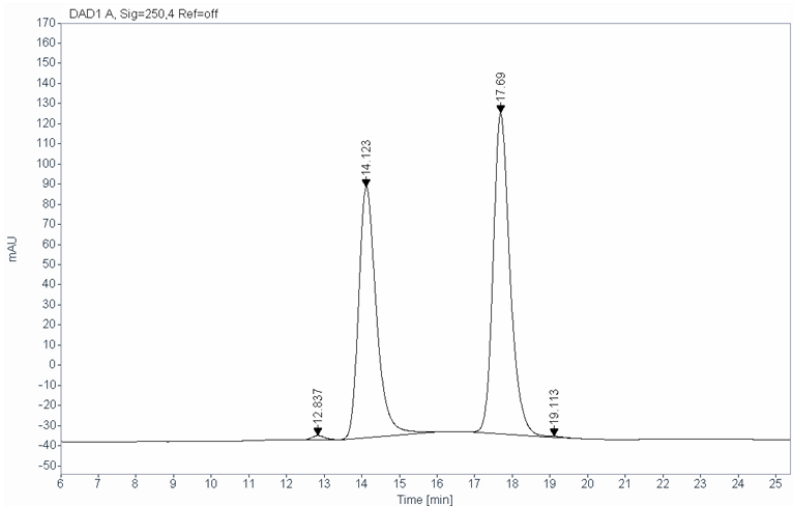



Chiral HPLC spectrum of *rac*-**5h**



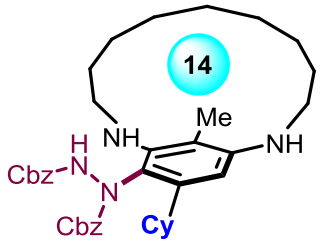

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 13.116 | 0.4668 | 1152.0011 | 41.1290 | 24.2786 |
| 14.701 | 0.5679 | 1256.0505 | 36.8604 | 26.4715 |
| 18.129 | 0.5703 | 1065.6919 | 31.1424 | 22.4596 |
| 19.711 | 0.8916 | 1271.1785 | 23.7617 | 26.7903 |

Chiral HPLC spectrum of **5h**

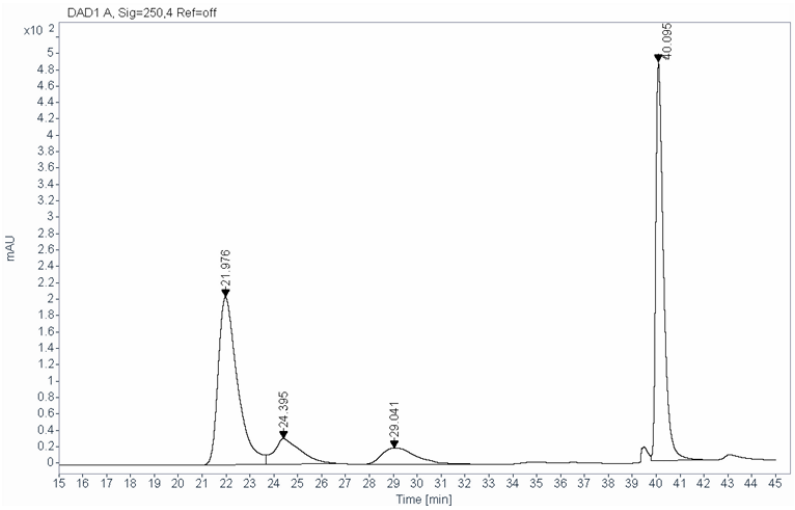



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 12.837 | 0.3440 | 48.1348 | 2.0799 | 0.5286 |
| 14.123 | 0.4995 | 4097.1758 | 124.6581 | 44.9929 |
| 17.690 | 0.5174 | 4948.1968 | 159.4074 | 54.3384 |
| 19.113 | 0.5041 | 12.7614 | 0.4219 | 0.1401 |

**Metacyclophanes 5i**

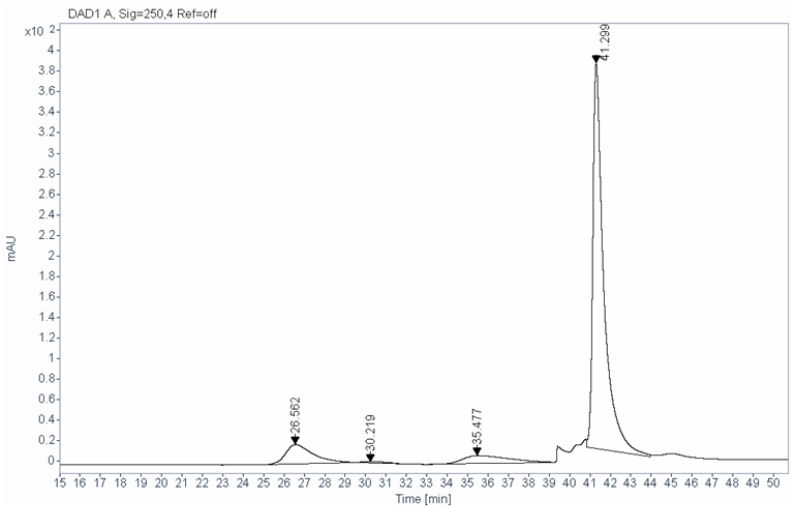



Chiral HPLC spectrum of *rac*-**5i**



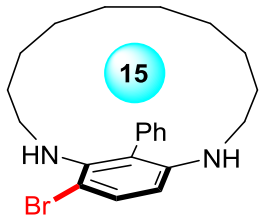

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 21.976 | 0.9303 | 11408.5596 | 204.3968 | 42.6010 |
| 24.395 | 1.2661 | 2373.5442 | 31.2456 | 8.8631 |
| 29.041 | 1.5287 | 2019.5338 | 20.0911 | 7.5412 |
| 40.095 | 0.3763 | 10978.4063 | 486.2772 | 40.9947 |

Chiral HPLC spectrum of **5i**

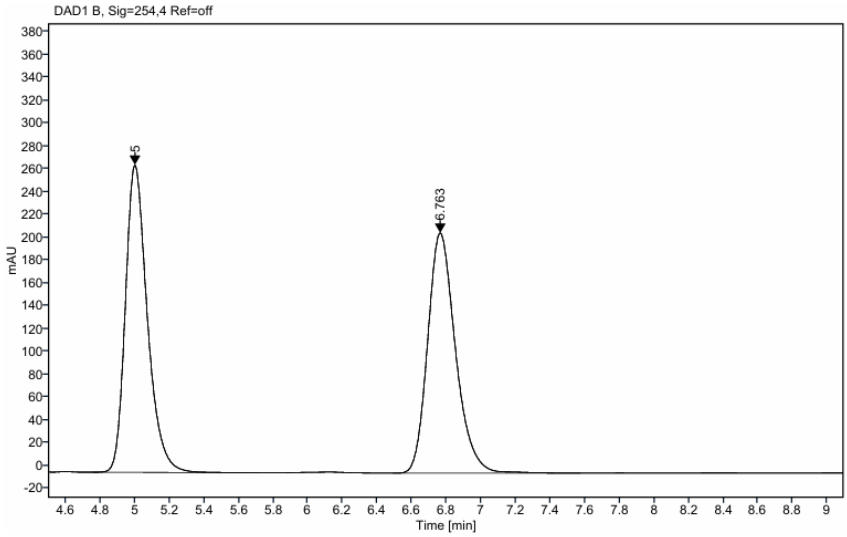



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 26.562 | 1.2732 | 1758.9406 | 18.8750 | 10.3603 |
| 30.219 | 1.0628 | 105.2024 | 1.1703 | 0.6197 |
| 35.477 | 1.8102 | 1206.2094 | 7.8260 | 7.1047 |
| 41.299 | 0.6179 | 13907.3281 | 375.1264 | 81.9154 |

**Metacyclophanes 7a**

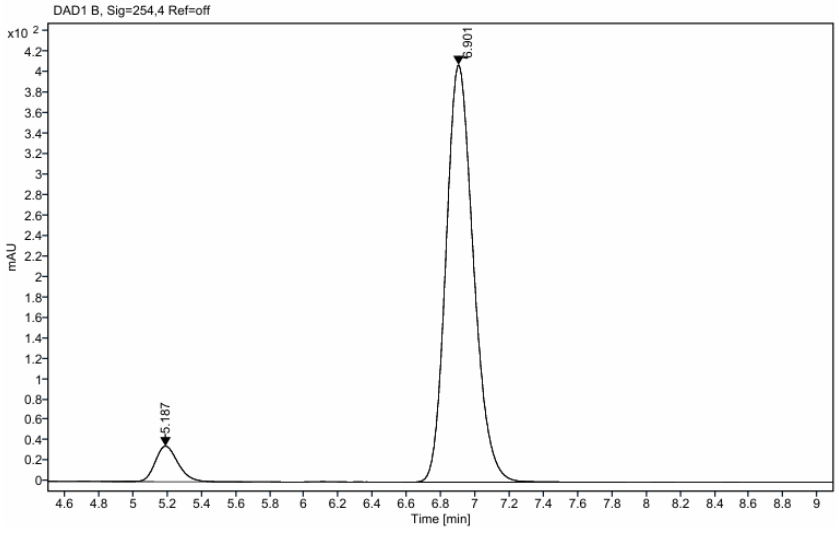



Chiral HPLC spectrum of *rac*-**7a**



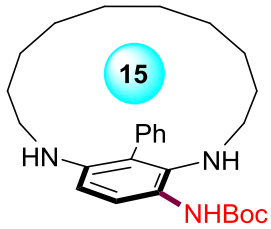

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 5.000 | 0.1344 | 2363.1582 | 269.3032 | 50.1828 |
| 6.763 | 0.1700 | 2345.9431 | 210.4652 | 49.8172 |

Chiral HPLC spectrum of **7a**

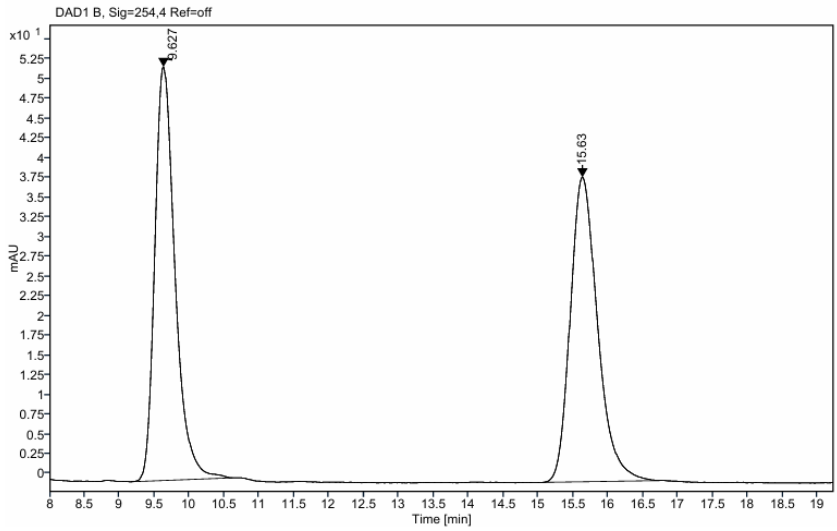



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 5.187 | 0.1448 | 324.2075 | 34.7515 | 6.6628 |
| 6.901 | 0.1698 | 4541.7017 | 408.2646 | 93.3372 |

**Metacyclophanes 9a**

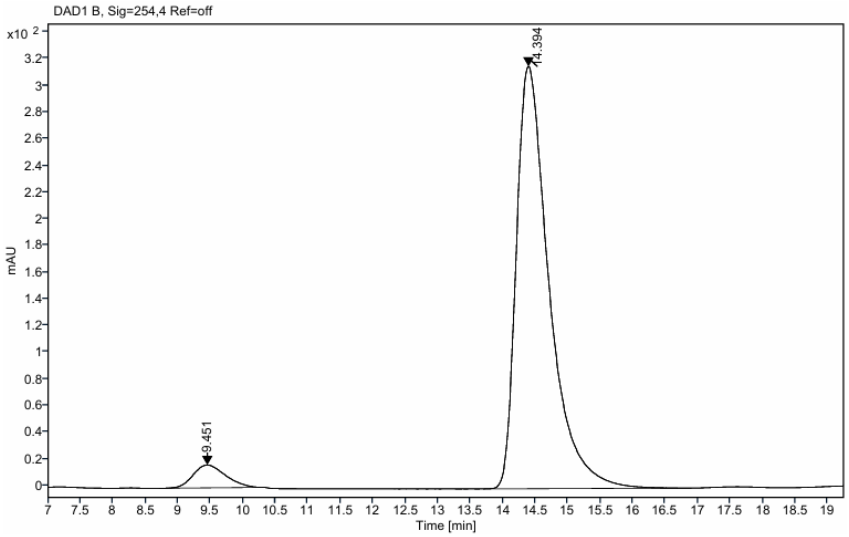



Chiral HPLC spectrum of *rac*-**9a**



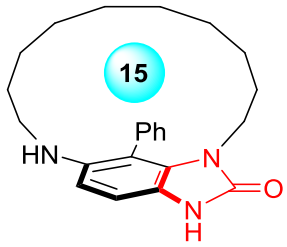

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 9.627 | 0.3069 | 1055.2700 | 52.4172 | 50.1210 |
| 15.630 | 0.4155 | 1050.1736 | 38.5871 | 49.8790 |

Chiral HPLC spectrum of **9a**

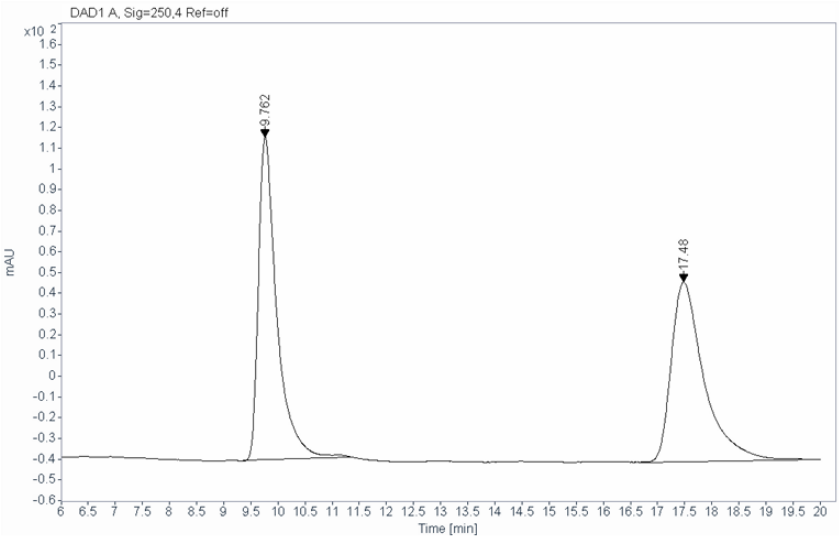



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 9.451 | 0.5195 | 592.6066 | 17.1359 | 5.0823 |
| 14.394 | 0.5258 | 11067.7051 | 316.6431 | 94.9177 |

**Metacyclophanes 10a**

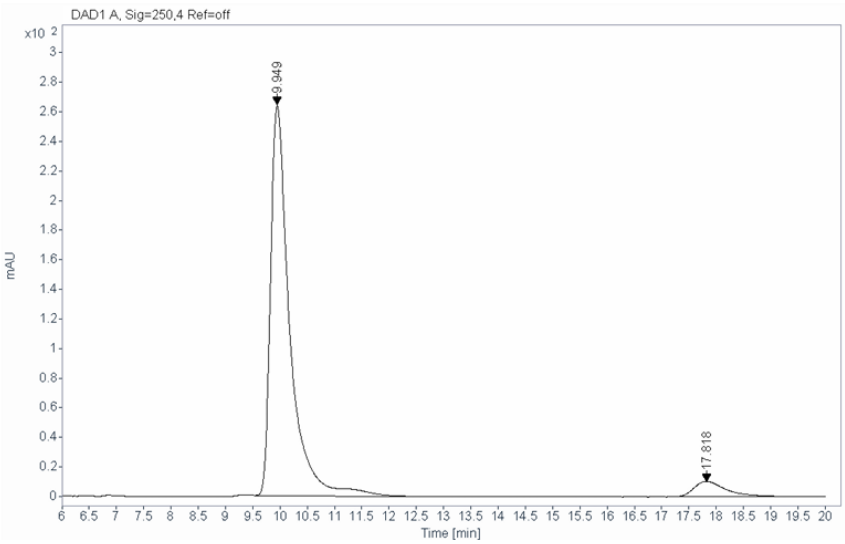



Chiral HPLC spectrum of *rac*-1**0a**



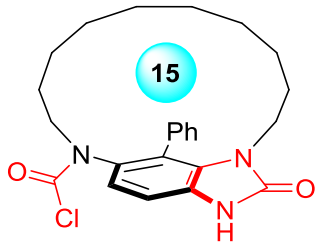

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 9.762 | 0.3922 | 3663.9919 | 155.7174 | 50.1151 |
| 17.480 | 0.6281 | 3647.1599 | 86.4709 | 49.8849 |

Chiral HPLC spectrum of **10a**

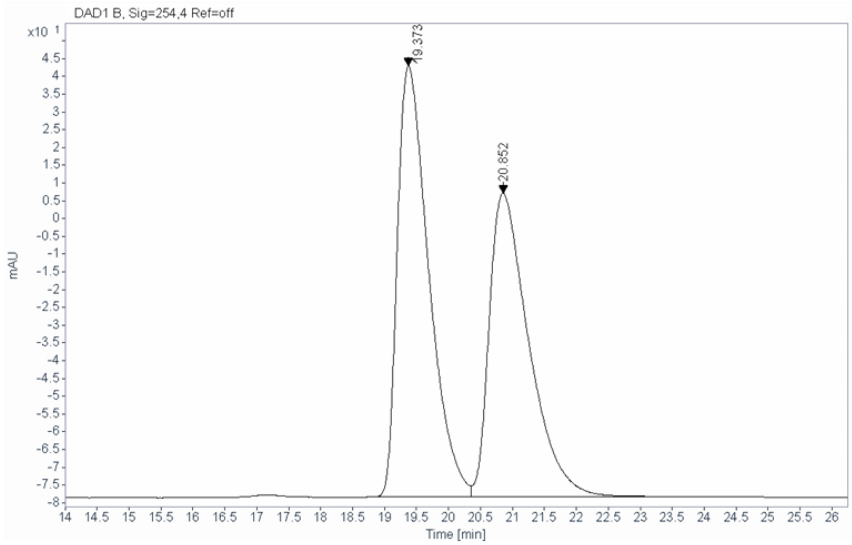



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 9.949 | 0.3574 | 6460.8750 | 264.0867 | 93.6860 |
| 17.818 | 0.5756 | 435.4335 | 10.5057 | 6.3140 |

**Metacyclophanes 11a**

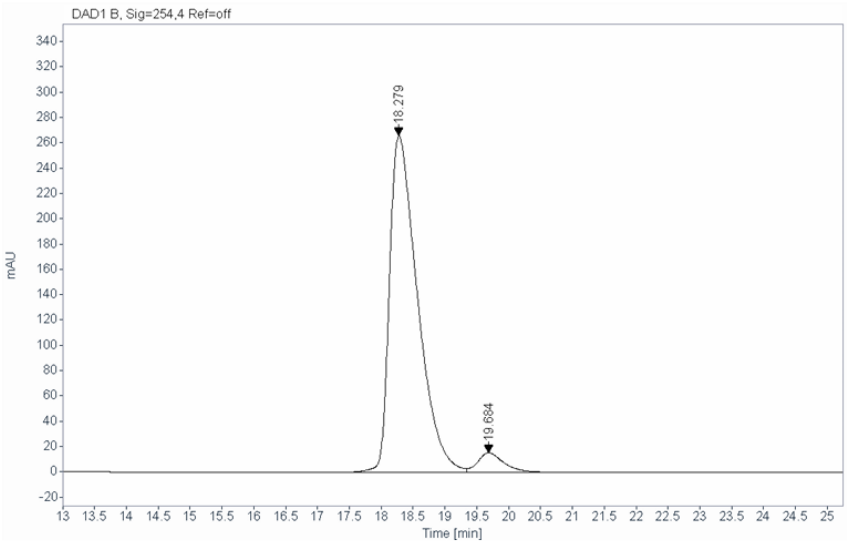



Chiral HPLC spectrum of *rac*-1**1a**



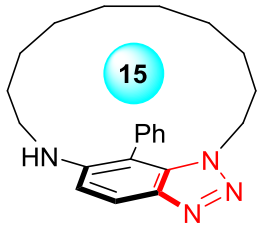

| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 19.373 | 0.5214 | 4148.9663 | 121.2032 | 53.0166 |
| 20.852 | 0.6441 | 3676.8210 | 85.4332 | 46.9834 |

Chiral HPLC spectrum of **11a**

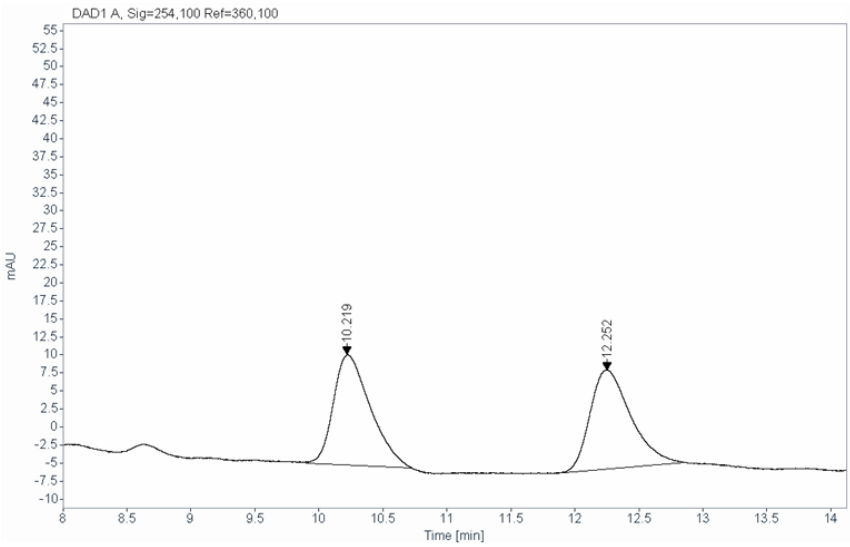



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 18.279 | 0.5090 | 8128.4111 | 266.1791 | 94.7993 |
| 19.684 | 0.4805 | 445.9297 | 15.4682 | 5.2007 |

**Metacyclophanes 12a**

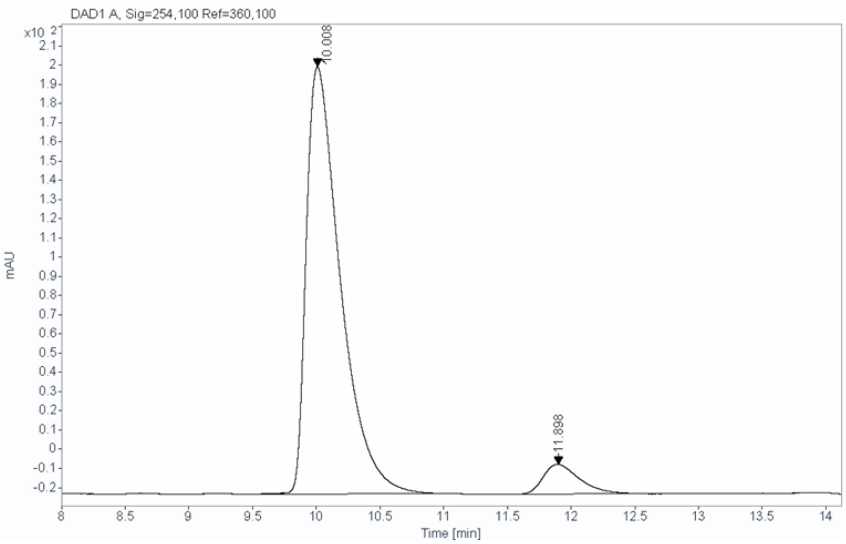



Chiral HPLC spectrum of *rac*-1**2a**




| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.219 | 0.3341 | 307.1372 | 15.3201 | 50.2452 |
| 12.252 | 0.2616 | 304.1393 | 13.7501 | 49.7548 |

Chiral HPLC spectrum of **12a**

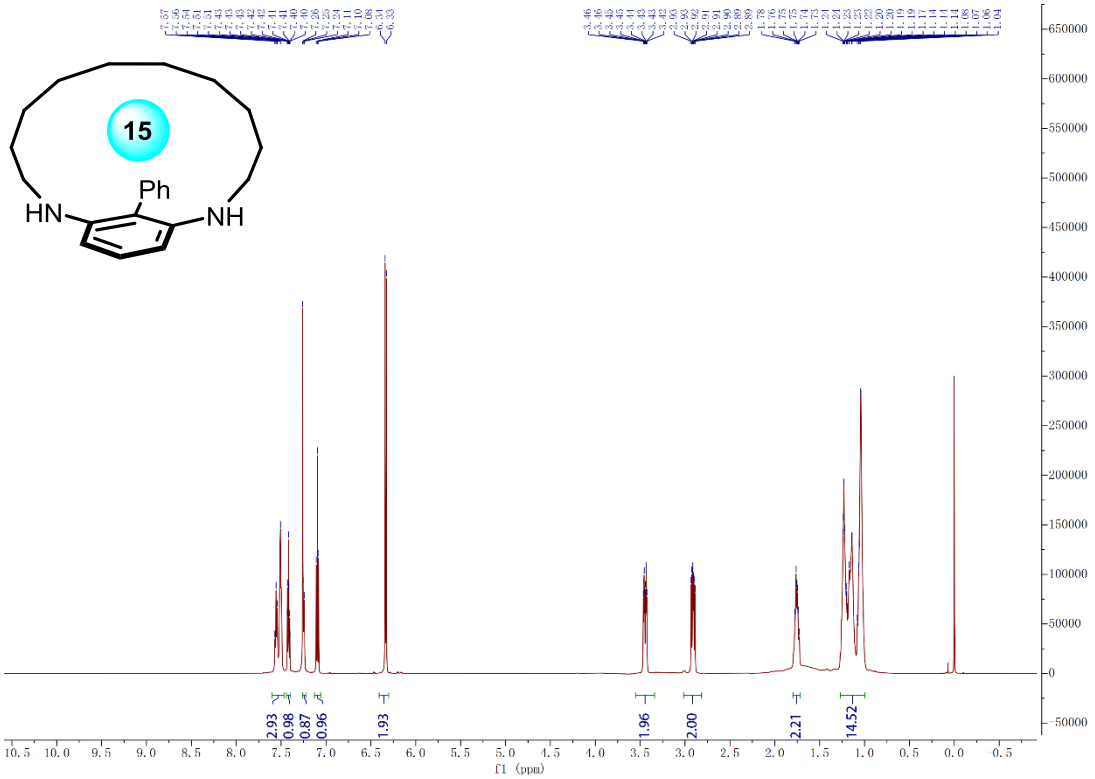



| RT [min] | Width [min] | Area | Height | Area% |
|---|---|---|---|---|
| 10.008 | 0.2568 | 4144.6689 | 222.4827 | 93.1295 |
| 11.898 | 0.2329 | 305.7689 | 15.4848 | 6.8705 |

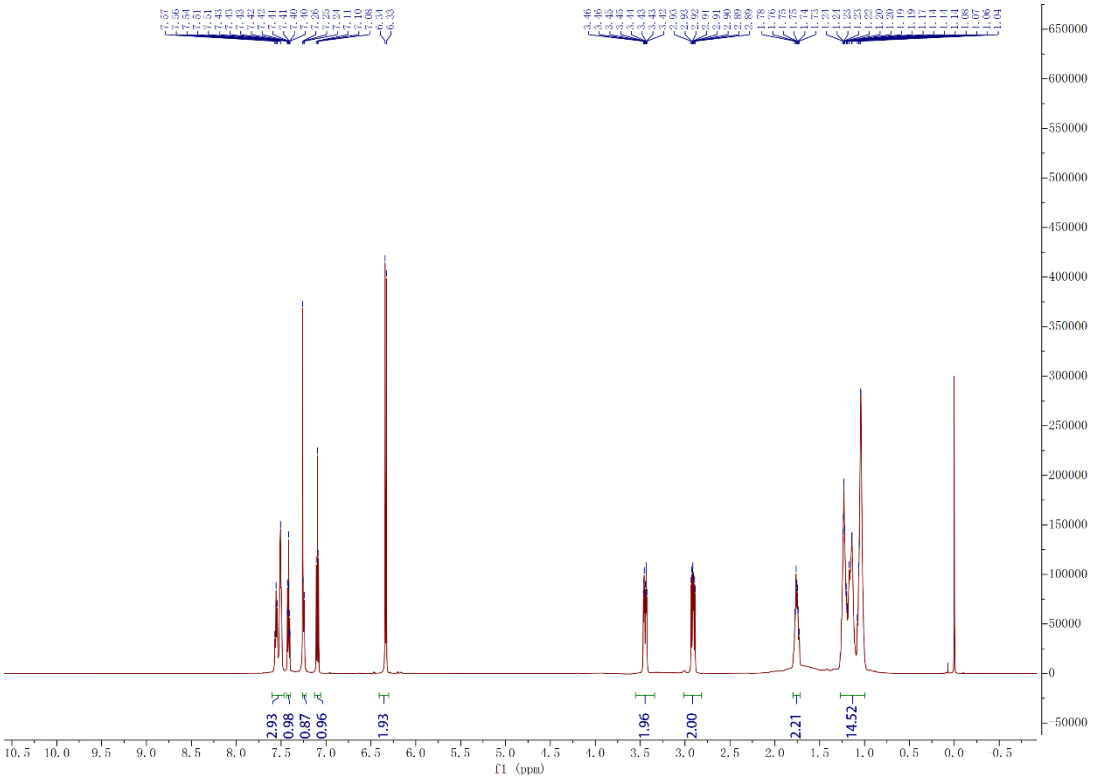
**NMR Spectrums**

$1^2$-phenyl-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1a**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

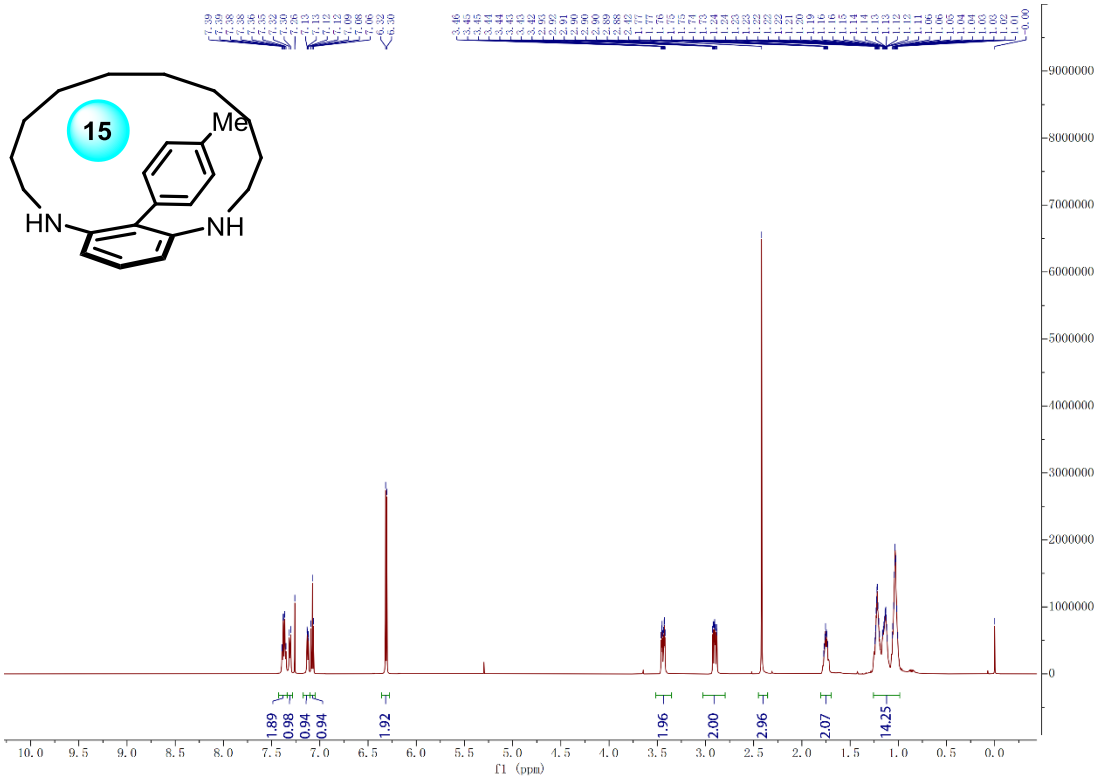



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

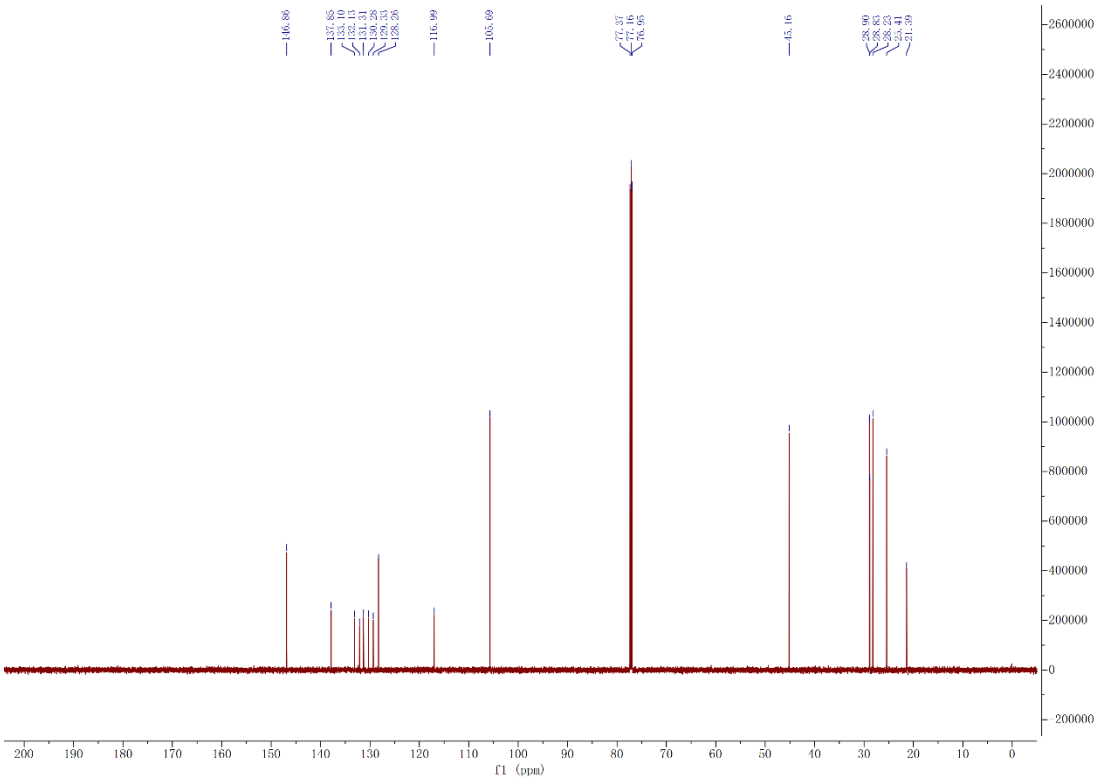


$1^2$-(*p*-tolyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1c**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

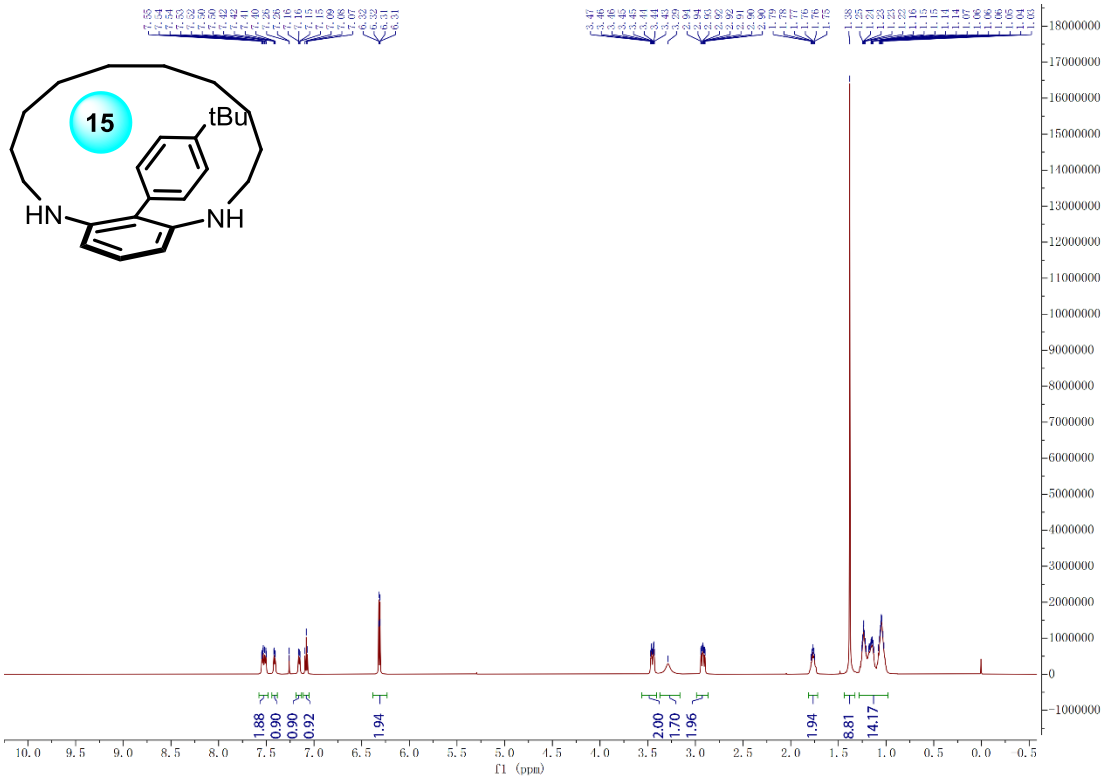



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

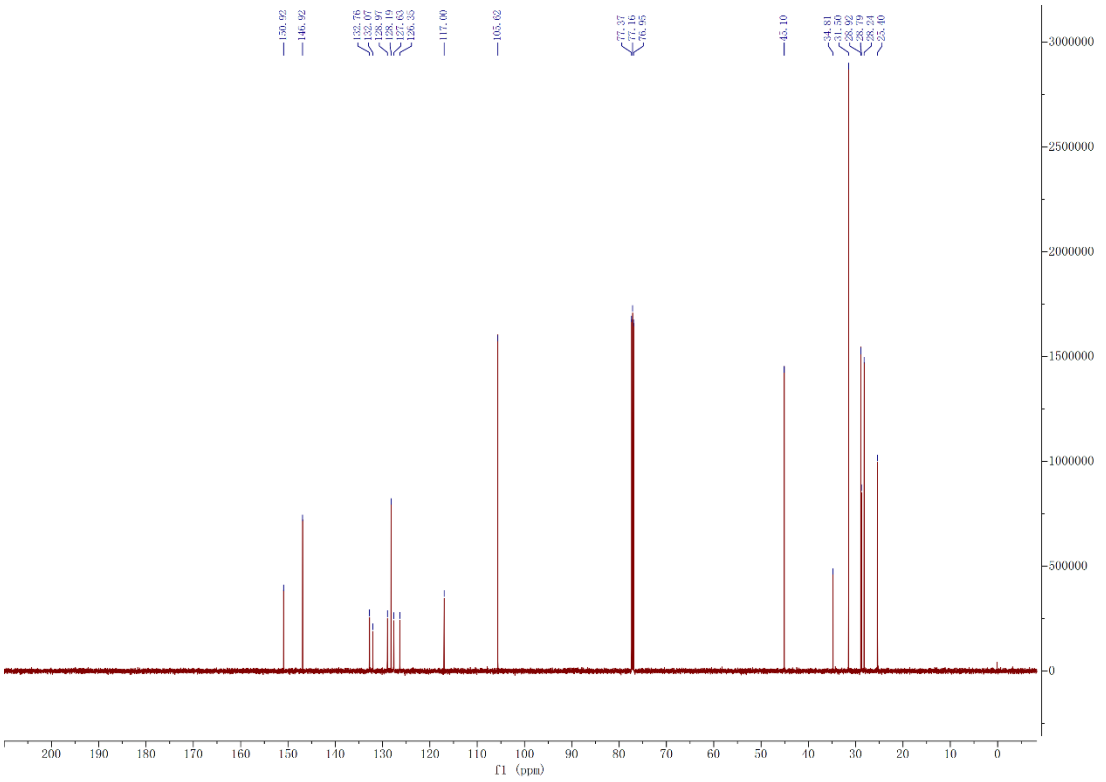


$1^2$-(4-(*tert*-butyl)phenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1d**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

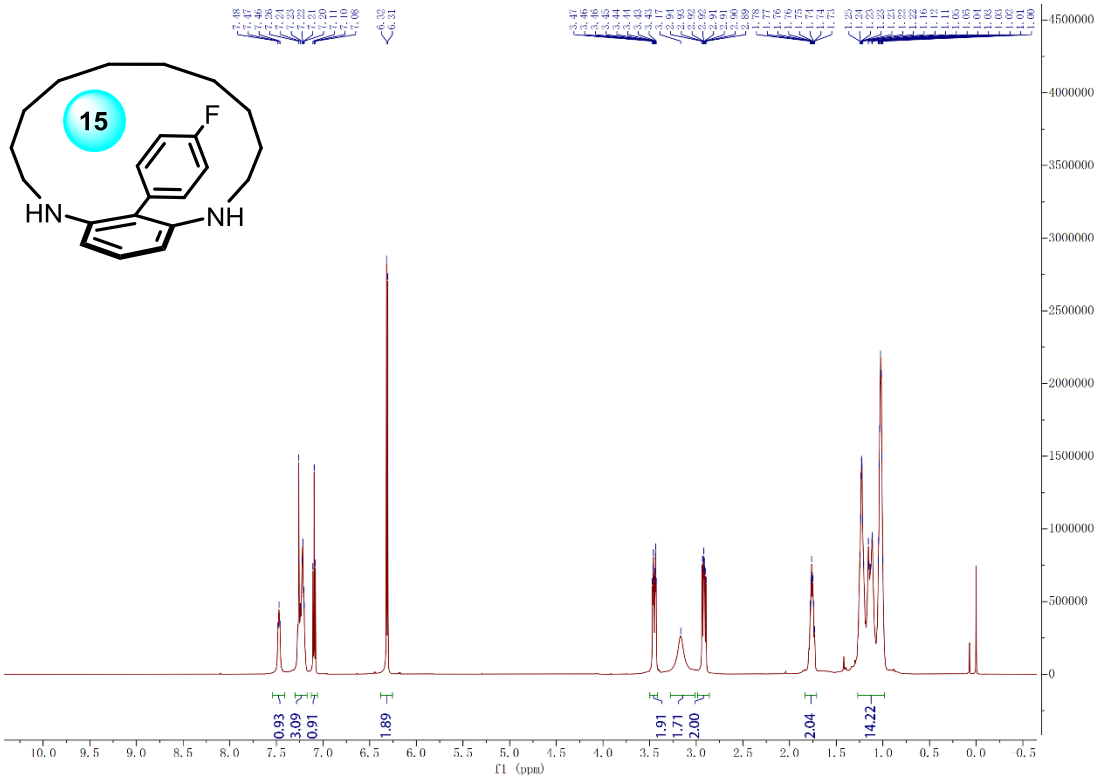



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

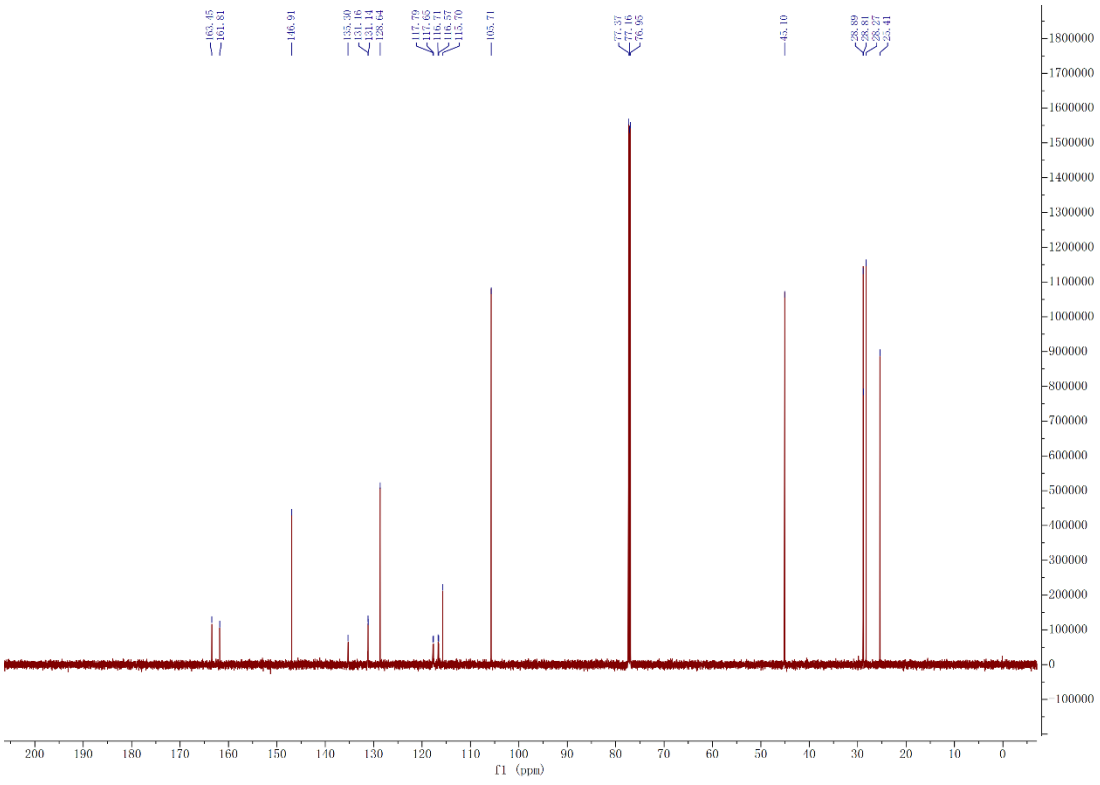


$1^2$-(4-fluorophenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1e**)

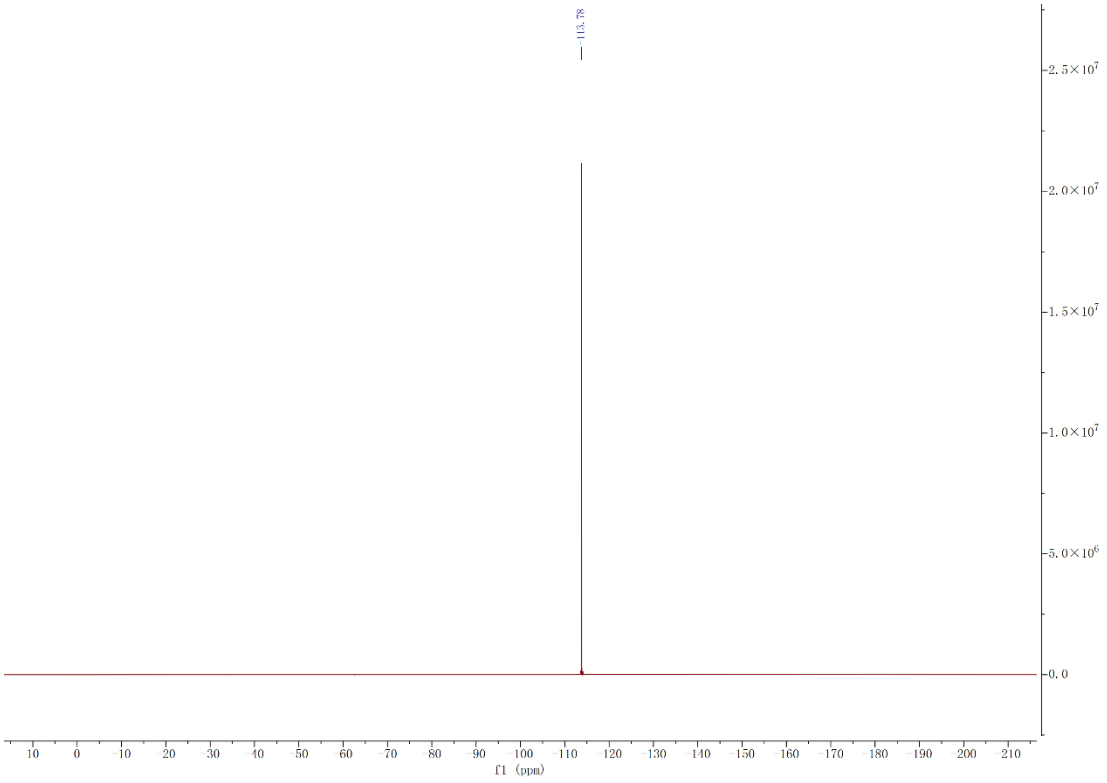
**$^1$H NMR** (600 MHz, $CDCl_3$)




**$^{13}$C NMR** (151 MHz, $CDCl_3$)

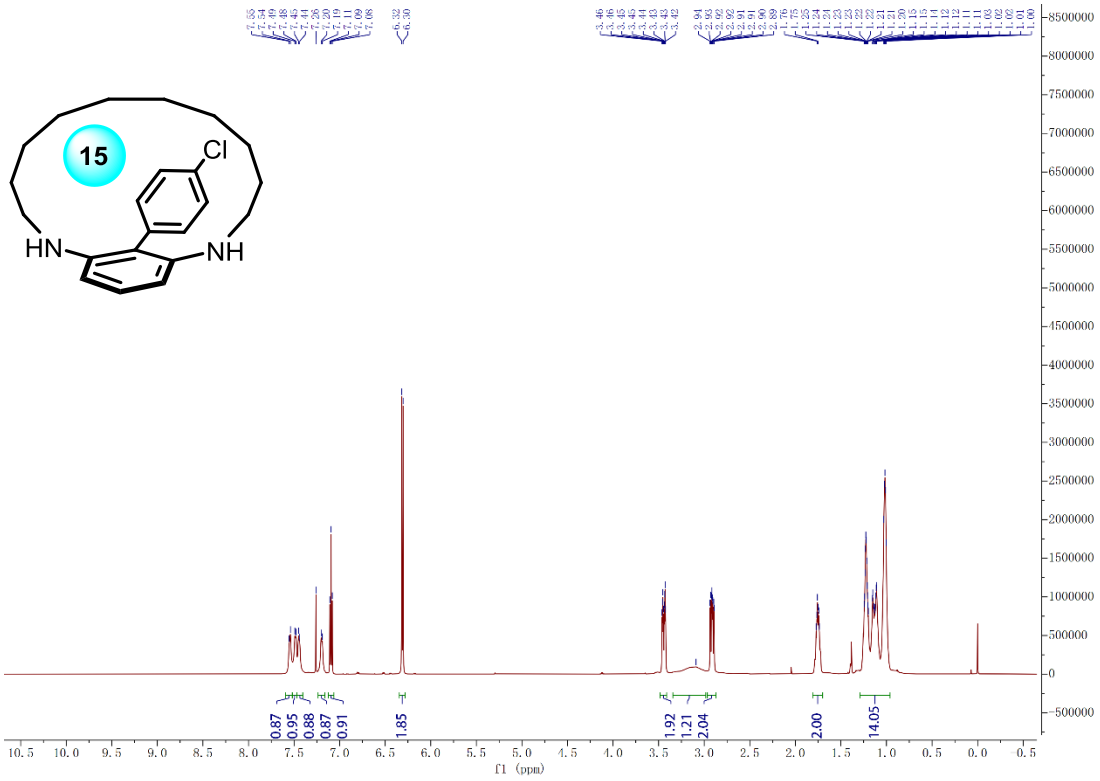


**$^{19}$F NMR** (565 MHz, $CDCl_3$)

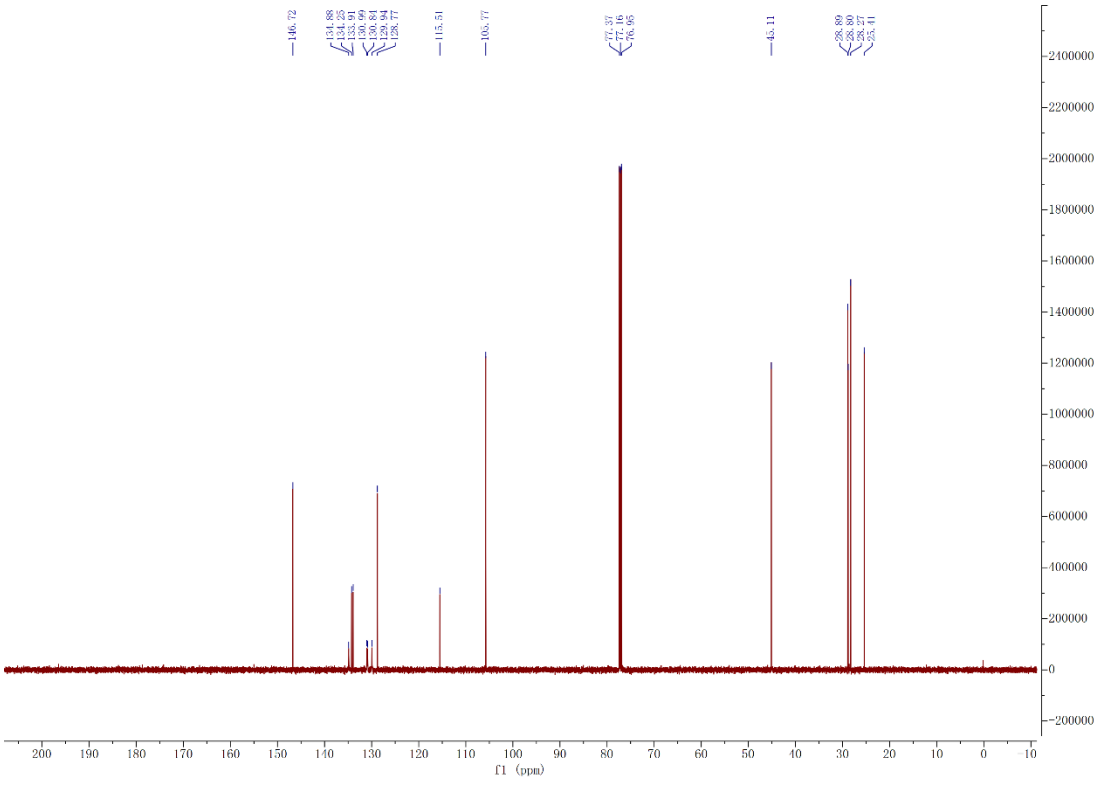


$1^2$-(4-chlorophenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1f**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

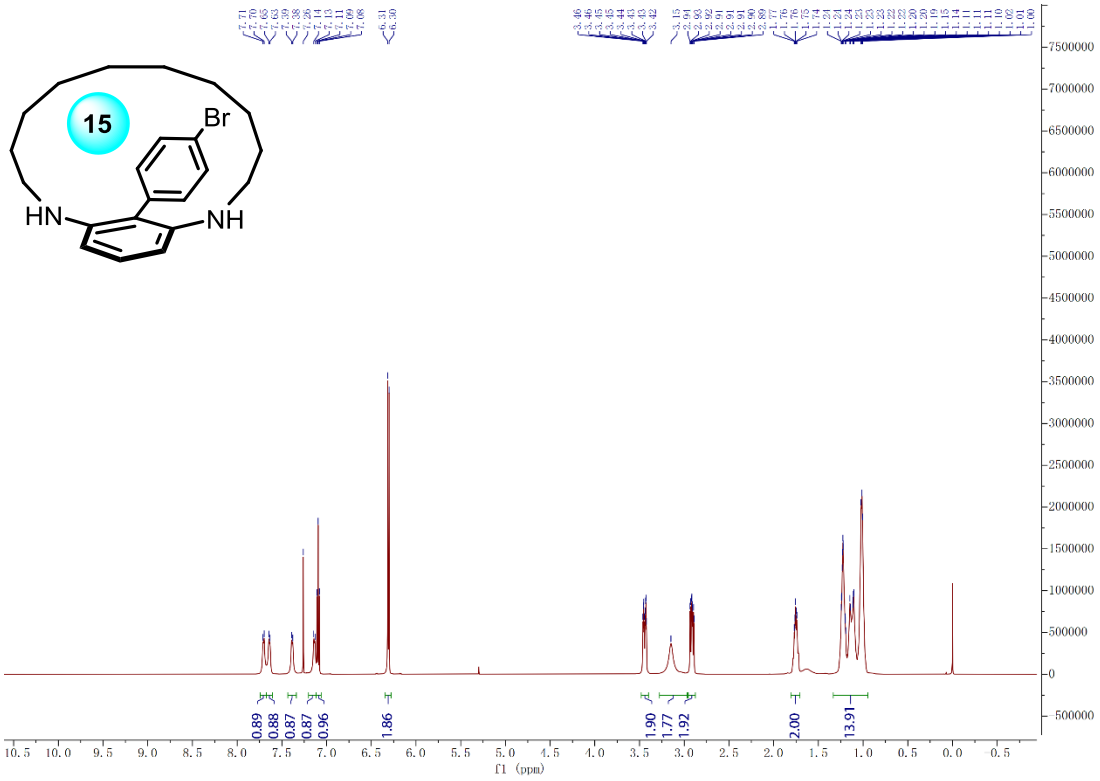



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

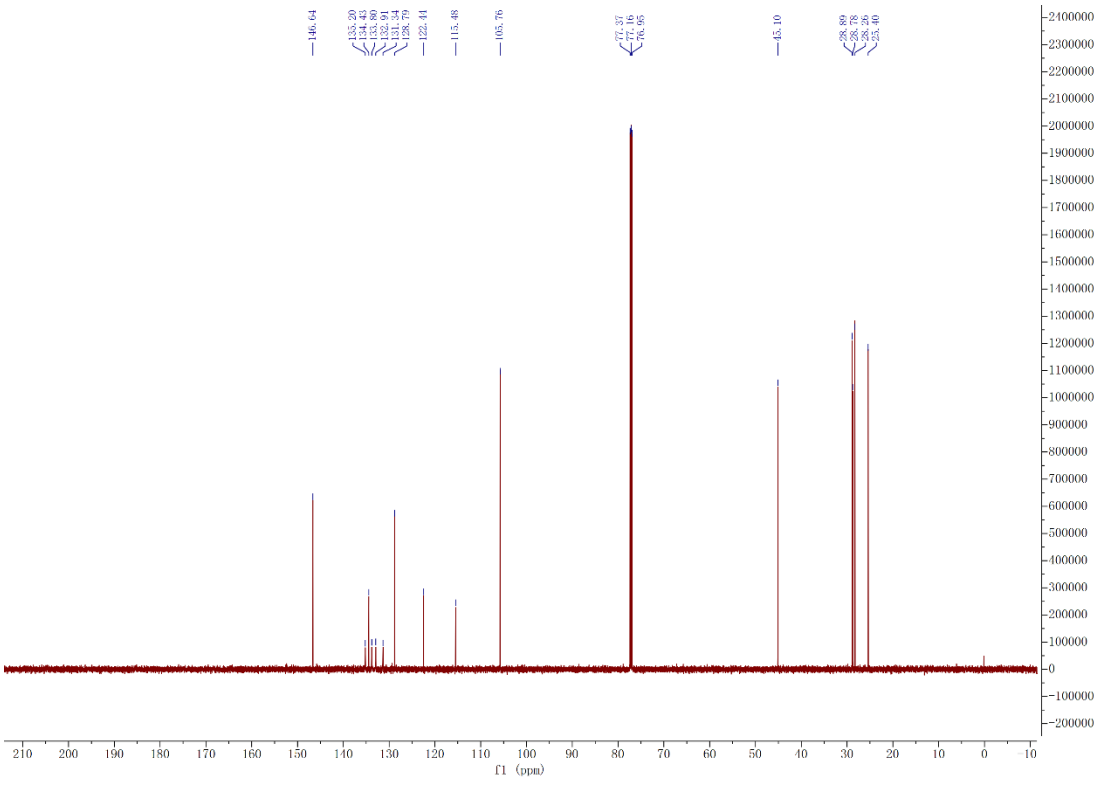


$1^2$-(4-bromophenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1g**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

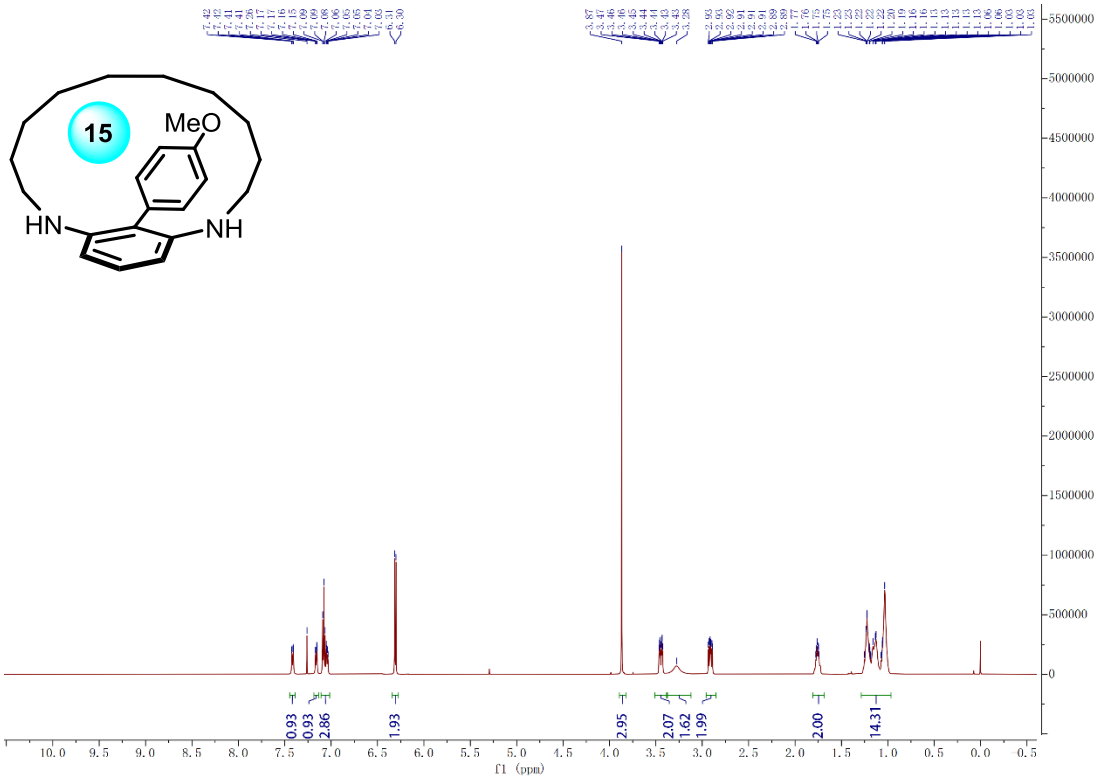



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

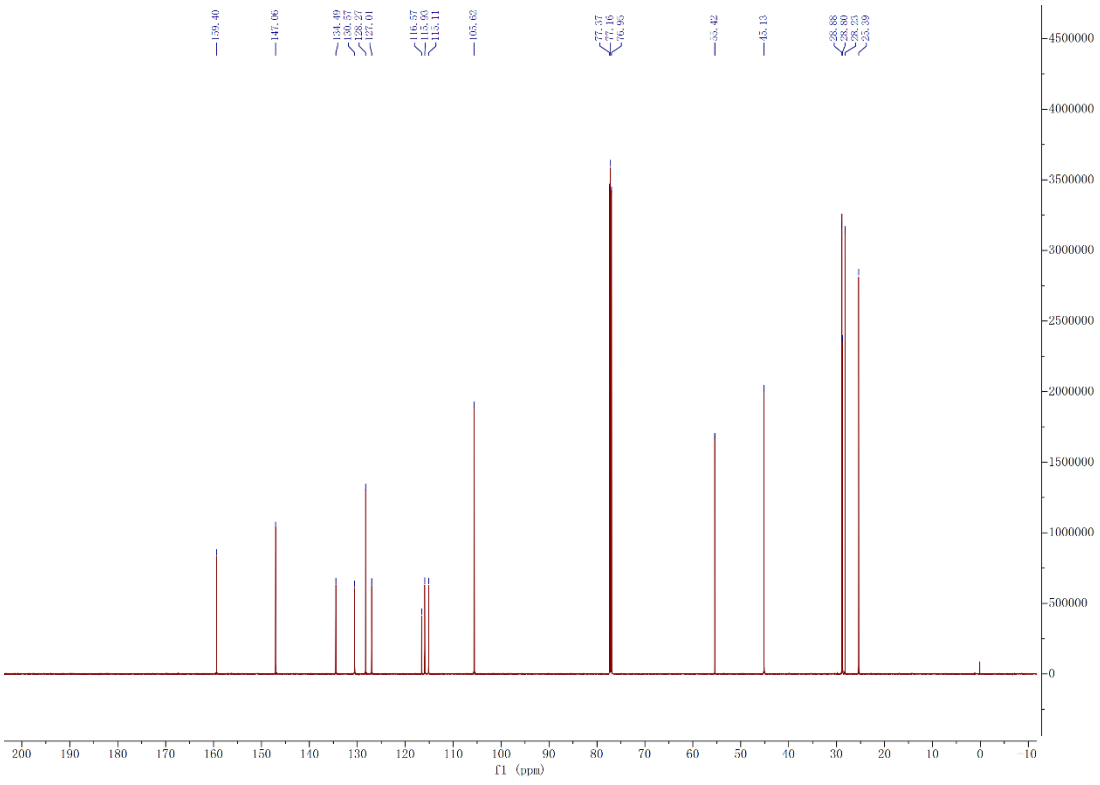


$1^2$-(4-methoxyphenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1h**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

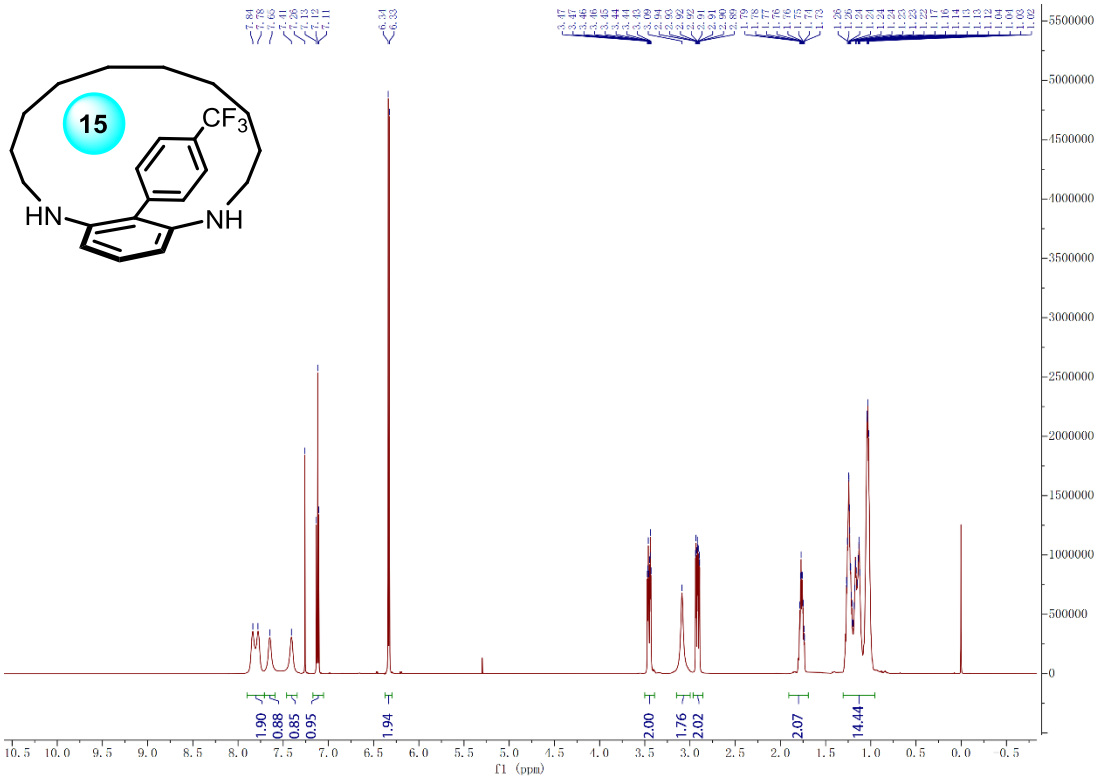



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

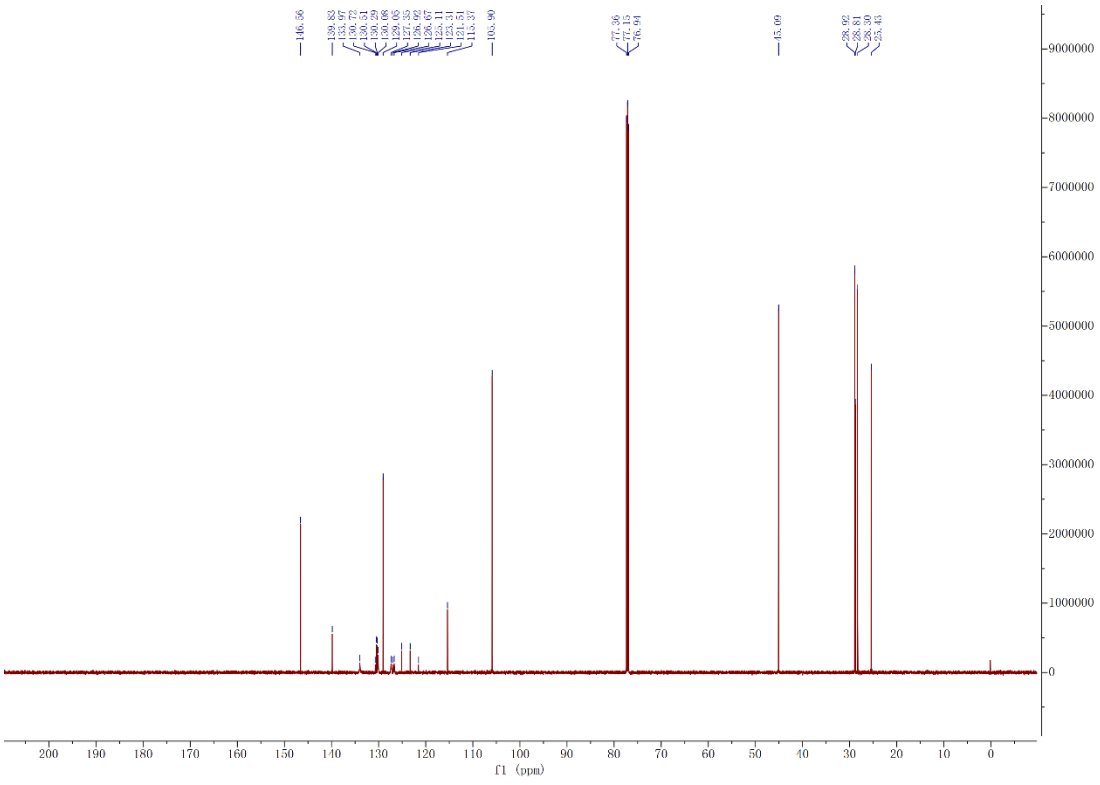


$1^2$-(4-(trifluoromethyl)phenyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1i**)

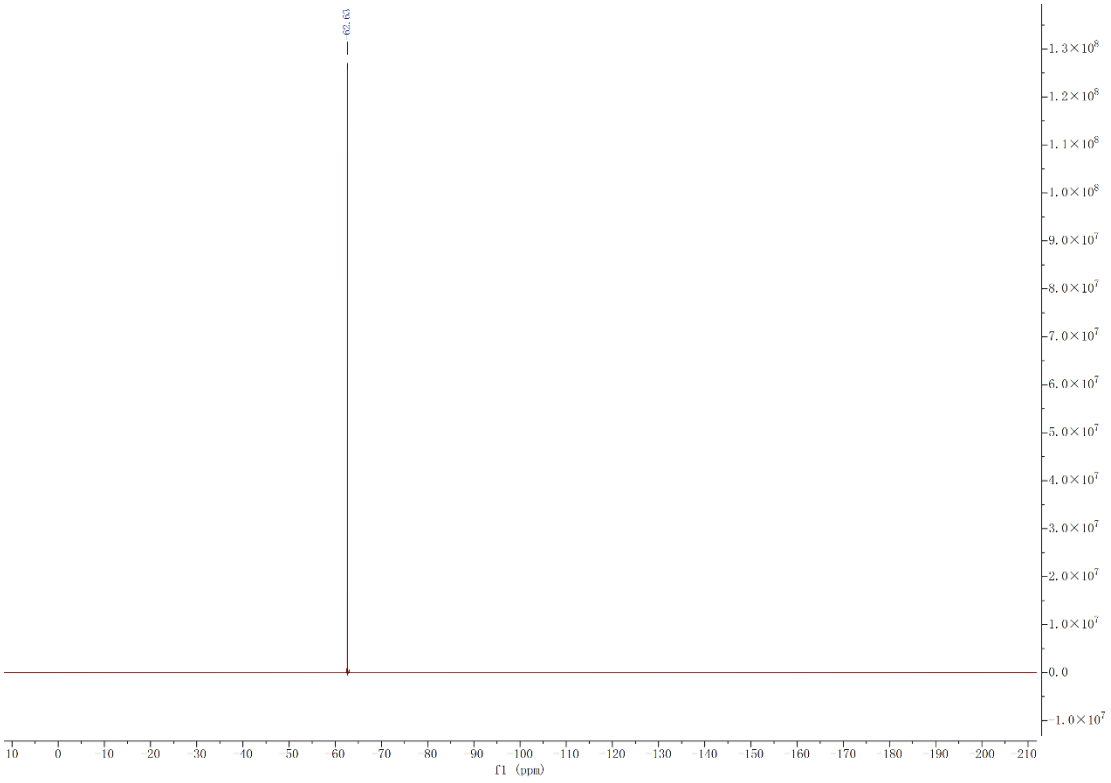
**$^1$H NMR** (600 MHz, $CDCl_3$)




**$^{13}$C NMR** (151 MHz, $CDCl_3$)

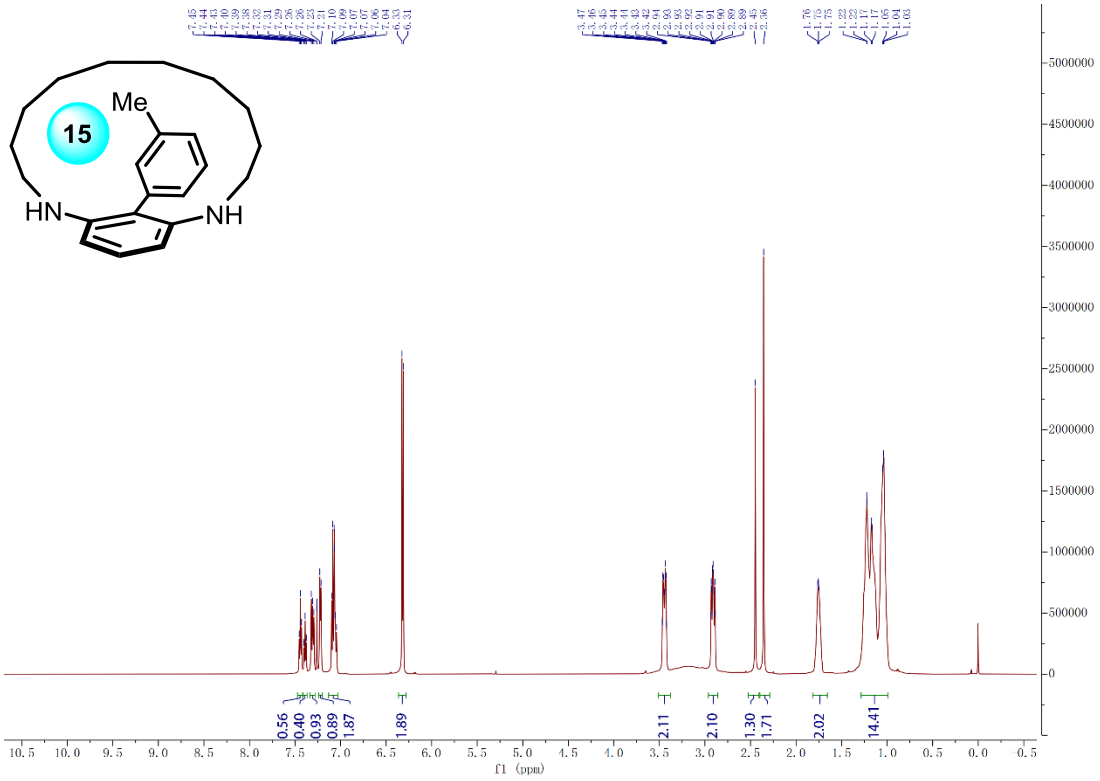


**$^{19}$F NMR** (565 MHz, $CDCl_3$)

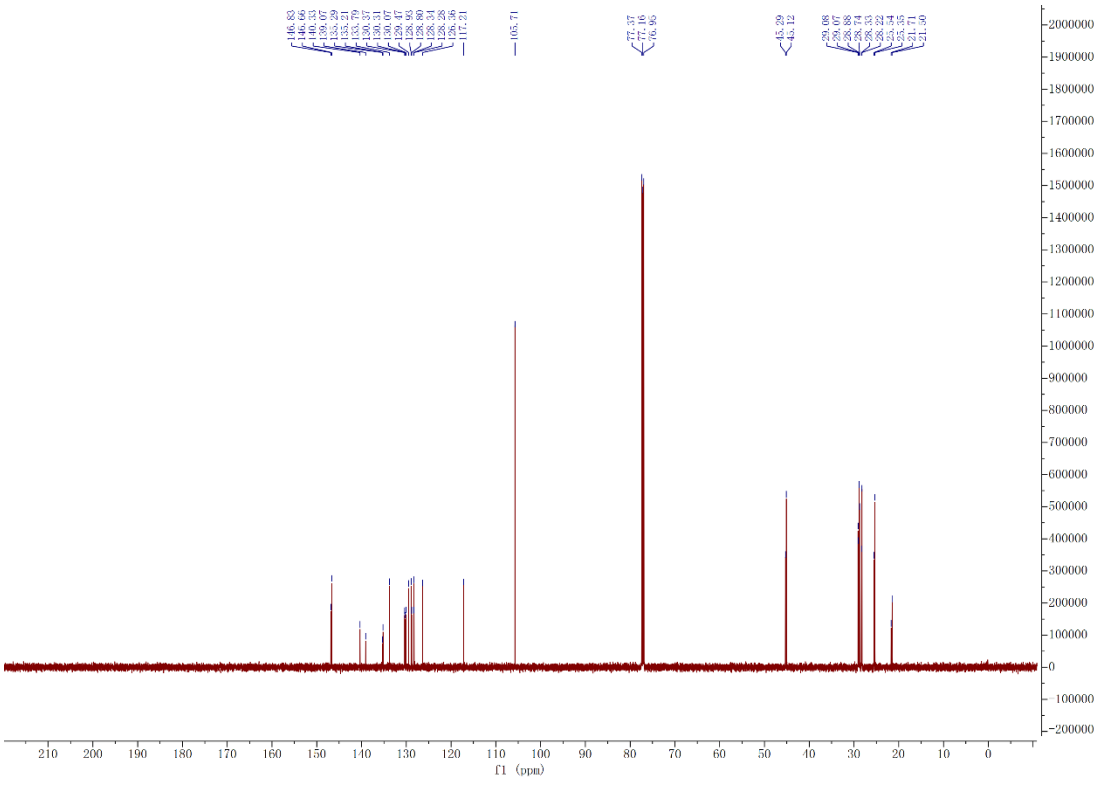


$1^2$-(*m*-tolyl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1j**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

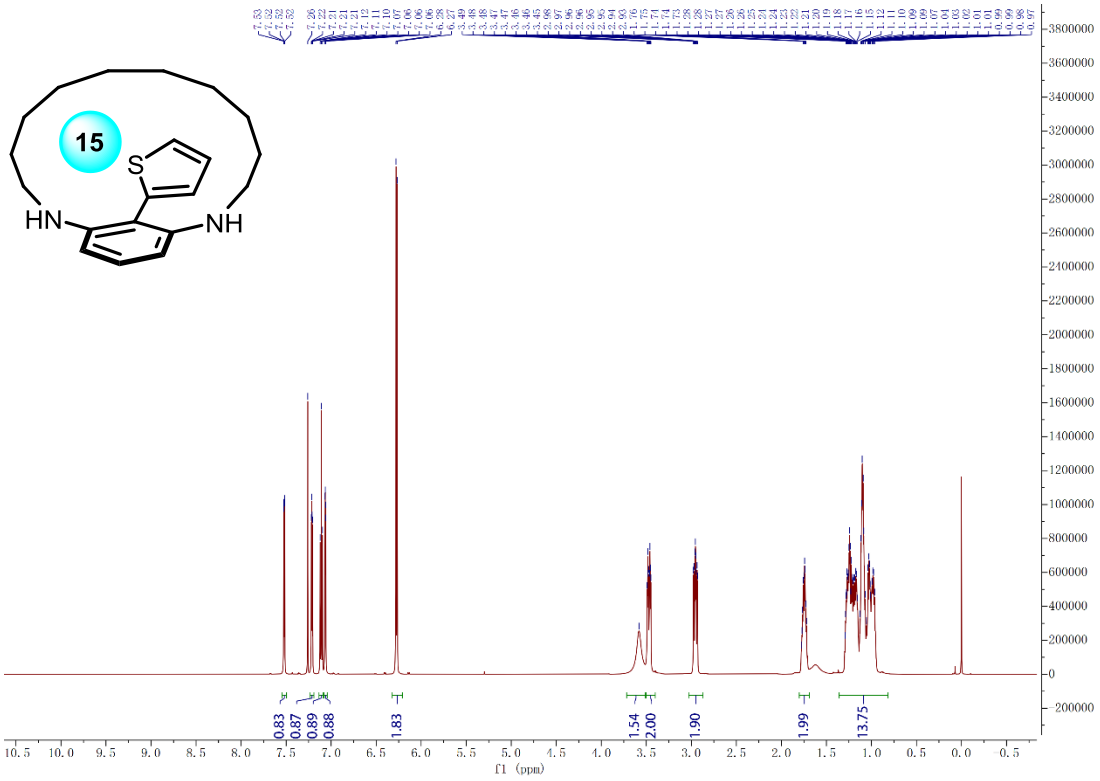



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

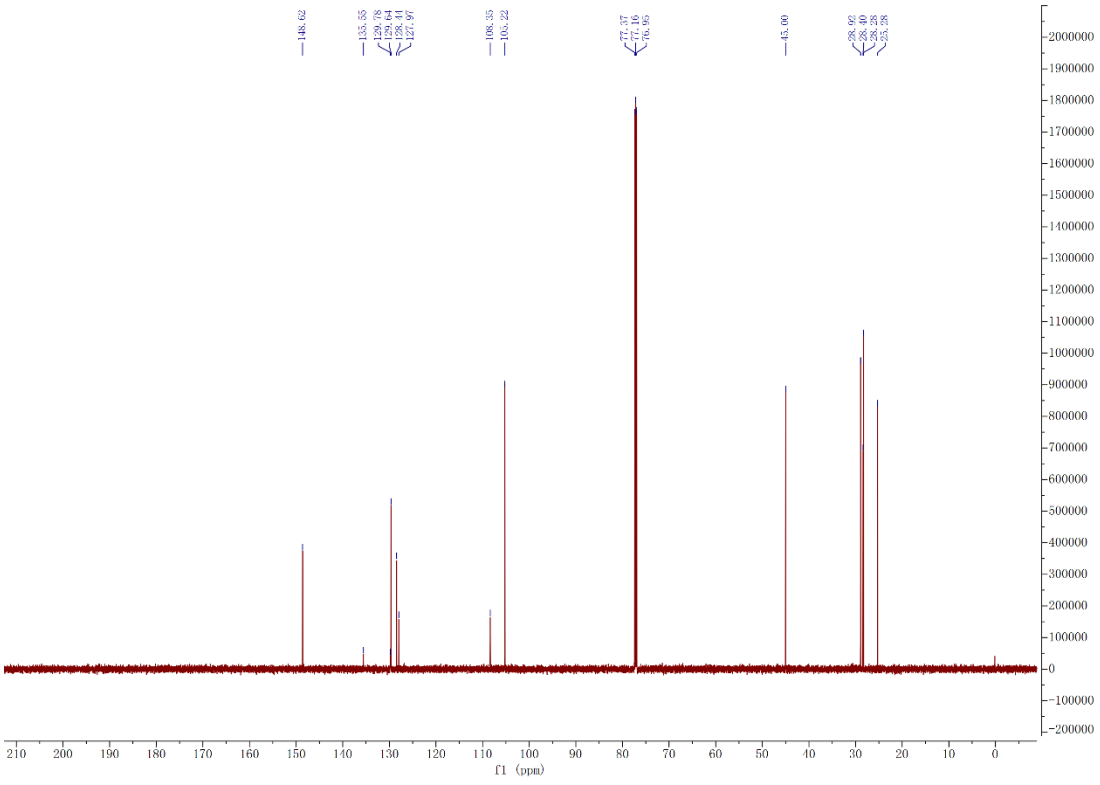


$1^2$-(thiophen-2-yl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1k**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

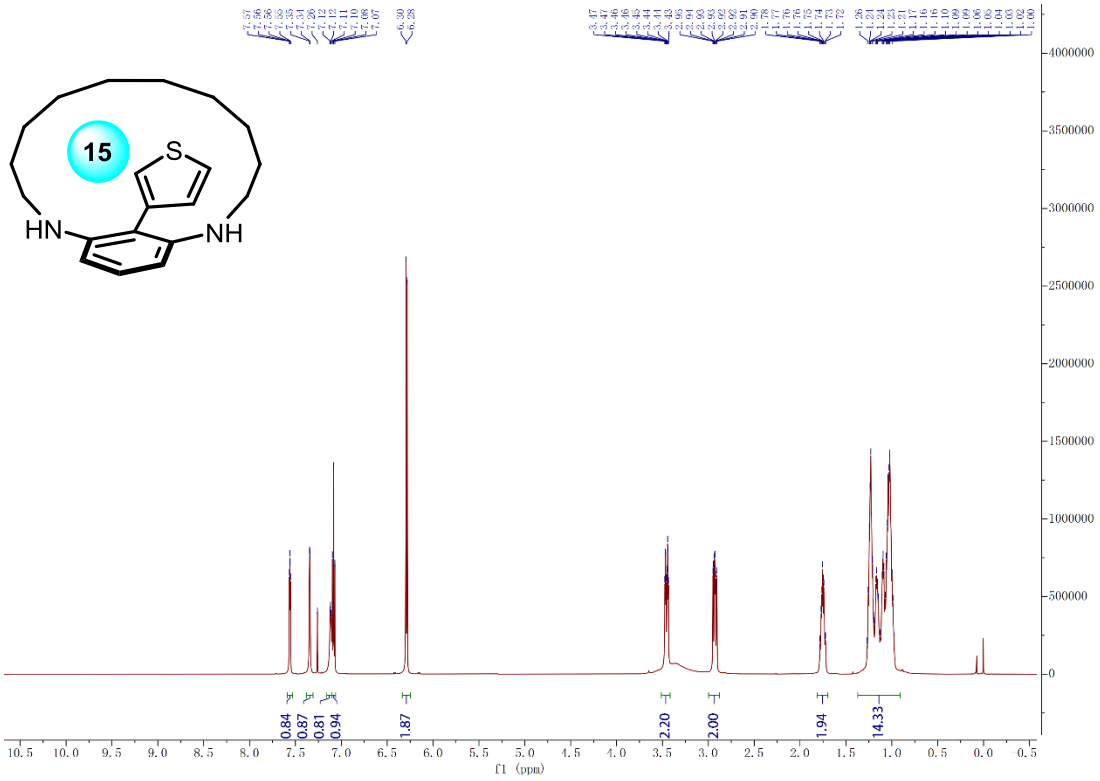



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

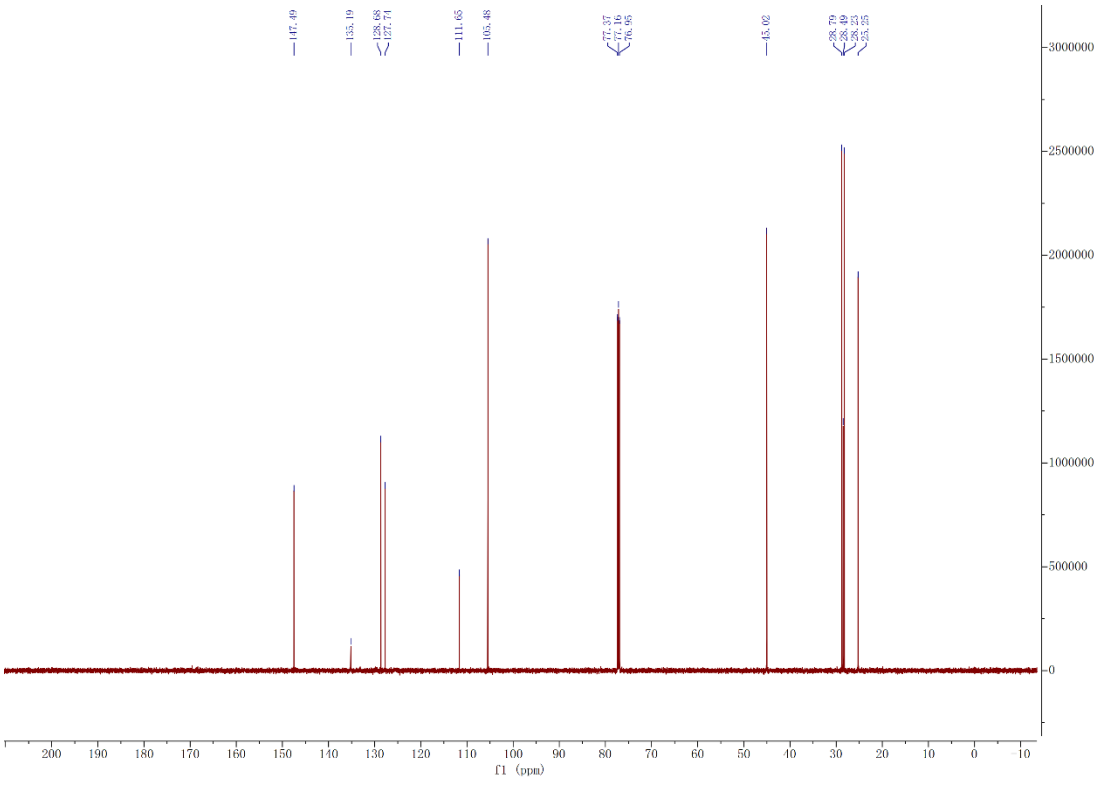


$1^2$-(thiophen-3-yl)-2,13-diaza-1(1,3)-benzenacyclotridecaphane (**1l**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

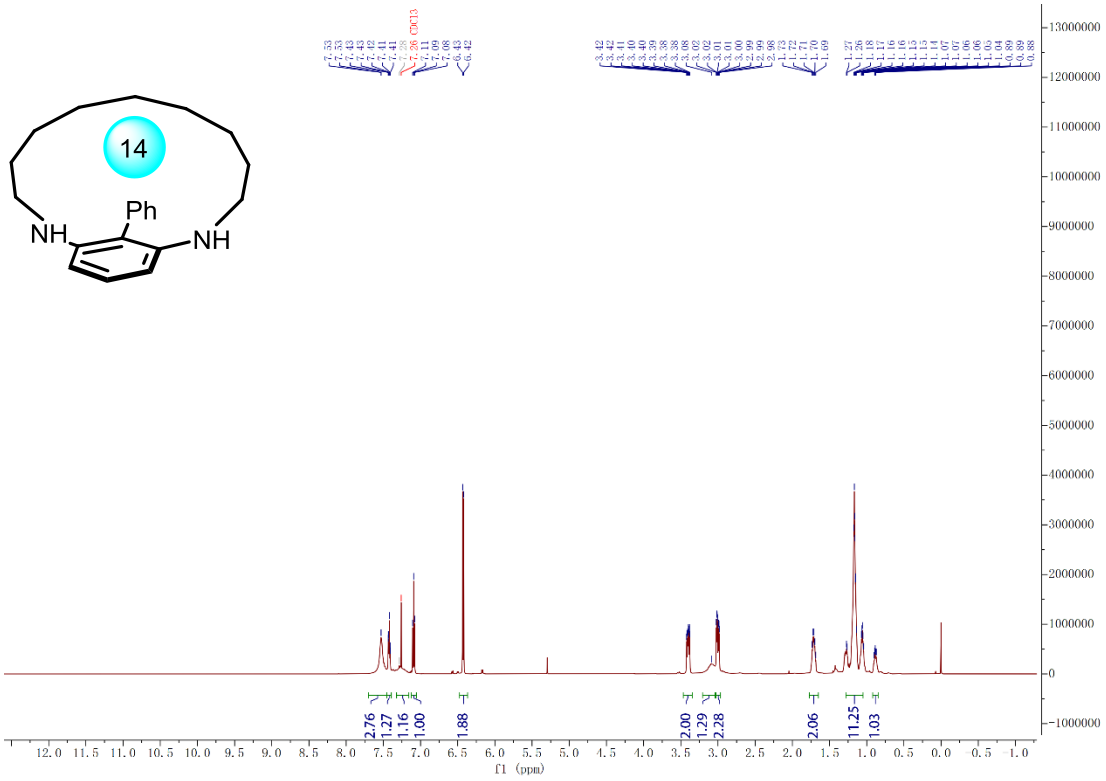



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

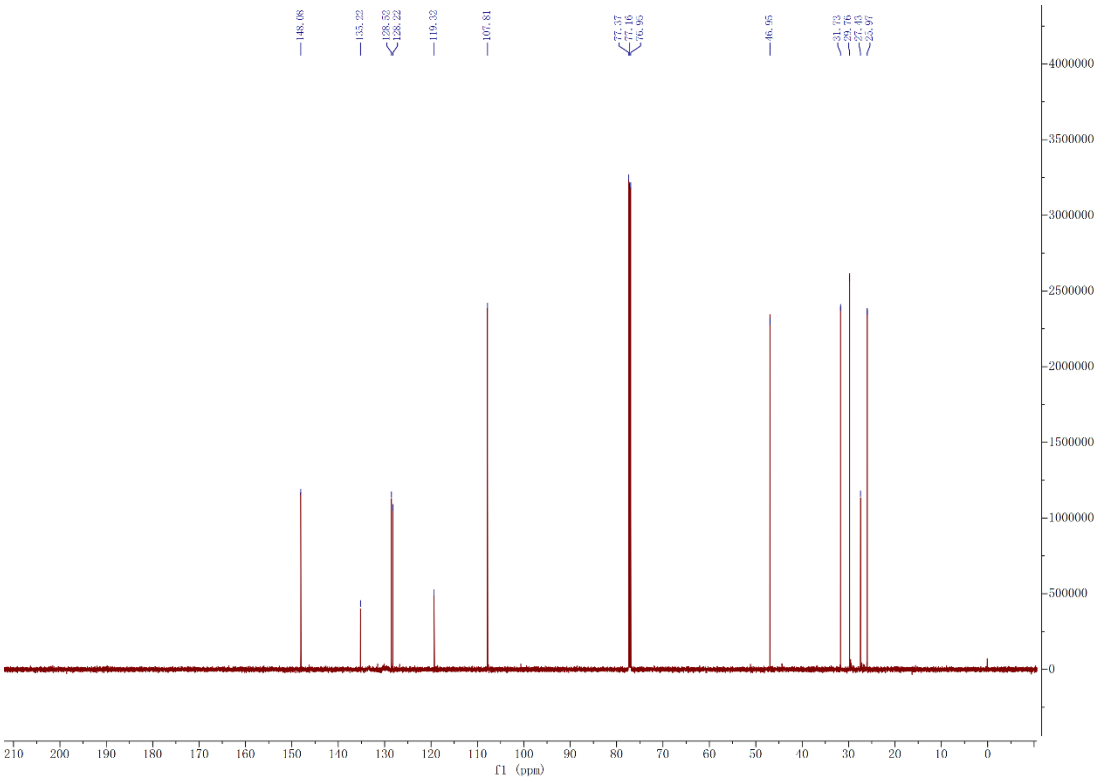


$1^2$-phenyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**1m**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

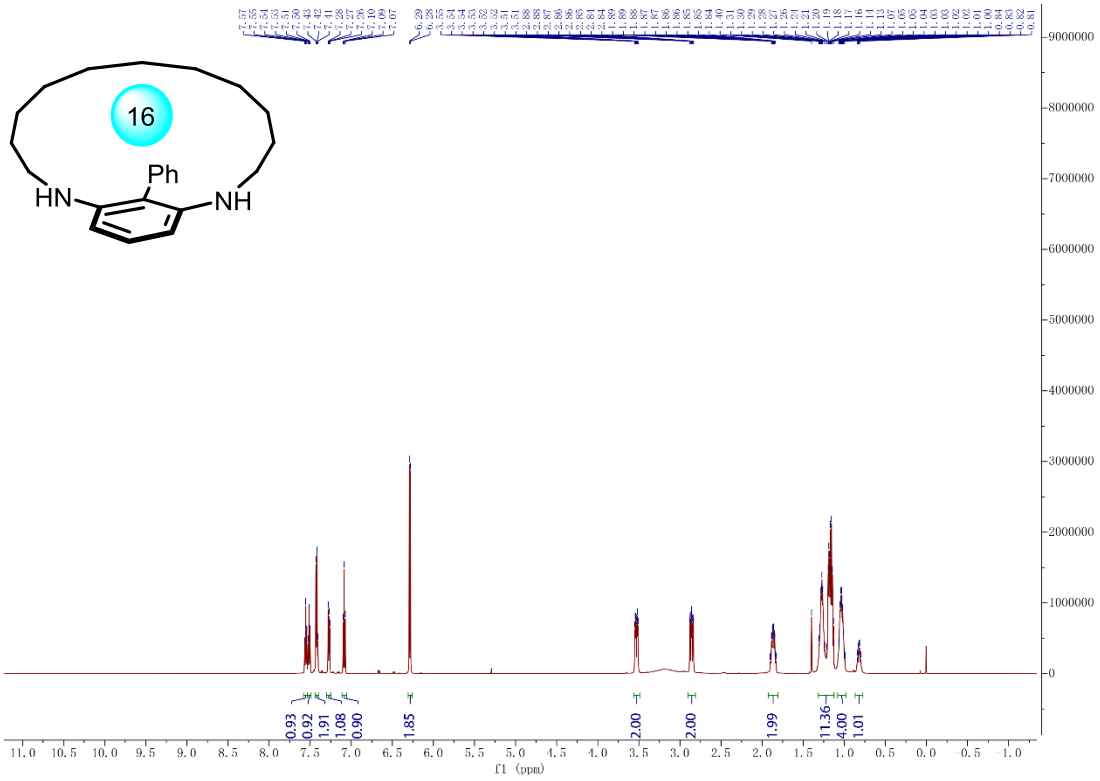



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

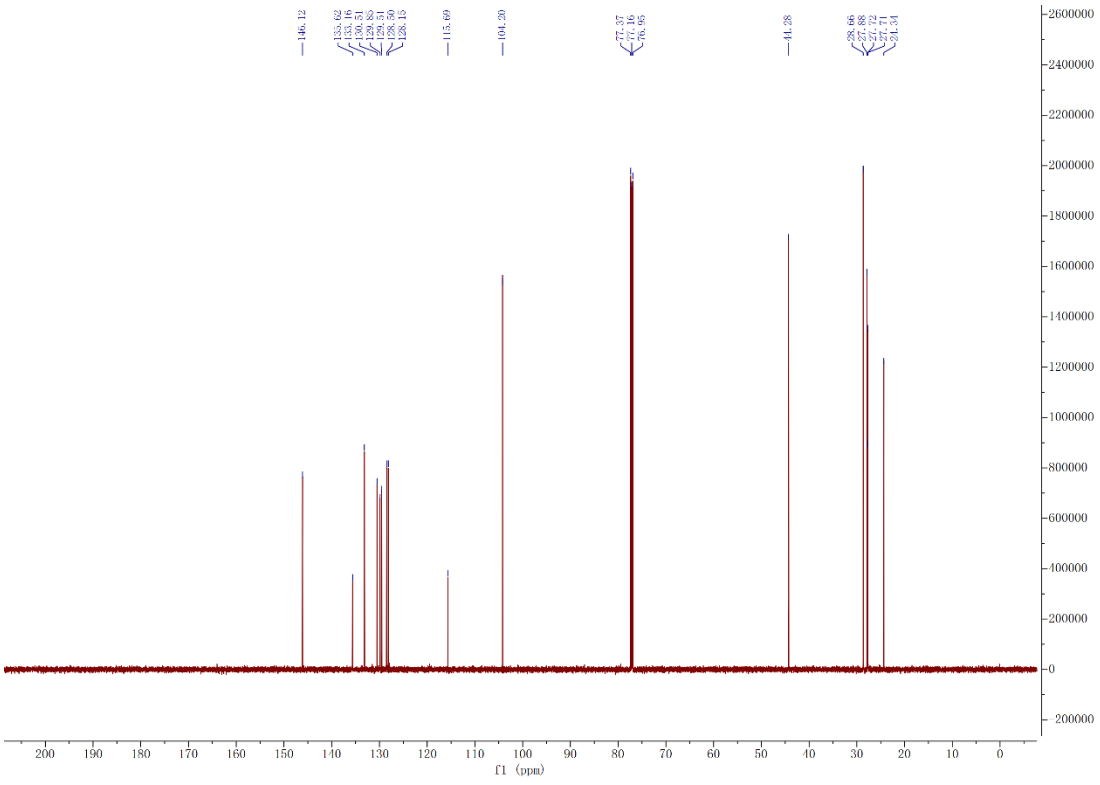


$1^2$-phenyl-2,14-diaza-1(1,3)-benzenacyclotetradecaphane (**1n**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

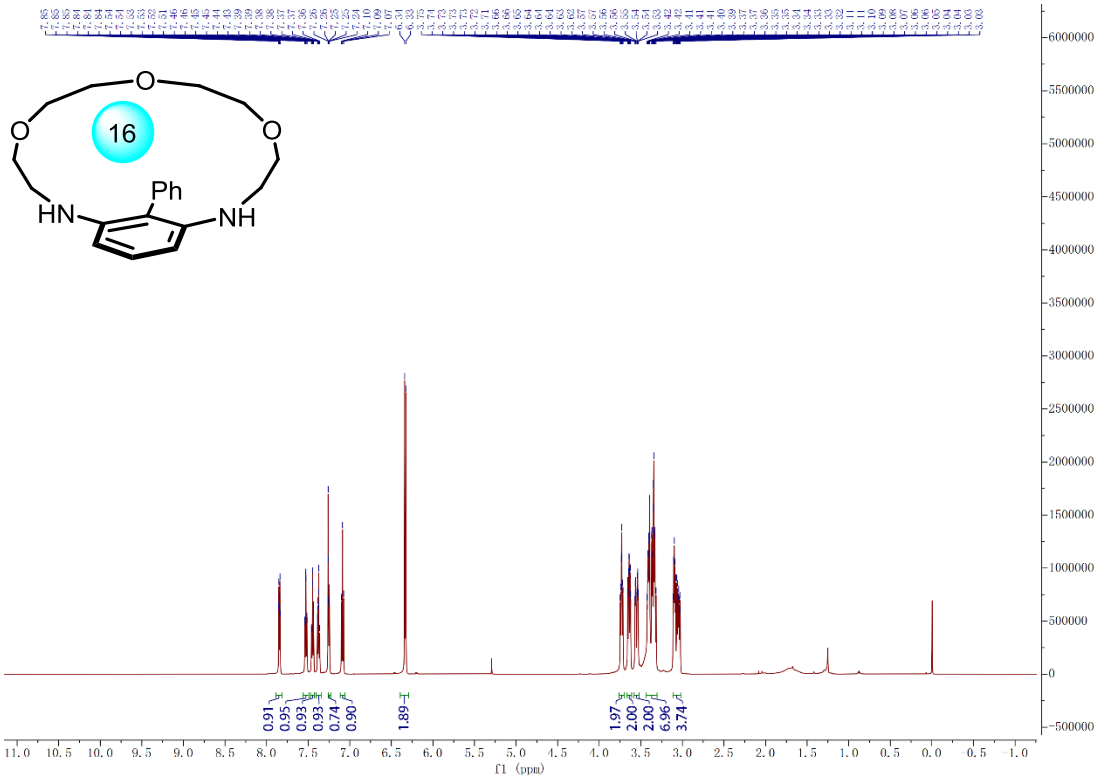



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

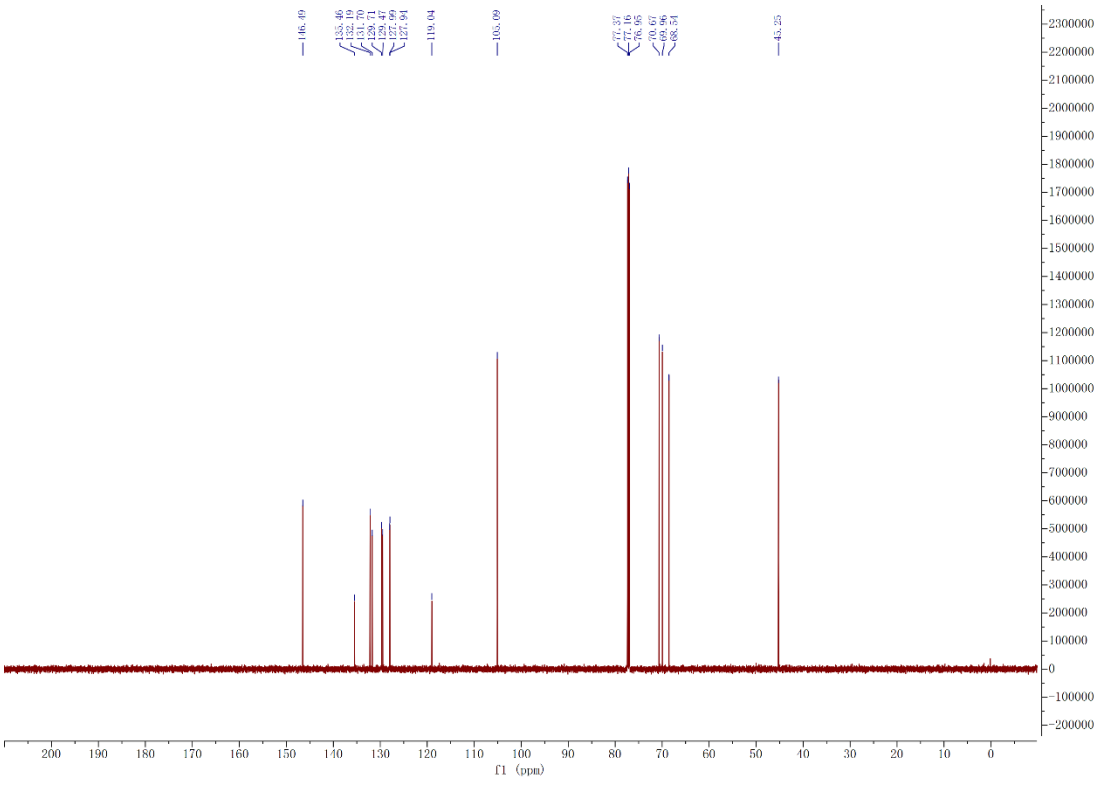


$1^2$-phenyl-5,8,11-trioxa-2,14-diaza-1(1,3)-benzenacyclotetradecaphane (**1o**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

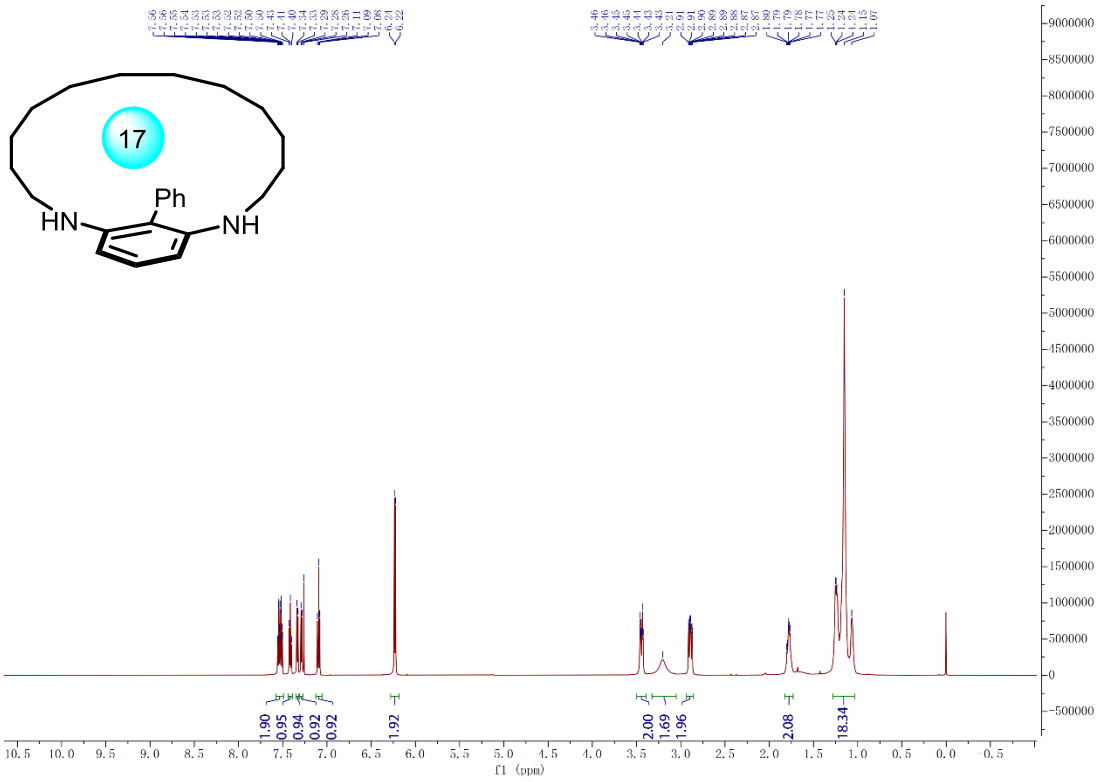



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

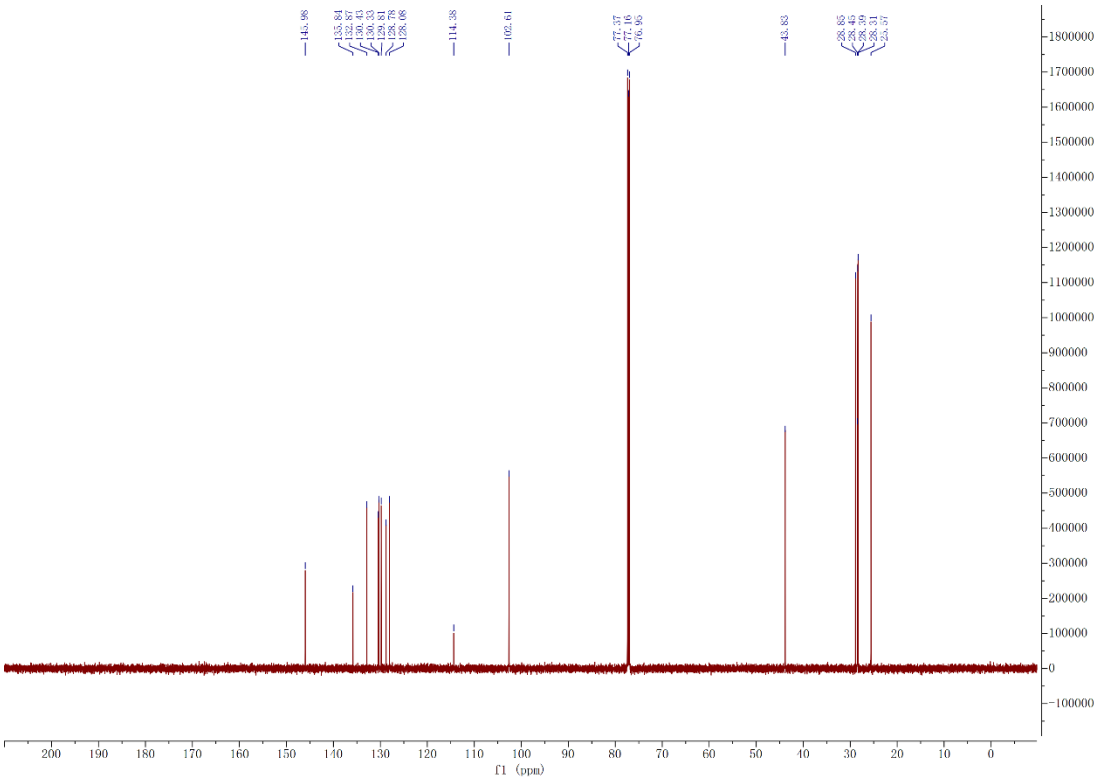


$1^2$-phenyl-2,15-diaza-1(1,3)-benzenacyclopentadecaphane (**1p**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

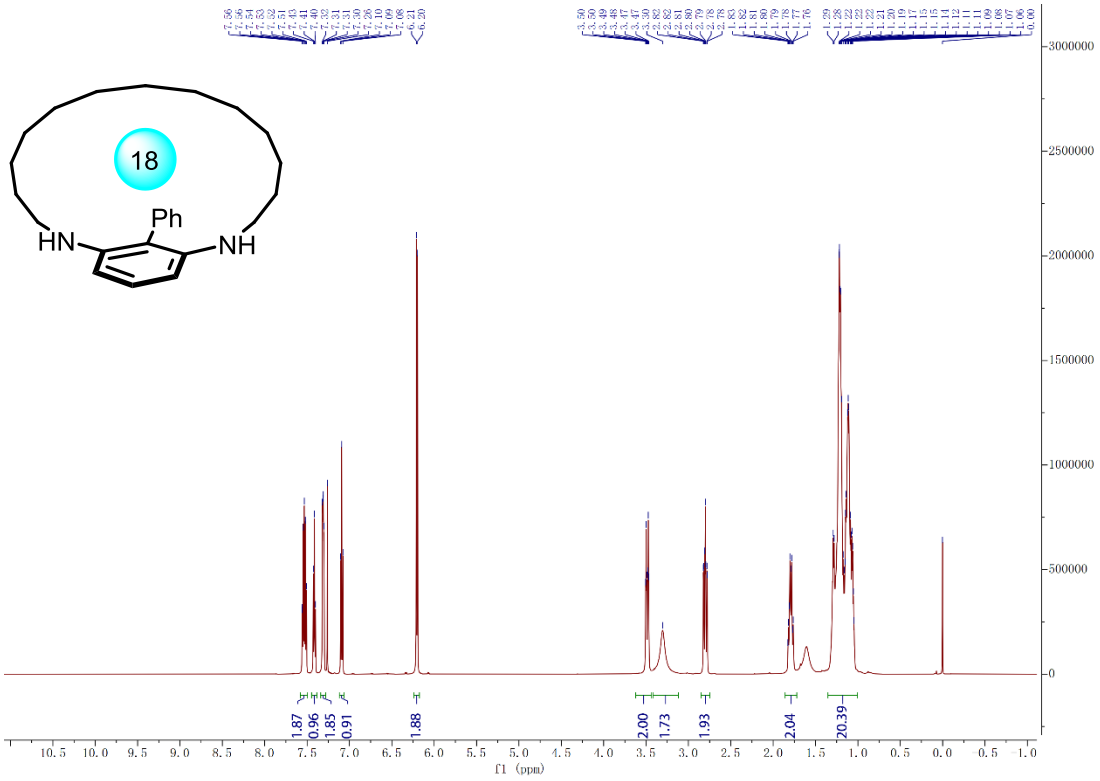



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

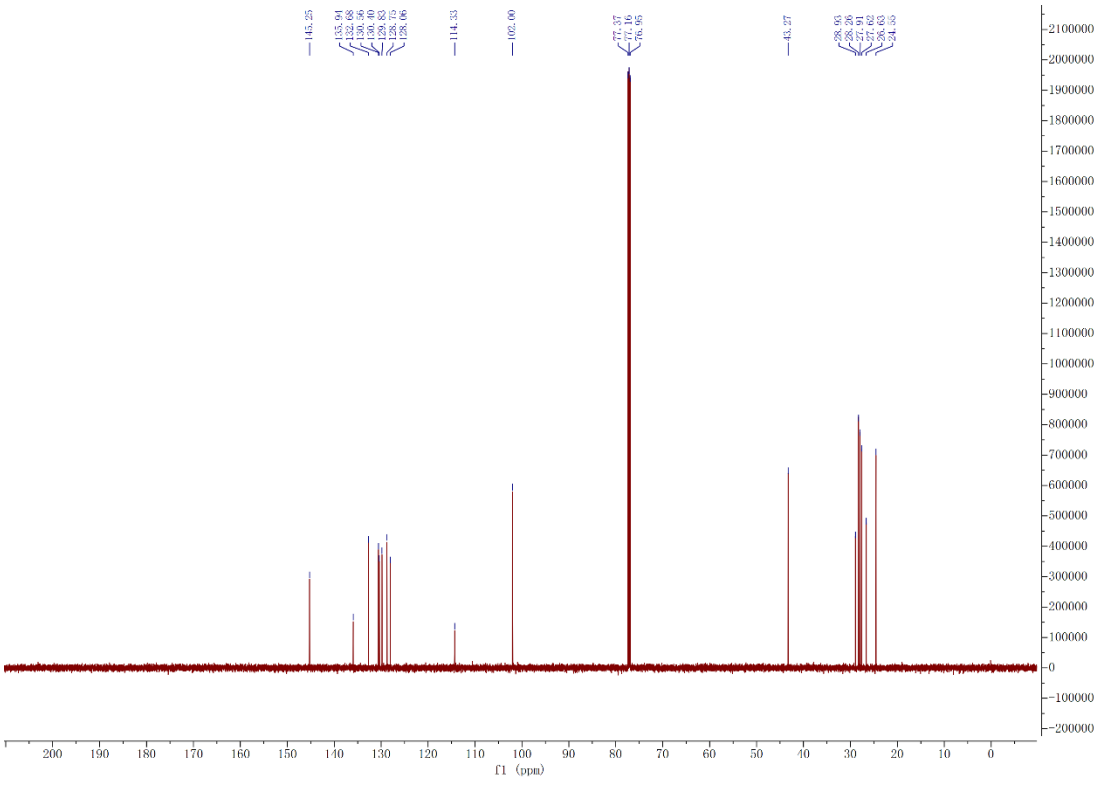


$1^2$-phenyl-2,16-diaza-1(1,3)-benzenacyclohexadecaphane (**1q**)

**$^1$H NMR** (600 MHz, $CDCl_3$)




**$^{13}$C NMR** (151 MHz, $CDCl_3$)

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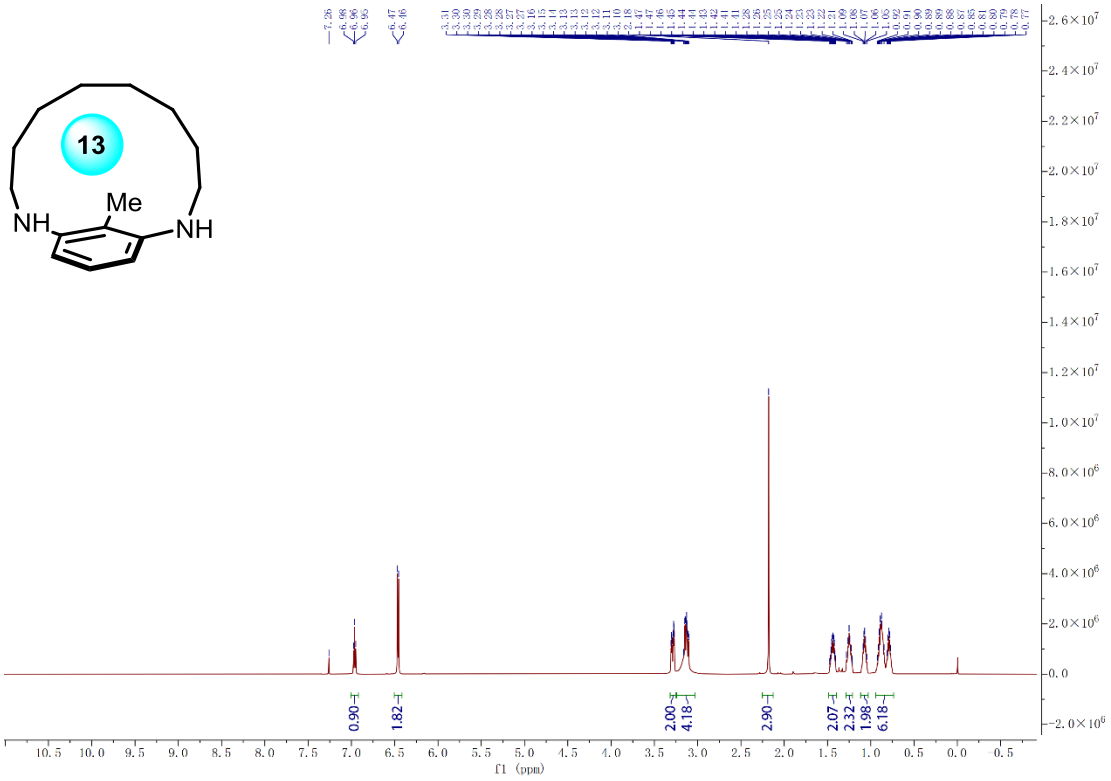
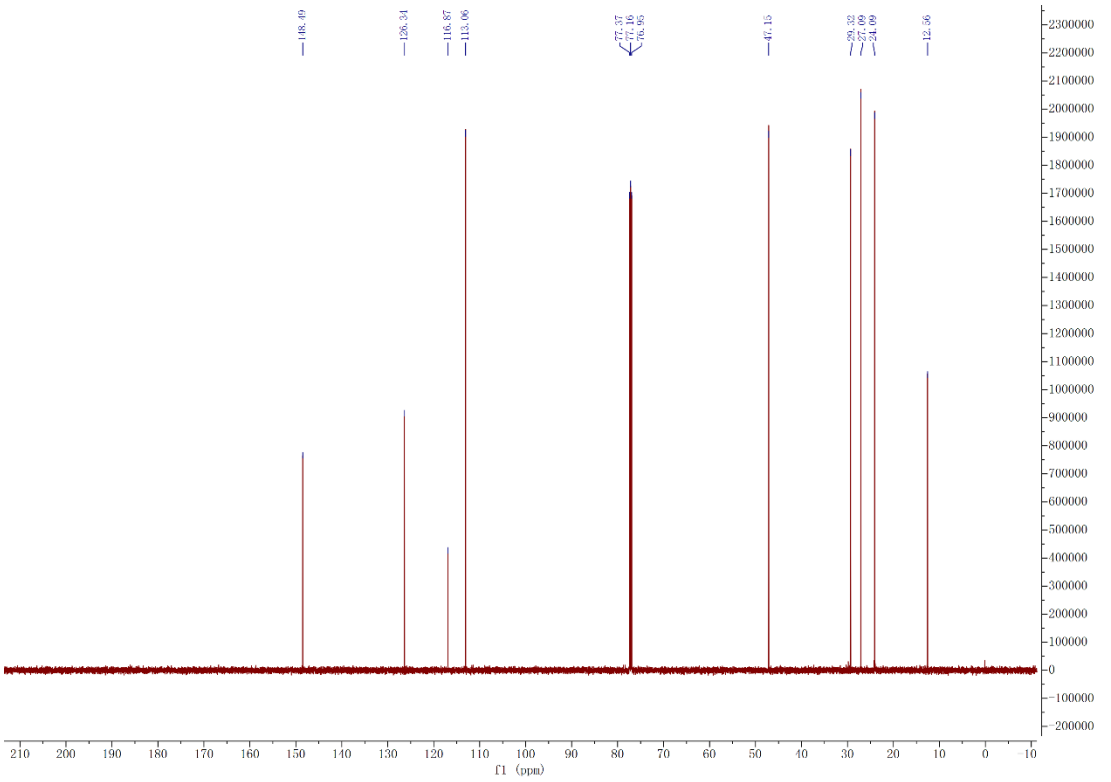
$1^2$-methyl-2,11-diaza-1(1,3)-benzenacycloundecaphane (**4a**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

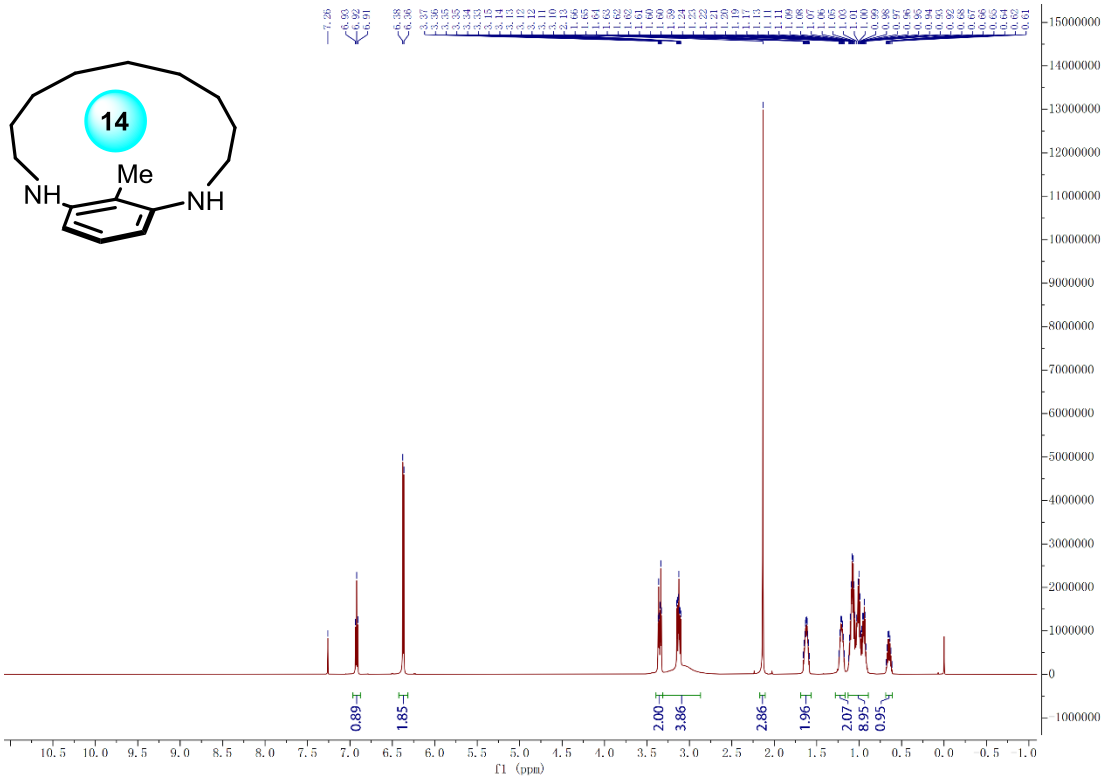



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

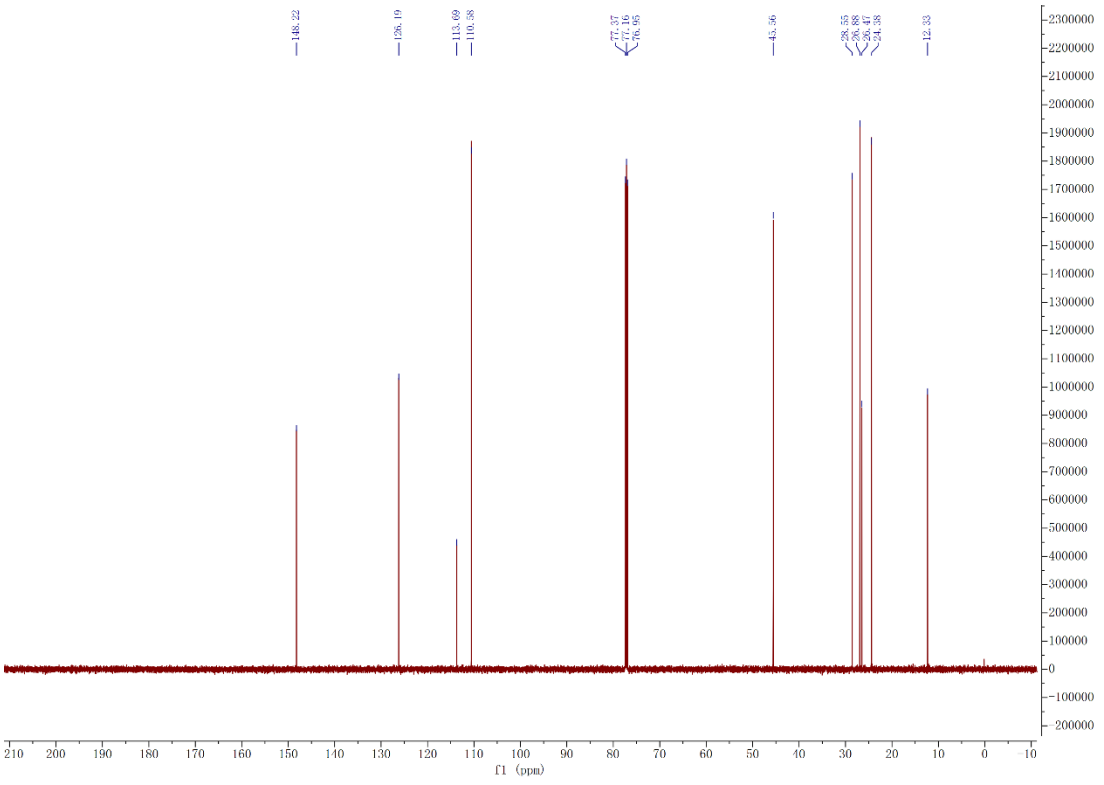


$1^2$-methyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4d**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

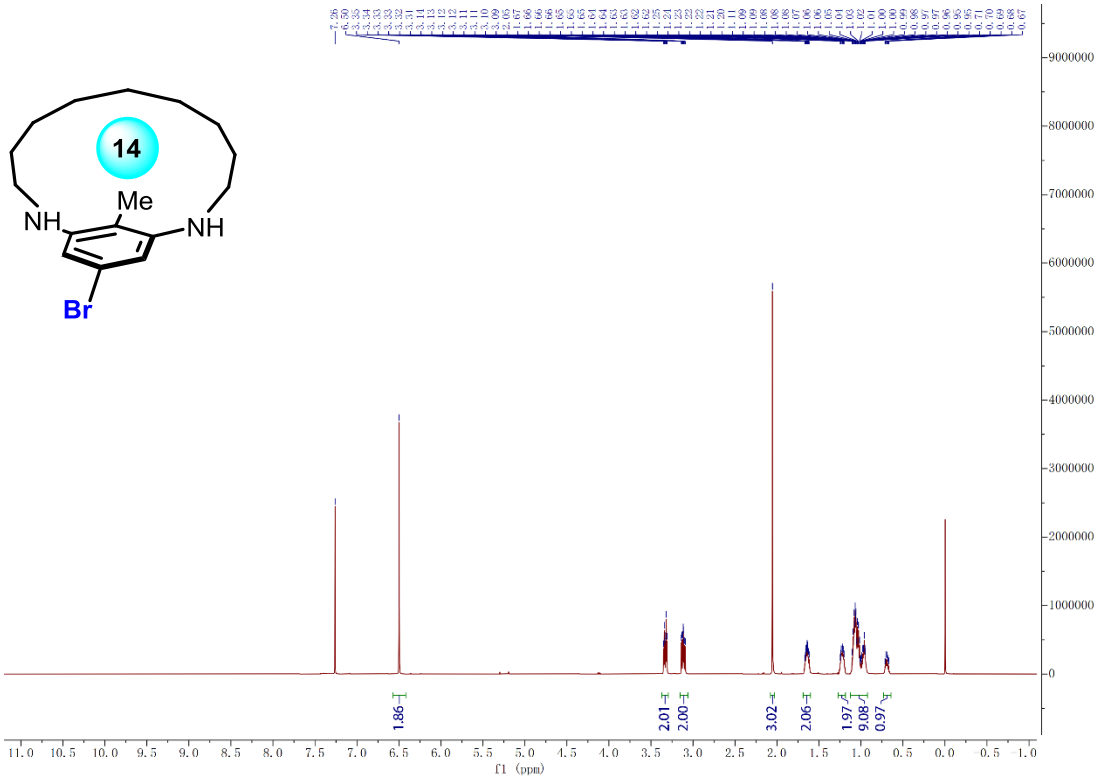



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

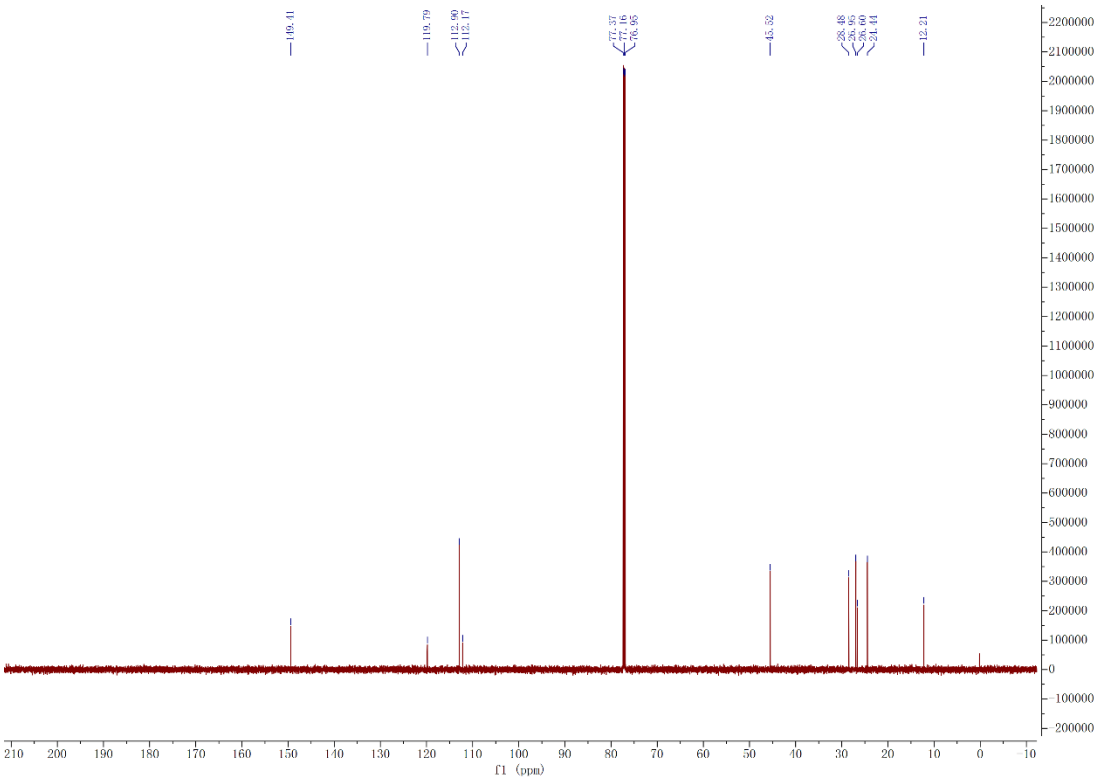


$1^5$-bromo-$1^2$-methyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4e**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

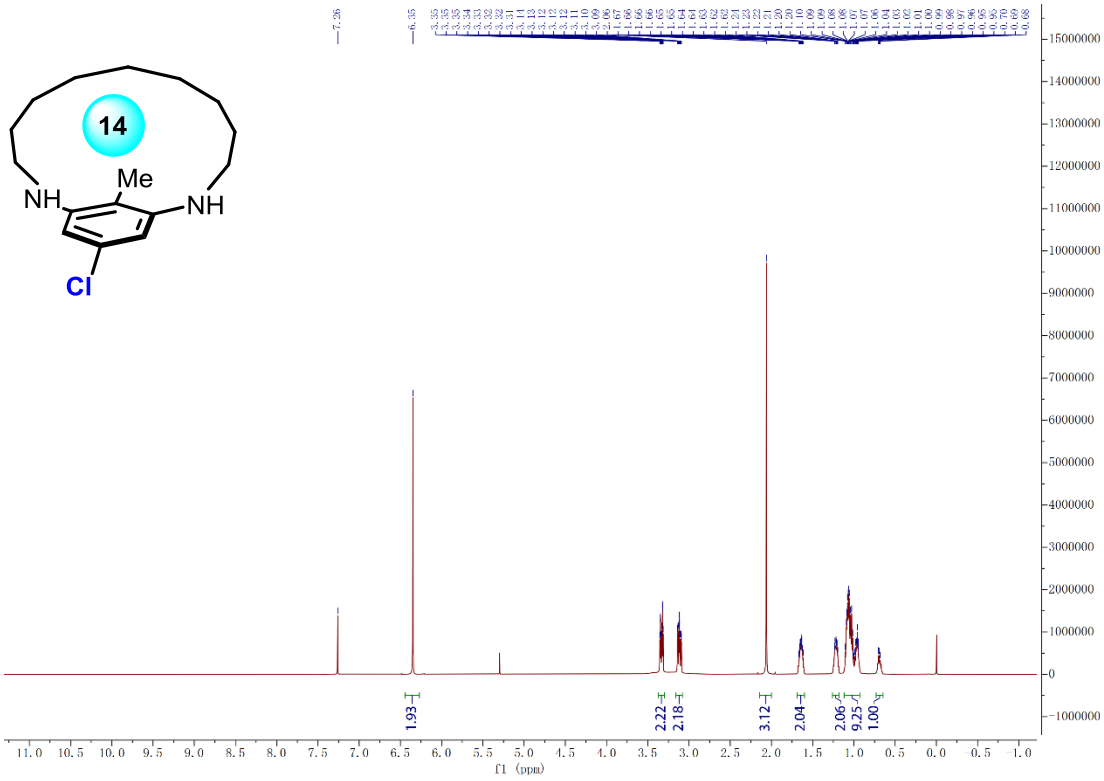



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

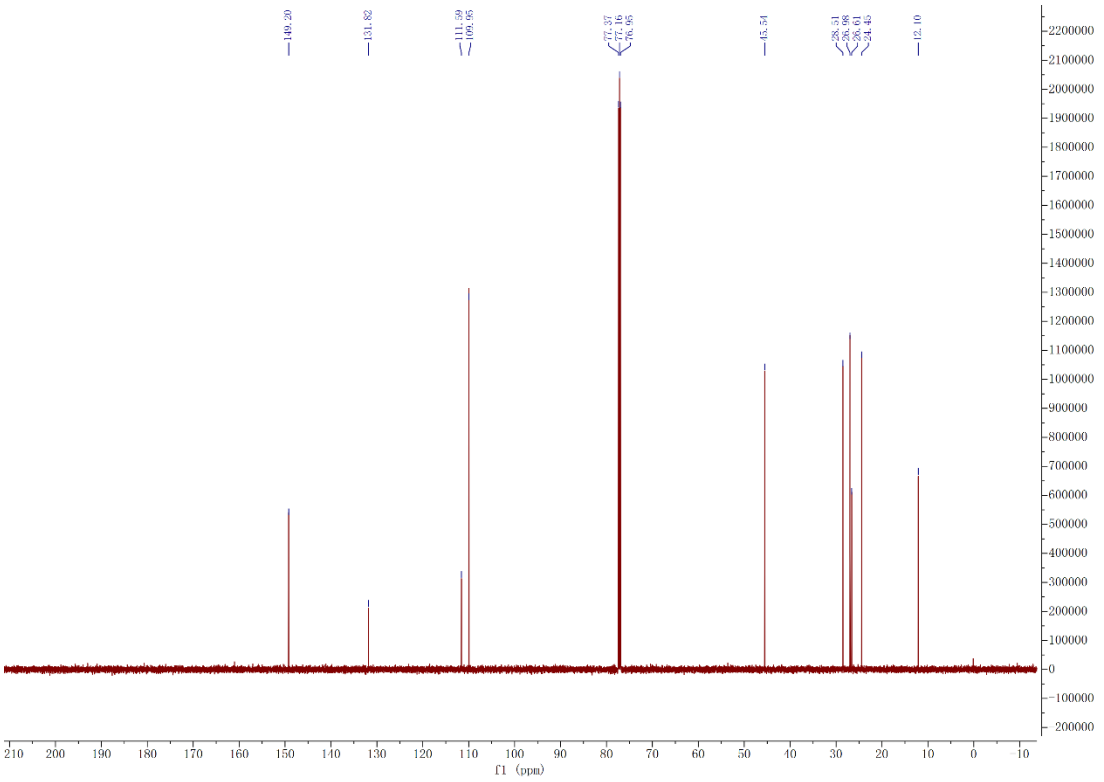


$1^5$-chloro-$1^2$-methyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4f**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

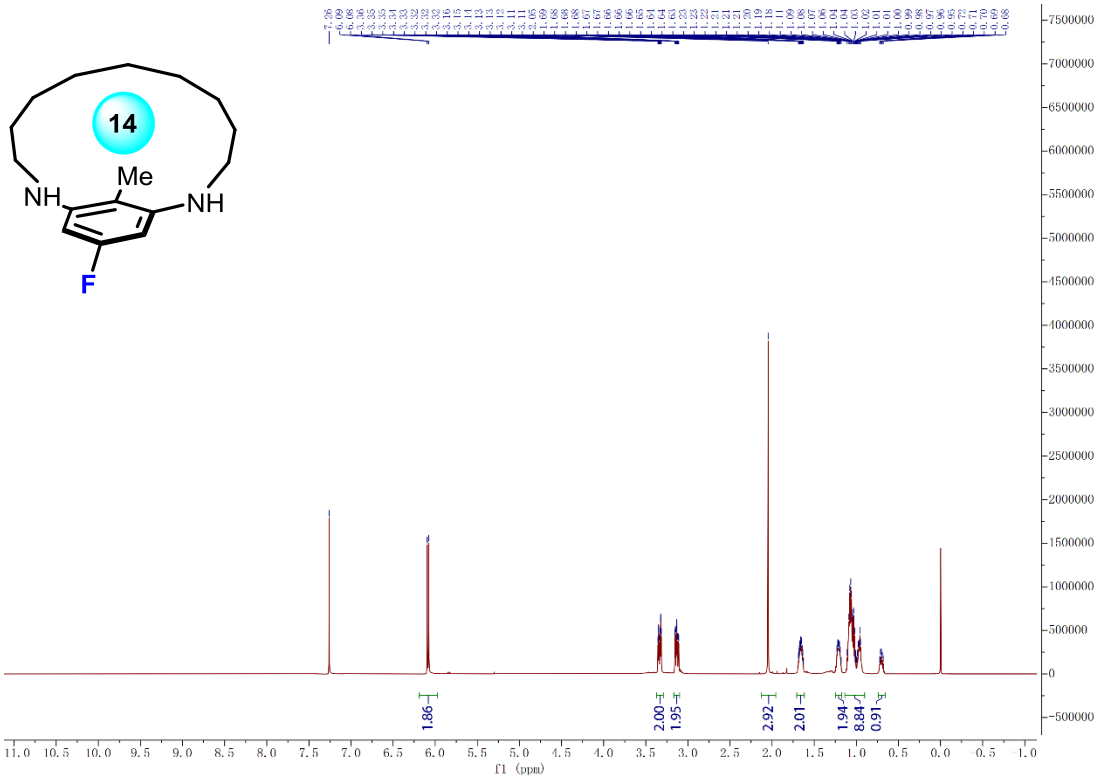



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

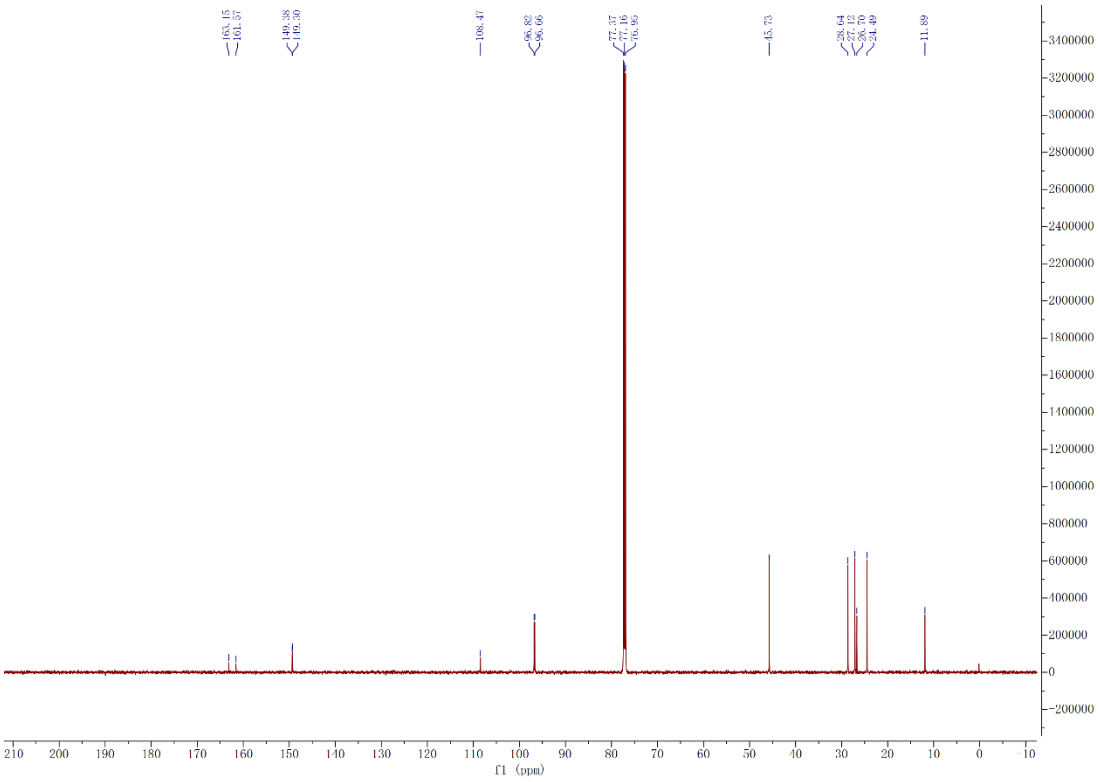


$1^5$-fluoro-$1^2$-methyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4g**)

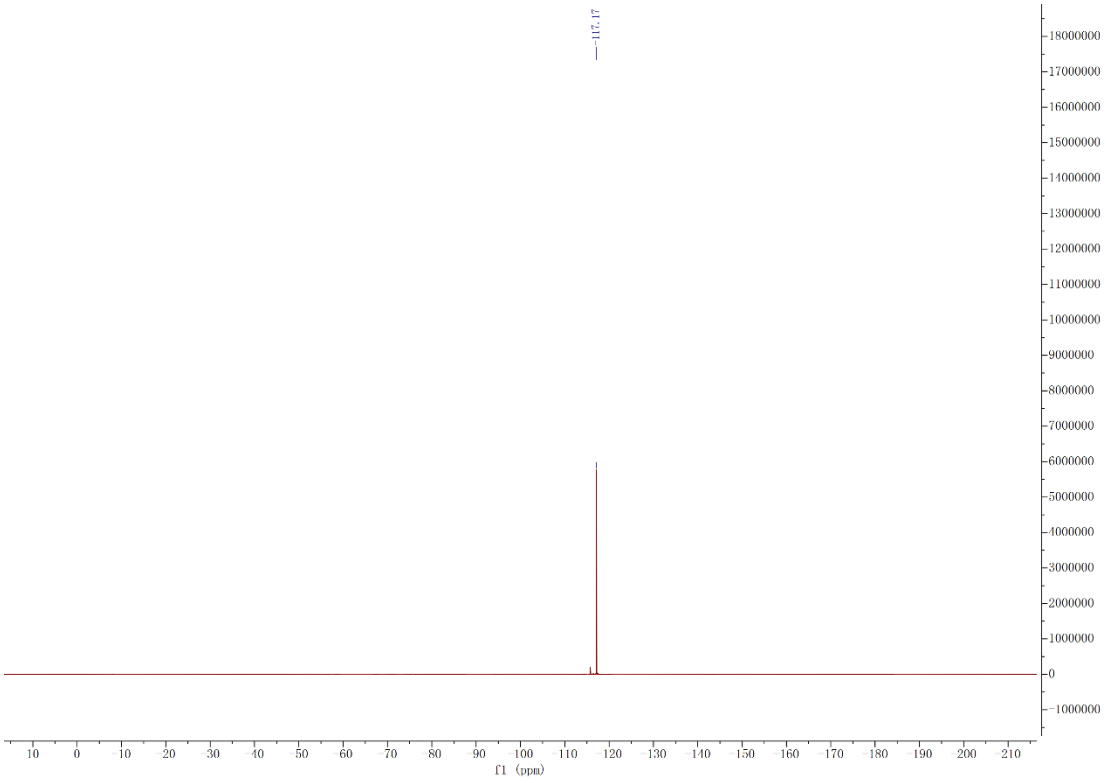
**$^1$H NMR** (600 MHz, $CDCl_3$)




**$^{13}$C NMR** (151 MHz, $CDCl_3$)

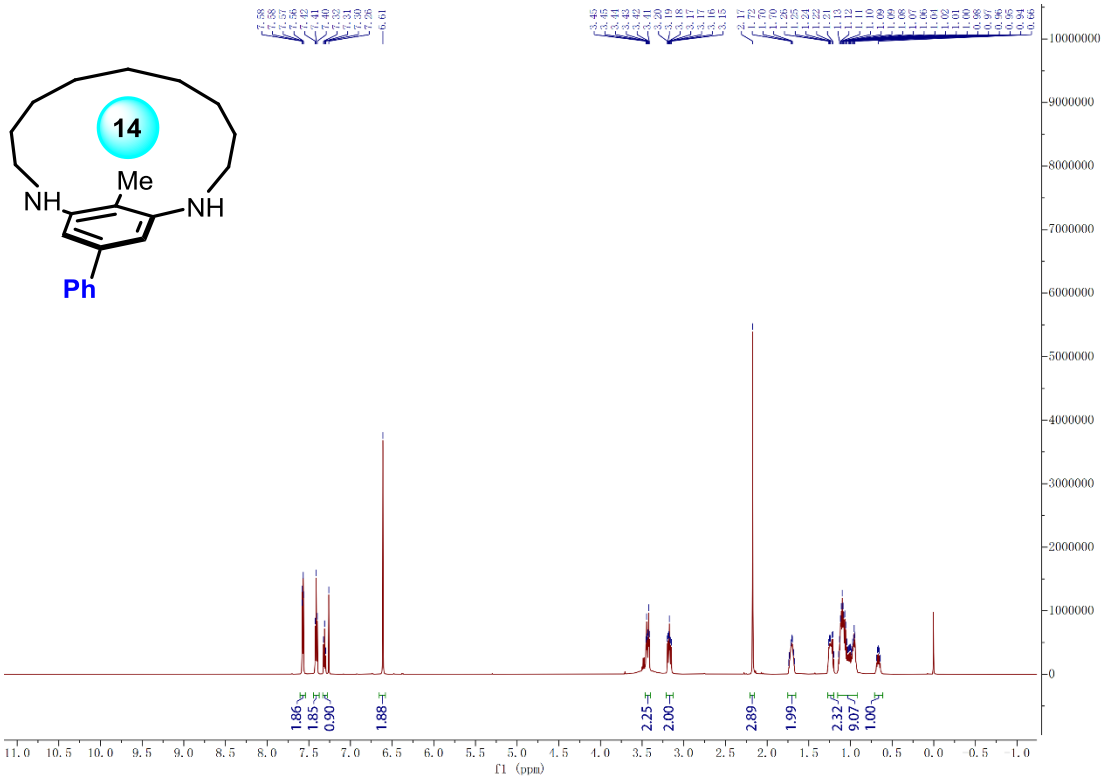


**$^{19}$F NMR** (565 MHz, $CDCl_3$)

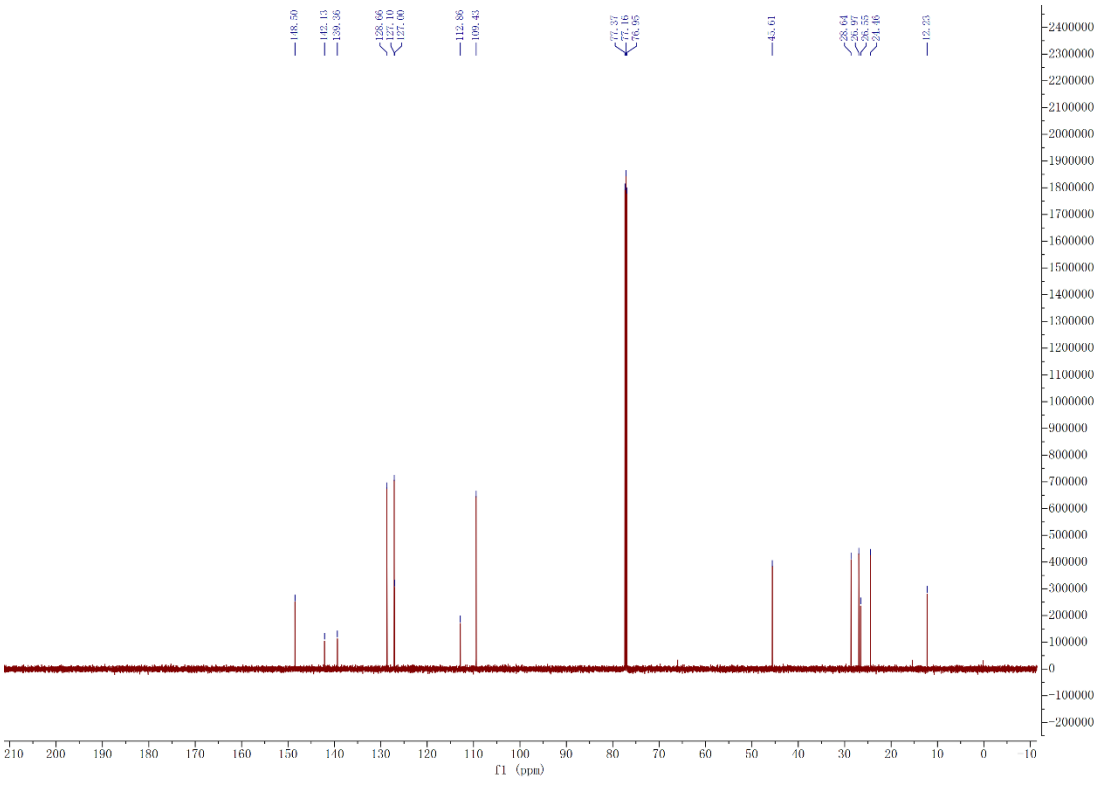


$1^2$-methyl-$1^5$-phenyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4h**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

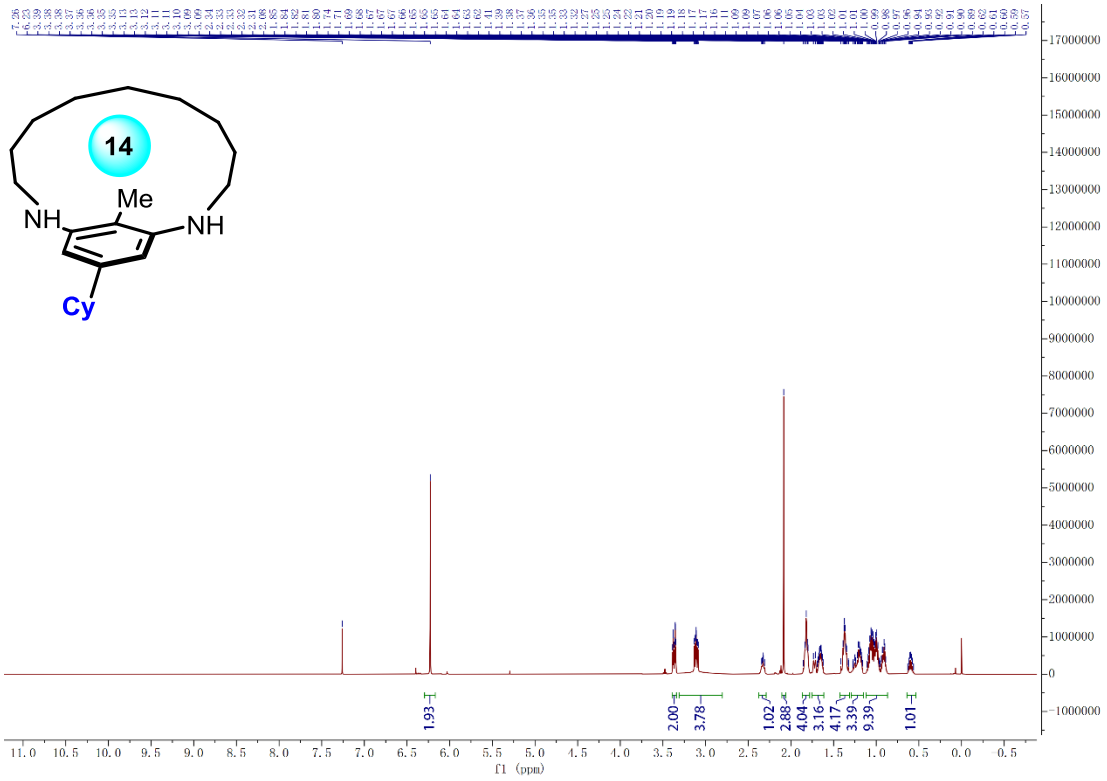



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

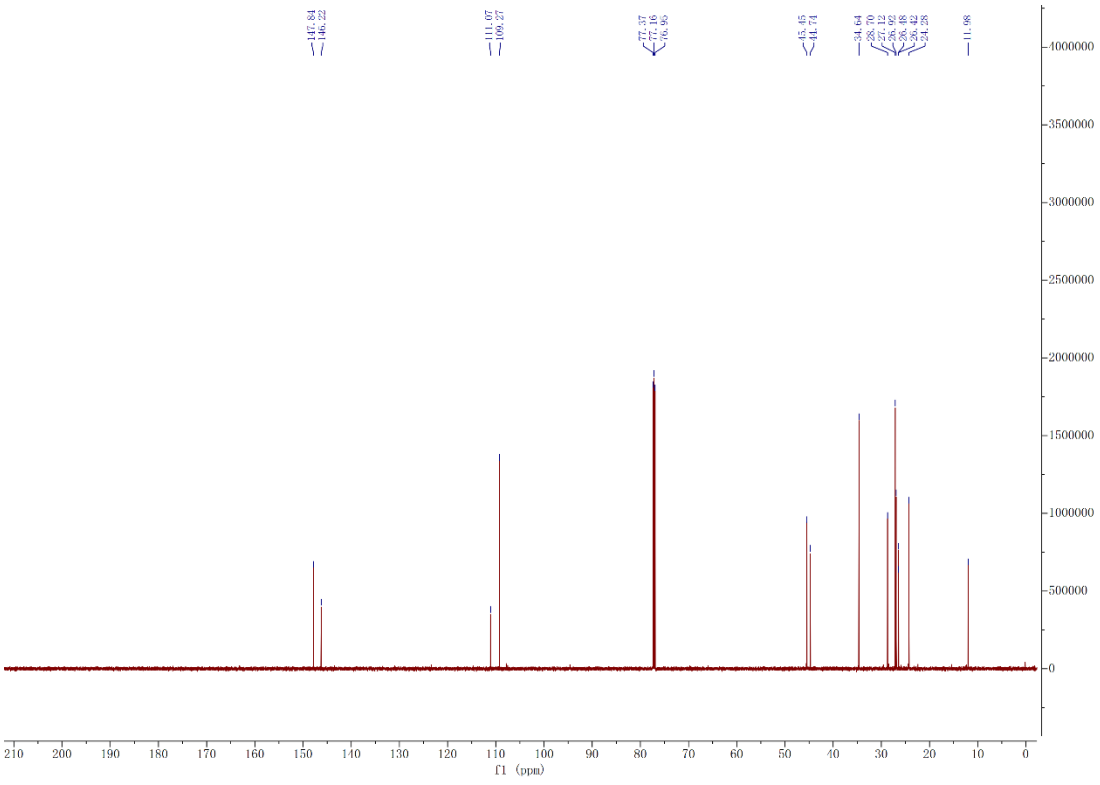


$1^5$-cyclohexyl-$1^2$-methyl-2,12-diaza-1(1,3)-benzenacyclododecaphane (**4i**)

**$^1$H NMR** (600 MHz, $CDCl_3$)

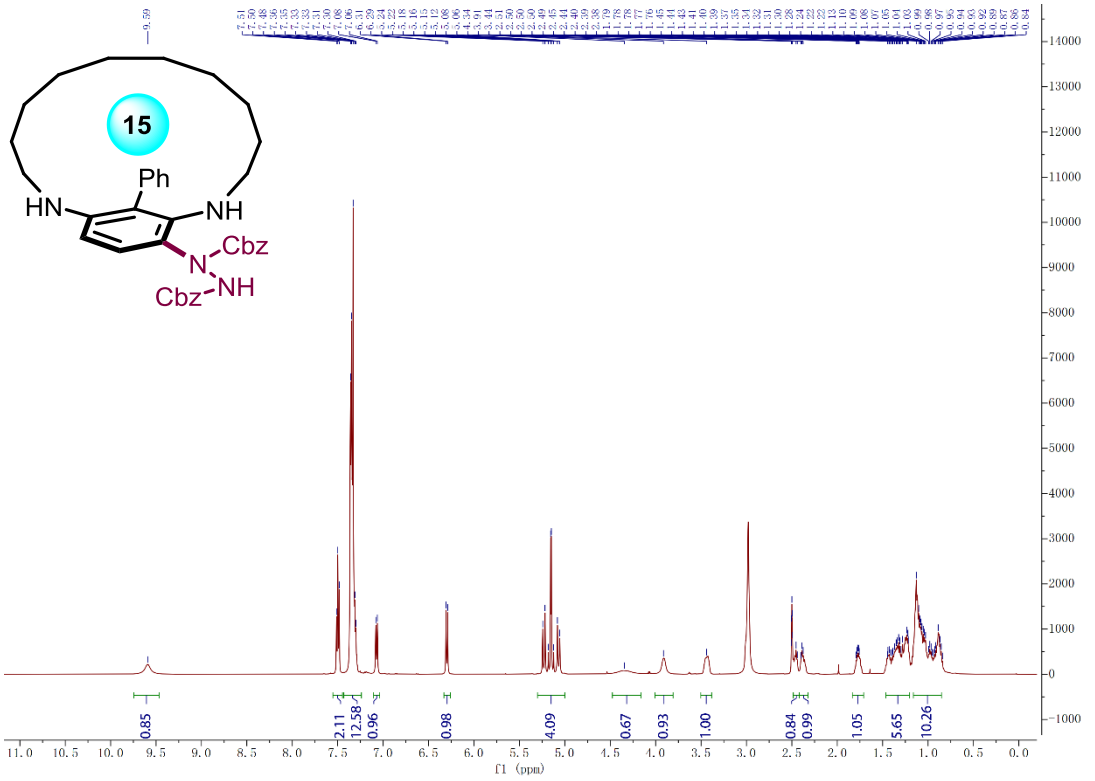



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

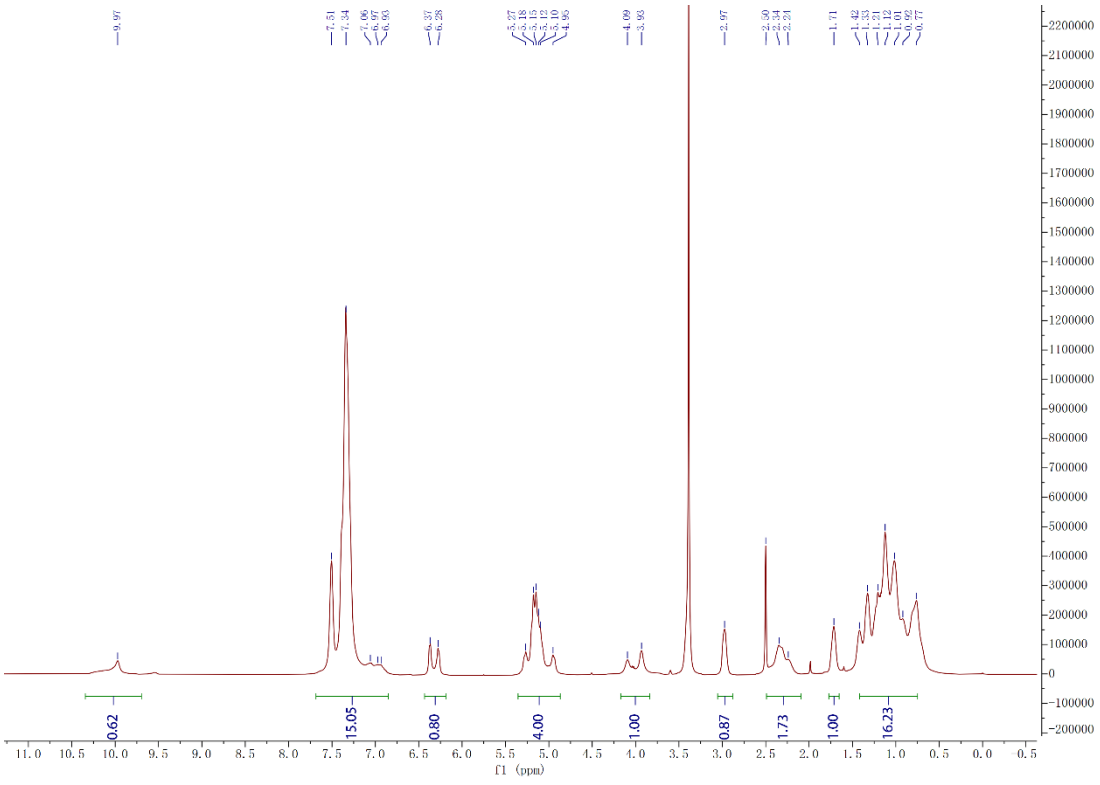


**Metacyclophanes 3a**

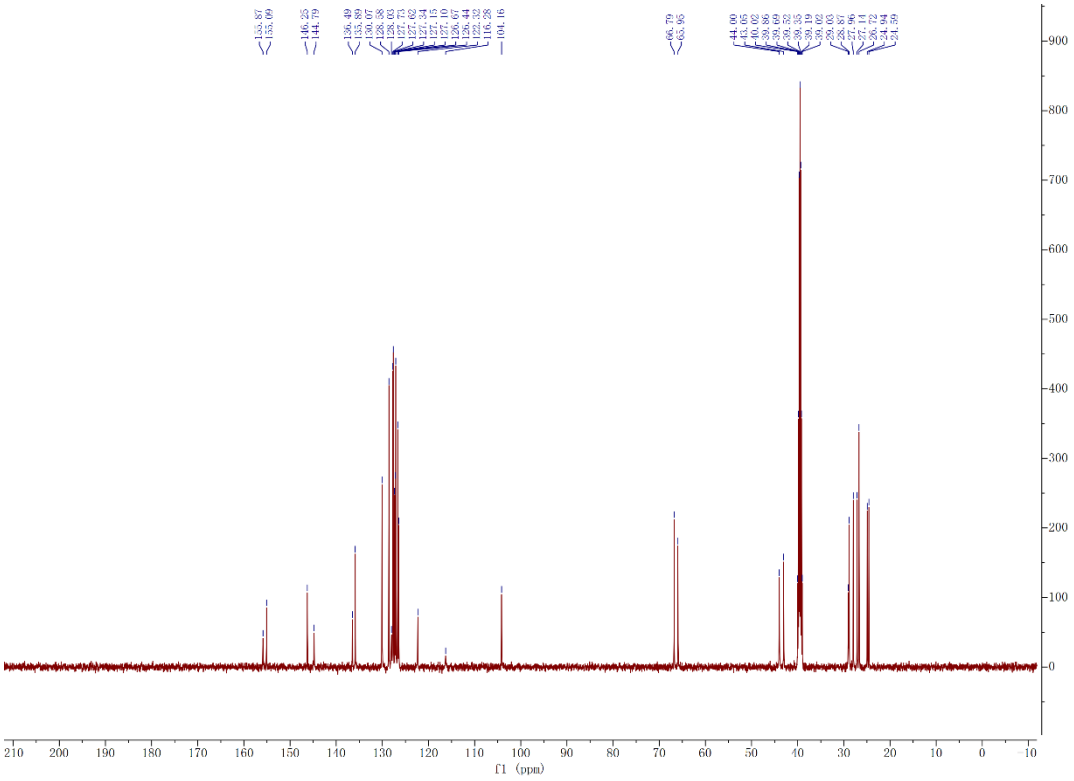
**$^1$H NMR** (500 MHz, DMSO-*d6*, 373 K)




**$^1$H NMR** (600 MHz, DMSO-*d6*, 298 K)

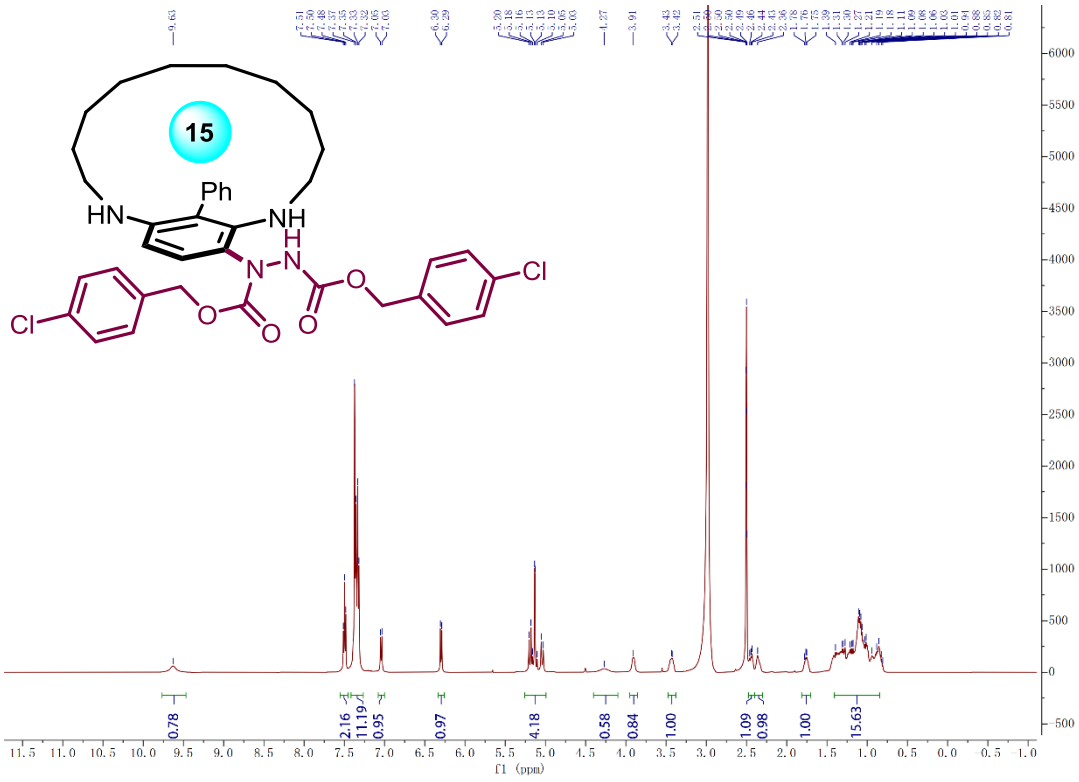


**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

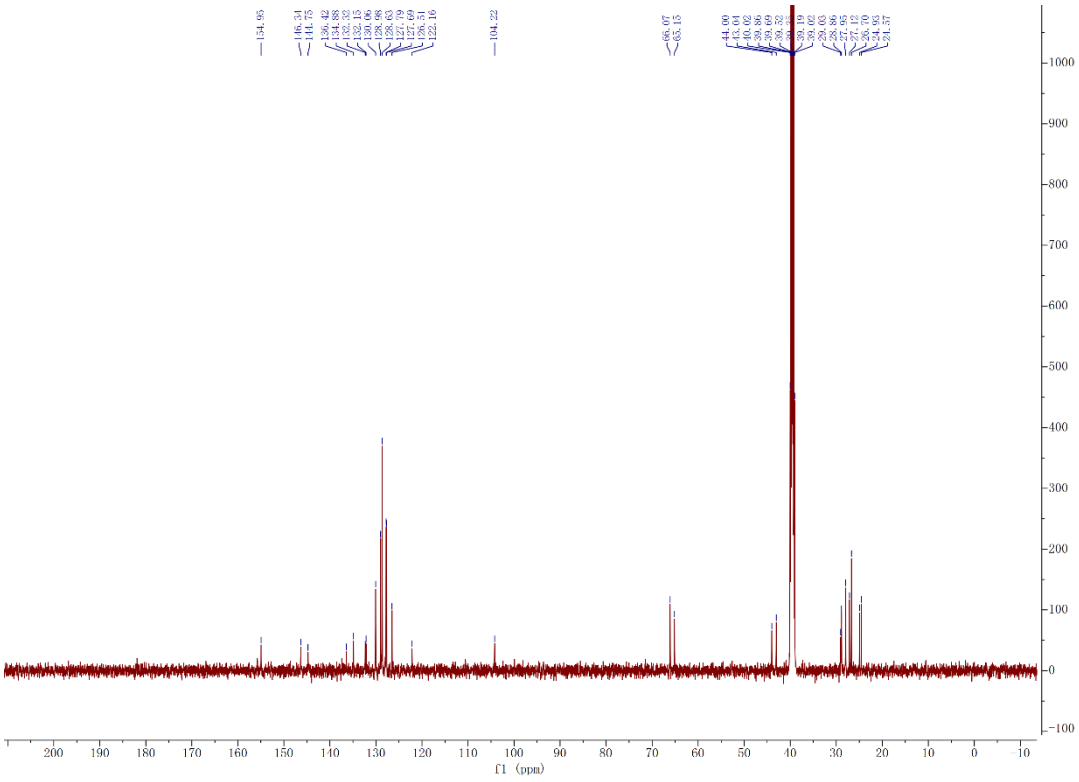


**Metacyclophanes 3b**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

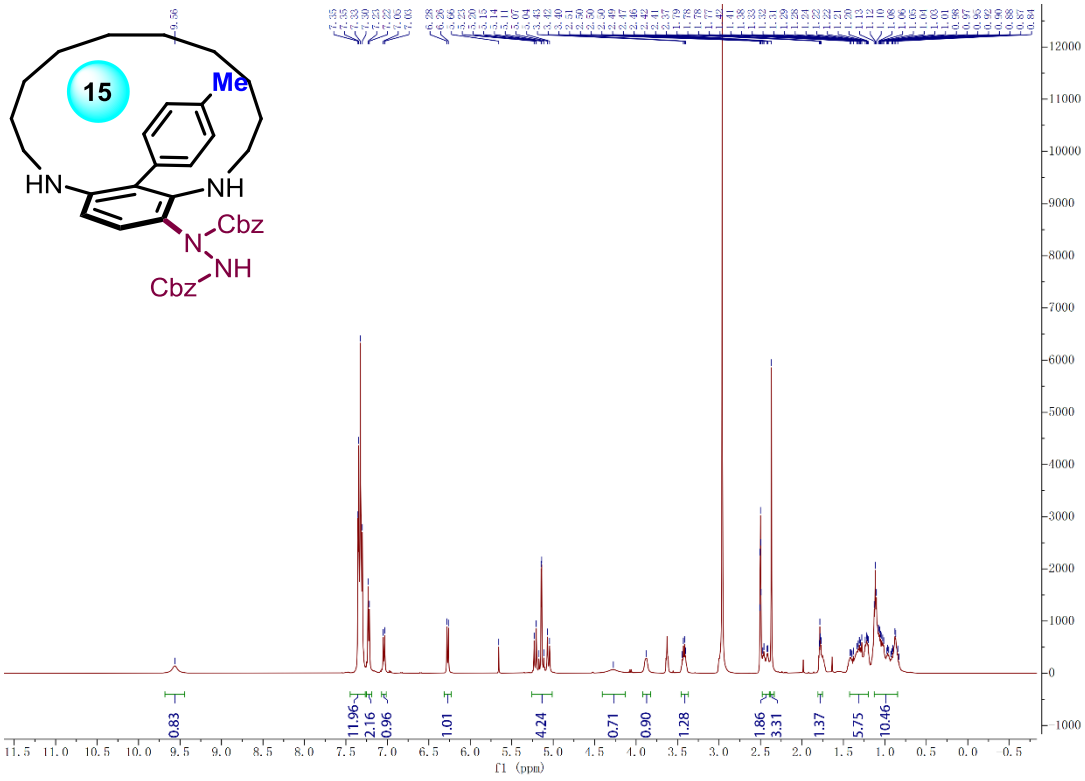



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

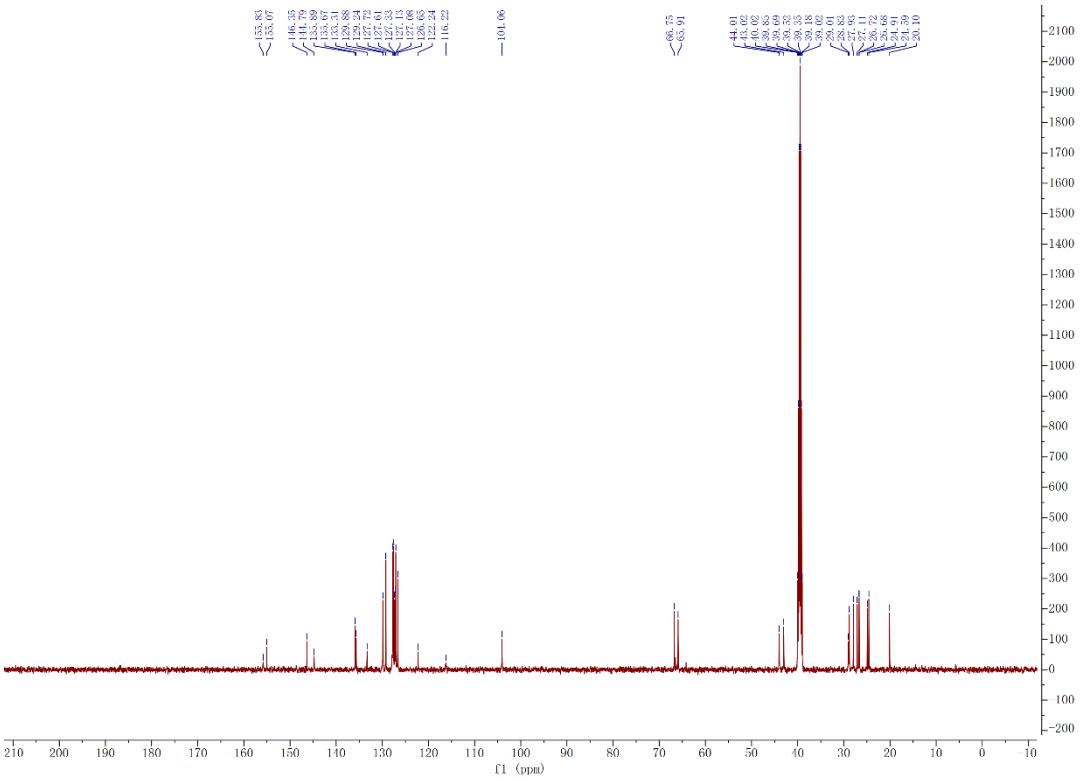


**Metacyclophanes 3c**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

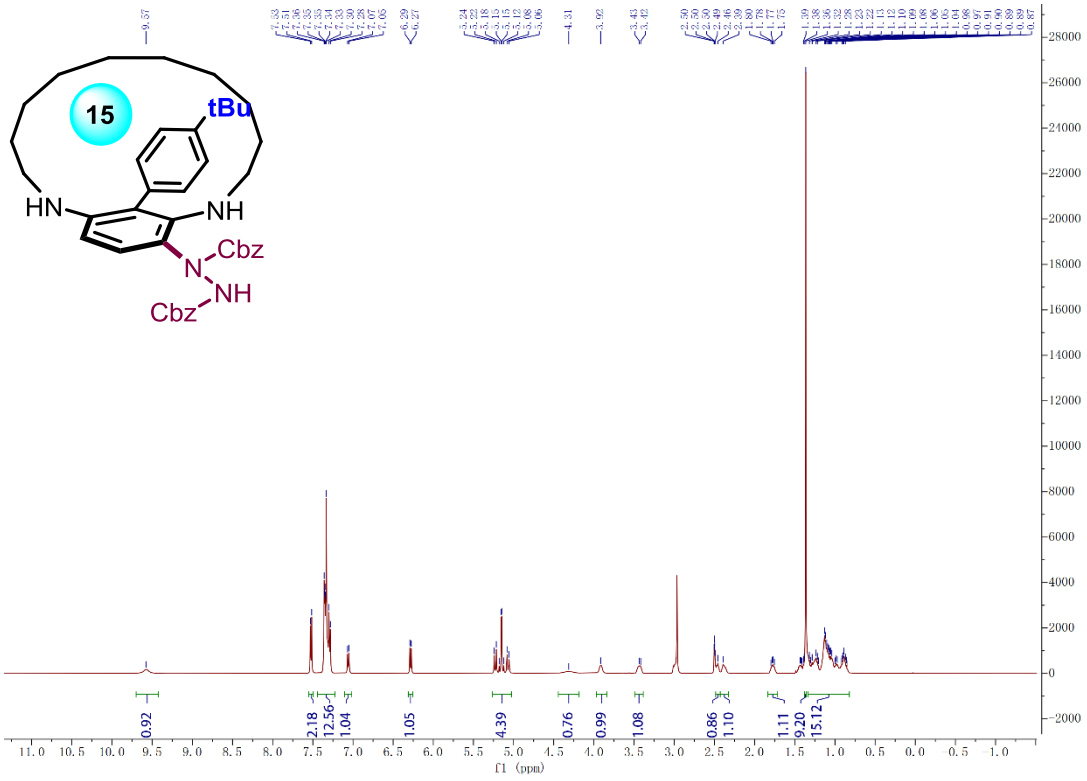



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

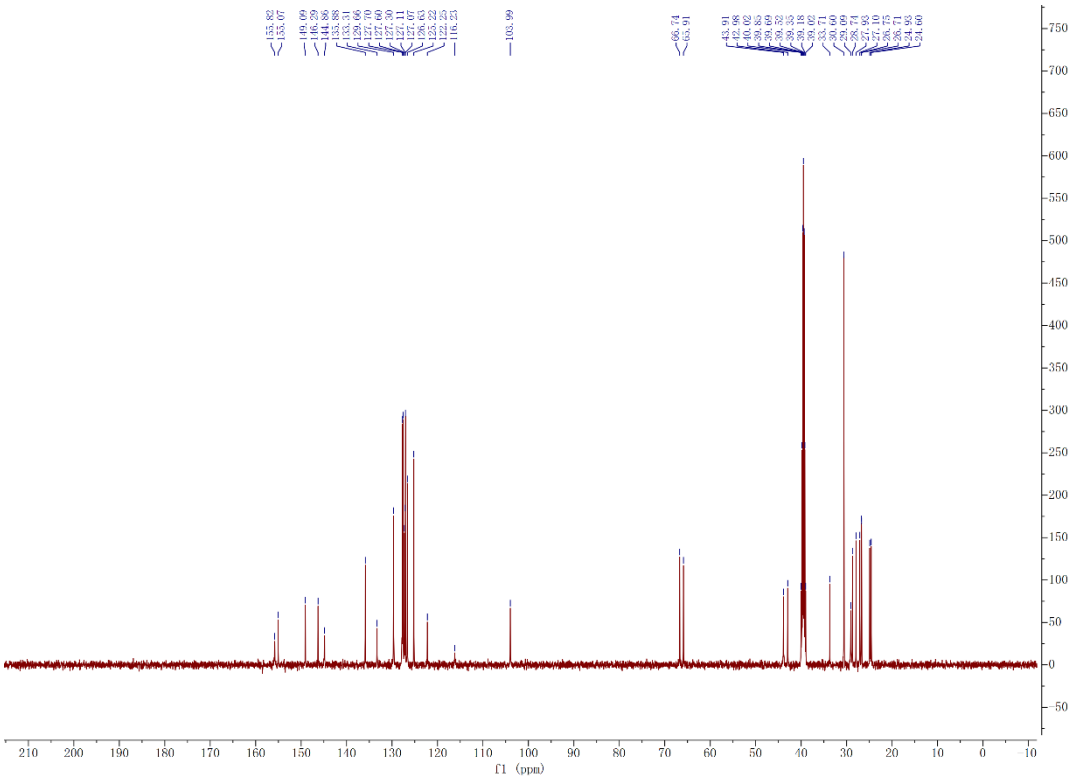


**Metacyclophanes 3d**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

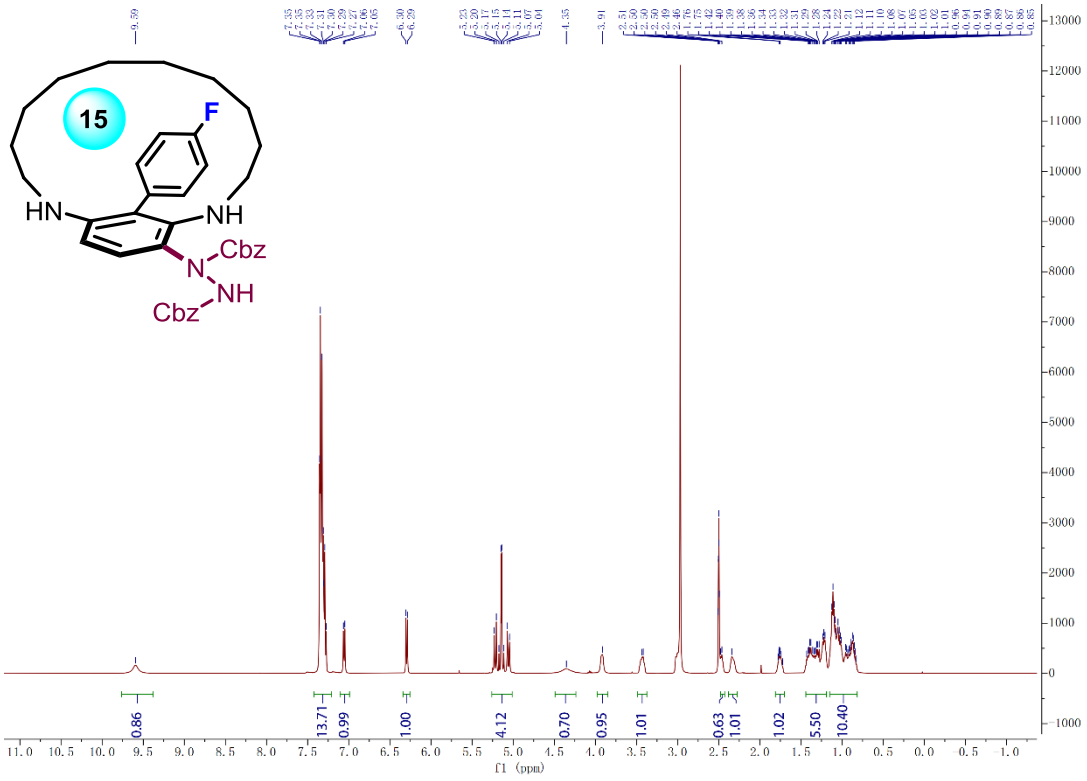



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

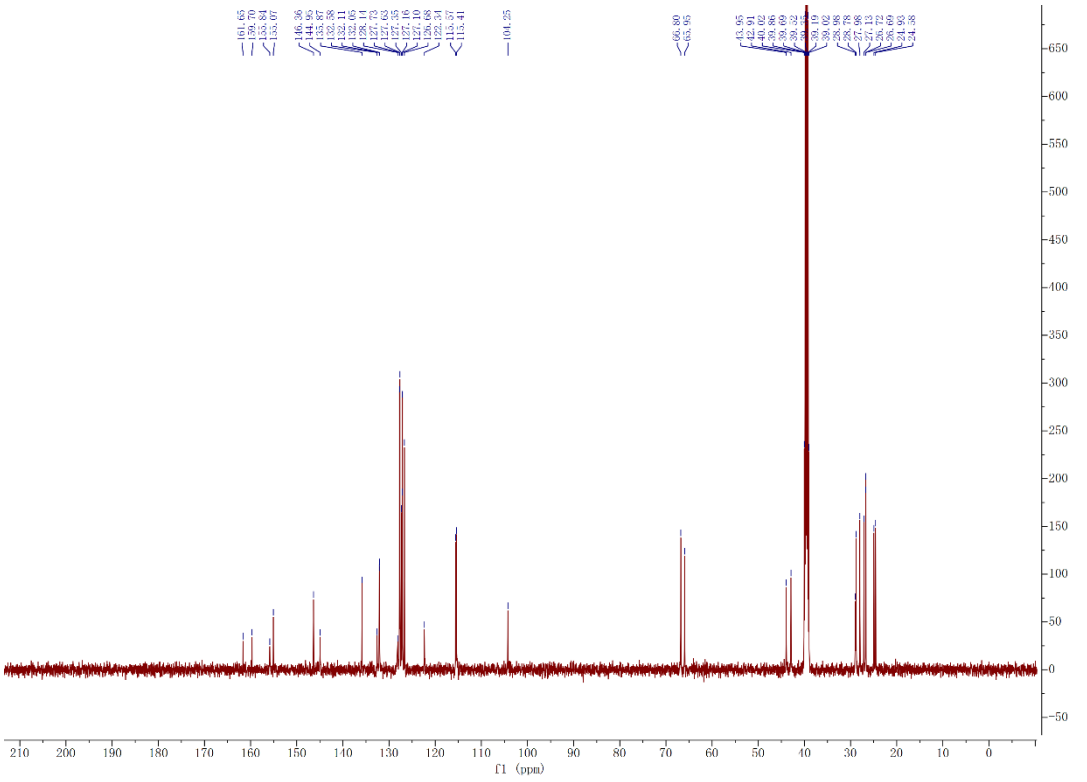


**Metacyclophanes 3e**

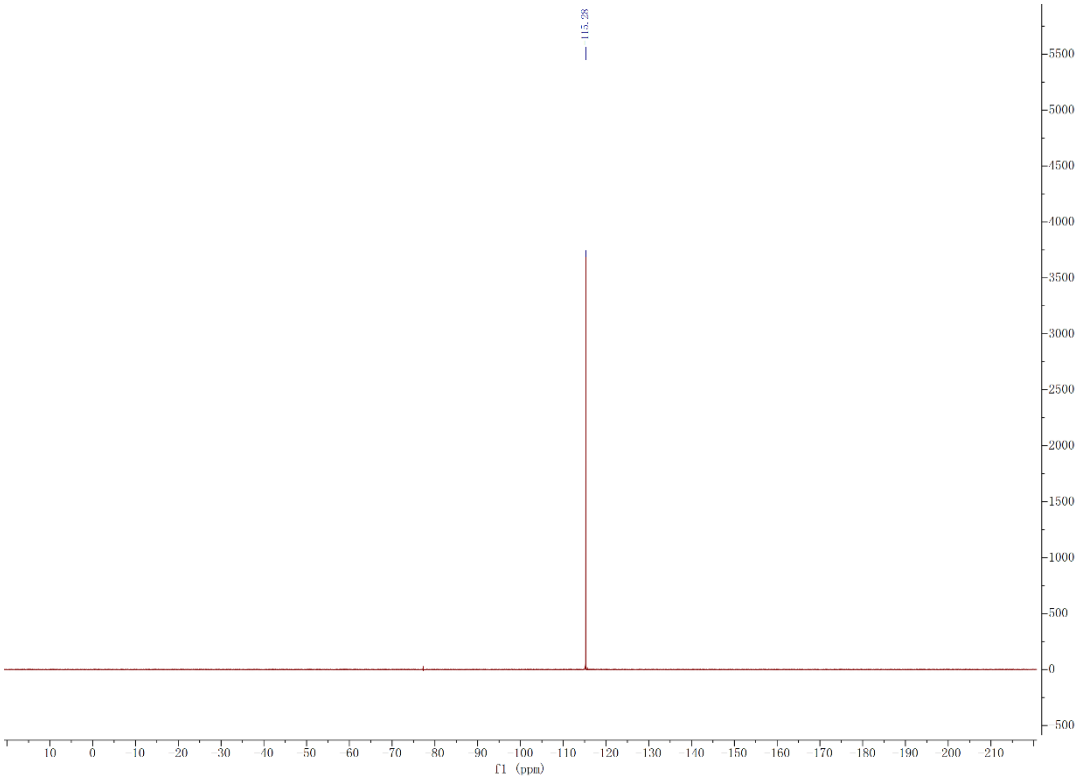
**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)




**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

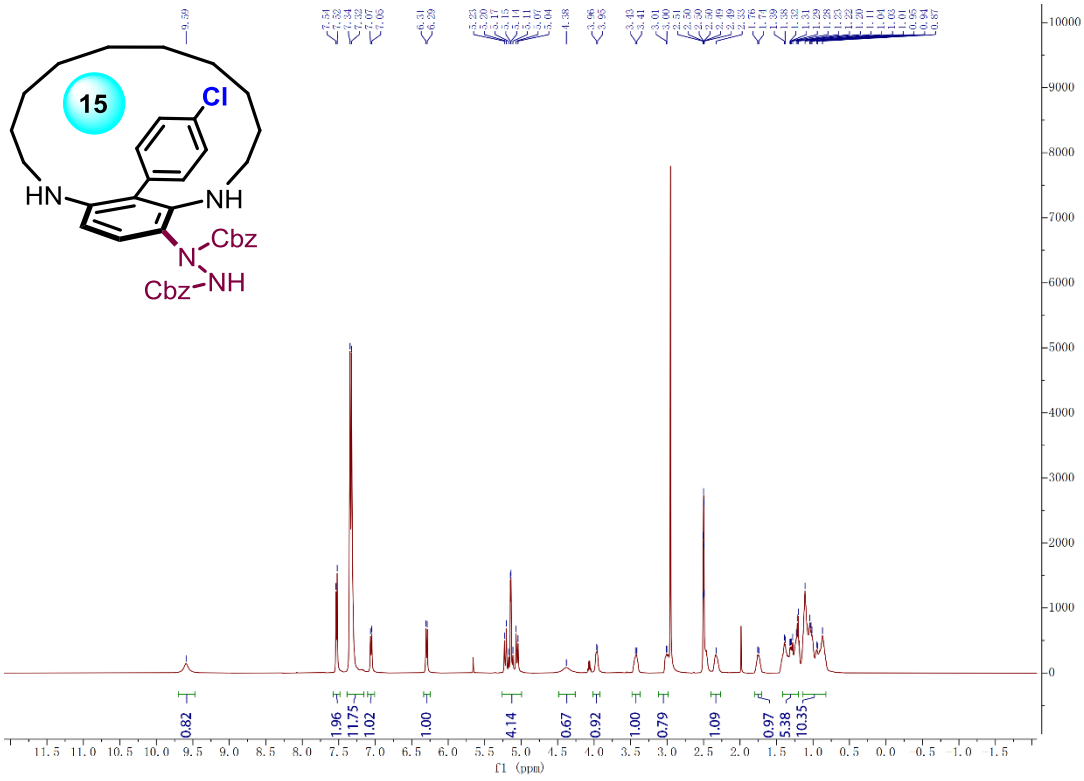


**$^{19}$F NMR** (471 MHz, DMSO-*d6*, 373 K)

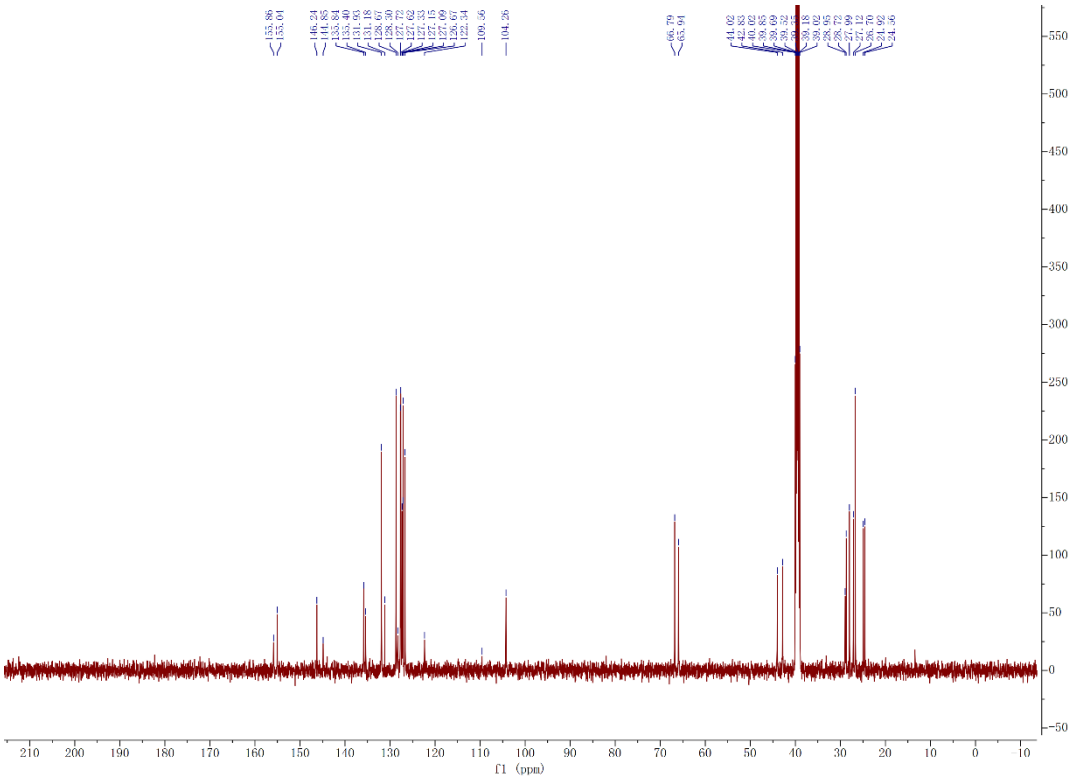


**Metacyclophanes 3f**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

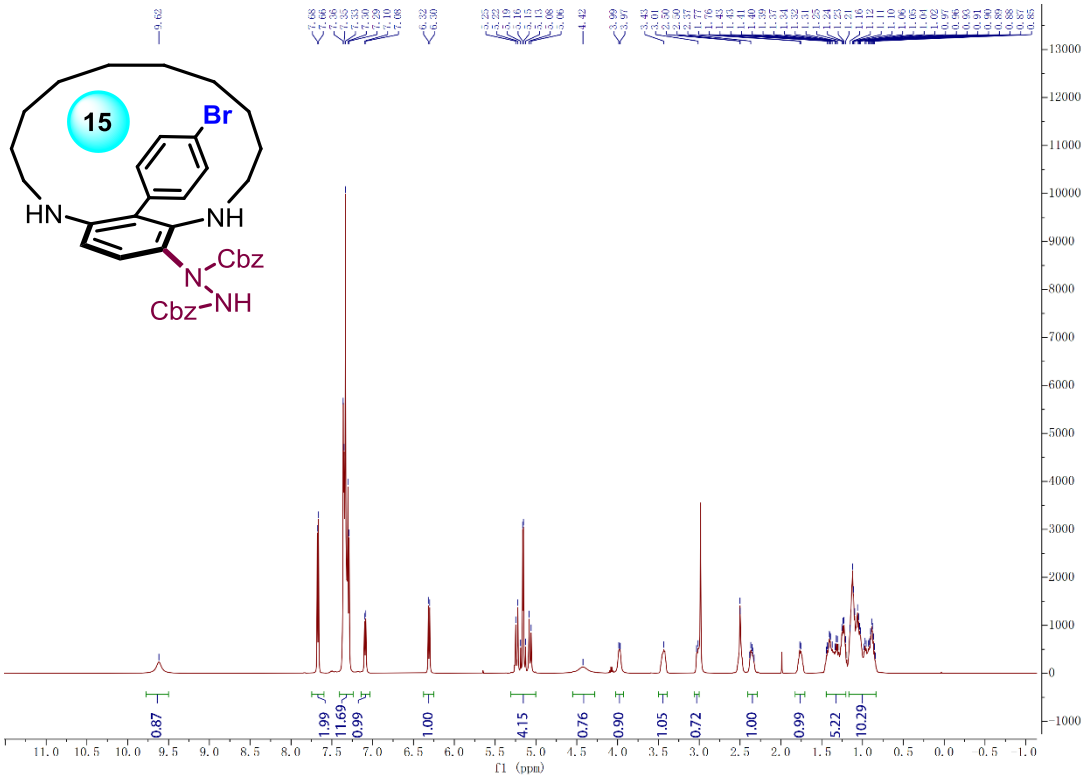



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

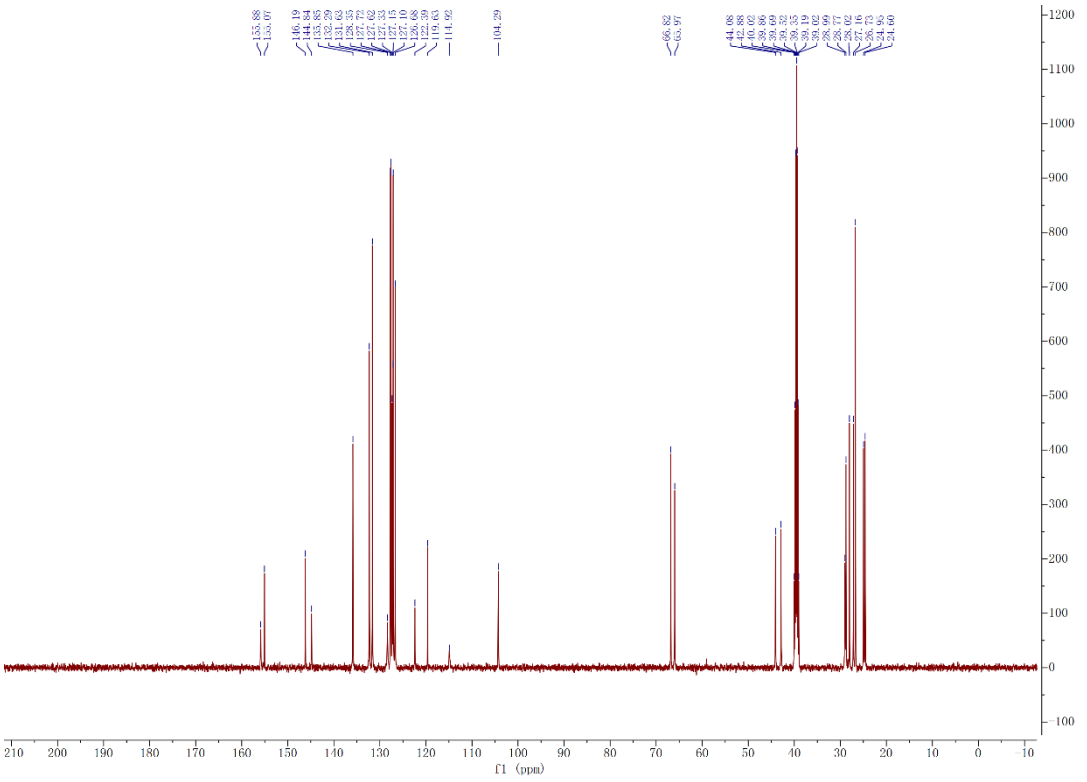


**Metacyclophanes 3g**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

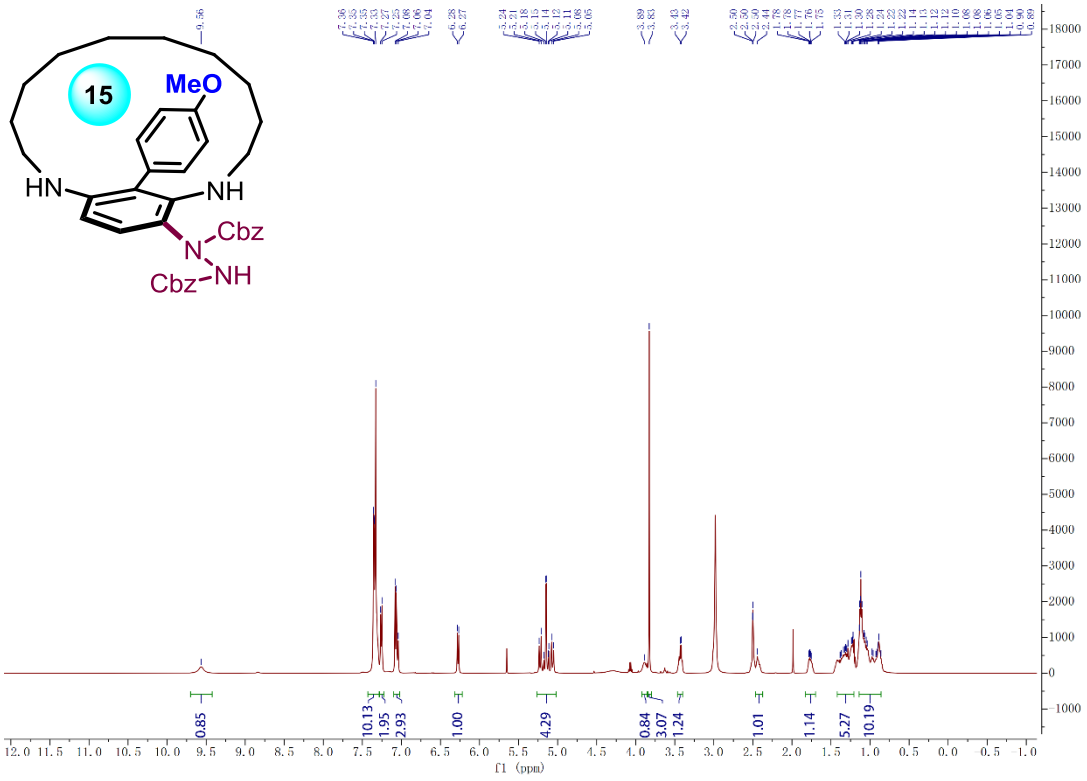



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

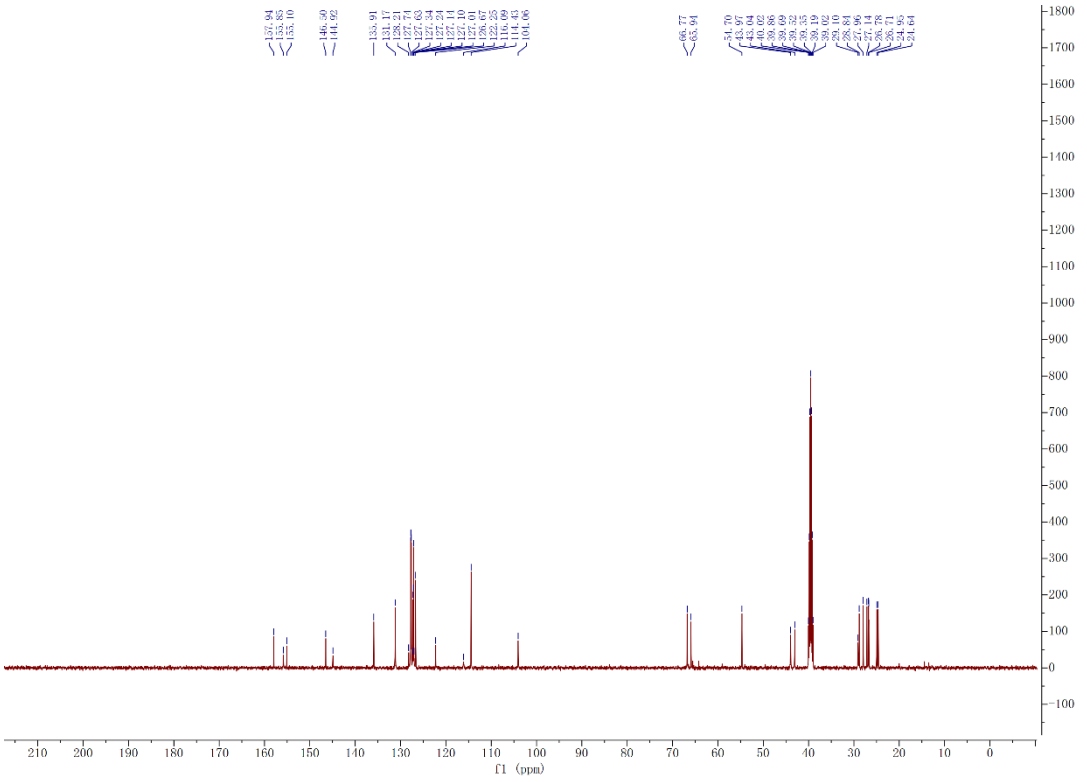


**Metacyclophanes 3h**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

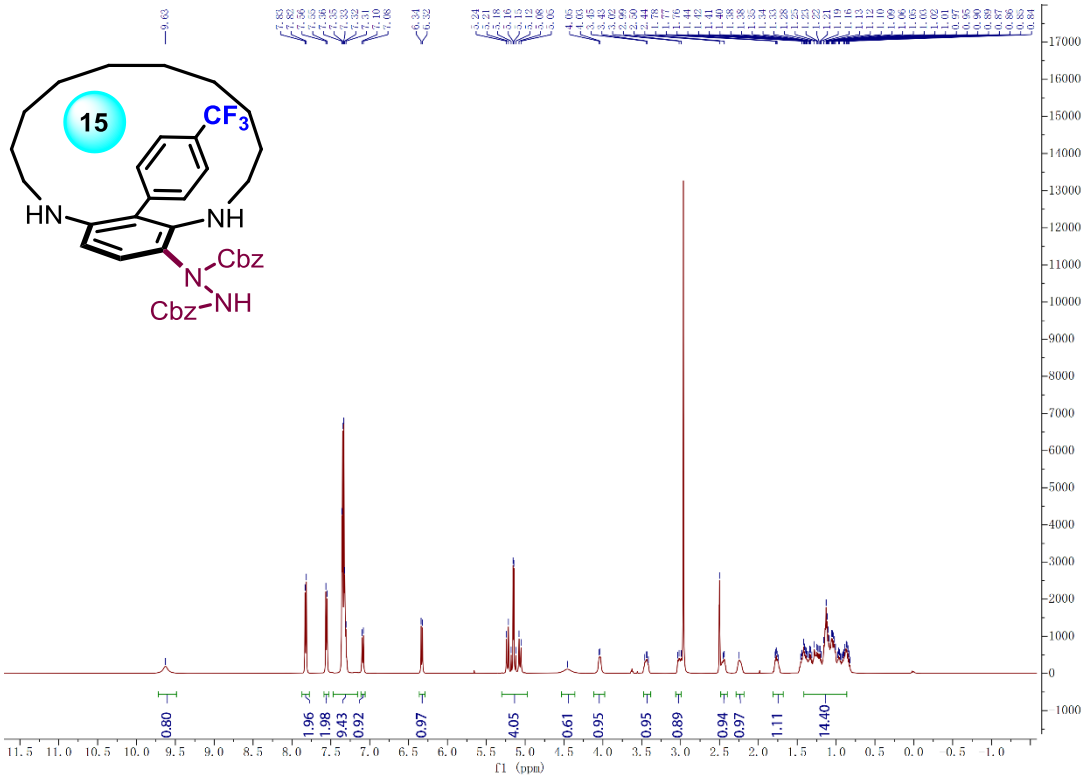



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

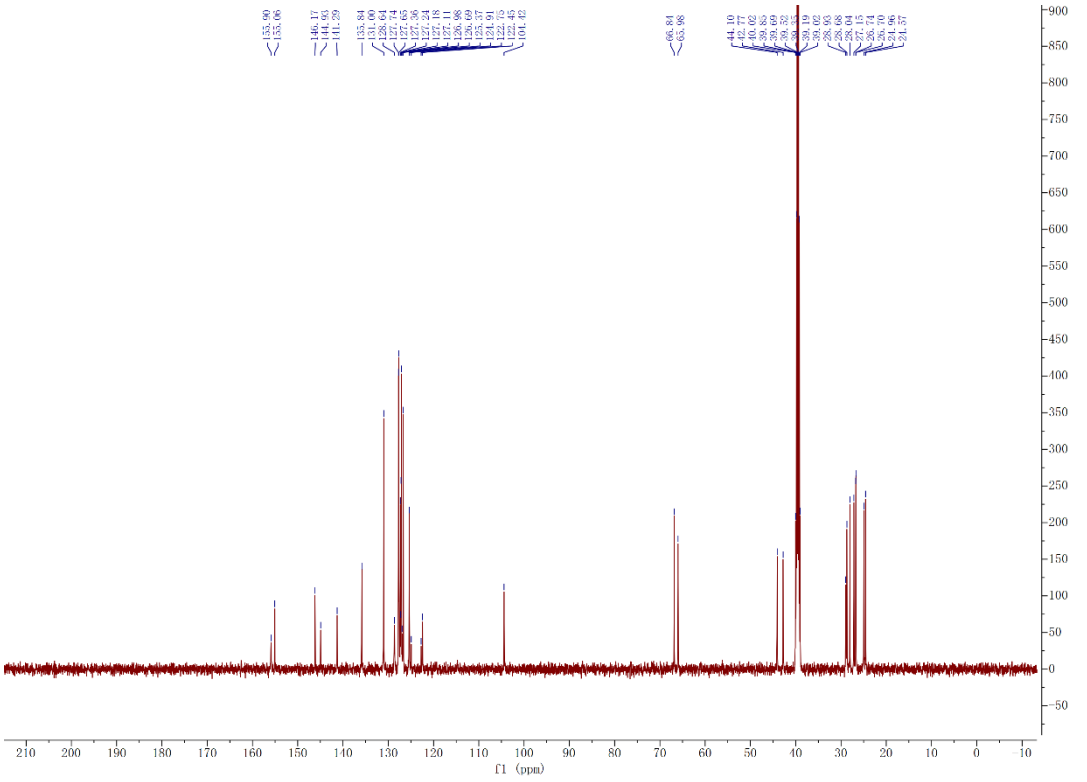


**Metacyclophanes 3i**

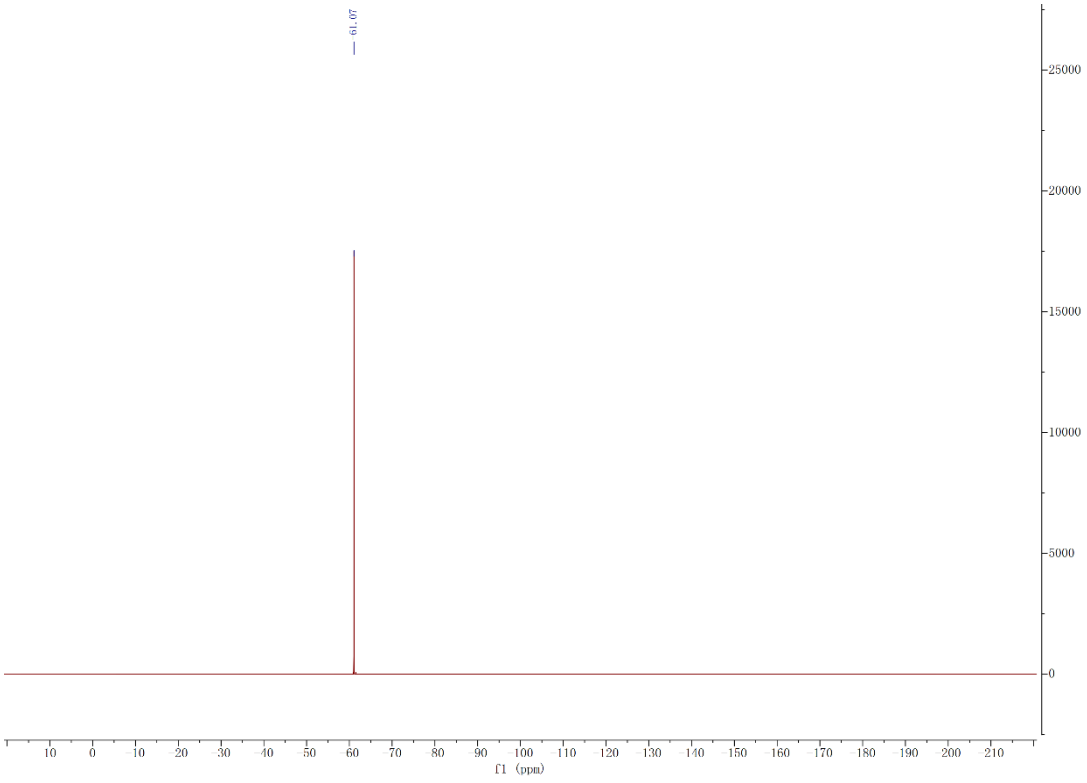
**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)




**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

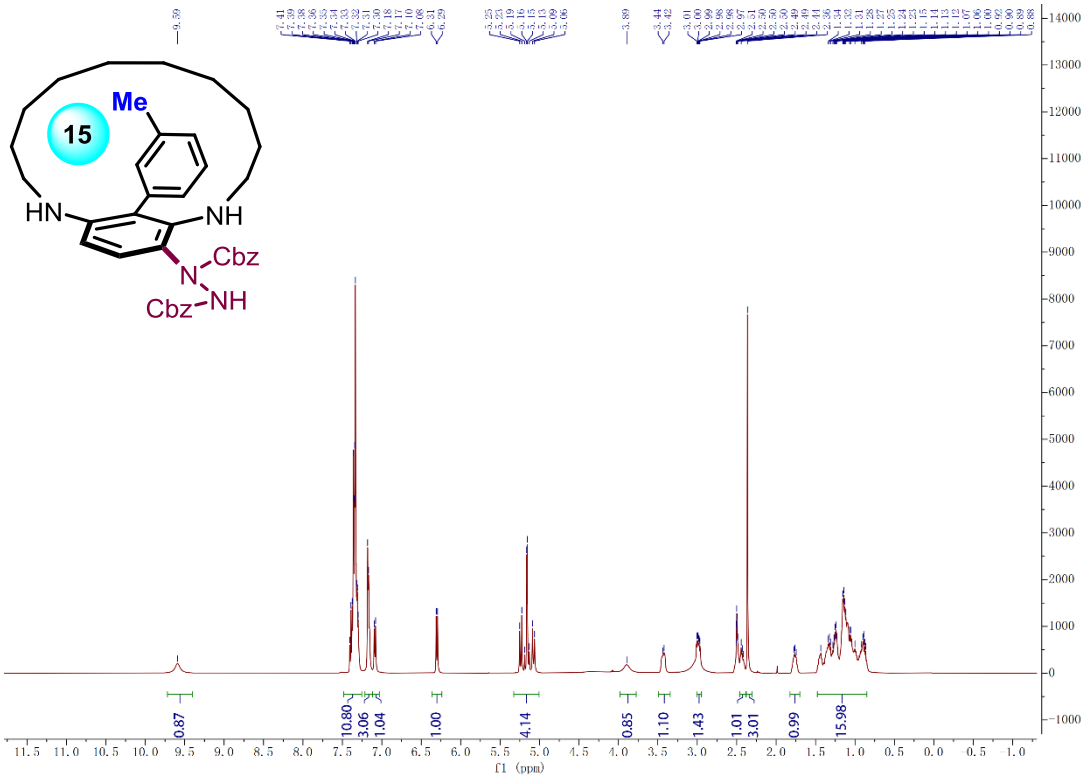


**$^{19}$F NMR** (471 MHz, DMSO-*d6*, 373 K)

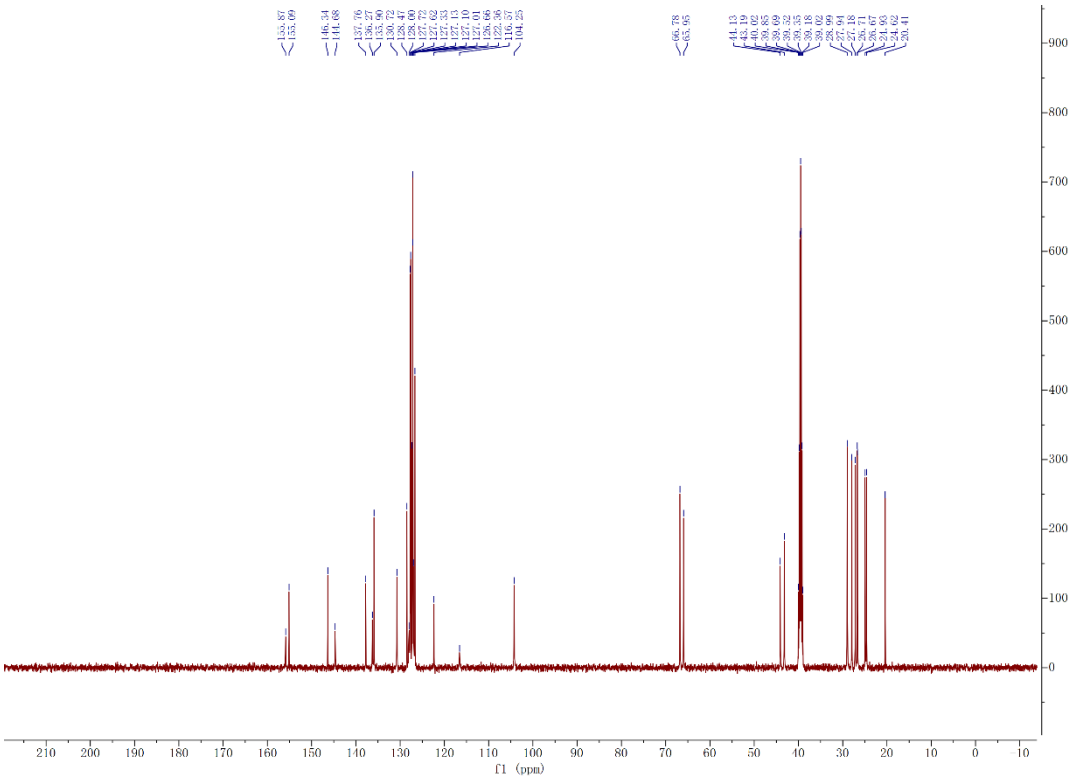


**Metacyclophanes 3j**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

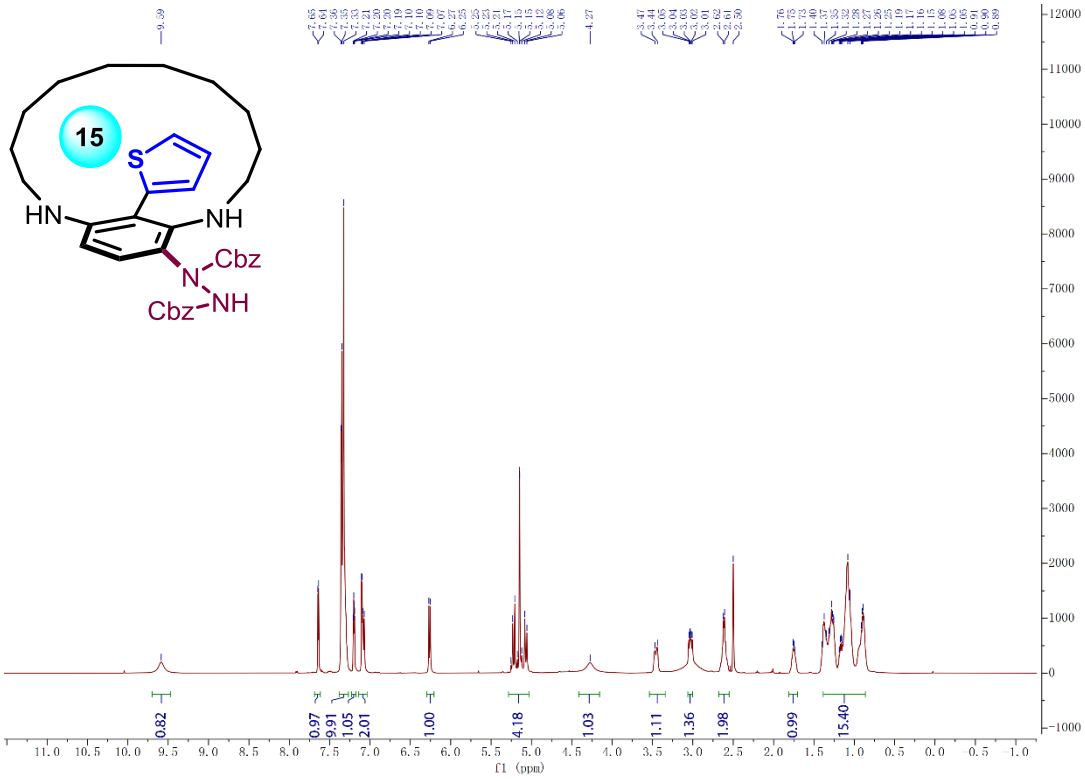



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

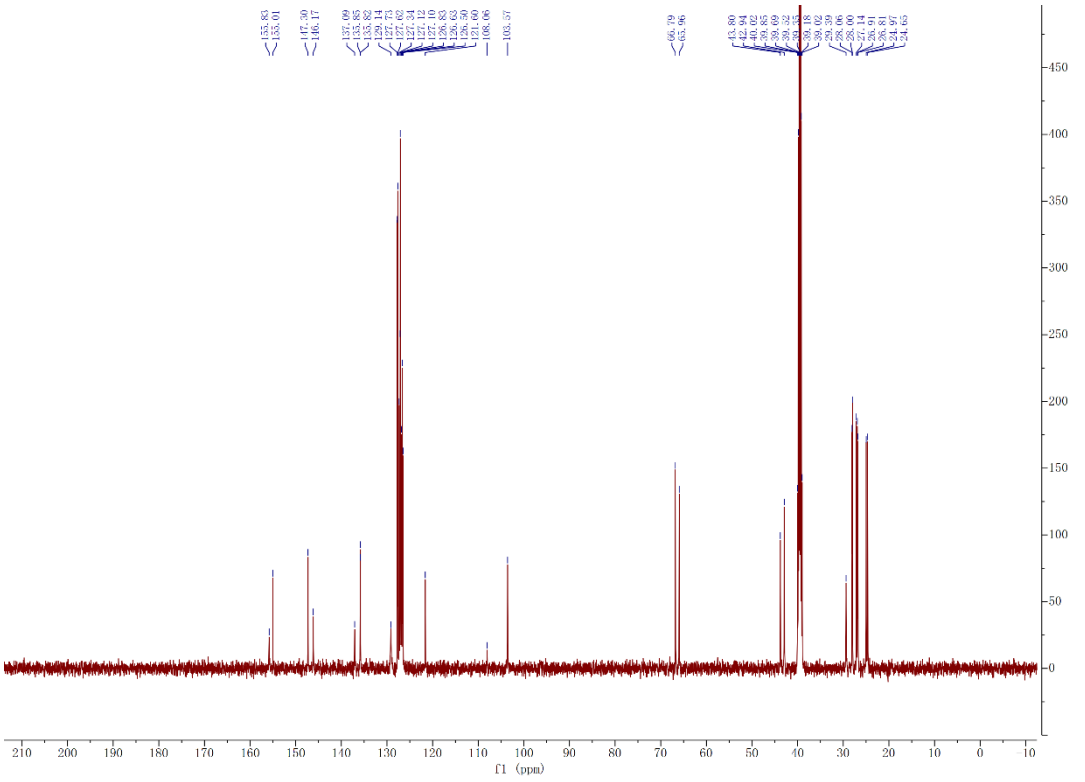


**Metacyclophanes 3k**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

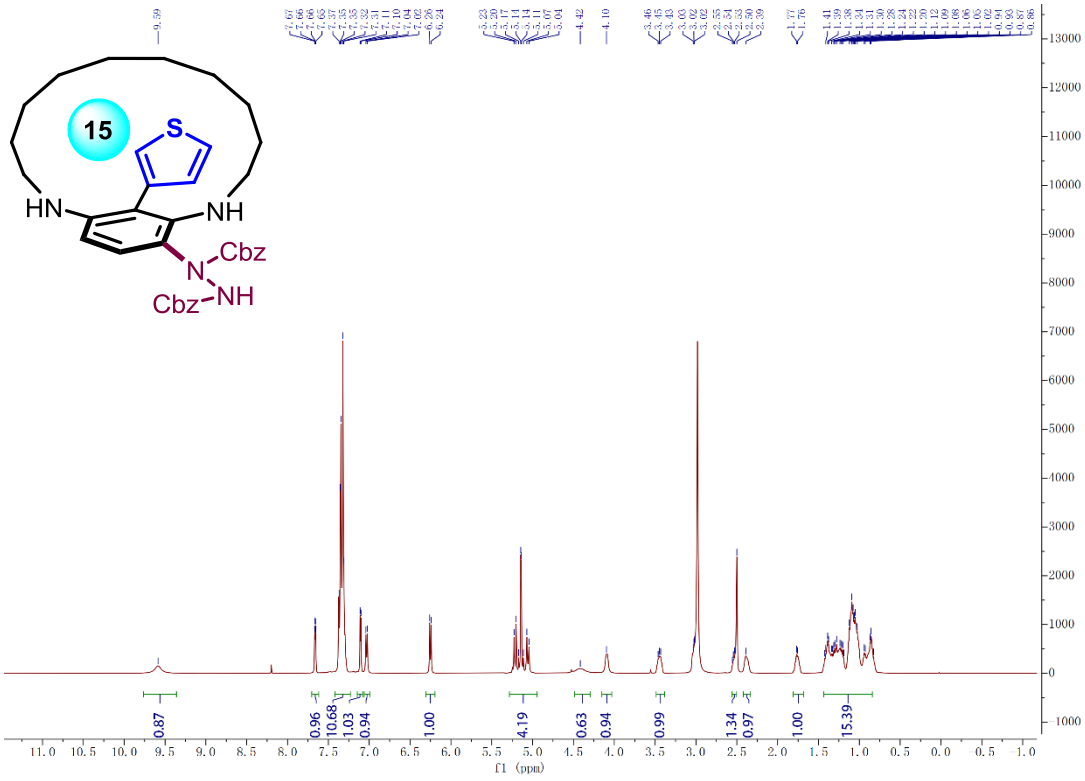



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

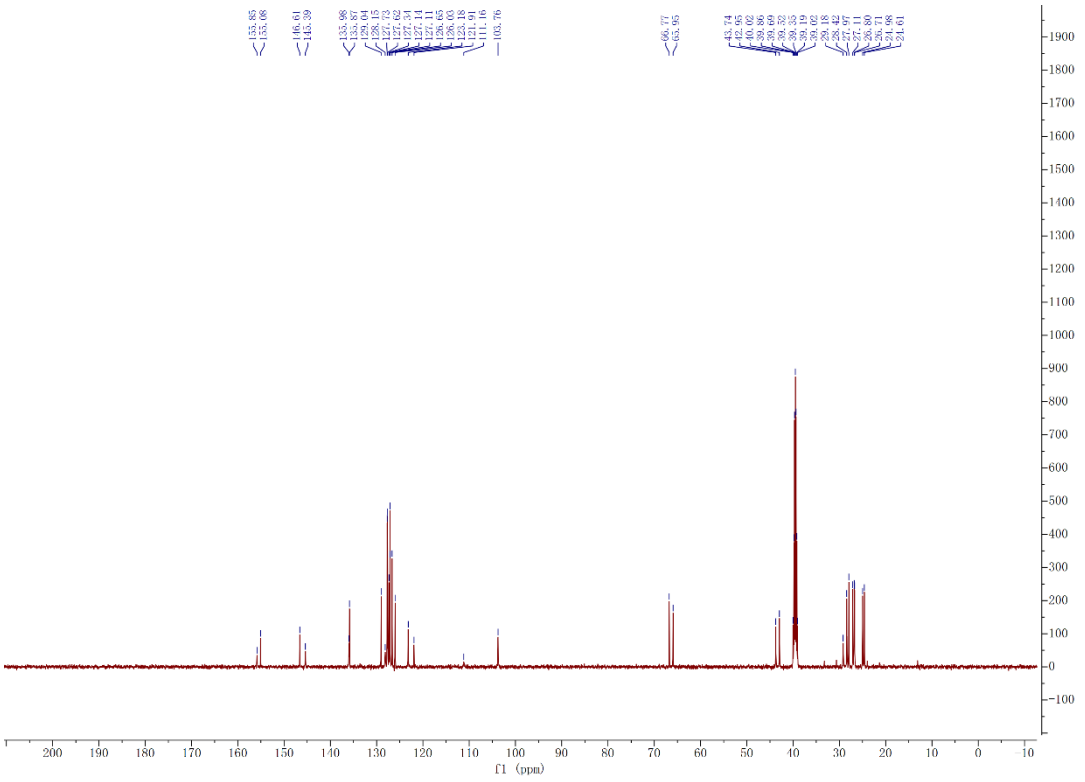


**Metacyclophanes 3l**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

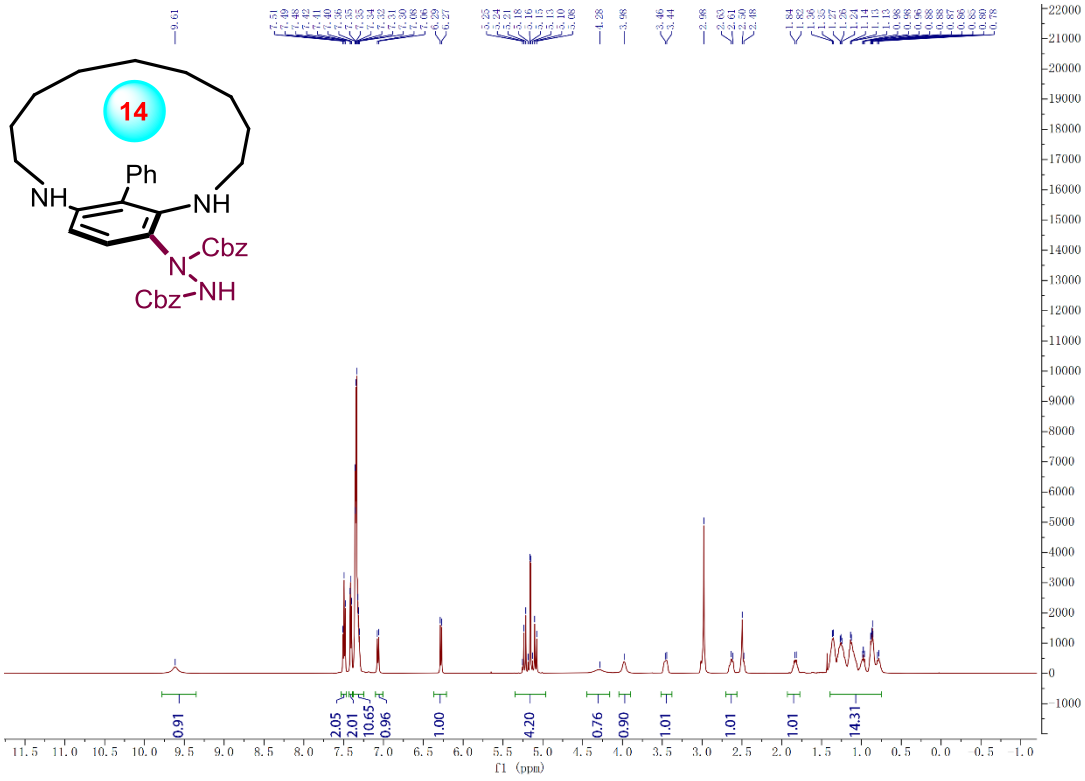



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

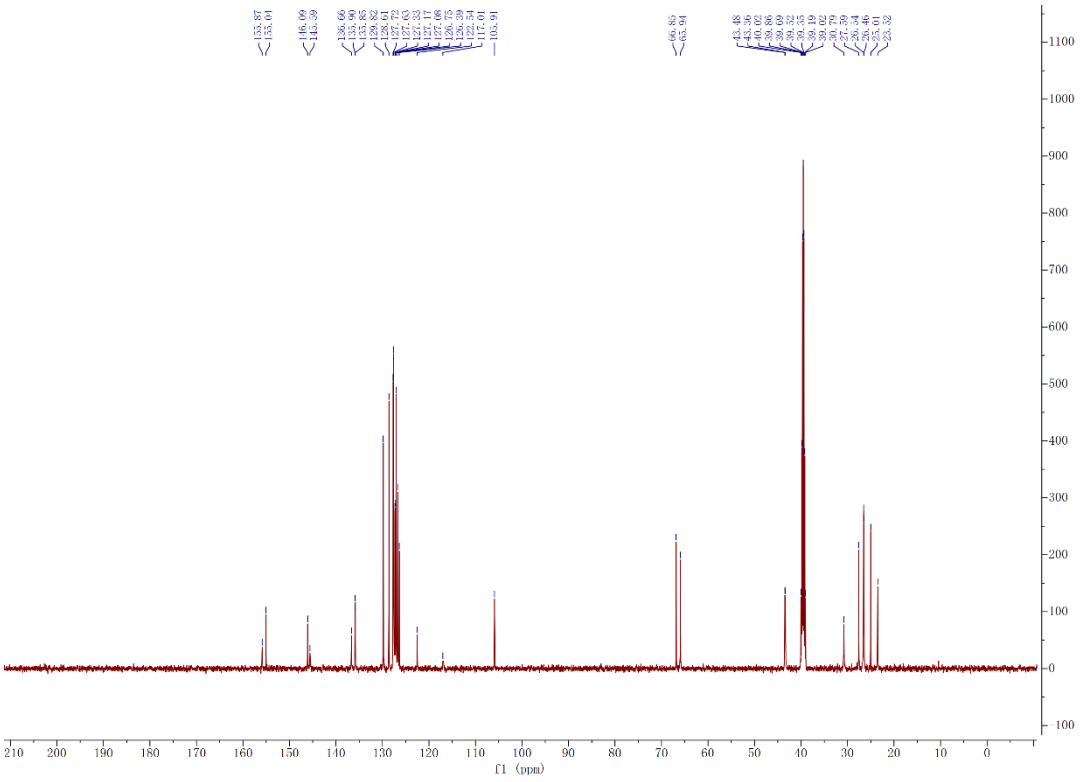


**Metacyclophanes 3m**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

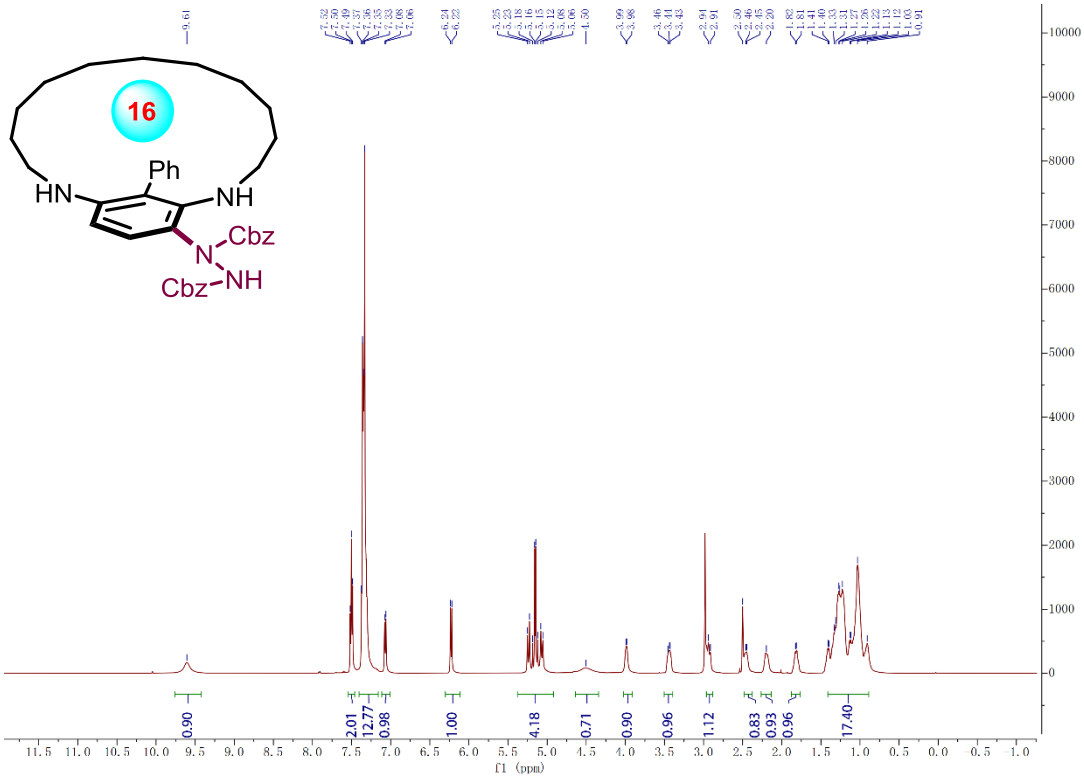



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

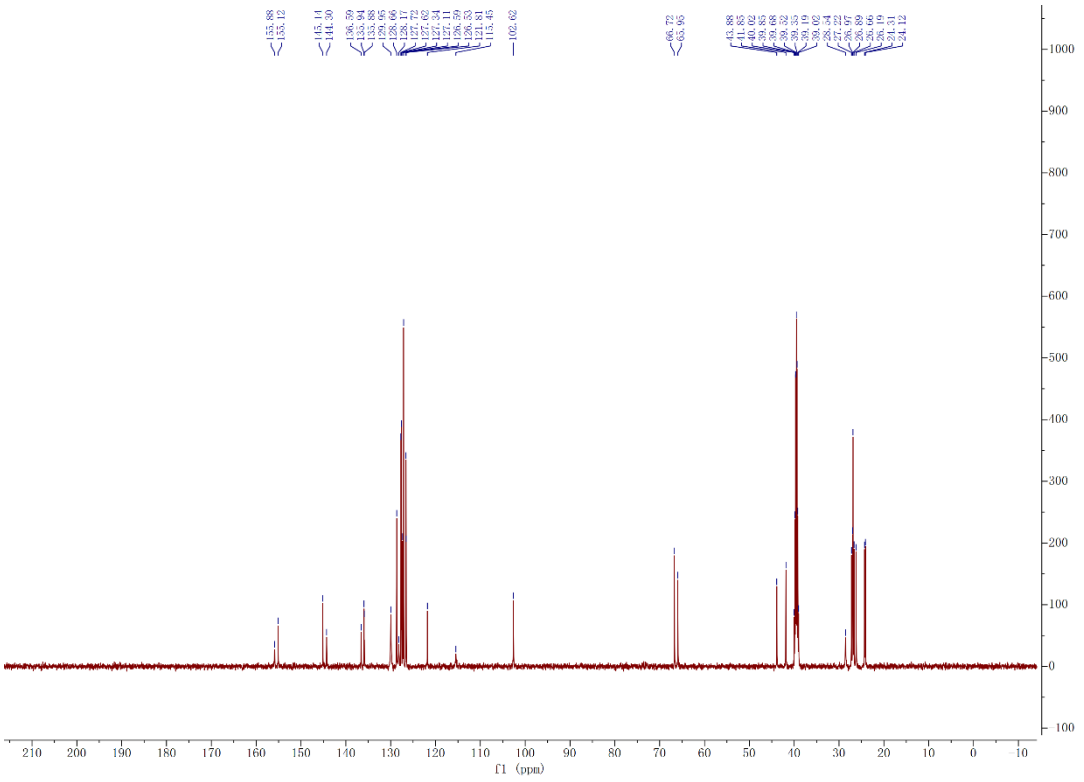


**Metacyclophanes 3n**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

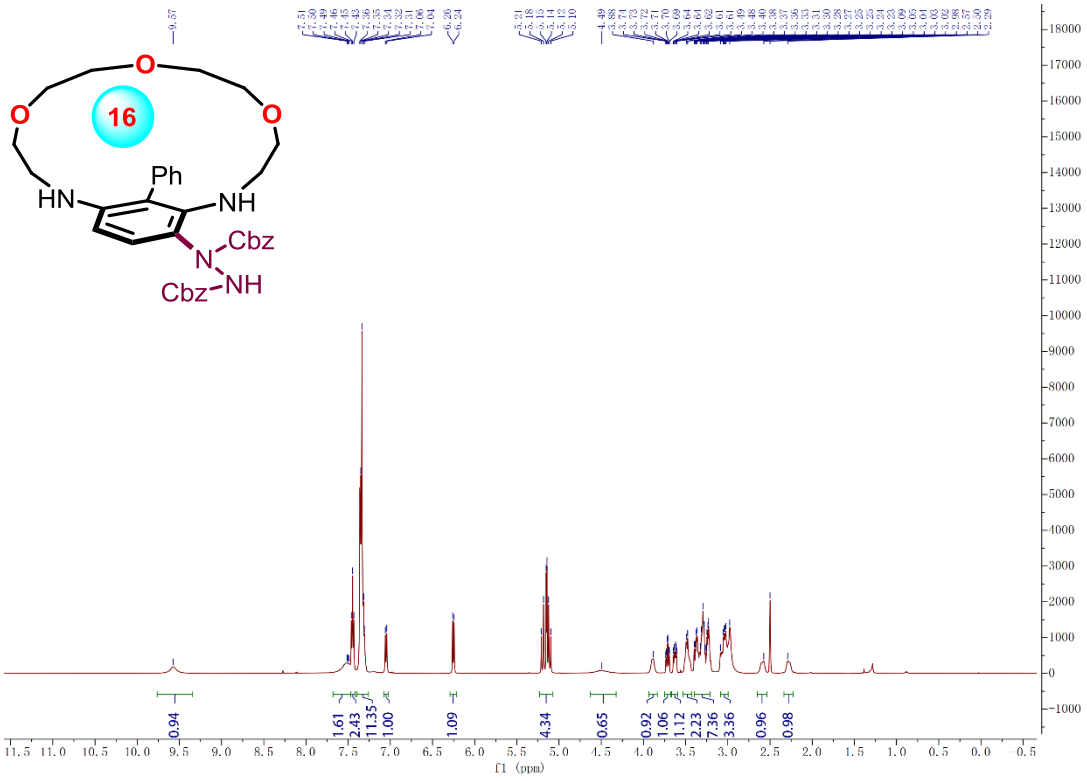



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

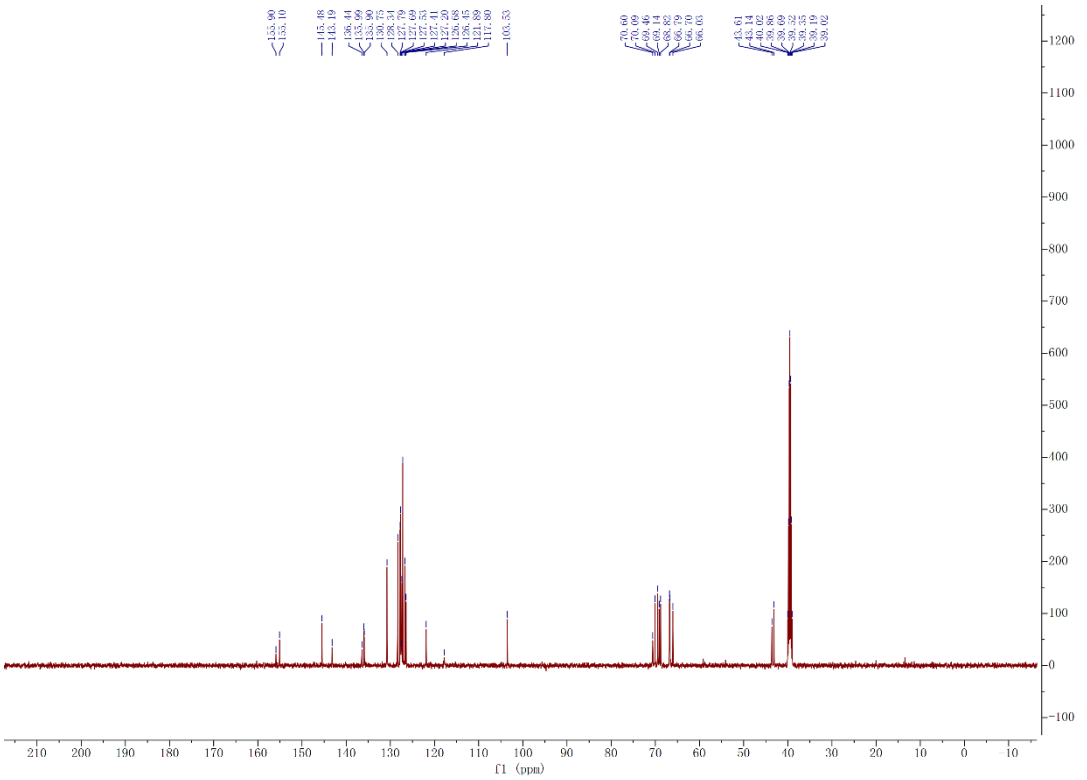


**Metacyclophanes 3o**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

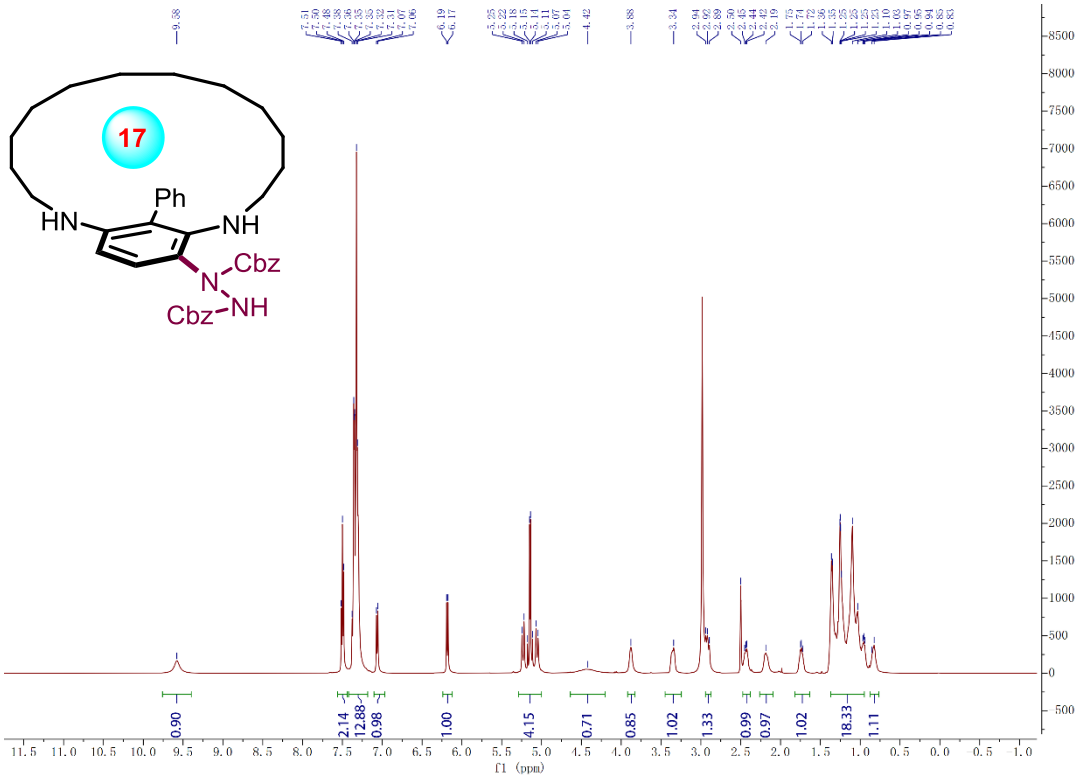



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

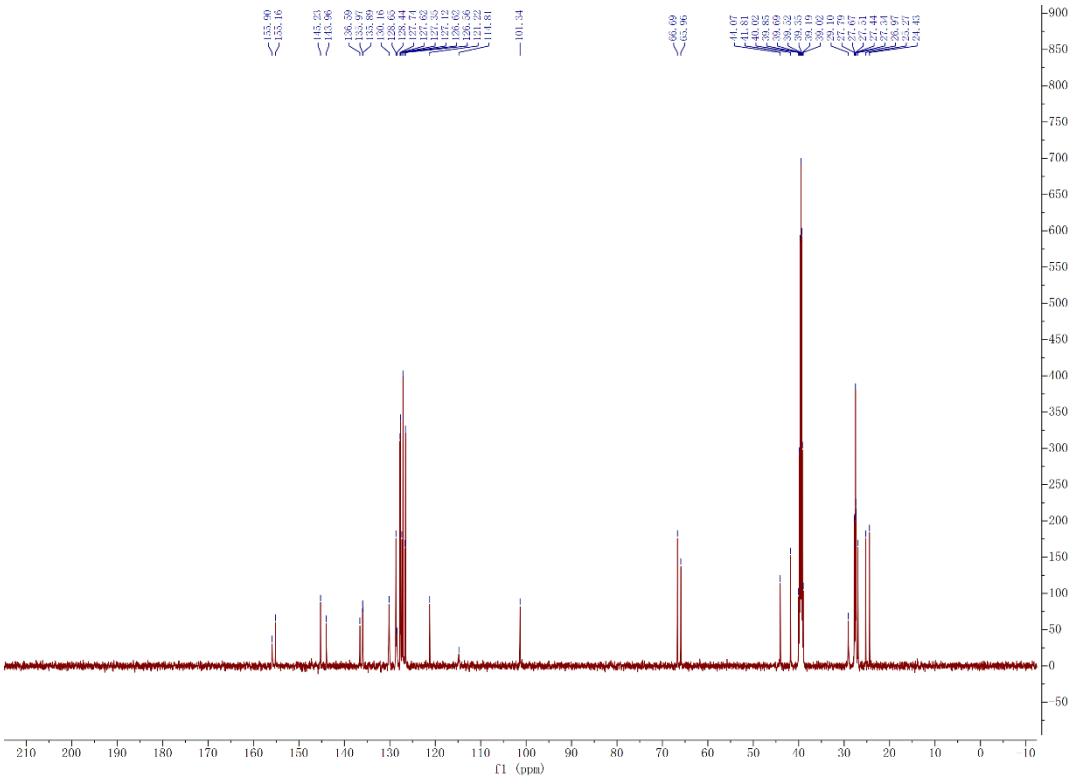


**Metacyclophanes 3p**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

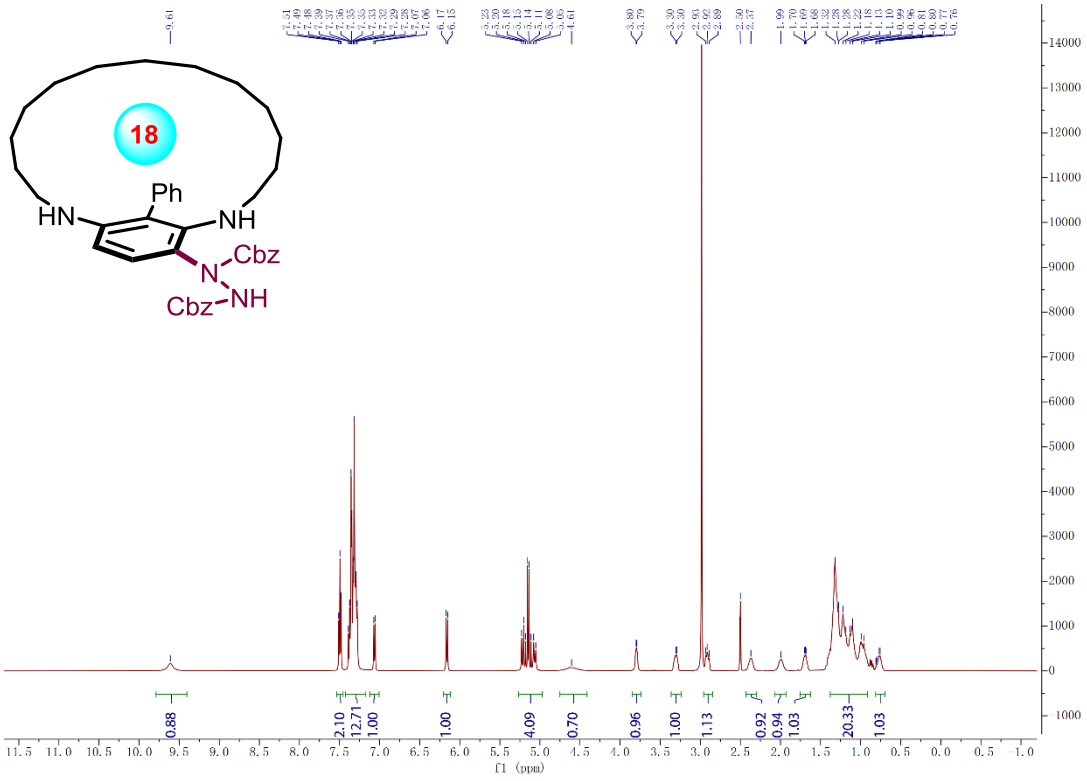



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

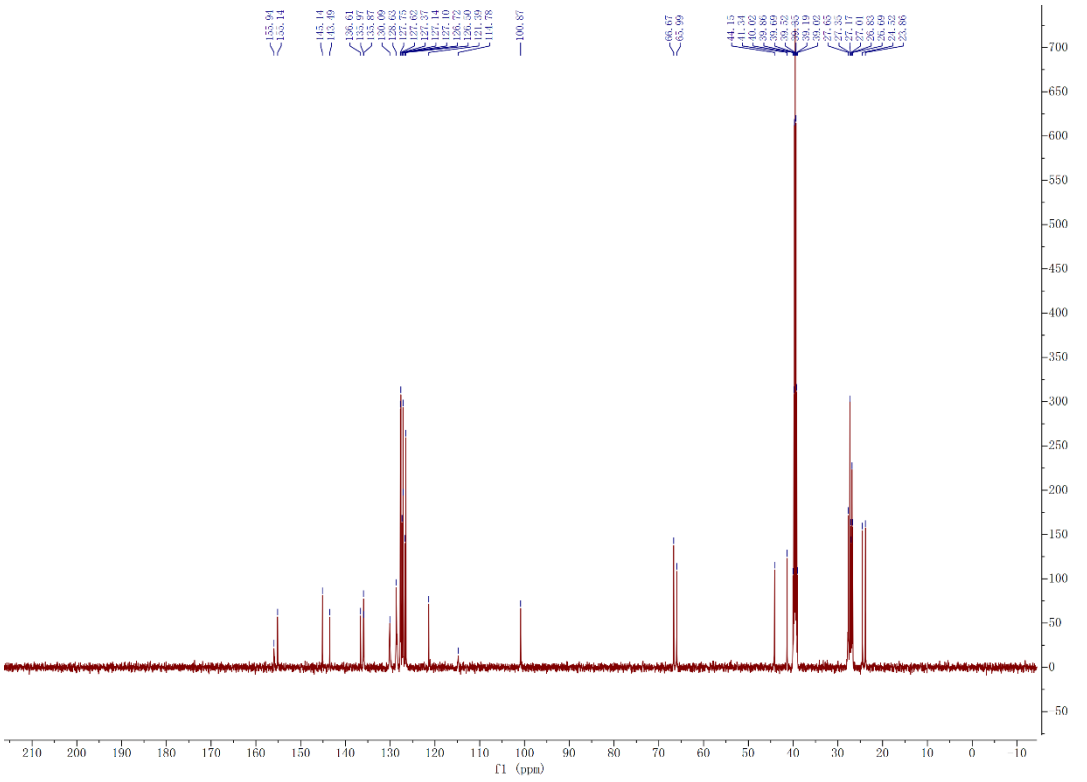


**Metacyclophanes 3q**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

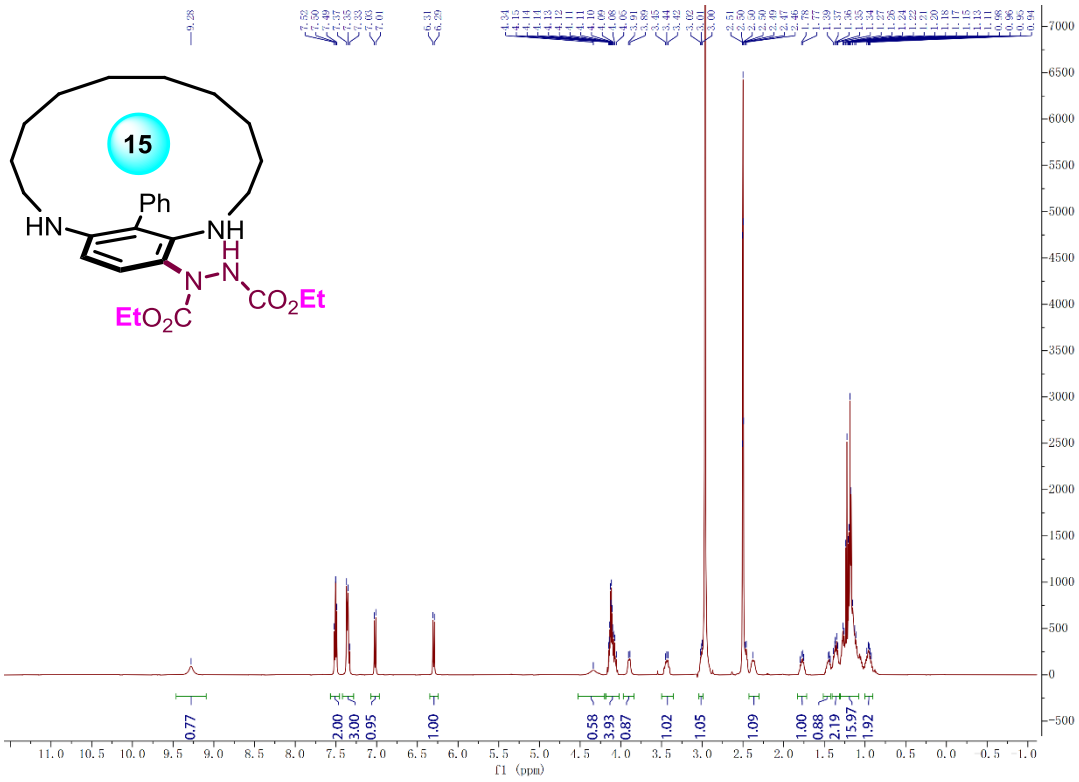



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

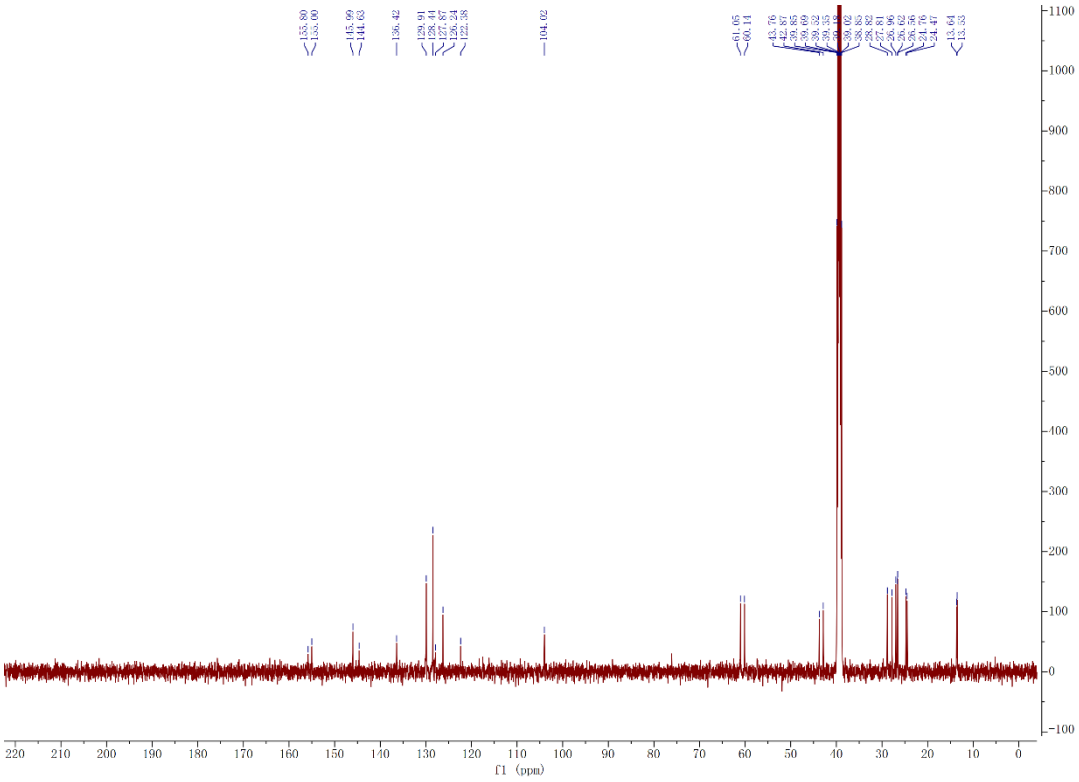


**Metacyclophanes 3ac**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

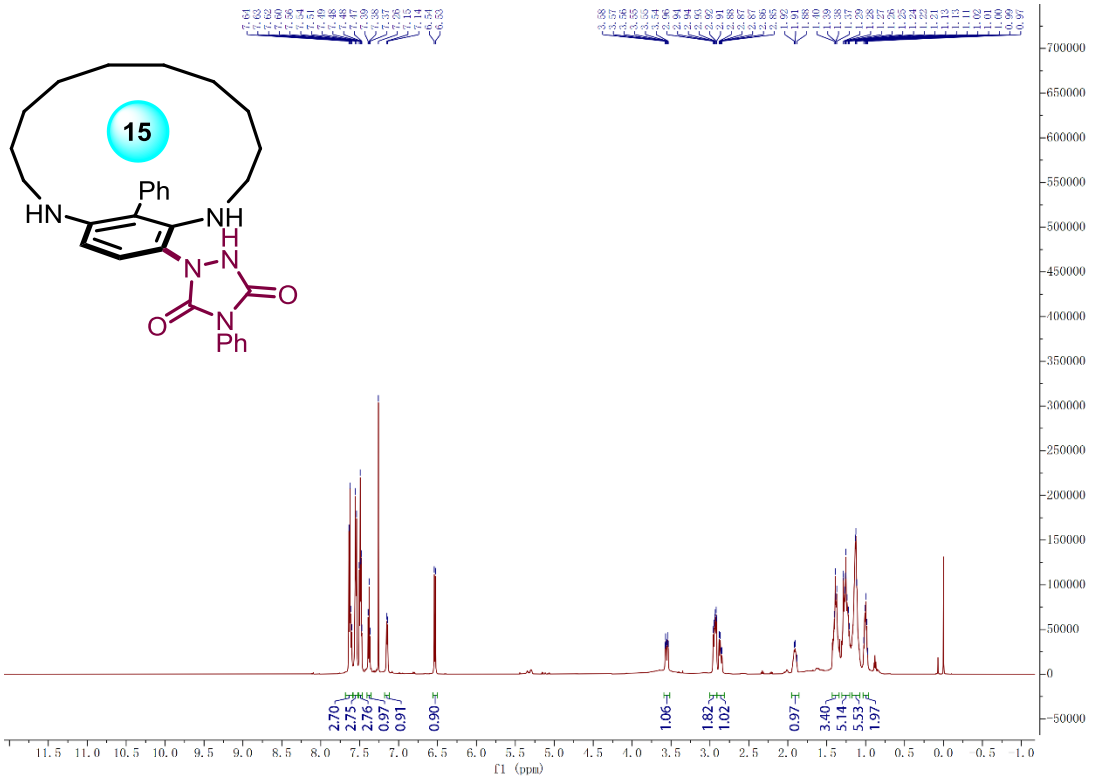



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

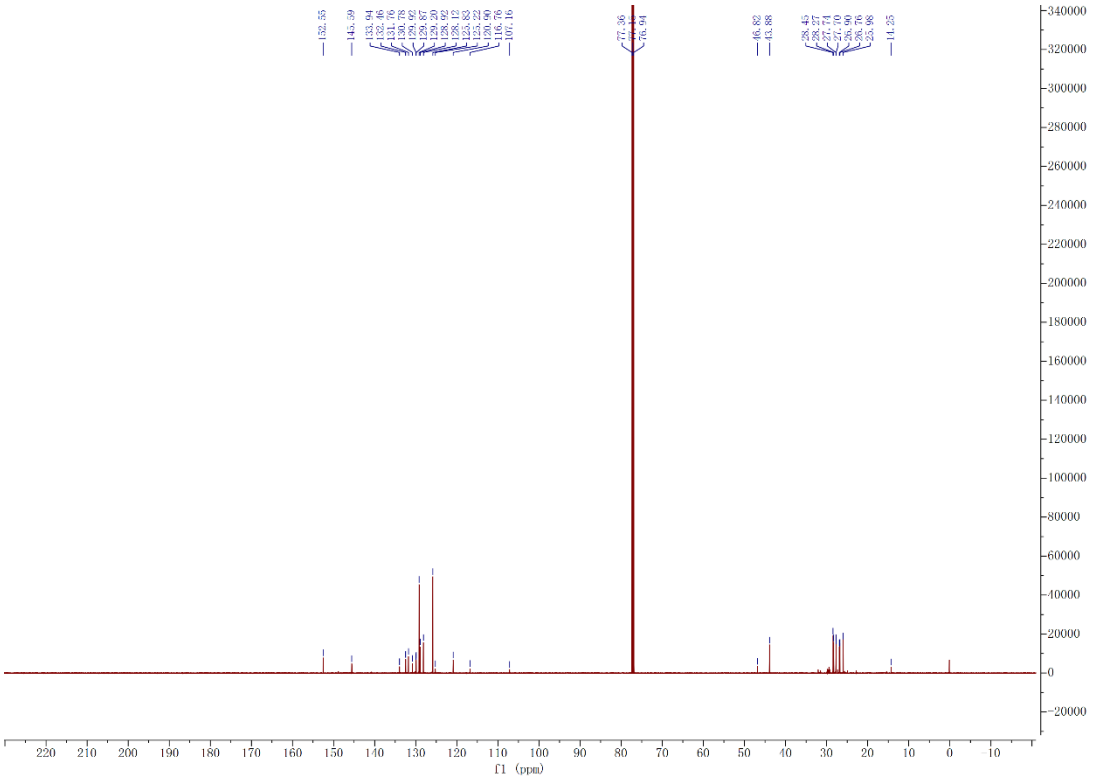


**Metacyclophanes 3ae**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

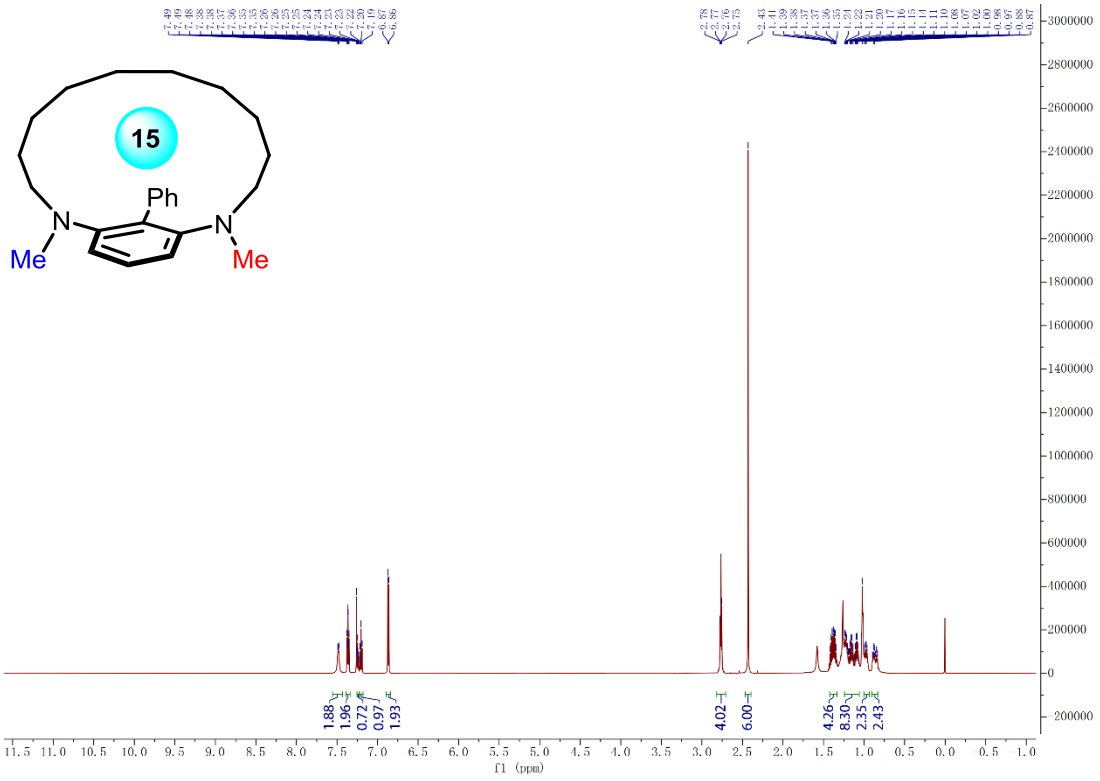



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

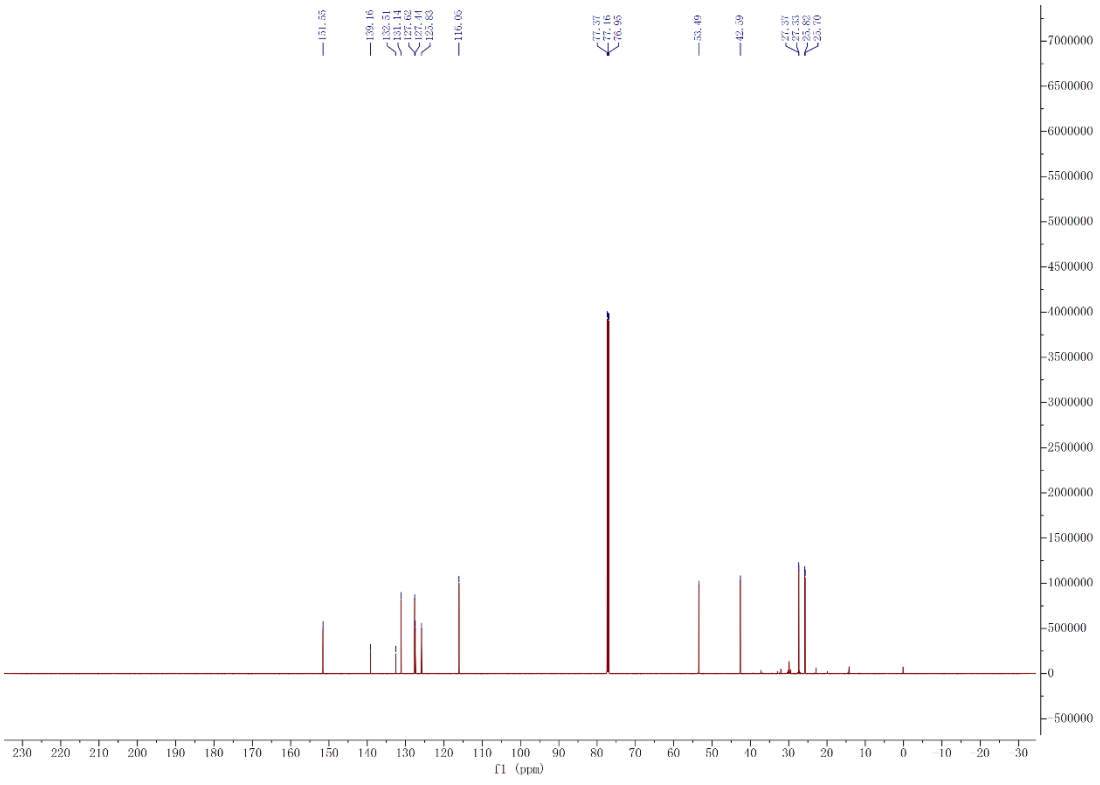


**Metacyclophanes 1a'**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

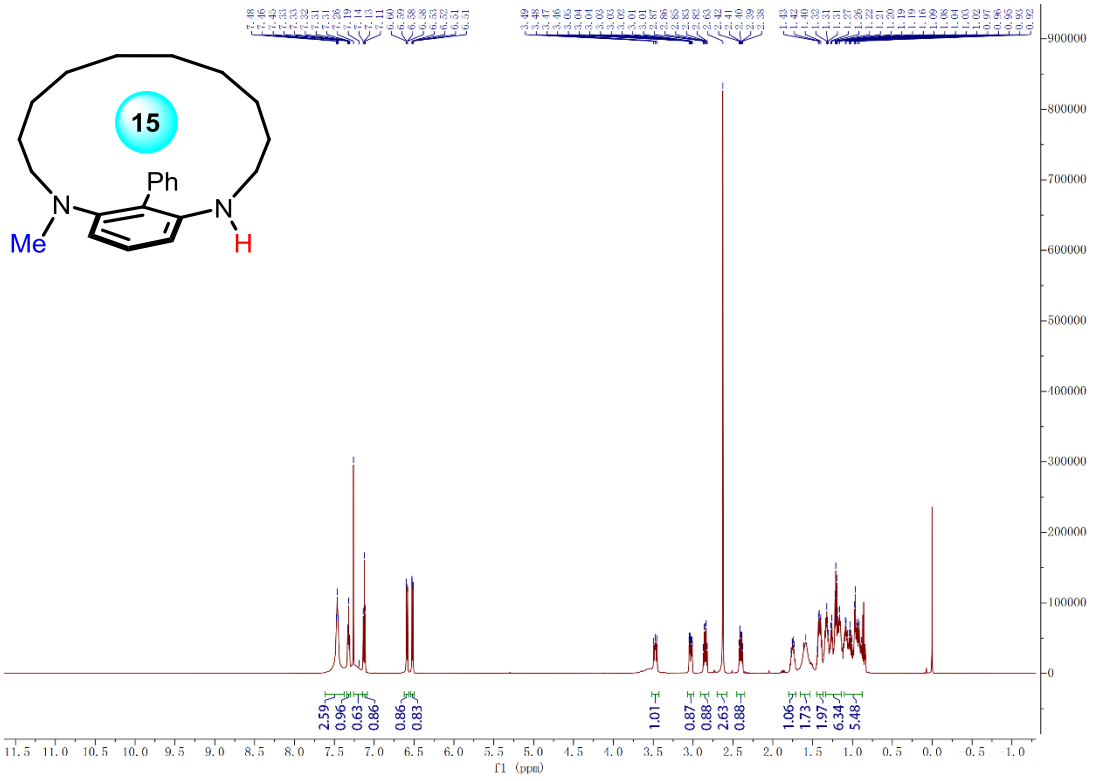



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

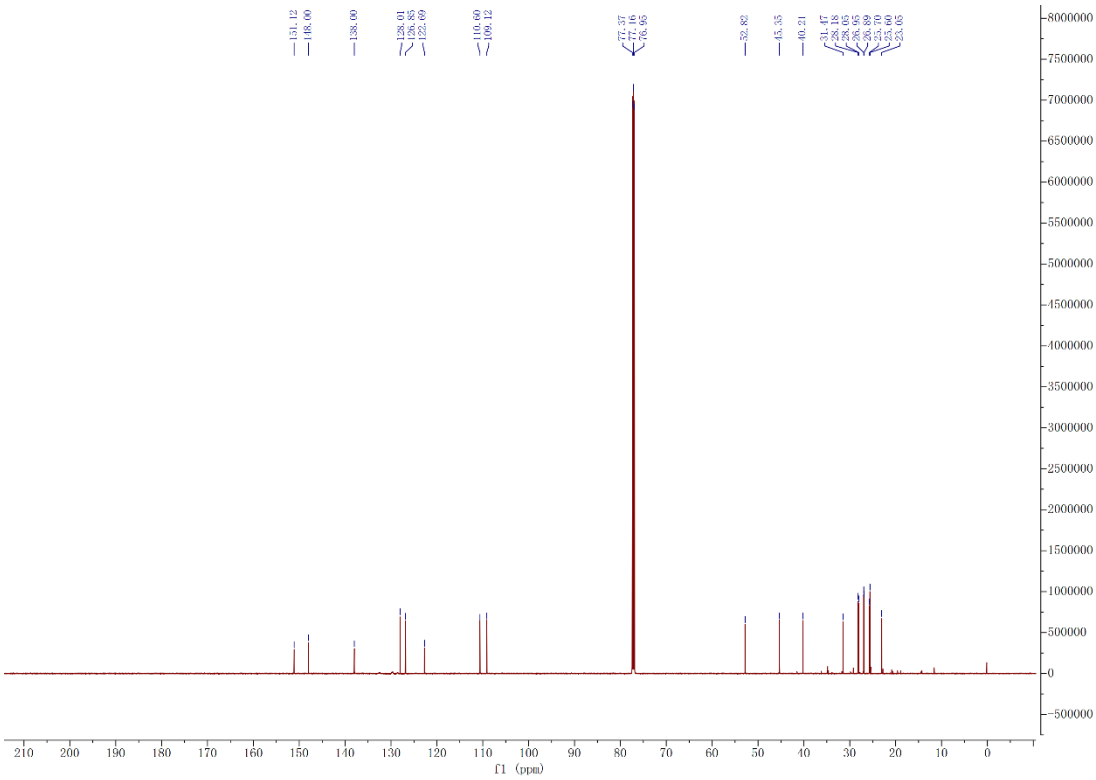


**Metacyclophanes 1a''**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

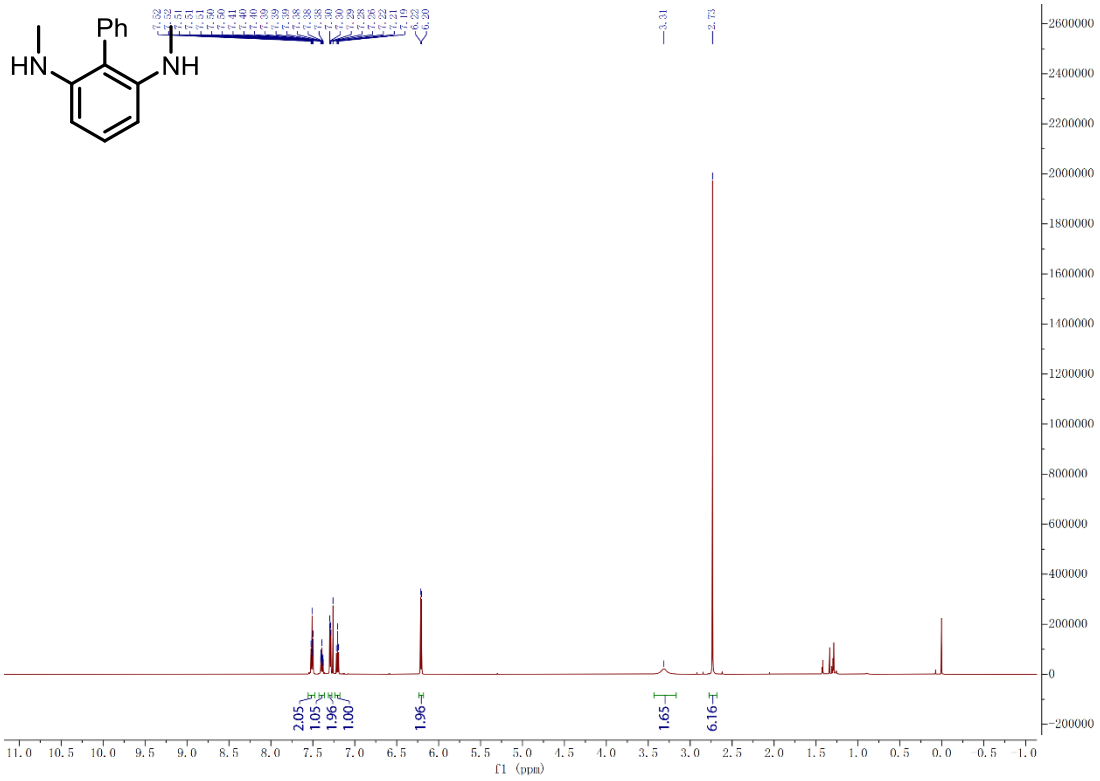



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

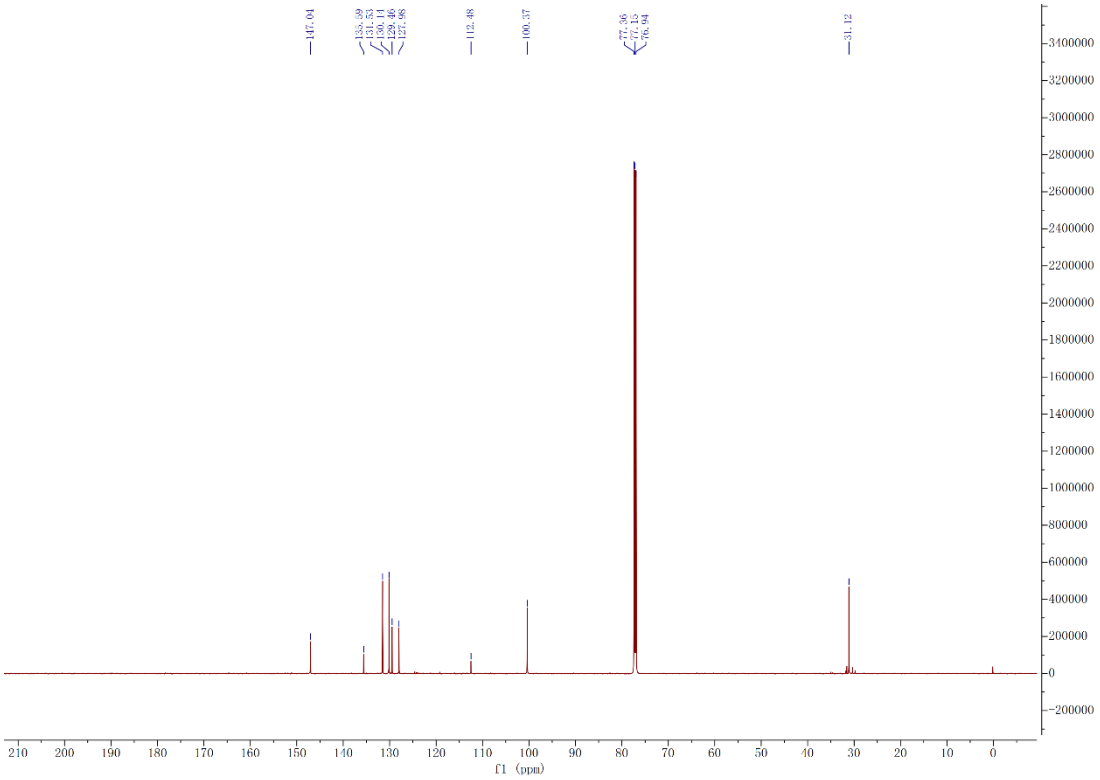


**Metacyclophanes 13a**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

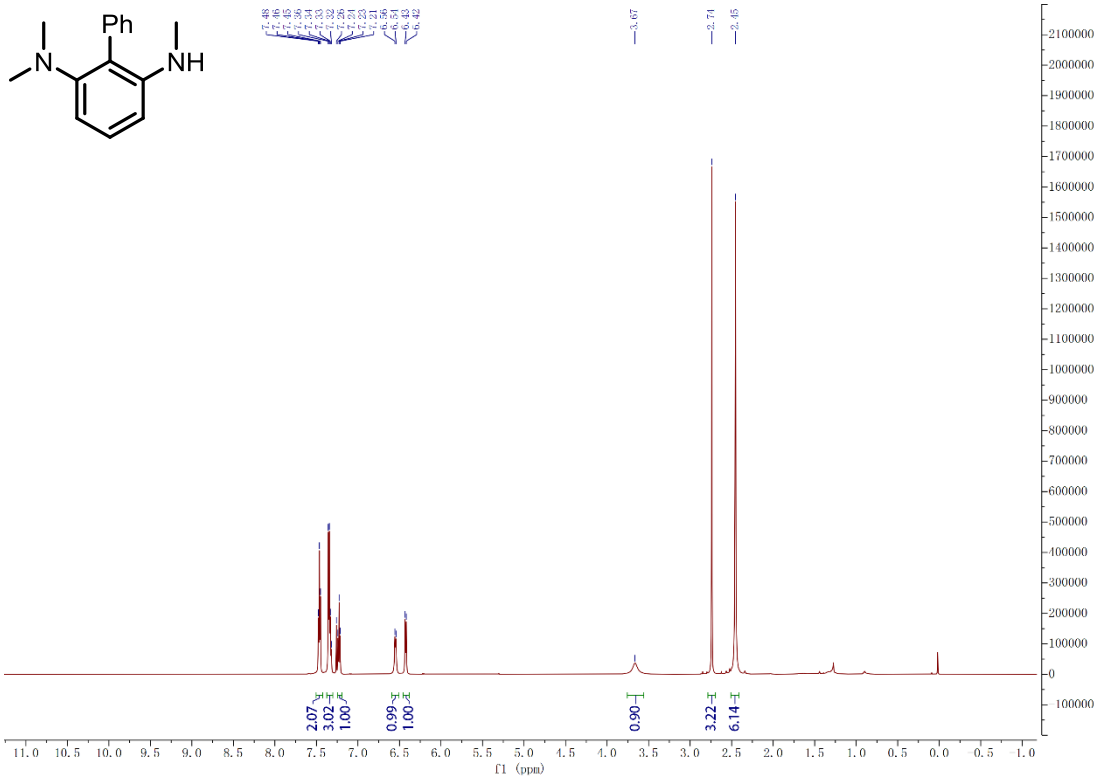



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

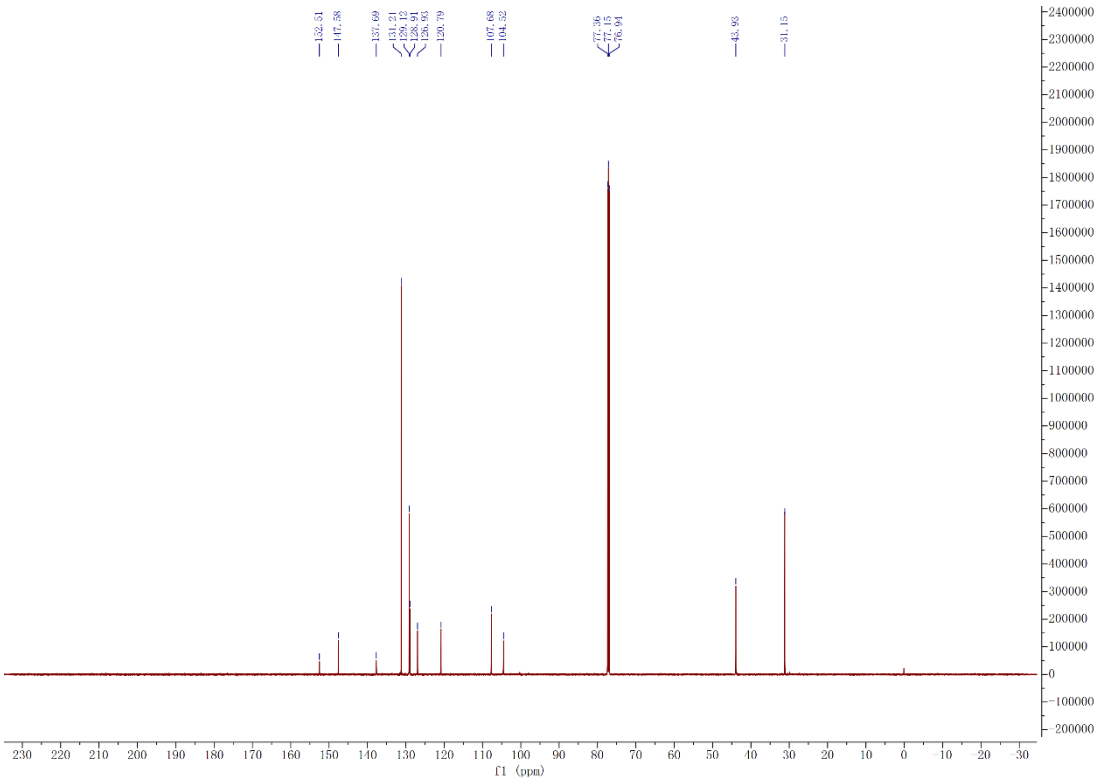


**Metacyclophanes 13a'**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

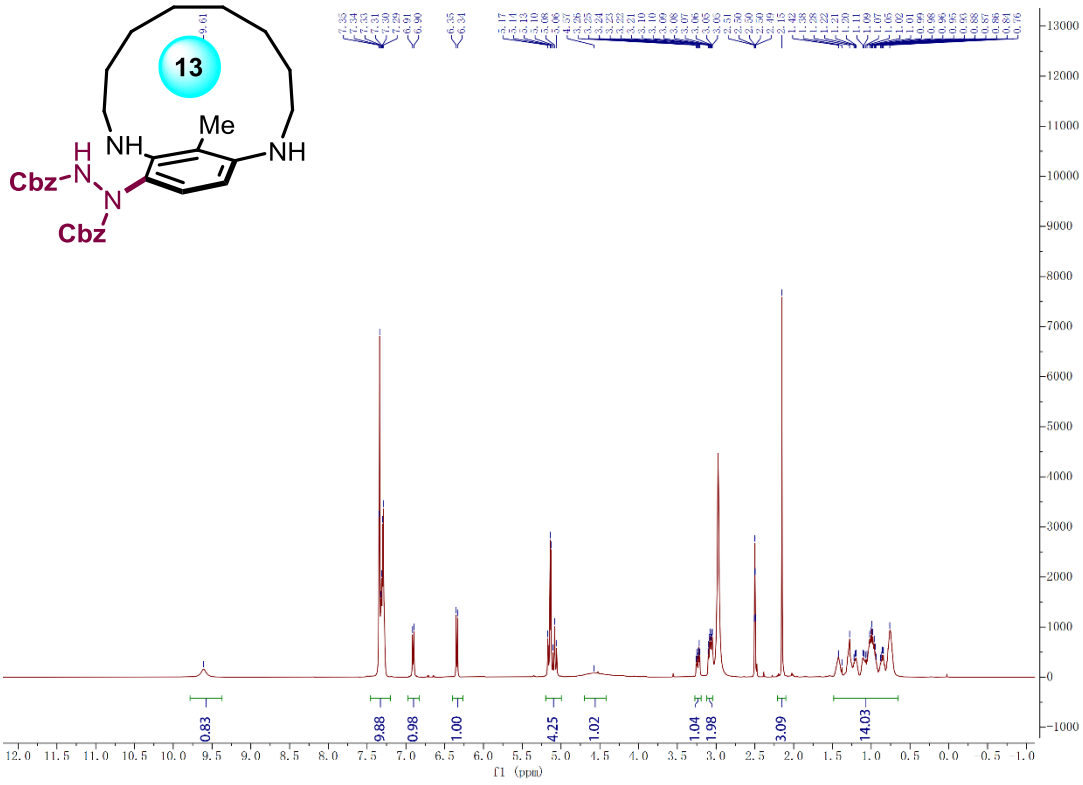



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

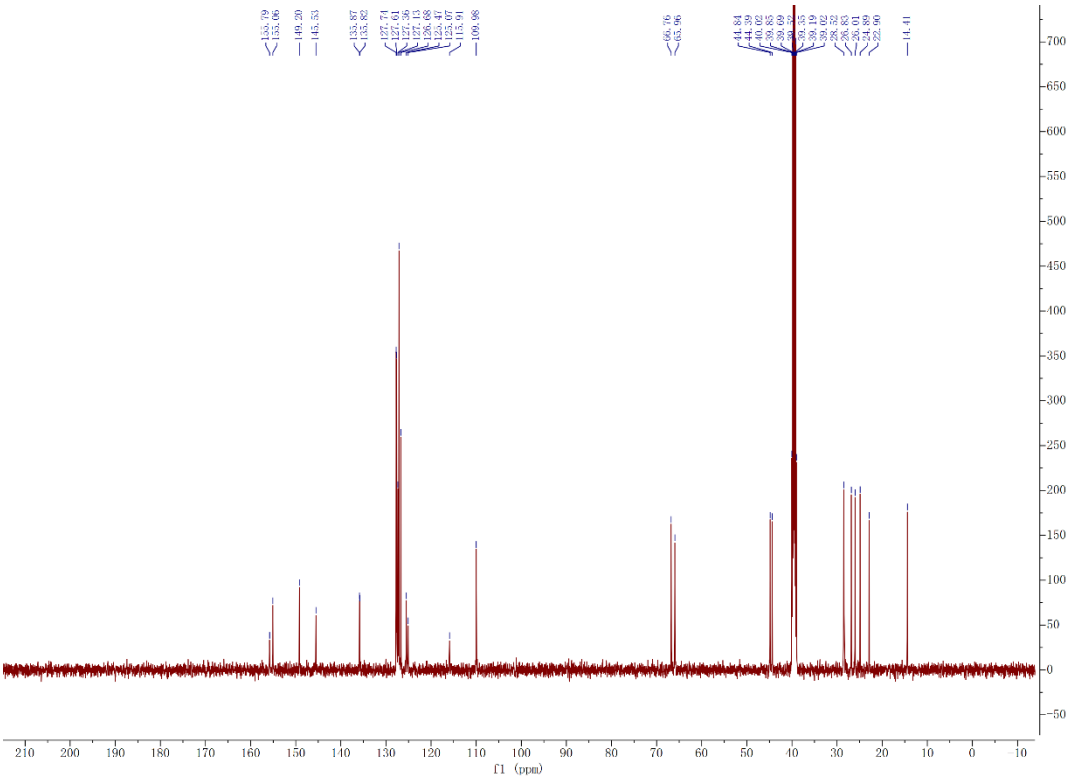


**Metacyclophanes 5a** and ***ent*-5a**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

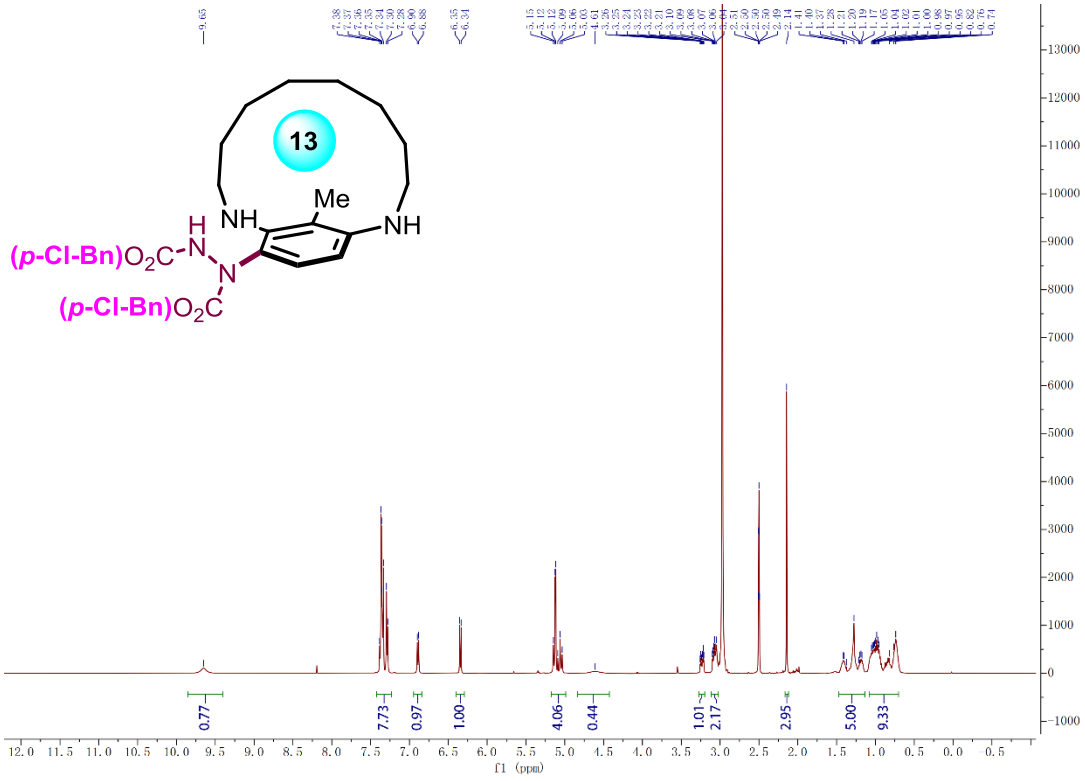



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

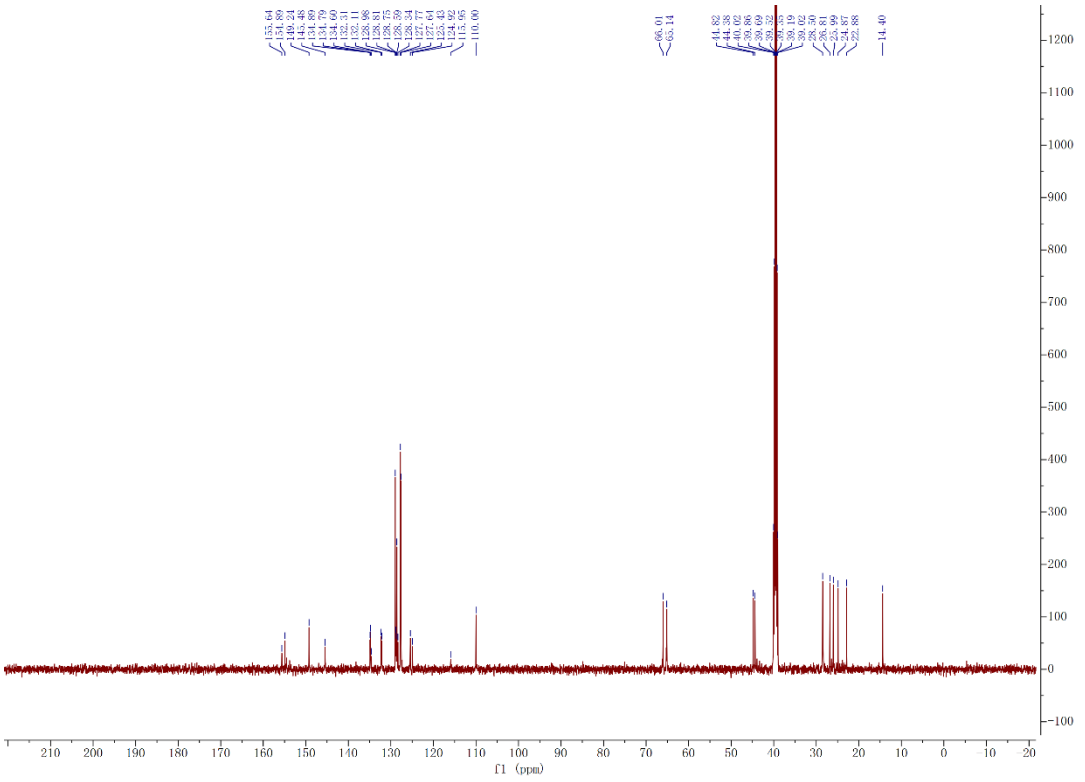


**Metacyclophanes 5b**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

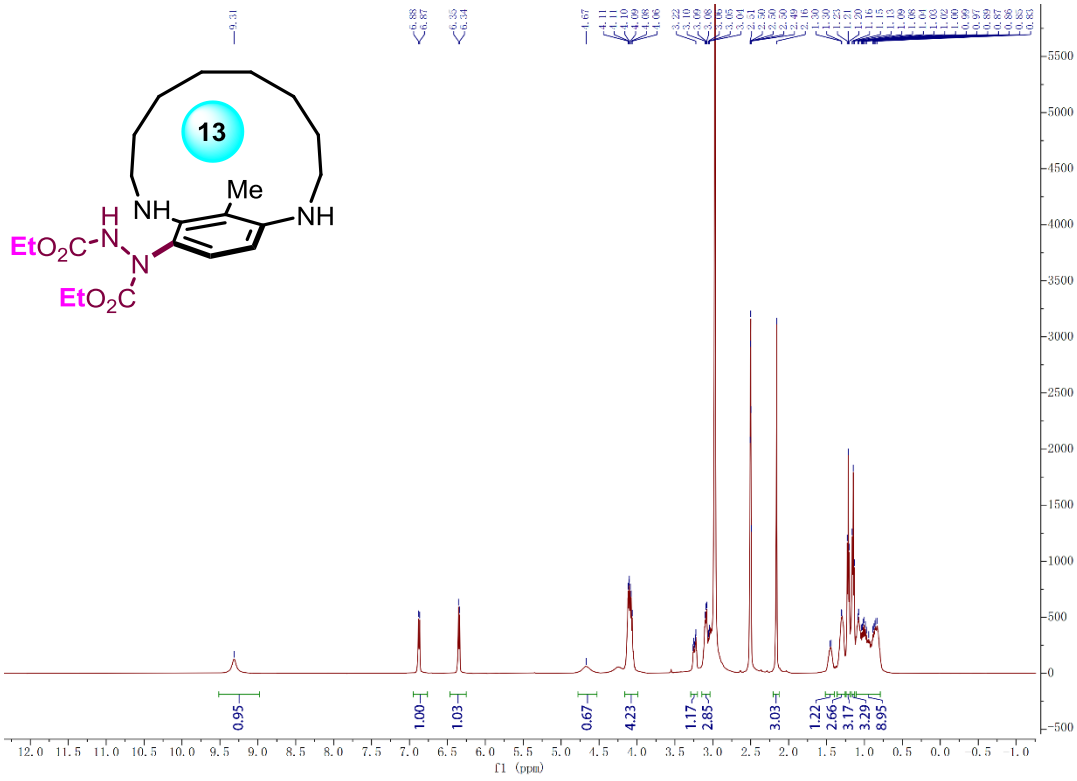



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

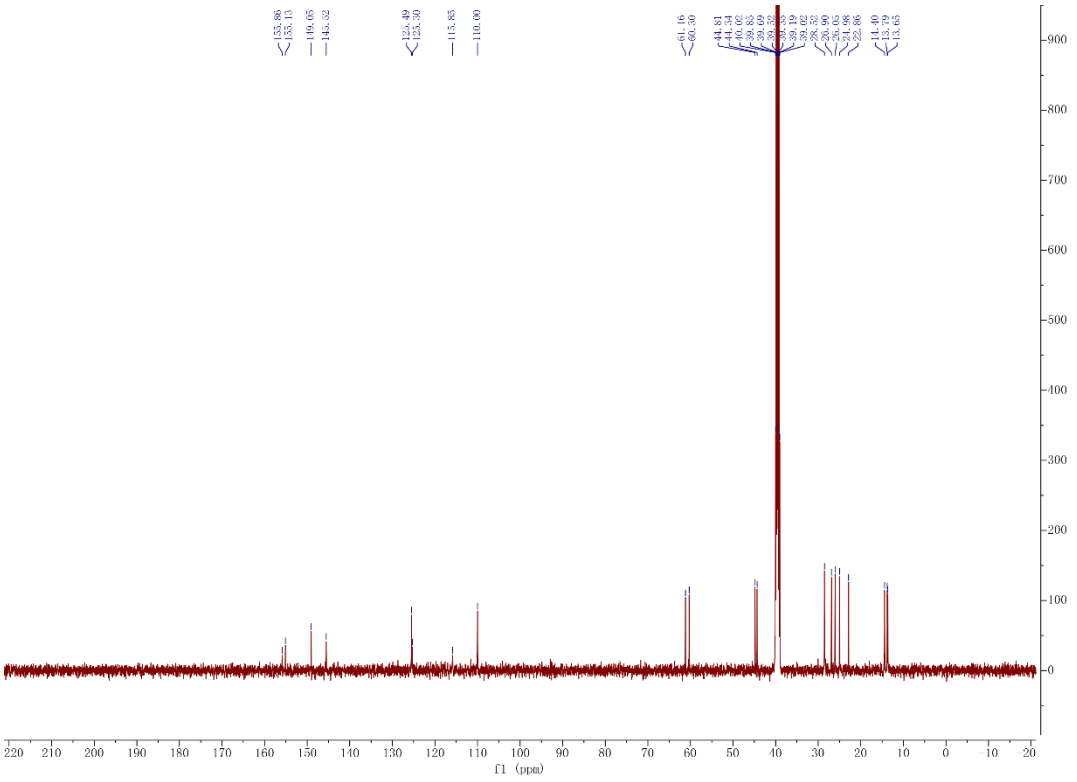


**Metacyclophanes 5c**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

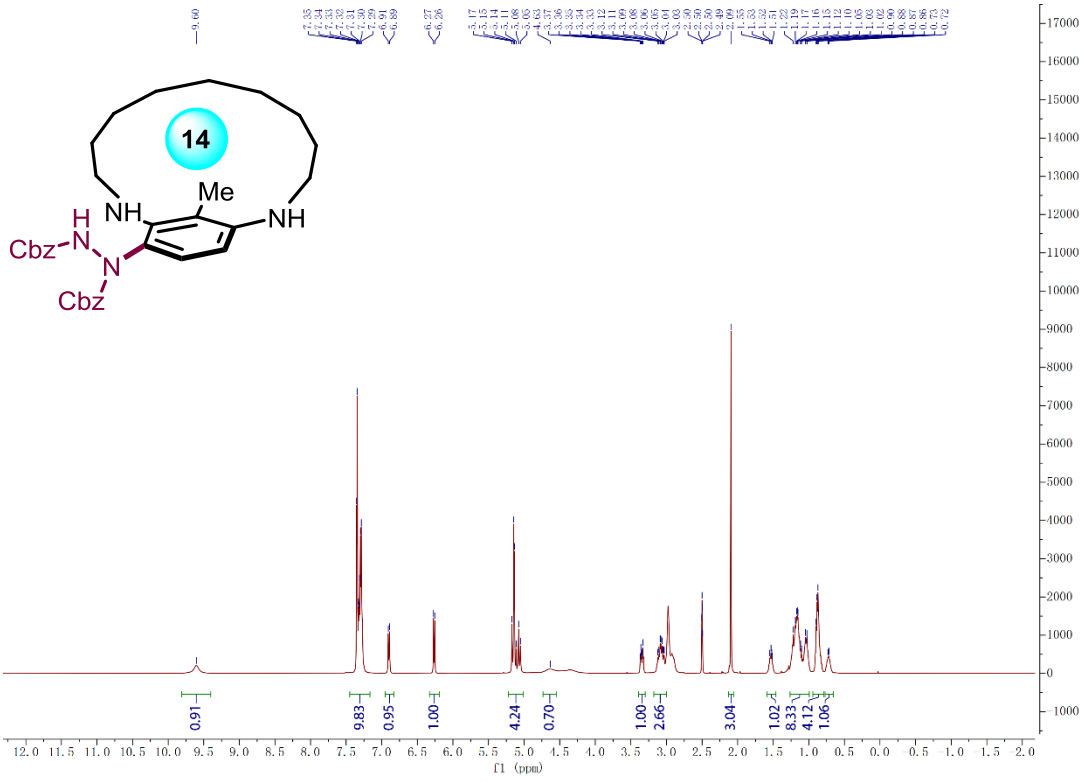



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

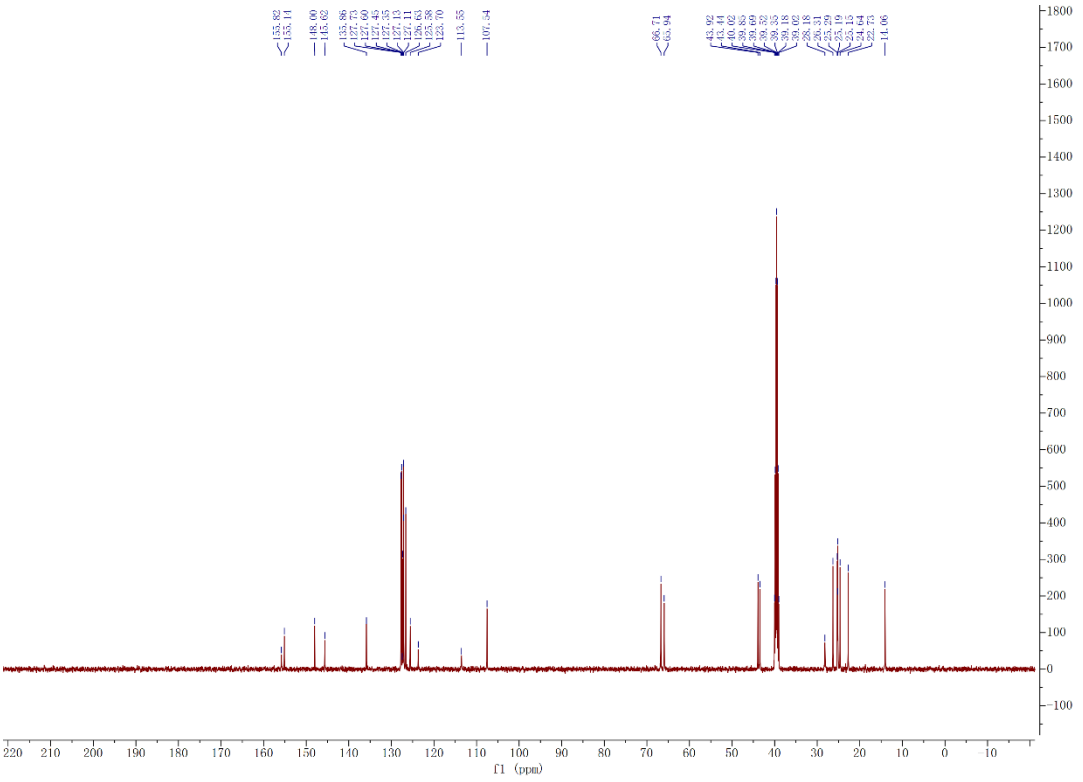


**Metacyclophanes 5d**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

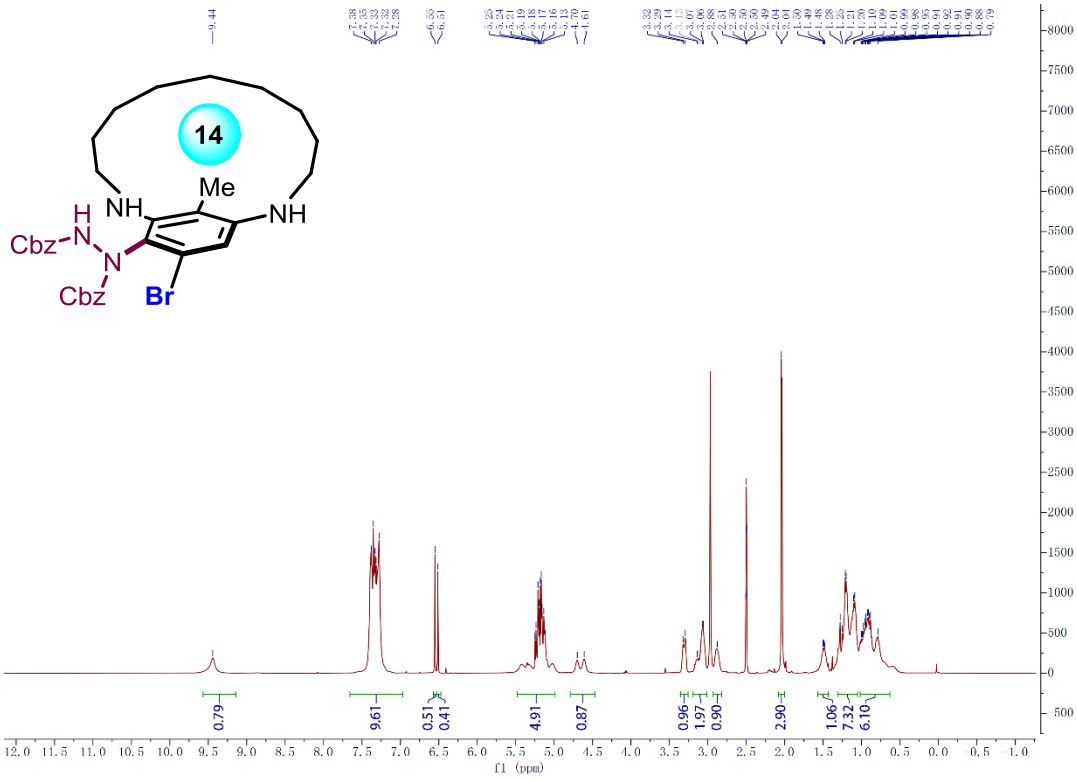



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

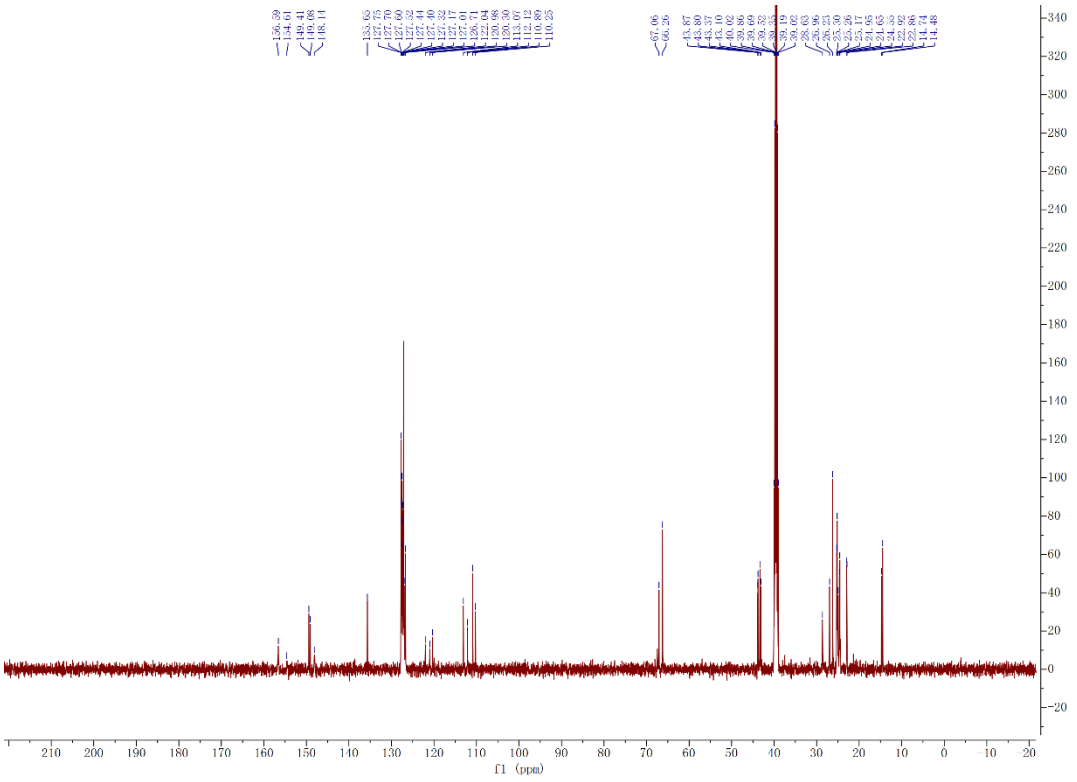


**Metacyclophanes 5e**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

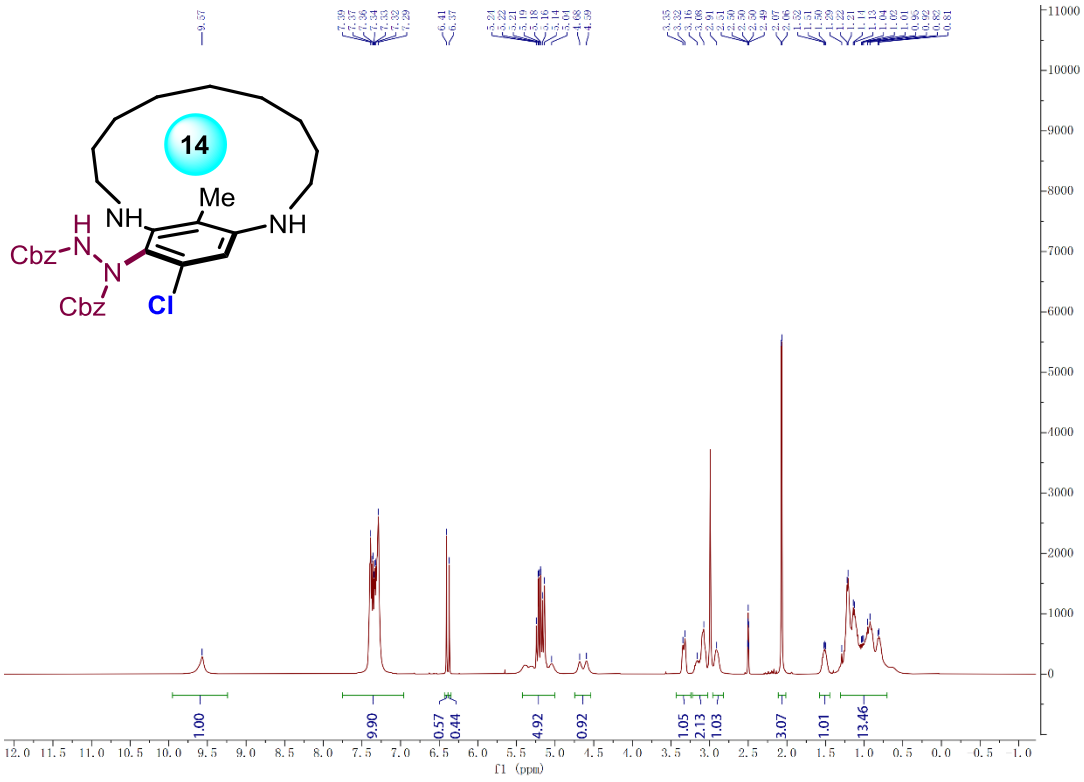



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

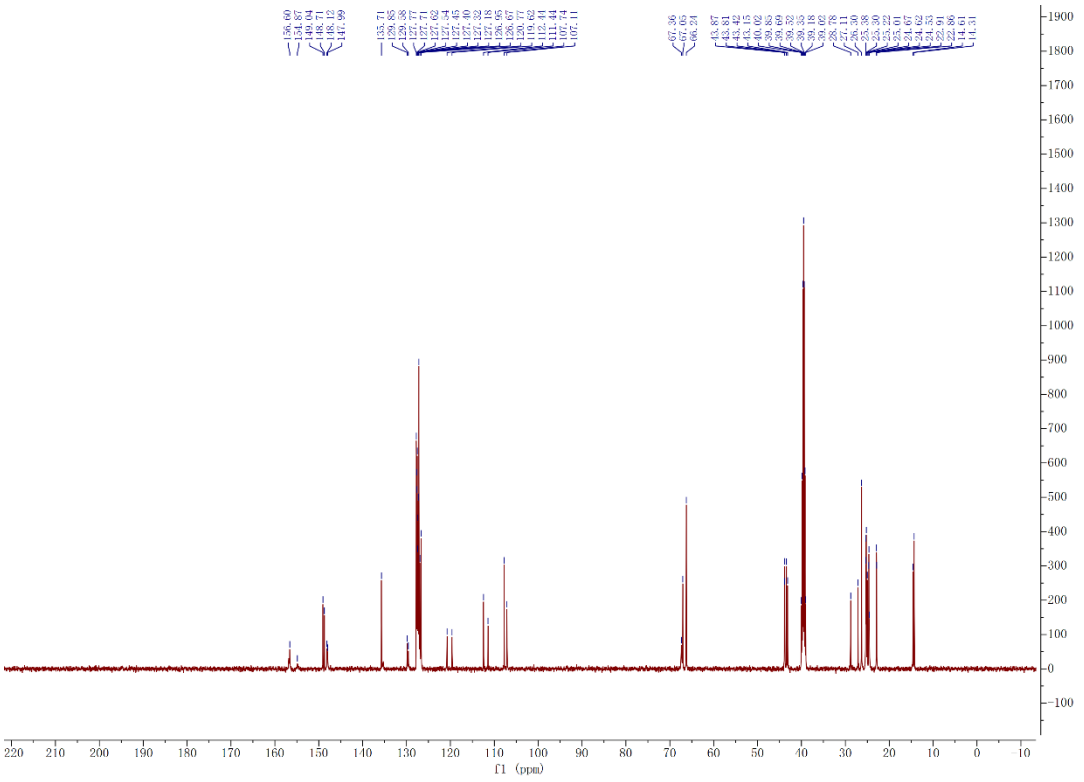


**Metacyclophanes 5f**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

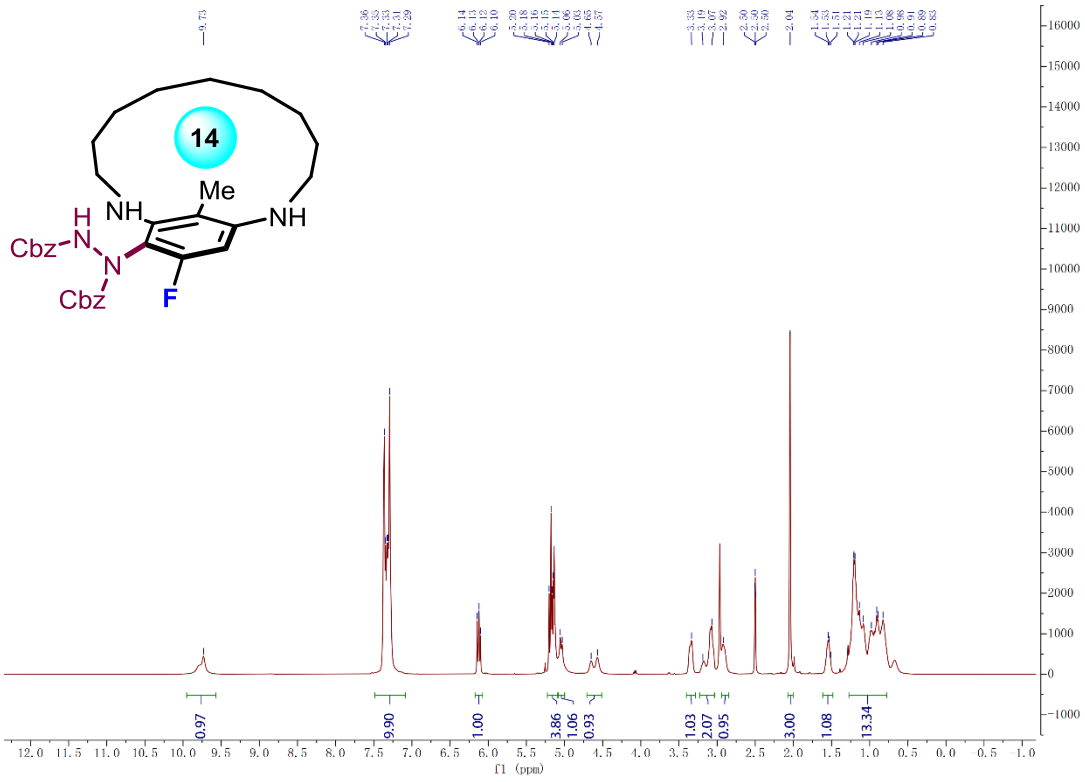



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

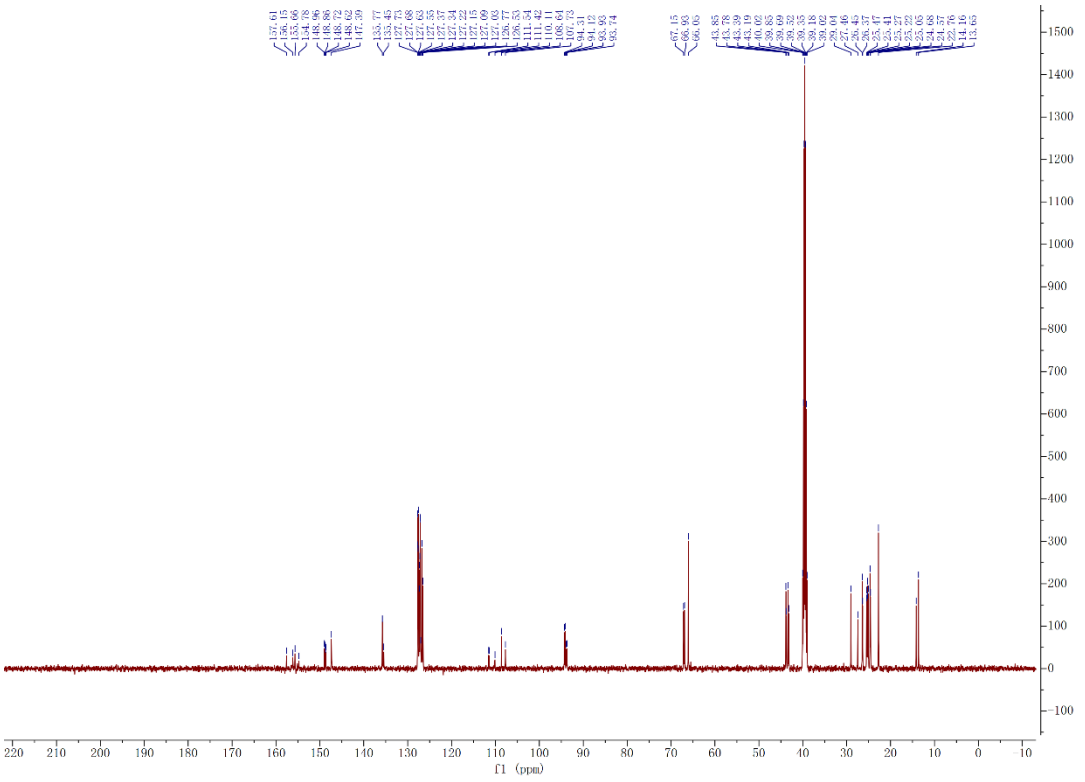


**Metacyclophanes 5g**

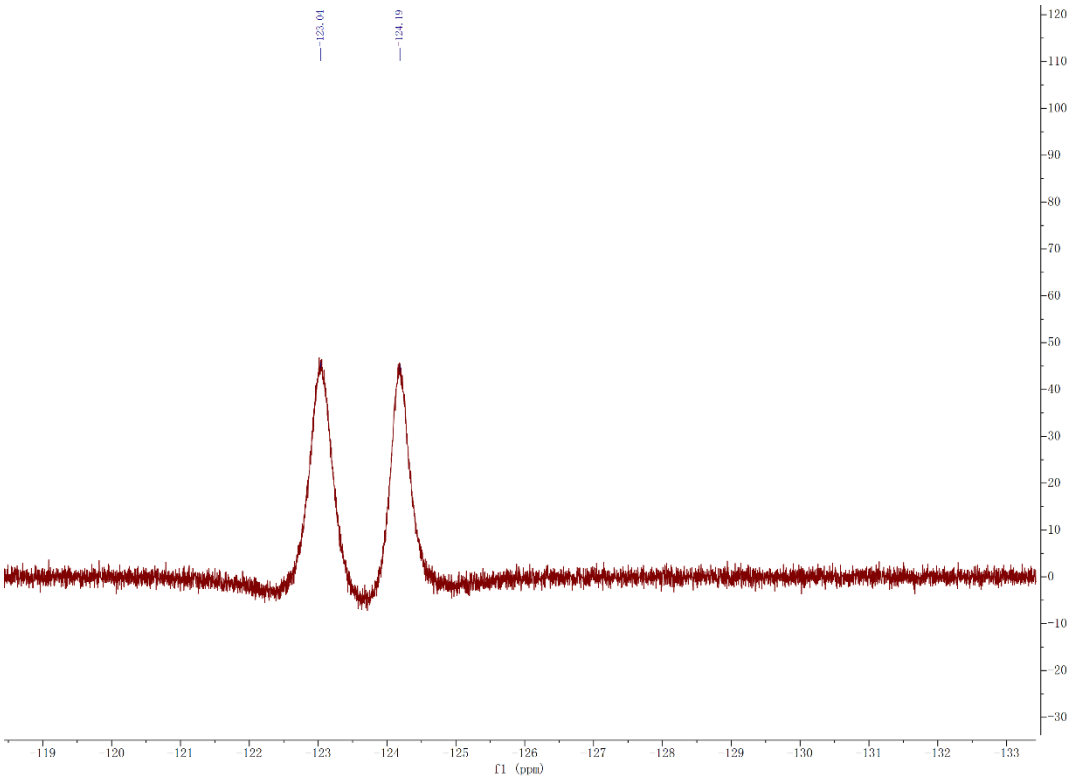
**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)




**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

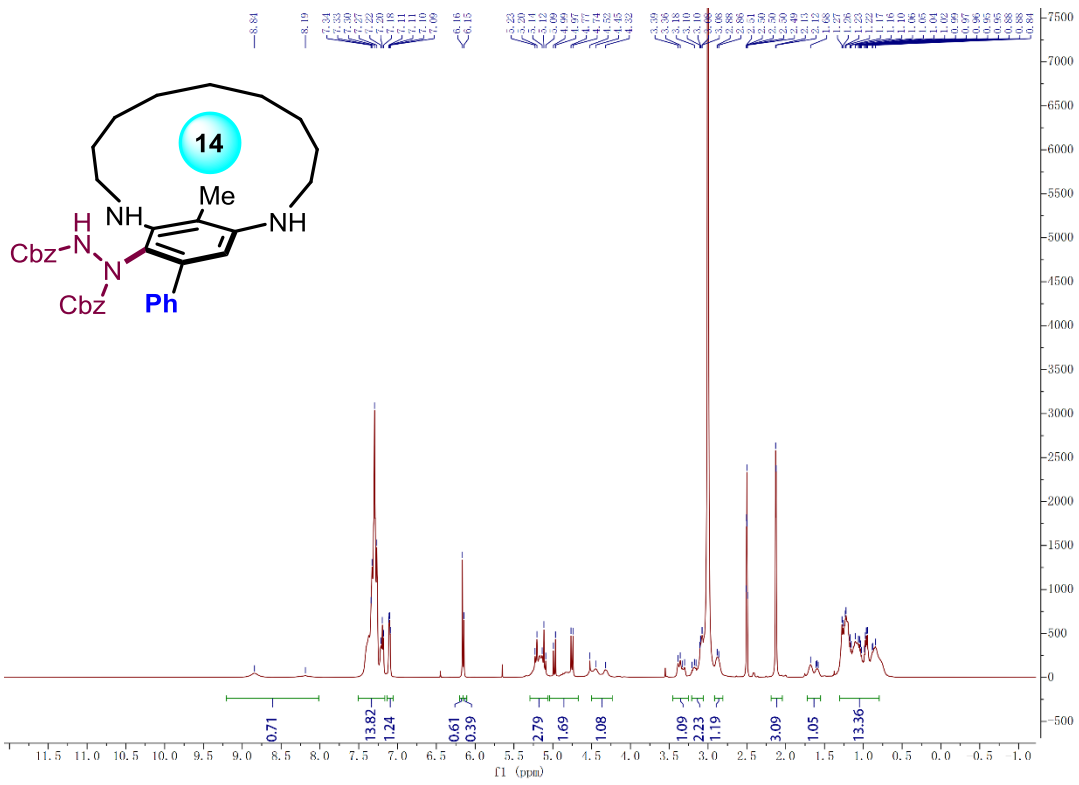


**$^{19}$F NMR** (471 MHz, DMSO-*d6*, 373 K)

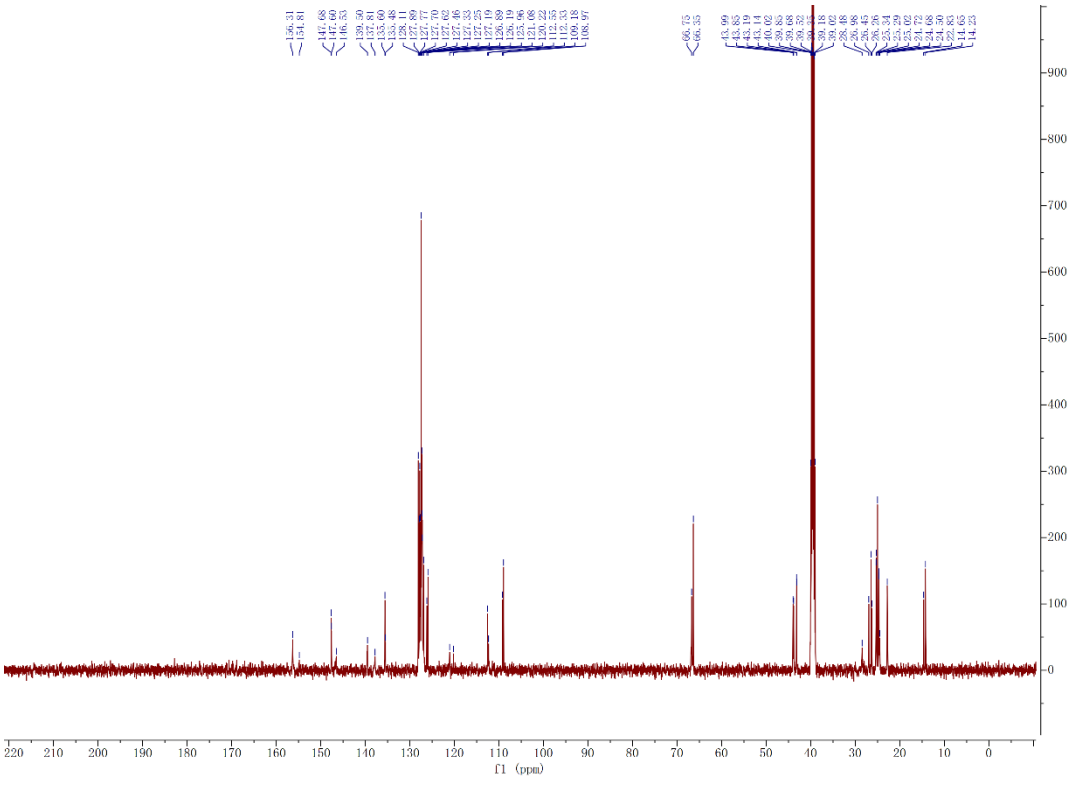


**Metacyclophanes 5h**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

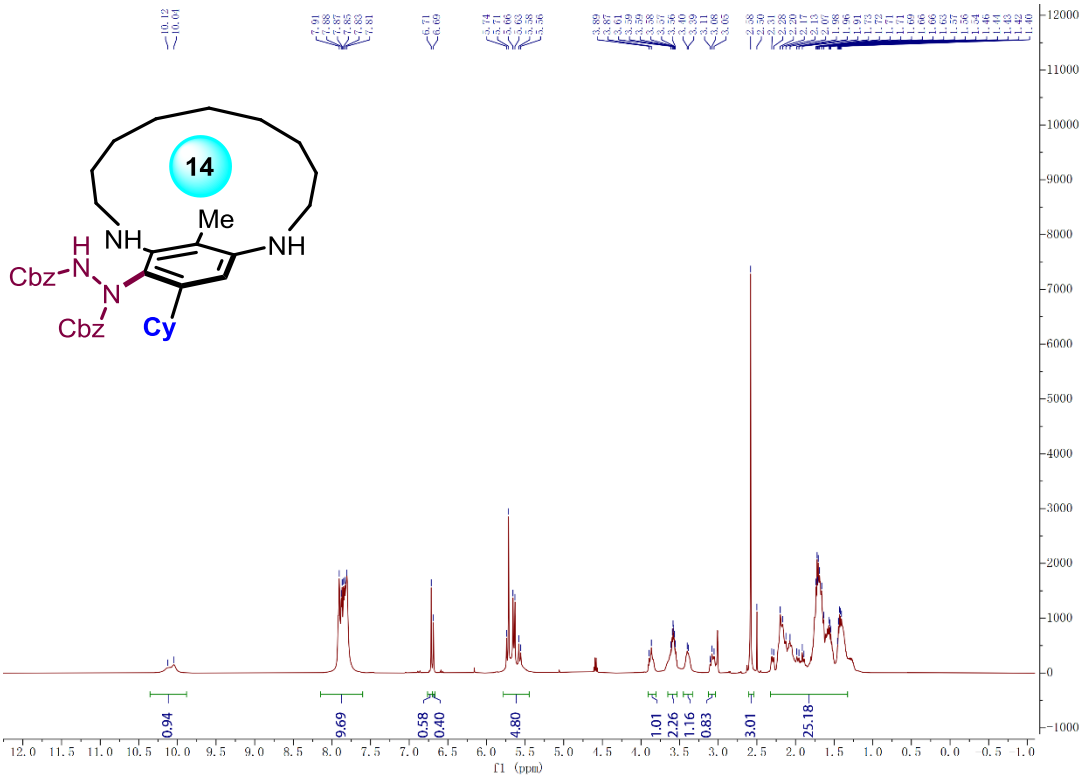



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

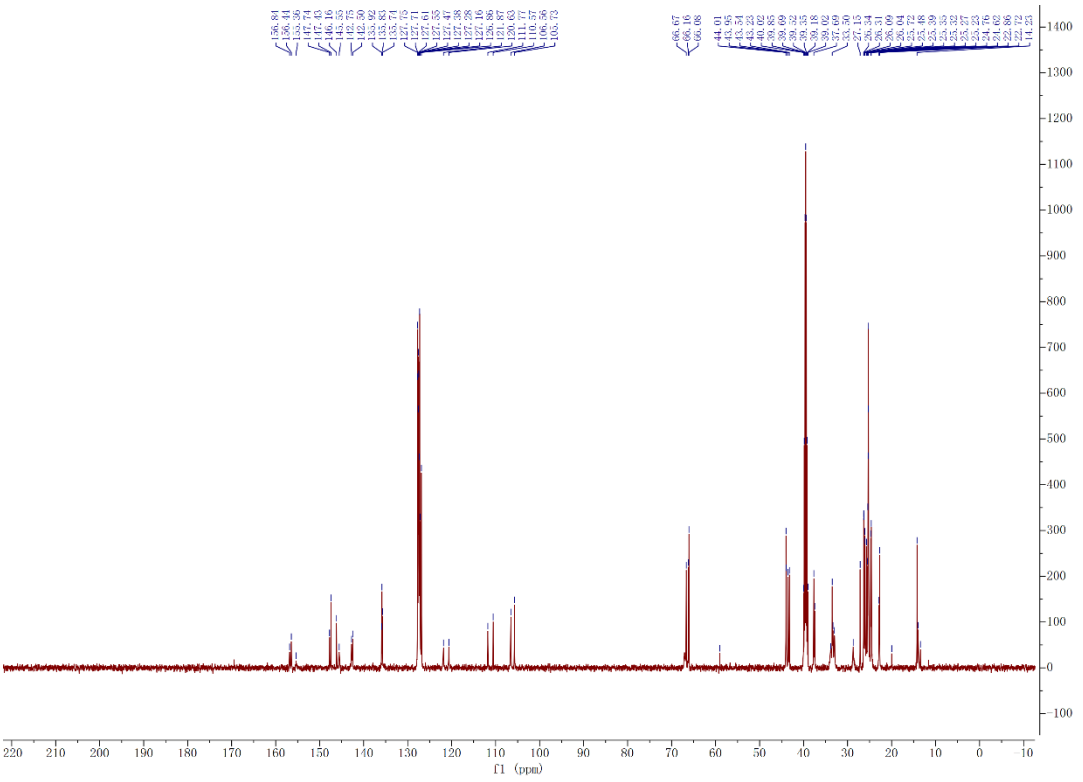


**Metacyclophanes 5i**

**$^{1}$H NMR** (500 MHz, DMSO-*d6*, 373 K)

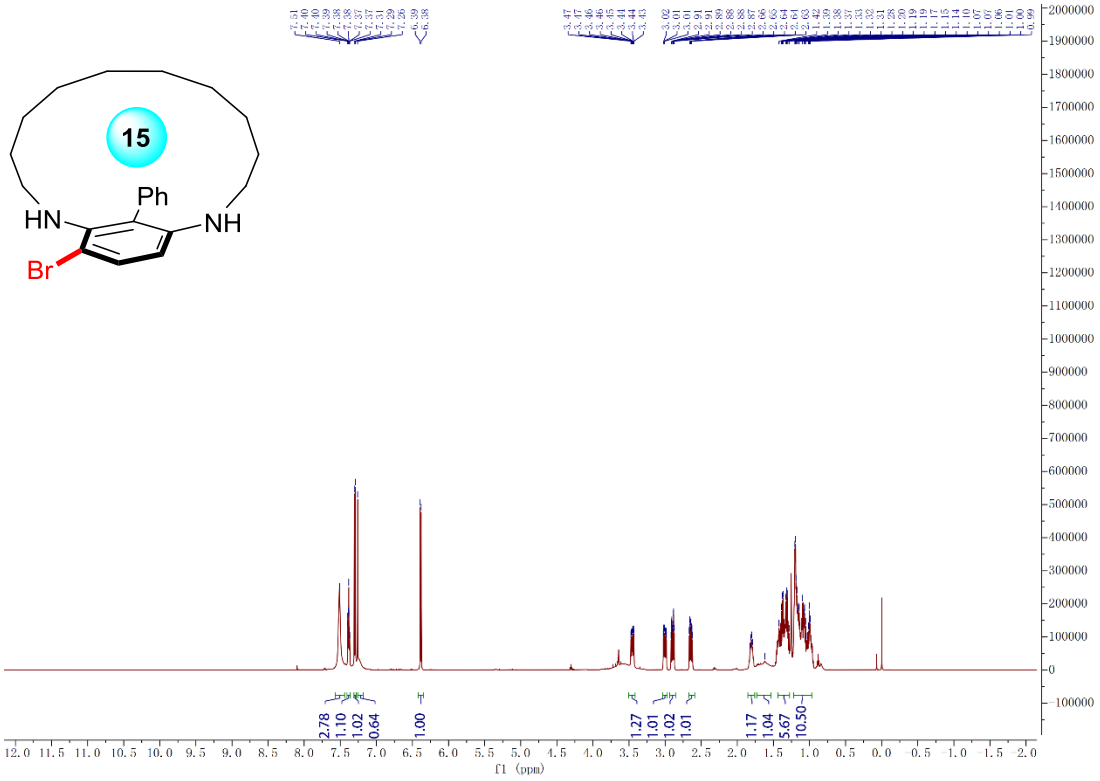



**$^{13}$C NMR** (126 MHz, DMSO-*d6*, 373 K)

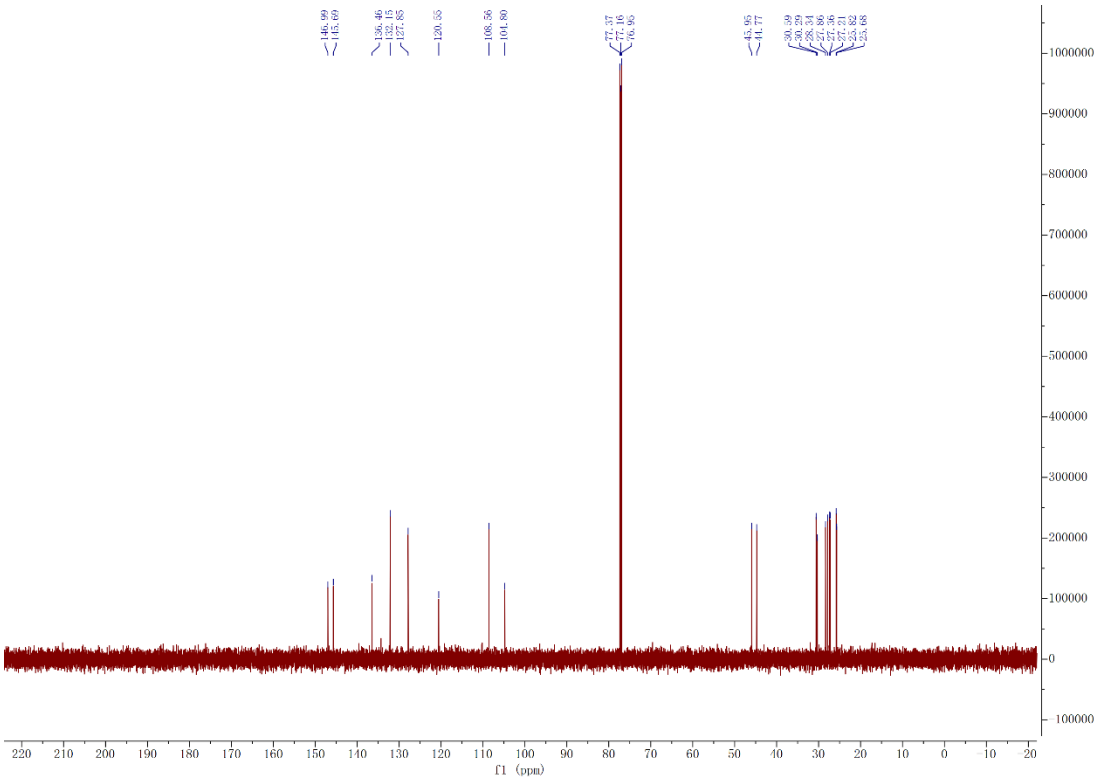


**Metacyclophanes 7a**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

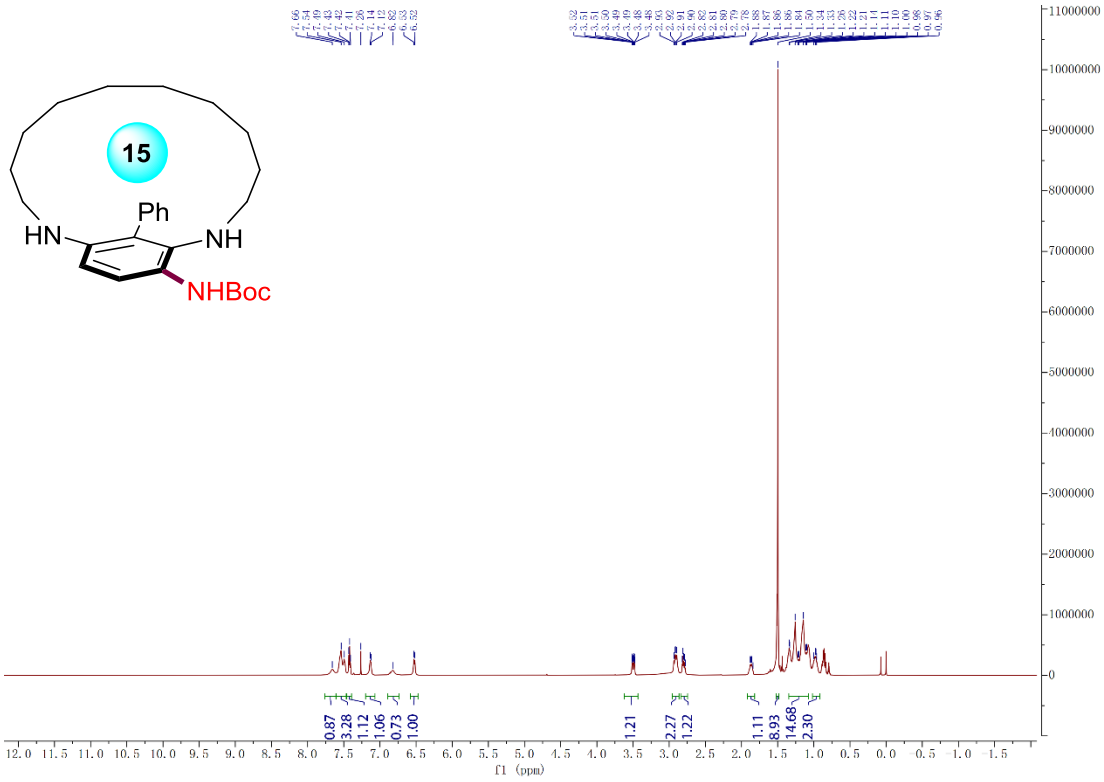



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

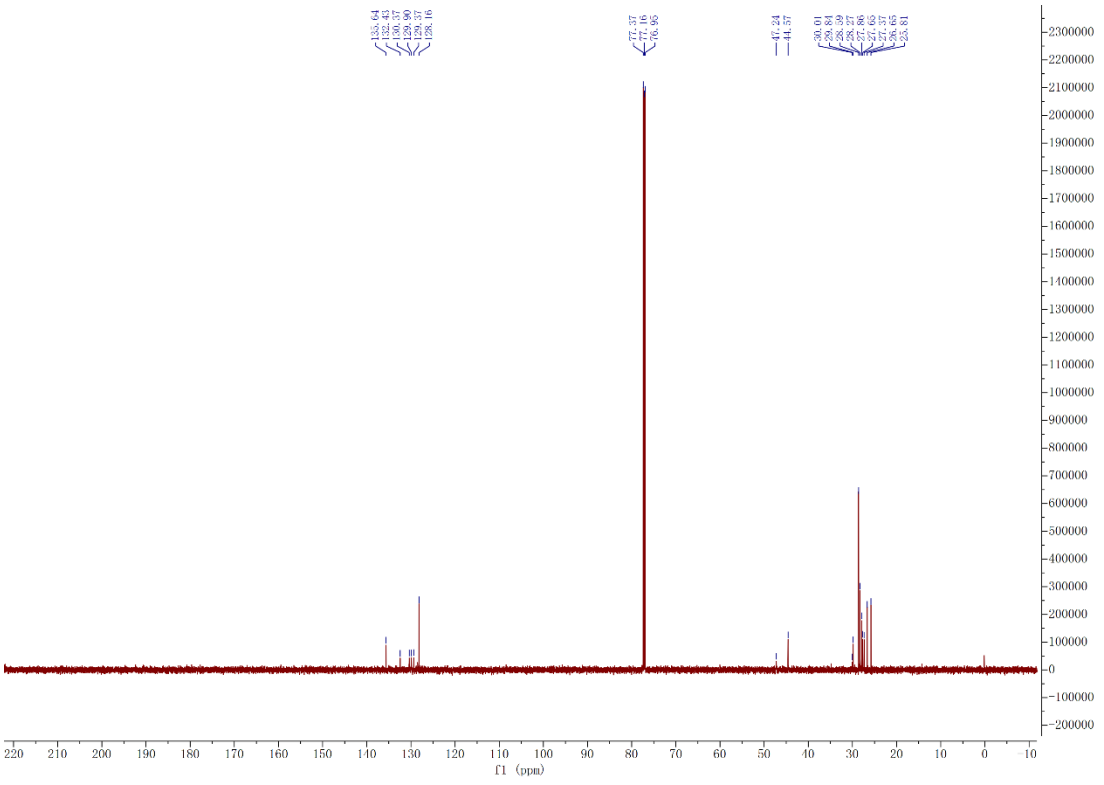


**Metacyclophanes 9a**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

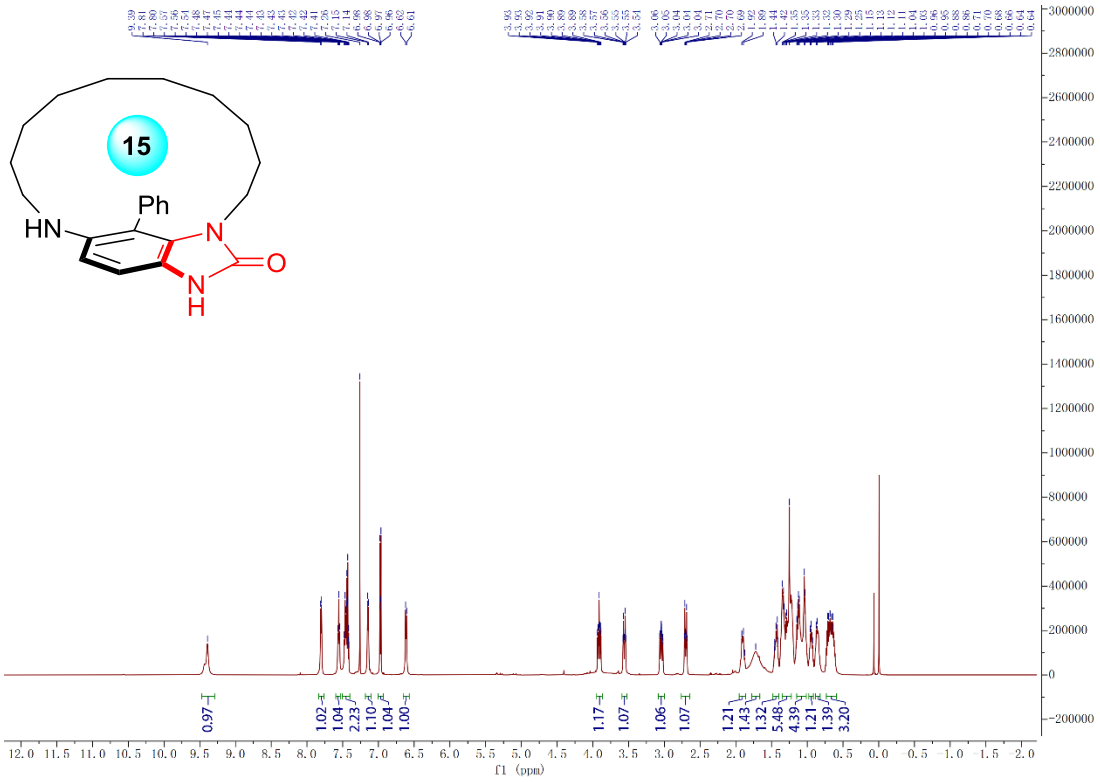



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

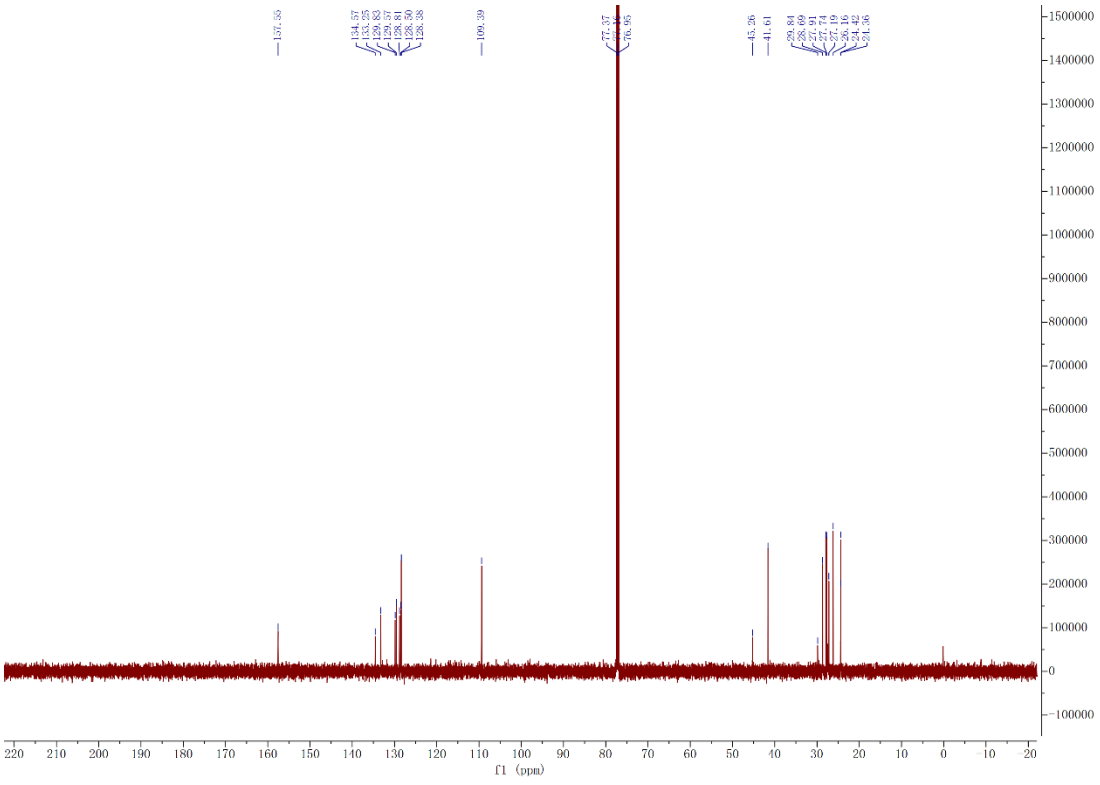


**Metacyclophanes 10a**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

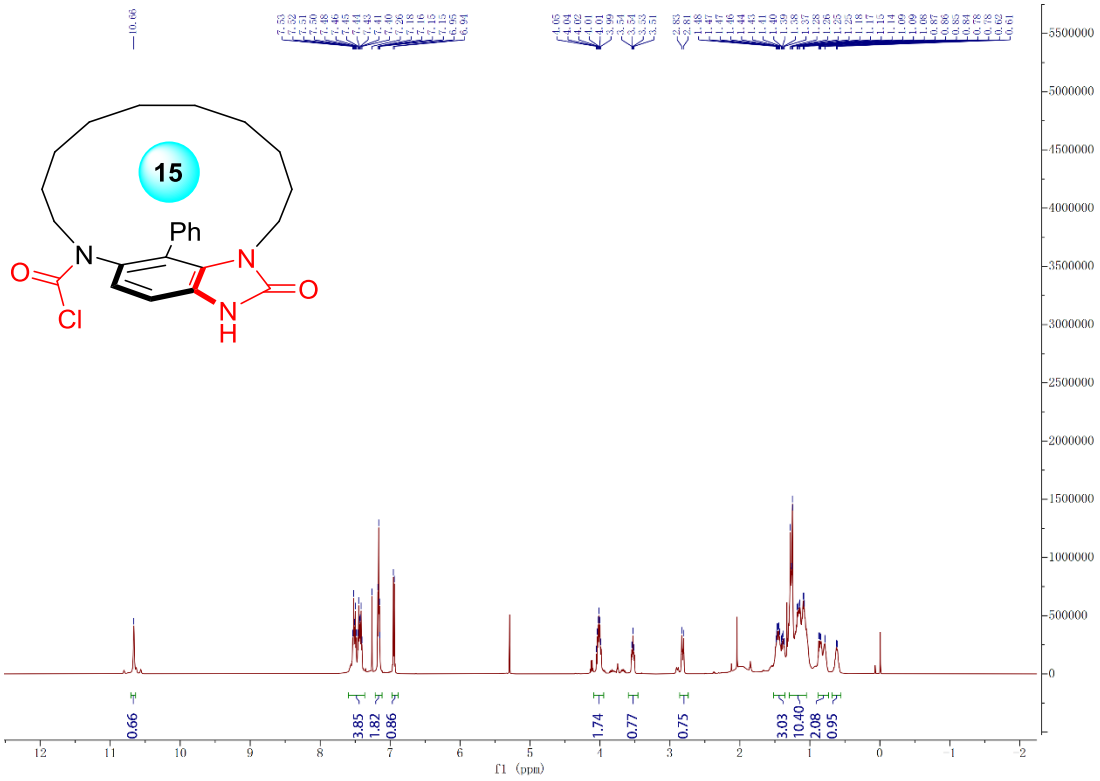



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

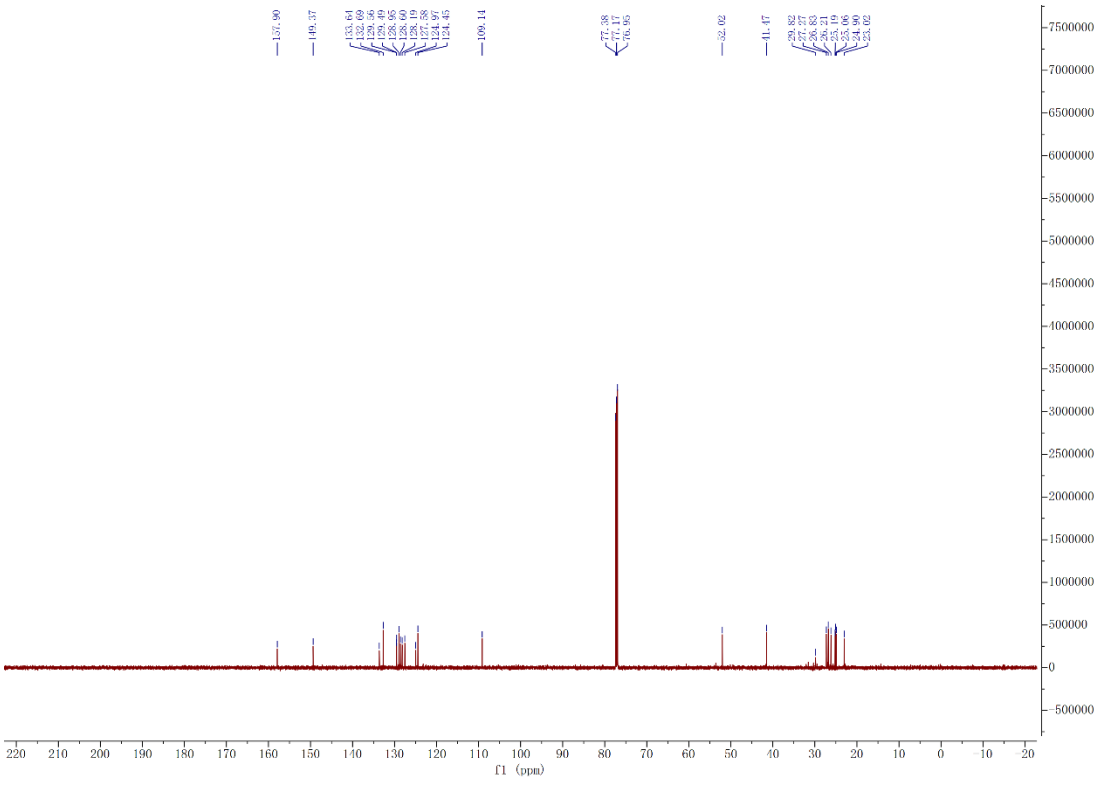


**Metacyclophanes 11a**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

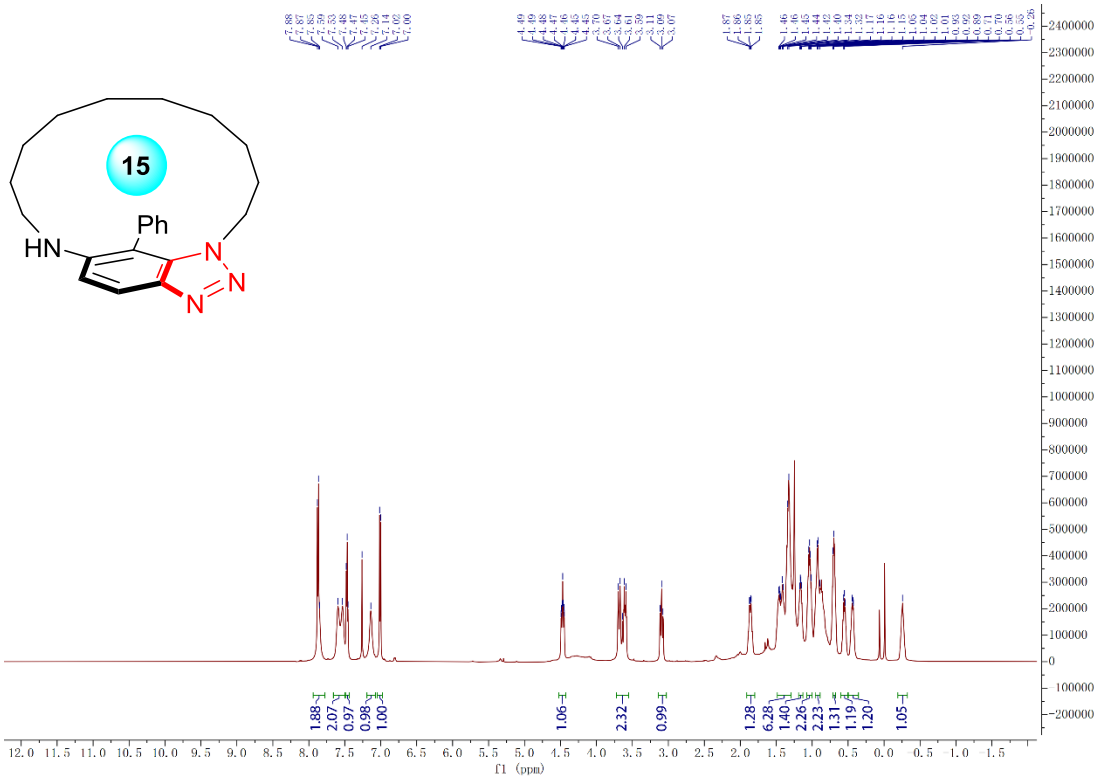



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

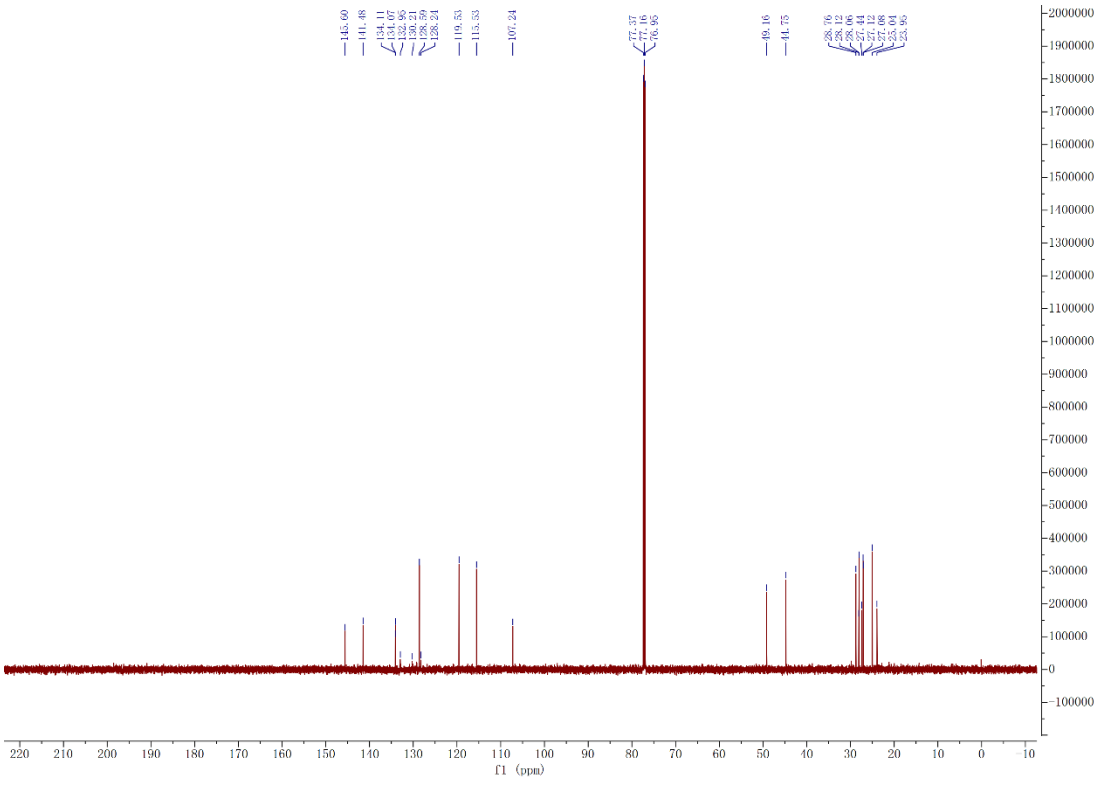


**Metacyclophanes 12a**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

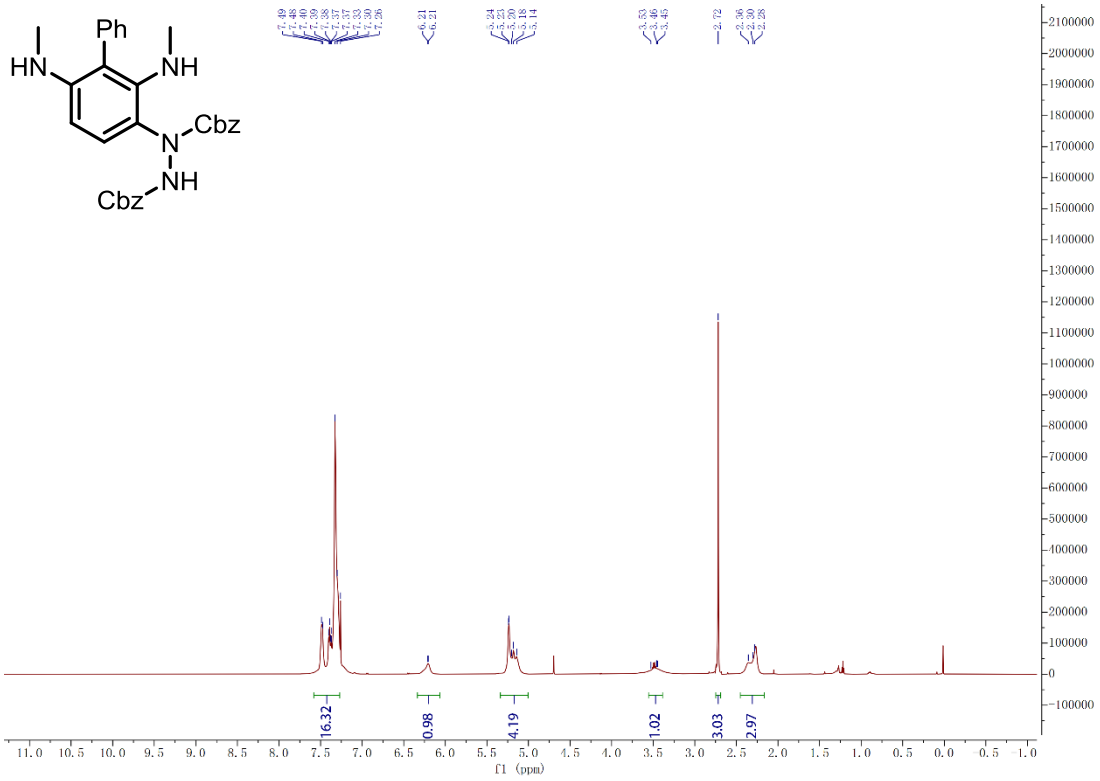



**$^{13}$C NMR** (151 MHz, $CDCl_3$)

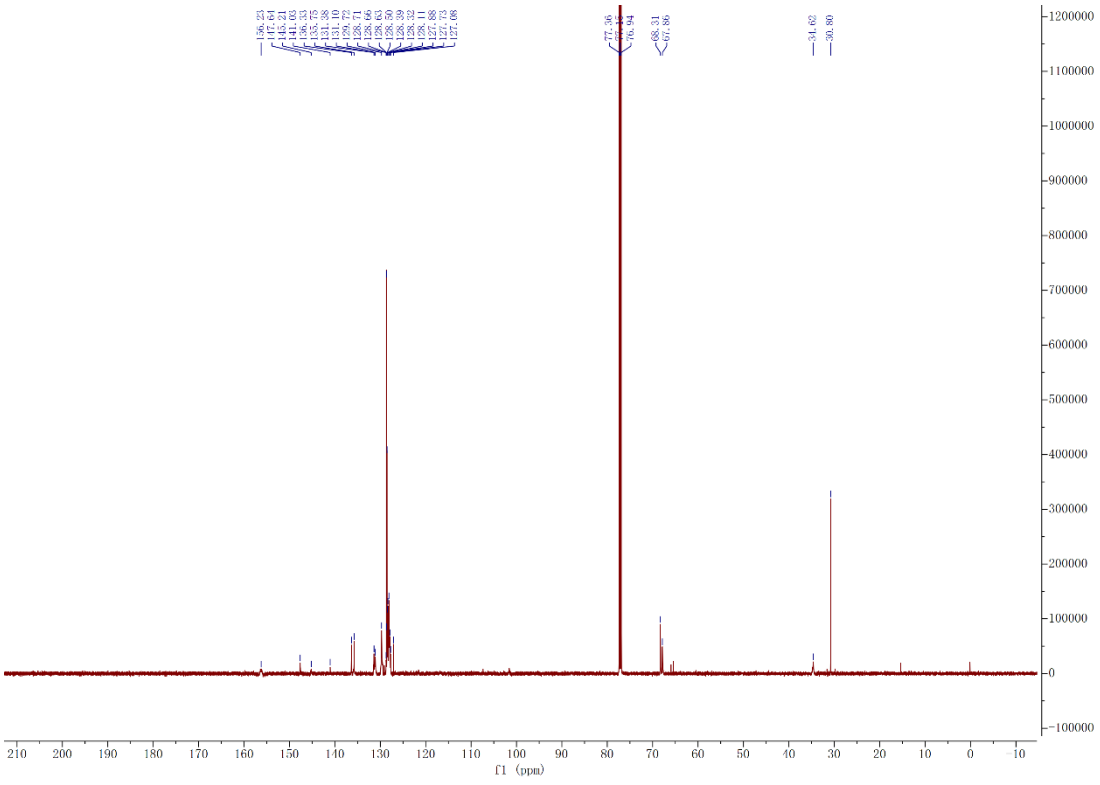


**Metacyclophanes 14a**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)

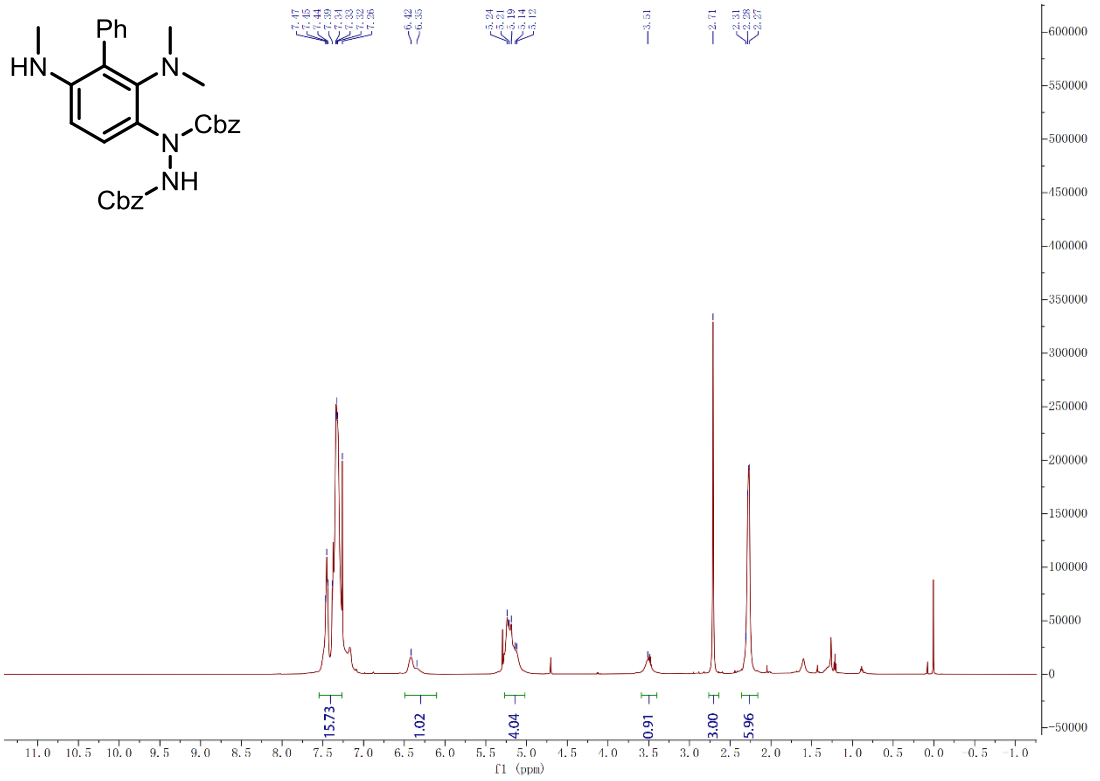



**$^{13}$C NMR** (151 MHz, $CDCl_3$)



**Metacyclophanes 14a'**

**$^{1}$H NMR** (600 MHz, $CDCl_3$)




**$^{13}$C NMR** (151 MHz, $CDCl_3$)