

## Self-Sorting Molecular Clips – Supporting Information

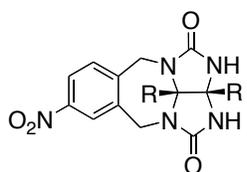
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<b>Table of Contents</b>	<b>Pages</b>
General experimental details .....	S2
Synthetic procedures and characterization data .....	S2 – S10
Details of the X-ray crystal Structures of <b>2•2, (+)-5•(-)-5, (+)-7•(+)-7, 8•8, and (±)-12</b> .....	S11 – S25
Additional <sup>1</sup> H NMR experiments .....	S26 – S33
<sup>1</sup> H and <sup>13</sup> C NMR spectra of new compounds .....	S34 – S65

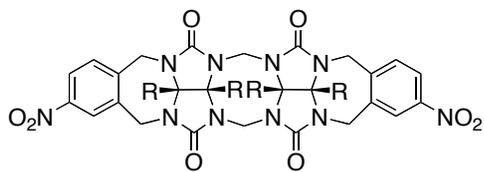
**General Experimental.** Starting materials were purchased from commercial suppliers and were used without further purification. Compounds **1**, **2**, ( $\pm$ )-**4**, ( $\pm$ )-**5**, **13** – **16**, **20**, ( $\pm$ )-**25**, ( $\pm$ )-**26**, and 4-morpholineglyoxyloyl chloride were prepared according to the literature procedures.<sup>1-6</sup> Melting points were measured in open capillary tubes and are uncorrected. NMR spectra were measured on commercial spectrophotometers operating at 400 or 500 MHz for <sup>1</sup>H and 100 or 125 MHz for <sup>13</sup>C. Mass spectrometry was performed using a VG 7070E magnetic sector instrument by electron impact (EI) or by fast atom bombardment (FAB) using the indicated matrix. The matrix “magic bullet” is a 5:1 (w:w) mixture of dithiothreitol:dithioerythritol.

### Synthetic Procedures and Characterization.

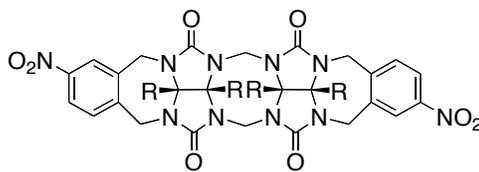


( $\pm$ )-**17** R = CO<sub>2</sub>Et

**Compound ( $\pm$ )-17:** Compound **16** (8.86 g, 31.0 mmol) was dissolved in anh. DMSO (120 mL) under N<sub>2</sub> and *t*-BuOK (7.41 g, 62.0 mmol) was added. After stirring for 12 min., **15** (2.10 g, 6.20 mmol) was added in one portion and stirring was continued for 2 h. The reaction mixture was poured into 0.1 N HCl (1 L) and extracted with EtOAc (3 x 1000 mL). The extracts were washed with brine (2 x 500 mL), dried over anh. MgSO<sub>4</sub> and concentrated. Flash chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/MeOH 25:1) gave impure ( $\pm$ )-**17** as a yellow solid. The impure solid was washed with EtOAc (1 mL), centrifuged, the supernatant decanted and the residue dried at high vacuum to obtain pure ( $\pm$ )-**17** as a white solid (650 mg, 1.50 mmol, 22%). M.p. 125-126 °C. TLC (CHCl<sub>3</sub>/MeOH 25:1) R<sub>f</sub> 0.14. IR (KBr, cm<sup>-1</sup>): 3422m, 2985w, 1717s, 1527m, 1463m, 1350m, 1271m. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): 8.19 (d, *J* = 2.2, 1H), 8.05 (dd, *J* = 2.2, *J* = 8.2, 1H), 7.51 (d, *J* = 8.2, 1H), 6.30 (s, 1H), 6.11 (s, 1H), 4.93 (d, *J* = 16.1, 1H), 4.92 (d, *J* = 16.1, 1H), 4.47 (d, *J* = 16.1, 1H), 4.46 (d, *J* = 16.1, 1H), 4.32 (q, *J* = 7.1, 2H), 4.24 (q, *J* = 7.1, 2H), 1.32 (t, *J* = 7.1, 3H), 1.27 (t, *J* = 7.1, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): 166.0, 165.7, 157.2, 157.0, 148.0, 143.6, 138.5, 131.2, 124.8, 123.8, 83.1, 74.0, 64.2, 63.9, 44.6, 14.4, 14.2 (only 17 of the 18 expected resonances were observed). MS (FAB, magic bullet): *m/z* 434 (100, [M + H]<sup>+</sup>). HR-MS (FAB, magic bullet, PEG): *m/z* 434.1303 ([M + H]<sup>+</sup>, C<sub>18</sub>H<sub>20</sub>N<sub>5</sub>O<sub>8</sub>, calcd 434.1312).



**18** R = CO<sub>2</sub>Et



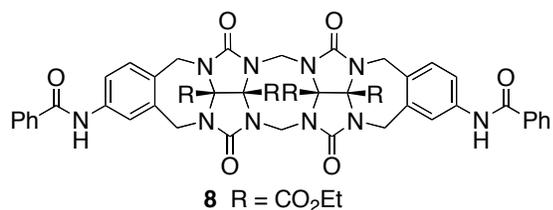
( $\pm$ )-**19** R = CO<sub>2</sub>Et

### Compound **18**

**and ( $\pm$ )-19:** A mixture of PTSA (3.51g, 18.4 mmol) in ClCH<sub>2</sub>CH<sub>2</sub>Cl

(100 mL) was heated under N<sub>2</sub> at reflux for 30 min. under an addition funnel filled with molecular sieves (4Å). Compound ( $\pm$ )-**17** (2.00 g, 4.6 mmol) and paraformaldehyde (414 mg, 13.8 mmol) were added and reflux was continued for 4 days. The reaction mixture was diluted

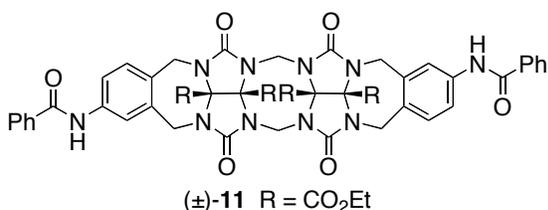
with EtOAc (1000 mL), washed with sat. aq. Na<sub>2</sub>CO<sub>3</sub>, dried over anh. MgSO<sub>4</sub>, and concentrated. Flash chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/CH<sub>3</sub>CN 3:1 and 1:1) gave impure (±)-**19** (447 mg, 0.502 mmol, 22%) and **18** (566 mg, 0.636 mmol, 28%), which were washed with EtOAc (1 mL), centrifuged, the supernatant decanted, and the residue dried under high vacuum, yielding product (±)-**19** (405 mg, 0.455 mmol, 20%) and **18** (479 mg, 0.538 mmol, 23%) as white solids. **Compound (±)-19**: M.p. >300 °C (dec.). TLC (CHCl<sub>3</sub>/MeOH 25:1) R<sub>f</sub> 0.12. IR (KBr, cm<sup>-1</sup>): 2984w, 1749s, 1528m, 1453s, 1349m, 1254s, 1019m, 911m. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): 8.15 (s, 2H), 8.02 (d, *J* = 8.2, 2H), 7.56 (d, *J* = 8.2, 2H), 5.79 (d, *J* = 16.2, 2H), 4.92 (d, *J* = 16.2, 2H), 4.83 (d, *J* = 16.2, 2H), 4.66 (d, *J* = 16.2, 2H), 4.62 (d, *J* = 16.2, 2H), 4.53 (d, *J* = 16.2, 2H), 4.30-4.20 (m, 8H), 1.30-1.15 (m, 12H). <sup>13</sup>C NMR (100 MHz, DMSO-*d*<sub>6</sub>): \_ 164.6, 163.8, 153.9, 146.9, 143.9, 138.5, 130.9, 123.9, 123.2, 79.8, 78.3, 64.5, 64.0, 47.4, 44.0, 43.8, 13.6, 13.5 (only 18 of the 19 expected resonances were observed). MS (FAB, magic bullet): *m/z* 891 (100, [M + H]<sup>+</sup>). HR-MS (FAB, magic bullet, CsI): *m/z* 1023.1505 ([M + Cs]<sup>+</sup>, C<sub>38</sub>H<sub>38</sub>N<sub>10</sub>O<sub>16</sub>Cs, calcd 1023.1522). **Compound 18**: M.p. >280 °C (dec.). TLC (CHCl<sub>3</sub>/MeOH 25:1) R<sub>f</sub> 0.07. IR (KBr, cm<sup>-1</sup>): 2984w, 1748s, 1528m, 1455s, 1349m, 1255s, 1019m, 912m. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): 8.16 (s, 2H), 8.02 (d, *J* = 8.0, 2H), 7.56 (d, *J* = 8.0, 2H), 5.79 (d, *J* = 16.1, 1H), 5.78 (d, *J* = 16.1, 1H), 4.92 (d, *J* = 16.1, 2H), 4.83 (d, *J* = 16.1, 2H), 4.66 (d, *J* = 16.1, 2H), 4.62 (d, *J* = 16.1, 2H), 4.53 (d, *J* = 16.1, 1H), 4.52 (d, *J* = 16.1, 1H), 4.30-4.20 (m, 8H), 1.30-1.15 (m, 12H). <sup>13</sup>C NMR (100 MHz, DMSO-*d*<sub>6</sub>): \_ 164.6, 163.8, 154.0, 153.8, 146.9, 143.9, 138.5, 130.7, 124.0, 123.1, 79.8, 78.3, 64.5, 64.0, 47.5, 43.9, 43.8, 13.6, 13.5 (only 19 of the 20 expected resonances were observed). MS (FAB, magic bullet): *m/z* 891 (100, [M + H]<sup>+</sup>). HR-MS (FAB, magic bullet): *m/z* 1023.1483 ([M + Cs]<sup>+</sup>, C<sub>38</sub>H<sub>38</sub>N<sub>10</sub>O<sub>16</sub>Cs, calcd 1023.1522).



**Compound 8**: A mixture of compound **18** (267 mg, 0.30 mmol) and 10% Pd/C (200 mg) in anh. DMF (20 mL) was stirred under H<sub>2</sub> (10 psi) at RT for 6 h in a Schlenk apparatus. The reaction mixture was filtered under Ar and concentrated under high

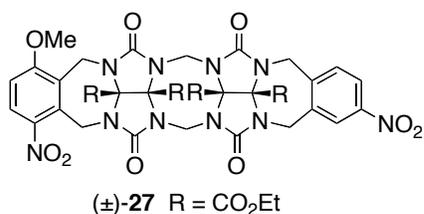
vacuum at RT to obtain a highly air and moisture sensitive diamine as a white solid. The crude solid was dissolved in a mixture of anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (10 mL) and distilled NEt<sub>3</sub> (1 mL) under Ar. This solution was added to a solution of benzoyl chloride (168 mg, 1.20 mmol) in anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (5 mL) at -78 °C. After 15 min., the cooling bath was removed and stirring was continued at room temperature for 8 h under Ar. The reaction mixture was diluted with CHCl<sub>3</sub> (200 mL), washed with sat. aq. NaHCO<sub>3</sub>, dried over anh. MgSO<sub>4</sub>, and concentrated. Flash chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/MeOH 20:1) gave impure **8**. The impure solid was washed with EtOAc (2 mL), centrifuged, the supernatant decanted and the residue dried at high vacuum to obtain pure **8** as a white solid (227 mg, 0.218 mmol, 73%). M.p. > 319 °C (dec.). TLC (CHCl<sub>3</sub>/MeOH 10:1) R<sub>f</sub> 0.44. IR (KBr, cm<sup>-1</sup>): 3435m, 2983w, 1745s, 1659m, 1596m, 1535m, 1456m, 1426m, 1254s, 1017m, 910m. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): 10.19 (s, 2H), 7.88 (d, *J* = 7.4, 4H), 7.68 (s, 2H), 7.65-7.50 (m, 4H), 7.50-7.40 (m, 4H), 7.23 (d, *J* = 8.2, 2H), 5.81 (d, *J* =

16.1, 1H), 5.80 (d,  $J = 16.1$ , 1H), 4.65-4.40 (m, 10H), 4.30-4.10 (m, 8H), 1.24 (t,  $J = 7.1$ , 6H), 1.20 (t,  $J = 7.1$ , 6H).  $^{13}\text{C}$  NMR (100 MHz, DMSO- $d_6$ ):  $\delta$  165.4, 165.1, 164.1, 154.1, 154.0, 138.7, 136.5, 134.7, 131.5, 131.2, 129.9, 128.3, 127.6, 121.3, 119.3, 80.0, 78.5, 64.3, 63.8, 47.3, 44.9, 44.2, 13.6, 13.5 (only 24 of the 25 expected resonances were observed). MS (FAB, magic bullet):  $m/z$  1039 (35,  $[\text{M} + \text{H}]^+$ ), 105 (100). HR-MS (FAB, magic bullet, CsI):  $m/z$  1171.2565 ( $[\text{M} + \text{Cs}]^+$ ,  $\text{C}_{52}\text{H}_{50}\text{N}_{10}\text{O}_{14}\text{Cs}$ , calcd 1171.2562).



**Compound (±)-11:** A mixture of compound (±)-**19** (138 mg, 0.16 mmol) and 10% Pd/C (100 mg) in anh. DMF (15 mL) was stirred under H<sub>2</sub> (10 psi) at RT for 6 h in a Schlenk apparatus. The reaction mixture was filtered under Ar and concentrated under high vacuum at RT to obtain a

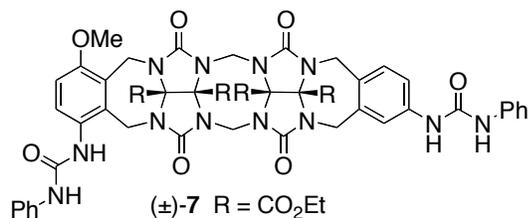
highly air and moisture sensitive diamine as a white solid. The crude solid was dissolved in a mixture of anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (5 mL) and distilled NEt<sub>3</sub> (1 mL) under Ar. This solution was added to a solution of benzoyl chloride (46 mg, 0.33 mmol) in anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (5 mL) at -78 °C. After 15 min., the cooling bath was removed and stirring was continued at room temperature for 8 h under Ar. The reaction mixture was diluted with CHCl<sub>3</sub> (200 mL), washed with sat. aq. NaHCO<sub>3</sub>, dried over anh. MgSO<sub>4</sub>, and concentrated. Flash chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/MeOH 50:1) gave impure (±)-**11** (123 mg, 0.118 mmol, 76%). The impure solid was washed with EtOAc/Hexane (2:1) (1 mL), centrifuged, the supernatant decanted and the residue dried at high vacuum to obtain pure (±)-**11** as a white solid (98 mg, 0.094 mmol, 60%). M.p. 212-214 °C. TLC (CHCl<sub>3</sub>/MeOH 10:1)  $R_f$  0.46. IR (KBr, cm<sup>-1</sup>): 3429m, 2983w, 2940w, 1744s, 1665m, 1596m, 1535m, 1455m, 1425m, 1253m, 1017m, 910m.  $^1\text{H}$  NMR (500 MHz, DMSO- $d_6$ ): 10.20 (s, 2H), 7.89 (d,  $J = 7.5$ , 4H), 7.68 (s, 2H), 7.61 (d,  $J = 7.9$ , 2H), 7.60-7.50 (m, 2H), 7.50-7.40 (m, 4H), 7.23 (d,  $J = 8.2$ , 2H), 5.80 (d,  $J = 16.2$ , 2H), 4.65-4.40 (m, 10H), 4.23 (q,  $J = 6.9$ , 4H), 4.20 (q,  $J = 6.9$ , 4H), 1.24 (t,  $J = 6.9$ , 6H), 1.20 (t,  $J = 6.9$ , 6H).  $^{13}\text{C}$  NMR (100 MHz, DMSO- $d_6$ ):  $\delta$  165.4, 165.0, 164.1, 154.1, 154.0, 138.7, 136.5, 134.7, 131.5, 131.2, 129.9, 128.2, 127.5, 121.3, 119.3, 80.0, 78.5, 64.3, 63.7, 47.3, 44.9, 44.2, 13.6, 13.5. MS (FAB, magic bullet):  $m/z$  1039 (100,  $[\text{M} + \text{H}]^+$ ). HR-MS (FAB, magic bullet, PEG, Li):  $m/z$  1045.3678 ( $[\text{M} + \text{Li}]^+$ ,  $\text{C}_{52}\text{H}_{50}\text{N}_{10}\text{O}_{14}\text{Li}$ , calcd 1045.3668).



**Compound (±)-27:** A solution of PTSA (2.812 g, 14.8 mmol) in ClCH<sub>2</sub>CH<sub>2</sub>Cl (80 mL) was heated under N<sub>2</sub> at reflux for 30 min. under an addition funnel filled with molecular sieves (4Å). Compound (±)-**25** (1.370 g, 2.96 mmol) and (±)-**26** (1.50 g, 2.96 mmol) were added and reflux was continued for 2 d. The reaction mixture was

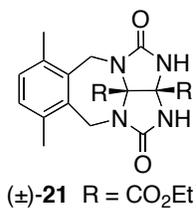
diluted with EtOAc (1000 mL), washed with sat. aq. Na<sub>2</sub>CO<sub>3</sub>, dried over anh. MgSO<sub>4</sub>, and

concentrated. Flash chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/CH<sub>3</sub>CN 10:1) gave an impure (±)-**27** (600 mg, 0.65 mmol, 22 %). The impure solid was washed with EtOAc (1 mL), centrifuged, the supernatant decanted and the residue dried at high vacuum to obtain pure (±)-**27** as a white solid (345 mg, 0.38 mmol, 13 %). M.p. >310 °C (dec.). TLC (CHCl<sub>3</sub>/MeOH 25:1) R<sub>f</sub> 0.17. IR (KBr, cm<sup>-1</sup>): 2986w, 1751s, 1524m, 1457m, 1348w, 1256s, 1086m, 1020m, 911m. <sup>1</sup>H NMR (500 MHz, DMSO-*d*<sub>6</sub>): 8.16 (d, *J* = 1.8, 1H), 8.02 (dd, *J* = 1.8, *J* = 8.2, 1H), 7.73 (d, *J* = 9.0, 1H), 7.53 (d, *J* = 8.2, 1H), 6.92 (d, *J* = 9.0, 1H), 5.77 (d, *J* = 16.1, 1H), 5.74 (d, *J* = 16.1, 1H), 5.33 (d, *J* = 16.1, 1H), 5.18 (d, *J* = 16.2, 1H), 4.93 (d, *J* = 16.2, 1H), 4.82 (d, *J* = 16.2, 1H), 4.64 (d, *J* = 16.2, 2H), 4.63 (d, *J* = 16.2, 1H), 4.54 (d, *J* = 16.2, 1H), 4.51 (d, *J* = 16.2, 1H), 4.30-4.20 (m, 9H), 3.74 (s, 3H), 1.30-1.15 (m, 12H). <sup>13</sup>C NMR (100 MHz, TFA-D): 166.1, 164.6, 161.1, 157.2, 157.0, 156.8, 143.3, 127.5, 126.1, 124.9, 124.2, 81.5, 81.1, 79.9, 66.2, 65.9, 55.9, 48.6, 48.4, 44.7, 36.4, 12.6, 12.5 (only 23 of the 39 expected resonances were observed). MS (FAB, magic bullet): *m/z* 921 (100, [M + H]<sup>+</sup>). HR-MS (FAB, magic bullet): *m/z* 1053.1676 ([M + Cs]<sup>+</sup>, C<sub>39</sub>H<sub>40</sub>N<sub>10</sub>O<sub>17</sub>Cs, calcd 1053.1627). X-ray crystal structure.



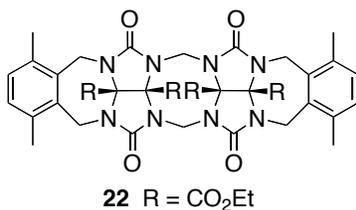
**Compound (±)-7:** A mixture of compound (±)-**27** (139 mg, 0.15 mmol) and 10% Pd/C (100 mg) in anh. DMF (20 mL) was stirred under H<sub>2</sub> (10-20 psi) at RT for 6 h in a Schlenk apparatus. The reaction mixture was filtered under Ar and concentrated under high vacuum at RT to obtain a highly air and moisture

sensitive diamine as a white solid. The crude solid was dissolved in a mixture of anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (20 mL) and distilled NEt<sub>3</sub> (5 mL) under Ar. To this solution was added phenyl isocyanate (44.6 mg, 0.38 mmol) and stirring was continued at RT for 8 h under Ar. The reaction mixture was diluted with CHCl<sub>3</sub> (200 mL), washed with sat. aq. NaHCO<sub>3</sub>, dried over anh. MgSO<sub>4</sub>, and concentrated. Flash chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/MeOH 100:1 then 50:1) gave (±)-**7** (65 mg, 0.06 mmol, 39 %) as a white solid. M.p. > 290 °C (dec.). TLC (CHCl<sub>3</sub>/MeOH 25:1) R<sub>f</sub> 0.17. IR (KBr, cm<sup>-1</sup>): 3391m, 2927w, 1749s, 1598m, 1548m, 1499m, 1443m, 1249s, 1083m, 1018m, 909m. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): 8.98 (s, 1H), 8.71 (s, 1H), 8.86 (s, 1H), 7.94 (s, 1H), 7.50-7.40 (m, 5H), 7.30-7.15 (m, 7H), 7.00-6.85 (m, 3H), 5.81 (d, *J* = 15.9, 1H), 5.80 (d, *J* = 15.9, 1H), 5.10 (d, *J* = 15.3, 1H), 4.80 (d, *J* = 15.8, 1H), 4.65-4.15 (m, 14H), 4.05 (q, *J* = 7.0, 2H), 3.76 (s, 3H), 1.25-1.05 (m, 12H). <sup>13</sup>C NMR (100 MHz, DMSO-*d*<sub>6</sub>): 165.2, 165.1, 164.2, 164.0, 154.7, 154.2, 154.1, 154.1, 153.9, 153.8, 152.3, 140.1, 139.5, 139.5, 136.9, 132.5, 130.2, 129.3, 129.1, 128.8, 128.7, 127.5, 123.9, 121.9, 121.5, 119.0, 118.2, 117.9, 116.8, 111.8, 79.9, 79.6, 78.7, 78.5, 64.4, 63.8, 63.6, 56.1, 47.3, 47.3, 45.0, 44.2, 36.3, 13.6, 13.5 (only 45 of the 49 expected resonances were observed). MS (FAB, magic bullet): *m/z* 1231 (100, [M + Cs]<sup>+</sup>). HR-MS (FAB, magic bullet, PEG): *m/z* 1231.2872 ([M + Cs]<sup>+</sup>, C<sub>53</sub>H<sub>54</sub>N<sub>12</sub>O<sub>15</sub>Cs, calcd 1231.2886).



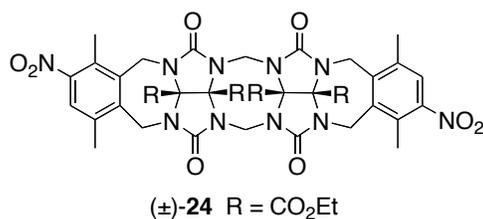
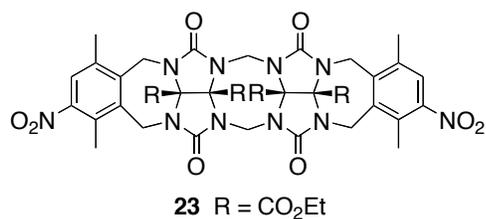
**Compound (±)-21:** A mixture of *p*-xylene (600 mL) and PTSA (30.84 g, 162.1 mmol) was refluxed under an addition funnel filled with 4Å molecular sieves for 1 h. Compound **20** (6.00 g, 16.21 mmol) was added in one portion and reflux was continued for 4 h. The reaction mixture was cooled to room temperature and *p*-xylene was distilled off under high vacuum. The residue was dissolved in CHCl<sub>3</sub> (1000 mL), washed with sat. aq. Na<sub>2</sub>CO<sub>3</sub>, dried over anh. MgSO<sub>4</sub>, and concentrated. Flash chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/MeOH 50:1) gave impure (±)-**21** as a yellow solid. The impure solid was washed with EtOAc (10 mL), centrifuged, the supernatant decanted and the residue dried at high vacuum to obtain pure (±)-**21** as a white solid (2.45 g, 5.88 mmol, 36%). M.p. 250-251 °C. TLC (CHCl<sub>3</sub>/MeOH 25:1) *R<sub>f</sub>* 0.25. IR (KBr, cm<sup>-1</sup>): 3432m, 3221m, 2982w, 2927w, 1755s, 1707s, 1475m, 1448m, 1278m, 1269m, 1150m, 1044m. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): 8.43 (s, 2H), 6.98 (s, 2H), 4.87 (d, *J* = 16.0, 2H), 4.30-4.20 (m, 4H), 4.15 (q, *J* = 7.1, 2H), 2.44 (s, 6H), 1.26 (t, *J* = 7.1, 3H), 1.21 (t, *J* = 7.1, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): 166.5, 166.4, 157.8, 135.7, 135.1, 130.7, 83.1, 74.3, 64.0, 63.6, 40.4, 20.5, 14.4, 14.2. MS (FAB, PEG): *m/z* 417 (100, [M + H]<sup>+</sup>). HR-MS (FAB, PEG): *m/z* 417.1778 ([M + H]<sup>+</sup>, C<sub>20</sub>H<sub>25</sub>N<sub>4</sub>O<sub>6</sub>, calcd 417.1774).

Flash chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/MeOH 50:1) gave impure (±)-**21** as a yellow solid. The impure solid was washed with EtOAc (10 mL), centrifuged, the supernatant decanted and the residue dried at high vacuum to obtain pure (±)-**21** as a white solid (2.45 g, 5.88 mmol, 36%). M.p. 250-251 °C. TLC (CHCl<sub>3</sub>/MeOH 25:1) *R<sub>f</sub>* 0.25. IR (KBr, cm<sup>-1</sup>): 3432m, 3221m, 2982w, 2927w, 1755s, 1707s, 1475m, 1448m, 1278m, 1269m, 1150m, 1044m. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): 8.43 (s, 2H), 6.98 (s, 2H), 4.87 (d, *J* = 16.0, 2H), 4.30-4.20 (m, 4H), 4.15 (q, *J* = 7.1, 2H), 2.44 (s, 6H), 1.26 (t, *J* = 7.1, 3H), 1.21 (t, *J* = 7.1, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): 166.5, 166.4, 157.8, 135.7, 135.1, 130.7, 83.1, 74.3, 64.0, 63.6, 40.4, 20.5, 14.4, 14.2. MS (FAB, PEG): *m/z* 417 (100, [M + H]<sup>+</sup>). HR-MS (FAB, PEG): *m/z* 417.1778 ([M + H]<sup>+</sup>, C<sub>20</sub>H<sub>25</sub>N<sub>4</sub>O<sub>6</sub>, calcd 417.1774).



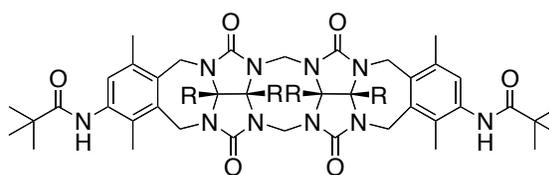
**Compound 22:** A mixture of PTSA (7.30 g, 38.4 mmol) in ClCH<sub>2</sub>CH<sub>2</sub>Cl (400 mL) heated under N<sub>2</sub> at reflux for 1 h. under an addition funnel filled with molecular sieves (4Å). Compound (±)-**21** (4.00 g, 9.6 mmol) and paraformaldehyde (864 mg, 28.8 mmol) were added in one portion and reflux was continued for 48 h. The reaction mixture was diluted with CHCl<sub>3</sub> (1000 mL), washed with sat. aq. Na<sub>2</sub>CO<sub>3</sub>, dried over anh. MgSO<sub>4</sub>, and concentrated. The residue was washed with CH<sub>3</sub>CN (10 mL), centrifuged, the supernatant decanted, and the residue was dried under high vacuum to obtain **22** (3.21 g, 3.73 mmol, 78%) as white solid. M.p. 309-310 °C. TLC (CHCl<sub>3</sub>/MeOH 50:1) *R<sub>f</sub>* 0.43. IR (KBr, cm<sup>-1</sup>): 2951w, 1738s, 1455s, 1434m, 1249s, 1016m, 908m. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): 6.96 (s, 4H), 6.01 (d, *J* = 16.0, 2H), 5.17 (d, *J* = 16.0, 4H), 4.66 (d, *J* = 16.0, 2H), 4.25-4.10 (m, 12H), 2.47 (s, 12H), 1.35-1.20 (m, 12H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): 166.5, 165.5, 155.2, 135.8, 135.2, 130.9, 80.0, 79.4, 64.1, 63.7, 48.2, 40.9, 20.7, 14.4, 14.3. MS (FAB, PEG/CsI): *m/z* 989 (100, [M + Cs]<sup>+</sup>). HR-MS (FAB, PEG CsI): *m/z* 989.2440 ([M + Cs]<sup>+</sup>, C<sub>42</sub>H<sub>48</sub>N<sub>8</sub>O<sub>12</sub>Cs, calcd 989.2446).

The residue was washed with CH<sub>3</sub>CN (10 mL), centrifuged, the supernatant decanted, and the residue was dried under high vacuum to obtain **22** (3.21 g, 3.73 mmol, 78%) as white solid. M.p. 309-310 °C. TLC (CHCl<sub>3</sub>/MeOH 50:1) *R<sub>f</sub>* 0.43. IR (KBr, cm<sup>-1</sup>): 2951w, 1738s, 1455s, 1434m, 1249s, 1016m, 908m. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): 6.96 (s, 4H), 6.01 (d, *J* = 16.0, 2H), 5.17 (d, *J* = 16.0, 4H), 4.66 (d, *J* = 16.0, 2H), 4.25-4.10 (m, 12H), 2.47 (s, 12H), 1.35-1.20 (m, 12H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): 166.5, 165.5, 155.2, 135.8, 135.2, 130.9, 80.0, 79.4, 64.1, 63.7, 48.2, 40.9, 20.7, 14.4, 14.3. MS (FAB, PEG/CsI): *m/z* 989 (100, [M + Cs]<sup>+</sup>). HR-MS (FAB, PEG CsI): *m/z* 989.2440 ([M + Cs]<sup>+</sup>, C<sub>42</sub>H<sub>48</sub>N<sub>8</sub>O<sub>12</sub>Cs, calcd 989.2446).



**Compound 23 and (±)-24:** A mixture of compound **22** (1.80 g, 2.1 mmol) in TFA (35 mL) was cooled to 0°C

using ice-water bath. To this mixture HNO<sub>3</sub> (35 mL) was added dropwise while stirring. The ice bath was removed after 15 min and stirring was continued for 4 h. The reaction was quenched with sat. aq. Na<sub>2</sub>CO<sub>3</sub> and extracted with CHCl<sub>3</sub> (500 mL). The extracts were washed with brine, dried over anh. MgSO<sub>4</sub>, and concentrated. Flash chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>) gave compound (±)-**24** (750 mg, 0.791 mmol, 38%) and compound **23** (860 mg, 0.908 mmol, 42%) as white solids. **Compound (±)-24**: M.p. 288-290 °C. TLC (CHCl<sub>3</sub>/MeOH 50:1) *R<sub>f</sub>* 0.46. IR (KBr, cm<sup>-1</sup>): 2981w, 1740s, 1529m, 1450s, 1364m, 1254s, 1020m, 911m. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): 7.45 (s, 2H), 5.97 (d, *J* = 16.0, 2H), 5.28 (d, *J* = 16.4, 2H), 5.23 (d, *J* = 16.4, 2H), 4.68 (d, *J* = 16.0, 2H), 4.30-4.15 (m, 12H), 2.56 (s, 6H), 2.52 (s, 6H), 1.36 (t, *J* = 7.1, 6H), 1.30 (t, *J* = 7.1, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): 166.1, 165.2, 155.1, 155.0, 150.9, 140.4, 138.9, 136.4, 129.0, 125.7, 79.5, 79.4, 64.3, 64.1, 48.3, 40.6, 20.6, 15.7, 14.4, 14.3 (only 20 of the 21 expected resonances were observed). MS (FAB, magic bullet, CsI): *m/z* 1079 (100, [M + Cs]<sup>+</sup>). HR-MS (FAB, magic bullet, CsI): *m/z* 1079.2174 ([M + Cs]<sup>+</sup>, C<sub>42</sub>H<sub>46</sub>N<sub>10</sub>O<sub>16</sub>Cs, calcd 1079.2148). **Compound 23**: M.p. 273-275 °C. TLC (CHCl<sub>3</sub>/MeOH 50:1) *R<sub>f</sub>* 0.43. IR (KBr, cm<sup>-1</sup>): 2984w, 1750s, 1526m, 1449s, 1366m, 1253s, 1020m, 910m. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): 7.40 (s, 2H), 5.99 (d, *J* = 16.0, 1H), 5.98 (d, *J* = 16.0, 1H), 5.27 (d, *J* = 16.4, 2H), 5.22 (d, *J* = 16.4, 2H), 4.69 (d, *J* = 16.0, 2H), 4.30-4.15 (m, 12H), 2.53 (s, 12H), 1.34 (t, *J* = 7.1, 6H), 1.29 (t, *J* = 7.1, 6H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): 166.1, 165.2, 155.1, 155.1, 150.8, 140.4, 138.9, 136.4, 129.0, 125.7, 79.6, 79.4, 64.3, 64.0, 48.3, 40.6, 40.6, 20.6, 15.7, 14.4, 14.3 (only 21 of the 22 expected resonances were observed). MS (FAB, CsI): *m/z* 1079 (100, [M + Cs]<sup>+</sup>). HR-MS (FAB, magic bullet, CsI): *m/z* 1079.2177 ([M + Cs]<sup>+</sup>, C<sub>42</sub>H<sub>46</sub>N<sub>10</sub>O<sub>16</sub>Cs, calcd 1079.2148).

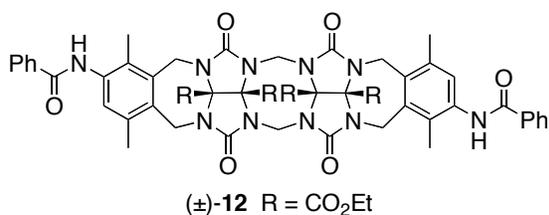


**10** R = CO<sub>2</sub>Et

**Compound 10**: A mixture of compound **23** (60 mg, 0.063 mmol) and 10% Pd/C (50 mg) in anh. DMF (9 mL) was stirred under H<sub>2</sub> (10 psi) at RT for 6 h in a Schlenk apparatus. The reaction mixture was filtered under Ar and concentrated under high vacuum at RT to obtain a highly air

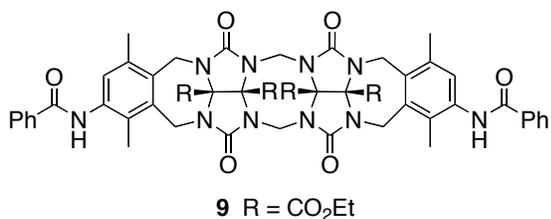
and moisture sensitive diamine as a white solid. The crude solid was dissolved in a mixture of anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (8 mL) and distilled NEt<sub>3</sub> (0.5 mL) under Ar. This solution was added to a solution of pivaloyl chloride (37 mg, 0.30 mmol) in anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (5 mL) at -78 °C. After 15 min., the cooling bath was removed and stirring was continued at room temperature for 6 h under Ar. The reaction mixture was diluted with CHCl<sub>3</sub> (100 mL), washed with sat. aq. NaHCO<sub>3</sub>, dried over anh. MgSO<sub>4</sub>, and concentrated. Radial chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/MeOH 100:1) gave impure **10**. The impure solid was washed with EtOAc (1 mL), centrifuged, the supernatant decanted and the residue dried at high vacuum to obtain pure **10** as white solid (50 mg, 0.047 mmol, 75%). M.p. 214-217 °C. TLC (CHCl<sub>3</sub>/MeOH 50:1) *R<sub>f</sub>* 0.17. IR (KBr, cm<sup>-1</sup>): 3429m, 2966w, 1748s, 1673m, 1511m, 1446s, 1367m, 1251s, 1015m, 908m. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): 8.82 (s, 2H), 6.85 (s, 2H), 5.73 (d, *J* = 16.0, 2H), 4.87 (d, *J* = 16.0, 2H), 4.80 (d, *J* = 16.0, 2H), 4.56 (d, *J* = 16.0, 1H), 4.52 (d, *J* = 16.0, 1H), 4.36 (d, *J* = 16.0, 2H),

4.33 (d,  $J = 16.0$ , 2H), 4.18 (q,  $J = 7.1$ , 2H), 4.12 (q,  $J = 7.1$ , 2H), 2.31 (s, 6H), 2.13 (s, 6H), 1.25-1.15 (m, 30H).  $^{13}\text{C}$  NMR (125 MHz, DMSO- $d_6$ ): 177.5, 166.6, 165.3, 155.6, 155.6, 137.6, 137.1, 134.8, 133.9, 132.0, 130.2, 80.6, 79.9, 65.6, 65.0, 48.6, 48.5, 39.8, 28.6, 20.7, 15.3, 14.9, 14.7 (only 23 of the 25 expected resonances were observed). MS (FAB, magic bullet, CsI):  $m/z$  1187 (100,  $[\text{M} + \text{Cs}]^+$ ). HR-MS (FAB, magic bullet, CsI):  $m/z$  1187.3807 ( $[\text{M} + \text{Cs}]^+$ ,  $\text{C}_{52}\text{H}_{66}\text{N}_{10}\text{O}_{14}\text{Cs}$ , calcd 1187.3814).



**Compound (±)-12:** A mixture of compound (±)-**24** (80 mg, 0.084 mmol) and 10% Pd/C (55 mg) in anh. DMF (10 mL) was stirred under H<sub>2</sub> (10 psi) at RT for 6 h in a Schlenk apparatus. The reaction mixture was filtered under Ar and concentrated under high vacuum at RT to obtain

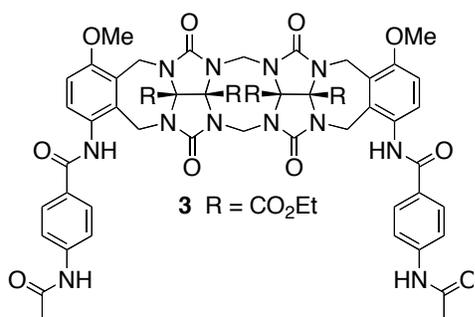
a highly air and moisture sensitive diamine as a white solid. The crude solid was dissolved in a mixture of anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (10 mL) and distilled NEt<sub>3</sub> (0.5 mL) under Ar. This solution was added to a solution of benzoyl chloride (59 mg, 0.41 mmol) in anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (5 mL) at -78 °C. After 15 min., the cooling bath was removed and stirring was continued at room temperature for 8 h under Ar. The reaction mixture was diluted with CHCl<sub>3</sub> (100 mL), washed with sat. aq. NaHCO<sub>3</sub>, dried over anh. MgSO<sub>4</sub>, and concentrated. Radial chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/MeOH 100:1) gave impure (±)-**12**. The impure solid was washed with EtOAc (1 mL), centrifuged, the supernatant decanted and the residue dried at high vacuum to obtain pure (±)-**12** as a white solid (67 mg, 0.061 mmol, 73%). M.p. 268-270 °C. TLC (CHCl<sub>3</sub>/MeOH 50:1)  $R_f$  0.26. IR (KBr, cm<sup>-1</sup>): 3427m, 2982w, 2930w, 1742s, 1656m, 1520m, 1447s, 1366m, 1255s, 1018m, 907m.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ): 9.89 (s, 2H), 7.95 (d,  $J = 7.2$ , 4H), 7.58 (t,  $J = 7.2$ , 2H), 7.50 (t,  $J = 7.2$ , 4H), 7.08 (s, 2H), 5.82 (d,  $J = 16.0$ , 2H), 4.97 (d,  $J = 16.0$ , 2H), 4.89 (d,  $J = 16.0$ , 2H), 4.61 (d,  $J = 16.0$ , 2H), 4.45 (d,  $J = 16.0$ , 2H), 4.42 (d,  $J = 16.0$ , 2H), 4.30-4.15 (m, 8H), 2.40 (s, 6H), 2.28 (s, 6H), 1.27 (t,  $J = 7.1$ , 3H), 1.22 (t,  $J = 7.1$ , 3H).  $^{13}\text{C}$  NMR (125 MHz, DMSO- $d_6$ ): 165.4, 165.2, 164.1, 154.4, 154.3, 136.1, 135.9, 134.3, 133.7, 133.1, 131.5, 130.7, 128.9, 128.4, 128.3, 127.5, 79.3, 78.7, 64.4, 63.7, 47.3, 19.6, 14.3, 13.7, 13.5 (only 25 of the 26 expected resonances were observed). MS (FAB, CsI):  $m/z$  1227 (100,  $[\text{M} + \text{Cs}]^+$ ). HR-MS (FAB, magic bullet, CsI):  $m/z$  1227.3158 ( $[\text{M} + \text{Cs}]^+$ ,  $\text{C}_{56}\text{H}_{58}\text{N}_{10}\text{O}_{14}\text{Cs}$ , calcd. 1227.3188).



**Compound 9:** A mixture of compound **23** (150 mg, 0.158 mmol) and 10% Pd/C (85 mg) in anh. DMF (20 mL) was stirred under H<sub>2</sub> (10 psi) at RT for 6 h in a Schlenk apparatus. The reaction mixture was filtered under Ar and concentrated under high vacuum at RT to obtain a highly air and moisture

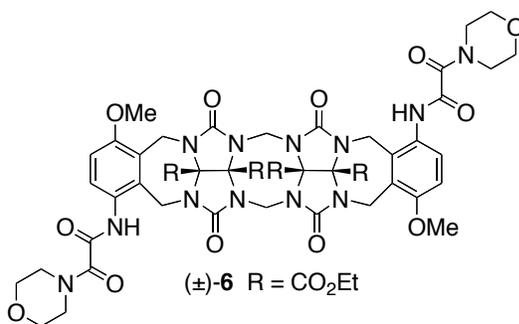
sensitive diamine as a white solid. The crude solid was dissolved in a mixture of anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (15 mL) and distilled NEt<sub>3</sub> (1.3 mL) under Ar. This solution was added to a solution of

benzoyl chloride (89 mg, 0.62 mmol) in anh. degassed  $\text{CH}_2\text{Cl}_2$  (10 mL) at  $-78\text{ }^\circ\text{C}$ . After 15 min., the cooling bath was removed and stirring was continued at room temperature for 10 h under Ar. The reaction mixture was diluted with  $\text{CHCl}_3$  (200 mL), washed with sat. aq.  $\text{NaHCO}_3$ , dried over anh.  $\text{MgSO}_4$ , and concentrated. Radial chromatography ( $\text{SiO}_2$ ,  $\text{CHCl}_3/\text{MeOH}$  100:1) gave impure **9**. The impure solid was washed with EtOAc (1 mL), centrifuged, the supernatant decanted and the residue dried at high vacuum to obtain pure **9** as a white solid (112 mg, 0.102 mmol, 65%). M.p. 281-284  $^\circ\text{C}$ . TLC ( $\text{CHCl}_3/\text{MeOH}$  50:1)  $R_f$  0.23. IR (KBr,  $\text{cm}^{-1}$ ): 3429m, 2928w, 1743s, 1650m, 1519m, 1451s, 1367m, 1254s, 1016m, 909m.  $^1\text{H}$  NMR (500 MHz,  $\text{DMSO}-d_6$ ): 9.88 (s, 2H), 7.95 (d,  $J = 7.4$ , 4H), 7.59 (m, 2H), 7.50 (t,  $J = 7.6$ , 4H), 7.09 (s, 2H), 5.82 (d,  $J = 16.2$ , 2H), 4.96 (d,  $J = 16.2$ , 2H), 4.89 (d,  $J = 16.2$ , 2H), 4.62 (d,  $J = 16.2$ , 1H), 4.59 (d,  $J = 16.2$ , 1H), 4.46 (d,  $J = 16.2$ , 2H), 4.42 (d,  $J = 16.2$ , 2H), 4.24 (q,  $J = 7.1$ , 2H), 4.18 (q,  $J = 7.1$ , 2H), 2.40 (s, 6H), 2.27 (s, 6H), 1.27 (t,  $J = 7.1$ , 3H), 1.21 (t,  $J = 7.1$ , 3H).  $^{13}\text{C}$  NMR (125 MHz,  $\text{DMSO}-d_6$ ): 165.8, 165.8, 164.5, 154.9, 136.5, 136.4, 134.9, 134.3, 133.5, 132.0, 131.3, 129.4, 128.9, 128.0, 79.8, 79.2, 64.9, 64.2, 47.8, 47.7, 20.0, 14.8, 14.1, 14.0 (only 24 of the 27 expected resonances were observed). MS (FAB, CsI):  $m/z$  1227 (100,  $[\text{M} + \text{Cs}]^+$ ). HR-MS (FAB, magic bullet, CsI):  $m/z$  1227.3192 ( $[\text{M} + \text{Cs}]^+$ ,  $\text{C}_{56}\text{H}_{58}\text{N}_{10}\text{O}_{14}\text{Cs}$ , calcd 1227.3188).



**Compound 3:** A mixture of compound **13** (72 mg, 0.076 mmol) and 10% Pd/C (50 mg) in anh. DMF (10 mL) was stirred under  $\text{H}_2$  (10 psi) at RT for 5 h in a Schlenk apparatus. The reaction mixture was filtered under Ar and concentrated under high vacuum at RT to obtain a highly air and moisture sensitive diamine as a white solid. The crude solid was dissolved in a mixture of anh. degassed  $\text{CH}_2\text{Cl}_2$  (10 mL) and distilled  $\text{NEt}_3$  (4 mL) under Ar. This solution was added to a

solution of 4-acetamidobenzoyl chloride (83 mg, 0.41 mmol) in anh. degassed  $\text{CH}_2\text{Cl}_2$  (5 mL) at  $-78\text{ }^\circ\text{C}$ . After 15 min., the cooling bath was removed and stirring was continued at room temperature for 6 h under Ar. The reaction mixture was diluted with  $\text{CHCl}_3$  (200 mL), washed with sat. aq.  $\text{NaHCO}_3$ , dried over anh.  $\text{MgSO}_4$ , and concentrated. Radial chromatography ( $\text{SiO}_2$ ,  $\text{CHCl}_3/\text{MeOH}$ , 100:4, then 100:6) gave **3** as white solid (50 mg, 0.041 mmol, 53%). M.p.  $> 310\text{ }^\circ\text{C}$  (dec.). TLC ( $\text{CHCl}_3/\text{MeOH}$  100:6)  $R_f$  0.24. IR (KBr,  $\text{cm}^{-1}$ ): 3324m, 2959w, 2924w, 1744s, 1600m, 1506m, 1456m, 1436m, 1369s, 1258s, 1081m, 1017m.  $^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ): 10.19 (s, 2H), 10.00 (s, 2H), 7.90-7.80 (m, 4H), 7.70-7.60 (m, 4H), 7.15-7.10 (m, 2H), 7.0-6.95 (m, 2H), 5.75-5.70 (m, 2H), 5.28 (d,  $J = 16.0$ , 2H), 4.75 (d,  $J = 16.0$ , 2H), 4.55 (d,  $J = 15.8$ , 1H), 4.30 (d,  $J = 15.8$ , 1H), 4.25-4.10 (m, 12H), 3.77 (s, 6H), 2.06 (s, 6H), 1.25-1.10 (m, 12H).  $^{13}\text{C}$  NMR (100 MHz,  $\text{DMSO}-d_6$ ): 169.2, 166.0, 165.4, 164.4, 155.0, 154.9, 154.4, 142.8, 134.7, 130.7, 129.0, 128.6, 127.9, 124.9, 118.7, 118.6, 111.9, 80.4, 79.0, 64.9, 64.3, 56.5, 47.9, 47.7, 36.6, 24.6, 14.1, 14.0. MS (FAB, CsI):  $m/z$  1345 (100,  $[\text{M} + \text{Cs}]^+$ ). HR-MS (FAB, CsI):  $m/z$  1345.3243 ( $[\text{M} + \text{Cs}]^+$ ,  $\text{C}_{58}\text{H}_{60}\text{N}_{12}\text{O}_{18}\text{Cs}$ , calcd 1345.3203).



**Compound (±)-6:** A mixture of compound (±)-14 (77 mg, 0.087 mmol) and 10% Pd/C (50 mg) in anh. DMF (10 mL) was stirred under H<sub>2</sub> (10 psi) at RT for 6 h in a Schlenk apparatus. The reaction mixture was filtered under Ar and concentrated under high vacuum at RT to obtain a highly air and moisture sensitive diamine as a white solid. The crude solid was dissolved in a mixture of anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (10 mL) and distilled NEt<sub>3</sub> (0.5

mL) under Ar. This solution was added to a solution of 4-morpholineglyoxyloyl chloride (34 mg, 0.19 mmol) in anh. degassed CH<sub>2</sub>Cl<sub>2</sub> (5 mL) at -78 °C. After 15 min., the cooling bath was removed and stirring was continued at room temperature for 6 h under Ar. The reaction mixture was diluted with CHCl<sub>3</sub> (200 mL), washed with sat. aq. NaHCO<sub>3</sub>, dried over anh. MgSO<sub>4</sub>, and concentrated. Radial chromatography (SiO<sub>2</sub>, CHCl<sub>3</sub>/MeOH 100:3) gave (±)-6 as white solid (45 mg, 0.038 mmol, 43%). M.p. > 330 °C (dec.). TLC (CHCl<sub>3</sub>/MeOH 100:4) R<sub>f</sub> 0.22. IR (KBr, cm<sup>-1</sup>): 3440m, 2979w, 2925w, 1748s, 1652m, 1455m, 1368w, 1270s, 1115w, 1082w, 1017w. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>): 10.44 (s, 2H), 7.16 (d, *J* = 8.9, 2H), 6.99 (d, *J* = 8.9, 2H), 5.77 (d, *J* = 16.0, 2H), 5.17 (d, *J* = 16.0, 2H), 4.80 (d, *J* = 16.0, 2H), 4.47 (d, *J* = 16.0, 2H), 4.32 (d, *J* = 16.0, 2H), 4.30 (d, *J* = 16.0, 2H), 4.25-4.05 (m, 8H), 3.79 (s, 6H), 3.70-3.50 (m, 16H), 1.22 (t, *J* = 7.0, 3H), 1.15 (t, *J* = 7.0, 3H). <sup>13</sup>C NMR (100 MHz, DMSO-*d*<sub>6</sub>): 166.0, 164.9, 163.6, 163.4, 155.7, 155.3, 155.0, 133.9, 128.5, 127.5, 125.6, 112.7, 80.5, 79.5, 67.3, 66.7, 65.3, 64.6, 57.0, 48.2, 47.1, 42.3, 37.0, 14.5, 14.4. MS (FAB, magic bullet): *m/z* 1174 (100, [M + H]<sup>+</sup>). HR-MS (FAB, magic bullet, CsI): *m/z* 1305.3125 ([M + Cs]<sup>+</sup>, C<sub>52</sub>H<sub>60</sub>N<sub>12</sub>O<sub>20</sub>Cs, calcd 1305.3101).

## References:

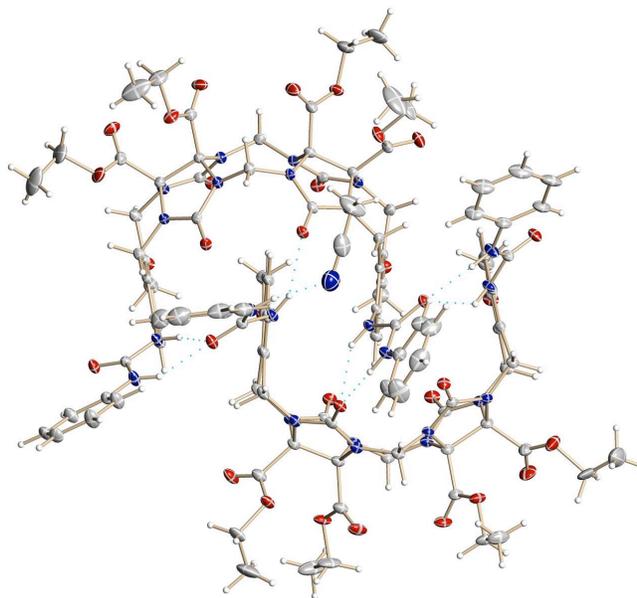
1. Chakraborty, A.; Wu, A.; Witt, D.; Lagona, J.; Fettingner, J. C.; Isaacs, L. *J. Am. Chem. Soc.* **2002**, *124*, 8297-8306.
2. Wu, A.; Chakraborty, A.; Fettingner, J. C.; Flowers II, R. A.; Isaacs, L. *Angew. Chem. Int. Ed.* **2002**, *41*, 4028-4031.
3. Wu, A.; Chakraborty, A.; Witt, D.; Lagona, J.; Damkaci, F.; Ofori, M.; Chiles, K.; Fettingner, J. C.; Isaacs, L. *J. Org. Chem.* **2002**, *67*, 5817-5830.
4. Wu, A.; Isaacs, L. *J. Am. Chem. Soc.* **2003**, *125*, 4831-4835.
5. Burnett, C. A.; Lagona, J.; Wu, A.; Shaw, J. A.; Coady, D.; Fettingner, J. C.; Day, A. I.; Isaacs, L. *Tetrahedron* **2003**, *59(11)*, 1961-1970.
6. Qin, S.; Yin, G. *Acta Crystallographica, Sect. E* **2005**, *E61(10)*, o3164-o3165.

## Details of the X-ray crystallographic structure determination of 2.

A colorless prism of  $(C_{54}H_{56}N_{12}O_{16}) \cdot 1.78CH_3CN$ , approximate dimensions  $0.27 \times 0.40 \times 0.48$  mm<sup>3</sup>, was used for the X-ray crystallographic analysis. The X-ray intensity data were measured at 220(2) K on a three-circle diffractometer system equipped with Bruker Smart1000 CCD area detector using a graphite monochromator and a MoKa fine-focus sealed tube ( $\lambda = 0.71073$  Å) operated at 50 kV and 40 mA. The detector was placed at a distance of 4.950 cm from the crystal.

A total of 672 frames were collected with a scan width of  $0.5^\circ$  in  $\omega$  and an exposure time of 38 sec/frame using SMART (Bruker, 1999). The total data collection time was 8.4 hours. The frames were integrated with SAINT software package using a narrow-frame integration algorithm. The integration of the data using a Monoclinic unit cell yielded a total of 43060 reflections to a maximum  $q$  angle of  $22.50^\circ$ , of which 15812 were independent (completeness = 98.1%,  $R_{int} = 4.15\%$ ,  $R_{sig} = 5.11\%$ ) and 11742 were greater than  $2s(I)$ . The final cell dimensions of  $a = 58.514(9)$  Å,  $b = 14.196(2)$  Å,  $c = 32.059(5)$  Å,  $a = 90^\circ$ ,  $b = 112.289(2)^\circ$ ,  $g = 90^\circ$ ,  $V = 24641(7)$  Å<sup>3</sup>, are based upon the refinement of the XYZ-centroids of 7354 reflections with  $2.1 < q < 23.8^\circ$  using SAINT. Analysis of the data showed 0 % decay during data collection. Data were corrected for absorption effects with the Semi-empirical from equivalents method using SADABS (Sheldrick, 1996). The minimum and maximum transmission coefficients were 0.954 and 0.974.

The structure was solved and refined using the SHELXS-97 (Sheldrick, 1990) and SHELXL-97 (Sheldrick, 1997) software in the space group  $C2/c$  with  $Z = 16$  for the formula unit  $(C_{54}H_{56}N_{12}O_{16}) \cdot 1.78CH_3CN$ . The final anisotropic full-matrix least-squares refinement on  $F^2$  with 1612 variables converged at  $R_1 = 6.18\%$  for the observed data and  $wR_2 = 14.85\%$  for all data. The goodness-of-fit was 1.000. The largest peak on the final difference map was  $0.379$  e/Å<sup>3</sup> and the largest hole was  $-0.289$  e/Å<sup>3</sup>. On the basis of the final model, the calculated density was  $1.296$  g/cm<sup>3</sup> and  $F(000)$ , 10099 e.



**Table S1.** Crystal data and structure refinement for **2**.

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X-ray lab book No.	1472
Empirical formula	(C <sub>54</sub> H <sub>56</sub> N <sub>12</sub> O <sub>16</sub> )·1.78CH <sub>3</sub> CN
Formula weight	1202.18
Temperature	220(2) K
Wavelength	0.71073 Å
Crystal size	0.48 × 0.40 × 0.27 mm <sup>3</sup>
Crystal habit	colorless prism
Crystal system	Monoclinic
Space group	C2/c
Unit cell dimensions	a = 58.514(9) Å     α = 90° b = 14.196(2) Å     β = 112.289(2)° c = 32.059(5) Å     γ = 90°
Volume	24641(7) Å <sup>3</sup>
Z	16
Density, ρ <sub>calc</sub>	1.296 g/cm <sup>3</sup>
Absorption coefficient, μ	0.097 mm <sup>-1</sup>
F(000)	10099 <sup>-</sup>
Diffractometer	Bruker Smart1000 CCD area detector
Radiation source	fine-focus sealed tube, MoKα
Generator power	50 kV, 40 mA
Detector distance	4.950 cm
Detector resolution	8.33 pixels/mm
Total frames	672
Frame size	512 pixels
Frame width	0.5 °
Exposure per frame	38 sec
Total measurement time	8.4 hours
Data collection method	ω and φ scans
θ range for data collection	2.37 to 22.50°
Index ranges	-62 ≤ h ≤ 62, -14 ≤ k ≤ 15, -32 ≤ l ≤ 33
Reflections collected	43060
Independent reflections	15812
Observed reflection, I>2σ(I)	11742
Coverage of independent reflections	98.1 %
Variation in check reflections	0 %
Absorption correction	Semi-empirical from equivalents SADABS (Sheldrick, 1996)
Max. and min. transmission	0.974 and 0.954

Structure solution technique	XM
Structure solution program	SHELXS-97 (Sheldrick, 1990)
Refinement technique	Full-matrix least-squares on $F^2$
Refinement program	SHELXL-97 (Sheldrick, 1997)
Function minimized	$\Sigma w(F_o^2 - F_c^2)^2$
Data / restraints / parameters	15812 / 114 / 1612
Goodness-of-fit on $F^2$	1.007
$\Delta/\sigma_{\max}$	0.000
Final R indices: $R_1$ , $I > 2\sigma(I)$	0.0618
$wR_2$ , all data	0.1485
$R_{\text{int}}$	0.0415
$R_{\text{sig}}$	0.0511
Weighting scheme	$w = 1/[\sigma^2(F_o^2) + (0.022P)^2 + 99.2P]$ , $P = [\max(F_o^2, 0) + 2F_o^2]/3$
Largest diff. peak and hole	0.379 and $-0.289 \text{ e}/\text{\AA}^3$

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$$R_1 = \Sigma ||F_o| - |F_c|| / \Sigma |F_o|, \quad wR_2 = [\Sigma w(F_o^2 - F_c^2)^2 / \Sigma w(F_o^2)^2]^{1/2}$$

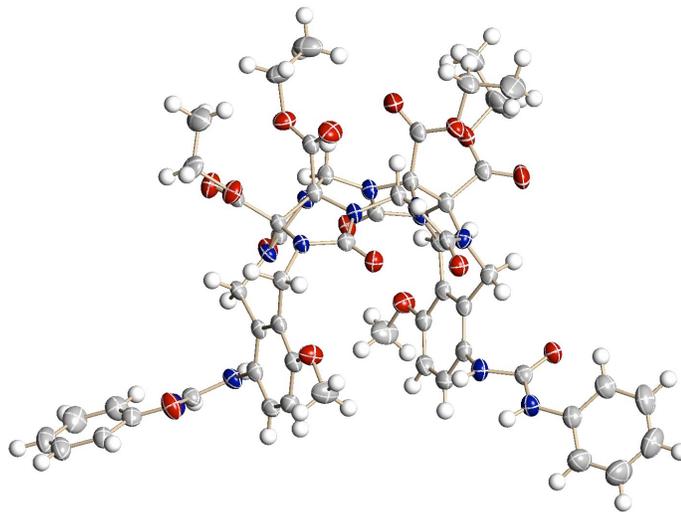
**Table S2.** Hydrogen bond information for **2** (Å and °).

D—H...A*	d(D—H)	d(H...A)	d(D...A)	$\angle(\text{DHA})$
N7A—H7A...O65B	0.87	2.10	2.876(4)	148.5
N9A—H9A...O65B	0.87	2.04	2.842(4)	153.2
N64A—H64A...O46B	0.870(10)	2.06(2)	2.837(4)	148(4)
N66A—H66A...O46B	0.87	2.24	3.013(4)	148.7
N7B—H7B...O65A	0.87	1.95	2.795(4)	162.7
N9B—H9B...O65A	0.87	2.34	3.013(4)	134.7
N64B—H64B...O46A	0.866(10)	2.23(2)	3.020(4)	152(4)
N66B—H66B...N1N	0.87	2.24	3.066(8)	159.1

\* D - donor atom, H - hydrogen, A - acceptor.

## Details of the X-ray crystallographic structure determination of ( $\pm$ )-5.

A colorless plate with approximate orthogonal dimensions 0.49 x 0.16 x 0.10 mm<sup>3</sup> was placed and optically centered on the Bruker SMART CCD system at -80 °C. The initial unit cell was indexed using a least-squares analysis of a random set of reflections collected from three series of 0.3° wide  $\omega$ -scans, 10 seconds per frame, and 25 frames per series that were well distributed in reciprocal space. Data frames were collected [MoK $\alpha$ ] with 0.2° wide  $\omega$ -scans, 30 seconds per frame and 909 frames per series. Five complete series were collected at varying  $\omega$  angles ( $\omega$ =0°, 72°, 144°, 216°, 288°). The crystal to detector distance was 4.900 cm, thus providing a complete sphere of data to  $2\theta_{\max}$  = 50.0°. A total of 33977 reflections were collected and corrected for Lorentz and polarization effects and absorption using Blessing's method as incorporated into the program SADABS<sup>1,2</sup> with 9582 unique [R(int) = 0.0375]



### Structural determination and Refinement:

All crystallographic calculations were performed on a Personal computer (PC) with a Pentium 1.80 GHz processor and 512 MB of extended memory. The SHELXTL<sup>3</sup> program package was implemented to determine the probable space group and set up the initial files. System symmetry, lack of systematic absences and intensity statistics indicated the centric triclinic space group P-1 (no. 2) while the other possibility was the chiral triclinic space group P1 (no. 1). The former was chosen. The structure was determined by direct methods with the successful location of nearly all non-hydrogen atoms using the program XS<sup>4</sup>. The structure was refined with XL<sup>5</sup>. One least-squares difference-Fourier cycle was required to locate the remaining non-hydrogen atoms. All full occupancy non-hydrogen atoms were refined anisotropically. Hydrogen atoms were placed in calculated positions but allowed to refine their thermal parameters during the final stages of refinement (U). The final structure was refined to convergence [ $\Delta/\sigma \leq 0.002$ ] with R(F) = 7.71 %, wR(F<sup>2</sup>) = 12.41 %, GOF = 0.995 for all 9582 unique reflections [R(F) = 4.45 %, wR(F<sup>2</sup>) = 11.19 % for those 6552 data with  $F_o > 4\sigma(F_o)$ ]. The final difference-Fourier map was featureless indicating that the structure is both correct and complete.

The function minimized during the full-matrix least-squares refinement was  $\sum w(F_o^2 - F_c^2)^2$  where  $w = 1/[\sigma^2(F_o^2) + (0.0324 * P)^2 + 0.2607 * P]$  and  $P = (\max(F_o^2, 0) + 2 * F_c^2) / 3$ . An empirical correction for extinction was also attempted but found to be negative and therefore not applied.

## References:

1. An Empirical Correction for Absorption Anisotropy, Blessing, R. H. (1995). Acta Cryst., A51, 33-38.
2. Sheldrick, G.M., SADABS 'Siemens Area Detector Absorption Correction' Universität Göttingen: Göttingen, Germany, 1996.
3. Sheldrick, G.M., (1994). SHELXTL/PC. Version 5.03. Siemens Analytical X-ray Instruments Inc., Madison, Wisconsin, USA.
4. Phase Annealing in SHELX-90: Direct Methods for Larger Structures, Sheldrick, G. M., (1990). Acta Cryst. A46, 467-473.
5. Sheldrick, G.M., (1993). Shelxl93 Program for the Refinement of Crystal Structures. University of Göttingen, Germany.

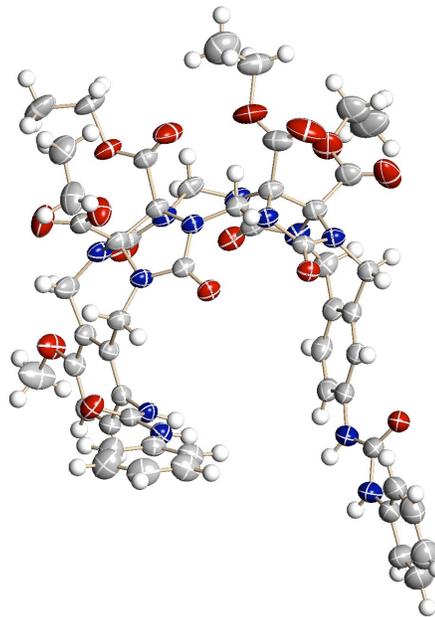
**Table S3.** Crystal data and structure refinement for ( $\pm$ )-**5**.

Identification code	859fff	
Empirical formula	$C_{56}H_{59}N_{13}O_{16}$	
Formula weight	1170.16	
Temperature	193(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P-1	
Unit cell dimensions	$a = 13.8516(13)$ Å	$\alpha = 70.395(2)^\circ$ .
	$b = 14.1773(13)$ Å	$\beta = 70.285(2)^\circ$ .
	$c = 16.0411(15)$ Å	$\gamma = 71.936(2)^\circ$ .
Volume	$2723.8(4)$ Å <sup>3</sup>	
Z	2	
Density (calculated)	$1.427$ Mg/m <sup>3</sup>	
Absorption coefficient	$0.107$ mm <sup>-1</sup>	
F(000)	1228	
Crystal size	$0.49 \times 0.16 \times 0.10$ mm <sup>3</sup>	
Theta range for data collection	2.38 to 25.00°.	
Index ranges	$-16 \leq h \leq 16, -16 \leq k \leq 16, -19 \leq l \leq 19$	
Reflections collected	33977	
Independent reflections	9582 [R(int) = 0.0375]	

Completeness to theta = 25.00°	99.9 %
Absorption correction	Empirical, SADABS
Max. and min. transmission	0.9896 and 0.9497
Refinement method	Full-matrix least-squares on F <sup>2</sup>
Data / restraints / parameters	9582 / 9 / 813
Goodness-of-fit on F <sup>2</sup>	0.995
Final R indices [I>2sigma(I)]	R1 = 0.0445, wR2 = 0.1119 [6552 Data]
R indices (all data)	R1 = 0.0771, wR2 = 0.1241
Largest diff. peak and hole	0.400 and -0.288 e.Å <sup>-3</sup>

## Details of the X-ray crystallographic structure determination of ( $\pm$ )-7.

A colorless block with approximate orthogonal dimensions 0.42 x 0.31 x 0.23 mm<sup>3</sup> was placed and optically centered on the Bruker SMART CCD system at -100 °C. The initial unit cell was indexed using a least-squares analysis of a random set of reflections collected from three series of 0.3° wide  $\omega$ -scans, 10 seconds per frame, and 35 frames per series that were well distributed in reciprocal space. Data frames were collected [MoK $\alpha$ ] with 0.3° wide  $\omega$ -scans, 14 seconds per frame and 606 frames per series. Five data series were collected at varying  $\omega$  angles ( $\omega = 0^\circ, 72^\circ, 144^\circ, 216^\circ, 288^\circ$ ), and additionally a partial repeat of the first series, 200 frames, for decay purposes. The crystal to detector distance was 4.425cm, thus providing a complete sphere of data to  $2\theta_{\max} = 55.15^\circ$ . A total of 202924 reflections were collected and corrected for Lorentz and polarization effects and absorption using Blessing's method as incorporated into the program SADABS<sup>1,2</sup> with 29559 unique.



### Structural determination and Refinement:

All crystallographic calculations were performed on a Personal computer (PC) with a Pentium 3.06 GHz processor and 512 MB of extended memory. The SHELXTL<sup>3</sup> program package was implemented to determine the probable space group and set up the initial files. System symmetry, lack of systematic absences and intensity statistics indicated the centrosymmetric triclinic space group P-1 (no. 2). The structure was determined by direct methods with the successful location of nearly two complete molecules of interest using the program XS<sup>4</sup>. The structure was refined with XL<sup>5</sup>. The 202924 data collected were merged based upon identical indices yielding 58828 data [ $R(\text{int}) = 0.0305$ ], truncated to  $2\theta_{\max} = 50.00^\circ$ , yielding 45011 data that were further merged during least-squares refinement to 22636 unique data [ $R(\text{int}) = 0.0146$ ]. A multitude of least-squares difference-Fourier cycles were required to locate the remaining full occupancy and disordered non-hydrogen atoms. All full occupancy non-hydrogen atoms were refined anisotropically. A variety of disorders were modeled both in the main molecules and also among the solvent molecules. Hydrogen atoms were placed in calculated positions. The final structure was refined to convergence [ $\Delta/\sigma \leq 0.001$ ] with  $R(F) = 8.15\%$ ,  $wR(F^2) = 21.79\%$ ,  $\text{GOF} = 1.111$  for all 22636 unique reflections [ $R(F) = 6.69\%$ ,  $wR(F^2) = 20.22\%$  for those 18174 data with  $F_o > 4\sigma(F_o)$ ]. The final difference-Fourier map was featureless indicating that the structure is both correct and complete.

The function minimized during the full-matrix least-squares refinement was  $\Sigma w(F_o^2 - F_c^2)^2$  where  $w = 1/[\sigma^2(F_o^2) + (0.1335 * P)^2 + 2.4058 * P]$  and  $P = (\max(F_o^2, 0) + 2 * F_c^2) / 3$ . An empirical correction for extinction was also attempted but found to be negative and therefore not applied.

References:

1. An Empirical Correction for Absorption Anisotropy, Blessing, R. H. (1995). Acta Cryst., A51, 33-38.
2. Sheldrick, G.M., SADABS 'Siemens Area Detector Absorption Correction' Universität Göttingen: Göttingen, Germany, 1996.
3. Sheldrick, G.M., (1994). SHELXTL/PC. Version 5.03. Siemens Analytical X-ray Instruments Inc., Madison, Wisconsin, USA.
4. Phase Annealing in SHELX-90: Direct Methods for Larger Structures, Sheldrick, G. M., (1990). Acta Cryst. A46, 467-473.
5. Sheldrick, G.M., (1993). Shelxl93 Program for the Refinement of Crystal Structures. University of Göttingen, Germany.

**Table S4.** Crystal data and structure refinement for  $[\text{C}_{53}\text{H}_{54}\text{N}_{12}\text{O}_{15}]_2[\text{C}_4\text{H}_8\text{O}_2]_5[\text{H}_2\text{O}]_{1.75}$ .

Identification code	1047bk18mi	
Empirical formula	$\text{C}_{252}\text{H}_{303}\text{N}_{48}\text{O}_{83.50}$	
Formula weight	5340.42	
Temperature	173(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P-1	
Unit cell dimensions	$a = 17.9029(6)$ Å	$\alpha = 66.9160(10)^\circ$ .
	$b = 20.2161(7)$ Å	$\beta = 77.2880(10)^\circ$ .
	$c = 20.8712(7)$ Å	$\gamma = 68.3660(10)^\circ$ .
Volume	$6434.3(4)$ Å <sup>3</sup>	
Z	1	
Density (calculated)	1.378 Mg/m <sup>3</sup>	
Absorption coefficient	0.105 mm <sup>-1</sup>	
F(000)	2819	
Crystal size	0.42 x 0.31 x 0.23 mm <sup>3</sup>	
Theta range for data collection	1.55 to 25.00°.	
Index ranges	-21 ≤ h ≤ 21, -24 ≤ k ≤ 24, -24 ≤ l ≤ 24	
Reflections collected	45011	
Independent reflections	22636 [R(int) = 0.0146]	

Completeness to theta = 25.00°	99.9 %
Absorption correction	Empirical, SADABS (multi-scan)
Max. and min. transmission	0.9765 and 0.9575
Refinement method	Full-matrix least-squares on F <sup>2</sup>
Data / restraints / parameters	22636 / 187 / 1758
Goodness-of-fit on F <sup>2</sup>	1.111
Final R indices [I>2sigma(I)]	R1 = 0.0669, wR2 = 0.2022 [18174 Data]
R indices (all data)	R1 = 0.0815, wR2 = 0.2179
Largest diff. peak and hole	0.547 and -0.671 e.Å <sup>-3</sup>

**Table S5.** Hydrogen bonds for [C<sub>53</sub>H<sub>54</sub>N<sub>12</sub>O<sub>15.12</sub>][C<sub>4</sub>H<sub>8</sub>O<sub>2</sub>]<sub>5</sub>[H<sub>2</sub>O]<sub>1.75</sub> [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(6A)-H(6A)...O(37A)#1	0.88	2.19	2.996(3)	153.0
N(6B)-H(6B)...O(37A)#1	0.88	2.22	3.049(3)	156.2
N(17A)-H(17A)...O(22)#1	0.88	2.56	3.425(3)	166.8
N(17B)-H(17B)...O(99)	0.88	2.01	2.827(4)	153.1
N(26A)-H(26A)...O(17A)#10	0.88	2.22	3.030(3)	153.1
N(26B)-H(26B)...O(17A)#10	0.88	2.18	2.994(3)	153.2
N(37A)-H(37A)...O(2)#1	0.88	2.21	3.080(3)	171.5
O(71)-H(71A)...O(6A)#20	0.94(2)	2.01(3)	2.875(5)	151(5)
O(71)-H(71B)...O(26A)	0.94(2)	1.96(4)	2.804(5)	147(6)
O(71A)-H(71C)...O(6A)#21	1.11(6)	2.01(3)	2.850(11)	129(3)
O(71A)-H(71D)...O(26A)	1.12(8)	2.36(15)	2.989(14)	114(11)
O(99)-H(99A)...O(22)#1	0.85(2)	1.94(2)	2.782(4)	172(6)
O(99)-H(99B)...O(91)	0.86(2)	2.26(5)	2.943(12)	137(7)

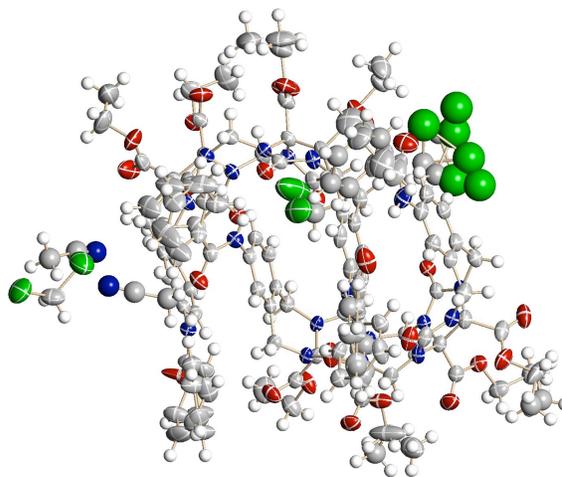
Symmetry transformations used to generate equivalent atoms:

#1 -x+1,-y+1,-z+1 #2 -x+2,-y+1,-z+1

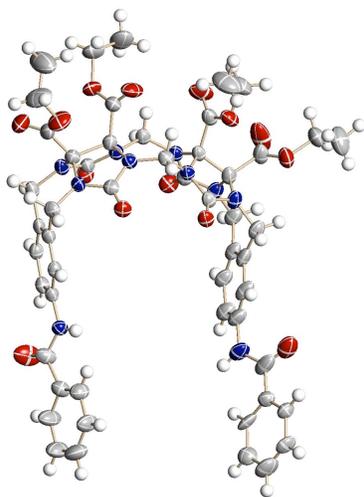
\* D - donor atom, H - hydrogen, A - acceptor.

## Details of the X-ray crystallographic structure determination of 8.

A colorless block with approximate orthogonal dimensions  $0.47 \times 0.23 \times 0.16 \text{ mm}^3$  was placed and optically centered on the Bruker SMART CCD system at  $-70^\circ\text{C}$ . The initial unit cell was indexed using a least-squares analysis of a random set of reflections collected from three series of  $0.3^\circ$  wide  $\omega$ -scans, 30 seconds per frame, and 25 frames per series that were well distributed in reciprocal space. Data frames were collected [MoK $\alpha$ ] with  $0.3^\circ$  wide  $\omega$ -scans, 20 seconds per frame and 606 frames per series. Eight complete series were collected at two detector settings and  $\omega = -18^\circ$  or  $\omega = -38^\circ$  with varying  $\varphi$  angles for each setting, ( $\varphi = 0^\circ, 90^\circ, 180^\circ, 270^\circ$ ). Additionally, 200 frames, a repeat of the first series for redundancy and decay purposes, were also collected. The crystal to detector distance was 7.950cm, thus providing a complete sphere of data to  $2\theta_{\text{max}} = 50.0^\circ$ . A total of 23564 reflections were collected and corrected for Lorentz and polarization effects and absorption using Blessing's method as incorporated into the program TWINABS<sup>1-3</sup> with 23582 unique. The additional reflections were generated due to overlaps.



### Structural determination and Refinement:



All crystallographic calculations were performed on a Personal computer (PC) with a Pentium 1.80 GHz processor and 512 MB of extended memory. During the initial unit cell determination it was quickly recognized that the crystals were twinned. Several crystals were tried but all possessed similar twinning behavior so a well diffracting one was chosen and from this a cell determined. Data collection was begun and the relative contributions from the two twin components were determined using the first data collection series. 999 reflections were randomly chosen via a thresholding routine and these reflections were then input into GEMINI<sup>4</sup> that determined the twin relationship between the two components. An additional check was performed via an exhaustive indexing search program Cell\_Now<sup>5</sup> that confirmed the cell and orientation matrices found with Gemini. The twin matrices corresponding to both components were input into SAINT<sup>6</sup> and the data were processed twice. At the completion of the first run, the optimized merged matrix was re-input and the data were processed a second time. The major component was now used for structure determination. The SHELXTL<sup>7</sup> program package was now implemented to determine, based upon intensity statistics and lack of systematic absences, the

centric triclinic, space group P-1 (no. 2). The structure was determined by direct methods using the program XS<sup>8</sup>. Refinement of two unique molecules with XL<sup>9</sup> and subsequent difference-Fourier maps and refinement cycles in between revealed the location of all of the atoms comprising the structure and also included an extremely disordered solvent region composed of partial occupancy CH<sub>2</sub>Cl<sub>2</sub> molecules with a second disordered region composed of somewhat well ordered CH<sub>2</sub>Cl<sub>2</sub> partial occupancy molecules and two partial occupancy CH<sub>3</sub>CN molecules. The main molecules of interest also possessed disordered side chains that were optimized individually. All of the full occupancy non-hydrogen atoms were refined anisotropically. Hydrogen atoms were placed in calculated positions. The final structure was refined to convergence [ $\Delta/\sigma \leq 0.001$ ] with R(F) = 9.36 %, wR(F<sup>2</sup>) = 21.31 %, GOF = 0.995 for all 23582 unmerged reflections [R(F) = 6.79 %, wR(F<sup>2</sup>) = 19.76 % for those 16342 data with Fo > 4 $\sigma$ (Fo)]. A final difference-Fourier map was featureless indicating that the structure is therefore both correct and complete.

The function minimized during the full-matrix least-squares refinement was  $\Sigma w(F_o^2 - F_c^2)^2$  where  $w = 1/[\sigma^2(F_o^2) + (0.1537 * P)^2 + 0.0 * P]$  and  $P = (\max(F_o^2, 0) + 2 * F_c^2) / 3$ . An empirical correction for extinction was also attempted but found to be negative and therefore not applied.

#### References:

1. An Empirical Correction for Absorption Anisotropy, Blessing, R. H. (1995). *Acta Cryst.*, A51, 33-38.
2. Sheldrick, G.M., SADABS 'Siemens Area Detector Absorption Correction' Universität Göttingen: Göttingen, Germany, 1996.
3. Sheldrick, G.M., TWINABS 'An Empirical Correction for Absorption Anisotropy applied to Twinned crystals' alpha version. Universität Göttingen: Göttingen, Germany, 2002.
4. GEMINI Twinning Solution program suite (2000), Bruker AXS, 5465 E. Cheryl Parkway, Madison, WI 53711.
5. Cell\_Now twin indexing program - personal communication from George Sheldrick.
6. SAINT v6.34B Software reference manual (1998), Bruker AXS, 5465 E. Cheryl Parkway, Madison, WI 53711.
7. Sheldrick, G.M., (1994). SHELXTL/PC. Version 5.03. Siemens Analytical X-ray Instruments Inc., Madison, Wisconsin, USA.
8. Phase Annealing in SHELX-90: Direct Methods for Larger Structures, Sheldrick, G. M., (1990). *Acta Cryst.* A46, 467-473.
9. Sheldrick, G.M., (1993). Shelxl93 Program for the Refinement of Crystal Structures. University of Göttingen, Germany.

**Table S6.** Crystal data and structure refinement for  $[\text{C}_{52}\text{H}_{50}\text{N}_{10}\text{O}_{14}]_2[\text{CH}_2\text{Cl}_2]_2[\text{CH}_3\text{CN}]_{0.5}$ .

Identification code	967cf1no12	
Empirical formula	C107 H105.50 Cl4 N20.50 O28	
Formula weight	2268.42	
Temperature	203(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P-1	
Unit cell dimensions	a = 15.4848(5) Å	$\alpha = 87.8303(12)^\circ$ .
	b = 16.8763(5) Å	$\beta = 70.8776(11)^\circ$ .
	c = 22.1548(7) Å	$\gamma = 83.9976(11)^\circ$ .
Volume	5440.1(3) Å <sup>3</sup>	
Z	2	
Density (calculated)	1.385 Mg/m <sup>3</sup>	
Absorption coefficient	0.196 mm <sup>-1</sup>	
F(000)	2366	
Crystal size	0.47 x 0.23 x 0.16 mm <sup>3</sup>	
Theta range for data collection	1.95 to 25.00°.	
Index ranges	-17 ≤ h ≤ 18, -20 ≤ k ≤ 20, 0 ≤ l ≤ 26	
Reflections collected	23564	
Independent reflections	23582 [R(int) = 0.0000]	
Completeness to theta = 25.00°	89.9 %	
Absorption correction	Twinabs, multi-scan	
Max. and min. transmission	0.9686 and 0.9130	
Refinement method	Full-matrix least-squares on F <sup>2</sup>	
Data / restraints / parameters	23582 / 15 / 1579	
Goodness-of-fit on F <sup>2</sup>	0.995	
Final R indices [I > 2σ(I)]	R1 = 0.0679, wR2 = 0.1976 [16342 Data]	
R indices (all data)	R1 = 0.0936, wR2 = 0.2131	
Largest diff. peak and hole	0.748 and -0.593 e.Å <sup>-3</sup>	

**Table S7.** Hydrogen bonds for  $[\text{C}_{52}\text{H}_{50}\text{N}_{10}\text{O}_{14}]_2[\text{CH}_2\text{Cl}_2]_2[\text{CH}_3\text{CN}]_{0.5}$  [Å and °].

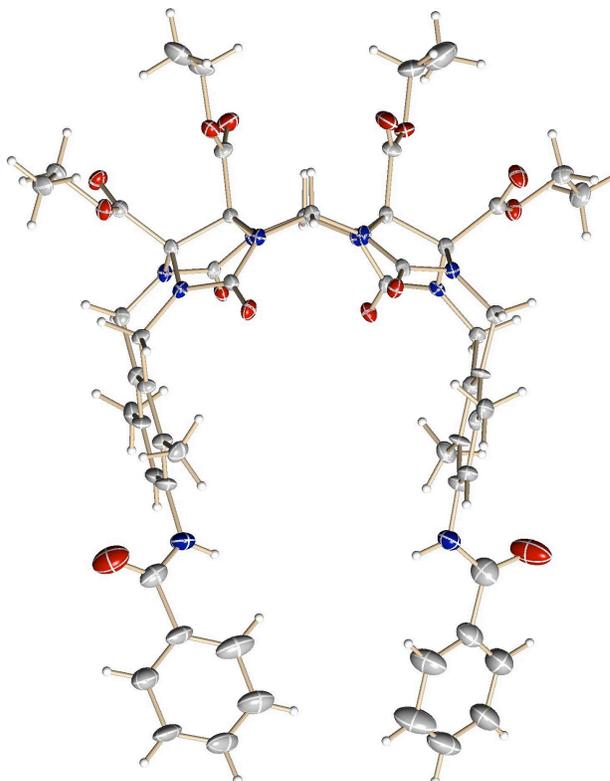
D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(7)-H(7)...O(36A)	0.87	2.19	3.005(4)	155.5
N(17)-H(17)...O(33)	0.87	2.25	3.074(5)	157.0
N(28)-H(28)...O(17A)	0.87	2.32	3.099(5)	149.5
N(36)-H(36)...O(2)	0.87	2.19	3.023(4)	159.8

## Details of the X-ray crystallographic structure determination of ( $\pm$ )-12.

A colorless pyramid of  $(C_{56}H_{58}N_{10}O_{14}) \cdot \sim 10.5CH_3CN$ , approximate dimensions 0.18 x 0.34 x 0.38 mm<sup>3</sup>, was used for the X-ray crystallographic analysis. The X-ray intensity data were measured at 220(2) K on a three-circle diffractometer system equipped with Bruker Smart 1000 CCD area detector using a graphite monochromator and a MoK $\alpha$  fine-focus sealed tube ( $\lambda = 0.71073 \text{ \AA}$ ) operated at 50 kV and 30 mA. The detector was placed at a distance of 4.939 cm from the crystal.

A total of 1824 frames were collected with a scan width of 0.5° in  $\omega$  and an exposure time of 23 sec/frame using SMART (Bruker, 1999). The total data collection time was 15.28 hours. The frames were integrated with SAINT software package using a narrow-frame integration algorithm. The integration of the data using a Monoclinic unit cell yielded a total of 32666 reflections to a maximum  $\theta$  angle of 25.00°, of which 11018 were independent (completeness = 99.9%,  $R_{int} = 2.87\%$ ,  $R_{sig} = 3.14\%$ ) and 9664 were greater than  $2\sigma(I)$ . The final cell dimensions of  $a = 16.7331(10) \text{ \AA}$ ,  $b = 11.8298(7) \text{ \AA}$ ,  $c = 16.4880(10) \text{ \AA}$ ,  $a = 90^\circ$ ,  $b = 104.6050(10)^\circ$ ,  $\gamma = 90^\circ$ ,  $V = 3158.3(3) \text{ \AA}^3$ , are based upon the refinement of the XYZ-centroids of 6589 reflections with  $2.1 < \theta < 27.5^\circ$  using SAINT. Analysis of the data showed 0 % decay during data collection. Data were corrected for absorption effects with the Semi-empirical from equivalents method using SADABS (Sheldrick, 1996). The minimum and maximum transmission coefficients were 0.933 and 0.983.

The structure was solved and refined using the SHELXS-97 (Sheldrick, 1990) and SHELXL-97 (Sheldrick, 1997) software in the space group  $Pc$  with  $Z = 2$  for the formula unit  $(C_{56}H_{58}N_{10}O_{14}) \cdot \sim 10.5CH_3CN$ . The final anisotropic full-matrix least-squares refinement on  $F^2$  with 729 variables converged at  $R_1 = 4.39\%$  for the observed data and  $wR_2 = 9.93\%$  for all data. The goodness-of-fit was 1.000. The largest peak on the final difference map was  $0.231 \text{ e/\AA}^3$  and the largest hole was  $-0.182 \text{ e/\AA}^3$ . On the basis of the final model, the calculated density was  $1.326 \text{ g/cm}^3$  and  $F(000)$ , 1334 e.



**Table S8.** Crystal data and structure refinement for ( $\pm$ )-**12**.

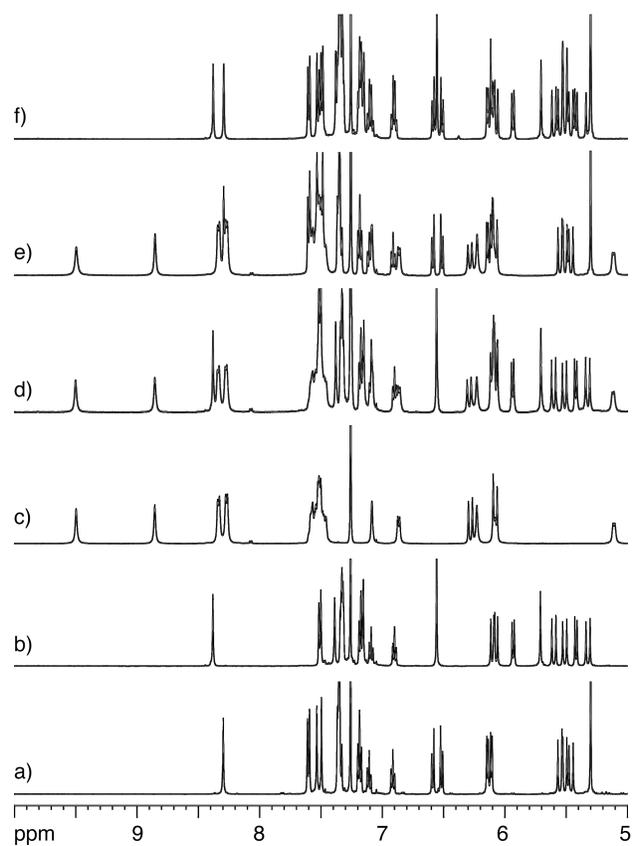
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X-ray lab book No.	1413
Crystal ID	Isaacs/Ghosh CT-CH3CN
Empirical formula	(C <sub>56</sub> H <sub>58</sub> N <sub>10</sub> O <sub>14</sub> )·~10.5CH <sub>3</sub> CN
Formula weight	1260.87
Temperature	220(2) K
Wavelength	0.71073 Å
Crystal size	0.38 x 0.34 x 0.18 mm <sup>3</sup>
Crystal habit	colorless pyramid
Crystal system	Monoclinic
Space group	Pc
Unit cell dimensions	a = 16.7331(10) Å    a = 90° b = 11.8298(7) Å    b = 104.6050(10)° c = 16.4880(10) Å    g = 90°
Volume	3158.3(3) Å <sup>3</sup>
Z	2
Density, $\rho_{\text{calc}}$	1.326 g/cm <sup>3</sup>
Absorption coefficient, $\mu$	0.096 mm <sup>-1</sup>
F(000)	1334 e
Diffractometer	Bruker Smart1000 CCD area detector
Radiation source	fine-focus sealed tube, MoKa
Generator power	50 kV, 30 mA
Detector distance	4.939 cm
Detector resolution	8.33 pixels/mm
Total frames	1824
Frame size	512 pixels
Frame width	0.5 °
Exposure per frame	23 sec
Total measurement time	15.28 hours
Data collection method	$\omega$ and $\varphi$ scans
q range for data collection	1.72 to 25.00°
Index ranges	-19 ≤ h ≤ 19, -14 ≤ k ≤ 14, -19 ≤ l ≤ 19
Reflections collected	32666
Independent reflections	11018
Observed reflection, I>2s(I)	9664
Coverage of independent reflections	99.9 %
Variation in check reflections	0 %
Absorption correction	Semi-empirical from equivalents SADABS (Sheldrick, 1996)

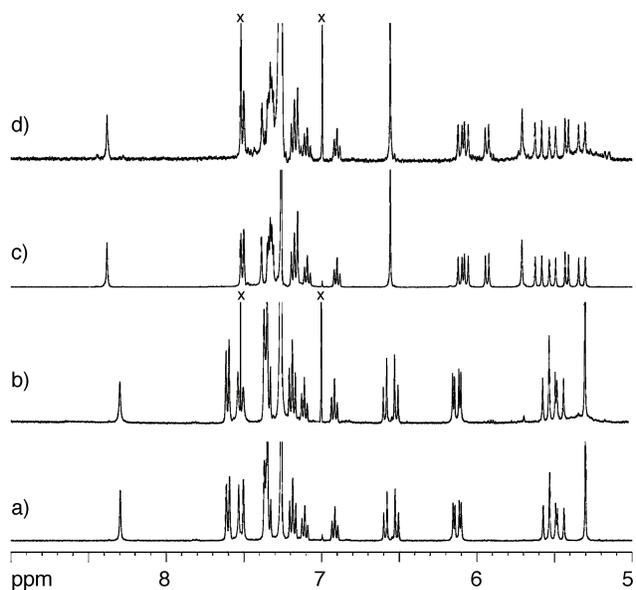
Max. and min. transmission	0.983 and 0.933
Structure solution technique	direct
Structure solution program	SHELXS-97 (Sheldrick, 1990)
Refinement technique	Full-matrix least-squares on $F^2$
Refinement program	SHELXL-97 (Sheldrick, 1997)
Function minimized	$\text{Sw}(F_o^2 - F_c^2)^2$
Data / restraints / parameters	11018 / 2 / 729
Goodness-of-fit on $F^2$	1.000
$D/s_{\text{max}}$	0.000
Final R indices: $R_1$ , $I > 2s(I)$	0.0439
$wR_2$ , all data	0.0993
$R_{\text{int}}$	0.0287
$R_{\text{sig}}$	0.0314
Weighting scheme	$w = 1/[s^2(F_o^2) + (0.0095P)^2 + 2.95P]$ , $P = [\max(F_o^2, 0) + 2F_o^2]/3$
Absolute structure parameter	-0.4(8)
Largest diff. peak and hole	0.231 and -0.182 $e/\text{\AA}^3$

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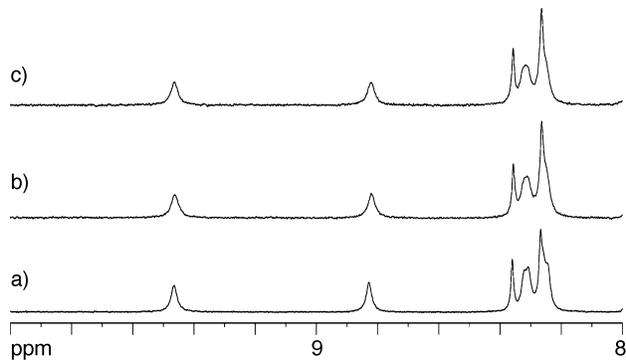

$$R_1 = \frac{\sum ||F_o| - |F_c||}{\sum |F_o|}, \quad wR_2 = [\text{Sw}(F_o^2 - F_c^2)^2 / \text{Sw}(F_o^2)^2]^{1/2}$$



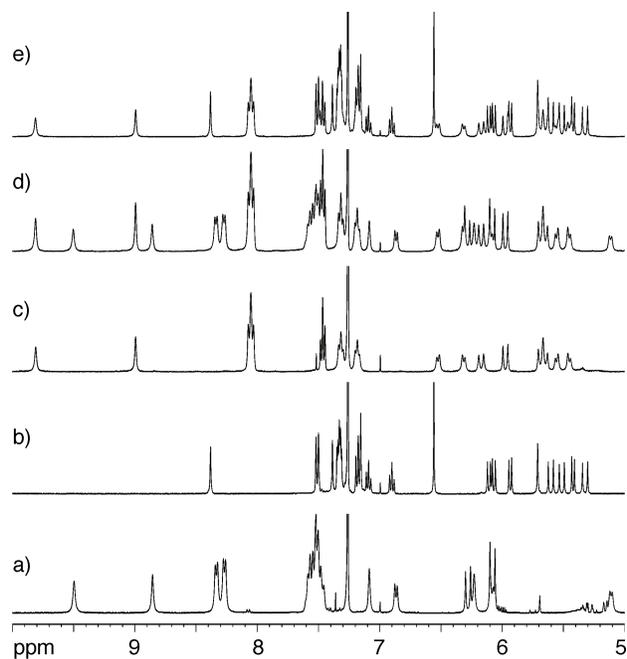
**Figure S1.** Portion of the <sup>1</sup>H NMR (5 mM, 500 MHz, CDCl<sub>3</sub>, RT) spectrum recorded for: a) **2•2**, b) (+)-**5•(-)-5**, c) **8•8**, d) a mixture of (+)-**5•(-)-5**, and **8•8**, e) a mixture of **2•2**, and **8•8**, and f) a mixture of **2•2**, and (+)-**5•(-)-5**.



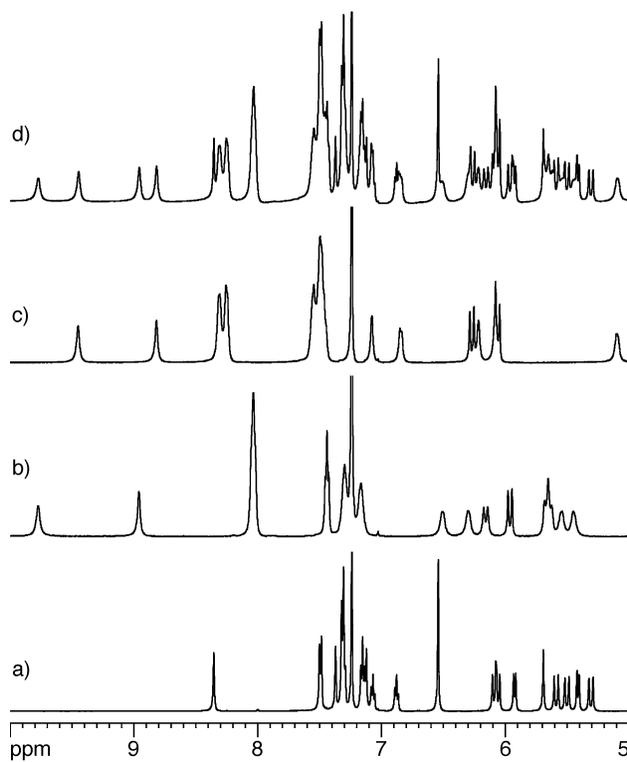
**Figure S2.** Portion of the variable concentration  $^1\text{H}$  NMR spectrum recorded for a (400 MHz,  $\text{CDCl}_3$ , RT): a) 5 mM of **2•2**, b) 50  $\mu\text{M}$  of **2•2**, c) 5 mM of (+)-**5•(-)-5** and d) 50  $\mu\text{M}$  of (+)-**5•(-)-5**.



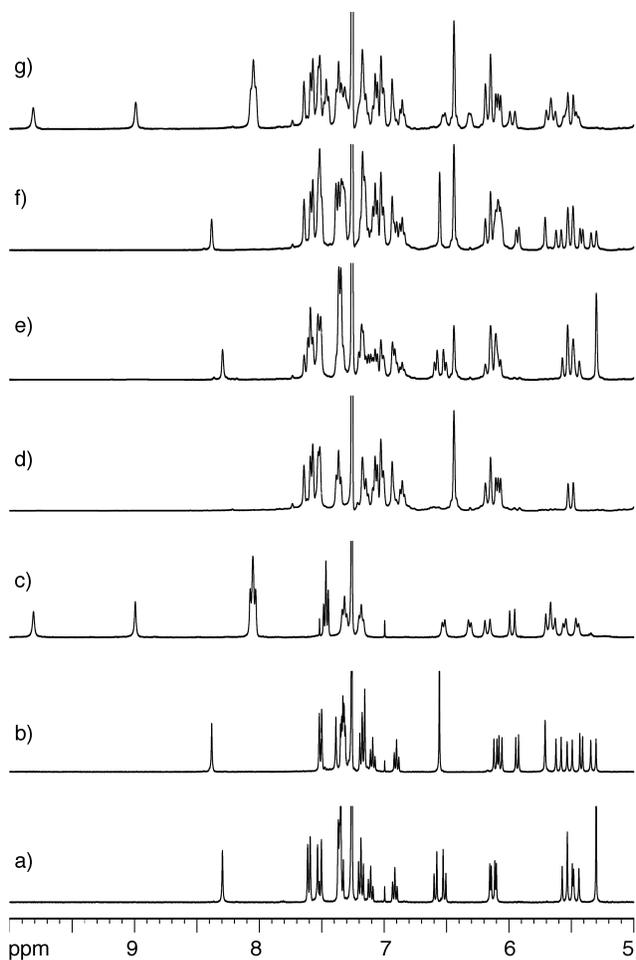
**Figure S3.** Portion of the variable concentration  $^1\text{H}$  NMR spectrum recorded for a mixture of **2•2**, (+)-**5•(-)-5**, and **8•8** (500 MHz,  $\text{CDCl}_3$ , RT): a) 5 mM, b) 1 mM, and c) 50  $\mu\text{M}$ .



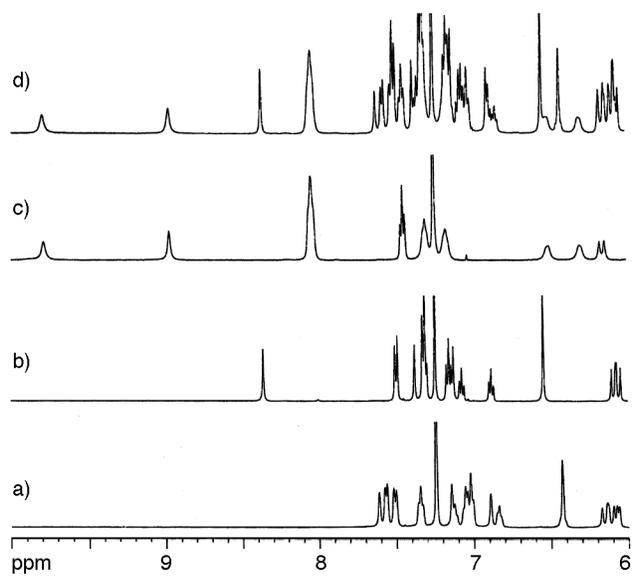
**Figure S4.**  $^1\text{H}$  NMR spectra (400 MHz, 298 K) for: a) **8•8**, b) **(+)-5•(-)-5**, c) **1•1**, d) a mixture of **1•1** and **8•8**, e) a mixture of **1•1** and **(+)-5•(-)-5**.



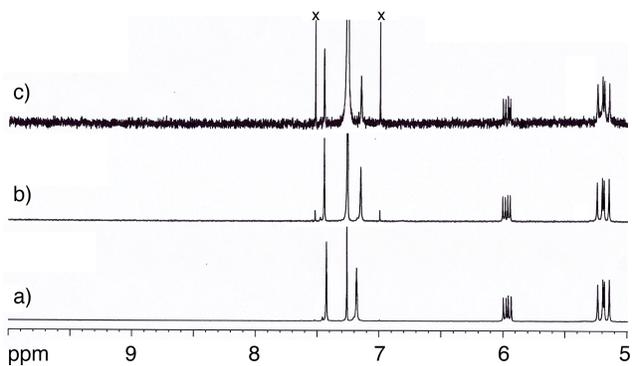
**Figure S5.**  $^1\text{H}$  NMR spectra (400 MHz, 298 K) for: a) **(+)-5•(-)-5**, b) **1•1**, c) **8•8**, and d) a mixture of **1•1**, **(+)-5•(-)-5**, and **8•8**.



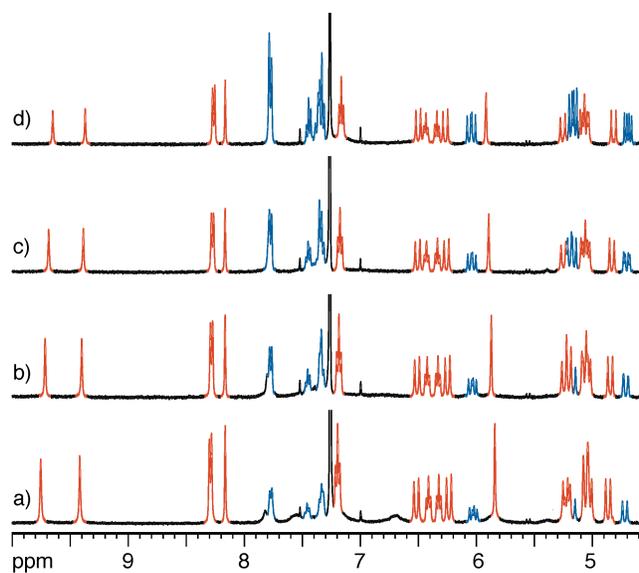
**Figure S6.** Portion of the  $^1\text{H}$  NMR (1mM, 500 MHz,  $\text{CDCl}_3$ , RT) spectrum recorded for: a) **2•2**, b) (+)-**5•(-)-5**, c) **1•1**, d) (+)-**7•(+)-7** e) a mixture of **2•2** and (+)-**7•(+)-7**, f) a mixture of (+)-**5•(-)-5** and (+)-**7•(+)-7**, g) a mixture of **1•1** and (+)-**7•(+)-7**.



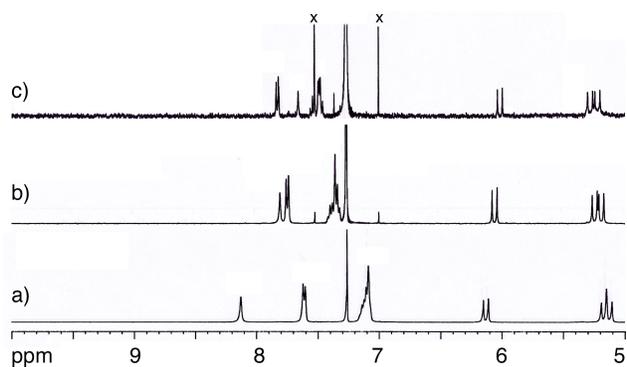
**Figure S7.** <sup>1</sup>H NMR spectra (400 MHz, 298 K) for: a) (+)-7•(+)-7, b) (+)-5•(-)-5, c) **1•1**, and d) a mixture of **1•1**, (+)-5•(-)-5, and (+)-7•(+)-7.



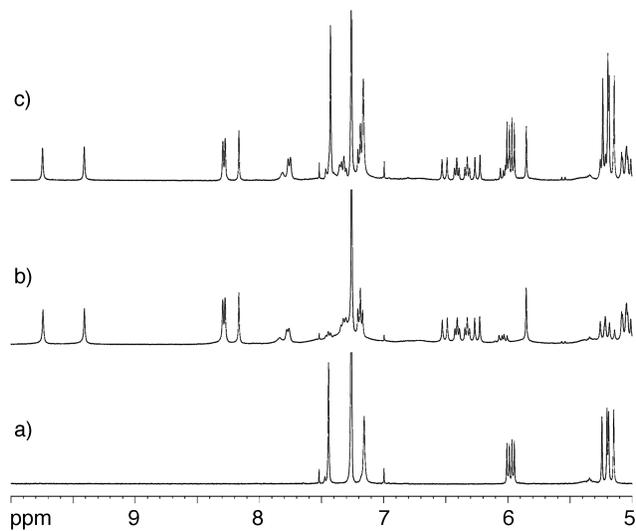
**Figure S8.** Portion of the variable concentration <sup>1</sup>H NMR spectrum recorded for **10** (400 MHz, CDCl<sub>3</sub>, RT): a) 10 mM, b) 1.0 mM, and c) 0.10 mM.



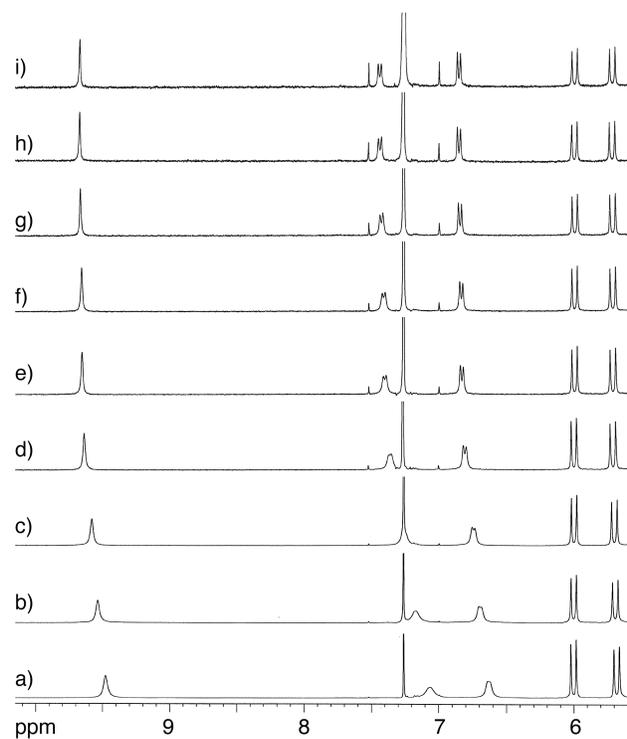
**Figure S9.** Portion of the variable temperature  $^1\text{H}$  NMR spectrum recorded for **9•9** (400 MHz, 2.5 mM,  $\text{CDCl}_3$ , RT): a) 18°C, b) 31°C, c) 41°C, and d) 55°C. Resonances are color coded as follows: dimeric **9•9**, red; and monomeric **9**, blue.



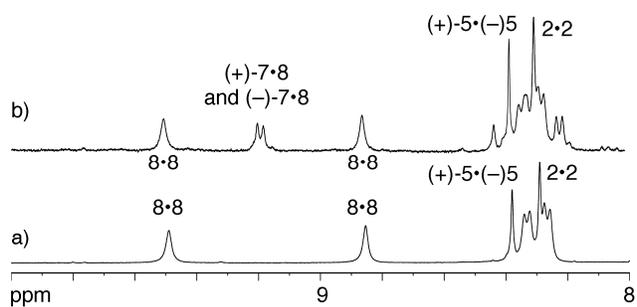
**Figure S10.** Portion of the variable concentration  $^1\text{H}$  NMR spectrum recorded for ( $\pm$ )-**12** (400 MHz,  $\text{CDCl}_3$ , RT): a) 10 mM, b) 1.0 mM, and c) 0.10 mM.



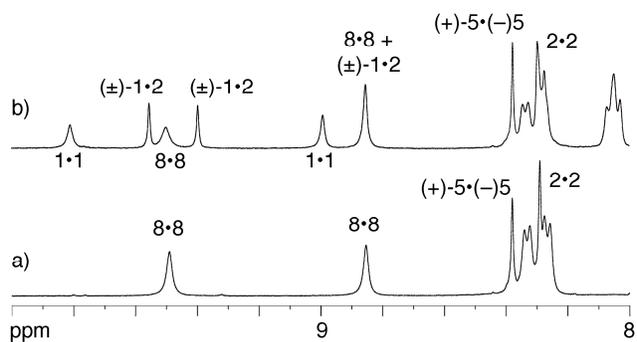
**Figure S11.**  $^1\text{H}$  NMR spectra (400 MHz, 298 K) for: a) **10•10**, b) **9•9**, c) **1•1**, and d) a mixture of **9•9**, and **10•10**.



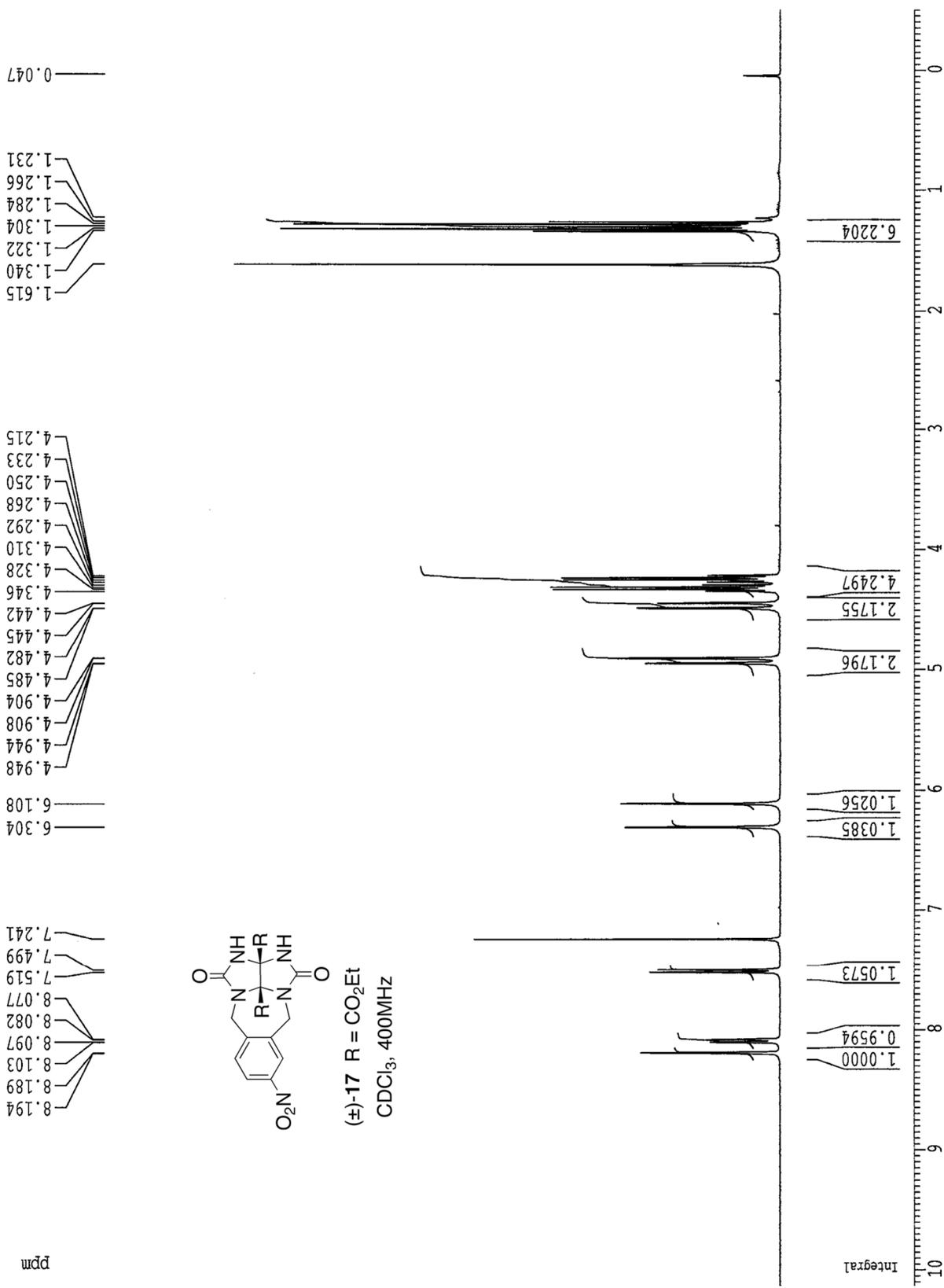
**Figure S12.** Portion of the variable concentration  $^1\text{H}$  NMR spectrum recorded for ( $\pm$ )-**6** (400 MHz,  $\text{CDCl}_3$ , RT): a) 15.51 mM, b) 9.30 mM, and c) 5.58 mM, d) 2.23 mM, e) 1.11 mM, f) 0.89 mM, g) 0.55 mM, h) 0.35 mM, i) 0.27 mM.

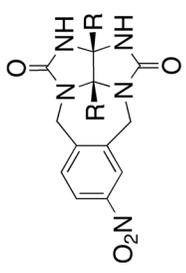
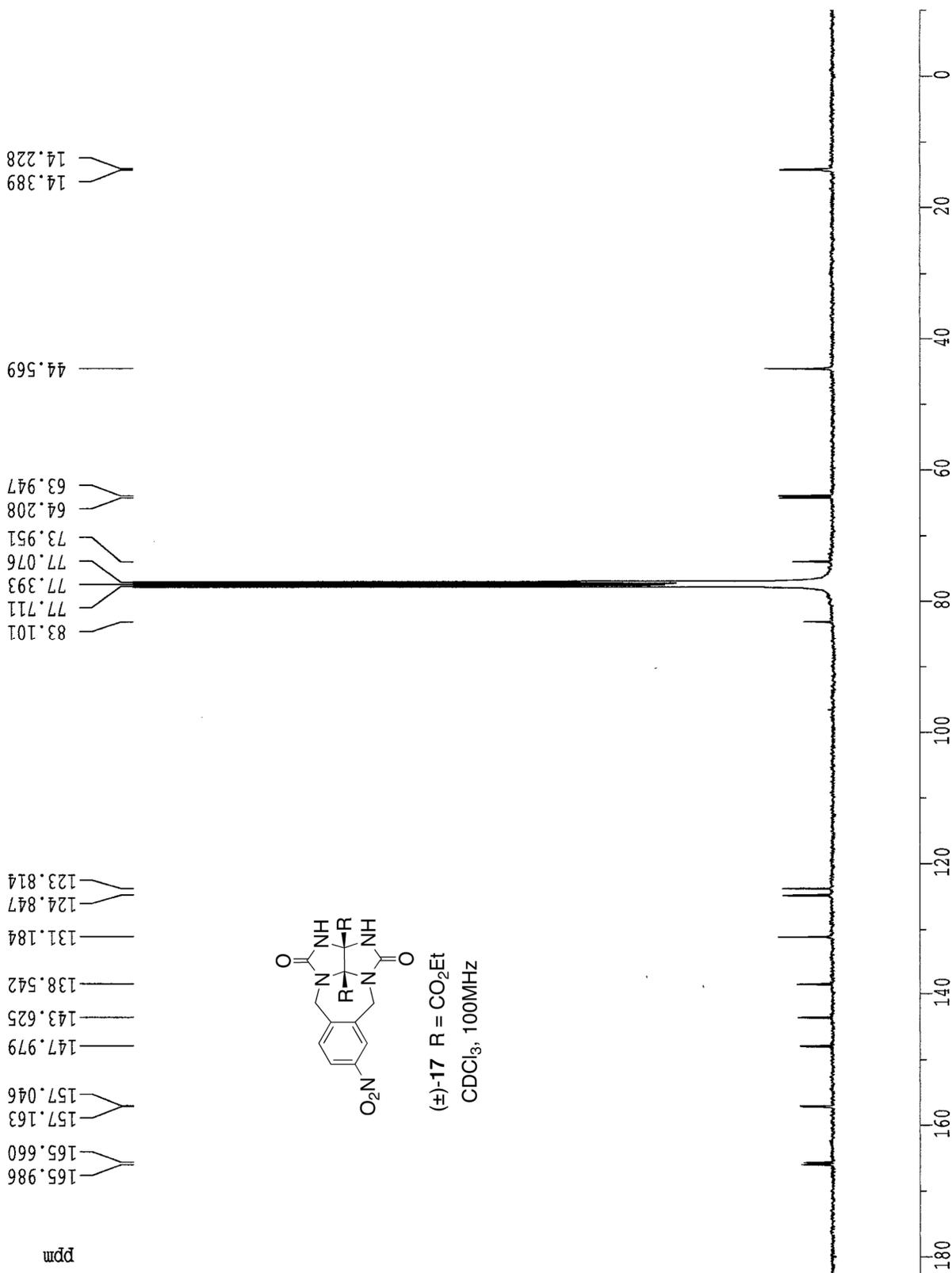


**Figure S13.** <sup>1</sup>H NMR spectra (400 MHz, 298 K) for: a) a mixture of **2•2**, (+)-**5•(-)-5**, and **8•8**, and b) a selective decomposition of **8•8** in the three component mixture by adding the racemic mixture comprising (+)-**7•(+)-7** and (-)-**7•(-)-7**.

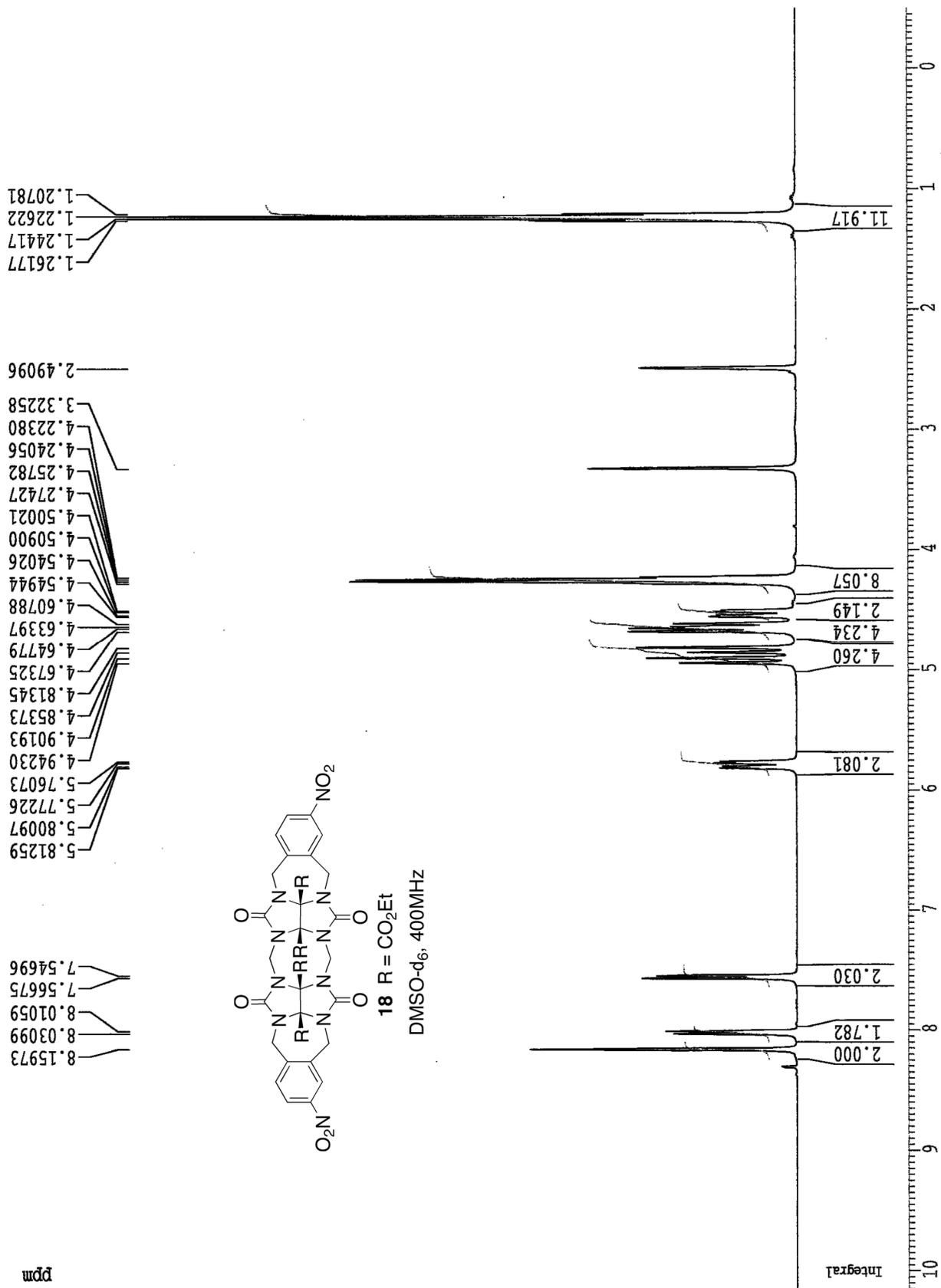


**Figure S14.** <sup>1</sup>H NMR spectra (400 MHz, 298 K) for: a) a mixture of **2•2**, (+)-**5•(-)-5**, and **8•8**, and b) a selective decomposition of **2•2** in the three component mixture by adding **1•1**.



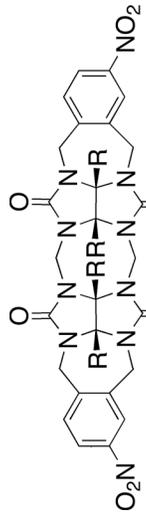


(-)-17 R = CO<sub>2</sub>Et  
CDCl<sub>3</sub>, 100MHz



ppm

- 164.571
- 163.778
- 153.968
- 153.818
- 146.857
- 143.876
- 138.500
- 130.738
- 124.027
- 123.137
- 79.809
- 79.104
- 78.323
- 64.490
- 63.997
- 47.479
- 43.919
- 43.847
- 40.124
- 39.916
- 39.708
- 39.499
- 39.290
- 39.082
- 38.873
- 13.581
- 13.457

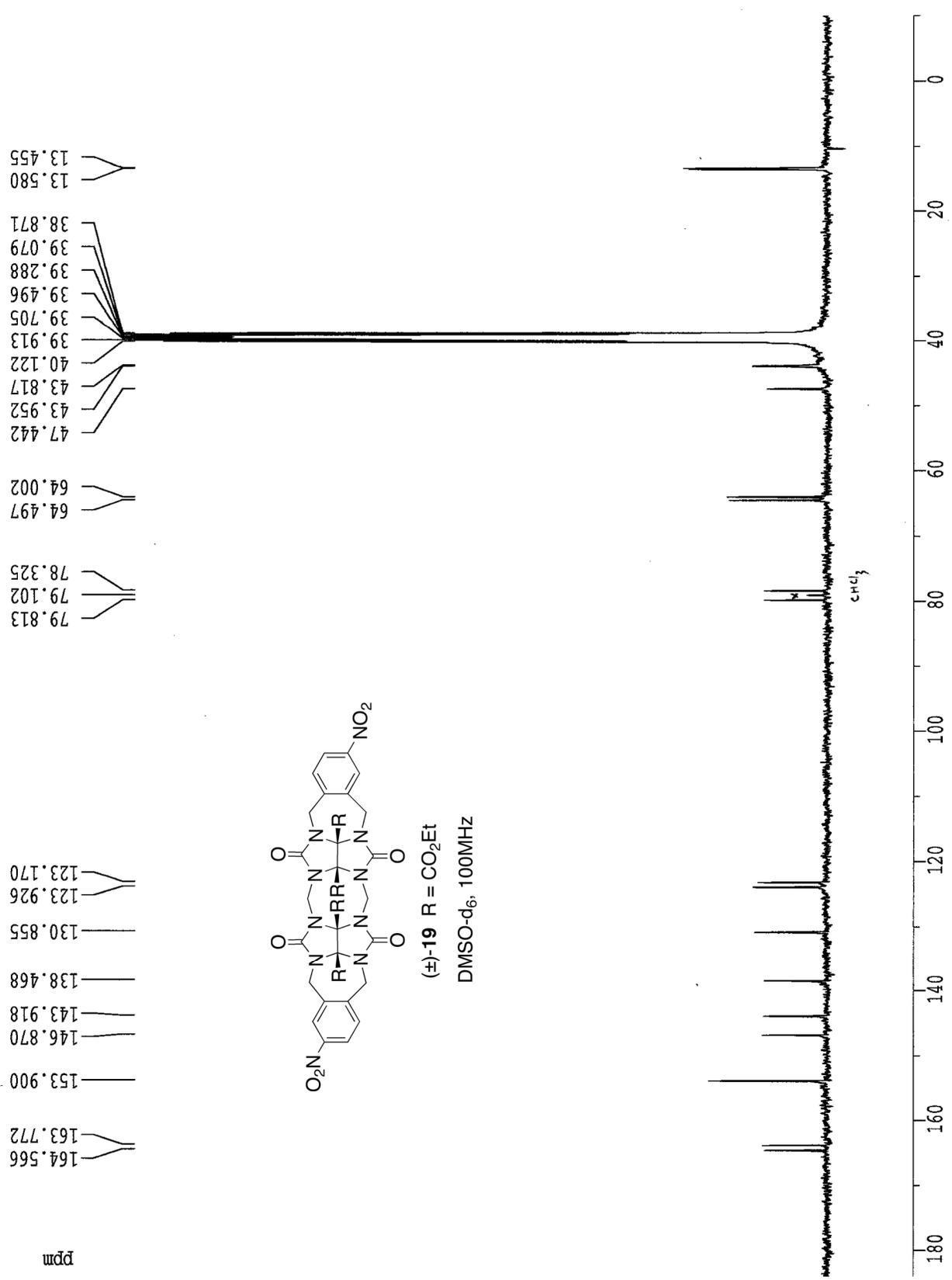


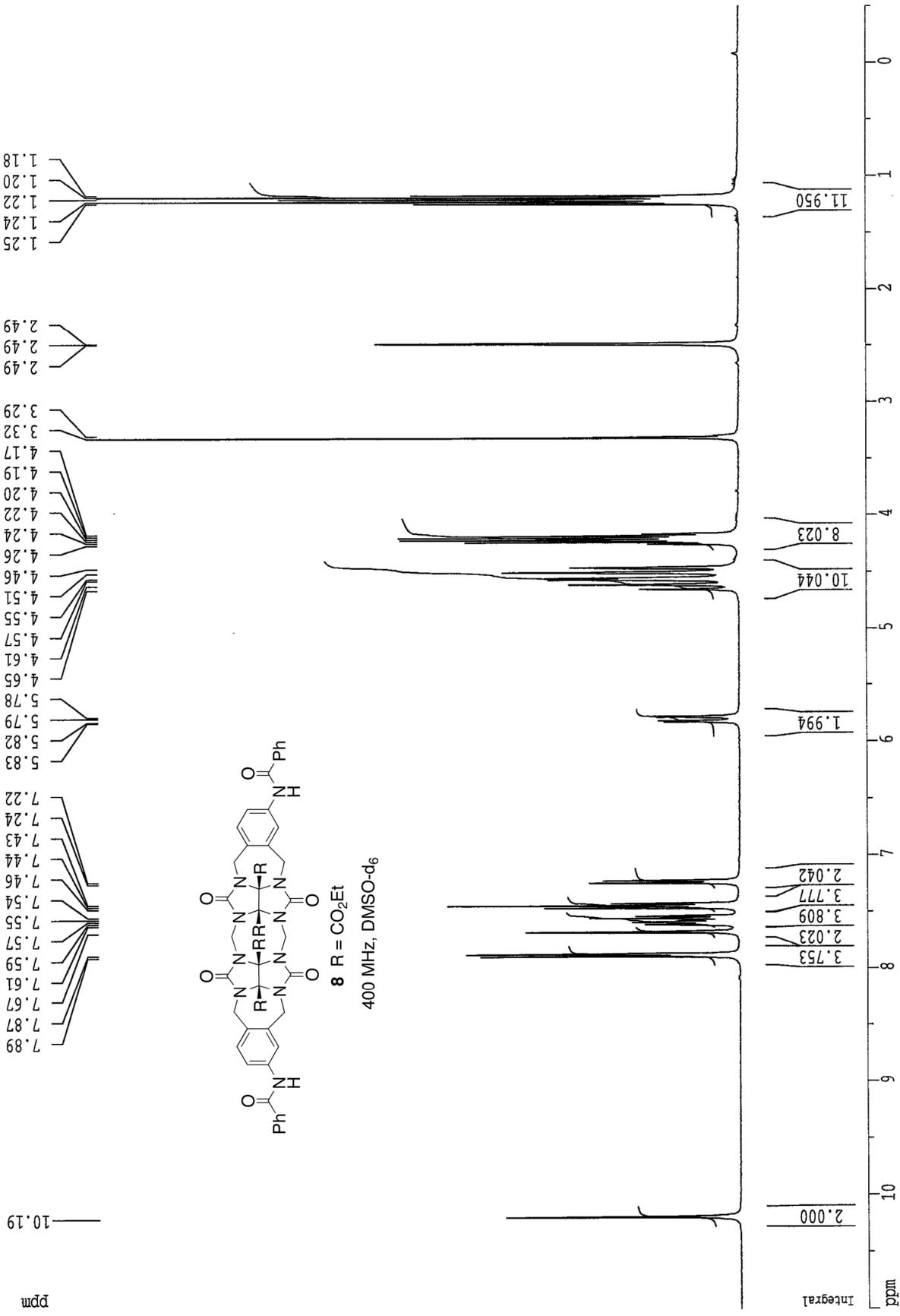
18 R = CO<sub>2</sub>Et  
DMSO-d<sub>6</sub>, 100MHz

x = CDCl<sub>3</sub>

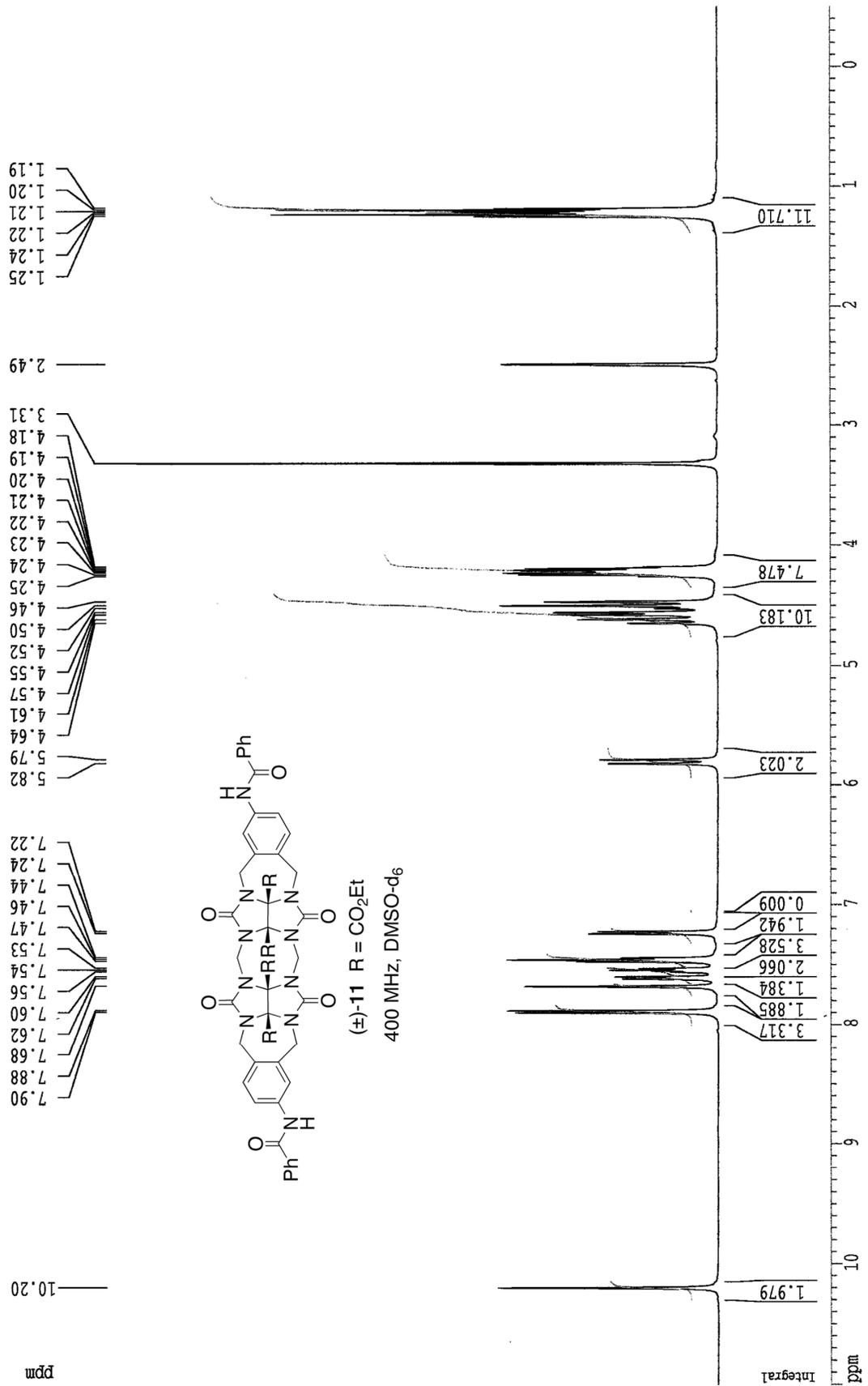


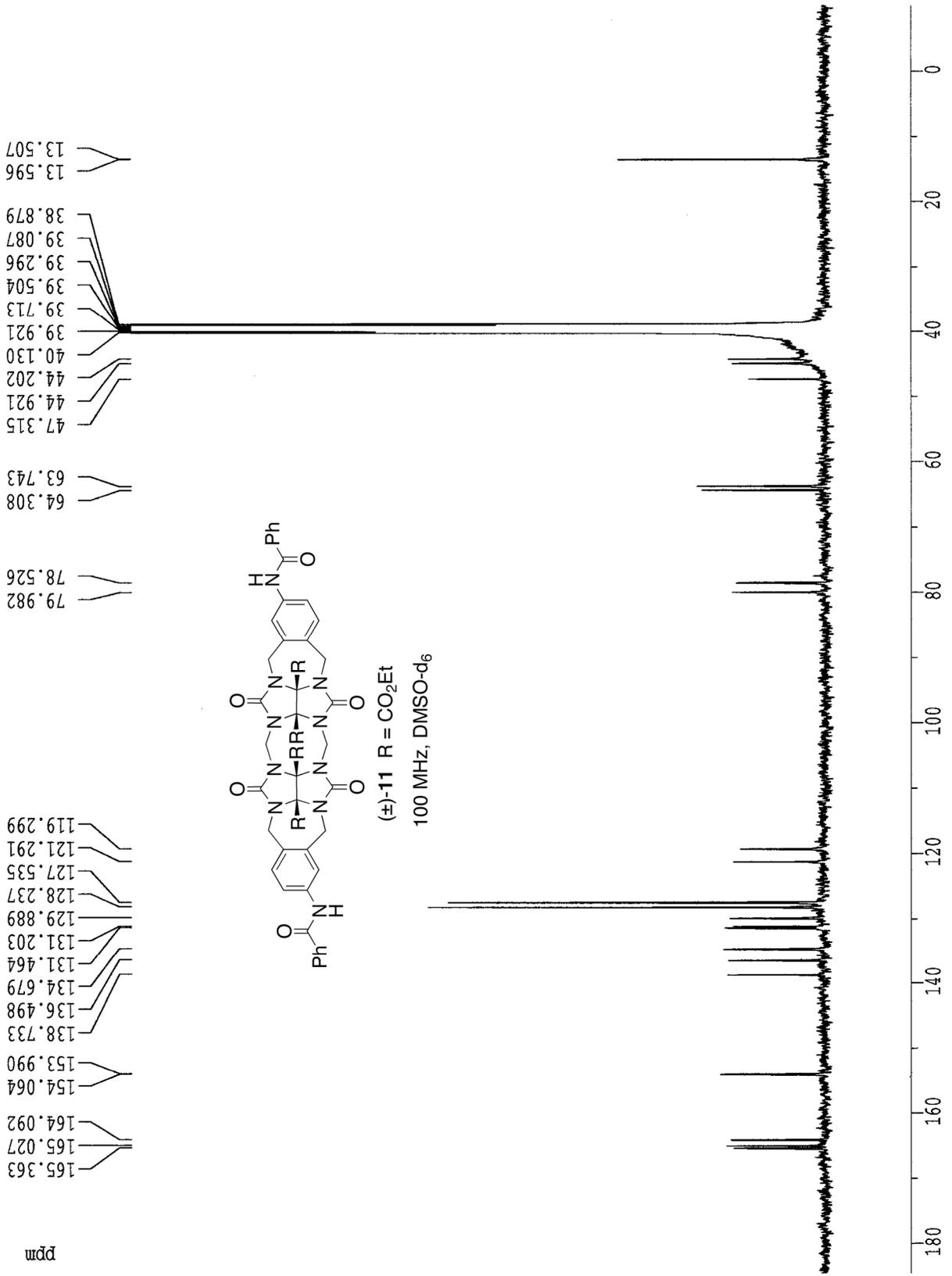














12.5  
12.6

36.4

44.7

48.4

48.6

55.9

65.9

66.2

76.7

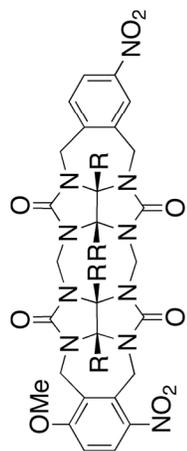
77.0

77.3

79.9

81.1

81.5



(+)-27 R = CO<sub>2</sub>Et  
TFA-D, 100MHz

109.9

110.4

111.0

112.7

113.2

113.7

115.5

116.0

116.5

118.8

124.2

124.9

126.1

127.5

143.3

156.8

157.0

157.2

161.1

161.6

162.0

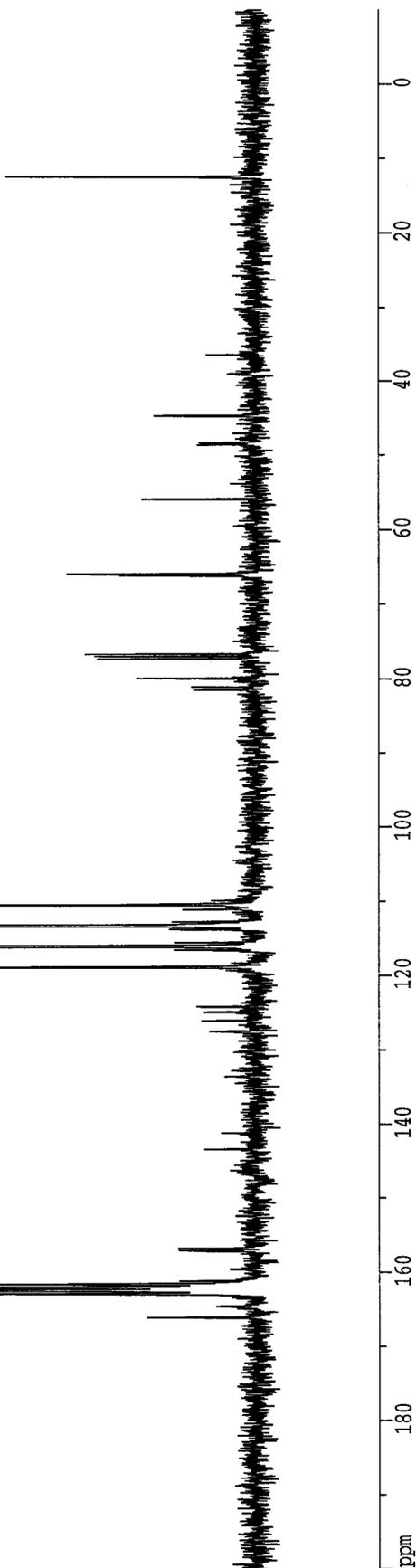
162.4

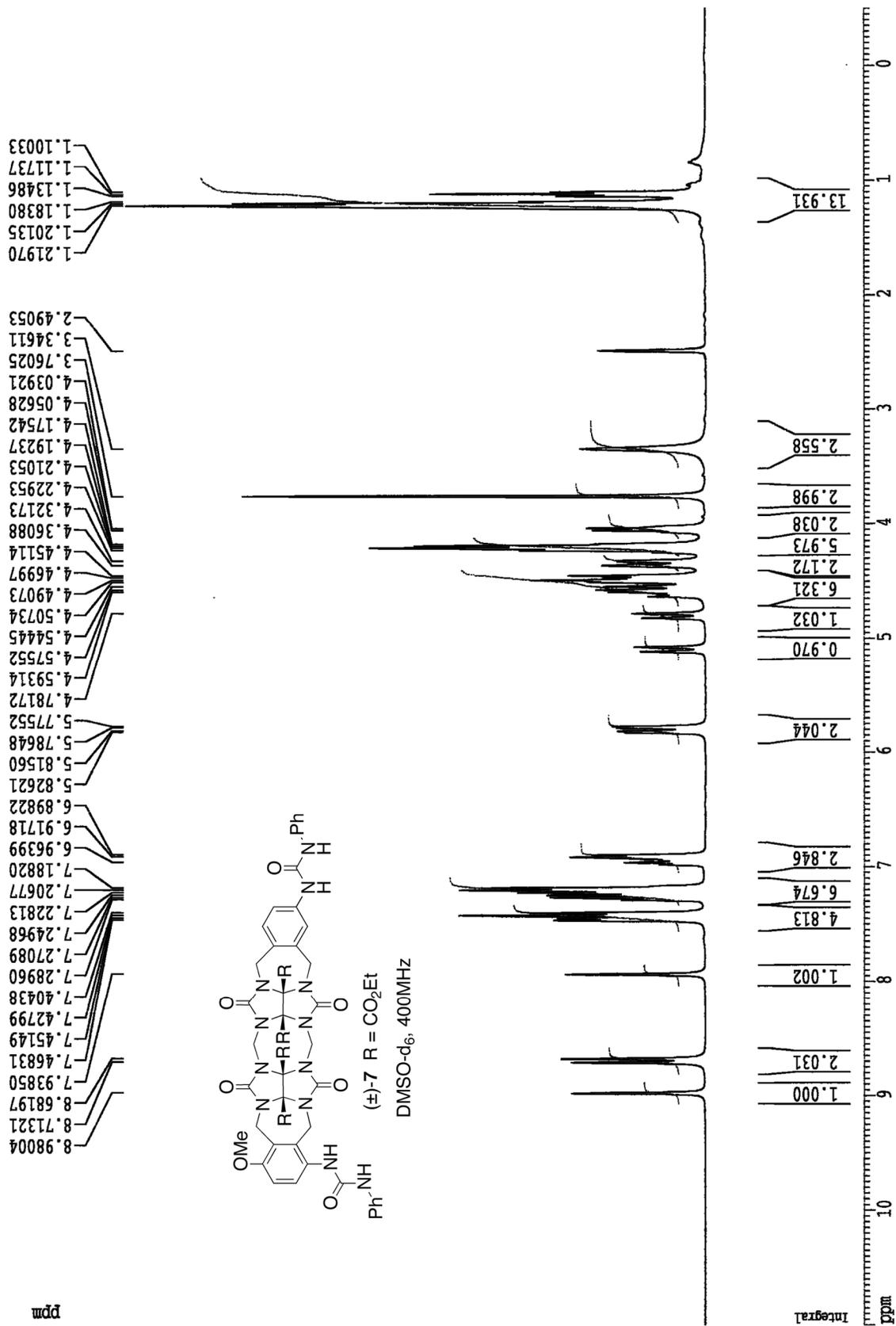
162.9

164.6

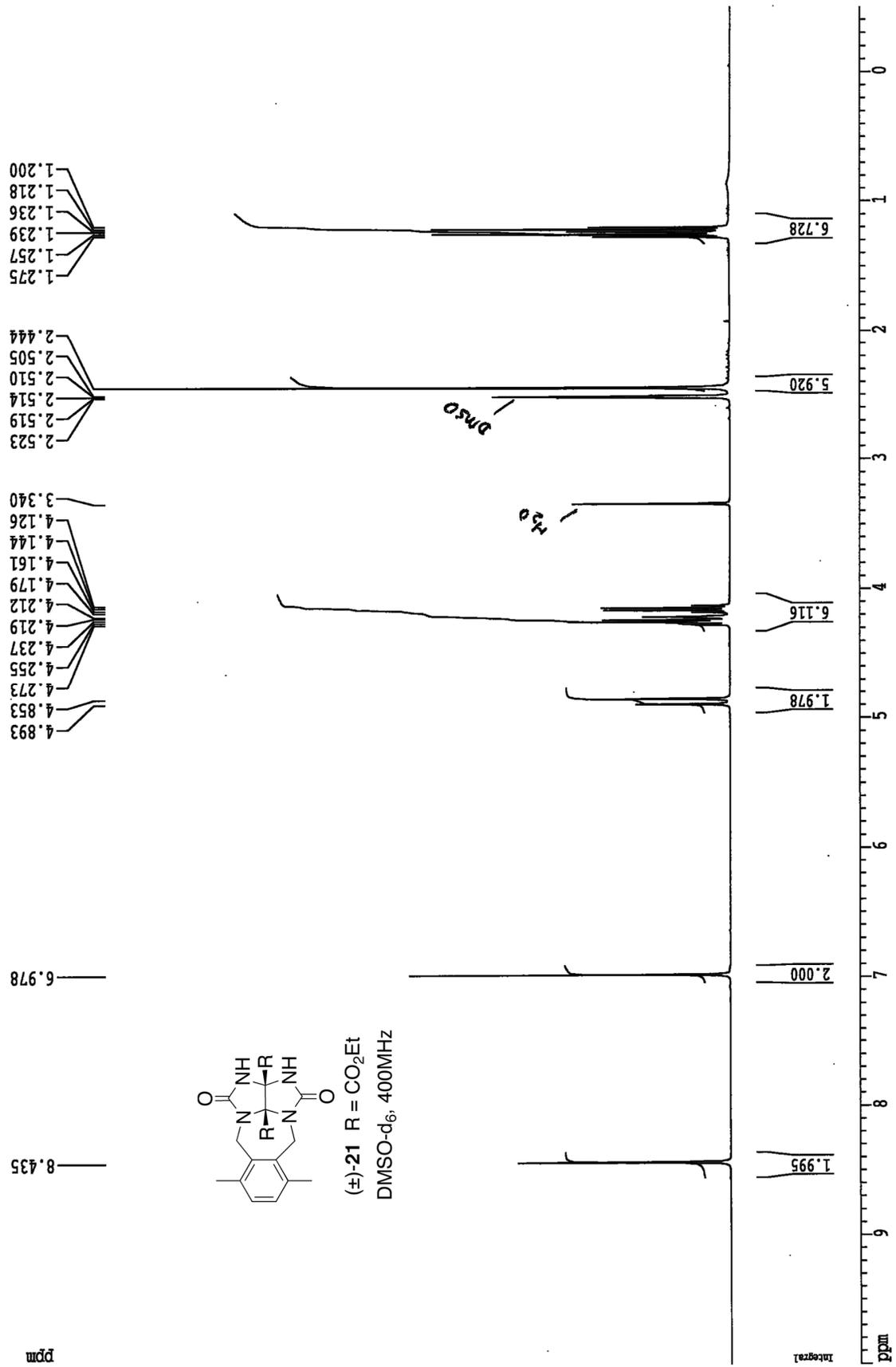
166.1

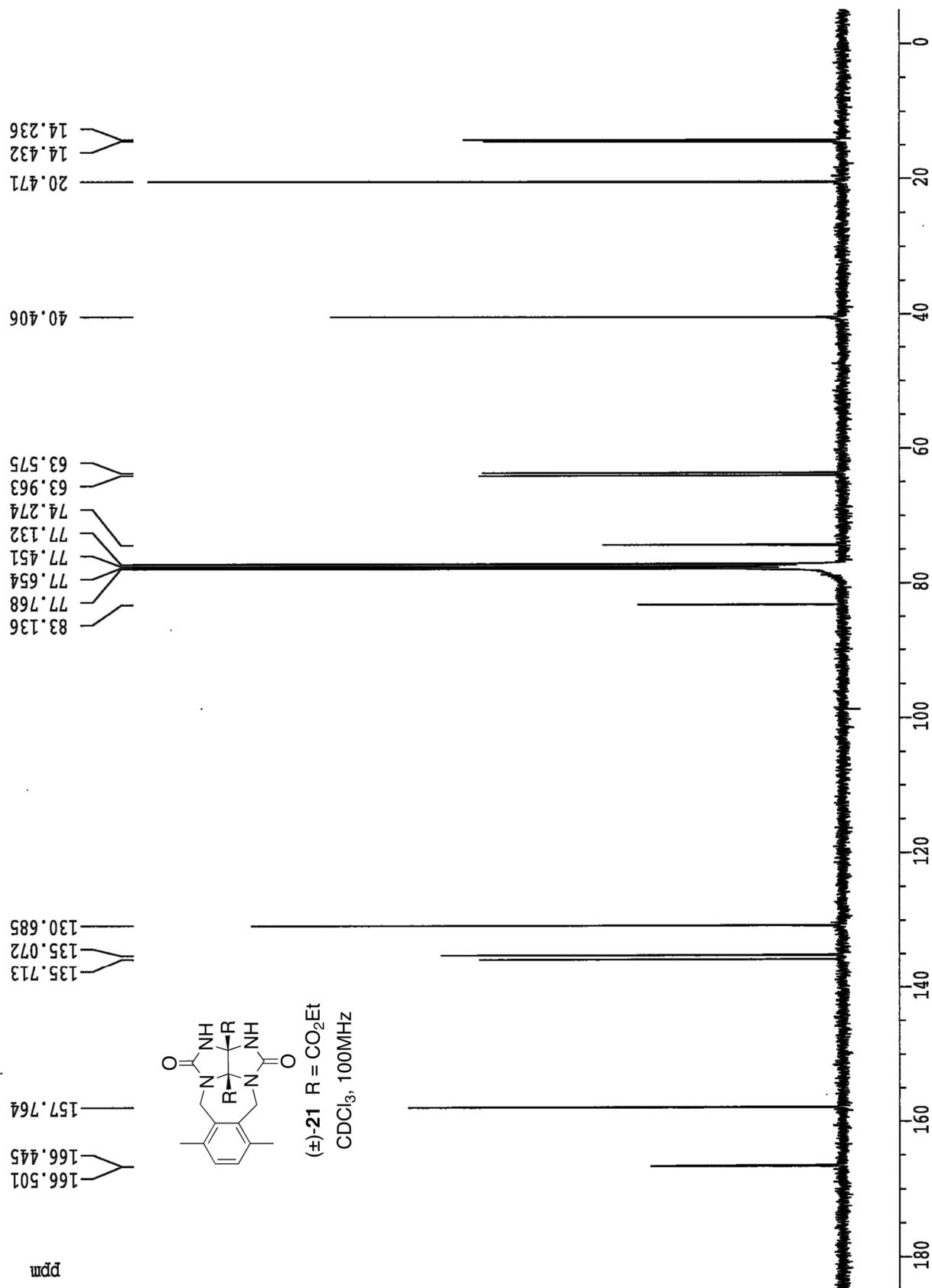
ppm

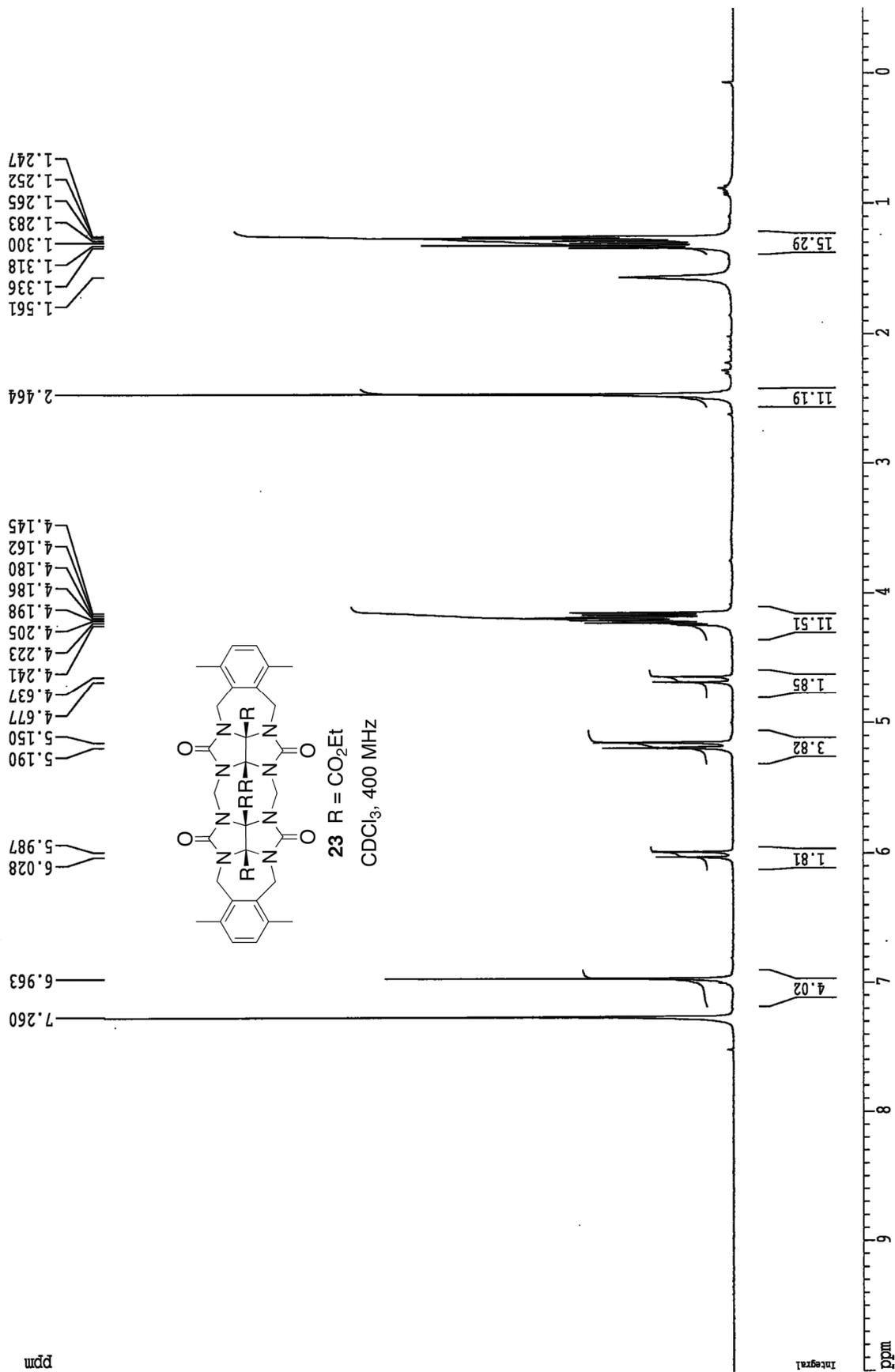


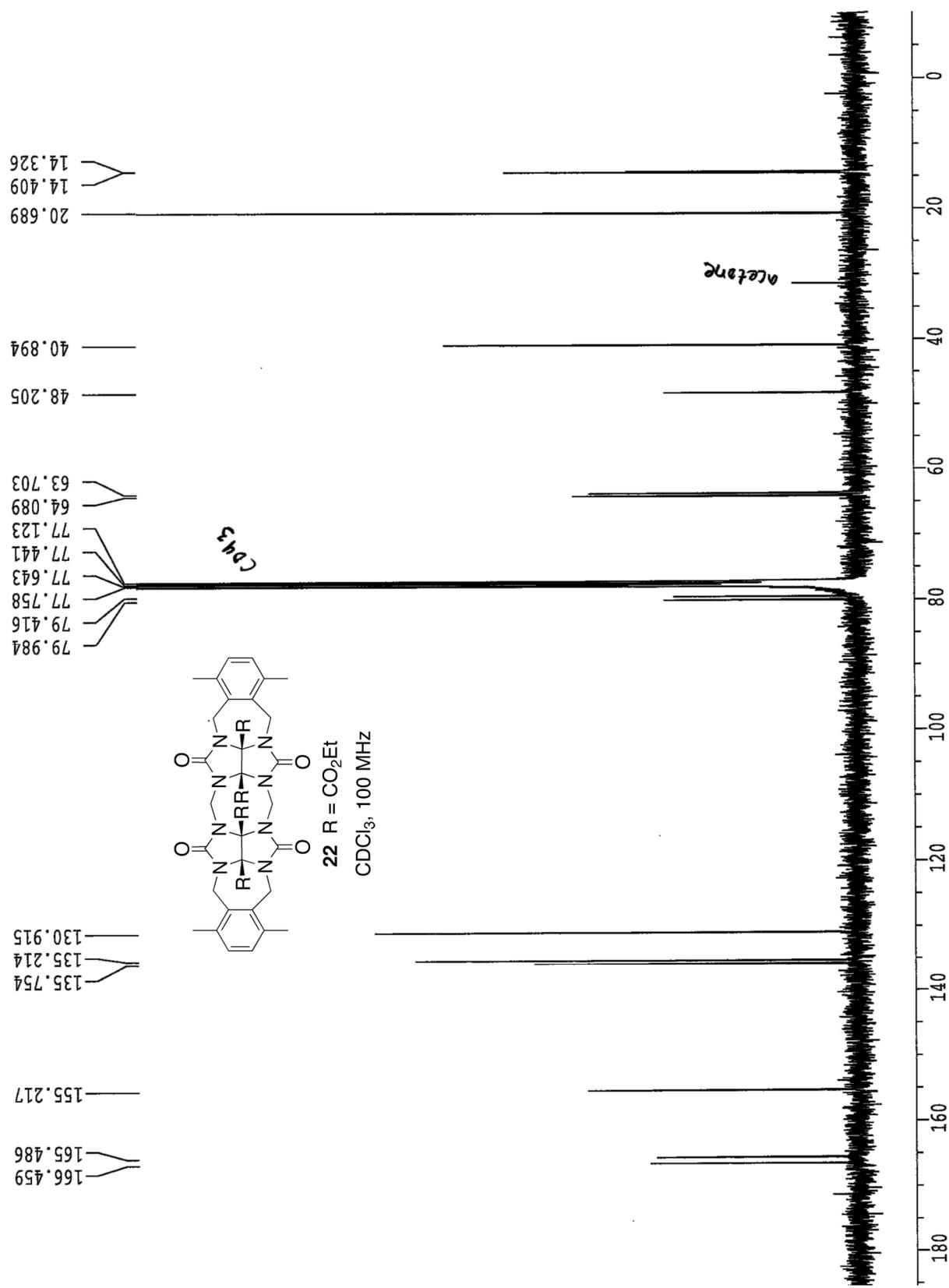


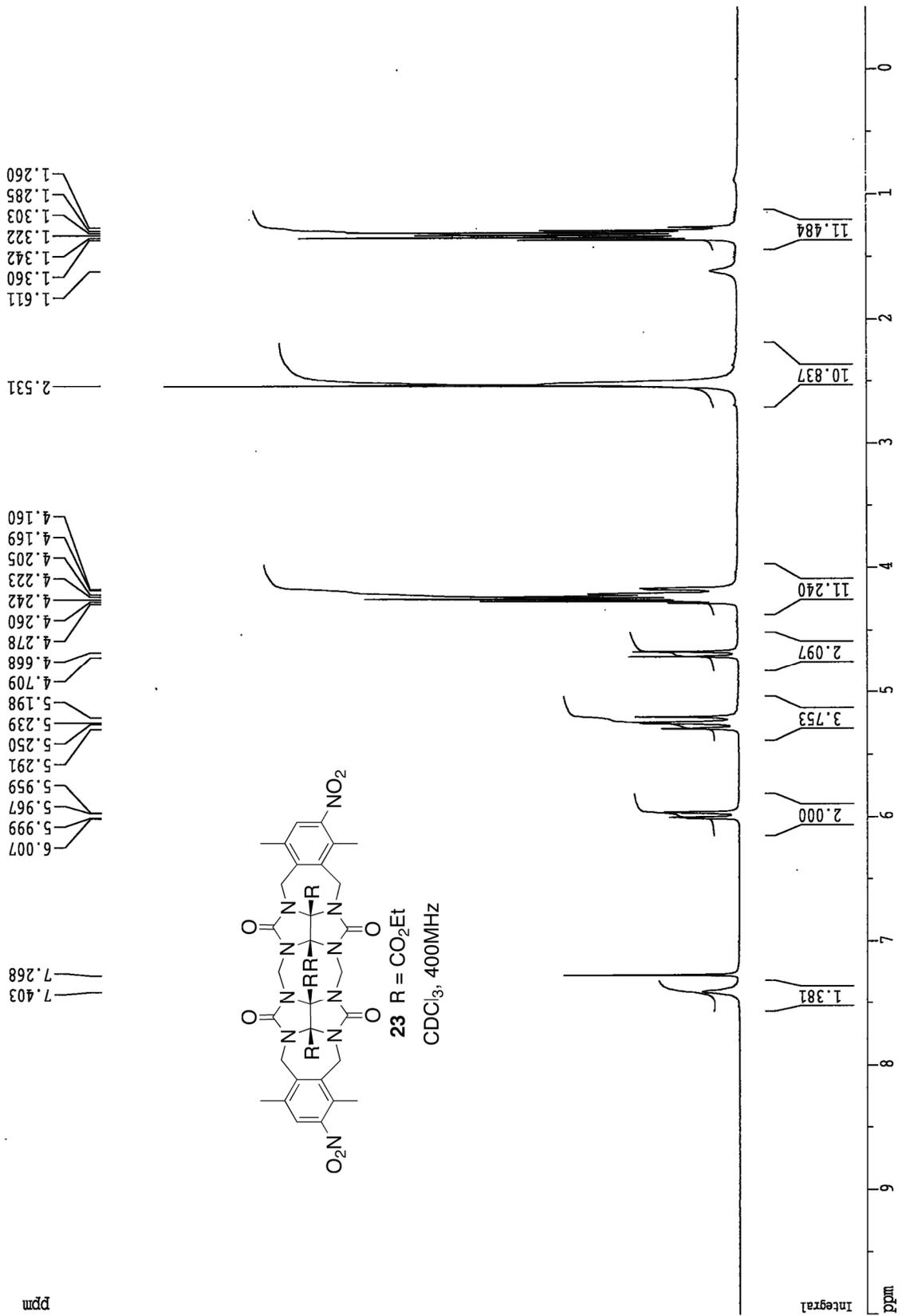


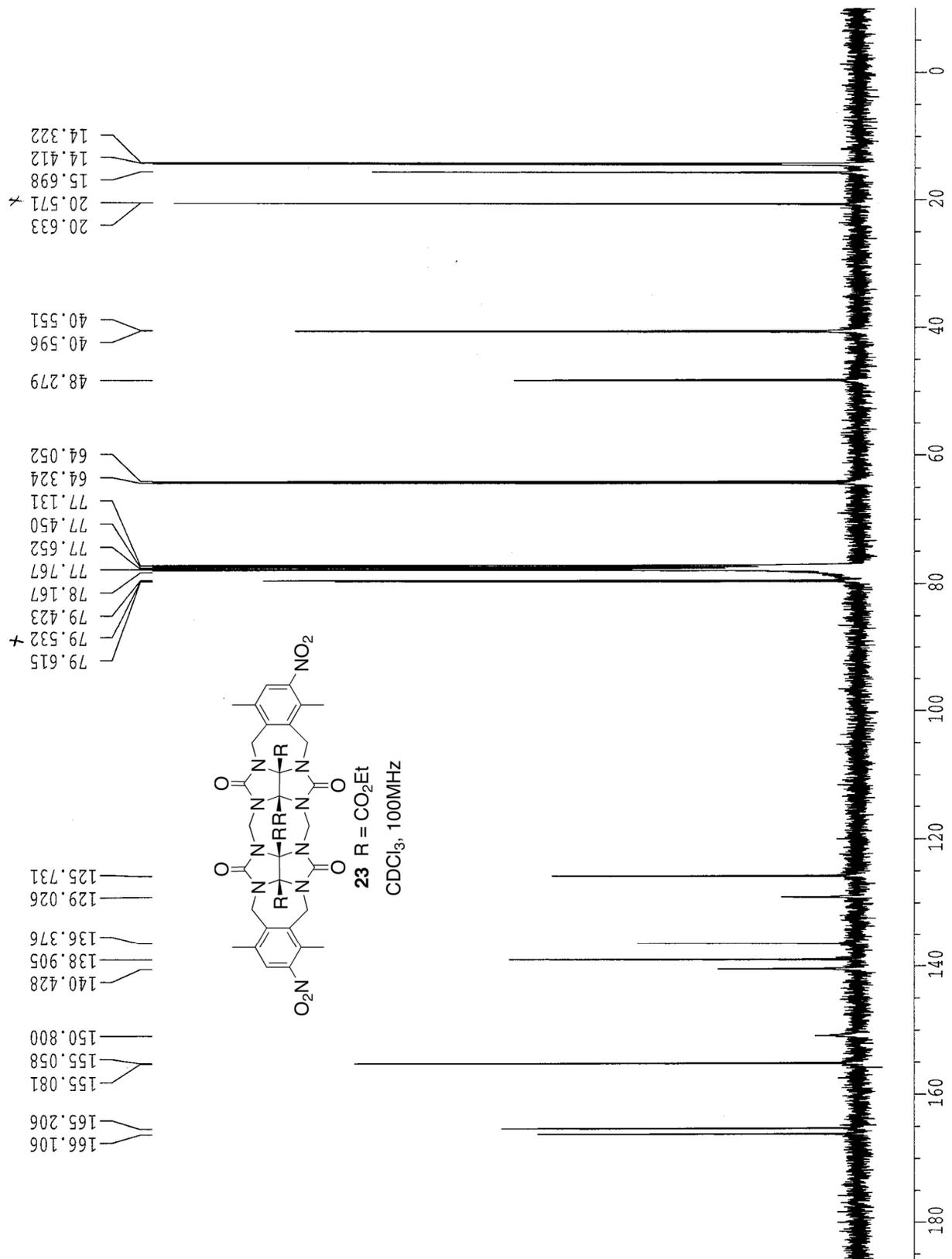


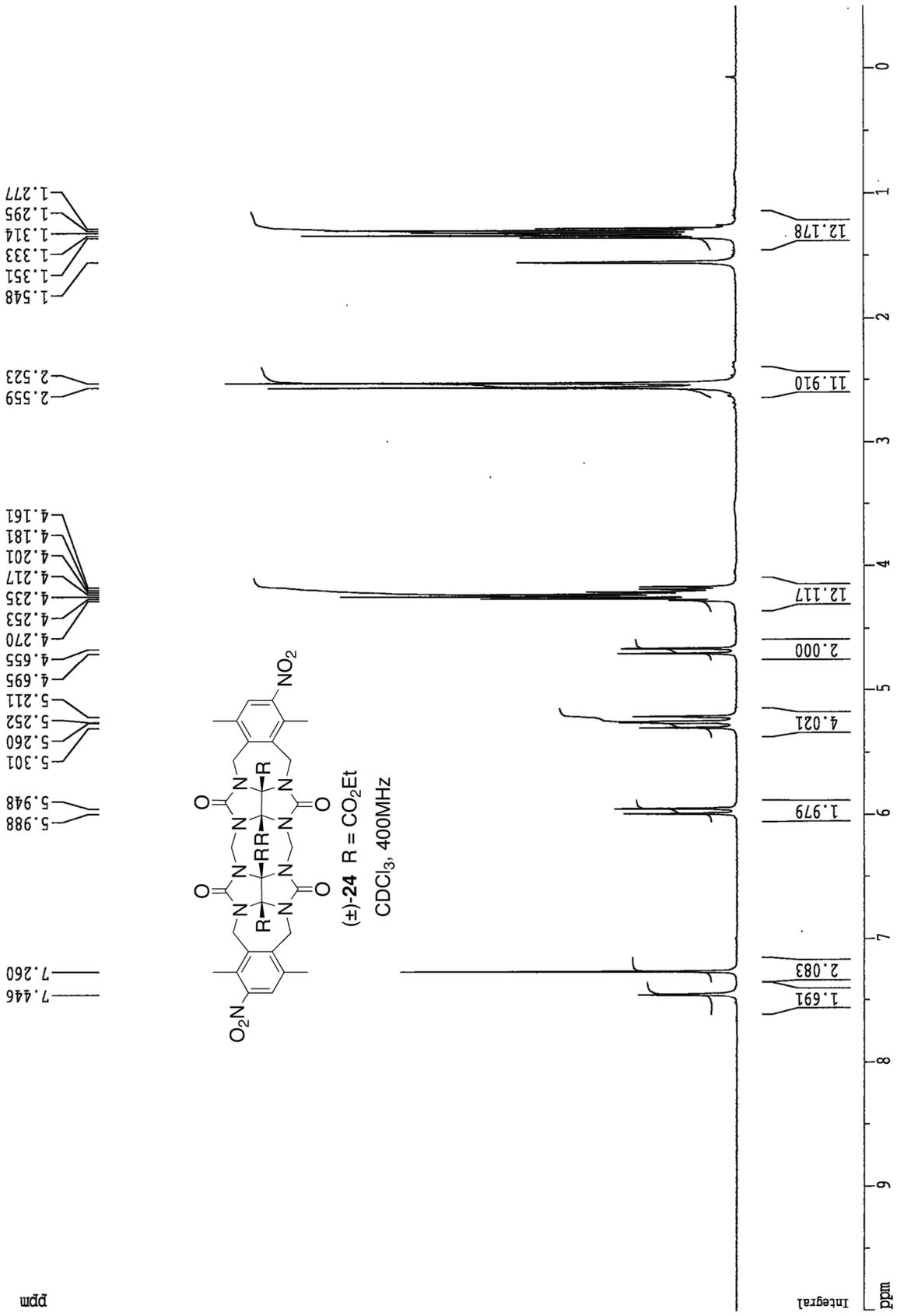




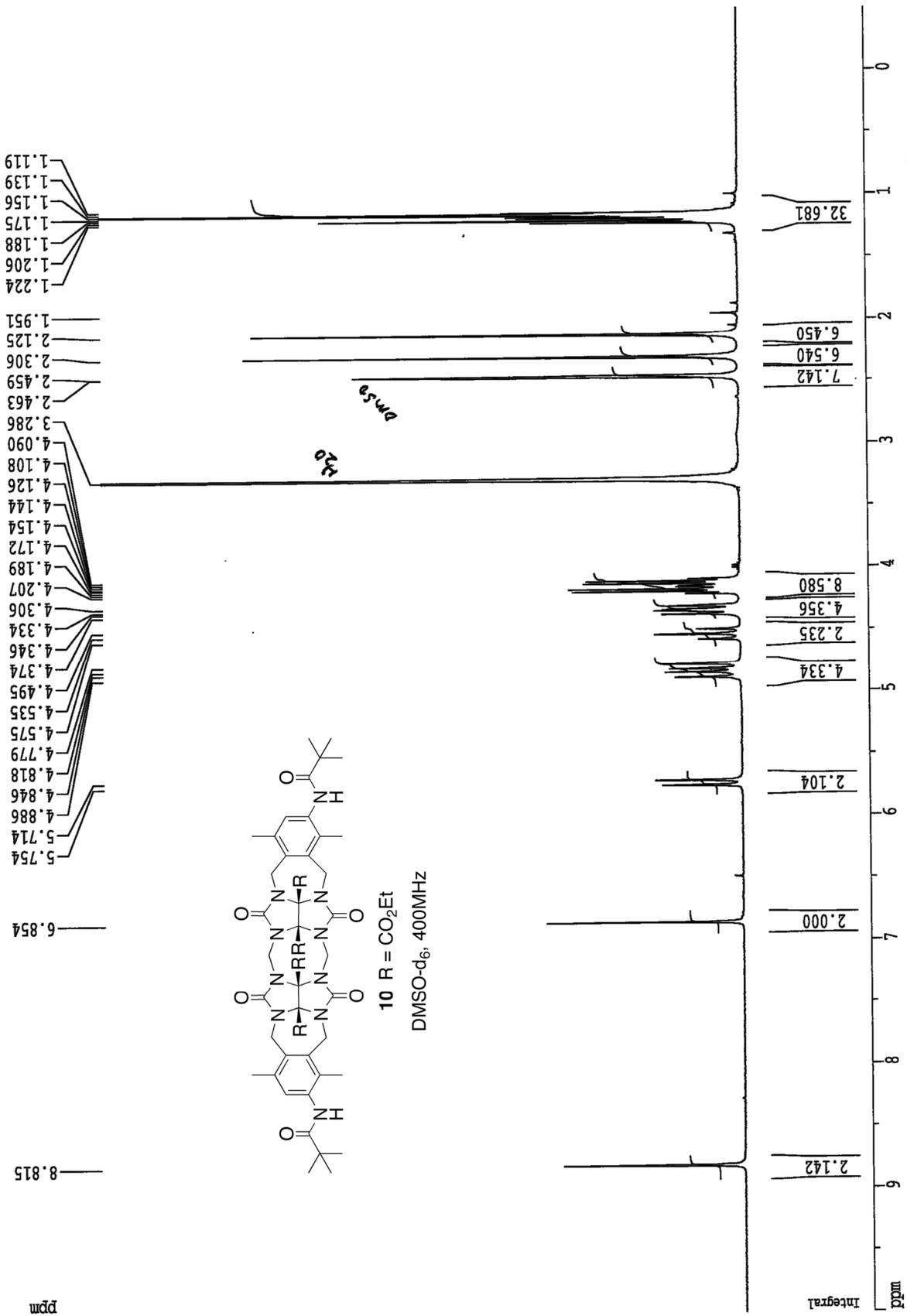


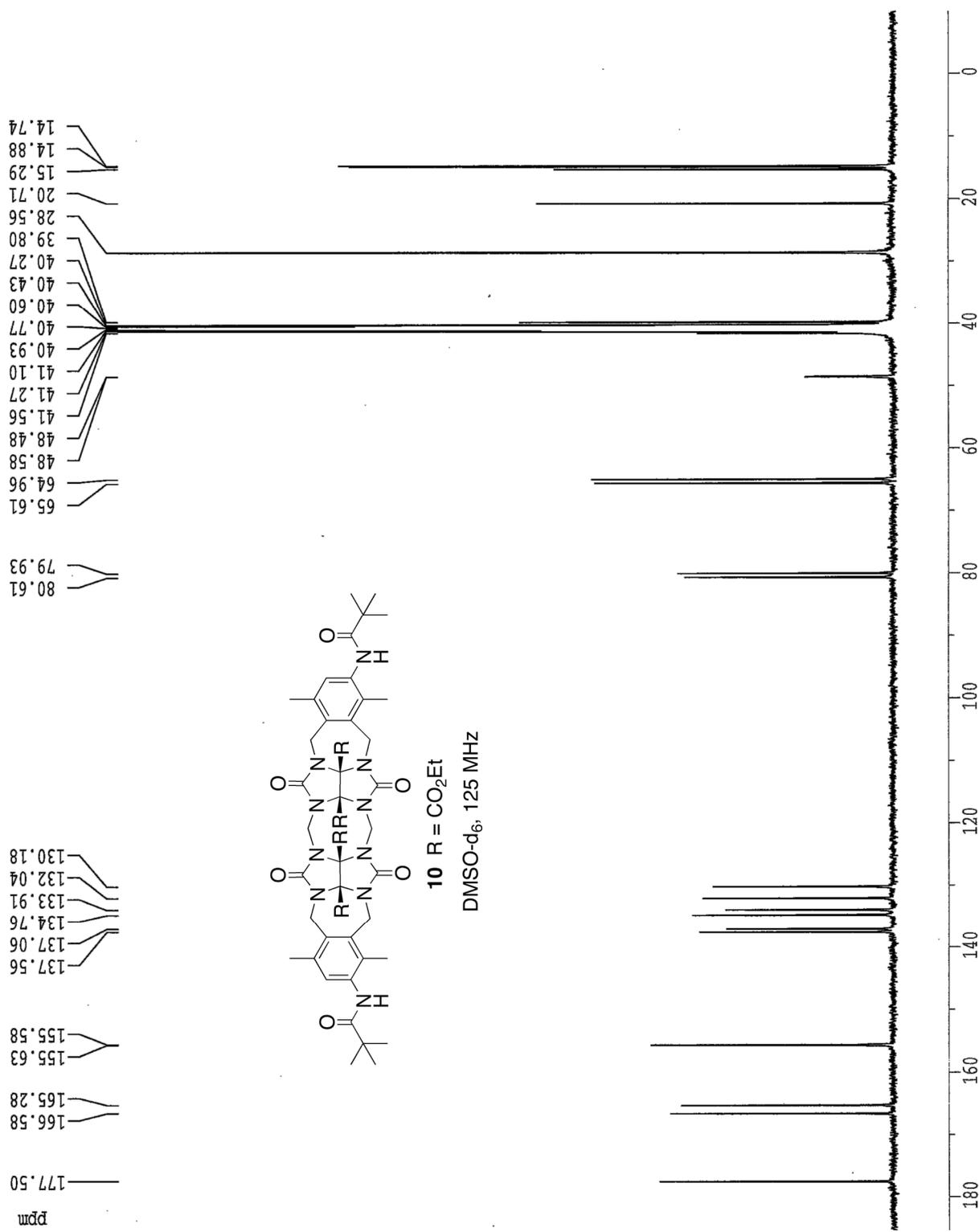


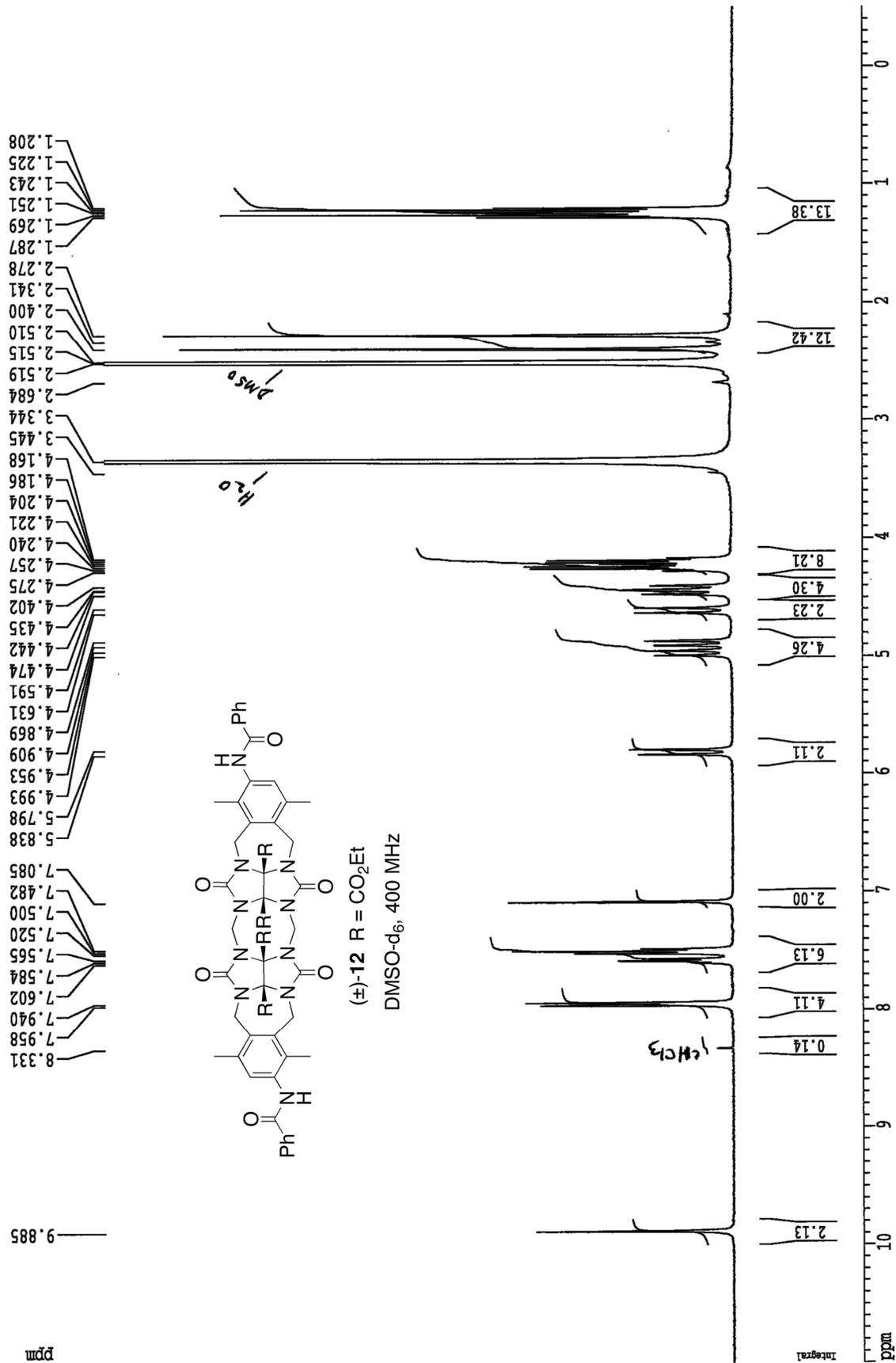




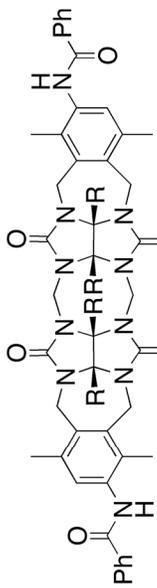




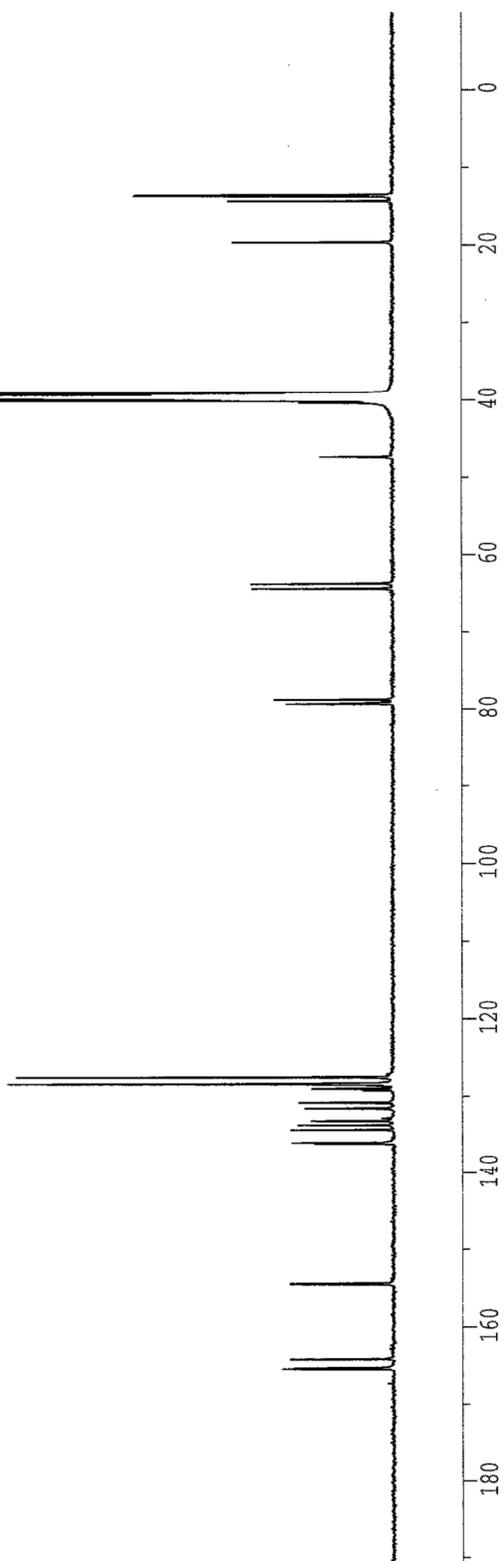


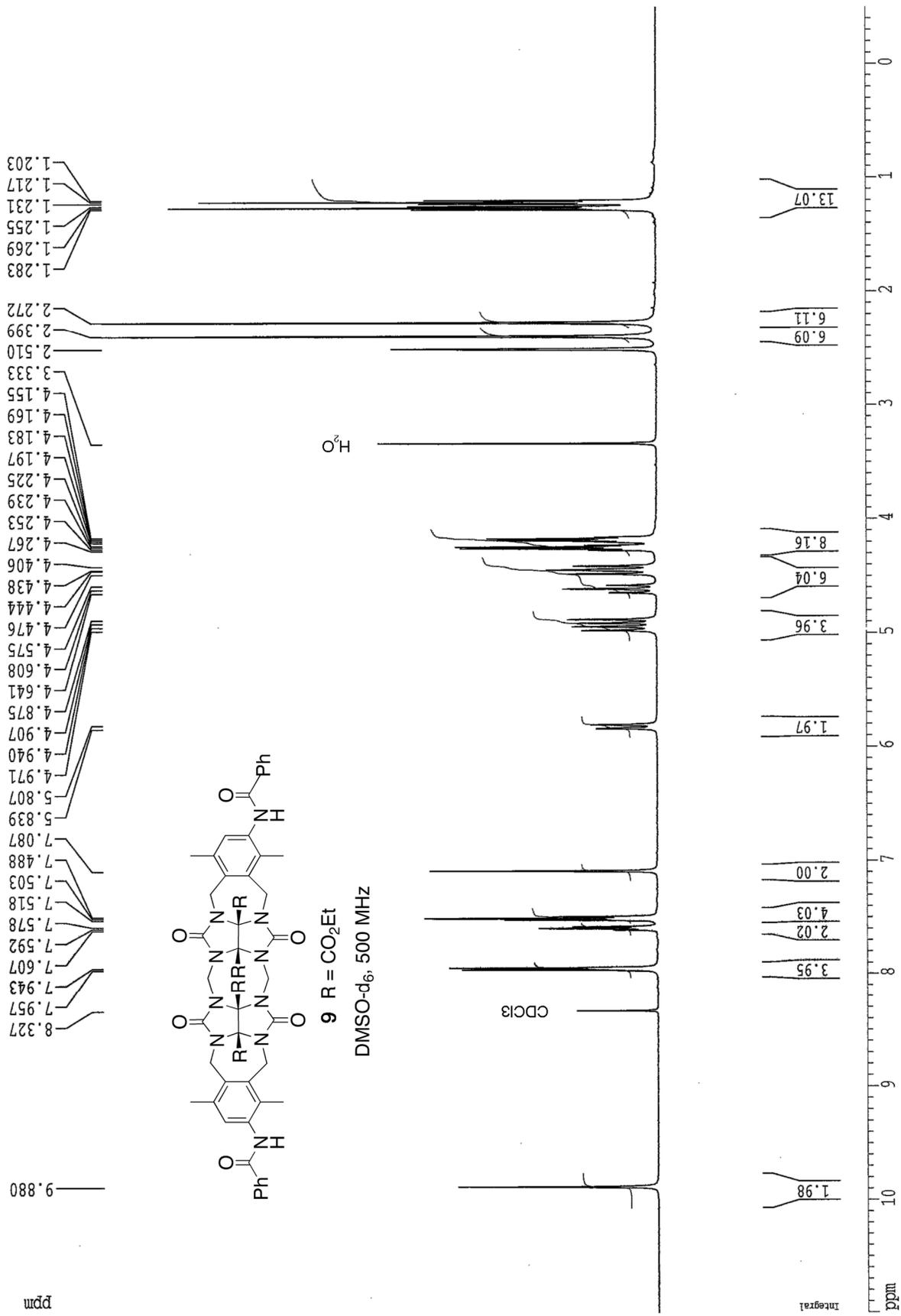


13.51  
13.65  
14.31  
19.58  
39.02  
39.19  
39.35  
39.52  
39.69  
39.85  
40.02  
40.33  
47.32  
63.72  
64.36  
78.69  
79.29  
127.47  
128.29  
128.37  
128.92  
130.74  
131.48  
133.13  
133.66  
134.31  
135.93  
136.08  
154.31  
154.44  
164.07  
165.23  
165.36



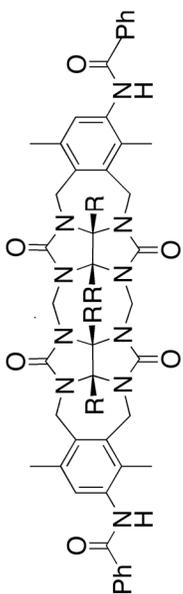
(±)-12 R = CO<sub>2</sub>Et  
DMSO-d<sub>6</sub>, 125 MHz



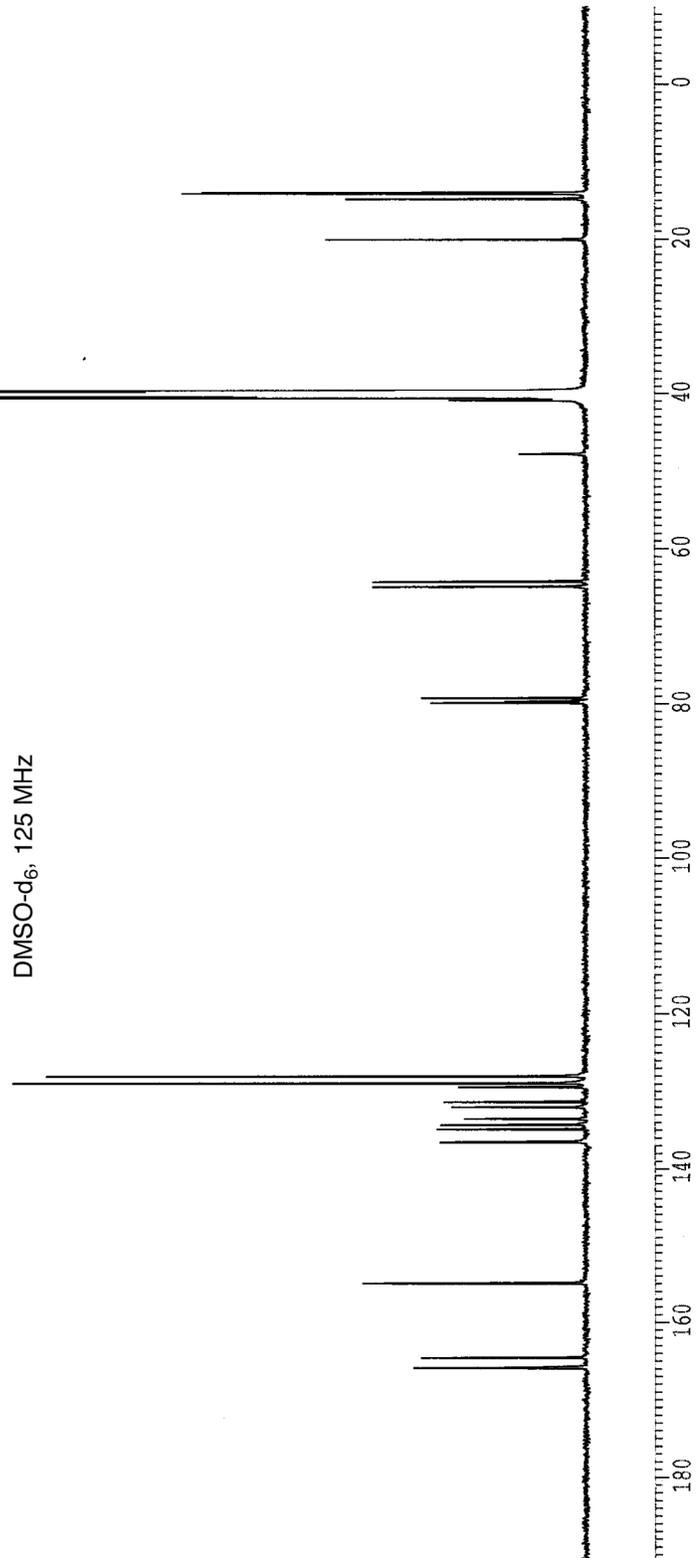


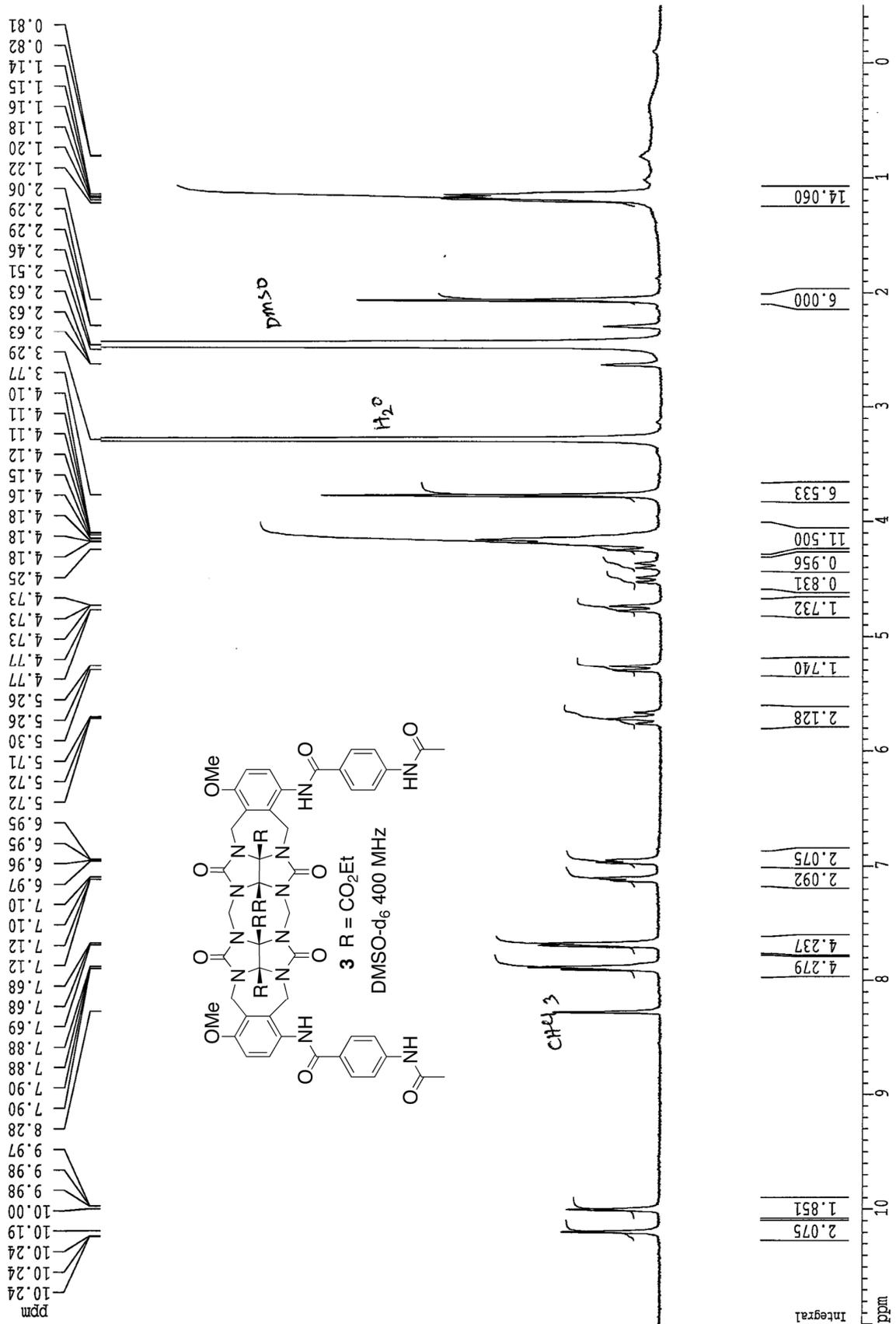
ppm

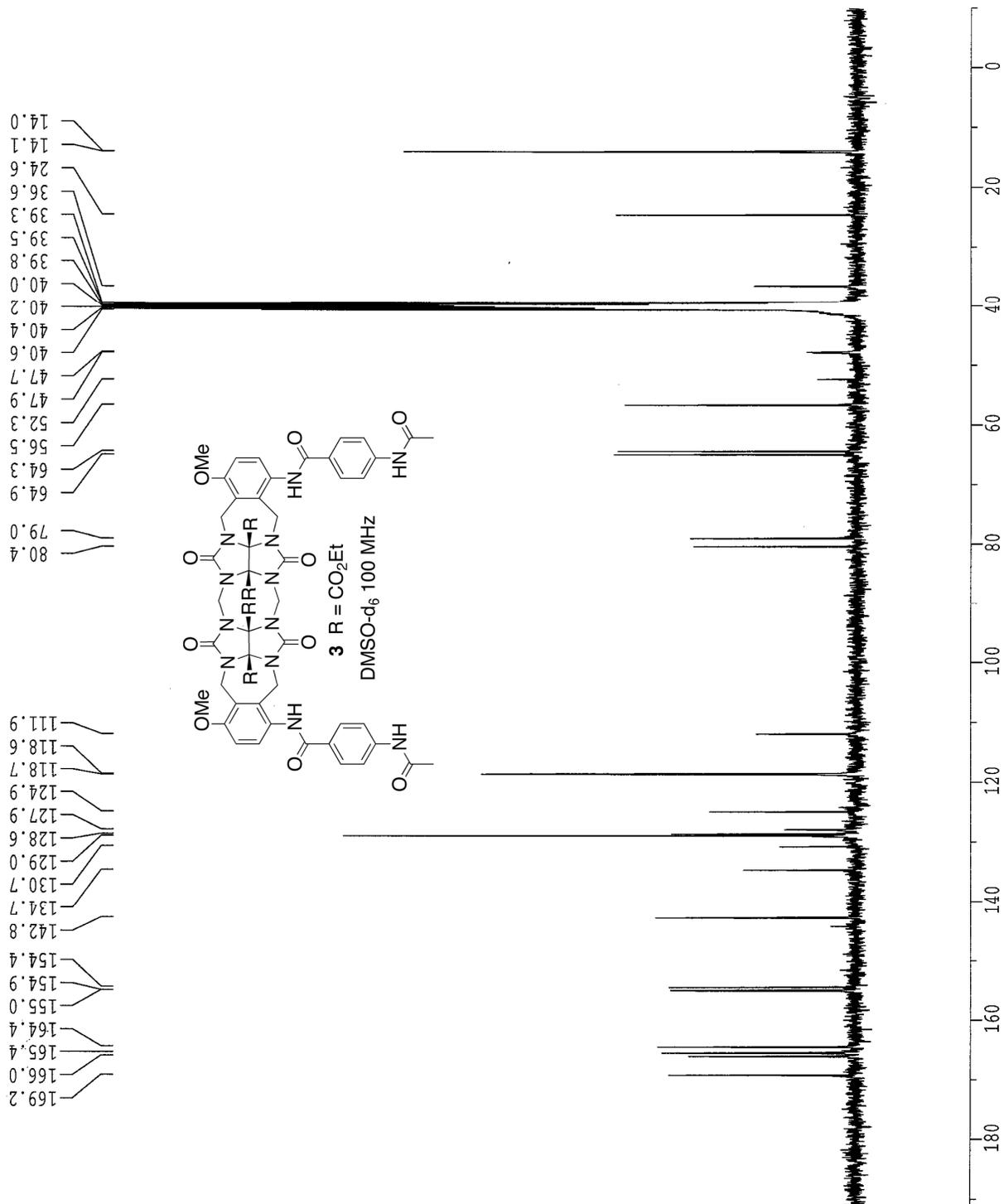
165.84  
165.75  
164.52  
154.89  
136.50  
136.44  
134.85  
134.26  
133.48  
131.97  
131.29  
129.37  
128.85  
127.98  
79.83  
79.64  
79.21  
64.86  
64.19  
47.82  
47.74  
40.87  
40.50  
40.34  
40.17  
40.00  
39.84  
39.67  
39.50  
20.03  
14.81  
14.13  
13.99

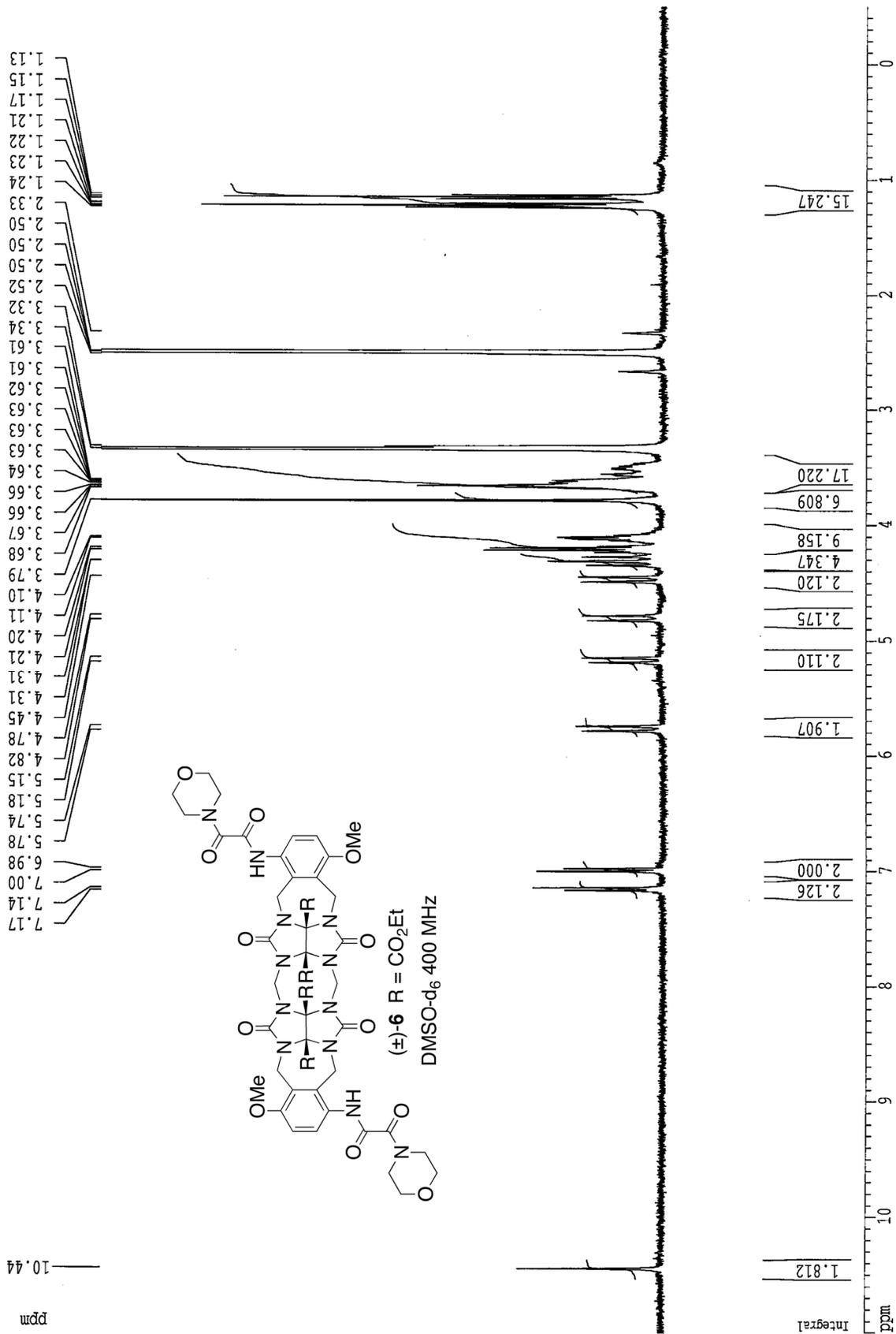


9 R = CO<sub>2</sub>Et  
DMSO-d<sub>6</sub>, 125 MHz









10.44  
ppm

Integral

