Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Photo-Induced Thiol-Ene Reactions for Late-Stage Functionalization of Unsaturated Polyether Macrocycles: Regio and Diastereoselective Access to Macrocyclic Dithiol Derivatives

Supporting Information

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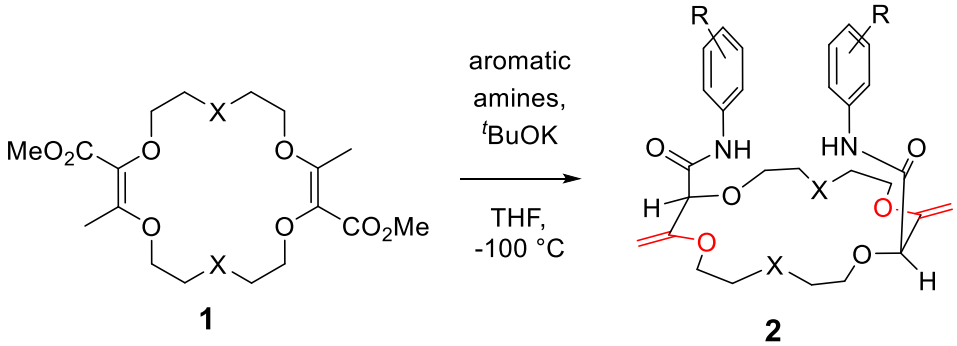
1. General Information and Materials

All reactions involving air sensitive compounds were carried out under N_2 or argon by means of an inert gas/vacuum double manifold line and standard Schlenk techniques using dry solvents. Unless otherwise stated, all reagents were purchased from commercial sources and used without further purification. *t*-BuOK was sublimed prior to use.

Analytical thin-layer chromatography (TLC) were performed with Silicagel 60 F_{254} aluminum sheets from Merck. Preparative TLC were performed with SiliaPlate TLCGlass Backed TLC Extra Hard Layer, 60Å (Size: 20X20 cm, thickness: 1000 μm, Indicator: F-254). Flash column chromatography were performed with Silica SiliaFlash P60, 40-63 μm (230-400 mesh). NMR spectra were recorded on a Bruker AVANCE I 300 MHz spectrometer, equipped with a 5 mm QNP D133 probe, a Bruker AVANCE III HD-*NanoBay* 300 MHz spectrometer, equipped with a 5 mm BB(F)-H-D probe, on a Bruker ADVANCE III HDNanoBay 400 MHz spectrometer, equipped with a 5 mm CryoProbe Prodigy, or on a Bruker II 500 MHz spectrometer, equipped with a 5 mm Cryogenic DCH ($^1H/^{13}C$) probe. ^1H NMR chemical shifts are given in ppm relative to Me_4Si using solvent resonances as internal standards ($CDCl_3$ δ = 7.26 ppm). Data was reported as follows: chemical shift (δ) in ppm, multiplicity (s = singulet, d = doublet, t = triplet, dd = doublet of doublet, q = quartet and m = multiplet), coupling constant (Hz) and integration. ^{13}C NMR chemicals shifts are given in ppm relative to Me_4Si with solvent resonances used as internal standards ($CDCl_3$ δ = 77.16 ppm). ^{19}F-NMR chemicals shifts are given in ppm. IR spectra were recorded with a Perkin-Elmer 100 FT-IR spectrometer using a diamond ATR Golden Gate sampling and are reported in wave numbers (cm^{-1}). Melting points (m.p.) were measured in open capillary tubes with a Büchi B-550 melting point apparatus and were uncorrected. Electrospray mass spectra were obtained on an API 150EX (AB/MDS Sciex) for the low resolution mass spectra (LR-ESI-MS) and on a QSTAR Pulsar (AB/MDS Sciex) spectrometer by the Department of Mass Spectroscopy at the University of Geneva for the high resolution mass spectra (HR-MS).

2. Synthesis of unsaturated ester macrocycle 1 and 2

Unsaturated ester macrocycle **1** and **2** were synthetized according to previously reported procedures from the literature (*ACS Catal.* **2016**, 6, 4877; *Chem. Sci.* **2015**, 6, 4923).



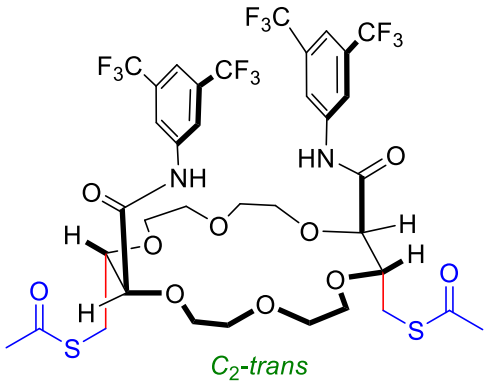
3. Photo-initiated thiol-ene click reaction

3.1 General procedure for the photo-initiated thiol-ene click reaction

To a suspension of macrocycle (0.1 mmol, 1.0 equiv.) in anhydrous toluene (1.0 mL) was added 2,2-dimethoxyphenylacetophenone (DMPA, 0.2 equiv.), followed by the addition of thiol reagent (10 equiv.). The mixture was irradiated (mercury lamp) for the stated time. Upon completion, the reaction mixture was then purified by column chromatography on silica gel to afford a mixture of diastereomers. Further purification of this mixture by silica gel preparative TLC afforded the corresponding macrocyclic dithiol derivatives.

3.2 Optimization studies

3.2.1 Characterization of 3a



C_2-trans

Chemical Formula: $C_{36}H_{38}F_{12}N_2O_{10}S_2$
Exact Mass: 950.1776

According to general procedure, **3a** (*C_2-trans*) was obtained as a white solid (25% yield).

R_f = 0.51 (SiO_2, pentane/ethyl acetate 1:1).

m.p.: 212-213 °C

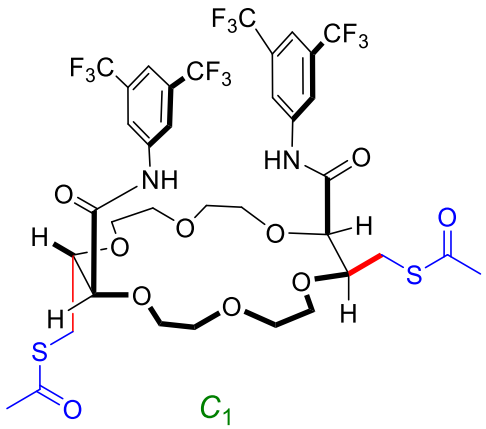
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.12 (s, 2H), 8.26 (s, 4H), 7.62 (s, 2H), 4.05 (d, *J* = 2.0 Hz, 2H), 3.88 (ddd, *J* = 11.1, 6.6, 1.6 Hz, 2H), 3.82 (ddd, *J* = 9.8, 4.5, 2.0 Hz, 2H), 3.78 – 3.71 (m, 4H), 3.68 – 3.57 (m, 6H), 3.55 – 3.48 (m, 2H), 3.45 – 3.38 (m, 4H), 3.32 (dd, *J* = 14.0, 9.7 Hz, 2H), 2.39 (s, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 195.7 (2 C), 170.5 (2 C), 139.3 (2 C), 132.1 (q, *J* = 33.2 Hz, 4 C), 123.5 (q, *J* = 273.4 Hz, 4 C), 120.1 (d, *J* = 4.1 Hz, 4 CH), 117.5 (2 CH), 81.0 (2 CH), 80.1 (2 CH), 71.4 (2 CH_2), 70.0 (2 CH_2), 69.6 (2 CH_2), 68.7 (2 CH_2), 30.9 (2 CH_3), 28.6 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.75.

IR (neat): $\tilde{\nu}$/cm^{-1} 3395, 3319, 2919, 1691, 1621, 1541, 1474, 1442, 1383, 1278, 1179, 1123, 964, 934, 884, 846, 734, 701, 682, 628, 560, 526, 509.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{36}H_{42}F_{12}N_3O_{10}S_2$ 968.2115, observed 968.2125 (1.1 ppm).



Chemical Formula: $C_{36}H_{38}F_{12}N_2O_{10}S_2$
Exact Mass: 950.1776

According to general procedure, **3a** (*C*$_1$) was obtained as a white solid (27% yield).

R$_f$ = 0.23 (SiO_2, pentane/ethyl acetate 1:1).

m.p.: 132-133 ºC

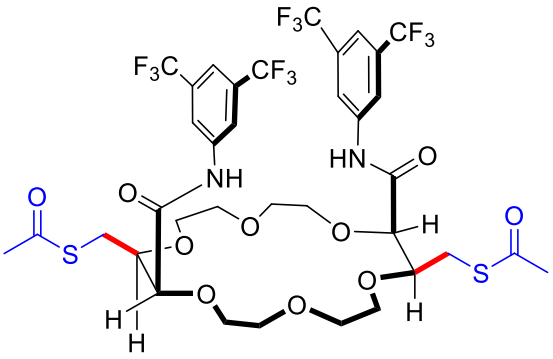
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.78 (s, 1H), 9.38 (s, 1H), 8.09 (s, 2H), 7.99 (s, 2H), 7.45 (d, *J* = 12.3 Hz, 2H), 4.04 – 3.81 (m, 12H), 3.72 – 3.44 (m, 8H), 3.32 – 3.04 (m, 4H), 2.37 (s, 3H), 2.34 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 195.7 (C), 194.8 (C), 170.1 (C), 169.1 (C), 139.24 (C), 139.21 (C), 131.9 (q, *J* = 33.2 Hz, 4 C), 123.2 (q, *J* = 272.7 Hz, 4 C), 119.5 (2 CH), 119.2 (2 CH), 117.6 (CH), 117.4 (CH), 81.7 (CH), 80.9 (CH), 80.3 (CH), 80.1 (CH), 71.6 (2 CH_2), 70.7 (CH_2), 70.5 (CH_2), 70.1 (CH_2), 69.0(CH_2), 68.2 (2 CH_2), 30.8 (CH_3), 30.7 (CH_3), 28.4 (CH_2), 28.2 (CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.90, -62.97.

IR (neat): $\tilde{\nu}$/cm^{-1} 3318, 2924, 1692, 1622, 1544, 1472, 1441, 1381, 1276, 1174, 1123, 1003, 961, 913, 886, 844, 732, 704, 682, 626, 578, 537.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{36}H_{42}F_{12}N_3O_{10}S_2$ 968.2115, observed 968.2127 (1.3 ppm).



C$_2$-*cis*

Chemical Formula: $C_{36}H_{38}F_{12}N_2O_{10}S_2$

Exact Mass: 950.1776

According to general procedure, **3a** (*C*$_2$-*cis*) was obtained as a white solid (38% yield).

R$_f$ = 0.16 (SiO_2, pentane/ethyl acetate 1:1).

m.p.: 188-189 °C

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.29 (s, 2H), 7.99 (d, *J* = 1.6 Hz, 4H), 7.30 (s, 2H), 4.02 – 3.92 (m, 8H), 3.84 (td, *J* = 10.0, 1.6 Hz, 2H), 3.78 – 3.66 (m, 6H), 3.60 (td, *J* = 10.1, 1.7 Hz, 2H), 3.50 (dt, *J* = 10.4, 2.1 Hz, 2H), 3.44 (dd, *J* = 14.0, 4.7 Hz, 2H), 3.33 (dd, *J* = 14.0, 9.9 Hz, 2H), 2.39 (s, 6H).

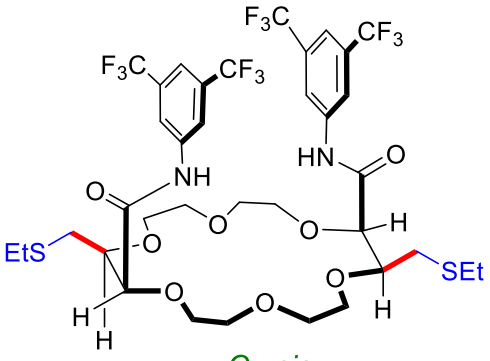
^{13}C NMR (126 MHz, $CDCl_3$) δ 196.3 (2 C), 168.7 (2 C), 139.0 (2 C), 131.5 (q, *J* = 33.6 Hz, 4 C), 123.1 (q, *J* = 273.5 Hz, 4 C), 118.7 (4 CH), 117.1 (2 CH), 80.6 (2 CH), 80.0 (2 CH), 71.0 (2 CH_2), 70.2 (2 CH_2), 69.7 (2 CH_2), 68.6 (2 CH_2), 30.9 (2 CH_3), 28.0 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.85.

IR (neat): $\tilde{\nu}$/cm^{-1} 3669, 3331, 2921, 1691, 1618, 1538, 1473, 1439, 1379, 1358, 1277, 1174, 1120, 957, 910, 888, 842, 791, 732, 703, 682, 625, 573, 518, 508, 503.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{36}H_{42}F_{12}N_3O_{10}S_2$ 968.2115, observed 968.2124 (1.0 ppm).

3.2.2 Characterization of 3b



Chemical Formula: $C_{36}H_{42}F_{12}N_2O_8S_2$
Exact Mass: 922.2191

According to general procedure, **3b** (*C*$_2$-*cis*) was obtained as a white solid (48% yield).

R$_f$ = 0.57 (SiO_2, pentane/ethyl acetate 1:1).

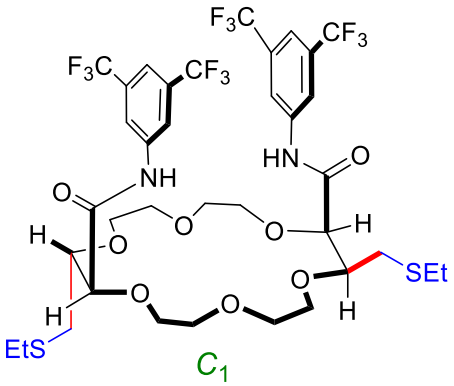
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.37 (s, 2H), 8.00 (d, *J* = 1.6 Hz, 4H), 7.32 (s, 2H), 4.19 (d, *J* = 2.2 Hz, 2H), 3.99 – 3.95 (m, 2H), 3.94 – 3.85 (m, 4H), 3.83 – 3.76 (m, 4H), 3.75 – 3.70 (m, 4H), 3.69 – 3.63 (m, 2H), 3.56 – 3.47 (m, 2H), 3.16 (dd, *J* = 13.5, 9.5 Hz, 2H), 2.89 (dd, *J* = 13.6, 5.0 Hz, 2H), 2.74 – 2.59 (m, 4H), 1.32 (t, *J* = 7.4 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.7 (2 C), 139.2 (2 C), 131.6 (q, *J* = 33.6 Hz, 4 C), 123.2 (q, *J* = 273.2 Hz, 4 C), 118.7 (4 CH), 117.0 (2 CH), 81.5 (2 CH), 80.4 (2 CH), 70.9 (2 CH_2), 70.2 (2 CH_2), 69.8 (2 CH_2), 68.8 (2 CH_2), 30.9 (2 CH_2), 27.3 (2 CH_2), 15.2 (2 CH_3).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.84.

IR (neat): $\tilde{\nu}$/cm^{-1} 3330, 2915, 1692, 1620, 1536, 1473, 1438, 1379, 1276, 1172, 1121, 925, 887, 842, 733, 703, 682, 654.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{36}H_{46}F_{12}N_3O_8S_2$ 940.2529, observed 940.2511 (-1.9 ppm).



Chemical Formula: $C_{36}H_{42}F_{12}N_2O_8S_2$
Exact Mass: 922.2191

According to general procedure, **3b** (C_1) was obtained as a colorless oil (26% yield).

R_f = 0.40 (SiO_2, pentane/ethyl acetate 1:1).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.92 (s, 1H), 9.39 (s, 1H), 8.12 (s, 2H), 8.04 (s, 2H), 7.50 (s, 2H), 4.31 (d, *J* = 1.9 Hz, 1H), 4.21 (d, *J* = 3.9 Hz, 1H), 4.08 (ddd, *J* = 10.0, 4.8, 2.0 Hz, 1H), 3.99 – 3.90 (m, 4H), 3.89 – 3.78 (m, 5H), 3.70 – 3.55 (m, 7H), 3.49 (m, 1H), 2.84 (m, 1H), 2.76 (m, 1H), 2.67 (m, 1H), 2.58 – 2.50 (m, 4H), 2.45 (m, 1H), 1.25 (t, *J* = 7.4 Hz, 3H), 1.22 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 170.8 (C), 169.6 (C), 139.5 (C), 139.4 (C), 132.1 (q, *J* = 33.1 Hz, 2 C), 132.0 (q, *J* = 33.3 Hz, 2 C), 123.3 (q, *J* = 273.3 Hz, 4 C), 120.0 (2 CH), 119.4 (2 CH), 117.6 (CH), 117.4 (CH), 82.0 (CH), 81.0 (CH), 80.4 (CH), 80.3 (CH), 71.6 (CH_2), 71.2 (CH_2), 70.8 (2 CH_2), 70.4 (CH_2), 70.0 (CH_2), 68.71 (CH_2), 68.66 (CH_2), 31.9 (CH_2), 30.9 (CH_2), 27.0 (CH_2), 26.6 (CH_2), 14.9 (CH_3), 14.8 (CH_3).

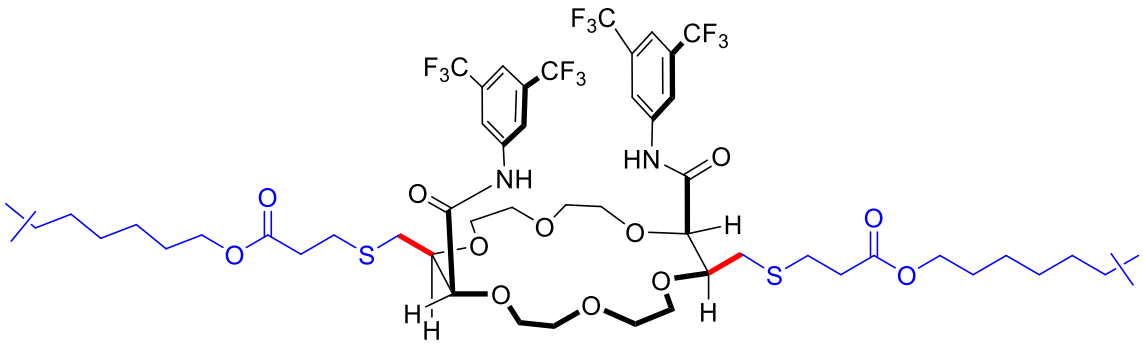
^{19}F NMR (282 MHz, $CDCl_3$) δ -62.87, -62.94.

IR (neat): $\tilde{\nu}$/cm^{-1} 3317, 2926, 1693, 1542, 1472, 1440, 1381, 1277, 1174, 1126, 934, 886, 732, 704, 682, 513.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{36}H_{46}F_{12}N_3O_8S_2$ 940.2529, observed 940.2520 (-1.0 ppm).

3.2.3 Characterization of 3c

Reagent **14c** is a mixture of regio and stereoisomers. This mixed composition has little influence on the stereochemistry of the thiol-ene addition but it complicates greatly the reporting of the spectral characteristics of compounds **3c**. As such, we provide the ^{1}H and ^{13}C NMR spectra in the dataset associated with this paper but do not give further details in the following paragraphs.



C_2-cis

Chemical Formula: $C_{54}H_{74}F_{12}N_2O_{12}S_2$
Exact Mass: 1234.4492

According to general procedure, **3c** (*C_2-cis*) was obtained as a colorless oil (49% yield).

R_f = 0.49 (Pentane/EtOAc = 1:1).

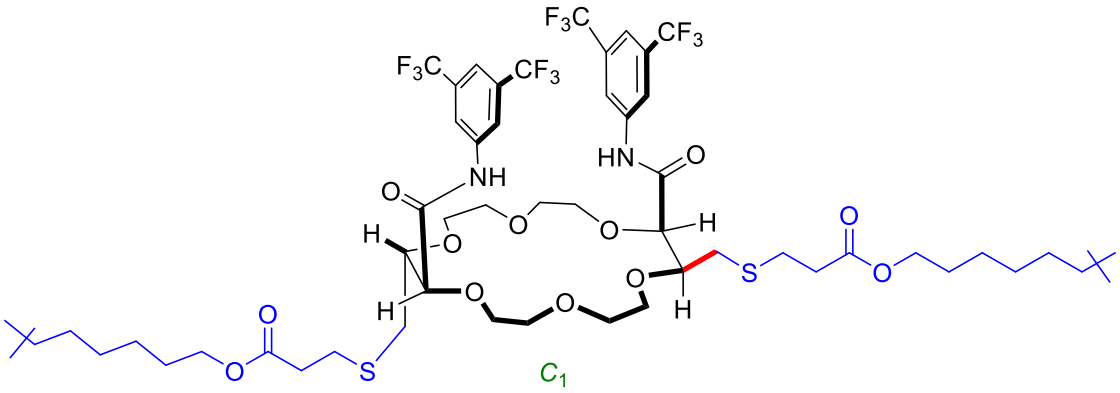
^{1}H NMR (500 MHz, Chloroform-*d*): As mentioned above, please consult the NMR spectrum in the dataset associated with this paper.

^{13}C NMR (126 MHz, $CDCl_3$): As mentioned above, please consult the NMR spectrum in the dataset associated with this paper.

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.82.

IR (neat): $\tilde{\nu}$/cm^{-1} 3331, 2926, 1733, 1694, 1538, 1473, 1438, 1381, 1279, 1176, 1130, 929, 887, 704, 683, 603, 569.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{54}H_{78}F_{12}N_3O_{12}S_2$ 1252.4830, observed 1252.4837 (0.5 ppm).



C_1

Chemical Formula: $C_{54}H_{74}F_{12}N_2O_{12}S_2$
Exact Mass: 1234.4492

According to general procedure, **3c** (C_1) was obtained as a colorless oil (26% yield).

R_f = 0.64 (Pentane/EtOAc = 1:1).

^{1}H NMR (500 MHz, Chloroform-*d*): As mentioned above, please consult the NMR spectrum in the dataset associated with this paper.

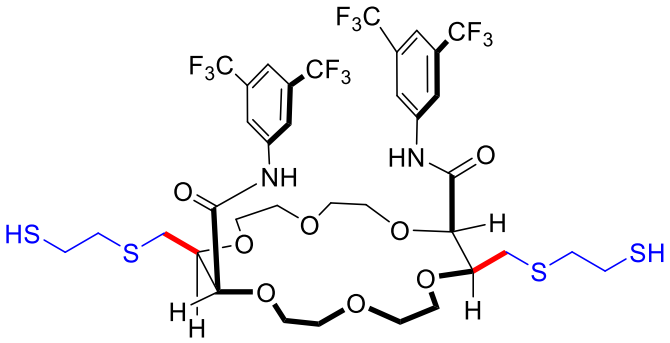
^{13}C NMR (126 MHz, $CDCl_3$): As mentioned above, please consult the NMR spectrum in the dataset associated with this paper.

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.85, -62.93.

IR (neat): $\tilde{\nu}$/cm^{-1} 3318, 2935, 1732, 1692, 1620, 1543, 1472, 1440, 1382, 1277, 1174, 1128, 934, 886, 704, 682, 567.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{54}H_{78}F_{12}N_3O_{12}S_2$ 1252.4830, observed 1252.4833 (0.2 ppm).

3.2.4 Characterization of 3d



C$_2$-*cis*

Chemical Formula: $C_{36}H_{42}F_{12}N_2O_8S_4$

Exact Mass: 986.1632

According to general procedure, **3d** (*C*$_2$-*cis*) was obtained as a white solid (57% yield).

R$_f$ = 0.45 (SiO_2, DCM/MeOH 95:5).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.28 (s, 2H), 7.98 (d, *J* = 1.7 Hz, 4H), 7.32 (s, 2H), 4.17 (d, *J* = 2.3 Hz, 2H), 4.02 – 3.96 (m, 2H), 3.95 – 3.85 (m, 4H), 3.82 – 3.75 (m, 4H), 3.75 – 3.68 (m, 4H), 3.65 (td, *J* = 10.1, 1.8 Hz, 2H), 3.55 – 3.49 (m, 2H), 3.19 (dd, *J* = 13.6, 9.4 Hz, 2H), 2.99 – 2.74 (m, 10H), 1.77 (t, *J* = 7.9 Hz, 2H).

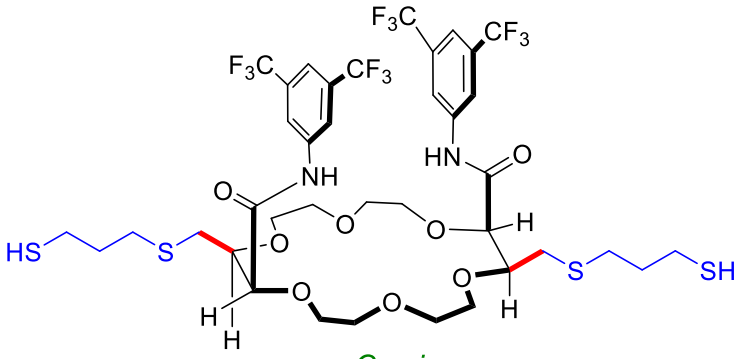
^{13}C NMR (126 MHz, $CDCl_3$) δ 168.6 (2 C), 139.0 (2 C), 131.6 (q, *J* = 33.3 Hz, 4 C), 123.2 (q, *J* = 273.4 Hz, 4 C), 118.7 (4 CH), 117.1 (2 CH), 81.6 (2 CH), 80.1 (2 CH), 71.1 (2 CH_2), 70.1 (2 CH_2), 69.8 (2 CH_2), 68.9 (2 CH_2), 37.4 (2 CH_2), 31.2 (2 CH_2), 25.0 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.79.

IR (neat): $\tilde{\nu}$/cm^{-1} 3328, 2912, 1692, 1619, 1538, 1474, 1438, 1380, 1278, 1173, 1125, 1003, 952, 910, 888, 843, 732, 703, 682.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{36}H_{46}F_{12}N_3O_8S_4$ 1004.1971, observed 1004.1967 (-0.4 ppm).

3.2.5 Characterization of 3e



Chemical Formula: $C_{38}H_{46}F_{12}N_2O_8S_4$
Exact Mass: 1014.1945

According to general procedure, **3e** (*C_2-cis*) was obtained (60% yield).

R_f = 0.56 (SiO_2, DCM/MeOH 98:2).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.30 (s, 2H), 7.99 (d, *J* = 1.6 Hz, 4H), 7.31 (s, 2H), 4.17 (d, *J* = 2.2 Hz, 2H), 4.03 – 3.96 (m, 2H), 3.96 – 3.84 (m, 4H), 3.83 – 3.62 (m, 10H), 3.52 (dt, *J* = 10.4, 2.2 Hz, 2H), 3.17 (dd, *J* = 13.6, 9.5 Hz, 2H), 2.88 (dd, *J* = 13.5, 5.1 Hz, 2H), 2.81 – 2.74 (m, 4H), 2.68 (dtd, *J* = 9.0, 6.9, 2.2 Hz, 4H), 2.00 – 1.90 (m, 4H), 1.38 (t, *J* = 8.0 Hz, 2H).

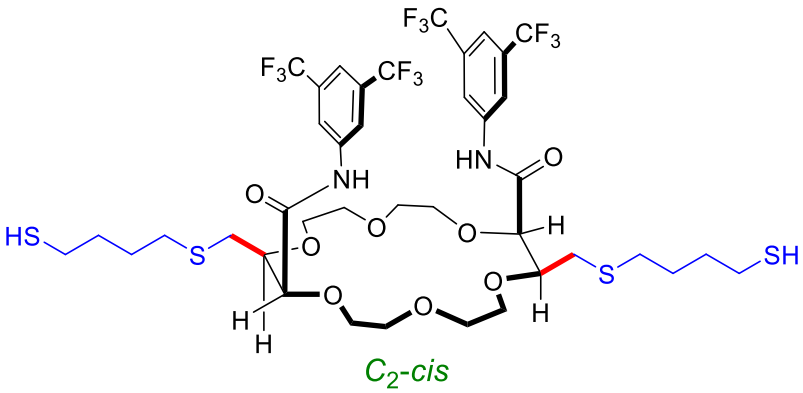
^{13}C NMR (126 MHz, $CDCl_3$) δ 168.6 (2 C), 139.1 (2 C), 131.5 (q, *J* = 33.5 Hz, 4 C), 123.2 (q, *J* = 273.5 Hz, 4 C), 118.7 (4 CH), 117.0 (2 CH), 81.5 (2 CH), 80.2 (2 CH), 71.1 (2 CH_2), 70.1 (2 CH_2), 69.8 (2 CH_2), 68.9 (2 CH_2), 33.5 (2 CH_2), 31.5 (2 CH_2), 31.2 (2 CH_2), 23.4 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ –62.80.

IR (neat): $\tilde{\nu}$/cm^{-1} 3329, 2919, 1691, 1536, 1473, 1438, 1379, 1276, 1172, 1121, 1094, 951, 927, 887, 842, 736, 702, 681.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{38}H_{50}F_{12}N_3O_8S_4$ 1032.2284, observed 1032.2304 (2.0 ppm).

3.2.6 Characterization of 3f



Chemical Formula: $C_{40}H_{50}F_{12}N_2O_8S_4$
Exact Mass: 1042.2258

According to general procedure, **3f** (*C*$_2$-*cis*) was obtained (27% yield).

R$_f$ = 0.65 (SiO$_2$, DCM/MeOH 98:2).

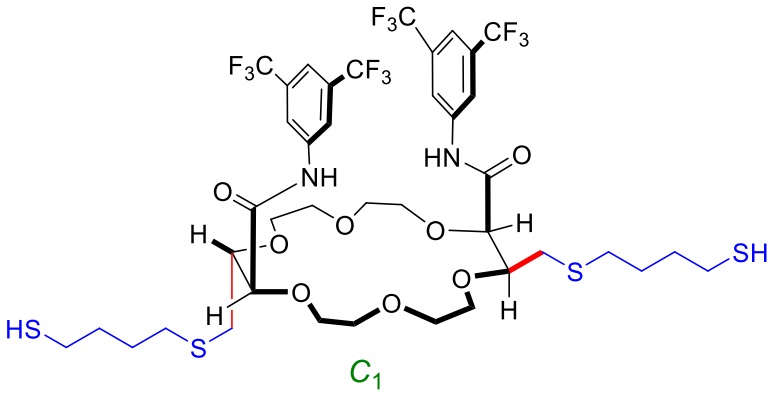
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.37 (s, 2H), 8.00 (d, *J* = 1.6 Hz, 4H), 7.32 (s, 2H), 4.17 (d, *J* = 2.2 Hz, 2H), 4.01 – 3.95 (m, 2H), 3.94 – 3.85 (m, 4H), 3.83 – 3.76 (m, 4H), 3.76 – 3.63 (m, 6H), 3.52 (dt, *J* = 10.5, 2.2 Hz, 2H), 3.15 (dd, *J* = 13.5, 9.4 Hz, 2H), 2.88 (dd, *J* = 13.6, 5.1 Hz, 2H), 2.73 – 2.61 (m, 4H), 2.61 – 2.52 (m, 4H), 1.82 – 1.71 (m, 8H), 1.37 (t, *J* = 7.8 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.6 (2 C), 139.1 (2 C), 131.6 (q, *J* = 33.4 Hz, 4 C), 123.2 (q, *J* = 273.5 Hz, 4 C), 118.7 (4 CH), 117.0 (2 CH), 81.5 (2 CH), 80.4 (2 CH), 71.0 (2 CH_2), 70.2 (2 CH_2), 69.8 (2 CH_2), 68.9 (2 CH_2), 33.0 (2 CH_2), 32.9 (2 CH_2), 31.3 (2 CH_2), 28.5 (2 CH_2), 24.3 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.83.

IR (neat): ṽ/cm^{-1} 3328, 2927, 1692, 1538, 1438, 1381, 1279, 1175, 1128, 888, 704, 623.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{40}H_{54}F_{12}N_3O_8S_4$ 1060.2597, observed 1060.2575 (-2.1 ppm).



Chemical Formula: $C_{40}H_{50}F_{12}N_2O_8S_4$
Exact Mass: 1042.2258

According to general procedure, **3f** (C_1) was obtained as a light yellow oil (15% yield).

R_f = 0.49 (SiO_2, DCM/MeOH 98:2).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.91 (s, 1H), 9.38 (s, 1H), 8.11 (d, *J* = 1.6 Hz, 2H), 8.04 (s, 2H), 7.50 (s, 2H), 4.30 (d, *J* = 1.9 Hz, 1H), 4.21 (d, *J* = 3.9 Hz, 1H), 4.07 (ddd, *J* = 9.8, 5.0, 2.0 Hz, 1H), 3.98 – 3.90 (m, 4H), 3.89 – 3.77 (m, 5H), 3.70 – 3.60 (m, 5H), 3.58 – 3.44 (m, 3H), 2.83 (m, 1H), 2.78 – 2.65 (m, 2H), 2.59 – 2.39 (m, 9H), 1.78 – 1.67 (m, 8H), 1.36 (t, *J* = 7.8 Hz, 1H), 1.34 (t, *J* = 7.8 Hz, 1H).

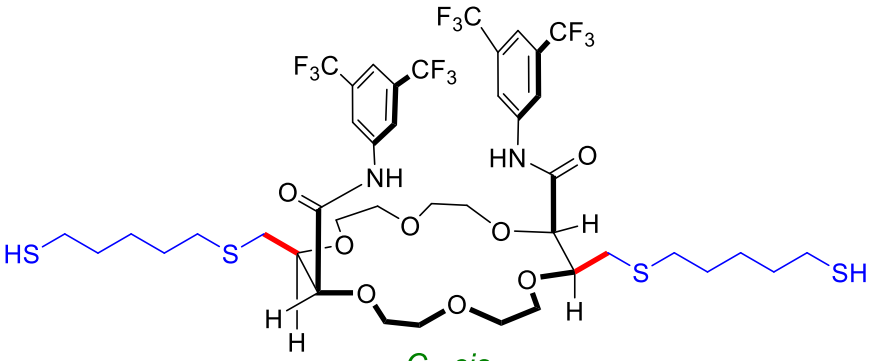
^{13}C NMR (126 MHz, $CDCl_3$) δ 170.7 (C), 169.6 (C), 139.4 (C), 139.3 (C), 132.1 (q, *J* = 33.4 Hz, 2 C), 132.0 (q, *J* = 33.6 Hz, 2 C), 123.3 (q, *J* = 273.4 Hz, 4 C), 120.0 (2 CH), 119.4 (2 CH), 117.7 (CH), 117.4 (CH), 82.0 (CH), 81.0 (CH), 80.4 (CH), 80.3 (CH), 71.6 (CH_2), 71.2 (CH_2), 71.0 (CH_2), 70.8 (CH_2), 70.5 (CH_2), 70.2 (CH_2), 70.0 (CH_2), 68.8 (CH_2), 33.0 (CH_2), 32.9 (CH_2), 32.5 (CH_2), 32.3 (CH_2), 32.1 (CH_2), 31.3 (CH_2), 28.2 (CH_2), 28.1 (CH_2), 24.30 (CH_2), 24.28 (CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.85, -62.91.

IR (neat): $\tilde{\nu}$/cm^{-1} 3315, 2926, 1693, 1543, 1472, 1440, 1382, 1278, 1174, 1127, 934, 887, 704, 682.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{40}H_{54}F_{12}N_3O_8S_4$ 1060.2597, observed 1060.2580 (-1.6 ppm).

3.2.7 Characterization of 3g



Chemical Formula: $C_{42}H_{54}F_{12}N_2O_8S_4$
Exact Mass: 1070.2571

According to general procedure, **3g** (*C*$_2$-*cis*) was obtained (34% yield).

R$_f$ = 0.74 (SiO$_2$, DCM/MeOH 98:2).

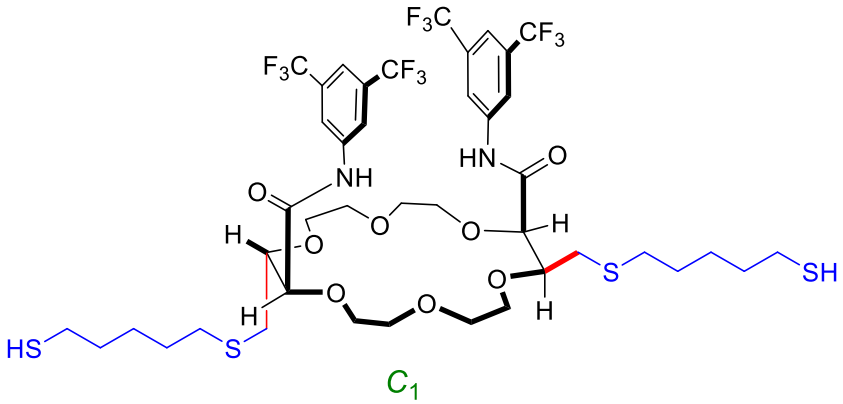
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.38 (s, 2H), 8.00 (d, *J* = 1.6 Hz, 4H), 7.32 (s, 2H), 4.17 (d, *J* = 2.2 Hz, 2H), 3.97 (dd, *J* = 8.2, 2.3 Hz, 2H), 3.94 – 3.84 (m, 4H), 3.84 – 3.76 (m, 4H), 3.74 – 3.62 (m, 6H), 3.52 (dt, *J* = 10.2, 2.3 Hz, 2H), 3.15 (dd, *J* = 13.5, 9.5 Hz, 2H), 2.87 (dd, *J* = 13.5, 5.1 Hz, 2H), 2.71 – 2.61 (m, 4H), 2.58 – 2.51 (m, 4H), 1.70 – 1.62 (m, 8H), 1.58 – 1.49 (m, 4H), 1.35 (t, *J* = 7.8 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.6 (2 C), 139.1 (2 C), 131.5 (q, *J* = 33.6 Hz, 4 C), 123.2 (q, *J* = 273.3 Hz, 4 C), 118.7 (4 CH), 117.0 (2 CH), 81.5 (2 CH), 80.4 (2 CH), 70.9 (2 CH_2), 70.2 (2 CH_2), 69.8 (2 CH_2), 68.8 (2 CH_2), 33.6 (2 CH_2), 33.3 (2 CH_2), 31.3 (2 CH_2), 29.4 (2 CH_2), 27.6 (2 CH_2), 24.6 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.83.

IR (neat): $\tilde{\nu}$/cm^{-1} 3329, 2928, 1693, 1538, 1474, 1438, 1380, 1278, 1174, 1127, 1004, 952, 930, 887, 843, 704, 682.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{42}H_{58}F_{12}N_3O_8S_4$ 1088.2910, observed 1088.2905 (-0.4 ppm).



C_1

Chemical Formula: $C_{42}H_{54}F_{12}N_2O_8S_4$

Exact Mass: 1070.2571

According to general procedure, **3f** (C_1) was obtained as a light yellow oil (21% yield).

R_f = 0.53 (SiO_2, DCM/MeOH 98:2).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.93 (s, 1H), 9.39 (s, 1H), 8.11 (d, *J* = 1.6 Hz, 2H), 8.04 (s, 2H), 7.50 (s, 2H), 4.30 (d, *J* = 1.9 Hz, 1H), 4.20 (d, *J* = 3.8 Hz, 1H), 4.07 (ddd, *J* = 9.8, 5.0, 1.9 Hz, 1H), 3.96 (m, 1H), 3.95 – 3.91 (m, 3H), 3.88 – 3.77 (m, 5H), 3.70 – 3.60 (m, 6H), 3.55 (dt, *J* = 10.3, 2.3 Hz, 1H), 3.49 (ddd, *J* = 11.4, 4.3, 1.9 Hz, 1H), 2.80 – 2.63 (m, 3H), 2.58 – 2.45 (m, 9H), 1.65 – 1.54 (m, 8H), 1.52 – 1.44 (m, 4H), 1.35 (t, *J* = 7.8 Hz, 1H), 1.33 (t, *J* = 7.8 Hz, 1H).

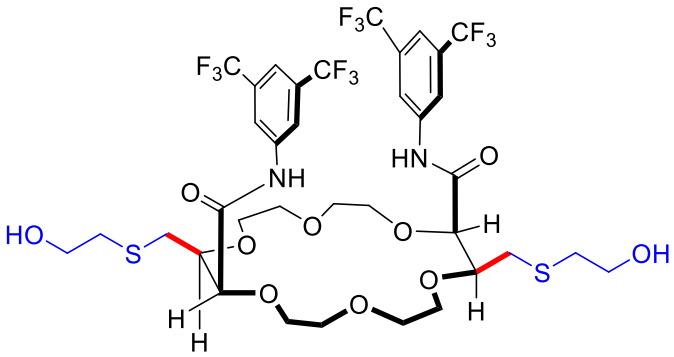
^{13}C NMR (126 MHz, $CDCl_3$) δ 170.7 (C), 169.5 (C), 139.4 (C), 139.3 (C), 132.03 (q, *J* = 33.2 Hz, 2 C), 132.00 (q, *J* = 33.3 Hz, 2 C), 123.2 (q, *J* = 273.4 Hz, 4 C), 120.0 (2 CH), 119.4 (2 CH), 117.6 (CH), 117.4 (CH), 82.0 (CH), 81.0 (CH), 80.4 (CH), 80.3 (CH), 71.6 (2 CH_2), 70.8 (2 CH_2), 70.4 (CH_2), 70.0 (CH_2), 68.8 (CH_2), 68.7 (CH_2), 33.64 (CH_2), 33.59 (CH_2), 33.0 (CH_2), 32.6 (CH_2), 32.3 (CH_2), 31.4 (CH_2), 29.15 (CH_2), 29.07 (CH_2), 27.6 (CH_2), 27.5 (CH_2), 24.6 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.85, -62.91.

IR (neat): $\tilde{\nu}$/cm^{-1} 3316, 2929, 1693, 1544, 1472, 1440, 1382, 1278, 1174, 1128, 934, 886, 704.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{42}H_{58}F_{12}N_3O_8S_4$ 1088.2910, observed 1088.2881 (-2.6 ppm).

3.2.8 Characterization of 3h



C_2-cis

Chemical Formula: $C_{36}H_{42}F_{12}N_2O_{10}S_2$
Exact Mass: 954.2089

According to general procedure, **3h** (*C_2-cis*) was obtained as a colorless oil (29% yield).

R_f = 0.08 (SiO_2, DCM/MeOH 95:5).

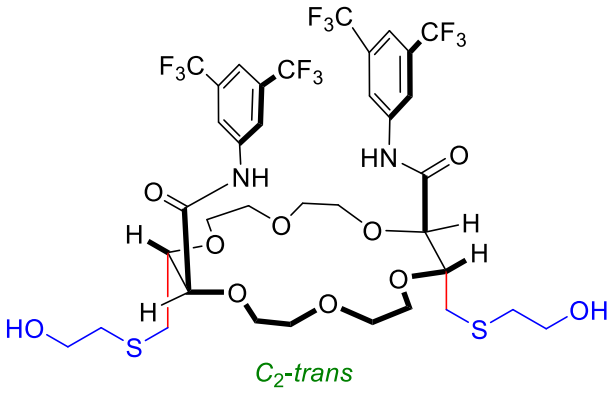
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.13 (s, 2H), 8.84 (s, 2H), 8.24 (s, 4H), 7.62 (s, 2H), 4.26 (d, *J* = 1.9 Hz, 2H), 3.96 (ddd, *J* = 9.1, 5.5, 1.8 Hz, 2H), 3.86 – 3.83 (m, 4H), 3.80 – 3.77 (m, 2H), 3.74 – 3.70 (m, 4H), 3.68 – 3.65 (m, 2H), 3.63 – 3.60 (m, 2H), 3.56 – 3.52 (m, 4H), 3.42 (dt, *J* = 10.6, 2.8 Hz, 2H), 3.15 (dd, *J* = 13.9, 9.0 Hz, 2H), 3.01 (dd, *J* = 13.9, 5.5 Hz, 2H), 2.84 – 2.81 (m, 4H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 170.7 (2 C), 139.3 (2 C), 132.0 (q, *J* = 33.4 Hz, 4 C), 123.4 (q, *J* = 273.3 Hz, 4 C), 120.2 (4 CH), 117.5 (2 CH), 80.5 (2 CH), 80.3 (2 CH), 71.2 (2 CH_2), 70.0 (2 CH_2), 69.9 (2 CH_2), 68.7 (2 CH_2), 61.4 (2 CH_2), 35.6 (2 CH_2), 31.8 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.77.

IR (neat): $\tilde{\nu}$/cm^{-1} 3325, 2921, 1692, 1540, 1474, 1439, 1381, 1279, 1175, 1127, 931, 889, 843, 703, 595.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{36}H_{43}F_{12}N_2O_{10}S_2$ 955.2162, observed 955.2212 (5.2 ppm).



C$_2$-*trans*

Chemical Formula: $C_{36}H_{42}F_{12}N_2O_{10}S_2$
Exact Mass: 954.2089

According to general procedure, **3h** (*C*$_2$-*trans*) was obtained as a colorless oil (13% yield).

R$_f$ = 0.42 (SiO_2, DCM/MeOH 95:5).

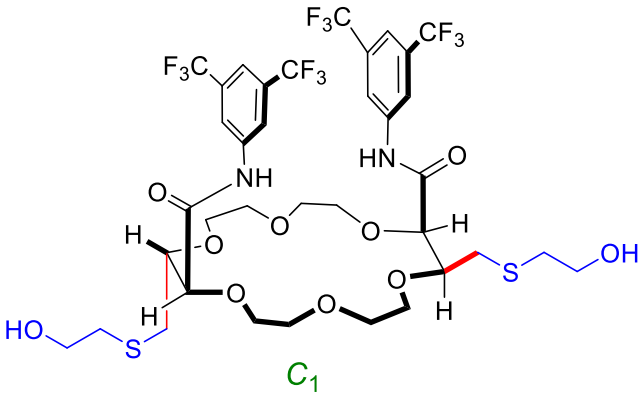
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.26 (s, 2H), 8.00 (d, *J* = 1.6 Hz, 4H), 7.35 (s, 2H), 4.24 (d, *J* = 2.3 Hz, 2H), 4.01 – 3.96 (m, 2H), 3.93 – 3.89 (m, 3H), 3.88 – 3.79 (m, 9H), 3.74 – 3.66 (m, 6H), 3.54 (dt, *J* = 10.3, 2.5 Hz, 2H), 3.22 – 3.12 (m, 2H), 2.98 – 2.78 (m, 8H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.8 (2 C), 139.1 (2 C), 131.8 (q, *J* = 33.6 Hz, 4 C), 123.2 (q, *J* = 273.3 Hz, 4 C), 118.9 (4 CH), 117.3 (2 CH), 81.6 (2 CH), 80.4 (2 CH), 71.2 (2 CH_2), 70.3 (2 CH_2), 69.9 (2 CH_2), 69.2 (2 CH_2), 61.1 (2 CH_2), 36.5 (2 CH_2), 31.0 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.82.

IR (neat): $\tilde{\nu}$/cm^{-1} 3320, 2938, 1737, 1542, 1381, 1280, 1177.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{36}H_{43}F_{12}N_2O_{10}S_2$ 955.2162, observed 955.2150 (-1.3 ppm).



C$_1$

Chemical Formula: $C_{36}H_{42}F_{12}N_2O_{10}S_2$
Exact Mass: 954.2089

According to general procedure, **3h** (*C*$_1$) was obtained as a colorless oil (31% yield).

R_f = 0.26 (SiO_2, DCM/MeOH 95:5).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.80 (s, 1H), 9.35 (s, 1H), 8.14 (s, 2H), 8.04 (s, 2H), 7.53 (s, 2H), 4.28 (dd, *J* = 14.8, 2.8 Hz, 2H), 4.16 – 4.02 (m, 2H), 3.97 – 3.79 (m, 8H), 3.74 (q, *J* = 6.2 Hz, 4H), 3.71 – 3.63 (m, 4H), 3.63 – 3.52 (m, 3H), 3.46 (m, 1H), 2.88 (m, 1H), 2.82 – 2.66 (m, 6H), 2.57 (s, 1H), 2.43 (br s, 1H), 2.21 (br s, 1H).

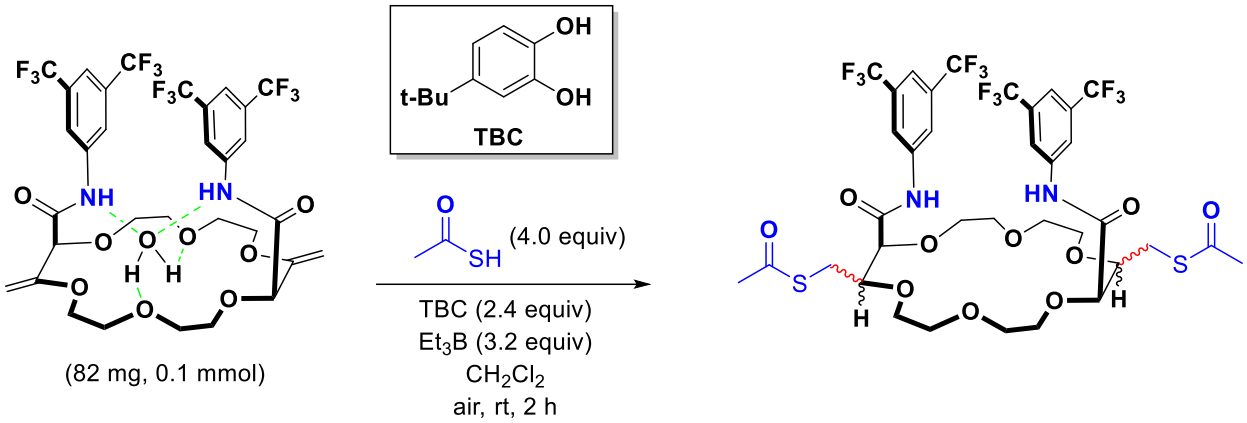
^{13}C NMR (126 MHz, $CDCl_3$) δ 170.6 (C), 169.7 (C), 139.3 (2 C), 132.1 (q, *J* = 33.3 Hz, 4 C), 123.3 (q, *J* = 273.4 Hz, 4 C), 119.9 (2 CH), 119.4 (2 CH), 117.7 (CH), 117.5 (CH), 82.0 (CH), 80.8 (CH), 80.6 (CH), 80.5 (CH), 71.6 (CH_2), 71.1 (CH_2), 70.9 (CH_2), 70.8 (CH_2), 70.5 (CH_2), 69.9 (CH_2), 68.8 (CH_2), 68.7 (CH_2), 61.2 (CH_2), 60.9 (CH_2), 36.5 (CH_2), 35.8 (CH_2), 31.9 (CH_2), 31.5 (CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.86, -62.94.

IR (neat): $\tilde{\nu}$/cm^{-1} 3314, 2922, 1691, 1544, 1473, 1441, 1382, 1279, 1175, 1128, 934, 888, 845, 732, 704, 683.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{36}H_{43}F_{12}N_2O_{10}S_2$ 955.2162, observed 955.2150 (-1.3 ppm).

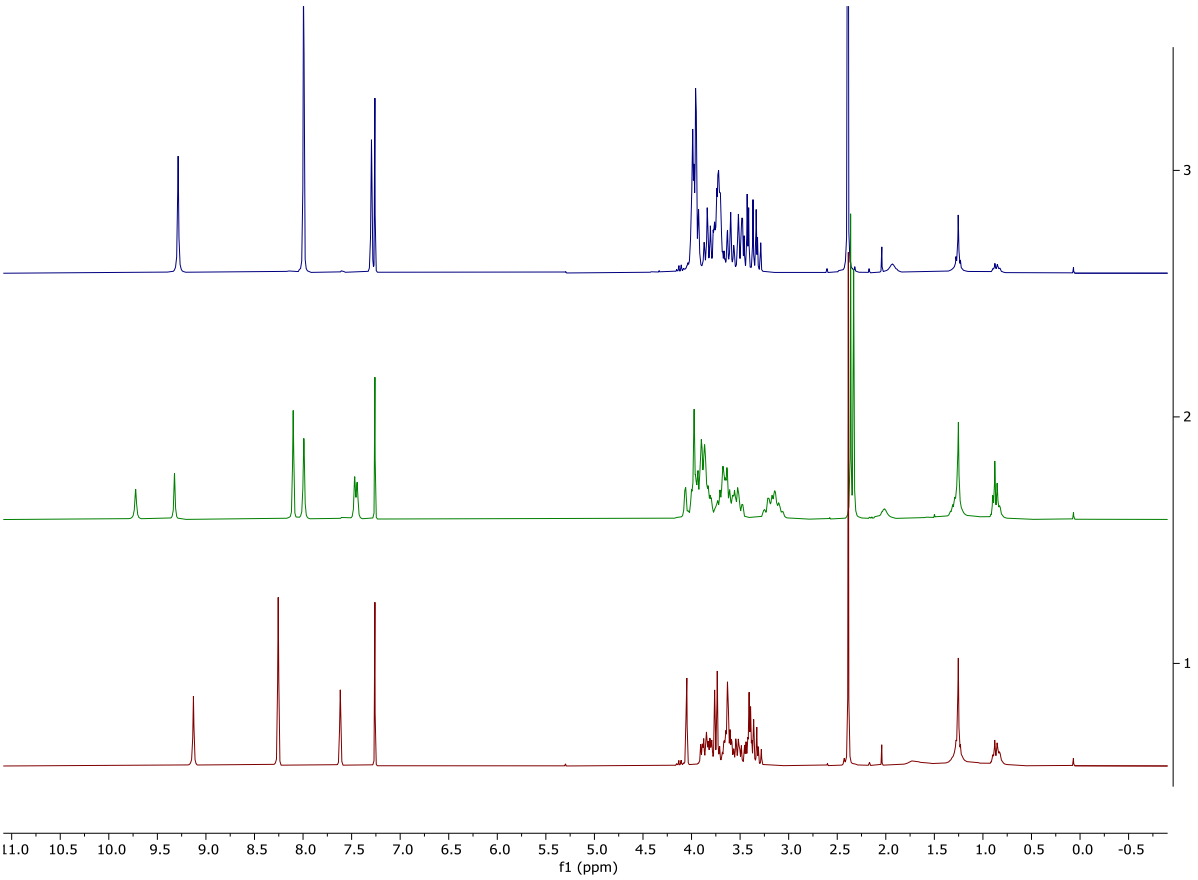
4. Et_3B-mediated thiol-ene reactions



4.1 General Procedure

To a flame-dried flask was added the staring macrocycle (0.1 mmol, 1.0 equiv.), TBC (3.2 equiv.) and thiolacetic acid (4.0 equiv.). The flask was evacuated and backfilled with nitrogen three times. Dichloromethane (0.15 mL) was added under nitrogen, followed by the dropwise addition of Et_3B (3.2 equiv., 1.0 M in hexane). The nitrogen flow was then stopped and replaced with a $CaCl_2$ guard tube and the reaction mixture was stirred at room temperature for 2.0 h. Upon completion, the mixture was filtered through a pad of basic alumina and the resulting solution was concentrated and then purified by Prep. TLC, giving the corresponding C_2-*trans* product (30 mg, 31% yield), C_1 product (25 mg, 26%) and C_2-*cis* product (21 mg, 22% yield).

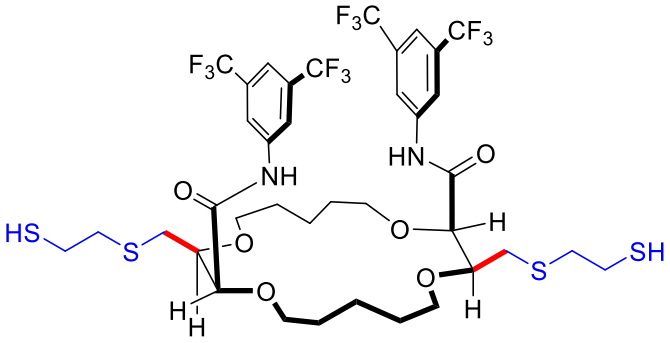
The corresponding NMR data is consistent with previous study using photo-induced method.



1: C_2-*trans* product; **2**: C_1 product; **3**: C_2-*cis* product.

5. Substrate scope

5.1 Characterization of 5



C_2-cis

Chemical Formula: $C_{38}H_{46}F_{12}N_2O_6S_4$

Exact Mass: 982.2047

According to general procedure, **5** (*C_2-cis*) was obtained (41% yield).

R_f = 0.41 (SiO_2, DCM/MeOH 99:1).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.67 (s, 2H), 8.03 (s, 4H), 7.56 (s, 2H), 4.20 (d, *J* = 2.1 Hz, 2H), 3.89 (ddd, *J* = 7.4, 6.4, 2.0 Hz, 2H), 3.81 – 3.71 (m, 6H), 3.65 – 3.58 (m, 2H), 2.87 – 2.68 (m, 12H), 1.80 – 1.63 (m, 14H).

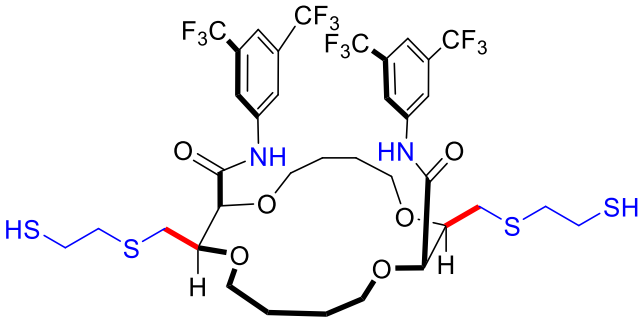
^{13}C NMR (126 MHz, $CDCl_3$) δ 168.9 (2 C), 138.7 (2 C), 132.5 (q, *J* = 33.5 Hz, 4 C), 123.1 (q, *J* = 273.3 Hz, 4 C), 119.3 (4 CH), 117.9 (2 CH), 81.0 (2 CH), 80.9 (2 CH), 72.2 (2 CH_2), 70.7 (2 CH_2), 37.2 (2 CH_2), 31.6 (2 CH_2), 29.6 (4 CH_2), 24.8 (2 CH_2), 23.7 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.97.

IR (neat): $\tilde{\nu}$/cm^{-1} 3372, 2929, 1693, 1621, 1532, 1472, 1438, 1380, 1277, 1174, 1129, 1005, 933, 886, 845, 736, 702, 682, 495, 489, 474, 465, 453.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{38}H_{46}F_{12}N_2O_6S_4$ 983.2120, observed 983.2082 (-3.8 ppm).

5.2 Characterization of 6



C_2-cis

Chemical Formula: $C_{36}H_{42}F_{12}N_2O_6S_4$
Exact Mass: 954.1734

According to general procedure, **6** (*C_2-cis*) was obtained (32% yield).

R_f = 0.37 (SiO_2, DCM/Et_2O 99:1).

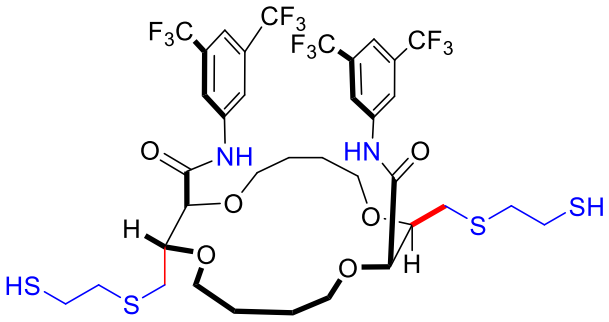
^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.79 (s, 2H), 8.07 (s, 4H), 7.62 (s, 2H), 4.20 (d, *J* = 1.9 Hz, 2H), 3.93 (td, *J* = 6.9, 1.9 Hz, 2H), 3.87 – 3.74 (m, 6H), 3.67 (ddd, *J* = 9.4, 7.0, 4.9 Hz, 2H), 2.90 – 2.62 (m, 12H), 1.98 – 1.88 (m, 2H), 1.87 – 1.71 (m, 6H), 1.68 (t, *J* = 8.0 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.9 (2 C), 138.7 (2 C), 132.6 (q, *J* = 33.5 Hz, 4 C), 123.2 (q, *J* = 273.2 Hz, 4 C), 119.6 (4 CH), 118.0 (2 CH), 81.5 (2 CH), 80.8 (2 CH), 72.5 (2 CH_2), 70.9 (2 CH_2), 37.1 (2 CH_2), 31.7 (2 CH_2), 27.0 (2 CH_2), 26.4 (2 CH_2), 24.7 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.97.

IR (neat): $\tilde{\nu}$/cm^{-1} 3369, 2929, 1690, 1621, 1535, 1472, 1439, 1380, 1276, 1174, 1128, 1006, 909, 887, 845, 732, 702, 682, 648, 558, 515, 496, 485, 469, 457, 451.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{36}H_{43}F_{12}N_2O_6S_4$ 955.1807, observed 955.1800 (-0.7 ppm).



C_1

Chemical Formula: $C_{36}H_{42}F_{12}N_2O_6S_4$
Exact Mass: 954.1734

According to general procedure, **6** (C_1) was obtained (10% yield).

R_f = 0.23 (SiO_2, DCM/Et_2O 99:1).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.89 (s, 1H), 8.76 (s, 1H), 8.15 (s, 1H), 8.06 (s, 1H), 7.65 (s, 1H), 7.63 (s, 1H), 4.31 (d, *J* = 2.0 Hz, 1H), 4.11 (d, *J* = 4.5 Hz, 1H), 4.00 (td, *J* = 6.8, 2.0 Hz, 1H), 3.90 (m, 1H), 3.84 – 3.72 (m, 6H), 3.67 (m, 1H), 3.53 (dt, *J* = 8.7, 5.8 Hz, 1H), 2.88 – 2.65 (m, 13H), 1.90 – 1.70 (m, 6H), 1.69 – 1.61 (m, 3H).

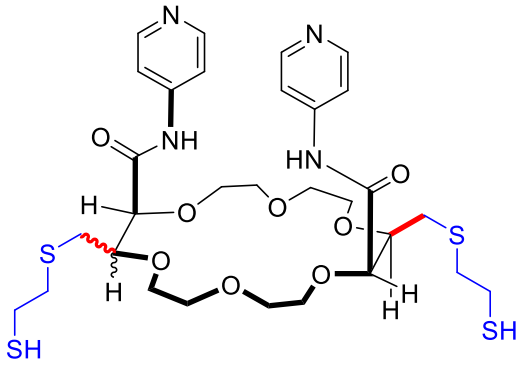
^{13}C NMR (126 MHz, $CDCl_3$) δ 170.3 (C), 169.2 (C), 138.8 (C), 138.7 (C), 132.7 (q, *J* = 33.6 Hz, 2 C), 132.6 (q, *J* = 33.6 Hz, 2 C), 123.2 (q, *J* = 273.8 Hz, 4 C), 119.51 (2 CH), 119.48 (2 CH), 118.1 (2 CH), 81.8 (CH), 81.4 (CH), 80.8 (CH), 80.5 (CH), 73.3 (2 CH_2), 71.8 (CH_2), 70.4 (CH_2), 37.1 (CH_2), 37.0 (CH_2), 33.3 (CH_2) 31.6 (CH_2), 27.9 (CH_2), 27.1 (CH_2), 26.3 (CH_2), 25.9 (CH_2), 24.9 (CH_2), 24.7 (CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.90, -62.99.

IR (neat): $\tilde{\nu}$/cm^{-1} 3345, 2929, 1691, 1536, 1473, 1440, 1381, 1278, 1176, 1131, 887, 702.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{36}H_{43}F_{12}N_2O_6S_4$ 955.1807, observed 955.1777 (-3.2 ppm).

5.3 Characterization of 7



Chemical Formula: $C_{30}H_{44}N_4O_8S_4$
Exact Mass: 716.2042

According to general procedure, **7** was obtained as a colorless oil (mixture of C_2-*cis* and C_1 products, 73% overall yield, *dr* (C_2-*cis*/C_1) 3.2:1).

R_f = 0.25 (SiO_2, DCM/MeOH 95:5).

The NMR data showed here is the major C_2-*cis* product.

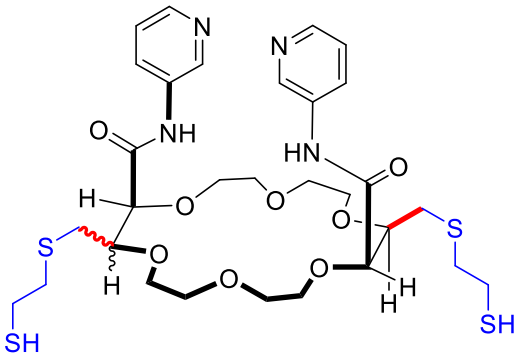
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.26 (s, 2H), 8.39 – 8.32 (m, 4H), 7.51 – 7.47 (m, 4H), 4.26 (d, *J* = 2.3 Hz, 2H), 4.00 – 3.63 (m, 15H), 3.59 – 3.53 (m, 2H), 3.41 (m, 1H), 2.98 – 2.67 (m, 12H), 1.73 (t, *J* = 7.9 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 169.2 (2 C), 150.6 (4 CH), 144.4 (2 C), 113.6 (4 CH), 81.7 (2 CH), 81.4 (2 CH), 71.1 (2 CH_2), 70.8 (2 CH_2), 70.43 (2 CH_2), 70.37 (2 CH_2), 37.3 (2 CH_2), 32.0 (2 CH_2), 24.9 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3329, 3040, 2920, 1691, 1586, 1509, 1413, 1331, 1269, 1208, 1092, 992, 920, 860, 826, 730, 699, 613, 591.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{30}H_{45}N_4O_8S_4$ 717.2115, observed 717.2150 (4.9 ppm).

5.4 Characterization of 8



Chemical Formula: $C_{30}H_{44}N_4O_8S_4$
Exact Mass: 716.2042

According to general procedure, **8** was obtained as a colorless oil (mixture of C_2-*cis* and C_1 products, 64% overall yield, *dr* (C_2-*cis*/C_1) 3.3:1).

R_f = 0.32 (SiO_2, DCM/MeOH 95:5).

The NMR data showed here is the major C_2-*cis* product.

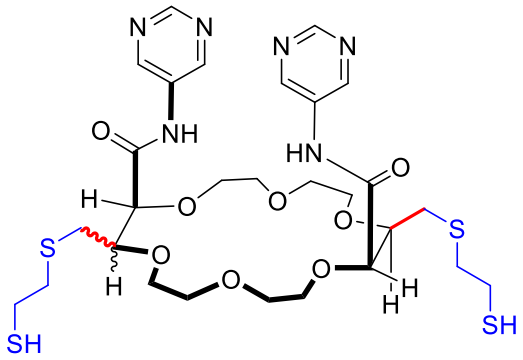
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.21 (s, 2H), 8.70 (d, *J* = 2.6 Hz, 2H), 8.29 (dd, *J* = 4.8, 1.5 Hz, 2H), 8.13 (ddd, *J* = 8.3, 2.7, 1.5 Hz, 2H), 7.17 (dd, *J* = 8.3, 4.7 Hz, 2H), 4.26 (d, *J* = 2.2 Hz, 2H), 3.93 – 3.54 (m, 18H), 2.91 – 2.64 (m, 12H), 1.73 (t, *J* = 7.9 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.9 (2 C), 145.3 (2 CH), 141.6 (2 CH), 134.5 (2 C), 126.8 (2 CH), 123.5 (2 CH), 81.9 (2 CH), 81.7 (2 CH), 70.9 (2 CH_2), 70.8 (2 CH_2), 70.7 (2 CH_2), 70.4 (2 CH_2), 37.2 (2 CH_2), 32.2 (2 CH_2), 24.9 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3328, 3044, 2910, 1679, 1588, 1527, 1482, 1422, 1331, 1272, 1192, 1095, 943, 921, 805, 732, 707, 624.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{30}H_{45}N_4O_8S_4$ 717.2115, observed 717.2098 (-2.3 ppm).

5.5 Characterization of 9



Chemical Formula: $C_{28}H_{42}N_6O_8S_4$
Exact Mass: 718.1947

According to general procedure, **9** was obtained as colorless oil (mixture of C_2-*cis* and C_1 products, 70% overall yield, *dr* (C_2-*cis*/C_1) 4.0:1).

R_f = 0.55 (SiO_2, DCM/MeOH 95:5).

The NMR data showed here is the major C_2-*cis* product.

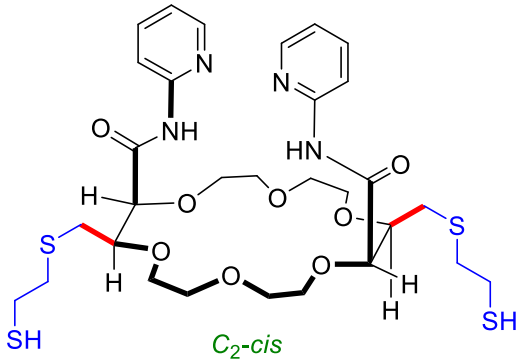
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.42 (s, 2H), 9.04 (s, 4H), 8.88 (s, 2H), 4.23 (d, *J* = 2.3 Hz, 2H), 3.92 – 3.53 (m, 18H), 3.02 – 2.74 (m, 12H), 1.75 (t, *J* = 8.0 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.9 (2 C), 154.1 (2 CH), 147.5 (4 CH), 133.3 (2 C), 81.5 (2 CH), 81.4 (2 CH), 70.8 (2 CH_2), 70.6 (2 CH_2), 70.3 (2 CH_2), 70.2 (2 CH_2), 37.4 (2 CH_2), 31.9 (2 CH_2), 25.0 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3311, 3044, 2915, 1685, 1577, 1520, 1430, 1343, 1271, 1189, 1092, 921, 901, 826, 722, 699, 624.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{28}H_{43}N_6O_8S_4$ 719.2020, observed 719.2026 (0.8 ppm).

5.6 Characterization of 10



C_2-cis

Chemical Formula: $C_{30}H_{44}N_4O_8S_4$
Exact Mass: 716.2042

According to general procedure, **10** (*C_2-cis*) was obtained as a colorless oil (25% yield).

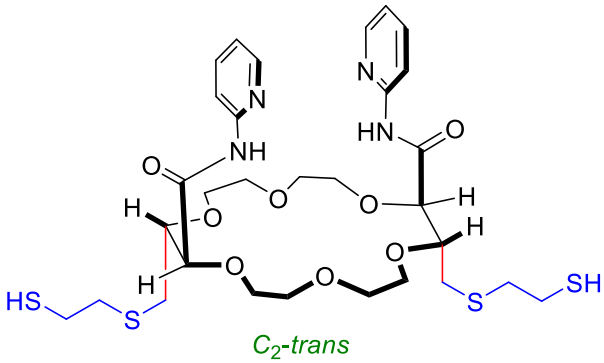
R_f = 0.25 (SiO_2, DCM/MeOH 95:5).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.45 (s, 2H), 8.33 – 8.30 (m, 2H), 8.21 (d, *J* = 8.3 Hz, 2H), 7.68 (td, *J* = 8.5, 8.0, 2.0 Hz, 2H), 7.03 (ddd, *J* = 7.4, 4.9, 1.0 Hz, 2H), 4.34 (d, *J* = 3.4 Hz, 2H), 4.00 – 3.74 (m, 10H), 3.68 – 3.47 (m, 8H), 2.87 – 2.66 (m, 10H), 2.57 (dd, *J* = 13.5, 7.5 Hz, 2H), 1.69 (t, *J* = 7.9 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 170.1 (2 C), 151.6 (2 C), 148.0 (2 CH), 138.1 (2 CH), 119.8 (2 CH), 114.6 (2 CH), 80.8 (2 CH), 80.6 (2 CH), 71.5 (2 CH_2), 70.9 (2 CH_2), 70.7 (2 CH_2), 70.5 (2 CH_2), 37.0 (2 CH_2), 32.2 (2 CH_2), 24.9 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3326, 2916, 1696, 1576, 1524, 1435, 1302, 1112, 780, 616.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{30}H_{45}N_4O_8S_4$ 717.2115, observed 717.2095 (-2.8 ppm).



C_2-trans

Chemical Formula: $C_{30}H_{44}N_4O_8S_4$
Exact Mass: 716.2042

According to general procedure, **10** (*C_2-trans*) was obtained as a colorless oil (14% yield).

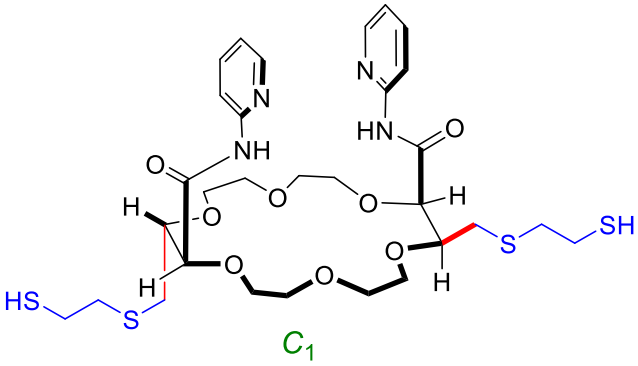
R_f = 0.33 (SiO_2, DCM/MeOH 95:5).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.25 (s, 2H), 8.29 (ddd, *J* = 4.9, 1.9, 0.9 Hz, 2H), 8.21 (dt, *J* = 8.4, 1.0 Hz, 2H), 7.70 (ddd, *J* = 8.7, 7.3, 1.9 Hz, 2H), 7.05 (ddd, *J* = 7.4, 4.9, 1.1 Hz, 2H), 4.52 (d, *J* = 2.1 Hz, 2H), 4.12 – 3.94 (m, 6H), 3.88 (ddd, *J* = 11.4, 3.6, 2.3 Hz, 2H), 3.82 – 3.74 (m, 4H), 3.74 – 3.64 (m, 4H), 3.58 – 3.51 (m, 2H), 2.86 – 2.74 (m, 6H), 2.73 – 2.58 (m, 6H), 1.69 (t, *J* = 8.0 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 169.5 (2 C), 151.0 (2 C), 148.2 (2 CH), 138.5 (2 CH), 120.2 (2 CH), 114.0 (2 CH), 82.4 (2 CH), 82.3 (2 CH), 71.54 (2 CH_2), 71.46 (2 CH_2), 71.3 (2 CH_2), 71.2 (2 CH_2), 37.0 (2 CH_2), 32.4 (2 CH_2), 24.8 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3383, 2920, 1690, 1575, 1515, 1434, 1349, 1302, 1204, 1105, 943, 780, 737, 700.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{30}H_{45}N_4O_8S_4$ 717.2115, observed 717.2089 (-3.6 ppm).



C$_1$

Chemical Formula: $C_{30}H_{44}N_4O_8S_4$

Exact Mass: 716.2042

According to general procedure, **10** (*C*$_1$) was obtained as a colorless oil (14% yield).

R_f = 0.51 (SiO_2, DCM/MeOH 95:5).

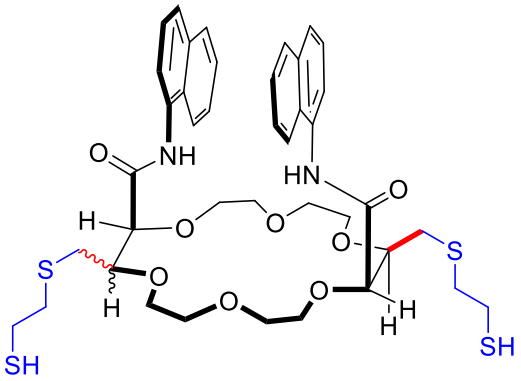
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.62 (s, 1H), 9.35 (s, 1H), 8.32 (tdd, *J* = 4.9, 2.0, 0.9 Hz, 2H), 8.27 (dt, *J* = 8.4, 1.0 Hz, 1H), 8.21 (dt, *J* = 8.3, 1.0 Hz, 1H), 7.75 – 7.65 (m, 2H), 7.04 (dddd, *J* = 16.8, 7.4, 4.9, 1.0 Hz, 2H), 4.50 (d, *J* = 3.3 Hz, 1H), 4.35 (d, *J* = 2.5 Hz, 1H), 4.13 (m, 1H), 4.02 – 3.67 (m, 13H), 3.60 – 3.43 (m, 4H), 2.86 (dd, *J* = 13.4, 5.9 Hz, 1H), 2.83 – 2.63 (m, 10H), 2.59 (dd, *J* = 13.4, 7.7 Hz, 1H), 1.77 – 1.64 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 170.2 (C), 169.6 (C), 151.5 (C), 151.2 (C), 148.3 (CH), 148.0 (CH), 138.4 (CH), 138.2 (CH), 120.1 (CH), 119.8 (CH), 114.23 (CH), 114.21 (CH), 82.9 (CH), 82.0 (CH), 81.8 (CH), 80.4 (CH), 71.3 (CH_2), 71.22 (CH_2), 71.19 (CH_2), 71.1 (CH_2), 71.0 (CH_2), 70.9 (CH_2), 70.7 (CH_2), 70.6 (CH_2), 37.1 (CH_2), 37.0 (CH_2), 33.2 (CH_2), 31.9 (CH_2), 24.8 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3319, 2919, 1689, 1575, 1516, 1461, 1433, 1345, 1300, 1196, 1100, 996, 957, 779, 734, 701.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{30}H_{45}N_4O_8S_4$ 717.2115, observed 717.2092 (-3.2 ppm).

5.7 Characterization of 11



Chemical Formula: $C_{40}H_{50}N_2O_8S_4$
Exact Mass: 814.2450

According to general procedure, **11** was obtained as a colorless oil (mixture of C_2-*cis* and C_1 products, 59% overall yield, *dr* (C_2-*cis*/C_1) 1.6:1).

R_f = 0.57 (SiO_2, DCM/MeOH 97:3).

The NMR data showed here is the major C_2-*cis* product.

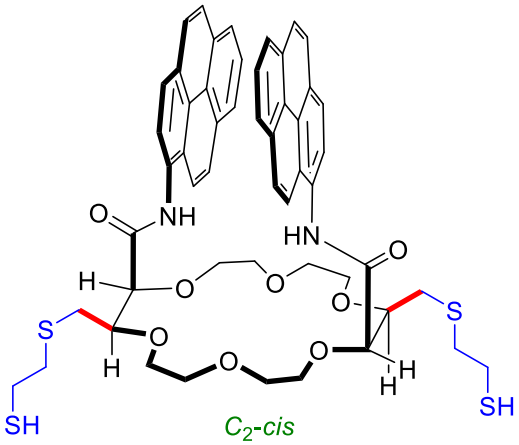
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.26 (s, 2H), 8.03 – 7.95 (m, 4H), 7.85 (dd, *J* = 7.7, 1.7 Hz, 2H), 7.69 (d, *J* = 8.2 Hz, 2H), 7.52 – 7.47 (m, 6H), 4.47 (d, *J* = 2.0 Hz, 2H), 4.06 – 3.75 (m, 18H), 2.86 – 2.60 (m, 12H), 1.67 (t, *J* = 8.0 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.8 (2 C), 134.2 (2 C), 132.2 (2 C), 128.8 (2 CH), 127.0 (2 CH), 126.3 (2 CH), 126.1 (2 CH), 125.9 (2 CH), 125.8 (2 CH), 121.1 (2 CH), 120.0 (2 CH), 82.5 (2 CH), 82.1 (2 CH), 71.4 (2 CH_2), 71.0 (2 CH_2), 70.69 (2 CH_2), 70.66 (2 CH_2), 37.1 (2 CH_2), 32.1(2 CH_2), 24.8 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3330, 3051, 2905, 1678, 1597, 1529, 1497, 1436, 1401, 1346, 1262, 1210, 1096, 931, 794, 771, 733, 699, 629, 606.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{40}H_{51}N_2O_8S_4$ 815.2523, observed 815.2501 (-2.6 ppm).

5.8 Characterization of 12



C_2-cis

Chemical Formula: $C_{52}H_{54}N_2O_8S_4$
Exact Mass: 962.2763

According to general procedure, using however degassed THF instead of toluene as solvent, **12** (*C_2-cis*) was obtained as a yellow solid (37% yield).

R_f = 0.5 (SiO_2, DCM/MeOH 96:4).

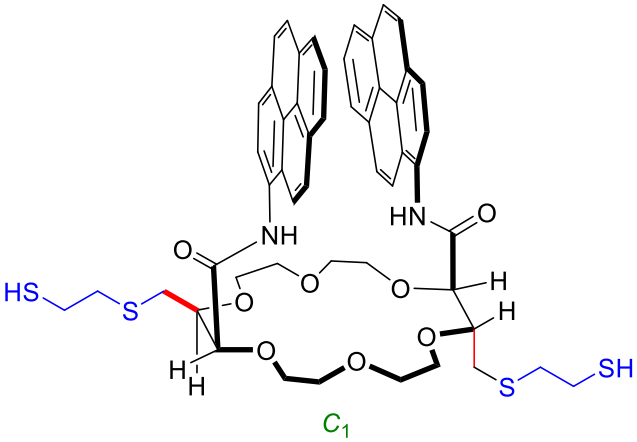
m.p.: 112-114 °C

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.66 (s, 2H), 8.21 (d, *J* = 8.3 Hz, 2H), 8.12 (dd, *J* = 8.2, 3.9 Hz, 4H), 8.06 (d, *J* = 7.5 Hz, 2H), 7.99 – 7.88 (m, 10H), 4.48 (d, *J* = 2.1 Hz, 2H), 4.10 – 3.89 (m, 14H), 3.86 – 3.80 (m, 2H), 3.76 (dt, *J* = 11.2, 2.7 Hz, 2H), 2.82 – 2.69 (m, 8H), 2.65 – 2.56 (m, 4H), 1.62 (t, *J* = 8.0 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 169.0 (2 C), 131.4 (2 C), 130.9 (2 C), 130.2 (2 C), 129.1 (2 C), 127.7 (2 CH), 127.4 (2 CH), 126.8 (2 CH), 126.2 (2 CH), 125.4 (2 CH), 125.2 (2 CH), 125.1 (2 CH), 125.0 (2 C), 124.7 (2 C), 123.6 (2 C), 121.8 (2 CH), 121.0 (2 CH), 82.9 (2 CH), 82.0 (2 CH), 71.5 (2 CH_2), 71.2 (4 CH_2), 70.8 (2 CH_2), 37.2 (2 CH_2), 32.2 (2 CH_2), 24.8 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3372, 3043, 2919, 1750, 1678, 1600, 1555, 1518, 1488, 1415, 1348, 1309, 1268, 1189, 1101, 918, 844, 760, 733, 714.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{52}H_{55}N_2O_8S_4$ 963.2836, observed 963.2873 (3.9 ppm).



C_1

Chemical Formula: $C_{52}H_{54}N_2O_8S_4$

Exact Mass: 962.2763

According to general procedure, using however degassed THF instead of toluene as solvent, **12** (C_1) was obtained as a yellow solid (17% yield).

R_f = 0.4 (SiO_2, DCM/MeOH 96:4).

m.p.: 116-118 °C

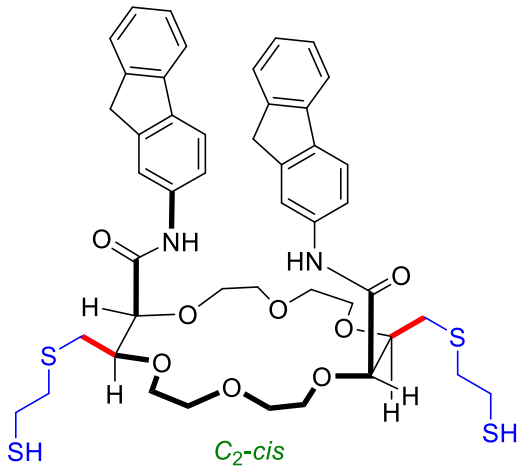
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.97 (s, 1H), 9.55 (s, 1H), 8.46 – 8.36 (m, 3H), 8.31 (d, *J* = 8.2 Hz, 1H), 8.20 – 8.09 (m, 6H), 8.09 – 7.94 (m, 8H), 4.40 (d, *J* = 6.2 Hz, 1H), 4.26 (d, *J* = 2.4 Hz, 1H), 4.15 (m, 1H), 4.08 (m, 1H), 4.04 – 3.88 (m, 10H), 3.87 – 3.78 (m, 3H), 3.77 – 3.68 (m, 3H), 2.40 – 2.16 (m, 4H), 2.13 – 2.06 (m, 2H), 2.04 – 1.84 (m, 6H), 1.27 – 1.20 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 170.6 (C), 170.0 (C), 131.4 (2 C), 131.1 (C), 130.9 (C), 130.83 (C), 130.77 (C), 129.5 (C), 129.4 (C), 127.7 (CH), 127.6 (CH) 127.4 (2 CH), 127.21 (CH), 127.19 (CH), 126.4 (CH), 126.3 (CH), 125.6 (CH), 125.5 (CH), 125.4 (CH), 125.3 (CH), 125.21 (CH), 125.18 (CH), 125.14 (C), 125.09 (C), 125.0 (C), 124.84 (C), 124.79 (C), 124.7 (C), 123.4 (CH), 122.9 (CH), 122.4 (CH), 122.3 (CH), 81.9 (CH), 81.3 (CH), 81.2 (CH), 81.0 (CH), 72.8 (CH_2), 72.2 (CH_2), 71.0 (CH_2), 70.6 (CH_2), 70.3 (CH_2), 70.0 (CH_2), 69.3 (CH_2), 68.9 (CH_2), 36.6 (CH_2), 36.5 (CH_2), 33.4 (CH_2), 30.8 (CH_2), 24.2 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3308, 3044, 2921, 1678, 1600, 1555, 1518, 1490, 1416, 1267, 1188, 1102, 962, 844, 760, 733, 714, 610.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{52}H_{55}N_2O_8S_4$ 963.2836, observed 963.2867 (3.2 ppm).

5.9 Characterization of 13



C_2-cis

Chemical Formula: $C_{46}H_{54}N_2O_8S_4$
Exact Mass: 890.2763

According to general procedure, **13** (*C_2-cis*) was obtained (38% yield).

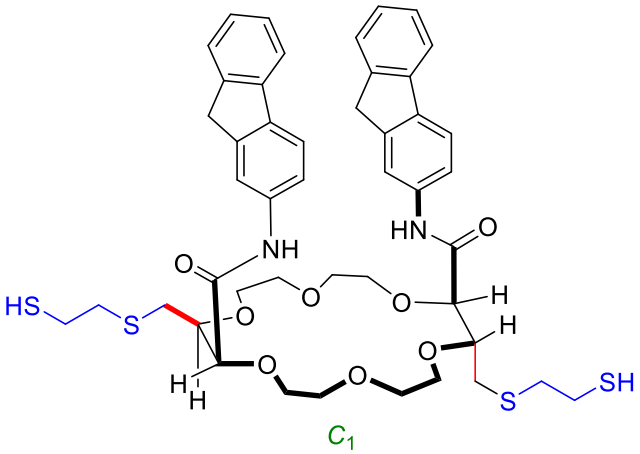
R_f = 0.45 (SiO_2, DCM/MeOH 97:3).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.09 (s, 2H), 7.89 (s, 2H), 7.62 (d, *J* = 7.5 Hz, 2H), 7.54 (d, *J* = 8.3 Hz, 2H), 7.45 (d, *J* = 6.4 Hz, 4H), 7.32 (t, *J* = 6.9 Hz, 2H), 7.24 (td, *J* = 7.4, 1.1 Hz, 2H), 4.34 (d, *J* = 2.1 Hz, 2H), 3.96 – 3.94 (m, 2H), 3.94 – 3.89 (m, 5H), 3.87 – 3.80 (m, 4H), 3.78 – 3.68 (m, 8H), 3.66 – 3.60 (m, 3H), 2.94 – 2.82 (m, 8H), 2.77 – 2.71 (m, 4H), 1.78 – 1.68 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.1 (2 C), 144.3 (2 C), 143.3 (2 C), 141.5 (2 C), 138.0 (2 C), 136.5 (2 C), 126.8 (2 CH), 126.3 (2 CH), 125.0 (2 CH), 120.1 (2 CH), 119.6 (2 CH), 118.4 (2 CH), 116.5 (2 CH), 82.0 (2 CH), 81.7 (2 CH), 71.2 (2 CH_2), 70.9 (2 CH_2), 70.8 (2 CH_2), 70.7 (2 CH_2), 37.3 (2 CH_2), 37.0 (2 CH_2), 32.3 (2 CH_2), 25.0 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3345, 2920, 1676, 1593, 1535, 1492, 1460, 1424, 1350, 1311, 1100, 650, 830, 767, 734.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{46}H_{55}N_2O_8S_4$ 891.2836, observed 891.2825 (-1.2 ppm).



C_1

Chemical Formula: $C_{46}H_{54}N_2O_8S_4$
Exact Mass: 890.2763

According to general procedure, **13** (C_1) was obtained (18% yield).

R_f = 0.49 (SiO_2, DCM/MeOH 97:3).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.50 (s, 1H), 9.08 (s, 1H), 7.93 (d, *J* = 7.7 Hz, 2H), 7.73 – 7.63 (m, 4H), 7.55 (dd, *J* = 8.1, 2.0 Hz, 1H), 7.52 – 7.45 (m, 3H), 7.39 – 7.32 (m, 2H), 7.27 (m, 1H), 7.25 (m, 1H), 4.25 (d, *J* = 5.0 Hz, 1H), 4.17 (d, *J* = 2.1 Hz, 1H), 4.11 – 4.03 (m, 2H), 4.00 – 3.91 (m, 4H), 3.87 – 3.71 (m, 11H), 3.65 (dd, *J* = 9.3, 4.8 Hz, 1H), 3.61 – 3.44 (m, 4H), 2.79 – 2.52 (m, 11H), 2.28 (dd, *J* = 13.4, 8.8 Hz, 1H), 1.66 – 1.60 (m, 2H).

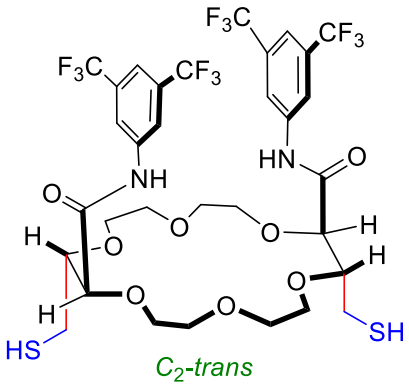
^{13}C NMR (126 MHz, $CDCl_3$) δ 169.6 (C), 169.2 (C), 144.3 (C), 144.2 (C), 143.4 (C), 143.3 (C), 141.5 (C), 141.5 (C), 138.4 (C), 138.2 (C), 136.8 (C), 136.6 (C), 126.9 (2 CH), 126.5 (2 CH), 125.13 (CH), 125.11 (CH), 120.1 (CH), 120.0 (CH), 119.8 (CH), 119.70 (CH), 119.67 (CH), 119.5 (CH), 117.8 (CH), 117.4 (CH), 82.5 (CH), 81.3 (CH), 81.0 (CH), 80.8 (CH), 72.1 (CH_2), 71.7 (CH_2), 71.5 (CH_2), 71.0 (CH_2), 70.33 (CH_2), 70.27 (CH_2), 69.8 (CH_2), 68.5 (CH_2), 37.3 (CH_2), 37.2 (CH_2), 37.0 (CH_2), 36.8 (CH_2), 33.5 (CH_2), 31.9 (CH_2), 24.8 (2 CH_2).

IR (neat): $\tilde{\nu}$/cm^{-1} 3321, 2922, 1677, 1592, 1535, 1460, 1424, 1348, 1310, 1264, 1102, 952, 872, 828, 767, 733.

HR-MS (ESI) $[M+H]^+$ *m/z* calculated for $C_{46}H_{55}N_2O_8S_4$ 891.2836, observed 891.2857 (2.4 ppm).

6. Deprotection of the acetyl groups

To a solution of macrocycle (1.0 equiv.) in a mixture of degassed MeOH/THF/H_2O (1.5/1.5/1) was added K_2CO_3 (4.0 equiv.) under nitrogen atmosphere. The mixture was then stirred at room temperature for 2 hours. Upon competition, a saturated aqueous NH_4Cl solution and DCM were added and the mixture was stirred for 1 h. The layers were separated and the aqueous phase was extracted with DCM (three times). The combined organic layers were dried over Na_2SO_4 and concentrated under vacuum. The residue was purified by prep. TLC, affording the corresponding macrocyclic dithiol.



C_2-trans

Chemical Formula: $C_{32}H_{34}F_{12}N_2O_8S_2$
Exact Mass: 866.1565

According to general procedure, *C_2-trans* product was obtained as a white solid (20 mg, 58% yield).

R_f = 0.27 (SiO_2, DCM/MeOH 98:2).

m.p.: 185-186 °C

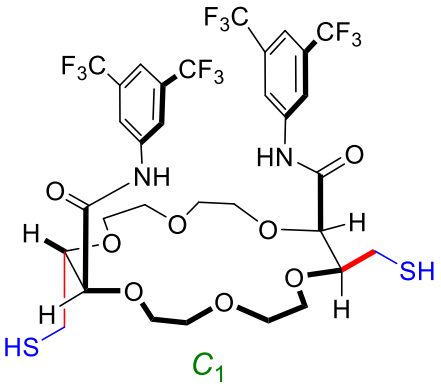
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.18 (s, 2H), 8.25 (s, 4H), 7.62 (s, 2H), 4.39 (d, *J* = 2.1 Hz, 2H), 3.82 (ddd, *J* = 9.5, 5.2, 2.1 Hz, 2H), 3.80 – 3.69 (m, 6H), 3.67 (ddd, *J* = 10.2, 7.9, 2.1 Hz, 2H), 3.63 – 3.56 (m, 2H), 3.55 – 3.45 (m, 4H), 3.43 – 3.34 (m, 2H), 3.10 (ddd, *J* = 13.8, 10.8, 9.5 Hz, 2H), 3.01 (ddd, *J* = 13.8, 6.4, 5.2 Hz, 2H), 1.46 (dd, *J* = 10.7, 6.4 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 170.8 (2 C), 139.3 (2 C), 132.1 (q, *J* = 33.4 Hz, 4 C), 123.5 (q, *J* = 273.3 Hz, 4 C), 120.0 (4 CH), 117.5 (2 CH), 83.0 (2 CH), 80.2 (2 CH), 71.2 (2 CH_2), 70.0 (2 CH_2), 69.7 (2 CH_2), 68.8 (2 CH_2), 24.1 (2 CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.76.

IR (neat): $\tilde{\nu}$/cm^{-1} 2921, 1691, 1542, 1473, 1442, 1382, 1279, 1177, 1130, 887, 682, 565, 523.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{32}H_{38}F_{12}N_3O_8S_2$ 884.1903, observed 884.1933 (3.4 ppm).



C_1

Chemical Formula: $C_{32}H_{34}F_{12}N_2O_8S_2$
Exact Mass: 866.1565

According to general procedure, C_1 product was obtained as a white solid (21 mg, 61% yield).

R_f = 0.42 (SiO_2, DCM/MeOH 98:2).

m.p.: 127-128 ºC

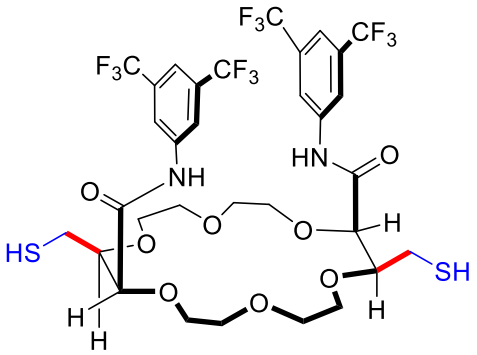
^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.90 (s, 1H), 9.35 (s, 1H), 8.11 (d, *J* = 1.6 Hz, 2H), 8.03 (s, 2H), 7.52 (d, *J* = 4.8 Hz, 2H), 4.35 (d, *J* = 2.0 Hz, 1H), 4.24 (d, *J* = 4.4 Hz, 1H), 4.00 (ddd, *J* = 9.4, 5.2, 2.0 Hz, 1H), 3.97 – 3.88 (m, 4H), 3.88 – 3.76 (m, 5H), 3.73 – 3.60 (m, 6H), 3.56 (dt, *J* = 10.0, 2.2 Hz, 1H), 3.52 (ddd, *J* = 11.4, 4.6, 1.8 Hz, 1H), 2.91 – 2.76 (m, 2H), 2.61 (dt, *J* = 13.1, 9.8 Hz, 1H), 2.44 (s, 1H), 1.44 – 1.36 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 170.5 (C), 169.6 (C), 139.34 (C), 139.37 (C), 132.1 (q, *J* = 33.3 Hz, 4 C), 123.2 (q, *J* = 273.5 Hz, 4 C), 120.1 (2 CH), 119.6 (2 CH), 117.8 (CH), 117.6 (CH), 83.24 (CH), 83.18 (CH), 81.2 (CH), 80.1 (CH), 71.8 (CH_2), 71.3 (CH_2), 70.7 (CH_2), 70.4 (CH_2), 70.24 (CH_2), 70.16 (CH_2), 69.0 (CH_2), 68.8 (CH_2), 24.5 (CH_2), 23.9 (CH_2).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.85, -62.96.

IR (neat): $\tilde{\nu}$/cm^{-1} 3315, 2924, 1691, 1622, 1543, 1472, 1441, 1381, 1277, 1174, 1126, 933, 887, 845, 733, 704, 682, 589, 510.

HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{32}H_{38}F_{12}N_3O_8S_2$ 884.1903, observed 884.1896 (-0.8 ppm).



C$_2$-*cis*

Chemical Formula: $C_{32}H_{34}F_{12}N_2O_8S_2$

Exact Mass: 866.1565

According to general procedure, *C*$_2$-*cis* was obtained as a white solid (38 mg, 38% yield).

R$_f$ = 0.83 (SiO_2, DCM/MeOH 98:2).

m.p.: 176-177 ºC

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.37 (s, 2H), 7.99 (d, *J* = 1.6 Hz, 4H), 7.32 (s, 2H), 4.29 (d, *J* = 2.5 Hz, 2H), 3.99 (ddd, *J* = 10.5, 2.8, 1.8 Hz, 2H), 3.95 – 3.87 (m, 4H), 3.83 – 3.71 (m, 8H), 3.69 – 3.64 (m, 2H), 3.55 – 3.51 (m, 2H), 3.11 (dt, *J* = 14.0, 9.6 Hz, 2H), 2.86 (ddd, *J* = 14.0, 8.7, 5.3 Hz, 2H), 1.71 – 1.65 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.7 (2 C), 139.0 (2 C), 131.6 (q, *J* = 33.4 Hz, 4 C), 123.1 (q, *J* = 273.5 Hz, 4 C), 118.8 (4 CH), 117.1 (2 CH), 83.8 (2 CH), 79.4 (2 CH), 71.0 ($2CH_2$), 70.3 ($2CH_2$), 69.8 ($2CH_2$), 69.1 ($2CH_2$), 23.2 ($2CH_2$).

^{19}F NMR (282 MHz, $CDCl_3$) δ -62.87.

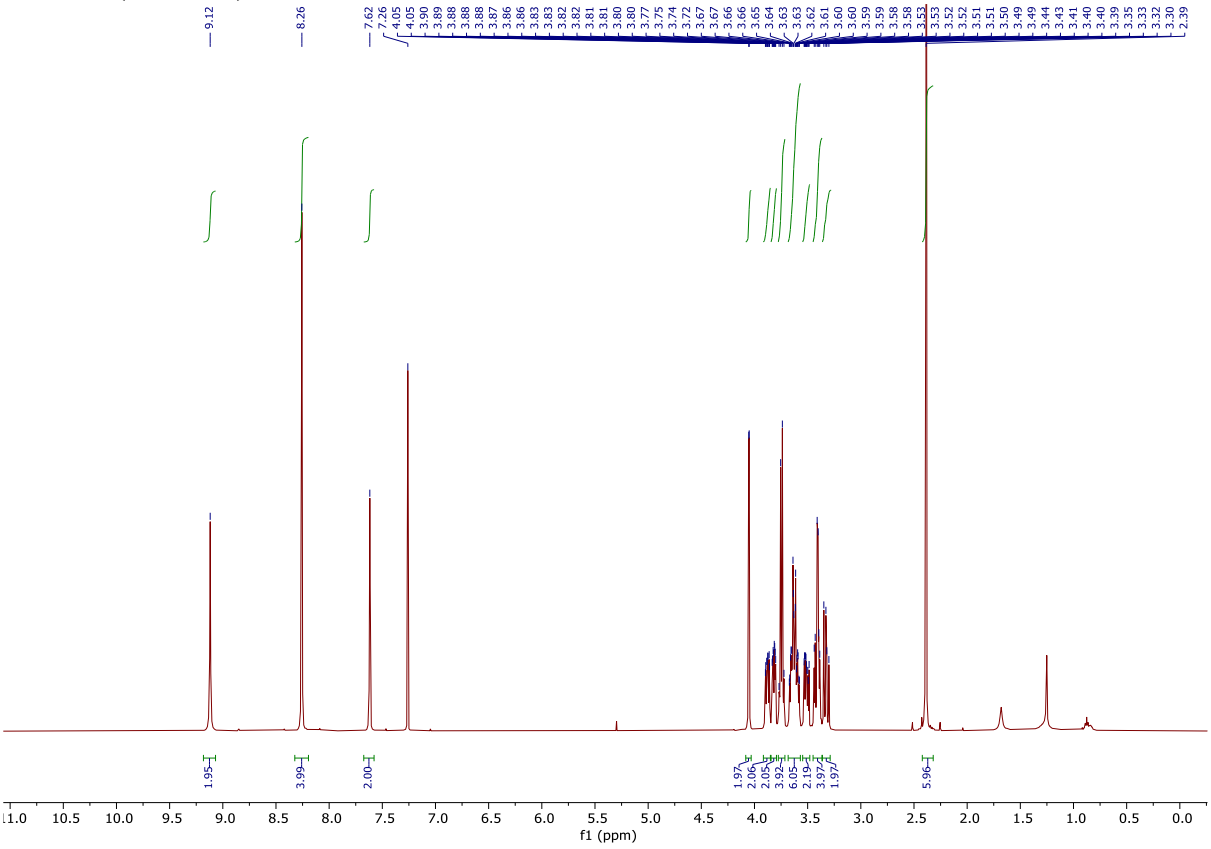
IR (neat): $\tilde{\nu}$/cm^{-1} 3329, 2922, 1691, 1538, 1473, 1439, 1380, 1278, 1175, 1127, 928, 888, 735, 703, 682, 527.

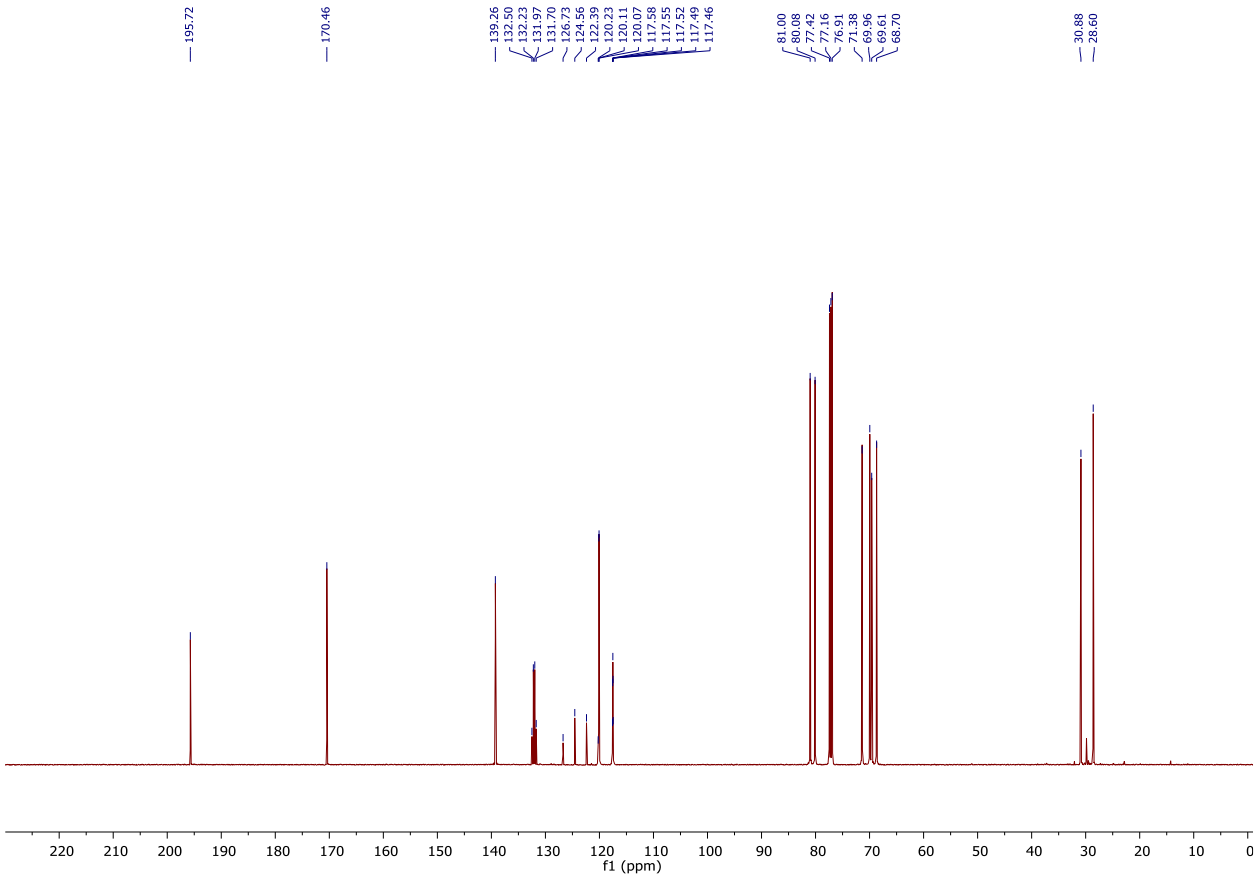
HR-MS (ESI) $[M+NH_4]^+$ *m/z* calculated for $C_{32}H_{38}F_{12}N_3O_8S_2$ 867.1638, observed 867.1630 (-0.9 ppm).

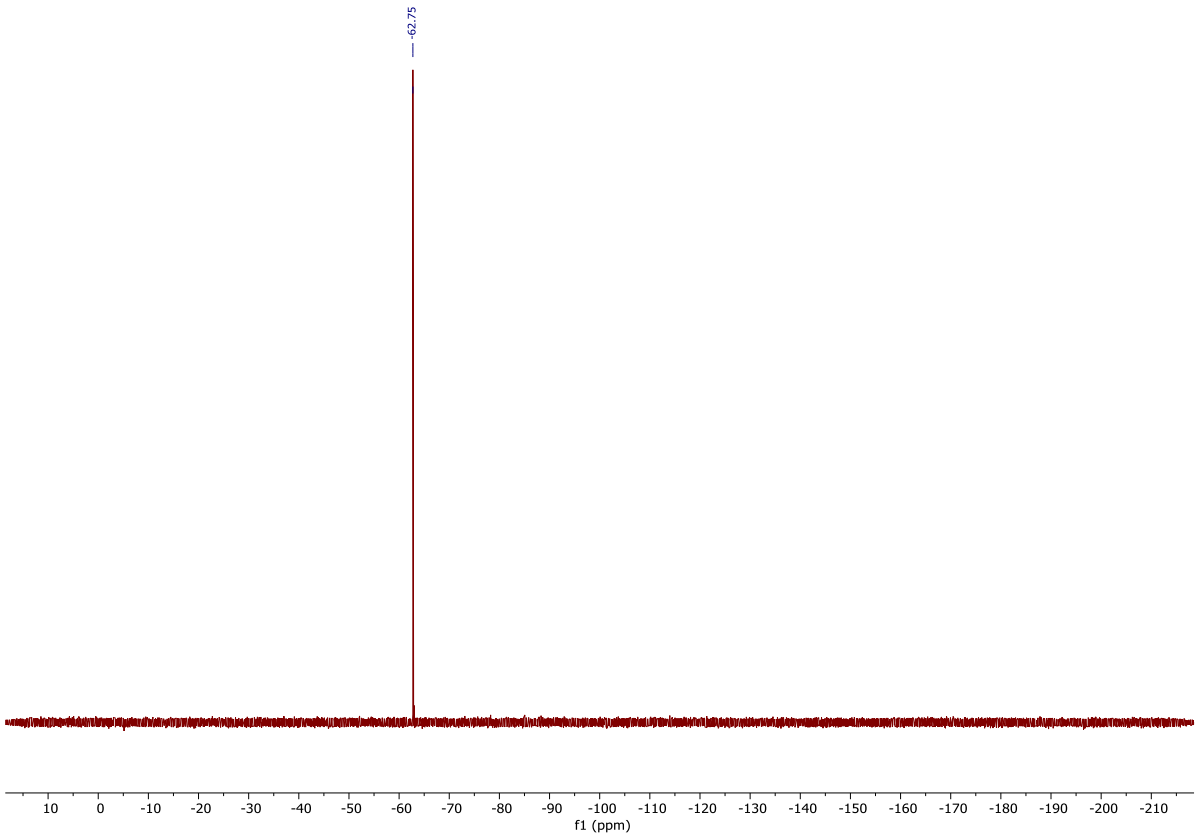
7. NMR spectra

7.1 Spectra of 3a

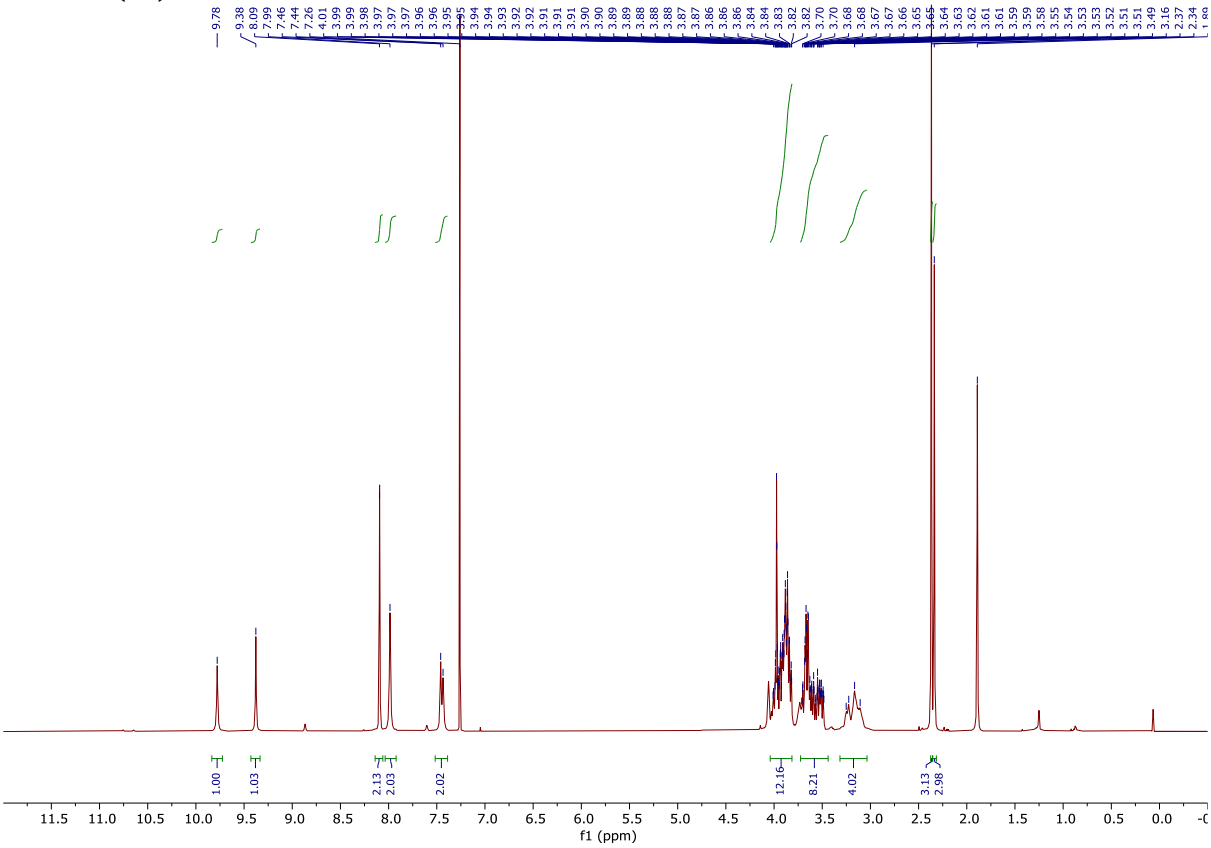
7.1.1 3a (C_2-*trans*)

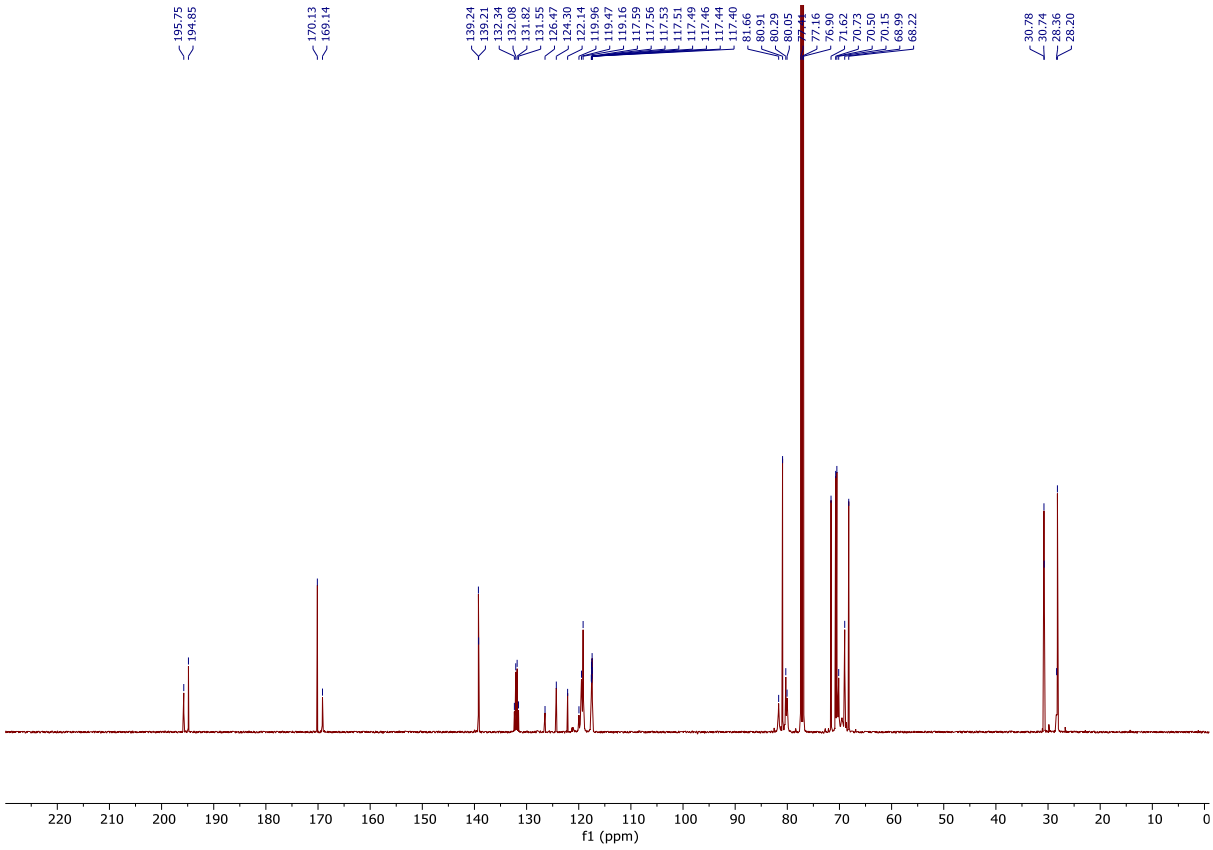


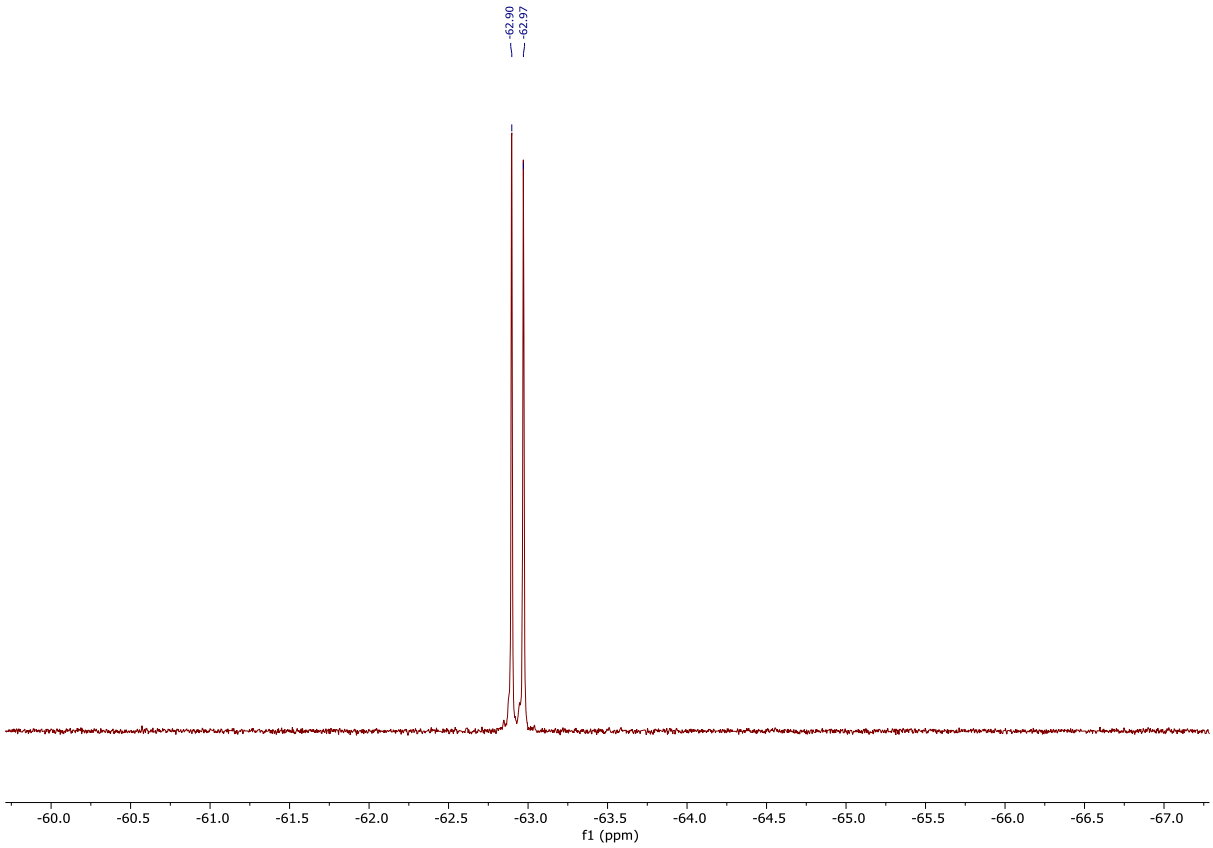

195.72
170.46
139.26
132.50
132.23
131.97
131.70
126.73
124.56
122.39
120.23
120.11
120.07
117.58
117.55
117.52
117.49
117.46
81.00
80.08
77.42
77.16
76.91
71.38
69.96
69.61
68.70
30.88
28.60
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-62.75
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

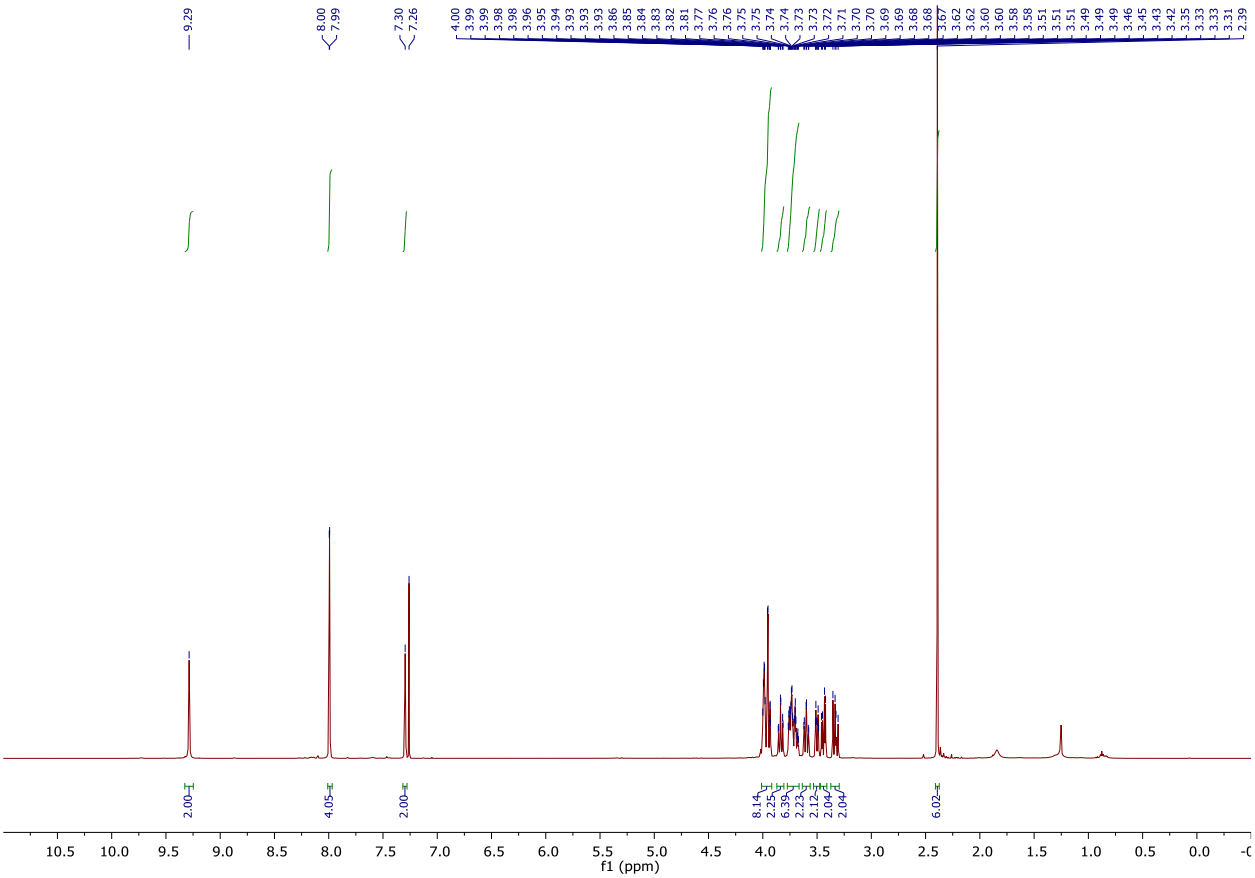
7.1.2 3a (C_1)




195.75
194.85
170.13
169.14
139.24
139.21
132.34
132.08
131.82
131.55
126.47
124.30
122.14
119.96
119.47
119.16
117.59
117.56
117.53
117.51
117.49
117.46
117.44
117.40
81.66
80.91
80.29
80.05
77.44
77.16
76.90
71.62
70.73
70.50
70.15
68.99
68.22
30.78
30.74
28.36
28.20
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-62.90
-62.97
-60.0 -60.5 -61.0 -61.5 -62.0 -62.5 -63.0 -63.5 -64.0 -64.5 -65.0 -65.5 -66.0 -66.5 -67.0
f1 (ppm)

7.1.3 3a (*C*$_2$-*cis*)


9.29
8.00
7.99
7.30
7.26
4.00
3.99
3.99
3.98
3.98
3.96
3.95
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3.93
3.93
3.93
3.86
3.85
3.84
3.83
3.82
3.81
3.77
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3.76
3.75
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3.74
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3.73
3.73
3.72
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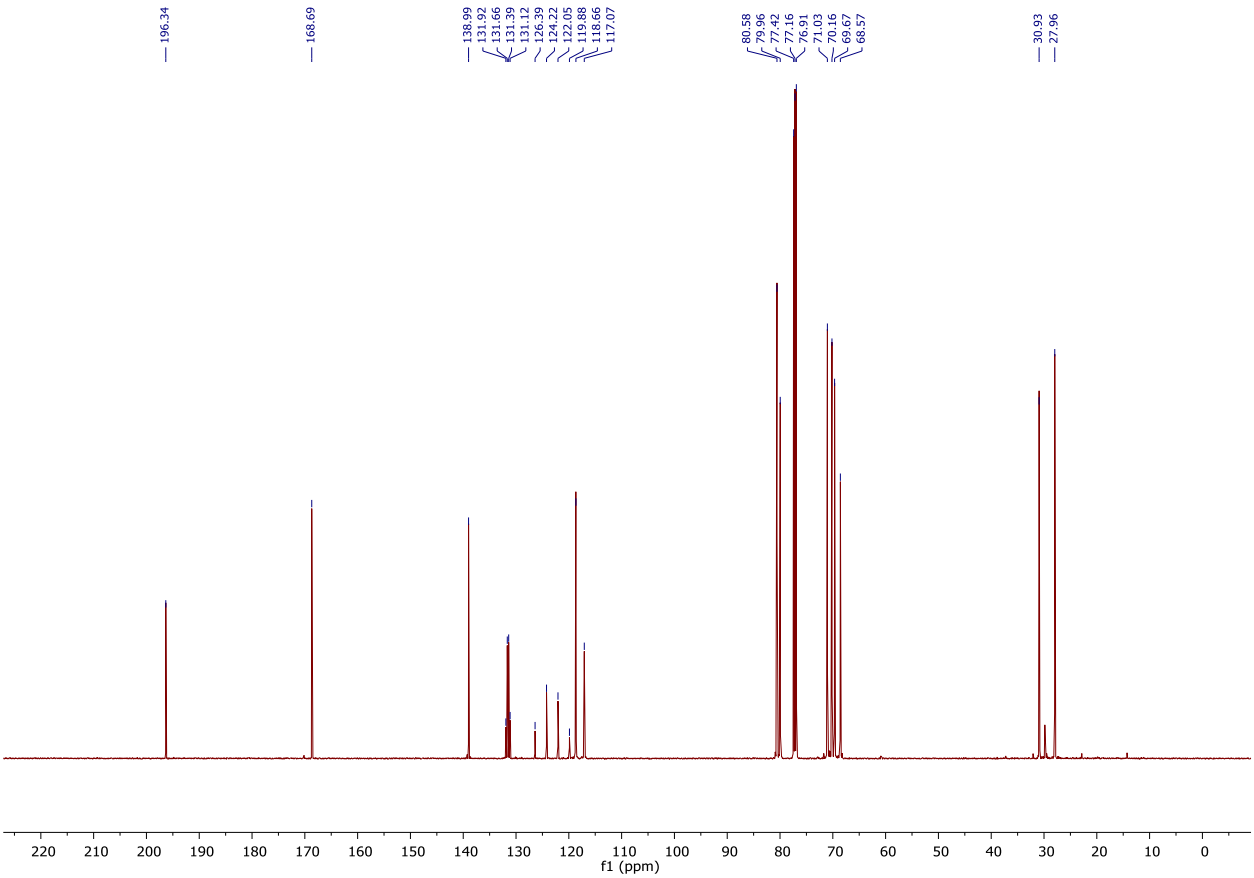
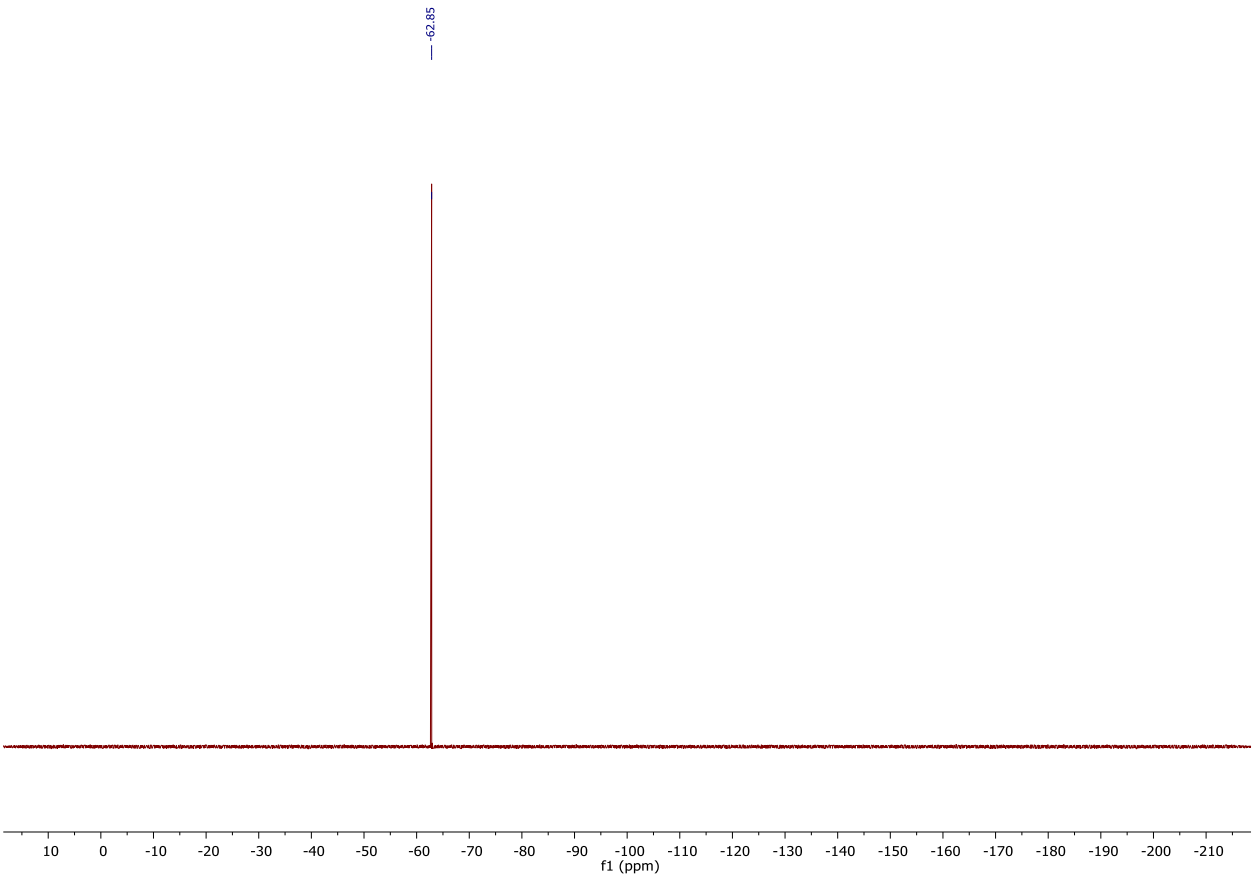
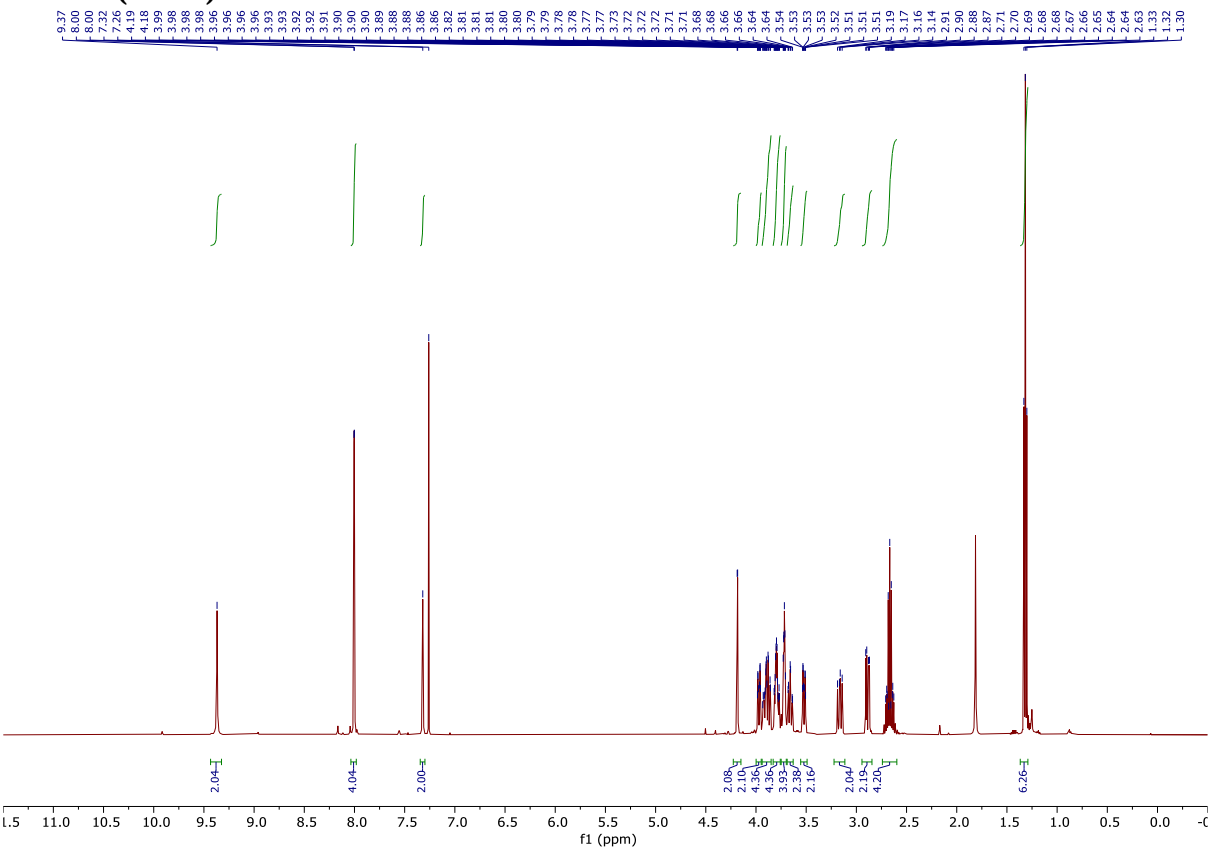
3.58
3.51
3.51
3.49
3.49
3.49
3.46
3.45
3.43
3.42
3.35
3.33
3.33
3.31
2.39
2.00
4.05
2.00
8.14
2.25
6.39
2.23
2.12
2.04
2.04
6.02
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

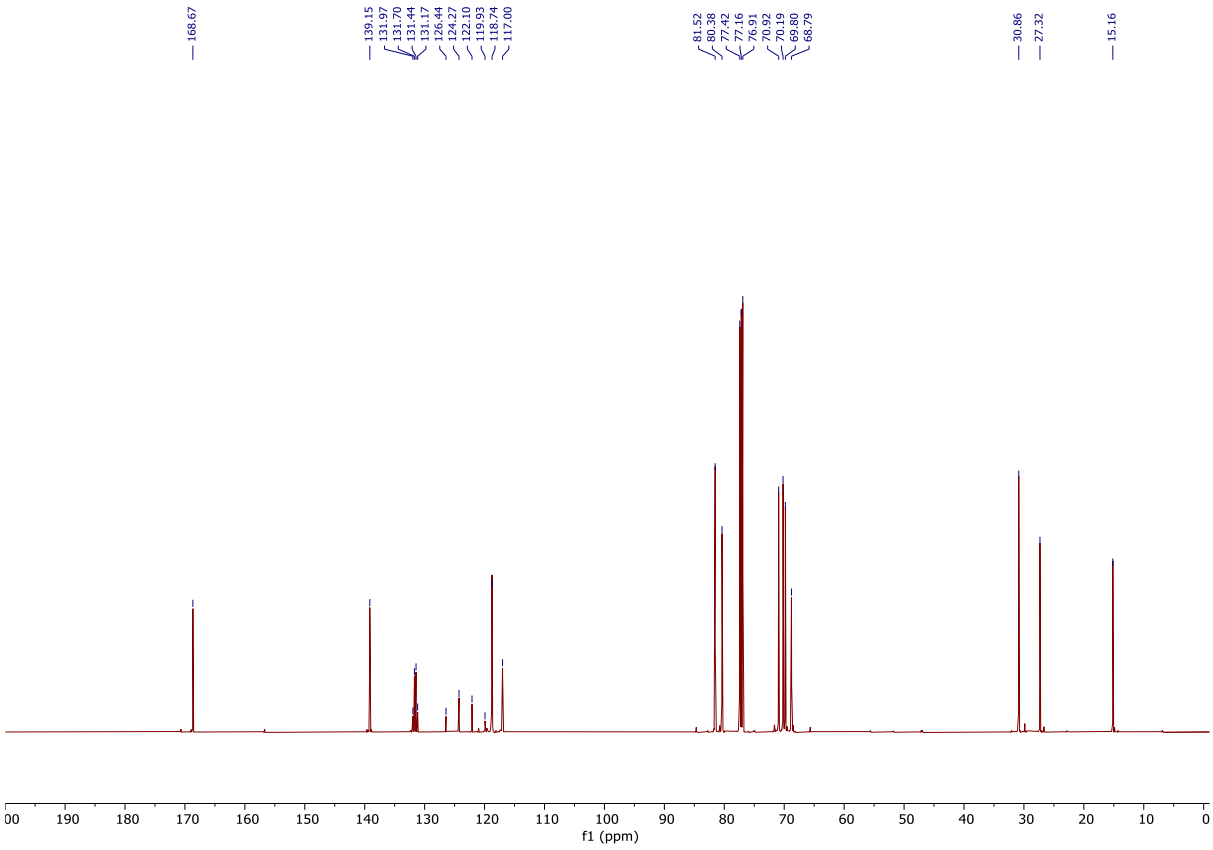

196.34
168.69
138.99
131.92
131.66
131.39
131.12
126.39
124.22
122.05
119.88
118.66
117.07
80.58
79.96
77.42
77.16
76.91
71.03
70.16
69.67
68.57
30.93
27.96
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-62.85
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

7.2 Spectra of 3b

7.2.1 3b (*C*$_2$-*cis*)




168.67
139.15
131.97
131.70
131.44
131.17
126.44
124.27
122.10
119.93
118.74
117.00
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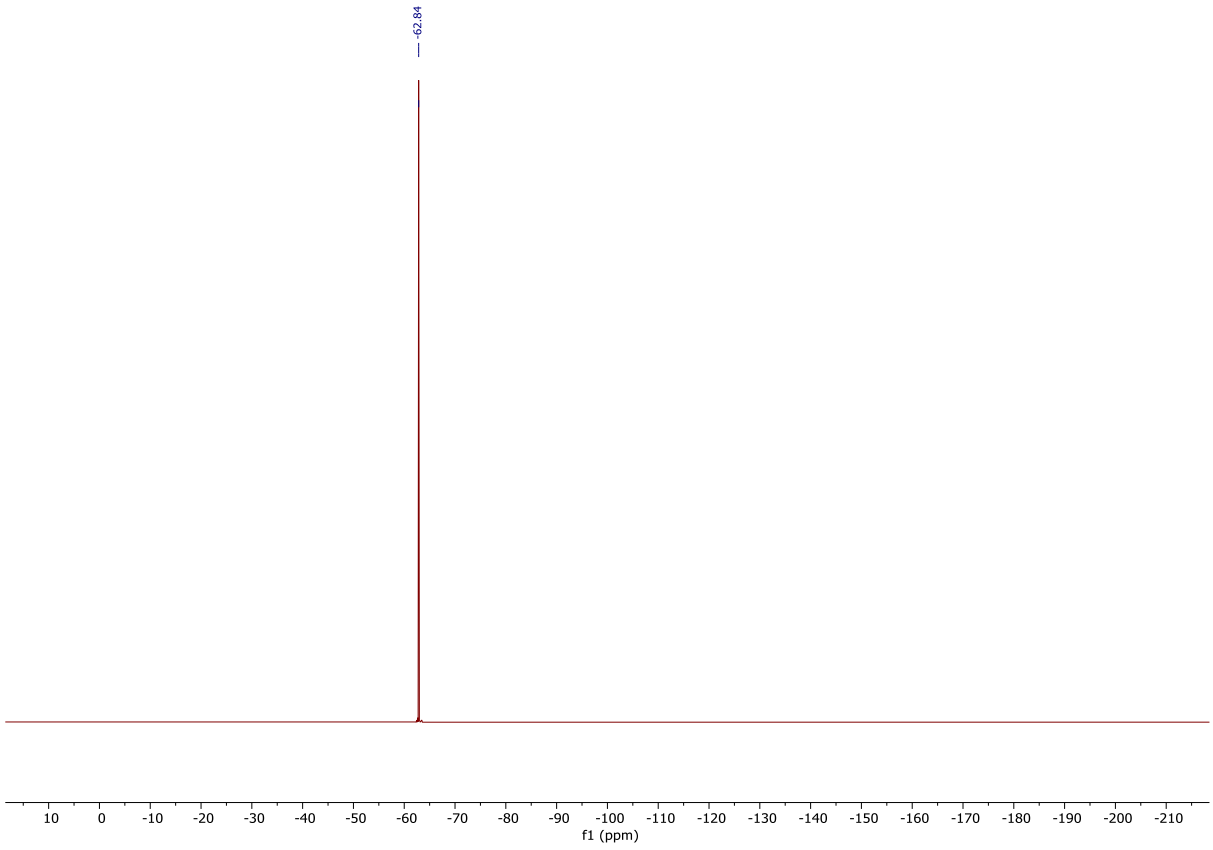
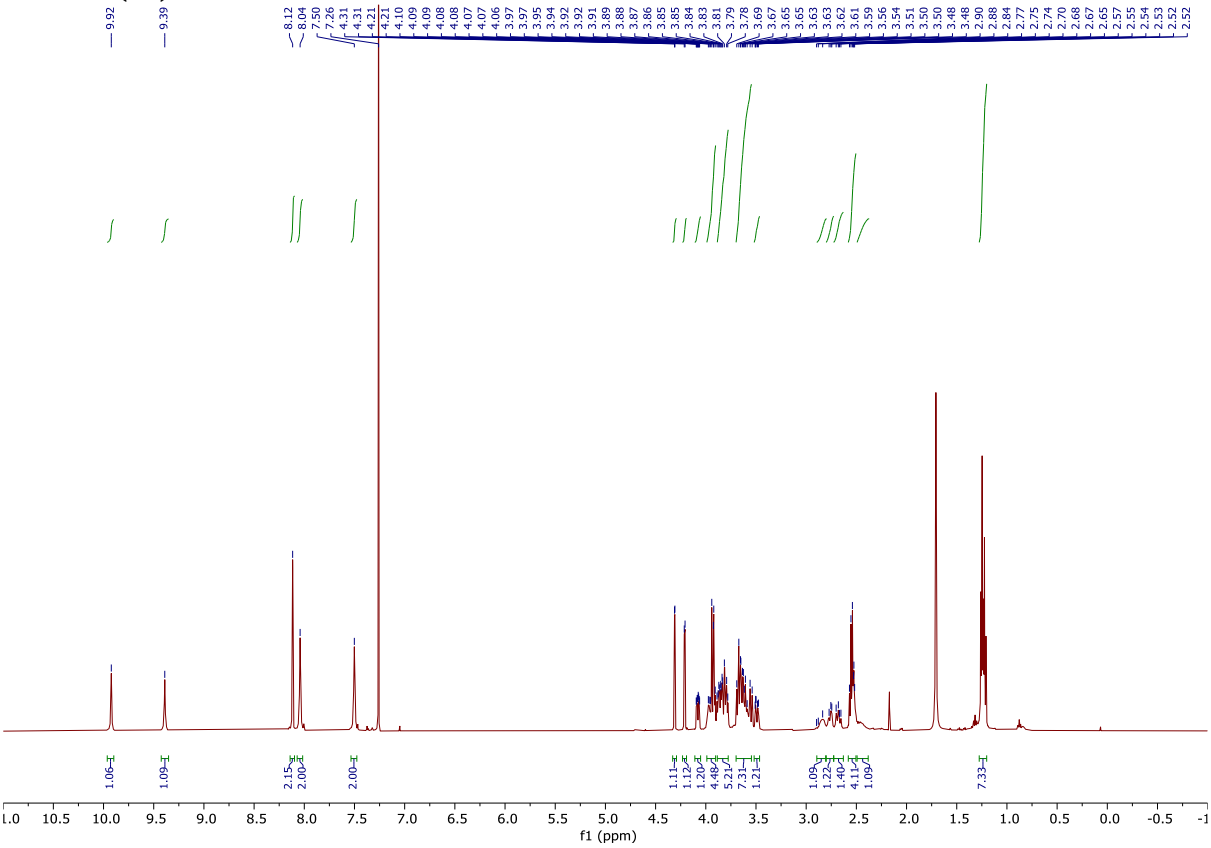
68.79
30.86
27.32
15.16
f1 (ppm)


-62.84
f1 (ppm)

7.2.2 3b (C_1)


9.92
9.39
8.12
8.04
7.50
7.26
4.31
4.31
4.21
4.21
4.10
4.09
4.09
4.08
4.08
4.07
4.07
4.06
3.97
3.97
3.95
3.94
3.92
3.92
3.91
3.89
3.88
3.87
3.86
3.85
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3.84
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3.81
3.79
3.78
3.69
3.67
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3.62
3.61
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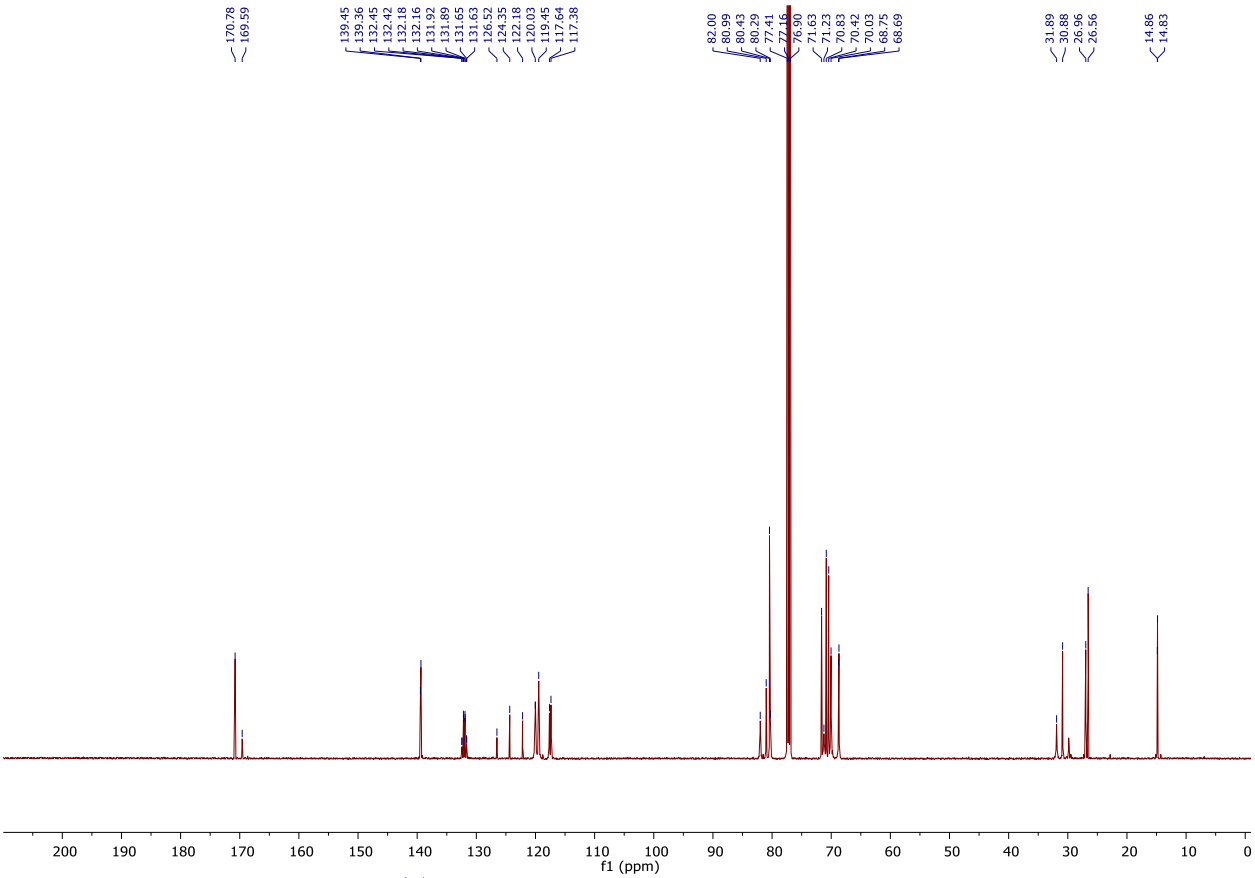
2.74
2.70
2.68
2.67
2.65
2.57
2.55
2.54
2.53
2.52
2.52
1.06
1.09
2.15
2.00
2.00
1.11
1.12
1.20
4.48
5.21
7.31
1.21
1.09
1.22
1.40
4.11
1.09
7.33
f1 (ppm)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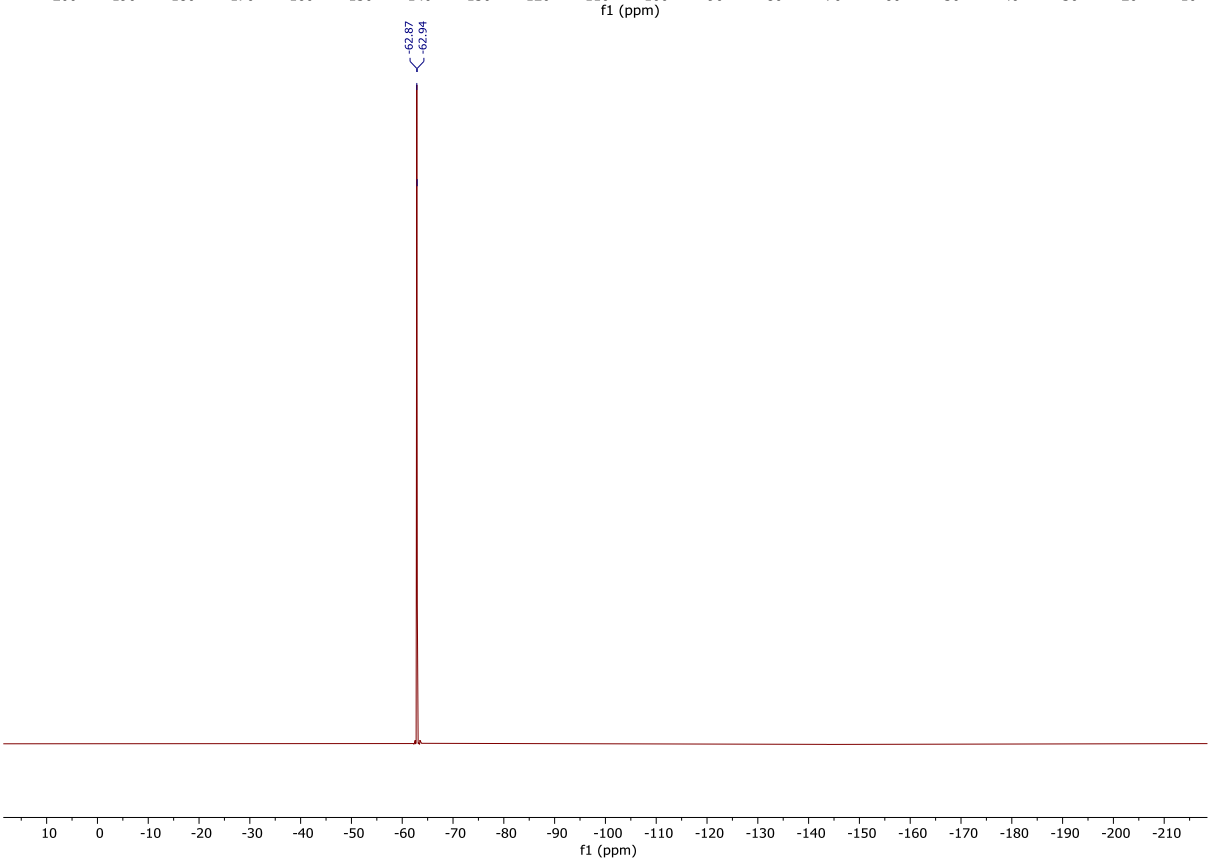
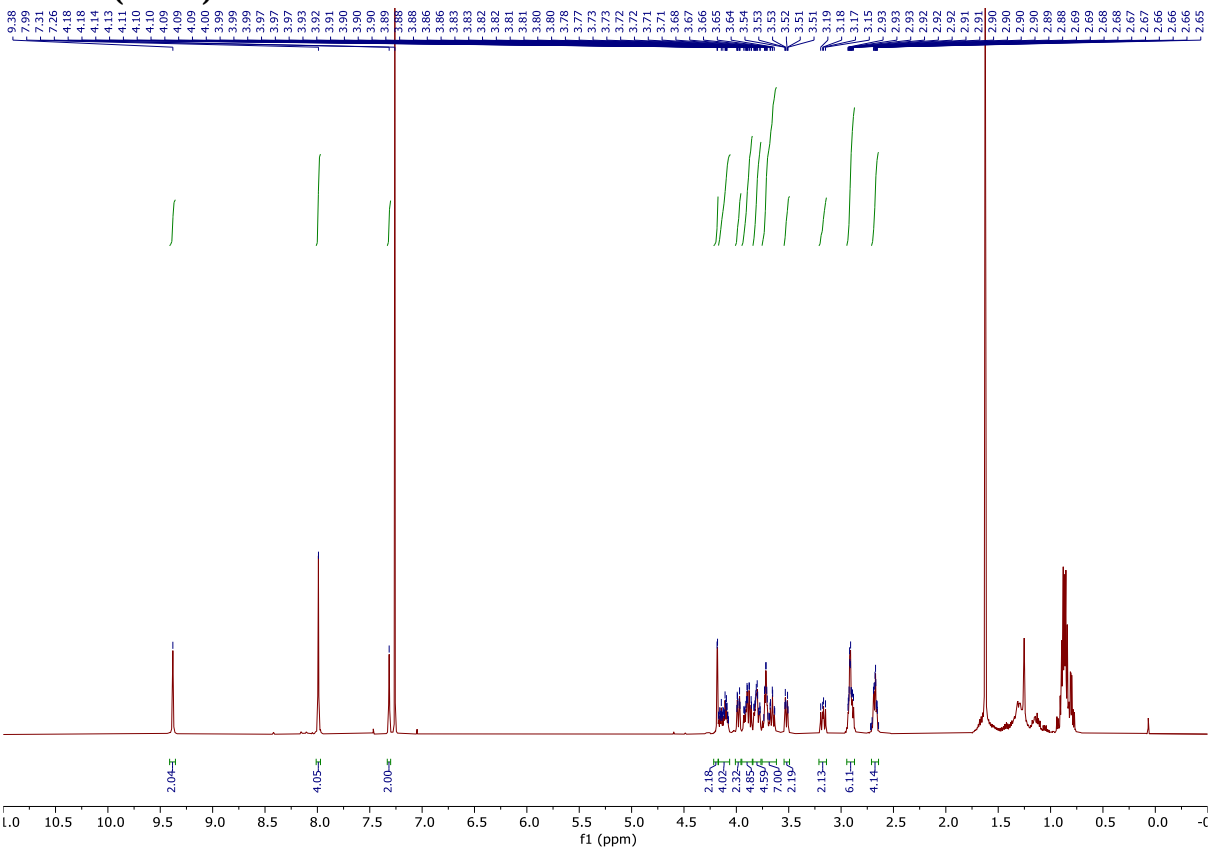
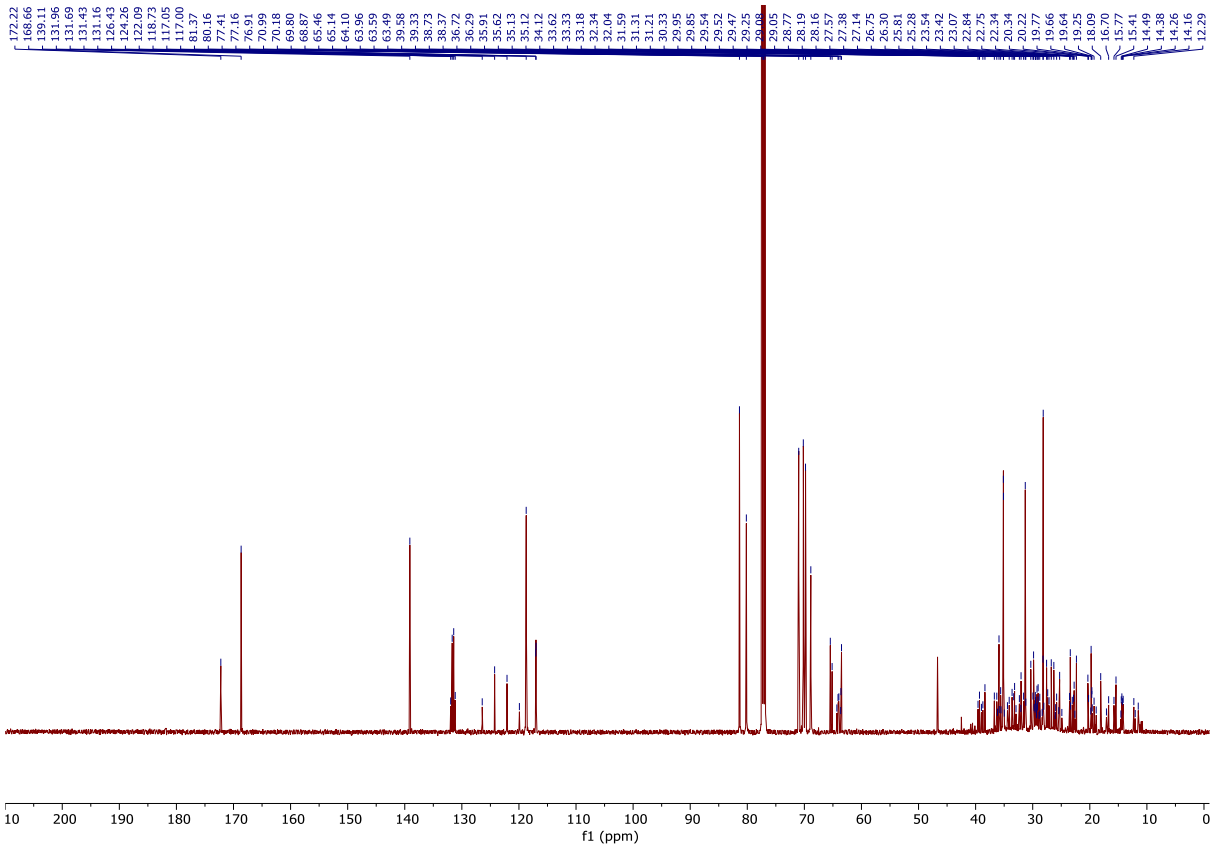
139.36
132.45
132.42
132.18
132.16
131.92
131.89
131.65
131.63
126.52
124.35
122.18
120.03
119.45
117.64
117.38
82.00
80.99
80.43
80.29
77.41
77.16
76.90
71.63
71.23
70.83
70.42
70.03
68.75
68.69
31.89
30.88
26.96
26.56
14.86
14.83
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

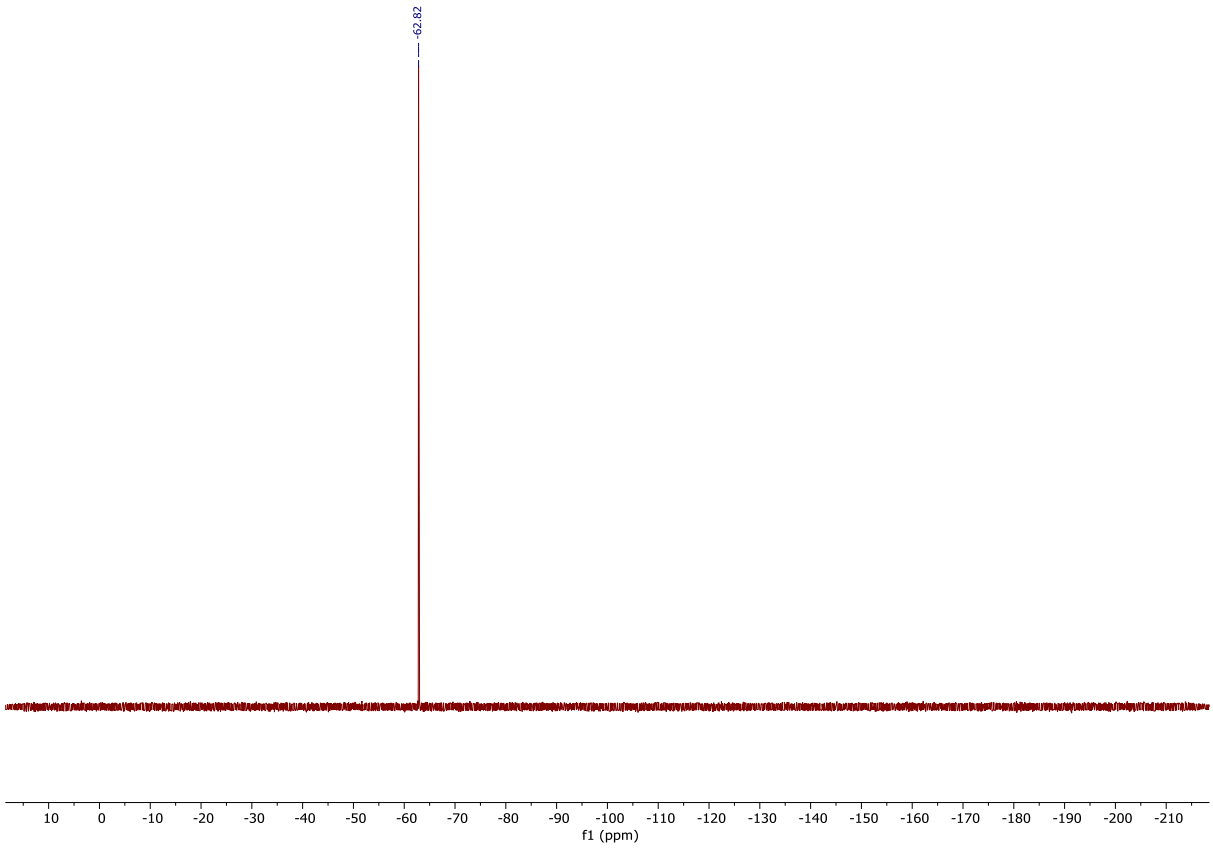

-62.87
-62.94
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

7.3 Spectra of 3c

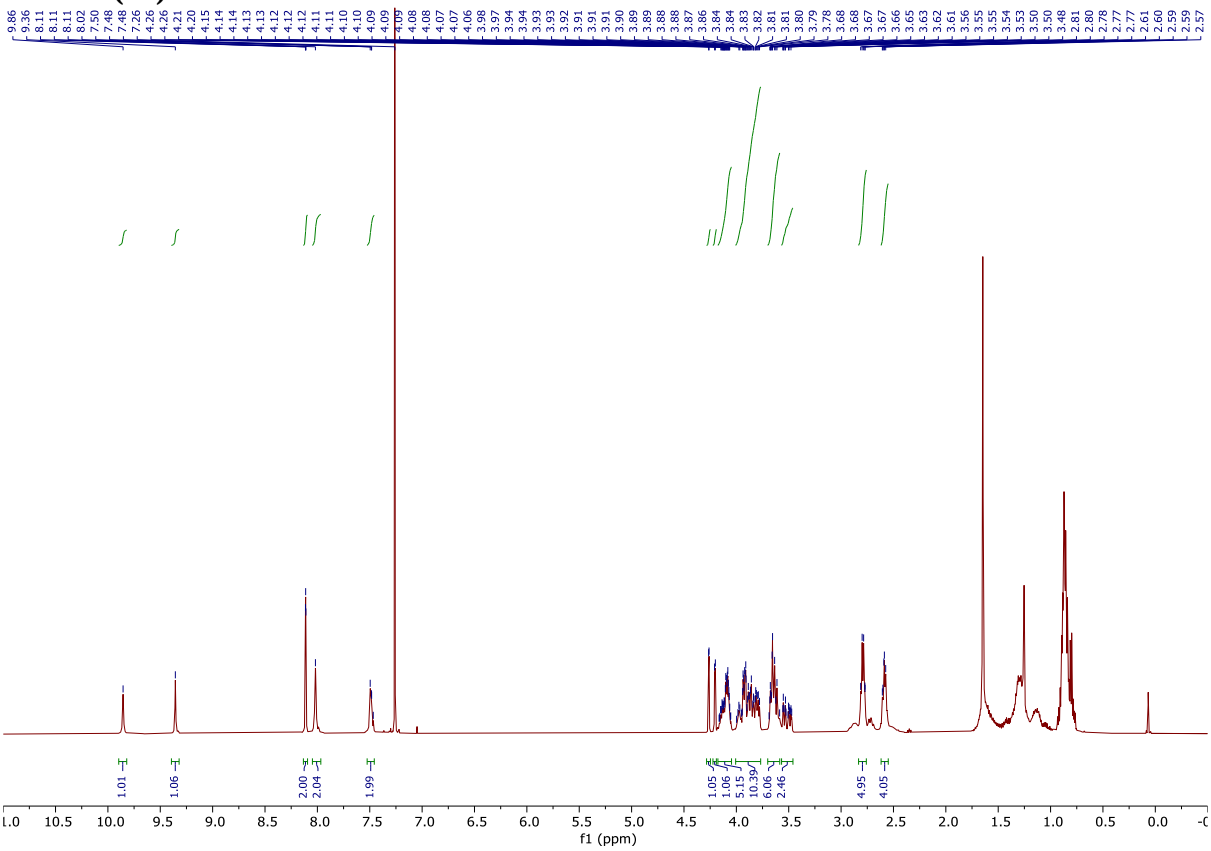
7.3.1 3c (*C*$_2$-*cis*)

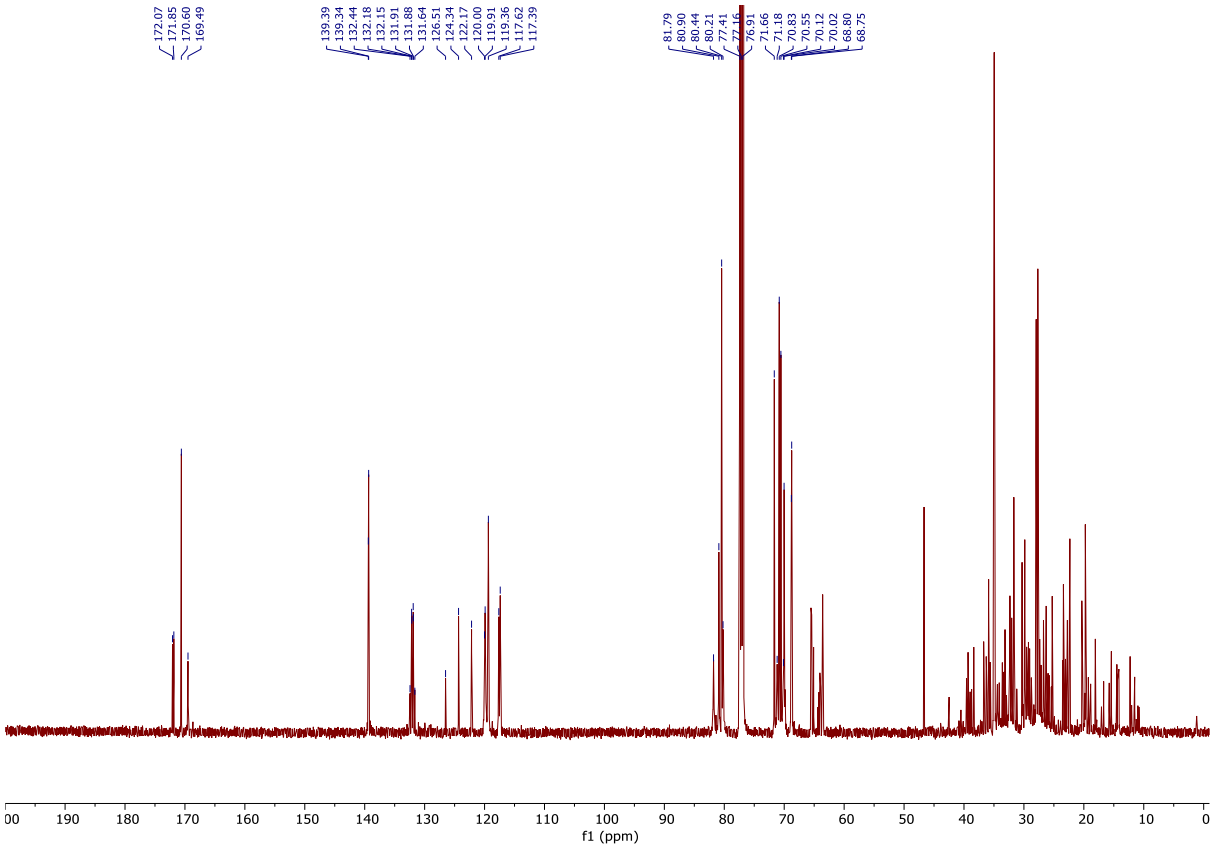


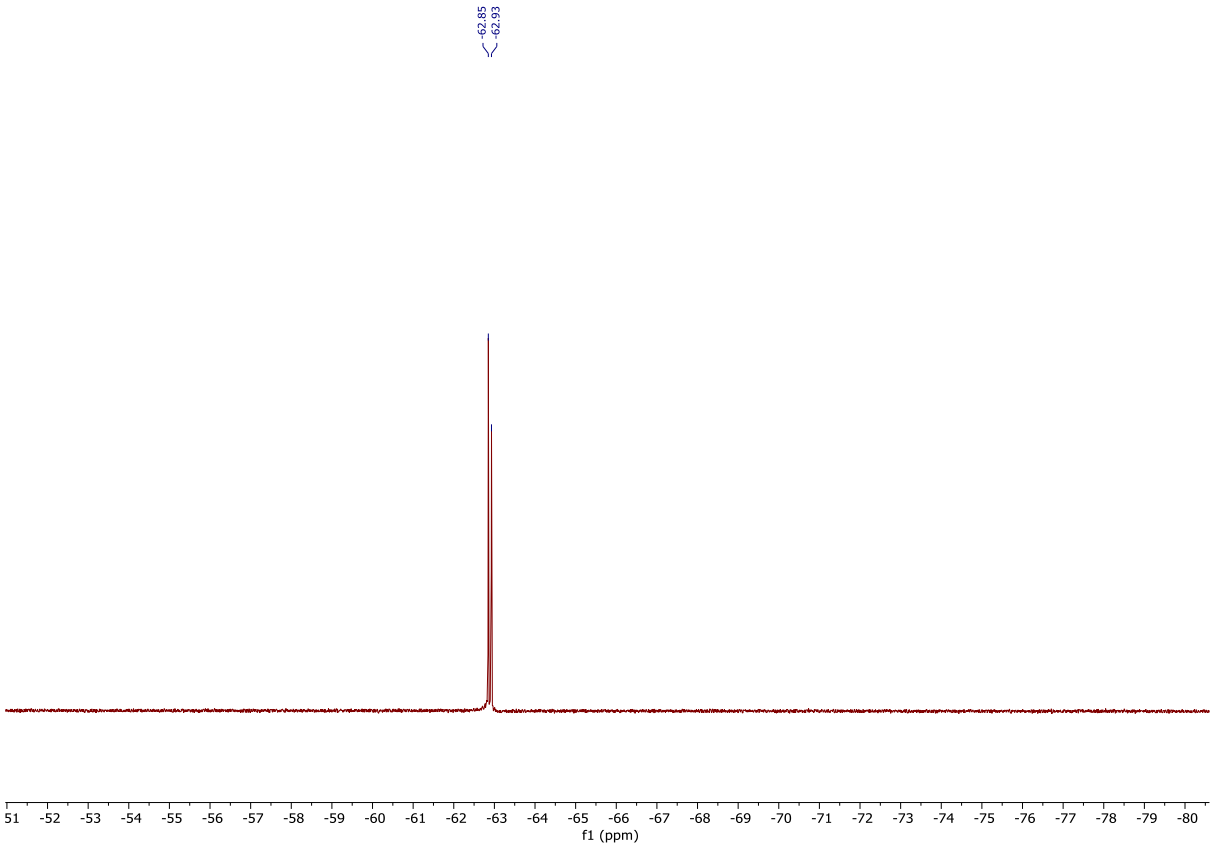

172.22
168.66
139.11
131.96
131.69
131.43
131.16
126.43
124.26
122.09
118.73
117.05
117.00
81.37
80.16
77.41
77.16
76.91
70.99
70.18
69.80
68.87
65.46
65.14
64.10
63.96
63.59
63.49
63.48
39.33
38.73
38.37
36.72
36.29
35.91
35.62
35.13
35.12
34.12
33.62
33.33
33.18
32.34
32.04
31.59
31.31
31.21
30.33
29.95
29.85
29.54
29.52
29.47
29.25
29.05
28.77
28.19
28.16
27.57
27.38
27.14
26.75
26.30
25.81
25.28
23.54
23.42
23.07
22.84
22.75
22.34
20.34
20.22
19.77
19.66
19.64
19.25
18.09
16.70
15.77
15.41
14.49
14.38
14.26
14.16
12.29
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-62.82
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

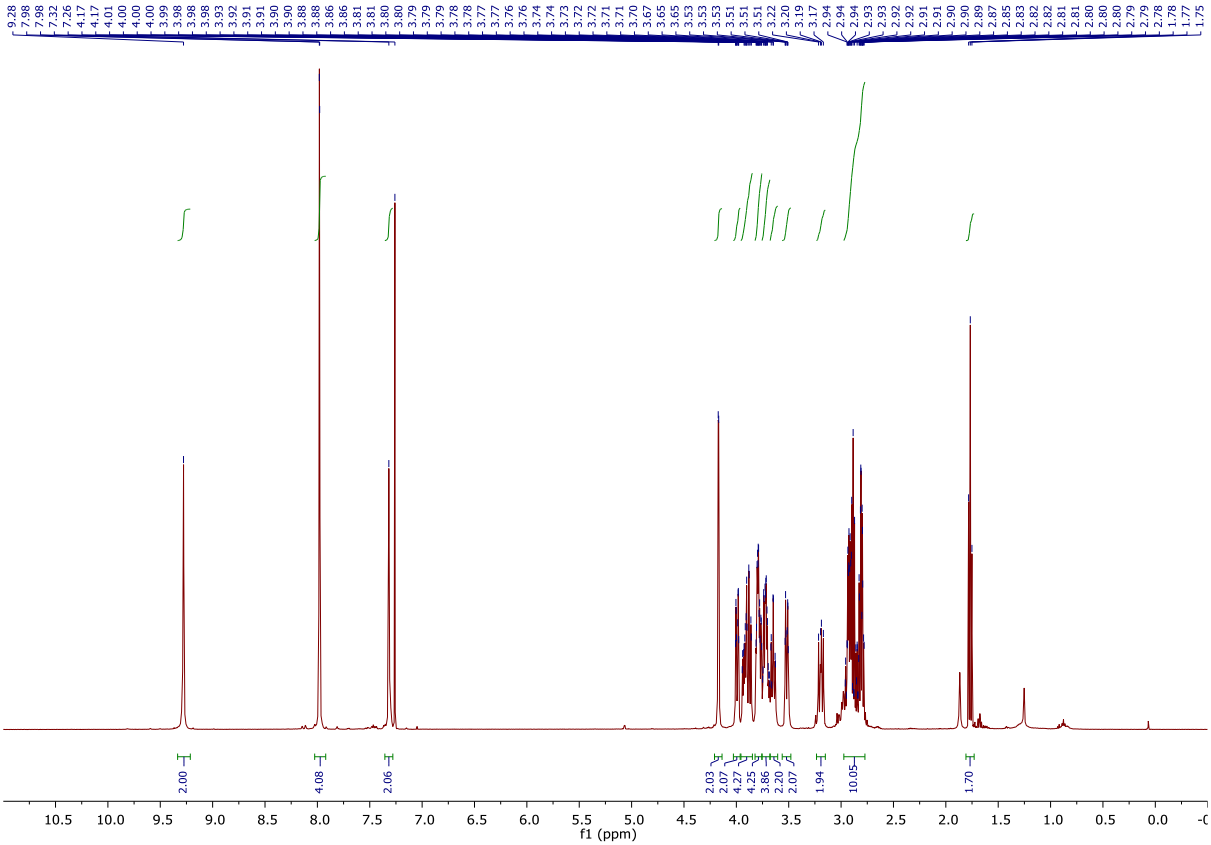
7.3.2 3c (C_1)

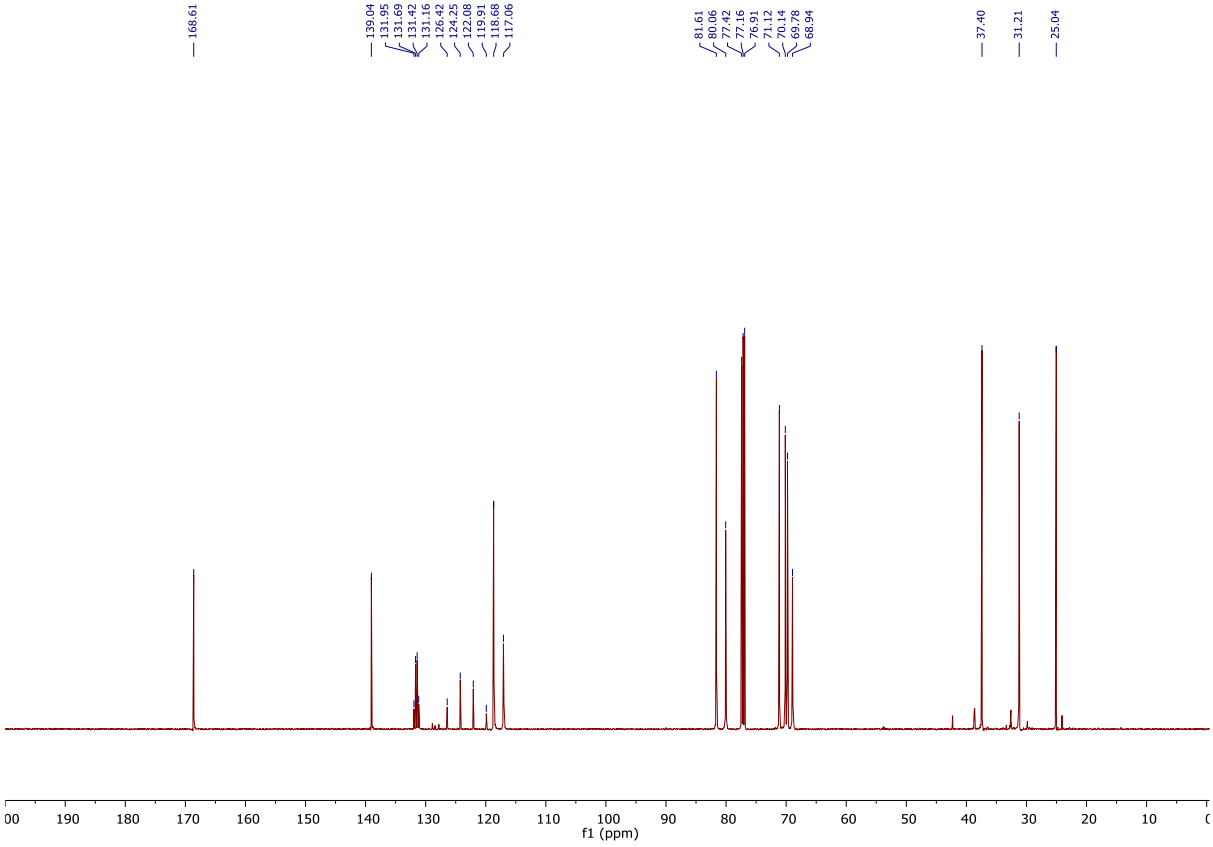

9.86 9.36 8.11 8.11 8.11 8.02 7.50 7.48 7.48 7.26 4.26 4.26 4.21 4.20 4.15 4.14 4.14 4.13 4.13 4.12 4.12 4.12 4.11 4.11 4.10 4.10 4.09 4.09 4.07 4.08 4.08 4.08 4.07 4.07 4.06 3.98 3.97 3.94 3.94 3.93 3.93 3.92 3.91 3.91 3.91 3.90 3.89 3.89 3.88 3.88 3.87 3.86 3.84 3.84 3.83 3.82 3.81 3.81 3.80 3.79 3.78 3.68 3.68 3.67 3.67 3.66 3.65 3.63 3.62 3.61 3.56 3.55 3.55 3.54 3.53 3.50 3.50 3.48 2.81 2.80 2.78 2.77 2.77 2.61 2.60 2.59 2.59 2.57
1.01 1.06 2.00 2.04 1.99 1.05 1.06 5.15 10.39 6.06 2.46 4.95 4.05
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

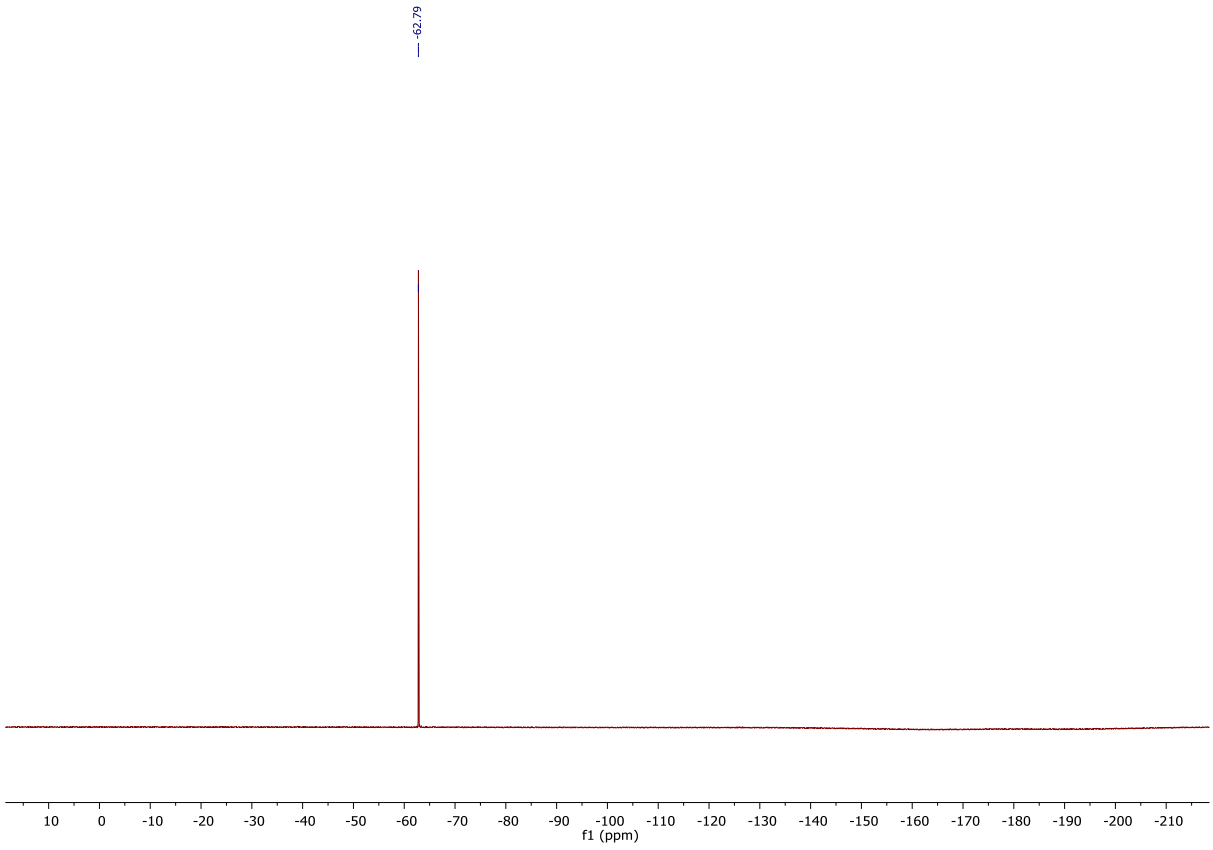

172.07
171.85
170.60
169.49
139.39
139.34
132.44
132.18
132.15
131.91
131.88
131.64
126.51
124.34
122.17
120.00
119.91
119.36
117.62
117.39
81.79
80.90
80.44
80.21
77.41
77.16
76.91
71.66
71.18
70.83
70.55
70.12
70.02
68.80
68.75
f1 (ppm)


-62.85
-62.93
f1 (ppm)

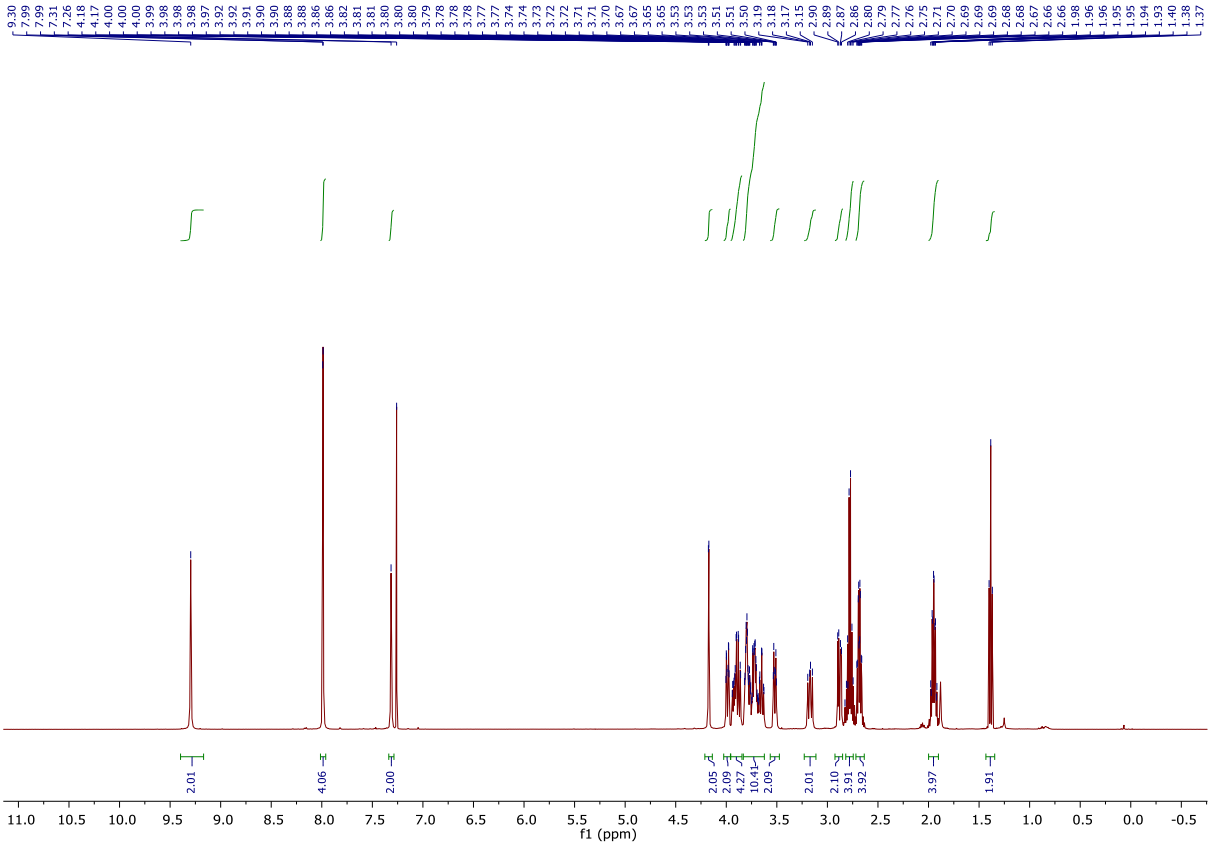
7.4 Spectra of 3d (*C*$_2$-*cis*)

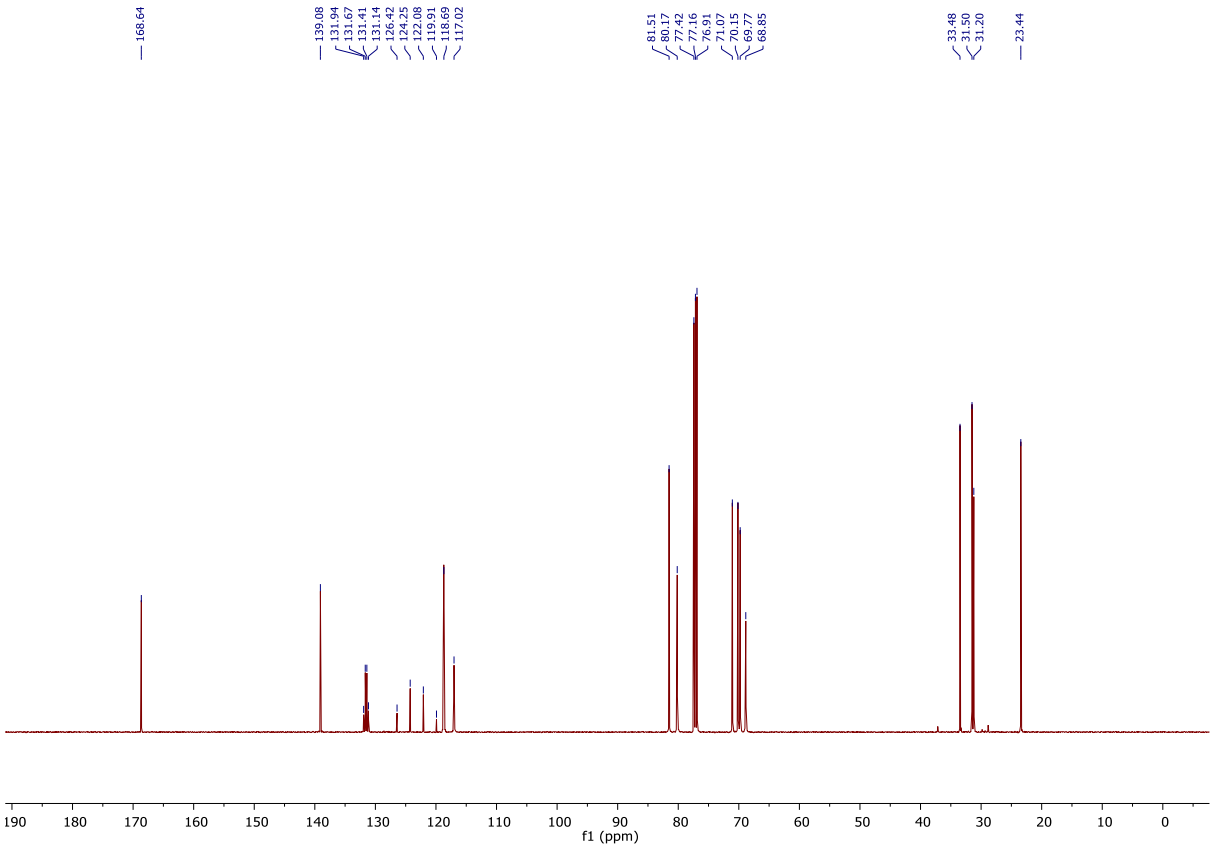


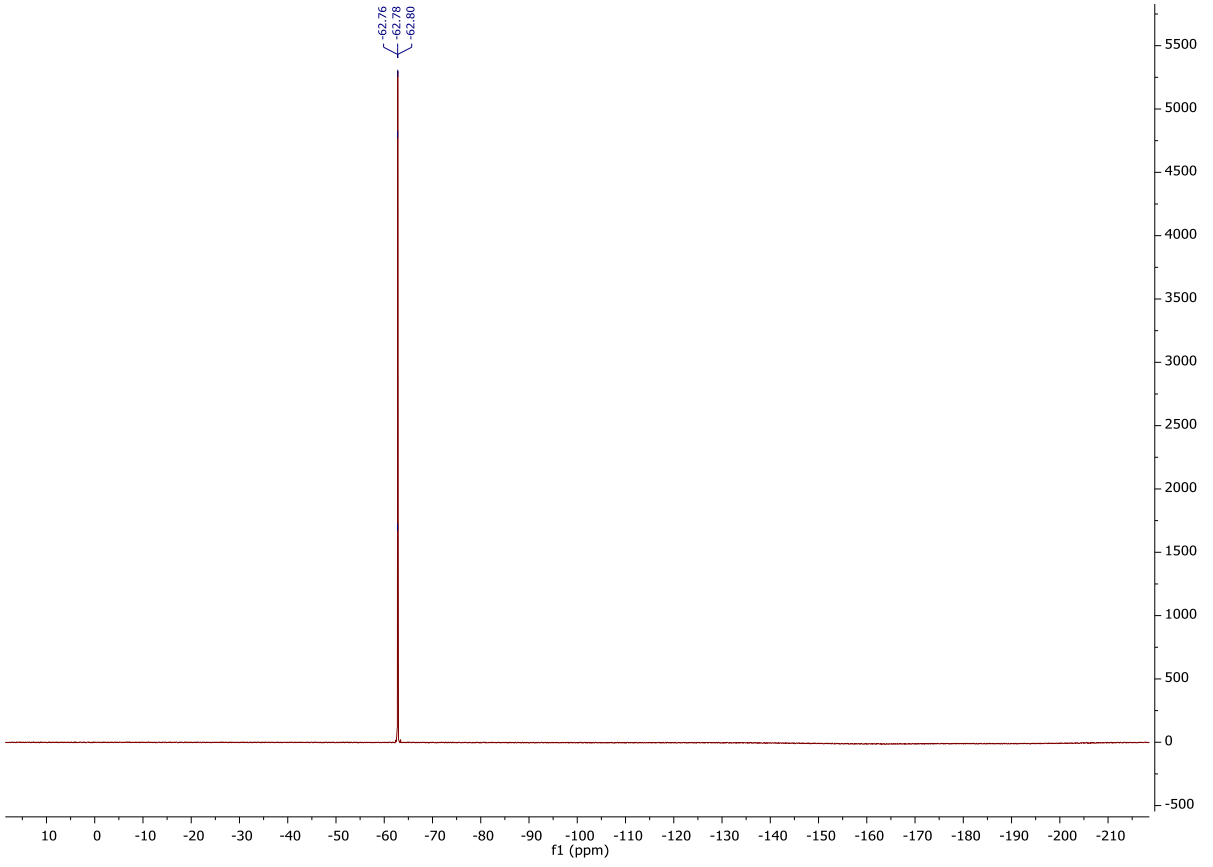

168.61
139.04
131.95
131.69
131.42
131.16
126.42
124.25
122.08
119.91
118.68
117.06
81.61
80.06
77.42
77.16
76.91
71.12
70.14
69.78
68.94
37.40
31.21
25.04
f1 (ppm)


-62.79
f1 (ppm)

7.5 Spectra of 3e (C_2-*cis*)

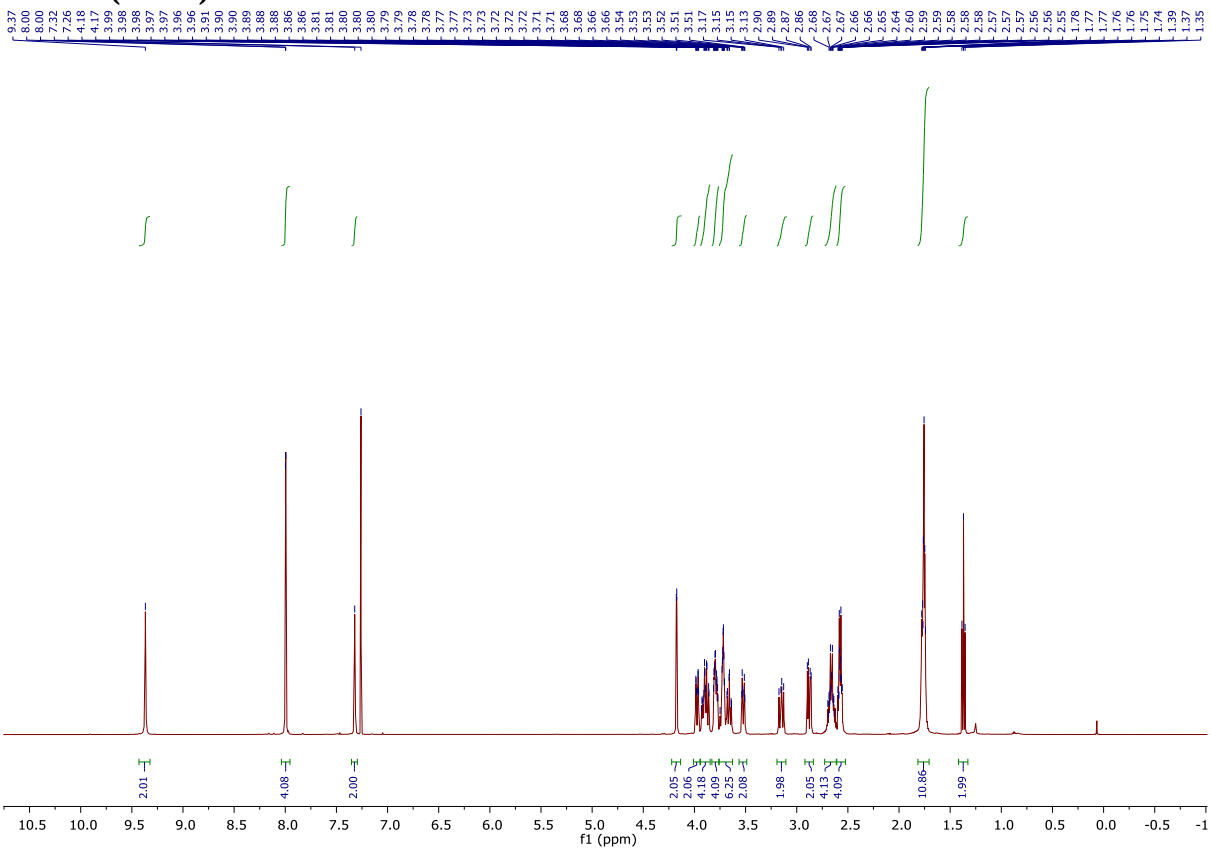


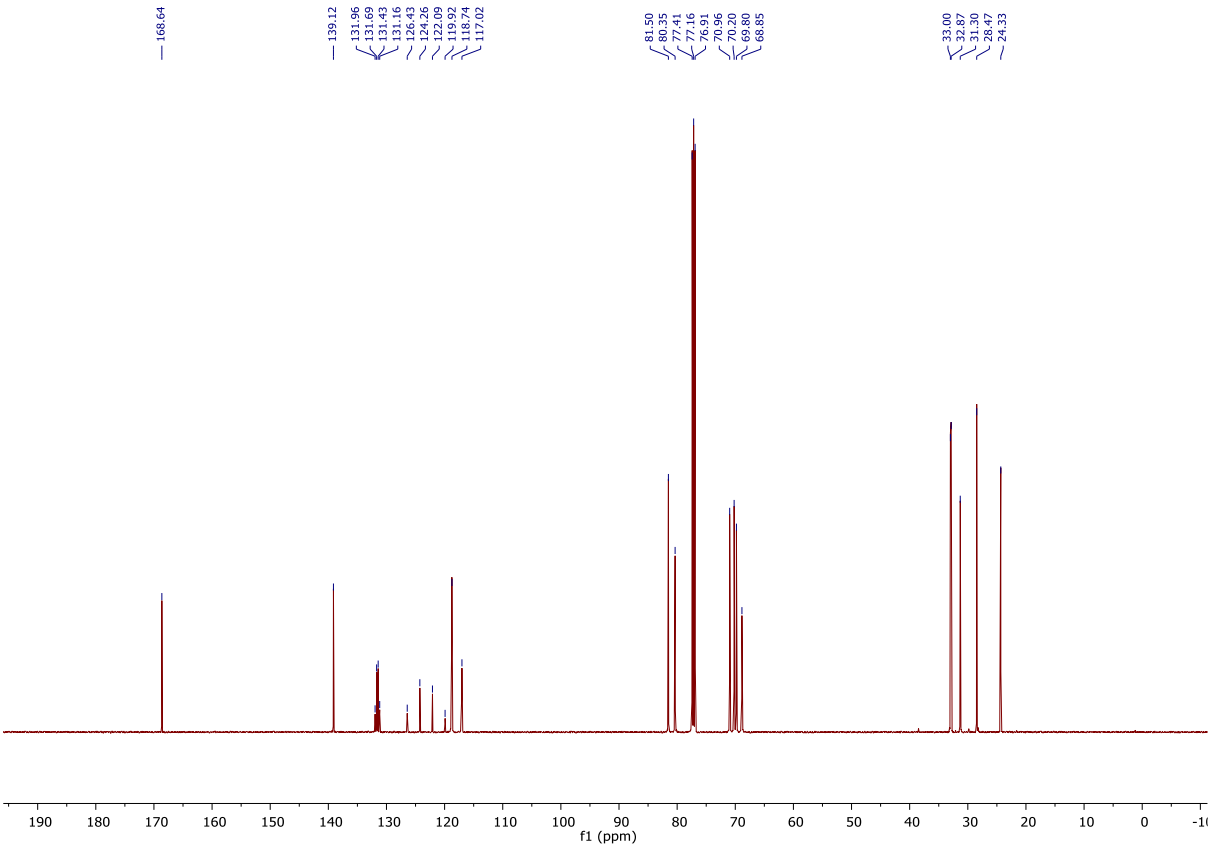

168.64
139.08
131.94
131.67
131.41
131.14
126.42
124.25
122.08
119.91
118.69
117.02
81.51
80.17
77.42
77.16
76.91
71.07
70.15
69.77
68.85
33.48
31.50
31.20
23.44
f1 (ppm)

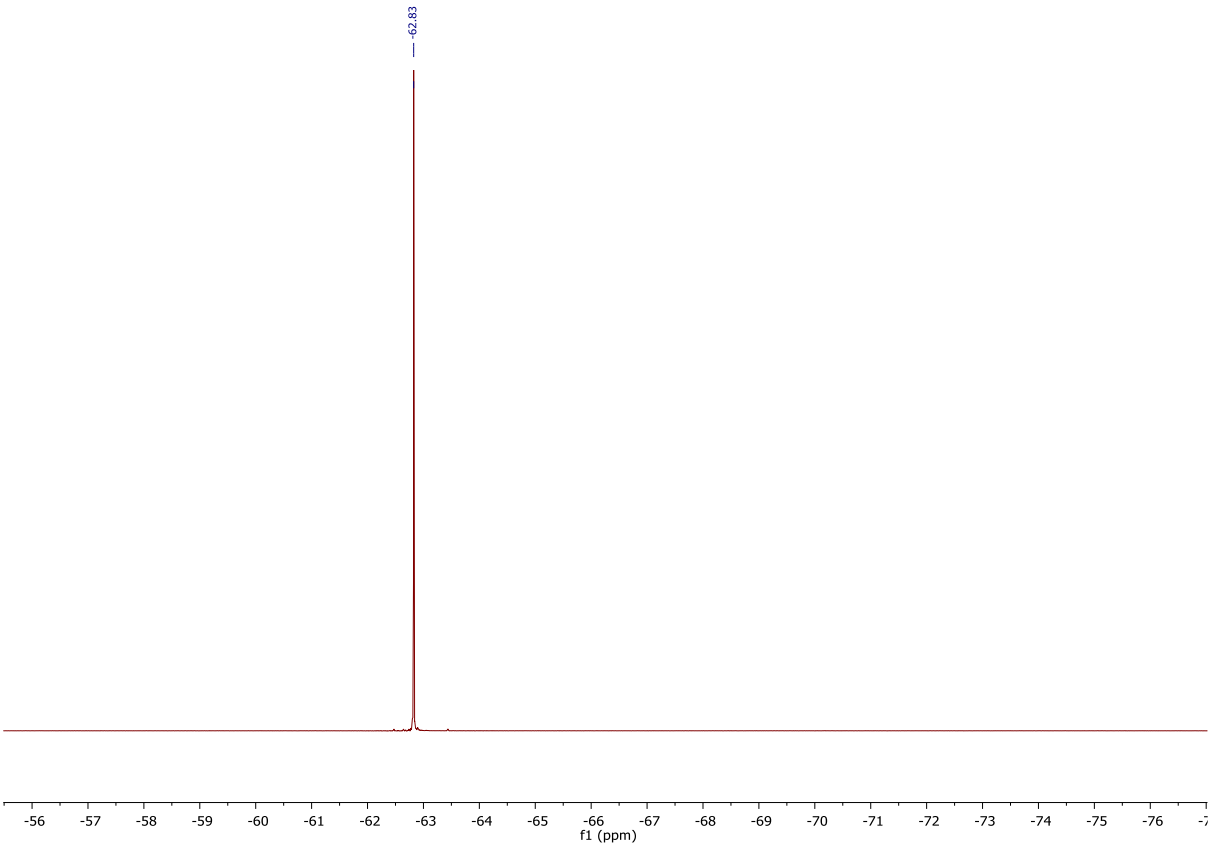

-62.76
-62.78
-62.80
f1 (ppm)

7.6 Spectra of 3f

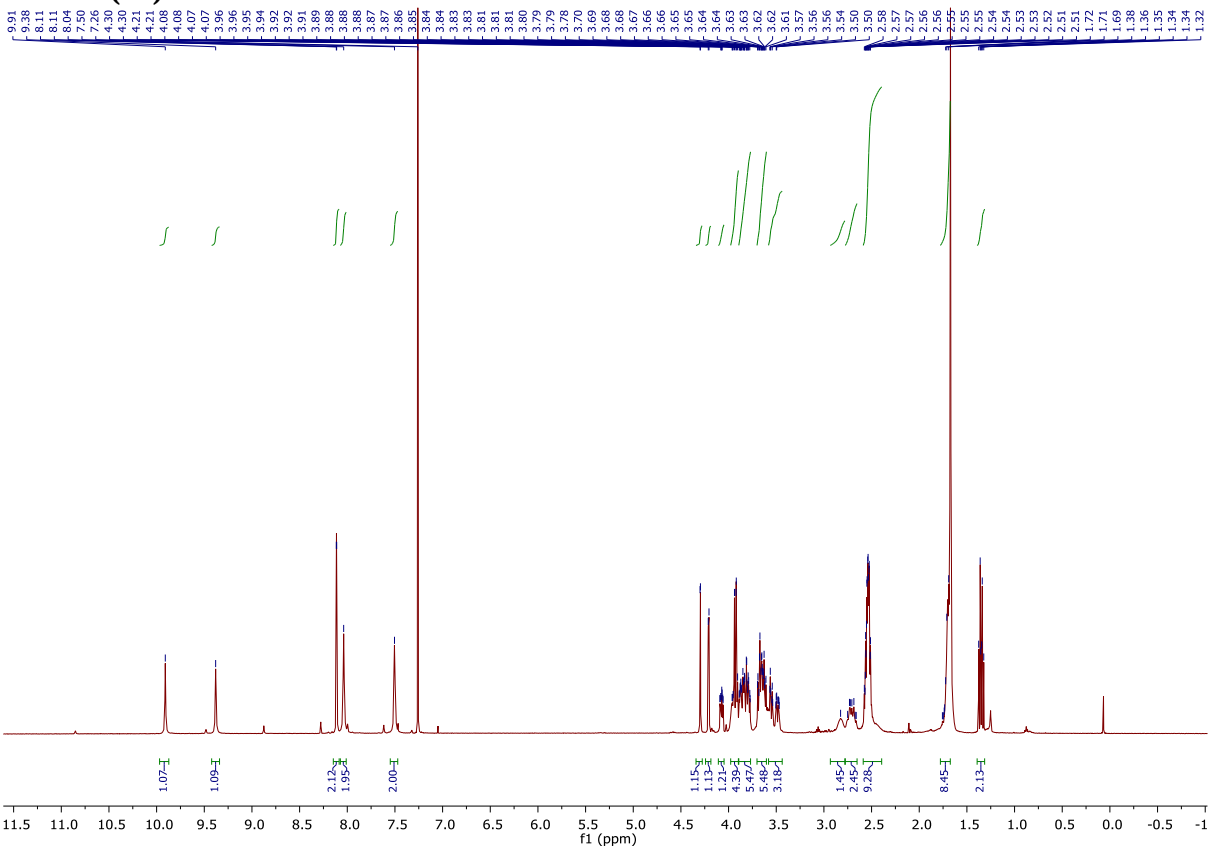
7.6.1 3f (*C*$_2$-*cis*)

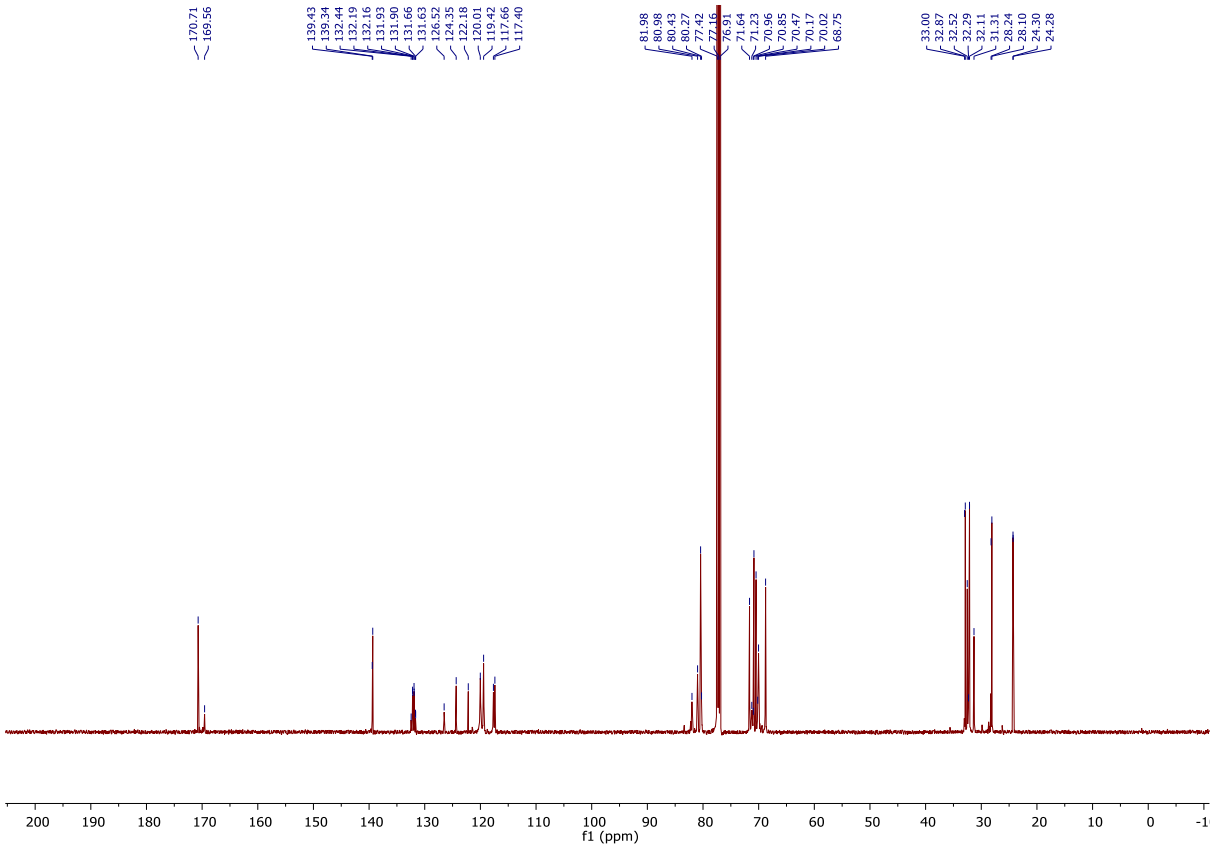


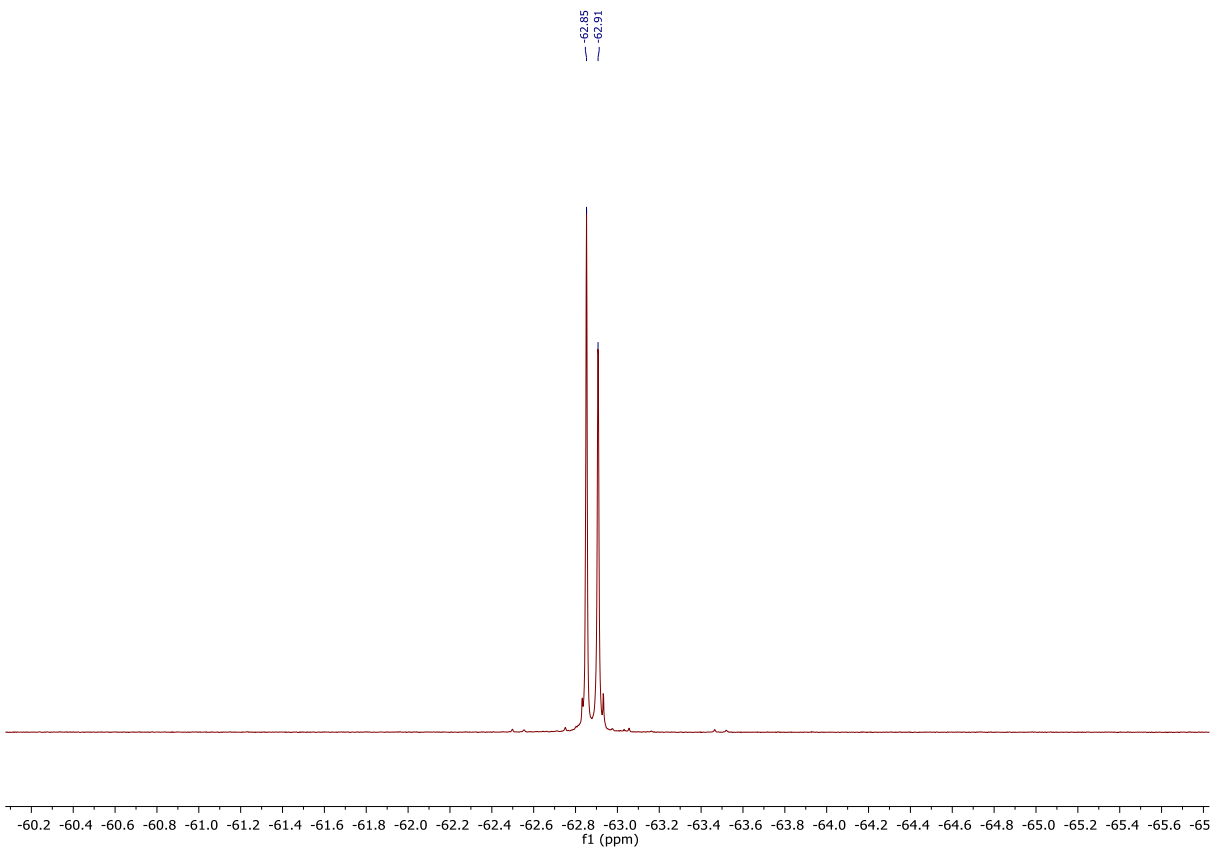

168.64
139.12
131.96
131.69
131.43
131.16
126.43
124.26
122.09
119.92
118.74
117.02
81.50
80.35
77.41
77.16
76.91
70.96
70.20
69.80
68.85
33.00
32.87
31.30
28.47
24.33
f1 (ppm)


-62.83
f1 (ppm)

7.6.2 3f (C_1)

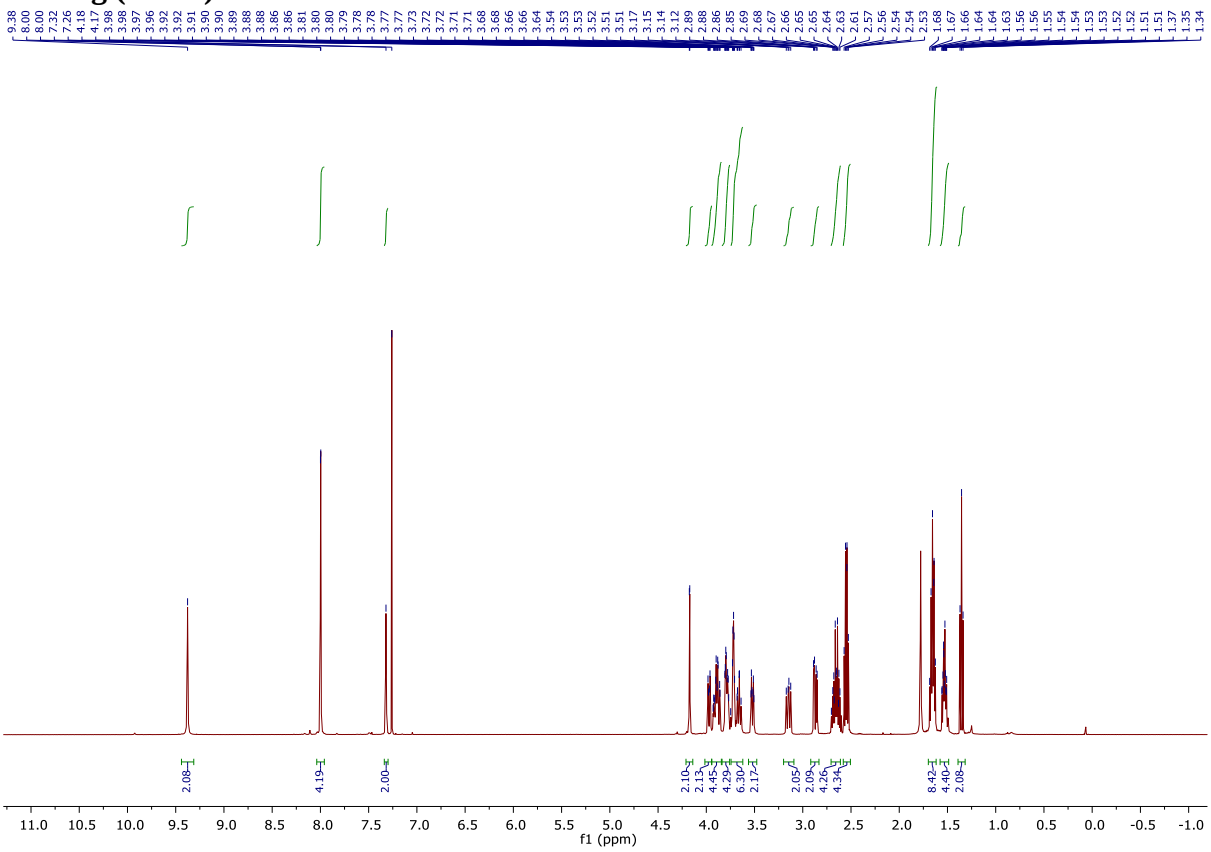


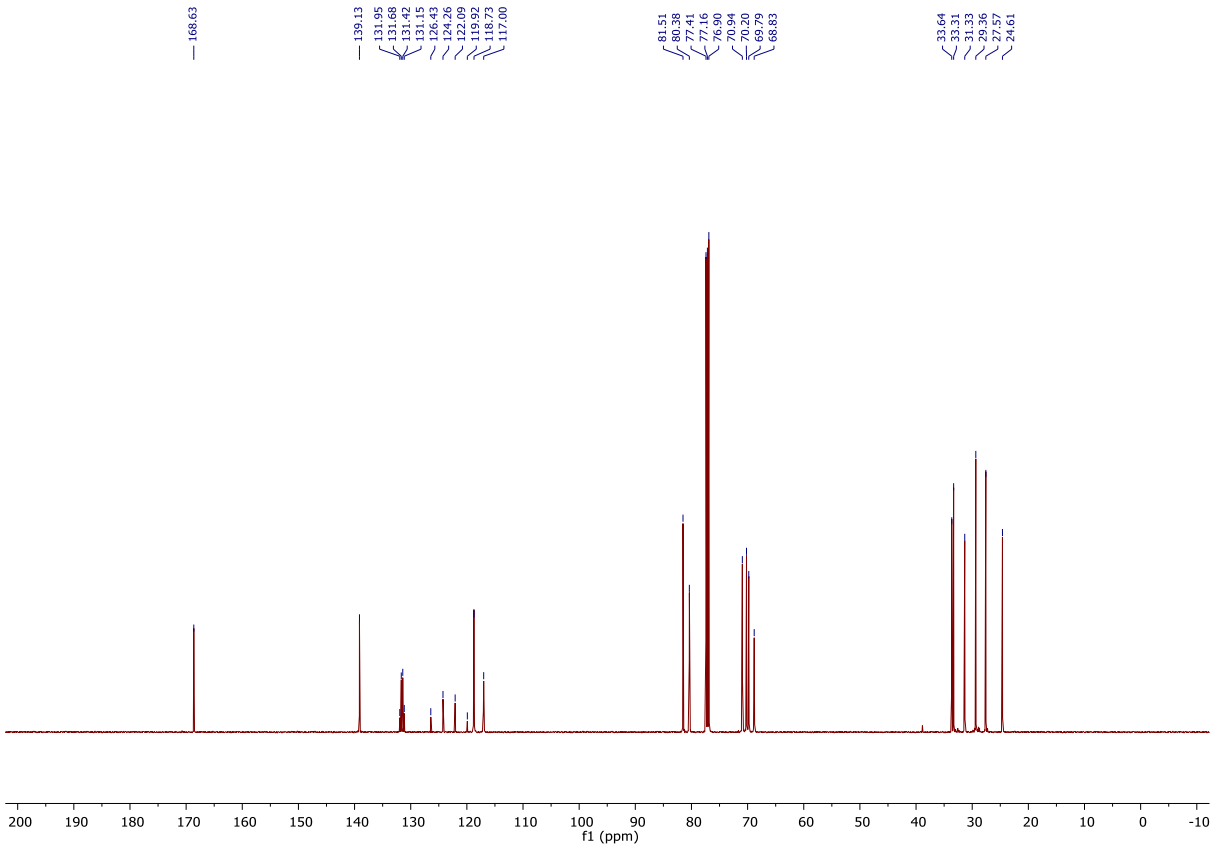

170.71
169.56
139.43
139.34
132.44
132.19
132.16
131.93
131.90
131.66
131.63
126.52
124.35
122.18
120.01
119.42
117.66
117.40
81.98
80.98
80.43
80.27
77.42
77.16
76.91
71.64
71.23
70.96
70.85
70.47
70.17
70.02
68.75
33.00
32.87
32.52
32.29
32.11
31.31
28.24
28.10
24.30
24.28
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
f1 (ppm)

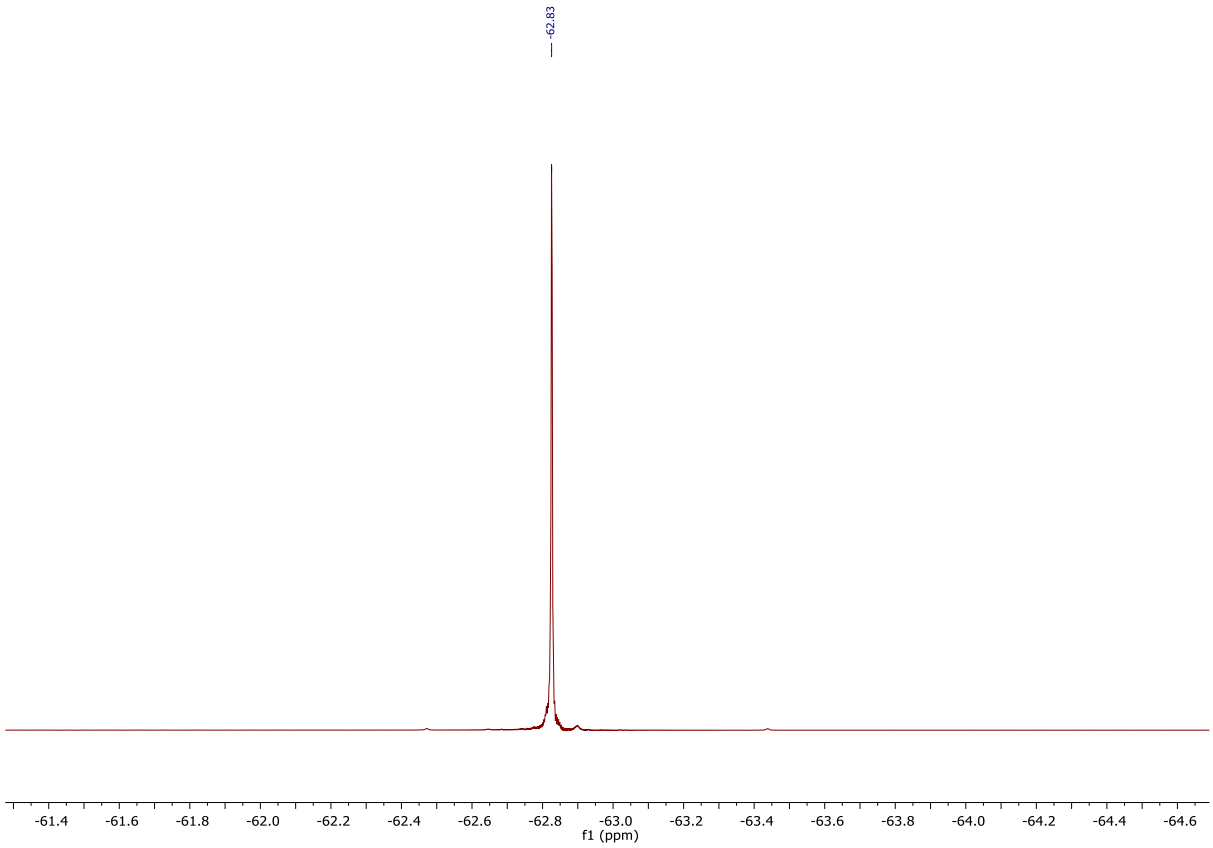

-62.85
-62.91
-60.2 -60.4 -60.6 -60.8 -61.0 -61.2 -61.4 -61.6 -61.8 -62.0 -62.2 -62.4 -62.6 -62.8 -63.0 -63.2 -63.4 -63.6 -63.8 -64.0 -64.2 -64.4 -64.6 -64.8 -65.0 -65.2 -65.4 -65.6 -65
f1 (ppm)

7.7 Spectra of 3g

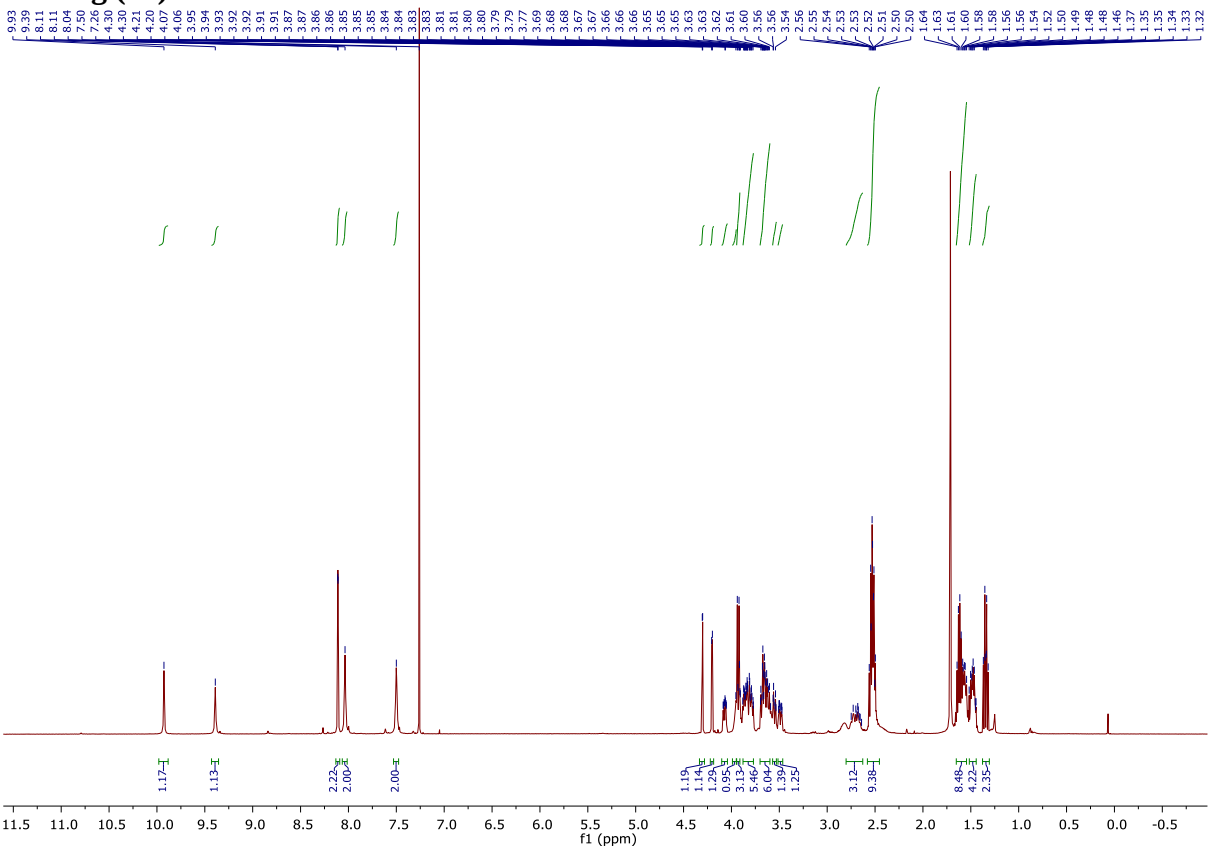
7.7.1 3g (*C*$_2$-*cis*)

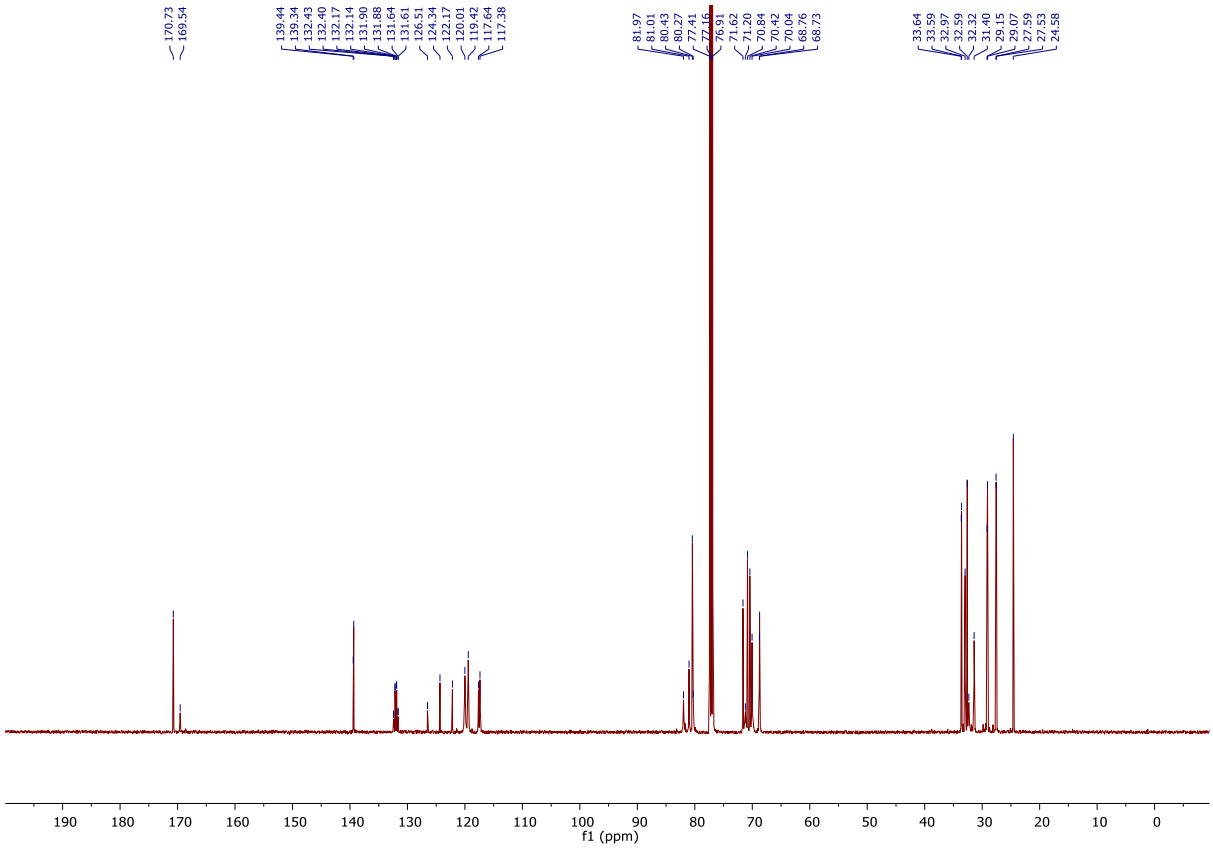


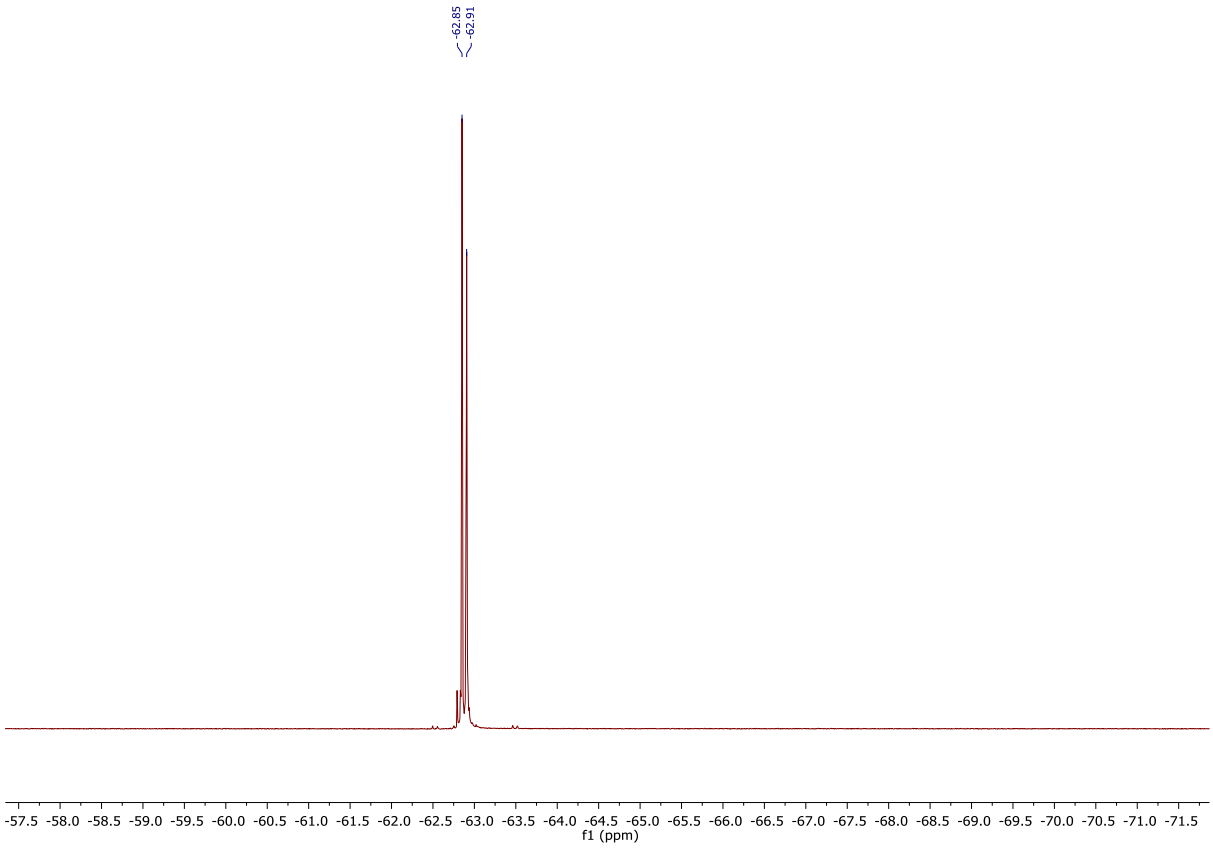

168.63
139.13
131.95
131.68
131.42
131.15
126.43
124.26
122.09
119.92
118.73
117.00
81.51
80.38
77.41
77.16
76.90
70.94
70.20
69.79
68.83
33.64
33.31
31.33
29.36
27.57
24.61
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


-62.83
-61.4 -61.6 -61.8 -62.0 -62.2 -62.4 -62.6 -62.8 -63.0 -63.2 -63.4 -63.6 -63.8 -64.0 -64.2 -64.4 -64.6
f1 (ppm)

7.7.2 3g (C_1)

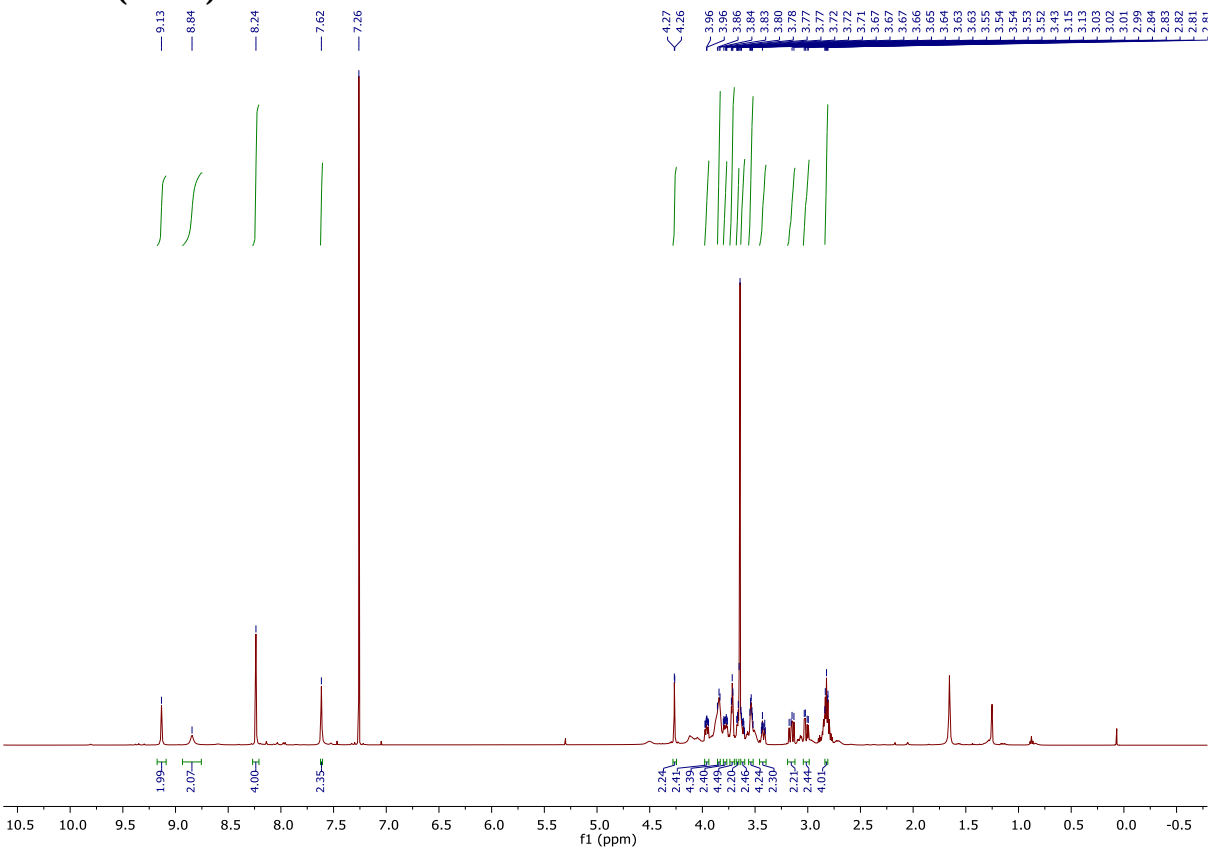


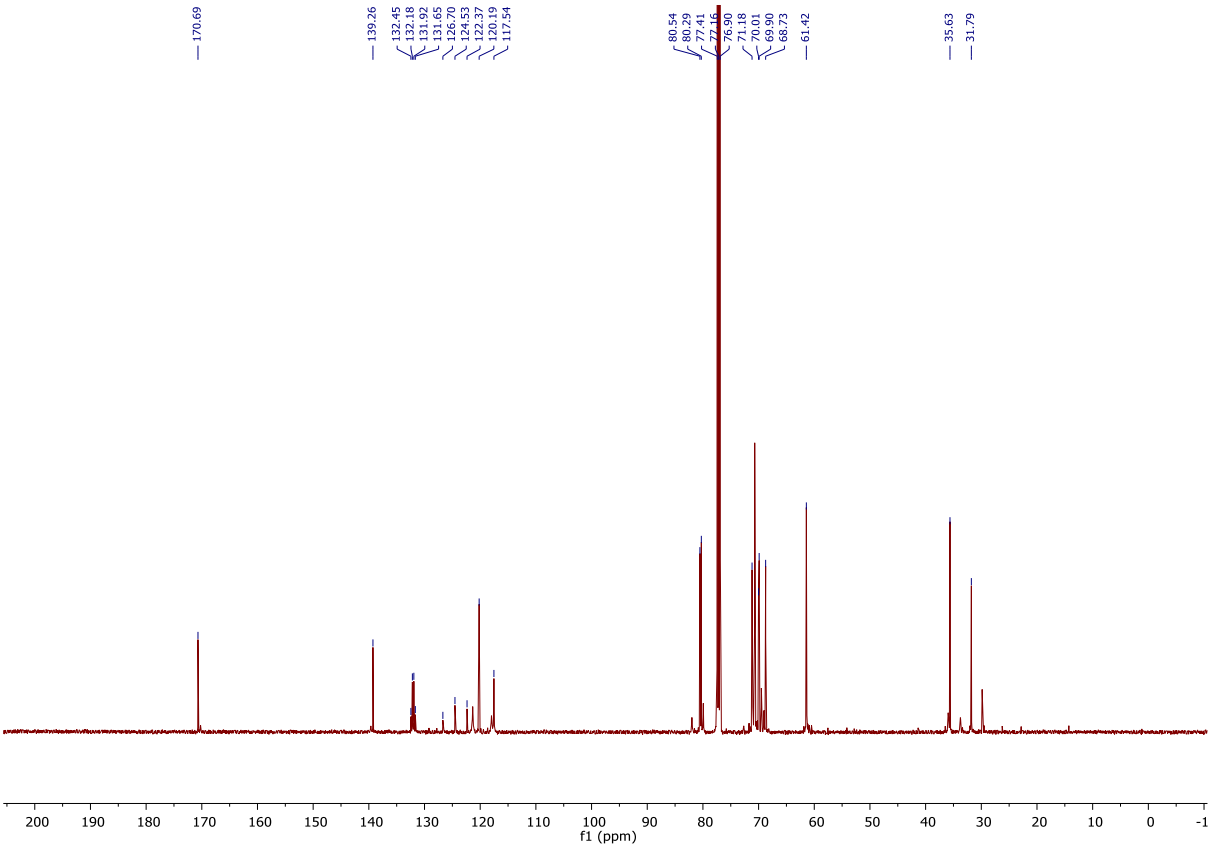

170.73
169.54
139.44
139.34
132.43
132.40
132.17
132.14
131.90
131.88
131.64
131.61
126.51
124.34
122.17
120.01
119.42
117.64
117.38
81.97
81.01
80.43
80.27
77.41
77.16
76.91
71.62
71.20
70.84
70.42
70.04
68.76
68.73
33.64
33.59
32.97
32.59
32.32
31.40
29.15
29.07
27.59
27.53
24.58
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

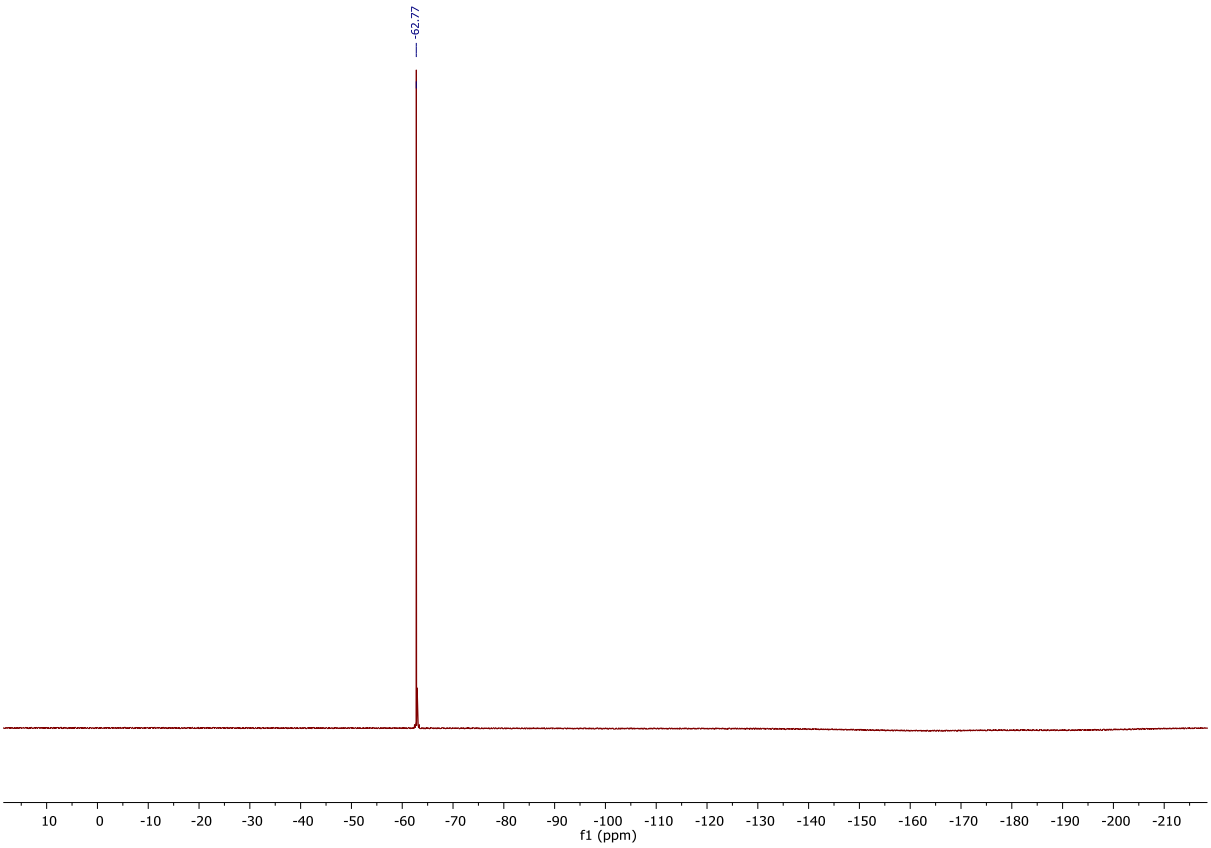

-62.85
-62.91
-57.5 -58.0 -58.5 -59.0 -59.5 -60.0 -60.5 -61.0 -61.5 -62.0 -62.5 -63.0 -63.5 -64.0 -64.5 -65.0 -65.5 -66.0 -66.5 -67.0 -67.5 -68.0 -68.5 -69.0 -69.5 -70.0 -70.5 -71.0 -71.5
f1 (ppm)

7.8 Spectra of 3h

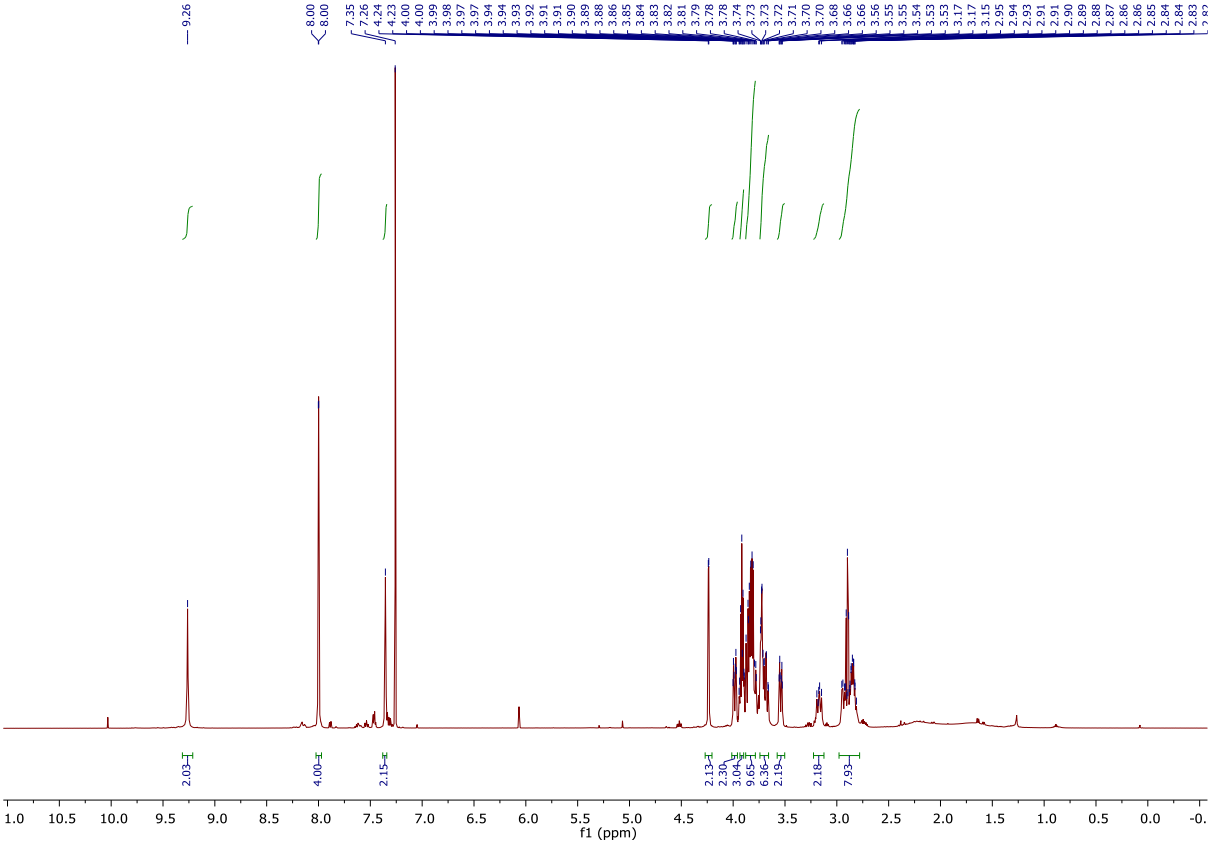
7.8.1 3h (*C*$_2$-*cis*)

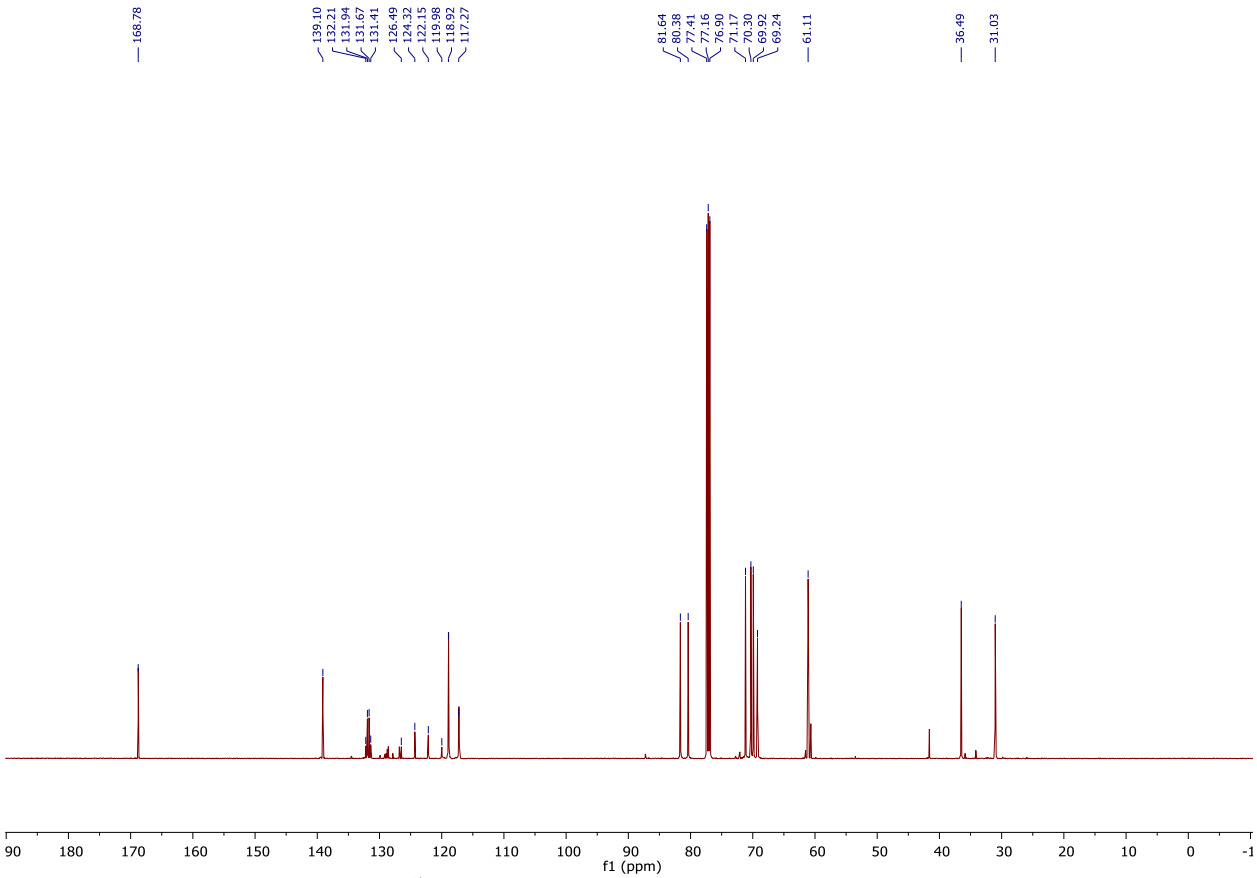


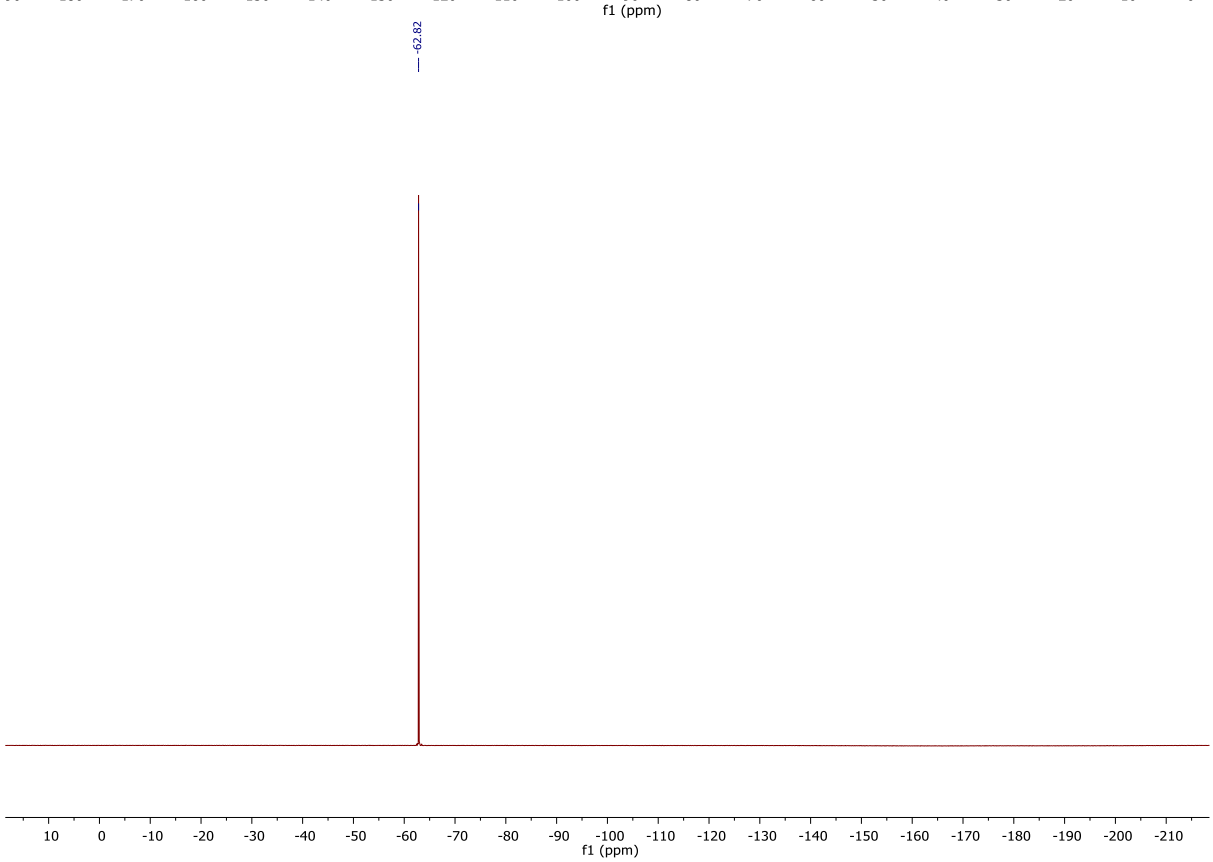

170.69
139.26
132.45
132.18
131.92
131.65
126.70
124.53
122.37
120.19
117.54
80.54
80.29
77.41
77.16
76.90
71.18
70.01
69.90
68.73
61.42
35.63
31.79
f1 (ppm)


-62.77
f1 (ppm)

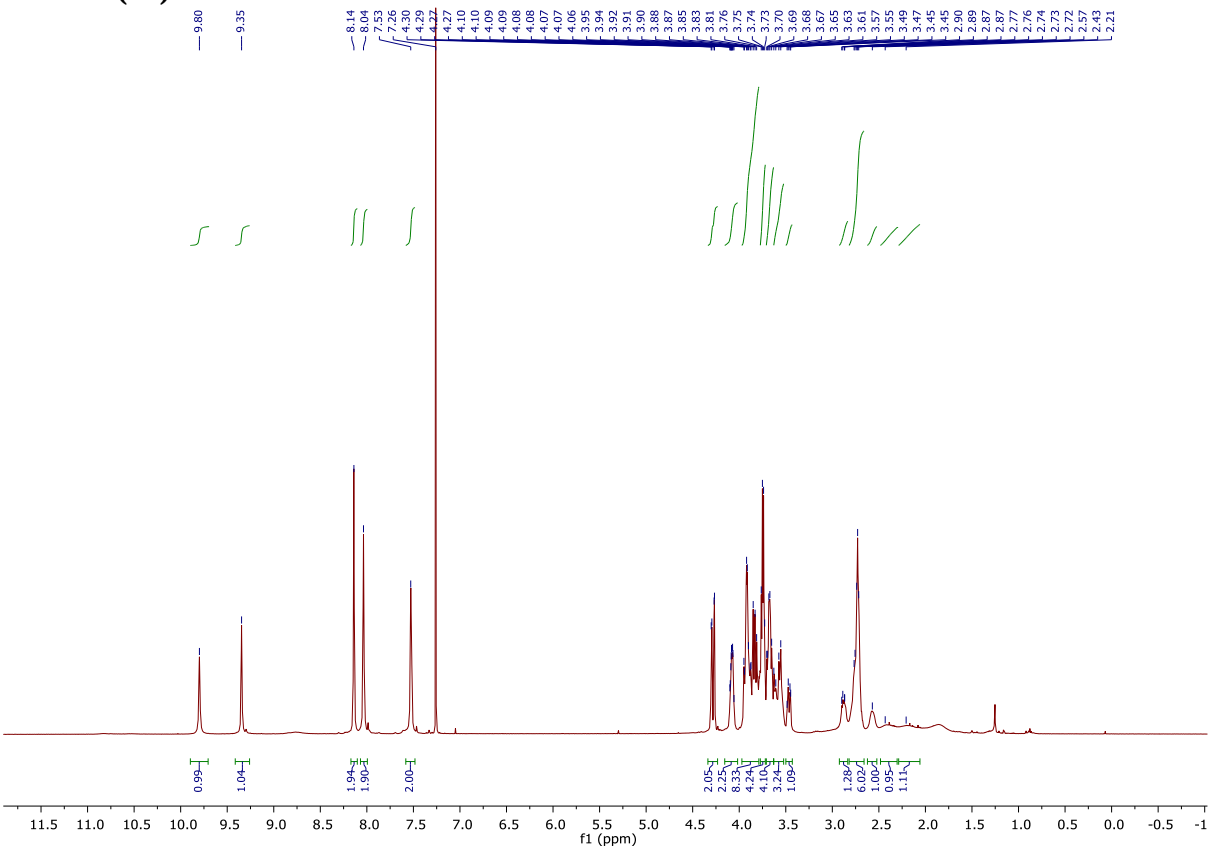
7.8.2 3h (*C*$_2$-*trans*)

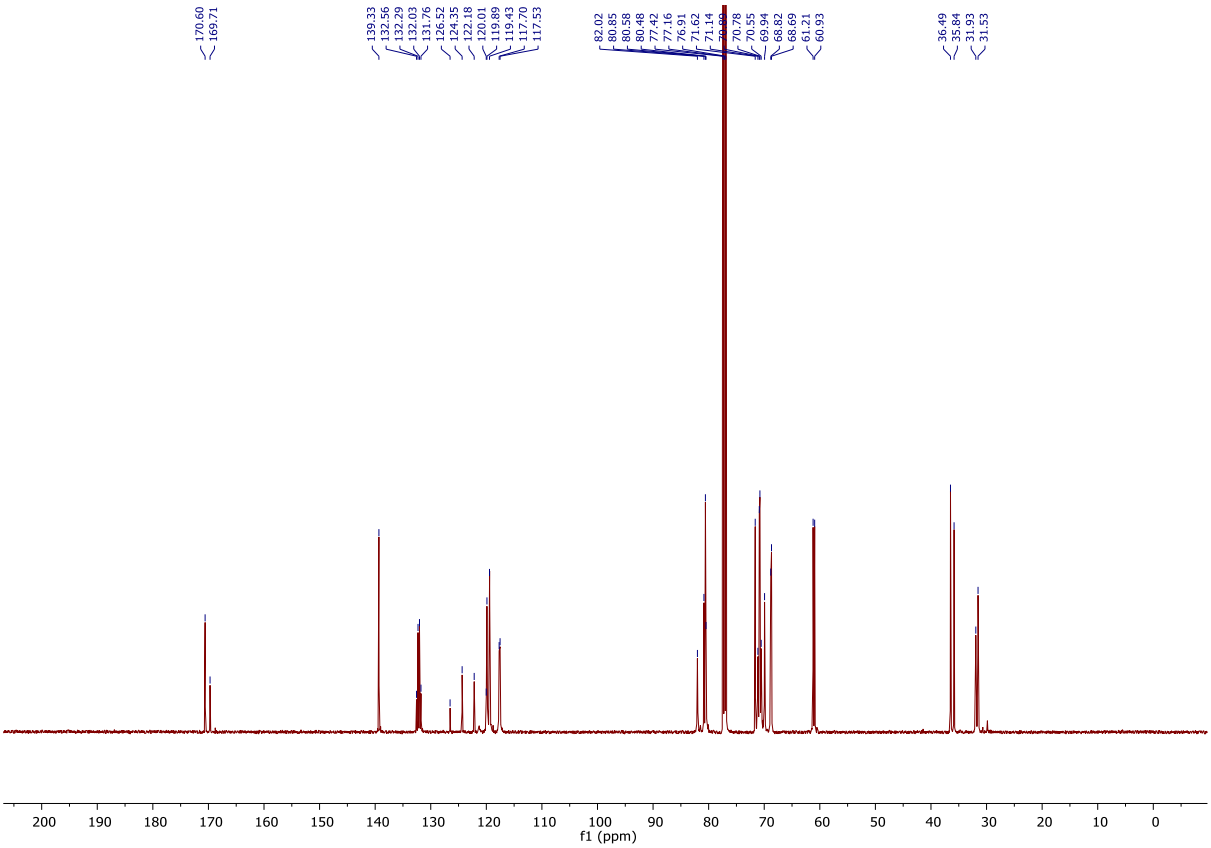


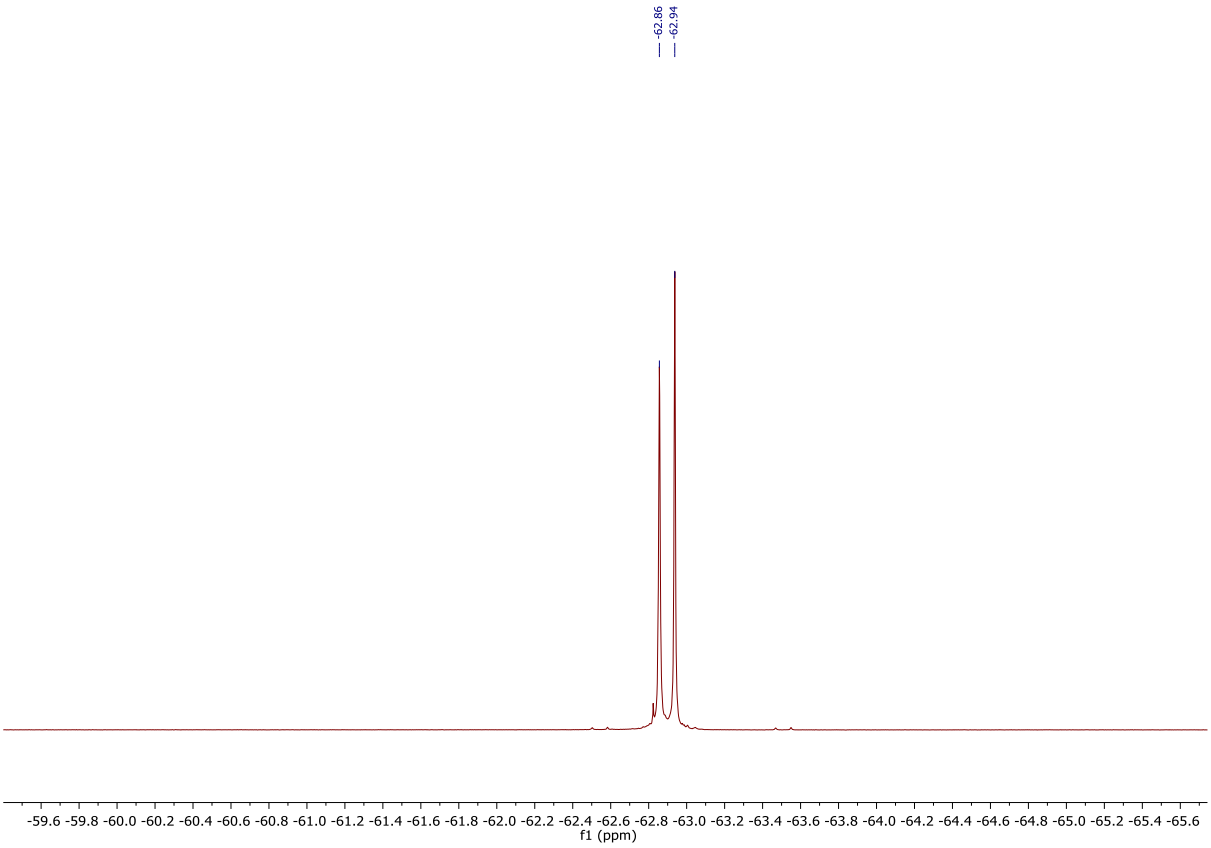

168.78
139.10
132.21
131.94
131.67
131.41
126.49
124.32
122.15
119.98
118.92
117.27
81.64
80.38
77.41
77.16
76.90
71.17
70.30
69.92
69.24
61.11
36.49
31.03
f1 (ppm)


-62.82
f1 (ppm)

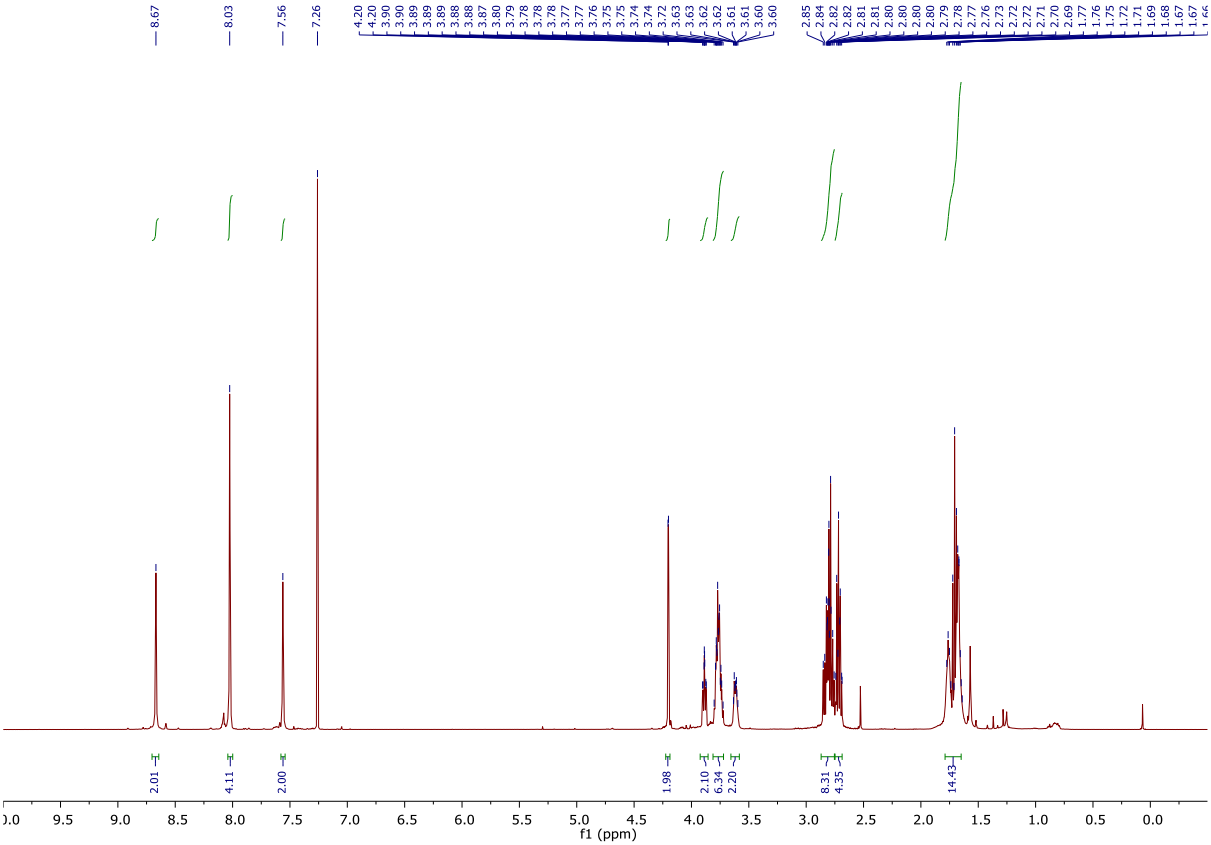
7.8.3 3h (C_1)

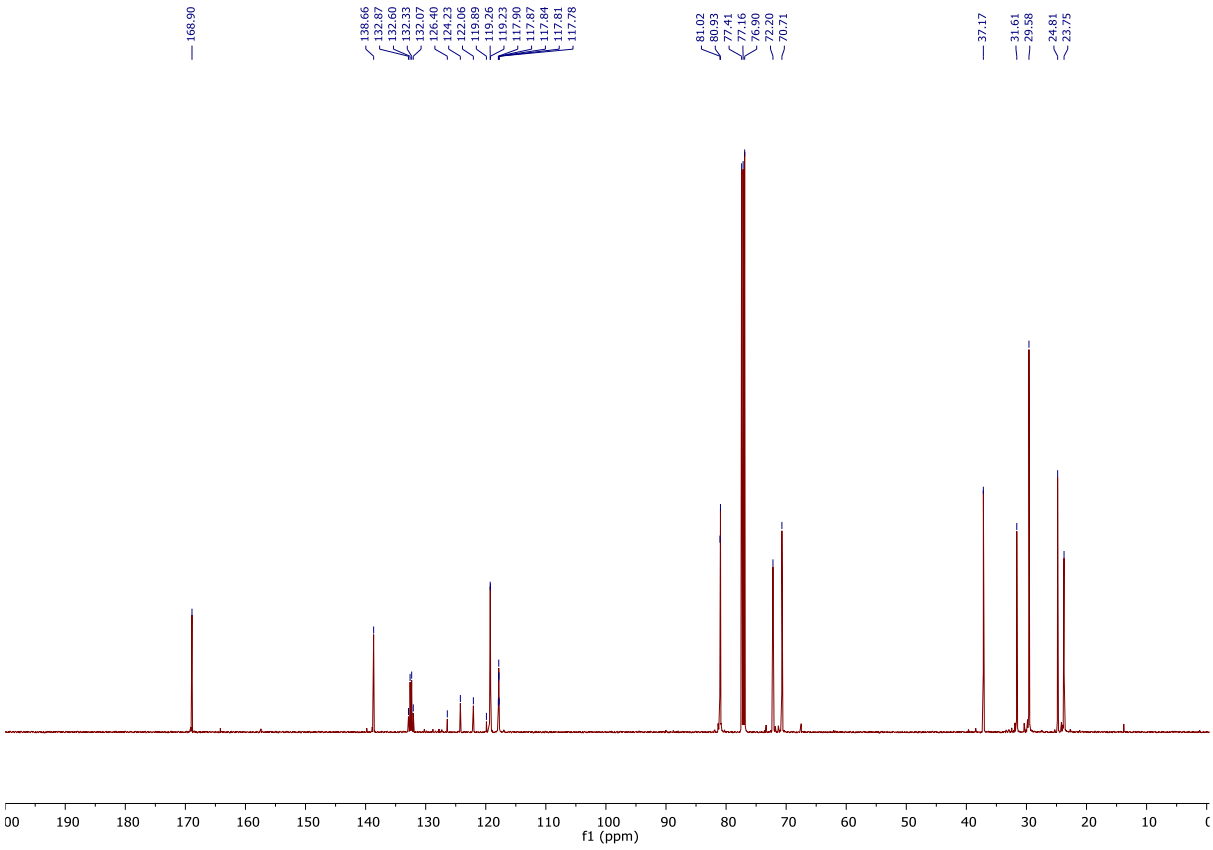

9.80
9.35
8.14
8.04
7.53
7.26
4.30
4.29
4.27
4.10
4.09
4.08
4.07
4.06
3.95
3.94
3.92
3.91
3.90
3.88
3.87
3.85
3.83
3.81
3.76
3.75
3.74
3.73
3.70
3.69
3.68
3.67
3.65
3.63
3.61
3.57
3.55
3.49
3.47
3.45
2.90
2.89
2.87
2.77
2.76
2.74
2.73
2.72
2.57
2.43
2.21
0.99
1.04
1.94
1.90
2.00
2.05
2.25
8.33
4.24
4.10
3.24
1.09
1.28
6.02
1.00
0.95
1.11
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

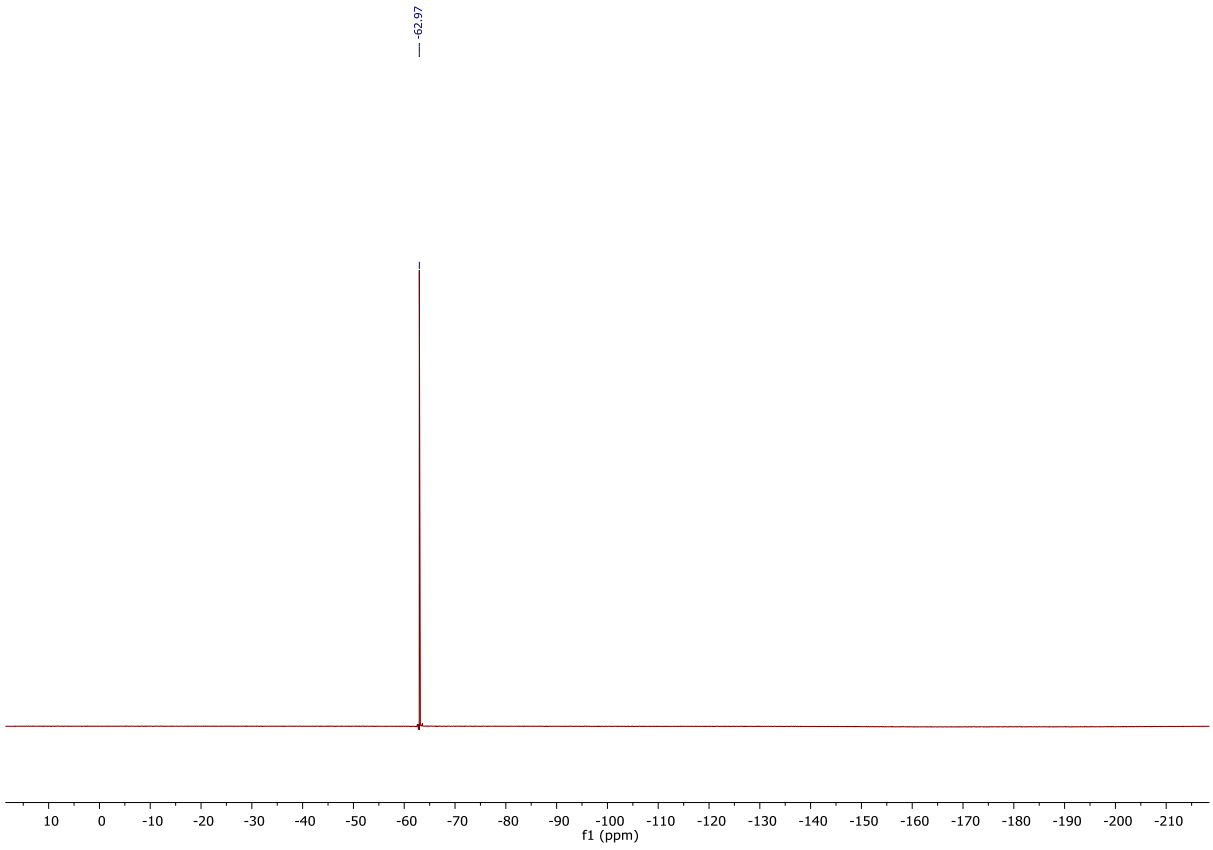

170.60
169.71
139.33
132.56
132.29
132.03
131.76
126.52
124.35
122.18
120.01
119.89
119.43
117.70
117.53
82.02
80.85
80.58
80.48
77.42
77.16
76.91
71.62
71.14
70.78
70.55
69.94
68.82
68.69
61.21
60.93
36.49
35.84
31.93
31.53
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-62.86
-62.94
-59.6 -59.8 -60.0 -60.2 -60.4 -60.6 -60.8 -61.0 -61.2 -61.4 -61.6 -61.8 -62.0 -62.2 -62.4 -62.6 -62.8 -63.0 -63.2 -63.4 -63.6 -63.8 -64.0 -64.2 -64.4 -64.6 -64.8 -65.0 -65.2 -65.4 -65.6
f1 (ppm)

7.9 Spectra of 5 (C_2-*cis*)

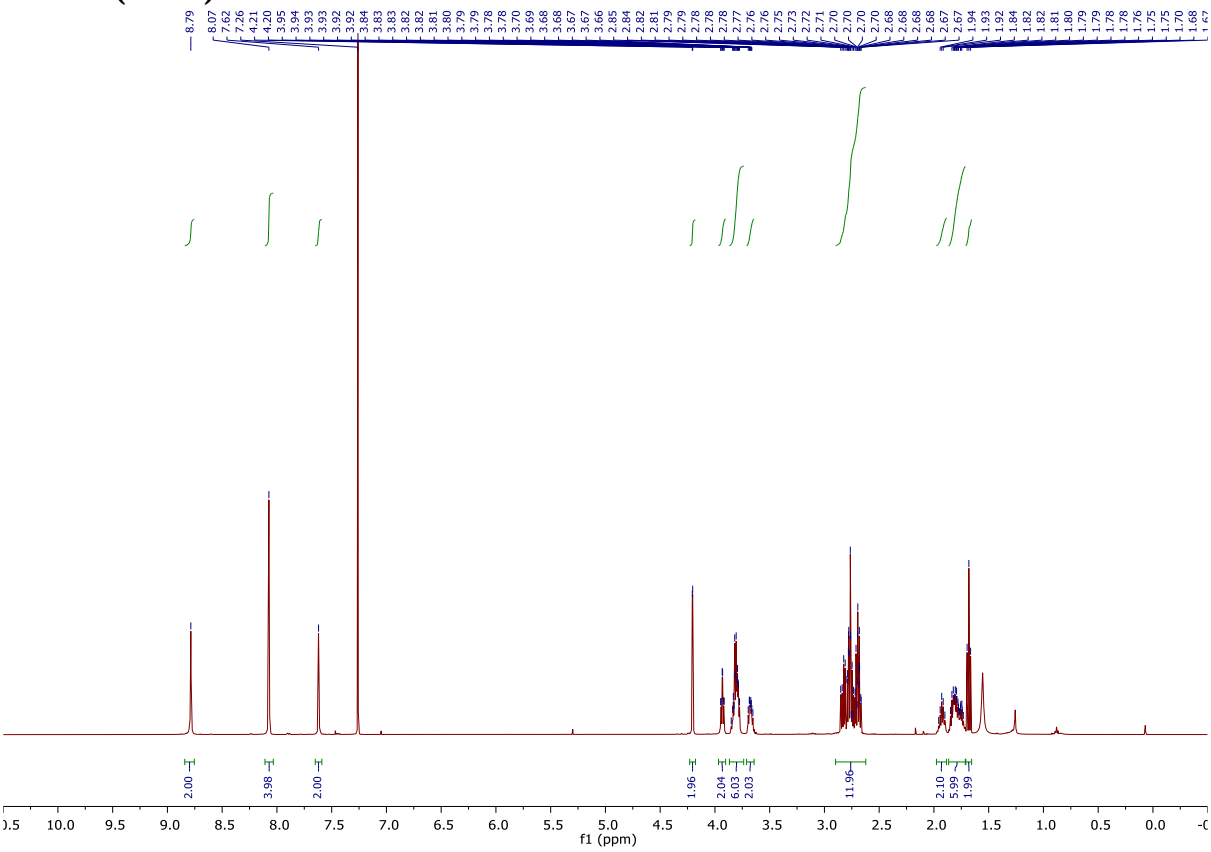


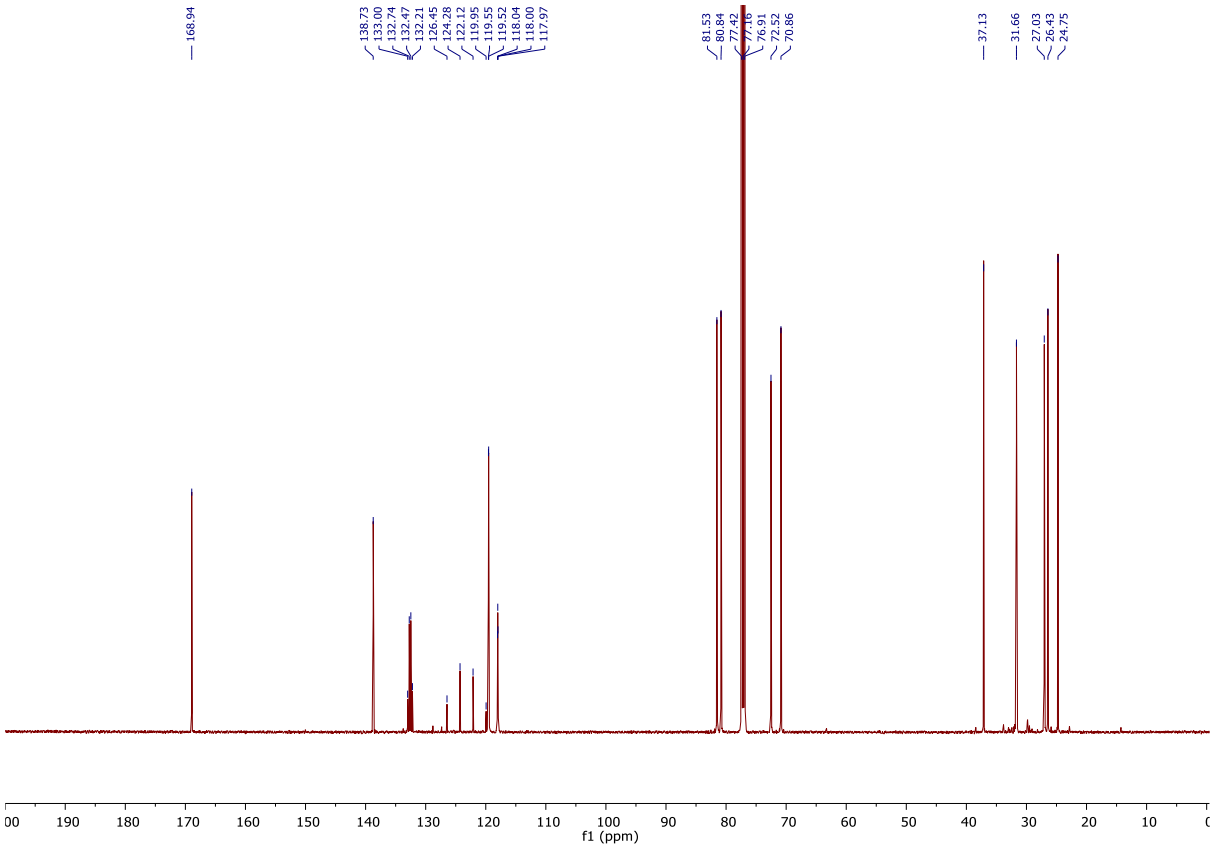

168.90
138.66
132.87
132.60
132.33
132.07
126.40
124.23
122.06
119.89
119.26
119.23
117.90
117.87
117.84
117.81
117.78
81.02
80.93
77.41
77.16
76.90
72.20
70.71
37.17
31.61
29.58
24.81
23.75
f1 (ppm)

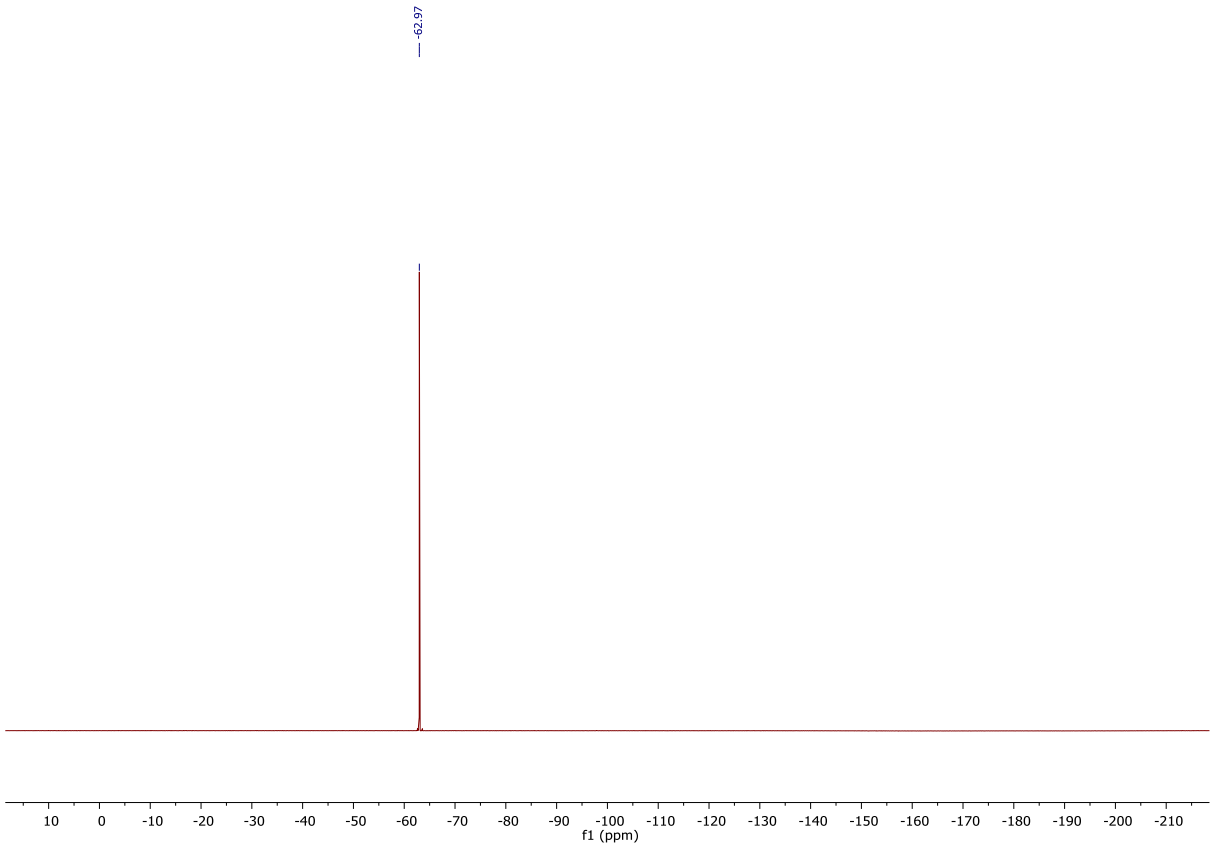

-62.97
f1 (ppm)

7.10 Spectra of 6

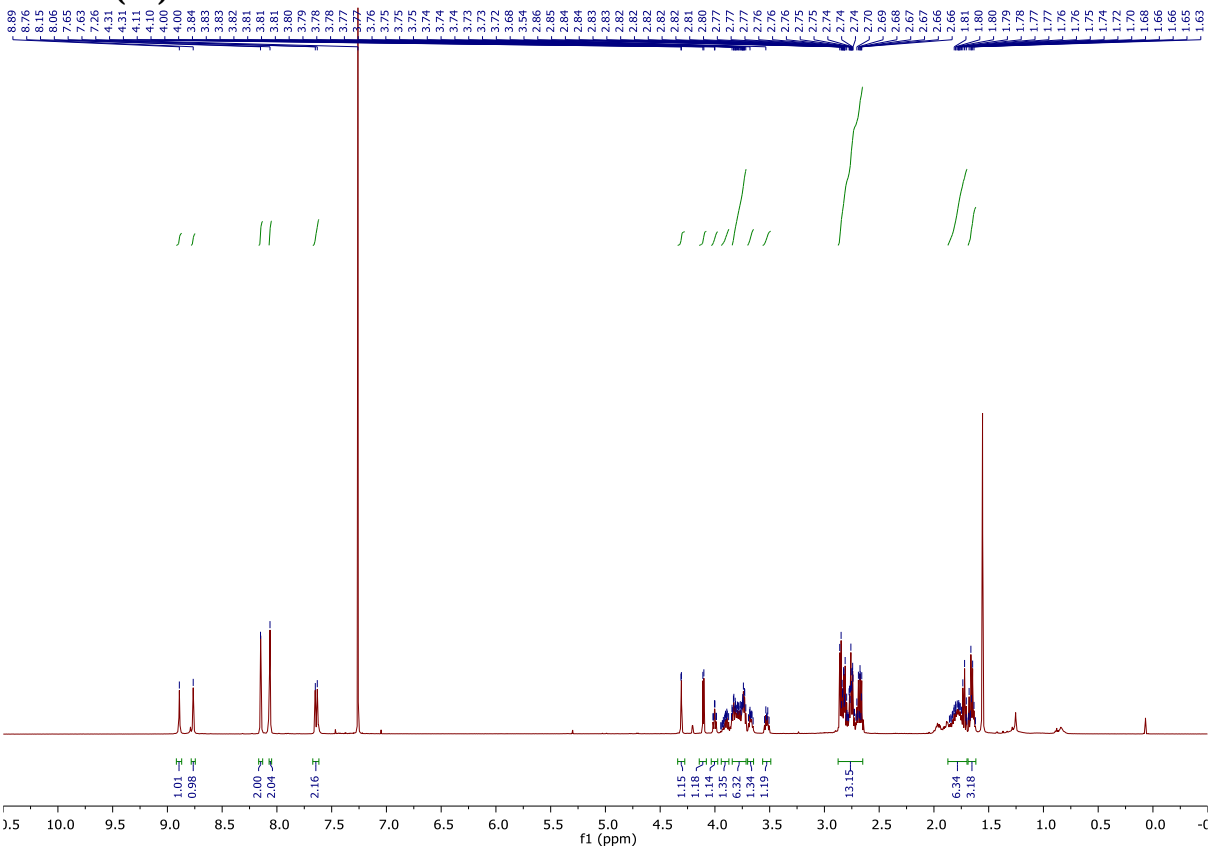
7.10.1 6 (*C*$_2$-*cis*)

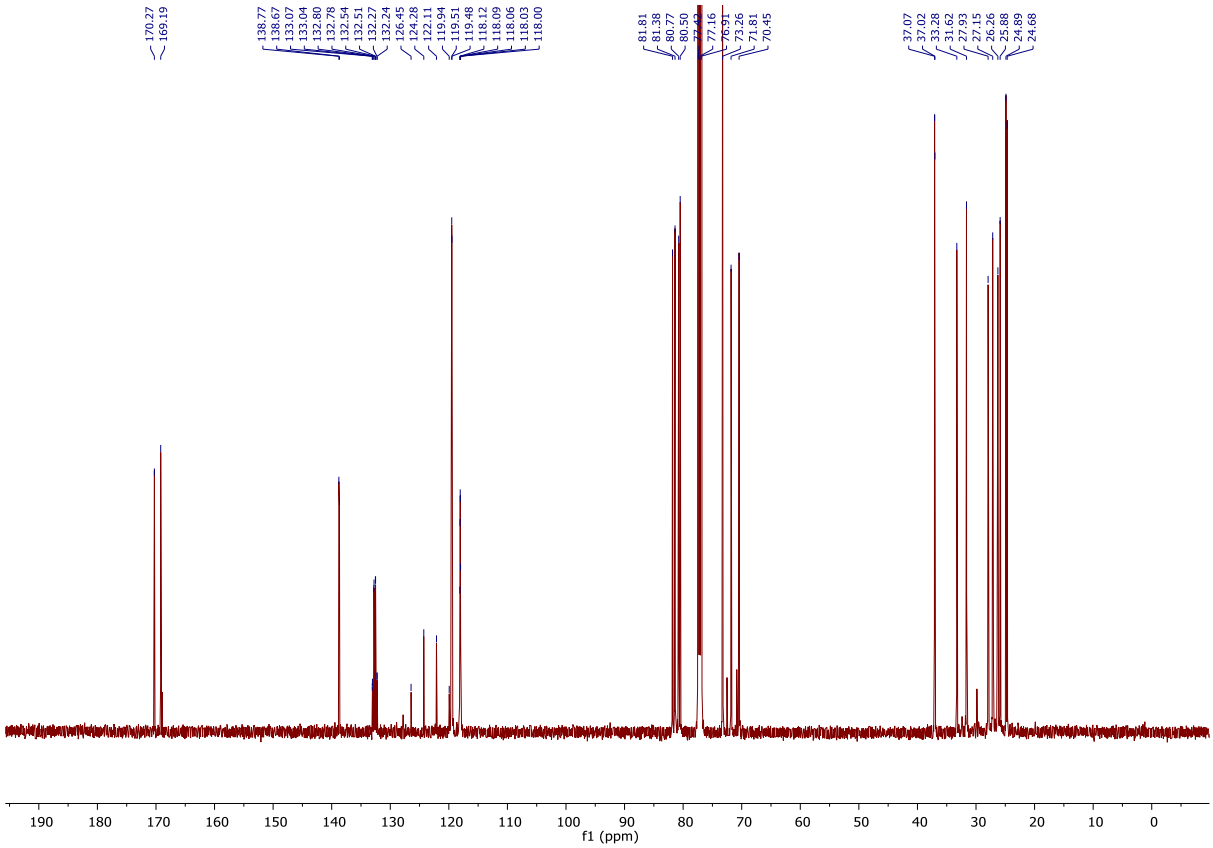


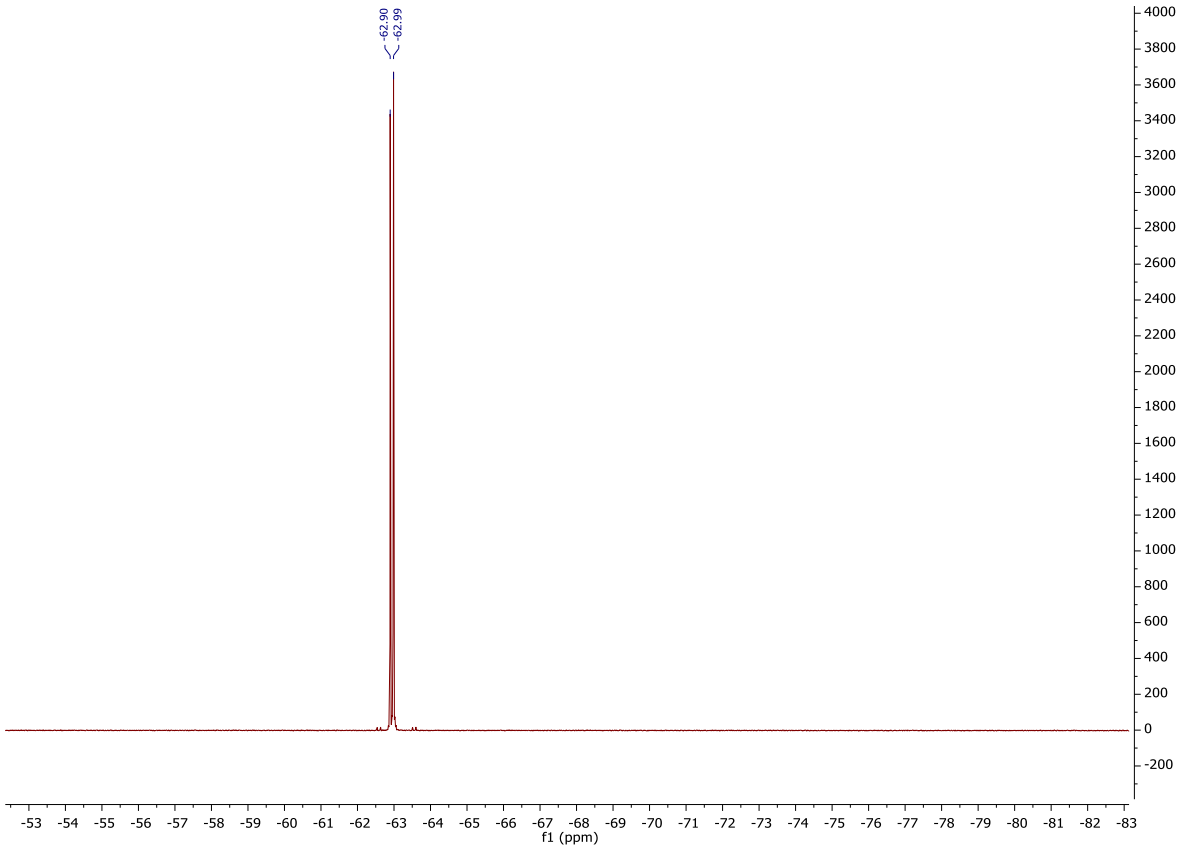

168.94
138.73
133.00
132.74
132.47
132.21
126.45
124.28
122.12
119.95
119.55
119.52
118.04
118.00
117.97
81.53
80.84
77.42
77.16
76.91
72.52
70.86
37.13
31.66
27.03
26.43
24.75
f1 (ppm)


-62.97
f1 (ppm)

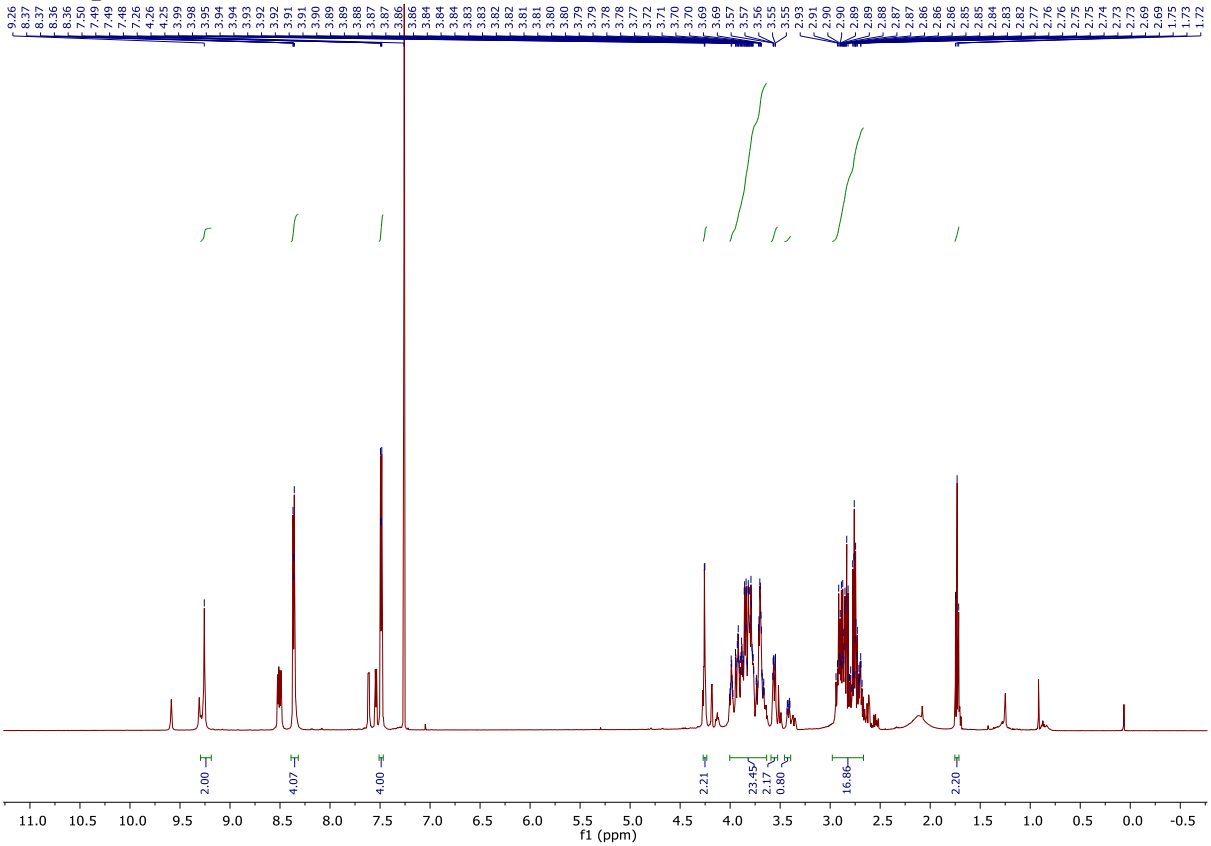
7.10.2 6 (C_1)

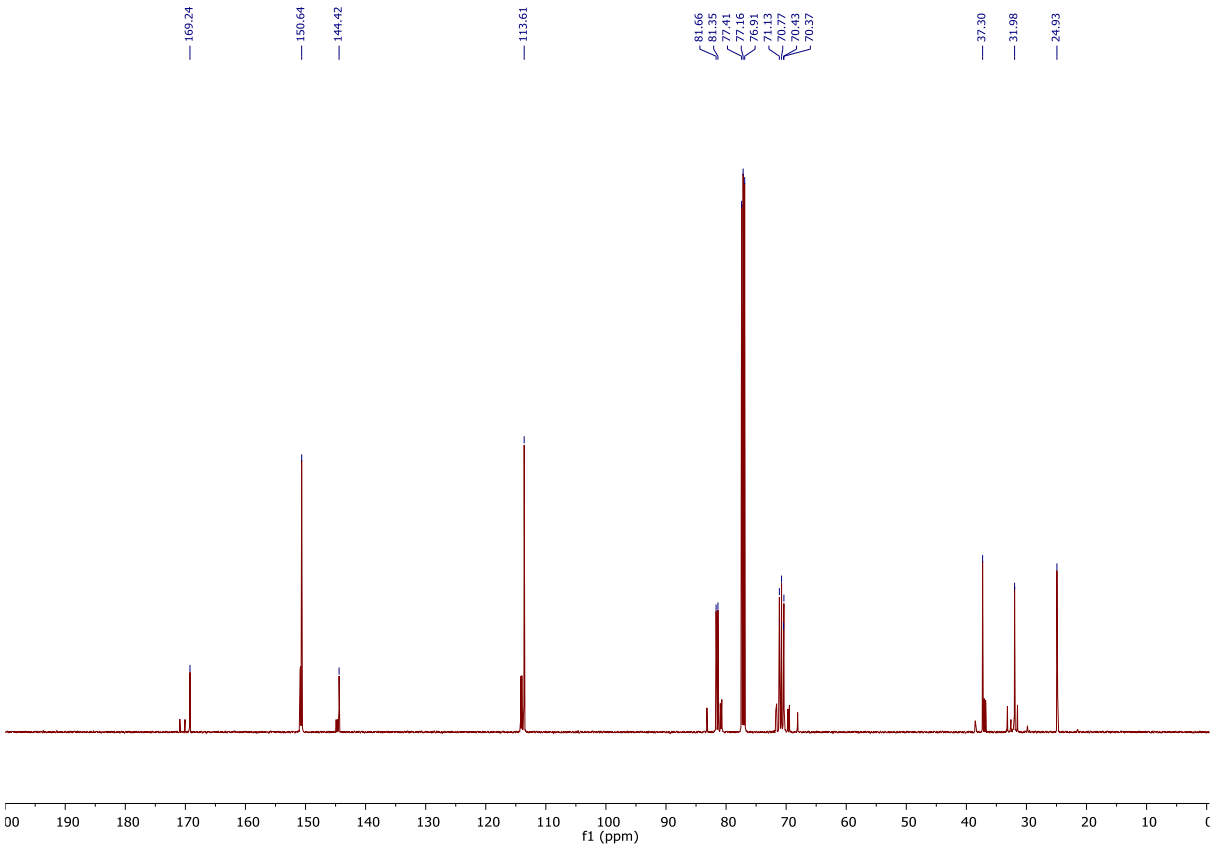



170.27
169.19
138.77
138.67
133.07
133.04
132.80
132.78
132.54
132.51
132.27
132.24
126.45
124.26
122.11
119.94
119.51
119.48
118.12
118.09
118.06
118.03
118.00
81.81
81.38
80.77
80.50
77.41
77.16
76.91
73.26
71.81
70.45
37.07
37.02
33.28
31.62
27.93
27.15
26.26
25.88
24.89
24.68
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

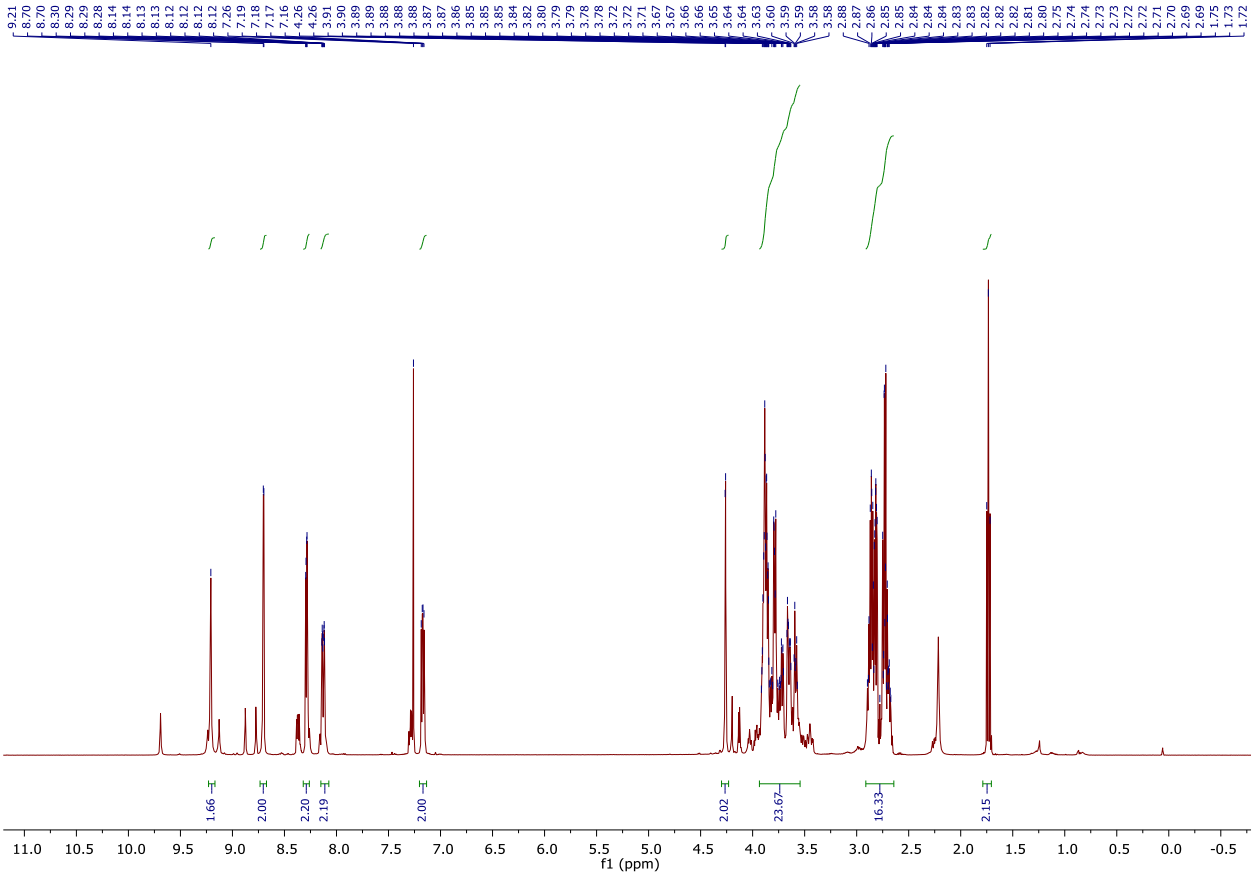

-62.90
-62.99
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400 200 0 -200
-53 -54 -55 -56 -57 -58 -59 -60 -61 -62 -63 -64 -65 -66 -67 -68 -69 -70 -71 -72 -73 -74 -75 -76 -77 -78 -79 -80 -81 -82 -83
f1 (ppm)

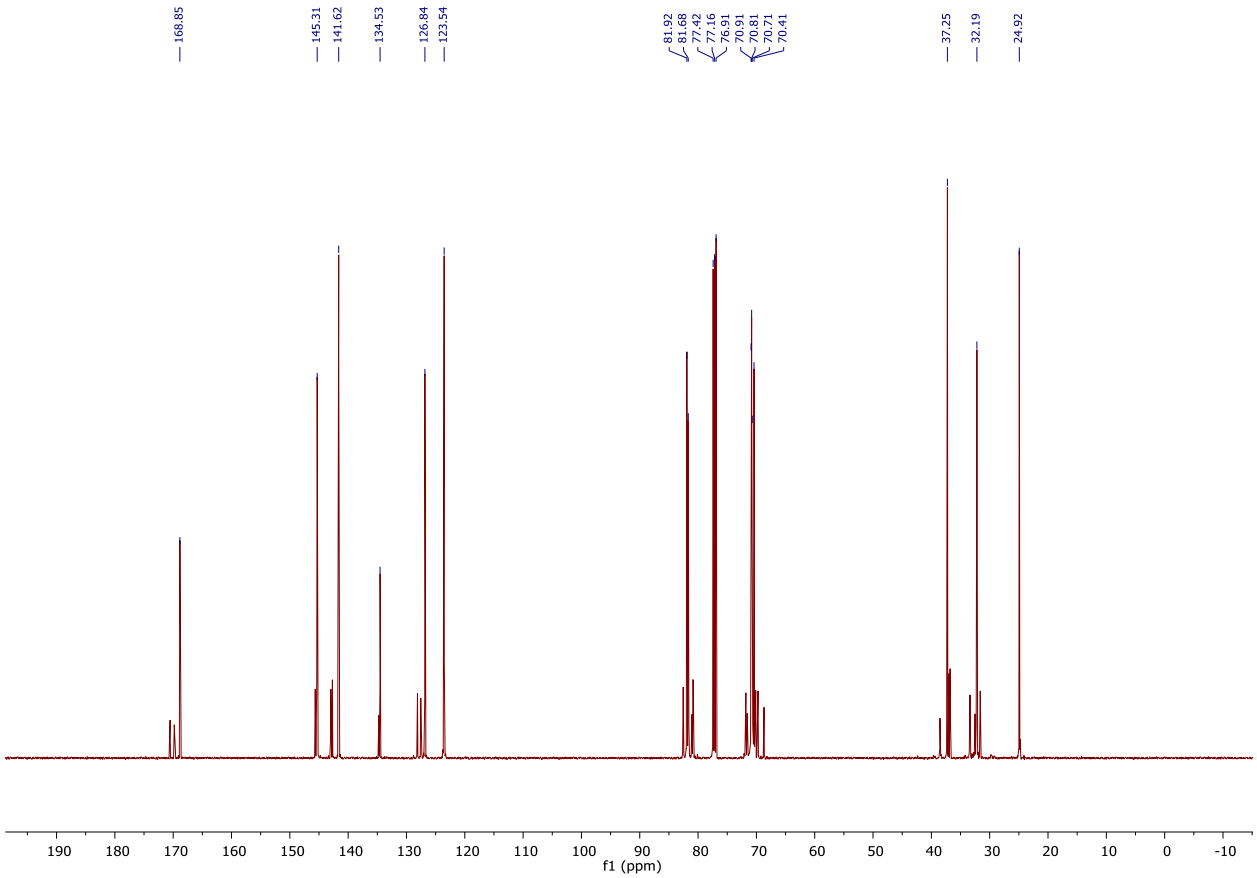
7.11 Spectra of 7



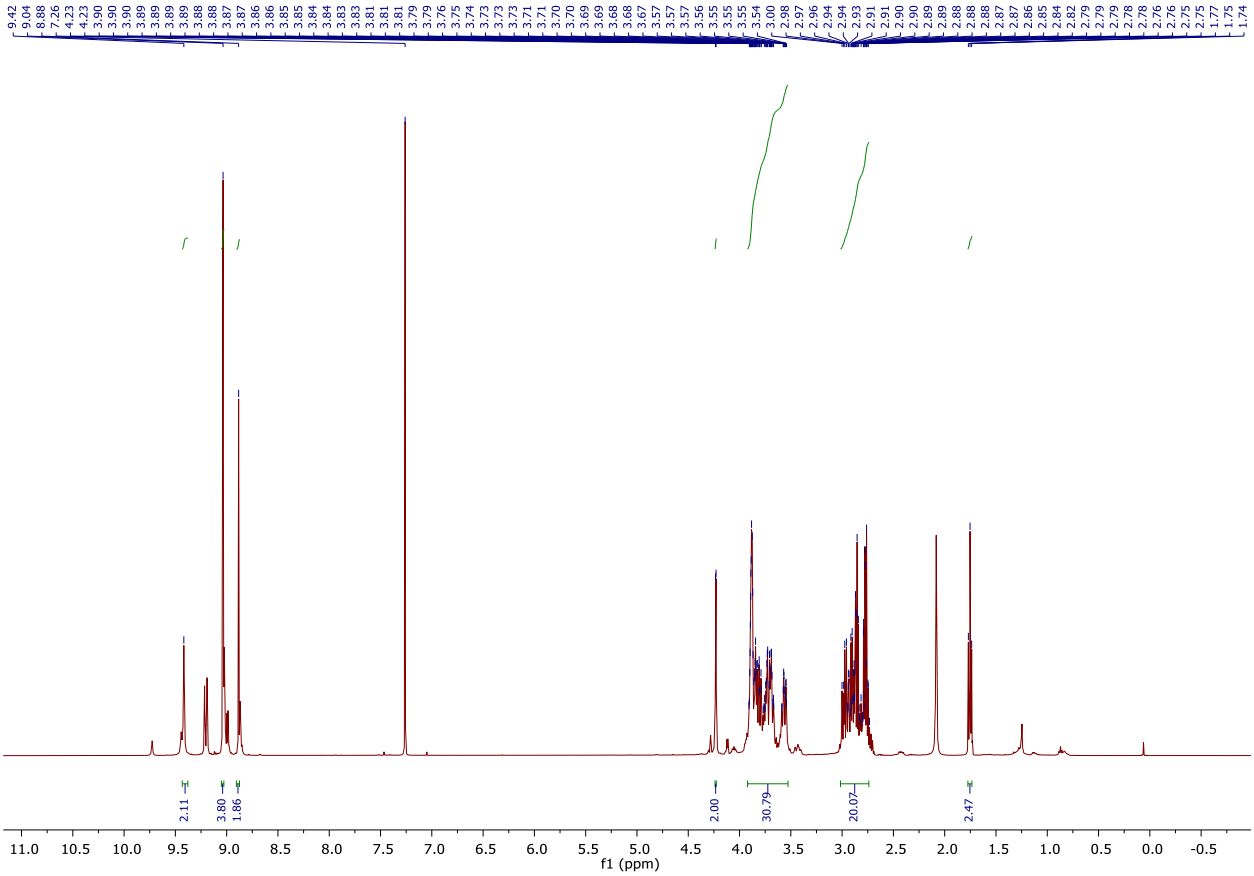

169.24
150.64
144.42
113.61
81.66
81.35
77.41
77.16
76.91
71.13
70.77
70.43
70.37
37.30
31.98
24.93
f1 (ppm)

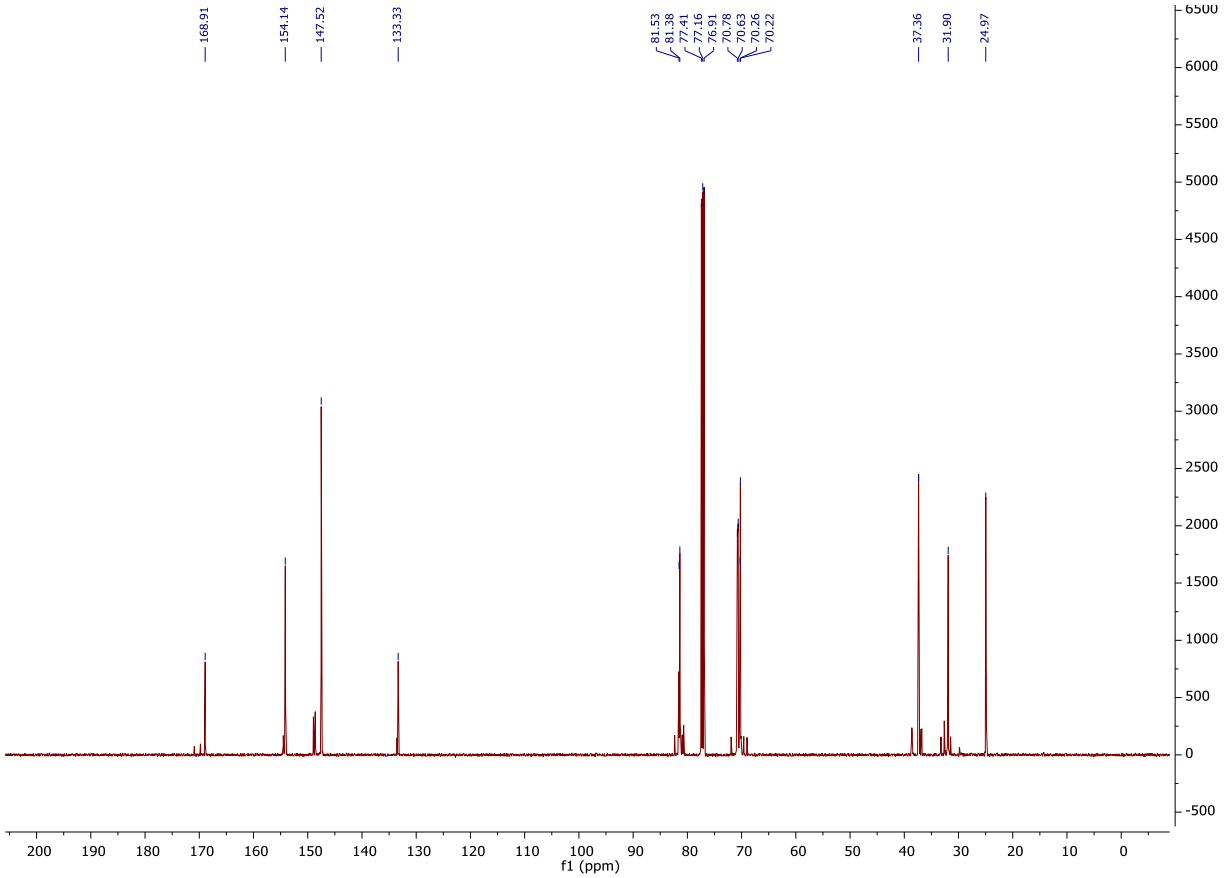
7.12 Spectra of 8




168.85
145.31
141.62
134.53
126.84
123.54
81.92
81.68
77.42
77.16
76.91
70.91
70.81
70.71
70.41
37.25
32.19
24.92
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

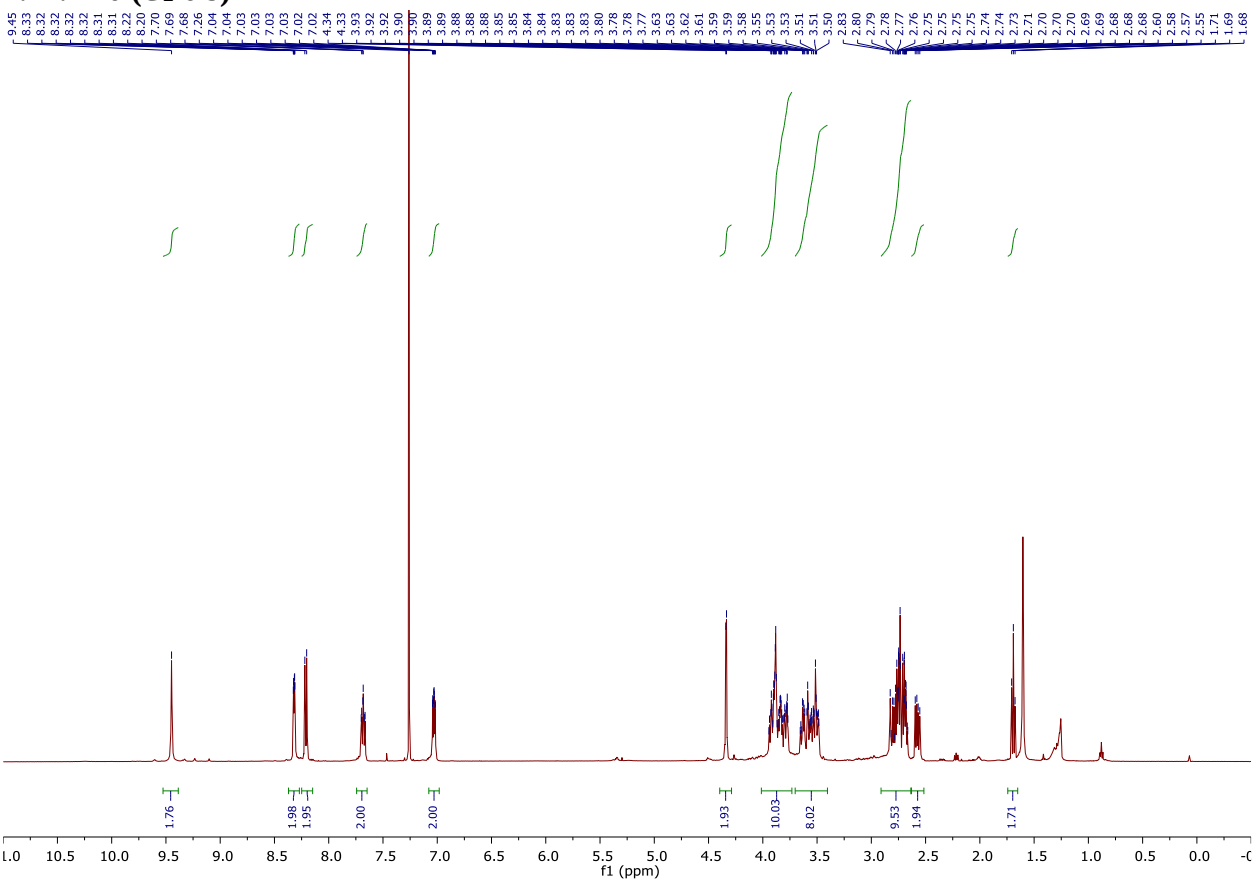
7.13 Spectra of 9

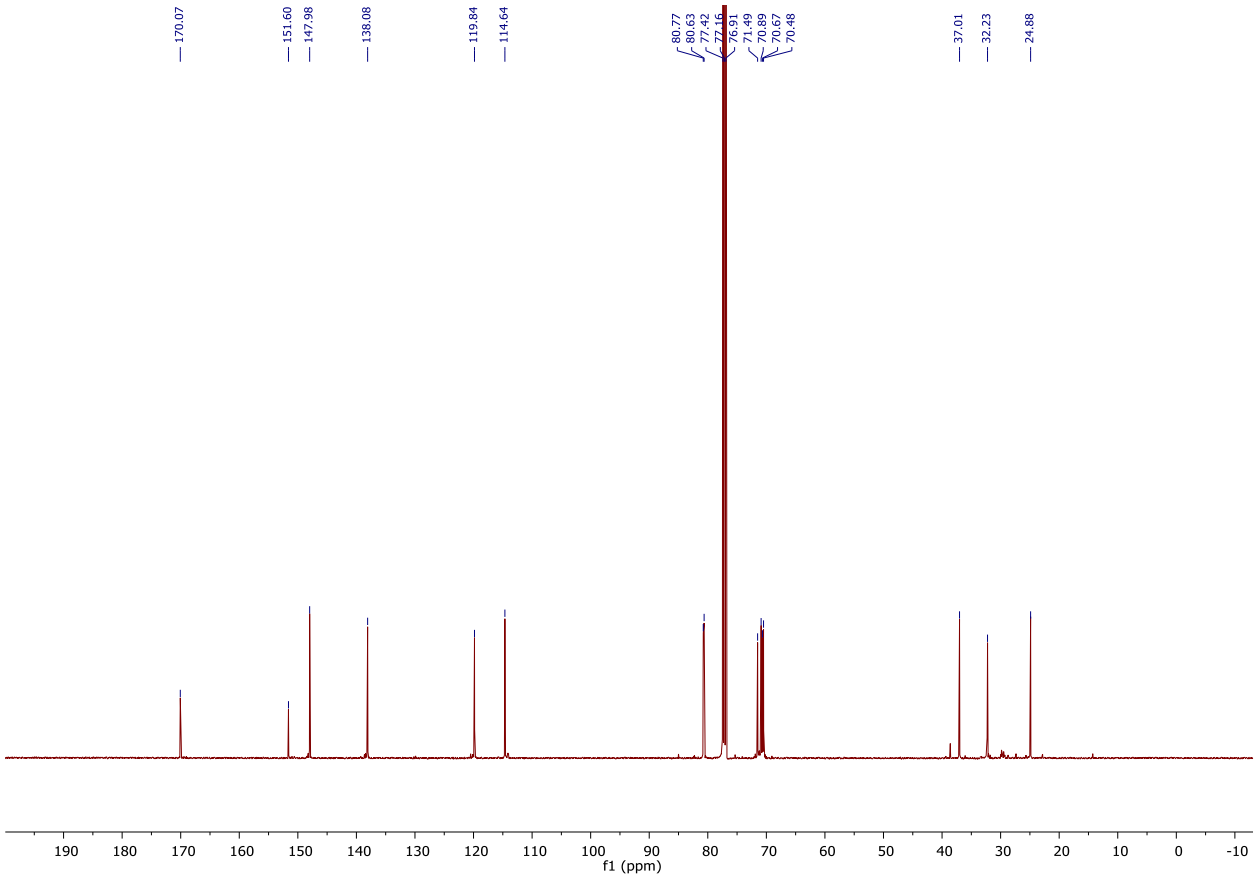



168.91
154.14
147.52
133.33
81.53
81.38
77.41
77.16
76.91
70.78
70.63
70.26
70.22
37.36
31.90
24.97
f1 (ppm)

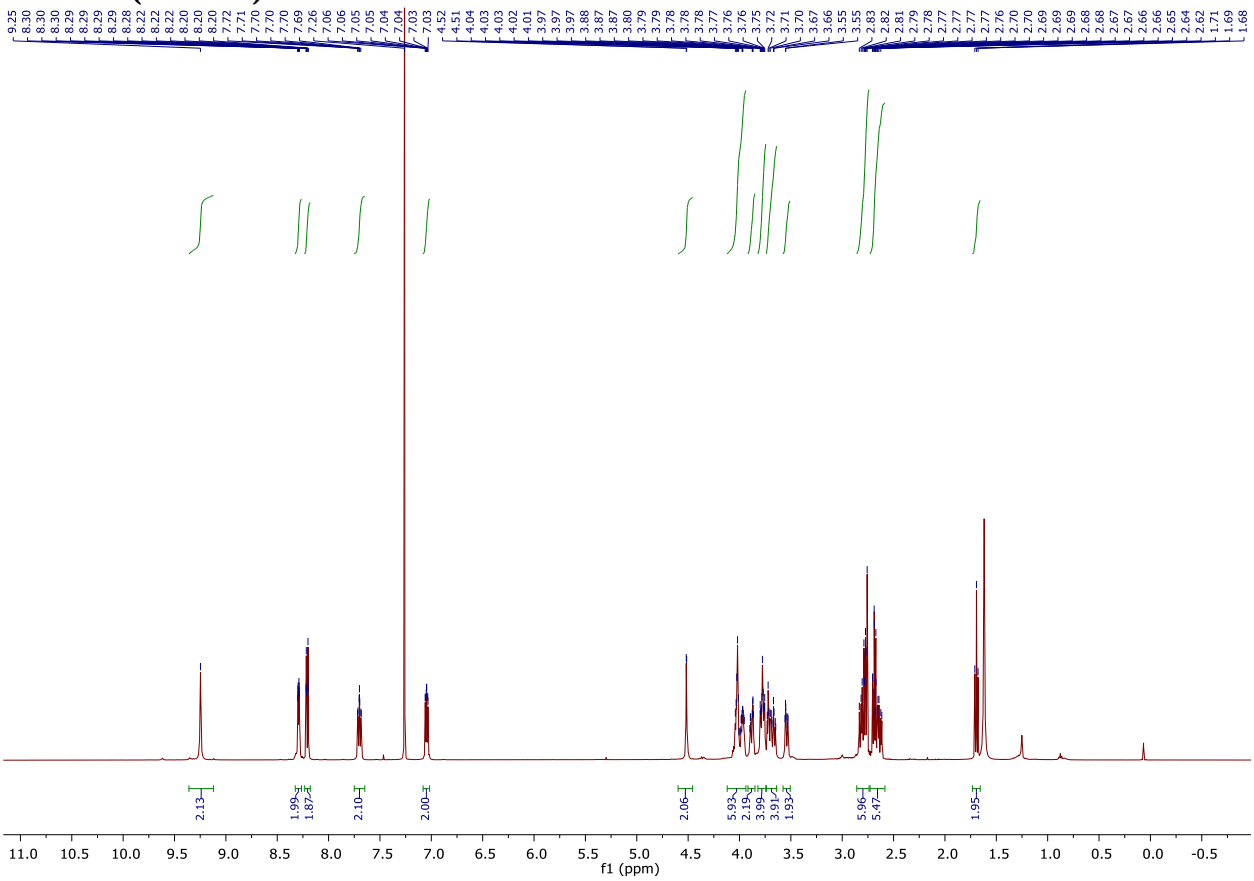
7.14 Spectra of 10

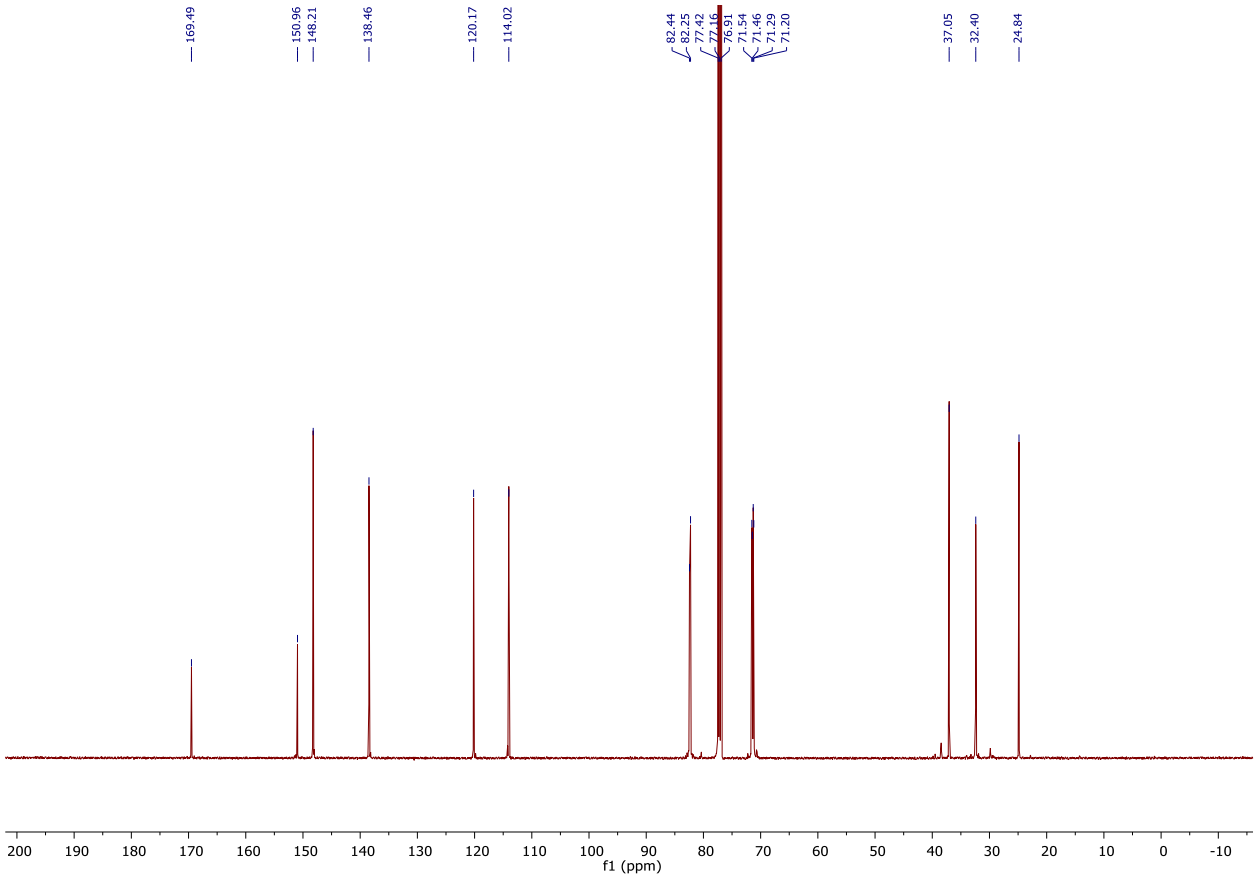
7.14.1 10 (*C*$_2$-*cis*)



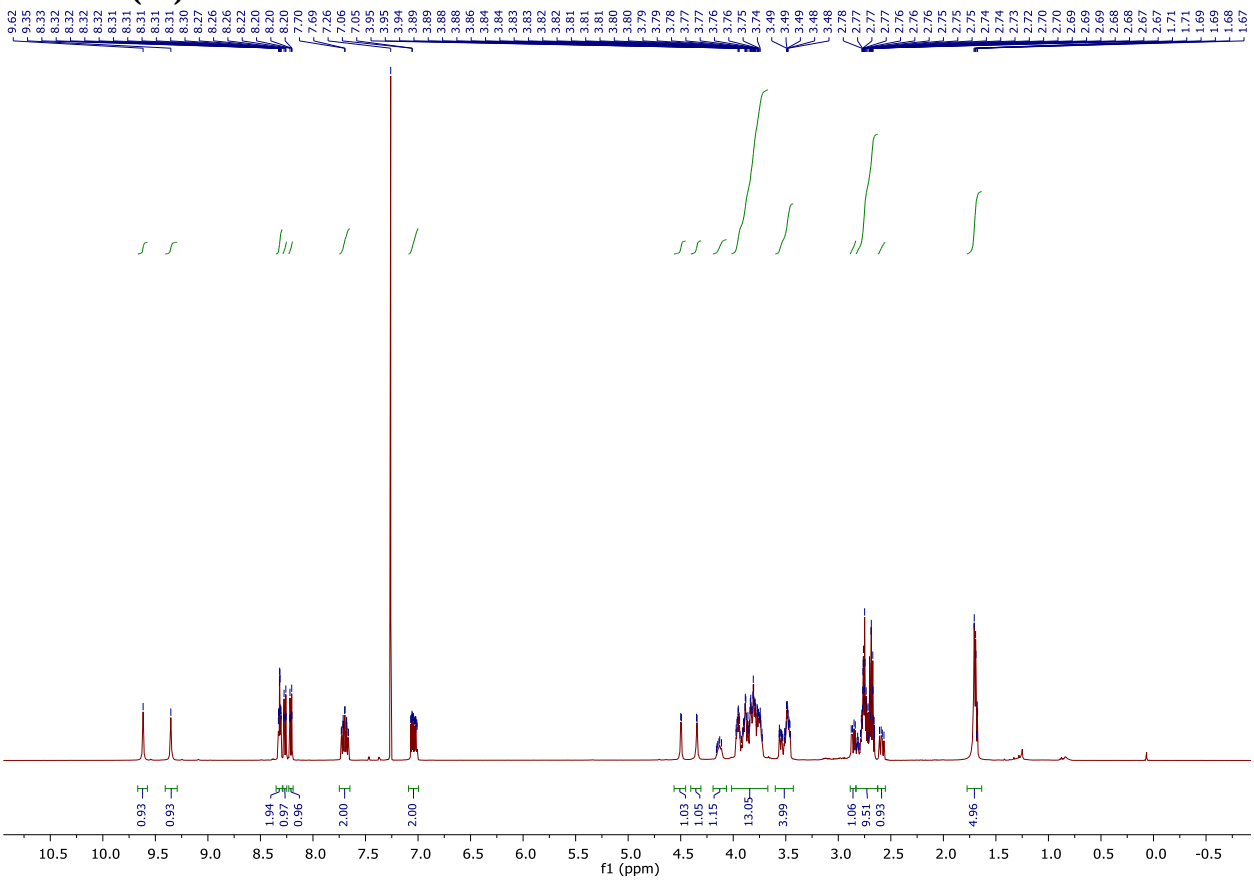

170.07
151.60
147.98
138.08
119.84
114.64
80.77
80.63
77.42
77.16
76.91
71.49
70.89
70.67
70.48
37.01
32.23
24.88
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

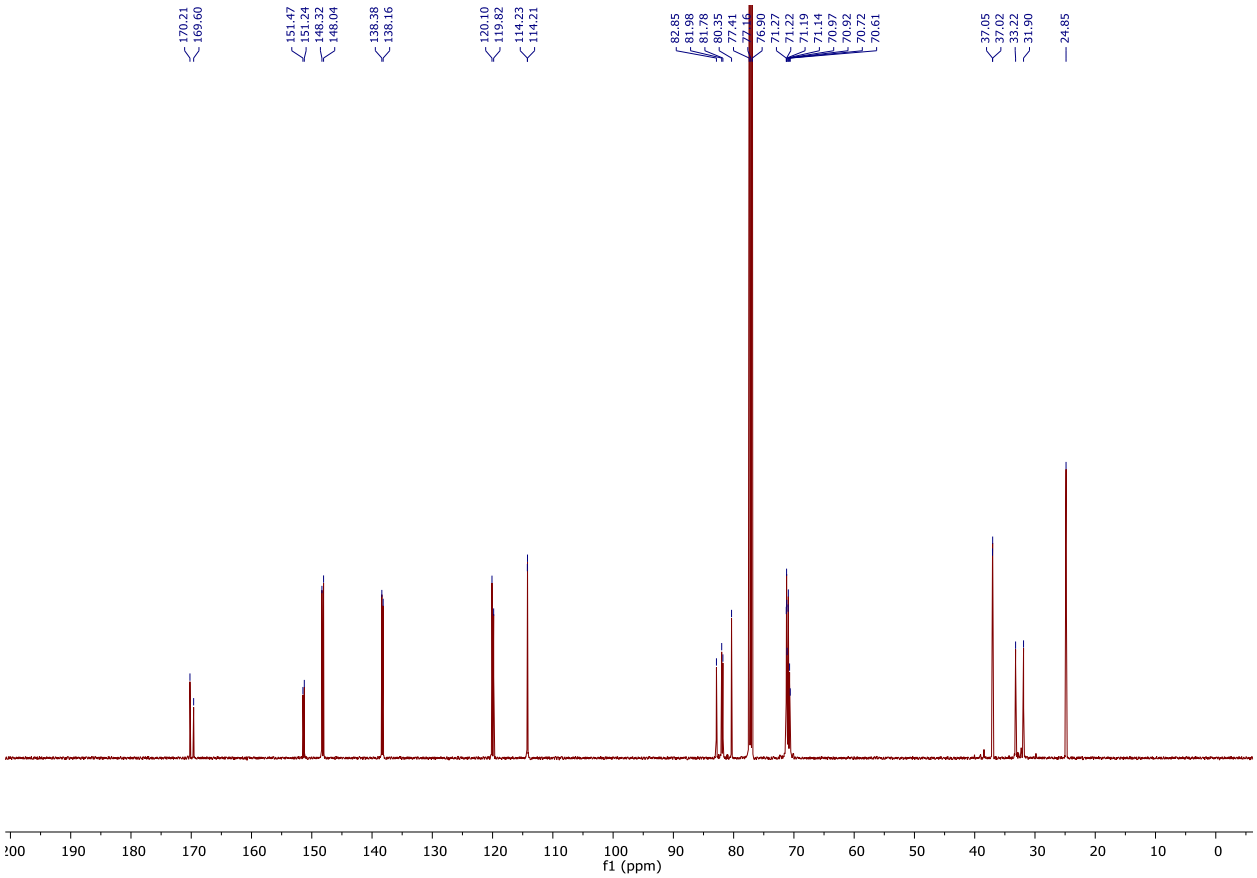
7.14.2 10 (*C*$_2$-*trans*)



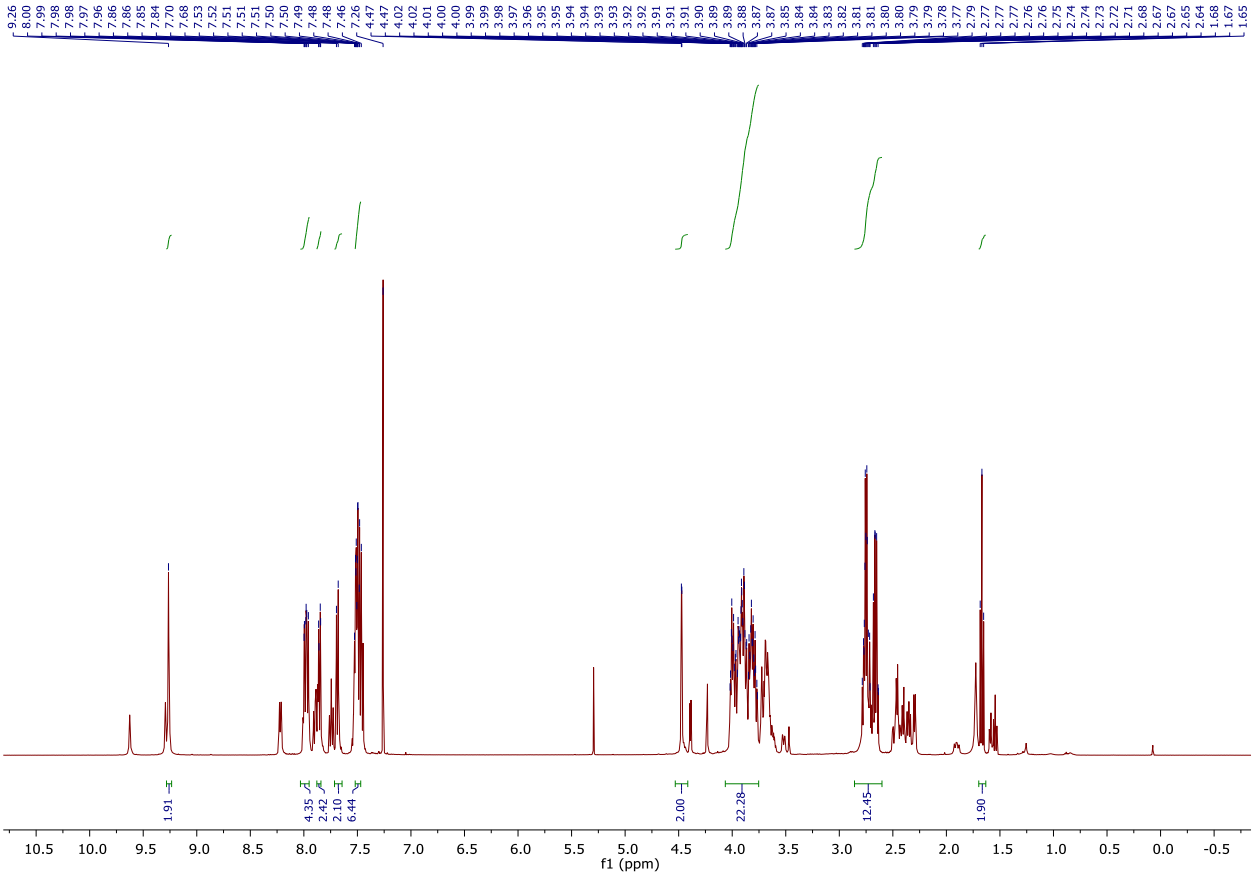

169.49
150.96
148.21
138.46
120.17
114.02
82.44
82.25
77.42
77.16
76.91
71.54
71.46
71.29
71.20
37.05
32.40
24.84
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

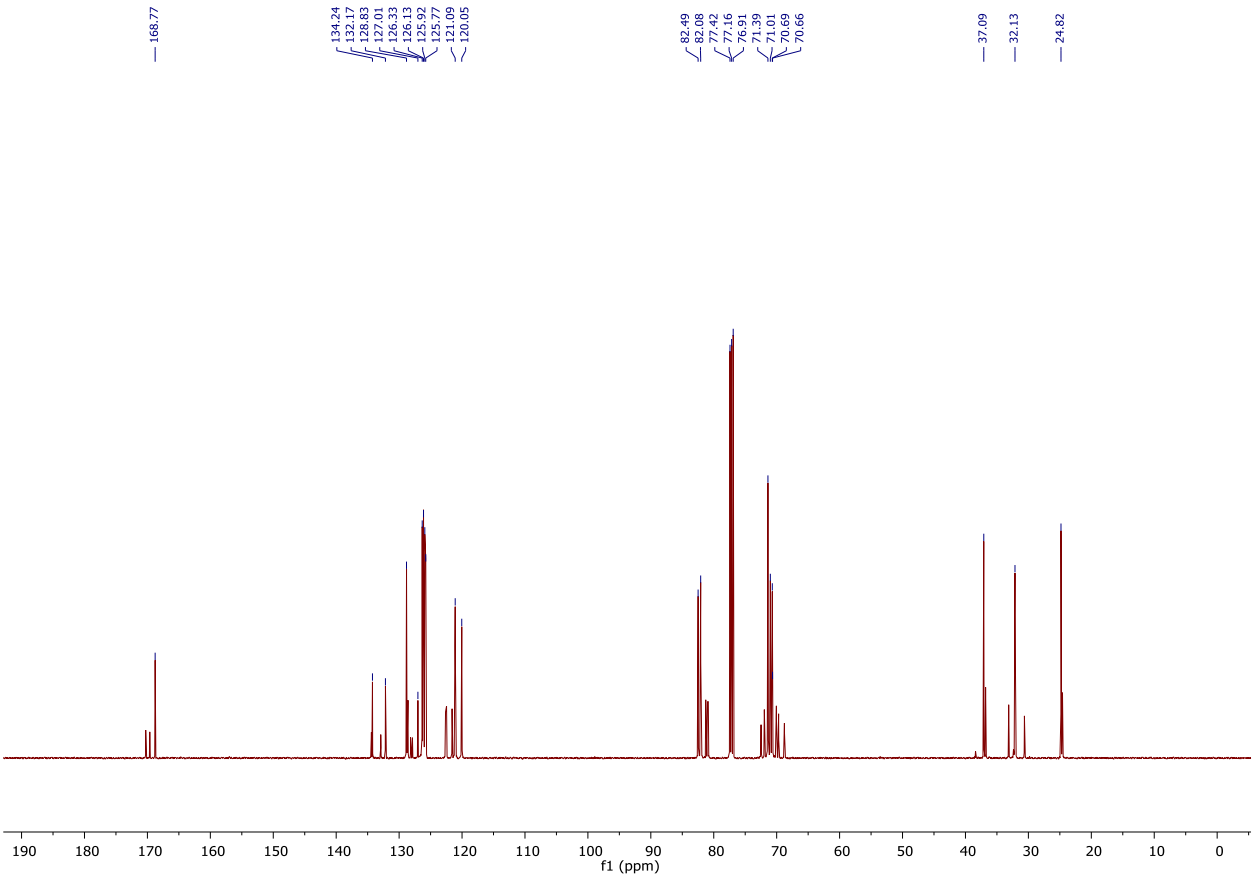
7.14.3 10 (C_1)


9.62 9.35 8.33 8.32 8.32 8.32 8.32 8.31 8.31 8.31 8.31 8.31 8.30 8.27 8.26 8.26 8.22 8.20 8.20 8.20 7.70 7.69 7.26 7.06 7.05 3.95 3.95 3.94 3.89 3.89 3.88 3.88 3.86 3.84 3.84 3.83 3.83 3.82 3.82 3.81 3.81 3.81 3.80 3.80 3.79 3.79 3.78 3.77 3.77 3.76 3.76 3.75 3.74 3.49 3.49 3.49 3.48 2.78 2.77 2.77 2.77 2.76 2.76 2.76 2.75 2.75 2.75 2.74 2.74 2.73 2.72 2.70 2.70 2.69 2.69 2.69 2.68 2.68 2.67 2.67 1.71 1.71 1.69 1.69 1.68 1.67
0.93 0.93 1.94 0.97 0.96 2.00 2.00 1.03 1.05 1.15 13.05 3.99 1.06 9.51 0.93 4.96
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


170.21
169.60
151.47
151.24
148.32
148.04
138.38
138.16
120.10
119.82
114.23
114.21
82.85
81.98
81.78
80.35
77.41
77.16
76.90
71.27
71.22
71.19
71.14
70.97
70.92
70.72
70.61
37.05
37.02
33.22
31.90
24.85
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

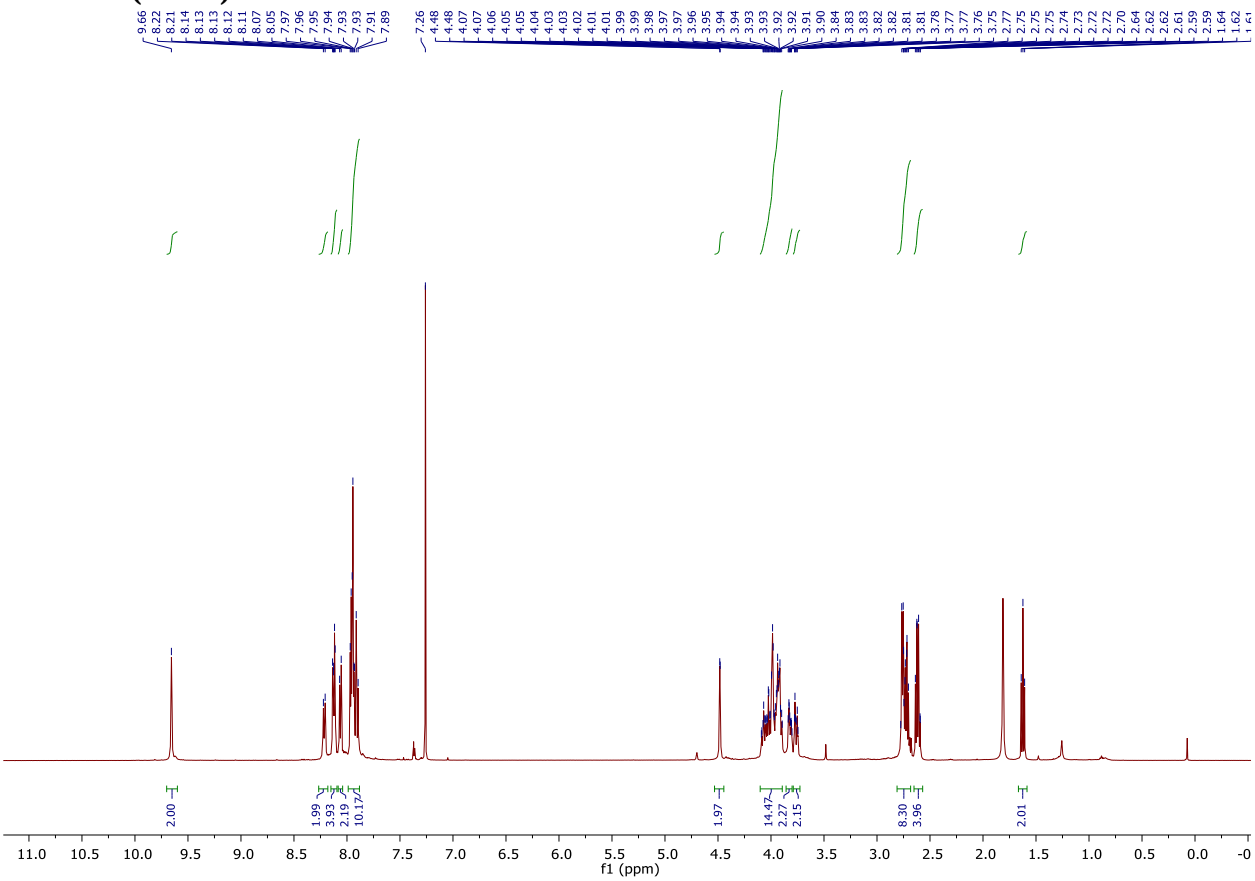
7.15 Spectra of 11

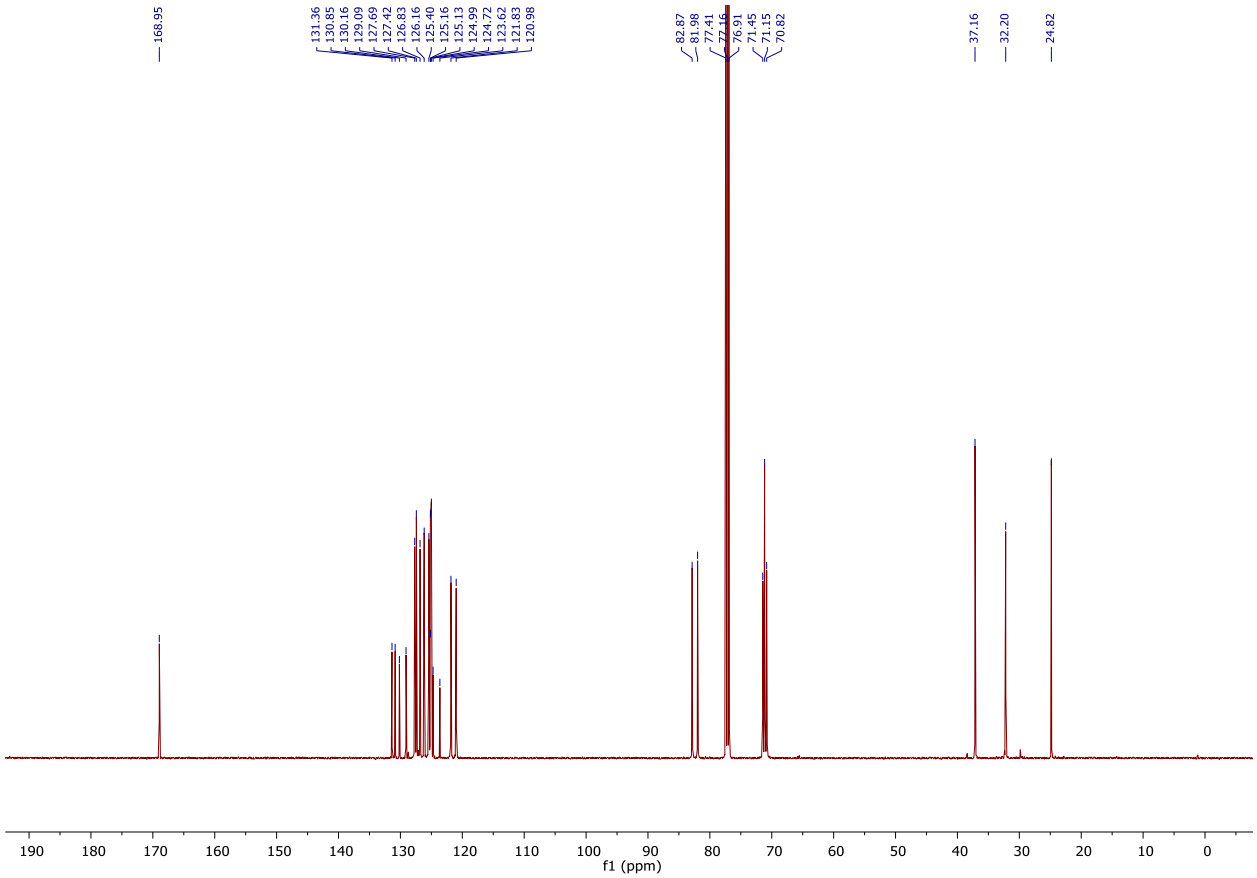



168.77
134.24
132.17
128.83
127.01
126.33
126.13
125.92
125.77
121.09
120.05
82.49
82.08
77.42
77.16
76.91
71.39
71.01
70.69
70.66
37.09
32.13
24.82
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

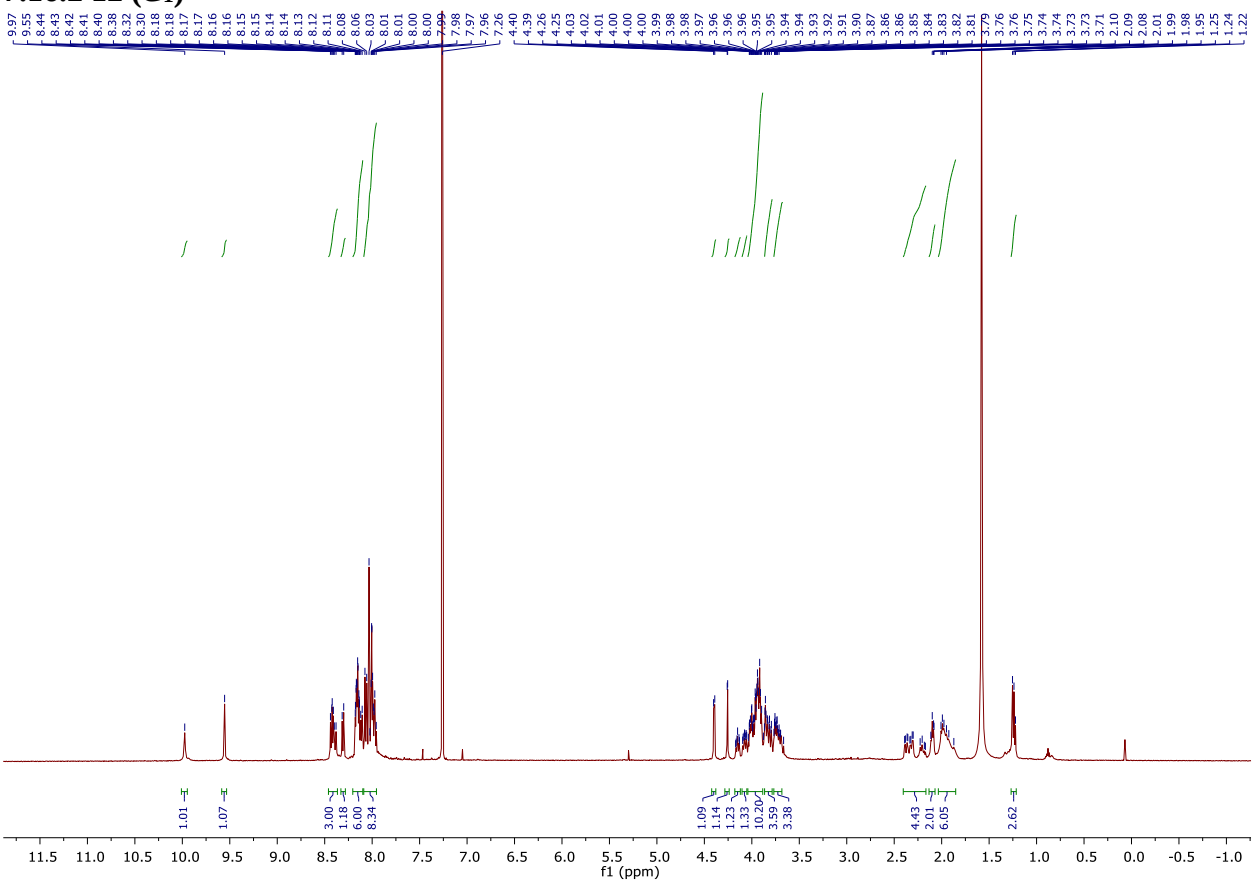
7.16 Spectra of 12

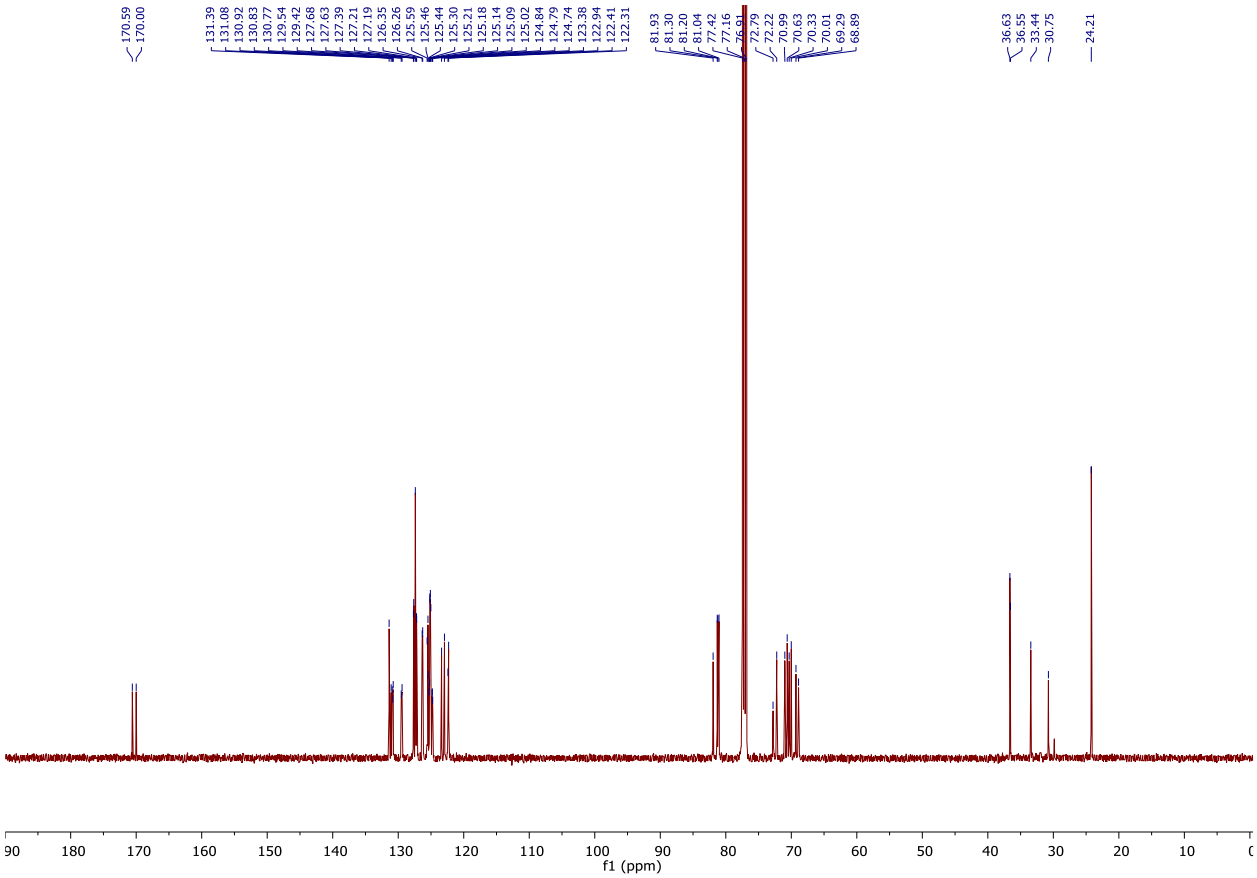
7.16.1 12 (*C*$_2$-*cis*)




168.95
131.36
130.85
130.16
129.09
127.69
127.42
126.83
126.16
125.40
125.16
125.13
124.99
124.72
123.62
121.83
120.98
82.87
81.98
77.41
77.16
76.91
71.45
71.15
70.82
37.16
32.20
24.82
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

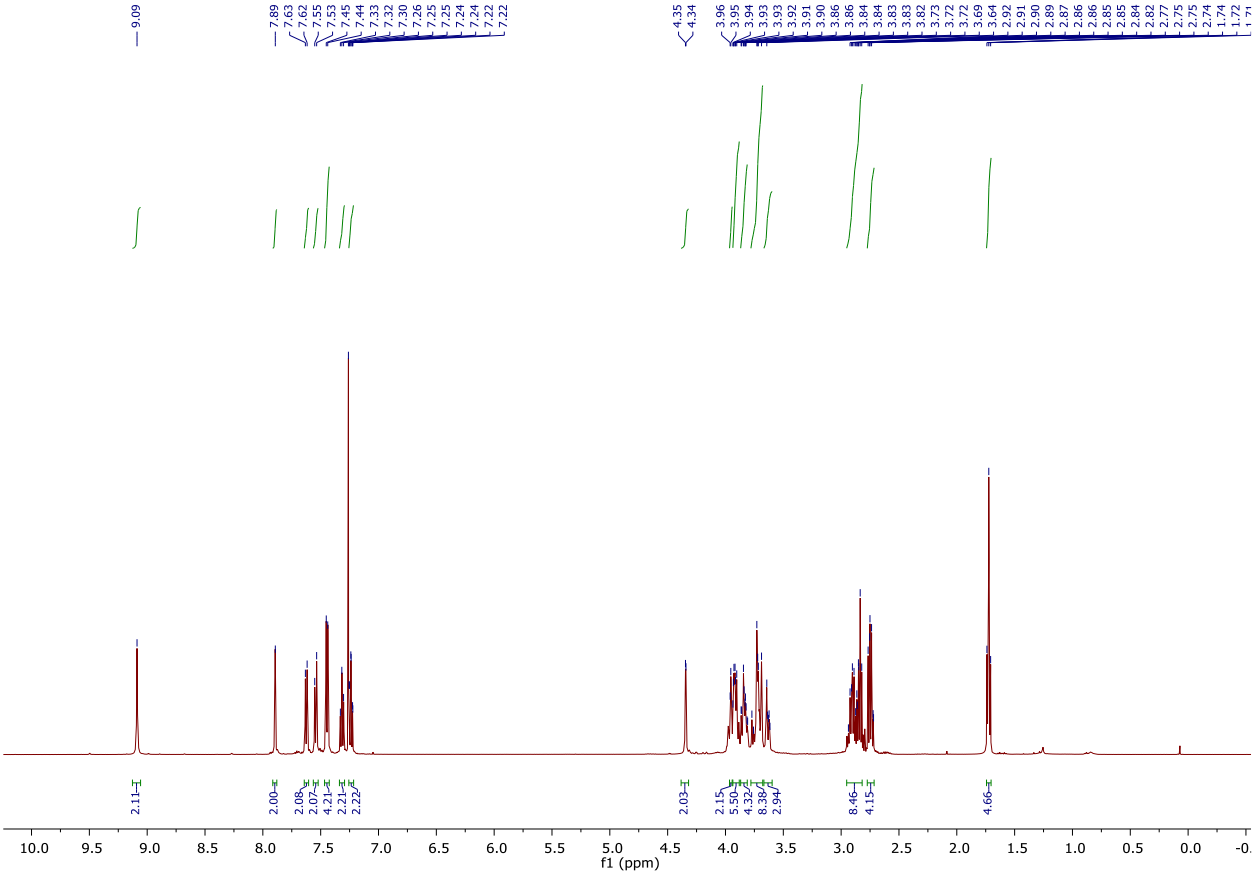
7.16.2 12 (C_1)

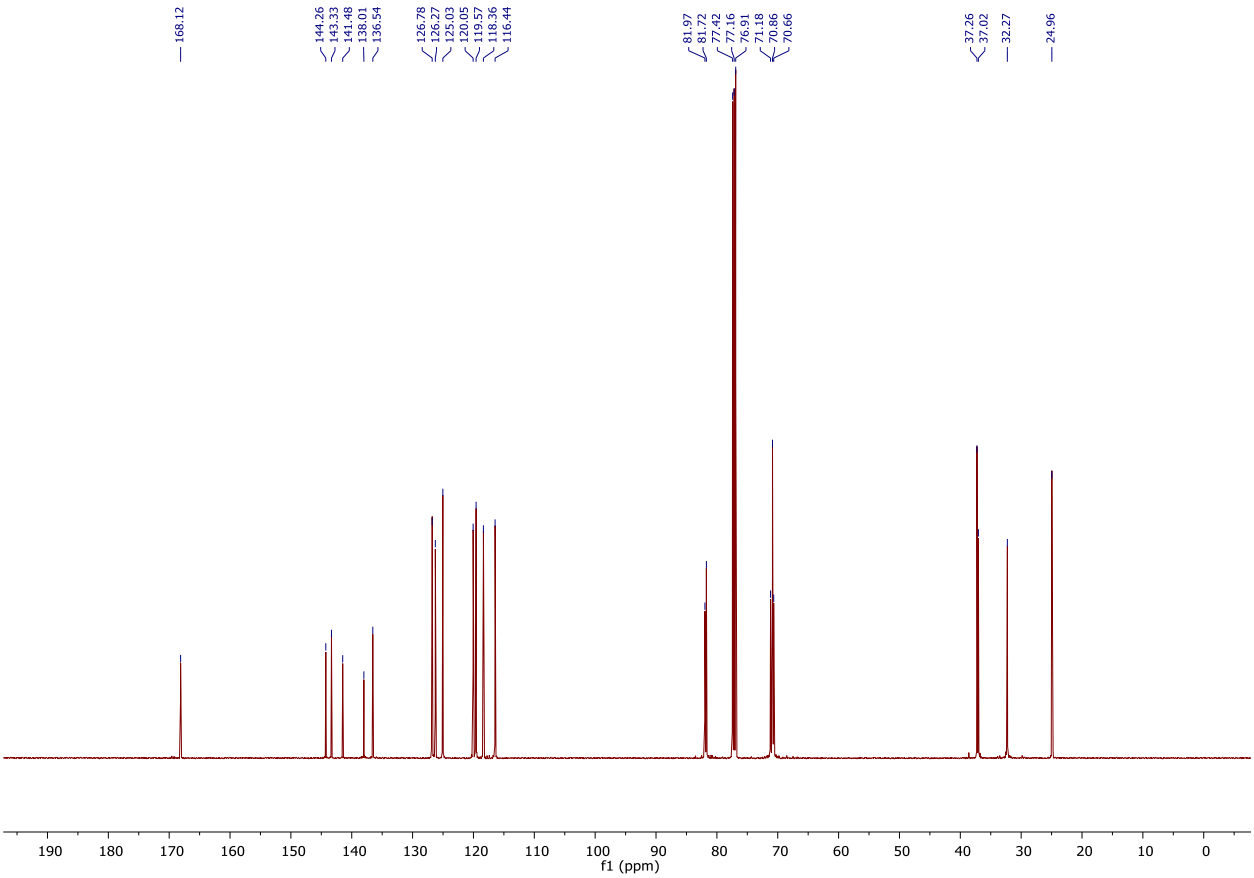



170.59
170.00
131.39
131.08
130.92
130.83
130.77
129.54
129.42
127.68
127.63
127.39
127.21
127.19
126.35
126.26
125.59
125.46
125.44
125.30
125.21
125.18
125.14
125.09
125.02
124.84
124.79
124.74
123.38
122.94
122.41
122.31
81.93
81.30
81.20
81.04
77.42
77.16
76.91
72.79
72.22
70.99
70.63
70.33
70.01
69.29
68.89
36.63
36.55
33.44
30.75
24.21
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

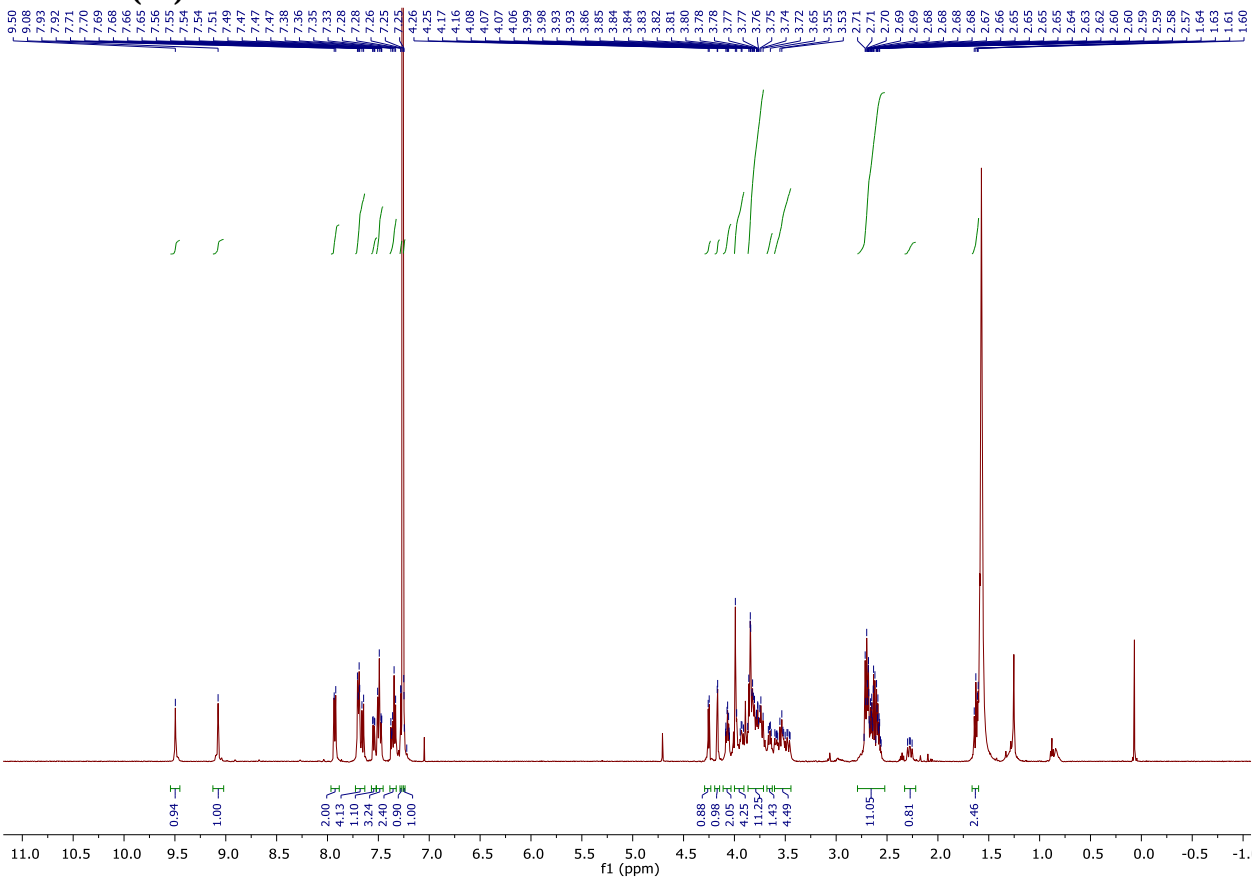
7.17 Spectra of 13

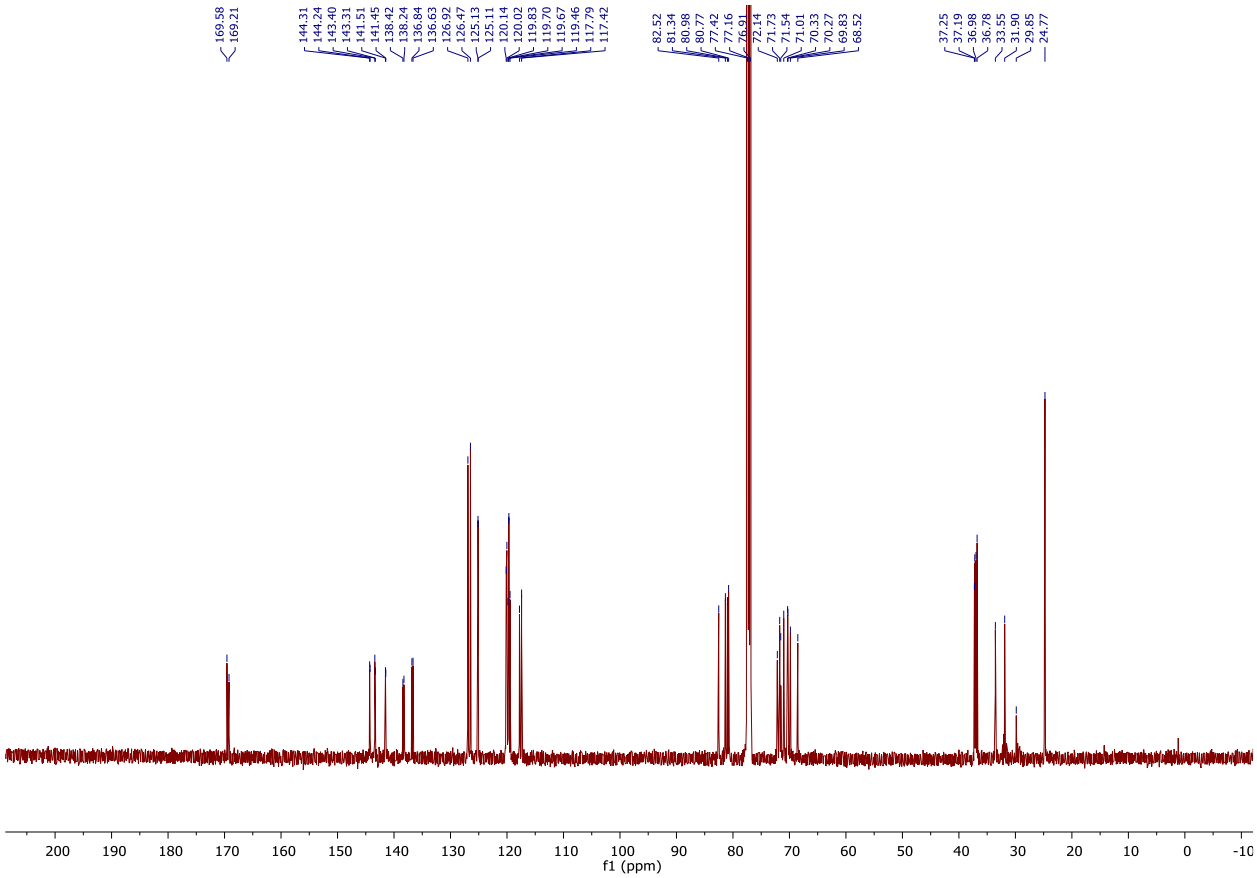
7.17.1 13 (C_2-*cis*)




168.12
144.26
143.33
141.48
138.01
136.54
126.78
126.27
125.03
120.05
119.57
118.36
116.44
81.97
81.72
77.42
77.16
76.91
71.18
70.86
70.66
37.26
37.02
32.27
24.96
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

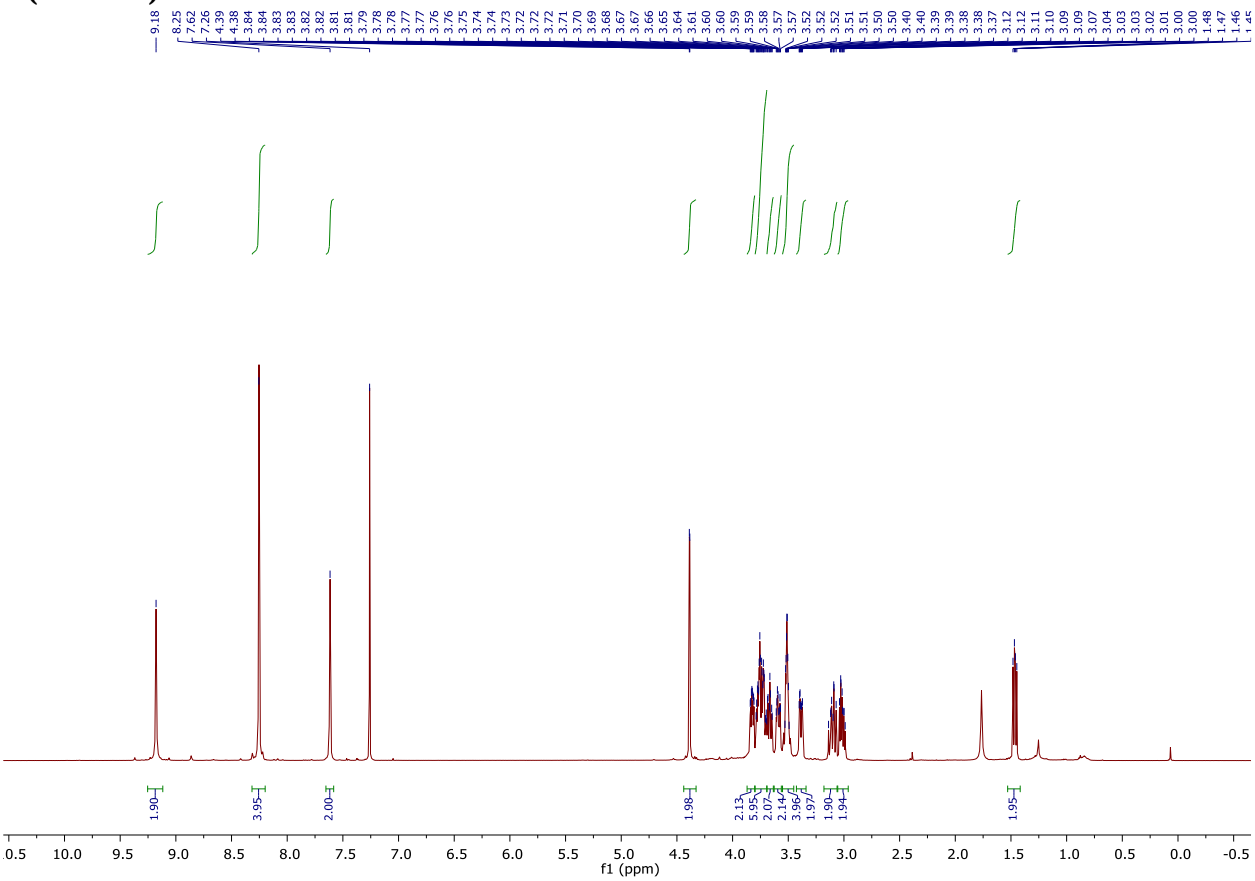
7.17.2 13 (C_1)

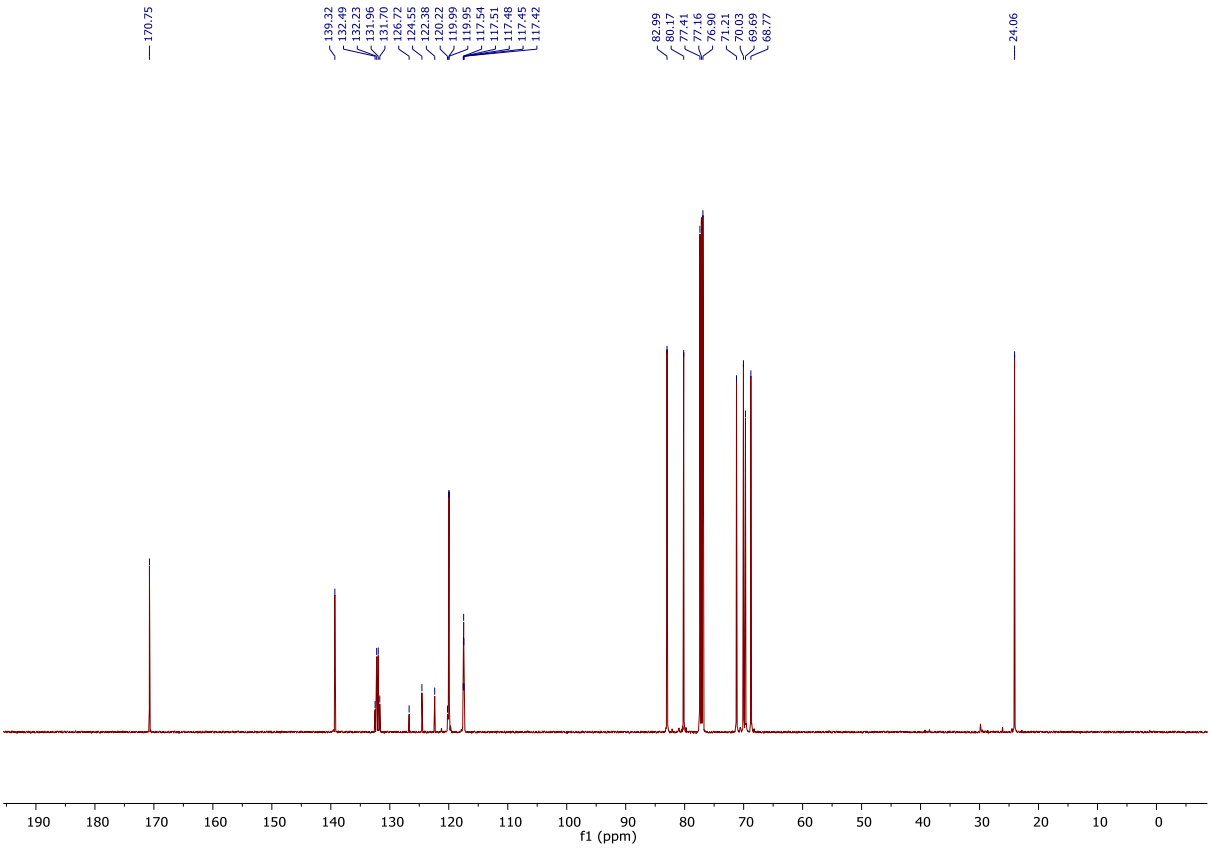


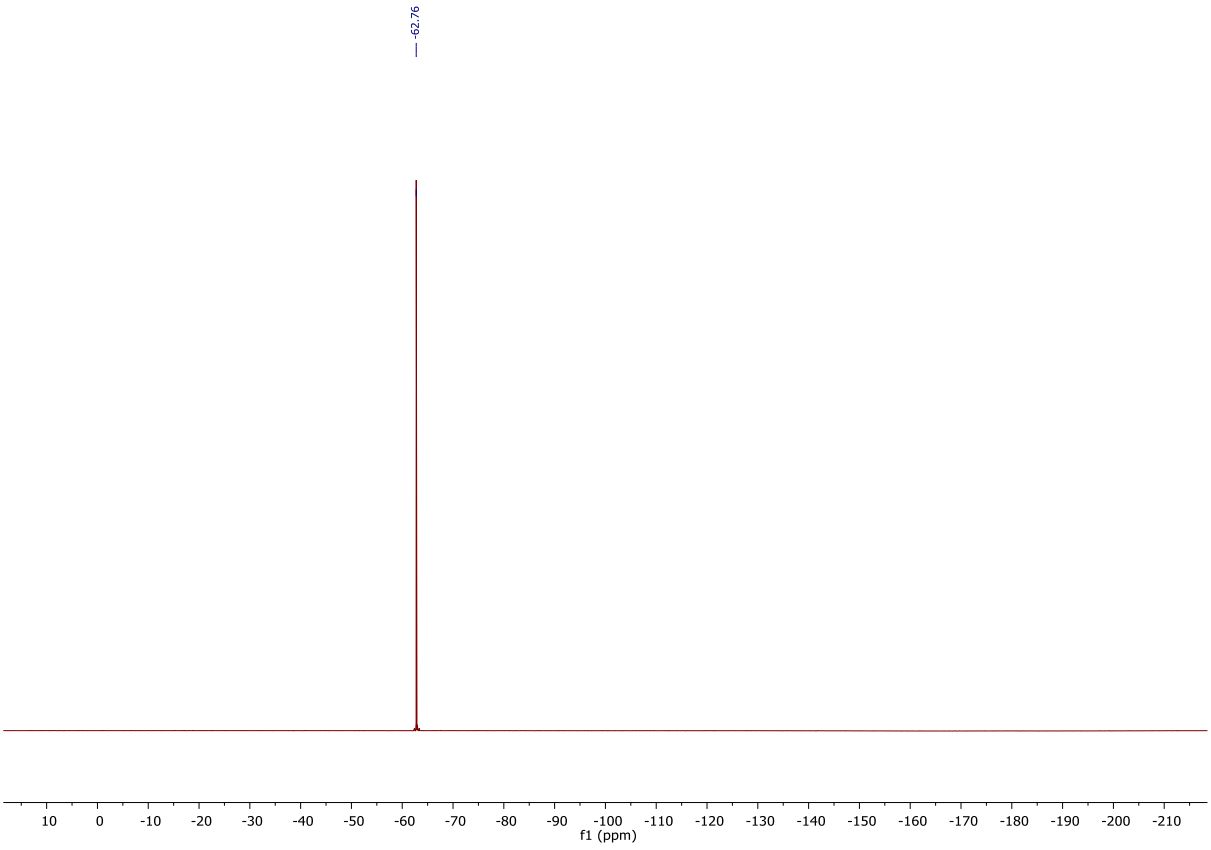

169.58
169.21
144.31
144.24
143.40
143.31
141.51
141.45
138.42
138.24
136.84
136.63
126.92
126.47
125.13
125.11
120.14
120.02
119.83
119.70
119.67
119.46
117.79
117.42
82.52
81.34
80.98
80.77
77.42
77.16
76.91
72.14
71.73
71.54
71.01
70.33
70.27
69.83
68.52
37.25
37.19
36.98
36.78
33.55
31.90
29.85
24.77
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

7.18 Deprotection of the acetyl groups (compound 4)

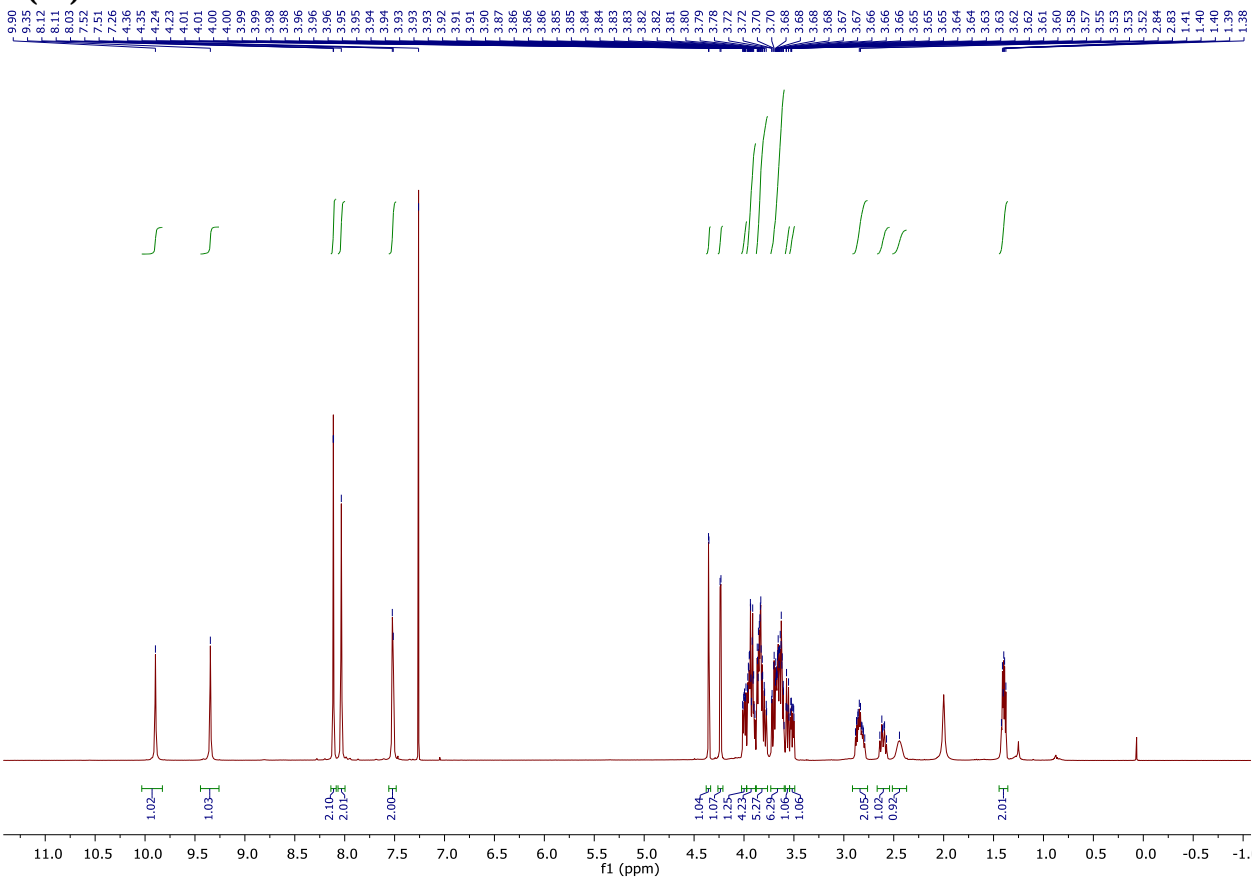
4 (*C*$_2$-*trans*)

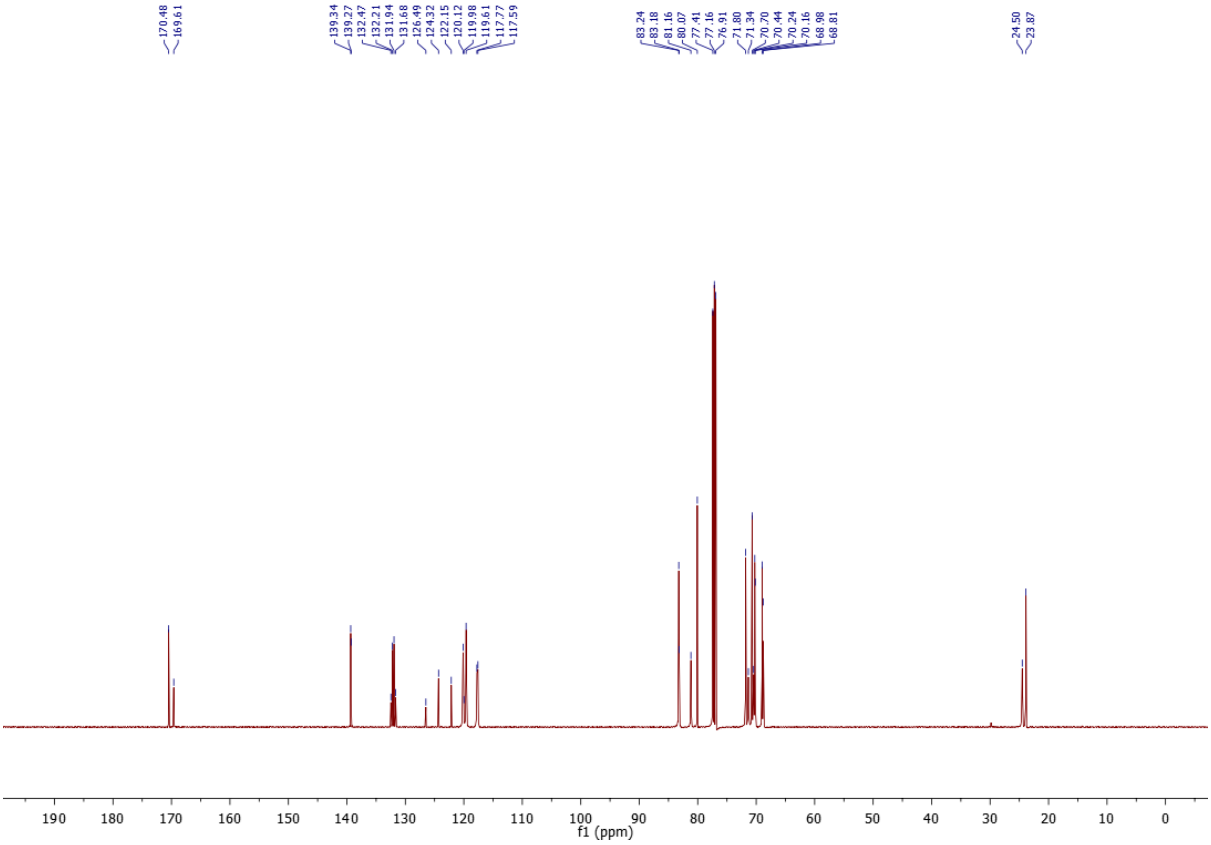



170.75
139.32
132.49
132.23
131.96
131.70
126.72
124.55
122.38
120.22
119.99
119.95
117.54
117.51
117.48
117.45
117.42
82.99
80.17
77.41
77.16
76.90
71.21
70.03
69.69
68.77
24.06
f1 (ppm)


-62.76
f1 (ppm)

4 (*C*1)

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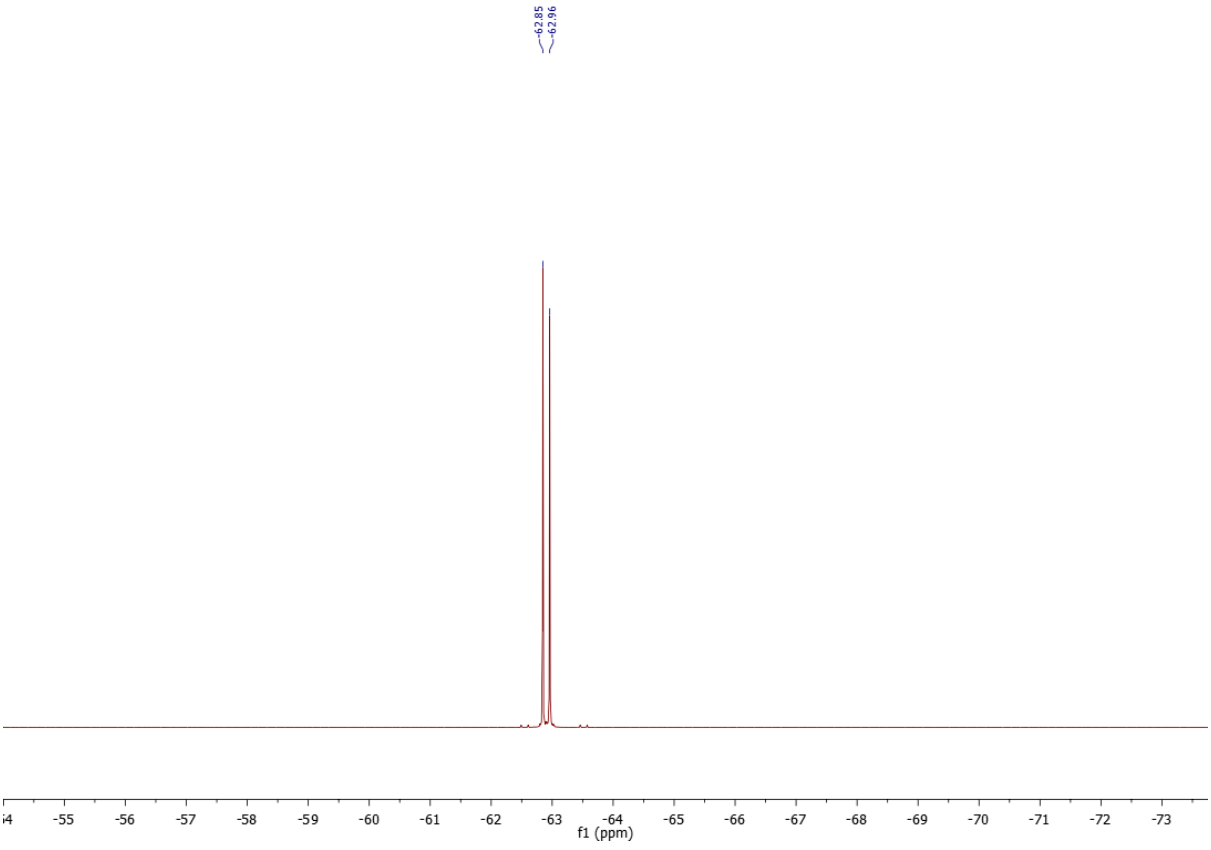
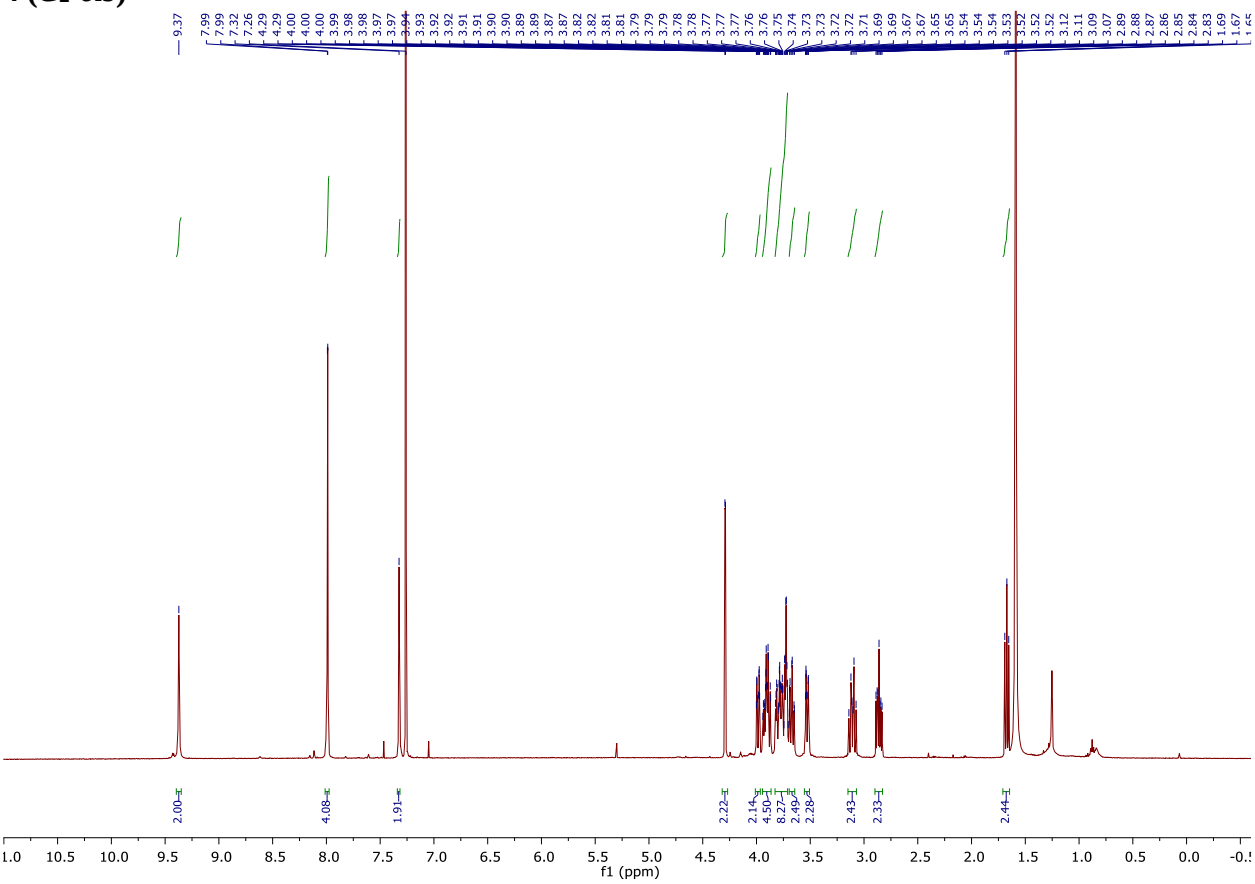
169.61
139.34
139.27
132.47
132.21
131.94
131.68
126.49
124.32
122.15
120.12
119.98
119.61
117.77
117.59
83.24
83.18
81.16
80.07
77.41
77.16
76.91
71.80
71.34
70.70
70.44
70.24
70.16
68.98
68.81
24.50
23.87
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-62.85
-62.96
-54 -55 -56 -57 -58 -59 -60 -61 -62 -63 -64 -65 -66 -67 -68 -69 -70 -71 -72 -73
f1 (ppm)

4 (*C*$_2$-*cis*)


9.37
7.99
7.99
7.32
7.26
4.29
4.29
4.00
4.00
4.00
3.99
3.98
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3.97
3.97
3.94
3.93
3.92
3.92
3.91
3.91
3.90
3.90
3.89
3.89
3.87
3.87
3.82
3.82
3.81
3.81
3.79
3.79
3.79
3.78
3.78
3.77
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3.77
3.76
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3.74
3.73
3.73
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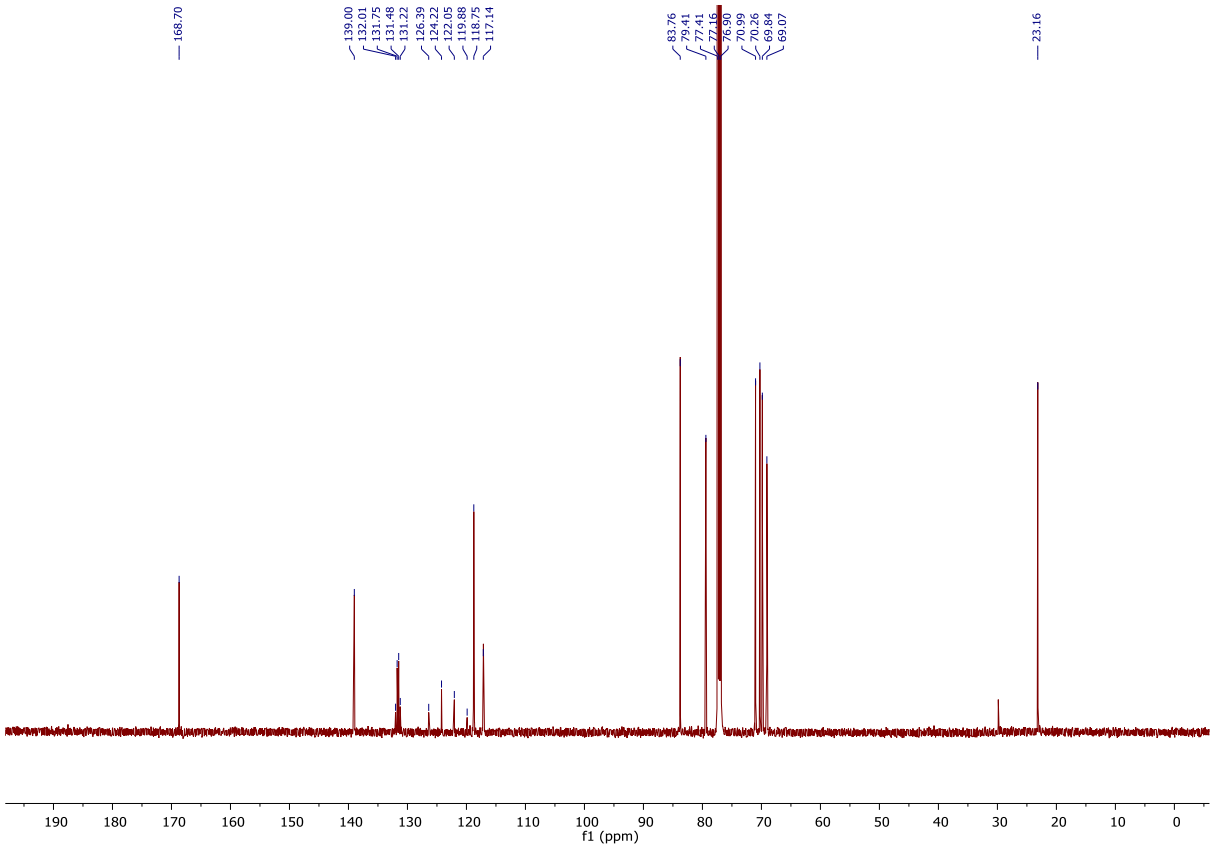
3.52
3.52
3.52
3.12
3.11
3.09
3.07
2.89
2.88
2.87
2.86
2.85
2.84
2.83
1.69
1.67
2.00
4.08
1.91
2.22
2.14
4.50
8.27
2.49
2.28
2.43
2.33
2.44
f1 (ppm)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139.00
132.01
131.75
131.48
131.22
126.39
124.22
122.05
119.88
118.75
117.14
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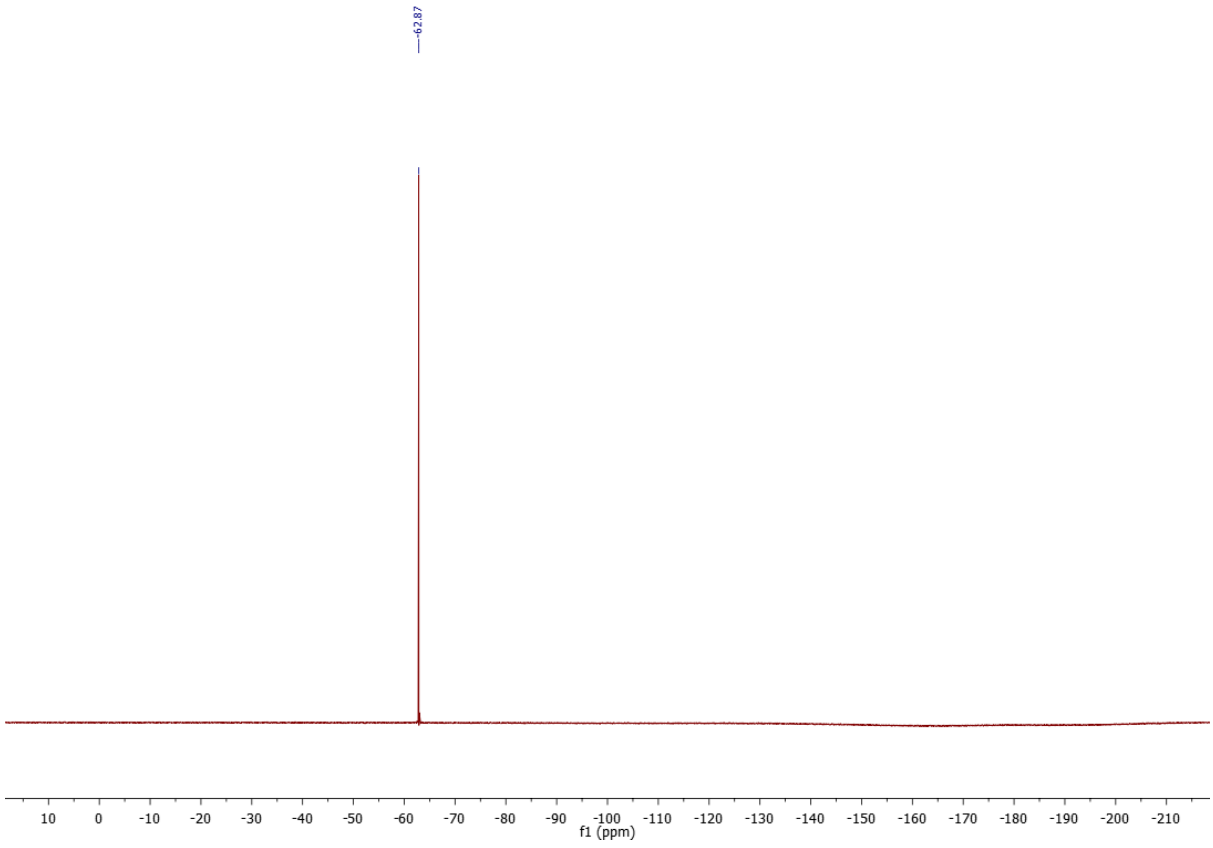
70.26
69.84
69.07
23.16
f1 (ppm)


-62.87
f1 (ppm)

8. X-ray

8.1 *C_2-trans*_3b

Table 1. Crystal data and structure refinement for *C_2-trans*_3b.

Empirical formula	C36 H38 F12 N2 O10 S2	
Formula weight	950.80	
Temperature	180.15 K	
Wavelength	1.54184 Å	
Crystal system	Monoclinic	
Space group	P 1 21/n 1	
Unit cell dimensions	a = 9.6208(2) Å	α= 90°.
	b = 17.3037(4) Å	β= 94.432(2)°.
	c = 25.0189(4) Å	γ = 90°.
Volume	4152.58(15) $Å^3$	
Z	4	
Density (calculated)	1.521 Mg/m^3	
Absorption coefficient	2.173 mm^{-1}	
F(000)	1952	
Crystal size	0.445 x 0.053 x 0.029 mm^3	
Theta range for data collection	3.108 to 73.594°.	
Index ranges	-9<=h<=11, -21<=k<=21, -30<=l<=30	
Reflections collected	16134	
Independent reflections	8157 [R(int) = 0.0262]	
Completeness to theta = 67.500°	100.0 %	
Absorption correction	Analytical	
Max. and min. transmission	0.949 and 0.629	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	8157 / 2 / 563	
Goodness-of-fit on F^2	1.073	
Final R indices [I>2sigma(I)]	R1 = 0.0883, wR2 = 0.2357	
R indices (all data)	R1 = 0.1096, wR2 = 0.2567	
Extinction coefficient	n/a	
Largest diff. peak and hole	1.539 and -0.681 $e.Å^{-3}$	

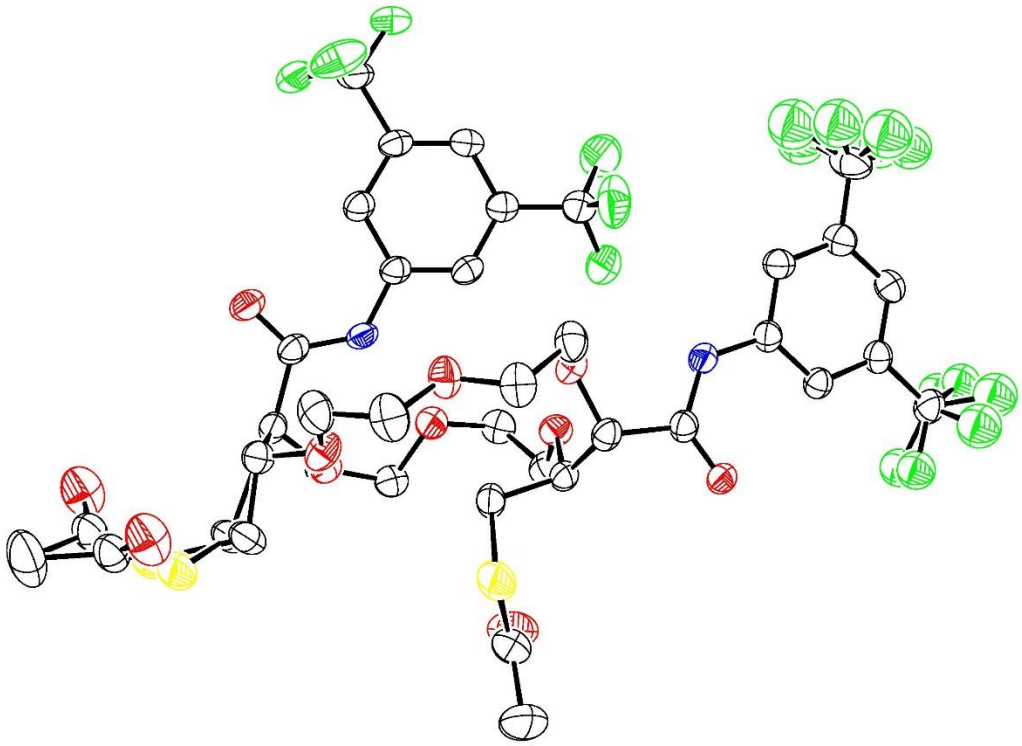


Figure 1- Ortep view of *C_2-trans*_3b (thermal ellispoids are drawn at 50% probability). Hydrogen atoms are omitted for clarity purpose.

Comments on the structure:

There are two disordered CF_3 groups (around the C3-axes) which were refined in two parts (refined occupancies were ~ 50% each) with constrained isotropic ADPs to be equal.

One C-S-C-O-CH_3 part is also disordered onto 2 positions with refined occupancies 0.6/0.4. Disordered atoms where refined with constrained anisotropic ADPs to be equal and with restrains on bond lengths for carbonyl groups.

8.2 *C_2-cis*_3b

Table 1. Crystal data and structure refinement for *C_2-cis*_3b.

Empirical formula	C36 H42 F12 N2 O8 S2	
Formula weight	922.83	
Temperature	180.15 K	
Wavelength	1.54184 Å	
Crystal system	Monoclinic	
Space group	P 1 21/c 1	
Unit cell dimensions	a = 8.68201(13) Å	α= 90°.
	b = 18.7358(3) Å	β= 97.5197(14)°.
	c = 25.4056(4) Å	γ = 90°.
Volume	4097.05(11) $Å^3$	
Z	4	
Density (calculated)	1.496 Mg/m^3	
Absorption coefficient	2.144 mm^{-1}	
F(000)	1904	
Crystal size	0.258 x 0.173 x 0.075 mm^3	
Theta range for data collection	2.940 to 73.633°.	
Index ranges	-10<=h<=8, -22<=k<=23, -31<=l<=28	
Reflections collected	28125	
Independent reflections	8173 [R(int) = 0.0258]	
Completeness to theta = 67.500°	100.0 %	
Absorption correction	Analytical	
Max. and min. transmission	0.863 and 0.631	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	8173 / 0 / 551	
Goodness-of-fit on F^2	1.056	
Final R indices [I>2sigma(I)]	R1 = 0.0757, wR2 = 0.2015	
R indices (all data)	R1 = 0.0860, wR2 = 0.2133	
Extinction coefficient	n/a	
Largest diff. peak and hole	1.250 and -0.926 $e.Å^{-3}$	

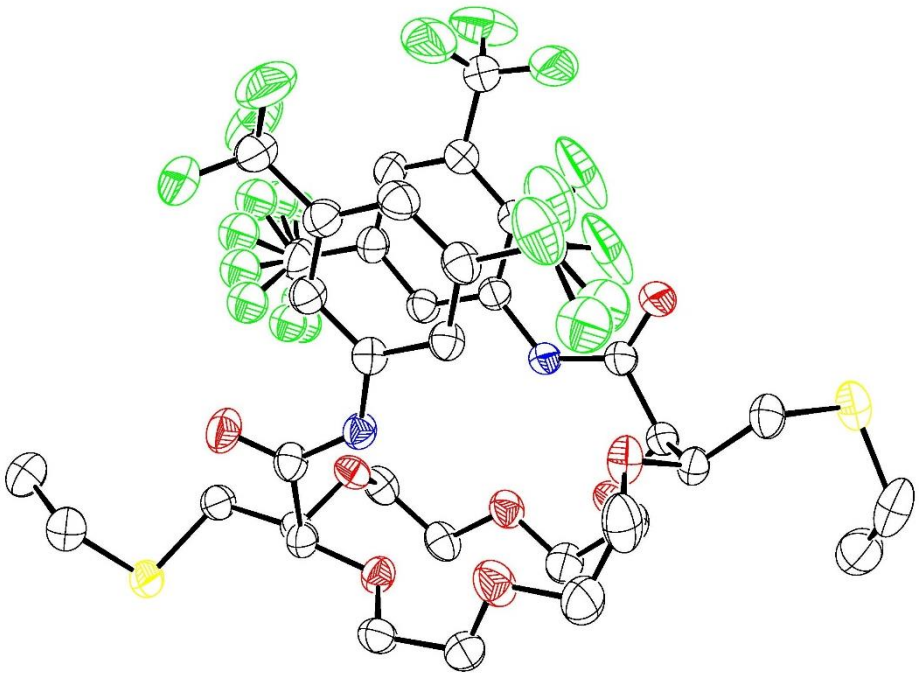


Figure 1- Ortep view of C_2-*cis*_3b (thermal ellispoids are drawn at 50% probability level). Hydrogen atoms are omitted for clarity reasons.

Comments: F atoms (of CF3 groups) are disordered around the C3 axes. Most pathological one were refined by splitting their positions in 2 or 3 parts.

8.3 *C_2-trans_4*

Table 1. Crystal data and structure refinement for *C_2-trans_4*.

Empirical formula	C32 H34 F12 N2 O8 S2	
Formula weight	866.73	
Temperature	180.15 K	
Wavelength	1.54184 Å	
Crystal system	Triclinic	
Space group	P -1	
Unit cell dimensions	a = 9.8217(5) Å	α= 83.763(5)°.
	b = 10.9991(7) Å	β= 77.823(5)°.
	c = 18.8342(12) Å	γ = 73.022(5)°.
Volume	1899.8(2) $Å^3$	
Z	2	
Density (calculated)	1.515 Mg/m^3	
Absorption coefficient	2.273 mm^{-1}	
F(000)	888	
Crystal size	0.241 x 0.098 x 0.02 mm^3	
Theta range for data collection	4.208 to 73.628°.	
Index ranges	-12<=h<=8, -13<=k<=12, -22<=l<=23	
Reflections collected	12306	
Independent reflections	7433 [R(int) = 0.0230]	
Completeness to theta = 67.500°	99.8 %	
Absorption correction	Analytical	
Max. and min. transmission	0.956 and 0.710	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	7433 / 0 / 515	
Goodness-of-fit on F^2	1.054	
Final R indices [I>2sigma(I)]	R1 = 0.0590, wR2 = 0.1536	
R indices (all data)	R1 = 0.0745, wR2 = 0.1696	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.656 and -0.616 $e.Å^{-3}$	

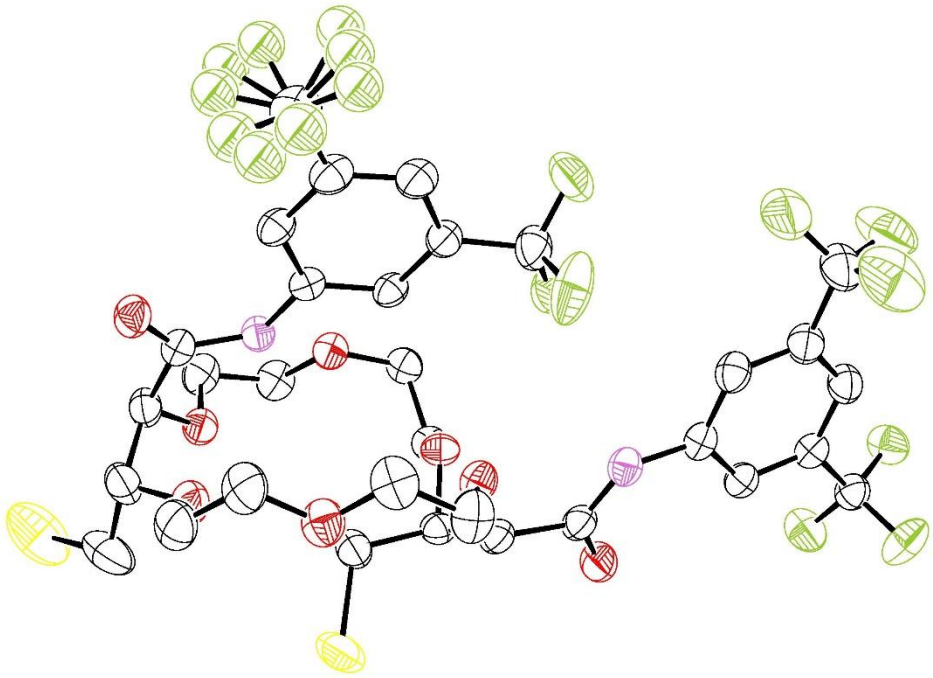


Figure 1- Ortep view of C_2-*trans*_4 (thermal ellipsoids are drawn at 50% probability). Hydrogen atoms are omitted for clarity reasons.

Table 2. Hydrogen bonds for eb256p_abs [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(2)-H(2A)...O(3)	0.88	2.28	3.063(3)	148.2

Symmetry transformations used to generate equivalent atoms:

8.4 *C_2-cis*_4

Table 1. Crystal data and structure refinement for *C_2-cis*_4.

Identification code	eb238p2_abs	
Empirical formula	C32 H34 F12 N2 O8 S2	
Formula weight	866.73	
Temperature	180.15 K	
Wavelength	1.54184 Å	
Crystal system	Monoclinic	
Space group	C 1 2/c 1	
Unit cell dimensions	a = 18.2004(5) Å	α= 90°.
	b = 12.6594(2) Å	β= 121.245(3)°.
	c = 19.4388(5) Å	γ = 90°.
Volume	3829.20(19) $Å^3$	
Z	4	
Density (calculated)	1.503 Mg/m^3	
Absorption coefficient	2.256 mm^{-1}	
F(000)	1776	
Crystal size	0.306 x 0.253 x 0.197 mm^3	
Theta range for data collection	4.417 to 73.513°.	
Index ranges	-20<=h<=22, -10<=k<=15, -24<=l<=23	
Reflections collected	6955	
Independent reflections	3759 [R(int) = 0.0128]	
Completeness to theta = 67.500°	99.9 %	
Absorption correction	Analytical	
Max. and min. transmission	0.730 and 0.597	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	3759 / 36 / 310	
Goodness-of-fit on F^2	1.053	
Final R indices [I>2sigma(I)]	R1 = 0.0584, wR2 = 0.1835	
R indices (all data)	R1 = 0.0630, wR2 = 0.1915	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.678 and -0.472 $e.Å^{-3}$	

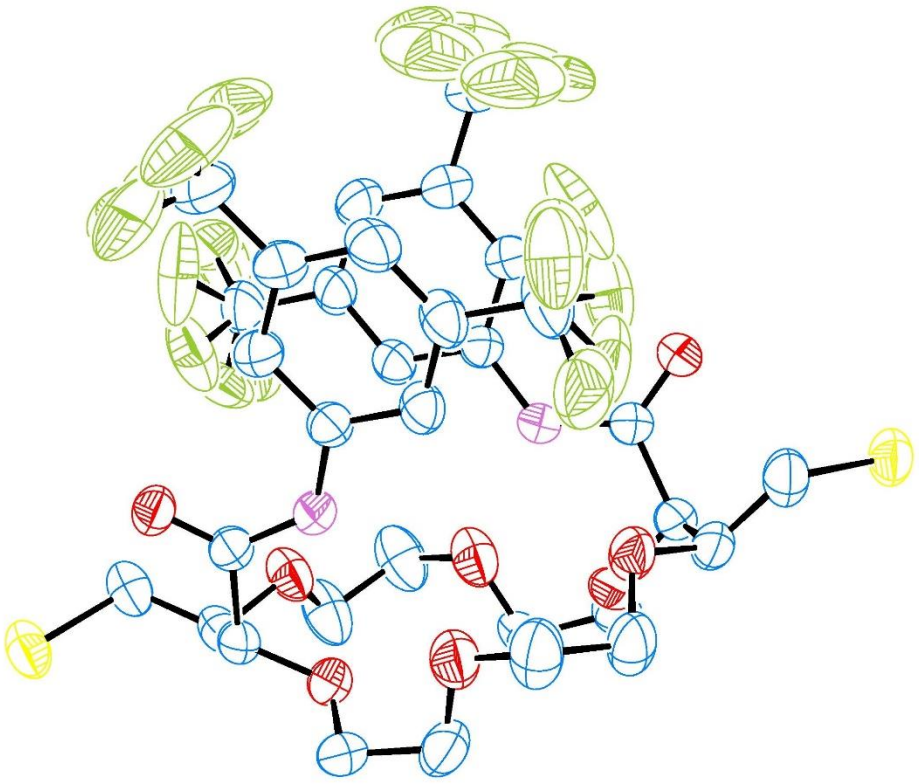


Figure 1- Ortep view of C_2-*cis*_4 (thermal ellispoids are drawn at 50% probability level). Hydrogen atoms are omitted for clarity reasons.