Chiral Helical Oligotriazoles: New Class of Anion-Binding Catalysts for the Asymmetric Dearomatization of Electron-Deficient *N*-Heteroarenes

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Supporting Information

Contents

General Information

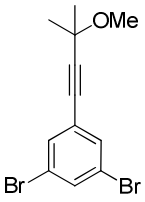
^{1}H, ^{13}C and **^{19}F NMR** spectra were recorded in acetone-D_6,[1] $CDCl_3$ and THF-D_8 (reference signals:[2] ^{1}H = 2.05 ppm, ^{13}C = 29.84 ppm, acetone-D_6; ^{1}H = 5.32 ppm, ^{13}C = 54.00 ppm, ^{13}C = 77.16 ppm, $CDCl_3$; ^{1}H = 3.58 ppm, ^{13}C = 25.37 ppm, THF-D_8) on a *Bruker ARX-300* and a *Varian AV*-300, 400 or 600 MHz. Chemical shifts (δ) are given in ppm and spin-spin coupling constants (J) are given in Hz. Analytical thin layer chromatography was performed using silica gel 60 F_{254} and a solution of $KMnO_4$ or phosphomolybdic acid served as staining agent. Column chromatography was performed on silica gel 60 (0.040-0.063 mm) or deactivated [3] silica gel 60 (0.040-0.063 mm). Exact masses (**HRMS (ES)**) were recorded on a *Bruker Daltonics MicroTof* spectrometer (samples in CH_3OH as solvent) or *LTQ Orbitap LTQ XL* (Thermo-Fisher Scientific, Bremen) (samples in MeOH/$CHCl_3$ as solvent). Melting points (**Mp**) were measured by differential scanning calorimetry with a *Ta Instruments Q20* calorimeter. Gas chromatography spectra (**GC-MS**) were recorded on an Agilent Technologies 7890A GC-system with an Agilent 5975C VL MSD or an Agilent 5975 inert Mass Selective Detector (EI) and a HP-5MS column (0.25 mm x 30 m, film: 0.25 µm). The major signals are quoted in m/z with the relative intensity in parentheses, the fragment according to the complete molecule is labeled with $[M]^+$. The used method starts with the injection temperature T_0. After holding this temperature for 3 min, the column is heated to temperature T_1 (ramp) and this temperature is held for an additional time t. Method: 50_40: T_0 = 50 °C, T_1 = 320 °C, ramp = 40 °C/min; t = 4 min. Chiral High Pressure Liquid Chromatography (HPLC) analysis was performed on a Agilent instrument. CD spectra were recorded on a J-815 (JASCO) spectrometer.

CH_2Cl_2 and Et_3N were distilled over CaH_2; and MTBE, THF and toluene were distilled and dried over Na. The starting materials 3-methoxy-3-methylbut-1-yne[4] and tosyl azide[5] were prepared following known literature procedures. Other solvents and commercially available reagents were used without further purification.

Synthesis of the triazole catalysts TetrakisTriazoles 1a and 2a-c & BisTriazole B1

TetrakisTriazole 1a

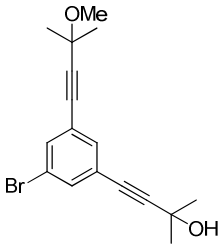
1,3-Dibromo-5-(3-methoxy-3-methylbut-1-yn-1-yl)benzene (9)



1,3,5-Tribromobenzene (14.17 g, 45.0 mmol, 3.0 equiv.), CuI (57 mg, 0.3 mmol, 2.0 mol%) and $[PdCl_2(PPh_3)_2]$ (105 mg, 0.15 mmol, 1.0 mol%) were suspended in THF (50 mL). 3-Methoxy-3-methylbut-1-yne (1.57 g, 15.0 mmol, 1.0 equiv.) and Et_3N (10 mL) were added and the resulting mixture was stirred at 50 °C in a flame-dried pressure schlenk tube under argon for 2 days. The crude product was filtered through celite and washed with ethyl acetate (3 × 10 mL) to remove solid material and Et_3N. After removing the solvent, excessive 1,3,5-tribromobenzene (8.49 g, 27.0 mmol) and the desired product **9** (3.98 g, 12.0 mmol, 80%) was isolated as a colourless oil by flash column chromatography (pentane/EtOAc, 50:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 7.61 (t, J = 1.8 Hz, 1H), 7.51 (d, J = 1.8 Hz, 2H), 3.40 (s, 3H), 1.52 (s, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$):

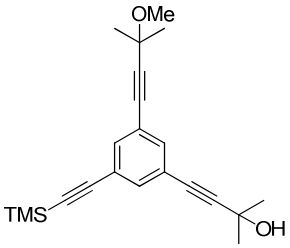
δ/ppm = 134.1, 133.3, 126.4, 122.7, 94.0, 81.5, 71.0, 52.0, 28.3; **HRMS (ES):** calculated for $[C_{12}H_{12}Br_2OAg]^+$: *m/z* = 436.8306, found: 436.8303.

1-Bromo-3-(3-Hydroxy-3-methylbut-1-in-1-yl)-5-(3-methoxy-3-methylbut-1-in-1-yl)benzene (10)



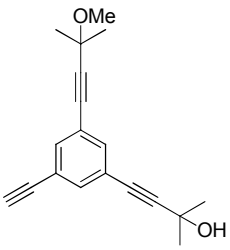
1,3-Dibromo-5-(3-methoxy-3-methylbut-1-yn-1-yl)benzene (**9**) (7.65 g, 23.00 mmol, 2.0 equiv.), CuI (46 mg, 0.24 mmol, 2.0 mol%) and $[PdCl_2(PPh_3)_2]$ (81mg, 0.12 mmol, 1.0 mol%) were suspended in THF (70 mL). 2-Methylbut-3-in-2-ol (1.13 mL, 11.50 mmol, 1.0 equiv.) and Et_3N (20 mL) were added and the resulting mixture was stirred at 50 °C in a flame-dried pressure schlenk tube under argon for 36 h. The crude product was filtered through celite and washed with ethyl acetate (3 × 10 mL) to remove solid material and Et_3N. After removing the solvent, the desired product **10** (2.71 g, 7.40 mmol, 99%) was isolated by flash column chromatography (pentane/EtOAc, 50:1→ 5:1) as a white solid, as well as the recovered 1,3-dibromo-5-(3-methoxy-3-methylbut-1-in-1-yl)benzene (4.14 g, 12.50 mmol). **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 7.52 – 7.48 (m, 2H), 7.41 (t, *J* = 1.4 Hz, 1H), 3.40 (s, 3H), 1.59 (s, 6H), 1.52 (s, 6H); **^{13}C NMR** (75 MHz,$CDCl_3$): δ/ppm = 134.2, 134.1, 133.5, 124.9, 124.8, 121.9, 95.8, 93.1, 82.2, 80.1, 71.0, 65.7, 51.9, 31.5, 28.3; **HRMS (ES):** *m/z* calculated for $[C_{17}H_{19}BrO_2Na]^+$: 357.0461, found: 357.0462; **ATR-FTIR** (cm^{-1}): 3396, 2983, 2936, 2825, 1587, 1554, 1426, 1361, 1250, 1361, 1250, 1171, 1145, 1076, 960, 933, 889, 866, 841, 809, 678.

1-(3-Hydroxy-3-methylbut-1-in-1-yl)-3-(3-methoxy-3-methylbut-1-in-1-yl)-5-((trimethylsilyl)ethinyl)-benzene (11)



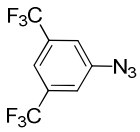
1-Bromo-3-(3-Hydroxy-3-methylbut-1-in-1-yl)-5-(3-methoxy-3-methylbut-1-in-1-yl)benzene (**10**) (67 mg, 0.20 mmol, 1.0 equiv.), $[Cu(MeCN)_4][BF_4]$ (1.3 mg, 4.00 µmol, 2 mol%) and $Pd(PPh_3)_4$ (2.3 mg, 2.00 µmol, 1 mol%) were suspended in THF (70 mL). Trimethylsilylacetylene (42 µL, 0.30 mmol, 1.5 equiv.) and Et_3N (0.2 mL) were added and the resulting mixture was stirred at 50 °C in a flame-dried pressure schlenk tube under argon for 24 h. The crude product was filtered through celite and washed with ethyl acetate (3 × 10 mL) to remove solid material and Et_3N. After removing the solvent, the desired product **10** (60 mg, 0.17 mmol, 85%) was isolated by flash column chromatography (pentane/EtOAc, 10:1) as a yellow resin. **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 7.46 (t, *J* = 1.6 Hz, 1H), 7.45 (t, *J* = 1.6 Hz, 1H), 7.41 (t, *J* = 1.6 Hz, 1H), 3.40 (s, 3H), 1.59 (s, 6H), 1.51 (s, 6H), 0.23 (s, 9H); **^{13}C NMR** (100 MHz,$CDCl_3$): δ/ppm = 134.7, 134.6, 134.6, 123.8, 123.5, 123.4, 103.3, 95.8, 95.0, 92.3, 82.8, 80.7, 71.0, 65.7, 51.9, 31.5, 28.4, 0.0; **HRMS (ES):** *m/z* calculated for $[C_{22}H_{28}O_2SiNa]^+$: 375.1751, found: 375.1749; **ATR-FTIR** (cm^{-1}): 2983, 2154, 1581, 1464, 1414, 1363, 1249, 1171, 1145, 1076, 998, 952, 922, 879, 841, 760, 743, 682, 657.

1-Ethynyl-3-(3-Hydroxy-3-methylbut-1-in-1-yl)-5-(3-methoxy-3-methylbut-1-in-1-yl)benzene (12)

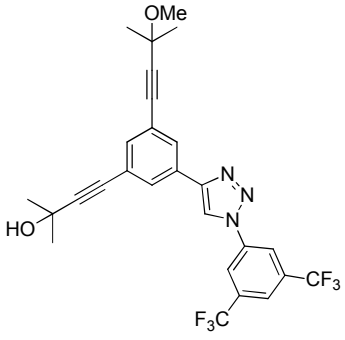


1-(3-Hydroxy-3-methylbut-1-in-1-yl)-3-(3-methoxy-3-methylbut-1-in-1-yl)-5-((trimethyl-silyl)ethinyl)benzene (**11**) (2.70 g, 7.66 mmol, 1.0 equiv.) was dissolved in MeOH (150 mL). After addition of KOH (319 mg, 7.66 mmol, 1.0 equiv.) the mixture was stirred overnight at room temperature. H_2O (50 mL) and HCl (7.66 mL, 1M aqueous solution, 7.66 mmol, 1.0 equiv.) was added and the resulting mixture was extracted with DCM (4 × 20 mL) and dried over $MgSO_4$. After removing the solvent under reduced pressure the desired product **12** (2.14 g, 7.64 mmol, >99%) was afforded as a slight yellow liquid. **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 7.48 – 7.44 (m, 3H), 3.41 (s, 3H), 3.08 (s, 1H), 1.60 (s, 6H), 1.52 (s, 6H); **^{13}C NMR** (100 MHz,$CDCl_3$): δ/ppm = 135.0, 134.8, 134.7, 123.6, 123.6, 122.8, 95.2, 92.5, 82.6, 82.0, 80.5, 78.5, 71.0, 65.7, 51.9, 31.5, 28.4; **HRMS (ES):** *m/z* calculated for $[C_{19}H_{20}O_2Na]^+$: 303.1356, found: 303.1352; **ATR-FTIR** (cm^{-1}): 3298, 2983, 1581, 1415, 1363, 1249, 1170, 1143, 1074, 947, 880, 830, 682, 639, 618.

4-(3-(1-(3,5-Bis(trifluoromethyl)phenyl)-1*H*-1,2,3-triazol-4-yl)-5-(3-methoxy-3-methylbut-1-in-1-yl)phenyl)-2-methylbut-3-in-2-ol (13)



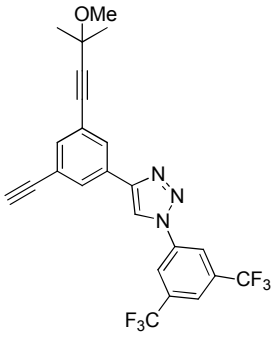
3,5-Bis(trifluoromethyl)aniline (1.55 mL, 9.97 mmol, 1.3 equiv.) was dissolved in TFA (25 mL) and cooled to 0 °C. After addition of $NaNO_2$ (794 mg, 11.50 mmol, 1.5 equiv.) the mixture was stirred for 30 min at 0 °C. NaN_3 (800 mg, 12.30 mmol, 1.6 equiv.) was added slowly (exothermic reaction, nitrous fumes) at 0° C and the mixture was stirred for 2 h at room temperature. Afterwards the reaction mixture was quenched by slow addition of H_2O (25 mL), followed by extraction with pentane (3 × 30 mL). The combined organic layers were washed with saturated aqueous $NaHCO_3$ solution (3 × 30 mL), concentrated under reduced pressure (volume: ~ 2 mL), and directly used as *in situ* 3,5-bis(trifluoromethyl)phenylazide.



Alkyne-**12** (2.15 g, 7.67 mmol, 1.0 equiv.), 0.04 M aqueous $CuSO_4$ solution (9.6 mL, 0.06 mmol, 5 mol%), sodium ascorbate (9.6 mL, 0.12 M aqueous solution, 0.18 mmol, 15 mol%) and the *in situ* 3,5-bis(trifluoromethyl)-phenylazide were combined in a solvent mixture of DCM (20 mL) and *t*BuOH (20 mL) and stirred 12 h at room temperature and 3 h at 50 °C. The reaction mixture was diluted with water (50 mL) followed by extraction with DCM (3 × 100 mL). The obtained organic phase was washed with aqueous ammonia (26%, 3 × 25 mL) and brine (20 mL), and dried over $MgSO_4$. The solvent was removed under reduced pressure obtaining a yellow solid. This crude product was dissolved in DCM and precipitated with pentane. The desired product **13** (3.45 g, 6.44 mmol, 84%) was obtained as slight yellow solid by filtration. **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 8.36 (s, 1H), 8.31 (s, 2H), 7.97 (s, 1H), 7.93 (t, *J* = 1.6 Hz, 1H), 7.91 (t, *J* = 1.6 Hz, 1H), 7.51 (t, *J* = 1.5 Hz, 1H), 3.44 (s, 3H), 2.18 (s, 1H), 1.63 (s, 6H), 1.55 (s, 6H); **^{13}C NMR** (75 MHz,$CDCl_3$): δ/ppm = 148.0, 137.9, 135.0, 133.8 (q, *J* = 34.5 Hz), 129.9, 128.8, 128.7, 124.2, 124.1, 122.7 (q, *J* = 273.3 Hz), 122.7 – 122.1 (m), 120.4 (q, *J* = 2.8 Hz), 117.8, 95.3,

92.6, 83.0, 80.9, 71.0, 65.7, 52.0, 31.6, 28.4; **^{19}F NMR** (282 MHz,$CDCl_3$): δ/ppm = -63.02; **HRMS (ES):** *m*/*z* calculated $[C_{27}H_{23}F_6N_3O_2Na]^+$: 558.1587, found: 558.1589; **ATR-FTIR** (cm^{-1}): 3478, 3120, 2939, 1591, 1496, 1473, 1409, 1354, 1273, 1181, 1135, 1077, 1049, 956, 931, 885, 846, 824, 717, 682; **Mp.:** 204-206 °C.

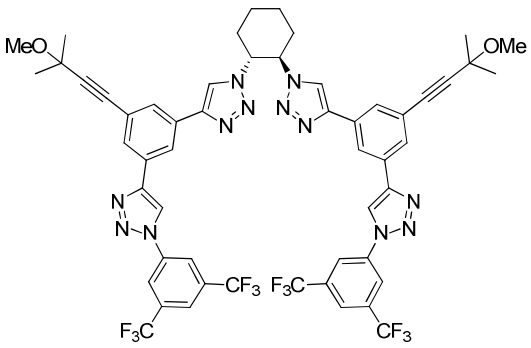
1-(3,5-bis(trifluoromethyl)phenyl)-4-(3-ethynyl-5-(3-methoxy-3-methylbut-1-in-1-yl)phenyl)-1*H*-1,2,3-triazole (14)



13 (3.13 g, 5.84 mmol, 1.0 equiv) and KOH (33 mg, 0.58 mmol, 10 mol%) were suspended in toluene (150 mL) and stirred for 4.5 h at 130 °C. The reaction mixture was neutralized with HCl (0.58 mL, 1.0 M aqueous solution, 0.58 mmol, 1.0 equiv.) and diluted with H_2O (50 mL). The resulting mixture was extracted with DCM (4 × 50 mL) and dried over $MgSO_4$. After removing the solvent under reduced pressure the crude product was dissolved in DCM/MeOH (100:1) and precipitated with pentane. The desired product **14** (2.75 g, 5.76 mmol, 99%) was obtained as slight yellow solid by filtration.

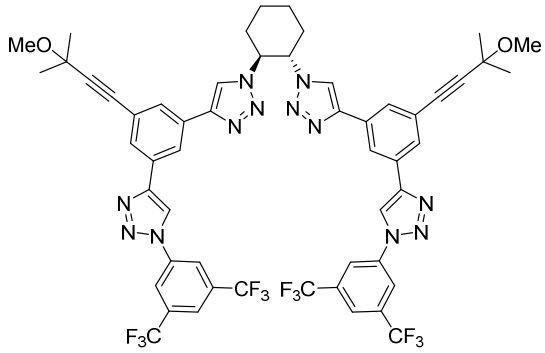
^{1}H NMR (300 MHz, $CDCl_3$): δ/ppm = 8.36 (s, 1H), 8.31 (s, 2H), 8.00 – 7.96 (m, 3H), 7.58 (bs, 1H), 3.45 (s, 3H), 3.14 (s, 1H), 1.56 (s, 6H); **^{13}C NMR** (75 MHz,$CDCl_3$): δ/ppm = 147.9, 137.9, 135.4, 133.9 (q, *J* = 34.5 Hz), 130.0, 129.4, 129.1, 124.3, 123.5, 122.7 (q, *J* = 273.3 Hz), 122.7 – 122.3 (m), 120.4 (q, *J* = 4.0 Hz), 117.8, 92.8, 82.8, 82.2, 78.7, 71.0, 52.0, 28.4; **^{19}F NMR** (282 MHz,$CDCl_3$): δ/ppm = -63.01; **HRMS (ES):** *m*/*z* calculated for $[C_{24}H_{17}F_6N_3ONa]^+$: 500.1168, found: 500.1172; **ATR-FTIR** (cm^{-1}): 3295, 3120, 2994, 2944, 1497, 1474, 1432, 1410, 1354, 1276, 1188, 1170, 1134, 1063, 1044, 896, 882, 850, 821, 710, 699, 690, 653; **Mp.:** 200-205 °C.

trans-1,2-Bis(4-(3-(1-(3,5-bis(trifluoromethyl)phenyl)-1H-1,2,3-triazol-4-yl)-5-(3-methoxy-3-methylbut-1-in-1-yl)phenyl)-1H-1,2,3-triazol-1-yl)cyclohexane (1a)



((*R*,*R*)-1a) (*R*,*R*)-Diaminocyclohexane (96 mg, 0.8 mmol, 1.0 equiv.), $NaHCO_3$ (538 mg, 6.4 mmol, 8.0 equiv.) and $CuSO_4$ (26 mg, 0.16 mmol, 20 mol%) were suspended in MeOH/Et_2O/H_2O (12 mL, 3:2:1). Nonafluorobutan-1-sulfonyl azide (780 mg, 2.4 mmol, 3.0 equiv.) was added and the mixture was stirred for 24 h at room temperature. A solution of "click"-alkyne **14** (782 mg, 1.64 mmol, 2.05 equiv.) in CH_2Cl_2/MeOH (24 mL, 10:1) and sodium ascorbate (476 mg, 2.4 mmol, 3.0 equiv.) was added. The reaction mixture was stirred for additional 48 h at room temperature. After removing the solvent under reduced pressure the residue was dissolved in DCM (50 mL). After washing with $NaHCO_3$ solution (4 × 10 mL), aqueous ammonia (26%, 2 × 10 mL) and H_2O (10 mL), the solvent was removed under reduced pressure. The residue was taken up with DCM (5 mL)

and dropped into fast stirred pentane (150 mL). The desired product precipitated as a white solid and was isolated by filtration **1a** (648 mg, 0.58 mmol, 72%). **^{1}H NMR** (600 MHz, THF-D_8): δ/ppm = 9.19 (s, 2H), 8.58 (s, 4H), 8.39 (t, *J* = 1.6 Hz, 2H), 8.27 (s, 2H), 8.12 (s, 2H), 7.90 (t, *J* = 1.6 Hz, 2H), 7.77 (t, *J* = 1.6 Hz, 2H), 5.23 – 5.16 (m, 2H), 3.36 (s, 6H), 2.44 – 2.28 (m, 4H), 2.10 – 2.03 (m, 2H), 1.49 (s, 12H); **^{13}C NMR** (150 MHz,THF-D_8): δ/ppm = 148.5, 146.4, 139.6, 133.9 (q, *J* = 34.0 Hz), 133.3, 132.0, 129.0, 128.4, 125.0,124.1 (q, *J* = 272.6 Hz), 123.0, 122.7 – 122.4 (m), 121.4, 121.2 (q, *J* = 4.0 Hz), 120.1, 92.7, 84.5, 71.5, 64.6, 51.9, 34.0, 28.8; **^{19}F NMR** (565 MHz,THF-D_8): δ/ppm = -63.71; **HRMS (ES):** *m/z* calculated for $[C_{54}H_{44}F_{12}N_{12}O_2Na]^+$: 1143.3411, found: 1143.3407; **ATR-FTIR** (cm^{-1}): 1608, 1495, 1357, 1279, 1231, 1175, 1140, 1074, 1038, 895, 847, 810, 710, 683, 654; **M.p.**: 115-125 °C; (*R,R*)-**1a**, $[\alpha]_{589}^{20}$: +23.4 (*c* 0.15, $CHCl_3$).

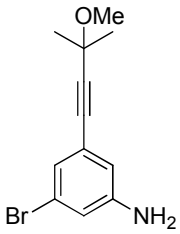


((*S,S*)-1a) The opposite enantiomer was obtained from the corresponding (*S,S*)-amine. (*S,S*)-Diaminocyclohexane (57 mg, 0.50 mmol, 1.00 equiv.), $NaHCO_3$ (336 mg, 4.00 mmol, 8.00 equiv.) and $CuSO_4$ (16 mg, 0.10 mmol, 20 mol%) were suspended in MeOH/Et_2O/H_2O (12 mL, 3:2:1). Nonafluorobutan-1-sulfonyl azide (488 mg, 1.50 mmol, 3.0 equiv.) was added and the mixture was stirred for 24 h at room temperature. A solution of "click"-alkyne **14** (489 mg, 1.03 mmol, 2.05 equiv.) in CH_2Cl_2/MeOH (11 mL, 10:1) and sodium ascorbate (297 mg, 1.50 mmol, 3.00 equiv.) was added. The reaction mixture was stirred for additional 48 h at room temperature. After removing the solvent under reduced pressure the residue was dissolved in DCM (50 mL). After washing with $NaHCO_3$ solution (4 × 10 mL), aqueous ammonia (26%, 2 × 10 mL) and H_2O (10 mL), the solvent was removed under reduced pressure. The desired product (124 mg, 0.11 mmol, 22%) was isolated (under non-optimized conditions) by flash column chromatography (CH_2Cl_2/EtOAc, 20:1 → 10:1) as a white solid. (*S,S*)-**1a**, $[\alpha]_{589}^{20}$: –22.9 (*c* 0.09, $CHCl_3$).

HPLC (Daicel Chiralpak IA, Hexane/iPrOH = 90:10, λ = 254 nm, 1.0 mL/min): t_R = 14.4 min (*R,R*)-**1a**, 19.8 min (*S,S*)-**1a**.

TetrakisTriazole 2a

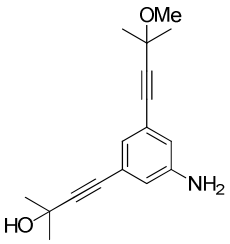
3-bromo-5-(3-methoxy-3-methylbut-1-yn-1-yl)aniline (15)



According to a procedure of *H. Xu et al.*[6] 1,3-dibromo-5-(3-methoxy-3-methylbut-1-in-1-yl)benzene **9** (4.9 g, 14.75 mmol, 1.0 equiv.), Cu_2O (105 mg, 0.74 mmol, 5 mol%), NH_3 (42.5 mL, 26% aqueous solution, 0.59 mol, 40.0 equiv.) and 1,4-dioxane (42.5 mL) were combined in a 100 mL pressure flask (The reaction is strongly pressure dependent! If the ratio of gas phase to liquid phase is changed, different temperatures and reaction times are required). The mixture was stirred for 12 h at 100 °C. Next, a saturated NaCl solution (100 mL) was added and the reaction mixture was extracted with EtOAc (3 × 100 mL). The crude product

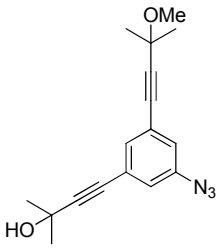
was adsorbed on silica and purified by flash column chromatography (pentane/EtOAc, 20:1 → 2:1). The desired product **15** (818 mg, 3.05 mmol, 21% (91% relative to conversion)) was obtained as a brown oil as well as the recovered starting material **9 (**3.77 g, 11.36 mmol, 77%). **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 6.96 (dd, *J* = 1.8, 1.3 Hz, 1H), 6.77 (dd, *J* = 2.2, 1.8 Hz, 1H), 6.65 (dd, *J* = 2.2, 1.3 Hz, 1H), 3.40 (s, 3H), 1.51 (s, 6H); **^{13}C NMR** (75 MHz, $CDCl_3$): δ/ppm = 147.5, 125.2, 124.6, 122.7, 118.0, 116.7, 91.7, 83.2, 71.0, 51.9, 28.4; **HRMS (ES):** *m/z* calculated for $[C_{12}H_{14}BrNONa]^+$: 290.0151, found: 290.0153; **ATR-FTIR** (cm^{-1}): 3471, 3361, 3233, 2984, 2936, 2826, 1621, 1594, 1565, 1434, 1303, 1245, 1172, 1068.

1-Amino-3-(3-hydroxy-3-methylbut-1-in-1-yl)-5-(3-methoxy-3-methylbut-1-in-1-yl)benzene (16)



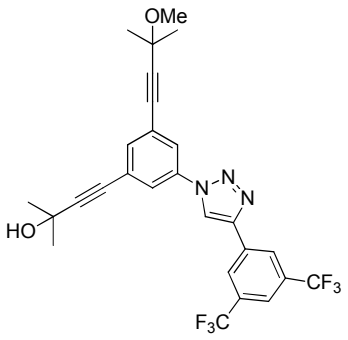
1-Amino-3-bromo-5-(3-methoxy-3-methylbut-1-in-1-yl)benzene (**15**) (6.28 g, 23.4 mmol, 1.0 equiv.), $[Cu(MeCN)_4][BF_4]$ (150 mg, 0.48 mmol, 2 mol%) and $Pd(PPh_3)_4$ (278 mg, 0.24 mmol, 1 mol%) were suspended in THF (65 mL). Trimethylsilylacetylene (42 µL, 0.30 mmol, 1.5 equiv.), 2-methylbut-3-in-2-ol (3.44 mL, 35.10 mmol, 1.5 equiv.) and Et_3N (6.5 mL) were added and the resulting mixture was stirred at 90 °C in a flame-dried pressure schlenk tube under argon for 40 h. The crude product was filtered through celite and washed with ethyl acetate (3 × 10 mL) to remove solid material and Et_3N. After removing the solvent, the desired product **16** (5.58 g, 20.5 mmol, 88%) was isolated by flash column chromatography (pentane/EtOAc, 2:1) as a brown resin. **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 6.91 (bs, 1H), 6.71 – 6.65 (m, 2H), 3.40 (s, 3H), 1.59 (s, 6H), 1.51 (s, 6H); **^{13}C NMR** (75 MHz,$CDCl_3$): δ/ppm = 146.3, 125.5, 123.9, 123.7, 118.1, 118.0, 93.8, 91.0, 83.8, 81.7, 71.0, 65.7, 51.9, 31.6, 28.5; **HRMS (ES):** *m/z* calculated for $[C_{17}H_{21}NO_2Na]^+$: 294.1465, found: 294.1475; **ATR-FTIR** (cm^{-1}): 2985, 2936, 1620, 1590, 1459, 1423, 1362, 1265, 1251, 1171, 1144, 1072, 950, 857, 831, 736, 704, 684.

1-Azido-3-(3-hydroxy-3-methylbut-1-in-1-yl)-5-(3-methoxy-3-methylbut-1-in-1-yl)benzene (17)



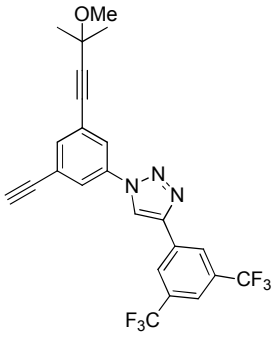
1-Amino-3-(3-hydroxy-3-methylbut-1-in-1-yl)-5-(3-methoxy-3-methylbut-1-in-1-yl)benzene (**16**) (3.25 g, 12.0 mmol, 1.0 equiv.) was dissolved in Et_2O (12 mL), H_2O (50 mL) and HCl (2.5 mL, 10 M aqueous solution, 25.2 mmol, 2.1 equiv.) were added and the resulting mixture was cooled to 0 °C. $NaNO_2$ (869 mg, 12.6 mmol, 1.05 equiv.) was added to the suspension. The resulting intense red suspension was stirred for 90 min at 0 °C. NaN_3 (819 mg, 12.6 mmol, 1.05 equiv.) was fractionally added and the reaction mixture was stirred for 30 min at 0 °C and additional 2 h at room temperature. The mixture was extracted with Et_2O (4 × 30 mL) and the resulting organic phases dried over $MgSO_4$. The crude product was adsorbed on silica and purified by flash column chromatography (pentane/EtOAc, 20:1 → 2:1). The desired product **17** (818 mg, 3.05 mmol, 21% (91% relative to conversion)) was obtained as brown oil. **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 7.24 (t, *J* = 1.4 Hz, 1H), 6.99 – 6.96 (m, 2H), 3.40 (s, 3H), 1.59 (s, 6H), 1.51 (s, 6H); **^{13}C NMR** (75 MHz,$CDCl_3$): δ/ppm = 140.4, 131.4, 124.7, 124.6, 121.8, 121.7, 95.5, 92.7, 82.6, 80.4, 71.0, 65.5, 51.9, 31.4, 28.3; **HRMS (ES):** *m/z* calculated for $[C_{17}H_{19}N_3O_2Na]^+$: 320.1369, found: 320.1367.

4-(3-(4-(3,5-bis(trifluoromethyl)phenyl)-1*H*-1,2,3-triazol-1-yl)-5-(3-methoxy-3-methylbut-1-in-1-yl)phenyl)-2-methylbut-3-in-2-ol (18)



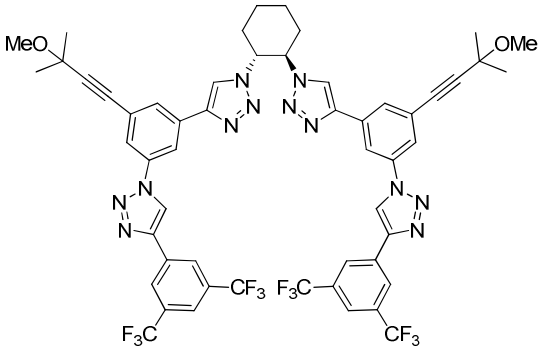
Azide **17** (1.07 g, 3.60 mmol, 1.0 equiv.), 0.04 M aqueous $CuSO_4$ solution (4.5 mL, 0.06 mmol, 5 mol%), sodium ascorbate (4.5 mL, 0.12 M aqueous solution, 0.18 mmol, 15 mol%) and 1-ethinyl-3,5-bis(trifluoromethyl)benzene (1.19 g, 5.00 mmol, 1.4 equiv.) were combined in a solvent mixture of DCM (9 mL) and *t*BuOH (9 mL) and stirred 48 h at 50 °C. The reaction mixture was diluted with water (20 mL) followed by extraction with DCM (3 × 75 mL). After washing with 26% aqueous ammonia (3 × 25 mL), the solvent was removed under reduced pressure. This crude product was dissolved in DCM and precipitated with pentane. The desired product **18** (1.91 g, 3.56 mmol, 99%) was obtained as slight yellow solid by filtration. **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 8.38 (s, 1H), 8.36 (s, 2H), 7.87 (s, 1H), 7.82 (t, *J* = 1.4 Hz, 1H), 7.81 (t, *J* = 1.4 Hz, 1H), 7.58 (t, *J* = 1.4 Hz, 1H), 3.44 (s, 3H), 2.14 (s, 1H), 1.64 (s, 6H), 1.56 (s, 6H); **^{13}C NMR** (75 MHz, $CDCl_3$): δ/ppm = 146.1, 136.7, 135.3, 132.6 (q, *J* = 33.6 Hz), 132.2, 125.9 (q, *J* = 3.4 Hz), 125.3, 125.2, 123.3 (q, *J* = 272.9 Hz), 123.0, 122.9, 122.5 – 121.9 (m), 118.6, 96.6, 94.1, 82.0, 80.0, 71.0, 65.7, 52.0, 31.5, 28.3; **^{19}F NMR** (282 MHz, $CDCl_3$): δ/ppm = -62.99; **HRMS (ES):** *m/z* calculated for $[C_{27}H_{23}F_6N_3O_2Na]^+$: 558.1587, found: 558.1587; **ATR-FTIR** (cm^{-1}): 3282, 2988, 2941, 1601, 1587, 1458, 1442, 1405, 1373, 1336, 1300, 1278, 1246, 1167, 1134, 1076, 1064, 1040, 1001, 962, 936, 896, 872, 845, 825, 795, 717, 700, 679; **M.p.**: 210-215 °C.

4-(3,5-Bis(trifluoromethyl)phenyl)-1-(3-ethinyl-5-(3-methoxy-3-methylbut-1-in-1-yl)phenyl)-1*H*-1,2,3-triazole (19)



18 (536 mg, 1.00 mmol, 1.0 equiv) and KOH (6 mg, 0.10 mmol, 10 mol%) were suspended in toluene (25 mL) and stirred for 4 h at 130 °C. The reaction mixture was neutralized with HCl (0.10 mL, 1.0 M aqueous solution, 0.10 mmol, 1.0 equiv.) and diluted with H_2O (10 mL). The resulting mixture was extracted with DCM (4 × 50 mL) and dried over $MgSO_4$. After removing the solvent under reduced pressure the crude product was dissolved in DCM/MeOH (100:1) and precipitated with pentane. The desired product **19** (440 mg, 0.92 mmol, 92%) was obtained as white solid by filtration. **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 8.38 (s, 1H), 8.36 (s, 2H), 7.89 – 7.86 (m, 3H), 7.64 (t, *J* = 1.4 Hz, 1H), 3.44 (s, 3H), 3.22 (s, 1H), 1.56 (s, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ/ppm = 146.1, 136.8, 135.7, 132.6 (q, *J* = 33.7 Hz), 132.2, 125.9 (q, *J* = 3.3 Hz), 125.5, 124.6, 123.6, 123.4, 123.3 (q, *J* = 267.2 Hz), 122.5 – 122.0 (m), 118.7, 94.3, 81.9, 81.2, 80.1, 71.0, 52.0, 28.3; **^{19}F NMR** (376 MHz, $CDCl_3$): δ/ppm = -63.00; **HRMS (ES):** *m/z* calculated for $[C_{24}H_{17}F_6N_3ONa]^+$: 500.1168, found: 500.1174; **ATR-FTIR** (cm^{-1}): 3308, 3099, 2992, 1601, 1585, 1444, 1372, 1327, 1277, 1240, 1184, 1166, 1130, 1062, 1033, 990, 888, 853, 821, 708, 699, 682, 655; **Mp.**: 193-197 °C.

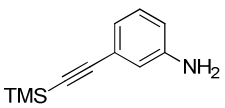
(*R,R*)-1,2-Bis(4-(3-(4-(3,5-bis(trifluoromethyl)phenyl)-1H-1,2,3-triazol-1-yl)-5-(3-methoxy-3-methylbut-1-in-1-yl)phenyl)-1H-1,2,3-triazol-1-yl)cyclohexane (2a)



(*R*,*R*)-Diaminocyclohexane (57 mg, 0.50 mmol, 1.00 equiv.), $NaHCO_3$ (336 mg, 4.00 mmol, 8.00 equiv.) and $CuSO_4$ (16 mg, 0.10 mmol, 20 mol%) were suspended in MeOH/Et_2O/H_2O (12 mL, 3:2:1). Nonafluorobutan-1-sulfonyl azide (488 mg, 1.50 mmol, 3.00 equiv.) was added and the mixture was stirred for 24h at room temperature. A solution of "click"-alkyne **19** (489 mg, 1.03 mmol, 2.05 equiv.) in CH_2Cl_2/MeOH (11 mL, 10:1) and sodium ascorbate (297 mg, 1.50 mmol, 3.00 equiv.) was added. The reaction mixture was stirred for additional 24 h at room temperature. After removing the solvent under reduced pressure the residue was dissolved in DCM (50 mL). After washing with $NaHCO_3$ solution (4 × 10 mL), aqueous ammonia (26%, 2 × 10 mL) and H_2O (10 mL), the mixture was dried over $MgSO_4$ and the solvent was removed under reduced pressure. The desired product **2a** (396 mg, 0.35 mmol, 70%) was isolated by flash column chromatography (DCM/EtOAc, 10:1 → 5:1) as a white solid. **^{1}H NMR** (300 MHz, THF-D_8): δ/ppm = 9.23 (s, 2H), 8.51 (s, 4H), 8.35 (s, 2H), 8.35 (t, *J* = 1.5 Hz, 1H), 7.98 (s, 2H), 7.86 (t, *J* = 1.5 Hz, 1H), 7.85 (t, *J* = 1.5 Hz, 1H), 5.30 – 5.11 (m, 2H), 3.36 (s, 6H), 2.48 – 2.26 (m, 4H), 2.15 – 2.00 (m, 2H), 1.49 (s, 12H); **^{13}C NMR** (150 MHz,THF-D_8): δ/ppm = 146.2, 1457, 138.5, 134.42 134.3, 133.0 (q, *J* = 33.3 Hz), 129.0, 126.4 (q, *J* = 3.8 Hz), 125.9, 124.5 (q, *J* = 272.5 Hz), 122.4 – 122.2 (m), 122.2, 122.0, 121.0, 117.0, 94.0, 83.5, 71.5, 64.8, 51.9, 33.9, 28.6, 25.6; **^{19}F NMR** (282 MHz,THF-D_8): δ/ppm = -63.76; **HRMS (ES):** *m/z* calculated for $[C_{54}H_{44}F_{12}N_{12}O_2Na]^+$: 1143.3411, found: 1143.3402; **ATR-FTIR** (cm^{-1}): 1613, 1596, 1464, 1375, 1323, 1277, 1238, 1172, 1131, 1074, 1033, 989, 896, 846, 806, 707, 682; $[\alpha]_{589}^{20}$ = +9.0 (*c* 0.15, $CHCl_3$); **Mp.**: 185-195 °C.

TetrakisTriazole 2b

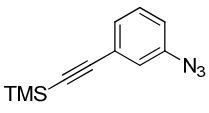
3-((Trimethylsilyl)ethinyl)aniline (20)



According to a procedure of *M. Erdélyi et al.*[7] 3-iodoaniline (3.25 mL, 27.00 mmol, 1.0 equiv.), trimethylsilylacetylene (4.48 mL, 32.40 mmol, 1.2 equiv.), CuI (206 mg, 1.08 mmol, 4 mol%) and $PdCl_2(PPh_3)_2$ (379 mg, 0.54 mmol, 2 mol%) were dissolved in Et_3N/DMF (70 mL, 1:1) and stirred for 4 days at room temperature. The reaction mixture was diluted with 1 M aqueous HCl solution (150 mL) and extracted with Et_2O (3 × 100 mL). The organic layers were washed with saturated $NaHCO_3$ solution (2 × 100 mL). The combined aqueous layer was again extracted with Et_2O (2 × 100 mL). All combined organic phases were dried over $MgSO_4$. The crude product was adsorbed on silica and purified by flash column chromatography (DCM). The desired product **20** (4.73 g, 25.00 mmol, 93%) was obtained as a brown oil. **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 7.08 (t, *J* = 7.8 Hz, 1H), 6.88 (dt, *J* = 7.8, 1.5 Hz, 1H), 6.79 (t, *J* = 1.5 Hz, 1H), 6.63 (dd, *J* = 7.8, 1.5 Hz, 1H), 3.65 (bs, 2H), 0.25 (s, 9H); **^{13}C**

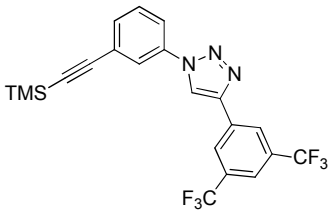
NMR (75 MHz,$CDCl_3$): δ/ppm = 146.2, 129.3, 123.8, 122.5, 118.3, 115.7, 105.5, 93.5, 0.1; **HRMS (ES):** *m/z* calculated for $[C_{11}H_{15}NSiNa]^+$: 190.1047, found: 190.1054.

3-Azido-1-((trimethylsilyl)ethinyl)benzene (21)[8]



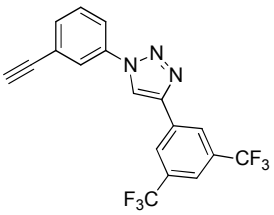
3-((Trimethylsilyl) ethinyl)aniline (**20**) (189 mg, 1.00 mmol, 1.00 equiv.) was suspended in HCl (2.1 mL, 1 M aqueous solution, 2.10 mmol, 2.10 equiv.) and cooled to 0 °C. $NaNO_2$ (73 mg, 1.05 mmol, 1.05 equiv.) was added and the resulting mixture was stirred 20 min at 0 °C. NaN_3 (69 mg, 1.05 mmol, 1.05 equiv.) was fractionally added and the reaction mixture was stirred for 10 min at 0 °C and additional 20 min at room temperature. The mixture was extracted with Et_2O (3 × 5 mL) and dried over $MgSO_4$. The desired product **21** (210 mg, 0.98 mmol, 98%) was obtained after a filtration through silica (pentane) as brown oil. **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 7.27 (td, *J* = 7.7, 0.6 Hz, 1H), 7.23 (dt, *J* = 7.7, 1.4 Hz, 1H), 7.13 (ddd, *J* = 2.2, 1.4, 0.6 Hz, 1H), 6.96 (ddd, *J* = 7.7, 2.2, 1.4 Hz, 1H), 0.25 (s, 9H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ/ppm = 140.3, 129.7, 128.6, 124.9, 122.3, 119.5, 104.0, 95.6, 0.0.

4-(3,5-Bis(trifluoromethyl)phenyl)-1-(3-((trimethylsilyl)ethinyl)phenyl)-1*H*-1,2,3-triazole (22)



Azide **21** (1.27 g, 5.90 mmol, 1.0 equiv.), 0.04 M aqueous $CuSO_4$ solution (7.4 mL, 0.06 mmol, 5 mol%), sodium ascorbate (7.4 mL, 0.12 M aqueous solution, 0.18 mmol, 15 mol%) and 1-ethinyl-3,5-bis(trifluoromethyl)benzene (1.76g, 7.38 mmol, 1.25 equiv.) were combined in a solvent mixture of DCM (15 mL) and *t*BuOH (15 mL) and stirred for 48 h at 50 °C. The reaction mixture was diluted with saturated NaCl solution (30 mL) followed by extraction with DCM (4 × 50 mL). After washing with aqueous ammonia (26%, 3 × 25 mL) the solvent was removed under reduced pressure. The desired product **22** (2.12 g, 4.67 mmol, 79%) was obtained as yellow solid by filtration. **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 8.38 (s, 1H), 8.36 (s, 2H), 7.90 – 7.84 (m, 2H), 7.80 (ddd, *J* = 7.8, 2.3, 1.4 Hz, 1H), 7.56 (dt, *J* = 7.8, 1.4 Hz, 1H), 7.50 (td, *J* = 7.8, 0.6 Hz, 1H), 0.28 (s, 9H); **^{13}C NMR** (75 MHz, $CDCl_3$): δ/ppm = 145.9, 136.7, 132.6, 132.5 (q, *J* = 33.6 Hz); 132.4, 130.1, 125.9 (q, *J* = 3.9 Hz), 123.7, 123.3 (q, *J* = 272.8 Hz), 122.4 – 121.8 (m), 120.6, 118.7, 103.1, 97.1, -0.1; **^{19}F NMR** (282 MHz,$CDCl_3$): δ/ppm = -63.0; **HRMS (ES):** *m/z* calculated for $[C_{21}H_{17}F_6N_3SiNa]^+$: 476.0988, found: 476.0983; **ATR-FTIR** (cm^{-1}): 2962, 2169, 1605, 1581, 1486, 1405, 1372, 1325, 1276, 1244, 1216, 1170, 1137, 1109, 1038, 993, 878, 842, 789, 759, 711, 682, 642; **Mp.**: 126-128 °C.

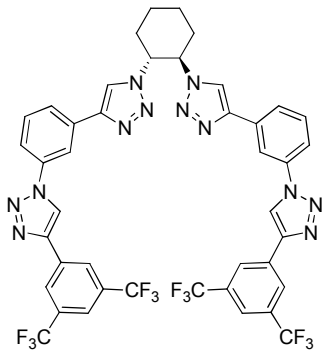
4-(3,5-Bis(trifluoromethyl)phenyl)-1-(3-ethinylphenyl)-1*H*-1,2,3-triazole (23)



22 (2.05 g, 4.52 mmol, 1.0 equiv.) was dissolved in MeOH (50 mL). After addition of KOH (253 mg, 4.52 mmol, 1.0 equiv.) the mixture was stirred for 12 h at room temperature. H_2O (50 mL) was added and the resulting mixture was extracted

with DCM (3 × 50 mL) and dried over $MgSO_4$. After removing the solvent under reduced pressure the desired product **23** (1.71 g, 4.50 mmol, >99%) was afforded as a yellow solid. **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 8.39 (s, 1H), 8.36 (s, 2H), 7.91 (t, *J* = 1.7 Hz, 1H), 7.87 (s, 1H), 7.83 (ddd, *J* = 7.8, 2.3, 1.4 Hz, 1H), 7.59 (dt, *J* = 7.8, 1.4 Hz, 1H), 7.53 (t, *J* = 7.8 Hz, 1H), 3.21 (s, 1H); **^{13}C NMR** (75 MHz,$CDCl_3$): δ/ppm = 146.0, 136.7, 132.9, 132.5 (q, *J* = 33.4 Hz), 132.3, 130.2, 125.9 (q, *J* = 3.7 Hz), 124.3, 124.0 , 123.3 (q, *J* = 272.8 Hz), 122.1 (hept, *J* = 3.8 Hz), 121.0, 118.7, 81.9, 79.5; **^{19}F NMR** (282 MHz,$CDCl_3$): δ/ppm = -63.00; **HRMS (ES):** *m/z* calculated for $[C_{18}H_9F_6N_3Na]^+$: 404.0593, found: 404.0599; **ATR FTIR** (cm^{-1}): 3261, 1607, 1582, 1485, 1407, 1371, 1325, 1275, 1241, 1177, 1125, 1104, 1087, 1039, 994, 897, 840, 789, 710, 700, 682, 651; **Mp.**: 144-146 °C.

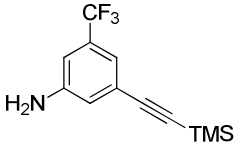
(*R,R*)-1,2-bis(4-(3-(4-(3,5-bis(trifluoromethyl)phenyl)-1H-1,2,3-triazol-1-yl)phenyl)-1H-1,2,3-triazol-1-yl)cyclohexane (TetraTri 2b)



(*R,R*)-Diaminocyclohexane (57 mg, 0.50 mmol, 1.00 equiv.), $NaHCO_3$ (336 mg, 4.00 mmol, 8.00 equiv.) and $CuSO_4$ (16 mg, 0.10 mmol, 20 mol%) were suspended in MeOH/Et_2O/H_2O (12 mL, 3:2:1). Nonafluorobutan-1-sulfonyl azide (488 mg, 1.50 mmol, 3.00 equiv.) was added and the mixture was stirred for 24h at ambient temperature. A solution of "click"-alkyne **23** (489 mg, 1.03 mmol, 2.05 equiv.) in CH_2Cl_2/MeOH (11 mL, 10:1) and sodium ascorbate (391 mg, 1.03 mmol, 2.05 equiv.) was added. The reaction mixture was stirred for additional 24 h at room temperature. After removing the solvent under reduced pressure, the residue was dissolved in DCM (50 mL). After washing with $NaHCO_3$ solution (4 × 10 mL), aqueous ammonia (26%, 2 × 10 mL) and H_2O (10 mL) the mixture was dried over $MgSO_4$ and the solvent was removed under reduced pressure. The desired product **2b** (312 mg, 0.34 mmol, 68%) was isolated by flash column chromatography (DCM/EtOAc, 10:1 → 5:1) as a white solid. **^{1}H NMR** (600 MHz, THF-D_8): δ/ppm = 9.15 (s, 2H), 8.51 (s, 4H), 8.32 (t, *J* = 1.6 Hz, 1H), 8.20 (s, 2H), 7.96 (s, 2H), 7.80 – 7.77 (m, 2H), 7.49 (t, *J* = 7.9 Hz, 2H), 5.25 – 5.16 (m, 2H), 2.45 – 2.30 (m, 4H), 2.12 – 2.02 (m, 2H); **^{13}C NMR** (150 MHz,THF-D_8): δ/ppm = 146.4, 146.1, 138.5, 134.6, 134.1, 133.0 (q, *J* = 33.2 Hz), 131.0, 126.4 (q, *J* = 3.7 Hz), 126.2, 124.6 (q, *J* = 272.5 Hz), 122.3 – 122.1 (m), 121.7, 121.1 – 120.9 (m), 119.8, 117.5, 64.7, 33.9; **^{19}F NMR** (564 MHz,THF-D_8): δ/ppm = -63.75; **HRMS (ES):** *m/z* calculated for $[C_{42}H_{28}F_{12}N_{12}Na]^+$: 951.2260, found: 951.2251; **ATR-FTIR** (cm^{-1}): 1617, 1589, 1372, 1327, 1313, 1276, 1235, 1175, 1126, 1111, 1045, 997, 896, 846, 792, 701, 682; $[\alpha]_{589}^{20}$: –10.0 (*c* 0.12, $CHCl_3$); **M.p.**: 250-252 °C.

TetrakisTriazole 2c

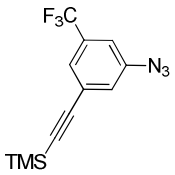
3-(Trifluoromethyl)-5-((trimethylsilyl)ethynyl)aniline (24)



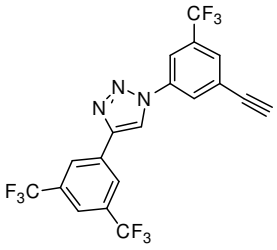
3-(Trifluoromethyl)-5-bromo-aniline (1.432 mL, 10.0 mmol, 1.0 equiv.) and $ZnBr_2$ (3.378 g, 15 mmol, 1.5 equiv.) were suspended in THF (50 mL) and stirred for

30 min at 80 °C. After cooling to room temperature trimethylsilylacetylene (2.08 mL, 15.0 mmol, 1.5 equiv.), CuI (76 mg, 0.04 mmol, 4 mol%), $Pd(PPh_3)_4$ (231 mg, 0.02 mmol, 2 mol%) and Et_3N (14 mL, 100 mmol, 10 equiv.) were added. The resulting mixture was stirred for 3 days at 80 °C. The crude product was filtered through celite to remove solid material and Et_3N. After removing the solvent, the desired product **24** (2.492 g, 9.7 mmol, 97%) was isolated by flash column chromatography (pentane/EtOAc, 9:1) as a brown resin. **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 6.87 (s, 1H), 6.68 (s, 1H), 6.60 (s, 1H), 3.58 (s, 2H), 0.01 (s, 9H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ/ppm = 146.5, 132.0 (q, *J* = 32.4 Hz), 124.9, 123.8 (q, *J* = 272.3 Hz), 121.0, 119.0 (q, *J* = 4.0 Hz), 111.7 (d, *J* = 4.0 Hz), 103.8, 95.4, -0.02; **^{19}F NMR** (376 MHz,THF-D_8): δ/ppm = -63.23; **HRMS (ES):** *m/z* calculated for $[C_{12}H_{14}F_3NSiNa]^+$: 280.0740, found: 280.0731; **ATR FTIR** (cm^{-1}): 3315, 2962, 2152, 1627, 1600, 1475, 1444, 1365, 1249, 1174, 1165, 1114, 999, 985, 891, 837, 721, 694.

4-(3,5-Bis(trifluoromethyl)phenyl)-1-(3-(trifluoromethyl)-5-((trimethylsilyl)ethynyl)phenyl)-1H-1,2,3 triazole (25)

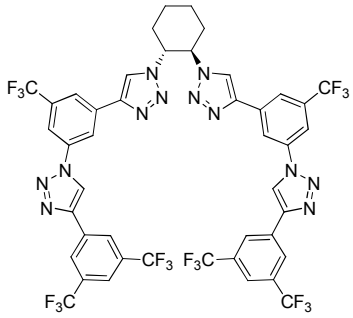


3-(Trifluoromethyl)-5-((trimethylsilyl)ethynyl)aniline **24** (1.544 g, 6.0 mmol, 1.2 equiv.) was dissolved in TFA (25 mL) and cooled to 0 °C. After addition of $NaNO_2$ (785 mg, 11.5 mmol, 2.3 equiv.) the mixture was stirred for 30 min at 0 °C. NaN_3 (813 mg, 12.5 mmol, 2.5 equiv.) was added slowly (exothermic reaction, nitrous fumes) at 0° C and the mixture was stirred for 2 h at room temperature. Afterwards the reaction mixture was quenched by slow addition of H_2O (25 mL), followed by extraction with pentane (3 × 30 mL). The combined organic layers were washed with saturated aqueous $NaHCO_3$ solution (3 × 30 mL), concentrated under reduced pressure (volume: ~ 2 mL), and directly used as *in situ* 3,5-bis(trifluoromethyl)phenylazide.



The *in situ* azide solution, 0.04 M aqueous $CuSO_4$ solution (5.0 mL, 0.2 mmol, 5 mol%), sodium ascorbate (0.149 g, 0.75 mmol, 15 mol%) and 1-ethinyl-3,5-bis(trifluoromethyl)benzene (1.29 g, 5.0 mmol, 1.0 equiv.) were combined in a solvent mixture of DCM (15 mL) and *t*BuOH (15 mL) and stirred for 3 days at 50 °C. The reaction mixture was diluted with H_2O (30 mL) followed by extraction with DCM (4 × 50 mL). After washing with aqueous ammonia (26%, 3 × 25 mL) the solvent was removed under reduced pressure. The desired product **25** (1.453 g, 3.24 mmol, 65%) was obtained as slight yellow solid by flash column chromatography (pentane/EtOAc, 9:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 8.45 (s, 1H), 8.38 (s, 2H), 8.14 (s, 1H), 8.10 (s, 1H), 7.90 (s, 1H), 7.85 (s, 1H), 3.33 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$): δ/ppm =146.5, 137.2, 133.0, 132.5 (q, *J* = 33.7 Hz), 132.0, 129.4 (q, *J* = 3.8 Hz), 126.8, 126.1-126.0 (m), 125.8 (q, *J* = 37.4 Hz), 123.3 (q, *J* = 272.5 Hz), 122.9 (q, *J* = 273.1 Hz), 122.4 (q, *J* = 3.7 Hz), 118.6, 117.6 (q, *J* = 3.8 Hz), 81.4, 80.6. **^{19}F NMR** (282 MHz, $CDCl_3$): δ/ppm = 62.99, -63.09. **HRMS (ES):** *m/z* calculated for $[C_{19}H_8F_9N_3Na]^+$: 472.0467; found: 472.0464; **ATR FTIR** (cm^{-1}):1602, 1305, 1276, 159, 1168, 1118, 1085, 1047, 1031, 999, 987, 889, 860, 844, 823, 806.

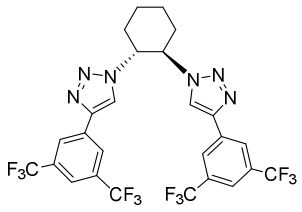
(1*R*,2*R*)-1,2-bis(4-(3-(4-(3,5-bis(trifluoromethyl)phenyl)-1H-1,2,3-triazol-1-yl)-5-(trifluoromethyl)-phenyl)-1H-1,2,3-triazol-1-yl)cyclohexane (2c)



(*R*,*R*)-Diaminocyclohexane (0.171 g, 1.5 mmol, 1.0 equiv.), $NaHCO_3$ (1.008 g, 12.0 mmol, 8.0 equiv.) and $CuSO_4$ (7.5 mL, 0.04 M aqueous solution, 0.3 mmol, 20 mol%) were suspended in MeOH/Et_2O (45 mL, 3:2). Nonafluorobutan-1-sulfonyl azide (0.843 mL, 4.5 mmol, 3.00 equiv.) was added and the mixture was stirred for 20 h at room temperature. A solution of "click"-alkyne **25** (1.348 g, 3.09 mmol, 1.03 equiv.) in CH_2Cl_2/MeOH (30 mL, 10:1) and sodium ascorbate (1.783 g, 9.0 mmol, 3.0 equiv.) were added. The reaction mixture was stirred for additional 3 days at room temperature. The solvent was removed under reduced pressure and the residue was solved in DCM (100 mL). After washing with $NaHCO_3$ solution (4 × 30 mL), aqueous ammonia (26%, 2 × 50 mL) and H_2O (50 mL) the mixture was dried over $MgSO_4$ and the solvent was removed *in vacuo*. The desired product **2c** (1.265 g, 1.2 mmol, 79%) was isolated by flash column chromatography (DCM) as a yellow solid. **^{1}H NMR** (300 MHz, acetone-D_6): δ/ppm = 9.34 (s, 2H), 8.67 (s, 2H), 8.45 (s, 2H), 8.41 (s,4H), 8.07 (s, 2H), 8.00 (s, 2H), 7.96 (s, 2H), 5.30 – 5.22 (m, 2H), 2.61 – 2.42 (m, 4H), 2.20 –2.10 (m, 2H), 1.90 – 1.77 (m, 2H). **^{13}C NMR** (75 MHz, acetone-D_6): δ/ppm = 146.0,145.1, 138.5, 134.9, 133.8, 132.9 (q, *J* = 33,0 Hz), 132.7 (q, *J* = 33,3 Hz), 126.3 (q, *J* = 3,2 Hz), 126.1 (q, *J* = 4,4 Hz), 124.4 (q, *J* = 272,2 Hz), 124.3 (q, *J* = 272,2 Hz), 122.7, 122.3 (q, *J* = 4,0 Hz), 121.4, 120.3, 116.0 (q, *J* = 3,7 Hz), 65.3, 32.9, 25.3. **^{19}F NMR** (282 MHz, acetone-D_6): δ/ppm = -63.56, -63.58. **HRMS (ES):** *m/z* calculated for $[C_{44}H_{26}F_{18}N_{12}Cl]^-$: 1099,1810; found: 1099,1835; **ATR-FTIR** (cm^{-1}): 1489, 1354, 1379, 1307, 1278, 1170, 1105, 1041, 898, 804, 682; $[\alpha]_{589}^{20}$: +4.6 (*c* 0.142, $CHCl_3$).

BisTriazole B1

(*R,R*)-1,2-Bis(4-(3,5-bis(trifluoromethyl)phenyl)-1*H*-1,2,3-triazole-1-yl)cyclohexane (B1)



(*R*,*R*)-Diaminocyclohexane (150 µL, 1.25 mmol, 1.0 equiv.), $NaHCO_3$ (0.84 g, 10.0 mmol, 8.0 equiv.) and $CuSO_4$ (20 mg, 0.13 mmol, 20 mol%) were suspended in MeOH/Et_2O/H_2O (9 mL, 6:3:2). Nonafluorobutan-1-sulfonyl azide (1.22 g, 3.74 mmol, 3.00 equiv.) was added and the mixture was stirred for 8 h at room temperature. A solution of 1-ethinyl-3,5-bis(trifluoromethyl)benzene (0.75 g, 3.13 mmol, 2.5 equiv.) and sodium ascorbate (0.75 g, 7.5 mmol, 3.0 equiv.) were added. The reaction mixture was stirred for additional 12 h at room temperature. The solvent was removed under reduced pressure and the residue was solved in DCM (30 mL). After washing with $NaHCO_3$ solution (4 × 10 mL), aqueous ammonia (26%, 2 × 10 mL) and H_2O (10 mL) the organic phase was dried over Na_2SO_4 and filtered. The resulting solution mixture was added dropwise into pentane and the formed solid was filtrated. The collected solid was dissolved in acetone and again precipitated by addition of the solution in pentane, providing the desired product **B1** (548.0 mg, 0.82 mmol, 66%) as a white solid. **^{1}H NMR** (400 MHz, acetone-D_6): δ/ppm = 8.65 (s, 2H), 8.34 (br s, 4H), 7.92 (s, 2H), 5.31 – 5.18 (m, 2H), 2.50 – 2.32 (m, 4H), 2.14 – 2.05 (m, 2H), 1.84 – 1.72 (m, 2H); **^{13}C NMR** (100 MHz, acetone-D_6): δ/ppm = 144.8, 134.5,

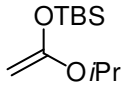
132.6 (q, *J* = 33.2 Hz), 126.2 (d, *J* = 4.1 Hz), 124.3 (q, *J* = 272.1 Hz), 122.7 , 122.2 – 121.4 (m), 64.9, 33.3, 25.2; **^{19}F-NMR** (300 MHz, acetone-D_6): δ/ppm = -63.63*;* **HRMS (ES):** m/z calculated for $[C_{26}H_{18}F_{12}N_6Na]^+$: 665.1294, found: 665.1290; **ATR-FTIR** (cm^{-1}): 1313, 1276, 1165, 1128, 1091, 898, 842, 702, 682; $[\alpha]_{589}^{20}$: +131.0 (*c* 0.155, $CHCl_3$); **M.p.:** 282-284 °C.

Preparation of the silyl ketene acetals 4

General procedure for the preparation of the silyl ketene acetals

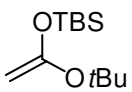
According to *Jacobsen et al.* [9] *n*-butyllithium (1.6 M in hexane; 1.1 equiv.) was added slowly to a solution of dry HN(*i*Pr)$_2$ (1.2 equiv.) in THF (2.5 mL/mmol) at 0°C. The mixture was stirred for 20 min at 0°C and then cooled to -78°C. The corresponding ester (1.0 equiv.) was added at -78°C over 10 min and the reaction was stirred for additional 30 min at -78°C. NMP (0.2 mL/mmol) was added slowly, followed by a slow addition (30 min) of a *tert*-butyldimethylsilyl chloride solution (1.2 equiv., dissolved in 0.2 mL/mmol of THF). The resulting reaction mixture was stirred for additional 30 min at -78°C and warmed to room temperature over a time of 1h. Then the solvent was removed under reduced pressure and the resulting residue was dissolved in pentane (6 mL/mmol), washed with H_2O (3 mL/mmol), $NaHCO_3$ saturated solution (3 mL/mmol), NaCl saturated solution (3 mL/mmol) and $CuSO_4$ (3 mL/mmol) solutions and dried over anhydrous $NaSO_4$. After removing the solvent under reduced pressure, the crude product was purified by vacuum distillation to afford the desired product as a colourless liquid.

1-(*tert*-Butyldimethylsilyloxy)-1-isopropoxyethene (4a)



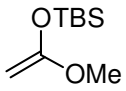
According to the general procedure *n*-butyllithium (1.6M in hexanes; 11.5 mL, 18.3 mmol, 1.1 equiv.), HN(*i*Pr)$_2$ (2.8 mL, 20.0 mmol, 1.2 equiv.), isopropyl acetate (1.96 mL, 16.7 mmol, 1.0 equiv.) and *tert*-butyldimethylsilyl chloride (3.000 g, 20.0 mmol, 1.2 equiv.) were put under reaction conditions. The resulting crude product was purified by distillation (b.p.: 100-110°C at 60 mbar) to afford the desired product (2.881 g, 13.3 mmol, 80 %). The analytical data match with those previously reported.[9] **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 4.19 (hept, *J* = 6.1 Hz, 1H), 3.27 (d, *J* = 2.3 Hz, 1H), 3.09 (d, *J* = 2.4 Hz, 1H), 1.25 (d, *J* = 6.1 Hz, 6H), 0.93 (s, 9H), 0.17 (s, 6H).

1-(*tert*-Butyldimethylsilyloxy)-1-(*tert*-butoxy)ethene (4b)



According to the general procedure *n*-butyllithium (1.6 M in hexane; 8.3 mL, 13.2 mmol, 1.1 equiv.), HN(*i*Pr)$_2$ (2.0 mL,14.4 mmol, 1.2 equiv.), *tert*-butyl acetate (1.6 mL, 12 mmol, 1.0 equiv.) and *tert*-butyldimethylsilyl chloride (2.170 g, 14.4 mmol, 1.2 equiv.) were put under reaction conditions. The resulting crude product was purified by distillation (b.p.: 50-57 °C at 3 mbar) to afford the desired product (1.512 g, 6.6 mmol, 55%). The analytical data match with those previously reported.[9] **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 3.47 (d, *J* = 1.3 Hz, 1H), 3.45 (d, *J* = 1.3 Hz, 1H), 1.35 (s, 9H), 0.93 (s, 9H), 0.19 (s, 6H).

1-(*tert*-Butyldimethylsilyloxy)-1-methoxyethene (4c)

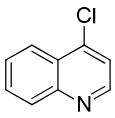


According to the general procedure *n*-butyllithium (1.6M in hexane; 11.5 mL, 18.3 mmol, 1.10 equiv.), $HN(iPr)_2$ (2.8 mL, 20.0 mmol, 1.2 equiv.), methyl acetate (1.3 mL, 16.7 mmol, 1.0 equiv.) and *tert*-butyldimethylsilyl chloride (3.000 g, 20.0 mmol, 1.20 equiv.) were added under reaction conditions. The resulting crude product was purified by distillation (b.p.: 80-85°C at 60 mbar) to afford the desired product (2.040 g, 10.8 mmol, 65%). The analytical data match with those previously reported.[9] **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm = 3.53 (s, 3H), 3.22 (d, *J* = 2.6 Hz, 1H), 3.10 (d, *J* = 2.6 Hz, 1H), 2.17 (s, 1H), 0.93 (s, 9H), 0.17 (s, 3H).

Quinoline derivatives 3m and 3p

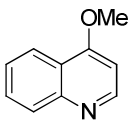
Adapting the experimental procedure reported by Ragaini *et al*[10] for the synthesis of phenanthroline derivatives, two quinoline derivatives were synthesized.

4-chloroquinoline (3m)



4-Hydroxiquinoline (500 mg, 3.44 mmol, 1.0 equiv.) and $POCl_3$ (5.7 mL, 14.0 mmol) were refluxed for 1 h in a dried Schlenk pressure tube. The mixture was allowed to cool and very slowly added under vigorous stirring to 20 mL of cold water immersed in an ice bath. The mixture was taken to pH 13 by the addition of NaOH pellets, maintaining the temperature at 0 ºC, extracted with CH_2Cl_2 (3 X 50 mL), and dried over Na_2SO_4. The solvent was removed under reduced pressure obtaining an oil, that was purified by column chromathography (pentane: AcOEt, 9:1) to afford 4-chloroquinoline (**27**) (447 mg, 2.73 mmol, 85%) as a white solid. **^{1}H NMR** (300 MHz, $CDCl_3$) δ/ppm = 8.79 (d, *J* = 4.7 Hz, 1H), 8.25 (dd, *J* = 8.4, 1.0 Hz, 1H), 8.13 (d, *J* = 8.4 Hz, 1H), 7.79 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.66 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.50 (d, *J* = 4.7 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 149.9, 149.1, 142.9, 130.6, 129.9, 127.8, 126.6, 124.3, 121.4. **HRMS (ES):** *m/z* calculated for $[C_9H_6ClNH]^+$: 164.0267, found: 164.0263; **ATR-FTIR** (cm^{-1}): 3048, 1585, 1556, 1495, 1381, 1296, 822, 752, 665.

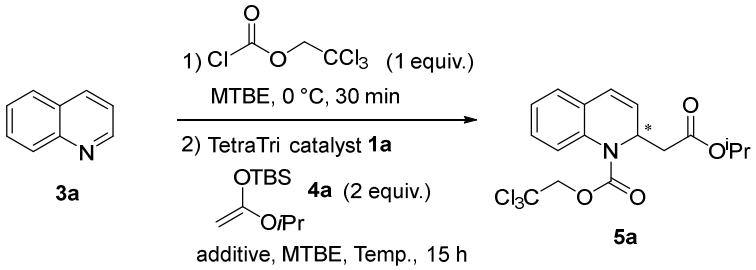
4-Methoxyquinoline (3p)



Sodium methoxide (202 mg, 3.74 mmol, 7.0 equiv.), MeOH anhydrous were added to a dried schlenk pressure tube. 4-chloroquinoline (87 mg, 0.53 mmol, 1.0 equiv.) was then added and the resulting mixture was refluxed for 2 days. The solvent was removed under reduced pressure and the obtained residue was purified by column chromatography (pentane: AcOEt, 1:1) to afford 4-methoxyquinoline (73 mg, 0.459 mmol, 86%) as colourless liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ/ppm = 8.76 (d, *J* = 5.3 Hz, 1H), 8.21 (ddd, *J* = 8.4, 1.4, 0.5 Hz, 1H), 8.06 (ddd, *J* = 8.5, 1.0, 0.5 Hz, 1H), 7.71 (ddd, *J* = 8.4, 6.9, 1.5 Hz, 1H), 7.51 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 6.76 (d, *J* = 5.3 Hz, 1H), 4.06 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 162.7, 151.2, 148.8, 130.1, 128.7, 125.9, 122.0, 121.5, 100.2, 55.9. **HRMS (ES):** *m/z* calculated for $[C_{10}H_9NOH]^+$: 160.0757, found: 160.0759; **ATR-FTIR** (cm^{-1}): 2938, 1591, 1572, 1506, 1392, 1312, 1111, 988, 763.

Organocatalytic reaction

Screening of the reaction temperature and anion effects



Entry	Cat. loading (mol%)	Temp [˚C]	Additive	Yield [%][a]	e.r.[b]
1	10	rt	--	76	70:30
2	10	0 – rt	--	64	77:23
3	10	-30	--	87	91:9
4	5	-30	--	74	91:9
5	10	-78	--	51	95:5
6	5	-78	--	42	95:5
7	10	-78 – rt	--	76	96:4
8	5	-78 – rt	--	64	95:5
9	2.5	-78 – rt	--	44	95:5
10	5	-78 – rt	--	95[c]	95:5
11	5	-78 – rt	NaBr (1 equiv.)	91	89:11
12	5	-78 – rt	$NaBF_4$ (1 equiv.)	73	87:13

[a] Yield of isolated product after column chromatography. [b] Enantiomeric ratio determined by HPLC using a commercially available chiral stationary-phase column (Diacel chiralcel OD-H). [c] 20 h reaction.

Note: Considering the unavailability of other TrocX acylating agents, the importance of Cl^- with respect to other counteranions was evaluated by adding 1 equiv. of Br^- (NaBr, entry 11) or the inert BF_4^- anion ($NaBF_4$, entry 12) to the reaction mixture. In the presence of these anions and the subsequent binding competation with the catalyst, the reaction proceeded well, but with notable lower enantioselectivity.

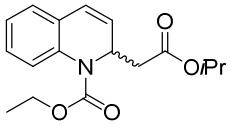
General procedure for the organocatalytic reaction

In a previously dried schlenk pressure tube, the corresponding quinoline derivative **3** (0.1 mmol) was dissolved in methyl-*tert*-butylether (MTBE) (2 mL, 0.05M). 2,2,2-Trichloroethyl chloroformate (TrocCl) (1.0 equiv.) was added at 0 °C. The resulting mixture was stirred for 30 min at 0°C and following cooled down to -78°C (dry ice/acetone bath). Catalyst **TetraTri 1a** (5 mol%) and silyl ketene acetal (2 equiv.) were added. The reaction mixture was stirred for 20 h (when used silyl ketene acetal isopropyl derivative) or 24 h (when used silyl ketene acetal *tert*-butyl derivative) and allowed to warm to ambient temperature during that time. The crude product was adsorbed on silica by adding small amount of SiO_2 and removing the solvent under reduced pressure. The crude product was purified by flash column chromatography to afford the desired product.

The racemic versions were prepared without catalyst. The reaction solution was stirred at -78 °C for 20 h and additional 24 h at ambient temperature or it was directly taken out of the -78 °C bath and stirred for 24 h at room temperature.

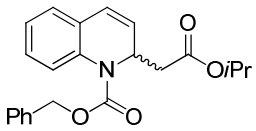
Products 5a-q, 6 and 7

Ethyl 2-(2-isopropoxy-2-oxoethyl)quinoline-1(2H)-carboxylate (6)



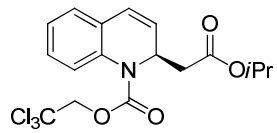
Quinoline (12.1 µL, 0.1 mmol, 1.0 equiv.), ethyl chlroroformate (10.0 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (11.2 mg, 0.10 mmol, 10 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were added according to the general procedure. The desired product (11.2 mg, 0.037 mmol, 37%) was isolated as colourless oil by flash column chromatography (pentane/EtOAc 20:1). The enantiomeric ratio was found to be 48:52 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) 1.0 mL/min, λ= 300 nm, *tr* (minor): 6.8 min, *tr* (major): 7.8 min.) **^{1}H NMR** (300 MHz, $CDCl_3$) δ/ppm = 7.58 (d, *J* = 8.1 Hz, 1H), 7.27-7.18 (m, 1H), 7.14 – 7.03 (m, 2H), 6.51 (d, *J* = 9.5 Hz, 1H), 6.11 (dd, *J* = 9.5, 5.9 Hz, 1H), 5.46 (td, *J* = 7.4, 5,9 Hz, 1H), 4.98 (hept, *J* = 6.3 Hz, 1H), 4.30 (dq, *J* = 10.7, 7.1 Hz, 1H), 4.20 (dq, *J* = 10.7, 7.1 Hz, 1H), 2.39 (d, *J* = 7.4 Hz, 2H), 1.31 (t, *J* = 7.1 Hz, 3H), 1.22 (d, *J* = 6.3 Hz, 3H), 1.20 (d, *J* = 6.3 Hz, 3H); **^{13}C NMR** (75 MHz, $CDCl_3$) δ/ppm = 170.0, 154.1, 134.3, 128.2, 127.8, 127.0, 126.5, 125.9, 124.9, 124.5, 68.2, 62.4, 49.5, 38.5, 21.9, 21.9, 14.6; **HRMS (ES):** *m/z* calculated for $[C_{17}H_{21}NO_4Na]^+$: 326.1363, found: 326.1356; **ATR-FTIR** (cm^{-1}): 2981, 2938, 1703, 1490, 1374, 1315, 1267, 1106, 1033, 763.

Benzyl 2-(2-isopropoxy-2-oxoethyl)quinoline-1(2H)-carboxylate (7)



Quinoline (12.1 µL, 0.1 mmol, 1.0 equiv.), benzyl chlroroformate (15.0 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (11.2 mg, 0.10 mmol, 10 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were added according to the general procedure. The desired product (21.3 mg, 0.058 mmol, 58%) was isolated as colourless oil by flash column chromatography (pentane/EtOAc 20:1). The enantiomeric ratio was found to be 42:58 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) 1.0 mL/min, λ= 300 nm, *tr* (minor): 10.6 min, *tr* (major): 12.1 min.) **^{1}H NMR** (300 MHz, $CDCl_3$) δ/ppm = 7.59 (br. s, 1H), 7.41 – 7.28 (m, 5H), 7.26-7.17 (m, 1H), 7.10-7.05 (m, 2H), 6.51 (d, *J* = 9.5 Hz, 1H), 6.11 (dd, *J* = 9.5, 5.9 Hz, 1H), 5.50 (td, *J* = 7.4, 5.9 Hz, 1H), 5.31 (d, *J* = 12.5 Hz, 1H), 5.18 (d, *J* = 12.5 Hz, 1H), 4.95 (hept, *J* = 6.3 Hz, 1H), 2.41 (d, *J* = 7.4 Hz, 2H), 1.18 (d, *J* = 6.3 Hz, 3H), 1.17 (d, *J* = 6.3 Hz, 3H); **^{13}C NMR** (75 MHz, $CDCl_3$) δ/ppm = 169.9, 154.0, 136.2, 134.1, 132.8, 128.7, 128.3, 128.2, 128.1, 127.9, 127.0, 126.5, 125.9, 125.0, 124.7, 87.5, 68.2, 68.0, 49.7, 38.4, 21.9, 21.9; **HRMS (ES):** *m/z* calculated for $[C_{22}H_{23}NO_4Na]^+$: 388.1519, found: 388.1519; **ATR-FTIR** (cm^{-1}): 2980, 2933, 1703, 1489, 1456, 1397, 1302, 1266, 1105, 1022, 963, 905, 823, 761, 697, 602, 459.

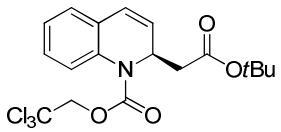
(*R*)-2,2,2-Trichloroethyl 2-(2-isopropoxy-2-oxoethyl)quinoline-1(2H)-carboxylate (5a)



Quinoline (12.1 µL, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were added according to the

general procedure. The desired product (38.7 mg, 0.095 mmol, 95%) was isolated by flash column chromatography (pentane/EtOAc 30:1). The enantiomeric ratio was found to be 95:5 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 6.7 min, *tr* (*R*): 7.6 min.) $[\alpha]_{589}^{20}$: –171 (*c* 0.25, $CHCl_3$). **^{1}H NMR** (400 MHz, $CDCl_3$) δ/ppm = 7.66 (br. s, 1H), 7.32 – 7.20 (m, 1H), 7.19 – 7.07 (m, 2H), 6.54 (d, *J* = 9.6 Hz, 1H), 6.15 (dd, *J* = 9.6, 5.9 Hz, 1H), 5.52 (td, *J* = 7.2, 5.9 Hz, 1H), 5.05 (br. s, 1H), 4.98 (hept, *J* = 6.3 Hz, 1H), 4.66 (br. s, 1H), 2.46 (d, *J* = 7.2 Hz, 2H), 1.22 (d, *J* = 6.3 Hz, 3H), 1.20 (d, *J* = 6.3 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 169.6, 152.4, 128.0, 127.1, 126.6, 126.0, 125.3, 95.2, 77.4, 75.6, 68.3, 50.1, 38.3, 29.9, 22.0, 21.9; **HRMS (ES):** *m/z* calculated for $[C_{17}H_{18}Cl_3NO_4Na]^+$: 428.0194, found: 428.0192; **ATR-FTIR** (cm^{-1}): 2950, 1716, 1491, 1398, 1373, 1313, 1267, 1128, 1105, 1033, 954, 810, 773, 754, 711.

(*R*)-2,2,2-Trichloroethyl 2-(2-(*tert*-butoxy)-2-oxoethyl)quinoline-1(2H)-carboxylate (5b)

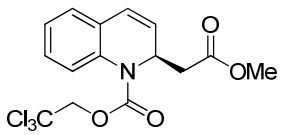


Quinoline (**3a**) (12.3 µL, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-(*tert*-butoxy)ethene (**4b**) (54 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (23.6 mg, 0.056 mmol, 56%) was isolated by flash column chromatography (pentane/EtOAc 20:1) as a slightly yellow oil.

Scale up: Following the general procedure, quinoline (**3a**) (123.4 µL, 1.0 mmol, 1.0 equiv.) was reacted with TrocCl (141.9 µL, 1.0 mmol, 1.0 equiv.). **TetraTri 1a** (28 mg, 0.025 mmol, 2.5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-(*tert*-butoxy)ethene (**4b**) (54 µL, 0.2 mmol, 2.0 equiv.) were added at -78ºC, the reaction mixture was slowly warmed up to r.t. overnight and then further stirred for 4 days at r.t.. The desired product (298.7 mg, 0.71 mmol, 71%) was isolated by flash column chromatography (pentane/EtOAc 20:1).

The enantiomeric ratio was found to be 98:2 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 6.0 min, *tr* (*R*): 6.8 min.) $[\alpha]_{589}^{20}$: –170 (*c* 1.15, $CHCl_3$). **^{1}H NMR** (600 MHz, $CDCl_3$) δ/ppm = 7.65 (br. s, 1H), 7.29 – 7.21 (m, 1H), 7.16 – 7.10 (m, 2H), 6.53 (d, *J* = 9.5 Hz, 1H), 6.16 (dd, *J* = 9.5, 5.8 Hz, 1H), 5.49 (dd, *J* = 13.3, 7.3 Hz, 1H), 5.07 (br. s, 1H), 4.62 (br. s, 1H), 2.41 (d, *J* = 7.3 Hz), 1.42 (s, 9H) **^{13}C NMR** (75 MHz, $CDCl_3$) δ/ppm = 169.3, 152.4, 130.3, 128.0, 127.9, 127.2, 126.5, 125.8, 125.3, 125.2, 95.2, 81.1, 75.6, 50.2, 39.9, 28.1. **HRMS (ES):** *m/z* calculated for $[C_{18}H_{20}Cl_3NO_4Na]^+$: 442.0350, found: 442.0344; **ATR-FTIR** (cm^{-1}): 2978, 1717, 1491, 1395, 1368, 1315, 1271, 1145, 1121, 754, 711.

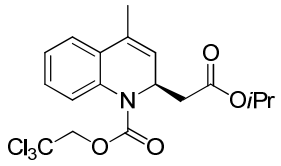
(*R*)-2,2,2-Trichloroethyl 2-(2-methoxy-2-oxoethyl)quinoline-1(2H)-carboxylate (5c)



Quinoline (**3a**) (13.2 µL, 0.11 mmol, 1.0 equiv.), TrocCl (15.2 µL, 0.11 mmol, 1.0 equiv.), **TetraTri 1a** (6.2 mg, 0.06 mmol, 5 mol%) and 1-*(tert*-butyldimethylsilyloxy)-1-methoxyethene (**4c**) (41.4 mg, 0.22 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (31.8 mg, 0.084 mmol, 76%) was isolated by flash column chromatography (pentane/EtOAc 20:1) as a colourless oil. The enantiomeric ratio

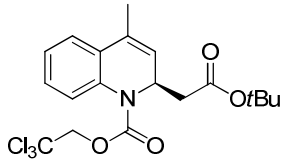
was found to be 89:11 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) hexane 1.0 mL/min, λ= 300 nm, *tr* (*S*): 10.2 min, *tr* (*R*): 14.5 min). $[\alpha]_{589}^{20}$: –102 (*c* 0.20, $CHCl_3$). **^{1}H NMR** (300 MHz, $CDCl_3$) δ/ppm = 7.66 (br. s, 1H), 7.33 – 7.20 (m, 1H), 7.16- 7.10 (m, 2H), 6.54 (d, *J* = 9.6 Hz, 1H), 6.14 (dd, *J* = 9.5, 5.9 Hz, 1H), 5.51 (dd, *J* = 13.3, 7.2 Hz, 1H), 5.06 (br. s, 1H), 4.67 (br. s, 1H), 3.64 (s, 3H), 2.50 (d, *J* = 7.2 Hz, 3H).**^{13}C NMR** (75 MHz, $CDCl_3$) δ/ppm = 170.6, 151.5, 133.1, 132.2, 128.1, 127.0, 126.6, 126.0, 125.4, 110.1, 95.2, 75.6, 52.0, 50.0, 37.7. **HRMS (ES):** *m/z* calculated for $[C_{15}H_{14}Cl_3NO_4Na]^+$: 399.9881, found: 399.9875; **ATR-FTIR** (cm^{-1}): 2953, 1732, 1715, 1491, 1396, 1315, 1267, 1122, 1034, 754, 711.

(*R*)-2,2,2-Trichloroethyl 2-(2-isopropoxy-2-oxoethyl)-4-methylquinoline-1(2H)-carboxylate (5d)



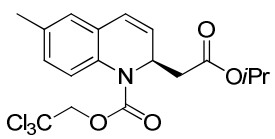
4-Methylquinoline (13.2 µL, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (36.1 mg, 0.086 mmol, 86%) was isolated by flash column chromatography (pentane/EtOAc 20:1) as a colourless oil. The enantiomeric ratio was found to be 92:8 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (98:2) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 8.0 min, *tr* (*R*): 9.0 min). $[\alpha]_{589}^{20}$: –120 (*c* 0.16, $CHCl_3$). **^{1}H NMR** (400 MHz, $CDCl_3$) δ/ppm = 7.65 (br. s, 1H), 7.29 (dd, *J* = 7.5, 1.6 Hz, 1H), 7.29-7.25 (m, 1H), 7.18 (td, *J* = 7.5, 1.3 Hz, 1H), 5.95 (d, *J* = 5.6 Hz, 1H), 5.44 (q, *J* = 6.6 Hz, 1H), 5.07 (s, 1H), 4.98 (hept, *J* = 6.3 Hz, 1H), 4.58 (s, 1H), 2.41 (d, *J* = 6.9 Hz, 2H), 2.08 (m, 3H), 1.22 (d, *J* = 6.0 Hz, 3H), 1.20 (d, *J* = 6.0 Hz, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 169.8, 152.2, 131.3, 128.9, 128.8, 127.8, 126.6, 125.2, 124.4, 123.5, 95.3, 75.6, 68.2, 49.8, 47.8, 22.0, 21.9, 18.6. **HRMS (ES):** *m/z* calculated for $[C_{18}H_{20}Cl_3NO_4Na]^+$: 442.0356, found: 442.0339; **ATR-FTIR** (cm^{-1}): 2980, 1721, 1491, 1396, 1373, 1315, 1269, 1227, 1144, 1105, 754, 714.

(*R*)-2,2,2-Trichloroethyl 2-(2-(*tert*-butoxy)-2-oxoethyl)-4-methylquinoline-1(2H)-carboxylate (5e)



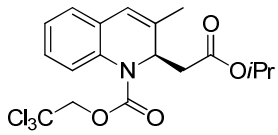
4-Methylquinoline (13.2 µL, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-(*tert*-butoxy)ethene (**4b**) (51 µL, 0.2 mmol, 2.0 equiv.) were added according to the general procedure. The desired product (22.9 mg, 0.054 mmol, 54%) was isolated by flash column chromatography (pentane/EtOAc 30:1). The enantiomeric ratio was found to be 98:2 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 5.8 min, *tr* (*R*): 6.5 min.) $[\alpha]_{589}^{20}$: –218 (*c* 0.25, $CHCl_3$). **^{1}H NMR** (600 MHz, $CDCl_3$) δ/ppm = 7.50 (s, 1H), 7.05 (d, *J* = 7.5 Hz, 1H), 6.98 – 6.89 (m, 1H), 6.48 (d, *J* = 10.1 Hz, 1H), 6.13 (s, 1H), 5.46 (q, *J* = 6.8 Hz, 1H), 5.14 (br. s, 1H), 4.51 (br. s, 1H), 2.47-2.35 (m, 2H), 2.31 (s, 3H), 1.42 (s, 9H); **^{13}C NMR** (150 MHz, $CDCl_3$) δ/ppm = 169.4, 152.4, 135.0, 128.7, 128.6, 127.1, 127.0, 126.9, 126.0, 125.9, 95.3, 81.1, 75.6, 50.2, 39.0, 28.2, 21.0; **HRMS (ES):** *m/z* calculated for $[C_{18}H_{20}Cl_3NO_4Na]^+$: 456.0507, found: 456.0505; **ATR-FTIR** (cm^{-1}): 2961, 1707, 1498, 1392, 1367, 1290, 1276, 1255, 1226, 1151, 1138, 1035, 815, 711.

(*R*)-2,2,2-Trichloroethyl 2-(2-isopropoxy-2-oxoethyl)-6-methylquinoline-1(2H)-carboxylate (5f)



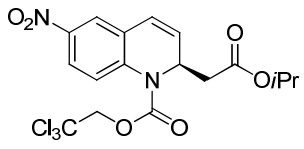
6-Methylquinoline (13.4 µL, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (33.6 mg, 0.080 mmol, 80%) was isolated by flash column chromatography (pentane/EtOAc 30:1). The enantiomeric ratio was found to be 97:3 by chiral HPLC (Chiralpak AD-H, hexane/isopropanol (98:2) 1.0 mL/min, λ= 300 nm, *tr* (*R*): 9.9 min, *tr* (*S*): 12.2 min.) $[\alpha]_{589}^{20}$: –251 (*c* 0.35, $CHCl_3$). **^{1}H NMR** (400 MHz, $CDCl_3$) δ/ppm = 7.52 (br. s, 1H), 7.06 (d, *J* = 9.0 Hz, 1H), 6.93 (d, *J* = 1.6 Hz, 1H), 6.49 (d, *J* = 9.6 Hz, 1H), 6.13 (dd, *J* = 8.6, 5.9 Hz, 1H), 5.49 (q, *J* = 7.0 Hz, 1H), 5.25 – 4.40 (m, 2H), 4.98 (hept, *J* = 6.3 Hz, 1H), 2.44 (br. s, 2H), 2.32 (s, 3H), 1.22 (d, *J* = 6.3 Hz, 3H), 1.20 (d, *J* = 6.3 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 169.5, 152.3, 135.0, 128.6, 128.6, 128.6, 127.0, 126.9, 126.0, 125.9, 95.2, 75.4, 68.1, 49.9, 25.7, 21.8, 21.8, 20.8; **HRMS (ES):** *m/z* calculated for $[C_{18}H_{20}Cl_3NO_4Na]^+$: 442.0350, found: 442.0344; **ATR-FTIR** (cm^{-1}): 2980, 1716, 1496, 1467, 1454, 1429, 1395,1313, 1267, 1259, 1230, 1182, 1159, 954, 927, 916, 900, 881, 815, 752.

(*R*)-2,2,2-Trichloroethyl 2-(2-isopropoxy-2-oxoethyl)-3-methylquinoline-1(2H)-carboxylate (5g)



3-Methylquinoline (13.4 µL, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (38.9 mg, 0.092 mmol, 92%) was isolated by flash column chromatography (pentane/EtOAc 20:1) as colourless oil. The enantiomeric ratio was found to be 72:28 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 6.0 min, *tr* (*R*): 6.9 min.) $[\alpha]_{589}^{20}$: –12 (*c* 0.25, $CHCl_3$). **^{1}H NMR** (400 MHz, $CDCl_3$) δ/ppm = 7.61 (s, 1H), 7.21 (t, *J* = 7.4 Hz, 1H), 7.12 (td, *J* = 7.4, 1.2 Hz, 1H), 7.06 (dd, *J* = 7.5, 1.6 Hz, 1H), 6.28 – 6.27 (m, 1H), 5.34-5.31 (m, 1H), 5.09 (d, *J* = 11.6 Hz, 1H), 4.96 (hept, *J* = 6.3 Hz, 1H), 4.55 (br. s, 1H), 2.41-2.36 (m, 1H), 2.32 (d, *J* = 9.5 Hz, 2H), 1.98 (d, *J* = 1.4 Hz, 3H), 1.22 (d, *J* = 6.3 Hz, 3H), 1.20 (d, *J* = 6.3 Hz, 3H).**^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 169.8, 152.4, 128.2, 127.1, 127.0, 125.7, 125.4, 121.7, 110.1, 95.2, 75.7, 68.4, 54.4, 36.4, 22.0, 21.8, 20.7. **HRMS (ES):** *m/z* calculated for $[C_{18}H_{20}Cl_3NO_4Na]^+$: 442.0356, found: 442.0349; **ATR-FTIR** (cm^{-1}): 2980, 1720, 1489, 1396, 1373, 1315, 1263, 1250, 1139, 1105, 1045, 1032, 816, 756, 716.

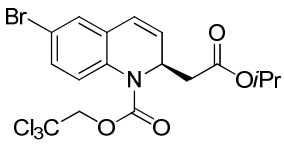
(*R*)-2,2,2-Trichloroethyl 2-(2-isopropoxy-2-oxoethyl)-6-nitroquinoline-1(2H)-carboxylate (5i)



6-Nitroquinoline (17.4 mg, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (24.5 mg, 0.054 mmol, 54%) was isolated by flash column chromatography (pentane/EtOAc 9:1) as a

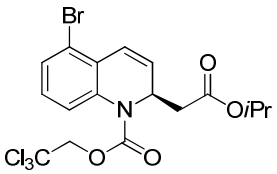
yellow solid. The enantiomeric ratio was found to be 94:6 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 14.9 min, *tr* (*R*): 16.9 min). $[\alpha]_{589}^{20}$: –260 (*c* 0.44, $CHCl_3$). **^{1}H NMR** (400 MHz, $CDCl_3$) δ/ppm = 8.12 (dd, *J* = 9.1, 2.7 Hz, 1H), 8.01 (d, *J* = 2.7 Hz, 1H), 7.88 (d, *J* = 9.1 Hz, 1H), 6.62 (d, *J* = 9.7 Hz, 1H), 6.31 (dd, *J* = 9.7, 5.9 Hz, 1H), 5.57 (td, *J* = 7.6, 5.9 Hz, 1H), 5.02 (d, *J* = 11.8 Hz, 1H), 4.98 (hept, *J* = 6.3 Hz, 1H), 4.75 (d, *J* = 11.8 Hz, 1H), 2.49 (d, *J* = 7.6 Hz, 2H), 1.21 (d, *J* = 6.3 Hz, 3H), 1.20 (d, *J* = 6.3 Hz, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 169.0, 151.9, 144.5, 139.3, 130.3, 127.5, 125.1, 124.7, 123.2, 121.8, 94.7, 75.9, 68.7, 50.6, 38.9, 21.9, 21.7. **HRMS (ES):** *m*/*z* calculated for $[C_{17}H_{17}Cl_3N_2O_6Na]^+$: 473.0050, found: 473.0046; **ATR-FTIR** (cm^{-1}): 2982, 1717, 1520, 1487, 1344, 1267, 1236, 1209, 1128, 1103, 1047, 800, 746, 714.

(*R*)-2,2,2-Trichloroethyl 6-bromo-2-(2-isopropoxy-2-oxoethyl)quinoline-1(2H)-carboxylate (5j)



6-Bromoquinoline (13.1 µL, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (29.8 mg, 0.062 mmol, 62%) was isolated by flash column chromatography (pentane/EtOAc 30:1). The enantiomeric ratio was found to be 95:5 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (98:2) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 9.3 min, *tr* (*R*): 9.9 min.) $[\alpha]_{589}^{20}$: –164 (*c* 0.20, $CHCl_3$). **^{1}H NMR** (400 MHz, $CDCl_3$) δ/ppm = 7.55 (br. s, 1H), 7.36 (dd, *J* = 8.7, 2.3 Hz, 1H), 6.47 (d, *J* = 9.7 Hz, 1H), 6.20 (dd, *J* = 9.7, 5.7 Hz, 1H), 5.51 (td, *J* = 7.3, 5.6 Hz, 1H), 5.02 (br. s), 4.98 (hept, *J* = 6.3 Hz, 1H), 4.65 (br. s, 1H), 2.45 (d, *J* = 7.3 Hz, 2H), 1.58 (s, 1H), 1.22 (d, *J* = 6.3 Hz, 3H), 1.20 (d, *J* = 6.3 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 169.2, 153.5, 152.0, 145.2, 130.7, 130.7, 130.6, 129.1, 129.0, 124.9, 124.8, 124.8, 94.9, 75.5, 68.3, 49.9, 21.8, 21.7; **HRMS (ES):** *m*/*z* calculated for $[C_{17}H_{17}BrCl_3NO_4H]^+$: 483.9479, found: 483.9477; **ATR-FTIR** (cm^{-1}): 2980, 1716, 1485, 1390, 1375, 1309, 1282, 1267, 1234, 1199, 1105, 1098, 1033, 813, 765.

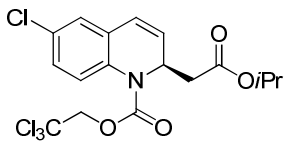
(*R*)-2,2,2-Trichloroethyl 5-bromo-2-(2-isopropoxy-2-oxoethyl)quinoline-1(2H)-carboxylate (5k)



5-Bromoquinoline (20.8 mg, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (32.1 mg, 0.066 mmol, 66%) was isolated by flash column chromatography (pentane/EtOAc 30:1). The enantiomeric ratio was found to be 95:5 by chiral HPLC (Chiralpak AD-H, hexane/isopropanol (98:2) 1.0 mL/min, λ= 300 nm, *tr* (*R*): 11.5 min, *tr* (*S*): 17.3 min.). $[\alpha]_{589}^{20}$: –153 (*c* 0.25, $CHCl_3$). **^{1}H NMR** (400 MHz, $CDCl_3$) δ/ppm = 7.60 (br. s, 1H), 7.38 (dd, *J* = 8.0, 1.1 Hz, 1H), 7.11 (t, *J* = 8.1 Hz, 1H), 6.92 (d, *J* = 9.7 Hz, 1H), 6.28 (dd, *J* = 9.8, 6.0 Hz, 1H), 5.53 (td, *J* = 7.4, 6.0 Hz, 1H), 5.03 (br. s, 1H), 5.00 (hept, *J* = 6.3 Hz, 1H), 4.64 (br. s, 1H), 2.44 (d, *J* = 7.4 Hz, 2H), 1.60 (s, 1H), 1.22 (d, *J* = 6.3 Hz, 3H), 1.20 (d, *J* = 6.3 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 169.2, 152.0, 129.4, 129.4, 128.4, 126.7, 126.6, 124.8, 124.7, 121.3, 94.9, 75.6, 68.3, 49.5, 37.8, 21.8, 21.7; **HRMS (ES):** *m*/*z* calculated for $[C_{17}H_{17}Cl_3NO_4Na]^+$: 507.9284, found:

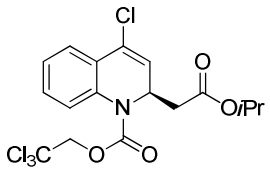
507.9274; **ATR-FTIR** (cm^{-1}): 2985, 1754, 1493, 1372, 1316, 1285, 1272, 1222, 1203, 1108, 1090, 1041, 831, 772.

(*R*)-2,2,2-Trichloroethyl 6-chloro-2-(2-isopropoxy-2-oxoethyl)quinoline-1(2H)-carboxylate (5l)



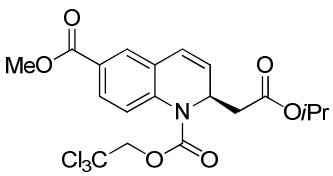
6-Chloroquinoline (16.3 mg, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (27.5 mg, 0.062 mmol, 62%) was isolated by flash column chromatography (pentane/EtOAc 30:1). The enantiomeric ratio was found to be 95:5 by chiral HPLC (Chiralpak AD-H, hexane/isopropanol (98:2) 1.0 mL/min, λ= 300 nm, *tr* (*R*): 12.6 min, *tr* (*S*): 15.8 min.). $[\alpha]_{589}^{20}$: –158 (*c* 0.75, $CHCl_3$). **^{1}H NMR** (400 MHz, $CDCl_3$) δ/ppm = 7.60 (br. s, 1H), 7.21 (dd, *J* = 8.7, 2.5 Hz, 1H), 7.11 (d, *J* = 2.5 Hz, 1H), 6.48 (d, *J* = 9.6 Hz, 1H), 6.21 (dd, *J* = 9.6, 5.8 Hz, 1H), 5.52 (td, *J* = 6.3, 5.8 Hz, 1H), 5.01 (br. s, 1H), 4.98 (hept, *J* = 6.3 Hz, 1H), 4.63 (s, 1H), 2.56 – 2.35 (m, 2H), 1.58 (s, 1H), 1.22 (d, *J* = 6.3 Hz, 3H), 1.20 (d, *J* = 6.3 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 169.4, 152.2, 138.6, 127.9, 127.8, 126.4, 126.3, 126.2, 125.0, 125.0, 95.1, 75.7, 68.7, 50.1, 29.9, 21.9, 21.9; **HRMS (ES):** *m/z* calculated for $[C_{17}H_{17}Cl_4NO_4Na]^+$: 463.9780, found: 463.9776; **ATR-FTIR** (cm^{-1}): 2980, 2918, 1716, 1485, 1392, 13751309, 1284, 1234, 1101, 817, 752, 669, 626.

(*R*)-2,2,2-Trichloroethyl 4-chloro-2-(2-isopropoxy-2-oxoethyl)quinoline-1(2H)-carboxylate (5m)



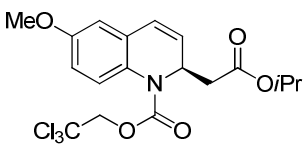
4-Chloroquinoline (13.0 µL, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (30.2 mg, 0.069 mmol, 69%) was isolated by flash column chromatography (pentane/EtOAc 20:1) as yellow oil. The enantiomeric ratio was found to be 89:11 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (98:2) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 7.1 min, *tr* (*R*): 7.9 min.) $[\alpha]_{589}^{20}$: +0.5 (*c* 0.55, $CHCl_3$). **^{1}H NMR** (600 MHz, $CDCl_3$) δ/ppm = 7.65 (br. s, 1H), 7.62 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.35 (t, *J* = 7.8 Hz, 1H), 7.24 (dd, *J* = 7.8, 0.8 Hz, 1H), 6.31 (d, *J* = 6.5 Hz, 1H), 5.57 (q, *J* = 7.1 Hz, 1H), 5.05 (br. s, 1H), 4.98 (hept, *J* = 6.3 Hz, 1H), 4.70 (br. s, 1H), 2.48 (d, *J* = 7.0 Hz, 1H), 1.22 (d, *J* = 6.3 Hz, 3H), 1.21 (d, *J* = 6.3 Hz, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ/ppm = 169.2, 152.1, 129.6, 129.4, 129.4, 125.6, 125.6, 125.6, 124.8, 110.2, 95.1, 75.7, 68.6, 50.9, 38.0, 22.0, 21.9. **HRMS (ES):** *m/z* calculated for $[C_{17}H_{17}Cl_4NO_4Na]^+$: 461.9809, found: 461.9795; **ATR-FTIR** (cm^{-1}): 2982, 1722, 1601, 1483, 1385, 1317, 1269, 1229, 1144, 1103, 1042, 756, 716.

(*R*)-6-Methyl 1-(2,2,2-trichloroethyl) 2-(2-isopropoxy-2-oxoethyl)quinoline-1,6(2H)-dicarboxylate (5n)



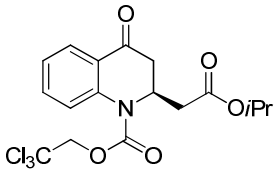
Methyl quinoline-6-carboxylate (18.7 mg, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4b**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (33.0 mg, 0.071 mmol, 71%) was isolated by flash column chromatography (pentane/EtOAc 10:1). The enantiomeric ratio was found to be 94:6 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 24.8 min, *tr* (*R*): 35.4 min.) $[\alpha]_{589}^{20}$: –202 (*c* 0.25, $CHCl_3$). **^{1}H NMR** (300 MHz, $CDCl_3$) δ/ppm = 7.92 (dd, *J* = 8.6, 2.1 Hz, 1H), 7.87 – 7.70 (m, 2H), 6.58 (d, *J* = 9.6 Hz, 1H), 6.20 (dd, *J* = 9.6, 5.9 Hz, 1H), 5.53 (td, *J* = 7.3, 5.9 Hz, 1H), 5.03 (d, *J* = 11.9 Hz, 1H), 4.97 (hept, *J* = 6.3 Hz, 1H), 4.70 (d, *J* = 11.9 Hz, 1H), 3.91 (s, 3H), 2.47 (d, *J* = 7.3 Hz, 2H), 1.62 (s, 1H), 1.21 (d, *J* = 6.3 Hz, 3H), 1.20 (d, *J* = 6.3 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 169.2, 166.4, 152.0, 129.2, 129.2, 128.0, 128.0, 126.7, 126.7, 125.4, 94.8, 75.6, 68.3, 52.2, 50.2, 38.5, 21.8, 21.7; **HRMS (ES):** *m/z* calculated for $[C_{19}H_{20}Cl_3NO_6Na]^+$: 486.0248, found: 486.00243; **ATR-FTIR** (cm^{-1}): 2982, 2953, 1716, 1606, 1573, 1492, 1442, 1392, 1375, 1269, 1228, 1199, 1130, 1105, 1033, 808, 763, 752, 713.

(*R*)-2,2,2-Trichloroethyl 2-(2-isopropoxy-2-oxoethyl)-6-methoxyquinoline-1(2H)-carboxylate (5o)



6-methoxyquinoline (13.8 µL, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (38.3 mg, 0.088 mmol, 88%) was isolated by flash column chromatography (pentane/EtOAc 20:1) as colourless oil. The enantiomeric ratio was found to be 95:5 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 9.7 min, *tr* (*R*): 14.0 min.) $[\alpha]_{589}^{20}$: –145 (*c* 0.42, $CHCl_3$). **^{1}H NMR** (300 MHz, $CDCl_3$) δ/ppm = 7.61-7.50 (m, 1H), 6.80 (dd, *J* = 8.8, 2.3 Hz, 1H), 6.65 (d, *J* = 2.9 Hz, 1H), 6.49 (d, *J* = 9.6 Hz, 1H), 6.19-6.14 (m, 1H), 5.13 (br. s, 1H), 5.13 (br. s, 1H), 4.97 (hept, *J* = 6.3 Hz, 1H), 4.50 (br. s, 1H), 3.80 (s, 3H), 2.44 (br. s, 2H), 1.21 (d, *J* = 6.3 Hz, 3H), 1.20 (d, *J* = 6.3 Hz, 3H); **^{13}C NMR** (75 MHz, $CDCl_3$) δ/ppm = 169.6, 157.0, 152.5, 132.8, 130.1, 129.4, 128.1, 126.0, 113.5, 111.2, 95.3, 75.7, 68.3, 55.6, 50.0, 37.7, 22.0, 21.9. **HRMS (ES):** *m/z* calculated for $[C_{18}H_{20}Cl_3NO_5Na]^+$: 458.0299, found: 458.0308; **ATR-FTIR** (cm^{-1}): 2980, 1717, 1497, 1396, 1375, 1265, 1119, 1107, 1034, 808, 714.

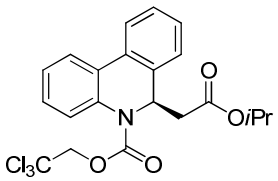
2,2,2-Trichloroethyl 2-(2-isopropoxy-2-oxoethyl)-4-oxo-3,4-dihydroquinoline-1(2H)-carboxylate (5p)



4-Methoxyquinoline (14.1 µL, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (31.2 mg, 0.074 mmol, 74%) was isolated by flash column chromatography (pentane/EtOAc 20:1) as a colourless oil.

The enantiomeric ratio was found to be 20:80 by chiral HPLC (Chiralpak OD-H, hexane/isopropanol (95:5) 1.0 mL/min, λ= 300 nm, *tr* (*S*): 12.1 min, *tr* (*R*): 15.0 min.) $[\alpha]_{589}^{20}$: –46 (*c* 0.96, $CHCl_3$). **^{1}H NMR** (300 MHz, $CDCl_3$): δ/ppm 8.01 (dd, *J* = 7.9, 1.7 Hz, 1H), 7.81 (d, *J* = 8.3 Hz, 1H), 7.58 (ddd, *J* = 8.6, 7.3, 1.7 Hz, 1H), 7.26 (td, *J* = 7.6, 1.1 Hz, 1H), 5.53 (tdd, *J* = 7.6, 5.9, 1.7 Hz, 1H), 5.09 (d, *J* = 11.9 Hz, 1H), 4.98 (hept, *J* = 6.3 Hz, 1H), 4.71 (d, *J* = 11.9 Hz, 1H), 3.13 (dd, *J* = 17.9, 5.9 Hz, 1H), 2.78 (dd, *J* = 17.9, 1.7 Hz, 1H), 2.67 – 2.45 (m, 2H), 1.19 (d, *J* = 6.3 Hz, 6H). **^{13}C NMR** (75 MHz, $CDCl_3$): δ/ppm = 192.2, 169.3, 152.1, 139.0, 134.9, 134.2, 127.2, 125.4, 125.2, 125.2, 75.8, 68.7, 51.6, 42.9, 37.2, 21.7. **HRMS (ES):** *m*/*z* calculated for $[C_{17}H_{18}Cl_3NO_5Na]^+$: 444.0148, found: 444.0146; **ATR-FTIR** (cm^{-1}): 2980, 1724, 1687, 1601, 1481, 1460, 1387, 1315, 1302, 1269, 1223, 1132, 1105, 1041, 820, 764, 714.

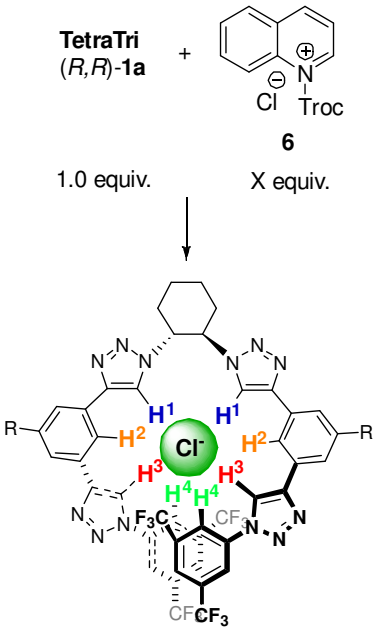
(*R*)-2,2,2-Trichloroethyl 6-(2-isopropoxy-2-oxoethyl)phenanthridine-5(6H)-carboxylate (5q)



Phenanthridine (17.9 mg, 0.1 mmol, 1.0 equiv.), TrocCl (14.2 µL, 0.1 mmol, 1.0 equiv.), **TetraTri 1a** (5.6 mg, 0.05 mmol, 5 mol%) and 1-(*tert*-butyldimethylsilyloxy)-1-isopropoxyethene (**4a**) (51 µL, 0.2 mmol, 2.0 equiv.) were reacted according to the general procedure. The desired product (40.1 mg, 0.088 mmol, 88%) was isolated by flash column chromatography (pentane/EtOAc 20:1). The enantiomeric ratio was found to be 90:10 by chiral HPLC (Chiralpak AD-H, hexane/isopropanol (90:10) 1.0 mL/min, λ= 300 nm, *tr* (*R*): 9.7 min, *tr* (*S*): 12.0 min). $[\alpha]_{589}^{20}$: –112 (*c* 0.45, $CHCl_3$). **^{1}H NMR** (300 MHz, $CDCl_3$) δ/ppm = 7.88 – 7.76 (m, 2H), 7.69 (br. s, 1H), 7.46 – 7.27 (m, 5H), 6.07 (dd, *J* = 8.5, 6.6 Hz, 1H), 5.12 (br. s, 1H), 4.99 (hept, *J* = 6.3 Hz, 1H) 4.44 (br. s, 1H), 2.68 – 2.33 (m, 2H), 1.64 (s, 1H), 1.23 (d, *J* = 6.3 Hz, 3H), 1.18 (d, *J* = 6.3 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ/ppm = 169.4, 152.0, 130.3, 128.6, 128.1, 127.9, 126.3, 126.1, 123.8, 123.8, 95.3, 75.5, 68.3, 39.3, 25.7, 21.9, 21.8; **HRMS (ES):** *m*/*z* calculated for $[C_{21}H_{20}Cl_3NO_4Na]^+$: 478.0350, found: 478.0345; **ATR-FTIR** (cm^{-1}): 2987, 1742, 1699, 1442, 1398, 1321, 1296, 1249, 1141, 1103, 1074, 1047, 1026, 750, 732.

NMR Titration

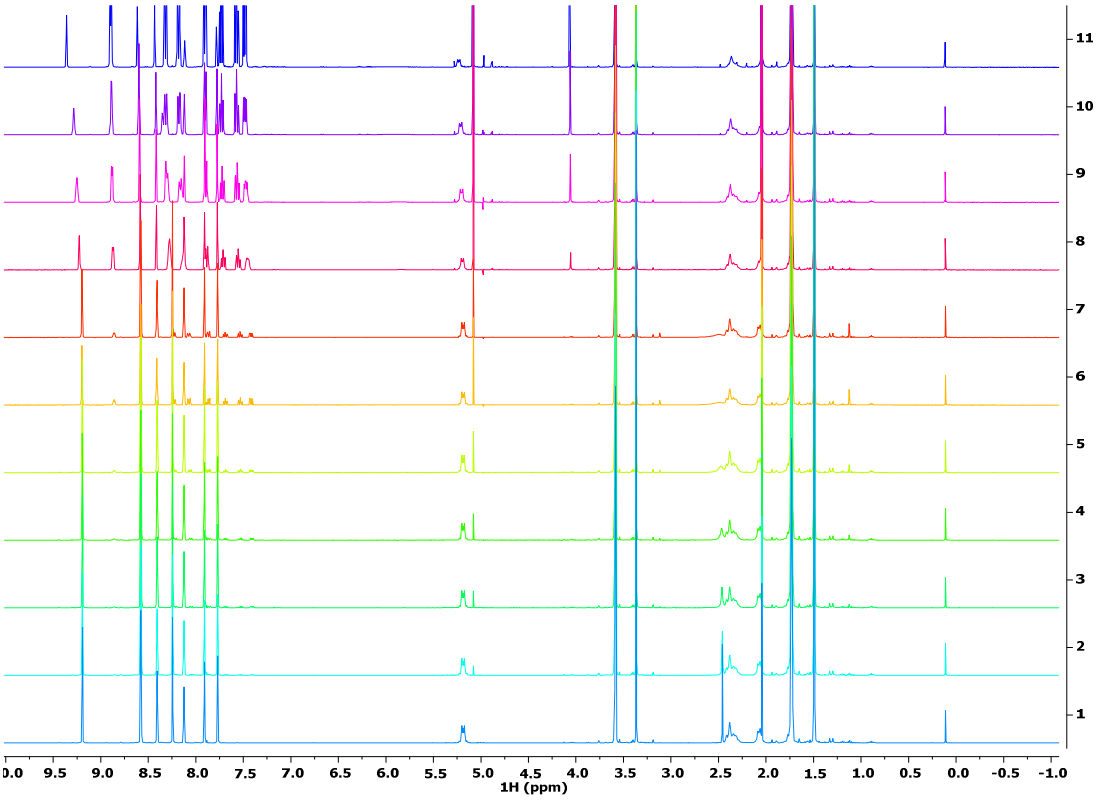
TetraTri 1b (0.005 M) in [D8]THF + 10 eq. 1-((2,2,2-trichloroethoxy)carbonyl)quinolin-1-ium chloride 6



(*R,R*)-1a - Cl$^-$-Anion Complex

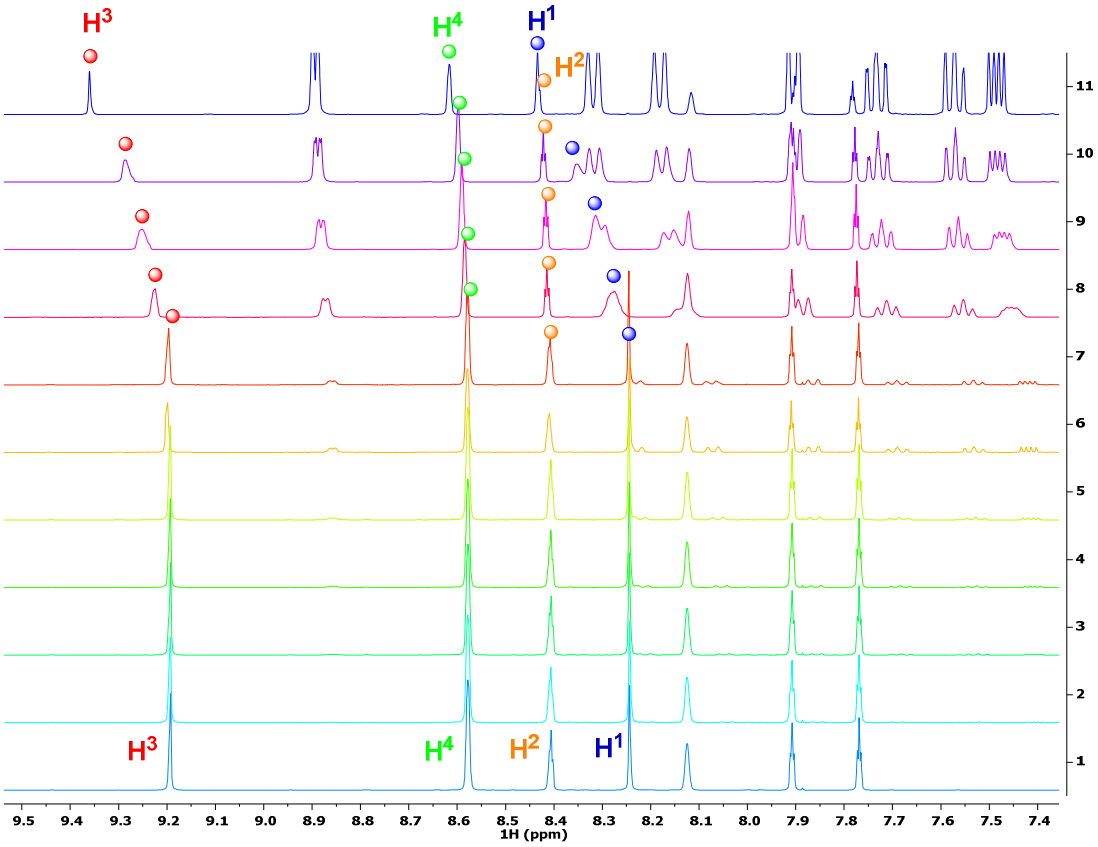
Equiv.	HTriazole /(ppm)	ΔHTriazole /(ppm)	[Cl-]free /(mol/L)
0	9.19	0	0.0000
0.1	9.19	0	0.0005
0.2	9.19	0	0.0010
0.3	9.19	0	0.0015
0.5	9.19	0	0.0025
0.8	9.2	0.01	0.0040
1	9.2	0.01	0.0050
2	9.22	0.03	0.0100
3	9.25	0.06	0.0150
5	9.29	0.1	0.0250
10	9.36	0.17	0.0500

Full spectra:



An increase of the equivalents of salt are shown from the bottom to the top of the figure.

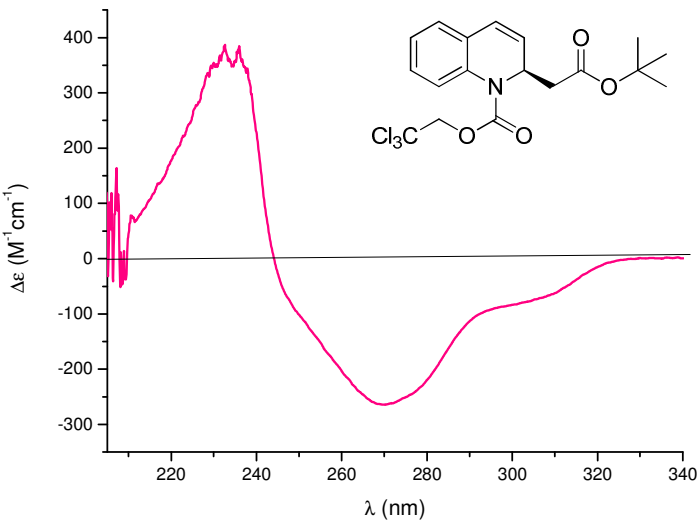
Zoom spectra:



Absolute configuration

1) CD Spectrum of product (*R*)-5b

The CD measurement was carried out on a J-815 (JASCO) spectrometer at room temperature. A 0.133 mM solution in THF of a sample of **5b** with 98:2 e.r. was employed, providing the spectrum shown below:



Conformation analysis / CD simulation of 5b with DFT

A conformational search was performed for (*S*)-**5b** with the SCAN program for general conformational search of the Tinker[11] package using the MM3 force field.[12] A few missing torsional parameters, all in relation to atom type 9 ("NSP2"), were added by choosing suitable parameters of similar atom type combinations:

Additional MM3 parameters (Tinker format) for the first conformational search

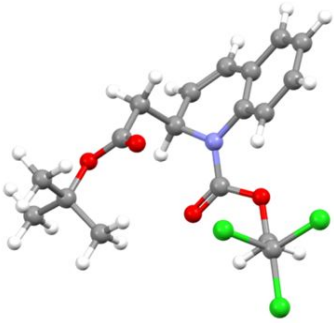
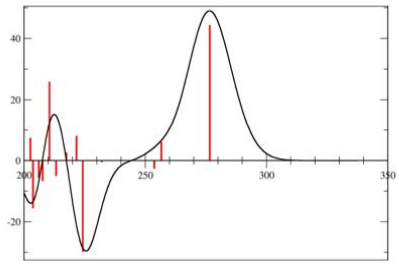
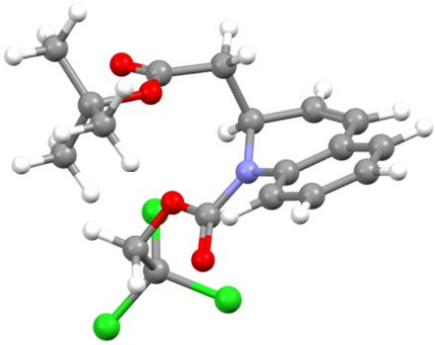
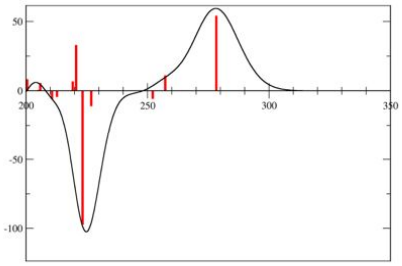
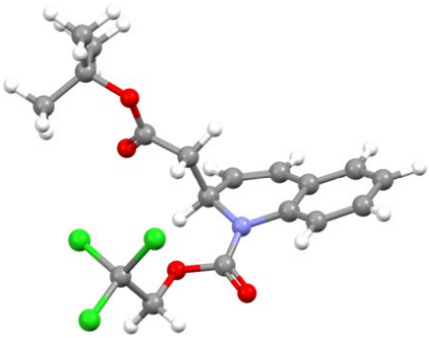
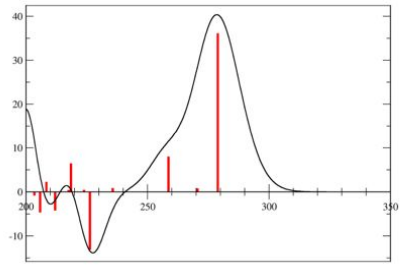
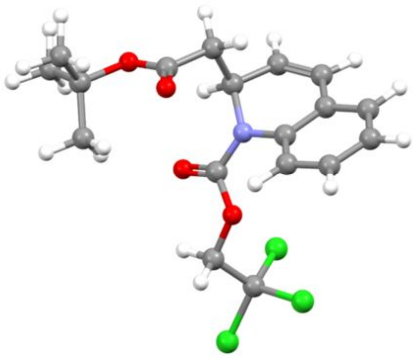
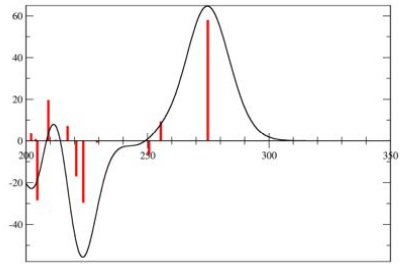
```
angle      6   3   9      0.900     112.50

torsion    2   1   9   3    2.300 0.0 1  -1.200 180.0 2   0.800 0.0 3

torsion    2   1   9   2    2.300 0.0 1  -1.200 180.0 2   0.800 0.0 3

torsion    6   3   9   1   -0.600 0.0 1   4.200 180.0 2   0.000 0.0 3

torsion    6   3   9   2   -0.600 0.0 1   4.200 180.0 2   0.000 0.0 3

torsion    9   1   2   2    0.250 0.0 1  -0.650 180.0 2   0.600 0.0 3

torsion    9   1   2   5    0.000 0.0 1   0.000 180.0 2   0.800 0.0 3

torsion    9   3   6   1    3.530 0.0 1   2.300 180.0 2  -3.530 0.0 3
```

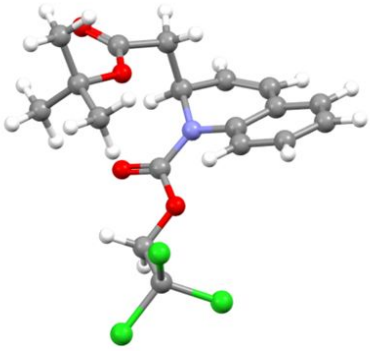
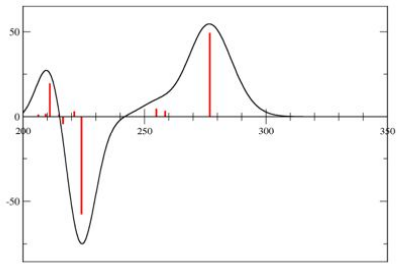
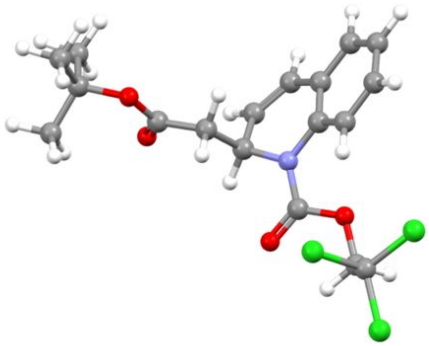
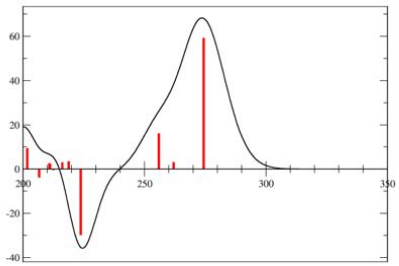
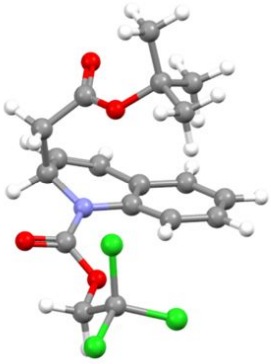
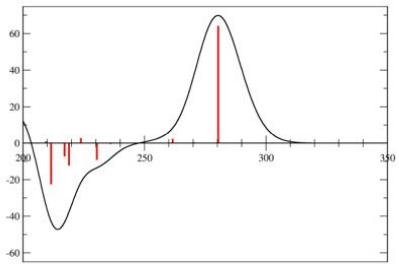
From the conformers obtained in the MM3 search, 143 structures were selected as unique by geometrical comparison (RSMD>=1.5Å) and DFT geometry optimizations were performed on these with TURBOMOLE[13], using the TPSS meta-GGA functional,[14] the triple zeta basis set def2-TZVP,[15] and the dispersion correction of Grimme et al.[16] with BJ damping[17] (TPSS-D3/def2-TZVP).

After optimization of the 143 conformations with DFT, 88 unique conformers were selected using an energy (ΔE>0.1 kcal/mol), dipole moment (Δμ>0.1 D) and geometry (RSMD>=1.8Å) criterion. A calculation of vibrational normal modes was done for all minima and the contribution of translations, rotations and normal vibrations to the free enthalpy at 298 K (G_{298}) added to the electronic energy to obtain the relative free energy ΔG(298K).[18] The 88 conformers were sorted according to ΔG(298K) and the CD spectra of conformers within a range of ΔG(298K) = 0-5 kcal/mol calculated with TD-DFT using the B3LYP functional[19] and the same basis set (B3LYP/def2-TZVP).

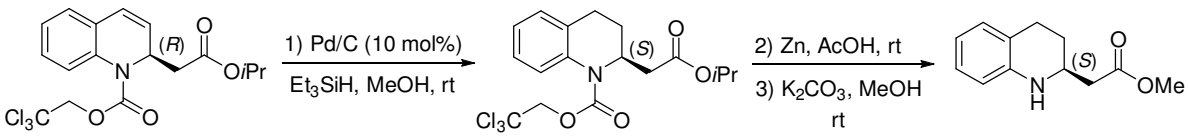
It turned out that one conformer (No. 093) is the most stable one by more than 0.8 kcal/mol on the free energy scale. The CD spectra of that and 8 more conformers in the range of ΔG(298K) = 0-1.5 kcal/mol look qualitatively very similar and have the inverse signature of the experimentally obtained CD spectrum of compound (*R*)-**5b**. We consider this as clear evidence for our stereochemical assignment.

Structures and CD spectra of the more stable conformers of the (*S*)-enantiomer of product **5b**

Conformer No. **[rel. ΔG(298)]** **(in kcal/mol)**	**Structure**	**calculated CD spectrum B3LYP/def2-TZVP** **(200-350nm)** **horizontal axis: [λ/nm]**
093 [0.0]		
179 [+0.82]		
328 [+0.86]		
225 [+0.90]		

Conformer No. [rel. ΔG(298)] (in kcal/mol)	Structure	calculated CD spectrum B3LYP/def2-TZVP (200-350nm) horizontal axis: [λ/nm]
071 [+0.99]		
006 [+1.15]		
029 [+1.21]		

2) Derivatization to β-amino ester 28 and comparison of the optical rotation:

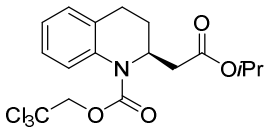


5a
93:7 e.r.

26
93:7 e.r.

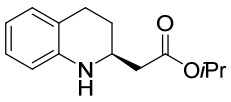
28
93:7 e.r.

2,2,2-Trichloroethyl (*S*)-2-(2-isopropoxy-2-oxoethyl)-3,4-dihydroquinoline-1(2*H*)-carboxylate (26)



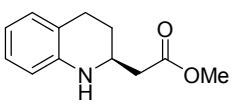
An enantioenriched sample of **5a** (147 mg, 0.36 mmol, 1.0 equiv., 93:7 e.r.), was reacted with Et_3SiH (115 µL, 0.72 mmol, 2 equiv.) in the presence of Pd/C (10 wt) (38.3 mg, 0.036 mmol, 10 mol%) in MeOH at r.t. After 1 h another portion of Et_3SiH (115 µL, 0.72 mmol, 2 equiv.) was added. The reaction was stirred vigorously for another 2 h. Then the mixture was filtrated through celite®, washed three times with AcOEt, and the solvent evaporated under reduced pressure. The desired product **26** (88.5 mg, 0.22 mmol, 60%) was isolated by flash column chromatography (pentane/EtOAc 20:1 → 10:1) as colourless oil. The enantiomeric ratio was found to be 93:7 by chiral HPLC (Chiralpak OD-H, heptane/isopropanol (95:5) 1.0 mL/min, λ= 230 nm, *tr* (*S*): 7.0 min, *tr* (*R*): 8.5 min.). $[\alpha]_{589}^{20}$: –4.2 (*c* 0.125, $CHCl_3$). **^{1}H NMR** (300 MHz, $CDCl_3$) δ/ppm = 7.57 (d, *J* = 7.9 Hz, 1H), 7.20 (td, *J* = 8.2, 7.6, 2.2 Hz, 1H), 7.15 – 7.03 (m, 2H), 5.10 – 4.90 (m, 3H), 4.65 (br d, *J* = 10.5 Hz, 1H), 2.79 – 2.59 (m, 3H), 2.50 – 2.27 (m, 2H), 1.71 (dq, *J* = 13.3, 6.6 Hz, 1H), 1.19 (d, *J* = 6.3 Hz, 6H); **^{13}C NMR** (75 MHz, $CDCl_3$) δ/ppm = 170.3, 152.9, 135.7, 128.0, 126.4, 125.2, 95.5, 75.4, 68.1, 51.2, 38.9, 29.0, 24.9, 21.9; **HRMS (ES):** *m/z* calculated for $[C_{17}H_{20}{}^{35}Cl_3NO_4Na]^+$: 430.0350, found: 430.0343.

Isopropyl (*S*)-2-(1,2,3,4-tetrahydroquinolin-2-yl)acetate (27)



26 (86.4 mg, 0.21 mmol, 1 equiv.) was treated with Zn powder (138.2 mg, 2.11 mmol, 10 equiv.) and AcOH (62.9 µL, 1.10 mmol, 5.2 equiv.) in THF/H_2O (1:1, 2 mL) at room temperature for 2.5 h. Then, an aq. sat. solution of K_2CO_3 was added, the reaction extracted with DCM (5 x 5 mL), the organic layers collected and the solvent removed under reduced pressure. The crude mixture was used directly for the next step without further purification. **^{1}H NMR** (300 MHz, $CDCl_3$) δ/ppm = 7.04 – 6.89 (m, 2H), 6.63 (td, *J* = 7.4, 1.2 Hz, 1H), 6.51 (dd, *J* = 7.9, 1.2 Hz, 1H), 5.06 (p, *J* = 6.3 Hz, 1H), 4.69 – 4.31 (m, 1H), 3.79 – 3.65 (m, 1H), 2.85 (ddd, *J* = 15.9, 10.0, 5.7 Hz, 1H), 2.73 (dt, *J* = 15.9, 5.1 Hz, 1H), 2.52-2.45 (m, 2H), 1.96 (dtd, *J* = 12.9, 5.4, 3.2 Hz, 1H), 1.71 (dddd, *J* = 12.9, 10.0, 8.9, 5.5 Hz, 1H), 1.26 (d, *J* = 6.3 Hz, 6H); **^{13}C NMR** (75 MHz, $CDCl_3$) δ/ppm = 172.0, 144.2, 129.4, 127.0, 121.0, 117.5, 114.7, 68.2, 48.0, 41.4, 28.2, 25.8, 22.0; **HRMS (ES):** *m/z* calculated for $[C_{14}H_{19}NO_2{\cdot}H]^+$: 235.1521, found: 235.1528.

Methyl (*S*)-2-(1,2,3,4-tetrahydroquinolin-2-yl)acetate (28)[20]

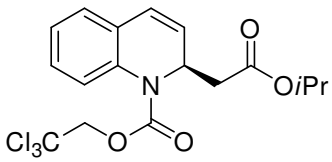


The crude product **27** was dissolved in MeOH (5mL) and K_2CO_3 (282.0 mg, 2.05 mmol, ~ 10 equiv.) was added. After stirring for 12 h, brine was added and the mixture extracted with AcOEt (3 x 10 mL), the organic layers collected and the solvent removed under reduced pressure. The desired product **28** (23.1 mg, 0.113 mmol, 53%/2-steps) was isolated by flash column chromatography (pentane → pentane/EtOAc 9:1) as yellow oil. The enantiomeric ratio was found to be 93:7 by chiral HPLC (Chiralpak OD-H, heptane/isopropanol (90:10) 1.0 mL/min, λ= 254 nm, *tr* (*R*): 8.1 min, *tr* (*S*): 10.5 min.). $[\alpha]_{589}^{20}$: +83.5 (*c* 0.23, $CHCl_3$) (Lit.[20a] (*S*)-**28** with 98.8:1.2 e.r. = $[\alpha]_{589}^{20}$: +104.7 (*c* 1.0, $CHCl_3$)). **^{1}H NMR** (300 MHz, $CDCl_3$) δ/ppm = 7.04 – 6.90 (m, 2H), 6.63 (td, *J* = 7.3, 1.2 Hz, 1H), 6.51 (dd, *J* = 7.9, 1.1 Hz, 1H), 4.48 (s, 1H), 3.80 – 3.65 (m, 1H), 3.72 (s, 3H), 2.93

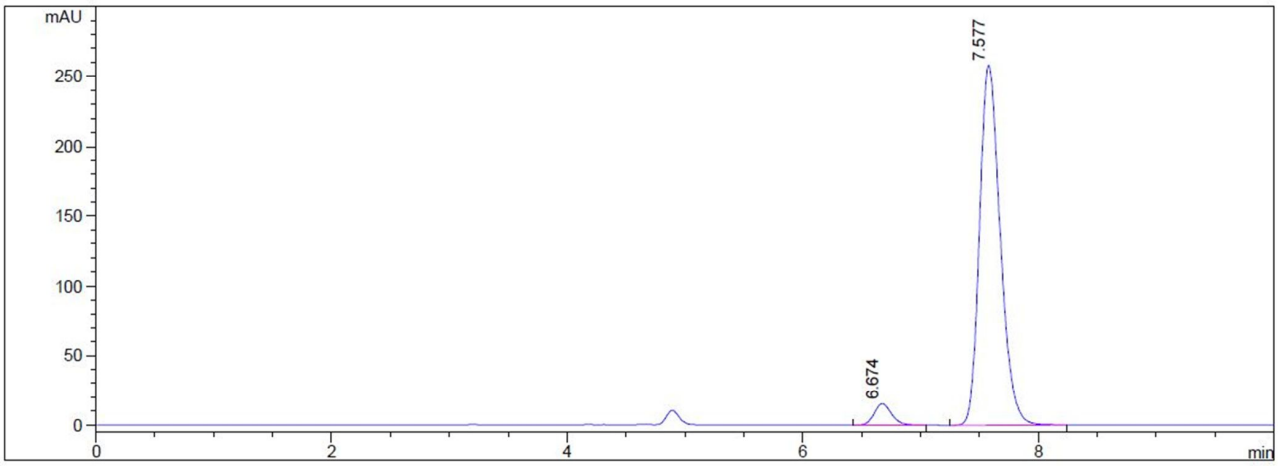
– 2.78 (m, 1H), 2.73 (dt, *J* = 16.4, 5.3 Hz, 1H), 2.59 – 2.49 (m, 2H), 1.97 (dtd, *J* = 12.9, 5.4, 3.2 Hz, 1H), 1.72 (dddd, *J* = 13.0, 10.0, 8.8, 5.5 Hz, 1H); **^{13}C NMR** (75 MHz, $CDCl_3$) δ/ppm = 172.9, 144.1, 129.3, 127.0, 121.0, 117.5, 114.7, 51.9, 47.9, 40.8, 28.1, 25.7. **HRMS (ES):** *m/z* calculated for $[C_{12}H_{15}NO_2 \cdot H]^+$: 206.1176, found: 206.1186.

HPLC-Data

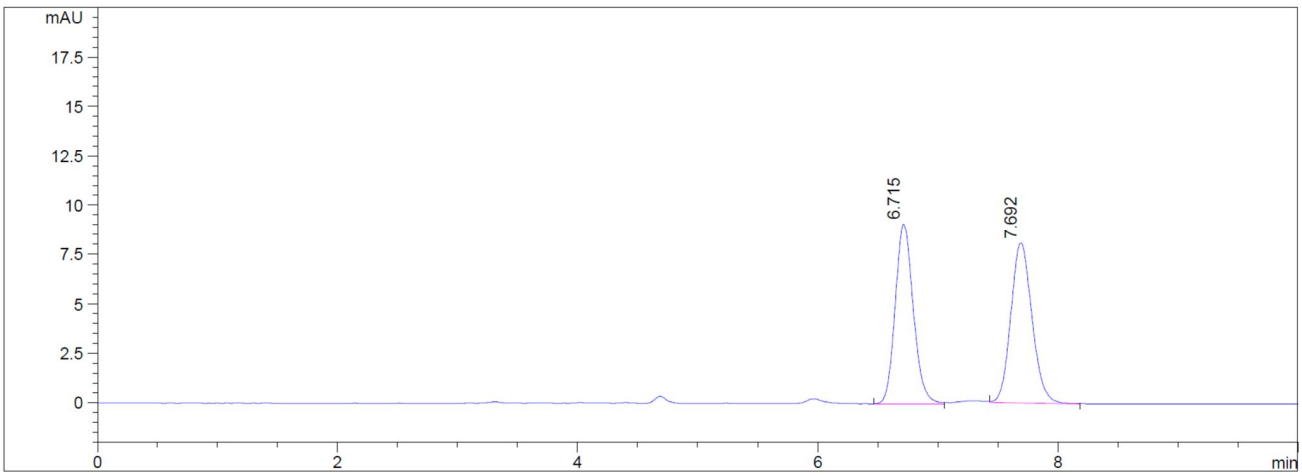
Product 5a



OD-H; Hexane : *i*PrOH = 95:5

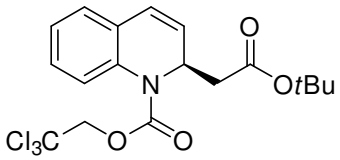


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	6.674	15.439	5.636	159.788	4.803
2	7.577	258.510	94.364	3167.151	95.197

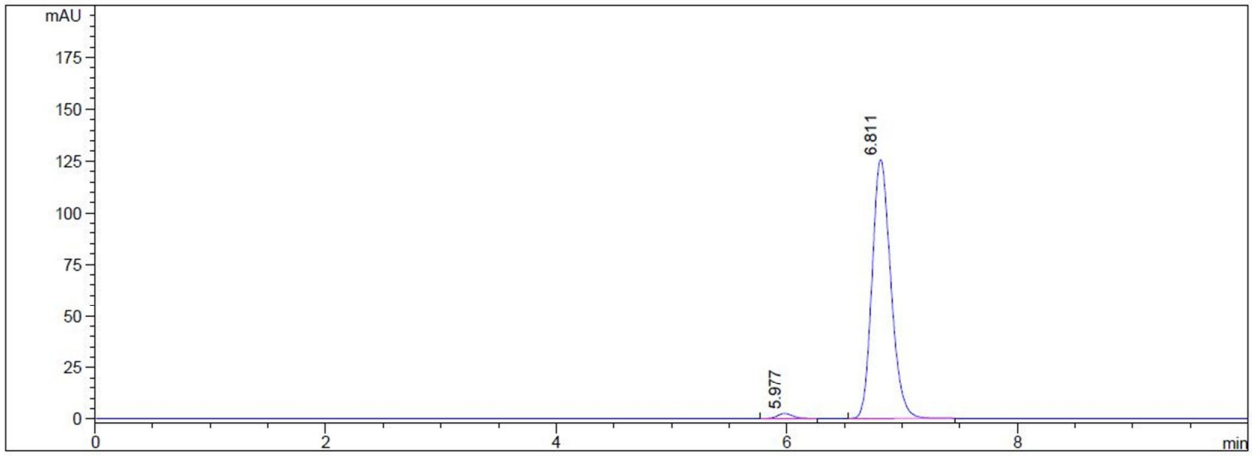


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	6.715	9.096	52.943	95.604	49.037
2	7.692	8.085	47.057	99.358	50.963

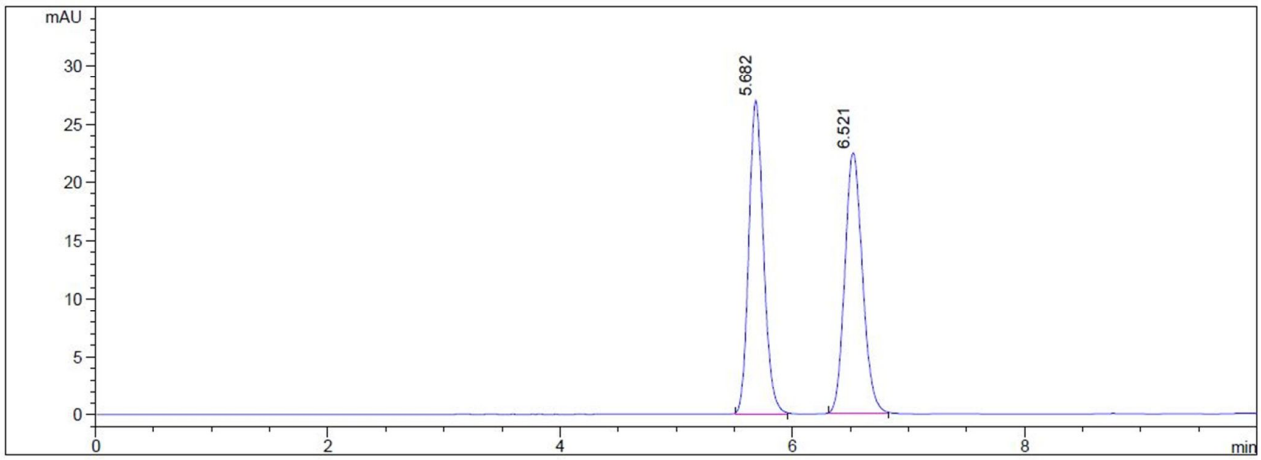
Product 5b



OD-H; Hexane : *i*PrOH = 95:5

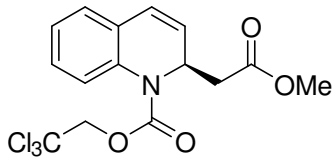


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	5.977	2.550	1.987	26.344	1.818
2	6.811	125.808	98.013	1422.668	98.182

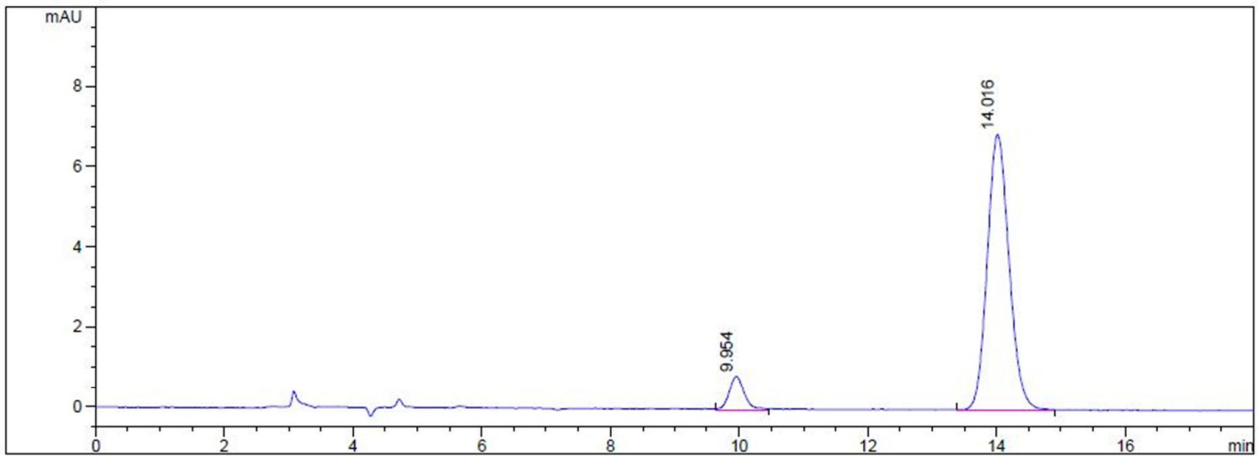


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	5.682	26.932	54.535	237.973	49.963
2	6.521	22.452	45.465	238.325	50.037

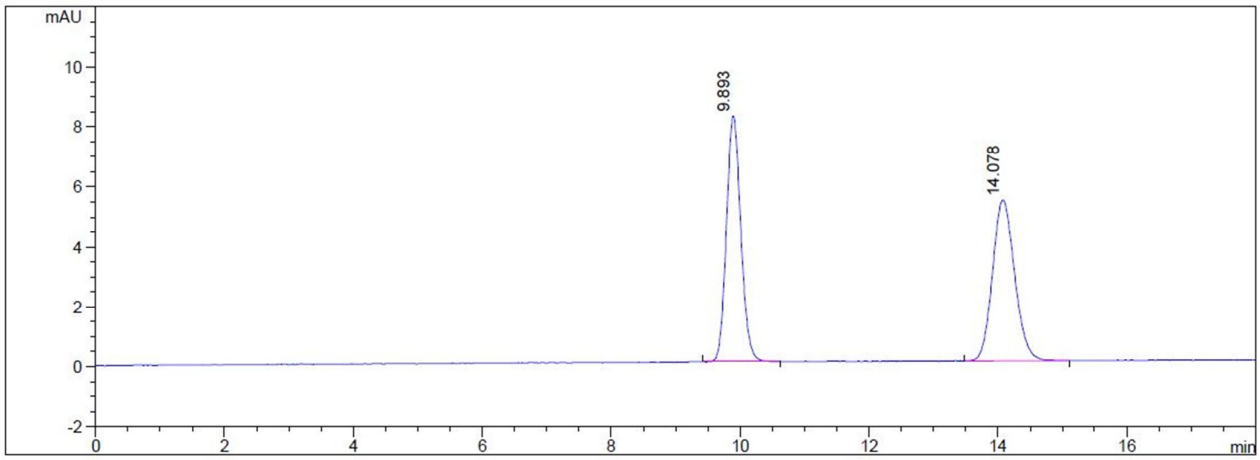
Product 5c



OD-H; Hexane : *i*PrOH = 95:5

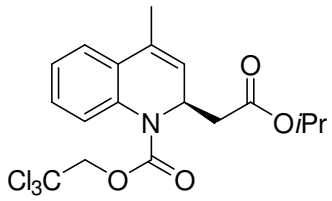


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	9.954	0.853	10.974	14.199	7.909
2	14.016	6.924	89.026	165.332	92.091

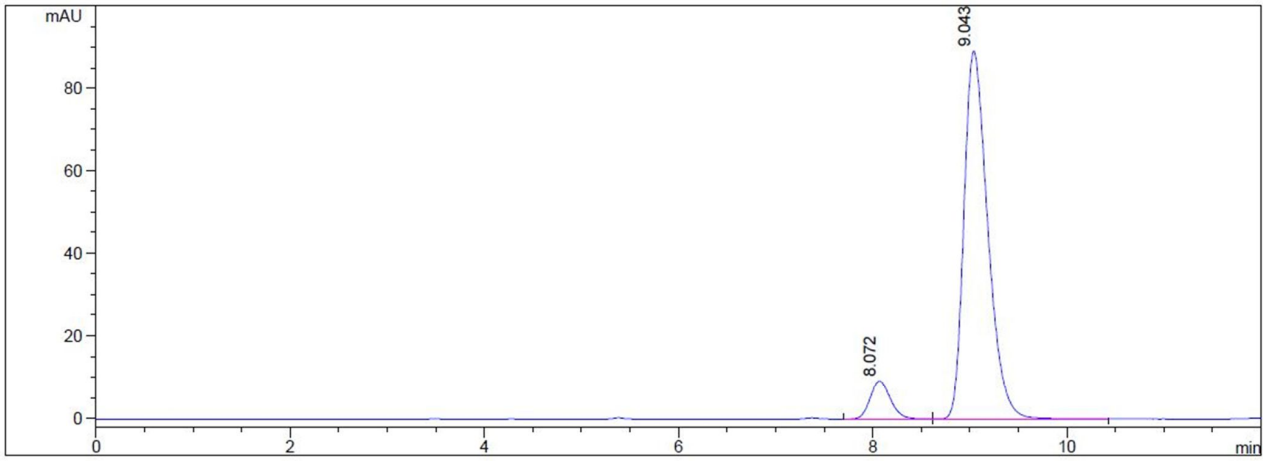


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	9.893	8.218	60.384	127.751	49.804
2	14.078	5.391	39.616	128.758	50.196

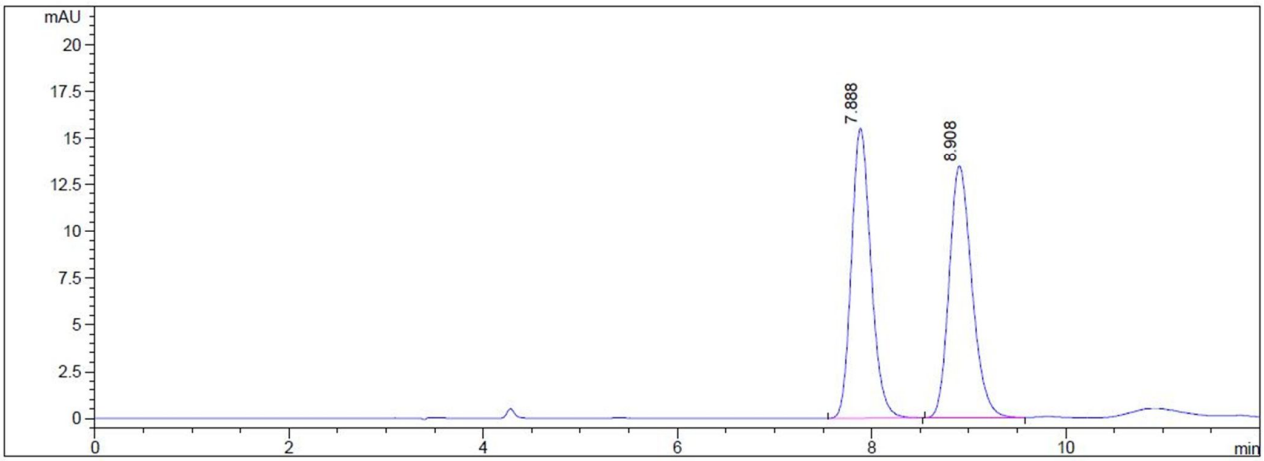
Product 5d



OD-H; Hexane : *i*PrOH = 98:2

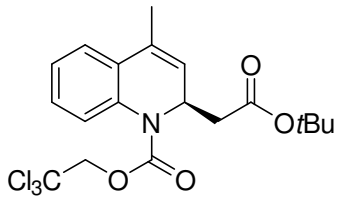


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	8.072	9.240	9.383	134.206	8.113
2	9.043	89.234	90.617	1519.942	91.887

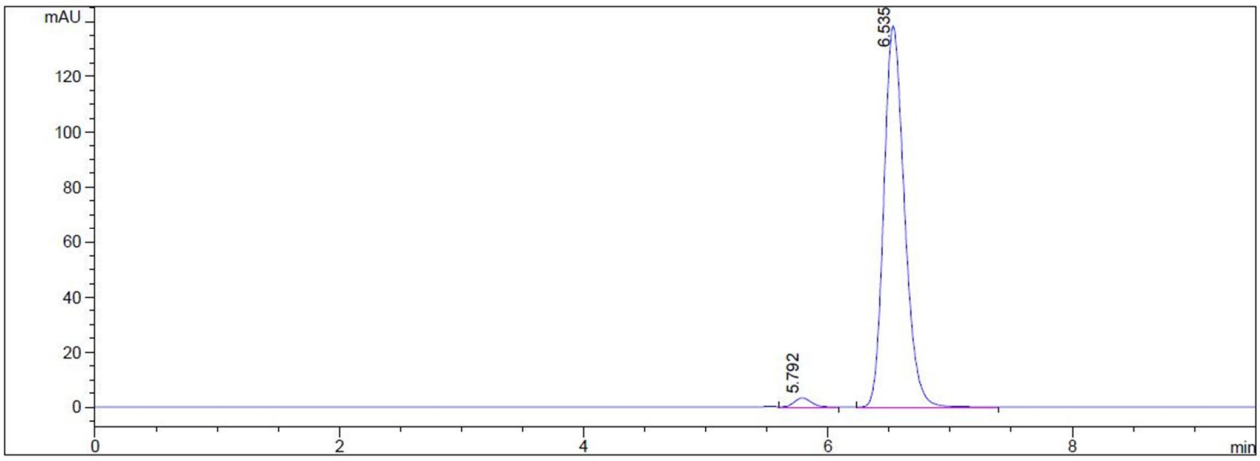


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	7.888	15.527	53.556	216.803	49.615
2	8.908	13.465	46.444	220.164	50.385

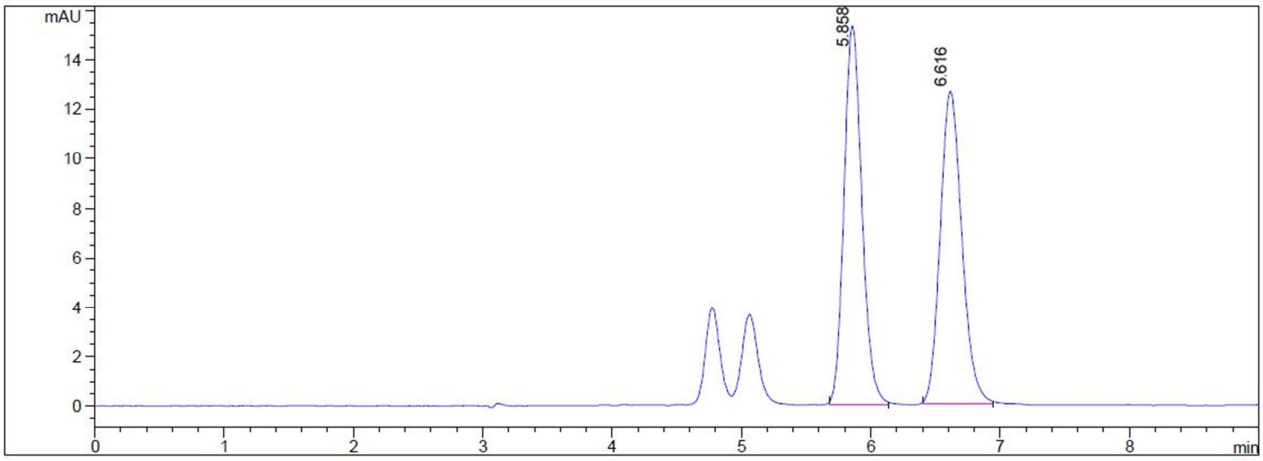
Product 5e



OD-H; Hexane : *i*PrOH = 95:5

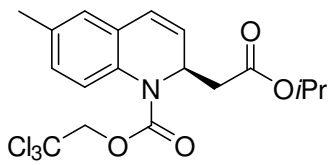


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	5.792	3.306	2.330	31.256	1.890
2	6.535	138.589	97.670	1622.914	98.110

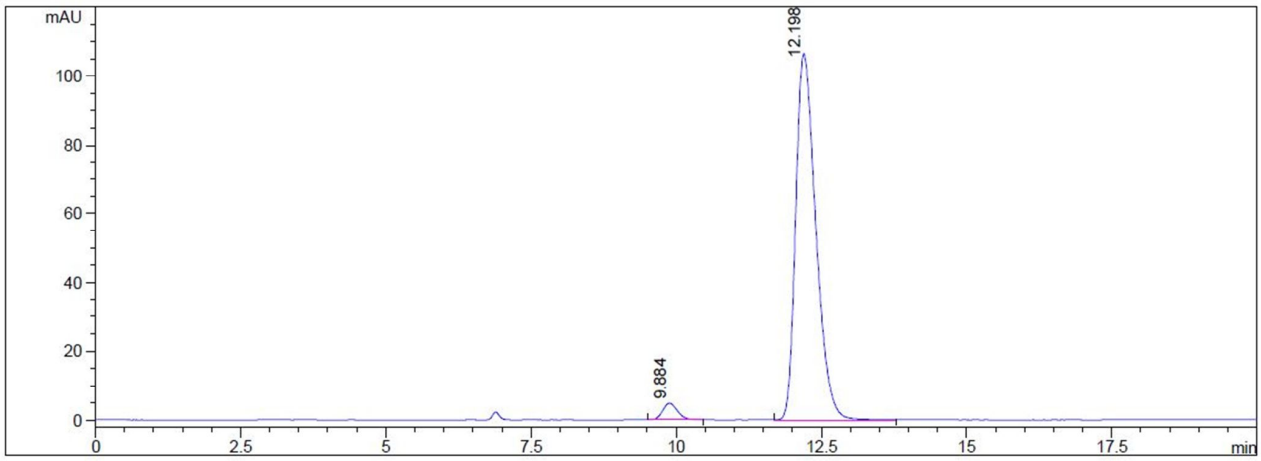


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	5.858	15.344	54.838	147.919	50.069
2	6.616	12.637	45.162	147.511	49.931

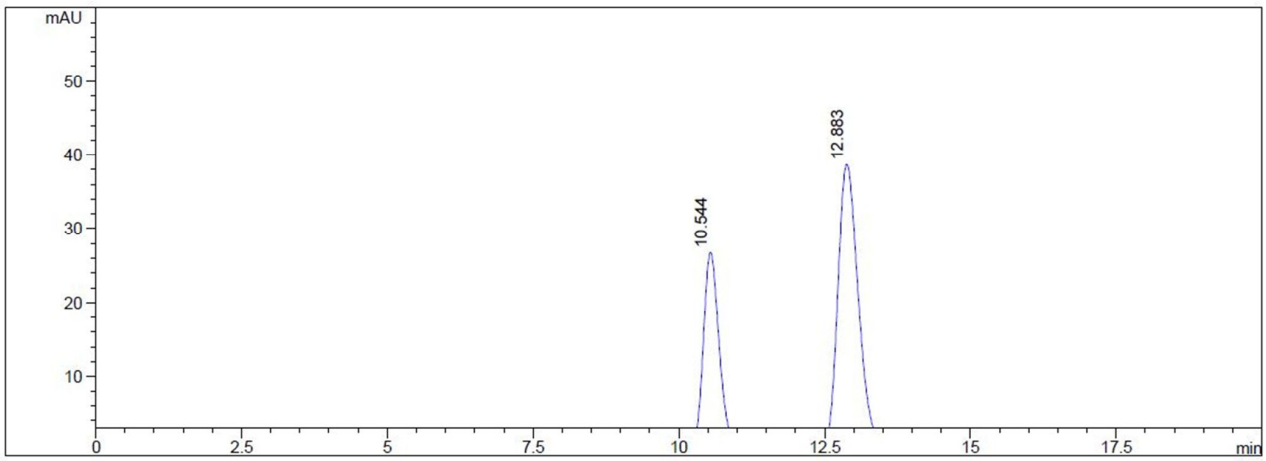
Product 5f



AD-H; Hexane : *i*PrOH = 98:2

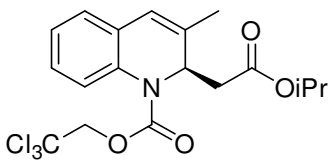


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	9.884	4.815	4.326	85.161	3.208
2	12.198	106.492	95.674	2569.281	96.792

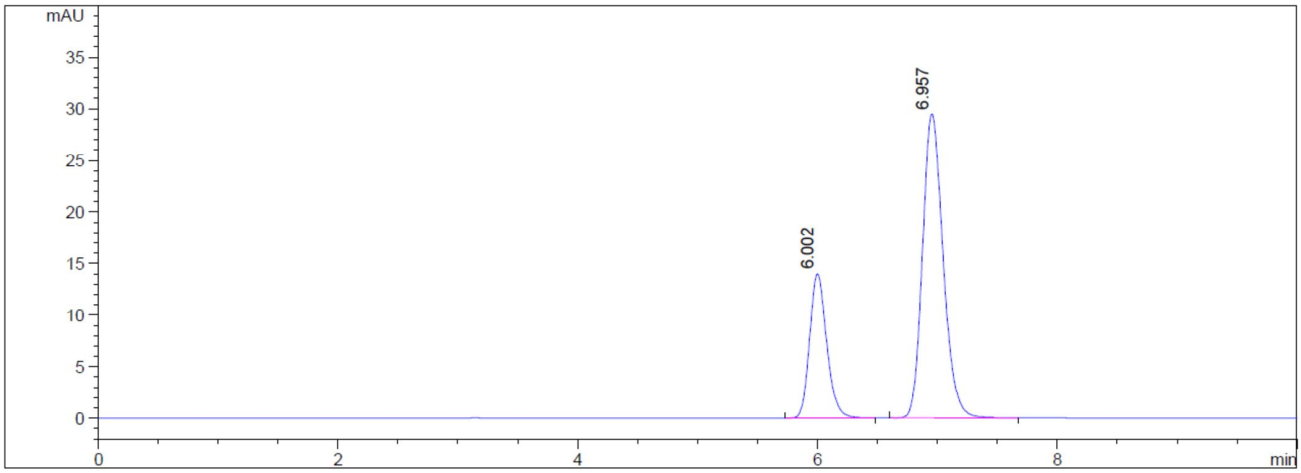


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	10.544	28.521	42.928	655.510	42.218
2	12.883	37.919	57.072	897.155	57.782

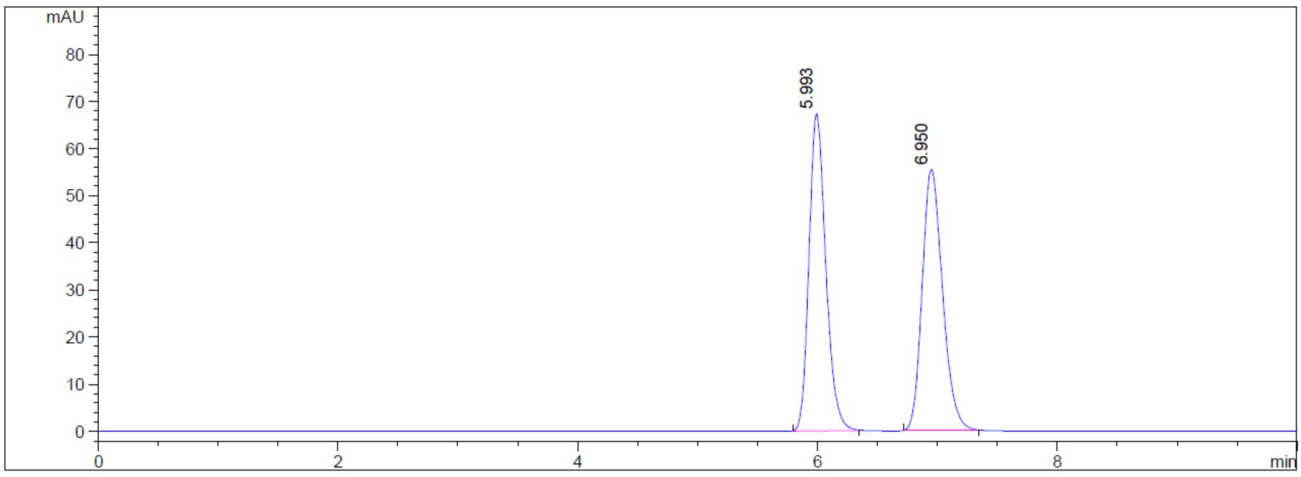
Product 5g



OD-H; Hexane : *i*PrOH = 99:1

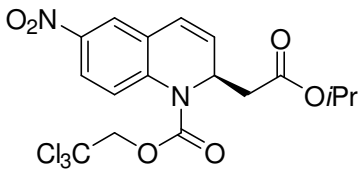


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	6.002	13.987	32.148	138.239	28.102
2	6.957	29.521	67.852	353.684	71.898

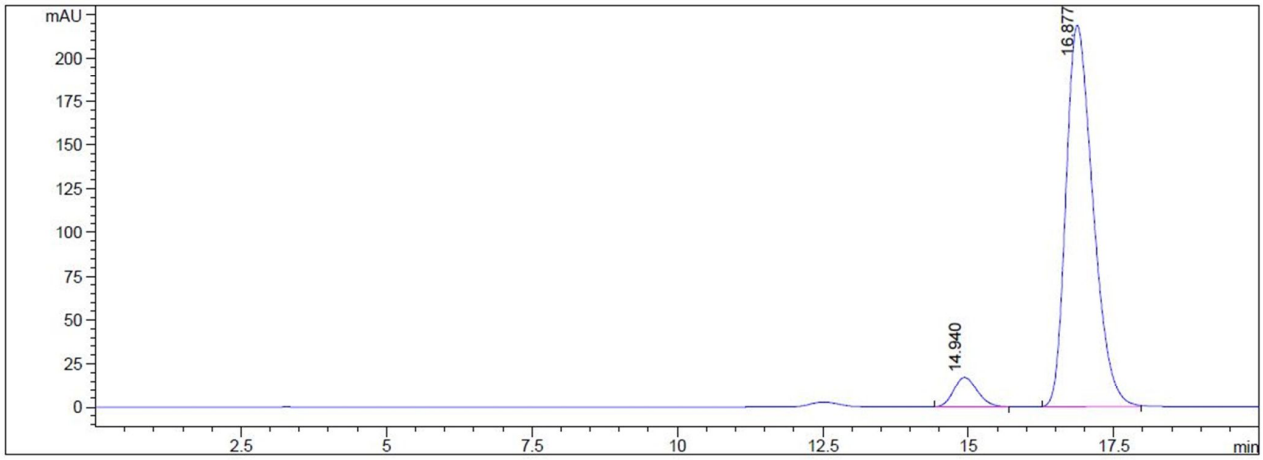


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	5.993	67.260	54.828	656.451	49.931
2	6.950	55.414	45.172	658.278	50.069

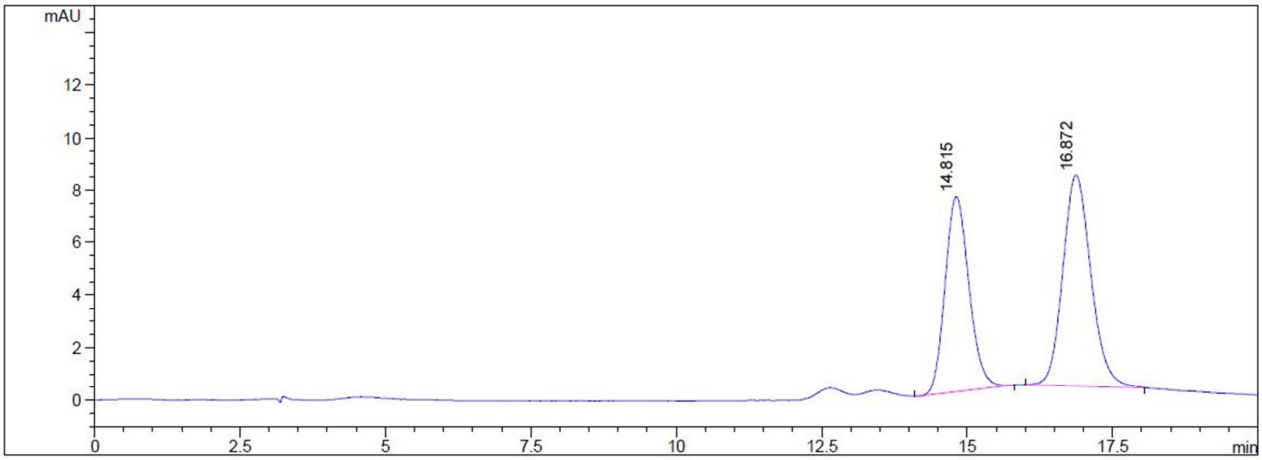
Product 5i



OD-H; Hexane : *i*PrOH = 95:5

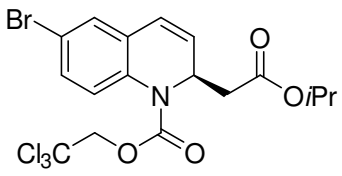


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	14.940	17.186	7.293	485.268	6.430
2	16.877	218.473	92.707	7061.931	93.570

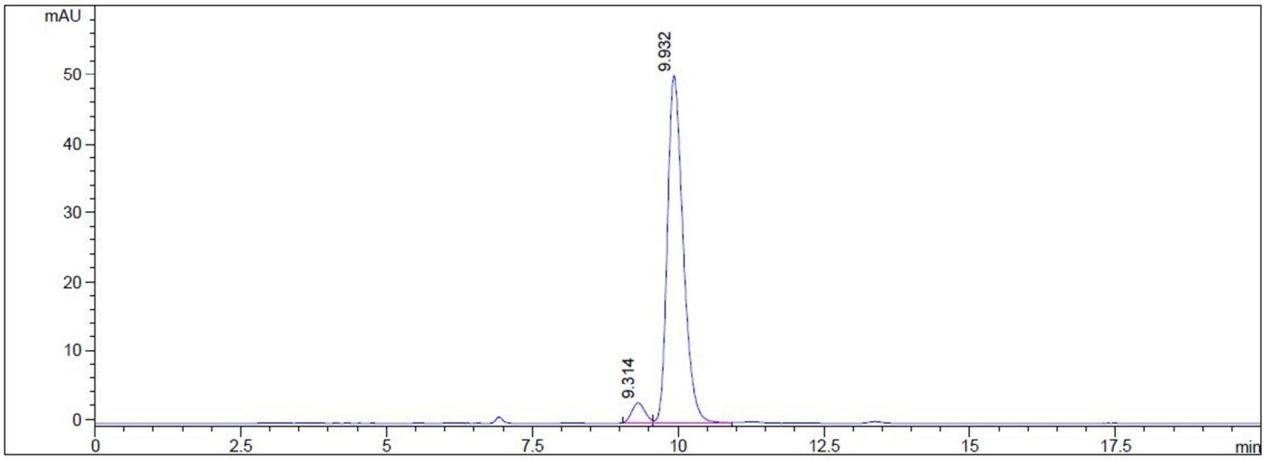


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	14.815	7.429	48.060	212.154	44.009
2	16.872	8.029	51.940	269.915	55.991

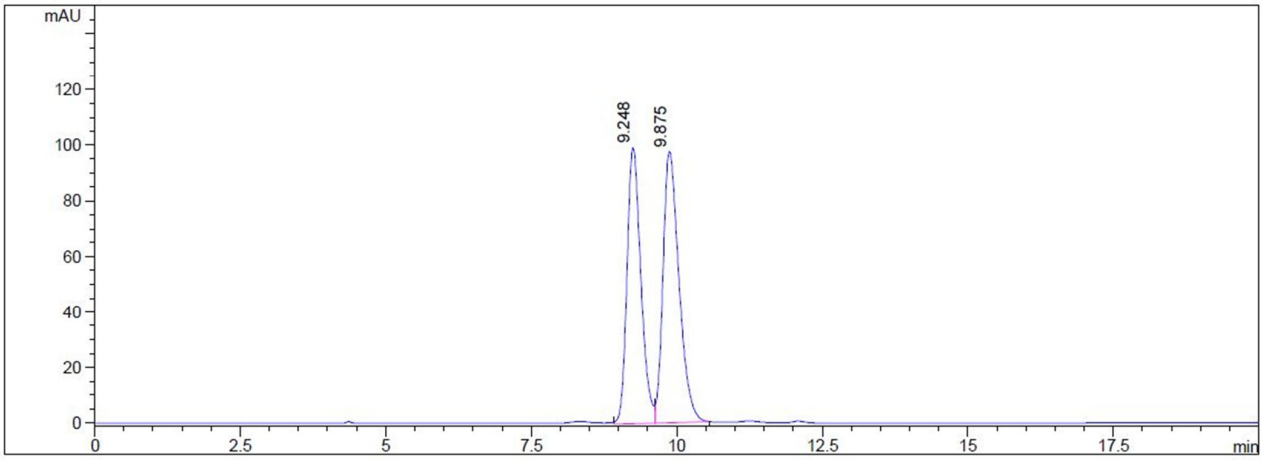
Product 5j



OD-H; Hexane : *i*PrOH = 95:5

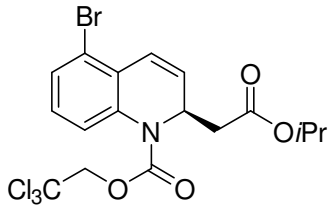


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	9.314	2.839	5.344	44.642	4.503
2	9.932	50.291	94.656	946.627	95.497

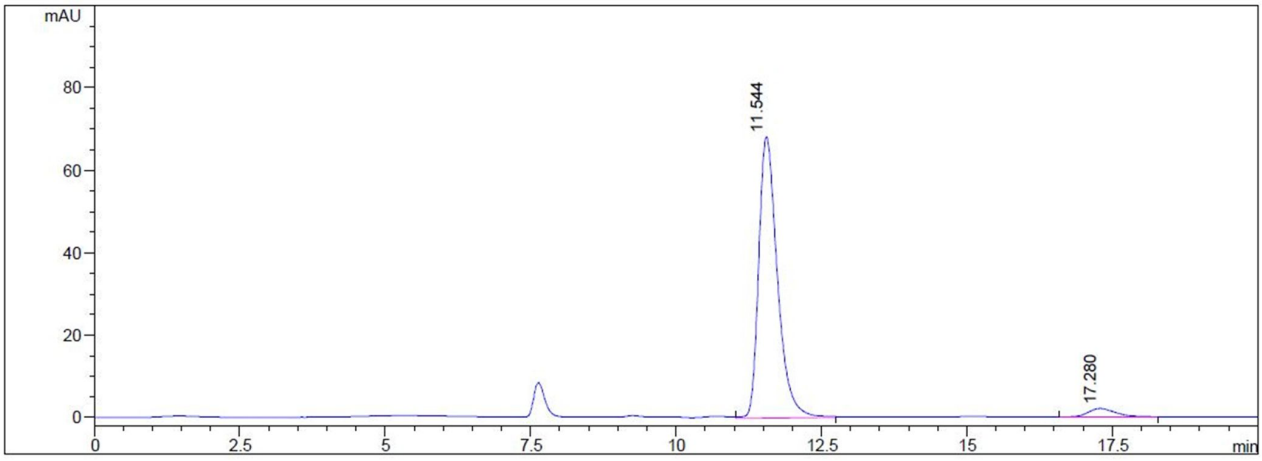


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	9.248	99.466	50.488	1651.612	47.102
2	9.875	97.544	49.512	1854.846	52.898

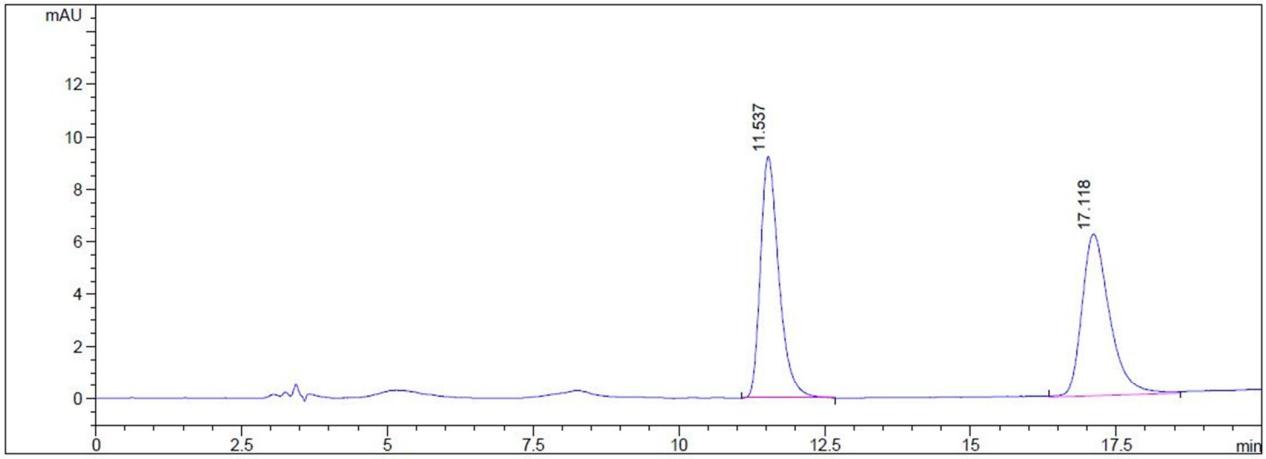
Product 5k



AD-H; Hexane : *i*PrOH = 98:2

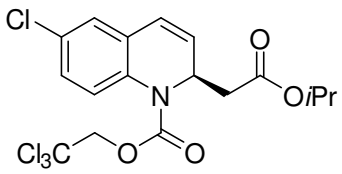


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	11.544	68.412	96.945	1532.551	94.927
2	17.280	2.156	3.055	81.899	5.073

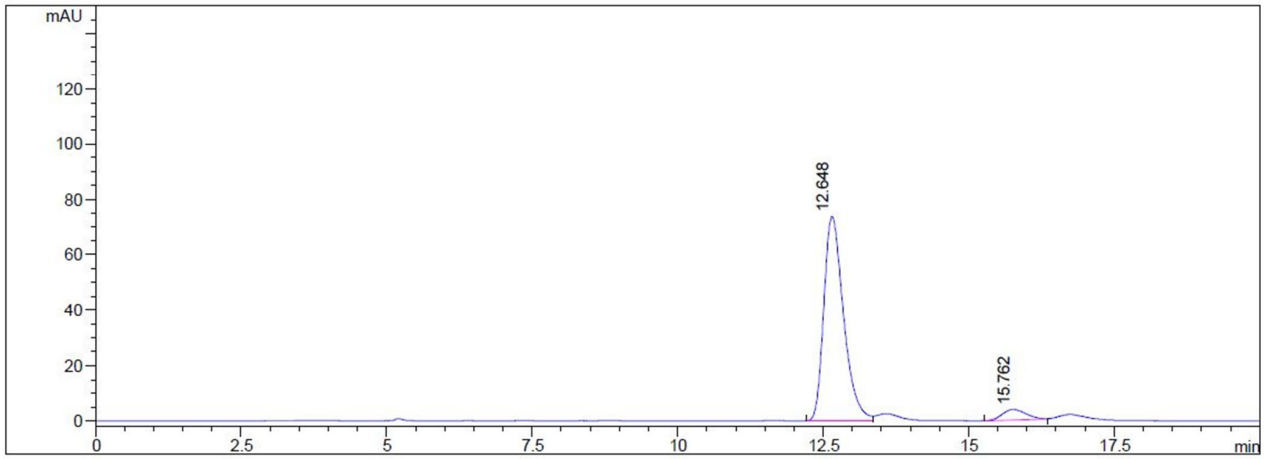


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	11.537	9.192	59.808	203.523	49.885
2	17.118	6.177	40.192	204.460	50.115

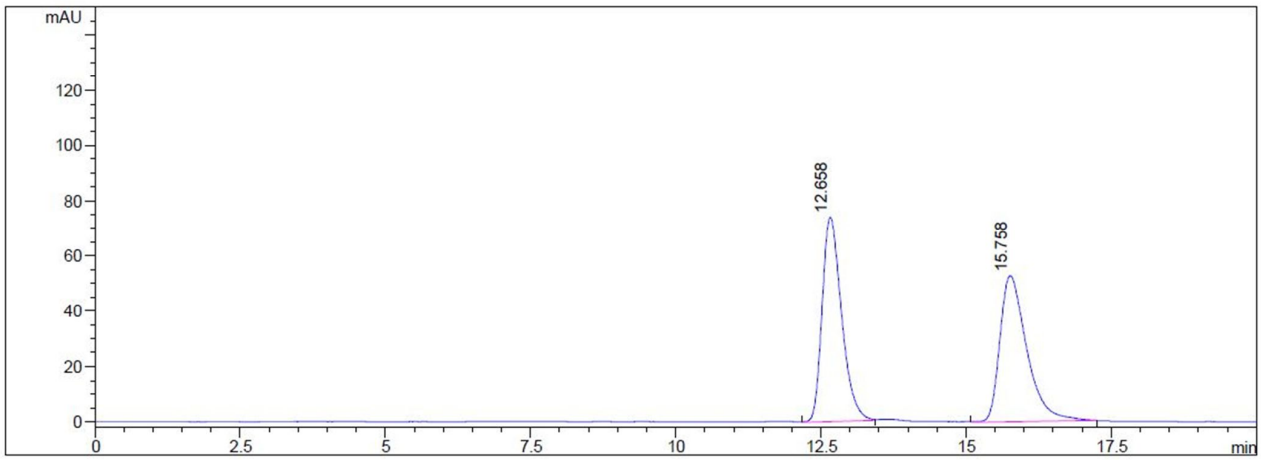
Product 5l



AD-H; Hexane : *i*PrOH = 98:2

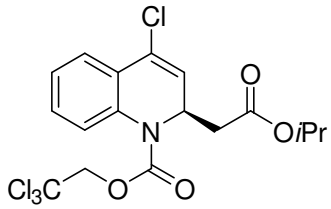


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	12.648	73.850	95.150	1744.146	94.346
2	15.762	3.764	4.850	104.517	5.654

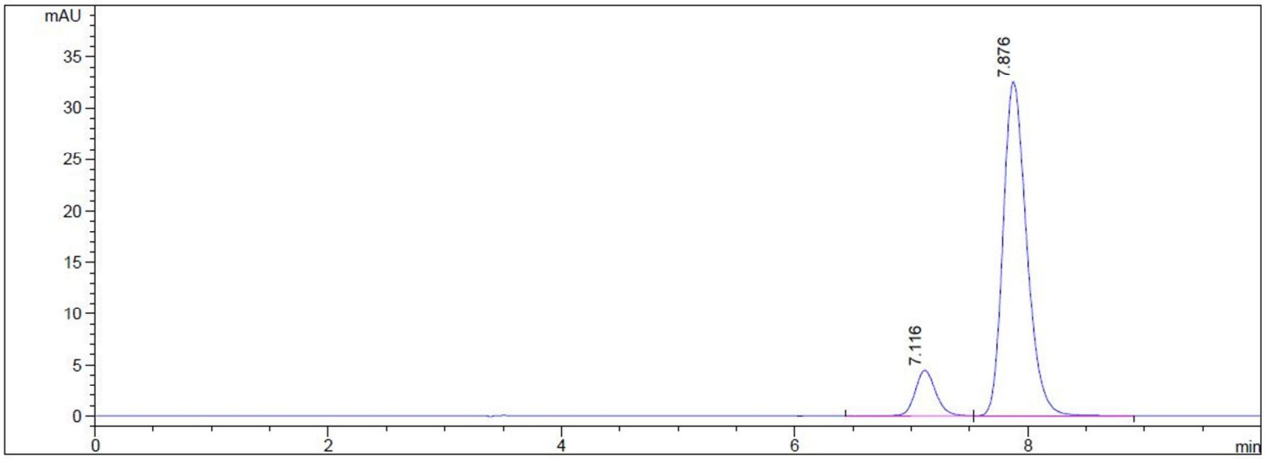


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	12.658	74.054	58.357	1725.363	50.405
2	15.758	52.845	41.643	1697.654	49.595

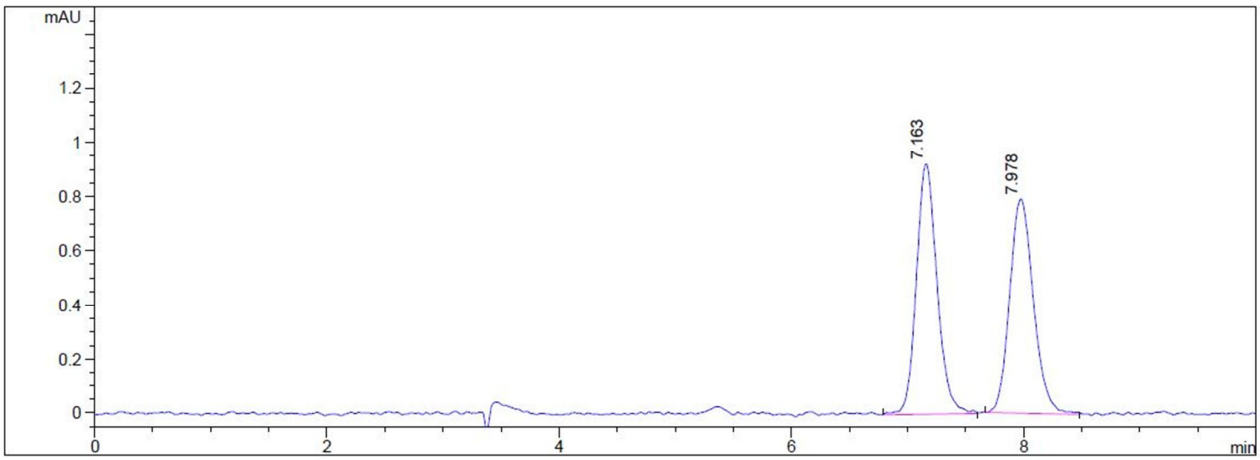
Product 5m



OD-H; Hexane : *i*PrOH = 98:2

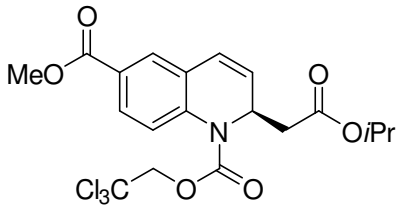


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	7.116	4.467	12.074	54.790	10.686
2	7.876	32.528	87.926	457.934	89.314

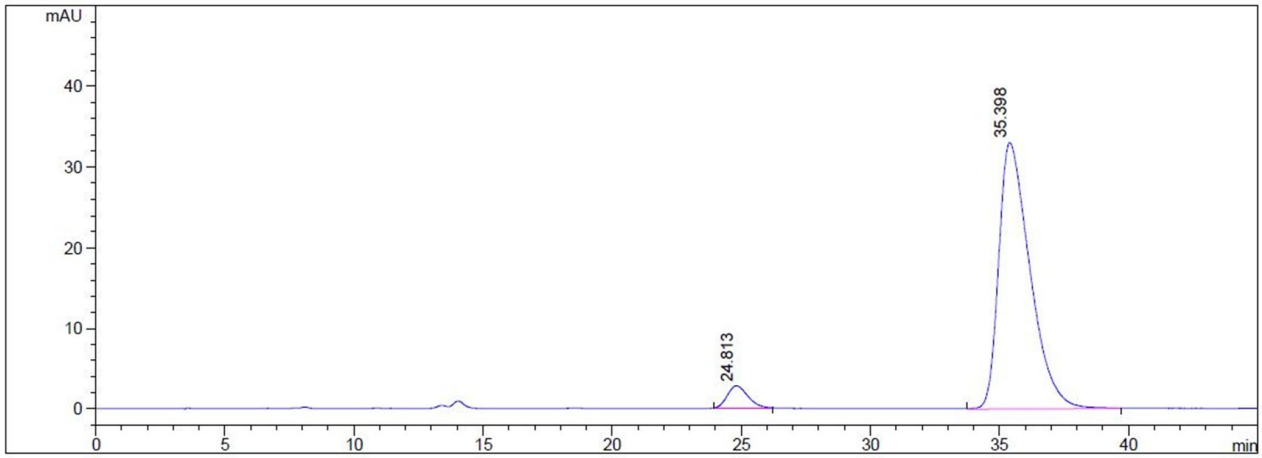


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	7.163	0.925	53.882	11.517	50.553
2	7.978	0.792	46.118	11.265	49.447

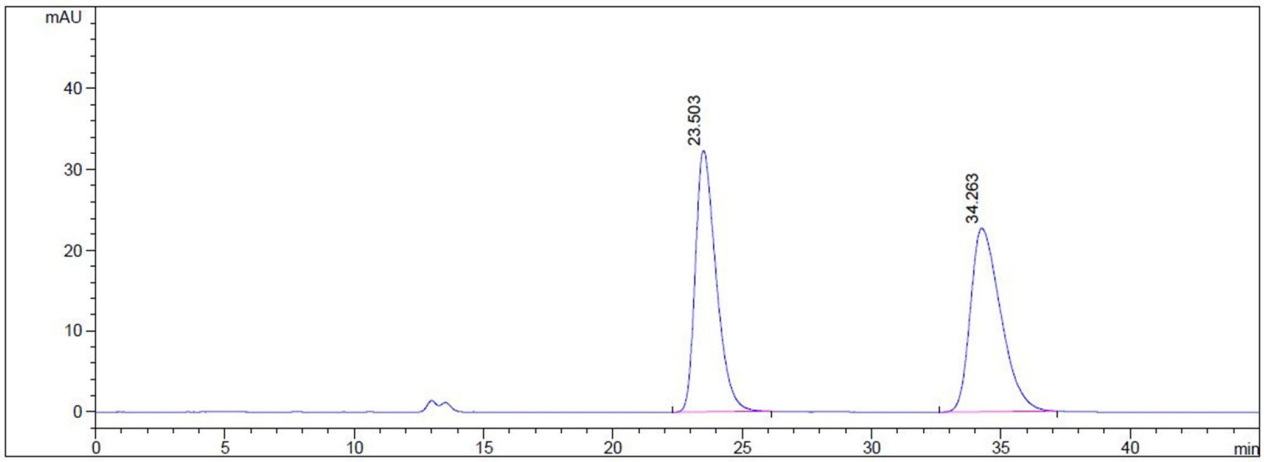
Product 5n



OD-H; Hexane : *i*PrOH = 95:5

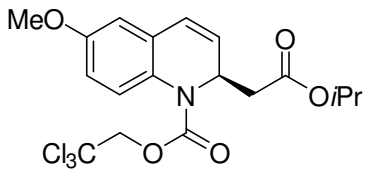


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	24.813	2.724	7.610	150.497	5.136
2	35.398	33.078	92.390	2779.792	94.864

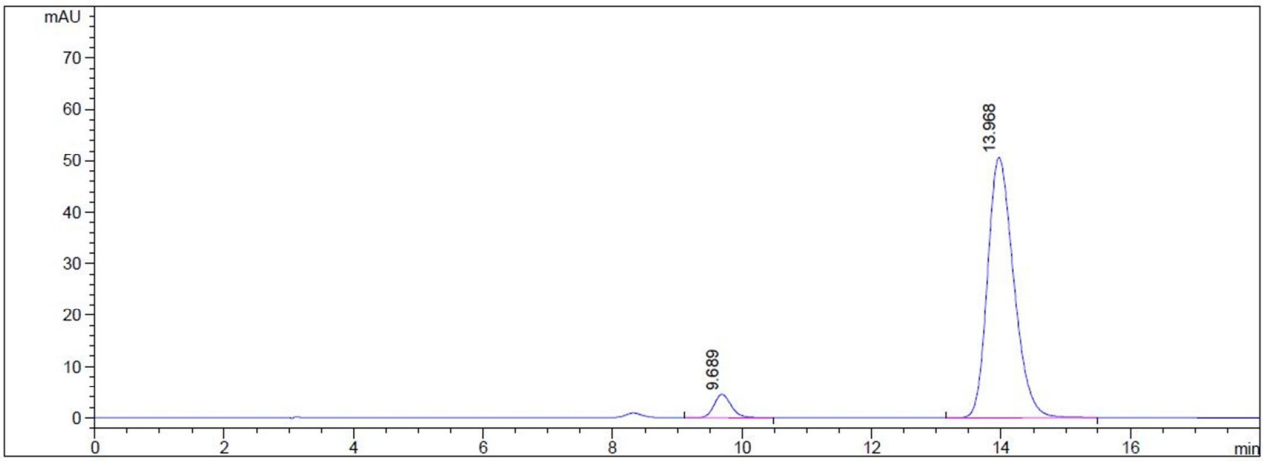


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	23.503	32.409	58.676	1806.654	49.319
2	34.263	22.825	41.324	1856.512	50.681

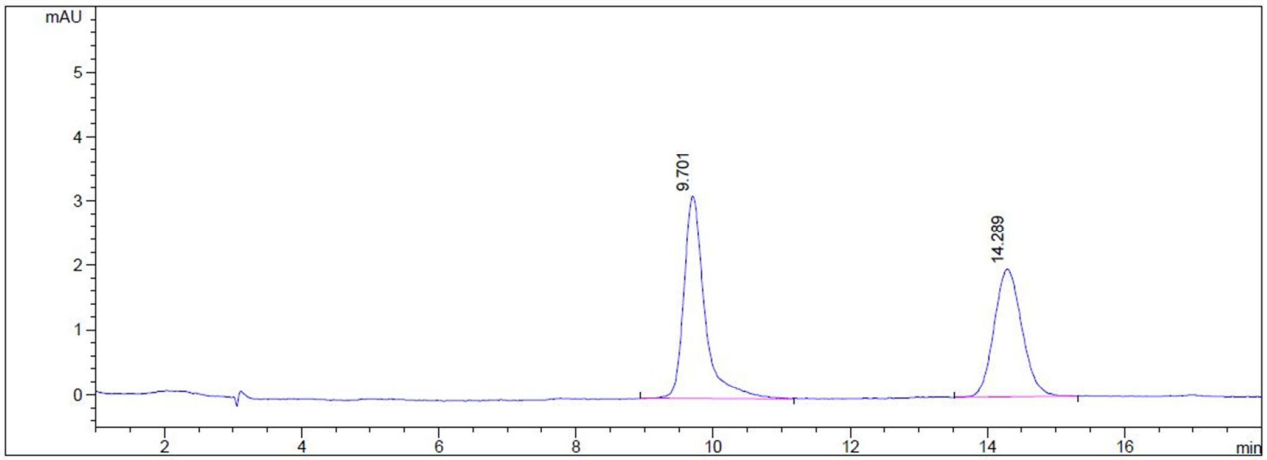
Product 5o



OD-H; Hexane : *i*PrOH = 95:5

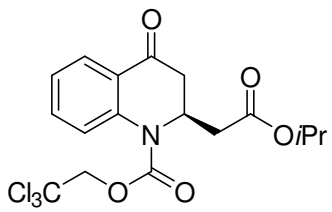


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	9.689	4.477	8.120	84.317	5.592
2	13.968	50.661	91.880	1423.366	94.408

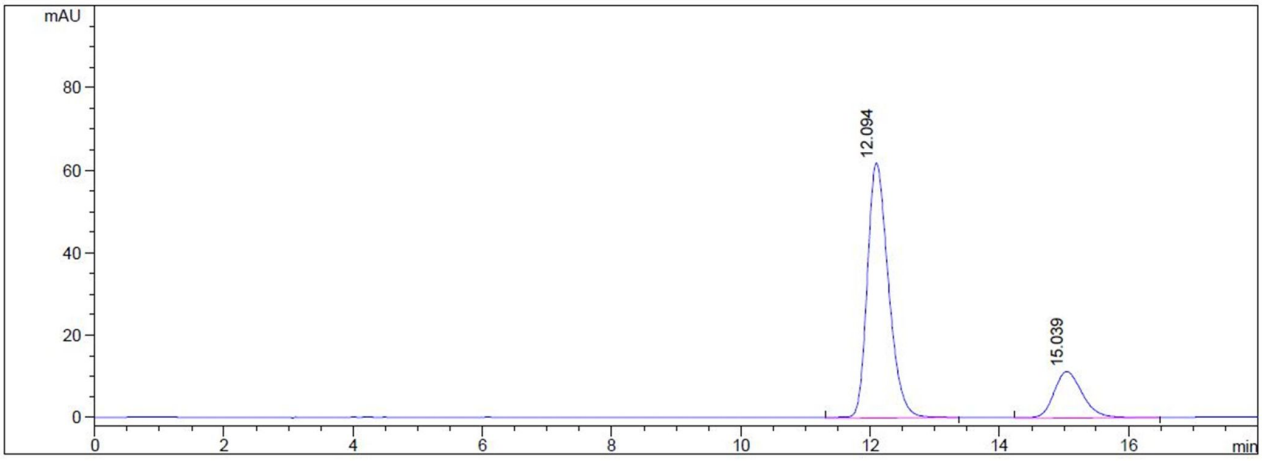


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	9.701	3.130	61.319	66.618	54.502
2	14.289	1.974	38.681	55.612	45.498

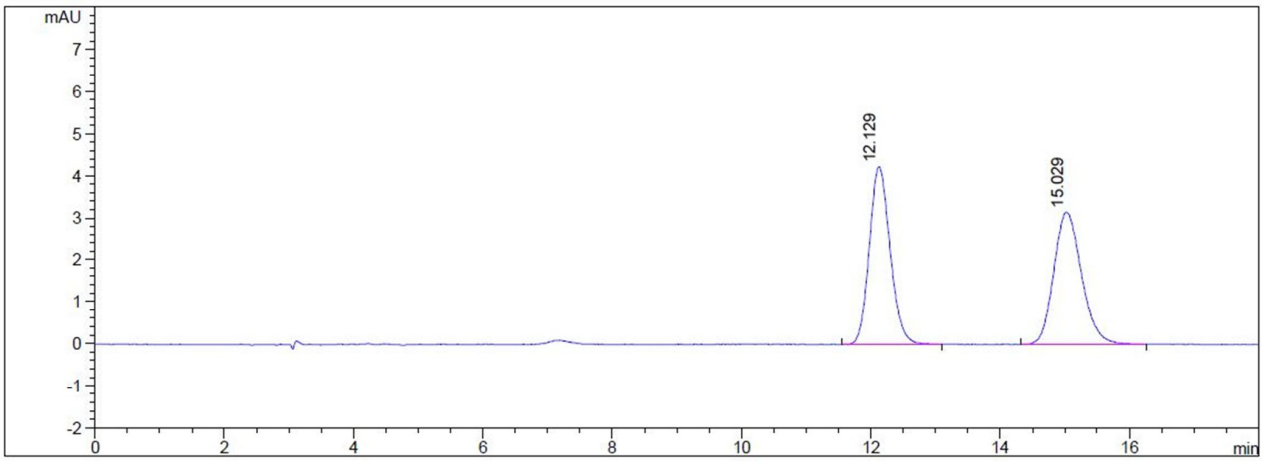
Product 5p



OD-H; Hexane : *i*PrOH = 95:5

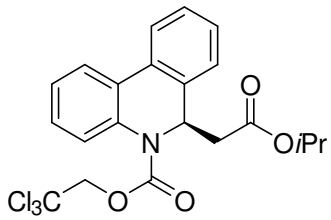


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	12.094	61.883	84.469	1415.296	80.249
2	15.039	11.378	15.531	348.337	19.751

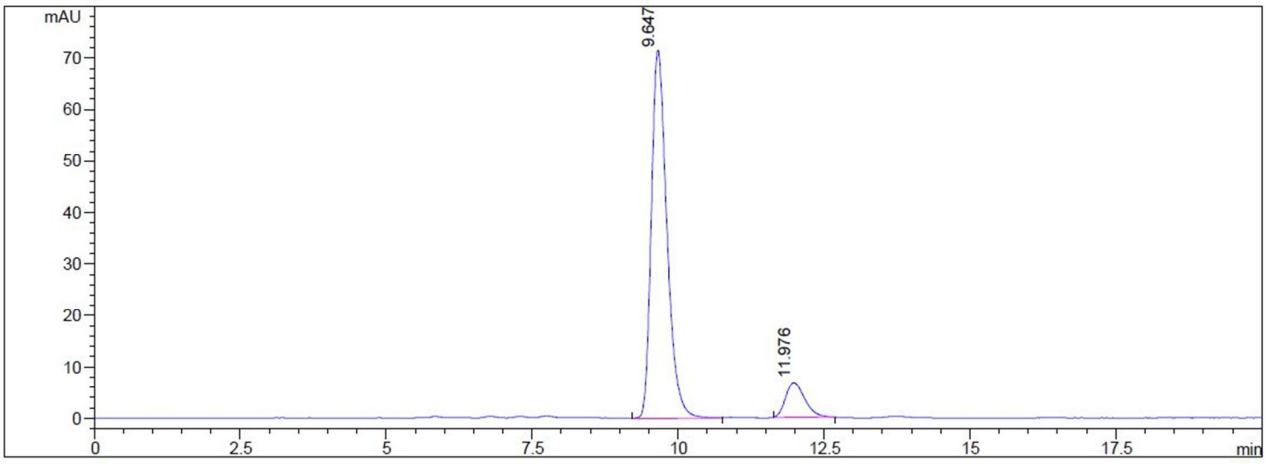


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	12.129	4.237	57.169	95.436	50.044
2	15.029	3.174	42.831	95.266	49.956

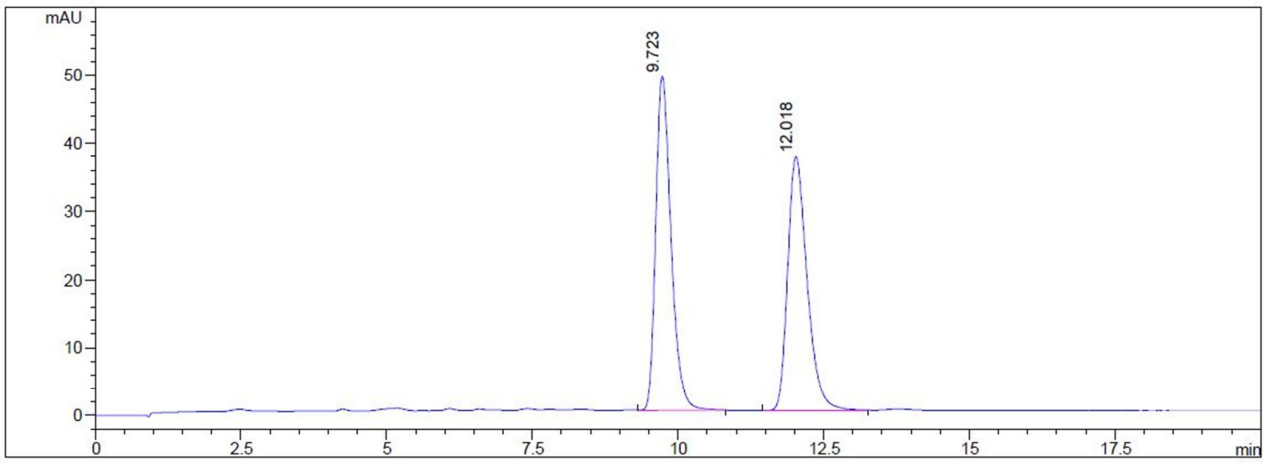
Product 5q



AD-H; Hexane : *i*PrOH = 90:10

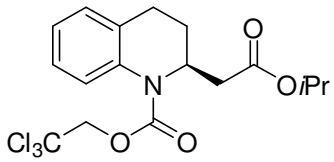


#	Meas. Ret. Time	Height	Height %	Area	Area %
1	9.647	71.630	91.389	1332.763	89.704
2	11.976	6.750	8.611	152.979	10.296



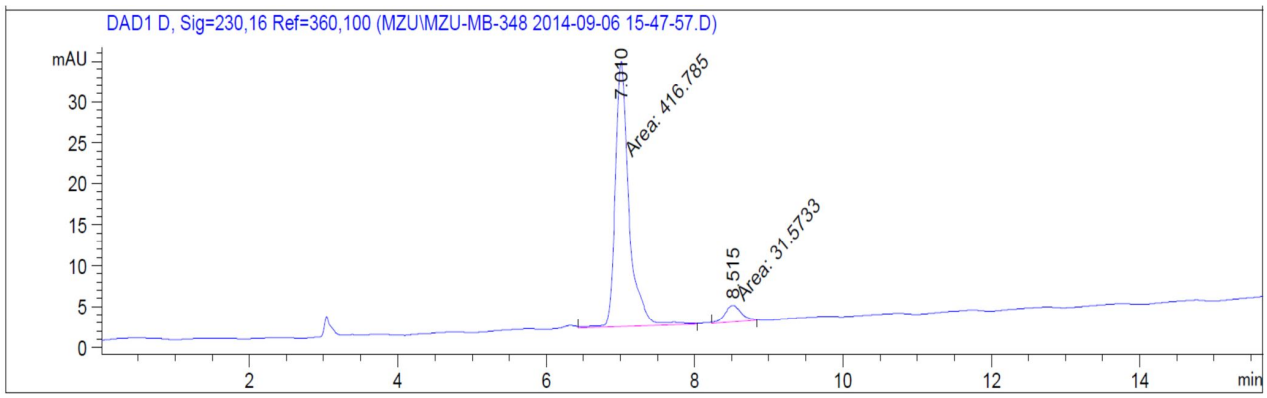
#	Meas. Ret. Time	Height	Height %	Area	Area %
1	9.723	49.049	56.848	894.805	50.869
2	12.018	37.233	43.152	864.226	49.131

Product 26



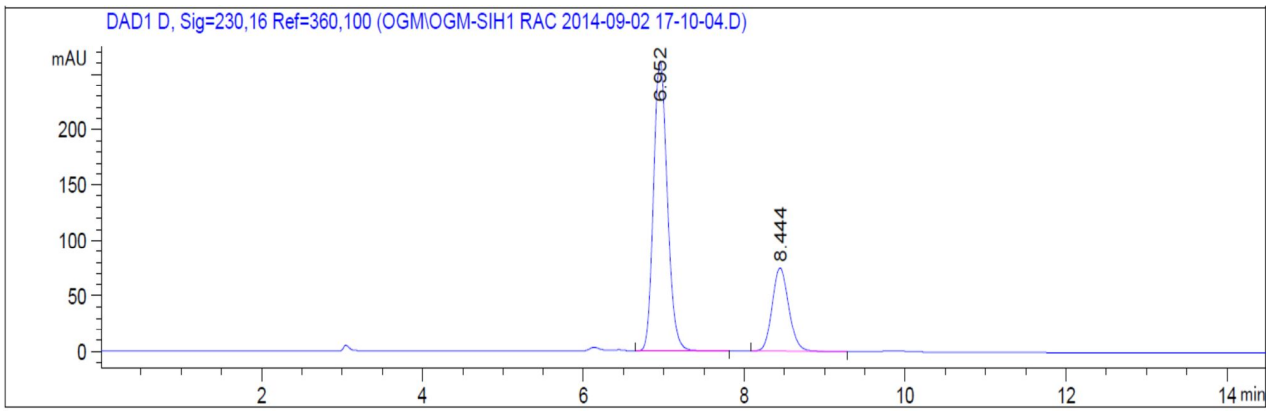
OD-H; Heptane : *i*PrOH = 95:5

Obtained from the reduction of a 93:7 e.r. sample of **5a**



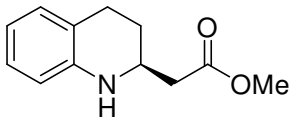
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.010	MM	0.2143	416.78482	32.41836	92.9580
2	8.515	MM	0.2561	31.57327	2.05485	7.0420

Obtained from the reduction of a 74:26 e.r. sample of **5a**

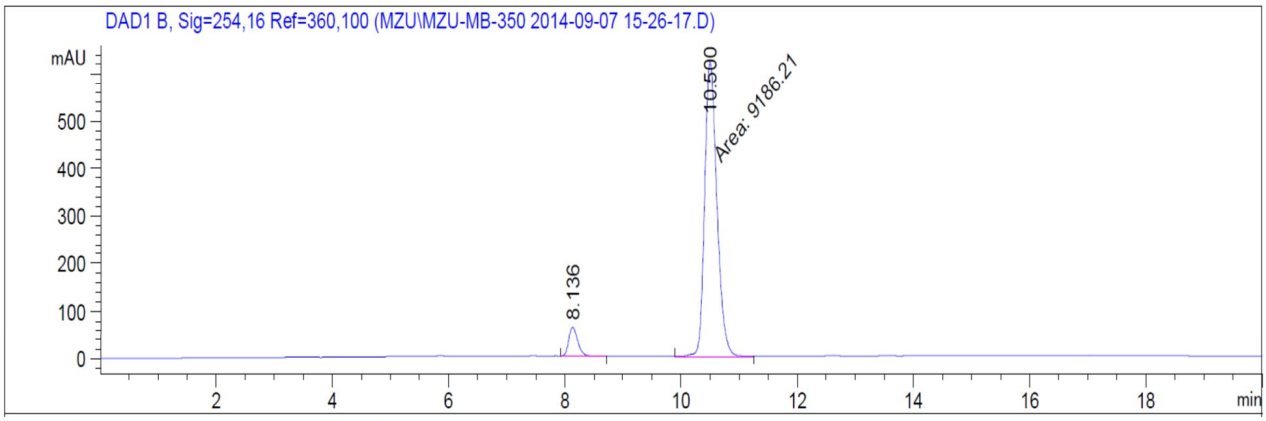


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.952	VB	0.1805	3058.32227	261.48410	73.8536
2	8.444	BB	0.2246	1082.74023	74.92842	26.1464

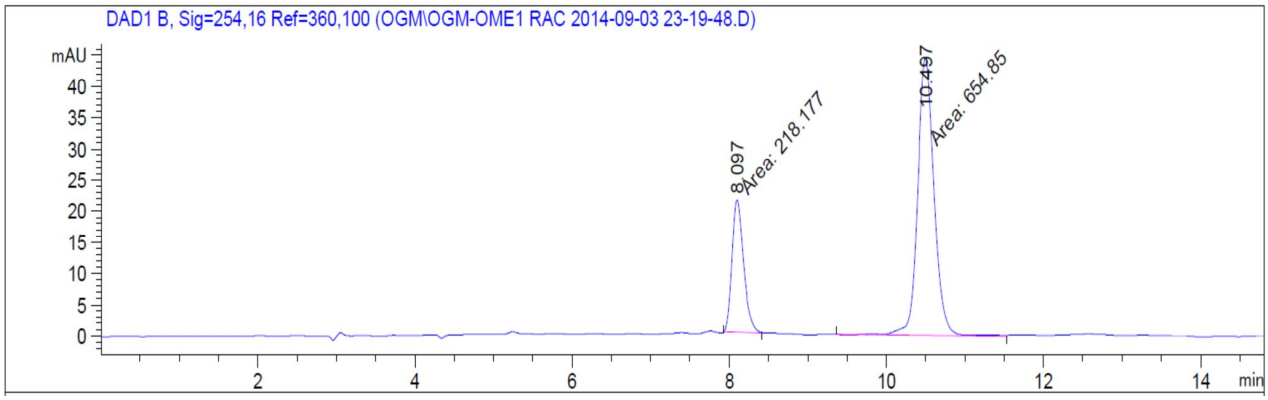
Product 28



OD-H; Heptane : *i*PrOH = 90:10

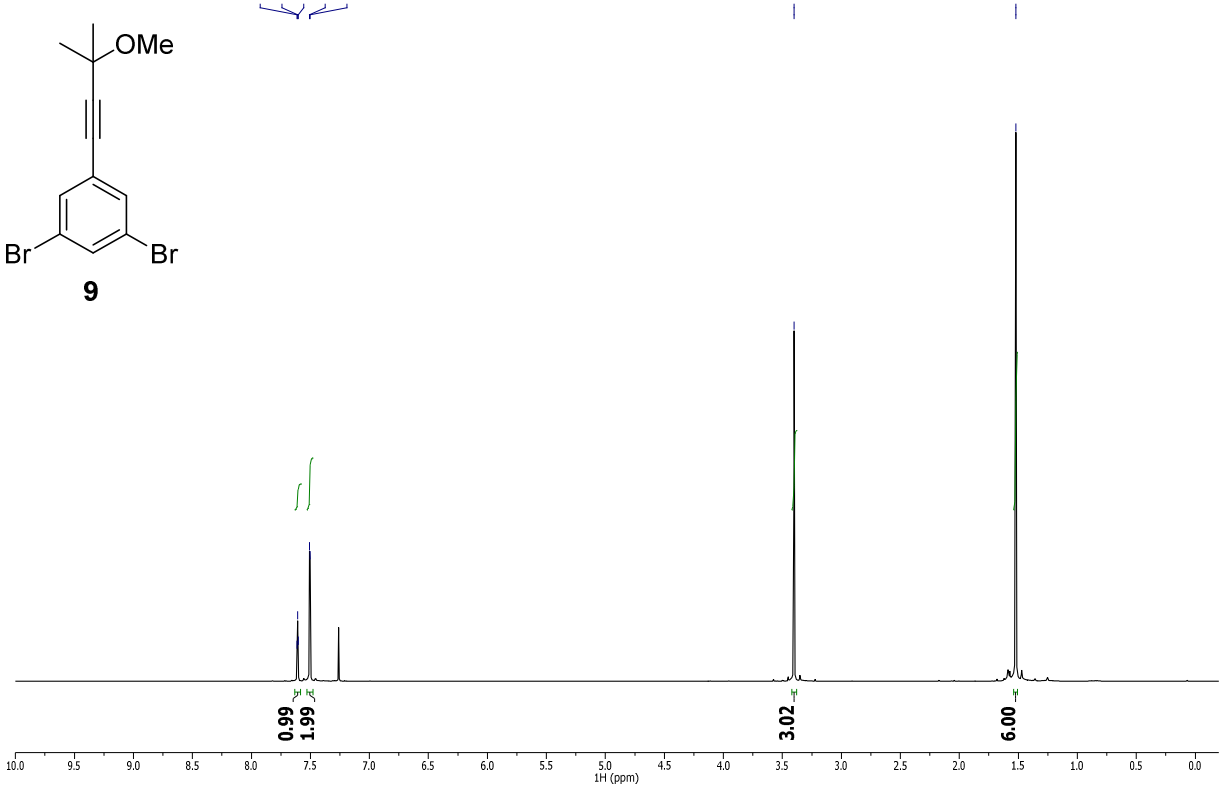


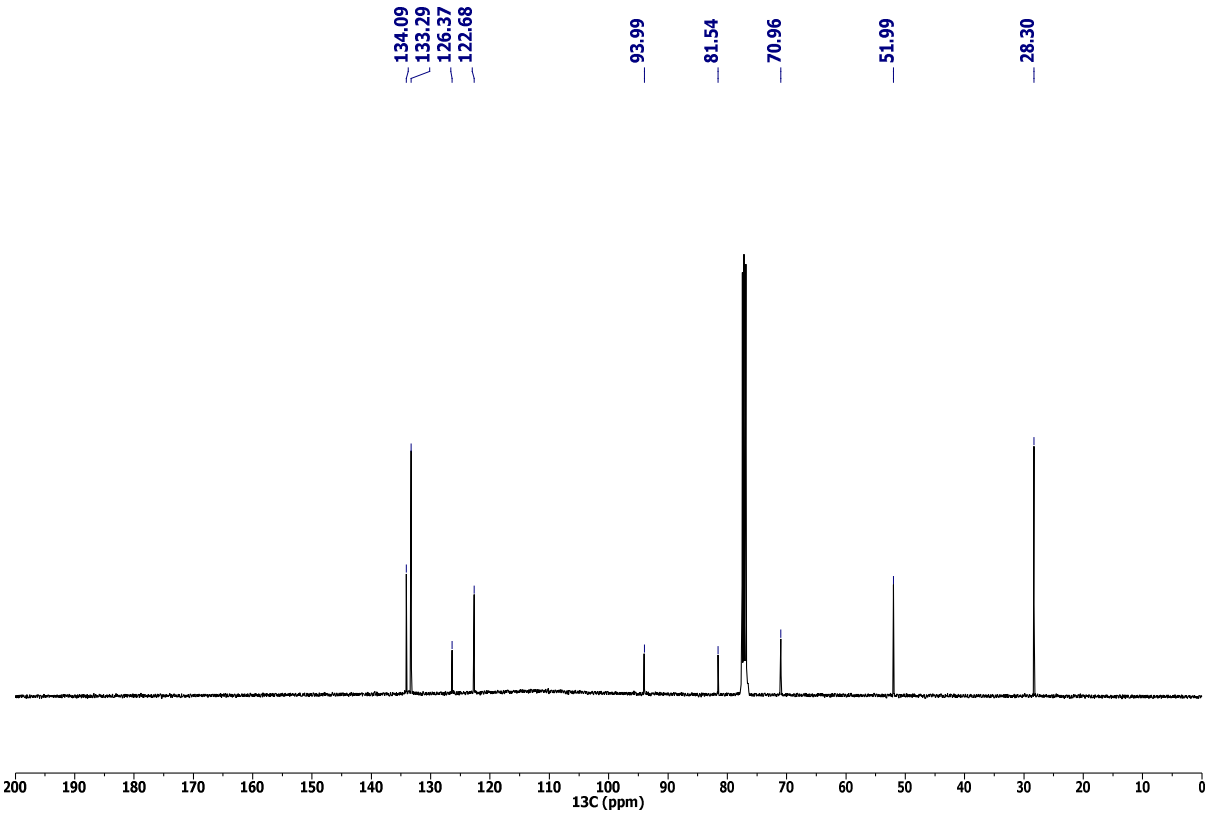
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.136	BB	0.1604	660.57416	62.94176	6.7085
2	10.500	MM	0.2454	9186.21094	623.78021	93.2915

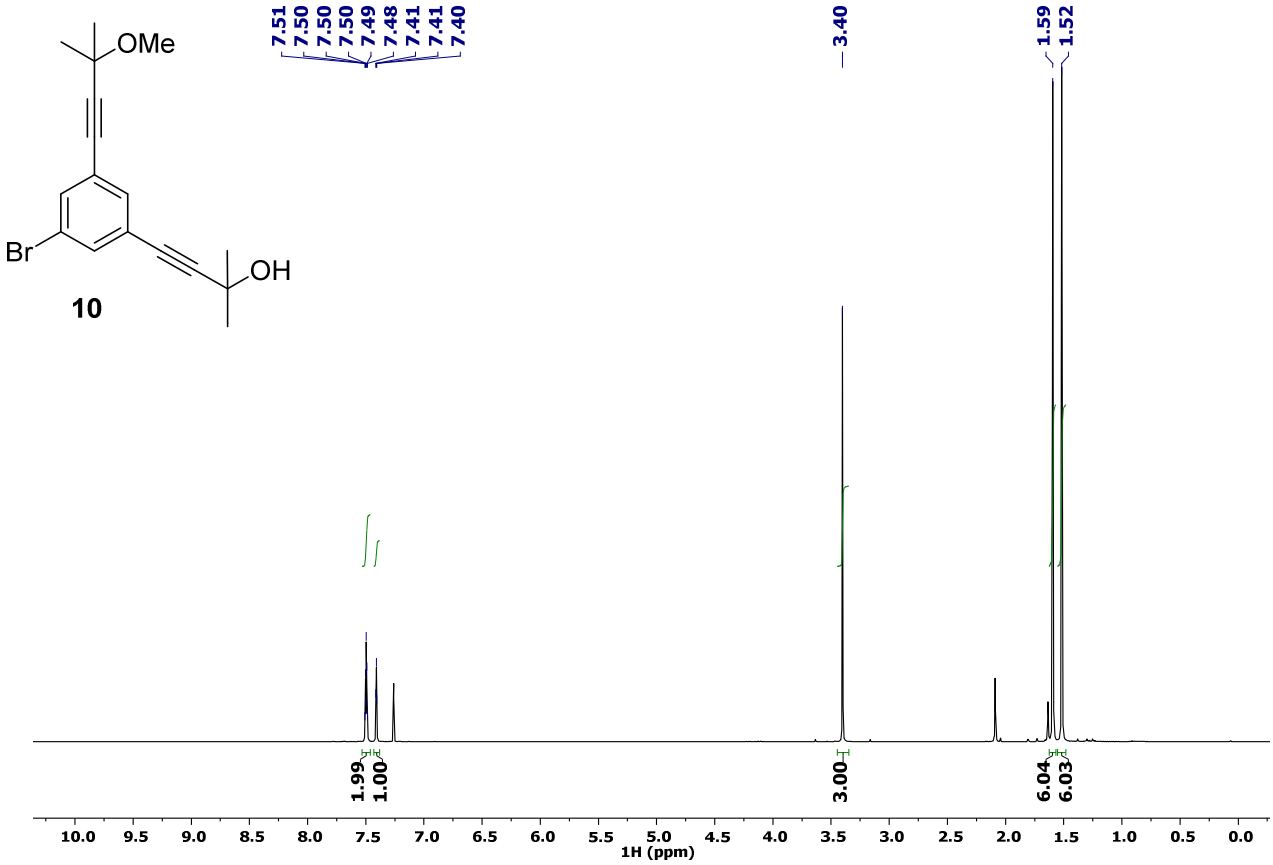


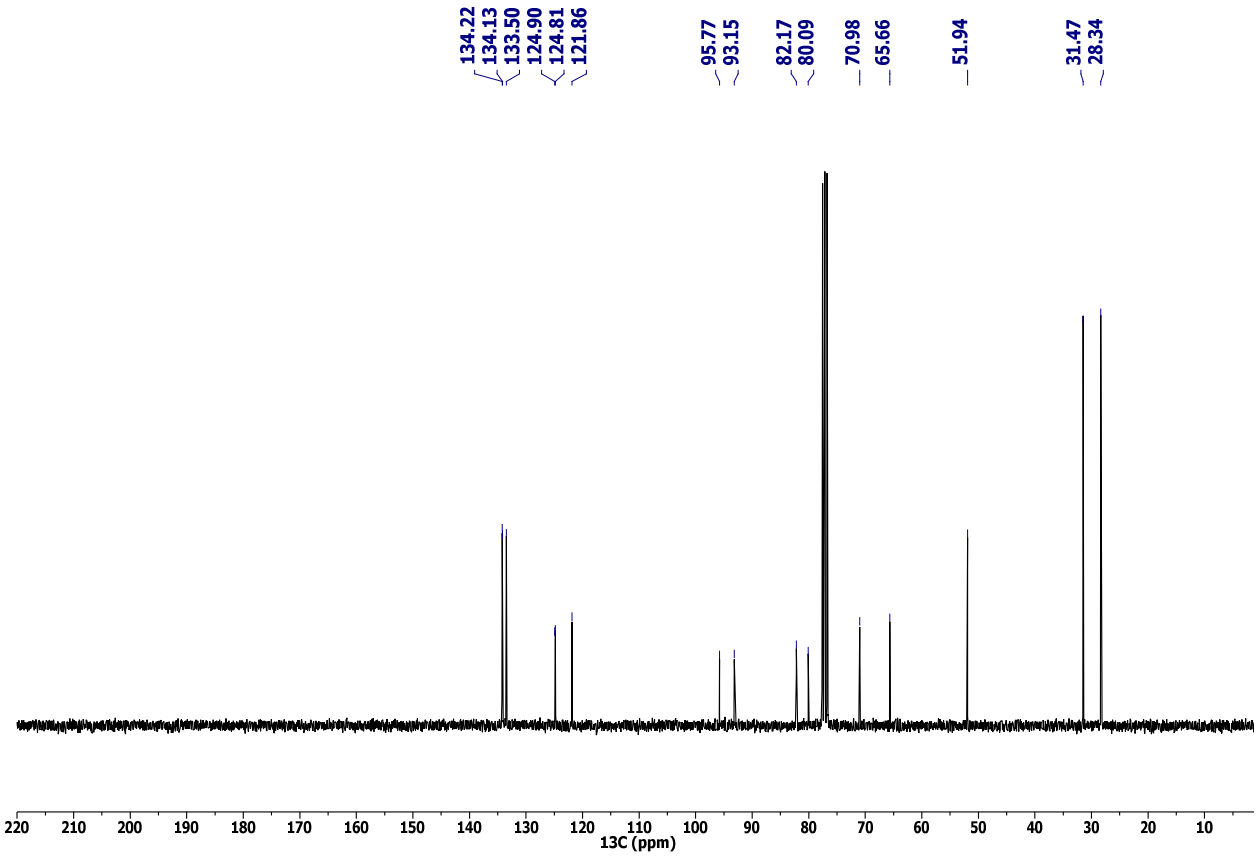
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.097	MM	0.1709	218.17741	21.28272	24.9909
2	10.497	MM	0.2447	654.84979	44.60128	75.0091

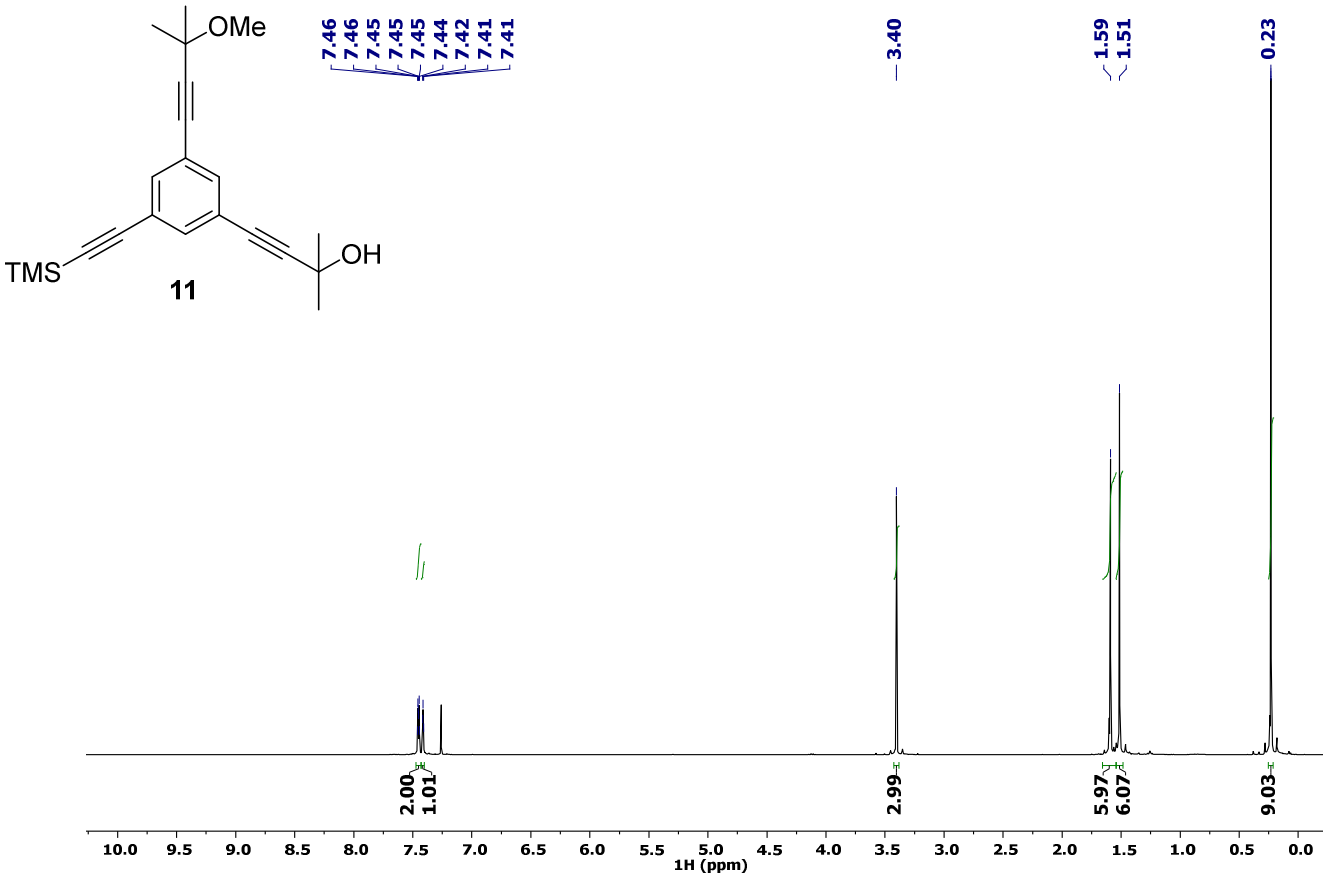
NMR-spectra

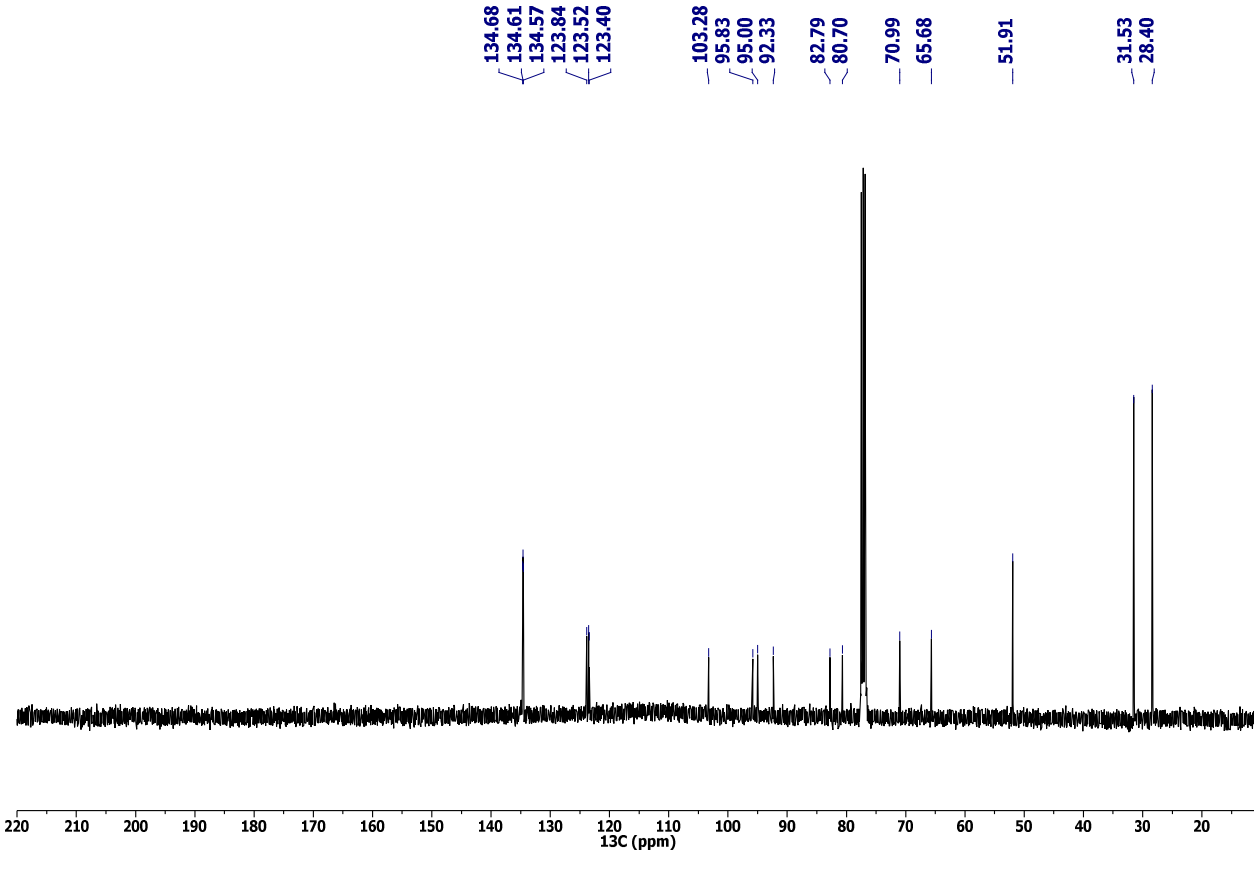

7.61
7.61
7.60
7.51
7.50
3.40
1.52
OMe
Br
Br
9
0.99
1.99
3.02
6.00
1H (ppm)

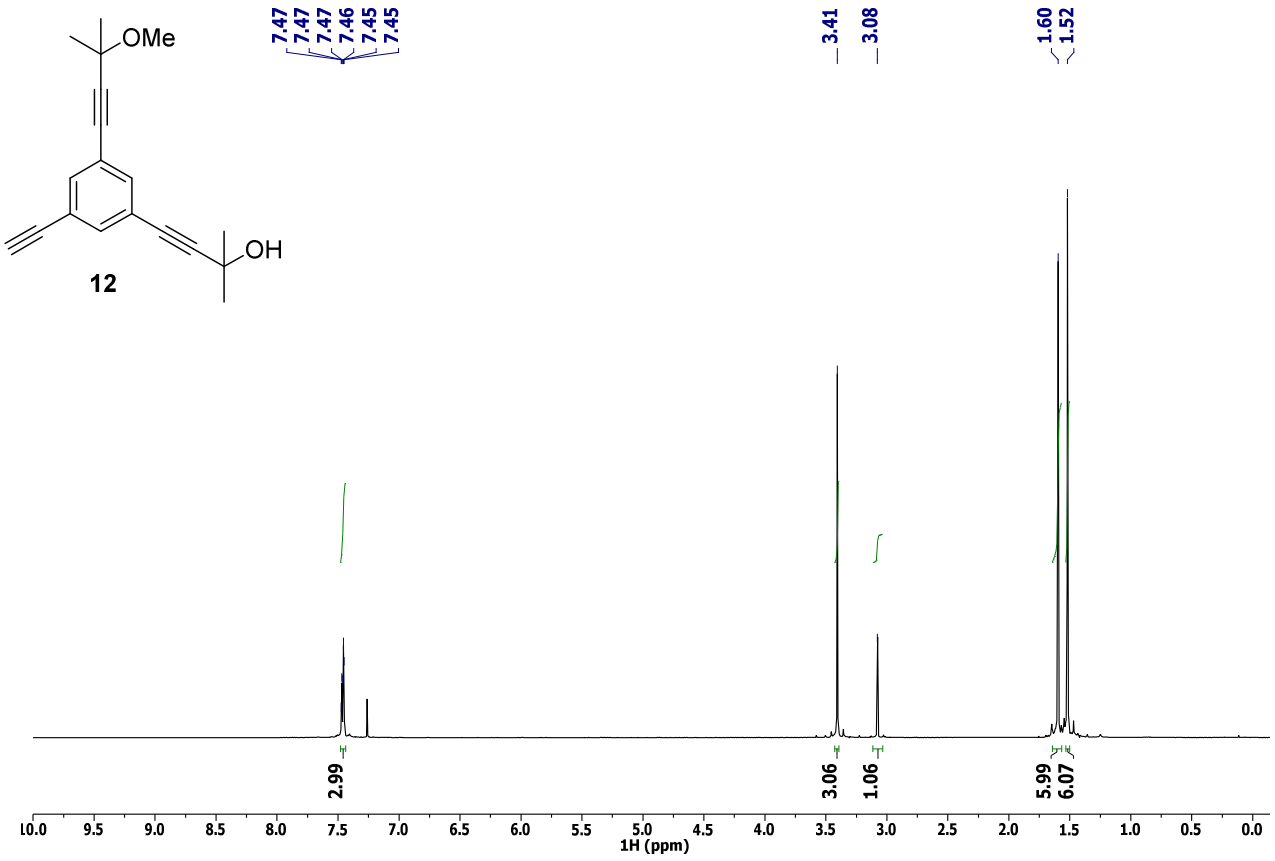

134.09
133.29
126.37
122.68
93.99
81.54
70.96
51.99
28.30
13C (ppm)

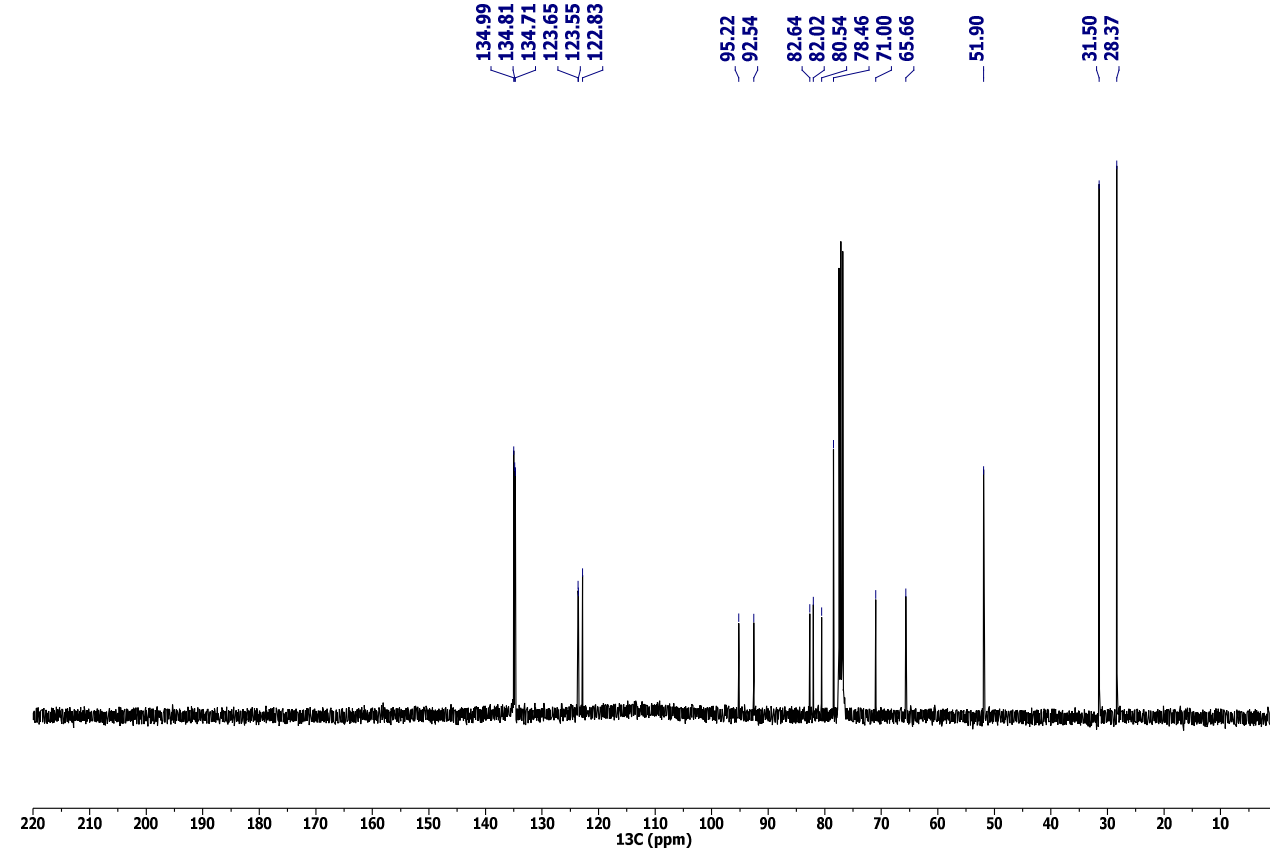

OMe
Br
OH
10
7.51
7.50
7.50
7.50
7.49
7.48
7.41
7.41
7.40
3.40
1.59
1.52
1.99
1.00
3.00
6.04
6.03
1H (ppm)

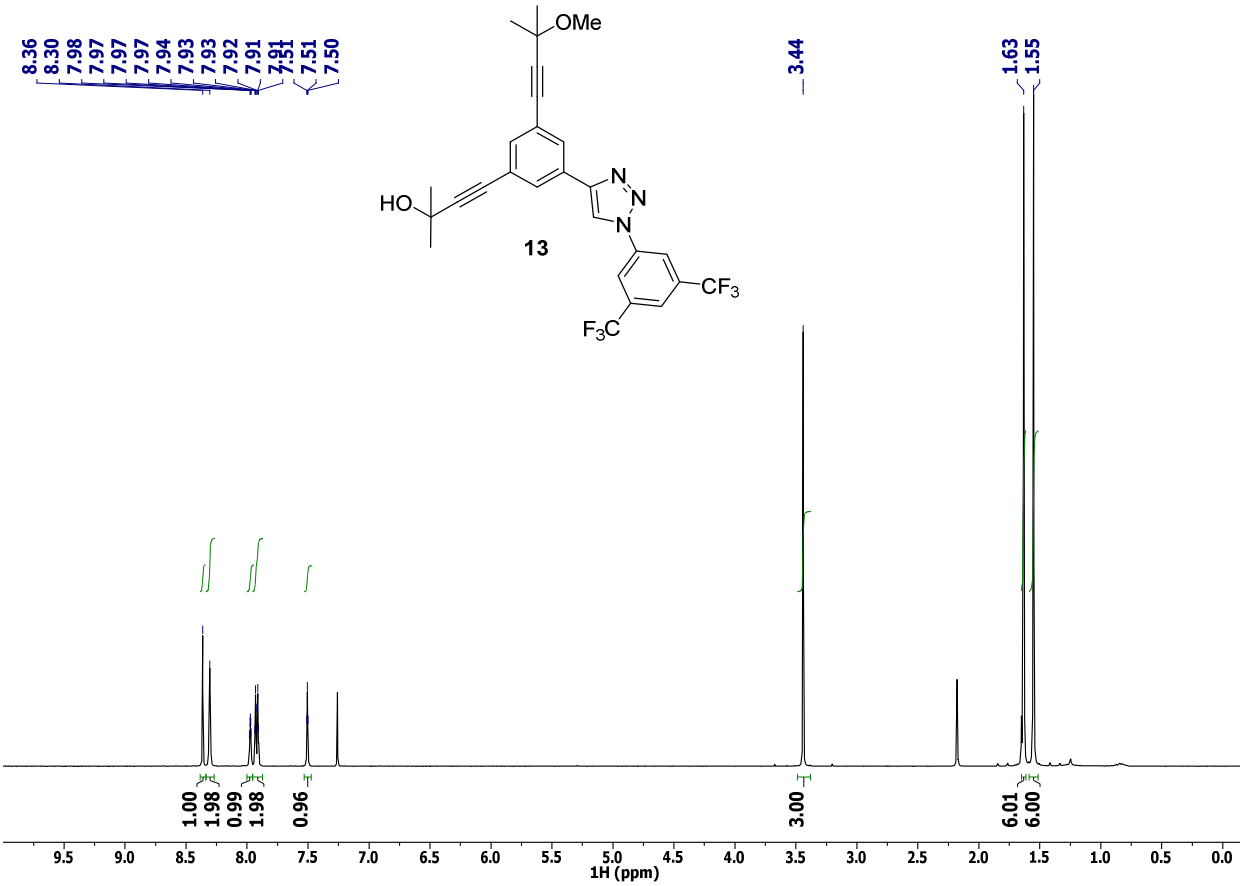

134.22
134.13
133.50
124.90
124.81
121.86
95.77
93.15
82.17
80.09
70.98
65.66
51.94
31.47
28.34
13C (ppm)

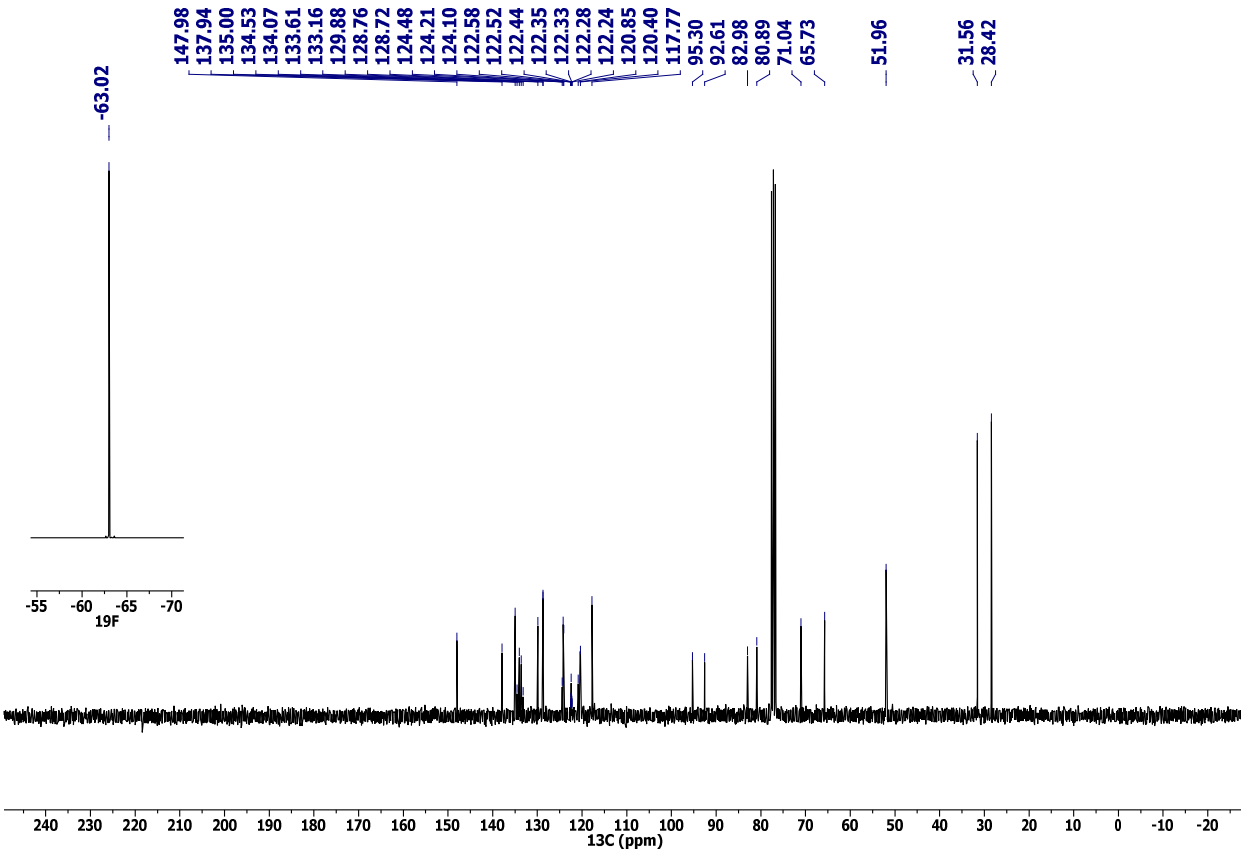

OMe
TMS
OH
11
7.46
7.46
7.45
7.45
7.45
7.44
7.42
7.41
7.41
3.40
1.59
1.51
0.23
2.00
1.01
2.99
5.97
6.07
9.03
1H (ppm)

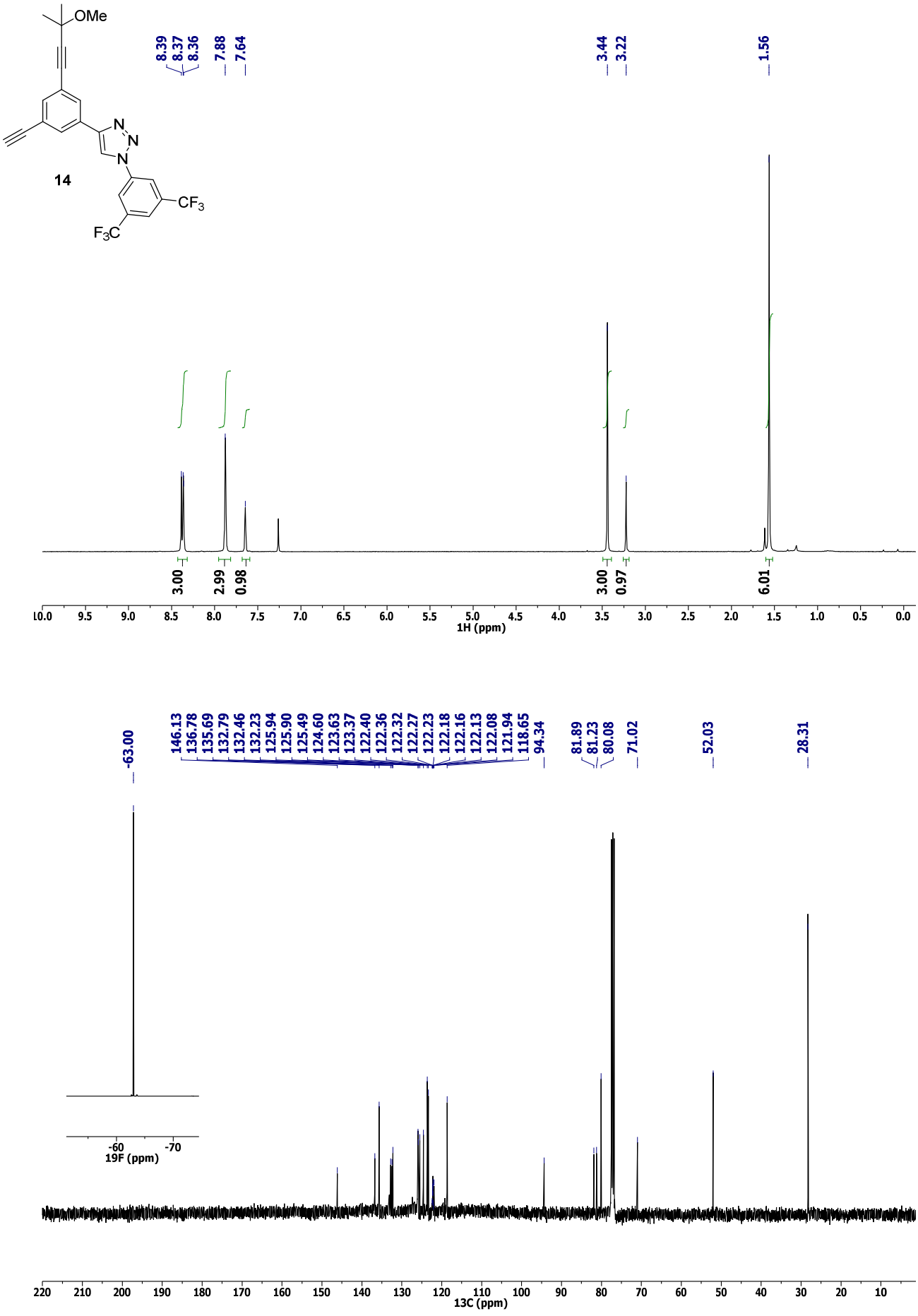

134.68
134.61
134.57
123.84
123.52
123.40
103.28
95.83
95.00
92.33
82.79
80.70
70.99
65.68
51.91
31.53
28.40
13C (ppm)

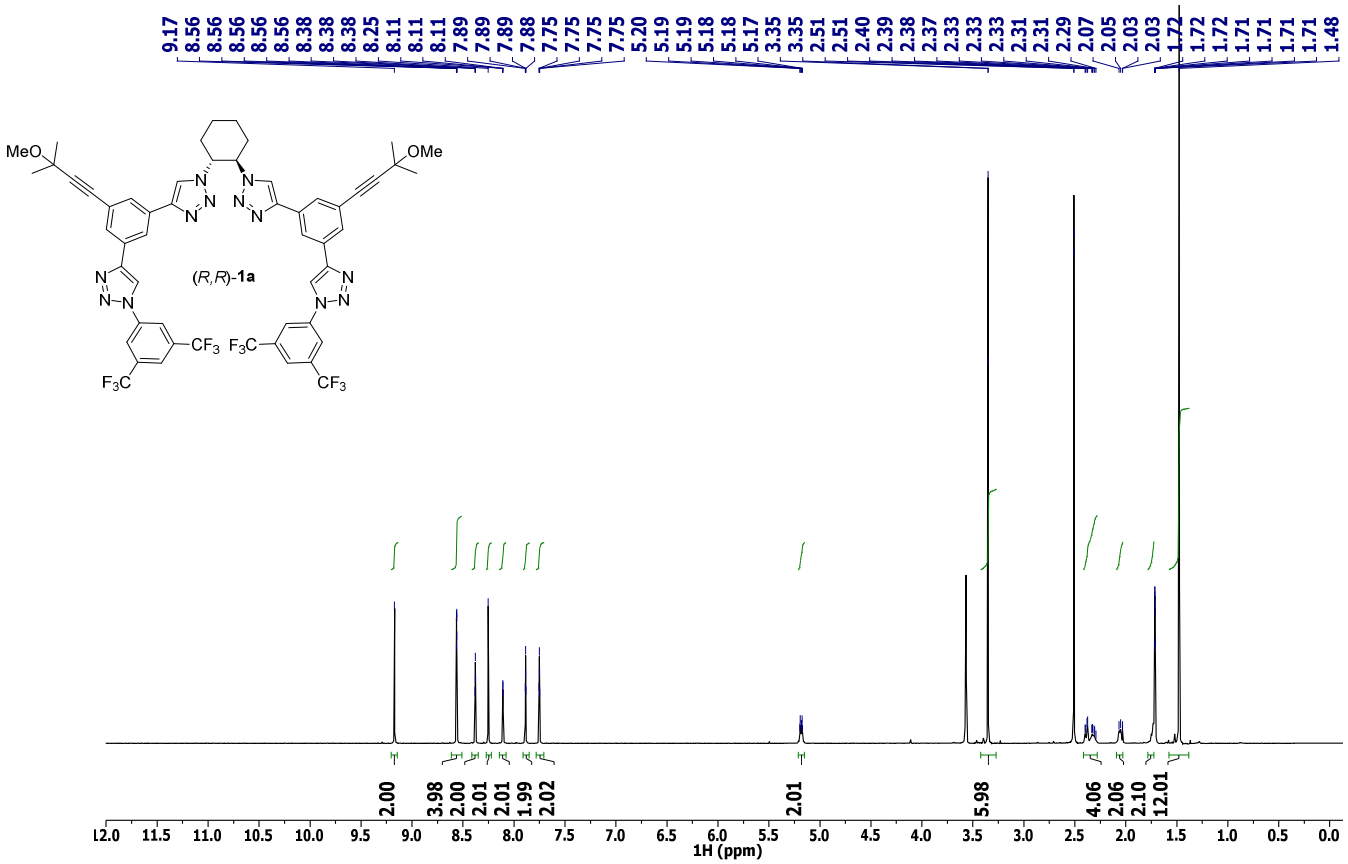

OMe
OH
12
7.47
7.47
7.47
7.46
7.45
7.45
3.41
3.08
1.60
1.52
2.99
3.06
1.06
5.99
6.07
1H (ppm)

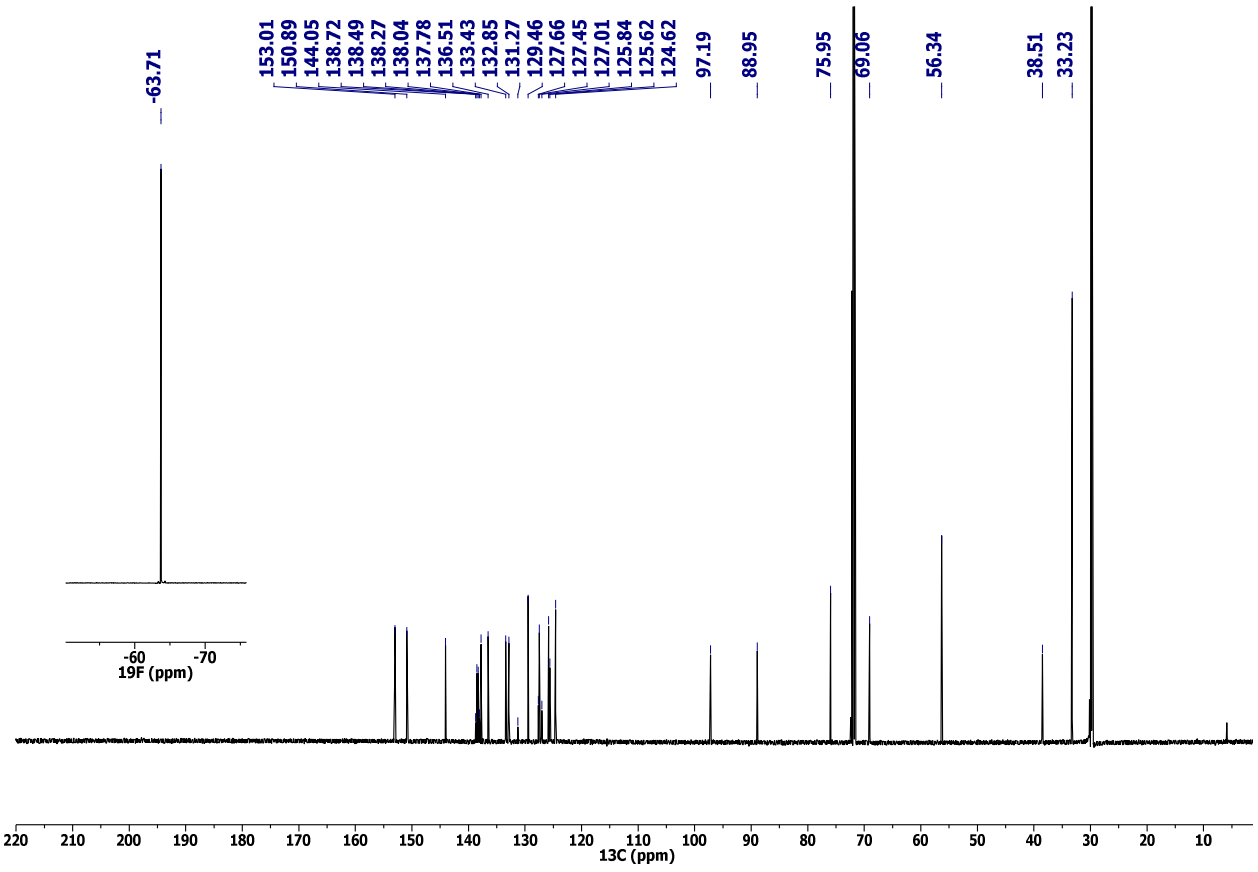

134.99
134.81
134.71
123.65
123.55
122.83
95.22
92.54
82.64
82.02
80.54
78.46
71.00
65.66
51.90
31.50
28.37
13C (ppm)

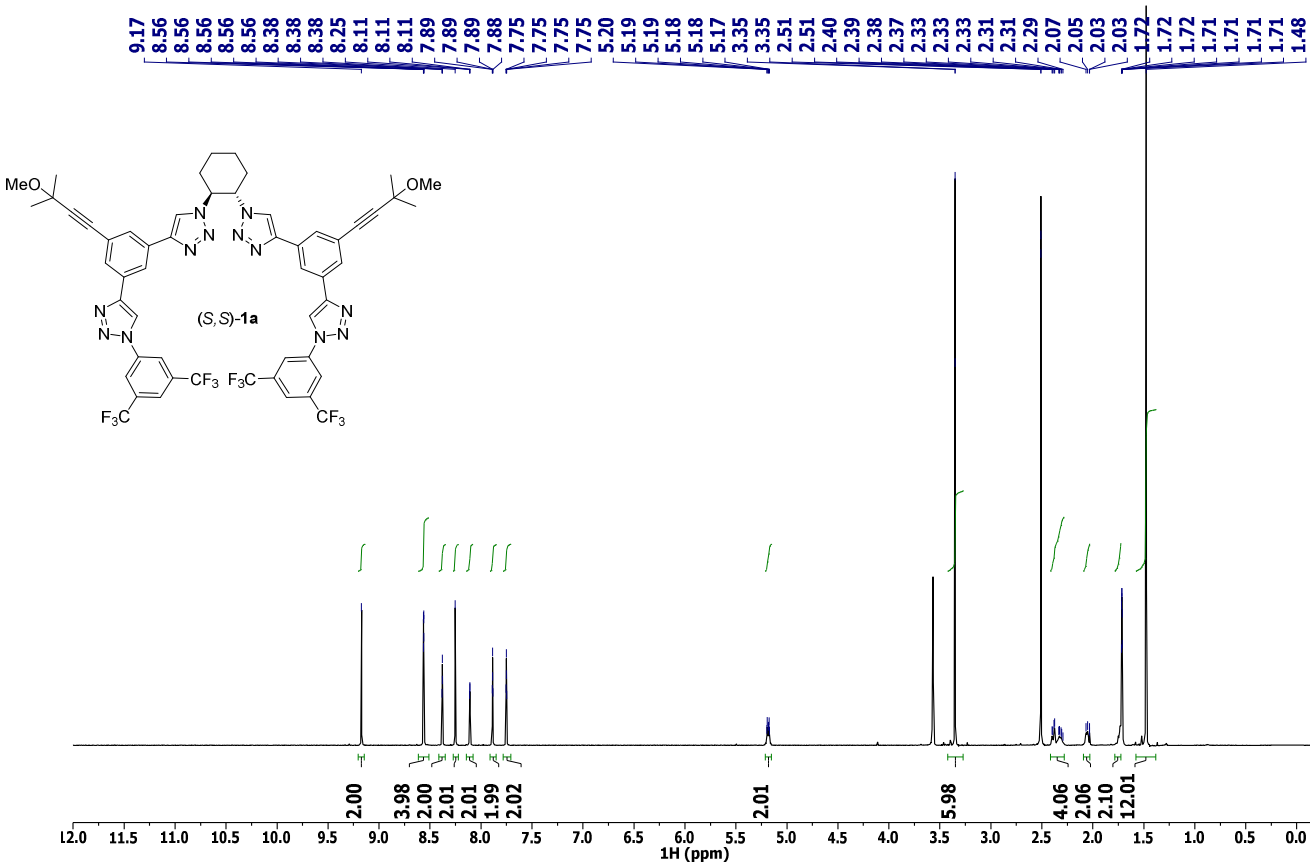

8.36
8.30
7.98
7.97
7.97
7.97
7.94
7.93
7.93
7.92
7.91
7.51
7.50
3.44
1.63
1.55
OMe
HO
N
N
N
CF3
F3C
13
1.00
1.98
0.99
1.98
0.96
3.00
6.01
6.00
1H (ppm)

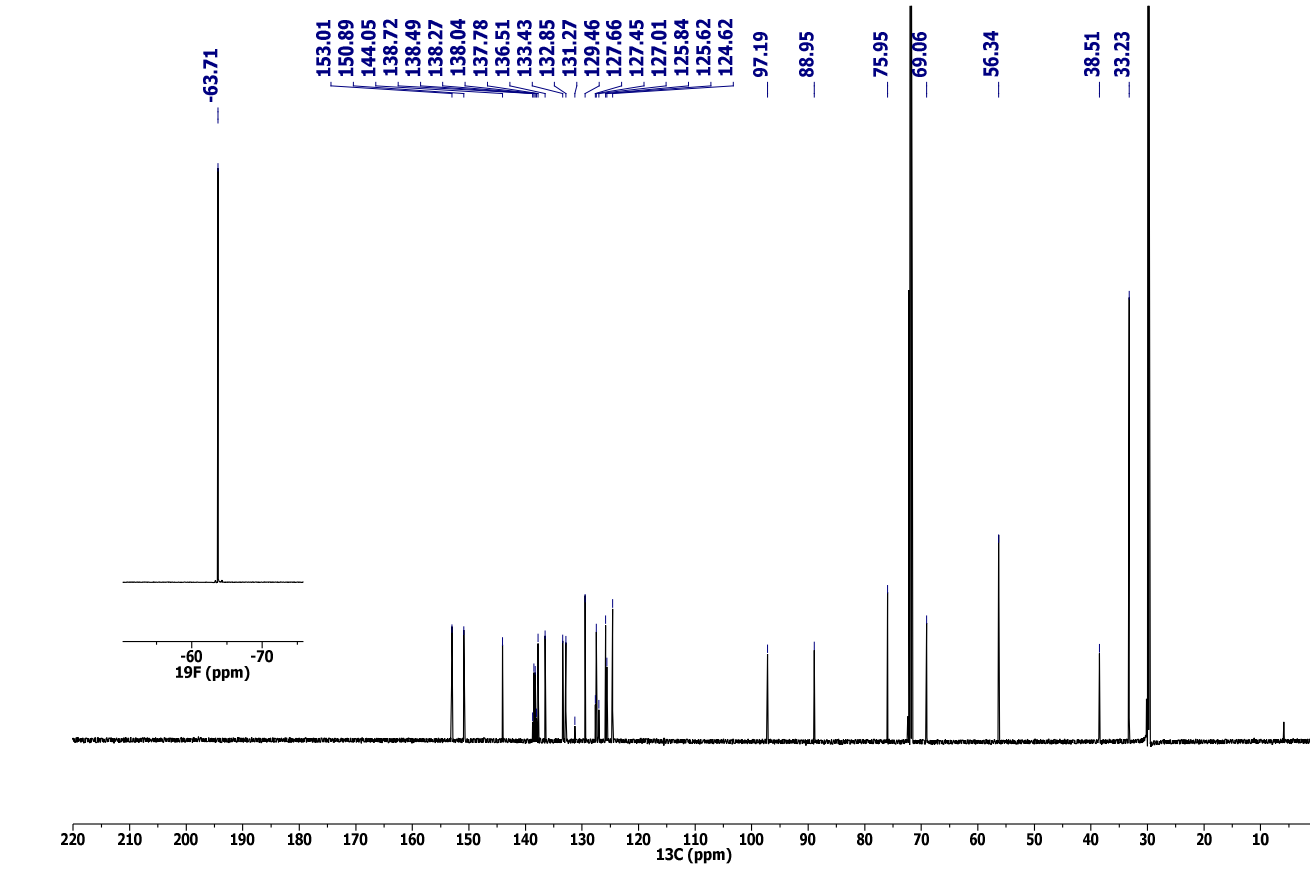

147.98
137.94
135.00
134.53
134.07
133.61
133.16
129.88
128.76
128.72
124.48
124.21
124.10
122.58
122.52
122.44
122.35
122.33
122.28
122.24
120.85
120.40
117.77
95.30
92.61
82.98
80.89
71.04
65.73
51.96
31.56
28.42
-63.02
19F
13C (ppm)

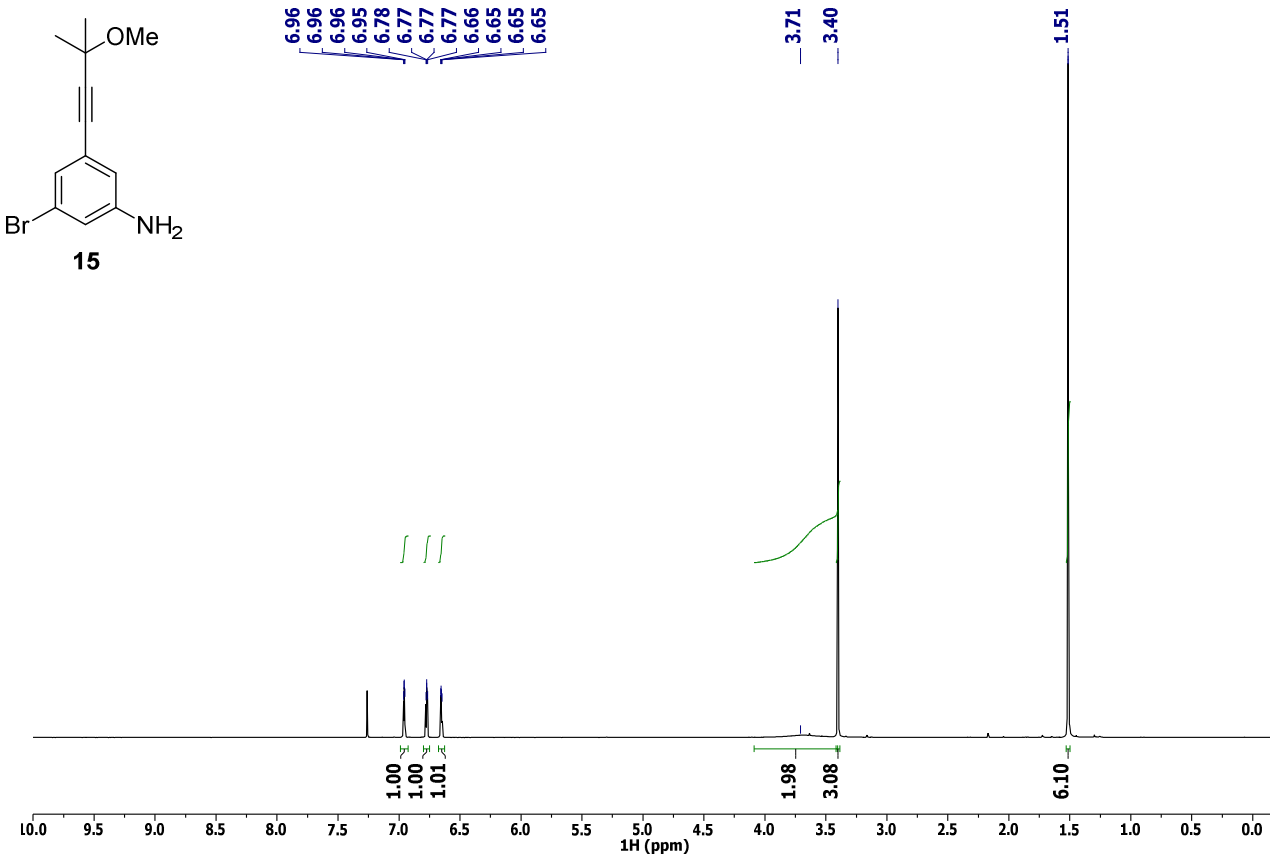

OMe
N
N
N
14
CF3
F3C
8.39
8.37
8.36
7.88
7.64
3.44
3.22
1.56
3.00
2.99
0.98
3.00
0.97
6.01
1H (ppm)
-63.00
146.13
136.78
135.69
132.79
132.46
132.23
125.94
125.90
125.49
124.60
123.63
123.37
122.40
122.36
122.32
122.27
122.23
122.18
122.16
122.13
122.08
121.94
118.65
94.34
81.89
81.23
80.08
71.02
52.03
28.31
-60
-70
19F (ppm)
13C (ppm)

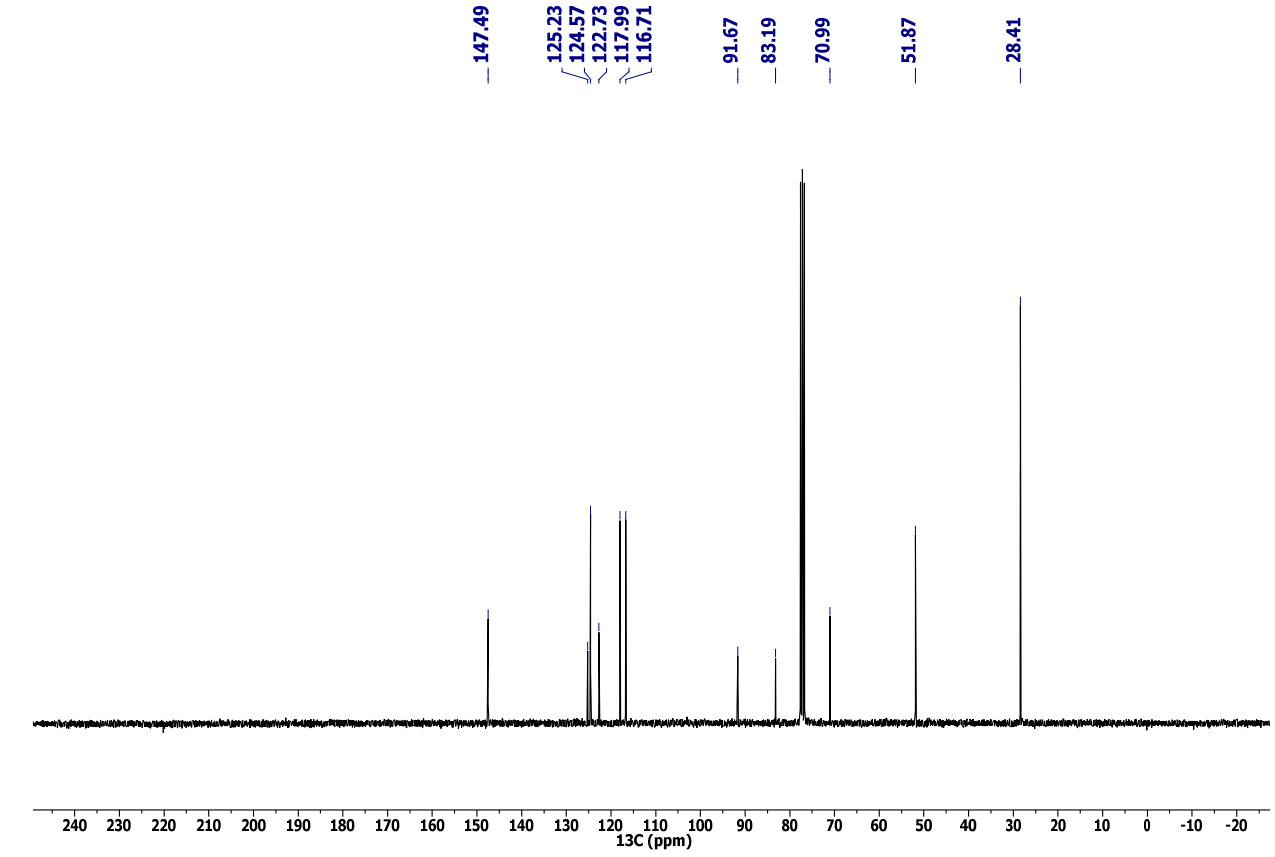

MeO
OMe
(R,R)-1a
CF3
F3C
F3C
CF3
1H (ppm)

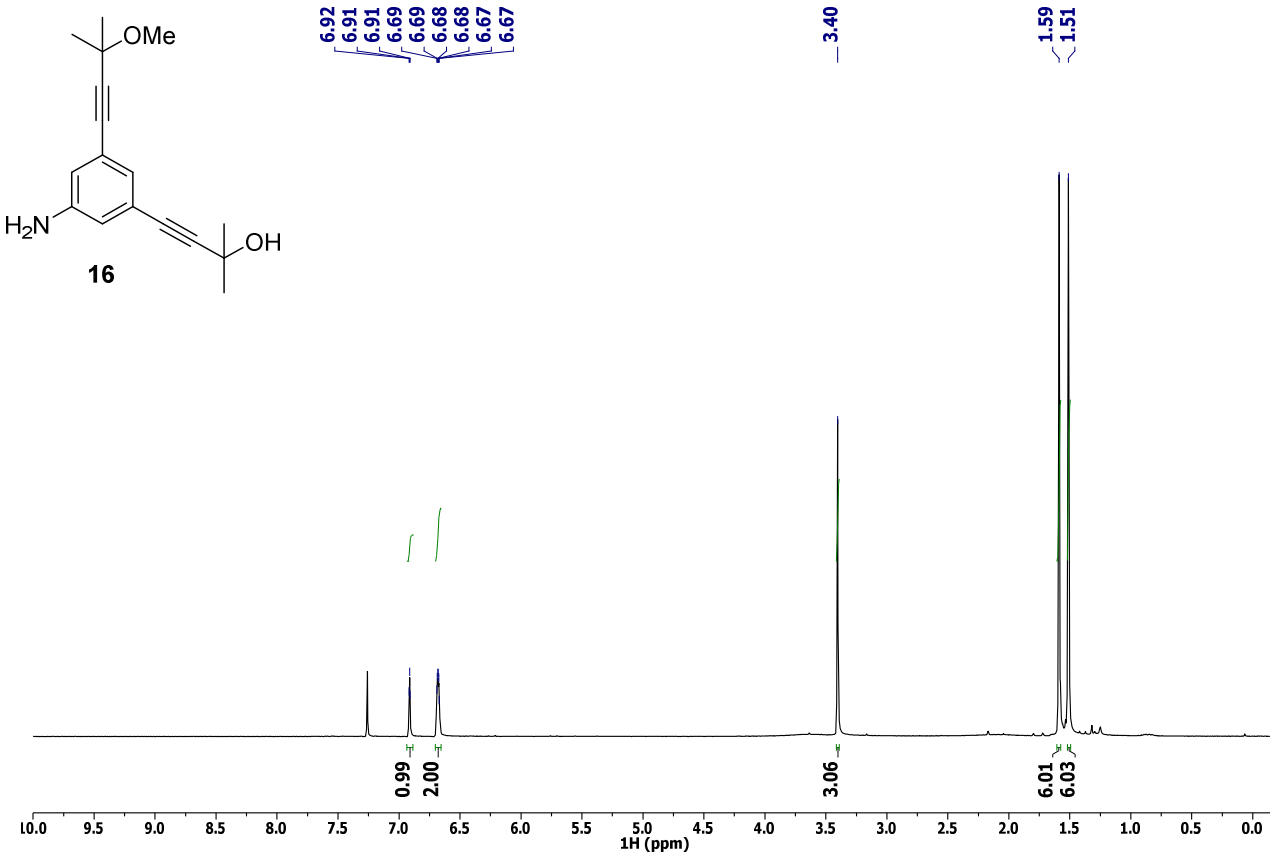

-63.71
19F (ppm)
13C (ppm)

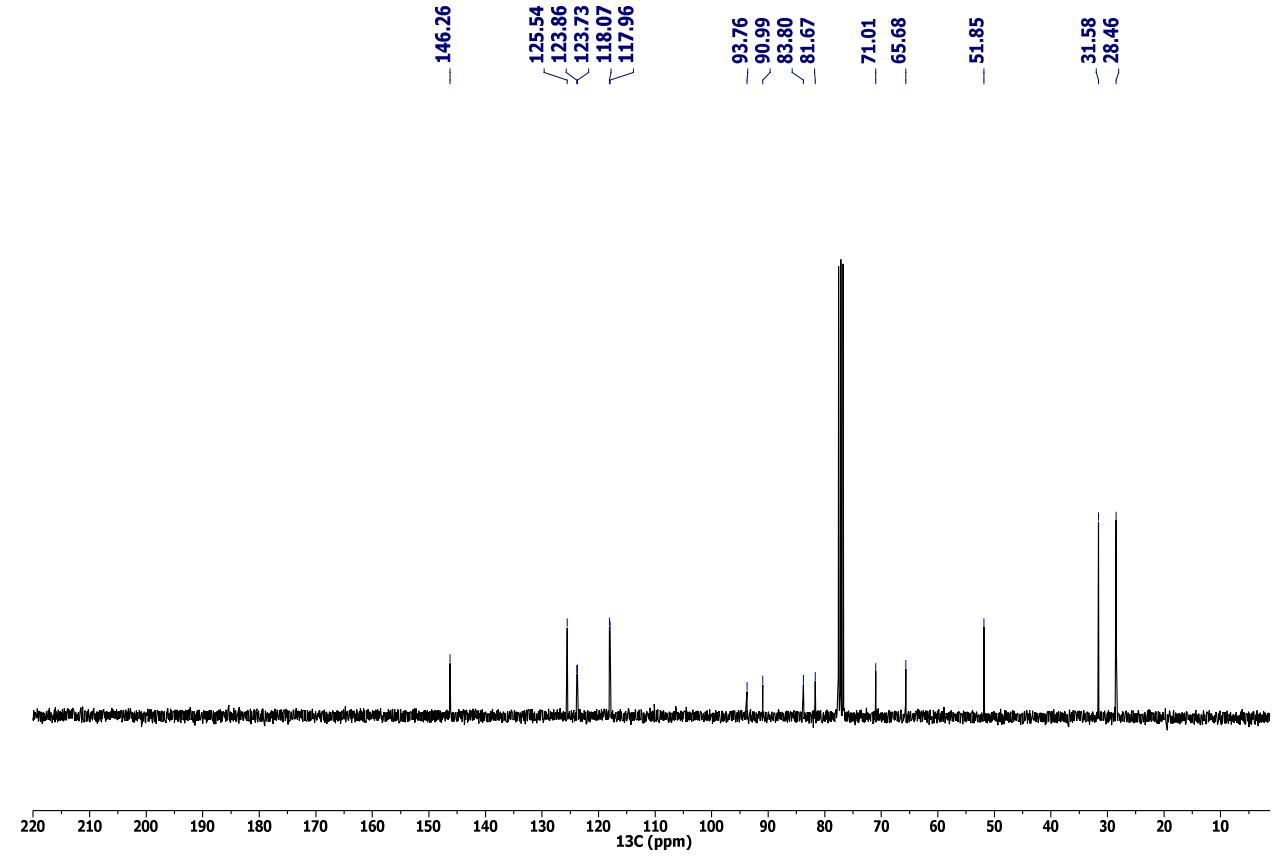

9.17 8.56 8.56 8.56 8.56 8.38 8.38 8.38 8.25 8.11 8.11 8.11 7.89 7.89 7.89 7.88 7.75 7.75 7.75 7.75 5.20 5.19 5.19 5.18 5.17 3.35 3.35 2.51 2.51 2.40 2.39 2.38 2.37 2.33 2.33 2.31 2.31 2.29 2.07 2.05 2.03 2.03 1.72 1.72 1.72 1.71 1.71 1.71 1.71 1.48
MeO
OMe
(S,S)-1a
CF3
F3C
F3C
CF3
2.00 3.98 2.00 2.01 2.01 1.99 2.02 2.01 5.98 4.06 2.06 2.10 12.01
12.0 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
1H (ppm)

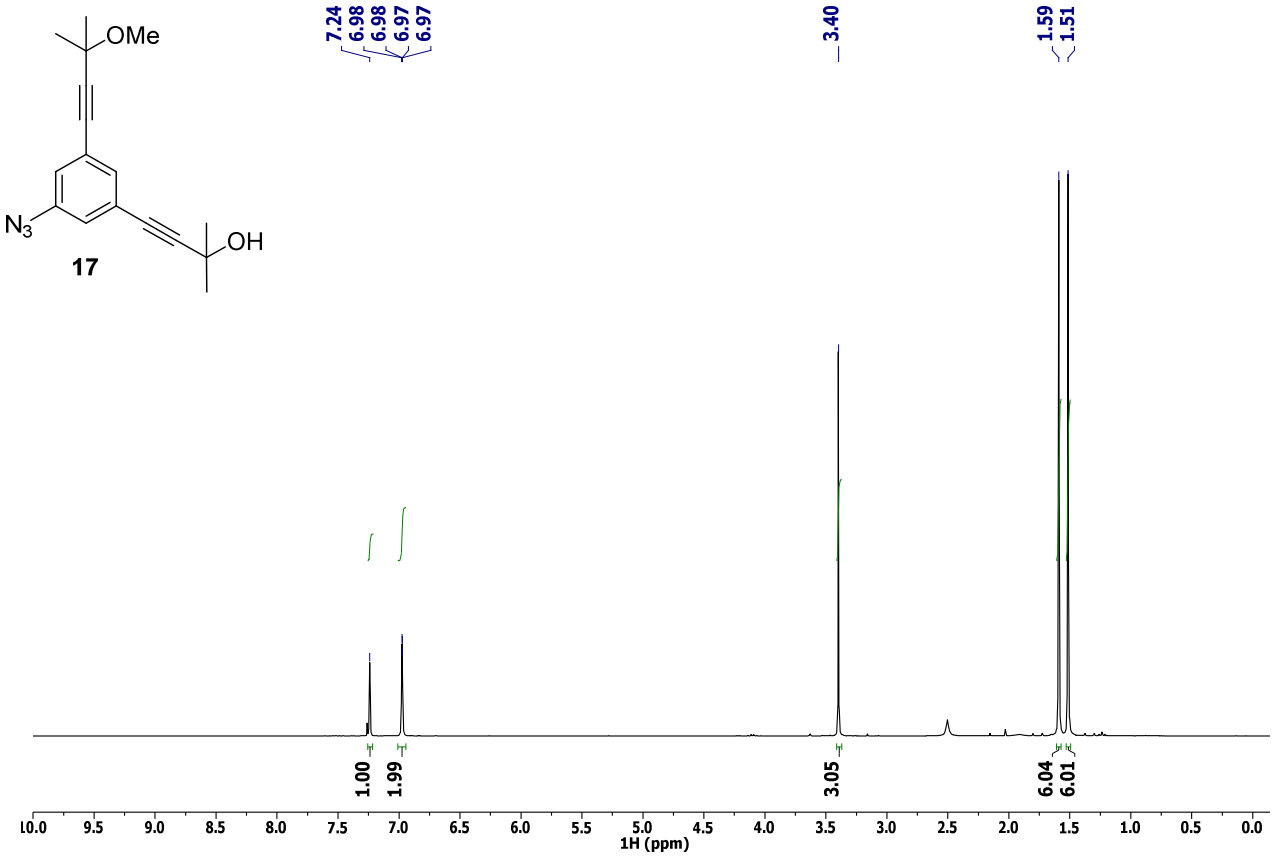

-63.71
153.01 150.89 144.05 138.72 138.49 138.27 138.04 137.78 136.51 133.43 132.85 131.27 129.46 127.66 127.45 127.01 125.84 125.62 124.62
97.19 88.95 75.95 69.06 56.34 38.51 33.23
-60 -70
19F (ppm)
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
13C (ppm)

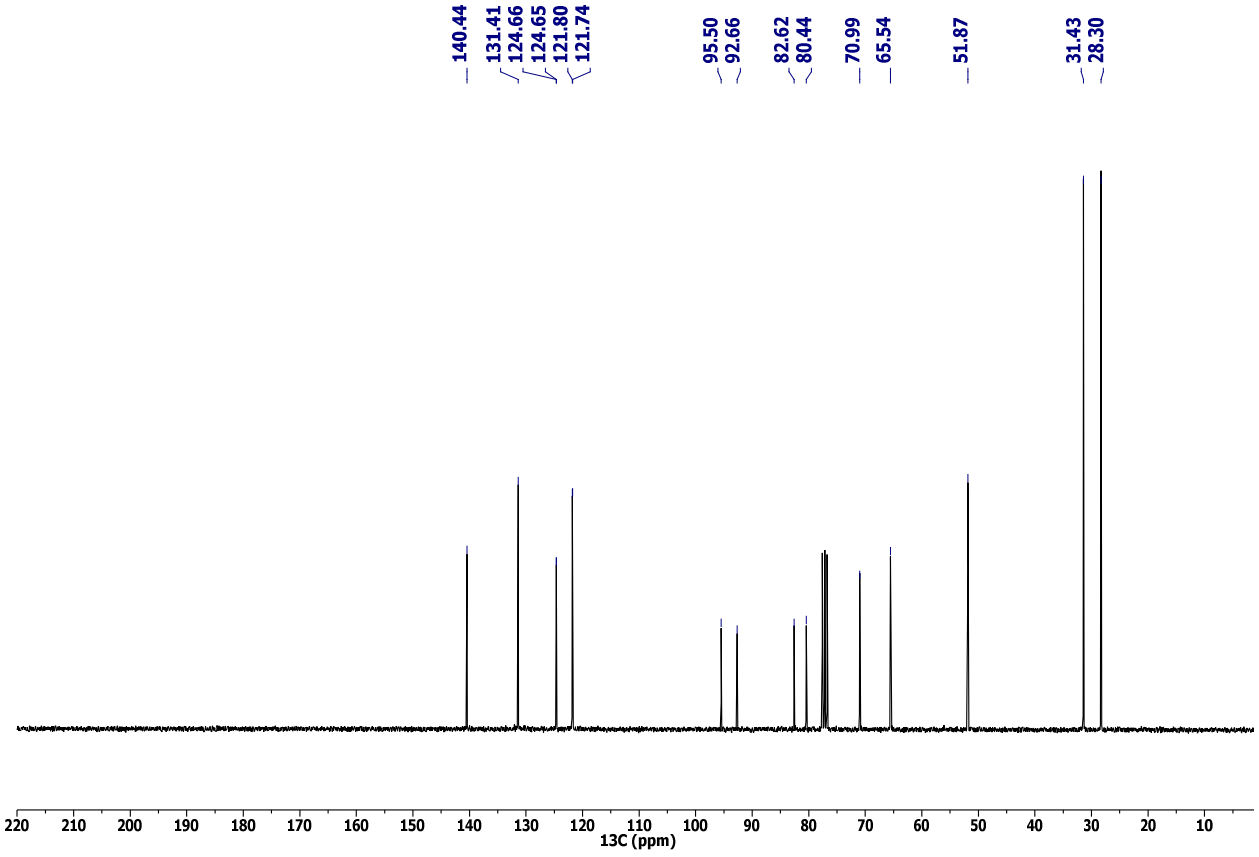

OMe
Br
NH2
15
6.96
6.96
6.96
6.95
6.78
6.77
6.77
6.77
6.66
6.65
6.65
6.65
3.71
3.40
1.51
1.00
1.00
1.01
1.98
3.08
6.10
1H (ppm)

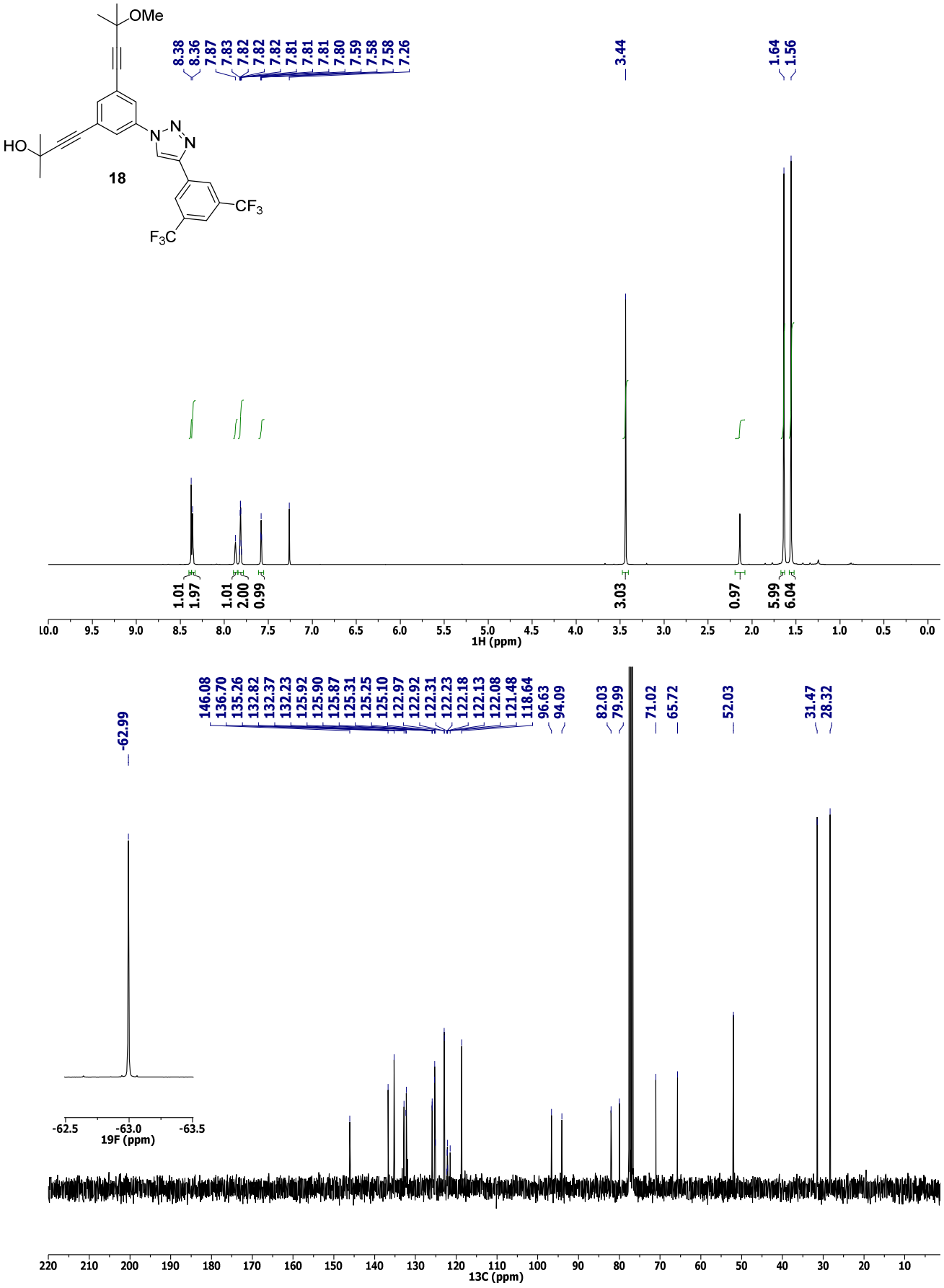

147.49
125.23
124.57
122.73
117.99
116.71
91.67
83.19
70.99
51.87
28.41
13C (ppm)

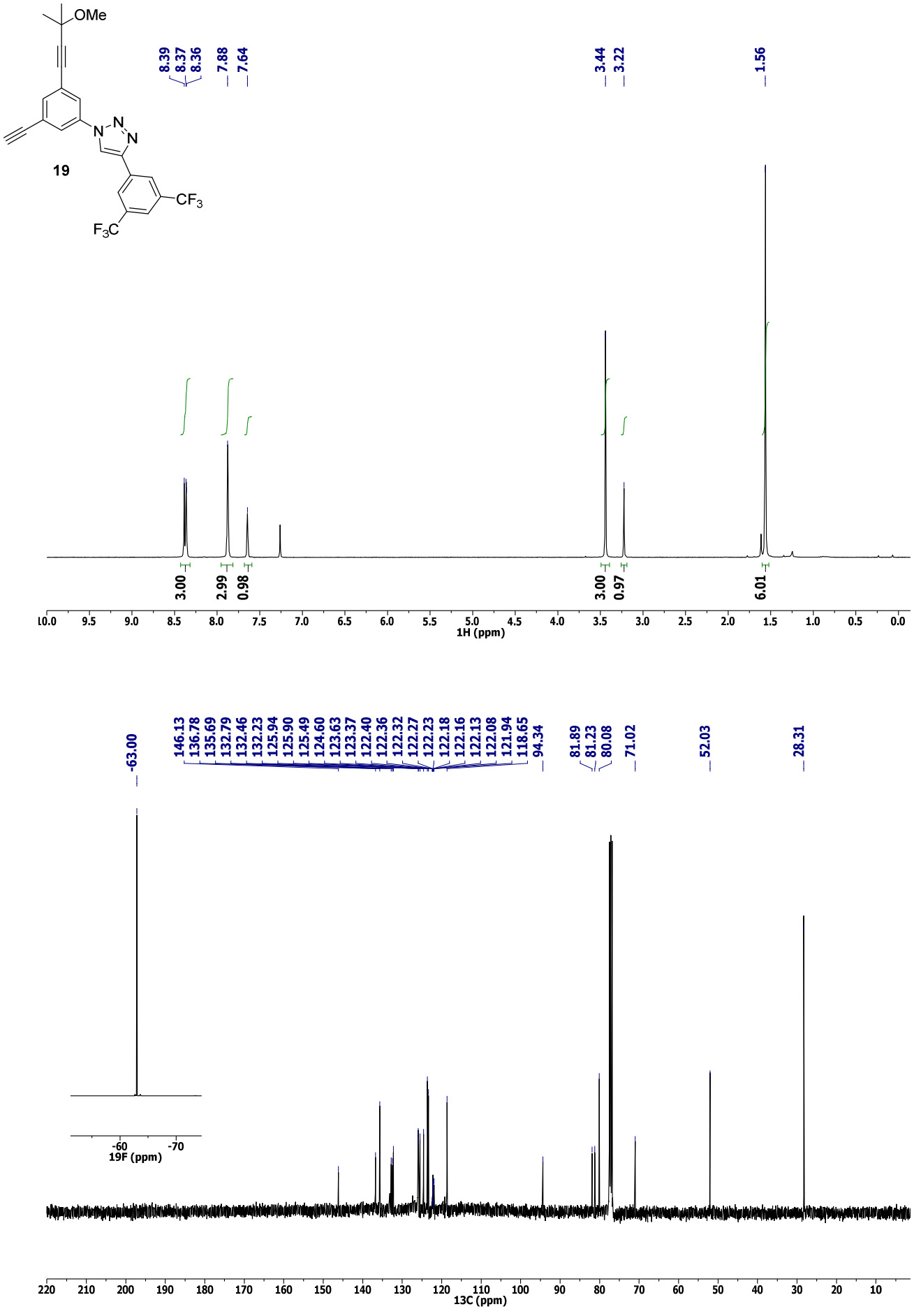

OMe
H2N
OH
16
6.92
6.91
6.91
6.69
6.69
6.68
6.68
6.67
6.67
3.40
1.59
1.51
0.99
2.00
3.06
6.01
6.03
1H (ppm)

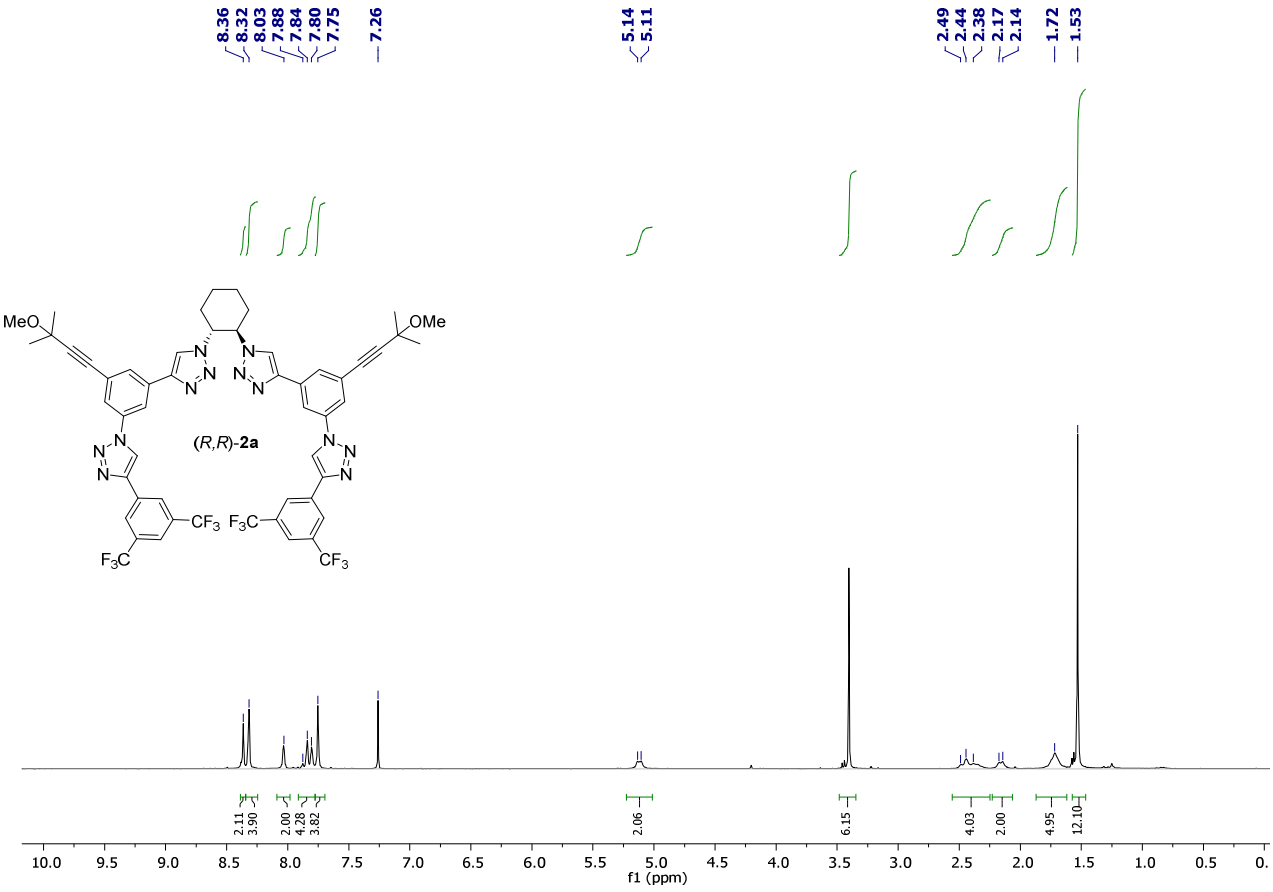

146.26
125.54
123.86
123.73
118.07
117.96
93.76
90.99
83.80
81.67
71.01
65.68
51.85
31.58
28.46
13C (ppm)

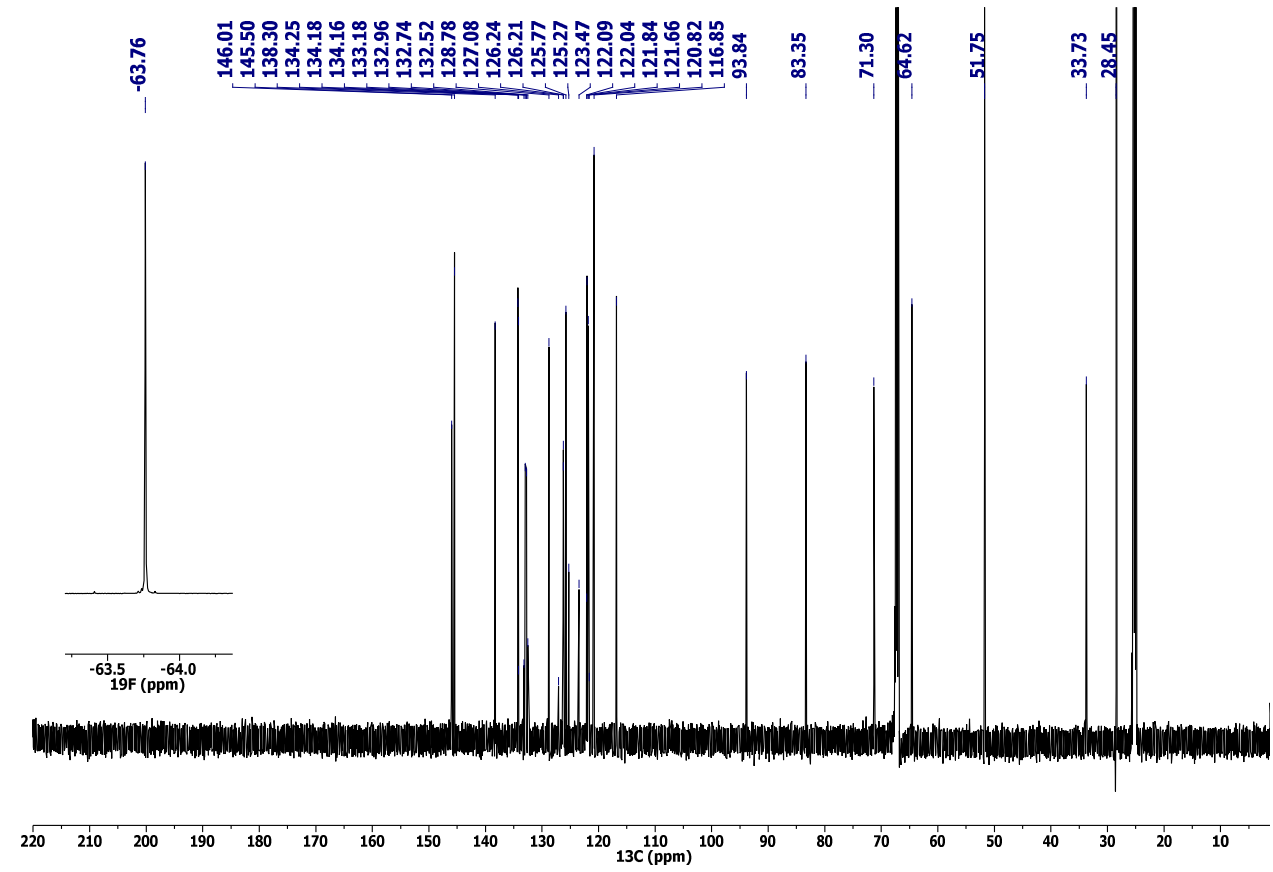

OMe
N3
OH
17
7.24
6.98
6.98
6.97
6.97
3.40
1.59
1.51
1.00
1.99
3.05
6.04
6.01
1H (ppm)

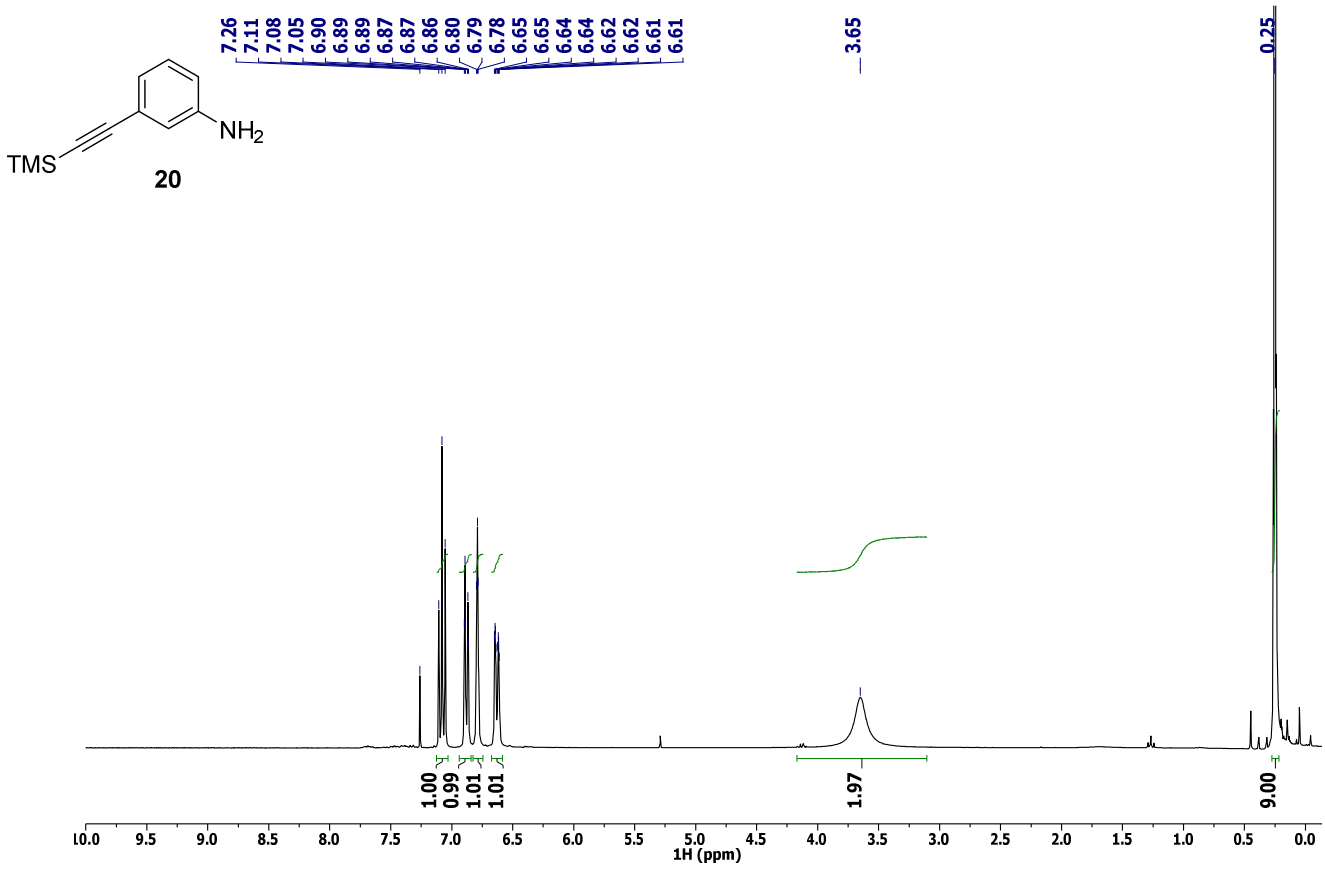

140.44
131.41
124.66
124.65
121.80
121.74
95.50
92.66
82.62
80.44
70.99
65.54
51.87
31.43
28.30
13C (ppm)

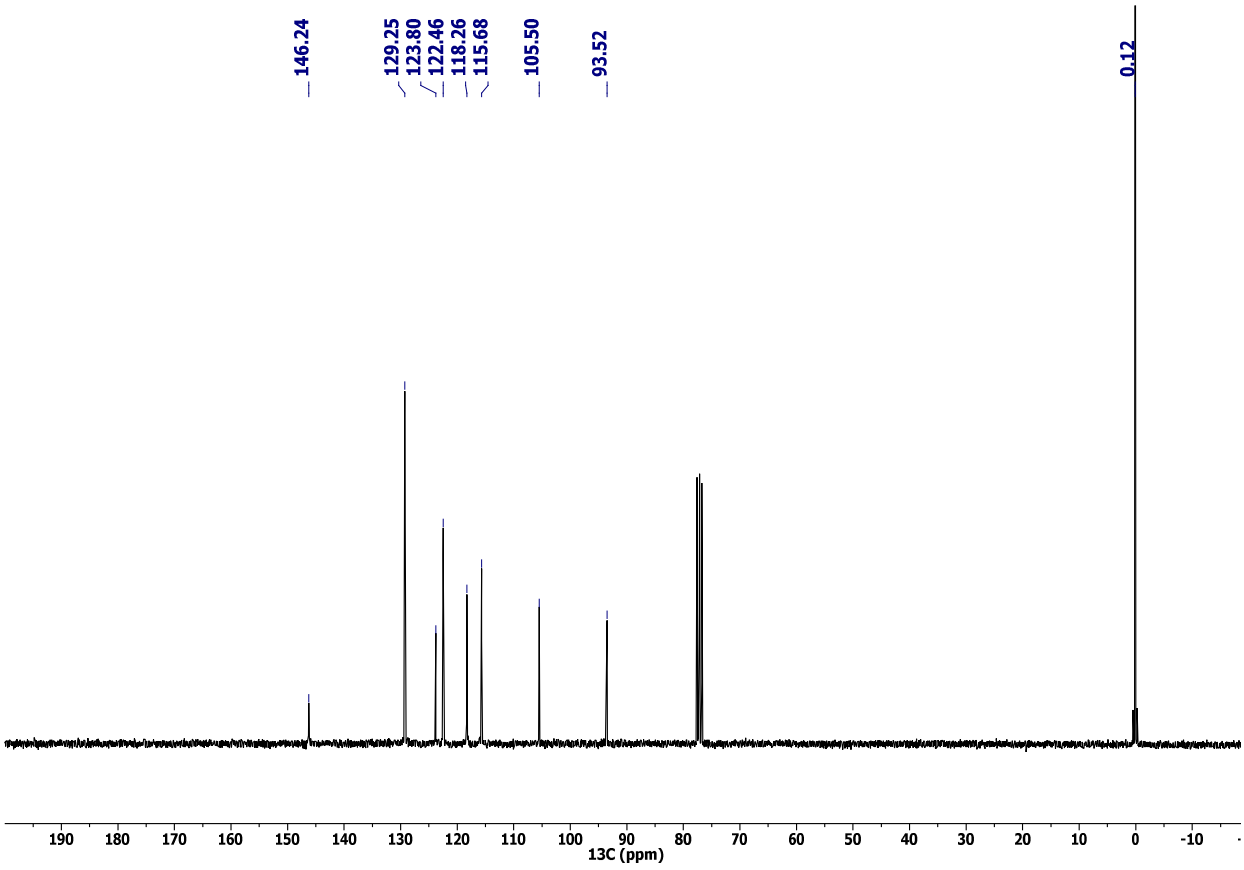

OMe
HO
N
N
N
CF3
F3C
18
8.38
8.36
7.87
7.83
7.82
7.82
7.82
7.81
7.81
7.81
7.80
7.59
7.58
7.58
7.26
3.44
1.64
1.56
1.01
1.97
1.01
2.00
0.99
3.03
0.97
5.99
6.04
1H (ppm)
146.08
136.70
135.26
132.82
132.37
132.23
125.92
125.90
125.87
125.31
125.25
125.10
122.97
122.92
122.31
122.23
122.18
122.13
122.08
121.48
118.64
96.63
94.09
82.03
79.99
71.02
65.72
52.03
31.47
28.32
-62.99
19F (ppm)
13C (ppm)


OMe
N
N
N
19
CF3
F3C
8.39
8.37
8.36
7.88
7.64
3.44
3.22
1.56
3.00
2.99
0.98
3.00
0.97
6.01
1H (ppm)
-63.00
146.13
136.78
135.69
132.79
132.46
132.23
125.94
125.90
125.49
124.60
123.63
123.37
122.40
122.36
122.32
122.27
122.23
122.18
122.16
122.13
122.08
121.94
118.65
94.34
81.89
81.23
80.08
71.02
52.03
28.31
-60
-70
19F (ppm)
13C (ppm)


8.36
8.32
8.03
7.88
7.84
7.80
7.75
7.26
5.14
5.11
2.49
2.44
2.38
2.17
2.14
1.72
1.53
MeO
OMe
(R,R)-2a
CF3
F3C
F3C
CF3
2.11
3.90
2.00
4.28
3.82
2.06
6.15
4.03
2.00
4.95
12.10
f1 (ppm)


-63.76
146.01
145.50
138.30
134.25
134.18
134.16
133.18
132.96
132.74
132.52
128.78
127.08
126.24
126.21
125.77
125.27
123.47
122.09
122.04
121.84
121.66
120.82
116.85
93.84
83.35
71.30
64.62
51.75
33.73
28.45
-63.5
-64.0
19F (ppm)
13C (ppm)


7.26
7.11
7.08
7.05
6.90
6.89
6.89
6.87
6.87
6.86
6.80
6.79
6.78
6.65
6.65
6.64
6.64
6.62
6.62
6.61
6.61
3.65
0.25
NH2
TMS
20
1.00
0.99
1.01
1.01
1.97
9.00
1H (ppm)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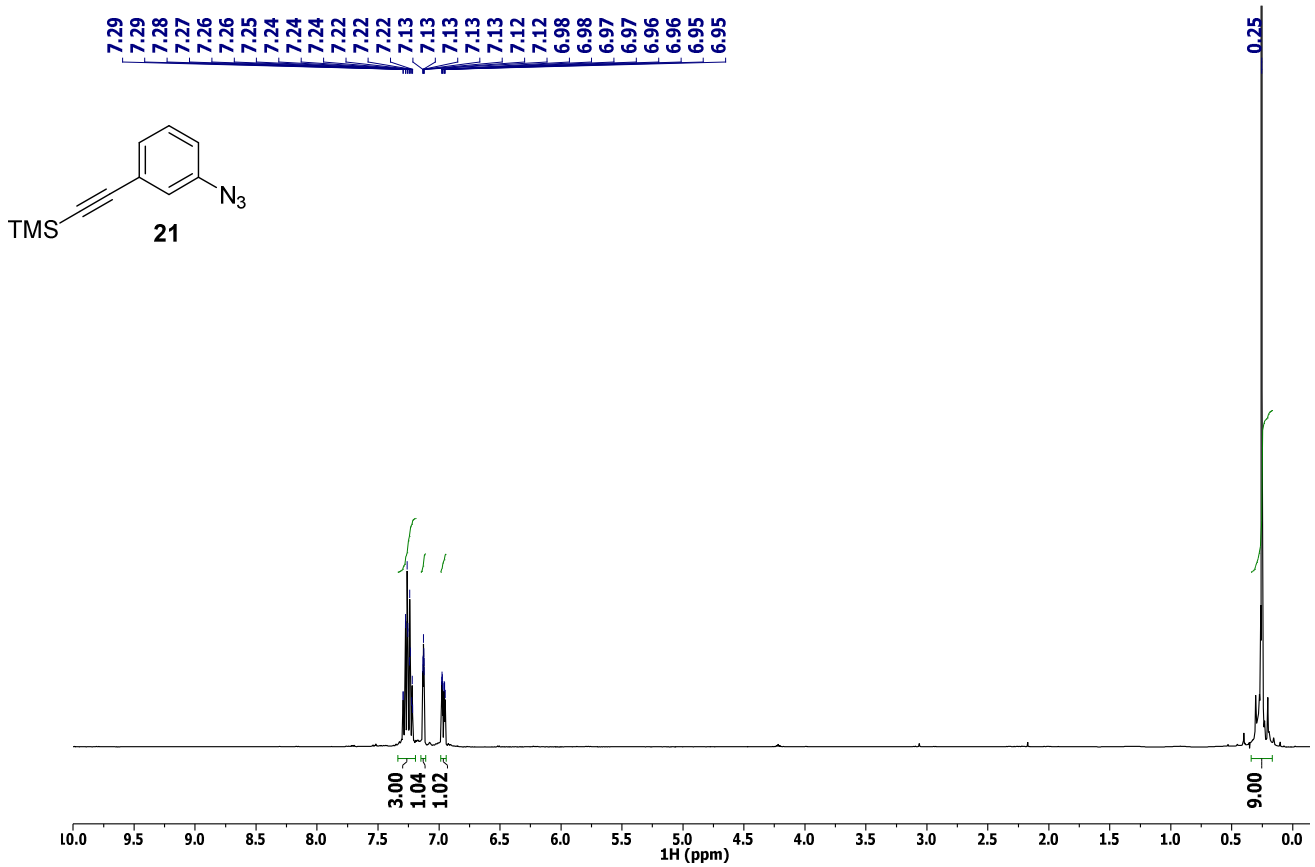
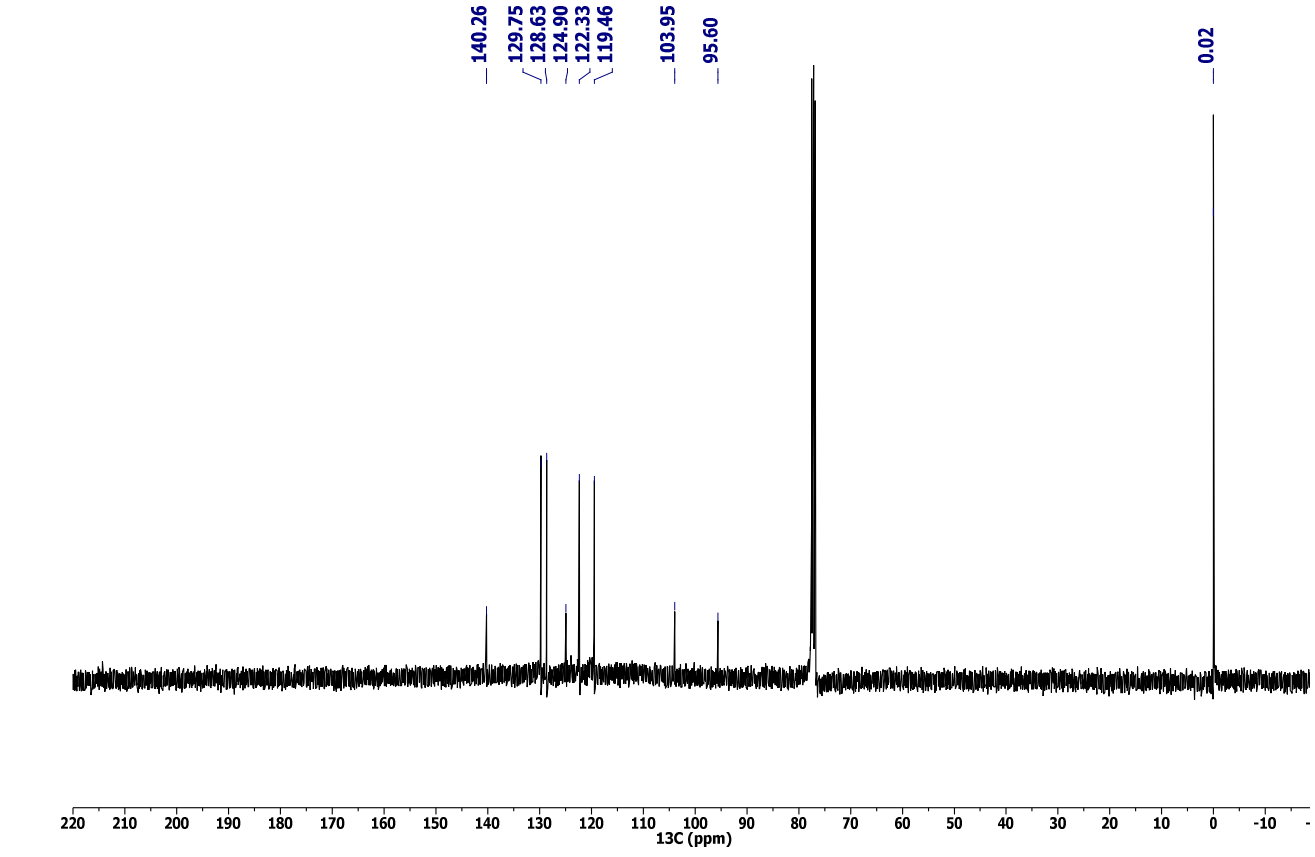
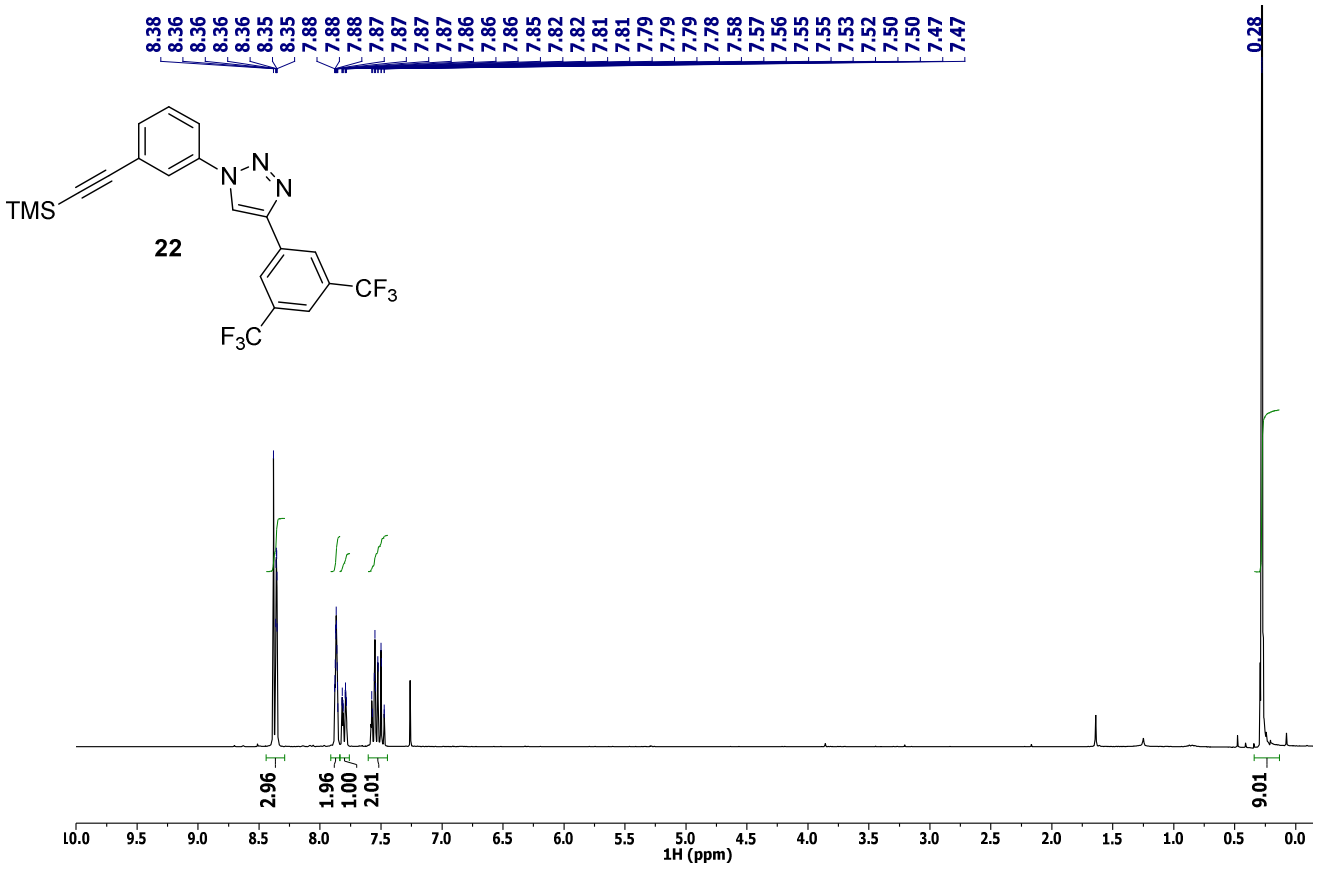
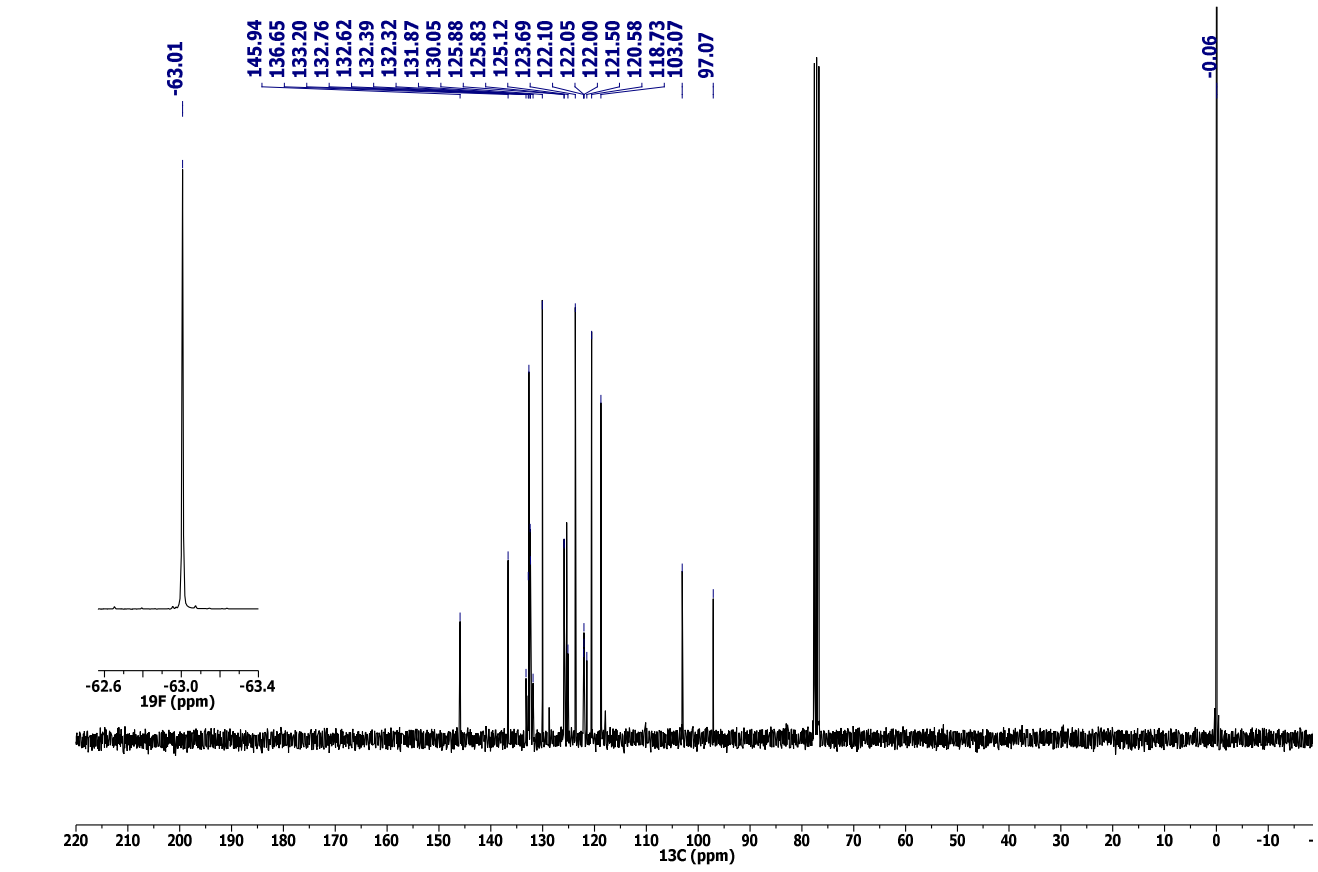
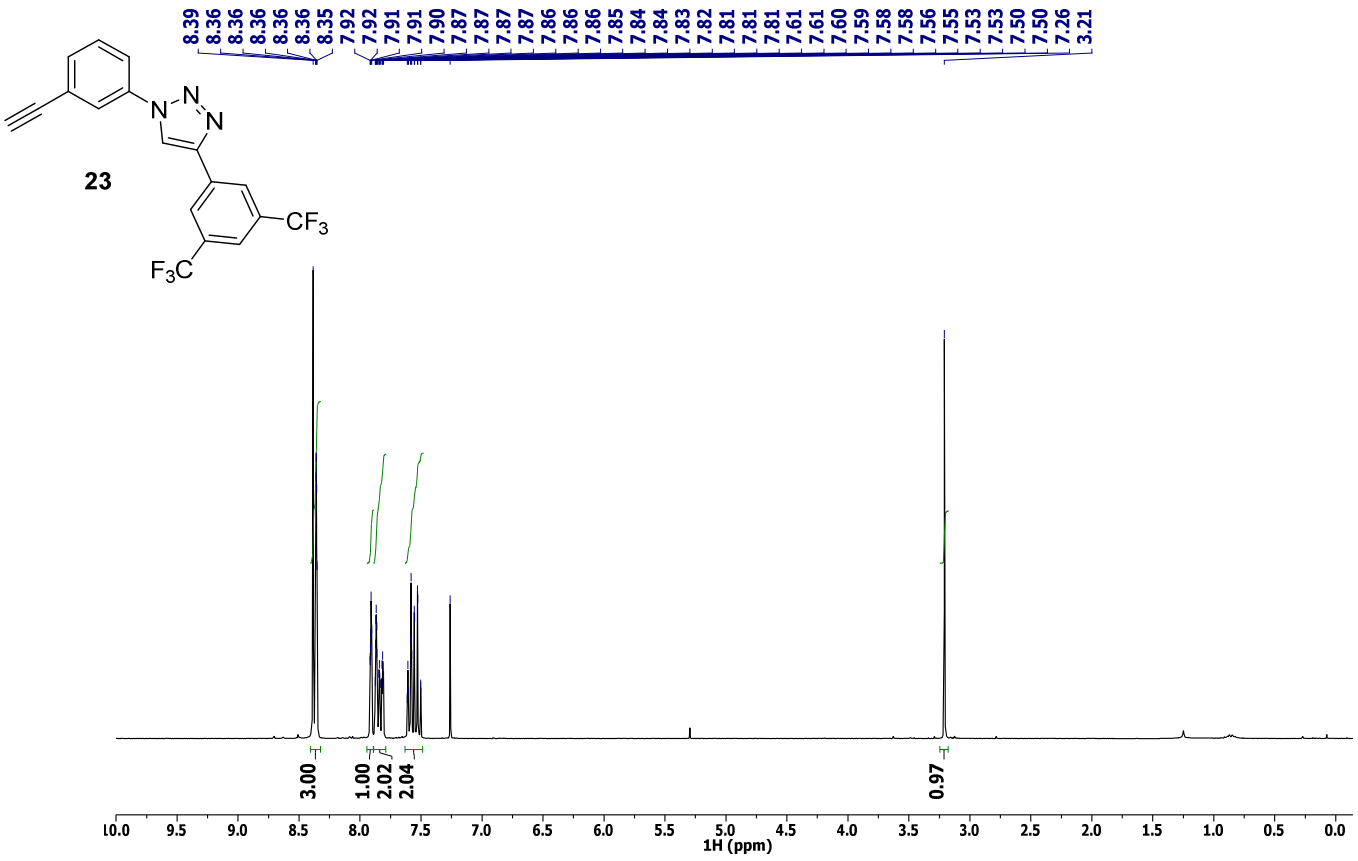
129.25
123.80
122.46
118.26
115.68
105.50
93.52
0.12
13C (ppm)

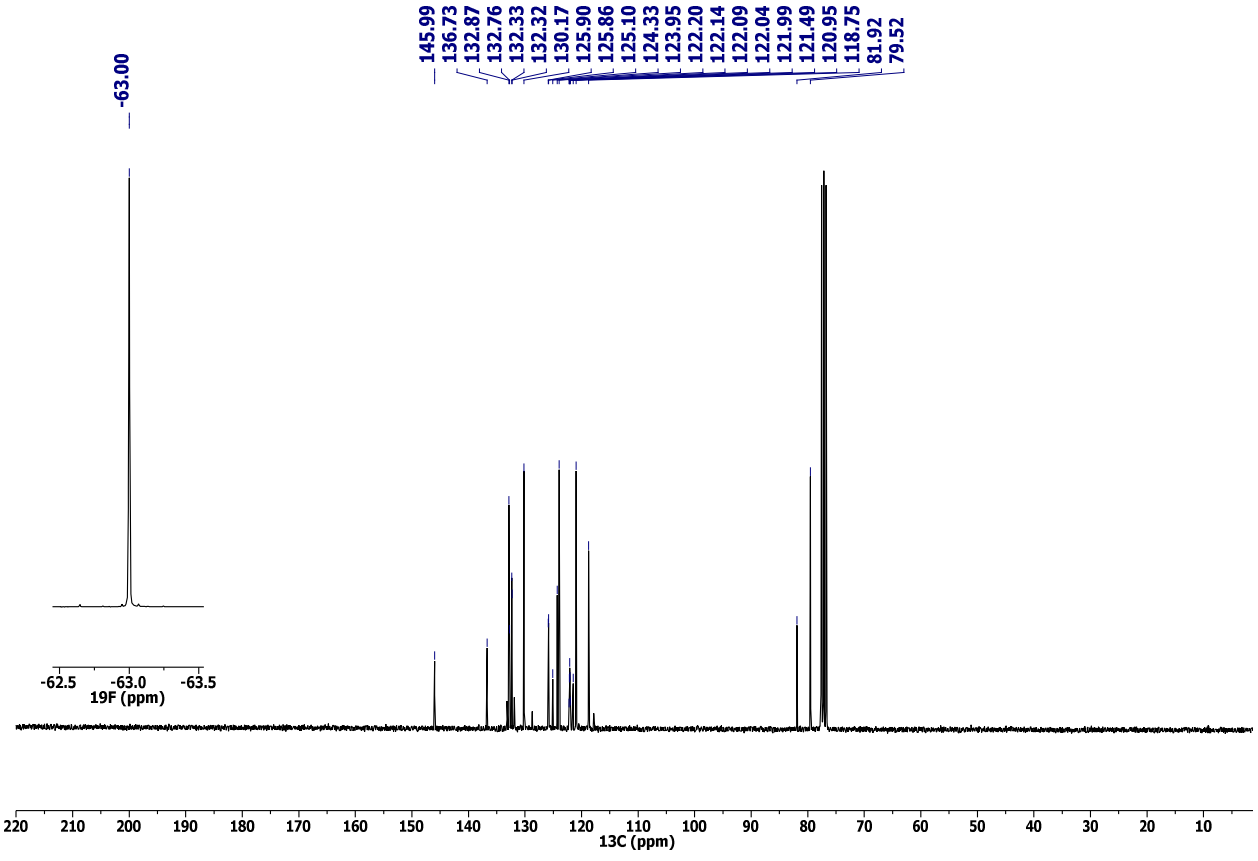

7.29
7.29
7.28
7.27
7.26
7.26
7.25
7.24
7.24
7.24
7.22
7.22
7.22
7.13
7.13
7.13
7.13
7.13
7.12
7.12
6.98
6.98
6.97
6.97
6.96
6.96
6.95
6.95
0.25
TMS
N3
21
3.00
1.04
1.02
9.00
1H (ppm)

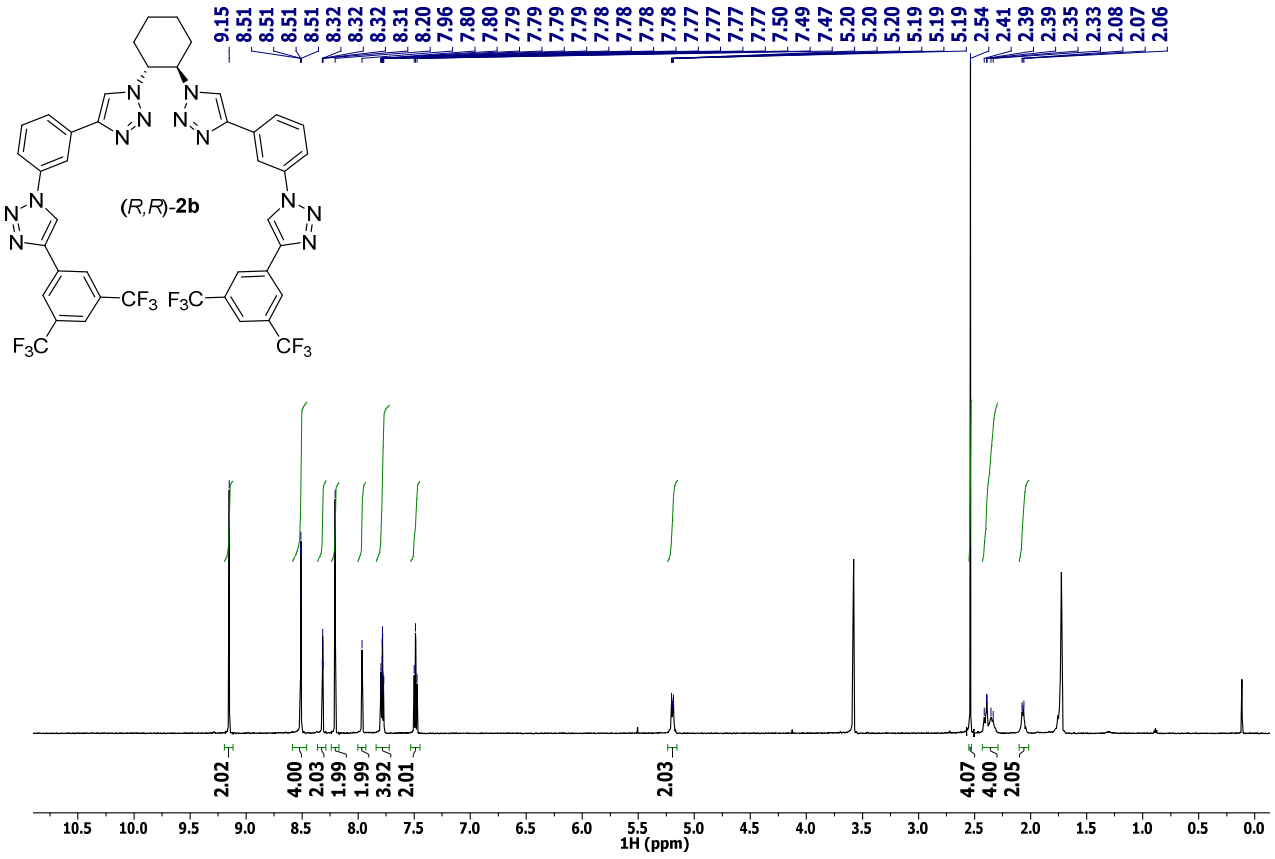

140.26
129.75
128.63
124.90
122.33
119.46
103.95
95.60
0.02
13C (ppm)

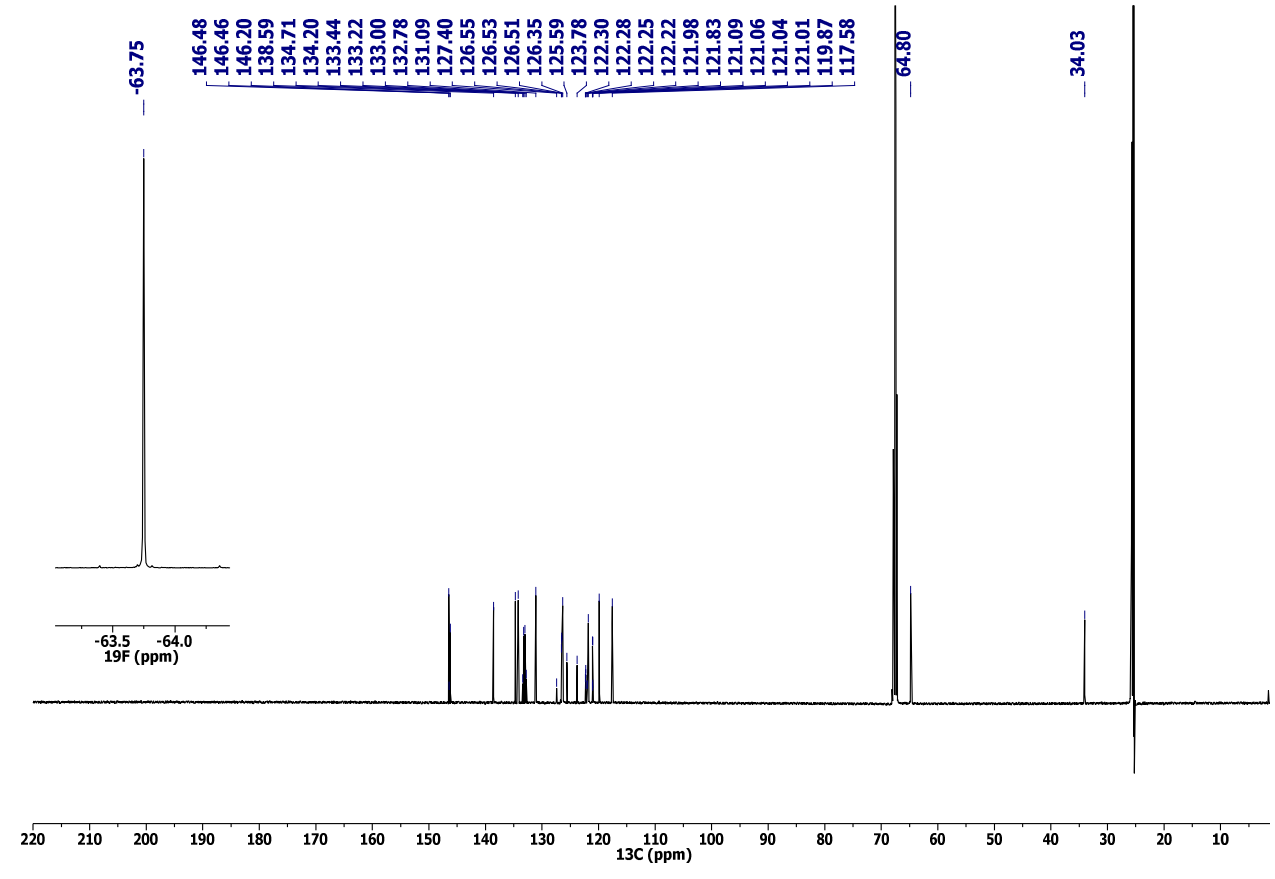

8.38 8.36 8.36 8.36 8.36 8.35 8.35 7.88 7.88 7.87 7.87 7.87 7.86 7.86 7.86 7.85 7.82 7.82 7.81 7.81 7.79 7.79 7.79 7.78 7.58 7.57 7.56 7.55 7.55 7.53 7.52 7.50 7.50 7.47 7.47
0.28
TMS
22
CF3
F3C
2.96
1.96
1.00
2.01
9.01
1H (ppm)

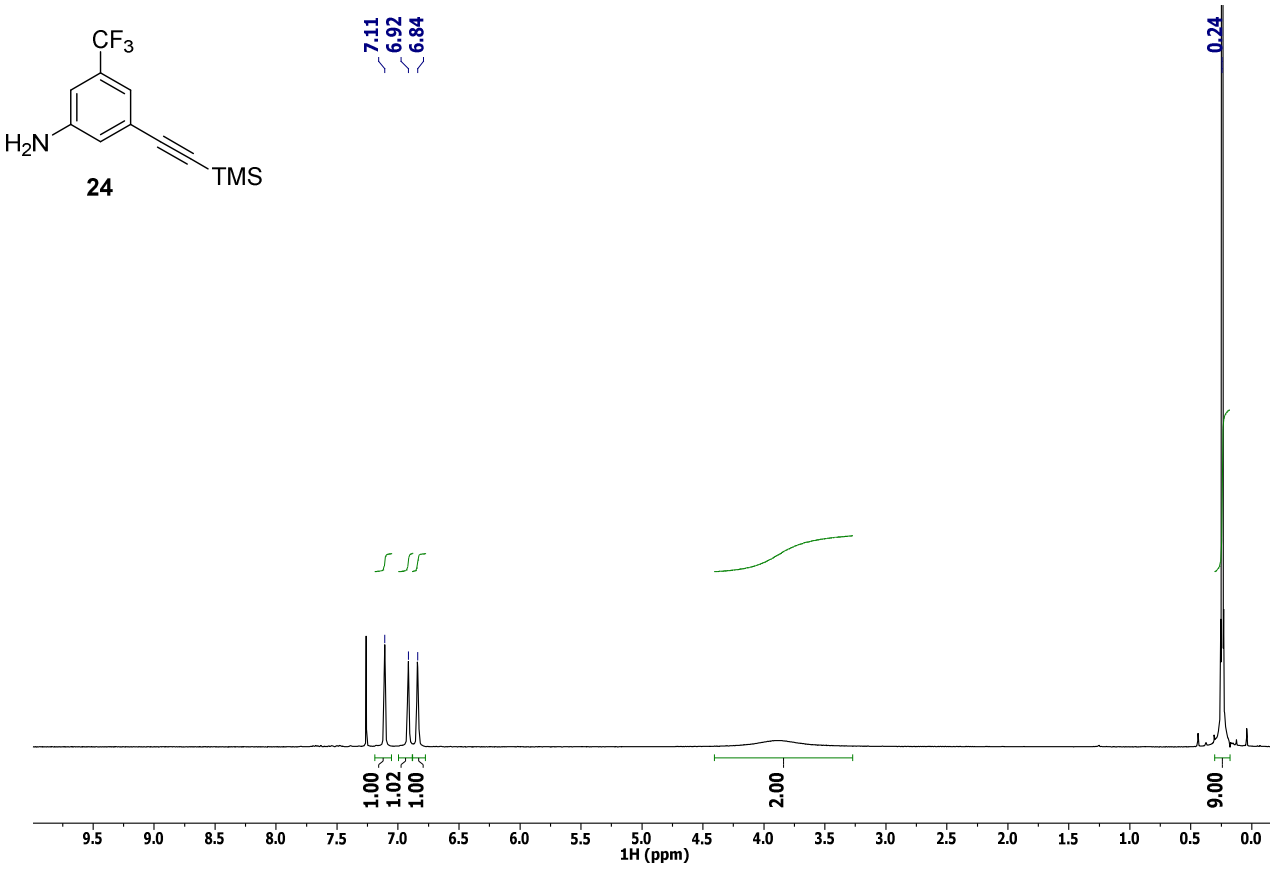

-63.01
145.94 136.65 133.20 132.76 132.62 132.39 132.32 131.87 130.05 125.88 125.83 125.12 123.69 122.10 122.05 122.00 121.50 120.58 118.73 103.07 97.07
-0.06
-62.6 -63.0 -63.4
19F (ppm)
13C (ppm)

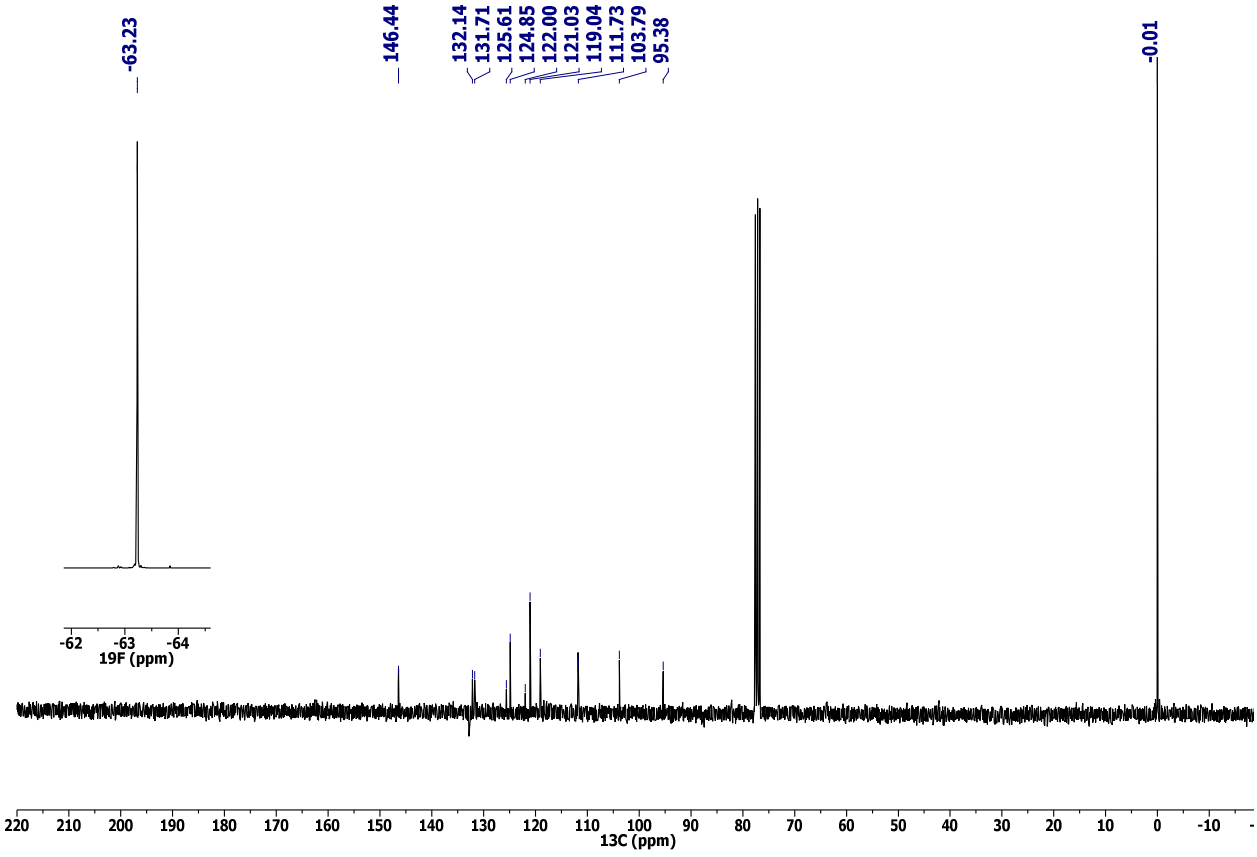

8.39 8.36 8.36 8.36 8.36 8.36 8.35 7.92 7.92 7.91 7.91 7.90 7.87 7.87 7.87 7.87 7.86 7.86 7.86 7.85 7.84 7.84 7.83 7.82 7.81 7.81 7.81 7.61 7.61 7.60 7.59 7.58 7.58 7.56 7.55 7.53 7.53 7.50 7.50 7.26 3.21
23
CF3
F3C
3.00
1.00
2.02
2.04
0.97
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
1H (ppm)

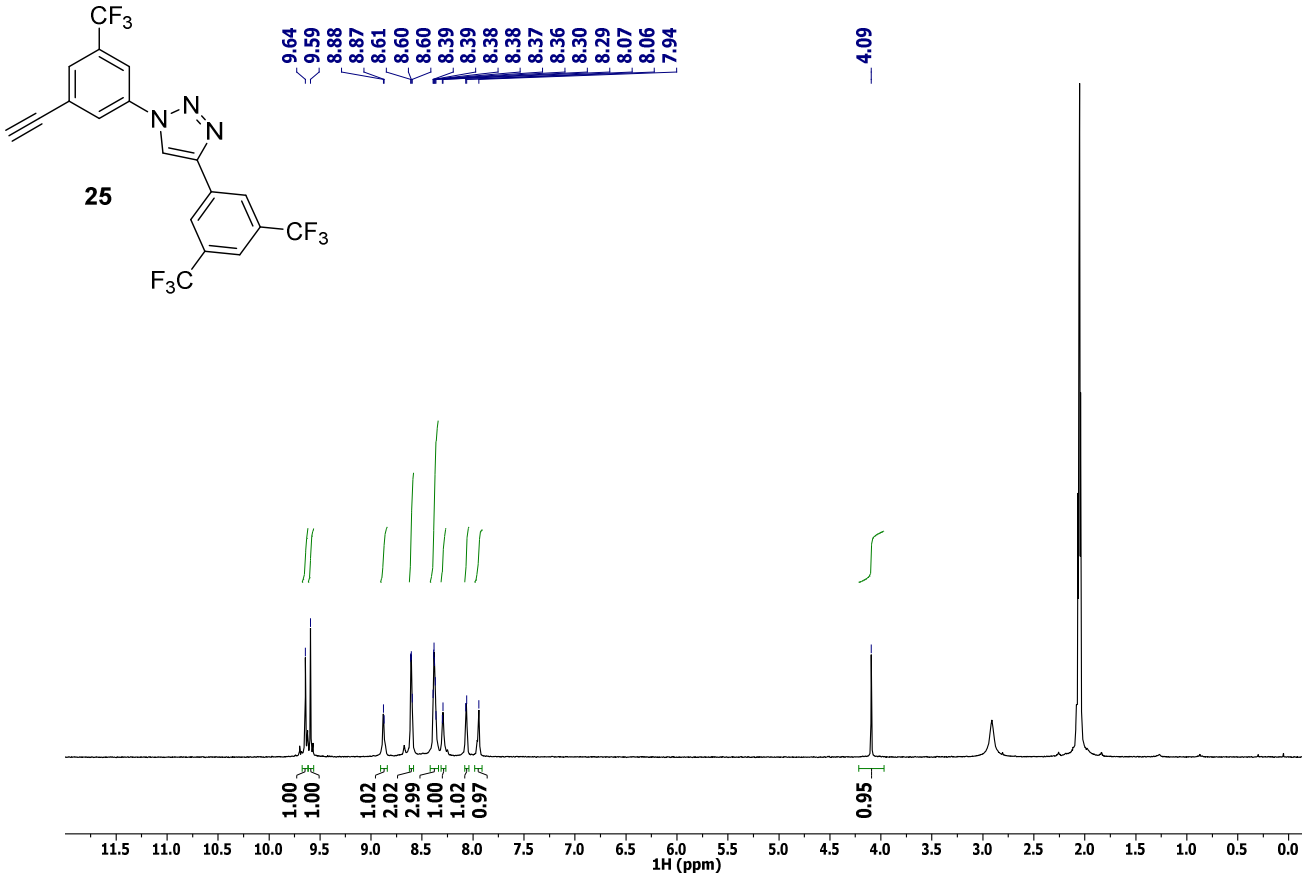

145.99 136.73 132.87 132.76 132.33 132.32 130.17 125.90 125.86 125.10 124.33 123.95 122.20 122.14 122.09 122.04 121.99 121.49 120.95 118.75 81.92 79.52
-63.00
-62.5 -63.0 -63.5
19F (ppm)
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
13C (ppm)

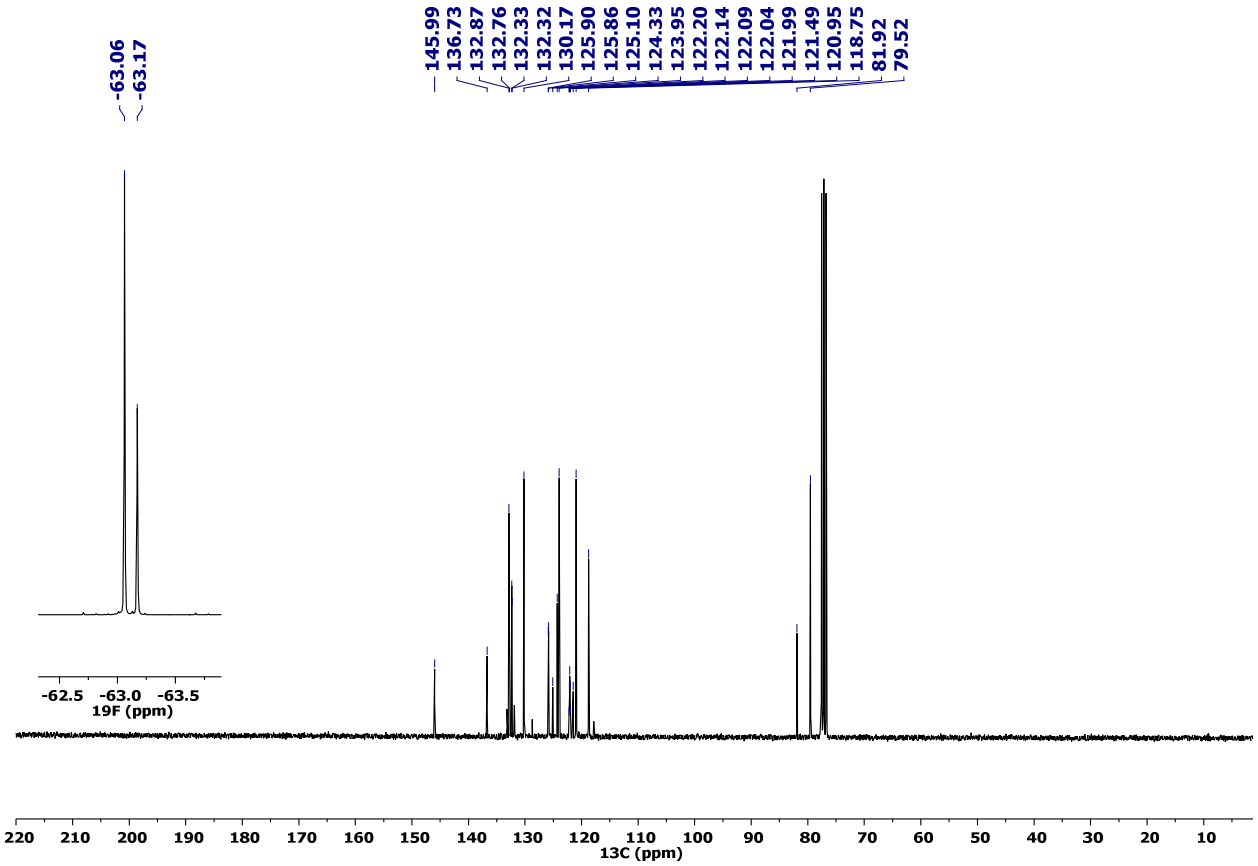

(R,R)-2b
CF3
F3C
F3C
CF3
9.15
8.51
8.51
8.51
8.51
8.32
8.32
8.32
8.31
8.20
7.96
7.80
7.80
7.79
7.79
7.79
7.79
7.78
7.78
7.78
7.78
7.77
7.77
7.77
7.77
7.50
7.49
7.47
5.20
5.20
5.20
5.19
5.19
5.19
2.54
2.41
2.39
2.39
2.35
2.33
2.08
2.07
2.06
2.02
4.00
2.03
1.99
1.99
3.92
2.01
2.03
4.07
4.00
2.05
1H (ppm)

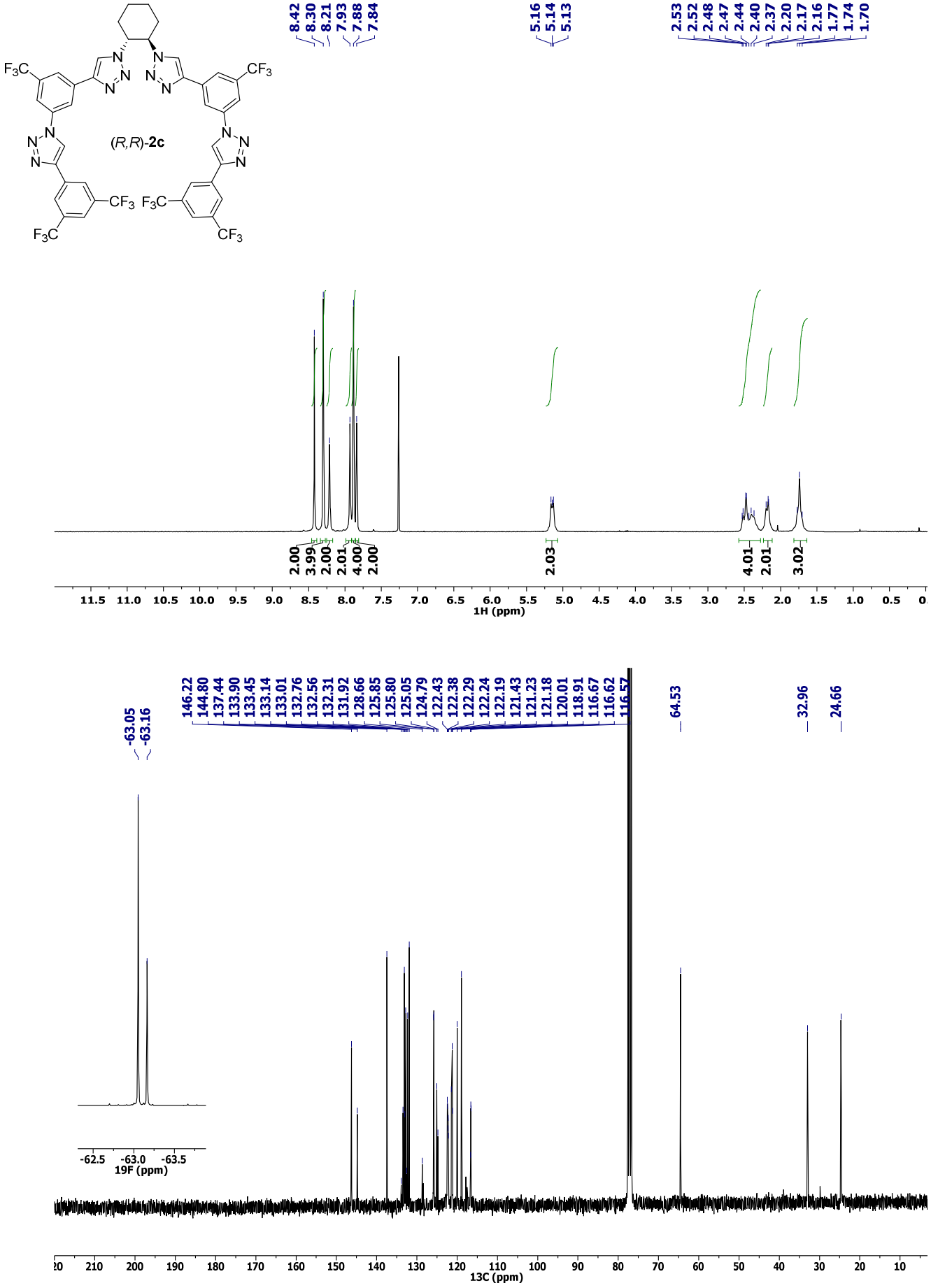

-63.75
146.48
146.46
146.20
138.59
134.71
134.20
133.44
133.22
133.00
132.78
131.09
127.40
126.55
126.53
126.51
126.35
125.59
123.78
122.30
122.28
122.25
122.22
121.98
121.83
121.09
121.06
121.04
121.01
119.87
117.58
64.80
34.03
-63.5
-64.0
19F (ppm)
13C (ppm)

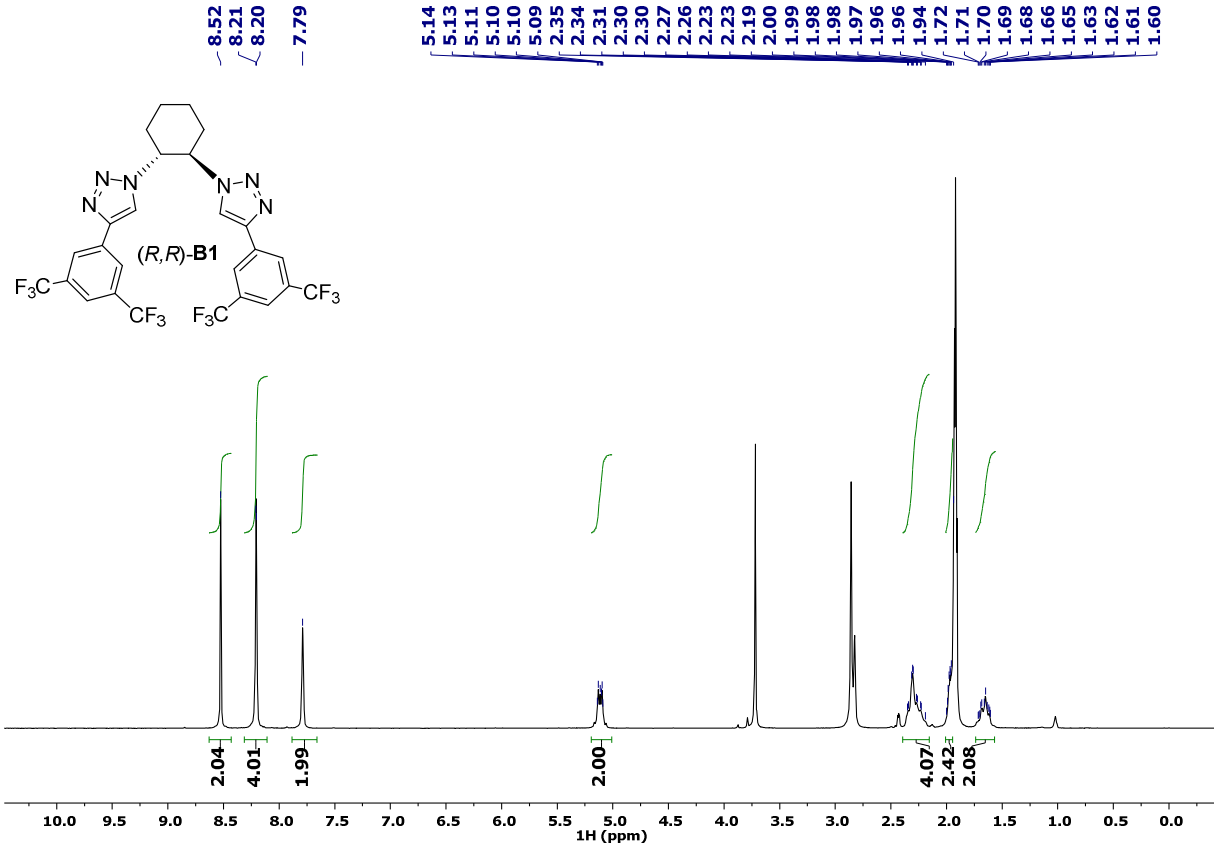

CF3
H2N
TMS
24
7.11
6.92
6.84
0.24
1.00
1.02
1.00
2.00
9.00
1H (ppm)

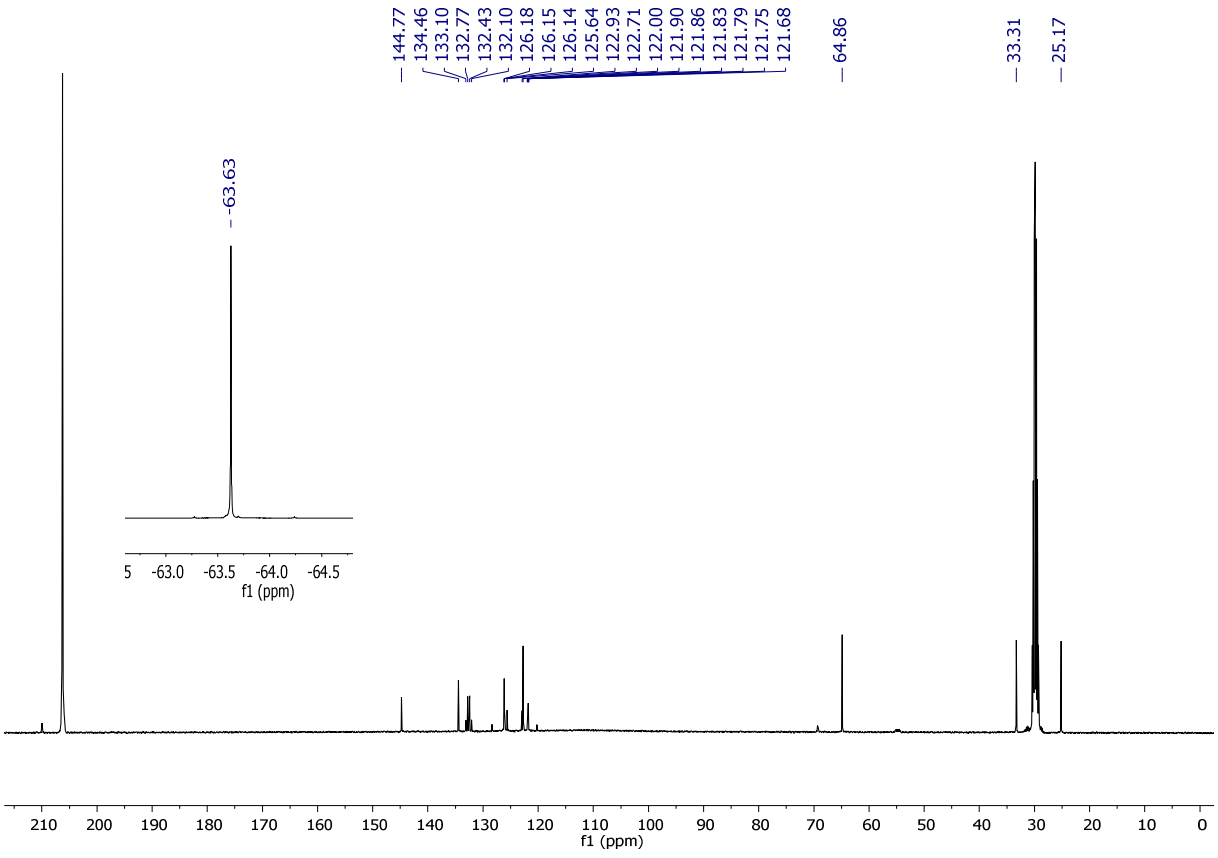

-63.23
146.44
132.14
131.71
125.61
124.85
122.00
121.03
119.04
111.73
103.79
95.38
-0.01
19F (ppm)
13C (ppm)

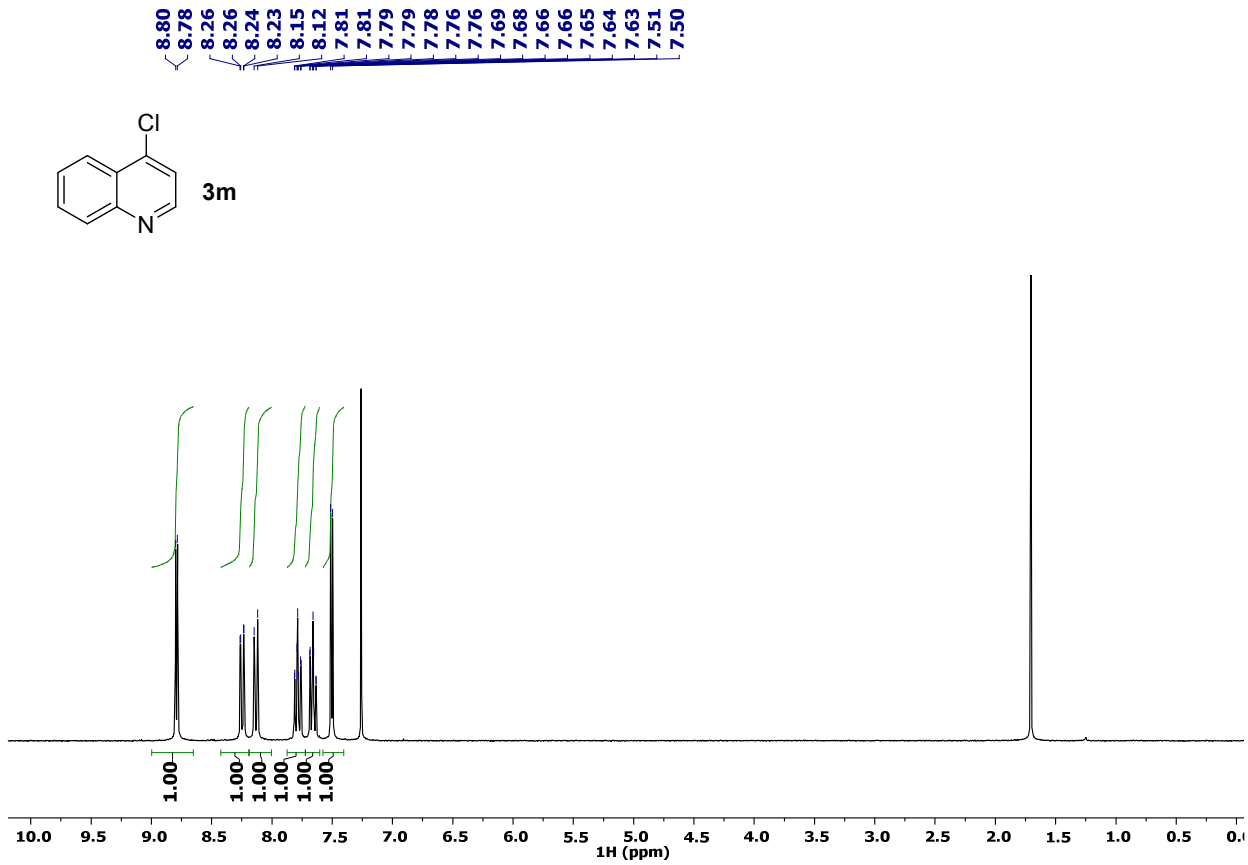

CF3
N
N
N
25
CF3
F3C
9.64
9.59
8.88
8.87
8.61
8.60
8.60
8.39
8.39
8.38
8.38
8.37
8.36
8.30
8.29
8.07
8.06
7.94
4.09
1.00
1.00
1.02
2.02
2.99
1.00
1.02
0.97
0.95
1H (ppm)

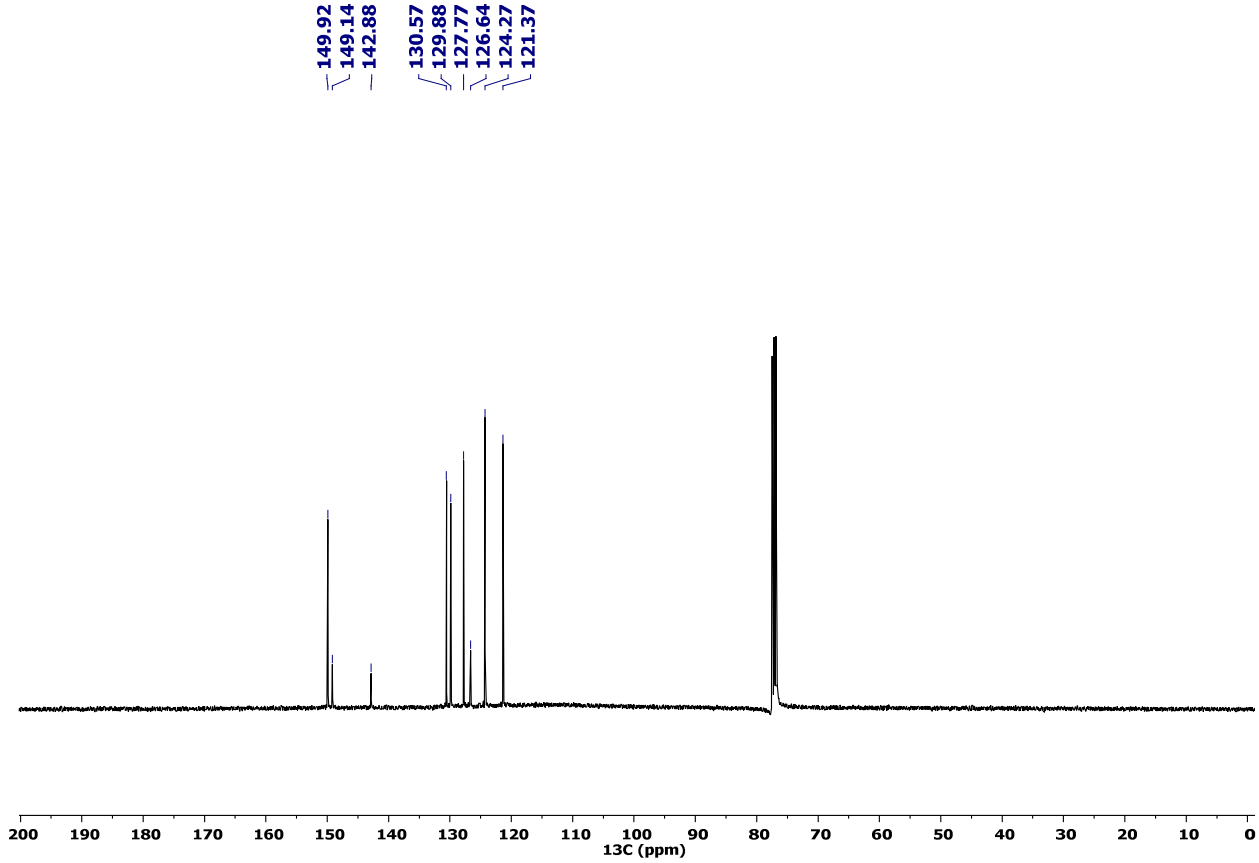

-63.06
-63.17
145.99
136.73
132.87
132.76
132.33
132.32
130.17
125.90
125.86
125.10
124.33
123.95
122.20
122.14
122.09
122.04
121.99
121.49
120.95
118.75
81.92
79.52
-62.5
-63.0
-63.5
19F (ppm)
13C (ppm)

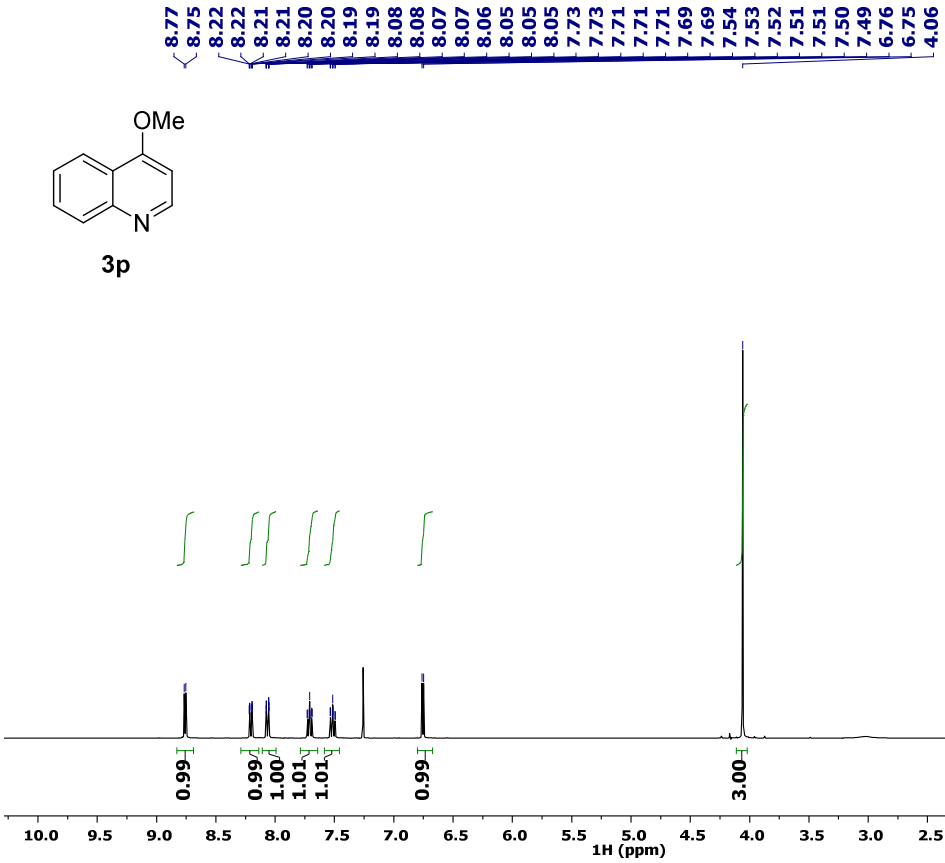

(R,R)-2c
F3C
CF3
8.42
8.30
8.21
7.93
7.88
7.84
5.16
5.14
5.13
2.53
2.52
2.48
2.47
2.44
2.40
2.37
2.20
2.17
2.16
1.77
1.74
1.70
2.00
3.99
2.00
2.01
4.00
2.00
2.03
4.01
2.01
3.02
1H (ppm)
146.22
144.80
137.44
133.90
133.45
133.14
133.01
132.76
132.56
132.31
131.92
128.66
125.85
125.80
125.05
124.79
122.43
122.38
122.29
122.24
122.19
121.43
121.23
121.18
120.01
118.91
116.67
116.62
116.57
64.53
32.96
24.66
-63.05
-63.16
19F (ppm)
13C (ppm)

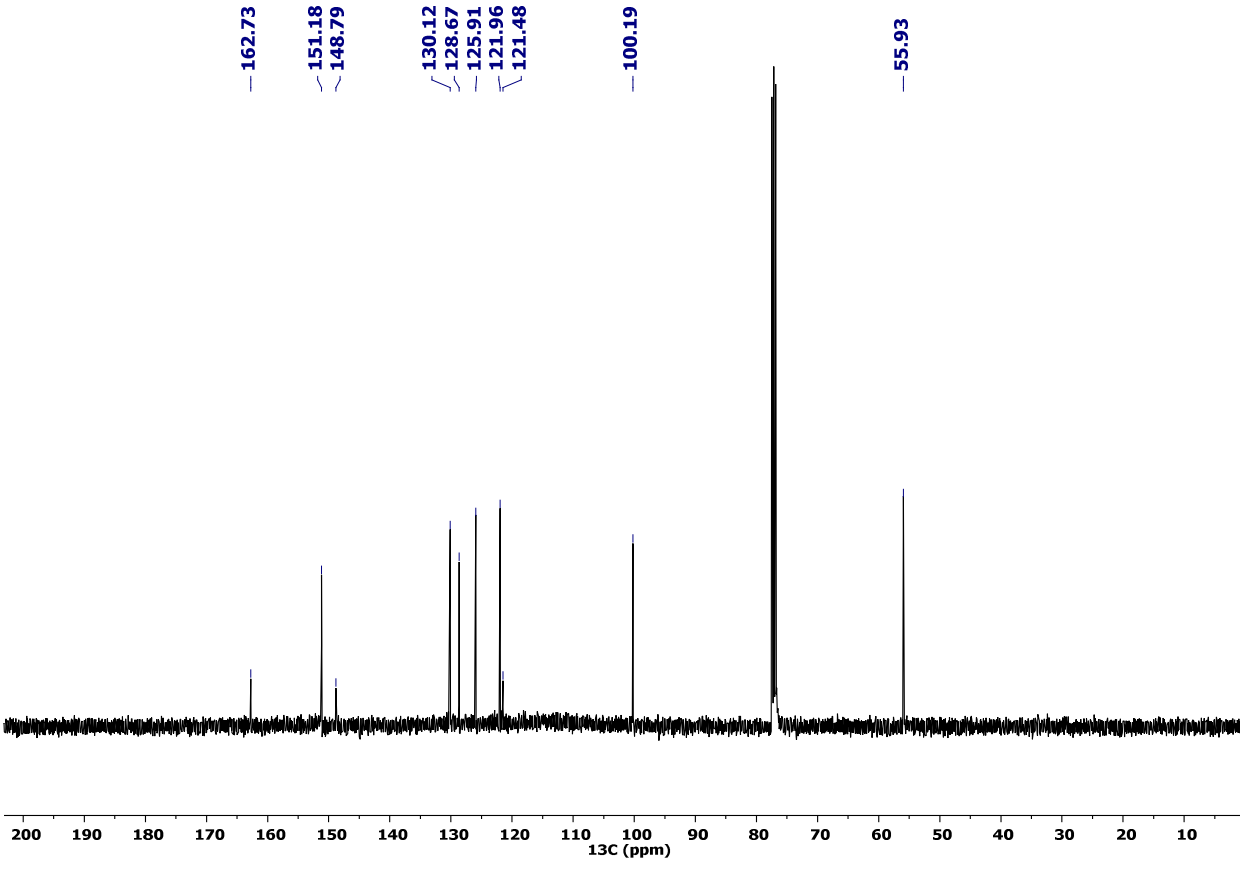

8.52
8.21
8.20
7.79
5.14
5.13
5.11
5.10
5.10
5.09
2.35
2.34
2.31
2.30
2.30
2.27
2.26
2.23
2.23
2.19
2.00
1.99
1.98
1.98
1.97
1.96
1.96
1.94
1.72
1.71
1.70
1.69
1.68
1.66
1.65
1.63
1.62
1.61
1.60
(R,R)-B1
F3C
CF3
CF3
F3C
2.04
4.01
1.99
2.00
4.07
2.42
2.08
1H (ppm)

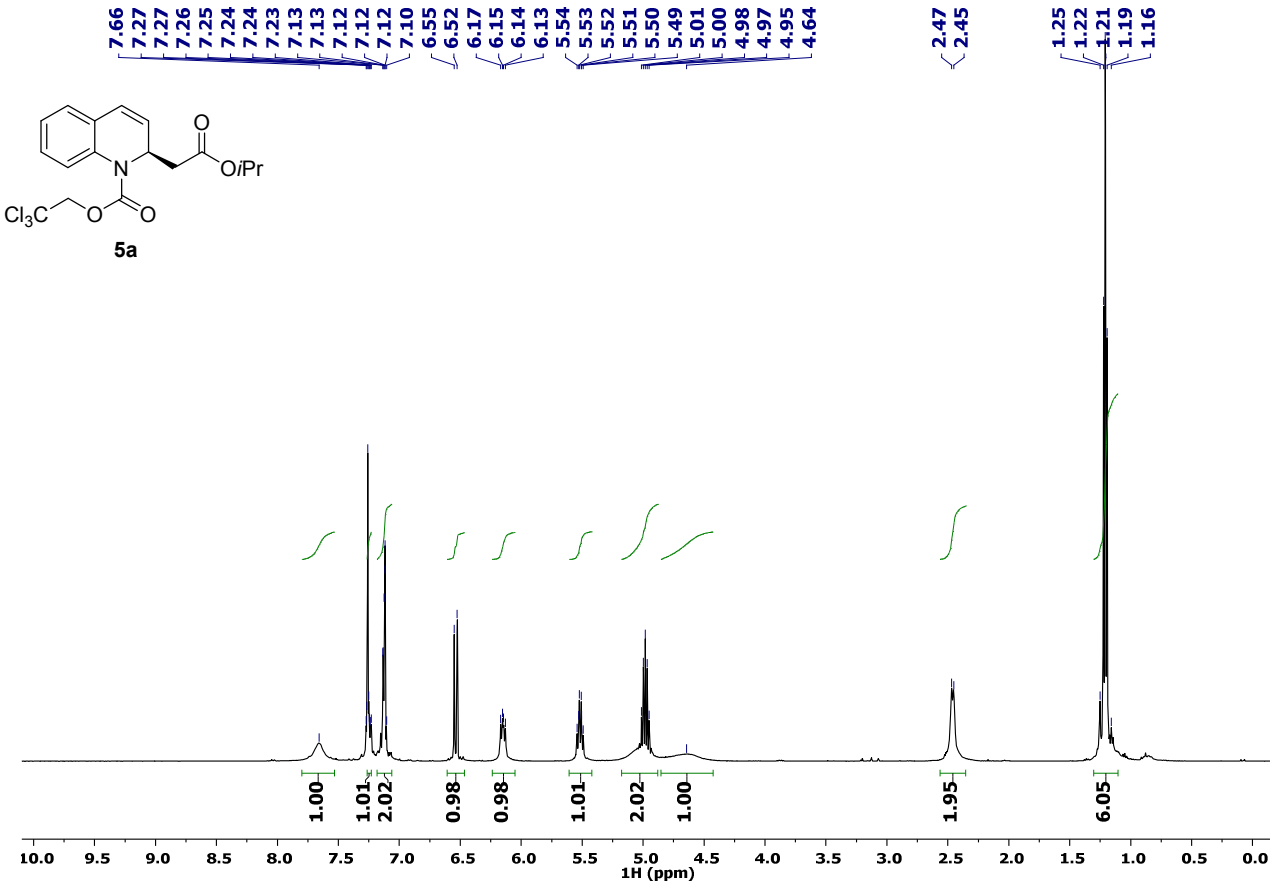

144.77
134.46
133.10
132.77
132.43
132.10
126.18
126.15
126.14
125.64
122.93
122.71
122.00
121.90
121.86
121.83
121.79
121.75
121.68
64.86
33.31
25.17
-63.63
-63.0
-63.5
-64.0
-64.5
f1 (ppm)
f1 (ppm)

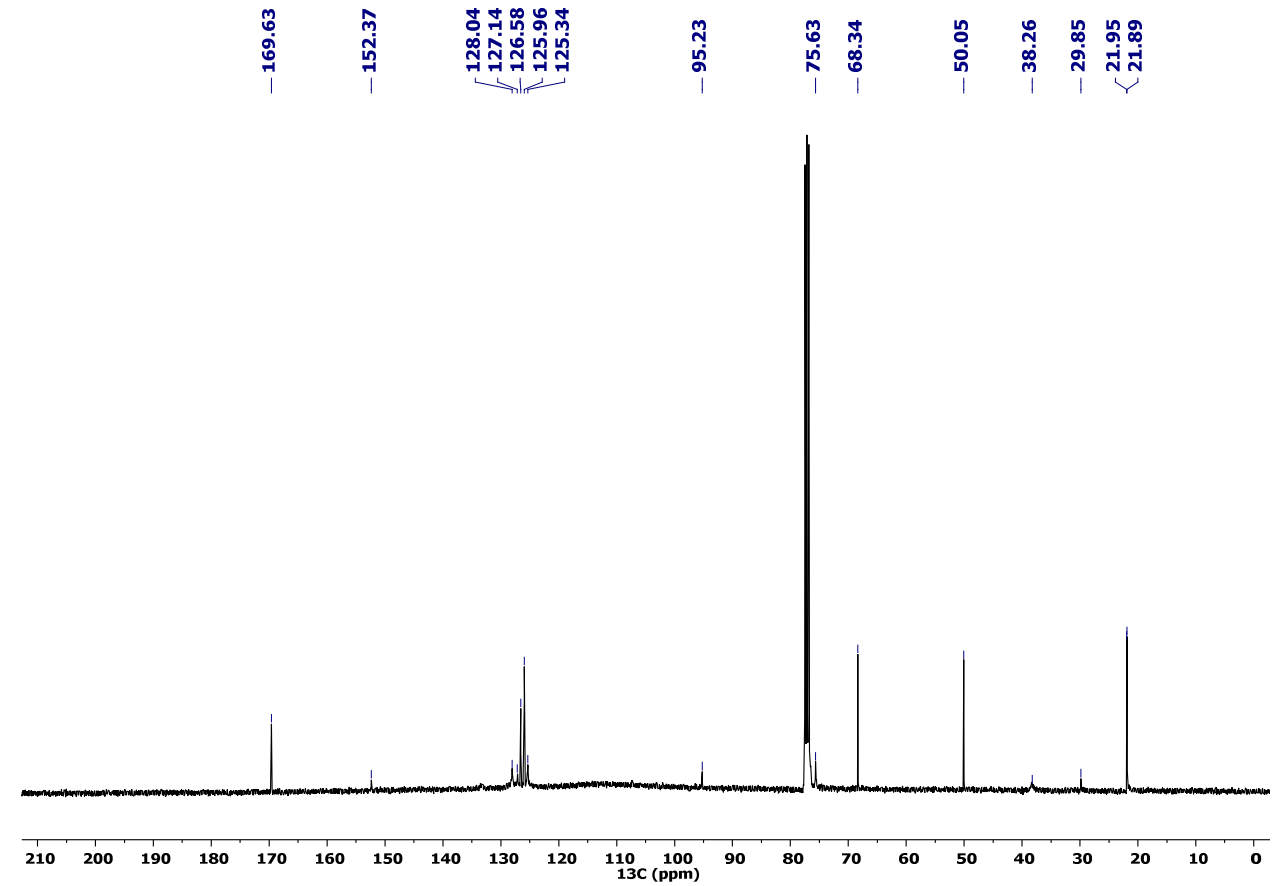

8.80
8.78
8.26
8.26
8.24
8.23
8.15
8.12
7.81
7.79
7.79
7.78
7.76
7.76
7.69
7.68
7.66
7.66
7.65
7.64
7.63
7.51
7.50
Cl
N
3m
1.00
1.00
1.00
1.00
1.00
1.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)

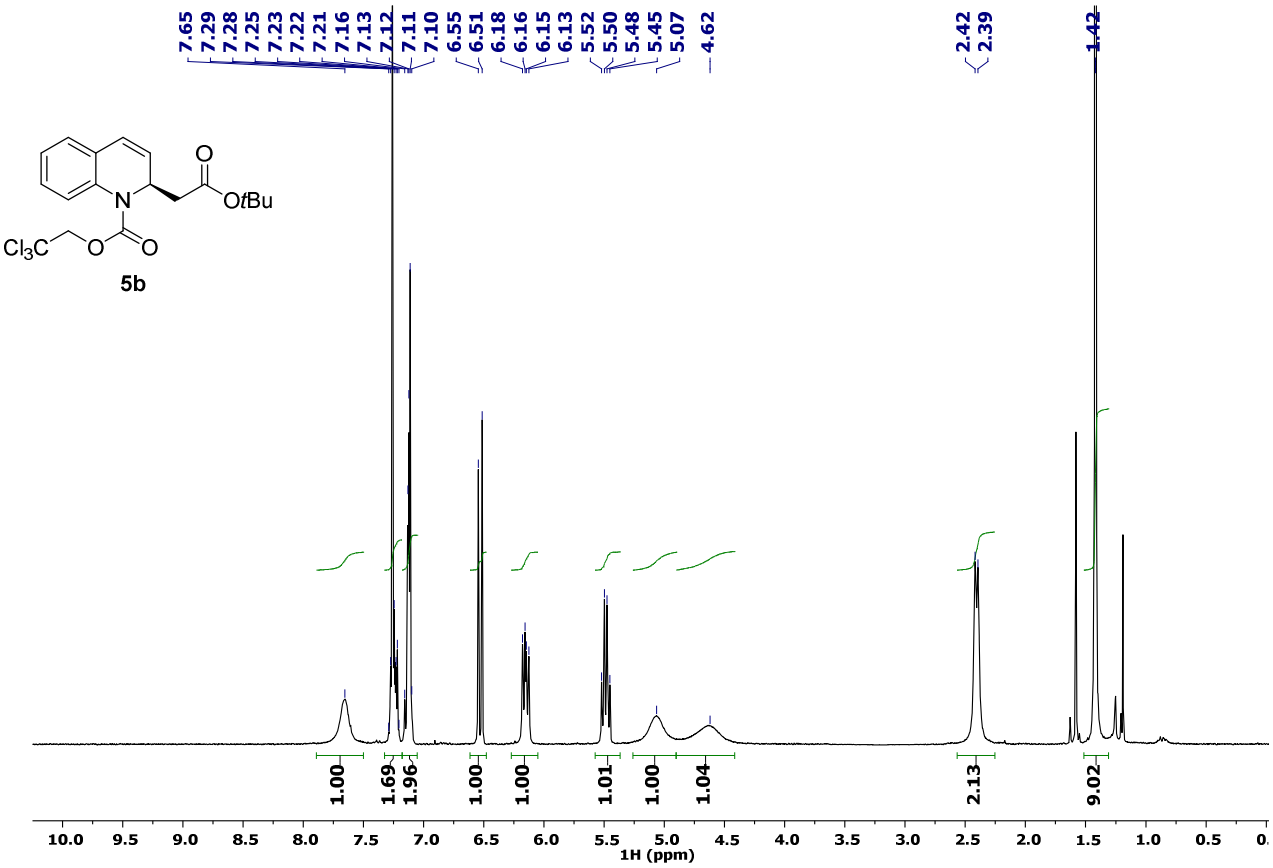

149.92
149.14
142.88
130.57
129.88
127.77
126.64
124.27
121.37
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
13C (ppm)

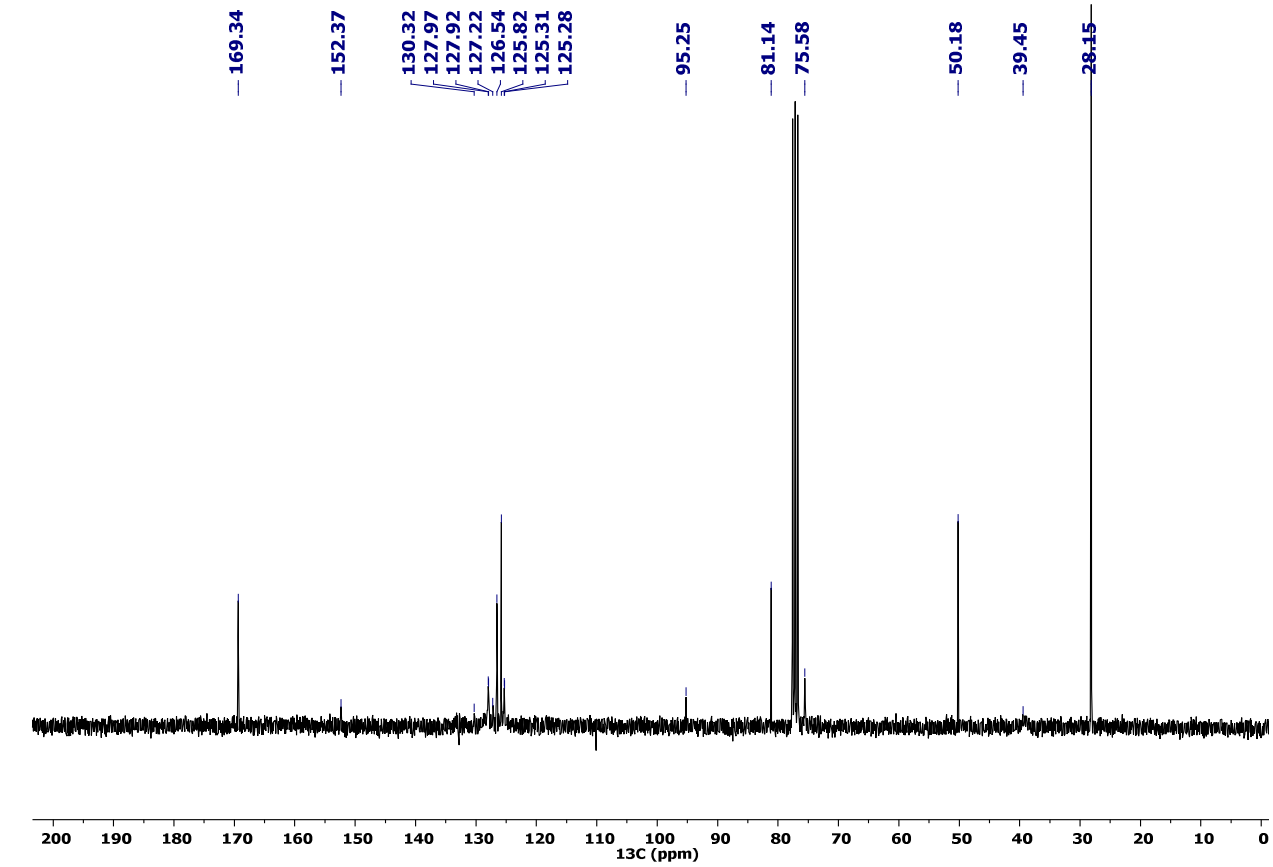

8.77
8.75
8.22
8.22
8.21
8.21
8.20
8.20
8.19
8.19
8.08
8.08
8.07
8.07
8.06
8.05
8.05
7.73
7.73
7.71
7.71
7.69
7.69
7.54
7.53
7.52
7.51
7.51
7.50
7.49
6.76
6.75
4.06
OMe
N
3p
0.99
0.99
1.00
1.01
1.01
0.99
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
1H (ppm)

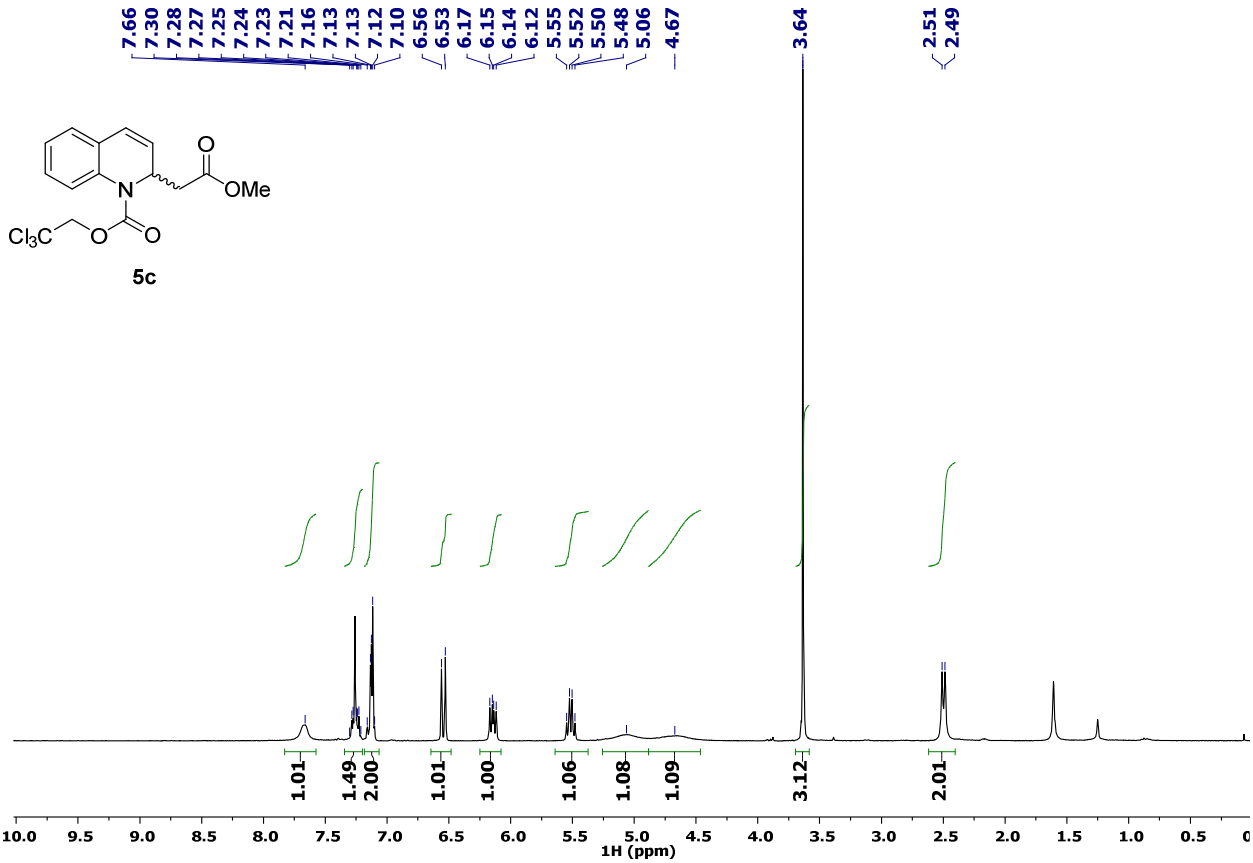

162.73
151.18
148.79
130.12
128.67
125.91
121.96
121.48
100.19
55.93
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
13C (ppm)

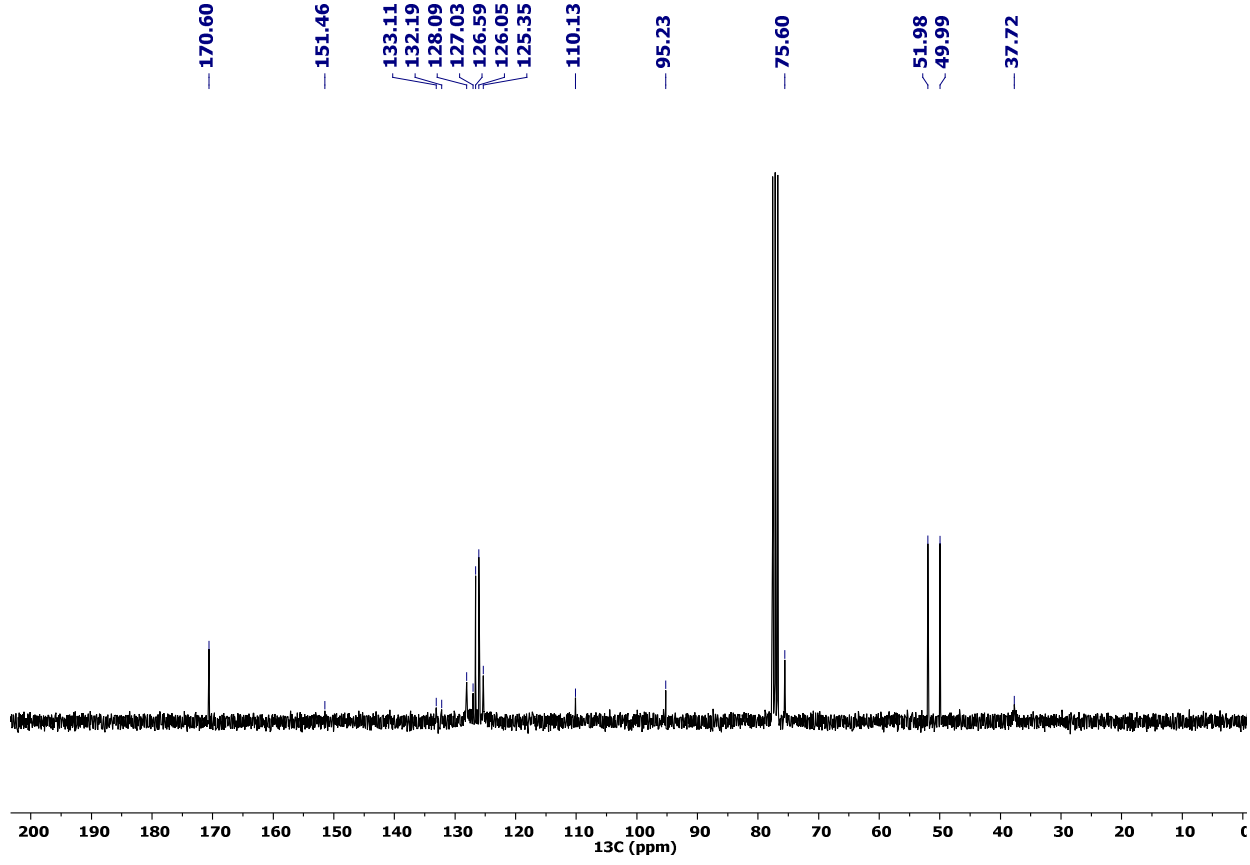

7.66 7.27 7.27 7.26 7.25 7.24 7.24 7.23 7.13 7.13 7.12 7.12 7.12 7.10 6.55 6.52 6.17 6.15 6.14 6.13 5.54 5.53 5.52 5.51 5.50 5.49 5.01 5.00 4.98 4.97 4.95 4.64 2.47 2.45 1.25 1.22 1.21 1.19 1.16
O
OiPr
N
Cl3C
O
O
5a
1.00 1.01 2.02 0.98 0.98 1.01 2.02 1.00 1.95 6.05
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
1H (ppm)

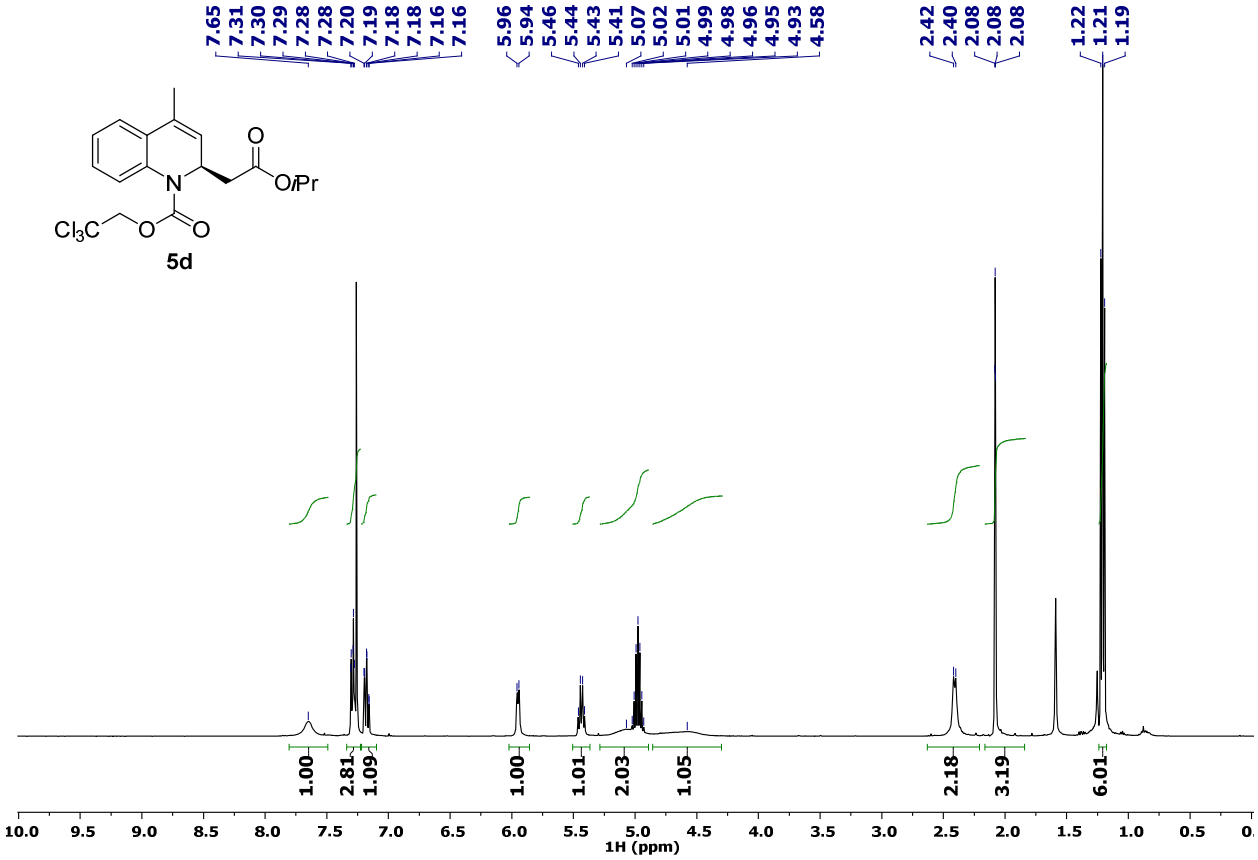

169.63 152.37 128.04 127.14 126.58 125.96 125.34 95.23 75.63 68.34 50.05 38.26 29.85 21.95 21.89
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
13C (ppm)

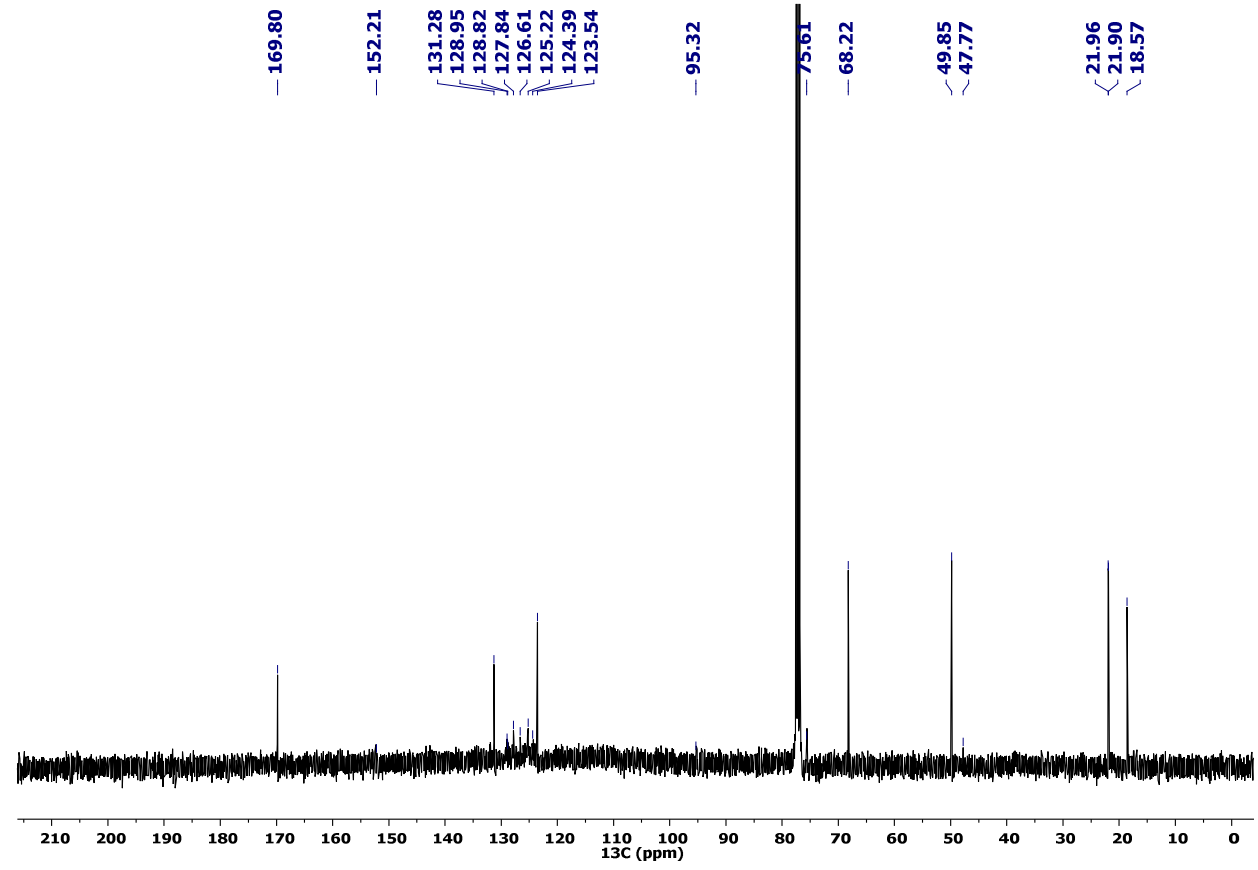

7.65
7.29
7.28
7.25
7.23
7.22
7.21
7.16
7.13
7.12
7.11
7.10
6.55
6.51
6.18
6.16
6.15
6.13
5.52
5.50
5.48
5.45
5.07
4.62
2.42
2.39
1.42
O
OtBu
N
Cl3C
O
O
5b
1.00
1.69
1.96
1.00
1.00
1.01
1.00
1.04
2.13
9.02
1H (ppm)

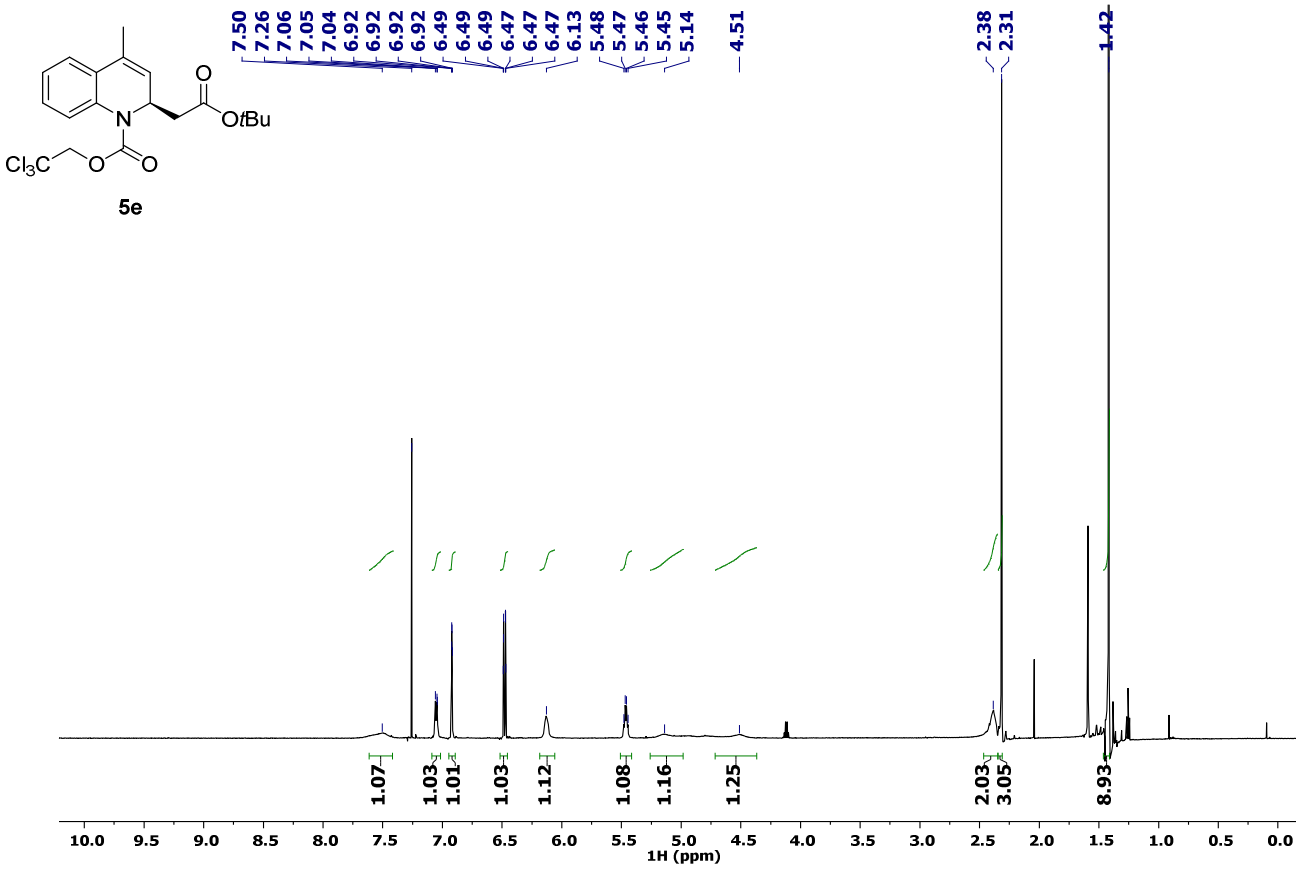

169.34
152.37
130.32
127.97
127.92
127.22
126.54
125.82
125.31
125.28
95.25
81.14
75.58
50.18
39.45
28.15
13C (ppm)


7.66
7.30
7.28
7.27
7.25
7.24
7.23
7.21
7.16
7.13
7.13
7.12
7.10
6.56
6.53
6.17
6.15
6.14
6.12
5.55
5.52
5.50
5.48
5.06
4.67
3.64
2.51
2.49
O
OMe
N
Cl3C
O
O
5c
1.01
1.49
2.00
1.01
1.00
1.06
1.08
1.09
3.12
2.01
1H (ppm)

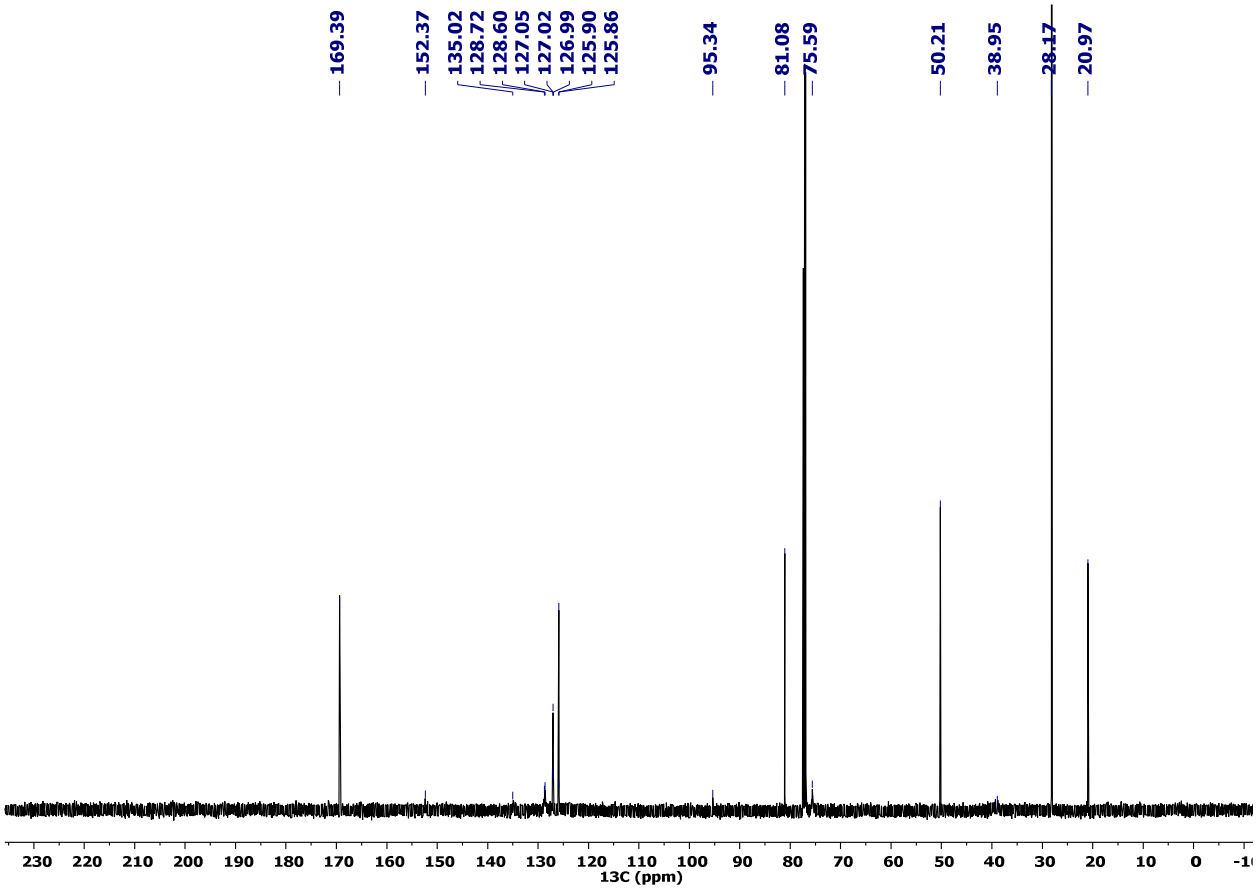

170.60
151.46
133.11
132.19
128.09
127.03
126.59
126.05
125.35
110.13
95.23
75.60
51.98
49.99
37.72
13C (ppm)

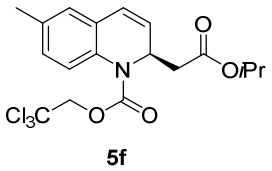

7.65
7.31
7.30
7.29
7.28
7.28
7.20
7.19
7.18
7.18
7.16
7.16
5.96
5.94
5.46
5.44
5.43
5.41
5.07
5.02
5.01
4.99
4.98
4.96
4.95
4.93
4.58
2.42
2.40
2.08
2.08
2.08
1.22
1.21
1.19
O
OiPr
N
Cl3C
O
O
5d
1.00
2.81
1.09
1.00
1.01
2.03
1.05
2.18
3.19
6.01
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)


169.80
152.21
131.28
128.95
128.82
127.84
126.61
125.22
124.39
123.54
95.32
75.61
68.22
49.85
47.77
21.96
21.90
18.57
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
13C (ppm)


7.50
7.26
7.06
7.05
7.04
6.92
6.92
6.92
6.92
6.49
6.49
6.49
6.47
6.47
6.47
6.13
5.48
5.47
5.46
5.45
5.14
4.51
2.38
2.31
1.42
1.07
1.03
1.01
1.03
1.12
1.08
1.16
1.25
2.03
3.05
8.93
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
1H (ppm)
O
OtBu
N
Cl3C
O
O

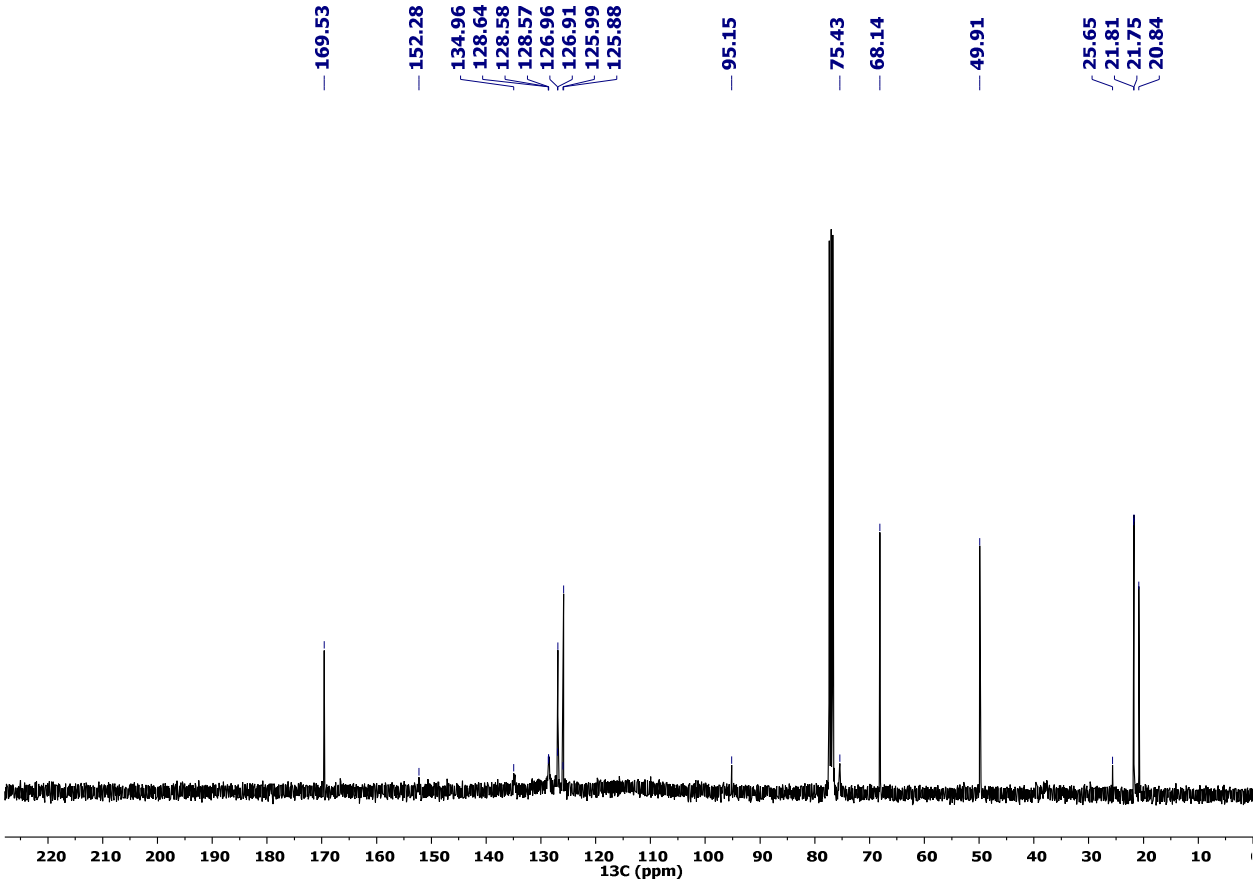
5e

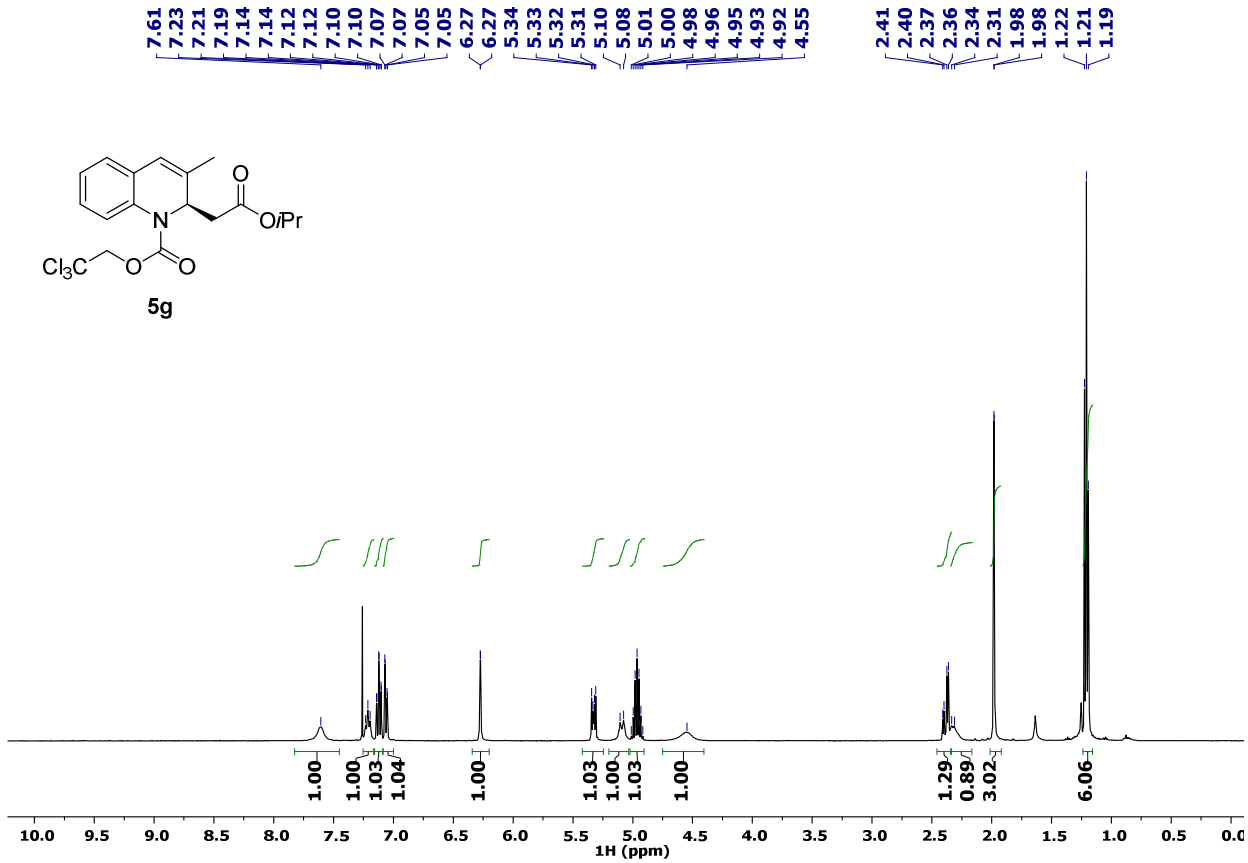

169.39
152.37
135.02
128.72
128.60
127.05
127.02
126.99
125.90
125.86
95.34
81.08
75.59
50.21
38.95
28.17
20.97
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
13C (ppm)

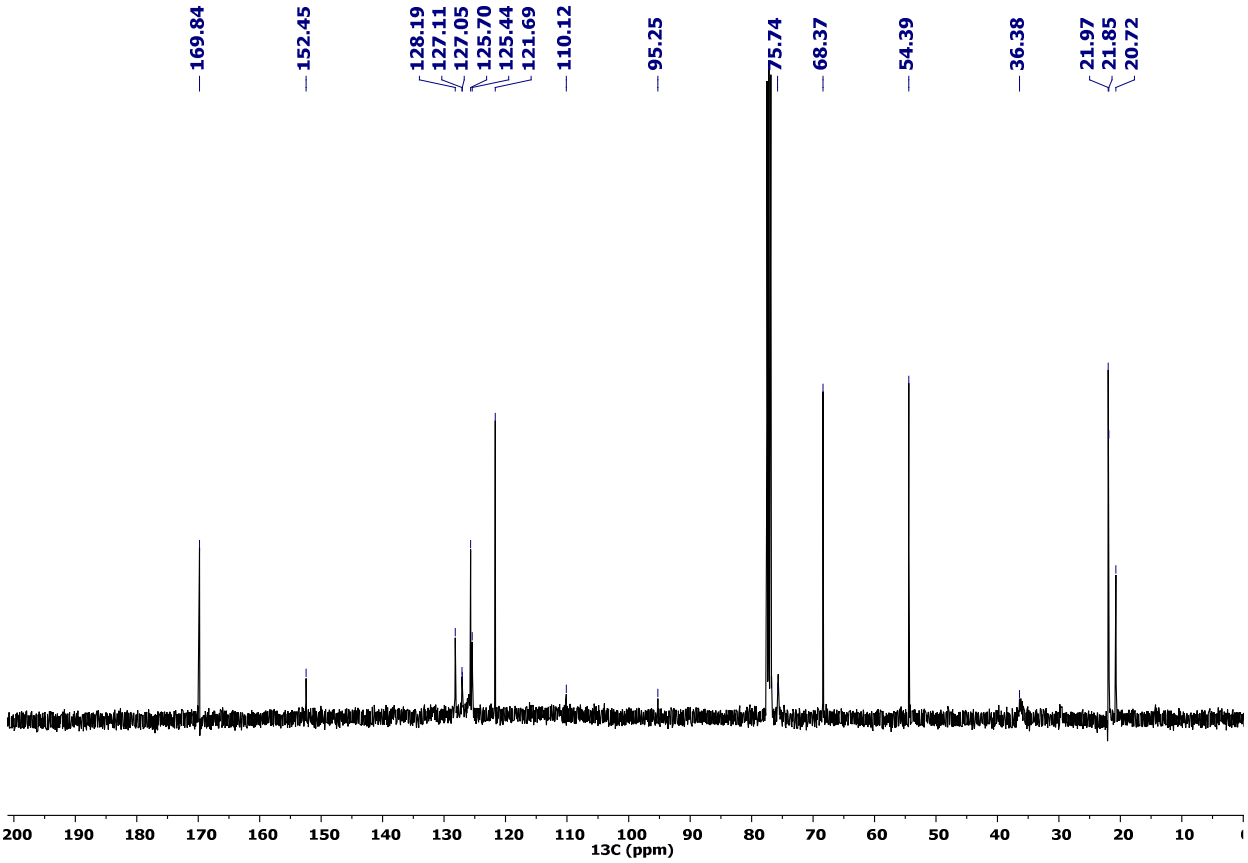

O
OiPr
N
Cl3C
O
O

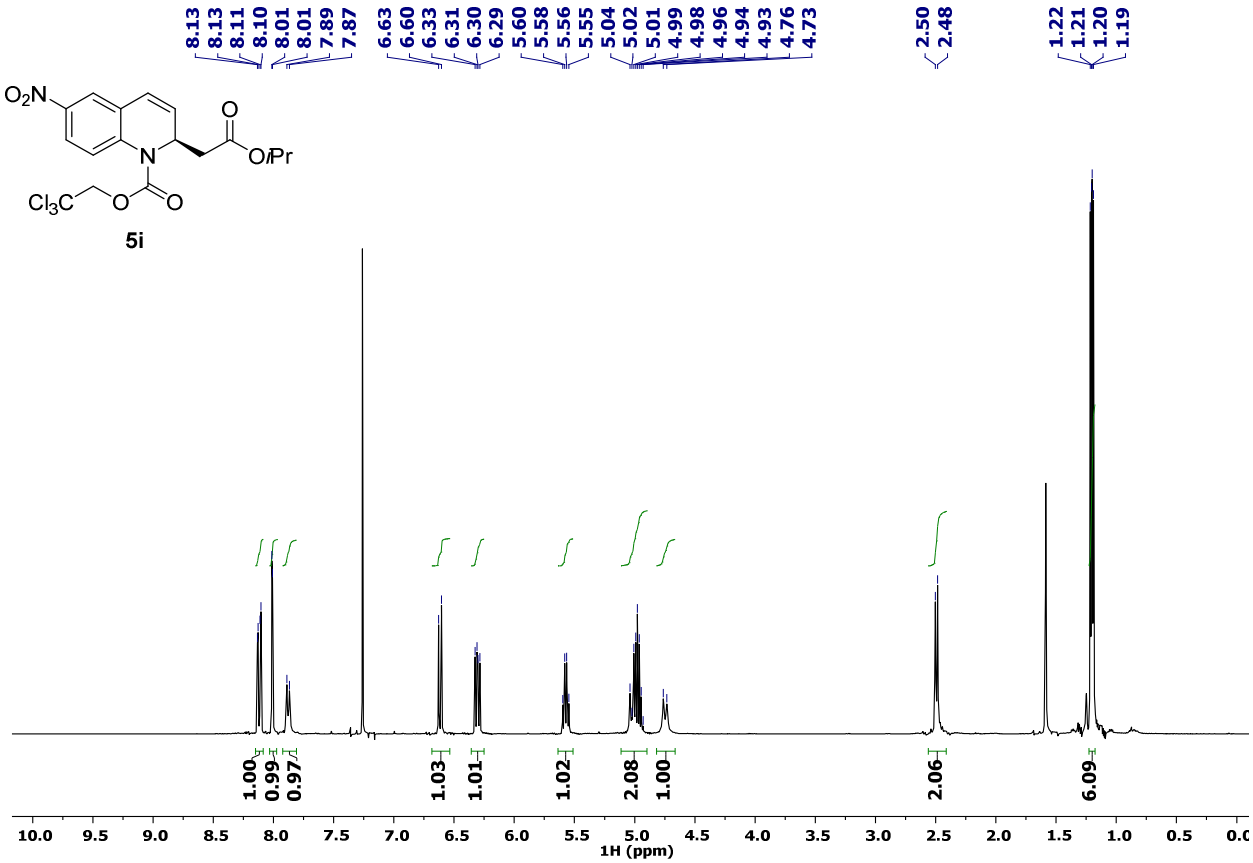
5f

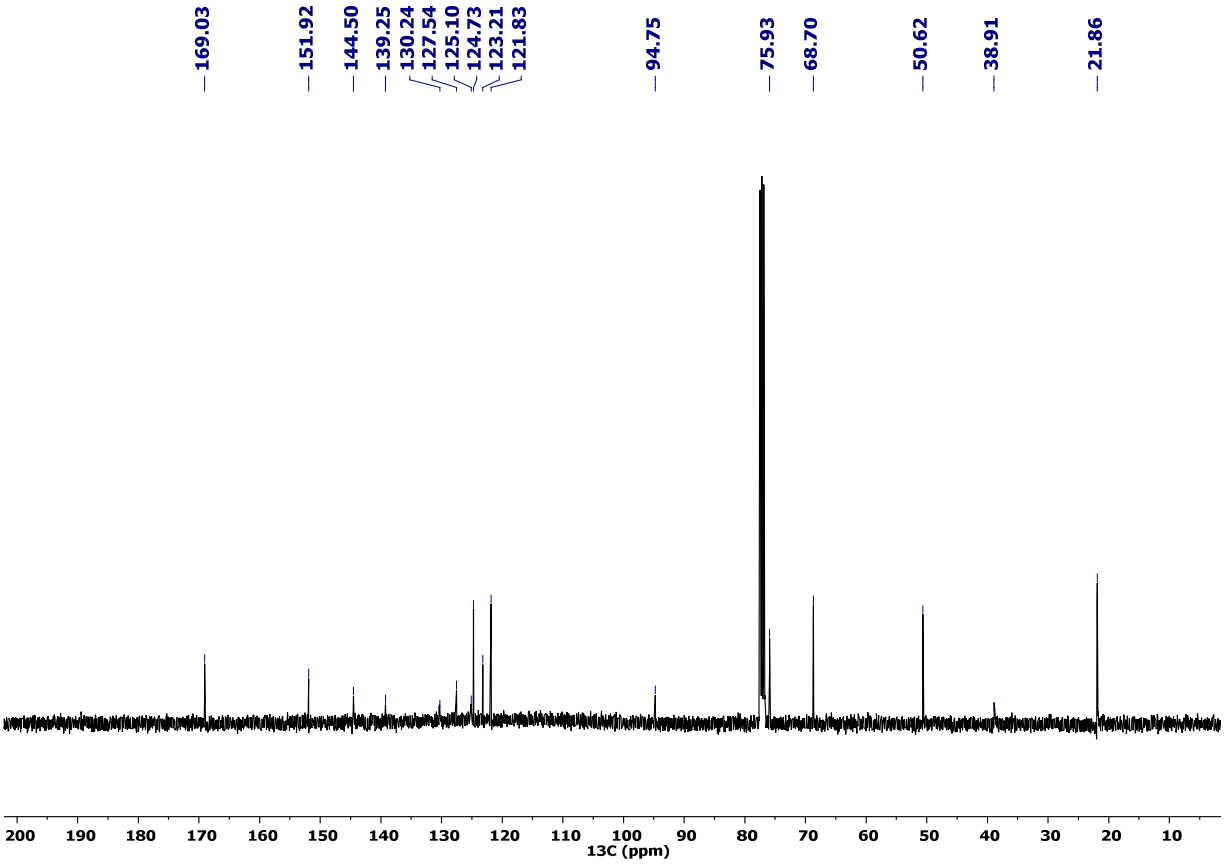
7.52
7.07
7.07
7.05
6.93
6.50
6.48
6.15
6.13
6.11
5.52
5.50
5.48
5.47
5.03
5.01
4.99
4.98
4.96
4.95
4.93
2.44
2.32
1.22
1.21
1.19
1.00
1.04
1.02
1.02
1.02
1.02
3.15
2.06
3.06
3.89
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
1H (ppm)

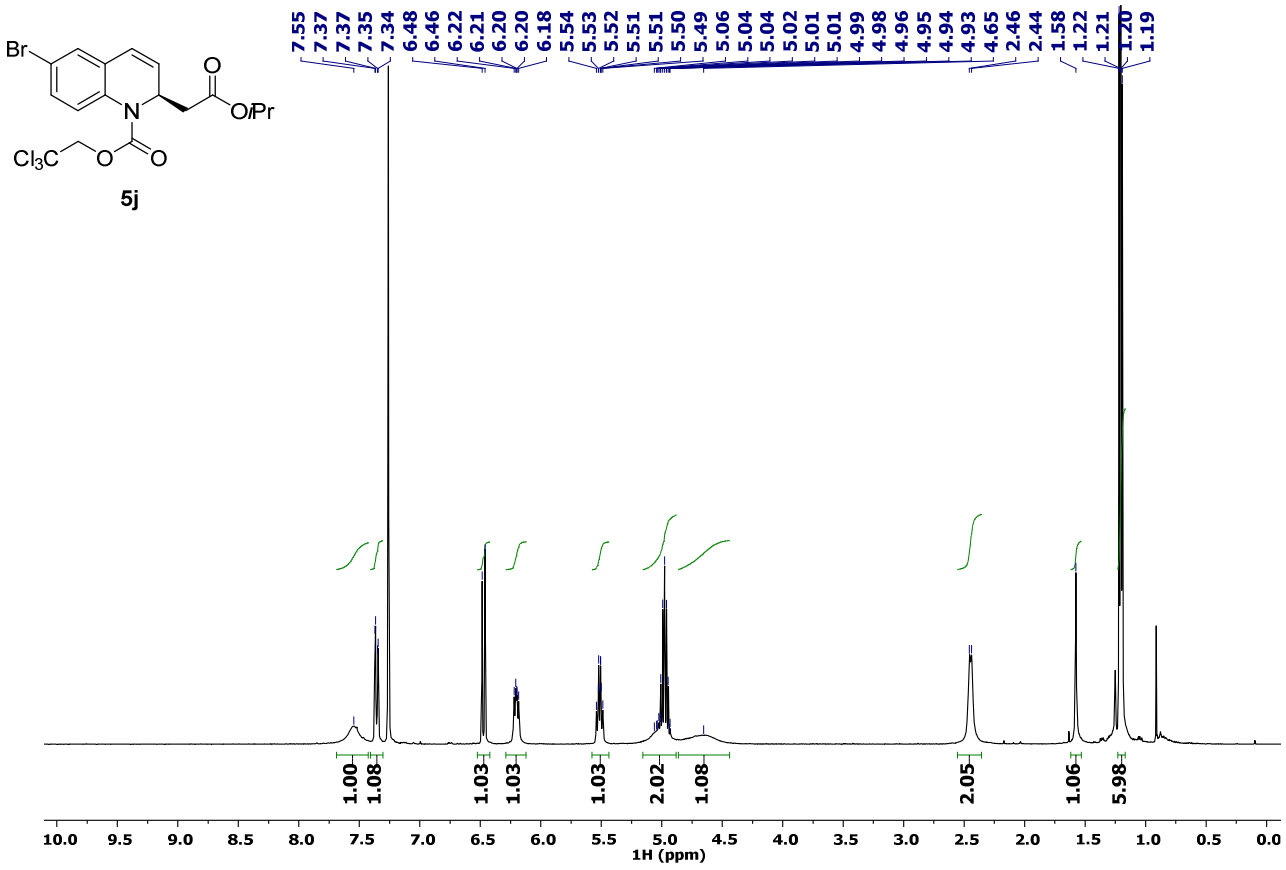

169.53
152.28
134.96
128.64
128.58
128.57
126.96
126.91
125.99
125.88
95.15
75.43
68.14
49.91
25.65
21.81
21.75
20.84
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
13C (ppm)

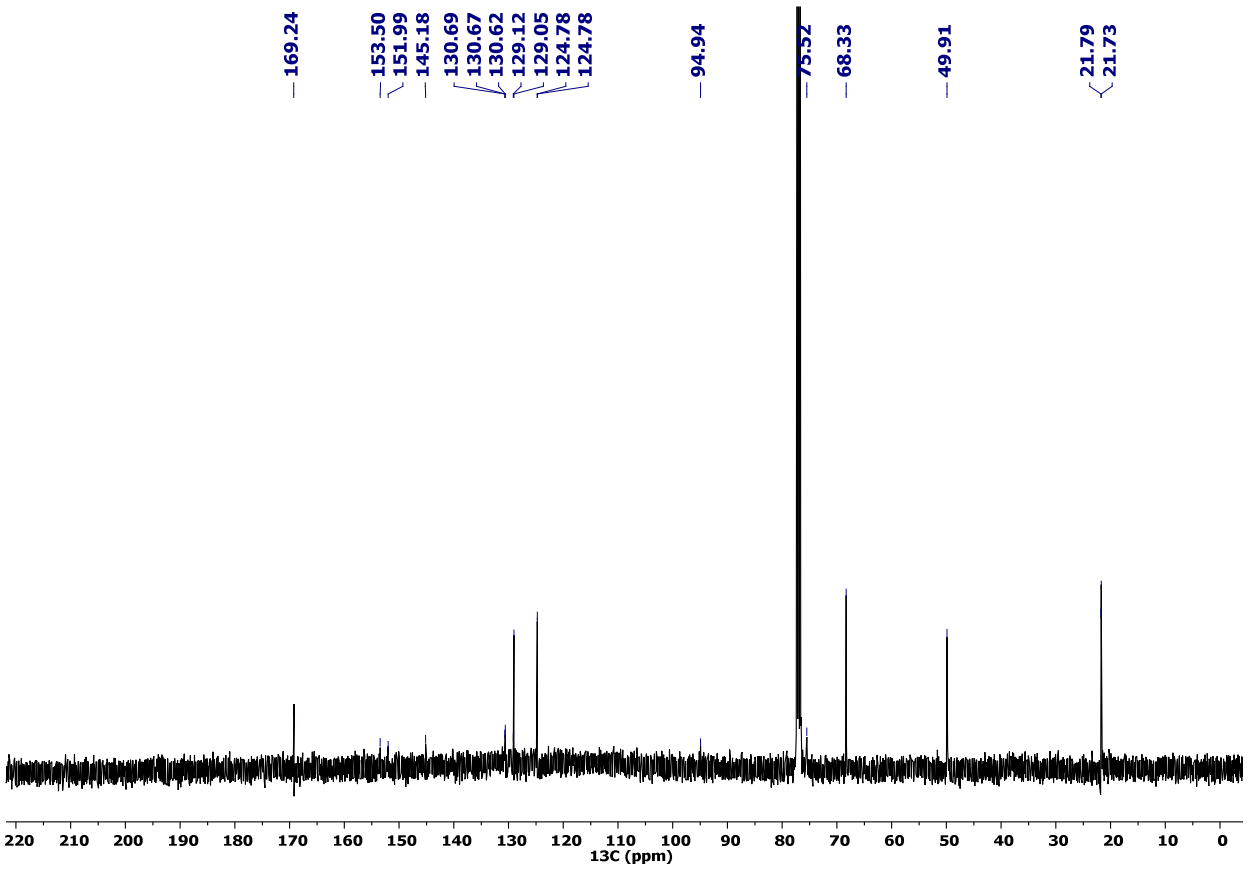

7.61 7.23 7.21 7.19 7.14 7.14 7.12 7.12 7.10 7.10 7.07 7.07 7.05 7.05 6.27 5.34 5.33 5.32 5.31 5.10 5.08 5.01 5.00 4.98 4.96 4.95 4.93 4.92 4.55
2.41 2.40 2.37 2.36 2.34 2.31 1.98 1.98 1.22 1.21 1.19
O
OiPr
N
Cl3C
O
O
5g
1.00 1.00 1.03 1.04 1.00 1.03 1.00 1.03 1.00 1.29 0.89 3.02 6.06
10.0 9.5 9.0 8.5 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
1H (ppm)

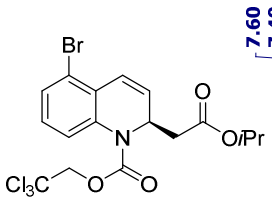

169.84 152.45 128.19 127.11 127.05 125.70 125.44 121.69 110.12 95.25 75.74 68.37 54.39 36.38 21.97 21.85 20.72
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
13C (ppm)


8.13
8.13
8.11
8.10
8.01
8.01
7.89
7.87
6.63
6.60
6.33
6.31
6.30
6.29
5.60
5.58
5.56
5.55
5.04
5.02
5.01
4.99
4.98
4.96
4.94
4.93
4.76
4.73
2.50
2.48
1.22
1.21
1.20
1.19
O2N
O
OiPr
N
Cl3C
O
O
5i
1.00
0.99
0.97
1.03
1.01
1.02
2.08
1.00
2.06
6.09
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
1H (ppm)


169.03
151.92
144.50
139.25
130.24
127.54
125.10
124.73
123.21
121.83
94.75
75.93
68.70
50.62
38.91
21.86
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
13C (ppm)

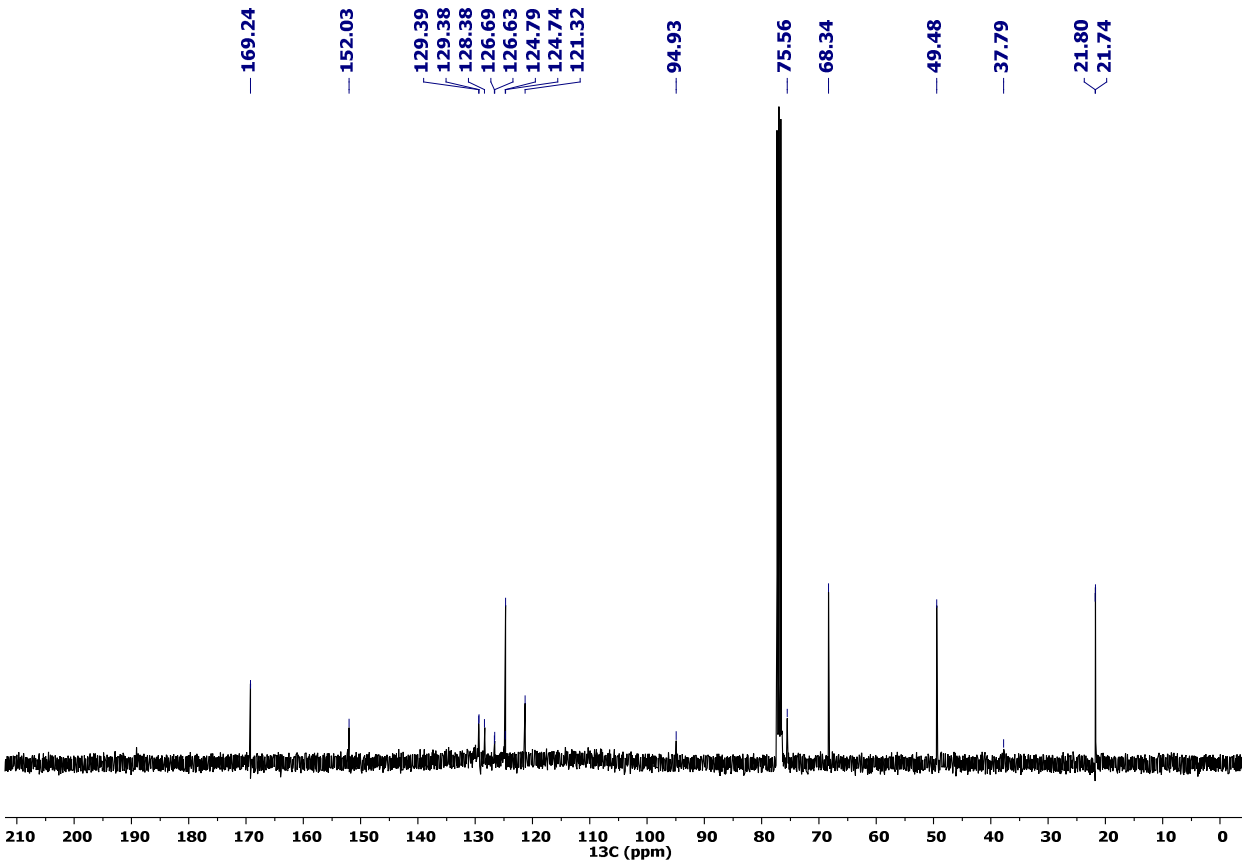

Br
O
OiPr
N
Cl3C
O
O
5j
7.55 7.37 7.37 7.35 7.34 6.48 6.46 6.22 6.21 6.20 6.20 6.18 5.54 5.53 5.52 5.51 5.51 5.50 5.49 5.06 5.04 5.04 5.02 5.01 5.01 4.99 4.98 4.96 4.95 4.94 4.93 4.65 2.46 2.44 1.58 1.22 1.21 1.20 1.19
1.00 1.08 1.03 1.03 1.03 2.02 1.08 2.05 1.06 5.98
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 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
1H (ppm)

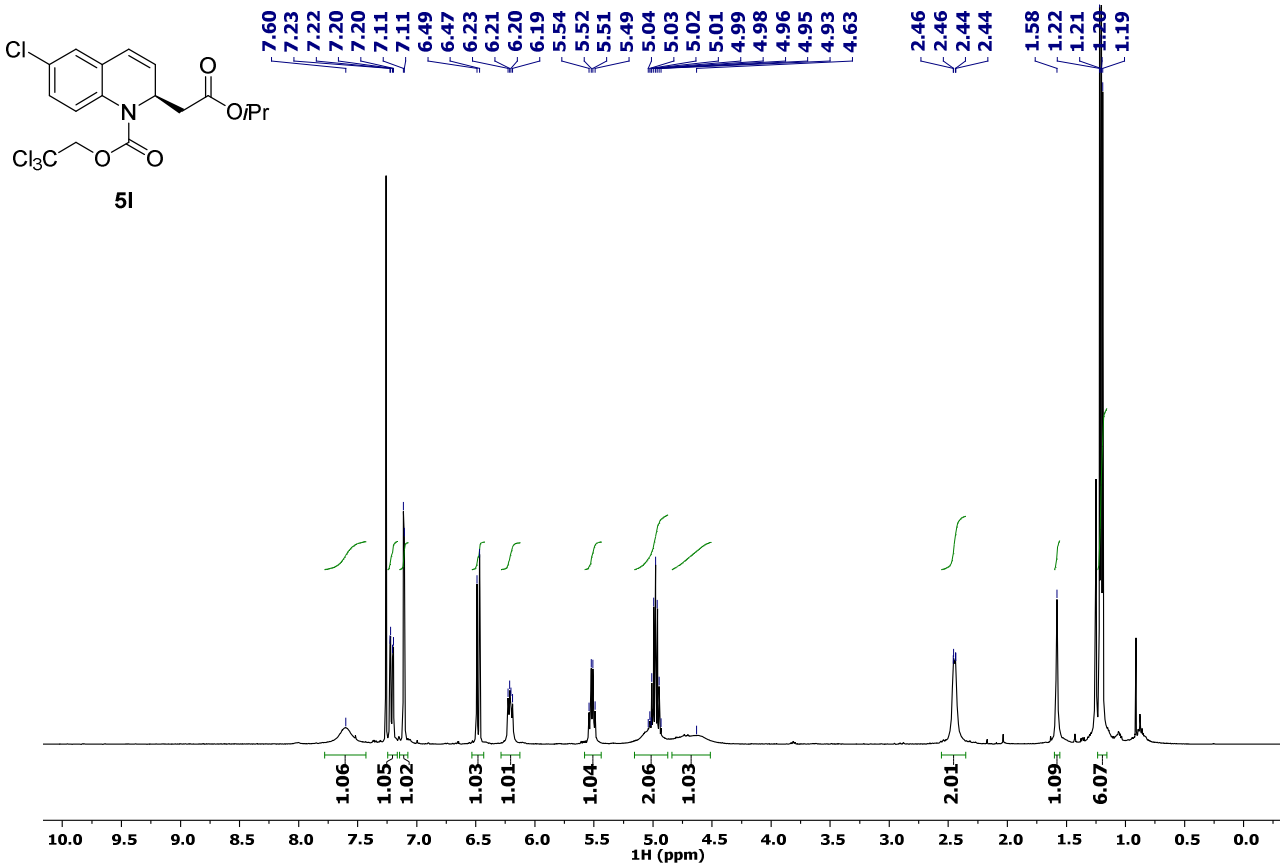

169.24 153.50 151.99 145.18 130.69 130.67 130.62 129.12 129.05 124.78 124.78 94.94 75.52 68.33 49.91 21.79 21.73
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
13C (ppm)

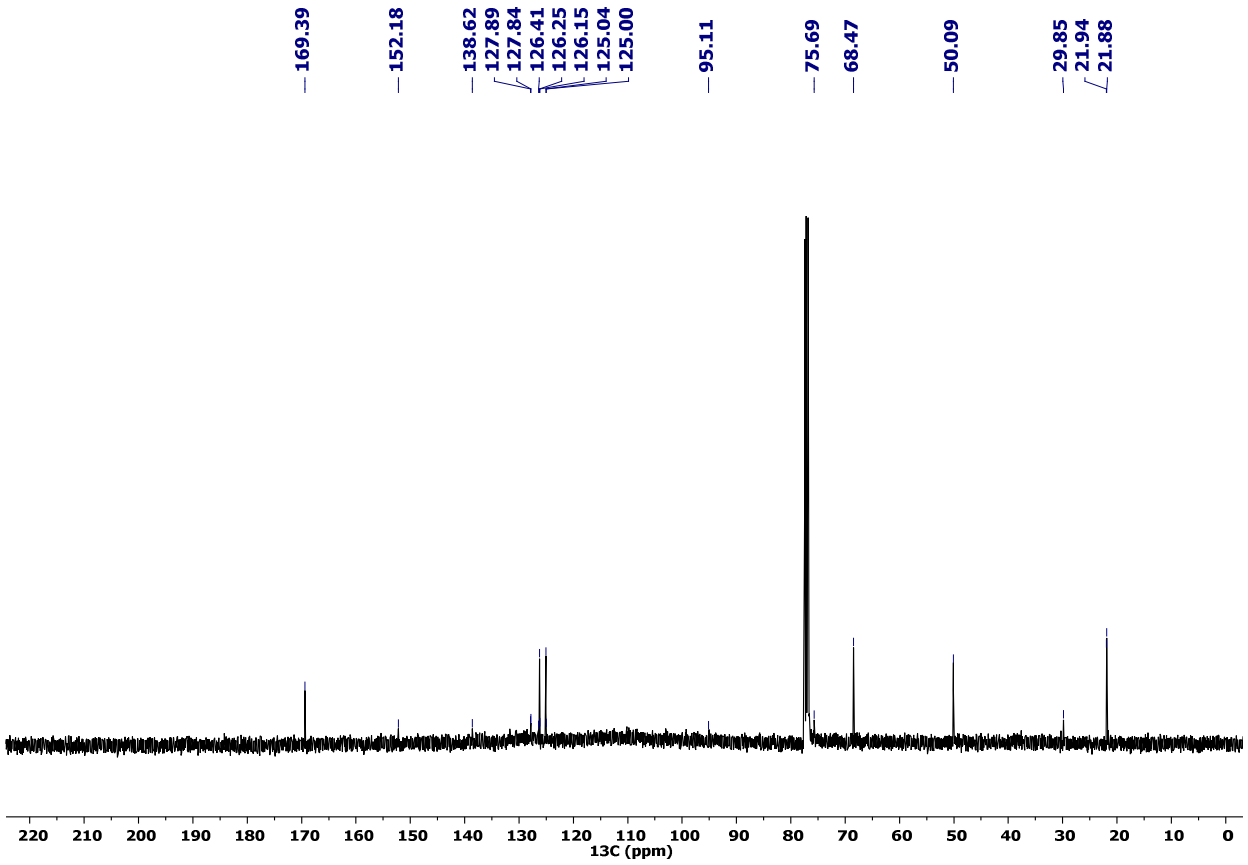

Br
O
O/Pr
N
Cl3C
O
O

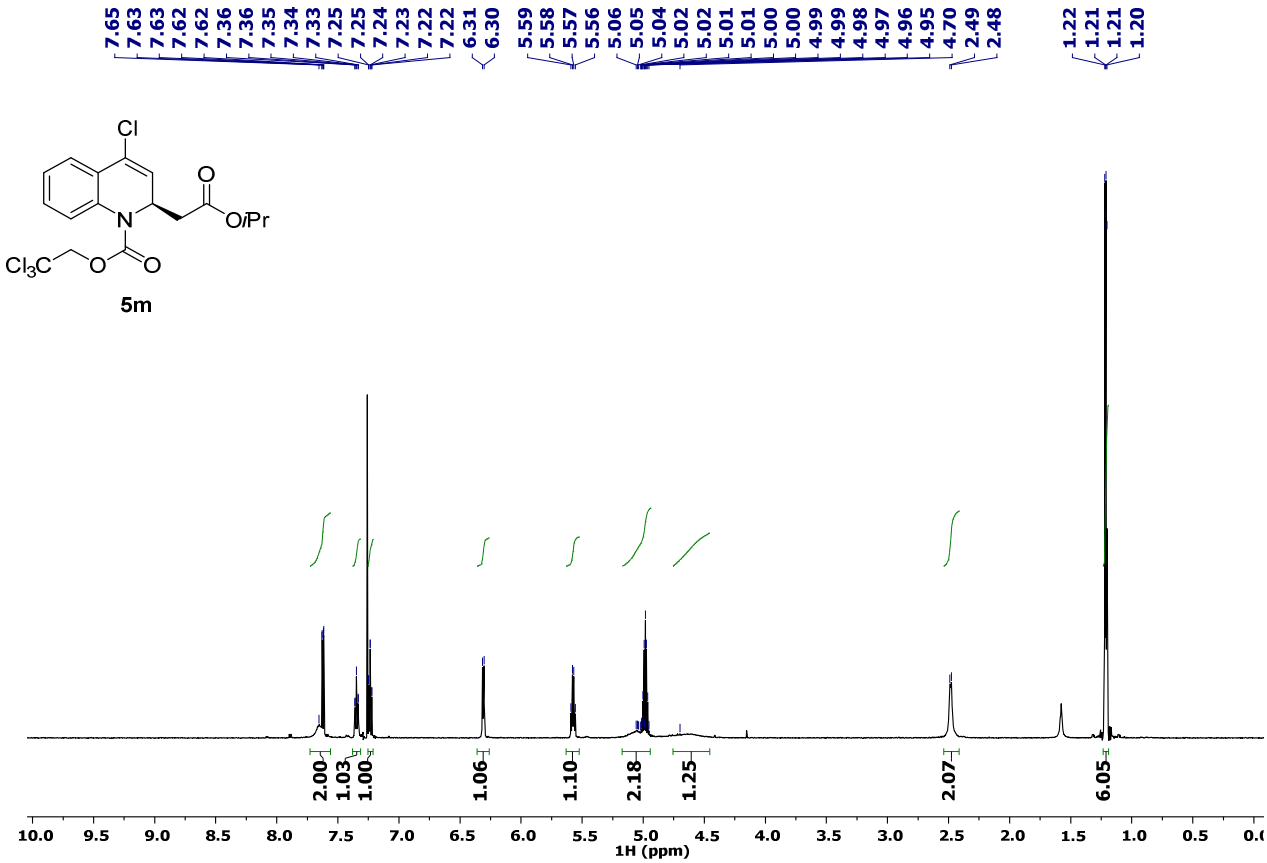
5k

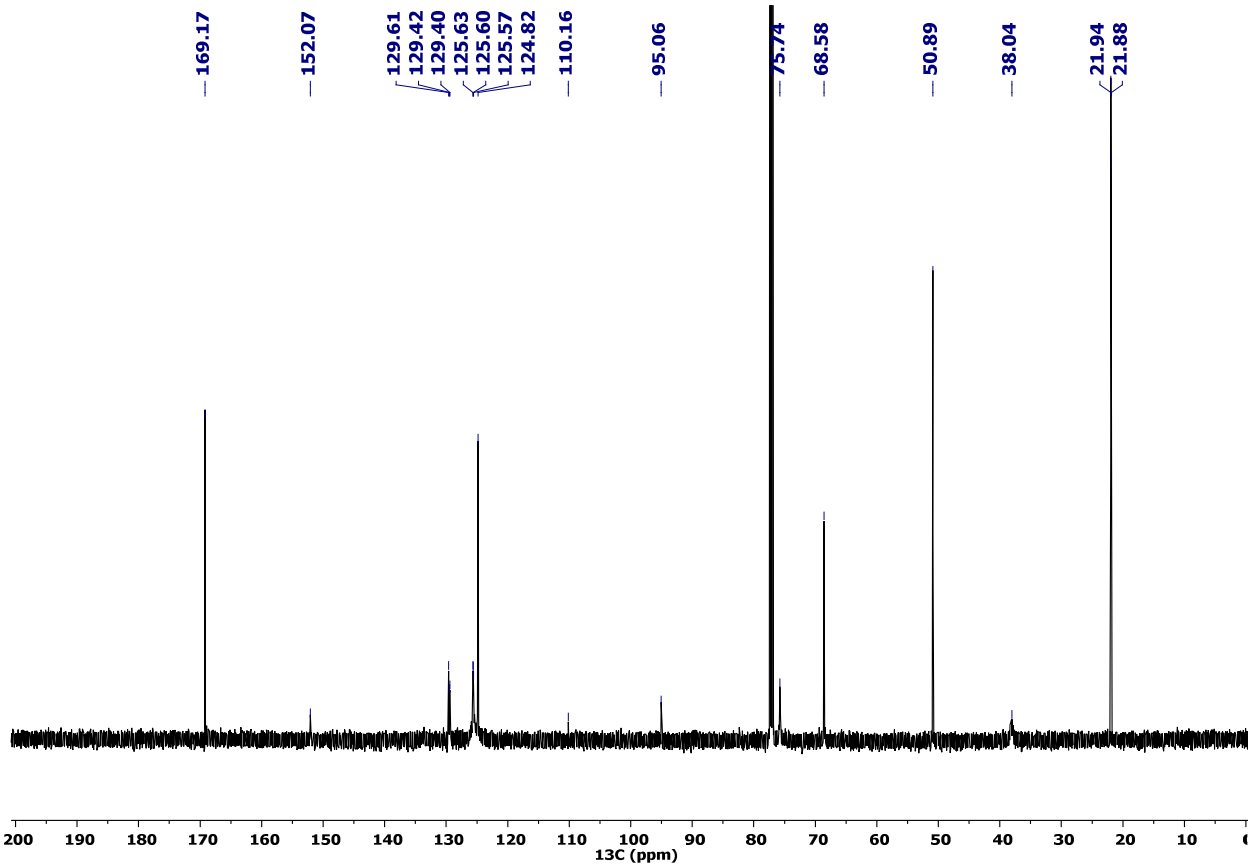
7.60
7.40
7.39
7.38
7.37
7.13
7.11
7.09
6.93
6.91
6.30
6.28
6.27
6.26
5.55
5.54
5.52
5.50
5.04
5.03
5.02
5.02
5.00
4.98
4.97
4.95
4.64
2.45
2.43
1.60
1.22
1.22
1.21
1.20
0.97
1.05
1.02
0.96
0.99
1.02
2.05
1.01
2.00
0.98
5.90
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
1H (ppm)

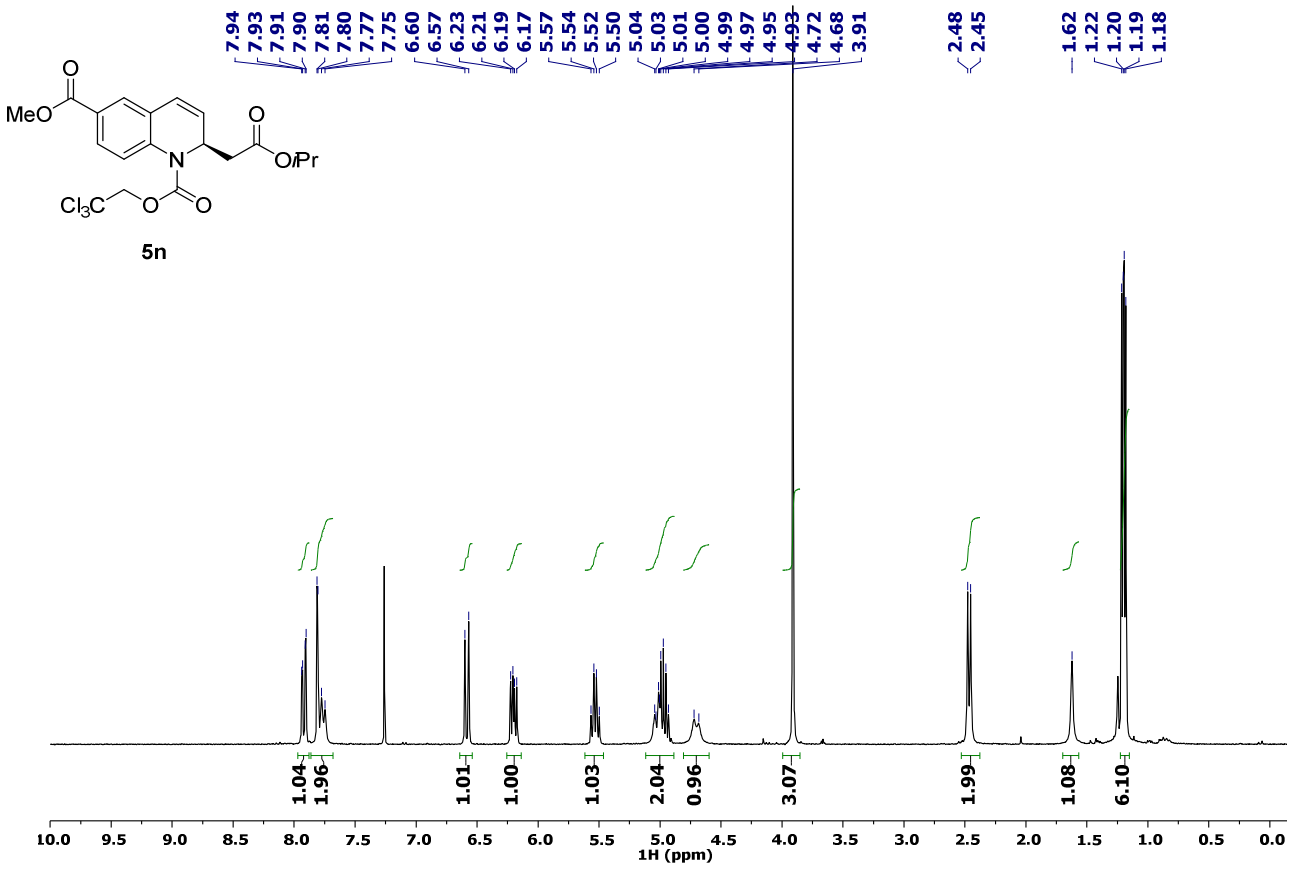

169.24
152.03
129.39
129.38
128.38
126.69
126.63
124.79
124.74
121.32
94.93
75.56
68.34
49.48
37.79
21.80
21.74
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
13C (ppm)


Cl
O
OiPr
N
Cl3C
O
O
5l
7.60 7.23 7.22 7.20 7.20 7.11 7.11 6.49 6.47 6.23 6.21 6.20 6.19 5.54 5.52 5.51 5.49 5.04 5.03 5.02 5.01 4.99 4.98 4.96 4.95 4.93 4.63
2.46 2.46 2.44 2.44
1.58 1.22 1.21 1.20 1.19
1.06 1.05 1.02 1.03 1.01 1.04 2.06 1.03 2.01 1.09 6.07
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
1H (ppm)

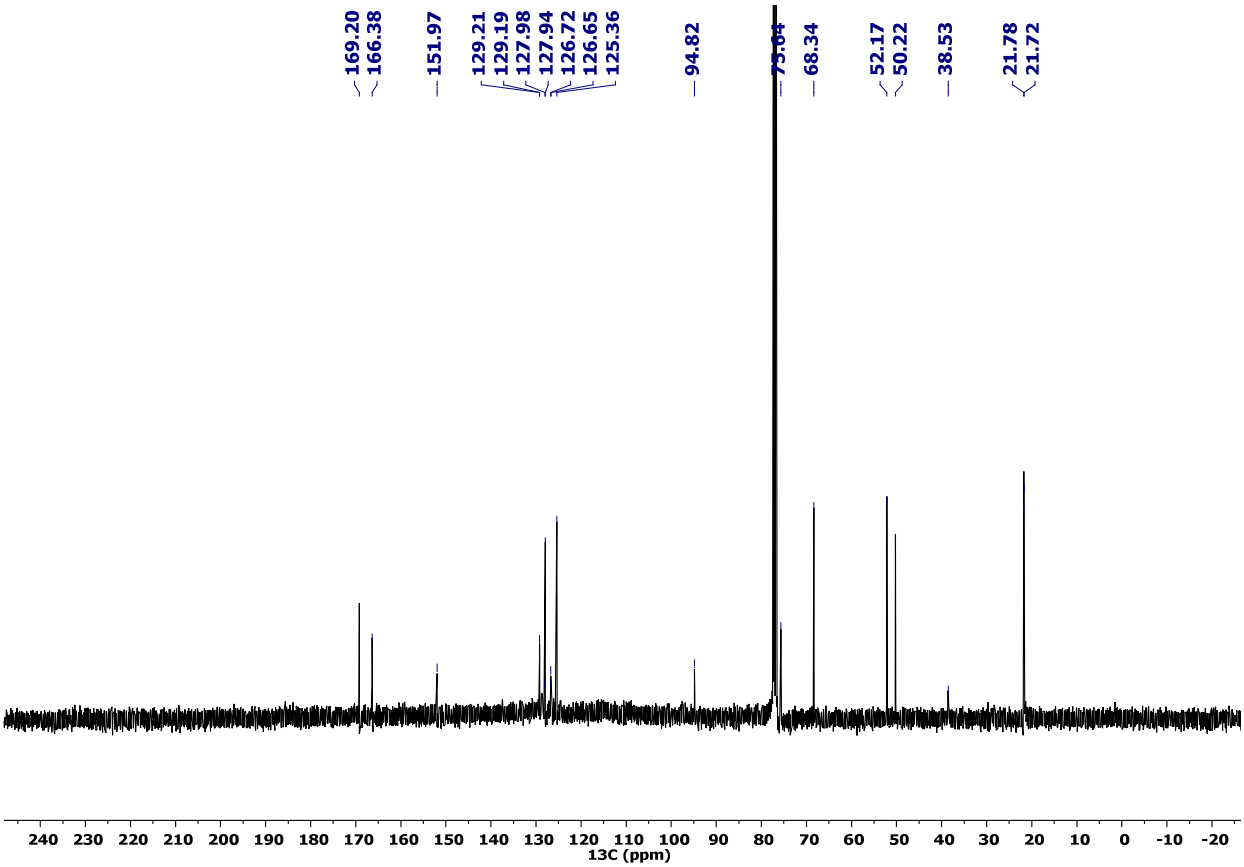

169.39
152.18
138.62
127.89
127.84
126.41
126.25
126.15
125.04
125.00
95.11
75.69
68.47
50.09
29.85
21.94
21.88
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
13C (ppm)

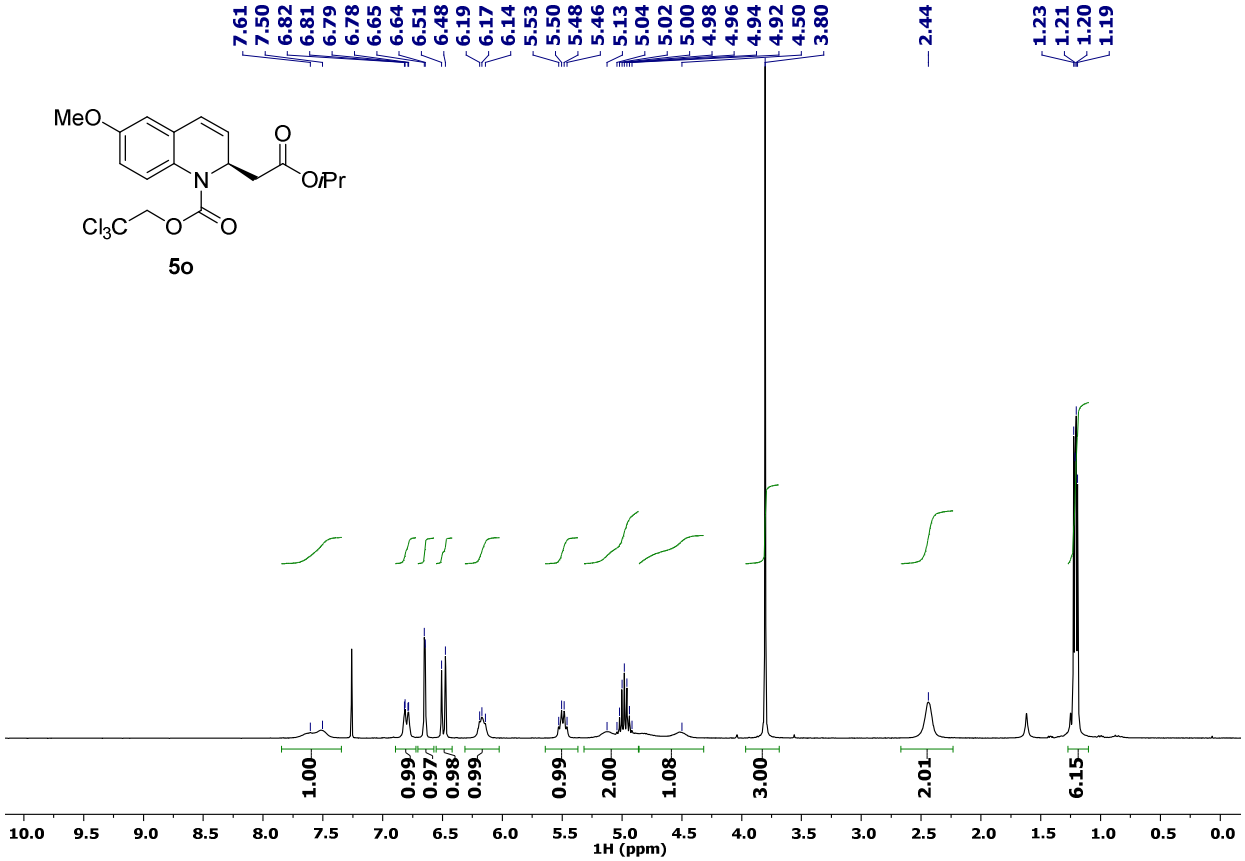

7.65 7.63 7.63 7.62 7.62 7.36 7.35 7.34 7.33 7.25 7.25 7.24 7.23 7.22 7.22 6.31 6.30 5.59 5.58 5.57 5.56 5.06 5.05 5.04 5.02 5.02 5.01 5.01 5.00 5.00 4.99 4.99 4.98 4.97 4.96 4.95 4.70 2.49 2.48 1.22 1.21 1.21 1.20
Cl
O
N
O
O
O
O
Cl3C
5m
2.00 1.03 1.00 1.06 1.10 2.18 1.25 2.07 6.05
10.0 9.5 9.0 8.5 8.0 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
1H (ppm)

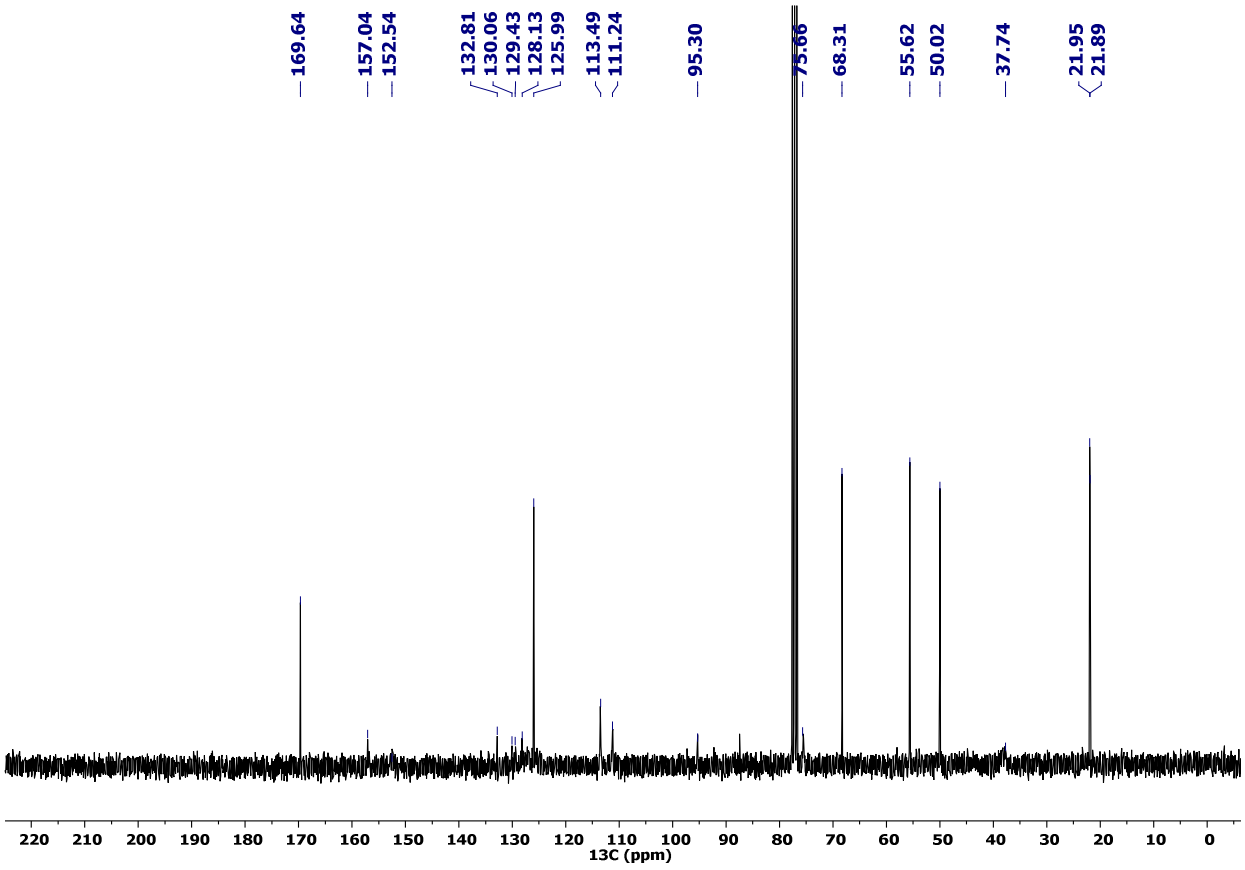

169.17 152.07 129.61 129.42 129.40 125.63 125.60 125.57 124.82 110.16 95.06 75.74 68.58 50.89 38.04 21.94 21.88
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
13C (ppm)

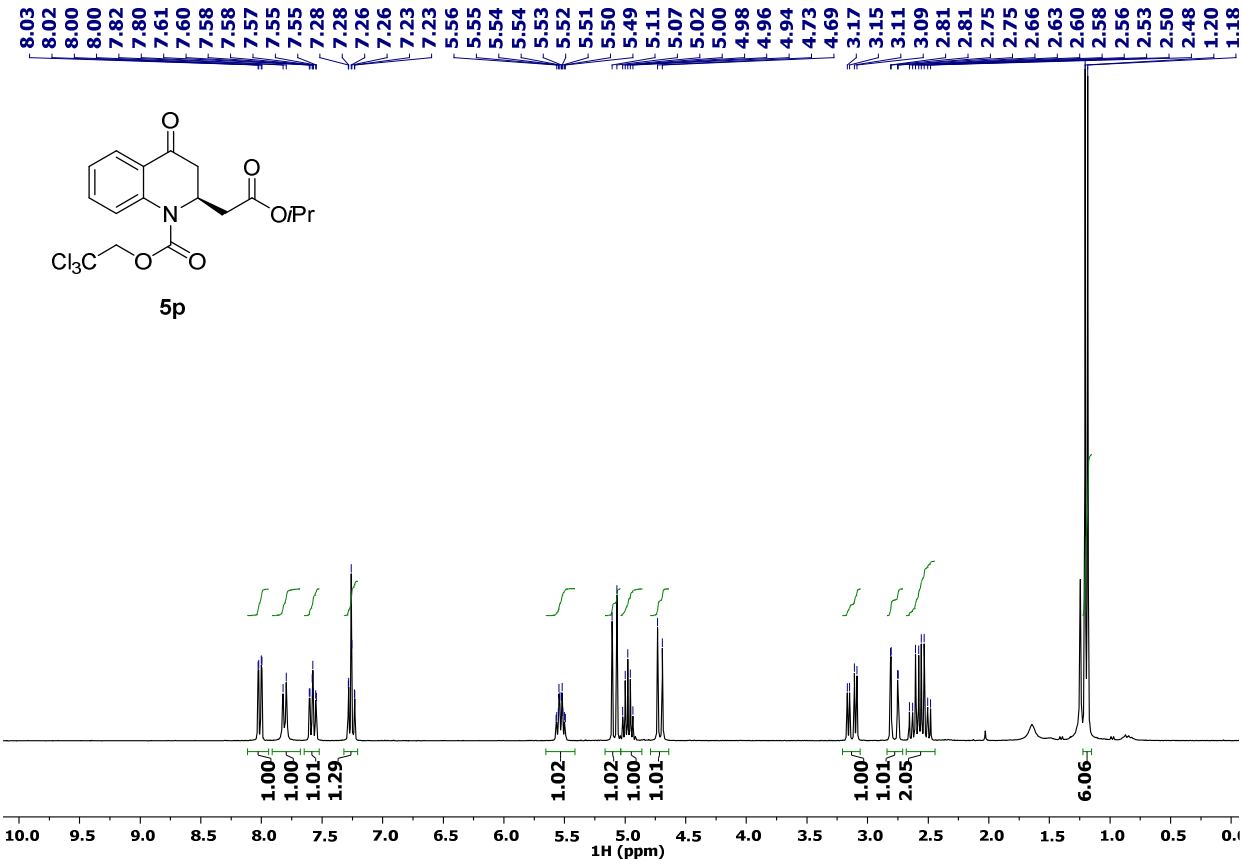

7.94
7.93
7.91
7.90
7.81
7.80
7.77
7.75
6.60
6.57
6.23
6.21
6.19
6.17
5.57
5.54
5.52
5.50
5.04
5.03
5.01
5.00
4.99
4.97
4.95
4.93
4.72
4.68
3.91
2.48
2.45
1.62
1.22
1.20
1.19
1.18
MeO
O
O
OiPr
N
Cl3C
O
O
1.04
1.96
1.01
1.00
1.03
2.04
0.96
3.07
1.99
1.08
6.10
1H (ppm)

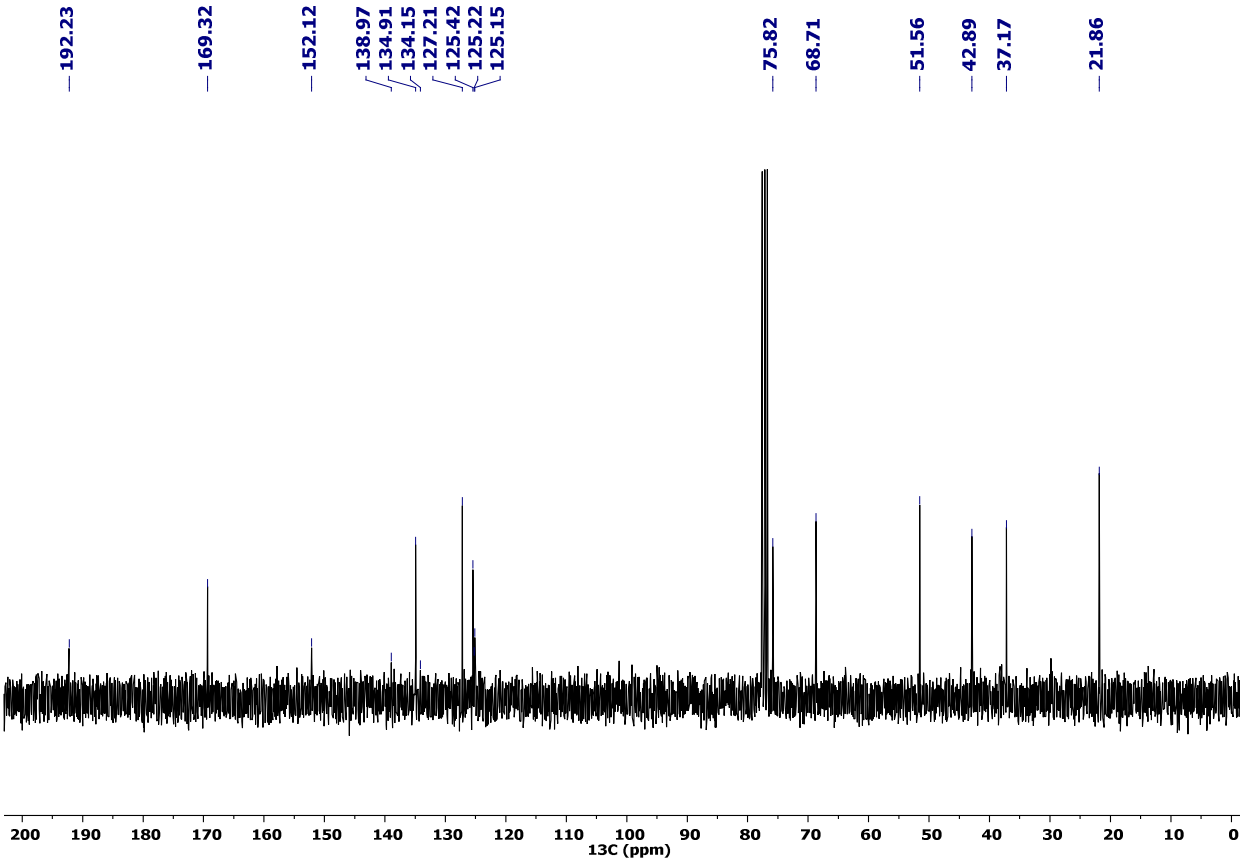
5n

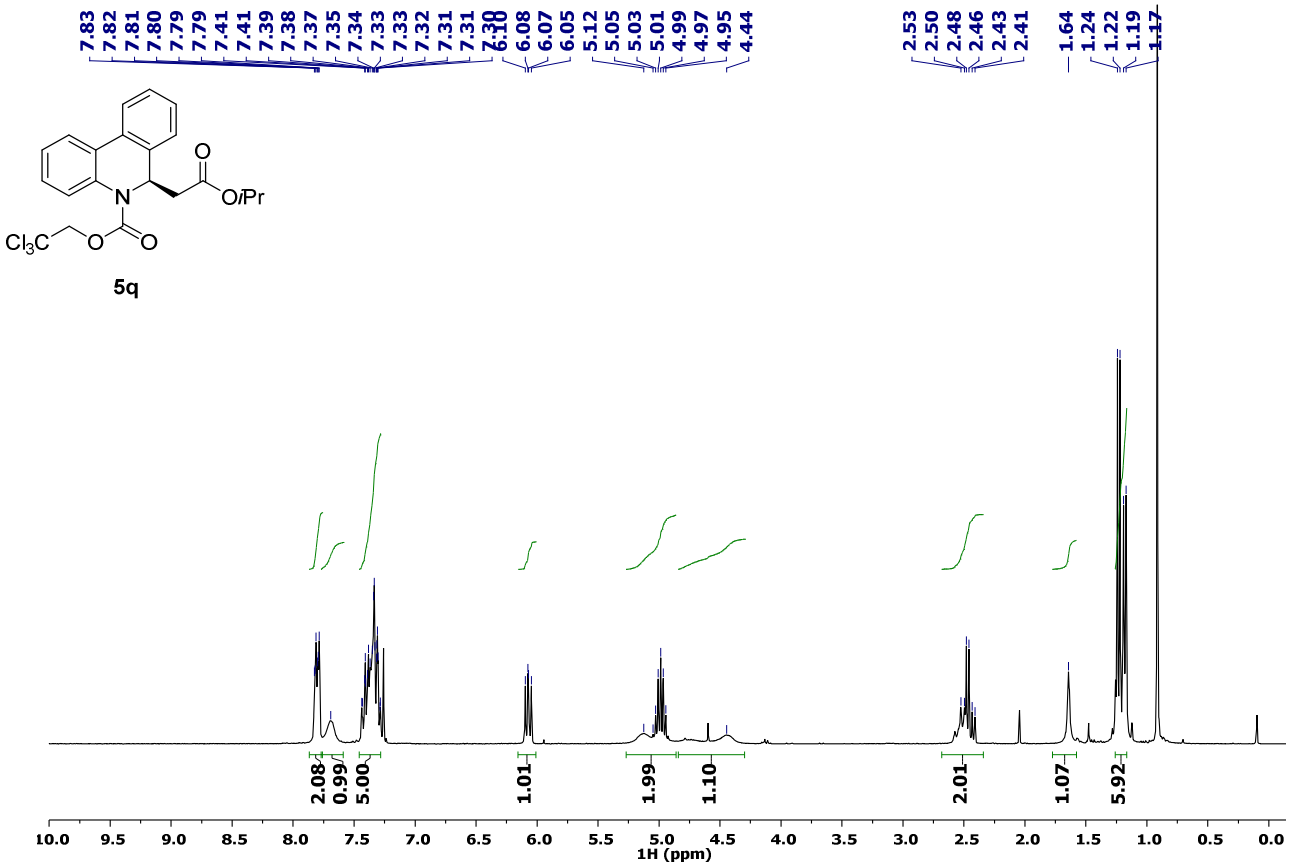

169.20
166.38
151.97
129.21
129.19
127.98
127.94
126.72
126.65
125.36
94.82
75.04
68.34
52.17
50.22
38.53
21.78
21.72
13C (ppm)


7.61
7.50
6.82
6.81
6.79
6.78
6.65
6.64
6.51
6.48
6.19
6.17
6.14
5.53
5.50
5.48
5.46
5.13
5.04
5.02
5.00
4.98
4.96
4.94
4.92
4.50
3.80
2.44
1.23
1.21
1.20
1.19
MeO
O
O/Pr
N
Cl3C
O
O
5o
1.00
0.99
0.97
0.98
0.99
0.99
2.00
1.08
3.00
2.01
6.15
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
1H (ppm)


169.64
157.04
152.54
132.81
130.06
129.43
128.13
125.99
113.49
111.24
95.30
75.66
68.31
55.62
50.02
37.74
21.95
21.89
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
13C (ppm)


8.03 8.02 8.00 8.00 7.82 7.80 7.61 7.60 7.58 7.58 7.57 7.55 7.55 7.28 7.28 7.26 7.26 7.23 7.23 5.56 5.55 5.54 5.54 5.53 5.52 5.51 5.50 5.49 5.11 5.07 5.02 5.00 4.98 4.96 4.94 4.73 4.69 3.17 3.15 3.11 3.09 2.81 2.81 2.75 2.66 2.63 2.60 2.58 2.56 2.53 2.50 2.48 1.20 1.18
O
O
N
O/Pr
Cl3C
O
O
5p
1.00 1.00 1.01 1.29 1.02 1.02 1.00 1.01 1.00 1.01 2.05 6.06
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
1H (ppm)


192.23 169.32 152.12 138.97 134.91 134.15 127.21 125.42 125.22 125.15 75.82 68.71 51.56 42.89 37.17 21.86
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
13C (ppm)


7.83
7.82
7.81
7.80
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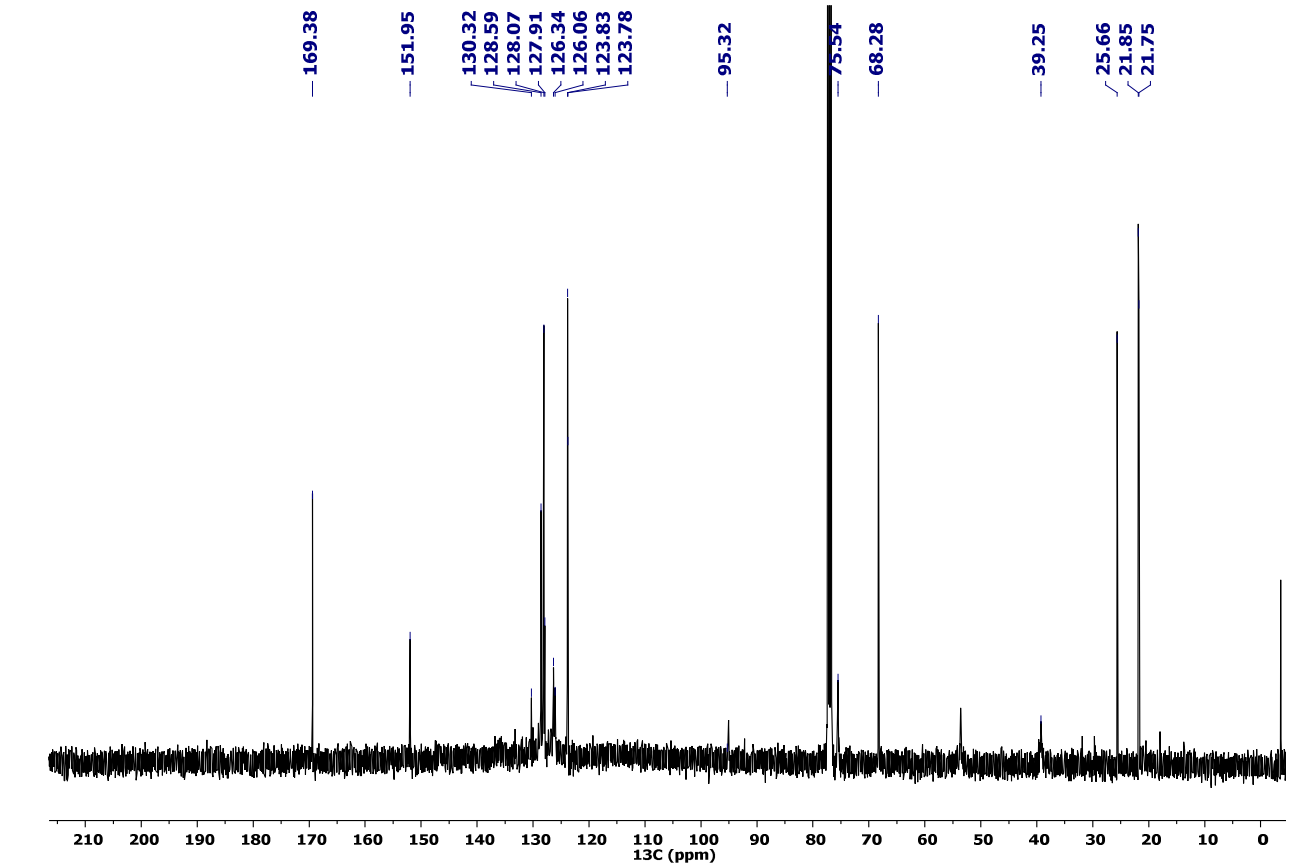
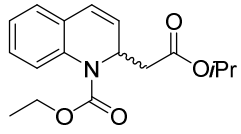
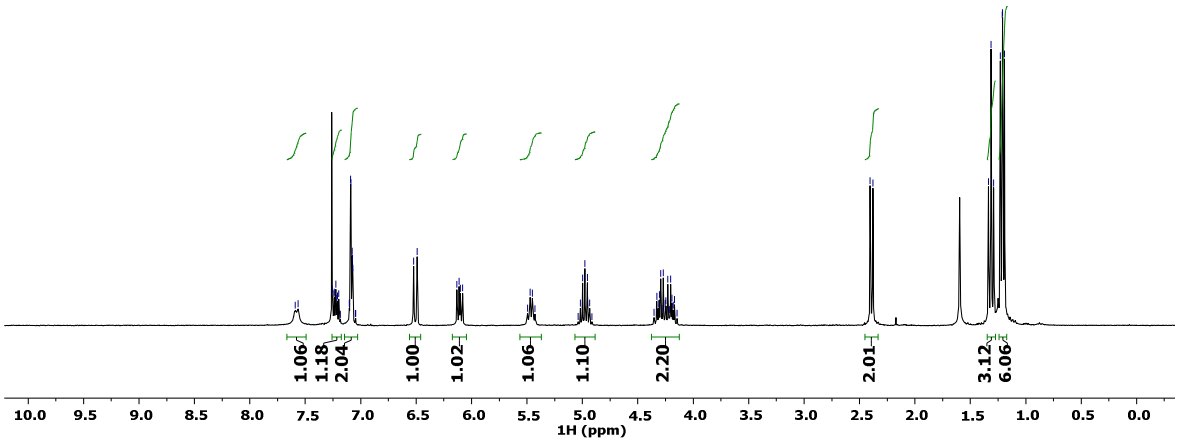
7.79
7.41
7.41
7.39
7.38
7.37
7.35
7.34
7.33
7.33
7.32
7.31
7.31
7.30
6.10
6.08
6.07
6.05
5.12
5.05
5.03
5.01
4.99
4.97
4.95
4.44
2.53
2.50
2.48
2.46
2.43
2.41
1.64
1.24
1.22
1.19
1.17
O
O/Pr
N
Cl3C
O
O
5q
2.08
0.99
5.00
1.01
1.99
1.10
2.01
1.07
5.92
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)

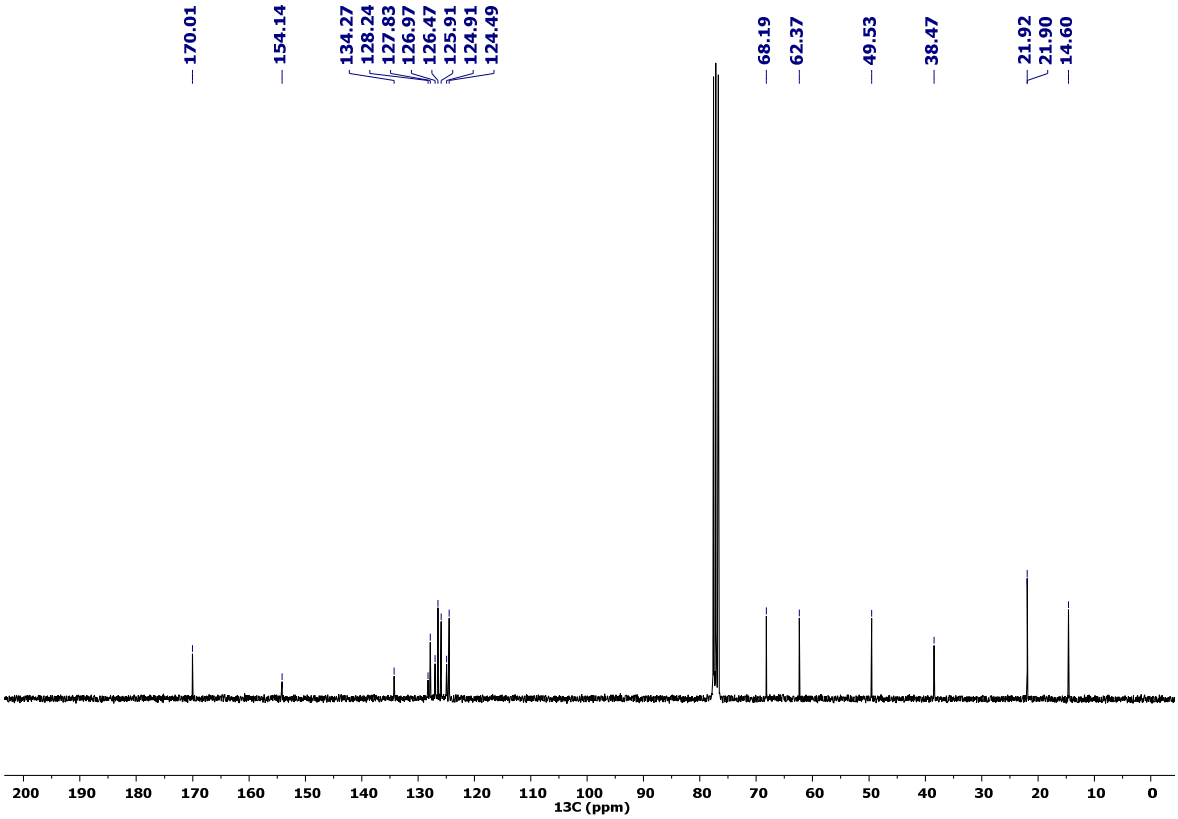

169.38
151.95
130.32
128.59
128.07
127.91
126.34
126.06
123.83
123.78
95.32
75.54
68.28
39.25
25.66
21.85
21.75
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
13C (ppm)

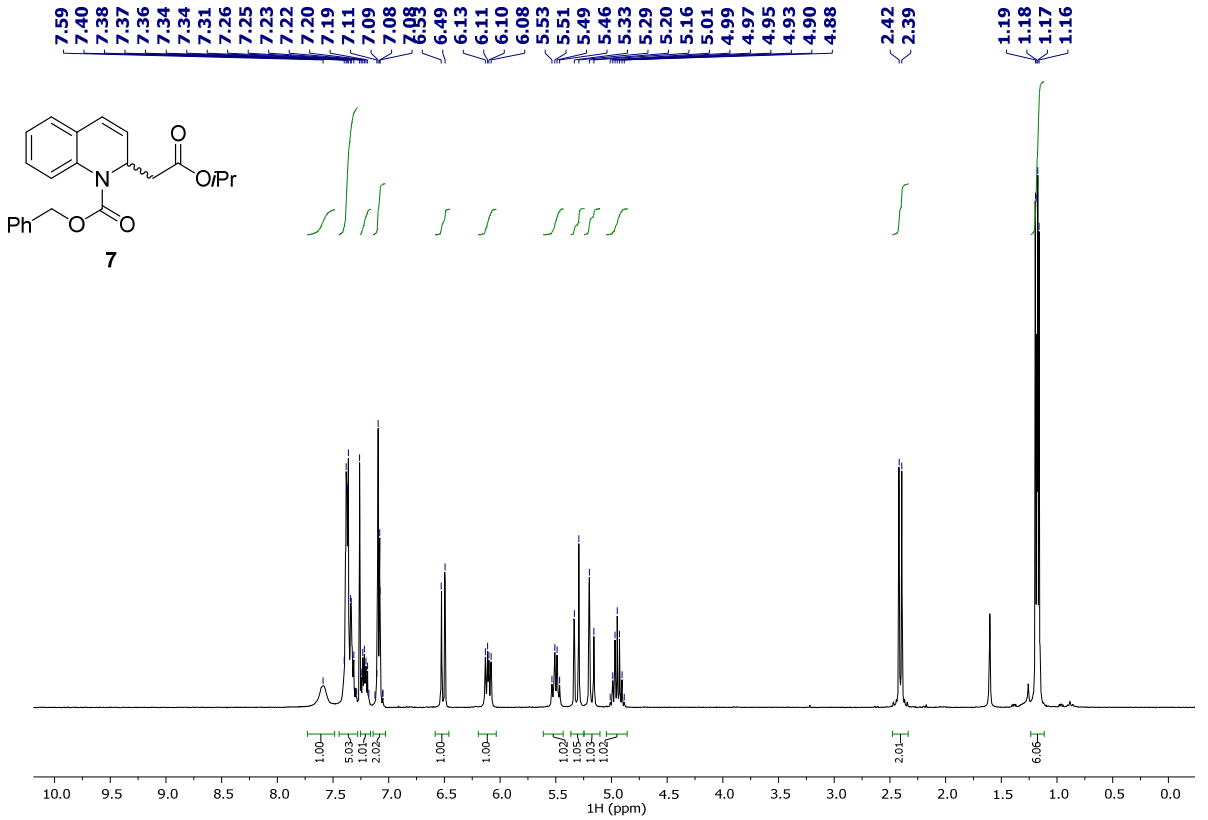

7.59
7.56
7.26
7.24
7.24
7.22
7.22
7.21
7.20
7.10
7.09
7.09
7.08
7.07
7.07
7.04
6.52
6.49
6.13
6.11
6.10
6.08
5.50
5.47
5.45
5.43
5.02
5.00
4.98
4.96
4.94
4.35
4.33
4.32
4.31
4.29
4.28
4.27
4.25
4.25
4.23
4.22
4.20
4.19
4.18
4.17
4.15
2.40
2.38
1.34
1.31
1.29
1.23
1.21
1.21
1.19

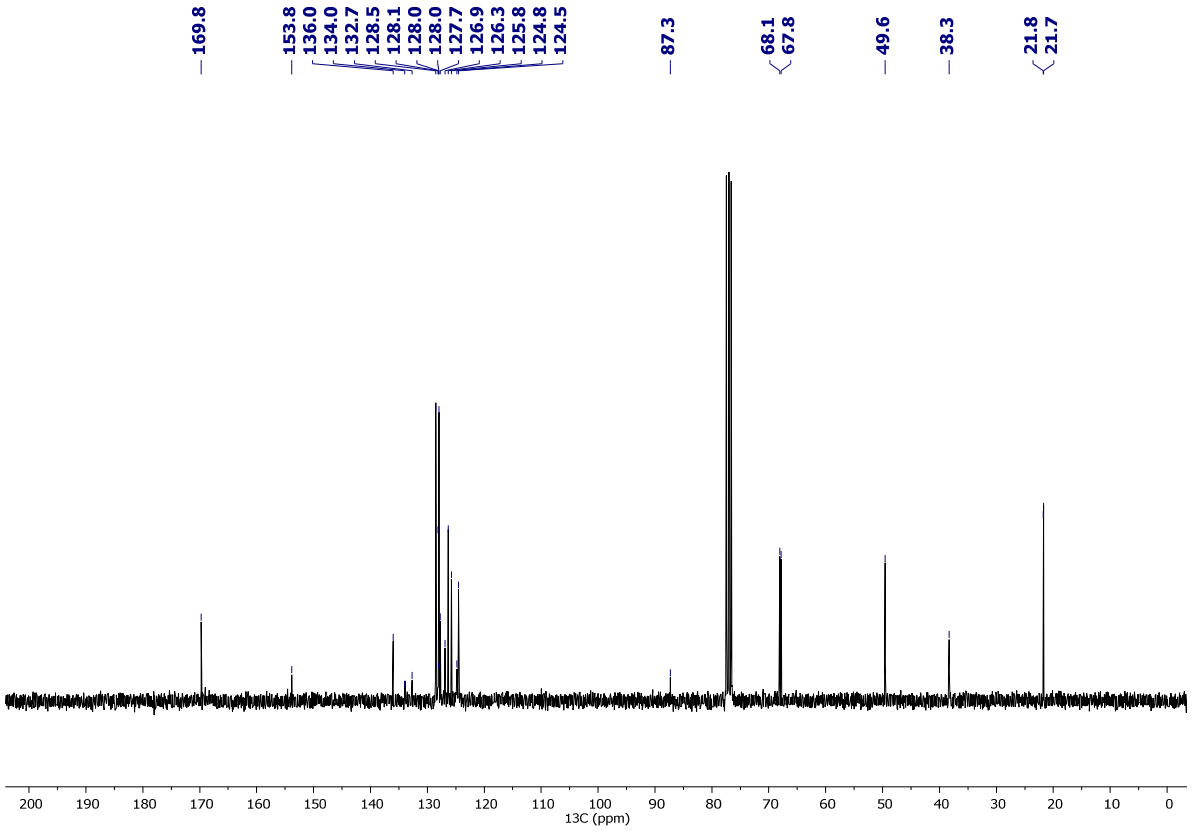

O
O*i*Pr
N
O
O

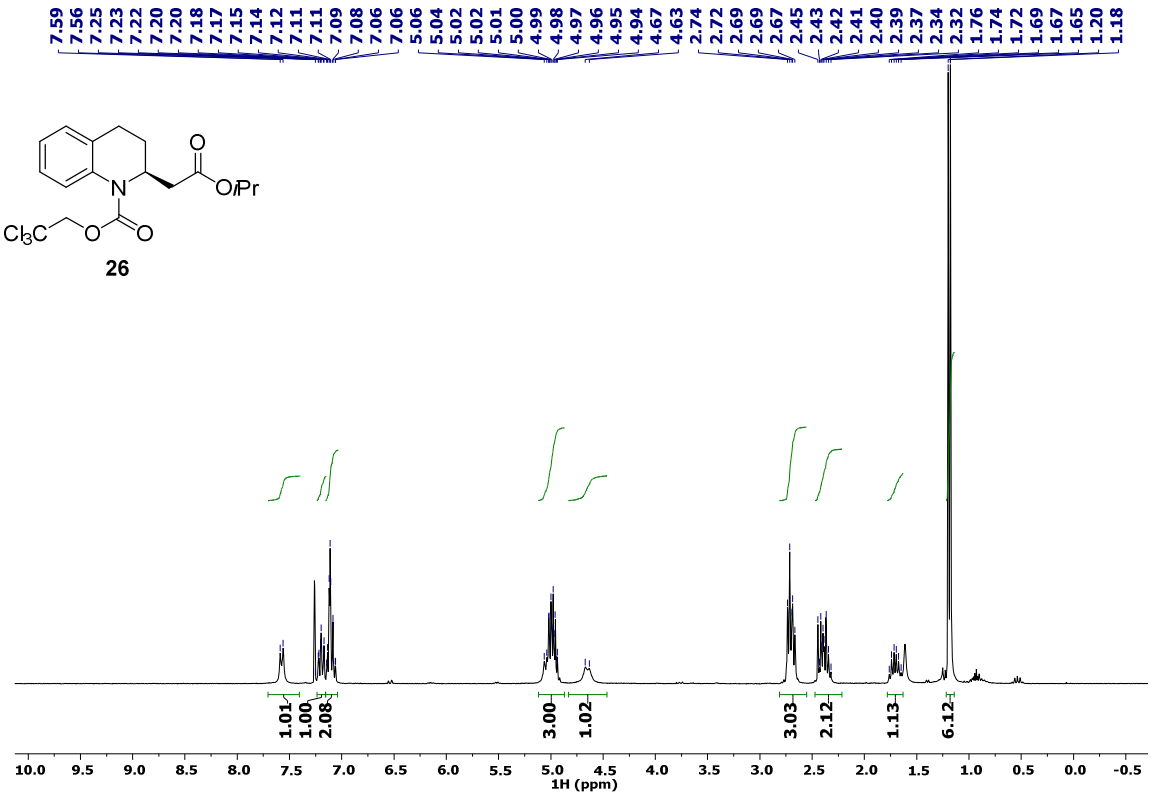
6

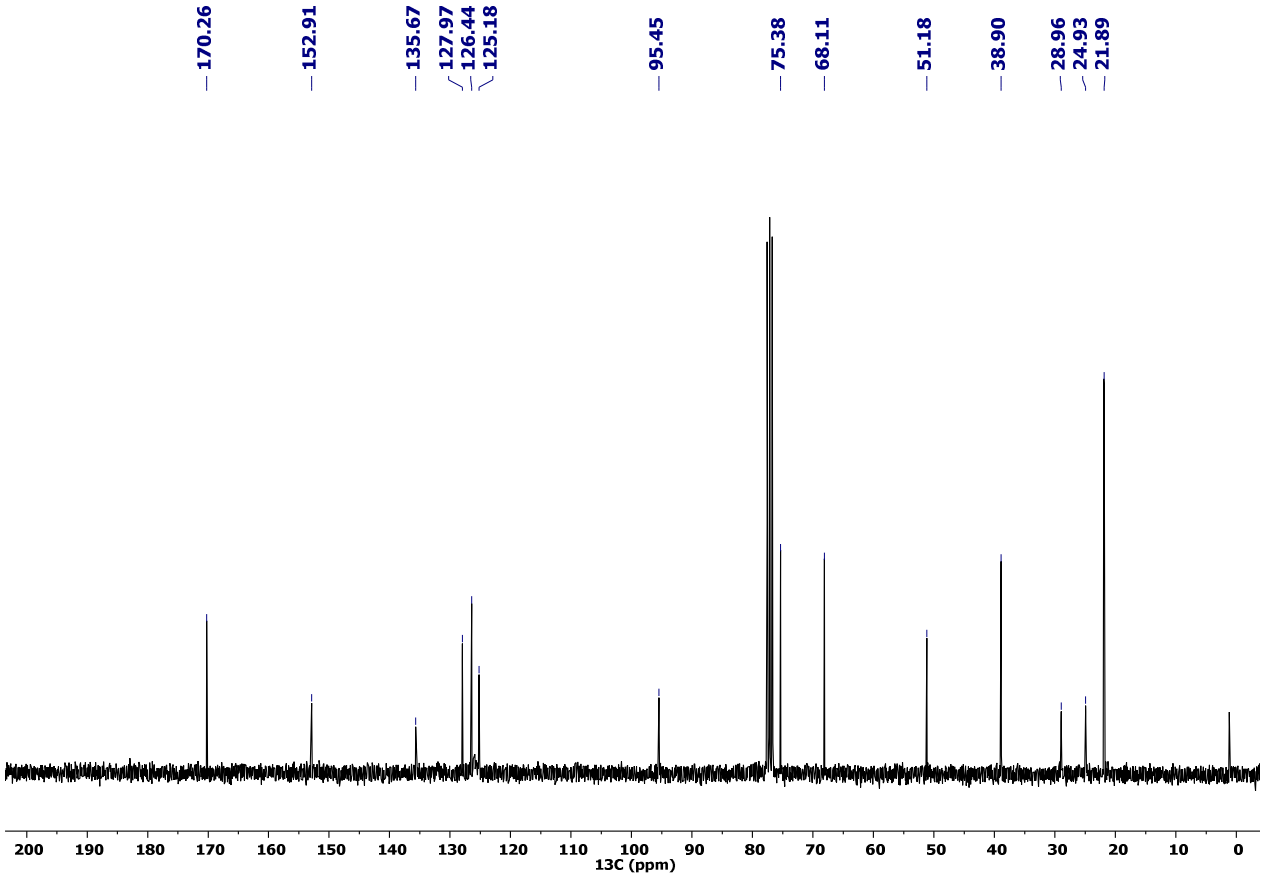

1.06
1.18
2.04
1.00
1.02
1.06
1.10
2.20
2.01
3.12
6.06
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)

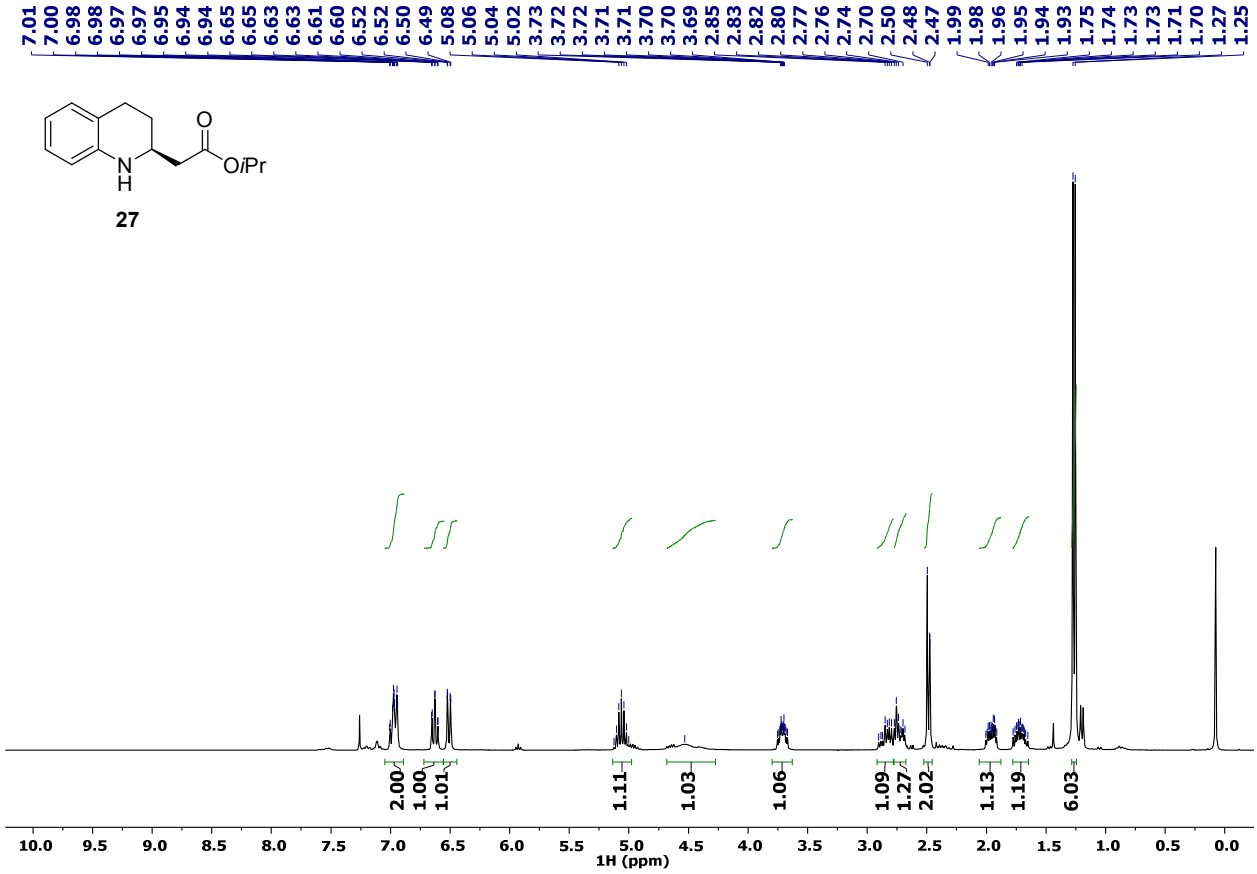

170.01
154.14
134.27
128.24
127.83
126.97
126.47
125.91
124.91
124.49
68.19
62.37
49.53
38.47
21.92
21.90
14.60
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
13C (ppm)

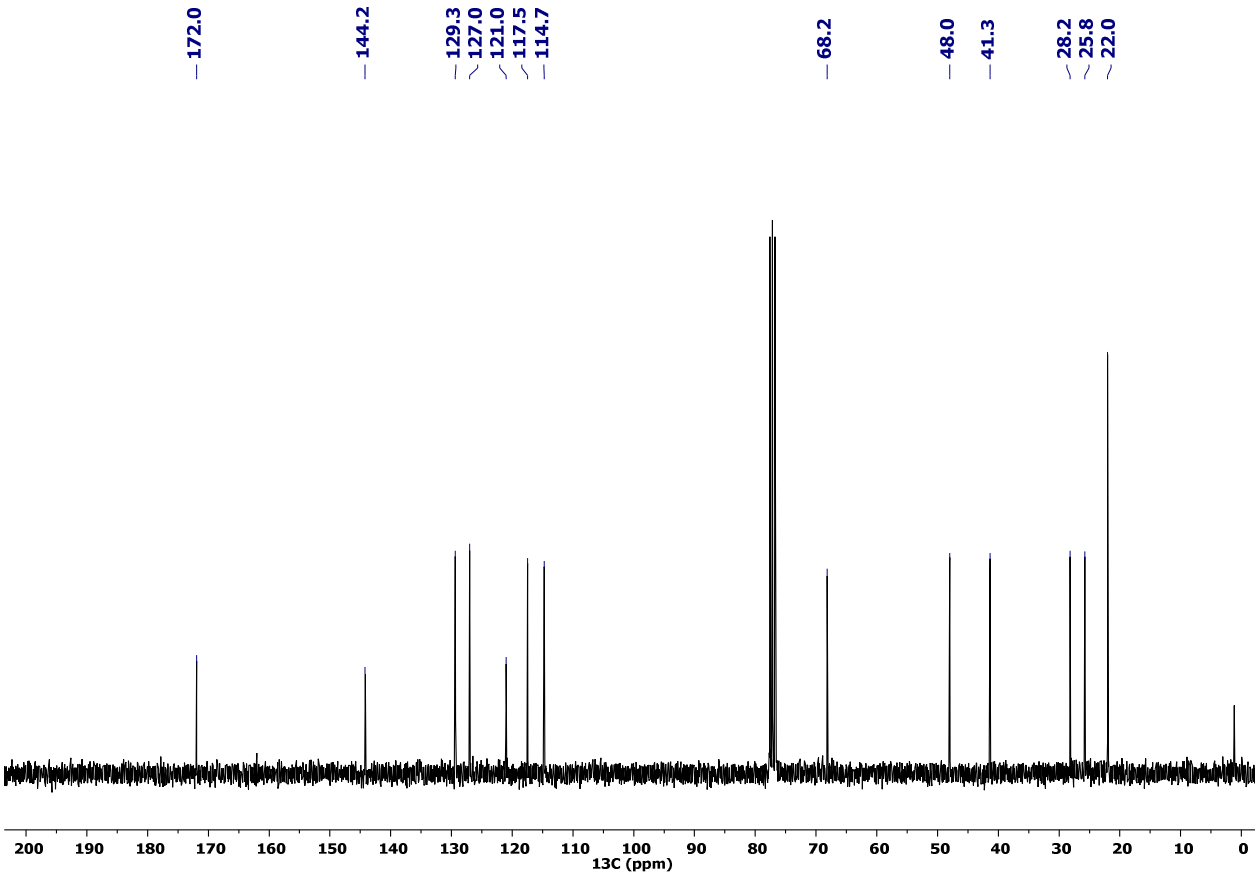

7.59
7.40
7.38
7.37
7.36
7.34
7.34
7.31
7.26
7.25
7.23
7.22
7.20
7.19
7.11
7.09
7.08
7.08
6.53
6.49
6.13
6.11
6.10
6.08
5.53
5.51
5.49
5.46
5.33
5.29
5.20
5.16
5.01
4.99
4.97
4.95
4.93
4.90
4.88
2.42
2.39
1.19
1.18
1.17
1.16
O
OiPr
N
Ph
O
O
7
1.00
5.03
1.01
2.02
1.00
1.00
1.02
1.05
1.03
1.02
2.01
6.06
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
1H (ppm)

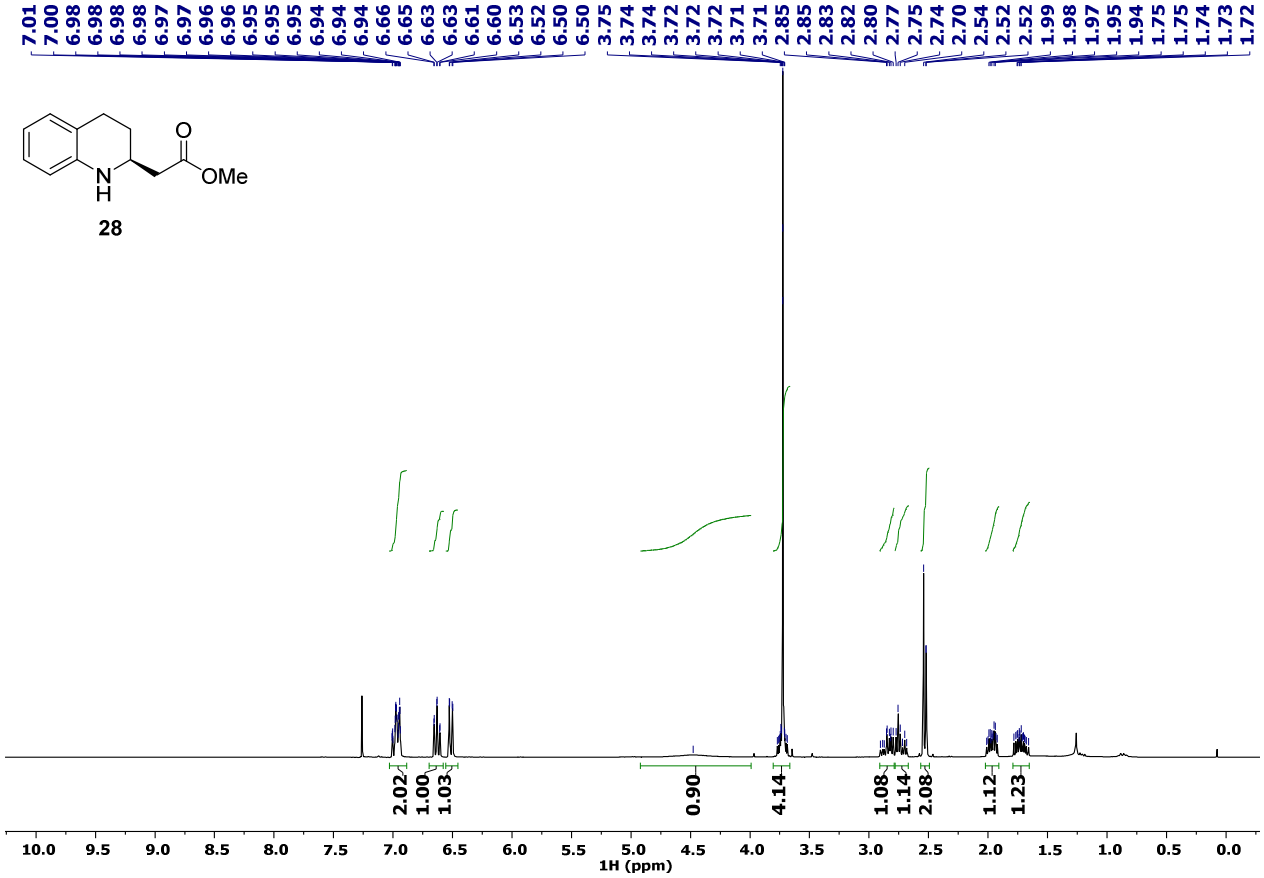

169.8
153.8
136.0
134.0
132.7
128.5
128.1
128.0
128.0
127.7
126.9
126.3
125.8
124.8
124.5
87.3
68.1
67.8
49.6
38.3
21.8
21.7
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
13C (ppm)

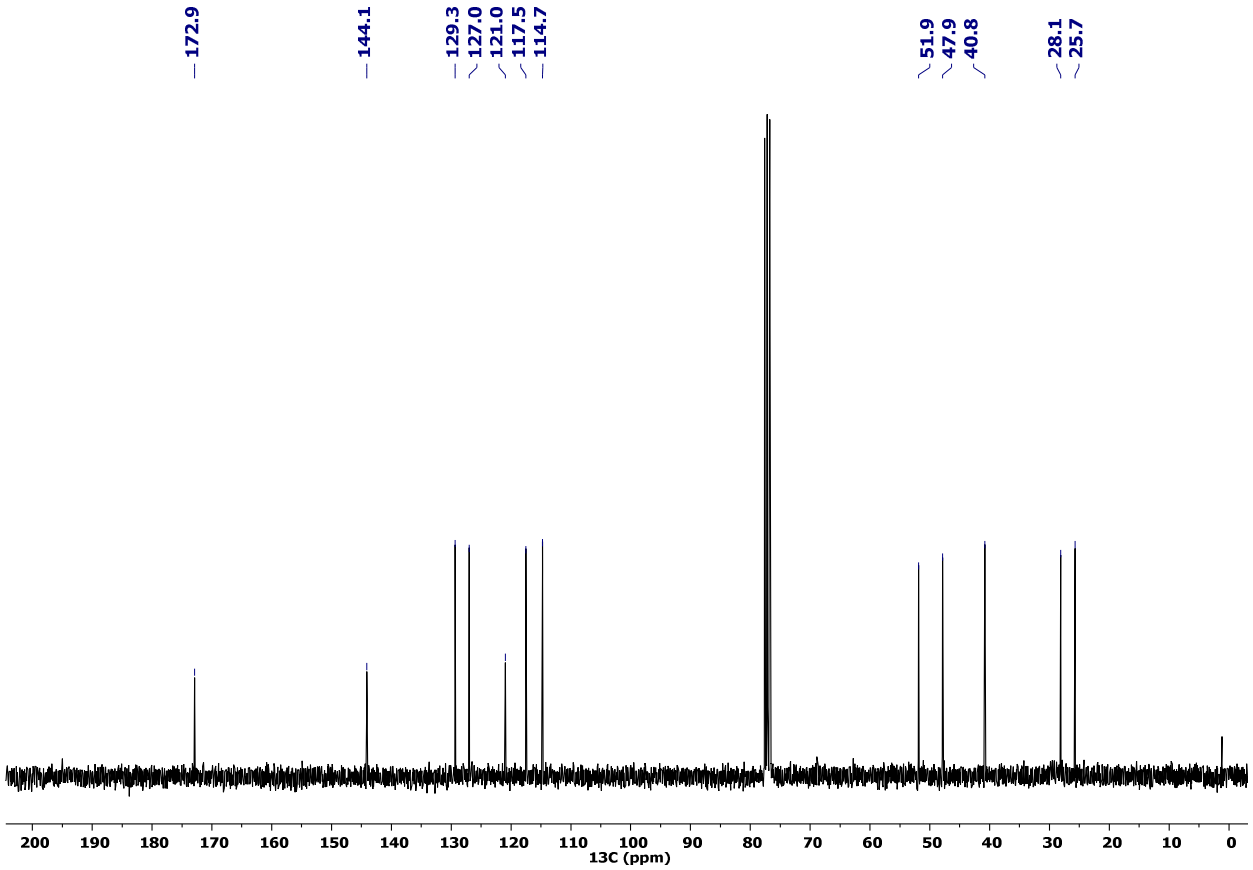

7.59 7.56 7.25 7.23 7.22 7.20 7.20 7.18 7.17 7.15 7.14 7.12 7.11 7.11 7.09 7.08 7.06 7.06
5.06 5.04 5.02 5.02 5.01 5.00 4.99 4.98 4.97 4.96 4.95 4.94 4.67 4.63
2.74 2.72 2.69 2.69 2.67 2.45 2.43 2.42 2.41 2.40 2.39 2.37 2.34 2.32 1.76 1.74 1.72 1.69 1.67 1.65 1.20 1.18
O
OiPr
N
Cl3C
O
O
26
1.01
1.00
2.08
3.00
1.02
3.03
2.12
1.13
6.12
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
1H (ppm)


170.26
152.91
135.67
127.97
126.44
125.18
95.45
75.38
68.11
51.18
38.90
28.96
24.93
21.89
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
13C (ppm)


7.01 7.00 6.98 6.98 6.97 6.97 6.95 6.94 6.94 6.65 6.65 6.63 6.63 6.61 6.60 6.52 6.52 6.50 6.49 5.08 5.06 5.04 5.02 3.73 3.72 3.72 3.71 3.71 3.70 3.70 3.69 2.85 2.83 2.82 2.80 2.77 2.76 2.74 2.70 2.50 2.48 2.47 1.99 1.98 1.96 1.95 1.94 1.93 1.75 1.74 1.73 1.73 1.71 1.70 1.27 1.25
O
N
H
OiPr
27
2.00 1.00 1.01 1.11 1.03 1.06 1.09 1.27 2.02 1.13 1.19 6.03
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
1H (ppm)


172.0 144.2 129.3 127.0 121.0 117.5 114.7 68.2 48.0 41.3 28.2 25.8 22.0
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
13C (ppm)


7.01 7.00 6.98 6.98 6.98 6.98 6.97 6.97 6.96 6.96 6.95 6.95 6.95 6.94 6.94 6.94 6.66 6.65 6.63 6.63 6.61 6.60 6.53 6.52 6.50 6.50
3.75 3.74 3.74 3.72 3.72 3.72 3.71 3.71 2.85 2.85 2.83 2.82 2.80 2.77 2.75 2.74 2.70 2.54 2.52 2.52 1.99 1.98 1.97 1.95 1.94 1.75 1.75 1.74 1.73 1.72
O
OMe
N
H
28
2.02 1.00 1.03 0.90 4.14 1.08 1.14 2.08 1.12 1.23
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
1H (ppm)


172.9
144.1
129.3
127.0
121.0
117.5
114.7
51.9
47.9
40.8
28.1
25.7
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
13C (ppm)

References

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