Supporting Information

Building Trisubstituted Ethylenes from Terminal Alkenes via Debrominative Ring-opening Trifluoromethylations of Geminal Dibromocyclopropanes

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1 General information

Reagents

All the solvents and reagents were obtained from commercial sources and used without purification unless mentioned otherwise. THF, Et_2O and 1,4-dioxane were distilled over CaH_2 and $LiAlH_4$ under N_2 atmosphere. Toluene, DCM and CH_3CN were distilled over CaH_2 under N_2. Acetone, EA, DMSO, DMA, DMF, DME, $CHCl_3$, HMPA, CH_3NO_2 were dried over activated 4A molecular sieves.

Instruments

All ^1H and ^{13}C NMR spectra were recorded on a JEOL ECZ 400 MHz or 600 MHz spectrometer. The chemical shift (δ) values are given in ppm and are referenced to TMS or residual solvent peaks. Chemical shifts of ^{19}F NMR are referred to $CFCl_3$ (δ = 0). Infrared spectra were obtained on a Nicolet AVATAR 360 FT-IR spectrometer. Gas chromatography coupled with mass spectrometry (GC-MS) was performed on a Orbitrap Exploris GC mass spectrometer under electrospray ionization (EI) mode. Melting points were measured on a WRX-4 (Shanghai Yice) micro melting point apparatus. X-ray diffraction experiment was performed on a Rigaku XtalLAB Synergy diffractometer using Cu or Mo Kα radiation.

Experimental techniques

All glassware was dried overnight at 100 °C prior to use. For reactions that require heating, a silicone oil bath was used. Purple light induced photocatalytic reactions were performed in a Schlenk tube under N_2 atmosphere. Thin-layer chromatography (TLC) was performed on silica gel plates (0.2–0.25 mm thickness). Visualization of TLC was achieved by the use of UV light (254 nm), $KMnO_4$ or PMA stain. Flash column chromatography was performed on a silica gel (Qingdao Haiyang, 200–300 mesh) column.

Photochemical set-up in our lab

Synthware® glassware made from borosilicate glass 3.3 and strips of 2835 light-emitting diode (120 LEDs/m, DC 12 V, 10 watt/m) surface-mounted on bare printed circuit board from Shenzhen Jinhongyan Lighting Co., Ltd. were used for photochemical reactions. A LED tube (inner diameter and height of 10 cm) was used as the lighting device for all photochemical reactions. The length of purple LED strip is 1.5 meters and the power is 15 W. The reaction temperature is controlled at about 25 °C by a small desk fan.

Fig. S1 | Photochemical set-up in our lab

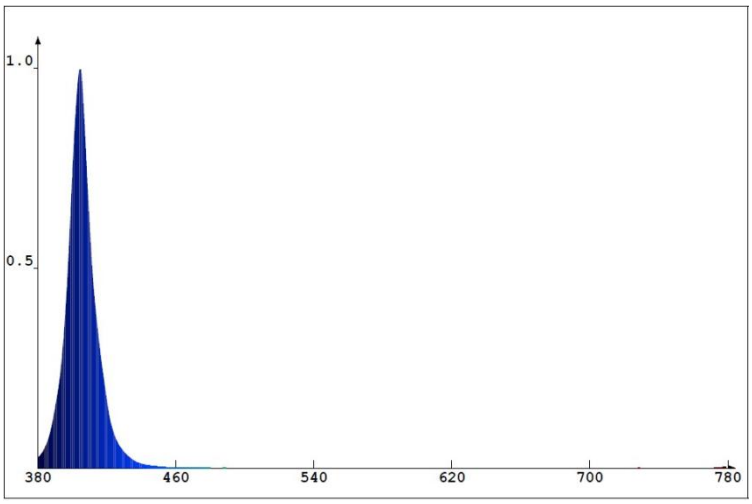


Fig. S2 | Luminous spectrum of purple LED (λ_p = 405 nm)

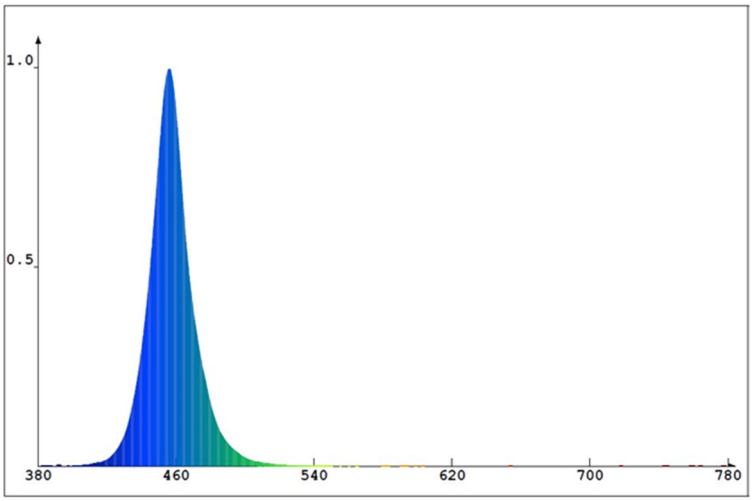


Fig. S3 | Luminous spectrum of blue LED (λ_p = 456 nm)

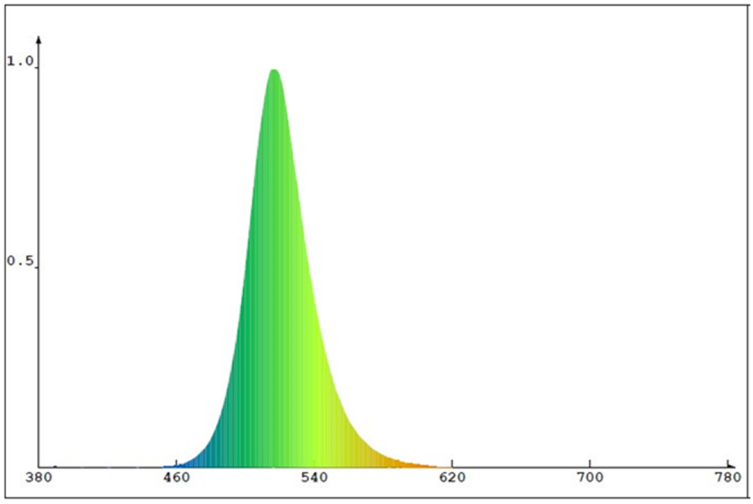
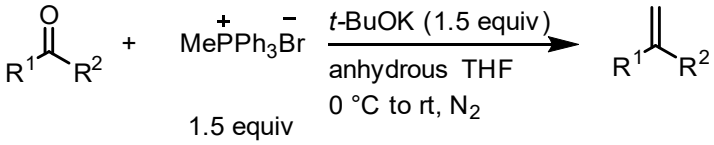


Fig. S4 | Luminous spectrum of green LED (λ_p = 516 nm)

2 Preparation of alkenes

2.1 Preparation of alkenes

General procedure[1]

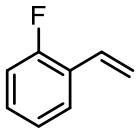


Olefins were synthesized by Wittig reaction of the corresponding aldehydes or ketones according to the known procedures in the literature.

To a 100 mL flame-dried Schlenk flask were added *t*-BuOK (3.37g, 30 mmol, 1.5 equiv), methyltriphenylphosphonium bromide (10.7g, 30 mmol, 1.5 equiv) and anhydrous THF (50 mL) under N_2 atmosphere. Forming sediment, the solution turns orange or yellow. The mixture was stirred at 0 ℃ for 0.5 h, and the corresponding aldehyde or ketone (20 mmol, 1.0 equiv) was added slowly under N_2 atmosphere. The resulting mixture was stirred at 0 ℃ for 10 min, and then stirring was continued for 8–12 hours at rt. Afterwards, THF was removed in vacuo to give the crude product. The residue was extracted with chloroform, and washed three times with H_2O. The solvents were removed by rotary evaporation, and the crude product was purified by column chromatography (hexanes/EA = 100:1 as eluent) to obtain the corresponding product as a colorless oil/solid.

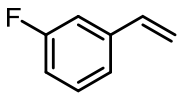
2.2 Physical data

1-Fluoro-2-vinylbenzene[2]



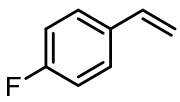
Yellow oil (2.0 g, 82% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.53 (td, *J* = 7.7, 1.8 Hz, 1H), 7.30 – 7.20 (m, 1H), 7.17 – 7.03 (m, 2H), 6.94 (m, 1H), 5.87 (dd, *J* = 17.8 Hz, 1H), 5.42 (d, *J* = 11.2Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 160.3 (d, *J* = 249.4 Hz), 129.3 (d, *J* = 4.0 Hz), 129.1 (d, *J* = 8.4 Hz), 127.1 (d, *J* = 3.7 Hz), 125.3 (d, *J* = 12.1 Hz), 124.0 (d, *J* = 3.8 Hz), 116.4 (d, *J* = 4.8 Hz), 115.7 (d, *J* = 22.1 Hz) ppm.

2-Fluoro-2-vinylbenzene



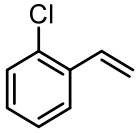
Yellow oil (2.0 g, 82% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.36 – 7.23 (m, 1H), 7.22 – 7.09 (m, 2H), 7.00 – 6.93 (m, 1H), 6.69 (m, 1H), 5.77 (d, *J* = 17.5 Hz, 1H), 5.32 (d, *J* = 10.9 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 163.1 (d, *J* = 244.5 Hz), 139.9 (d, *J* = 7.7 Hz), 135.8 (d, *J* = 3.1 Hz), 129.9 (d, *J* = 8.2 Hz), 122.1 (d, *J* = 3.0 Hz), 115.2, 114.6 (d, *J* = 21.4 Hz), 112.6 (d, *J* = 21.7 Hz) ppm.

3-Fluoro-2-vinylbenzene[3]



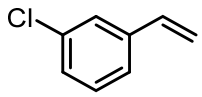
Yellow oil (2.2 g, 92% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.44 – 7.37 (m, 2H), 7.09 – 6.97 (m, 2H), 6.70 (m 1H), 5.69 (d, *J* = 18.1 Hz, 1H), 5.25 (d, *J* = 10.9 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 162.4 (d, *J* = 246.6 Hz), 135.7, 133.7 (d, *J* = 3.4 Hz), 127.7 (d, *J* = 8.0 Hz), 115.4 (d, *J* = 21.5 Hz), 113.5 (d, *J* = 2.2 Hz) ppm.

1-Chloro-2-vinylbenzene



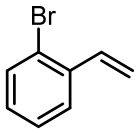
Yellow oil (1.9 g, 69% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.58 (dt, *J* = 7.6, 1.4 Hz, 1H), 7.37 (dt, *J* = 7.9, 1.3 Hz, 1H), 7.29 – 7.19 (m, 2H), 7.14 (m, 1H), 5.76 (d, *J* = 17.5 Hz, 1H), 5.40 (d, *J* = 11.0 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 135.7, 133.2, 129.6, 128.8, 126.8, 126.5, 116.5 ppm.

2-Chloro-2-vinylbenzene



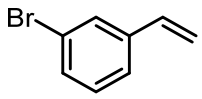
Yellow oil (2.0 g, 72% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.41 (s, 1H), 7.31 – 7.22 (m, 3H), 6.67 (m, 1H), 5.77 (d, *J* = 17.6 Hz, 1H), 5.32 (d, *J* = 10.9 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 139.4, 135.6, 134.5, 129.7, 127.7, 126.2, 124.4, 115.3 ppm.

1-Bromo-2-vinylbenzene



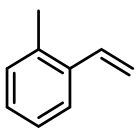
Yellow oil (2.9 g, 80% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.57 (dd, *J* = 8.0, 1.4 Hz, 2H), 7.34 – 7.23 (m, 1H), 7.16 – 7.10 (m, 1H), 7.10 – 7.05 (m, 1H), 5.72 (d, *J* = 17.5 Hz, 1H), 5.38 (d, *J* = 10.9 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 137.4, 135.8, 132.8, 129.1, 127.5, 126.8, 116.7 ppm.

2-Bromo-2-vinylbenzene



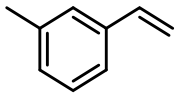
Yellow oil (3.1 g, 85% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.58 (t, *J* = 1.8 Hz, 1H), 7.40 (ddd, *J* = 7.9, 2.0, 1.1 Hz, 1H), 7.36 – 7.31 (m, 1H), 7.20 (t, *J* = 7.8 Hz, 1H), 6.66 (m, 1H), 5.77 (d, *J* = 17.5 Hz, 1H), 5.32 (d, *J* = 10.9 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 139.6, 135.4, 130.6, 130.0, 129.1, 124.8, 122.7, 115.3 ppm.

1-Methyl-2-vinylbenzene



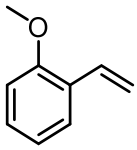
Yellow oil (1.7 g, 72% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.56 – 7.51 (m, 1H), 7.24 – 7.18 (m, 3H), 7.00 (m, 1H), 5.70 (d, *J* = 17.4 Hz, 1H), 5.35 (d, *J* = 11.0 Hz, 1H), 2.41 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 136.8, 135.4, 134.8, 130.2, 127.6, 126.1, 125.3, 115.1, 19.7 ppm.

2-Methyl-2-vinylbenzene



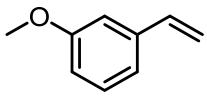
Yellow oil (2.0 g, 85% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.41 – 7.20 (m, 3H), 7.11 (s, 1H), 6.73 (m, 1H), 5.77 (d, *J* = 17.6 Hz,1H), 5.26 (d, *J* = 10.9 Hz, 1H), 2.39 (s, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 138.0, 137.5, 136.9, 128.6, 128.4, 126.9, 123.3, 113.6, 21.4 ppm.

1-Methoxy-2-vinylbenzene



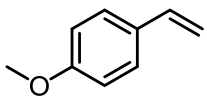
Yellow oil (1.9 g, 71% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.55 (d, *J* = 7.6 Hz, 1H), 7.30 (ddd, *J* = 8.3, 7.3, 1.7 Hz, 1H), 7.15 (ddd, *J* = 17.6, 11.1, 1.5 Hz, 1H), 7.01 (td, *J* = 7.4, 0.9 Hz, 1H), 6.93 (m, 1H), 5.82 (d, *J* = 17.7 Hz, 1H), 5.35 (d, *J* = 11.2 Hz, 1H), 3.89 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 156.7, 131.7, 128.8, 126.5, 120.6, 114.3, 110.8, 55.3 ppm.

2-Methoxy-2-vinylbenzene



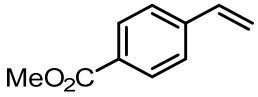
Yellow oil (2.3 g, 86% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.62 – 7.54 (m, 1H), 7.41 – 7.27 (m, 2H), 7.22 – 7.12 (m, 1H), 7.05 (m, 1H), 6.11 (d, *J* = 17.5 Hz, 1H), 5.61 (d, *J* = 11.1 Hz, 1H), 4.17 (d, *J* = 1.7 Hz, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.8, 139.0, 136.7, 129.5, 118.9, 114.1, 113.4, 111.5, 55.2 ppm.

3-Methoxy-2-vinylbenzene



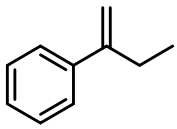
Yellow oil (2.4 g, 90% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.47 – 7.40 (m, 2H), 6.98 – 6.92 (m, 2H), 6.77 (m, 1H), 5.75 – 5.68 (m, 1H), 5.29 – 5.18 (m, 1H), 3.86 (s, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.3, 136.1, 130.3, 127.3, 113.8, 111.4, 55.0 ppm.

Methyl 4-vinylbenzoate



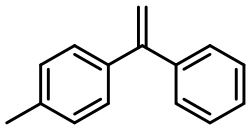
White solid (2.4 g, 73% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.99 (d, *J* = 8.4 Hz, 2H), 7.45 (d, *J* = 8.3 Hz, 2H), 6.74 (m, 1H), 5.85 (d, *J* = 17.5 Hz, 1H), 5.37 (d, *J* = 10.9 Hz, 1H), 3.90 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 166.8, 141.8, 136.0, 129.8, 129.2, 126.0, 116.4, 52.0 ppm.

But-1-en-2-ylbenzene



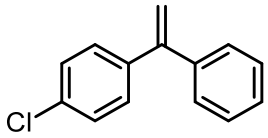
Yellow oil (1.6 g, 61% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.57 – 7.53 (m, 2H), 7.47 – 7.43 (m, 2H), 7.39 (m, 1H), 5.43 (d, *J* = 3.3 Hz, 1H), 5.21 (d, *J* = 1.6 Hz, 1H), 2.69 – 2.63 (m, 2H), 1.25 (m, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 150.1, 141.5, 128.2, 127.2, 126.0, 110.9, 28.1, 12.9 ppm.

1-Methyl-4-(1-phenylvinyl)benzene



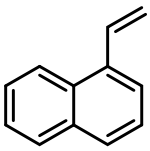
Yellow oil (2.5 g, 64% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.48 – 7.29 (m, 7H), 7.23 (dd, *J* = 8.1, 2.3 Hz, 2H), 5.56 – 5.50 (m, 2H), 2.46 (s, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 149.9, 141.7, 138.6, 137.4, 128.8, 128.3, 128.1, 127.6, 113.6, 21.1 ppm.

1-Chloro-4-(1-phenylvinyl)benzene



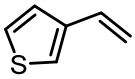
Yellow oil (2.7 g, 64% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.40 – 7.29 (m, 9H), 5.49 (dd, *J* = 12.1, 1.1 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 149.0, 141.0, 139.9, 133.6, 129.5, 128.3, 128.2, 128.2, 127.9, 114.7 ppm.

1-Vinylnaphthalene



Yellow oil (2.1 g, 69% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 8.20 (dd, *J* = 8.7, 2.7 Hz, 1H), 7.95 – 7.90 (m, 1H), 7.86 (dd, *J* = 8.3, 2.5 Hz, 1H), 7.71 (dd, *J* = 7.2, 2.9 Hz, 1H), 7.61 – 7.49 (m, 4H), 5.88 (dd, *J* = 17.3, 2.0 Hz, 1H), 5.56 (dd, *J* = 10.9, 1.8 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 135.6, 134.4, 133.6, 131.1, 128.5, 128.1, 126.0, 125.7, 125.6, 123.7, 123.6, 117.1 ppm.

3-Vinylthiophene

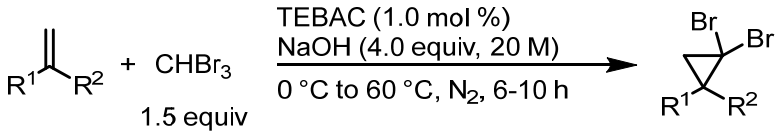


Yellow oil (1.7 g, 77% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.30 (dd, *J* = 5.1, 2.9 Hz, 1H), 7.28 (dd, *J* = 5.1, 1.4 Hz, 1H), 7.20 (dd, *J* = 2.9, 1.4 Hz, 1H), 6.75 (m 1H), 5.62 (d, *J* = 17.5 Hz, 1H), 5.23 (d, *J* = 10.8 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 140.5, 130.9, 125.9, 124.7, 122.3, 113.5 ppm.

3 Preparation of *gem*-dihalocyclopropanes

3.1 Preparation of *gem*-dihalocyclopropanes

General procedure A[4]

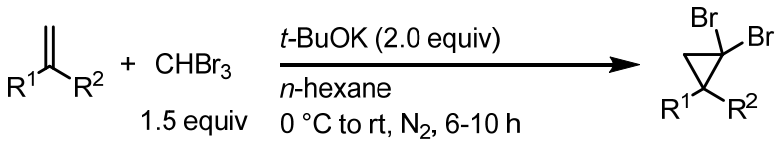


Most *gem*-dibromocyclopropanes were prepared from the alkenes, bromoform and NaOH under phase-transfer catalysis (PTC) according to the known procedures in the literature.

To a solution of the corresponding alkene (20 mmol, 1.0 equiv), bromoform (7.6 g, 30 mmol, 1.5 equiv) and phase transfer catalyst $BnNEt_3Cl$ (TEBAC, 46 mg, 0.02 mmol, 1.0 mol %) was added dropwise a solution of NaOH (3.2 g, 80 mmol, 4.0 equiv, 20 M) at 0 ℃, and the mixture was stirred at room temperature for 0.5 h, then heated to 60 ℃ and further stirred until conversion was complete as observed by TLC analysis. Water and EA were added and the aqueous phase was extracted with EA (20 mL × 3). The combined organic phases were washed with saturated NaCl solution, dried over anhydrous Na_2SO_4 and the solvent removed under reduced pressure. Purification by column

chromatography on silica gel (hexanes as eluent) gave pure *gem*-dibromocyclopropane derivative as a colorless liquid/solid.

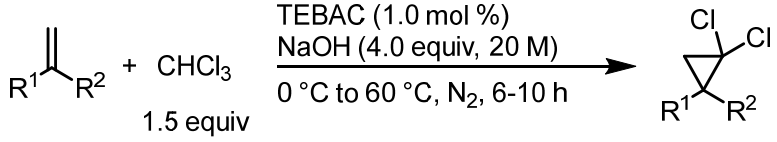
General procedure B[5]



In a 250 mL two-necked flask equipped with a large stirring bar, the corresponding alkene (20 mmol, 1.0 equiv.) and *t*-BuOK (4.5 g, 40 mmol,2.0 equiv) were suspended in *n*-hexane at 0 ℃. Bromoform (7.6 g, 30 mmol, 1.5 equiv) was added dropwise under N_2 atmosphere. The resulting solution was stirred at 0 ℃ for 0.5 h and then the stirring was continued for 8–12 hours at rt and further stirred until conversion was complete as observed by TLC analysis. Then, the organic solvent was removed under reduced pressure and the residue was extracted with DCM (20 mL × 3). The organic phases were collected, dried over anhydrous Na_2SO_4, and the solvent was removed under reduced pressure. Purification by column chromatography on silica gel (hexanes as eluent) gave pure *gem*-dibromocyclopropane derivative as a colorless liquid/solid.

Note：It is necessary to use *n*-hexane instead of petroleum ether as the solvent. Usually, petroleum ether contains olefin impurities, which will bring side products after reaction with $CHBr_3$.

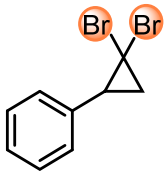
General procedure C[6]



To a solution of the corresponding alkene (20 mmol, 1.0 equiv), chloroform (7.6 g, 30 mmol, 1.5 equiv) and TEBAC (46 mg, 0.02 mmol, 1.0 mol %) was added dropwise a solution of NaOH (3.2 g, 80 mmol, 4.0 equiv, 20 M) at 0 ℃, and the mixture was stirred at room temperature for 0.5 h, then heated to 60 ℃ and further stirred until conversion was complete as observed by TLC analysis. Water and EA were added and the aqueous phase was extracted with EA (20 mL × 3). The combined organic phases were washed with saturated NaCl solution, dried over anhydrous Na_2SO_4 and the solvent removed under reduced pressure. Purification by column chromatography on silica gel (hexanes as eluent) gave pure *gem*-dichlorocyclopropane derivative as a colorless oil.

3.2 Physical data

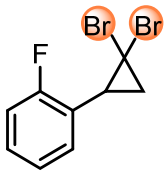
(2,2-Dibromocyclopropyl)benzene (1a)



General procedure A was applied.

Yellow oil (4.1 g, 75% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.42 – 7.31 (m, 3H), 7.29 – 7.24 (m, 2H), 2.97 (dd, *J* = 10.5, 8.3 Hz, 1H), 2.14 (dd, *J* = 10.5, 7.7 Hz, 1H), 2.02 (t, *J* = 8.0 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 135.9, 128.8, 128.2, 127.6, 35.9, 28.4, 27. 2 ppm.

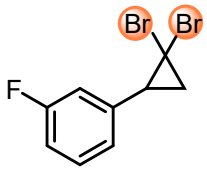
1-(2,2-Dibromocyclopropyl)-2-fluorobenzene (1b)



General procedure A was applied.

Yellow oil (3.8 g, 65% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.33 (tdd, *J* = 7.6, 5.2, 1.8 Hz, 1H), 7.17 – 7.09 (m, 2H), 7.09 – 7.05 (m, 1H), 3.02 (dd, *J* = 10.3, 8.5 Hz, 1H), 2.19 (dd, *J* = 10.4, 7.6 Hz, 1H), 2.05 (t, *J* = 8.0 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 162.4 (d, *J* = 248.3 Hz), 129.4, 123.8, 115.3 (d, *J* = 21.6 Hz), 30.6 (d, *J* = 2.7 Hz), 27.1, 26.8 ppm.

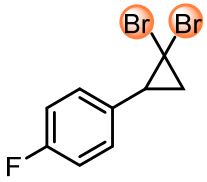
1-(2,2-Dibromocyclopropyl)-3-fluorobenzene (1c)



General procedure A was applied.

Yellow oil (4.0 g, 68% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.34 (td, *J* = 8.0, 5.9 Hz, 1H), 7.11 – 7.01 (m, 2H), 6.98 (dt, *J* = 9.9, 2.2 Hz, 1H), 2.96 (dd, *J* = 10.5, 8.3 Hz, 1H), 2.17 (dd, *J* = 10.5, 7.8 Hz, 1H), 2.01 (t, *J* = 8.1 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 162.8 (d, *J* = 246.2 Hz), 138.6 (d, *J* = 7.8 Hz), 130.0 (d, *J* = 8.3 Hz), 125.0 (d, *J* = 3.3 Hz), 116.1 (d, *J* = 22.1 Hz), 114.8 (d, *J* = 21.0 Hz), 35.7 (d, *J* = 2.2 Hz), 27.8, 27.6 ppm.

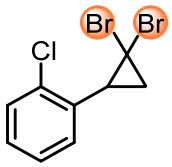
1-(2,2-Dibromocyclopropyl)-4-fluorobenzene (1d)



General procedure A was applied.

Yellow oil (4.2 g, 72% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.44 – 7.35 (m, 2H), 7.26 – 7.17 (m, 2H), 3.08 (dd, *J* = 10.6, 8.3 Hz, 1H), 2.34 – 2.26 (m, 1H), 2.16 – 2.09 (m, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 162.2 (d, *J* = 246.4 Hz), 131.8 (d, *J* = 3.4 Hz), 130.5 (d, *J* = 8.3 Hz), 115.4 (d, *J* = 2.8 Hz), 115.2 (d, *J* = 2.6 Hz), 35.2, 28.1, 27.4 ppm.

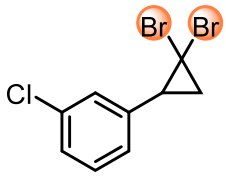
1-Chloro-2-(2,2-dibromocyclopropyl)benzene (1e)



General procedure A was applied.

Yellow oil (4.3 g, 69% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.48 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.27 (m, 2H), 7.10 – 7.02 (m, 1H), 3.01 (dd, *J* = 10.3, 8.4 Hz, 1H), 2.19 (dd, *J* = 10.3, 7.7 Hz, 1H), 2.05 (t, *J* = 8.1 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 136.6, 134.9, 129.3, 128.9, 126.6, 34.9, 27.3, 27.0 ppm.

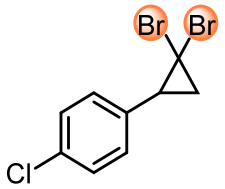
1-Chloro-3-(2,2-dibromocyclopropyl)benzene (1f)



General procedure A was applied.

Yellow oil (4.2 g, 68% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.32 – 7.27 (m, 2H), 7.24 (d, *J* = 2.2 Hz, 1H), 7.14 (dt, *J* = 5.8, 2.1 Hz, 1H), 2.92 (dd, *J* = 10.5, 8.3 Hz, 1H), 2.14 (dd, *J* = 10.5, 7.8 Hz, 1H), 1.98 (t, *J* = 8.1 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 137.9, 134.1, 129.5, 129.0, 127.7, 127.1, 35.3, 27.5, 27.3 ppm.

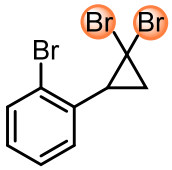
1-Chloro-4-(2,2-dibromocyclopropyl)benzene (1g)



General procedure A was applied.

Yellow oil (4.7 g, 76% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.39 – 7.31 (m, 2H), 7.23 – 7.17 (m, 2H), 2.93 (dd, *J* = 10.5, 8.3 Hz, 1H), 2.16 (dd, *J* = 10.5, 7.8 Hz, 1H), 1.98 (t, *J* = 8.1 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 134.7, 133.6, 130.4, 128.7, 35.4, 28.1, 27.6 ppm.

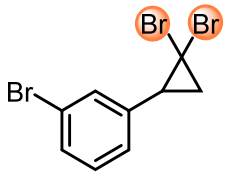
1-Bromo-2-(2,2-dibromocyclopropyl)benzene (1h)



General procedure A was applied.

Yellow oil (5.1 g, 72% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.69 (dt, *J* = 7.9, 1.6 Hz, 1H), 7.35 – 7.28 (m, 1H), 7.23 (m, 1H), 7.08 (dd, *J* = 7.7, 2.0 Hz, 1H), 3.00 (ddd, *J* = 10.5, 8.2, 2.2 Hz, 1H), 2.22 (ddd, *J* = 10.3, 7.7, 2.3 Hz, 1H), 2.08 (td, *J* = 8.1, 2.3 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 136.7, 132.5, 129. 5, 129.1, 127.2, 127.0, 36.9, 27.6, 27.2 ppm.

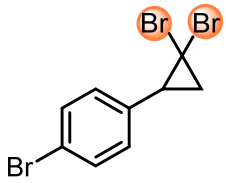
1-Bromo-3-(2,2-dibromocyclopropyl)benzene (1i)



General procedure A was applied.

Yellow oil (5.6 g, 79% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.47 (dt, *J* = 7.6, 1.7 Hz, 1H), 7.42 (d, *J* = 1.9 Hz, 1H), 7.25 – 7.18 (m, 2H), 2.93 (dd, *J* = 10.5, 8.3 Hz, 1H), 2.15 (dd, *J* = 10.5, 7.9 Hz, 1H), 2.00 (t, *J* = 8.1 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 138.1, 131.8, 130.6, 129.7, 127.5, 122.2, 35.2, 27.5, 27.2 ppm.

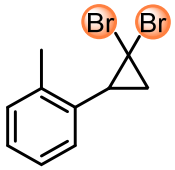
1-Bromo-4-(2,2-dibromocyclopropyl)benzene (1j)



General procedure A was applied.

Yellow solid (5.9 g, 83% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.49 (d, *J* = 8.4 Hz, 2H), 7.13 (d, *J* = 8.5 Hz, 2H), 2.90 (dd, *J* = 10.5, 8.3 Hz, 1H), 2.15 (ddd, *J* = 10.4, 7.8, 0.7 Hz, 1H), 2.01 – 1.94 (m, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 135.0, 131.4, 130.6, 121.6, 35.3, 27.6, 27.4 ppm.

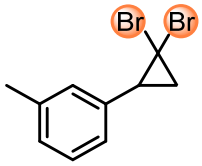
1-(2,2-Dibromocyclopropyl)-2-methylbenzene (1k)



General procedure A was applied.

Yellow oil (4.0 g, 69% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.39 (m, 2H), 7.30 (td, *J* = 7.2, 2.3 Hz, 1H), 7.11 (d, *J* = 7.6 Hz, 1H), 2.94 (dd, *J* = 10.4, 8.4 Hz, 1H), 2.64 (s, 3H), 2.25 (dd, *J* = 10.4, 7.6 Hz, 1H), 2.19 – 2.09 (m, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 138.9, 135.3, 129.8, 127.7, 127.5, 125.7, 35.2, 28.4, 26.7, 20.2 ppm.

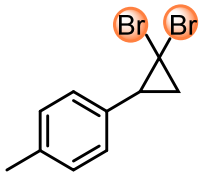
1-(2,2-Dibromocyclopropyl)-3-methylbenzene (1l)



General procedure A was applied.

Yellow oil (4.4 g, 76% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.31 (t, *J* = 7.6 Hz, 1H), 7.19 (d, *J* = 7.7 Hz, 1H), 7.16 – 7.13 (m, 1H), 7.10 (dd, *J* = 7.8, 1.7 Hz, 1H), 2.98 (dd, *J* = 10.5, 8.4 Hz, 1H), 2.43 (s, 3H), 2.16 (dd, *J* = 10.5, 7.8 Hz, 1H), 2.05 (t, *J* = 8.1 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 137.8, 135.8, 129.7, 128.3, 128.1, 125.8, 35.8, 28.6, 27.1, 21.4 ppm.

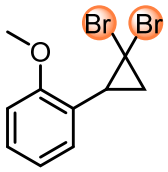
1-(2,2-Dibromocyclopropyl)-4-methylbenzene (1m)



General procedure A was applied.

Yellow oil (5.1 g, 88% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.26 – 7.16 (m, 4H), 2.95 (dd, *J* = 10.8, 7.7 Hz, 1H), 2.44 (s, 3H), 2.18 (dd, *J* = 10.7, 7.7 Hz, 1H), 2.07 (t, *J* = 8.0 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.3, 133.1, 129.1, 128.8, 35.7, 28.9, 27.3, 21.4 ppm.

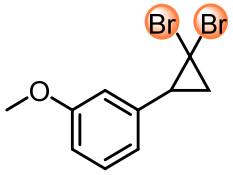
1-(2,2-Dibromocyclopropyl)-2-methoxybenzene (1n)



General procedure A was applied.

Yellow oil (4.8 g, 78% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.36 – 7.29 (m, 1H), 6.99 – 6.82 (m, 3H), 3.95 (s, 3H), 3.04 – 2.92 (m, 1H), 2.10 (dd, *J* = 10.4, 7.6 Hz, 1H), 1.98 (dd, *J* = 8.6, 7.6 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 159.3, 128.9, 128.4, 125.5, 120.1, 110.4, 55.8, 32.1, 29.0, 26.7 ppm.

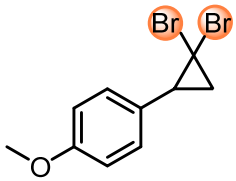
1-(2,2-Dibromocyclopropyl)-3-methoxybenzene (1o)



General procedure A was applied.

Yellow oil (4,6 g, 75% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.29 (t, *J* = 7.9 Hz, 1H), 6.91 – 6.84 (m, 2H), 6.81 (t, *J* = 2.3 Hz, 1H), 3.84 (s, 3H), 2.95 (dd, *J* = 10.5, 8.3 Hz, 1H), 2.14 (dd, *J* = 10.5, 7.7 Hz, 1H), 2.01 (t, *J* = 8.0 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.4, 137.4, 129.2, 121.2, 114.7, 112.9, 55.2, 35.8, 28.3, 27.2 ppm.

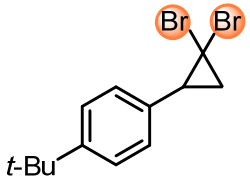
1-(2,2-Dibromocyclopropyl)-4-methoxybenzene (1p)



General procedure A was applied.

Yellow oil (920 mg, 69% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.22 – 7.02 (m, 2H), 7.00 – 6.80 (m, 2H), 3.82 (s, 3H), 2.91 (ddd, *J* = 10.6, 8.1, 2.2 Hz, 1H), 2.11 (ddd, *J* = 10.1, 7.7, 2.0 Hz, 1H), 1.96 (td, *J* = 8.0, 2.2 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.0, 130.0, 128.1, 113.7, 55.2, 35.3, 29.3, 27.3 ppm.

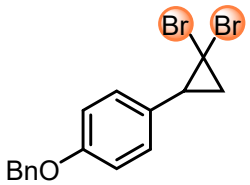
1-(*tert*-Butyl)-4-(2,2-dibromocyclopropyl)benzene (1q)



General procedure A was applied.

White solid (5.1 g, 77% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.43 – 7.34 (m, 2H), 7.21 – 7.16 (m, 2H), 2.92 (dd, *J* = 10.5, 8.3 Hz, 1H), 2.12 (dd, *J* = 10.6, 7.7 Hz, 1H), 1.99 (t, *J* = 8.0 Hz, 1H), 1.33 (s, 9H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 150.6, 133.0, 128.5, 125.2, 35.6, 34.6, 31.3, 28.8, 27.4 ppm.

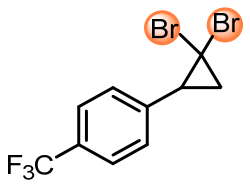
1-(Benzyloxy)-4-(2,2-dibromocyclopropyl)benzene (1r)



General procedure A was applied.

White solid (6.7 g, 88% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.53 – 7.49 (m, 2H), 7.49 – 7.45 (m, 2H), 7.43 – 7.39 (m, 1H), 7.25 – 7.22 (m, 2H), 7.06 – 7.02 (m, 2H), 5.11 (s, 2H), 2.96 (dd, *J* = 10.6, 8.2 Hz, 1H), 2.15 (dd, *J* = 10.6, 7.7 Hz, 1H), 2.01 (t, *J* = 8.0 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.2, 136.8, 129.9, 128.5, 128.3, 127.9, 127.4, 114.5, 69.9, 35.2, 29.2, 27.2 ppm.

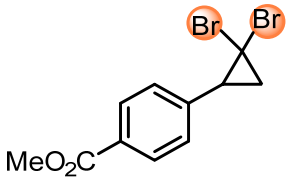
1-(2,2-Dibromocyclopropyl)-4-(trifluoromethyl)benzene (1s)



General procedure A was applied.

Yellow oil (4.9 g, 71% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.62 (d, *J* = 8.1 Hz, 2H), 7.41 – 7.36 (m, 2H), 3.06 – 2.95 (m, 3H), 2.21 (dd, *J* = 10.5, 7.9 Hz, 1H), 2.06 (t, *J* = 8.1 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 139.9, 129.7 (q, *J* = 33.1 Hz), 129.3, 125.3 (q, *J* = 3.8 Hz), 124.1 (q, *J* = 272.1 Hz), 35.5, 27.5, 27.0 ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -62.36 ppm.

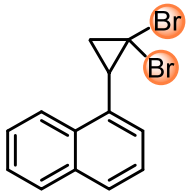
Methyl 4-(2,2-dibromocyclopropyl)benzoate (1t)



General procedure B was applied.

White solid (5.0 g, 76% yield); R_f = 0.5 (50:1 hexanes/EA); m.p. 54.2–54.6 °C; IR (film) ν_{max} 2965, 1969, 1752, 1365, 806, 676, 605 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.01 (dd, *J* = 8.4, 2.7 Hz, 2H), 7.30 (dd, *J* = 8.3, 3.1 Hz, 2H), 3.89 (s, 3H), 2.97 (dd, *J* = 10.5, 8.3 Hz, 1H), 2.16 (m, 1H), 2.09 – 1.98 (m, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 166.5, 140.9, 129.4, 129.3, 128.8, 52.0, 35.6, 27.4, 27.3 ppm; HRMS (EI) Calcd for $C_{11}H_{10}Br_2O_2$ 331.90475; Found 331.90479.

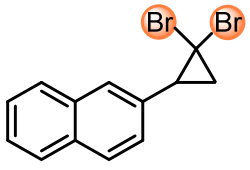
1-(2,2-Dibromocyclopropyl)naphthalene (1u)



General procedure B was applied.

White solid (5.8 g, 89% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 8.28 (m, 1H), 7.93 (m, 1H), 7.85 (m, 1H), 7.72 – 7.64 (m, 1H), 7.62 – 7.55 (m, 1H), 7.44 (m, 1H), 7.22 (m, 1H), 3.30 (t, *J* = 9.5 Hz, 1H), 2.34 – 2.30 (m, 1H), 2.22 (td, *J* = 8.1, 2.6 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 133.7, 133.5, 133.2, 128.6, 128.4, 126.8, 126.2, 125.7, 125.2, 124.7, 34.8, 28.3, 27.0 ppm.

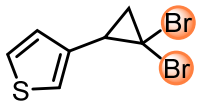
2-(2,2-Dibromocyclopropyl)naphthalene (1v)



General procedure B was applied.

White solid (5.1 g, 78% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.90 (m, 3H), 7.71 (m, 1H), 7.62 – 7.46 (m, 3H), 3.18 (t, *J* = 9.3 Hz, 1H), 2.23 (t, *J* = 8.6 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 133.8, 133.3, 132.9, 128.1, 128.0, 128.0, 127.8, 127.3, 126.5, 126.3, 36.3, 28.7, 27.5 ppm.

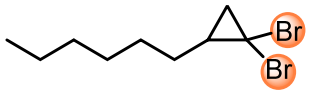
3-(2,2-Dibromocyclopropyl)thiophene (1w)



General procedure B was applied.

Yellow oil (5.0 g, 89% yield); IR (film) ν_{max} 3246, 2769, 1530, 848 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.31 (dd, *J* = 5.0, 3.0 Hz, 1H), 7.10 (dt, *J* = 3.0, 1.1 Hz, 1H), 7.04 (dd, *J* = 5.0, 1.3 Hz, 1H), 2.89 (ddd, *J* = 10.5, 8.1, 0.9 Hz, 1H), 2.16 (dd, *J* = 10.5, 7.6 Hz, 1H), 1.95 – 1.90 (m, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 137.5, 128.1, 125.6, 123.3, 31.5, 28.8, 28.4 ppm; HRMS (EI) Calcd for $C_7H_6Br_2S$ 279.85570; Found 279.85578.

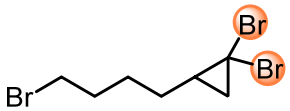
1,1-Dibromo-2-hexylcyclopropane (1x)



General procedure B was applied.

Colorless oil (2.3 g, 69% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 1.74 (dd, *J* = 10.2, 7.1 Hz, 1H), 1.65 – 1.51 (m, 3H), 1.50 – 1.40 (m, 2H), 1.39 – 1.25 (m, 6H), 1.19 (t, *J* = 7.4 Hz, 1H), 0.90 (t, *J* = 7.0 Hz, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 32.6, 31.7, 31.5, 29.7, 28.9, 28.5, 28.3, 22.6, 14.1 ppm.

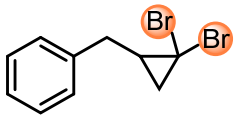
1,1-Dibromo-2-(4-bromobutyl)cyclopropane (1y)



General procedure A was applied.

Yellow oil (5.3 g, 79% yield); IR (film) ν_{max} 3346, 3105, 2933, 651 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 3.50 – 3.34 (m, 2H), 1.92 (m, 2H), 1.74 (m, 1H), 1.70 – 1.39 (m, 5H), 1.25 – 1.16 (m, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 33.7, 32.4, 31.9, 31.2, 29.3, 28.6, 27.1 ppm; HRMS (EI) Calcd for $C_7H_{11}Br_3$ 331.84109; Found 331.84116.

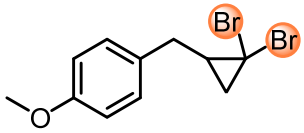
((2,2-Dibromocyclopropyl)methyl)benzene (1z)



General procedure B was applied.

Colorless oil (4.4 g, 77% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.40 – 7.30 (m, 4H), 7.29 (d, *J* = 7.1 Hz, 1H), 3.06 (dd, *J* = 15.3, 6.7 Hz, 1H), 2.79 (dd, *J* = 15.4, 6.2 Hz, 2H), 1.89 (qd, *J* = 10.4, 4.9 Hz, 1H), 1.42 (t, *J* = 6.6 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 139.2, 128.6, 128.3, 126.5, 38.1, 31.9, 29.0, 28.4 ppm.

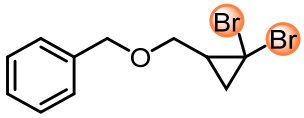
1-((2,2-Dibromocyclopropyl)methyl)-4-methoxybenzene (1a')



General procedure B was applied.

Colorless oil (5.3 g, 83% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.26 – 7.20 (m, 2H), 6.90 (dd, *J* = 9.2, 2.4 Hz, 2H), 3.82 (s, 3H), 3.01 – 2.92 (m, 1H), 2.76 – 2.69 (m, 1H), 1.92 – 1.80 (m, 2H), 1.39 (td, *J* = 6.2, 5.7, 1.8 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 158.2, 131.2, 129.3, 114.0, 55.2, 37.3, 32.1, 29.1, 28.4 ppm.

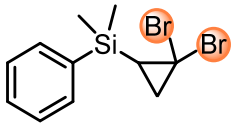
(((2,2-Dibromocyclopropyl)methoxy)methyl)benzene (1b')



General procedure B was applied.

Colorless oil (5.0 g, 79% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.40 – 7.34 (m, 4H), 7.33 – 7.29 (m, 1H), 4.65 – 4.56 (m, 2H), 3.67 – 3.55 (m, 2H), 1.96 (m, 1H), 1.82 (dd, *J* = 10.5, 7.4 Hz, 1H), 1.38 (t, *J* = 7.6 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.9, 128.4, 127.8 (d, *J* = 2.6 Hz), 72.9, 71.5, 30.2, 26.6, 26.1 ppm.

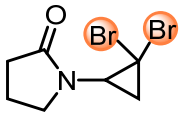
(2,2-Dibromocyclopropyl)dimethyl(phenyl)silane (1c')



General procedure B was applied.

Colorless oil (4.1 g, 61% yield); IR (film) ν_{max} 2984, 1846, 1220, 887 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.69 – 7.62 (m, 2H), 7.48 – 7.42 (m, 3H), 1.95 (dd, J = 12.5, 6.0 Hz, 1H), 1.62 (dd, J = 10.0, 6.0 Hz, 1H), 0.55 (s, 3H), 0.44 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.2, 133.9, 129.4, 127.9, 26.2, 25.4, 22.5, -2.8, -2.9 ppm; HRMS (EI) Calcd for $C_{11}H_{14}Br_2Si$ 331.92315; Found 331.92307.

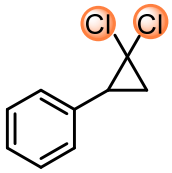
1-(2,2-Dibromocyclopropyl)pyrrolidin-2-one (1d')



General procedure B was applied.

Yellow oil (4.0 g, 72% yield); IR (film) ν_{max} 3320, 1762, 1254, 884 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 3.48 (dt, *J* = 9.0, 6.7 Hz, 1H), 3.42 – 3.34 (m, 1H), 3.15 (dd, *J* = 9.7, 6.4 Hz, 1H), 2.38 (td, *J* = 7.9, 2.6 Hz, 2H), 2.19 (dd, *J* = 9.0, 6.3 Hz, 1H), 2.11 – 1.92 (m, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 176.2, 47.6, 40.9, 31.3, 28.0, 25.4, 18.2 ppm; HRMS (EI) Calcd for $C_7H_9Br_2NO$ 280.90509; Found 280.90492.

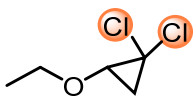
(2,2-Dichlorocyclopropyl)benzene (1e')



General procedure C was applied.

Colorless oil (3.1 g, 82% yield); ^1H NMR (600 MHz, Chloroform-*d*) δ 7.38 (td, *J* = 7.9, 7.5, 2.1 Hz, 2H), 7.33 (td, *J* = 7.1, 1.9 Hz, 1H), 7.30 – 7.26 (m, 2H), 2.94 (m, 1H), 2.00 (m, 1H), 1.89 (m, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 134.6, 128.8, 128.3, 127.6, 60.7, 35.4, 25.7 ppm.

1,1-Dibromo-2-hexylcyclopropane (1f')

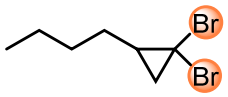


General procedure C was applied.

Colorless oil (2.1 g, 67% yield); ^1H NMR (600 MHz, Chloroform-*d*) δ 3.85 – 3.78 (m, 1H), 3.77 – 3.67 (m, 1H), 3.53 (ddd, *J* = 8.1, 5.0, 1.1 Hz, 1H), 1.65 (td, *J* = 8.4, 1.2 Hz, 1H), 1.51 (ddd, *J* = 8.5, 5.1, 1.4

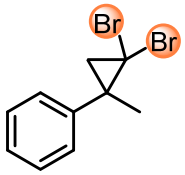
Hz, 1H), 1.28 (td, *J* = 7.1, 1.2 Hz, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 67.2, 63.1, 29.7, 27.9, 14.9 ppm.

1,1-Dibromo-2-butylcyclopropane (1g′)



Yellow oil (2.2 g, 86% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 1.74 (dd, *J* = 10.2, 7.0 Hz, 1H), 1.64 – 1.58 (m, 1H), 1.57 – 1.50 (m, 2H), 1.49 – 1.42 (m, 2H), 1.41 – 1.36 (m, 2H), 1.19 (dd, *J* = 7.8, 7.1 Hz, 1H), 0.93 (t, *J* = 7.3 Hz, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 32.3, 31.4, 30.5, 29.7, 28.5, 22.4, 14.0 ppm.

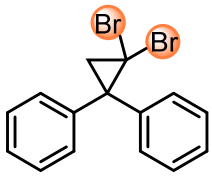
(2,2-Dibromo-1-methylcyclopropyl)benzene (1h′)



General procedure B was applied.

Yellow oil (3.9 g, 68% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.39 (td, *J* = 7.5, 0.8 Hz, 2H), 7.36 – 7.30 (m, 3H), 2.20 (d, *J* = 7.5 Hz, 1H), 1.81 (d, *J* = 7.6 Hz, 1H), 1.75 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 142.3, 128.4, 128.3, 127.2, 36.7, 35.7, 33.7, 27.7 ppm.

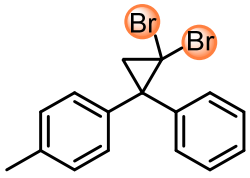
(2,2-Dibromocyclopropane-1,1-diyl)dibenzene (1j′)



General procedure B was applied.

White solid (5.3 g, 75% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.55 – 7.50 (m, 4H), 7.32 (m, 4H), 7.25 – 7.20 (m, 2H), 2.48 (s, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 141.9, 129.2, 128.4, 127.3, 45.1, 34.5, 33.9 ppm.

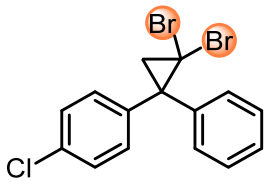
1-(2,2-Dibromo-1-phenylcyclopropyl)-4-methylbenzene (1k′)[7]



General procedure B was applied.

White solid (5.6 g, 77% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.55 – 7.51 (m, 2H), 7.44 – 7.41 (m, 2H), 7.35 – 7.30 (m, 2H), 7.25 – 7.22 (m, 1H), 7.15 (dd, *J* = 7.6, 1.2 Hz, 2H), 2.47 (d, *J* = 1.0 Hz, 2H), 2.31 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 142.1, 139.0, 137.1, 129.2, 129.1, 129.0, 128.4, 127.2, 44.8, 34.5, 34.2, 21.1 ppm.

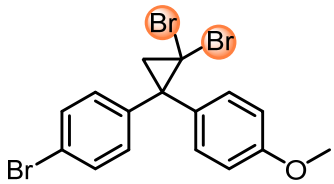
1-Chloro-4-(2,2-dibromo-1-phenylcyclopropyl)benzene (1l′)



General procedure B was applied.

White solid (5.9 g, 77% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.51 – 7.38 (m, 4H), 7.36 – 7.27 (m, 4H), 7.26 – 7.20 (m, 1H), 2.49 (dd, *J* = 7.6, 1.5 Hz, 1H), 2.44 (dd, *J* = 7.5, 1.4 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 141.4, 140.4, 133.3, 130.6, 129.1, 128.7, 128.6, 127.5, 44.4, 34.6, 33.3 ppm.

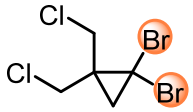
1-Bromo-4-(2,2-dibromo-1-(4-methoxyphenyl)cyclopropyl)benzene (1m′)



General procedure B was applied.

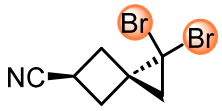
White solid (5.8 g, 63% yield); R_f = 0.5 (50:1 hexanes/EA); m.p. 121.9–122.4 °C; IR (film) ν_{max} 3108, 2653, 1657, 859, 643 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.85 – 7.34 (m, 6H), 7.00 – 6.69 (m, 2H), 3.77 (s, 3H), 2.42 (d, *J* = 10.4 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 158.9, 141.2, 133.6, 131.6, 130.8, 130.2, 121.3, 113.9, 55.2, 43.9, 34.6, 33.8 ppm; HRMS (EI) Calcd for $C_{16}H_{13}Br_3O$ 457.85165; Found 457.85157.

1,1-Dibromo-2,2-bis(chloromethyl)cyclopropane (1n′)



From commercial source.

(3*r*,5*r*)-1,1-Dibromospiro[2.3]hexane-5-carbonitrile (1o′-*trans*)

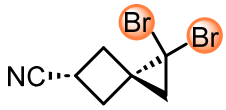


General procedure B was applied.

trans means the cyano group and the dibrominated carbon are on the opposite sides of the cyclobutane ring.

White solid (2.2 g, total 83% yield); R_f = 0.5 (20:1 hexanes/AcOEt); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 3.26 (tt, *J* = 9.5, 6.4 Hz, 1H), 2.90 – 2.75 (m, 2H), 2.61 – 2.47 (m, 2H), 1.74 (s, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 121.9, 33.8, 33.1, 33.0, 31.8, 16.3 ppm.

(3*s*,5*s*)-1,1-Dibromospiro[2.3]hexane-5-carbonitrile (1o′-*cis*)

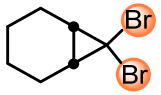


General procedure B was applied.

cis means the cyano group and the dibrominated carbon are on the same side of the cyclobutane ring.

White solid (2.2 g, total 83% yield); R_f = 0.3 (20:1 hexanes/AcOEt); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 3.25 (ttd, *J* = 9.3, 8.0, 1.6 Hz, 1H), 2.87 (ddt, *J* = 11.7, 8.0, 1.4 Hz, 2H), 2.55 – 2.34 (m, 2H), 1.72 (d, *J* = 1.5 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 121.2, 34.1, 33.5, 31.8, 31.3, 14.9 ppm.

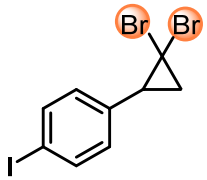
1-(2,2-7,7-Dibromobicyclo[4.1.0]heptane (1p′)



General procedure B was applied.

Yellow oil (3.6 g, 92% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 2.00 (dq, *J* = 13.9, 6.5 Hz, 2H), 1.83 (dd, *J* = 5.9, 2.7 Hz, 2H), 1.57 (dt, *J* = 14.1, 6.0 Hz, 2H), 1.42 – 1.32 (m, 2H), 1.27 – 1.12 (m, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 40.8, 27.0, 20.7, 20.1 ppm.

Dibromocyclopropyl)-4-iodobenzene

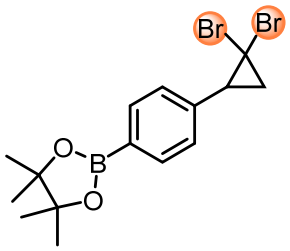


General procedure B was applied.

Yellow solid (6.8 g, 85% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.7 – 7.6 (m, 2H), 7.0 (dd, *J* =

8.4, 2.5 Hz, 2H), 2.9 (dd, *J* = 10.5, 8.2 Hz, 1H), 2.1 (dd, *J* = 10.5, 7.7 Hz, 1H), 2.0 (t, *J* = 8.1 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 137.4, 135.7, 130.8, 93.2, 35.4, 27.6, 27.3 ppm.

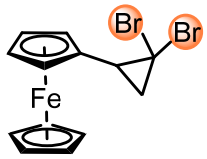
2-(4-(2,2-Dibromocyclopropyl)phenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane



General procedure B was applied.

Yellow oil (6.6 g, 83% yield); R_f = 0.5 (50:1 hexanes/AcOEt); IR (film) ν_{max} 3162, 2153, 1766, 962 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 7.7 Hz, 2H), 7.28 – 7.24 (m, 2H), 2.97 (dd, *J* = 10.4, 8.4 Hz, 1H), 2.19 – 2.10 (m, 1H), 2.05 (t, *J* = 8.1 Hz, 1H), 1.35 (s, 12H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 139.0, 134.7, 128.2, 83.8, 36.0, 28.2, 27.2, 24.9 ppm; HRMS (EI) Calcd for $C_{15}H_{19}BBr_2O_2$ 399.98449; Found 399.98456.

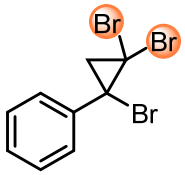
(2,2-Dibromocyclopropyl)ferrocene



General procedure B was applied.

Red solid (6.4 g, 84% yield); R_f = 0.4 (50:1 hexanes/AcOEt); m.p. 63.4–64.2 °C; IR (film) ν_{max} 3965, 2106, 1763, 626 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 4.41 (dt, *J* = 2.6, 1.4 Hz, 1H), 4.22 (td, *J* = 2.5, 1.2 Hz, 1H), 4.18 (s, 5H), 4.14 (td, *J* = 2.5, 1.2 Hz, 1H), 4.00 (dt, *J* = 2.6, 1.4 Hz, 1H), 2.64 (dd, *J* = 10.6, 8.1 Hz, 1H), 2.07 (dd, *J* = 10.6, 7.5 Hz, 1H), 1.65 (t, *J* = 7.8 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 83.4, 69.6, 68.7, 68.6, 67.7, 67.4, 32.4, 30.3, 28.4 ppm; HRMS (EI) Calcd for $C_{13}H_{12}Br_2Fe$ 381.86552; Found 381.86549.

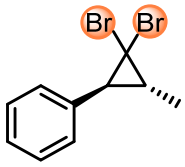
(1,2,2-Tribromocyclopropyl)benzene



General procedure B was applied.

Yellow oil (5.0 g, 71% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.50 – 7.45 (m, 1H), 7.42 – 7.30 (m, 2H), 2.52 (dt, *J* = 9.3, 1.2 Hz, 1H), 2.26 (dt, *J* = 9.3, 1.3 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 140.0, 129.1, 128.9, 128.6, 42.9, 37.1, 31.8 ppm.

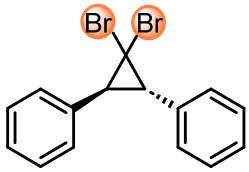
2,2-Dibromo-3-methylcyclopropyl)benzene



General procedure B was applied.

White solid (4.3 g, 73% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.44 – 7.36 (m, 3H), 7.32 – 7.28 (m, 2H), 2.52 (d, *J* = 8.4 Hz, 1H), 2.02 (dq, *J* = 8.5, 6.2 Hz, 1H), 1.52 (dd, *J* = 6.3, 1.1 Hz, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 136.3, 128.6, 128.2, 127.4, 42.2, 38.9, 30.2, 17.4 ppm.

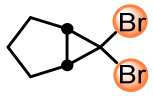
(3,3-Dibromocyclopropane-1,2-diyl)dibenzene



General procedure B was applied.

White solid (3.6 g, 93% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.52 – 7.43 (m, 10H), 3.36 (s, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 136.0, 128.9, 128.5, 127.9, 40.1, 36.8 ppm.

6,6-Dibromobicyclo[3.1.0]hexane[8]



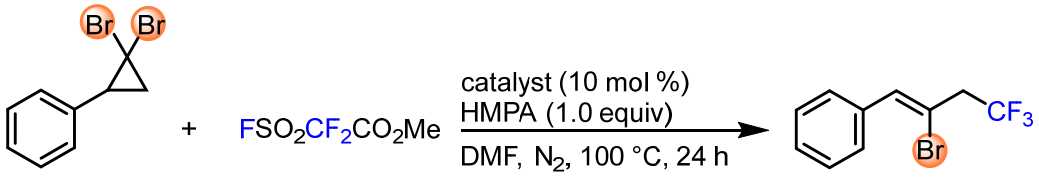
General procedure B was applied.

Yellow oil (3.7 g, 78% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 2.24 (dd, *J* = 4.2, 1.7 Hz, 1H), 2.11 – 1.98 (m, 1H), 1.88 (ddd, *J* = 13.9, 8.7, 4.4 Hz, 1H), 1.78 – 1.67 (m, 1H) ppm; ^{13}C NMR (75 MHz, Chloroform-*d*) δ 40.8, 39.9, 29.5, 25.9 ppm.

4 Reactions of *gem*-dihalocyclopropanes with Chen's reagent

4.1 Optimization of the conditions for the reaction of 1a with Chen's reagent

Table S1 Effect of catalyst.

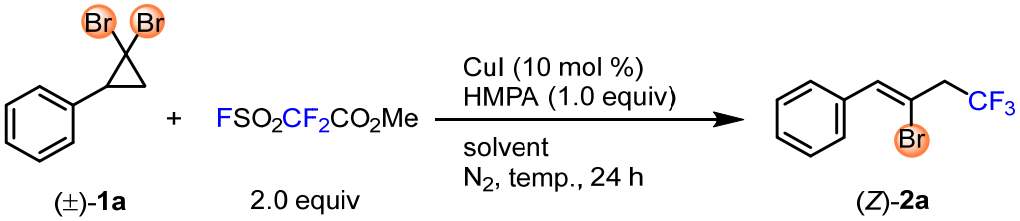


(±)-**1a** 2.0 equiv (*Z*)-**2a**

Entry	Catalyst	Yield (%)[a]	Entry	Catalyst	Yield (%)[a]
1	CuCl	57	6	CuOAc	12
2	CuBr	69	7	CuOTf	trace
3	CuI	88	8	$CuCl_2$	0
4	CuCN	36	9	$CuBr_2$	0
5	CuTc	22	10	—	0

[a] Yield was based on **1a**.

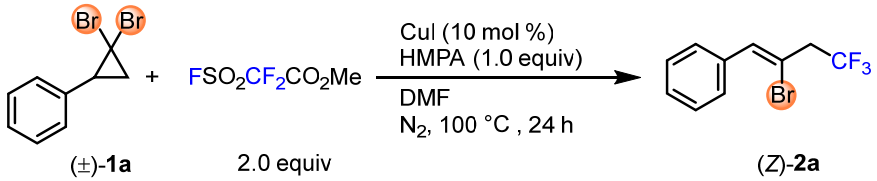
Table S2 Effect of solvent.



(±)-**1a** 2.0 equiv (*Z*)-**2a**

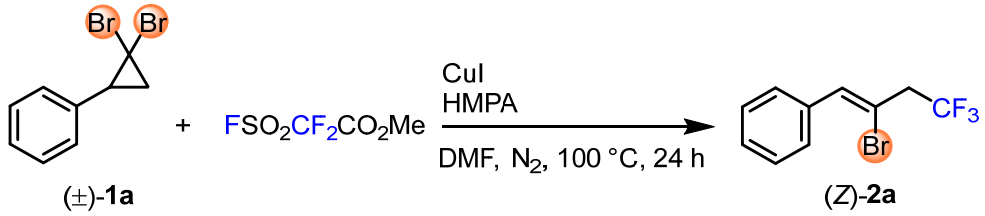
Entry	Solvent	Temp. (°C)	Yield (%)[a]	Entry	Solvent	Temp. (°C)	Yield (%)[a]
1	benzene	80	0	9	EA	80	0
2	toluene	110		10	acetone	60	
3	DCM	40		11	HMPA	120	16
4	DCE	80		12	DMSO	100	31
5	THF	60		13	DMI	100	25
6	DME	80		14	DMF	80	88
7	1,4-dioxane	100		15	CH_3OH	65	0
8	CH_3CN	80					

[a] Yield was based on **1a**.



(±)-**1a** 2.0 equiv (*Z*)-**2a**

Table S3 Effect of the molar ratio of reactants.

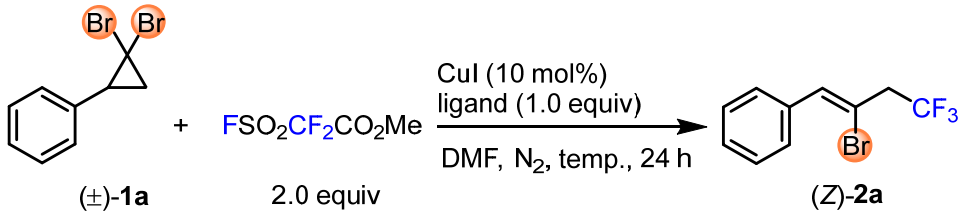


(±)-**1a** (*Z*)-**2a**

Entry	Chen's reagent : HMPA : CuI	Yield (%)[a]	Entry	Chen's reagent : HMPA : CuI	Yield (%)[a]
1	2.0 : 1.0 : 0.0	0	9	2.0 : 1.0 : 0.1	88
2	2.0 : 1.0 : 0.05	60	10	2.0 : 2.0 : 0.1	79
3	2.0 : 1.0 : 0.1	88	11	2.0 : 3.0 : 0.1	77
4	2.0 : 1.0 : 0.5	74	11	1.0 : 1.0 : 0.1	70
5	2.0 : 1.0 : 1.0	58	12	1.5 : 1.0 : 0.1	81
6	2.0 : 0.0 : 0.1	10	13	2.0 : 1.0 : 0.1	88
7	2.0 : 0.1 : 0.1	30	14	3.0 : 1.0 : 0.1	80
8	2.0 : 0.5 : 0.1	62			

[a] Yield was based on limited reactant.

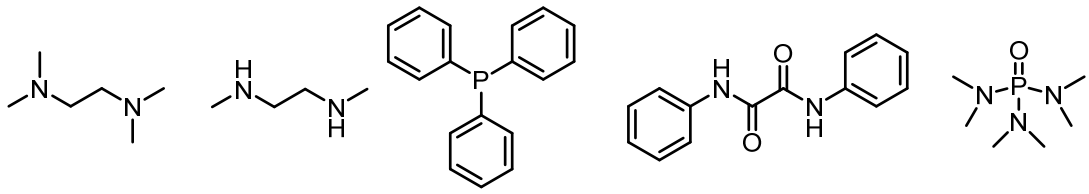
Table S4 Effect of the ligand and temperature.



(±)-**1a** 2.0 equiv (*Z*)-**2a**

Entry	Temp. (°C)	Ligand	Yield (%)[a]
1	100	—	10
2		TMEDA	28
3		DMEDA	19
4		Oxanilide	22
5		HMPA	88
6		PPh_3	62
7	60	HMPA	0
8	80		0
9	100		88
10	120		67

[a] Yield was based on **1a**.



TMEDA **DMEDA** **PPh_3** **Oxanilide** **HMPA**

Fig. S5 | Structures of ligands used in screening.

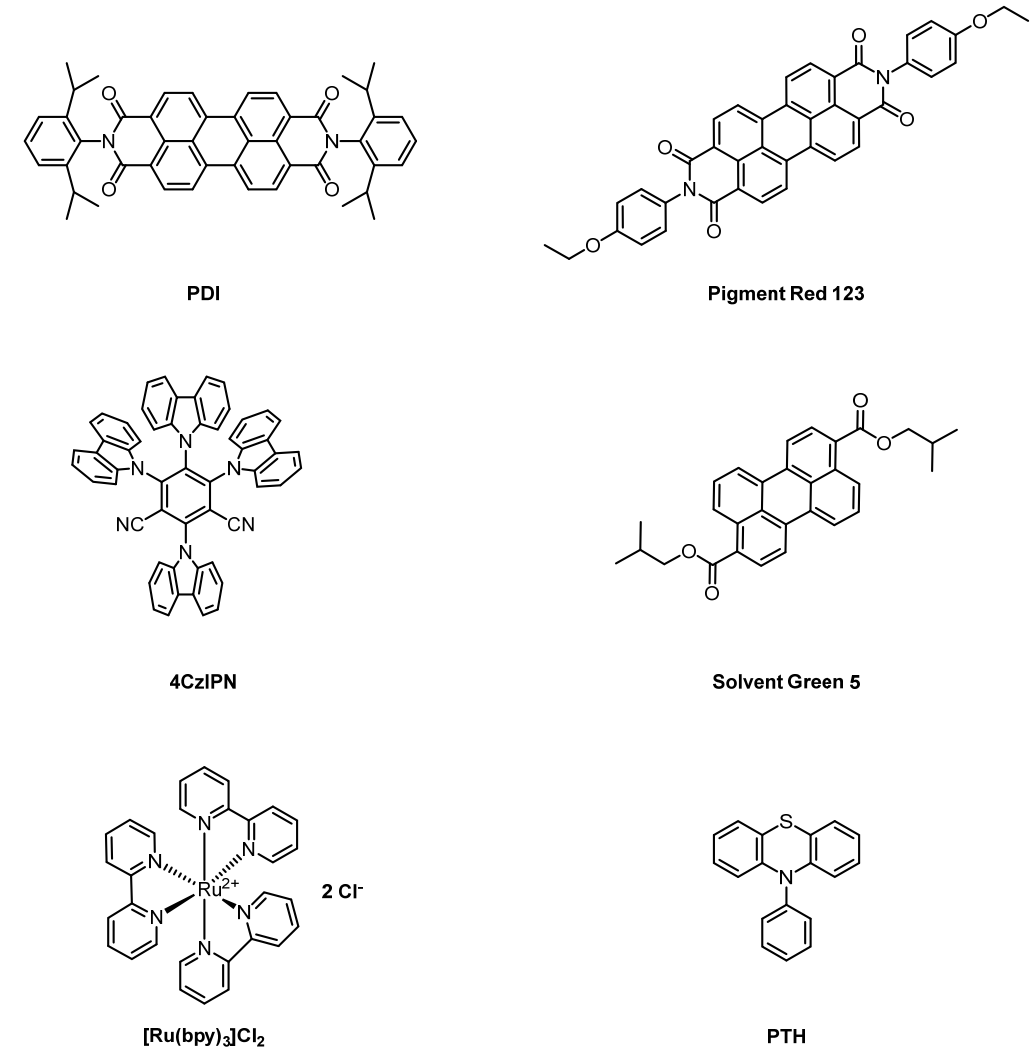
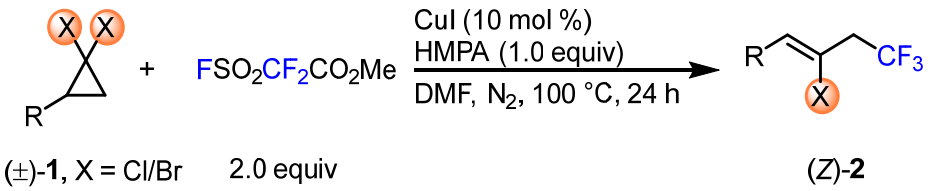


Fig. S6 | Structures of photocatalysts used in screening.

4.2 Typical procedure

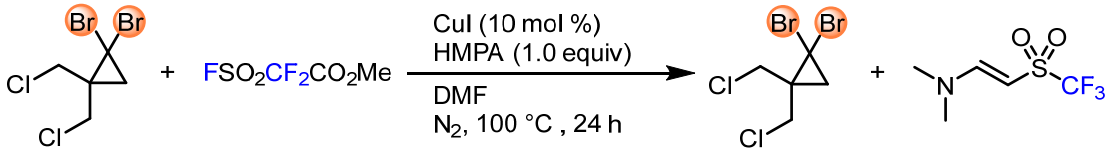


(±)-**1**, X = Cl/Br 2.0 equiv (*Z*)-**2**

A dry 50 mL Schlenk tube charged with a stirring bar was evacuated and backfilled with N_2 (three times). Copper(I) iodide (20 mg, 0.1 mmol, 10 mol %), HMPA (179 mg, 1.0 mmol, 1.0 equiv) and anhydrous DMF (4.0 mL) were added under N_2 atmosphere. After the mixture had been stirred for 15 min at room temperature, *gem*-dihalocyclopropane (1.0 mmol, 1.0 equiv), FSO_2CF_2COOMe (384 mg,

2.0 mmol, 2.0 equiv) and DMF (6.0 mL) were added. The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 100 ℃ (oil bath). The reaction was monitored by TLC. Upon completion (24 h), the reaction mixture was cooled to room temperature, quenched carefully with H_2O (50 mL), extracted with DCM (30 mL × 3). The combined extracts were dried over anhydrous Na_2SO_4. After removal of the solvent under vacuum with a rotary evaporator, the crude product was purified by column chromatography on silica gel using hexanes as eluent to afford the desired trifluoromethylated product.

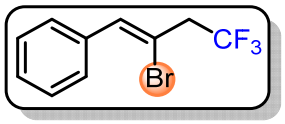
4.3 Side product



In several cases where the *gem*-dibromocyclopropane was not converted, we got a product of the reaction between Chen's reagent and DMF, and determined its structure by single crystal XRD analysis.

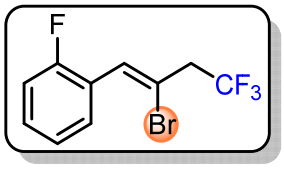
4.4 Physical data

(*Z*)-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)benzene (2a)



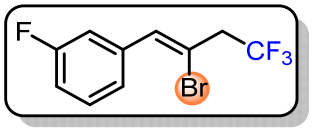
Colorless oil (232 mg, 88% yield); The assignment of the structure was based on NOE experiments. R_f = 0.7 (hexanes); IR (film) ν_{max} 3026, 1660, 1597, 1452, 1141, 1026, 825, 748 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.63 (d, *J* = 7.3 Hz, 2H), 7.44 – 7.39 (m, 2H), 7.39 – 7.34 (m, 1H), 7.01 (s, 1H), 3.44 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 135.1, 135.0, 129.0, 128.6, 128.2, 125.0 (q, *J* = 278.4 Hz), 111.7 (q, *J* = 6.8 Hz), 47.0 (q, *J* = 30.3 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.98 ppm; HRMS (EI) Calcd for $C_{10}H_8BrF_3$ 263.97615; Found 263.97564.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-2-fluorobenzene (2b)



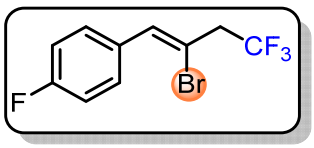
Colorless oil (200 mg, 71% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 3022, 1687, 1430, 1358, 1032, 877, 699 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.83 (td, *J* = 7.3, 1.4 Hz, 1H), 7.33 (m, 1H), 7.17 (td, *J* = 7.6, 1.2 Hz, 1H), 7.10 – 7.05 (m, 2H), 3.46 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 160.0 (d, *J* = 249.3 Hz), 130.3 (d, *J* = 8.5 Hz), 129.9 (d, *J* = 2.6 Hz), 128.2 (d, *J* = 4.9 Hz), 124.8 (q, *J* = 278.2 Hz), 123.7 (d, *J* = 3.7 Hz), 123.1 (d, *J* = 13.4 Hz), 115.4 (d, *J* = 21.6 Hz), 114.6, 46.9 (q, *J* = 30.4 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.93, -114.48 ppm; HRMS (EI) Calcd for $C_{10}H_7BrF_4$ 281.96673; Found 281.96635.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-3-fluorobenzene (2c)



Colorless oil (192 mg, 68% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 3028, 1652, 1522, 1263, 1135, 1029, 825 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.42 – 7.30 (m, 3H), 7.04 (td, *J* = 7.5, 2.3 Hz, 1H), 6.96 (s, 1H), 3.43 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 162.5 (d, *J* = 245.8 Hz), 136.9 (d, *J* = 8.0 Hz), 133.9, 129.8 (d, *J* = 8.3 Hz), 124.9 (d, *J* = 3.0 Hz), 124.8 (q, *J* = 278.2 Hz), 115.6 (d, *J* = 17.1 Hz), 115.5 (d, *J* = 15.2 Hz), 113.1 (q, *J* = 3.1 Hz), 47.0 (q, *J* = 30.5 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.93 (t, *J* = 9.7 Hz), -112.63 ppm; HRMS (EI) Calcd for $C_{10}H_7BrF_4$ 281.96673; Found 281.96625.

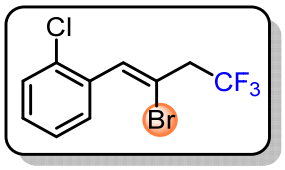
(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-4-fluorobenzene (2d)



Colorless oil (197 mg, 70% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 3019, 1666, 1347, 1251, 1140, 1031, 815, 757 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.68 – 7.53 (m, 2H), 7.13 – 7.02 (m, 2H), 6.95 (s, 1H), 3.42 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 162.5 (d, *J* = 249.3 Hz), 141.9, 133.9, 130.9 (d, *J* = 8.2 Hz), 124.9 (q, *J* = 278.3 Hz), 115.3 (d, *J* = 21.6 Hz), 111.7, 47.0 (q,

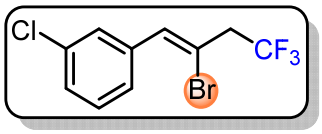
J = 30.3 Hz) ppm; ^{19}F NMR (376 MHz,) δ -65.03 (t, J = 9.9 Hz), -111.82 ppm; HRMS (EI) Calcd for $C_{10}H_7BrF_4$ 281.96673; Found 281.96643.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-2-chlorobenzene (2e)



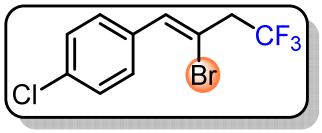
Colorless oil (197 mg, 66% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 2922, 1712, 1467, 1381, 1026, 752 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.71 – 7.63 (m, 1H), 7.43 – 7.38 (m, 1H), 7.32 – 7.27 (m, 2H), 7.10 (s, 1H), 3.48 (q, J = 9.6 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 133.9, 133.5, 132.8, 130.6, 129.7, 129.3, 126.4, 124.8 (q, J = 278.3 Hz), 115.0 (q, J = 3.7 Hz), 46.4 (q, J = 30.5 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.88 (t, J = 9.8 Hz) ppm; HRMS (EI) Calcd for $C_{10}H_7BrClF_3$ 297.93718; Found 297.93635.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-3-chlorobenzene (2f)



Colorless oil (209 mg, 70% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 3037, 1672, 1452, 1044, 764, 694 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.60 (m, 1H), 7.46 (ddd, J = 5.4, 3.9, 1.7 Hz, 1H), 7.32 (td, J = 4.3, 1.9 Hz, 2H), 6.94 (s, 1H), 3.43 (q, J = 9.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 136.7, 134.2, 133.7, 129.5, 128.8, 128.6, 127.1, 124.8 (q, J = 278.3 Hz), 113.4 (q, J = 3.7 Hz), 46.9 (q, J = 30.4 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -64.92 (t, J = 10.0 Hz) ppm; HRMS (EI) Calcd for $C_{10}H_7BrClF_3$ 297.93718; Found 297.93633.

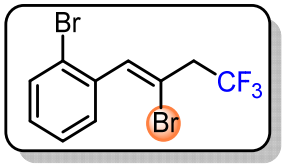
(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-4-chlorobenzene (2g)



Colorless oil (218 mg, 73% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 2974, 1704, 1544, 1410, 1031, 686 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.55 (d, J = 8.5 Hz, 2H), 7.36 (d, J = 8.5 Hz, 2H), 6.94 (s, 1H), 3.43 (q, J = 9.7 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 134.4, 133.9, 133.3, 130.3, 128.5, 124.8 (q, J = 280.5 Hz), 112.5 (q, J = 3.4 Hz), 47.0 (q, J = 30.4 Hz) ppm; ^{19}F NMR (376 MHz,

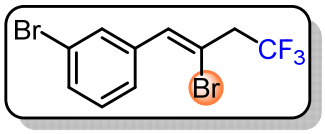
Chloroform-*d*) δ -64.95 (t, *J* = 10.0 Hz) ppm; HRMS (EI) Calcd for $C_{10}H_7BrClF_3$ 297.93718; Found 297.93617.

(*Z*)-1-Bromo-2-(2-bromo-4,4,4-trifluorobut-1-en-1-yl)benzene (2h)



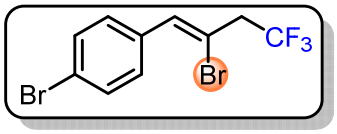
Colorless oil (270 mg, 79% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 3014, 1677, 1541, 1024, 688 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.61 (t, *J* = 8.5 Hz, 2H), 7.34 (t, *J* = 7.6 Hz, 1H), 7.21 (dd, *J* = 8.7, 6.8 Hz, 1H), 7.05 (s, 1H), 3.47 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 135.9, 135.0, 132.5, 130.8, 129.8, 127.0, 124.8 (q, *J* = 278.5 Hz), 123.5, 114.9 (q, *J* = 4.5 Hz), 46.3 (q, *J* = 30.5 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.81 (t, *J* = 9.8 Hz) ppm; HRMS (EI) Calcd for $C_{10}H_7Br_2F_3$ 341.88666; Found 341.88618.

(*Z*)-1-Bromo-3-(2-bromo-4,4,4-trifluorobut-1-en-1-yl)benzene (2i)



Colorless oil (280 mg, 82% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 3028, 1644, 1564, 1374, 1041, 678 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.73 (t, *J* = 1.9 Hz, 1H), 7.48 (m, 2H), 7.28 – 7.21 (m, 1H), 6.91 (s, 1H), 3.41 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.0, 133.6, 131.7, 131.5, 129.8, 127.5, 124.8 (q, *J* = 278.9 Hz), 122.3, 113.5 (q, *J* = 2.1 Hz), 46.9 (q, *J* = 30.4 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -64.90 (t, *J* = 9.4 Hz) ppm; HRMS (EI) Calcd for $C_{10}H_7Br_2F_3$ 341.88666; Found 341.88604.

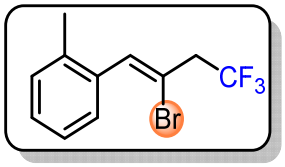
(*Z*)-1-Bromo-4-(2-bromo-4,4,4-trifluorobut-1-en-1-yl)benzene (2j)



Colorless oil (280 mg, 82% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 2975, 1743, 1420, 1403, 1071, 701 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.55 – 7.41 (m, 4H), 6.92 (s, 1H), 3.42 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 137.4, 133.9, 131.5, 130.5, 124.8 (q, *J* = 278.5 Hz),

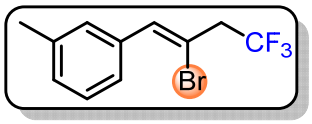
122.6, 112.7 (q, J = 3.2 Hz), 47.0 (q, J = 30.4 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -64.93 (t, J = 9.7 Hz) ppm; HRMS (EI) Calcd for $C_{10}H_7Br_2F_3$ 341.88666; Found 341.88610.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-2-methylbenzene (2k)



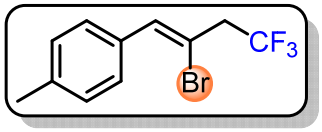
Colorless oil (189 mg, 68% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 3008, 1683, 1367, 1110, 1028, 755 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.44 – 7.38 (m, 1H), 7.28 – 7.17 (m, 4H), 7.03 (s, 1H), 3.46 (q, J = 9.7 Hz, 2H), 2.26 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 136.1, 135.2, 135.0, 129.9, 128.7, 128.3, 125.6, 124.9 (q, J = 278.2 Hz), 114.3 (q, J = 3.3 Hz), 46.1 (q, J = 30.5 Hz), 19.6 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.07 (t, J = 9.8 Hz) ppm; HRMS (EI) Calcd for $C_{11}H_{10}BrF_3$ 277.99180; Found 277.99194.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-3-methylbenzene (2l)



Colorless oil (211 mg, 76% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 2988, 1710, 1462, 1363, 1017, 772 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.48 – 7.39 (m, 2H), 7.29 (t, J = 7.7 Hz, 1H), 7.17 (m, 1H), 6.97 (s, 1H), 3.43 (q, J = 9.7 Hz, 2H), 2.39 (s, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 137.9, 135.2, 134.9, 129.6, 129.3, 128.1, 126.0, 125.0 (q, J = 278.4 Hz), 111.4 (q, J = 3.3 Hz), 47.0 (q, J = 30.3 Hz), 21.4 ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -65.01 (t, J = 9.5 Hz) ppm; HRMS (EI) Calcd for $C_{11}H_{10}BrF_3$ 277.99180; Found 277.99190.

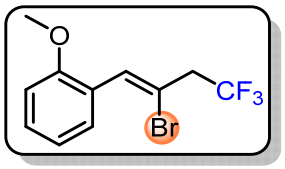
(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-4-methylbenzene (2m)



Colorless oil (234 mg, 84% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 3015, 1688, 1355, 1263, 1024, 812, 756 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.55 – 7.50 (m, 2H), 7.23 – 7.17 (m, 2H), 6.96 (s, 1H), 3.42 (q, J = 9.5 Hz, 2H), 2.37 (s, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 138.6, 135.0, 132.1, 128.9, 128.9 125.0 (q, J = 278.2 Hz), 110.7 (q, J = 3.4 Hz), 47.1 (q, J = 30.3 Hz), 21.3 ppm; ^{19}F

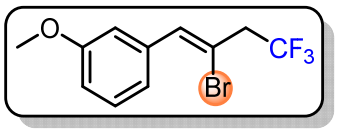
NMR (376 MHz, Chloroform-*d*) δ -65.05 (t, *J* = 10.0 Hz) ppm; HRMS (EI) Calcd for $C_{11}H_{10}BrF_3$ 277.99180; Found 277.99179.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-2-methoxybenzene (2n)



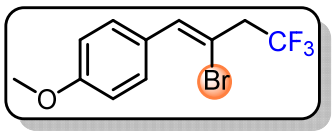
Colorless oil (168 mg, 57% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 3128, 1658, 1582, 1262, 1112, 1038, 778 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.78 (ddd, *J* = 7.7, 1.8, 0.7 Hz, 1H), 7.38 – 7.30 (m, 1H), 7.14 (s, 1H), 6.99 (td, *J* = 7.6, 1.1 Hz, 1H), 6.89 (dd, *J* = 8.3, 1.1 Hz, 1H), 3.84 (s, 3H), 3.45 (q, *J* = 9.8 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 157.0, 131.0, 129.9, 129.8, 125.0 (q, *J* = 278.3 Hz), 124.1, 120.0, 112.1 (q, *J* = 3.3 Hz), 110.4, 55.5, 46.9 (q, *J* = 30.2 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -64.99 (t, *J* = 9.7 Hz) ppm; HRMS (EI) Calcd for $C_{11}H_{10}BrF_3O$ 293.98671; Found 293.98630.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-3-methoxybenzene (2o)



Colorless oil (182 mg, 62% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 3074, 1652, 1577, 1259, 1114, 1041, 770 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.30 (t, *J* = 8.0 Hz, 1H), 7.20 (t, *J* = 2.1 Hz, 1H), 7.15 (m, 1H), 6.96 (s, 1H), 6.90 (ddd, *J* = 8.2, 2.6, 1.0 Hz, 1H), 3.83 (s, 3H), 3.42 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.4, 136.2, 134.9, 125.0 (q, *J* = 278.5 Hz), 121.6, 114.4, 114.1, 111.9 (q, *J* = 3.5 Hz), 55.3, 47.1 (q, *J* = 30.2 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -64.98 (t, *J* = 9.6 Hz) ppm; HRMS (EI) Calcd for $C_{11}H_{10}BrF_3O$ 293.98671; Found 293.98632.

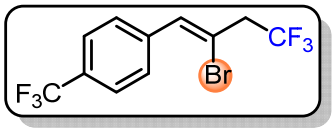
(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-4-methoxybenzene (2p)



Colorless oil (185 mg, 63% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 3079, 1662, 1585, 1267, 1115, 1035, 786 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.64 – 7.57 (m, 2H), 6.92 (m, 1H), 6.91 – 6.90 (m, 2H), 3.83 (s, 3H), 3.40 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.7,

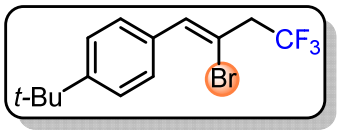
134.4, 130.5, 127.3, 125.1 (q, J = 278.4 Hz), 113.6, 109.4 (q, J = 3.2 Hz), 55.3, 47.1 (q, J = 30.3 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -65.12 (t, J = 9.9 Hz) ppm; HRMS (EI) Calcd for $C_{11}H_{10}BrF_3O$ 293.98671; Found 293.98630.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-4-(trifluoromethyl)benzene (2q)



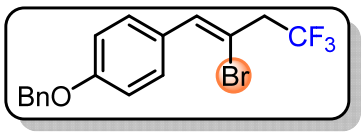
Colorless oil (199 mg, 60% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 3016, 2988, 1652, 1558, 1458, 1038, 698 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.73 (d, J = 8.4 Hz, 2H), 7.66 (d, J = 8.4 Hz, 2H), 7.03 (s, 1H), 3.46 (q, J = 9.6 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 138.5, 133.8, 130.3 (q, J = 33.0 Hz), 129.2, 125.2 (q, J = 3.9 Hz), 124.8 (q, J = 279.7 Hz), 124.1 (q, J = 273.7 Hz), 114.3 (q, J = 3.4 Hz), 46.9 (q, J = 30.6 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -62.66, -64.87 (t, J = 9.5 Hz) ppm; HRMS (EI) Calcd for $C_{11}H_7BrF_6$ 331.96353; Found 331.96340.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)-4-(*tert*-butyl)benzene (2r)



Colorless oil (275 mg, 86% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 3016, 2988, 1652, 1558, 1458, 1038, 698 cm^{-1}; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.66 – 7.51 (m, 2H), 7.44 – 7.38 (m, 2H), 6.96 (s, 1H), 3.42 (q, J = 9.7 Hz, 2H), 1.35 (s, 9H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 151.8, 134.8, 132.0, 128.8, 125.2, 125.0 (q, J = 278.0 Hz), 110.6 (q, J = 4.2 Hz), 47.2 (q, J = 30.0 Hz), 34.7, 31.2 ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -65.06 (t, J = 9.9 Hz) ppm; HRMS (EI) Calcd for $C_{14}H_{16}BrF_3$ 320.03875; Found 320.03841.

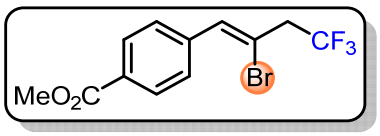
(*Z*)-1-(Benzyloxy)-4-(2-bromo-4,4,4-trifluorobut-1-en-1-yl)benzene (2s)



Colorless oil (311 mg, 84% yield); R_f = 0.6 (hexanes); IR (film) ν_{max} 3078, 2826, 1672, 1581, 1442, 1026, 782 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.71 – 7.63 (m, 2H), 7.51 – 7.48 (m, 2H), 7.45 (ddd, J = 7.7, 6.4, 1.2 Hz, 2H), 7.43 – 7.37 (m, 1H), 7.07 – 7.02 (m, 2H), 6.94 (s, 1H), 5.13 (s, 2H), 3.43 (q, J = 9.8 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 158.9, 136.7, 134.4, 130.5, 128.6,

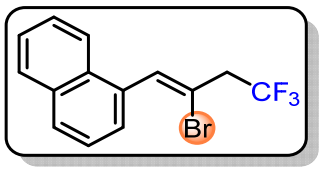
128.0, 127.4, 125.1 (q, J = 278.5 Hz), 114.5, 109.5 (q, J = 4.3 Hz), 70.0, 47.1 (q, J = 30.2 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.95 (t, J = 9.7 Hz) ppm; HRMS (EI) Calcd for $C_{17}H_{14}BrF_3O$ 370.01801; Found 370.01750.

Methyl (*Z*)-4-(2-bromo-4,4,4-trifluorobut-1-en-1-yl)benzoate (2t)



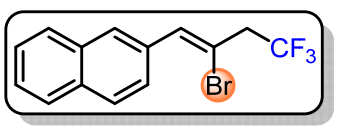
Colorless oil (184 mg, 57% yield); R_f = 0.5 (50:1 hexanes/EA); IR (film) ν_{max} 3132, 2930, 1544, 1104, 767 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 8.07 – 7.96 (m, 2H), 7.65 (d, J = 8.2 Hz, 2H), 7.03 (s, 1H), 3.93 (s, 3H), 3.45 (q, J = 9.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 166.6, 139.4, 134.2, 129.9, 129.5, 128.9, 124.8 (q, J = 276.6 Hz), 114.0 (q, J = 2.6 Hz), 52.2, 47.1 (q, J = 31.4 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -64.86 (t, J = 9.3 Hz) ppm; HRMS (EI) Calcd for $C_{12}H_{10}BrF_3O_2$ 321.98163; Found 321.98159.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)naphthalene (2u)



Colorless oil (207 mg, 66% yield); R_f = 0.7 (hexanes); m.p. 66.5–67.1 °C; IR (film) ν_{max} 3068, 3054, 2867, 1703, 1672, 1209, 867, 676, 481 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.95 – 7.82 (m, 3H), 7.61 (d, J = 7.1 Hz, 1H), 7.59 – 7.48 (m, 3H), 7.45 (s, 1H), 3.58 (q, J = 9.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 134.2, 133.4, 133.0, 130.9, 128.7, 128.6, 126.8, 126.5, 126.1, 125.2, 125.0 (q, J = 278.4 Hz), 124.1, 115.7 (q, J = 3.0 Hz), 46.2 (q, J = 30.3 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.81 (t, J = 9.6 Hz) ppm; HRMS (EI) Calcd for $C_{14}H_{10}BrF_3$ 313.99180; Found 313.99155.

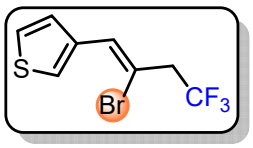
(*Z*)-2-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)naphthalene (2v)



White solid (239 mg, 76% yield); R_f = 0.7 (hexanes); m.p. 67.1–67.6 °C; IR (film) ν_{max} 3073, 3048, 2876, 1712, 1654, 872, 688, 476 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 8.15 – 8.06 (m, 1H), 7.90

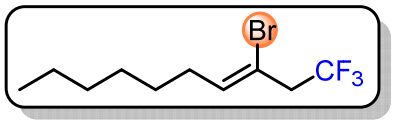
– 7.82 (m, 3H), 7.72 (dd, J = 8.5, 1.8 Hz, 1H), 7.55 – 7.47 (m, 2H), 7.15 (s, 1H), 3.49 (q, J = 9.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 135.1, 133.1, 133.0, 132.4, 128.7, 128.3, 127.8, 127.7, 126.7, 126.4, 126.3, 125.0 (q, J = 278.1 Hz), 112.0 (q, J = 3.6 Hz), 47.1 (q, J = 30.3 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -64.89 (t, J = 9.6 Hz) ppm; HRMS (EI) Calcd for $C_{14}H_{10}BrF_3$ 313.99180; Found 313.99136.

(*Z*)-3-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)thiophene (2w)



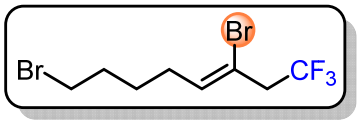
Colorless oil (170 mg, 63% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 3922, 3106, 2916, 1772, 1671, 876, 615, 453 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.83 (dt, J = 3.0, 0.9 Hz, 1H), 7.47 (dd, J = 5.1, 1.3 Hz, 1H), 7.33 (dd, J = 5.1, 3.0 Hz, 1H), 7.00 (s, 1H), 3.41 (q, J = 9.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 135.8, 129.4, 128.3, 126.2, 125.0, 125.0 (q, J = 278.5 Hz), 110.2 (q, J = 3.4 Hz), 46.9 (q, J = 30.3 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.10 (t, J = 9.1 Hz) ppm; HRMS (EI) Calcd for $C_8H_6BrF_3S$ 269.93257; Found 269.93263.

(*Z*)-3-Bromo-1,1,1-trifluorodec-3-ene (2x)



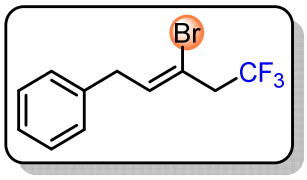
Colorless oil (207 mg, 76% yield); R_f = 0.9 (hexanes); The assignment of the structure was based on NOE experiments. IR (film) ν_{max} 3075, 1641, 1443, 1376, 1179, 877 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 5.96 (t, J = 6.9 Hz, 1H), 3.23 (q, J = 9.8 Hz, 2H), 2.20 (q, J = 7.2 Hz, 2H), 1.48 – 1.38 (m, 2H), 1.36 – 1.25 (m, 6H), 0.93 – 0.85 (m, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.5, 125.0 (q, J = 277.9 Hz), 112.6 (q, J = 3.4 Hz), 45.4 (q, J = 30.3 Hz), 31.7, 31.6, 28.8, 27.9, 22.6, 14.0 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.39 (t, J = 10.0 Hz) ppm; HRMS (EI) Calcd for $C_{10}H_{16}BrF_3$ 272.03875; Found 272.03881.

(*Z*)-3,8-Dibromo-1,1,1-trifluorooct-3-ene (2y)



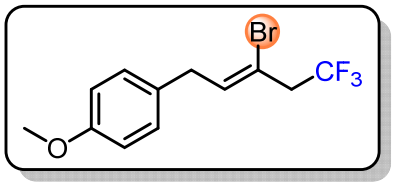
Colorless oil (270 mg, 84% yield); R_f = 0.9 (hexanes); IR (film) ν_{max} 3122, 2963, 1657, 1488, 1326, 1237, 857 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 5.95 (t, *J* = 7.0 Hz, 1H), 3.42 (t, *J* = 6.6 Hz, 2H), 3.30 – 3.15 (m, 2H), 2.25 (q, *J* = 7.3 Hz, 2H), 1.88 (dt, *J* = 15.1, 6.8 Hz, 2H), 1.68 – 1.50 (m, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 136.4, 124.9 (q, *J* = 278.3 Hz), 113.5 (q, *J* = 3.6 Hz), 45.3 (q, *J* = 30.3 Hz), 33.3, 31.9, 30.7, 26.4 ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -65.29 (t, *J* = 10.0 Hz) ppm; HRMS (EI) Calcd for $C_8H_{11}Br_2F_3$ 321.91796; Found 321.91787.

(*Z*)-(3-Bromo-5,5,5-trifluoropent-2-en-1-yl) benzene (2z)



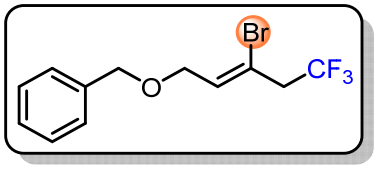
Colorless oil (170 mg, 61% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 3044, 2874, 1684, 1251, 1114, 851, 662 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.35 (t, *J* = 7.6 Hz, 2H), 7.30 – 7.27 (m, 1H), 7.25 – 7.22 (m, 2H), 6.18 (t, *J* = 7.0 Hz, 1H), 3.61 (d, *J* = 7.0 Hz, 2H), 3.31 (q, *J* = 9.8 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 138.2, 135.9, 128.7, 128.4, 126.6, 124.9 (q, *J* = 278.3 Hz), 113.7 (q, *J* = 3.8 Hz), 45.3 (q, *J* = 30.3 Hz), 38.0 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.06 (t, *J* = 9.8 Hz) ppm; HRMS (EI) Calcd for $C_{11}H_{10}BrF_3$ 277.99180; Found 277.99179.

(*Z*)-1-(3-Bromo-5,5,5-trifluoropent-2-en-1-yl)-4-methoxybenzene (2a')



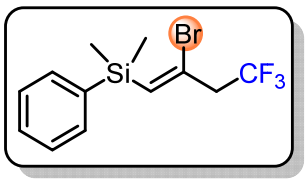
Colorless oil (250 mg, 81% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 3057, 2901, 1645, 1209, 1184, 884, 775 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.15 (d, *J* = 8.6 Hz, 2H), 6.88 (d, *J* = 8.6 Hz, 2H), 6.15 (t, *J* = 7.0 Hz, 1H), 3.81 (s, 3H), 3.54 (d, *J* = 7.0 Hz, 2H), 3.30 (q, *J* = 9.8 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 158.3, 136.3, 130.1, 129.3, 124.9 (q, *J* = 278.1 Hz), 114.0, 113.3 (q, *J* = 3.2 Hz), 55.2, 45.3 (q, *J* = 30.4 Hz), 37.1 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.09 (t, *J* = 9.8 Hz) ppm; HRMS (EI) Calcd for $C_{12}H_{12}BrF_3O$ 308.00236; Found 308.00200.

(*Z*)-(((3-Bromo-5,5,5-trifluoropent-2-en-1-yl)oxy)methyl)benzene (2b')



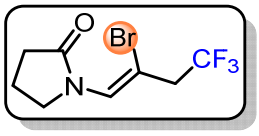
Colorless oil (256 mg, 83% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 3098, 2876, 1673, 1255, 1174, 812, 745 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.42 – 7.34 (m, 5H), 7.32 (td, *J* = 6.0, 2.5 Hz, 1H), 6.25 (t, *J* = 5.4 Hz, 1H), 4.54 (s, 2H), 4.20 (d, *J* = 5.5 Hz, 2H), 3.27 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 137.6, 134.5, 128.5, 127.9, 124.6 (q, *J* = 278.8 Hz), 114.0 (q, *J* = 4.9 Hz), 72.8, 69.6, 45.3 (q, *J* = 30.7 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -65.02 (t, *J* = 9.7 Hz) ppm; HRMS (EI) Calcd for $C_{12}H_{12}BrF_3O$ 308.00236; Found 308.00221.

(*Z*)-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)dimethyl(phenyl)silane (2c')



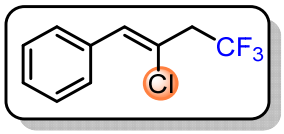
Colorless oil (254 mg, 79% yield); R_f = 0.8 (hexanes); IR (film) ν_{max} 3085, 2946, 1722, 1244, 1209, 1074, 846, 667 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.59 – 7.52 (m, 2H), 7.39 (d, *J* = 6.3 Hz, 3H), 6.51 (s, 1H), 3.34 (q, *J* = 9.9 Hz, 2H), 0.51 (s, 6H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.1, 136.8, 133.8, 129.3, 127.9, 127.7 (q, *J* = 2.8 Hz), 124.6 (q, *J* = 278.3 Hz), 49.2 (q, *J* = 29.8 Hz), -2.4 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.96 (t, *J* = 9.7 Hz) ppm; HRMS (EI) Calcd for $C_{21}H_{14}BrF_3Si$ 322.00002; Found 322.00013.

(*Z*)-1-(2-Bromo-4,4,4-trifluorobut-1-en-1-yl)pyrrolidin-2-one (2d')



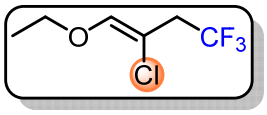
Colorless oil (89.4 mg, 33% yield); R_f = 0.4 (10:1 hexanes/EA); IR (film) ν_{max} 1669, 1275, 1188, 831 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.21 (s, 1H), 3.84 (ddd, *J* = 9.1, 6.1, 1.9 Hz, 2H), 3.02 (q, *J* = 10.0 Hz, 2H), 2.51 (t, *J* = 8.1 Hz, 2H), 2.15 (m, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 175.7, 133.4 (q, *J* = 3.3 Hz), 123.1 (q, *J* = 277.5 Hz), 47.3 (q, *J* = 6.8 Hz), 31.9, 29.8, 29.7 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.10 (t, *J* = 9.9 Hz) ppm; HRMS (EI) Calcd for $C_8H_9BrF_3NO$ 270.98196; Found 270.98203.

(*Z*)-(2-Chloro-4,4,4-trifluorobut-1-en-1-yl) benzene (2e')



Colorless oil (172 mg, 78% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 3021, 1684, 1354, 1273, 1146, 1027, 823, 691 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.68 – 7.62 (m, 2H), 7.45 – 7.37 (m, 2H), 7.37 – 7.30 (m, 1H), 6.70 (s, 1H), 3.27 (q, *J* = 9.7 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 133.9, 131.5, 129.2, 128.5, 128.3, 124.8 (q, *J* = 278.3 Hz), 121.8 (q, *J* = 3.5 Hz), 45.2 (q, *J* = 30.6 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -65.09 (t, *J* = 10.0 Hz) ppm; HRMS (EI) Calcd for $C_{10}H_8ClF_3$ 220.02666; Found 220.02660.

(*Z*)-2-Chloro-1-ethoxy-4,4,4-trifluorobut-1-ene (2f')



Colorless oil (920 mg, 52% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 3021, 1684, 1354, 1273, 1146, 1027, 823, 691 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 6.38 (s, 1H), 3.98 (q, *J* = 7.1 Hz, 2H), 3.00 – 2.92 (m, 2H), 1.33 (t, *J* = 7.1 Hz, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 145.7, 125.0 (q, *J* = 278.0 Hz), 100.2, 69.3, 39.1 (q, *J* = 31.2 Hz), 15.2 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -66.10 (t, *J* = 10.4 Hz) ppm; HRMS (EI) Calcd for $C_6H_8ClF_3O$ 188.02158; Found 188.02164.

4.5 2D Nuclear Overhauser Effect (NOE) analysis

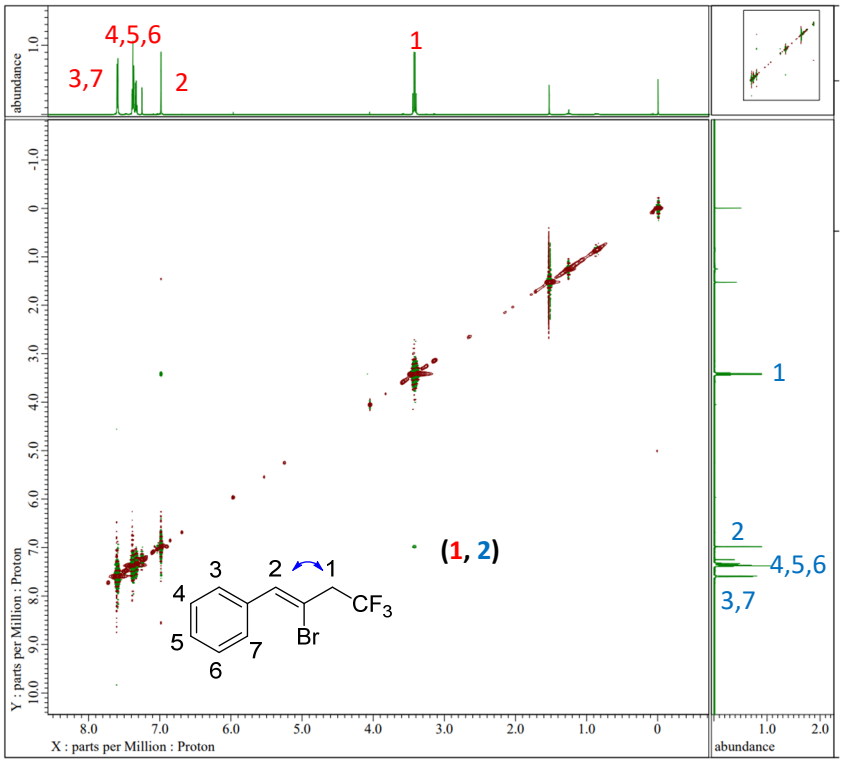


Fig. S7 | 2D NOESY spectrum ($CDCl_3$, 600 MHz, 25 °C, mixing time = 500 ms) of **2a**.

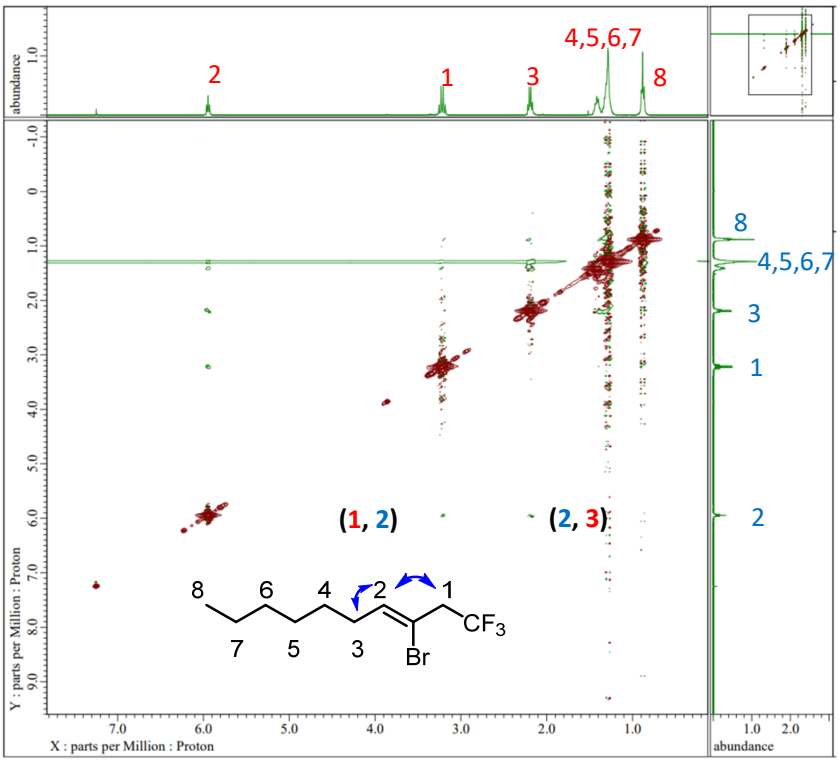
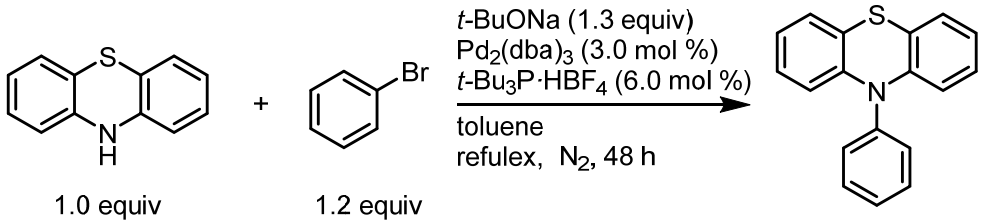


Fig. S8 | 2D NOESY spectrum ($CDCl_3$, 400 MHz, 25 °C, mixing time = 500 ms) of **2x**.

5 Photocatalytic preparations of monobromocyclopropanes

5.1 Preparation of photocatalyst PTH



10-Phenyl-10*H*-phenothiazine was similarly synthesized according to the reported procedure[9].

A dry Schlenk tube charged with a stirring bar was evacuated and backfilled with N_2 (three times). Phenothiazine (2.0 g, 10 mmol, 1.0 equiv) was dissolved in anhydrous toluene (0.50 M). Bromobenzene (1.9 g, 12 mmol, 1.2 equiv), *t*-BuONa (1.3 g, 13 mmol, 1.3 equiv) and *t*-$Bu_3P{\cdot}HBF_4$ (17 mg, 0.60 mmol, 6.0 mol %) were added, followed by $Pd_2(dba)_3$ (27 mg, 0.30 mmol, 3.0 mol %). The reaction mixture was degassed in three freeze-pump-thaw cycles and finally stirred under reflux for 48 h. After cooling to room temperature, 100 mL EA and 50 mL water were added to the reaction mixture. After phase separation, the aqueous phase was extracted additionally with EA (3 × 100 mL). The combined organic phases were dried over Na_2SO_4, the solvent evaporated and the residue was purified by column chromatography on silica gel using a mixture of hexanes and ethyl acetate (V/V = 30:1) as eluent to give the desired product.

5.2 Optimization of the conditions for reductive monodebromination of 1a

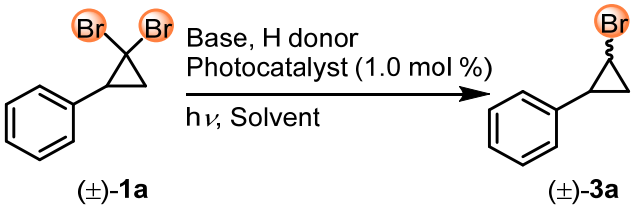


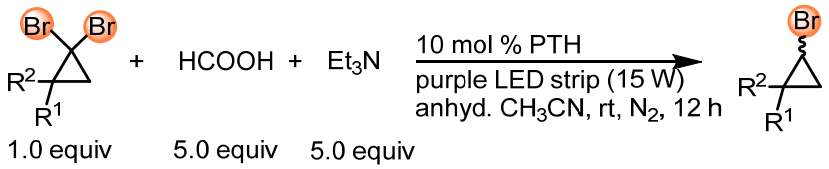
Table S5 Optimization of the conditions for debrominative reduction of **1a**.

Entry	Base	H donor	Photocatalyst (1.0 mol %)	Ligth source	Solvent	Yield (%)[a]
1	Et_3N	none	$[Ru(bpy)_3]Cl_2{\cdot}6H_2O$	Blue LED	DMSO	0

2			Pigment Red 123	Green LED		
3			Solvent Green 5	Blue LED		
4			PDI	Blue LED		
5			PTH	Purple LED		
6	Et_3N	2,4,6-triisopropylbenzenethiol	$[Ru(bpy)_3]Cl_2·6H_2O$	Blue LED		
7			4-CzIPN	Blue LED		
8	Et_3N	HCOOH	PTH (10 mol %)	Purple LED	CH_3CN	85
9	none	HCOOH		Purple LED		0
10	Et_3N	none		Purple LED		0
11	Et_3N	HCOOH	PDI	Blue LED	DMSO	50

[a] Yield was based on **1a**.

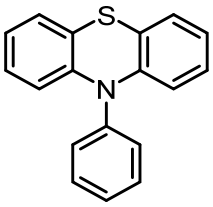
5.3 Typical procedure for reductive monodebrominations



A dry Schlenk tube charged with a stirring bar was evacuated and backfilled with N_2 (three times). *gem*-Dibromocyclopropane (1.0 mmol, 1.0 equiv), PTH (312 mg, 0.01mmol, 10 mol %), Et_3N (605 mg, 5.0 mmol, 5.0 equiv) and anhydrous acetonitrile (10 mL) were added under N_2 atmosphere. The mixture was stirred for 30 min before HCOOH (230 mg, 5.0 mmol, 5.0 equiv) was added dropwise. The reaction mixture was degassed by freeze-pump-thaw method and then stirred under irradiation with purple LEDs (400 nm, approximately 3.0 cm distance from the tube). The mixture was maintained at approximately 25 °C by a desk fan in air-conditioned room. The reaction was monitored by TLC. Upon completion (12 h), the mixture was concentrated in vacuo. The crude product was purified by flash chromatography on silica gel (100:1 hexanes/EA) to give pure monobromocyclopropane derivative as a colorless oil/solid.

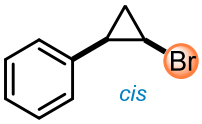
5.4 Physical data

10-Phenyl-10*H*-phenothiazine[9]



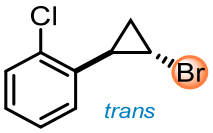
White solid (2.5 g, 92% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.61 (t, *J* = 7.9 Hz, 1H), 7.49 (t, *J* = 7.5 Hz, 1H), 7.43 – 7.37 (m, 1H), 7.03 (dd, *J* = 7.4, 1.7 Hz, 1H), 6.83 (m, 2H), 6.22 (dd, *J* = 8.0, 1.5 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 144.2, 141.0, 130.8, 130.7, 128.1, 126.8, 126.7, 122.4, 120.2, 116.0 ppm.

(*cis*-2-Bromocyclopropyl)benzene (3a)



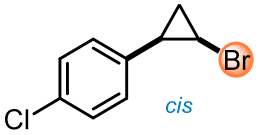
Yellow oil (188 mg, total 96% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.36 – 7.30 (m, 2H), 7.29 – 7.26 (m, 1H), 7.26 – 7.23 (m, 2H), 3.31 (td, *J* = 7.6, 4.6 Hz, 1H), 2.31 (dt, *J* = 9.6, 7.6 Hz, 1H), 1.58 (ddd, *J* = 9.6, 7.5, 6.8 Hz, 1H), 1.33 (td, *J* = 7.2, 4.6 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.1, 129.2, 127.9, 126.8, 24.0, 22.0, 14.1 ppm.

1-(*trans*-2-Bromocyclopropyl)-2-chlorobenzene (3e)



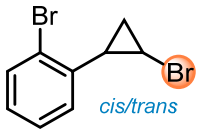
Yellow oil (184 mg, total 80% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.40 – 7.36 (m, 1H), 7.22 – 7.10 (m, 2H), 6.96 – 6.88 (m, 1H), 2.98 (m, 1H), 2.65 (ddd, *J* = 10.1, 6.8, 3.8 Hz, 1H), 1.54 (ddd, *J* = 9.7, 6.7, 4.5 Hz, 1H), 1.48 (q, *J* = 6.9 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.2, 135.6, 129.4, 127.9, 126.8, 126.7, 25.0, 20.8, 17.6 ppm.

1-(*cis*-2-Bromocyclopropyl)-4-chlorobenzene (3g)



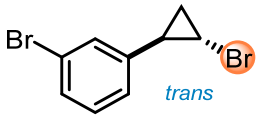
Yellow oil (214 mg, total 93% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.39 – 7.31 (m, 2H), 7.22 – 7.15 (m, 2H), 3.31 (td, *J* = 7.6, 4.6 Hz, 1H), 2.28 (dt, *J* = 9.5, 7.5 Hz, 1H), 1.60 (ddd, *J* = 9.5, 7.6, 6.9 Hz, 1H), 1.30 (ddd, *J* = 7.5, 6.9, 4.6 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 135.6, 132.4, 130.5, 128.0, 23.7, 21.4, 14.4 ppm.

1-Bromo-2-(2-bromocyclopropyl)benzene (3h)



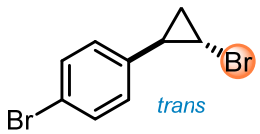
Yellow oil (208 mg, 76% yield); *trans* : *cis* = 3 : 1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.61 (dt, *J* = 8.1, 1.5 Hz, 1H), 7.59 – 7.53 (m, 3H), 7.33 – 7.25 (m, 1H), 7.22 (tt, *J* = 7.6, 1.7 Hz, 3H), 7.20 – 7.12 (m, 2H), 7.09 (tt, *J* = 7.6, 1.8 Hz, 3H), 6.95 – 6.89 (m, 3H), 3.42 (m, 1H), 2.95 (m, 3H), 2.61 (m, 3H), 2.46 – 2.33 (m, 1H), 1.64 (m, 1H), 1.57 – 1.43 (m, 6H), 1.38 (m, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 138.9, 137.1, 132.7, 132.4, 130.2, 128.4, 128.2, 127.4, 127.2, 127.0, 126.9, 126.1, 27.6, 23.7, 23.1, 21.1, 17.7, 14.5 ppm.

1-Bromo-3-(*trans*-2-bromocyclopropyl)benzene (3i)



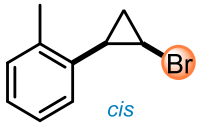
Yellow oil (233 mg, total 85% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.34 (ddd, *J* = 8.0, 2.0, 1.0 Hz, 1H), 7.20 (t, *J* = 1.9 Hz, 1H), 7.15 (t, *J* = 7.8 Hz, 1H), 6.99 (dt, *J* = 7.7, 1.4 Hz, 1H), 3.01 (ddd, *J* = 7.8, 4.6, 3.5 Hz, 1H), 2.36 (ddd, *J* = 9.9, 6.5, 3.5 Hz, 1H), 1.52 (ddd, *J* = 9.8, 6.8, 4.6 Hz, 1H), 1.45 (dt, *J* = 7.7, 6.7 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 142.2, 130.0, 129.6, 129.1, 124.7, 122.7, 26.5, 21.2, 19.0 ppm.

1-Bromo-4-(*trans*-2-bromocyclopropyl)benzene (3j)



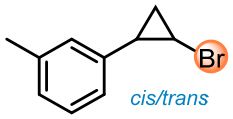
Yellow oil (249 mg, total 91% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.48 – 7.37 (m, 2H), 6.97 – 6.87 (m, 2H), 2.98 (ddd, *J* = 7.8, 4.5, 3.5 Hz, 1H), 2.35 (ddd, *J* = 9.9, 6.5, 3.5 Hz, 1H), 1.51 (ddd, *J* = 9.8, 6.8, 4.5 Hz, 1H), 1.42 (dt, *J* = 7.6, 6.7 Hz, 1H).ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 138.8, 131.6, 127.7, 120.2, 26.4, 21.2, 18.9 ppm.

1-(*cis*-2-Bromocyclopropyl)-2-methylbenzene (3k)



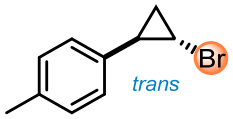
Yellow oil (158 mg, total 75% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.25 – 7.22 (m, 2H), 7.21 – 7.17 (m, 1H), 7.15 – 7.12 (m, 1H), 3.39 (td, *J* = 7.4, 4.2 Hz, 1H), 2.40 (s, 3H), 2.23 (dt, *J* = 9.4, 7.6 Hz, 1H), 1.60 (ddd, *J* = 9.4, 7.4, 6.7 Hz, 1H), 1.39 (ddd, *J* = 7.7, 6.7, 4.2 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 138.8, 135.8, 129.6, 128.7, 127.0, 125.5, 23.0, 21.1, 19.7, 13.6 ppm.

1-(2-Bromocyclopropyl)-3-methylbenzene (3l)



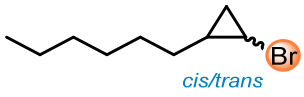
Yellow oil (193 mg, 92% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.22 (dd, *J* = 14.4, 6.8 Hz, 2H), 7.14 – 7.06 (m, 8H), 6.95 – 6.84 (m, 2H), 3.33 (td, *J* = 7.6, 4.5 Hz, 2H), 3.05 (dt, *J* = 7.8, 4.1 Hz, 1H), 2.40 (s, 8H), 2.36 (s, 3H), 2.33 – 2.28 (m, 2H), 1.59 (dt, *J* = 9.6, 7.1 Hz, 2H), 1.50 (ddd, *J* = 14.0, 8.0, 4.6 Hz, 2H), 1.35 (td, *J* = 7.2, 4.5 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 139.7, 138.2, 137.5, 137.0, 130.0, 128.4, 127.8, 127.5, 127.3, 126.8, 126.1, 122.9, 26.8, 24.0, 22.0, 21.7, 21.4, 21.3, 18.8, 14.1 ppm.

1-(*trans*-2-Bromocyclopropyl)-4-methylbenzene (3m)



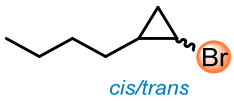
Yellow oil (185 mg, total 88% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.13 (dd, *J* = 8.3, 2.8 Hz, 2H), 7.01 – 6.96 (m, 2H), 3.02 (m, 1H), 2.40 (m, 1H), 2.35 (s, 3H), 1.50 (m, 1H), 1.47 – 1.42 (m, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 136.7, 136.1, 129.2, 125.9, 26.5, 21.6, 21.0, 18.7 ppm.

1-Bromo-2-hexylcyclopropane (3x)



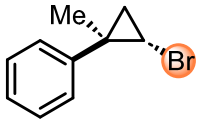
Colorless oil (182 mg, 89% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 3.05 (td, *J* = 7.4, 4.3 Hz, 1H), 2.59 (dt, *J* = 7.1, 3.4 Hz, 0.55H), 1.73 (dd, *J* = 10.2, 7.1 Hz, 0.26H), 1.56 – 1.13 (m, 25.50H), 0.97 (ddd, *J* = 9.6, 6.2, 3.8 Hz, 0.76H), 0.93 – 0.81 (m, 7.85H), 0.74 (dt, *J* = 7.4, 6.1 Hz, 0.60H), 0.49 (td, *J* = 6.7, 4.2 Hz, 1.05H) ppm.

1-Bromo-2-butylcyclopropane (3g′)



Colorless oil (121 mg, 69% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 3.05 (td, *J* = 7.4, 4.3 Hz, 1H), 2.59 (dt, *J* = 7.2, 3.3 Hz, 0.5H), 1.59 – 1.43 (m, 3.5H), 1.41 – 1.28 (m, 6.5H), 1.21 – 1.11 (m, 2H), 0.97 (ddd, *J* = 9.3, 6.2, 3.8 Hz, 0.5H), 0.85 – 0.79 (m, 5.5H), 0.75 (dt, *J* = 7.4, 6.1 Hz, 2H), 0.49 (ddd, *J* = 7.0, 6.2, 4.3 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 32.5, 31.2, 30.9, 30.8, 24.0, 22.9, 22.5, 22.3, 20.0, 16.8, 15.8, 15.0, 14.1, 14.0 ppm.

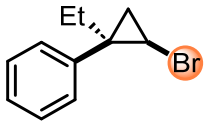
***trans*-2-Bromo-1-methylcyclopropyl)benzene (3h′)**



trans means Br and the phenyl group are on the opposite sides of the cyclopropane ring.

Yellow oil (172 mg, total 82% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.39 – 7.33 (m, 4H), 7.30 – 7.27 (m, 1H), 3.11 (dd, *J* = 7.4, 4.4 Hz, 1H), 1.47 (s, 3H), 1.42 – 1.36 (m, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 142.2, 129.4, 128.1, 126.8, 28.3, 27.6, 26.9, 22.1 ppm.

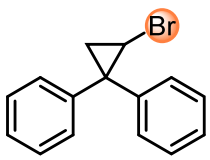
***cis*-2-Bromo-1-ethylcyclopropyl)benzene (3i′)**



cis means Br and the phenyl group are on the same side of the cyclopropane ring.

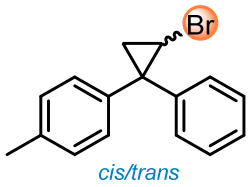
Yellow oil (186 mg, total 83% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.37 – 7.23 (m, 5H), 3.31 (ddd, *J* = 8.0, 4.6, 1.1 Hz, 1H), 2.08 – 1.84 (m, 2H), 1.59 (m, 1H), 1.33 (d, *J* = 1.7 Hz, 1H), 1.06 (ddd, *J* = 6.0, 4.5, 1.2 Hz, 1H), 0.95 (td, *J* = 7.4, 1.5 Hz, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 142.6, 128.8, 128.3, 126.6, 31.9, 30.8, 30.0, 29.7, 21.7, 11.0 ppm.

(2-Bromocyclopropane-1,1-diyl)dibenzene (3j′)



Yellow solid (248 mg, 91% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.56 – 7.38 (m, 4H), 7.38 – 7.20 (m, 6H), 3.76 (dd, *J* = 7.8, 4.8 Hz, 1H), 2.00 – 1.77 (m, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 144.1, 140.6, 130.4, 128.5, 128.2, 127.7, 127.1, 126.6, 36.2, 28.3, 23.8 ppm.

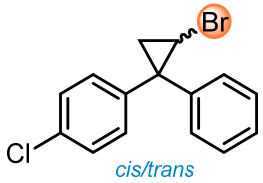
1-(2-Bromo-1-phenylcyclopropyl)-4-methylbenzene (3k′)



trans means Br and the *p*-tolyl group are on the opposite sides of the cyclopropane ring.

Yellow solid (243 mg, 85% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.53 – 7.47 (m, 1H), 7.47 – 7.37 (m, 2H), 7.37 – 7.29 (m, 2H), 7.29 – 7.20 (m, 3H), 7.20 – 7.13 (m, 1H), 3.76 (m, 1H), 2.41 (dd, *J* = 31.8, 5.1 Hz, 3H), 1.97 – 1.84 (m, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 144.3, 141.2, 140.8, 137.7, 136.6, 136.2, 130.3, 130.2, 129.2, 128.9, 128.5, 128.1, 127.6, 127.6, 126.9, 126.5, 35.9, 35.8, 28.5, 28.3, 23.8, 23.7, 21.1, 20.9 ppm.

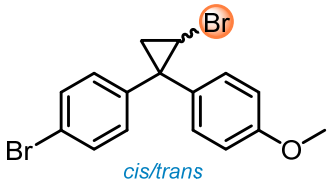
1-(2-Bromo-1-phenylcyclopropyl)-4-chlorobenzene (3l′)



trans means Br and the *p*-chlorophenyl group are on the opposite sides of the cyclopropane ring.

Yellow solid (269 mg, 88% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.43 – 7.27 (m, 6H), 7.21 (ddd, *J* = 20.3, 8.0, 2.0 Hz, 4H), 3.69 (m, 1H), 1.96 – 1.76 (m, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 143.5, 142.6, 140.1, 139.2, 133.0, 132.5, 131.7, 129.1, 128.7, 128.4, 128.3, 127.6, 127.3, 126.8, 35.7, 35.7, 28.0, 28.0, 23.9, 23.9 ppm.

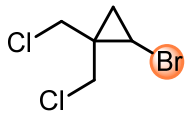
1-Bromo-4-(2-bromo-1-(4-methoxyphenyl)cyclopropyl)benzene (3m′)



Yellow solid (289 mg, 76% yield); R_f = 0.5 (50:1 hexanes/EA); m.p. 110.6–111.4 °C; IR (film) ν_{max} 3104, 2740, 1544, 718 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.48 – 7.43 (m, 2H), 7.38 – 7.34 (m, 4H), 7.29 – 7.26 (m, 4H), 7.26 – 7.22 (m, 2H), 7.15 – 7.12 (m, 2H), 7.10 – 7.04 (m, 4H), 6.91 – 6.85

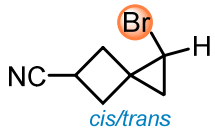
(m, 4H), 6.81 – 6.78 (m, 2H), 3.80 (s, 6H), 3.75 (s, 3H), 3.62 (ddd, J = 7.9, 6.2, 4.8 Hz, 3H), 1.82 (td, J = 7.8, 6.5 Hz, 3H), 1.78 (dd, J = 6.6, 4.8 Hz, 2H), 1.73 (dd, J = 6.5, 4.7 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 158.7, 158.4, 143.5, 140.2, 135.6, 132.3, 131.9, 131.6, 131.4, 131.3, 129.3, 128.8, 121.0, 120.4, 114.1, 113.7, 55.3, 55.2, 35.2, 35.0, 28.4, 27.9, 24.2, 23.7 ppm; HRMS (EI) Calcd for $C_{16}H_{14}Br_2O$ 379.94114; Found 379.94122.

2-Bromo-1,1-bis(chloromethyl)cyclopropane (3n′)



Colorless oil (186 mg, 87% yield); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 4.00 (d, J = 11.8 Hz, 1H), 3.87 – 3.64 (m, 2H), 3.45 (dt, J = 11.7, 1.2 Hz, 1H), 3.12 (ddd, J = 7.9, 4.9, 0.7 Hz, 1H), 1.46 (ddd, J = 7.9, 7.0, 0.8 Hz, 1H), 1.12 (ddd, J = 7.2, 5.0, 1.0 Hz, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 47.6, 47.5, 28.8, 26.4, 22.7 ppm.

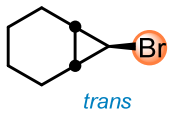
1-Bromospiro[2.3]hexane-5-carbonitrile (3o′)



The starting *gem*-dibromocyclopropane was used as a mixture of diastereomers.

White solid (186 mg, 91% yield); R_f = 0.5 (50:1 hexanes/EA); m.p. 56.9–57.5 °C; IR (film) ν_{max} 2375, 2263, 1553, 1047, 852, 617 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 3.27 (tt, J = 9.2, 7.4 Hz, 1H), 2.92 (dd, J = 8.0, 4.5 Hz, 1H), 2.82 – 2.73 (m, 1H), 2.66 – 2.56 (m, 1H), 2.49 – 2.38 (m, 2H), 1.34 – 1.25 (m, 1H), 0.90 (dd, J = 7.1, 4.5 Hz, 1H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 121.8, 34.1, 33.4, 33.2, 33.2, 24.9, 23.1, 21.8, 17.0, 14.8 ppm; HRMS (EI) Calcd for C_7H_8BrN 184.98401; Found 184.98414.

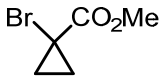
7-Bromobicyclo[4.1.0]heptane (3p′)[10]



Only *trans*-diastereomer was obtained. *trans* means Br and the cyclohexane ring are on the opposite sides of the cyclopropane ring.

Colorless oil (120 mg, 69% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 2.05 – 1.95 (m, 1H), 1.87 – 1.80 (m, 1H), 1.61 – 1.55 (m, 1H), 1.37 (d, J = 1.3 Hz, 2H), 1.29 (s, 1H), 1.26 – 1.24 (m, 3H), 1.23 – 1.16 (m, 1H), 0.87 (m, 1H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 29.7, 21.3, 19.9, 12.0 ppm.

Methyl 1-bromocyclopropanecarboxylate (3q′)

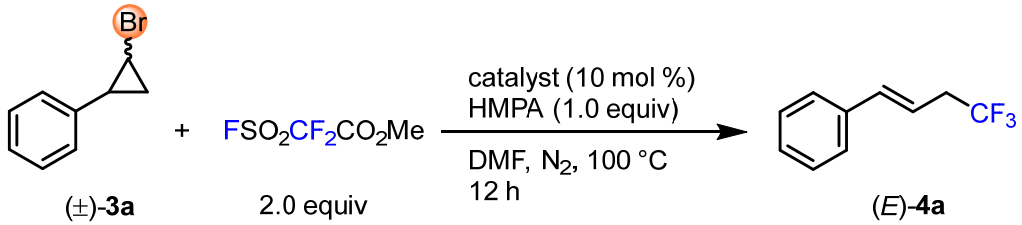


From commercial source.

6 Reactions of monobromocyclopropanes with Chen's reagent

6.1 Optimization of the conditions for the reaction of 3a with Chen's reagent

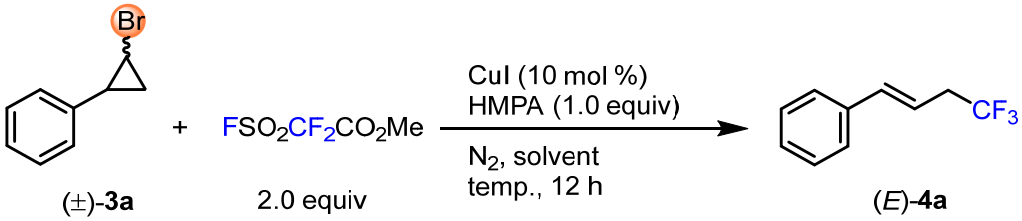
Table S6 Effect of catalyst.



Entry	Catalyst	Yield (%)[a]	Entry	Catalyst	Yield (%)[a]
1	CuCl	37	6	CuOAc	32
2	CuBr	72	7	CuOTf	46
3	CuI	81	8	$CuCl_2$	0
4	CuCN	24	9	$CuBr_2$	0
5	CuTc	47	10	—	0

[a] Yield was based on **3a**.

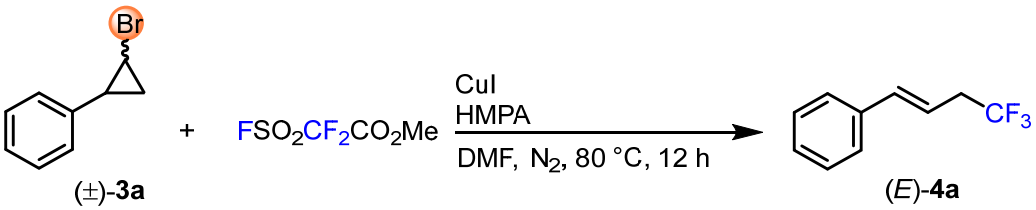
Table S7 Effect of solvent.



Entry	Solvent	Temp. (°C)	Yield (%)[a]	Entry	Solvent	Temp. (°C)	Yield (%)[a]
1	benzene	80	0	9	EA	80	0
2	toluene	110		10	acetone	60	
3	DCM	40		11	HMPA	120	18
4	DCE	80		12	DMSO	100	21
5	THF	60		13	DMI	100	44
6	DME	80		14	DMF	80	92
7	1,4-dioxane	40		15	CH_3OH	65	0
8	CH_3CN	80					

[a] Yield was based on **3a**.

Table S8 Effect of the molar ratio of reactants.

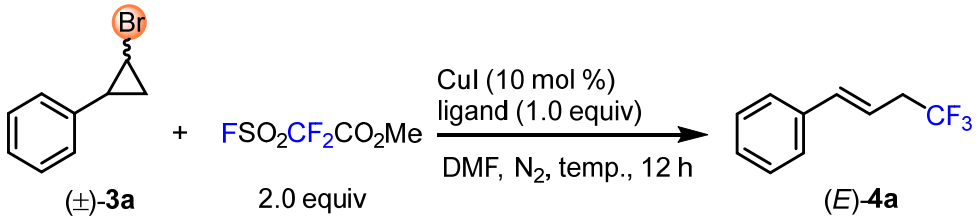


(±)-**3a** (*E*)-**4a**

Entry	Chen's reagent : HMPA : CuI	Yield (%)[a]	Entry	Chen's reagent : HMPA : CuI	Yield (%)[a]
1	2.0 : 1.0 : 0.0	0	9	2.0 : 1.0 : 0.1	92
2	2.0 : 1.0 : 0.05	60	10	2.0 : 2.0 : 0.1	81
3	2.0 : 1.0 : 0.1	92	11	2.0 : 3.0 : 0.1	78
4	2.0 : 1.0 : 0.5	83	11	1.0 : 1.0 : 0.1	61
5	2.0 : 1.0 : 1.0	68	12	1.5 : 1.0 : 0.1	81
6	2.0 : 0.0 : 0.1	43	13	2.0 : 1.0 : 0.1	92
7	2.0 : 0.1 : 0.1	57	14	3.0 : 1.0 : 0.1	86
8	2.0 : 0.5 : 0.1	83			

[a] Yield was based on **3a**.

Table S9 Effect of the temperature and ligand.

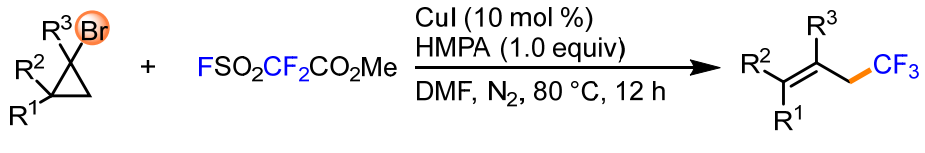


(±)-**3a** 2.0 equiv (*E*)-**4a**

Entry	Temp. (°C)	Ligand	Yield (%)[a]
1	100	—	22
2		TMEDA	31
3		DMEDA	24
4		Oxanilide	18
5		HMPA	92
6		PPh_3	60
7	20	HMPA	0
8	40		0
9	60		0
10	80		92
11	100		75

[a] Yield was based on **3a**.

6.2 Typical procedure

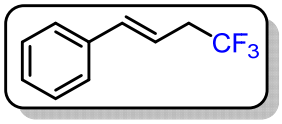


3 2.0 equiv **4**

A dry 50 mL Schlenk tube charged with a stirring bar was evacuated and backfilled with N_2 (three times). Copper(I) iodide (20 mg, 0.1 mmol, 10 mol %), HMPA (179 mg, 1.0 mmol, 1.0 equiv) and anhydrous DMF (4.0 mL) were added under N_2 atmosphere. After the mixture had been stirred for 15 min at room temperature, monobromocyclopropane (1.0 mmol, 1.0 equiv), FSO_2CF_2COOMe (384 mg, 2.0 mmol, 2.0 equiv) and DMF (6.0 mL) were added. The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 80 ℃ (oil bath). The reaction was monitored by TLC. Upon completion (12 h), the reaction mixture was cooled to room temperature, quenched carefully with H_2O (50 mL), extracted with DCM (30 mL × 3). The combined extracts were dried over anhydrous Na_2SO_4. After removal of the solvent under vacuum with a rotary evaporator, the crude product was purified by column chromatography on silica gel using hexanes as eluent to afford the desired trifluoromethylated product.

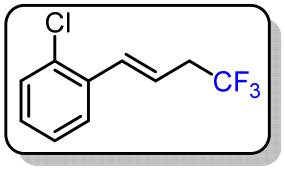
6.3 Physical data

(*E*)-(4,4,4-Trifluorobut-1-en-1-yl)benzene (4a)[11]



Colorless oil (172 mg, 92% yield); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.35 (dt, *J* = 28.7, 6.3 Hz, 3H), 7.30 – 7.18 (m, 2H), 6.60 (d, *J* = 15.9 Hz, 1H), 6.10 (dd, *J* = 13.2, 5.7 Hz, 1H), 3.04 – 2.90 (m, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 136.7, 136.2, 128.6, 128.1, 126.4, 125.0 (q, *J* = 277.1 Hz), 117.2 (q, *J* = 3.1 Hz), 37.7 (q, *J* = 29.8 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -66.12 (t, *J* = 10.7 Hz) ppm.

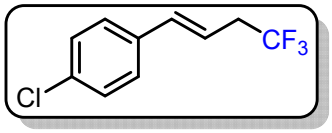
(*E*)-1-Chloro-2-(4,4,4-trifluorobut-1-en-1-yl)benzene (4e)



Colorless oil (161 mg, 73% yield); R_f = 0.7 (hexanes); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.60 – 7.46 (m, 1H), 7.44 – 7.31 (m, 1H), 7.23 (dt, *J* = 9.0, 7.4 Hz, 2H), 7.03 (d, *J* = 15.8 Hz, 1H), 6.18 – 5.97 (m, 1H), 3.17 – 2.92 (m, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 134.4, 129.7, 129.1, 126.9,

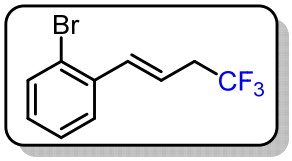
125.8 (q, J = 276.6 Hz), 120.0 (q, J = 3.8 Hz), 37.8 (q, J = 29.6 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-d) δ -64.88 (t, J = 9.8 Hz) ppm.

(*E*)-1-Chloro-4-(4,4,4-trifluorobut-1-en-1-yl)benzene (4g)



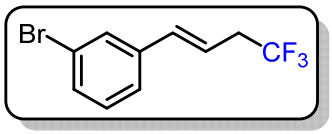
Colorless oil (196 mg, 89% yield); R_f = 0.7 (hexanes); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.30 (s, 4H), 6.56 (dt, J = 16.0, 1.5 Hz, 1H), 6.09 (dt, J = 15.8, 7.2 Hz, 1H), 2.99 (qdd, J = 10.6, 7.2, 1.4 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 135.4, 134.7, 133.8, 128.8, 127.6, 125.8 (q, J = 276.7 Hz), 117.9 (q, J = 3.4 Hz), 37.6 (q, J = 30.3 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -66.06 (t, J = 10.7 Hz) ppm.

(*E*)-1-Bromo-2-(4,4,4-trifluorobut-1-en-1-yl)benzene (4h)



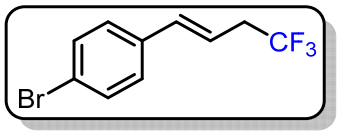
Colorless oil (198 mg, 75% yield); R_f = 0.7 (hexanes); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.54 (ddd, J = 18.5, 7.9, 1.5 Hz, 2H), 7.29 (td, J = 7.6, 1.3 Hz, 1H), 7.14 (td, J = 7.7, 1.7 Hz, 1H), 6.97 (d, J = 15.7 Hz, 1H), 6.07 (dt, J = 15.7, 7.2 Hz, 1H), 3.06 (qdd, J = 10.6, 7.2, 1.5 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 136.1, 135.5, 133.0, 129.4, 127.6, 127.2, 125.8 (q, J = 277.6 Hz), 123.5, 120.2 (q, J = 3.7 Hz), 37.7 (q, J = 30.1 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -65.97 (t, J = 10.5 Hz) ppm.

(*E*)-1-Bromo-3-(4,4,4-trifluorobut-1-en-1-yl)benzene (4i)



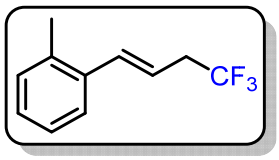
Colorless oil (216 mg, 82% yield); R_f = 0.7 (hexanes); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.54 (t, J = 1.8 Hz, 1H), 7.41 (ddd, J = 7.9, 2.0, 1.1 Hz, 1H), 7.30 (dd, J = 7.8, 1.5 Hz, 1H), 7.20 (td, J = 7.8, 1.2 Hz, 1H), 6.53 (d, J = 15.9 Hz, 1H), 6.22 – 6.01 (m, 1H), 3.01 (qdd, J = 10.8, 7.2, 1.6 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 138.2, 135.2, 130.9, 130.1, 129.3, 125.8 (q, J = 276.7 Hz), 125.1, 122.8, 118.8 (q, J = 3.7 Hz), 37.5 (q, J = 30.1 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.96 (t, J = 10.8 Hz) ppm.

(*E*)-1-Bromo-4-(4,4,4-trifluorobut-1-en-1-yl)benzene (4j)



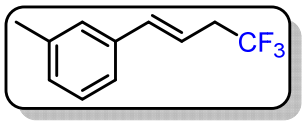
Colorless oil (230 mg, 87% yield); R_f = 0.7 (hexanes); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.56 – 7.36 (m, 2H), 7.29 – 7.18 (m, 2H), 6.55 (d, *J* = 15.8 Hz, 1H), 6.11 (dt, *J* = 15.9, 7.2 Hz, 1H), 2.99 (qdd, *J* = 10.6, 7.3, 1.4 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 135.5, 135.1, 131.8, 127.9, 125.8 (q, *J* = 276.7 Hz), 122.0, 118.0 (q, *J* = 3.5 Hz), 37.6 (q, *J* = 29.9 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -66.02 (t, *J* = 10.8 Hz) ppm.

(*E*)-1-Methyl-2-(4,4,4-trifluorobut-1-en-1-yl)benzene (4k)



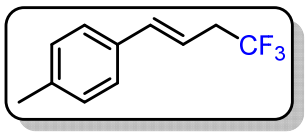
Colorless oil (160 mg, 80% yield); R_f = 0.7 (hexanes); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.47 – 7.38 (m, 1H), 7.22 – 7.12 (m, 3H), 6.84 (dd, *J* = 15.7, 1.9 Hz, 1H), 6.00 (dt, *J* = 15.7, 7.2 Hz, 1H), 3.03 (qdd, *J* = 10.6, 7.2, 1.4 Hz, 2H), 2.36 (s, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 135.4, 134.7, 130.3, 128.0, 126.2, 125.9 (q, *J* = 276.6 Hz), 125.8, 118.6 (q, *J* = 3.6 Hz), 37.9 (q, *J* = 29.8 Hz), 19.7 ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -66.16 (t, *J* = 10.5 Hz) ppm.

(*E*)-1-Methyl-3-(4,4,4-trifluorobut-1-en-1-yl)benzene (4l)



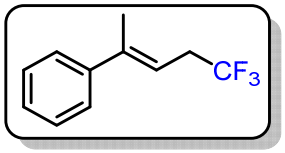
Colorless oil (174 mg, 87% yield); R_f = 0.7 (hexanes); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.25 – 7.17 (m, 3H), 7.11 (d, *J* = 7.4 Hz, 1H), 6.59 (d, *J* = 15.8 Hz, 1H), 6.12 (m, 1H), 3.00 (qdd, *J* = 10.6, 7.2, 1.4 Hz, 2H), 2.38 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 138.2, 136.7, 136.1, 128.9, 128.5, 127.1, 125.9 (q, *J* = 276.6 Hz), 123.6, 116.9 (q, *J* = 3.7 Hz), 37.7 (q, *J* = 30.0 Hz), 21.3 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -66.13 (t, *J* = 10.8 Hz) ppm.

(*E*)-1-Methyl-4-(4,4,4-trifluorobut-1-en-1-yl)benzene (4m)



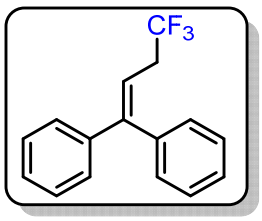
Colorless oil (186 mg, 93% yield); R_f = 0.7 (hexanes); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.35 – 7.28 (m, 2H), 7.16 (d, *J* = 8.0 Hz, 2H), 6.59 (d, *J* = 15.8 Hz, 1H), 6.08 (dt, *J* = 15.9, 7.3 Hz, 1H), 2.99 (qdd, *J* = 10.7, 7.2, 1.4 Hz, 2H), 2.36 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 138.0, 136.5, 133.5, 129.3, 126.3, 126.0 (q, *J* = 276.6 Hz), 116.1 (q, *J* = 3.7 Hz), 37.7 (q, *J* = 29.9 Hz), 21.2 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -66.16 (t, *J* = 10.8 Hz) ppm.

(*E*)-(5,5,5-Trifluoropent-2-en-2-yl)benzene (4h′)



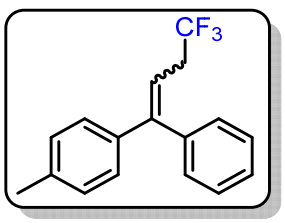
Colorless oil (108 mg, 54% yield); R_f = 0.7 (hexanes); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.40 (d, *J* = 7.1 Hz, 2H), 7.35 (t, *J* = 7.5 Hz, 2H), 7.30 (d, *J* = 7.3 Hz, 1H), 5.74 (t, *J* = 7.4 Hz, 1H), 3.02 (qd, *J* = 10.8, 7.2 Hz, 2H), 2.10 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 142.7, 141.4, 128.3, 127.5, 126.4 (q, *J* = 276.7 Hz), 125.9, 115.0 (q, *J* = 3.4 Hz), 33.7 (q, *J* = 29.6 Hz), 16.3 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.82 (t, *J* = 10.8 Hz) ppm.

(4,4,4-Trifluorobut-1-ene-1,1-diyl)dibenzene (4j′)[10]



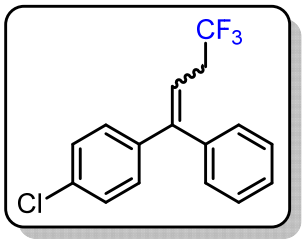
Colorless oil (199 mg, 76% yield); R_f = 0.5 (hexanes); ^{1}H NMR (600 MHz, Chloroform- *d*) δ 7.44 – 7.39 (m, 2H), 7.39 – 7.34 (m, 1H), 7.29 (td, *J* = 6.1, 2.9 Hz, 3H), 7.26 – 7.23 (m, 2H), 7.20 – 7.16 (m, 2H), 6.08 (t, *J* = 7.4 Hz, 1H), 2.92 (qd, *J* = 10.7, 7.4 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 147.7, 141.4, 138.7, 129.5, 128.5, 128.3, 127.9, 127.7, 127.4, 126.1 (q, *J* = 277.6 Hz), 116.0 (q, *J* = 3.9 Hz), 34.8 (q, *J* = 29.6 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform- *d*) δ -65.5 (t, *J* = 10.9 Hz) ppm.

1-Methyl-4-(4,4,4-trifluoro-1-phenylbut-1-en-1-yl)benzene (4k′)



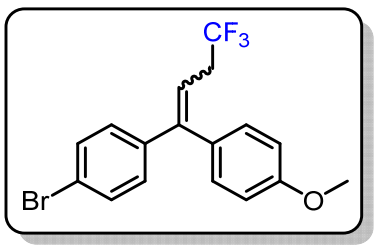
Colorless oil (190 mg, 69% yield); ratio = 1:2; R_f = 0.6 (hexanes); IR (film) ν_{max} 2922, 1712, 1467, 1381, 1026, 752 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.39 (ddd, *J* = 13.4, 7.8, 6.0 Hz, 1H), 7.30 – 7.18 (m, 4H), 7.16 – 7.04 (m, 4H), 6.04 (t, *J* = 7.4 Hz, 1H), 3.12 – 2.69 (m, 2H), 2.38 (d, *J* = 24.4 Hz, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 147.6, 147.5, 141.6, 138.9, 138.6, 137.8, 137.4, 135.7, 129.5, 129.5, 129.2, 129.0, 128.5, 128.2, 127.8, 127.6, 127.6, 127.4, 127.3, 124.8, 121.7 (q, *J* = 276.0 Hz), 115.8 (q, *J* = 3.2 Hz), 115.1 (q, *J* = 3.2 Hz), 34.8 (q, *J* = 29.6 Hz), 34.7 (q, *J* = 29.6 Hz), 21.2, 21.1 ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -65.59 (q, *J* = 10.9 Hz) ppm; HRMS (EI) Calcd for $C_{17}H_{15}F_3$ 276.11259; Found 276.11206.

1-Chloro-4-(4,4,4-trifluoro-1-phenylbut-1-en-1-yl)benzene (4l′)[12]



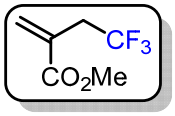
Colorless oil (213 mg, 72% yield); ratio = 4:5; R_f = 0.7 (hexanes); ^1H NMR (600 MHz, Chloroform-*d*) δ 7.43 – 7.35 (m, 3H), 7.29 (d, *J* = 1.5 Hz, 1H), 7.25 – 7.20 (m, 2H), 7.18 – 7.09 (m, 3H), 6.06 (dt, *J* = 17.8, 7.5 Hz, 1H), 2.90 (m, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 151.5, 151.4, 139.8, 138.6, 136.7, 135.6, 134.7, 134.6, 130.7, 129.2, 129.0, 128.8, 128.6, 128.5, 128.4, 127.5, 119.4 (q, *J* = 328.2 Hz), 109.3, 109.2, 51.6ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.53 (q, *J* = 11.0 Hz) ppm.

1-Bromo-4-(4,4,4-trifluoro-1-(4-methoxyphenyl)but-1-en-1-yl)benzene (4m′)



Colorless oil (289 mg, 78% yield); ratio = 1:2; R_f = 0.6 (50:1 hexanes/EA); IR (film) ν_{max} 3102, 1686, 1465, 1044, 622 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.59 – 7.49 (m, 2H), 7.16 – 7.13 (m, 2H), 7.07 – 7.00 (m, 2H), 6.85 – 6.79 (m, 2H), 5.98 (t, *J* = 7.5 Hz, 1H), 3.80 (s, 3H), 2.86 (qd, *J* = 10.6, 7.5 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 159.6, 146.1, 137.8, 133.4, 131.8, 131.3, 128.5, 126.0 (q, *J* = 278.2 Hz), 121.8, 114.6 (q, *J* = 3.5 Hz), 113.7, 55.3, 34.7 (q, *J* = 29.7 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.59 (t, *J* = 10.8 Hz) ppm; HRMS (EI) Calcd for $C_{17}H_{14}BrF_3O$ 370.01801; Found 370.01752.

Methyl 4,4,4-trifluoro-2-methylenebutanoate (4q′)



Colorless oil (80.7 mg, 48% yield); R_f = 0.7 (hexanes); IR (film) ν_{max} 2984, 1742, 1398, 1301, 1072 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 6.49 (s, 1H), 5.91 (s, 1H), 3.79 (s, 3H), 3.18 (q, *J* = 10.6 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 166.1, 131.3, 130.1 (q, *J* = 2.4 Hz), 126.3 (q, *J* = 277.0 Hz), 52.4, 35.3 (q, *J* = 31.0 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.69 (t, *J* = 10.8 Hz) ppm; HRMS (EI) Calcd for $C_6H_7F_3O_2$ 168.03981; Found 168.03976.

7 Conversions of 2a

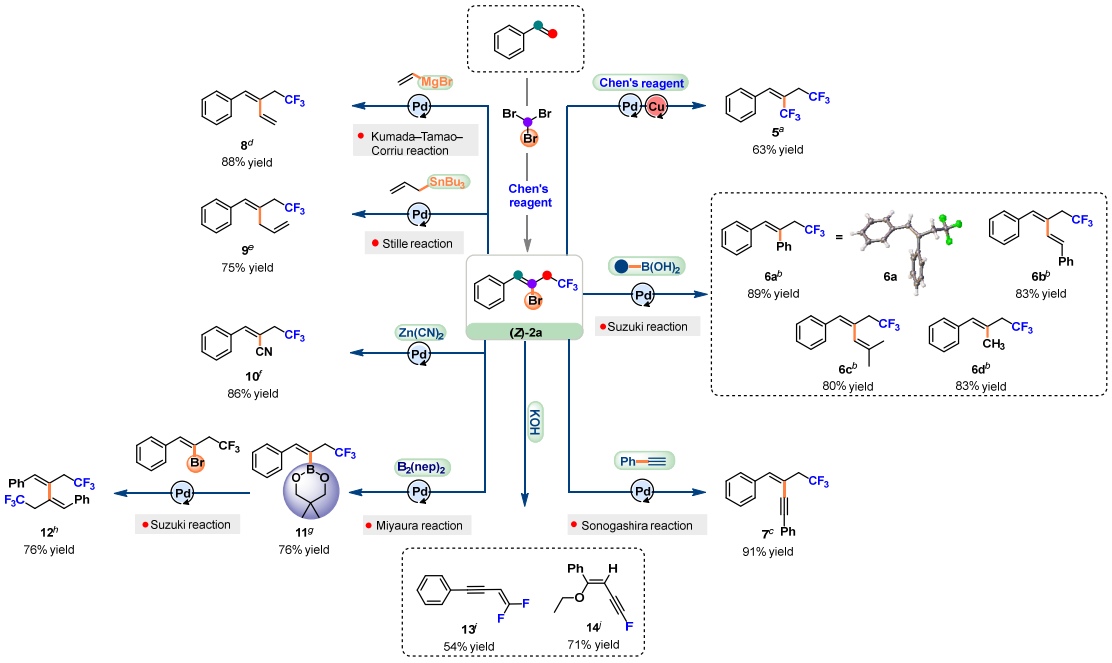
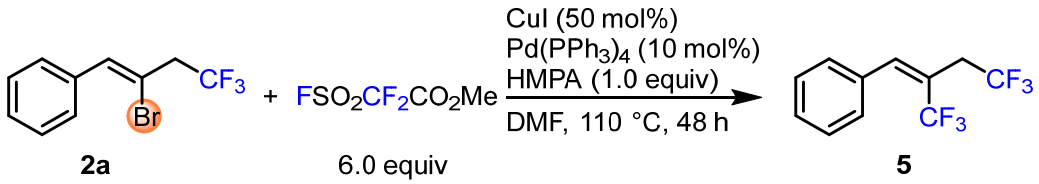


Fig. S9 | The transformations of (*Z*)-**2a**.

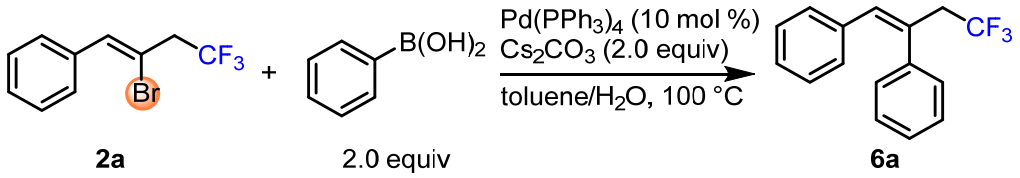
7.1 Experimental procedures



2a 6.0 equiv **5**

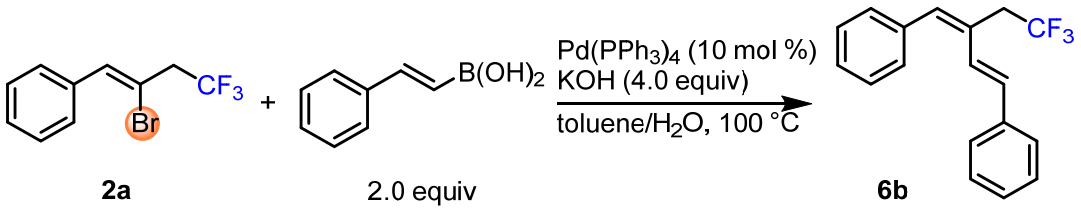
A dry 50 mL Schlenk tube charged with a stirring bar was evacuated and backfilled with N_2 (three times). Copper(I) iodide (50 mg, 0.5 mmol, 50 mol %), HMPA (179 mg, 1.0 mmol, 1.0 equiv), $Pd(PPh_3)_4$ (115 mg, 0.1 mmol, 10 mol %) and anhydrous DMF (4.0 mL) were added under N_2

atmosphere. After the mixture had been stirred for 15 min at room temperature, **2a** (264 mg, 1.0 mmol, 1.0 equiv.), FSO_2CF_2COOMe (1.15 g, 6.0 mmol, 6.0 equiv) and DMF (6.0 mL) were added. The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 110 ℃ (oil bath). Every 16 hours 2.0 equiv of FSO_2CF_2COOMe was added for two times. The reaction was monitored by TLC. Upon completion (48 h), the reaction mixture was cooled to room temperature, quenched carefully with H_2O (50 mL), and extracted with DCM (30 mL × 3). The combined extracts were dried over anhydrous Na_2SO_4. After removal of the solvent under vacuum with a rotary evaporator, the crude product was purified by column chromatography on silica gel using hexanes as eluent to afford **5** as a colorless oil (160 mg, 63% yield).



2a 2.0 equiv **6a**

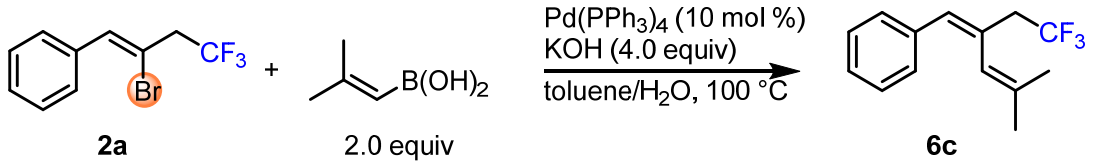
An oven-dried flask was charged with **2a** (264mg, 1.0 mmol), phenyl boronic acid (244 mg, 2.0 mmol, 2.0 equiv), $Pd(PPh_3)_4$ (115 mg, 0.1 mmol, 10 mol %), toluene/water (10/1 v/v ratio) (10.0 mL), and Cs_2CO_3 (752 mg, 2.0 mmol, 2.0 equiv). The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 100 ℃ (oil bath) under a nitrogen atmosphere, and was stirred until maximum conversion of **2a** to product occurred. The reaction mixture was cooled to room temperature, and concentrated in vacuo. The residue was directly purified by flash chromatography on silica gel (100:1 hexanes/EA) to give the Suzuki coupling product **6a** (232 mg, 89% yield).



2a 2.0 equiv **6b**

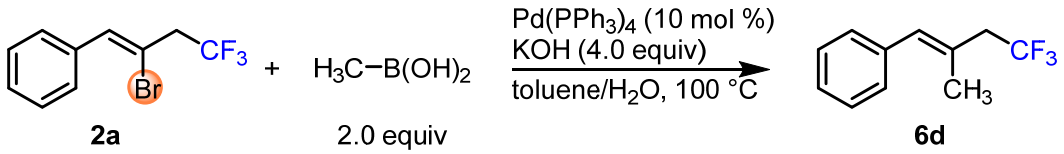
An oven-dried flask was charged with **2a** (264 mg, 1.0 mmol), (*E*)-styrylboronic acid (244 mg, 2.0 mmol, 2.0 equiv), $Pd(PPh_3)_4$ (115mg, 0.1 mmol, 10 mol %), toluene/water (10/1 v/v ratio) (10 mL), and KOH (264 mg, 85%, 4.0 mmol, 4.0 equiv). The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 100 ℃ (oil bath) under a nitrogen atmosphere, and was stirred until maximum conversion of **2a** to product occurred. The reaction mixture was cooled to room temperature, and concentrated in vacuo. The residue was directly purified by flash chromatography on silica gel

(100:1 hexanes/EA) to give **6b** (239 mg, 83% yield).



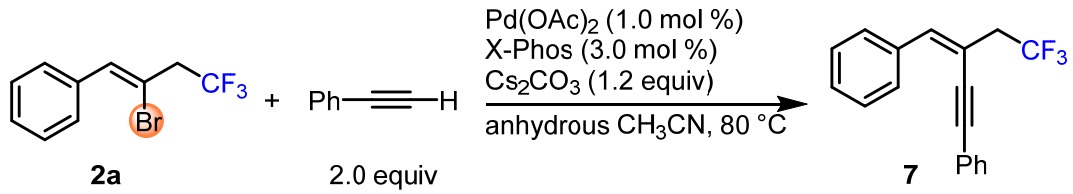
2a 2.0 equiv **6c**

An oven-dried flask was charged with **2a** (264 mg, 1.0 mmol), (2-methylprop-1-en-1-yl)boronic acid (244 mg, 2.0 mmol, 2.0 equiv), $Pd(PPh_3)_4$ (115mg, 0.1 mmol, 10 mol %), toluene/water (10/1 v/v ratio) (10 mL), and KOH (98.8 mg, 85%, 1.5 mmol, 1.5 equiv). The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 100 ℃ (oil bath) under a nitrogen atmosphere, and was stirred until maximum conversion of **2a** to product occurred. The reaction mixture was cooled to room temperature, and concentrated in vacuo. The residue was directly purified by flash chromatography on silica gel (100:1 hexanes/EA) to give **6c** (192 mg, 80% yield).



2a 2.0 equiv **6d**

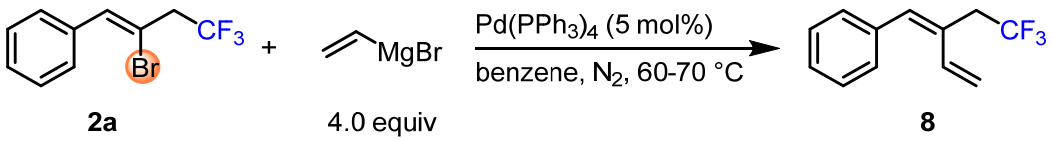
An oven-dried flask was charged with **2a** (264 mg, 1.0 mmol), methylboronic acid (120 mg, 2.0 mmol, 2.0 equiv), $Pd(PPh_3)_4$ (115mg, 0.1 mmol, 10 mol %), toluene/water (10/1 v/v ratio) (10 mL), and KOH (264 mg, 85%, 4.0 mmol, 4.0 equiv). The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 100 ℃ (oil bath) under a nitrogen atmosphere, and was stirred until maximum conversion of **2a** to product occurred. The reaction mixture was cooled to room temperature, and concentrated in vacuo. The residue was directly purified by flash chromatography on silica gel (100:1 hexanes/EA) to give **6d** (168 mg, 84% yield).



2a 2.0 equiv **7**

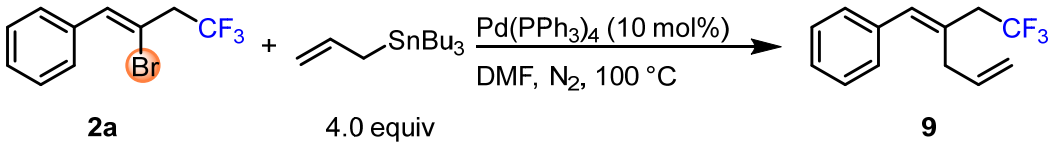
An oven-dried Schlenk tube was evacuated and backfilled with N_2 (the cycle was performed three times), and then charged under a positive pressure of N_2 with $Pd(OAc)_2$ (2.25 mg, 1.0 mmol, 1 mol %), X-Phos (14.3 mg, 3.0 mmol, 3 mol %), and Cs_2CO_3 (391 mg, 1.2 mmol, 1.2 equiv), followed by anhydrous acetonitrile (6.0 mL), **2a** (264 mg, 1.0 mmol, 1.0 equiv) and phenylacetylene (204 mg, 2.0 mmol, 2.0 equiv). The reaction mixture was degassed by freeze-

pump-thaw method and then stirred at 80 °C (oil bath) under a nitrogen atmosphere, and was stirred until maximum conversion of **2a** to product occurred. The reaction mixture was cooled to room temperature, and concentrated in vacuo. The residue was directly purified by flash chromatography on silica gel (100:1 hexanes/EA) to give the corresponding product **7** (260 mg, 91% yield).



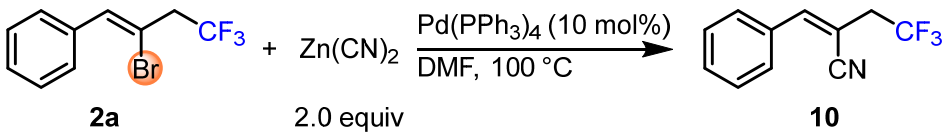
2a 4.0 equiv **8**

To a Schlenk flask charged with **2a** (264 mg, 1.0 mmol), vinyl magnesium bromide (1.0 M in THF, 8 mL, 8 mmol), $Pd(PPh_3)_4$ (58 mg, 0.1 mmol) was added benzene (6 mL) under N_2 atmosphere. This reaction mixture was heated at 70 °C for 12 hours. The reaction was monitored by TLC. Upon completion, sat. aq. NH_4Cl (4 mL) was added to quench the reaction. The aqueous mixture was extracted with ethyl acetate (3 × 20 mL). The organic layers were dried over anhydrous Na_2SO_4. After evaporation of the solvents, the crude product was purified by flash chromatography on silica gel (200:1 hexanes/AcOEt) to give product **8** (187 mg, 88% yield).



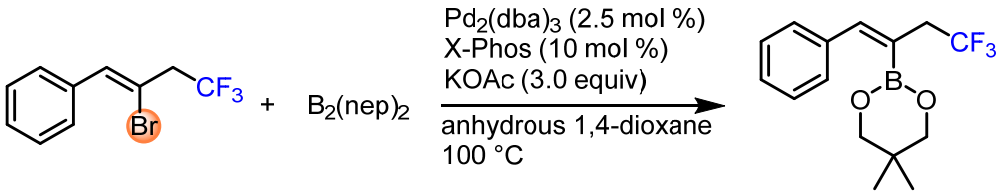
2a 4.0 equiv **9**

An oven-dried Schlenk tube was evacuated and backfilled with nitrogen (the cycle was performed three times), and then charged under a positive pressure of nitrogen with **2a** (264 mg, 1.0 mmol), allyltributylstannane (336 mg, 2.0 mmol), $Pd(PPh_3)_4$ (58 mg, 0.1 mmol), and DMF (10 mL). The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 100 °C (oil bath) under a nitrogen atmosphere for 24 h. More allyltributylstannane (336 mg, 2.0 mmol) was added and stirring was continued for another 12 h until maximum conversion of **2a** to product occurred. Upon completion of the reaction, the mixture was cooled to room temperature. Saturated brine was added to dilute the reaction mixture, followed by extraction with DCM (30 mL × 3). The organic layers were collected, dried over anhydrous sodium sulfate, and the solvents were removed under reduced pressure to afford the crude product. The residue was purified by flash chromatography on silica gel (hexanes) to give product **9** (170 mg, 75% yield).



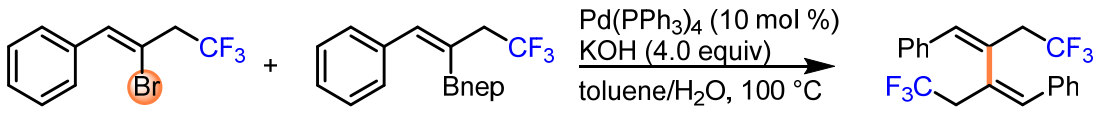
2a 2.0 equiv **10**

To a Schlenk flask charged with **2a** (264 mg, 1.0 mmol), $Zn(CN)_2$ (50 mg, 2.0 mmol), and $Pd(PPh_3)_4$ (115 mg, 0.1 mmol, 10 mol %) was added DMF (10 mL) under nitrogen. Then the mixture was heated to 100 °C for 12 h. After cooling to room temperature, the mixture was filtered under vacuum and the filter cake was washed by DCM, and then the filtrate was concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel (100:1 hexanes/EA as eluent) to afford **10** (181 mg, 86%) as a solid.



2a 2.0 equiv **11**

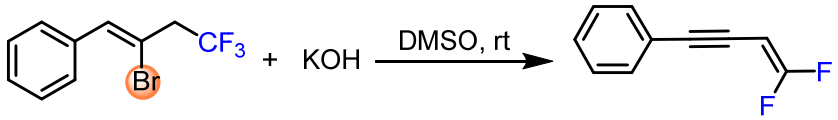
An oven-dried Schlenk tube was evacuated and backfilled with nitrogen (the cycle was performed three times), and then charged under a positive pressure of nitrogen with $Pd_2(dba)_3$ (23 mg, 0.025 mmol, 2.5 mol %), X-Phos (48 mg, 0.10 mmol, 10 mol %), KOAc (294 mg, 3.0 mmol, 3.0 equiv), $B_2(nep)_2$ (452 mg, 2.0 mmol, 2.0 equiv), **2a** (264 mg, 1.0 mmol,1.0 equiv), and 10 mL anhydrous 1,4-dioxane. The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 100 °C (oil bath) under a nitrogen atmosphere, and was stirred until maximum conversion of **2a** to product occurred. Then the reaction mixture was cooled to rt, filtered through Celite, and the filter cake washed with DCM (20 mL × 3). The organic layer was dried over anhydrous Na_2SO_4. The solvent was removed and the residue was purified by flash chromatography on silica gel (50:1 hexanes/EA) to give **11** (227 mg, 62% yield).



2a **11**, 2.0 equiv **12**

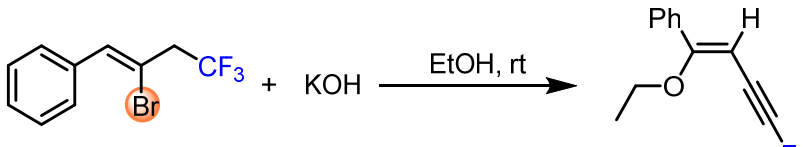
An oven-dried flask was charged with **2a** (264 mg, 1.0 mmol), **11** (120 mg, 2.0 mmol, 2.0 equiv), $Pd(PPh_3)_4$ (115mg, 0.1 mmol, 10 mol %), toluene/water (10/1 v/v ratio) (10 mL), and KOH (264 mg, 85%, 4.0 mmol, 4.0 equiv). The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 100 °C (oil bath) under a nitrogen atmosphere, and was stirred until maximum conversion of

2a to product occurred. The reaction mixture was cooled to room temperature, and concentrated in vacuo. The residue was directly purified by flash chromatography on silica gel (50:1 hexanes/EA) to give **12** (281 mg, 76% yield).



2a 1.5 equiv **13**

An oven-dried flask was charged with **2a** (264 mg, 1.0 mmol), KOH (98.8 mg, 85%, 1.5 mmol, 1.5 equiv), and anhydrous DMSO (6.0 mL). The reaction mixture was degassed by freeze-pump-thaw method and then stirred at rt under a nitrogen atmosphere, and was stirred until maximum conversion of **2a** to product occurred. The reaction mixture was quenched carefully with H_2O (50 mL), extracted with DCM (30 mL × 3). The combined extracts were dried over anhydrous Na_2SO_4. After removal of the solvent under vacuum with a rotary evaporator, the crude product was purified by column chromatography on silica gel using hexanes as eluent to afford the desired product **13** as a colorless oil (88.6 mg, 54% yield).

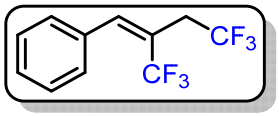


2a 1.5 equiv **14**

An oven-dried flask was charged with **2a** (264 mg, 1.0 mmol), KOH (98.8 mg, 85%, 1.5 mmol, 1.5 equiv), and anhydrous EtOH (6.0 mL). The reaction mixture was degassed by freeze-pump-thaw method and then stirred at rt under a nitrogen atmosphere, and was stirred until maximum conversion of **2a** to product occurred. The reaction mixture was quenched carefully with H_2O (50 mL), extracted with DCM (30 mL × 3). The combined extracts were dried over anhydrous Na_2SO_4. After removal of the solvent under vacuum with a rotary evaporator, the crude product was purified by column chromatography on silica gel using hexanes as eluent to afford the desired product **14** as a colorless oil (135 mg, 71% yield).

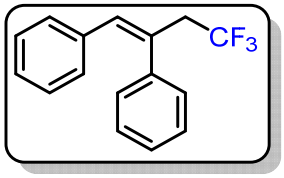
7.2 Physical data

(*Z*)-(4,4,4-Trifluoro-2-(trifluoromethyl)but-1-en-1-yl)benzene (5)



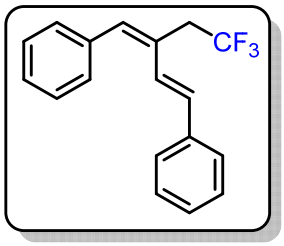
Colorless oil (160 mg, 63% yield); R_f = 0.7 (100:1 hexanes/EA); IR (film) ν_{max} 3009, 1570, 1324, 1124, 682 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.40 – 7.33 (m, 5H), 7.10 (s, 1H), 3.15 (qd, *J* = 10.2, 0.9 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 143.1 (q, *J* = 3.4 Hz), 133.6, 129.0, 129.0, 128.6 (q, *J* = 2.4 Hz), 128.3, 124.9 (q, *J* = 276.0 Hz), 122.7 (q, *J* = 276.5 Hz), 37.0 (q, *J* = 31.6 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -58.66 (t, *J* = 4.6 Hz), -65.69 (t, *J* = 12.0 Hz) ppm; HRMS (EI) Calcd for $C_{11}H_8F_6$ 254.05302; Found 254.05324.

(*Z*)-(4,4,4-Trifluorobut-1-ene-1,2-diyl)dibenzene (6a)



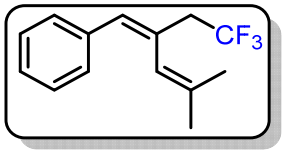
White solid (232 mg, 89% yield); R_f = 0.7 (100:1 hexanes/EA); IR (film) ν_{max} 3015, 1668, 1417, 1035, 759 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.36 – 7.29 (m, 3H), 7.24 – 7.19 (m, 2H), 7.16 – 7.10 (m, 3H), 7.01 – 6.94 (m, 2H), 6.70 (s, 1H), 3.29 (q, *J* = 10.5 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 139.6, 136.1, 133.3, 131.5, 129.2, 128.7, 128.6, 128.0, 127.6, 127.2, 125.8 (q, *J* = 279.5 Hz), 44.0 (q, *J* = 28.1 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.07 (t, *J* = 9.9 Hz) ppm; HRMS (EI) Calcd for $C_{16}H_{13}F_3$ 262.09694; Found 262.09699.

((1*Z*,3*E*)-2-(2,2,2-Trifluoroethyl)buta-1,3-diene-1,4-diyl)dibenzene (6b)



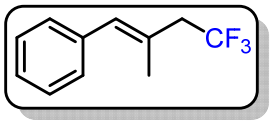
White solid (239 mg, 83% yield); R_f = 0.7 (100:1 hexanes/EA); m.p. 62.5–63.1 °C; IR (film) ν_{max} 3036, 1693, 1650, 1304, 1012, 842 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.45 – 7.29 (m, 10H), 7.29 – 7.20 (m, 2H), 6.80 – 6.73 (m, 1H), 3.28 (q, *J* = 10.7 Hz, 2H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.1, 136.5, 135.5, 132.8, 131.0, 129.6, 129.2, 128.7, 128.4, 127.9, 127.6, 126.7, 125.7 (q, *J* = 279.5 Hz), 38.3 (q, *J* = 29.5 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.15 (t, *J* = 10.8 Hz) ppm; HRMS (EI) Calcd for $C_{18}H_{15}F_3$ 288.11259; Found 288.11263.

(*Z*)-(4-Methyl-2-(2,2,2-trifluoroethyl)penta-1,3-dien-1-yl)benzene (6c)



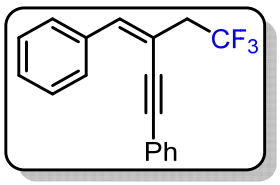
Colorless oil (192 mg, 80% yield); R_f = 0.6 (100:1 hexanes/EA); IR (film) ν_{max} 3312, 1573, 1043, 687 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.44 – 7.36 (m, 2H), 7.28 (q, *J* = 7.6, 6.5 Hz, 2H), 7.19 (q, *J* = 7.2, 6.4 Hz, 1H), 6.44 (s, 1H), 5.77 (s, 1H), 2.96 (qd, *J* = 11.3, 10.7, 5.3 Hz, 2H), 1.76 (s, 3H), 1.36 (s, 3H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.3, 136.5, 132.9, 128.6, 128.5, 128.1, 127.0 (q, *J* = 6.1 Hz), 124.2 (q, *J* = 277.5 Hz), 122.5, 43.2 (q, *J* = 28.1 Hz), 25.5, 19.4 ppm; HRMS (EI) Calcd for $C_{15}H_{14}F_3$ 240.11259; Found 240.11220.

(*E*)-(4,4,4-Trifluoro-2-methylbut-1-en-1-yl)benzene (6d)[13]



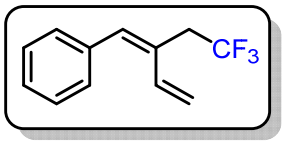
Colorless oil (168 mg, 84% yield); R_f = 0.8 (100:1 hexanes/EA); ^1H NMR (600 MHz, Chloroform-*d*) δ 7.37 (t, *J* = 7.5 Hz, 2H), 7.28 (d, *J* = 7.8 Hz, 2H), 6.50 (s, 1H), 2.95 (q, *J* = 10.9 Hz, 2H), 1.99 (s, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 137.1, 132.2, 128.9, 128.2, 127.8 (q, *J* = 2.4 Hz), 126.9, 126.2 (q, *J* = 278.8 Hz), 44.3 (q, *J* = 28.6 Hz), 18.3 ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -64.48 (t, *J* = 10.9 Hz) ppm.

(*Z*)-(2-(2,2,2-Trifluoroethyl)but-1-en-3-yne-1,4-diyl)dibenzene (7)



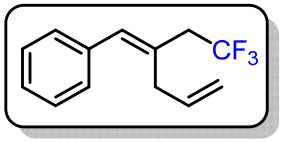
Colorless oil (260 mg, 91% yield); R_f = 0.6 (100:1 hexanes/EA); IR (film) ν_{max} 3248, 3072, 1588, 664 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.92 (dd, *J* = 7.7, 2.6 Hz, 2H), 7.50 (dq, *J* = 5.9, 3.4 Hz, 2H), 7.38 (tqd, *J* = 9.5, 7.0, 3.0 Hz, 6H), 6.77 (s, 1H), 3.17 (q, *J* = 10.2 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 140.1, 135.6, 131.5, 128.8, 128.7, 128.4, 128.3, 125.6 (q, *J* = 277.9 Hz), 110.5 (q, *J* = 3.6, 3.1 Hz), 96.5, 88.2, 43.1 (q, *J* = 29.3 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -65.11 (t, *J* = 10.8 Hz) ppm; HRMS (EI) Calcd for $C_{18}H_{13}F_3$ 286.09694; Found 286.09687.

(*Z*)-(2-(2,2,2-trifluoroethyl)buta-1,3-dien-1-yl)benzene (8)



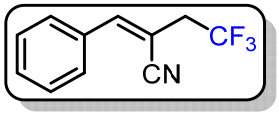
Colorless oil (187 mg, 88% yield); R_f = 0.5 (200:1 hexanes/AcOEt); IR (film) ν_{max} 2926, 2855, 1492, 1440, 1351, 1255, 1133, 1094, 910, 698 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.41 – 7.28 (m, 5H), 6.94 – 6.83 (m, 1H), 6.70 (s, 1H), 5.44 (d, *J* = 17.6 Hz, 1H), 5.29 (dd, *J* = 11.2, 1.7 Hz, 1H), 3.16 (qd, *J* = 10.7, 0.9 Hz, 2H) ppm; ^{13}C NMR (100 MHz, Chloroform-*d*) δ 136.2, 135.3, 133.4, 129.4, 128.2, 128.2, 128.1, 127.5, 116.4, 37.6 (q, *J* = 29.6 Hz) ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -64.3 ppm; HRMS (EI) Calcd for $C_{12}H_{11}F_3$ 212.08128; Found 212.08096.

(*E*)-(2-(2,2,2-trifluoroethyl)penta-1,4-dien-1-yl)benzene (9)



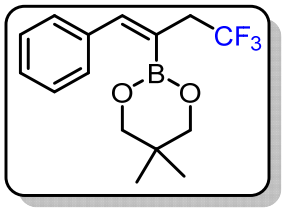
Colorless oil (170 mg, 75% yield); R_f = 0.2 (hexanes); IR (film) ν_{max} 3027, 1638, 1601, 1495, 1257, 699 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.40 – 7.33 (m, 2H), 7.31 – 7.24 (m, 3H), 6.66 (s, 1H), 5.85 (dd, *J* = 16.5, 10.1 Hz, 1H), 5.25 – 5.10 (m, 2H), 3.12 (d, *J* = 6.2 Hz, 2H), 2.95 (q, *J* = 10.9 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 136.7, 134.9, 133.6, 129.3, 128.5, 128.3, 127.1, 126.2 (q, *J* = 277.8 Hz), 117.1, 40.2 (q, *J* = 28.8 Hz), 35.3 ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -64.26 (t, *J* = 11.0 Hz) ppm; HRMS (EI) Calcd for $C_{13}H_{13}F_3$ 226.09694; Found 226.09676.

(*Z*)-2-Benzylidene-4,4,4-trifluorobutanenitrile (10)[14]



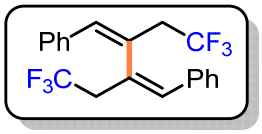
White solid (182 mg, 86% yield); R_f = 0.3 (20:1 hexanes/EA); ^1H NMR (600 MHz, Chloroform-*d*) δ 7.82 – 7.78 (m, 2H), 7.48 – 7.43 (m, 3H), 7.17 (s, 1H), 3.16 (q, J = 9.8 Hz, 2H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 150.3, 132.5, 131.3, 129.1, 129.0, 124.6 (q, *J* = 277.9 Hz), 117.5, 99.2 (q, *J* = 3.4 Hz), 40.0 (q, *J* = 31.2 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -65.80 (t, *J* = 10.0 Hz) ppm.

(*E*)-5,5-Dimethyl-2-(4,4,4-trifluoro-1-phenylbut-1-en-2-yl)-1,3,2-dioxaborinane (11)



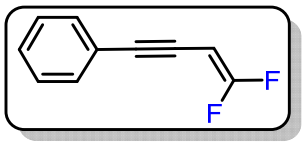
Colorless oil (227 mg, 62% yield); R_f = 0.4 (50:1 hexanes/EA); IR (film) ν_{max} 3051, 1647, 1318, 746 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.40 – 7.24 (m, 5H), 7.07 (s, 1H), 3.62 (s, 4H), 3.08 (q, *J* = 11.0 Hz, 2H), 1.00 (s, 6H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 146.1, 138.1, 128.2, 127.9, 127.9, 127.5, 126.4 (q, *J* = 277.0 Hz), 72.1, 41.4 (q, *J* = 28.5 Hz), 31.5, 22.0 ppm; ^{19}F NMR (565 MHz, Chloroform-*d*) δ -65.29 (t, *J* = 11.7 Hz) ppm; HRMS (EI) Calcd for $C_{15}H_{18}BF_3O_2$ 298.13519; Found 298.13526.

((1*Z*,3*Z*)-2,3-Bis(2,2,2-trifluoroethyl)buta-1,3-diene-1,4-diyl)dibenzene (12)



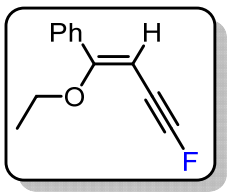
Colorless oil (281 mg, 76% yield); R_f = 0.5 (50:1 hexanes/EA); IR (film) ν_{max} 3072, 1564, 1372, 1128, 760 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.52 – 7.47 (m, 4H), 7.39 – 7.27 (m, 6H), 6.75 (s, 2H), 2.91 (q, *J* = 10.7 Hz, 4H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 135.8, 133.5, 129.8, 128.7, 128.3, 128.1, 125.7 (q, *J* = 279.1 Hz), 40.6 (q, *J* = 29.5 Hz) ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -63.53 (t, *J* = 10.4 Hz) ppm; HRMS (EI) Calcd for $C_{20}H_{16}F_6$ 370.11562; Found 370.11520.

(4,4-Difluorobut-3-en-1-yn-1-yl)benzene (13)[15]



Colorless oil (88.6 mg, 54% yield); R_f = 0.8 (hexanes); ^1H NMR (400 MHz, Chloroform-*d*) δ 7.44 (dd, *J* = 6.7, 3.0 Hz, 2H), 7.34 – 7.29 (m, 3H), 4.81 (d, *J* = 23.0 Hz, 1H) ppm; ^{13}C NMR (75 MHz, Chloroform-*d*) δ 161.8 (dd, *J* = 300.4, 294.4 Hz), 131.4, 128.5, 128.3, 122.8, 93.2 (dd, J = 9.1, 3.8 Hz), 77.6 (dd, *J* = 12.1, 4.5 Hz), 65.7 (dd, *J* = 42.3, 18.1 Hz); ^{19}F NMR (282 MHz, Chloroform-*d*) δ -74.50 (dd, *J* = 22.9, 4.2 Hz), -79.78 (d, *J* = 4.2 Hz) ppm.

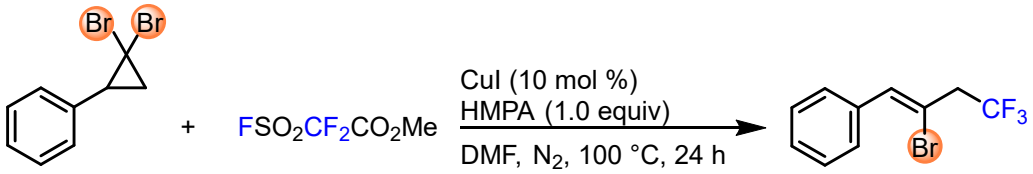
(*Z*)-(1-Ethoxy-4-fluorobut-1-en-3-yn-1-yl)benzene (14)



Colorless oil (135 mg, 71% yield); R_f = 0.4 (hexanes); IR (film) ν_{max} 3210, 1874, 1653, 1554, 951, 772 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) δ 7.43 – 7.38 (m, 2H), 7.33 – 7.25 (m, 4H), 4.25 (d, *J* = 27.8

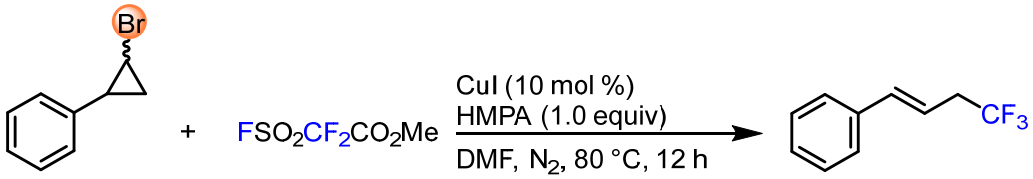
Hz, 1H), 4.00 (q, J = 7.0 Hz, 2H), 1.39 (td, J = 7.1, 0.8 Hz, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 164.7 (d, J = 268.7 Hz), 131.1, 128.2, 127.6, 123.9, 90.9, 81.5, 66.1 (d, J = 2.8 Hz), 61.6 (d, J = 25.2 Hz), 14.1 ppm; ^{19}F NMR (376 MHz, Chloroform-*d*) δ -72.16 (d, J = 28.2 Hz) ppm; HRMS (EI) Calcd for $C_{12}H_{11}FO$ 190.07939; Found 190.07946.

8 Gram-scale reactions



(±)-**1a** 2.0 equiv (*Z*)-**2a**

A dry 100 mL Schlenk tube charged with a stirring bar was evacuated and backfilled with N_2 (three times). Copper(I) iodide (100 mg, 0.5 mmol, 10 mol %), HMPA (895 mg, 5.0 mmol, 1.0 equiv) and anhydrous DMF (10 mL) were added under N_2 atmosphere. After the mixture had been stirred for 15 min at room temperature, *gem*-dibromocyclopropane **1a** (1.38 g, 5.0 mmol, 1.0 equiv), FSO_2CF_2COOMe (1.92 g, 10.0 mmol, 2.0 equiv) and DMF (15 mL) were added. The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 100 ℃ (oil bath). The reaction was monitored by TLC. Upon completion (24 h), the reaction was cooled to room temperature, quenched carefully with H_2O (50 mL), and extracted with DCM (30 mL × 3). The combined extracts were dried over anhydrous Na_2SO_4. After removal of the solvent under vacuum with a rotary evaporator, the crude product was purified by flash chromatography on silica gel using hexanes as eluent to give **2a** (colorless oil, 1.10 g, 83% yield).



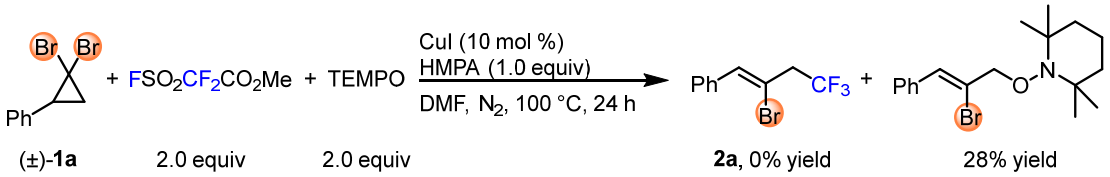
(±)-**3a** 2.0 equiv (*E*)-**4a**

Copper(I) iodide (200 mg, 1.0 mmol, 10 mol %), HMPA (1.79 g, 10 mmol, 1.0 equiv), monobromocyclopropane **3a** (1.97 g, 10 mmol, 1.0 equiv) and FSO_2CF_2COOMe (3.84 g, 10 mmol, 2.0 equiv) were reacted in anhydrous DMF at 80 ℃ (oil bath) for 12 h. The crude product was purified by flash chromatography on silica gel using petroleum ether as eluent to give **4a** (colorless oil, 1.60 g, 86%

yield).

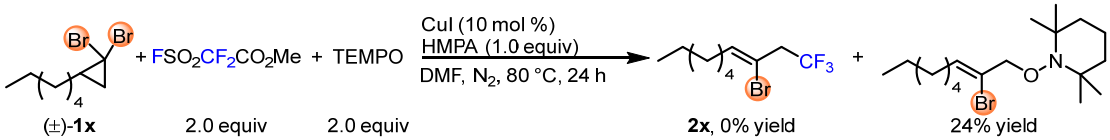
9 Mechanistic experiments

9.1 Radical-trapping experiments



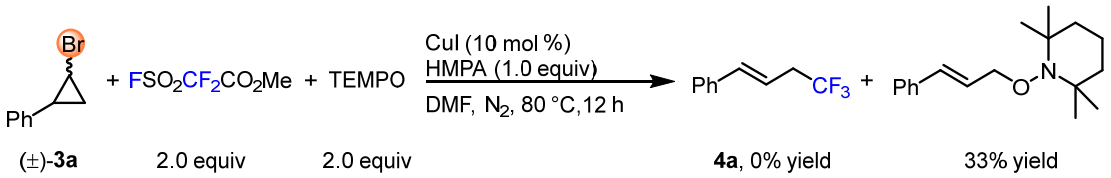
(±)-**1a** 2.0 equiv 2.0 equiv **2a**, 0% yield 28% yield

A dry 50 mL Schlenk tube charged with a stirring bar was evacuated and backfilled with N_2 (three times). Copper(I) iodide (20 mg, 0.1 mmol, 10 mol %), HMPA (179 mg, 1.0 mmol, 1.0 equiv) and anhydrous DMF (4.0 mL) were added under N_2 atmosphere. After the mixture had been stirred for 15 min at room temperature, *gem*-dibromocyclopropane **1a** (274 mg, 1.0 mmol, 1.0 mmol, 1.0 equiv), FSO_2CF_2COOMe (384 mg, 2.0 mmol, 2.0 equiv), TEMPO (312 mg, 2.0 mmol, 2.0 equiv) and anhydrous DMF (6.0 mL) were added. The reaction mixture was degassed by freeze-pump-thaw method and then stirred at 100 ℃ (oil bath). After 24 h, the reaction mixture was cooled to room temperature, quenched carefully with a significant amount of water, and extracted with DCM (20 mL × 5). Subsequently, the combined extracts were dried over anhydrous Na_2SO_4. After removal of the solvent under vacuum with a rotary evaporator, the crude product was purified by column chromatography on silica gel (50:1 hexanes/EA as eluent) to give the TEMPO coupling product (70 mg, 28% yield).



(±)-**1x** 2.0 equiv 2.0 equiv **2x**, 0% yield 24% yield

Copper(I) iodide (20 mg, 0.1 mmol, 10 mol %), HMPA (179 mg, 1.0 mmol, 1.0 equiv), *gem*-dibromocyclopropane **1x** (282 mg, 1.0 mmol, 1.0 equiv), FSO_2CF_2COOMe (384 mg, 2.0 mmol, 2.0 equiv) and TEMPO (312 mg, 2.0 mmol, 2.0 equiv) were reacted at 80 ℃ (oil bath) in anhydrous DMF for 24 h. The crude product was purified by flash chromatography on silica gel (50:1 hexanes/EA as eluent) to give the TEMPO coupling product (87 mg, 24% yield).

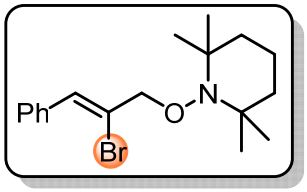


(±)-**3a** 2.0 equiv 2.0 equiv **4a**, 0% yield 33% yield

Copper(I) iodide (20 mg, 0.1 mmol, 10 mol %), HMPA (179 mg, 1.0 mmol, 1.0 equiv), monobromocyclopropane **3a** (196 mg, 1.0 mmol, 1.0 equiv), FSO_2CF_2COOMe (384 mg, 2.0 mmol, 2.0 equiv) and TEMPO (312 mg, 2.0 mmol, 2.0 equiv) were reacted at 80 ℃ (oil bath) in anhydrous DMF for 12 h. The crude product was purified by flash chromatography on silica gel (50:1 hexanes/EA as eluent) to give the TEMPO coupling product (91 mg, 33% yield).

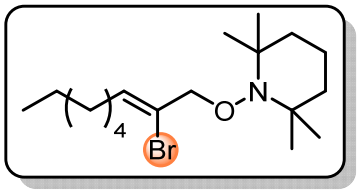
9.2 Physical data

(*Z*)-1-((2-Bromo-3-phenylallyl)oxy)-2,2,6,6-tetramethylpiperidine



Colorless oil (28% yield); R_f = 0.3 (50:1 hexanes/EA); IR (film) ν_{max} 3253, 3020, 1532, 1441, 899, 741 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 7.68 – 7.59 (m, 2H), 7.41 – 7.27 (m, 3H), 7.10 (s, 1H), 4.58 (d, *J* = 1.5 Hz, 2H), 1.65 – 1.52 (m, 2H), 1.52 – 1.38 (m, 4H), 1.24 (s, 6H), 1.18 (s, 6H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 135.4, 129.1, 128.7, 128.1, 127.9, 121.2, 82.0, 60.1, 39.7, 32.9, 20.3, 17.1 ppm; HRMS (EI) Calcd for $C_{18}H_{26}BrNO$ 351.11978; Found 351.11983.

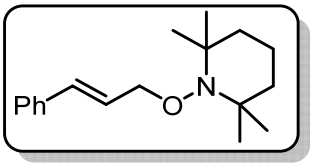
(*Z*)-1-((2-Bromopent-2-en-1-yl)oxy)-2,2,6,6-tetramethylpiperidine



Colorless oil (24% yield); R_f = 0.5 (50:1 hexanes/EA); IR (film) ν_{max} 3320, 3002, 1842, 1311, 659 cm^{-1}; ^1H NMR (400 MHz, Chloroform-*d*) δ 5.99 (t, *J* = 6.9 Hz, 1H), 4.39 (s, 2H), 2.19 (q, *J* = 7.2 Hz, 2H), 1.44 (dd, *J* = 12.2, 5.3 Hz, 6H), 1.31 (dt, *J* = 14.7, 5.0 Hz, 8H), 1.20 – 1.10 (m, 12H), 0.89 (t, *J* = 6.2 Hz, 3H) ppm; ^{13}C NMR (101 MHz, Chloroform-*d*) δ 131.0, 122.0, 81.3, 60.0, 39.7, 32.9, 31.6, 30.8,

28.9, 28.3, 22.6, 20.2, 17.1, 14.1 ppm; HRMS (EI) Calcd for $C_{18}H_{34}BrNO$ 359.18238; Found 359.18249.

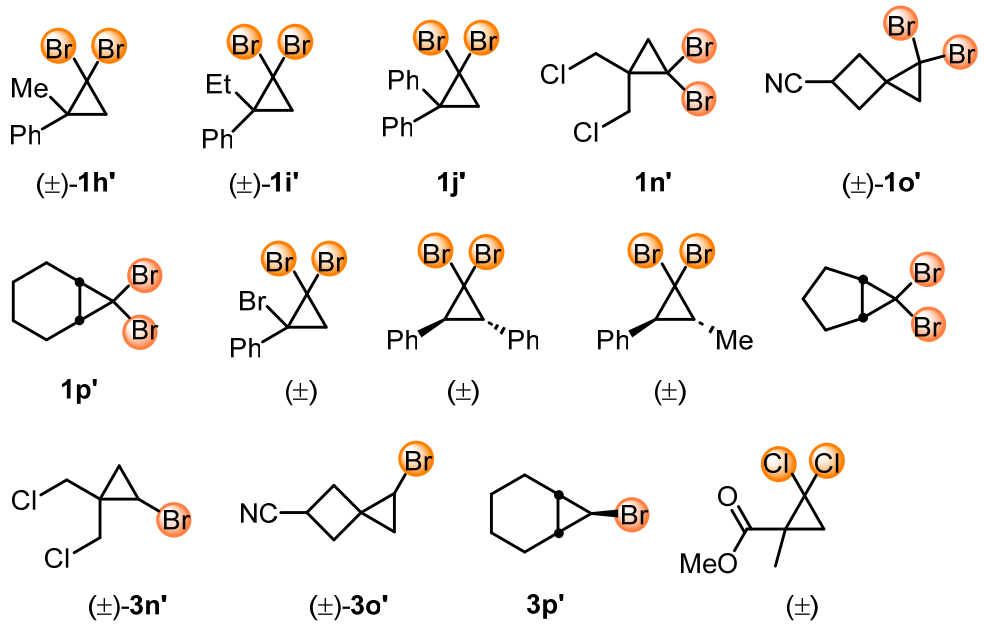
1-(Cinnamyloxy)-2,2,6,6-tetramethylpiperidine[16]



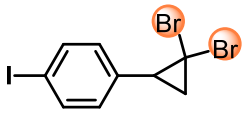
Colorless oil (33% yield); R_f = 0.4 (50:1 hexanes/EA); ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.41 (d, *J* = 7.3 Hz, 2H), 7.32 (t, *J* = 7.6 Hz, 2H), 7.24 (t, *J* = 7.3 Hz, 1H), 6.61 (d, *J* = 16.0 Hz, 1H), 6.30 (dt, *J* = 15.9, 5.9 Hz, 1H), 4.47 (dd, *J* = 5.9, 1.5 Hz, 2H), 1.59 (m, 1H), 1.49 (dd, *J* = 8.9, 4.4 Hz, 4H), 1.35 (dt, *J* = 13.3, 3.4 Hz, 1H), 1.23 (s, 6H), 1.16 (s, 6H) ppm; ^{13}C NMR (151 MHz, Chloroform-*d*) δ 137.1, 131.4, 128.5, 127.4, 126.4, 125.6, 78.0, 59.8, 39.7, 33.0, 20.2, 17.2 ppm.

10 Unsuccessful reactants

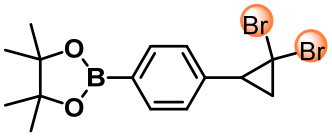
10.1 Unconverted reactants for dehalogenative ring-opening trifluoromethylations



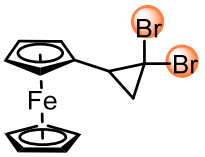
10.2 Unsuccessful reactants for debrominative ring-opening trifluoromethylations



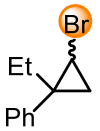
(±)



(±)

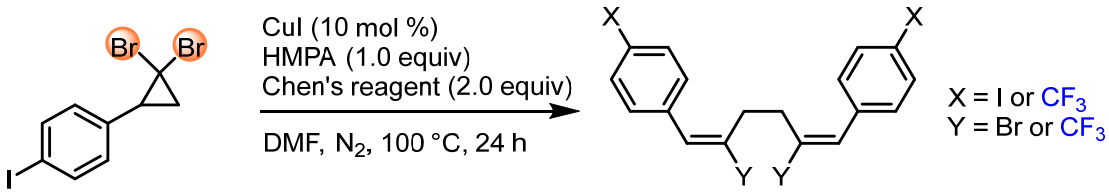


(±)



(±)-**3i'**

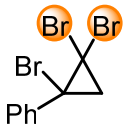
The above bromocyclopropanes were all converted under the reaction conditions but each gave a complicated mixture.



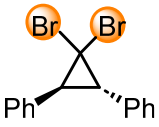
(±) ca. 20% yield

After column chromatography on silica gel, colorless crystals (ca. 20% yield based on dibromocyclopropane) were obtained from the reaction of 1,1-dibromo-2-(4-iodophenyl)cyclopropane and Chen's reagent. Single crystal XRD analysis indicated the crystals consisted of two or more products, in which the two C=C bonds were both in *trans*-configuration and the iodo or bromo group was substituted by CF_3.

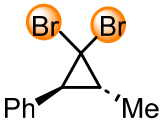
10.3 Unconverted reactants for reductive dehalogenations



(±)



(±)



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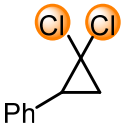

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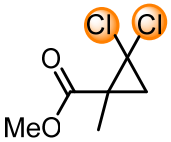

(±)

11 References

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[2] Shinan Luan, Thomas Castanheiro and Thomas Poisson, *Org. Lett.*, **2023**, *25*, 1678–1682.

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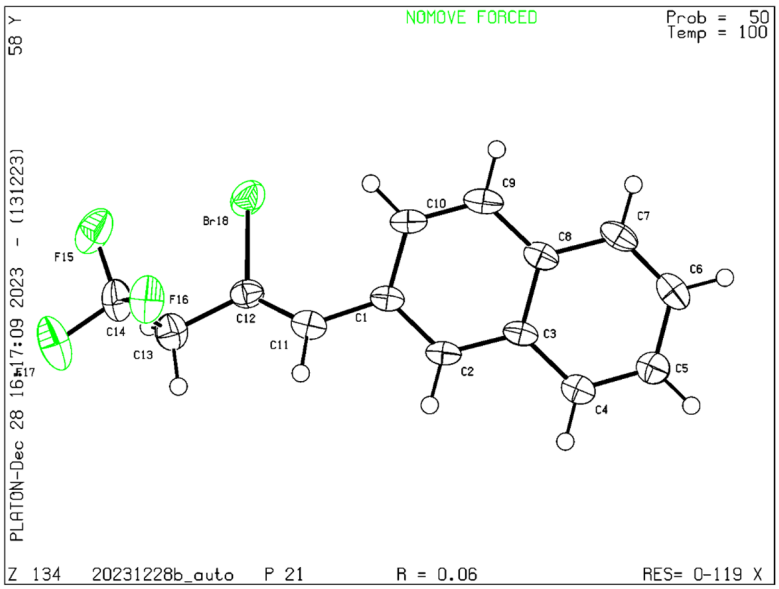
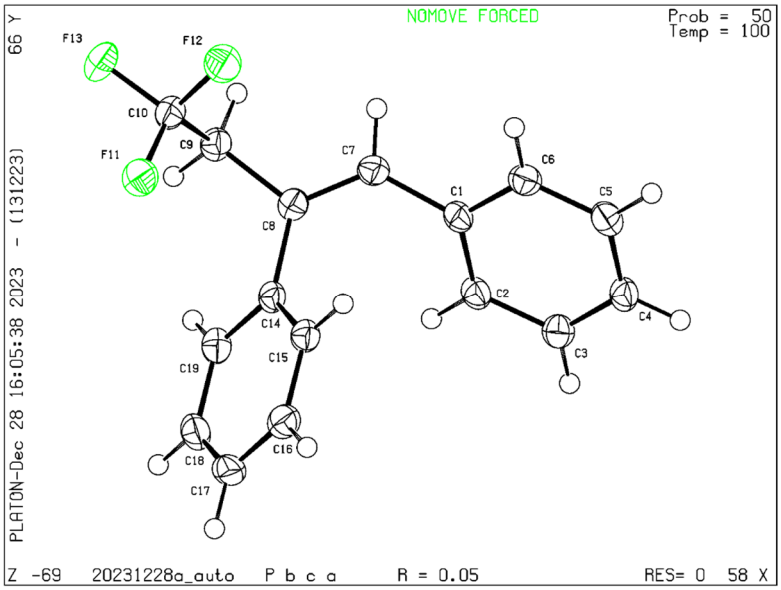
12 Crystal data

CCDC numbers: 2322379; 2322380; 2348125.

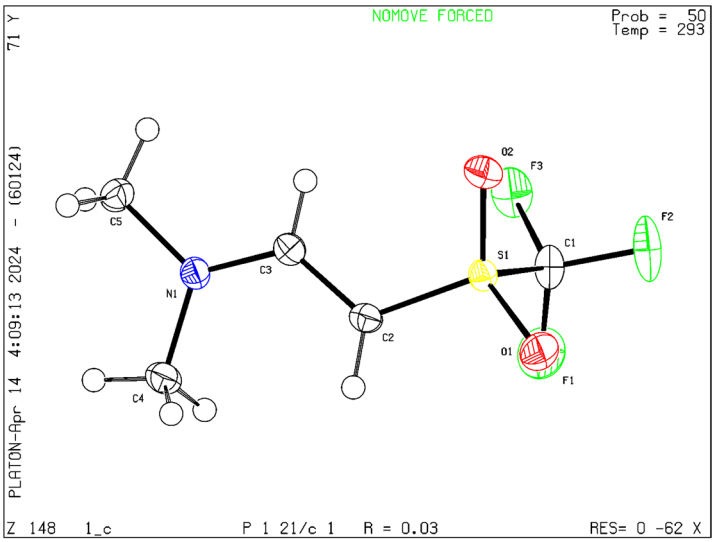
Single crystals of **2v** or **6a** were obtained from a *n*-hexane solution by slow evaporation of the solvent at rt. Single crystals of (*E*)-*N*,*N*-dimethyl-2-((trifluoromethyl)sulfonyl)ethen-1-amine were obtained by layering an EA solution with *n*-hexane and subsequent slow evaporation of the solvents at rt. The ellipsoid contour probability level is 50%.



Crystal data and structure refinement for 2v.	
Temperature/K	100(2)
Crystal system	monoclinic
Space group	$P2_1$
a/Å	7.78987(17)
b/Å	5.88492(15)
c/Å	13.8221(3)
α/°	90
β/°	101.509(2)
γ/°	90
Volume/Å^3	620.90(2)
Z	2
ρ_{calc}g/cm^3	1.686
μ/mm^{-1}	4.690
F(000)	312.0
Crystal size/mm^3	0.05 × 0.02 × 0.02
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	6.526 to 152.518
Index ranges	$-9 \le h \le 9$, $-7 \le k \le 7$, $-17 \le l \le 17$
Reflections collected	11084
Independent reflections	2484 [R_{int} = 0.0751, R_{sigma} = 0.0376]
Data/restraints/parameters	2484/1/163
Goodness-of-fit on F^2	1.131
Final R indexes [I>=2σ (I)]	R_1 = 0.0618, wR_2 = 0.1723
Final R indexes [all data]	R_1 = 0.0627, wR_2 = 0.1738
Largest diff. peak/hole / e Å^{-3}	0.77/-0.73

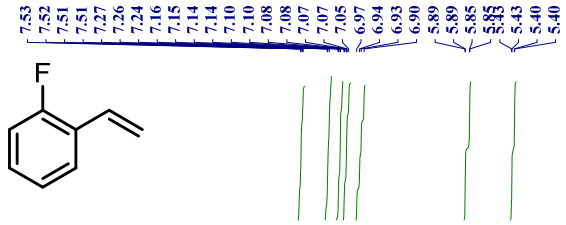


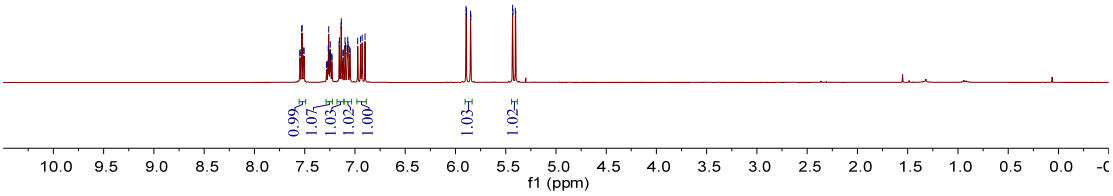
Crystal data and structure refinement for 6a.	
Temperature/K	100(2)
Crystal system	orthorhombic
Space group	Pbca
a/Å	5.6746(10)
b/Å	17.7150(18)
c/Å	25.651(2)
α/°	90
β/°	90
γ/°	90
Volume/Å^3	2578.6(6)
Z	8
ρ_{calc}g/cm^3	1.351
μ/mm^{-1}	0.912
F(000)	1088.0
Crystal size/mm^3	0.300 × 0.300 × 0.100
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	6.892 to 151.912
Index ranges	-6 ≤ h ≤ 7, -21 ≤ k ≤ 20, -31 ≤ l ≤ 32
Reflections collected	22921
Independent reflections	2646 [R_{int} = 0.1343, R_{sigma} = 0.0747]
Data/restraints/parameters	2646/0/173
Goodness-of-fit on F^2	1.081
Final R indexes [I>=2σ (I)]	R_1 = 0.0533, wR_2 = 0.1338
Final R indexes [all data]	R_1 = 0.0615, wR_2 = 0.1416

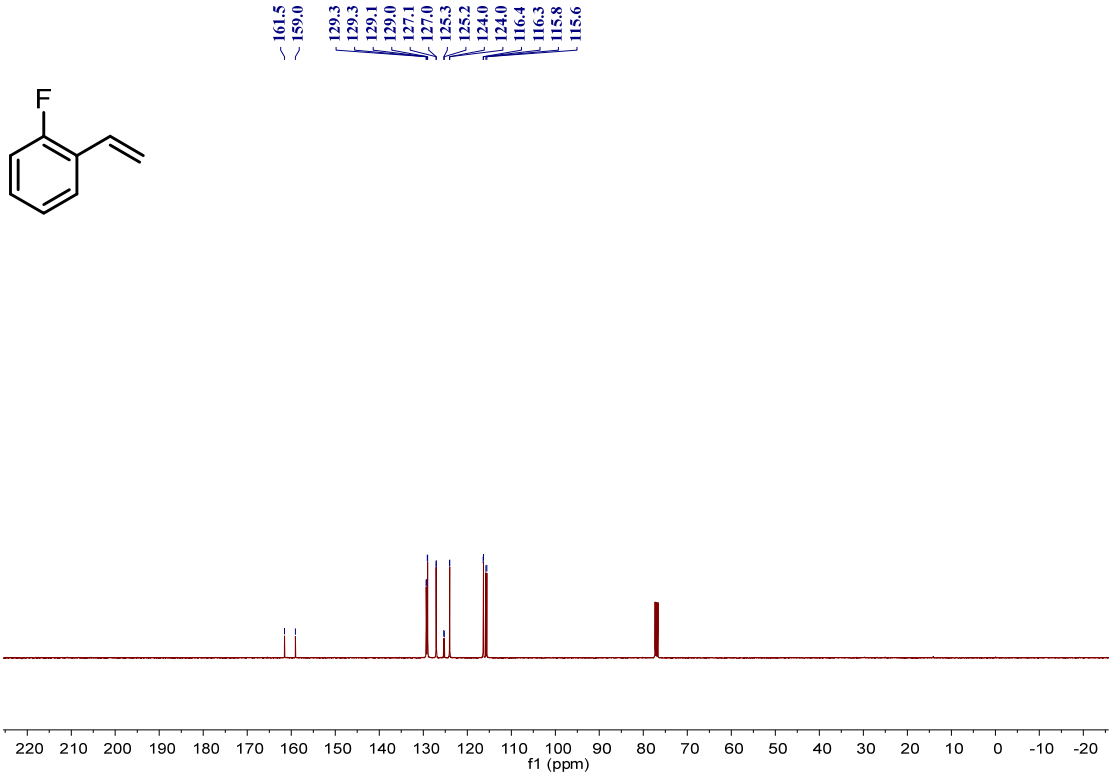


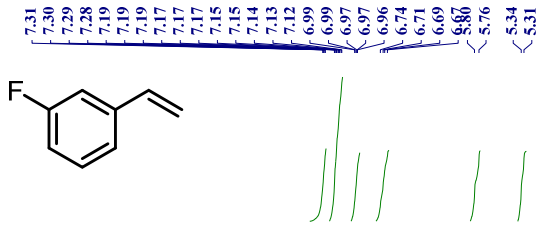
Crystal data and structure refinement for *N*,*N*-dimethyl-2-triflylethenamine.	
Temperature/K	100.00(10)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	9.4692(3)
b/Å	9.0363(2)
c/Å	10.2290(3)
α/°	90
β/°	108.996(3)
γ/°	90
Volume/Å^3	827.59(4)
Z	4
ρ_{calc}g/cm^3	1.631
μ/mm^{-1}	0.403
F(000)	416.0
Crystal size/mm^3	0.200 × 0.200 × 0.100
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	6.806 to 59.596
Index ranges	$-13 \leq h \leq 13$, $-12 \leq k \leq 12$, $-13 \leq l \leq 14$
Reflections collected	17782
Independent reflections	2206 [R_{int} = 0.0353, R_{sigma} = 0.0202]
Data/restraints/parameters	2206/0/111
Goodness-of-fit on F^2	1.146
Final R indexes [I>=2σ (I)]	R_1 = 0.0342, wR_2 = 0.0884
Final R indexes [all data]	R_1 = 0.0394, wR_2 = 0.0913

13 NMR spectra





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7.12
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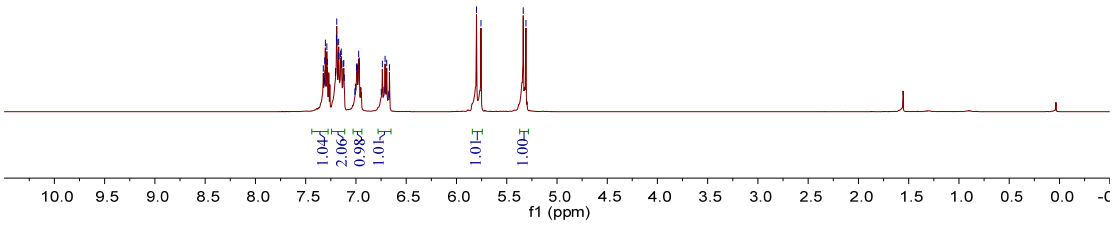
6.97
6.96
6.74
6.71
6.69
5.80
5.76
5.34
5.31
F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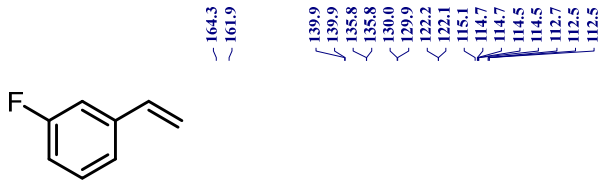
2.06
0.98
1.01
1.01
1.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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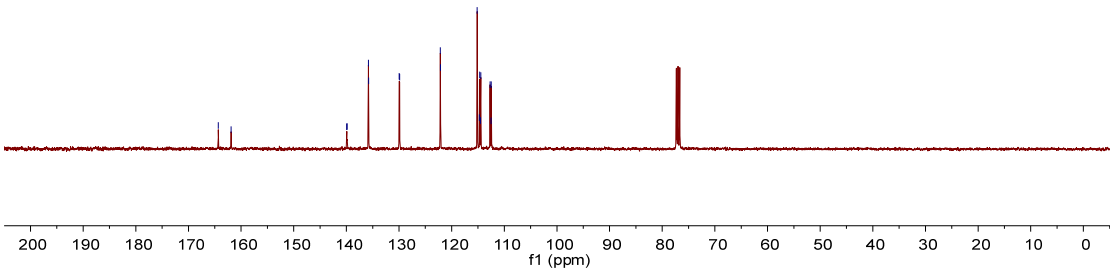
114.5
114.5
112.7
112.5
112.5
F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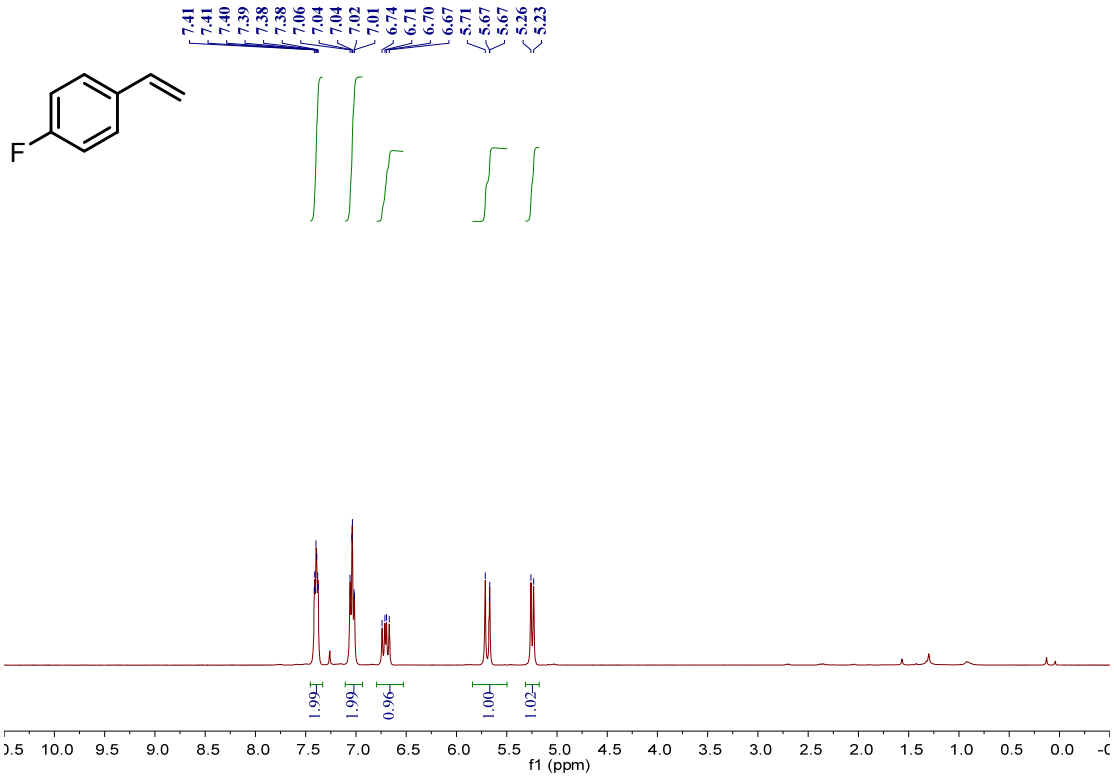
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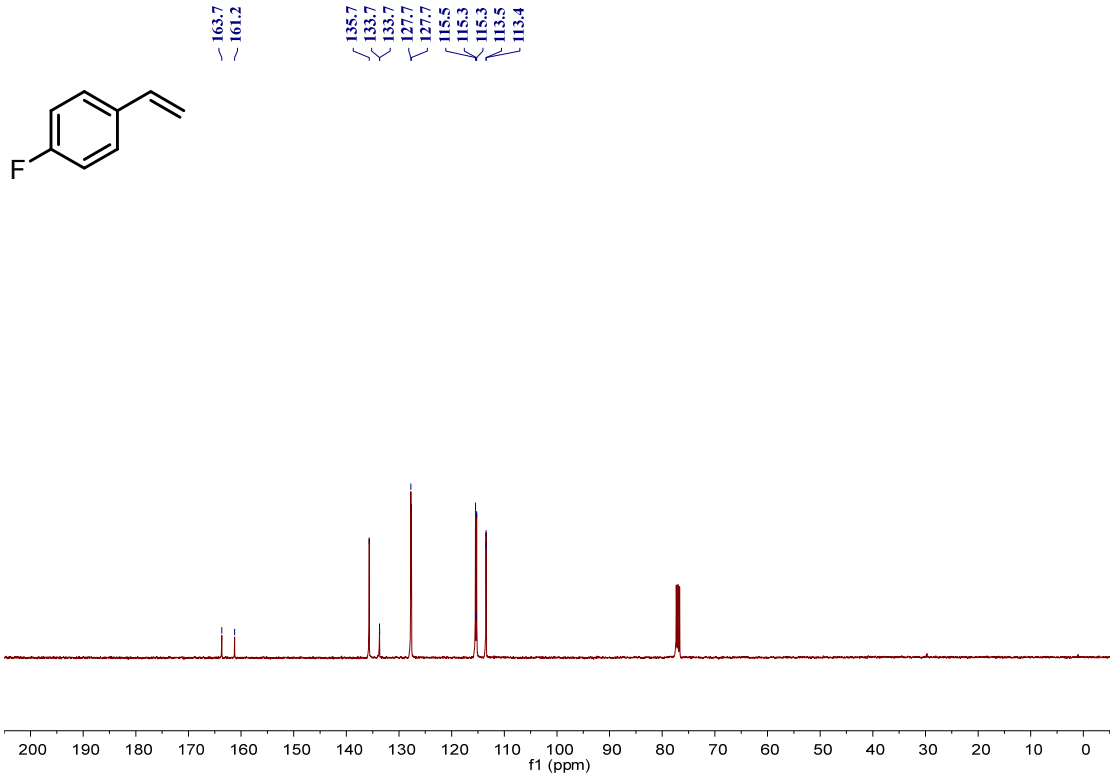
f1 (ppm)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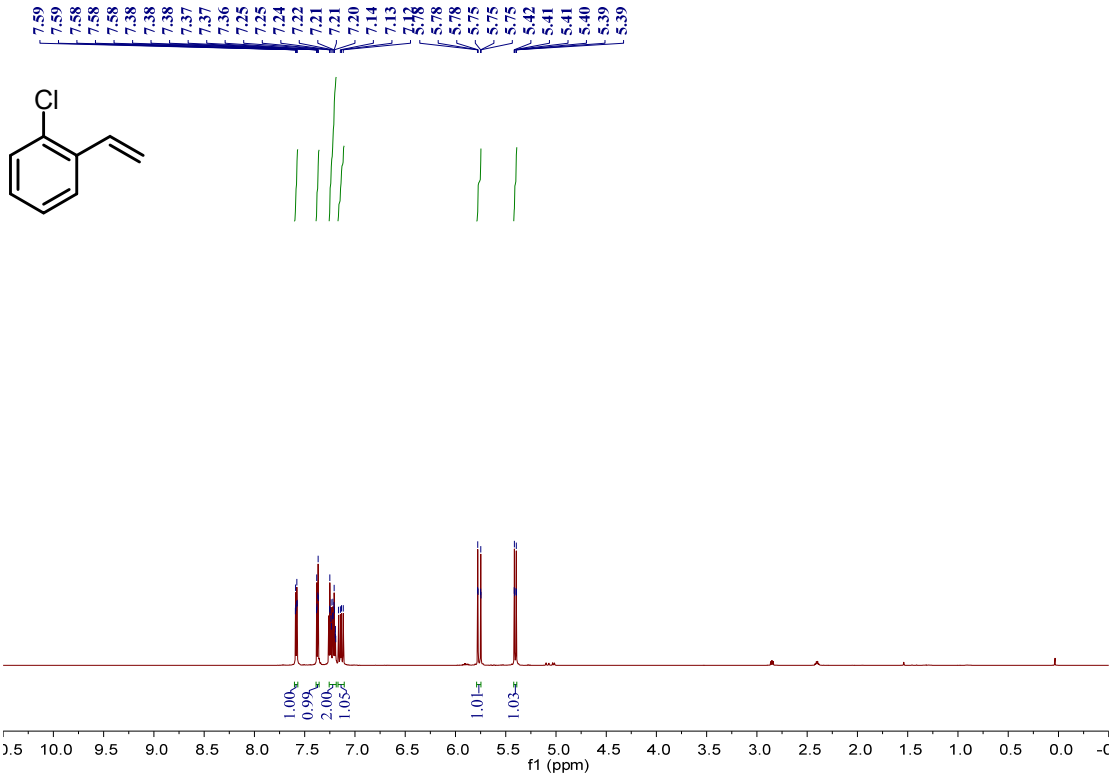
115.3
113.5
113.4
F
f1 (ppm)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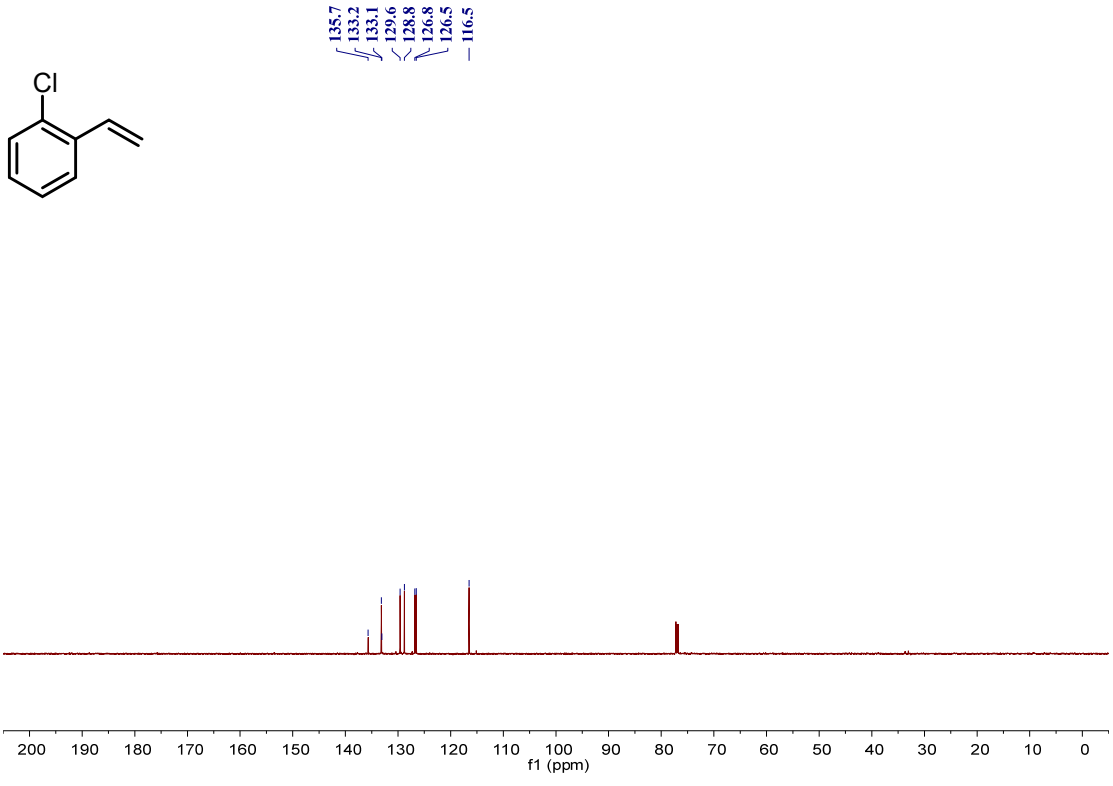
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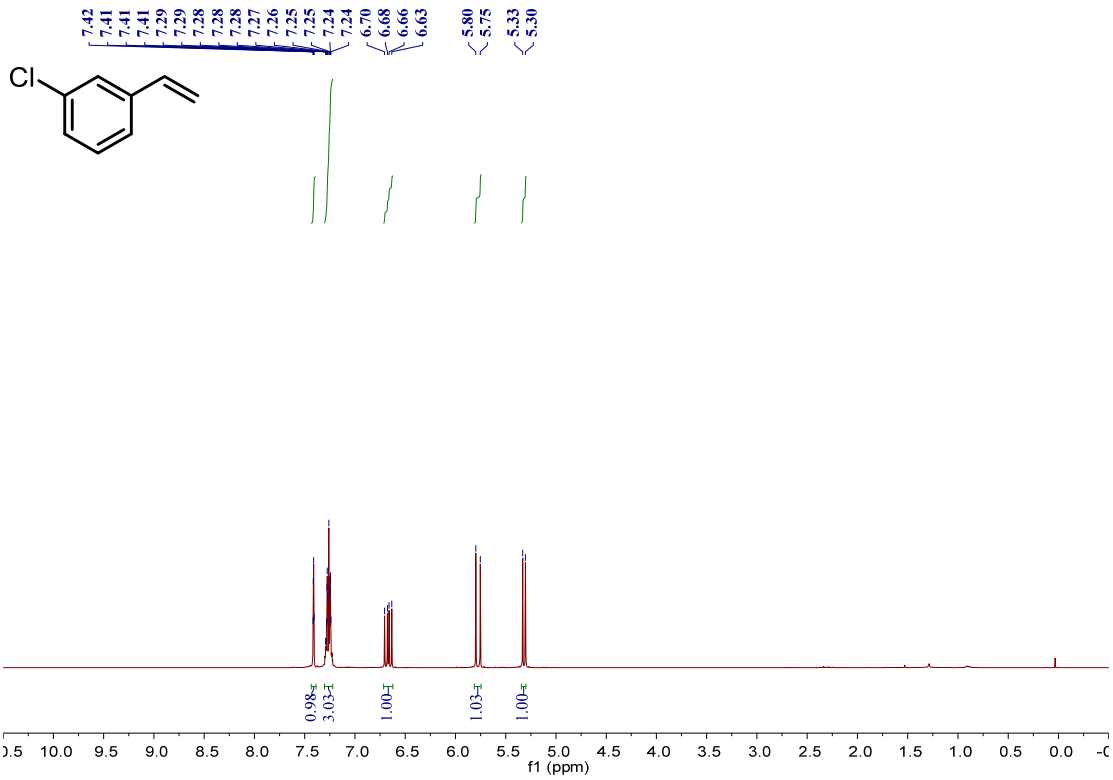
116.5
Cl
f1 (ppm)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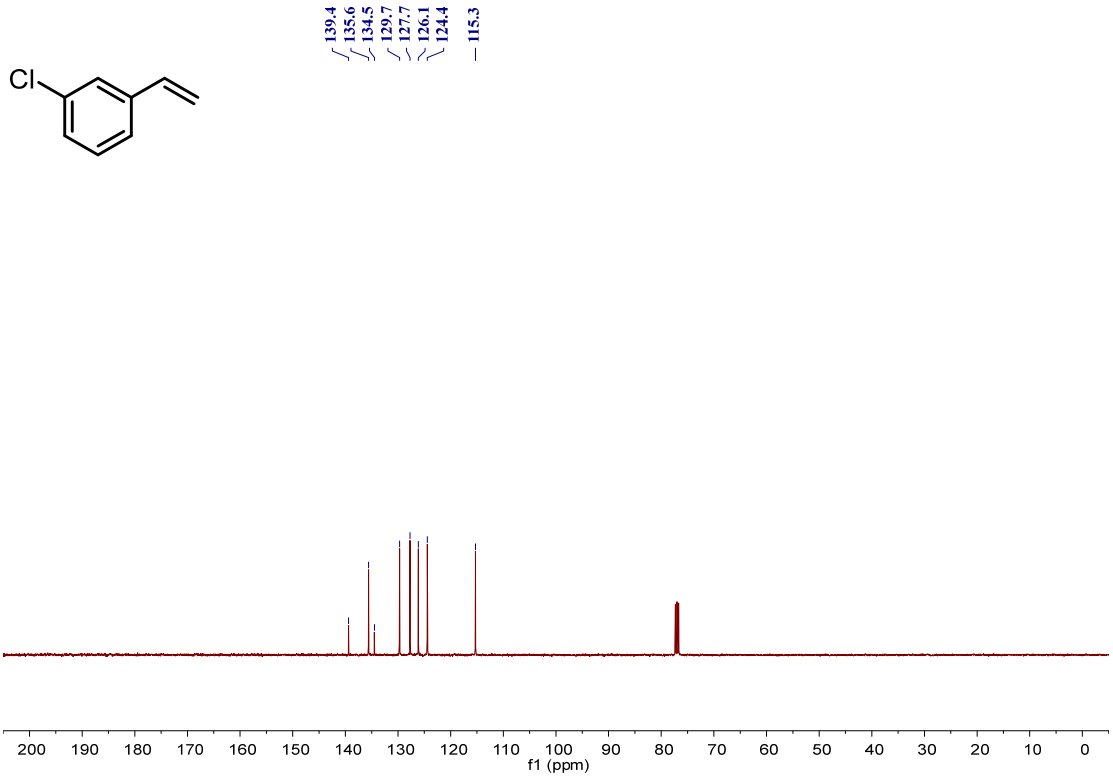
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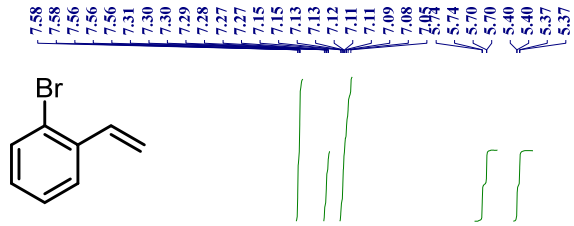
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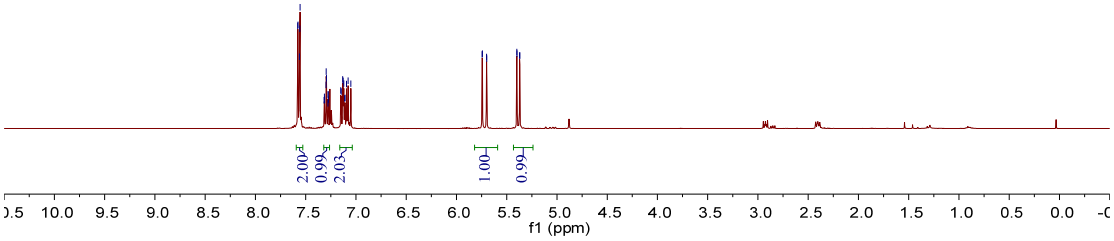
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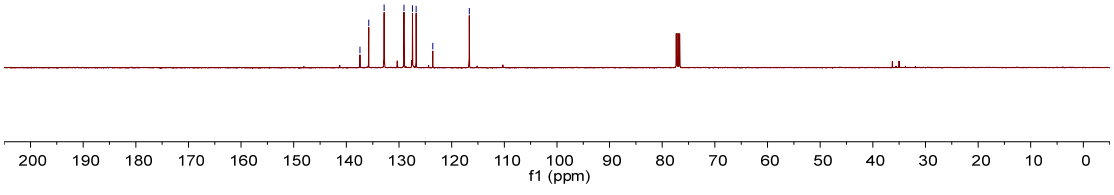
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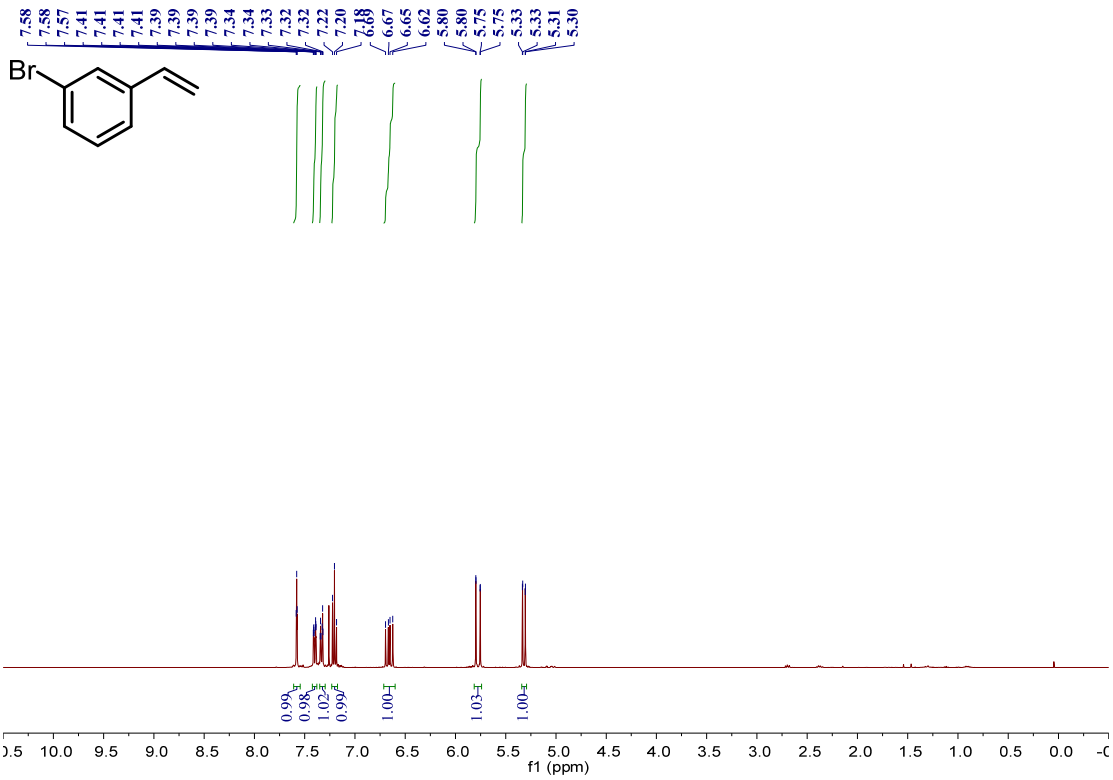
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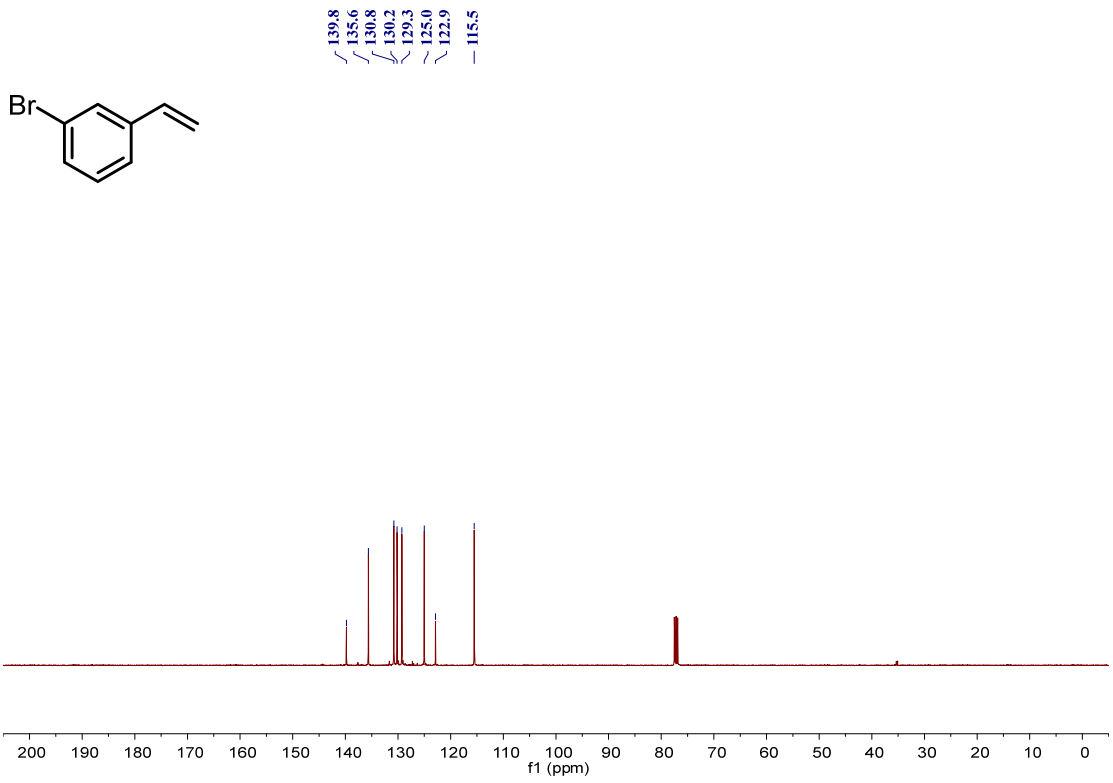
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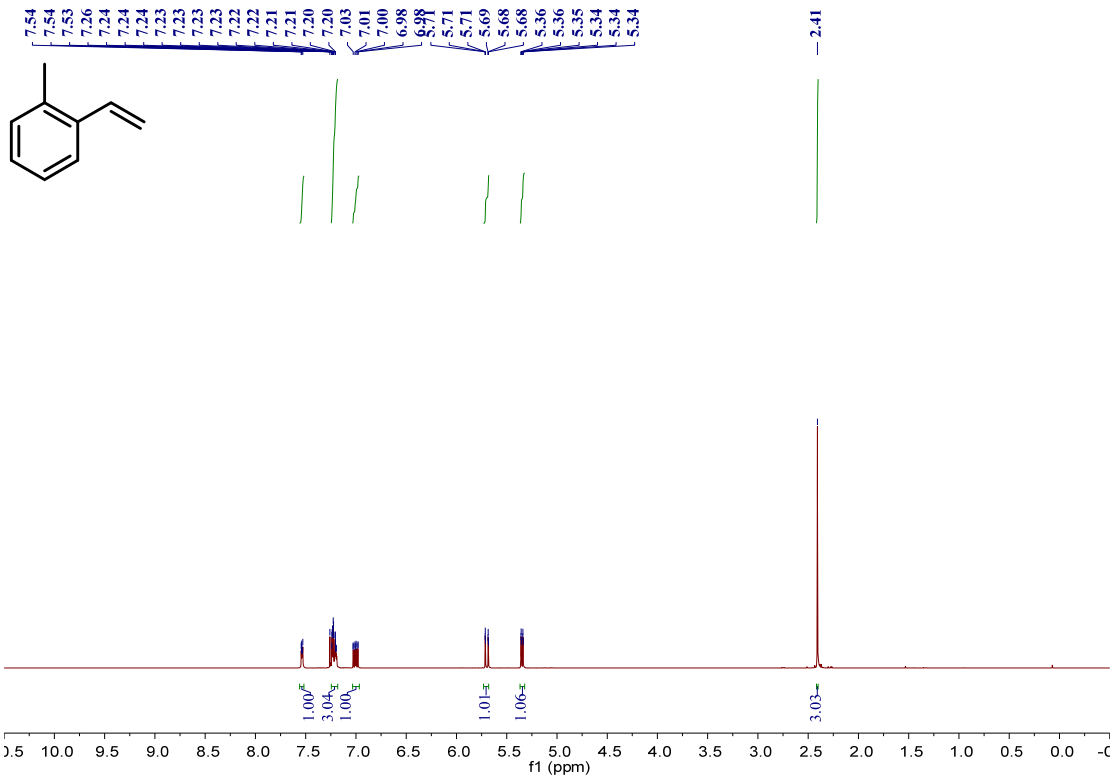
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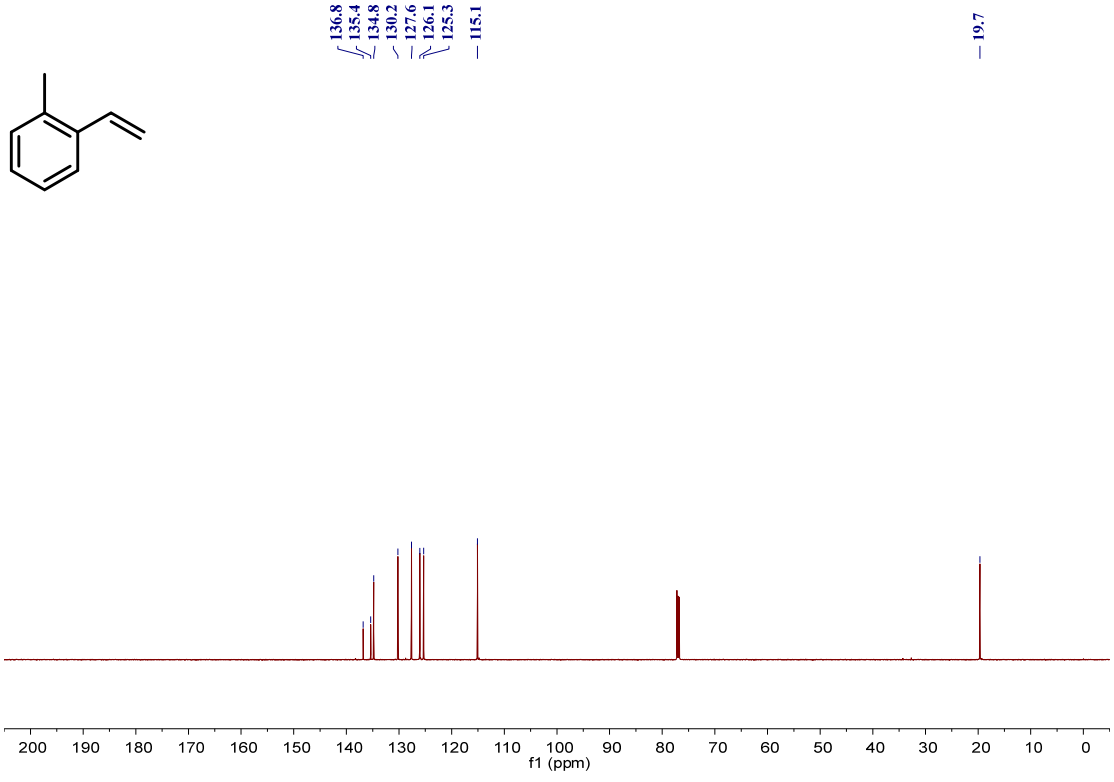
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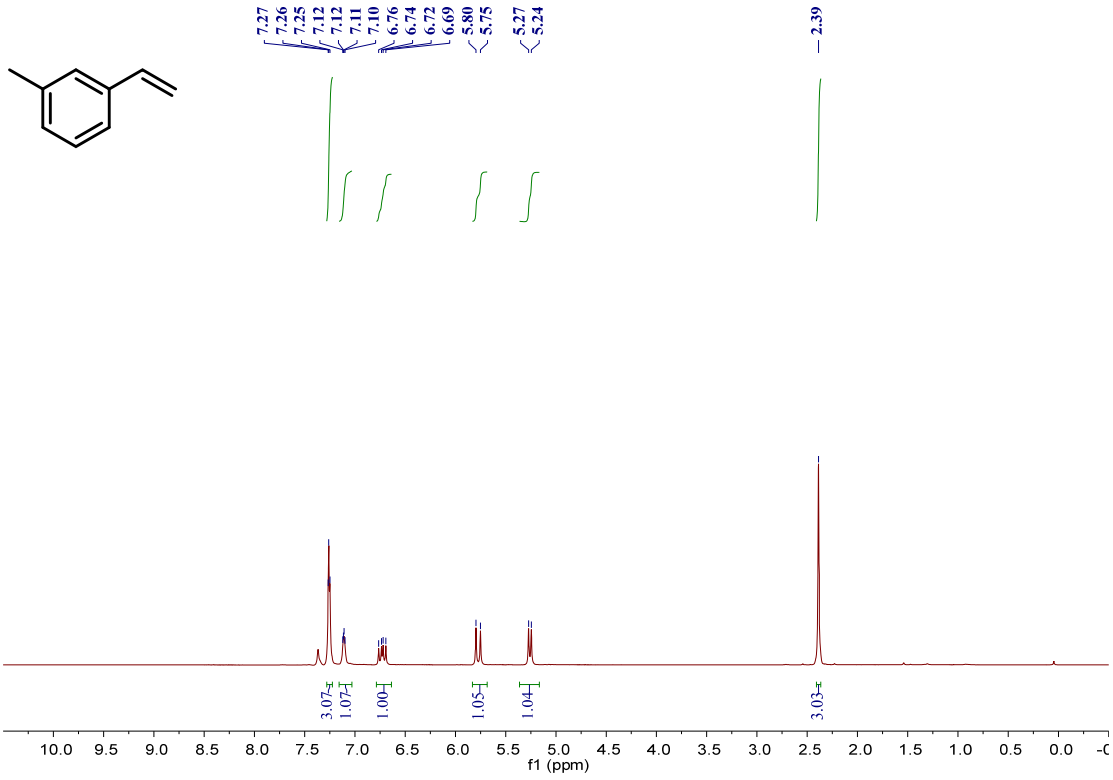
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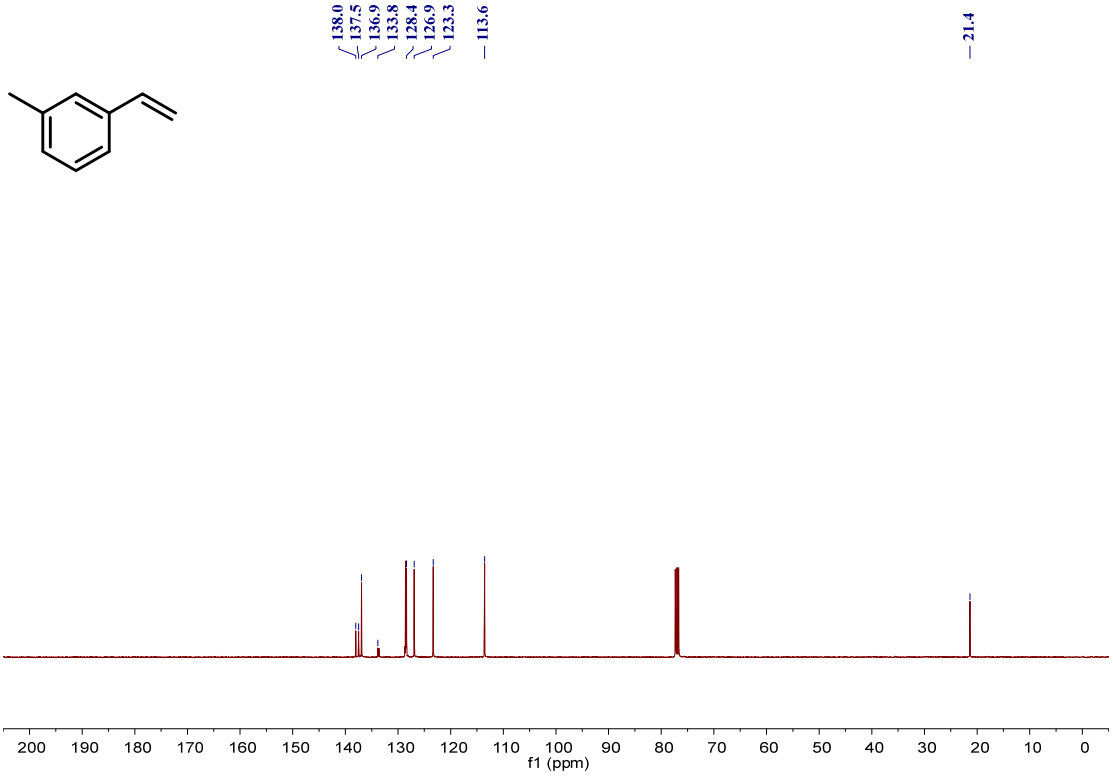
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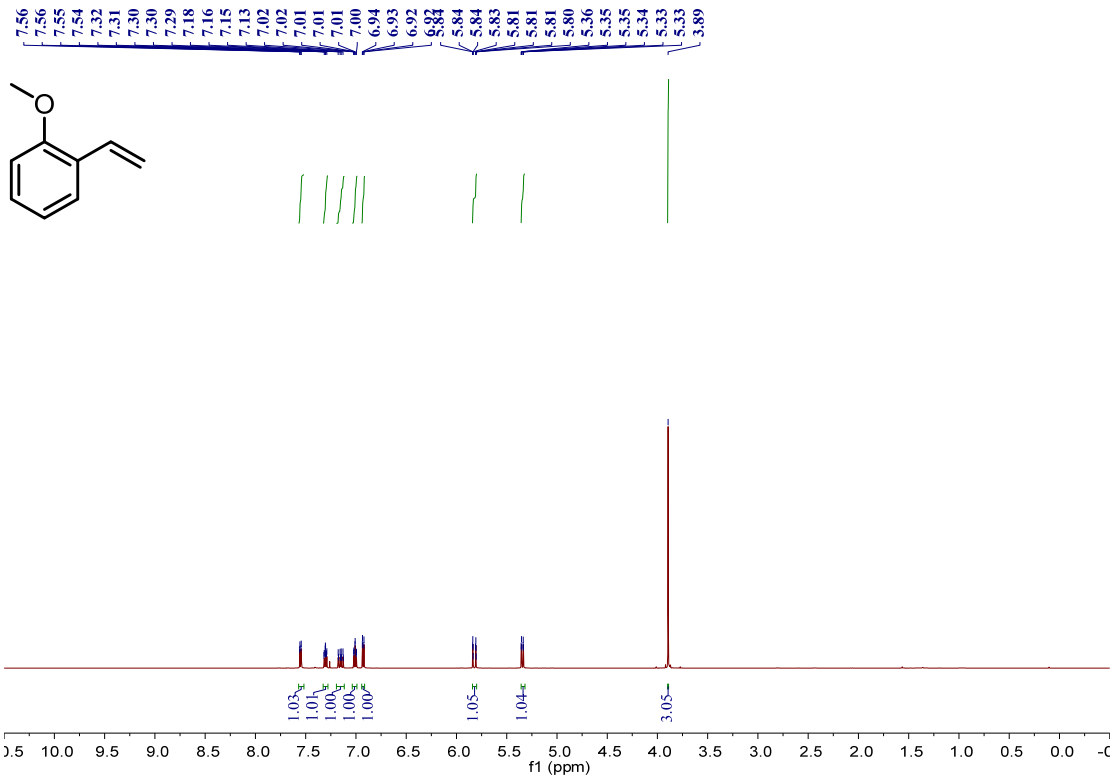
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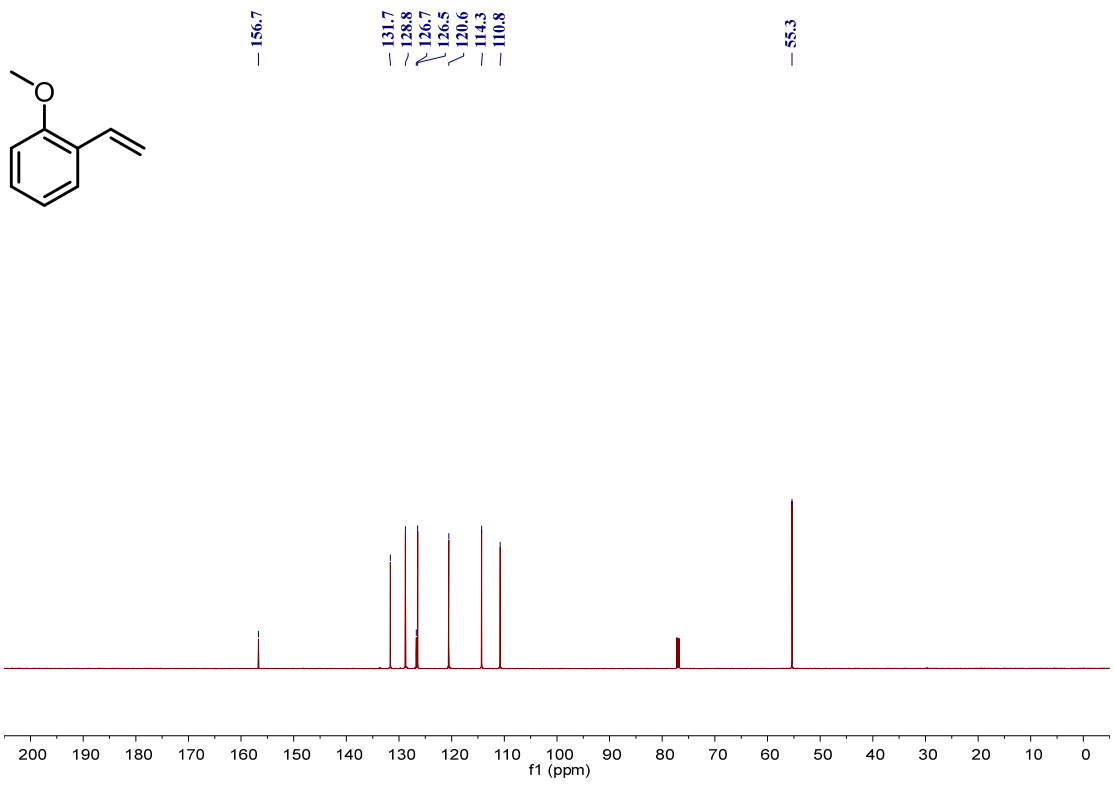
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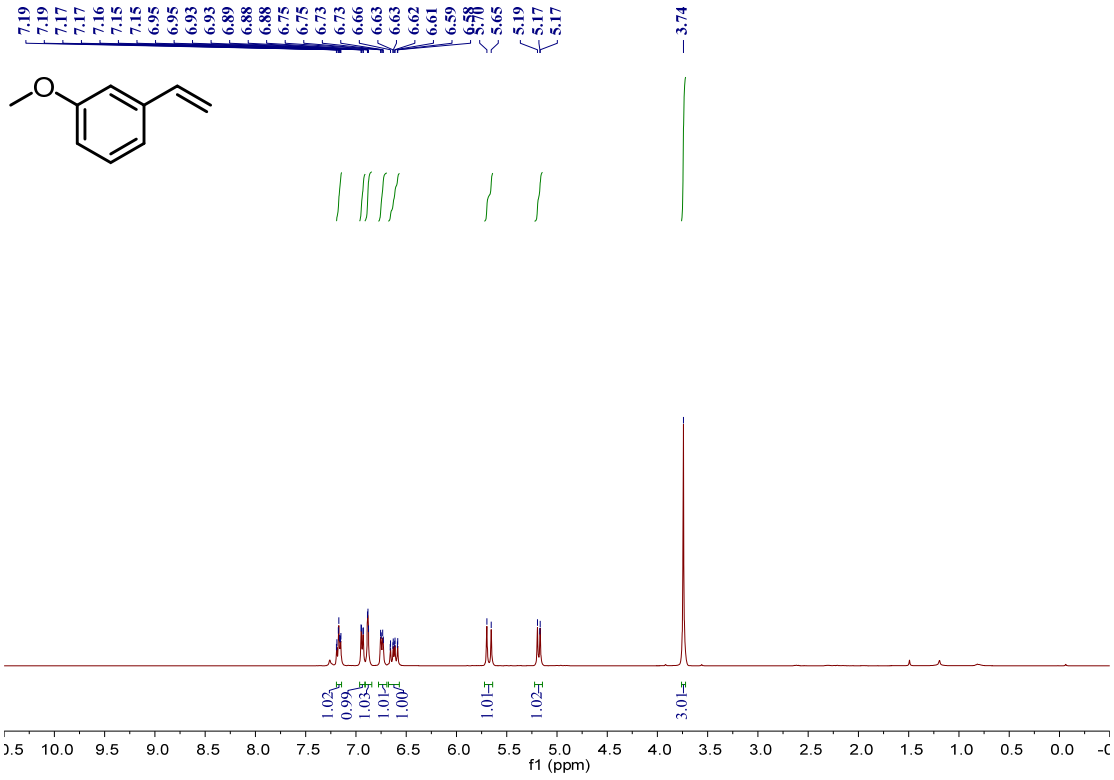
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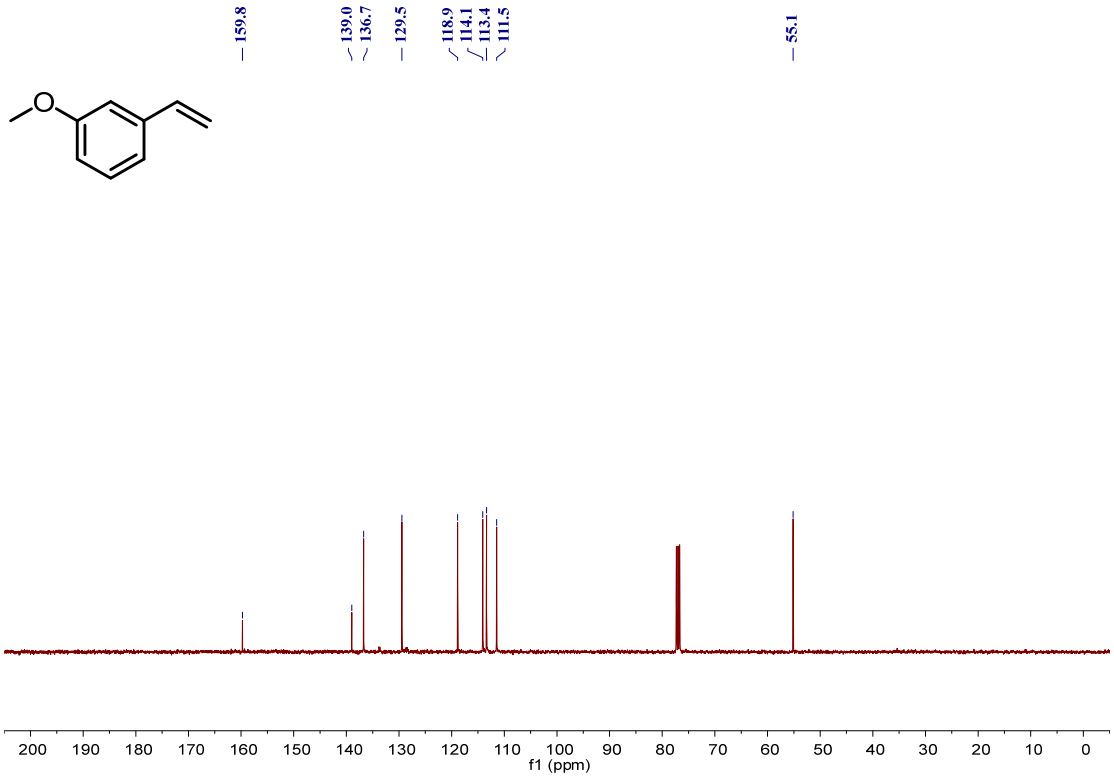
1.02
3.01
f1 (ppm)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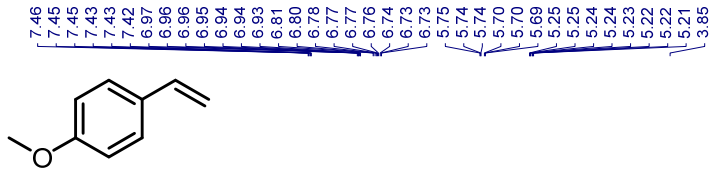
136.7
129.5
118.9
114.1
113.4
111.5
55.1
f1 (ppm)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6.96
6.96
6.95
6.94
6.94
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6.81
6.80
6.78
6.77
6.77
6.76
6.74
6.73
6.73
5.75
5.74
5.74
5.70
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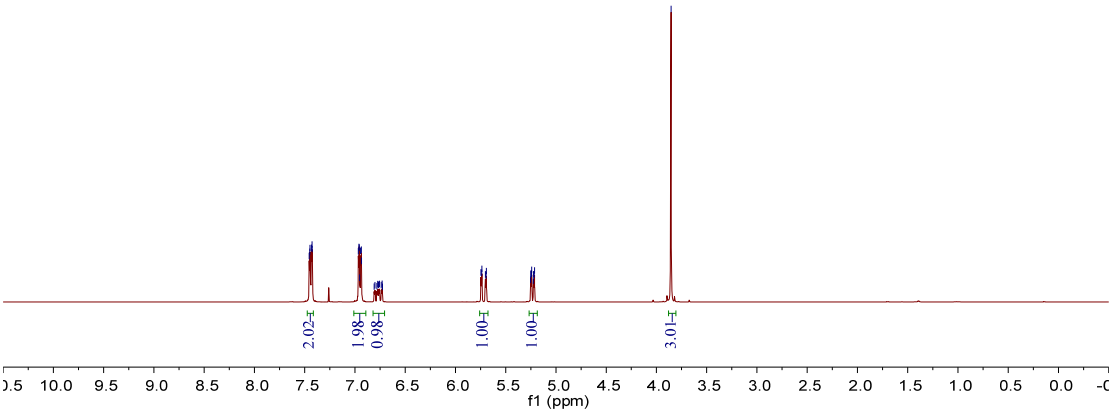
5.24
5.23
5.22
5.22
5.21
3.85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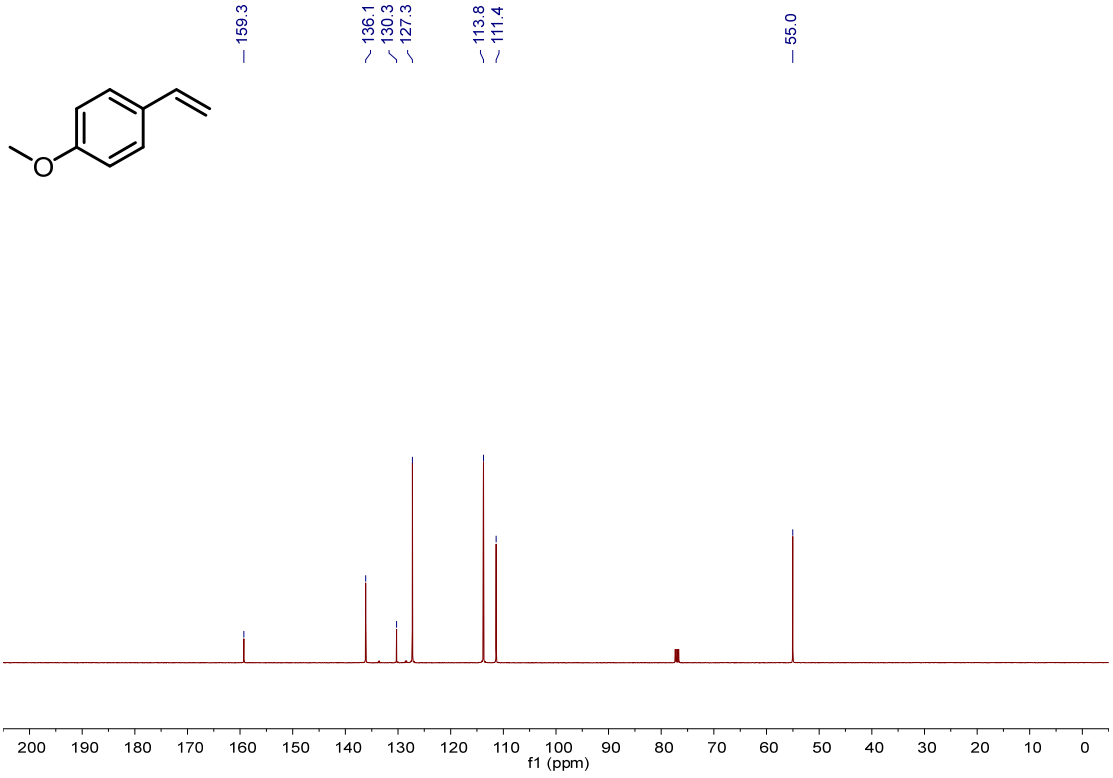
1.98
0.98
1.00
1.00
3.01
f1 (ppm)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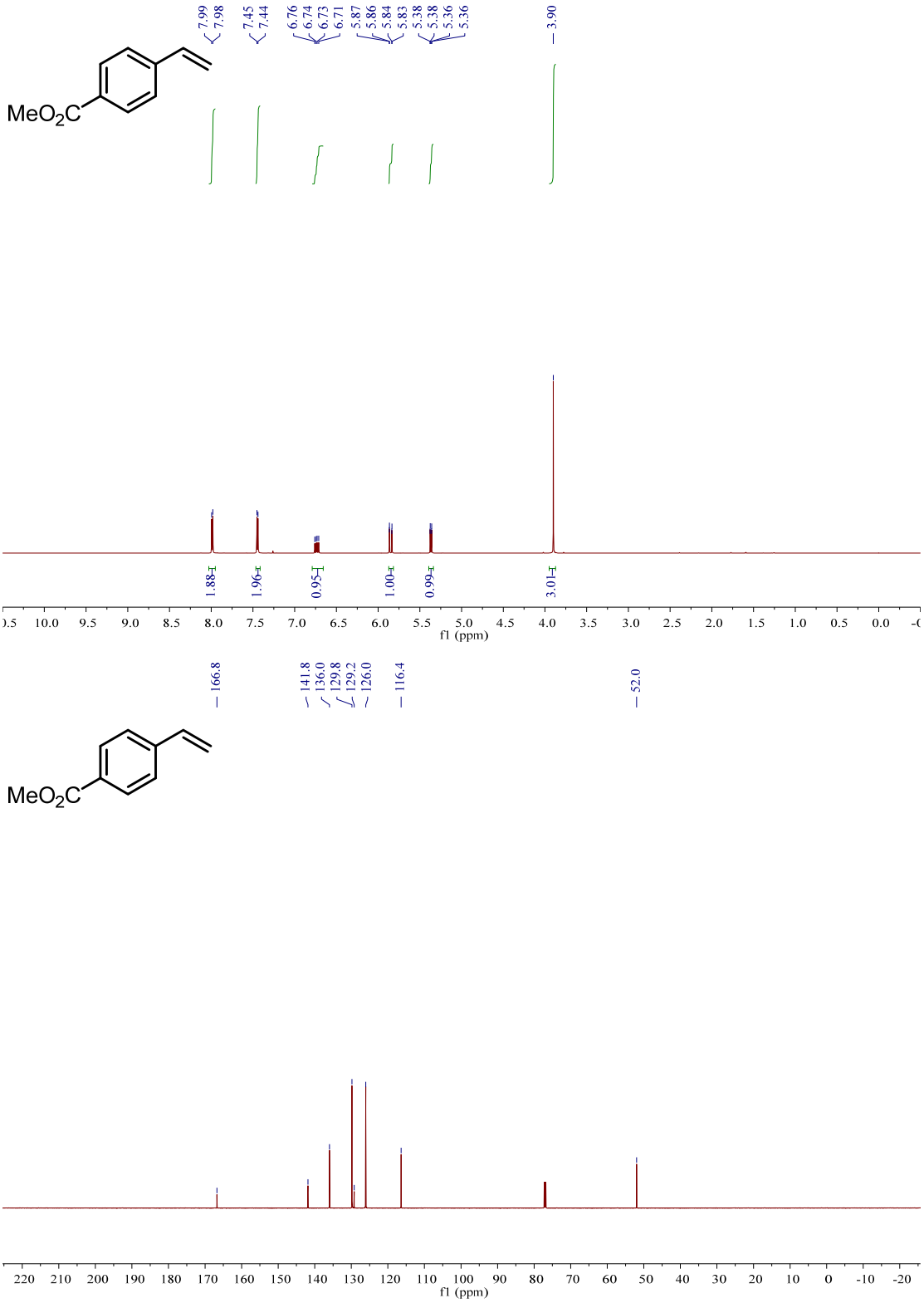
130.3
127.3
113.8
111.4
55.0
f1 (ppm)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7.45
7.44
6.76
6.74
6.73
6.71
5.87
5.86
5.84
5.83
5.38
5.36
5.36
3.90
MeO2C
1.88
1.96
0.95
1.00
0.99
3.01
f1 (ppm)
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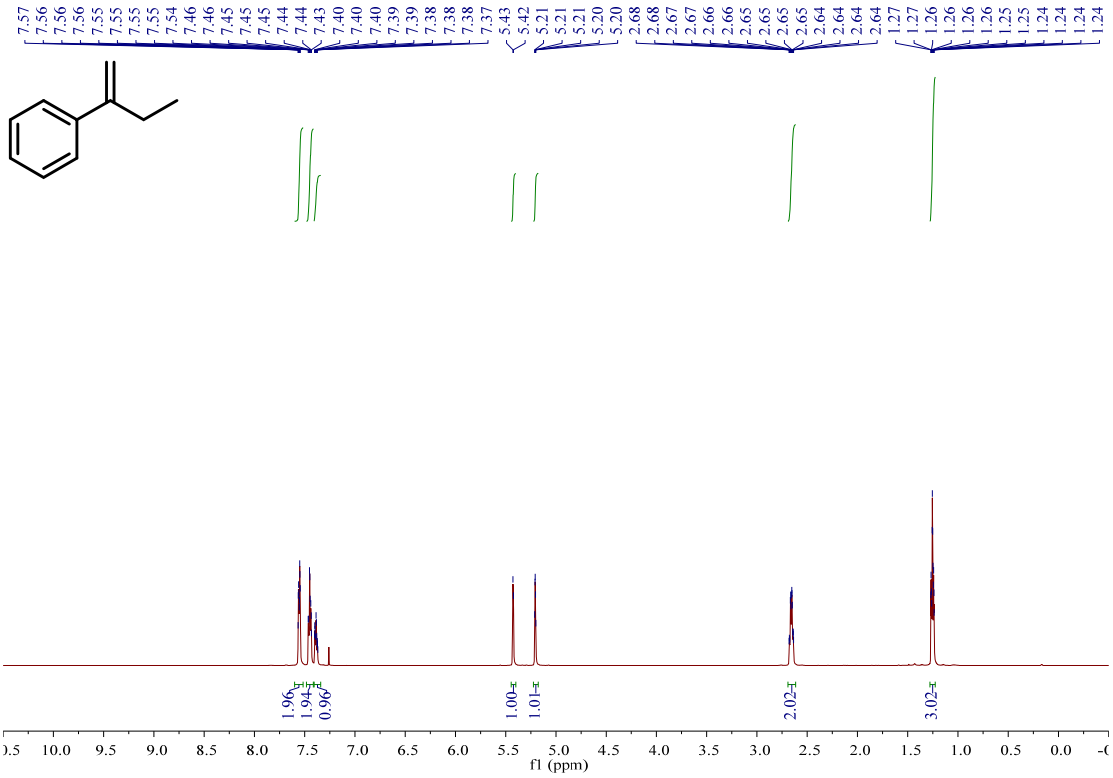
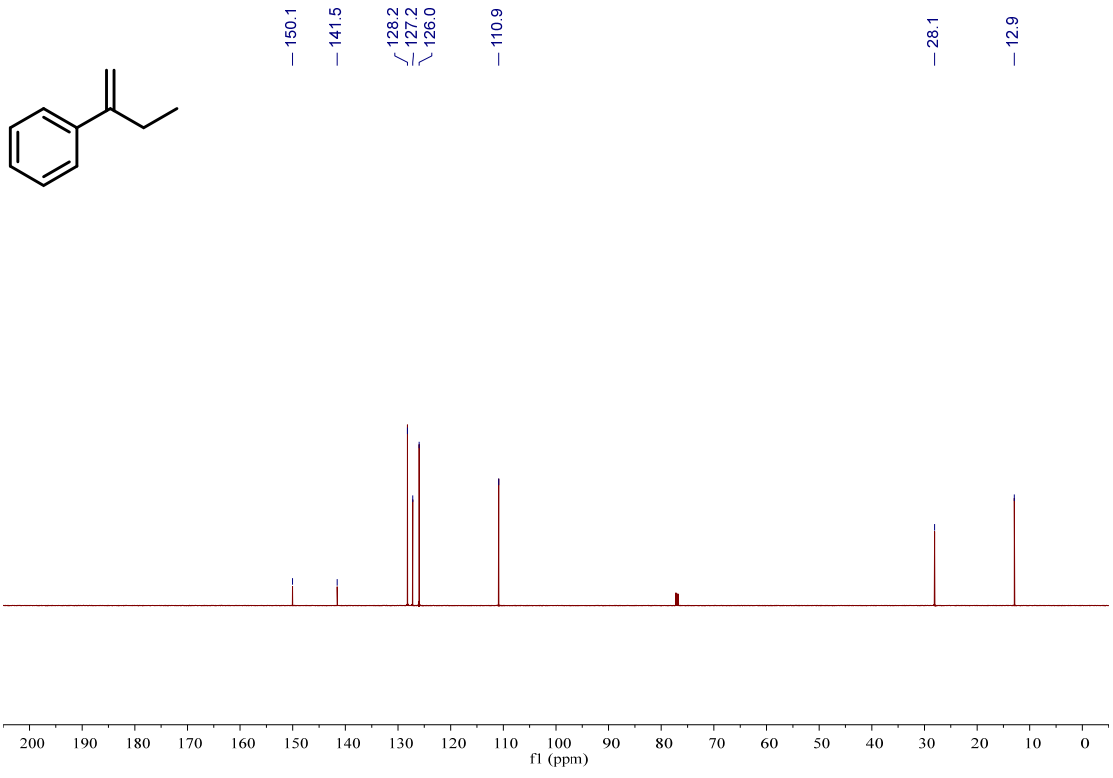
141.8
136.0
129.8
129.2
126.0
116.4
52.0
MeO2C
f1 (ppm)


7.57 7.56 7.56 7.56 7.55 7.55 7.55 7.55 7.54 7.46 7.46 7.45 7.45 7.45 7.44 7.44 7.43 7.40 7.40 7.40 7.39 7.39 7.38 7.38 7.37 5.43 5.42 5.21 5.21 5.21 5.20 5.20 2.68 2.68 2.67 2.67 2.66 2.66 2.65 2.65 2.65 2.64 2.64 2.64 2.64 1.27 1.27 1.26 1.26 1.26 1.26 1.25 1.24 1.24 1.24 1.24
1.96
1.94
0.96
1.00
1.01
2.02
3.02
f1 (ppm)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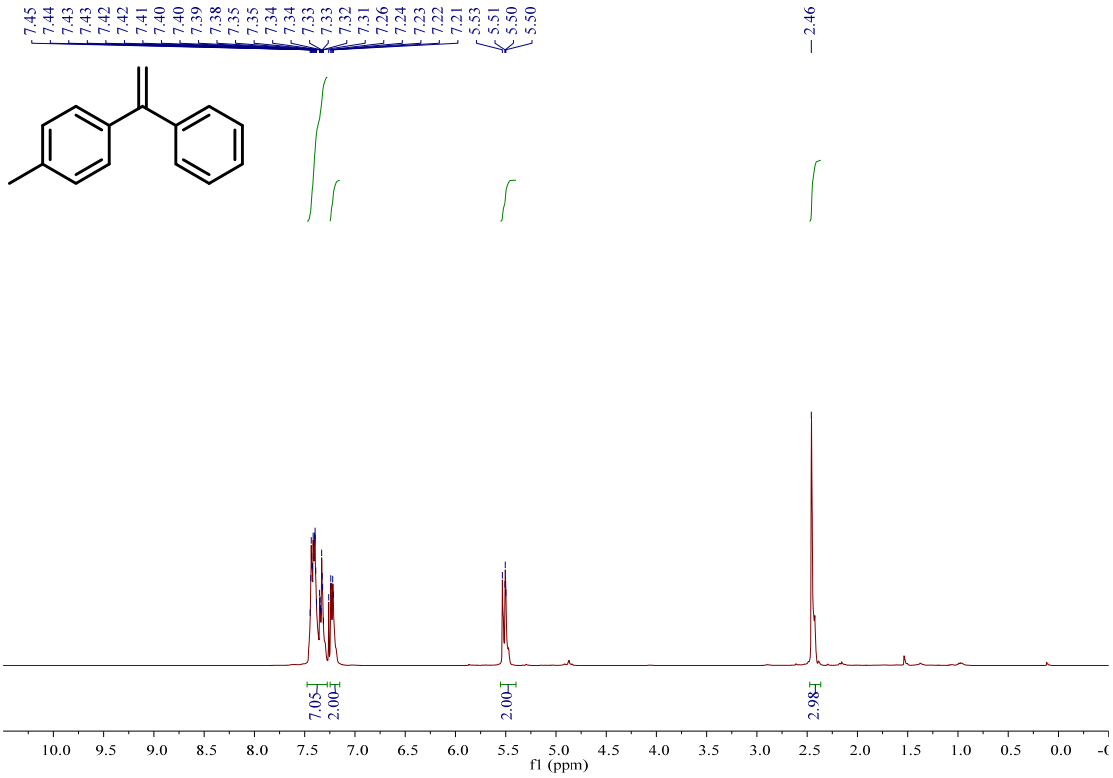
28.1
12.9
f1 (ppm)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7.34
7.34
7.33
7.33
7.32
7.31
7.26
7.24
7.23
7.22
7.21
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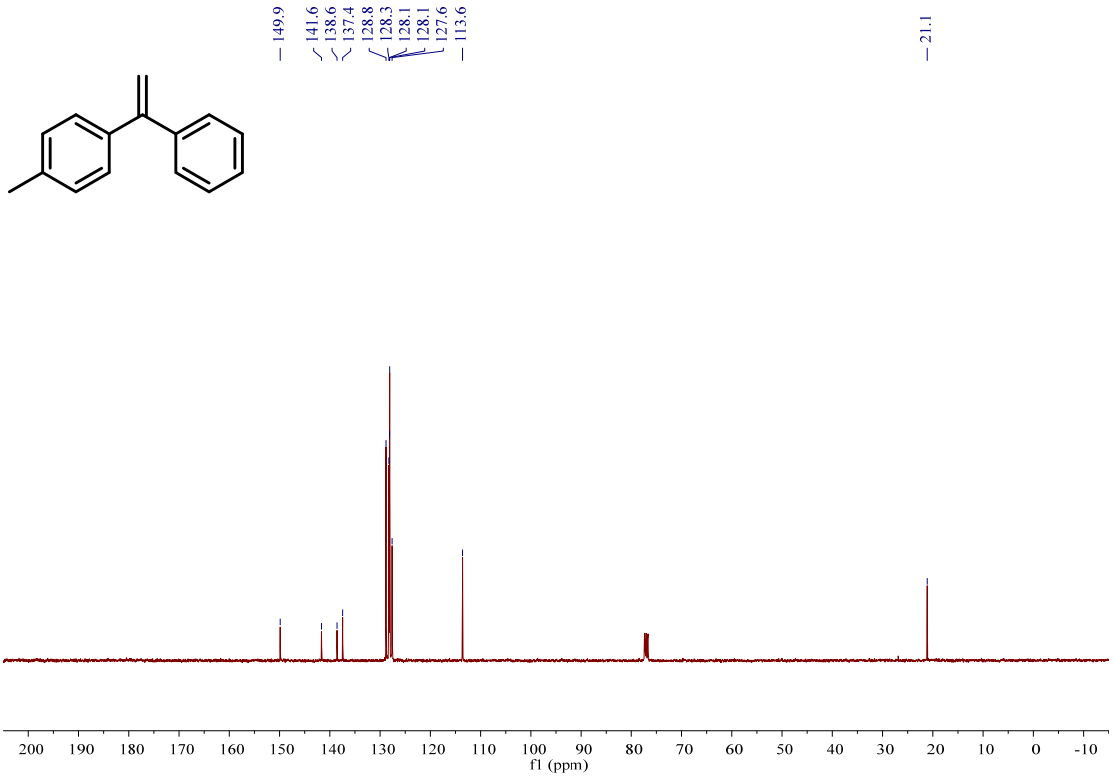
5.50
5.50
2.46
7.05
2.00
2.00
2.98
f1 (ppm)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138.6
137.4
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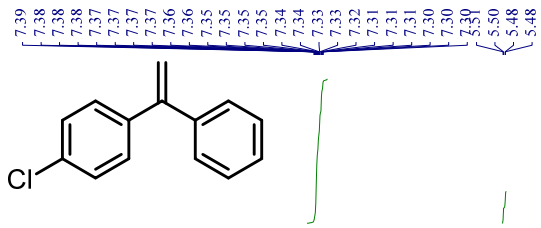
128.3
128.1
128.1
127.6
113.6
21.1
f1 (ppm)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7.38
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7.37
7.37
7.37
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7.36
7.35
7.35
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7.34
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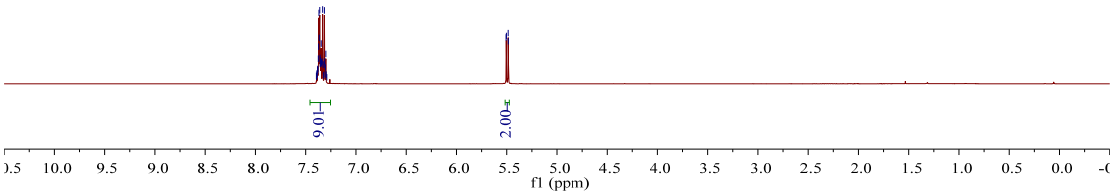
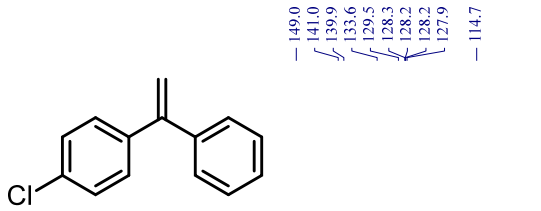
7.30
7.30
5.50
5.48
5.48
Cl


9.01
2.00
f1 (ppm)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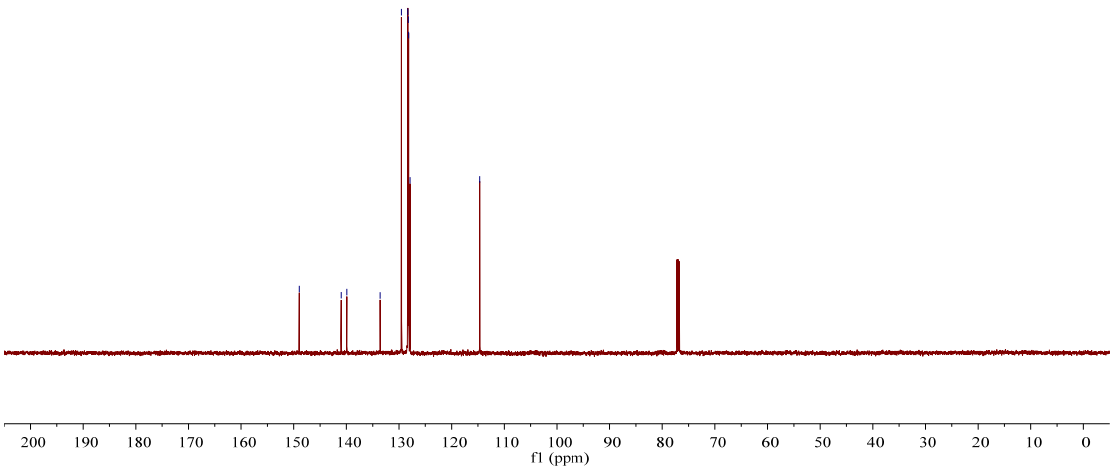
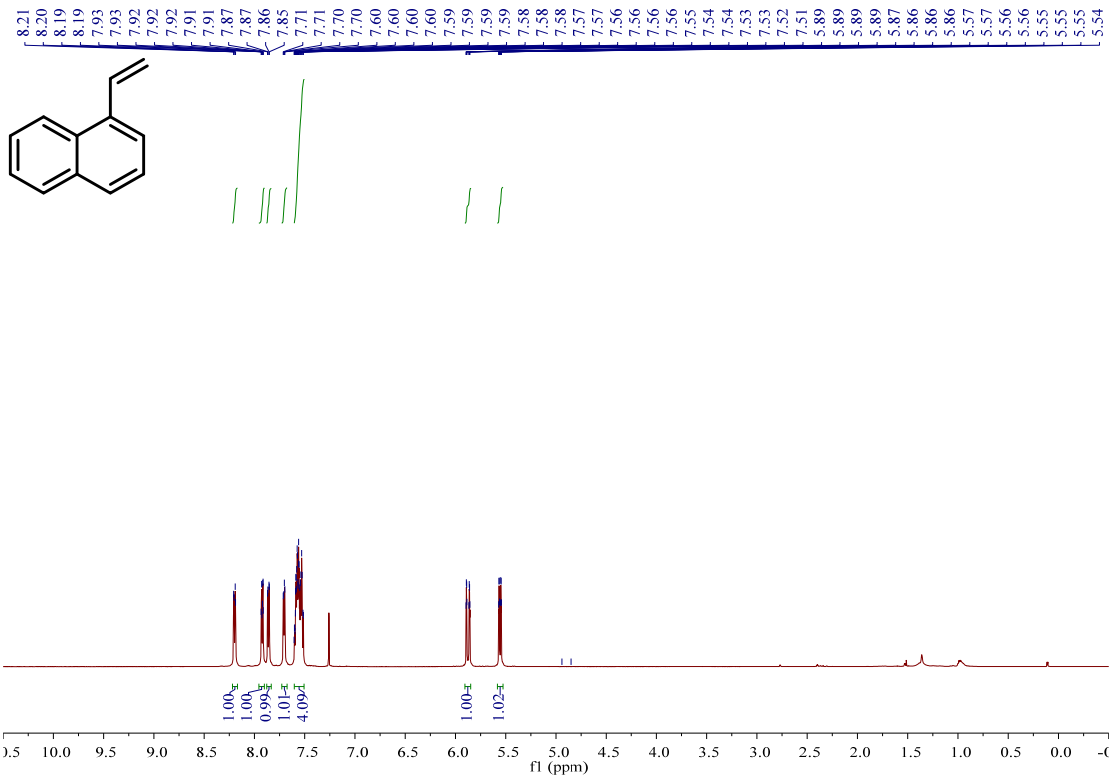
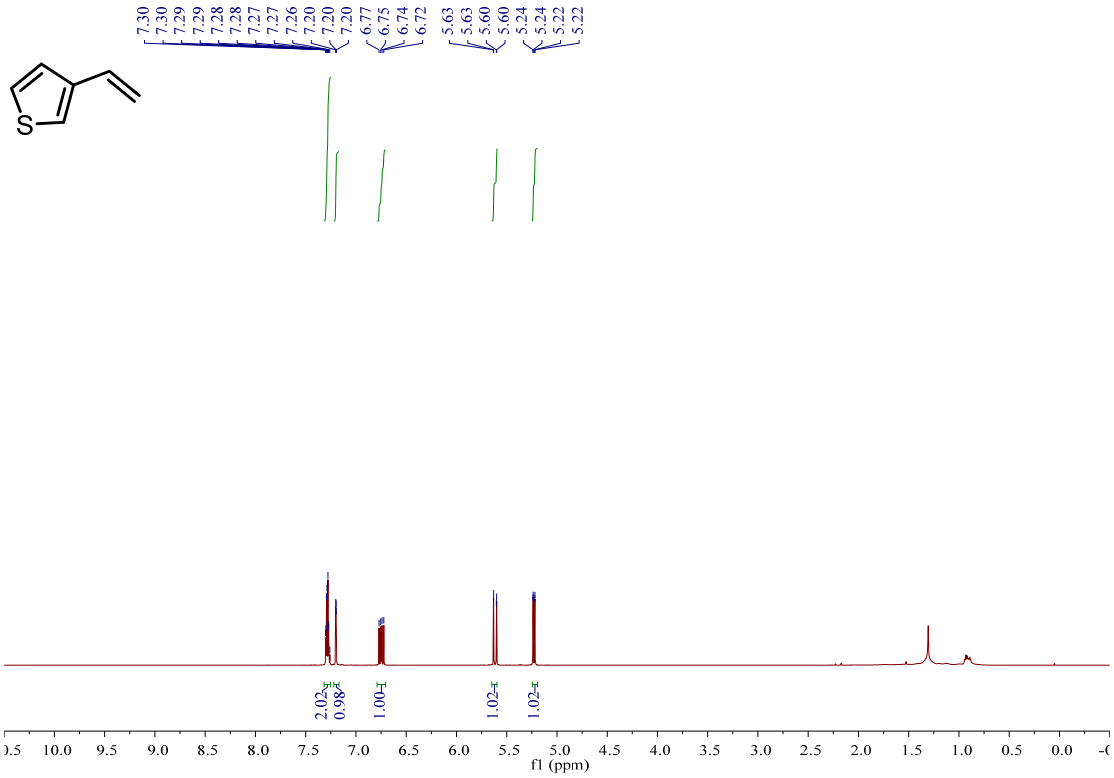
141.0
139.9
133.6
129.5
128.3
128.2
128.2
127.9
114.7
Cl


f1 (ppm)


8.21 8.20 8.19 8.19 7.93 7.93 7.92 7.92 7.92 7.91 7.91 7.87 7.87 7.86 7.85 7.71 7.71 7.70 7.70 7.60 7.60 7.60 7.60 7.59 7.59 7.59 7.59 7.58 7.58 7.58 7.57 7.57 7.56 7.56 7.56 7.56 7.55 7.54 7.54 7.53 7.53 7.52 7.51 5.89 5.89 5.89 5.89 5.87 5.86 5.86 5.86 5.57 5.57 5.56 5.56 5.55 5.55 5.55 5.54
1.00 1.00 0.99 1.01 4.09 1.00 1.02
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
135.6 134.3 133.6 131.1 128.5 128.1 126.0 125.7 125.6 123.7 123.6 117.1
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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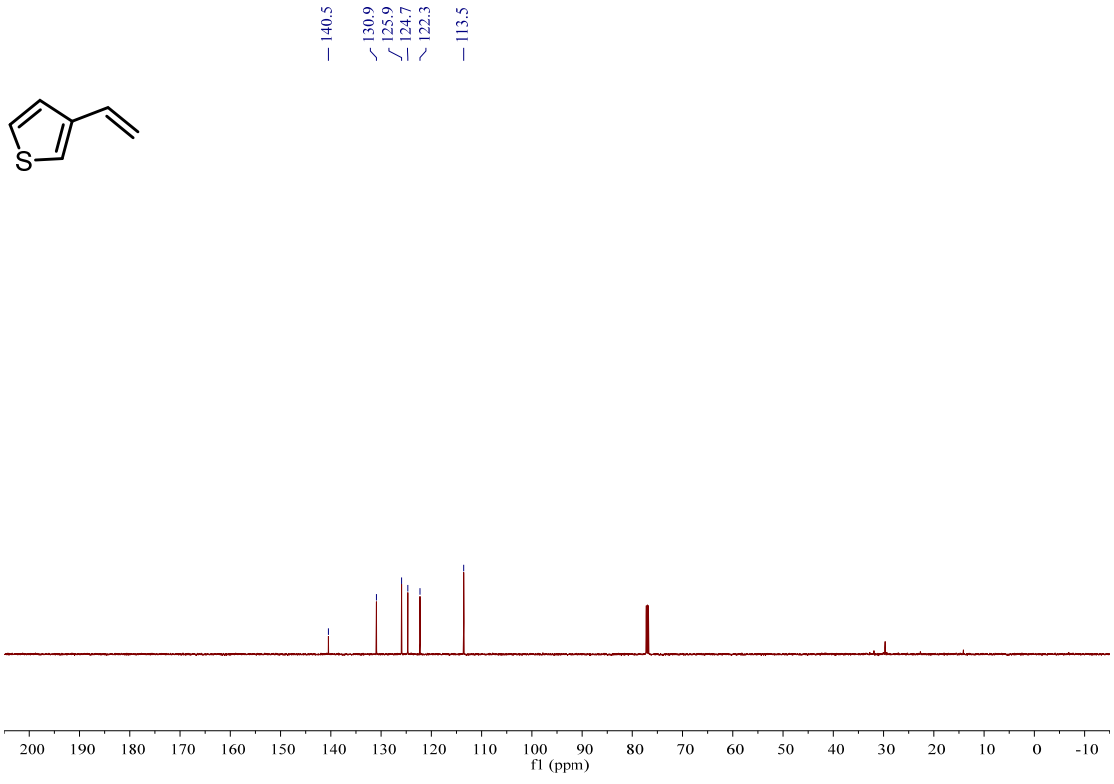
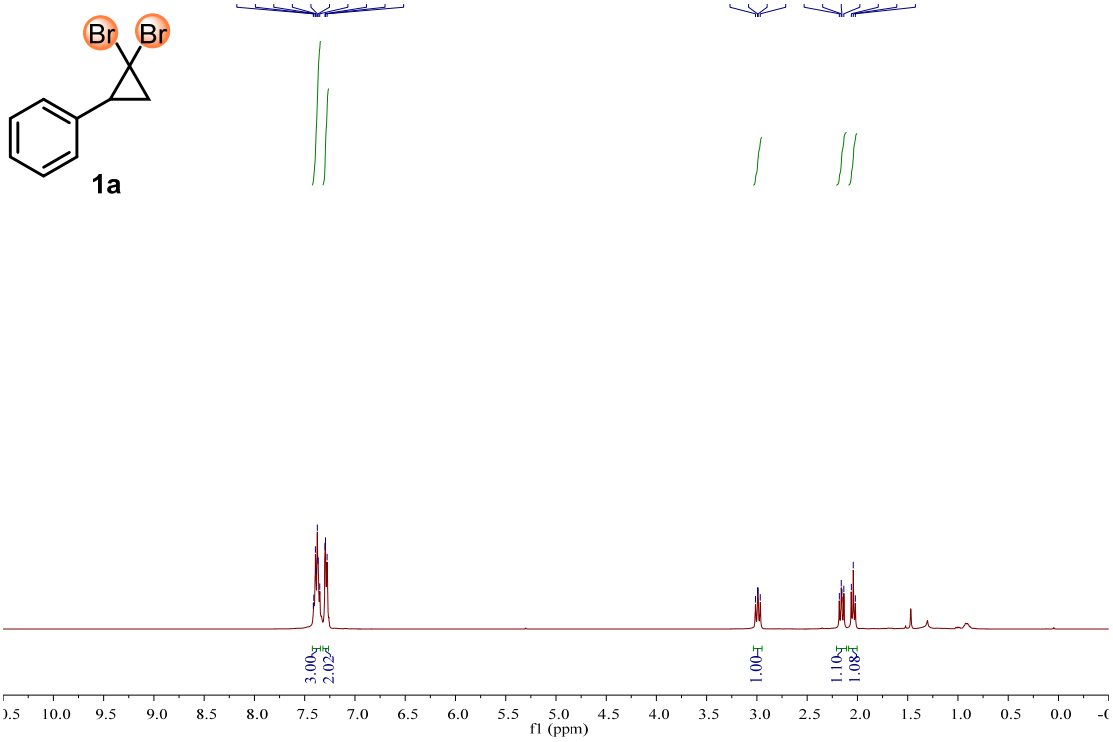
7.28
7.27
7.27
7.26
7.20
7.20
7.20
6.77
6.75
6.74
6.72
5.63
5.63
5.60
5.60
5.24
5.24
5.22
5.22
S
2.02
0.98
1.00
1.02
1.02
f1 (ppm)


140.5
130.9
125.9
124.7
122.3
113.5
S
f1 (ppm)


Br
Br
1a
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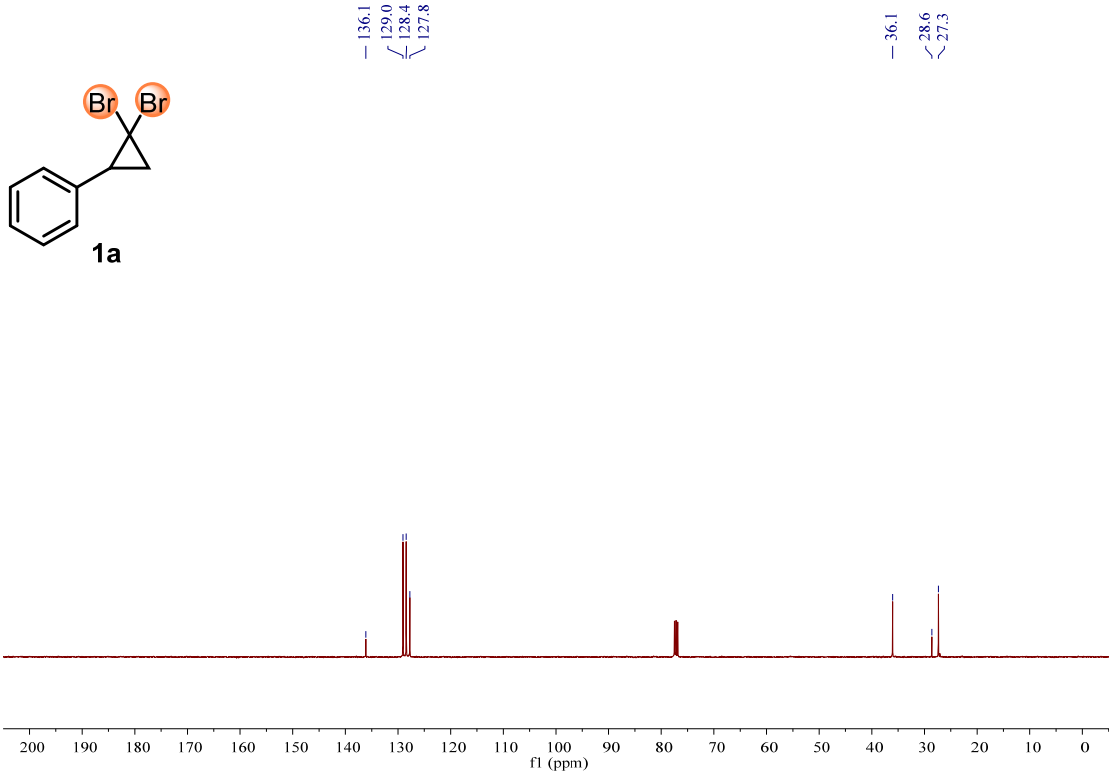
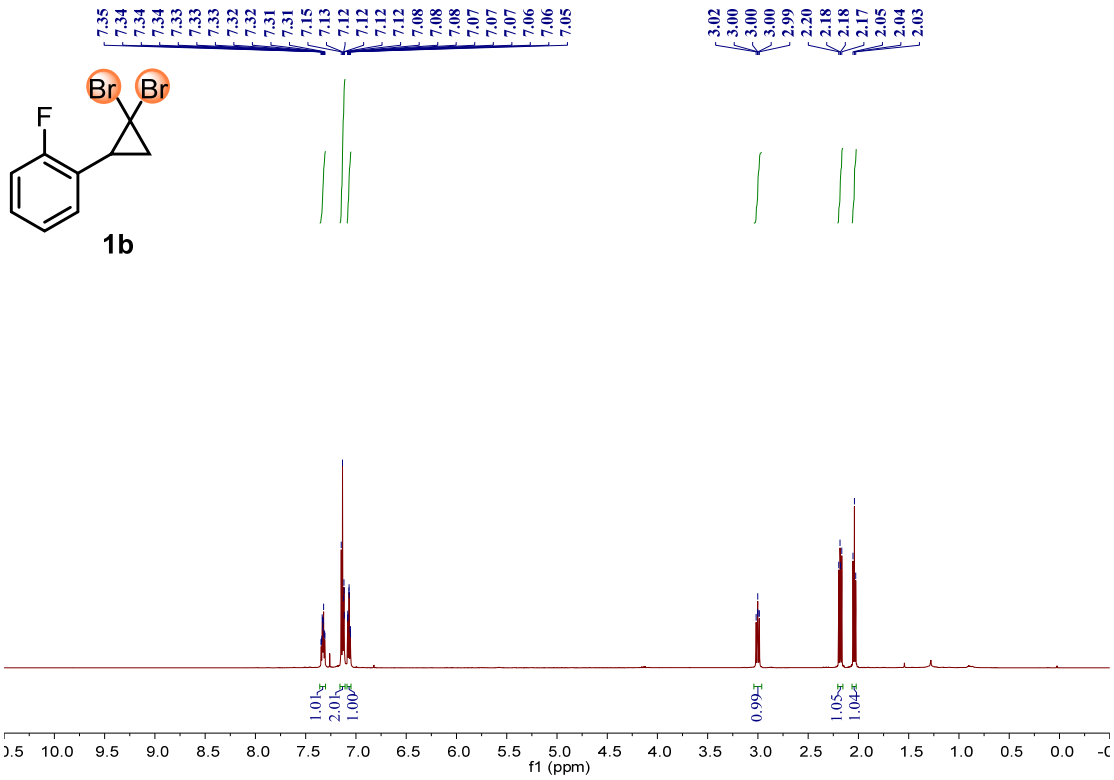
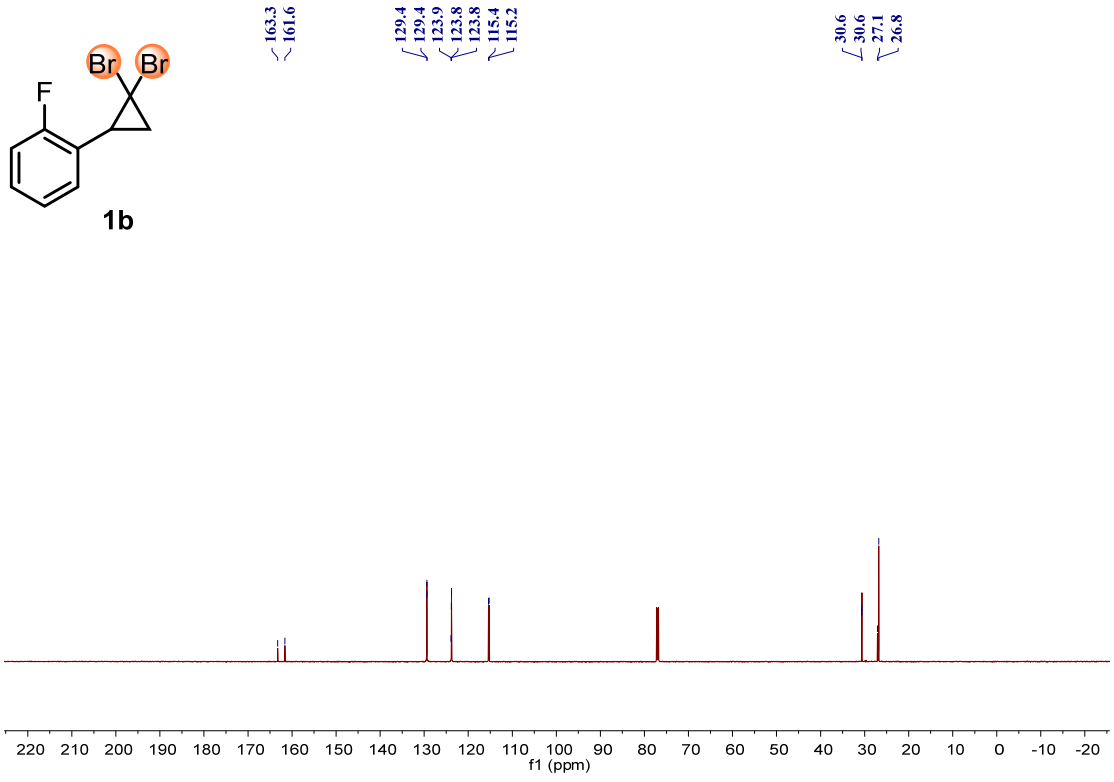
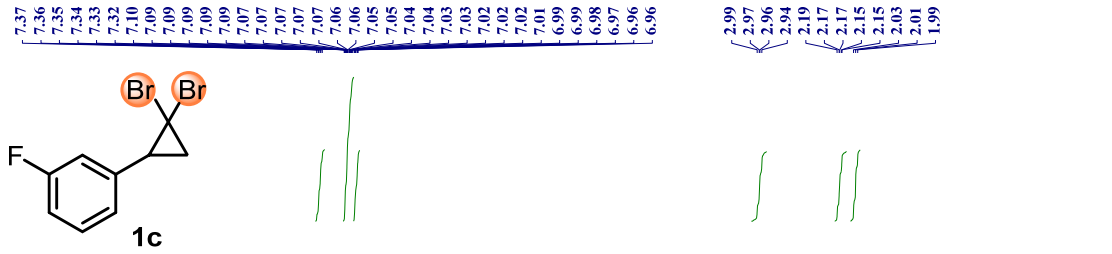
7.39
7.37
7.37
7.35
7.30
7.29
7.28
3.01
2.99
2.99
2.97
2.18
2.16
2.15
2.14
2.06
2.04
2.02
3.00
2.02
1.00
1.10
1.08
f1 (ppm)


Br
Br
1a
136.1
129.0
128.4
127.8
36.1
28.6
27.3
f1 (ppm)


7.35 7.34 7.34 7.34 7.33 7.33 7.33 7.32 7.32 7.31 7.31 7.15 7.13 7.12 7.12 7.12 7.12 7.08 7.08 7.08 7.07 7.07 7.07 7.06 7.06 7.05
3.02 3.00 3.00 3.00 2.99 2.20 2.18 2.18 2.17 2.05 2.04 2.03
Br Br
F
1b
1.01 2.01 1.00 0.99 1.05 1.04
f1 (ppm)


163.3 161.6
129.4 129.4 123.9 123.8 123.8 115.4 115.2
30.6 30.6 27.1 26.8
Br Br
F
1b
f1 (ppm)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2.97
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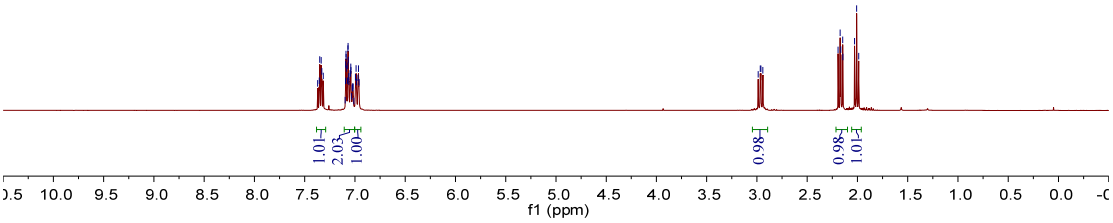
2.17
2.17
2.15
2.15
2.03
2.01
1.99
Br
Br
F
1c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2.03
1.00
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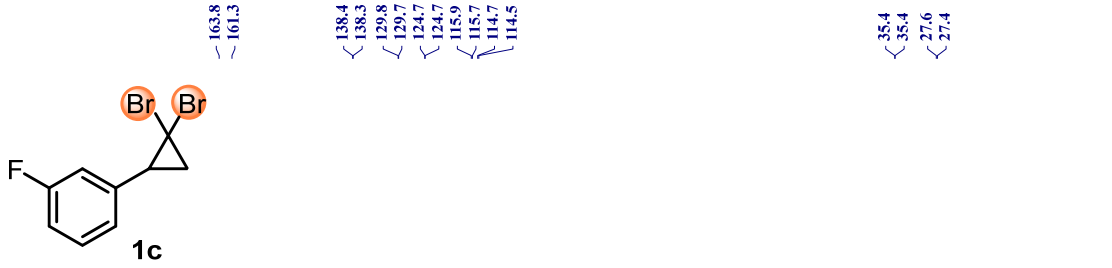
0.98
1.01
f1 (ppm)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138.3
129.8
129.7
124.7
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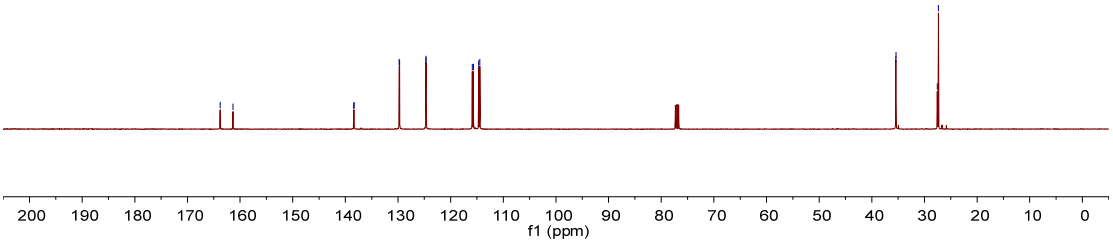
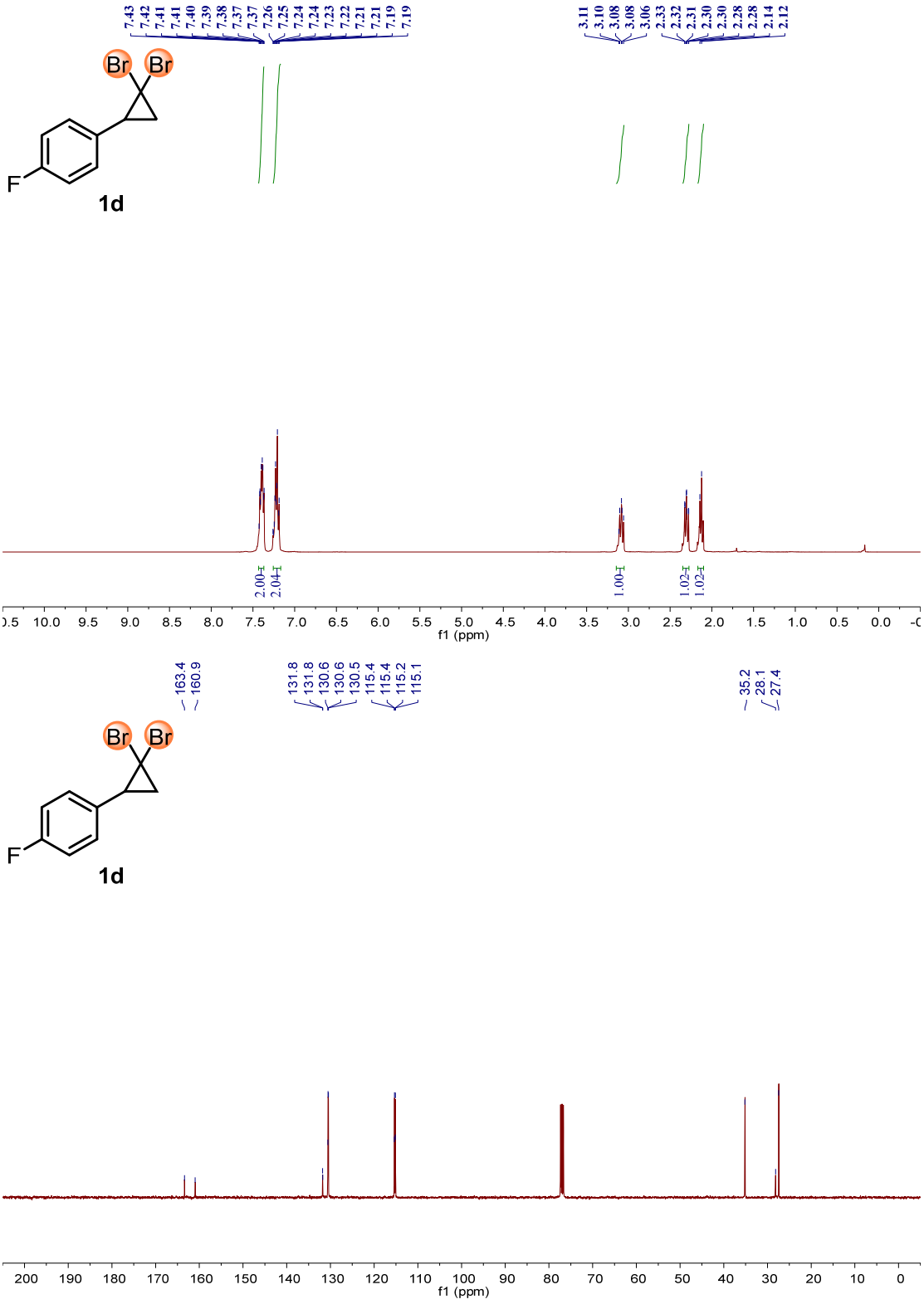
114.7
114.5
35.4
35.4
27.6
27.4
Br
Br
F
1c


f1 (ppm)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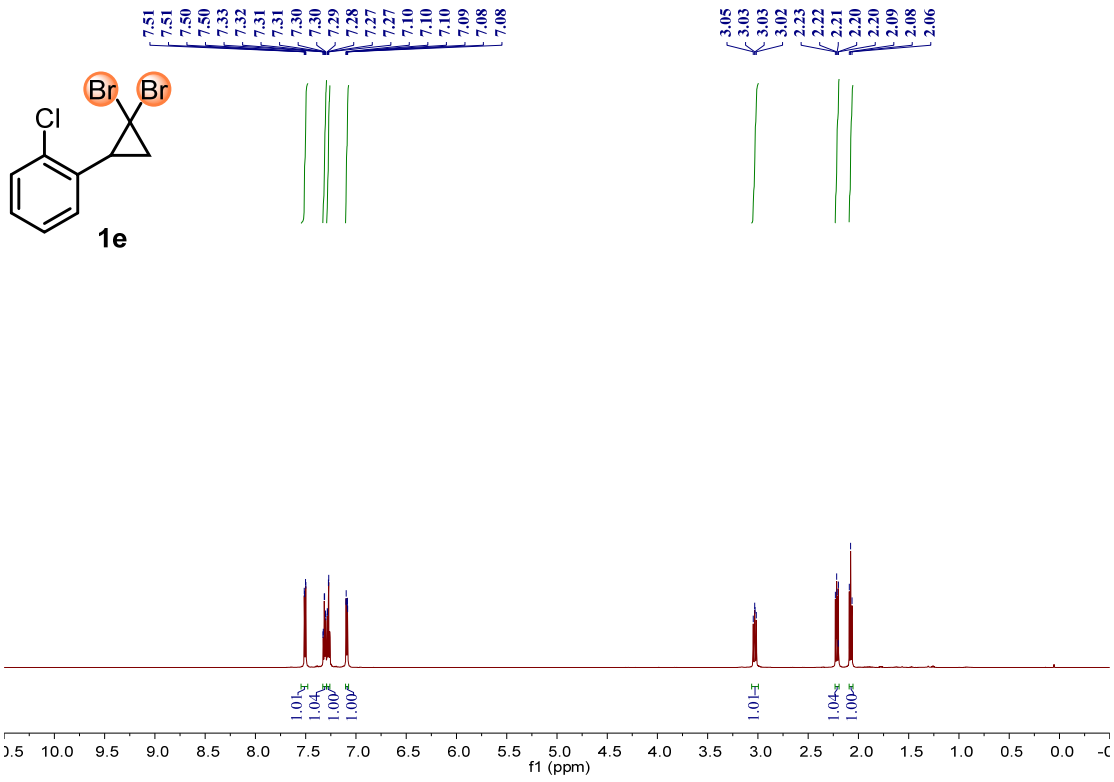
7.21
7.19
7.19
3.11
3.10
3.08
3.08
3.06
2.33
2.32
2.31
2.30
2.30
2.28
2.28
2.14
2.12
Br
Br
F
1d
2.00
2.04
1.00
1.02
1.02
f1 (ppm)
163.4
160.9
131.8
131.8
130.6
130.6
130.5
115.4
115.4
115.2
115.1
35.2
28.1
27.4
Br
Br
F
1d
f1 (ppm)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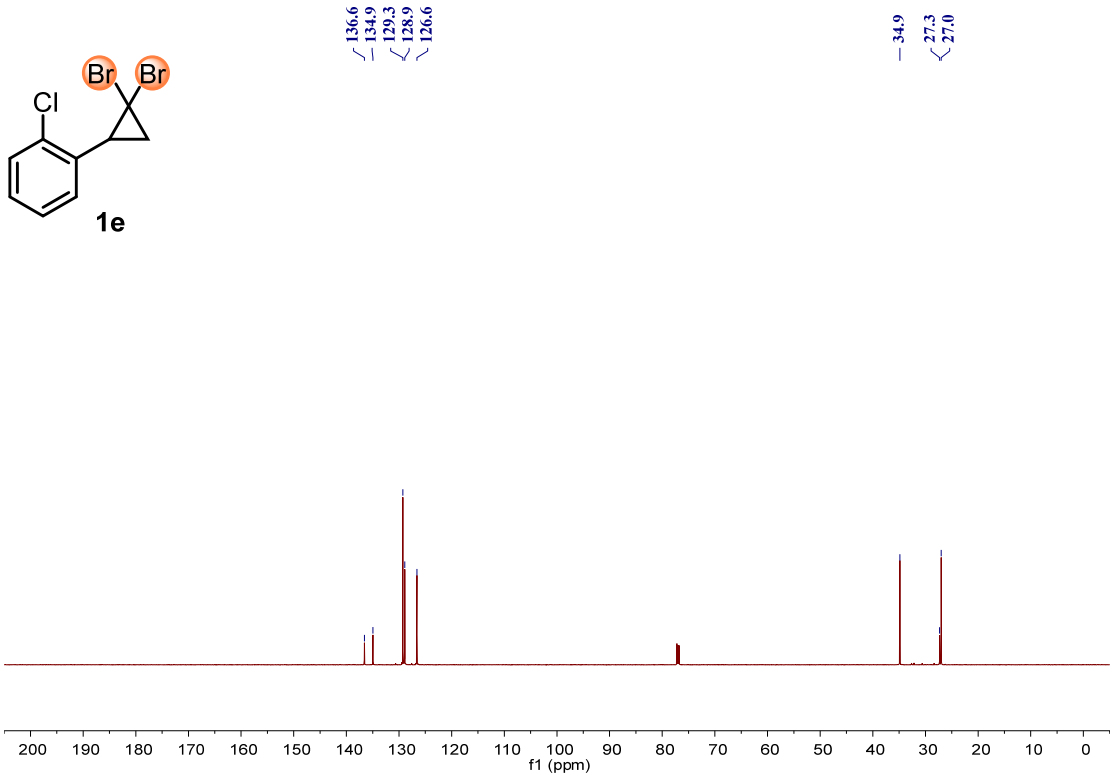
7.10
7.10
7.10
7.09
7.08
7.08
3.05
3.03
3.03
3.02
2.23
2.22
2.21
2.20
2.20
2.09
2.08
2.06
Br
Br
Cl
1e
1.01
1.04
1.00
1.00
1.01
1.04
1.00
f1 (ppm)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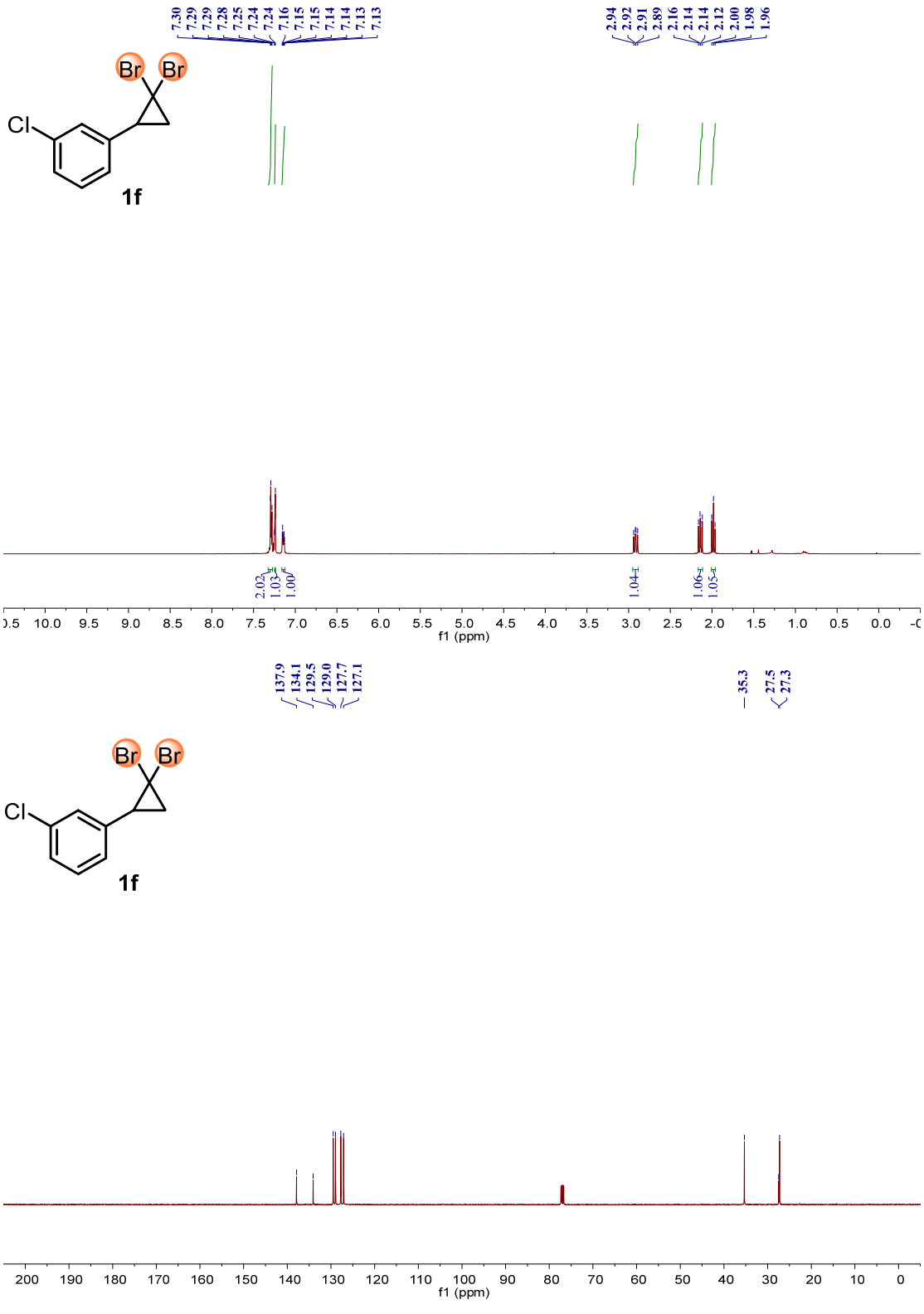
34.9
27.3
27.0
Br
Br
Cl
1e
f1 (ppm)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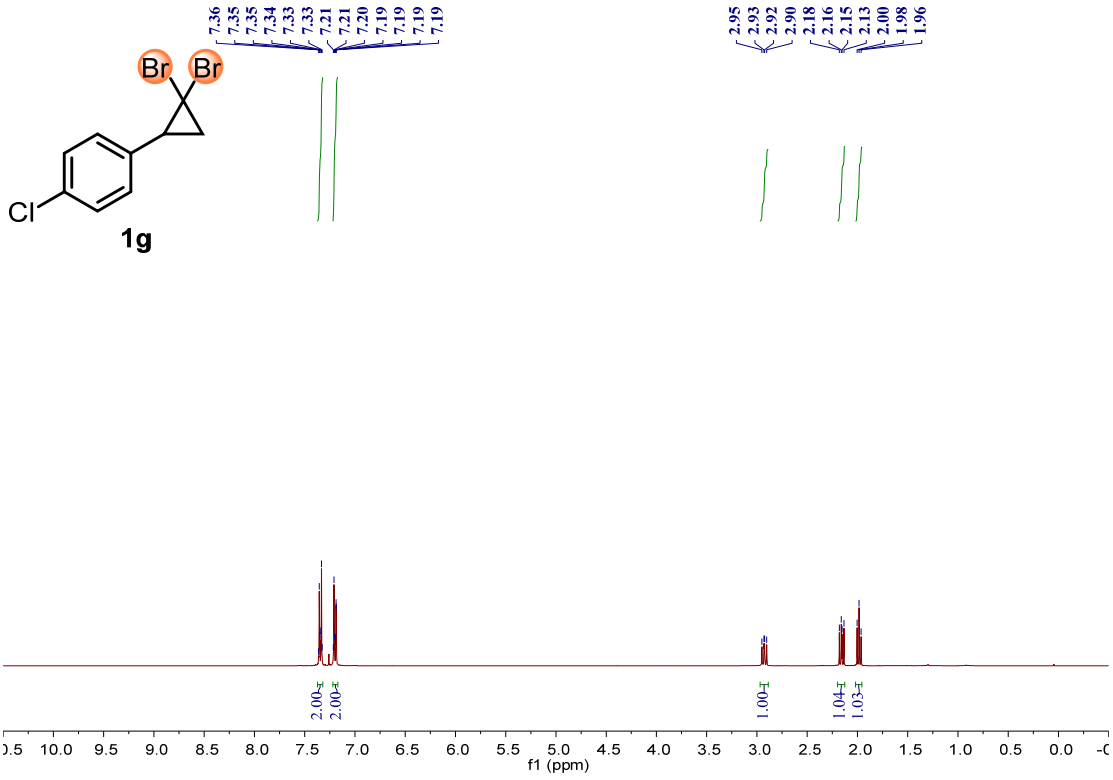
7.14
7.14
7.13
7.13
2.94
2.92
2.91
2.89
2.16
2.14
2.14
2.12
2.00
1.98
1.96
Br
Br
Cl
1f
2.02
1.03
1.00
1.04
1.06
1.05
f1 (ppm)
137.9
134.1
129.5
129.0
127.7
127.1
35.3
27.5
27.3
Br
Br
Cl
1f
f1 (ppm)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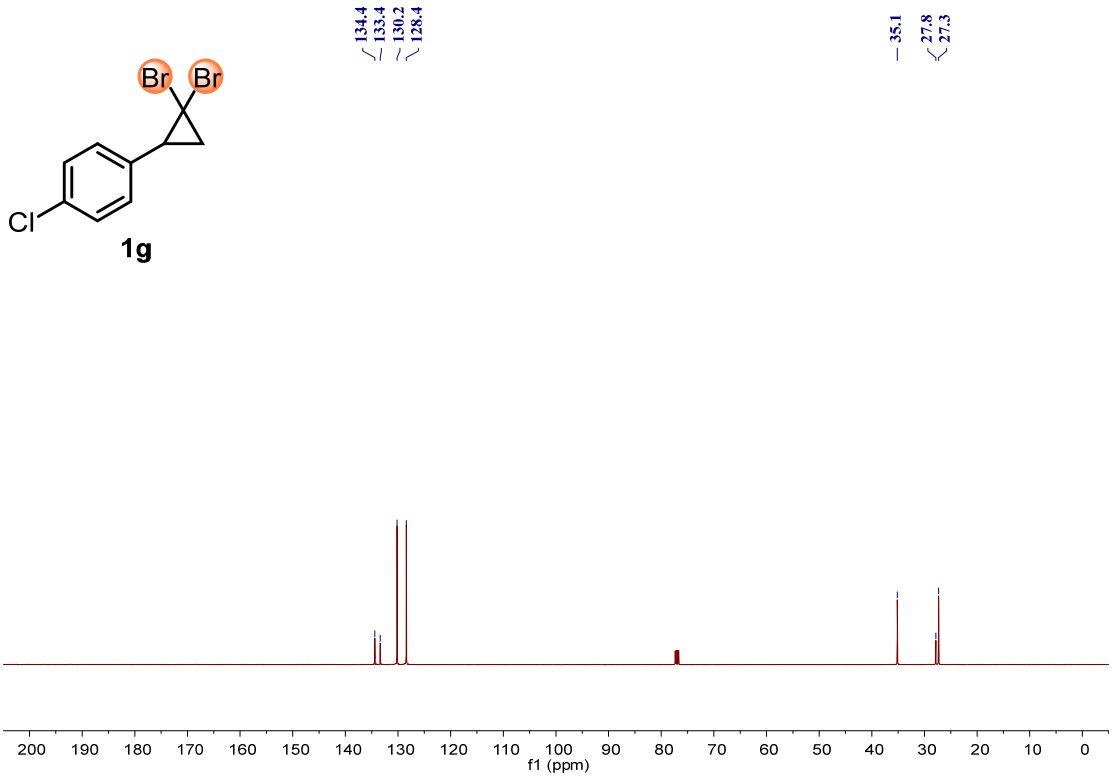
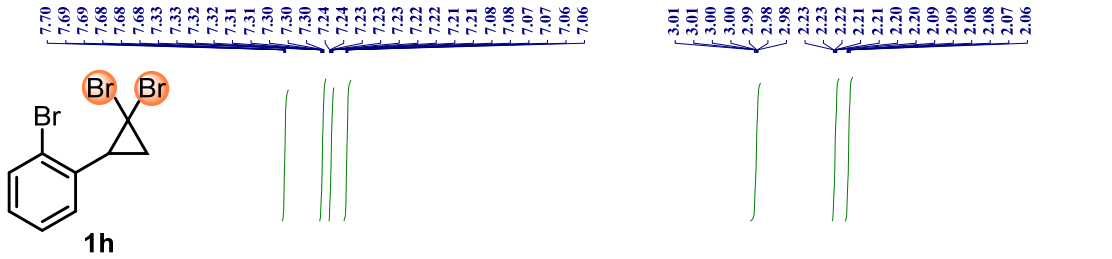
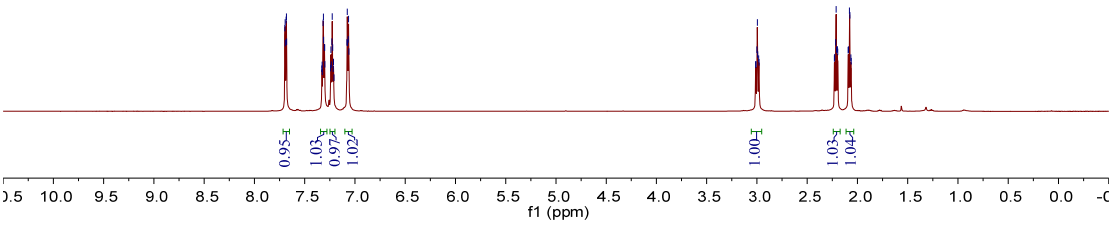
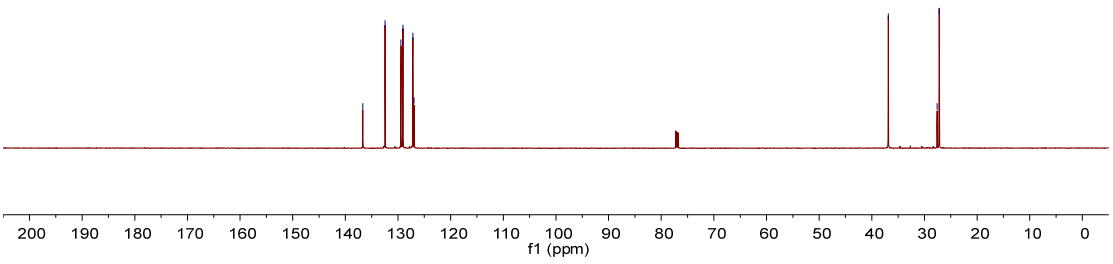
7.19
7.19
2.95
2.93
2.92
2.90
2.18
2.16
2.15
2.13
2.00
1.98
1.96
Br
Br
Cl
1g
2.00
2.00
1.00
1.04
1.03
f1 (ppm)

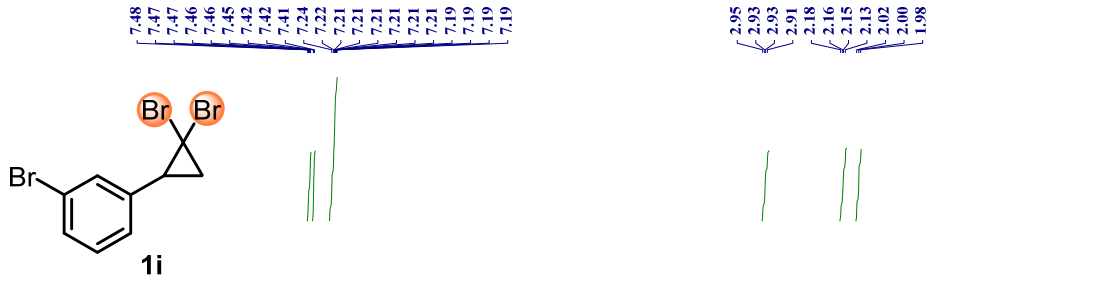

134.4
133.4
130.2
128.4
35.1
27.8
27.3
Br
Br
Cl
1g
f1 (ppm)

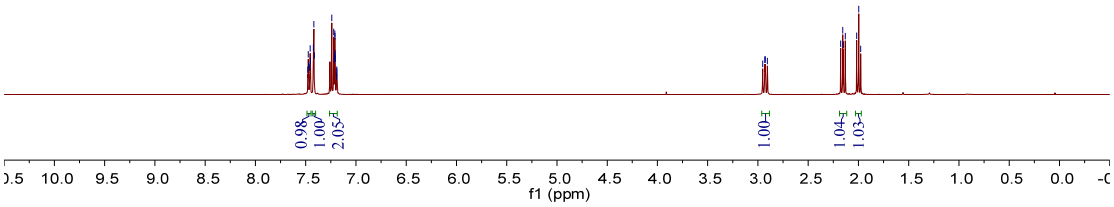

7.70 7.69 7.69 7.68 7.68 7.68 7.33 7.33 7.32 7.32 7.31 7.31 7.30 7.30 7.30 7.24 7.24 7.23 7.23 7.23 7.22 7.22 7.21 7.21 7.08 7.08 7.07 7.07 7.06 7.06
3.01 3.01 3.00 3.00 2.99 2.98 2.98 2.23 2.23 2.22 2.21 2.21 2.20 2.20 2.09 2.09 2.08 2.08 2.07 2.06
Br Br Br
1h


0.95 1.03 0.97 1.02 1.00 1.03 1.04
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

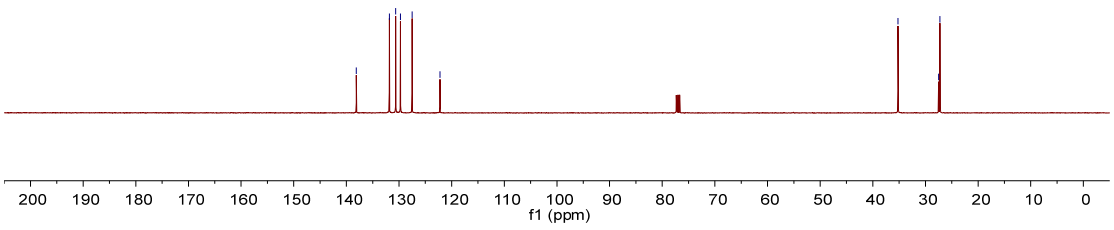

136.7 132.5 129.4 129.1 127.2 126.9
36.9 27.6 27.2
Br Br Br
1h

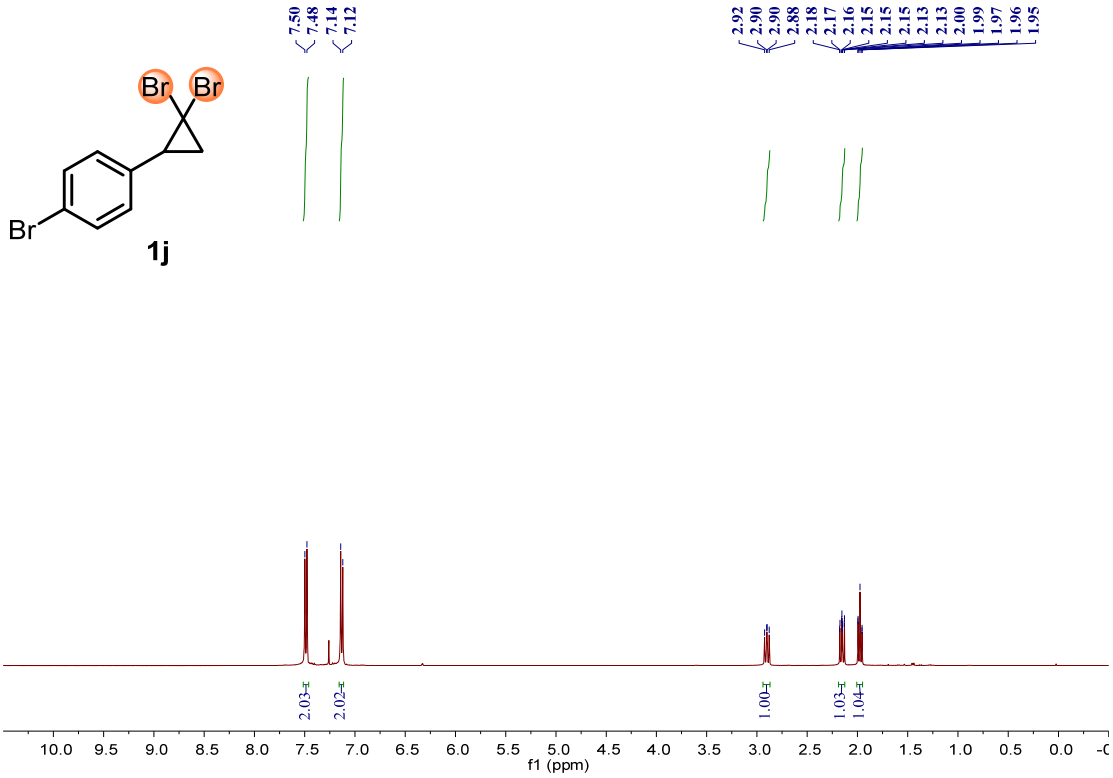

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

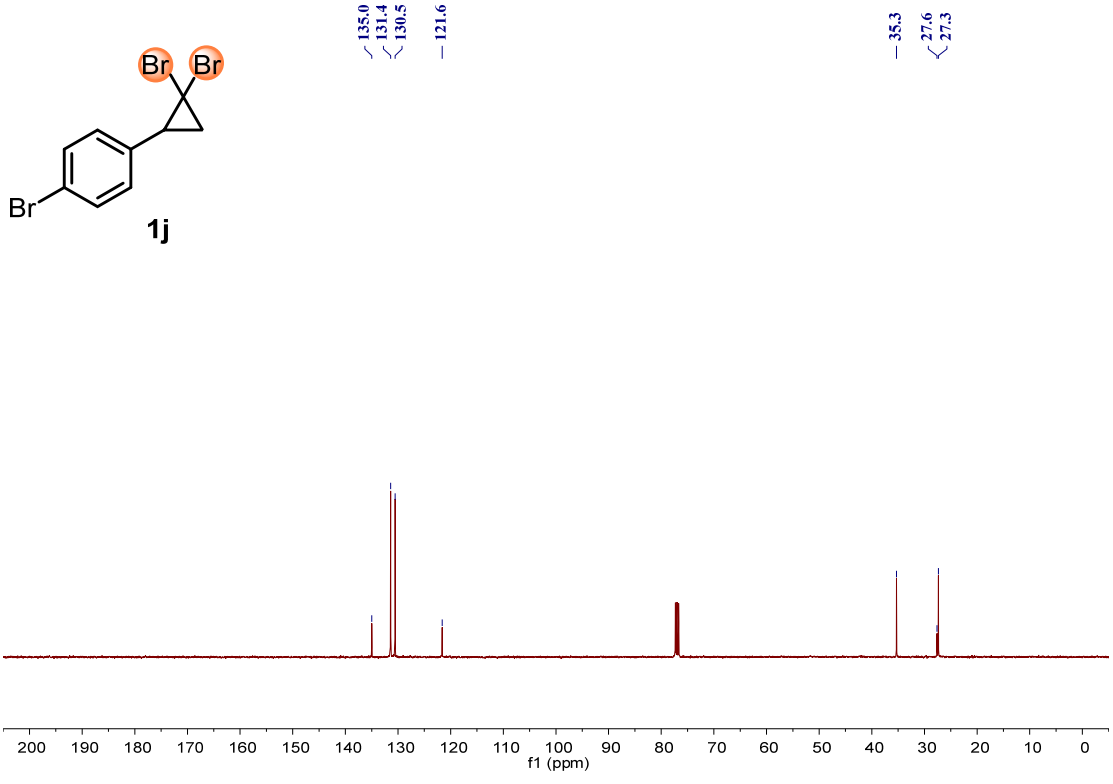

7.48
7.47
7.47
7.46
7.46
7.45
7.42
7.42
7.41
7.24
7.22
7.21
7.21
7.21
7.21
7.21
7.21
7.19
7.19
7.19
7.19
2.95
2.93
2.93
2.91
2.18
2.16
2.15
2.13
2.02
2.00
1.98
Br
Br
Br
1i

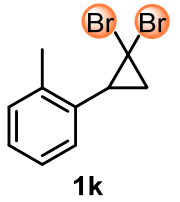

0.98
1.00
2.05
1.00
1.04
1.03
f1 (ppm)


138.1
131.8
130.6
129.7
127.5
122.2
35.2
27.5
27.2
Br
Br
Br
1i

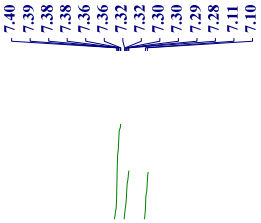

f1 (ppm)

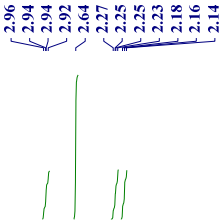

Br
Br
Br
1j
7.50
7.48
7.14
7.12
2.92
2.90
2.90
2.88
2.18
2.17
2.16
2.15
2.15
2.15
2.13
2.13
2.00
1.99
1.97
1.96
1.95
2.03
2.02
1.00
1.03
1.04
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

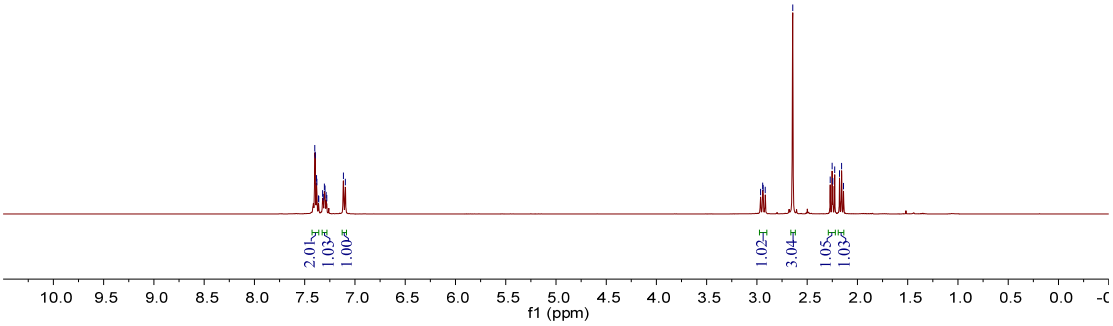

Br
Br
Br
1j
135.0
131.4
130.5
121.6
35.3
27.6
27.3
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

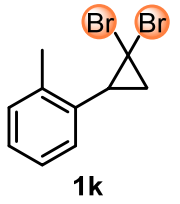

Br
Br

1k


7.40
7.39
7.38
7.38
7.36
7.36
7.32
7.32
7.30
7.30
7.29
7.28
7.11
7.10


2.96
2.94
2.94
2.92
2.64
2.27
2.25
2.25
2.23
2.18
2.16
2.14

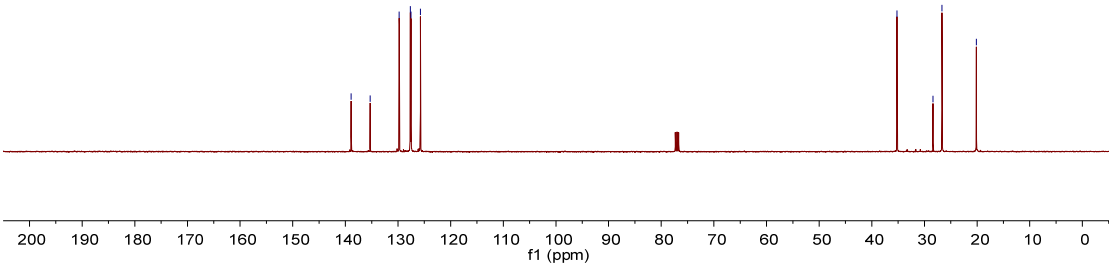

2.01
1.03
1.00
1.02
3.04
1.05
1.03
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

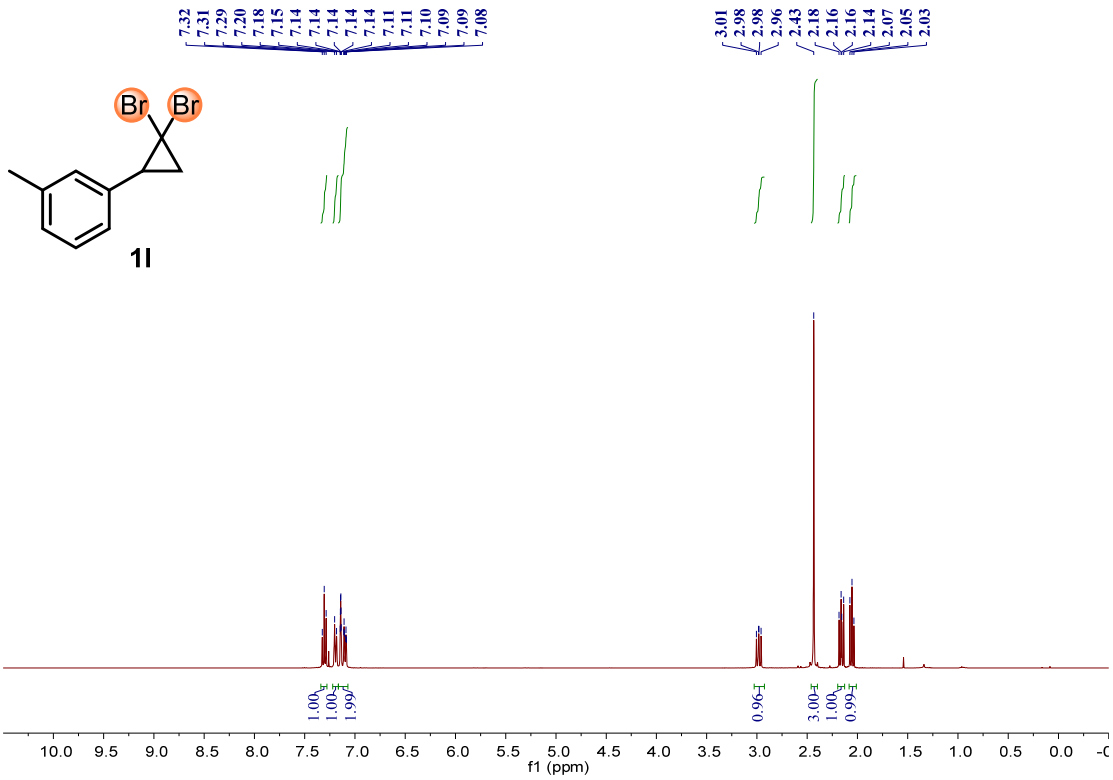

Br
Br

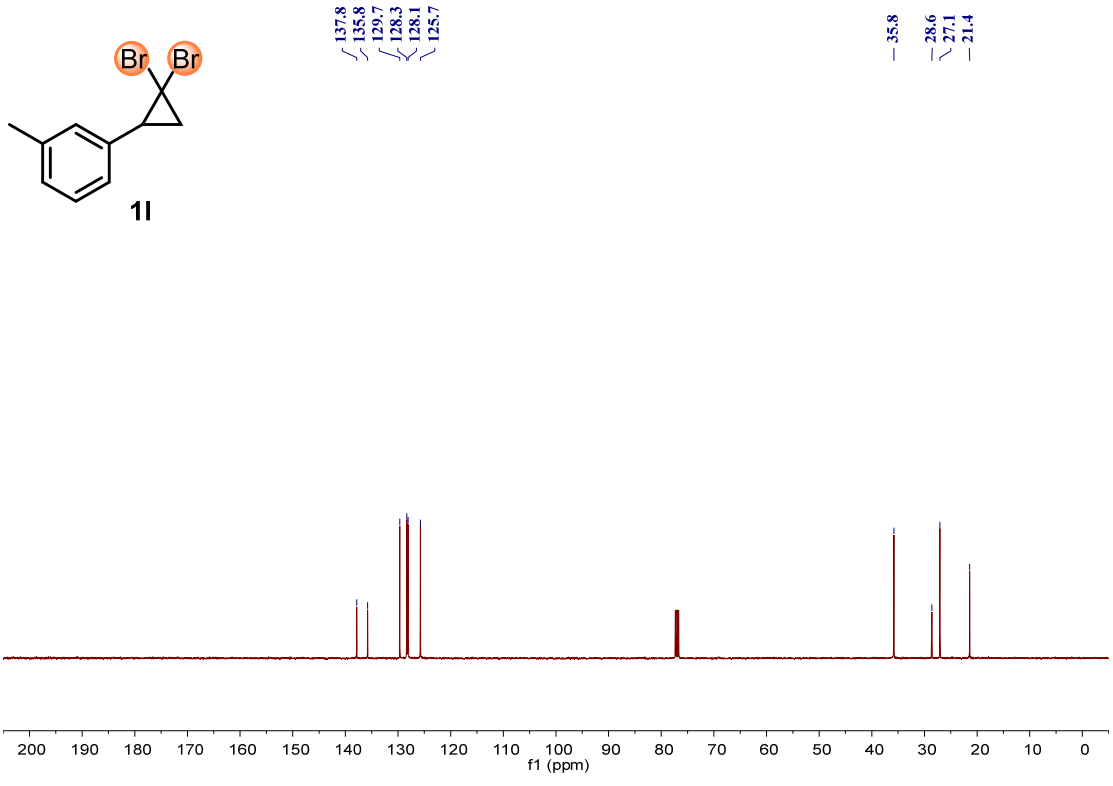
1k

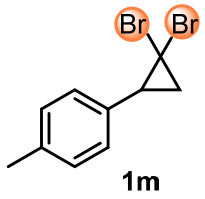

138.9
135.3
129.8
127.7
127.5
125.7


35.2
28.4
26.7
20.2


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

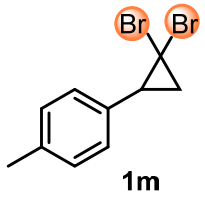

7.32
7.31
7.29
7.20
7.18
7.15
7.14
7.14
7.14
7.14
7.14
7.11
7.11
7.10
7.09
7.09
7.08
3.01
2.98
2.98
2.96
2.43
2.18
2.16
2.16
2.14
2.07
2.05
2.03
Br
Br
1l
1.00
1.00
1.99
0.96
3.00
1.00
0.99
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


137.8
135.8
129.7
128.3
128.1
125.7
35.8
28.6
27.1
21.4
Br
Br
1l
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


Br
Br

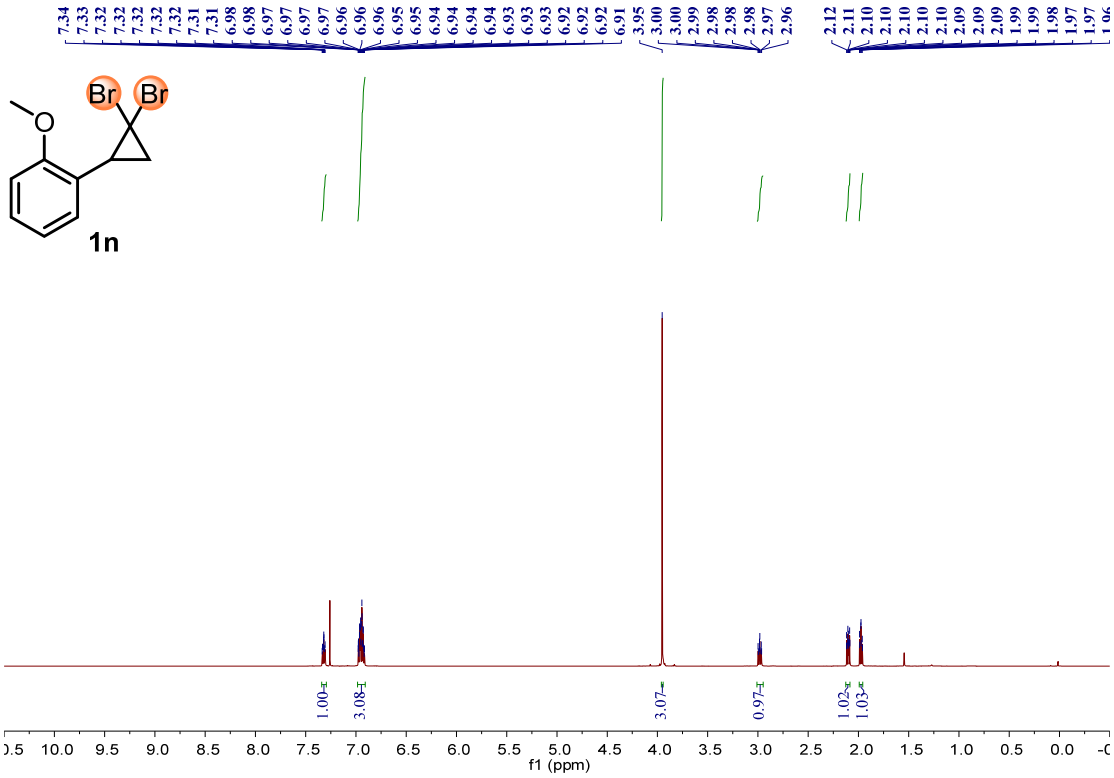
1m

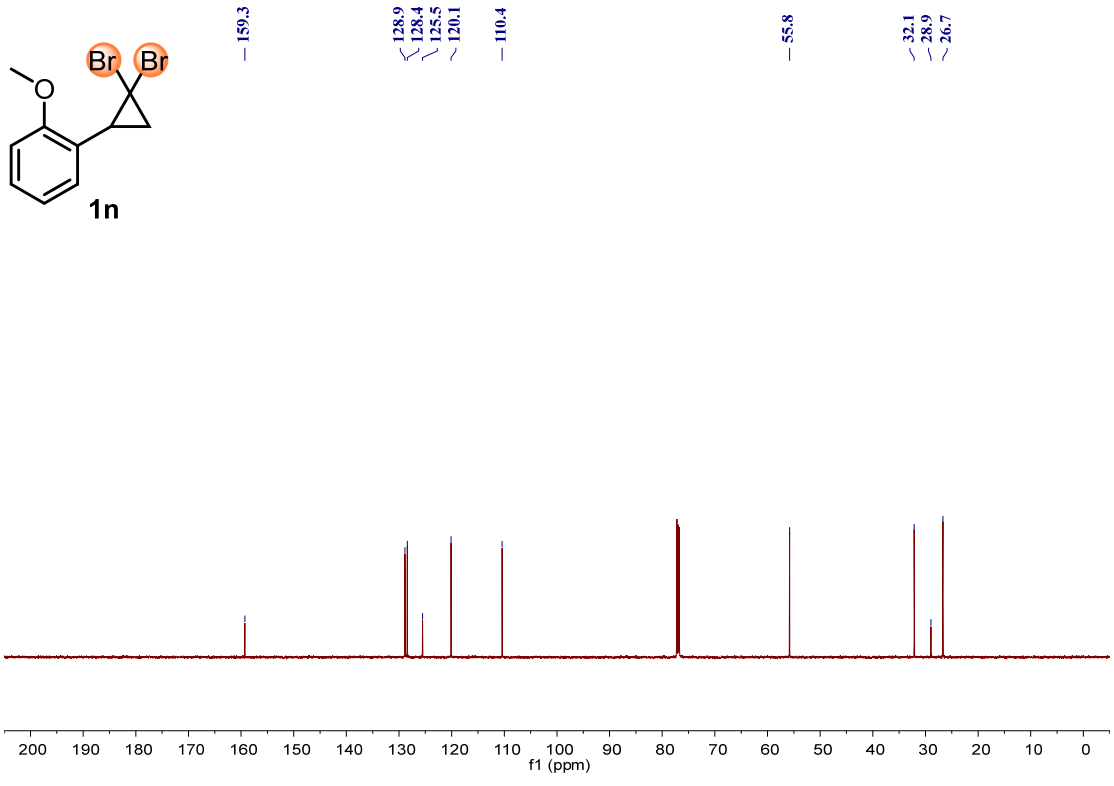
7.26
7.25
7.25
7.23
7.22
7.20
7.19
7.18
7.16
7.16
7.15
3.01
3.00
2.98
2.96
2.95
2.93
2.92
2.44
2.17
2.17
2.15
2.14
2.13
2.13
2.12
2.12
2.06
2.05
2.04
2.03
2.02
2.01
2.00
4.25
1.00
3.09
1.06
1.03
f1 (ppm)

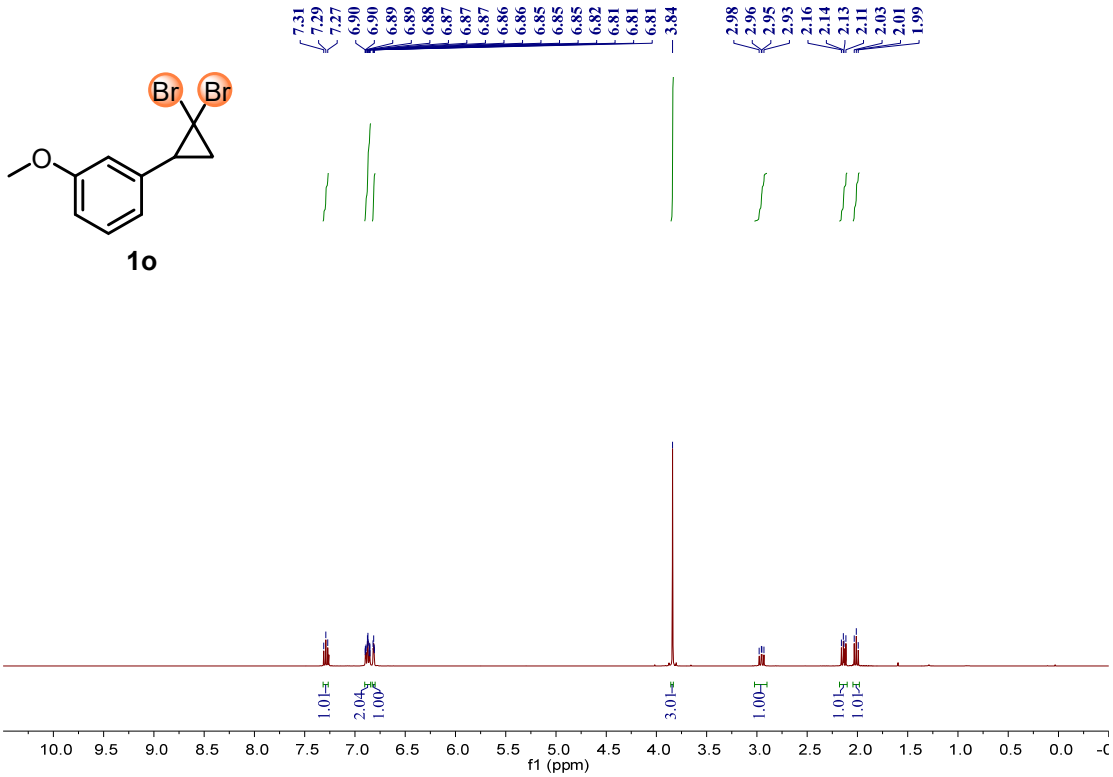

Br
Br

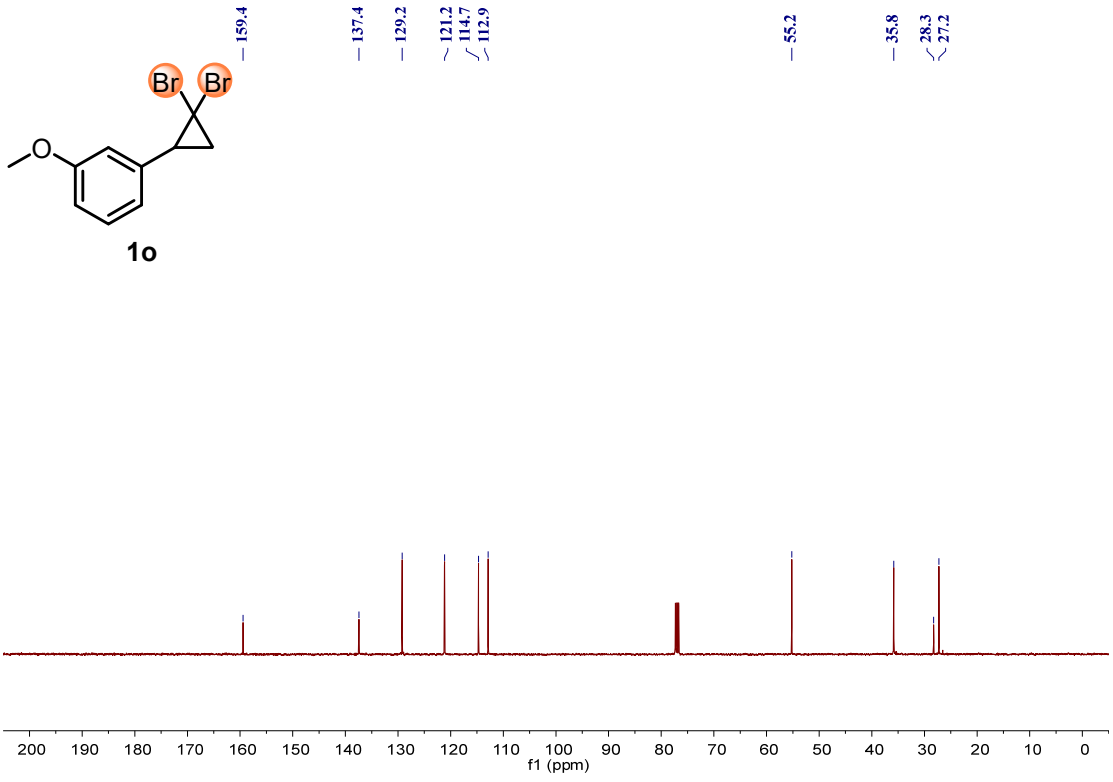
1m

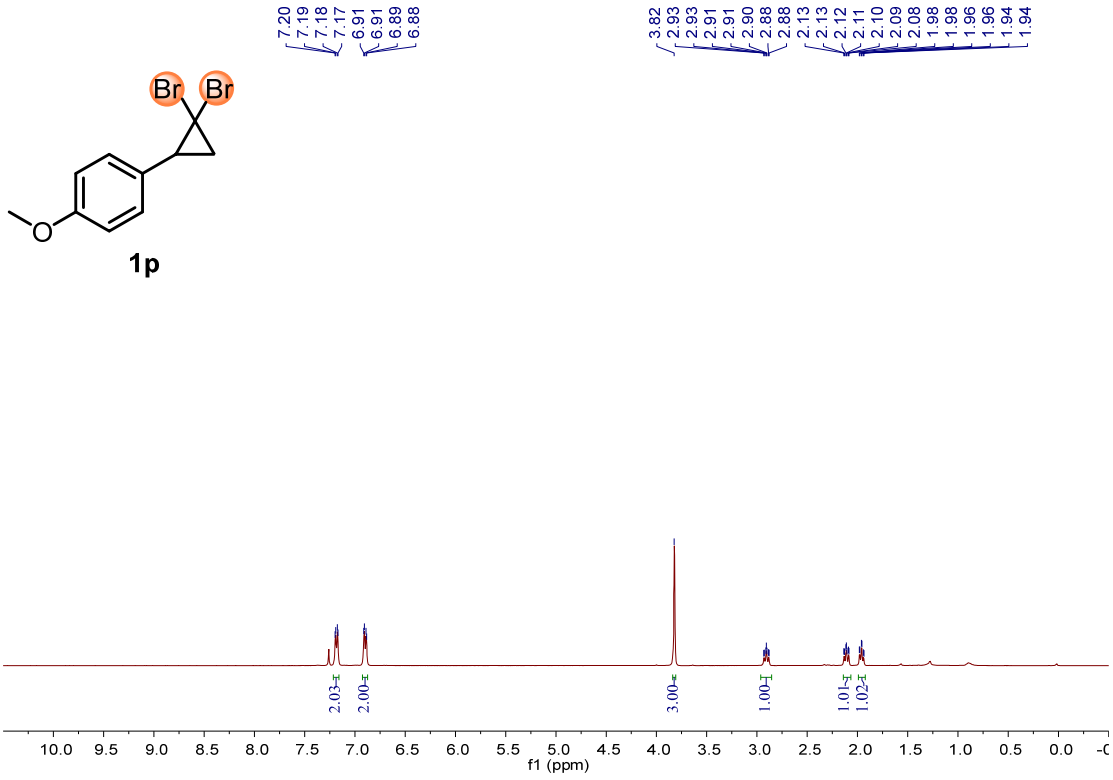
137.3
133.0
129.1
128.8
35.7
29.1
27.3
21.3
f1 (ppm)

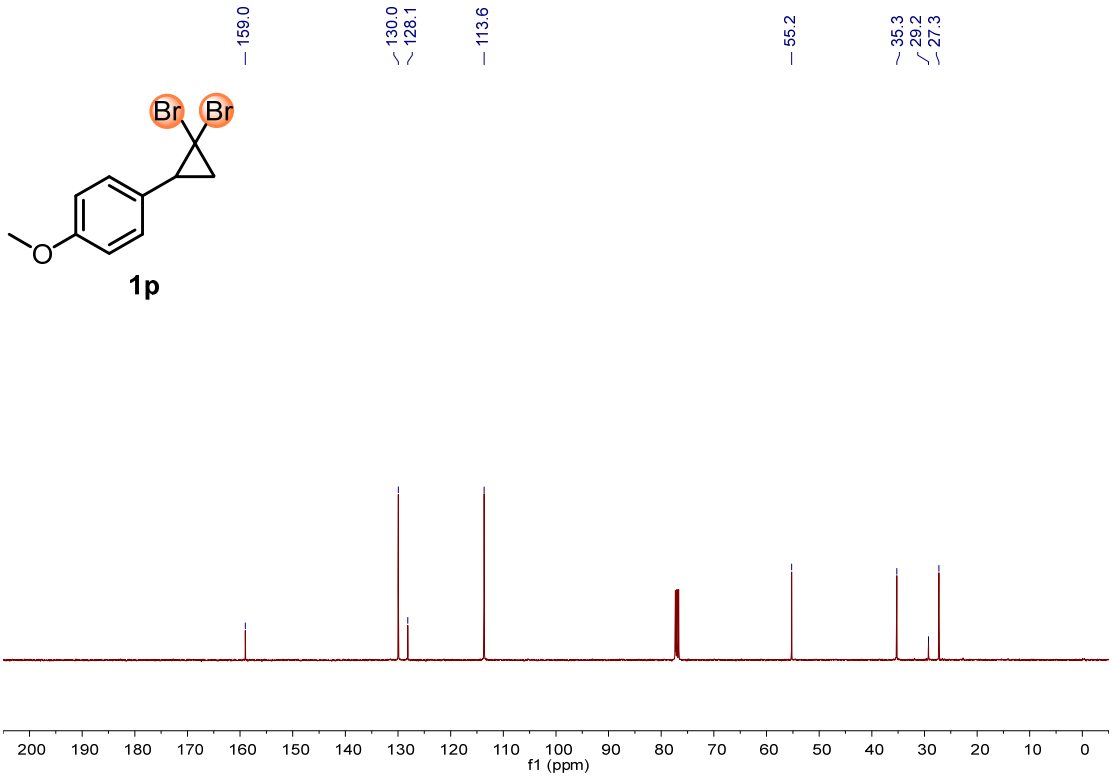

Br
Br
O
1n
7.34 7.33 7.32 7.32 7.32 7.32 7.31 7.31 6.98 6.98 6.97 6.97 6.97 6.97 6.96 6.96 6.96 6.95 6.95 6.94 6.94 6.94 6.94 6.93 6.93 6.92 6.92 6.92 6.91 3.95 3.00 3.00 2.99 2.98 2.98 2.98 2.97 2.96 2.12 2.11 2.10 2.10 2.10 2.10 2.09 2.09 2.09 1.99 1.99 1.98 1.97 1.97
1.00 3.08 3.07 0.97 1.02 1.03
f1 (ppm)

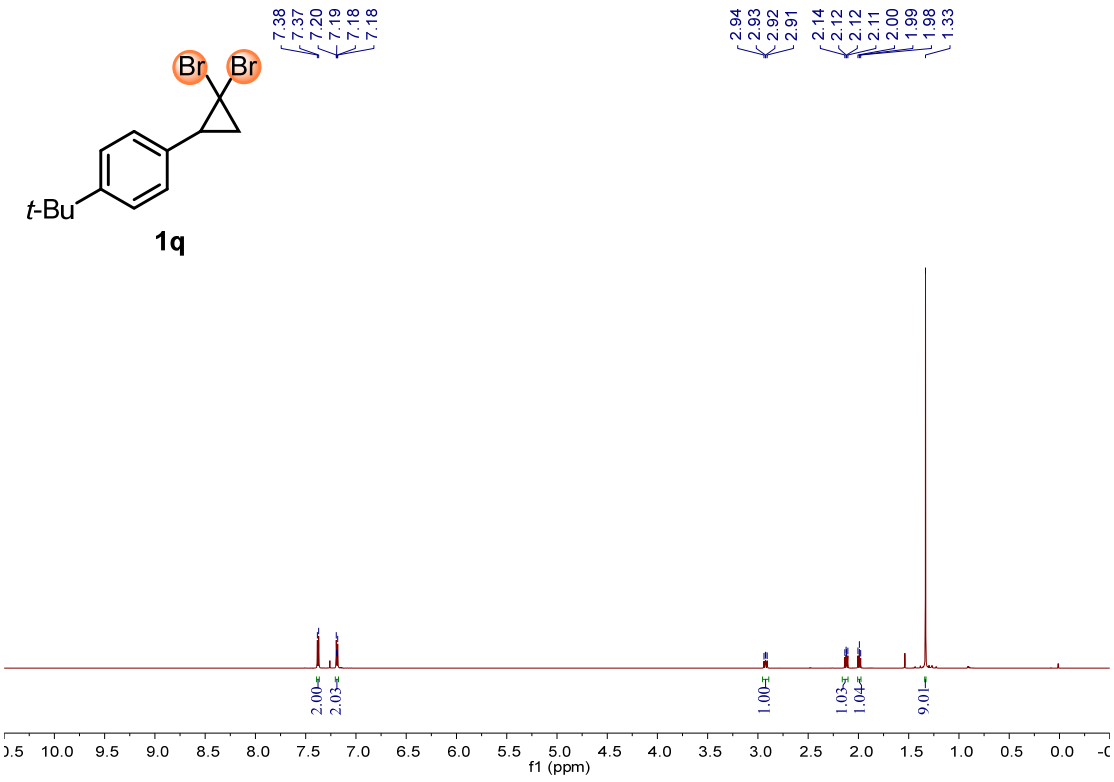

Br
Br
O
1n
159.3
128.9 128.4 125.5 120.1
110.4
55.8
32.1 28.9 26.7
f1 (ppm)

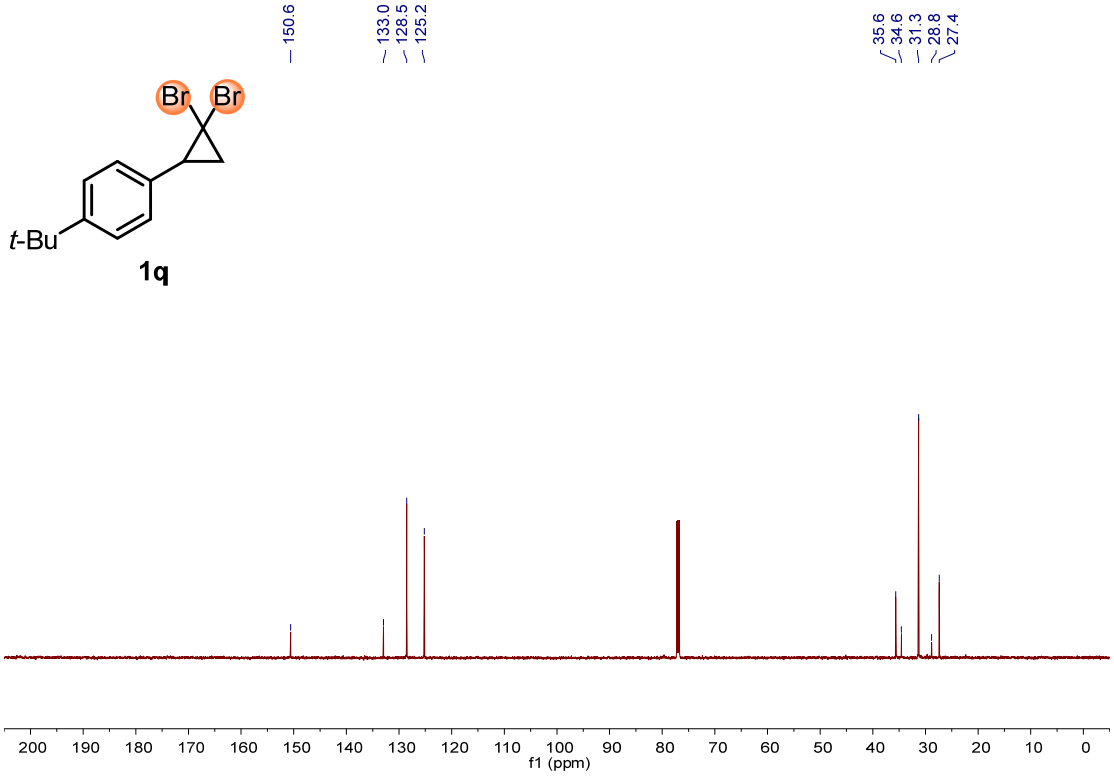

Br
Br
O
1o
7.31
7.29
7.27
6.90
6.90
6.89
6.89
6.88
6.87
6.87
6.87
6.86
6.86
6.85
6.85
6.85
6.82
6.81
6.81
6.81
3.84
2.98
2.96
2.95
2.93
2.16
2.14
2.13
2.11
2.03
2.01
1.99
1.01
2.04
1.00
3.01
1.00
1.01
1.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

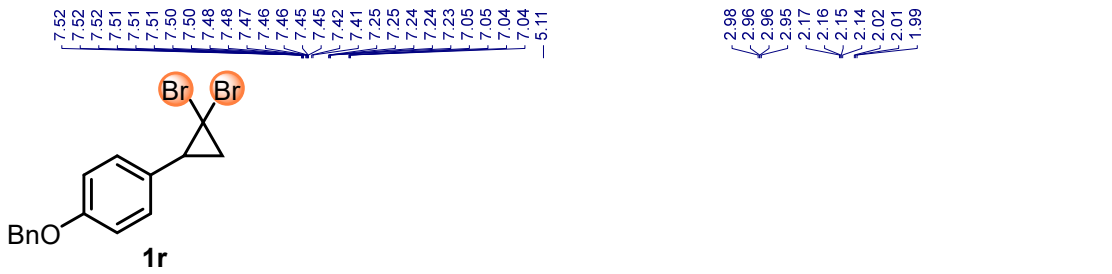

Br
Br
O
1o
159.4
137.4
129.2
121.2
114.7
112.9
55.2
35.8
28.3
27.2
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

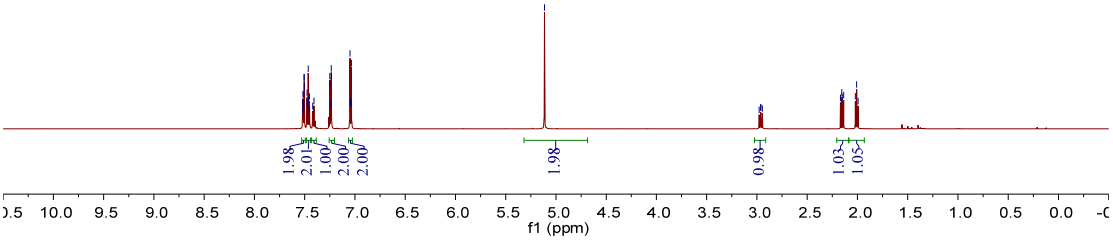

7.20
7.19
7.18
7.17
6.91
6.91
6.89
6.88
3.82
2.93
2.93
2.91
2.91
2.90
2.88
2.88
2.13
2.13
2.12
2.11
2.10
2.09
2.08
1.98
1.98
1.96
1.96
1.94
1.94
Br
Br
O
1p
2.03
2.00
3.00
1.00
1.01
1.02
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

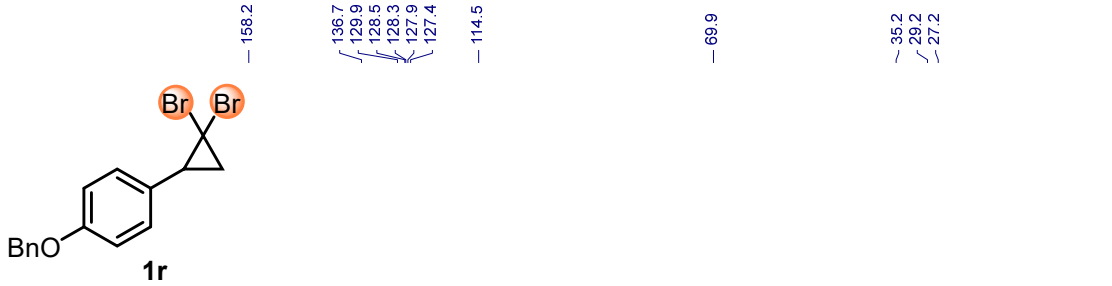

159.0
130.0
128.1
113.6
55.2
35.3
29.2
27.3
Br
Br
O
1p
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

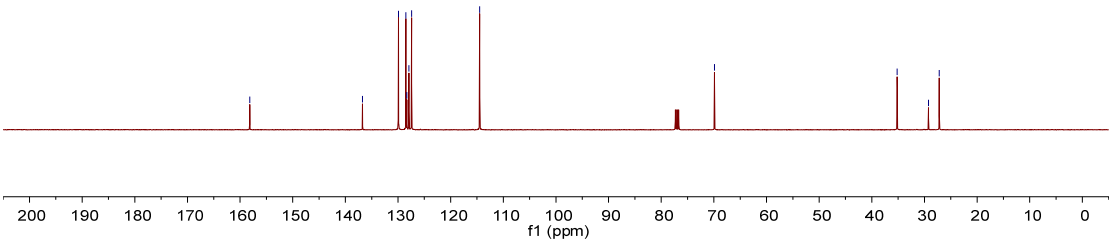

7.38
7.37
7.20
7.19
7.18
7.18
2.94
2.93
2.92
2.91
2.14
2.12
2.12
2.11
2.00
1.99
1.98
1.33
Br
Br
t-Bu
1q
2.00
2.03
1.00
1.03
1.04
9.01
f1 (ppm)


150.6
133.0
128.5
125.2
35.6
34.6
31.3
28.8
27.4
Br
Br
t-Bu
1q
f1 (ppm)

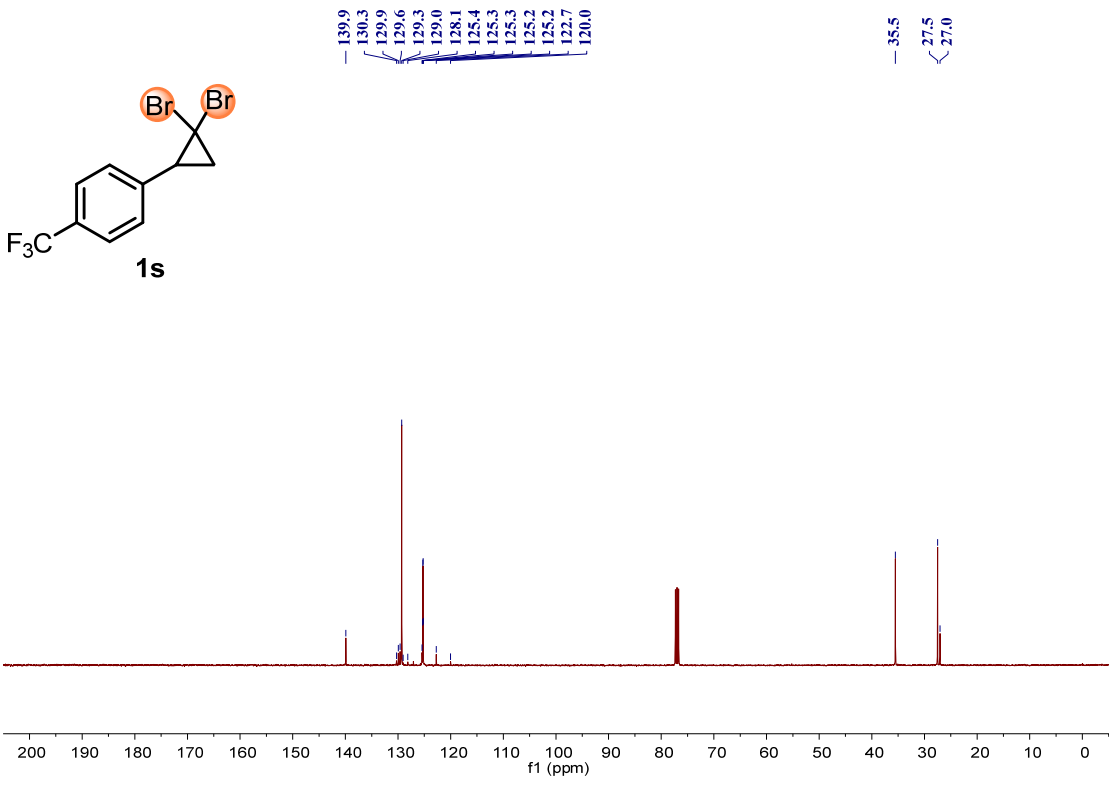

7.52
7.52
7.52
7.51
7.51
7.51
7.50
7.50
7.48
7.48
7.47
7.46
7.46
7.45
7.45
7.42
7.41
7.25
7.25
7.24
7.24
7.23
7.05
7.05
7.04
7.04
5.11
2.98
2.96
2.96
2.95
2.17
2.16
2.15
2.14
2.02
2.01
1.99
Br
Br
BnO
1r

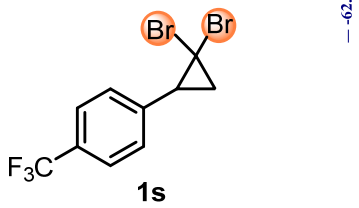

1.98
2.01
1.00
2.00
2.00
1.98
0.98
1.03
1.05
f1 (ppm)


158.2
136.7
129.9
128.5
128.3
127.9
127.4
114.5
69.9
35.2
29.2
27.2
Br
Br
BnO
1r


f1 (ppm)

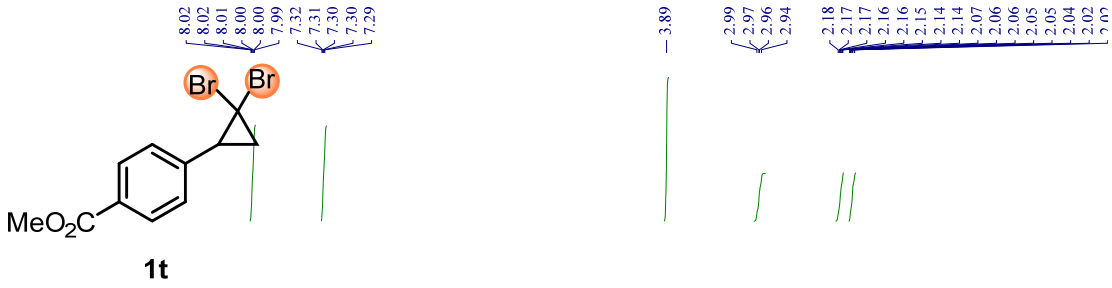

7.63
7.61
7.39
7.39
7.37
7.37
7.37
3.03
3.01
3.00
3.00
2.98
2.23
2.21
2.21
2.19
2.08
2.06
2.04
Br
Br
F3C
1s
2.00
2.02
1.00
1.03
1.02
f1 (ppm)


139.9
130.3
129.9
129.6
129.3
129.0
128.1
125.4
125.3
125.2
125.2
122.7
120.0
35.5
27.5
27.0
Br
Br
F3C
1s
f1 (ppm)

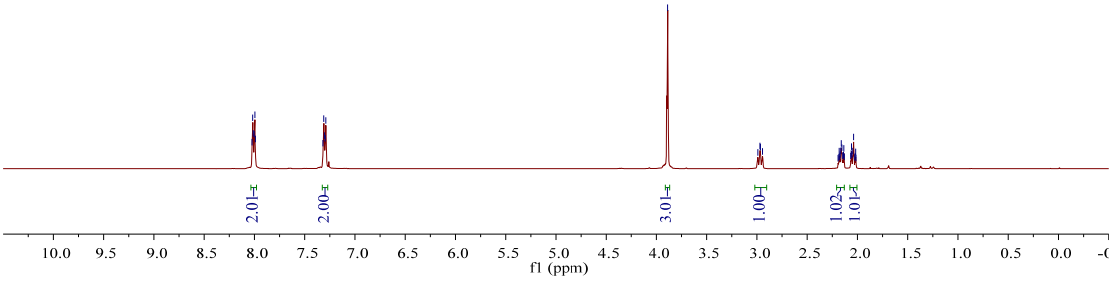

Br
Br
F3C

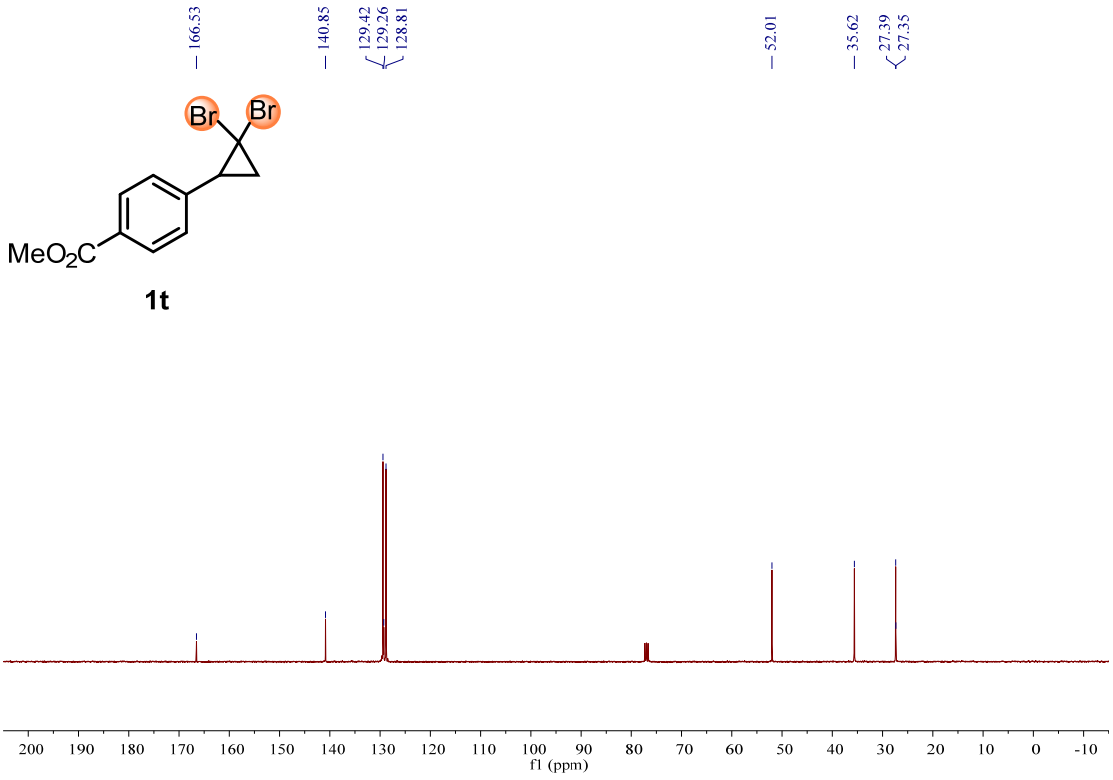
1s

-62.36
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)

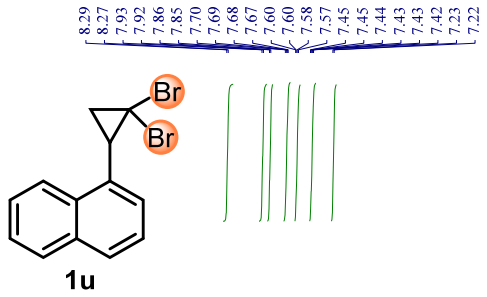

8.02
8.02
8.01
8.00
8.00
7.99
7.32
7.31
7.30
7.30
7.29
3.89
2.99
2.97
2.96
2.94
2.18
2.17
2.17
2.16
2.16
2.15
2.14
2.14
2.07
2.06
2.06
2.05
2.05
2.04
2.02
Br
Br
MeO2C

1t

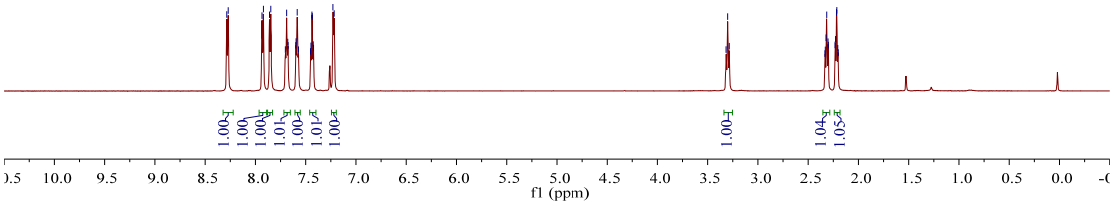

2.01
2.00
3.01
1.00
1.02
1.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

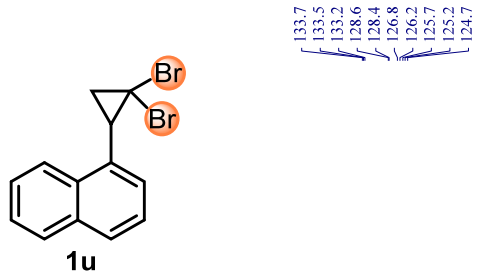

166.53
140.85
129.42
129.26
128.81
52.01
35.62
27.39
27.35
Br
Br
MeO2C
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

1t

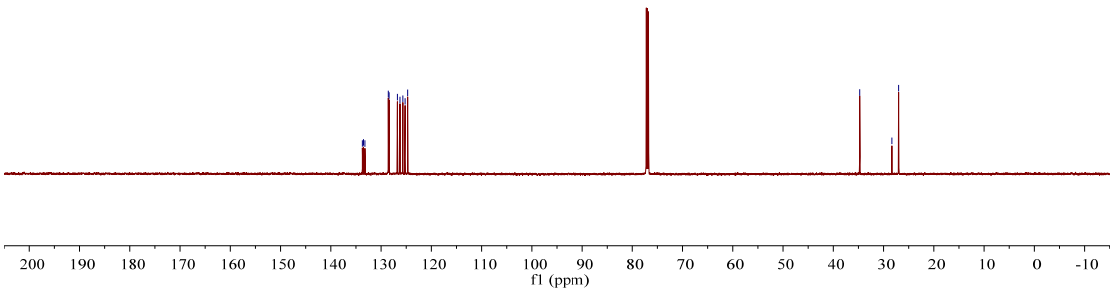

8.29
8.27
7.93
7.92
7.86
7.85
7.70
7.69
7.68
7.67
7.60
7.60
7.58
7.57
7.45
7.45
7.44
7.43
7.43
7.42
7.23
7.22
3.32
3.30
3.29
2.33
2.33
2.32
2.32
2.30
2.30
2.23
2.23
2.22
2.21
2.21
2.20
Br
Br

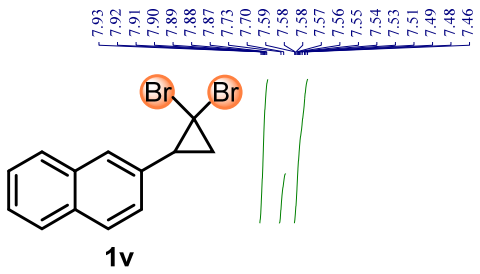
1u


1.00
1.00
1.00
1.01
1.00
1.01
1.00
1.00
1.04
1.05
f1 (ppm)

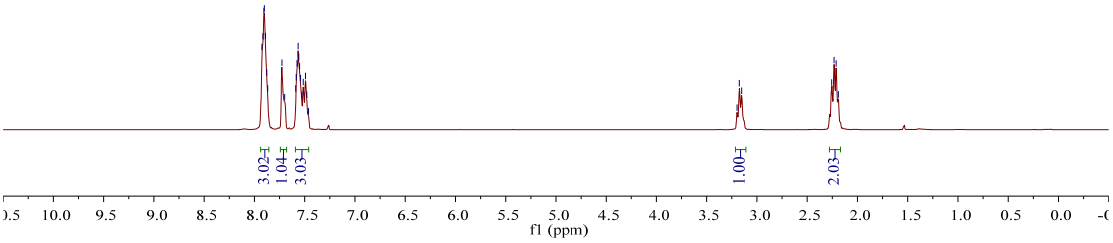

133.7
133.5
133.2
128.6
128.4
126.8
126.2
125.7
125.2
124.7
34.7
28.3
27.0
Br
Br

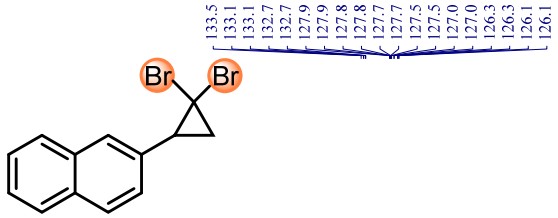
1u


f1 (ppm)

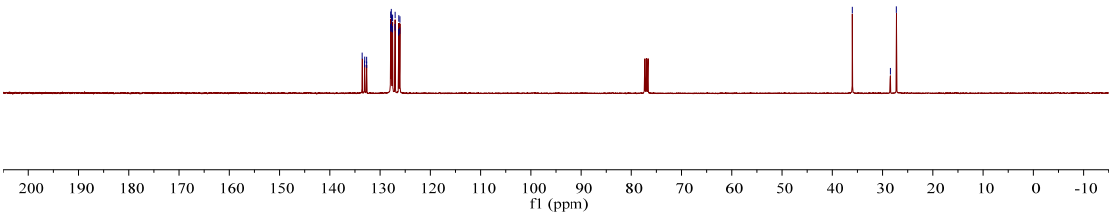

7.93
7.92
7.91
7.90
7.89
7.88
7.87
7.73
7.70
7.59
7.58
7.58
7.57
7.56
7.55
7.54
7.53
7.51
7.49
7.48
7.46
3.20
3.18
3.15
2.26
2.23
2.21
2.19
Br
Br

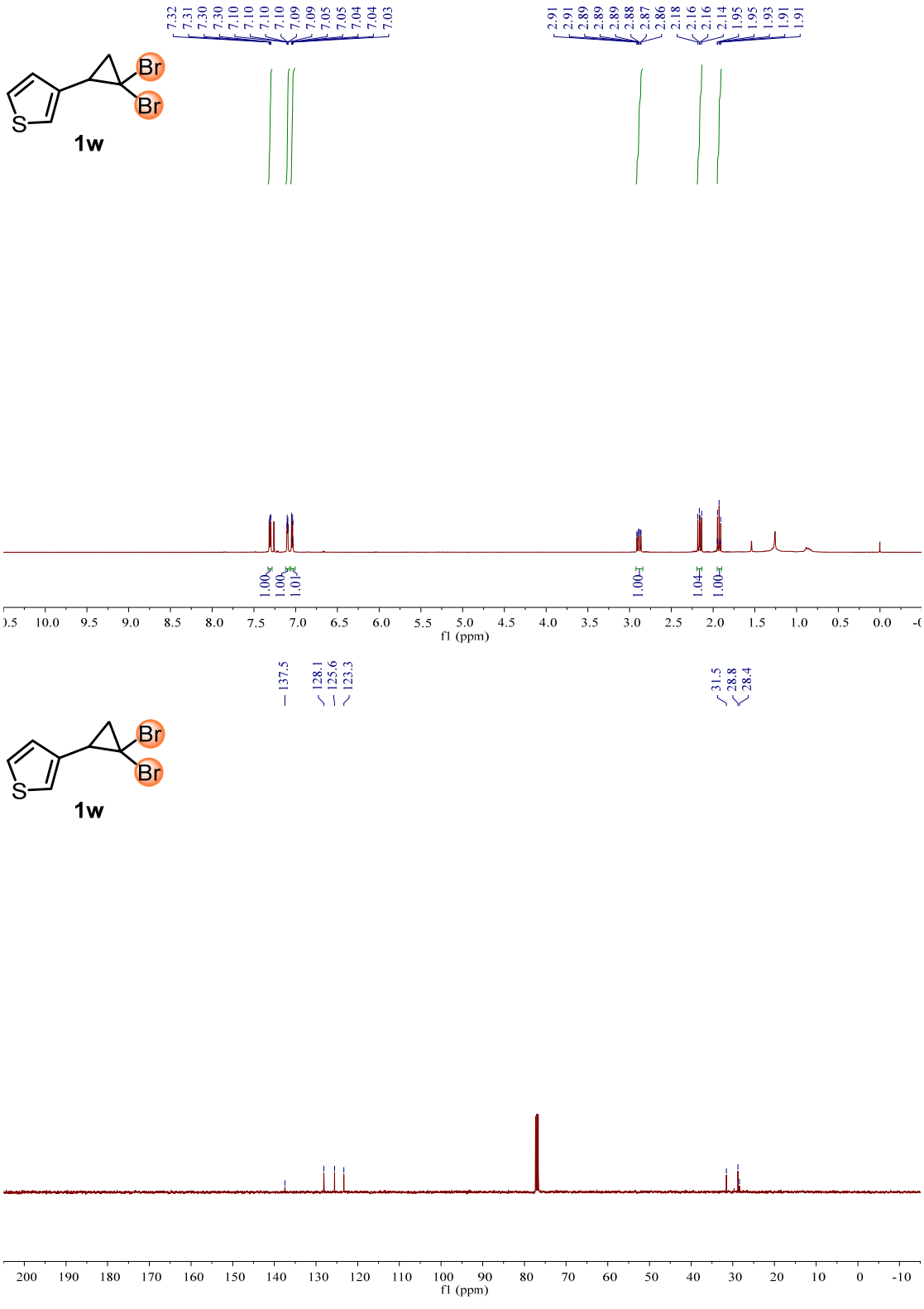
1v

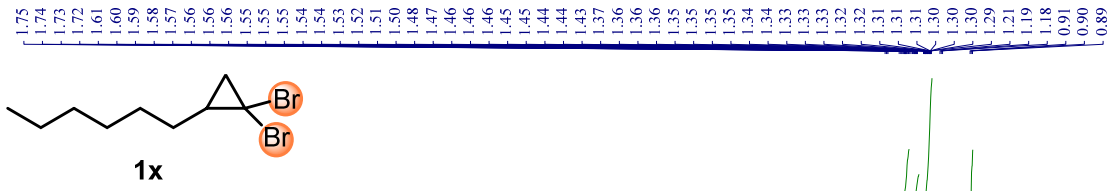

3.02
1.04
3.03
1.00
2.03
f1 (ppm)


133.5
133.1
133.1
132.7
132.7
127.9
127.9
127.8
127.8
127.7
127.7
127.5
127.5
127.0
127.0
126.3
126.3
126.1
126.1
36.0
28.5
27.2
Br
Br

1v

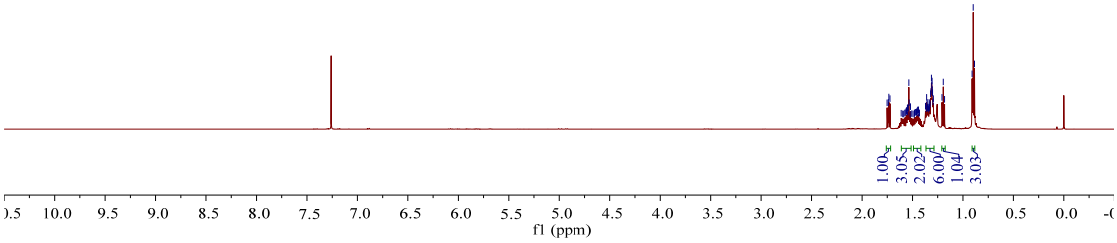

f1 (ppm)


7.32
7.31
7.30
7.30
7.10
7.10
7.10
7.10
7.09
7.09
7.05
7.05
7.04
7.04
7.03
2.91
2.91
2.89
2.89
2.89
2.88
2.87
2.86
2.18
2.16
2.16
2.14
1.95
1.95
1.93
1.91
1.91
Br
Br
S
1w
1.00
1.00
1.01
1.00
1.04
1.00
f1 (ppm)
137.5
128.1
125.6
123.3
31.5
28.8
28.4
Br
Br
S
1w
f1 (ppm)

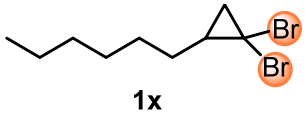

1.75
1.74
1.73
1.72
1.61
1.60
1.59
1.58
1.57
1.56
1.56
1.56
1.55
1.55
1.55
1.54
1.54
1.53
1.52
1.51
1.50
1.48
1.47
1.46
1.46
1.46
1.45
1.45
1.44
1.44
1.43
1.37
1.36
1.36
1.36
1.35
1.35
1.35
1.35
1.34
1.34
1.33
1.33
1.33
1.32
1.32
1.31
1.31
1.31
1.30
1.30
1.30
1.29
1.21
1.19
1.18
0.91
0.90
0.89

Br
Br

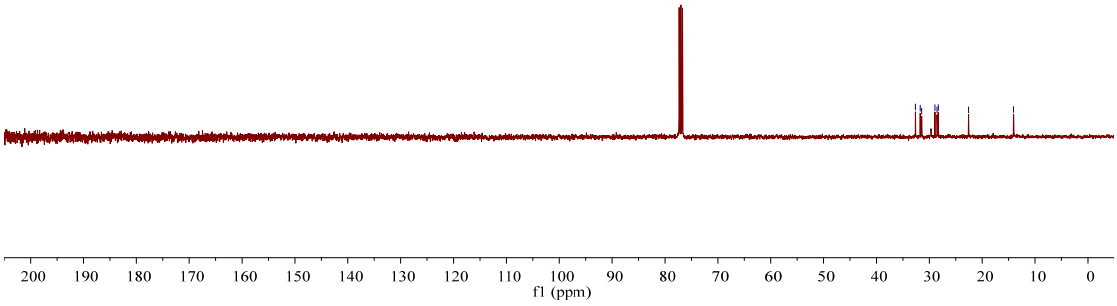
1x

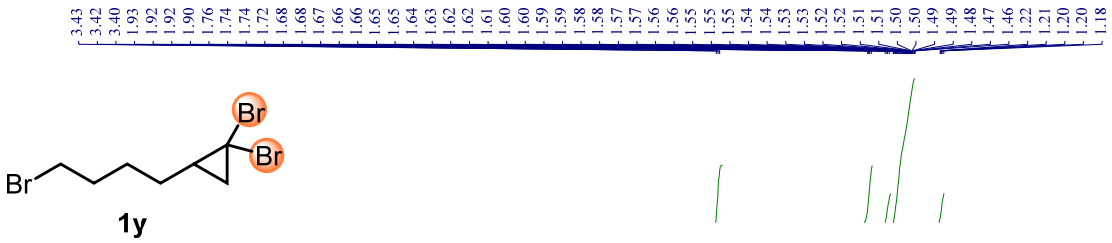

1.00
3.05
2.02
6.00
1.04
3.03
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


32.6
31.7
31.5
28.9
28.5
28.3
22.6
14.1

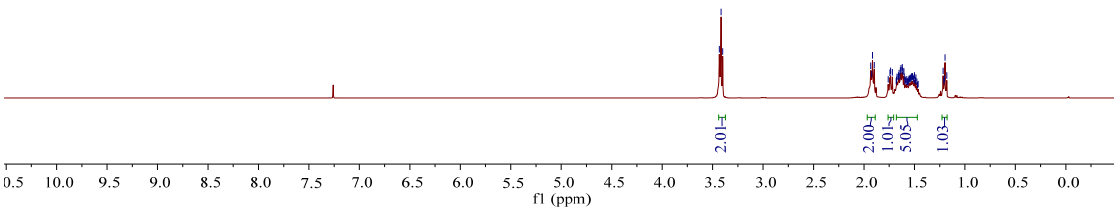

Br
Br

1x

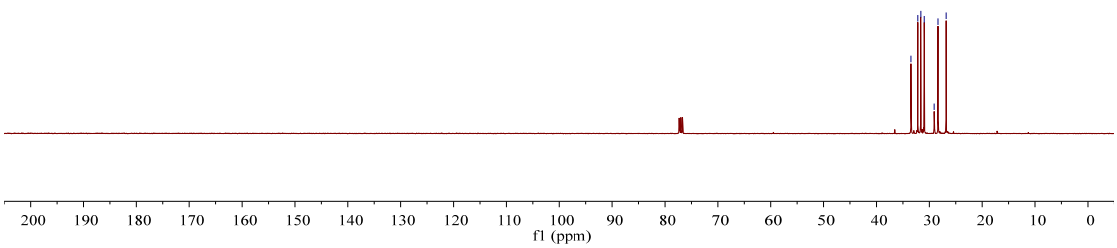

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

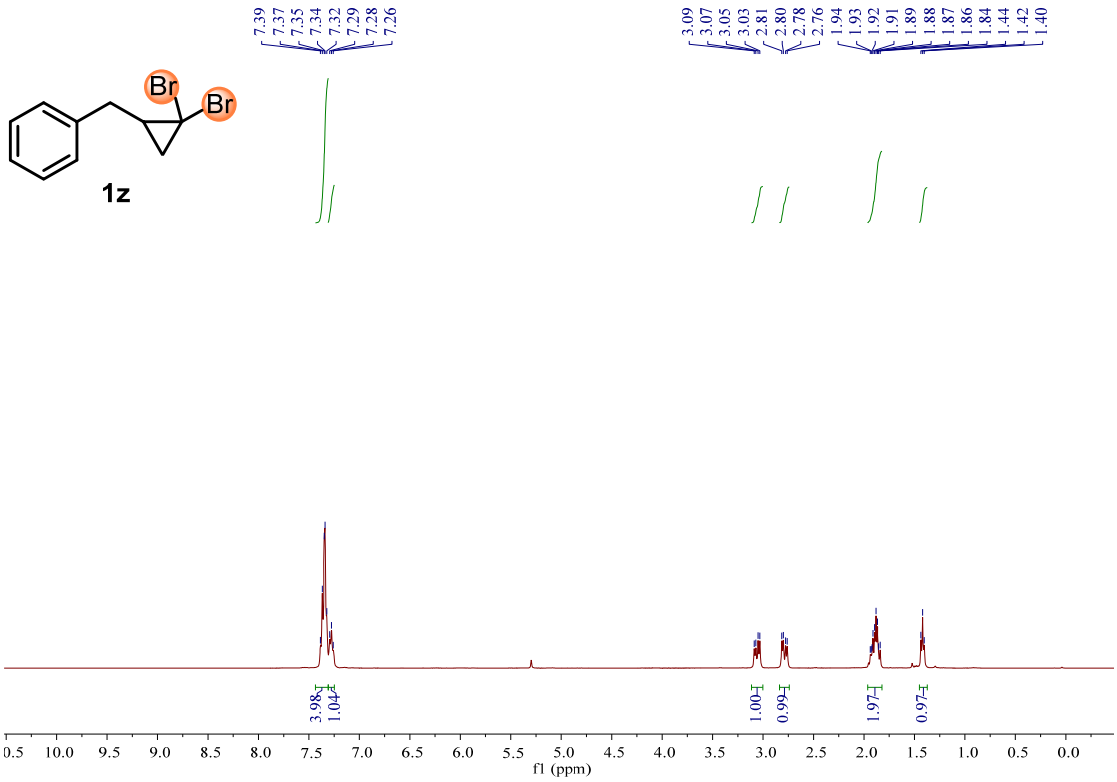


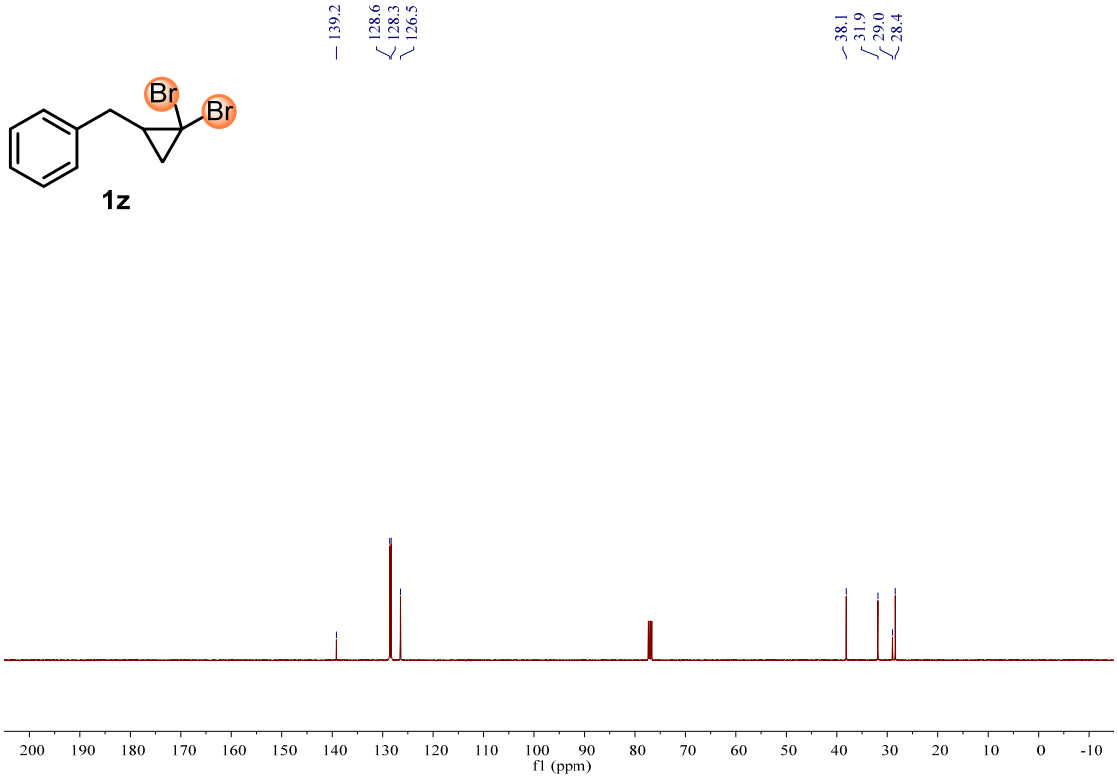
1y

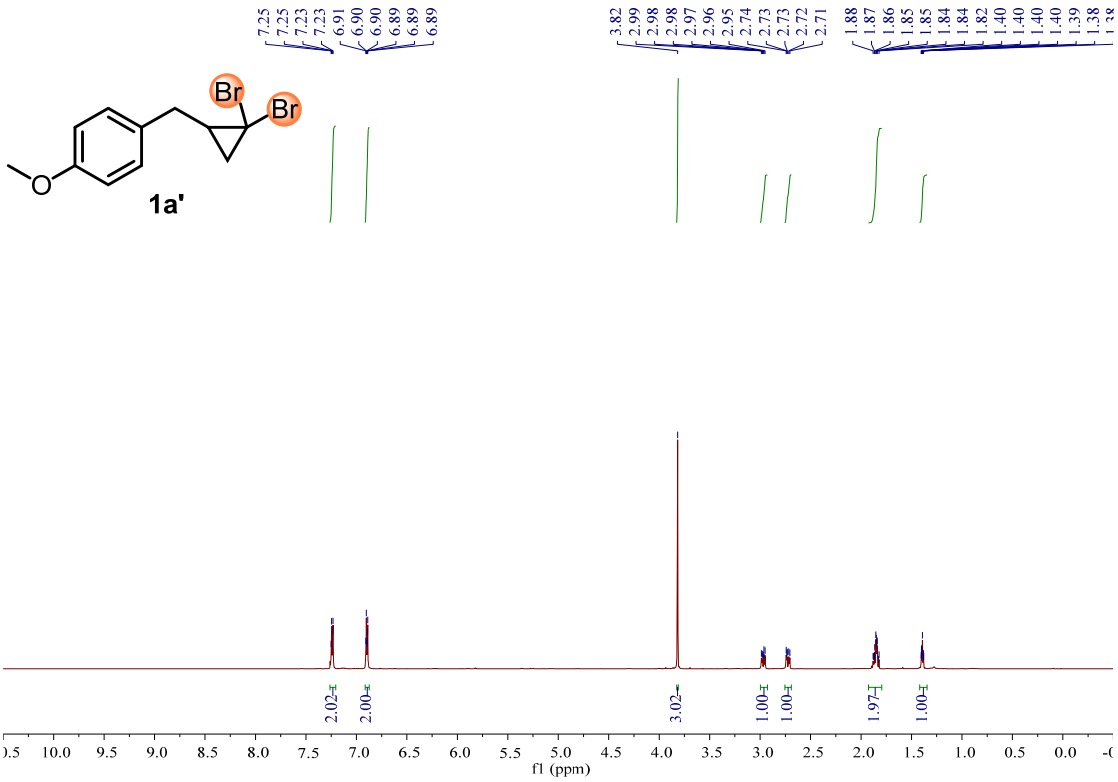


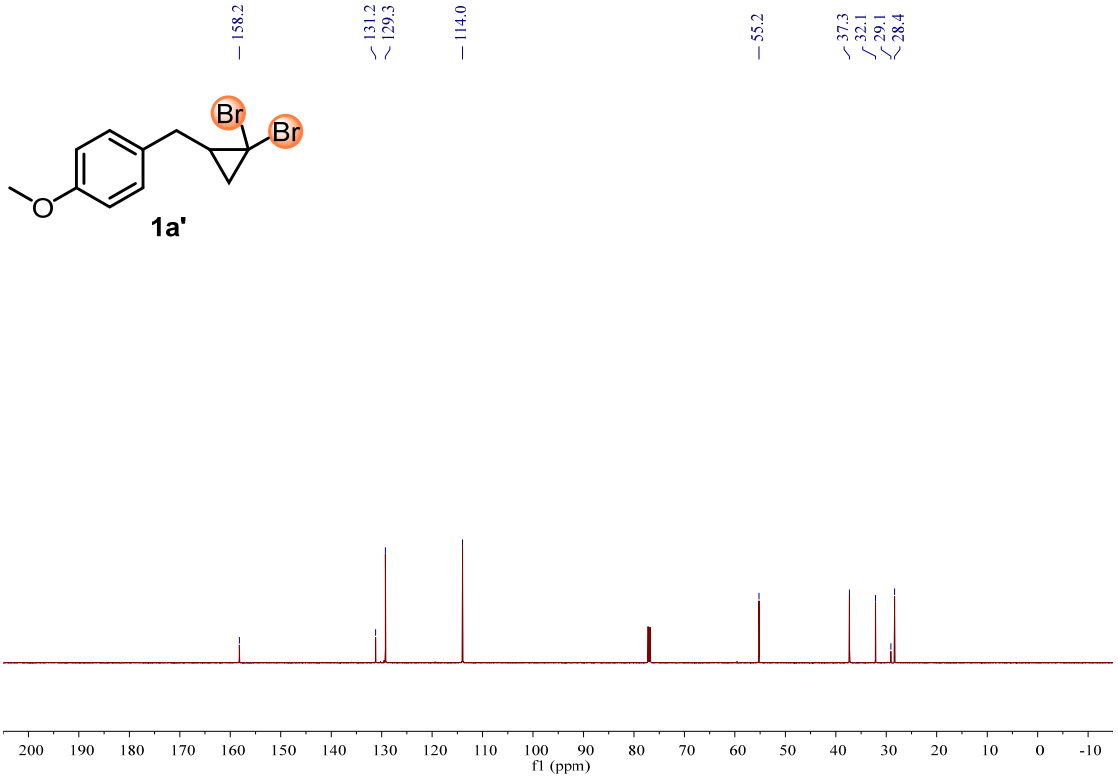
1y

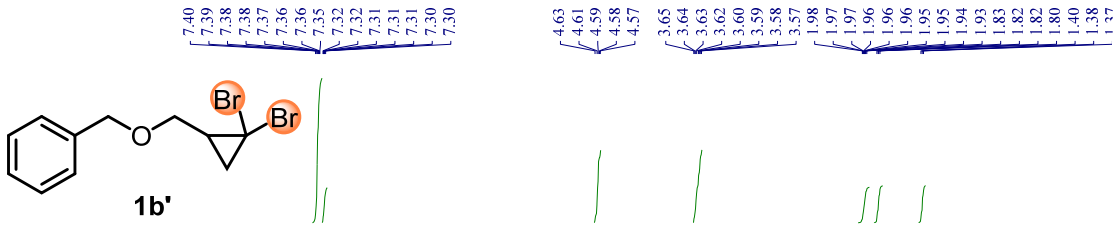


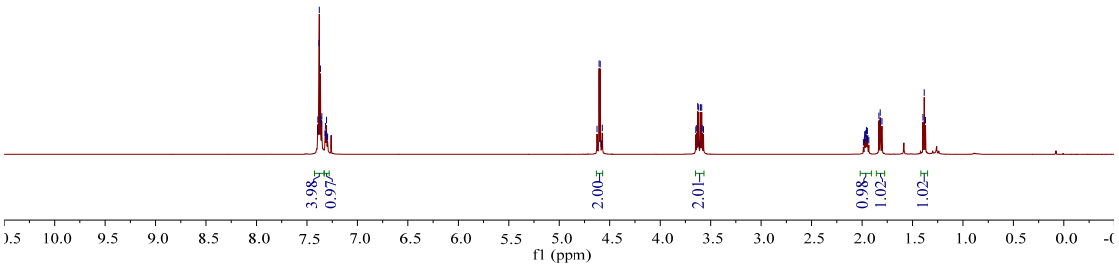

7.39
7.37
7.35
7.34
7.32
7.29
7.28
7.26
3.09
3.07
3.05
3.03
2.81
2.80
2.78
2.76
1.94
1.93
1.92
1.91
1.89
1.88
1.87
1.86
1.84
1.44
1.42
1.40
Br
Br
1z
3.98
1.04
1.00
0.99
1.97
0.97
f1 (ppm)


139.2
128.6
128.3
126.5
38.1
31.9
29.0
28.4
Br
Br
1z
f1 (ppm)

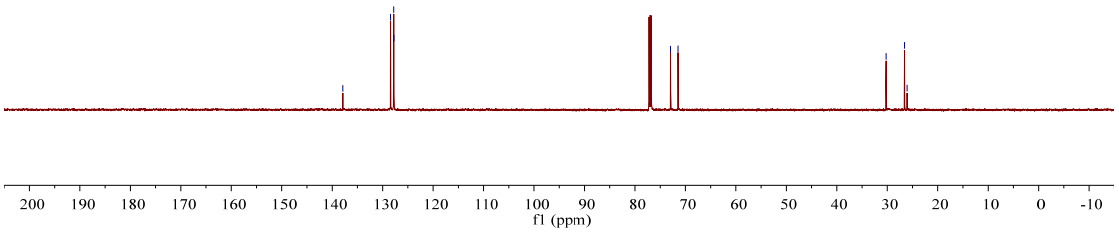

7.25
7.25
7.23
7.23
6.91
6.90
6.90
6.89
6.89
6.89
3.82
2.99
2.98
2.98
2.97
2.96
2.95
2.74
2.73
2.73
2.72
2.71
1.88
1.87
1.86
1.85
1.85
1.84
1.84
1.82
1.40
1.40
1.40
1.39
1.38
Br
Br
O
1a'
2.02
2.00
3.02
1.00
1.00
1.97
1.00
f1 (ppm)

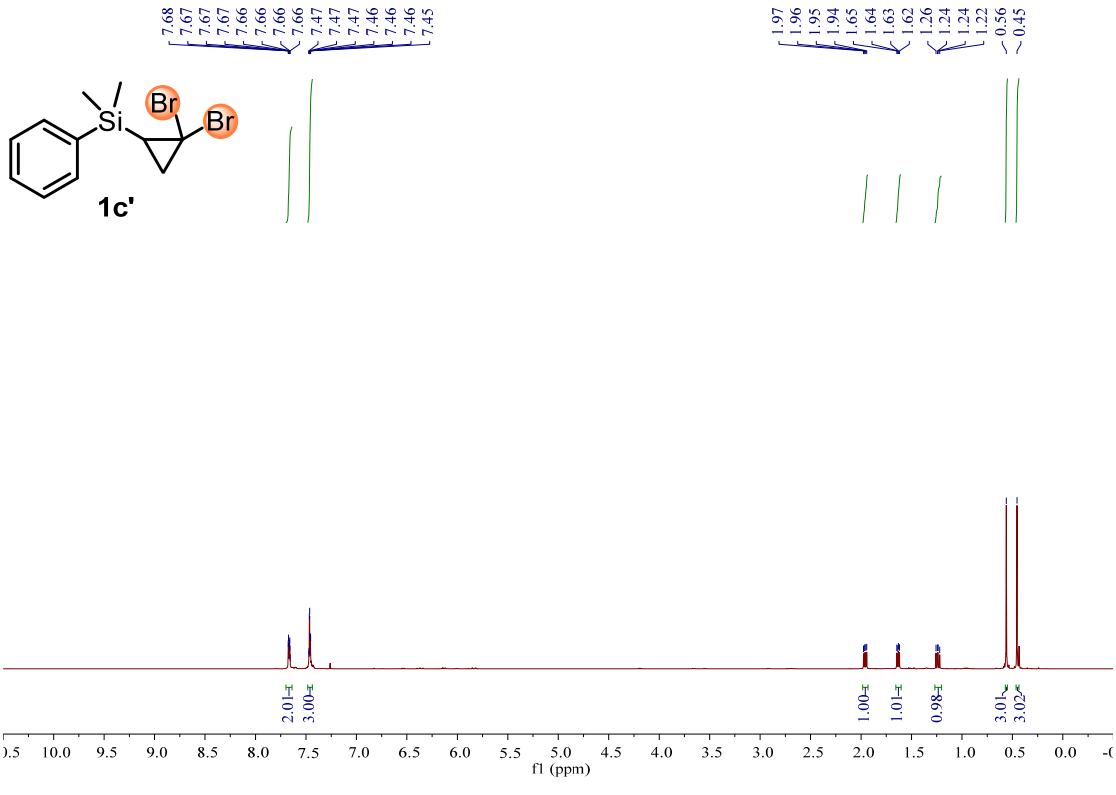

158.2
131.2
129.3
114.0
55.2
37.3
32.1
29.1
28.4
Br
Br
O
1a'
f1 (ppm)

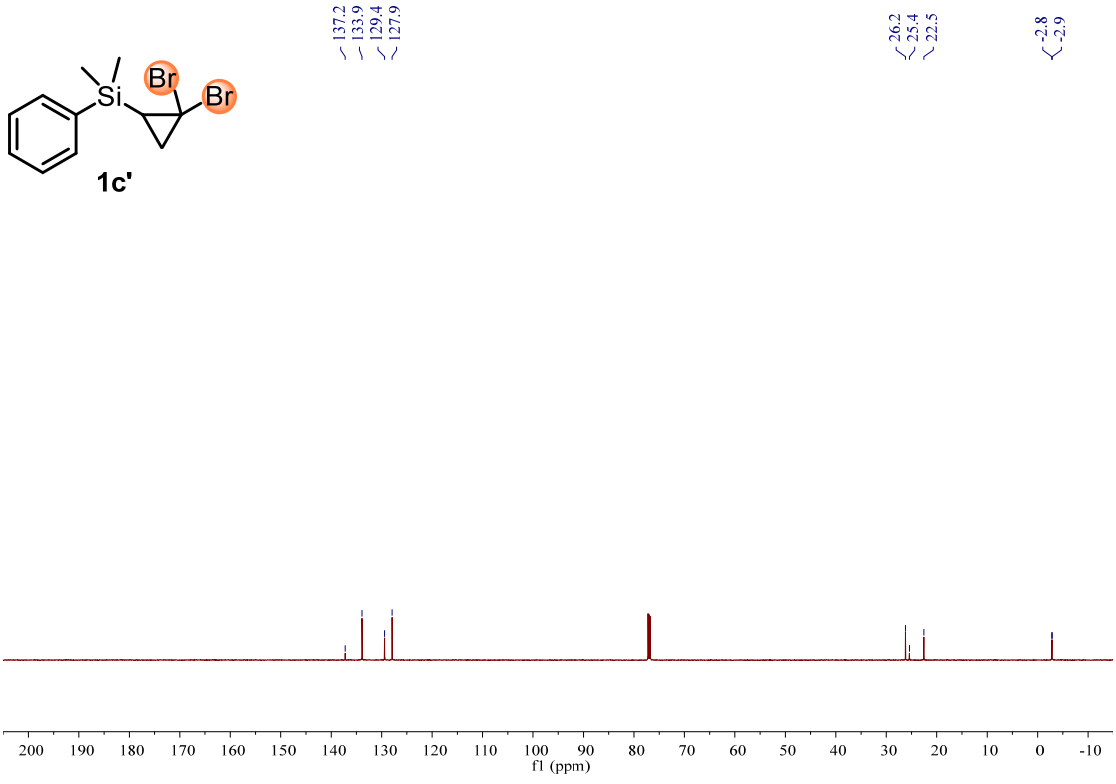

7.40
7.39
7.38
7.38
7.37
7.36
7.36
7.35
7.32
7.32
7.31
7.31
7.31
7.30
7.30
4.63
4.61
4.59
4.58
4.57
3.65
3.64
3.63
3.62
3.60
3.59
3.58
3.57
1.98
1.97
1.97
1.96
1.96
1.96
1.95
1.95
1.94
1.93
1.83
1.82
1.82
1.80
1.40
1.38
Br
Br
O
1b'

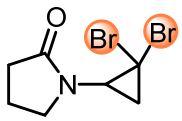

3.98
0.97
2.00
2.01
0.98
1.02
1.02
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


137.9
128.4
127.8
127.8
72.9
71.5
30.2
26.6
26.1
Br
Br
O
1b'

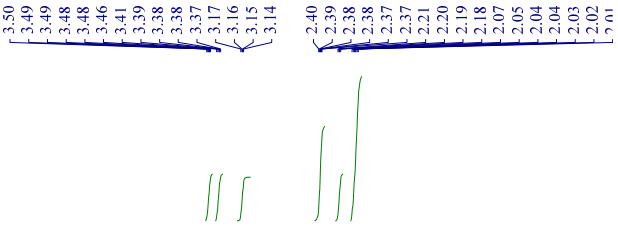

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

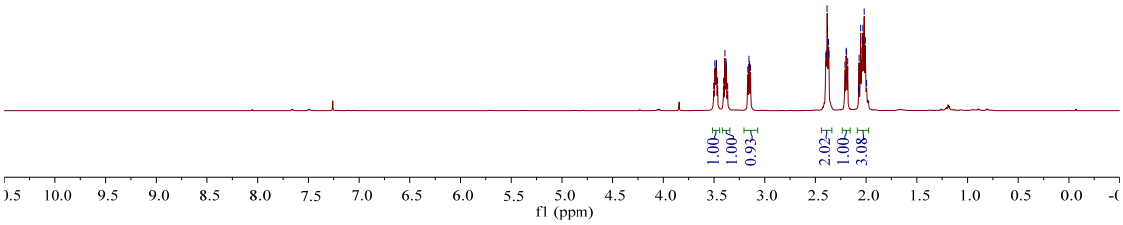

7.68
7.67
7.67
7.67
7.66
7.66
7.66
7.66
7.47
7.47
7.47
7.46
7.46
7.46
7.45
1.97
1.96
1.95
1.94
1.65
1.64
1.63
1.62
1.26
1.24
1.24
1.22
0.56
0.45
Br
Br
Si
1c'
2.01
3.00
1.00
1.01
0.98
3.01
3.02
f1 (ppm)


137.2
133.9
129.4
127.9
26.2
25.4
22.5
-2.8
-2.9
Br
Br
Si
1c'
f1 (ppm)

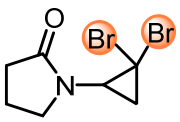

O
Br
Br
N

1d'

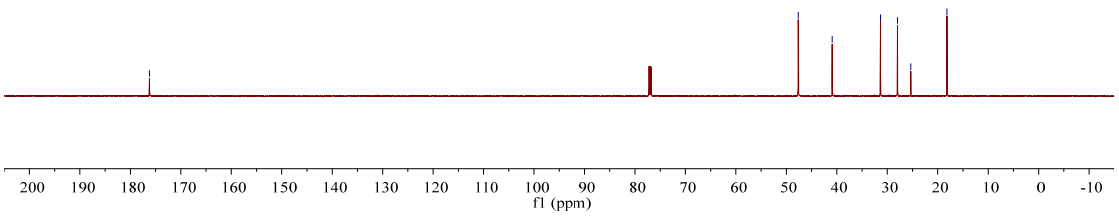

3.50
3.49
3.49
3.48
3.48
3.46
3.41
3.39
3.38
3.38
3.37
3.17
3.16
3.15
3.14
2.40
2.39
2.38
2.38
2.37
2.37
2.21
2.20
2.19
2.18
2.07
2.05
2.04
2.04
2.03
2.02

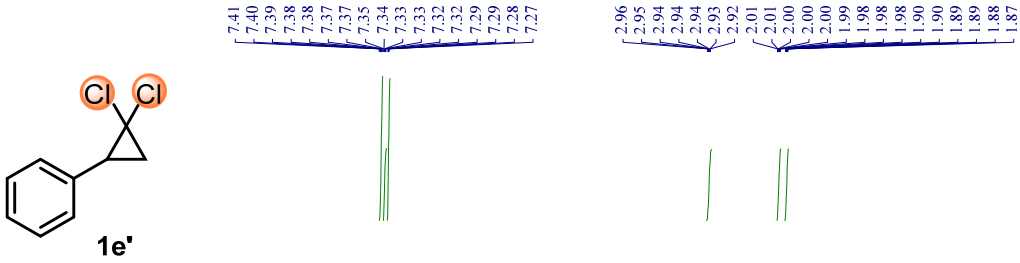

1.00
1.00
0.93
2.02
1.00
3.08
f1 (ppm)


176.2
47.6
40.9
31.3
28.0
25.4
18.2


O
Br
Br
N

1d'


f1 (ppm)


7.41
7.40
7.39
7.38
7.38
7.37
7.37
7.35
7.34
7.33
7.33
7.32
7.32
7.29
7.29
7.28
7.27
2.96
2.95
2.94
2.94
2.94
2.93
2.92
2.01
2.01
2.00
2.00
2.00
1.99
1.98
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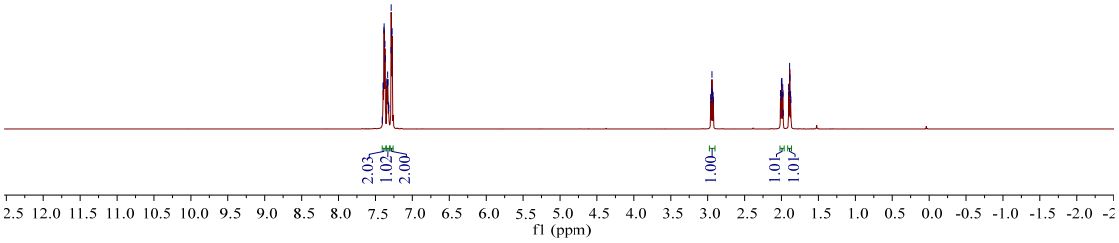
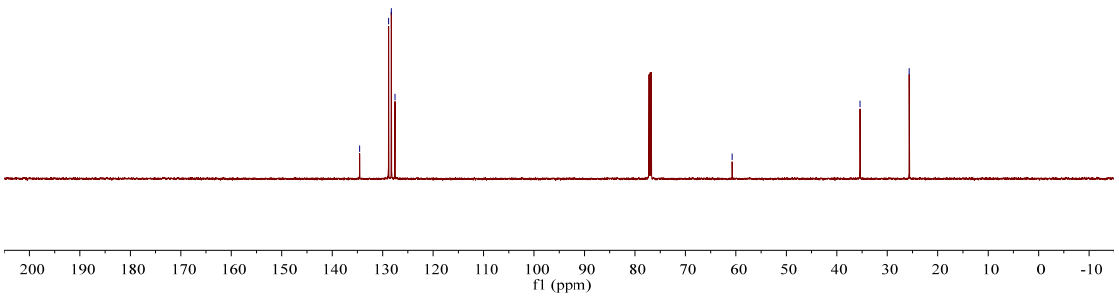
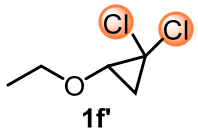
1.98
1.90
1.90
1.89
1.89
1.88
1.87
Cl
Cl
1e'


2.03
1.02
2.00
1.00
1.01
1.01
2.5 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 -0.5 -1.0 -1.5 -2.0 -2
f1 (ppm)

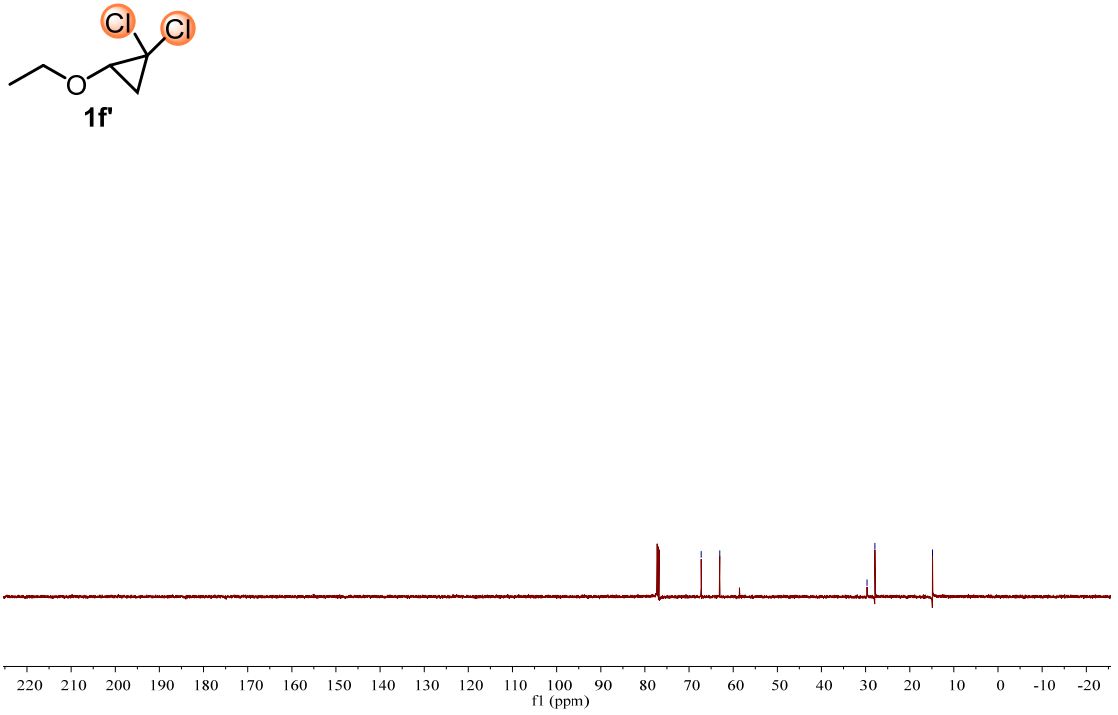

134.6
128.8
128.3
127.6
60.7
35.4
25.6
Cl
Cl
1e'


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

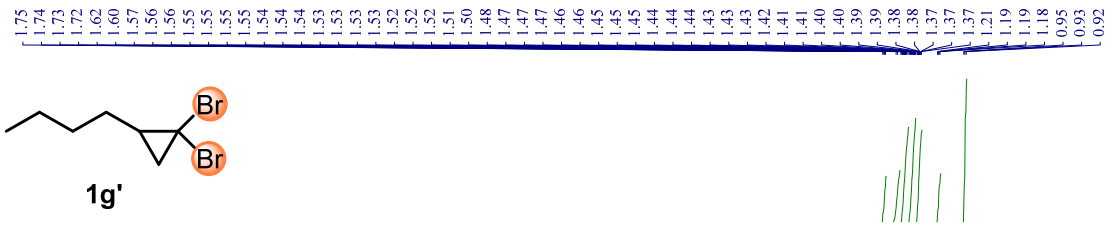

Cl
Cl
O

1f'

3.85
3.85
3.84
3.84
3.83
3.83
3.82
3.81
3.81
3.81
3.80
3.80
3.75
3.75
3.74
3.74
3.73
3.73
3.72
3.72
3.71
3.71
3.71
3.71
3.70
3.70
3.54
3.54
3.53
3.53
3.53
3.53
3.52
3.52
1.66
1.65
1.65
1.64
1.63
1.53
1.52
1.52
1.52
1.51
1.29
1.29
1.28
1.28
1.27
1.00
1.00
0.97
1.04
0.98
3.03
f1 (ppm)

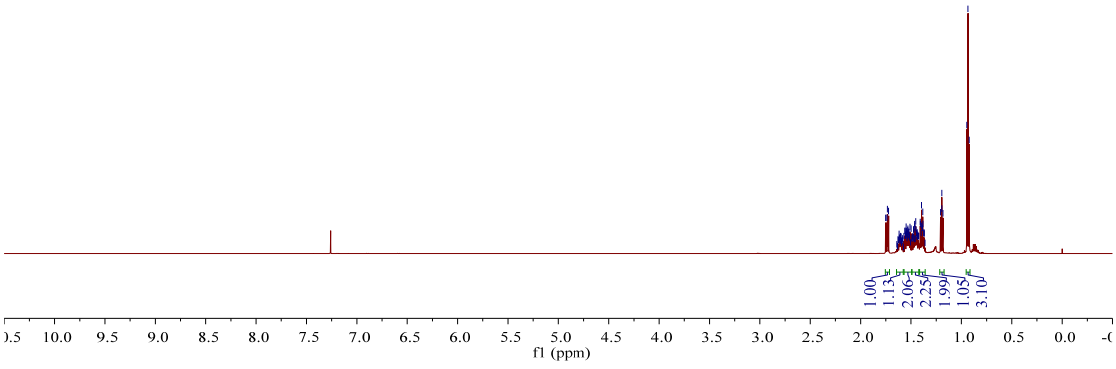

67.2
63.1
29.7
27.5
14.5
f1 (ppm)

Cl
Cl
O
1f'


1.75 1.74 1.73 1.72 1.62 1.60 1.57 1.56 1.56 1.55 1.55 1.55 1.55 1.54 1.54 1.54 1.53 1.53 1.53 1.53 1.52 1.52 1.52 1.51 1.50 1.48 1.47 1.47 1.47 1.46 1.46 1.45 1.45 1.45 1.44 1.44 1.44 1.43 1.43 1.43 1.42 1.41 1.41 1.40 1.40 1.39 1.39 1.38 1.38 1.37 1.37 1.37 1.21 1.19 1.19 1.18 0.95 0.93 0.92

Br
Br

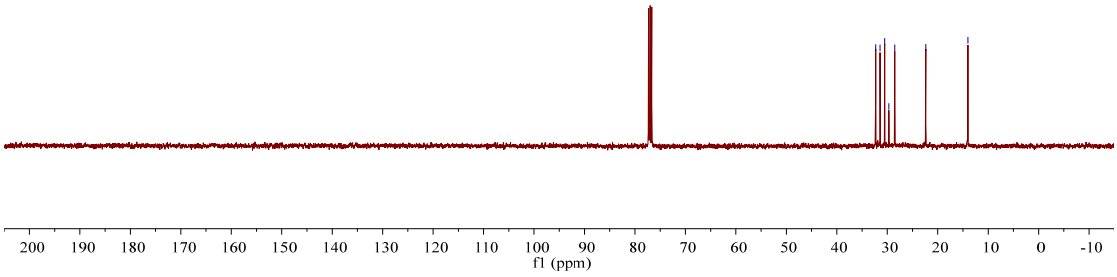
1g'

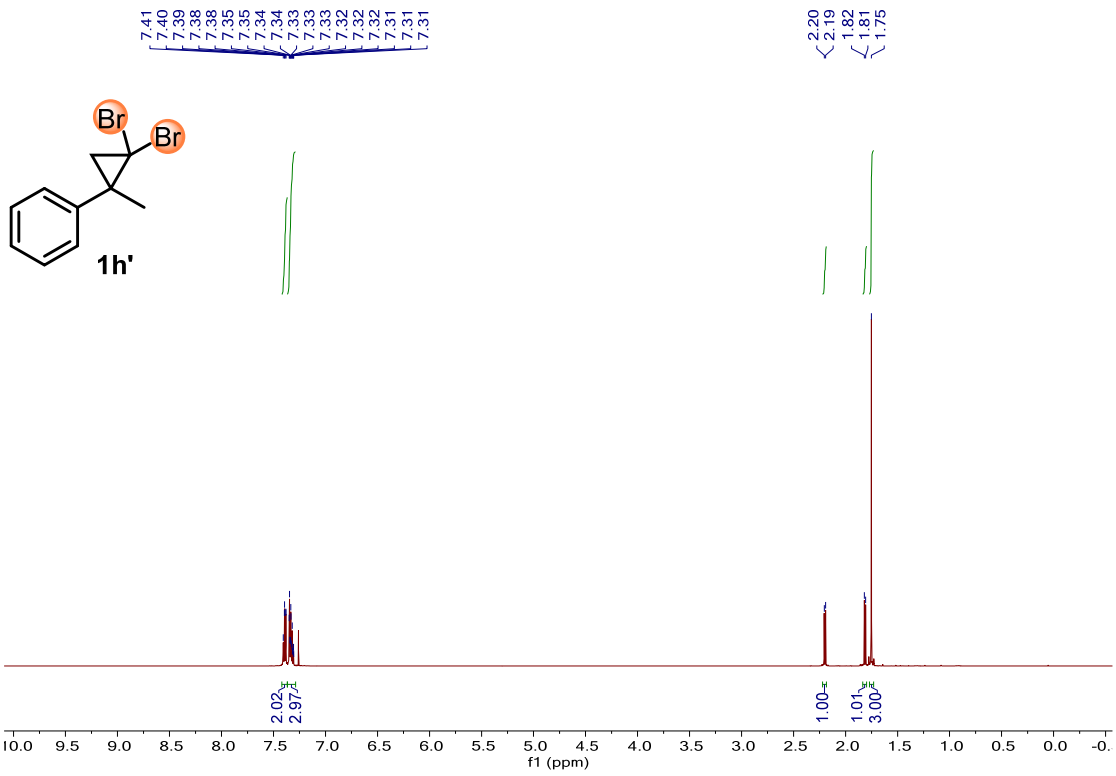

1.00
1.13
2.06
2.25
1.99
1.05
3.10
f1 (ppm)

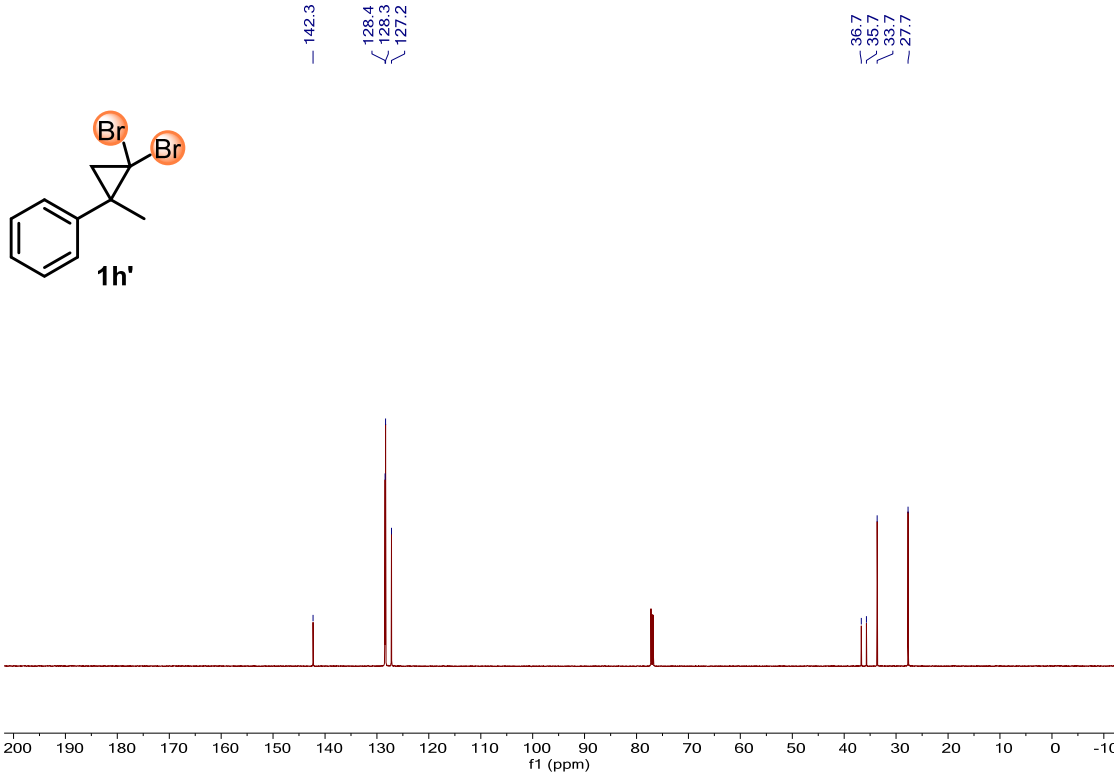

32.3
31.4
30.5
29.7
28.5
22.4
14.0

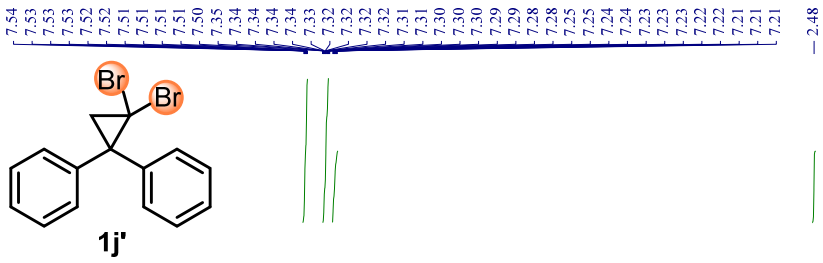

Br
Br

1g'


f1 (ppm)

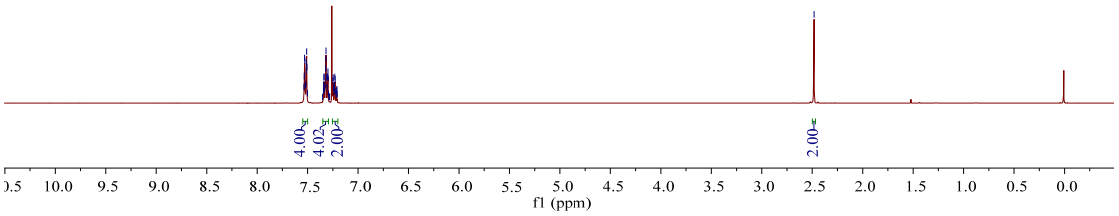

7.41
7.40
7.39
7.38
7.38
7.35
7.35
7.34
7.34
7.33
7.33
7.33
7.32
7.32
7.32
7.31
7.31
7.31
2.20
2.19
1.82
1.81
1.75
Br
Br
1h'
2.02
2.97
1.00
1.01
3.00
f1 (ppm)


142.3
128.4
128.3
127.2
36.7
35.7
33.7
27.7
Br
Br
1h'
f1 (ppm)

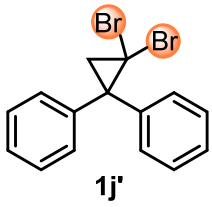

7.54
7.53
7.53
7.53
7.52
7.52
7.51
7.51
7.51
7.51
7.50
7.35
7.34
7.34
7.34
7.34
7.33
7.32
7.32
7.32
7.31
7.31
7.30
7.30
7.30
7.29
7.29
7.28
7.28
7.25
7.25
7.24
7.24
7.23
7.23
7.23
7.22
7.22
7.21
7.21
7.21
2.48

Br
Br

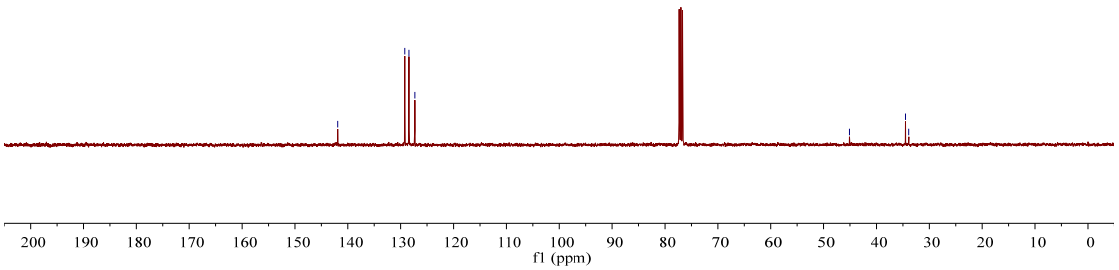
1j'

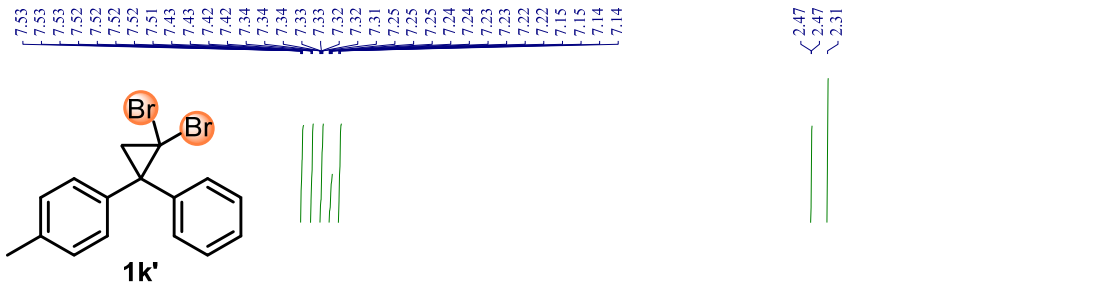

4.00
4.02
2.00
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

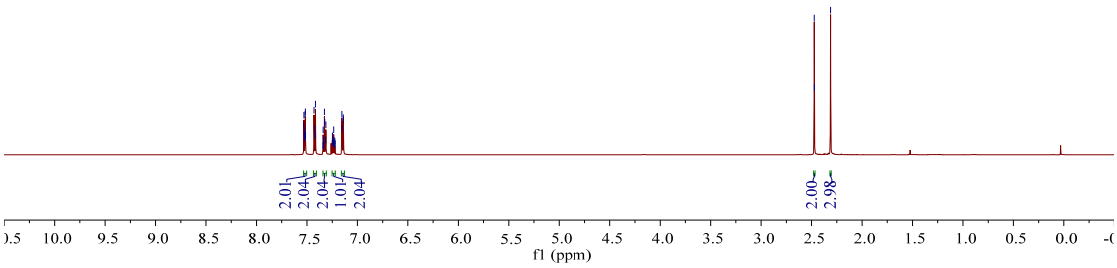

141.9
129.2
128.4
127.3
45.1
34.5
33.9


Br
Br

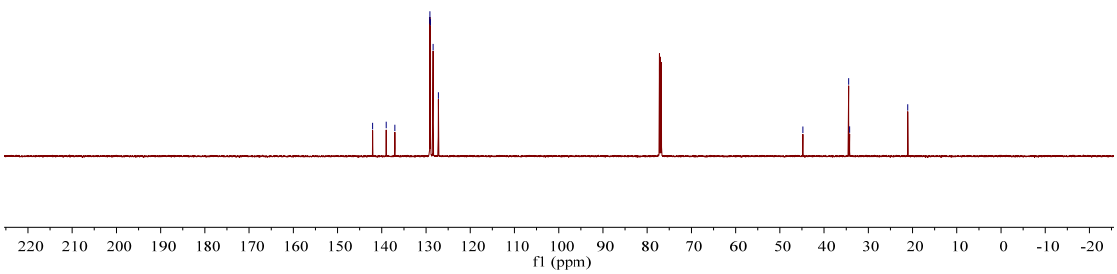
1j'

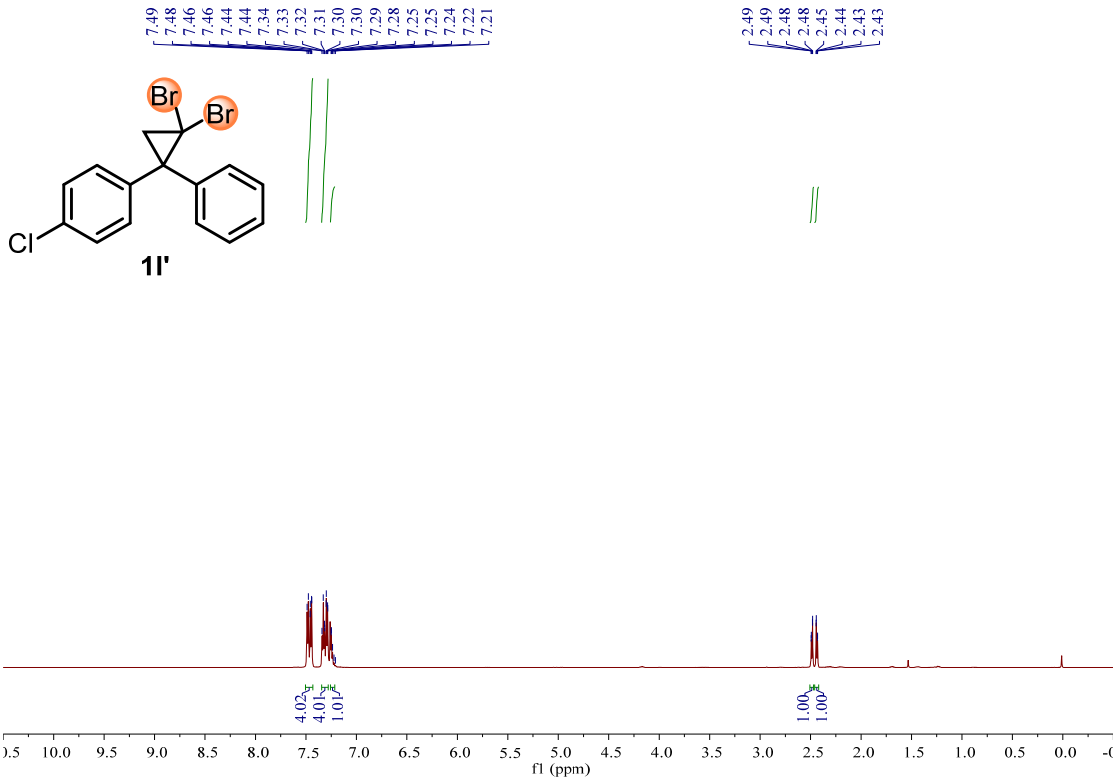

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

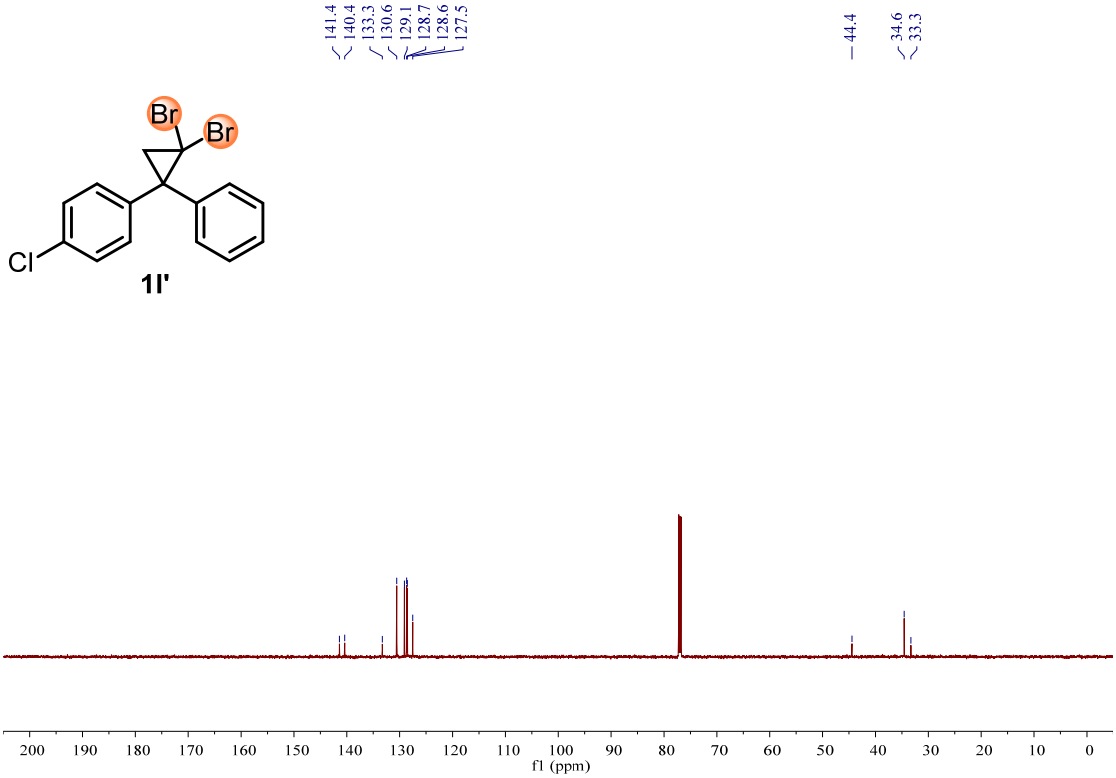

7.53
7.53
7.53
7.52
7.52
7.52
7.52
7.51
7.43
7.43
7.42
7.42
7.34
7.34
7.34
7.33
7.33
7.32
7.32
7.31
7.25
7.25
7.25
7.24
7.24
7.23
7.23
7.22
7.22
7.15
7.15
7.14
7.14
2.47
2.47
2.31
Br
Br
1k'

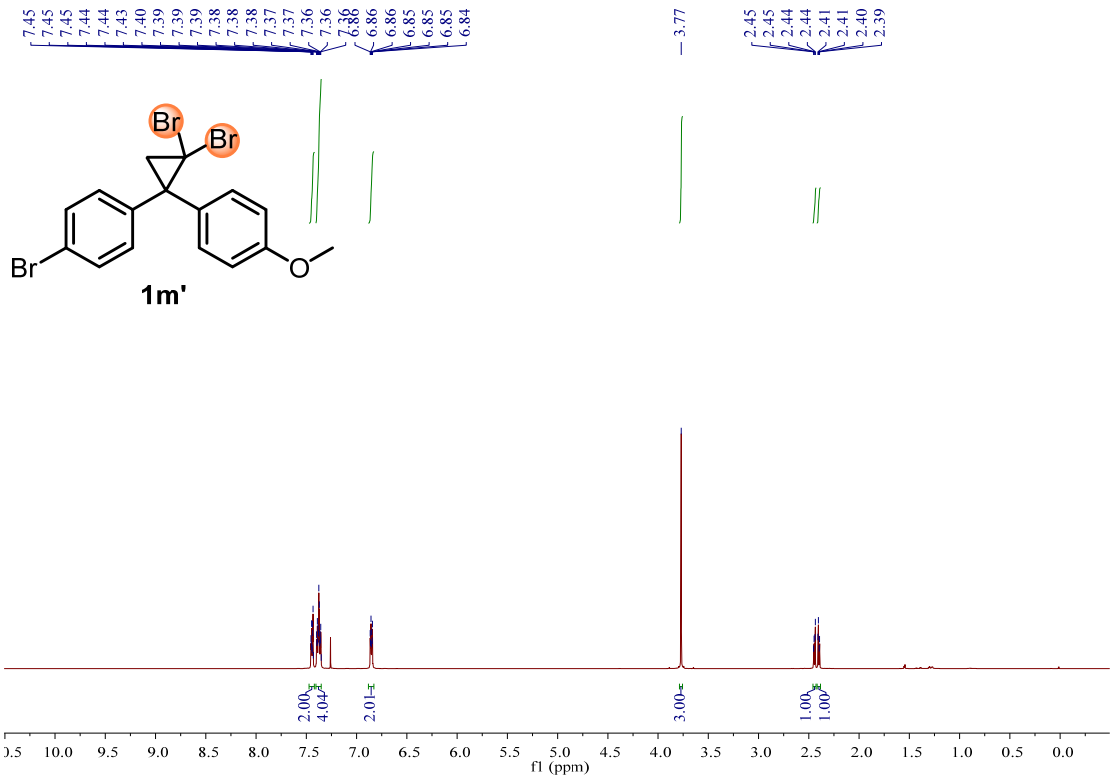

2.01
2.04
2.04
1.01
2.04
2.00
2.98
f1 (ppm)

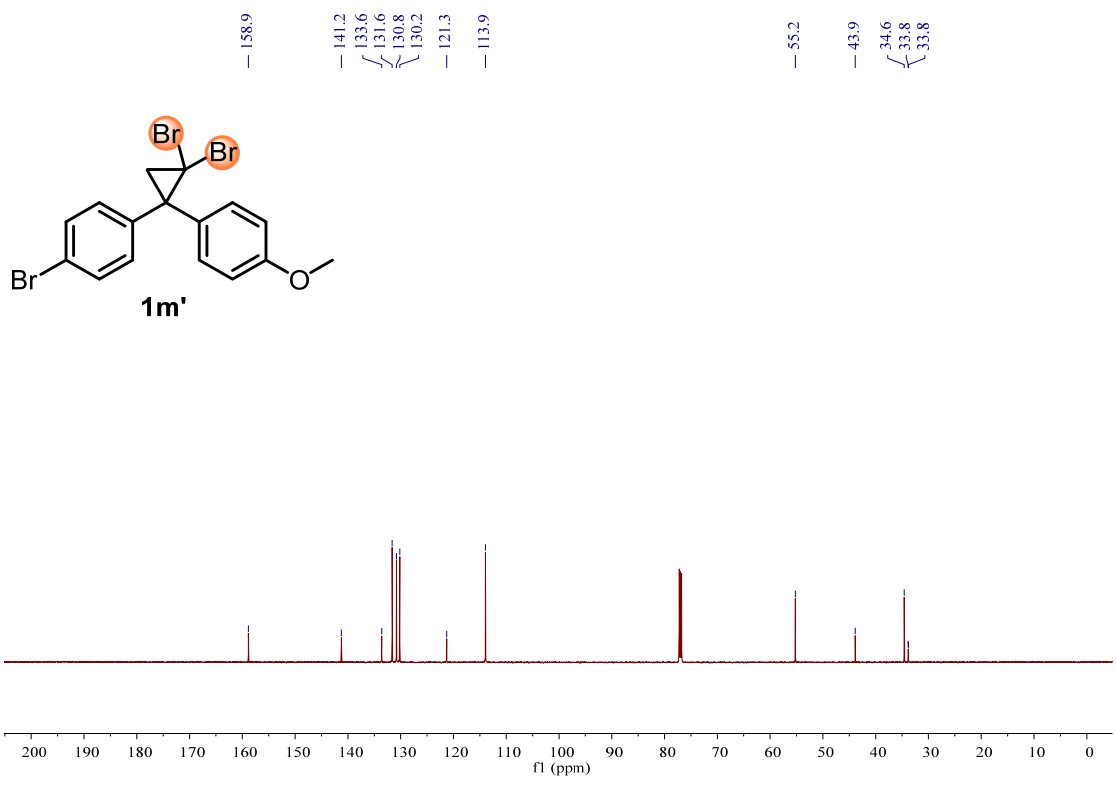

142.1
139.0
137.1
129.1
129.1
129.0
128.4
127.2
44.8
34.5
34.2
21.1
Br
Br
1k'

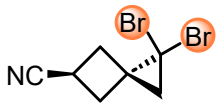

f1 (ppm)


7.49
7.48
7.46
7.46
7.44
7.44
7.34
7.33
7.32
7.31
7.30
7.30
7.29
7.28
7.25
7.25
7.24
7.22
7.21
2.49
2.49
2.48
2.48
2.45
2.44
2.43
2.43
Br
Br
Cl
1l'
4.02
4.01
1.01
1.00
1.00
f1 (ppm)

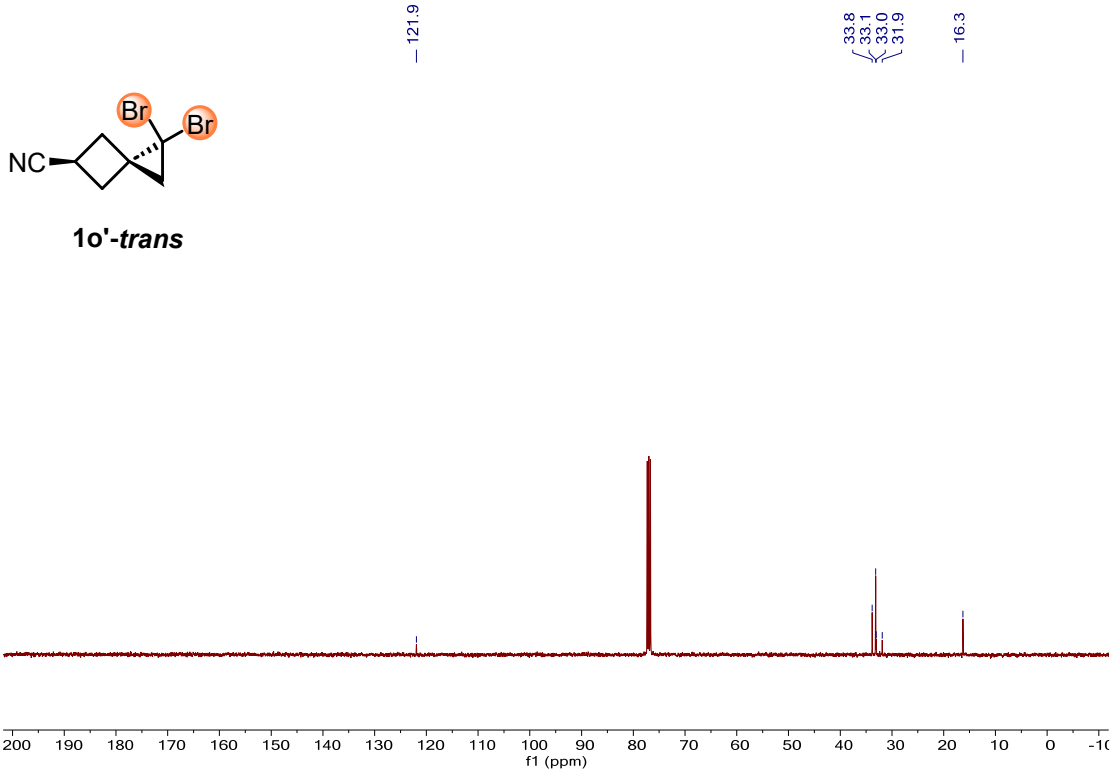

141.4
140.4
133.3
130.6
129.1
128.7
128.6
127.5
44.4
34.6
33.3
Br
Br
Cl
1l'
f1 (ppm)


7.45
7.45
7.45
7.44
7.44
7.43
7.40
7.39
7.39
7.39
7.38
7.38
7.38
7.37
7.37
7.36
7.36
7.36
6.88
6.86
6.86
6.85
6.85
6.85
6.84
3.77
2.45
2.45
2.44
2.44
2.41
2.41
2.40
2.39
Br
Br
Br
O
1m'
2.00
4.04
2.01
3.00
1.00
1.00
f1 (ppm)

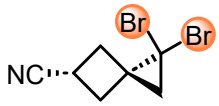

158.9
141.2
133.6
131.6
130.8
130.2
121.3
113.9
55.2
43.9
34.6
33.8
33.8
Br
Br
Br
O
1m'
f1 (ppm)



1o'-*trans*

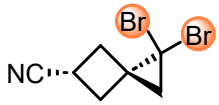


1o'-*trans*


Br
Br
NC

1o'-*cis*

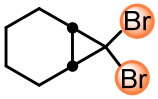
3.29
3.29
3.27
3.27
3.26
3.25
3.25
3.24
3.24
3.23
3.22
3.22
3.20
3.20
2.89
2.89
2.89
2.89
2.87
2.87
2.87
2.86
2.86
2.86
2.84
2.84
2.84
2.46
2.46
2.45
2.44
2.44
2.43
2.43
2.41
2.40
1.72
1.72
1.00
2.04
2.05
2.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


Br
Br
NC

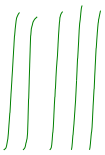
1o'-*cis*

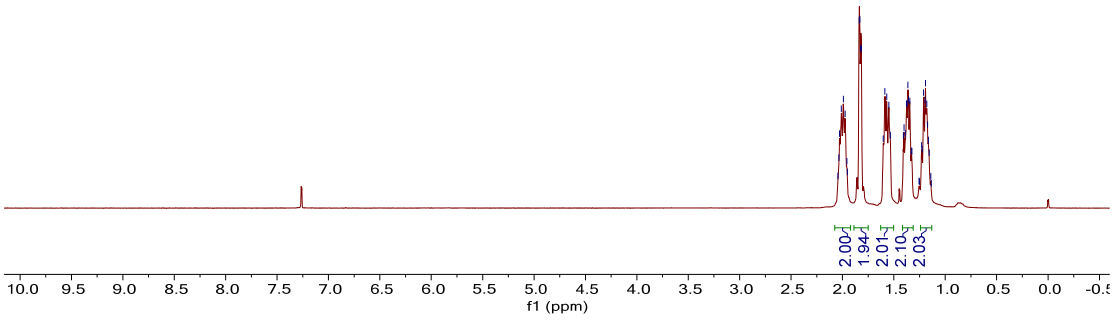
121.2
34.2
33.5
31.8
31.3
14.9
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


2.04
2.04
2.03
2.01
1.99
1.97
1.96
1.95
1.84
1.83
1.82
1.82
1.60
1.59
1.57
1.55
1.53
1.41
1.40
1.39
1.38
1.37
1.36
1.36
1.34
1.33
1.33
1.25
1.25
1.23
1.22
1.21
1.20
1.19
1.18
1.17
1.16
1.16
1.14
1.14

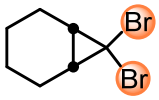

Br
Br

1p'

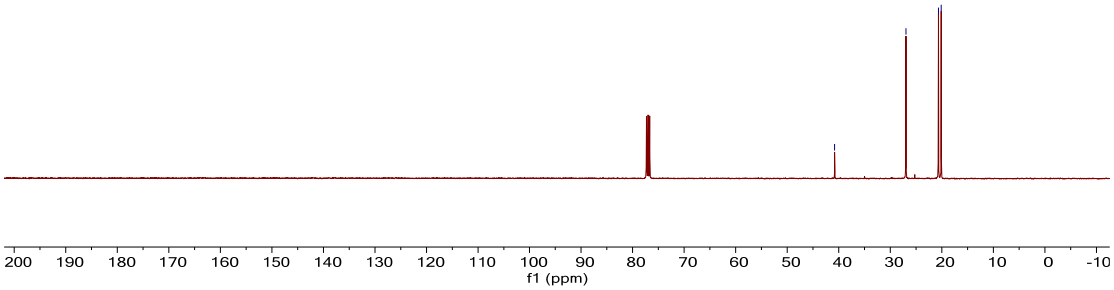


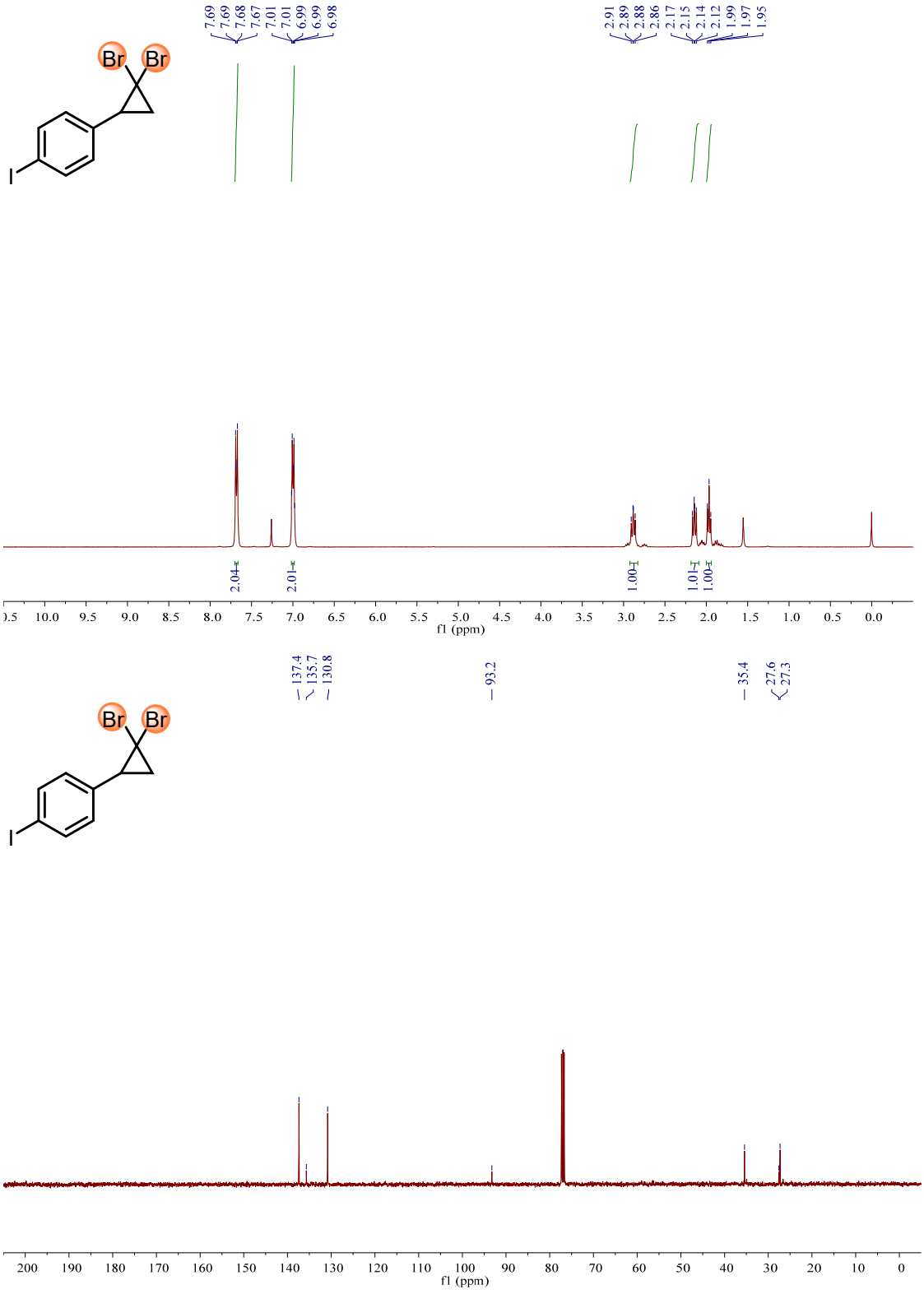

2.00
1.94
2.01
2.10
2.03
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

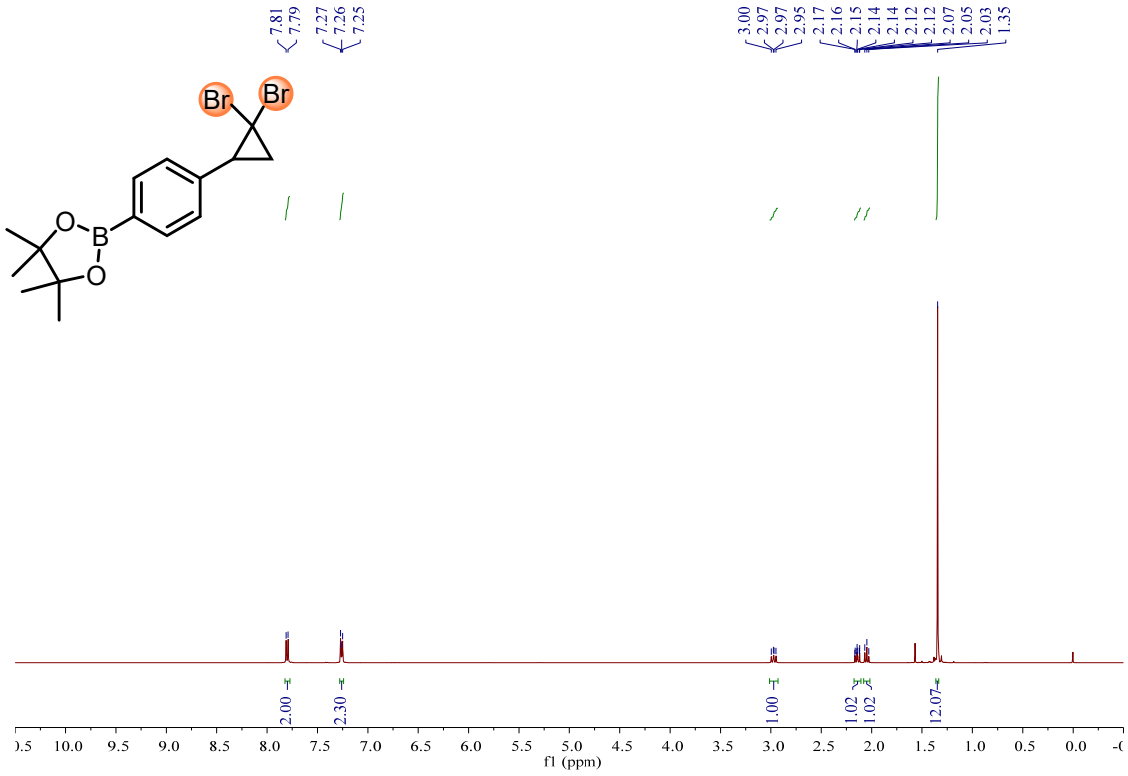

40.8
27.0
20.7
20.1

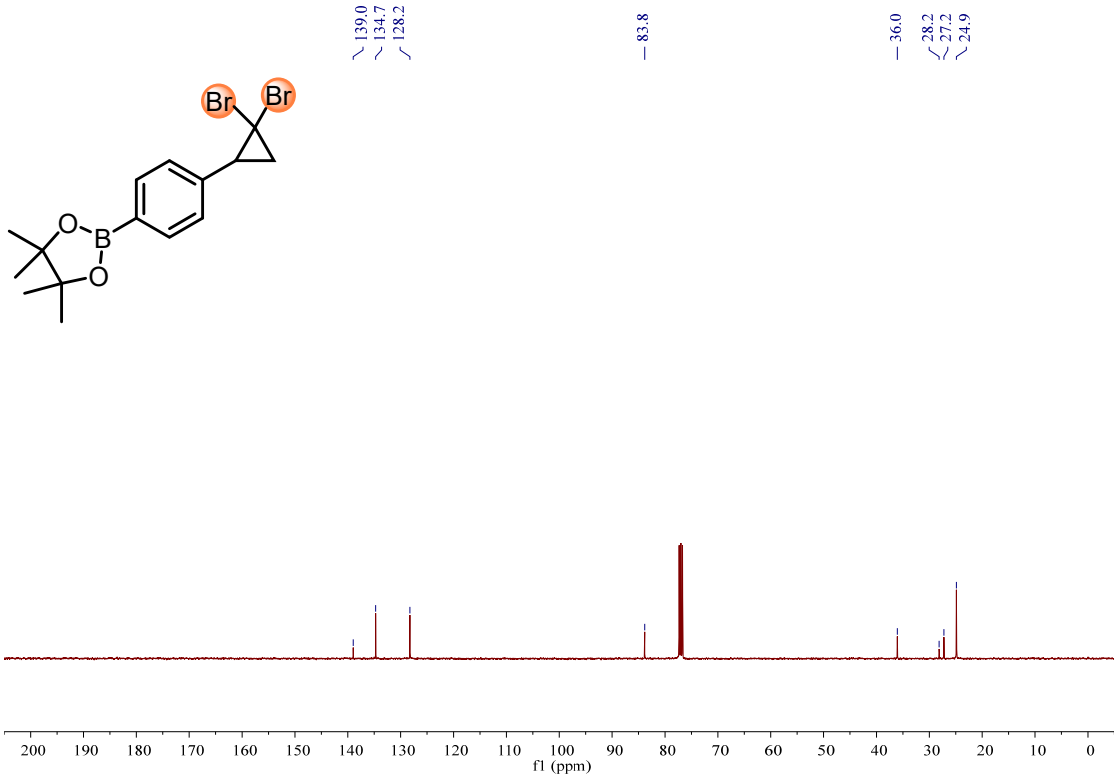

Br
Br

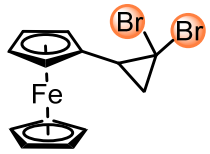
1p'


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

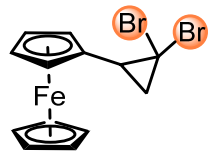

Br
Br
I
7.69
7.69
7.68
7.67
7.01
7.01
6.99
6.99
6.98
2.91
2.89
2.88
2.86
2.17
2.15
2.14
2.12
1.99
1.97
1.95
2.04
2.01
1.00
1.01
1.00
f1 (ppm)
137.4
135.7
130.8
93.2
35.4
27.6
27.3
Br
Br
I
f1 (ppm)


7.81
7.79
7.27
7.26
7.25
3.00
2.97
2.97
2.95
2.17
2.16
2.15
2.14
2.14
2.12
2.12
2.07
2.05
2.03
1.35
Br
Br
O
B
O
2.00
2.30
1.00
1.02
1.02
12.07
f1 (ppm)

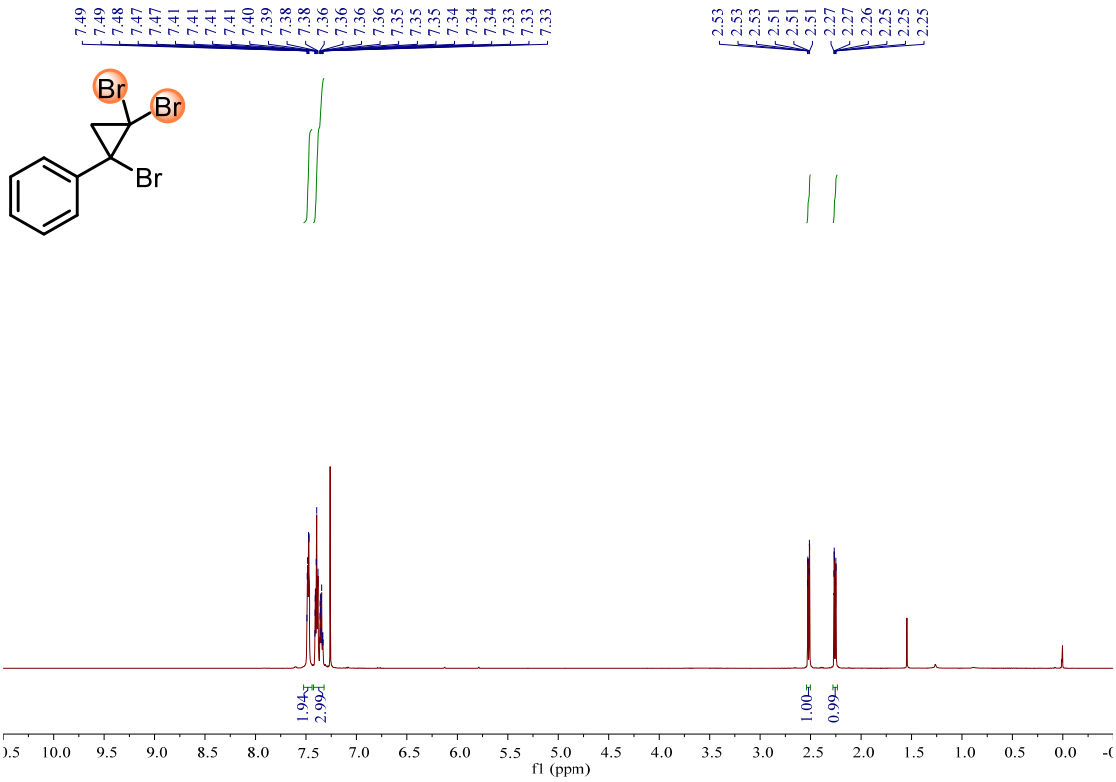

139.0
134.7
128.2
83.8
36.0
28.2
27.2
24.9
Br
Br
O
B
O
f1 (ppm)

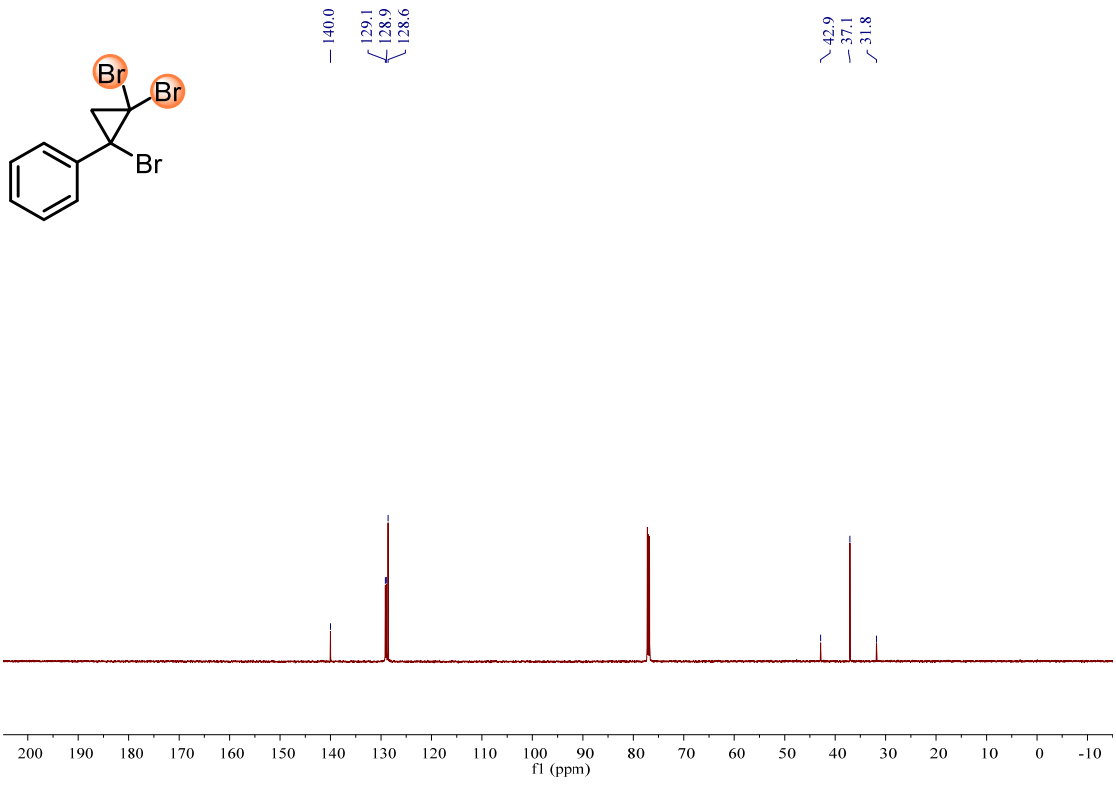

Br
Br
Fe

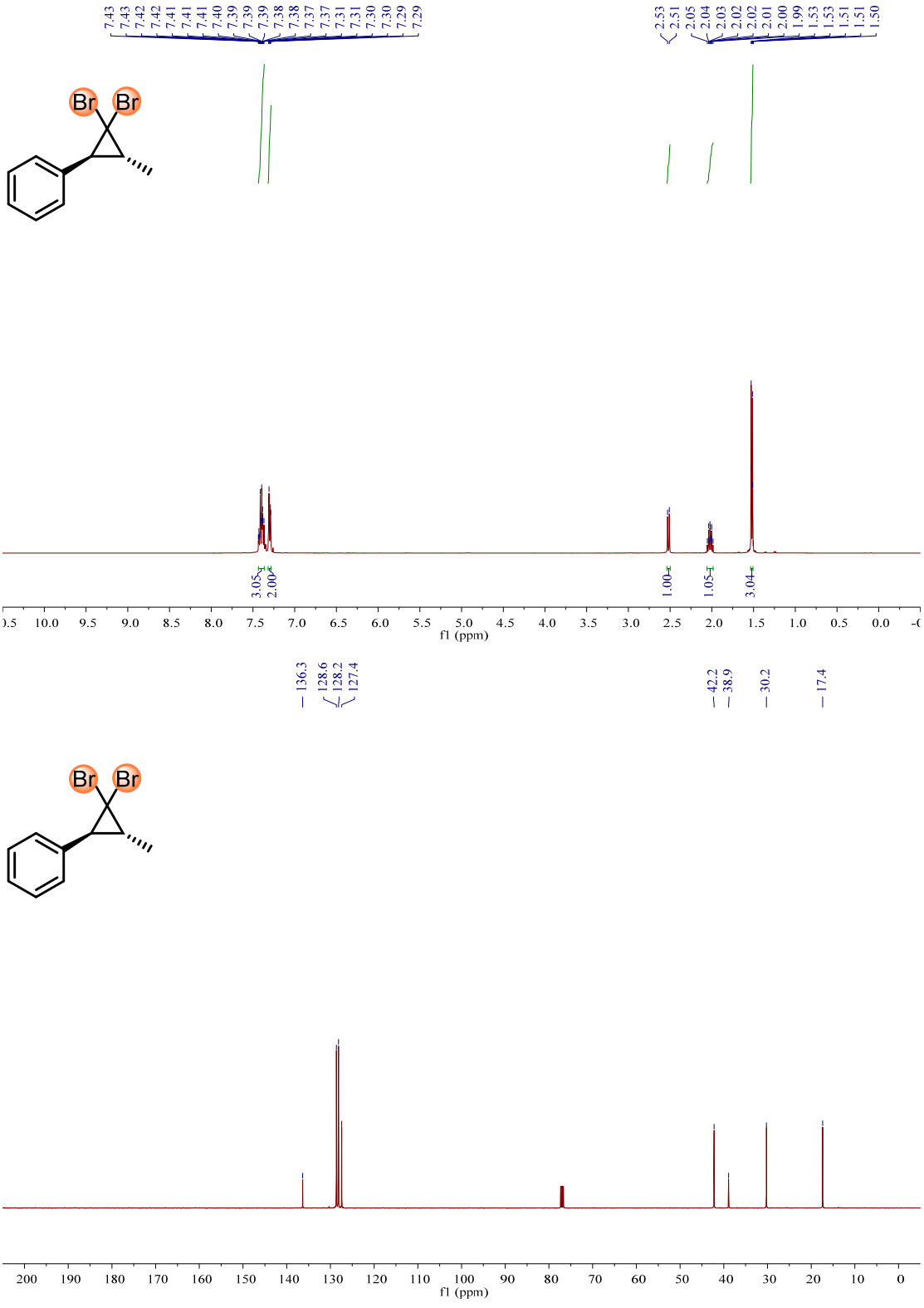
4.41
4.41
4.41
4.40
4.40
4.22
4.22
4.22
4.21
4.21
4.21
4.18
4.15
4.14
4.14
4.14
4.14
4.14
4.00
4.00
4.00
3.99
3.99
2.66
2.65
2.64
2.63
2.08
2.07
2.06
2.05
1.66
1.65
1.64
0.98
1.00
4.95
1.00
0.99
1.00
1.02
1.02
f1 (ppm)

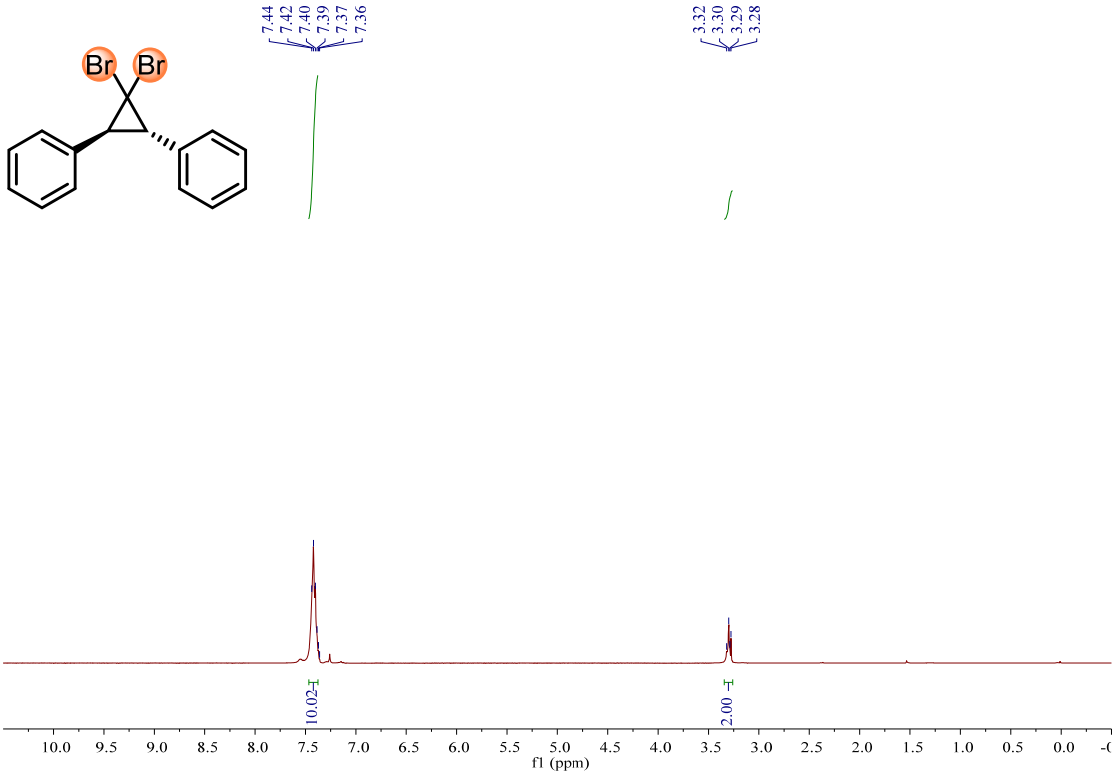

Br
Br
Fe

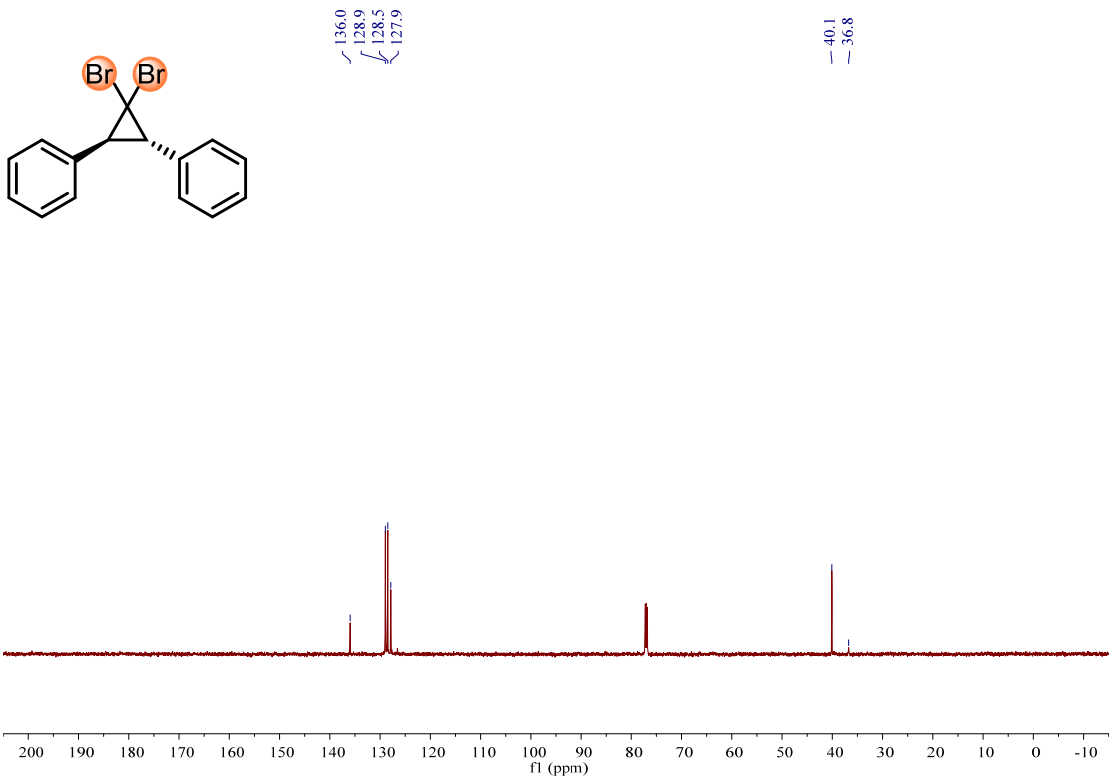
83.4
69.6
68.7
68.6
67.7
67.4
32.4
30.3
28.4
f1 (ppm)

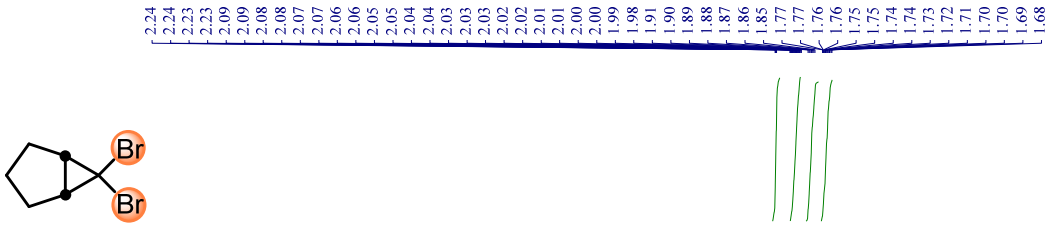

7.49
7.49
7.48
7.47
7.47
7.41
7.41
7.41
7.41
7.40
7.39
7.38
7.38
7.36
7.36
7.36
7.36
7.35
7.35
7.35
7.34
7.34
7.34
7.33
7.33
7.33
2.53
2.53
2.53
2.51
2.51
2.51
2.27
2.27
2.26
2.25
2.25
2.25
Br
Br
Br
1.94
2.99
1.00
0.99
f1 (ppm)

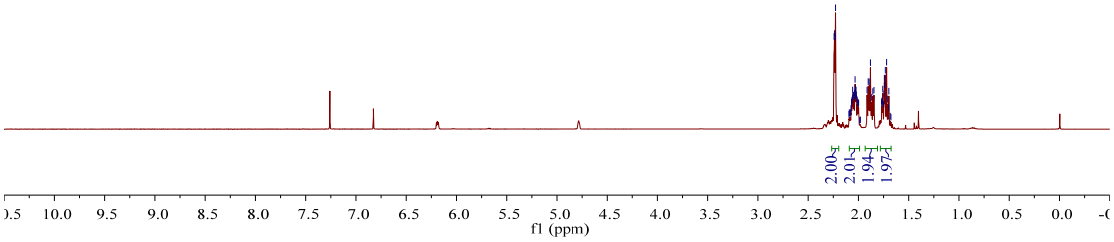

140.0
129.1
128.9
128.6
42.9
37.1
31.8
Br
Br
Br
f1 (ppm)

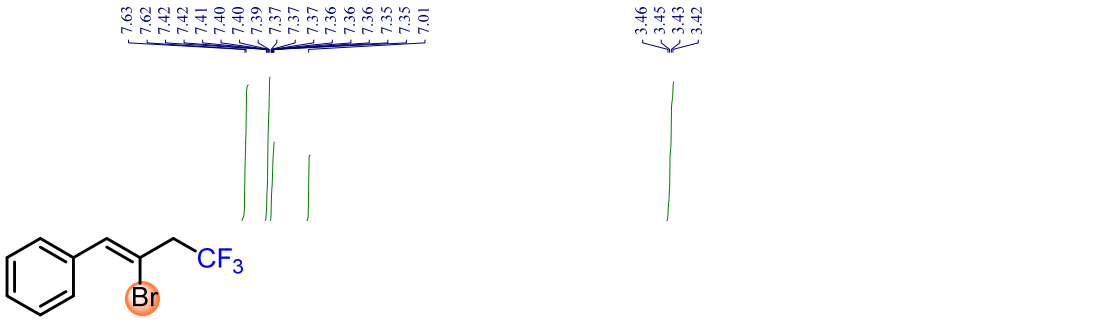

7.43
7.43
7.42
7.42
7.41
7.41
7.41
7.40
7.39
7.39
7.39
7.38
7.38
7.37
7.37
7.31
7.30
7.30
7.29
7.29
2.53
2.51
2.05
2.04
2.03
2.02
2.02
2.01
2.00
1.99
1.53
1.53
1.51
1.51
1.50
Br
Br
3.05
2.00
1.00
1.05
3.04
f1 (ppm)
136.3
128.6
128.2
127.4
42.2
38.9
30.2
17.4
Br
Br
f1 (ppm)


Br
Br
7.44
7.42
7.40
7.39
7.37
7.36
3.32
3.30
3.29
3.28
10.02
2.00
f1 (ppm)

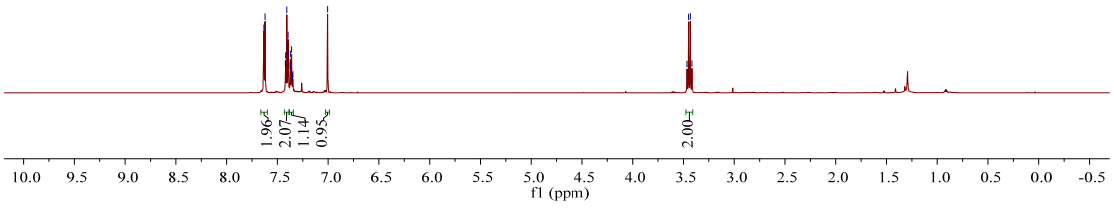

Br
Br
136.0
128.9
128.5
127.9
40.1
36.8
f1 (ppm)

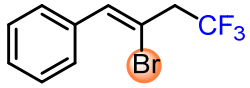






2a

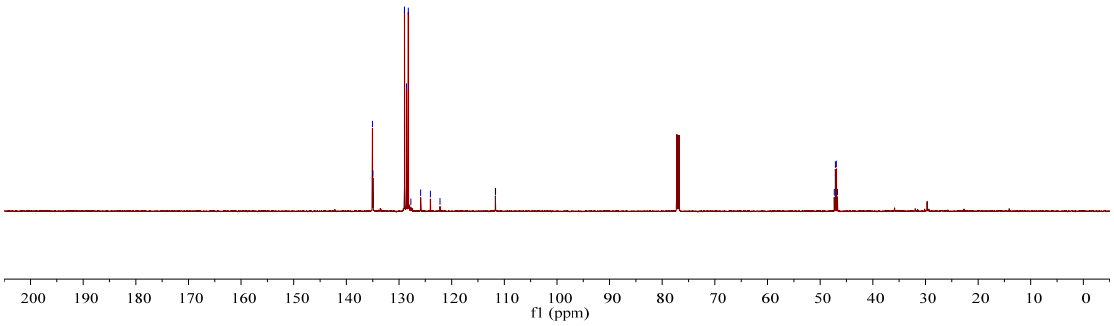


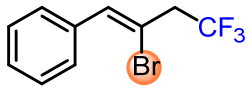

CF3
Br

2a


135.1
135.0
129.0
128.6
128.2
127.7
125.9
124.1
122.2
111.7
111.7

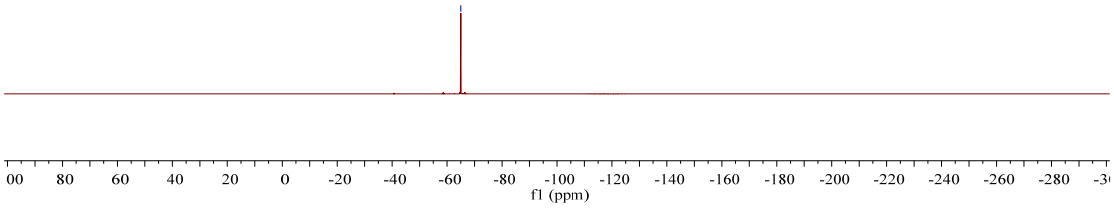

47.3
47.1
46.9
46.7

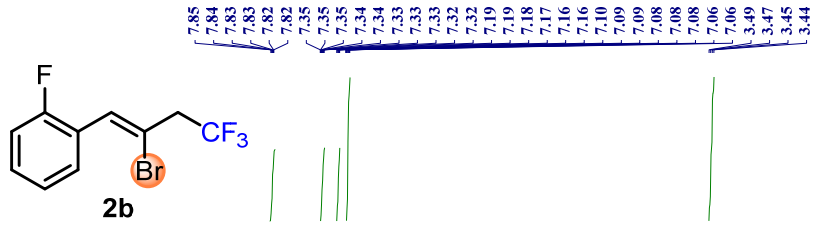

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


CF3
Br

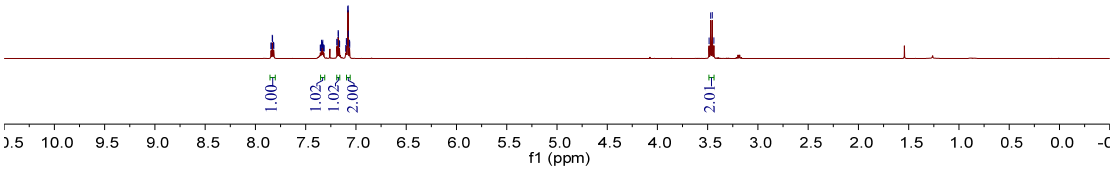
2a

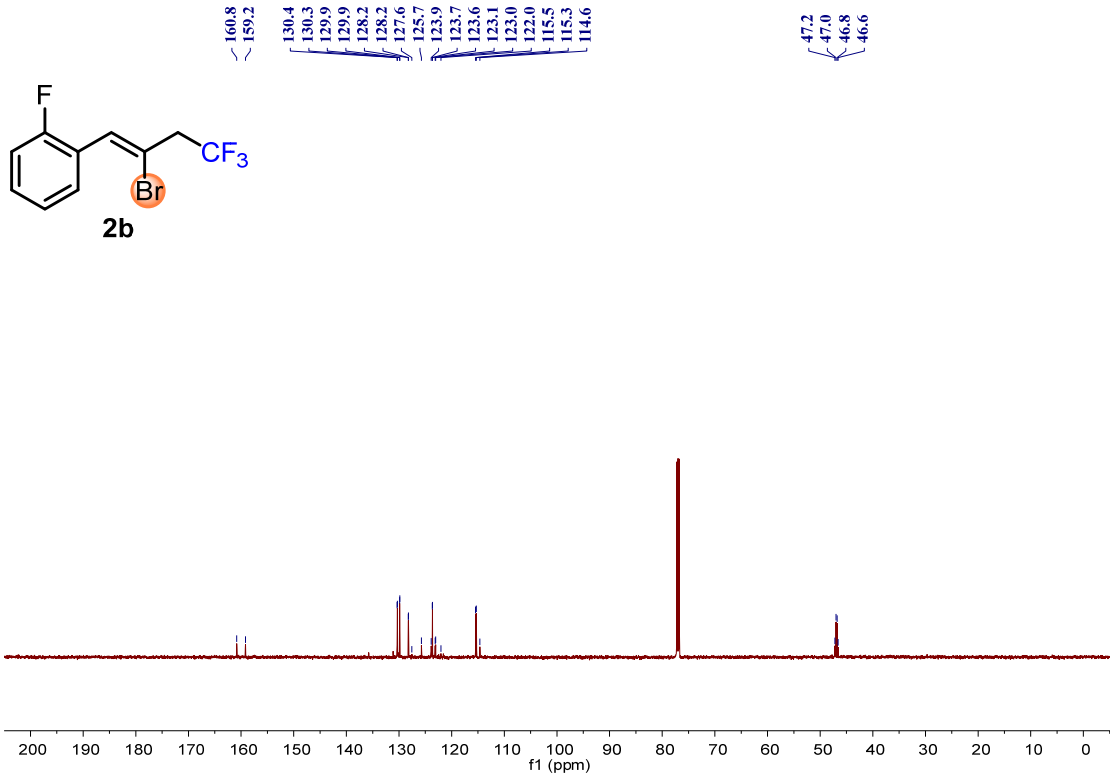

-64.98


00 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280
f1 (ppm)

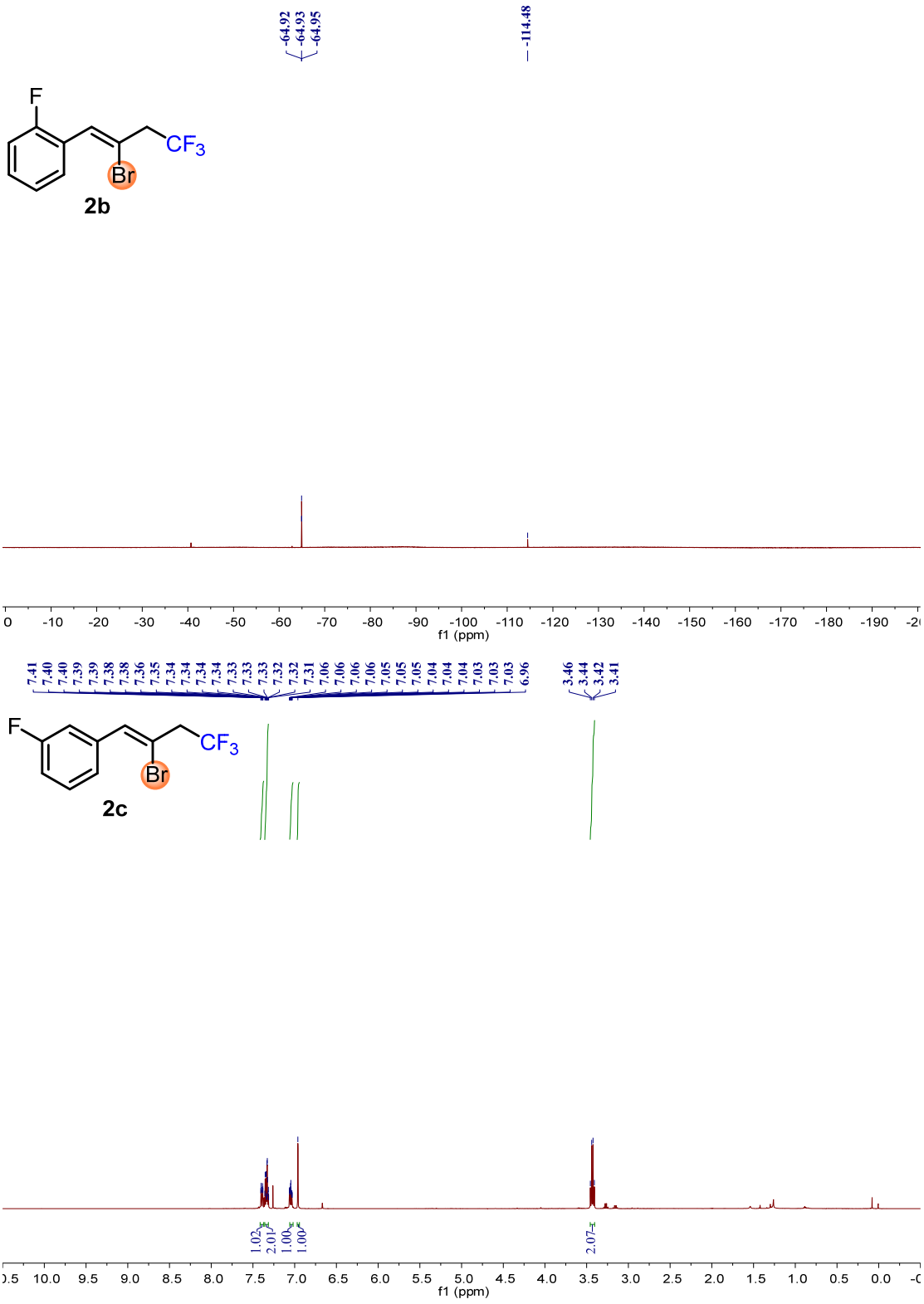

7.85
7.84
7.83
7.83
7.82
7.82
7.35
7.35
7.35
7.34
7.34
7.33
7.33
7.33
7.32
7.32
7.19
7.19
7.18
7.17
7.16
7.16
7.10
7.09
7.09
7.08
7.08
7.08
7.06
7.06
3.49
3.47
3.45
3.44
F
CF3
Br

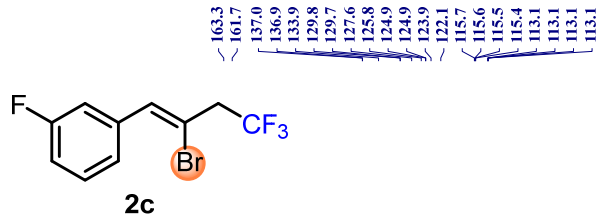
2b


1.00
1.02
1.02
2.00
2.01
f1 (ppm)

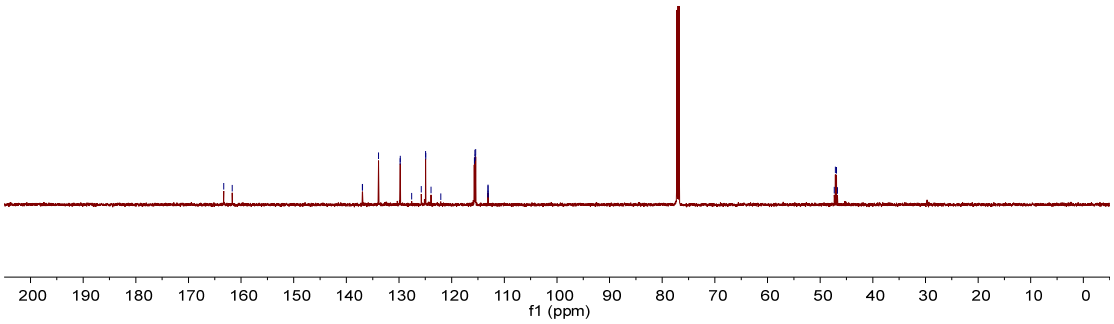

160.8
159.2
130.4
130.3
129.9
129.9
128.2
128.2
127.6
125.7
123.9
123.7
123.6
123.1
123.0
122.0
115.5
115.3
114.6
47.2
47.0
46.8
46.6
F
CF3
Br
f1 (ppm)

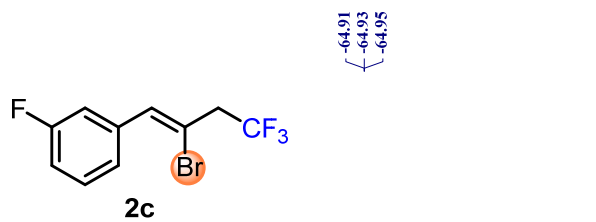
2b


-64.92
-64.93
-64.95
-114.48
F
CF3
Br
2b
f1 (ppm)
7.41
7.40
7.40
7.39
7.39
7.38
7.38
7.36
7.35
7.34
7.34
7.34
7.34
7.33
7.33
7.33
7.32
7.32
7.31
7.06
7.06
7.06
7.06
7.06
7.05
7.05
7.05
7.04
7.04
7.04
7.03
7.03
7.03
6.96
3.46
3.44
3.42
3.41
F
CF3
Br
2c
1.02
2.01
1.00
1.00
2.07
f1 (ppm)

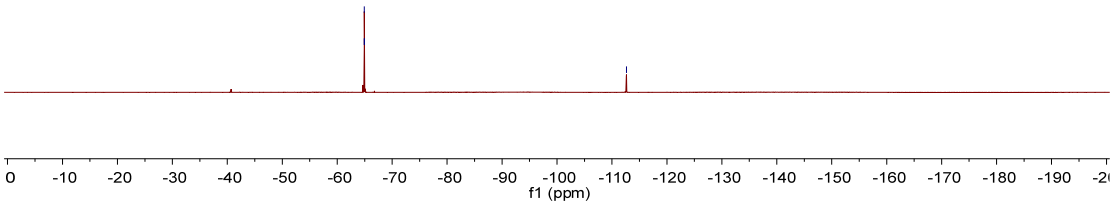

163.3
161.7
137.0
136.9
133.9
129.8
129.7
127.6
125.8
124.9
124.9
123.9
122.1
115.7
115.6
115.5
115.4
113.1
113.1
113.1
113.1
47.3
47.1
46.9
46.7
F
CF3
Br

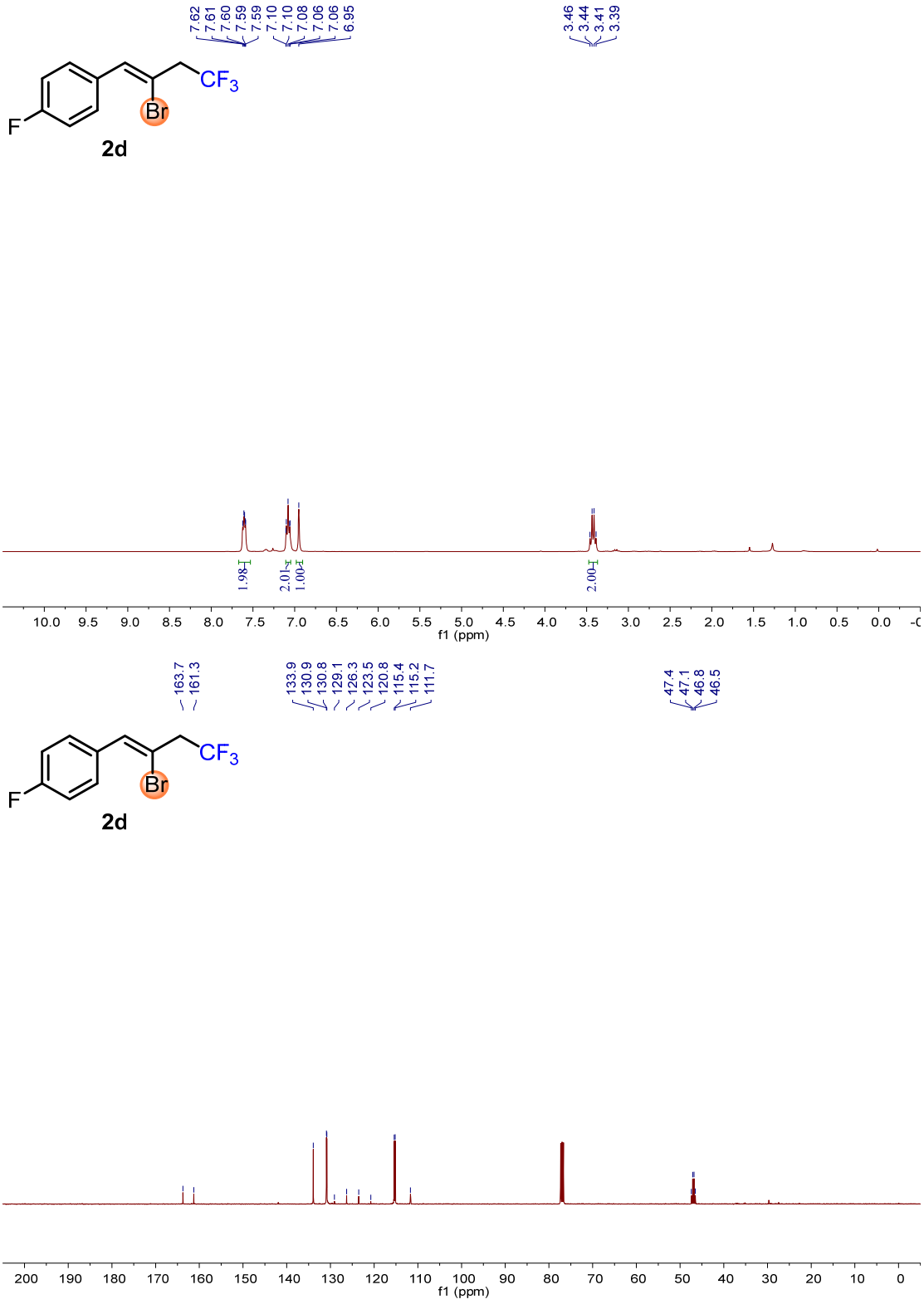
2c

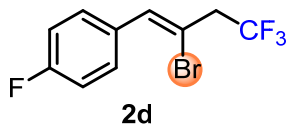

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-64.91
-64.93
-64.95
-112.63
F
CF3
Br

2c

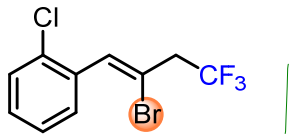

0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)


7.62
7.61
7.60
7.59
7.59
7.10
7.10
7.08
7.06
7.06
6.95
3.46
3.44
3.41
3.39
CF3
Br
F
2d
1.98
2.01
1.00
2.00
f1 (ppm)
163.7
161.3
133.9
130.9
130.8
129.1
126.3
123.5
120.8
115.4
115.2
111.7
47.4
47.1
46.8
46.5
CF3
Br
F
2d
f1 (ppm)


CF3
Br
F

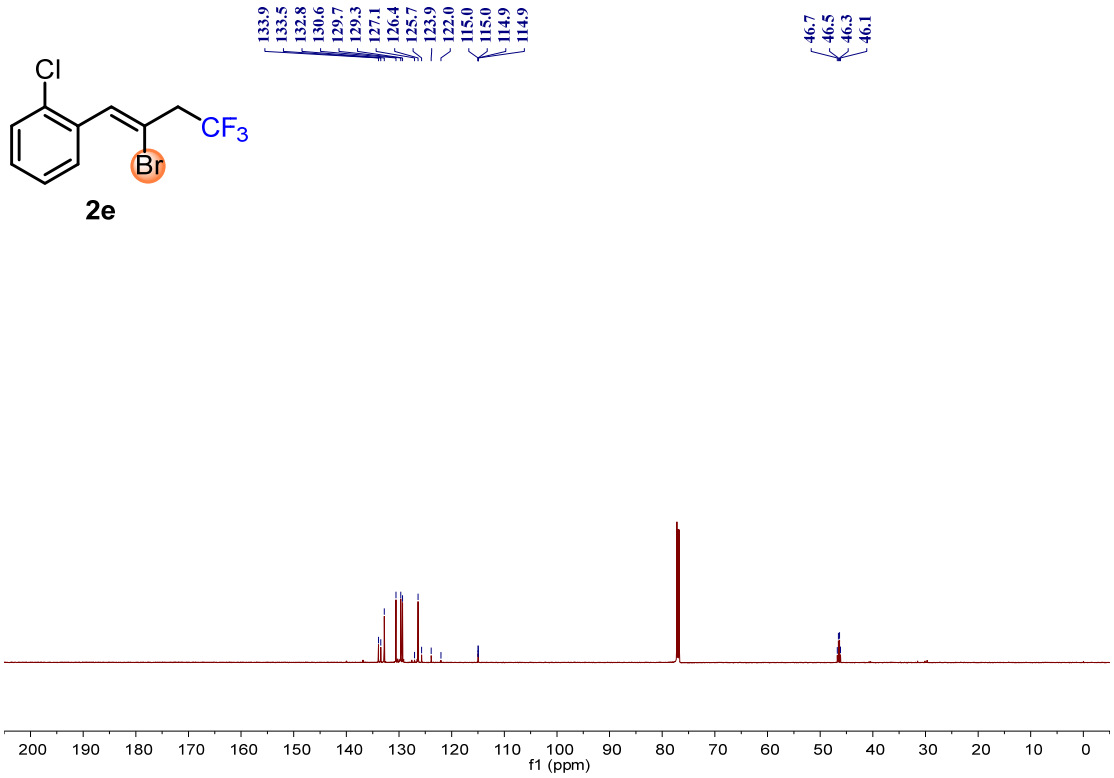
2d

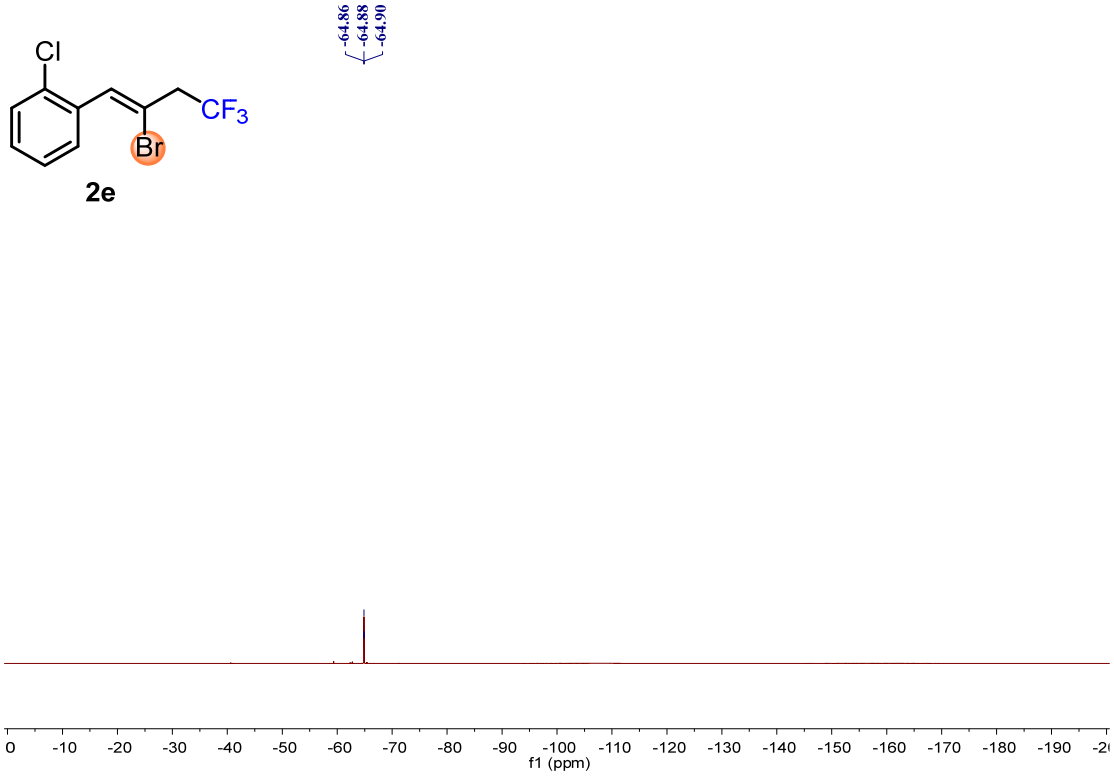
-65.00
-65.03
-65.05
-111.82
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220
f1 (ppm)

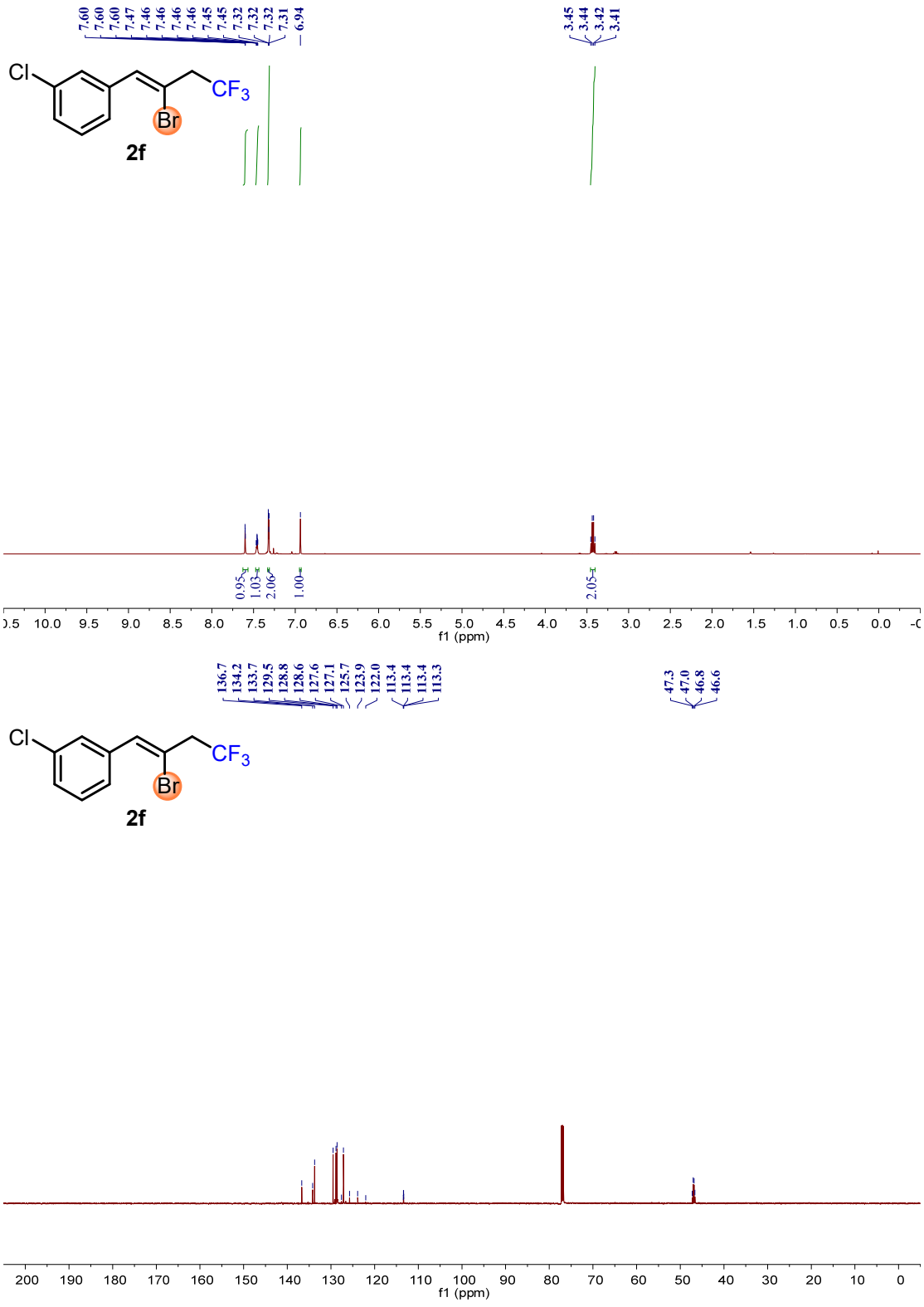

Cl
CF3
Br

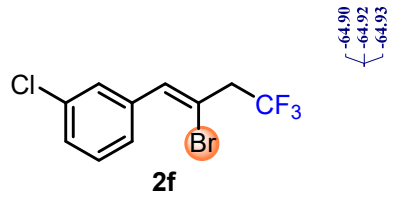
2e

7.68
7.67
7.67
7.67
7.67
7.67
7.66
7.66
7.42
7.41
7.41
7.41
7.40
7.40
7.30
7.30
7.29
7.29
7.28
7.10
3.50
3.49
3.47
3.45
0.99
1.02
2.01
1.00
2.04
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

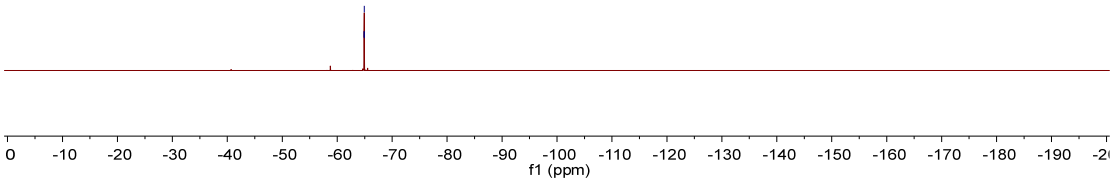

133.9
133.5
132.8
130.6
129.7
129.3
127.1
126.4
125.7
123.9
122.0
115.0
115.0
114.9
114.9
46.7
46.5
46.3
46.1
Cl
CF3
Br
2e
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

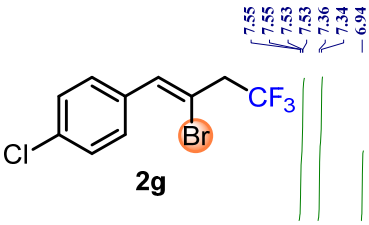

-64.86
-64.88
-64.90
Cl
CF3
Br
2e
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)


7.60
7.60
7.60
7.47
7.46
7.46
7.46
7.46
7.45
7.45
7.32
7.32
7.32
7.31
6.94
3.45
3.44
3.42
3.41
Cl
CF3
Br
2f
0.95
1.03
2.06
1.00
2.05
f1 (ppm)
136.7
134.2
133.7
129.5
128.8
128.6
127.6
127.1
125.7
123.9
122.0
113.4
113.4
113.4
113.3
47.3
47.0
46.8
46.6
Cl
CF3
Br
2f
f1 (ppm)


-64.90
-64.92
-64.93
Cl
CF3
Br

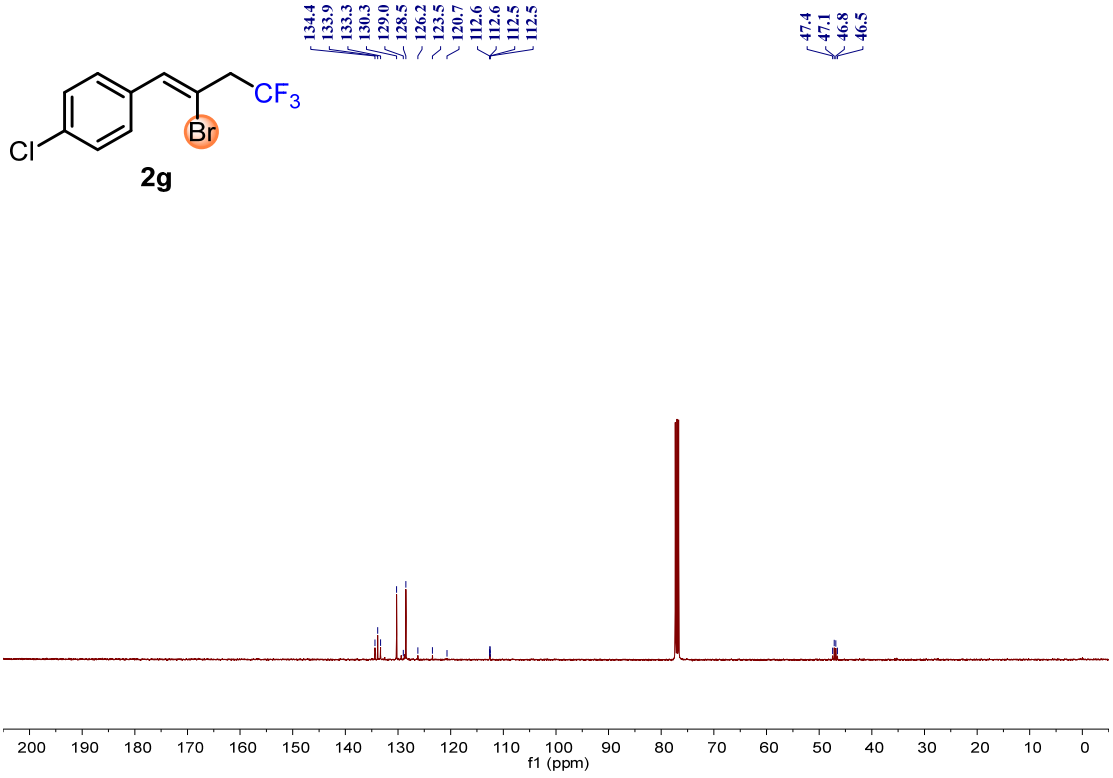
2f

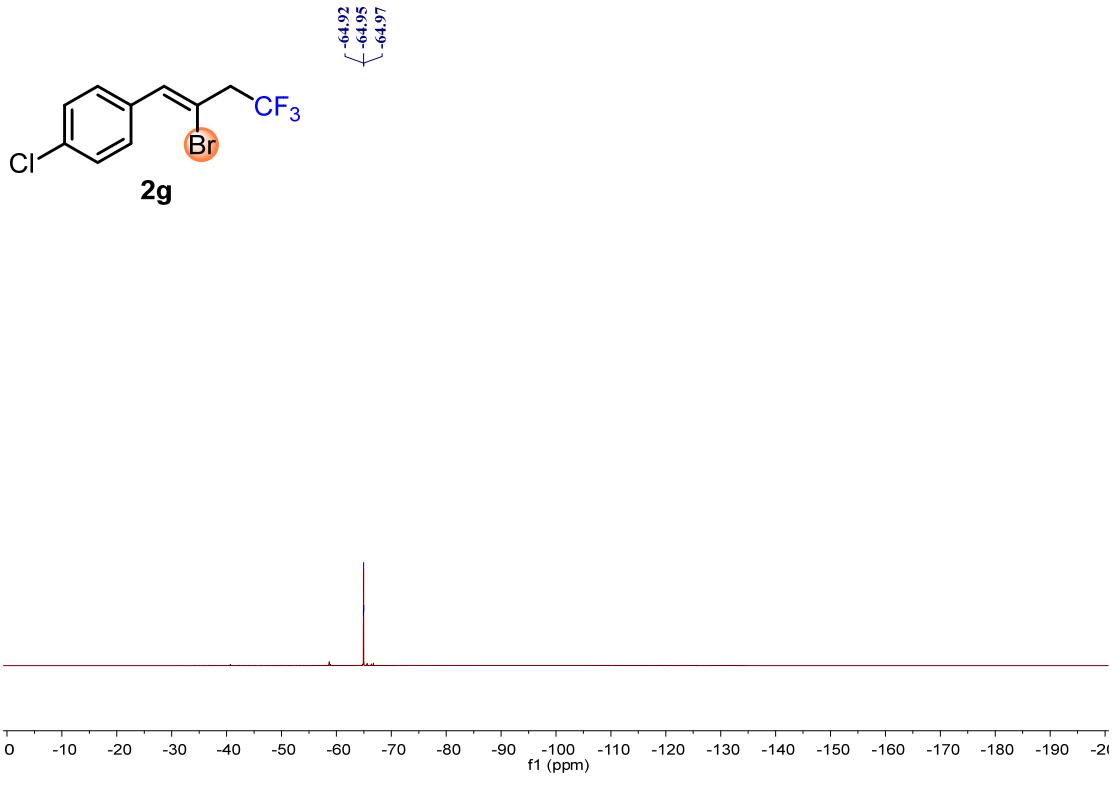

0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)

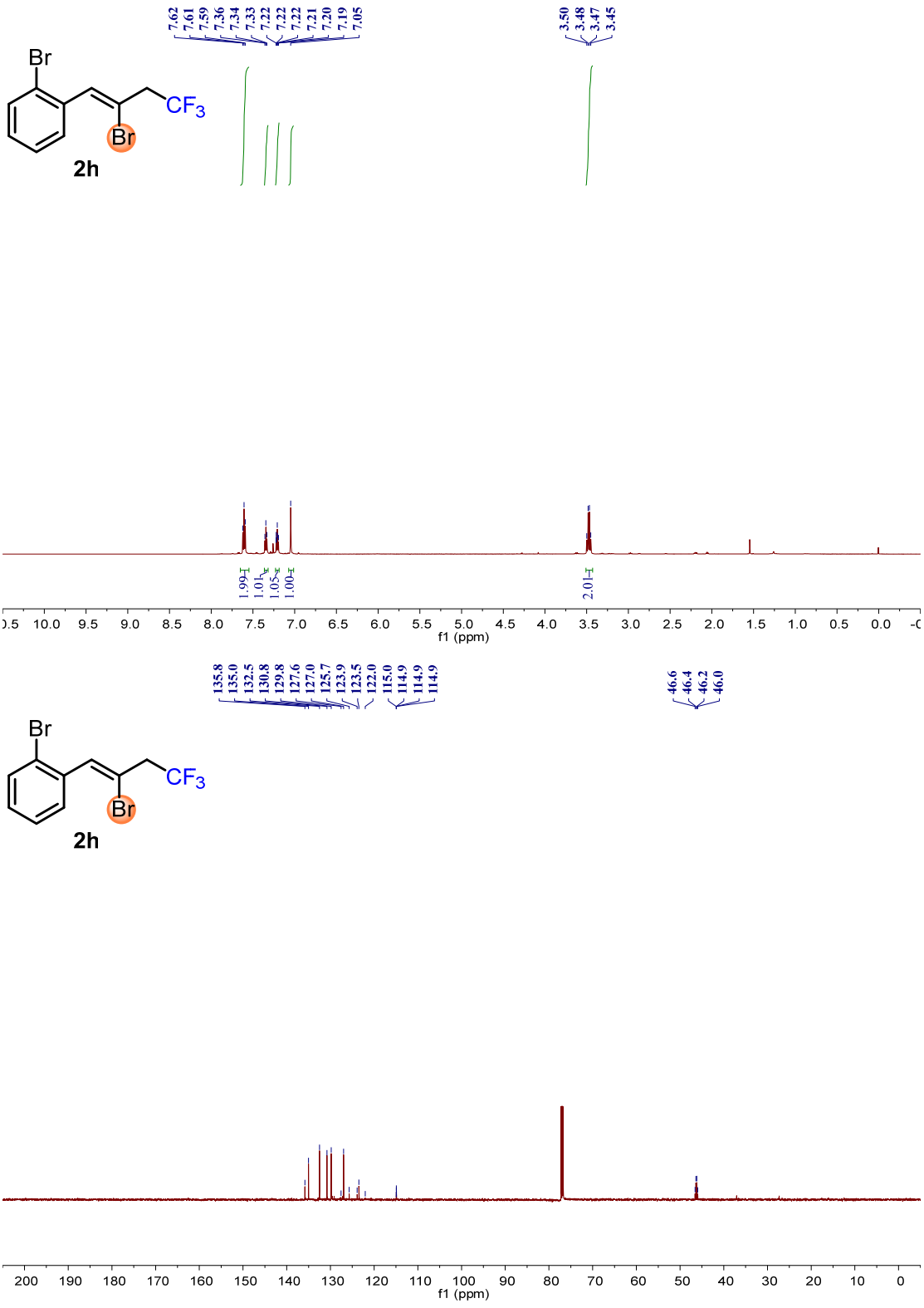

7.55
7.55
7.53
7.53
7.36
7.34
6.94
CF3
Br
Cl

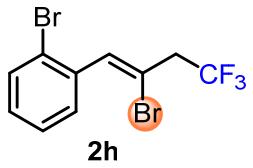
2g

3.46
3.43
3.41
3.38
2.03
2.05
1.00
2.00
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
f1 (ppm)


134.4
133.9
133.3
130.3
129.0
128.5
126.2
123.5
120.7
112.6
112.6
112.5
112.5
47.4
47.1
46.8
46.5
CF3
Br
Cl
2g
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

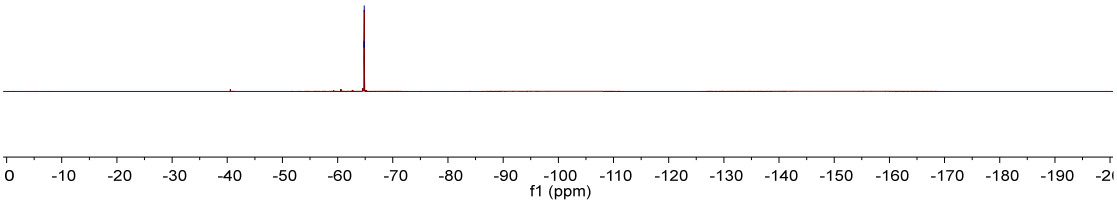

-64.92
-64.95
-64.97
CF3
Br
Cl
2g
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)

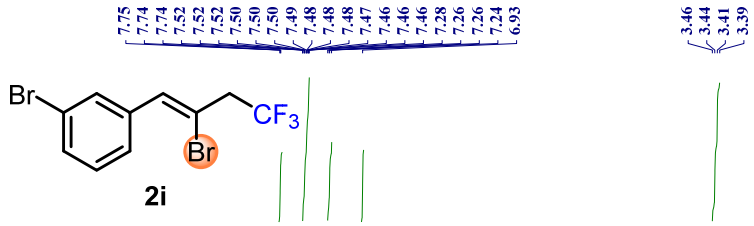

7.62
7.61
7.59
7.36
7.34
7.33
7.22
7.22
7.22
7.21
7.20
7.19
7.05
3.50
3.48
3.47
3.45
Br
CF3
Br
2h
1.99
1.01
1.05
1.00
2.01
f1 (ppm)
135.8
135.0
132.5
130.8
129.8
127.6
127.0
125.7
123.9
123.5
122.0
115.0
114.9
114.9
114.9
46.6
46.4
46.2
46.0
Br
CF3
Br
2h
f1 (ppm)


Br
CF3
Br

2h

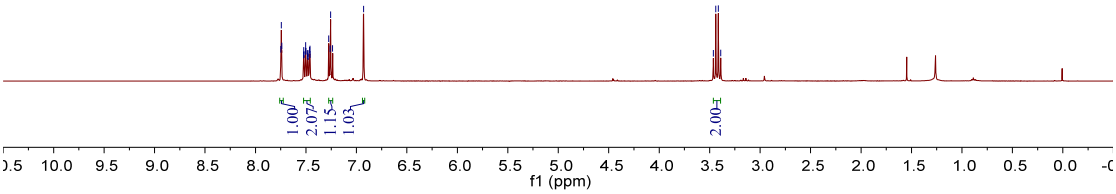

-64.79
-64.81
-64.83

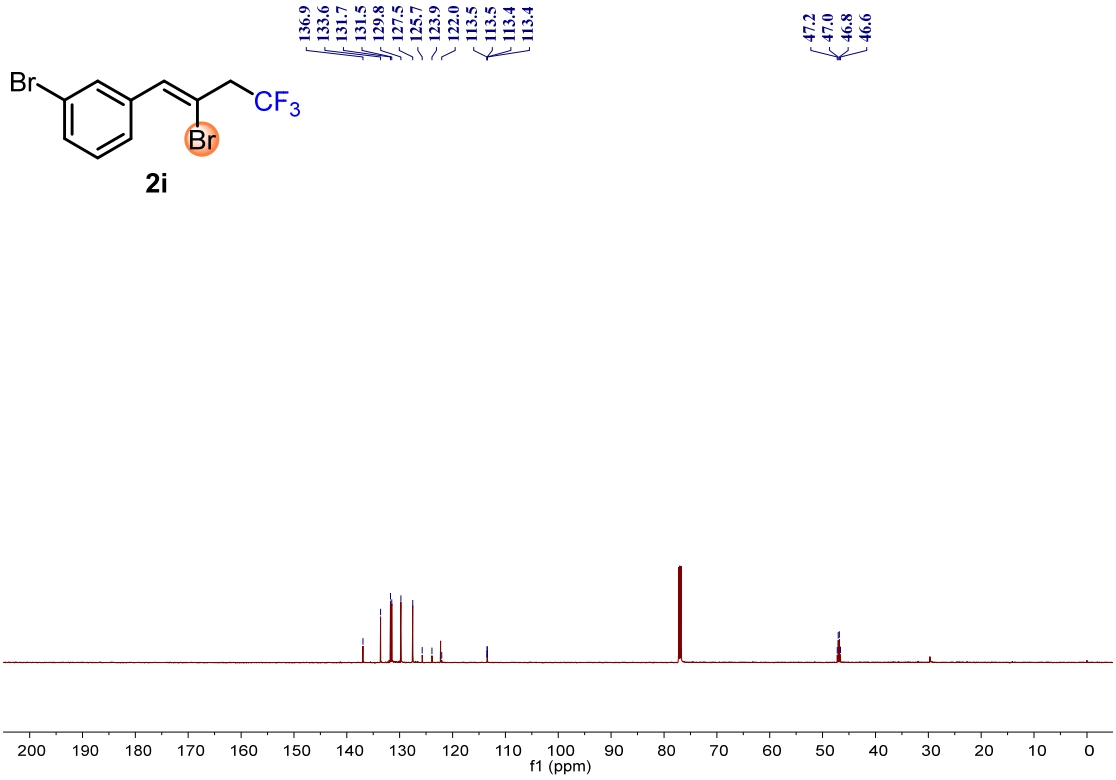

f1 (ppm)

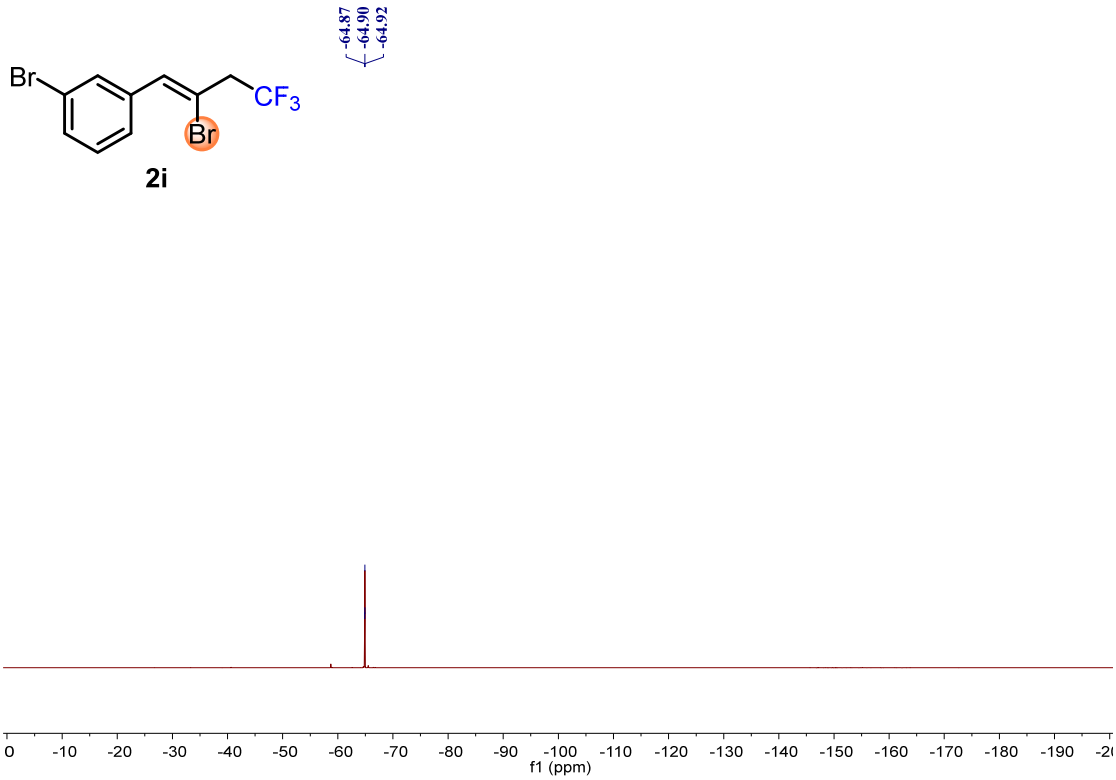

7.75
7.74
7.74
7.52
7.52
7.52
7.50
7.50
7.50
7.49
7.48
7.48
7.48
7.47
7.46
7.46
7.46
7.28
7.26
7.26
7.24
6.93
3.46
3.44
3.41
3.39

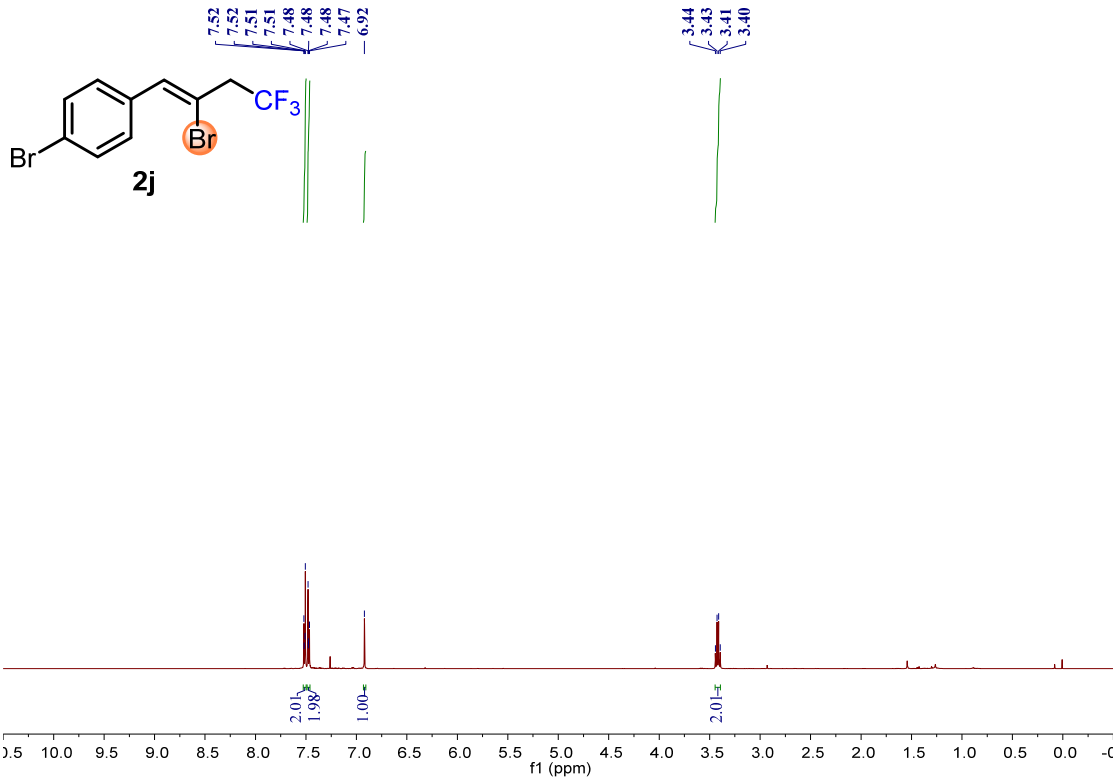
Br
CF3
Br

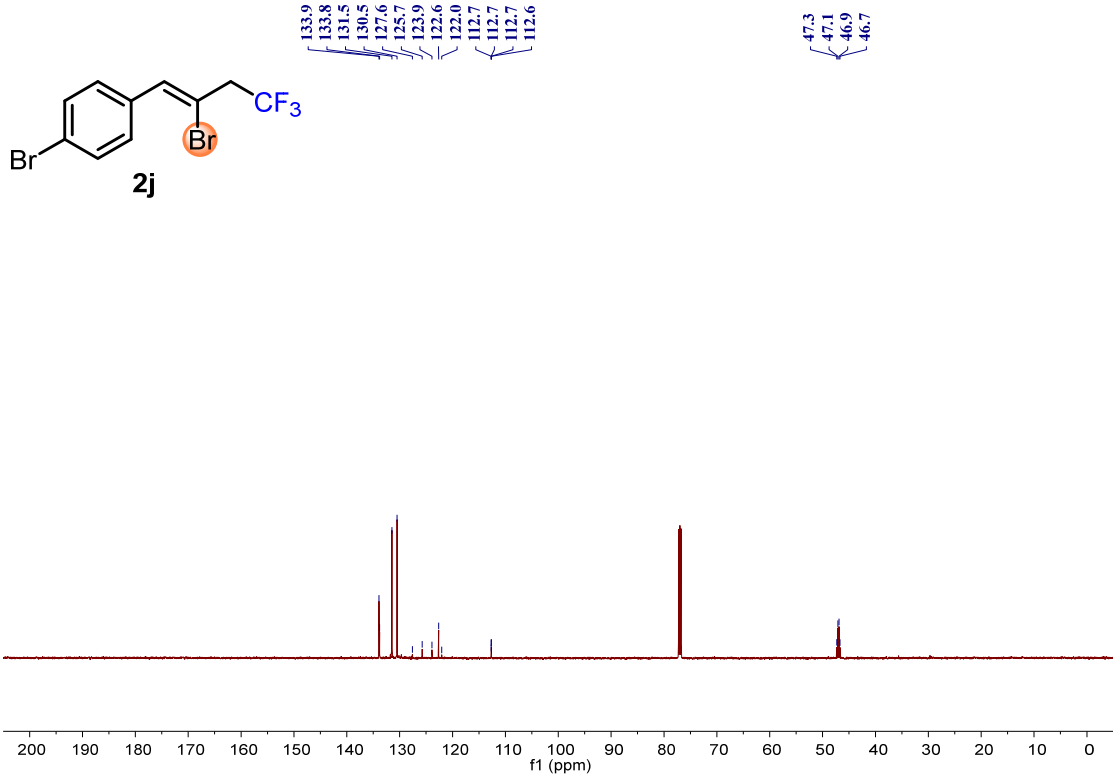
2i


1.00
2.07
1.15
1.03
2.00
f1 (ppm)


136.9
133.6
131.7
131.5
129.8
127.5
125.7
123.9
122.0
113.5
113.5
113.4
113.4
47.2
47.0
46.8
46.6
Br
CF3
Br
2i
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-64.87
-64.90
-64.92
Br
CF3
Br
2i
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)


7.52
7.52
7.51
7.51
7.48
7.48
7.48
7.47
6.92
3.44
3.43
3.41
3.40
CF3
Br
Br
2j
2.01
1.98
1.00
2.01
f1 (ppm)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133.8
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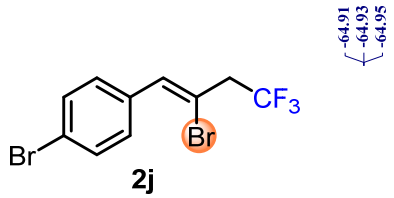
127.6
125.7
123.9
122.6
122.0
112.7
112.7
112.7
112.6
47.3
47.1
46.9
46.7
CF3
Br
Br
2j
f1 (ppm)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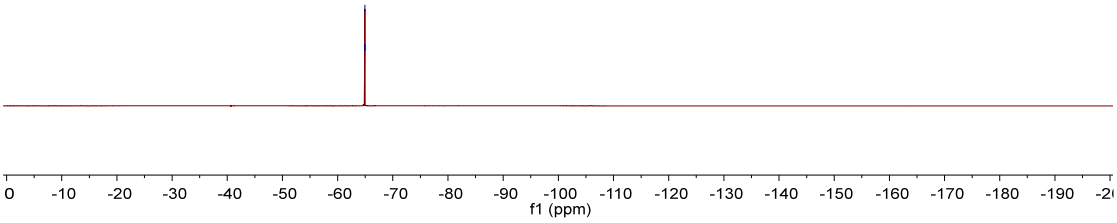
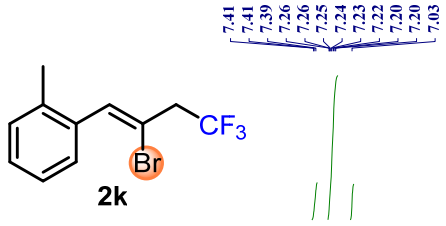
-64.93
-64.95
CF3
Br
Br

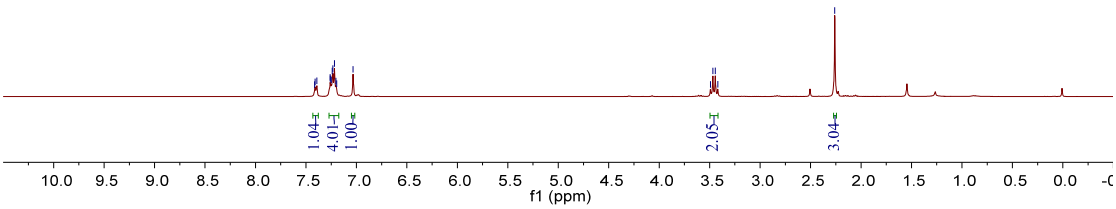
2j

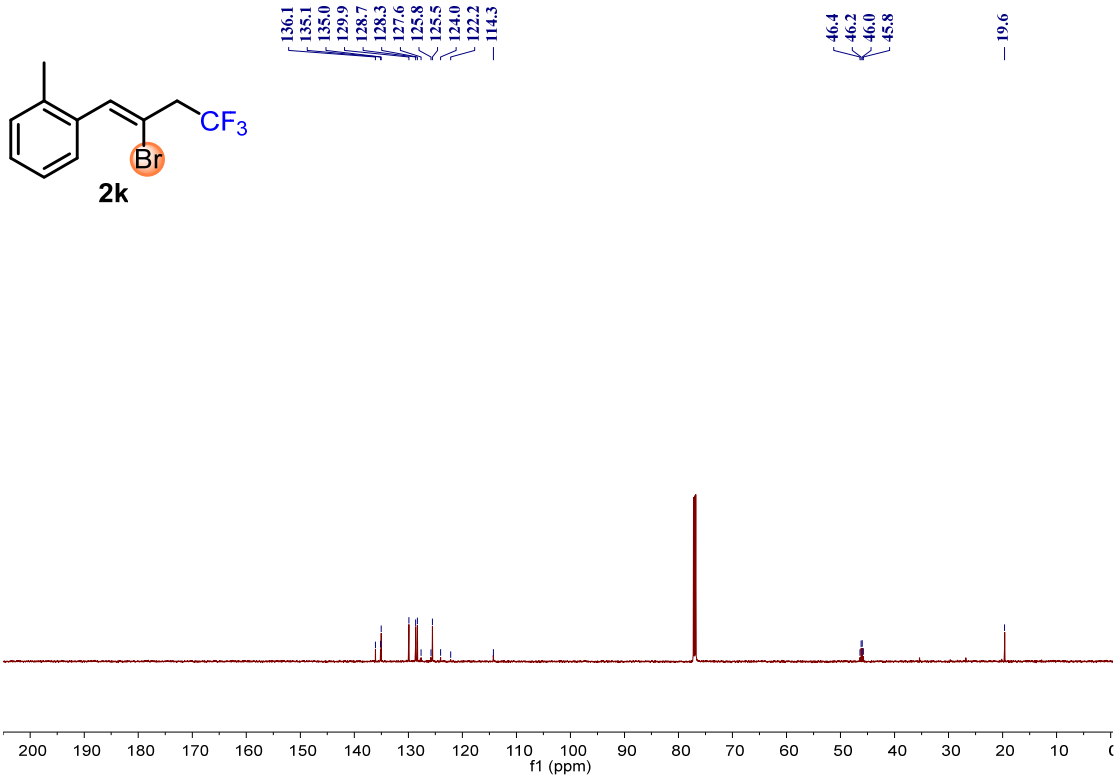

0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)


CF3
Br

2k

7.41
7.41
7.39
7.26
7.26
7.25
7.24
7.23
7.22
7.20
7.20
7.03
3.49
3.47
3.44
3.42
2.26


1.04
4.01
1.00
2.05
3.04
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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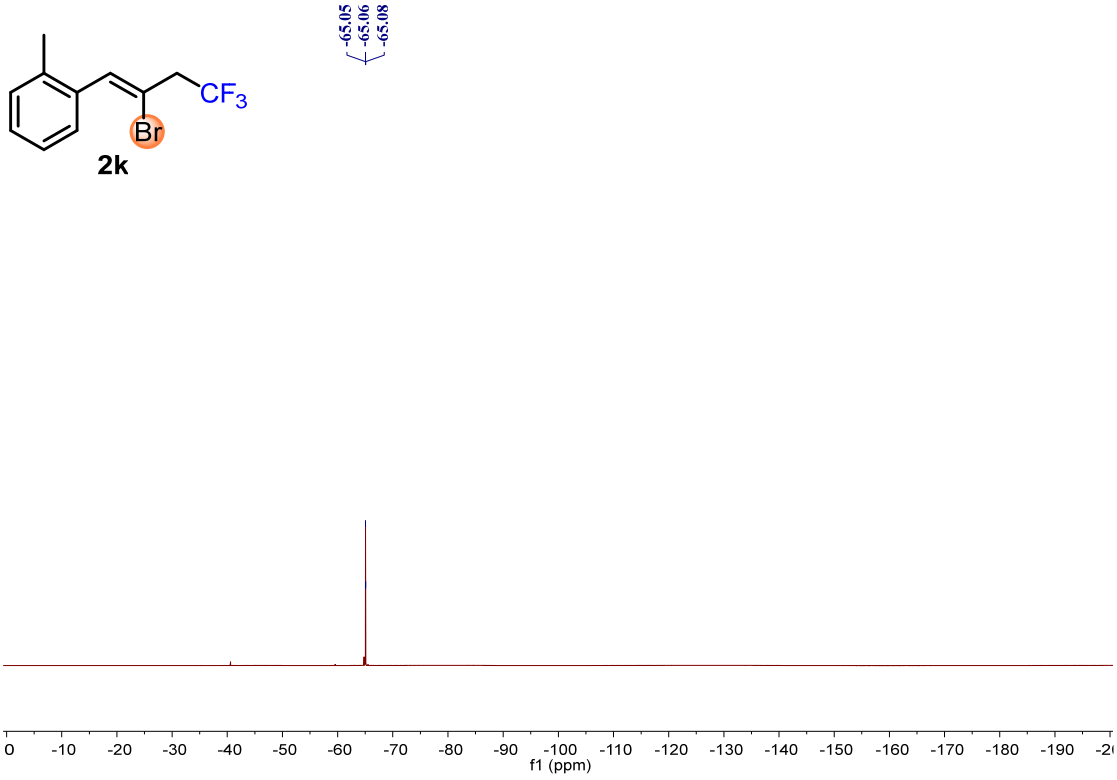
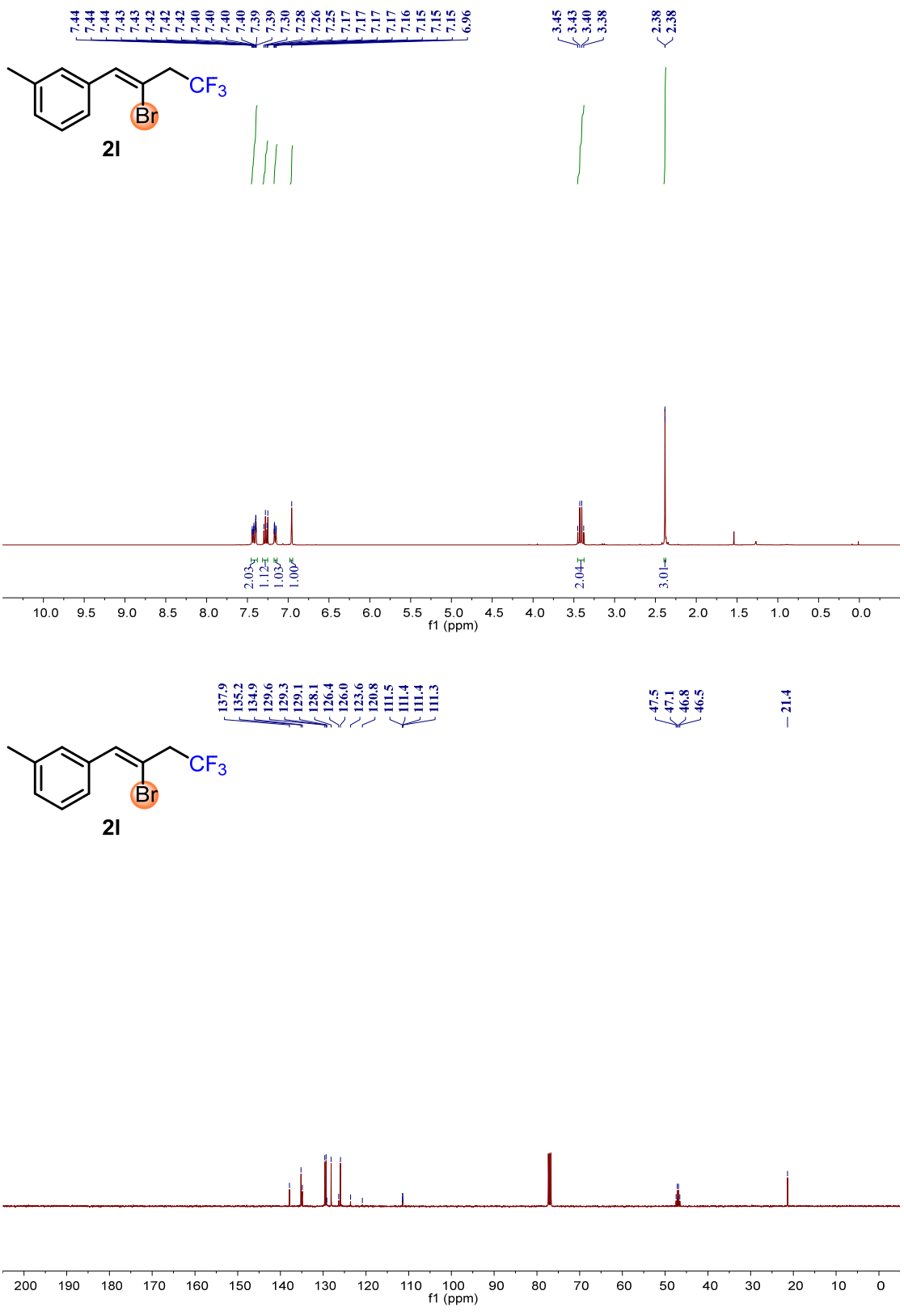
135.1
135.0
129.9
128.7
128.3
127.6
125.8
125.5
124.0
122.2
114.3
46.4
46.2
46.0
45.8
19.6
CF3
Br
2k
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


-65.05
-65.06
-65.08
CF3
Br
2k
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)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7.44
7.44
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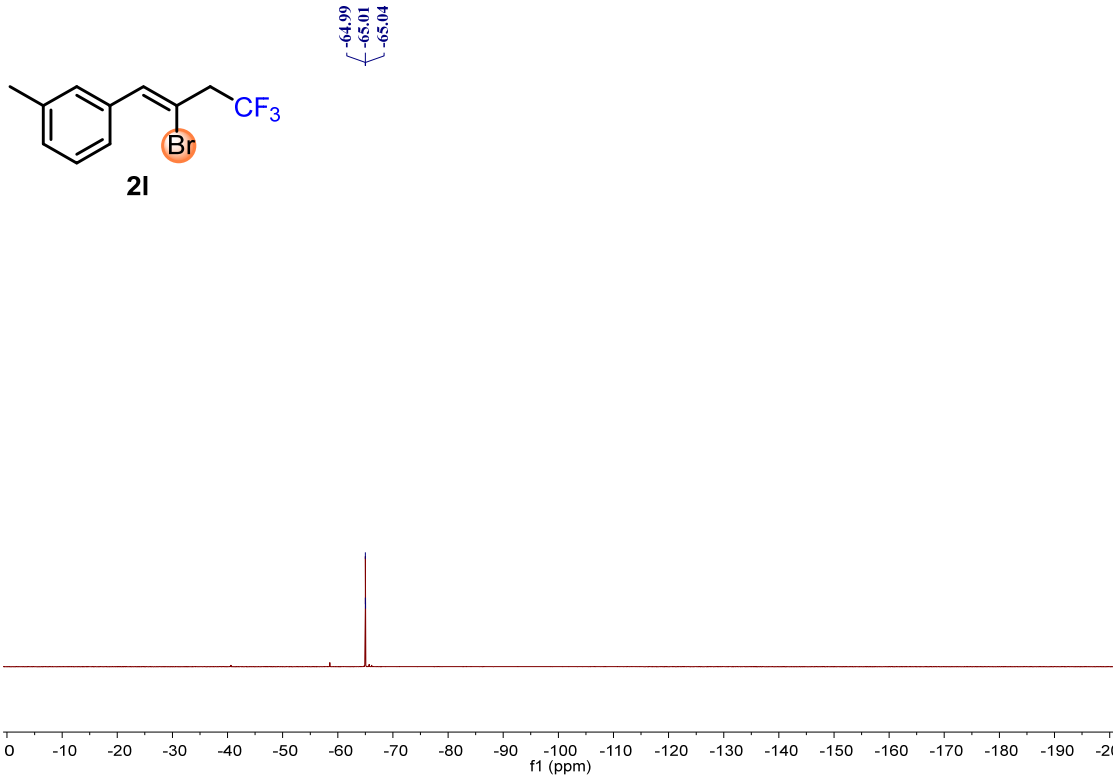
7.42
7.42
7.42
7.40
7.40
7.40
7.40
7.39
7.39
7.30
7.28
7.26
7.25
7.17
7.17
7.17
7.16
7.15
7.15
7.15
6.96
3.45
3.43
3.40
3.38
2.38
2.38
CF3
Br
2l
2.03
1.12
1.03
1.00
2.04
3.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
137.9
135.2
134.9
129.6
129.3
129.1
128.1
126.4
126.0
123.6
120.8
111.5
111.4
111.4
111.3
47.5
47.1
46.8
46.5
21.4
CF3
Br
2l
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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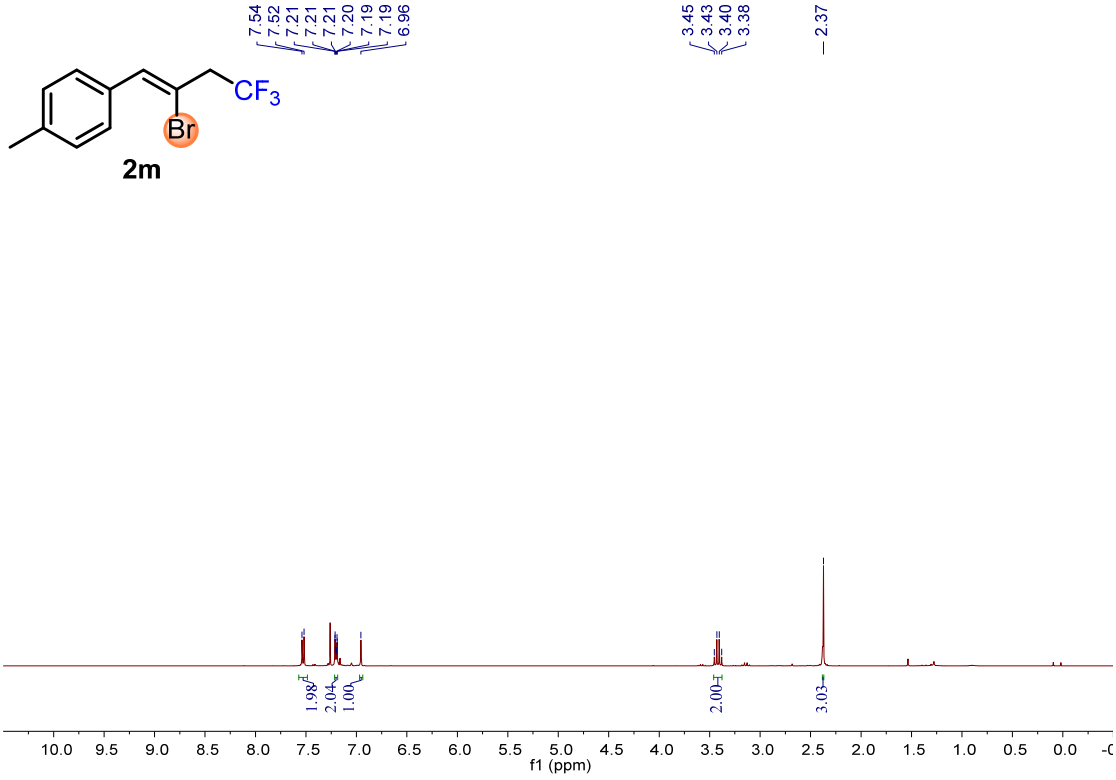
-65.01
-65.04
CF3
Br
2l
f1 (ppm)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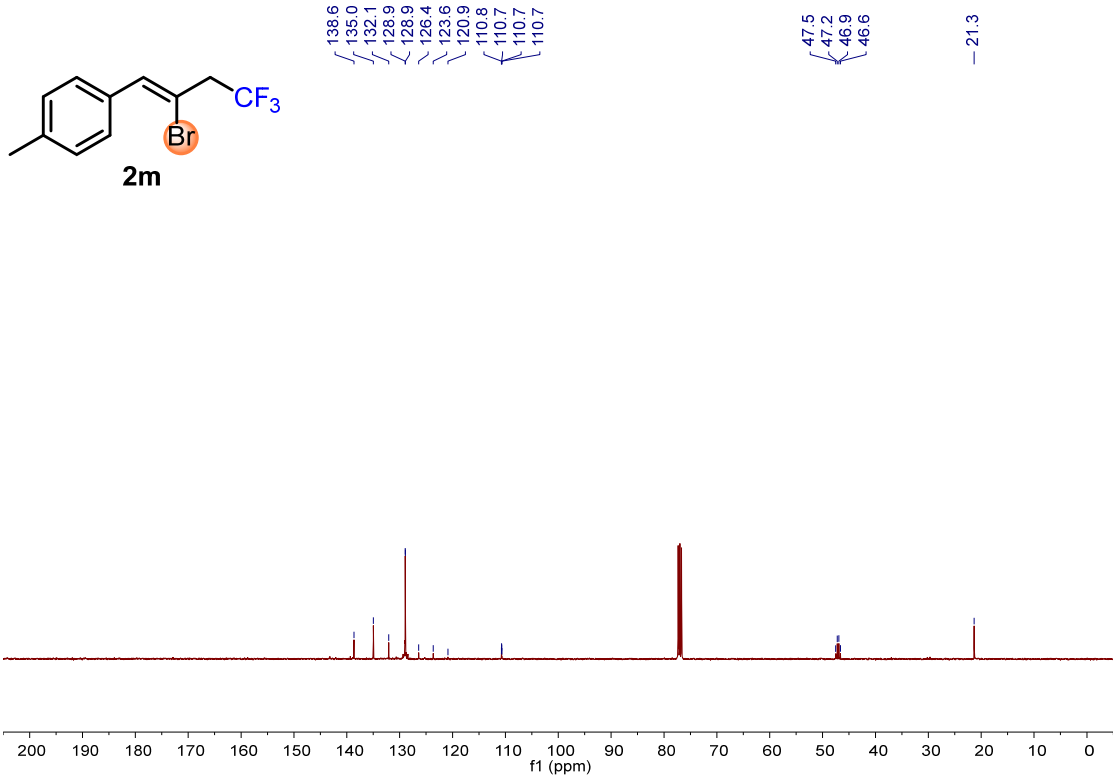
7.21
7.21
7.21
7.20
7.19
7.19
6.96
3.45
3.43
3.40
3.38
2.37
CF3
Br
2m
1.98
2.04
1.00
2.00
3.03
f1 (ppm)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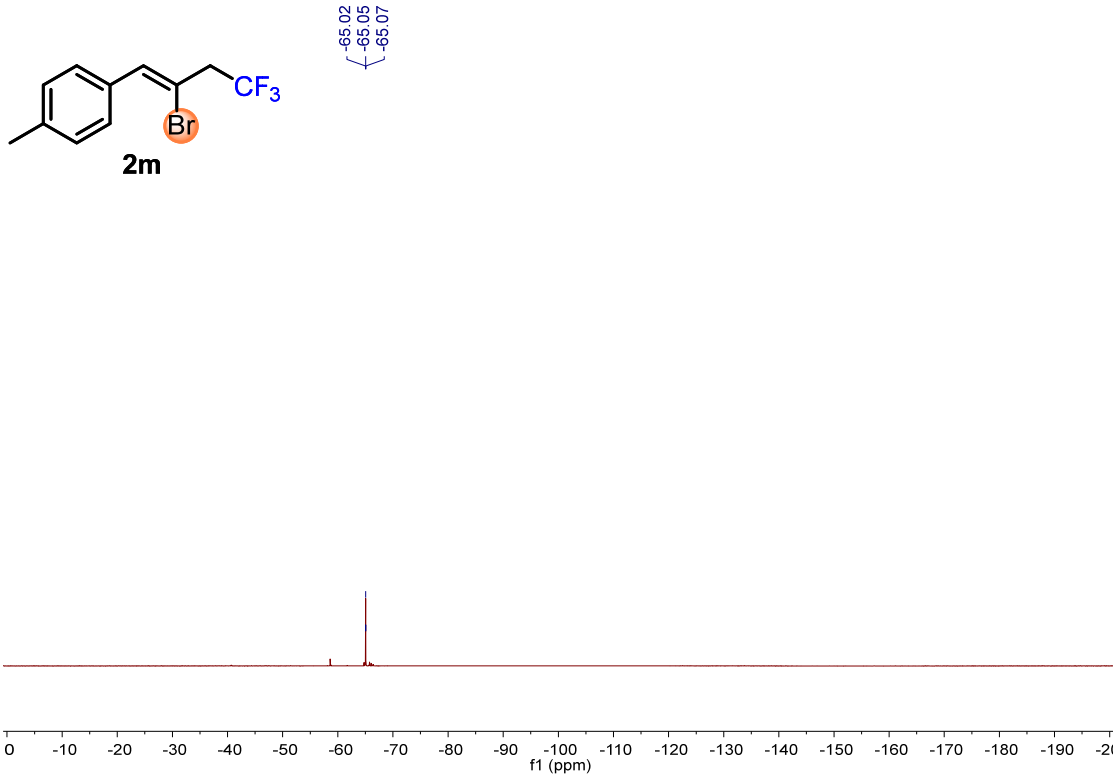
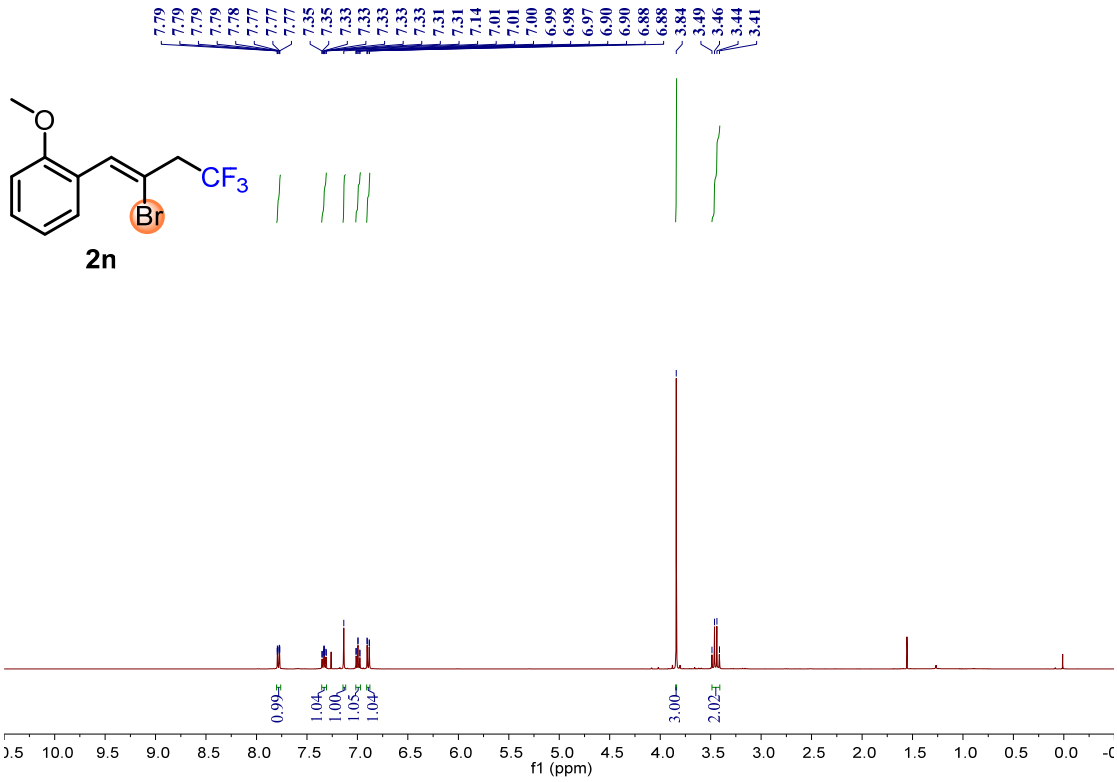
135.0
132.1
128.9
128.9
126.4
123.6
120.9
110.8
110.7
110.7
110.7
47.5
47.2
46.9
46.6
21.3
CF3
Br
2m
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-65.02
-65.05
-65.07
CF3
Br
2m
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)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7.77
7.77
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7.35
7.33
7.33
7.33
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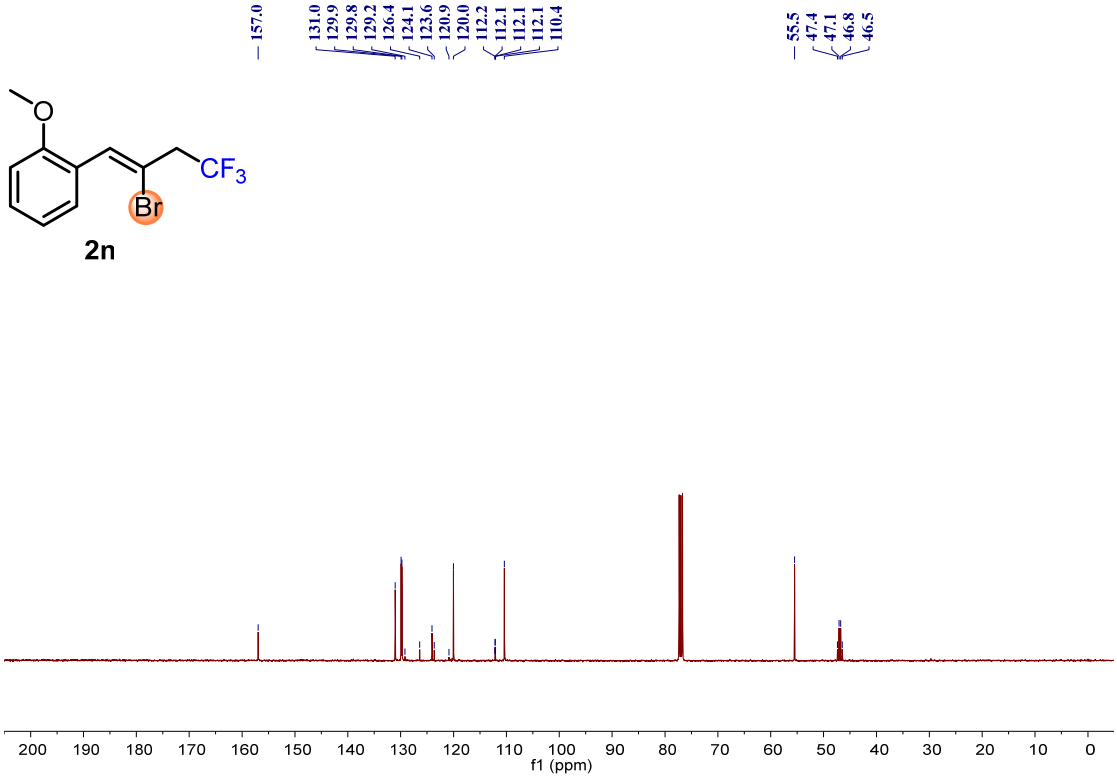
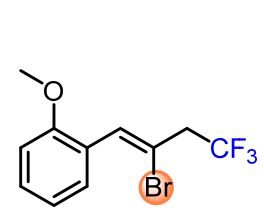
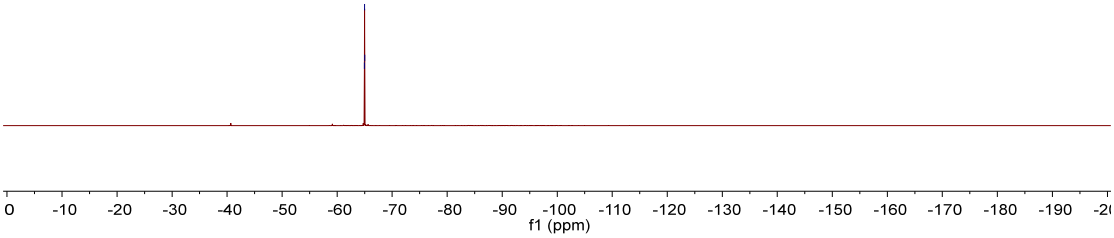
7.33
7.31
7.31
7.14
7.01
7.01
7.00
6.99
6.98
6.97
6.90
6.90
6.88
6.88
3.84
3.49
3.46
3.44
3.41
O
CF3
Br
2n
0.99
1.04
1.00
1.05
1.04
3.00
2.02
f1 (ppm)

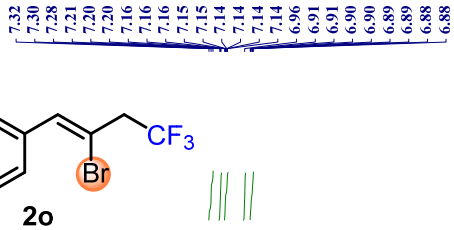

157.0
131.0
129.9
129.8
129.2
126.4
124.1
123.6
120.9
120.0
112.2
112.1
112.1
112.1
110.4
55.5
47.4
47.1
46.8
46.5
O
CF3
Br
2n
f1 (ppm)


O
CF3
Br

2n


-64.97
-64.99
-65.02


0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)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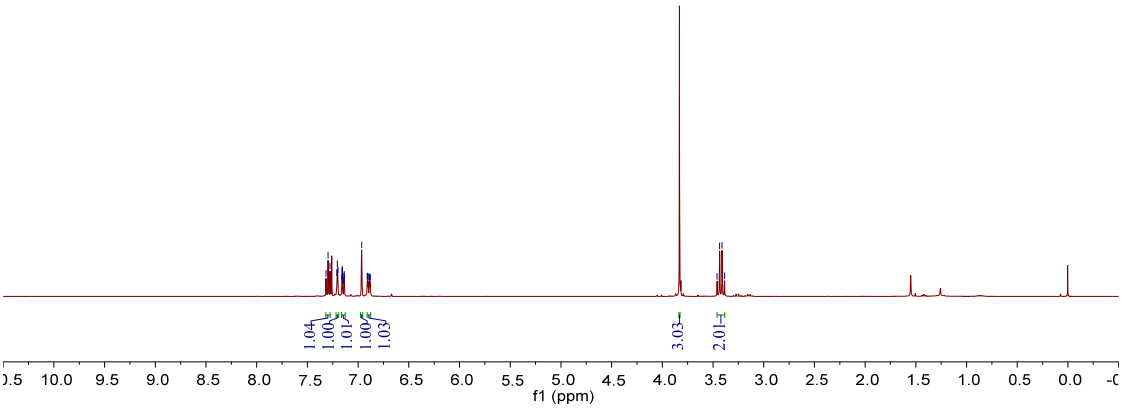
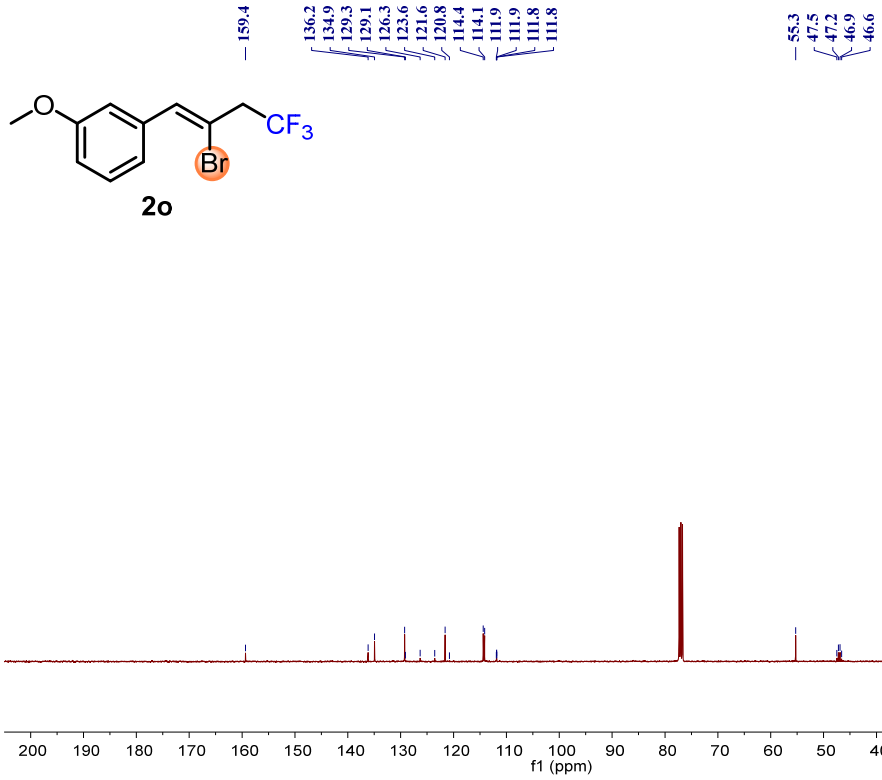
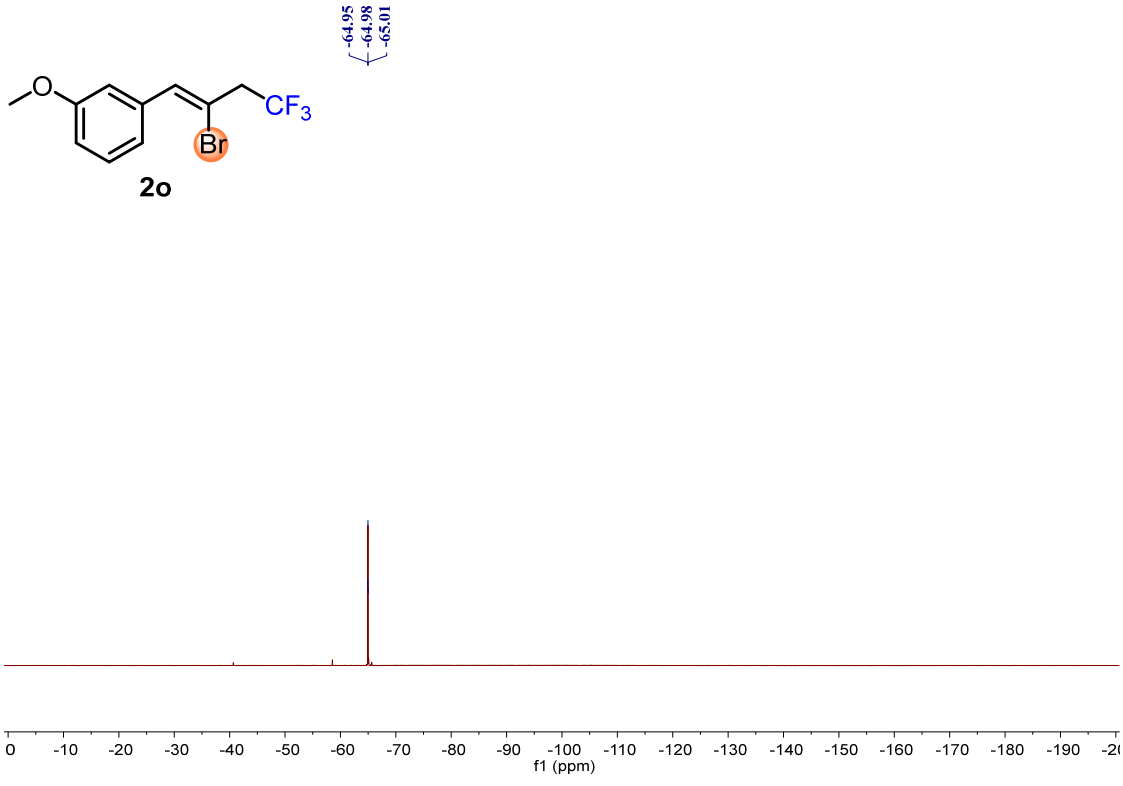
7.30
7.28
7.21
7.20
7.20
7.16
7.16
7.16
7.15
7.15
7.14
7.14
7.14
7.14
6.96
6.91
6.91
6.90
6.90
6.89
6.89
6.88
6.88
3.46
3.44
3.41
3.39

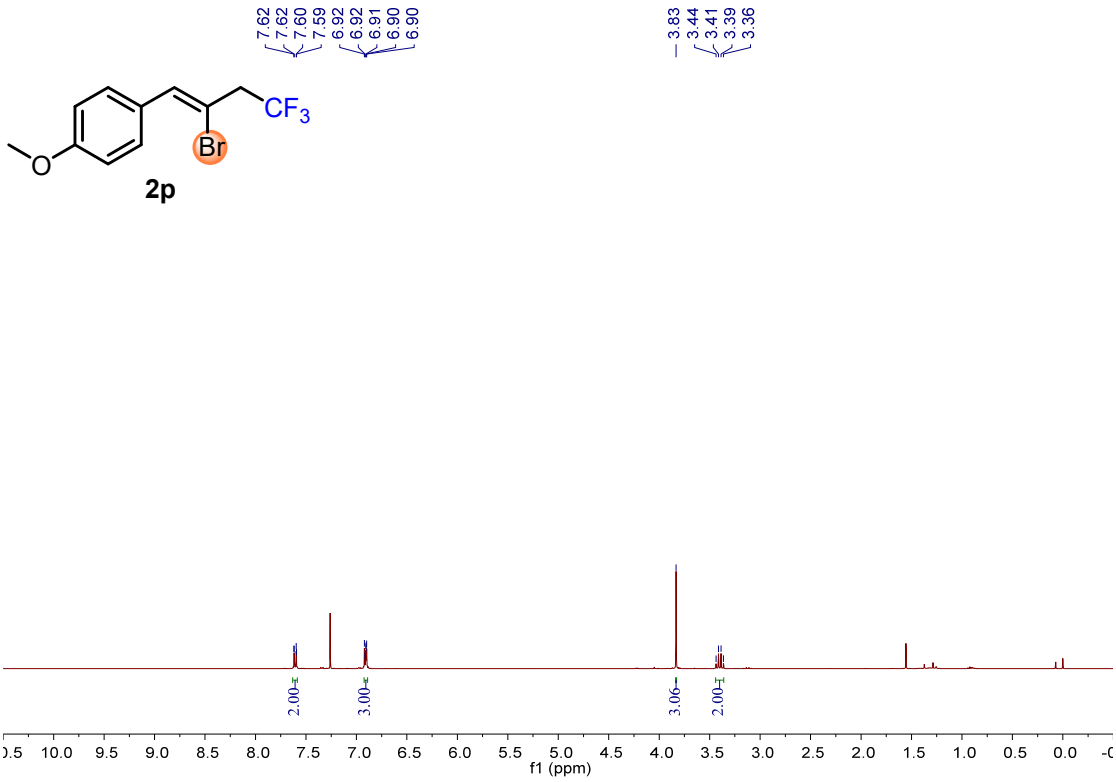
O
CF3
Br

2o


1.04
1.00
1.01
1.00
1.03
3.03
2.01
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
0.0
f1 (ppm)


159.4
136.2
134.9
129.3
129.1
126.3
123.6
121.6
120.8
114.4
114.1
111.9
111.9
111.8
111.8
55.3
47.5
47.2
46.9
46.6
O
CF3
Br
2o
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-64.95
-64.98
-65.01
O
CF3
Br
2o
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)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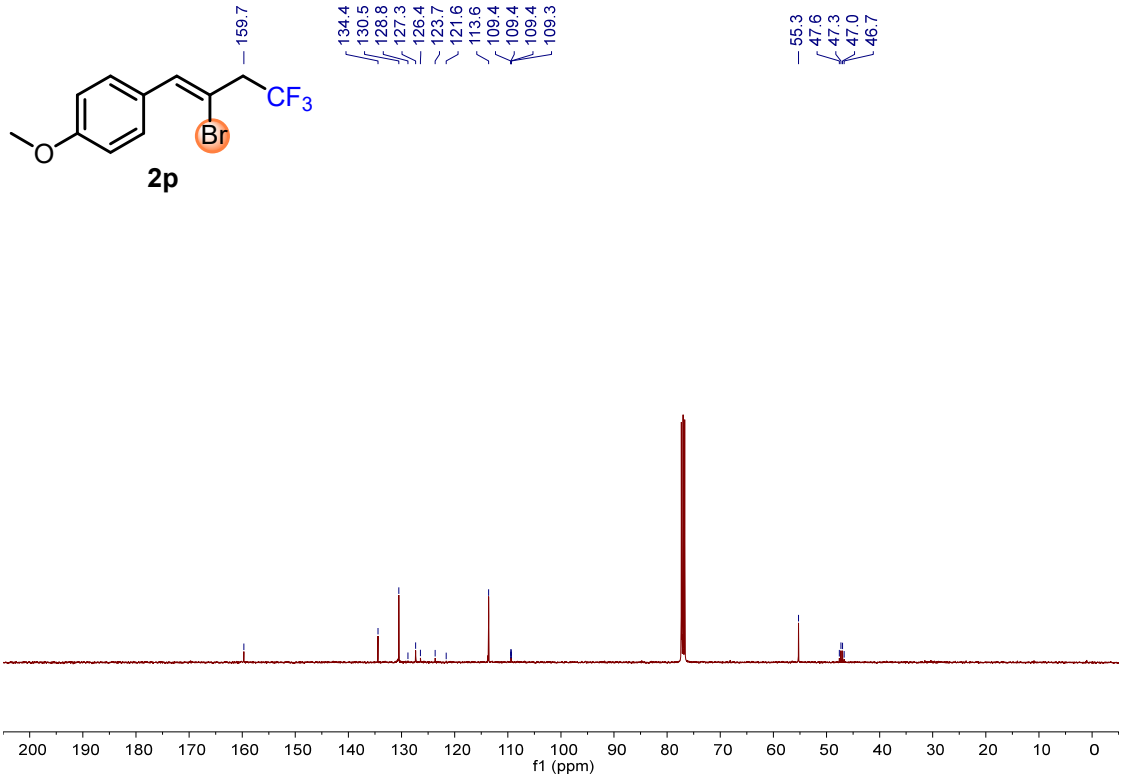
7.62
7.60
7.59
6.92
6.92
6.91
6.90
6.90
3.83
3.44
3.41
3.39
3.36
CF3
Br
O
2p
2.00
3.00
3.06
2.00
f1 (ppm)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134.4
130.5
128.8
127.3
126.4
123.7
121.6
113.6
109.4
109.4
109.4
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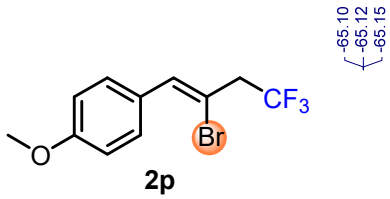
55.3
47.6
47.3
47.0
46.7
CF3
Br
O
2p
f1 (ppm)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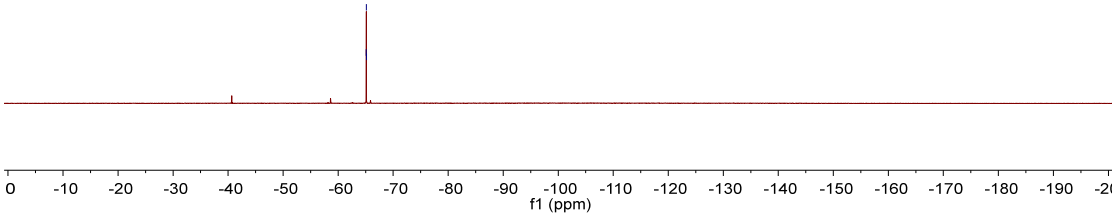
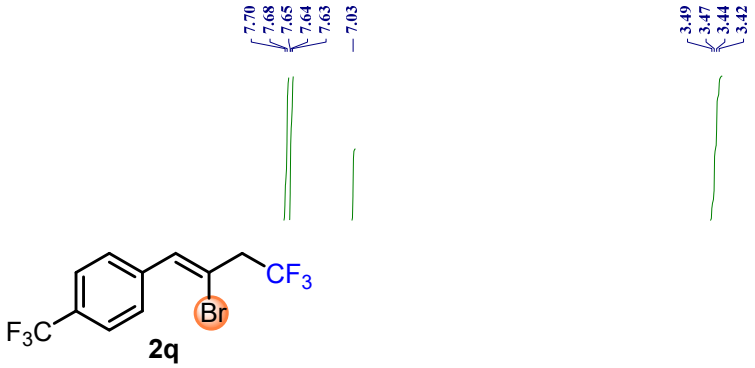
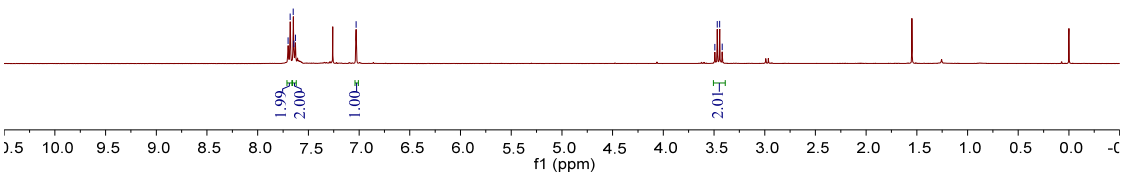
-65.12
-65.15
CF3
Br
O

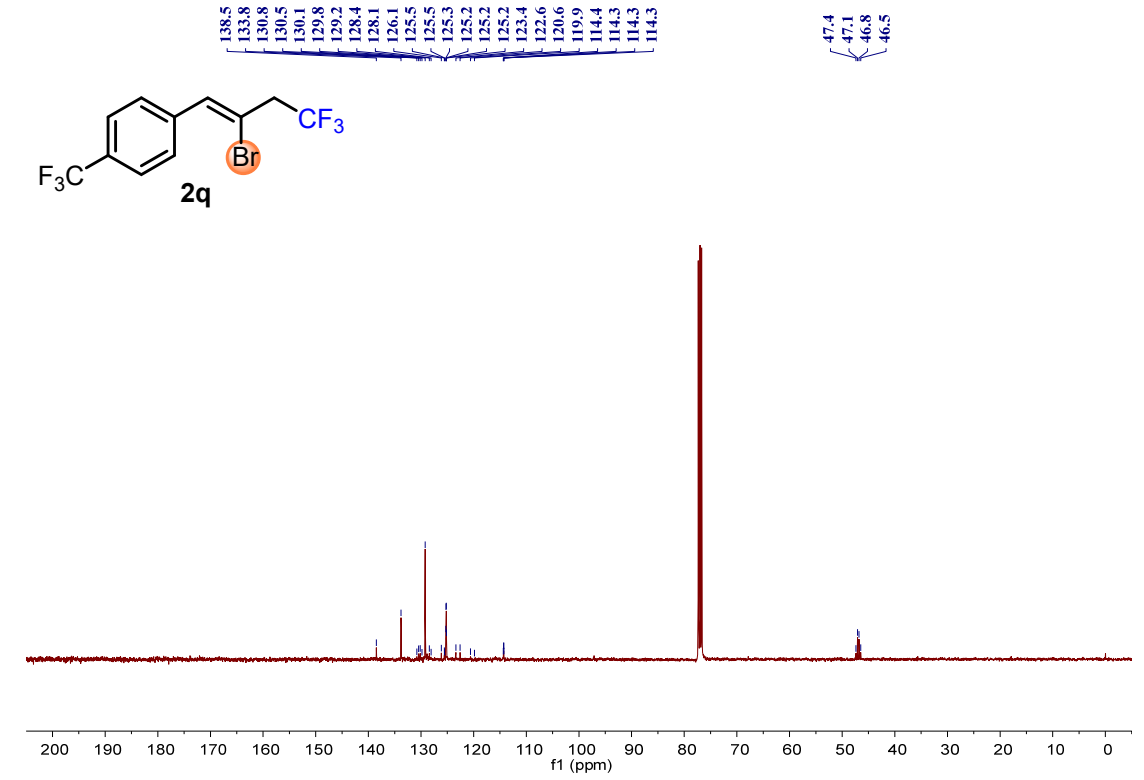
2p


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


7.70
7.68
7.65
7.64
7.63
7.03
3.49
3.47
3.44
3.42
CF3
Br
F3C

2q


1.99
2.00
1.00
2.01
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
0.0
f1 (ppm)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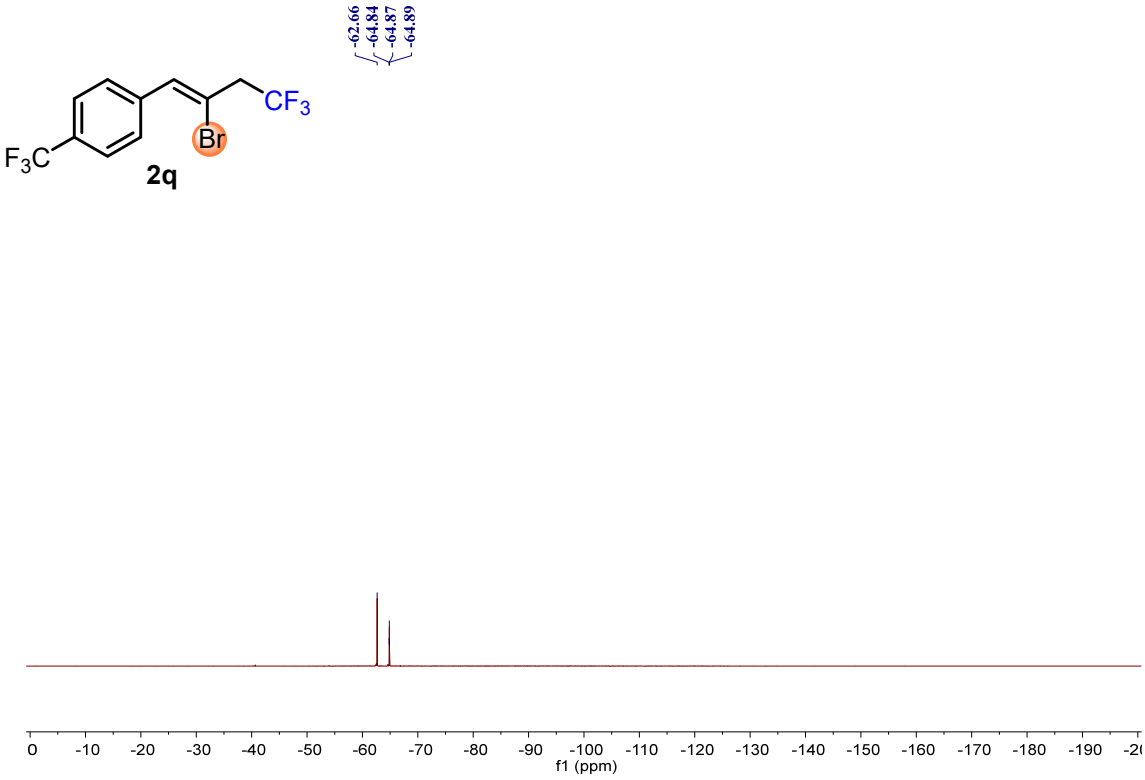
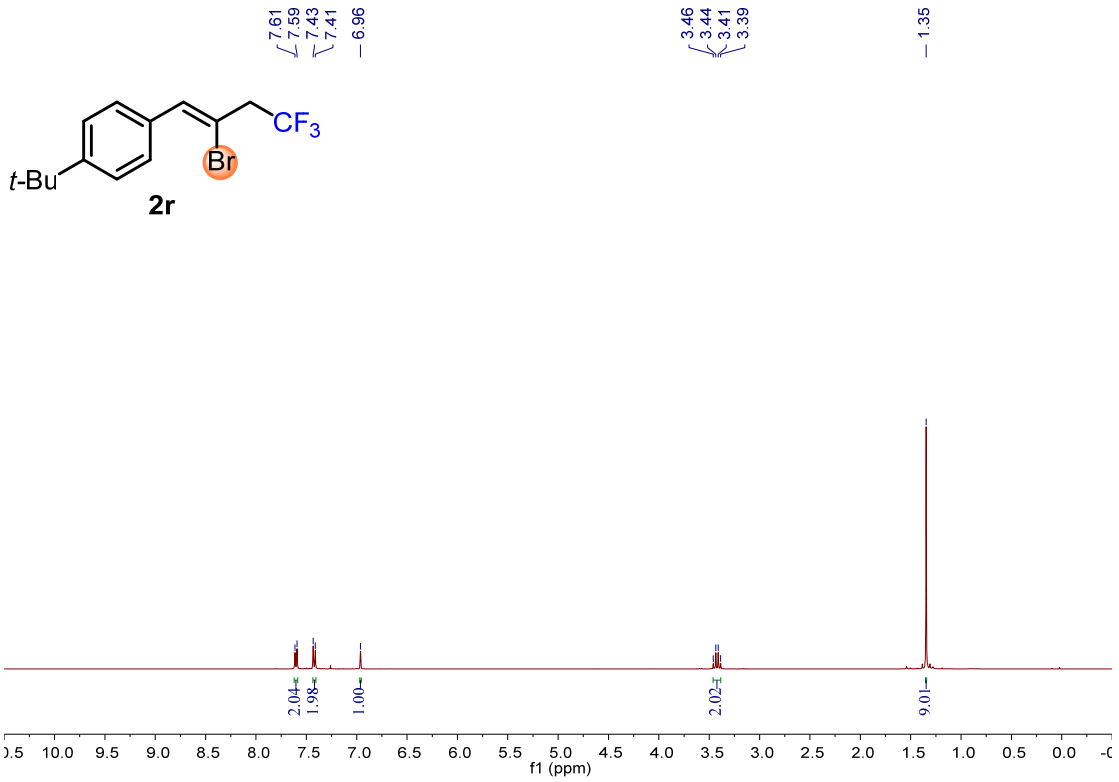
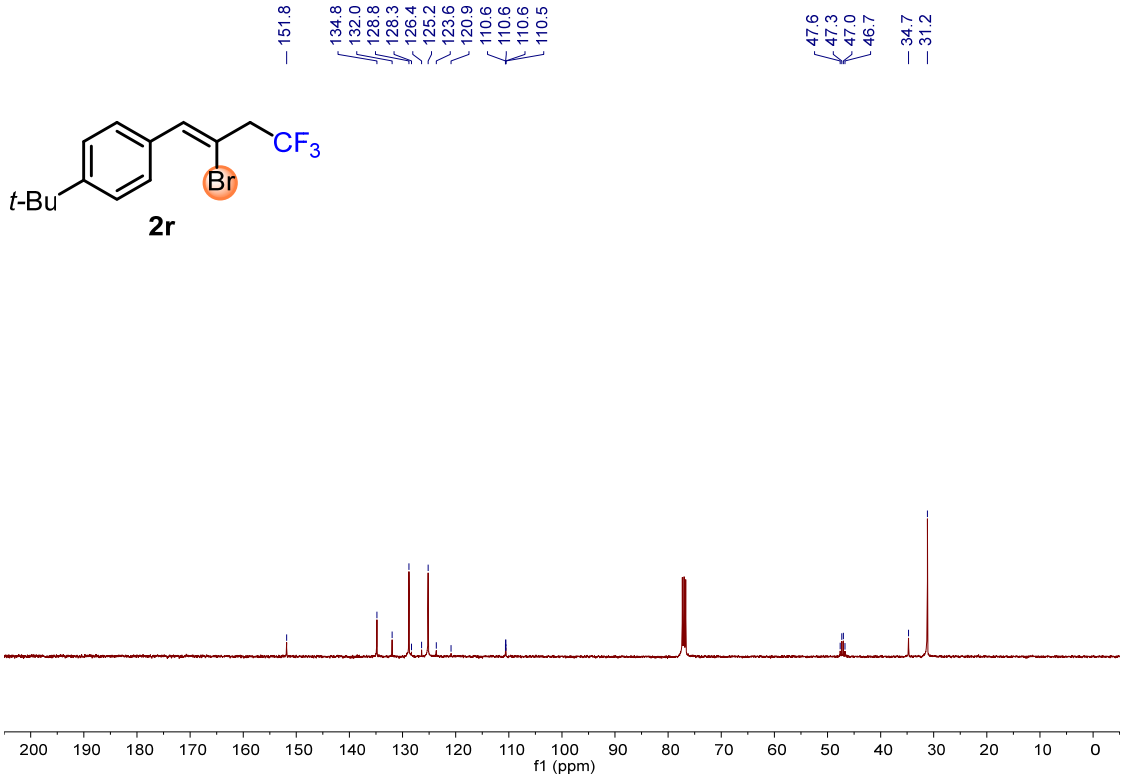
133.8
130.8
130.5
130.1
129.8
129.2
128.4
128.1
126.1
125.5
125.5
125.3
125.2
125.2
125.2
123.4
122.6
120.6
119.9
114.4
114.3
114.3
114.3
47.4
47.1
46.8
46.5
CF3
Br
F3C
2q
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-62.66
-64.84
-64.87
-64.89
CF3
Br
F3C
2q
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)


7.61
7.59
7.43
7.41
6.96
3.46
3.44
3.41
3.39
1.35
CF3
Br
t-Bu
2r
2.04
1.98
1.00
2.02
9.01
f1 (ppm)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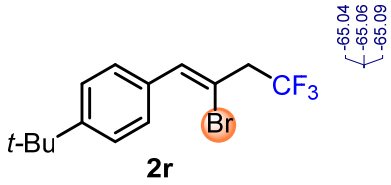
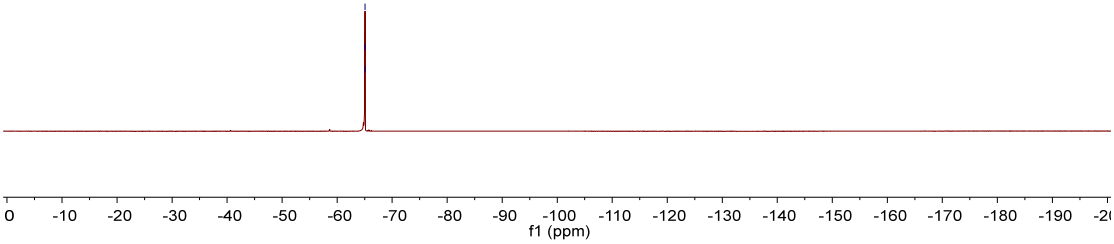
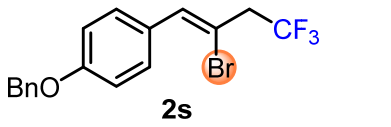
134.8
132.0
128.8
128.3
126.4
125.2
123.6
120.9
110.6
110.6
110.6
110.5
47.6
47.3
47.0
46.7
34.7
31.2
CF3
Br
t-Bu
2r
f1 (ppm)


-65.04
-65.06
-65.09
CF3
Br
t-Bu

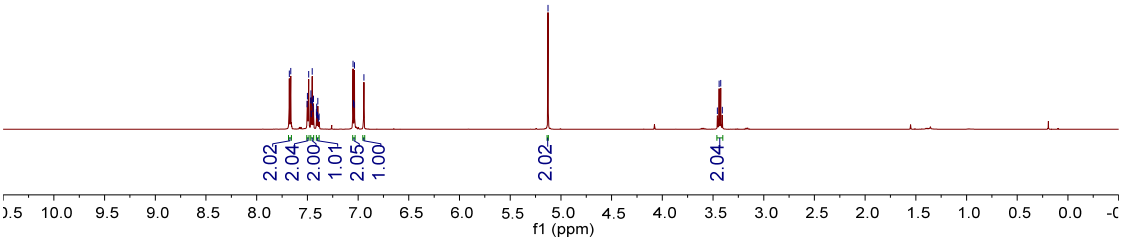
2r

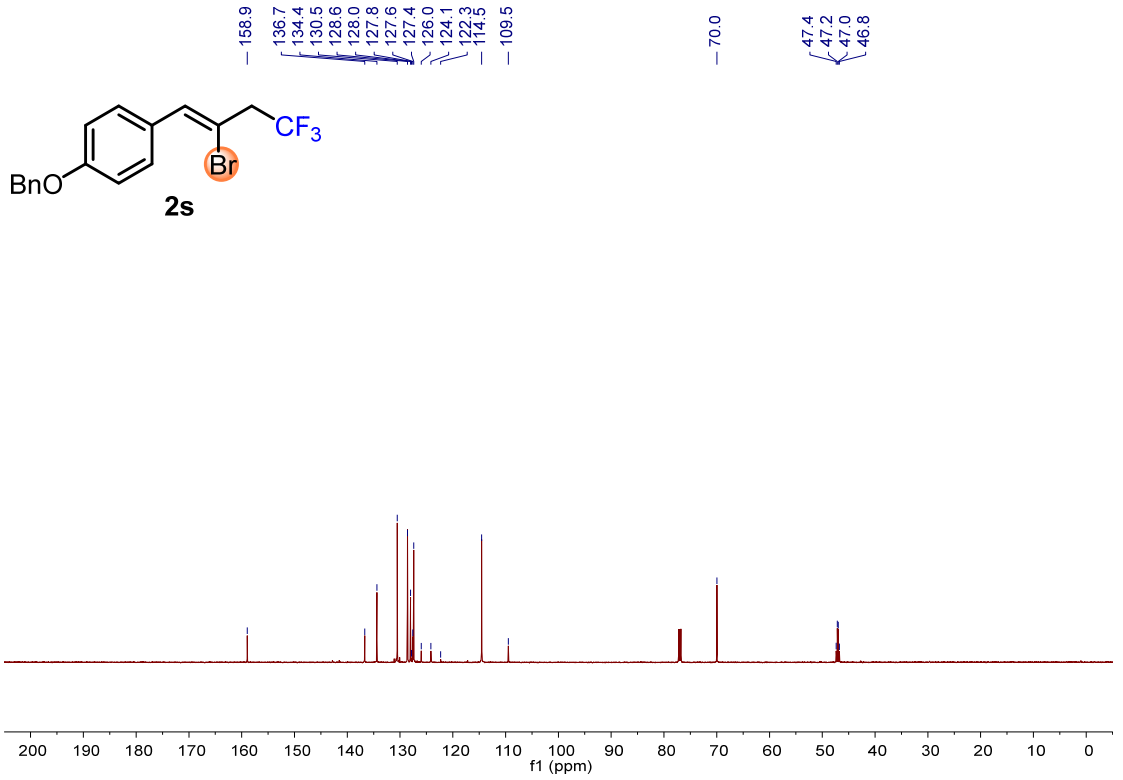

f1 (ppm)

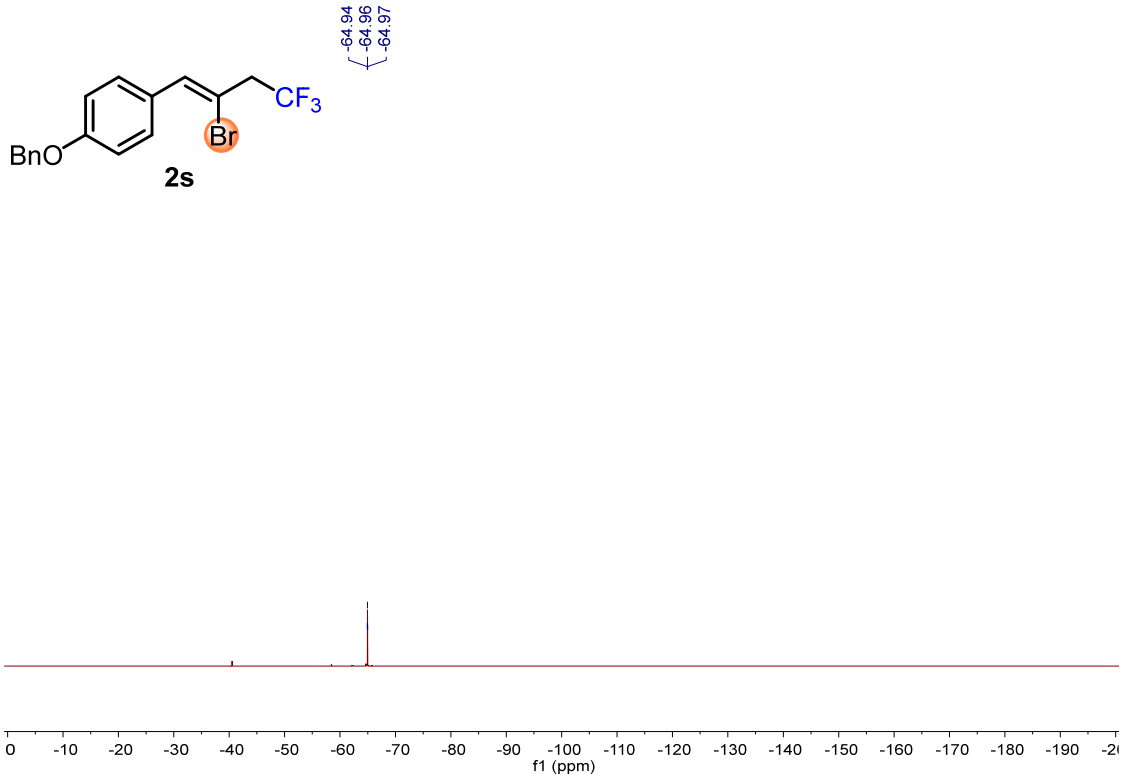

7.68
7.66
7.50
7.49
7.47
7.47
7.46
7.46
7.45
7.45
7.44
7.44
7.41
7.41
7.41
7.40
7.40
7.39
7.38
7.05
7.05
7.04
7.04
6.94
5.13
3.46
3.44
3.42
3.41

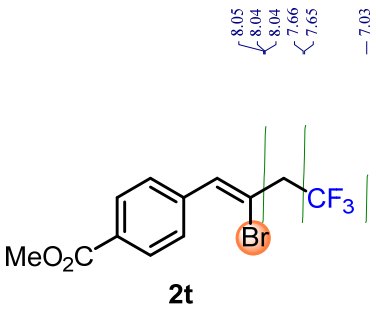

CF3
Br
BnO

2s

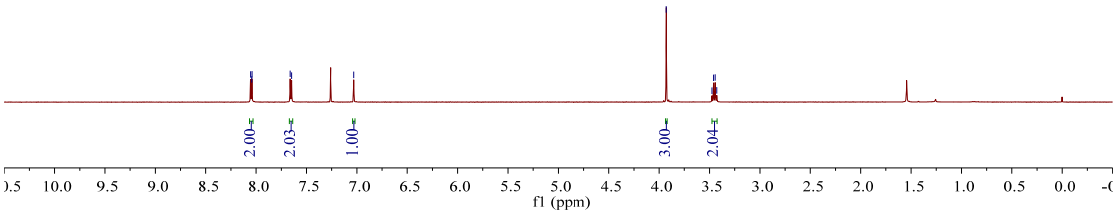

2.02
2.04
2.00
1.01
2.05
1.00
2.02
2.04
f1 (ppm)

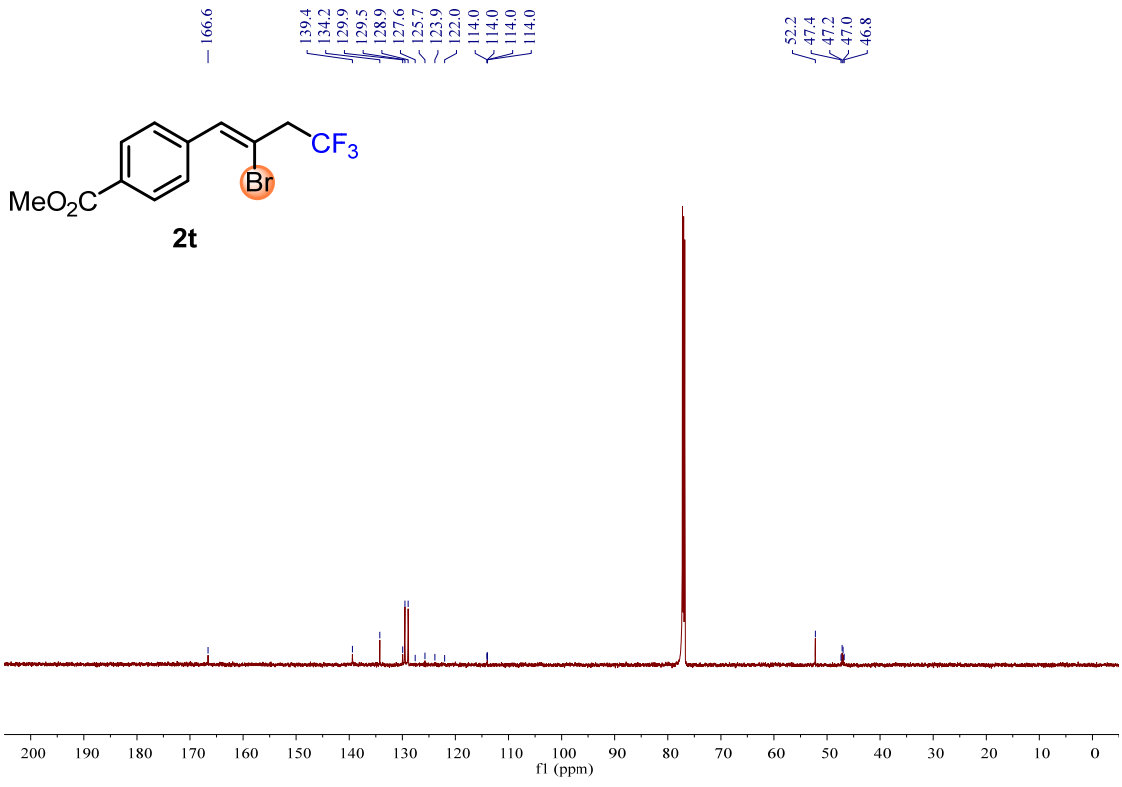

158.9
136.7
134.4
130.5
128.6
128.0
127.8
127.6
127.4
126.0
124.1
122.3
114.5
109.5
70.0
47.4
47.2
47.0
46.8
CF3
Br
BnO
2s
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-64.94
-64.96
-64.97
CF3
Br
BnO
2s
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)

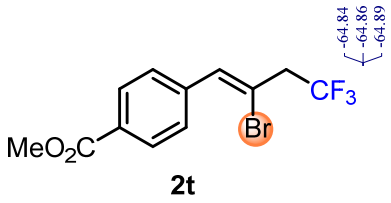

8.05
8.04
8.04
7.66
7.65
7.03
3.93
3.48
3.46
3.44
3.43
CF3
Br
MeO2C

2t

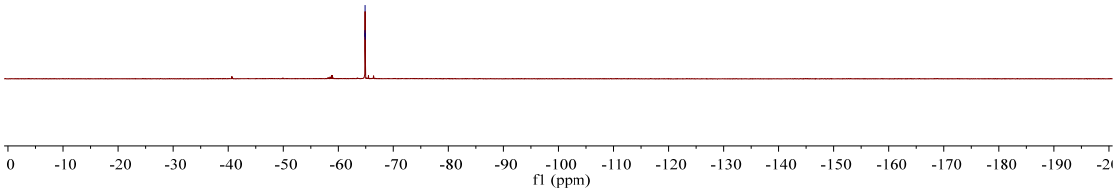

2.00
2.03
1.00
3.00
2.04
f1 (ppm)

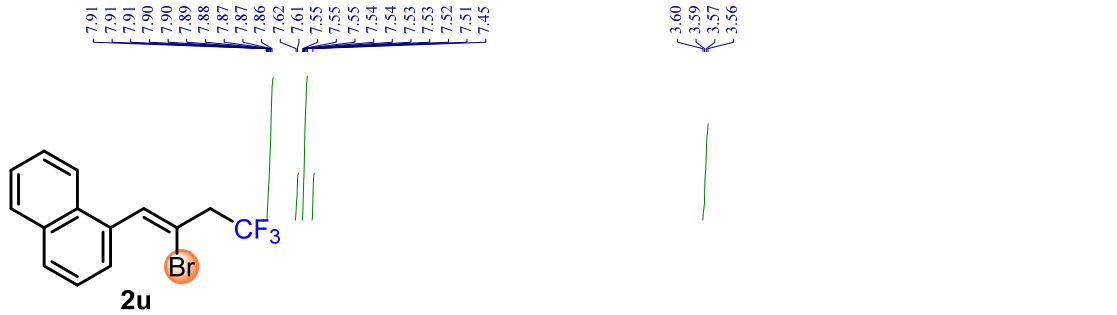

166.6
139.4
134.2
129.9
129.5
128.9
127.6
125.7
123.9
122.0
114.0
114.0
114.0
114.0
52.2
47.4
47.2
47.0
46.8
CF3
Br
MeO2C
f1 (ppm)

2t

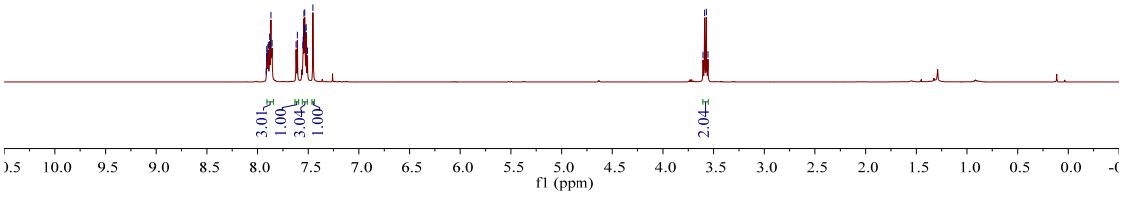

-64.84
-64.86
-64.89
CF3
Br
MeO2C

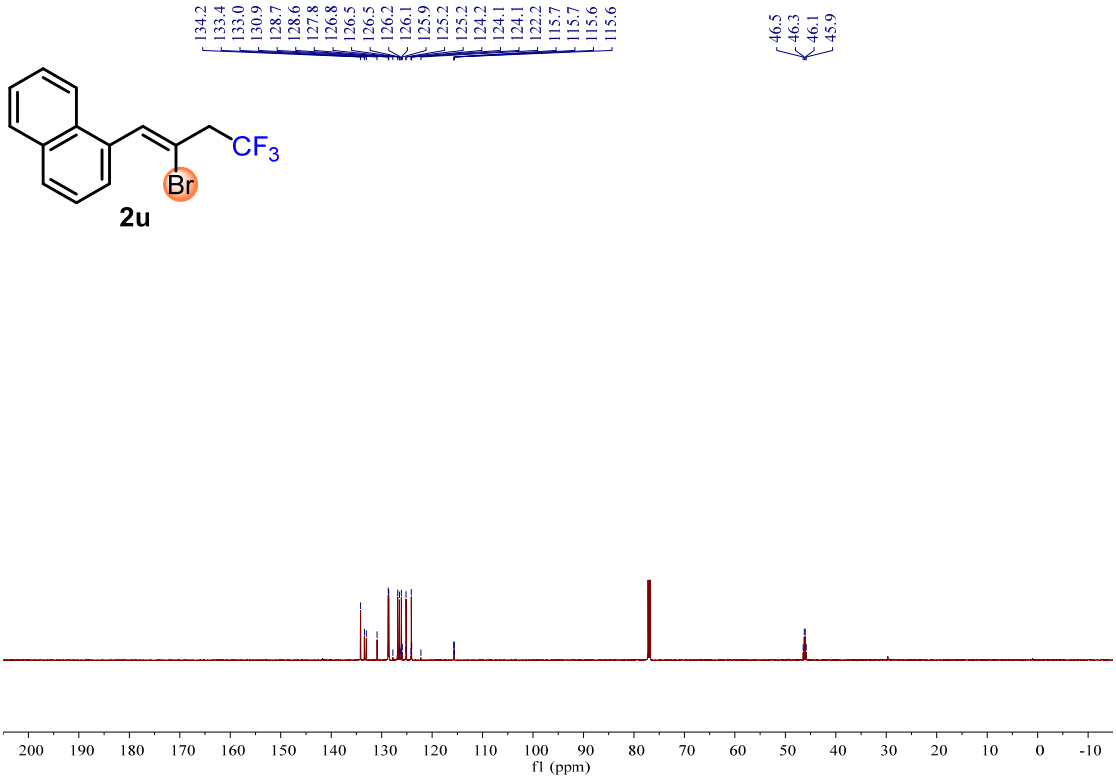
2t

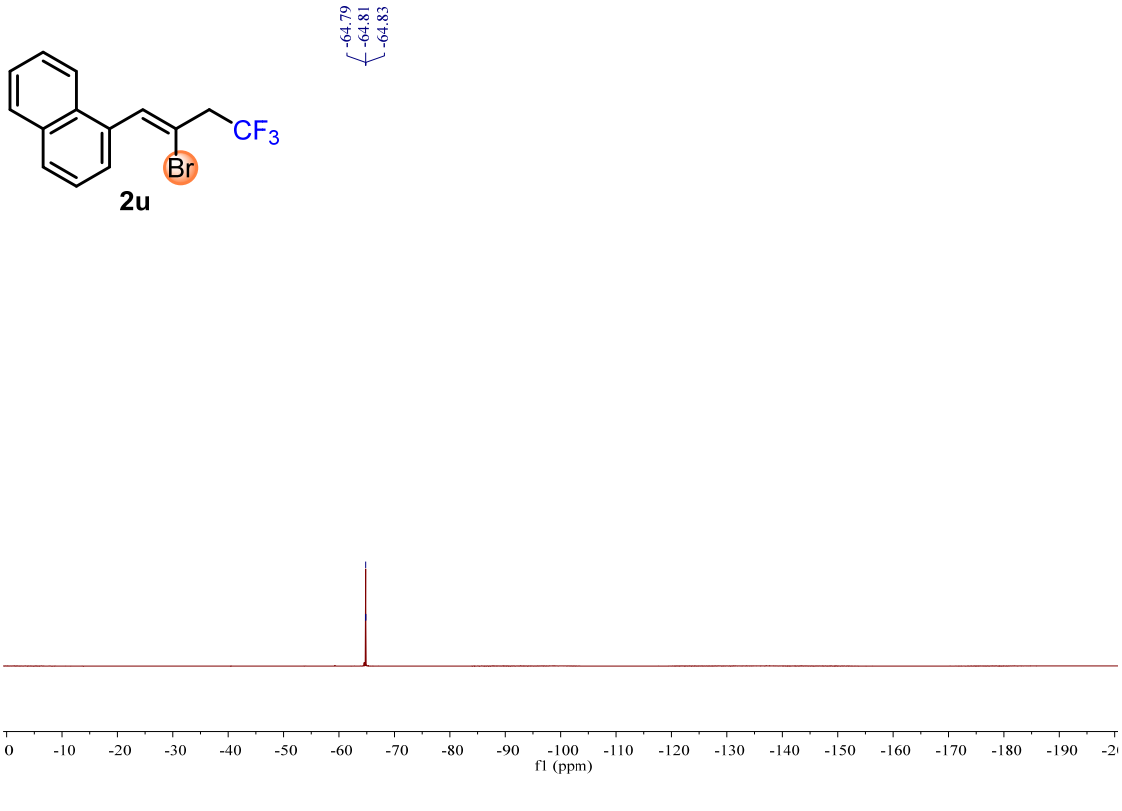

f1 (ppm)

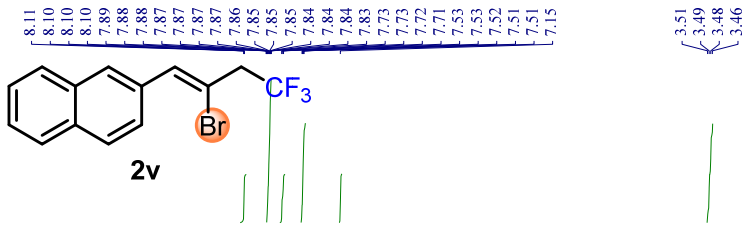

7.91
7.91
7.91
7.90
7.90
7.89
7.88
7.87
7.87
7.86
7.62
7.61
7.55
7.55
7.55
7.54
7.54
7.53
7.53
7.52
7.51
7.45
3.60
3.59
3.57
3.56
CF3
Br

2u

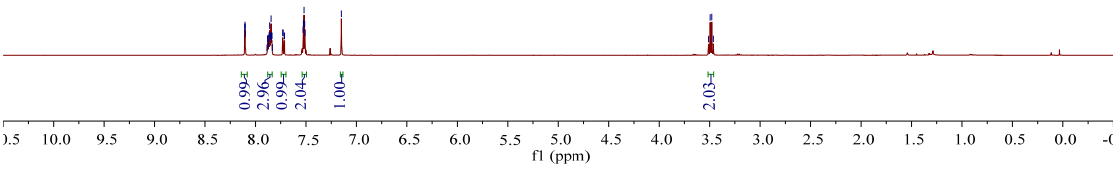

3.01
1.00
3.04
1.00
2.04
f1 (ppm)

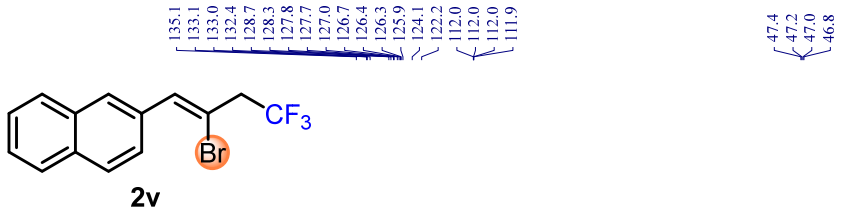

134.2
133.4
133.0
130.9
128.7
128.6
127.8
126.8
126.5
126.5
126.2
126.1
125.9
125.2
125.2
124.2
124.1
124.1
122.2
115.7
115.7
115.6
115.6
46.5
46.3
46.1
45.9
CF3
Br
2u
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


-64.79
-64.81
-64.83
CF3
Br
2u
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)

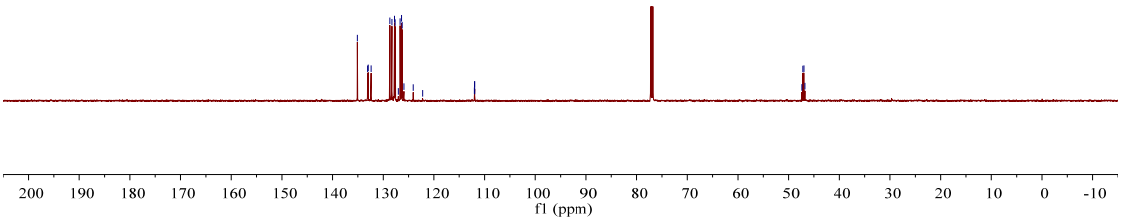

8.11
8.10
8.10
8.10
7.89
7.88
7.88
7.87
7.87
7.87
7.87
7.86
7.85
7.85
7.85
7.84
7.84
7.84
7.84
7.83
7.73
7.73
7.72
7.71
7.53
7.53
7.52
7.51
7.51
7.15
3.51
3.49
3.48
3.46
CF3
Br

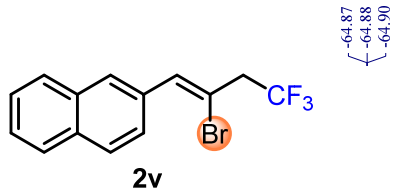
2v


0.99
2.96
0.99
2.04
1.00
2.03
f1 (ppm)

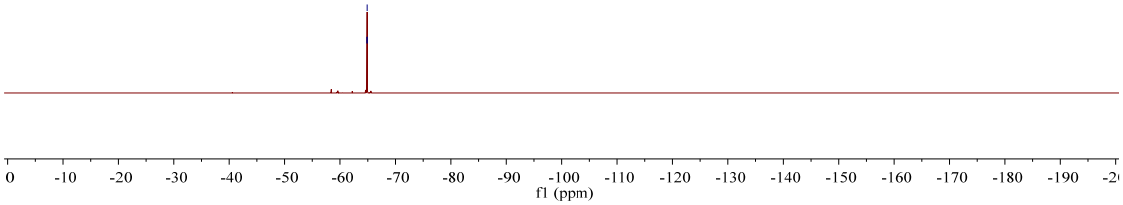

135.1
133.1
133.0
132.4
128.7
128.3
127.8
127.7
127.0
126.7
126.4
126.3
125.9
124.1
122.2
112.0
112.0
112.0
111.9
47.4
47.2
47.0
46.8
CF3
Br

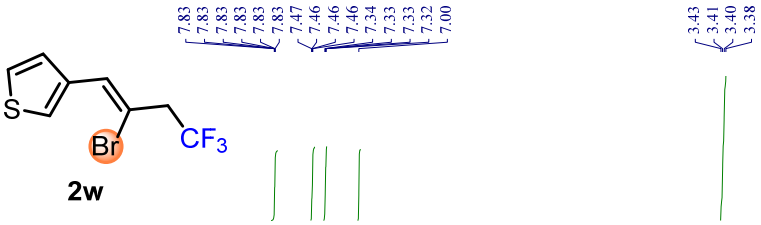
2v


f1 (ppm)

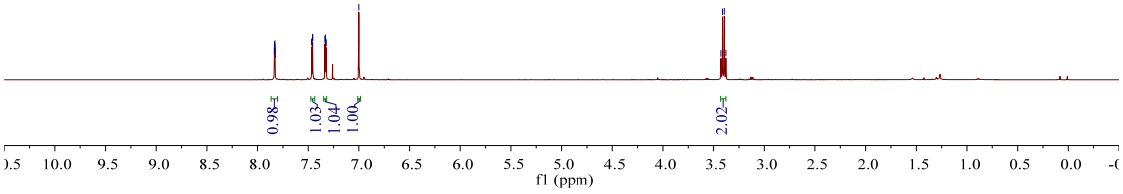

-64.87
-64.88
-64.90
CF3
Br

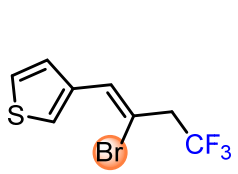
2v


f1 (ppm)


7.83
7.83
7.83
7.83
7.83
7.83
7.47
7.46
7.46
7.46
7.34
7.33
7.33
7.32
7.00
3.43
3.41
3.40
3.38
S
Br
CF3

2w

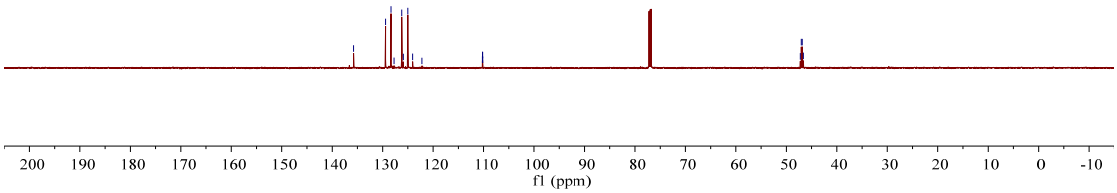

0.98
1.03
1.04
1.00
2.02
f1 (ppm)

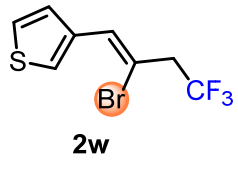

S
Br
CF3

2w


135.8
129.4
128.3
127.7
126.2
125.9
125.0
124.1
122.2
110.2
110.2
110.2
110.2

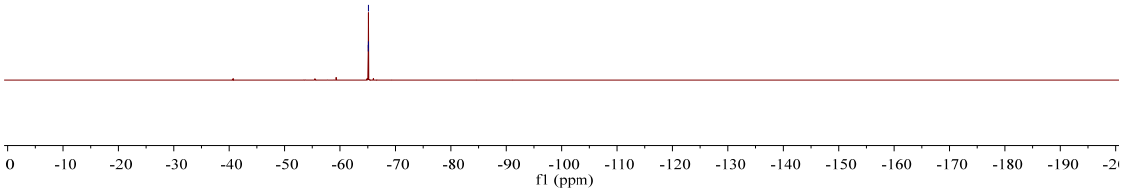

47.2
47.0
46.8
46.6

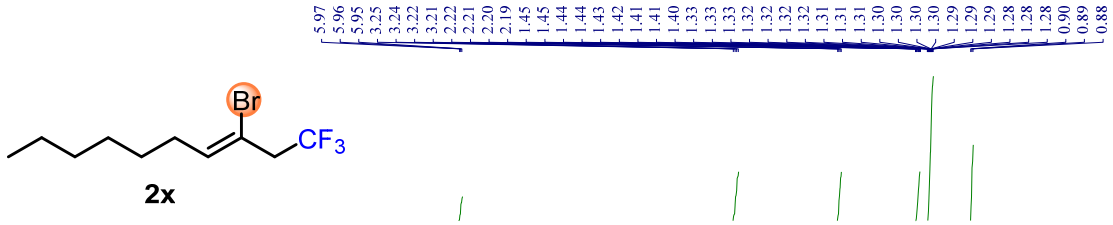

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


S
Br
CF3

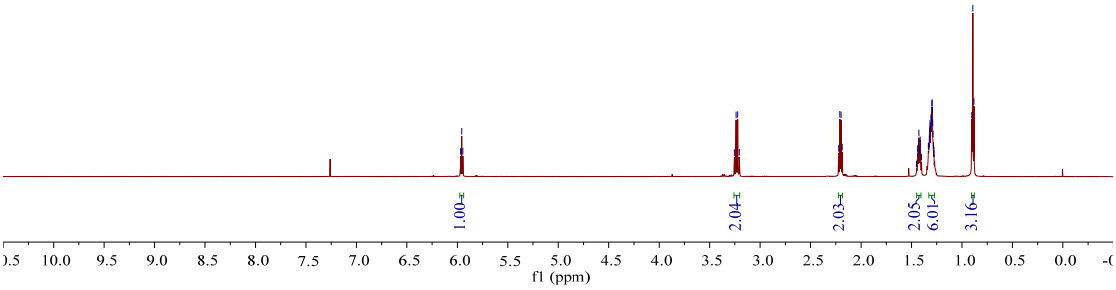
2w


-65.10
-65.12
-65.13

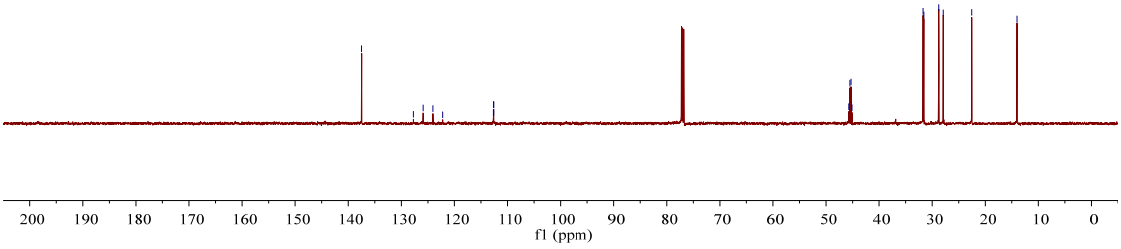

0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)

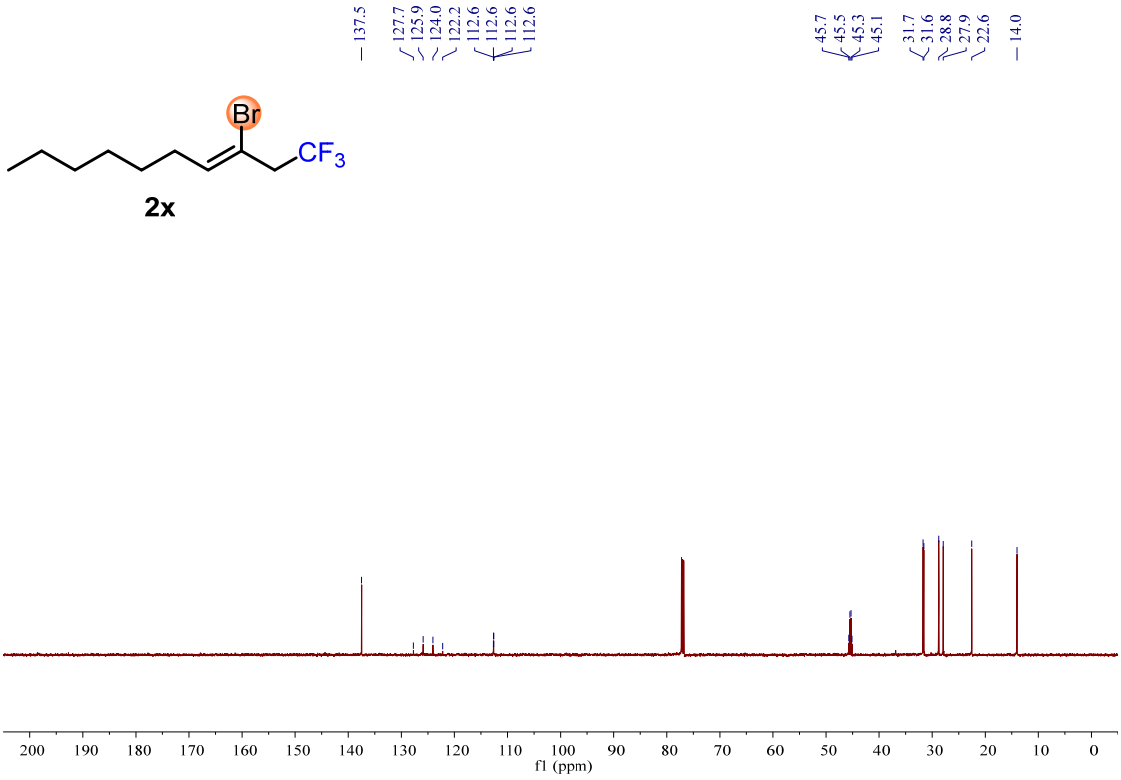


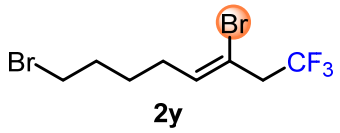
2x



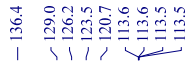
2x

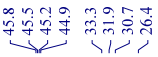


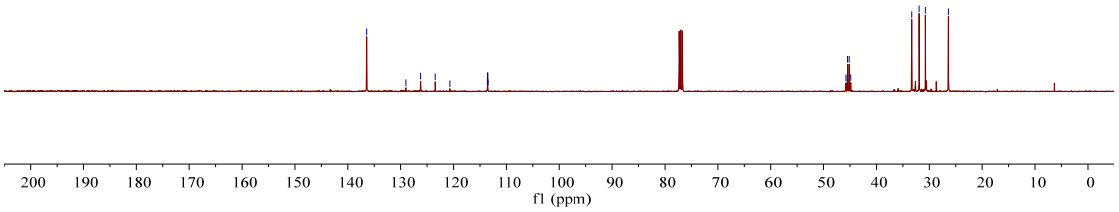

137.5
127.7
125.9
124.0
122.2
112.6
112.6
112.6
112.6
45.7
45.5
45.3
45.1
31.7
31.6
28.8
27.9
22.6
14.0
Br
CF3
2x
f1 (ppm)
5.97
5.95
5.94
3.44
3.42
3.41
3.28
3.27
3.25
3.25
3.23
3.23
3.22
3.20
2.28
2.26
2.24
2.22
1.90
1.89
1.88
1.88
1.88
1.87
1.85
1.62
1.61
1.60
1.59
1.58
Br
CF3
2y
1.00
2.01
2.07
2.04
1.99
2.01
f1 (ppm)


Br
Br
CF3

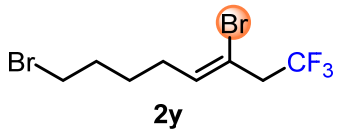
2y


136.4
129.0
126.2
123.5
120.7
113.6
113.6
113.5
113.5

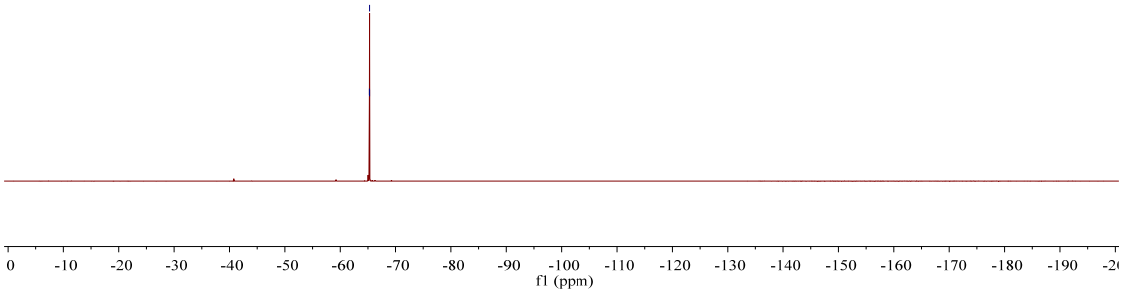

45.8
45.5
45.2
44.9
33.3
31.9
30.7
26.4

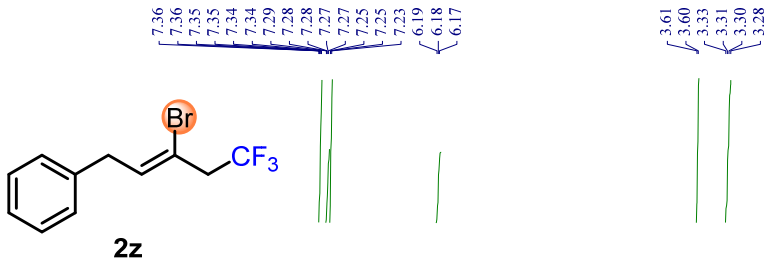

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-65.26
-65.29
-65.32

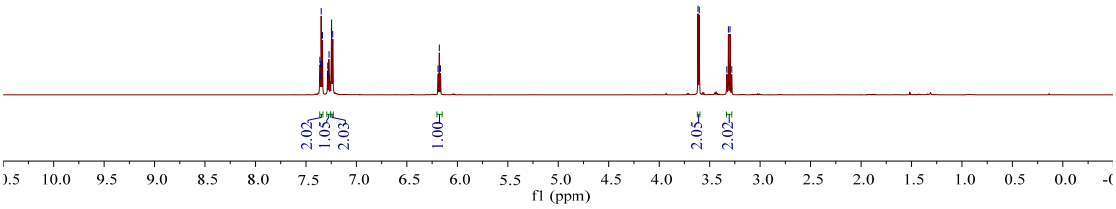

Br
Br
CF3

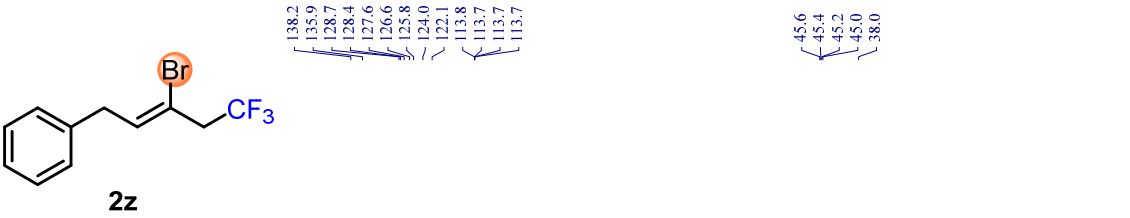
2y


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

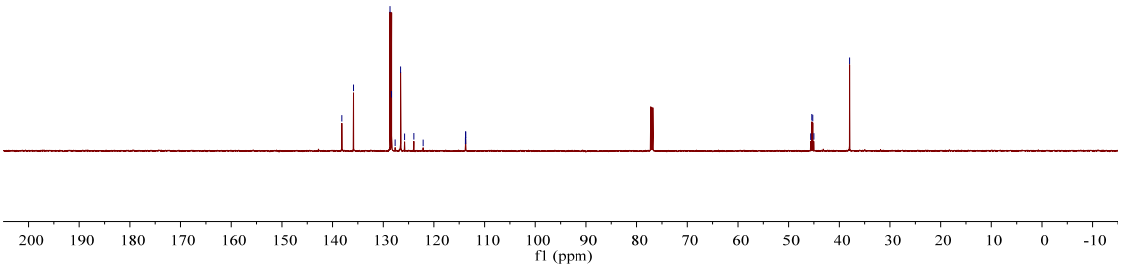

7.36
7.36
7.35
7.35
7.34
7.34
7.29
7.28
7.28
7.27
7.27
7.25
7.25
7.23
6.19
6.18
6.17
3.61
3.60
3.33
3.31
3.30
3.28
Br
CF3

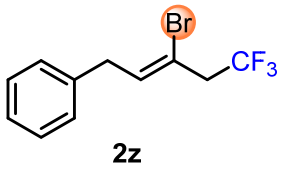
2z


2.02
1.05
2.03
1.00
2.05
2.02
f1 (ppm)


138.2
135.9
128.7
128.4
127.6
126.6
125.8
124.0
122.1
113.8
113.7
113.7
113.7
45.6
45.4
45.2
45.0
38.0
Br
CF3

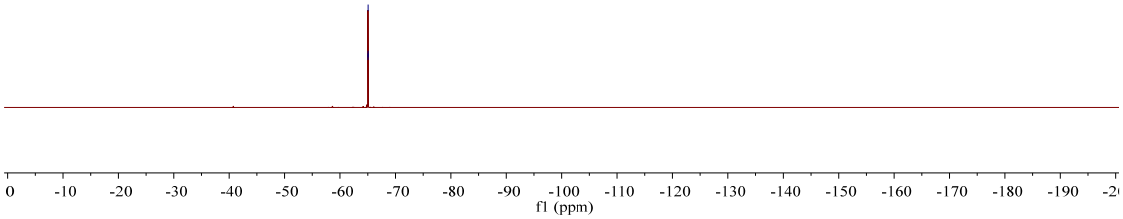
2z

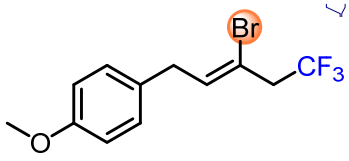

f1 (ppm)


Br
CF3

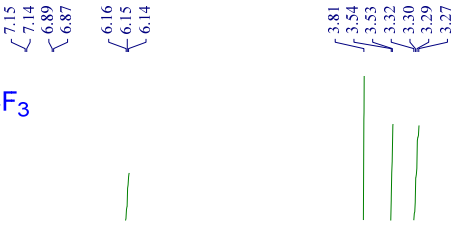
2z

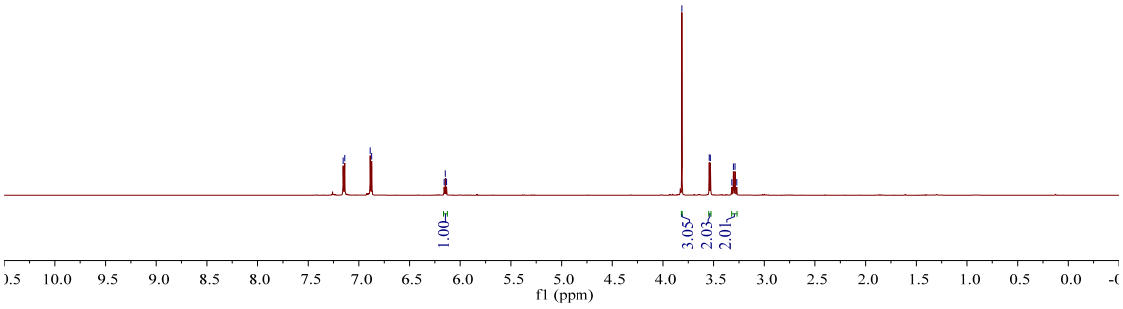

-65.04
-65.06
-65.08

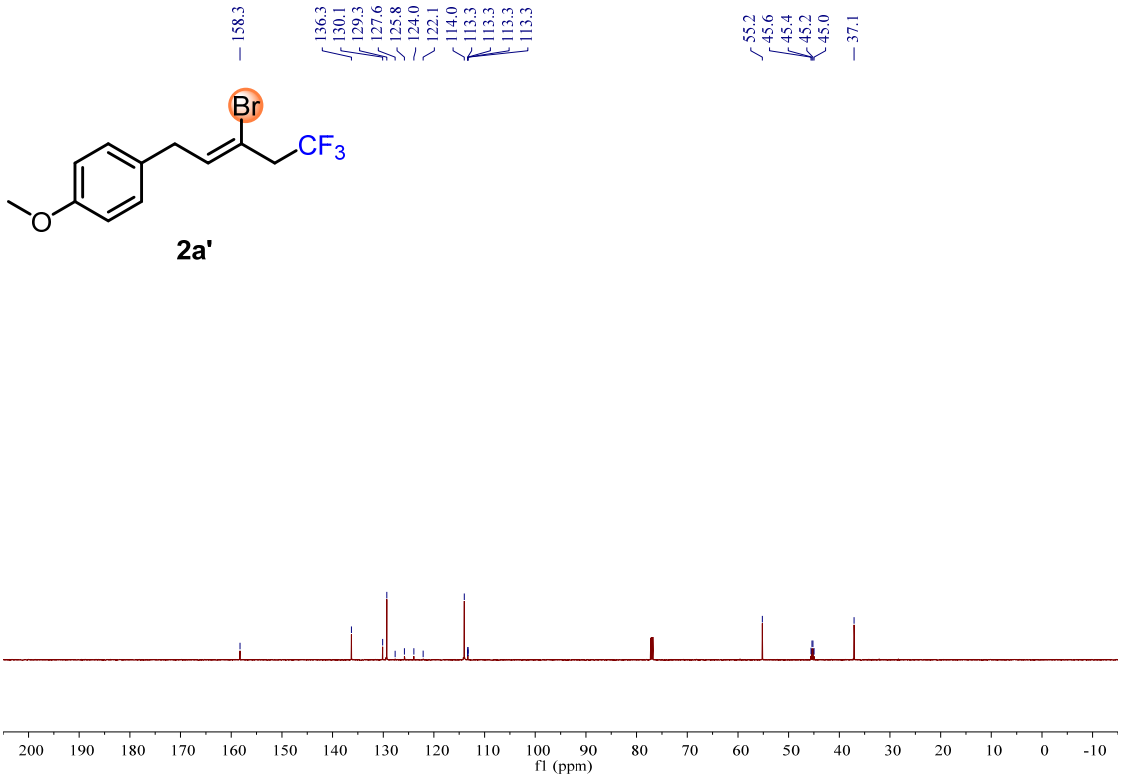

0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)

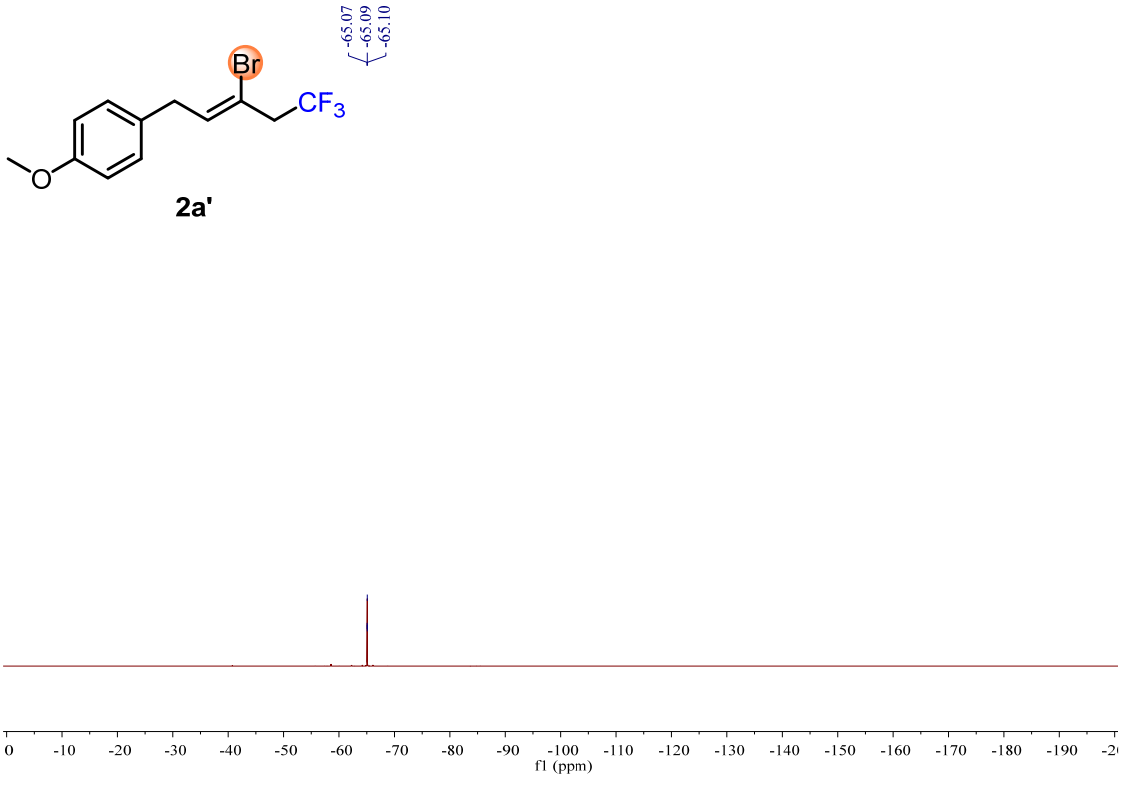

Br
CF3
O

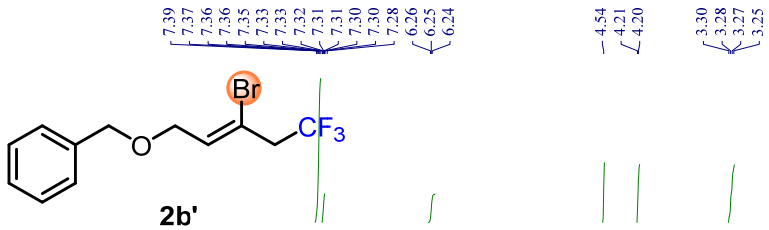
2a'


7.15
7.14
6.89
6.87
6.16
6.15
6.14
3.81
3.54
3.53
3.32
3.30
3.29
3.27

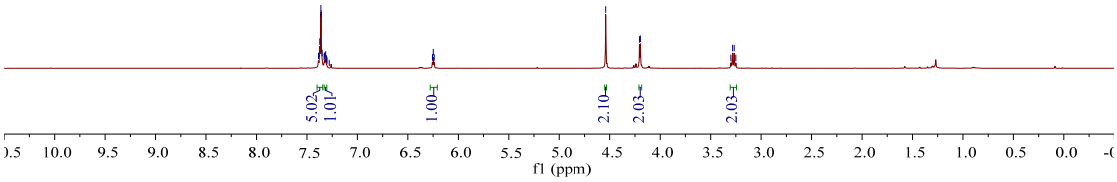

1.00
3.05
2.03
2.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

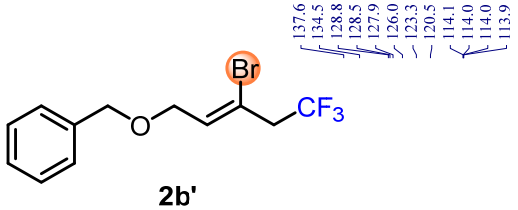

158.3
136.3
130.1
129.3
127.6
125.8
124.0
122.1
114.0
113.3
113.3
113.3
113.3
55.2
45.6
45.4
45.2
45.0
37.1
Br
CF3
O
2a'
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


-65.07
-65.09
-65.10
Br
CF3
O
2a'
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)


7.39
7.37
7.36
7.36
7.35
7.33
7.33
7.32
7.31
7.31
7.30
7.30
7.28
6.26
6.25
6.24
4.54
4.21
4.20
3.30
3.28
3.27
3.25
Br
CF3
O

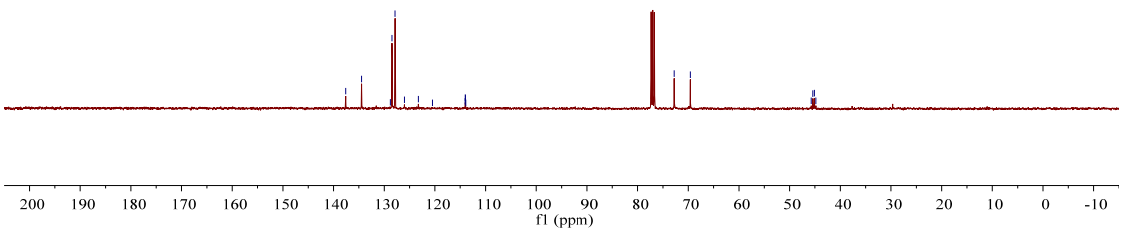
2b'

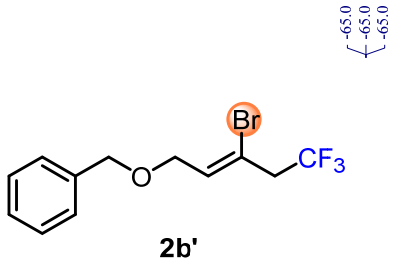

5.02
1.01
1.00
2.10
2.03
2.03
f1 (ppm)


Br
CF3
O

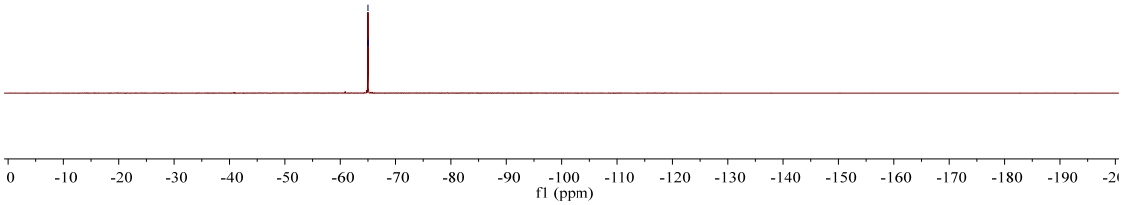
2b'

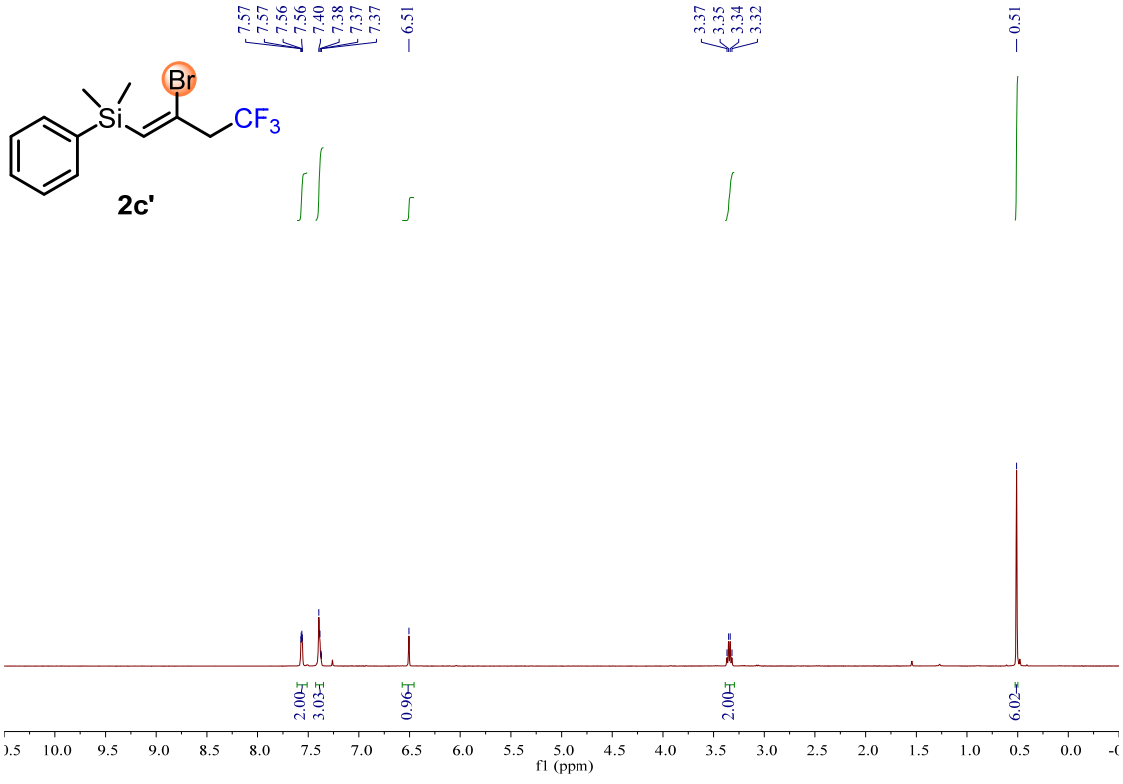

137.6
134.5
128.8
128.5
127.9
126.0
123.3
120.5
114.1
114.0
114.0
113.9
72.8
69.6
45.7
45.4
45.1
44.8


f1 (ppm)

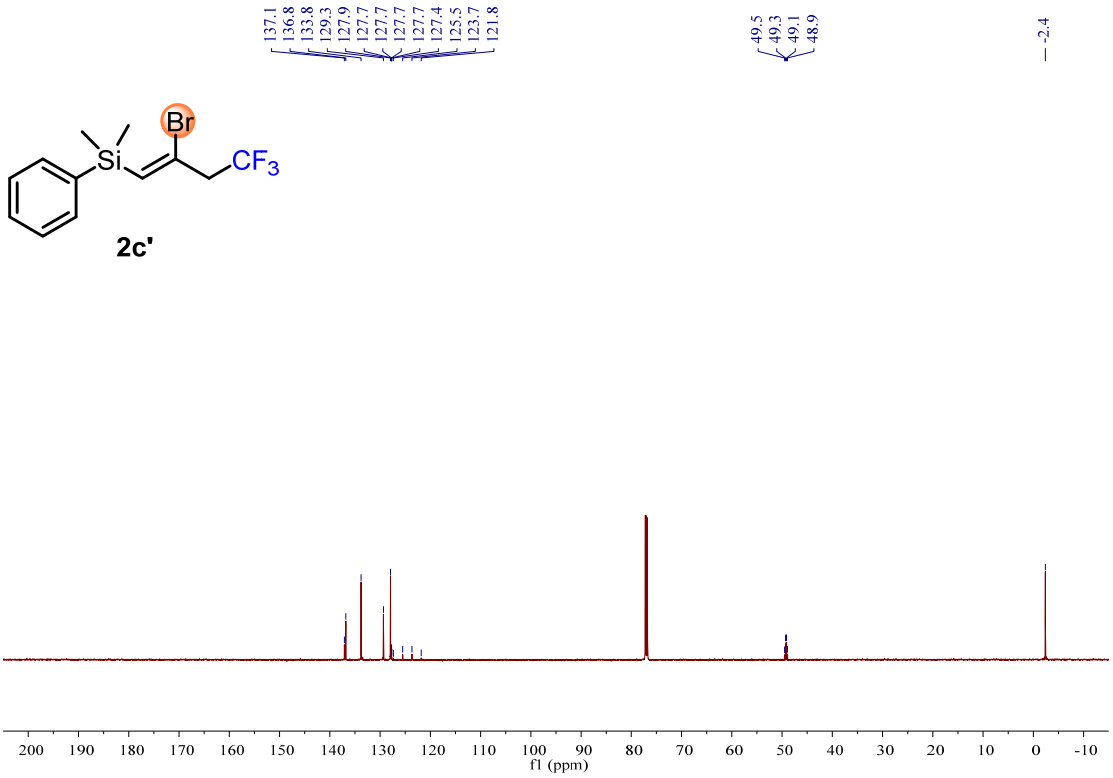

-65.0
-65.0
-65.0
Br
CF3
O

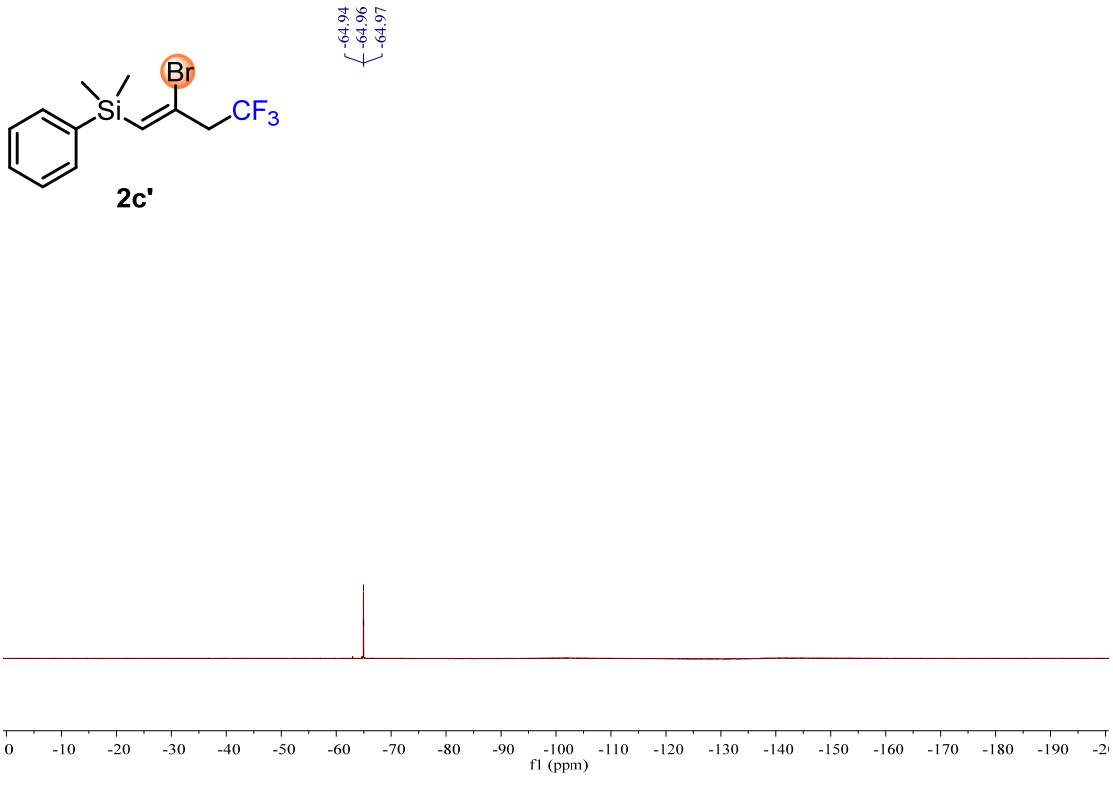
2b'

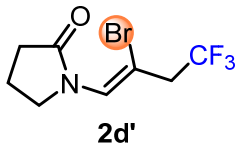

0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)


7.57
7.57
7.56
7.56
7.40
7.38
7.37
7.37
6.51
3.37
3.35
3.34
3.32
0.51
Br
Si
CF3
2.00
3.03
0.96
2.00
6.02
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

2c'

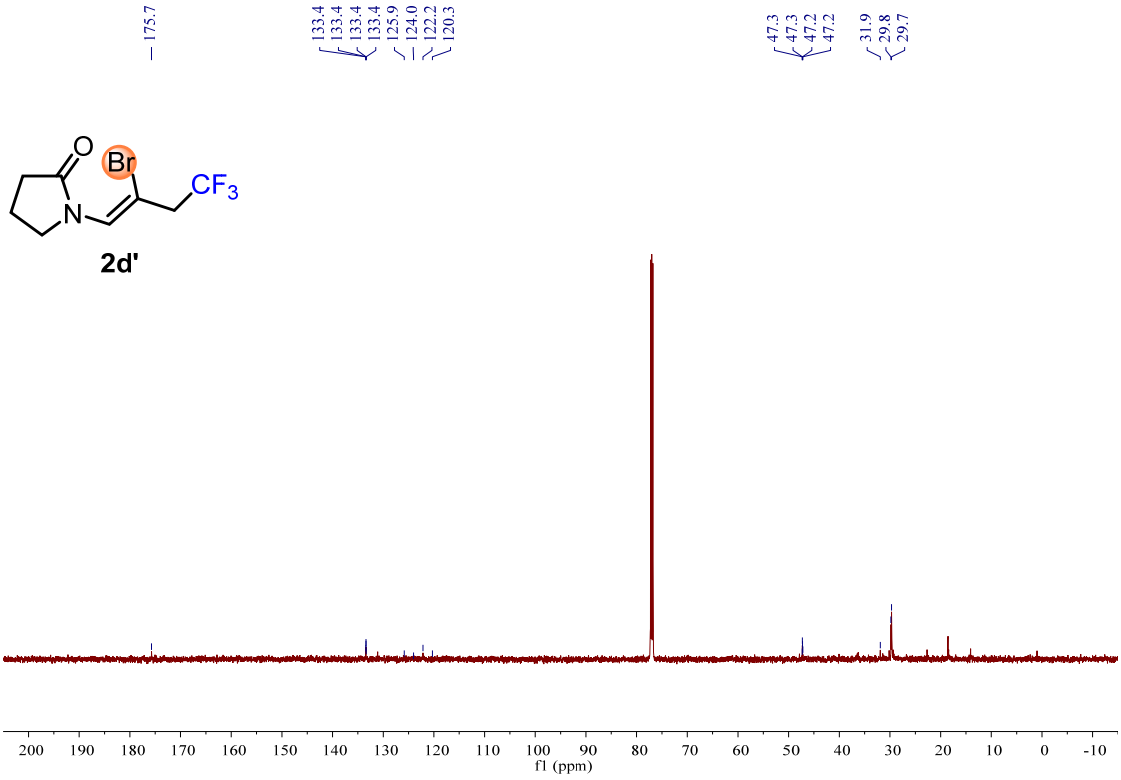

137.1
136.8
133.8
129.3
127.9
127.7
127.7
127.7
127.7
127.4
125.5
123.7
121.8
49.5
49.3
49.1
48.9
-2.4
Br
Si
CF3
2c'
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


-64.94
-64.96
-64.97
Br
Si
CF3
2c'
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)


O
Br
N
CF3

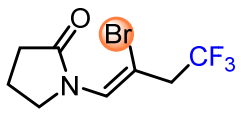
2d'

7.21
3.86
3.85
3.85
3.84
3.84
3.83
3.83
3.04
3.03
3.01
2.99
2.52
2.51
2.50
2.17
2.17
2.16
2.15
2.13
2.12
1.00
2.01
2.04
2.09
2.02
f1 (ppm)


175.7
133.4
133.4
133.4
133.4
125.9
124.0
122.2
120.3
47.3
47.3
47.2
47.2
31.9
29.8
29.7
f1 (ppm)

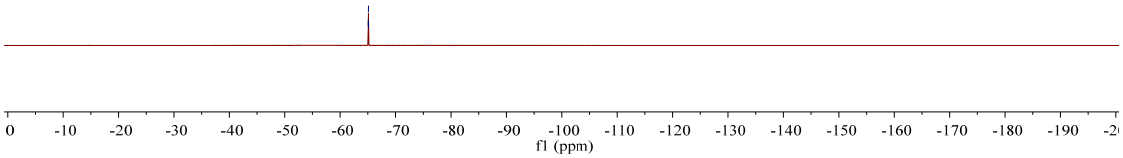
O
Br
N
CF3

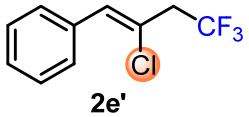
2d'


O
Br
N
CF3

2d'


-65.08
-65.10
-65.12

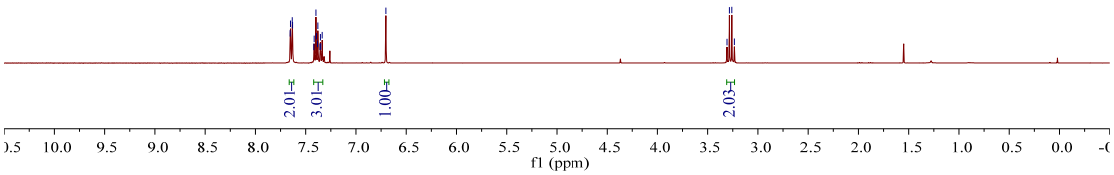

0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)

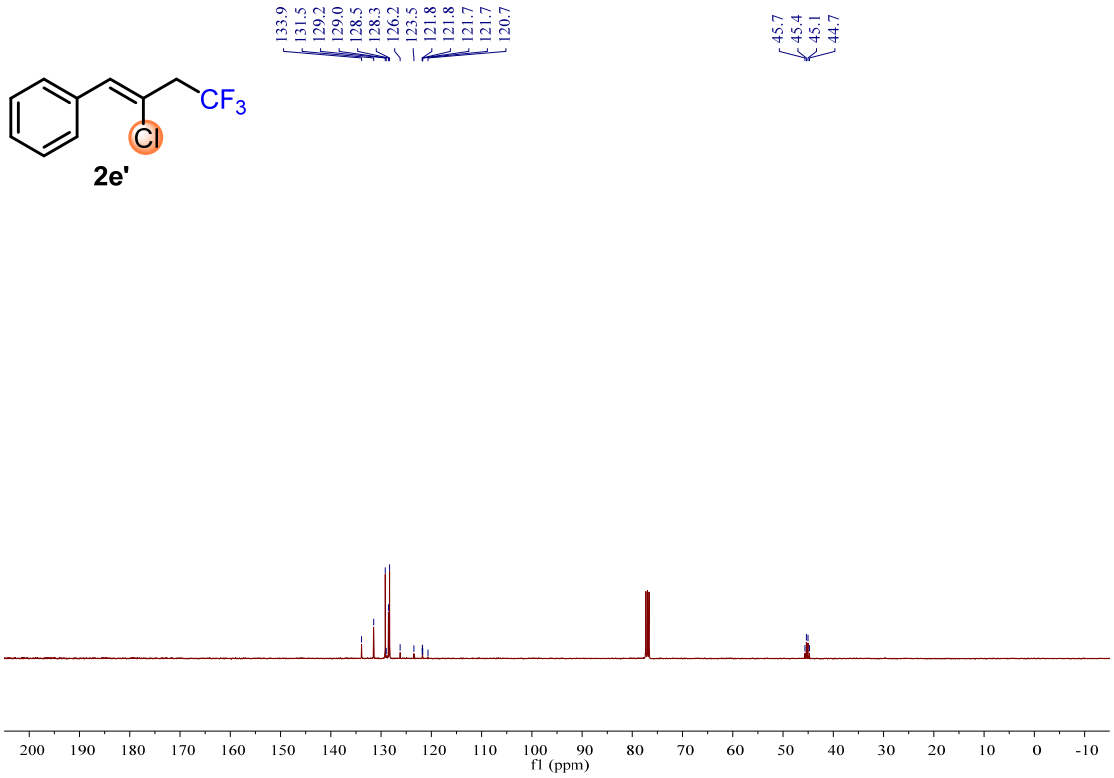

CF3
Cl

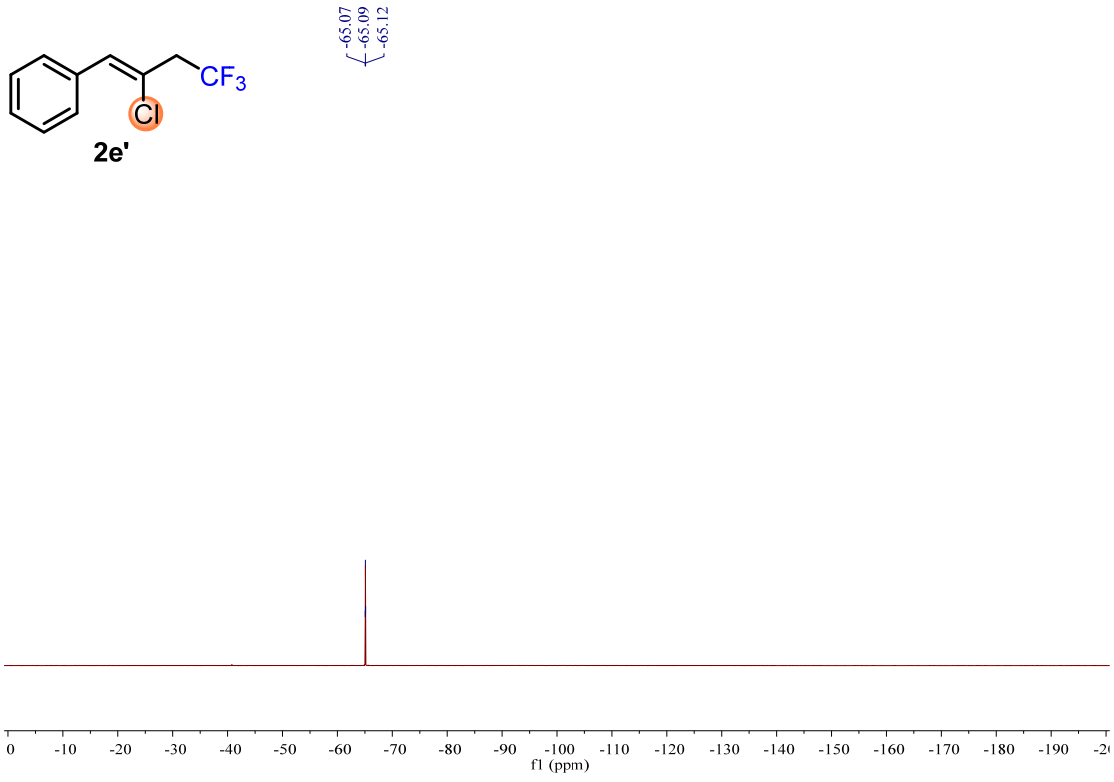
2e'

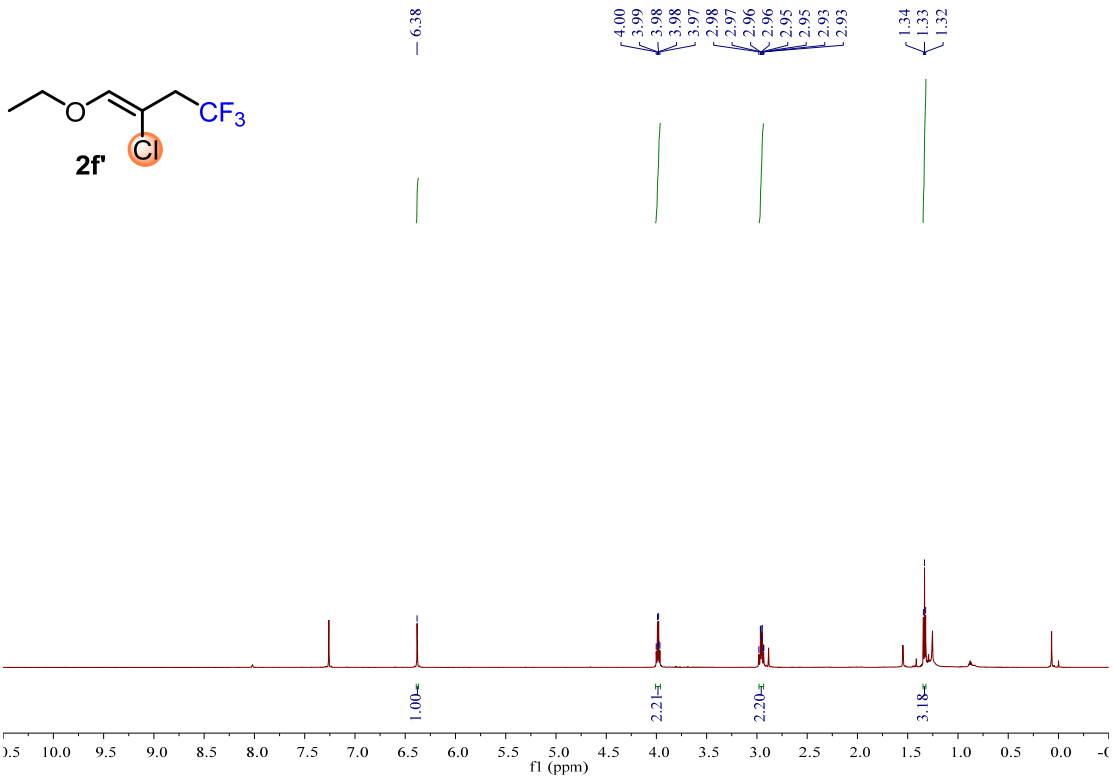
7.65
7.65
7.63
7.63
7.42
7.42
7.40
7.39
7.38
7.38
7.36
7.35
7.35
7.34
6.70

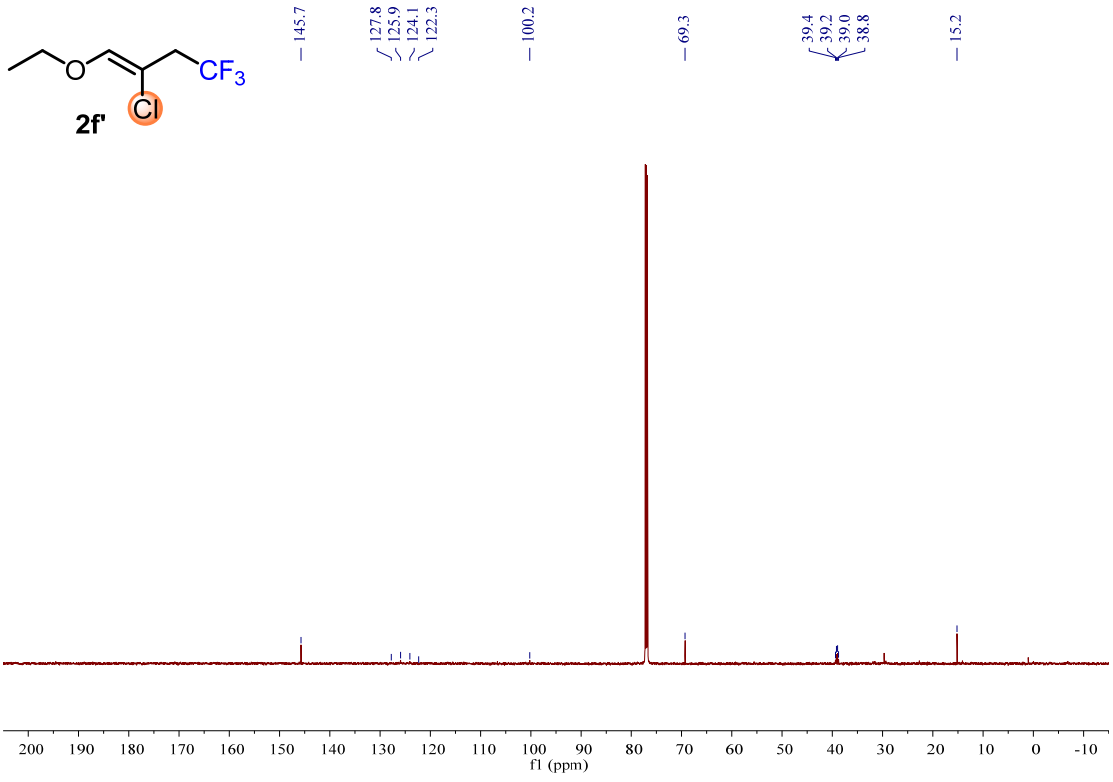

3.31
3.28
3.26
3.24

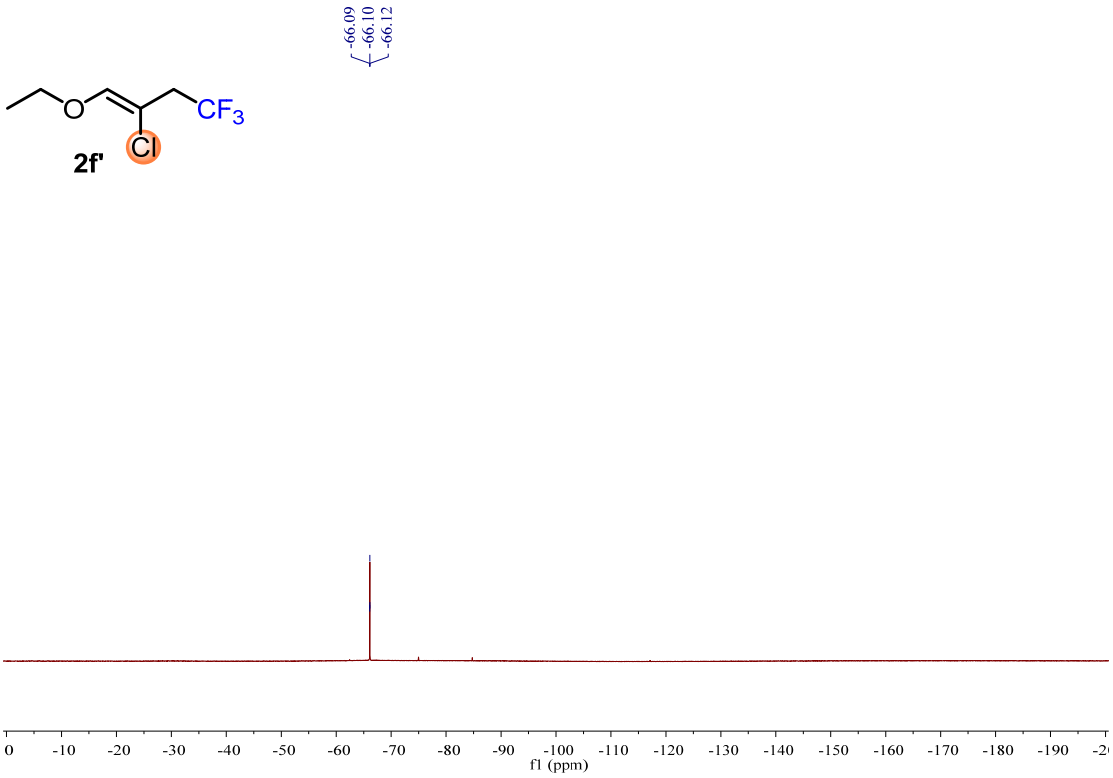

2.01
3.01
1.00
2.03
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

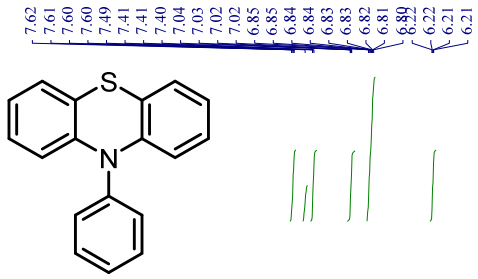

133.9
131.5
129.2
129.0
128.5
128.3
126.2
123.5
121.8
121.8
121.7
121.7
120.7
45.7
45.4
45.1
44.7
CF3
Cl
2e'
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


-65.07
-65.09
-65.12
CF3
Cl
2e'
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)


2f'
6.38
4.00
3.99
3.98
3.98
3.97
2.98
2.97
2.96
2.96
2.95
2.95
2.93
2.93
1.34
1.33
1.32
1.00
2.21
2.20
3.18
f1 (ppm)


2f'
145.7
127.8
125.9
124.1
122.3
100.2
69.3
39.4
39.2
39.0
38.8
15.2
f1 (ppm)


-66.09
-66.10
-66.12
O
CF3
Cl
2f'
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)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7.61
7.60
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7.41
7.41
7.40
7.04
7.03
7.02
7.02
6.85
6.85
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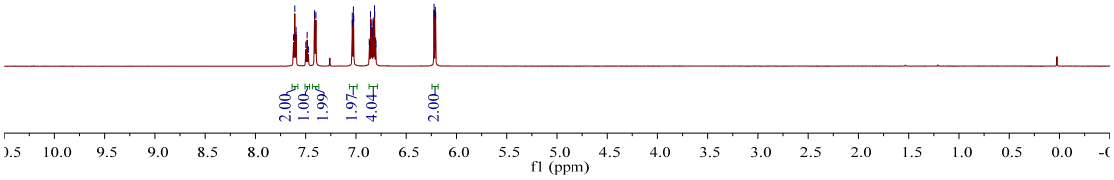
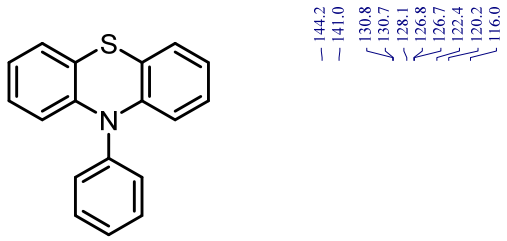
6.22
6.22
6.21
6.21
S
N


2.00
1.00
1.99
1.97
4.04
2.00
f1 (ppm)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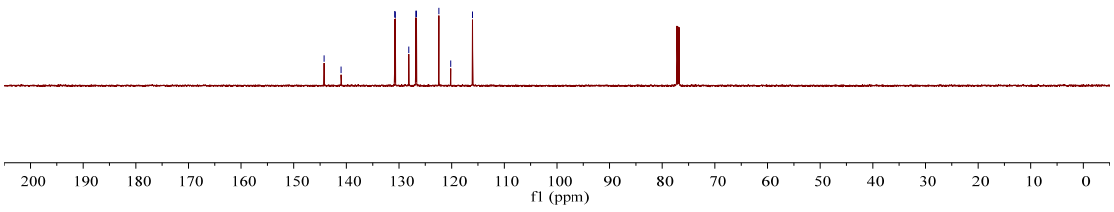
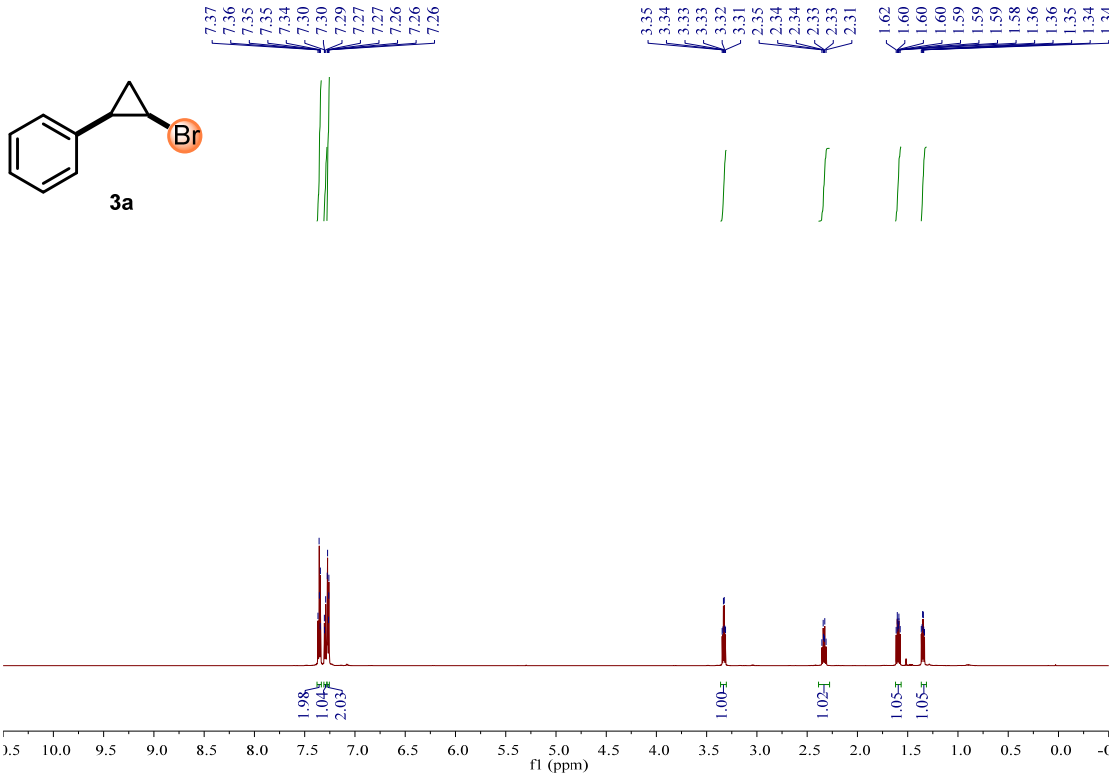
141.0
130.8
130.7
128.1
126.8
126.7
122.4
120.2
116.0
S
N


f1 (ppm)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7.34
7.30
7.30
7.29
7.27
7.27
7.26
7.26
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3.34
3.33
3.33
3.32
3.31
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2.33
2.31
1.62
1.60
1.60
1.60
1.59
1.59
1.59
1.58
1.36
1.36
1.35
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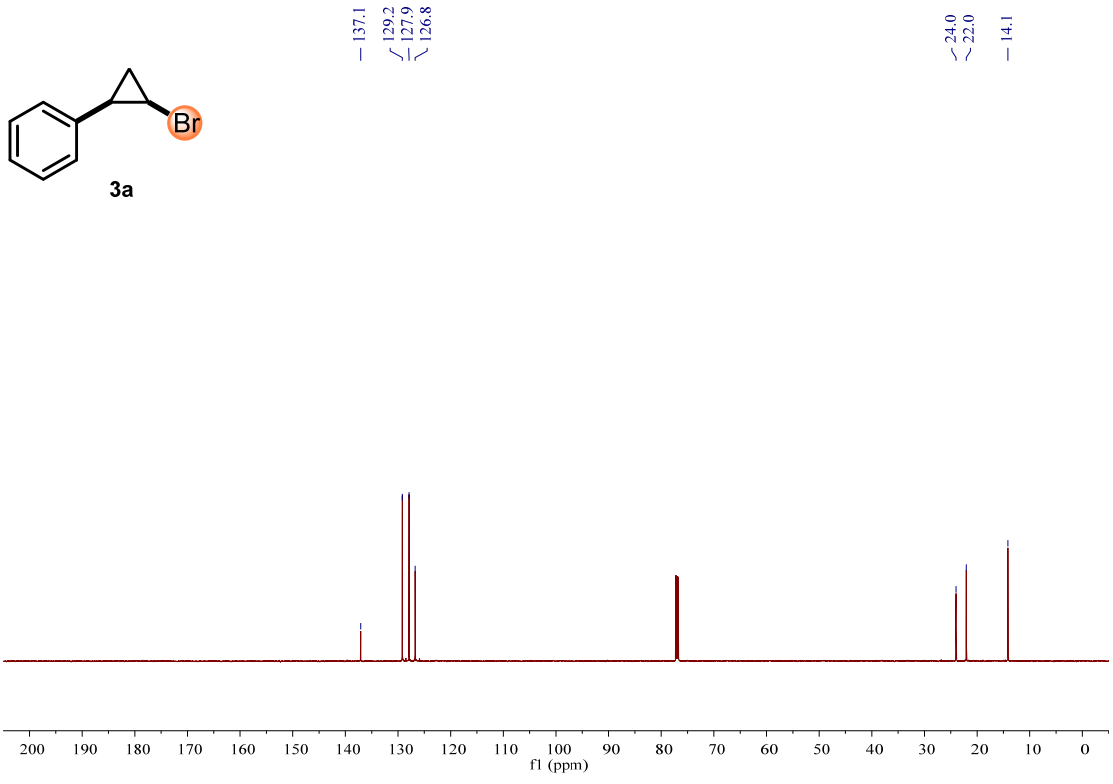
Br
3a
1.98
1.04
2.03
1.00
1.02
1.05
1.05
f1 (ppm)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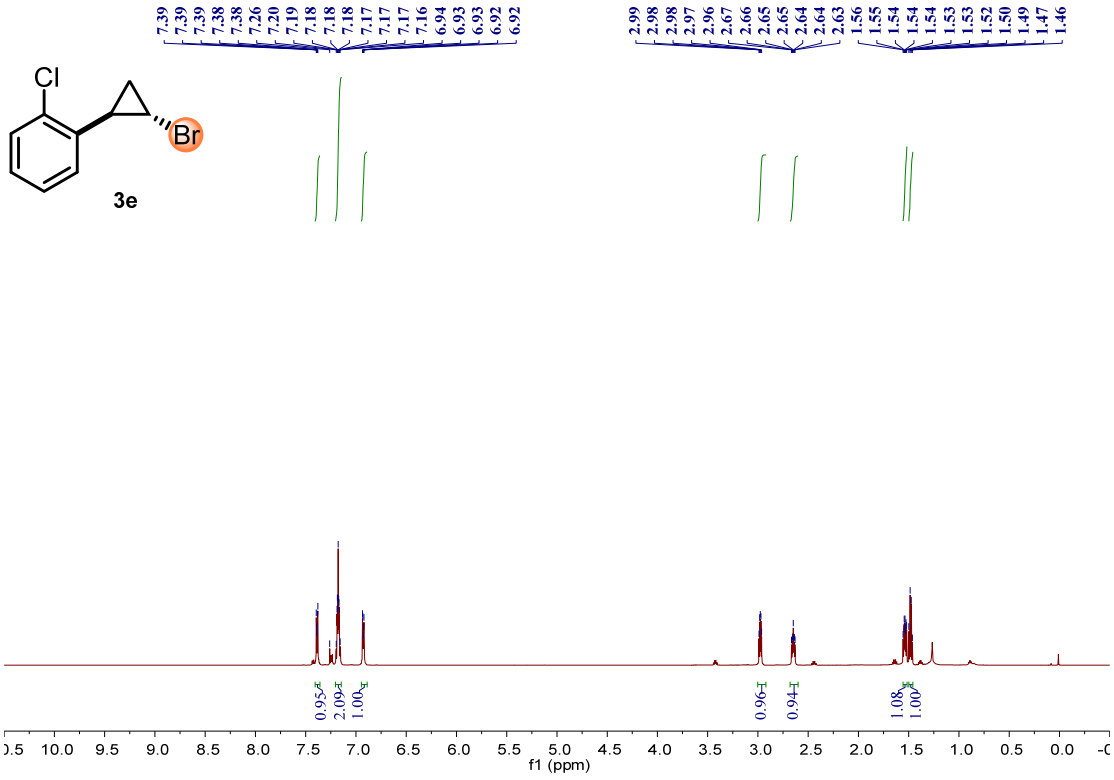
129.2
127.9
126.8
24.0
22.0
14.1
Br
3a
f1 (ppm)


7.39
7.39
7.39
7.38
7.38
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7.19
7.18
7.18
7.18
7.17
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7.17
7.16
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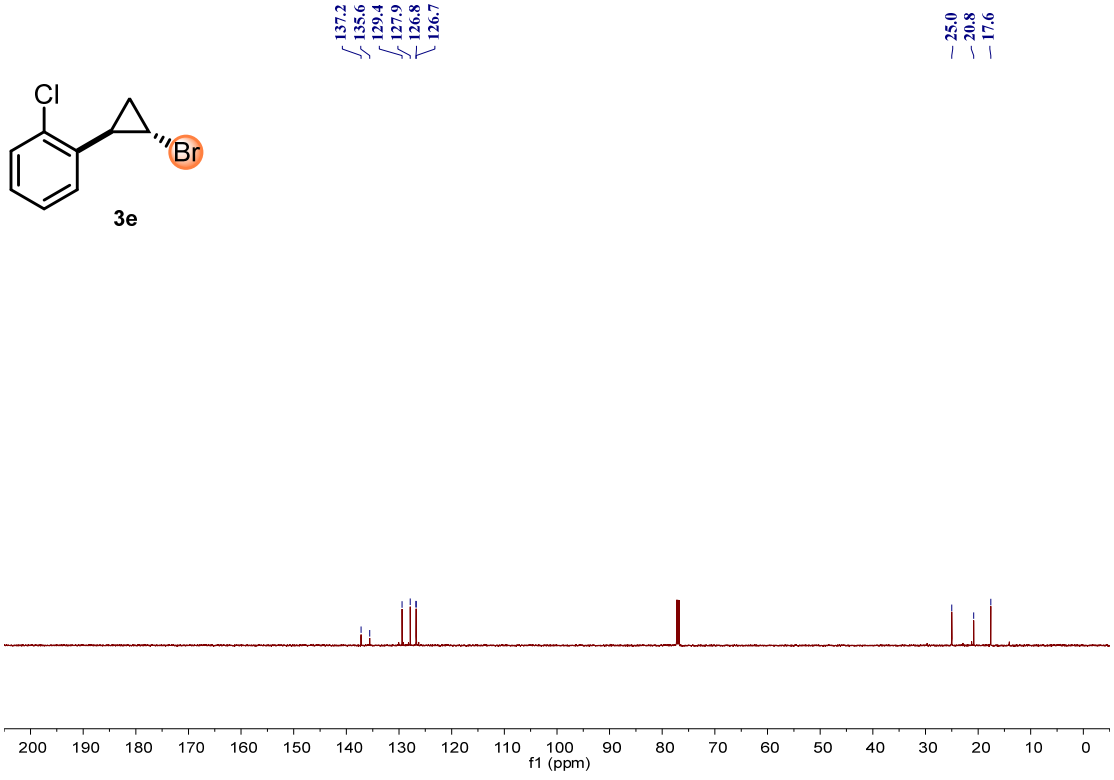
6.93
6.93
6.92
6.92
2.99
2.98
2.98
2.97
2.96
2.67
2.66
2.65
2.65
2.64
2.64
2.63
1.56
1.55
1.54
1.54
1.54
1.53
1.53
1.52
1.50
1.49
1.47
1.46
Cl
Br
3e
0.95
2.09
1.00
0.96
0.94
1.08
1.00
f1 (ppm)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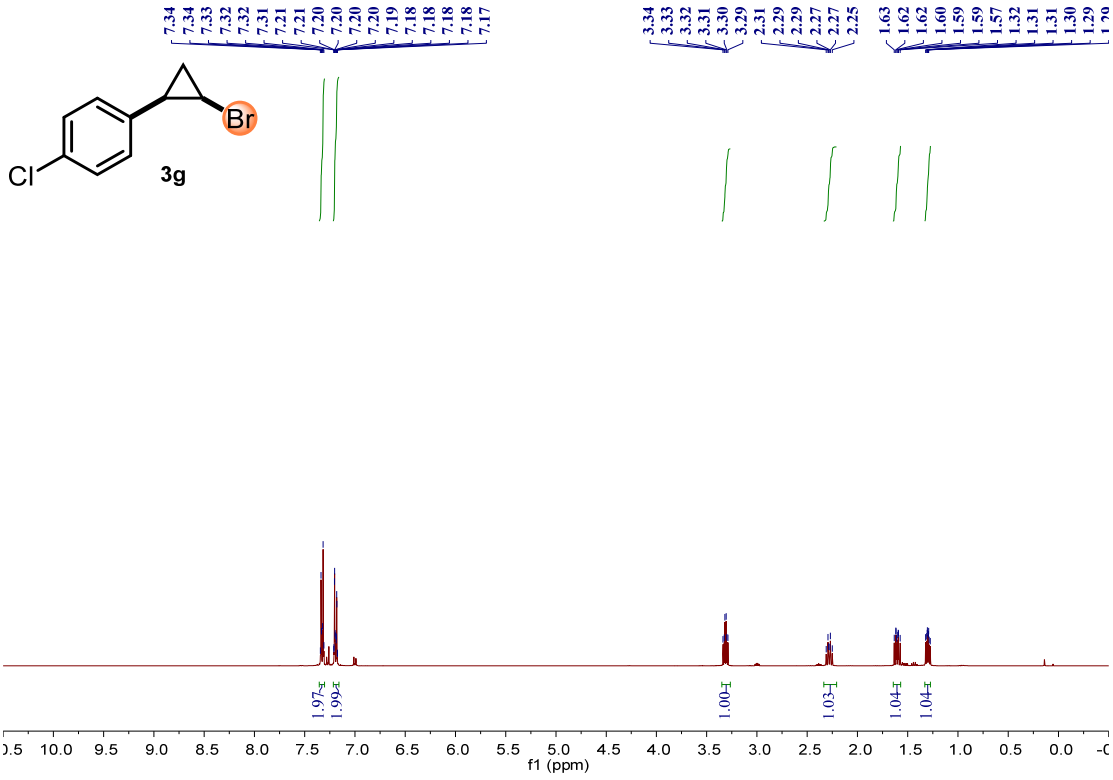
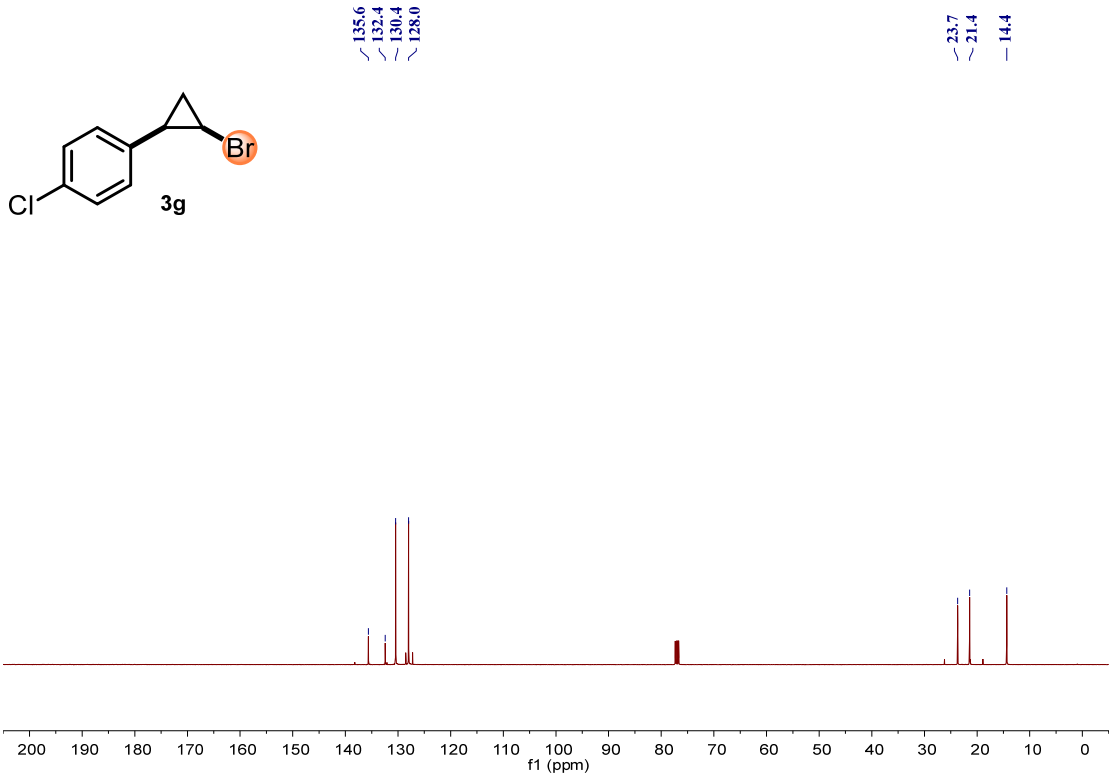
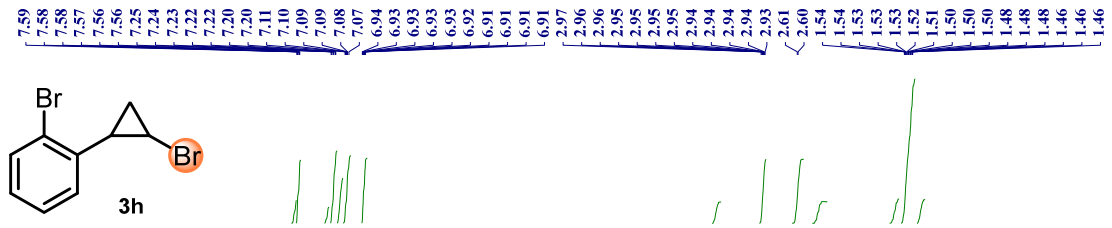
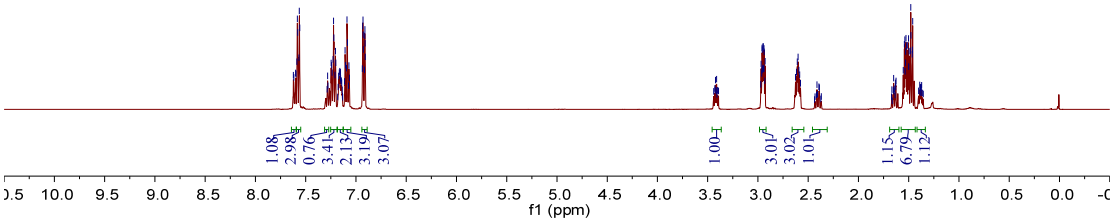
135.6
129.4
127.9
126.8
126.7
25.0
20.8
17.6
Cl
Br
3e
f1 (ppm)


7.34
7.34
7.33
7.32
7.32
7.31
7.21
7.21
7.20
7.20
7.20
7.20
7.19
7.18
7.18
7.18
7.17
3.34
3.33
3.32
3.31
3.30
3.29
2.31
2.29
2.29
2.27
2.27
2.25
1.63
1.62
1.62
1.60
1.59
1.59
1.57
1.32
1.31
1.31
1.30
1.29
Br
Cl
3g
1.97
1.99
1.00
1.03
1.04
1.04
f1 (ppm)

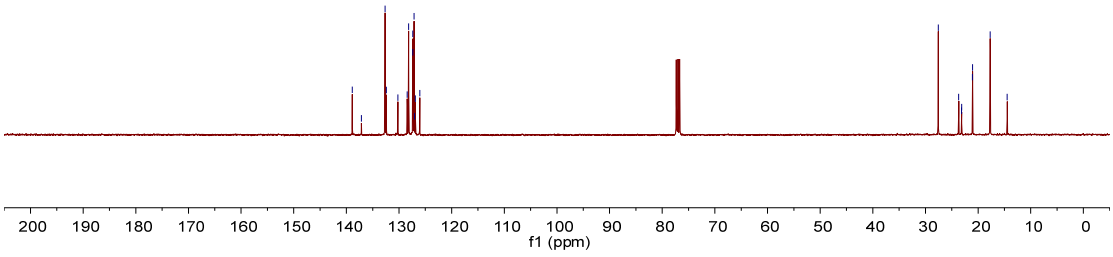

135.6
132.4
130.4
128.0
23.7
21.4
14.4
Br
Cl
3g
f1 (ppm)


7.59 7.58 7.58 7.57 7.56 7.56 7.25 7.24 7.23 7.22 7.22 7.20 7.20 7.11 7.10 7.09 7.09 7.08 7.07 6.94 6.93 6.93 6.93 6.92 6.91 6.91 6.91 2.97 2.96 2.96 2.95 2.95 2.95 2.94 2.94 2.94 2.94 2.93 2.61 2.60 1.54 1.54 1.53 1.53 1.53 1.52 1.51 1.50 1.50 1.50 1.48 1.48 1.48 1.46 1.46 1.46
Br
Br
3h

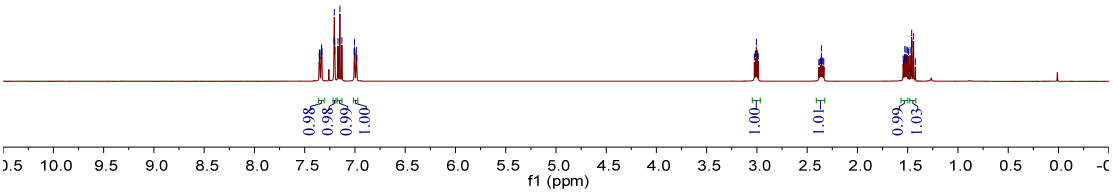

1.08 2.98 0.76 3.41 2.13 3.19 3.07 1.00 3.01 3.02 1.01 1.15 6.79 1.12
f1 (ppm)


138.9 137.1 132.7 132.4 130.2 128.4 128.2 127.4 127.4 127.2 127.0 126.9 126.1 27.6 23.7 23.1 23.1 21.1 21.0 17.7 14.5

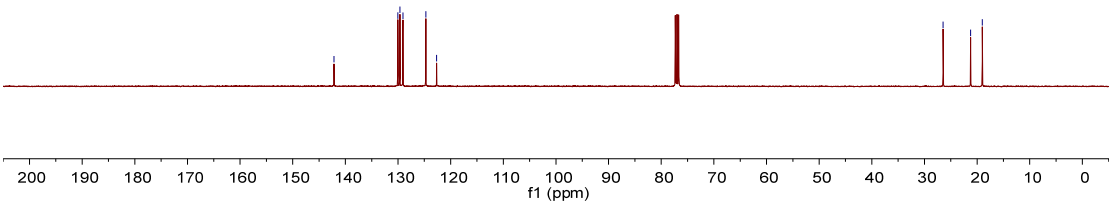

Br
Br
3h

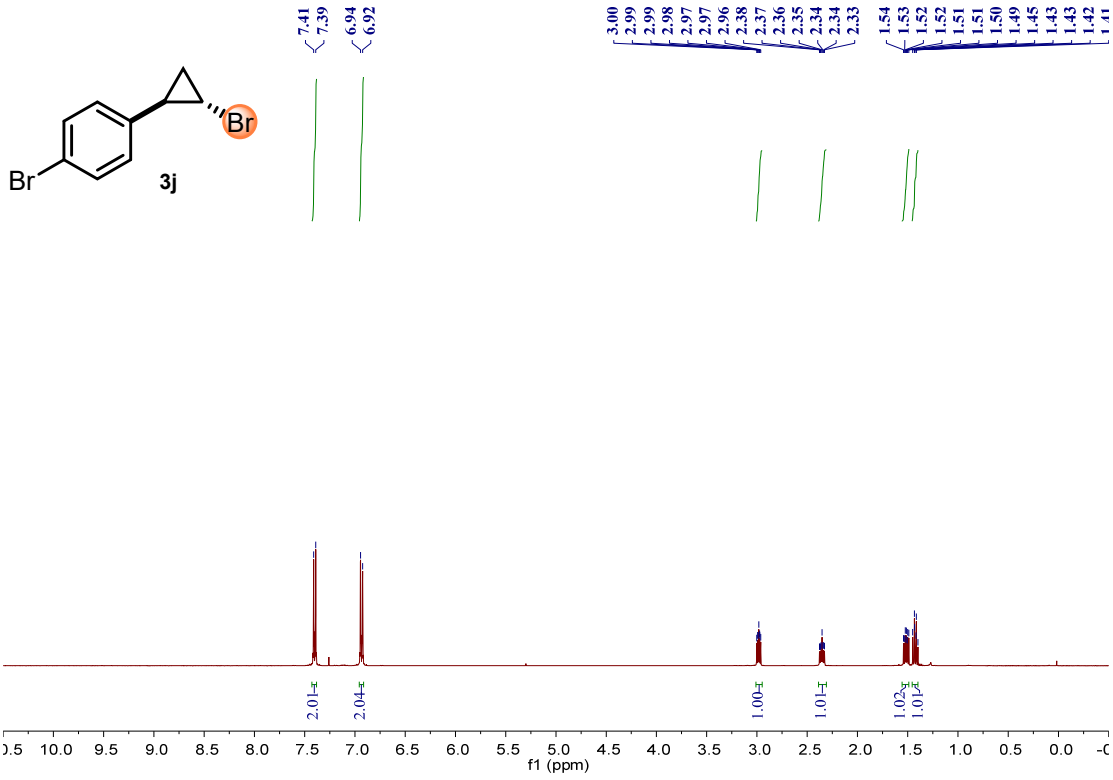

f1 (ppm)

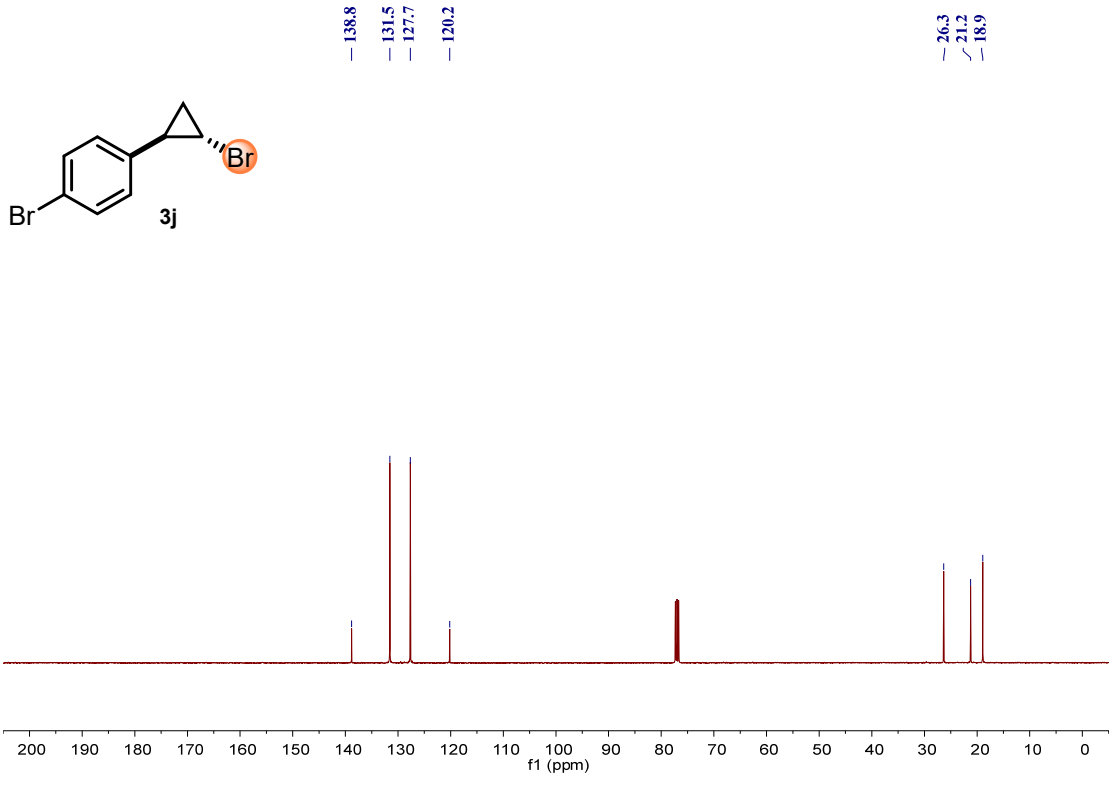

7.36
7.35
7.35
7.35
7.34
7.33
7.33
7.33
7.21
7.20
7.20
7.17
7.15
7.13
7.01
7.00
7.00
6.99
6.98
3.03
3.02
3.01
3.01
3.00
2.99
2.99
2.38
2.37
2.36
2.35
2.34
2.33
1.55
1.53
1.53
1.52
1.52
1.51
1.50
1.49
1.48
1.46
1.46
1.44
Br
Br
3i

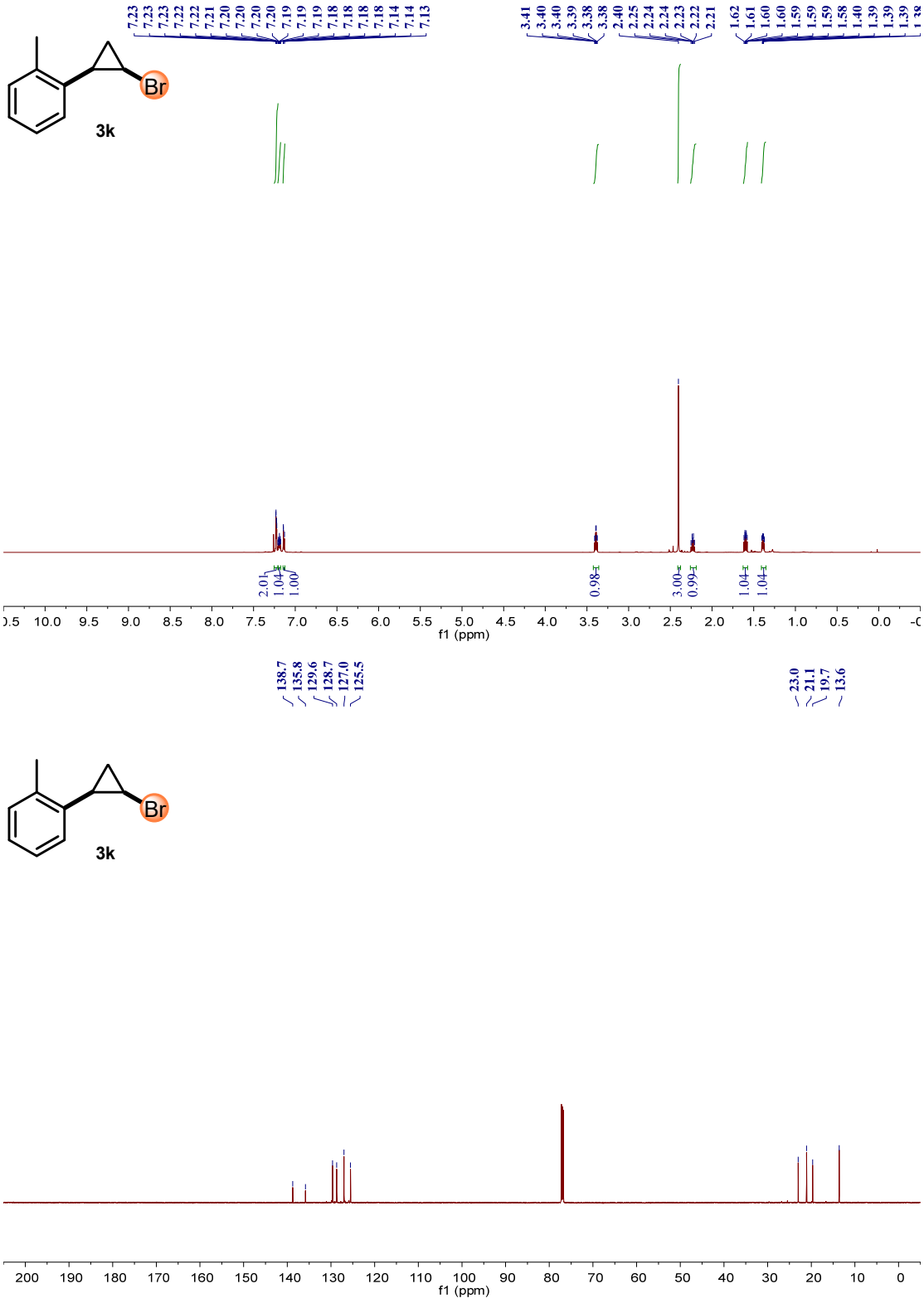

0.98
0.98
0.99
1.00
1.00
1.01
0.99
1.03
f1 (ppm)

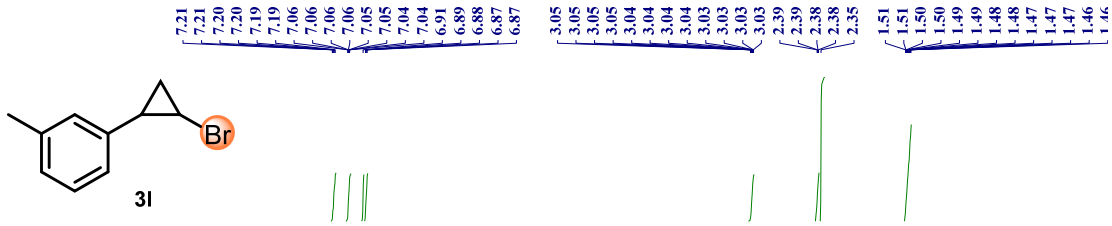

142.2
130.0
129.6
129.1
124.7
122.7
26.5
21.2
19.0
Br
Br
3i

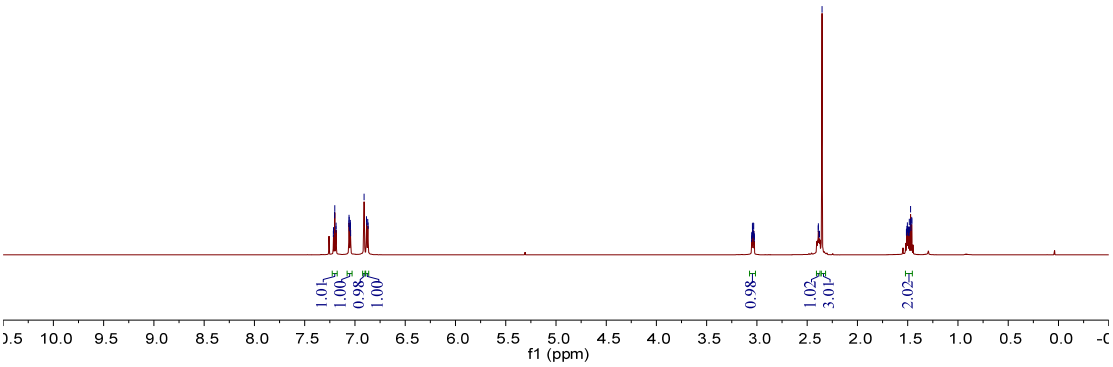

f1 (ppm)


Br
Br
3j
7.41
7.39
6.94
6.92
3.00
2.99
2.99
2.98
2.97
2.97
2.96
2.38
2.37
2.36
2.35
2.34
2.34
2.33
1.54
1.53
1.52
1.52
1.51
1.51
1.50
1.49
1.45
1.43
1.43
1.42
2.01
2.04
1.00
1.01
1.02
1.01
f1 (ppm)

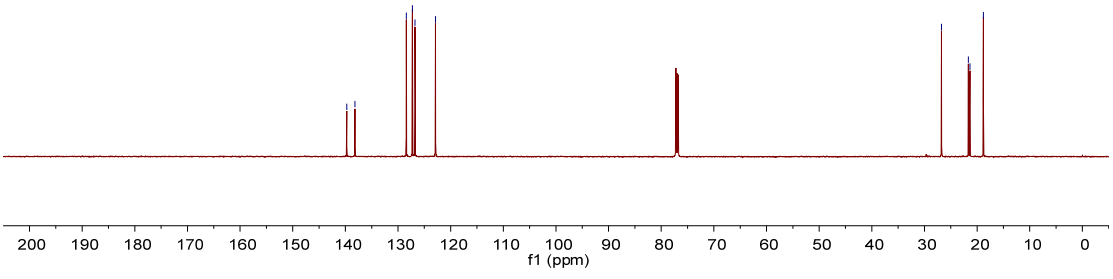

138.8
131.5
127.7
120.2
26.3
21.2
18.9
Br
Br
3j
f1 (ppm)

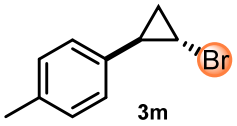

Br
3k
7.23 7.23 7.23 7.22 7.22 7.21 7.20 7.20 7.20 7.20 7.19 7.19 7.19 7.18 7.18 7.18 7.18 7.14 7.13
3.41 3.40 3.40 3.39 3.38 3.38 2.40 2.25 2.24 2.24 2.23 2.22 2.21
1.62 1.61 1.60 1.60 1.59 1.59 1.59 1.58 1.40 1.39 1.39 1.39
2.01 1.04 1.00 0.98 3.00 0.99 1.04 1.04
f1 (ppm)
138.7 135.8 129.6 128.7 127.0 125.5
23.0 21.1 19.7 13.6
Br
3k
f1 (ppm)


7.21 7.21 7.20 7.20 7.19 7.19 7.06 7.06 7.06 7.06 7.05 7.05 7.04 7.04 6.91 6.89 6.88 6.87 6.87
3.05 3.05 3.05 3.05 3.04 3.04 3.04 3.04 3.03 3.03 3.03 3.03 2.39 2.39 2.38 2.38 2.35
1.51 1.51 1.50 1.50 1.49 1.49 1.48 1.48 1.47 1.47 1.47 1.46
Br
3l


1.01
1.00
0.98
1.00
0.98
1.02
3.01
2.02
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


139.7
138.2
128.4
127.3
126.8
122.9
26.8
21.7
21.3
18.8
Br
3l


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


Br

3m


7.13
7.12
7.12
7.00
7.00
6.99
6.99
6.98
6.98


3.02
3.02
3.02
3.01
2.40
2.40
2.39
2.39
2.35
2.35
2.34
1.51
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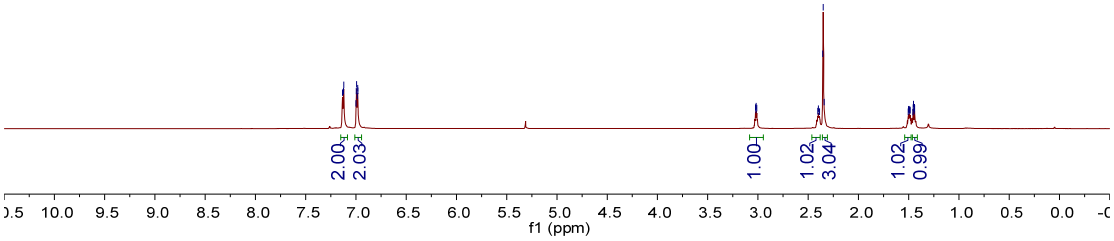
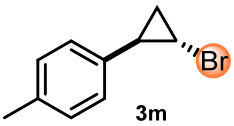
1.45
1.45
1.45
1.44
1.44
1.44

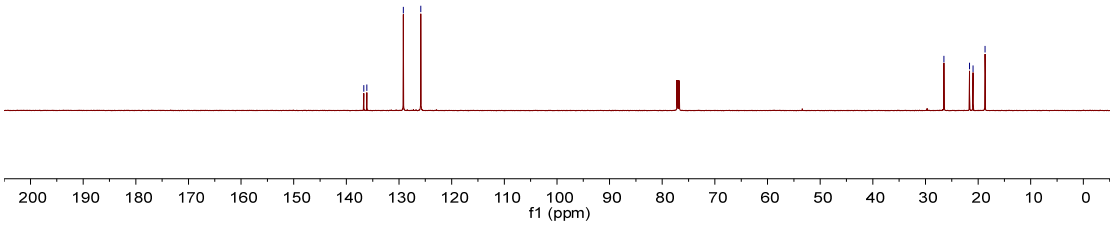

2.00
2.03
1.00
1.02
3.04
1.02
0.99
f1 (ppm)

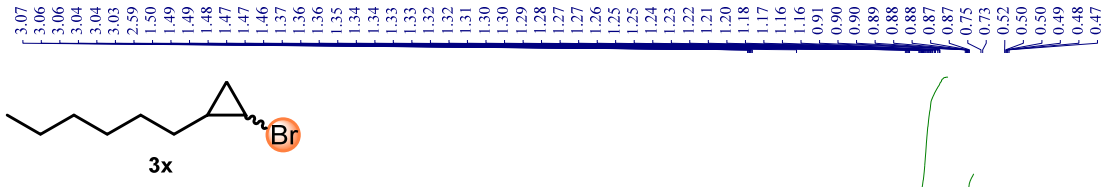

136.7
136.1
129.2
125.9


26.5
21.6
21.0
18.7


Br

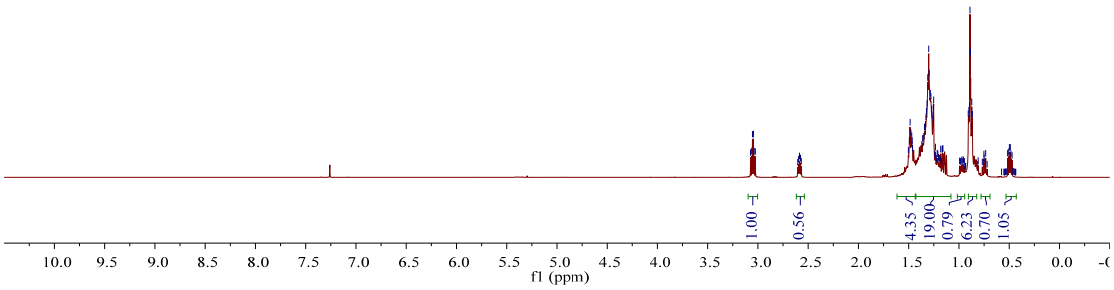
3m

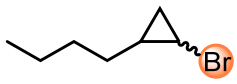

f1 (ppm)



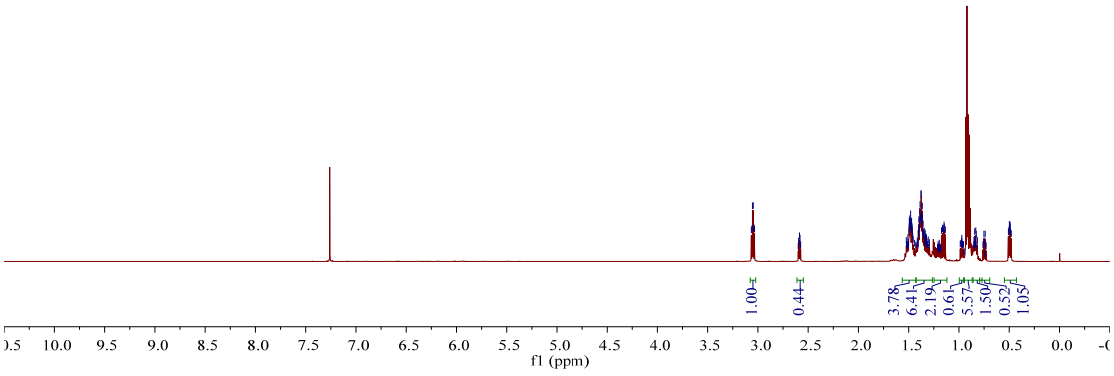
Br

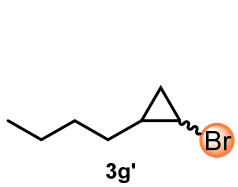
3x


1.00
0.56
4.35
19.00
0.79
6.23
0.70
1.05
f1 (ppm)

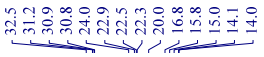

Br

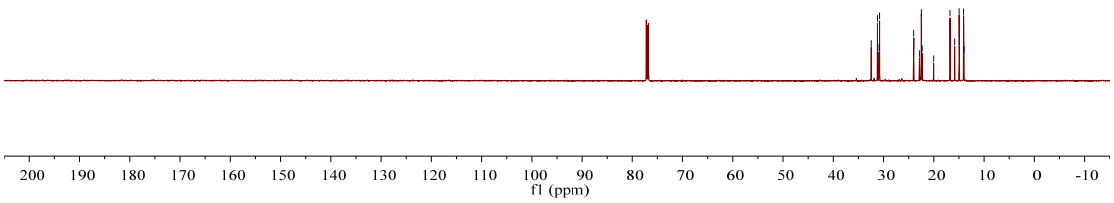
3g'

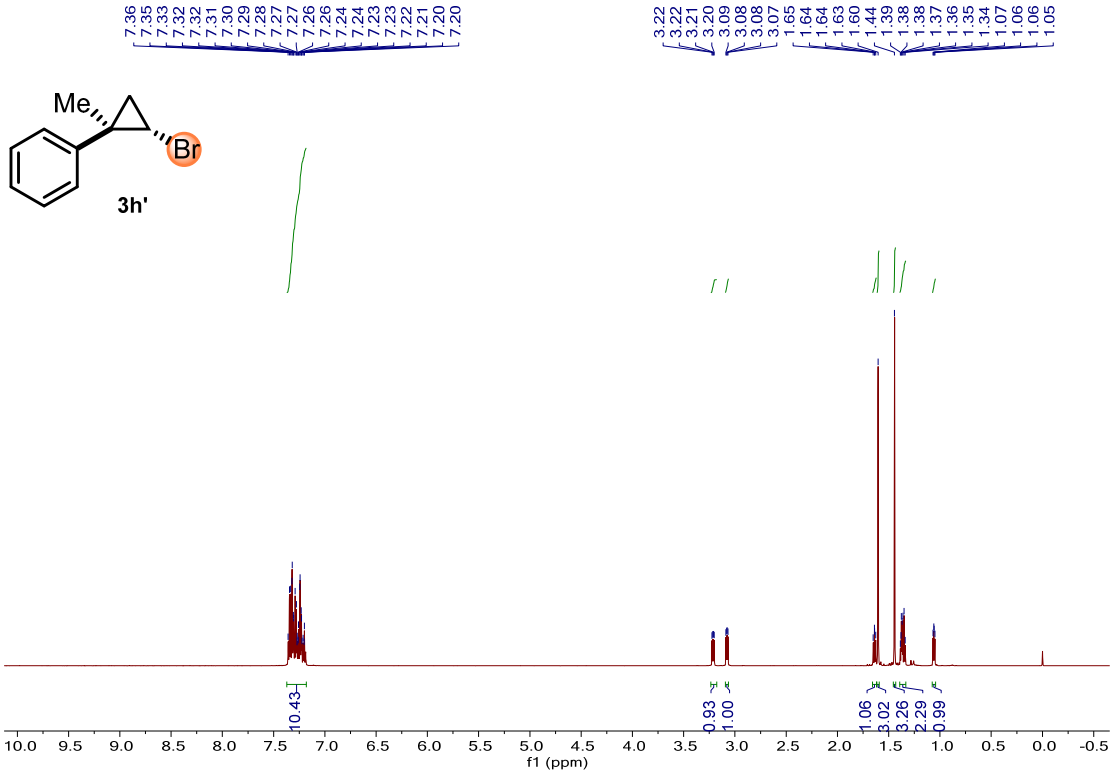

1.00
0.44
3.78
6.41
2.19
0.61
5.57
1.50
0.52
1.05
f1 (ppm)


Br

3g'


32.5
31.2
30.9
30.8
24.0
22.9
22.5
22.3
20.0
16.8
15.8
15.0
14.1
14.0


200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.29
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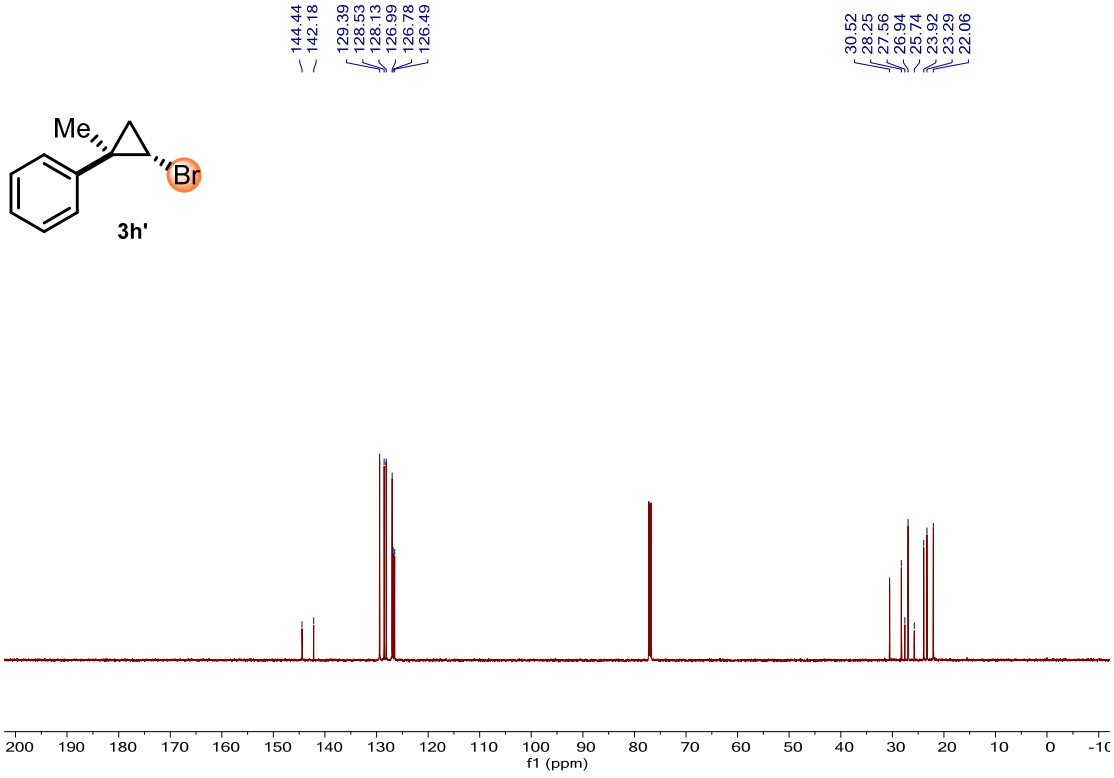
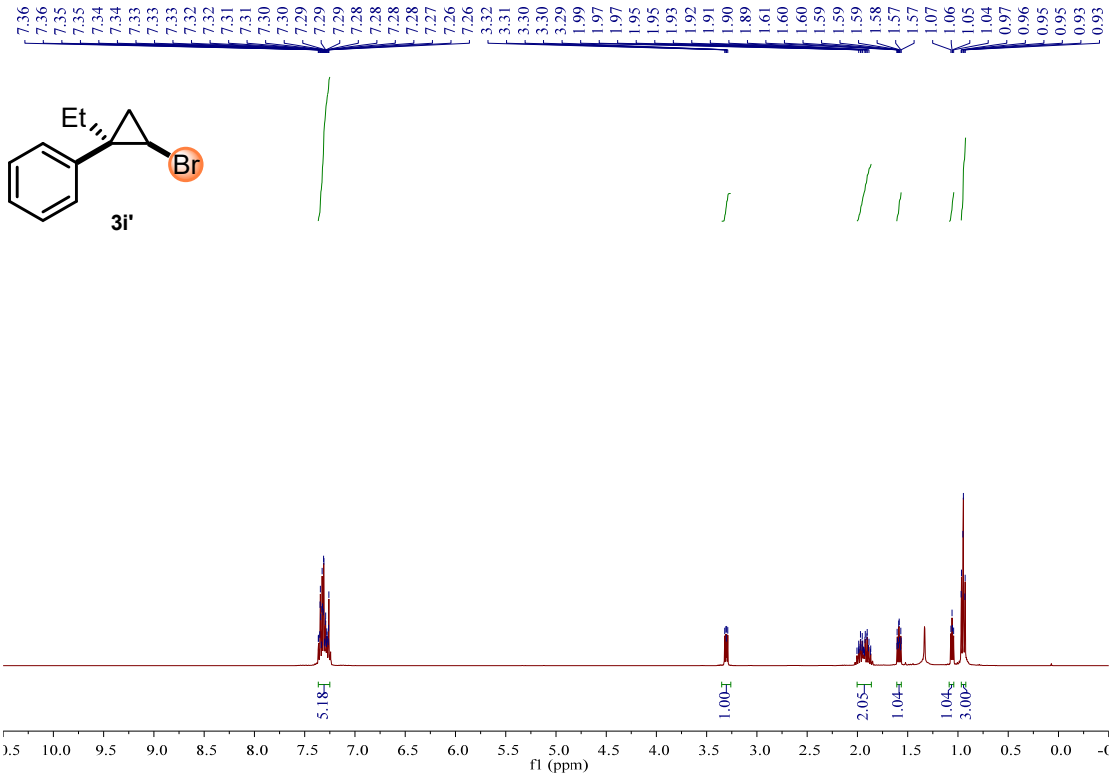
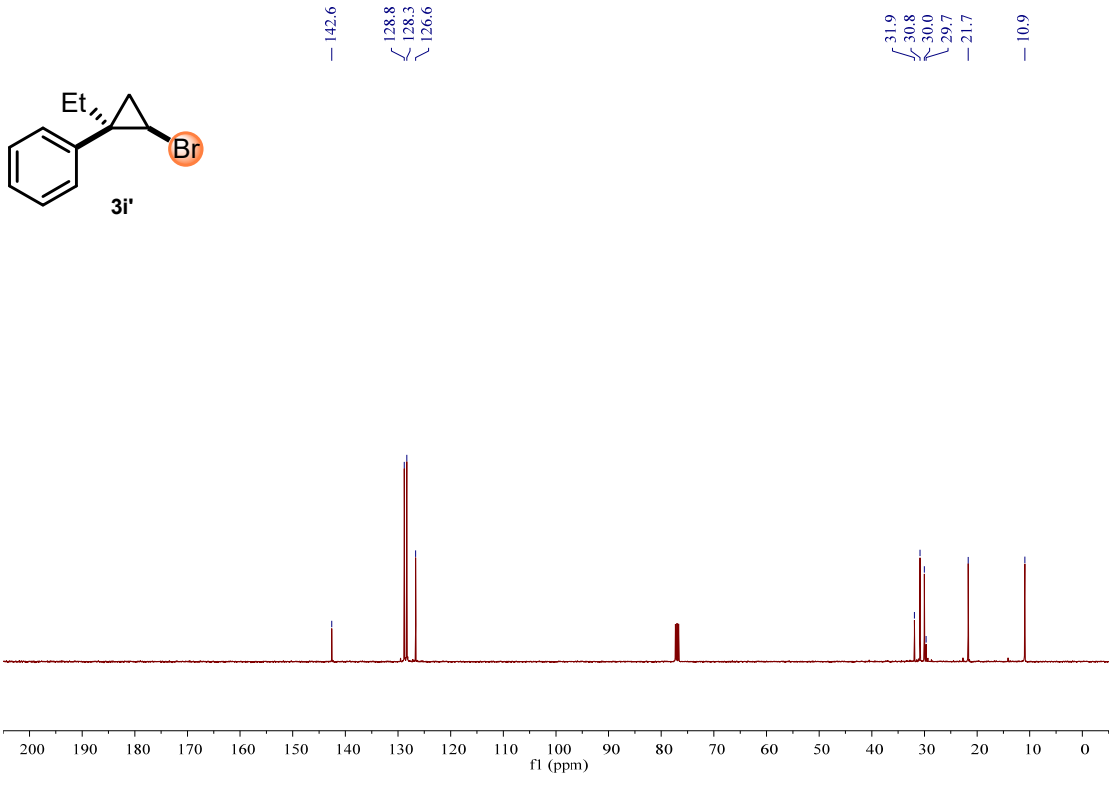
7.27
7.27
7.26
7.26
7.24
7.24
7.23
7.23
7.22
7.21
7.20
7.20
3.22
3.22
3.21
3.20
3.09
3.08
3.08
3.07
1.65
1.64
1.64
1.63
1.60
1.44
1.39
1.38
1.38
1.37
1.36
1.35
1.34
1.07
1.06
1.06
1.05
Me
Br
3h'
10.43
0.93
1.00
1.06
3.02
3.26
2.29
0.99
f1 (ppm)

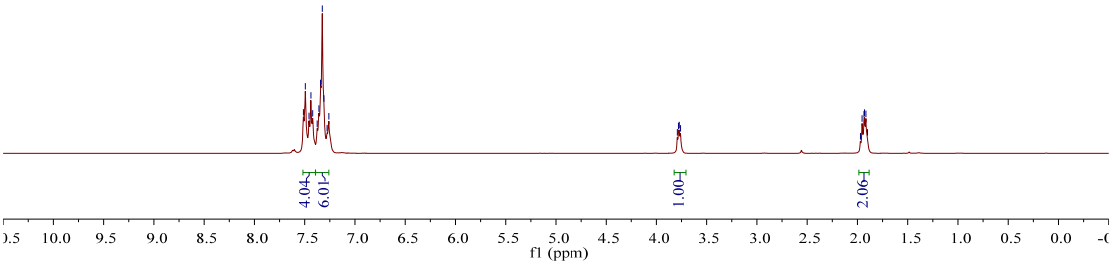

144.44
142.18
129.39
128.53
128.13
126.99
126.78
126.49
30.52
28.25
27.56
26.94
25.74
23.92
23.29
22.06
Me
Br
3h'
f1 (ppm)

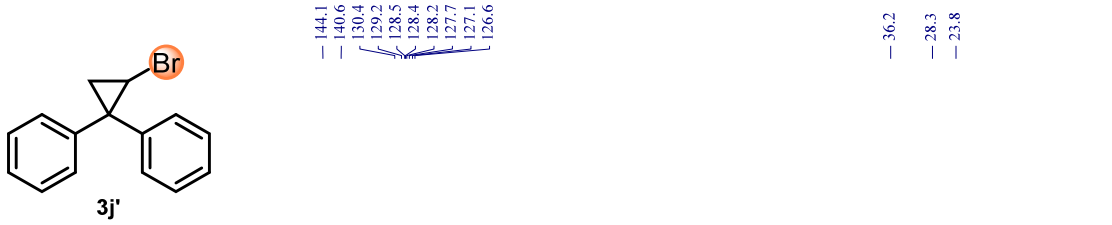

7.36 7.36 7.35 7.35 7.34 7.34 7.33 7.33 7.33 7.32 7.32 7.31 7.31 7.30 7.30 7.29 7.29 7.29 7.28 7.28 7.28 7.28 7.27 7.26 7.26
3.32 3.31 3.30 3.30 3.29 1.99 1.97 1.97 1.95 1.95 1.93 1.92 1.91 1.90 1.89 1.61 1.60 1.60 1.59 1.59 1.59 1.58 1.57 1.57
1.07 1.06 1.05 1.04 0.97 0.96 0.95 0.95 0.93 0.93
Et
Br
3i'
5.18
1.00
2.05
1.04
1.04
3.00
f1 (ppm)


142.6
128.8
128.3
126.6
31.9
30.8
30.0
29.7
21.7
10.9
Et
Br
3i'
f1 (ppm)

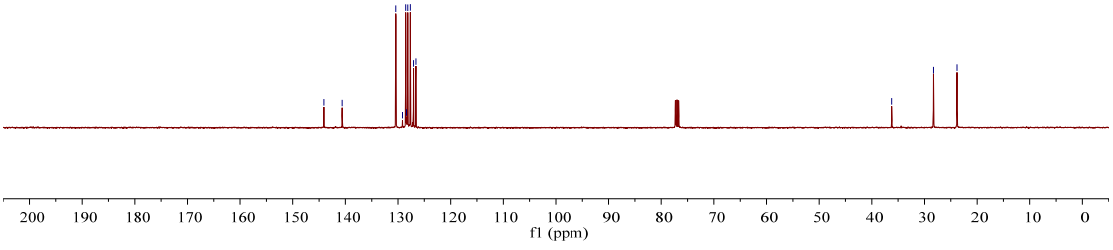

7.51
7.49
7.46
7.44
7.42
7.38
7.36
7.34
7.33
7.31
7.28
7.26
3.79
3.78
3.77
3.76
1.97
1.95
1.94
1.93
1.92
1.90
Br

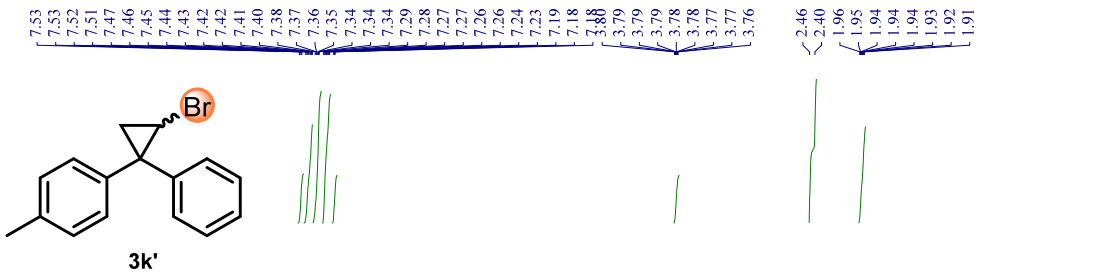
3j'


4.04
6.01
1.00
2.06
f1 (ppm)


144.1
140.6
130.4
129.2
128.5
128.4
128.2
127.7
127.1
126.6
36.2
28.3
23.8
Br

3j'


f1 (ppm)


7.53
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7.51
7.47
7.46
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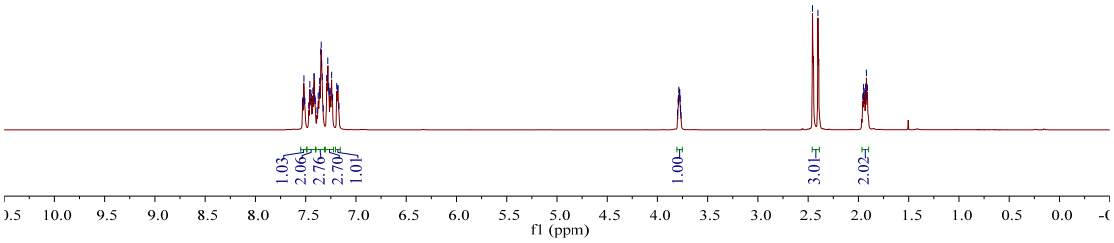
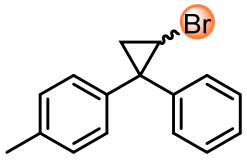
7.44
7.43
7.42
7.42
7.41
7.40
7.38
7.37
7.36
7.35
7.34
7.34
7.34
7.29
7.28
7.27
7.27
7.26
7.26
7.24
7.23
7.19
7.18
3.80
3.79
3.79
3.79
3.78
3.78
3.77
3.77
3.76
2.46
2.40
1.96
1.95
1.94
1.94
1.94
1.93
1.92
1.91

Br

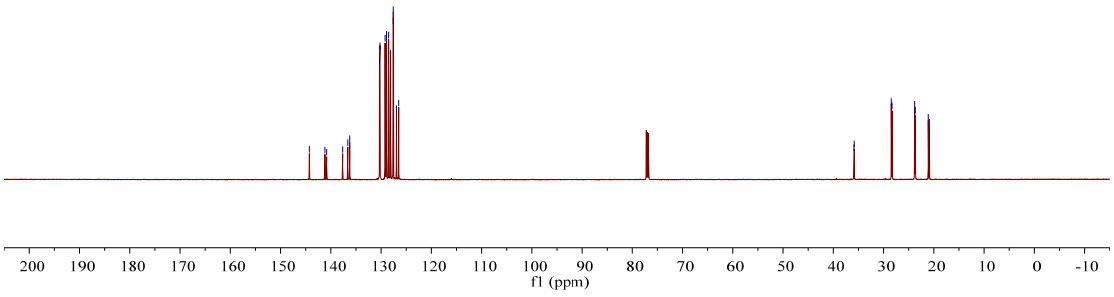
3k'

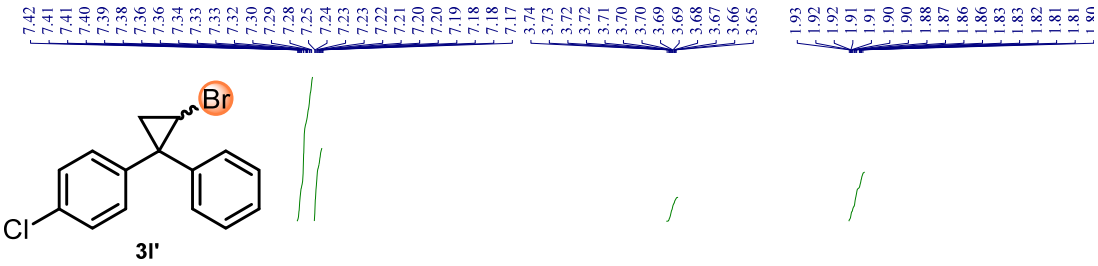

1.03
2.06
2.76
2.70
1.01
1.00
3.01
2.02
f1 (ppm)


144.3
141.2
140.8
137.7
136.6
136.2
130.3
130.2
129.2
128.9
128.5
128.1
127.6
127.6
126.9
126.5
35.9
35.8
28.5
28.3
23.8
23.7
21.1
20.9

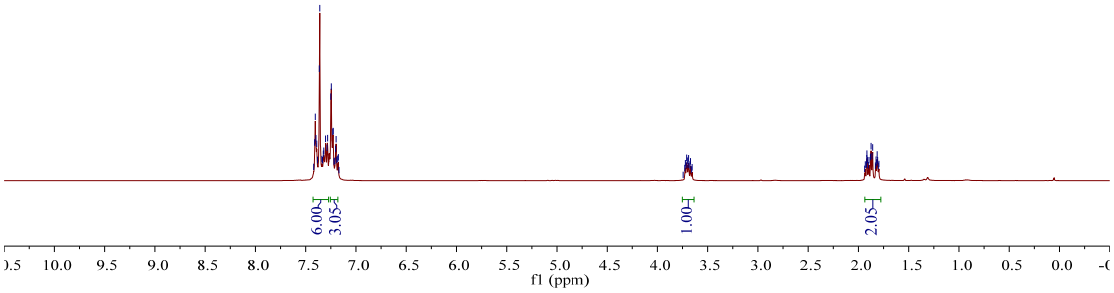

Br

3k'

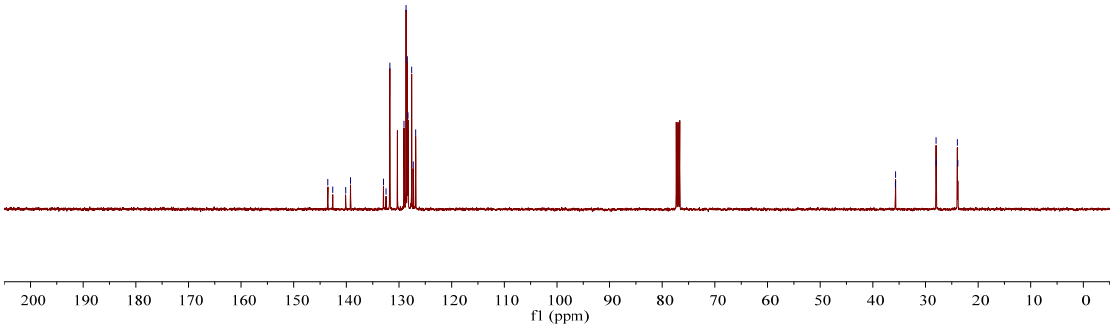

f1 (ppm)

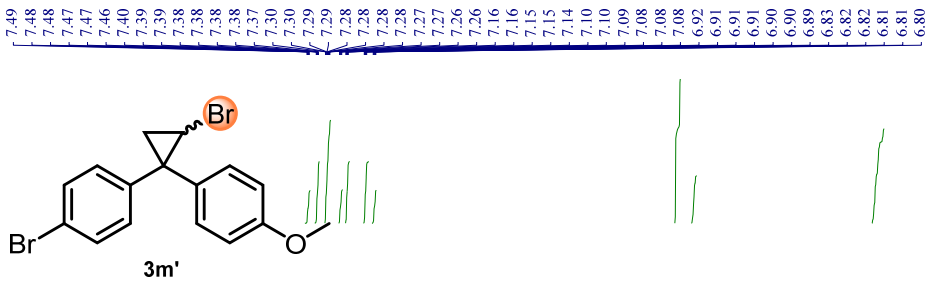


3l'



3l'

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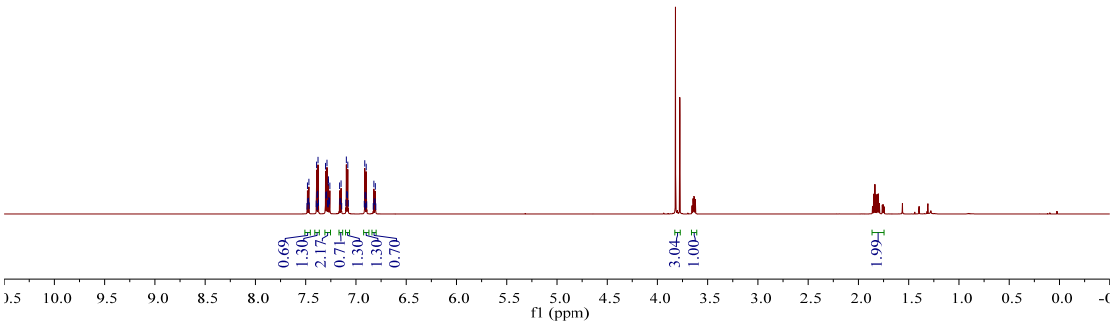
7.37
7.30
7.29
7.29
7.28
7.28
7.28
7.28
7.27
7.26
7.26
7.16
7.16
7.15
7.15
7.14
7.10
7.10
7.09
7.08
7.08
7.08
6.92
6.91
6.91
6.91
6.90
6.90
6.89
6.83
6.82
6.82
6.81
6.81
6.80

Br
Br
O

3m'


0.69
1.30
2.17
0.71
1.30
1.30
0.70
3.04
1.00
1.99
f1 (ppm)


158.71
158.44
143.51
140.19
135.64
132.29
131.91
131.60
131.43
131.35
129.26
128.84
121.04
120.43
114.06
113.70
55.28
55.19
35.23
35.03
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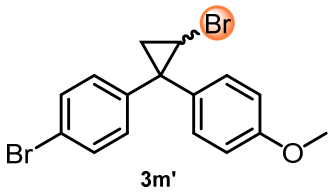
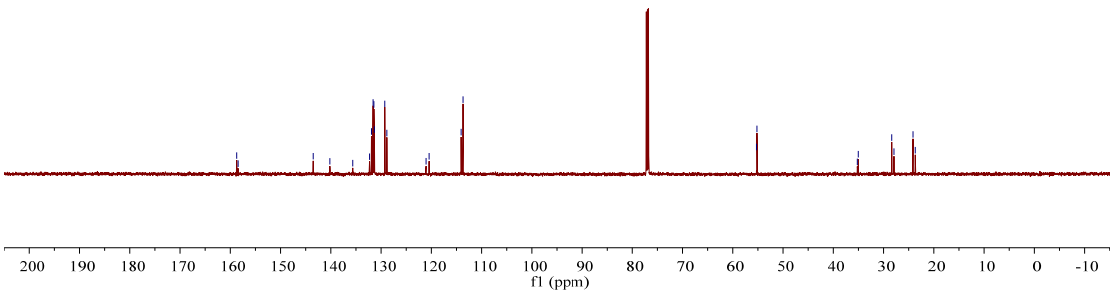
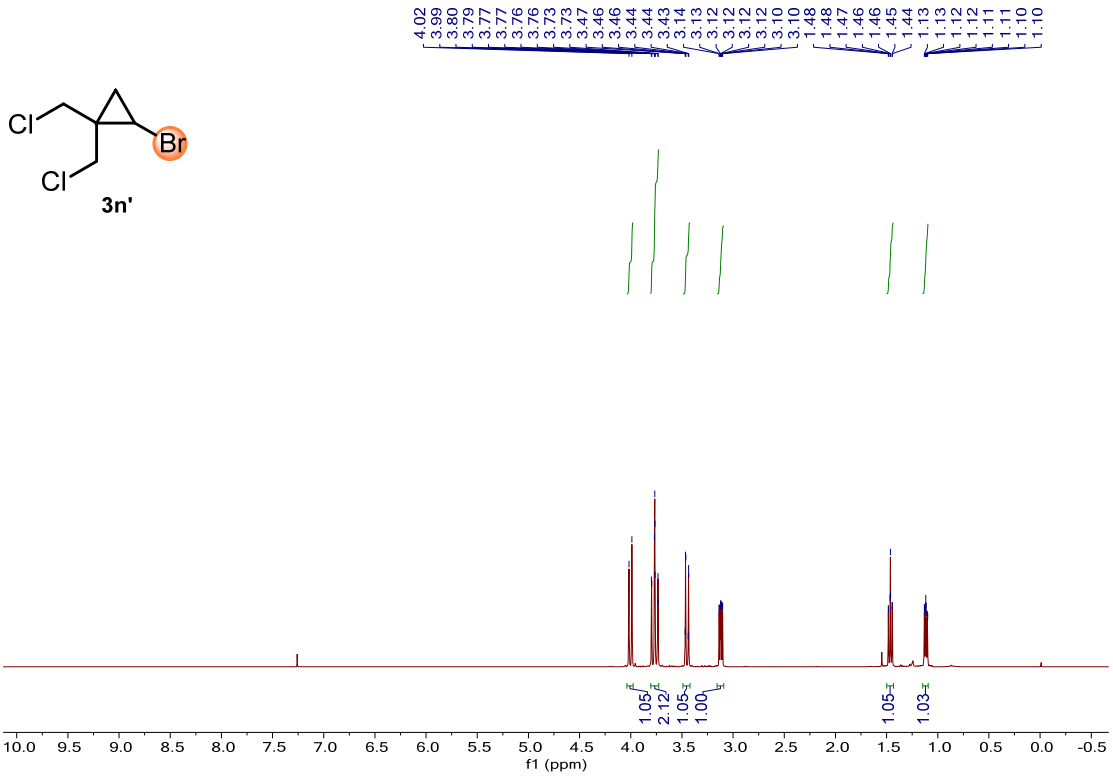
27.93
24.15
23.69


Br
Br
O

3m'


f1 (ppm)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3.99
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3.77
3.76
3.76
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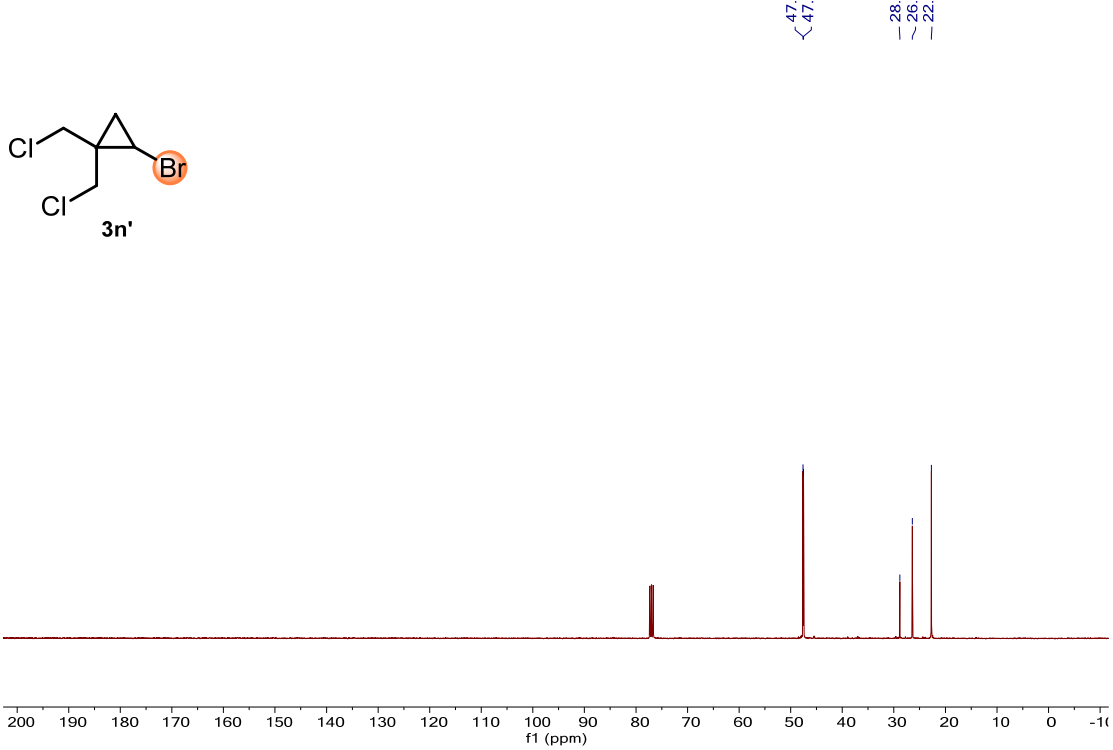
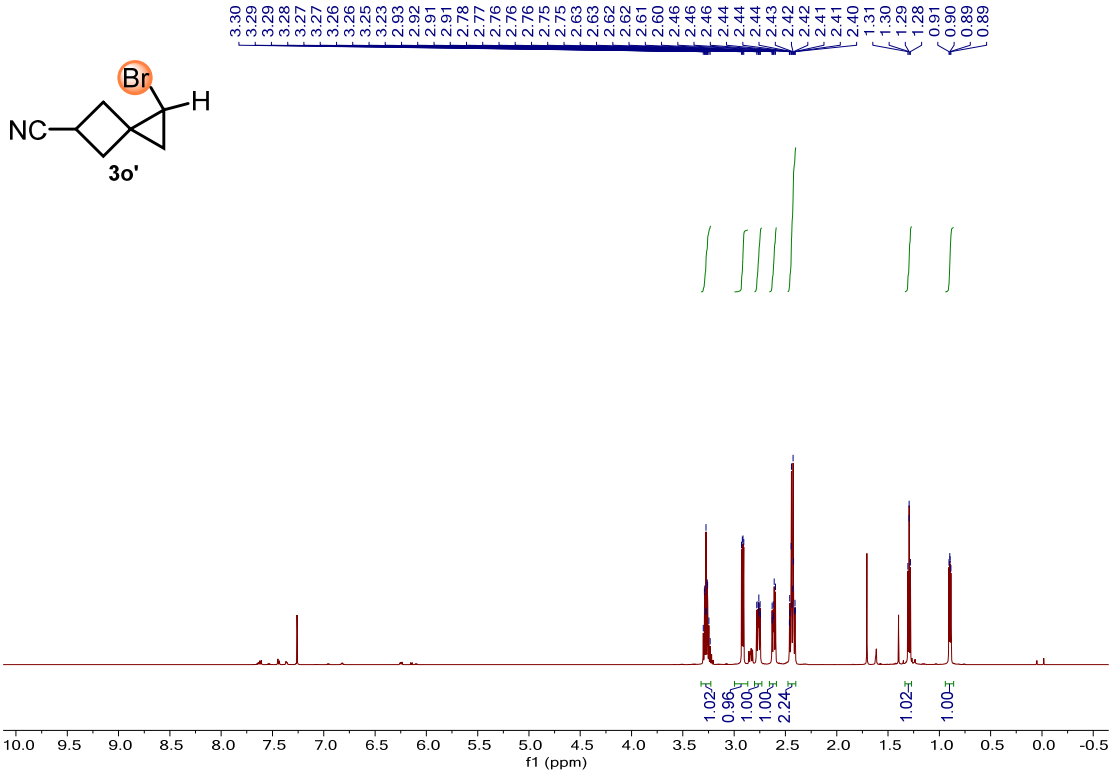
3.73
3.47
3.46
3.46
3.44
3.44
3.43
3.14
3.13
3.12
3.12
3.12
3.12
3.10
3.10
1.48
1.48
1.47
1.46
1.46
1.45
1.44
1.13
1.12
1.12
1.11
1.11
1.10
1.10
Cl
Cl
Br
3n'
1.05
2.12
1.05
1.00
1.05
1.03
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


47.63
47.50
28.83
26.40
22.73
Cl
Cl
Br
3n'
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


3.30
3.29
3.29
3.28
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3.26
3.26
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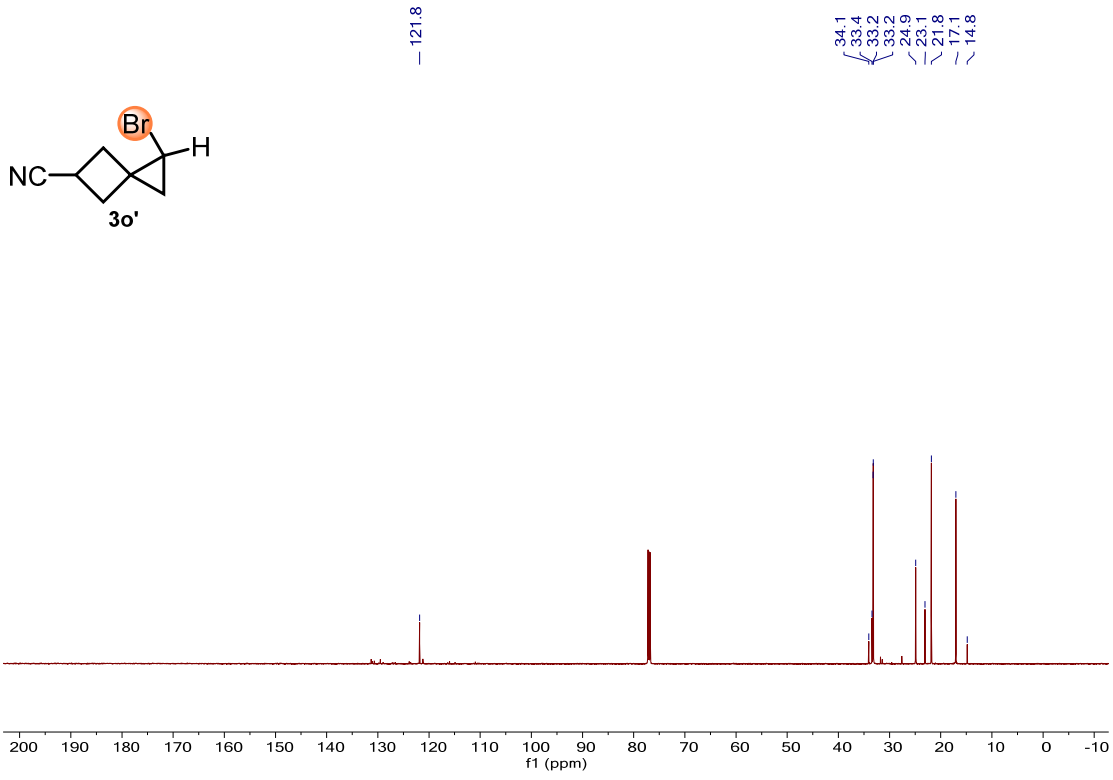
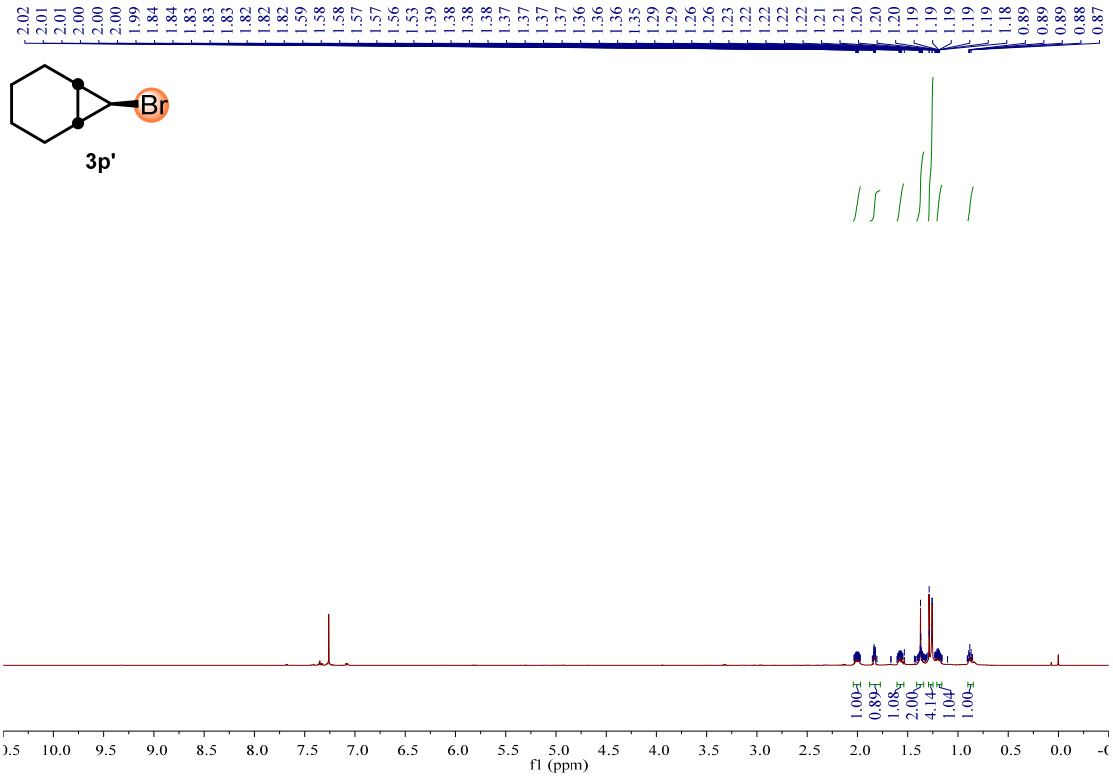
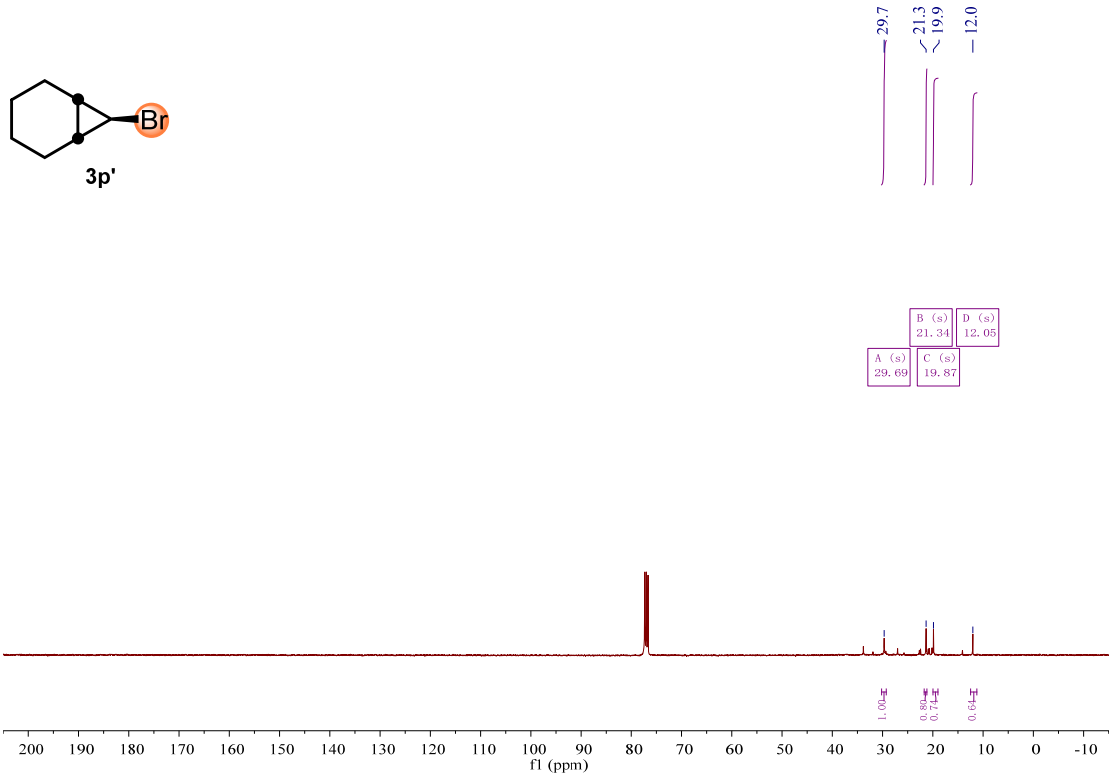
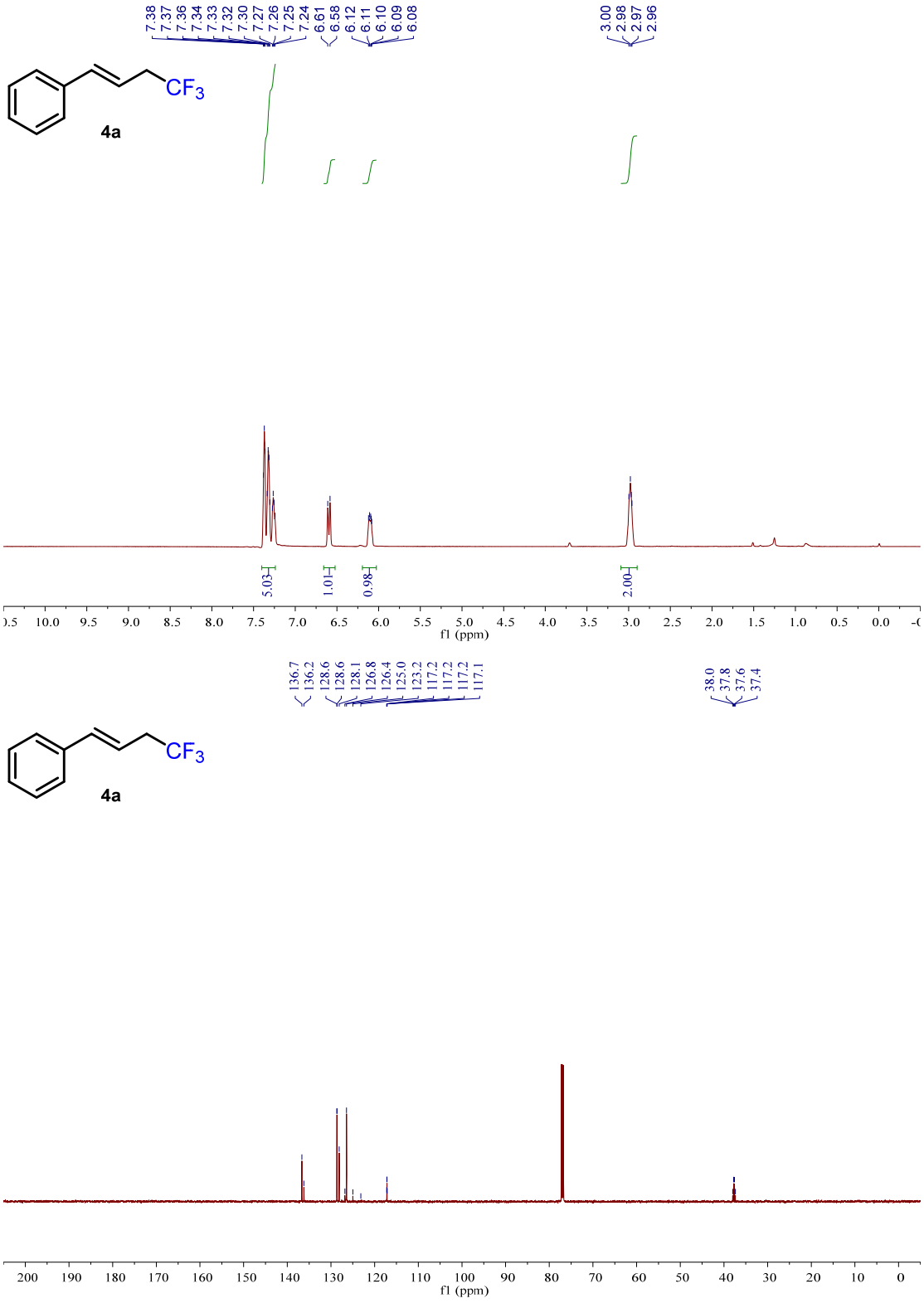
3.23
2.93
2.92
2.91
2.91
2.78
2.77
2.76
2.76
2.76
2.75
2.75
2.63
2.62
2.62
2.61
2.60
2.46
2.46
2.44
2.44
2.44
2.43
2.42
2.42
2.41
2.41
2.40
1.31
1.30
1.29
1.28
0.91
0.90
0.89
0.89
Br
H
NC
3o'
1.02
0.96
1.00
1.00
2.24
1.02
1.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


121.8
34.1
33.4
33.2
33.2
24.9
23.1
21.8
17.1
14.8
Br
H
NC
3o'
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


Br
3p'
1.00
0.89
1.08
2.00
4.14
1.04
1.00
f1 (ppm)


Br
3p'
29.7
21.3
19.9
12.0
B (s)
21.34
D (s)
12.05
A (s)
29.69
C (s)
19.87
1.00
0.80
0.74
0.64
f1 (ppm)


7.38
7.37
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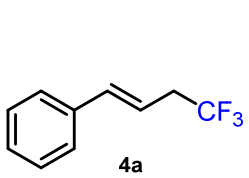
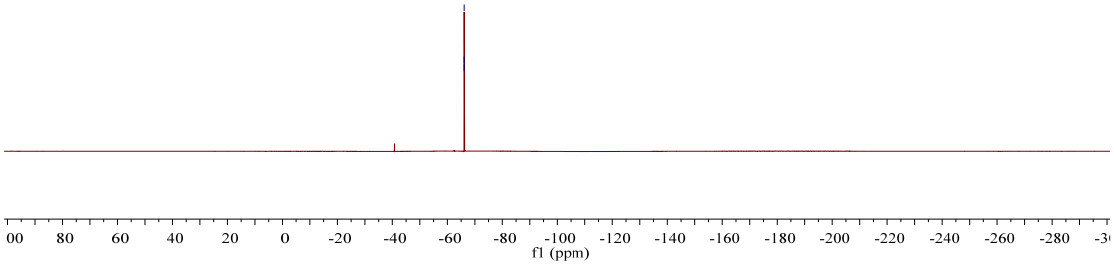
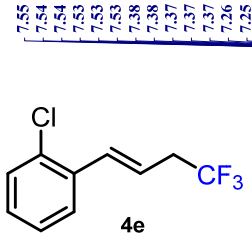
7.34
7.33
7.32
7.30
7.27
7.26
7.25
7.24
6.61
6.58
6.12
6.11
6.10
6.09
6.08
3.00
2.98
2.97
2.96
CF3
4a
5.03
1.01
0.98
2.00
f1 (ppm)
136.7
136.2
128.6
128.6
128.1
126.8
126.4
125.0
123.2
117.2
117.2
117.2
117.1
38.0
37.8
37.6
37.4
CF3
4a
f1 (ppm)


CF3

4a


-66.10
-66.12
-66.14


f1 (ppm)


Cl
CF3

4e

7.55
7.54
7.54
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7.53
7.53
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7.38
7.37
7.37
7.37
7.26
7.25
7.24
7.23
7.23
7.22
7.22
7.22
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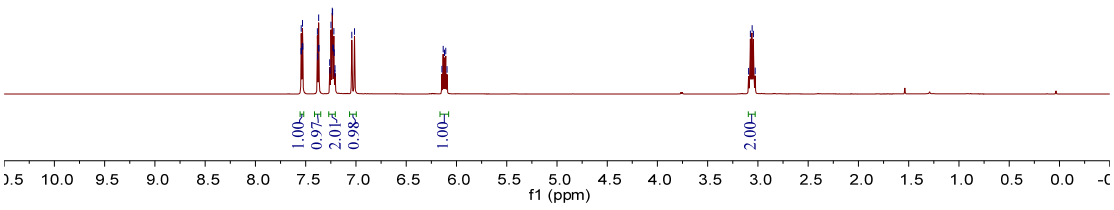
6.13
6.12
6.11
6.09
3.09
3.08
3.06
3.05
3.03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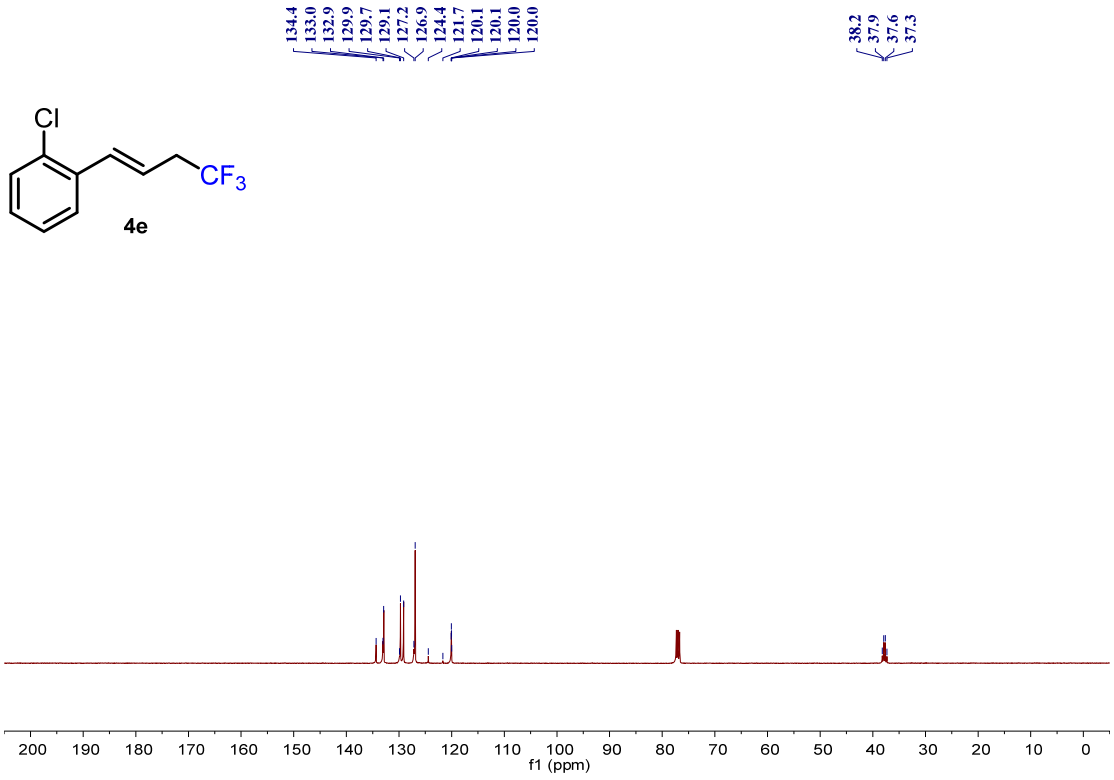
0.97
2.01
0.98
1.00
2.00
f1 (ppm)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132.9
129.9
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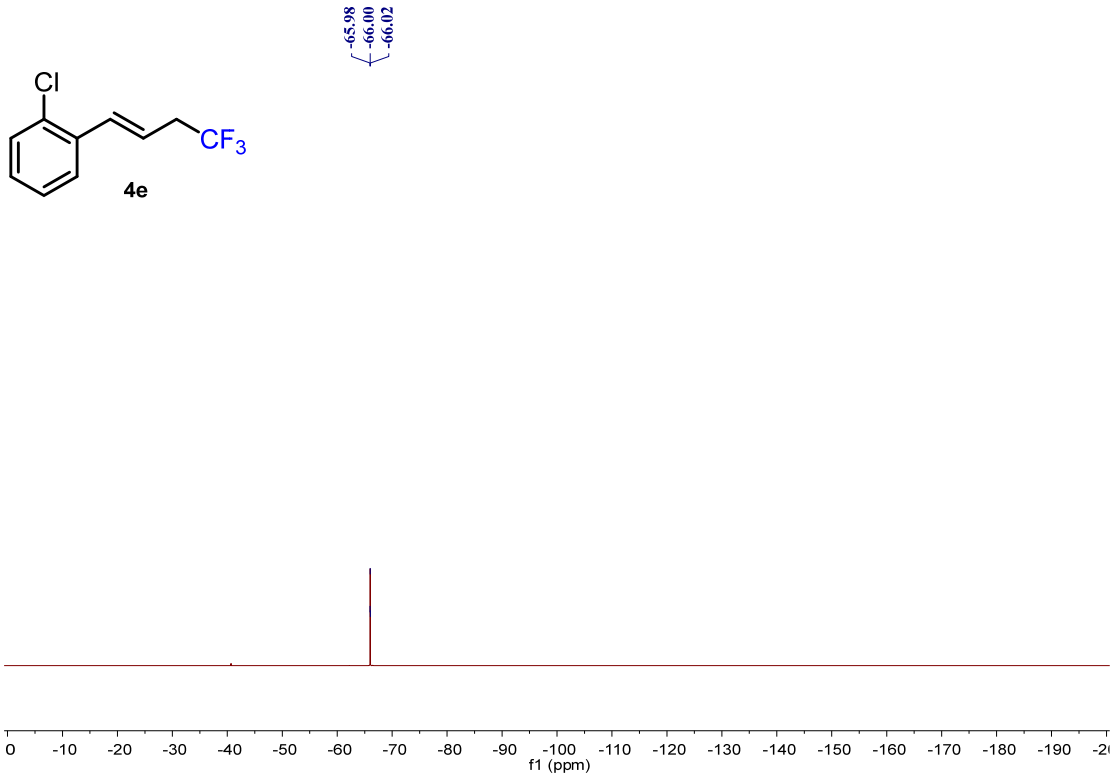
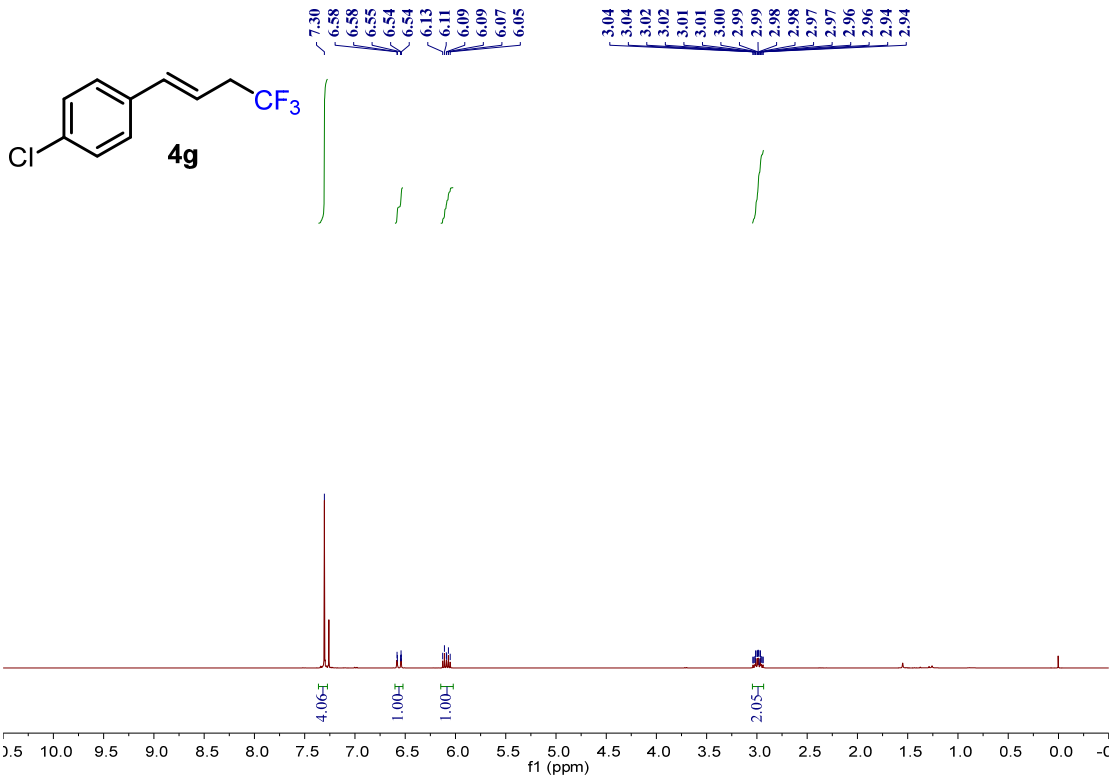
129.1
127.2
126.9
124.4
121.7
120.1
120.1
120.0
120.0
38.2
37.9
37.6
37.3
Cl
CF3
4e
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-65.98
-66.00
-66.02
Cl
CF3
4e
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)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6.07
6.05
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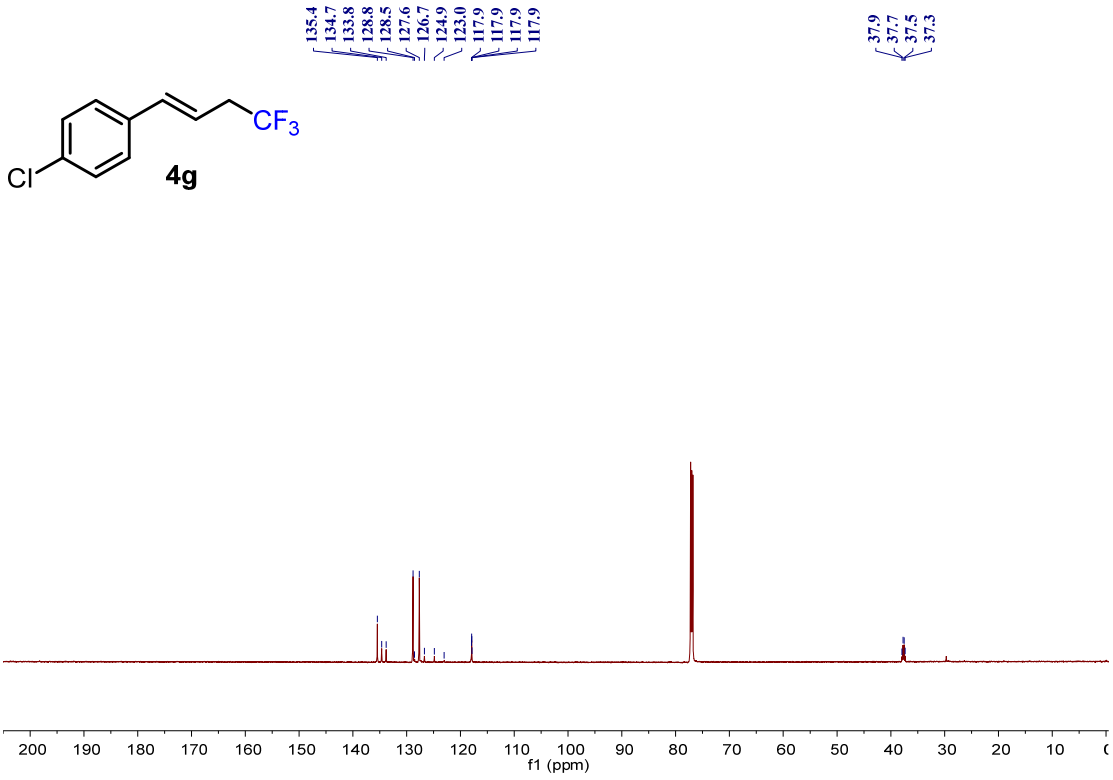
3.04
3.02
3.02
3.01
3.01
3.00
2.99
2.99
2.98
2.98
2.97
2.97
2.96
2.96
2.94
2.94
CF3
Cl
4g
4.06
1.00
1.00
2.05
f1 (ppm)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128.5
127.6
126.7
124.9
123.0
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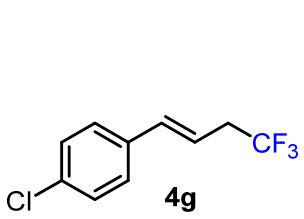
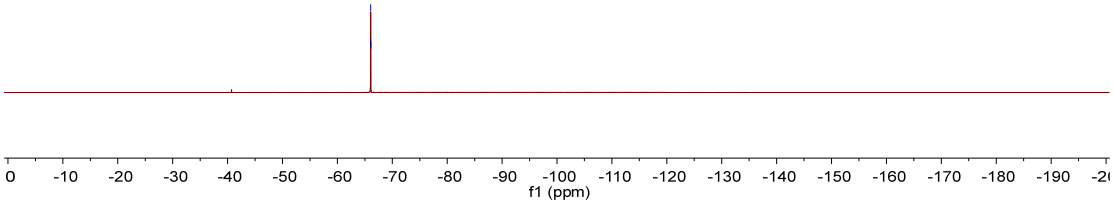
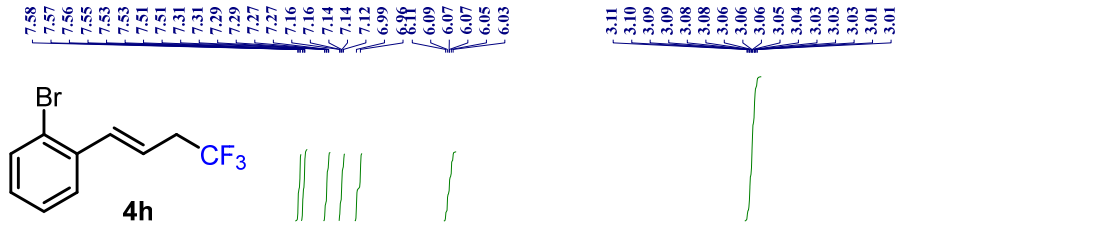
117.9
117.9
37.9
37.7
37.5
37.3
CF3
Cl
4g
f1 (ppm)


-66.03
-66.06
-66.09
CF3
Cl

4g


f1 (ppm)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7.27
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7.14
7.12
6.99
6.96
6.11
6.09
6.07
6.07
6.05
6.03
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3.09
3.09
3.08
3.08
3.06
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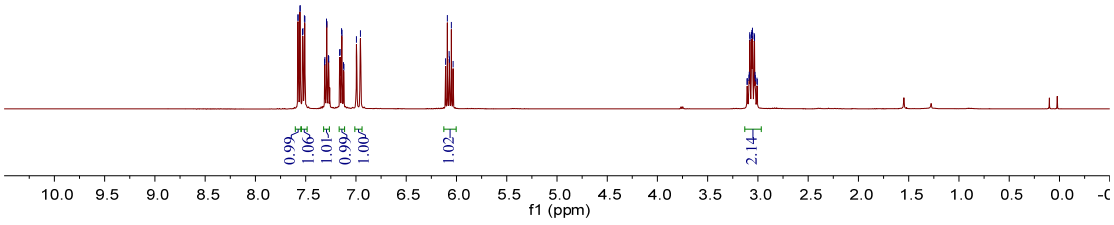
3.05
3.04
3.03
3.03
3.03
3.01
3.01
Br
CF3

4h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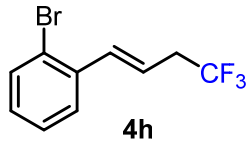
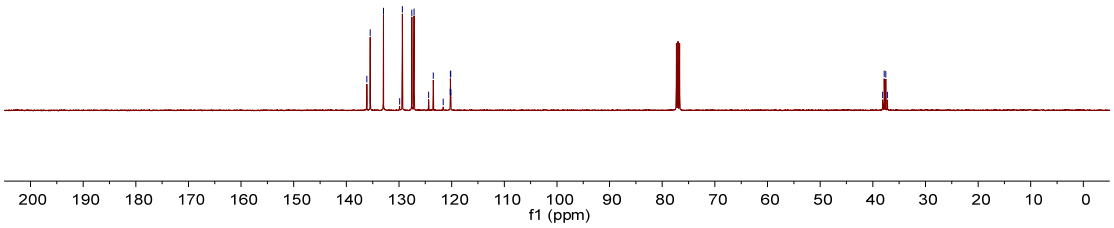
f1 (ppm)


Br
CF3

4h


136.1
135.5
133.0
129.9
129.4
127.6
127.2
124.4
123.5
121.6
120.3
120.2
120.2
120.2


38.1
37.8
37.5
37.2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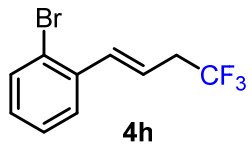
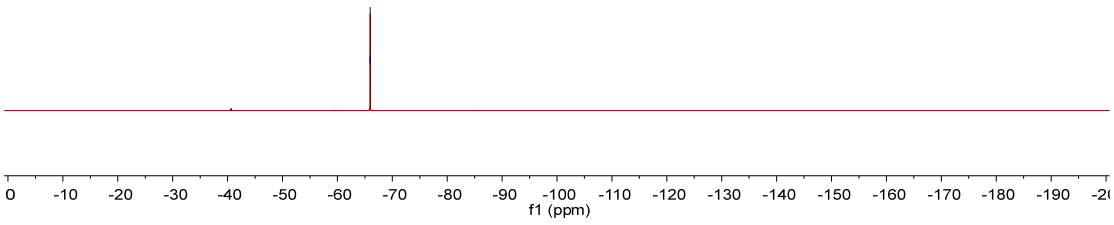
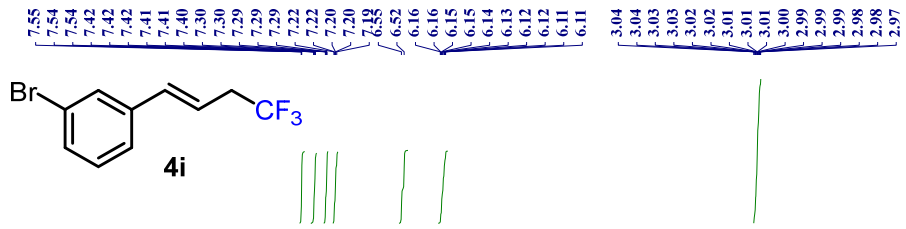
f1 (ppm)


Br
CF3

4h


-65.94
-65.97
-66.00


0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)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6.11
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3.04
3.03
3.03
3.02
3.02
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2.99
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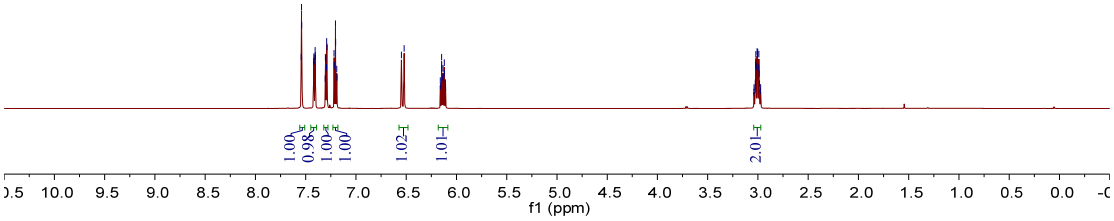
2.98
2.98
2.97
Br
CF3
4i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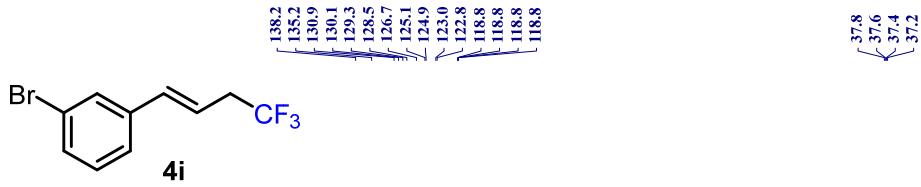
0.98
1.00
1.00
1.02
1.01
2.01
f1 (ppm)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135.2
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129.3
128.5
126.7
125.1
124.9
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122.8
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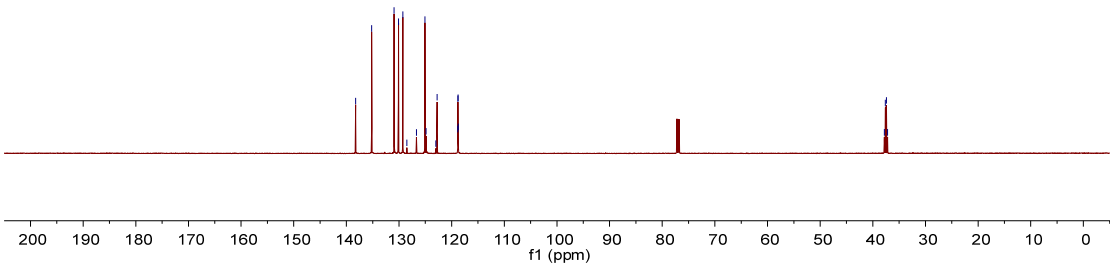
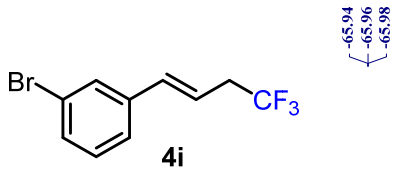
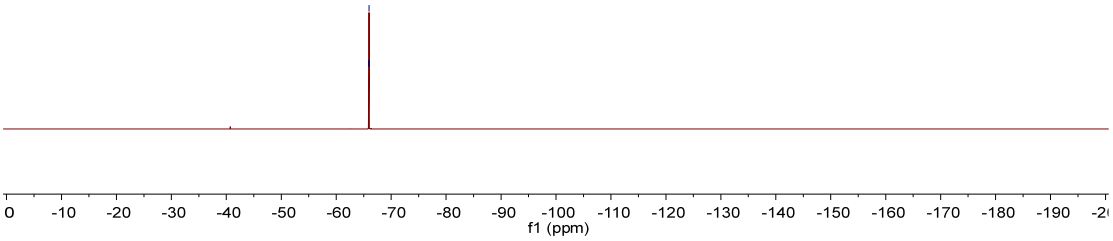
37.6
37.4
37.2
Br
CF3
4i

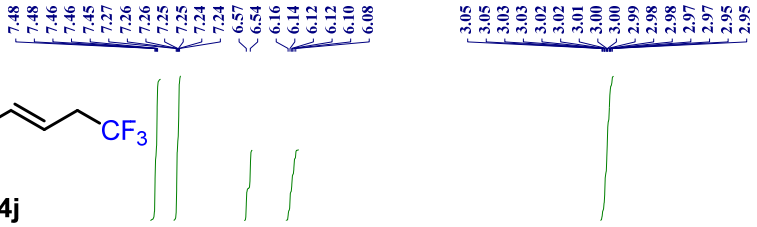

f1 (ppm)


Br
CF3

4i

-65.94
-65.96
-65.98


f1 (ppm)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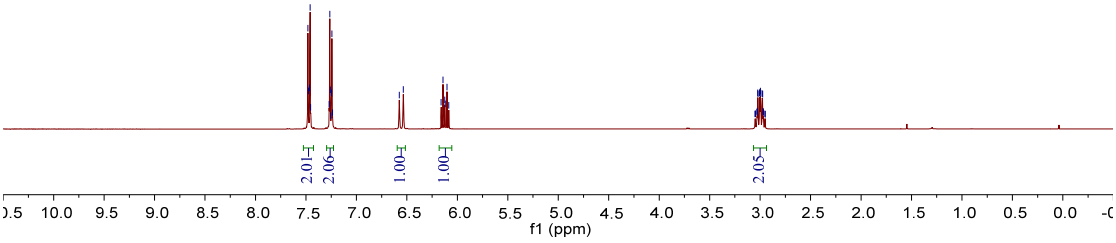
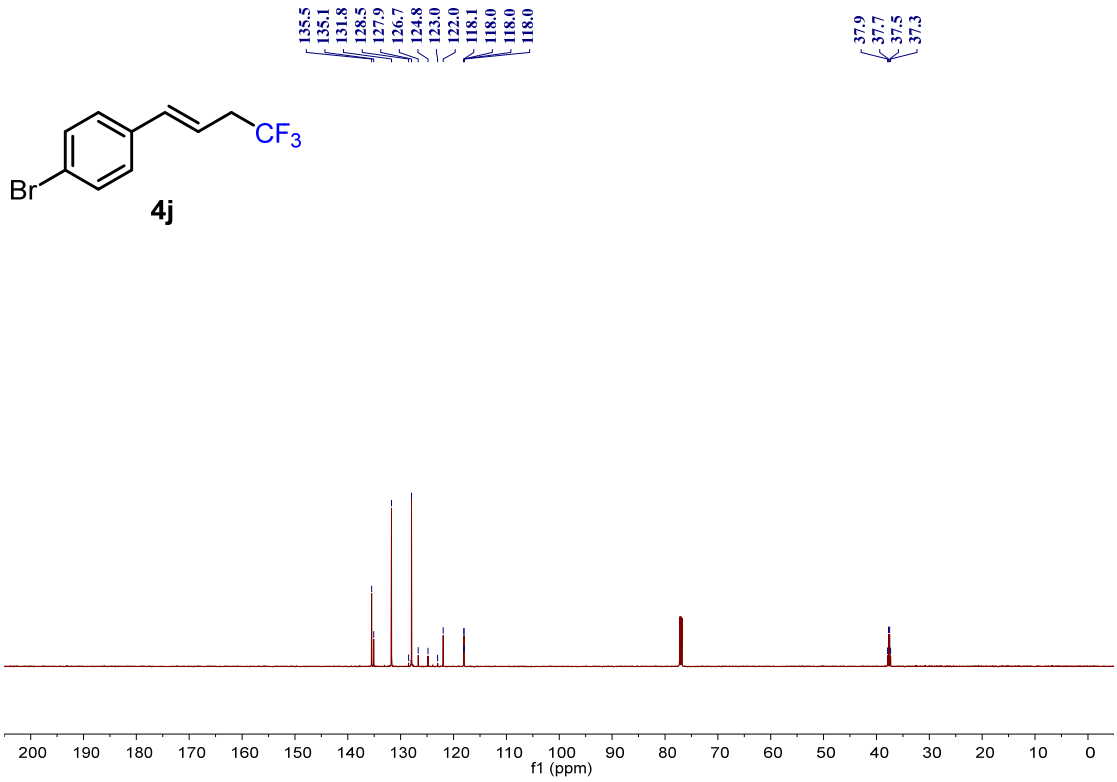
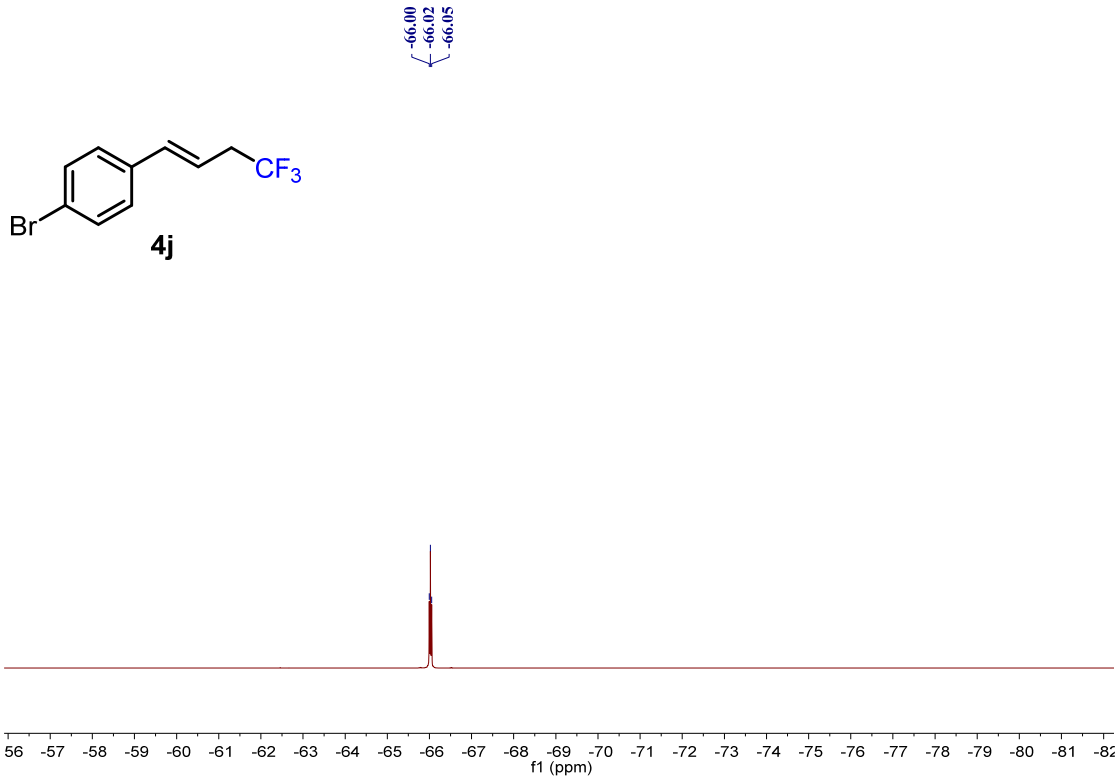
6.14
6.12
6.12
6.10
6.08
3.05
3.05
3.03
3.03
3.02
3.02
3.01
3.00
3.00
2.99
2.98
2.98
2.97
2.97
2.95
2.95

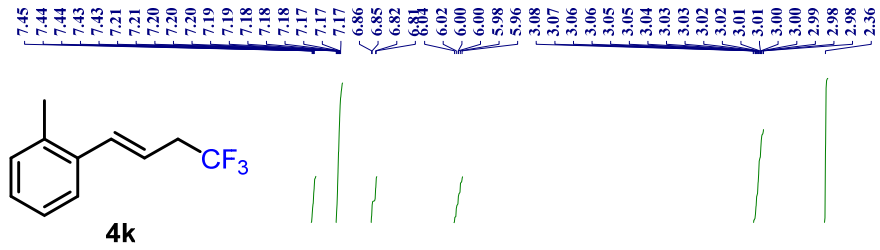
CF3
Br

4j

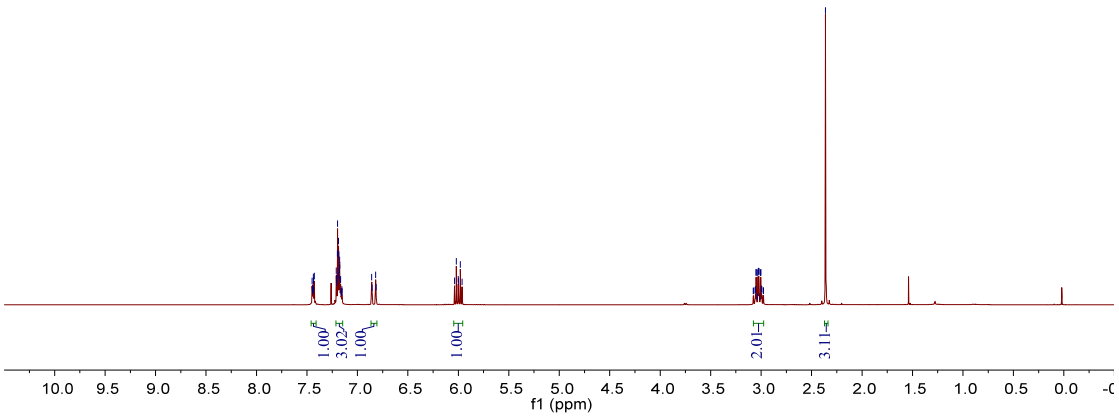

2.01
2.06
1.00
1.00
2.05
f1 (ppm)


135.5
135.1
131.8
128.5
127.9
126.7
124.8
123.0
122.0
118.1
118.0
118.0
118.0
37.9
37.7
37.5
37.3
CF3
Br
4j
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

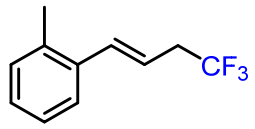

-66.00
-66.02
-66.05
CF3
Br
4j
56 -57 -58 -59 -60 -61 -62 -63 -64 -65 -66 -67 -68 -69 -70 -71 -72 -73 -74 -75 -76 -77 -78 -79 -80 -81 -82
f1 (ppm)


7.45 7.44 7.44 7.43 7.43 7.21 7.21 7.20 7.20 7.20 7.19 7.19 7.18 7.18 7.18 7.17 7.17 7.17
6.86 6.85 6.82 6.02 6.00 6.00 5.98 5.96
3.08 3.07 3.06 3.06 3.05 3.05 3.04 3.03 3.03 3.02 3.02 3.01 3.01 3.00 3.00 2.99 2.98 2.98 2.36
CF3

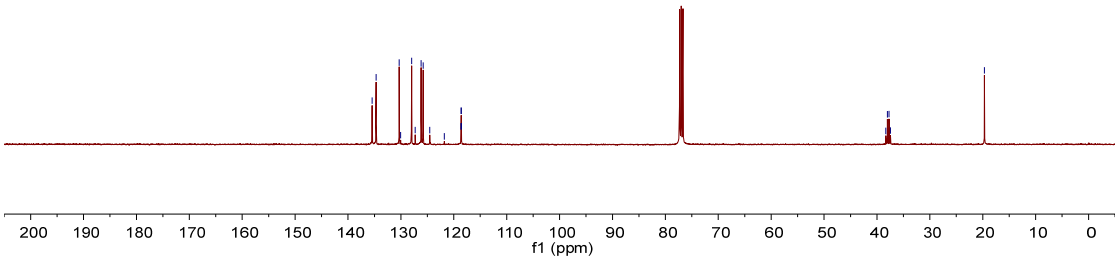
4k

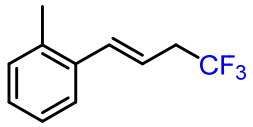

1.00
3.02
1.00
1.00
2.01
3.11
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


135.4 134.7 130.3 130.0 128.0 127.3 126.2 125.8 124.5 121.8 118.7 118.6 118.6 118.6
38.3 38.0 37.7 37.4
19.7

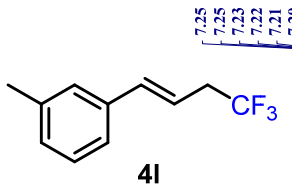

CF3

4k

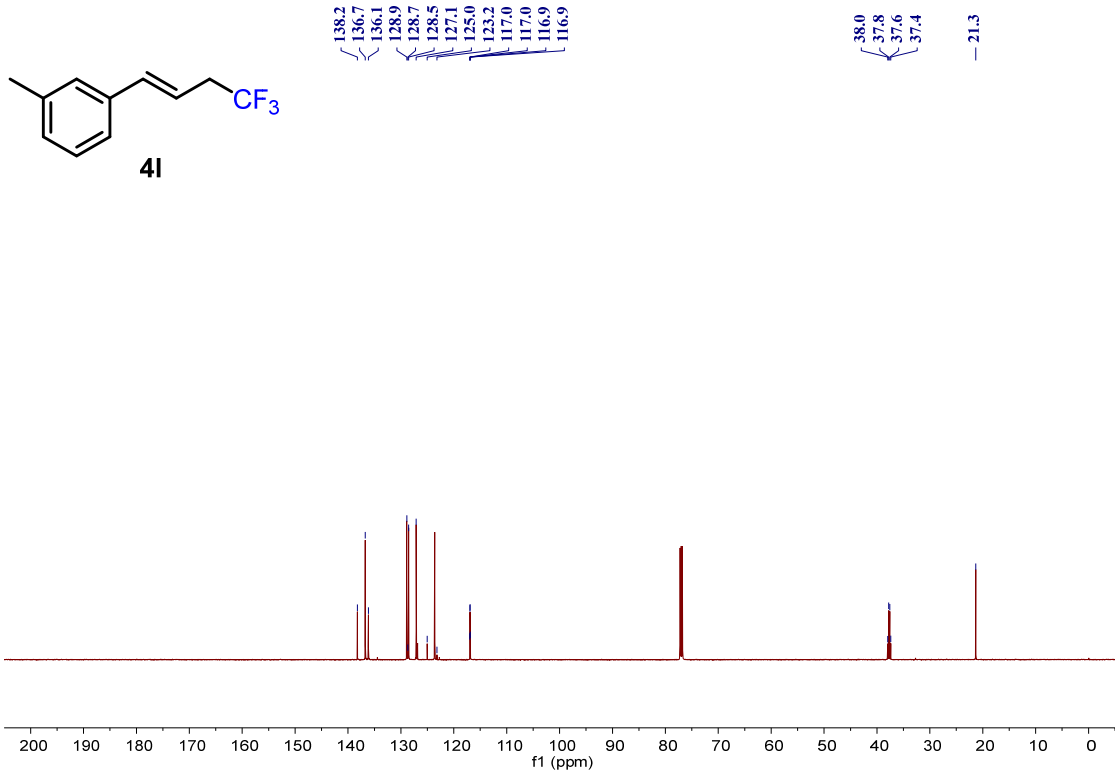

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

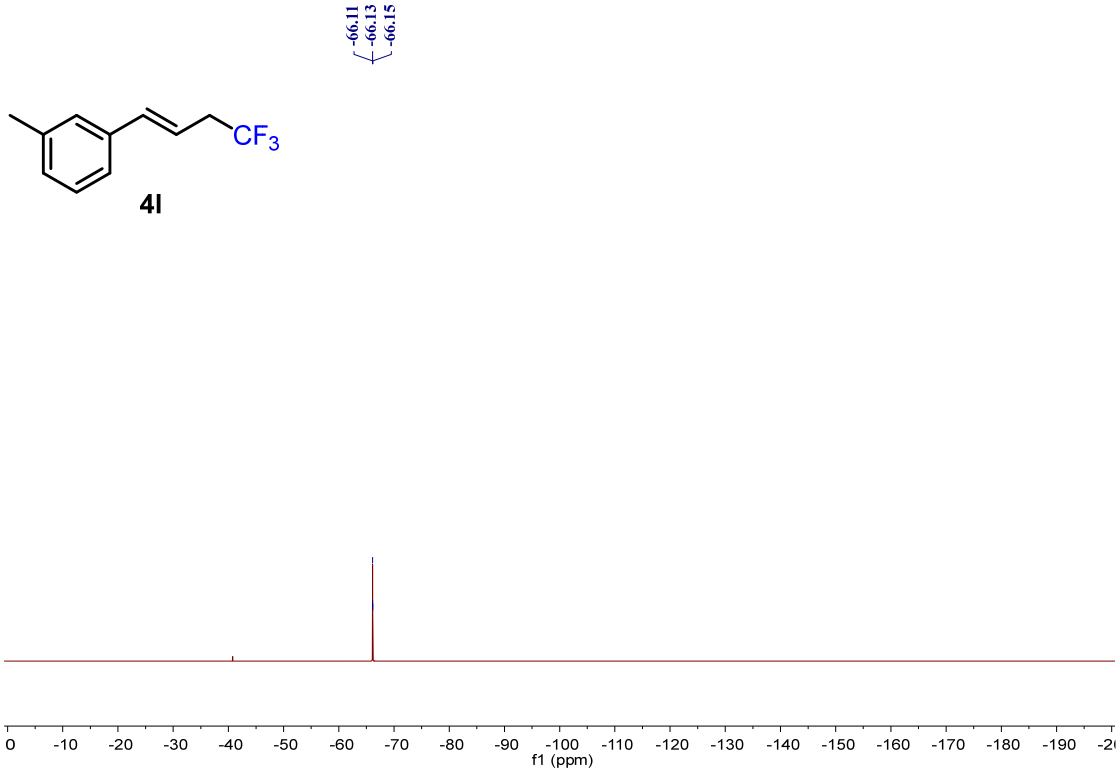


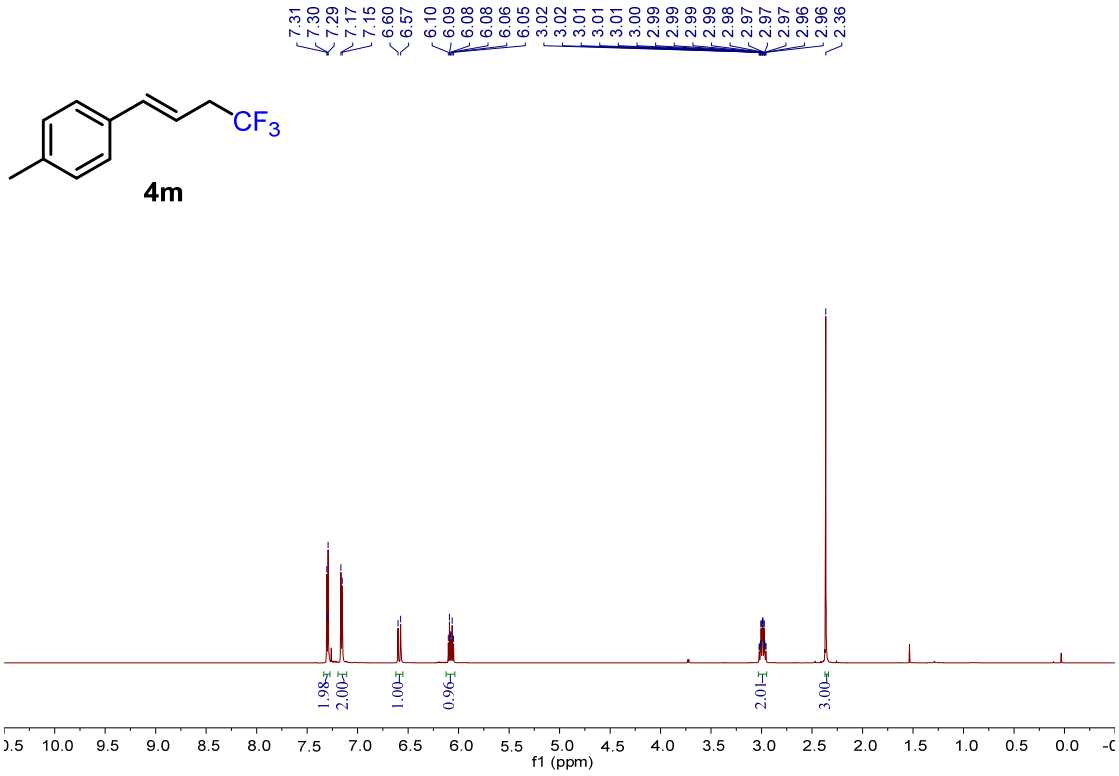
4k

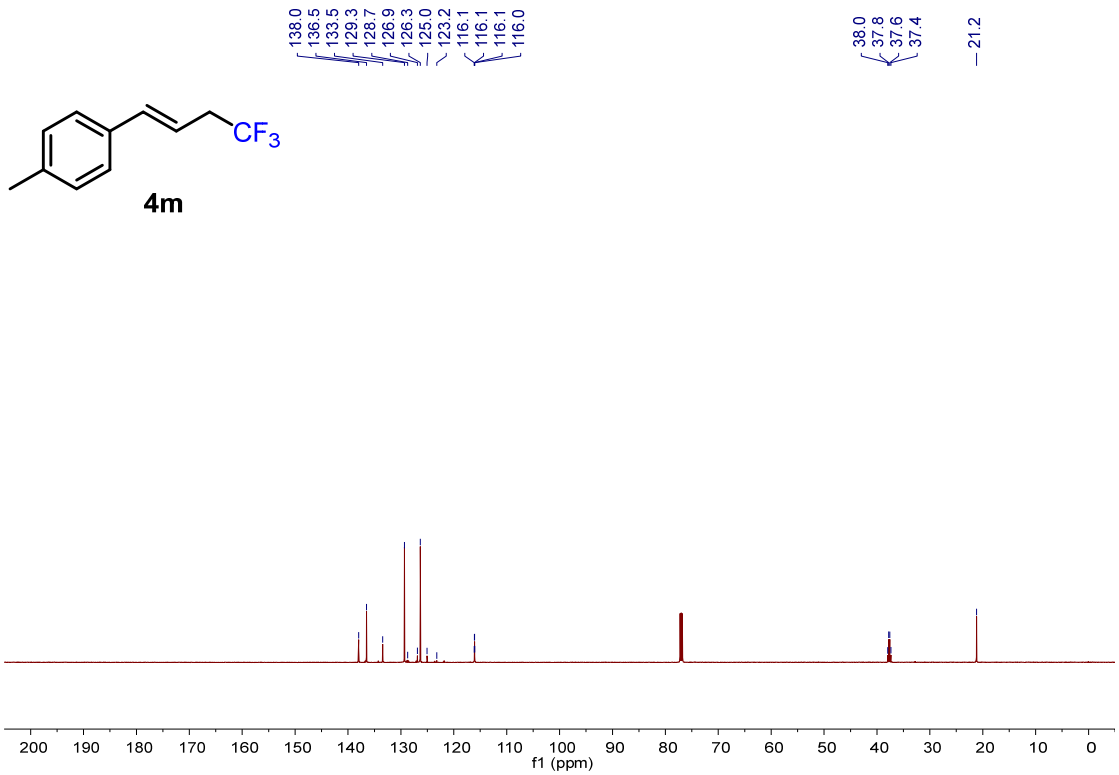


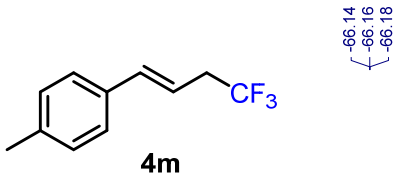
4l


138.2
136.7
136.1
128.9
128.7
128.5
127.1
125.0
123.2
117.0
117.0
116.9
116.9
38.0
37.8
37.6
37.4
21.3
CF3
4l
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


-66.11
-66.13
-66.15
CF3
4l
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)

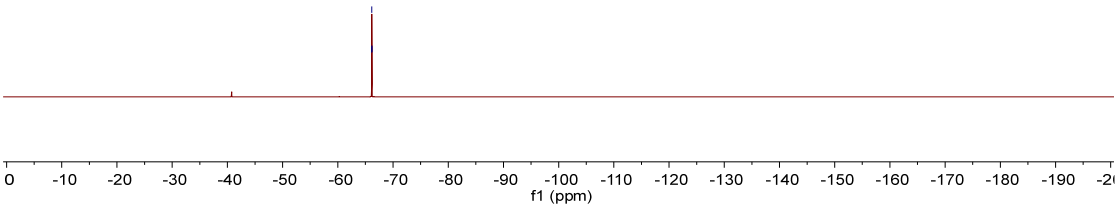

7.31
7.30
7.29
7.17
7.15
6.60
6.57
6.10
6.09
6.08
6.08
6.06
6.05
3.02
3.02
3.01
3.01
3.01
3.00
2.99
2.99
2.99
2.99
2.98
2.97
2.97
2.97
2.96
2.96
2.36
CF3
4m
1.98
2.00
1.00
0.96
2.01
3.00
f1 (ppm)

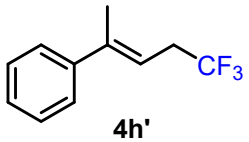

138.0
136.5
133.5
129.3
128.7
126.9
126.3
125.0
123.2
116.1
116.1
116.1
116.0
38.0
37.8
37.6
37.4
21.2
CF3
4m
f1 (ppm)


CF3

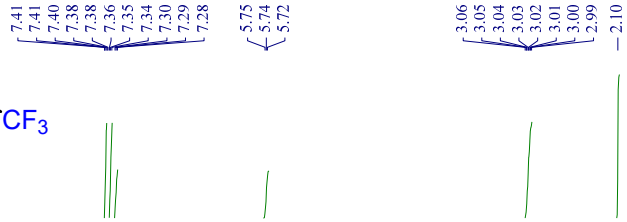
4m

-66.14
-66.16
-66.18


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


CF3

4h'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7.41
7.40
7.38
7.38
7.36
7.35
7.34
7.30
7.29
7.28
5.75
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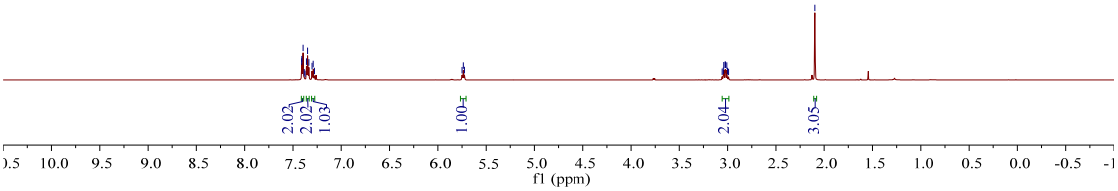
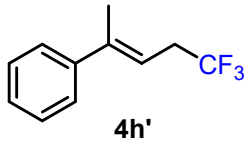
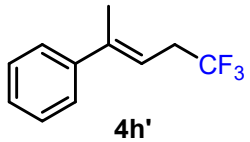
3.06
3.05
3.04
3.03
3.02
3.01
3.00
2.99
2.10


2.02
2.02
1.03
1.00
2.04
3.05
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 -0.5
f1 (ppm)


CF3

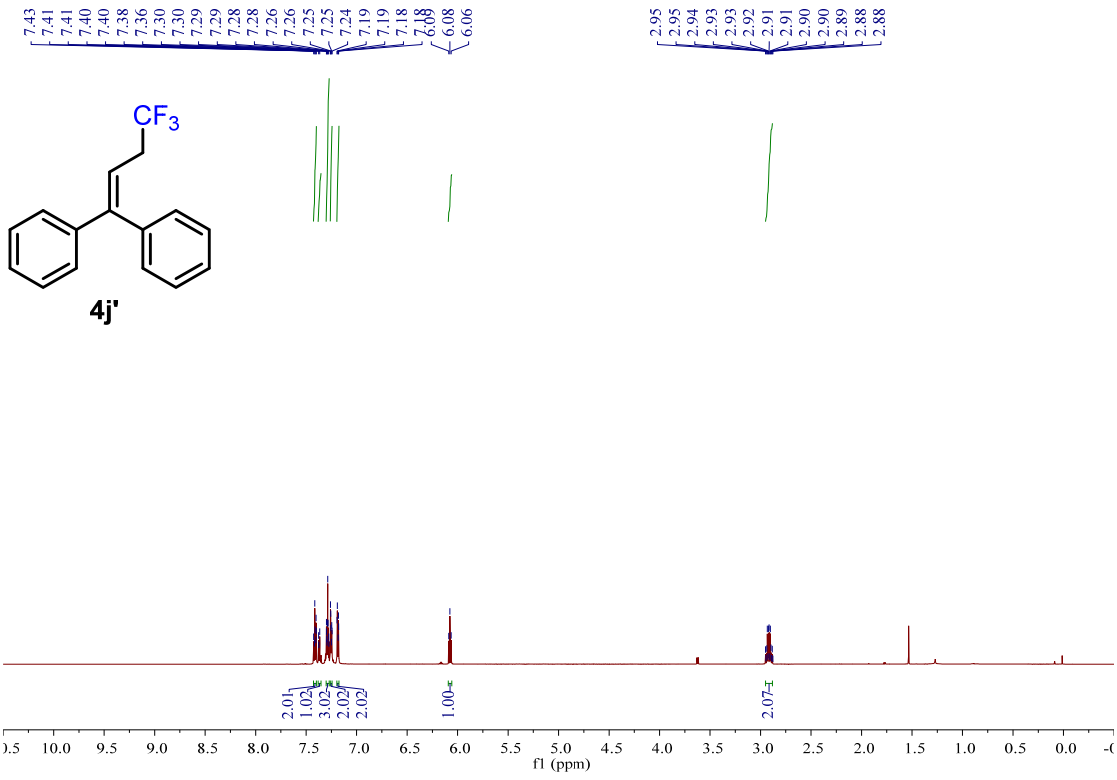
4h'

142.7
141.4
129.1
128.3
127.6
127.5
127.3
125.9
125.4
120.2
115.0
115.0
115.0
115.0
34.0
33.8
33.6
33.4
16.3
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


CF3

4h'

-65.79
-65.82
-65.84
-10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -20
f1 (ppm)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7.41
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7.40
7.38
7.36
7.30
7.30
7.29
7.29
7.28
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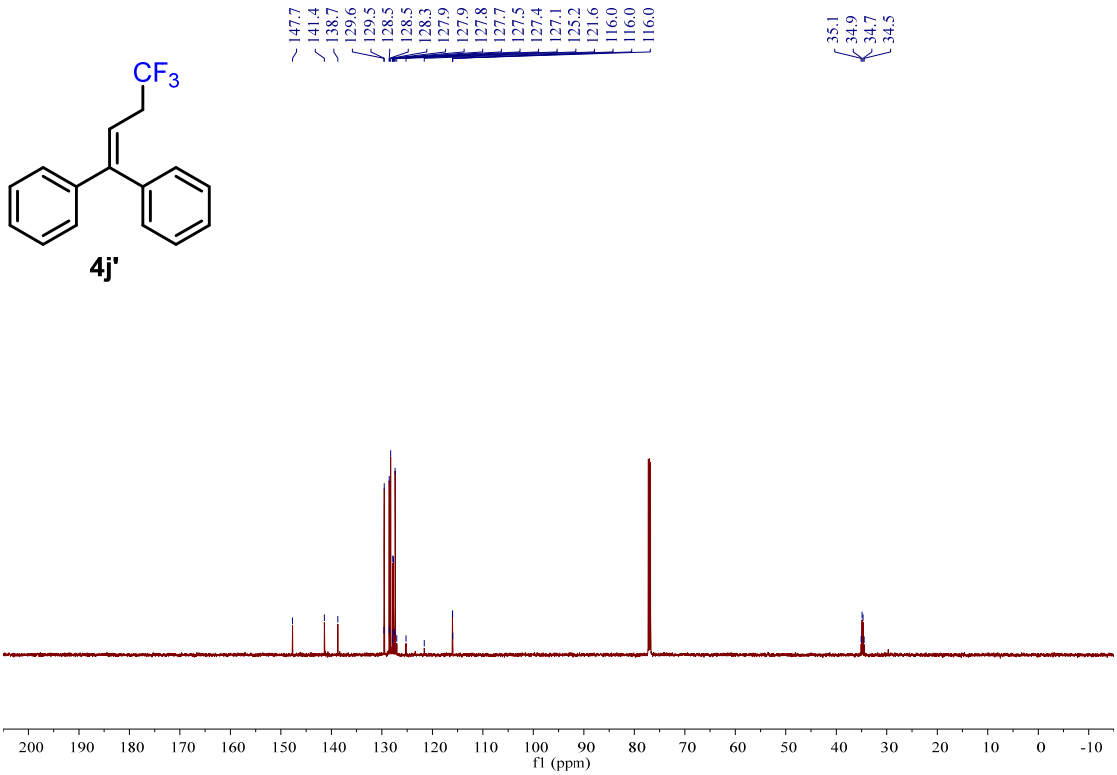
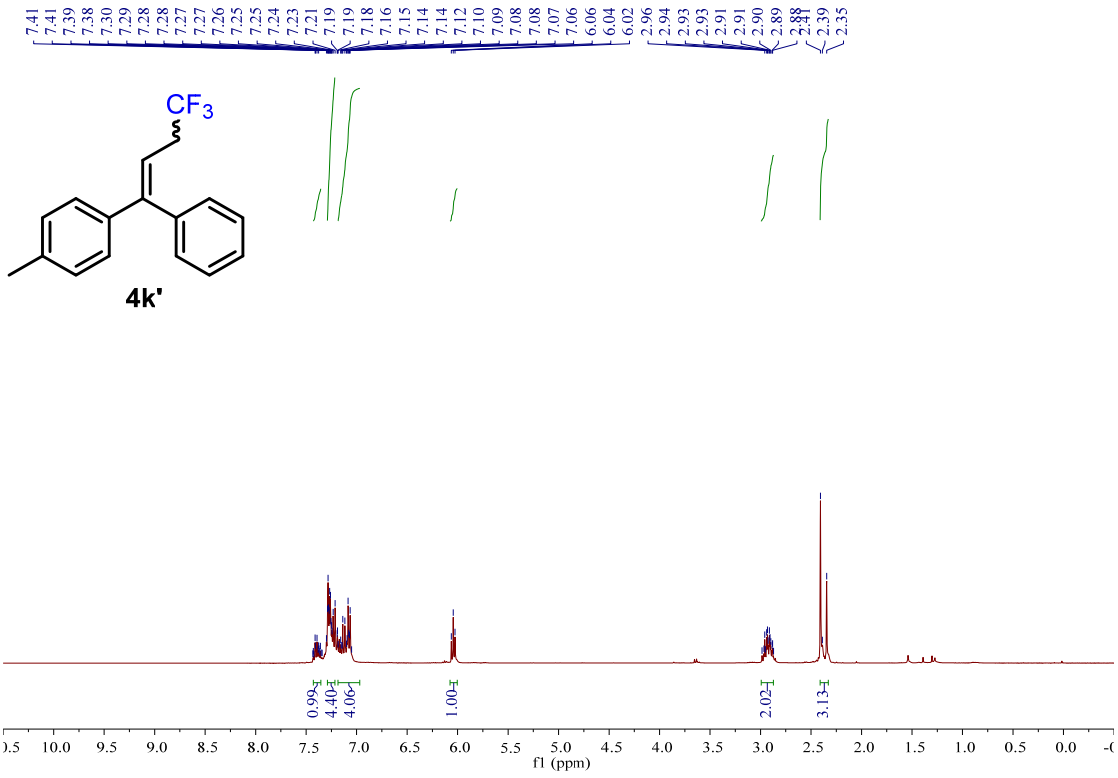
7.26
7.26
7.25
7.25
7.24
7.19
7.19
7.18
7.18
6.08
6.08
6.06
2.95
2.95
2.94
2.93
2.93
2.92
2.91
2.91
2.90
2.90
2.89
2.88
2.88
CF3
4j'
2.01
1.02
3.02
2.02
2.02
1.00
2.07
f1 (ppm)


147.7
141.4
138.7
129.6
129.5
128.5
128.5
128.3
127.9
127.9
127.8
127.7
127.5
127.4
127.1
125.2
121.6
116.0
116.0
116.0
35.1
34.9
34.7
34.5
CF3
4j'
f1 (ppm)

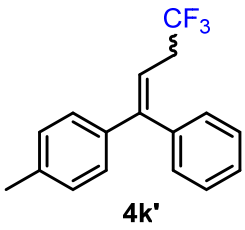

CF3
-65.57
-65.59
-65.61
f1 (ppm)

4j'

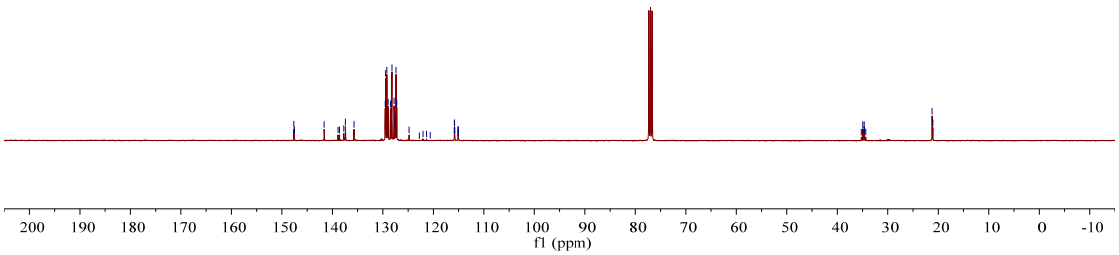

CF3
7.41
7.41
7.39
7.38
7.30
7.29
7.28
7.28
7.27
7.27
7.26
7.25
7.25
7.24
7.23
7.21
7.19
7.19
7.18
7.16
7.15
7.14
7.14
7.12
7.10
7.09
7.08
7.08
7.07
7.06
6.06
6.04
6.02
2.96
2.94
2.93
2.93
2.91
2.91
2.90
2.89
2.88
2.41
2.39
2.35
0.99
4.40
4.06
1.00
2.02
3.13
f1 (ppm)

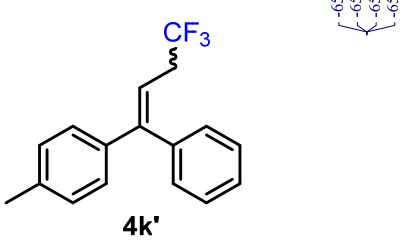
4k'


147.6
147.5
141.6
138.9
138.6
137.8
137.4
135.7
129.5
129.5
129.2
128.9
128.5
128.2
127.8
127.6
127.6
127.4
127.2
124.8
122.8
122.1
121.3
120.6
115.9
115.8
115.8
115.8
115.1
115.1
115.1
115.0
35.2
35.0
34.9
34.7
34.6
34.4
21.2
21.1


CF3

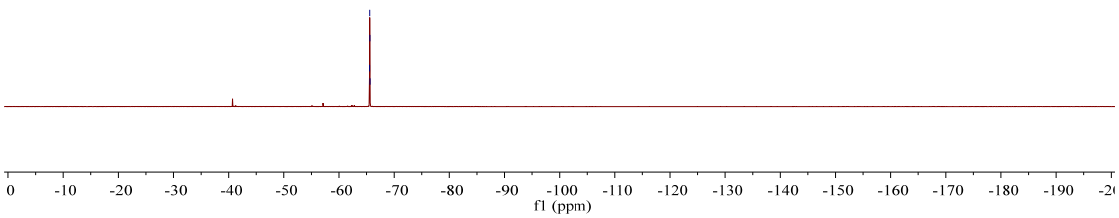
4k'

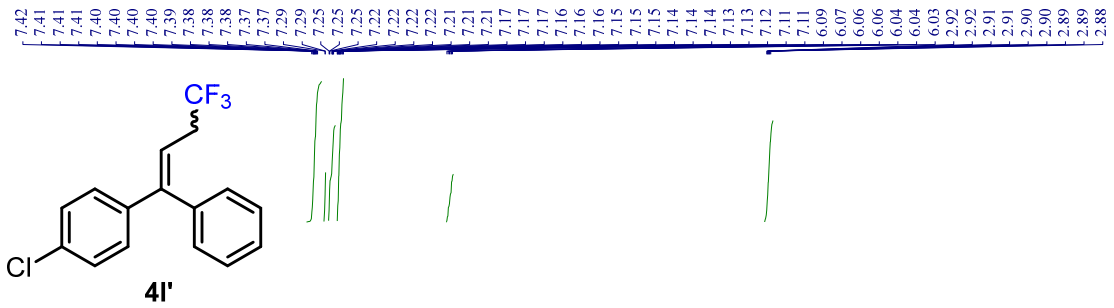

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


CF3


-65.54
-65.57
-65.60
-65.63

4k'


0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)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7.40
7.40
7.39
7.38
7.38
7.38
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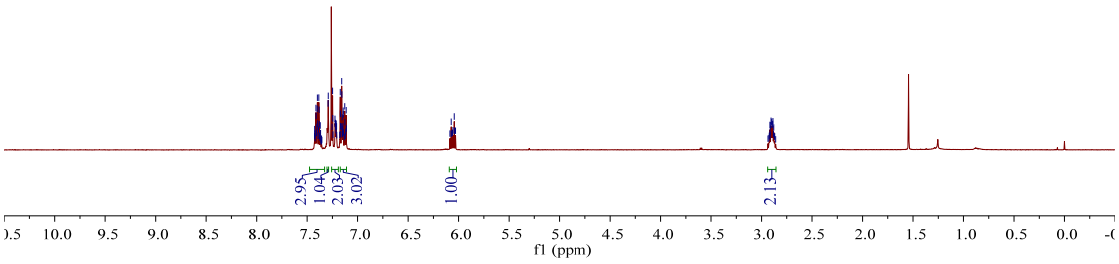
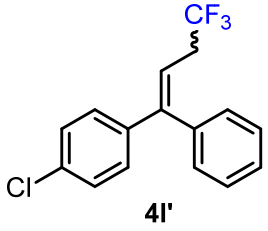
7.37
7.29
7.29
7.25
7.25
7.25
7.22
7.22
7.22
7.21
7.21
7.21
7.17
7.17
7.17
7.16
7.16
7.16
7.15
7.15
7.15
7.14
7.14
7.14
7.13
7.13
7.12
7.11
7.11
6.09
6.07
6.06
6.06
6.04
6.04
6.03
2.92
2.92
2.91
2.91
2.90
2.90
2.89
2.89
2.88

CF3
Cl

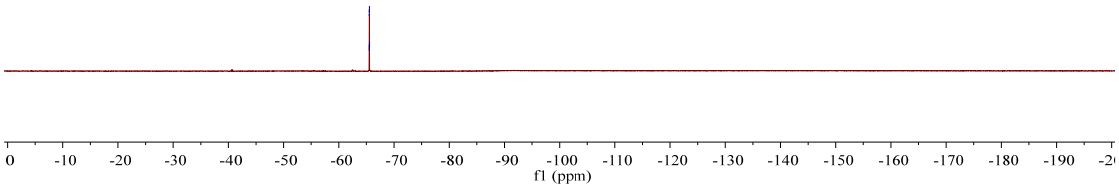
4l'

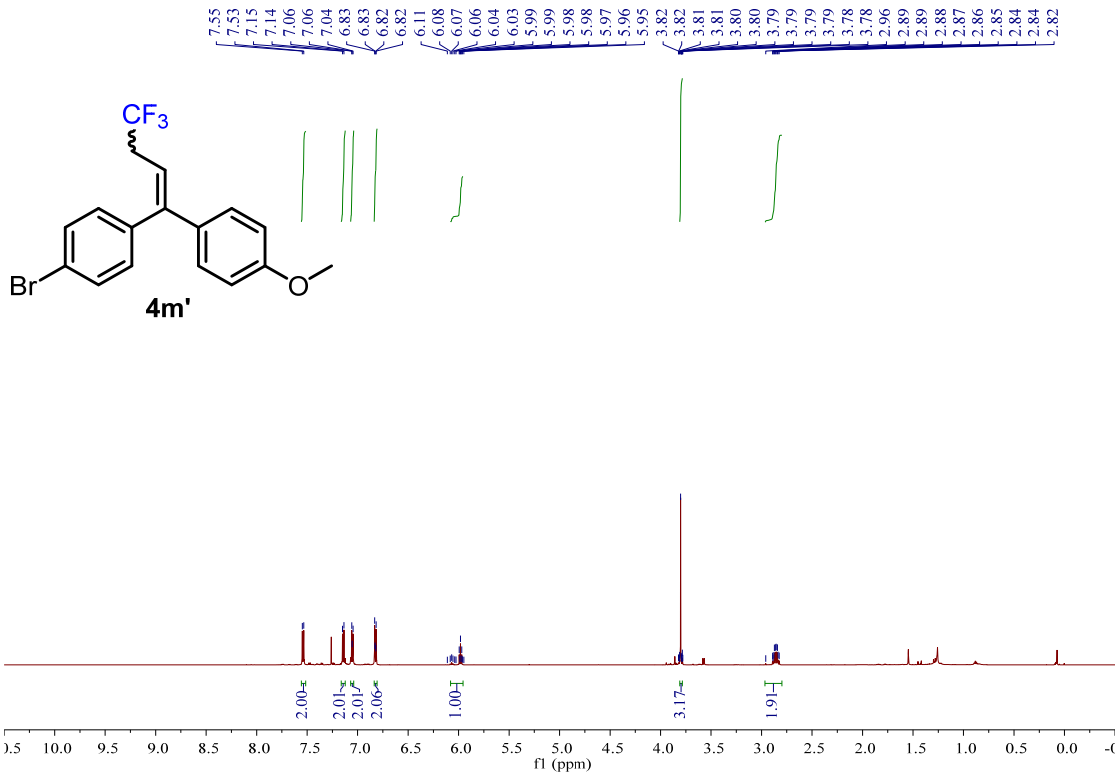

2.95
1.04
2.03
3.02
1.00
2.13
f1 (ppm)

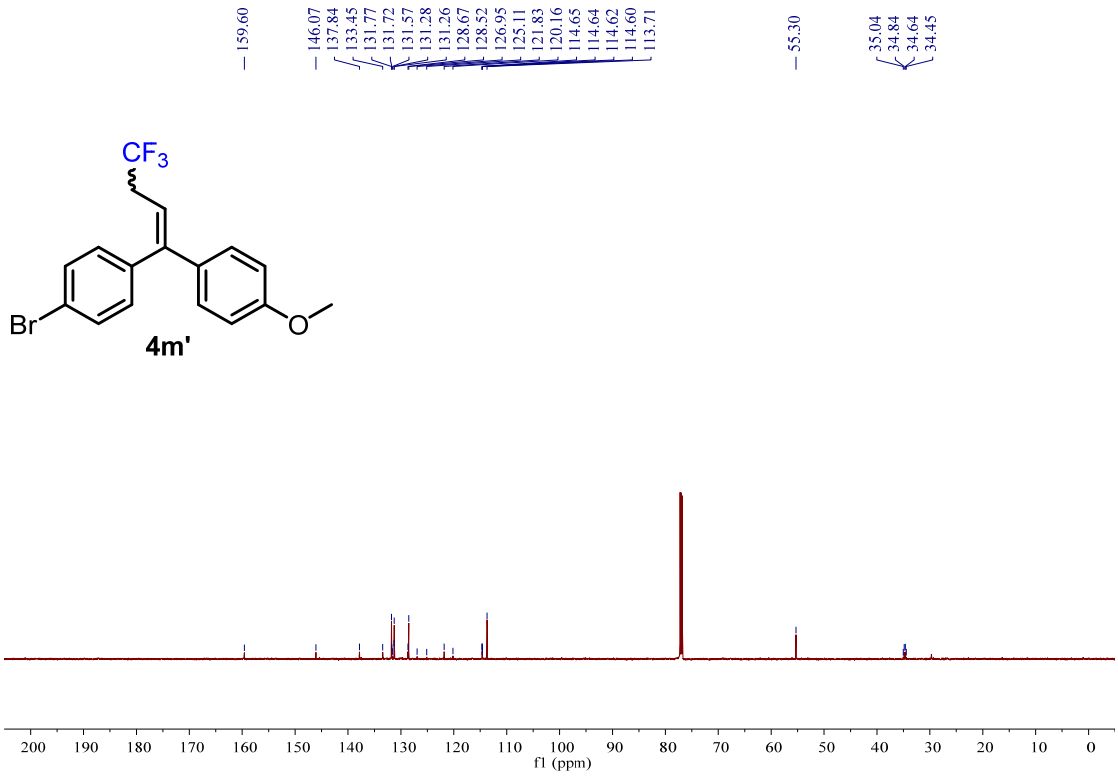

-65.50
-65.52
-65.54
-65.56

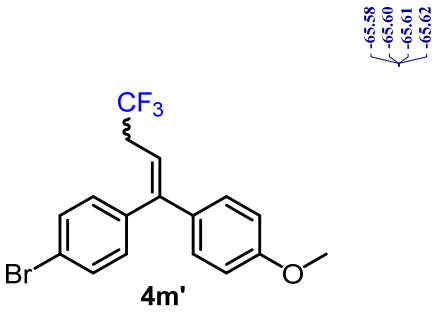

CF3
Cl

4l'


f1 (ppm)

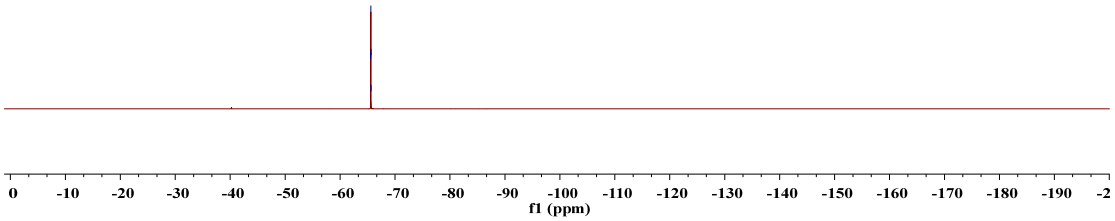

7.55
7.53
7.15
7.14
7.06
7.06
7.04
6.83
6.82
6.82
6.11
6.08
6.07
6.06
6.04
6.03
5.99
5.99
5.98
5.98
5.97
5.96
5.95
3.82
3.82
3.81
3.81
3.80
3.80
3.79
3.79
3.79
3.79
3.78
3.78
2.96
2.89
2.89
2.88
2.87
2.86
2.85
2.84
2.84
2.82
CF3
Br
O
4m'
2.00
2.01
2.01
2.06
1.00
3.17
1.91
f1 (ppm)

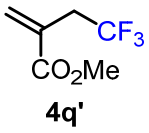

159.60
146.07
137.84
133.45
131.77
131.72
131.57
131.28
131.26
128.67
128.52
126.95
125.11
121.83
120.16
114.65
114.64
114.62
114.60
113.71
55.30
35.04
34.84
34.64
34.45
CF3
Br
O
4m'
f1 (ppm)


CF3
Br
O

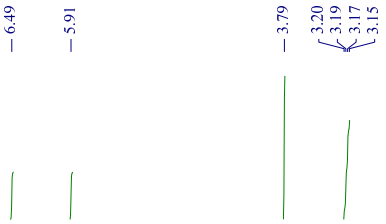
4m'

-65.58
-65.60
-65.61
-65.62


0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -2
f1 (ppm)


CF3
CO2Me

4q'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5.91
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3.20
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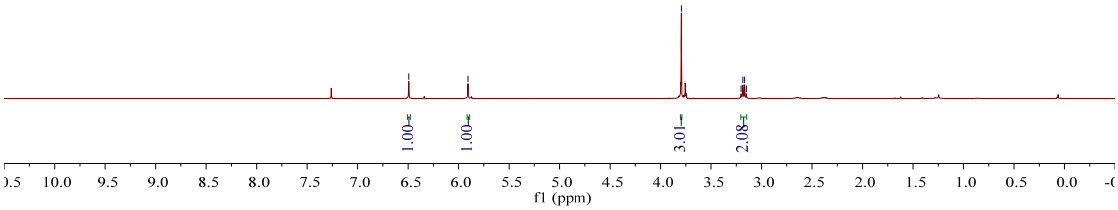
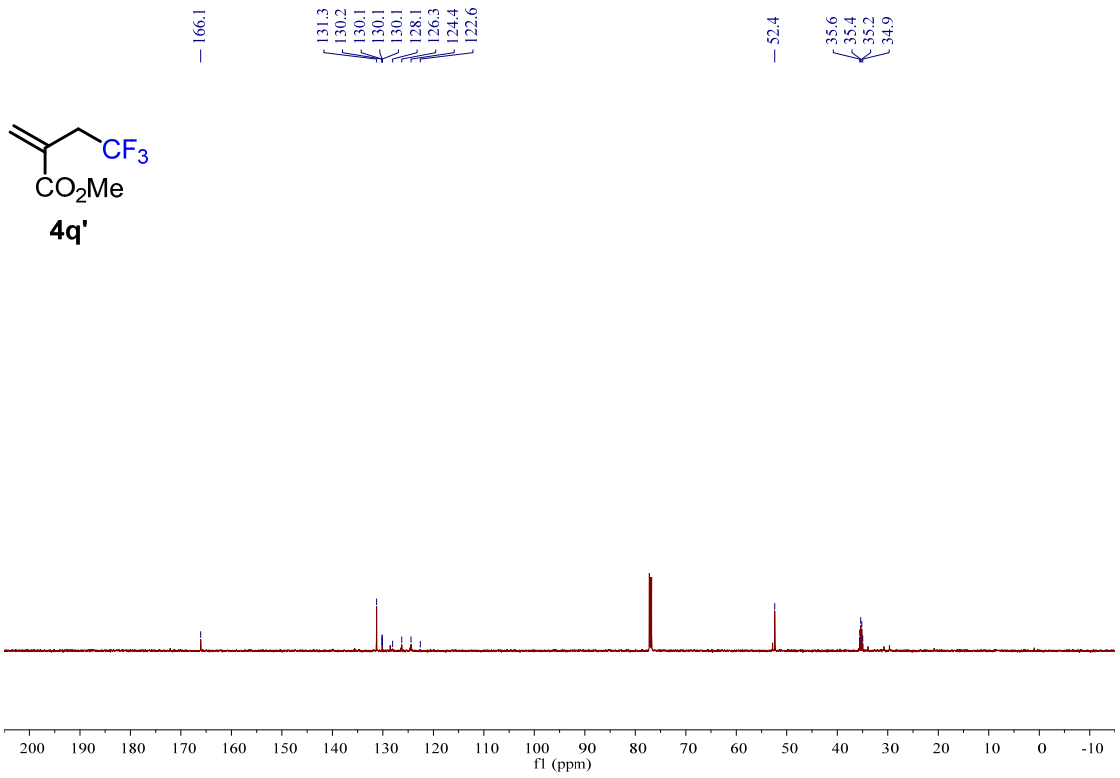
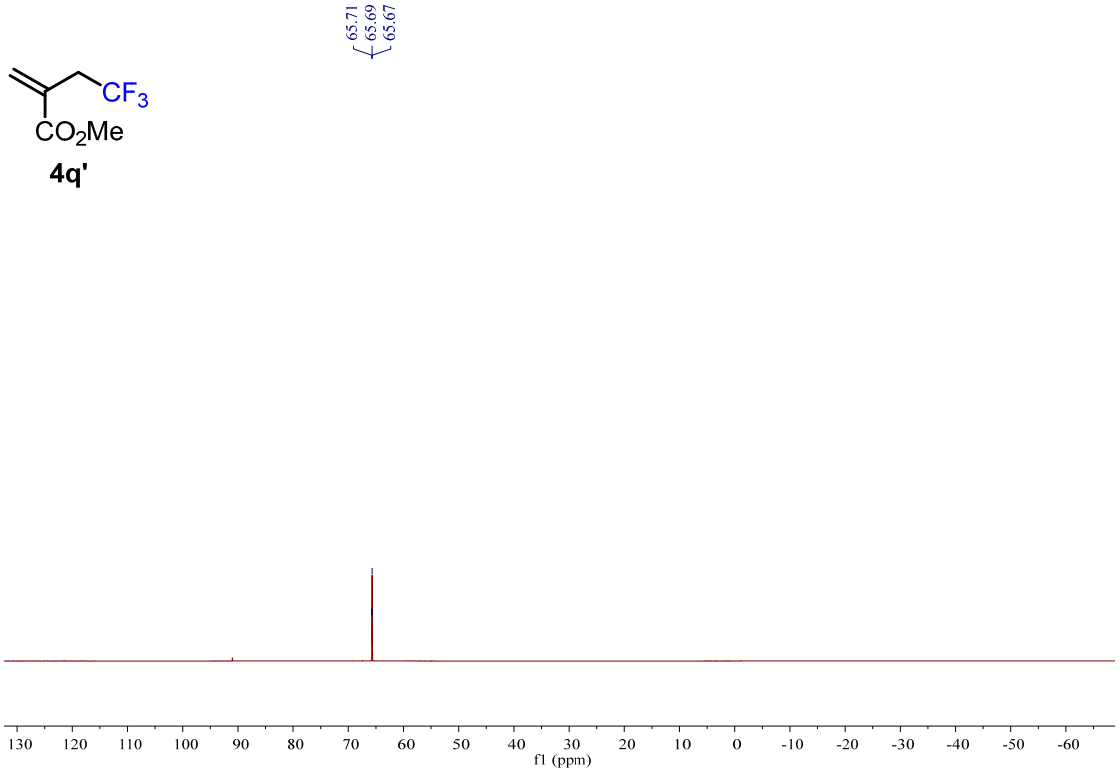
3.15


1.00
1.00
3.01
2.08
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


166.1
131.3
130.2
130.1
130.1
130.1
128.1
126.3
124.4
122.6
52.4
35.6
35.4
35.2
34.9
CF3
CO2Me
4q'
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


65.71
65.69
65.67
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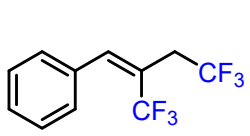
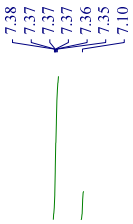
CO2Me
4q'
130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60
f1 (ppm)


CF3
CF3

5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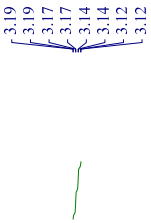
7.37
7.37
7.36
7.35
7.10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3.19
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3.17
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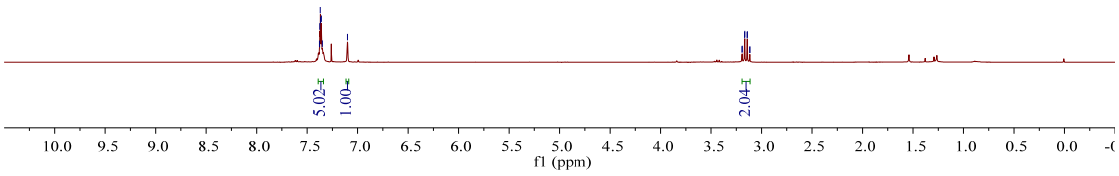
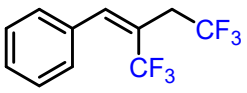
3.14
3.12
3.12


5.02
1.00
2.04
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


CF3
CF3

5


143.1
143.1
143.1
143.0
133.6
129.0
129.0
129.0
128.6
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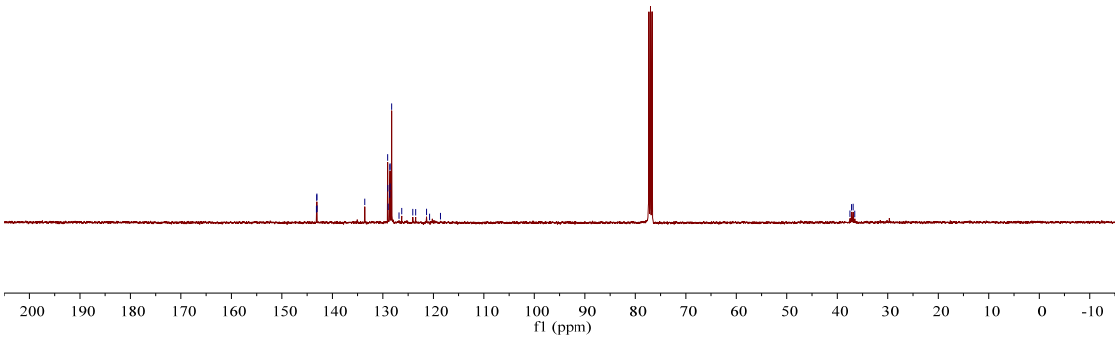
128.6
128.6
128.3
126.8
126.3
124.1
123.5
121.3
120.8
118.6


37.5
37.2
36.9
36.5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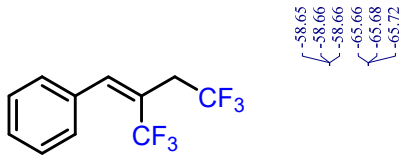
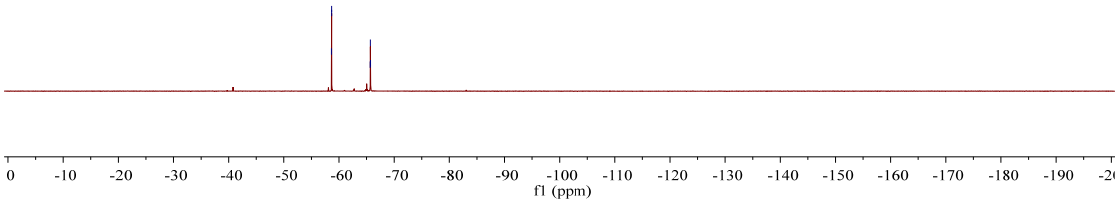
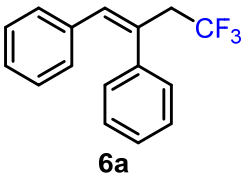
f1 (ppm)


CF3
CF3

5

-58.65
-58.66
-58.66
-65.66
-65.68
-65.72


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


CF3

6a

7.69
7.69
7.68
7.68
7.67
7.67
7.67
7.66
7.66
7.66
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7.65
7.65
7.64
7.63
7.57
7.57
7.56
7.56
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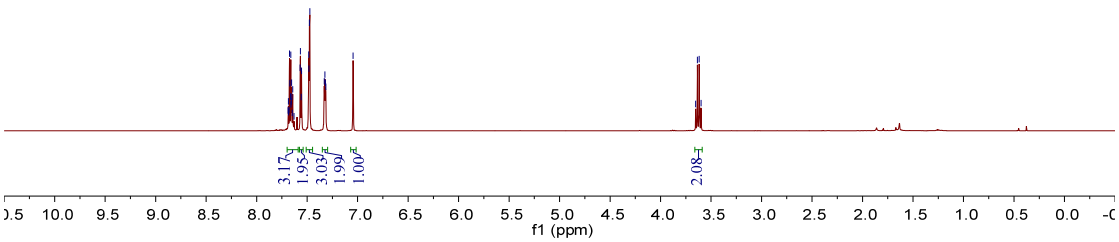
7.31
7.04
3.65
3.63
3.62
3.60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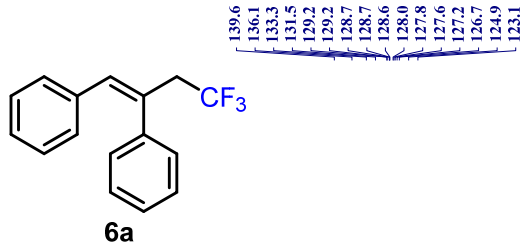
1.95
3.03
1.99
1.00
2.08
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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129.2
129.2
128.7
128.7
128.6
128.0
127.8
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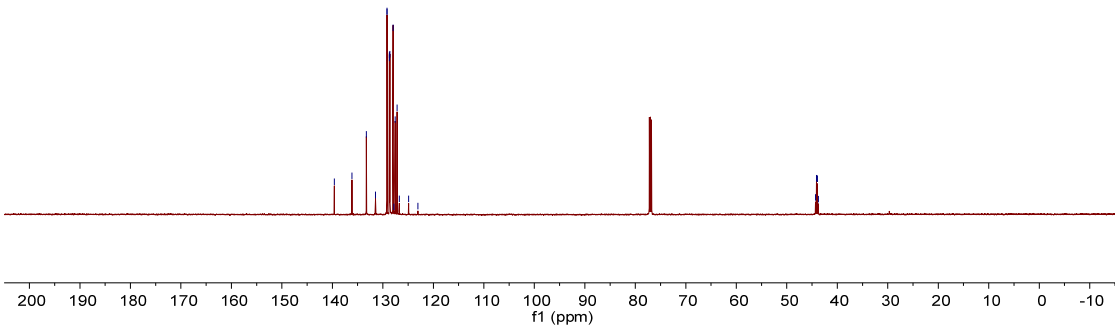
127.2
126.7
124.9
123.1
44.3
44.1
43.9
43.8
CF3

6a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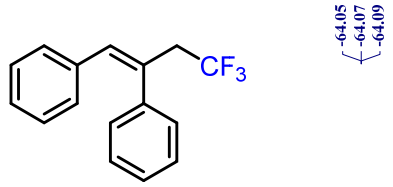
f1 (ppm)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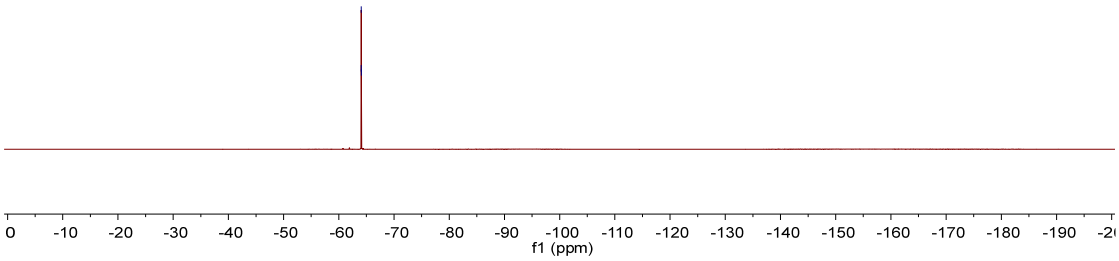
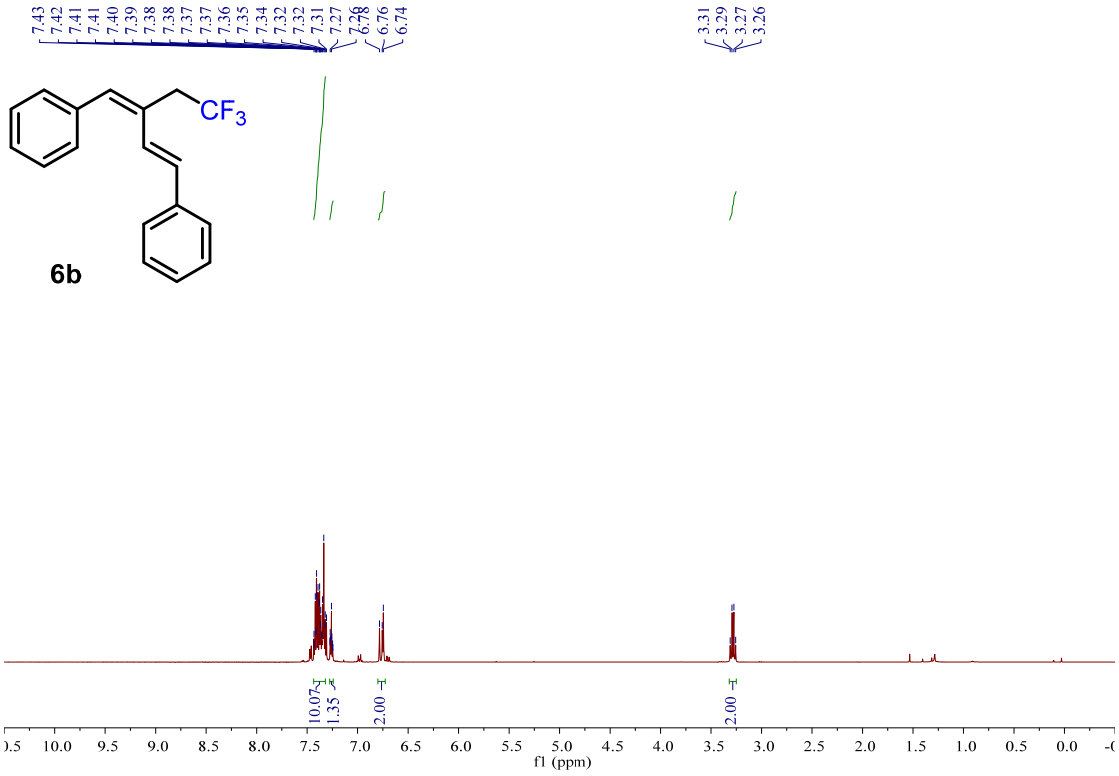
-64.07
-64.09
CF3

6a


0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)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7.41
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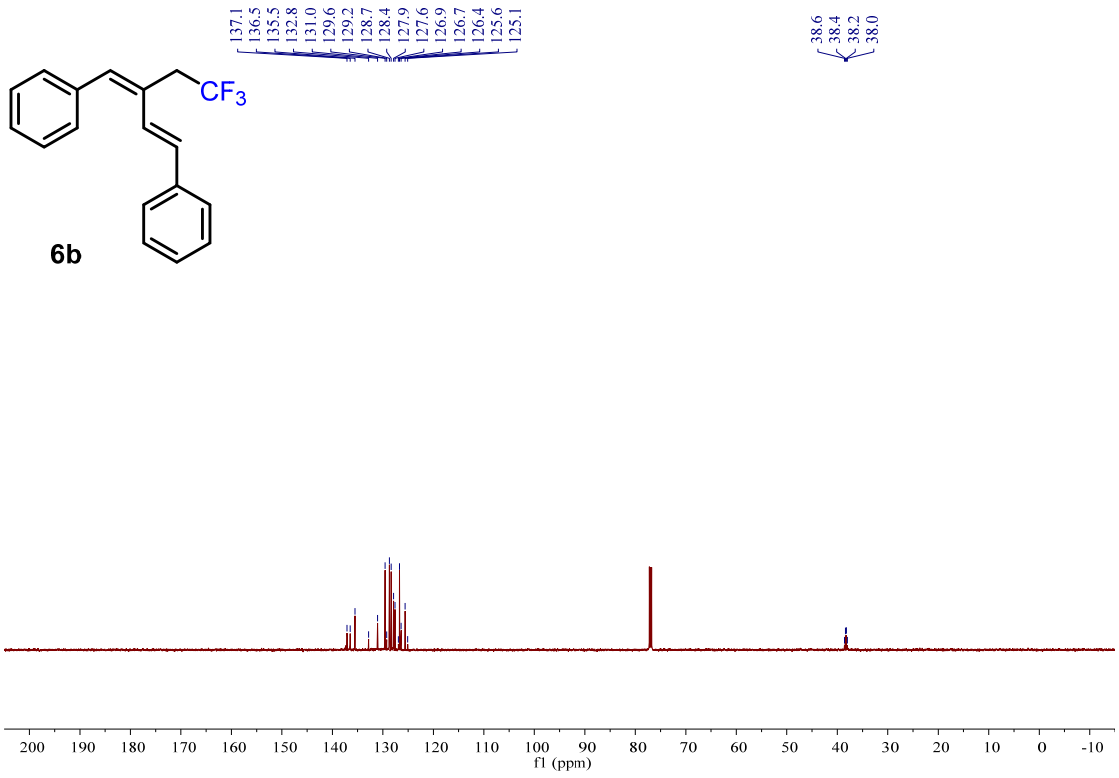
7.38
7.38
7.37
7.37
7.36
7.35
7.34
7.32
7.32
7.31
7.27
6.78
6.76
6.74
3.31
3.29
3.27
3.26
CF3
6b
10.07
1.35
2.00
2.00
f1 (ppm)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136.5
135.5
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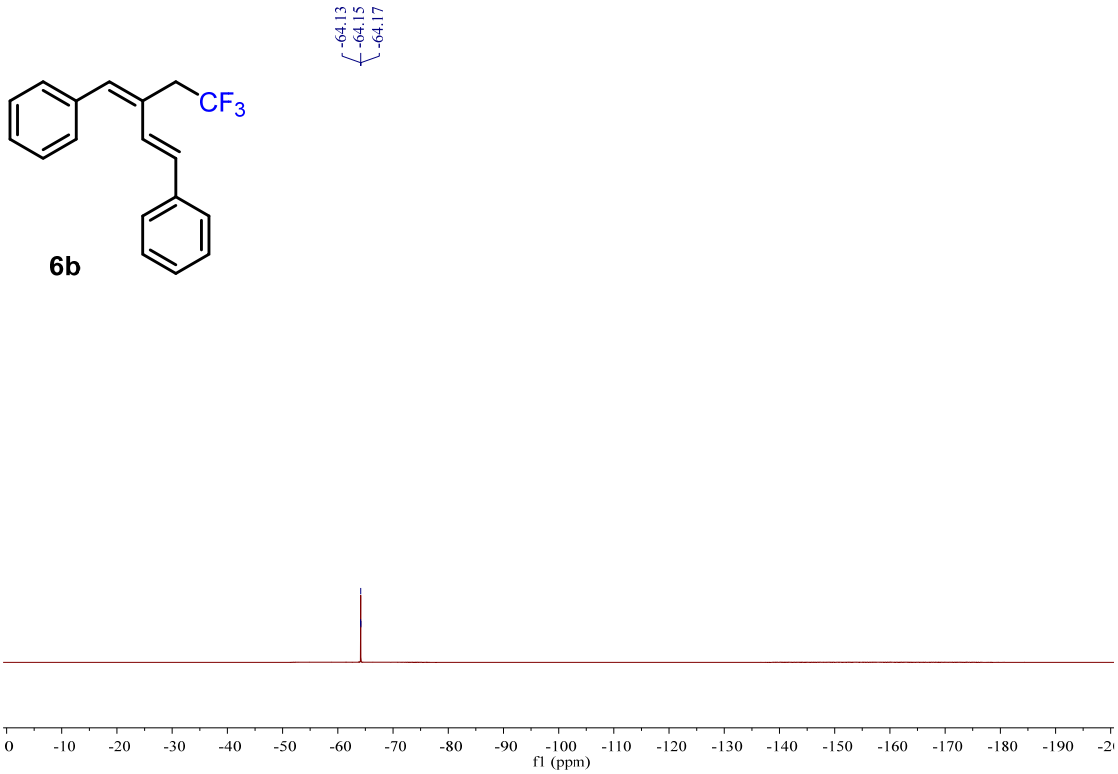
129.6
129.2
128.7
128.4
127.9
127.6
126.9
126.7
126.4
125.6
125.1
38.6
38.4
38.2
38.0
CF3
6b
f1 (ppm)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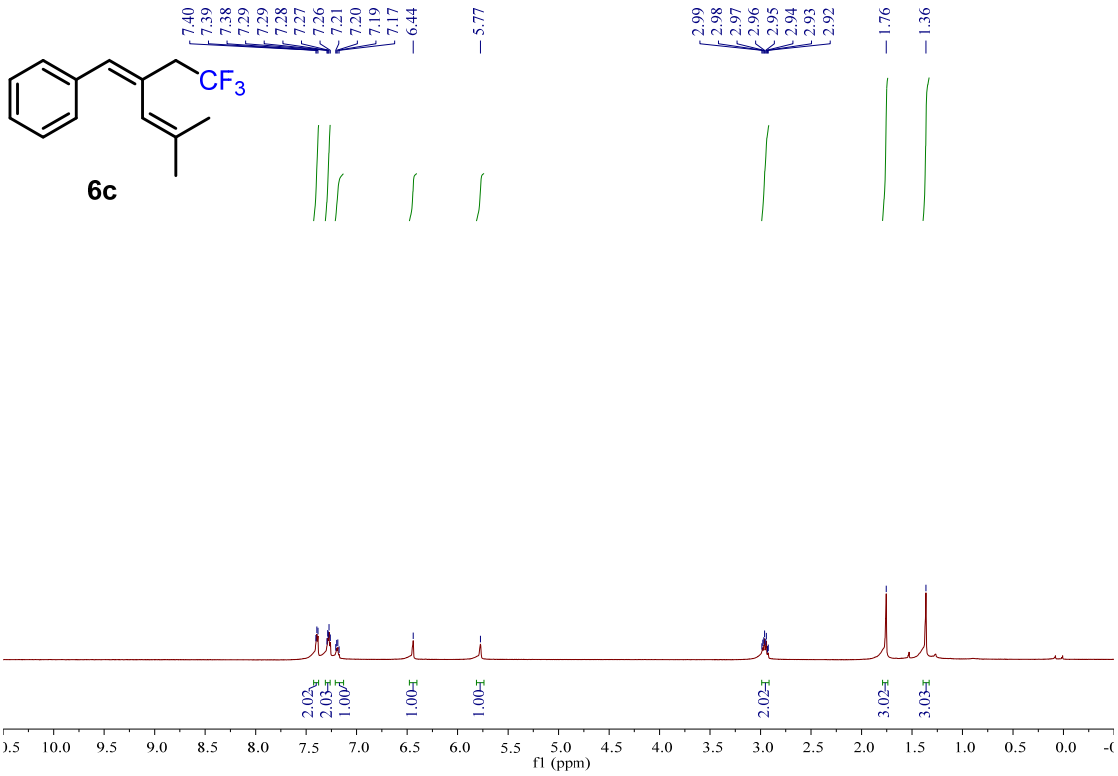
-64.15
-64.17
CF3
6b
f1 (ppm)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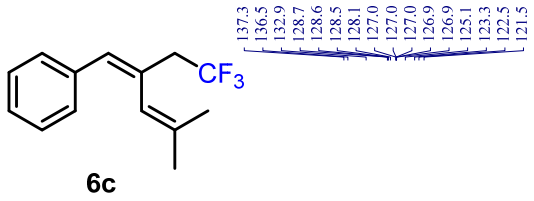
7.29
7.28
7.27
7.26
7.21
7.20
7.19
7.17
6.44
5.77
2.99
2.98
2.97
2.96
2.95
2.94
2.93
2.92
1.76
1.36
CF3
6c
2.02
2.03
1.00
1.00
1.00
2.02
3.02
3.03
f1 (ppm)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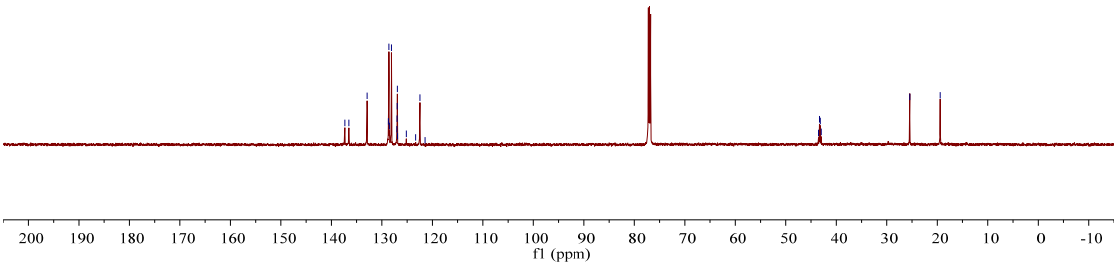
128.6
128.5
128.1
127.0
127.0
127.0
126.9
126.9
125.1
123.3
122.5
121.5
43.5
43.3
43.2
43.0
25.5
19.4
CF3

6c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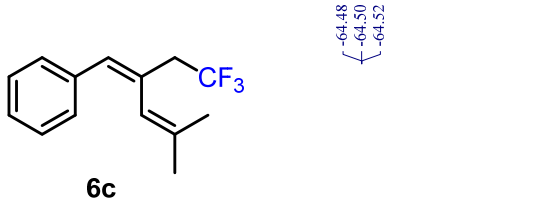
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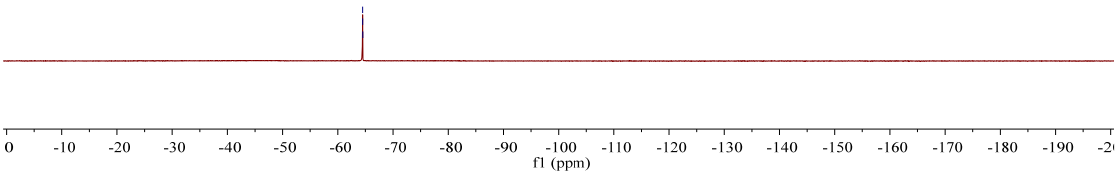
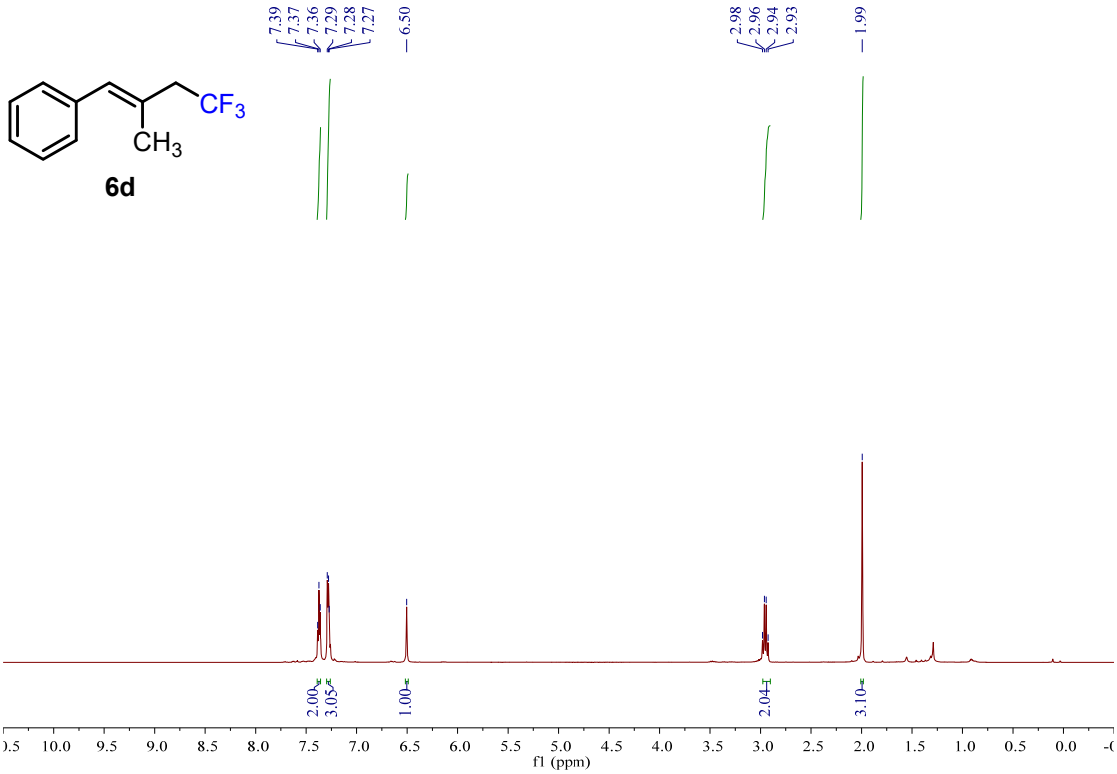
-64.50
-64.52
CF3

6c


0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)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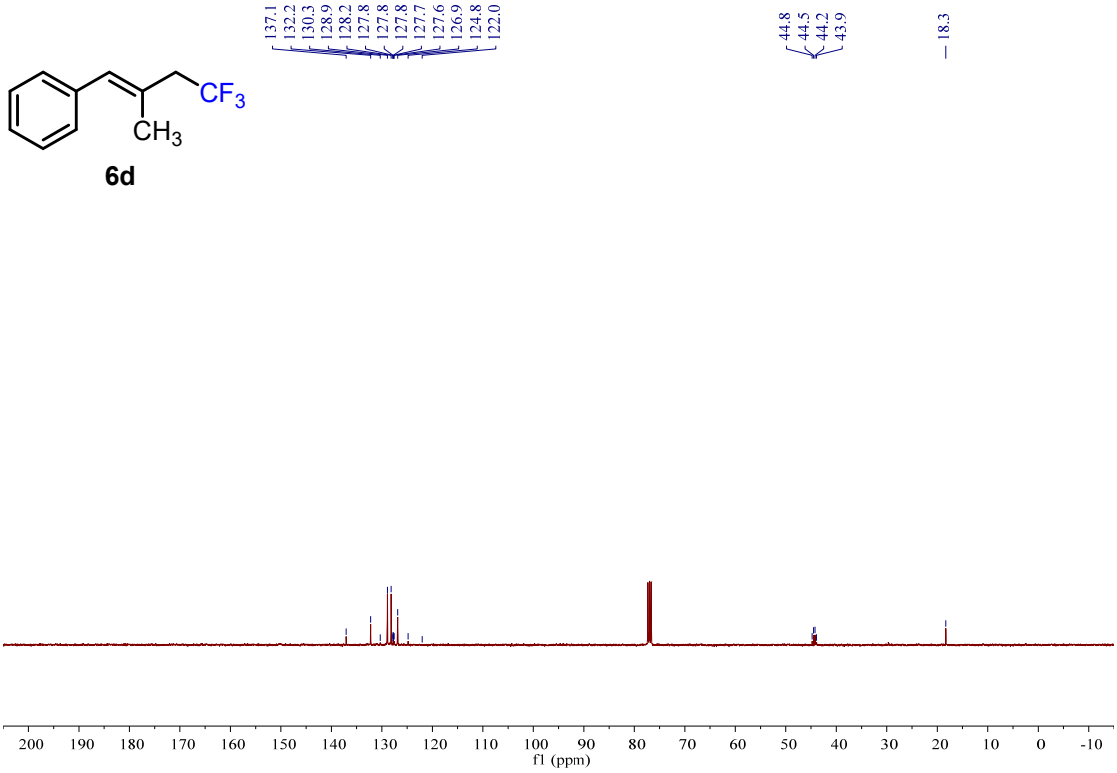
7.28
7.27
6.50
2.98
2.96
2.94
2.93
1.99
CF3
CH3
6d
2.00
3.05
1.00
2.04
3.10
f1 (ppm)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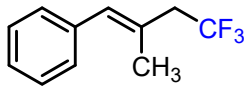
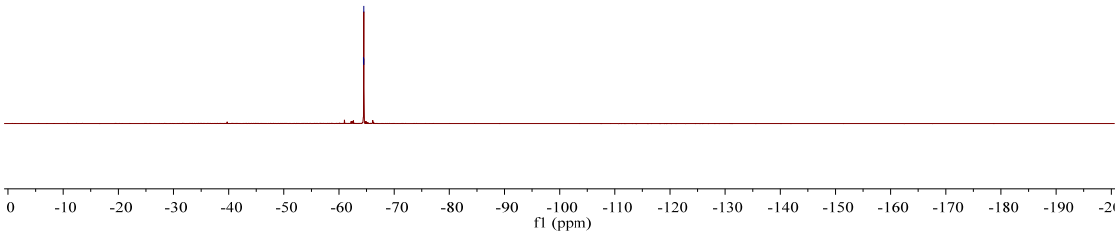
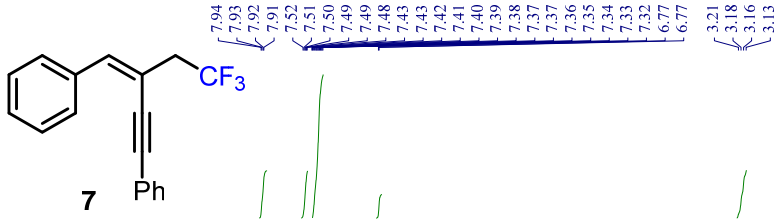
44.2
43.9
18.3
CF3
CH3
6d
f1 (ppm)


CF3
CH3

6d


-64.45
-64.48
-64.51


f1 (ppm)


CF3
Ph

7

7.94
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7.92
7.91
7.52
7.51
7.50
7.49
7.49
7.48
7.43
7.43
7.42
7.41
7.40
7.39
7.38
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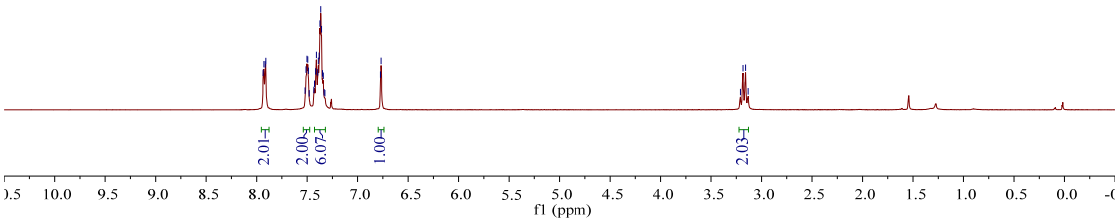
3.16
3.13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2.00
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1.00
2.03
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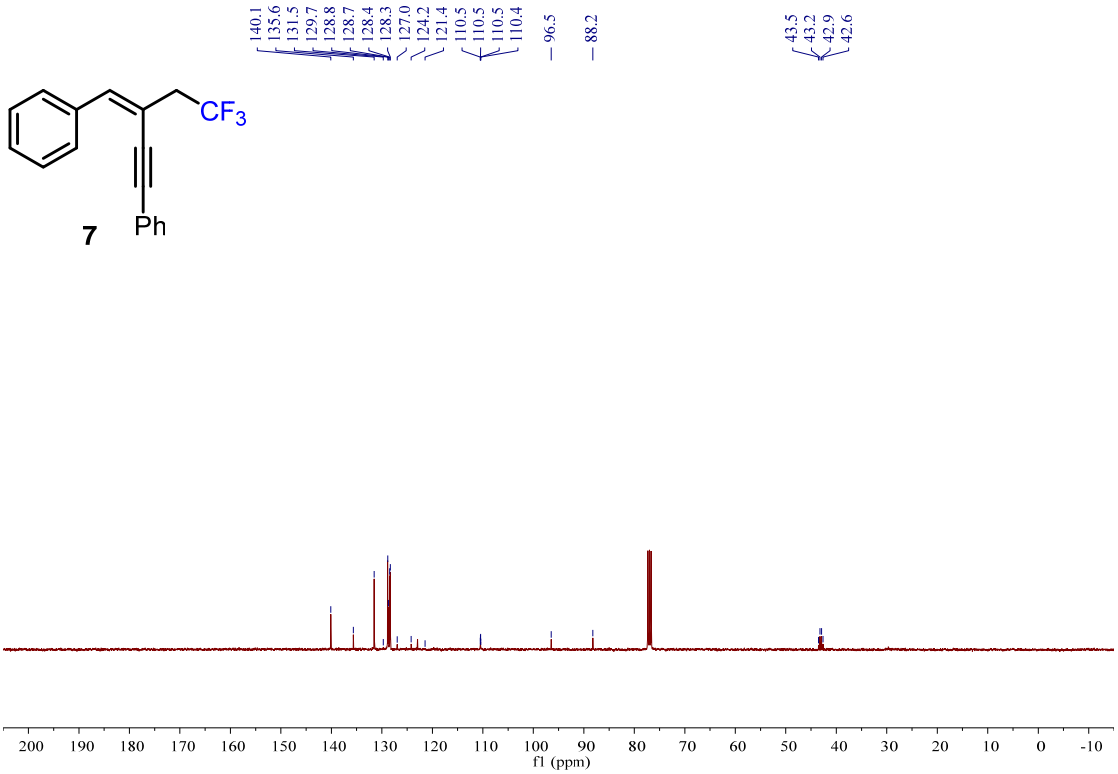
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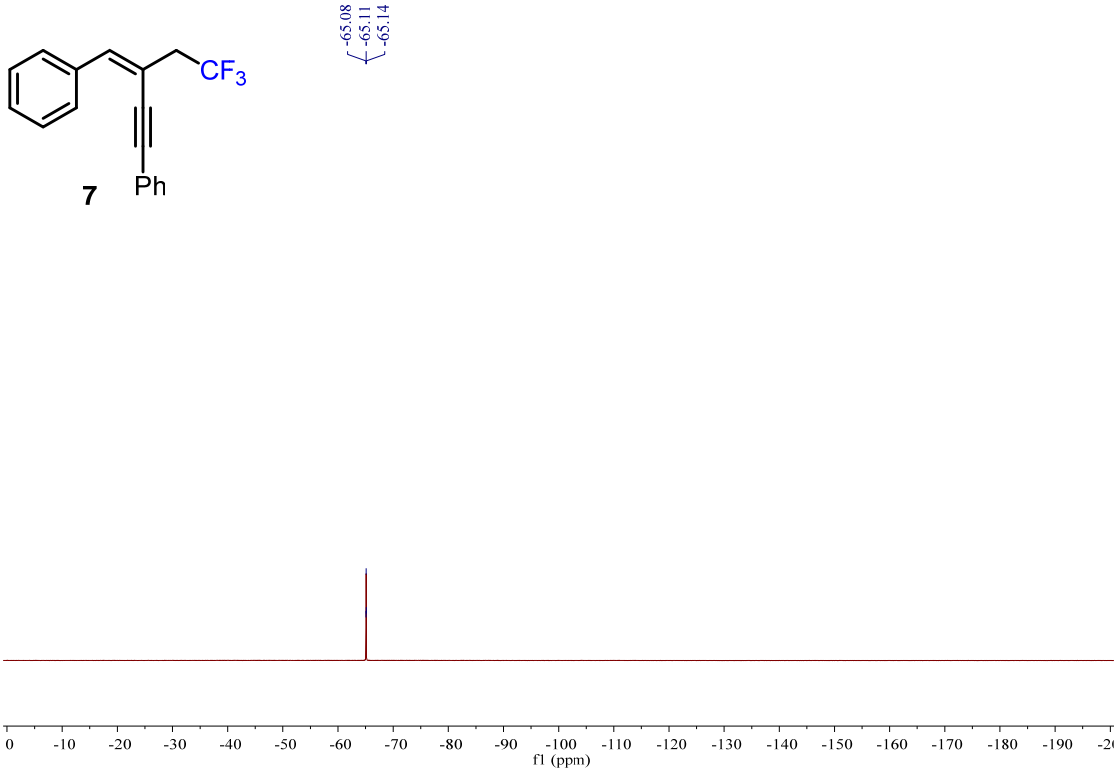
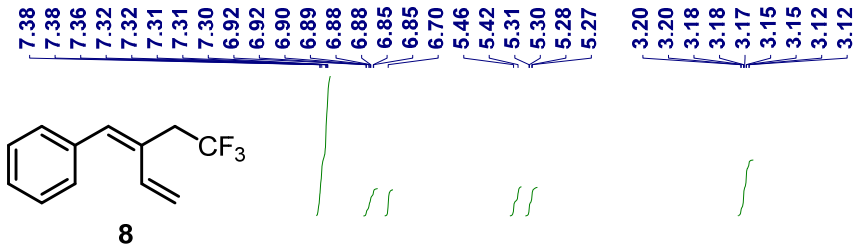
127.0
124.2
121.4
110.5
110.5
110.5
110.4
96.5
88.2
43.5
43.2
42.9
42.6
CF3
Ph
7
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


-65.08
-65.11
-65.14
CF3
Ph
7
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)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7.31
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7.30
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6.92
6.90
6.89
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6.88
6.85
6.85
6.70
5.46
5.42
5.31
5.30
5.28
5.27
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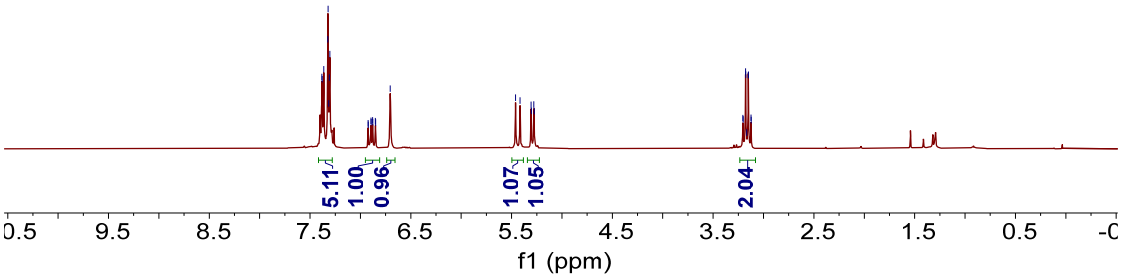
3.20
3.18
3.18
3.17
3.15
3.15
3.12
3.12
CF3

8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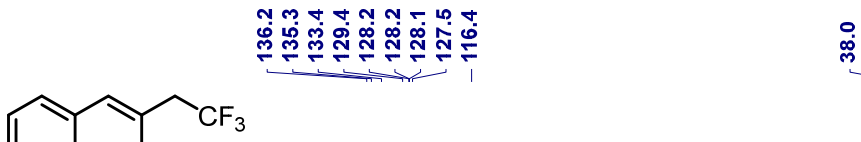
1.07
1.05
2.04
0.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)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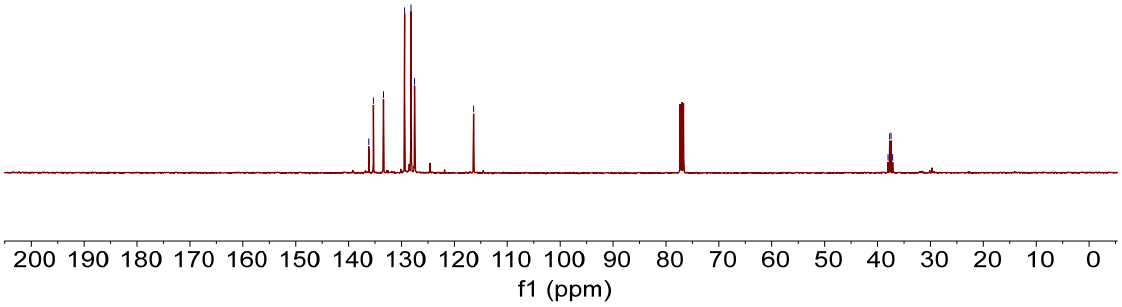
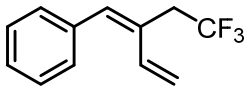
135.3
133.4
129.4
128.2
128.2
128.1
127.5
116.4
38.0
37.7
37.4
37.1
CF3

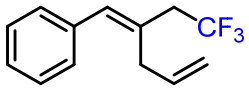
8


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


CF3

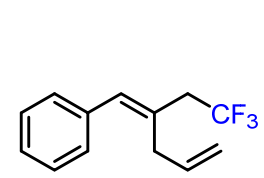
8

-64.31
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)


CF3

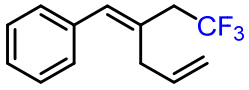
9

7.39 7.38 7.37 7.36 7.35 7.30 7.29 7.29 7.28 7.27 7.27 7.26 6.66 5.90 5.89 5.88 5.87 5.86 5.85 5.83 5.83 5.82 5.80 5.21 5.21 5.20 5.20 5.19 5.19 5.18 5.17 5.15 5.14 5.14 5.13 3.13 3.11 2.99 2.97 2.94 2.91
2.06 3.00 1.00 0.98 2.04 2.00 2.01
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 0.0
f1 (ppm)


CF3

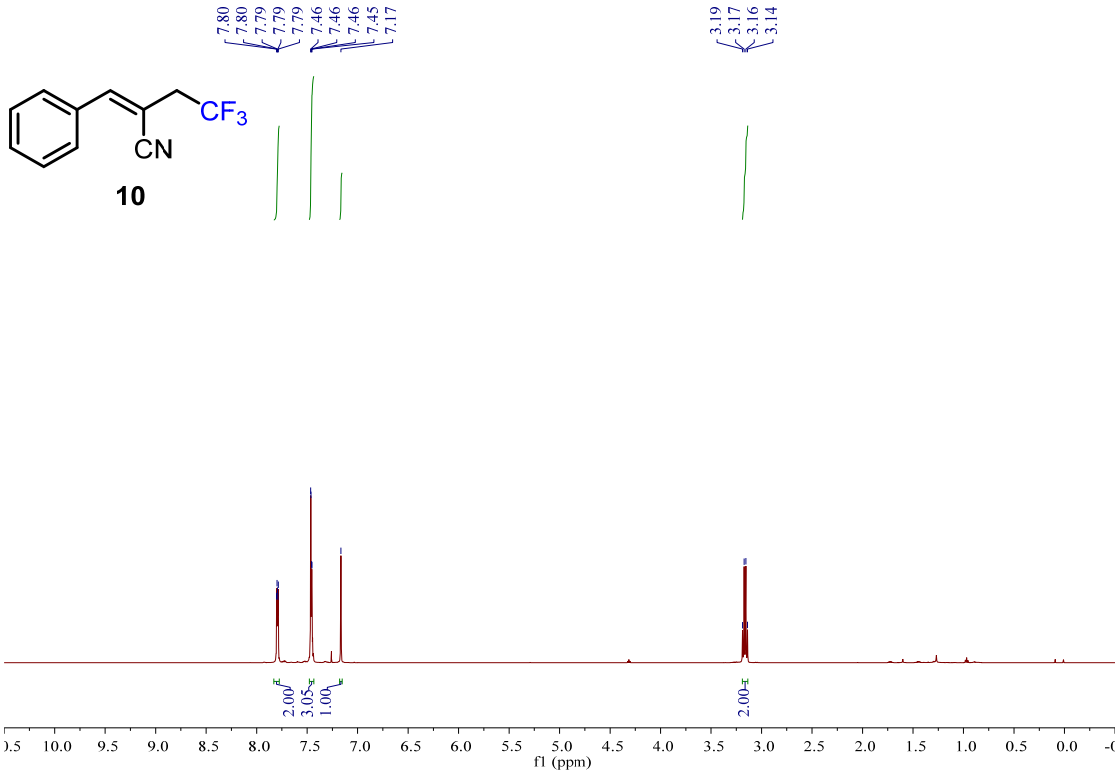
9

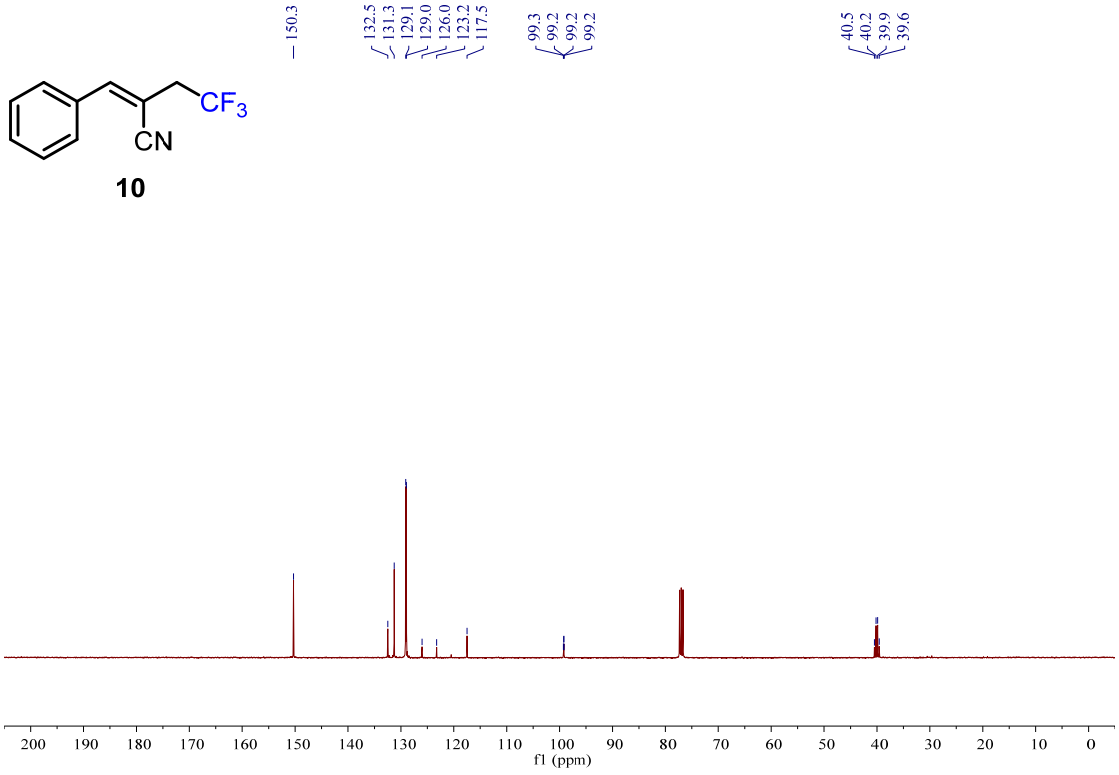
136.7
134.9
133.6
130.3
129.3
128.5
128.5
128.3
127.6
127.1
124.8
122.0
117.1
40.6
40.3
40.0
39.7
35.3
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

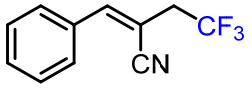

CF3

9

-64.23
-64.26
-64.29
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)

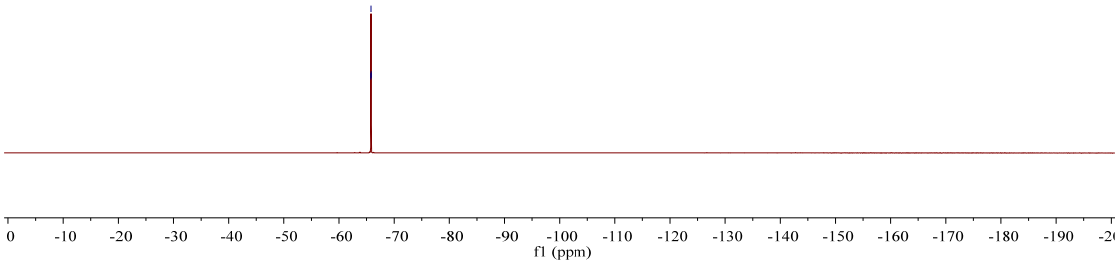

7.80
7.80
7.79
7.79
7.79
7.46
7.46
7.46
7.45
7.17
3.19
3.17
3.16
3.14
CF3
CN
10
2.00
3.05
1.00
2.00
f1 (ppm)

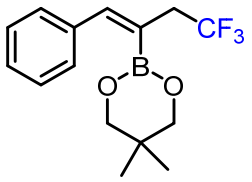

150.3
132.5
131.3
129.1
129.0
126.0
123.2
117.5
99.3
99.2
99.2
99.2
40.5
40.2
39.9
39.6
CF3
CN
10
f1 (ppm)


CF3
CN

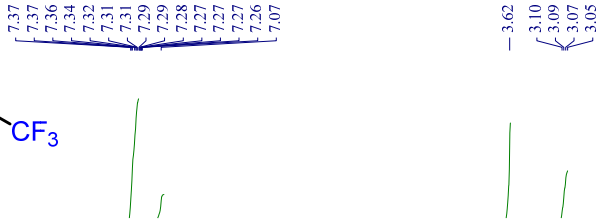
10

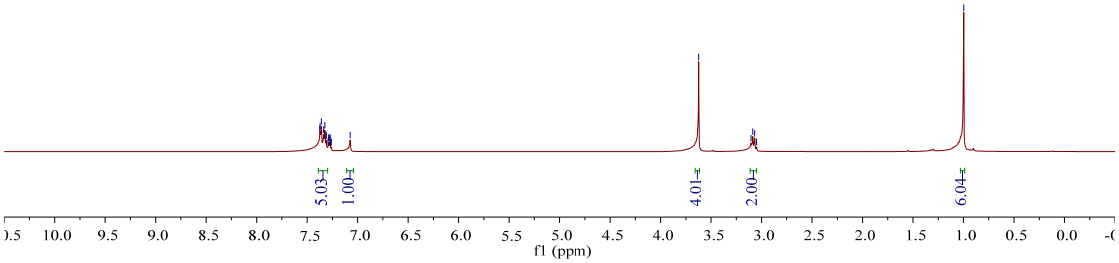

-65.77
-65.80
-65.83

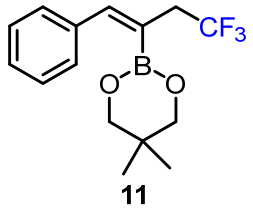

0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)


CF3
B
O
O

11

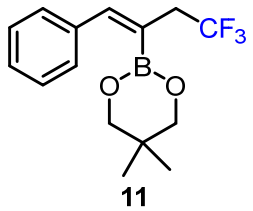

7.37
7.37
7.36
7.34
7.32
7.31
7.31
7.29
7.29
7.28
7.27
7.27
7.27
7.26
7.07
3.62
3.10
3.09
3.07
3.05
1.00


5.03
1.00
4.01
2.00
6.04
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


CF3
B
O
O

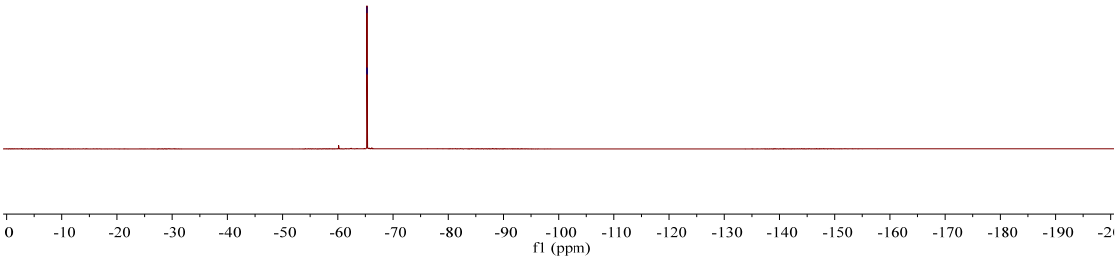
11

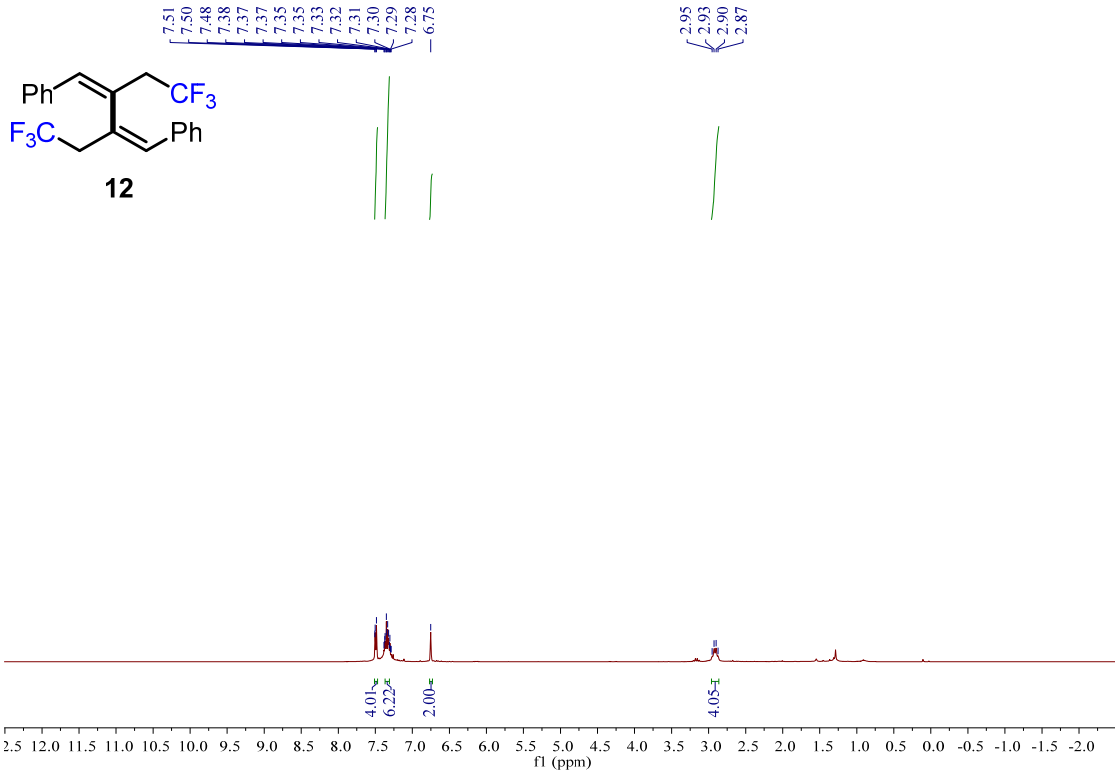
146.1
138.1
129.1
128.2
127.9
127.9
127.5
127.3
125.5
123.6
72.1
41.7
41.5
41.3
41.1
31.5
22.0
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

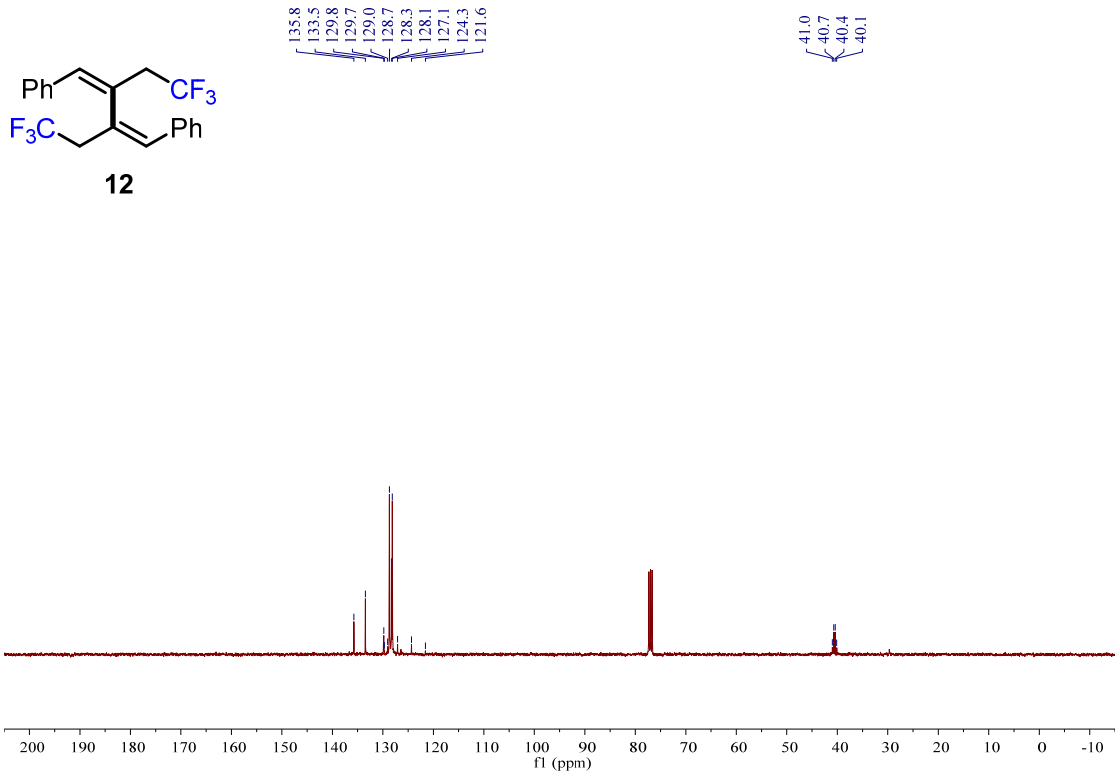

CF3
B
O
O

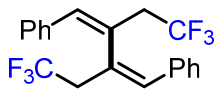
11


-65.26
-65.29
-65.31


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

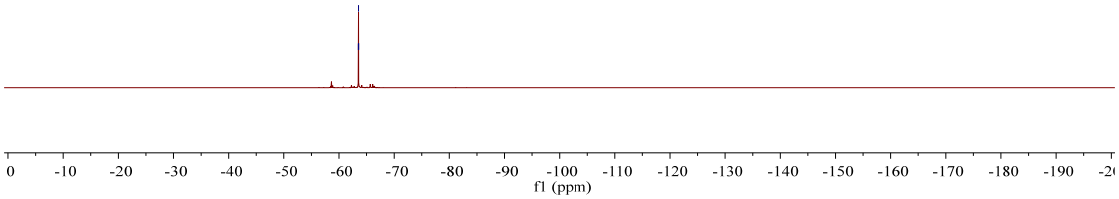

7.51
7.50
7.48
7.38
7.37
7.37
7.35
7.35
7.33
7.32
7.31
7.30
7.29
7.28
6.75
2.95
2.93
2.90
2.87
Ph
CF3
F3C
Ph
12
4.01
6.22
2.00
4.05
f1 (ppm)

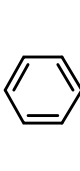

135.8
133.5
129.8
129.7
129.0
128.7
128.3
128.1
127.1
124.3
121.6
41.0
40.7
40.4
40.1
Ph
CF3
F3C
Ph
12
f1 (ppm)


Ph
CF3
F3C
Ph

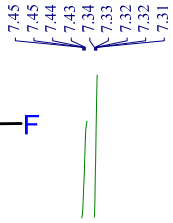
12


-63.50
-63.53
-63.56

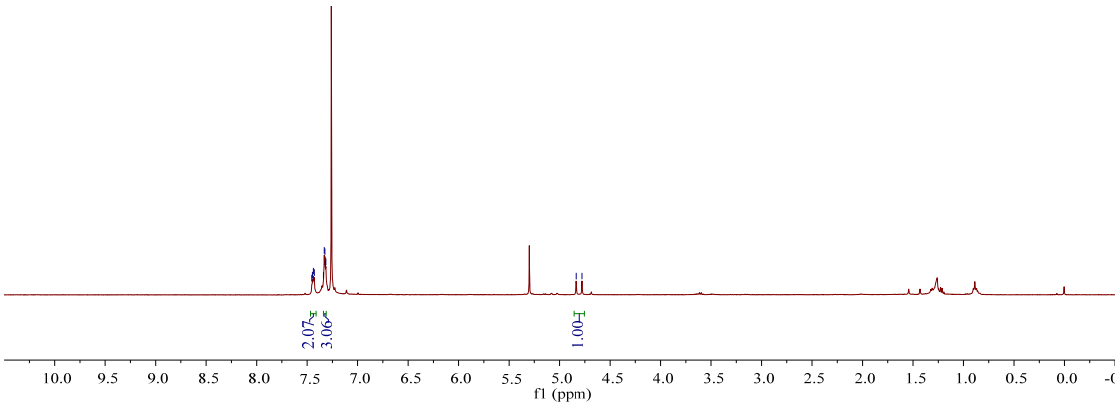

f1 (ppm)

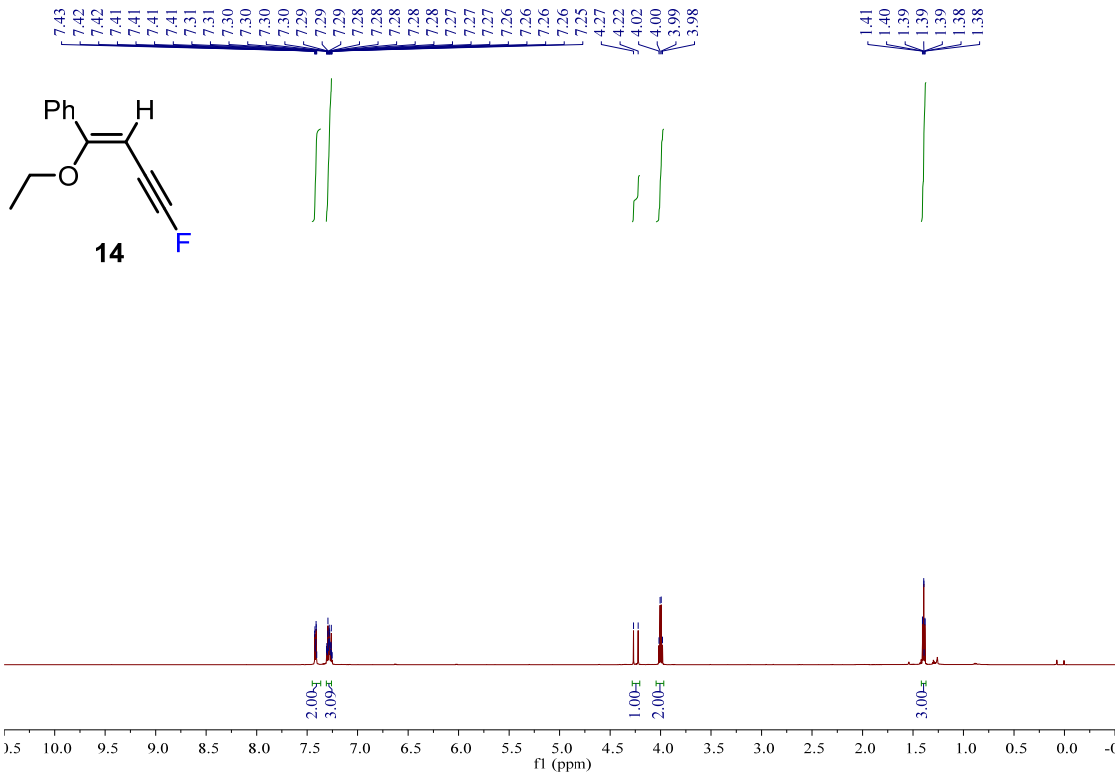


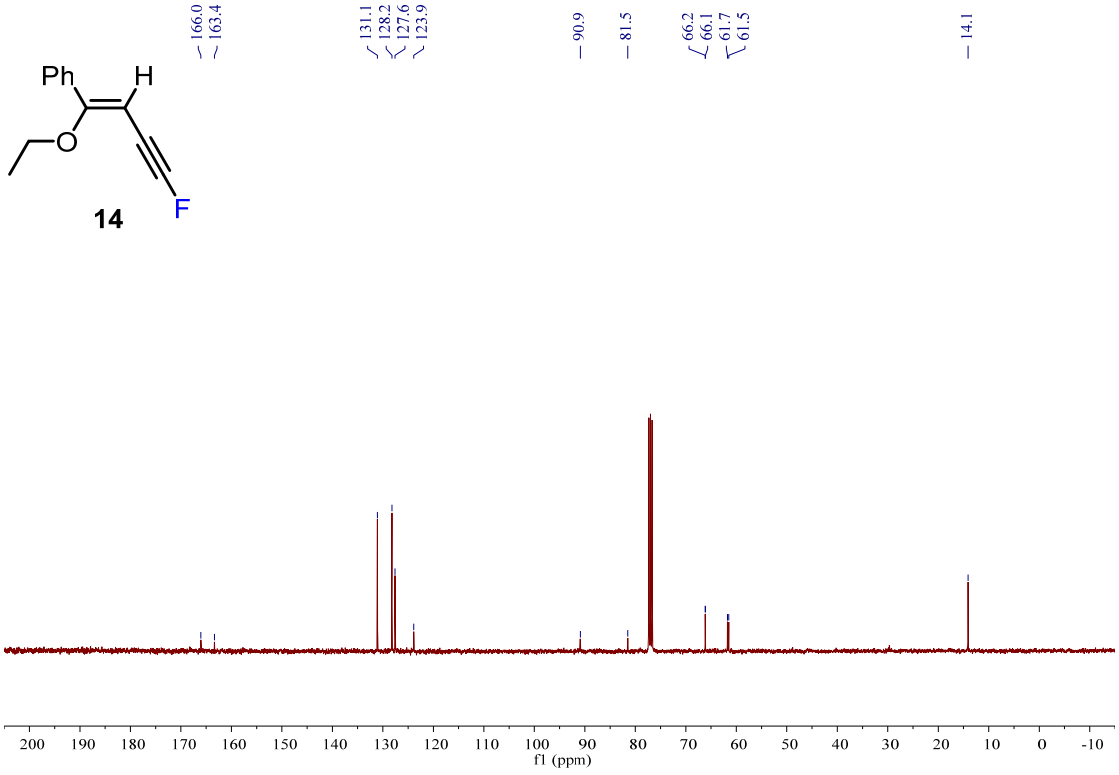
13

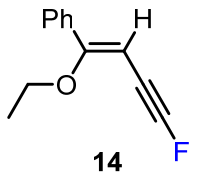

7.45
7.45
7.44
7.43
7.34
7.33
7.32
7.32
7.31


4.84
4.78


2.07
3.06
1.00
f1 (ppm)

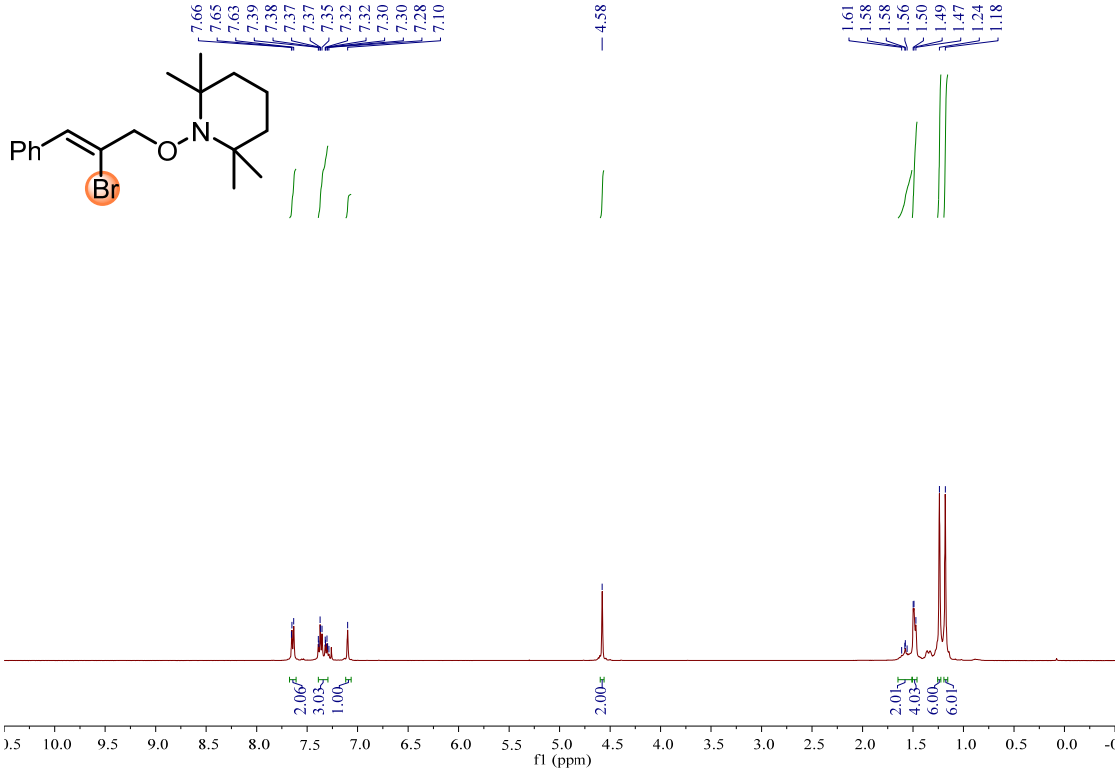

7.43 7.42 7.42 7.41 7.41 7.41 7.41 7.31 7.31 7.30 7.30 7.30 7.29 7.29 7.29 7.28 7.28 7.28 7.28 7.28 7.27 7.27 7.27 7.26 7.26 7.26 7.26 7.25 4.27 4.22 4.02 4.00 3.99 3.98
1.41 1.40 1.39 1.39 1.39 1.38 1.38
Ph
H
O
F
14
2.00
3.09
1.00
2.00
3.00
f1 (ppm)

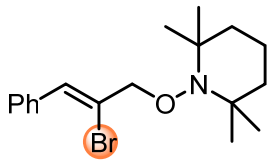

166.0 163.4 131.1 128.2 127.6 123.9 90.9 81.5 66.2 66.1 61.7 61.5 14.1
Ph
H
O
F
14
f1 (ppm)


Ph
H
O
F

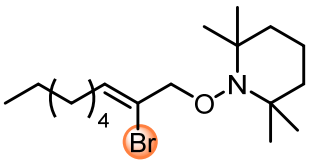
14

-72.12
-72.20
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)

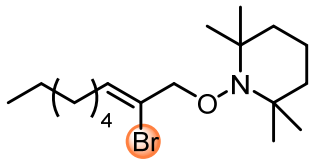

7.66
7.65
7.63
7.39
7.38
7.37
7.37
7.35
7.32
7.32
7.30
7.30
7.28
7.10
4.58
1.61
1.58
1.58
1.56
1.50
1.49
1.47
1.24
1.18
Ph
N
O
Br
2.06
3.03
1.00
2.00
2.01
4.03
6.00
6.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


Ph
O
N
Br

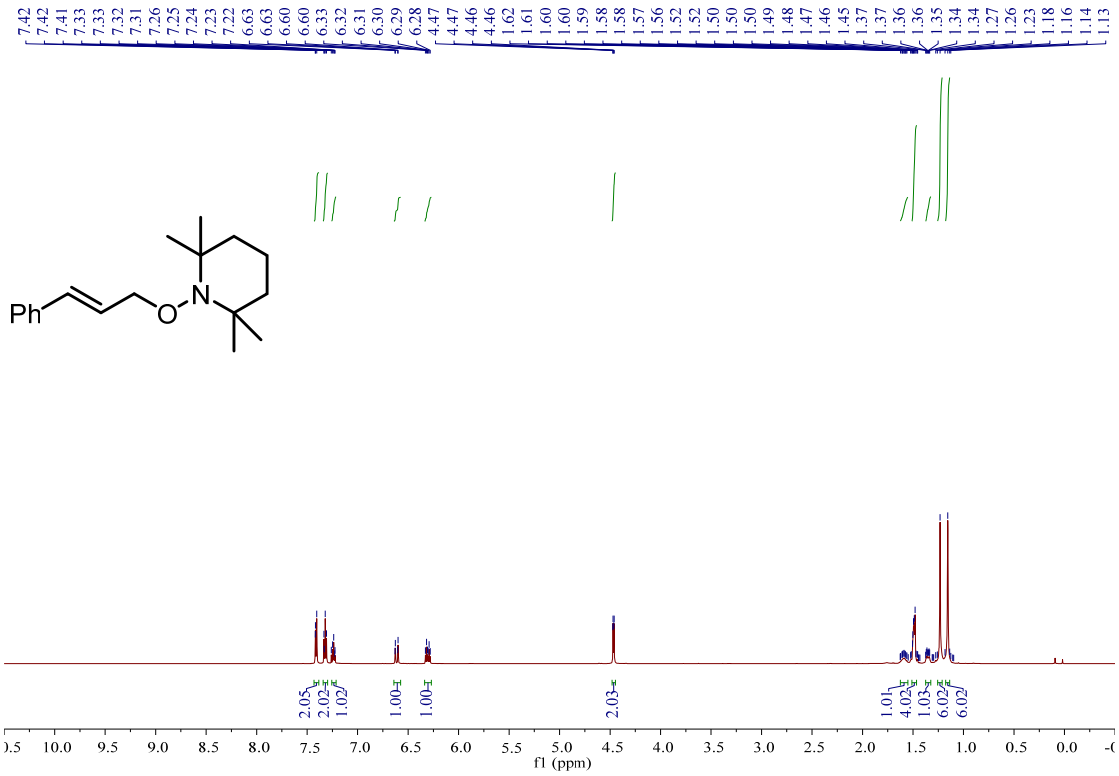
135.4
129.1
128.1
127.9
121.2
82.0
60.1
39.7
32.9
20.3
17.1
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

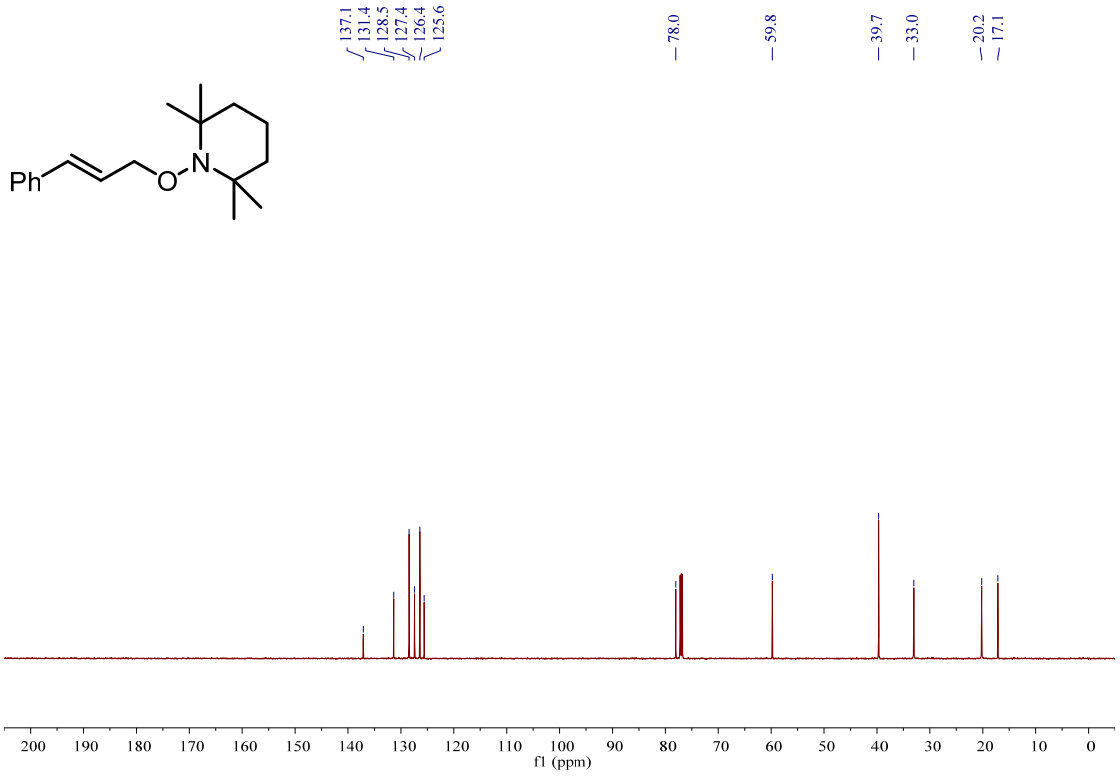

4
O
N
Br

5.99
5.97
5.96
4.38
2.21
2.19
2.17
2.15
1.17
1.13
1.12
0.89
0.87
0.87
0.86
1.00
2.03
2.01
6.00
8.02
12.05
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
f1 (ppm)


4
Br
O
N

131.0
122.0
81.3
60.0
39.8
39.7
32.9
31.6
30.8
28.9
28.3
22.6
20.2
17.1
14.0
f1 (ppm)


7.42
7.42
7.41
7.33
7.33
7.32
7.31
7.26
7.25
7.24
7.23
7.22
6.63
6.63
6.60
6.60
6.33
6.32
6.31
6.30
6.29
6.28
4.47
4.47
4.46
4.46
1.62
1.61
1.60
1.60
1.59
1.58
1.58
1.57
1.56
1.52
1.52
1.50
1.50
1.50
1.49
1.48
1.47
1.46
1.45
1.37
1.37
1.36
1.36
1.35
1.34
1.34
1.27
1.26
1.23
1.18
1.16
1.14
1.13
Ph
O
N
2.05
2.02
1.02
1.00
1.00
2.03
1.01
4.02
1.03
6.02
6.02
f1 (ppm)


137.1
131.4
128.5
127.4
126.4
125.6
78.0
59.8
39.7
33.0
20.2
17.1
Ph
O
N
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)