Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Copper-catalyzed Trifluoromethylation of Styrene Derivatives with CF_3SO_2Na

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Contents

1. General Information

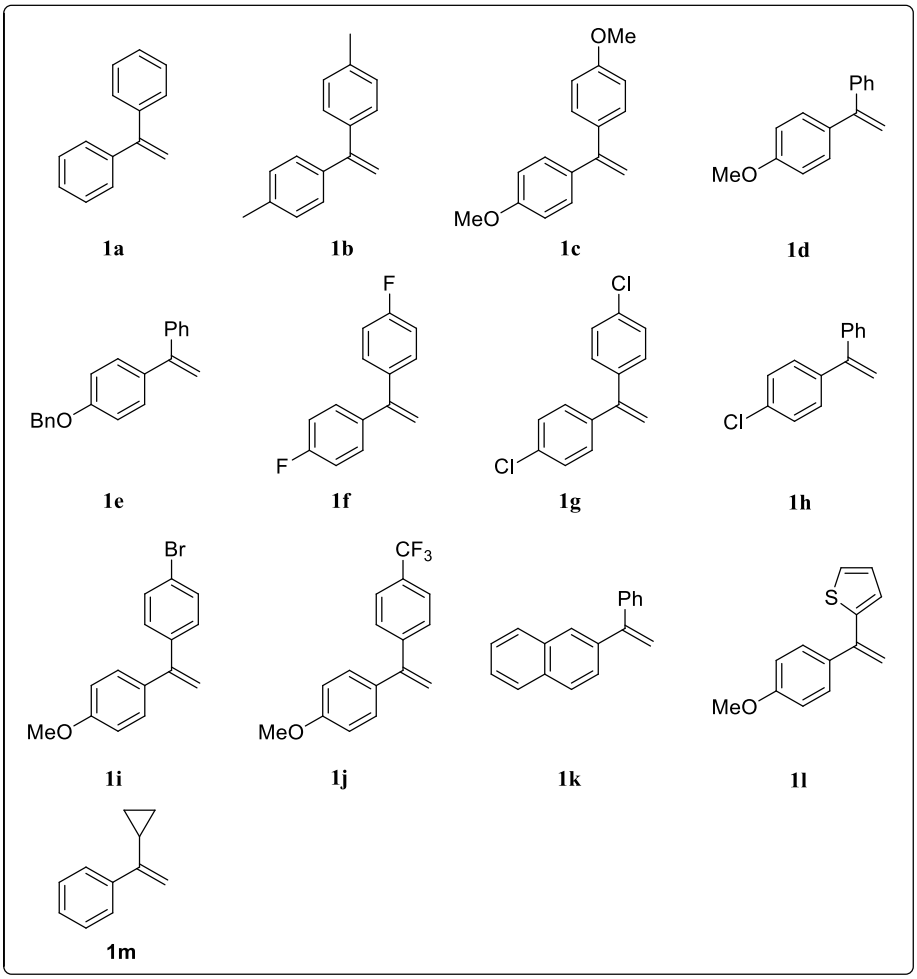
Unless otherwise noted, all reagents and solvents were purchased from the commercial sources and used as received.

The di-*tert*-butyl peroxide (DTBP) and 1-methylimidazole (NMI) were purchased from Alfa-Aesar, copper(I) iodide was purchased from Stream. Thin layer chromatography (TLC) was used to monitor the reaction progress on Merck 60 F254 precoated silica gel plate (0.2 mm thickness). TLC spots were visualized by UV-light irradiation on Spectroline Model ENF-24061/F 254 nm. Other visualization method was staining with a basic solution of potassium permanganate or acidic solution of ceric molybdate, followed by heating.

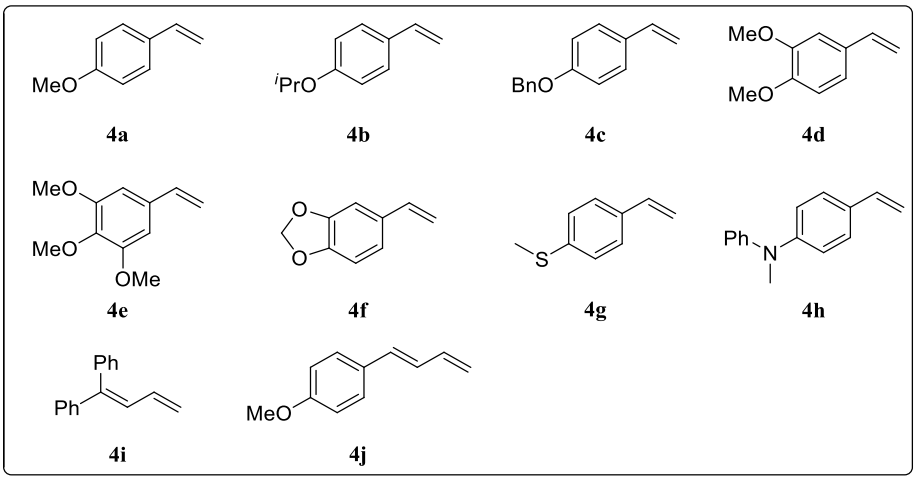
Flash column chromatography was performed using Merck silica gel 60 with analytical grade solvents as eluents.

^{1}H NMR, ^{13}C NMR, ^{19}F NMR and NOESY spectra were recorded using Bruker Avance 300 MHz spectrometers and Bruker Avance 400 MHz spectrometers. Chemical shifts are reported in ppm downfield relative to TMS and were referenced to the signal of chloroform-d (δ=7.26, singlet). Multiplicities were given as: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, bs = broad singlet, dd=doublets of doublet, dq=doublets of quartet. Values of coupling constant are reported as *J* in Hz. HRMS spectra were recorded on a Waters Q–Tof Permier Spectrometer

2. General procedures for the synthesis of styrene derivatives.



1a was commercially available, **1b** – **l**[1] and **1m**[2] were prepared following the reported procedure.



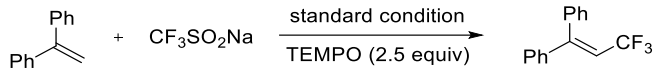
4a – **h**[2], **4i**[1] and **4j**[2] were prepared following the reported procedure.

3. General procedures for the trifluoromethylation of styrene derivatives

To a 8 mL sample vial, charged with CuI (3.8 mg, 0.02 mmol, 10 mol%), $^{n}Bu_4NI$ (14.8 mg, 0.04 mmol, 20 mol%) and CF_3SO_2Na (75.0 mg, 0.48 mmol. 2.4 equiv) in 1,2-dichloroethane (1 mL) was sequentially added 1-methylimidazole (2.5 mg, 0.03 mmol, 15 mol%), di-*tert* butyl peroxide (58.5 mg, 0.4 mmol, 2 equiv) and olefin (0.2 mmol, 1 equiv) under nitrogen atmosphere at room temperature. The vial was sealed with screw cap and stirred at 120 ºC for 12 h. After cooling to room temperature, the reaction mixture was diluted with EtOAc (5 mL), filtered through filter paper and concentrated *under vacuum*. Purification by silica gel column chromatograph using EtOAc and hexane as eluent affords the target product.

4. Mechanism study

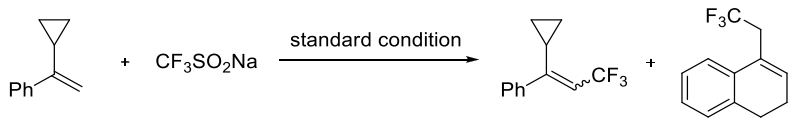
I. Controlled reaction with TEMPO



1a **2** **3a**, 0%

General procedure: the reaction were performed using standard condition with the extra addition of TEMPO (78.1 mg, 0.5 mmol, 2.5 equiv).

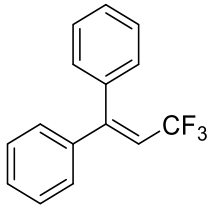
II. Controlled reaction with radical clock.



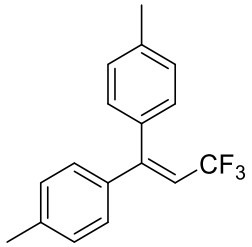
1m **2** **3m**, 0% **6**, 21%

General procedure: the reaction were performed using standard condition.

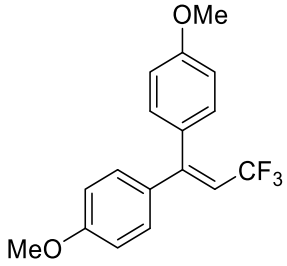
5. Characterization data for the trifluoromethylated styrene derivatives



(3,3,3-Trifluoroprop-1-ene-1,1-diyl)dibenzene (**3a**)
Colorless oil.
Yield = 73%
^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.41 – 7.37 (m, 3H), 7.36 – 7.30 (m, 3H), 7.27 – 7.22 (m, 4H), 6.12 (q, *J* = 8.4 Hz, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 152.4 (q, *J* = 6 Hz), 140.1, 137.2, 129.4, 129.1 (q, *J* = 2 Hz), 128.5, 128.4, 128.0, 127.9, 123.1 (q, *J* = 269 Hz), 115.4 (q, *J* = 34 Hz).
^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -55.6 (d, *J* = 8.4 Hz).
HRMS (ESI, m/z): calcd for $C_{15}H_{12}F_3^+$ $[M+H]^+$ 249.0891, found: 249.0900.

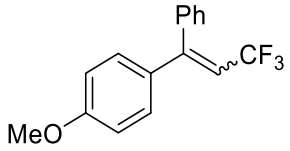


4,4'-(3,3,3-Trifluoroprop-1-ene-1,1-diyl)bis(methylbenzene) (**3b**)
Colorless oil.
Yield = 83%
^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.22 – 7.16 (m, 2H), 7.16 – 7.08 (m, 6H), 6.06 (q, *J* = 8.4 Hz, 1H), 2.39 (s, 3H), 2.35 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 152.4 (q, *J* = 6 Hz), 139.5, 138.3, 137.6, 134.5, 129.1, 129.1 (q, *J* = 2 Hz), 128.7, 127.9, 123.3 (q, *J* = 268 Hz), 114.3 (q, *J* = 34 Hz), 21.3, 21.2.
^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -55.3 (d, *J* = 8.4 Hz).
HRMS (ESI, m/z): calcd for $C_{17}H_{16}F_3^+$ $[M+H]^+$ 277.1204, found: 277.1194.

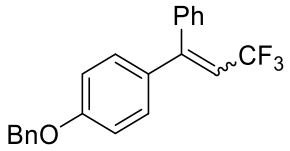


4,4'-(3,3,3-Trifluoroprop-1-ene-1,1-diyl)bis(methoxybenzene) (**3c**)
Light yellow oil.
Yield = 77%

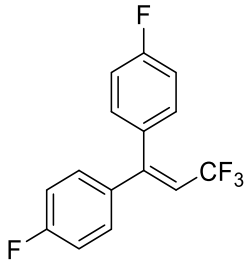
^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.22 – 7.14 (m, 4H), 6.94 – 6.88 (m, 2H), 6.88 – 6.82 (m, 2H), 5.99 (q, *J* = 8.4 Hz, 1H), 3.85 (s, 3H), 3.82 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 160.6, 159.8, 151.8 (q, *J* = 6 Hz), 133.0, 130.6 (q, *J* = 2 Hz), 129.8, 129.5, 123.4 (q, *J* = 268 Hz), 113.7, 113.4, 113.1 (q, *J* = 34 Hz), 56.3, 56.2.
^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -55.0 (d, *J* = 8.4 Hz).
HRMS (ESI, m/z): calcd for $C_{17}H_{16}F_3O_2^+$ $[M+H]^+$ 309.1102, found: 309.1102.



(*E*/*Z*)-1-Methoxy-4-(3,3,3-trifluoro-1-phenylprop-1-enyl)benzene (**3d**)
Colorless oil.
Yield = 84%, *E*/*Z* = 2:1.
^{1}H NMR of the *E*/*Z* mixture (400 MHz, $CDCl_3$) δ (ppm): 7.41 – 7.32 (m, 3H, mixture), 7.27 – 7.21 (m, 2H, mixture), 7.20 – 7.15 (m, 2H, mixture), 6.94 – 6.89 (m, 2H, minor), 6.87 – 6.82 (m, 2H, major), 6.06 (q, *J* = 8.4 Hz, 1H, major), 6.04 (q, *J* = 8.4 Hz, 1H, minor), 3.85 (s, 3H, minor), 3.81 (s, 1H, major).
^{13}C NMR of the *E*/*Z* mixture (100 MHz, $CDCl_3$) δ (ppm): 160.7, 159.8, 152.4 (q, *J* = 5 Hz), 151.8 (q, *J* = 5 Hz), 140.7, 137.5, 132.4, 130.6 (q, *J* = 2 Hz), 129.6, 129.3, 129.3, 129.1 (q, *J* = 2 Hz), 128.4, 128.3, 128.2, 128.0, 123.3 (q, *J* = 269 Hz), 123.2 (q, *J* = 269 Hz), 114.9 (q, *J* = 33 Hz), 114.0, 113.5 (q, *J* = 33 Hz), 113.4, 55.3, 55.2.
^{19}F NMR of the *E*-mixture (376 MHz, $CDCl_3$) δ (ppm): -55.2 (d, *J* = 8.3 Hz).
^{19}F NMR of the *Z*-mixture (376 MHz, $CDCl_3$) δ (ppm): -55.5 (d, *J* = 8.3 Hz).
HRMS (ESI, m/z): calcd for $C_{16}H_{14}F_3O^+$ $[M+H]^+$ 279.0997, found: 279.0993.



(*E*/*Z*)-1-(Benzyloxy)-4-(3,3,3-trifluoro-1-phenylprop-1-enyl)benzene (**3e**)
White solid.
Yield = 82%, *E*/*Z* = 2 : 1.
^{1}H NMR of the *E*/*Z* mixture (400 MHz, $CDCl_3$) δ (ppm): 7.46 – 7.30 (m, 8H, mixture), 7.25 – 7.21 (m, 2H, mixture), 7.19 – 7.15 (m, 2H, mixture), 7.00 – 6.96 (m, 2H, minor), 6.93 – 6.88 (m, 2H, major), 6.05 (q, *J* = 8.4 Hz, 1H, major), 6.04 (q, *J* = 8.4 Hz, 1H, minor), 5.08 (s, 2H, minor), 5.06 (s, 1H, major).
^{13}C NMR of the *E*/*Z* mixture (100 MHz, $CDCl_3$) δ (ppm): 159.8, 159.1, 152.3 (q, *J* = 5 Hz), 151.8 (q, *J* = 5 Hz), 140.7, 137.4, 136.7, 136.5, 132.6, 130.7 (q, *J* = 2 Hz), 129.8, 129.3, 129.3, 129.1 (q, *J* = 2 Hz), 128.6, 128.6, 128.4, 128.3, 128.2, 128.1, 128.1, 128.0, 127.6, 127.4, 123.3 (q, *J* = 268 Hz), 123.2 (q, *J* = 268 Hz), 115.0 (q, *J* = 33 Hz), 114.7, 114.3, 113.6 (q, *J* = 33 Hz), 70.1.
^{19}F NMR of the *E*-mixture (376 MHz, $CDCl_3$) δ (ppm): -55.1 (d, *J* = 7.9 Hz).
^{19}F NMR of the *Z*-mixture (376 MHz, $CDCl_3$) δ (ppm): -55.4 (d, *J* = 8.3 Hz).
HRMS (ESI, m/z): calcd for $C_{22}H_{18}F_3O^+$ $[M+H]^+$ 355.1310, found: 355.1299.



4,4'-(3,3,3-Trifluoroprop-1-ene-1,1-diyl)bis(fluorobenzene) (**3f**)

Colorless oil.

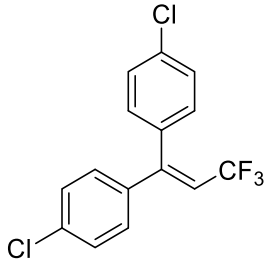
Yield = 72%

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.25 – 7.18 (m, 4H), 7.12 – 7.00 (m, 4H), 6.08 (q, *J* = 8.4 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 164.5 (d, *J* = 62 Hz), 162.0 (d, *J* = 62 Hz), 150.4 (q, *J* = 6 Hz), 136.1 (d, *J* = 3 Hz), 133.0 (d, *J* = 4 Hz), 131.0 (dq, J_1 = 9 Hz, J_2 = 2 Hz), 129.8 (d, *J* = 8 Hz), 122.9 (q, *J* = 269 Hz), 115.6 (q, *J* = 33 Hz), 115.6 (d, *J* = 22 Hz), 115.3 (d, *J* = 22 Hz).

^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -55.6 (d, *J* = 8.4 Hz), -111.4 (m), -112.6 (m).

HRMS (ESI, m/z): calcd for $C_{15}H_{10}F_3^+$ $[M+H]^+$ 285.0703, found: 285.0689.



4,4'-(3,3,3-Trifluoroprop-1-ene-1,1-diyl)bis(chlorobenzene) (**3g**)

Colorless oil.

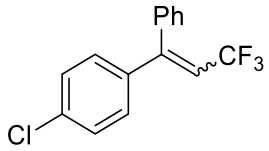
Yield = 65%

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.41 – 7.35 (m, 2H), 7.35 – 7.28 (m, 2H), 7.21 – 7.11 (m, 4H), 6.12 (q, *J* = 8.4 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 150.2 (q, *J* = 6 Hz), 138.1, 135.9, 135.2, 135.0, 130.4 (q, *J* = 2 Hz), 129.2, 128.8, 128.5, 122.7 (q, *J* = 269 Hz), 116.3 (q, *J* = 34 Hz).

^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -55.7 (d, *J* = 7.9 Hz).

HRMS (ESI, m/z): calcd for $C_{15}H_{10}Cl_2F_3^+$ $[M+H]^+$ 317.0112, found: 317.0096.



(*E*/*Z*)-1-Chloro-4-(3,3,3-trifluoro-1-phenylprop-1-enyl)benzene (**3h**)

Light yellow oil.

Yield = 68%, *E*/*Z* = 1 : 1.

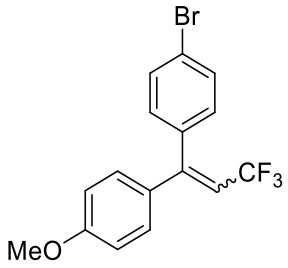
^{1}H NMR of the *E*/*Z* mixture (400 MHz, $CDCl_3$) δ (ppm): 7.42 – 7.28 (m, 5H, mixture), 7.25 –

7.15 (m, 4H, mixture), 6.14 (q, *J* = 8.4 Hz, 1H), 6.11 (q, *J* = 8.4 Hz, 1H).

^{13}C NMR of the *E*/*Z* mixture (100 MHz, $CDCl_3$) δ (ppm): 151.3 (q, *J* = 5 Hz), 151.3 (q, *J* = 5 Hz), 139.6, 138.6, 136.8, 135.7, 135.6, 134.7, 130.5 (q, *J* = 2 Hz), 129.6, 129.2, 129.0 (q, *J* = 2 Hz), 128.7, 128.7, 128.6, 128.4, 128.2, 127.9, 122.9 (q, *J* = 269 Hz), 122.9 (q, *J* = 269 Hz), 116.3 (q, *J* = 33 Hz), 116.1 (q, *J* = 33 Hz).

^{19}F NMR of the *E*/*Z* mixture (376 MHz, $CDCl_3$) δ (ppm): -55.6 (d, *J* = 8.4 Hz), -55.7 (d, *J* = 8.4 Hz).

HRMS (ESI, m/z): calcd for $C_{15}H_{11}ClF_3^+$ $[M+H]^+$ 283.0501, found: 283.0492.



(*E*/*Z*)-1-Bromo-4-(3,3,3-trifluoro-1-(4-methoxyphenyl)prop-1-enyl)benzene (**3i**)

Colorless oil.

Yield = 83%, *E*/*Z* = 1 : 3.

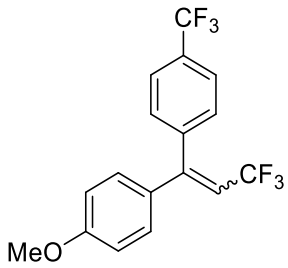
^{1}H NMR of the *E*/Z mixture (400 MHz, $CDCl_3$) δ (ppm): 7.55 – 7.50 (m, 2H, major), 7.48 – 7.44 (m, 2H, minor), 7.18 – 7.09 (m, 4H, mixture), 6.94 – 6.89 (m, 2H, minor), 6.87 – 6.82 (m, 2H, major), 6.07 (q, *J* = 8.4 Hz, 1H, major), 6.02 (q, *J* = 8.4 Hz, 1H, minor), 3.85 (s, 3H, minor), 3.82 (s, 1H, major).

^{13}C NMR of the *E*/*Z* mixture (100 MHz, $CDCl_3$) δ (ppm): 160.8, 160.1, 151.3 (q, *J* = 5 Hz), 150.6 (q, *J* = 5 Hz), 139.7, 136.4, 131.8, 131.6, 130.8 (q, *J* = 2 Hz), 130.6 (q, *J* = 2 Hz), 129.7, 129.3, 129.0, 123.8, 122.8 (q, *J* = 269 Hz), 123.0 (q, *J* = 269 Hz), 122.7, 115.2 (q, *J* = 34 Hz), 113.9, 113.9 (q, *J* = 34 Hz), 113.6, 55.4, 55.2.

^{19}F NMR of the *E*-mixture (376 MHz, $CDCl_3$) δ (ppm): -55.7(d, *J* = 8.3 Hz).

^{19}F NMR of the *Z*-mixture (376 MHz, $CDCl_3$) δ (ppm): -55.1 (d, *J* = 8.3 Hz).

HRMS (ESI, m/z): calcd for $C_{16}H_{13}BrF_3O^+$ $[M+H]^+$ 357.0102, found: 357.0091.



(*E*/*Z*)-1-Methoxy-4-(3,3,3-trifluoro-1-(4-(trifluoromethyl)phenyl)prop-1-enyl)benzene (**3j**)

Colorless oil.

Yield = 75%, *E*/*Z* = 6 : 1.

^{1}H NMR of the *E*/Z mixture (400 MHz, $CDCl_3$) δ (ppm): 7.69 – 7.63 (m, 2H, major), 7.61 – 7.57 (m, 2H, minor), 7.39 – 7.27 (m, 2H, mixture), 7.18 – 7.05 (m, 2H, mixture), 6.95 – 6.90 (m, 2H, minor), 6.89 – 6.83 (m, 2H, major), 6.14 (q, *J* = 8.4 Hz, 1H, major), 6.07 (q, *J* = 8.4 Hz, 1H, minor),

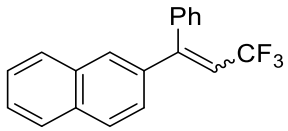
3.85 (s, 3H, minor), 3.82 (s, 1H, major).

^{13}C NMR of the *E*-isomer (100 MHz, $CDCl_3$) δ (ppm): 160.9, 150.4 (q, *J* = 5 Hz), 141.2, 131.4, 130.6 (q, *J* = 32 Hz), 129.5 (q, *J* = 2 Hz), 129.2, 125.0 (q, *J* = 4 Hz), 124.0 (q, *J* = 271 Hz), 123.0 (q, *J* = 268 Hz), 114.4 (q, *J* = 34 Hz), 114.0, 55.4.

^{19}F NMR of the *E*-mixture (376 MHz, $CDCl_3$) δ (ppm): -55.2 (d, *J* = 8.3 Hz), -62.6.

^{19}F NMR of the *Z*-mixture (376 MHz, $CDCl_3$) δ (ppm): -55.9 (d, *J* = 8.3 Hz), -62.8.

HRMS (ESI, m/z): calcd for $C_{17}H_{13}F_6O^+$ $[M+H]^+$ 347.0871, found: 347.0876.



(*E*/*Z*)-2-(3,3,3-Trifluoro-1-phenylprop-1-enyl)naphthalene (**3k**)

White solid.

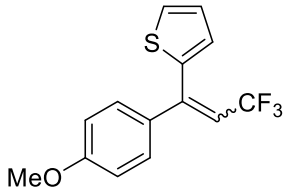
Yield = 74%, *E*/*Z* = 1 : 1.

^{1}H NMR of the *E*/*Z* mixture (400 MHz, $CDCl_3$) δ (ppm): 7.90 – 7.62 (m, 4H, mixture), 7.57 – 7.47 (m, 2H, mixture), 7.57 – 7.47 (m, 2H, mixture), 7.39 – 7.27 (m, 4H, mixture), 6.27 (q, *J* = 8.4 Hz, 1H), 6.22 (q, *J* = 8.4 Hz, 1H).

^{13}C NMR of the *E*/*Z* mixture (100 MHz, $CDCl_3$) δ (ppm): 152.4, 152.3, 140.1, 137.4, 137.2, 134.7, 133.6, 133.1, 132.9, 132.8, 129.4, 129.2 (q, *J* = 2 Hz), 128.6, 128.5, 128.3, 128.2, 128.1, 128.1, 127.7, 127.7, 127.6, 127.0, 126.8, 126.8, 126.6, 126.6, 126.4, 124.8, 123.1 (q, *J* = 269 Hz), 123.1 (q, *J* = 269 Hz), 122.9 (q, *J* = 269 Hz), 115.8 (q, *J* = 33 Hz).

^{19}F NMR of the *E*/*Z* mixture (376 MHz, $CDCl_3$) δ (ppm): -55.4 (d, *J* = 8.3 Hz), -55.5 (d, *J* = 8.3 Hz).

HRMS (ESI, m/z): calcd for $C_{19}H_{114}F_3^+$ $[M+H]^+$ 299.1048, found: 299.1053.



(*E*/*Z*)-2-(3,3,3-Trifluoro-1-(4-methoxyphenyl)prop-1-enyl)thiophene (**3l**)

Yellow solid.

Yield = 76%, *E*/*Z* = 3 : 1.

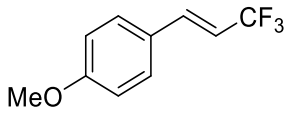
^{1}H NMR of the *E*-isomer (400 MHz, $CDCl_3$) δ (ppm): 7.33 (dd, J_1 = 5.2 Hz, J_2 = 1.2 Hz, 1H), 7.26 – 7.23 (m, 2H), 6.98 – 6.95 (m, 1H), 6.95 – 6.90 (m, 2H), 6.85 – 6.82 (m, 1H), 6.13 (q, *J* = 8.4 Hz, 1H), 3.85 (s, 3H).

^{1}H NMR of the *Z*-isomer (400 MHz, $CDCl_3$) δ (ppm): 7.45 (dd, J_1 = 5.2 Hz, J_2 = 1.2 Hz, 1H), 7.28 – 7.26 (m, 2H), 7.22 – 7.20 (m, 1H), 7.09 – 7.06 (m, 1H), 6.88 – 6.85 (m, 2H), 5.95 (q, *J* = 8.4 Hz, 1H), 3.82 (s, 3H).

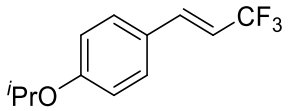
^{13}C NMR of the *E*-isomer (100 MHz, $CDCl_3$) δ (ppm): 160.9, 145.4 (q, *J* = 5 Hz), 144.3, 130.2 (q, *J* = 2 Hz), 129.6, 129.2, 127.8, 127.7, 123.1 (q, *J* = 269 Hz), 113.4, 112.7 (q, *J* = 34 Hz), 55.2.

^{13}C NMR of the *Z*-isomer (100 MHz, $CDCl_3$) δ (ppm): 160.0, 145.1 (q, *J* = 5 Hz), 138.1, 132.9, 129.8 (q, *J* = 2 Hz), 128.6, 128.0, 126.8, 123.0 (q, *J* = 269 Hz), 114.9 (q, *J* = 33 Hz), 113.7, 55.4.

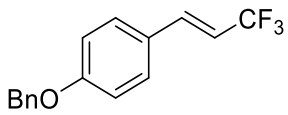
^{19}F NMR of the *E*-mixture (376 MHz, $CDCl_3$) δ (ppm): -55.0 (d, *J* = 8.6 Hz).
^{19}F NMR of the *Z*-mixture (376 MHz, $CDCl_3$) δ (ppm): -55.6 (d, *J* = 7.9 Hz).
HRMS (ESI, m/z): calcd for $C_{14}H_{12}F_3OS^+$ $[M+H]^+$ 285.0561, found: 285.0566.



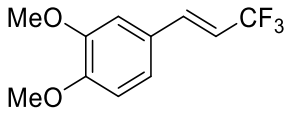
(*E*)-1-Methoxy-4-(3,3,3-trifluoroprop-1-enyl)benzene (**5a**)
Colorless oil.
Yield = 69%
^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.44 – 7.35 (m, 2H), 7.09 (dq, J_1 = 16.0 Hz, J_2 = 2.4 Hz, 1H), 6.95 – 6.86 (m, 1H), 6.06 (dq, J_1 = 16.0 Hz, J_2 = 6.4 Hz, 1H), 3.84 (s, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 161.0, 137.1 (q, *J* = 7 Hz), 129.0, 126.1, 123.9 (q, *J* = 267 Hz), 114.3, 113.4 (q, *J* = 34 Hz), 55.3.
^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -62.8 (dd, J_1 = 6.4 Hz, J_2 = 2.4 Hz).
HRMS (ESI, m/z): calcd for $C_{10}H_{10}F_3O^+$ $[M+H]^+$ 203.0684, found: 203.0687.



(*E*)-1-Isopropoxy-4-(3,3,3-trifluoroprop-1-enyl)benzene (**5b**)
Colorless oil.
Yield = 53%
^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.38 (d, *J* = 8.4 Hz, 1H) 7.08 (dq, J_1 = 16.0 Hz, J_2 = 2.4 Hz, 1H), 6.88 (d, *J* = 8.4 Hz, 1H), 6.05 (dq, J_1 = 16.0 Hz, J_2 = 6.4 Hz, 1H), 4.64 – 4.53 (m, 1H), 1.36 (d, *J* = 6.0 Hz, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 159.5, 137.1 (q, *J* = 6 Hz), 129.0, 125.7, 124.0 (q, *J* = 267 Hz), 116.0, 113.2 (q, *J* = 34 Hz), 70.0, 22.0.
^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -62.8 (dd, J_1 = 6.4 Hz, J_2 = 2.4 Hz).
HRMS (ESI, m/z): calcd for $C_{12}H_{14}F_3O^+$ $[M+H]^+$ 231.0997, found: 231.1003.



(*E*)-1-(Benzyloxy)-4-(3,3,3-trifluoroprop-1-enyl)benzene (**5c**)
White solid (m.p. = 59 – 63 °C)
Yield = 62%
^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.46 – 7.37 (m, 6H) 7.37 – 7.32 (m, 1H), 7.08 (dq, J_1 = 16.0 Hz, J_2 = 2.4 Hz, 1H), 7.01 – 6.94 (m, 2H), 6.07 (dq, J_1 = 16.0 Hz, J_2 = 6.4 Hz, 1H), 5.10 (s, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 160.2, 137.0 (q, *J* = 7 Hz), 136.4, 129.0, 128.6, 128.1, 127.4, 126.3, 123.9 (q, *J* = 267 Hz), 115.2, 113.5 (q, *J* = 33 Hz), 70.0.
^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -62.8 (dd, J_1 = 6.4 Hz, J_2 = 2.4 Hz).
HRMS (ESI, m/z): calcd for $C_{16}H_{14}F_3O^+$ $[M+H]^+$ 279.0997, found: 279.0988.



(*E*)-1,2-Dimethoxy-4-(3,3,3-trifluoroprop-1-enyl)benzene (**5d**)

Light yellow oil.

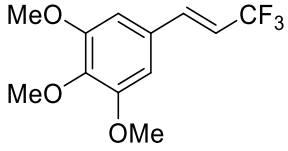
Yield = 74%

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.08 (dq, J_1 = 16.0 Hz, J_2 = 2.4 Hz, 1H), 7.02 (dd, J_1 = 8.4 Hz, J_2 = 2.4 Hz, 1H), 6.99 – 6.95 (m, 1H), 6.86 (d, J = 8.4 Hz, 1H), 6.07 (dq, J_1 = 16.0 Hz, J_2 = 6.4 Hz, 1H), 3.92 (s, 3H), 3.91 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 150.7, 149.2, 137.4 (q, J = 7 Hz), 126.3, 123.8 (q, J = 267 Hz), 121.6, 113.6 (q, J = 34 Hz), 111.1, 109.3, 55.9, 55.9.

^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -62.8 (dd, J_1 = 6.4 Hz, J_2 = 2.4 Hz).

HRMS (ESI, m/z): calcd for $C_{11}H_{12}F_3O_2^+$ $[M+H]^+$ 233.0789, found: 233.0791.



(*E*)-1,2,3-Trimethoxy-5-(3,3,3-trifluoroprop-1-enyl)benzene (**5e**)

White solid (m.p. = 104 – 106 °C).

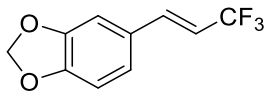
Yield = 67%

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.07 (dq, J_1 = 16.0 Hz, J_2 = 2.4 Hz, 1H), 6.67 (s, 1H), 6.11 (dq, J_1 = 16.0 Hz, J_2 = 6.4 Hz, 1H), 3.88 (s, 6H), 3.82 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 153.5, 139.8, 137.6 (q, J = 7 Hz), 128.9, 123.6 (q, J = 267 Hz), 115.2 (q, J = 34 Hz), 104.7, 60.9, 56.1.

^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -63.1 (dd, J_1 = 6.4 Hz, J_2 = 2.4 Hz).

HRMS (ESI, m/z): calcd for $C_{12}H_{14}F_3O_3^+$ $[M+H]^+$ 263.0895, found: 263.0903.



(*E*)-5-(3,3,3-Trifluoroprop-1-enyl)benzo[d][1,3]dioxole (**5f**)

Colorless oil

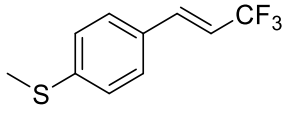
Yield = 65%

^{1}H NMR (300 MHz, $CDCl_3$) δ (ppm): 7.04 (dq, J_1 = 16.0 Hz, J_2 = 2.4 Hz, 1H), 6.97 -6.89 (m, 2H), 6.84 – 6.77 (m, 1H), 6.08 – 5.95 (m, 1H), 6.01 (s, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 149.2, 148.4, 137.2 (q, J = 7 Hz), 127.7, 123.8 (q, J = 267 Hz), 123.4, 113.9 (q, J = 33 Hz), 108.5, 106.2, 101.5.

^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -62.9 (d, J = 6.4 Hz).

HRMS (ESI, m/z): calcd for $C_{10}H_8F_3O_2^+$ $[M+H]^+$ 217.0476, found: 217.0466.



(*E*)-Methyl(4-(3,3,3-trifluoroprop-1-enyl)phenyl)sulfane (**5g**)

White solid (59 – 60 °C).

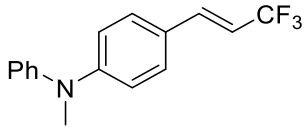
Yield = 62%

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.39 – 7.34 (m, 2H) 7.26 – 7.21 (m, 2H), 7.09 (dq, J_1 = 16.0 Hz, J_2 = 2.4 Hz, 1H), 6.15 (dq, J_1 = 16.0 Hz, J_2 = 6.4 Hz, 1H), 2.50 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 141.4, 137.0 (q, J = 7 Hz), 129.9, 127.8, 126.1, 123.7 (q, J = 267 Hz), 114.8 (q, J = 34 Hz), 15.2.

^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -63.1 (dd, J_1 = 6.4 Hz, J_2 = 2.4 Hz).

HRMS (ESI, m/z): calcd for $C_{10}H_{10}F_3S^+$ $[M+H]^+$ 219.0455, found: 219.0459.



(*E*)-N-Methyl-N-phenyl-4-(3,3,3-trifluoroprop-1-enyl)aniline (**5h**)

Light yellow solid (m.p. = 65 – 68 °C).

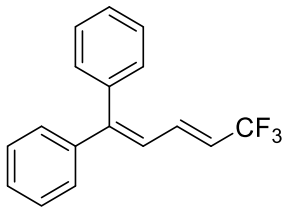
Yield = 51%

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.40 – 7.33 (m, 2H), 7.33 – 7.28 (m, 2H), 7.20 – 7.11 (m, 3H), 7.05 (dq, J_1 = 16.0 Hz, J_2 = 2.4 Hz, 1H), 6.88 – 6.81 (m, 2H), 6.00 (dq, J_1 = 16.0 Hz, J_2 = 2=6.4 Hz, 1H), 3.35 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 150.4, 148.0, 137.3 (q, J = 7 Hz), 129.6, 128.6, 124.5, 124.3, 124.2 (q, J = 267 Hz), 123.9, 116.2, 111.9 (q, J = 34 Hz),40.2.

^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -62.4 (dd, J_1 = 6.4 Hz, J_2 = 2.4 Hz).

HRMS (ESI, m/z): calcd for $C_{16}H_{15}F_3N^+$ $[M+H]^+$ 278.1157, found: 278.1164.



(*E*)-(5,5,5-Trifluoropenta-1,3-diene-1,1-diyl)dibenzene (**5i**)

Colorless oil

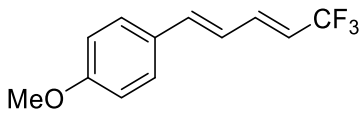
Yield = 59%

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.46 – 7.40 (m, 3H), 7.35 – 7.28 (m, 5H), 7.23 – 7.18 (m, 2H), 5.92 – 5.80 (m, 1H).

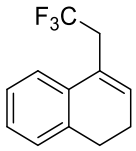
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 149.9, 141.2, 138.4, 135.1 (q, J = 7 Hz), 130.2, 128.6, 128.4, 128.3, 128.2, 128.0, 123.8, 123.5 (q, J = 267 Hz), 119.2 (q, J = 34 Hz).

^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -63.0 (d, J = 6.4 Hz).

HRMS (ESI, m/z): calcd for $C_{17}H_{14}F_3^+$ $[M+H]^+$ 275.1048, found: 275.1053.



1-Methoxy-4-((1*E*,3*E*)-5,5,5-trifluoropenta-1,3-dienyl)benzene (**5j**)
Light yellow solid (m.p. = 72 – 74 °C).
Yield = 33%
^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.42 – 7.35 (m, 2H), 6.93 – 6.83 (m, 3H), 6.80 – 6.72 (m, 1H), 6.68 – 6.60 (m, 1H), 5.80 – 5.68 (m, 1H), 3.83 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 160.3, 138.9, 137.8 (q, *J* = 7 Hz), 128.6, 128.4, 123.6 (q, *J* = 267 Hz), 122.8, 117.1 (q, *J* = 33 Hz), 114.3, 55.3.
^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -62.9 (d, *J* = 6.4 Hz).
HRMS (ESI, m/z): calcd for $C_{12}H_{12}F_3O^+$ $[M+H]^+$ 229.0840, found: 229.0834.

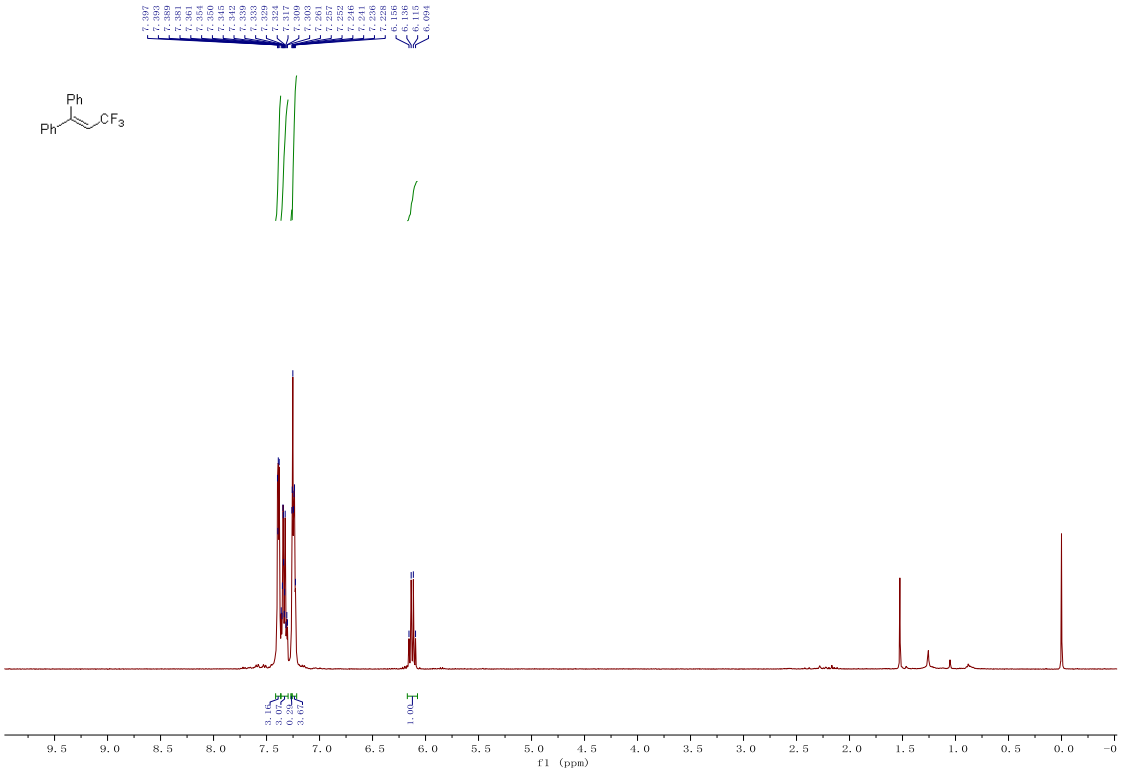


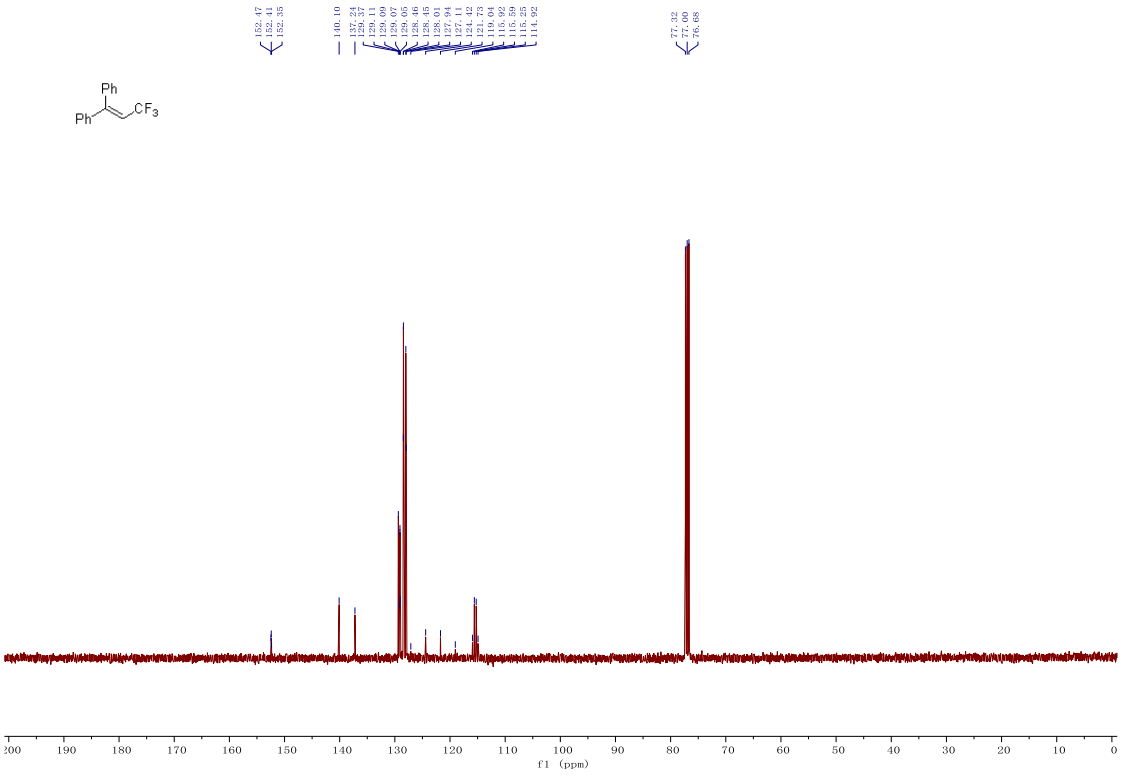
4-(2,2,2-Trifluoroethyl)-1,2-dihydronaphthalene (**6**)
Colorless oil
Yield = 21%
^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.25 – 7.10 (m, 4H) 7.26 – 7.21 (m, 2H), 6.14 (t, *J* = 4.8 Hz, 1H), 3.24 (qd, J_1 = 10.8 Hz, J_2 = 1.2 Hz, 2H), 2.79 (t, *J* = 8.0 Hz, 2H), 2.37 – 2.29 (m, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 136.3, 133.7, 132.0, 127.8, 127.3, 126.7 (q, *J* = 3 Hz), 126.4, 126.0 (q, *J* = 275 Hz), 122.7, 36.8 (q, *J* = 29 Hz), 27.9, 23.2.
^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -64.5 (t, *J* = 11.3 Hz).
HRMS (ESI, m/z): calcd for $C_{12}H_{11}F_3^+$ $[M+H]^+$ 213.0891, found: 213.0894.

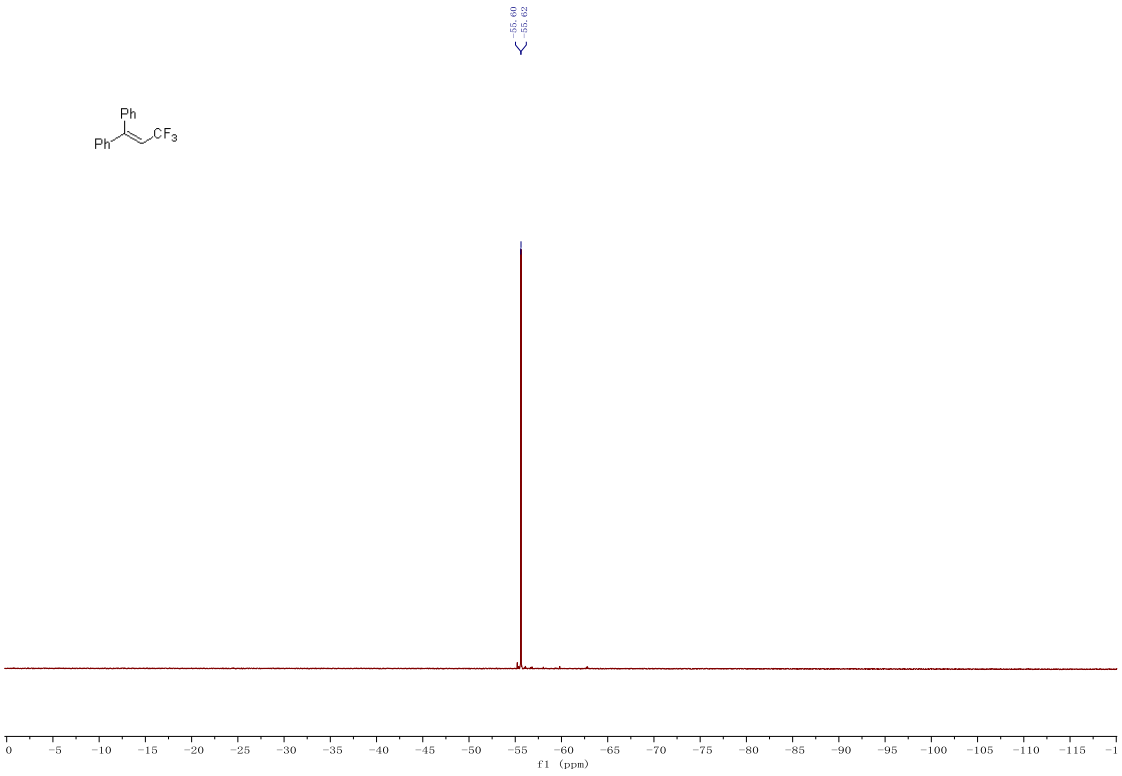
6. Reference

1. T. Wang, Y. Hu, S. Zhang, *Org. Biomol. Chem.* **2010**, *8*, 2312.
2. A. J. Perkowski, W. You, D. A. Nicewicz, *J. Am. Chem. Soc.* **2015**, *137*, 7580.

7. ^{1}H, ^{13}C, ^{19}F NMR spectra



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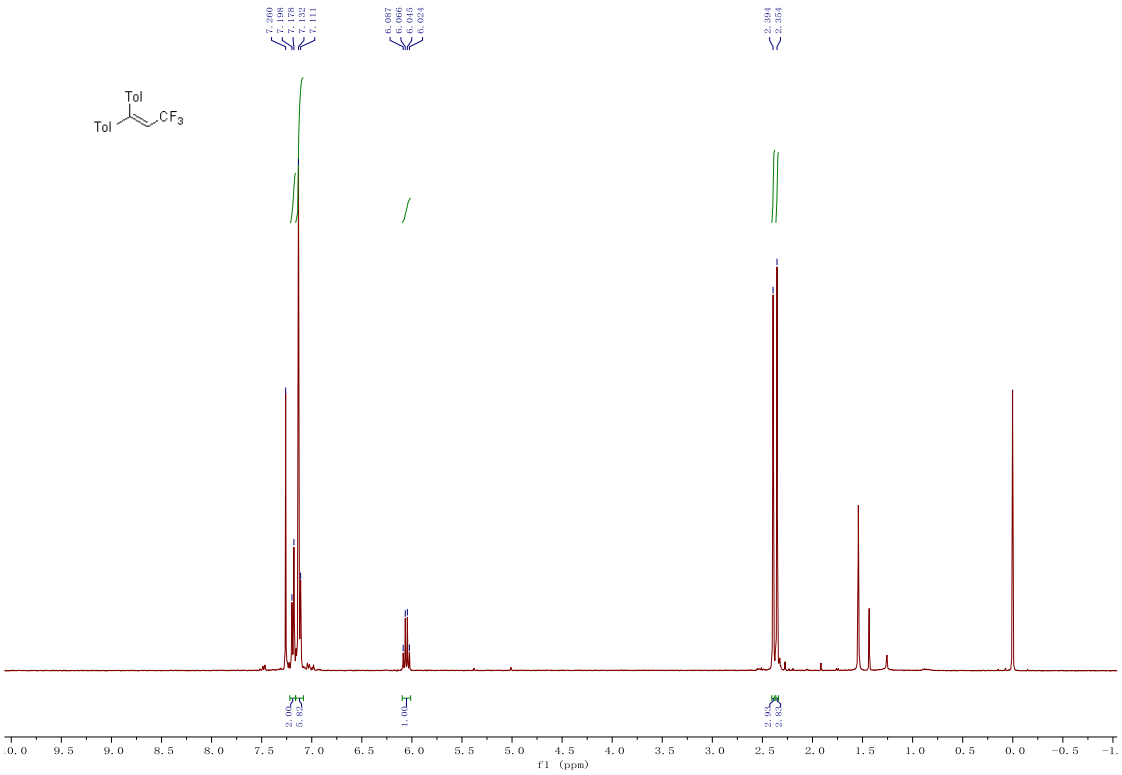
Ph
Ph
CF3
f1 (ppm)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6.045
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Tol
Tol
CF3
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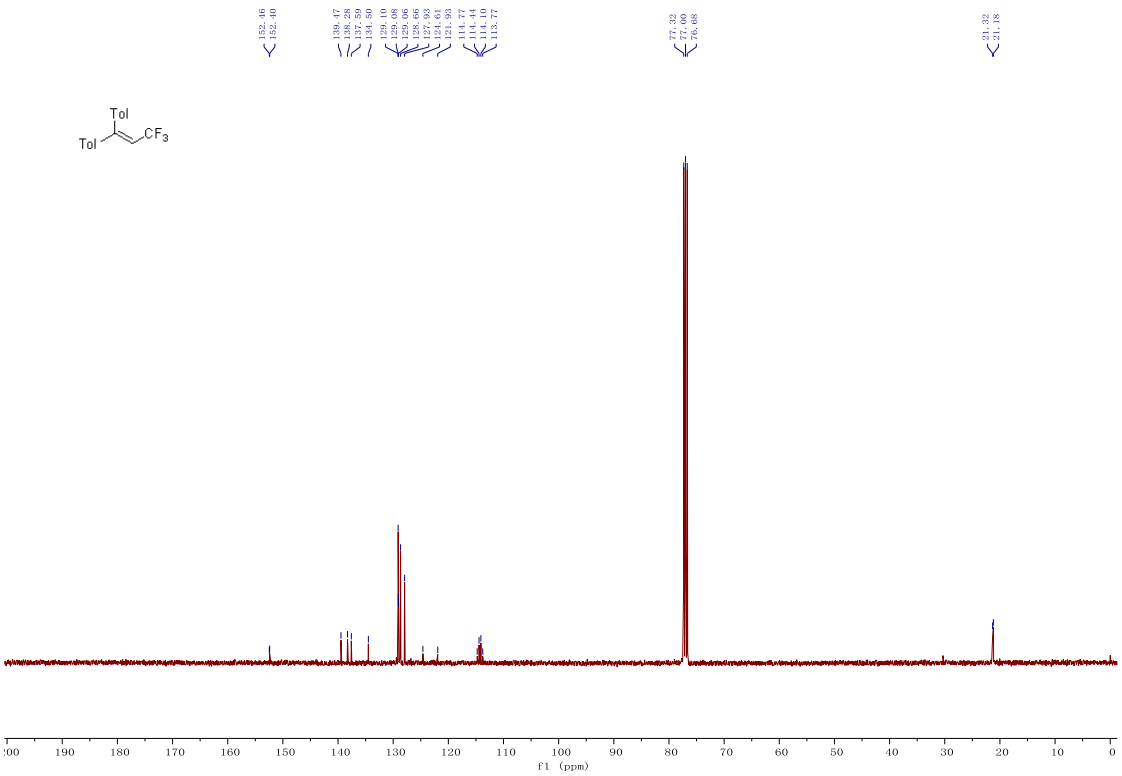
5.82
1.00
2.93
2.83
f1 (ppm)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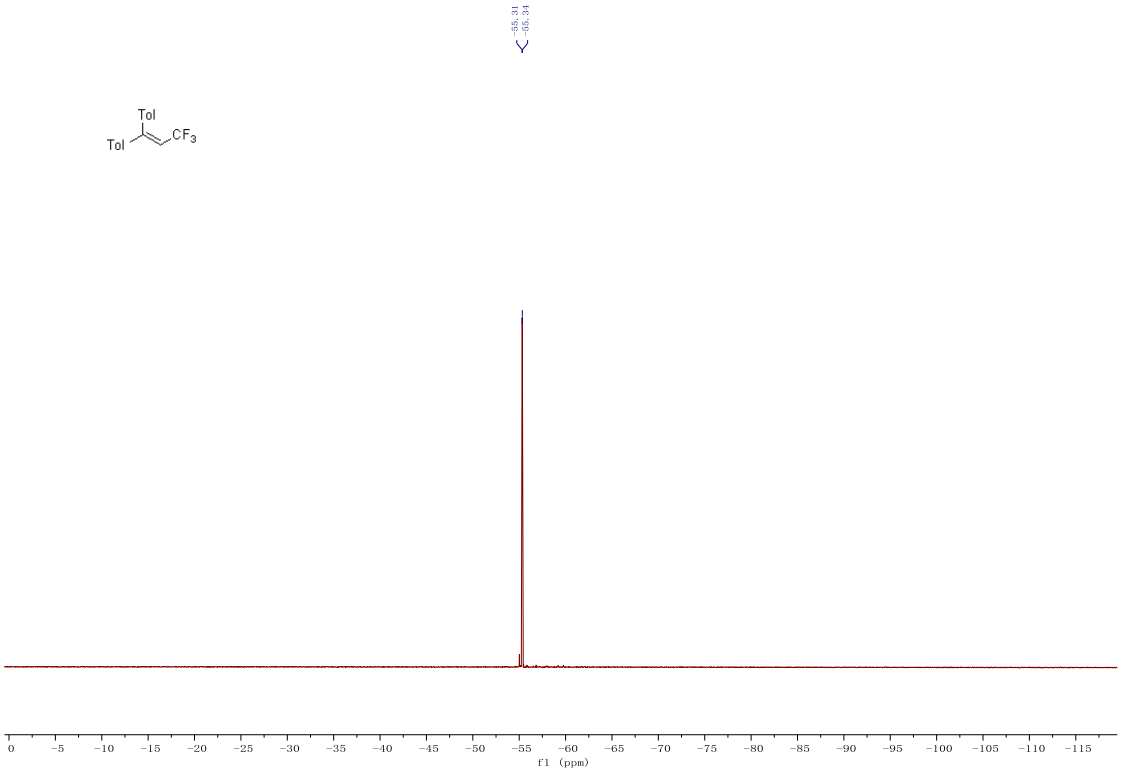
21.32
21.18
Tol
Tol
CF3
f1 (ppm)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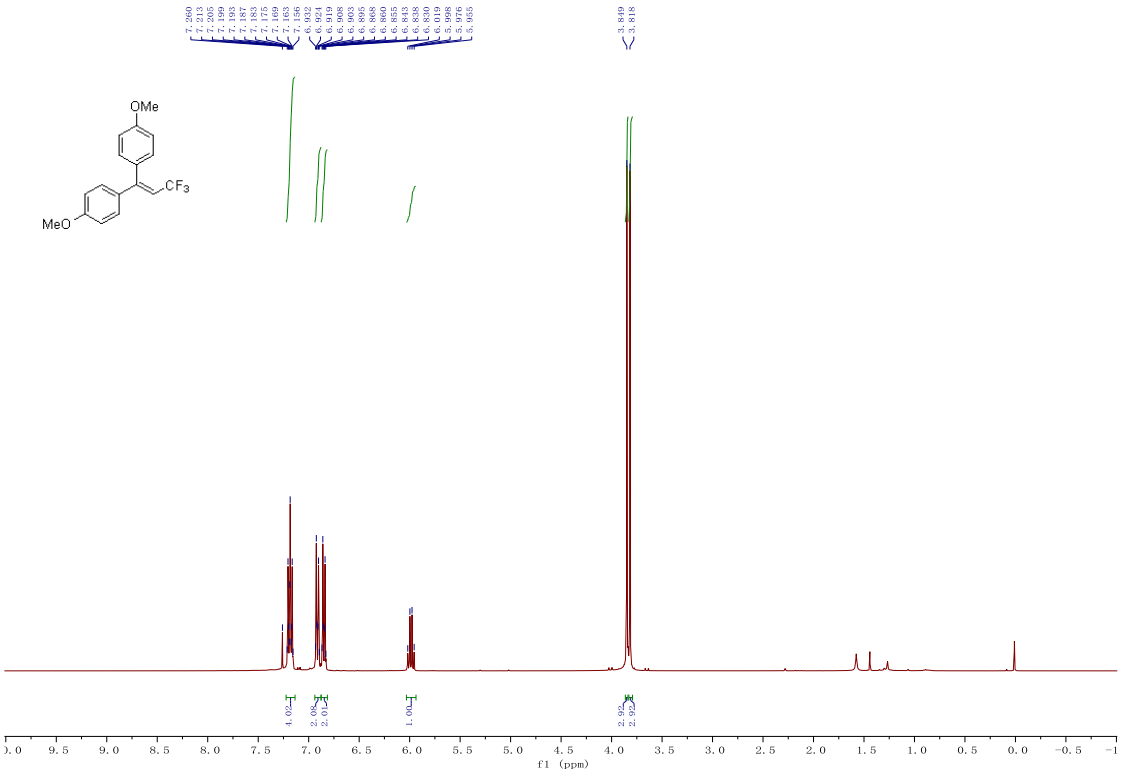
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6.838
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6.819
6.998
5.976
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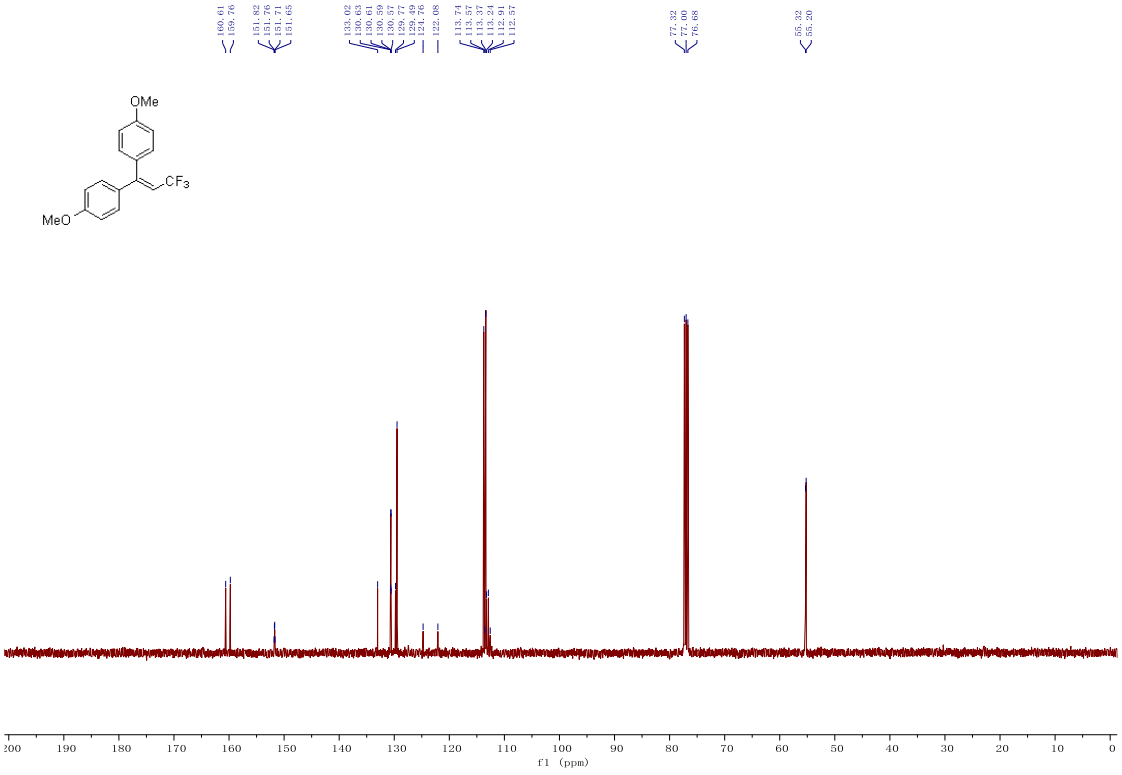
f1 (ppm)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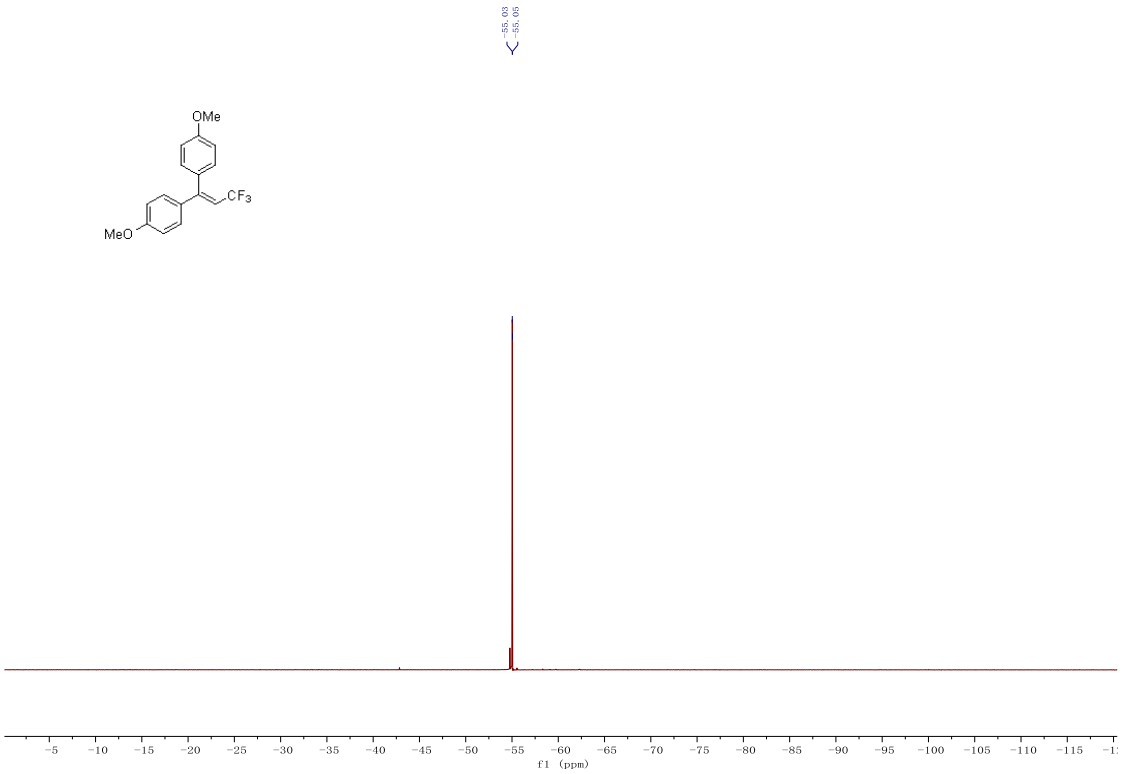
OMe
CF3
MeO
f1 (ppm)


OMe
CF3
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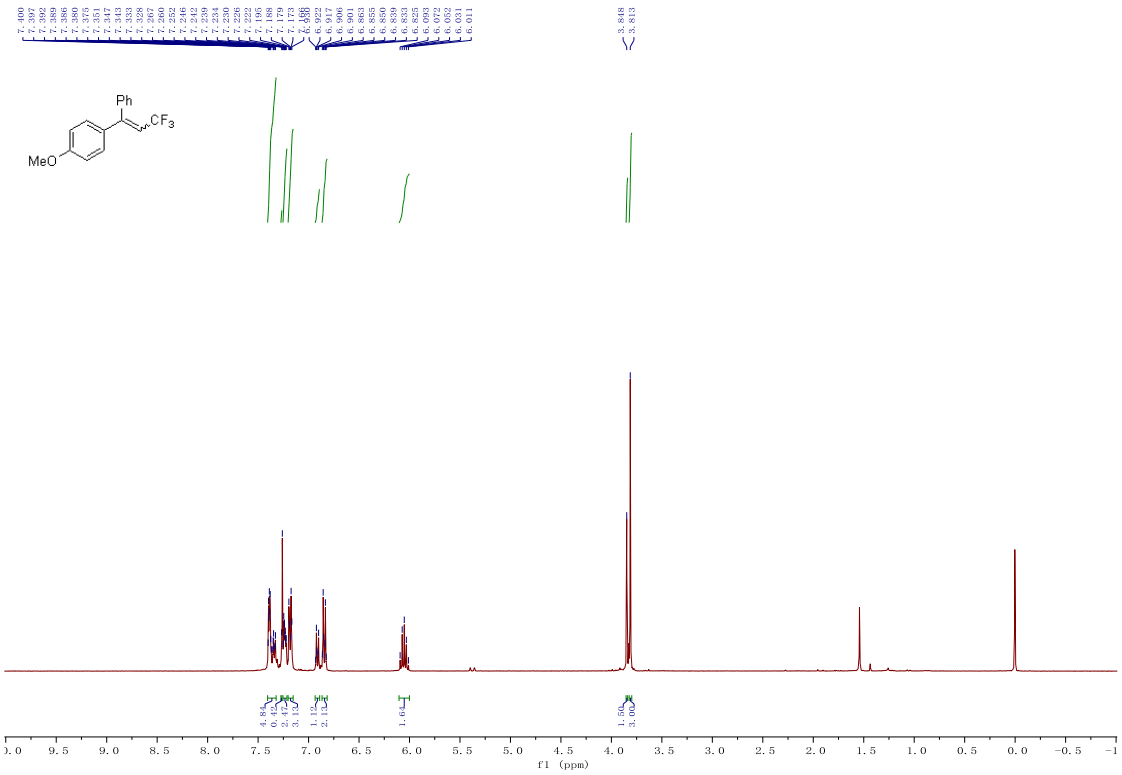
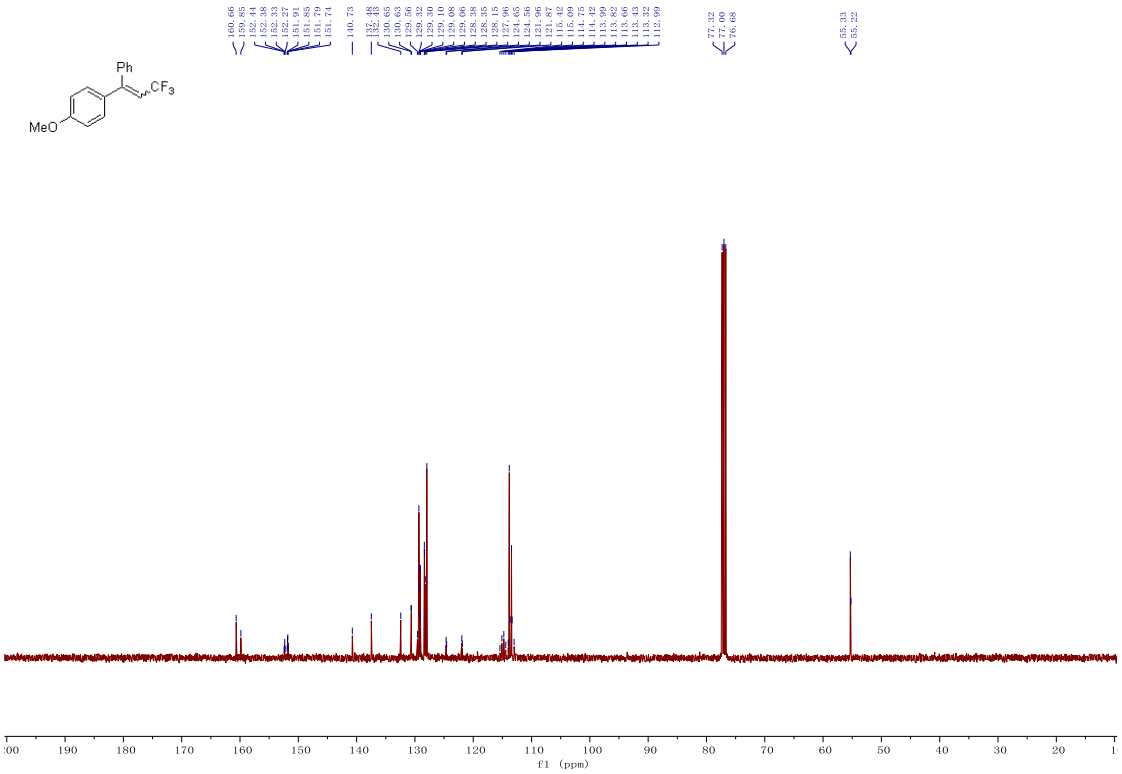
-55.05
f1 (ppm)


Ph
CF3
MeO
3.848
3.843
f1 (ppm)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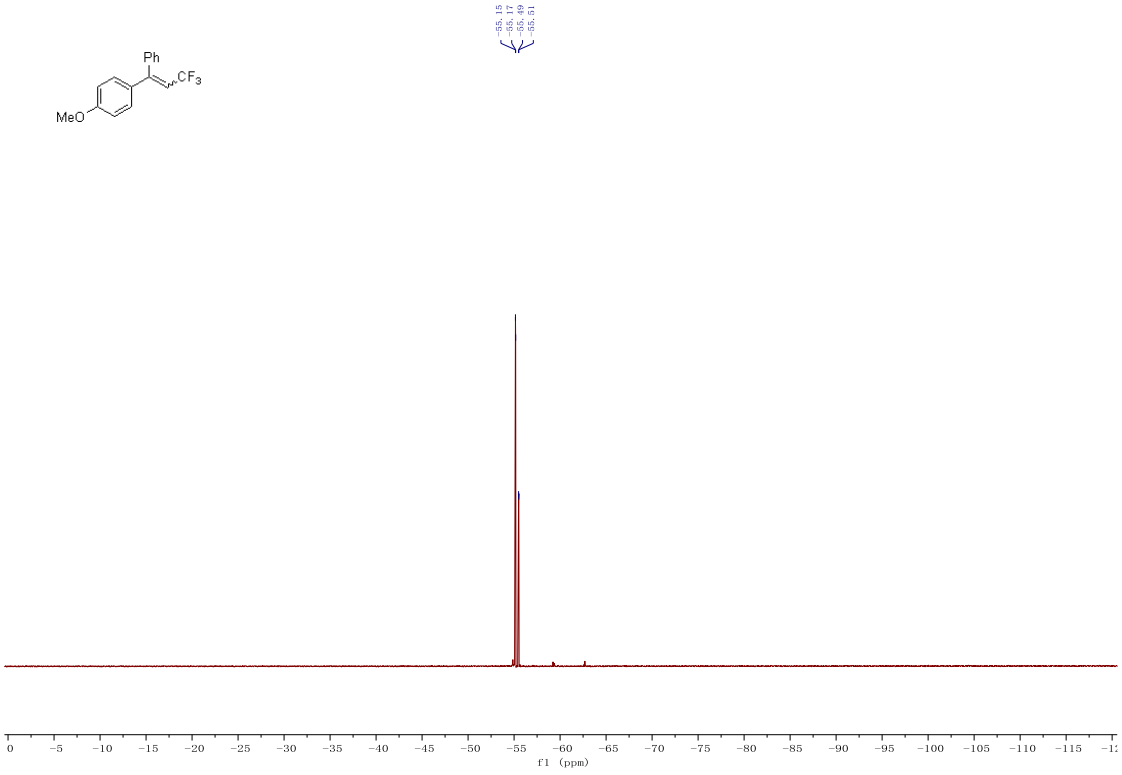
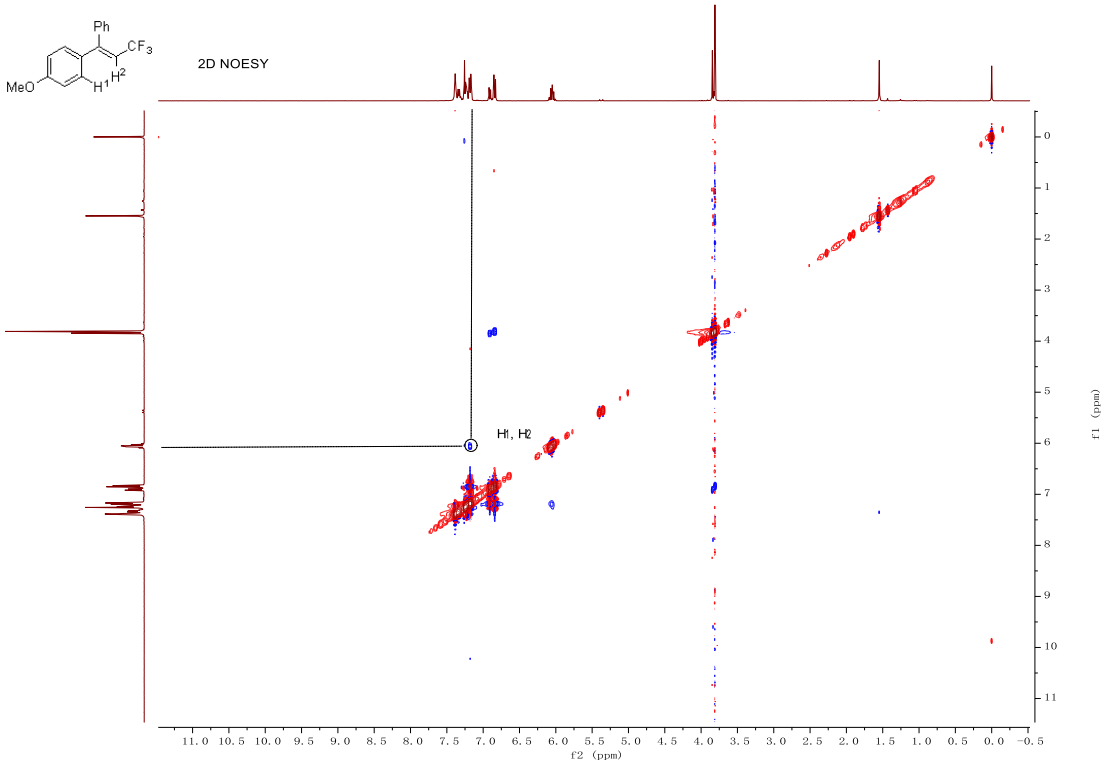
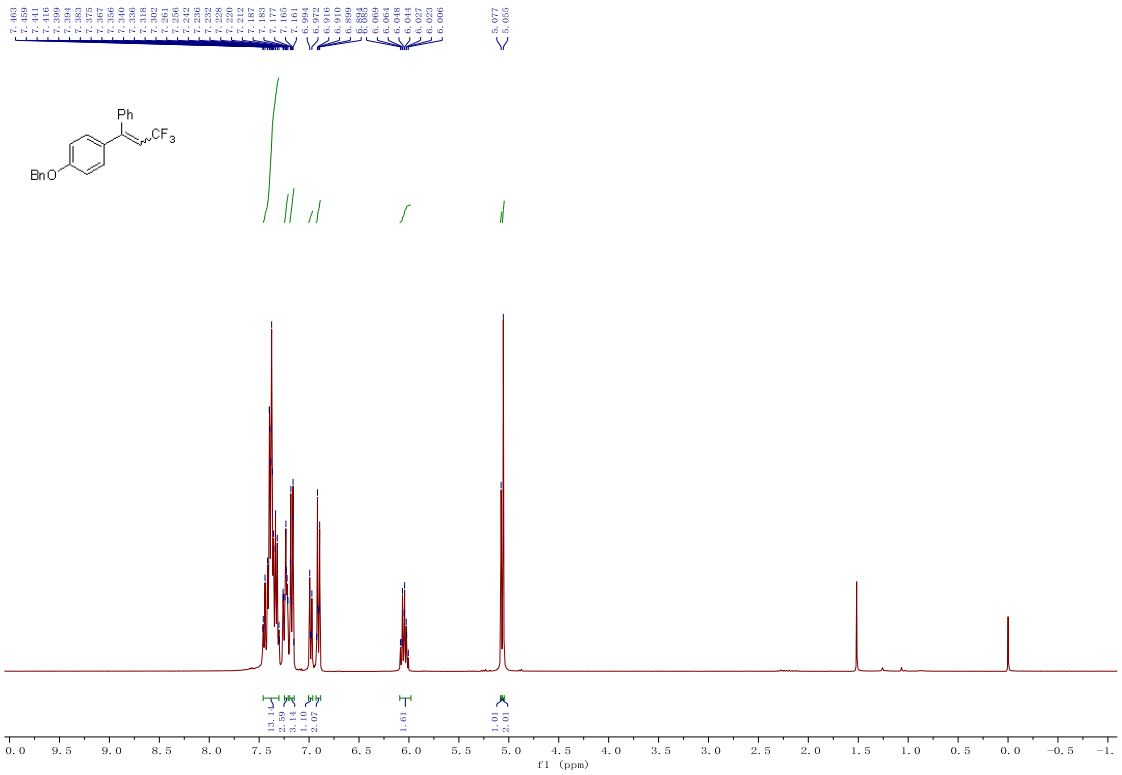
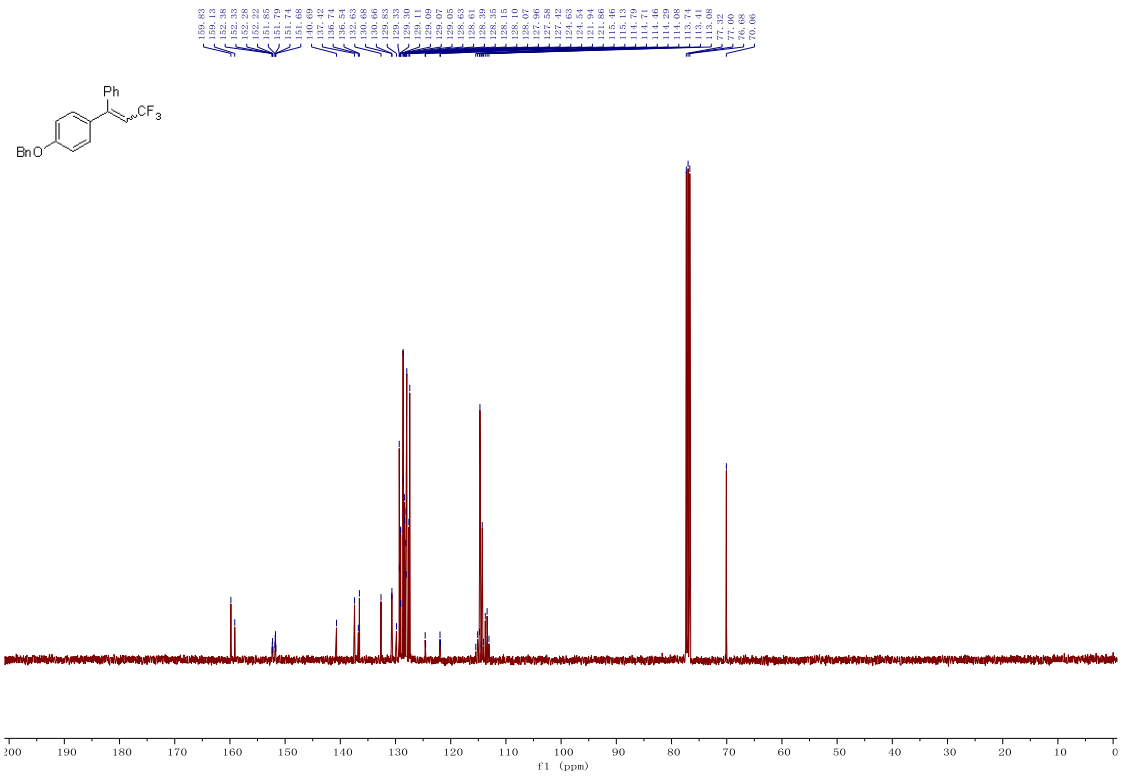
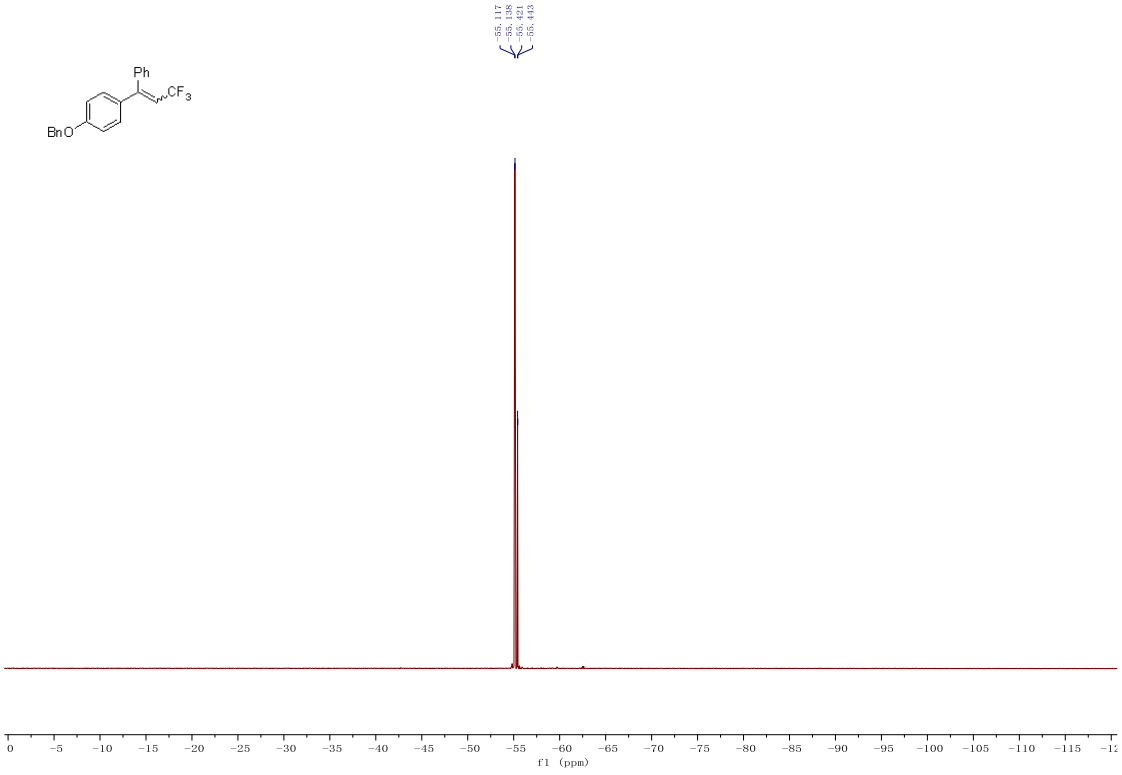
CF3
MeO
160.66
159.85
155.44
152.38
152.33
152.27
151.91
151.85
151.79
151.74
140.73
132.48
132.33
130.65
130.63
129.56
129.32
129.30
129.10
129.08
128.66
128.38
128.35
128.15
127.96
127.65
124.56
121.96
121.87
121.83
115.09
114.75
114.42
114.09
113.82
113.66
113.43
113.33
112.99
77.32
77.00
76.68
55.33
55.22
f1 (ppm)

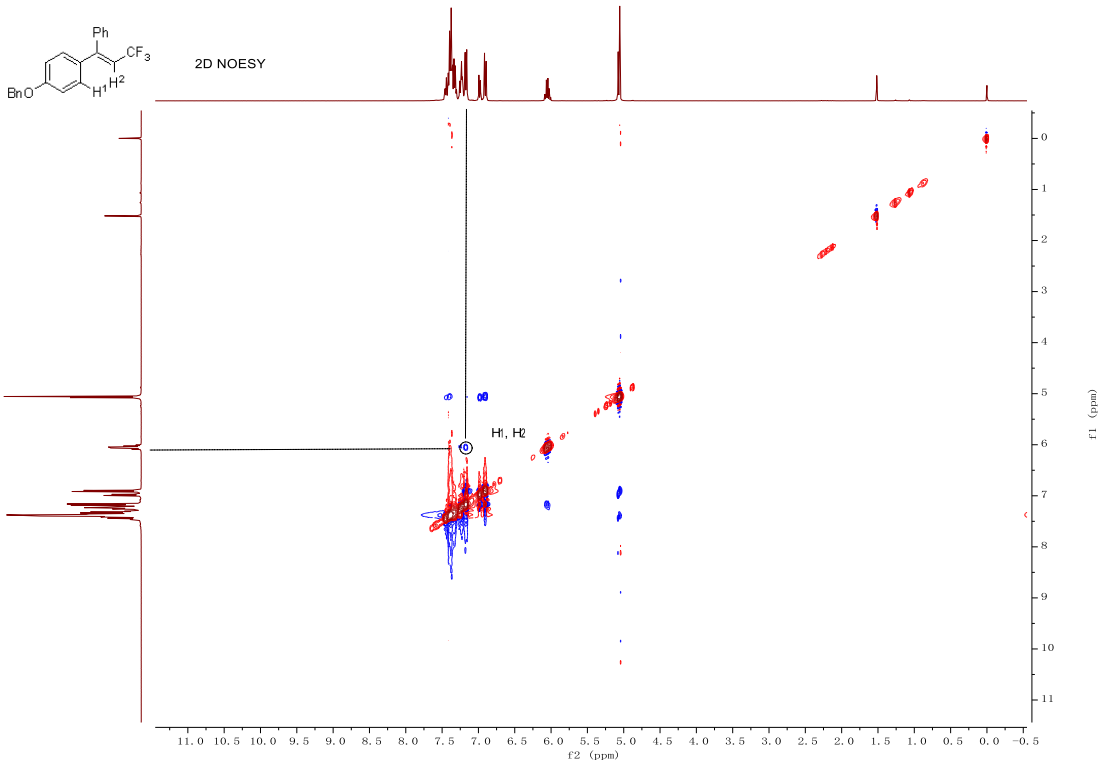

Ph
CF3
MeO
-55.15
-55.17
-55.69
-55.71
f1 (ppm)

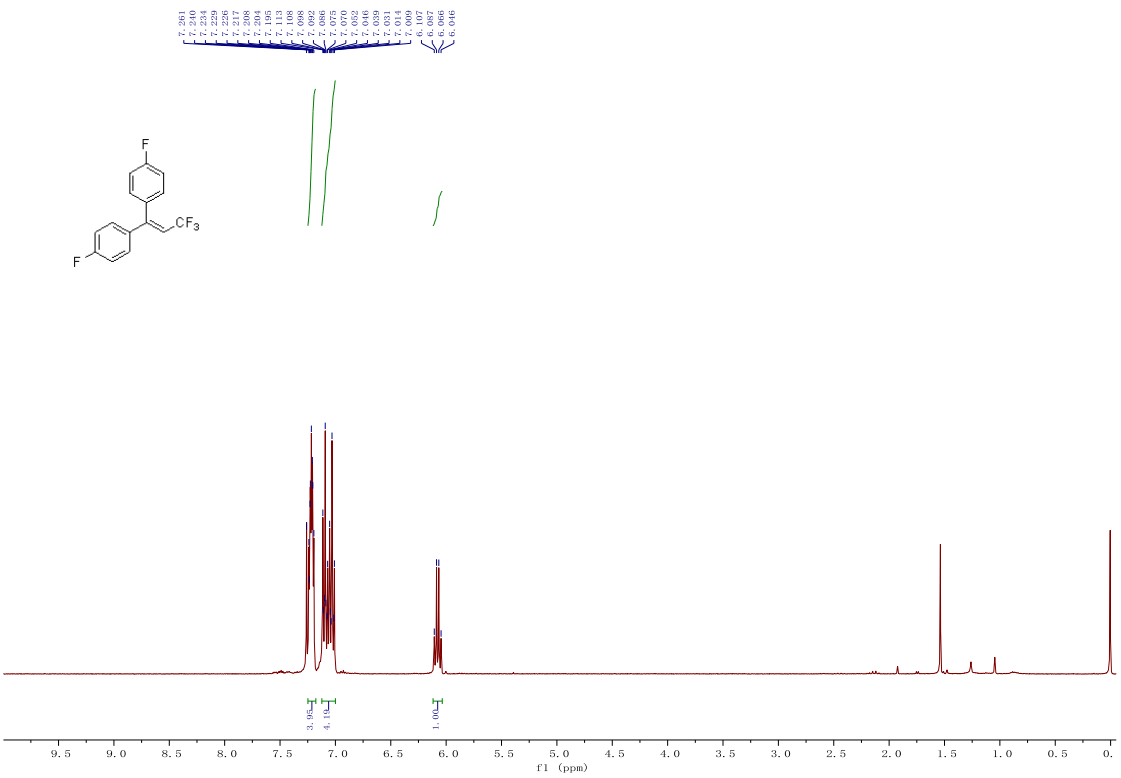

Ph
CF3
MeO
H1
H2
2D NOESY
H1, H2
f2 (ppm)
f1 (ppm)

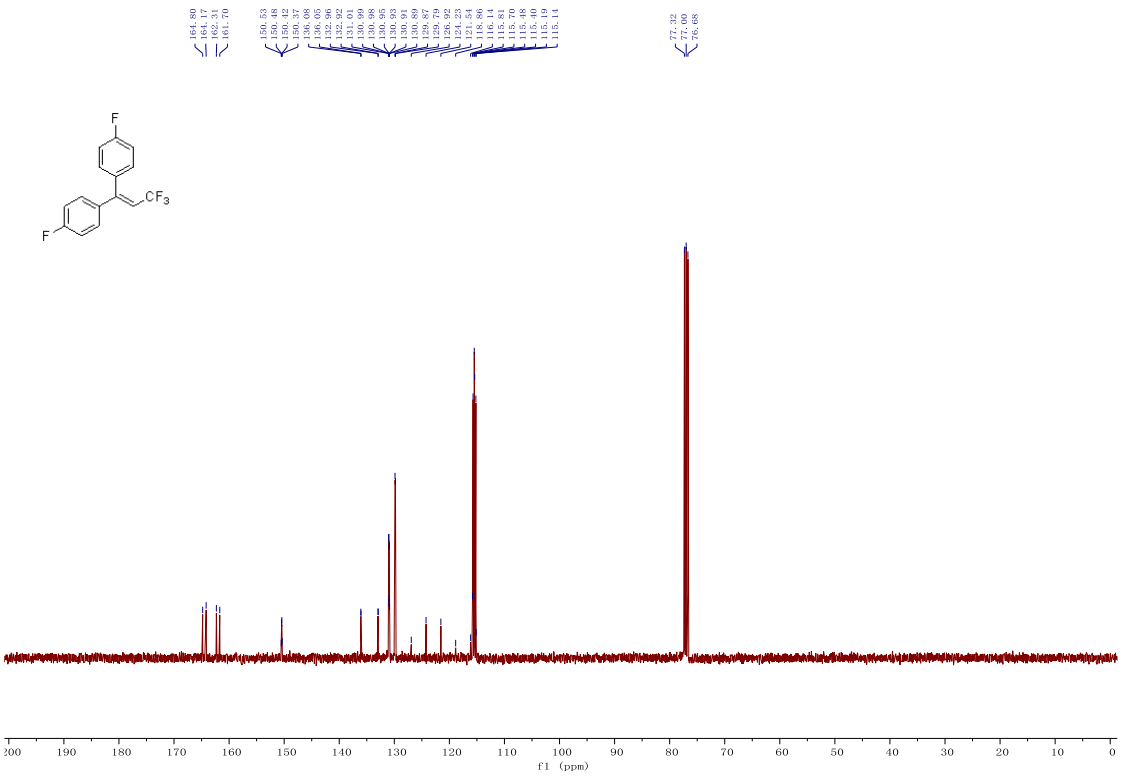

Ph
CF3
BnO
f1 (ppm)


Ph
CF3
BnO
f1 (ppm)


Ph
CF3
BnO
f1 (ppm)


Ph
CF3
BnO
H1
H2
2D NOESY
H1, H2
f2 (ppm)
f1 (ppm)


F
CF3
F
3.05
4.19
1.00
f1 (ppm)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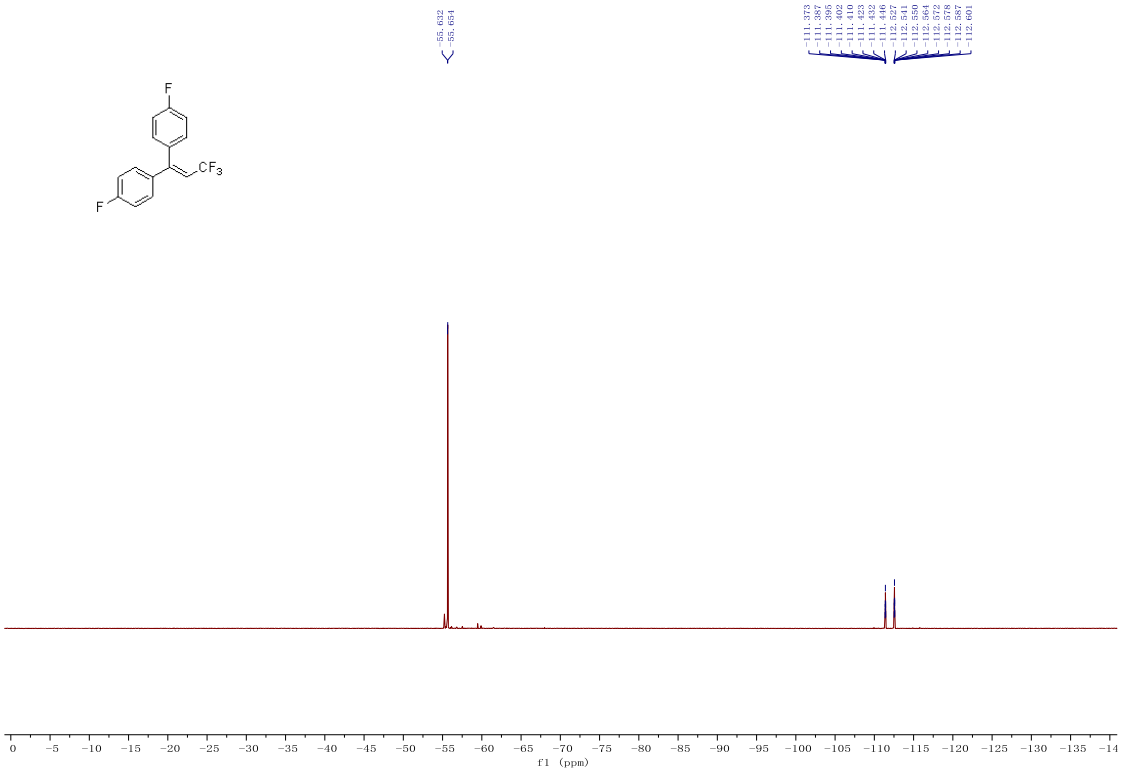
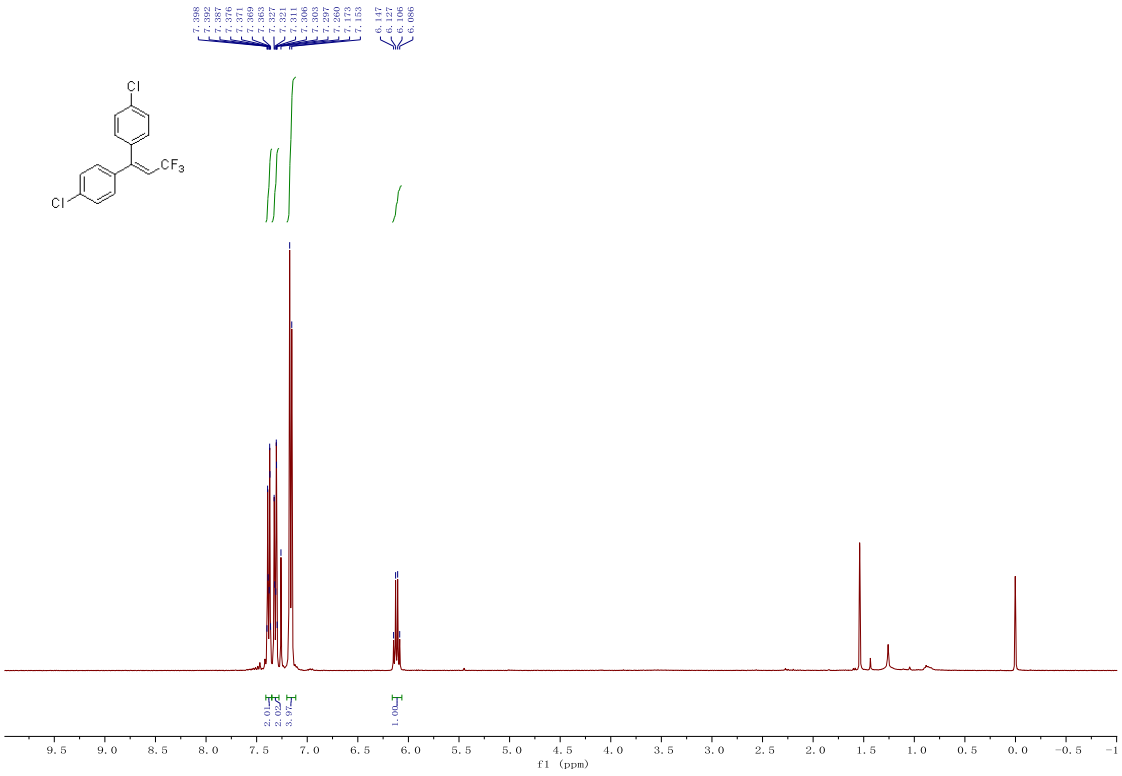
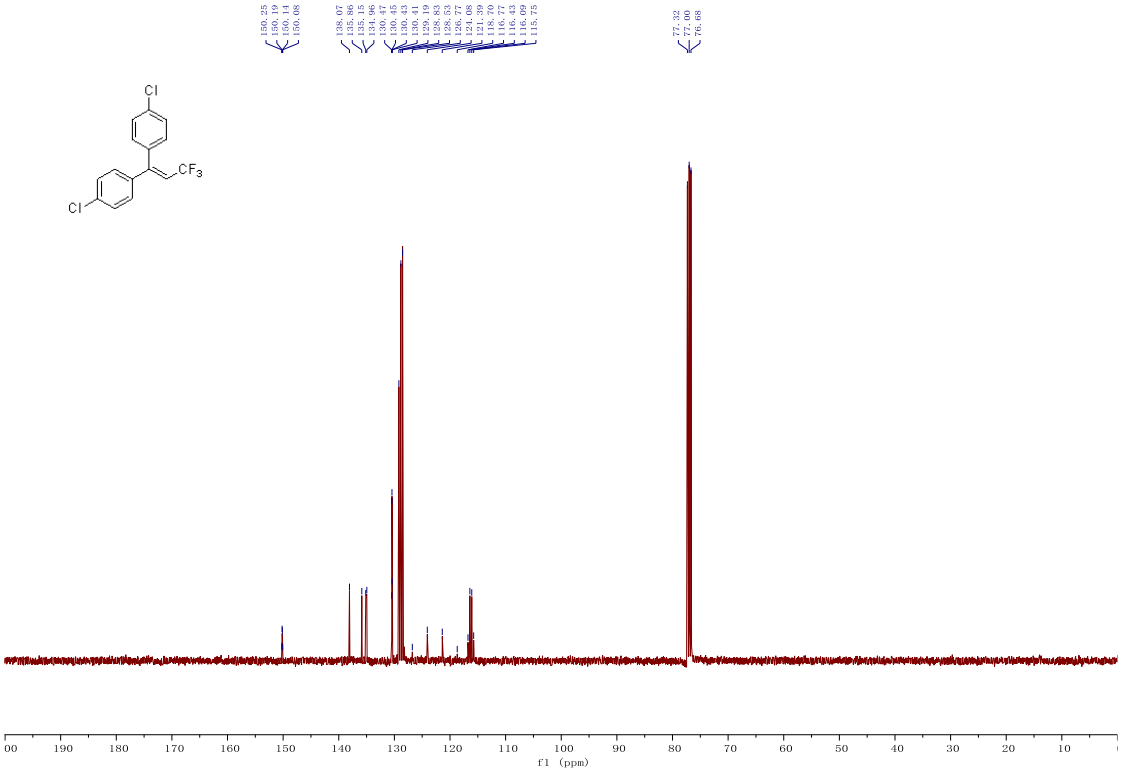
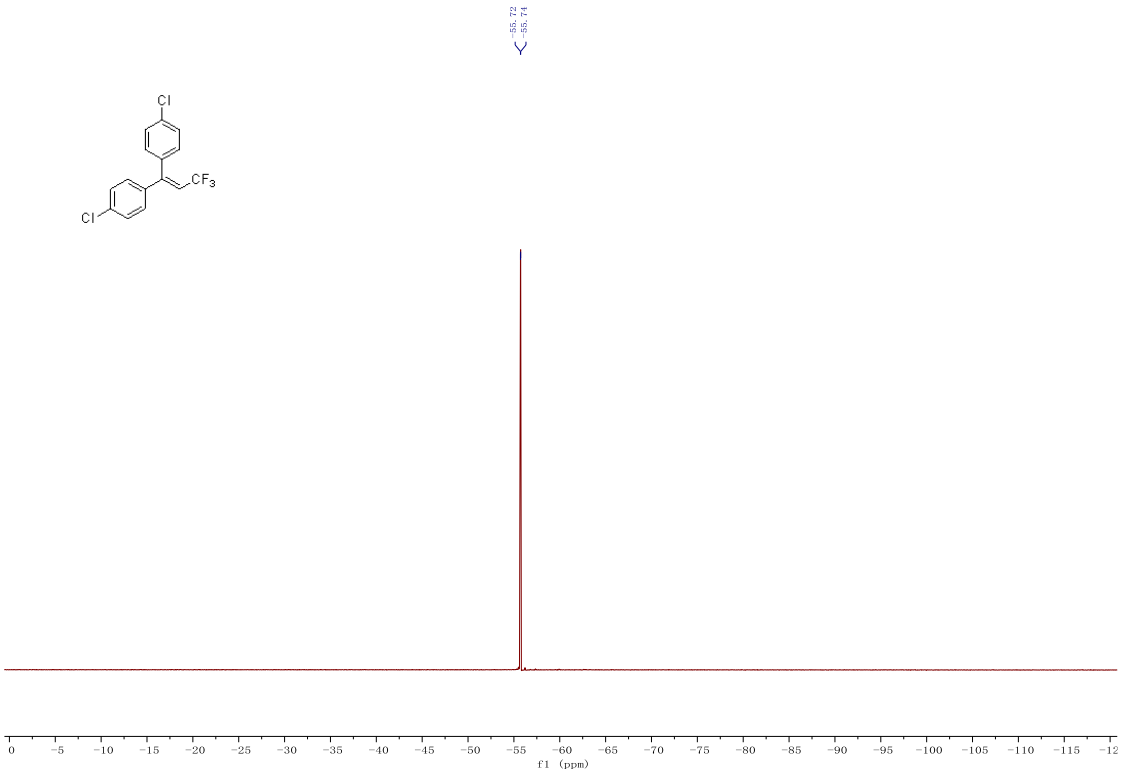
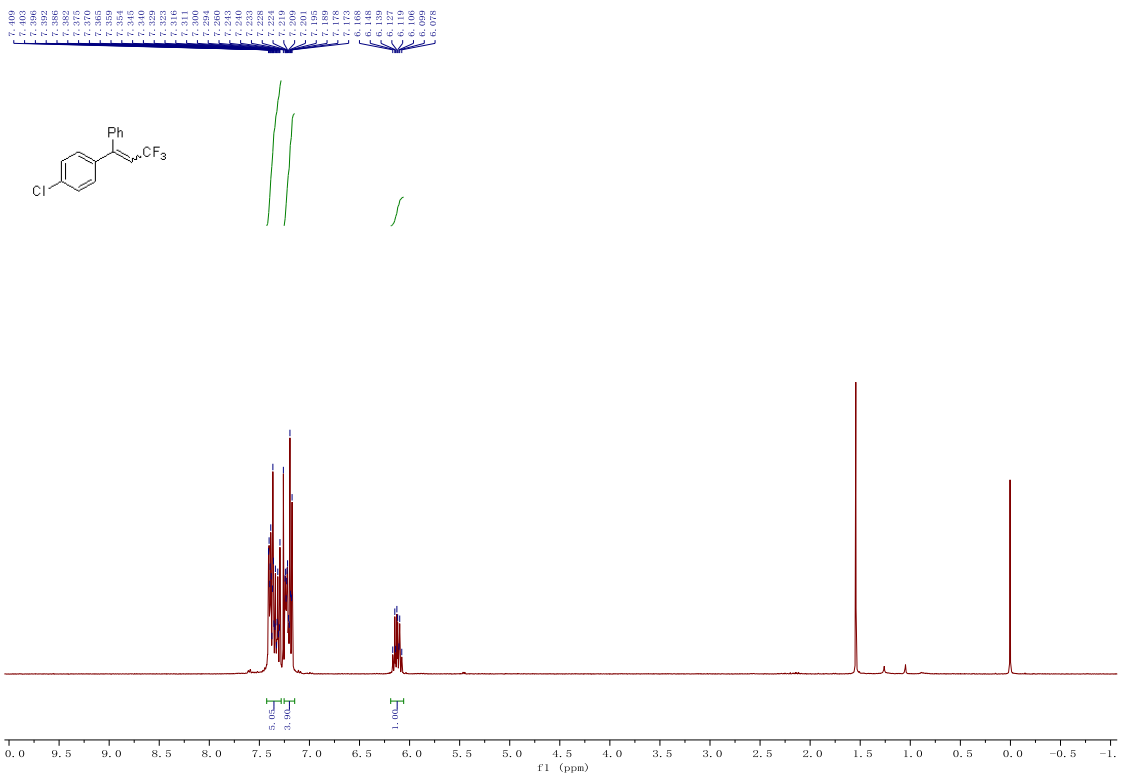
164.17
162.31
161.70
150.53
150.48
150.42
150.37
136.08
136.05
132.96
132.92
131.01
130.99
130.98
130.95
130.95
130.91
130.89
129.87
129.79
126.92
124.23
121.54
116.86
116.14
115.81
115.70
115.48
115.46
115.19
115.14
77.32
77.00
76.68
F
CF3
F
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

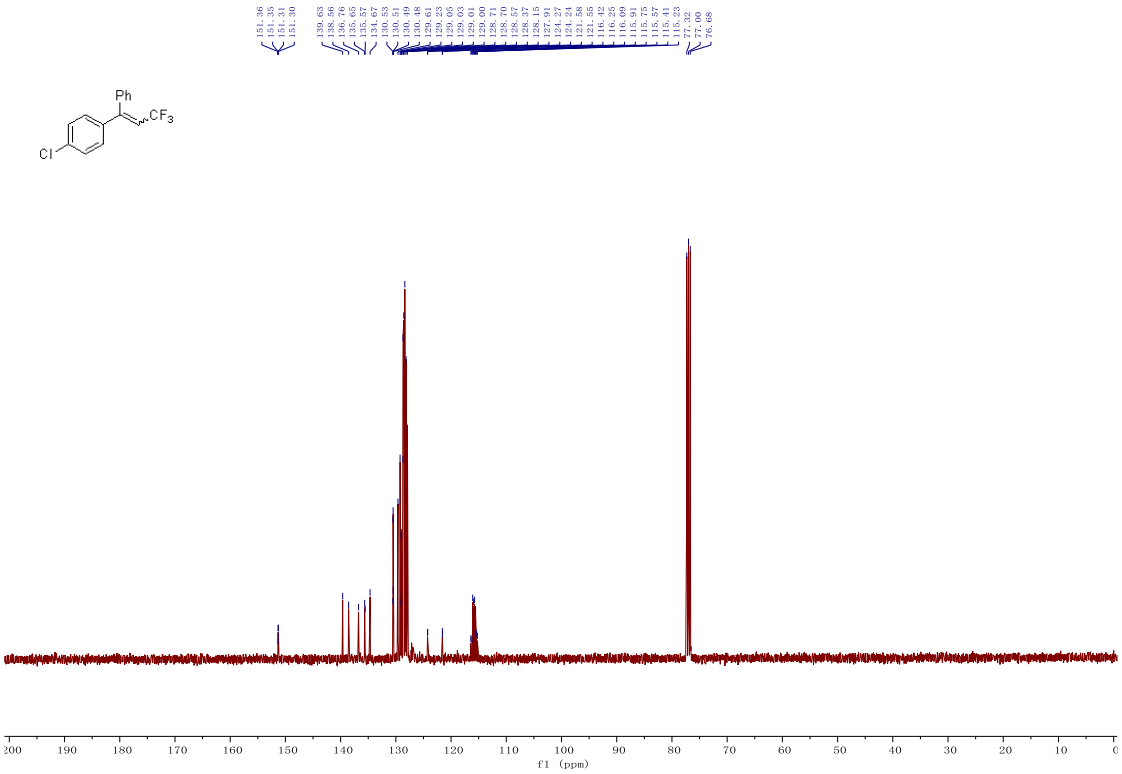

55.632
55.654
111.373
111.387
111.395
111.402
111.410
111.423
111.432
111.446
112.527
112.541
112.550
112.564
112.572
112.578
112.587
112.601
F
CF3
F
0
−5
−10
−15
−20
−25
−30
−35
−40
−45
−50
−55
−60
−65
−70
−75
−80
−85
−90
−95
−100
−105
−110
−115
−120
−125
−130
−135
−14
f1 (ppm)

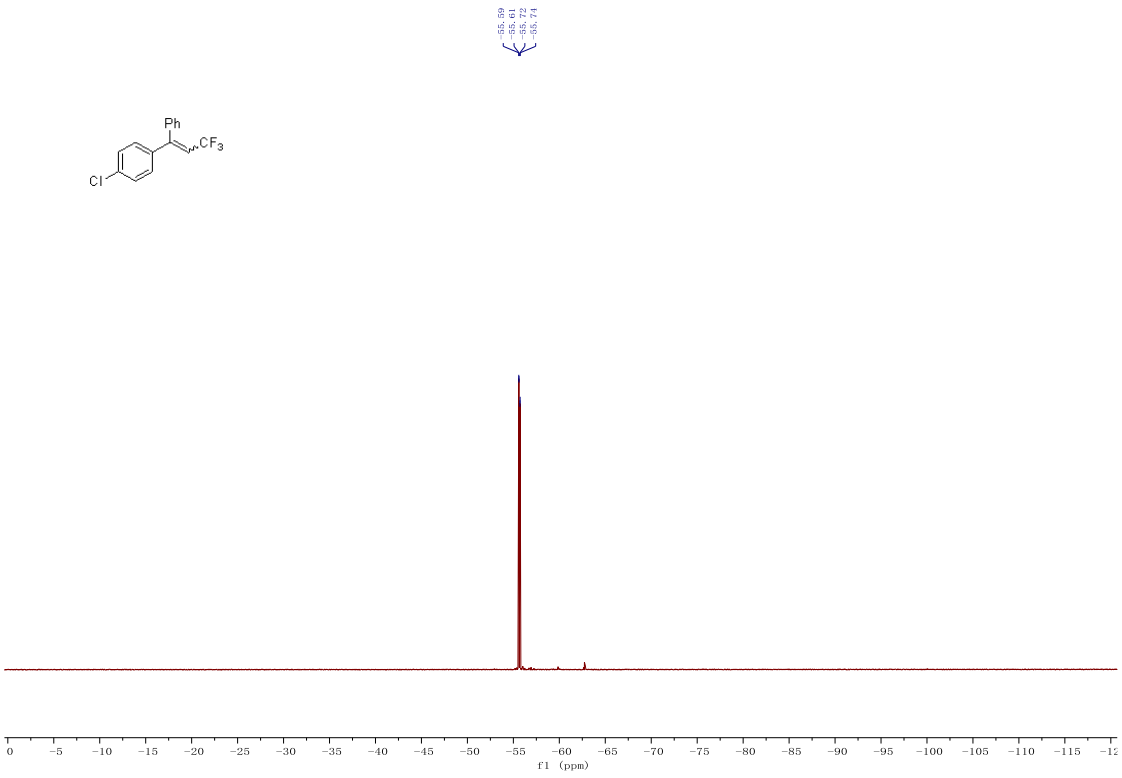

7.398
7.392
7.387
7.376
7.373
7.369
7.363
7.327
7.321
7.311
7.306
7.303
7.297
7.290
7.173
7.153
6.147
6.127
6.106
6.086
Cl
CF3
Cl
2.01
2.02
3.97
1.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f1 (ppm)

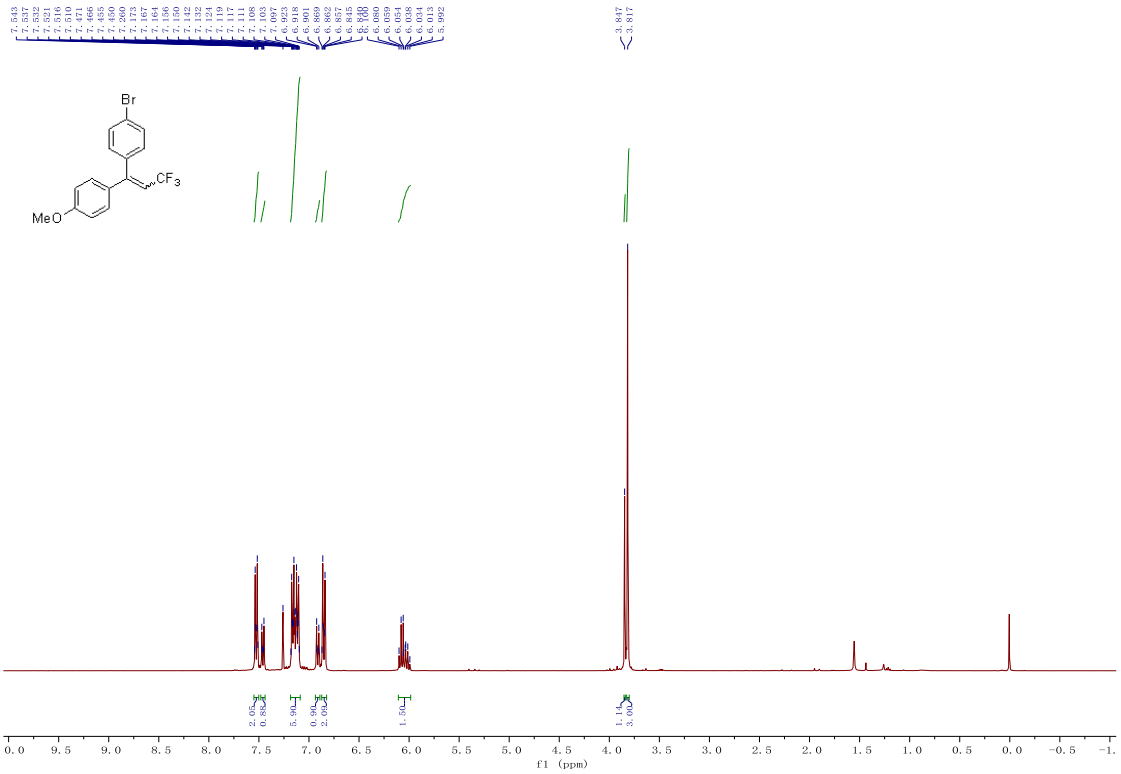

150.25
150.19
150.14
150.08
138.67
135.86
135.15
134.96
130.47
130.45
130.43
130.41
129.19
128.83
128.55
126.77
124.08
121.39
118.70
116.77
116.43
116.09
115.75
77.32
77.00
76.68
Cl
CF3
Cl
00 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

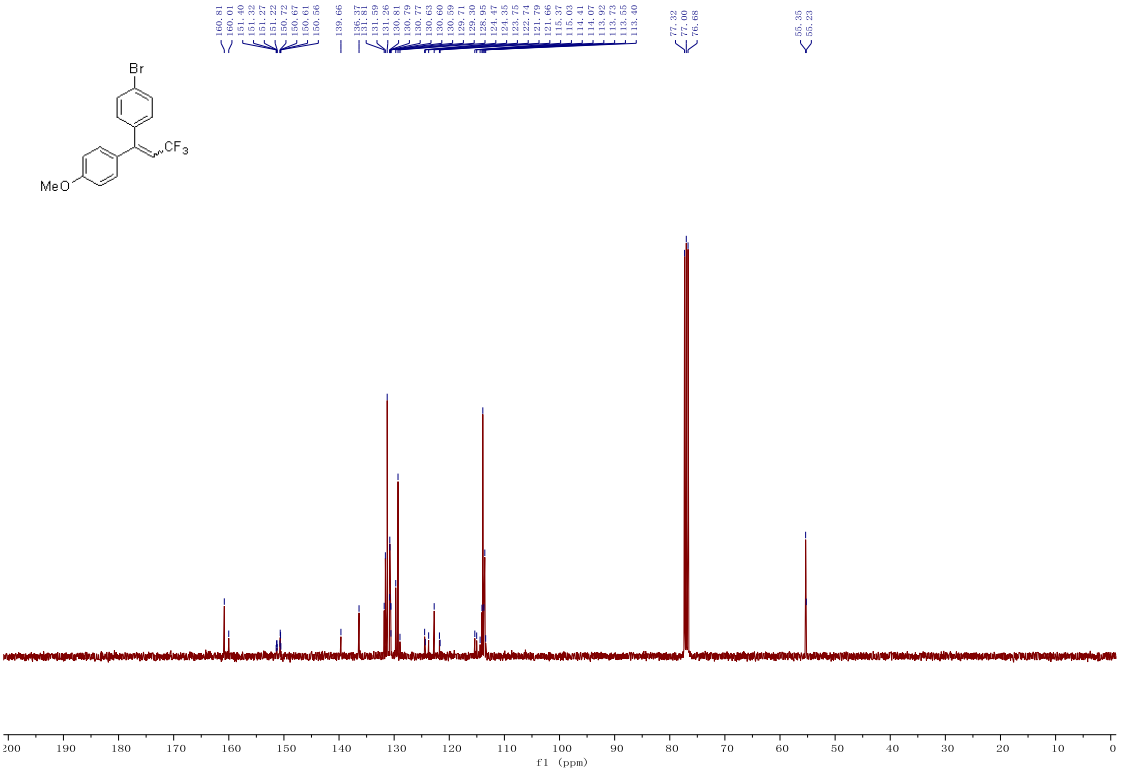

-55.72
-55.74
Cl
CF3
Cl
f1 (ppm)

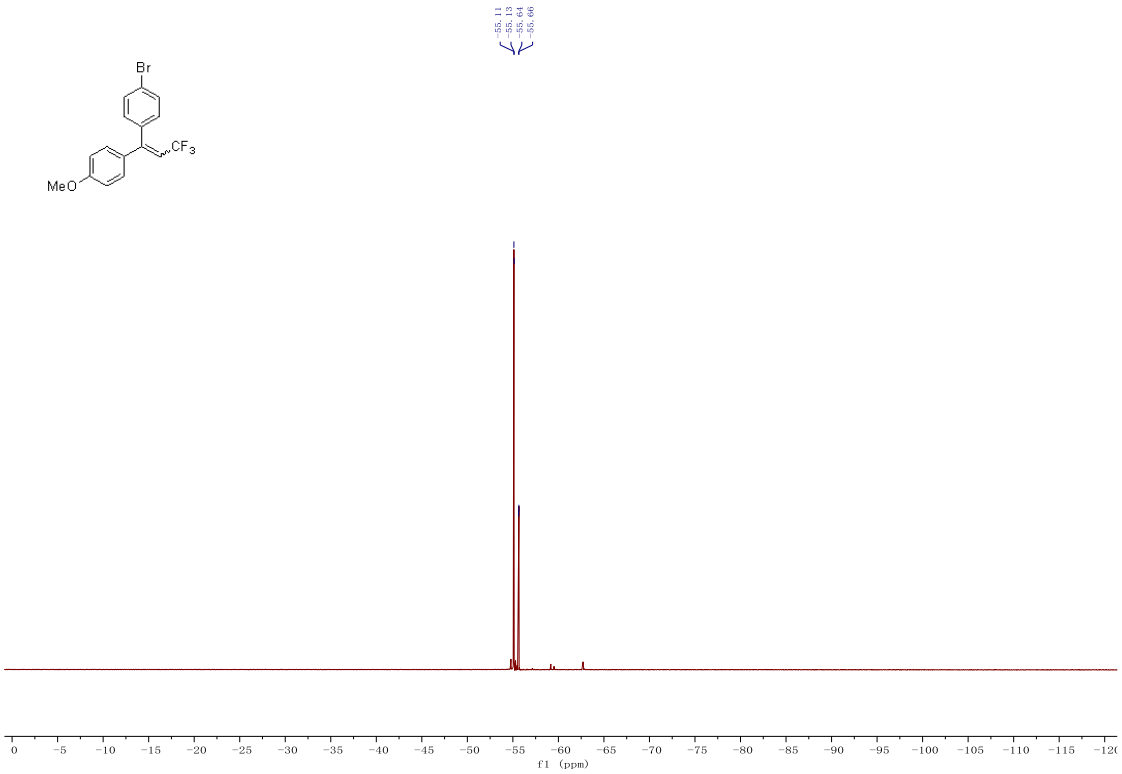

Ph
CF3
Cl
5.05
3.90
1.00
f1 (ppm)

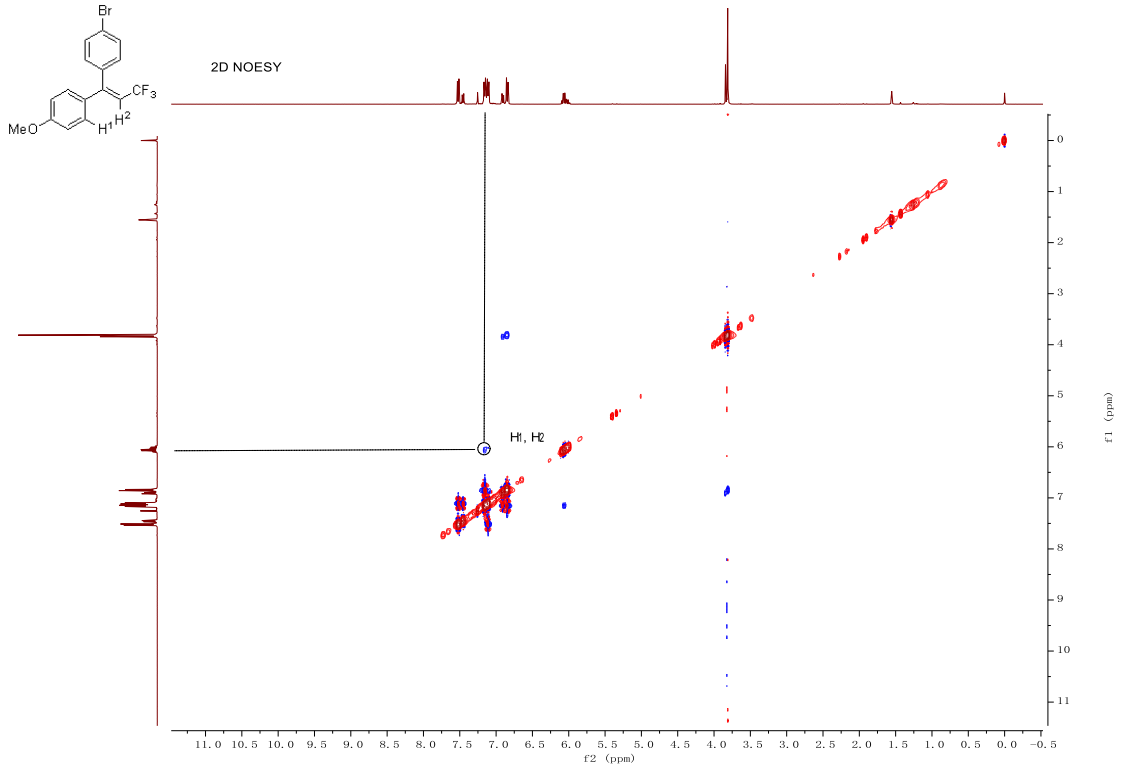

Ph
CF3
Cl
f1 (ppm)

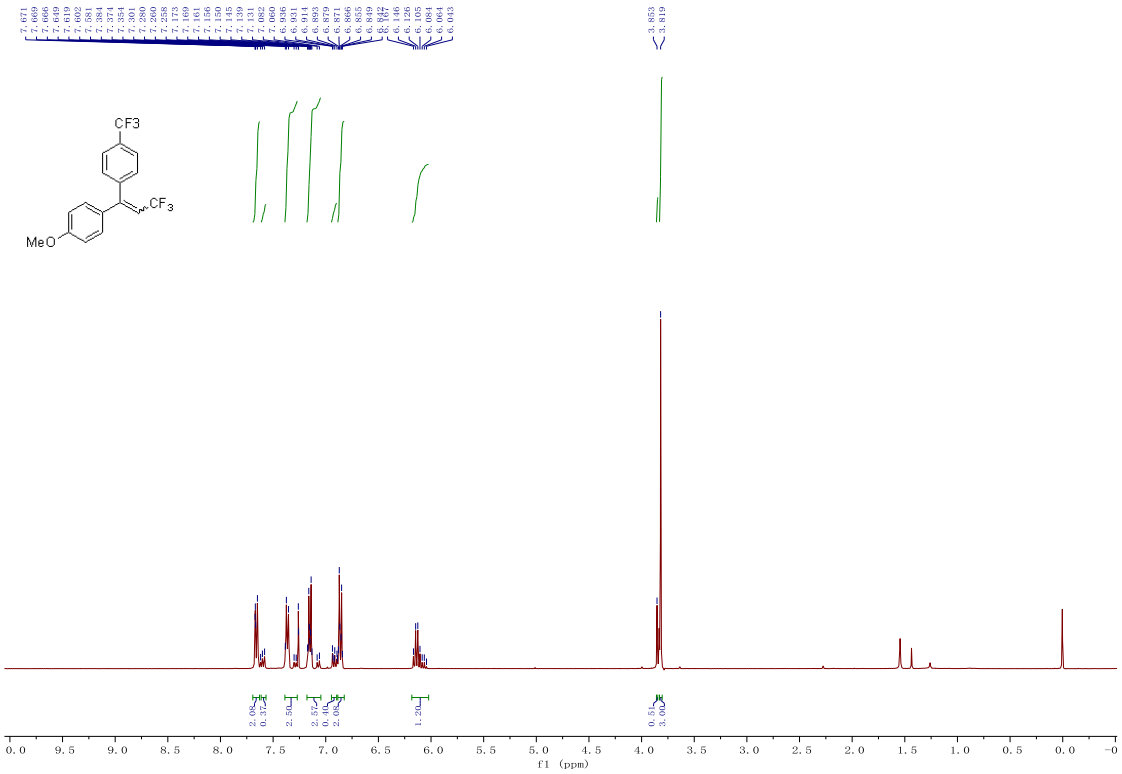

Ph
CF3
Cl
f1 (ppm)

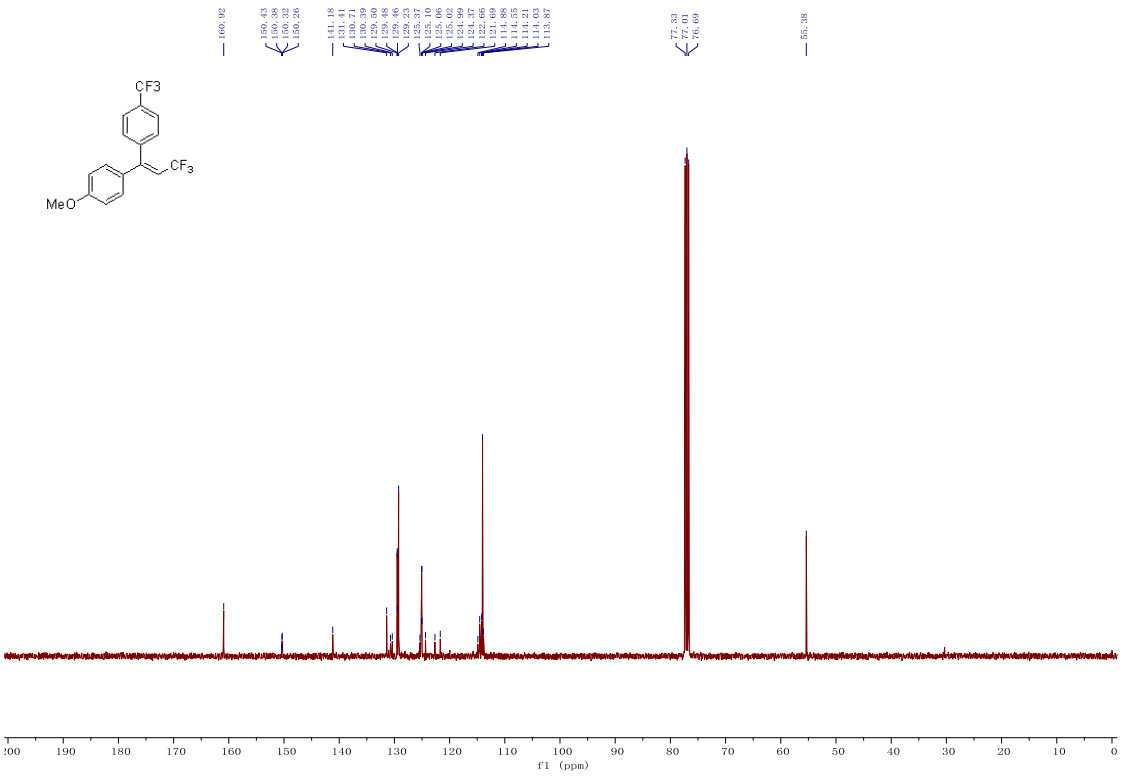

Br
CF3
MeO
f1 (ppm)

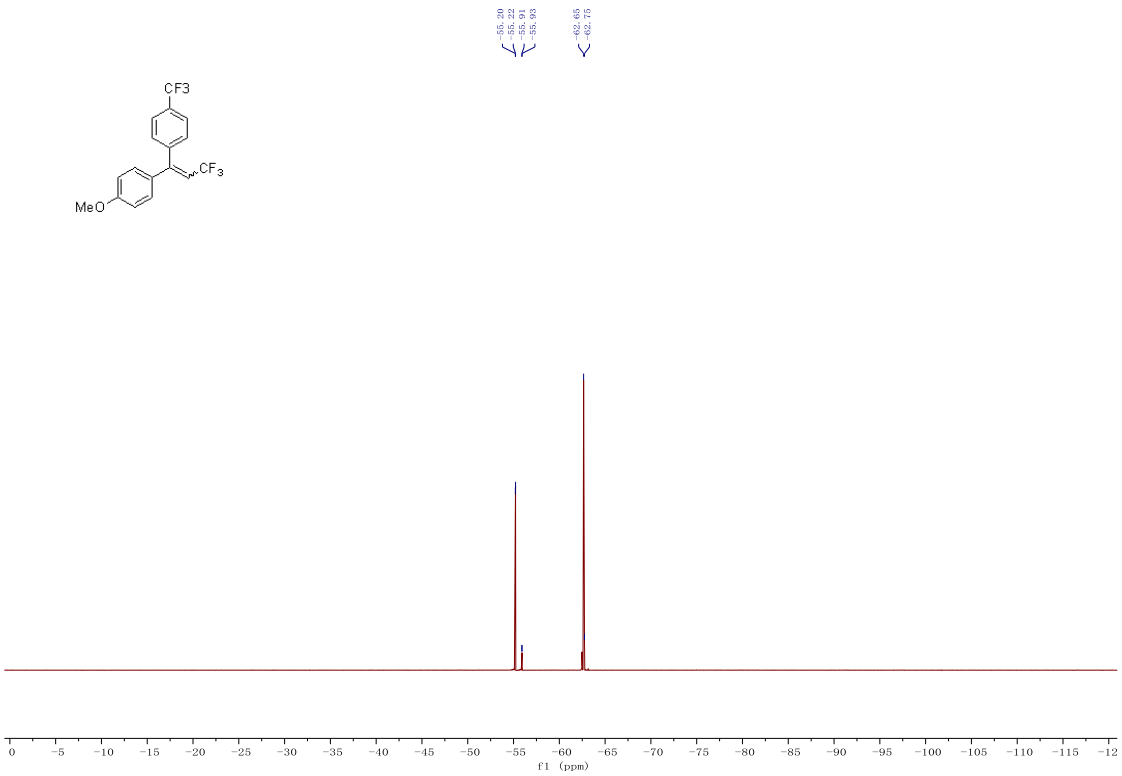

Br
CF3
MeO
f1 (ppm)


Br
CF3
MeO
-55.11
-55.13
-55.64
-55.66
f1 (ppm)


Br
CF3
MeO
H1
H2
2D NOESY
Ht, H2
f2 (ppm)
f1 (ppm)


CF3
CF3
MeO
f1 (ppm)


CF3
CF3
MeO
f1 (ppm)


CF3
CF3
MeO
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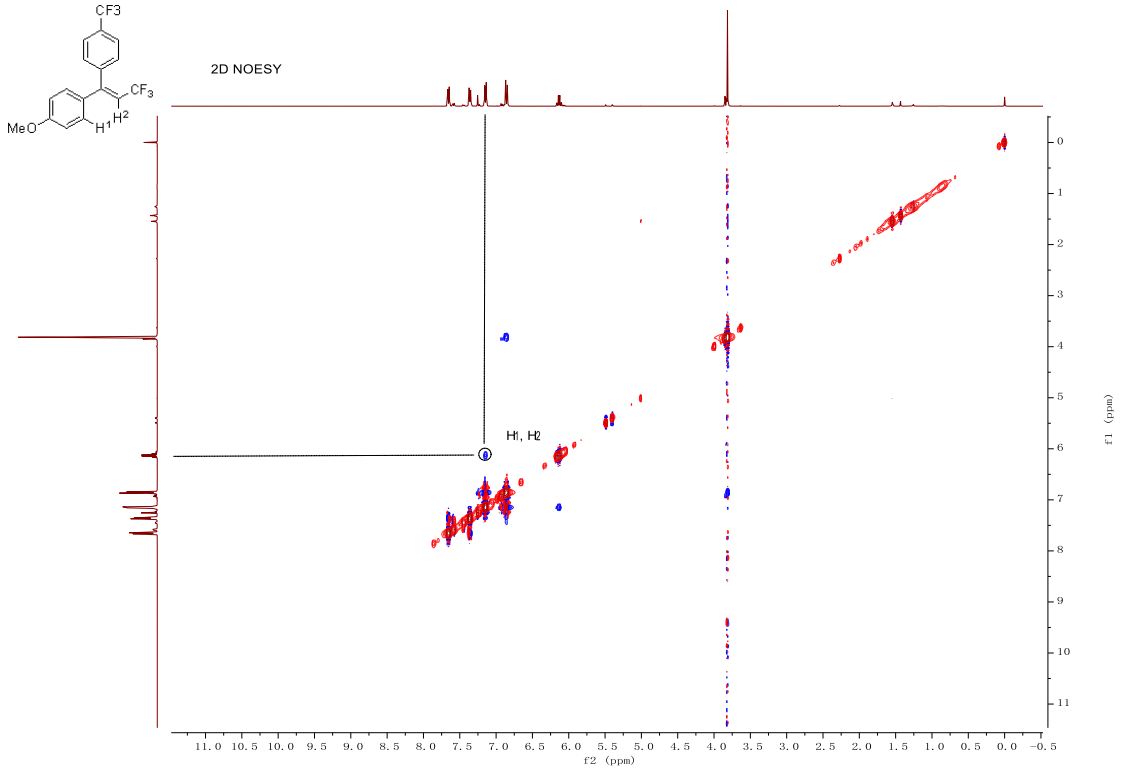
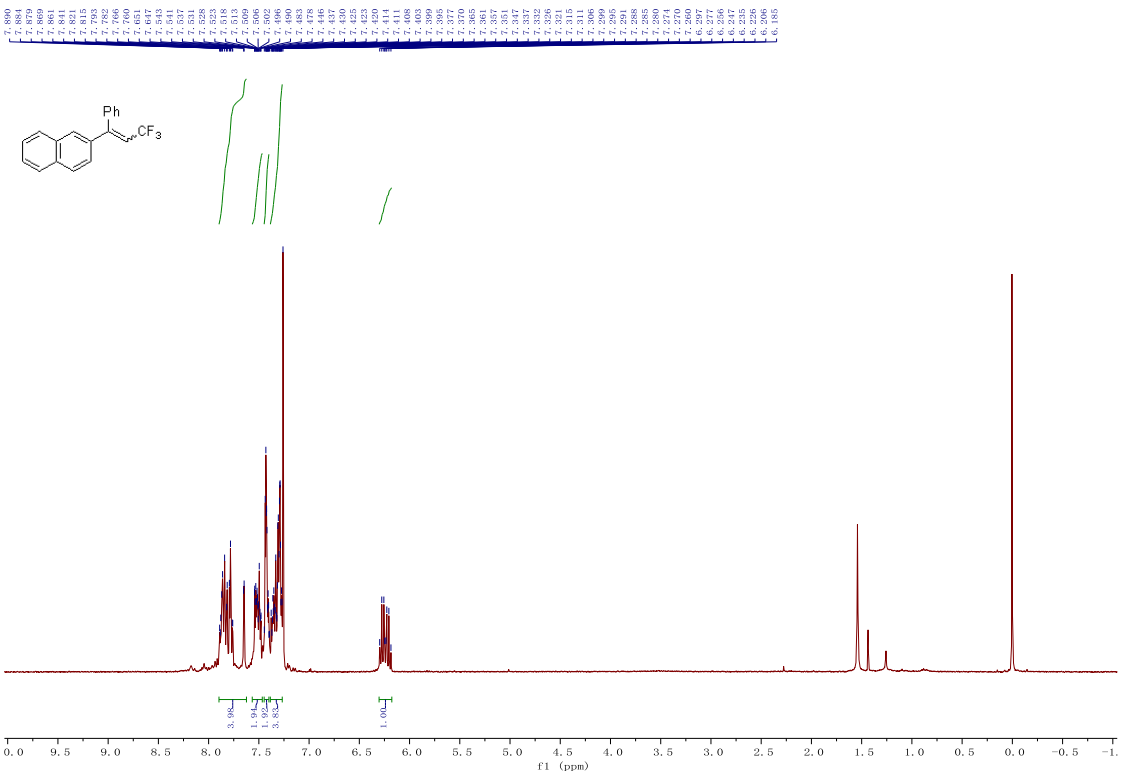
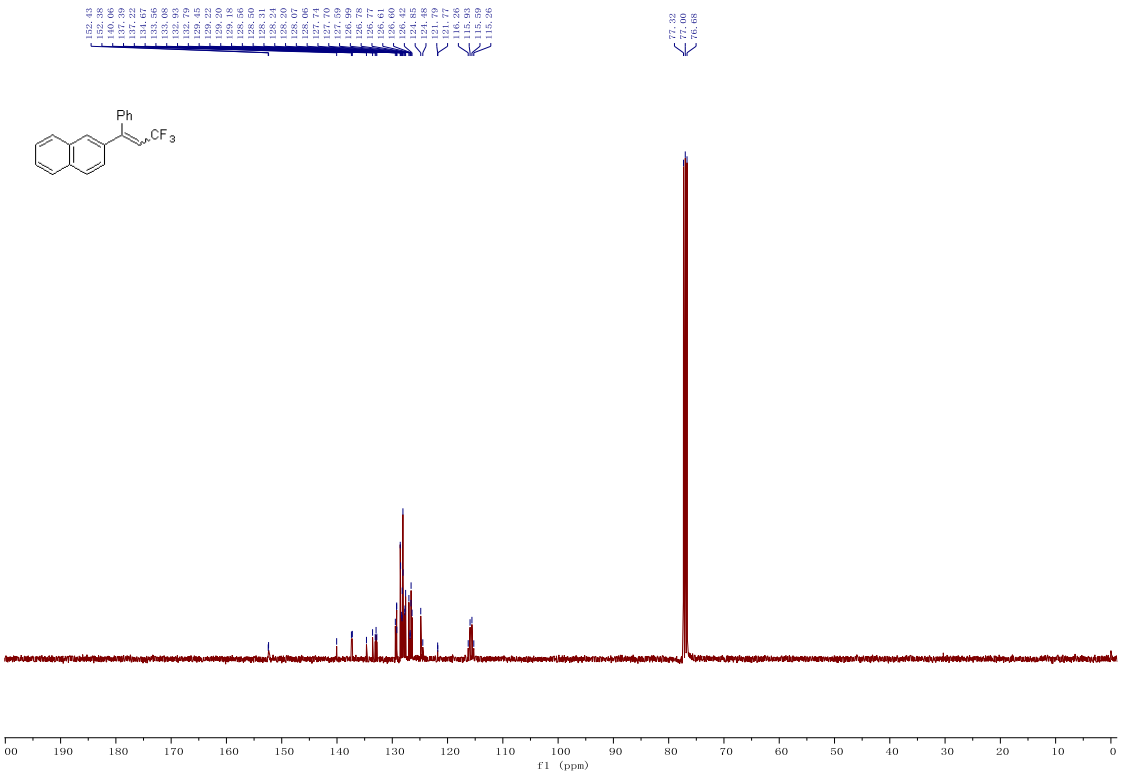
-55.22
-55.91
-55.93
-62.65
-62.75
f1 (ppm)


CF3
CF3
MeO
H1
H2
2D NOESY
H1, H2
f2 (ppm)
f1 (ppm)


Ph
CF3
3.98
1.97
1.95
3.83
1.00
f1 (ppm)


Ph
CF3
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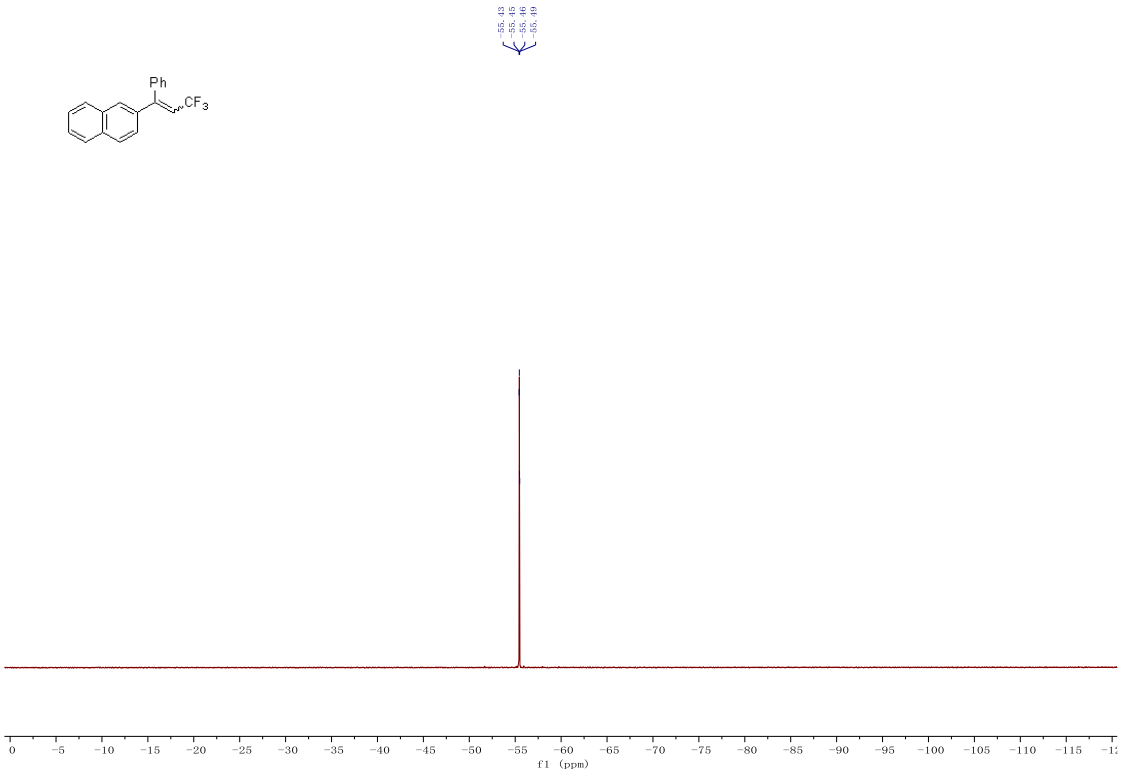
77.00
76.68
f1 (ppm)


Ph
CF3
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-55.45
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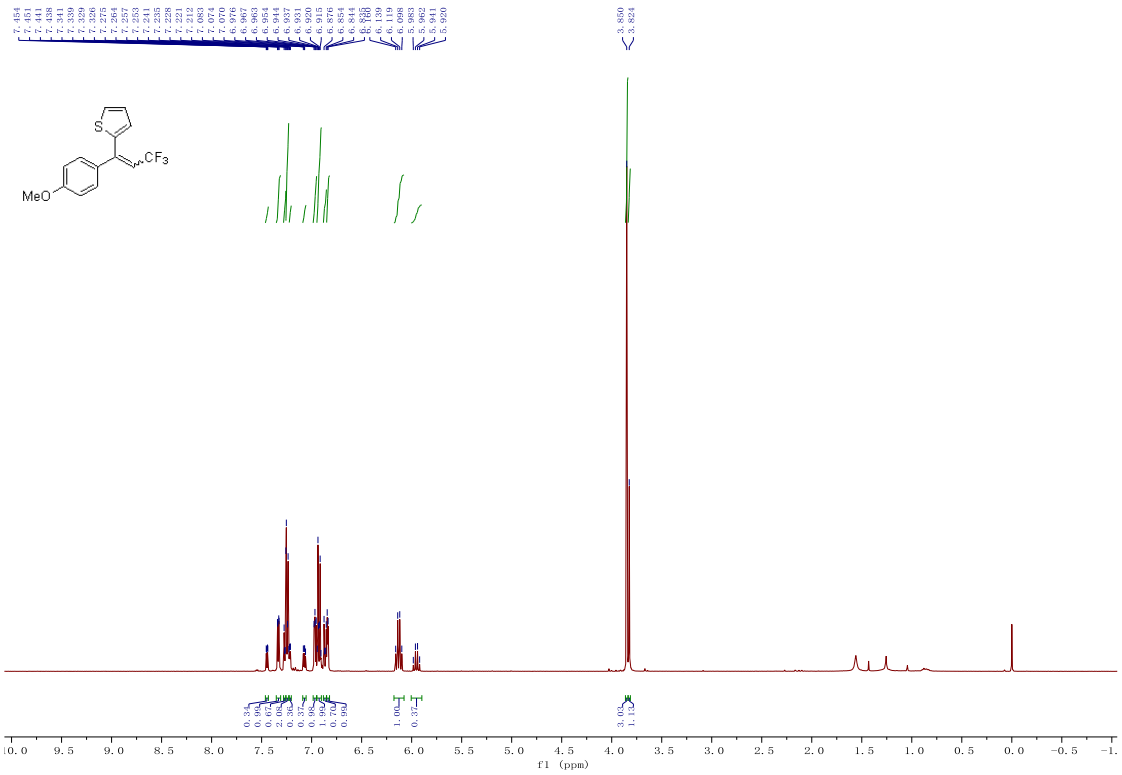
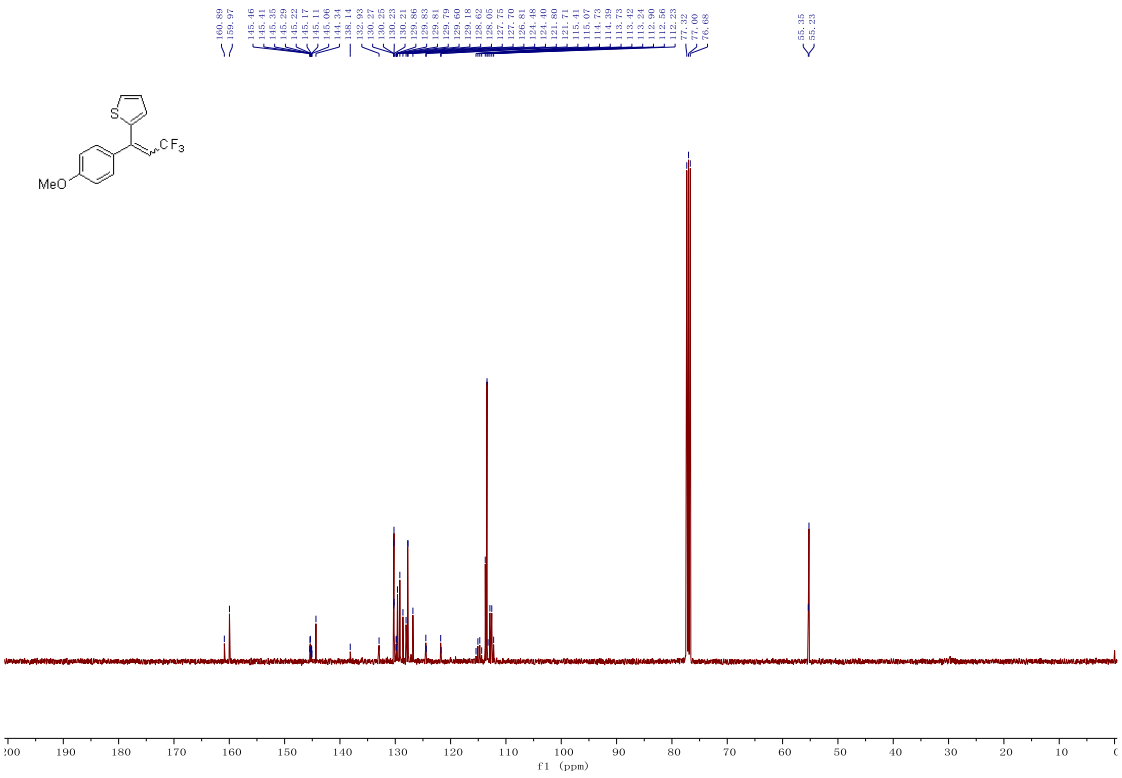
-55.49
f1 (ppm)


S
CF3
MeO
3.850
3.824
f1 (ppm)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144.94
144.84
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132.93
130.27
130.25
130.23
130.21
129.86
129.83
129.81
129.79
129.60
129.18
128.62
128.05
127.75
127.70
126.81
124.48
124.40
121.80
121.71
115.41
115.07
114.73
114.39
113.73
113.42
113.24
112.90
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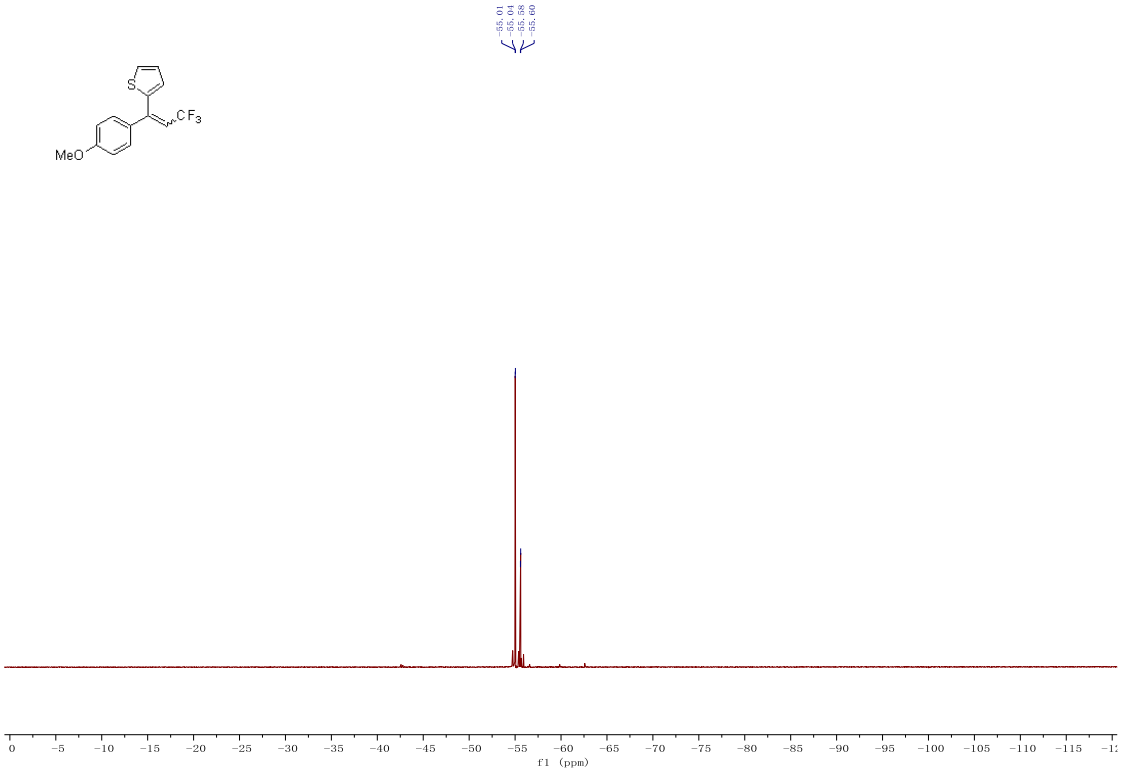
112.23
77.32
77.00
76.68
55.35
55.28
S
CF3
MeO
f1 (ppm)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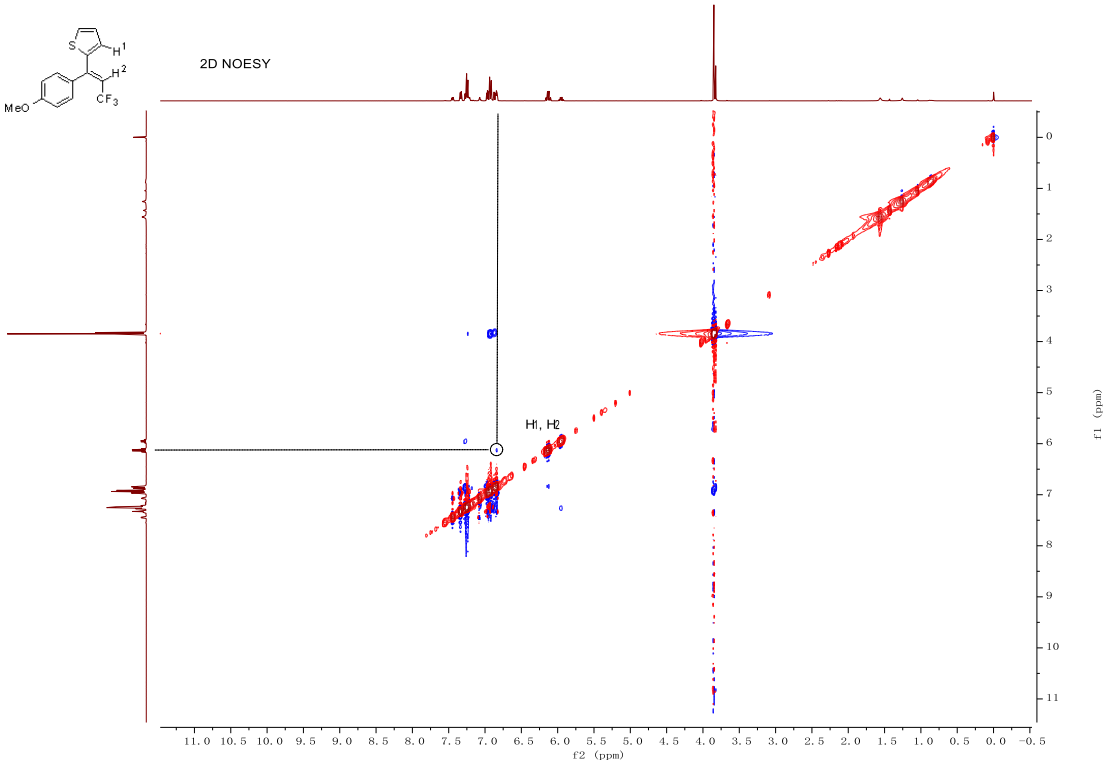
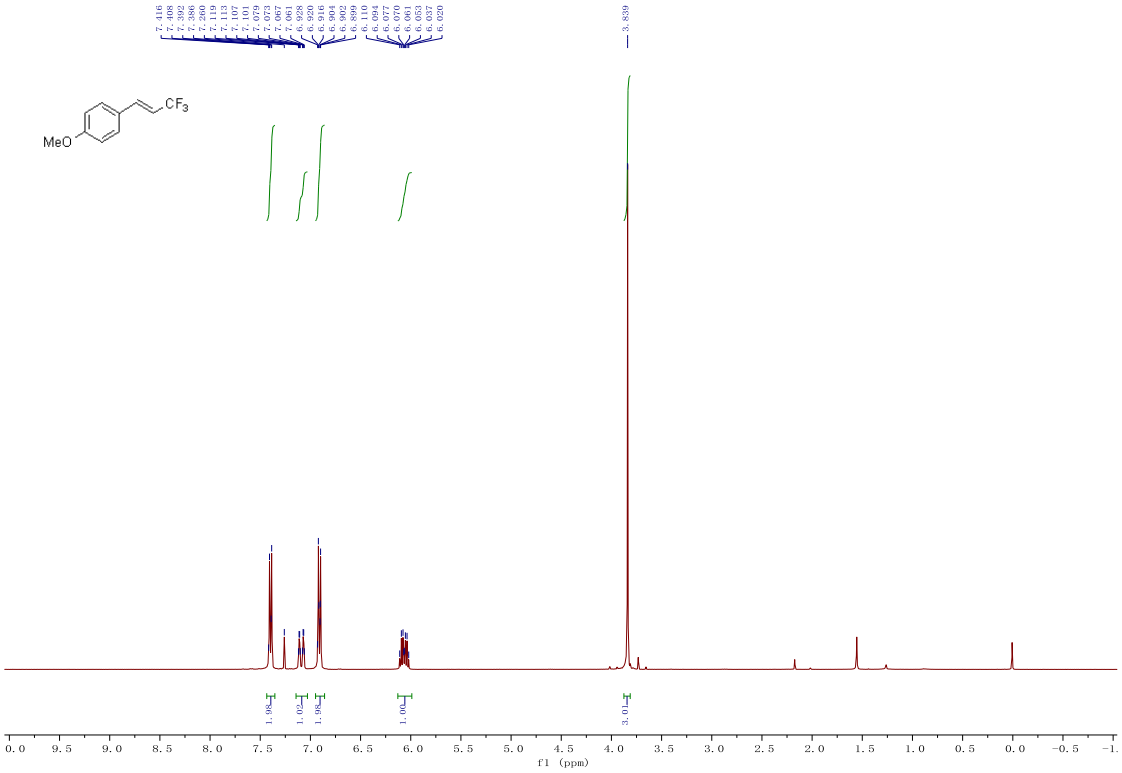
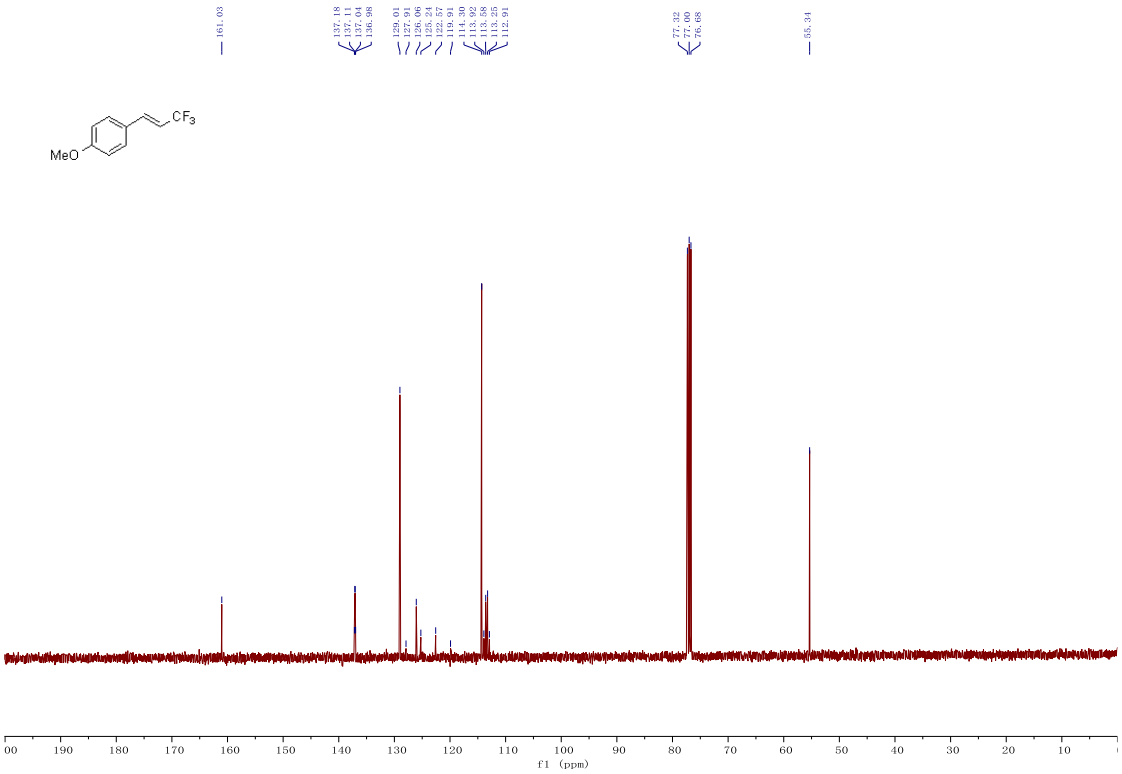
-55.04
-55.38
-55.60
S
CF3
MeO
f1 (ppm)


2D NOESY
MeO
S
H1
H2
CF3
H1, H2
f2 (ppm)
f1 (ppm)


MeO
CF3
f1 (ppm)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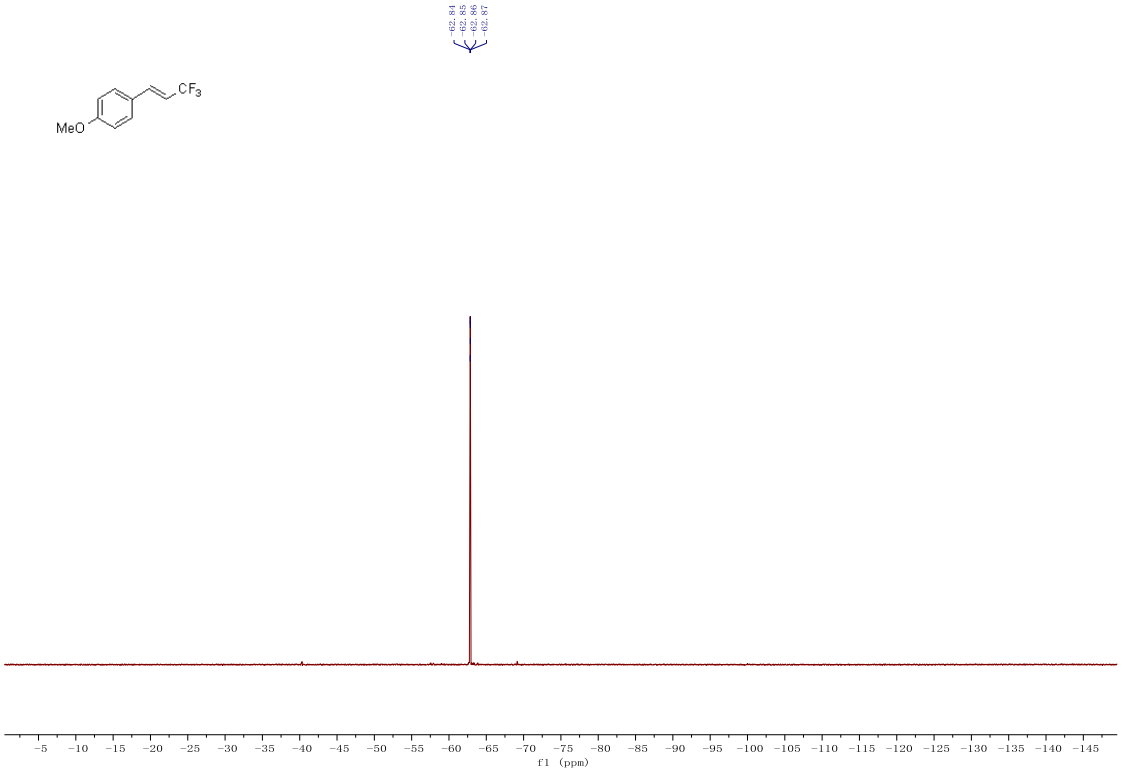
137.11
137.04
136.98
129.01
127.91
126.06
125.24
122.57
119.81
114.30
113.92
113.58
113.25
112.91
77.32
77.00
76.68
55.34
MeO
CF3
f1 (ppm)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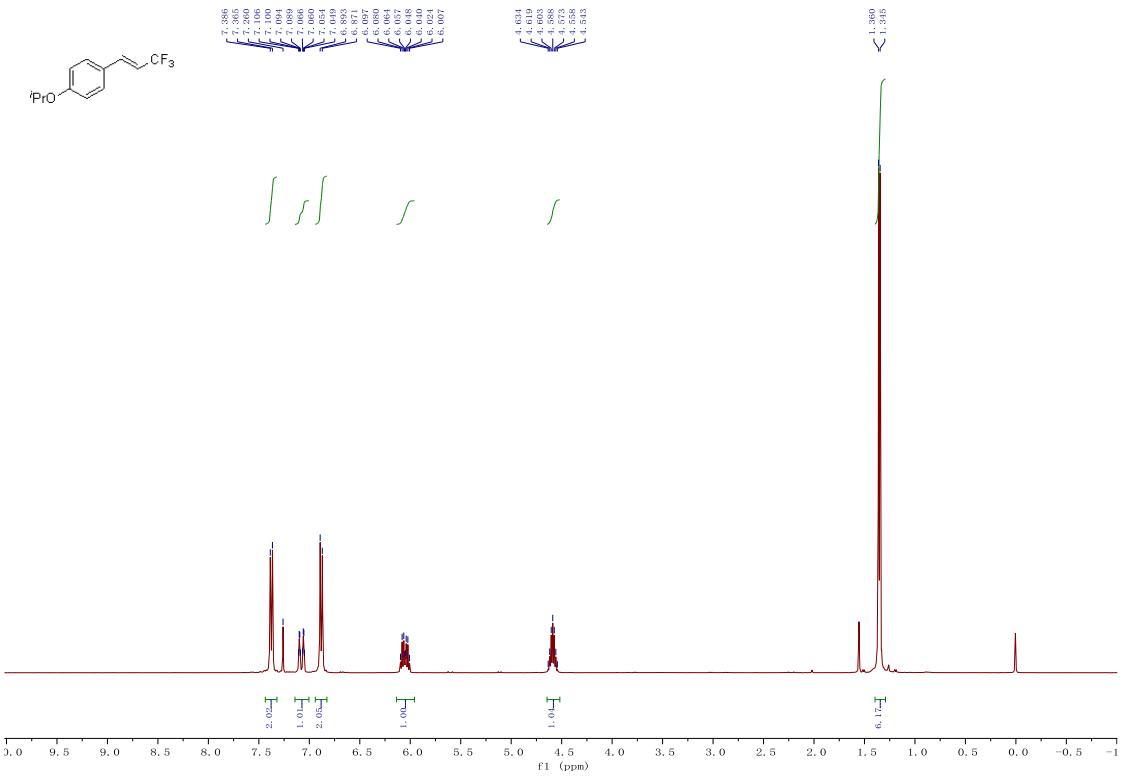
-62.85
-62.86
-62.87
MeO
CF3
f1 (ppm)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7.106
7.090
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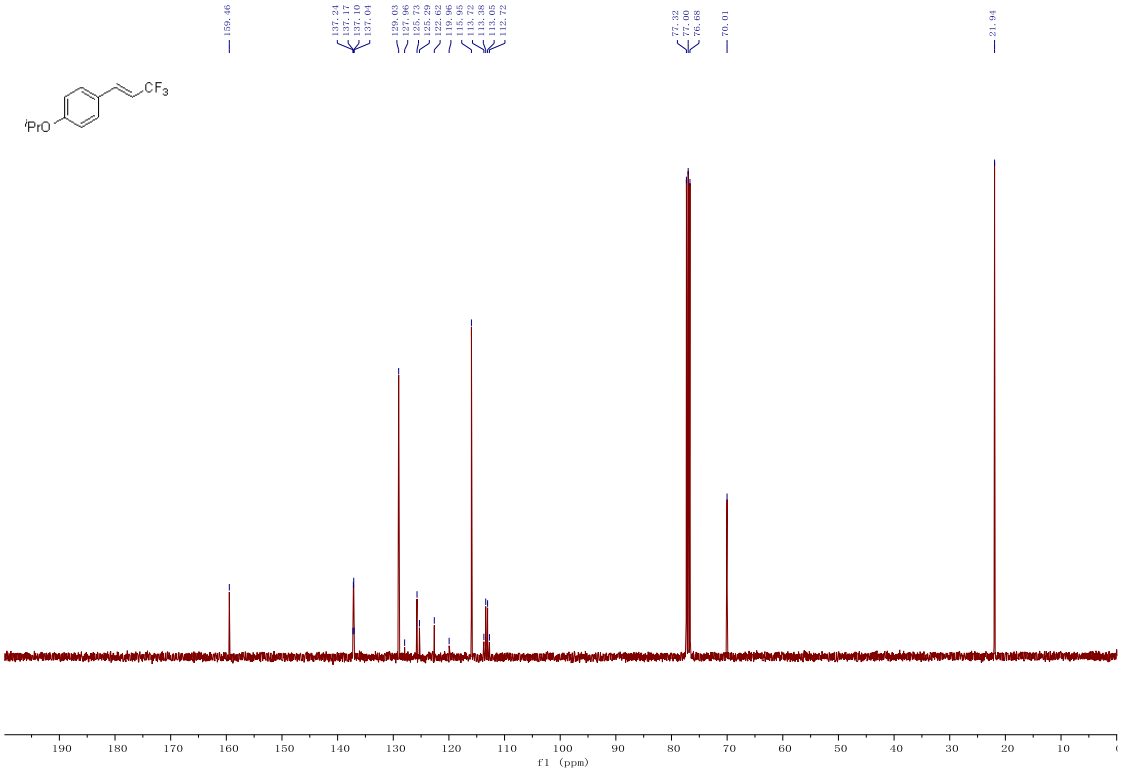
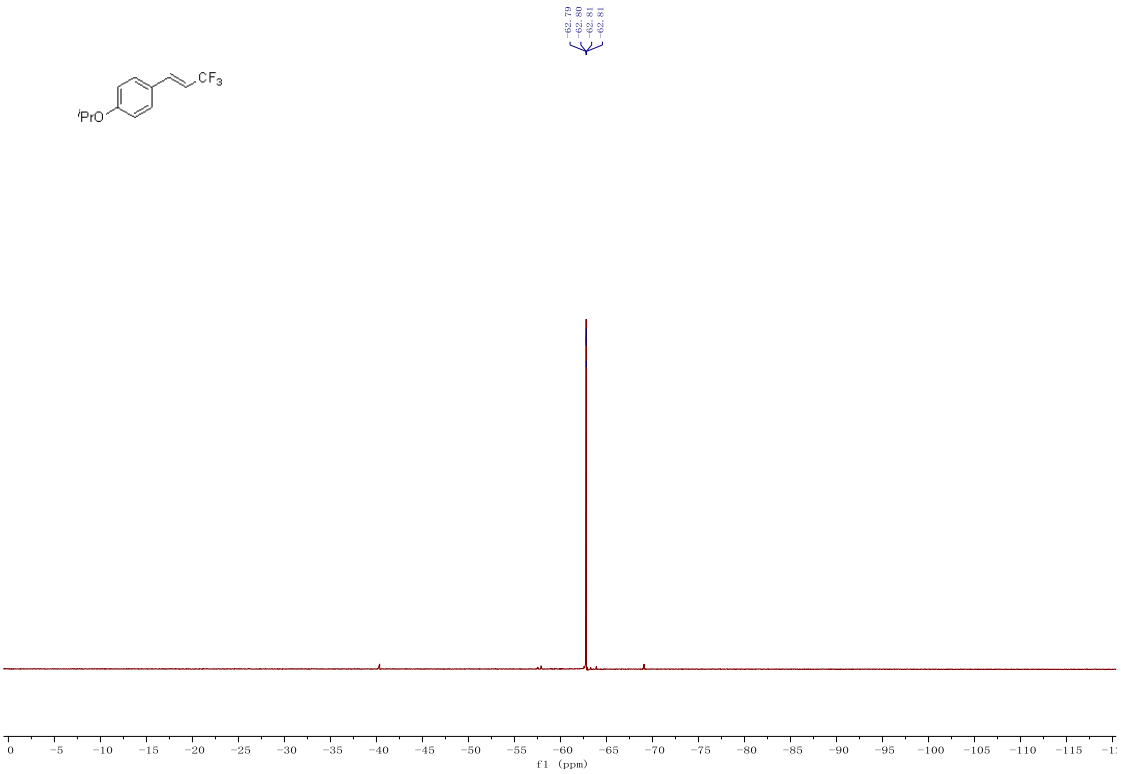
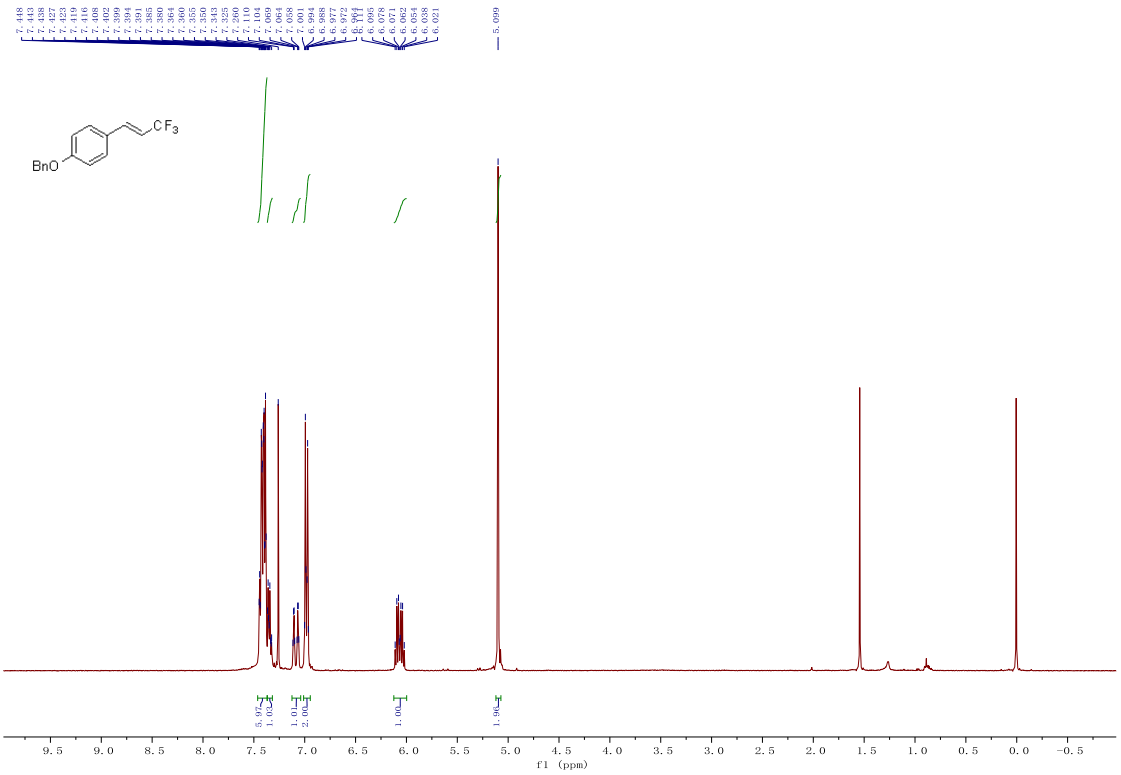
7.089
7.066
7.060
7.054
7.049
6.893
6.871
6.097
6.080
6.064
6.057
6.048
6.040
6.024
6.007
4.634
4.619
4.603
4.588
4.573
4.558
4.543
1.360
1.345
2.00
1.01
2.05
1.00
1.04
6.17
f1 (ppm)


159.46
137.24
137.17
137.10
137.04
129.03
127.96
125.73
125.29
122.62
118.96
115.95
113.72
113.38
113.05
112.72
77.32
77.00
76.68
70.01
21.94
f1 (ppm)


-62.79
-62.80
-62.81
-62.81
CF3
iPrO
f1 (ppm)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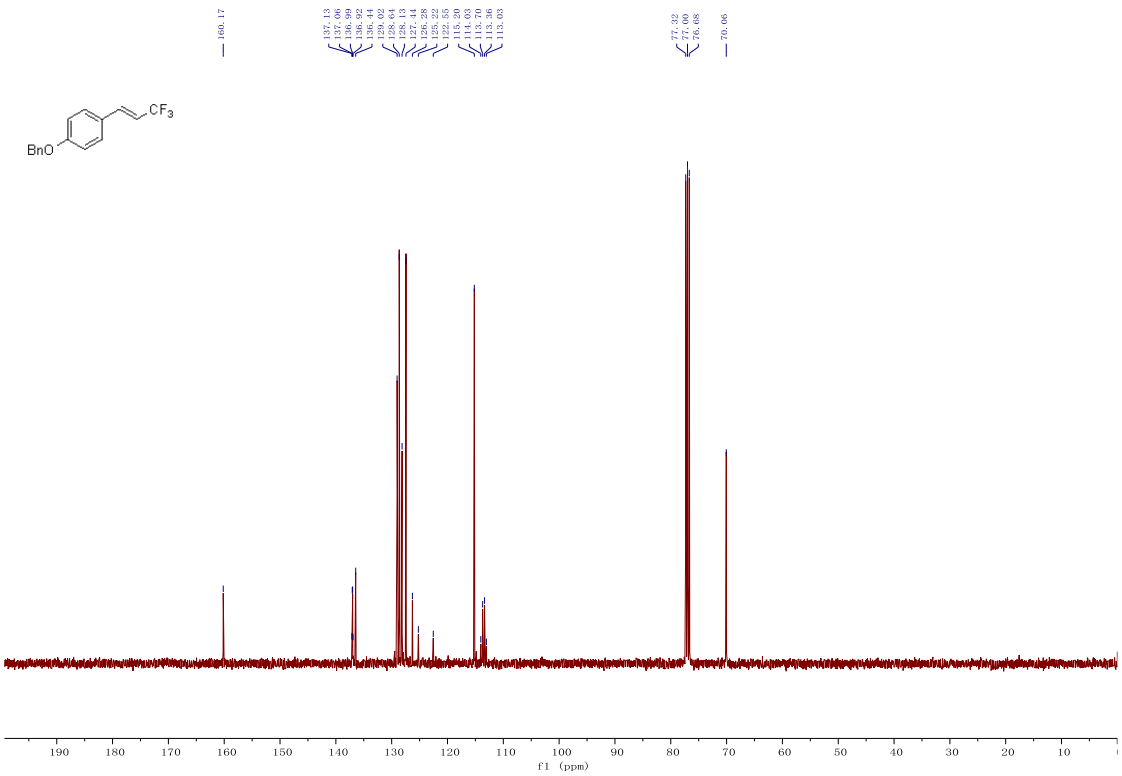
7.438
7.427
7.423
7.419
7.416
7.408
7.402
7.399
7.394
7.391
7.385
7.380
7.364
7.360
7.355
7.350
7.343
7.335
7.260
7.110
7.104
7.089
7.084
7.058
7.001
6.994
6.988
6.977
6.972
6.971
6.095
6.078
6.071
6.062
6.054
6.038
6.021
5.099
CF3
BnO
5.97
1.03
1.01
2.00
1.00
1.96
f1 (ppm)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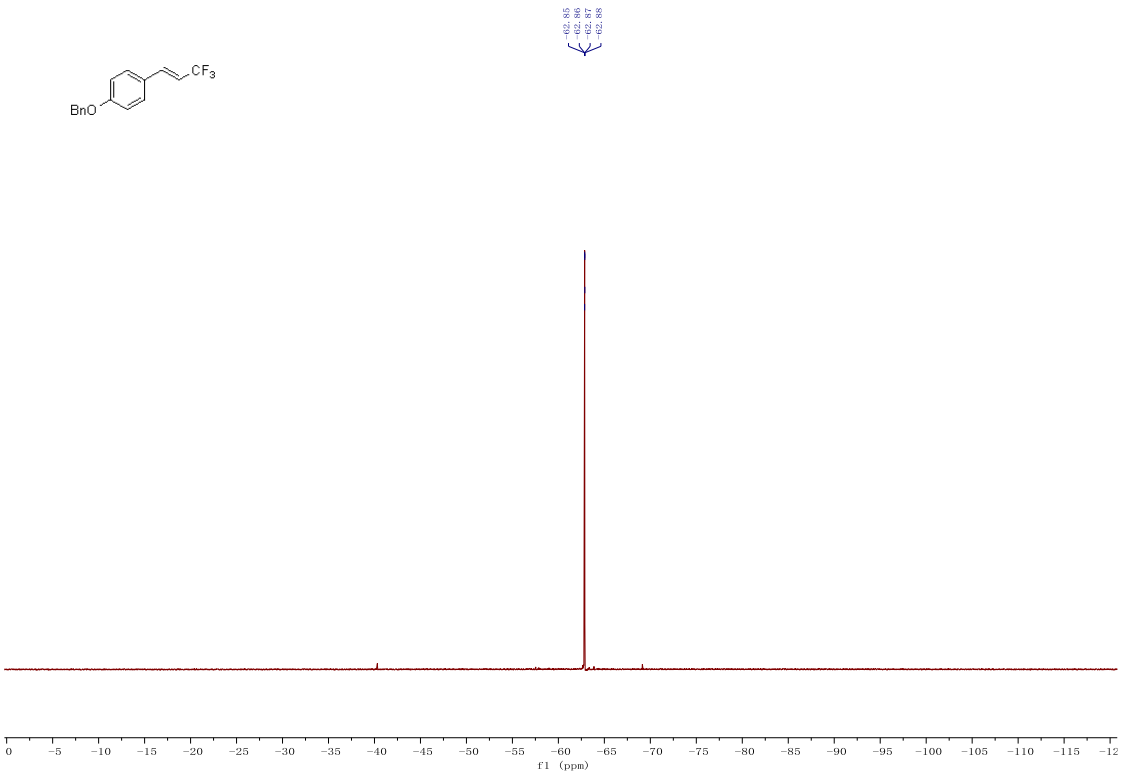
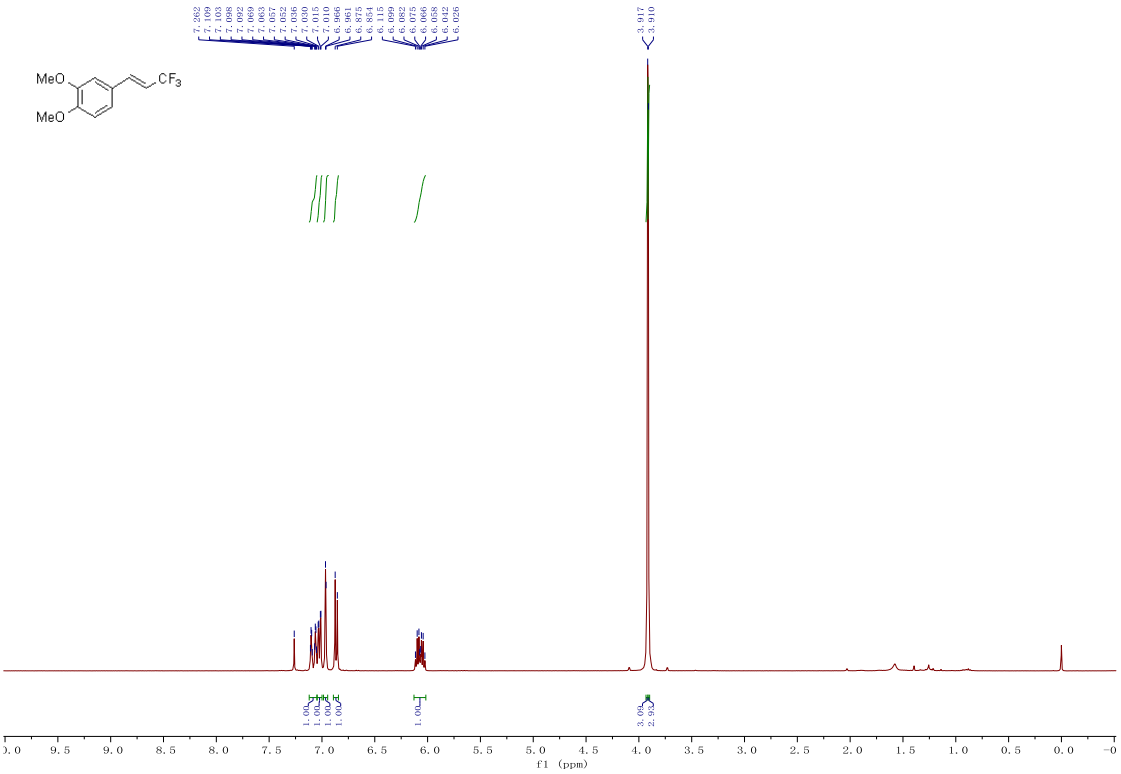
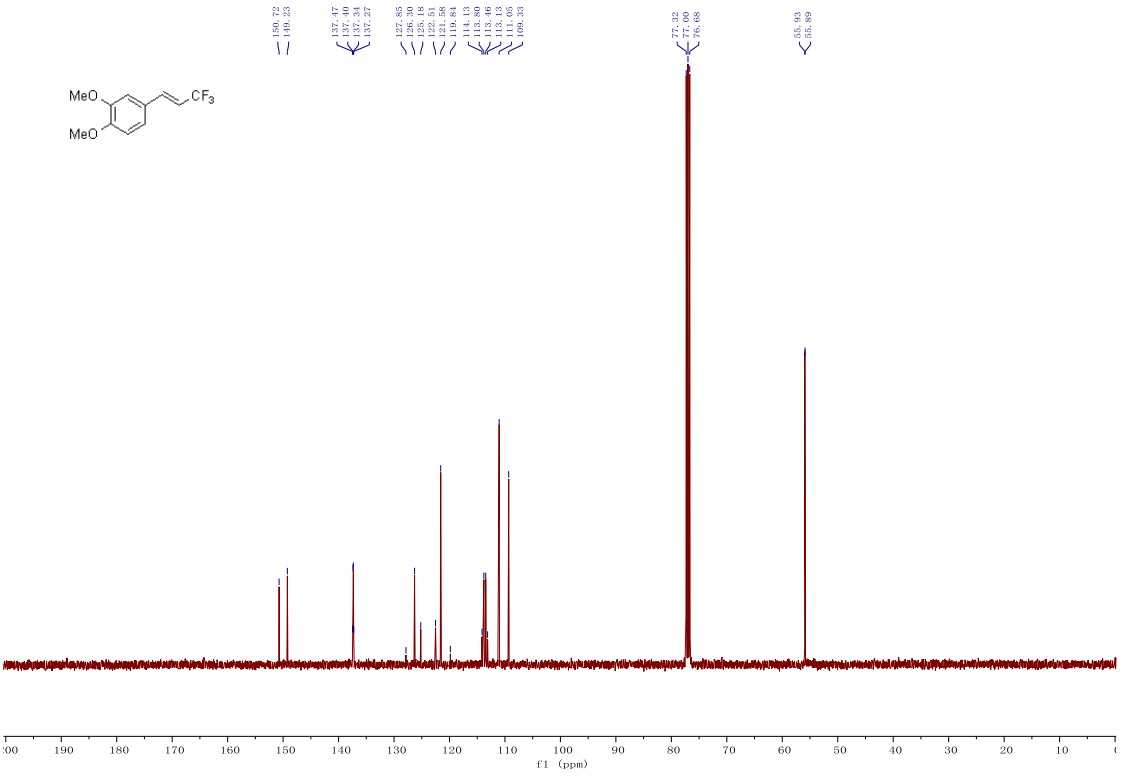
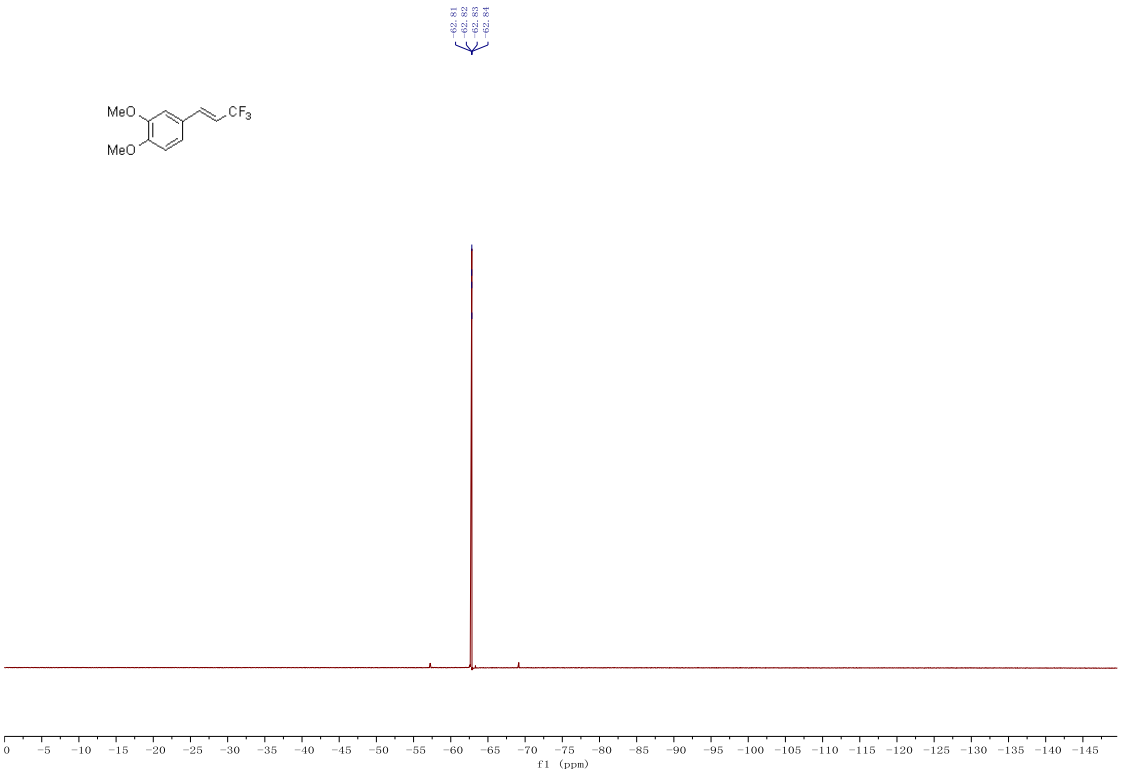
137.13
135.66
136.99
136.92
136.44
129.02
128.64
128.13
127.44
126.28
125.22
122.55
115.20
114.03
113.76
113.36
113.03
77.32
77.00
76.68
70.06
BnO
CF3
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


-62.85
-62.86
-62.87
-62.88
BnO
CF3
0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -12
f1 (ppm)


MeO
MeO
CF3
f1 (ppm)


MeO
MeO
CF3
f1 (ppm)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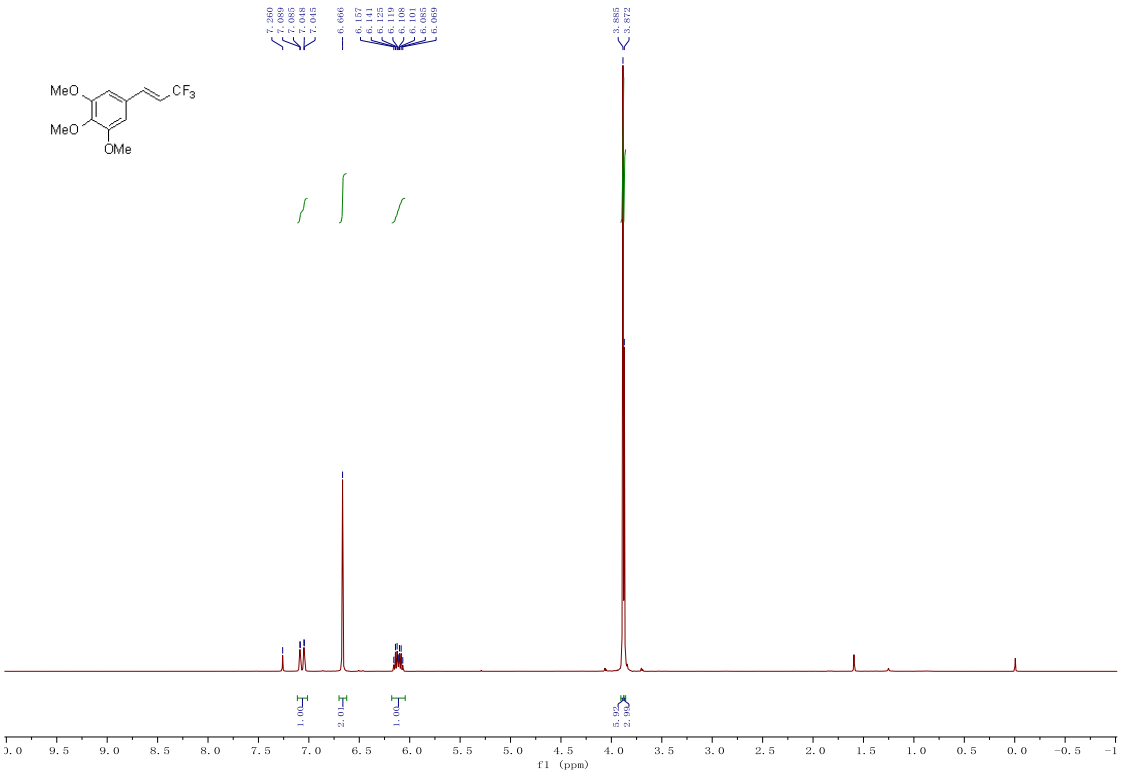
-62.83
-62.84
MeO
MeO
CF3
f1 (ppm)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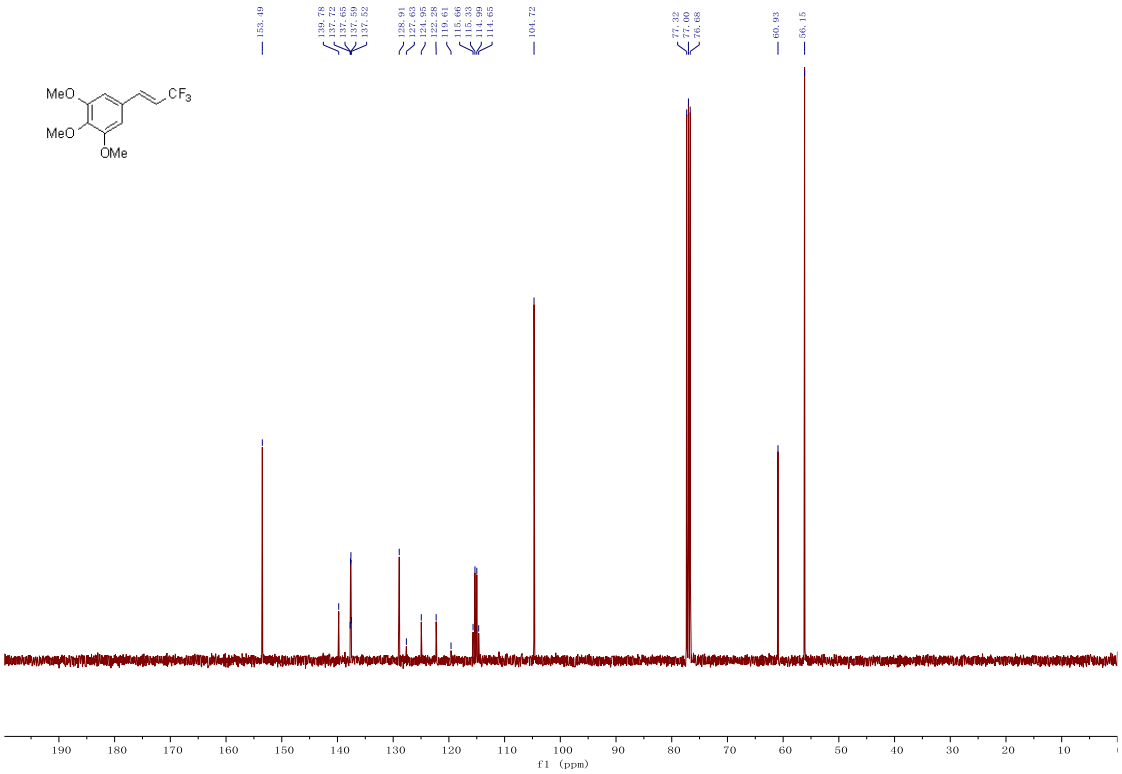
7.868
7.865
7.048
7.045
6.666
6.157
6.141
6.135
6.119
6.108
6.101
6.085
6.069
3.885
3.872
MeO
MeO
OMe
CF3
1.00
2.01
1.00
5.92
2.99
f1 (ppm)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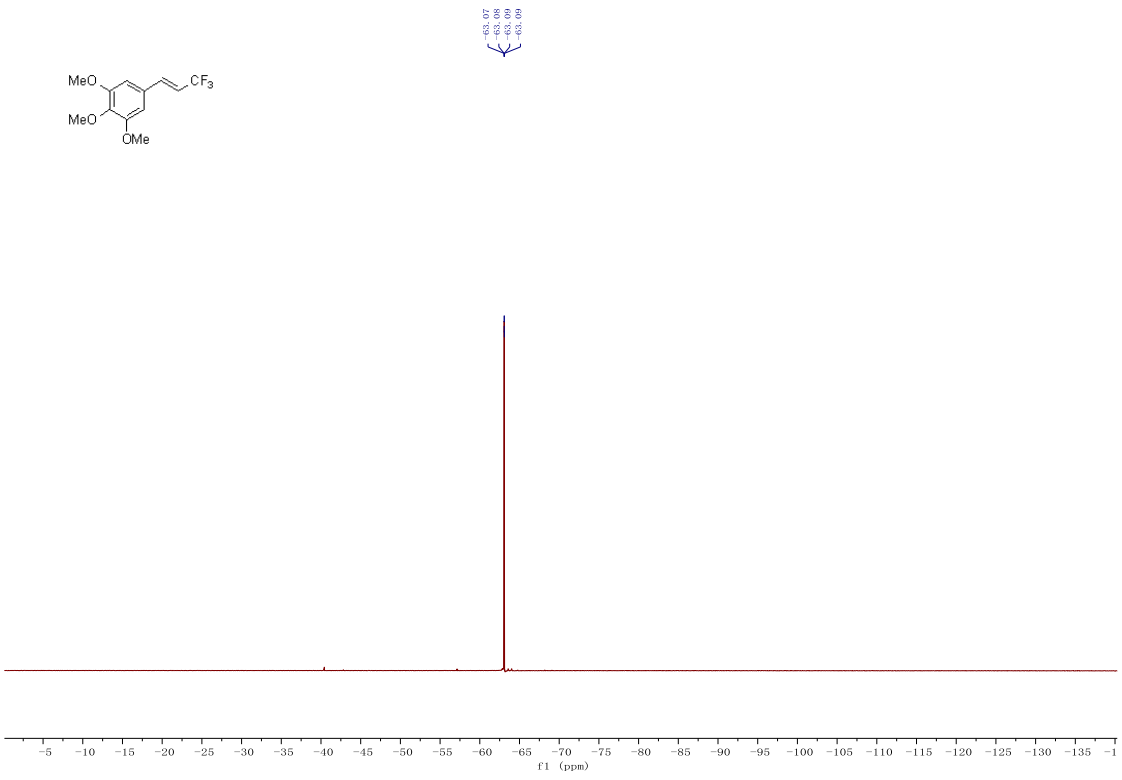
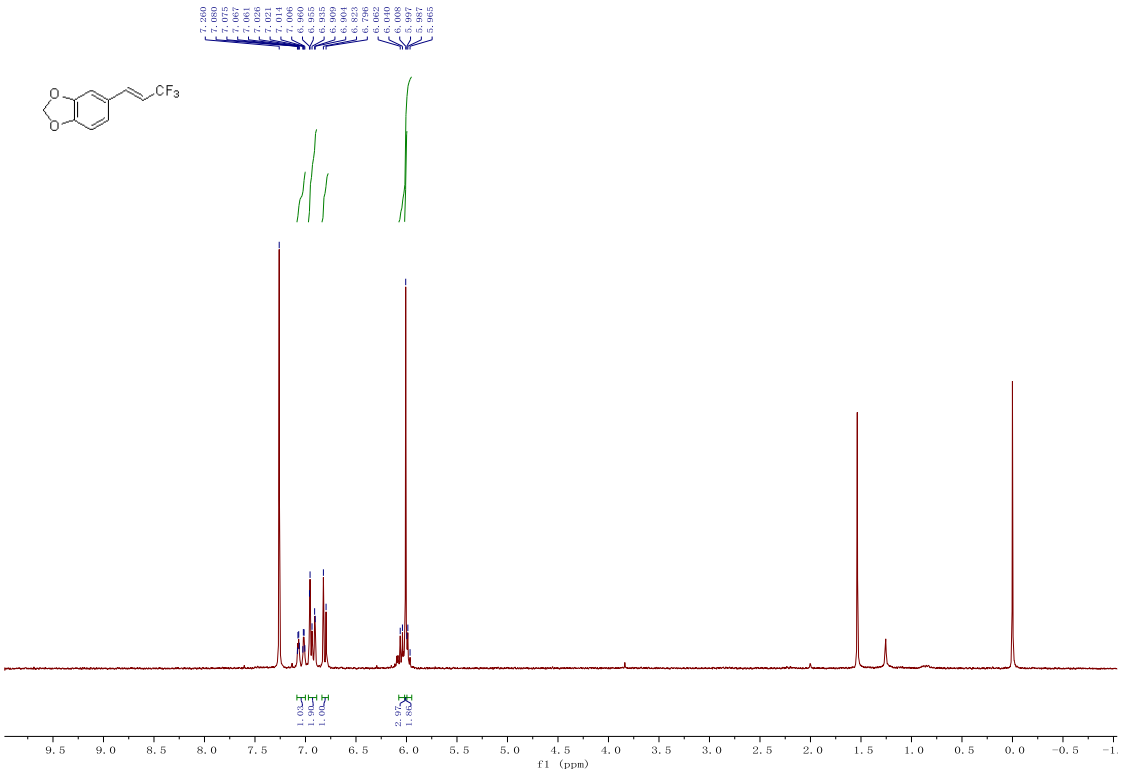
137.59
137.52
128.91
127.63
121.95
121.26
119.61
115.66
115.33
114.99
111.65
104.72
77.32
77.00
76.68
60.93
56.15
MeO
MeO
OMe
CF3
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


-63.07
-63.08
-63.09
-63.09
MeO
MeO
OMe
CF3
-5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120 -125 -130 -135
f1 (ppm)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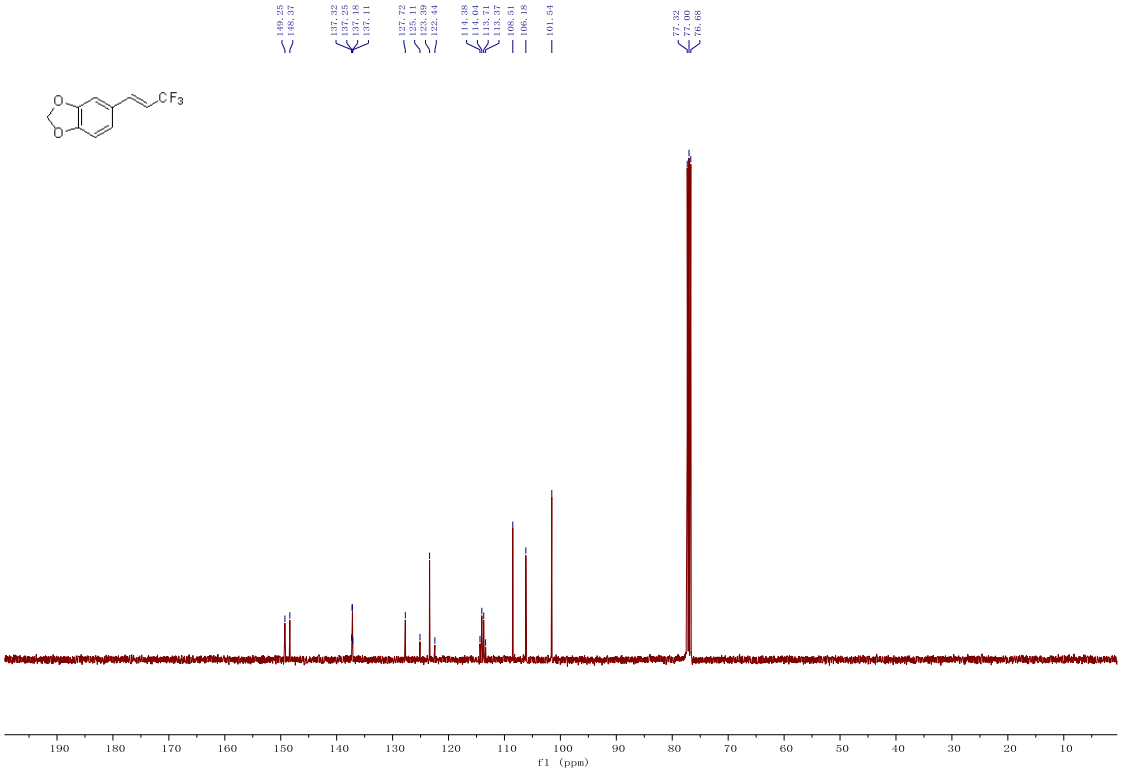
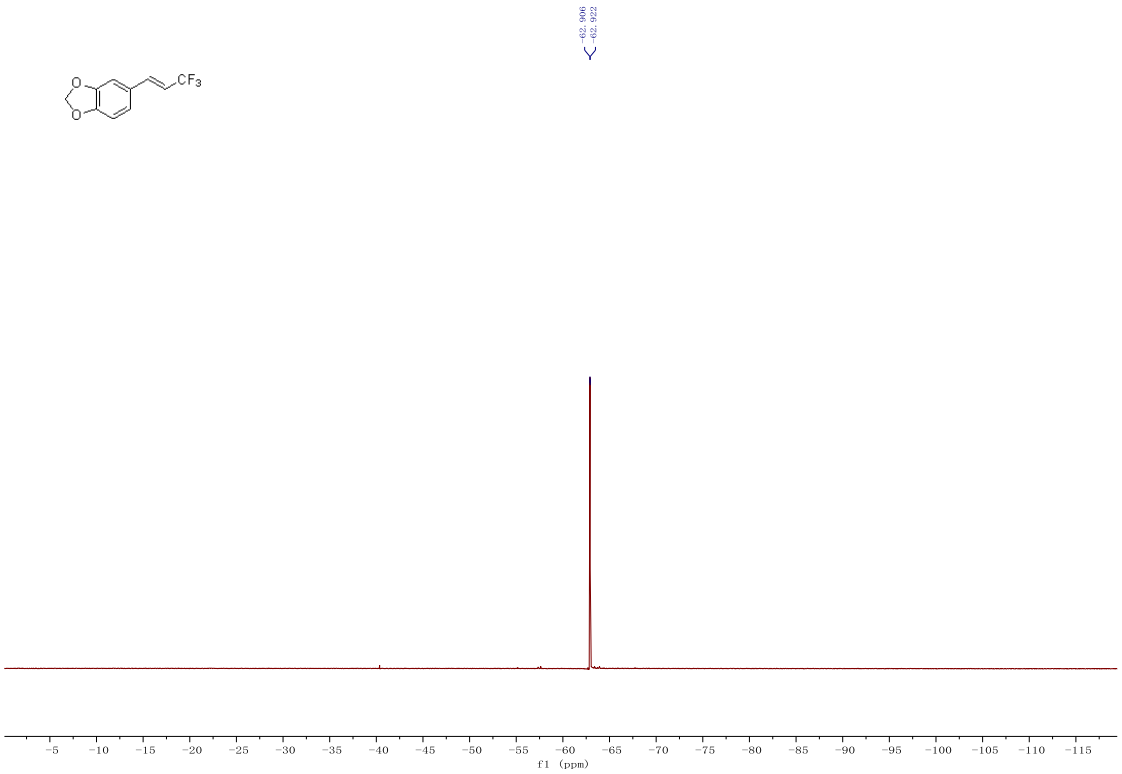
7.080
7.075
7.067
7.061
7.026
7.021
7.014
7.006
6.960
6.955
6.955
6.909
6.904
6.823
6.798
6.062
6.040
6.008
5.987
5.987
5.965
CF3
1.03
1.96
1.04
2.97
1.80
f1 (ppm)


149.25
148.37
137.32
137.25
137.18
137.11
127.72
125.11
123.39
122.44
114.38
114.04
113.71
113.37
108.81
106.18
101.84
77.32
77.00
76.68
CF3
f1 (ppm)


O
O
CF3
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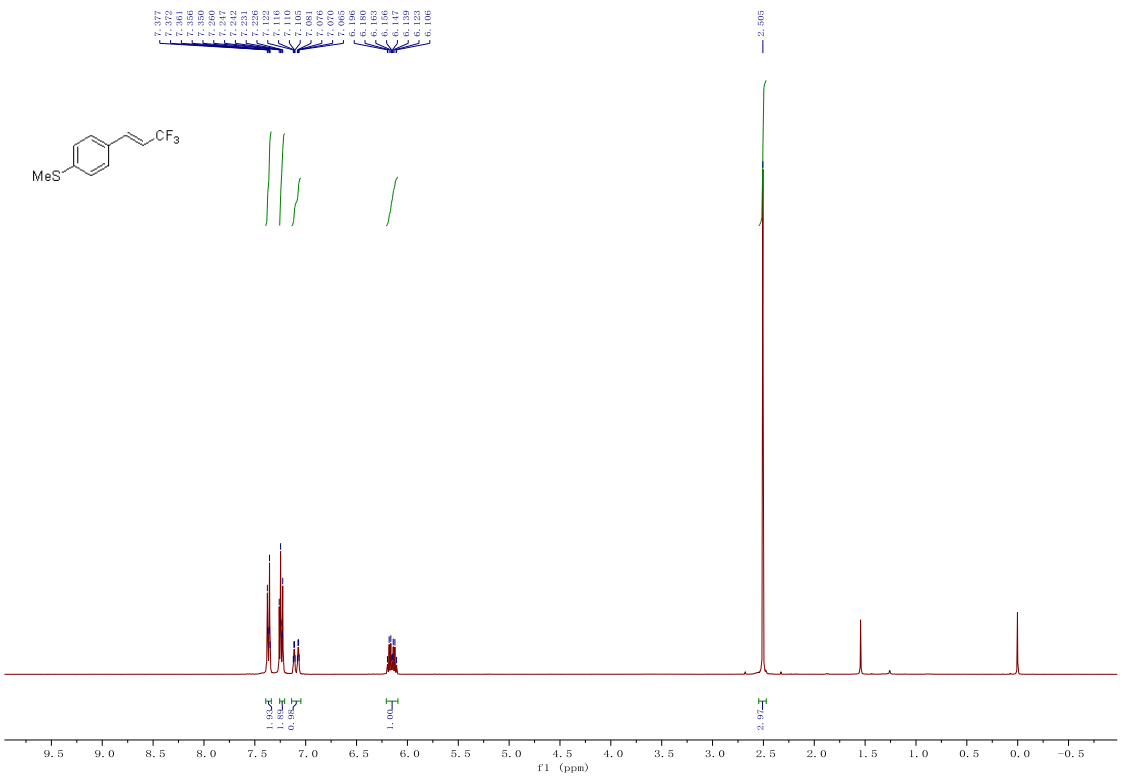
-62.922
f1 (ppm)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7.242
7.231
7.226
7.122
7.116
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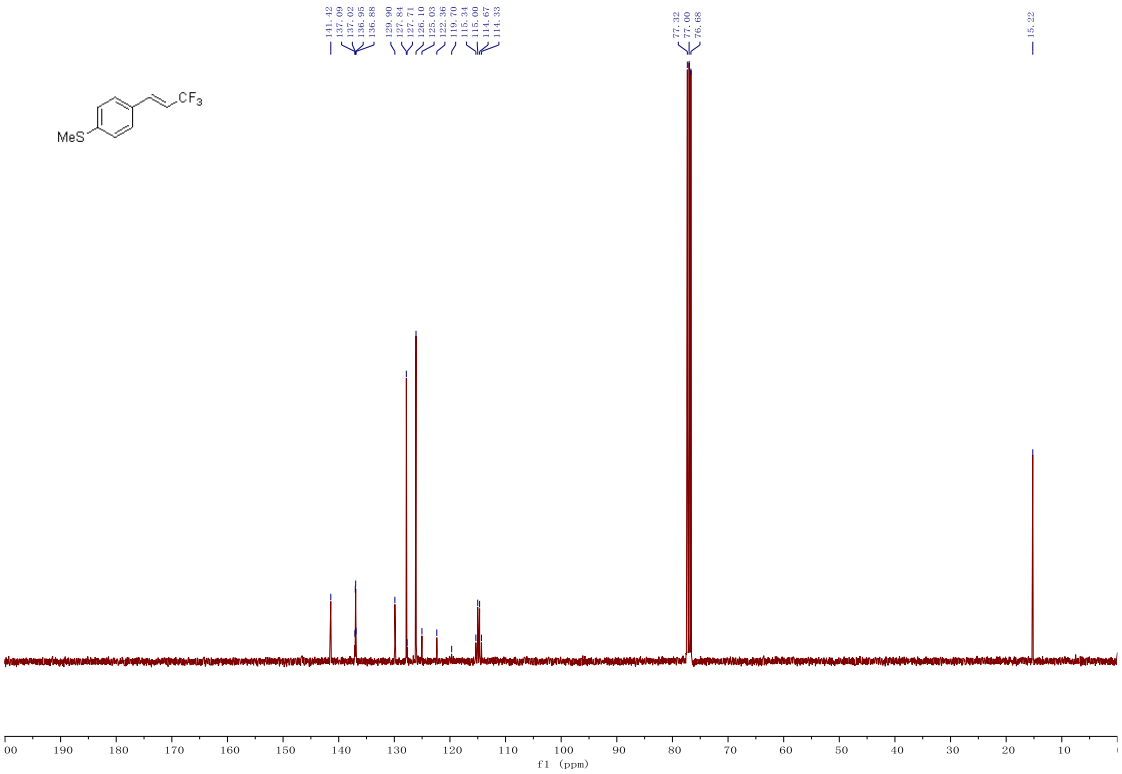
7.105
7.081
7.076
7.070
7.065
6.186
6.180
6.163
6.156
6.147
6.138
6.123
6.106
2.505
CF3
MeS
1.82
1.84
0.98
1.04
2.97
f1 (ppm)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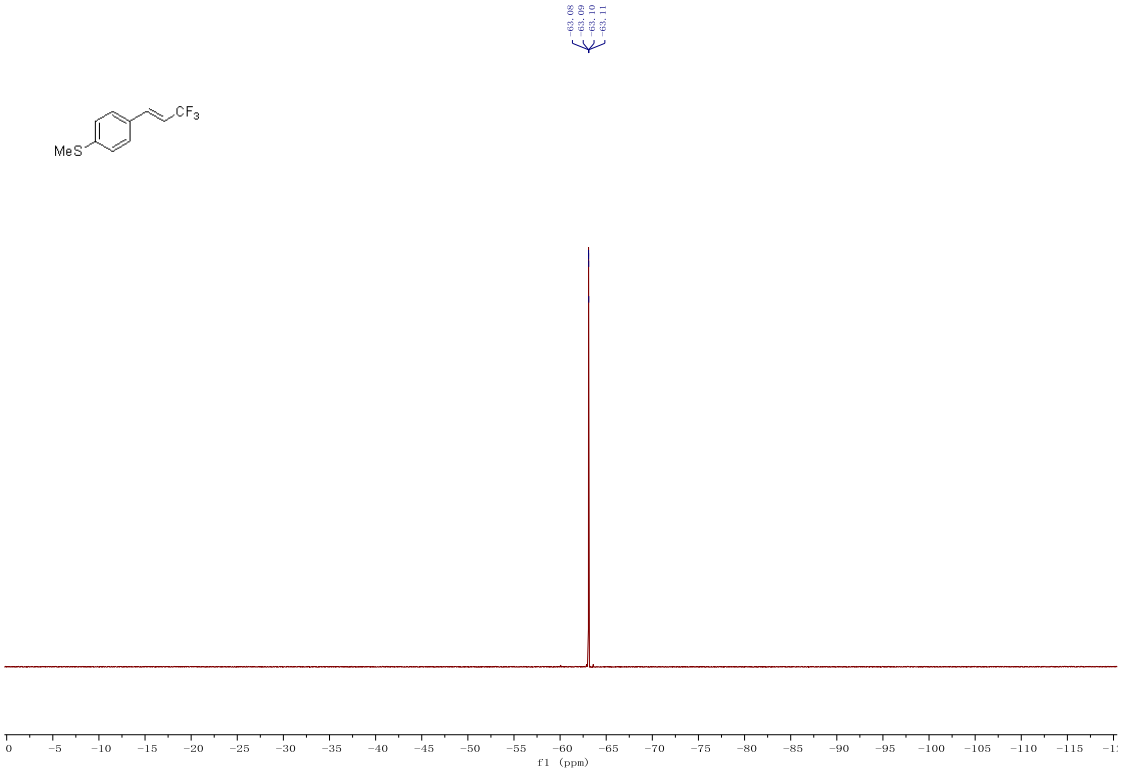
135.69
136.95
136.88
129.90
127.84
127.71
126.10
125.03
122.36
119.70
115.34
115.06
114.67
114.33
77.32
77.00
76.68
15.22
MeS
CF3
f1 (ppm)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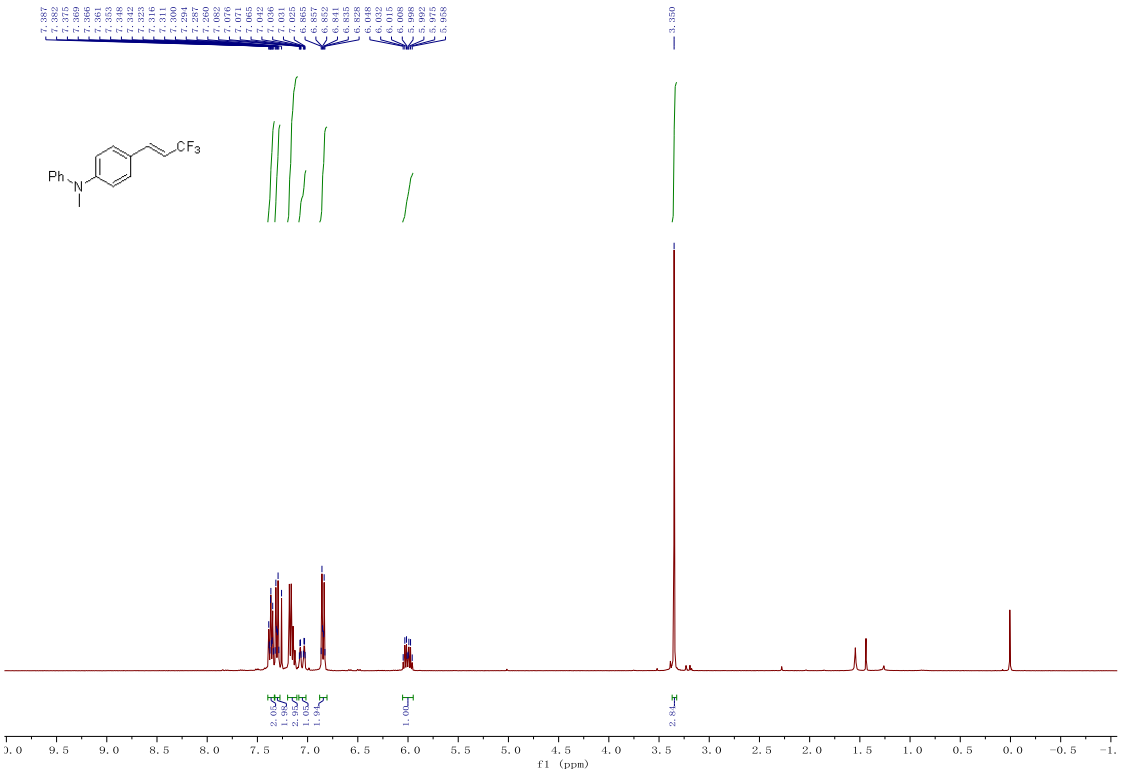
-63.09
-63.10
-63.11
MeS
CF3
f1 (ppm)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7.361
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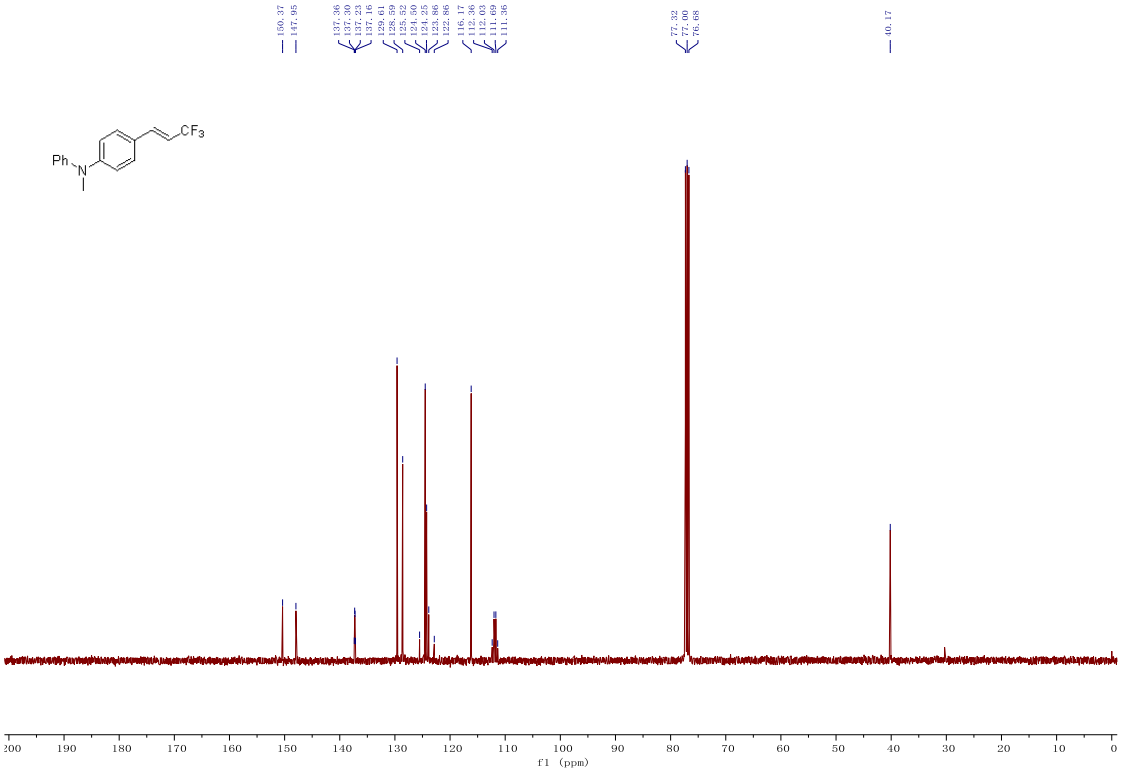
7.325
7.316
7.311
7.300
7.294
7.287
7.260
7.082
7.076
7.071
7.065
7.042
7.036
7.031
7.025
6.865
6.857
6.852
6.841
6.835
6.828
6.048
6.042
6.015
6.008
5.998
5.992
5.975
5.958
3.350
Ph
N
CF3
2.05
1.98
2.03
1.05
1.94
1.00
2.84
f1 (ppm)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137.23
137.16
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128.89
125.52
124.50
124.25
123.86
122.86
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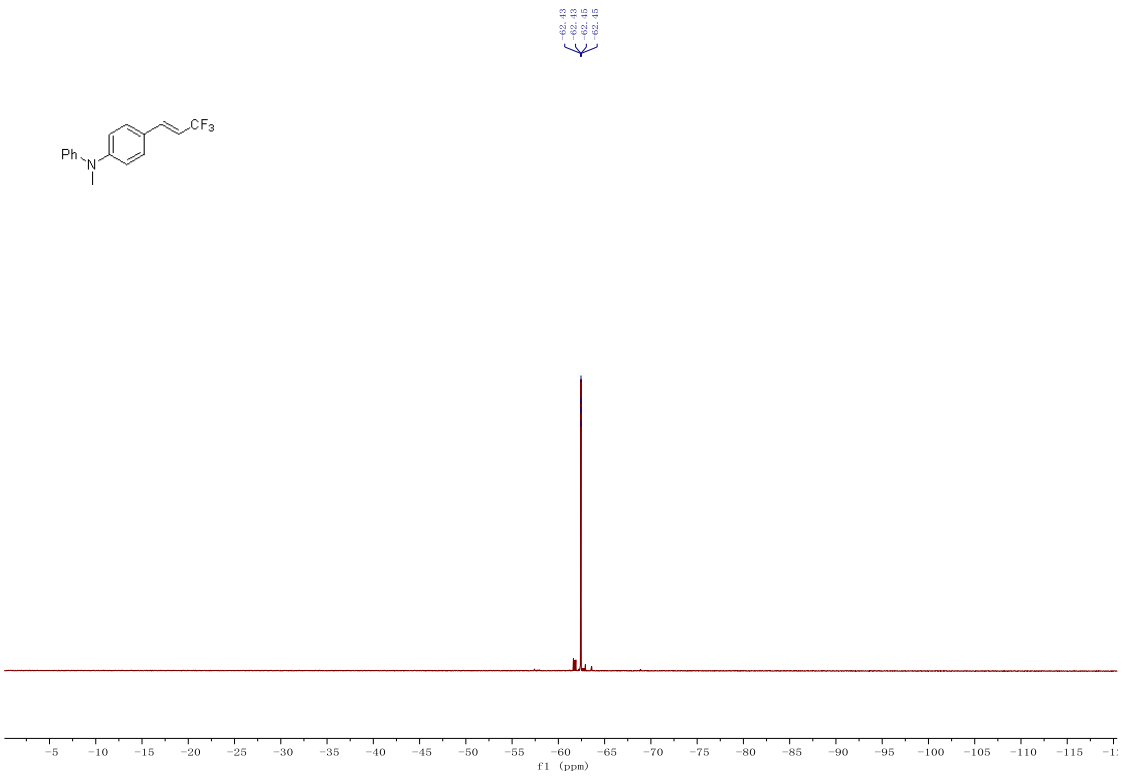
76.68
40.17
Ph
N
CF3
f1 (ppm)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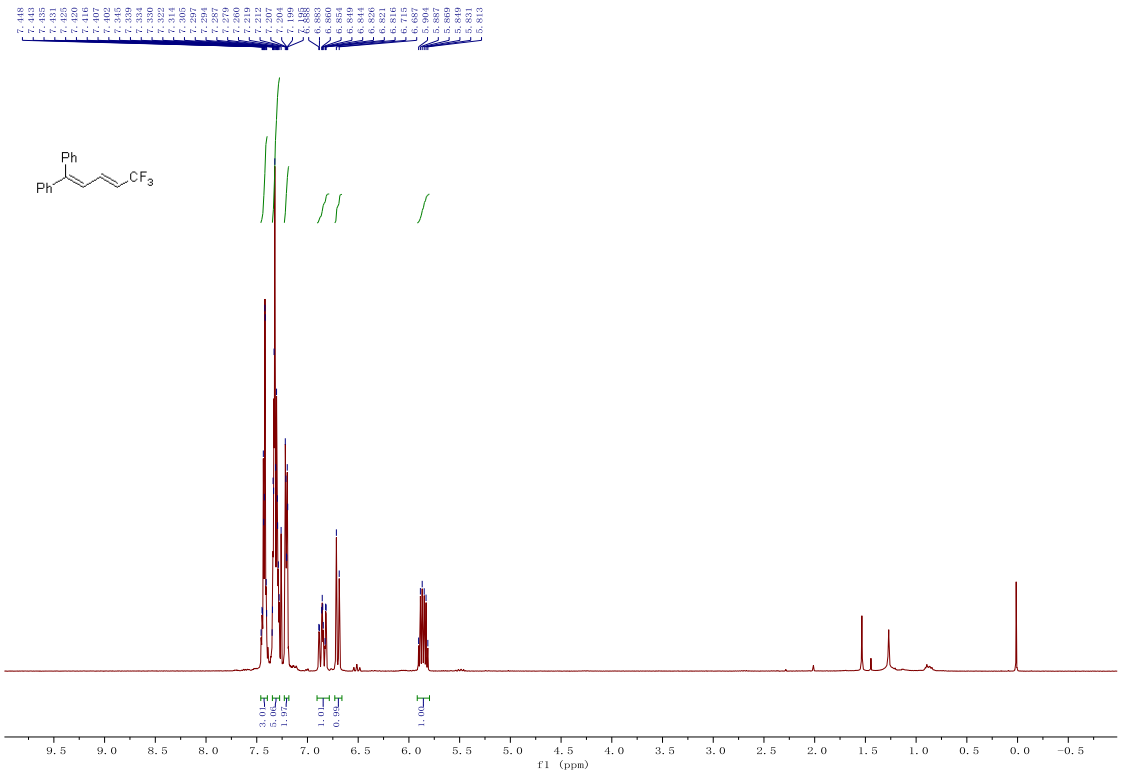
-62.45
Ph
N
CF3
f1 (ppm)


Ph
Ph
CF3
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5.06
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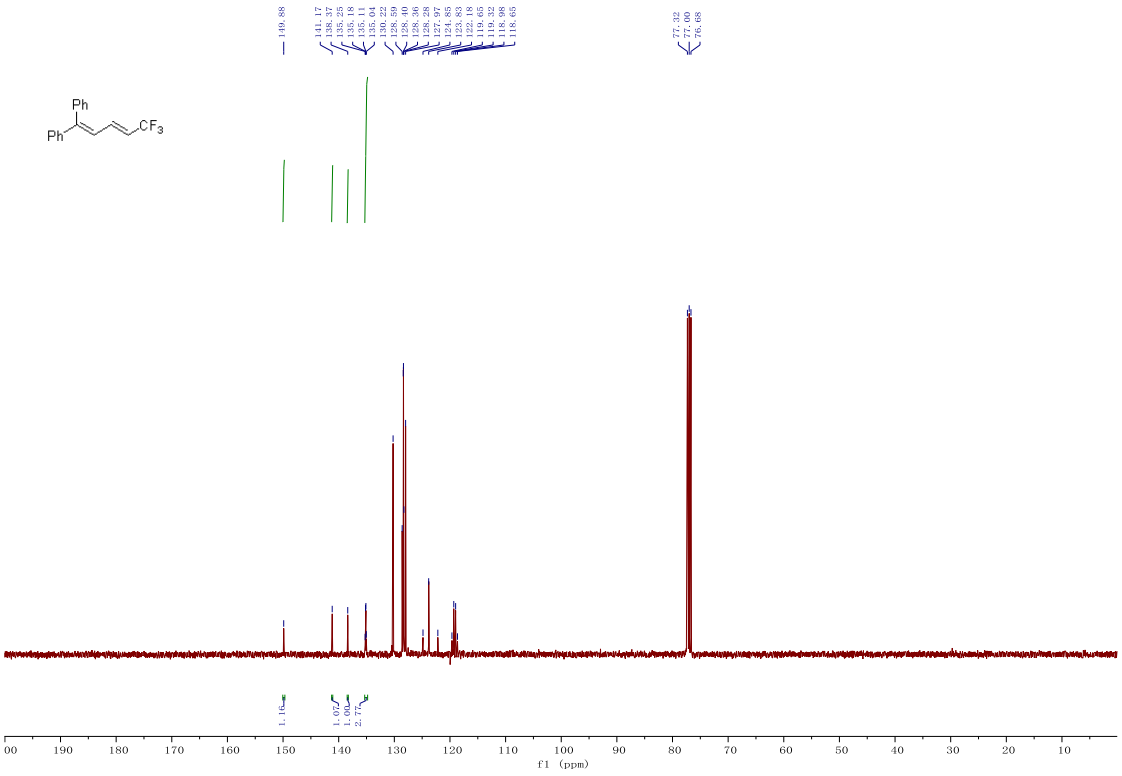
1.01
0.99
1.00
f1 (ppm)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135.11
135.04
130.22
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128.40
128.36
128.28
127.97
127.85
123.83
122.18
119.65
119.32
118.98
118.65
77.32
77.00
76.68
Ph
Ph
CF3
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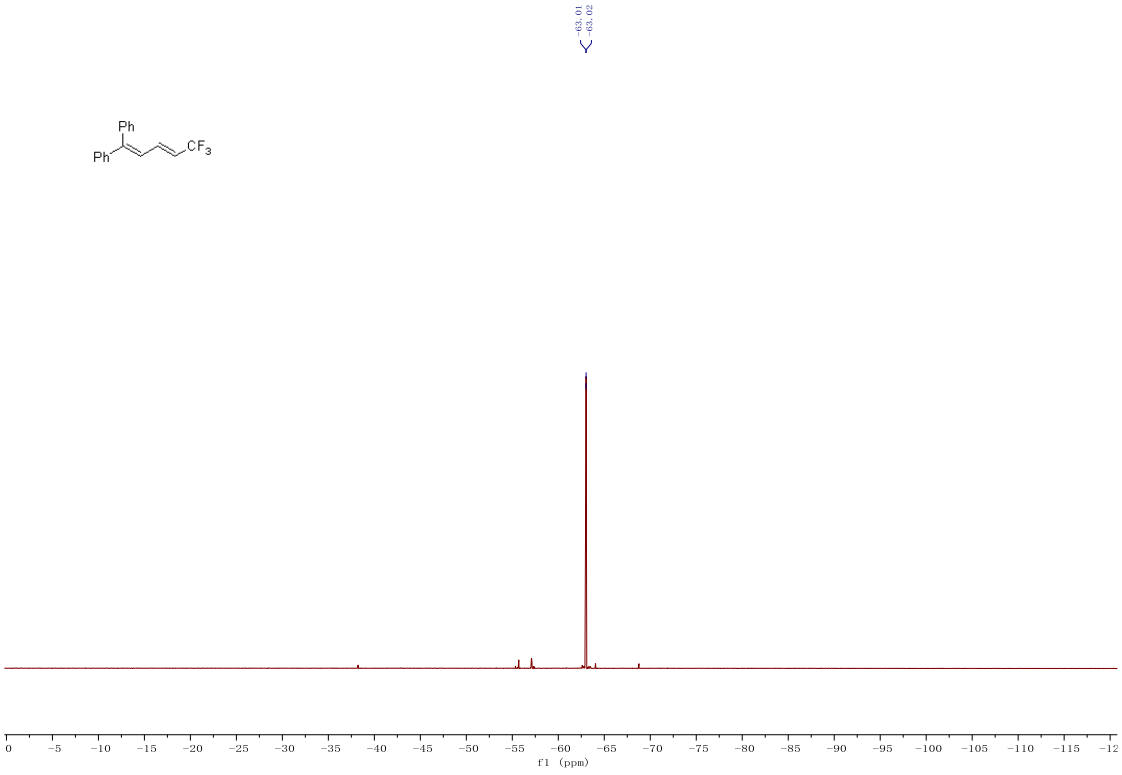
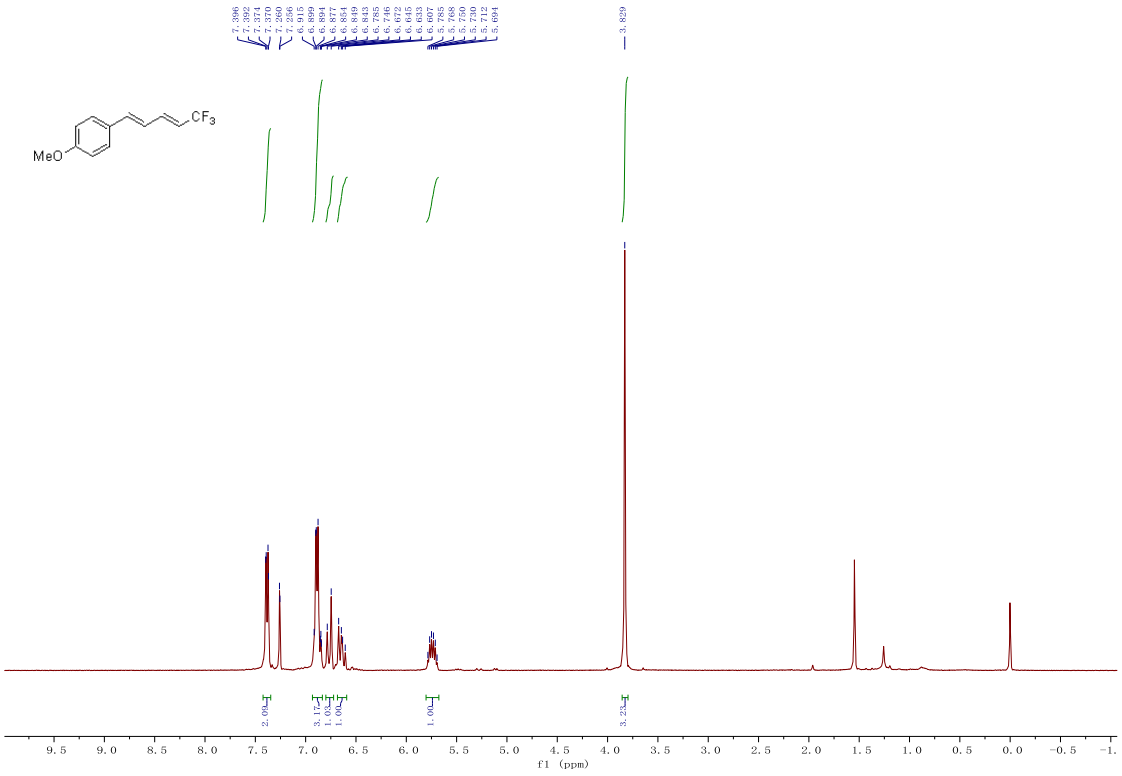
1.07
1.00
2.77
f1 (ppm)


-63.01
-63.02
Ph
Ph
CF3
f1 (ppm)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6.877
6.854
6.849
6.843
6.785
6.746
6.672
6.645
6.633
6.607
5.785
5.768
5.750
5.730
5.712
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MeO
CF3
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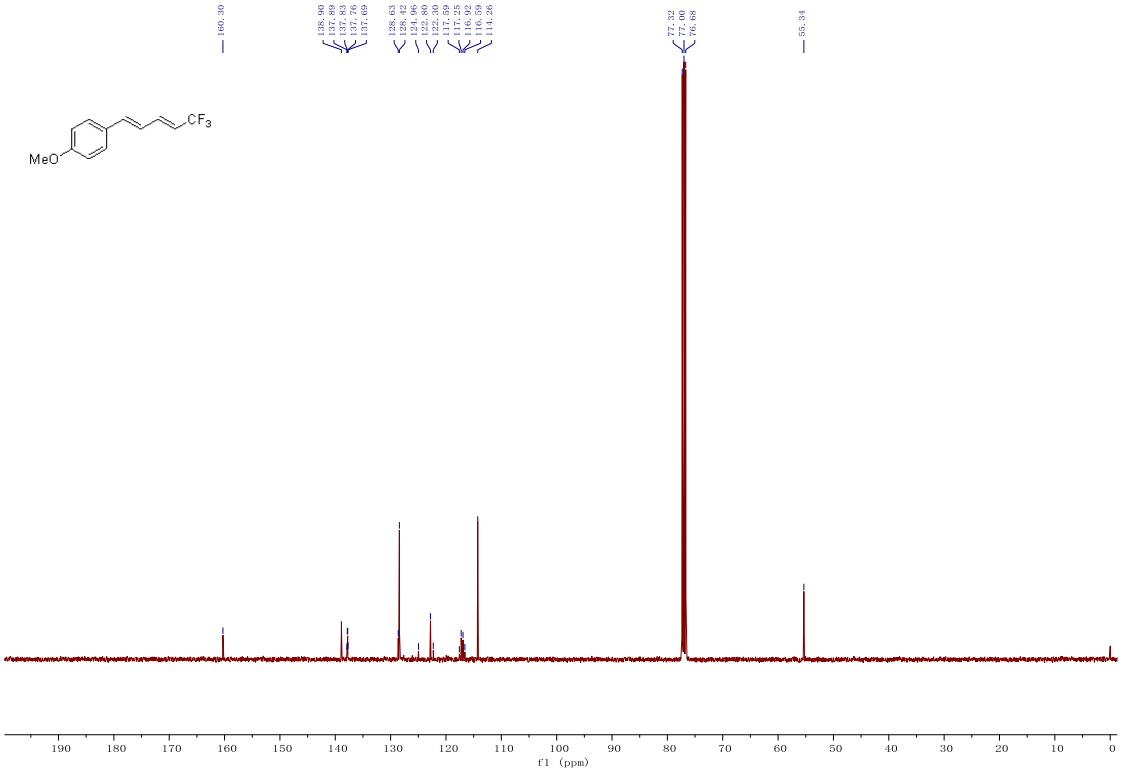
3.17
1.03
1.00
1.00
3.23
f1 (ppm)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137.69
128.63
128.42
124.96
122.80
122.30
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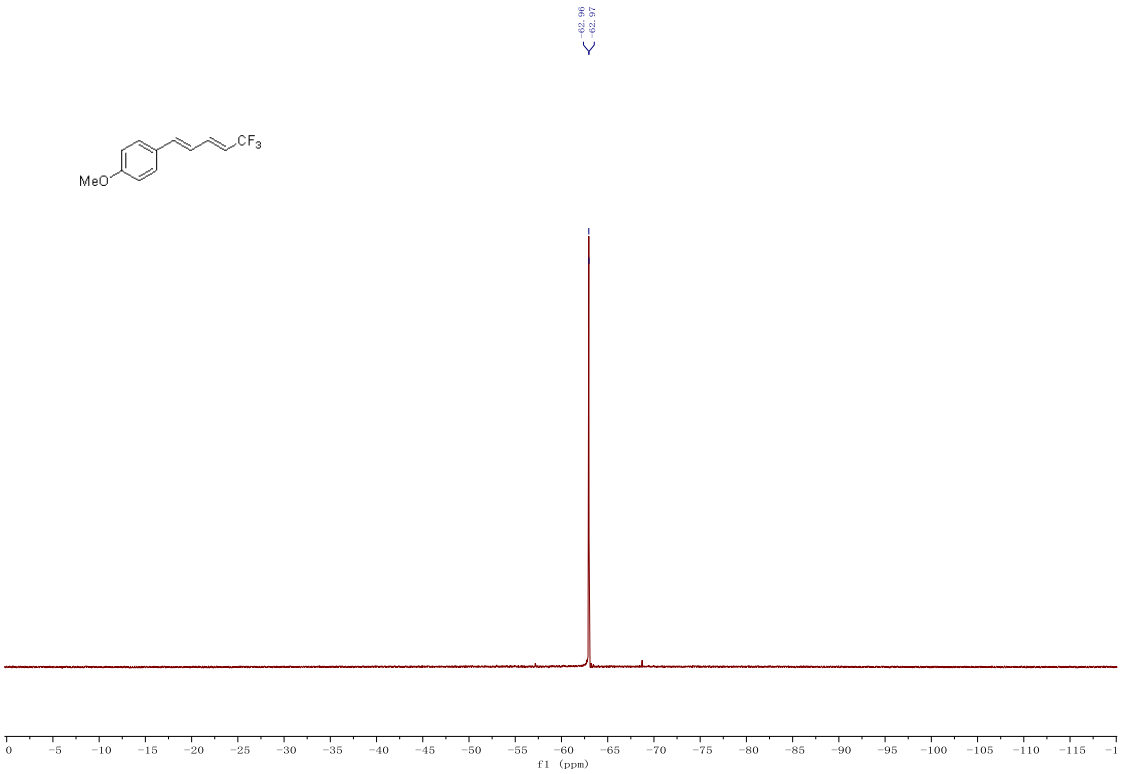
117.25
116.92
116.59
114.56
77.32
77.00
76.68
55.34
MeO
CF3
f1 (ppm)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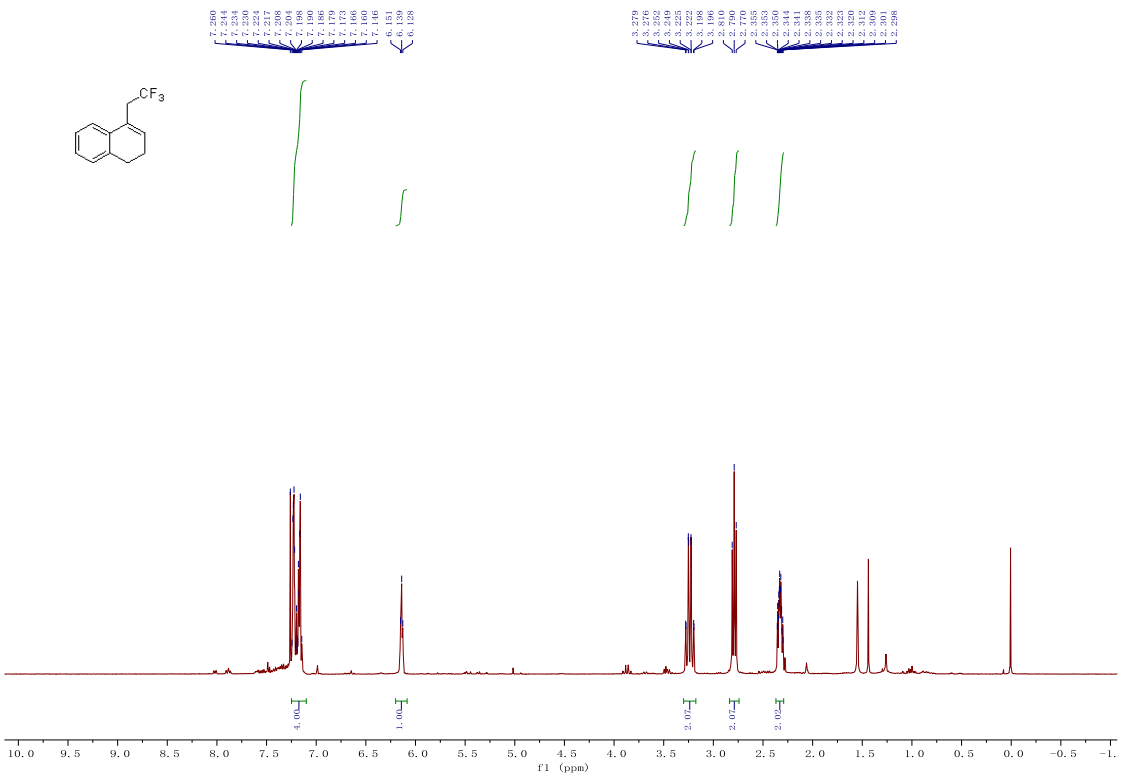
-62.97
MeO
CF3
f1 (ppm)


CF3
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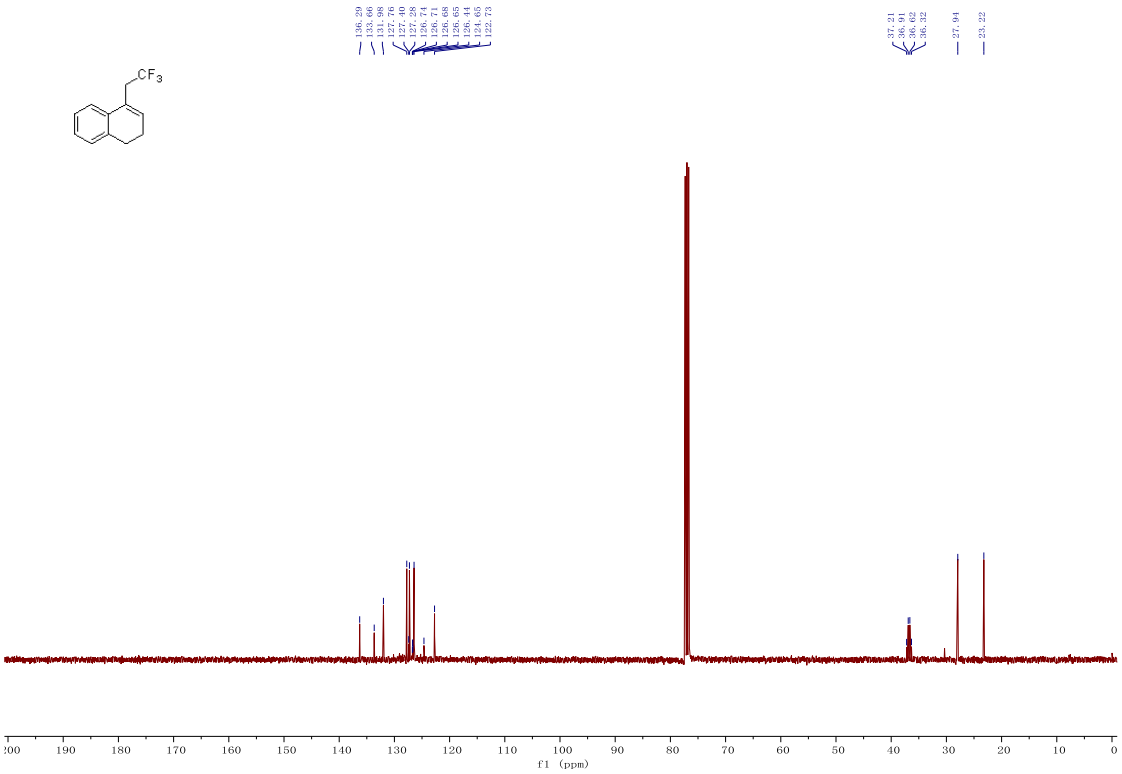
2.07
2.07
2.02
f1 (ppm)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122.73
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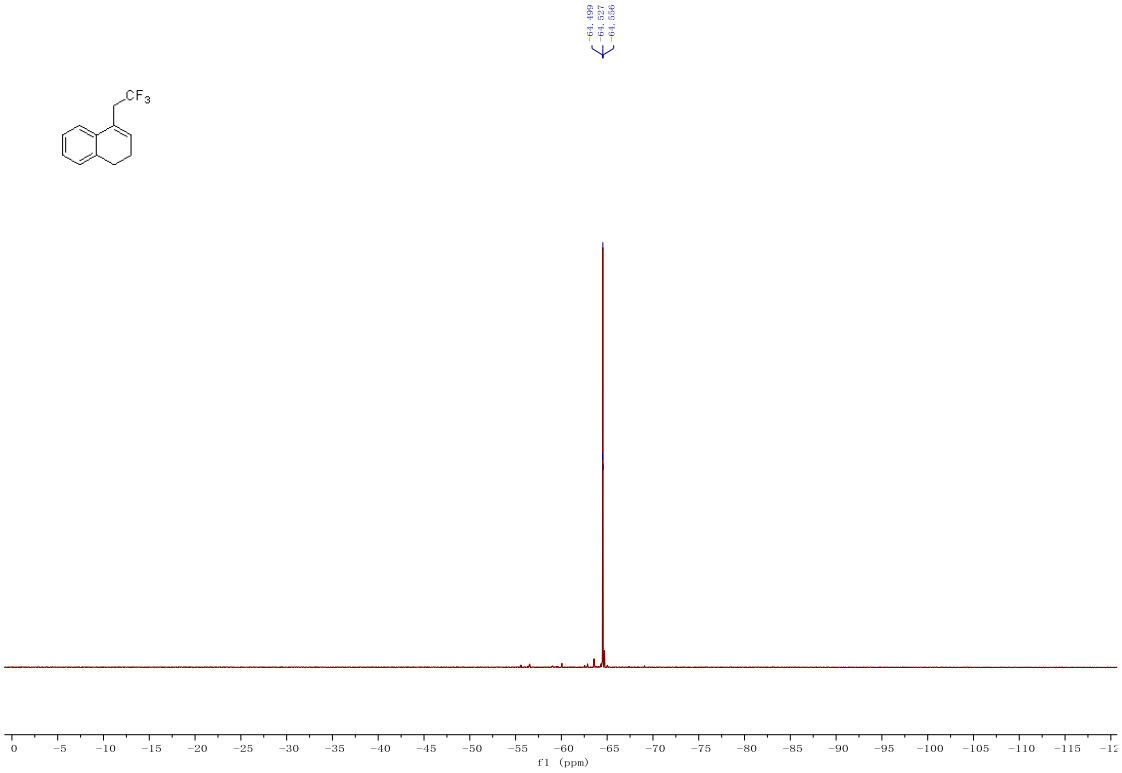
36.91
36.62
36.32
27.94
23.22
CF3
f1 (ppm)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CF3
f1 (ppm)