Supporting Information

Light-Driven Heterogeneous Semiconductor CdS Catalyzed Defluorination Reaction for the Synthesis of *γ*,*γ*-Difluoroolefin Ketones

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1. General Information

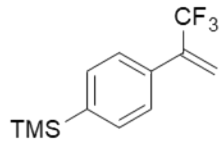
Reagents, Materials, and Instrumentation

Reagents were purchased from commercial sources and used as received without any further purification. The conversion was monitored by thin-layer chromatography (TLC). Thin-layer chromatography (TLC) was performed on commercial silica gel plates, and flash column chromatography was performed with 200-300 mesh silica gel cartridges. Visualization of TLC achieved using ultraviolet light (254 and 365 nm). ^{1}H, ^{13}C, and ^{19}F Nuclear magnetic resonance (NMR) spectra were obtained on a Bruker Avance III 400 and 700 MHz instrument in $CDCl_3$. Trifluoromethylbenzene was used as an internal standard to calculate the ^{19}F-yield. Chemical shifts were reported in parts per million (ppm) relative to the solvent resonance as the internal standard ($CDCl_3$ δH = 7.26 ppm, tetramethylsilane = 0 ppm). Coupling constants (*J*) were given in Hz. Multiplicities were indicated as follows: s (singlet), d (doublet), t (triplet), q (quartet), and m (multiplet). The photocatalytic parallel reactor (WATTCAS, WP-TEC-1020SL) is generally used for reaction irradiation. For our experiments, blue LEDs (455-460 nm, 1-10 W) modules are used. The light source intensity for irradiation is 100%, with a stirring rate of 700 rpm. The reaction temperature is maintained near room temperature (25 °C) using a low-temperature circulator (EYELA, Cool Ace CCA-1112), which is set at 25 °C. The morphology and structure of CdS nanostrips were observed using a Hitachi JSM-7800F scanning electron microscope (SEM) operated at an accelerating voltage of 3.0 kV and a JEM-2100 transmission electron microscope (TEM) operated at an accelerating voltage of 120.0 kV. X-ray diffraction (XRD) patterns were performed on a Bruker D8-Advance X-ray diffractometer (Bruker, Germany) using a Cu Kα radiation source. The scanning speed was 10° min−1, and the tube voltage and current were 40 kV and 40 mA, respectively. N_2 sorption isotherms were measured at 77K using a QuadraSorb SI4 Station, and the samples were degassed at 150 °C for 6 h before measurement. The total specific surface area (SBET) was determined by a multipoint BET method; the single-point pore volume was estimated from the amount adsorbed at a relative pressure of 0.99. Surface compositions were determined by X-ray photoelectron spectroscopy (XPS) using a Thermo Scientific ESCALAB 250Xi instrument with Al Kα radiation anode (hv =1486.6 eV), and the C 1s line (284.6 eV) was used as the reference to correct the binding energies (BE). A Lambda 950 spectrophotometer was used to record the diffuse reflectance Ultraviolet-visible (UV-vis) spectroscopy of photocatalysts, and a Steady-State/transient fluorescence spectrometer was used for fluorescence studies.

2. Preparation of Photocatalyst

CdS nanostrips were synthesized via a solvothermal method with some modifications in the procedure.[1] Briefly, 0.24 mmol $Cd(OAc)_2{\cdot}_2H_2O$ and 85 mmol thiourea ($SC(NH_2)_2$) were dispersed in 70 mL ethylenediamine and stirred for 1 h. The mixture was then transferred into a Teflon-lined stainless-steel autoclave, heated to 180 °C for 48 hours, and cooled naturally to room temperature. After that, the yellow solid was collected by centrifugation, washed with ethanol and deionized water several times, and dried in a 60 °C vacuum oven for 12 h.

3. List of prepared substrates *α*-trifluoromethyl alkene



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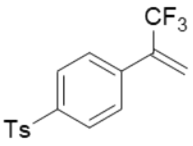

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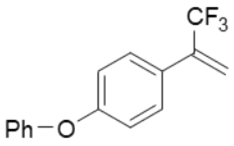

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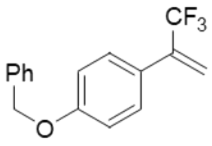

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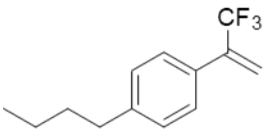

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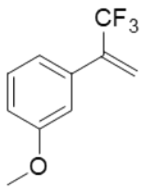

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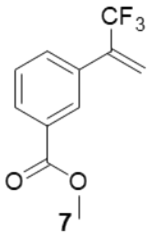

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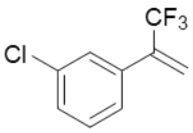

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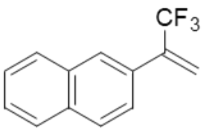

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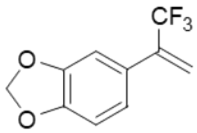

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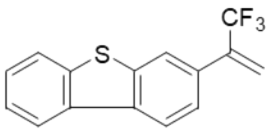

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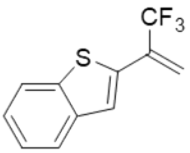

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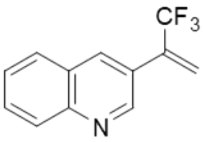

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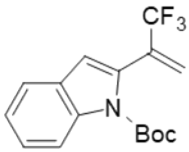

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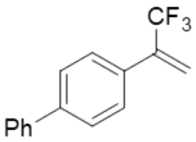

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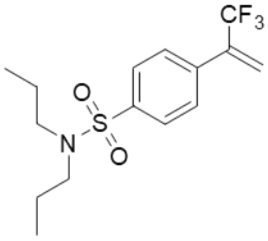

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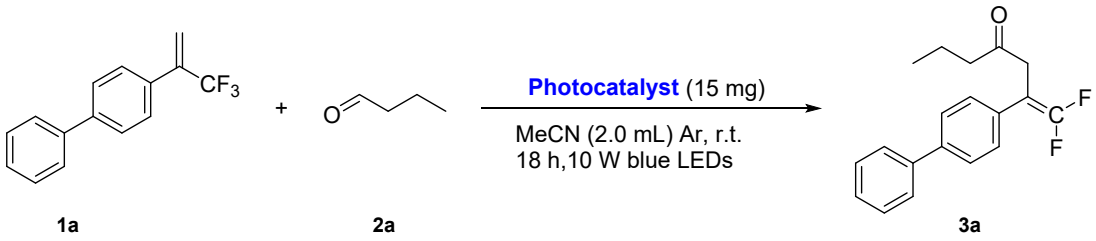
These substrates were prepared according to literature reports.[2, 3]

4. Optimization of the reaction conditions and control experiments

Table S1. Screening of photocatalyst

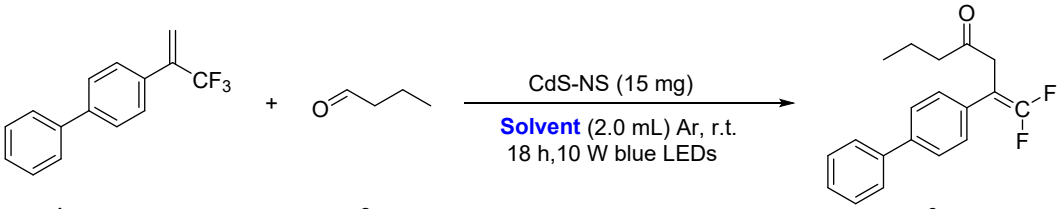


1a **2a** **3a**

Entry	Photocatalyst	Yield [%] **3a**
1	CdS nanostrips (CdS-NS)	39
2	Graphitic carbon nitride (g-C_3N_4)	NR
3	Titanium dioxide nanotube (TiO_2-NT)	8
4	Mesoporous graphitic carbon nitride (mpg-CN)	NR

General conditions: **1a** (0.15 mmol, 1.5 equiv), **2a** (0.1 mmol, 1 equiv), photocatalyst (15 mg) in MeCN (2.0 mL) was irradiated with 10 W blue LEDs at room temperature under Ar for 18 h.

Table S2. Screening of solvent

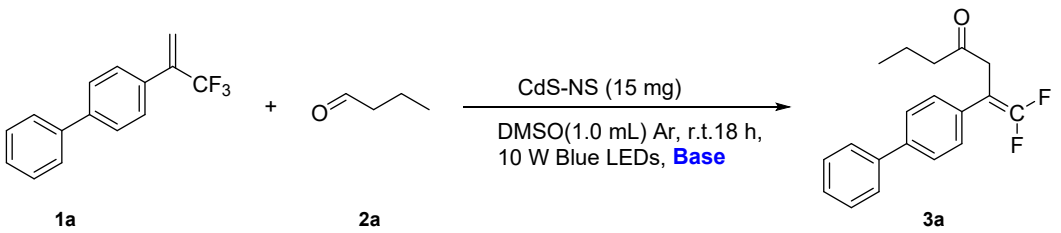


1a **2a** **3a**

Entry	Solvent	Yield [%] 3a
1	MeCN	39
2	DMSO	52
3	DMF	39
4	THF	26
5	EA	8
6	Toluene	16
7	DMSO (1 mL)	57

General conditions: **1a** (0.15 mmol, 1.5 equiv), **2a** (0.1 mmol, 1 equiv), CdS-nanostrips (15 mg) in different solvents (2 mL) were irradiated with 10 W blue LEDs at room temperature under Ar for 18 h.

Table S3. Screening of base

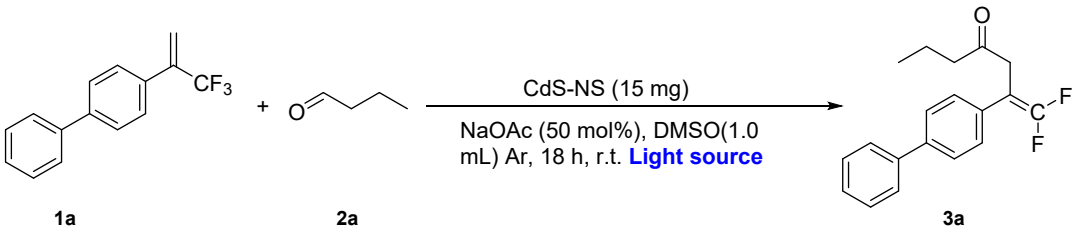


1a **2a** **3a**

Entry	Base		Yield [%] **3a**
1	K_3PO_4	(0.5 equiv)	38
2	NaH_2PO_4	(0.5 equiv)	33
3	NaOAc	(0.5 equiv)	69
4	NaOAc	(2.0 equiv)	52
5	Na_2HPO_4	(0.5 equiv)	34
6	DIPEA	(2.0 equiv)	20
7	Cs_2CO_3	(0.5 equiv)	trace

General conditions: **1a** (0.15 mmol, 1.5 equiv), **2a** (0.1 mmol, 1 equiv), CdS-nanostrips (15 mg), and different bases (0.5 to 2 equiv) in DMSO (1 mL) were irradiated with 10 W blue LEDs at room temperature under Ar for 18 h.

Table S4. Screening of different lights

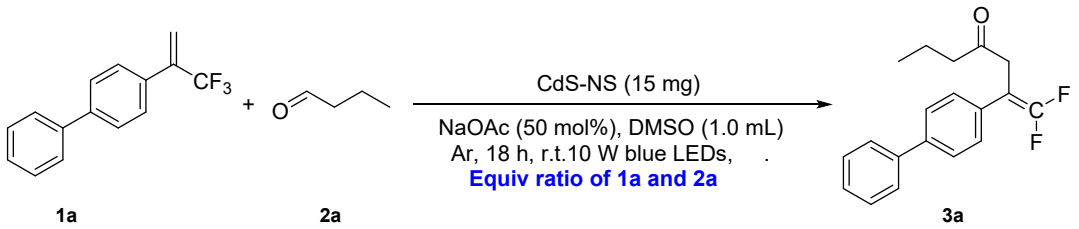


1a **2a** **3a**

Entry	light source	Yield [%] **3a**
1	Kessil lamp 455 nm	31
2	LEDs 395 nm	50
3	CFL 6000-6500K	40
4	Glob lamp	22
5	LEDs 455 nm	68

General conditions: **1a** (0.15 mmol, 1.5 equiv), **2a** (0.1 mmol, 1 equiv), CdS-nanostrips (15 mg), and NaOAc (0.075 mmol, 0.5 equiv) in DMSO (1 mL) were irradiated with a different light source at room temperature under Ar for 18 h.

Table S5. Evaluation of stoichiometric ratio

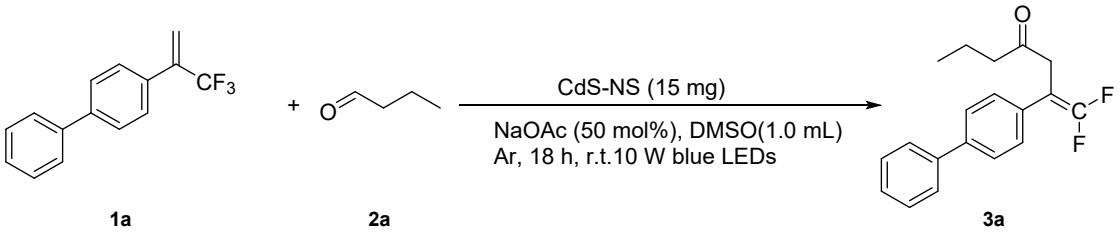


1a **2a** **3a**

Entry	Equiv ratio of 1a and 2a	Yield [%] **3a**
1	1a : 2a = 1 : 0.6	55
2	1a : 2a = 1 : 1.0	70
3	1a : 2a = 1 : 1.3	96
4	1a : 2a = 1 : 1.6	66
5	1a : 2a = 1 : 2.0	63

General conditions: **1a** (0.15 mmol, 1.0 equiv), **2a** (xx mmol, xx equiv), CdS-nanostrips (15 mg), and NaOAc base (0.5 equiv) in DMSO (1 mL) were irradiated with 10 W blue LEDs at room temperature under Ar for 18 h.

Table S6. Determination of the recyclability property



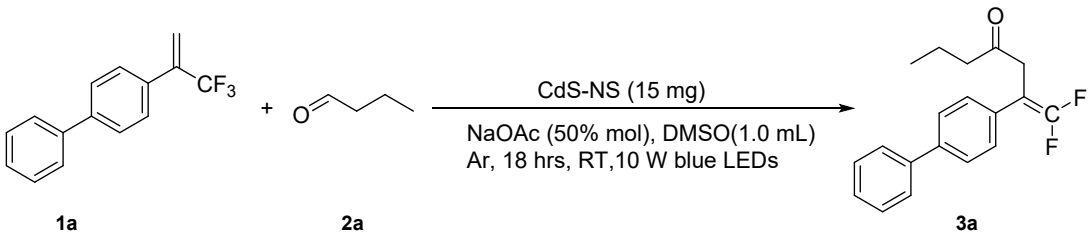
1a **2a** **3a**

Entry	Recyclability	Yield [%] 3a
1	Recycle 0	94
2	Recycle 1	84
3	Recycle 2	86
4	Recycle 3	87
5	Recycle 4	78

General conditions: **1a** (0.15 mmol, 1.0 equiv), **2a** (0.2 mmol, 1.3 equiv), CdS-nanostrips (15 mg), and NaOAc (0.5 equiv) in DMSO (1 mL) were irradiated with 10 W blue LEDs at room temperature under Ar for 18 h. By centrifuging the reaction mixture, the recovered catalyst was recycled and reused four times.

5. Mechanistic investigations

5.1 Control experiments



1a **2a** **3a**

Entry	Variation from the standard conditions	Yield [%] 3a
1	Under air	trace
2	Without light	n.r
3	Without catalyst	n.r
4	With TEOA	trace
5	With $K_2S_2O_8$	9
6	With TEMPO	n.d

General conditions: **1a** (0.15 mmol, 1.0 equiv), **2a** (0.2 mmol, 1.3 equiv), CdS-nanostrips (15 mg), NaOAc (0.5 equiv), and different electron-hole pairs inhibition reagents in DMSO (1 mL) were irradiated with 10 W blue LEDs at room temperature under Ar for 18 h.

5.2 Radical trapping experiment

Standard reaction was set up on a 0.15 mmol scale according to the general procedure. After 1 h of the reaction, a solution of TEMPO (118 mg, 5.0 equiv in dry DMSO) was added, and the mixture was irradiated for another 4 h. Then, the reaction mixture was sent for HRMS analysis, and HRMS detected the radical adduct. The resulting mass spectrum shows a peak corresponding to the coupled product between TEMPO radical and the expected acyl radical (HRMS): $C_{13}H_{25}NO_2^+$ $[M+H]^+$ Calcd 228.1958, Found 228.1960.

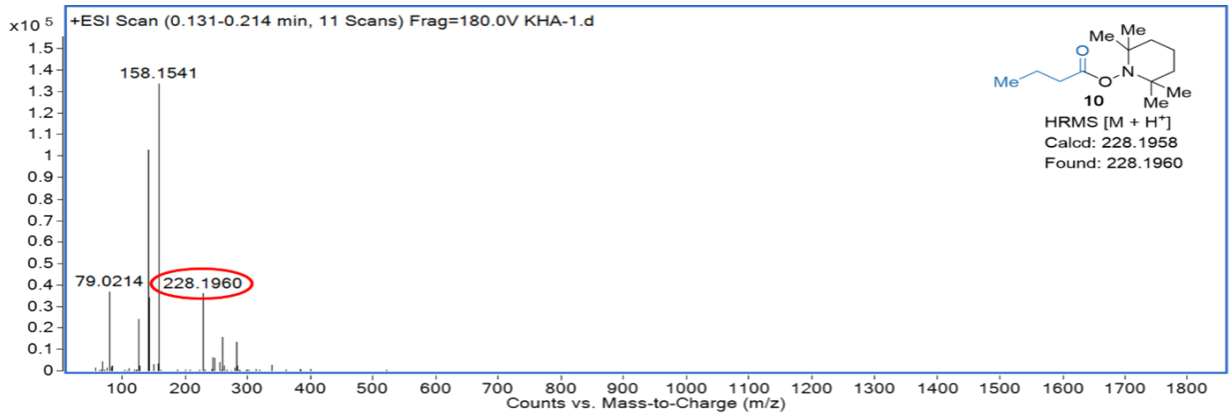


Figure S1: HR-MS spectrum of TEMPO adduct

6. Electron paramagnetic resonance (EPR) spectroscopy

Electron paramagnetic resonance (EPR) spectroscopy was conducted at normal room temperature using a JES-X320 spectrometer. A solution containing 5,5-dimethyl-l-pyrroline-N-oxide (DMPO) at a concentration of 50 mM was employed as the spin-trap agent for the paramagnetic species. To conduct in situ EPR measurements, a solution was prepared by adding **1a** (0.15 mmol, 1.0 equiv), **2a** (0.2 mmol, 1.3 equiv), NaOAc (0.5 equiv), CdS-nanostrips (15 mg), and 20 µL of DMPO to 1 mL of DMSO. The catalyst was then dispersed by sonication. Subsequently, the enclosed glass capillary containing the suspension mentioned earlier was inserted into a glass tube. Afterward, the glass tube was placed within the EPR cavity and exposed to radiation from a 300 W Xenon lamp. The resulting spectra were collected at specific intervals.

7. Photoelectrochemical measurements

We used a CHI 660B electrochemical instrument to record the photoelectrochemical measurements of the CdS nanostrips. An indium-tin oxide (ITO) glass measuring 1 cm by 3 cm was cleaned to prepare the working electrode. Furthermore, the Ag/AgCl electrode was used as the reference electrode and the carbon as the counter electrode. The electrolyte was a 0.1 M Na_2SO_4 aqueous solution, and the light source was a 40 W Kessil LED lamp (Kessil PR160-456 nm. After dispersing 5 mg of the photocatalysts in 1 mL of EtOH, 0.1 mL of a homogenous suspension was added dropwise straight onto the ITO glass surface. The ITO glass containing the samples was then allowed to dry at room temperature.

8. Stern–Volmer Fluorescence Quenching Studies

Fluorescence measurements were performed on a Steady-state/transient fluorescence spectrometer model QM400 using an excitation wavelength of 370 nm and a slit width of 5 nm. The emission intensity of CdS (0.05 M in DMSO) was recorded in a screw-capped quartz cuvette under oxygen-free conditions. To evaluate fluorescence quenching, a predetermined amount (a range of concentration) of substrate **1a** was added, followed by purging with Ar for 10 min prior to measurement. For substrate 2a, the same experimental procedure was followed. CdS fluorescence was measured under identical conditions after the addition of varying concentrations of 2a, with each sample purged with Ar for 10 min prior to analysis. No measurable change in fluorescence intensity was observed, indicating that substrate 2a does not quench the excited state of CdS under these conditions

Stern–Volmer analysis was conducted according to Stern Volmer equation:

$$I_0/I = 1 + K_q[Q]$$

where I_0 is the fluorescence intensity of CdS in the absence of quencher, I is the intensity in the presence of increasing concentrations of quencher, K_{sv} is the Stern–Volmer quenching constant, and [Q] represents the concentration of the quencher.

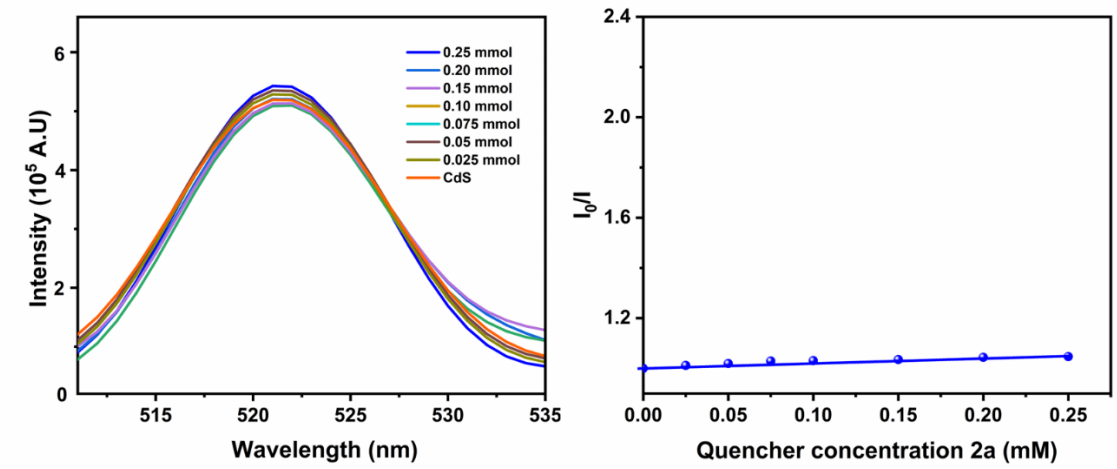


Figure S2: Stern–Volmer quenching studies of 2a

9. Characterization of recovered CdS nanosheets

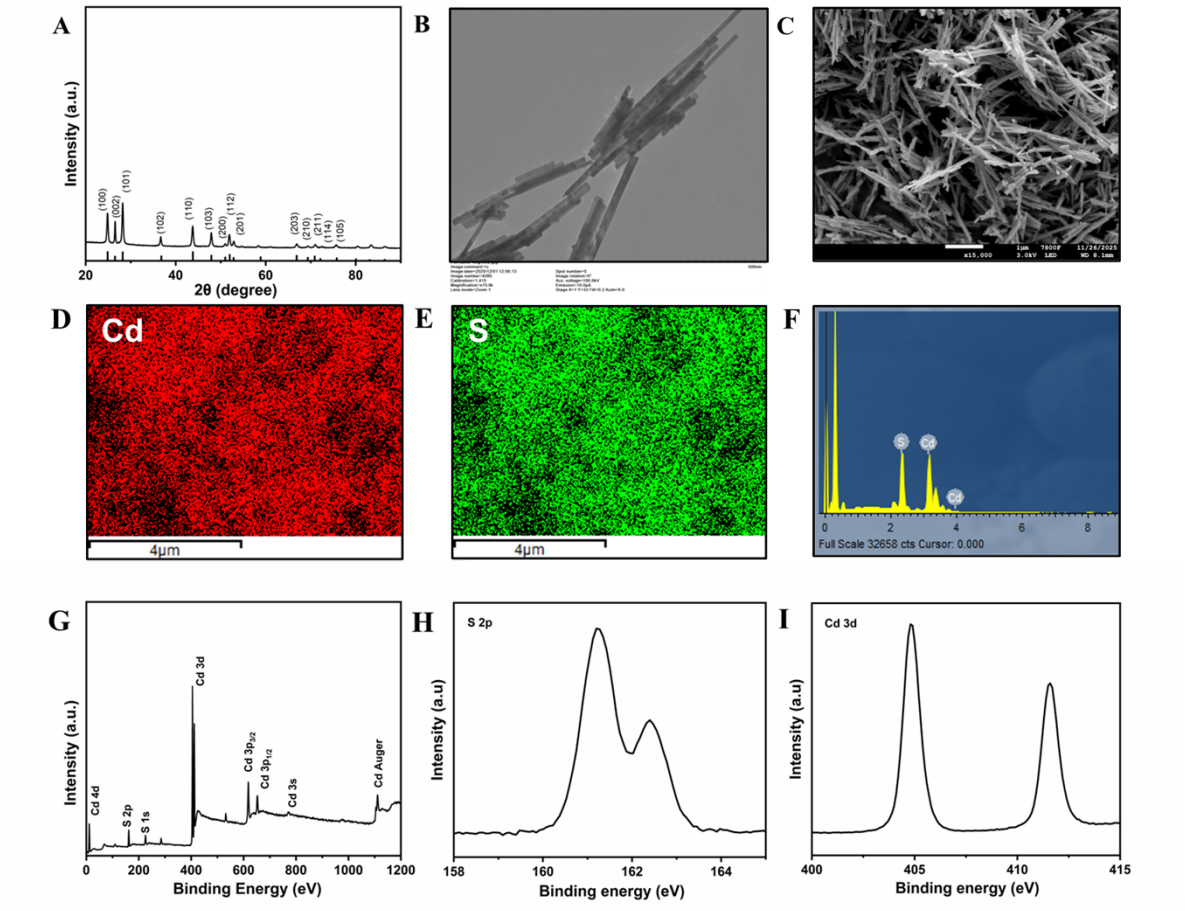


Figure S3: Characterization of recovered CdS nanostrips. A) XRD patterns. B) TEM image. C) SEM image. D) Elemental mapping Cd. E) Elemental mapping S. F) EDX analysis. G) XPS survey. H) S 2p XPS. I) Cd 3d XPS

The physical properties of the recovered catalyst were thoroughly characterized using XRD, TEM, SEM, and XPS. No noticeable structural or electronic changes were observed compared with the fresh CdS nanosheets. All characteristic peaks and features appeared at their expected positions, confirming that the structural integrity and optical properties of CdS were well preserved after catalysis.

10. Experimental Procedures

10.1 General Procedure for synthesis of *γ*,*γ*-difluoroallylic ketone

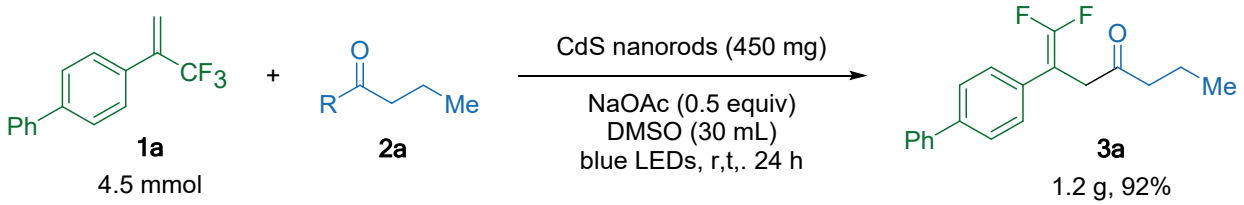
Condition a: The whole reaction was generally added inside the glove box. The CdS nanostrips (15 mg), *α*-trifluoromethyl alkenes (0.15 mmol, 1.0 equiv), butyraldehyde (0.2 mmol, 1.3 equiv), sodium acetate (0.075 mmol, 0.5 equiv), and dimethyl sulfoxide (1.0 mL) were added to an oven-dried reaction tube under an Ar atmosphere. The reaction tubes were closed with a rubber septum and sealed with parafilm tape. The reaction mixture was placed on a photoreactor, fixed the stirring at 700 rpm, and irradiated with a 10 W blue LED at room temperature (25 ºC) for 18 h. When the reaction was completed, 5 (mL) water was added to the reaction and extracted with ethyl acetate, washed with brine, dried over anhydrous sodium sulfate, concentrated in a vacuum rotatory evaporator, and purified by column chromatography (hexane/ethyl acetate) to afford the *γ*,*γ*-difluoroallylic ketones.

Condition b: The whole reaction was added inside the glove box. The CdS nanostrips (15 mg), *α*-trifluoromethyl alkenes (0.15 mmol, 1.0 equiv), benzaldehyde (0.2 mmol, 1.3 equiv), sodium acetate (0.075 mmol, 0.5 equiv), and acetonitrile (1.0 mL) were added to an oven-dried reaction tube under an Ar atmosphere. The reaction tubes were closed with a rubber septum and sealed with parafilm tape. The reaction mixture was placed on a photoreactor, fixed the stirring at 700 rpm, and irradiated with a 10 W blue LED at room temperature (25 ºC) for 18 h. When the reaction was completed, 5 (mL) water was added to the reaction and extracted with ethyl acetate, washed with brine, dried over anhydrous sodium sulfate, concentrated in a vacuum rotatory evaporator, and purified by column chromatography (hexane/ethyl acetate) to afford the *γ*,*γ*-difluoroallylic ketones.

10.2 Procedure for large-scale (gram-scale) reaction

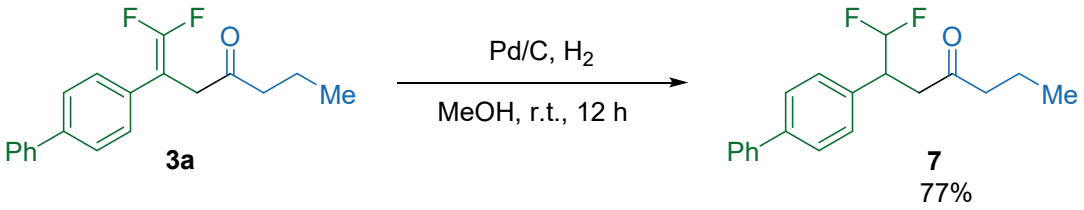
An oven-dried round-bottom flask (100 mL) equipped with a magnetic stir bar was charged with *α*-trifluoroalkene **1a** (4.5 mmol), butyraldehyde **2a** (6.0 mmol), CdS nanostrips (450 mg), NaOAc (2.2 mmol), and anhydrous dimethyl sulfoxide (30 mL) under an Ar atmosphere in the glove box. A rubber septum tightly enclosed the vessel under an Ar atmosphere and was secured with parafilm tape to ensure it was completely packed. The mixture was irradiated with blue LEDs approximately a distance of approximately 3 cm from the reaction. For 24 h under continuous stirring at 800 rpm. The table fan was fixed with the reaction to maintain the temperature of the reaction. Then the reaction mixture was filtered, and 100 mL of distilled water was added, extracted with ethyl acetate (3 × 100 mL), washed with brine solution, dried over anhydrous sodium sulfate, and concentrated under reduced pressure. The crude product was purified by

flash column chromatography on silica gel using the indicated solvent system (hexane: ethyl acetate, 20:1) to afford the product with 92% yield.



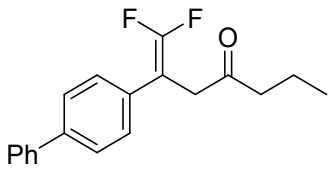
10.3 Selective transformations of product 3a

The oven-dried reaction tube was charged with 2-([1,1'-biphenyl]-4-yl)-1,1-difluorohept-1-en-4-one (**3a)** (60.0 mg, 0.2 mmol), MeOH (2.0 mL), and 10% Pd/C (8.4 mg), then the tube was evacuated and backfilled with H_2 four times, and placement of hydrogen (balloon) was placed in the reaction tube. The resulting solution was stirred at room temperature for 12 h. Upon completion, the mixture was quenched with H_2O and extracted with EtOAc (3 x 20 mL). The combined organic phases were washed with brine solution, dried with anhydrous sodium sulfate, filtered, and concentrated under reduced pressure. The crude product **7** was purified by flash column chromatography (SiO_2 200- 300 mesh; gradient eluent: PE/EA= 100/5) to yield **7** (46.6 mg, 77%) as a yellow liquid.



11. Characterization data of products

3a. 2-([1,1'-biphenyl]-4-yl)-1,1-difluorohept-1-en-4-one

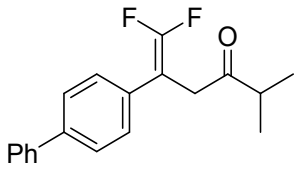


According to the general procedure, **condition a**. Light yellow solid, yield 94% (42.3 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 (dd, *J* = 8.0, 2.0 Hz, 4H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.40 – 7.35 (m, 3H), 3.49 (d, *J* = 1.8 Hz, 2H), 2.46 (t, *J* = 7.3 Hz, 2H), 1.62 (dd, *J* = 14.7, 7.4 Hz, 2H), 0.90 (t, *J* = 7.4 Hz, 3H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.8, 154.9 (dd, *J* = 293.7, 288.4 Hz), 140.5, 140.4, 132.2 (t, *J* = 4.1 Hz), 128.9,

128.4 – 128.2 (m), 127.6, 127.3, 127.1, 87.1 (dd, *J* = 22.1, 16.3 Hz), 44.0, 42.2 (d, *J* = 1.9 Hz), 17.2, 13.7.**^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.45 (dt, *J* = 35.5, 2.1 Hz), -88.66 (d, *J* = 35.6 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{19}H_{18}F_2OH^+$ 301.1402, found 301.1400. The compound data are in agreement with the literature[3]

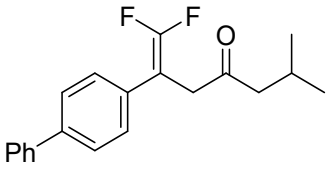
3b. 5-([1,1'-biphenyl]-4-yl)-6,6-difluoro-2-methylhex-5-en-3-one



According to the general procedure, **condition a**. Yellow solid, yield 70% (31.5 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.53 (m, 4H), 7.43 (t, *J* = 7.6 Hz, 2H), 7.35 (d, *J* = 8.4 Hz, 3H), 3.55 (t, *J* = 2.1 Hz, 2H), 2.71 (dt, *J* = 13.8, 6.9 Hz, 1H), 1.13 (s, 3H), 1.11 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 210.1, 154.8, 140.4, 140.2, 132.3, 128.8, 128.2 (t, *J* = 3.5 Hz), 127.4, 127.2, 127.0, 87.5 – 86.4 (m), 40.3, 39.8, 18.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -86.78 – -88.21 (m), -88.95 (d, *J* = 36.3 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{19}H_{18}F_2OH^+$ 301.1402, found 301.1391. The compound data are in agreement with the literature[3]

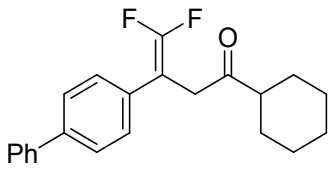
3c. 2-([1,1'-biphenyl]-4-yl)-1,1-difluoro-6-methylhept-1-en-4-one



According to general procedure **condition a**. Yellow solid, yield 93% (43.8 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.56 (m, 4H), 7.45 (dd, *J* = 10.4, 4.7 Hz, 2H), 7.40 – 7.33 (m, 3H), 3.47 (t, *J* = 2.1 Hz, 2H), 2.35 (d, *J* = 6.9 Hz, 2H), 2.16 (dt, *J* = 13.5, 6.7 Hz, 1H), 0.91 (s, 3H), 0.90 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.3, 154.8 (dd, *J* = 293.7, 288.3 Hz), 140.4, 140.3 (s, *J* = 11.6 Hz), 132.2 (t, *J* = 4.1 Hz), 128.8, 127.5, 127.2, 127.0, 87.0 (dd, *J* = 22.2, 16.3 Hz), 50.9, 42.6 (d, *J* = 1.9 Hz), 24.5, 22.5. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.47 (dt, *J* = 35.7, 2.3 Hz), -88.73 (d, *J* = 35.7 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{20}H_{20}F_2OH^+$ 315.1560, found 315.1574.

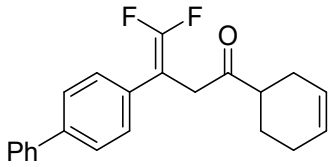
3d. 3-([1,1'-biphenyl]-4-yl)-1-cyclohexyl-4,4-difluorobut-3-en-1-one



According to the general procedure **condition a**, yellow oil was obtained with a yield of 89% (43.8 mg). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.61 – 7.55 (m, 4H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.35 (d, *J* = 6.2 Hz, 3H), 3.54 (t, *J*

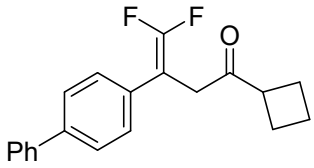
= 2.1 Hz, 2H), 2.45 (tt, *J* = 11.2, 3.3 Hz, 1H), 1.81 (ddd, *J* = 12.2, 8.5, 7.8 Hz, 4H), 1.44 – 1.14 (m, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 209.3, 154.7 (dd, *J* = 293.2, 288.1 Hz), 140.4, 140.2, 128.8, 128.3 – 128.1 (m), 127.4, 127.2, 127.0, 86.9 (dd, *J* = 22.1, 16.5 Hz), 50.2, 40.1 (d, *J* = 2.0 Hz), 28.5, 25.7, 25.6 **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.87 (dt, *J* = 36.3, 2.2 Hz), -88.95 (d, *J* = 36.4 Hz). **HRMS (ESI)** m/z $[M+Na]^+$ calcd for $C_{22}H_{22}F_2ONa^+$ 363.1531, found 363.1520. The compound data is in agreement with the literature[3]

3e. 3-([1,1'-biphenyl]-4-yl)-1-(cyclohex-3-en-1-yl)-4,4-difluorobut-3-en-1-one



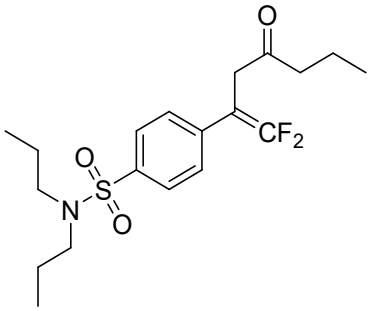
According to the general procedure **condition, a**. Yellow oil, yield 83% (42.1 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.55 (m, 4H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.35 (t, *J* = 8.0 Hz, 3H),5.70 (s, 2H), 3.71 – 3.47 (m, 2H), 2.81 – 2.60 (m, 1H), 2.25 – 2.14 (m, 2H), 2.14 – 2.06 (m, 2H), 1.73 – 1.48 (m, 2H). **^{13}C NMR** (176 MHz, $CDCl_3$) δ 212.8 – 205.0 (m), 154.8 (dd, *J* = 293.3, 288.2 Hz), 140.4, 140.2, 132.3 (t, *J* = 4.0 Hz), 128.8, 128.2 (t, *J* = 3.5 Hz), 127.4, 127.2, 127.0, 126.7, 125.1, 86.9 (dd, *J* = 22.1, 16.5 Hz), 46.0, 40.2 (d, *J* = 1.8 Hz), 26.8, 24.6 (d, *J* = 4.9 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.75 (dd, *J* = 36.1, 2.0 Hz), -88.82 (d, *J* = 36.1 Hz). **HRMS (ESI**) m/z $[M+H]^+$ calcd for $C_{22}H_{20}F_2OH^+$ 339.1555, found 339.1538.

3f. 3-([1,1'-biphenyl]-4-yl)-1-cyclobutyl-4,4-difluorobut-3-en-1-one



According to the general procedure **conditions, a.** White solid, yield 91% (42.6 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.56 (m, 4H), 7.44 (dd, *J* = 10.3, 4.8 Hz, 2H), 7.40 – 7.33 (m, 3H), 3.45 (t, *J* = 2.2 Hz, 2H), 3.40 – 3.29 (m, 1H), 2.31 – 2.08 (m, 4H), 2.04 – 1.76 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 207.4, 154.8 (dd, *J* = 293.6, 288.4 Hz), 140.4, 140.3, 132.2 (t, *J* = 4.1 Hz), 128.8, 128.2 – 128.0 (m), 127.4, 127.2, 127.0, 86.8 (dd, *J* = 22.1, 16.2 Hz), 44.8, 39.5 (d, *J* = 1.9 Hz), 24.4, 17.7. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.52 (dt, *J* = 35.7, 2.4 Hz), -88.65 (d, *J* = 35.6 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{20}H_{19}F_2OH^+$ 313.1398, found 313.1388.

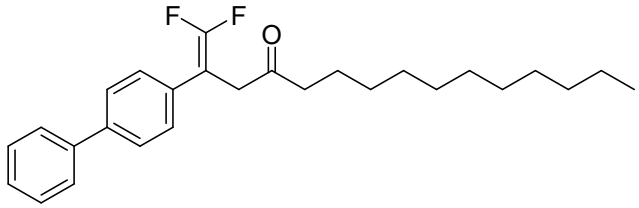
3g. 4-(1,1-difluoro-4-oxohept-1-en-2-yl)-N,N-dipropylbenzenesulfonamide



According to the general procedure, **condition a**. White solid, yield 72% (41.8 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (dd, *J* = 8.3, 4.4 Hz, 2H), 7.42 (t, *J* = 10.4 Hz, 2H), 3.48 (t, *J* = 2.0 Hz, 2H), 3.10 – 3.02 (m, 4H), 2.52 – 2.38 (m, 2H), 1.67 – 1.47 (m, 6H), 1.02 – 0.75 (m, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.1 – 205.9 (m), 155.1 (dd, *J* = 295.4, 290.1 Hz), 138.9, 86.6 (dd, *J* = 23.1, 15.7 Hz), 50.1, 44.1, 41.6 (d, *J* = 1.8 Hz), 22.1, 17.1, 13.5, 11.1. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -85.13 (dt, *J* = 30.6, 2.3 Hz), -86.75 (d, *J* = 30.5 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{19}H_{27}F_2NO_3SH^+$ 388.1752, found 388.1757.

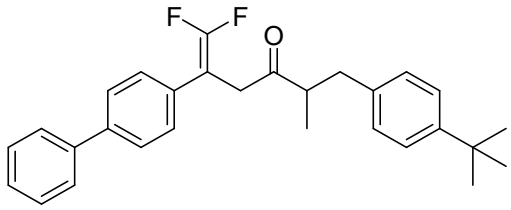
3h. 2-([1,1'-biphenyl]-4-yl)-1,1-difluoropentadec-1-en-4-one



According to the general procedure **condition, a. White solid, yield** 91% (56.2 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.56 (m, 4H), 7.44 (t, J = 7.5 Hz, 2H), 7.39 – 7.33 (m, 3H), 3.49 (s, 2H), 2.47 (t, J = 7.4 Hz, 2H), 1.62 – 1.52 (m, 2H), 1.30-1.25 (m, 16H), 0.88 (t, J = 6.8 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 207.00 – 205.99 (m), 154.84 (dd, J = 293.6, 288.4 Hz), 140.42, 140.34, 132.16 (t, J = 4.0 Hz), 128.82, 128.27 – 128.08 (m), 127.49, 127.27, 127.02, 87.05 (dd, J = 22.1, 16.2 Hz), 42.94 – 41.27 (m), 31.92, 29.62, 29.47, 29.38, 29.35, 29.12, 23.71, 22.70, 14.13. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.40 – -87.56 (m), -88.66 (d, J = 35.5 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{27}H_{34}F_2O^+$ 413.2656, found 413.2652

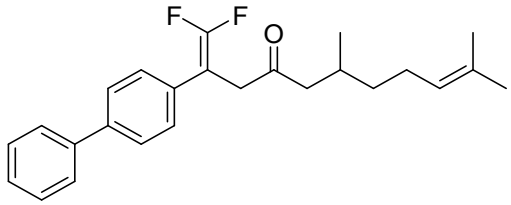
3i. 5-([1,1'-biphenyl]-4-yl)-1-(4-(tert-butyl)phenyl)-6,6-difluoro-2-methylhex-5-en-3-one



According to the general procedure, **condition, a**. Pale yellow solid, yield 86% (55.7 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 (dd, J = 8.1, 1.0 Hz, 2H), 7.53 (d, J = 8.4 Hz, 2H), 7.44 (dd, J = 9.3, 4.7 Hz, 2H), 7.38 – 7.27 (m, 3H), 7.24 (d, J = 7.4 Hz, 2H), 7.04 (d, J = 8.3 Hz, 2H), 3.47 (dt, J = 17.7, 2.1 Hz, 1H), 3.33 (dt, J = 17.8, 2.2 Hz, 1H), 2.98 – 2.88 (m, 2H), 2.58 (dt, J = 12.2, 4.4 Hz, 1H), 1.29 (m, 9H), 1.12 – 1.08 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 209.88, 160.12 – 159.33 (m), 149.22, 140.46, 140.18, 136.26, 132.22, 128.82, 128.60, 128.16 (d, J = 3.5 Hz), 127.45, 127.17, 127.02, 125.38, 86.90, 47.41, 41.64, 38.75, 34.39, 31.37, 16.76. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.36 (dt, J = 35.4, 2.3 Hz), -88.67 (d, J = 35.3 Hz).**HRMS (ESI)** m/z $[M+Na]^+$ calcd for $C_{29}H_{30}F_2O^+$ 455.2162, found 455.2133

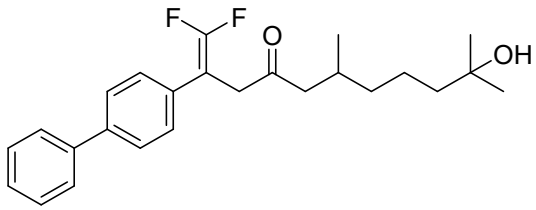
3j. 2-([1,1'-biphenyl]-4-yl)-1,1-difluoro-6,10-dimethylundeca-1,9-dien-4-one



According to the general procedure, **condition a**. White solid, yield 81% (46.4 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.55 (m, 4H), 7.44 (t, J = 7.5 Hz, 2H), 7.39 – 7.32 (m, 3H), 5.10 – 5.02 (m, 1H), 3.47 (t, J = 2.0 Hz, 2H), 2.45 (dd, J = 16.1, 5.7 Hz, 1H), 2.28 (dd, J = 16.1, 8.1 Hz, 1H), 2.06 – 1.89 (m, 3H), 1.66 (d, J = 0.7 Hz, 3H), 1.57 (s, 3H), 1.19 (ddd, J = 8.9, 7.8, 6.2 Hz, 3H), 0.87 (d, J = 6.6 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.47, 157.71, 140.43, 140.33, 132.16, 131.63, 128.82, 128.34 – 128.07 (m), 127.48, 127.26, 127.03, 124.19, 86.89 (d, J = 16.4 Hz), 49.46, 42.60, 36.86, 28.87, 25.70, 25.42, 19.68, 17.65. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.47 (dt, J = 35.6, 2.2 Hz), -88.73 (d, J = 35.6 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{25}H_{28}F_2O^+$ 383.2186, found 383.2168

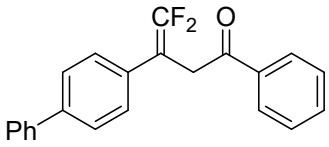
3k. 2-([1,1'-biphenyl]-4-yl)-1,1-difluoro-10-hydroxy-6,10-dimethylundec-1-en-4-one



According to the general procedure, **condition a**. White solid, yield 79% (47.4 mg).

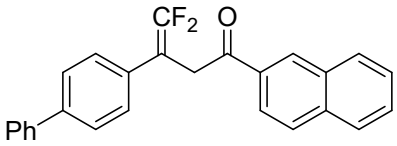
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 (dd, J = 8.0, 1.5 Hz, 4H), 7.43 (t, J = 7.5 Hz, 2H), 7.39 – 7.32 (m, 3H), 4.12 (q, J = 7.1 Hz, 1H), 3.47 (d, J = 1.9 Hz, 2H), 2.45 (dd, J = 16.2, 5.9 Hz, 1H), 2.29 (dd, J = 16.2, 7.8 Hz, 1H), 2.08 – 1.96 (m, 1H), 1.45 – 1.34 (m, 2H), 1.29 – 1.22 (m, 2H), 1.18 (s, 6H), 1.17 – 1.10 (m, 2H), 0.87 (d, J = 6.6 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.49 (d, J = 3.0 Hz), 154.83 (dd, J = 293.7, 288.4 Hz), 140.35 (d, J = 7.5 Hz), 132.15 (t, J = 4.0 Hz), 128.84, 128.28 – 128.16 (m), 127.51, 127.25, 127.01, 87.01 (dd, J = 22.1, 16.3 Hz), 70.92, 70.92, 60.43, 49.46, 43.87, 42.63 (d, J = 1.8 Hz), 37.24, 29.84 – 28.55 (m), 21.66, 19.77, 14.21. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.45 (dt, J = 35.6, 2.2 Hz), -88.72 (d, J = 35.7 Hz). **HRMS (ESI)** m/z $[M+Na]^+$ calcd for $C_{25}H_{30}F_2O_2^+$ 423.2112, found 423.2096

4a. 3-([1,1'-biphenyl]-4-yl)-4,4-difluoro-1-phenylbut-3-en-1-one



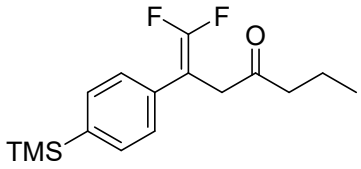
According to the general procedure, **condition b**. White solid, yield 67% (32.2 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 (dd, *J* = 3.8, 0.9 Hz, 2H), 7.67 (dd, *J* = 5.0, 0.9 Hz, 2H), 7.56 (dd, *J* = 8.2, 2.0 Hz, 2H), 7.45 – 7.39 (m, 4H), 7.34 (d, *J* = 7.4 Hz, 2H), 7.15 (dd, *J* = 4.9, 3.9 Hz, 2H), 4.03 (t, *J* = 2.1 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 191.1, 159.2 – 150.7 (m), 140.4 (d, *J* = 5.8 Hz), 134.9, 132.4, 132.1, 131.0, 129.7, 128.8, 128.7, 128.2 (t, *J* = 3.5 Hz), 127.4, 127.2, 127.0, 86.7 (d, *J* = 22.1 Hz), 38.2 (d, *J* = 2.4 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -90.14 (d, *J* = 42.0 Hz), -90.57 (d, *J* = 42.0 Hz). The compound data are in agreement with the literature[5]

4b. 3-([1,1'-biphenyl]-4-yl)-4,4-difluoro-1-(naphthalen-2-yl)but-3-en-1-one



According to general procedure **condition b**. Colorless oil, yield 46% (33.5 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (dd, *J* = 8.6, 1.5 Hz, 1H), 7.97 (d, *J* = 8.0 Hz, 1H), 7.94 – 7.88 (m, 1H), 7.63 (t, *J* = 7.4 Hz, 2H), 7.58 (m, *J* = 7.3 Hz, 5H), 7.43 (t, *J* = 7.4 Hz, 4H), 7.34 (t, *J* = 7.3 Hz, 1H), 4.25 (s, 2H). **^{13}C NMR** (176 MHz, $CDCl_3$) δ 188.6 – 188.2 (m), 158.2 – 152.5 (m), 143.4 , 143.2 , 141.3 , 140.5, 140.4, 140.3, 134.3, 134.1, 132.2, 132.2, 129.4, 128.8 (d, *J* = 3.0 Hz), 128.3 (t, *J* = 3.5 Hz), 128.2, 127.5 (d, *J* = 2.1 Hz), 127.4, 127.5, 127.0, 86.9 (dd, *J* = 21.7, 17.5 Hz), 39.2 – 38.2 (m). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.46 (d, *J* = 35.9 Hz), -88.40 (d, *J* = 35.9 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{26}H_{18}F_2OH^+$ 385.1398, found 385.1399.

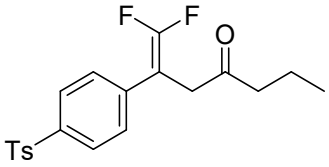
5a. 1,1-difluoro-2-(4-(trimethylsilyl)phenyl)hept-1-en-4-one



According to the general procedure, **condition a**. Yellow solid, yield 89% (39.5 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 8.1 Hz, 2H), 7.28 (d, *J* = 1.1 Hz, 2H), 3.44 (t, *J* = 2.1 Hz, 2H), 2.43 (t, *J* = 7.3 Hz, 2H), 1.59 (dd, *J* = 14.7, 7.4 Hz, 2H), 0.89 (t, *J* = 7.4 Hz, 3H), 0.26 (s, 9H). **^{13}C NMR** (101 MHz, CDCl3) δ 207.8 (d, J = 2.4 Hz), 207.8, 156.0 (dd, J = 293.7, 288.2 Hz), 141.1, 134.7 (s, J = 24.0 Hz), 129.4 – 127.6 (m), 88.4 (dd, J = 21.9, 16.2 Hz), 45.0, 43.2 (d, J = 1.9 Hz), 18.3, 14.8. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.54 (dt, *J* = 35.5, 2.1 Hz), -88.84 (d, *J* = 35.5 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{16}H_{23}F_2OSiH^+$ 297.1481, found 297.1474.

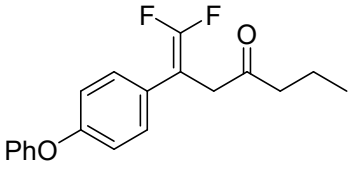
5b. 1,1-difluoro-2-(4-tosylphenyl)hept-1-en-4-one



According to the general procedure, **condition a**. Yellow solid, yield 90% (51.1 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, *J* = 8.3 Hz, 2H), 7.30 (d, *J* = 8.1 Hz, 2H), 7.19 (d, *J* = 8.2 Hz, 2H), 6.94 (d, *J* = 8.7 Hz, 2H), 3.40 (t, *J* = 1.9 Hz, 2H), 2.44 (s, 3H), 2.41 (t, *J* = 7.3 Hz, 2H), 1.57 (dd, *J* = 14.7, 7.4 Hz, 2H), 0.86 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 210.3 – 203.3 (m), 154.8 (dd, *J* = 293.9, 288.8 Hz), 148.6, 145.5, 132.3 (dd, *J* = 9.1, 4.9 Hz), 129.8, 129.3 – 129.0 (m), 128.5, 122.5, 86.4 (dd, *J* = 22.9, 16.3 Hz), 44.0, 42.0 (d, *J* = 1.8 Hz), 21.7, 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -86.98 (dd, *J* = 19.2, 17.2 Hz), -88.38 (d, *J* = 34.2 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{20}H_{20}F_2O_3SH^+$ 379.1179, found 379.1186.

5c. 1,1-difluoro-2-(4-phenoxyphenyl)hept-1-en-4-one

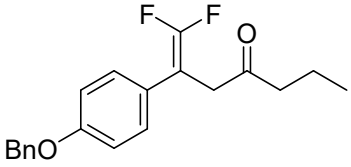


According to general procedure **condition a**. Yellow oil, yield 87% (41.2 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (ddd, *J* = 16.0, 10.0, 6.9 Hz, 5H), 7.22 (d, *J* = 8.1 Hz, 2H), 7.00 – 6.91 (m, 2H), 5.06 (s, 2H), 3.41 (t, *J* = 2.1 Hz, 2H), 2.41 (t, *J* = 7.3 Hz, 2H), 1.57 (dd, *J* = 14.7, 7.4 Hz, 2H), 0.88

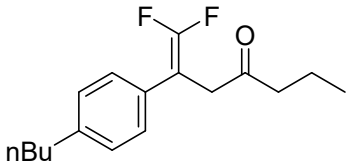
(t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.8 (d, *J* = 2.3 Hz), 158.0, 154.6 (dd, *J* = 292.1, 287.5 Hz), 136.8, 129.1 (t, *J* = 3.6 Hz), 128.6, 128.0, 127.4, 125.6 (t, *J* = 3.9 Hz), 114.9, 86.7 (dd, *J* = 22.1, 16.7 Hz), 70.0, 43.8, 42.32 (d, *J* = 1.8 Hz), 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -89.11 (dt, *J* = 39.0, 2.3 Hz), -90.12 (d, *J* = 38.9 Hz). **HRMS (ESI)** m/z $[M+Na]^+$ calcd for $C_{19}H_{18}F_2O_2Na^+$ 339.1167, found 339.1188.

5d. 2-(4-(benzyloxy)phenyl)-1,1-difluorohept-1-en-4-one



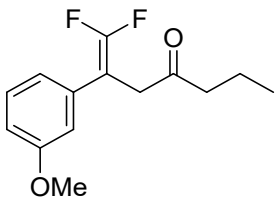
According to the general procedure, **condition a**. Green solid, yield 81% (40.1 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.32 (m, 5H), 7.21 (d, *J* = 8.2 Hz, 2H), 6.94 (d, *J* = 8.8 Hz, 2H), 5.06 (s, 2H), 3.41 (d, *J* = 1.9 Hz, 2H), 2.40 (t, *J* = 7.3 Hz, 2H), 1.57 (dd, *J* = 14.7, 7.3 Hz, 2H), 0.88 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.9 (d, *J* = 2.4 Hz), 158.0, 154.5 (dd, *J* = 292.1, 287.5 Hz), 136.7, 129.0 (t, *J* = 3.6 Hz), 128.6, 128.0, 127.5, 125.6 (t, *J* = 3.9 Hz), 114.9, 86.7 (dd, *J* = 22.1, 16.7 Hz), 70.0, 43.8, 42.3 (d, *J* = 1.8 Hz), 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -88.98 – -89.19 (m), -90.12 (d, *J* = 38.9 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{17}H_{22}F_2O_2H^+$ 297.1661, found 297.1657.

5e. 2-(4-butylphenyl)-1,1-difluorohept-1-en-4-one



According to the general procedure, **condition a**. Yellow solid, yield 53% (22.5 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22 – 7.18 (m, 2H), 7.15 (d, *J* = 8.3 Hz, 2H), 3.43 (t, *J* = 2.1 Hz, 2H), 2.62 – 2.55 (m, 2H), 2.42 (t, *J* = 7.3 Hz, 2H), 1.64 – 1.54 (m, 4H), 1.35 (dq, *J* = 14.5, 7.3 Hz, 2H), 0.92 (t, *J* = 7.3 Hz, 3H), 0.88 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 208.7 – 205.3 (m), 154.6 (dd, *J* = 292.9, 287.6 Hz), 142.3, 130.3 (t, *J* = 4.0 Hz), 128.6, 127.7 – 127.4 (m), 87.1 (dd, *J* = 21.8, 16.5 Hz), 43.8, 42.2 (d, *J* = 2.0 Hz), 35.2, 33.4, 22.3, 17.1, 13.9, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -88.44 (dt, *J* = 37.5, 2.3 Hz), -89.56 (d, *J* = 37.5 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{17}H_{22}F_2OH^+$ 281.1711, found 281.1714.

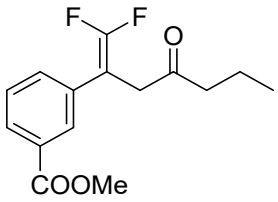
5f. 1,1-difluoro-2-(3-methoxyphenyl)hept-1-en-4-one



According to the general procedure, **condition a**. Colorless oil, yield 75% (28.5 mg).

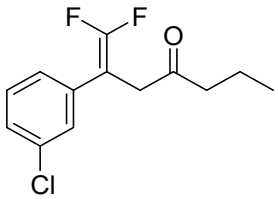
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 – 7.27 (m, 1H), 6.89 (d, *J* = 7.8 Hz, 1H), 6.87 (d, *J* = 0.9 Hz, 1H), 6.85 – 6.78 (m, 1H), 3.82 (s, 3H), 3.46 (t, *J* = 2.2 Hz, 2H), 2.45 (t, *J* = 7.3 Hz, 2H), 1.66 – 1.56 (m, 2H), 0.91 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.6, 159.6, 154.8 (dd, *J* = 293.4, 288.0 Hz), 134.6 (d, *J* = 4.0 Hz), 129.5, 120.2 (t, *J* = 3.5 Hz), 114.2 – 113.6 (m), 112.9, 87.2 (dd, *J* = 22.1, 16.3 Hz), 55.2, 43.9, 42.2 (d, *J* = 1.9 Hz), 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.70 (dt, *J* = 35.6, 2.4 Hz), -88.53 (d, *J* = 35.5 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{14}H_{16}F_2O_2H^+$ 255.1197, found 255.1203.

5g. methyl 3-(1,1-difluoro-4-oxohept-1-en-2-yl)benzoate



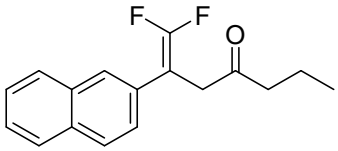
According to the general procedure, **condition a**. Yellow solid, yield 89% (37.6 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (dd, *J* = 6.9, 1.3 Hz, 2H), 7.50 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.42 (t, *J* = 8.1 Hz, 1H), 3.91 (s, 3H), 3.48 (t, *J* = 2.1 Hz, 2H), 2.43 (t, *J* = 7.3 Hz, 2H), 1.63 – 1.54 (m, 2H), 0.88 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.2 (d, *J* = 3.2 Hz), 166.7, 154.9 (dd, *J* = 293.7, 288.8 Hz), 133.7 (t, *J* = 4.2 Hz), 132.6 – 132.3 (m), 130.5, 128.8 (t, *J* = 3.5 Hz), 128.7, 128.6, 86.7 (dd, *J* = 22.8, 16.5 Hz), 52.2, 44.1, 41.9 (d, *J* = 1.9 Hz), 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.20 (dd, *J* = 34.5, 1.6 Hz), -88.51 (d, *J* = 34.5 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{15}H_{16}F_2O_3H^+$ 283.1140, found 283.1137.

5h. 2-(3-chlorophenyl)-1,1-difluorohept-1-en-4-one



According to the general procedure, **condition a**. Yellow solid, yield 72% (38.2 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 – 7.22 (m, 3H), 7.19 – 7.15 (m, 1H), 3.43 (t, *J* = 2.2 Hz, 2H), 2.43 (t, *J* = 7.3 Hz, 2H), 1.67 – 1.56 (m, 2H), 0.89 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.1, 154.9 (dd, *J* = 294.1, 289.0 Hz), 135.1 (t, *J* = 4.2 Hz), 134.4, 129.8, 128.2 – 127.8 (m), 127.7, 126.0 (t, *J* = 3.5 Hz), 86.5 (dd, *J* = 23.0, 16.3 Hz), 44.1, 41.8 (d, *J* = 1.8 Hz), 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -86.80 (dd, *J* = 33.5, 1.8 Hz), -87.92 (d, *J* = 33.5 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{13}H_{13}ClF_2OH^+$ 259.0696, found 259.0682.

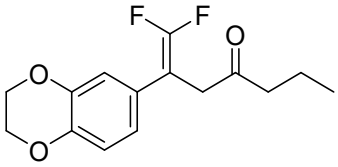
5i. 1,1-difluoro-2-(naphthalen-2-yl)hept-1-en-4-one



According to the general procedure, **condition a**. Brown solid, yield 93% (38.3 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 – 7.78 (m, 3H), 7.73 (s, 1H), 7.50 – 7.46 (m, 2H), 7.44 (dd, *J* = 5.1, 3.4 Hz, 1H), 3.55 (t, *J* = 2.2 Hz, 2H), 2.45 (t, *J* = 7.3 Hz, 2H), 1.60 (dd, *J* = 14.7, 7.4 Hz, 2H), 0.88 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.6 (d, *J* = 3.2 Hz), 155.0 (dd, *J* = 293.5, 288.6 Hz), 133.2, 132.5, 130.7 (t, *J* = 4.0 Hz), 128.2, 128.0, 127.6, 127.0 (t, *J* = 3.6 Hz), 126.4, 126.3, 125.6 (dd, *J* = 4.5, 2.6 Hz), 87.4 (dd, *J* = 22.1, 16.4 Hz), 44.0, 42.3 (d, *J* = 1.9 Hz), 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.40 – -87.62 (m), -88.77 – -88.99 (m). **HRMS (ESI)** m/z $[M+K]^+$ calcd for $C_{17}H_{16}F_2OK^+$ 313.0801, found 313.0815.

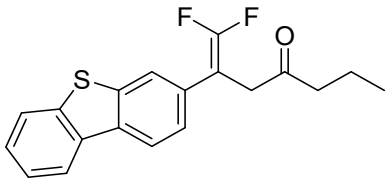
5j. 2-(2,3-dihydrobenzo[b][1,4]dioxin-6-yl)-1,1-difluorohept-1-en-4-one



According to the general procedure, **condition a**. Brown oil, yield 90% (36.2 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.80 (s, 1H), 6.77 (d, *J* = 8.1 Hz, 1H), 6.72 (dd, *J* = 8.1, 1.0 Hz, 1H), 5.95 (s, 2H), 3.39 (t, *J* = 2.2 Hz, 2H), 2.41 (t, *J* = 7.3 Hz, 2H), 1.58 (dd, *J* = 14.7, 7.4 Hz, 2H), 0.88 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 209.0 – 204.3 (m), 154.6 (dd, *J* = 292.1, 287.7 Hz), 147.8, 146.9, 126.8 (t, *J* = 3.9 Hz), 121.5 (t, *J* = 3.5 Hz), 108.5 (dd, *J* = 4.5, 3.1 Hz), 108.3, 101.2, 87.0 (dd, *J* = 22.6, 16.8 Hz), 43.9, 42.4 (d, *J* = 1.8 Hz), 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -88.87 (dt, *J* = 38.2, 2.4 Hz), -89.62 (d, *J* = 38.1 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{14}H_{14}F_2O_3H^+$ 269.0984, found 269.0985.

5k. 2-(dibenzo[b,d]thiophen-3-yl)-1,1-difluorohept-1-en-4-one

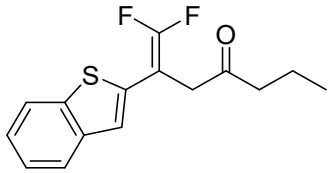


According to the general procedure, **condition a**. Yellow oil, yield 91% (45.1 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.17 – 8.11 (m, 1H), 8.09 (dd, *J* = 7.7, 1.1 Hz, 1H), 7.87 – 7.81 (m, 1H), 7.50 – 7.42 (m, 3H), 7.40 (d, *J* = 6.5 Hz, 1H), 3.56 (t, *J* = 1.9 Hz, 2H), 2.38 (t, *J* = 7.3 Hz, 2H), 1.75 – 1.42 (m,

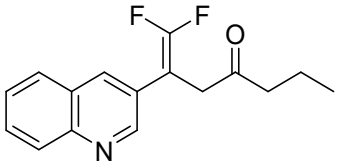
2H), 0.83 (t, *J* = 7.4 Hz, 3H) **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.3 – 205.5 (m), 154.5 (t, *J* = 291.4 Hz), 139.3, 139.0, 136.1, 135.7, 128.2 (dd, *J* = 4.9, 1.9 Hz), 128.0 – 127.9 (m), 127.0, 124.8, 124.5, 122.7, 121.8, 121.3, 86.0 (dd, *J* = 23.6, 20.4 Hz), 44.3, 41.5, 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -85.25 (d, *J* = 31.8 Hz), -88.58 (d, *J* = 31.7 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{19}H_{16}F_2OSH^+$ 331.0963, found 331.0946.

5l. 2-(benzo[b]thiophen-2-yl)-1,1-difluorohept-1-en-4-one



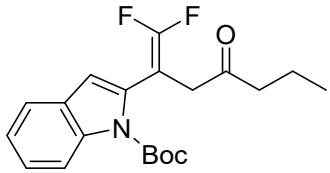
According to the general procedure, **condition a**. Yellow oil, yield 74% (31.0 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.2 Hz, 1H), 7.71 (dd, *J* = 6.8, 1.8 Hz, 1H), 7.32 (tt, *J* = 8.5, 3.5 Hz, 2H), 7.18 (s, 1H), 3.53 (t, *J* = 2.0 Hz, 2H), 2.50 (t, *J* = 7.3 Hz, 2H), 1.63 (dd, *J* = 14.7, 7.4 Hz, 2H), 0.91 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (176 MHz, $CDCl_3$) δ 206.1, 157.0 – 152.9 (m), 139.3, 135.2, 124.6, 124.5, 123.5, 122.7 – 122.1 (m), 121.8, 84.4, 43.5, 41.7 (d, *J* = 1.9 Hz), 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -81.37 (d, *J* = 24.7 Hz), -86.43 (dt, *J* = 24.9, 2.4 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{16}H_{15}F_2NOH^+$ 281.0806, found 281.0815.

5m. 1,1-difluoro-2-(quinolin-3-yl)hept-1-en-4-one



According to general procedure **condition a**. Yellow oil, yield 94% (38.7 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.86 (s, 1H), 8.06 (dd, *J* = 13.2, 5.1 Hz, 2H), 7.79 (d, *J* = 8.1 Hz, 1H), 7.70 (t, *J* = 7.7 Hz, 1H), 7.54 (t, *J* = 7.5 Hz, 1H), 3.57 (s, 2H), 2.47 (t, *J* = 7.3 Hz, 2H), 1.61 (dd, *J* = 14.7, 7.4 Hz, 2H), 0.89 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 205.9 (d, *J* = 2.3 Hz), 155.2 (dd, *J* = 294.1, 290.2 Hz), 149.7 (dd, *J* = 5.0, 2.6 Hz), 147.0, 134.8 (t, *J* = 3.6 Hz), 129.8, 129.1, 127.8, 127.5, 127.1, 126.7, 89.6 – 85.2 (m), 44.2, 41.7 (d, *J* = 1.9 Hz), 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -85.89 – -86.07 (m), -87.59 (dd, *J* = 32.7, 0.9 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{16}H_{15}F_2NOH^+$ 276.1194, found 276.1202.

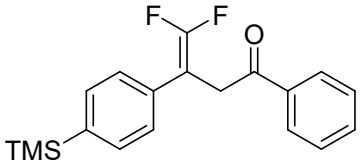
5n. tert-butyl 2-(1,1-difluoro-4-oxohept-1-en-2-yl)-1H-indole-1-carboxylate



According to the general procedure, **condition a**. Yellow oil, yield 47% (25.6 mg).

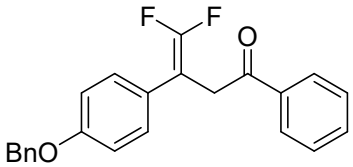
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 (d, *J* = 8.4 Hz, 1H), 7.51 (d, *J* = 7.8 Hz, 1H), 7.30 (ddd, *J* = 8.5, 7.3, 1.3 Hz, 1H), 7.25 – 7.19 (m, 1H), 6.63 (s, 1H), 3.39 (t, *J* = 1.9 Hz, 2H), 2.41 (t, *J* = 7.3 Hz, 2H), 1.67 (s, 9H), 1.63 – 1.50 (m, 2H), 0.88 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.0, 156.3 (d, *J* = 289.4 Hz), 149.8, 136.4, 130.7 (d, *J* = 7.7 Hz), 128.9, 124.6, 123.0, 120.8, 115.6, 112.1, 84.2, 82.0 (dd, *J* = 28.8, 19.7 Hz), 44.3, 42.5, 28.1, 17.0, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -86.50 (dd, *J* = 31.9, 1.7 Hz), -89.05 (dt, *J* = 32.0, 2.0 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{20}H_{23}F_2NO_3H^+$ 364.1724, found 364.1737.

6a. 4,4-difluoro-1-phenyl-3-(4-(trimethylsilyl)phenyl)but-3-en-1-one



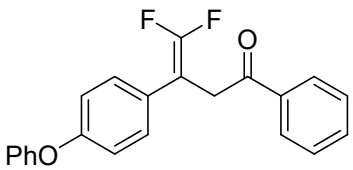
According to the general procedure, **condition b**. Pale yellow oil, yield 96% (47.5 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 – 7.95 (m, 2H), 7.62 – 7.57 (m, 1H), 7.48 (dt, *J* = 7.4, 3.5 Hz, 4H), 7.33 – 7.29 (m, 2H), 4.07 (t, *J* = 2.1 Hz, 2H), 0.25 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 196.5, 159.6 – 151.2 (m), 140.9, 137.5, 135.0 (d, *J* = 4.0 Hz), 134.7, 134.6, 129.9, 129.3, 128.3 (t, *J* = 3.4 Hz), 88.3 (dd, *J* = 21.6, 17.1 Hz), 39.3 (d, *J* = 2.5 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.68 (dt, *J* = 36.0, 2.2 Hz), -88.68 (d, *J* = 36.0 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{19}H_{20}F_2OSiH^+$ 331.1324, found 331.1327.

6b. 3-(4-(benzyloxy)phenyl)-4,4-difluoro-1-phenylbut-3-en-1-one



According to the general procedure, **condition b**. Yellow solid, yield 54% (29.4 mg).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (dd, *J* = 5.2, 3.3 Hz, 2H), 7.62 – 7.56 (m, 1H), 7.47 (dd, *J* = 10.6, 4.7 Hz, 2H), 7.43 – 7.31 (m, 5H), 7.26 – 7.21 (m, 2H), 6.95 – 6.91 (m, 2H), 5.04 (s, 2H), 4.03 (t, *J* = 2.1 Hz, 2H). **^{13}C NMR** (176 MHz, $CDCl_3$) δ 195.5, 158.0, 154.5 (dd, *J* = 291.4, 287.6 Hz), 136.8, 136.3, 133.4, 129.2 (t, *J* = 3.4 Hz), 128.7, 128.6, 128.1, 128.0, 127.47 (d, *J* = 4.3 Hz), 125.8 (t, *J* = 3.8 Hz), 114.8, 86.6 (dd, *J* = 21.9, 17.8 Hz), 70.0 (d, *J* = 28.8 Hz), 38.4 (d, *J* = 2.3 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -89.15 (dt, *J* = 39.3, 2.3 Hz), -89.96 (d, *J* = 39.2 Hz). **HRMS (ESI)** m/z $[M+Na]^+$ calcd for $C_{23}H_{18}F_2O_2Na^+$ 387.1167, found 387.1157.

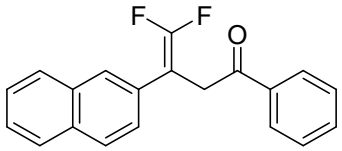
6c. 4,4-difluoro-3-(4-phenoxyphenyl)-1-phenylbut-3-en-1-one



According to general procedure **condition b**. Dark yellow solid, yield 75% (43.8 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 – 7.94 (m, 2H), 7.60 (t, *J* = 7.4 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 2H), 7.33 (dd, *J* = 8.3, 7.6 Hz, 2H), 7.28 (s, 2H), 7.11 (t, *J* = 7.4 Hz, 1H), 7.01 (d, *J* = 7.7 Hz, 2H), 6.98 – 6.92 (m, 2H), 4.05 (t, *J* = 2.0 Hz, 2H). **^{13}C NMR** (176 MHz, $CDCl_3$) δ 195.4 (d, *J* = 2.7 Hz), 156.7, 156.6, 154.6 (dd, *J* = 291.8, 287.9 Hz), 136.2, 133.5, 129.7, 129.4 (t, *J* = 3.4 Hz), 128.7, 128.1, 123.5, 119.1, 118.5, 86.6 (dd, *J* = 22.2, 17.6 Hz), 38.4 (d, *J* = 2.2 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -88.51 (dt, *J* = 38.1, 2.1 Hz), -89.36 (d, *J* = 37.8 Hz). **HRMS (ESI)** m/z $[M+K]^+$ calcd for $C_{22}H_{16}F_2O_2K^+$ 389.0750, found 389.0740.

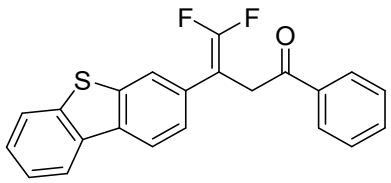
6d. 4,4-difluoro-3-(naphthalen-2-yl)-1-phenylbut-3-en-1-one



According to the general procedure, **condition b**. Brown oil, yield 98% (45.2 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 – 7.97 (m, 2H), 7.83 – 7.75 (m, 4H), 7.62 – 7.57 (m, 1H), 7.51 – 7.44 (m, 5H), 4.17 (t, *J* = 2.1 Hz, 2H). **^{13}C NMR** (176 MHz, $CDCl_3$) δ 195.5 – 195.1 (m), 154.9 (dd, *J* = 292.7, 288.6 Hz), 136.2, 133.4, 133.1, 132.4, 130.9 (t, *J* = 4.0 Hz), 128.7, 128.1, 128.1, 127.9, 127.5, 127.1 (t, *J* = 3.5 Hz), 126.2, 126.2, 125.8 – 125.7 (m), 87.3 (dd, *J* = 22.0, 17.4 Hz), 38.4 (d, *J* = 2.3 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -87.59 (dt, *J* = 36.0, 2.2 Hz), -88.77 (d, *J* = 35.9 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{20}H_{14}F_2OH^+$ 309.1085, found 309.1073.

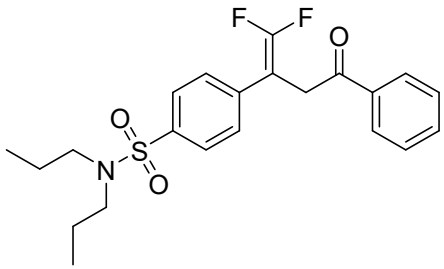
6e. 3-(dibenzo[b,d]thiophen-3-yl)-4,4-difluoro-1-phenylbut-3-en-1-one



According to the general procedure, **condition b**. Yellow solid, yield 94% (51.3 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 – 8.07 (m, 2H), 7.97 – 7.91 (m, 2H), 7.89 – 7.83 (m, 1H), 7.55 (t, *J* = 7.4 Hz, 1H), 7.50 – 7.39 (m, 6H), 4.20 (t, *J* = 1.8 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 194.9, 154.6 (t, *J* = 291.3 Hz), 139.5, 139.1, 136.2, 136.0, 135.7, 133.4, 128.7, 128.3, 128.1 (s, *J* = 10.5 Hz), 126.9, 124.8, 124.5, 122.7, 121.7, 121.3, 86.0 (dd, *J* = 23.4, 20.9 Hz), 37.8. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -85.03 (d, *J* = 31.9 Hz), -88.30 – -88.59 (m). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{22}H_{14}F_2OSH^+$ 365.0812, found 365.0814.

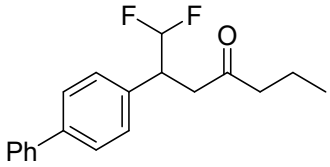
6f. 4-(1,1-difluoro-4-oxo-4-phenylbut-1-en-2-yl)-N,N-dipropylbenzenesulfonamide



According to general **procedure condition b**. Colorless oil, yield 74% (56.8 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 7.4 Hz, 2H), 7.75 (d, *J* = 8.5 Hz, 2H), 7.62 (t, *J* = 7.4 Hz, 1H), 7.50 (t, *J* = 7.7 Hz, 2H), 7.44 (d, *J* = 8.0 Hz, 2H), 4.10 (t, *J* = 1.9 Hz, 2H), 3.13 – 2.97 (m, 4H), 1.55 (d, *J* = 7.6 Hz, 4H), 0.86 (t, *J* = 7.4 Hz, 6H). **^{13}C NMR** (176 MHz, $CDCl_3$) δ 194.9, 155.1 (dd, *J* = 294.9, 290.0 Hz), 138.9, 137.7 (t, *J* = 4.4 Hz), 136.0, 133.7, 128.8, 128.4 – 128.3 (m), 128.1, 127.2, 86.6 (dd, *J* = 23.0, 16.3 Hz), 50.1, 37.9 (d, *J* = 2.2 Hz), 22.1, 11.1. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -84.99 – -85.22 (m), -86.42 (d, *J* = 30.6 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{22}H_{25}F_2NO_3SH^+$ 303.1560, found 303.1561.

7. 2-([1,1'-biphenyl]-4-yl)-1,1-difluoroheptan-4-one



According to the procedure selective transformation of **3a**. White solid, yield 77% (46.5 mg).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (dd, *J* = 7.6, 4.6 Hz, 4H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.39 – 7.32 (m, 3H), 5.97 (td, *J* = 56.6, 3.0 Hz, 1H), 3.78 (qdd, *J* = 11.1, 5.7, 3.0 Hz, 1H), 3.01 (ddd, *J* = 25.7, 17.6, 6.9 Hz, 2H), 2.47 – 2.30 (m, 2H), 1.64 – 1.51 (m, 2H), 0.86 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 207.7, 140.7, 140.5, 135.3 (d, *J* = 3.5 Hz), 129.2, 128.8, 127.4 (d, *J* = 1.7 Hz), 127.0, 117.1 (t, *J* = 244.5 Hz), 45.3, 44.1 (t, *J* = 20.2 Hz), 41.5 – 41.04 (m), 17.1, 13.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -119.64 (ddd, *J* = 277.3, 56.7, 15.2 Hz), -122.76 (ddd, *J* = 277.3, 56.6, 18.3 Hz). **HRMS (ESI)** m/z $[M+H]^+$ calcd for $C_{19}H_{20}F_2OH^+$ 303.1560, found 303.1561.

12. Reference

1 F. Xie, Z. Mao, D. P. Curran, H. Liang, W. Dai, *Angewandte Chemie* **2023**,*135*, e202306846

2 C. Zhu, M. M. Sun, K. Chen, H. Liu, C. Feng, *Angewandte Chemie International Edition* **2021**, *60*, 20237-20242

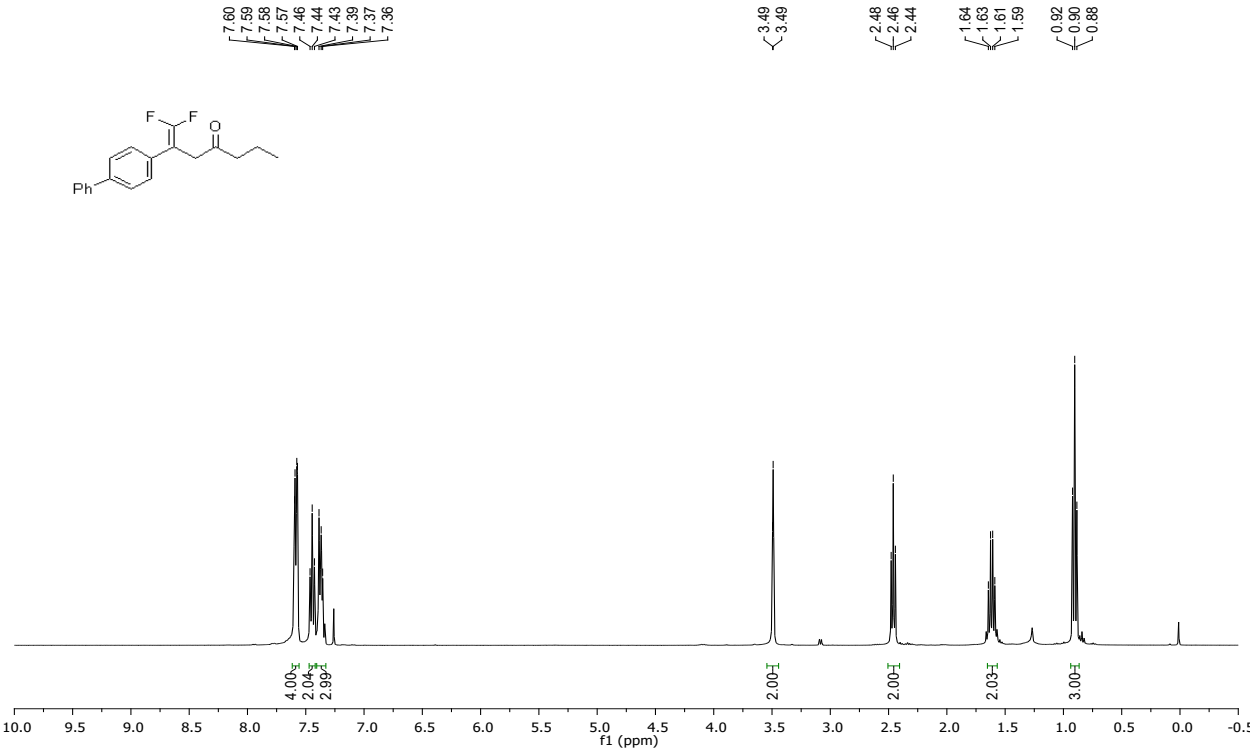
3 C. Yao, S. Wang, J. Norton, M. Hammond, *Journal of the American Chemical Society,* **2020**, *142*, 4793-4799

4 Y.-Q. Guo, Y. Wu, R. Wang, H. Song, Y. Liu, Q. Wang, *Organic Letters* **2021**, 23, 2353-2358

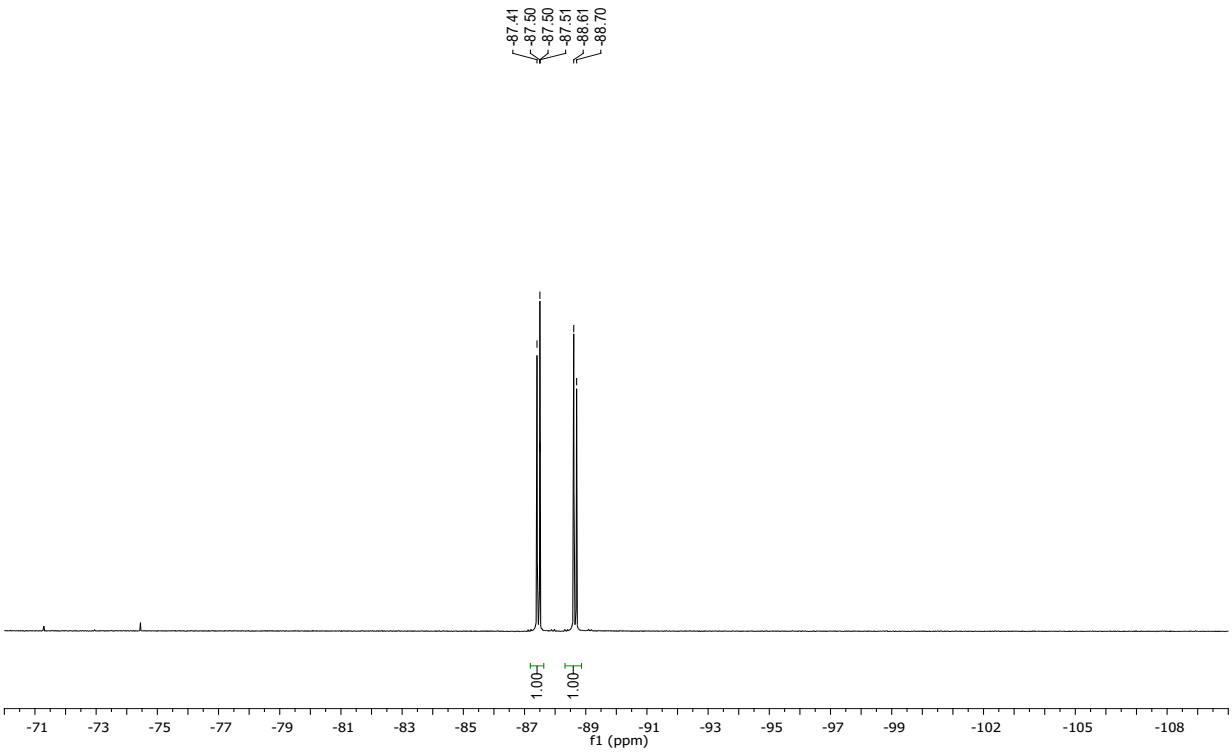
5 T. Xiao, L. Li and L. Zhou, *The Journal of Organic Chemistry*, **2016**, *81*, 7908-7916

13. NMR Spectra

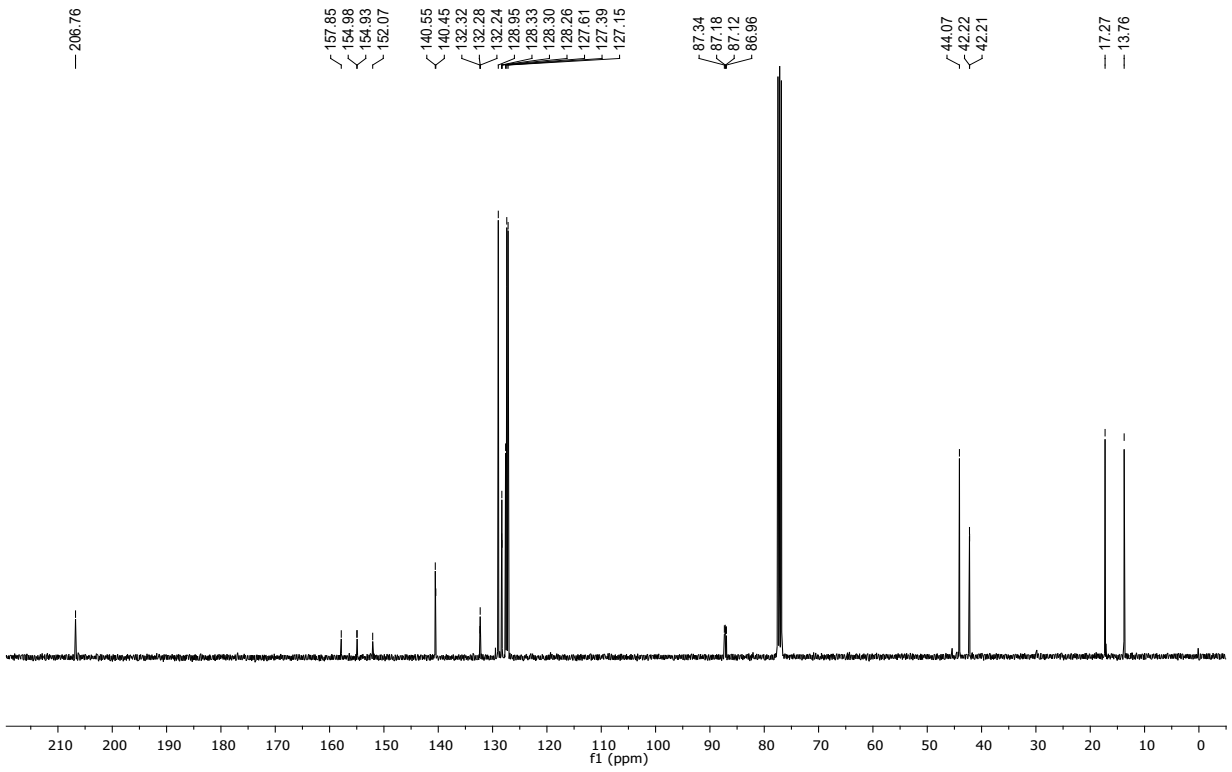
^{1}H NMR spectrum of compound 3a



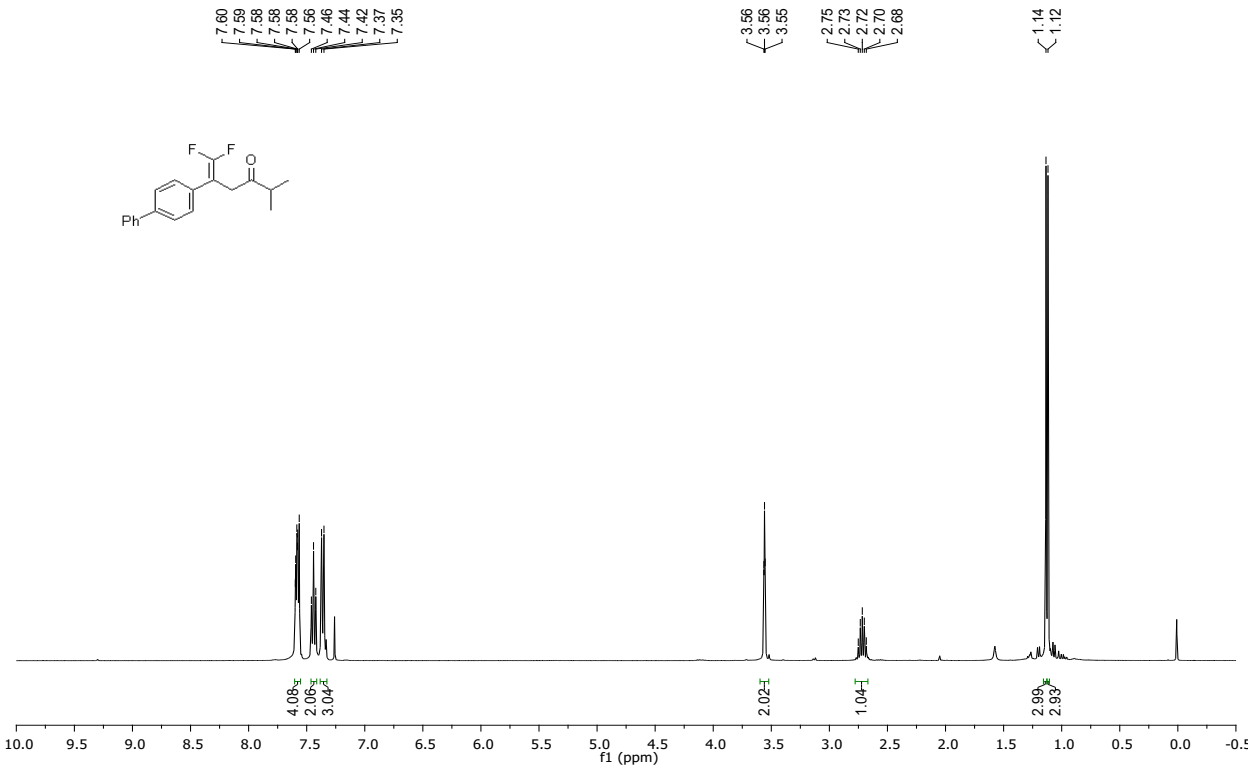
^{19}F NMR spectrum of compound 3a



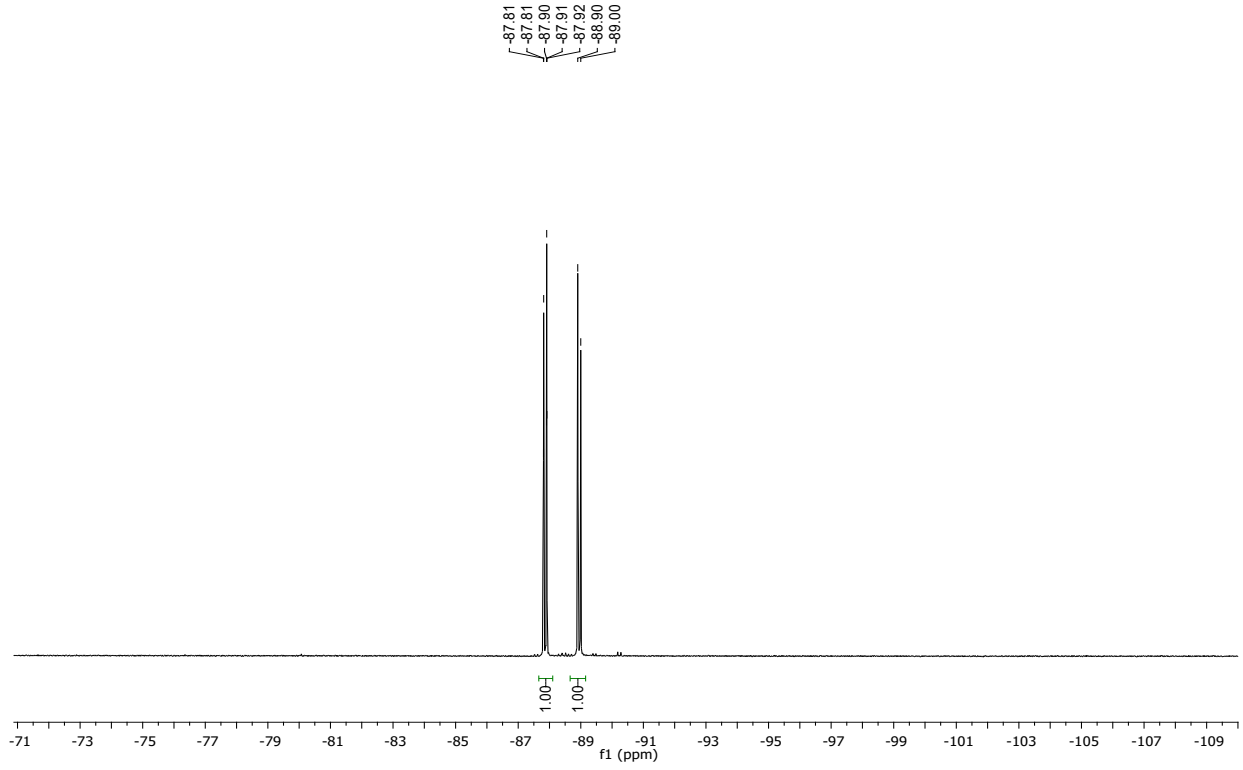
^{13}CNMR spectrum of compound 3a



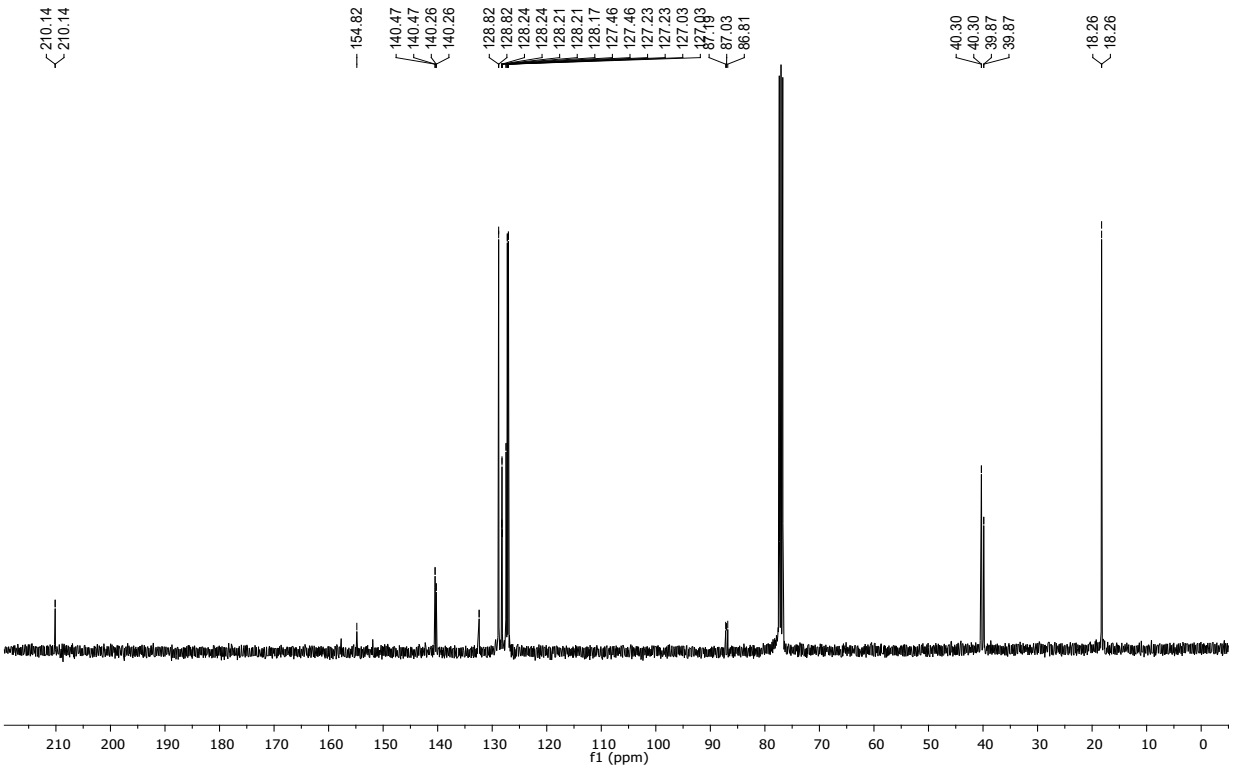
^{1}H NMR spectrum of compound 3b



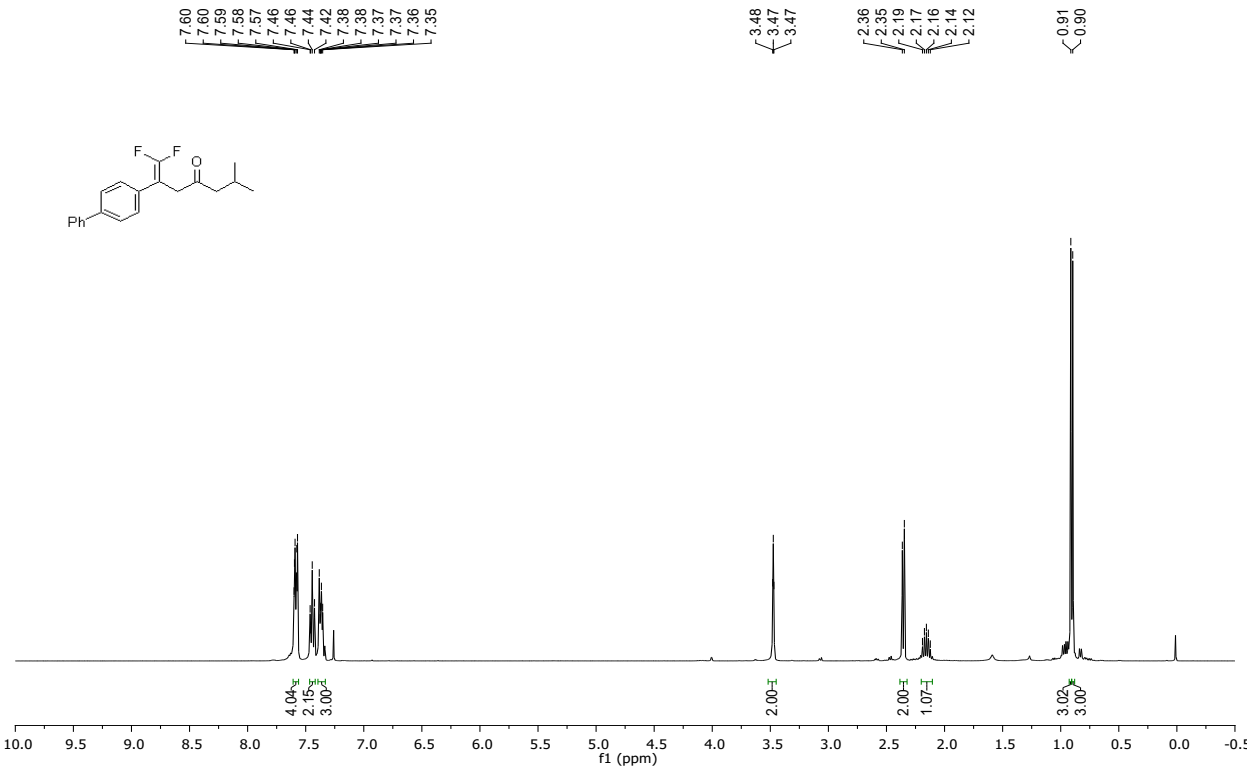
^{19}F NMR spectrum of compound 3b



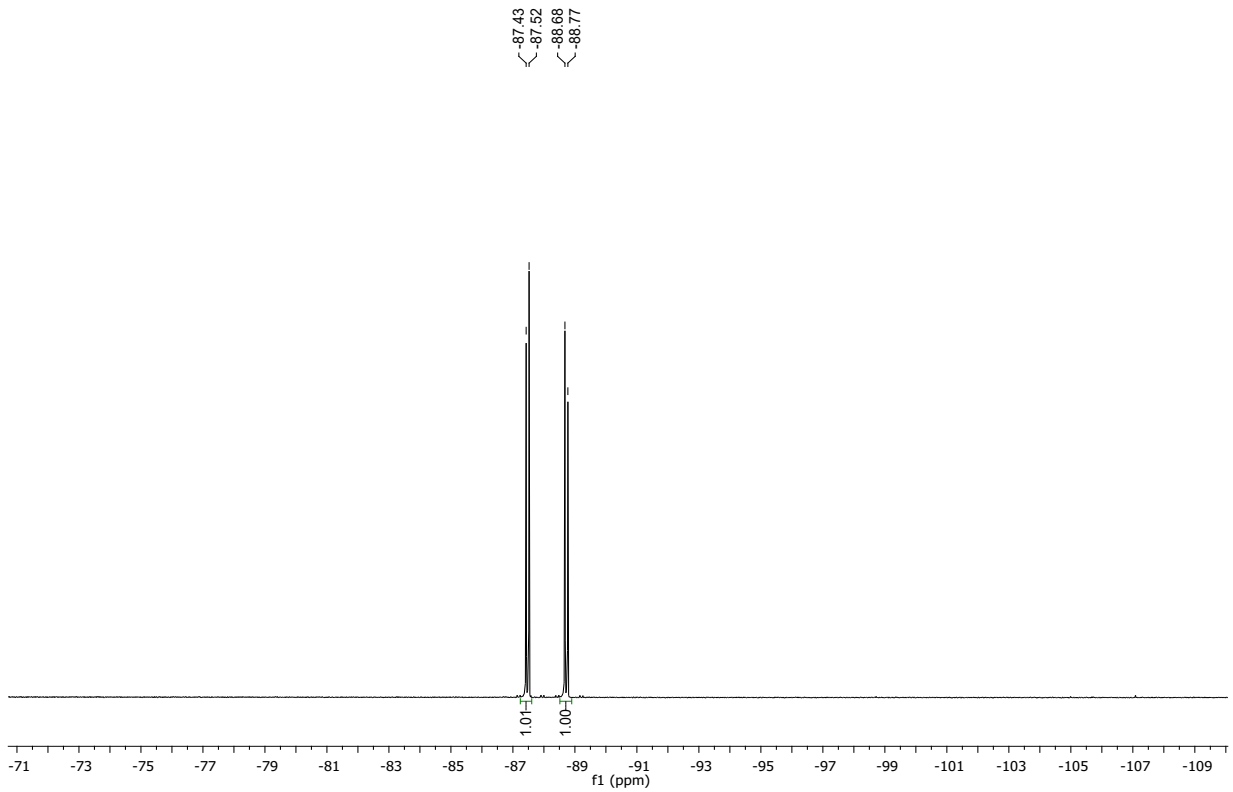
^{13}CNMR spectrum of compound 3b

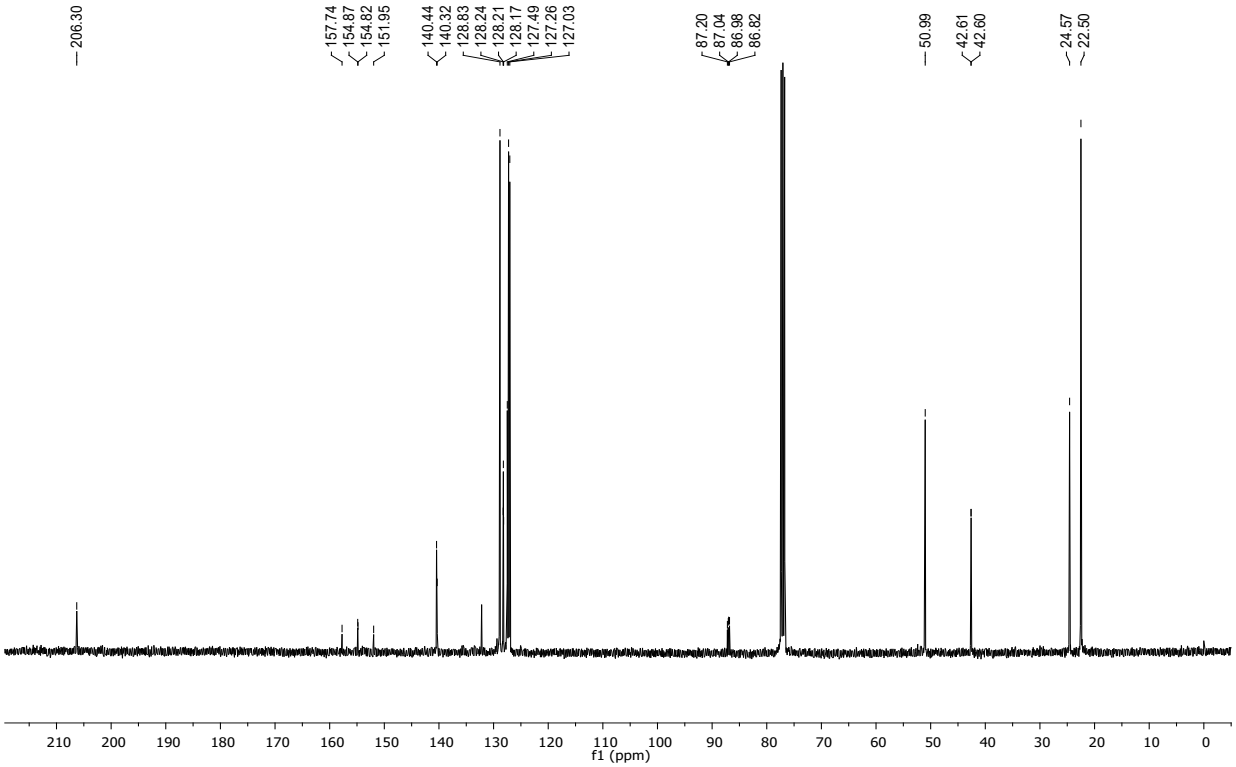


^{1}H NMR spectrum of compound 3c



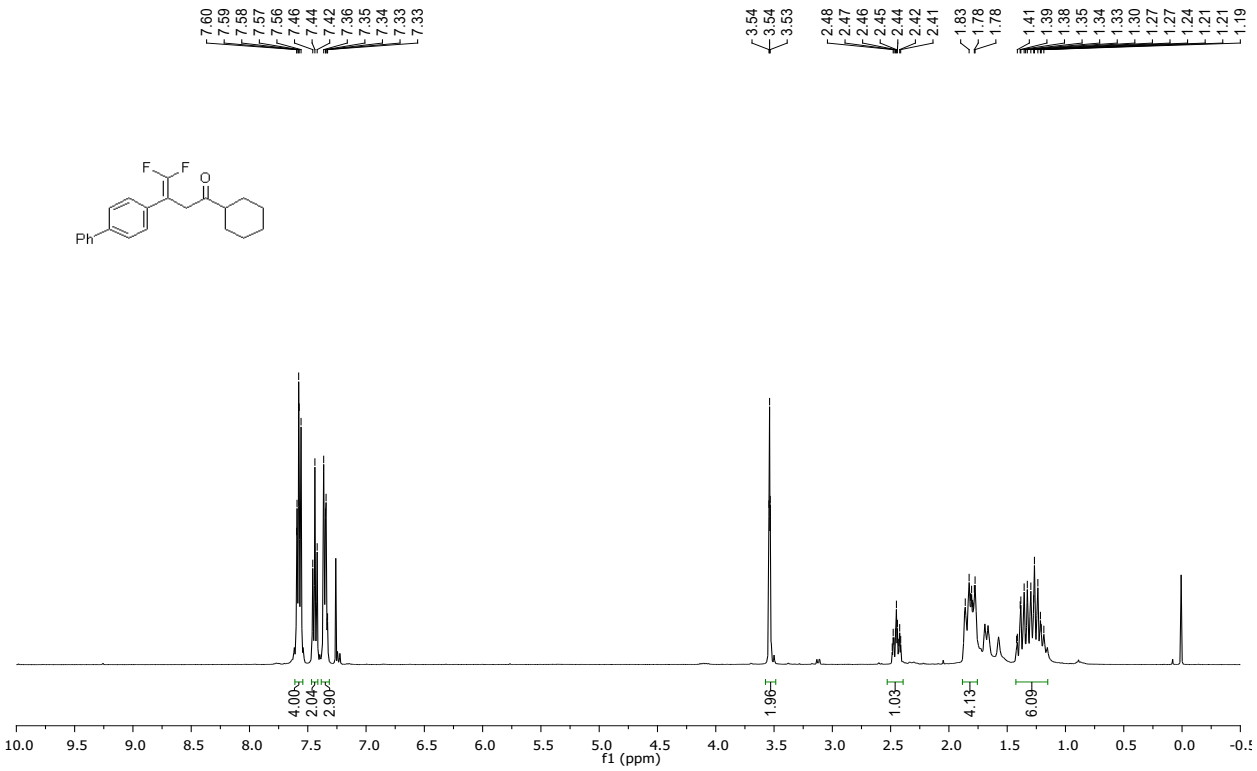
^{19}F NMR spectrum of compound 3c



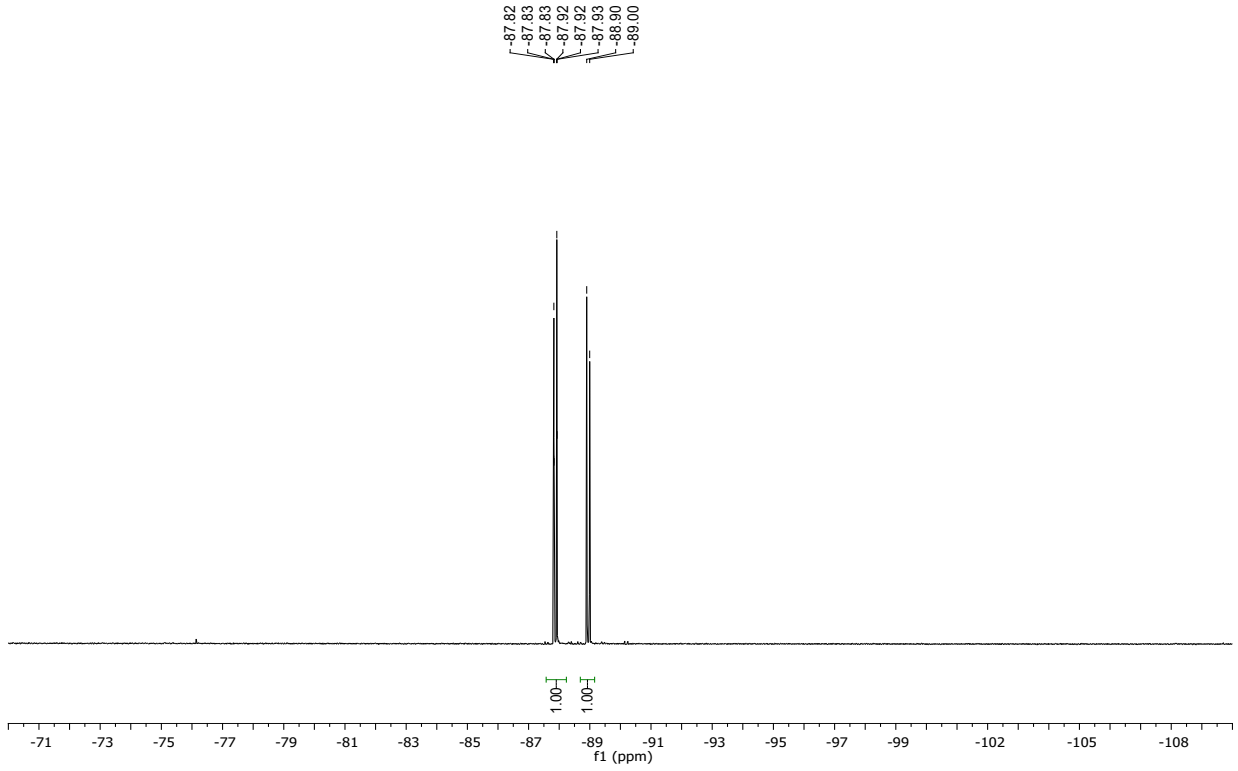


^{13}CNMR spectrum of compound 3c

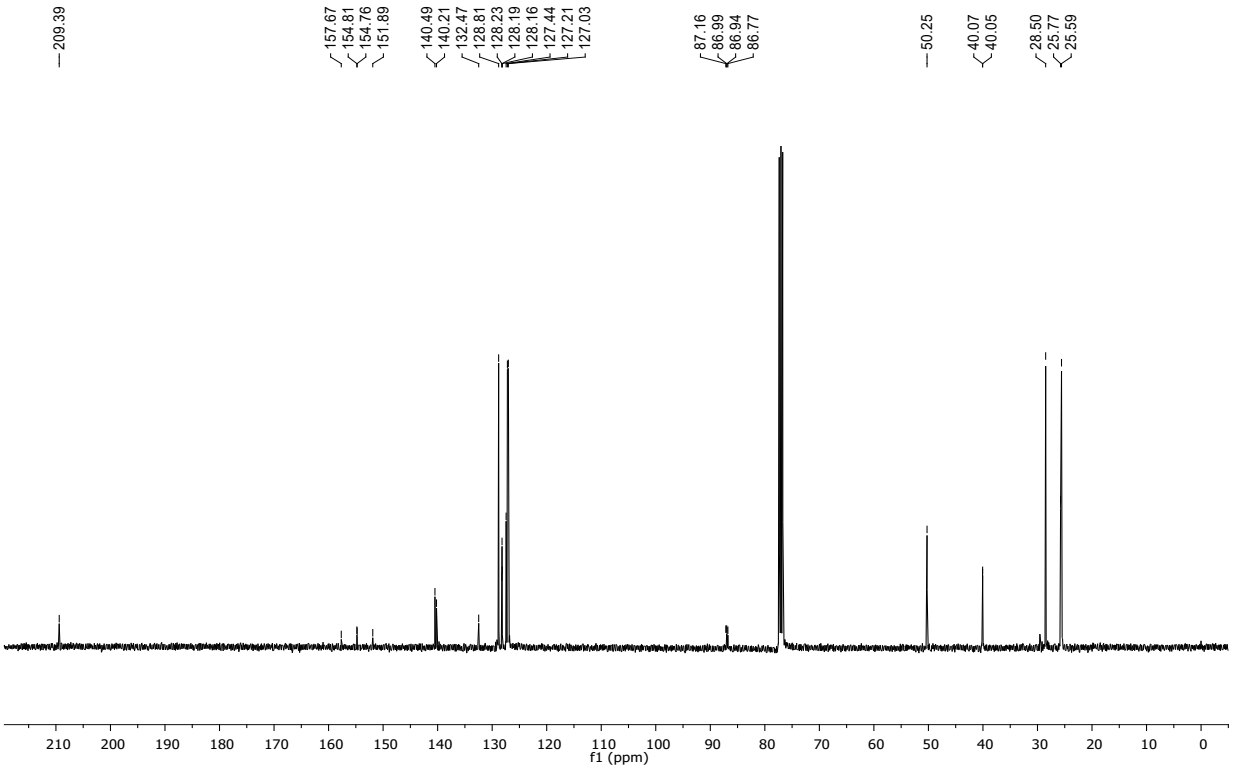
^{1}H NMR spectrum of compound 3d



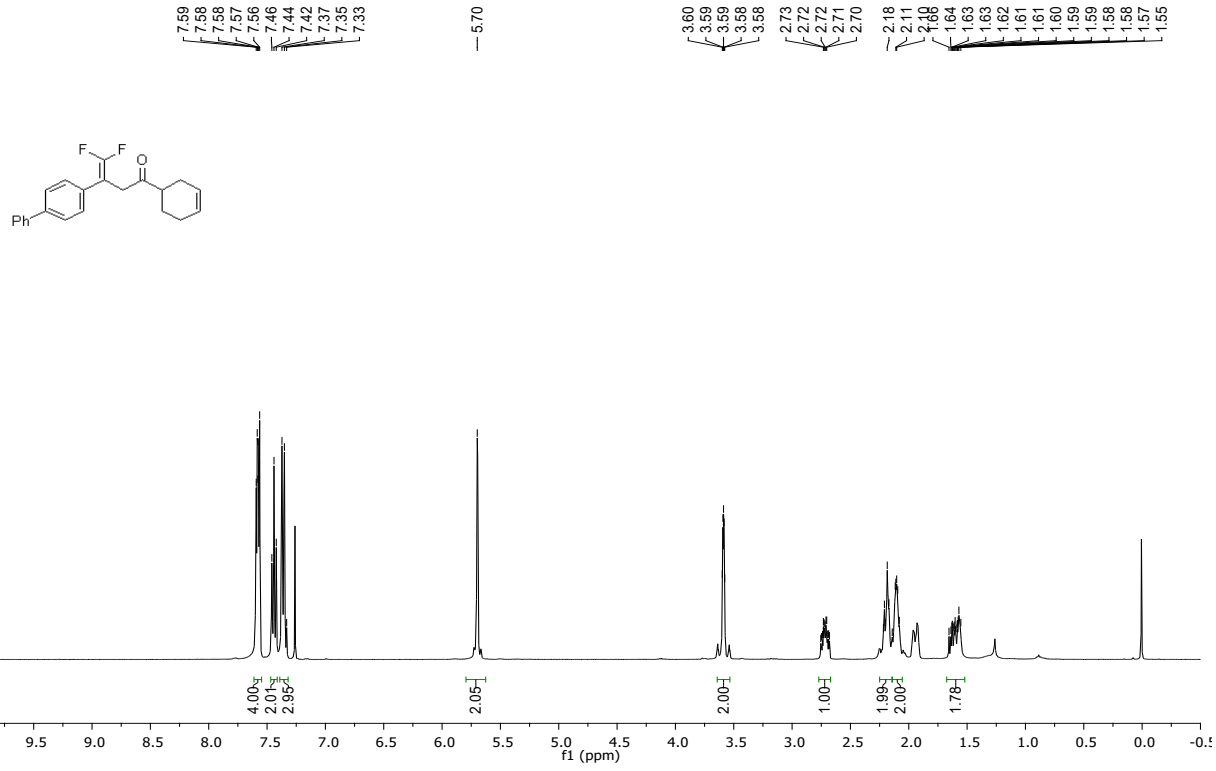
^{19}F NMR spectrum of compound 3d



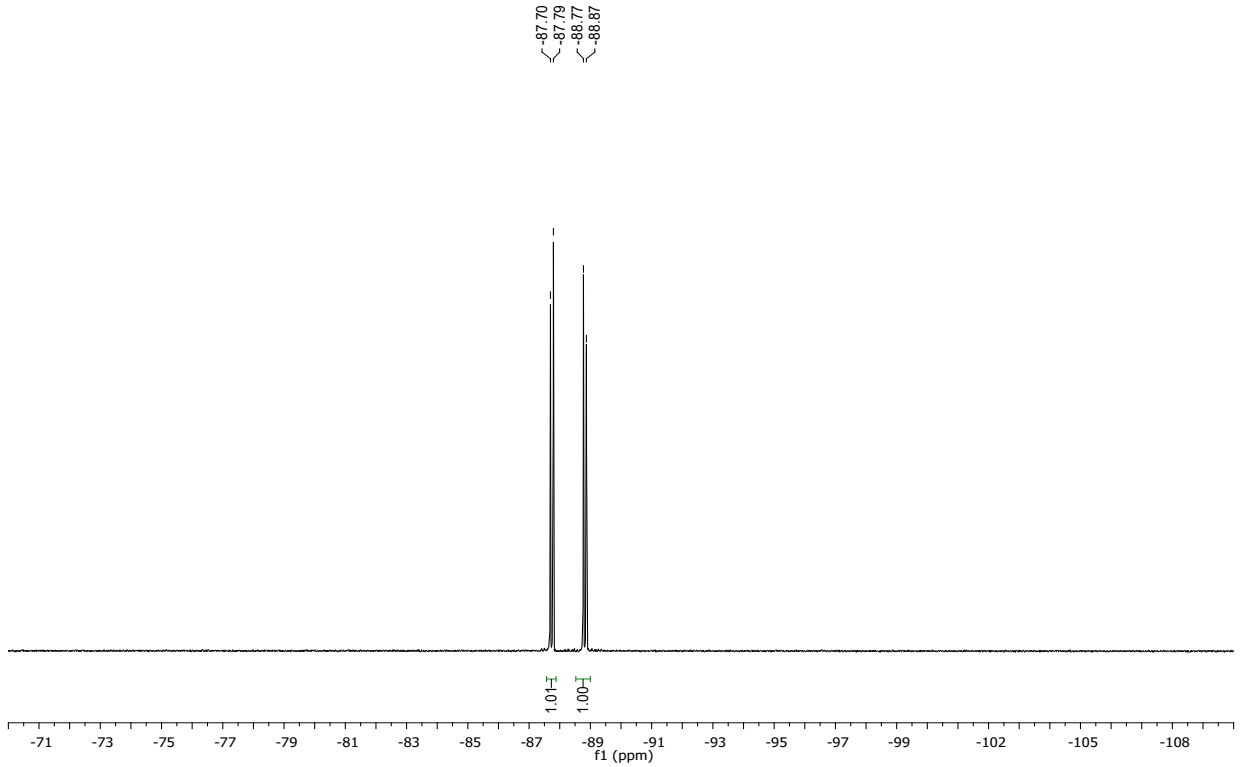
^{13}CNMR spectrum of compound 3d



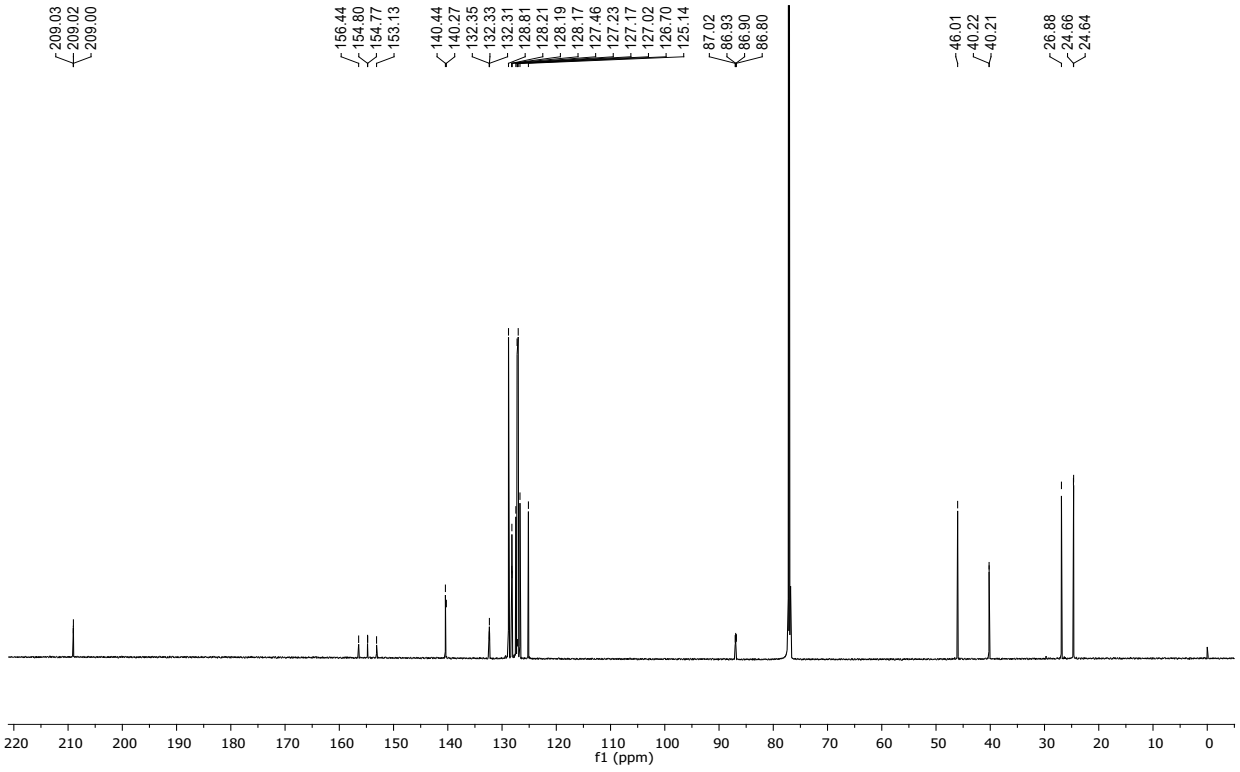
^{1}H NMR spectrum of compound 3e



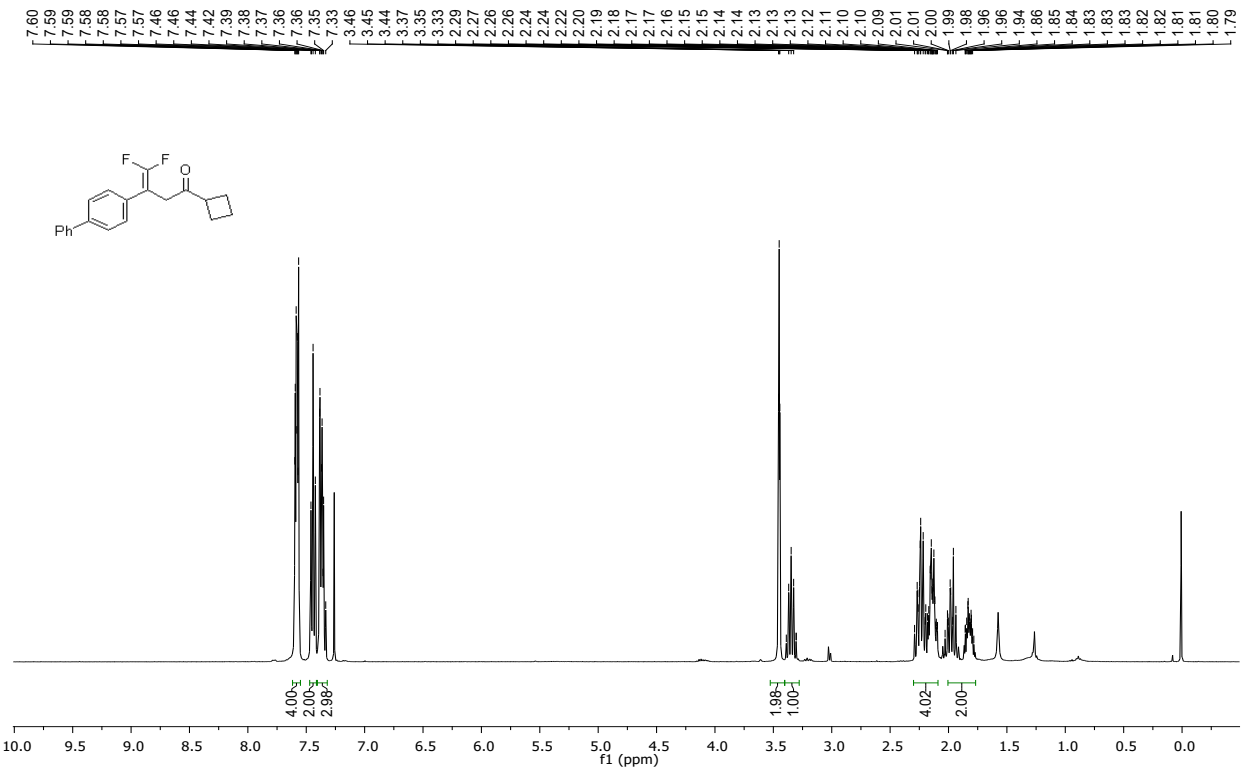
^{19}F NMR spectrum of compound 3e



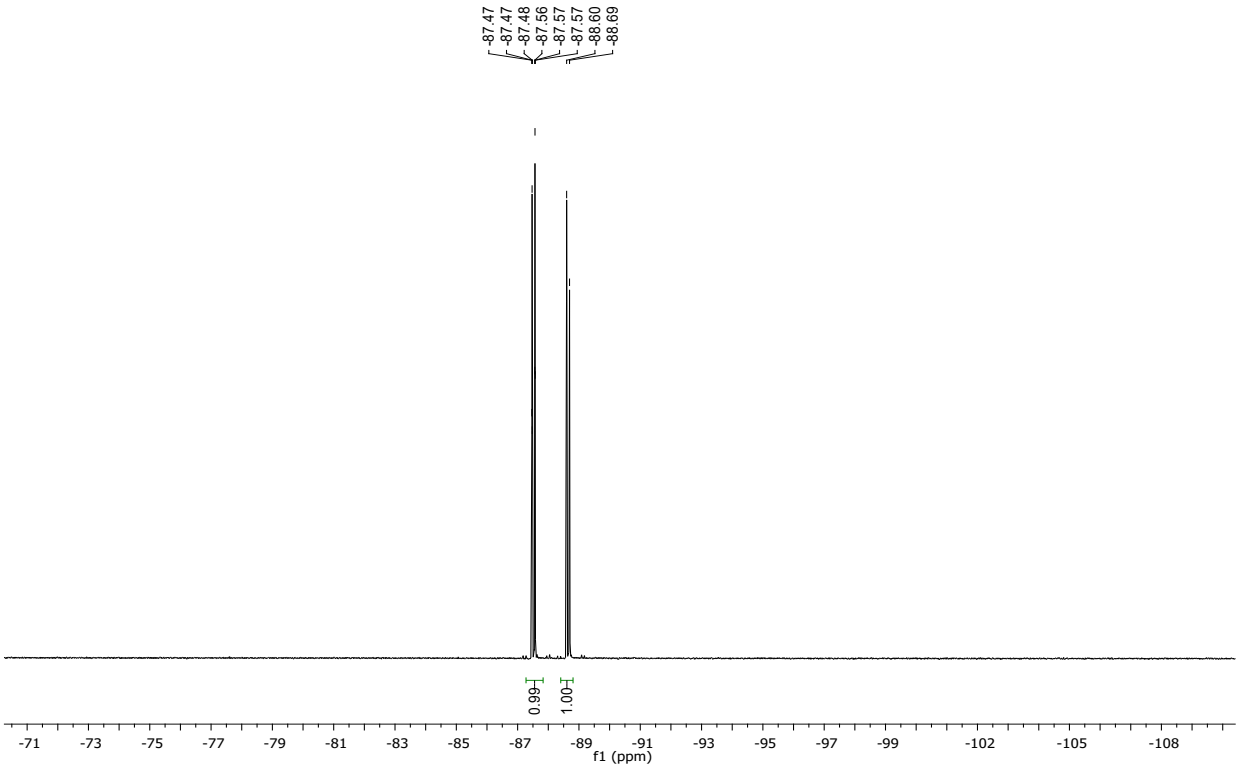
^{13}CNMR spectrum of compound 3e



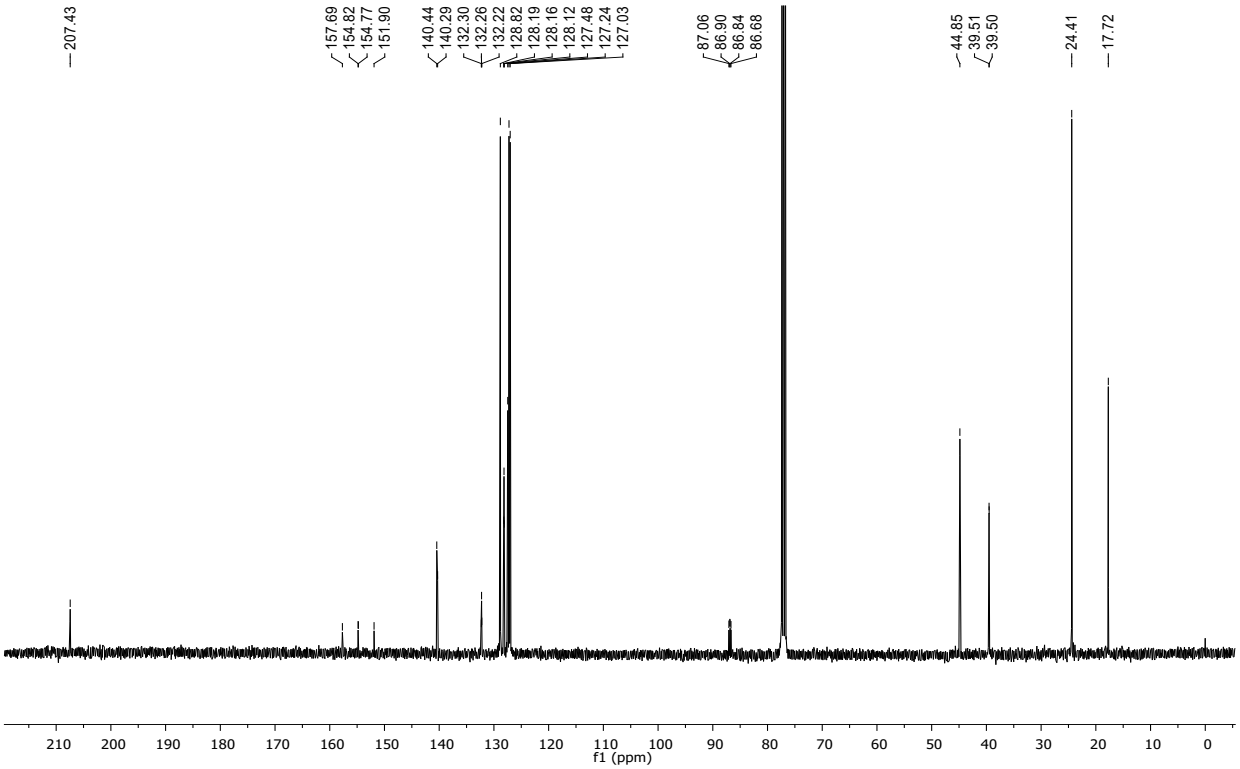
^{1}H NMR spectrum of compound 3f



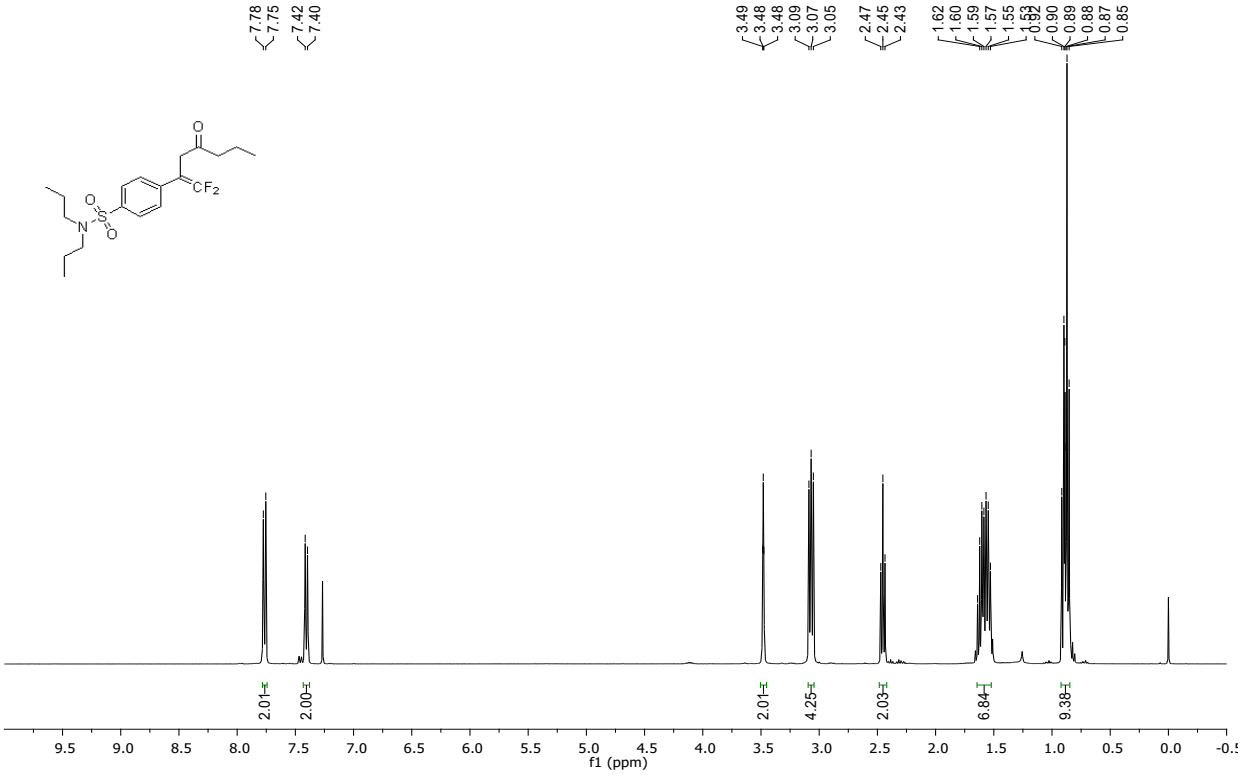
^{19}F NMR spectrum of compound 3f



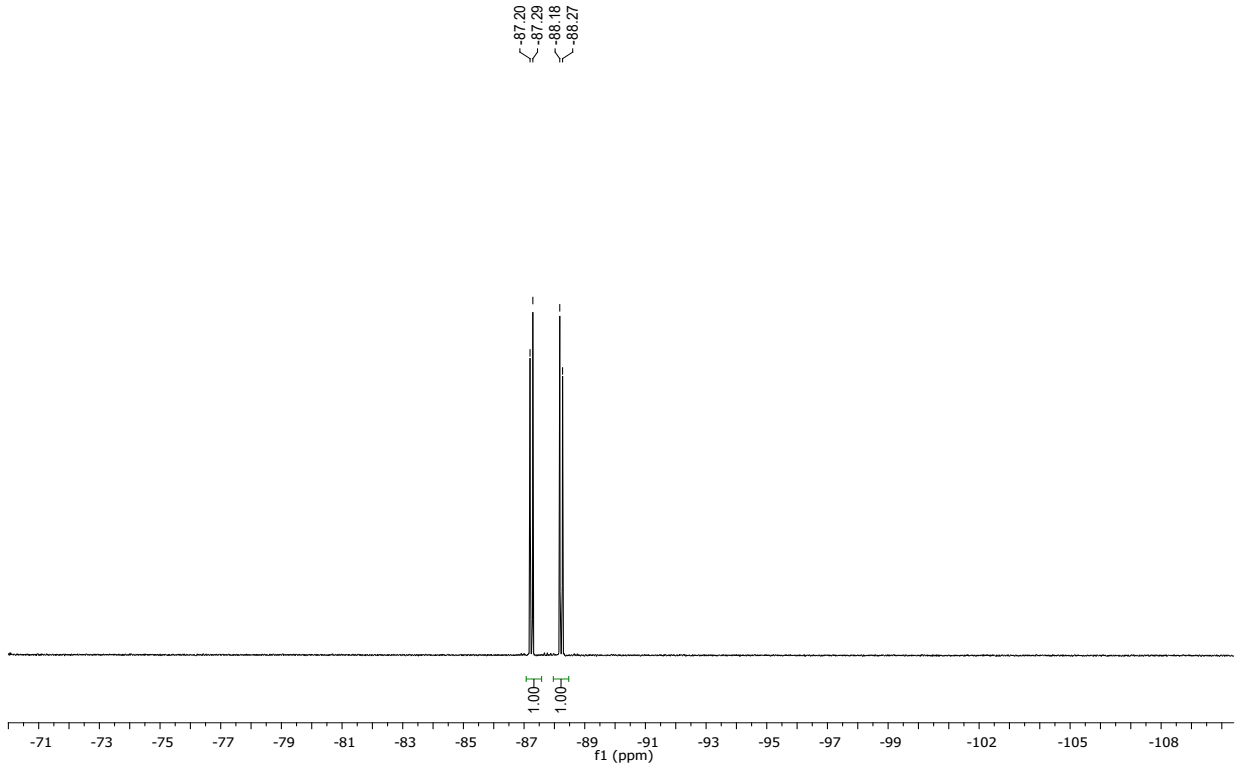
^{13}CNMR spectrum of compound 3f



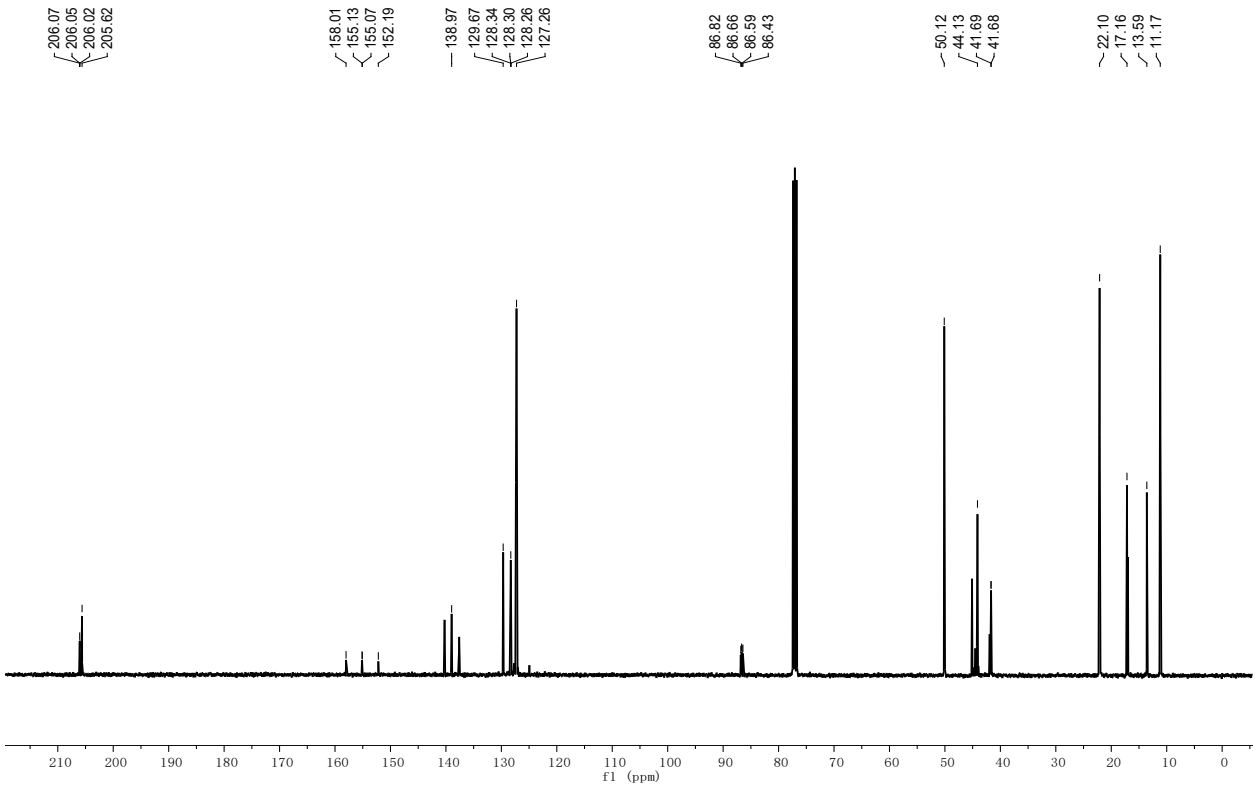
^{1}H NMR spectrum of compound 3g



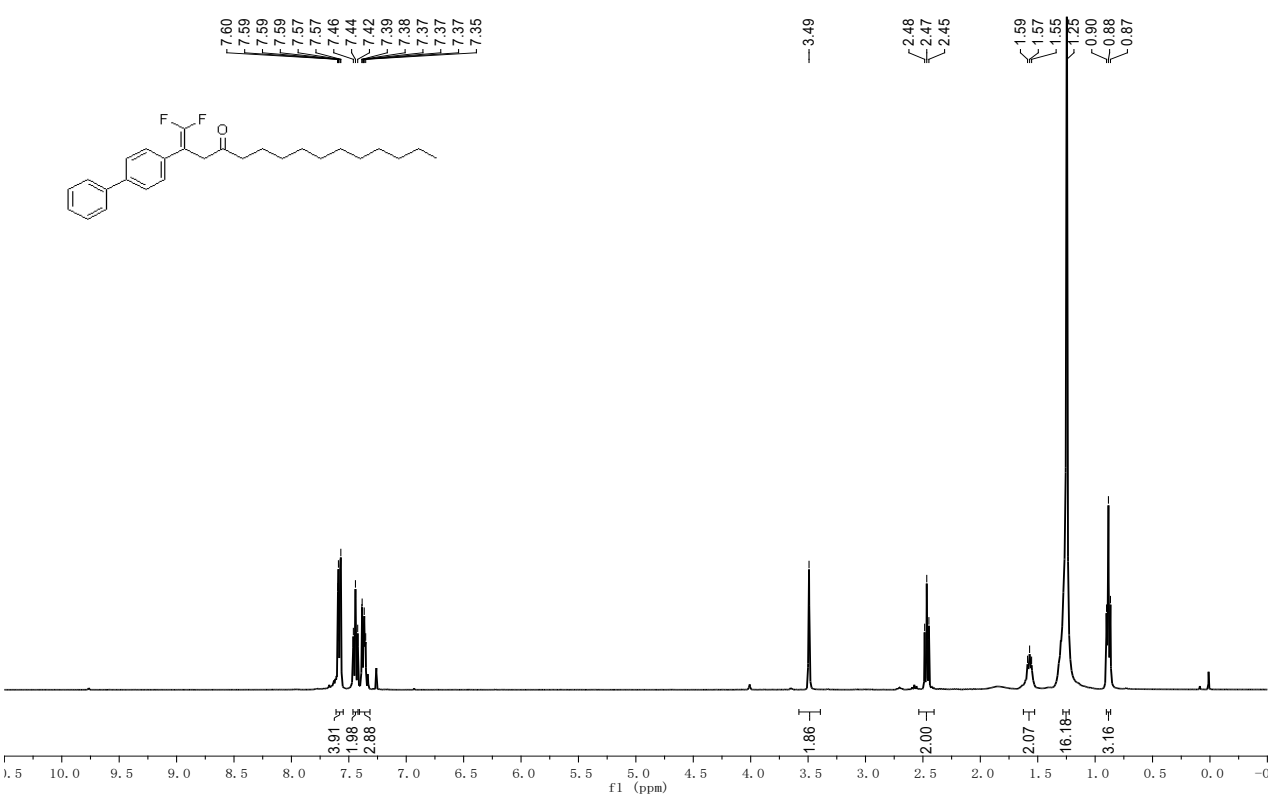
^{19}F NMR spectrum of compound 3g



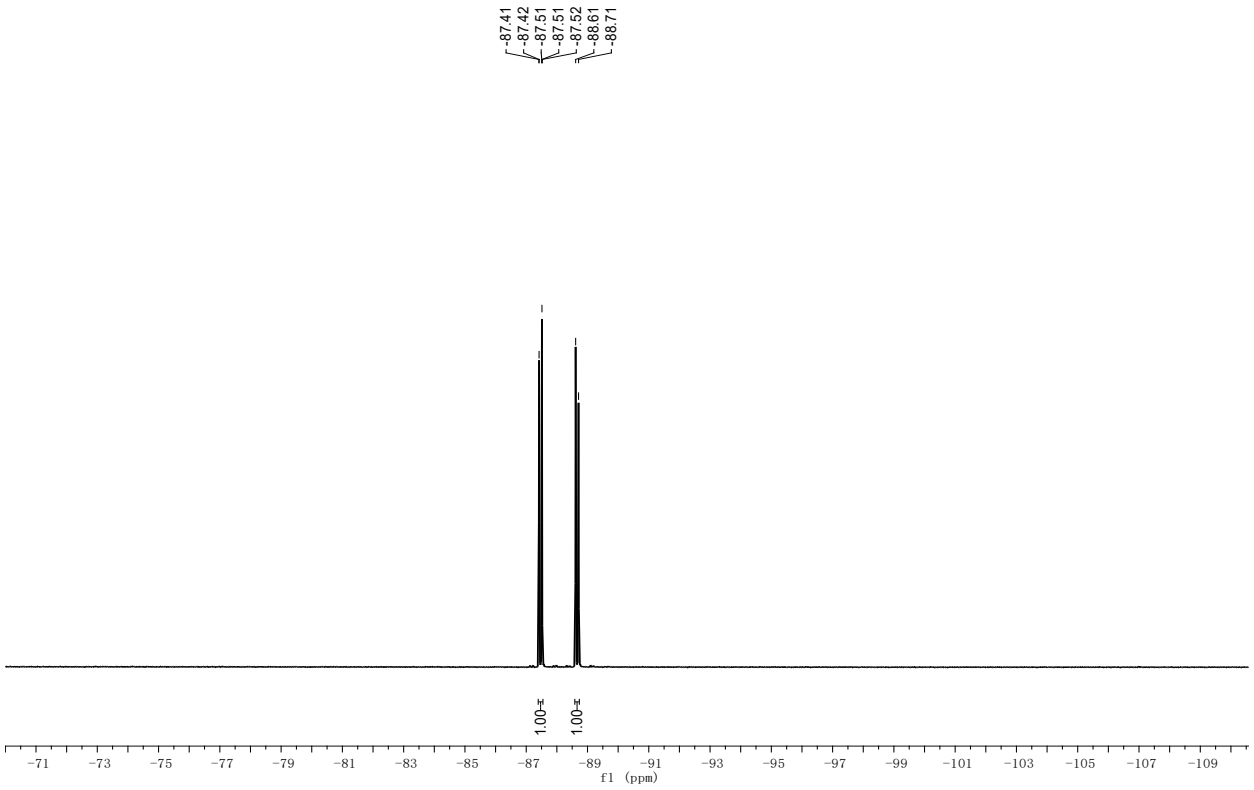
^{13}C NMR spectrum of compound 3g



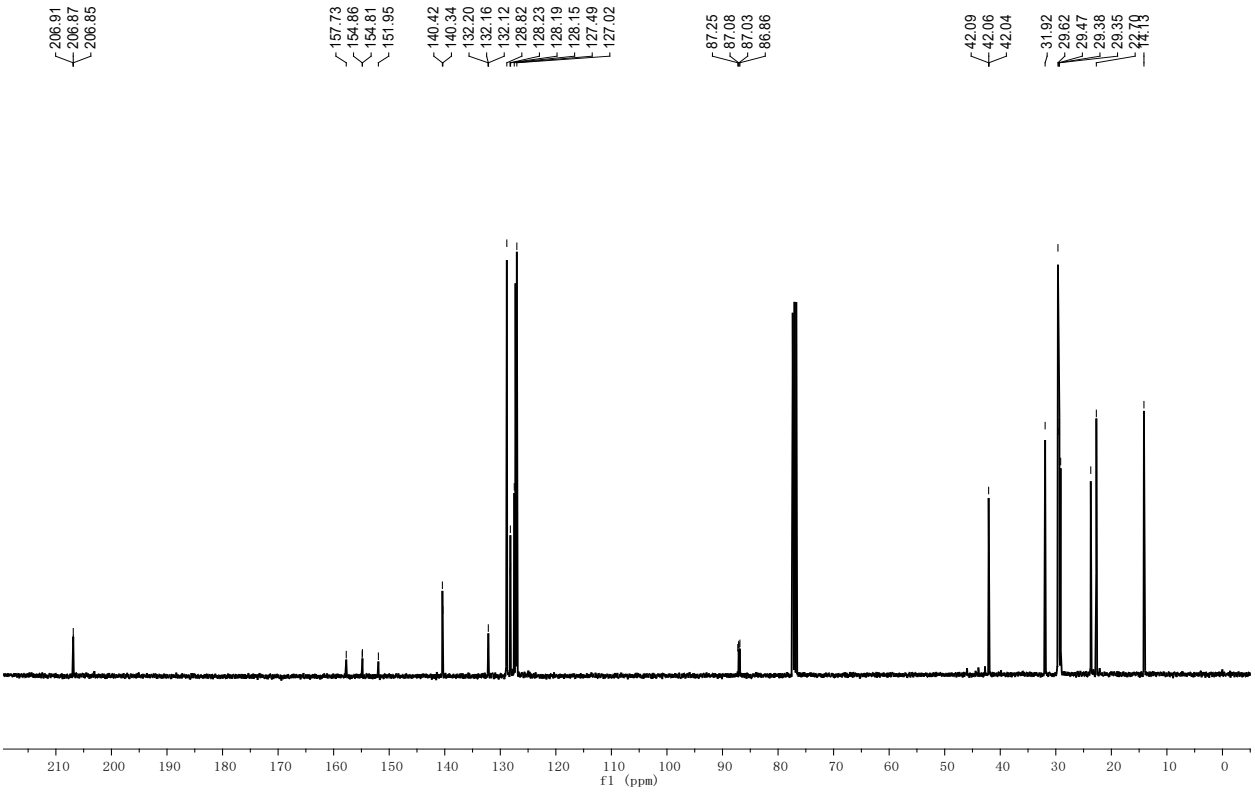
^{1}H NMR spectrum of compound 3h



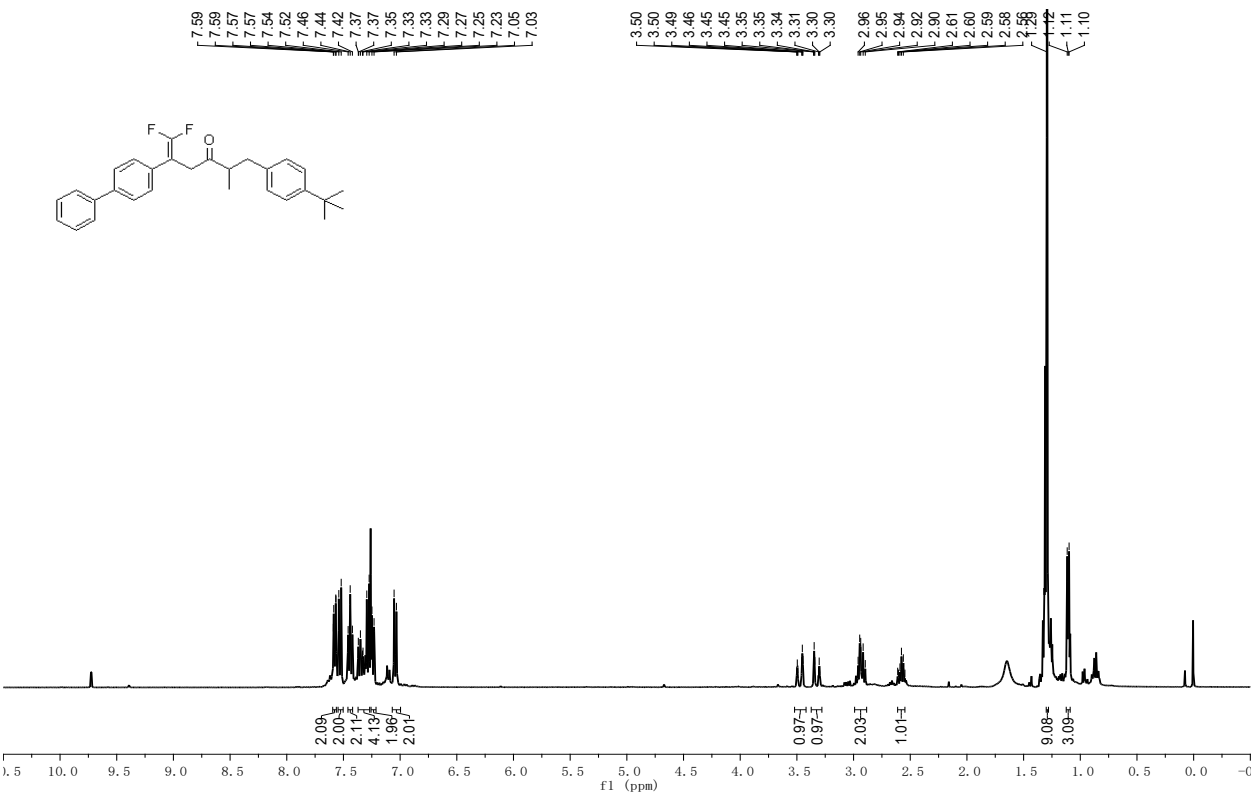
^{19}F NMR spectrum of compound 3h



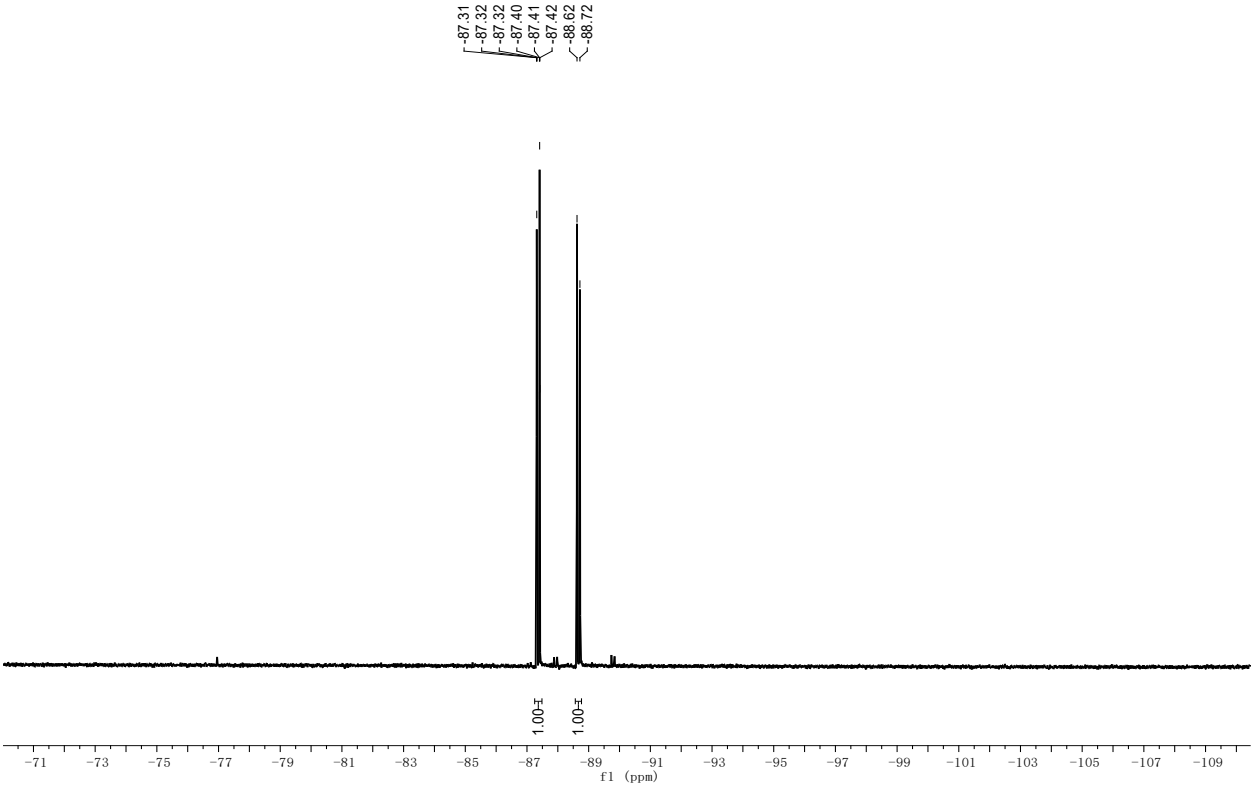
^{13}CNMR spectrum of compound 3h



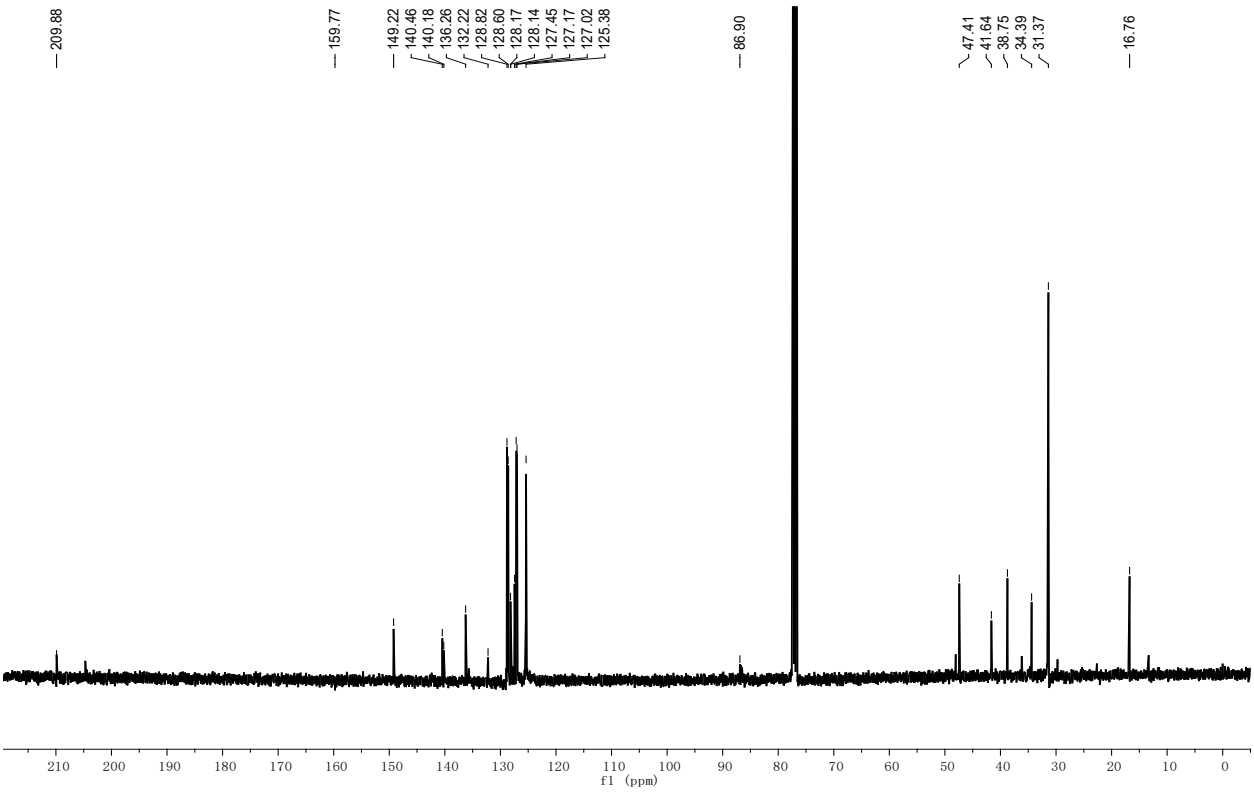
^{1}H NMR spectrum of compound 3i



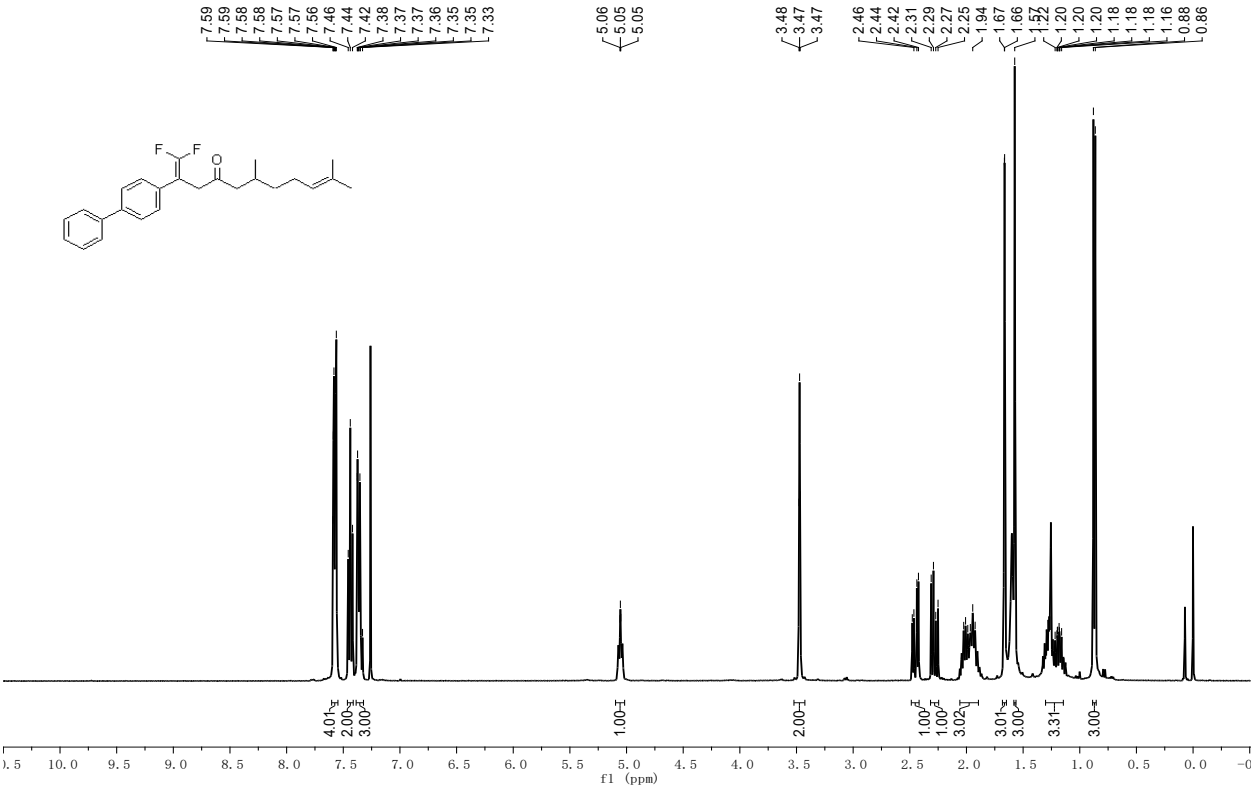
^{19}F NMR spectrum of compound 3i



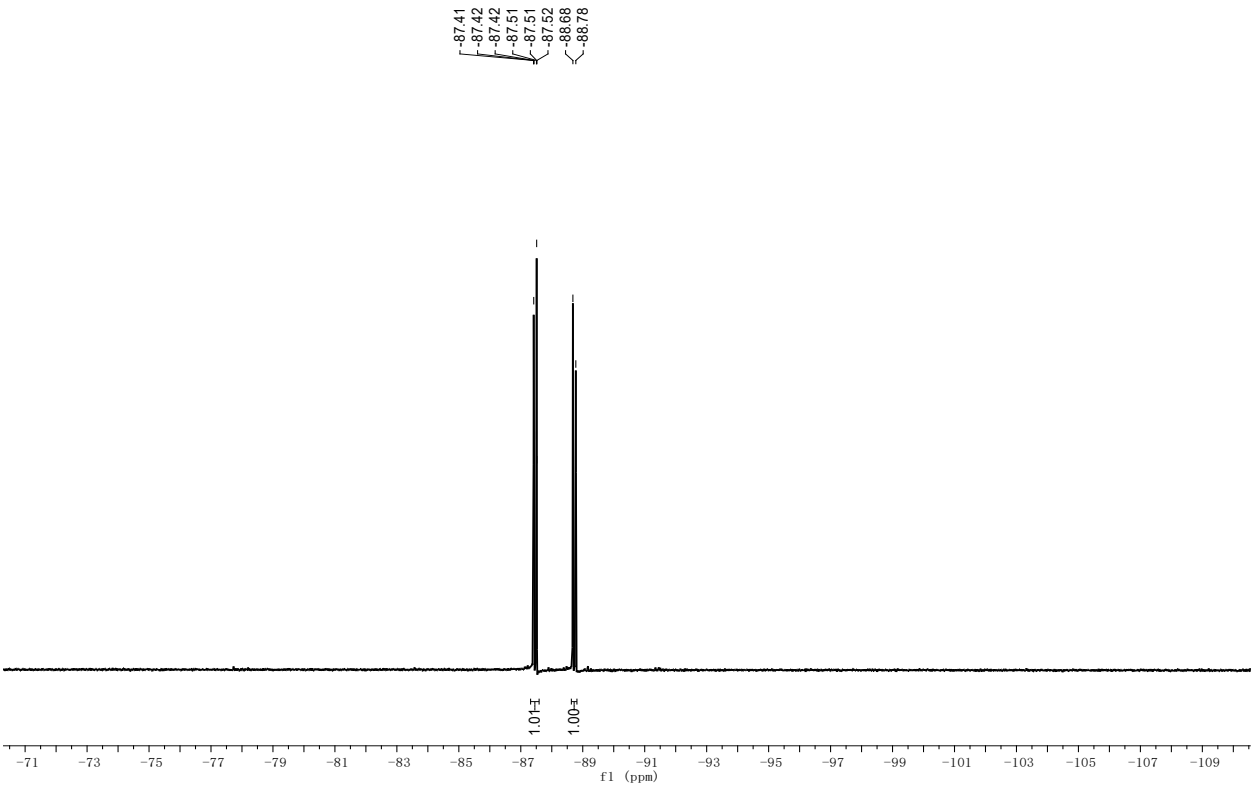
^{13}CNMR spectrum of compound 3i



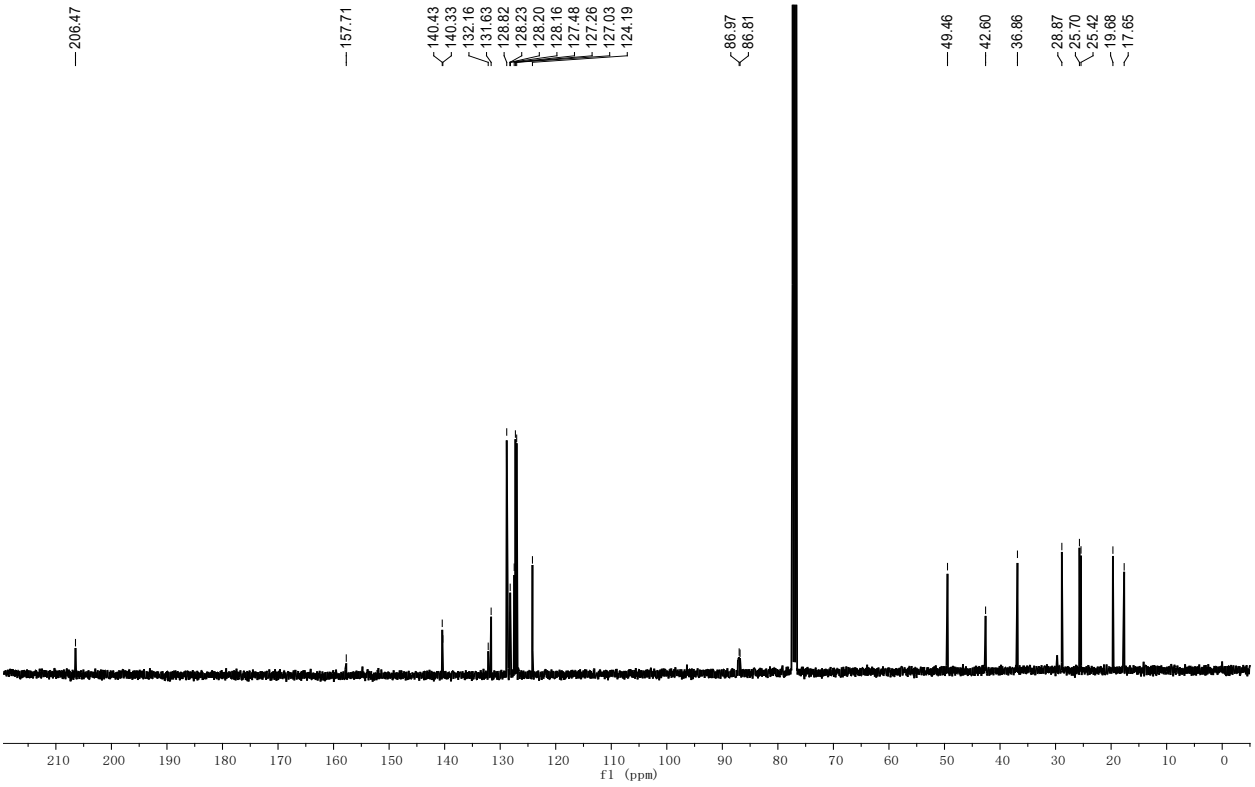
^{1}H NMR spectrum of compound 3j



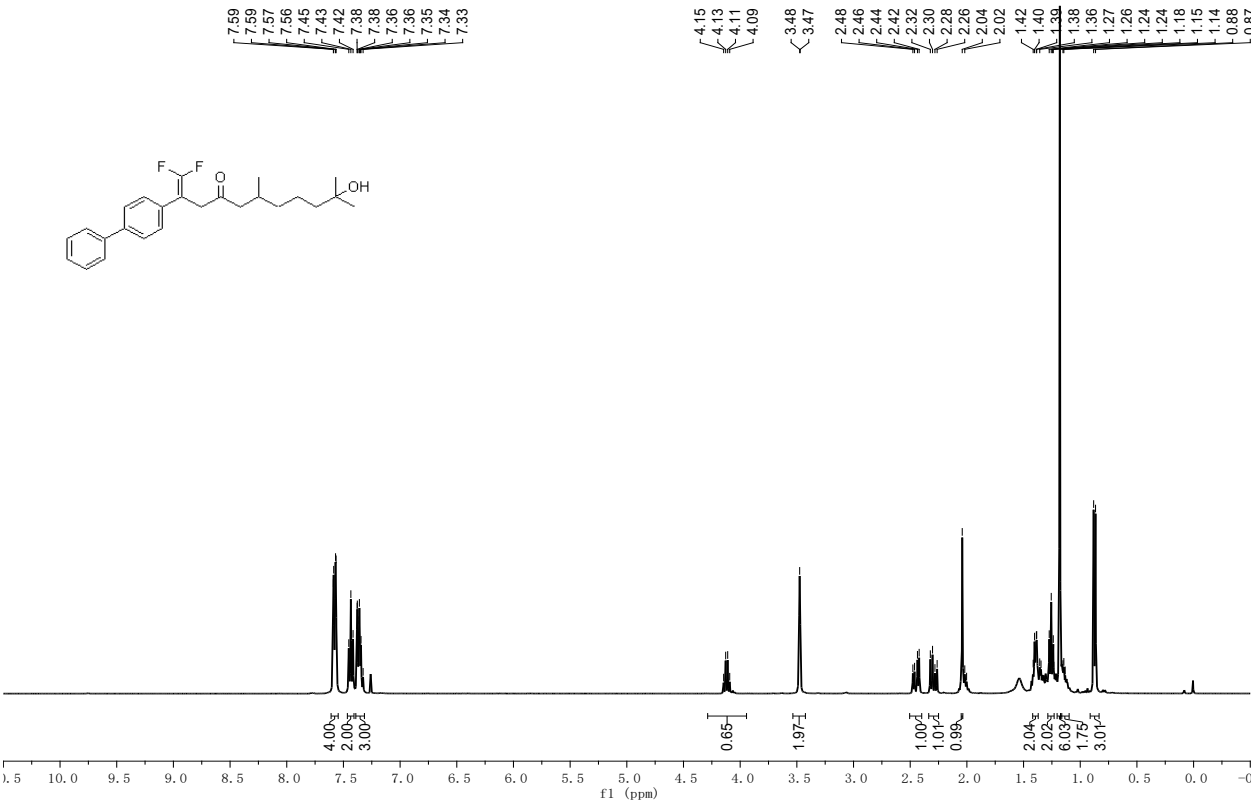
^{19}F NMR spectrum of compound 3j



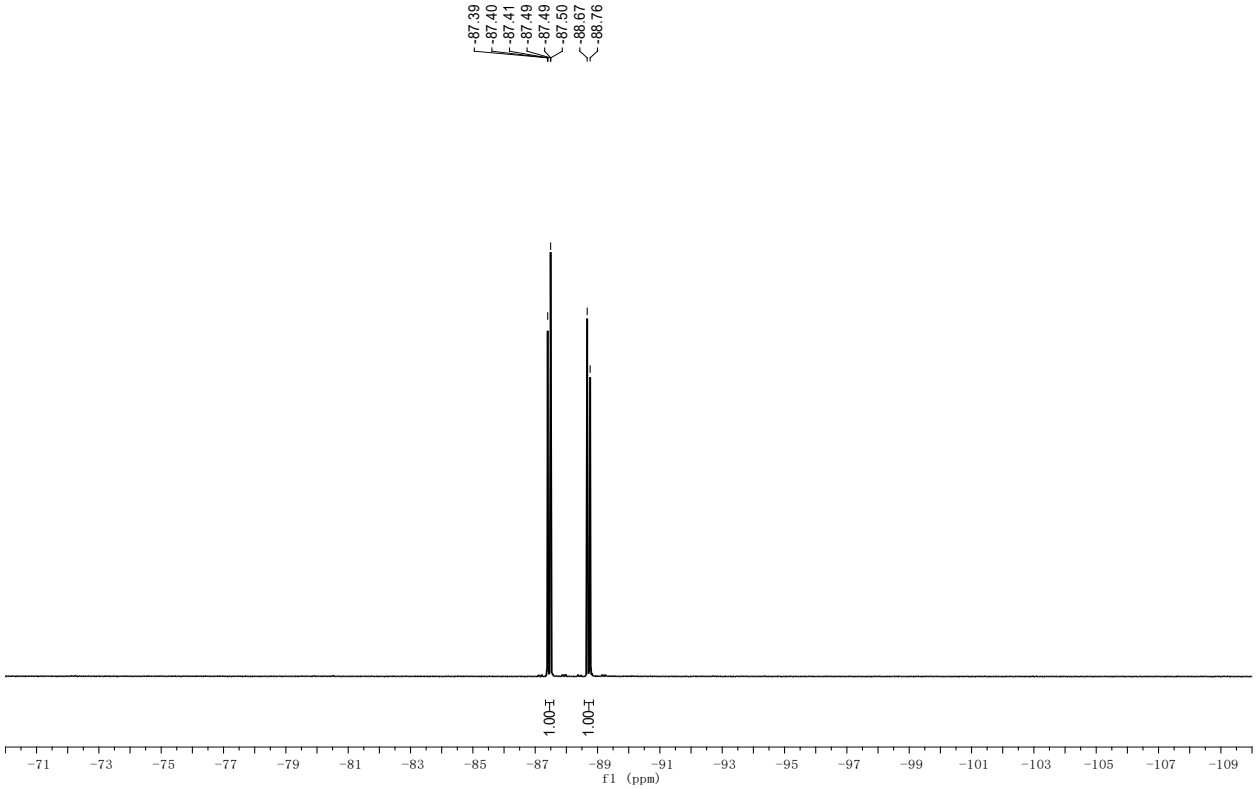
^{13}CNMR spectrum of compound 3j



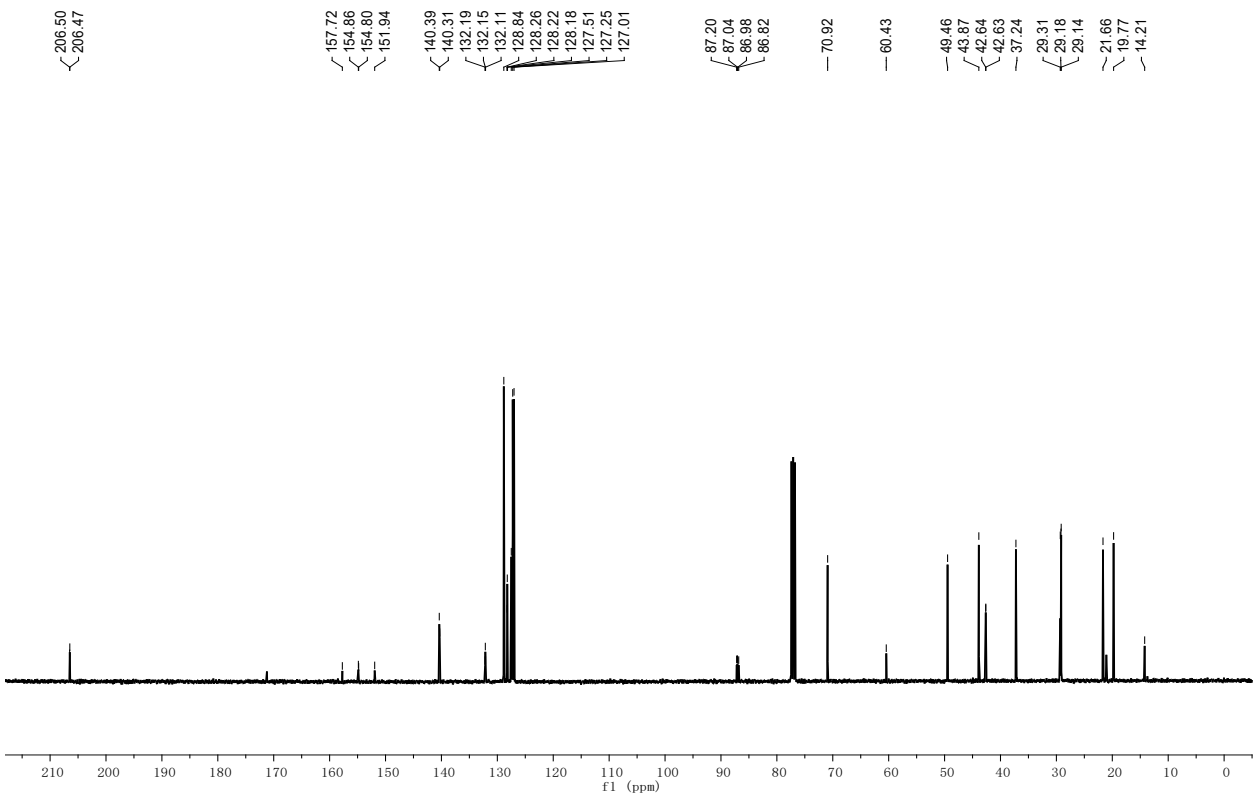
^{1}H NMR spectrum of compound 3k



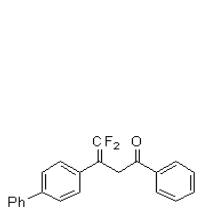
^{19}F NMR spectrum of compound 3k



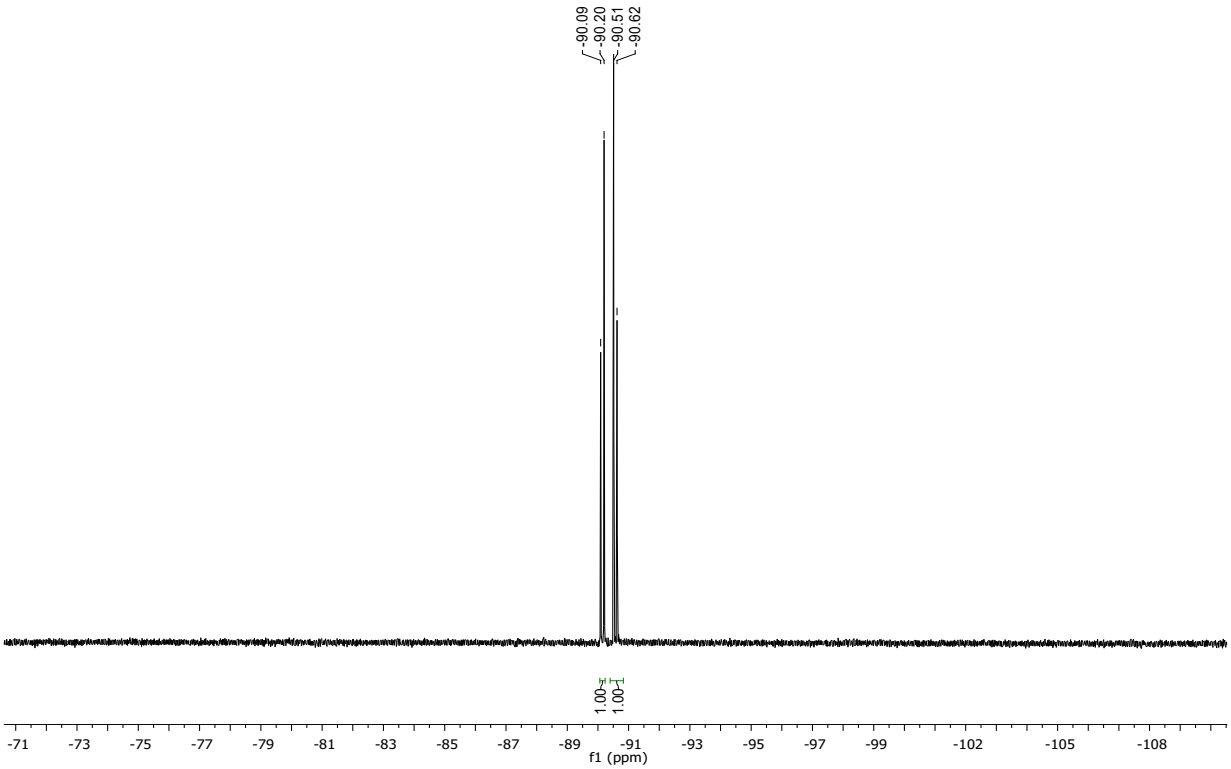
^{13}CNMR spectrum of compound 3k



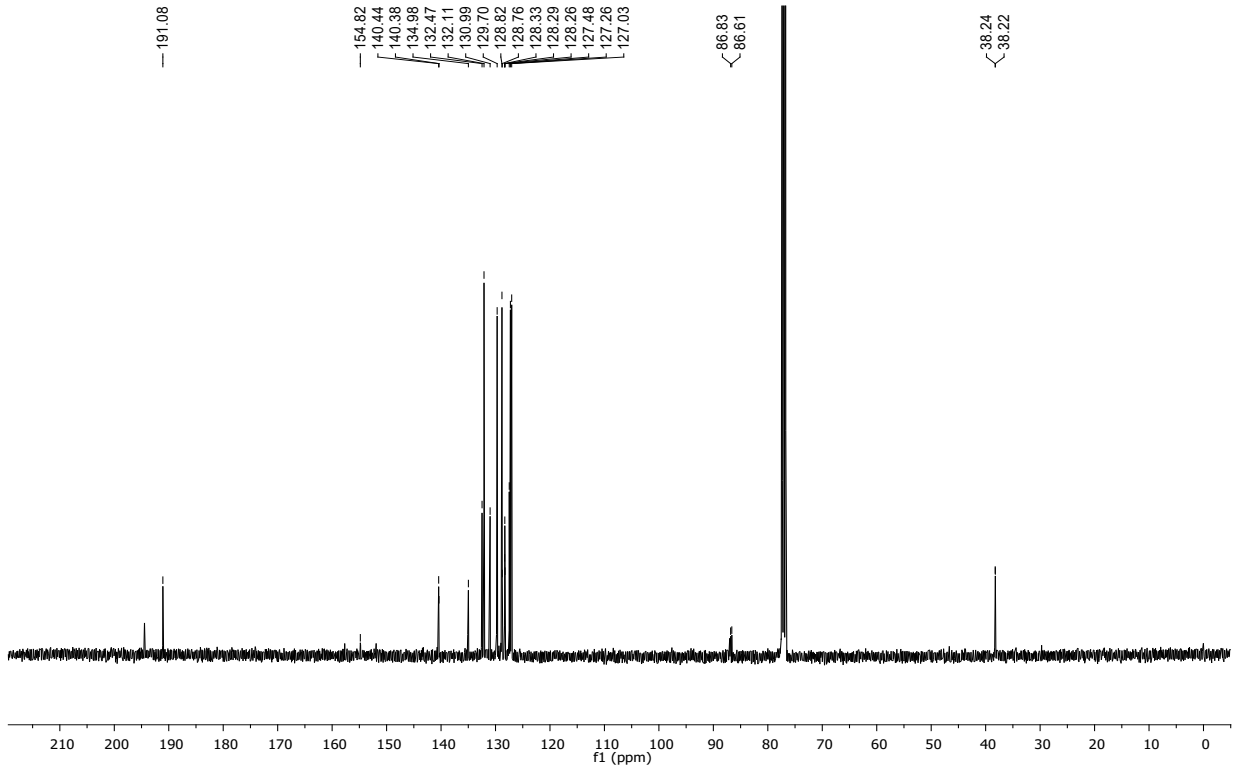
^{1}H NMR spectrum of compound 4a



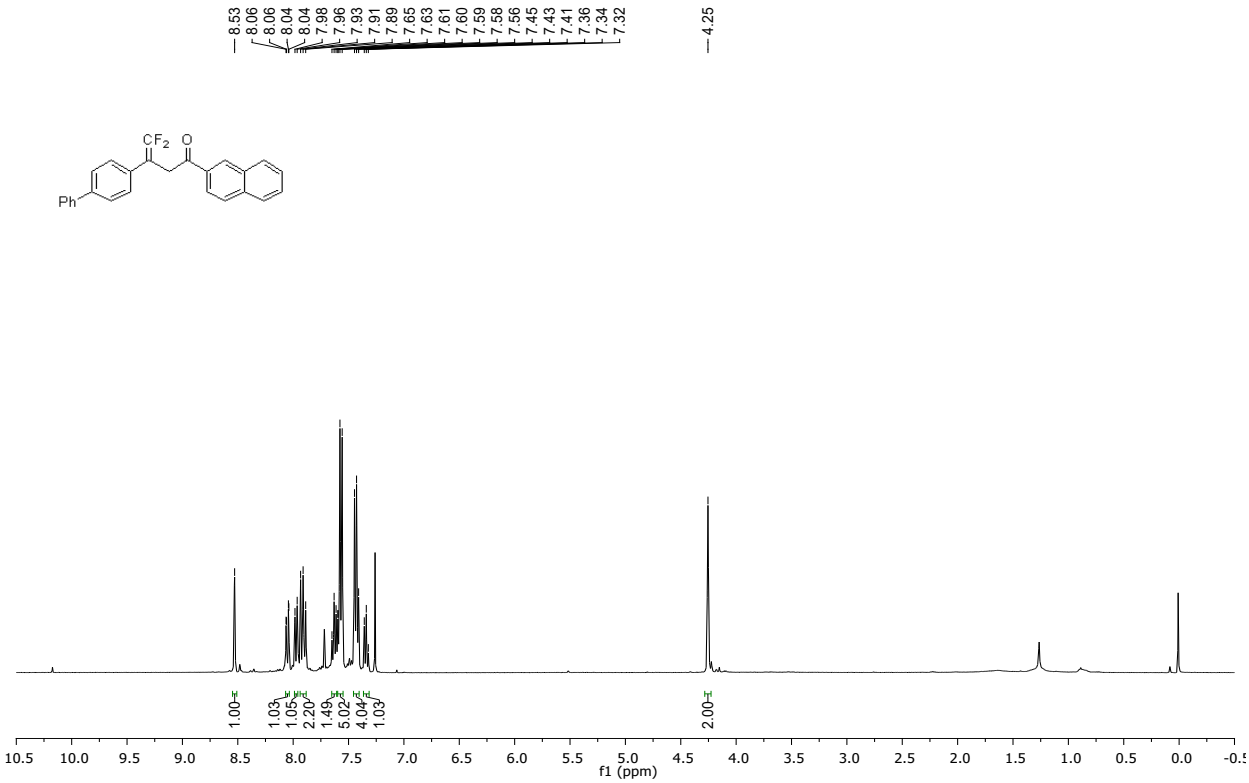
^{19}F NMR spectrum of compound 4a



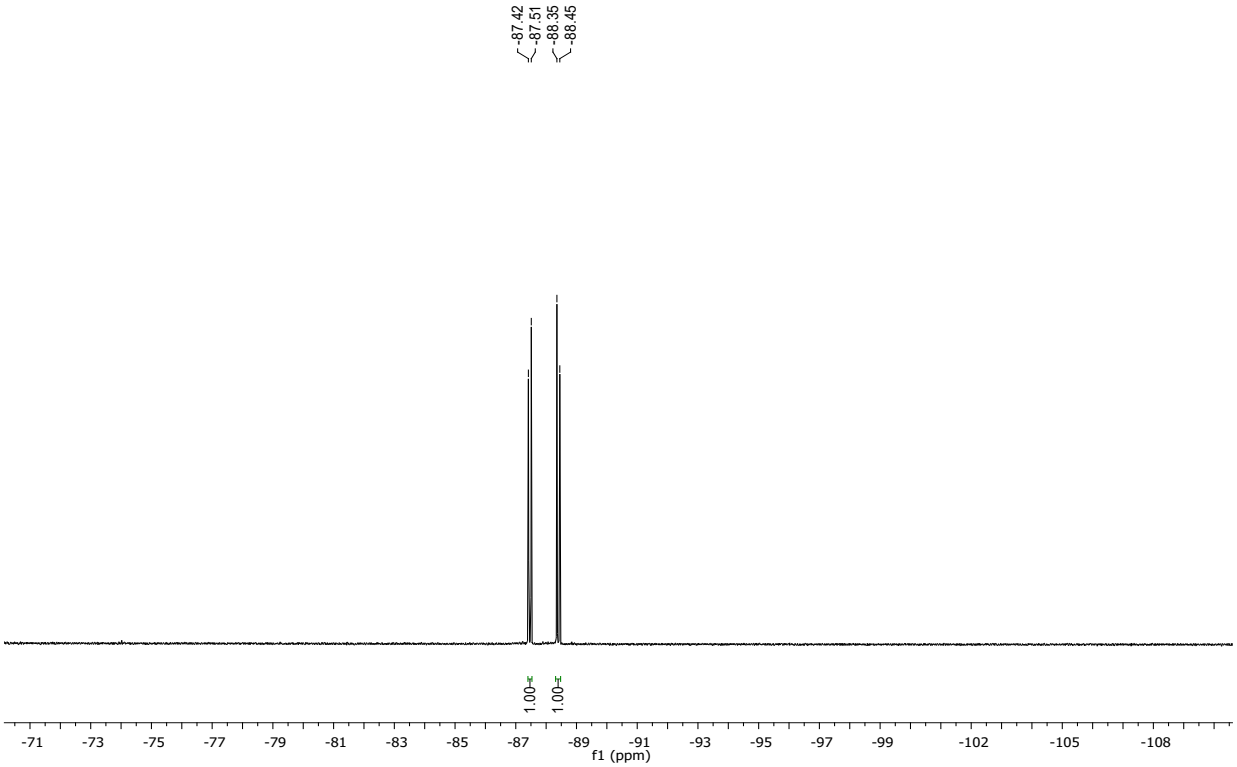
^{13}C NMR spectrum of compound 4a



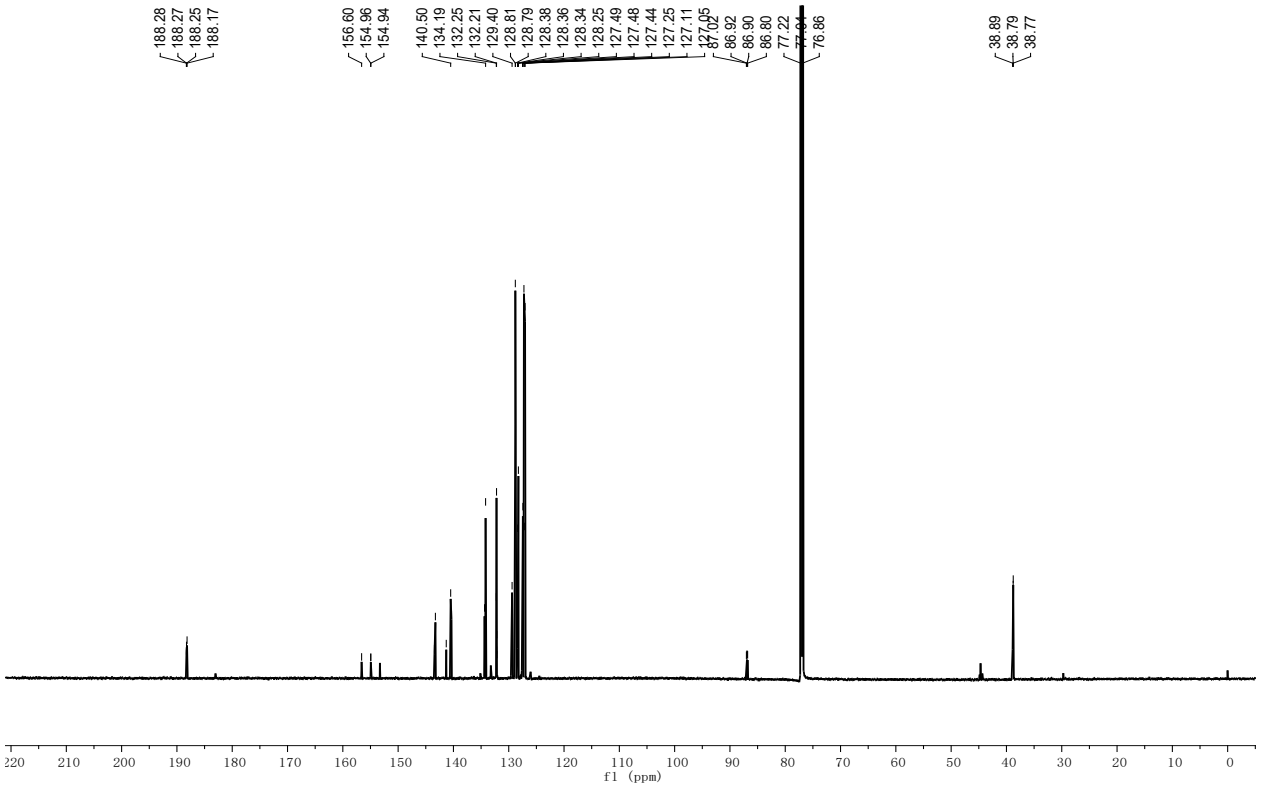
^{1}H NMR spectrum of compound 4b



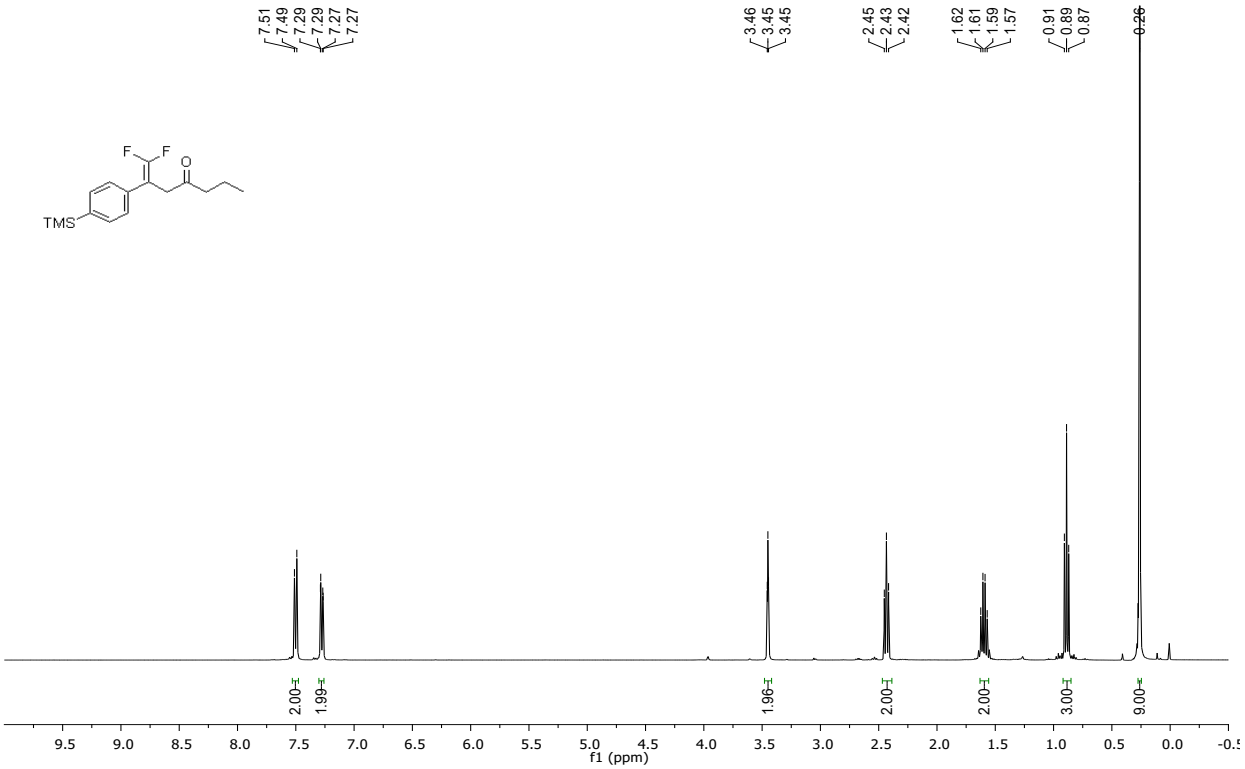
^{19}F NMR spectrum of compound 4b



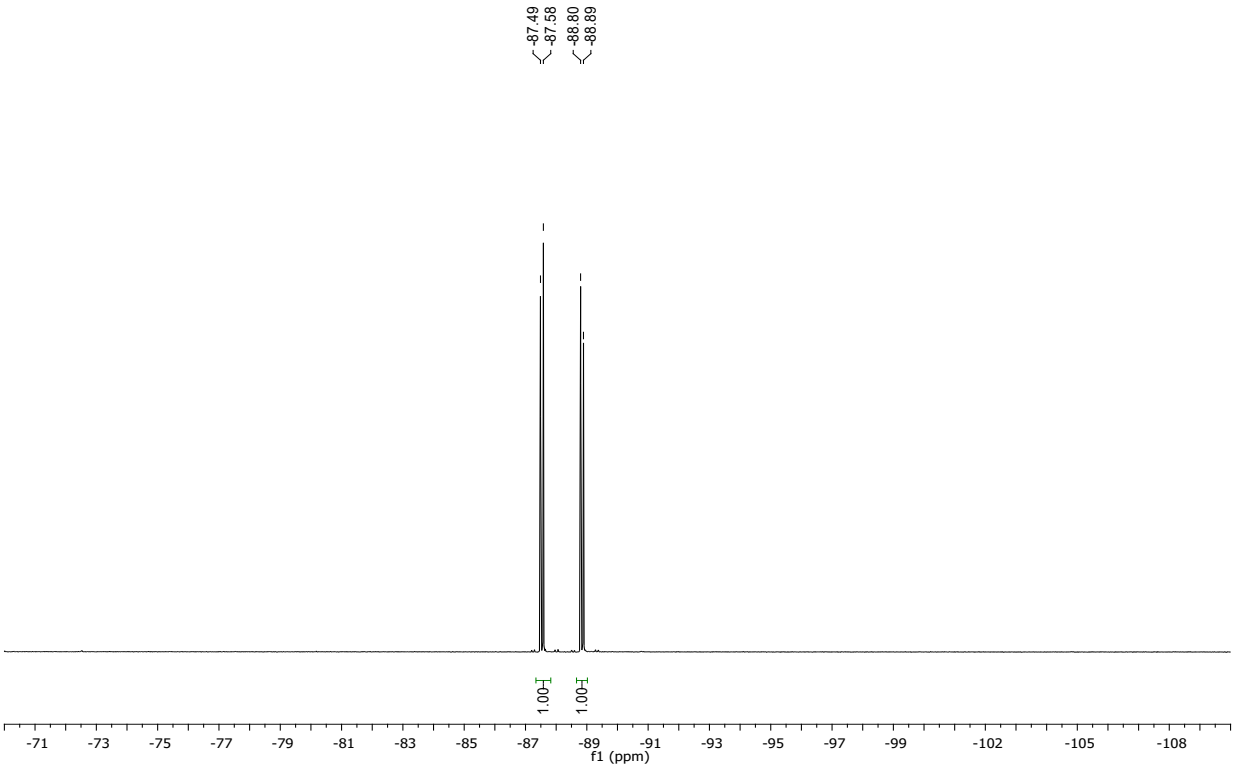
^{13}C NMR spectrum of compound 4b



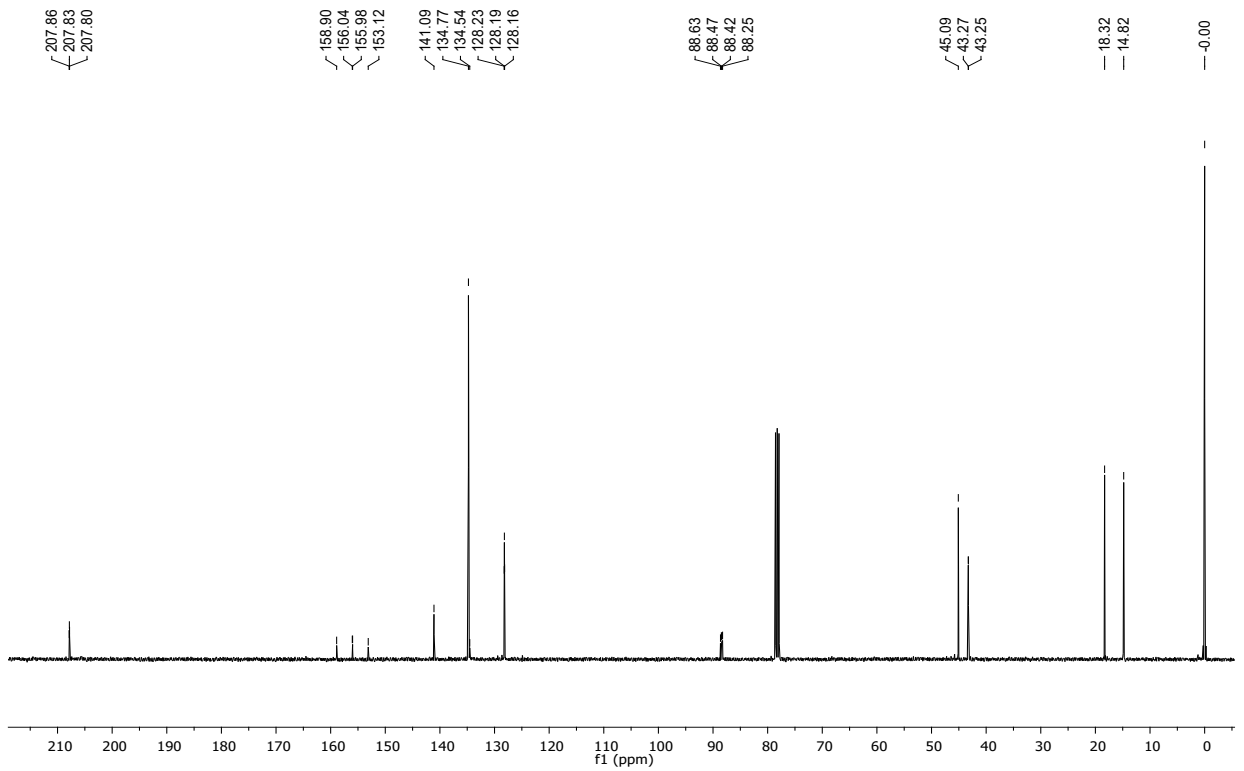
^{1}H NMR spectrum of compound 5a



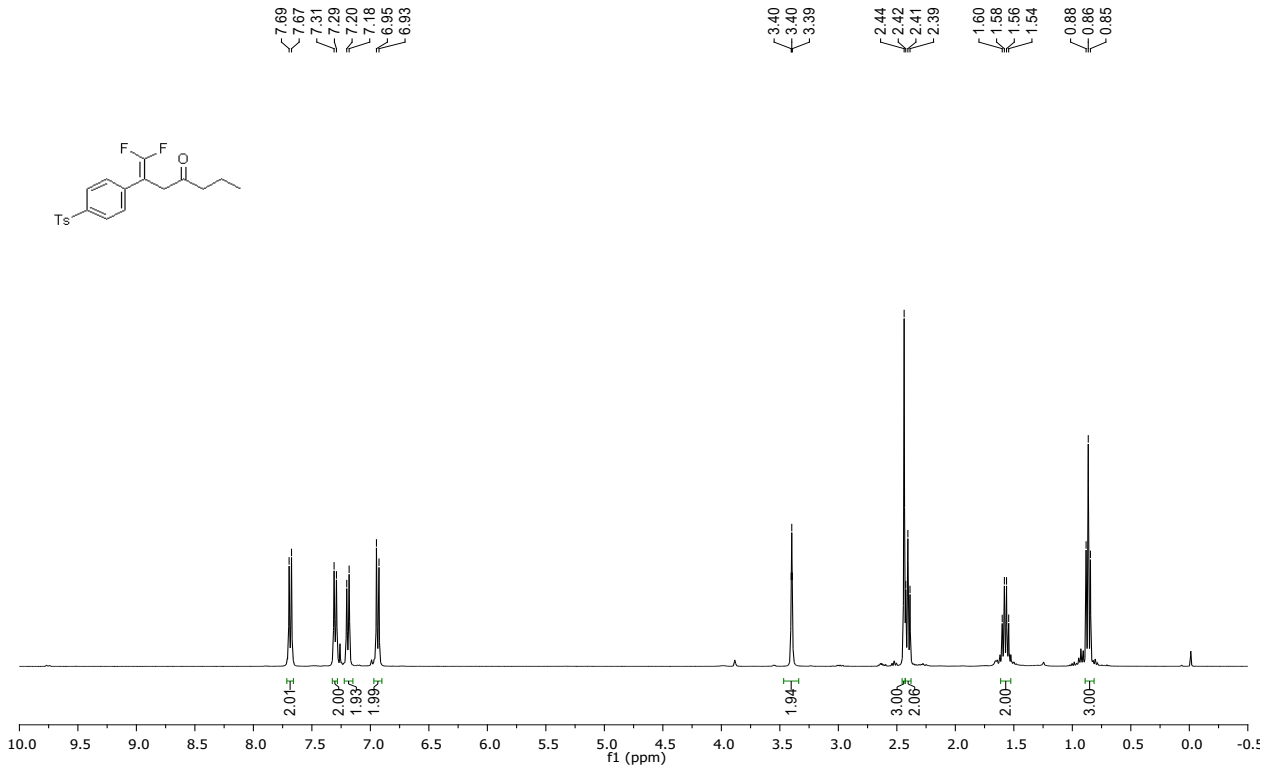
^{19}F NMR spectrum of compound 5a



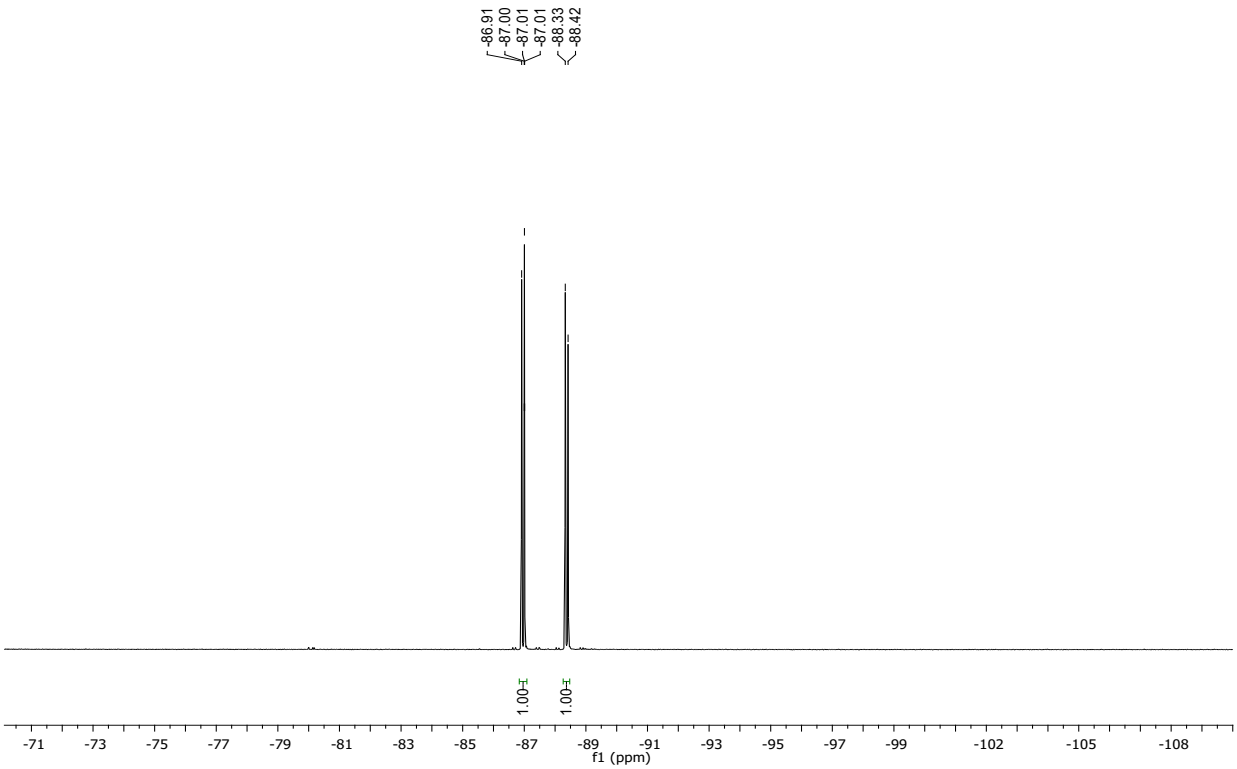
^{13}CNMR spectrum of compound 5a



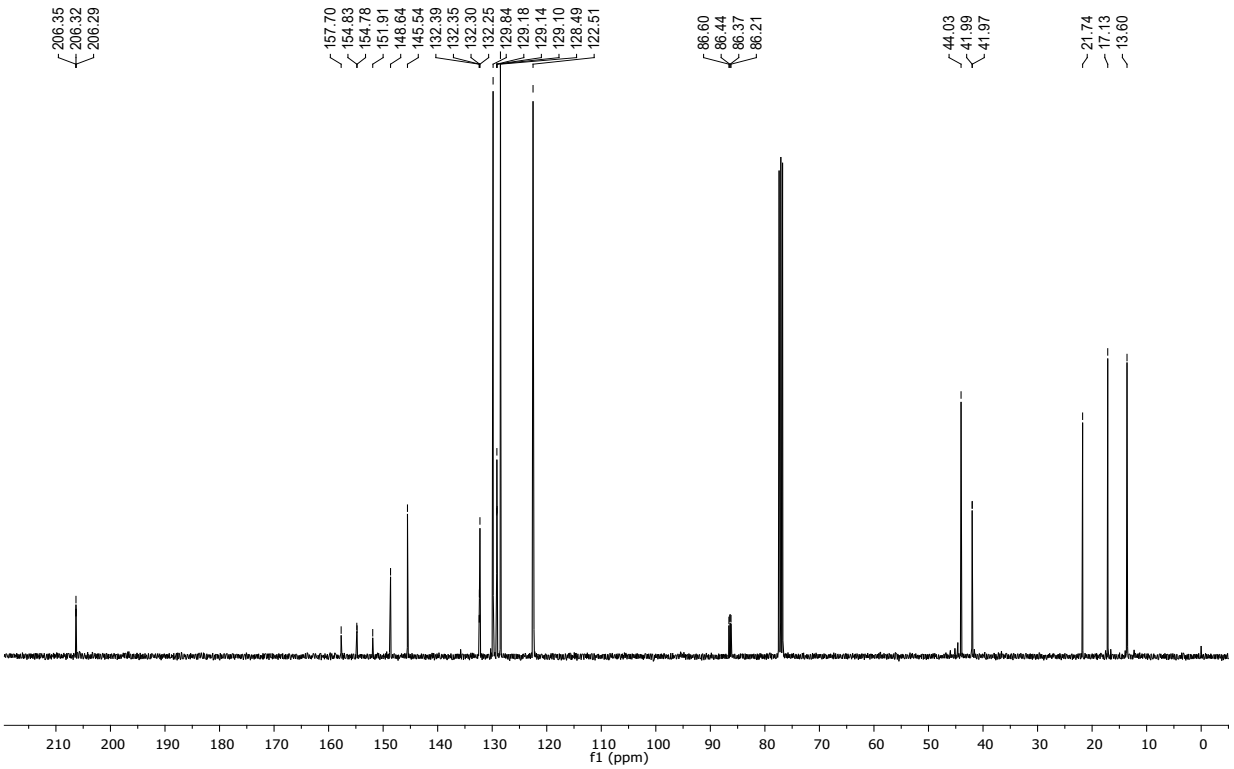
^{1}H NMR spectrum of compound 5b



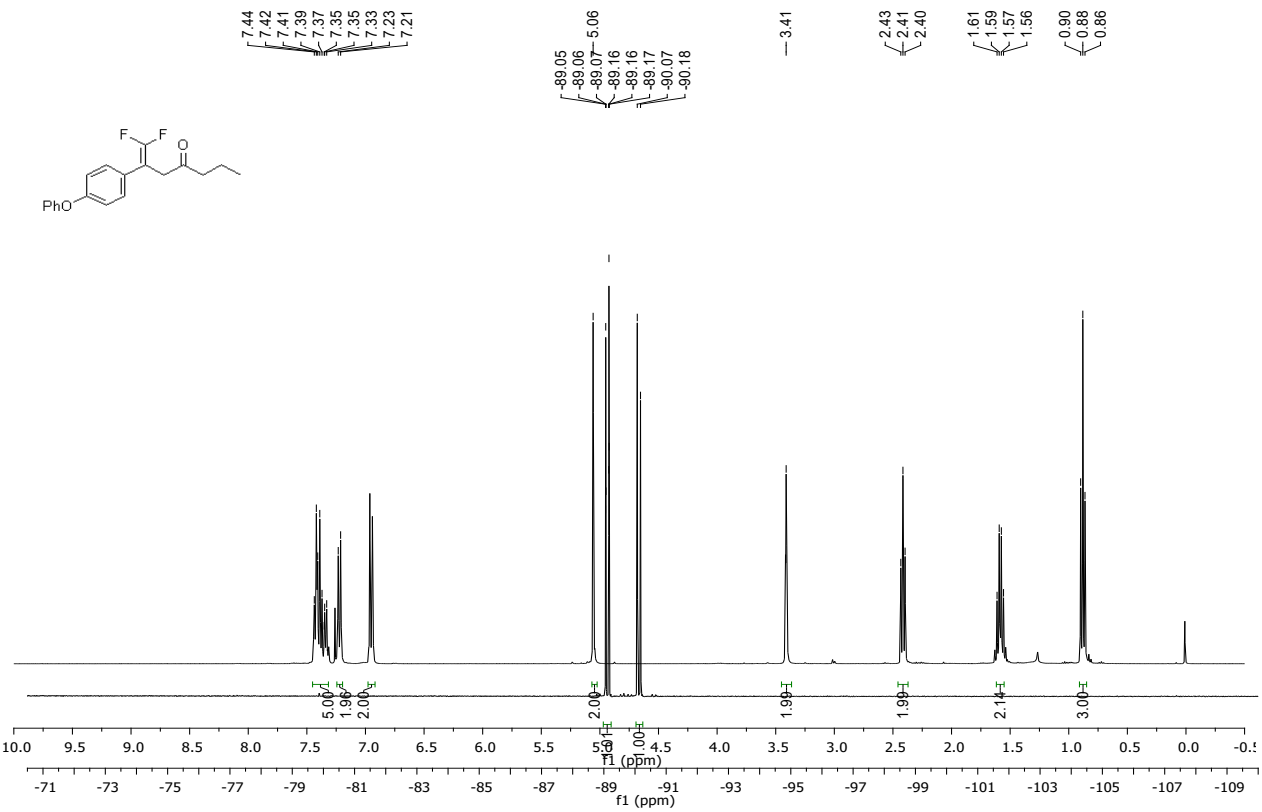
^{19}F NMR spectrum of compound 5b



^{13}CNMR spectrum of compound 5b

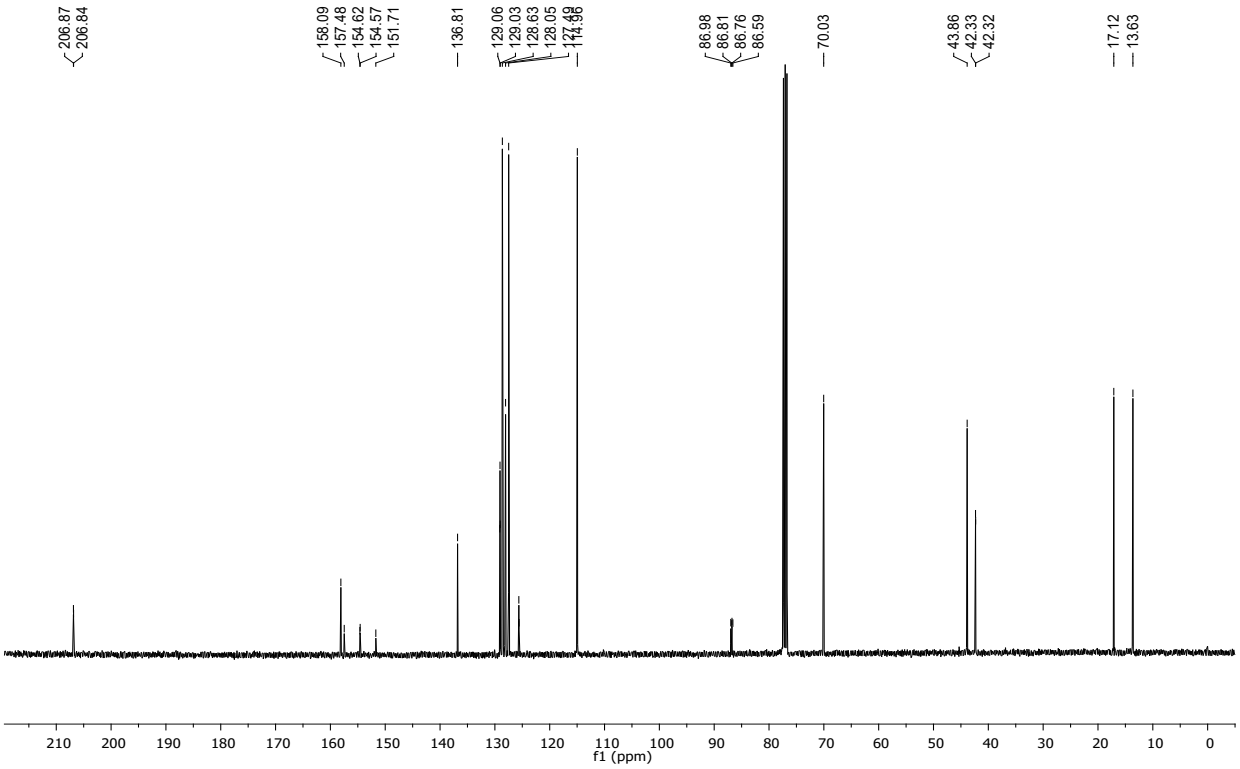


^{1}H NMR spectrum of compound 5c

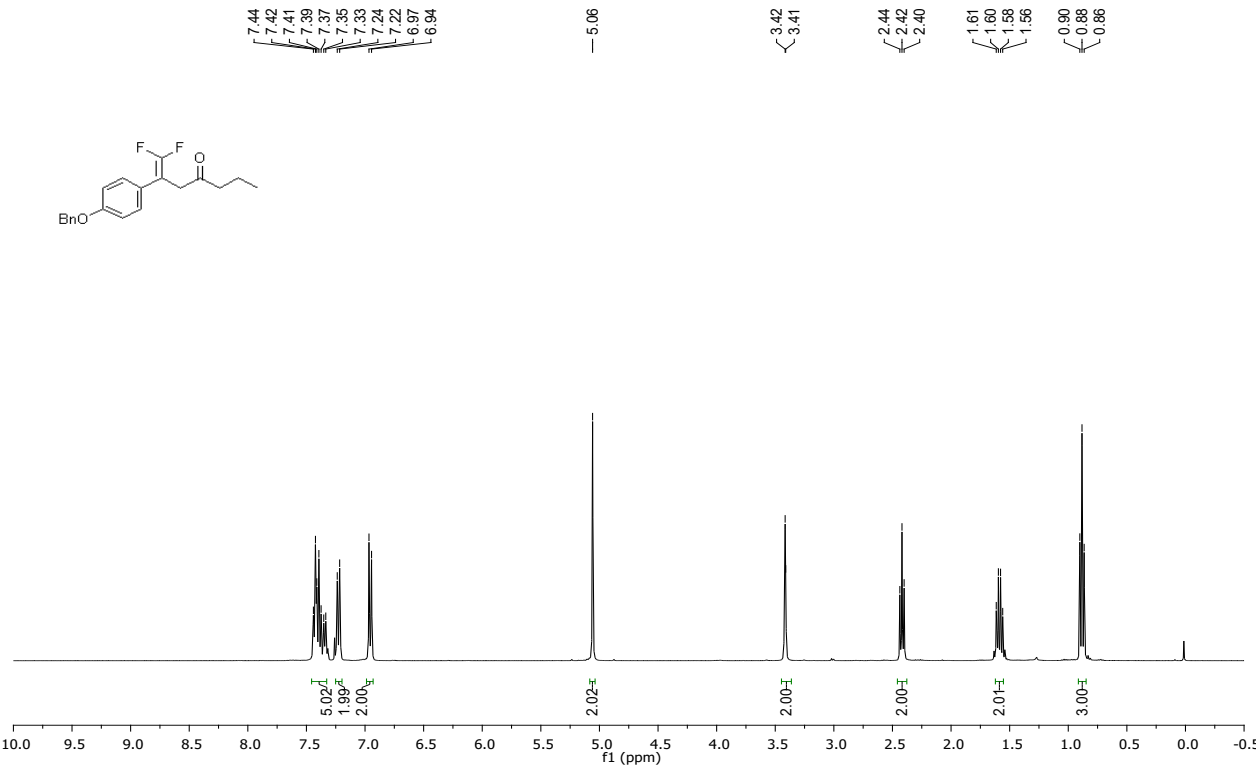


^{19}F NMR spectrum of compound 5c

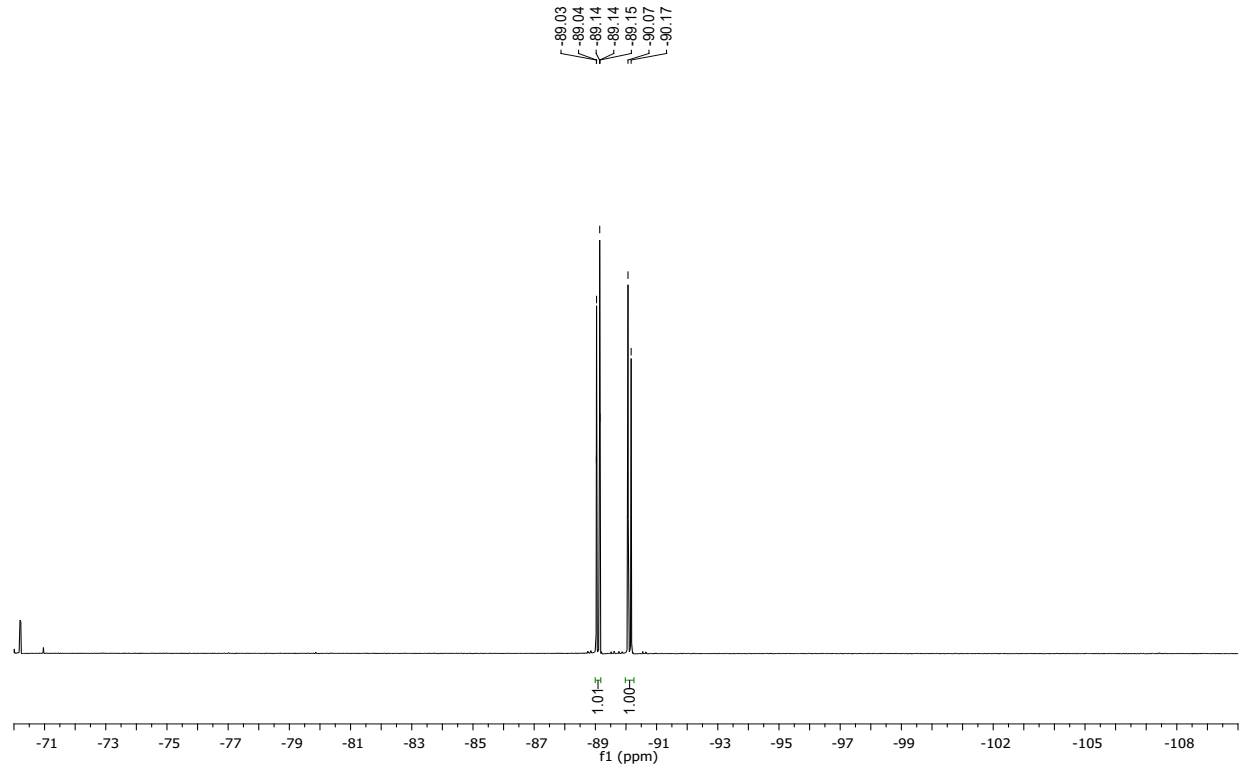
^{13}CNMR spectrum of compound 5c



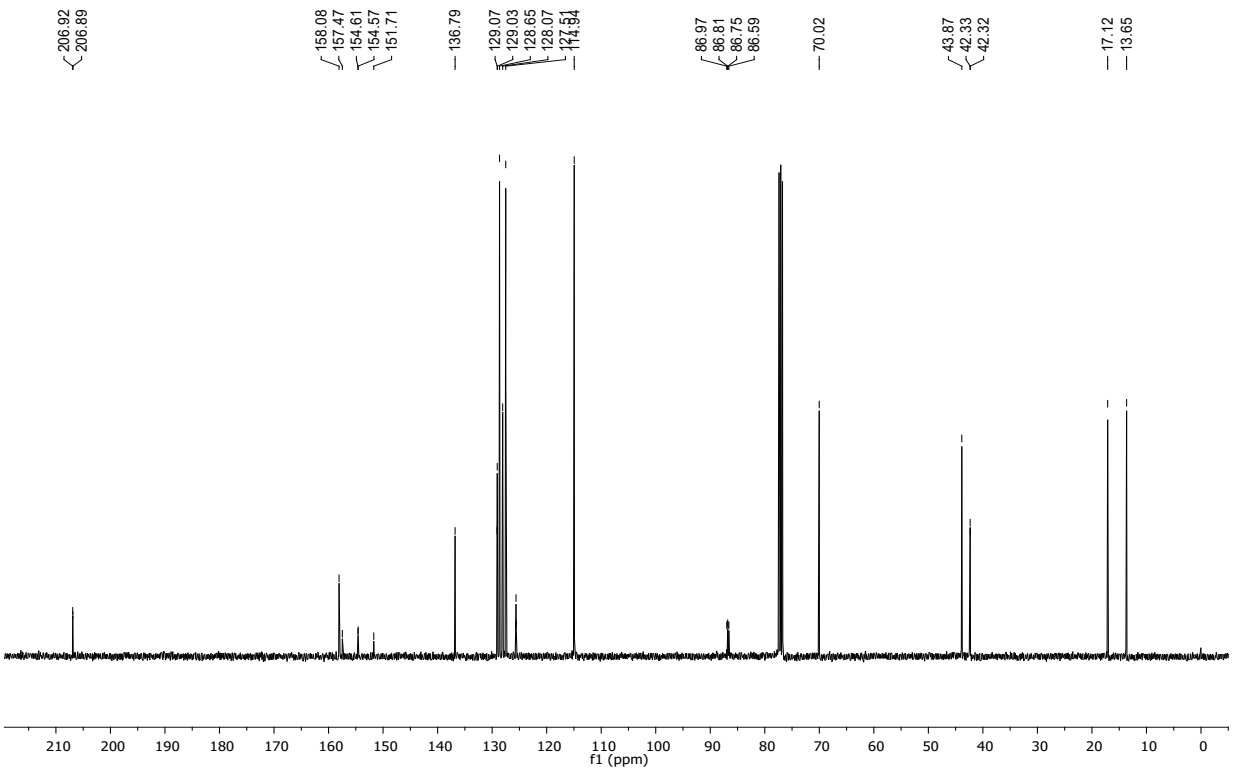
^{1}H NMR spectrum of compound 5d



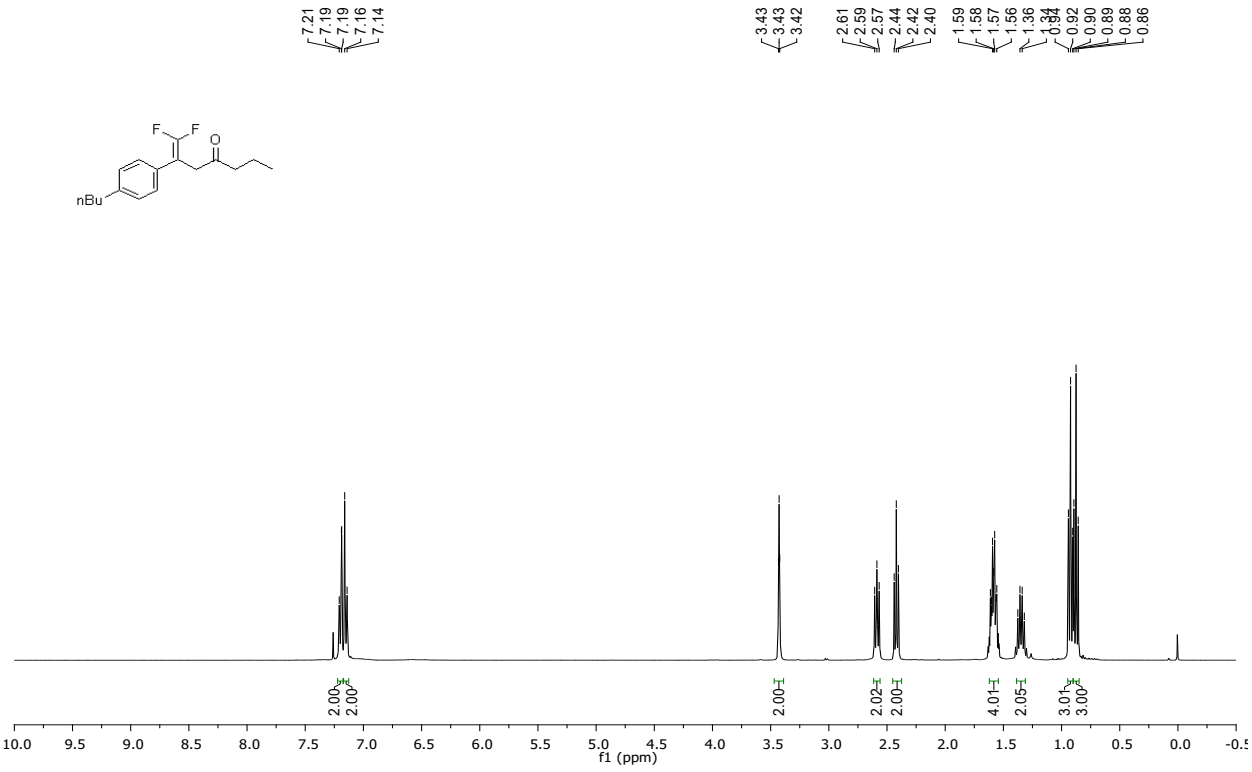
^{19}F NMR spectrum of compound 5d



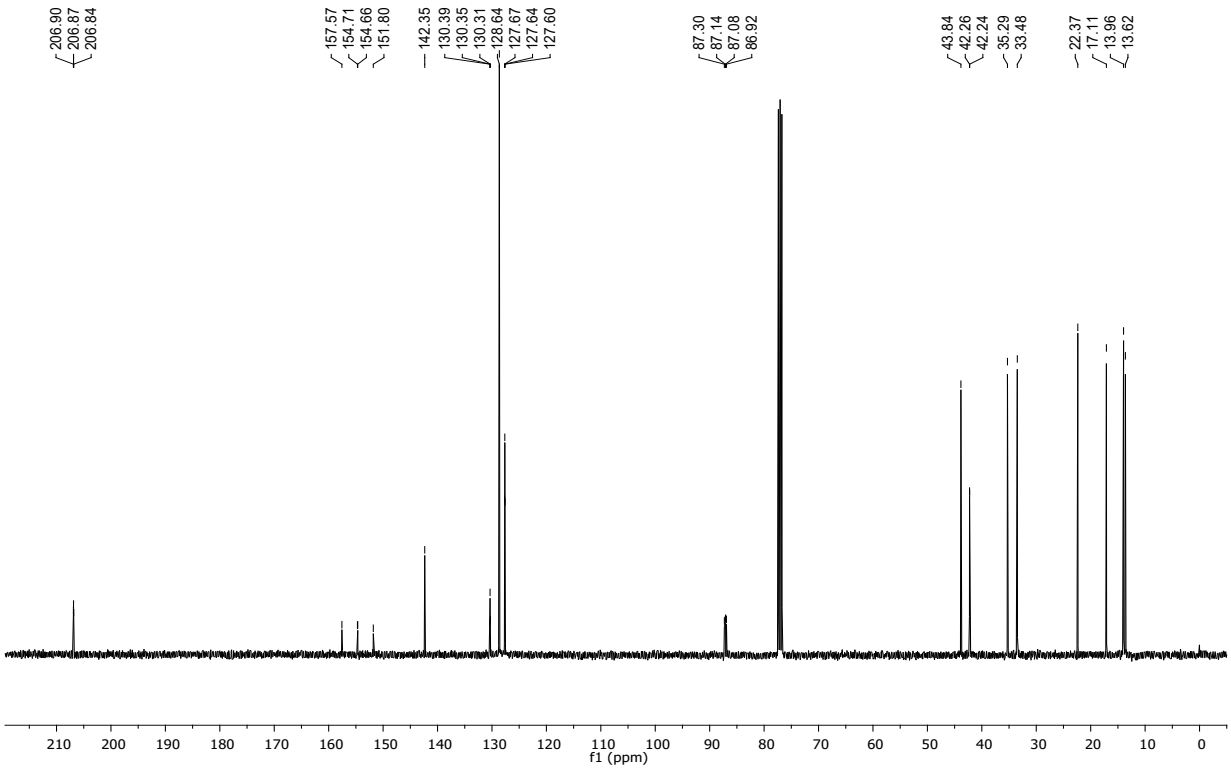
^{13}CNMR spectrum of compound 5d



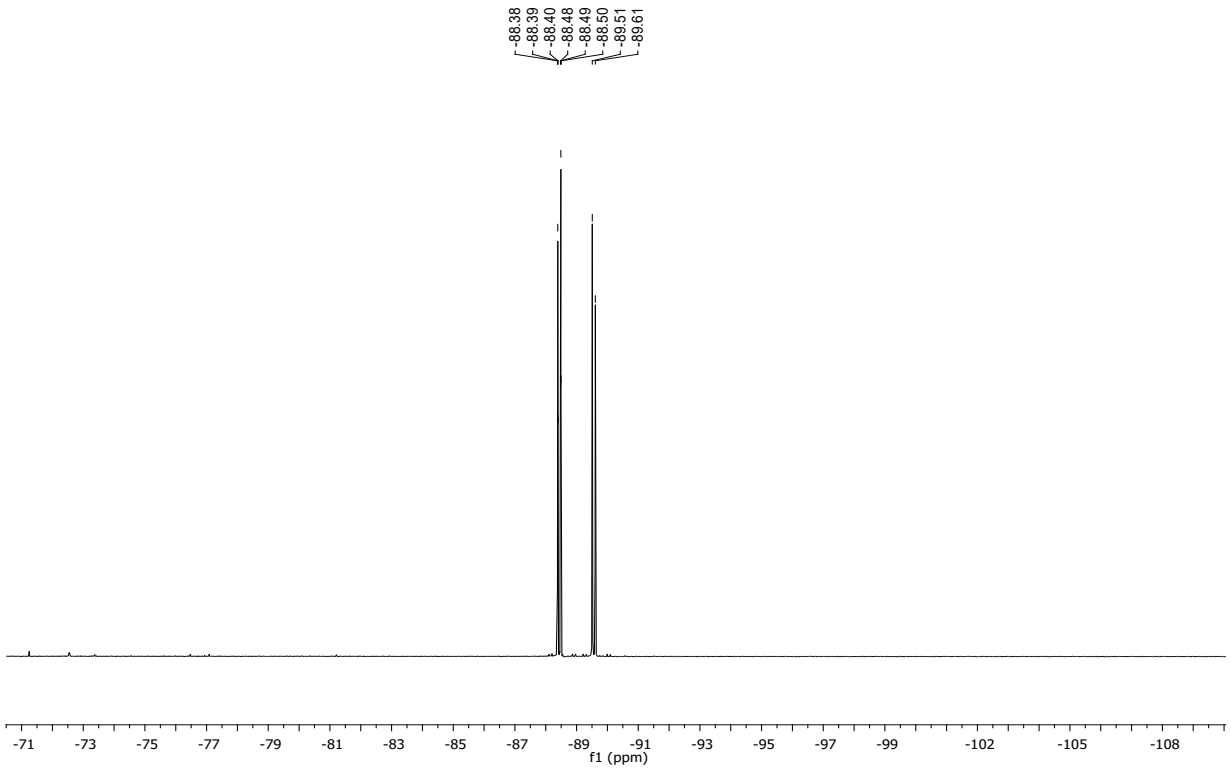
^{1}H NMR spectrum of compound 5e



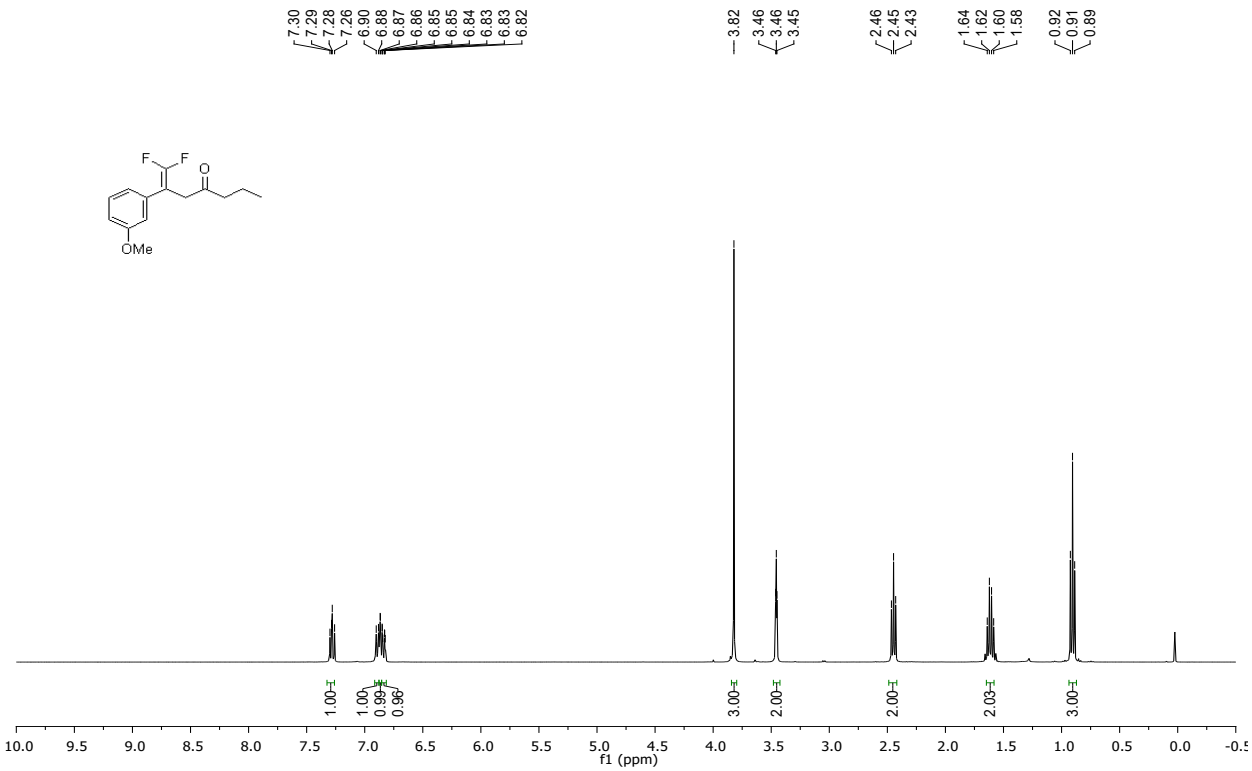
^{13}CNMR spectrum of compound 5e



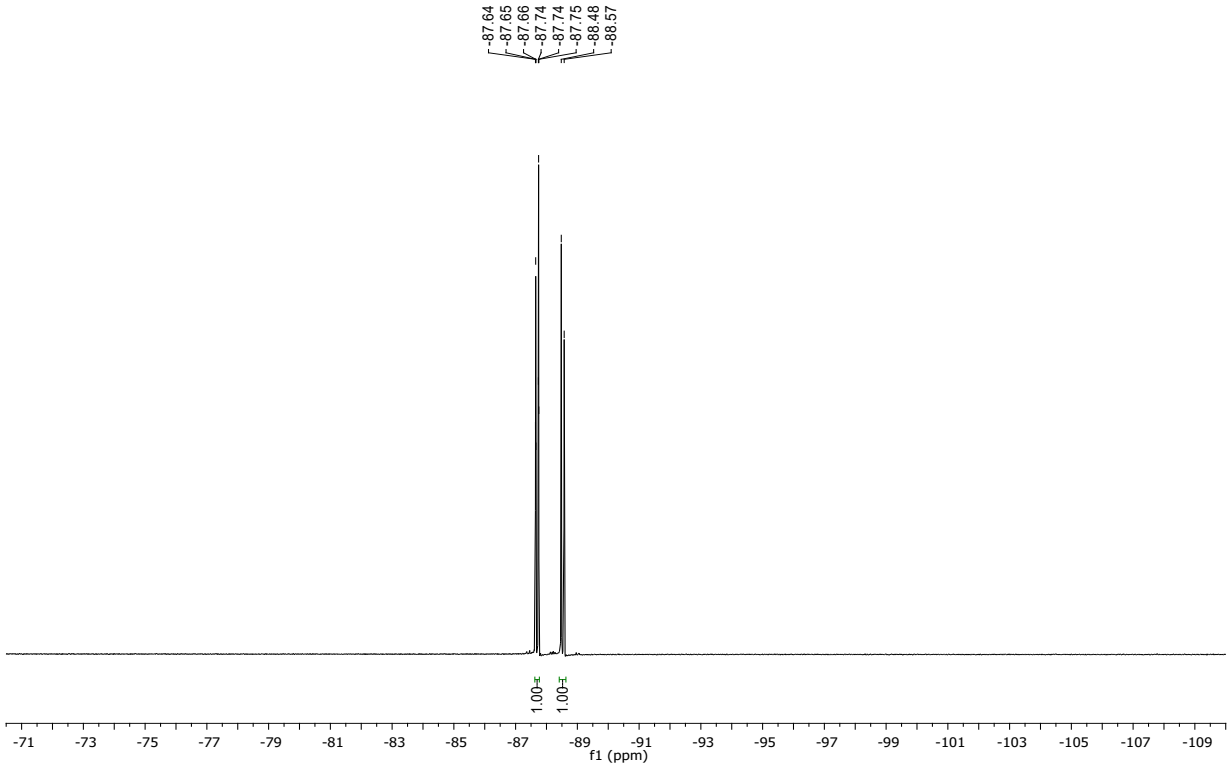
^{19}F NMR spectrum of compound 5e



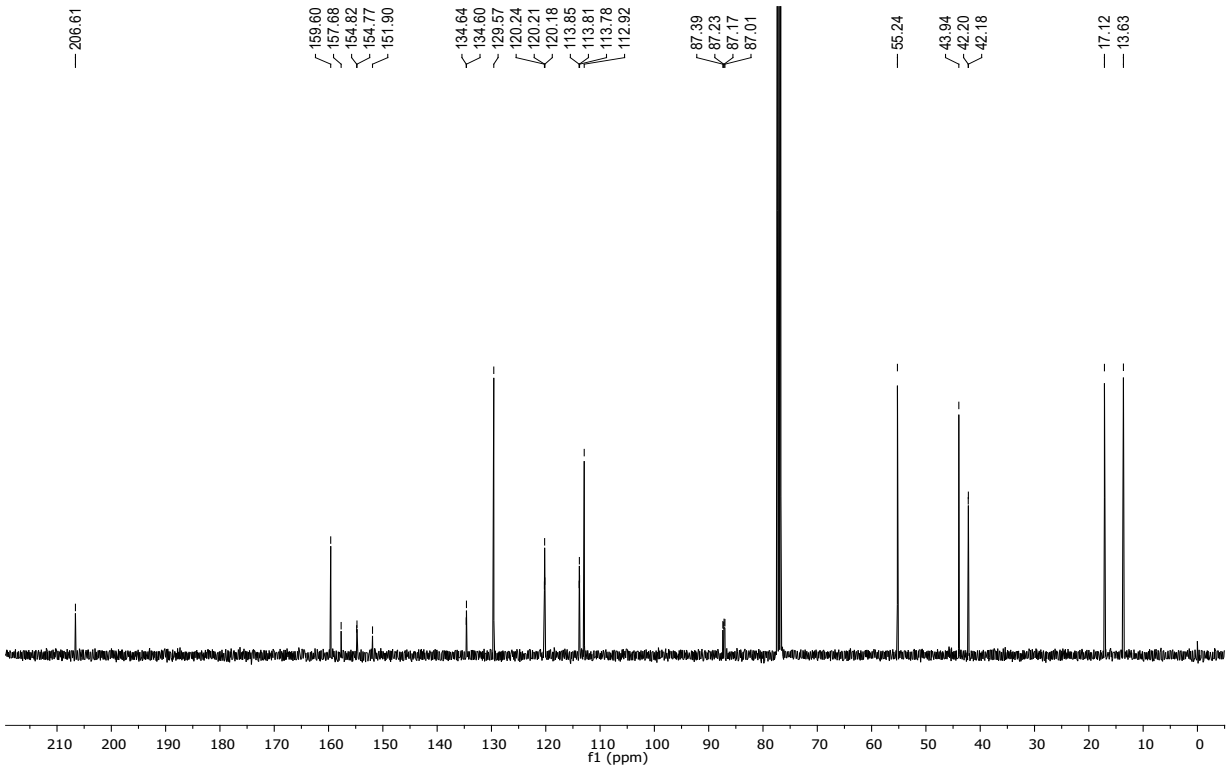
^{1}H NMR spectrum of compound 5f



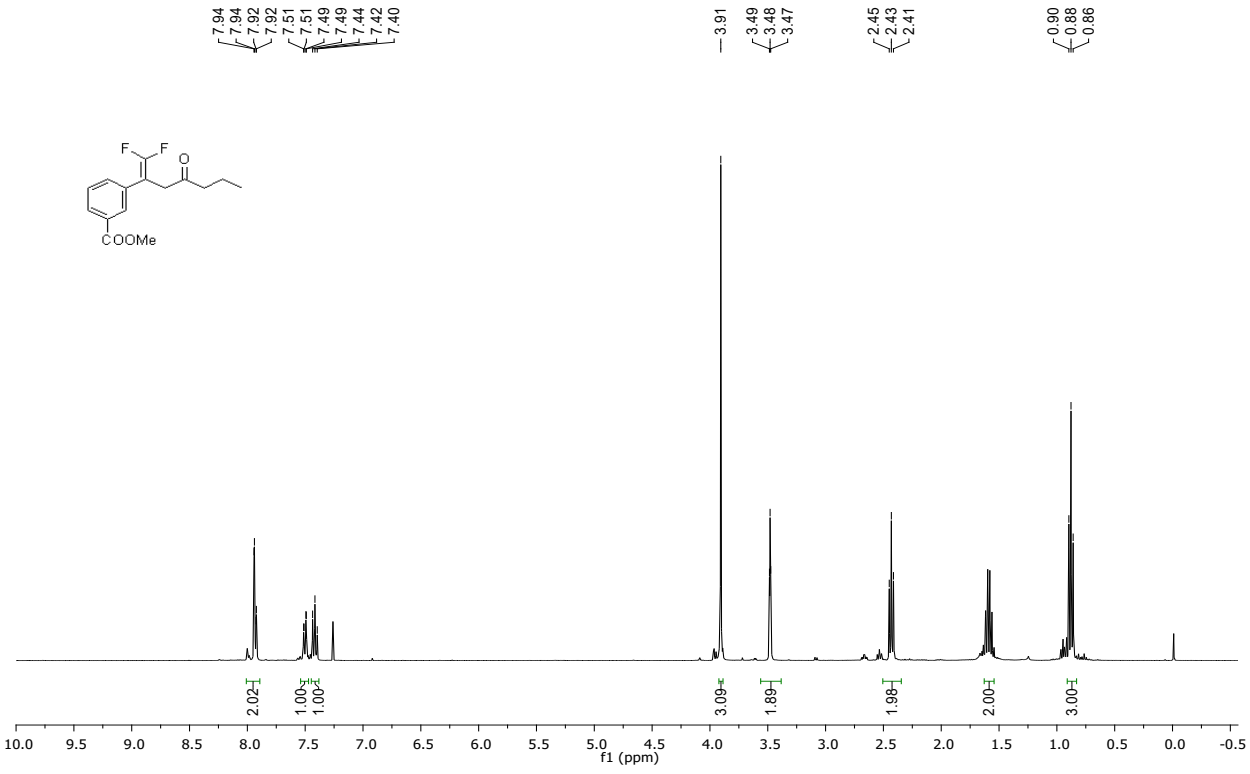
^{19}F NMR spectrum of compound 5f



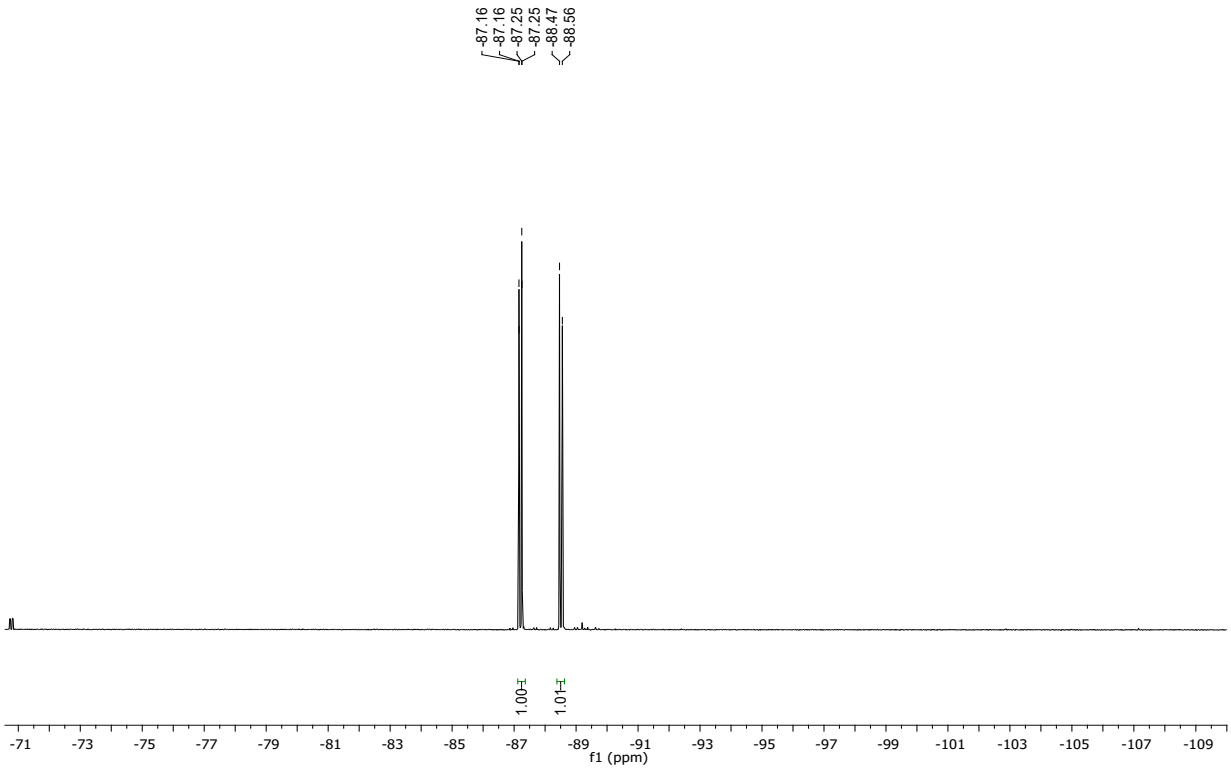
^{13}CNMR spectrum of compound 5f



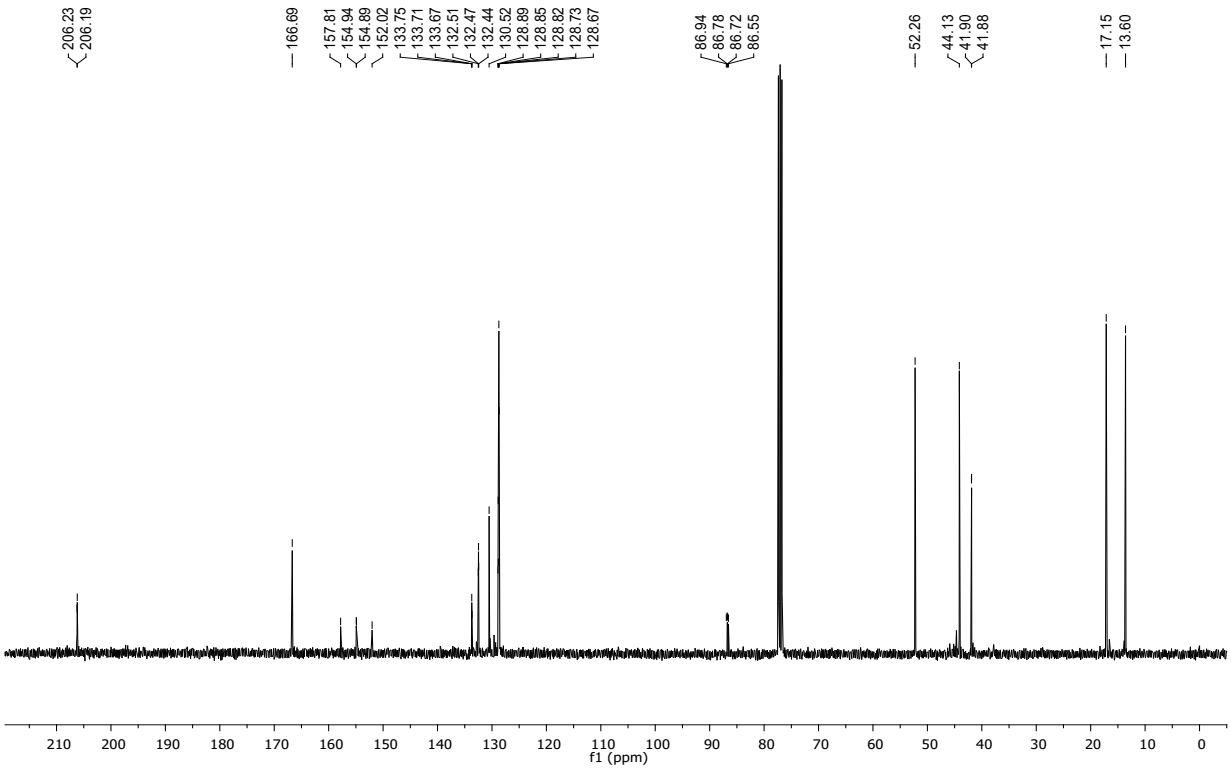
^{1}H NMR spectrum of compound 5g



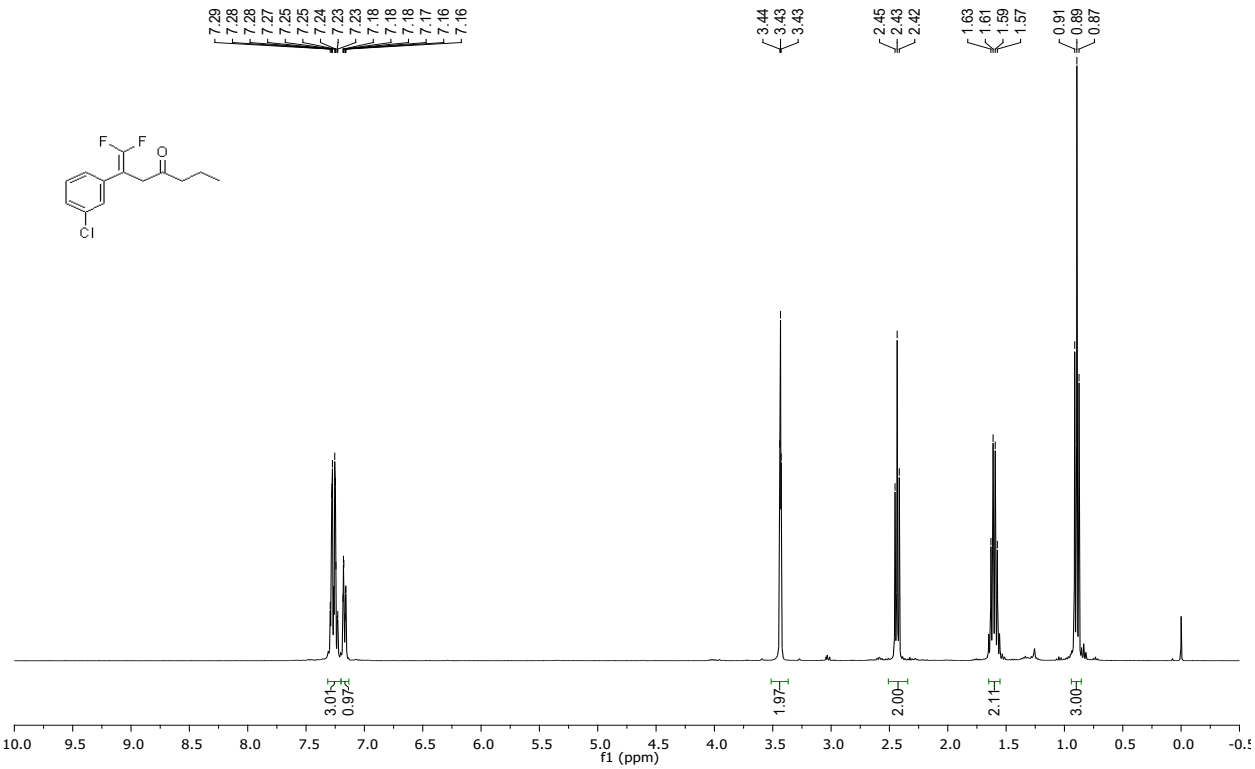
^{19}F NMR spectrum of compound 5g



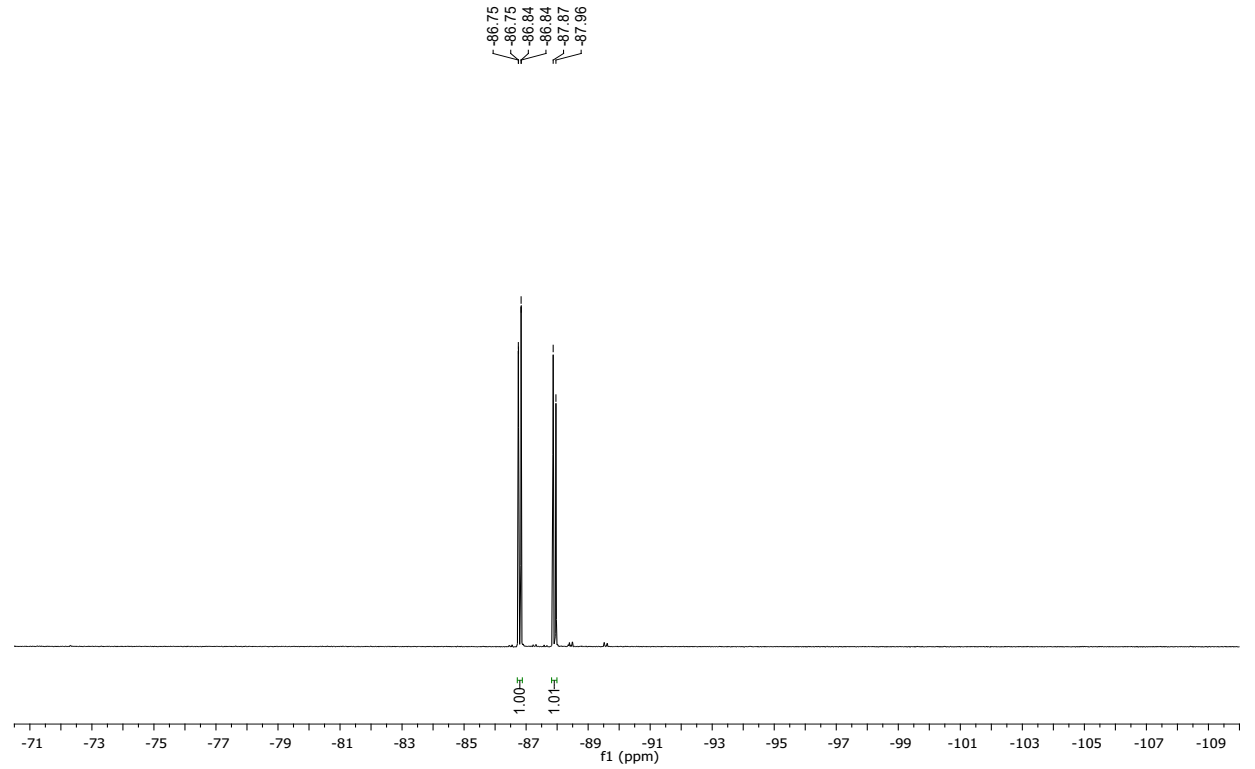
^{13}CNMR spectrum of compound 5g



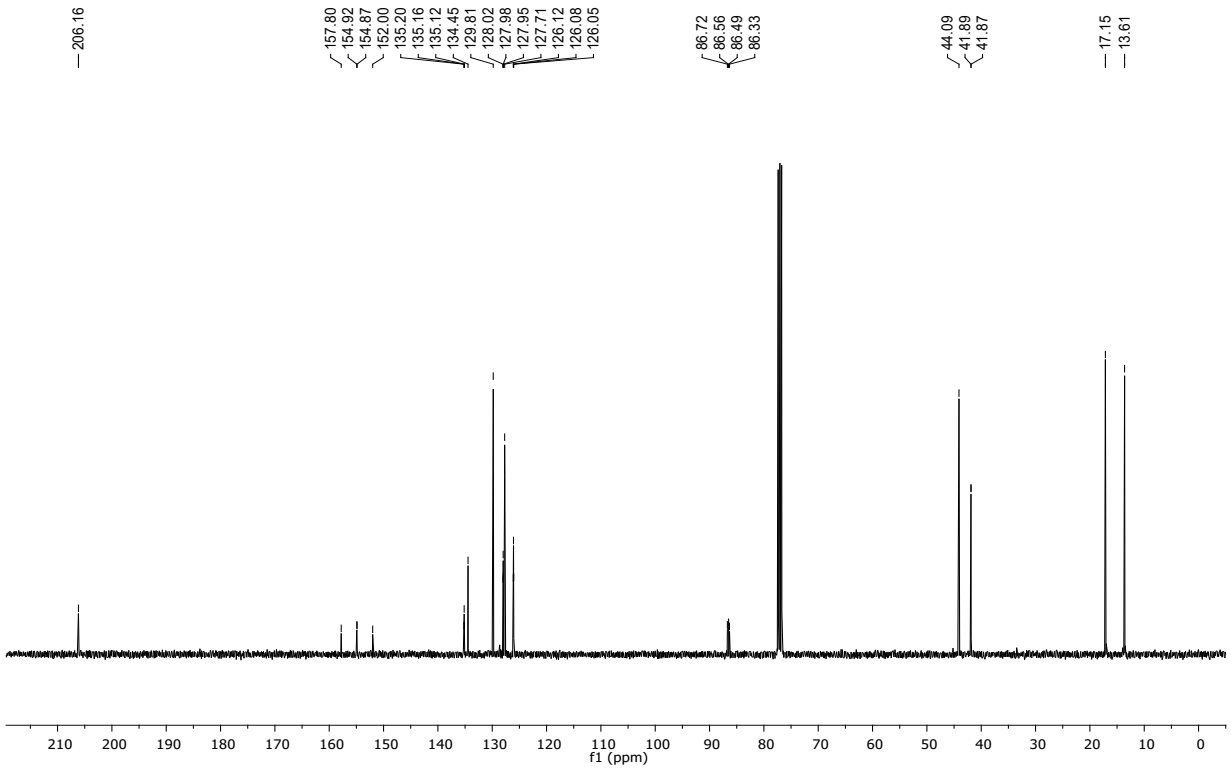
^{1}H NMR spectrum of compound 5h



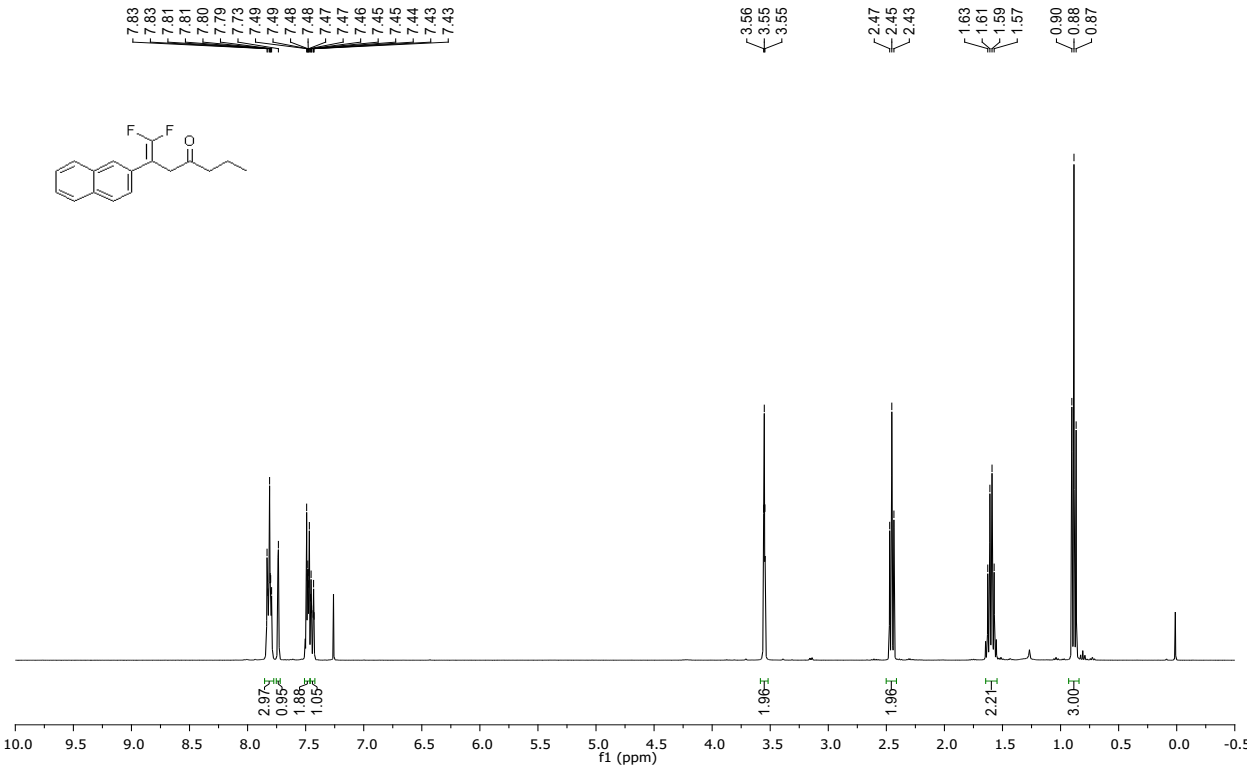
^{19}F NMR spectrum of compound 5h



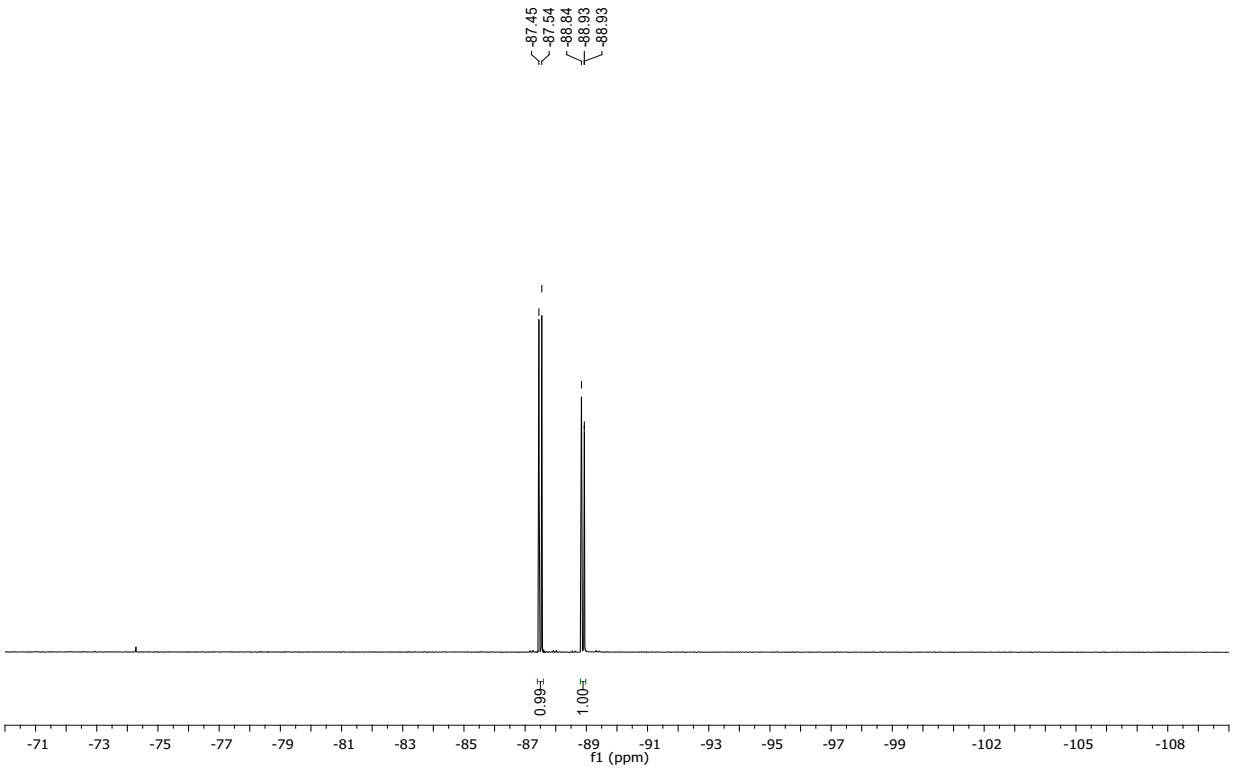
^{13}CNMR spectrum of compound 5h



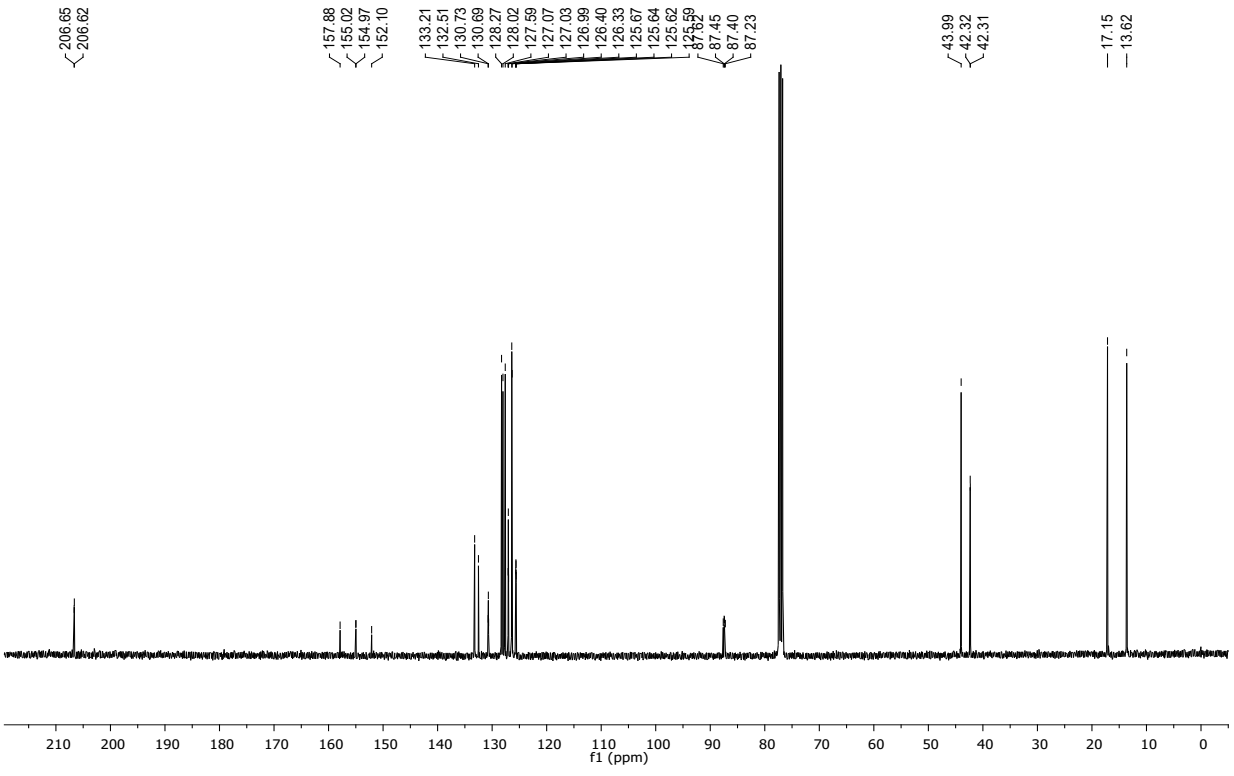
^{1}H NMR spectrum of compound 5i



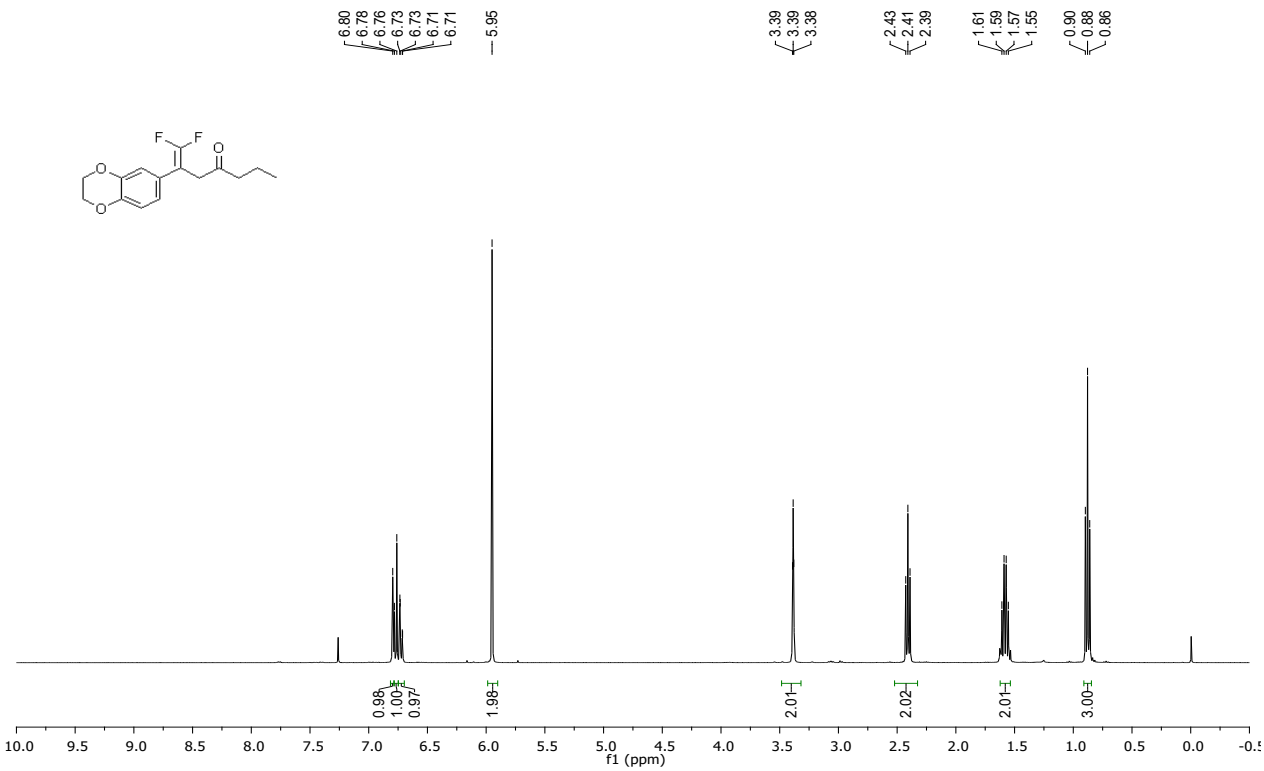
^{19}F NMR spectrum of compound 5i



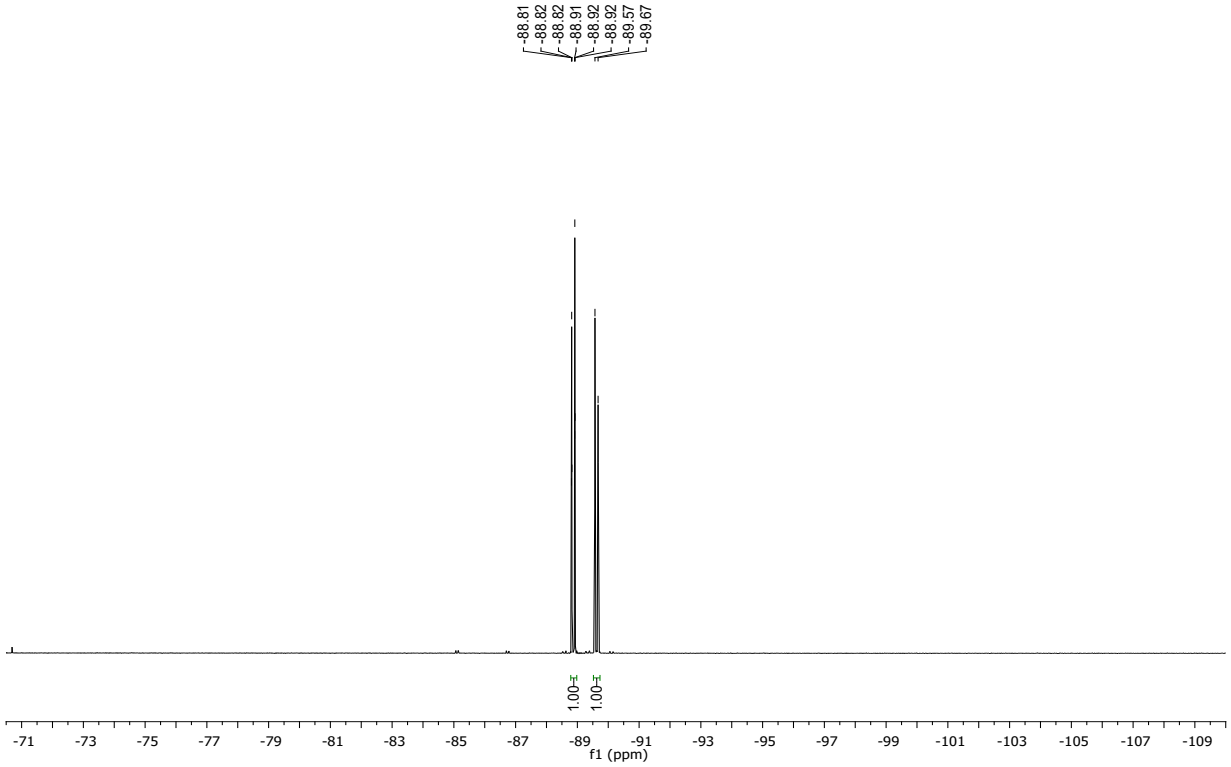
^{13}CNMR spectrum of compound 5i



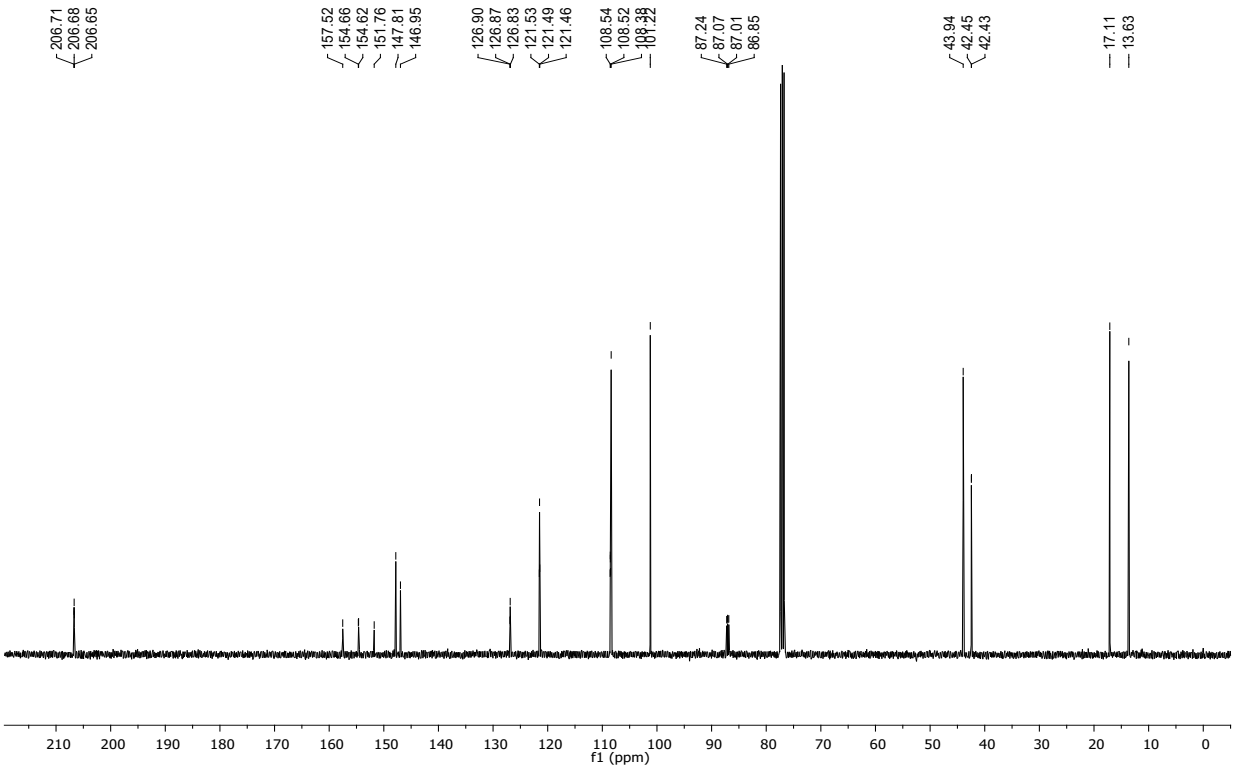
^{1}H NMR spectrum of compound 5j



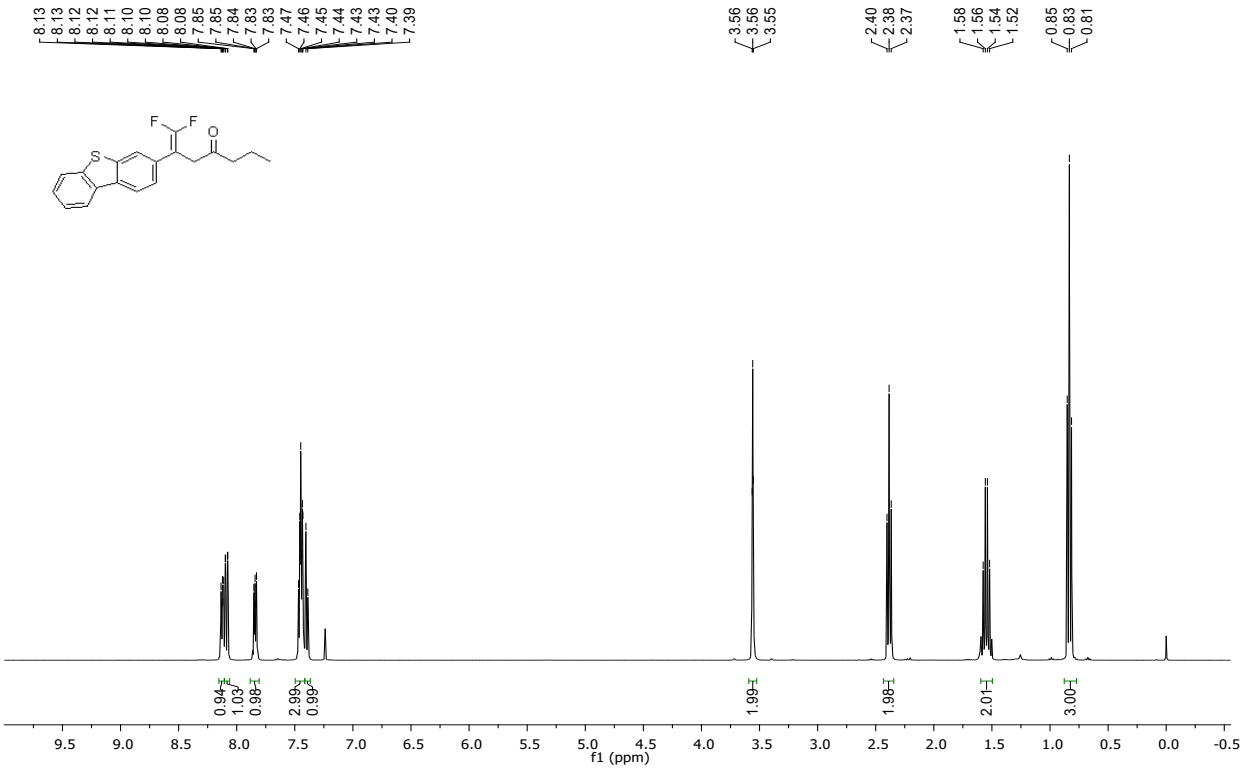
^{19}F NMR spectrum of compound 5j



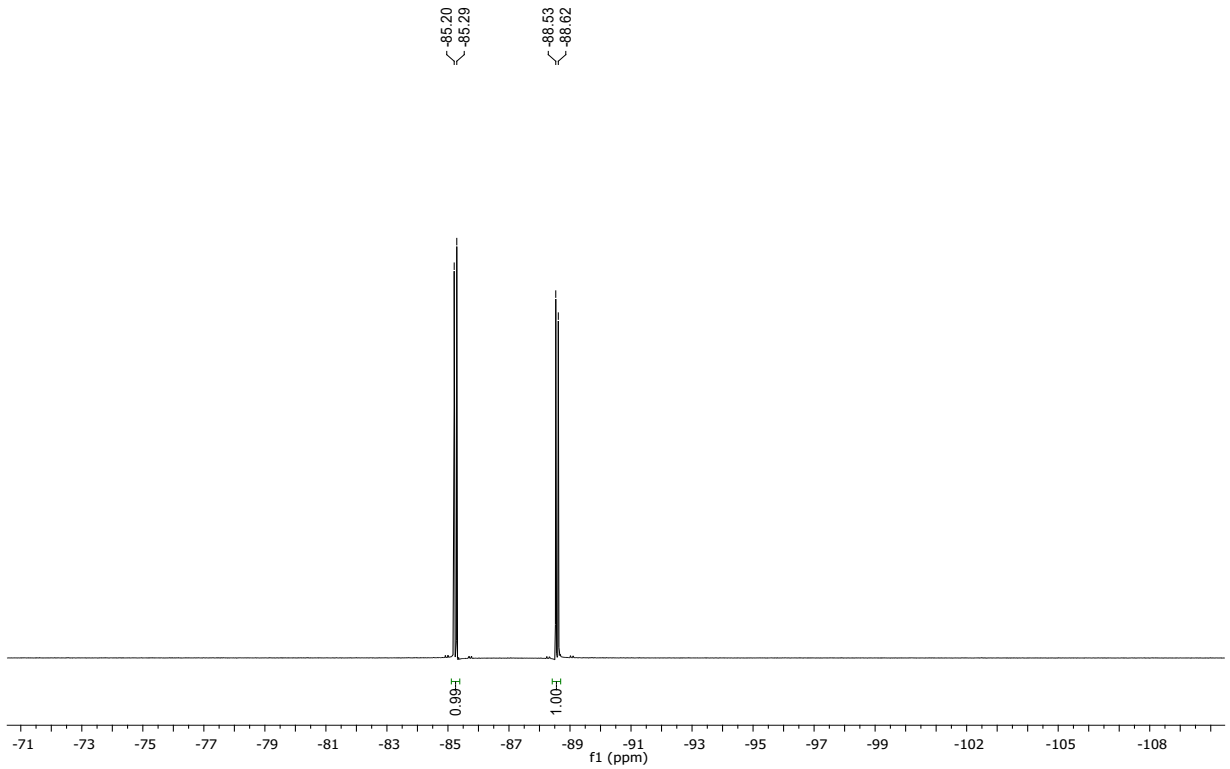
^{13}CNMR spectrum of compound 5j



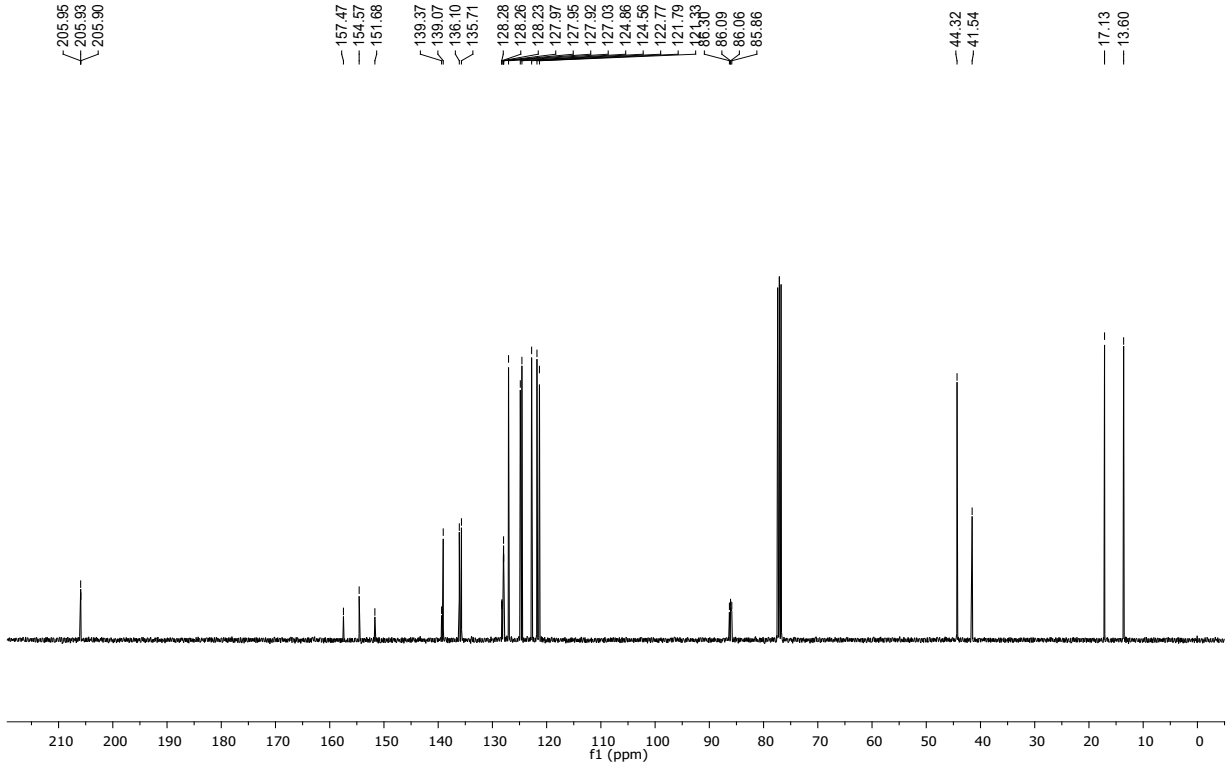
^{1}H NMR spectrum of compound 5k



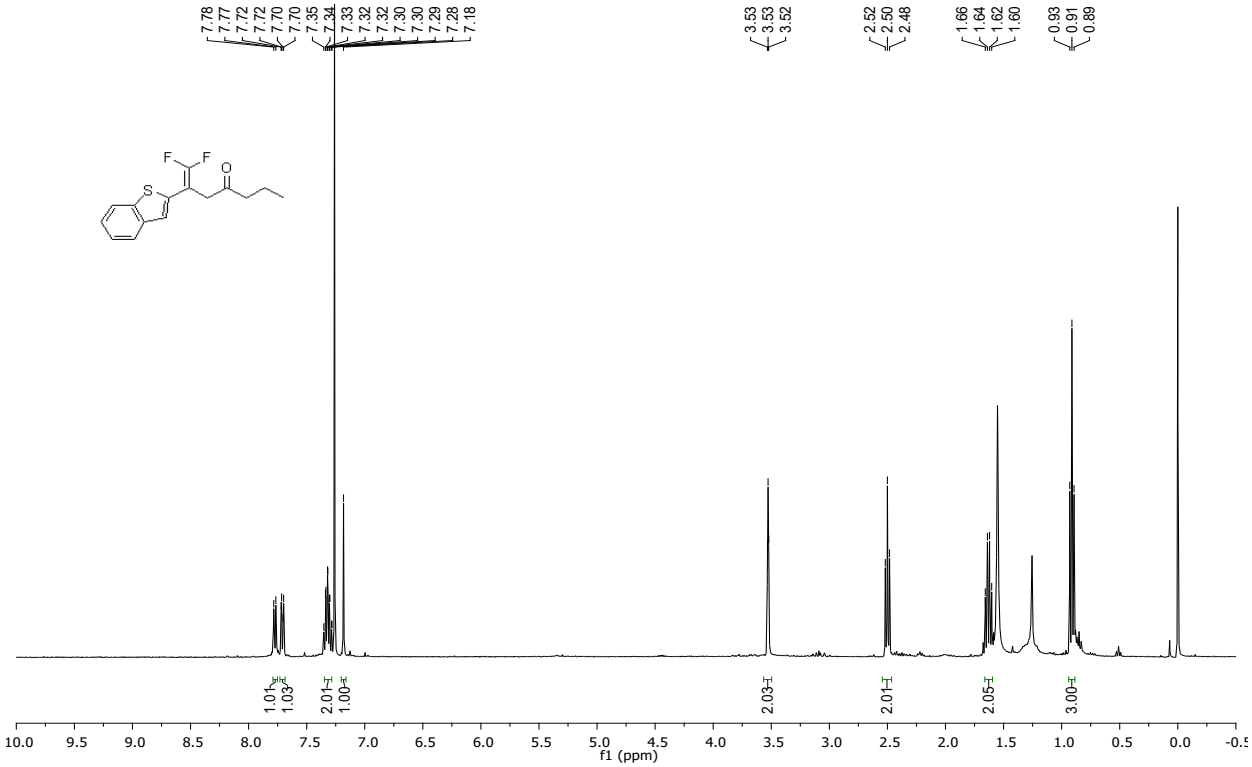
^{19}F NMR spectrum of compound 5k



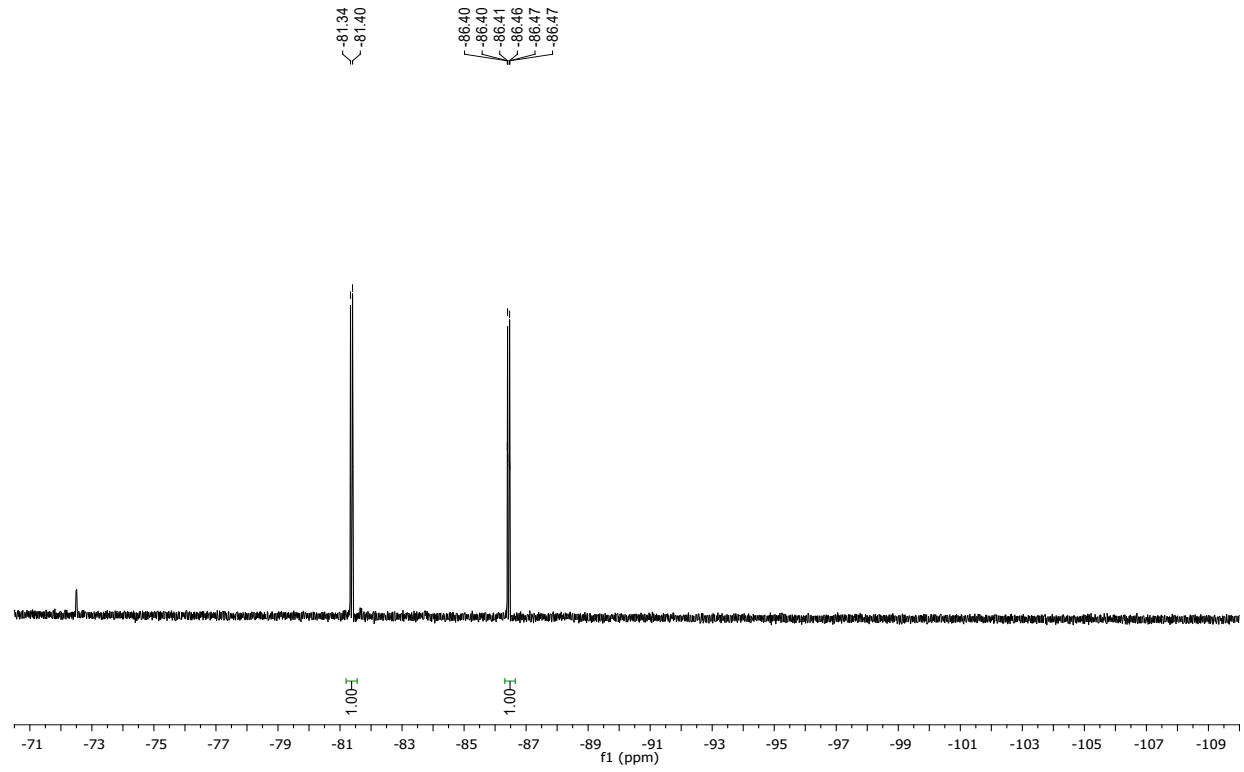
^{13}CNMR spectrum of compound 5k



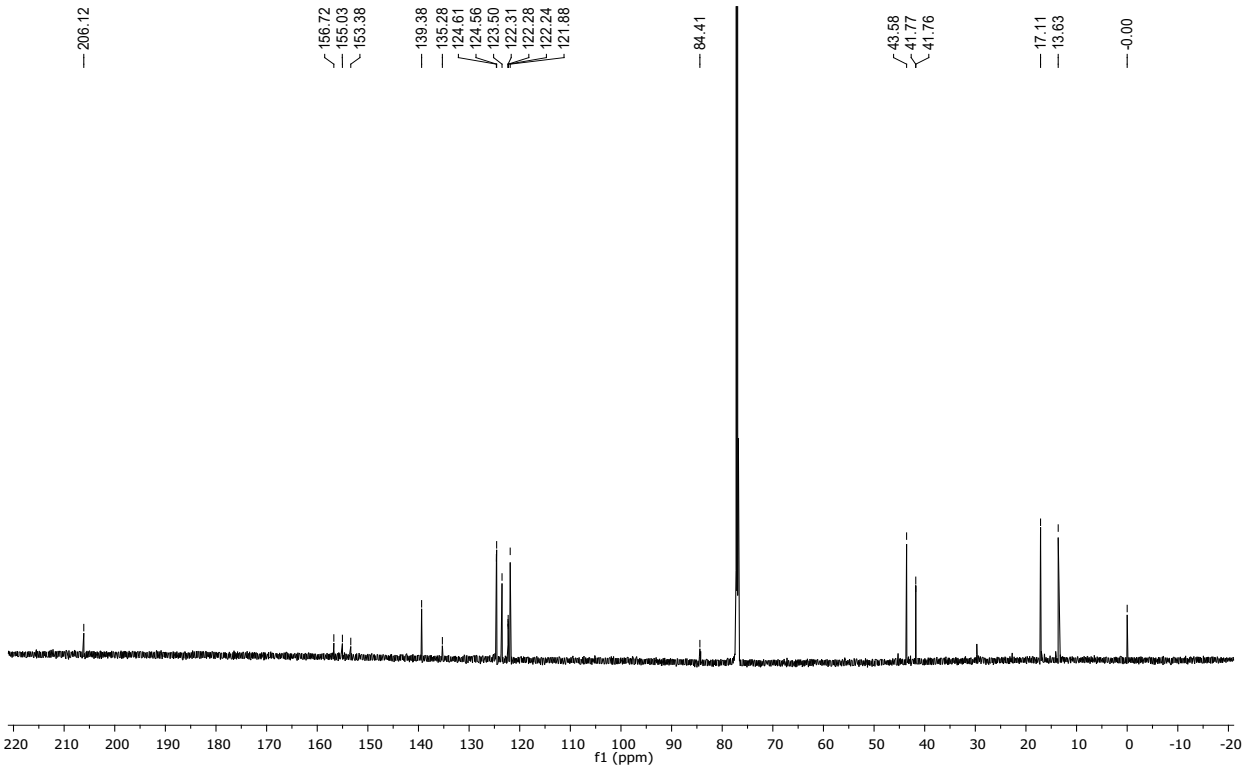
^{1}H NMR spectrum of compound 5l



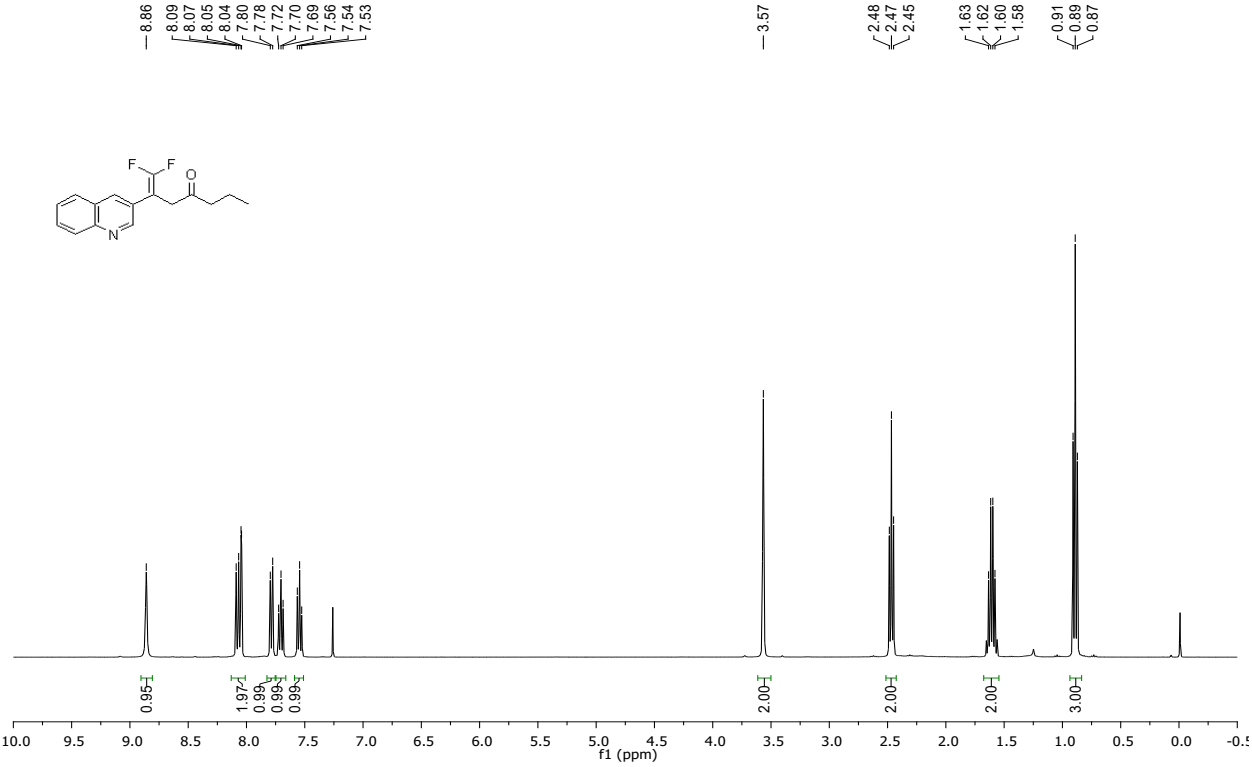
^{19}F NMR spectrum of compound 5l



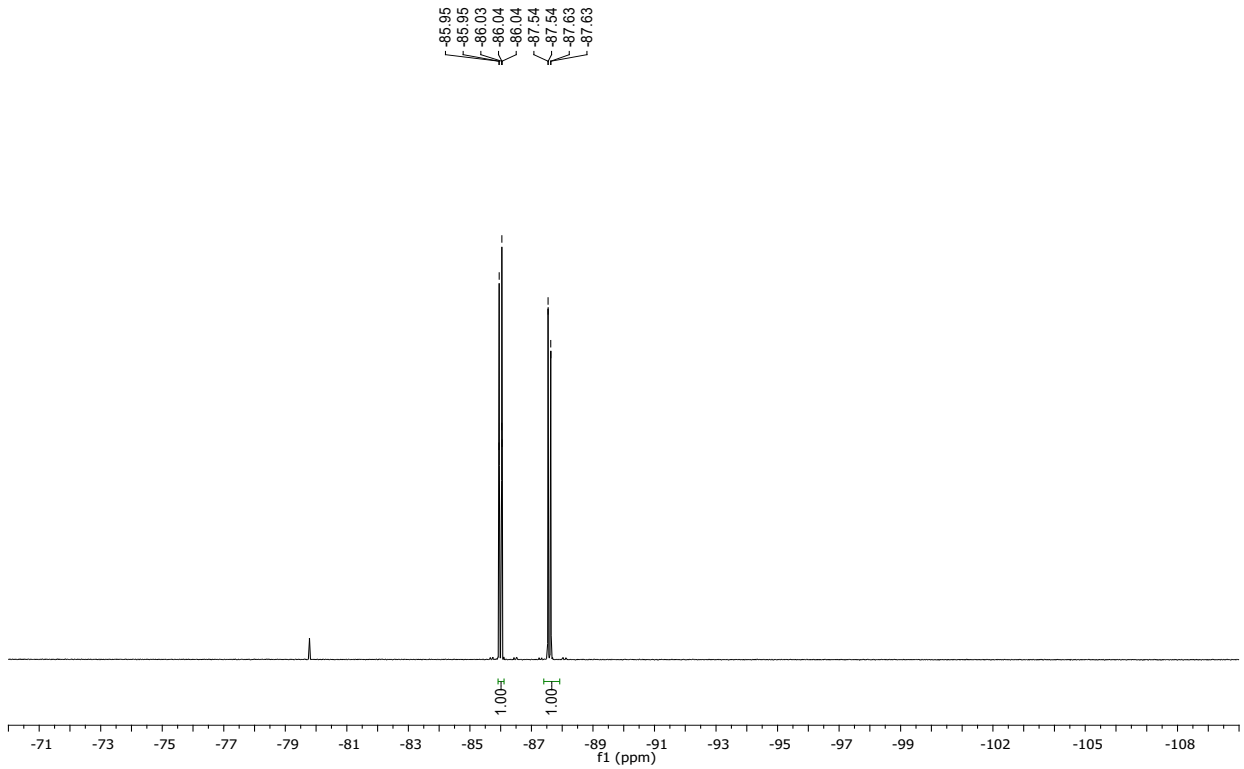
^{13}CNMR spectrum of compound 5l



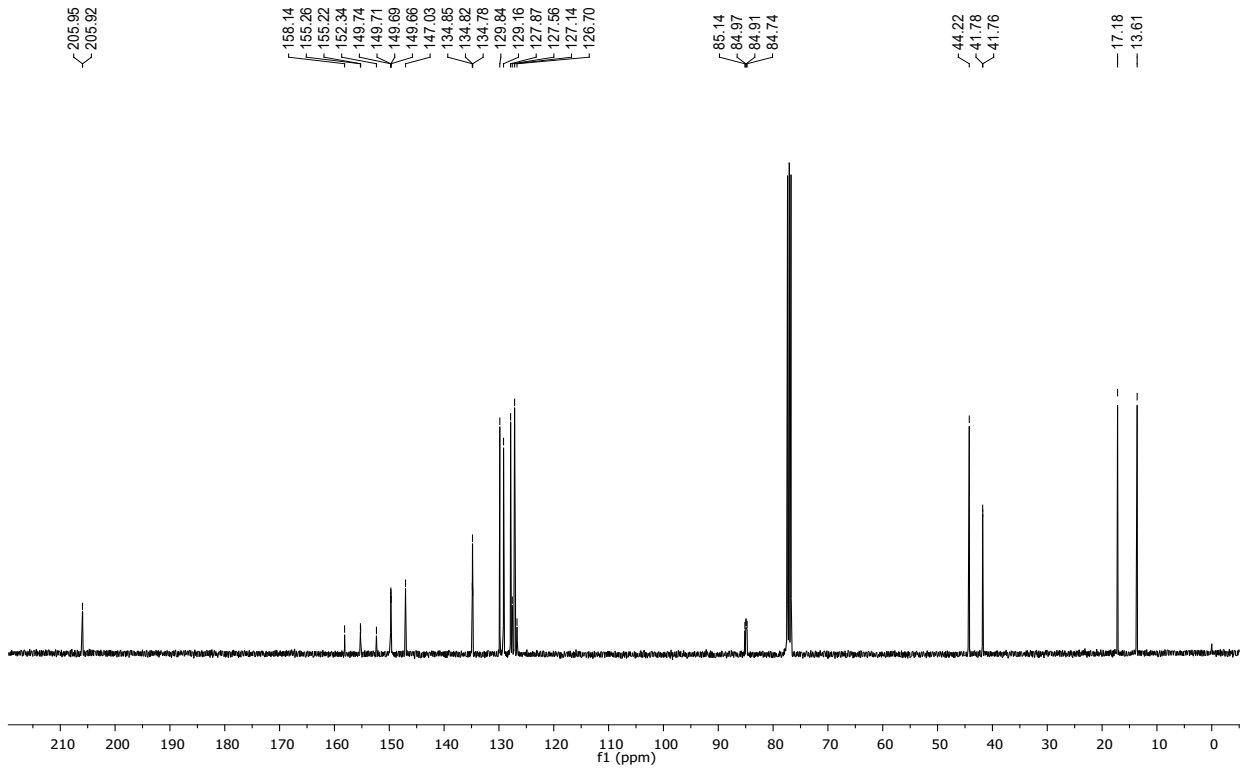
^{1}H NMR spectrum of compound 5m



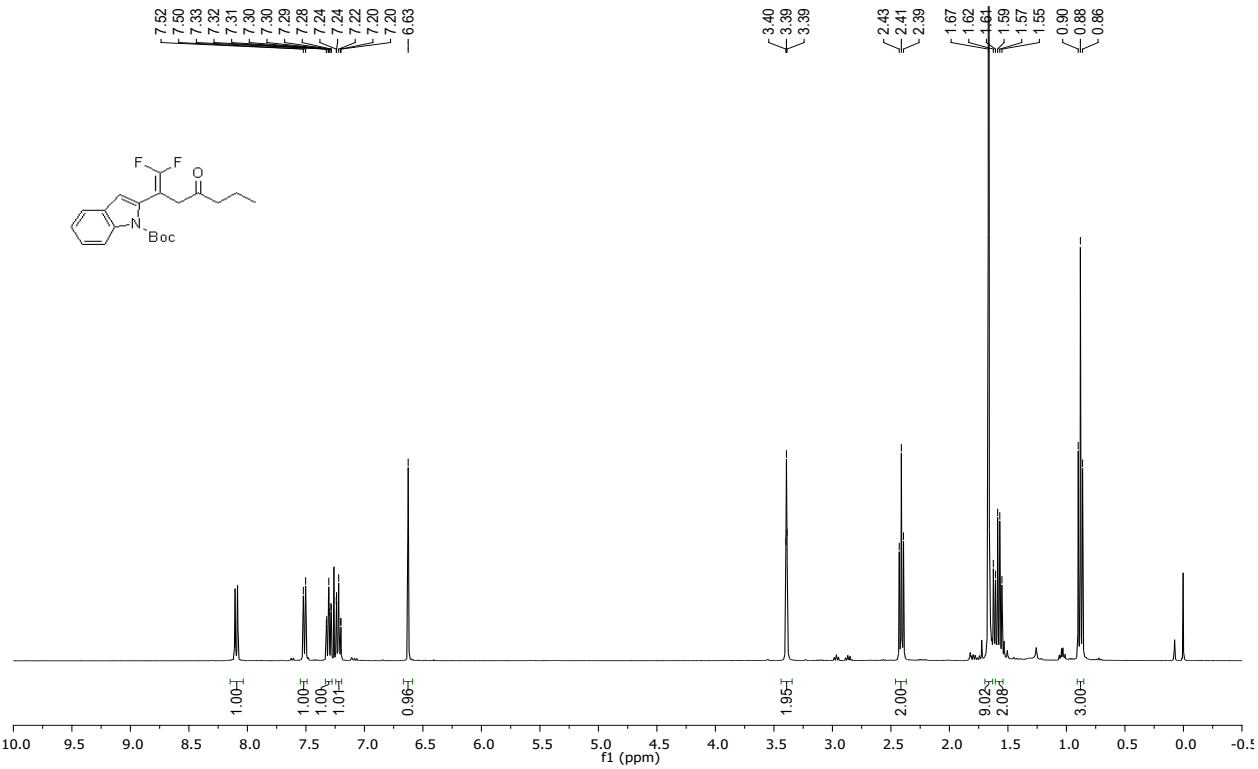
^{19}F NMR spectrum of compound 5m



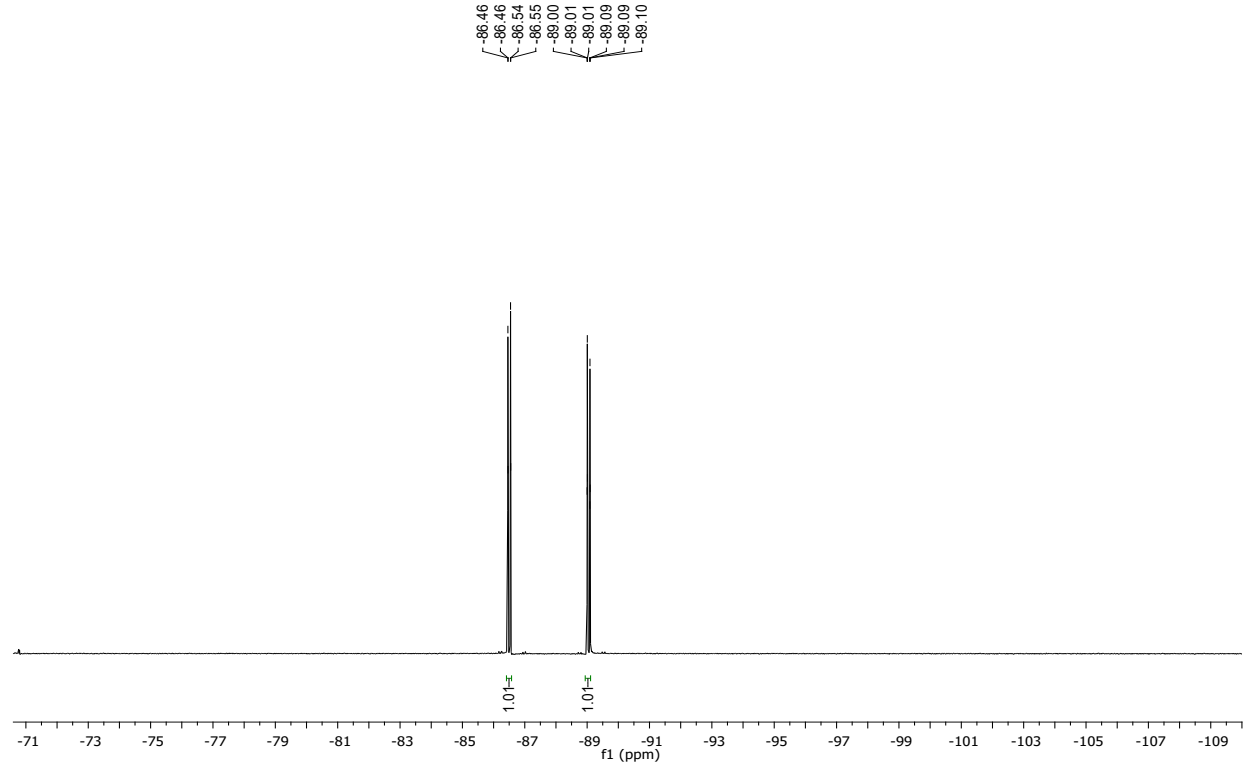
^{13}CNMR spectrum of compound 5m



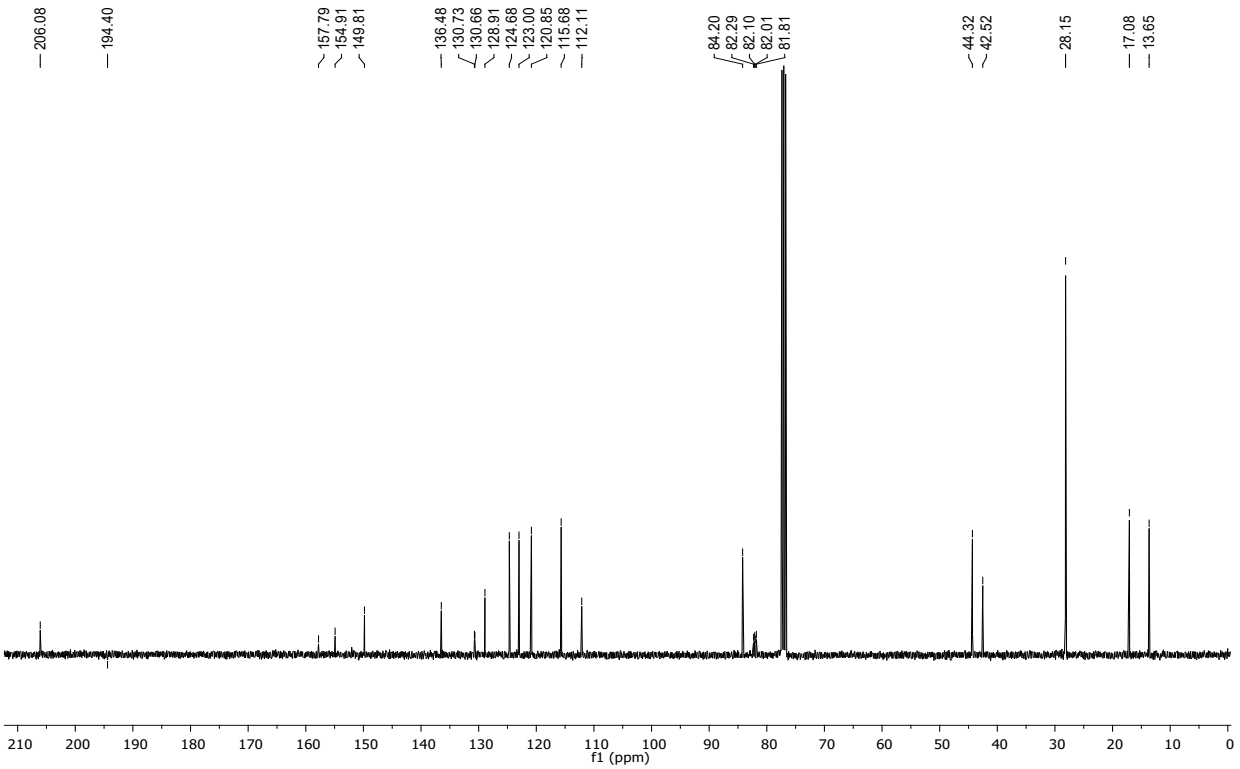
^{1}H NMR spectrum of compound 5n



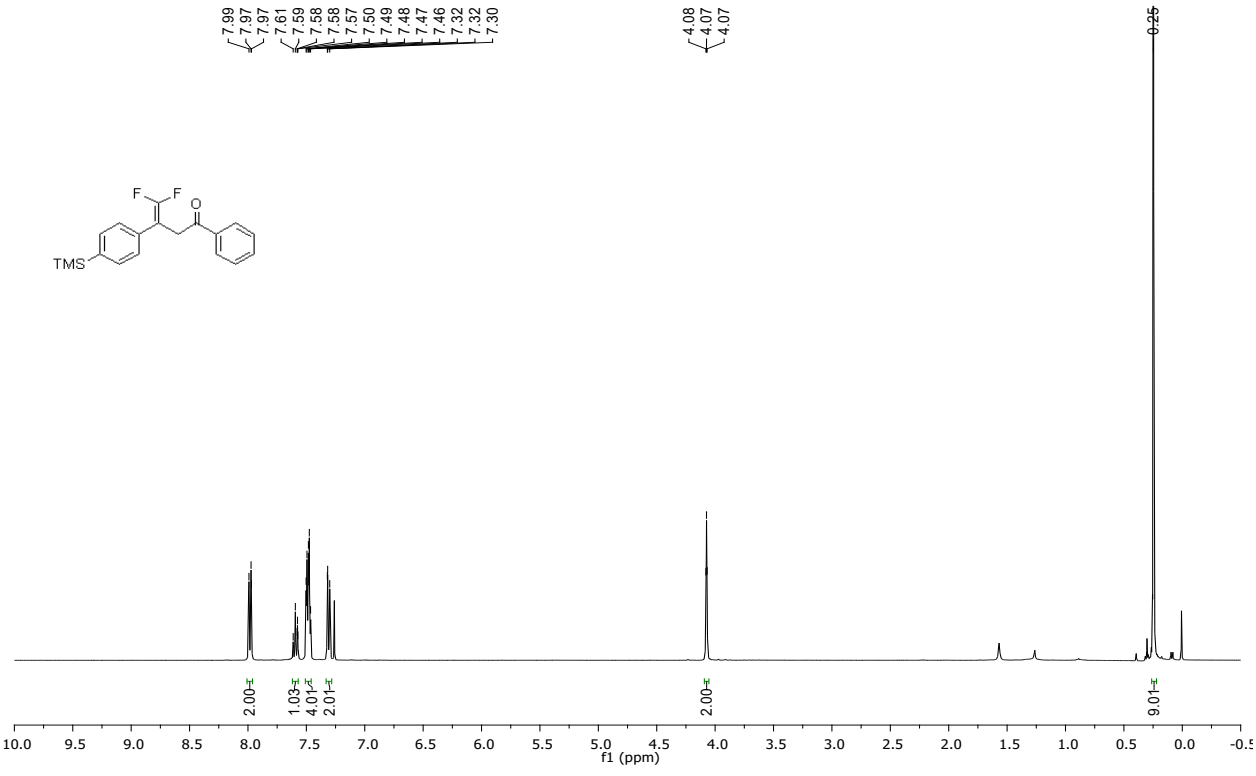
^{19}F NMR spectrum of compound 5n



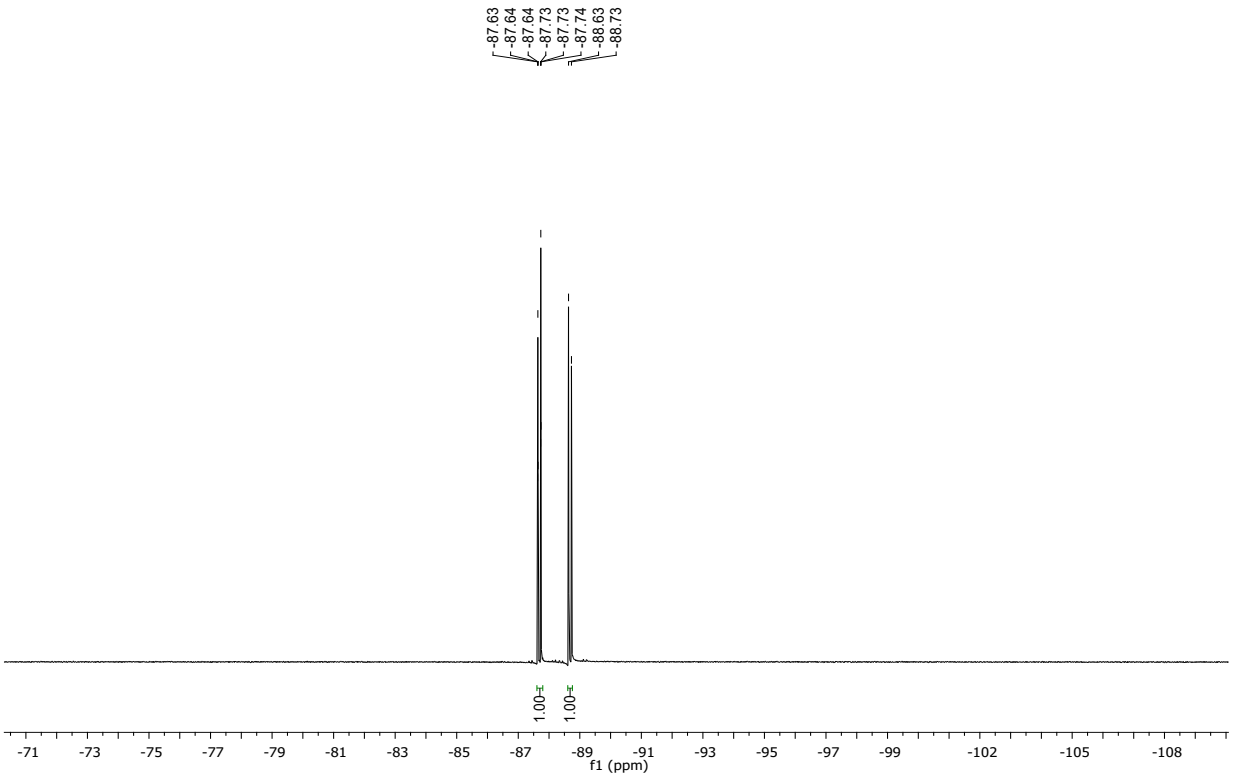
^{13}CNMR spectrum of compound 5n



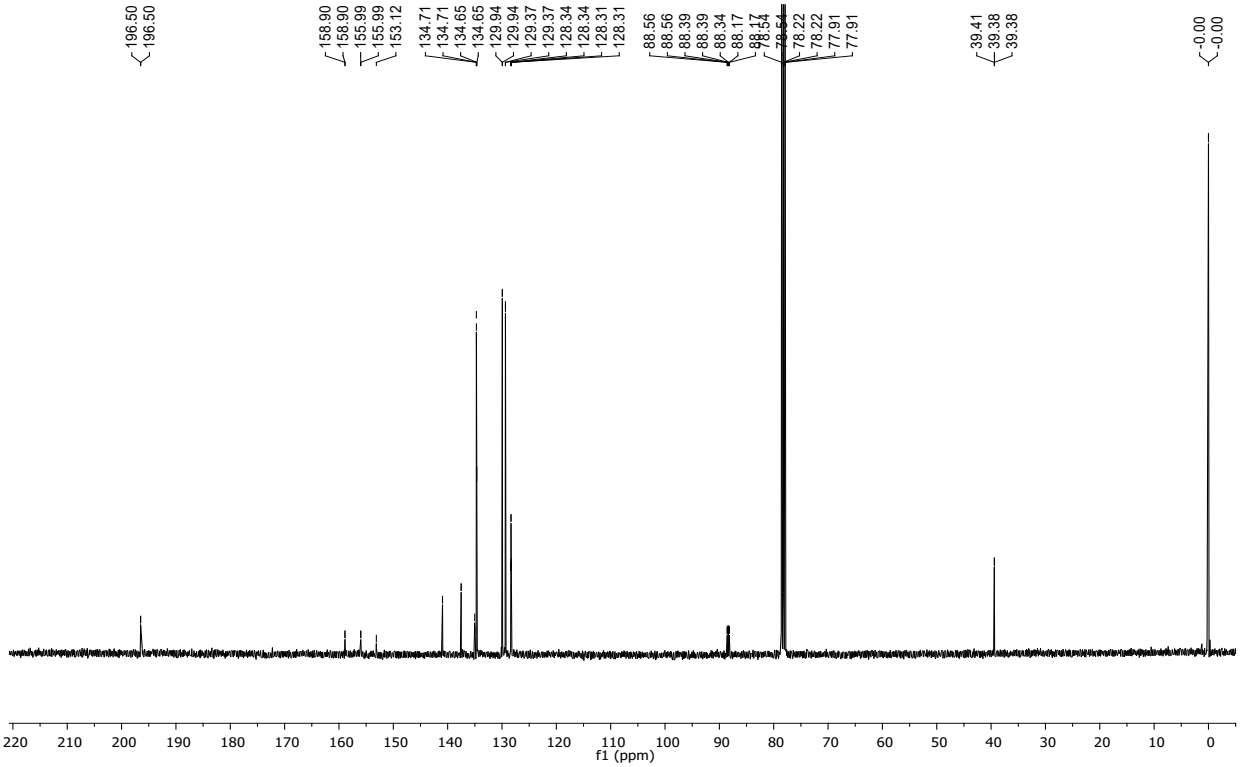
^{1}H NMR spectrum of compound 6a



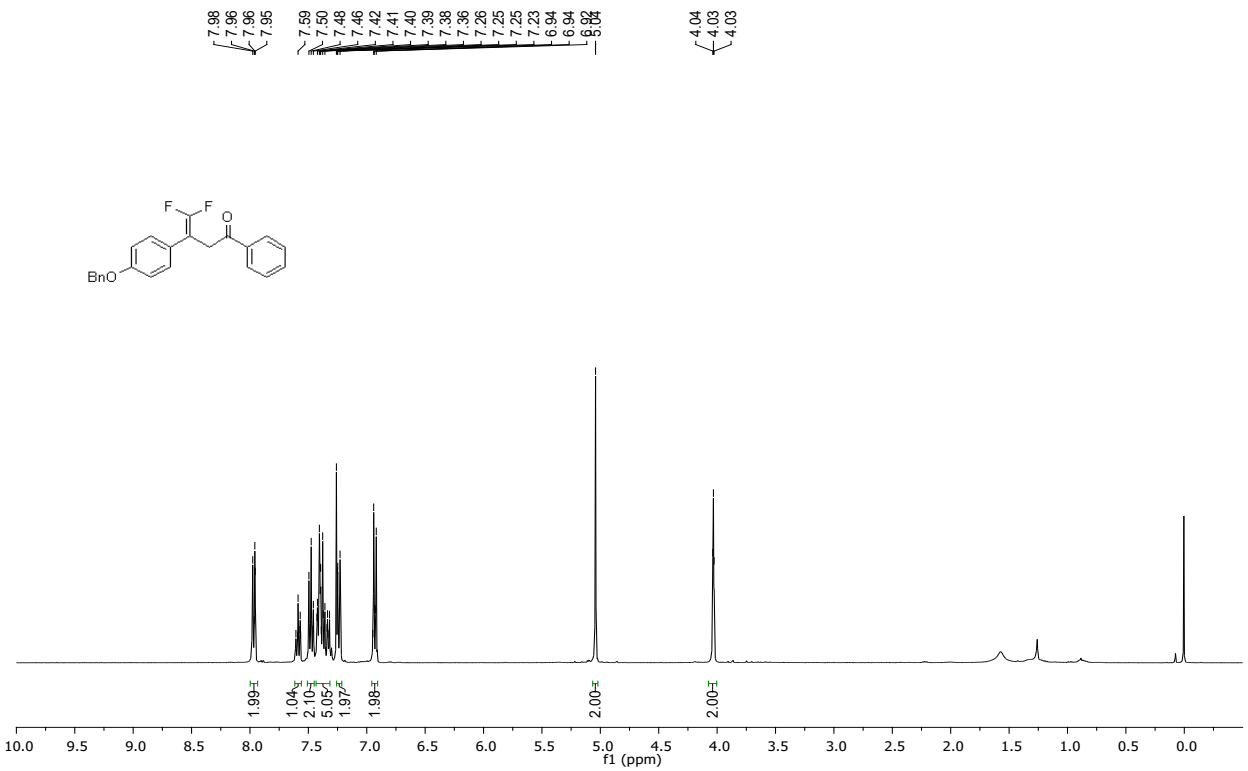
^{19}F NMR spectrum of compound 6a



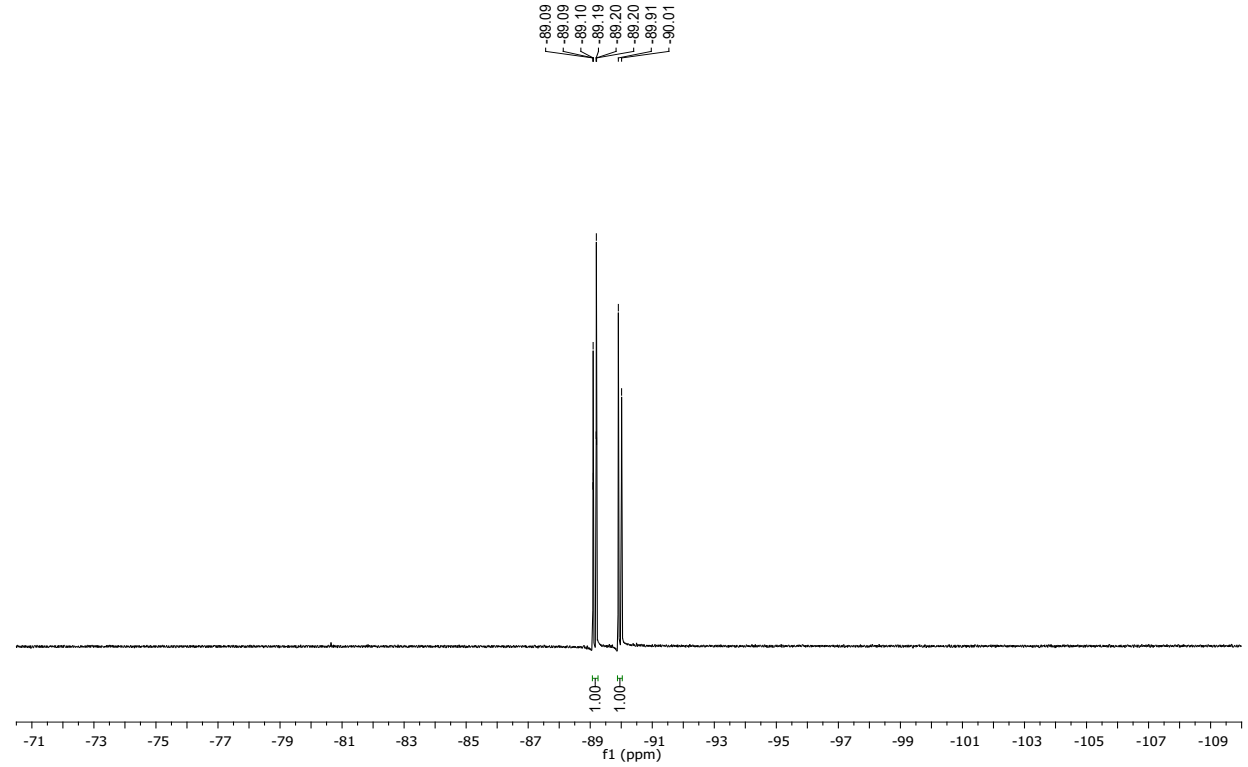
^{13}CNMR spectrum of compound 6a



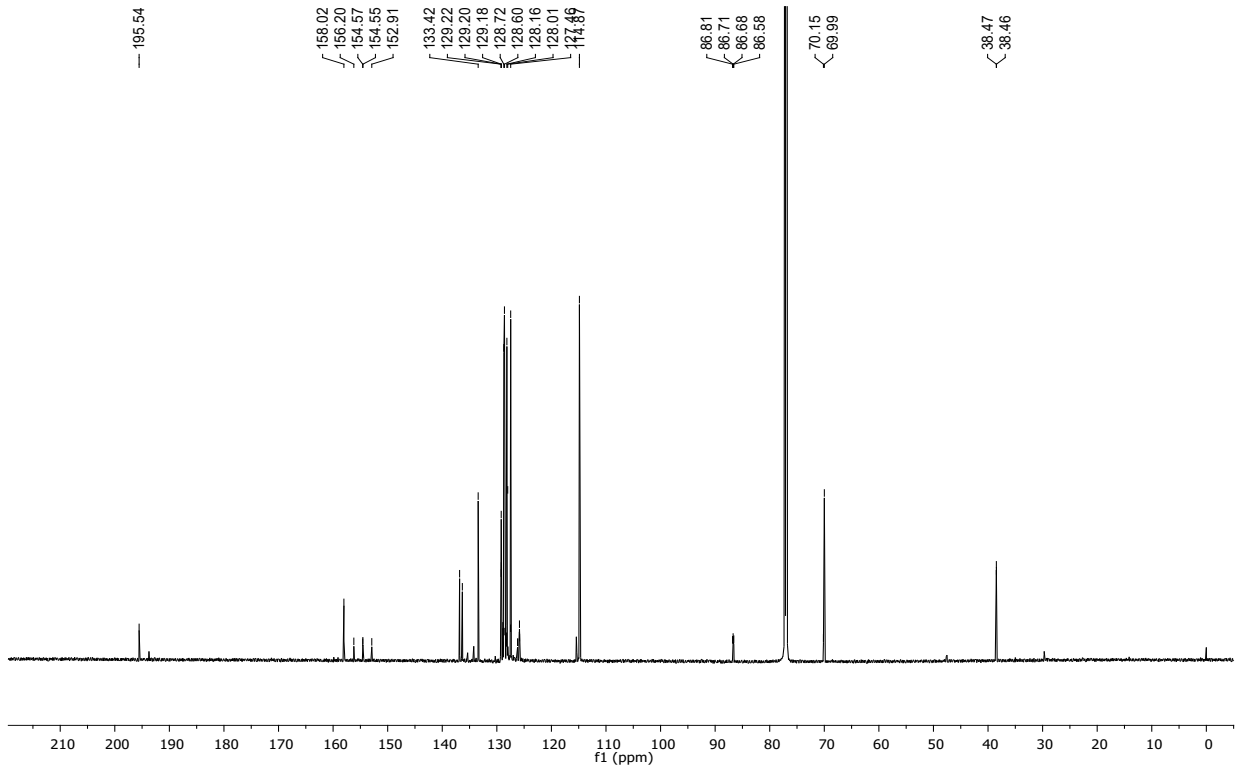
^{1}H NMR spectrum of compound 6b



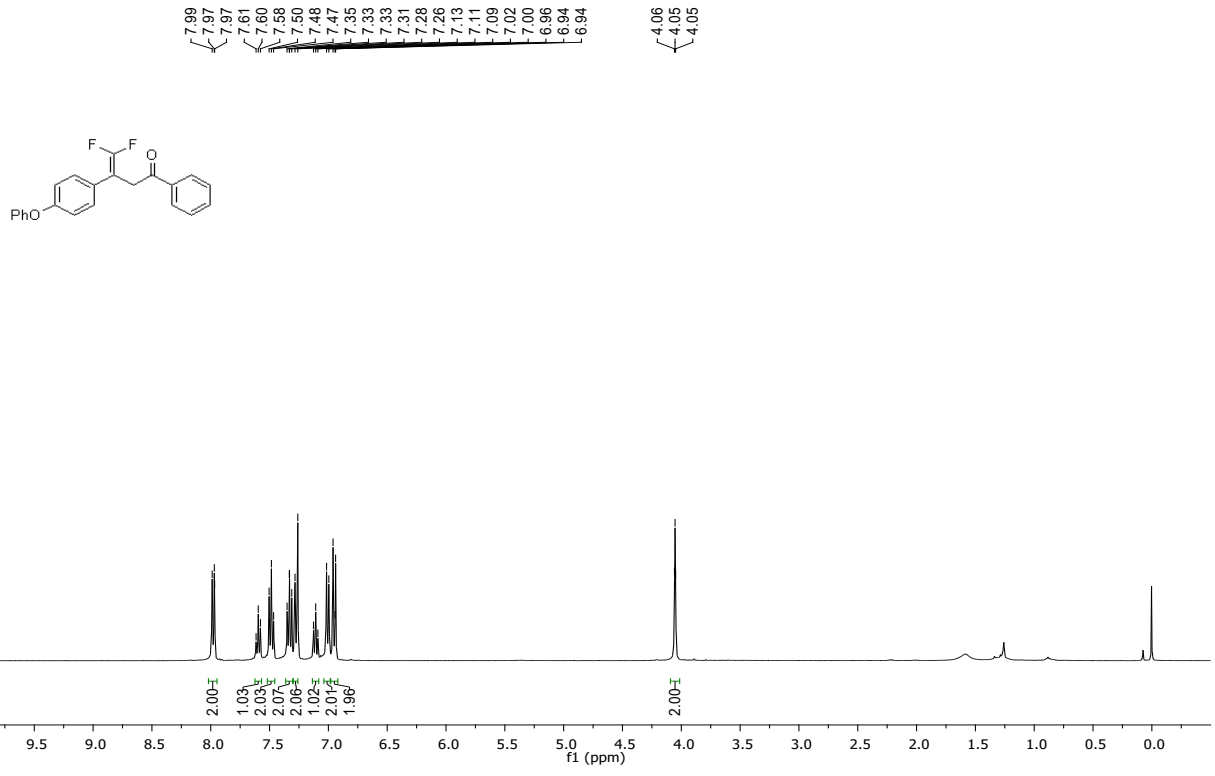
^{19}F NMR spectrum of compound 6b



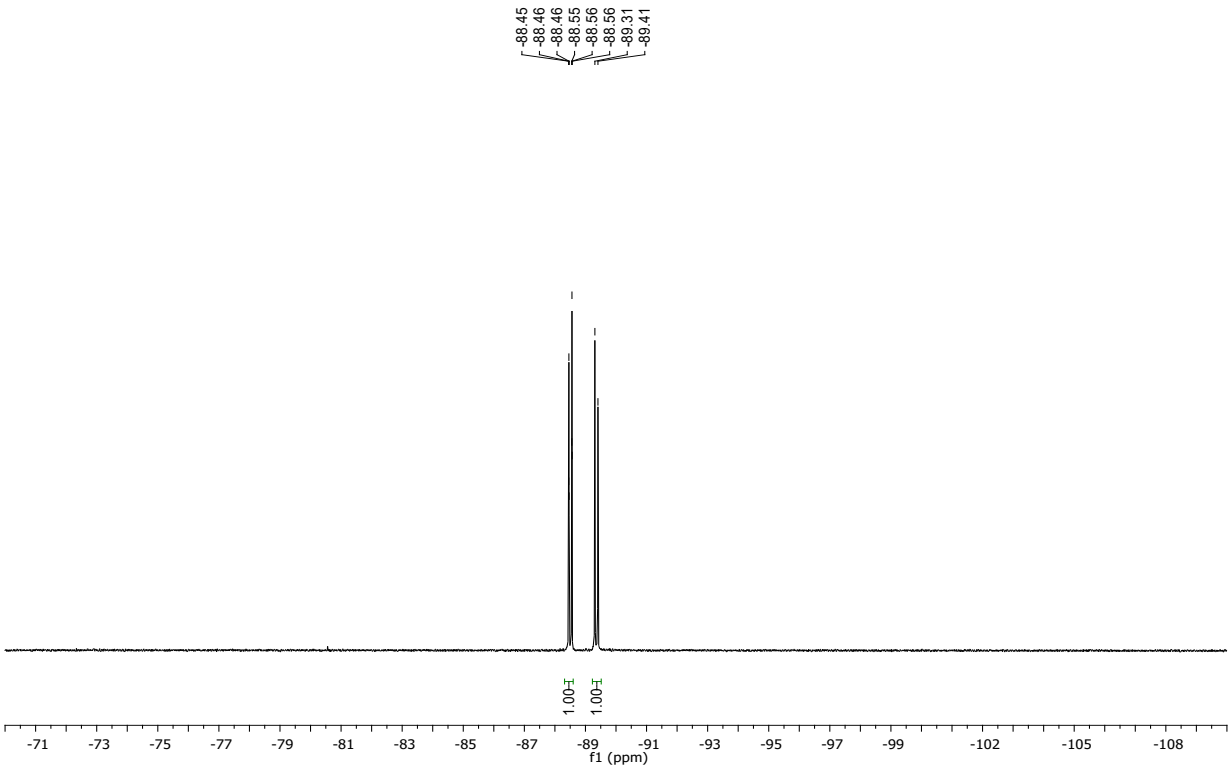
^{13}CNMR spectrum of compound 6b



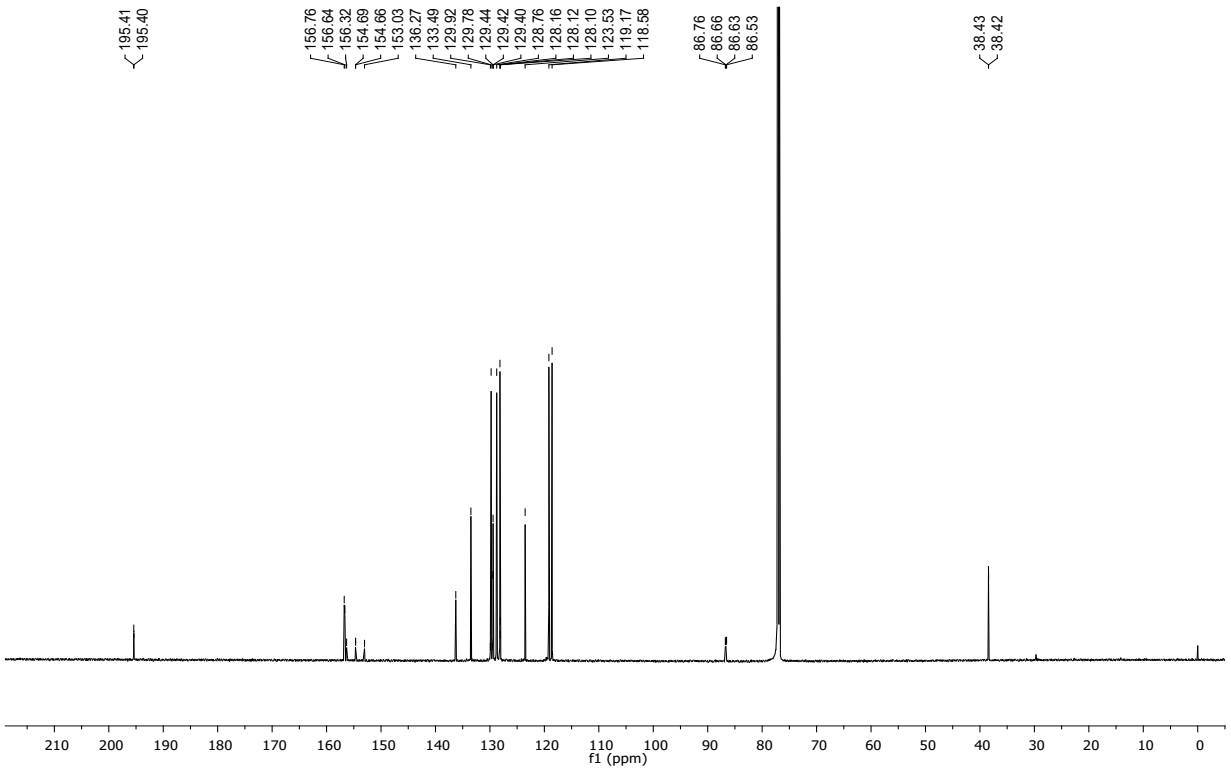
^{1}H NMR spectrum of compound 6c



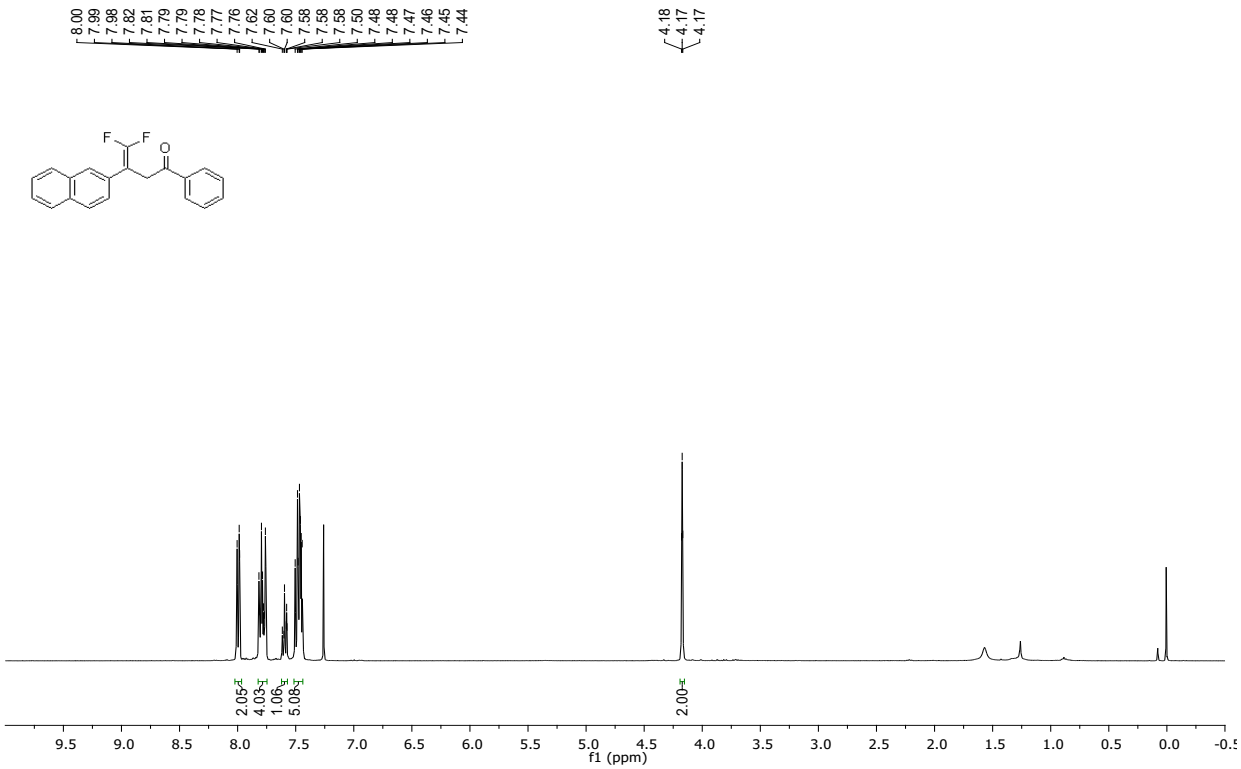
^{19}F NMR spectrum of compound 6c



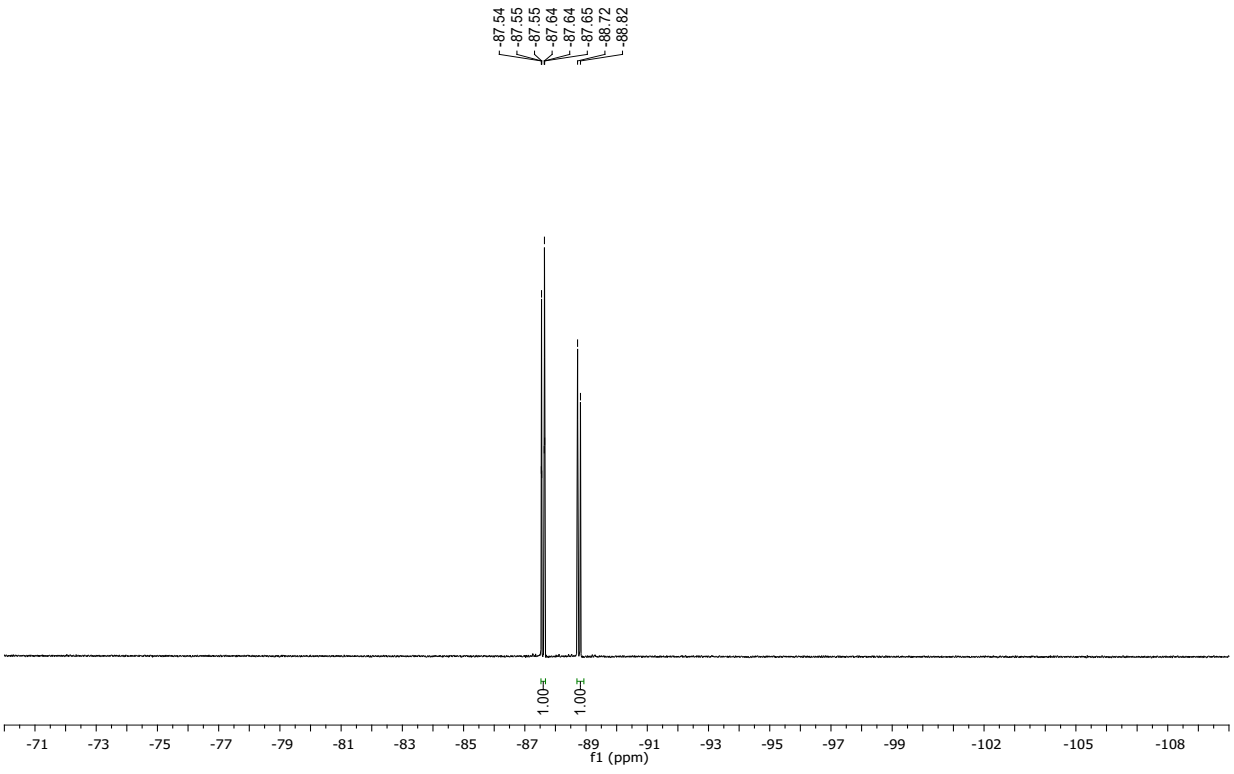
^{13}CNMR spectrum of compound 6c



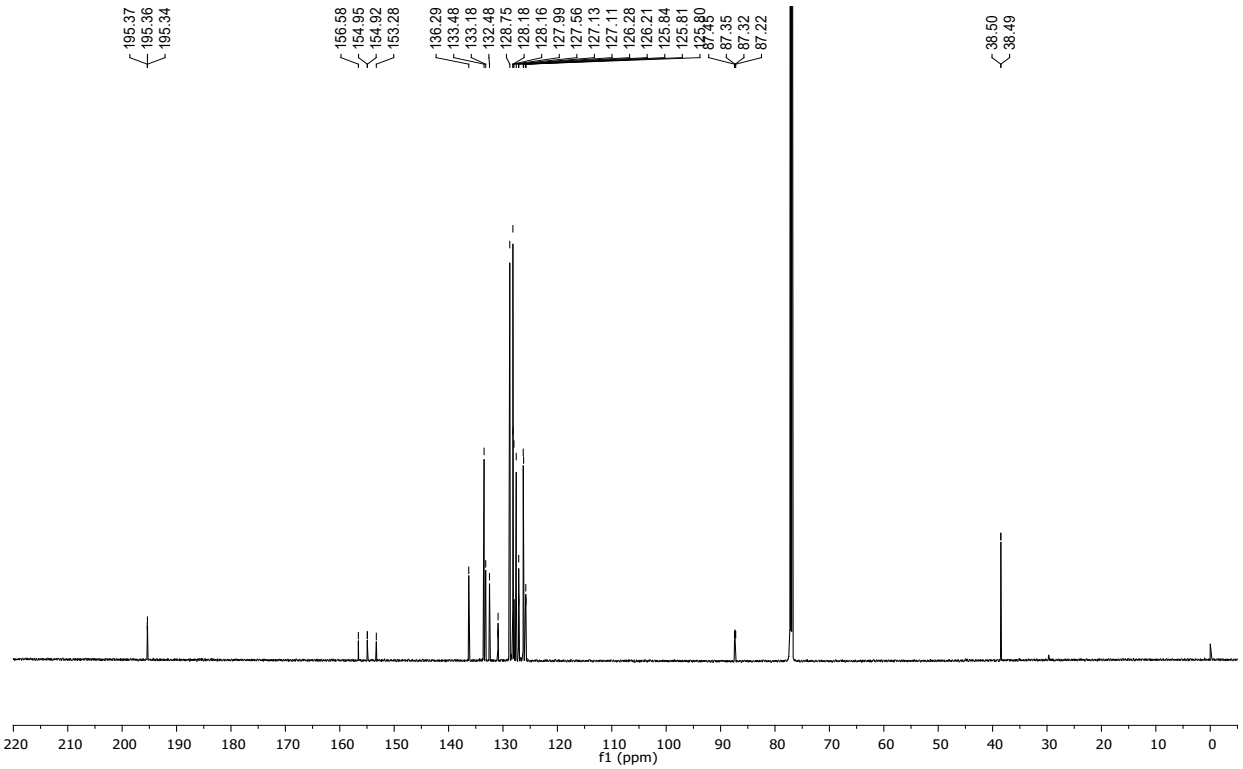
^{1}H NMR spectrum of compound 6d



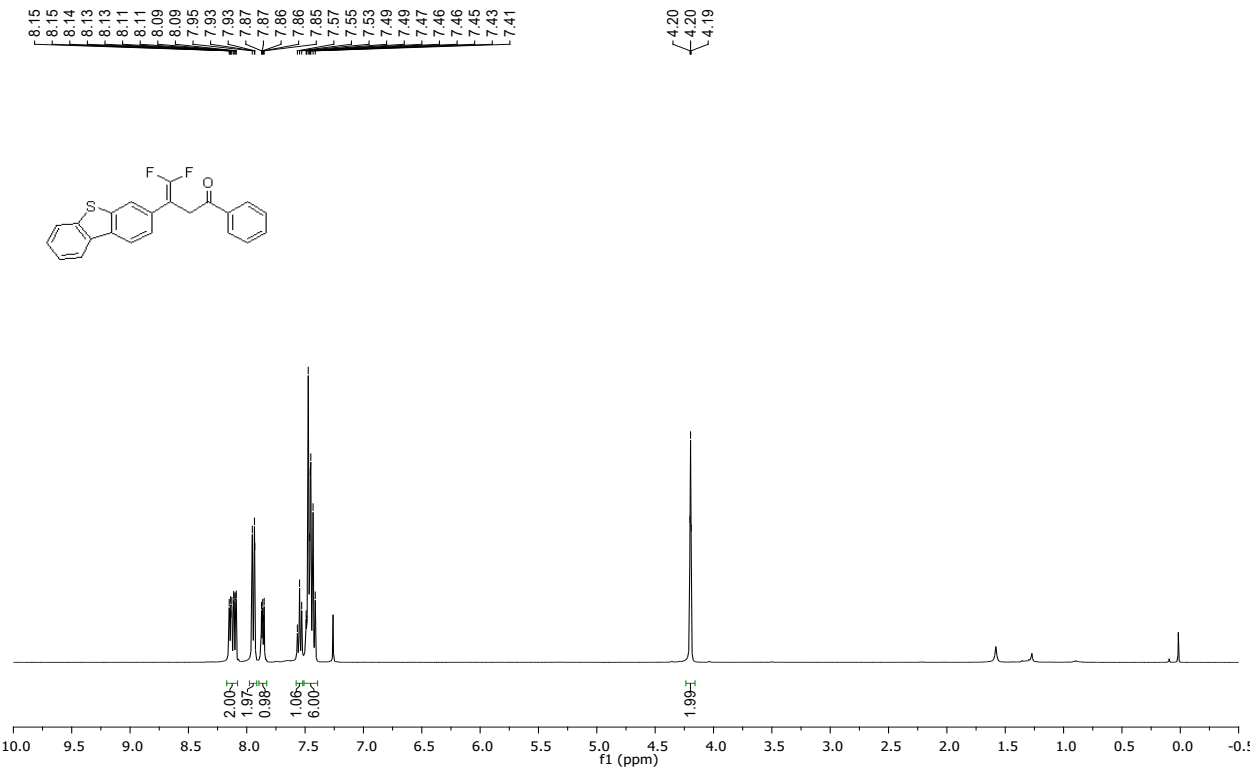
^{19}F NMR spectrum of compound 6d



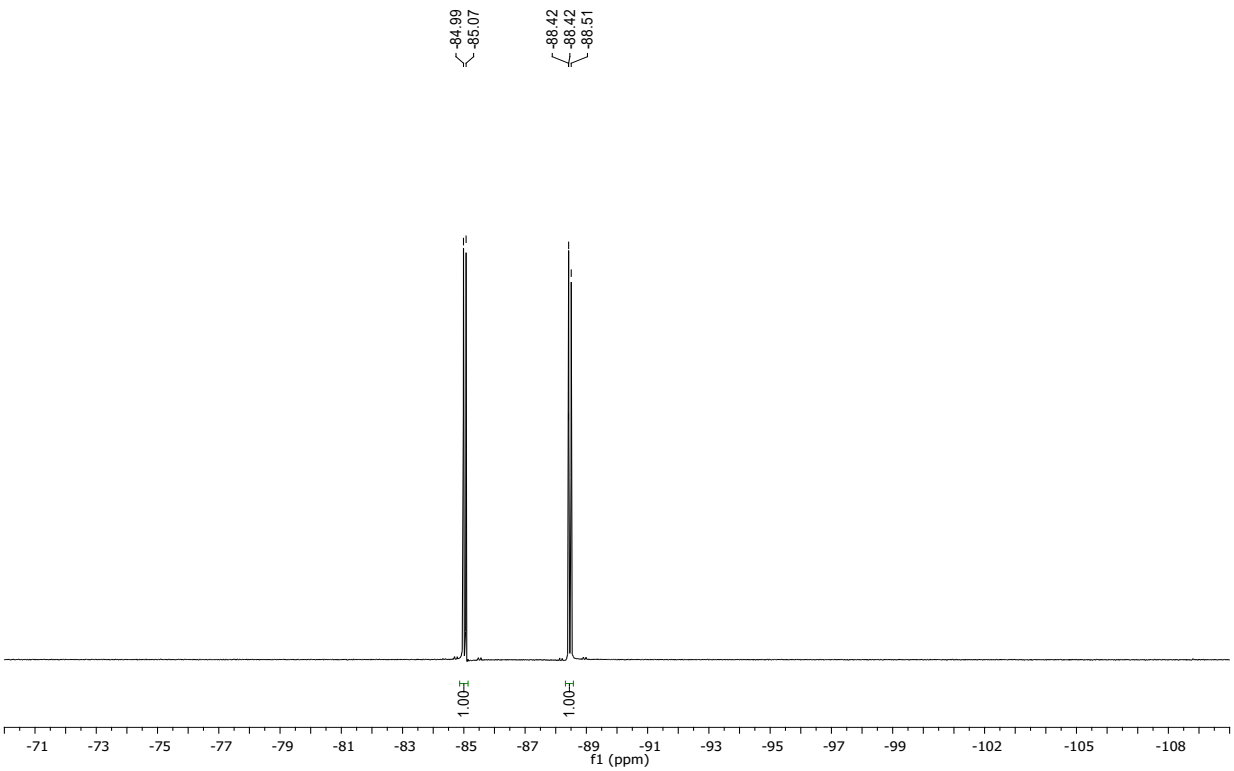
^{13}CNMR spectrum of compound 6d



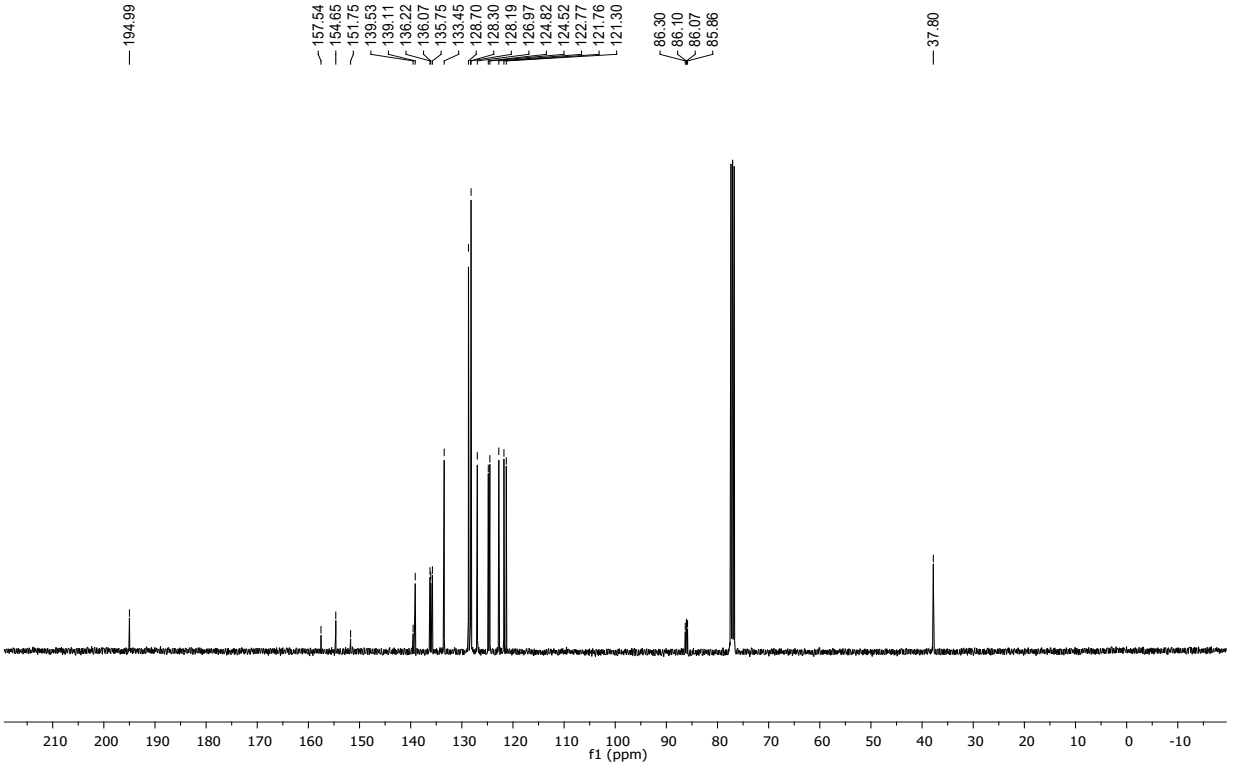
^{1}H NMR spectrum of compound 6e



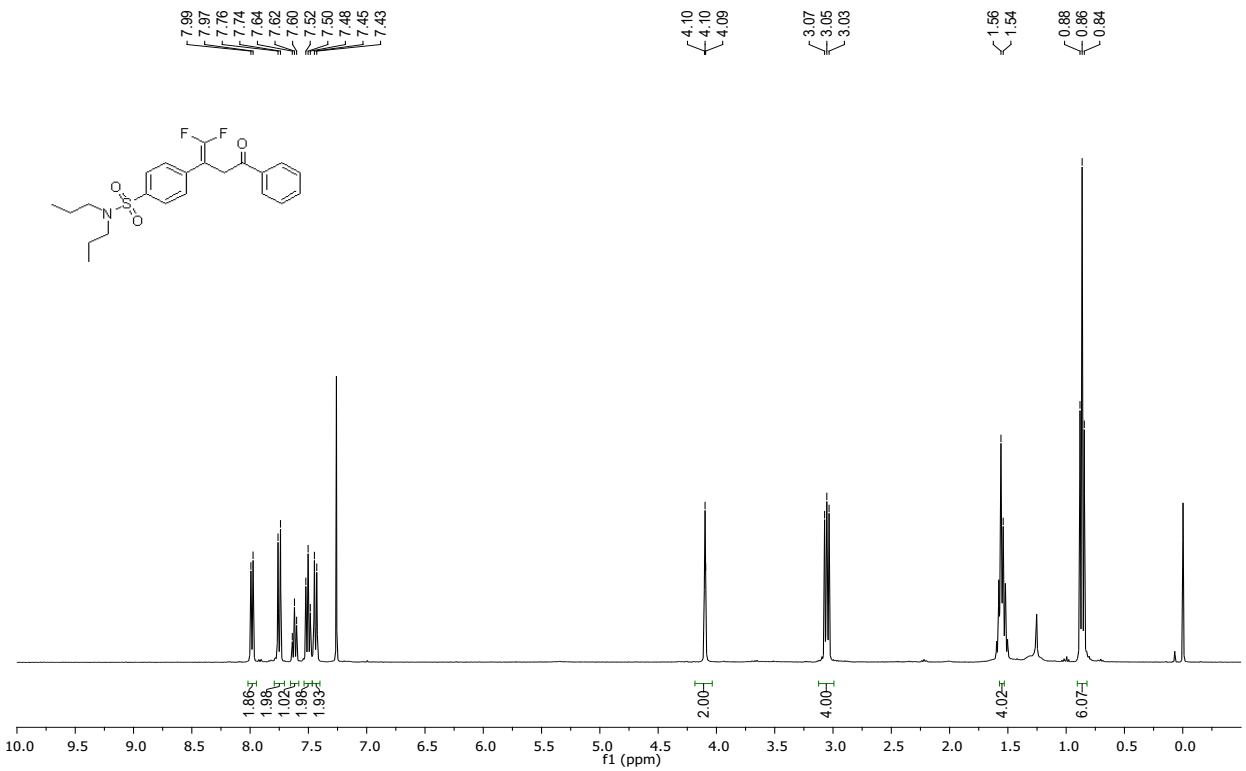
^{19}F NMR spectrum of compound 6e



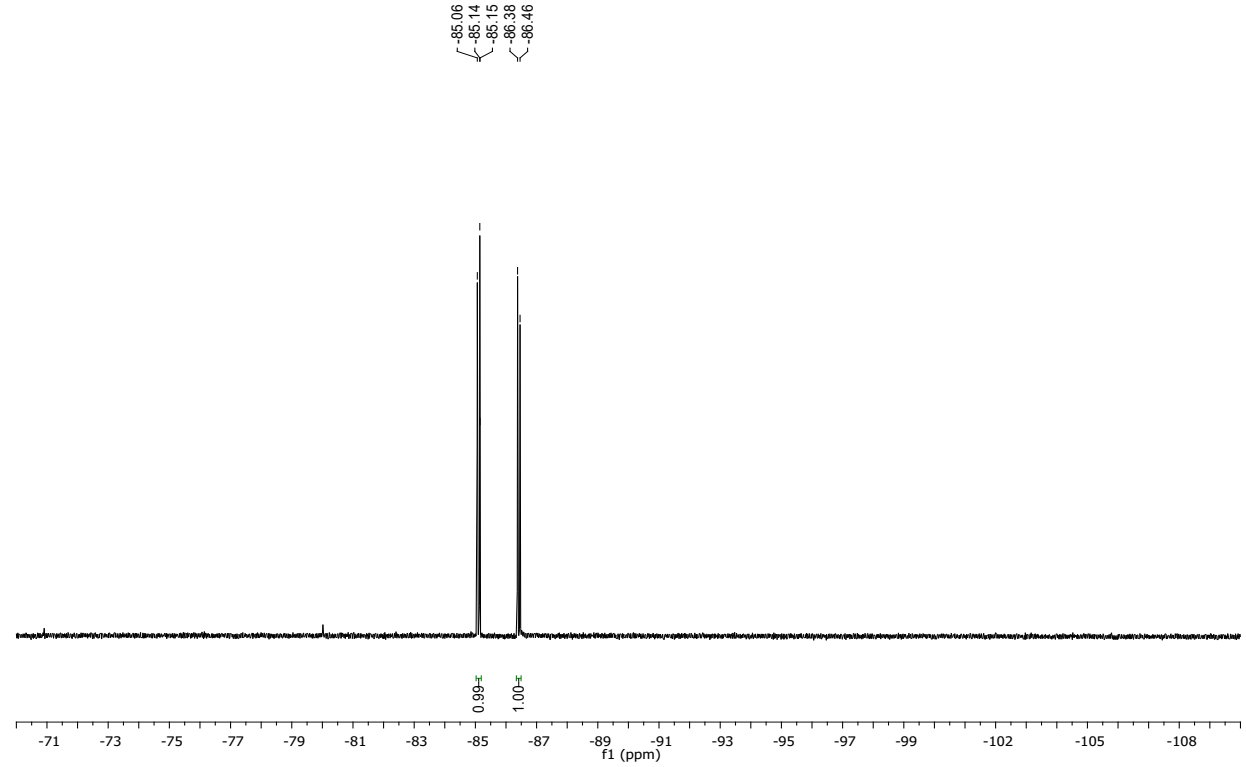
^{13}CNMR spectrum of compound 6e



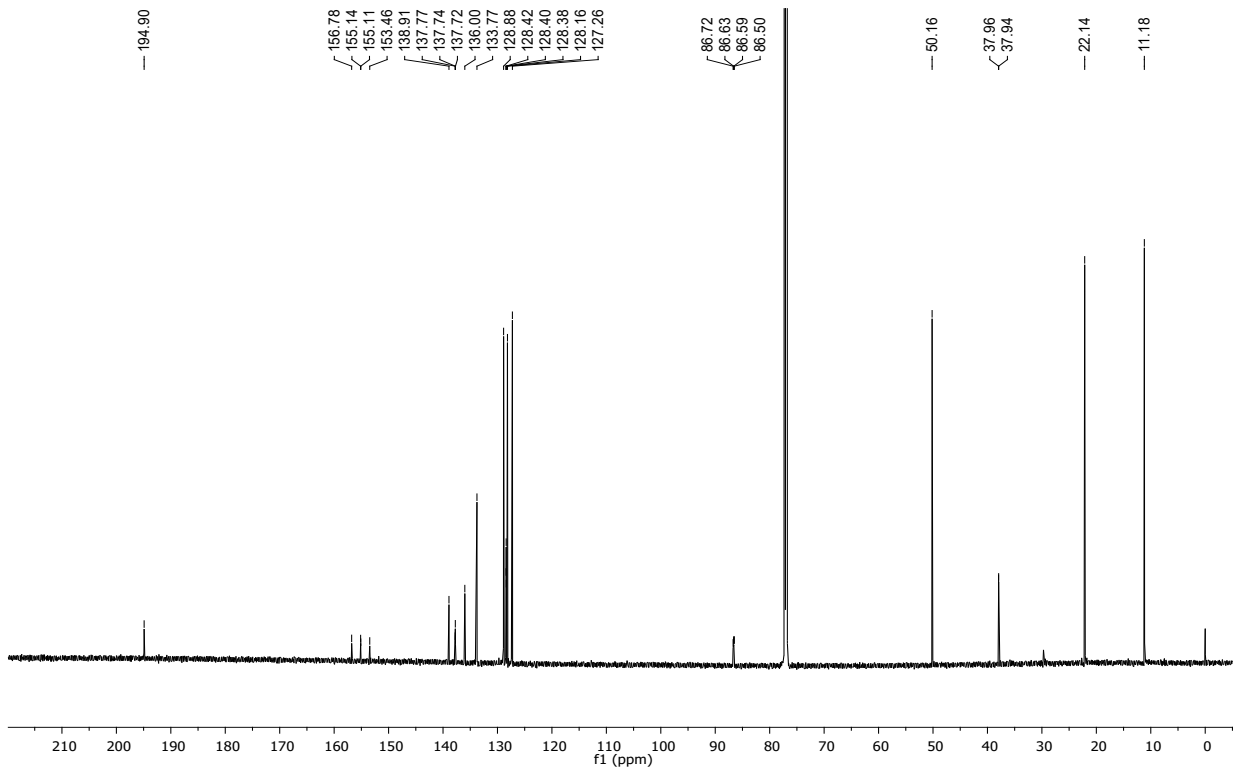
^{1}H NMR spectrum of compound 6f



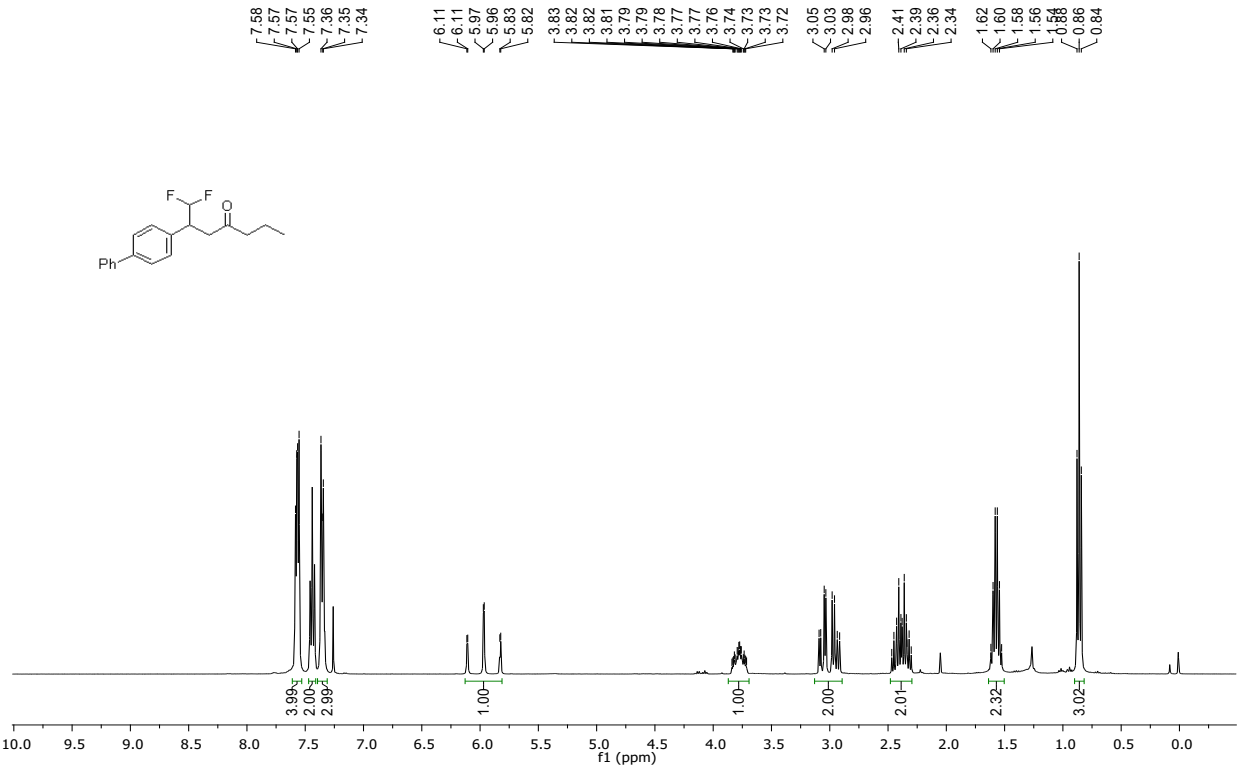
^{19}F NMR spectrum of compound 6f



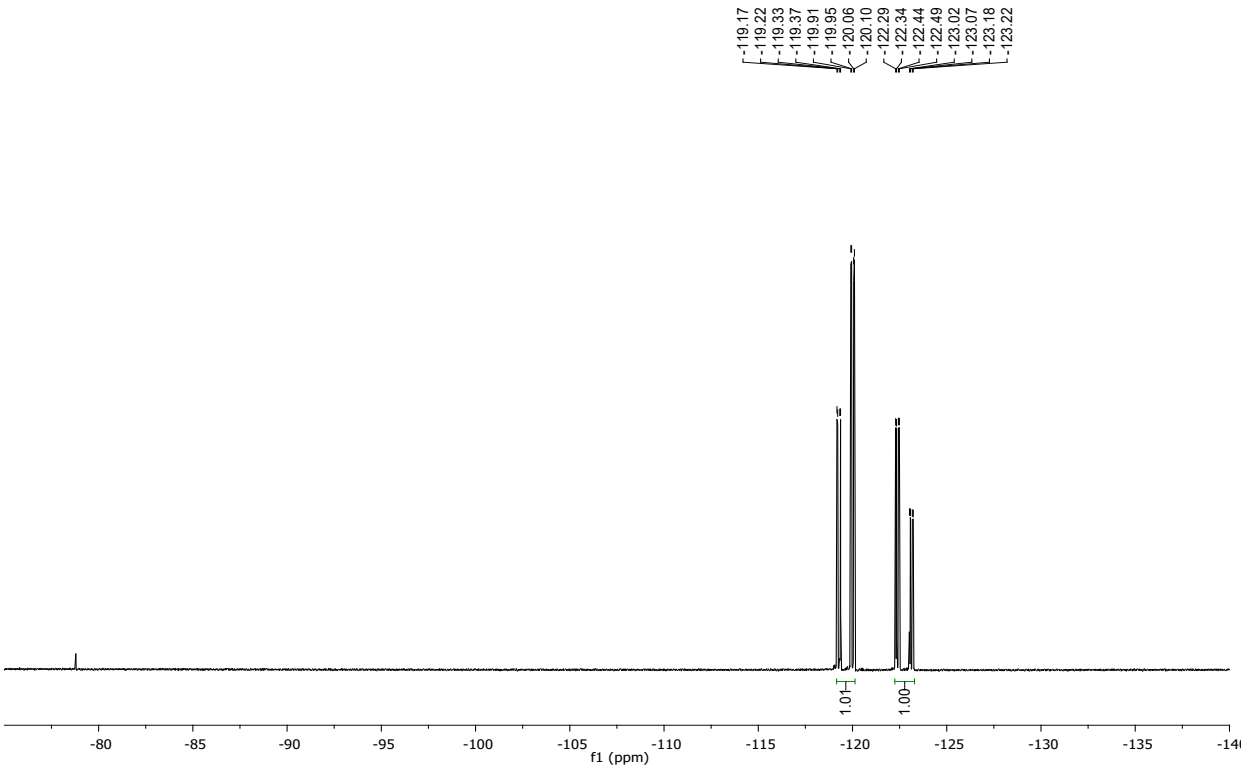
^{13}CNMR spectrum of compound 6f



^{1}H NMR spectrum of compound 7



^{19}F NMR spectrum of compound 7



^{13}C NMR spectrum of compound 7