Supporting Information

Palladium-catalyzed allylic alkylation dearomatization of β-naphthols and indoles with *gem*-difluorinated cyclopropanes

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Content

1. General Information

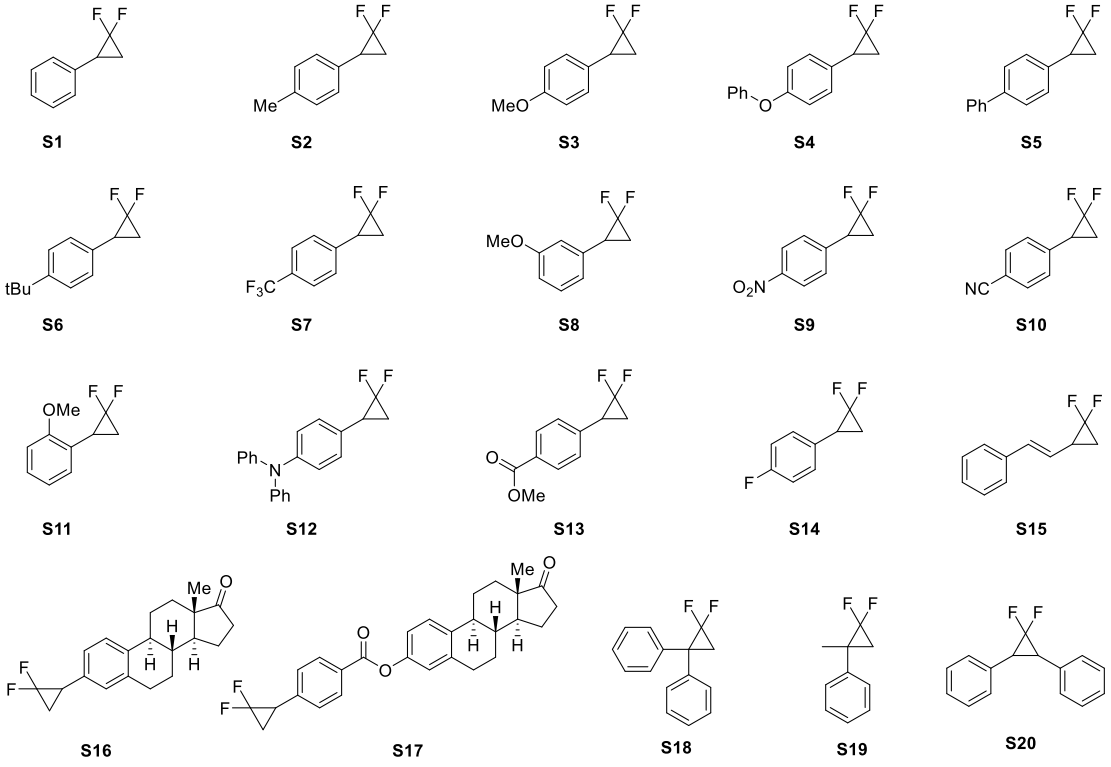
Reagents and Solvents: PE refers to petroleum ether b.p. 60−90 ℃ and EA refers to ethyl acetate. All other starting materials and solvents were commercially available and were used without further purification unless otherwise stated.

Chromatography: Flash column chromatography was carried out using commercially available 200−300 mesh under pressure unless otherwise indicated. Gradient flash chromatography was conducted eluting with PE/EA, they are listed as volume/volume ratios.

Data collection: ^{1}H NMR, ^{13}C NMR and ^{19}F NMR spectra were collected on BRUKER AV-300 (300 MHz) spectrometer using $CDCl_3$ as solvent. Chemical shifts of ^{1}H NMR were recorded in parts per million (ppm, δ) relative to tetramethylsilane (δ = 0.00 ppm) with the solvent resonance as an internal standard ($CDCl_3$: δ = 7.26 ppm). Data are reported as follows: chemical shift in ppm (δ), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, brs = broad singlet, m = multiplet), coupling constant (Hz), and integration. Chemical shifts of ^{13}C NMR were reported in ppm with the solvent as the internal standard ($CDCl_3$: δ = 77.16 ppm). High Resolution Mass measurement was performed on Agilent Q-TOF 6520 mass spectrometer with electron spray ionization (ESI) as the ion source. Melting point (m.p.) was measured on a microscopic melting point apparatus.

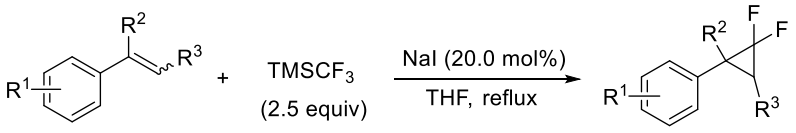
2. Preparation of Starting Materials

Table S1. Substituted *gem*-difluorinated cyclopropanes



2.1 General Procedure for the Synthesis of gem-Difluorinated Cyclopropanes

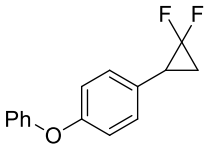
S1-S20 were synthesized according to the reported procedures,[1-5] characterization of unreported *gem*-difluorinated cyclopropanes **S4**, **S8**, **S12**, **S13** are listed below.
Substituted *gem*-difluorinated cyclopropanes were prepared according to the reported literature[2] as the following procedures:



To a 250 mL pressure tube charged with a tefloncoated stir bar was added anhydrous NaI (0.3 g, 2.0 mmol, 0.2 equiv), 50.0 mL of freshly distilled THF as solvent, and the corresponding alkene (10.0 mmol, 1.0 equiv) in that order under argon atmosphere. To this mixture was added $TMSCF_3$ (3.6 g, 25.0 mmol, 2.5 equiv). The reaction vessel was sealed and reflux in an oil bath for a period of 4 h. The reaction mixture was evaporated to dryness under reduced pressure to remove THF. The crude was extracted with ether (30.0 mL) and washed with water (20.0 mL), saturated Na_2SO_3 solution (20.0 mL), saturated $NaHCO_3$ solution (20.0 mL), and water (20.0 mL), in that order. The ether layer was then collected and dried over anhydrous Na_2SO_4. The ether layer was evaporated under reduced pressure to obtain the crude products. The crude products were purified by flash chromatography on silica gel (PE/EA) to afford the desired products.

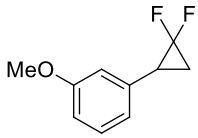
2.2 Characterization of the Substrates

***1-(2,2-difluorocyclopropyl)-4-phenoxybenzene* (S4)**



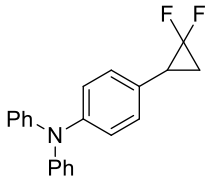
2.09 g, 85% yield, colorless oil, R_f = 0.3 (PE = 100%), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.36 – 7.29 (m, 2H), 7.20 – 7.15 (m, 2H), 7.12 – 7.07 (m, 1H), 7.02 – 6.93 (m, 4H), 2.77 – 2.66 (m, 1H), 1.85 – 1.73 (m, 1H), 1.62 – 1.51(m, 1H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 157.1, 156.5, 129.9, 129.5, 128.4, 123.4, 119.0, 118.9, 112.6 (dd, *J* = 286.8, 283.9 Hz), 26.6 (t, *J* = 11.5 Hz), 17.1 (t, *J* = 10.5 Hz) ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -126.02 (d, *J* = 153.8 Hz), -142.23 (d, *J* = 153.8 Hz) ppm; **HRMS (ESI)** *m*/*z* Calcd for $[C_{15}H_{13}F_2O + H]^+$ 247.0929, found 247.0919.

1-(2,2-difluorocyclopropyl)-3-methoxybenzene (S8)



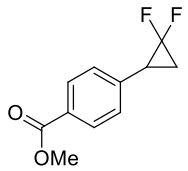
1.66 g, 90% yield, colorless oil, R_f = 0.3 (PE = 100%), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.25 – 7.20 (m, 1H), 6.82 – 6.75 (m, 3H), 3.78 (s, 3H), 2.76 – 2.65 (m, 1H), 1.84 – 1.72 (m, 1H), 1.65 – 1.54 (m, 1H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 159.7, 135.2, 129.5, 120.4 (t, *J* = 1.6 Hz), 114.0 (t, *J* = 1.7 Hz), 112.6 (dd, *J* = 286.7, 284.2 Hz), 112.5, 55.2, 27.2 (t, *J* = 11.4 Hz), 17.0 (t, *J* = 10.5 Hz) ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -125.67 (d, *J* = 153.7 Hz), -142.16 (d, *J* = 153.4 Hz) ppm; **HRMS (ESI)** *m*/*z* Calcd for $[C_{10}H_{11}F_2O + H]^+$ 185.0772, found 185.0768.

4-(2,2-difluorocyclopropyl)-N,N-diphenylaniline (S12)



2.41 g, 75% yield, white solid, R_f = 0.75 (PE/EA = 9:1), m.p. 65 – 66 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.27 – 7.20 (m, 4H), 7.10 – 7.05 (m, 6H), 7.05 – 7.02 (m, 2H), 7.02 – 6.97 (m, 2H), 2.74 – 2.63 (m, 1H), 1.84-1.72 (m, 1H), 1.62 – 1.49 (m, 1H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 147.7, 146.9, 129.3, 128.9 (t, *J* = 1.6 Hz), 127.6, 124.3, 123.8, 122.9, 112.8 (dd, *J* = 287.0, 284.0 Hz), 26.8 (t, *J* = 11.5 Hz), 17.1 (t, *J* = 10.5 Hz) ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -125.83 (d, *J* = 153.6 Hz), -142.26 (d, *J* = 153.5 Hz) ppm; **HRMS (ESI)** *m*/*z* Calcd for $[C_{21}H_{18}F_2N + H]^+$ 322.1402, found 322.1402.

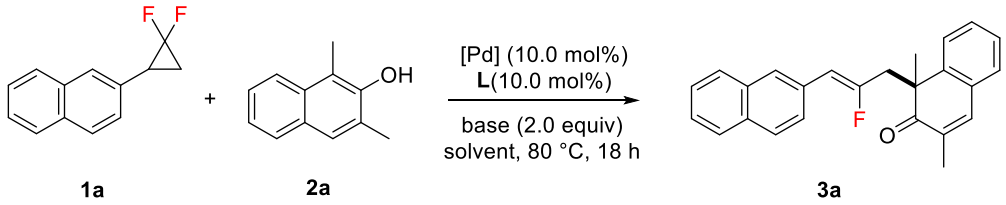
methyl 4-(2,2-difluorocyclopropyl)benzoate (S13)



1.70 g, 80% yield, colorless oil, R_f = 0.5 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.02 – 7.98 (m, 2H), 7.30 – 7.26 (m, 2H), 3.91 (s, 3H), 2.84 – 2.73 (m, 1H), 1.95 – 1.83 (m, 1H), 1.74 – 1.63 (m, 1H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 166.8, 139.0, 129.7, 129.0, 127.9 (t, *J* = 1.7 Hz), 112.3 (dd, *J* = 287.6, 284.1 Hz), 52.1, 27.3 (t, *J* = 11.5 Hz), 17.5 (t, *J* = 10.5 Hz) ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -125.54 (d, *J* = 154.4 Hz), -142.18 (d, *J* = 154.1 Hz) ppm; **HRMS (ESI)** *m*/*z* Calcd for $[C_{11}H_{11}F_2O_2 + H]^+$ 213.0722, found 213.0723.

3. Optimization of Reaction Conditions for the Synthesis of Products 3a and 5a

Table S2. Screening of base, catalysts and ligands[a,b]

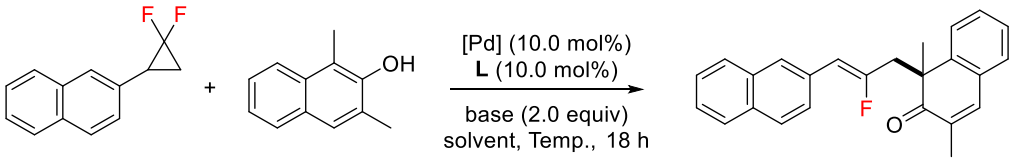


1a **2a** **3a**

entry	catalyst	ligand	base	solvent	yield
1	$Pd(OTFA)_2$	XPhos	K_3PO_4	THF	37%
2	$Pd(OTFA)_2$	XPhos	Cs_2CO_3	THF	51%
3	$Pd(OTFA)_2$	XPhos	$KHCO_3$	THF	15%
4	$Pd(OTFA)_2$	XPhos	LiO^tBu	THF	86%
5	$Pd(OTFA)_2$	XPhos	NaO^tBu	THF	74%
6	$Pd(OTFA)_2$	XPhos	KO^tBu	THF	71%
7	$PdCl_2$	XPhos	LiO^tBu	THF	trace
8	$Pd(OAc)_2$	XPhos	LiO^tBu	THF	83%
9	$Pd(PPh_3)_4$	XPhos	LiO^tBu	THF	80%
10	$Pd_2(dba)_3$	XPhos	LiO^tBu	THF	85%
11	**$[\eta^3\text{-}C_3H_5PdCl]_2$**	**XPhos**	**LiO^tBu**	**THF**	**92%**
12	$[\eta^3\text{-}C_3H_5PdCl]_2$	Cy_3P	LiO^tBu	THF	46%
13	$[\eta^3\text{-}C_3H_5PdCl]_2$	PPh_3	LiO^tBu	THF	<5%
14	$[\eta^3\text{-}C_3H_5PdCl]_2$	SPhos	LiO^tBu	THF	58%
15	$[\eta^3\text{-}C_3H_5PdCl]_2$	XantPhos	LiO^tBu	THF	37%
16	$[\eta^3\text{-}C_3H_5PdCl]_2$	^{t}Bu-XPhos	LiO^tBu	THF	15%
17	$[\eta^3\text{-}C_3H_5PdCl]_2$	DavePhos	LiO^tBu	THF	40%

[a]Reaction conditions: **1a** (0.2 mmol), **2a** (0.3 mmol), [Pd] (10.0 mol%), ligand (10.0 mol%), base (2.0 equiv.), solvent (2.0 mL), at 80 °C under Ar atmosphere for 18 h, sealed tube. [b]Isolated yield.

Table S3. Screening of solvents and temperature[a,b]

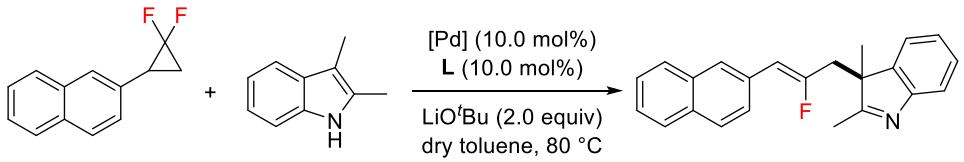


1a **2a** **3a**

entry	catalyst	ligand	temperature	solvent	yield
1	**$[\eta^3\text{-}C_3H_5PdCl]_2$**	**XPhos**	**80 °C**	**THF**	**92%**
2	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	80 °C	mesitylene	90%
3	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	80 °C	toluene	87%
4	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	80 °C	CH_3CN	33%
5	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	80 °C	1,4-dioxane	74%
6	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	60 °C	THF	67%
7	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	100 °C	THF	87%
8	–	XPhos	80 °C	THF	n.r.
9	$[\eta^3\text{-}C_3H_5PdCl]_2$	–	80 °C	THF	n.r.

[a]Reaction conditions: **1a** (0.2 mmol), **2a** (0.3 mmol), $[\eta^3\text{-}C_3H_5PdCl]_2$ (5.0 mol%), XPhos (10.0 mol%), LiO^{t}Bu (2.0 equiv.), solvent (2.0 mL), under Ar atmosphere for 18 h, sealed tube. [b]Isolated yield. n.r. = no reaction.

Table S4. Screening of catalysts[a,b]

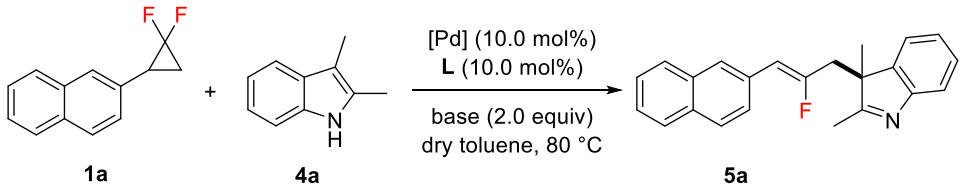


1a **4a** **5a**

entry	catalyst	ligand	base	temperature	yield
1	$Pd(OTFA)_2$	XPhos	LiO^{t}Bu	80 °C	44%
2	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	80 °C	45%
3	$Pd(OAc)_2$	XPhos	LiO^{t}Bu	80 °C	57%
4	$Pd_2(dba)_3$	XPhos	LiO^{t}Bu	80 °C	43%
5	$PdCl_2$	XPhos	LiO^{t}Bu	80 °C	n.r.
6	$Pd(PP_3)_4$	XPhos	LiO^{t}Bu	80 °C	46%
7	**$Pd(XantPhos)Cl_2$**	**XPhos**	**LiO^{t}Bu**	**80 °C**	**80%**
8	$Pd(dppf)Cl_2$	XPhos	LiO^{t}Bu	80 °C	40%
9[c]	$Pd(XantPhos)Cl_2$	XPhos	LiO^{t}Bu	80 °C	55%

[a]Reaction conditions: **1a** (0.1 mmol), **5a** (0.15 mmol), [Pd] (10.0 mol%), XPhos (10.0 mol%), LiO^{t}Bu (2.0 equiv.), dry toluene (2.0 mL), at 80 °C under Ar atmosphere for 24 h, sealed tube. [b]Isolated yield. [c]$Pd(XantPhos)Cl_2$ (5.0 mol%). n.r. = no reaction.

Table S5. Screening of ligands, temperature and base[a,b]



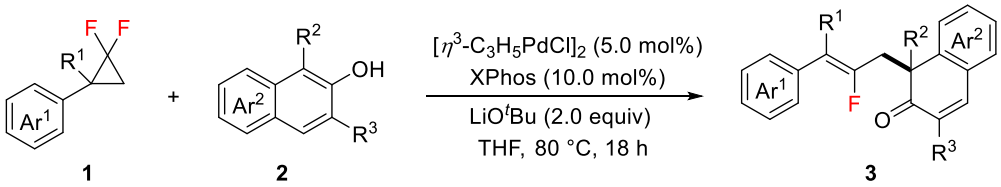
1a 4a 5a

entry	catalyst	ligand	base	temperature	yield
1	$Pd(XantPhos)Cl_2$	PPh_3	LiO^tBu	80 °C	62%
2	$Pd(XantPhos)Cl_2$	SPhos	LiO^tBu	80 °C	60%
3	$Pd(XantPhos)Cl_2$	^{t}Bu-XPhos	LiO^tBu	80 °C	10%
4	$Pd(XantPhos)Cl_2$	DPPF	LiO^tBu	80 °C	51%
5	$Pd(XantPhos)Cl_2$	DavePhos	LiO^tBu	80 °C	76%
6	$Pd(XantPhos)Cl_2$	XantPhos	LiO^tBu	80 °C	44%
7	$Pd(XantPhos)Cl_2$	-	LiO^tBu	80 °C	27%
8	$Pd(XantPhos)Cl_2$	XPhos	LiO^tBu	100 °C	58%
9	$Pd(XantPhos)Cl_2$	XPhos	LiO^tBu	60 °C	43%
10	$Pd(XantPhos)Cl_2$	XPhos	Li_2CO_3	80 °C	n.r.
11	$Pd(XantPhos)Cl_2$	XPhos	KO^tBu	80 °C	trace
12	$Pd(XantPhos)Cl_2$	XPhos	K_2CO_3	80 °C	<5%
13	$Pd(XantPhos)Cl_2$	XPhos	K_3PO_4	80 °C	45%
14	$Pd(XantPhos)Cl_2$	XPhos	Cs_2CO_3	80 °C	43%

[a]Reaction conditions: **1a** (0.1 mmol), **5a** (0.15 mmol), $Pd(XantPhos)Cl_2$ (10.0 mol%), ligand (10.0 mol%), base (2.0 equiv.), toluene (2.0 mL), at 80 °C under Ar atmosphere for 24 h, sealed tube. [b]Isolated yield. n.r. = no reaction.

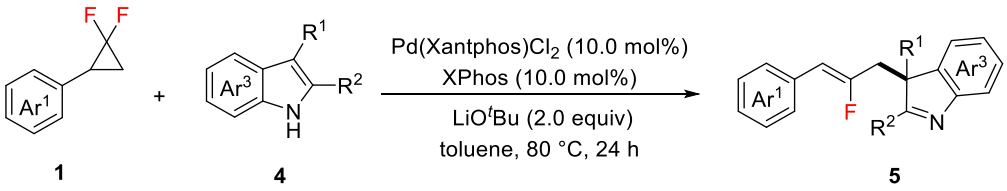
4. General Experimental Procedures

4.1 General Procedure for the Preparation of Compounds 3



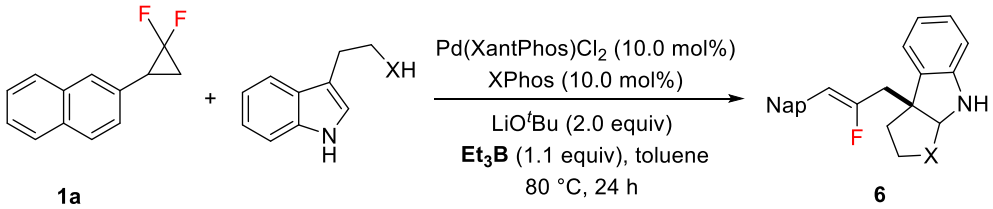
A sealed tube was charged with *gem*-difluorinated cyclopropanes **1** (0.2 mmol, 1.0 equiv), β-naphthols **2** (0.3 mmol, 1.5 equiv), $[\eta^3\text{-}C_3H_5PdCl]_2$ (3.7 mg, 0.01 mmol, 5.0 mol%), XPhos (9.5 mg, 0.02 mmol, 10.0 mol%), LiO^{t}Bu (32.0 mg, 0.4 mmol, 2.0 equiv), and THF (2.0 mL) under argon atmosphere. The reaction mixture was vigorously stirred at 80 °C (oil temperature) for 18 h. After cooling to room temperature, the reaction mixture was diluted with EA (10.0 mL) and filtered through a plug of celite. The filtrate was concentrated *in vacuo* to give dark residue, which was purified by flash chromatography on silica gel with PE/EA (*v*/*v* = 200:1 to 100:1) to afford dearomative products **3**.

4.2 General Procedure for the Preparation of Compounds 5



A sealed tube was charged with *gem*-difluorinated cyclopropanes **1** (0.2 mmol, 1.0 equiv), indoles **4** (0.3 mmol, 1.5 equiv), Pd(XantPhos)Cl_2 (15.1 mg, 0.02 mmol, 10.0 mol%), XPhos (9.5 mg, 0.02 mmol, 10.0 mol%), LiO^{t}Bu (32.0 mg, 0.4 mmol, 2.0 equiv), and anhydrous toluene (2.0 mL) under argon atmosphere. The reaction mixture was vigorously stirred at 80 °C (oil temperature) for 24 h. After cooling to room temperature, the reaction mixture was diluted with EA (10.0 mL) and filtered through a plug of celite. The filtrate was concentrated *in vacuo* to give dark residue, which was purified by flash chromatography on silica gel with PE/EA (*v*/*v* = 20:1 to 5:1) to afford dearomative products **5**.

4.3 General Procedure for the Preparation of Compounds 6

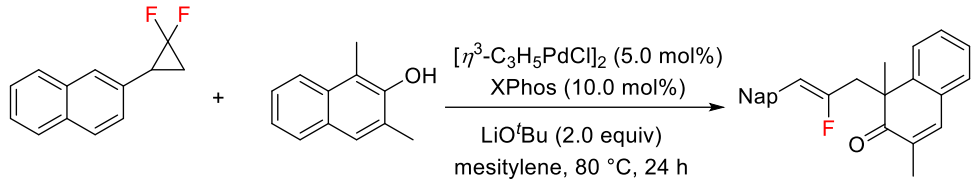


1a **6**

A sealed tube was charged with 2-(2,2-difluorocyclopropyl)naphthalene **1a** (40.8 mg, 0.2 mmol, 1.0 equiv), tryptophol or tryptamines (0.3 mmol, 1.5 equiv), Pd(XantPhos)Cl_2 (15.1 mg, 0.02 mmol, 10.0 mol%), XPhos (9.5 mg, 0.02 mmol, 10.0 mol%), LiO^tBu (32.0 mg, 0.4 mmol, 2.0 equiv), Et_3B (0.22 mL, 1 mol/L in THF, 1.1 equiv), and anhydrous toluene (2.0 mL) under argon atmosphere. The reaction mixture was vigorously stirred at 80 °C (oil temperature) for 24 h. After cooling to room temperature, the reaction mixture was diluted with EA (10.0 mL) and filtered through a plug of celite. The filtrate was concentrated under reduced pressure and purified by flash chromatography on silica gel with PE/EA (*v*/*v* = 20:1 to 5:1) to afford the desired products **6**.

5. Further Functionalization of the Products

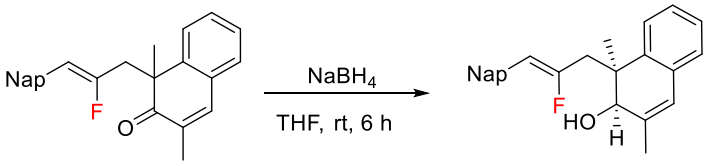
5.1 Scale-up (5.0 mmol) Experiment of 3a



1a 5.0 mmol | **2a** 7.5 mmol | **3a** 1.62 g, 91% yield

A sealed tube was charged with 2-(2,2-difluorocyclopropyl)naphthalene **1a** (1.02 g, 5.0 mmol, 1.0 equiv), β-naphthol **2a** (1.29 g, 7.5 mmol, 1.5 equiv), $[\eta^3\text{-}C_3H_5PdCl]_2$ (91.5 mg, 0.25 mmol, 5.0 mol%), XPhos (238.4 mg, 0.5 mmol, 10.0 mol%), LiO^tBu (800.5 mg, 10.0 mmol, 2.0 equiv), and mesitylene (50.0 mL) under argon atmosphere. The reaction mixture was vigorously stirred at 80 °C (oil temperature) for 24 h. After cooling to room temperature, the reaction mixture was diluted with EA (30.0 mL) and filtered through a plug of celite. The filtrate was concentrated *in vacuo* to give dark residue, which was purified by flash chromatography on silica gel with PE/EA (*v*/*v* = 200:1 to 100:1) to afford the product **3a**.

5.2 Synthetic Transformation of 3a to 7[6-8]



3a | **7**, 90% yield, dr > 20:1

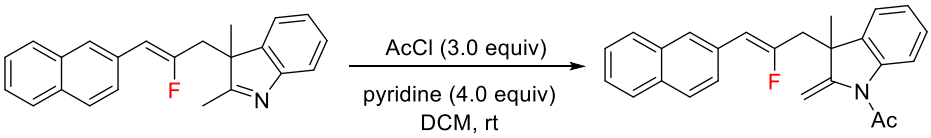
To a solution of **3a** (71.2 mg, 0.2 mmol) in anhydrous THF (2.0 mL), $NaBH_4$ (9.8 mg, 0.24 mmol) was added. The reaction mixture was stirred at rt for 6 h. After the reaction was completed (monitored by TLC), the solvent was removed under reduced pressure. Then dr ratio was determined by ^{1}H NMR of the crude reaction mixture. Then the residue was purified by silica gel column chromatography with PE/EA (*v*/*v* = 10:1, TLC: R_f = 0.4, PE/EA = 9:1) to afford the desired product **7** as a colorless oil. The relative configuration of **7** was confirmed by the NOE spectra.

(Z)-1-(2-fluoro-3-(naphthalen-2-yl)allyl)-1,3-dimethyl-1,2-dihydronaphthalen-2-ol (7)

64.5 mg, 90% yield, colorless oil, R_f = 0.4 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.87 – 7.86 (m, 1H), 7.79 – 7.75 (m, 3H), 7.62 (dd, *J* = 8.6, 1.7 Hz, 1H), 7.46 – 7.38 (m, 2H), 7.31 – 7.27 (m, 1H), 7.22 – 7.13 (m, 2H), 7.08 – 7.02 (m, 1H),

6.24 (q, *J* = 1.7 Hz, 1H), 5.61 (d, *J* = 39.6 Hz, 1H), 4.07 (d, *J* = 7.5 Hz, 1H), 3.00 – 2.80 (m, 2H), 2.00 (d, *J* = 1.7 Hz, 3H), 1.64 (d, *J* = 7.8 Hz, 1H), 1.34 (d, *J* = 1.7 Hz, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 159.6 (d, *J* = 267.6 Hz), 139.7, 138.0, 133.5, 132.7, 132.3 (d, *J* = 1.7 Hz), 131.4 (d, *J* = 2.7 Hz), 128.0, 127.9, 127.6, 127.3 (d, *J* = 7.7 Hz), 127.2, 127.0, 126.7 (d, *J* = 7.6 Hz), 126.7, 126.1, 125.8, 125.1, 123.8, 109.9 (d, *J* = 8.6 Hz), 75.6, 43.3 (d, *J* = 3.9 Hz), 37.5 (d, *J* = 24.6 Hz), 23.8 (d, *J* = 1.8 Hz), 20.9 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -92.77 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{25}H_{24}FO + Na]^+$ 381.1625, found 381.1628.

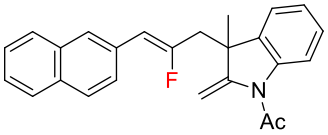
5.3 Synthetic Transformation of 5a to 8[9]



5a **8**, 94% yield

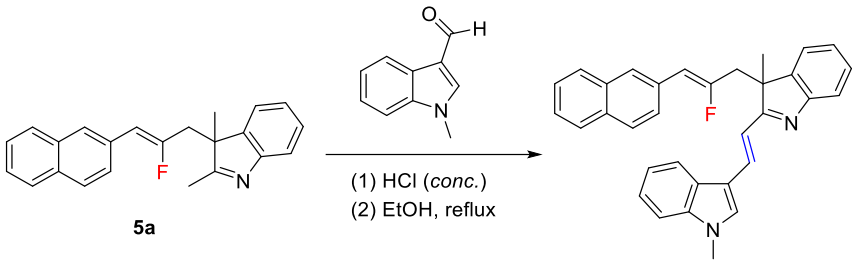
A sealed tube was charged with **5a** (65.8 mg, 0.2 mmol), pyridine (64 μL, 0.8 mmol, 4.0 equiv) and the corresponding chloride (43 μL, 0.6 mmol, 3.0 equiv) were added. The reaction mixture was stirred at room temperature until completion (monitored by TLC). Then saturated $NaHCO_3$ (10.0 mL) was added, and the mixture was extracted with CH_2Cl_2 (10.0 x 3 mL) and dried with Na_2SO_4. The mixture was concentrated in vacuo. The residue was purified by silica gel column chromatography PE/EA (*v*/*v* = 50:1 to 10:1) to afford the desired product **8**.

(Z)-3-(2-fluoro-3-(3-methoxyphenyl)allyl)-2,3-dimethyl-3H-indole (8)



69.5 mg, 94% yield, yellow oil, R_f = 0.6 (PE/EA = 6:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.1 Hz, 1H), 7.76 – 7.70 (m, 4H), 7.49 (d, *J* = 8.6 Hz, 1H), 7.44 – 7.37 (m, 2H), 7.27 – 7.19 (m, 2H), 7.10 (t, *J* = 7.4 Hz, 1H), 5.38 (d, J = 38.6 Hz, 1H), 5.19 (d, *J* = 2.4 Hz, 1H), 4.90 (d, *J* = 2.3 Hz, 1H), 2.60 (dd, *J* = 22.7, 3.5 Hz, 2H), 2.43 (s, 3H), 1.55 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.6, 157.5 (d, *J* = 267.8 Hz), 154.4, 141.7, 136.2, 133.4, 132.4, 130.8 (d, *J* = 2.7 Hz), 128.2, 128.1, 128.0, 127.6, 127.4 (d, *J* = 7.4 Hz), 126.5 (d, *J* = 7.6 Hz), 126.2, 126.0, 124.4, 122.6, 116.8, 109.9 (d, *J* = 8.4 Hz), 96.9, 47.6 (d, *J* = 3.6 Hz), 46.8 (d, *J* = 24.6 Hz), 25.6, 25.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -95.79 ppm; **HRMS** (**ESI**) m/z Calcd for $[C_{25}H_{22}FNO + H]^+$ 372.1758, found 372.1762.

5.4 Synthetic Transformation of 5a to 9[9]

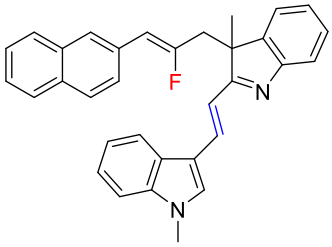


5a

9, 90% yield

Concentrated hydrochloric acid (1.5 mL) was added dropwise into **5a** (60.2 mg, 0.2 mmol). The mixture was stirred at room temperature for 30 min. Then excess reagent was removed by rotary evaporation under reduced pressure to give the HCl salt. The HCl salt was then dissolved in anhydrous ethanol (10.0 mL) followed the addition of *N*-methyl indole-3-carbaldehyde (38.2 mg, 0.24 mmol, 1.2 equiv). The mixture was allowed to reflux for 4 h under argon atmosphere. The reaction was monitored by TLC until completion. Then the reaction mixture was cooled to room temperature and extracted with DCM (20.0 mL). The combined organic layer was washed with water and brine, and dried over anhydrous Na_2SO_4. Solvent was evaporated to obtain a dark residue, which was further purified by flash column chromatography using PE/EA (*v*/*v* = 4:1) as the eluent to give the product **9**.

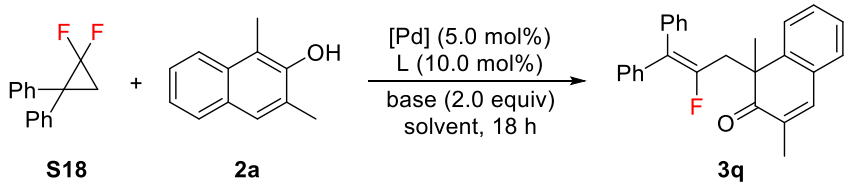
3-((Z)-2-fluoro-3-(naphthalen-2-yl)allyl)-3-methyl-2-((E)-2-(1-methyl-1H-indol-3-yl)vinyl)-3H-indole (9)



84.6 mg, 90% yield, yellow solid, R_f = 0.5 (PE/EA = 2:1), m.p. 100 – 102 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.09 (d, *J* = 16.1 Hz, 1H), 7.99 (d, *J* = 7.9 Hz, 1H), 7.77 – 7.70 (m, 4H), 7.61 (d, *J* = 7.7 Hz, 1H), 7.52 (dd, *J* = 8.7, 1.7 Hz, 1H), 7.44 – 7.40 (m, 2H), 7.39 – 7.28 (m, 5H), 7.21 – 7.15 (m, 2H), 7.05 (d, *J* = 16.1 Hz, 1H), 5.50 (d, *J* = 38.7 Hz, 1H), 3.76 (s, 3H), 2.97 (dd, *J* = 21.5, 14.7 Hz, 1H), 2.77 (dd, *J* = 22.8, 14.7 Hz, 1H), 1.61 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 182.6, 157.6 (d, *J* = 268.0 Hz), 154.8, 143.4, 138.1, 133.4, 132.4, 132.4, 132.0, 130.8 (d, *J* = 2.3 Hz), 128.3, 128.1, 127.9, 127.6, 127.5, 126.7 (d, *J* = 7.6 Hz), 126.2, 126.1, 126.0, 124.8, 122.9, 122.3, 121.2, 120.7, 120.1, 114.5, 113.7, 110.1, 109.7 (d, *J* = 7.9 Hz), 55.5 (d, *J* = 3.0 Hz), 41.1 (d, *J* = 25.1 Hz), 33.1, 22.4 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -95.06 ppm; **HRMS** (**ESI**) m/z Calcd for $[C_{33}H_{27}FN_2 + H]^+$ 471.2231, found 471.2226.

6. Optimization of Reaction Conditions for the Synthesis of Product 3q

Table S6. Screening of reaction conditions[a]

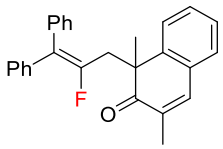


S18 **2a** **3q**

entry	catalyst	ligand	base	temperature	solvent	yield[b]
1	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	80 °C	THF	n.d.
2	$Pd_2(dba)_3\ CHCl_3$	XPhos	LiO^{t}Bu	80 °C	THF	n.d.
3	$Pd(OAc)_2$	XPhos	LiO^{t}Bu	80 °C	THF	n.d.
4	$Pd(PP_3)_4$	XPhos	LiO^{t}Bu	80 °C	THF	n.d.
5	$Pd(TFA)_2$	XPhos	LiO^{t}Bu	80 °C	THF	n.d.
6	$[\eta^3\text{-}C_3H_5PdCl]_2$	PPh_3	LiO^{t}Bu	80 °C	THF	n.d.
7	$[\eta^3\text{-}C_3H_5PdCl]_2$	SPhos	LiO^{t}Bu	80 °C	THF	n.d.
8	$[\eta^3\text{-}C_3H_5PdCl]_2$	XantPhos	LiO^{t}Bu	80 °C	THF	n.d.
9	$[\eta^3\text{-}C_3H_5PdCl]_2$	^{t}Bu-XPhos	LiO^{t}Bu	80 °C	THF	n.d.
10	$[\eta^3\text{-}C_3H_5PdCl]_2$	DavePhos	LiO^{t}Bu	80 °C	THF	n.d.
11	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	80 °C	mesitylene	<5%
12	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	80 °C	toluene	trace
13	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	80 °C	1,4-dioxane	n.d.
14	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	80 °C	DCE	n.d.
15	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	80 °C	CH_3CN	n.d.
16	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	K_2CO_3	80 °C	mesitylene	18%
17	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	K_3PO_4	80 °C	mesitylene	23%
18	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	K_2HPO_4	80 °C	mesitylene	n.d.
19	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	Li_2CO_3	80 °C	mesitylene	n.d.
20	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	Cs_2CO_3	80 °C	mesitylene	12%
21[c]	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	K_3PO_4	80 °C	mesitylene	26%
22[d]	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	K_3PO_4	80 °C	mesitylene	29%
23	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	K_3PO_4	100 °C	mesitylene	35%
24[c]	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	K_3PO_4	100 °C	mesitylene	32%

[a]Reaction conditions: **S18** (0.05 mmol), **2a** (0.075 mmol), catalyst (5.0 mol%), ligand (10.0 mol%), base (2.0 equiv.), solvent (0.5 mL), at 80 °C under Ar atmosphere for 18 h, sealed tube. [b]Isolated yield. [c]for 24 h. [d]for 36 h. n.d. = not detected.

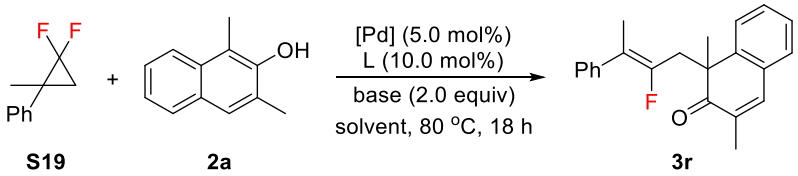
1-(2-fluoro-3,3-diphenylallyl)-1,3-dimethylnaphthalen-2(1H)-one (3q)



33.2 mg, 35% yield, colorless oil, R_f = 0.5 (PE/EA=9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.36 – 7.25 (m, 6H), 7.25 – 7.17 (m, 1H), 7.16 – 7.05 (m, 3H), 7.00 – 6.89 (m, 3H), 6.82 – 6.73 (m, 2H), 3.39 (dd, *J* = 14.7, 5.6 Hz, 1H), 2.94 (dd, *J* = 34.2, 14.7 Hz, 1H), 2.02 (d, *J* = 1.4 Hz, 3H), 1.35 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.5, 154.8 (d, *J* = 259.9 Hz), 143.7, 141.2, 138.5 (d, *J* = 7.8 Hz), 137.3, 132.1 (d, *J* = 1.5 Hz), 130.4 (d, *J* = 3.0 Hz), 130.0, 129.5, 129.4, 128.6, 128.5, 128.3, 127.8, 127.3, 127.0, 126.9, 122.5 (d, *J* = 15.2 Hz), 49.8, 41.6 (d, *J* = 25.2 Hz), 28.6, 16.2 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -103.7 ppm; **HRMS (ESI)** m/z Calcd for $[C_{27}H_{23}FO + Na]^+$ 405.1625, found 405.1625.

7. Optimization of Reaction Conditions for the Synthesis of Product 3r

Table S7. Screening of reaction conditions[a]

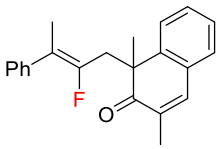


S19 **2a** **3r**

entry	catalyst	ligand	base	solvent	yield[b]
1	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	THF	n.d.
2	$Pd_2(dba)_3\ CHCl_3$	XPhos	LiO^{t}Bu	THF	n.d.
3	$Pd(OAc)_2$	XPhos	LiO^{t}Bu	THF	n.d.
4	$Pd(PP_3)_4$	XPhos	LiO^{t}Bu	THF	n.d.
5	$Pd(TFA)_2$	XPhos	LiO^{t}Bu	THF	n.d.
6	$[\eta^3\text{-}C_3H_5PdCl]_2$	PPh_3	LiO^{t}Bu	THF	n.d.
7	$[\eta^3\text{-}C_3H_5PdCl]_2$	SPhos	LiO^{t}Bu	THF	n.d.
8	$[\eta^3\text{-}C_3H_5PdCl]_2$	XantPhos	LiO^{t}Bu	THF	n.d.
9	$[\eta^3\text{-}C_3H_5PdCl]_2$	^{t}Bu-XPhos	LiO^{t}Bu	THF	n.d.
10	$[\eta^3\text{-}C_3H_5PdCl]_2$	DavePhos	LiO^{t}Bu	THF	n.d.
11	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	mesitylene	15%
12	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	toluene	19%
13	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	1,4-dioxane	n.d.
14	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	DCE	n.d.
15	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	CH_3CN	n.d.
16	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	K_2CO_3	mesitylene	17%
17	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	K_3PO_4	mesitylene	15%
18	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	K_2HPO_4	mesitylene	10%
19	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	Li_2CO_3	mesitylene	trace
20	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	Cs_2CO_3	mesitylene	8%
21[c]	$[\eta^3\text{-}C_3H_5PdCl]_2$	XPhos	LiO^{t}Bu	mesitylene	27%

[a]Reaction conditions: **S19** (0.05 mmol), **2a** (0.075 mmol), catalyst (5.0 mol%), ligand (10.0 mol%), base (2.0 equiv.), solvent (0.5 mL), at 80 °C under Ar atmosphere for 18 h, sealed tube. [b]Isolated yield. [c]at 100 °C. n.d. = not detected.

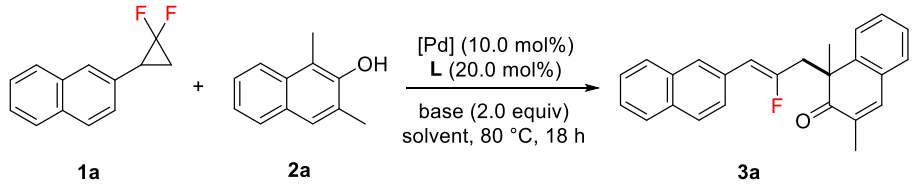
1-(2-fluoro-3-phenylbut-2-en-1-yl)-1,3-dimethyl-4a,8a-dihydronaphthalen-2(1H)-one (3r)



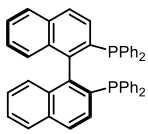
15.2 mg, 27% yield, colorless oil, R_f = 0.5 (PE/EA=9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.44 – 7.42 (m, 1H), 7.36 – 7.30 (m, 1H), 7.29 – 7.27 (m, 1H), 7.26 – 7.23 (m, 2H), 7.22 – 7.18 (m, 2H), 7.17 – 7.15 (m, 1H), 7.04 – 7.00 (m, 2H), 3.12 (dd, *J* = 17.6, 14.6 Hz, 1H), 2.89 (dd, *J* = 27.4, 14.5 Hz, 1H), 2.00 (d, *J* = 1.4 Hz, 3H), 1.59 – 1.58 (m, 6H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.9, 152.0 (d, *J* = 249.9 Hz), 144.1, 141.4, 138.3, 132.4, 130.2, 128.6 (d, *J* = 6.2 Hz), 128.0, 128.0, 127.9, 127.0, 126.7, 126.7, 115.3 (d, *J* = 14.2 Hz), 50.2 (d, *J* = 2.4 Hz), 42.6 (d, *J* = 27.1 Hz), 25.9, 17.4 (d, *J* = 3.8 Hz), 16.2 ppm; **^{19}F NMR** (282 NMz, $CDCl_3$) δ -102.9 ppm; **HRMS (ESI)** m/z Calcd for $[C_{22}H_{21}FO + H]^+$ 321.1649, found 321.1649.

8. Optimization of the Asymmetric Reaction Conditions for Product 3a

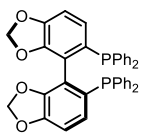
Table S8. Preliminary Asymmetric Study[a]



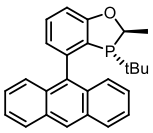
1a **2a** **3a**



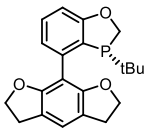
L1



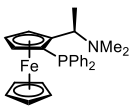
L2



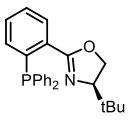
L3



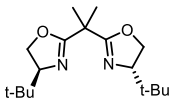
L4



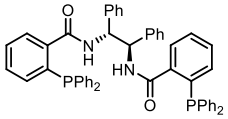
L5



L6



L7

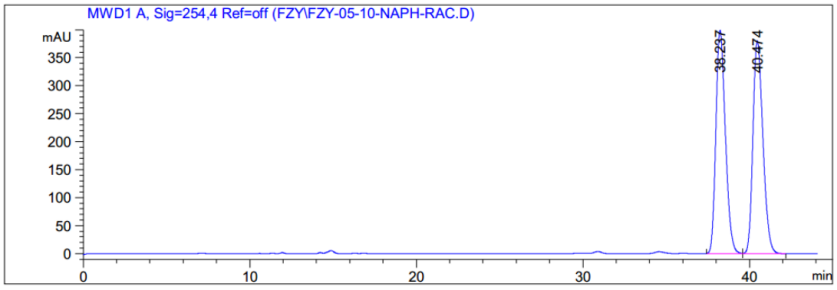


L8

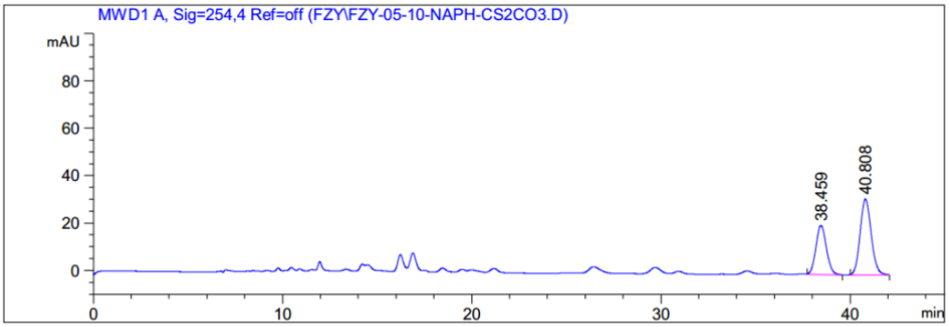
entry	catalyst	ligand	base	solvent	yield[b]	ee[c]
1	$[\eta^3\text{-}C_3H_5PdCl]_2$	**L1**	LiO^{t}Bu	THF	<5%	4%
2	$Pd_2(dba)_3.CHCl_3$	**L1**	LiO^{t}Bu	THF	<5%	0
3	$Pd(OAc)_2$	**L1**	LiO^{t}Bu	THF	5%	4%
4	$Pd(TFA)_2$	**L1**	LiO^{t}Bu	THF	9%	16%
5	**$Pd(TFA)_2$**	**L1**	**Cs_2CO_3**	**THF**	**10%**	**24%**
6	$Pd(TFA)_2$	**L1**	K_2CO_3	THF	n.d.[d]	/
7	$Pd(TFA)_2$	**L1**	CsF	THF	<5%	10%
8	$Pd(TFA)_2$	**L1**	Cs_2CO_3	CH_3CN	n.d.	/
9	$Pd(TFA)_2$	**L1**	Cs_2CO_3	mesitylene	5%	16%
10	$Pd(TFA)_2$	**L1**	Cs_2CO_3	DCE	<5%	10%
11[e]	$Pd(TFA)_2$	**L1**	Cs_2CO_3	THF	5%	16%
12	$Pd(TFA)_2$	**L2**	Cs_2CO_3	THF	trace	/
13	$Pd(TFA)_2$	**L3**	Cs_2CO_3	THF	<5%	4%
14	$Pd(TFA)_2$	**L4**	Cs_2CO_3	THF	n.d.	/
15	$Pd(TFA)_2$	**L5**	Cs_2CO_3	THF	n.d.	/
16	$Pd(TFA)_2$	**L6**	Cs_2CO_3	THF	n.d.	/
17	$Pd(TFA)_2$	**L7**	Cs_2CO_3	THF	n.d.	/
18	$Pd(TFA)_2$	**L8**	Cs_2CO_3	THF	n.d.	/

[a] Reaction conditions: **1a** (0.05 mmol), **2a** (0.075 mmol), [Pd] (10.0 mol%), **L** (20.0 mol%), base (2.0 equiv.), solvent (0.5 mL), at 80 °C under Ar atmosphere for 18 h, sealed tube. [b] Isolated yields. [c] The ee values of the products were determined by chiral-phase HPLC analysis. [d] n.d.= not detected. [e] 100 °C.

HPLC: *Daicel Chiralcel IC-3,* n-*hexane/isopropanol 98/2, flow rate = 0.5 mL/min, uv-vis λ = 254 nm,* t_{R1} *= 38.5 min (minor),* t_{R2} *= 40.8 min (major).*



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	38.237	BV	0.6157	1.58650e4	399.12805	49.9634
2	40.474	VB	0.6471	1.58883e4	380.56332	50.0366
Totals :				3.17533e4	779.69138	

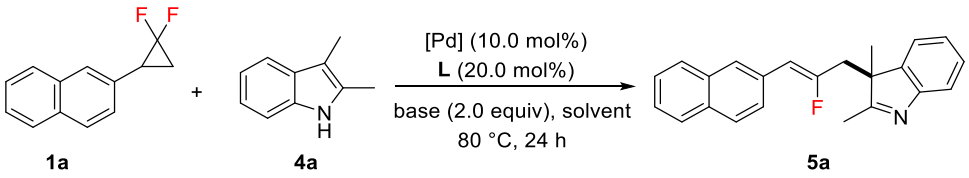


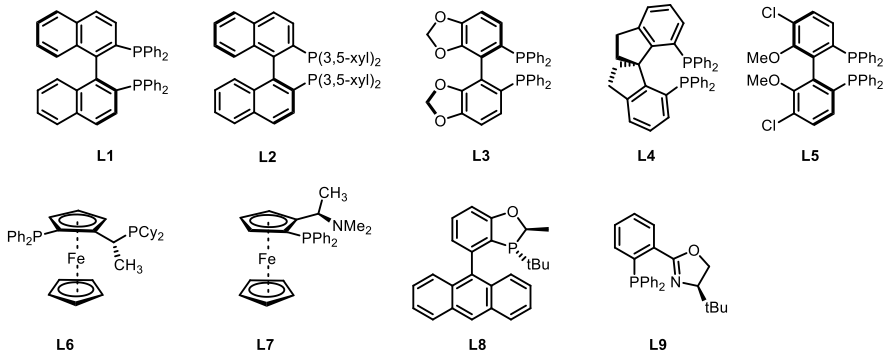
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	38.459	BB	0.6027	799.14227	20.68655	38.1369
2	40.808	BB	0.6337	1296.31445	31.92790	61.8631
Totals :				2095.45673	52.61445	

Supplementary Figure 1. HPLC Chromatographs of compound **3a**

9. Optimization of the Asymmetric Reaction Conditions for Product 5a

Table S9. Preliminary Asymmetric Study[a]

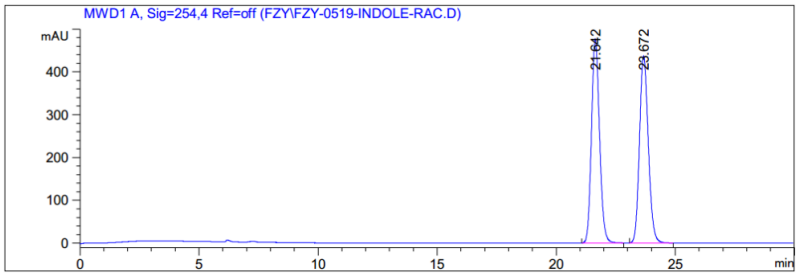




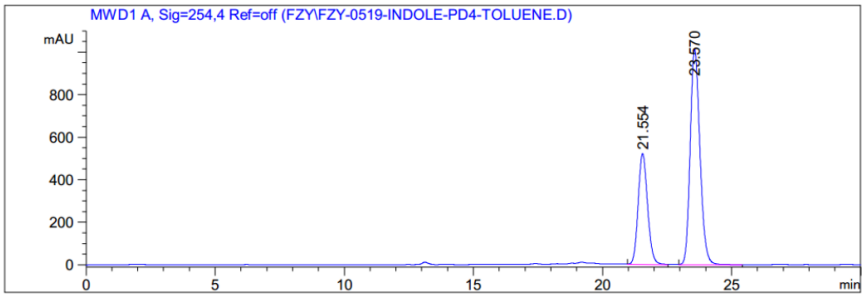
entry	catalyst	ligand	base	yield[b]	ee[c]
1	$Pd(XantPhos)Cl_2$	**L1**	LiO^tBu	21%	4%
2	$Pd(TFA)_2$	**L1**	LiO^tBu	13%	12%
3	$Pd(OAc)_2$	**L1**	LiO^tBu	14%	4%
4	**$PdCl_2$**	**L1**	**LiO^tBu**	**19%**	**34%**
5	$Pd(COD)Cl_2$	**L1**	LiO^tBu	18%	32%
6	$Pd(dba)_2$	**L1**	LiO^tBu	5%	14%
7	$PdCl_2$	**L2**	LiO^tBu	5%	-16%
8	$PdCl_2$	**L3**	LiO^tBu	7%	-28%
9	$PdCl_2$	**L4**	LiO^tBu	5%	6%
10	$PdCl_2$	**L5**	LiO^tBu	5%	16%
11	$PdCl_2$	**L6**	LiO^tBu	5%	28%
12	$PdCl_2$	**L7**	LiO^tBu	7%	-10%
13	$PdCl_2$	**L8**	LiO^tBu	6%	14%
14	$PdCl_2$	**L9**	LiO^tBu	<5%	-8%
15	$PdCl_2$	**L1**	Na_2CO_3	11%	14%
16	$PdCl_2$	**L1**	$LiOCH_3$	15%	26%
17	$PdCl_2$	**L1**	DIPEA	trace	/

[a] Reaction conditions: **1a** (0.05 mmol), **2a** (0.075 mmol), [Pd] (10.0 mol %), **L** (20.0 mol%), base (2.0 equiv.), solvent = toluene (0.5 mL), at 80 °C under Ar atmosphere for 24 h, sealed tube. [b] Isolated yields. [c] The ee values of the products were determined by chiral-phase HPLC analysis. [d] n.r. = no reaction.

HPLC: *Daicel Chiralcel AD-H,* n-*hexane/isopropanol 95/5, flow rate = 1.0 mL/min, uv-vis λ =254 nm,* t_{R1} *= 21.6 min (minor),* t_{R2} *= 23.6 min (major).*



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	21.642	BB	0.3628	1.12241e4	476.58194	49.9804
2	23.672	BB	0.3963	1.12329e4	436.36609	50.0196
Totals :				2.24570e4	912.94803	

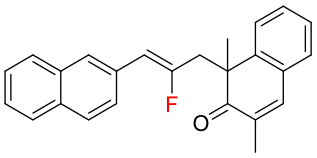


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	21.554	BV	0.4014	1.32946e4	521.49860	33.3211
2	23.570	VB	0.4023	2.66039e4	1013.18097	66.6789
Totals :				3.98986e4	1534.67957	

Supplementary Figure 2. HPLC Chromatographs of compound **5a**

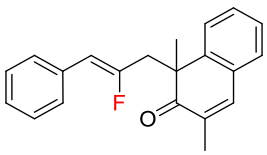
10. Characterization of the Products

(Z)-1-(2-fluoro-3-(naphthalen-2-yl)allyl)-1,3-dimethylnaphthalen-2(1H)-one (3a)



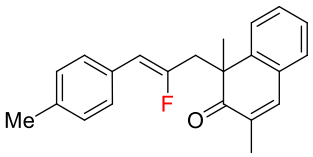
65.5 mg, 92% yield, white solid, R_f = 0.5 (PE/EA = 9:1), m.p. 100 – 101 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.71 – 7.66 (m, 2H), 7.64 (d, *J* = 9.3 Hz, 2H), 7.43 – 7.32 (m, 5H), 7.27 – 7.19 (m, 3H), 5.26 (d, *J* = 38.8 Hz, 1H), 3.27 (dd, *J* = 16.9, 14.6 Hz, 1H), 2.83 (dd, *J* = 22.8, 14.6 Hz, 1H), 2.01 (d, *J* = 1.4 Hz, 3H), 1.52 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.7, 157.8 (d, *J* = 267.8 Hz), 143.9, 141.8, 133.3, 132.3 (d, *J* = 1.7 Hz), 130.8 (d, *J* = 2.7 Hz), 130.0, 128.8 (d, *J* = 2.3 Hz), 127.9, 127.7, 127.5, 127.3, 127.2, 127.1, 126.6, 126.5, 126.1, 125.8, 108.6 (d, *J* = 8.1 Hz), 50.2 (d, *J* = 1.8 Hz), 45.6 (d, *J* = 25.0 Hz), 27.8, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -95.80 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{25}H_{21}FO + Na]^+$ 379.1469, found 379.1468.

(Z)-1-(2-fluoro-3-phenylallyl)-1,3-dimethylnaphthalen-2(1H)-one (3b)



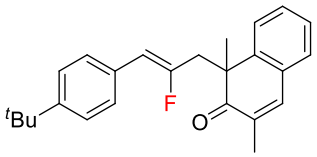
59.0 mg, 93% yield, colorless oil, R_f = 0.5 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.42 – 7.38 (m, 1H), 7.37 – 7.31 (m, 1H), 7.27 – 7.22 (m, 3H), 7.21 – 7.17 (m, 4H), 7.15 – 7.08 (m, 1H), 5.11 (d, *J* = 38.9 Hz, 1H), 3.23 (dd, *J* = 16.4, 14.7 Hz, 1H), 2.79 (dd, *J* = 22.8, 14.6 Hz, 1H), 2.00 (d, *J* = 1.3 Hz, 3H), 1.51 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.7, 157.4 (d, *J* = 267.2 Hz), 143.9, 141.8, 133.3 (d, *J* = 2.5 Hz), 132.3, 130.0, 128.8 (d, *J* = 2.8 Hz), 128.4, 128.3, 128.2, 127.1, 126.8 (d, *J* = 2.3 Hz), 126.5, 108.5 (d, *J* = 8.3 Hz), 50.1 (d, *J* = 1.7 Hz), 45.5 (d, *J* = 25.1 Hz), 27.8, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.98 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{21}H_{19}FO + Na]^+$ 329.1312, found 329.1317.

(Z)-1-(2-fluoro-3-(p-tolyl)allyl)-1,3-dimethylnaphthalen-2(1H)-one (3c)



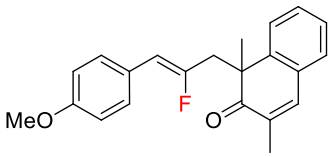
58.3 mg, 91% yield, colorless oil, R_f = 0.5 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.41 – 7.37 (m, 1H), 7.36 – 7.30 (m, 1H), 7.27 – 7.19 (m, 3H), 7.11 – 7.07 (m, 2H), 7.00 (d, *J* = 8.1 Hz, 2H), 5.07 (d, *J* = 39.1 Hz, 1H), 3.20 (dd, *J* = 16.7, 14.6 Hz, 1H), 2.77 (dd, *J* = 22.9, 14.6 Hz, 1H), 2.25 (s, 3H), 1.99 (d, *J* = 1.4 Hz, 3H), 1.50 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.7, 156.8 (d, *J* = 266.2 Hz), 144.0, 141.7, 136.6 (d, *J* = 2.5 Hz), 132.3, 130.5 (d, *J* = 2.4 Hz), 130.0, 129.0, 128.8 (d, *J* = 2.5 Hz), 128.3, 128.2, 127.0, 126.6, 108.3 (d, *J* = 8.4 Hz), 50.2 (d, *J* = 1.9 Hz), 45.6 (d, *J* = 25.3 Hz), 27.7, 21.2, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -98.90 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{22}H_{21}FO + Na]^+$ 343.1469, found 343.1472.

(Z)-1-(3-(4-(tert-butyl)phenyl)-2-fluoroallyl)-1,3-dimethylnaphthalen-2(1H)-one (3d)



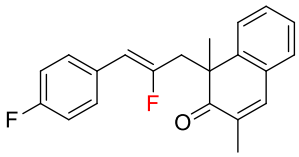
57.0 mg, 79% yield, colorless oil, R_f = 0.7 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.42 – 7.37 (m, 1H), 7.36 – 7.31 (m, 1H), 7.27 – 7.19 (m, 5H), 7.16 – 7.12 (m, 2H), 5.10 (d, *J* = 39.2 Hz, 1H), 3.23 (dd, *J* = 16.1, 14.8 Hz, 1H), 2.78 (dd, *J* = 23.2, 14.6 Hz, 1H), 2.00 (d, *J* = 1.4 Hz, 3H), 1.50 (s, 3H), 1.25 (s, 9H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.7, 157.0 (d, *J* = 266.2 Hz), 149.8 (d, *J* = 2.0 Hz), 144.0, 141.7, 132.3, 130.5 (d, *J* = 2.3 Hz), 130.0, 128.8 (d, *J* = 1.8 Hz), 128.1, 128.0, 127.0, 126.6, 125.2, 108.2 (d, *J* = 8.5 Hz), 50.1 (d, *J* = 1.9 Hz), 45.4 (d, *J* = 25.2 Hz), 34.5, 31.2, 27.9, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -98.78 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{25}H_{27}FO + Na]^+$ 385.1938, found 385.1939.

(Z)-1-(2-fluoro-3-(4-methoxyphenyl)allyl)-1,3-dimethylnaphthalen-2(1H)-one (3e)



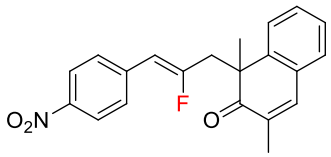
59.2 mg, 88% yield, colorless oil, R_f = 0.4 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.42 – 7.38 (m, 1H), 7.37 – 7.31 (m, 1H), 7.27 – 7.20 (m, 3H), 7.17 – 7.12 (m, 2H), 6.76 – 6.71 (m, 2H), 5.05 (d, *J* = 39.1 Hz, 1H), 3.73 (s, 3H), 3.19 (dd, *J* = 17.0, 14.6 Hz, 1H), 2.77 (dd, *J* = 22.8, 14.6 Hz, 1H), 2.00 (d, *J* = 1.4 Hz, 3H), 1.51 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.8, 158.3 (d, *J* = 2.8 Hz), 156.0 (d, *J* = 264.6 Hz), 144.0, 141.7, 132.3, 130.0, 129.6, 129.5, 128.8 (d, *J* = 2.8 Hz), 127.0, 126.5, 126.0 (d, *J* = 2.3 Hz), 113.7, 107.9 (d, *J* = 8.7 Hz), 55.2, 50.2 (d, *J* = 1.9 Hz), 45.6 (d, *J* = 25.4 Hz), 27.6, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -100.79 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{22}H_{21}FO_2 + Na]^+$ 359.1418, found 359.1411.

(Z)-1-(2-fluoro-3-(4-fluorophenyl)allyl)-1,3-dimethylnaphthalen-2(1H)-one (3f)



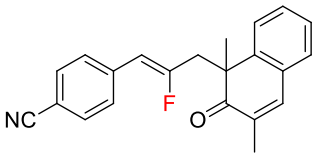
51.8 mg, 80% yield, yellow oil , R_f = 0.6 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.41 – 7.31 (m, 2H), 7.28 – 7.21 (m, 3H), 7. 18 – 7.10 (m, 2H), 6.91 – 6.83 (m, 2H), 5.07 (d, *J* = 38.5 Hz, 1H), 3.22 (dd, *J* = 16.8, 14.6 Hz, 1H), 2.78 (dd, *J* = 22.7, 14.6 Hz, 1H), 2.00 (d, *J* = 1.4 Hz, 3H), 1.50 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.6, 163.1, 163.1, 159.9, 159.8, 158.9, 158.9, 155.3, 155.3, 143.9, 141.8, 132.3, 130.0, 130.0, 129.9, 129.8, 129.4, 129.4, 129.4, 129.3, 128.8, 128.8, 127.7, 127.1, 126.5, 115.1 (d, *J* = 21.4 Hz), 107.4 (d, *J* = 8.4 Hz), 50.1 (d, *J* = 1.7 Hz), 45.3 (d, *J* = 25.1 Hz), 27.8, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -99.30 (d, *J* = 1.6 Hz), -114.70 (d, *J* = 1.5 Hz) ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{21}H_{18}F_2O + Na]^+$ 347.1218, found 347.1221.

(Z)-1-(2-fluoro-3-(4-nitrophenyl)allyl)-1,3-dimethylnaphthalen-2(1H)-one (3g)



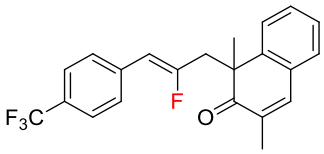
50.0 mg, 71% yield, yellow oil , R_f = 0.3 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.06 – 8.02 (m, 2H), 7.43 – 7.35 (m, 2H), 7.34 – 7.32 (m, 1H), 7.31 – 7.25 (m, 4H), 5.21 (d, *J* = 37.6 Hz, 1H), 3.33 (dd, *J* = 16.4, 14.8 Hz, 1H), 2.86 (dd, *J* = 22.5, 14.7 Hz, 1H), 2.01 (d, *J* = 1.4 Hz, 3H), 1.52 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.2, 160.7 (d, *J* = 274.0 Hz), 146.1 (d, *J* = 2.8 Hz), 143.5, 141.9, 139.8 (d, *J* = 2.6 Hz), 132.2, 129.9, 129.0 (d, *J* = 4.4 Hz), 128.8, 128.7, 127.3, 126.4, 123.6, 107.0 (d, *J* = 7.7 Hz), 50.1 (d, *J* = 1.3 Hz), 44.9 (d, *J* = 24.3 Hz), 28.3, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -91.67 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{21}H_{18}FNO_3 + Na]^+$ 374.1163, found 374.1167.

(Z)-4-(3-(1,3-dimethyl-2-oxo-1,2-dihydronaphthalen-1-yl)-2-fluoroprop-1-en-1-yl)benzonitrile (3h)



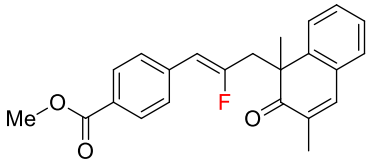
47.2 mg, 71% yield, yellow oil , R*f* = 0.3 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.46 (d, *J* = 8.3 Hz, 2H), 7.42 – 7.34 (m, 2H), 7.30 – 7.24 (m, 5H), 5.15 (d, *J* = 37.7 Hz, 1H), 3.30 (t, *J* = 15.6, 1H), 2.84 (dd, *J* = 22.5, 14.7 Hz, 1H), 2.01 (d, *J* = 1.5 Hz, 3H), 1.51 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.3, 160.2 (d, *J* = 272.8 Hz), 143.6, 141.9, 137.8 (d, *J* = 2.5 Hz), 132.2, 132.0, 129.9, 128.9 (d, *J* = 4.2 Hz), 128.7, 128.6, 127.2, 126.4, 119.0, 110.0 (d, *J* = 2.7 Hz), 107.3 (d, *J* = 7.6 Hz), 50.1 (d, *J* = 1.1 Hz), 44.9 (d, *J* = 24.4 Hz), 28.3, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -92.54 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{22}H_{18}FNO + H]^+$ 332.1445, found 332.1448.

(Z)-1-(2-fluoro-3-(4-(trifluoromethyl)phenyl)allyl)-1,3-dimethylnaphthalen-2(1H)-one (3i)



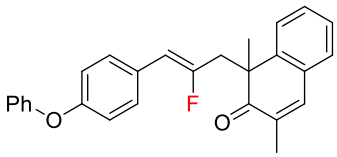
56.8 mg, 76% yield, colorless oil , R_f = 0.5 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.45 – 7.42 (m, 2H), 7.40 – 7.33 (m, 2H), 7.29 – 7.23f (m, 5H), 5.15 (d, *J* = 38.0 Hz, 1H), 3.28 (dd, *J* = 16.6, 14.6 Hz, 1H), 2.82 (dd, *J* = 22.8, 14.6 Hz, 1H), 2.01 (d, *J* = 1.4 Hz, 3H), 1.51 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.4, 159.2 (d, *J* = 270.7 Hz), 143.7, 141.8, 136.8, 136.7, 136.7, 132.3, 130.0, 128.9, 128.9, 128.8, 128.7, 128.4, 128.3, 127.2, 126.4, 125.9, 125.1 (q, *J* = 3.9 Hz), 122.3, 107.4 (d, *J* = 8.1 Hz), 50.1 (d, *J* = 1.5 Hz), 45.2 (d, *J* = 24.7 Hz), 28.0, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -62.59, -94.80 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{22}H_{18}F_4O + H]^+$ 375.1367, found 375.1365.

(Z)-methyl 4-(3-(1,3-dimethyl-2-oxo-1,2-dihydronaphthalen-1-yl)-2-fluoroprop-1-en-1-yl)benzoate (3j)



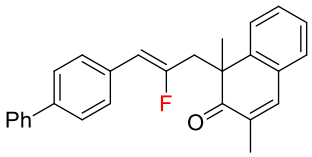
46.0 mg, 63% yield, yellow oil, R_f = 0.3 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.88 – 7.84 (m, 2H), 7.42 – 7.33 (m, 2H), 7.29 – 7.22 (m, 5H), 5.16 (d, *J* = 38.3 Hz, 1H), 3.86 (s, 3H), 3.28 (dd, *J* = 16.4, 14.8 Hz, 1H), 2.82 (dd, *J* = 22.6, 14.7 Hz, 1H), 2.00 (d, *J* = 1.4 Hz, 3H), 1.51 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.4, 166.8, 159.2 (d, *J* = 271.2 Hz), 143.7, 141.8, 137.8 (d, *J* = 2.6 Hz), 132.2, 129.9, 129.5, 128.9, 128.9, 128.1, 128.1 (d, *J* = 7.6 Hz), 127.2, 126.4, 107.9 (d, *J* = 7.9 Hz), 52.0, 50.1 (d, *J* = 1.5 Hz), 45.2 (d, *J* = 24.7 Hz), 28.0, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -94.12 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{23}H_{21}FO_3 + H]^+$ 365.1547, found 365.1554.

(Z)-1-(2-fluoro-3-(4-phenoxyphenyl)allyl)-1,3-dimethylnaphthalen-2(1H)-one (3k)



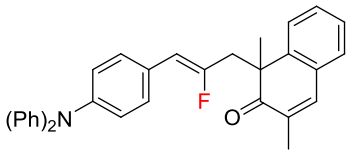
65.1 mg, 82% yield, colorless oil, R_f = 0.5 (PE/EA = 20:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.42 – 7.38 (m, 1H), 7.37 – 7.32 (m, 1H), 7.32 – 7.21 (m, 5H), 7.19 – 7.14 (m, 2H), 7.09 – 7.04 (m, 1H), 6.97 – 6.92 (m, 2H), 6.85 – 6.80 (m, 2H), 5.08 (d, *J* = 38.8 Hz, 1H), 3.22 (dd, *J* = 16.7, 14.6 Hz, 1H), 2.78 (dd, *J* = 22.8, 14.6 Hz, 1H), 2.00 (d, *J* = 1.4 Hz, 3H), 1.50 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.7, 158.6 (d, *J* = 264.3 Hz), 157.0, 156.0 (d, *J* = 2.9 Hz), 144.0, 141.7, 132.3, 130.0, 129.8, 129.8, 129.7, 128.8 (d, *J* = 3.1 Hz), 128.5 (d, *J* = 2.3 Hz), 127.1, 126.5, 123.3, 119.0, 118.5, 107.7 (d, *J* = 8.6 Hz), 50.2 (d, *J* = 1.7 Hz), 45.4 (d, *J* = 25.2 Hz), 27.8, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -99.50 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{27}H_{23}FO_2 + Na]^+$ 421.1574, found 421.1578.

(Z)-1-(3-([1,1'-biphenyl]-4-yl)-2-fluoroallyl)-1,3-dimethylnaphthalen-2(1H)-one (3l)



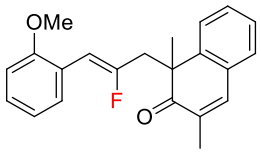
58.1 mg, 76% yield, white solid, R_f = 0.6 (PE/EA = 9:1), m.p. 90 – 91 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.54 – 7.50 (m, 2H), 7.45 – 7.34 (m, 6H), 7.33 – 7.28 (m, 2H), 7.27 – 7.22 (m, 4H), 5.15 (d, *J* = 38.9 Hz, 1H), 3.26 (dd, *J* = 16.6, 14.6 Hz, 1H), 2.81 (dd, *J* = 22.9, 14.6 Hz, 1H), 2.01 (d, *J* = 1.3 Hz, 3H), 1.52 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.7, 157.7 (d, *J* = 267.6 Hz), 143.9, 141.8, 140.7, 139.5 (d, *J* = 2.5 Hz), 132.4 (d, *J* = 2.5 Hz), 132.3, 130.0, 128.9, 128.8 (d, *J* = 1.5 Hz), 128.8, 128.7, 127.3, 127.1, 126.9, 126.5, 108.1 (d, *J* = 8.3 Hz), 50.2 (d, *J* = 1.8 Hz), 45.5 (d, *J* = 25.1 Hz), 27.9, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.37 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{27}H_{23}FO + Na]^+$ 405.1625, found 405.1630.

(Z)-1-(3-(4-(diphenylamino)phenyl)-2-fluoroallyl)-1,3-dimethylnaphthalen-2(1H)-one (3m)



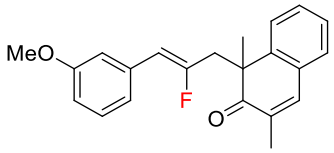
74.0 mg, 78% yield, colorless oil, R_f = 0.5 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.42 – 7.32 (m, 2H), 7.28 – 7.22 (m, 4H), 7.21 – 7.17 (m, 3H), 7.12 – 6.95 (m, 8H), 6.91 – 6.86 (m, 2H), 5.06 (d, *J* = 39.2 Hz, 1H), 3.22 (dd, *J* = 16.5, 14.6 Hz, 1H), 2.78 (dd, *J* = 22.9, 14.6 Hz, 1H), 2.01 (d, *J* = 1.4 Hz, 3H), 1.50 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.7, 156.5 (d, *J* = 265.6 Hz), 147.5, 146.4 (d, *J* = 2.7 Hz), 144.0, 141.7, 132.3, 130.0, 129.3, 129.2, 129.2, 128.8 (d, *J* = 2.8 Hz), 127.5 (d, *J* = 2.6 Hz), 127.0, 126.5, 124.4, 123.2, 122.9, 108.0 (d, *J* = 8.6 Hz), 50.2 (d, *J* = 1.5 Hz), 45.4 (d, *J* = 25.4 Hz), 27.8, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -99.52 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{33}H_{28}FNO + Na]^+$ 496.2047, found 496.2055.

(Z)-1-(2-fluoro-3-(2-methoxyphenyl)allyl)-1,3-dimethylnaphthalen-2(1H)-one (3n)



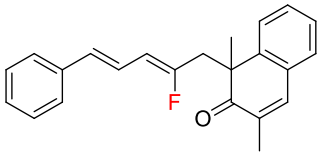
47.1 mg, 70% yield, pale yellow oil, R_f = 0.4 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.43 – 7.38 (m, 2H), 7.36 – 7.30 (m, 1H), 7.27 – 7.21 (m, 3H), 7.10 (td, *J* = 8.3, 1.7 Hz, 1H), 6.82 – 6.72 (m, 2H), 5.52 (d, *J* = 40.0 Hz, 1H), 3.70 (s, 3H), 3.24 (t, *J* = 15.0 Hz, 1H), 2.81 (dd, *J* = 23.1, 14.6 Hz, 1H), 2.01 (d, *J* = 1.3 Hz, 3H), 1.51 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.8, 157.2 (d, *J* = 266.2 Hz), 155.9, 144.0, 141.6, 132.3, 130.0, 129.8, 129.6, 128.8 (d, *J* = 8.0 Hz), 128.0, 126.9, 126.6, 122.2 (d, *J* = 2.2 Hz), 120.4, 110.4, 102.1 (d, *J* = 7.0 Hz), 55.5, 50.1, 45.8 (d, *J* = 25.6 Hz), 27.6, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -100.01 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{22}H_{21}FO_2 + Na]^+$ 359.1418, found 359.1420.

(Z)-1-(2-fluoro-3-(3-methoxyphenyl)allyl)-1,3-dimethylnaphthalen-2(1H)-one (3o)



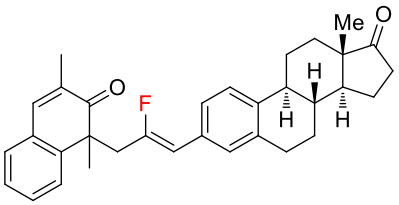
53.8 mg, 80% yield, colorless oil, R_f = 0.6 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.42 – 7.32 (m, 2H), 7.27 – 7.21 (m, 3H), 7.13 – 7.08 (m, 1H), 6.78 – 6.75 (m, 2H), 6.70 – 6.66 (m, 1H), 5.08 (d, *J* = 38.6 Hz, 1H), 3.71 (s, 3H), 3.23 (dd, *J* = 16.3, 14.7 Hz, 1H), 2.78 (dd, *J* = 23.0, 14.6 Hz, 1H), 2.00 (d, *J* = 1.4 Hz, 3H), 1.50 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.6, 159.4, 157.6 (d, *J* = 267.5 Hz), 143.9, 141.8, 134.6 (d, *J* = 2.4 Hz), 132.2, 130.0, 129.1, 128.8, 128.8, 127.1, 126.5, 121.0 (d, *J* = 6.9 Hz), 113.8 (d, *J* = 7.9 Hz), 112.5 (d, *J* = 2.1 Hz), 108.4 (d, *J* = 8.0 Hz), 55.1, 50.1 (d, *J* = 1.7 Hz), 45.4 (d, *J* = 25.2 Hz), 27.9, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.17 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{22}H_{21}FO_2 + Na]^+$ 359.1418, found 359.1420.

1-((2Z,4E)-2-fluoro-5-phenylpenta-2,4-dien-1-yl)-1,3-dimethylnaphthalen-2(1H)-one (3p)



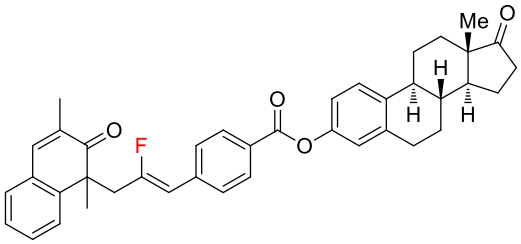
43.8 mg, 66% yield, pale yellow oil, R_f = 0.4 (PE/EA = 20:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.39 – 7.33 (m, 2H), 7.31 – 7.21 (m, 7H), 7.19 – 7.13 (m, 1H), 6.73 (dd, *J* = 15.9, 10.8 Hz, 1H), 6.25 (d, *J* = 15.9 Hz, 1H), 5.06 (dd, *J* = 34.8, 10.8 Hz, 1H), 3.18 (dd, *J* = 16.7, 14.6 Hz, 1H), 2.75 (dd, *J* = 22.7, 14.6 Hz, 1H), 2.01 (d, *J* = 1.4 Hz, 3H), 1.48 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.6, 157.7 (d, *J* = 265.6 Hz), 143.9, 141.8, 137.2, 132.2, 130.5 (d, *J* = 3.5 Hz), 129.9, 128.9, 128.8, 128.6, 127.5, 127.1, 126.5, 126.3, 120.3 (d, *J* = 5.3 Hz), 109.6 (d, *J* = 11.6 Hz), 50.1 (d, *J* = 1.1 Hz), 44.7 (d, *J* = 24.6 Hz), 27.8, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -99.86 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{23}H_{21}FO + Na]^+$ 355.1469, found 355.1464.

(8R,9S,13S,14S)-3-((Z)-3-(1,3-dimethyl-2-oxo-1,2-dihydronaphthalen-1-yl)-2-fluoroprop-1-en-1-yl)-13-methyl-7,8,9,11,12,13,15,16-octahydro-6H-cyclopenta[a]phenanthren-17(14H)-one (3t)



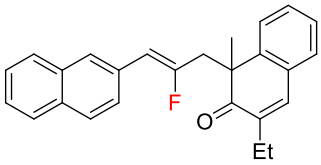
75.3 mg, 78% yield, colorless oil, R_f = 0.4 (PE/EA = 4:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.42 – 7.30 (m, 2H), 7.27 – 7.21 (m, 3H), 7.13 (d, *J* = 8.1 Hz, 1H), 7.02 – 6.96 (m, 2H), 5.08 (d, *J* = 39.2 Hz, 1H), 3.24 (dd, *J* = 16.6, 14.6 Hz, 1H), 2.85 – 2.73 (m, 3H), 2.49 (dd, *J* = 18.5, 8.4 Hz, 1H), 2.39 – 2.33 (m, 1H), 2.22 – 2.05 (m, 2H), 2.03 – 1.98 (m, 4H), 1.95 – 1.91 (m, 1H), 1.65 – 1.52 (m, 3H), 1.50 (s, 3H), 1.46 – 1.26 (m, 4H), 0.87 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 220.9, 202.7, 157.1 (d, *J* = 266.9 Hz), 143.9, 141.8, 138.5 (d, *J* = 2.0 Hz), 136.3, 132.2, 130.9 (d, *J* = 2.4 Hz), 130.0, 128.9 (d, *J* = 7.0 Hz), 128.8, 128.8, 127.0, 126.5, 125.9 (d, *J* = 7.1 Hz), 125.2, 108.1 (d, *J* = 8.4 Hz), 50.5, 50.1, 48.0, 45.3 (d, *J* = 25.0 Hz), 44.4, 38.1, 35.9, 31.6, 29.3, 27.9, 26.5, 25.6, 21.6, 16.1, 13.8 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -98.52 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{33}H_{35}FO_2 + Na]^+$ 505.2513, found 505.2518.

(8R,9S,13S,14S)-13-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-3-yl 4-((Z)-3-(1,3-dimethyl-2-oxo-1,2-dihydronaphthalen-1-yl)-2-fluoroprop-1-en-1-yl)benzoate (3u)



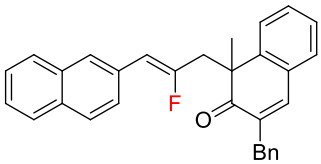
102.4 mg, 85% yield, white solid, R_f = 0.4 (PE/EA = 2:1), m.p. =113 – 114 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.02 – 7.98 (m, 2H), 7.44 – 7.34 (m, 2H), 7.32 – 7.24 (m, 6H), 6.95 – 6.89 (m, 2H), 5.20 (d, *J* = 38.2 Hz, 1H), 3.29 (dd, *J* = 16.5, 14.7 Hz, 1H), 2.94 – 2.78 (m, 3H), 2.55 – 2.38 (m, 2H), 2.34 – 2.25 (m, 1H), 2.20 – 2.09 (m, 1H), 2.05 – 1.93 (m, 6H), 1.64 – 1.40 (m, 9H), 0.91 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 220.8, 202.4, 165.1, 159.6 (d, *J* = 271.7 Hz), 148.8, 143.7, 141.8, 138.5 (d, *J* = 2.6 Hz), 138.1, 137.4, 132.3, 130.1, 130.0, 128.9, 128.9, 128.3, 128.2, 127.6 (d, *J* = 2.3 Hz), 127.2, 126.5, 121.7, 118.9, 107.8 (d, *J* = 7.7 Hz), 50.4, 50.1 (d, *J* = 1.4 Hz), 48.0, 45.3 (d, *J* = 24.5 Hz), 44.2, 38.0, 35.9, 31.6, 29.4, 28.1, 26.4, 25.8, 21.6, 16.0, 13.9 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -93.50 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{40}H_{39}FO_4 + H]^+$ 603.2905, found 603.2919.

(Z)-3-ethyl-1-(2-fluoro-3-(naphthalen-2-yl)allyl)-1-methylnaphthalen-2(1H)-one (3v)



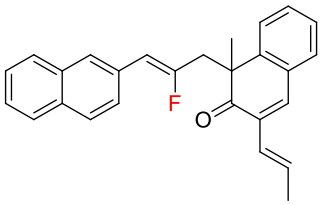
66.0 mg, 89% yield, colorless oil, R_f = 0.5 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 – 7.66 (m, 2H), 7.66 – 7.59 (m, 2H), 7.44 – 7.31 (m, 5H), 7.27 – 7.22 (m, 2H), 7.18 (t, 1H), 5.25 (d, *J* = 38.9 Hz, 1H), 3.27 (dd, *J* = 17.2, 14.6 Hz, 1H), 2.82 (dd, *J* = 22.4, 14.6 Hz, 1H), 2.54 – 2.33 (m, 2H), 1.52 (s, 3H), 1.12 (t, *J* = 7.4 Hz, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.3, 157.8 (d, *J* = 268.0 Hz), 143.8, 140.3, 137.7, 133.3, 132.3, 130.9 (d, *J* = 2.4 Hz), 130.1, 129.0, 128.9, 128.0, 127.7, 127.5, 127.2 (d, *J* = 7.4 Hz), 127.1, 126.5 (d, *J* = 7.6 Hz), 126.5, 126.1, 125.8, 108.7 (d, *J* = 8.0 Hz), 50.3, 45.6 (d, *J* = 25.2 Hz), 27.7, 22.6, 12.7 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.09 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{26}H_{23}FO + Na]^+$ 393.1625, found 393.1629.

(Z)-3-benzyl-1-(2-fluoro-3-(naphthalen-2-yl)allyl)-1-methylnaphthalen-2(1H)-one (3w)



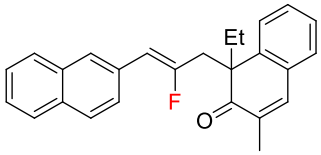
72.6 mg, 84% yield, pale yellow oil, R_f = 0.4 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.73 – 7.58 (m, 4H), 7.42 – 7.31 (m, 5H), 7.24 – 7.12 (m, 7H), 7.04 – 7.03 (m, 1H), 5.20 (d, *J* = 38.9 Hz, 1H), 3.80 – 3.68 (m, 2H), 3.25 (dd, *J* = 17.7, 14.6 Hz, 1H), 2.82 (dd, *J* = 21.8, 14.6 Hz, 1H), 1.52 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 201.9, 157.7 (d, *J* = 267.9 Hz), 144.0, 142.3, 139.2, 135.7, 133.4, 132.3 (d, *J* = 1.8 Hz), 130.8 (d, *J* = 2.6 Hz), 129.8, 129.3 (d, *J* = 10.9 Hz), 129.3, 128.5, 128.0, 127.7, 127.5, 127.3 (d, *J* = 7.5 Hz), 127.1, 126.6, 126.6, 126.5, 126.3, 126.1, 125.9, 108.7 (d, *J* = 8.0 Hz), 50.5 (d, *J* = 1.7 Hz), 45.6 (d, *J* = 25.1 Hz), 35.4, 27.7 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -96.88 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{31}H_{25}FO - H]^-$ 431.1816, found 431.1823.

1-((Z)-2-fluoro-3-(naphthalen-2-yl)allyl)-1-methyl-3-((E)-prop-1-en-1-yl)naphthalen-2(1H)-one (3x)



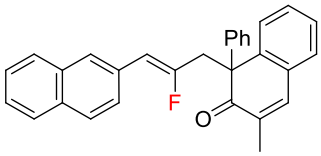
61.9 mg, 81% yield, yellow oil, R_f = 0.4 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.73 – 7.68 (m, 2H), 7.67 – 7.64 (m, 2H), 7.44 – 7.31 (m, 6H), 7.29 – 7.23 (m, 2H), 6.51 – 6.36 (m, 2H), 5.29 (d, *J* = 38.8 Hz, 1H), 3.29 (dd, *J* = 16.7, 14.6 Hz, 1H), 2.85 (dd, *J* = 22.8, 14.6 Hz, 1H), 1.89 – 1.87 (m, 3H), 1.55 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 201.6, 157.6 (d, *J* = 267.8 Hz), 143.7, 138.3, 133.3, 132.2 (d, *J* = 1.7 Hz), 131.6, 130.8 (d, *J* = 2.5 Hz), 130.1, 129.5 (d, *J* = 4.6 Hz), 129.1, 127.9, 127.7, 127.5, 127.3, 127.2, 127.2, 126.5 (d, *J* = 7.7 Hz), 126.5, 126.0, 125.8, 124.9, 108.8 (d, *J* = 8.1 Hz), 50.9 (d, *J* = 1.7 Hz), 45.3 (d, *J* = 25.2 Hz), 27.3, 19.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.14 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{27}H_{23}FO + Na]^+$ 405.1625, found 405.1631.

(Z)-1-ethyl-1-(2-fluoro-3-(naphthalen-2-yl)allyl)-3-methylnaphthalen-2(1H)-one (3y)



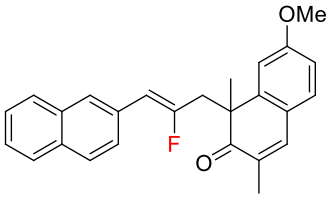
70.0 mg, 95% yield, pale yellow oil, R_f = 0.5 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.71 – 7.66 (m, 2H), 7.64 – 7.60 (m, 2H), 7.40 – 7.32 (m, 5H), 7.27 – 7.19 (m, 3H), 5.25 (d, *J* = 38.9 Hz, 1H), 3.28 (dd, *J* = 16.2, 14.4 Hz, 1H), 2.80 (dd, *J* = 23.7, 14.4 Hz, 1H), 2.34 – 2.23 (m, 1H), 1.99 (d, *J* = 1.3 Hz, 3H), 1.95 – 1.84 (m, 1H), 0.50 (t, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.9, 157.8 (d, *J* = 267.9 Hz), 142.4, 142.2, 133.5, 133.3, 132.2 (d, J = 1.8 Hz), 131.6, 130.9 (d, *J* = 2.3 Hz), 128.8, 128.7, 127.9, 127.7, 127.5, 127.2 (d, *J* = 7.5 Hz), 127.0, 126.5 (d, *J* = 7.0 Hz), 126.5, 126.0, 125.8, 108.4 (d, *J* = 8.0 Hz), 55.0, 46.0 (d, *J* = 24.8 Hz), 36.4, 15.9, 8.8 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -96.96 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{26}H_{23}FO + Na]^+$ 393.1625, found 393.1633.

(Z)-1-(2-fluoro-3-(naphthalen-2-yl)allyl)-3-methyl-1-phenylnaphthalen-2(1H)-one (3z)



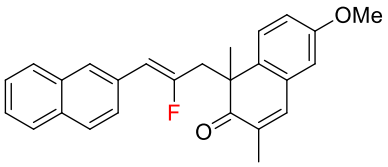
45.0 mg, 54% yield, white solid, R_f = 0.8 (PE/EA = 9:1), m.p.= 126 – 127 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.73 – 7.68 (m, 2H), 7.66 – 7.61 (m, 2H), 7.40 – 7.33 (m, 3H), 7.32 – 7.21 (m, 7H), 7.15 – 7.09 (m, 3H), 5.36 (d, *J* = 38.9 Hz, 1H), 4.13 (dd, *J* = 14.1, 13.1 Hz, 1H), 3.23 (dd, *J* = 25.0, 14.1 Hz, 1H), 1.97 (d, *J* = 1.3 Hz, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 200.4, 157.5 (d, *J* = 268.1 Hz), 143.4, 143.1, 142.0, 133.3, 132.4, 132.3 (d, *J* = 1.6 Hz), 131.0, 130.8 (d, *J* = 2.6 Hz), 129.3, 128.9, 128.7, 128.7, 127.9, 127.7, 127.5 (d, *J* = 3.5 Hz), 127.3, 127.2, 127.2, 126.5 (d, *J* = 7.4 Hz), 126.1, 125.8, 109.2 (d, *J* = 8.2 Hz), 58.0 (d, *J* = 1.7 Hz), 43.5 (d, *J* = 24.3 Hz), 16.2 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.55 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{30}H_{23}FO + Na]^+$ 441.1625, found 441.1627.

(Z)-1-(2-fluoro-3-(naphthalen-2-yl)allyl)-7-methoxy-1,3-dimethylnaphthalen-2(1H) -one (3aa)



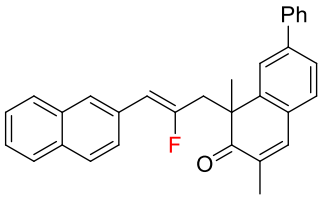
74.9 mg, 97% yield, pale yellow oil, R_f = 0.5 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.73 – 7.64 (m, 4H), 7.42 – 7.34 (m, 3H), 7.21 – 7.15 (m, 2H), 6.97 (d, *J* = 2.5 Hz, 1H), 6.78 (dd, *J* = 8.4, 2.5 Hz, 1H), 5.30 (d, *J* = 38.9 Hz, 1H), 3.81 (s, 3H), 3.27 (dd, *J* = 17.2, 14.7 Hz, 1H), 2.81 (dd, *J* = 21.8, 14.6 Hz, 1H), 1.98 (d, *J* = 1.3 Hz, 3H), 1.52 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.5, 160.4, 157.8 (d, *J* = 268.0 Hz), 146.1, 141.8, 133.3, 132.2 (d, *J* = 1.5 Hz), 130.9 (d, *J* = 2.6 Hz), 130.2, 129.7, 127.9, 127.7, 127.5, 127.2 (d, *J* = 7.4 Hz), 126.5 (d, *J* = 7.4 Hz), 126.0, 125.8, 123.4, 113.4, 111.7, 108.6 (d, *J* = 8.0 Hz), 55.4, 50.3 (d, *J* = 1.4 Hz), 45.5 (d, *J* = 25.1 Hz), 28.1, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.17 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{26}H_{23}FO_2 – H]^-$ 385.1609, found 385.1621.

(Z)-1-(2-fluoro-3-(naphthalen-2-yl)allyl)-6-methoxy-1,3-dimethylnaphthalen-2(1H)-one (3ab)



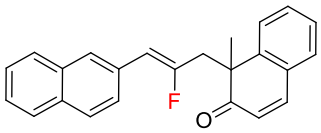
74.5 mg, 96% yield, pale yellow oil, R_f = 0.5 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 – 7.68 (m, 2H), 7.67 – 7.64 (m, 2H), 7.42 – 7.34 (m, 3H), 7.31 (d, *J* = 8.6 Hz, 1H), 7.18 (d, *J* = 1.5 Hz, 1H), 6.90 (dd, *J* = 8.6, 2.7 Hz, 1H), 6.73 (d, *J* = 2.7 Hz, 1H), 5.27 (d, *J* = 38.9 Hz, 1H), 3.78 (s, 3H), 3.24 (dd, *J* = 16.9, 14.5 Hz, 1H), 2.79 (dd, *J* = 23.1, 14.5 Hz, 1H), 2.00 (d, *J* = 1.4 Hz, 3H), 1.50 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 203.0, 157.9 (d, *J* = 267.9 Hz), 158.3, 141.7, 135.9, 133.3, 132.8, 132.2 (d, *J* = 1.7 Hz), 131.0, 130.9 (d, *J* = 2.6 Hz), 127.9, 127.7, 127.7, 127.5, 127.2 (d, *J* = 7.5 Hz), 126.5 (d, *J* = 7.4 Hz), 126.1, 125.8, 114.8, 113.3, 108.6 (d, *J* = 8.1 Hz), 55.3, 49.7 (d, *J* = 1.7 Hz), 45.7 (d, *J* = 24.9 Hz), 27.9, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.23 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{26}H_{23}FO_2 + Na]^+$ 409.1574, found 409.1581.

(Z)-1-(2-fluoro-3-(naphthalen-2-yl)allyl)-1,3-dimethyl-7-phenylnaphthalen-2(1H)-one (3ac)



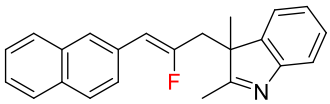
78.5 mg, 90% yield, pale yellow oil, R_f = 0.5 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.70 – 7.61 (m, 5H), 7.58 – 7.54 (m, 2H), 7.46 – 7.32 (m, 7H), 7.26 – 7.19 (m, 2H), 5.32 (d, *J* = 38.8 Hz, 1H), 3.27 (dd, *J* = 17.9, 14.6 Hz, 1H), 2.89 (dd, *J* = 22.4, 14.6 Hz, 1H), 2.02 (d, *J* = 1.4 Hz, 3H), 1.57 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 202.6, 157.9 (d, *J* = 267.9 Hz), 144.4, 141.7, 141.5, 140.7, 133.4, 132.3 (d, *J* = 1.7 Hz), 132.2, 130.8 (d, *J* = 2.7 Hz), 129.3, 129.1, 129.0, 128.0, 127.8, 127.8, 127.5, 127.4, 127.2, 126.5 (d, *J* = 7.4 Hz), 126.1, 126.0, 125.9, 125.7, 109.0 (d, *J* = 8.0 Hz), 50.5 (d, *J* = 2.0 Hz), 45.6 (d, *J* = 25.0 Hz), 27.7, 16.2 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -95.80 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{31}H_{25}FO + Na]^+$ 455.1782, found 455.1784.

(Z)-1-(2-fluoro-3-(naphthalen-2-yl)allyl)-1-methylnaphthalen-2(1H)-one (3ad)



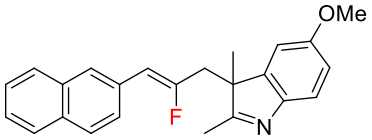
45.8 mg, 67% yield, yellow oil, R_f = 0.4 (PE/EA = 9:1), **^{1}H NMR** (300 MHz, $CDCl_3$)) δ 7.73 – 7.67 (m, 3H), 7.66 – 7.63 (m, 3H), 7.47 – 7.35 (m, 6H), 7.32 – 7.23 (m, 2H), 6.22 (d, *J* = 9.8 Hz, 1H), 5.30 (d, *J* = 39.0 Hz, 1H), 3.32 (dd, *J* = 16.6, 14.8 Hz, 1H), 2.86 (dd, *J* = 22.6, 14.7 Hz, 1H), 1.53 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$)) δ 202.6, 157.6 (d, *J* = 267.7 Hz), 145.4, 144.6, 133.3, 132.3 (d, *J* = 1.7 Hz), 130.8 (d, *J* = 2.7 Hz), 129.9 (d, *J* = 17.1 Hz), 129.5, 128.0, 127.7, 127.5, 127.3, 127.2, 127.2, 126.9, 126.5 (d, *J* = 7.5 Hz), 126.1, 125.8, 124.9, 108.8 (d, *J* = 8.0 Hz), 50.5 (d, *J* = 1.7 Hz), 45.0 (d, *J* = 25.1 Hz), 28.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$)) δ -97.32 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{24}H_{19}FO + Na]^+$ 365.1312, found 365.1315.

(Z)-3-(2-fluoro-3-(naphthalen-2-yl)allyl)-2,3-dimethyl-3H-indole (5a)



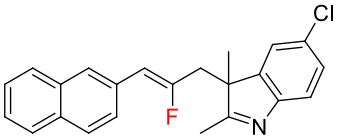
52.7 mg, 80% yield, yellow solid, R_f = 0.4 (PE/EA = 2:1), m.p. 117 – 118 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 – 7.69 (m, 4H), 7.55 – 7.52 (m, 1H), 7.47 – 7.38 (m, 3H), 7.34 – 7.28 (m, 2H), 7.21 – 7.16 (m, 1H), 5.36 (d, *J* = 38.7 Hz, 1H), 2.87 (dd, *J* = 22.5, 14.7 Hz, 1H), 2.63 (dd, *J* = 20.4, 14.7 Hz, 1H), 2.37 (s, 3H), 1.41 (d, *J* = 1.0 Hz, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 185.8, 157.1 (d, *J* = 267.3 Hz), 154.2, 142.7, 133.3, 132.4 (d, *J* = 1.6 Hz), 130.5 (d, *J* = 2.8 Hz), 128.1, 128.0, 127.9, 127.5, 127.4 (d, *J* = 7.5 Hz), 126.5 (d, *J* = 7.5 Hz), 126.2, 126.0, 125.2, 122.3 (d, *J* = 1.0 Hz), 120.2, 109.3 (d, *J* = 8.3 Hz), 56.6 (d, *J* = 2.7 Hz), 40.3 (d, *J* = 26.2 Hz), 22.0, 16.0 (d, *J* = 1.7 Hz) ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.13 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{23}H_{20}FN + H]^+$ 330.1653, found 330.1655.

(Z)-3-(2-fluoro-3-(naphthalen-2-yl)allyl)-5-methoxy-2,3-dimethyl-3H-indole (5b)



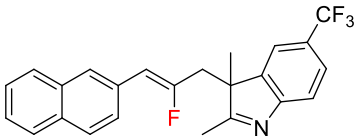
45.3 mg, 63% yield, yellow oil , R_f = 0.4 (PE/EA = 2:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 – 7.70 (m, 4H), 7.47 (dd, *J* = 8.6, 1.7 Hz, 1H), 7.45 – 7.40 (m, 3H), 6.89 (d, *J* = 2.5 Hz, 1H), 6.82 (dd, *J* = 8.4, 2.5 Hz, 1H), 5.38 (d, *J* = 38.7 Hz, 1H), 3.75 (s, 3H), 2.84 (dd, *J* = 22.0, 14.7 Hz, 1H), 2.61 (dd, *J* = 20.6, 14.7 Hz, 1H), 2.33 (s, 3H), 1.40 (d, *J* = 1.0 Hz, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 183.6, 157.9, 157.1 (d, J = 267.4 Hz), 147.9, 144.3, 133.3, 132.4 (d, *J* = 1.4 Hz), 130.5 (d, *J* = 2.8 Hz), 128.0, 127.9, 127.5, 127.4 (d, *J* = 7.5 Hz), 126.5 (d, *J* = 7.5 Hz), 126.2, 126.0, 120.4, 112.7, 109.3 (d, *J* = 8.2 Hz), 109.0 (d, *J* = 1.0 Hz), 56.7 (d, *J* = 2.7 Hz), 55.7, 40.3 (d, *J* = 26.2 Hz), 22.2, 15.9 (d, *J* = 1.6 Hz) ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -96.99 ppm; **HRMS (ESI)** *m*/*z* Calcd for $[C_{24}H_{22}FNO + H]^+$ 360.1758, found 360.1763.

(Z)-5-chloro-3-(2-fluoro-3-(naphthalen-2-yl)allyl)-2,3-dimethyl-3H-indole (5c)



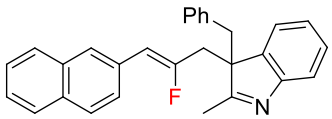
41.4 mg, 57% yield, yellow solid , R_f = 0.3 (PE/EA = 2:1), m.p. 120 – 121 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 – 7.70 (m, 4H), 7.47 – 7.40 (m, 4H), 7.31 – 7.25 (m, 2H), 5.39 (d, *J* = 38.6 Hz, 1H), 2.84 (dd, *J* = 23.2, 14.8 Hz, 1H), 2.67 (dd, *J* = 19.3, 14.7 Hz, 1H), 2.36 (s, 3H), 1.39 (d, *J* = 0.8 Hz, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 186.3, 156.5 (d, *J* = 267.0 Hz), 152.8, 144.5, 133.3, 132.4 (d, *J* = 1.9 Hz), 131.0, 130.3 (d, *J* = 2.7 Hz), 128.3, 128.0, 128.0, 127.6, 127.5 (d, *J* = 7.7 Hz), 126.4 (d, *J* = 7.4 Hz), 126.2, 126.1, 122.8, 121.0, 109.6 (d, *J* = 8.3 Hz), 57.1 (d, *J* = 2.3 Hz), 40.2 (d, *J* = 25.9 Hz), 22.0, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.79 ppm; **HRMS (ESI)** *m*/*z* Calcd for $[C_{23}H_{19}ClFN + H]^+$ 364.1263, found 364.1270.

(Z)-3-(2-fluoro-3-(naphthalen-2-yl)allyl)-2,3-dimethyl-5-(trifluoromethyl)-3H-indole (5d)



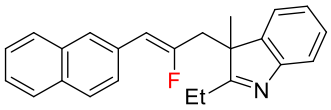
40.5 mg, 51% yield, yellow oil, R_f = 0.3 (PE/EA = 2:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.77 – 7.70 (m, 4H), 7.60 – 7.58 (m, 3H), 7.45 – 7.39 (m, 3H), 5.38 (d, *J* = 38.5 Hz, 1H), 2.90 (dd, *J* = 23.4, 14.7 Hz, 1H), 2.70 (dd, *J* = 19.4, 14.7 Hz, 1H), 2.42 (s, 3H), 1.44 (d, *J* = 0.8 Hz, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 189.0, 157.0, 156.4 (d, *J* = 267.0 Hz), 143.3, 133.3, 132.5, 130.1 (d, *J* = 2.5 Hz), 128.0, 128.0, 127.6, 127.5, 127.5, 127.1, 126.7, 126.4, 126.3, 126.2, 126.1, 125.9 (q, *J* = 3.9 Hz), 122.8, 120.3, 119.4, 119.3, 109.8 (d, *J* = 8.4 Hz), 57.1 (d, *J* = 2.3 Hz), 40.3 (d, *J* = 26.3 Hz), 21.8, 16.3 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -61.31, -98.04 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{24}H_{19}F_4N + H]^+$ 398.1526, found 398.1536.

(Z)-3-benzyl-3-(2-fluoro-3-(naphthalen-2-yl)allyl)-2-methyl-3H-indole (5e)



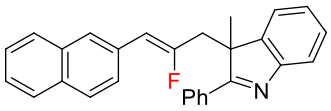
57.5 mg, 71% yield, yellow solid, R_f = 0.7 (PE/EA = 2:1), m.p. 99 – 100 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 – 7.66 (m, 4H), 7.44 – 7.36 (m, 4H), 7.28 – 7.23 (m, 4H), 7.19 – 7.16 (m, 2H), 7.12 – 7.04 (m, 3H), 6.79 – 6.75 (m, 2H), 5.31 (d, *J* = 38.8 Hz, 1H), 3.34 (d, *J* = 13.5 Hz, 1H), 3.08 – 2.81 (m, 3H), 2.44 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 183.9, 156.6 (d, *J* = 267.1 Hz), 154.9, 140.0, 135.3, 133.3, 132.4 (d, *J* = 1.7 Hz), 130.4 (d, *J* = 2.7 Hz), 129.5, 128.3, 128.0, 127.9, 127.8, 127.5, 127.4 (d, *J* = 7.5 Hz), 127.0, 126.5 (d, *J* = 7.3 Hz), 126.1, 126.0, 124.8, 123.3, 120.1, 109.4 (d, *J* = 8.4 Hz), 61.8 (d, *J* = 2.8 Hz), 42.1, 39.6 (d, *J* = 26.0 Hz), 17.0 (d, *J* = 2.1 Hz) ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.19 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{29}H_{24}FN + H]^+$ 406.1966, found 406.1970.

(Z)-2-ethyl-3-(2-fluoro-3-(naphthalen-2-yl)allyl)-3-methyl-3H-indole (5f)



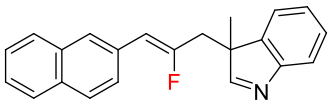
43.2 mg, 63% yield, yellow oil, R_f = 0.6 (PE/EA = 2:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 – 7.69 (m, 4H), 7.61 – 7.58 (m, 1H), 7.47 – 7.40 (m, 3H), 7.34 – 7.28 (m, 2H), 7.19 (td, *J* = 7.3, 1.1 Hz, 1H), 5.34 (d, *J* = 38.7 Hz, 1H), 2.89 (dd, *J* = 22.2, 14.7 Hz, 1H), 2.76 – 2.56 (m, 3H), 1.43 (t, 3H), 1.42 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 189.9, 157.1 (d, *J* = 267.4 Hz), 154.1, 142.7, 133.3, 132.4 (d, *J* = 1.7 Hz), 130.5 (d, *J* = 2.7 Hz), 128.1, 128.0, 127.9, 127.5, 127.4 (d, *J* = 7.4 Hz), 126.5 (d, *J* = 7.5 Hz), 126.2, 126.0, 125.1, 122.2 (d, *J* = 1.0 Hz), 120.3, 109.3 (d, *J* = 8.3 Hz), 56.7 (d, *J* = 2.8 Hz), 40.4 (d, *J* = 25.9 Hz), 22.5 (d, *J* = 1.2 Hz), 22.2 (d, *J* = 1.1 Hz), 10.5 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.12 ppm; **HRMS (ESI)** *m*/*z* Calcd for $[C_{23}H_{22}FN + H]^+$ 344.1809, found 344.1816.

(Z)-3-(2-fluoro-3-(naphthalen-2-yl)allyl)-3-methyl-2-phenyl-3H-indole (5g)



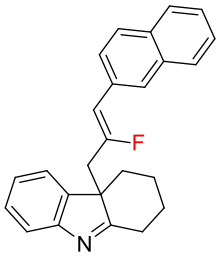
55.5 mg, 71% yield, yellow oil, R_f = 0.7 (PE/EA = 2:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.18 – 8.14 (m, 2H), 7.73 – 7.64 (m, 5H), 7.53 – 7.48 (m, 3H), 7.42 – 7.34 (m, 5H), 7.26 (td, *J* = 7.4, 1.1 Hz, 1H), 5.23 (d, *J* = 38.6 Hz, 1H), 3.17 (dd, *J* = 20.2, 14.8 Hz, 1H), 2.91 (dd, *J* = 22.4, 14.8 Hz, 1H), 1.74 (d, *J* = 1.0 Hz, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 181.5, 157.1 (d, *J* = 268.0 Hz), 153.6, 144.4, 133.5, 133.3, 132.4, 130.7, 130.6 (d, *J* = 2.7 Hz), 128.8, 128.4, 128.3, 128.0, 127.8, 127.5, 127.4, 127.3, 126.5 (d, *J* = 7.5 Hz), 126.1, 125.9 (d, *J* = 2.7 Hz), 122.1, 121.2, 109.4 (d, *J* = 8.0 Hz), 56.7 (d, *J* = 2.8 Hz), 41.6 (d, *J* = 25.7 Hz), 23.6 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -96.49 ppm; **HRMS (ESI)** *m*/*z* Calcd for $[C_{28}H_{22}FN + H]^+$ 392.1809, found 392.1810.

(Z)-3-(2-fluoro-3-(naphthalen-2-yl)allyl)-3-methyl-3H-indole (5h)



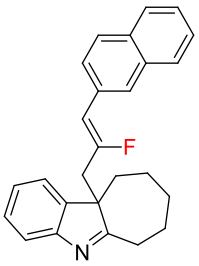
31.5 mg, 50% yield, yellow oil, R_f = 0.4 (PE/EA = 6:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.22 (d, *J* = 2.5 Hz, 1H), 7.87 – 7.86 (m, 1H), 7.81 – 7.77 (m, 3H), 7.68 – 7.58 (m, 2H), 7.49 – 7.41 (m, 2H), 7.40 – 7.34 (m, 2H), 7.31 – 7.29 (m, 1H), 5.65 (d, *J* = 38.5 Hz, 1H), 2.83 – 2.59 (m, 2H), 1.47 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 178.1, 157.3 (d, *J* = 268.0 Hz), 154.4, 142.8, 133.4, 132.5, 130.5 (d, *J* = 2.4 Hz), 128.3, 128.1, 127.6, 127.5, 126.5, 126.4, 126.3, 126.1, 121.8, 121.5, 109.8 (d, *J* = 8.4 Hz), 56.1 (d, *J* = 3.6 Hz), 39.9 (d, *J* = 26.9 Hz), 19.4 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -96.88 ppm; **HRMS (ESI)** *m*/*z* Calcd for $[C_{22}H_{18}FN + H]+$ 316.1496, found 316.1495.

(Z)-4a-(2-fluoro-3-(naphthalen-2-yl)allyl)-2,3,4,4a-tetrahydro-1H-carbazole (5i)



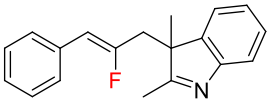
44.0 mg, 62% yield, yellow solid, R_f = 0.4 (PE/EA = 2:1), m.p. 152 – 153 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.68 (m, 4H), 7.61 – 7.58 (m, 1H), 7.46 – 7.39 (m, 3H), 7.37 – 7.29 (m, 2H), 7.18 (td, *J* = 7.4, 1.1 Hz, 1H), 5.33 (d, *J* = 38.8 Hz, 1H), 3.03 – 2.90 (m, 2H), 2.75 – 2.61 (m, 2H), 2.56 – 2.48 (m, 1H), 2.26 – 2.20 (m, 1H), 1.94 – 1.70 (m, 2H), 1.55 – 1.39 (m, 1H), 1.26 – 1.14 (m, 1H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 187.9, 157.3 (d, *J* = 267.5 Hz), 154.9, 143.7, 133.3, 132.4 (d, *J* = 1.6 Hz), 130.6 (d, *J* = 2.8 Hz), 128.0, 128.0, 127.9, 127.5, 127.4 (d, *J* = 7.5 Hz), 126.5 (d, *J* = 7.5 Hz), 126.2, 125.9, 124.8, 122.4 (d, *J* = 1.8 Hz), 120.5, 109.3 (d, *J* = 8.3 Hz), 56.8 (d, *J* = 3.0 Hz), 37.2, 36.9 (d, *J* = 26.0 Hz), 30.2, 29.0, 21.3 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.19 ppm; **HRMS (ESI)** *m*/*z* Calcd for $[C_{25}H_{22}FN + H]^+$ 356.1809, found 356.1816.

(Z)-10a-(2-fluoro-3-(naphthalen-2-yl)allyl)-6,7,8,9,10,10a-hexahydrocyclohepta[b]indole (5j)



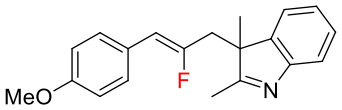
46.5 mg, 65% yield, yellow oil, R_f = 0.5 (PE/EA = 2:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.77 – 7.70 (m, 4H), 7.52 – 7.49 (m, 1H), 7.47 – 7.38 (m, 3H), 7.32 – 7.25 (m, 2H), 7.20 – 7.15 (m, 1H), 5.32 (d, *J* = 38.5 Hz, 1H), 3.07 – 2.99 (m, 1H), 2.87 (dd, *J* = 22.3, 14.4 Hz, 1H), 2.74 – 2.58 (m, 2H), 2.20 (dd, *J* = 14.2, 8.5 Hz, 1H), 2.13 – 2.02 (m, 1H), 1.99 – 1.91 (m, 1H), 1.83 – 1.73 (m, 1H), 1.70 – 1.56 (m, 2H), 1.54 – 1.41 (m, 1H), 0.77 – 0.64 (m, 1H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 190.1, 157.1 (d, *J* = 267.5 Hz), 154.8, 142.7, 133.3, 132.4 (d, *J* = 1.7 Hz), 130.6 (d, *J* = 2.6 Hz), 128.1, 128.0, 127.9, 127.5, 127.4 (d, *J* = 7.5 Hz), 126.5 (d, *J* = 7.4 Hz), 126.1, 125.9, 125.1, 122.3, 120.0, 109.5 (d, *J* = 8.4 Hz), 61.2 (d, *J* = 3.3 Hz), 40.9 (d, *J* = 26.0 Hz), 34.6, 31.6, 30.5, 28.9, 24.6 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -96.25 ppm; **HRMS (ESI)** *m/z* Calcd for $[C_{26}H_{24}FN + H]^+$ 370.1966, found 370.1977.

(Z)-3-(2-fluoro-3-phenylallyl)-2,3-dimethyl-3H-indole (5k)



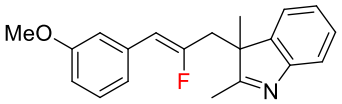
28.0 mg, 50% yield, yellow oil, R_f = 0.6 (PE/EA = 2:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.53 (d, *J* = 8.3 Hz, 1H), 7.33 – 7.22 (m, 6H), 7.17 (td, *J* = 7.1, 3.9 Hz, 2H), 5.21 (d, *J* = 38.6 Hz, 1H), 2.82 (dd, *J* = 22.4, 14.7 Hz, 1H), 2.58 (dd, *J* = 20.4, 14.7 Hz, 1H), 2.35 (s, 3H), 1.39 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 185.9, 156.8 (d, *J* = 266.9 Hz), 154.2, 142.7, 133.1 (d, *J* = 2.4 Hz), 128.6, 128.5, 128.2, 127.2 (d, *J* = 2.3 Hz), 125.2, 122.3, 120.2, 109.3 (d, *J* = 8.4 Hz), 56.7 (d, *J* = 2.4 Hz), 40.2 (d, *J* = 26.1 Hz), 22.1, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.60 ppm; **HRMS** (**ESI**) m/z Calcd for $[C_{19}H_{18}FN + H]^+$ 280.1496, found 280.1500.

(Z)-3-(2-fluoro-3-(4-methoxyphenyl)allyl)-2,3-dimethyl-3H-indole (5l)



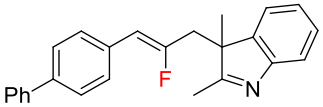
42.0 mg, 68% yield, yellow oil, R_f = 0.5 (PE/EA = 2:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.53 (d, *J* = 7.8 Hz, 1H), 7.33 – 7.24 (m, 4H), 7.18 (t, *J* = 7.4 Hz, 1H), 6.79 (d, *J* = 8.3 Hz, 2H), 5.17 (d, *J* = 39.0 Hz, 1H), 3.77 (s, 3H), 2.81 (dd, *J* = 22.5, 14.7 Hz, 1H), 2.56 (dd, *J* = 20.7, 14.7 Hz, 1H), 2.35 (s, 3H), 1.39 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 186.1, 158.6 (d, *J* = 2.6 Hz), 155.5 (d, *J* = 264.1 Hz), 154.1, 142.8, 129.8 (d, *J* = 7.4 Hz), 128.1, 125.8 (d, *J* = 2.2 Hz), 125.2, 122.4, 120.2, 113.8, 108.7 (d, *J* = 8.8 Hz), 56.7 (d, *J* = 3.4 Hz), 55.3, 40.2 (d, *J* = 26.3 Hz), 22.1, 16.1 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -100.42 ppm; **HRMS** (**ESI**) m/z Calcd for $[C_{20}H_{20}FNO + H]^+$ 310.1602, found 310.1607.

(Z)-3-(2-fluoro-3-(3-methoxyphenyl)allyl)-2,3-dimethyl-3H-indole (5m)



39.5 mg, 65% yield, yellow oil, R_f = 0.5 (PE/EA = 2:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.53 (d, *J* = 7.9 Hz, 1H), 7.33 – 7.25 (m, 2H), 7.21 – 7.14 (m, 2H), 6.88 – 6.86 (m, 2H), 6.74 (d, *J* = 8.4 Hz, 1H), 5.19 (d, *J* = 38.4 Hz, 1H), 3.75 (s, 3H), 2.82 (dd, *J* = 22.5, 14.6 Hz, 1H), 2.58 (dd, *J* = 20.4, 14.6 Hz, 1H), 2.35 (s, 3H), 1.39 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 185.8, 159.5, 156.9 (d, *J* = 267.5 Hz), 154.1, 142.6, 134.3 (d, *J* = 2.3 Hz), 129.3, 128.1, 125.2, 122.3, 121.1 (d, *J* = 7.0 Hz), 120.1, 113.9 (d, *J* = 8.1 Hz), 112.8, 109.2 (d, *J* = 7.8 Hz), 56.6 (d, *J* = 2.5 Hz), 55.2, 40.1 (d, *J* = 26.1 Hz), 22.0, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -96.79 ppm; **HRMS** (**ESI**) m/z Calcd for $[C_{20}H_{20}FNO + H]^+$ 310.1602, found 310.1607.

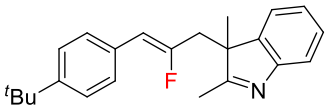
(Z)-3-(3-([1,1'-biphenyl]-4-yl)-2-fluoroallyl)-2,3-dimethyl-3H-indole (5n)



50.0 mg, 70% yield, yellow solid, R_f = 0.5 (PE/EA = 2:1), m.p. 118 – 119 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.57 – 7.53 (m, 3H), 7.49 (d, *J* = 8.0 Hz, 2H), 7.43 – 7.36 (m, 4H), 7.34 – 7.28 (m, 3H), 7.23 – 7.16 (m, 1H), 5.25 (d, *J* = 38.7 Hz, 1H), 2.84 (dd, *J* = 22.5, 14.6 Hz, 1H), 2.60 (dd, *J* = 20.4, 14.7 Hz, 1H), 2.36 (s, 3H), 1.40 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 185.8, 157.0 (d, *J* = 267.4 Hz), 154.2, 142.7,

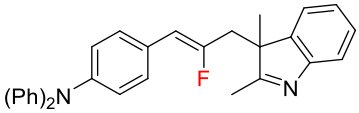
140.7, 139.9 (d, *J* = 1.9 Hz), 132.1 (d, *J* = 2.5 Hz), 128.9, 128.8, 128.1, 127.4, 127.1, 127.0, 125.2, 122.3, 120.2, 108.9 (d, *J* = 8.4 Hz), 56.6, 40.2 (d, *J* = 26.0 Hz), 22.0, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.00 ppm; **HRMS** (**ESI**) m/z Calcd for $[C_{25}H_{22}FN + H]^+$ 356.1809, found 356.1814.

(Z)-3-(3-(4-(tert-butyl)phenyl)-2-fluoroallyl)-2,3-dimethyl-3H-indole (5o)



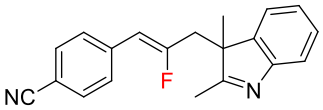
43.2 mg, 64% yield, yellow oil, R_f = 0.4 (PE/EA = 4:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.53 (d, *J* = 7.7 Hz, 1H), 7.32 – 7.24 (m, 6H), 7.17 (t, *J* = 7.4 Hz, 1H), 5.21 (d, *J* = 39.0 Hz, 1H), 2.81 (dd, *J* = 22.6, 14.6 Hz, 1H), 2.57 (dd, *J* = 20.4, 14.6 Hz, 1H), 2.34 (s, 3H), 1.39 (s, 3H), 1.28 (s, 9H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 185.9, 156.3 (d, *J* = 265.8 Hz), 154.1, 150.2 (d, *J* = 1.9 Hz), 142.7, 130.2 (d, *J* = 2.1 Hz), 128.2 (d, *J* = 7.1 Hz), 128.0, 125.3, 125.1, 122.3, 120.1, 109.0 (d, *J* = 8.6 Hz), 56.6 (d, *J* = 2.2 Hz), 40.1 (d, *J* = 26.3 Hz), 34.6, 31.3, 22.0, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -98.36 ppm; **HRMS** (**ESI**) m/z Calcd for $[C_{23}H_{26}FN + H]^+$ 336.2122, found 336.2124.

(Z)-4-(3-(2,3-dimethyl-3H-indol-3-yl)-2-fluoroprop-1-en-1-yl)-N,N-diphenylaniline (5p)



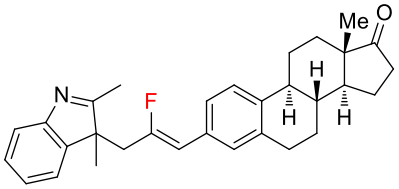
73.6 mg, 82% yield, yellow oil, R_f = 0.5 (PE/EA = 2:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.54 (d, *J* = 7.2 Hz, 1H), 7.30 (td, *J* = 6.7, 6.0, 1.6 Hz, 2H), 7.22 – 7.15 (m, 6H), 7.07 – 7.04 (m, 4H), 7.02 – 6.92 (m, 4H), 5.16 (d, *J* = 39.1 Hz, 1H), 2.82 (dd, *J* = 22.4, 14.7 Hz, 1H), 2.58 (dd, *J* = 20.6, 14.7 Hz, 1H), 2.35 (s, 3H), 1.39 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 185.9, 155.8 (d, *J* = 265.8 Hz), 154.0, 147.5, 146.7 (d, *J* = 2.1 Hz), 142.8, 129.4, 129.3, 128.1, 127.1 (d, *J* = 2.0 Hz), 125.2, 124.5, 123.3, 123.0, 122.3, 120.1, 108.8 (d, *J* = 8.3 Hz), 56.7 (d, *J* = 2.6 Hz), 40.1 (d, *J* = 26.1 Hz), 22.0, 16.0 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -99.09 ppm; **HRMS** (**ESI**) m/z Calcd for $[C_{31}H_{27}FN_2 + Na]^+$ 469.2050, found 469.2049.

(Z)-4-(3-(2,3-dimethyl-3H-indol-3-yl)-2-fluoroprop-1-en-1-yl)benzonitrile (5q)



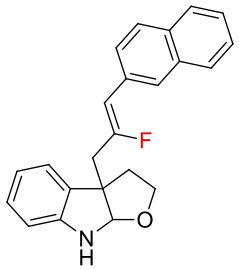
31.5 mg, 52% yield, yellow oil, R_f = 0.4 (PE/EA = 2:1), **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.57 – 7.52 (m, 3H), 7.38 – 7.31 (m, 4H), 7.23 (td, *J* = 7.3, 1.1 Hz, 1H), 5.22 (d, *J* = 37.6 Hz, 1H), 2.92 (dd, *J* = 23.1, 14.8 Hz, 1H), 2.72 (dd, *J* = 19.5, 14.7 Hz, 1H), 2.39 (s, 3H), 1.44 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 185.4, 159.3 (d, *J* = 272.0 Hz), 154.1, 142.2, 137.5 (d, *J* = 2.7 Hz), 132.1, 128.8 (d, *J* = 7.9 Hz), 128.3, 125.3, 122.0, 120.2, 118.9, 110.3 (d, *J* = 2.6 Hz), 107.8 (d, *J* = 7.9 Hz), 56.6, 40.2 (d, *J* = 25.5 Hz), 22.2, 15.9 ppm; ^{19}F NMR (282 MHz, $CDCl_3$) δ -92.44 ppm; **HRMS** (**ESI**) m/z Calcd for $[C_{20}H_{17}FN_2 + H]^+$ 305.1449, found 305.1454.

(8R,9S,13S,14S)-3-((Z)-3-(2,3-dimethyl-3H-indol-3-yl)-2-fluoroprop-1-en-1-yl)-13-methyl-7,8,9,11,12,13,15,16-octahydro-6H-cyclopenta[a]phenanthren-17(14H)-one (5r)



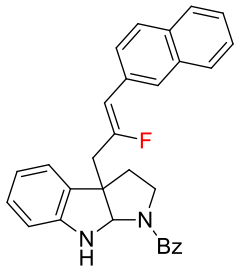
66.1 mg, 73% yield, yellow solid, R_f = 0.4 (PE/EA = 2:1), m.p. 156 – 158 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.52 (d, J = 7.4 Hz, 1H), 7.31 – 7.26 (m, 2H), 7.19 – 7.24 (m, 2H), 7.11 – 7.06 (m, 2H), 5.17 (d, J = 39.0 Hz, 1H), 2.87 – 2.75 (m, 3H), 2.64 – 2.44 (m, 2H), 2.34 (s, 3H), 2.26 – 1.91 (m, 6H), 1.64 – 1.42 (m, 6H), 1.38 (s, 3H), 0.87 (s, 3H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 220.9, 185.9, 156.5 (d, *J* = 265.8 Hz), 154.1, 142.7, 138.9, 136.5, 130.6 (d, *J* = 2.2 Hz), 129.0 (d, *J* = 7.0 Hz), 128.0, 126.0 (d, *J* = 7.0 Hz), 125.4, 125.1, 122.3, 120.1, 108.9 (d, *J* = 8.5 Hz), 56.6, 50.4, 48.0, 44.4, 40.1 (d, *J* = 25.9 Hz), 38.1, 35.9, 31.6, 29.4, 26.5, 25.7, 22.1, 21.6, 16.0, 13.8 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -98.15 ppm; **HRMS** (**ESI**) m/z Calcd for $[C_{31}H_{34}FNO + H]^+$ 456.2697, found 456.2688.

(Z)-3a-(2-fluoro-3-(naphthalen-2-yl)allyl)-3,3a,8,8a-tetrahydro-2H-furo[2,3-b]indole (6a)



55.2 mg, 80% yield, white solid, R_f = 0.5 (PE/EA = 9:1), m.p. 141 – 142 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.85 (d, *J* = 1.7 Hz, 1H), 7.81 – 7.75 (m, 3H), 7.58 (dd, *J* = 8.6, 1.7 Hz, 1H), 7.48 – 7.40 (m, 2H), 7.12 – 7.04 (m, 2H), 6.73 (td, *J* = 7.5, 1.0 Hz, 1H), 6.62 – 6.59 (m, 1H), 5.65 – 5.47 (m, 2H), 4.59 (s, 1H), 4.04 – 3.98 (m, 1H), 3.61 – 3.53 (m, 1H), 2.93 – 2.68 (m, 2H), 2.43 – 2.33 (m, 1H), 2.30 – 2.23 (m, 1H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 158.2 (d, *J* = 267.2 Hz), 149.4, 133.4, 132.4 (d, *J* = 1.7 Hz), 131.0, 130.8 (d, *J* = 2.7 Hz), 128.6, 128.0 (d, *J* = 5.9 Hz), 127.6, 127.4 (d, *J* = 7.6 Hz), 126.6 (d, *J* = 7.5 Hz), 126.2, 126.0, 124.1, 119.0, 109.7 (d, *J* = 8.3 Hz), 108.6, 97.8 (d, *J* = 2.2 Hz), 67.7, 57.0 (d, *J* = 3.6 Hz), 41.3, 41.0, 39.4 (d, *J* = 1.8 Hz) ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -98.38 ppm; **HRMS** (**ESI**) *m*/*z* Calcd for $[C_{23}H_{20}FNO + H]^+$ 346.1602, found 346.1605.

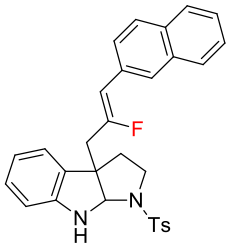
(Z)-(3a-(2-fluoro-3-(naphthalen-2-yl)allyl)-3,3a,8,8a-tetrahydropyrrolo[2,3-b]indol-1(2H)-yl)(phenyl)methanone (6b)



71.7 mg, 80% yield, white solid, R_f = 0.5 (PE/EA = 2:1), m.p. 190 – 191 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.87 (s, 1H), 7.80 – 7.76 (m, 3H), 7.61 (dd, *J* = 8.6, 1.7 Hz, 1H), 7.50 – 7.30 (m, 7H), 7.15 – 7.10 (m, 2H), 6.75 (t, *J* = 7.4 Hz, 1H), 6.68 (d, *J* = 7.7 Hz, 1H), 5.64 (s, 1H), 5.54 (d, *J* = 39.0 Hz, 1H), 3.60 – 3.54 (m, 1H), 3.38 – 3.22 (m, 1H), 2.86 – 2.64 (m, 2H), 2.42 – 2.27 (m, 2H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.9, 157.8 (d, *J* = 266.9 Hz), 149.4, 136.1, 133.4, 132.4 (d, *J* = 1.2 Hz), 130.7, 130.7, 130.1, 128.9, 128.2, 128.0, 127.9, 127.5, 127.4, 127.1, 126.5 (d, *J* = 7.5 Hz), 126.1, 125.9, 123.7, 118.9, 110.0 (d, *J* = 8.1 Hz), 109.5, 80.7, 55.2 (d, *J* = 4.0 Hz), 49.3, 40.7

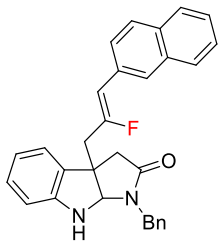
(d, *J* = 26.0 Hz), 35.2 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -97.56 ppm; **HRMS** (**ESI**) *m*/*z* Calcd for $[C_{30}H_{25}FN_2O + H]^+$ 449.2024, found 449.2020.

(Z)-3a-(2-fluoro-3-(naphthalen-2-yl)allyl)-1-tosyl-1,2,3,3a,8,8a-hexahydropyrrolo[2,3-b]indole (6c)



80.7 mg, 81% yield, white solid, R_f = 0.5 (PE/EA = 4:1), m.p. 151 – 152 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.89 – 7.84 (m, 4H), 7.75 – 7.71 (m, 2H), 7.60 – 7.50 (m, 3H), 7.18 (td, *J* = 7.6, 1.3 Hz, 1H), 7.12 – 7.09 (m, 3H), 6.82 (td, *J* = 7.4, 1.0 Hz, 1H), 6.75 (d, *J* = 7.8 Hz, 1H), 5.57 (d, *J* = 39.1 Hz, 1H), 5.35 (s, 1H), 3.53 – 3.46 (m, 1H), 3.27 – 3.18 (m, 1H), 2.70 (s, 1H), 2.62 (d, *J* = 2.2 Hz, 1H), 2.29 – 2.23 (m, 1H), 2.20 (s, 3H), 2.12 – 2.02 (m, 1H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 157.6 (d, *J* = 267.1 Hz), 148.7, 143.6, 135.7, 133.4, 132.5, 130.6 (d, *J* = 2.5 Hz), 130.5, 129.8, 129.0, 128.1, 128.0, 127.6, 127.5 (d, *J* = 7.8 Hz), 126.9, 126.5 (d, *J* = 7.7 Hz), 126.4, 126.2, 123.3, 119.5, 110.3, 110.1, 82.5, 57.3 (d, *J* = 4.1 Hz), 47.9, 40.3 (d, *J* = 25.1 Hz), 34.8, 21.3 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -96.81 – -97.11 (m, 1F) ppm; **HRMS** (**ESI**) *m*/*z* Calcd for $[C_{30}H_{27}FN_2O_2S + H]^+$ 499.1850, found 499.18479.

(Z)-1-benzyl-3a-(2-fluoro-3-(naphthalen-2-yl)allyl)-3,3a,8,8a-tetrahydropyrrolo[2,3-b]indol-2(1H)-one (6d)

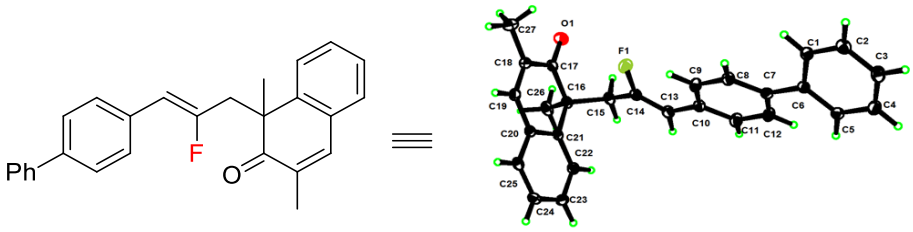


80.7 mg, 90% yield, white solid, R_f = 0.4 (PE/EA = 4:1), m.p. 79 – 80 °C, **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.79 – 7.74 (d, *J* = 8.2 Hz, 4H), 7.51 (dd, *J* = 8.6, 1.6 Hz, 1H), 7.48 – 7.41 (m, 2H), 7.24 – 7.19 (m, 5H), 7.09 (dd, *J* = 11.1, 7.6 Hz, 2H), 6.81 (t, *J* = 7.4 Hz, 1H), 6.55 (d, *J* = 7.8 Hz, 1H), 5.47 (d, *J* = 39.2 Hz, 1H), 5.13 (s, 1H), 4.81 (d, *J* = 15.2 Hz, 1H), 4.27 (d, *J* = 15.2 Hz, 1H), 3.09 – 2.88 (m, 2H), 2.77 – 2.58 (m, 2H) ppm; **^{13}C NMR** (75 MHz, $CDCl_3$) δ 172.4, 157.2 (d, *J* = 266.6 Hz), 147.3, 136.2, 133.6, 133.4, 132.5, 130.4 (d, *J* = 2.3 Hz), 129.2, 128.9, 128.1, 127.9, 127.7, 127.6,

127.6, 126.5, 126.4, 126.3, 126.1, 124.0, 120.5, 111.2, 110.4 (d, *J* = 8.1 Hz), 80.1 (d, *J* = 1.9 Hz), 77.3, 50.2 (d, *J* = 3.4 Hz), 43.8, 41.7 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -99.11 ppm; **HRMS** (**ESI**) *m*/*z* Calcd for $[C_{30}H_{25}FN_2O + H]^+$ 449.2024, found 449.2022.

11. X-ray Crystallography Data of 3l and 5a

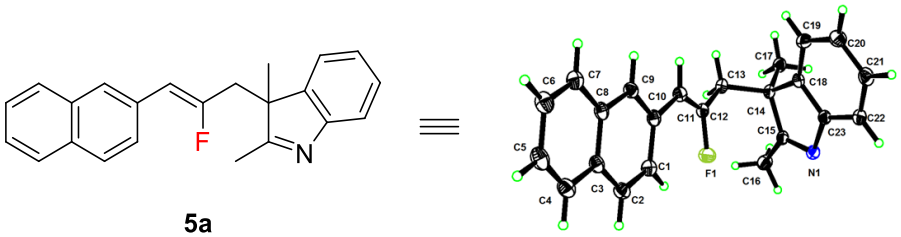
Procedure for recrystallization of compounds **3l** and **5a**: hexane was slowly added into the solution of target product in dichloromethane (with different concentration), then the dichloromethane was evaporated from the mixed solvent system at room temperature under dark and ventilated place, the crystals were obtained after a few days.



3l

Crystallographic Data of 3l

CCDC number	1974934
Bond precision	C-C = 0.0030 A Wavelength = 0.71073
Cell	A = 9.3789(4) b = 9.7180(3) c = 22.5084(9) alpha = 90 beta = 100.325(2) gamma = 90
Temperature	170 K
Volume	2018.29(13)
Space group	P 1 21/c 1
Sum formula	C_{27} H_{23} F O
Mr	382.45
Dx,g cm-3	1.259
Z	4
Mu (mm-1)	0.081
F000	808.0
h,k,lmax	11, 12, 28
Nref	4068
Tmin,Tmax	0.638, 0.745
Correction method	# Reported T Limits: Tmin = 0.638 Tmax = 0.745
AbsCorr	MULTI-SCAN
Data completeness	0.983
Theta(max)	26.392
R(reflections)	0.0519(2564)
wR2(reflections)	0.1435(4068)
S	1.020



5a

Crystallographic Data of 5a

CCDC number	1974930
Bond precision	C-C = 0.0030 A Wavelength = 0.71073
Cell	A = 23.0769(10) b = 6.4038(2) c = 24.0305(10) alpha=90 beta = 97.876(2) gamma = 90
Temperature	170 K
Volume	3517.7(2)
Space group	C 1 2/c 1
Sum formula	C23 H20 F N
Mr	329.40
Dx,g cm-3	1.244
Z	8
Mu (mm-1)	0.079
F000	1392.0
h,k,lmax	28,8,30
Nref	3570
Tmin,Tmax	0.684,0.745
Correction method	# Reported T Limits: Tmin = 0.684 Tmax = 0.745
AbsCorr	MULTI-SCAN
Data completeness	0.993
Theta(max)	26.424
R(reflections)	0.0503(2367)
wR2(reflections)	0.1235(3570)
S	1.035

12. References

(1) Wang, F.; Luo T.; Hu, J.; Wang, Y.; Krishnan, H. S.; Jog, P. V.; Ganesh, S. K.; Prakash, G. K. S.; Olah, G. A. *Angew. Chem., Int. Ed*. **2011**, *50*, 7153–7157.

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(6) Fang, X.; Zeng, Y.; Li, Q.; Wu, Z.; Yao, H.; Lin, A. *Org. Lett*. **2018**, *20*, 2530–2533.

(7) Zhuo, C.-X.; You, S.-L. *Angew. Chem., Int. Ed*. **2013**, *52*, 10056–10059.

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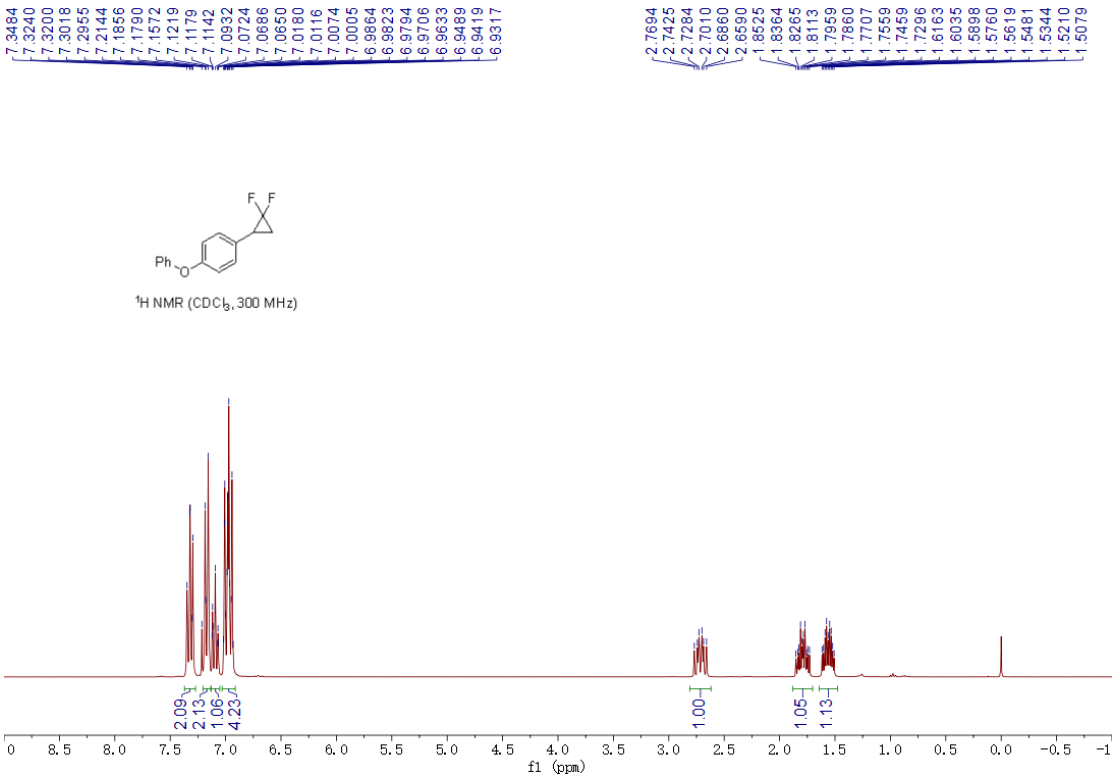
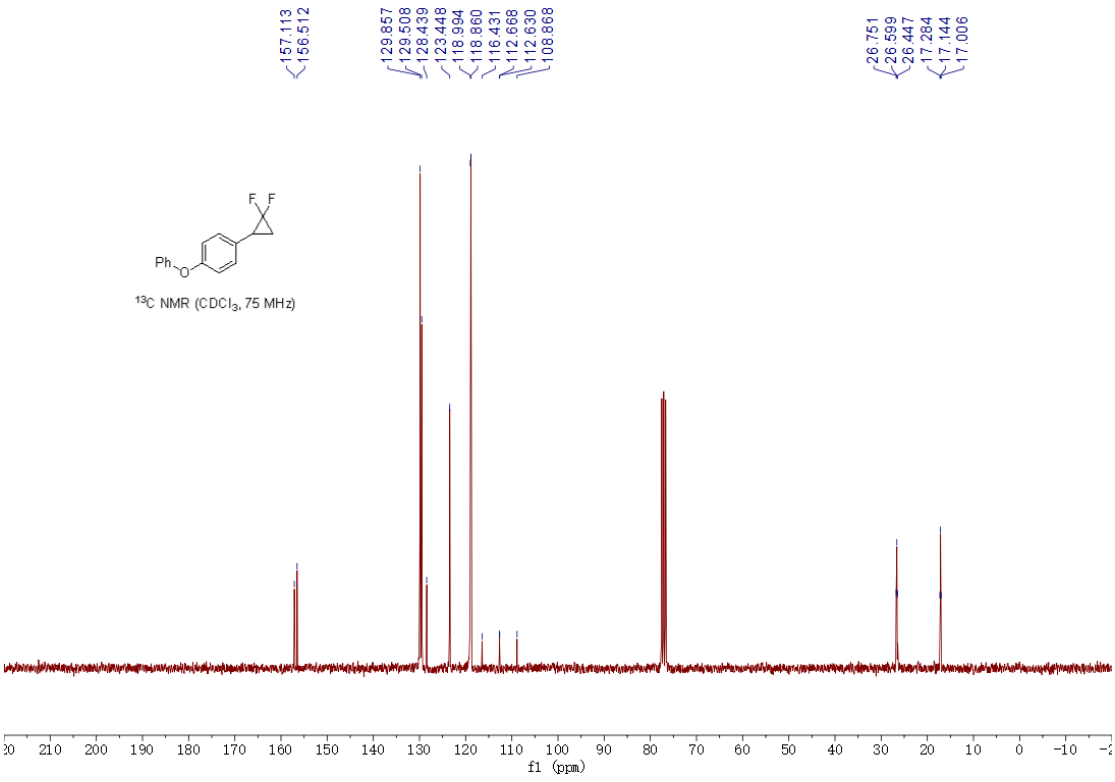
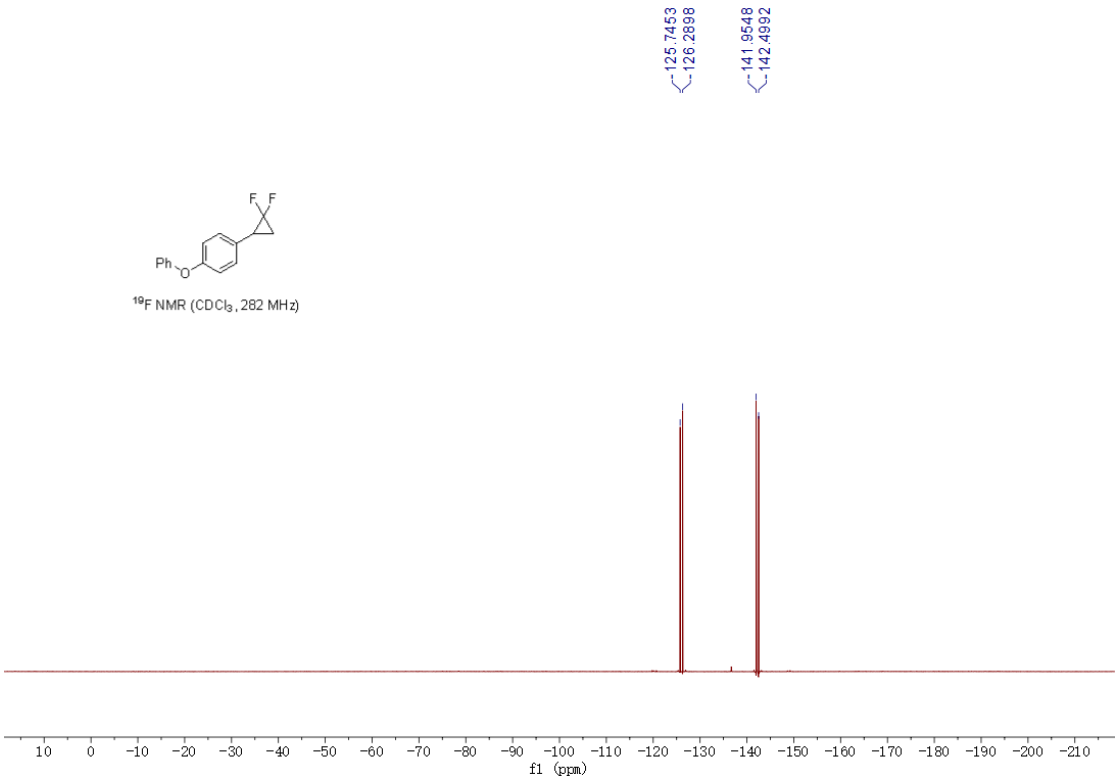
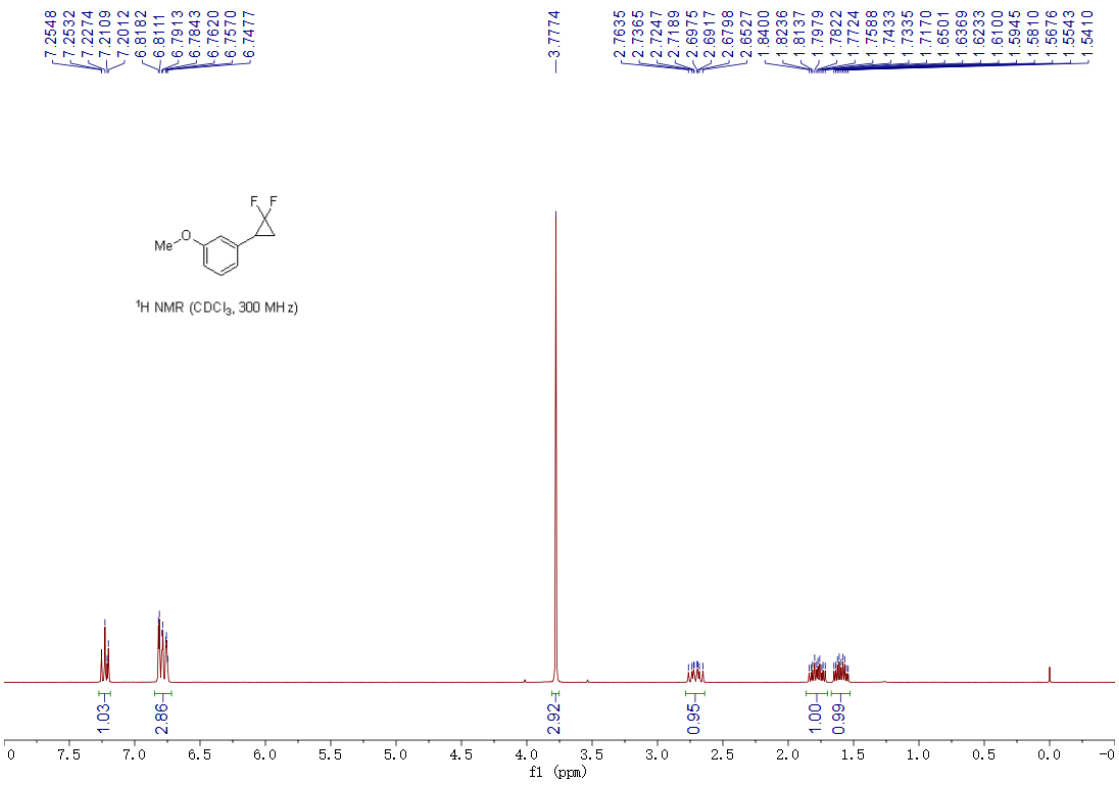
(9) Fang, X.; Li, Q.; Shi, R.; Yao, H.; Lin, A. *Org. Lett*. **2018**, *20*, 6084–6088.

13. NMR Copies of Substrates and Products






125.7453
126.2898
141.9548
142.4992
F F
Ph
O
19F NMR (CDCl3, 282 MHz)
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)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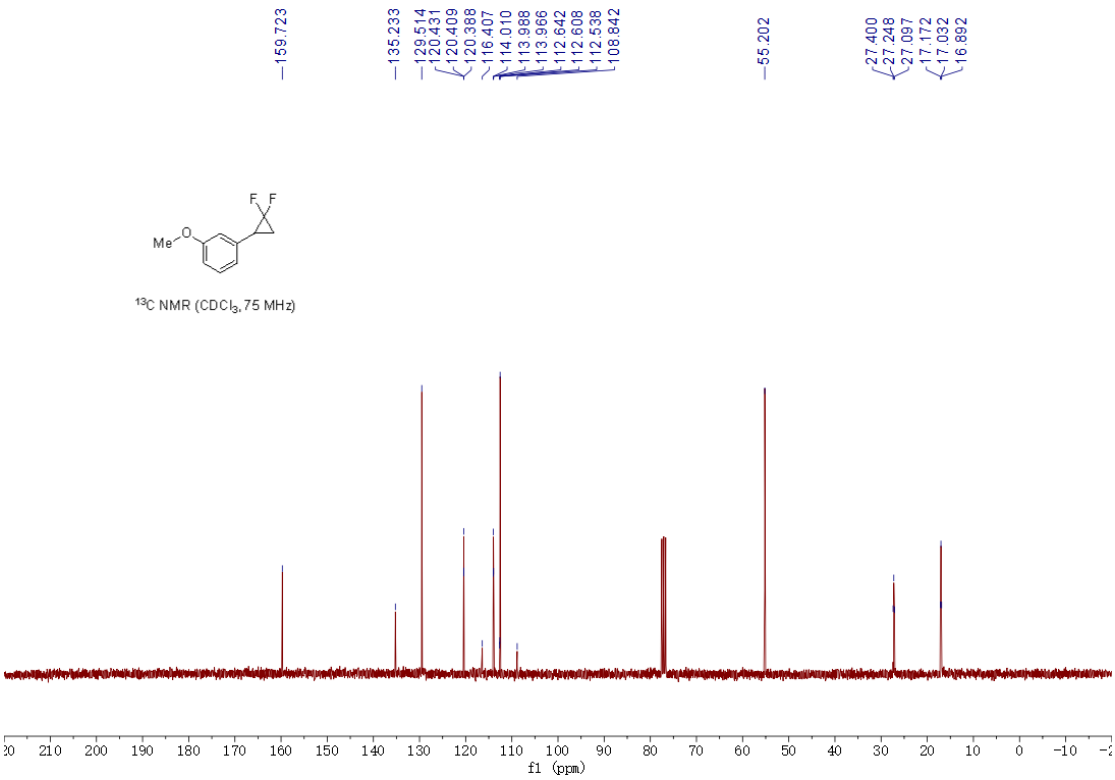
7.2532
7.2274
7.2109
7.2012
6.8182
6.8111
6.7913
6.7843
6.7620
6.7570
6.7477
3.7774
2.7635
2.7365
2.7247
2.7189
2.6975
2.6917
2.6798
2.6527
1.8400
1.8236
1.8137
1.7979
1.7822
1.7724
1.7588
1.7433
1.7335
1.7170
1.6501
1.6369
1.6233
1.6100
1.5945
1.5810
1.5676
1.5543
1.5410
F F
Me
O
1H NMR (CDCl3, 300 MHz)
1.03
2.86
2.92
0.95
1.00
0.99
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
f1 (ppm)


159.723
135.233
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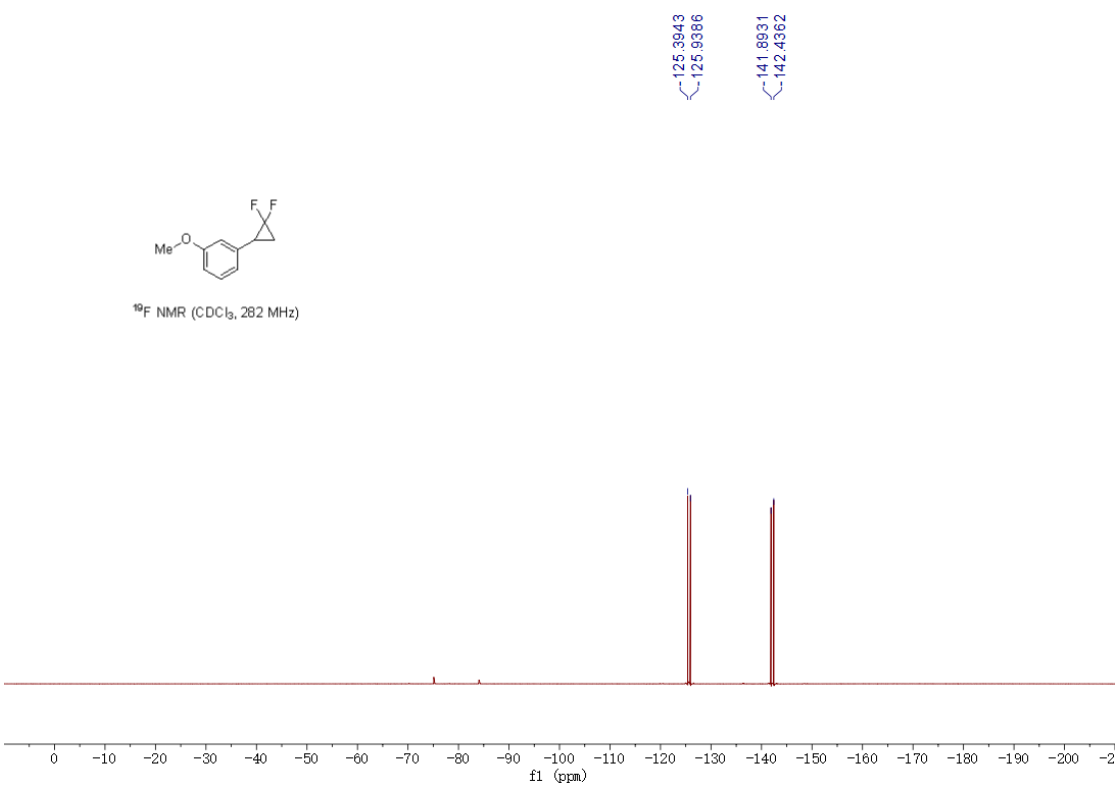
120.409
120.388
116.407
114.010
113.988
113.966
112.642
112.608
112.538
108.842
55.202
27.400
27.248
27.097
17.172
17.032
16.892
F F
Me O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)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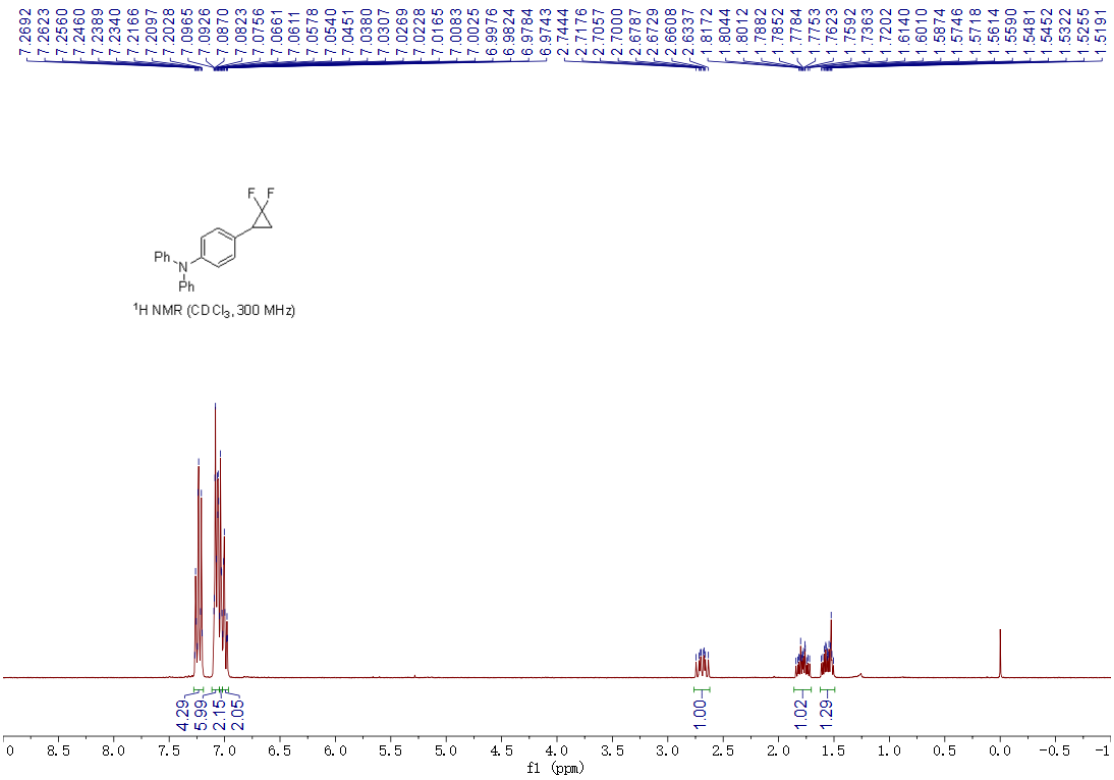
141.8931
142.4362
F F
Me O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)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7.2460
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7.2028
7.0965
7.0926
7.0870
7.0823
7.0756
7.0661
7.0611
7.0578
7.0540
7.0451
7.0380
7.0307
7.0269
7.0228
7.0165
7.0083
7.0025
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6.9824
6.9784
6.9743
2.7444
2.7176
2.7057
2.7000
2.6787
2.6729
2.6608
2.6337
1.8172
1.8044
1.8012
1.7882
1.7852
1.7784
1.7753
1.7623
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1.7363
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1.6010
1.5874
1.5746
1.5718
1.5614
1.5590
1.5481
1.5452
1.5322
1.5255
1.5191
F F
Ph N Ph
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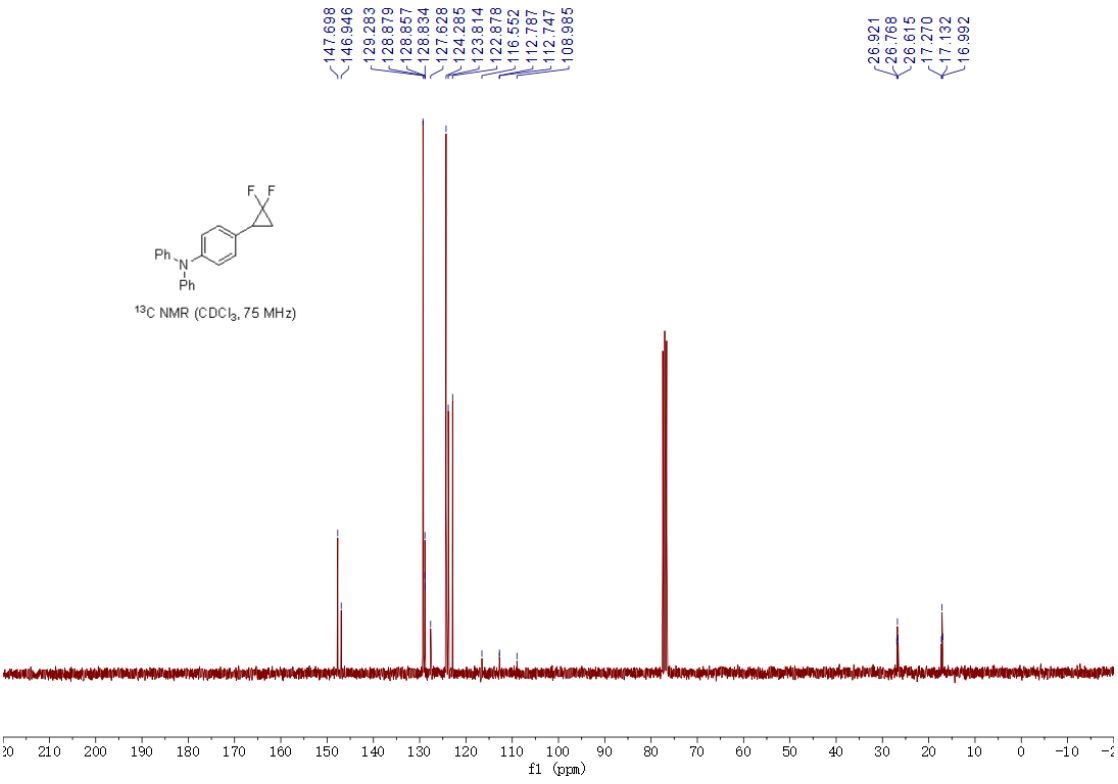
2.15
2.05
1.00
1.02
1.29
f1 (ppm)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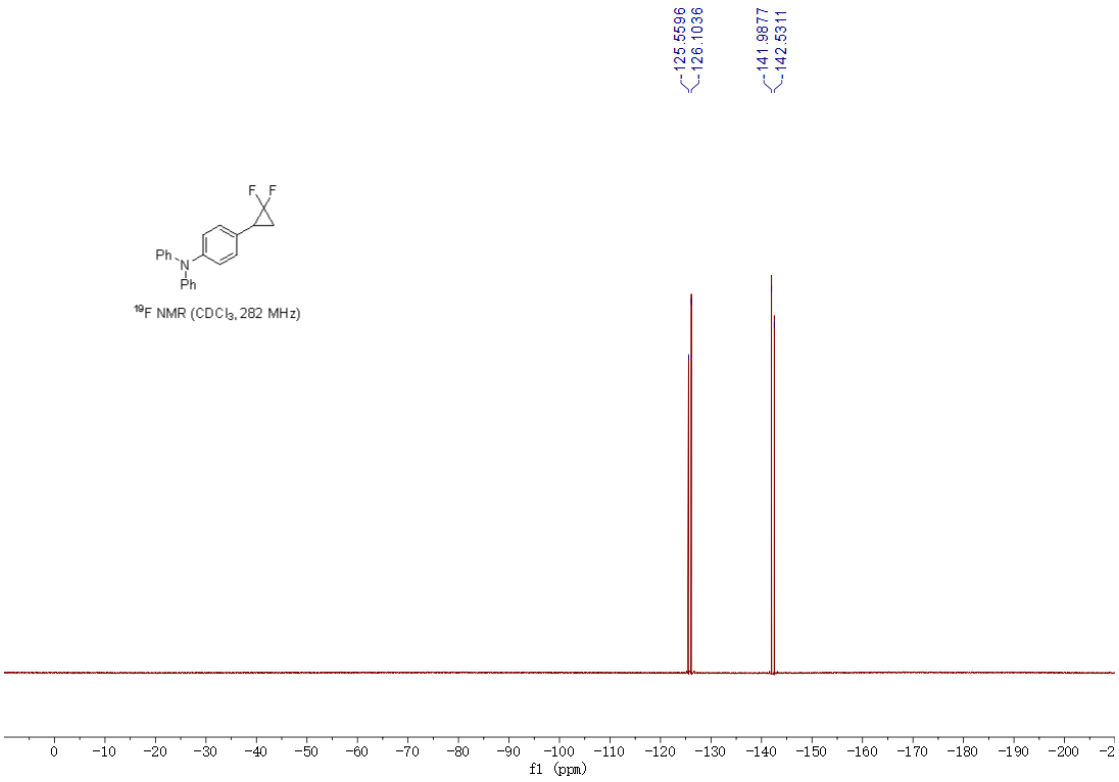
128.879
128.857
128.834
127.628
124.285
123.814
122.878
116.552
112.787
112.747
108.985
26.921
26.768
26.615
17.270
17.132
16.992
F F
Ph N Ph
13C NMR (CDCl3, 75 MHz)
f1 (ppm)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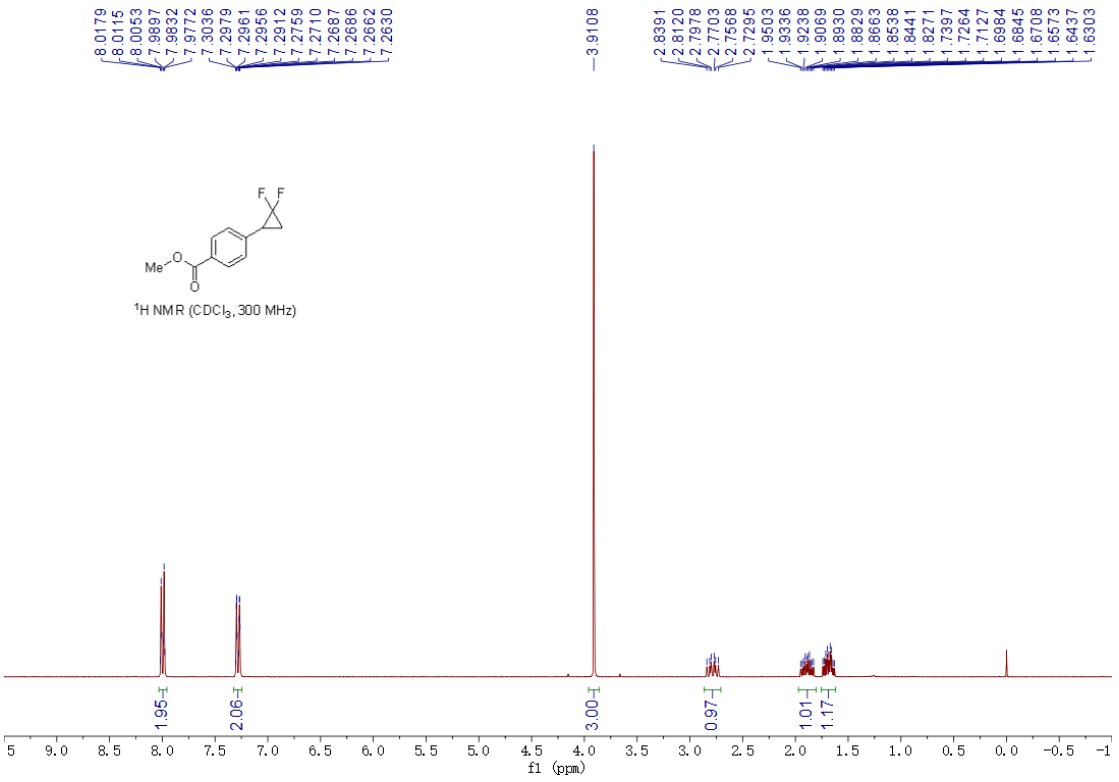
141.9877
142.5311
F F
Ph
N
Ph
^{19}F NMR ($CDCl_3$, 282 MHz)
f1 (ppm)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7.2686
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1.6573
1.6437
1.6303
F F
Me
O
O
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2.06
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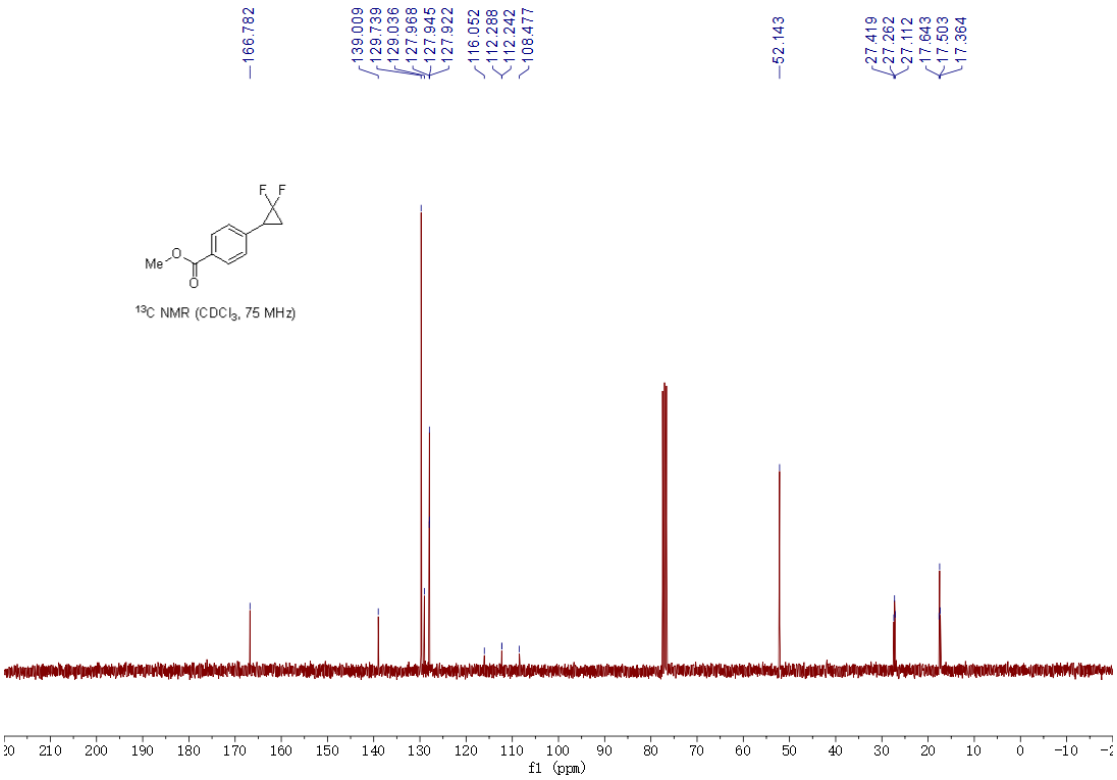
0.97
1.01
1.17
f1 (ppm)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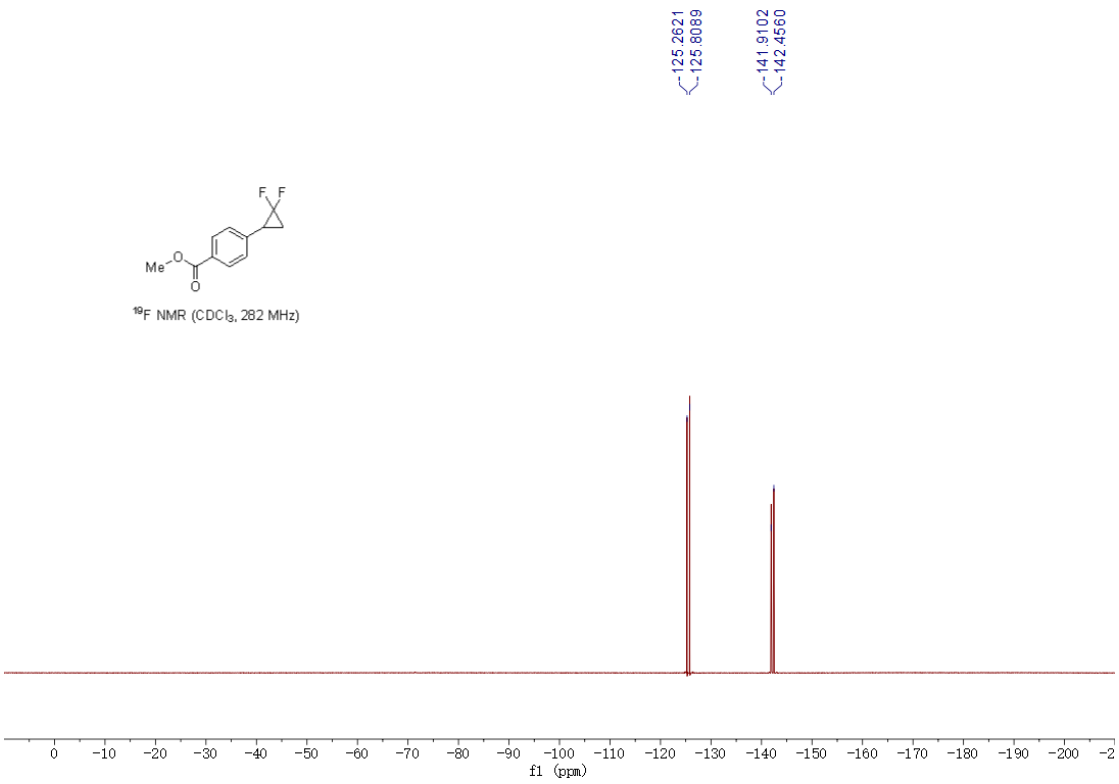
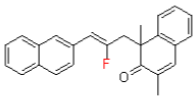
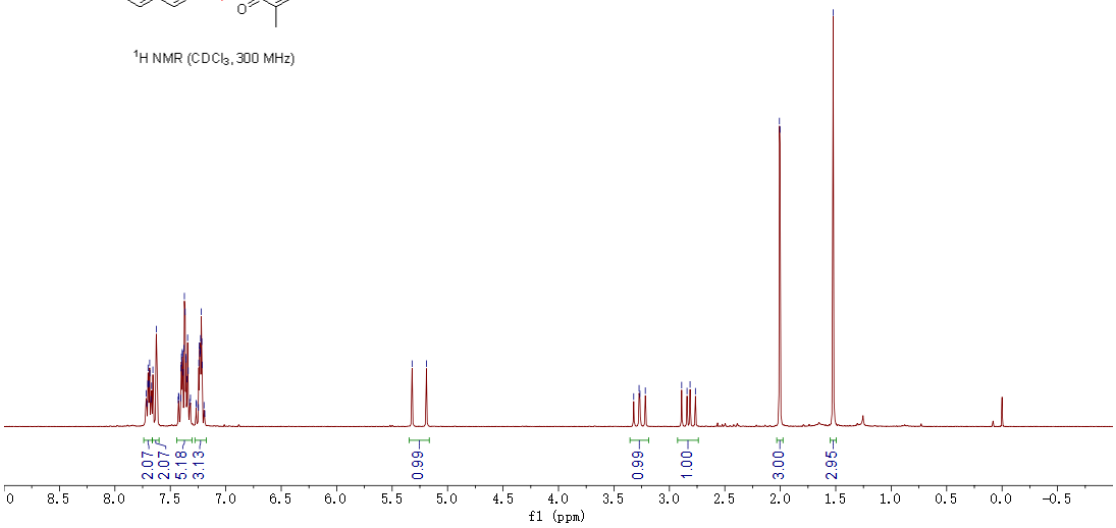
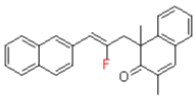
108.477
52.143
27.419
27.262
27.112
17.643
17.503
17.364
F F
Me O
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)


125.2621
125.8089
141.9102
142.4560
F F
Me O
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

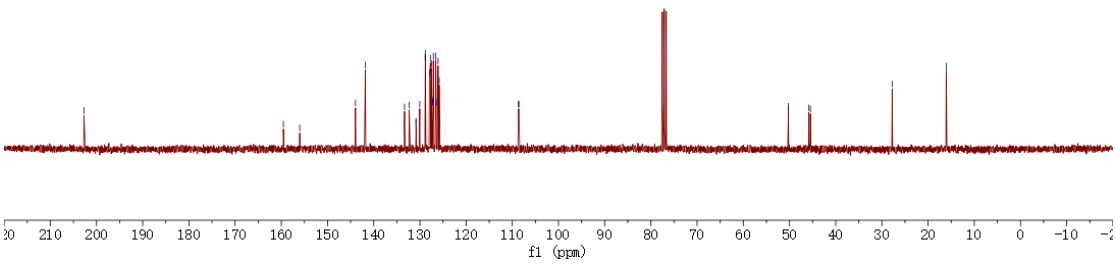


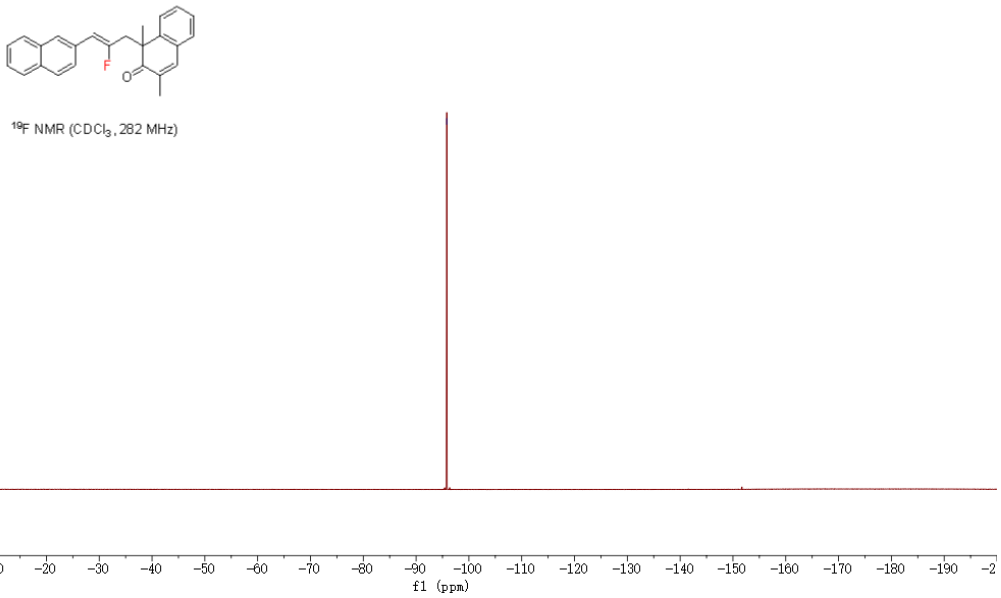
^{1}H NMR ($CDCl_3$, 300 MHz)



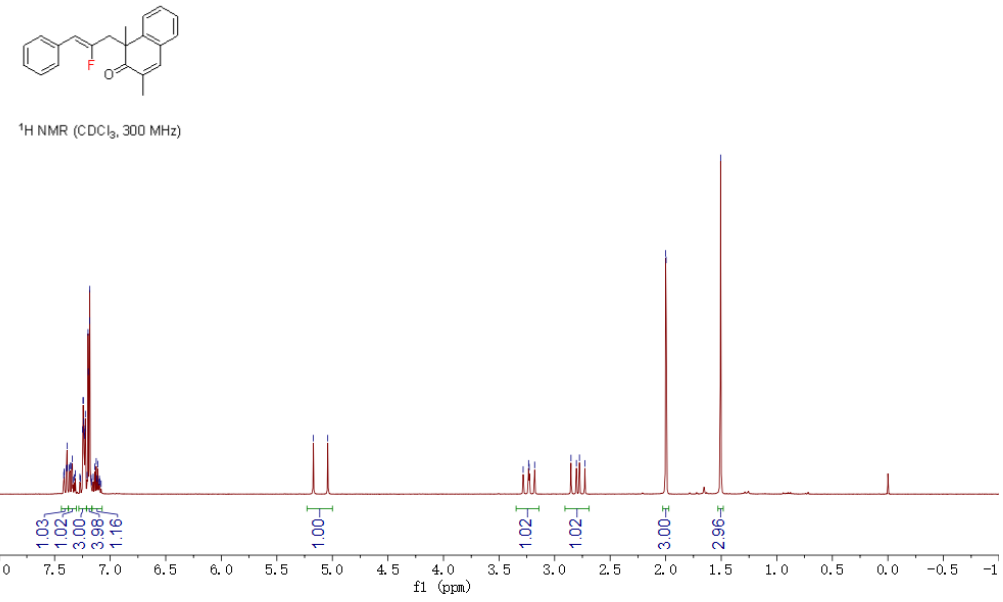


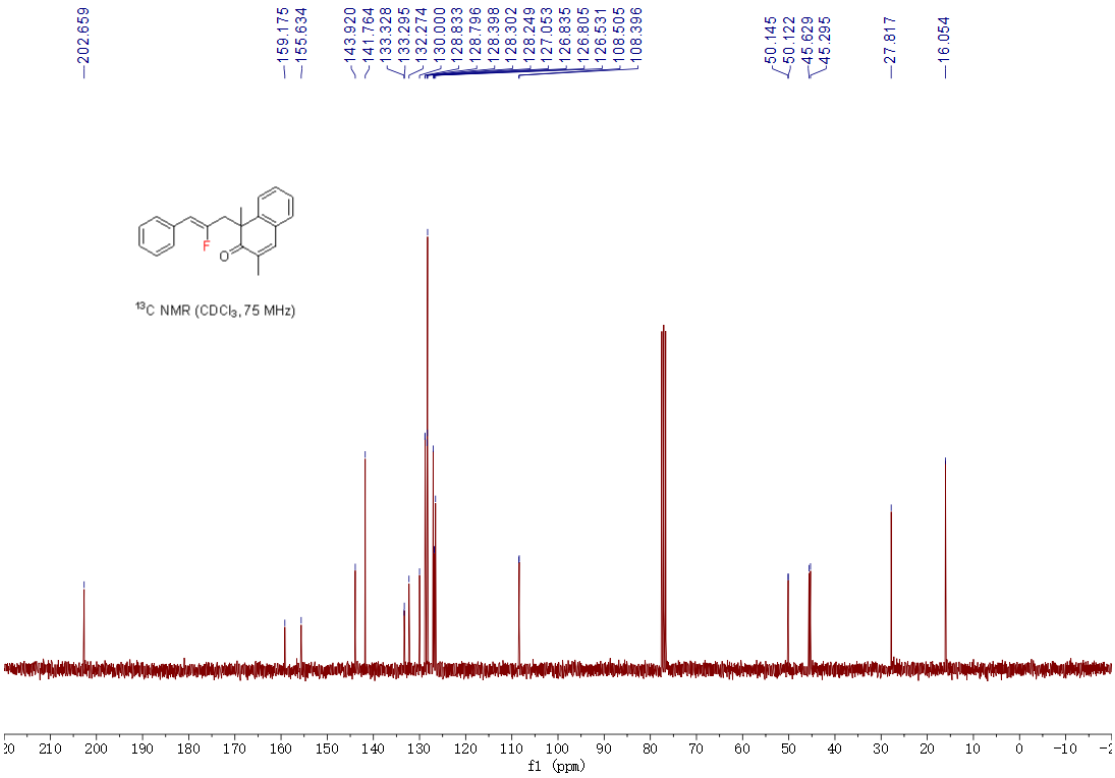
^{13}C NMR ($CDCl_3$, 75 MHz)

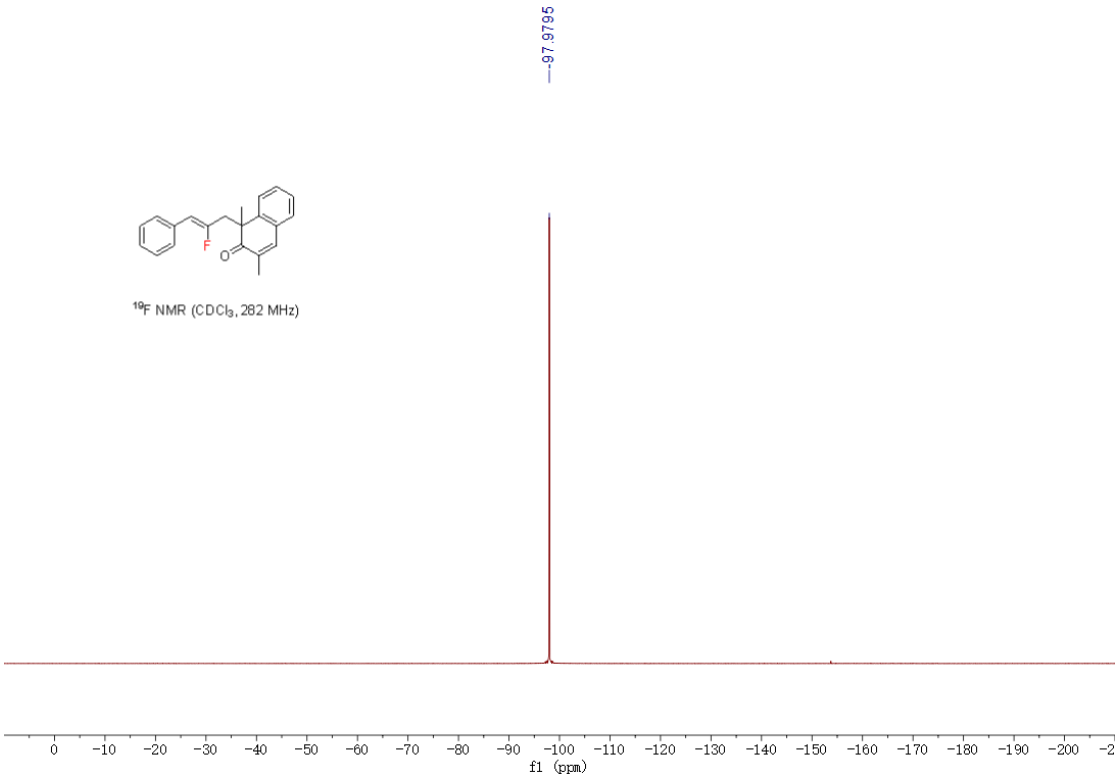


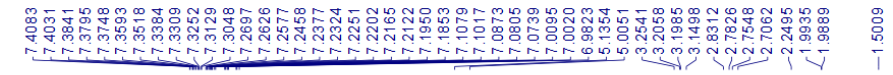

-95.8024
F
O
^{19}F NMR ($CDCl_3$, 282 MHz)
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -2
f1 (ppm)

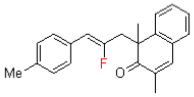

7.4179
7.4154
7.4130
7.3939
7.3881
7.3848
7.3689
7.3610
7.3484
7.3405
7.3231
7.3144
7.2730
7.2479
7.2432
7.2432
7.2379
7.2336
7.2316
7.2266
7.2231
7.2076
7.1993
7.1970
7.1856
7.1835
7.1713
7.1528
7.1389
7.1256
7.1109
5.1713
5.0418
3.2832
3.2340
3.2283
2.8524
2.8038
2.7763
2.7277
2.0007
1.9962
1.5057


F
O
^{1}H NMR ($CDCl_3$, 300 MHz)
1.03
1.02
3.00
3.98
1.16
1.00
1.02
1.02
3.00
2.96
0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

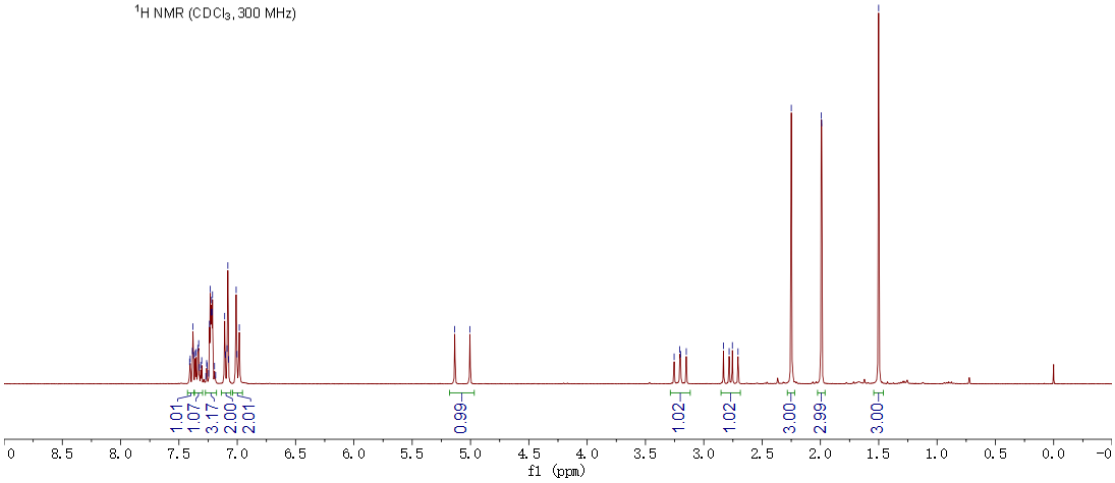

202.659
159.175
155.634
143.920
141.764
133.328
133.295
132.274
130.000
128.833
128.796
128.398
128.302
128.249
127.053
126.835
126.805
126.531
108.505
108.396
50.145
50.122
45.629
45.295
27.817
16.054
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

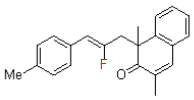

97.9795
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)



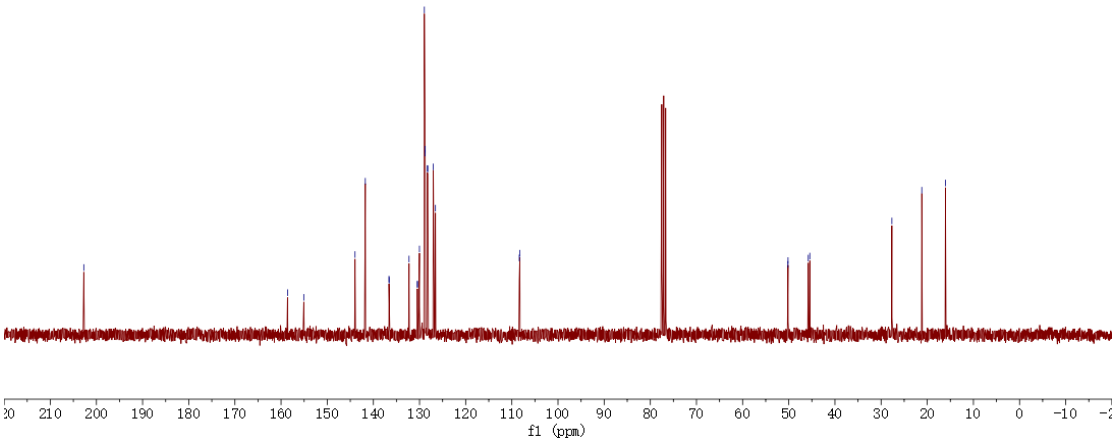


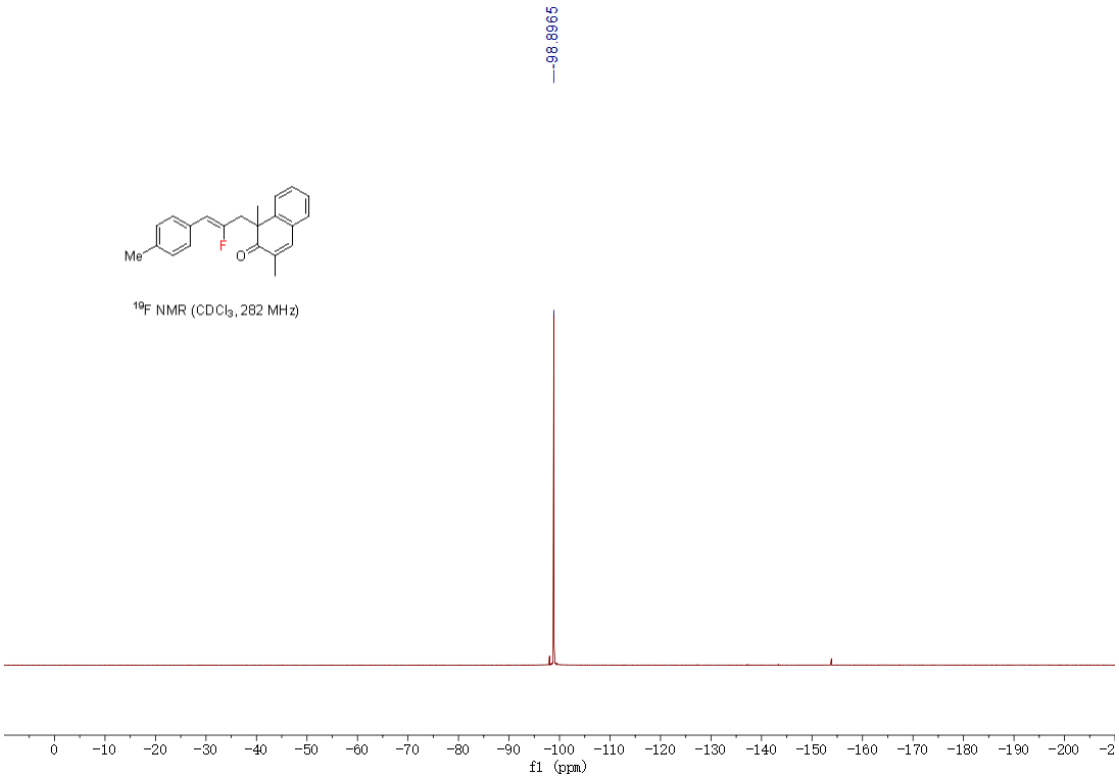
^{1}H NMR ($CDCl_3$, 300 MHz)

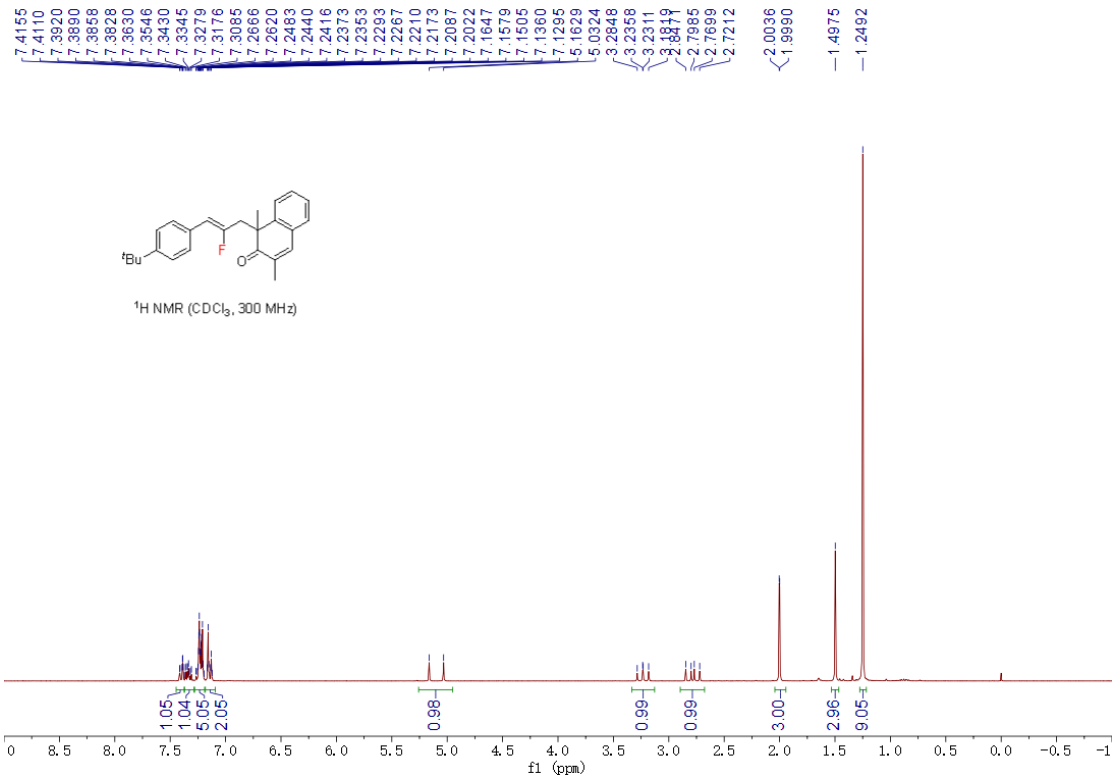


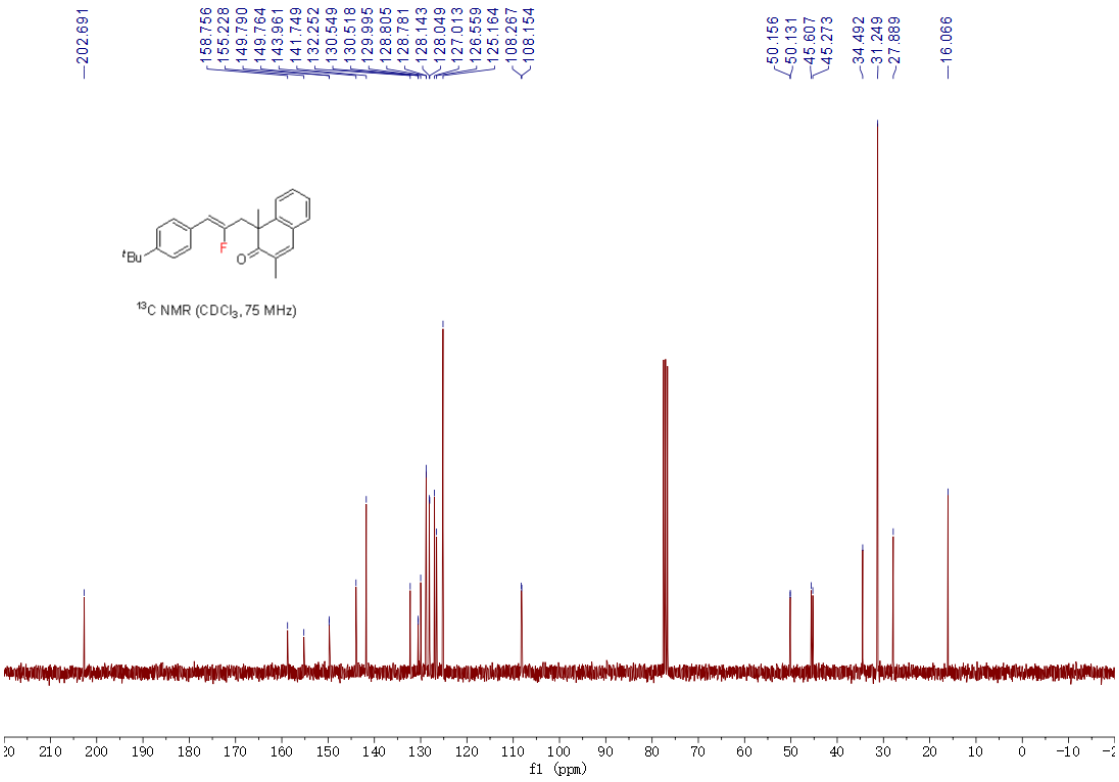


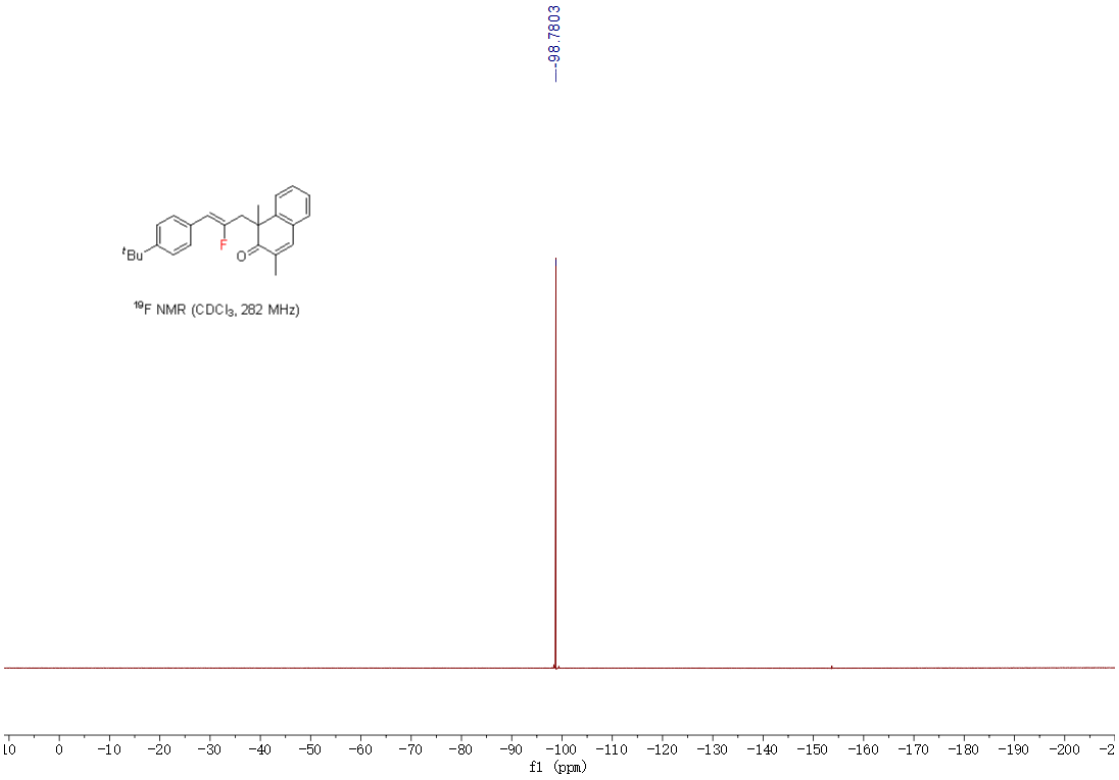
^{13}C NMR ($CDCl_3$, 75 MHz)

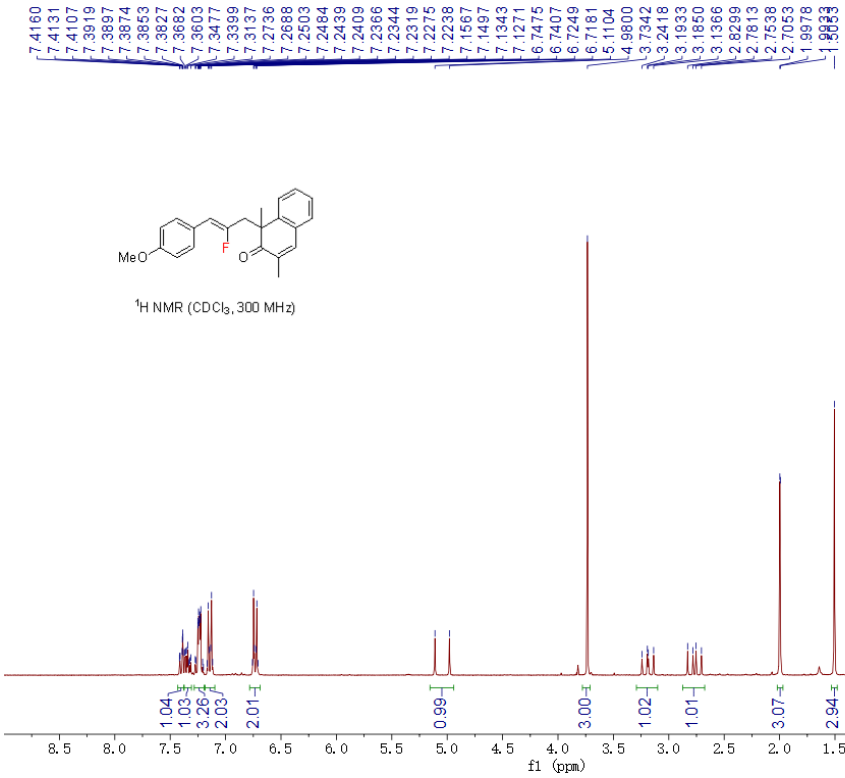


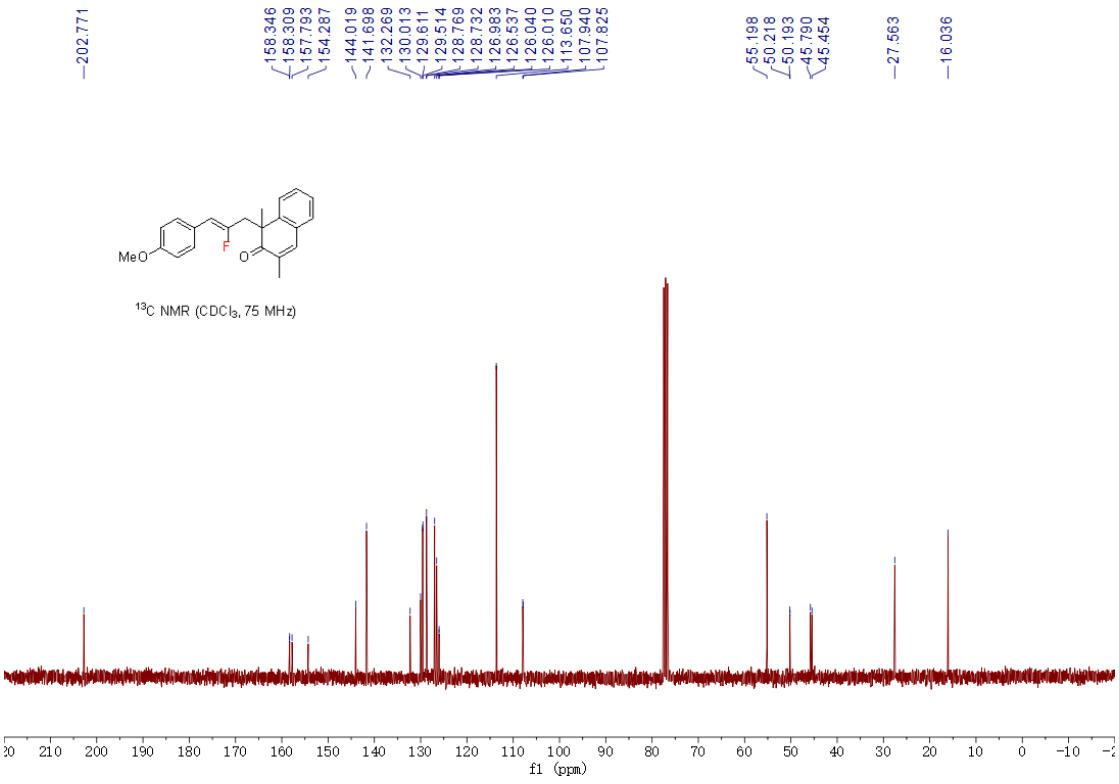

-98.8965
Me
F
O
^{19}F NMR ($CDCl_3$, 282 MHz)
f1 (ppm)

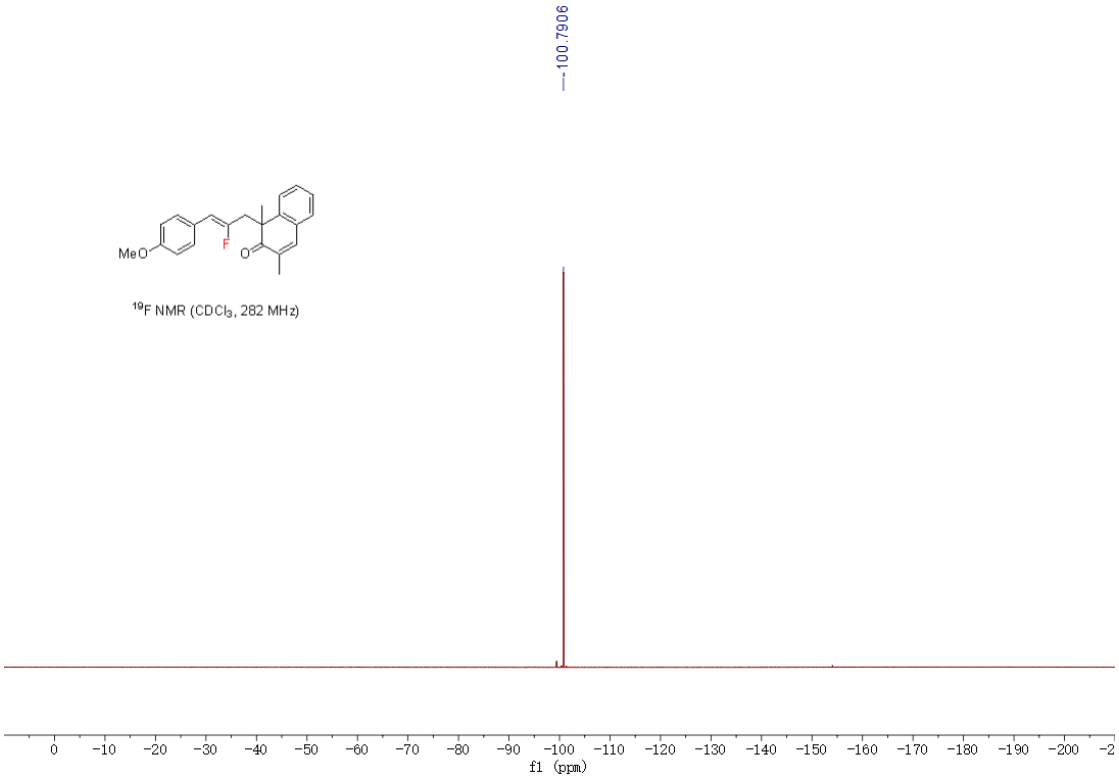

7.4155
7.4110
7.3920
7.3890
7.3858
7.3828
7.3630
7.3546
7.3430
7.3345
7.3279
7.3176
7.3085
7.2666
7.2620
7.2483
7.2440
7.2416
7.2373
7.2353
7.2293
7.2267
7.2210
7.2173
7.2087
7.2022
7.1647
7.1579
7.1505
7.1360
7.1295
5.1629
5.0324
3.2848
3.2358
3.2311
2.7985
2.7699
2.7212
2.0036
1.9990
1.4975
1.2492
^{t}Bu
F
O
^{1}H NMR ($CDCl_3$, 300 MHz)
1.05
1.04
5.05
2.05
0.98
0.99
0.99
3.00
2.96
9.05
f1 (ppm)

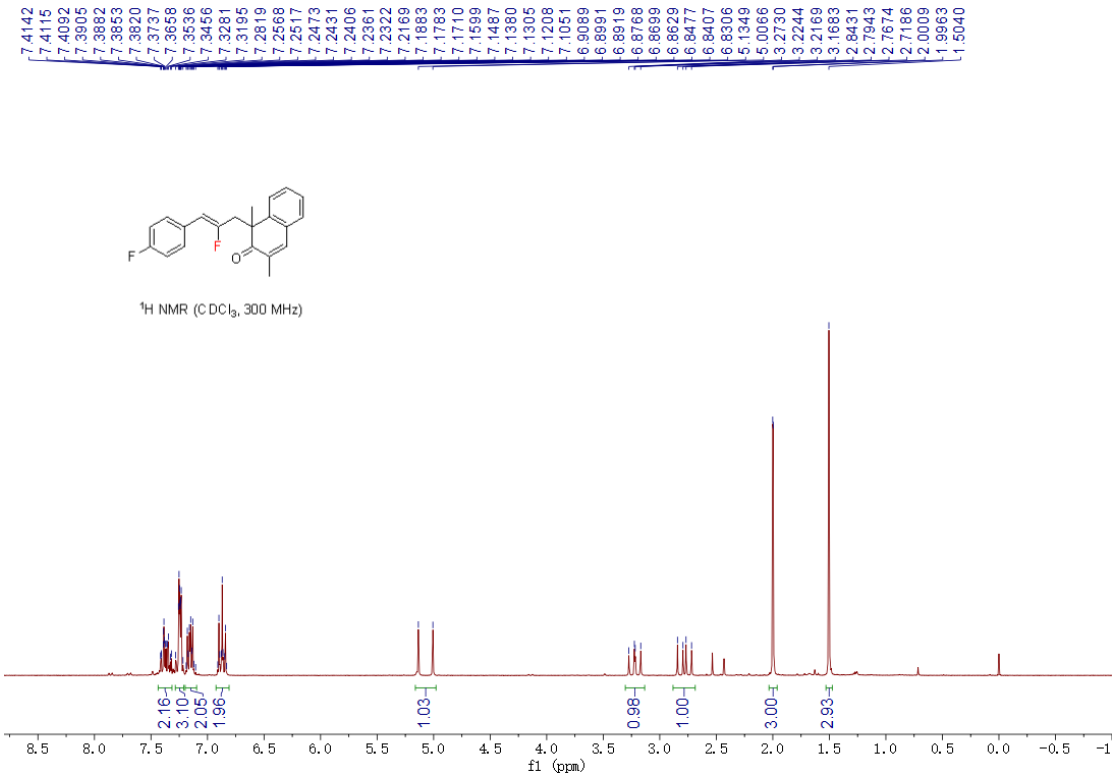

202.691
158.756
155.228
149.790
149.764
143.961
141.749
132.252
130.549
130.518
129.995
128.805
128.781
128.143
128.049
127.013
126.559
125.164
108.267
108.154
50.156
50.131
45.607
45.273
34.492
31.249
27.889
16.066
tBu
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

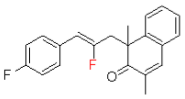

98.7803
tBu
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)


7.4160
7.4131
7.4107
7.3919
7.3897
7.3874
7.3853
7.3827
7.3682
7.3603
7.3477
7.3399
7.3137
7.2736
7.2688
7.2503
7.2484
7.2439
7.2409
7.2366
7.2344
7.2319
7.2275
7.2238
7.1567
7.1497
7.1343
7.1271
6.7475
6.7407
6.7249
6.7181
5.1104
4.9800
3.7342
3.2418
3.1933
3.1850
3.1366
2.8299
2.7813
2.7538
2.7053
1.9978
MeO
F
O
1H NMR (CDCl3, 300 MHz)
1.04
1.03
3.26
2.03
2.01
0.99
3.00
1.02
1.01
3.07
2.94
f1 (ppm)

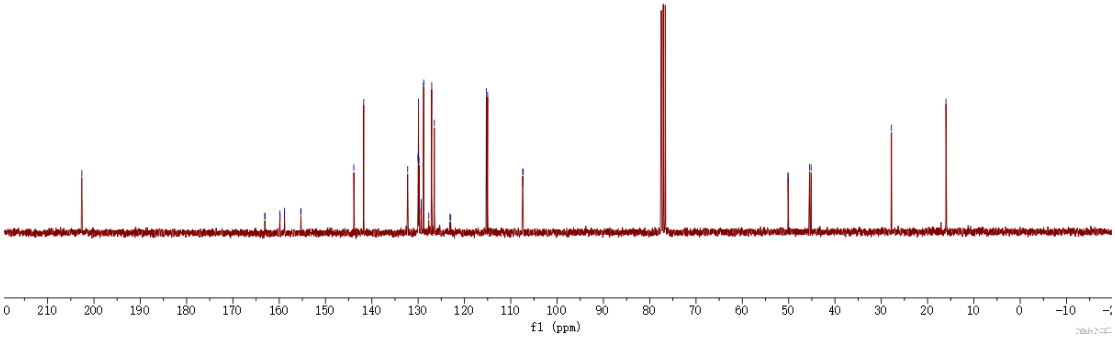

202.771
158.346
158.309
157.793
154.287
144.019
141.698
132.269
130.013
129.611
129.514
128.769
128.732
126.983
126.537
126.040
126.010
113.650
107.940
107.825
55.198
50.218
50.193
45.790
45.454
27.563
16.036
MeO
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

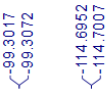

-100.7906
MeO
F
O
^{19}F NMR (CDCl$_3$, 282 MHz)
f1 (ppm)

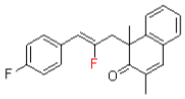

F
F
O
^{1}H NMR (CDCl$_3$, 300 MHz)
2.16
3.10
2.05
1.96
1.03
0.98
1.00
3.00
2.93
f1 (ppm)



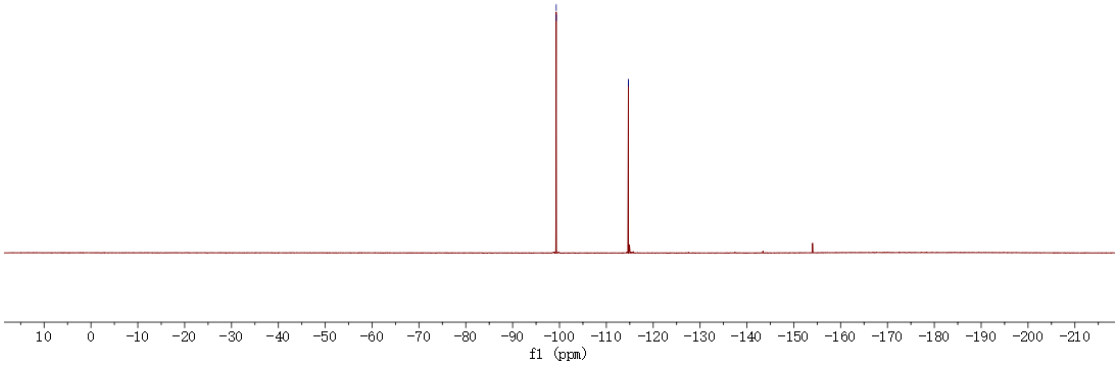
^{13}C NMR ($CDCl_3$, 75 MHz)

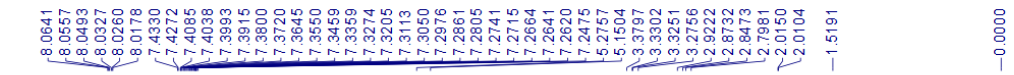


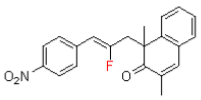




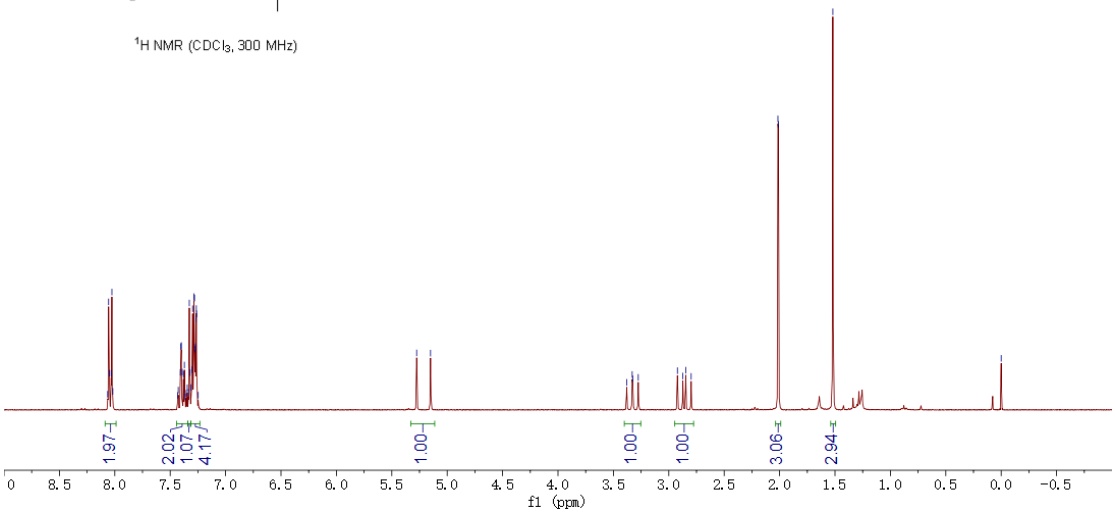
^{19}F NMR ($CDCl_3$, 283 MHz)

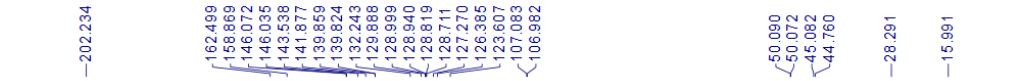


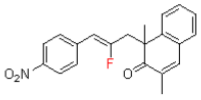




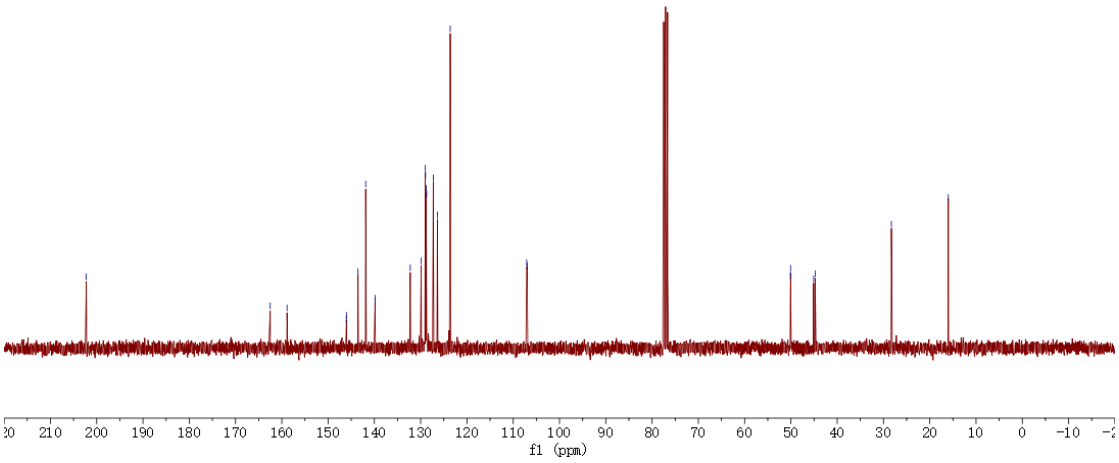
^{1}H NMR ($CDCl_3$, 300 MHz)

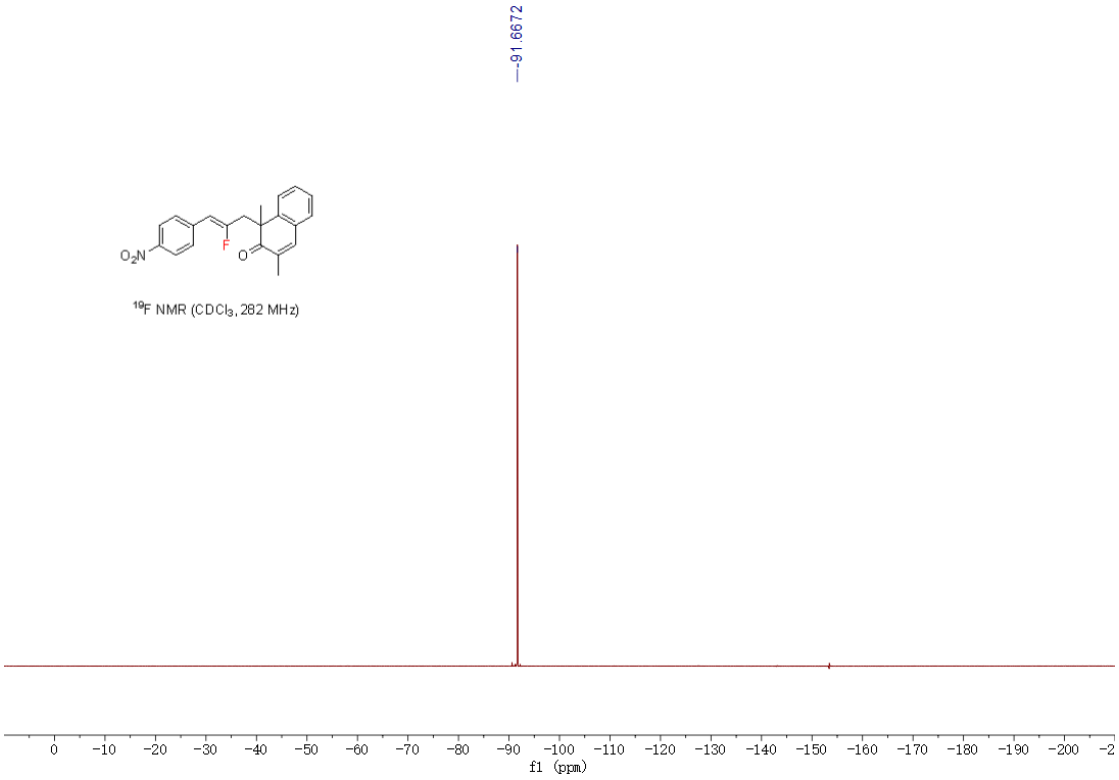


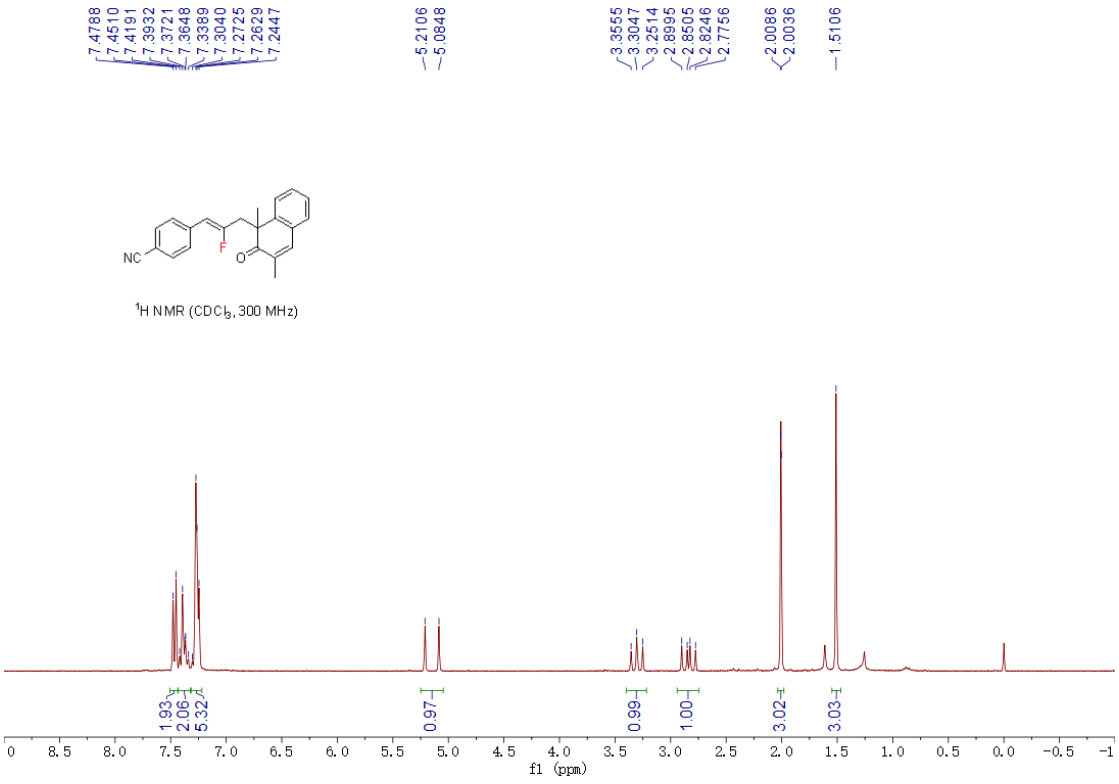


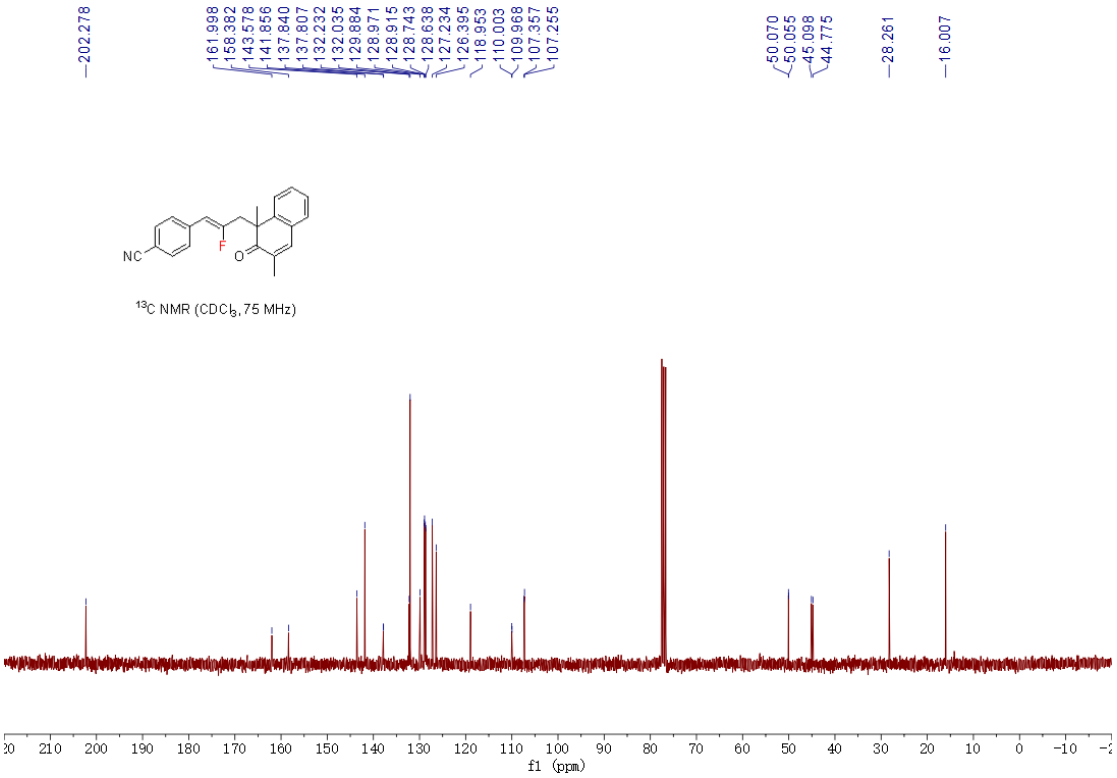


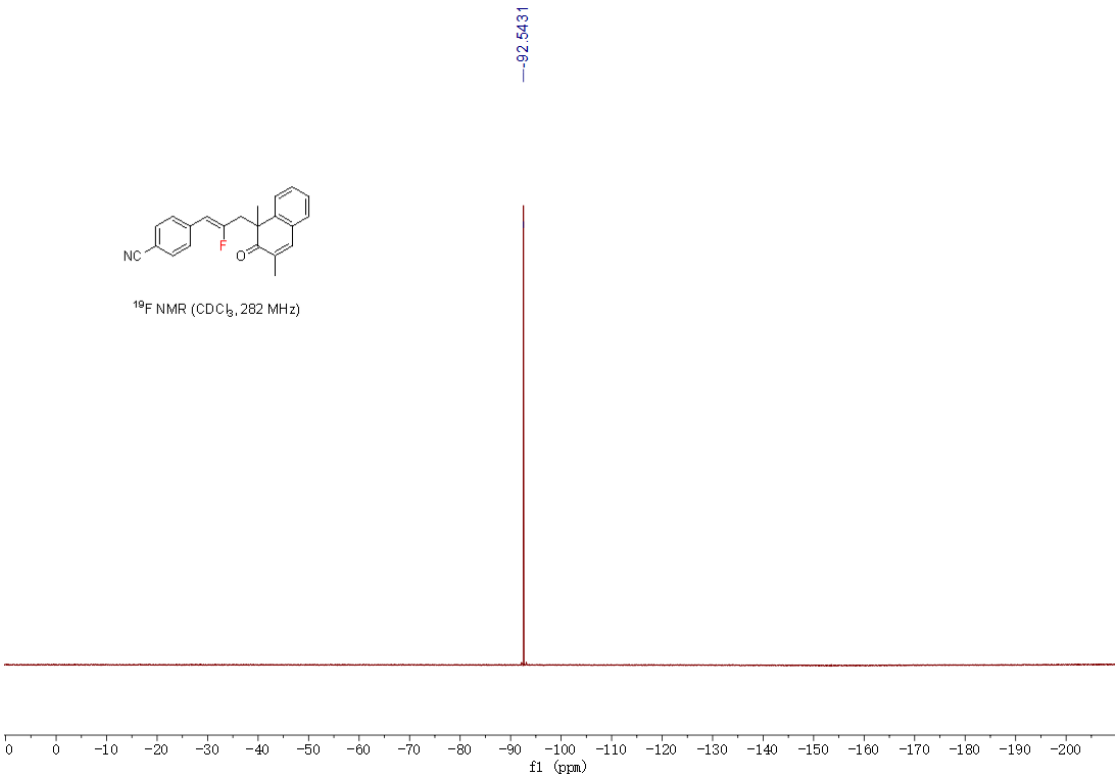
^{13}C NMR ($CDCl_3$, 75 MHz)

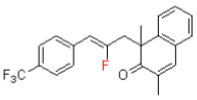



-91.6672
O2N
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

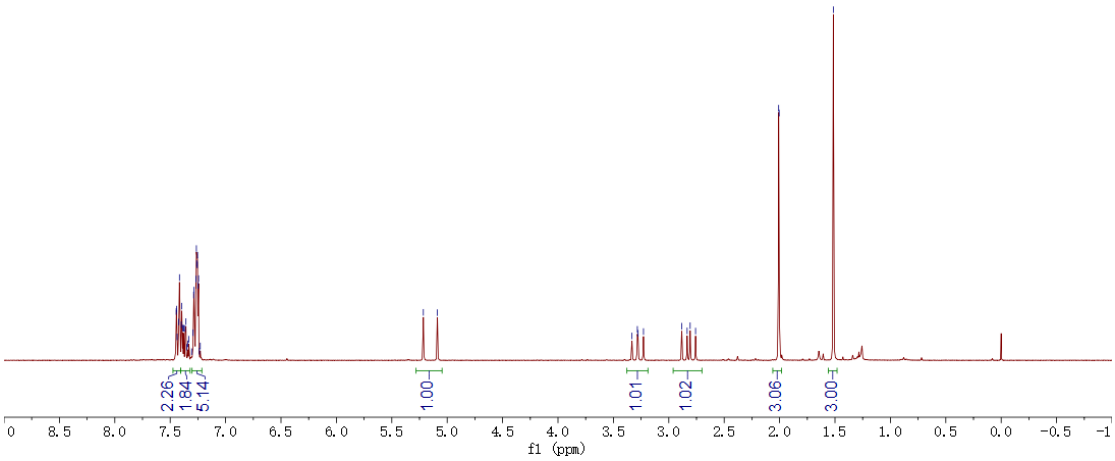

7.4788
7.4510
7.4191
7.3932
7.3721
7.3648
7.3389
7.3040
7.2725
7.2629
7.2447
5.2106
5.0848
3.3555
3.3047
3.2514
2.8995
2.8505
2.8246
2.7756
2.0086
2.0036
1.5106
NC
F
O
1H NMR (CDCl3, 300 MHz)
1.93
2.06
5.32
0.97
0.99
1.00
3.02
3.03
f1 (ppm)

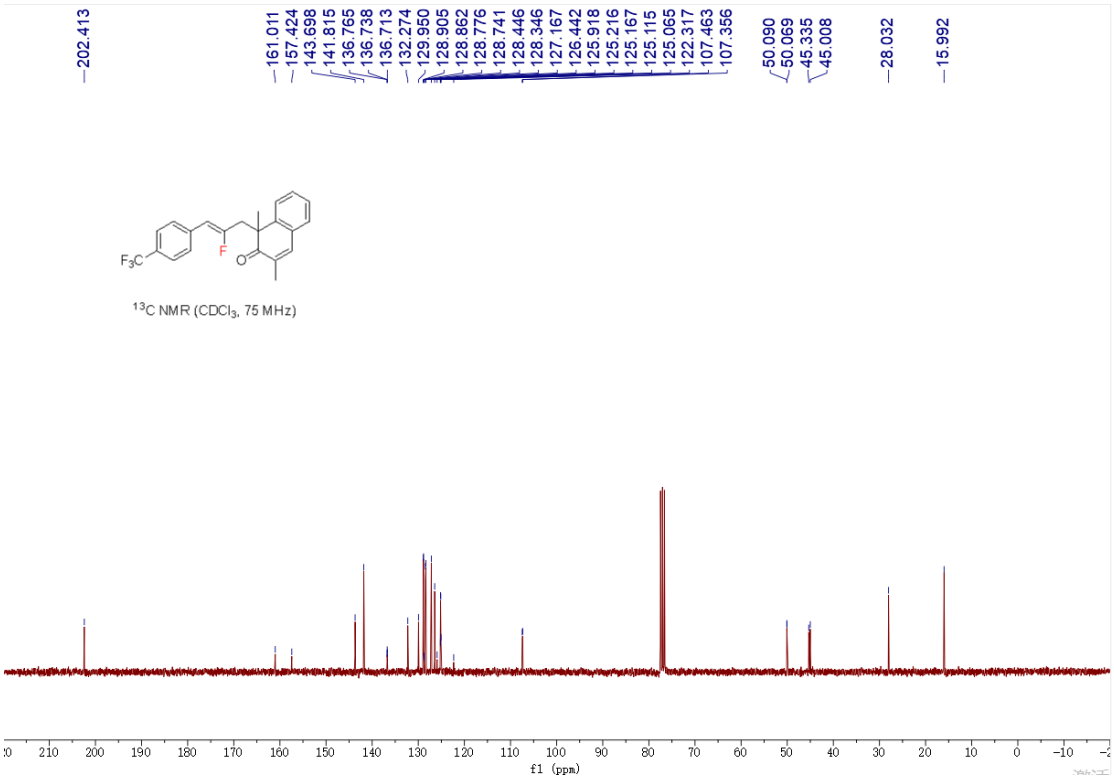

202.278
161.998
158.382
143.578
141.856
137.840
137.807
132.232
132.035
129.884
128.971
128.915
128.743
128.638
127.234
126.395
118.953
110.003
109.968
107.357
107.255
50.070
50.055
45.098
44.775
28.261
16.007
NC
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)


-92.5431
NC
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

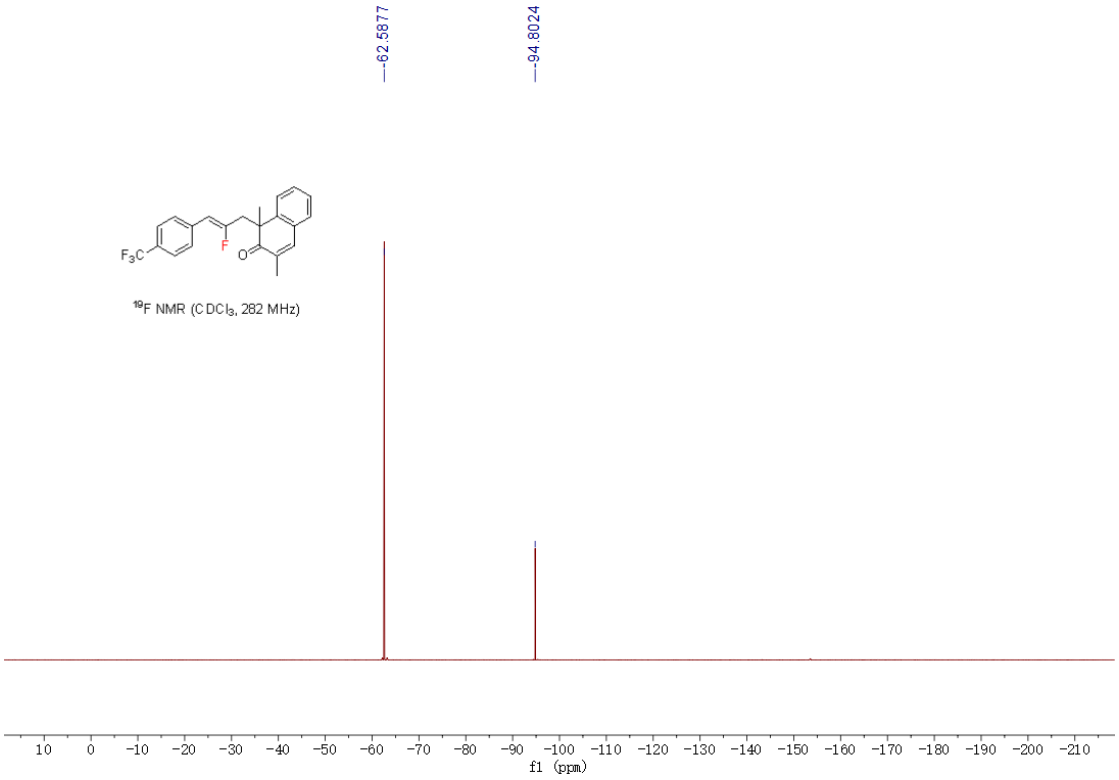


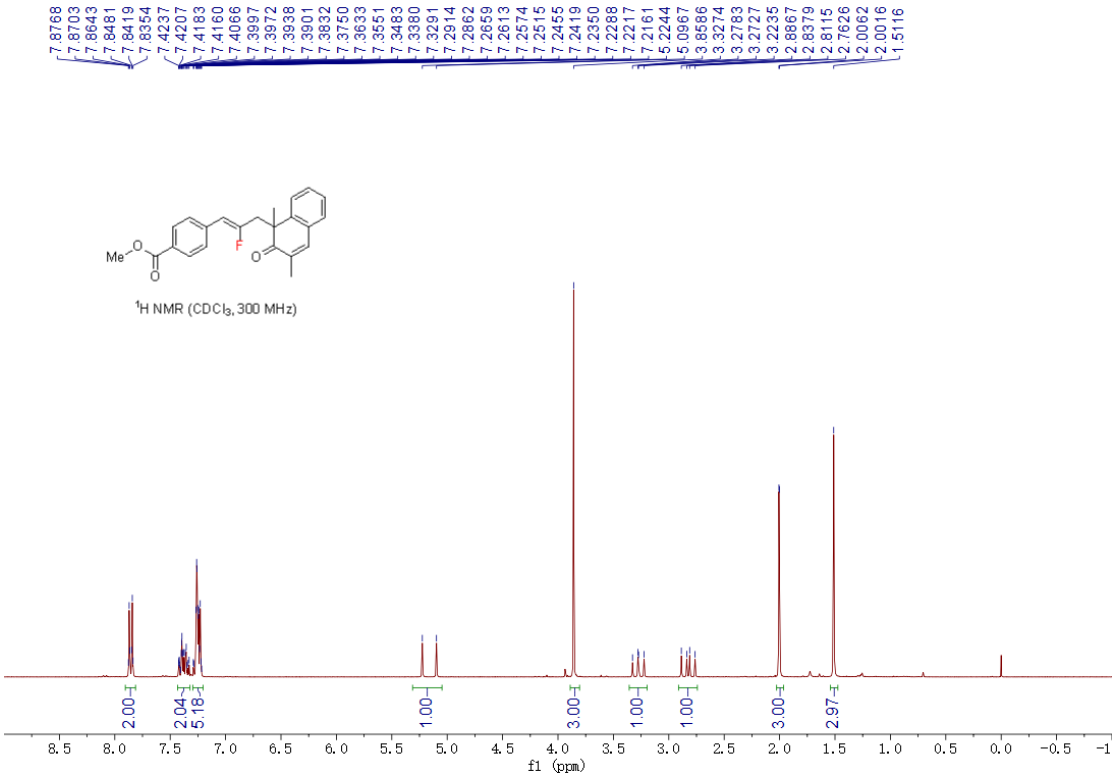
^{1}H NMR ($CDCl_3$, 300 MHz)

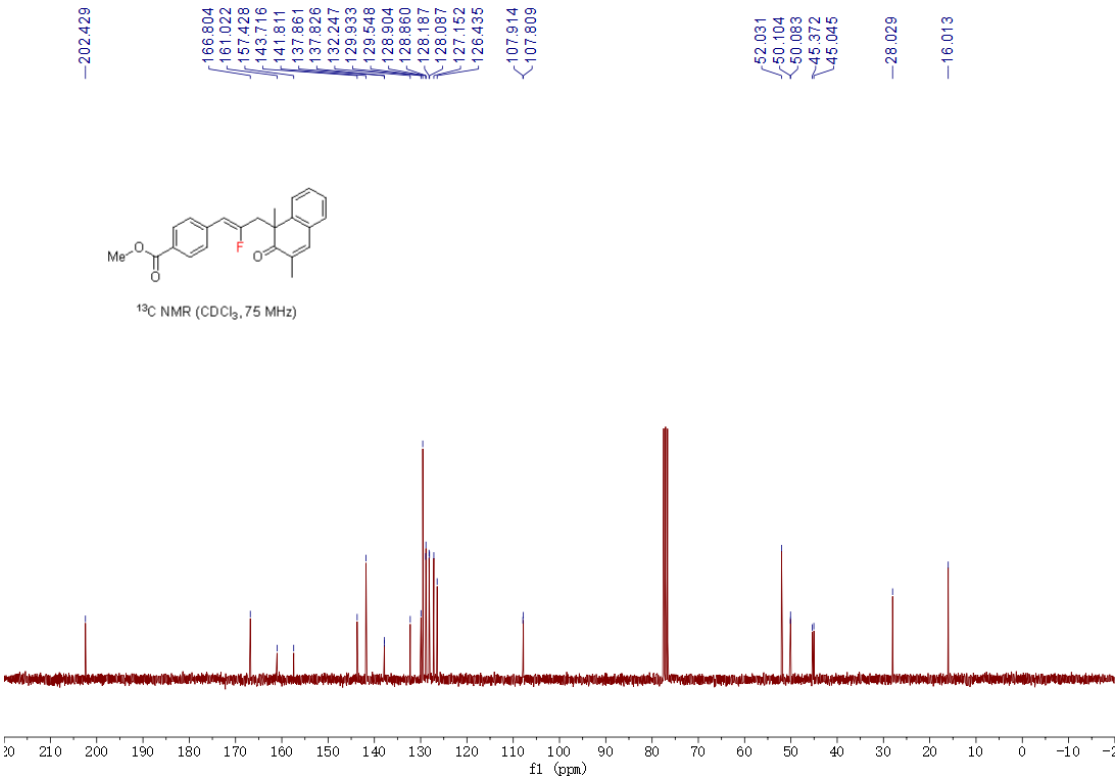


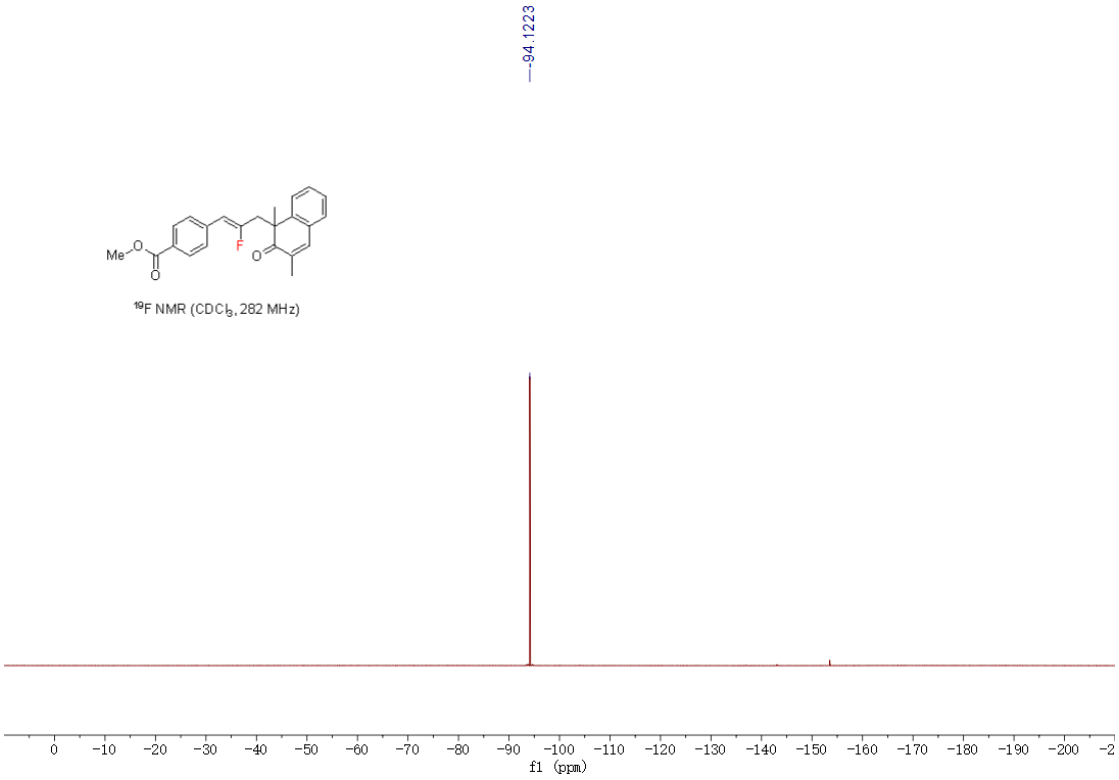


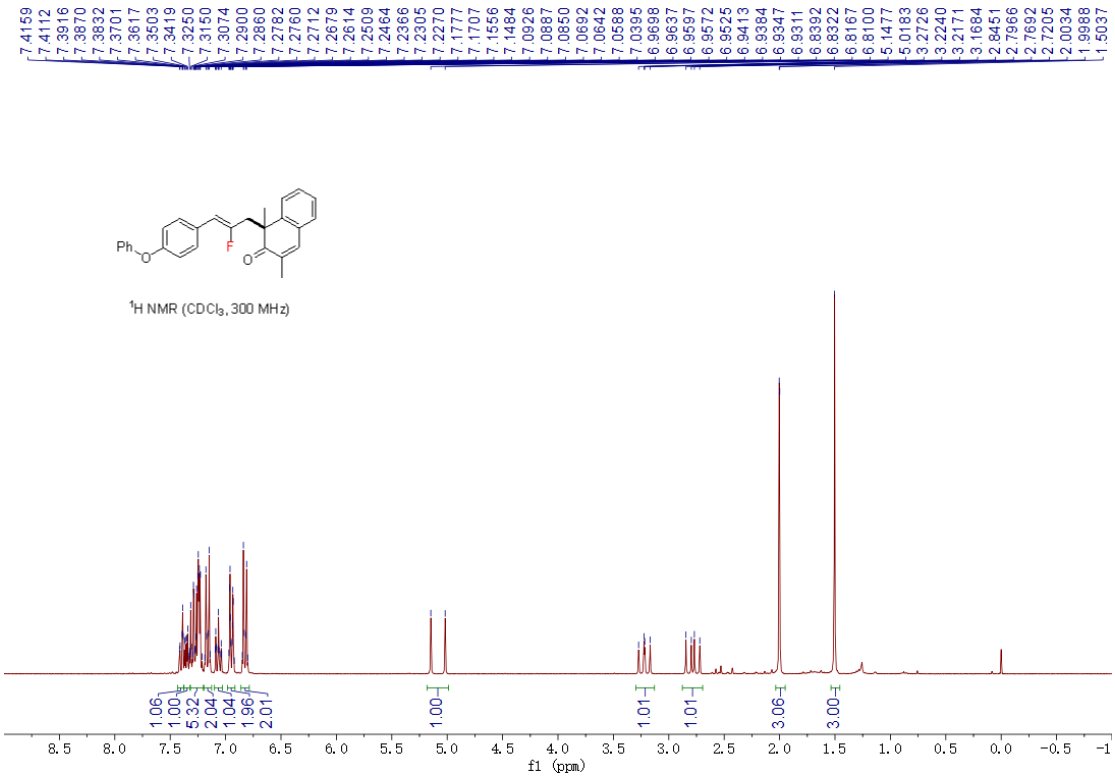
^{13}C NMR ($CDCl_3$, 75 MHz)

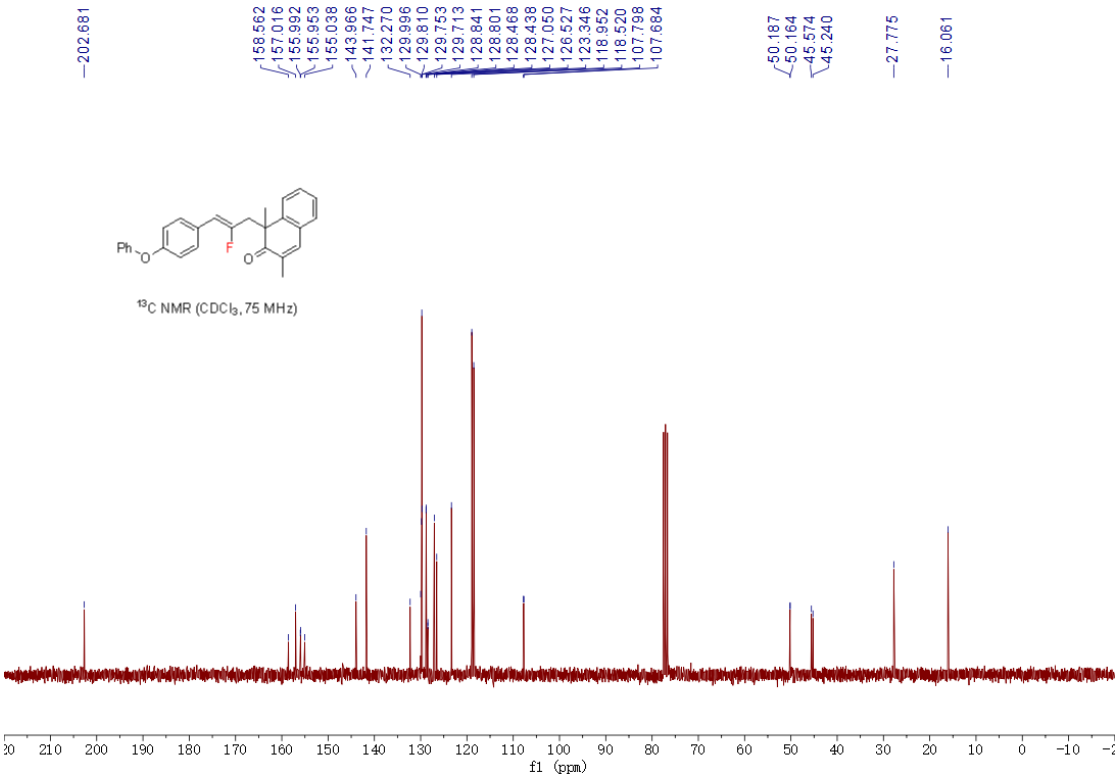

-62.5877
-94.8024
F3C
F
O
19F NMR (CDCl3, 282 MHz)
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

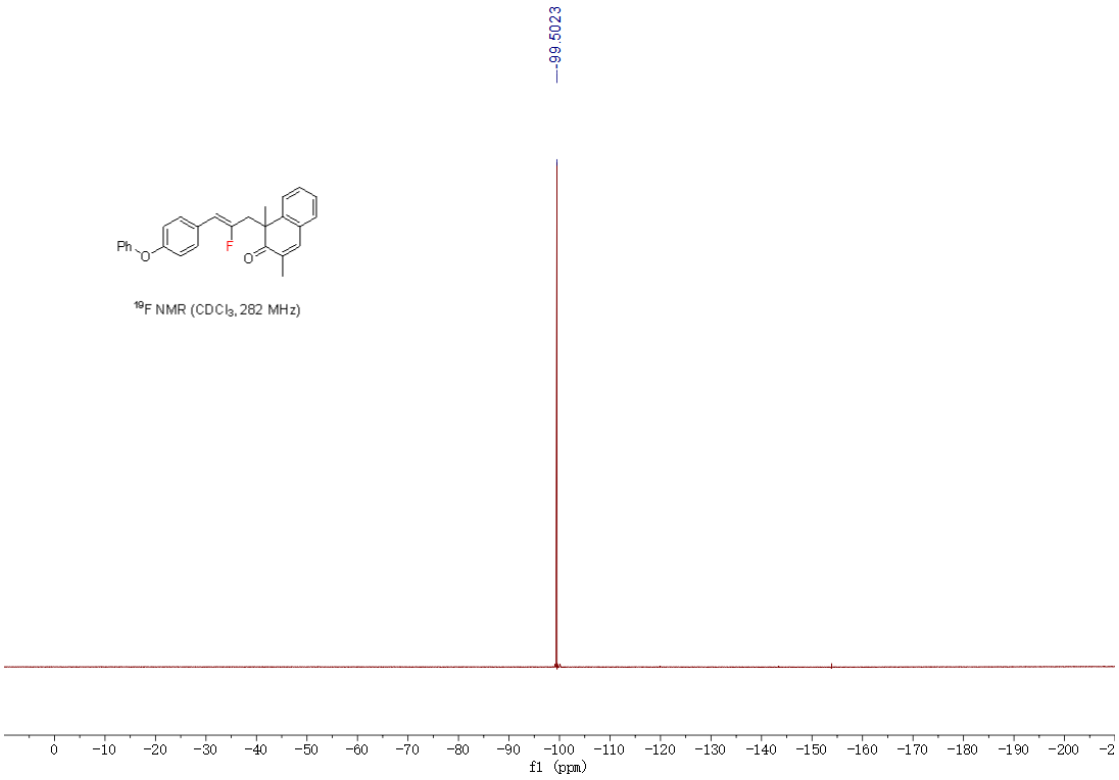

7.8768
7.8703
7.8643
7.8481
7.8419
7.8354
7.4237
7.4207
7.4183
7.4160
7.4066
7.3997
7.3972
7.3938
7.3901
7.3832
7.3750
7.3633
7.3551
7.3483
7.3380
7.3291
7.2914
7.2862
7.2659
7.2613
7.2574
7.2515
7.2455
7.2419
7.2350
7.2288
7.2217
7.2161
5.2244
5.0967
3.8586
3.3274
3.2783
3.2727
3.2235
2.8867
2.8379
2.8115
2.7626
2.0062
2.0016
1.5116
Me
O
F
O
O
1H NMR (CDCl3, 300 MHz)
2.00
2.04
5.18
1.00
3.00
1.00
1.00
3.00
2.97
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

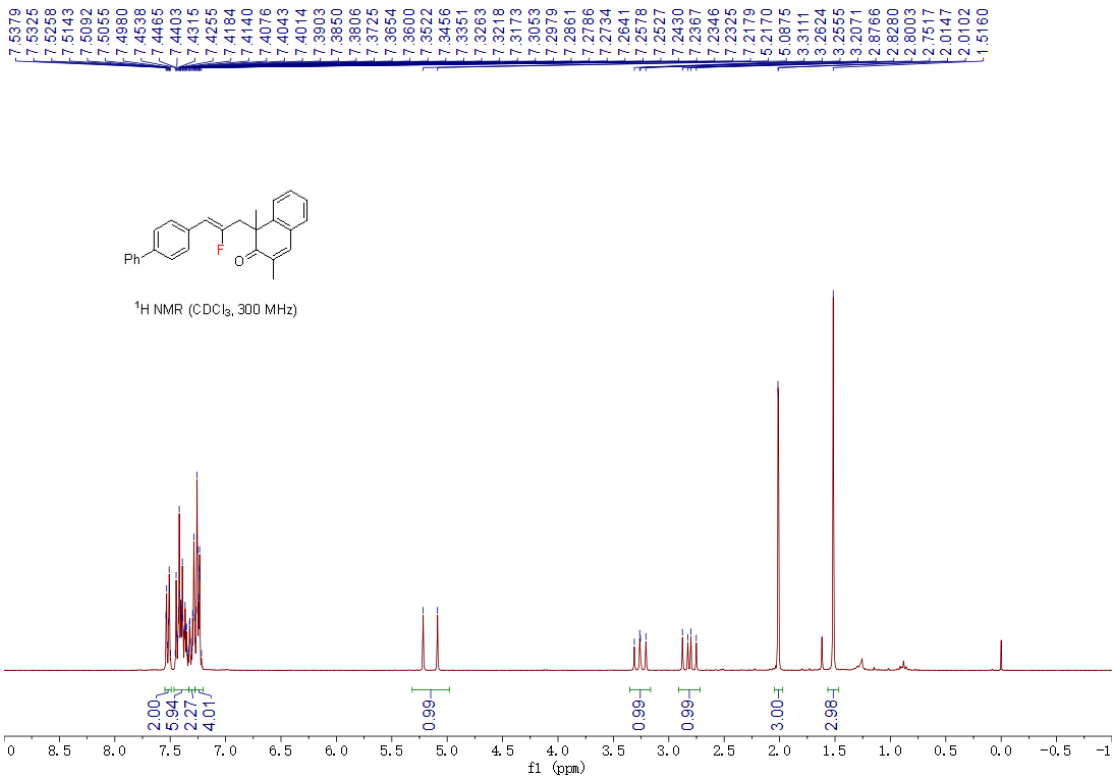

202.429
166.804
161.022
157.428
143.716
141.811
137.861
137.826
132.247
129.933
129.548
128.904
128.860
128.187
128.087
127.152
126.435
107.914
107.809
52.031
50.104
50.083
45.372
45.045
28.029
16.013
Me
O
O
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

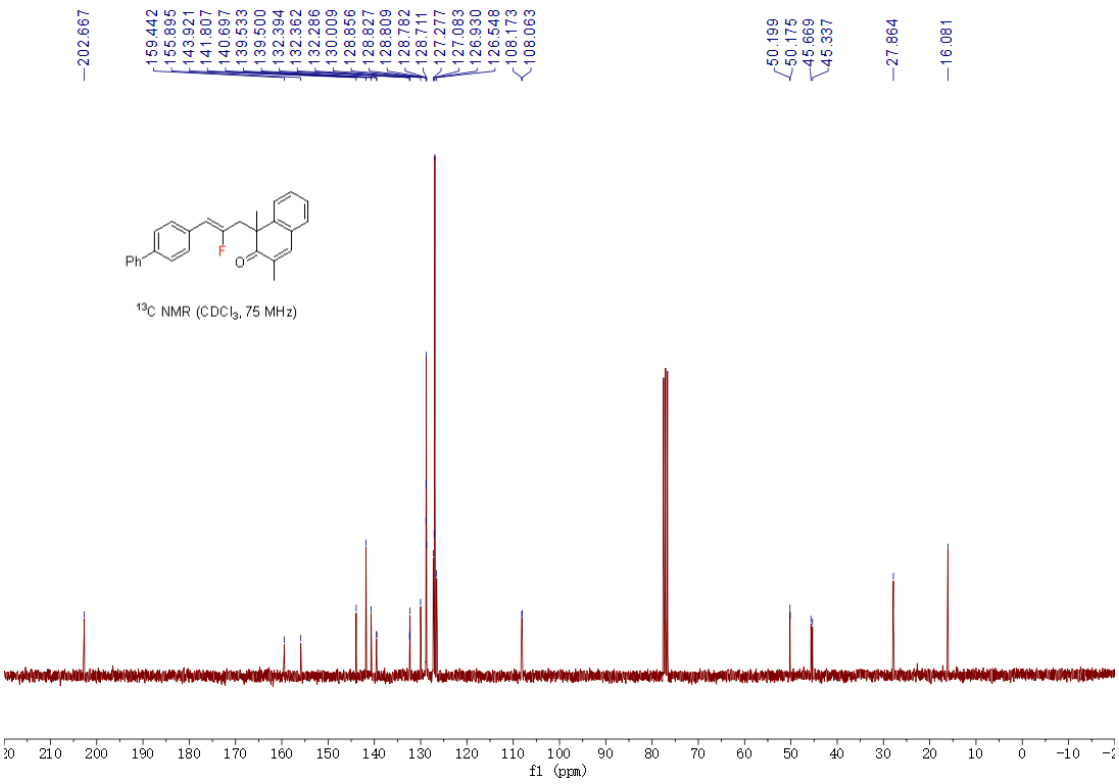

94.1223
Me
O
O
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

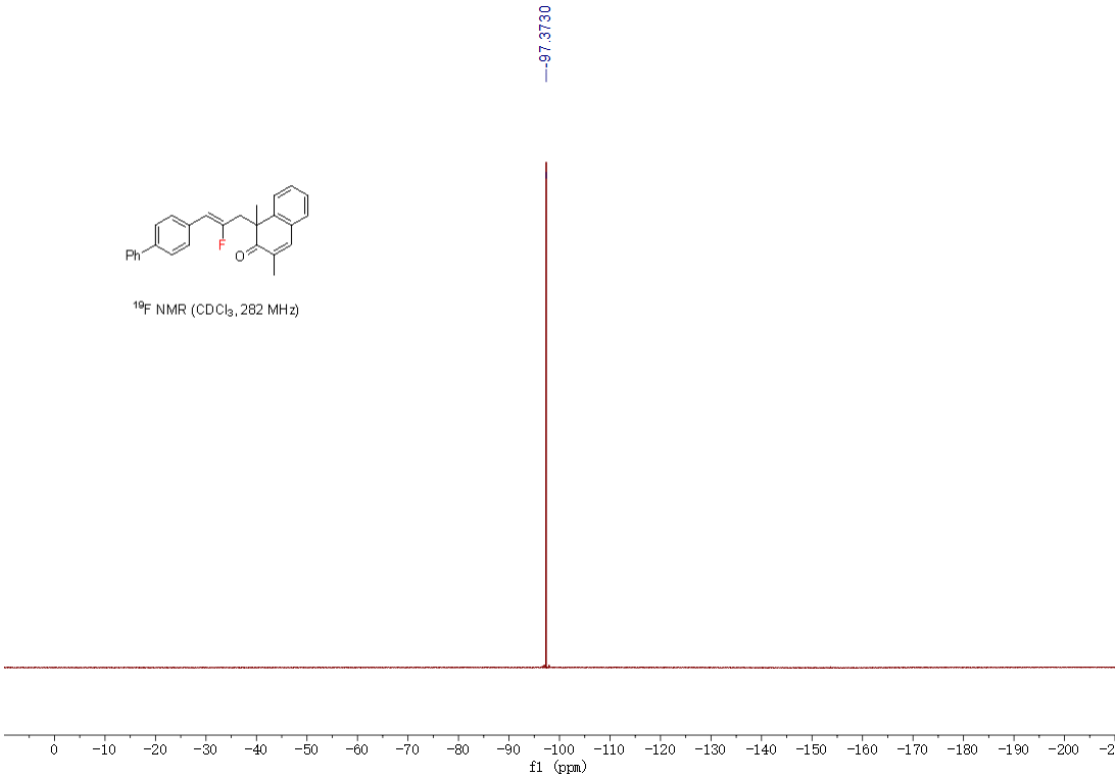

7.4159
7.4112
7.3916
7.3870
7.3832
7.3701
7.3617
7.3503
7.3419
7.3250
7.3150
7.3074
7.2900
7.2860
7.2782
7.2760
7.2712
7.2679
7.2614
7.2509
7.2464
7.2366
7.2305
7.2270
7.1777
7.1707
7.1556
7.1484
7.0926
7.0887
7.0850
7.0692
7.0642
7.0588
7.0395
6.9698
6.9637
6.9597
6.9572
6.9525
6.9413
6.9384
6.9347
6.9311
6.8392
6.8322
6.8167
6.8100
5.1477
5.0183
3.2726
3.2240
3.2171
3.1684
2.8451
2.7966
2.7692
2.7205
2.0034
1.9988
1.5037
Ph
O
F
O
1H NMR (CDCl3, 300 MHz)
1.06
1.00
5.32
2.04
1.04
1.96
2.01
1.00
1.01
1.01
3.06
3.00
f1 (ppm)

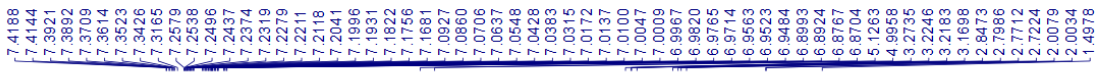

202.681
158.562
157.016
155.992
155.953
155.038
143.966
141.747
132.270
129.996
129.810
129.753
129.713
128.841
128.801
128.468
128.438
127.050
126.527
123.346
118.952
118.520
107.798
107.684
50.187
50.164
45.574
45.240
27.775
16.061
Ph
O
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

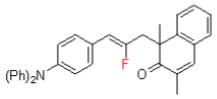

-99.5023
Ph
O
F
O
^{19}F NMR ($CDCl_3$, 282 MHz)
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -2
f1 (ppm)


7.5379
7.5325
7.5258
7.5143
7.5092
7.5055
7.4980
7.4538
7.4465
7.4403
7.4315
7.4255
7.4184
7.4140
7.4076
7.4043
7.4014
7.3903
7.3850
7.3806
7.3725
7.3654
7.3600
7.3522
7.3456
7.3351
7.3263
7.3218
7.3173
7.3053
7.2979
7.2861
7.2786
7.2734
7.2641
7.2578
7.2527
7.2430
7.2367
7.2346
7.2325
7.2179
7.2170
5.0875
3.3111
3.2624
3.2555
3.2071
2.8766
2.8280
2.8003
2.7517
2.0147
2.0102
1.5160
Ph
O
F
^{1}H NMR ($CDCl_3$, 300 MHz)
2.00
5.94
2.27
4.01
0.99
0.99
0.99
3.00
2.98
0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

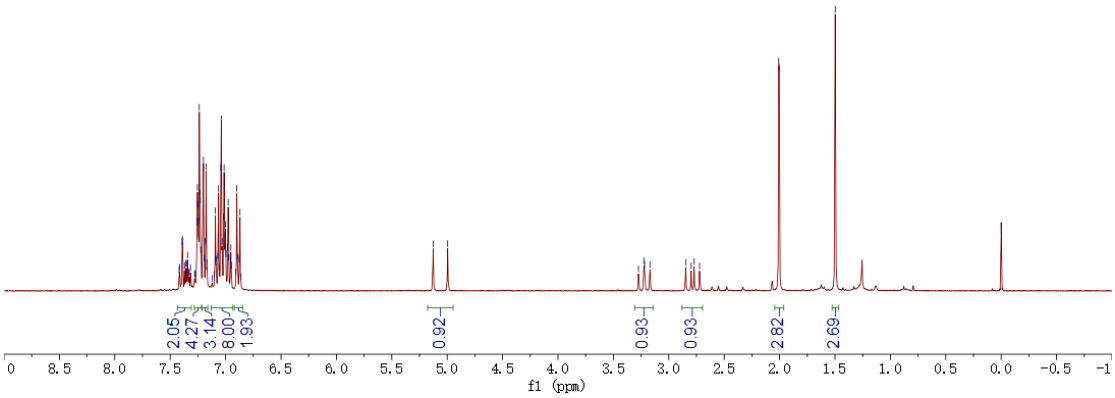

202.667
159.442
155.895
143.921
141.807
140.697
139.533
139.500
132.394
132.362
132.286
130.009
128.856
128.827
128.809
128.782
128.711
127.277
127.083
126.930
126.548
108.173
108.063
50.199
50.175
45.669
45.337
27.864
16.081
Ph
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

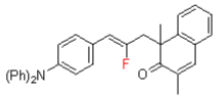

97.3730
Ph
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)



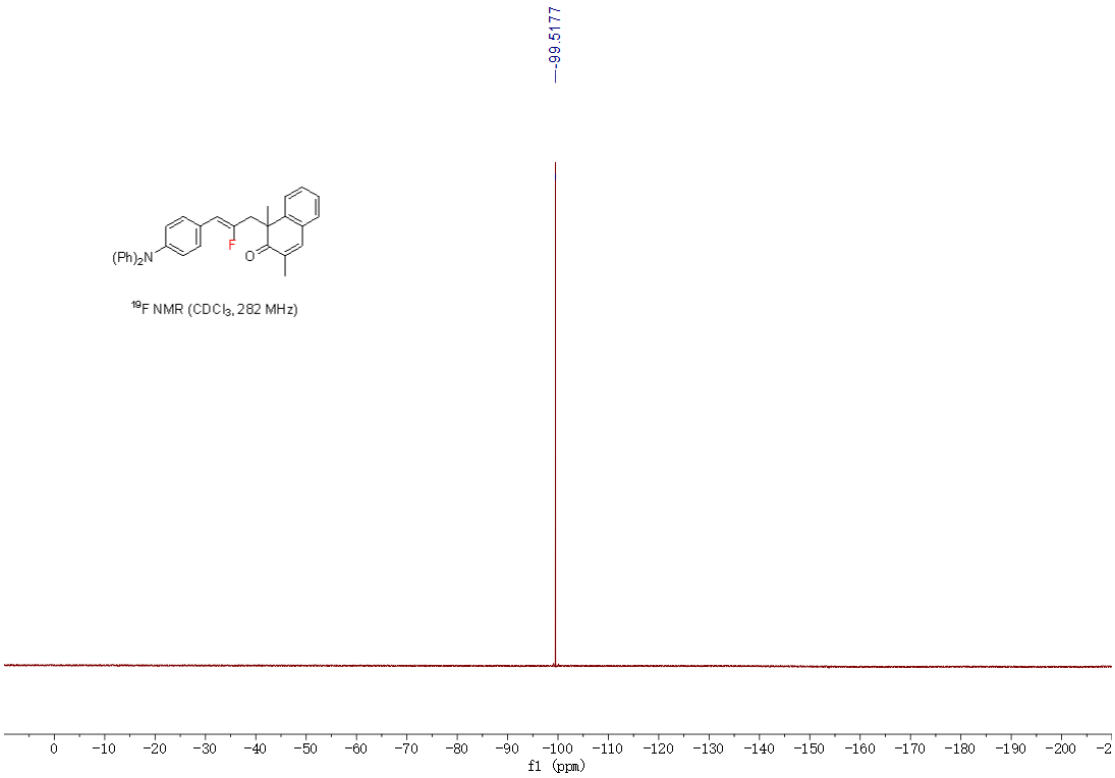


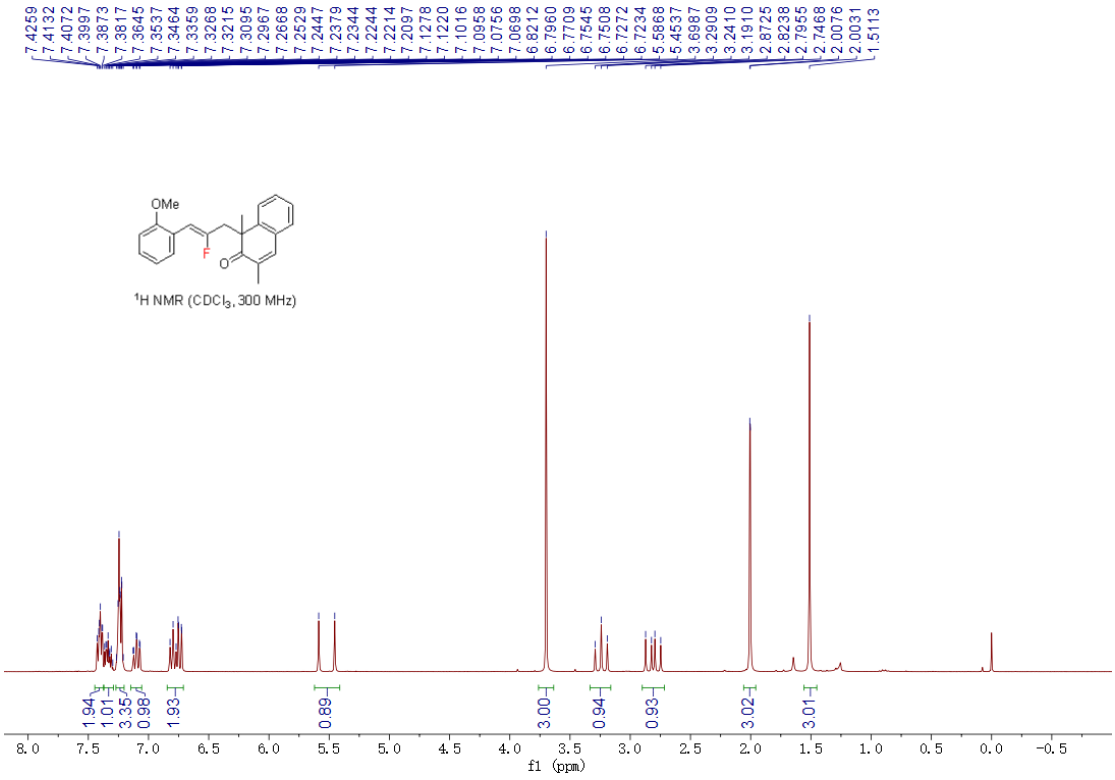
^{1}H NMR ($CDCl_3$, 300 MHz)

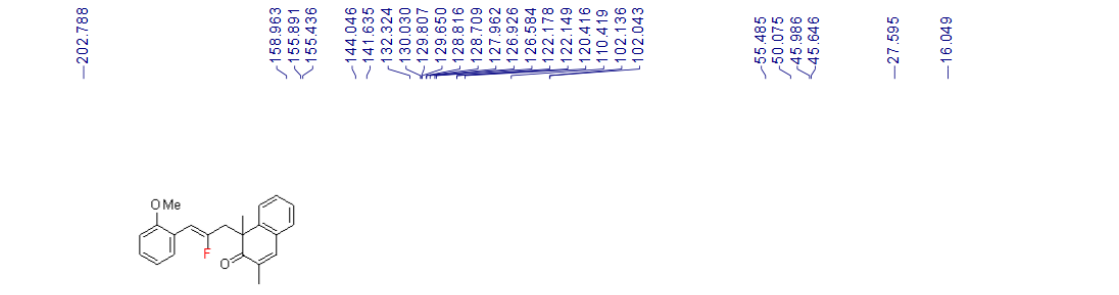




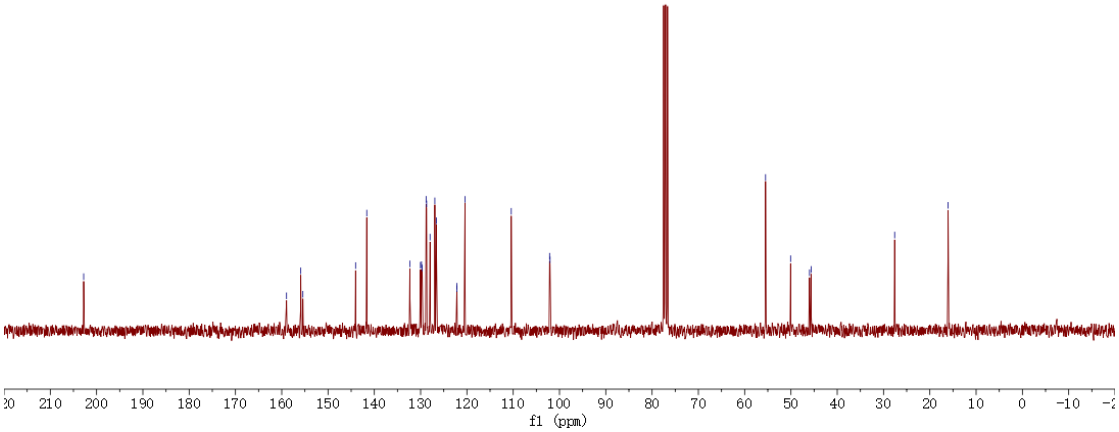
^{13}C NMR ($CDCl_3$, 75 MHz)

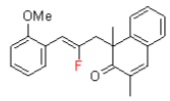

-99.5177
(Ph)2N
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)


7.4259
7.4132
7.4072
7.3997
7.3873
7.3817
7.3645
7.3537
7.3464
7.3359
7.3268
7.3215
7.3095
7.2967
7.2668
7.2529
7.2447
7.2379
7.2344
7.2244
7.2214
7.2097
7.1278
7.1220
7.1016
7.0958
7.0756
7.0698
6.8212
6.7960
6.7709
6.7545
6.7508
6.7272
6.7234
6.5868
5.4537
3.6987
3.2909
3.2410
3.1910
2.8725
2.8238
2.7955
2.7468
2.0076
2.0031
1.5113
OMe
F
O
1H NMR (CDCl3, 300 MHz)
1.94
1.01
3.35
0.98
1.93
0.89
3.00
0.94
0.93
3.02
3.01
f1 (ppm)

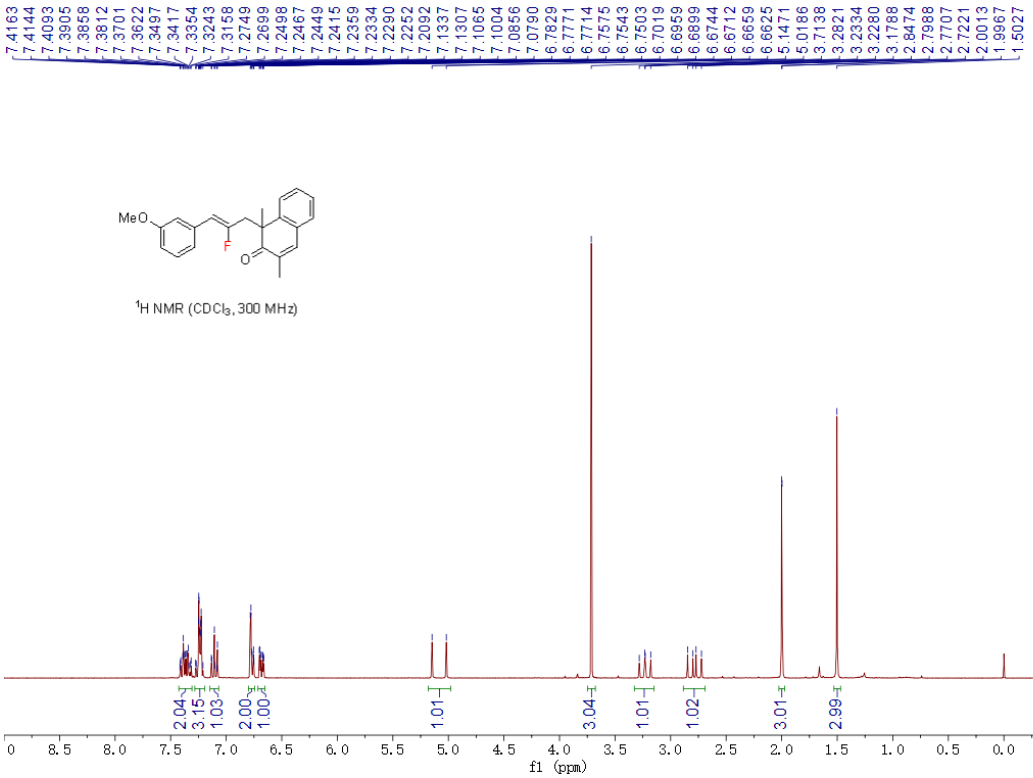


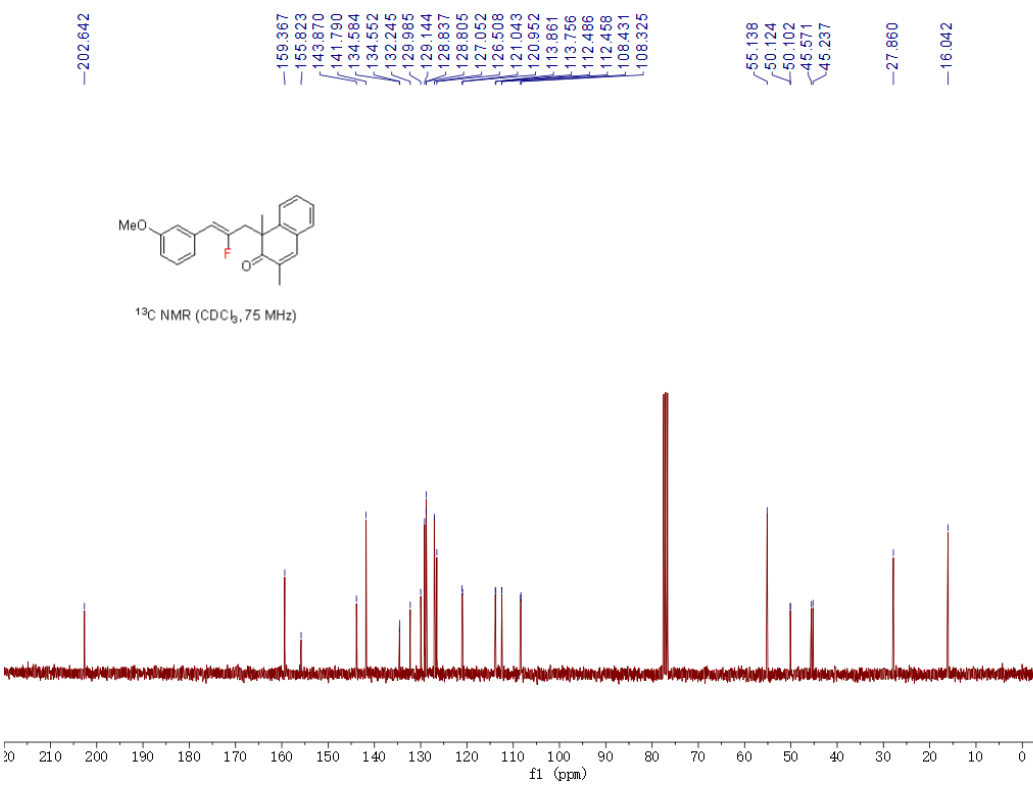
^{13}C NMR ($CDCl_3$, 75 MHz)

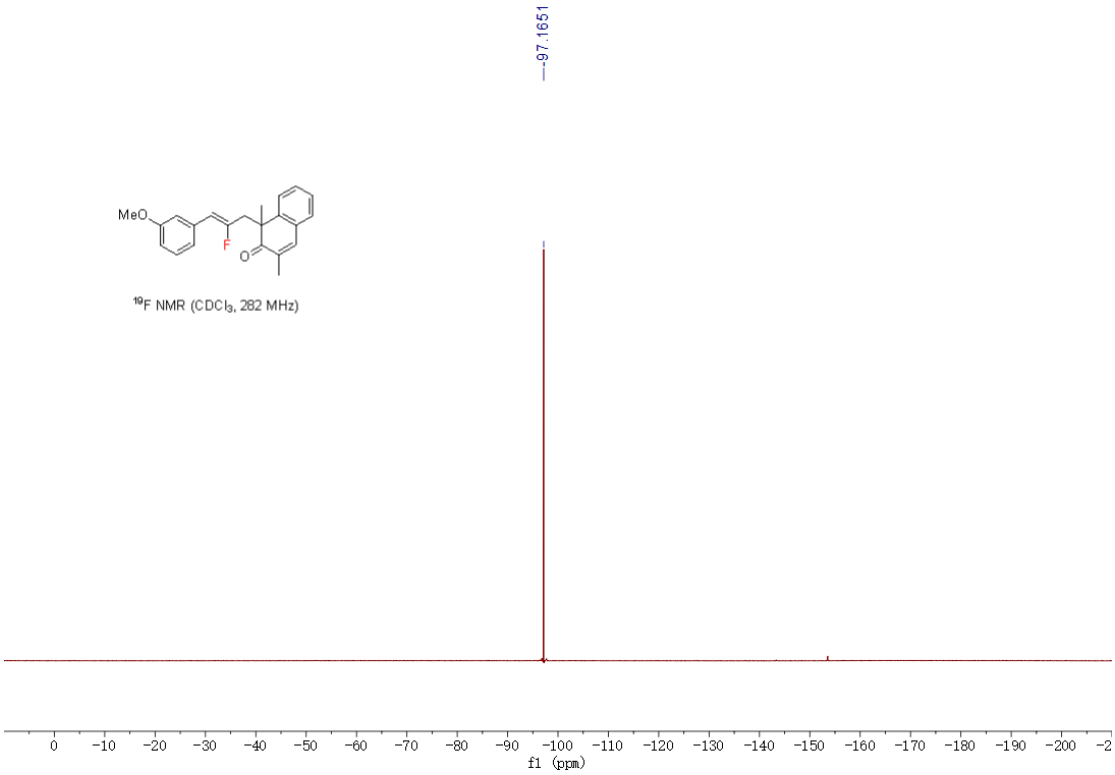


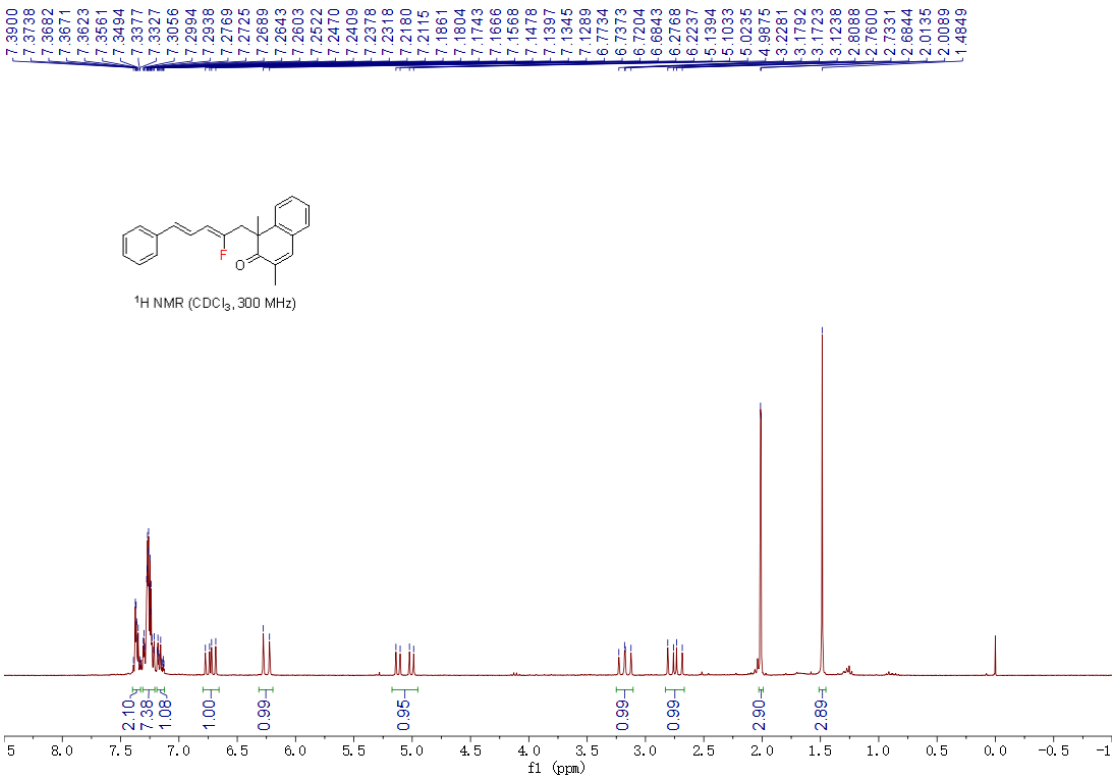


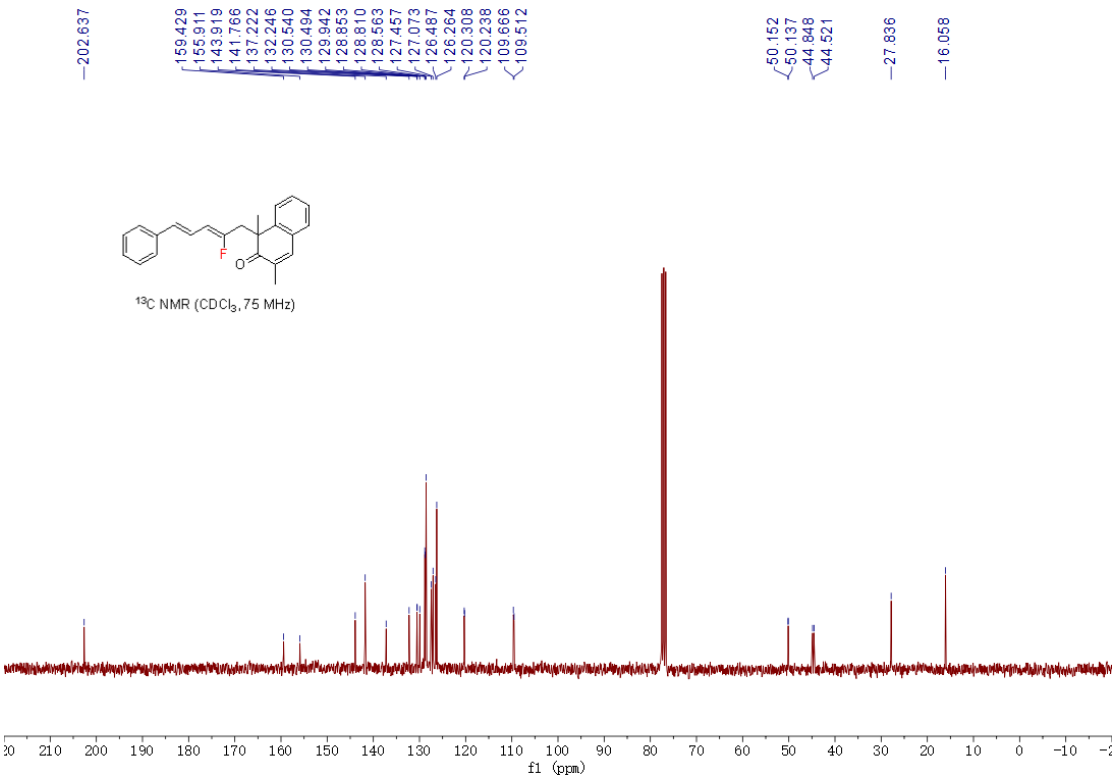
^{19}F NMR ($CDCl_3$, 282 MHz)

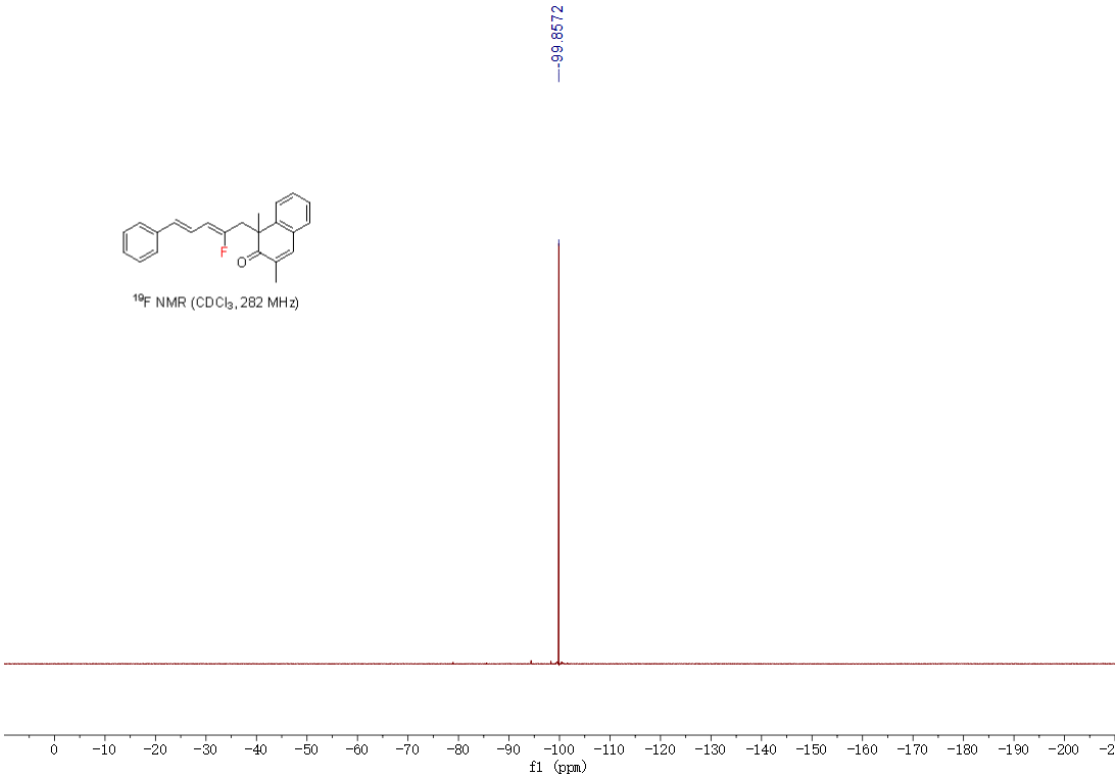

7.4163
7.4144
7.4093
7.3905
7.3858
7.3812
7.3701
7.3622
7.3497
7.3417
7.3354
7.3243
7.3158
7.2749
7.2699
7.2498
7.2467
7.2449
7.2415
7.2359
7.2334
7.2290
7.2252
7.2092
7.1337
7.1307
7.1065
7.1004
7.0856
7.0790
6.7829
6.7771
6.7714
6.7575
6.7543
6.7503
6.7019
6.6959
6.6899
6.6744
6.6712
6.6659
6.6625
5.1471
5.0186
3.7138
3.2821
3.2334
3.2280
3.1788
2.8474
2.7988
2.7707
2.7221
2.0013
1.9967
1.5027
MeO
F
O
1H NMR (CDCl3, 300 MHz)
2.04
3.15
1.03
2.00
1.00
1.01
3.04
1.01
1.02
3.01
2.99
f1 (ppm)

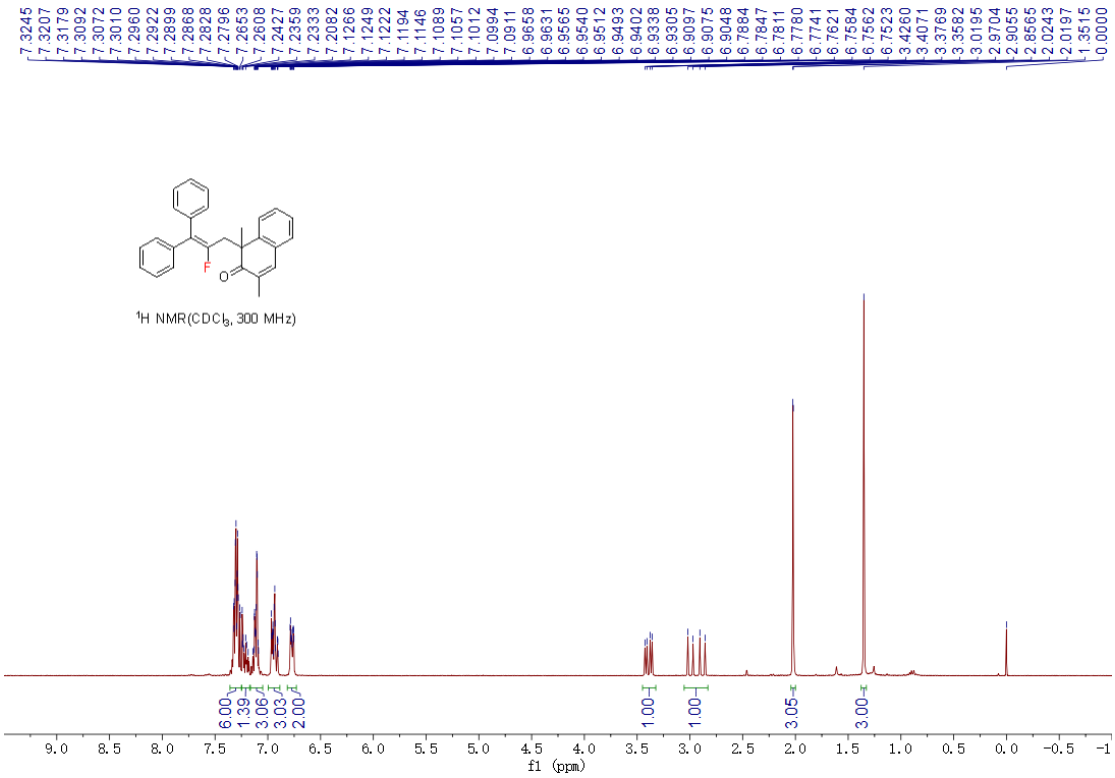

202.642
159.367
155.823
143.870
141.790
134.584
134.552
132.245
129.985
129.144
128.837
128.805
127.052
126.508
121.043
120.952
113.861
113.756
112.486
112.458
108.431
108.325
55.138
50.124
50.102
45.571
45.237
27.860
16.042
MeO
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

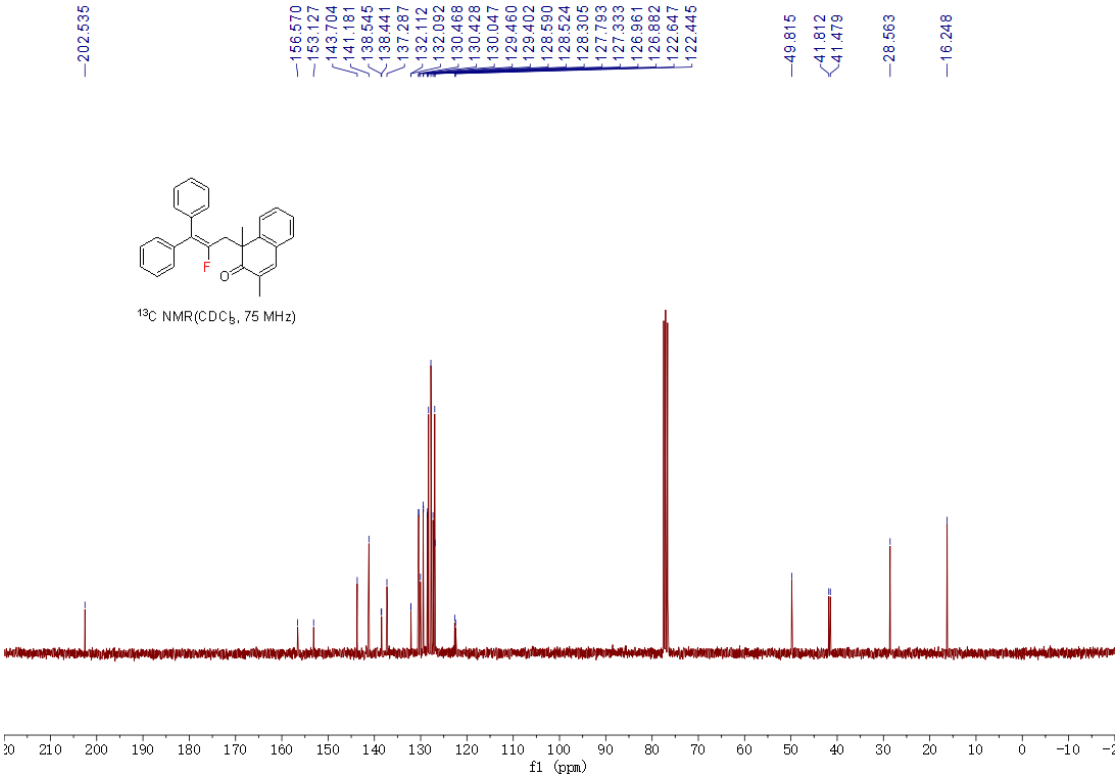

-97.1651
MeO
F
O
^{19}F NMR ($CDCl_3$, 282 MHz)
f1 (ppm)

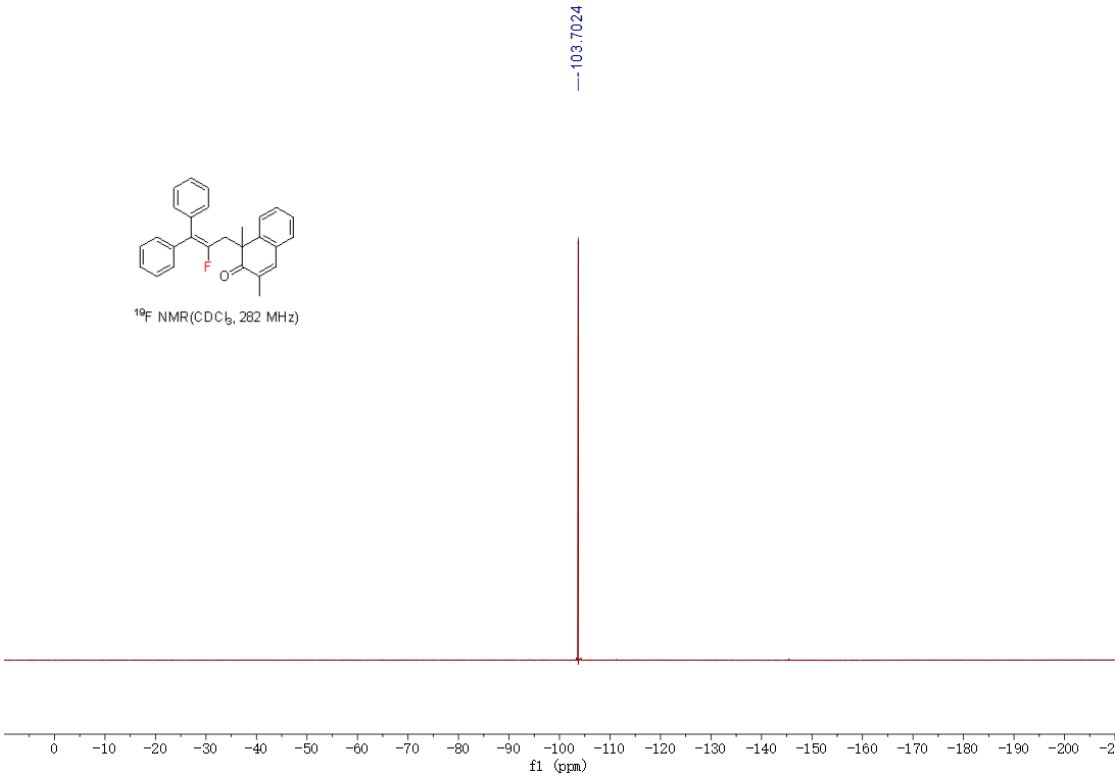

F
O
^{1}H NMR ($CDCl_3$, 300 MHz)
2.10
7.38
1.08
1.00
0.99
0.95
0.99
0.99
2.90
2.89
f1 (ppm)

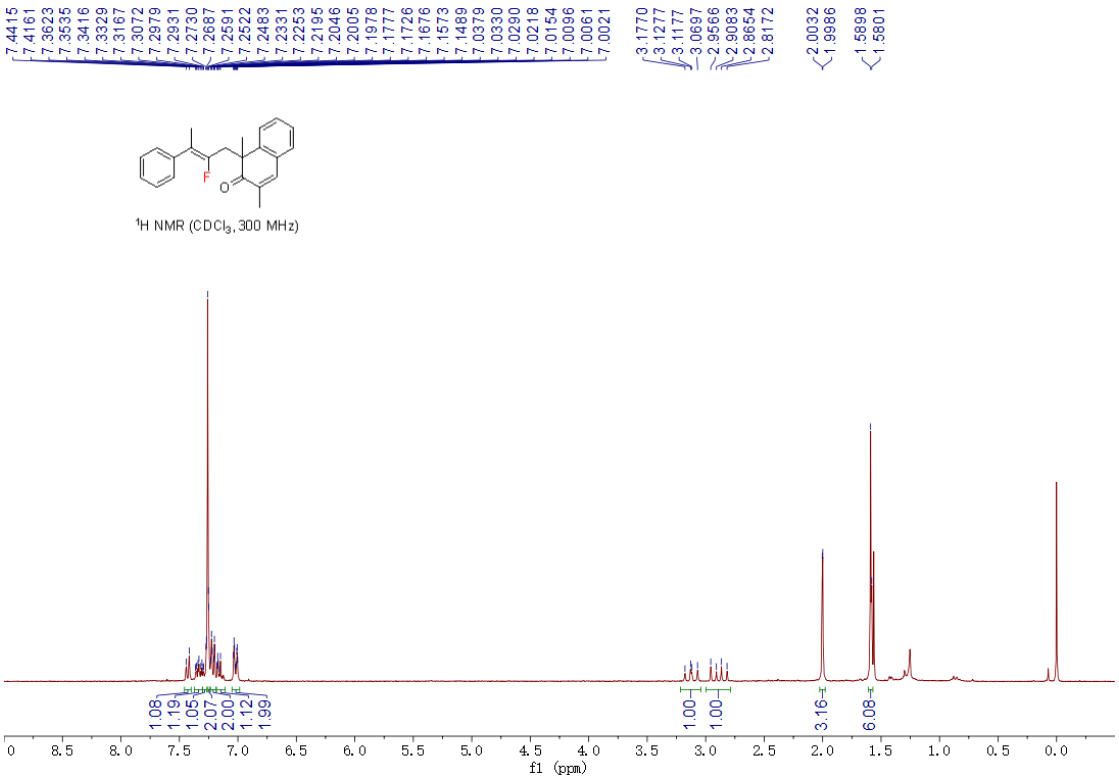

202.637
159.429
155.911
143.919
141.766
137.222
132.246
130.540
130.494
129.942
128.853
128.810
128.563
127.457
127.073
126.487
126.264
120.308
120.238
109.666
109.512
50.152
50.137
44.848
44.521
27.836
16.058
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

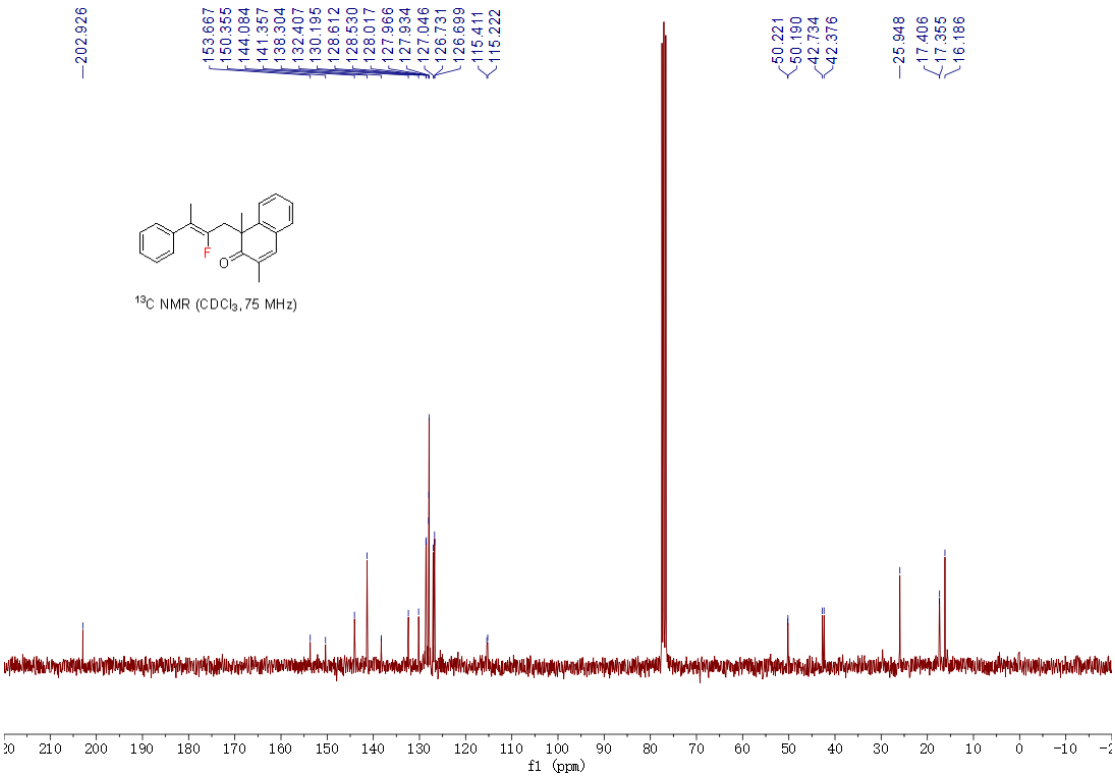

99.8572
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

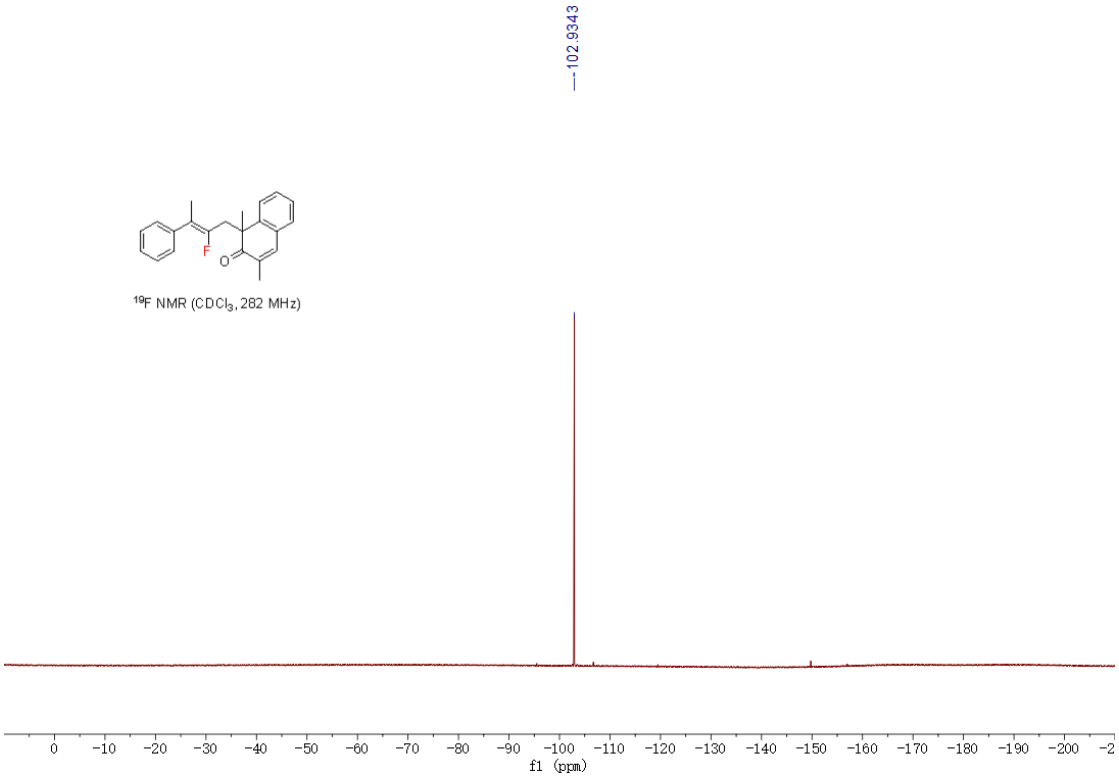

7.3245
7.3207
7.3179
7.3092
7.3072
7.3010
7.2960
7.2922
7.2899
7.2868
7.2828
7.2796
7.2653
7.2608
7.2427
7.2359
7.2333
7.2082
7.1266
7.1249
7.1222
7.1194
7.1146
7.1089
7.1057
7.1012
7.0994
7.0911
6.9658
6.9631
6.9565
6.9540
6.9512
6.9493
6.9402
6.9338
6.9305
6.9097
6.9075
6.9048
6.7884
6.7847
6.7811
6.7780
6.7741
6.7621
6.7584
6.7562
6.7523
3.4260
3.4071
3.3769
3.3582
3.0195
2.9704
2.9055
2.8565
2.0243
2.0197
1.3515
0.0000
F
O
1H NMR(CDCl3, 300 MHz)
6.00
1.39
3.06
3.03
2.00
1.00
1.00
3.05
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

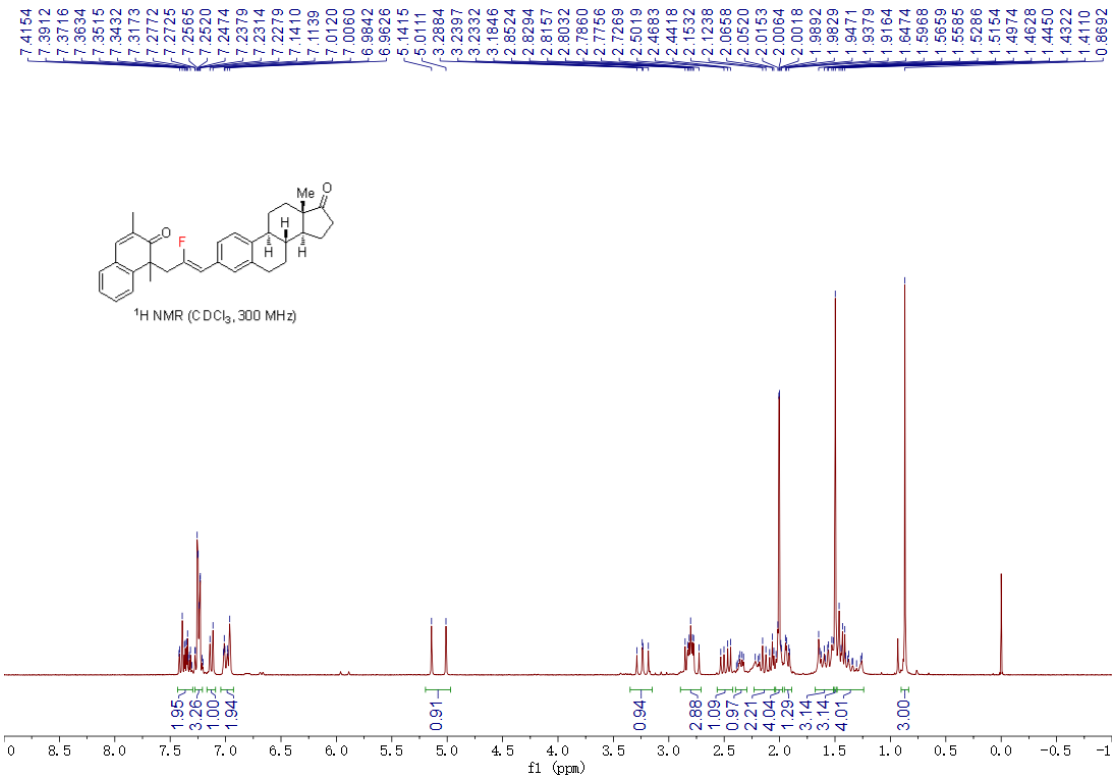

202.535
156.570
153.127
143.704
141.181
138.545
138.441
137.287
132.112
132.092
130.468
130.428
130.047
129.460
129.402
128.590
128.524
128.305
127.793
127.333
126.961
126.882
122.647
122.445
49.815
41.812
41.479
28.563
16.248
F
O
13C NMR(CDCl3, 75 MHz)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

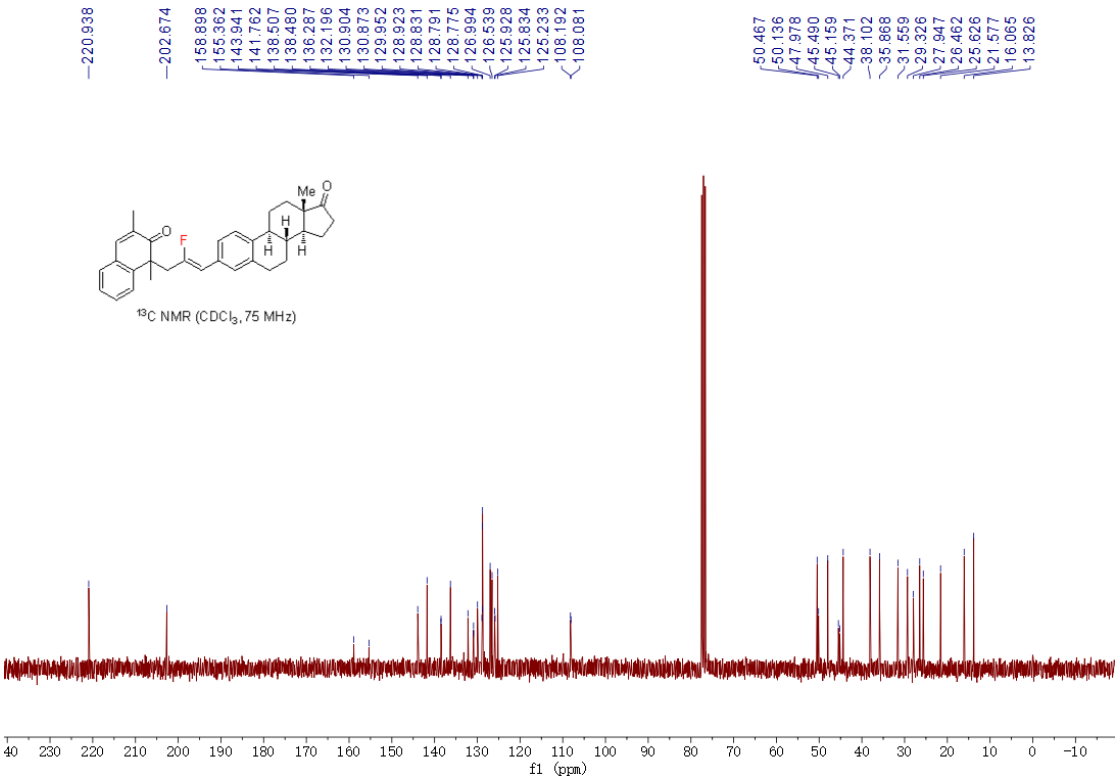

-103.7024
F
O
^{19}F NMR(CDCl$_3$, 282 MHz)
f1 (ppm)

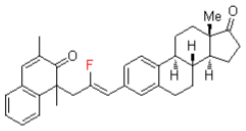

7.4415
7.4161
7.3623
7.3535
7.3416
7.3329
7.3167
7.3072
7.2979
7.2931
7.2730
7.2687
7.2591
7.2522
7.2483
7.2331
7.2253
7.2195
7.2046
7.2005
7.1978
7.1777
7.1726
7.1676
7.1573
7.1489
7.0379
7.0330
7.0290
7.0218
7.0154
7.0096
7.0061
7.0021
3.1770
3.1277
3.1177
3.0697
2.9566
2.9083
2.8654
2.8172
2.0032
1.9986
1.5898
1.5801
F
O
^{1}H NMR (CDCl$_3$, 300 MHz)
1.08
1.19
1.05
2.07
2.00
1.12
1.99
1.00
1.00
3.16
6.08
f1 (ppm)


202.926
153.667
150.355
144.084
141.357
138.304
132.407
130.195
128.612
128.530
128.017
127.966
127.934
127.046
126.731
126.699
115.411
115.222
50.221
50.190
42.734
42.376
25.948
17.406
17.355
16.186
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

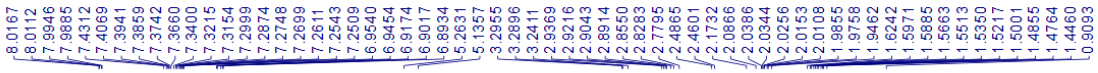

102.9343
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

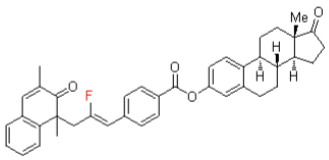

7.4154
7.3912
7.3716
7.3634
7.3515
7.3432
7.3173
7.2772
7.2725
7.2565
7.2520
7.2474
7.2379
7.2314
7.2279
7.1410
7.1139
7.0120
7.0060
6.9842
6.9626
5.1415
5.0111
3.2884
3.2397
3.2332
3.1846
2.8524
2.8294
2.8157
2.8032
2.7860
2.7756
2.7269
2.5019
2.4683
2.4418
2.1532
2.1238
2.0658
2.0520
2.0153
2.0064
2.0018
1.9892
1.9829
1.9471
1.9379
1.9164
1.6474
1.5968
1.5659
1.5585
1.5286
1.5154
1.4974
1.4628
1.4450
1.4322
1.4110
0.8692
Me
O
O
F
H
H
H
1H NMR (CDCl3, 300 MHz)
1.95
3.26
1.00
1.94
0.91
0.94
2.88
1.09
0.97
2.21
4.04
1.29
3.14
3.14
4.01
3.00
f1 (ppm)


220.938
202.674
158.898
155.362
143.941
141.762
138.507
138.480
136.287
132.196
130.904
130.873
129.952
128.923
128.831
128.791
128.775
126.994
126.539
125.928
125.834
125.233
108.192
108.081
50.467
50.136
47.978
45.490
45.159
44.371
38.102
35.868
31.559
29.326
27.947
26.462
25.626
21.577
16.065
13.826
Me
O
O
F
H
H
H
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

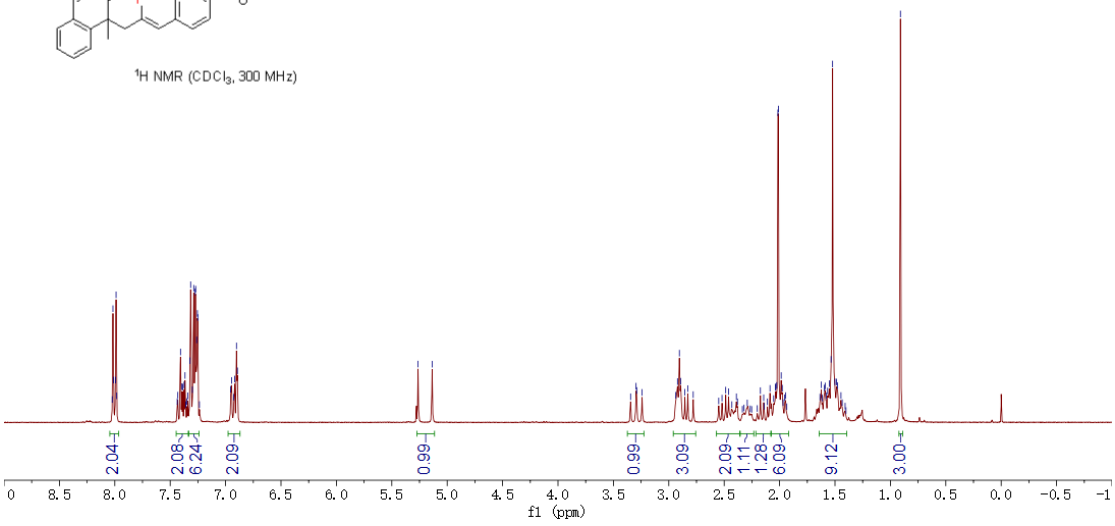


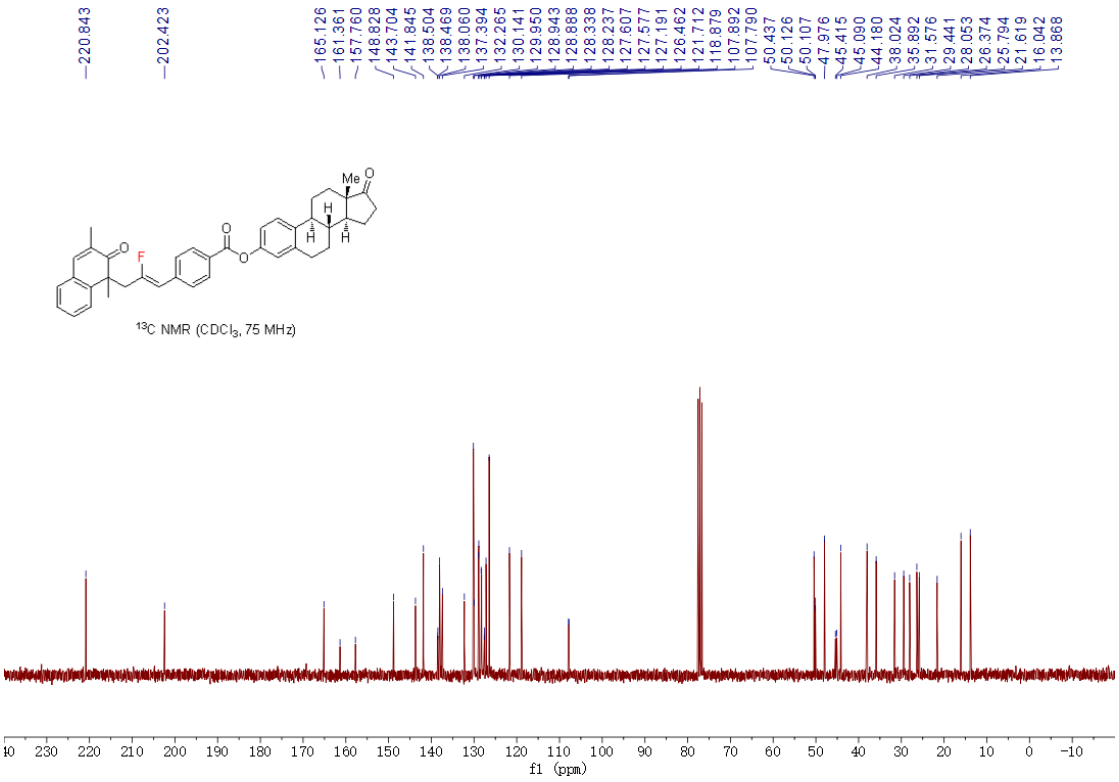
^{19}F NMR ($CDCl_3$, 282 MHz)

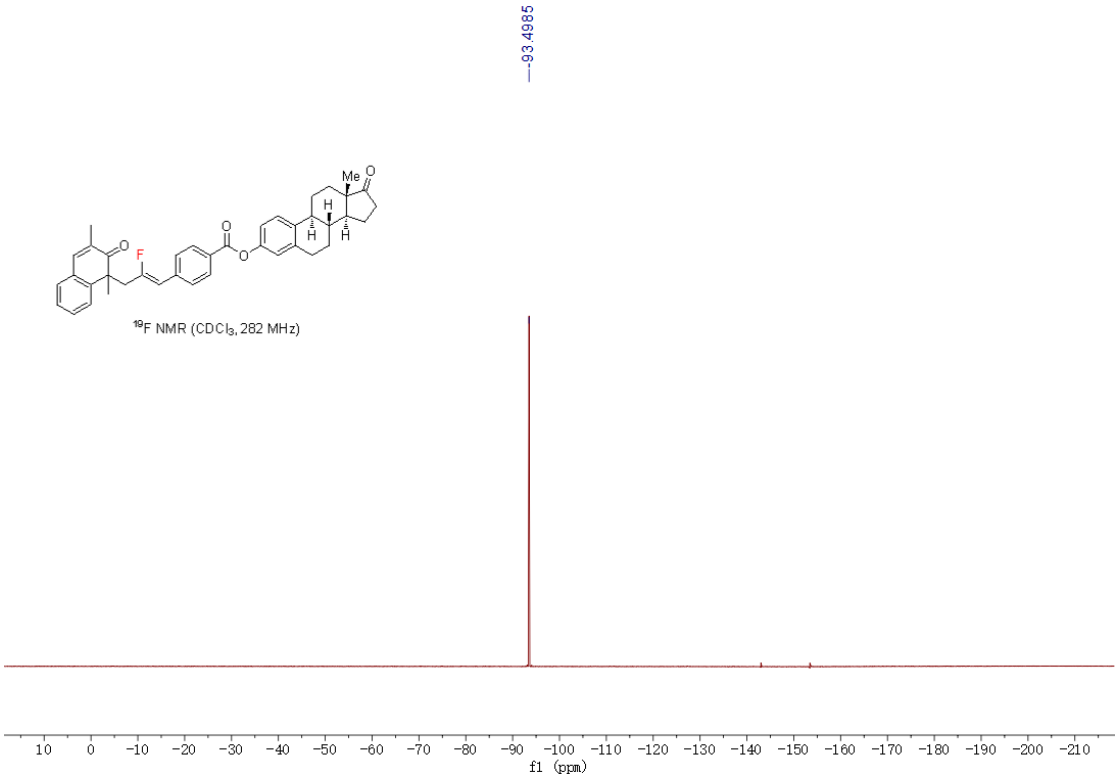


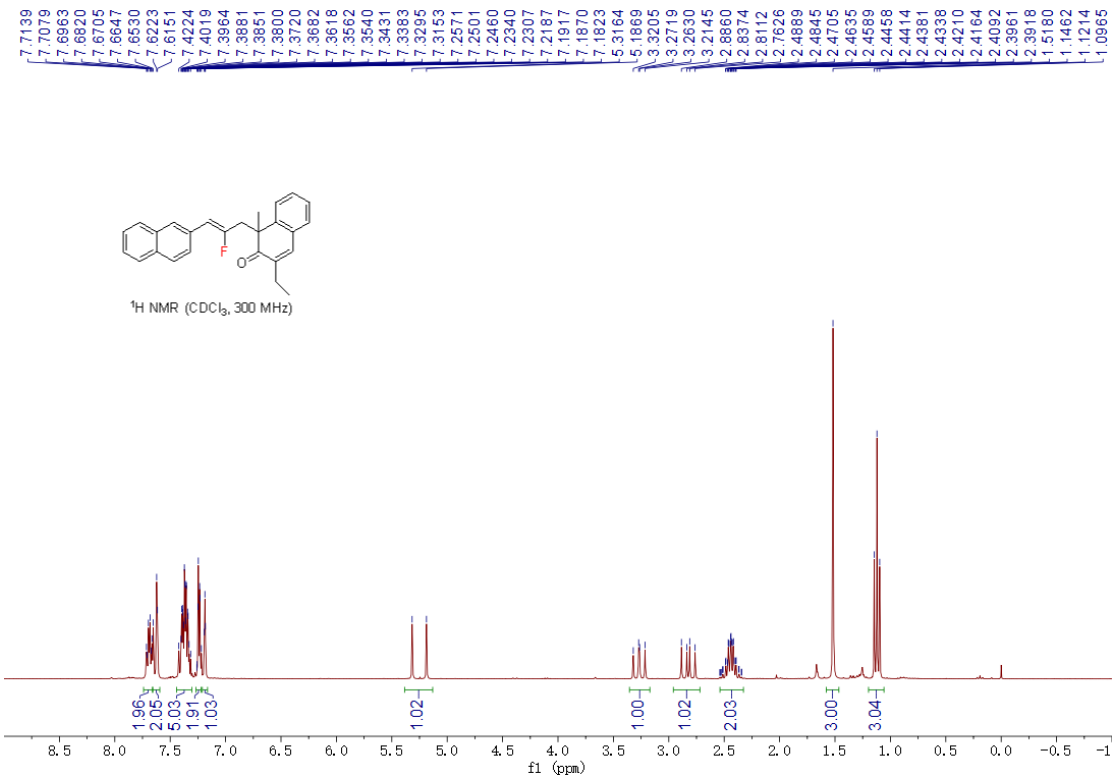


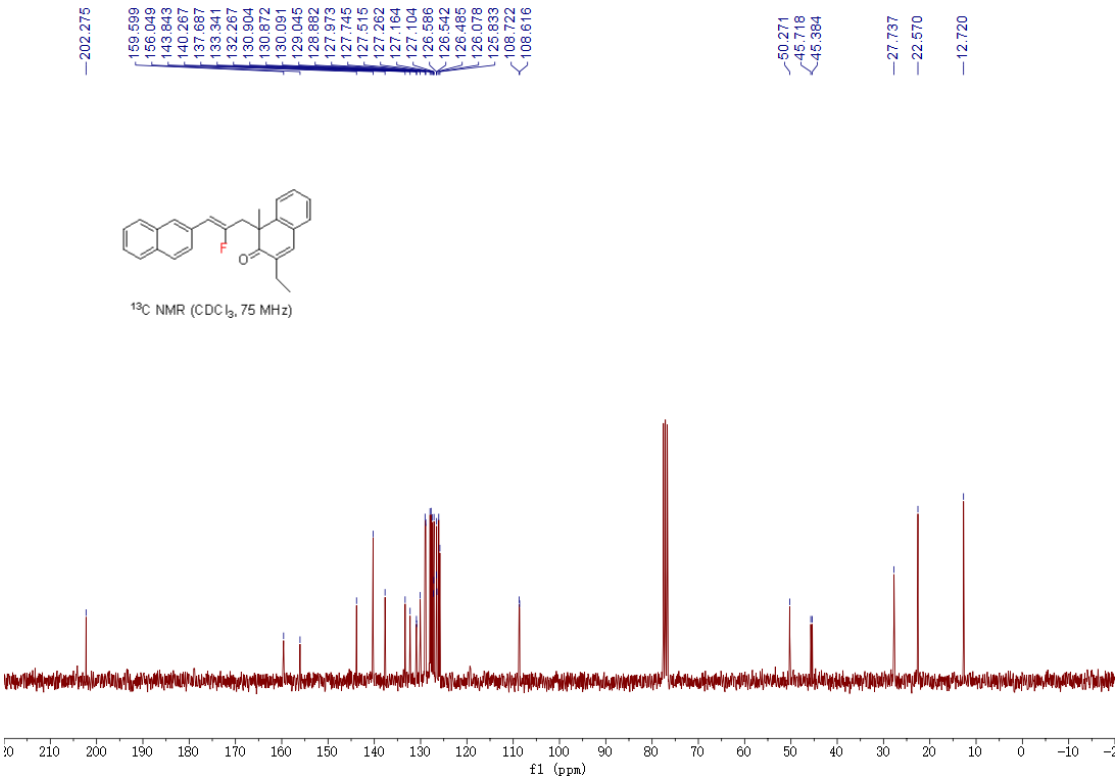
^{1}H NMR ($CDCl_3$, 300 MHz)

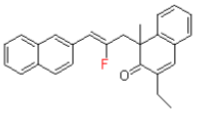



220.843
202.423
165.126
161.361
157.760
148.828
143.704
141.845
138.504
138.469
138.060
137.394
132.265
130.141
129.950
128.943
128.888
128.338
128.237
127.607
127.577
127.191
126.462
121.712
118.879
107.892
107.790
50.437
50.126
50.107
47.976
45.415
45.090
44.180
38.024
35.892
31.576
29.441
28.053
26.374
25.794
21.619
16.042
13.868
Me
O
H
H
H
O
O
F
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

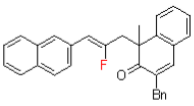

93.4985
Me
O
H
H
H
O
O
F
19F NMR (CDCl3, 282 MHz)
f1 (ppm)


7.7139
7.7079
7.6963
7.6820
7.6705
7.6647
7.6530
7.6223
7.6151
7.4224
7.4019
7.3964
7.3881
7.3851
7.3800
7.3720
7.3682
7.3618
7.3562
7.3540
7.3431
7.3383
7.3295
7.3153
7.2571
7.2501
7.2460
7.2340
7.2307
7.2187
7.1917
7.1870
7.1823
5.3164
5.1869
3.3205
3.2719
3.2630
3.2145
2.8860
2.8374
2.8112
2.7626
2.4889
2.4845
2.4705
2.4635
2.4589
2.4458
2.4414
2.4381
2.4338
2.4210
2.4164
2.4092
2.3961
2.3918
1.5180
1.1462
1.1214
1.0965
F
O
1H NMR (CDCl3, 300 MHz)
1.96
2.05
5.03
1.91
1.03
1.02
1.00
1.02
2.03
3.00
3.04
f1 (ppm)

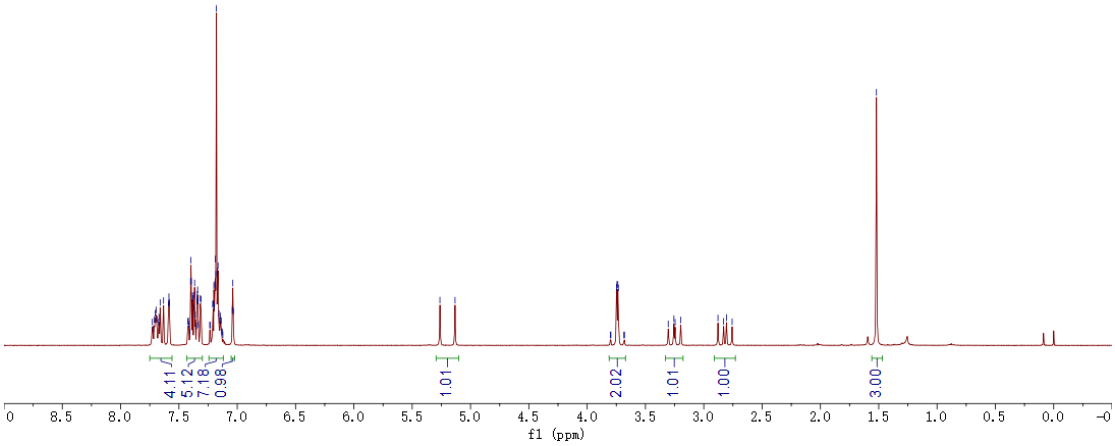

202.275
159.599
156.049
143.843
140.267
137.687
133.341
132.267
130.904
130.872
130.091
129.045
128.882
127.973
127.745
127.515
127.262
127.164
127.104
126.586
126.542
126.485
126.078
125.833
108.722
108.616
50.271
45.718
45.384
27.737
22.570
12.720
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

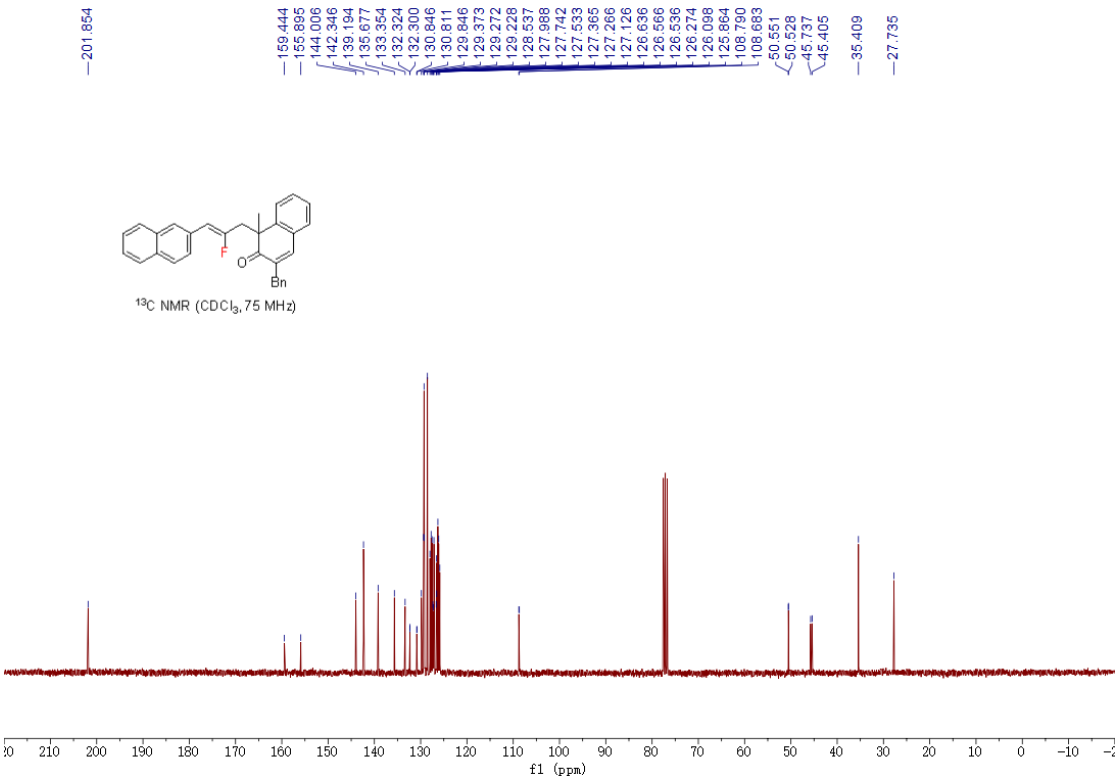


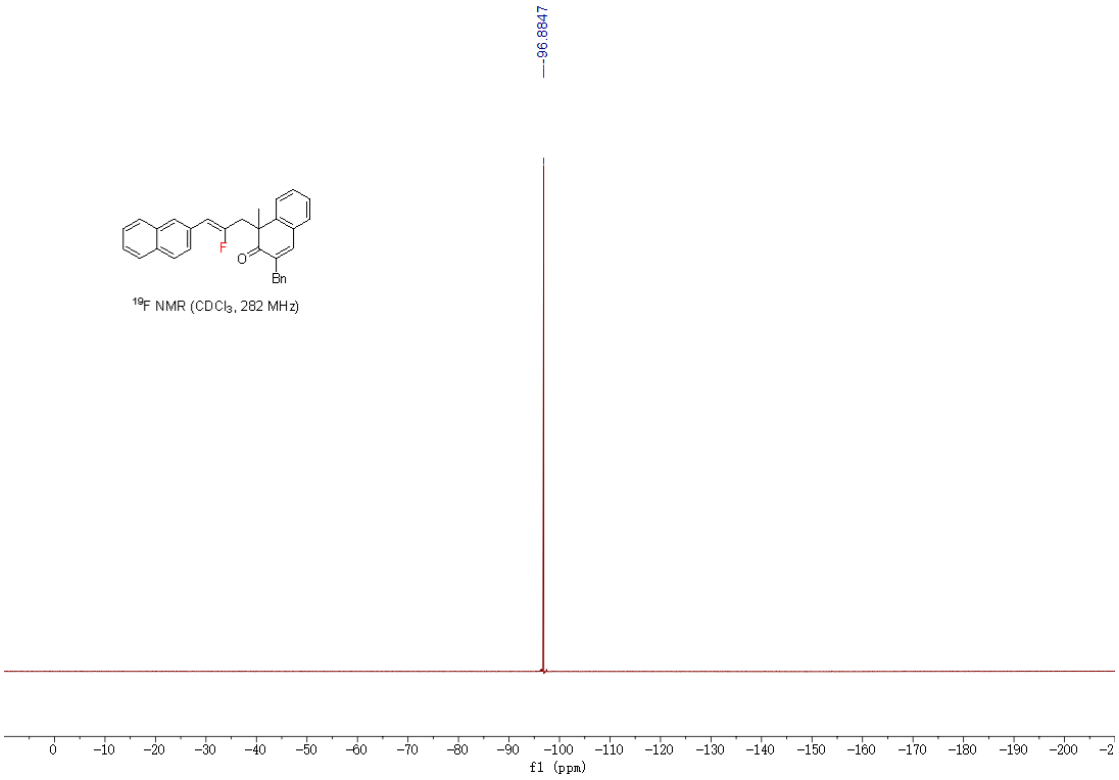
^{19}F NMR ($CDCl_3$, 282 MHz)

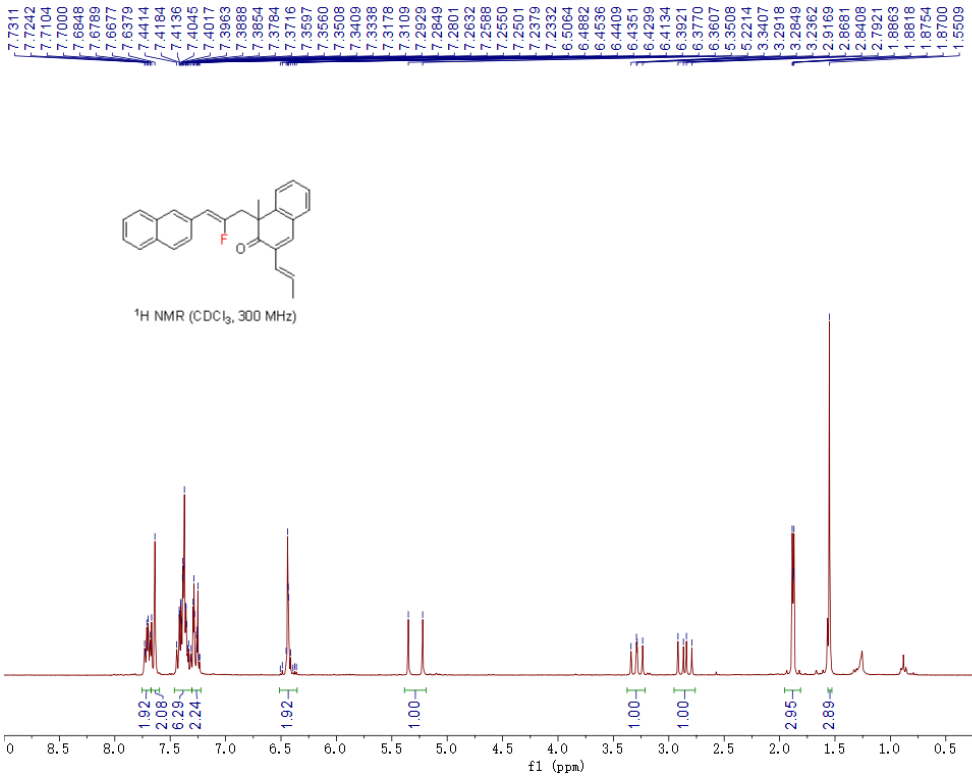


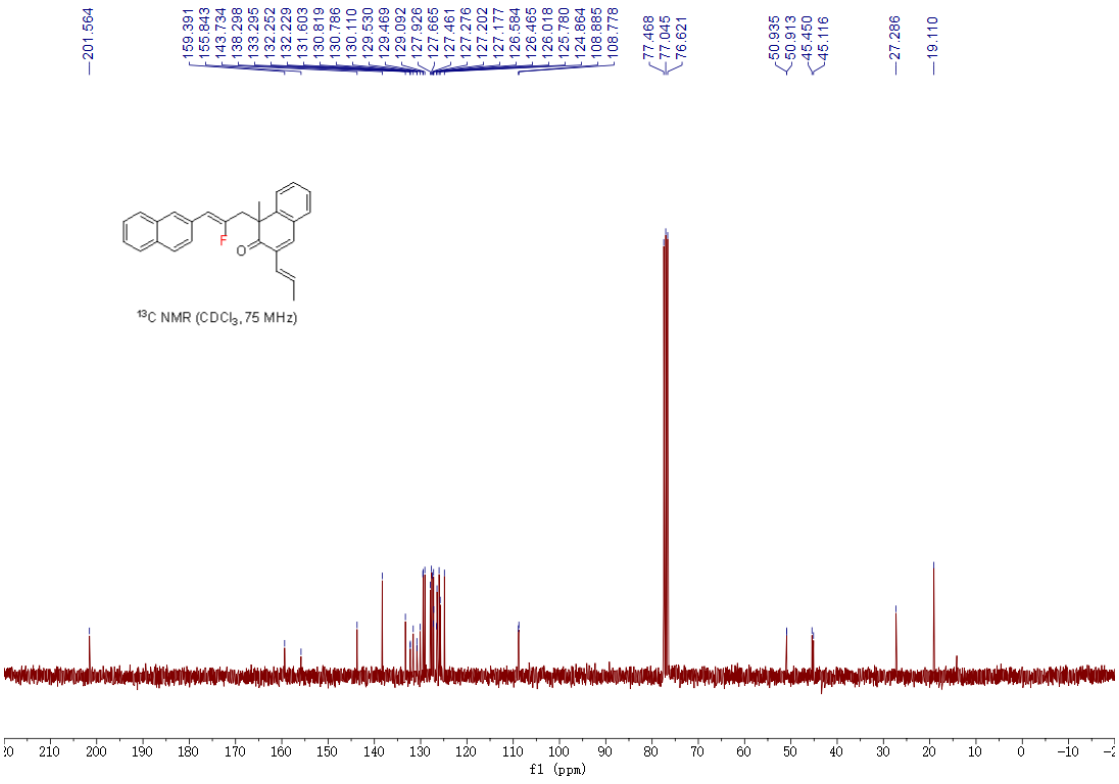
^{1}H NMR ($CDCl_3$, 300 MHz)

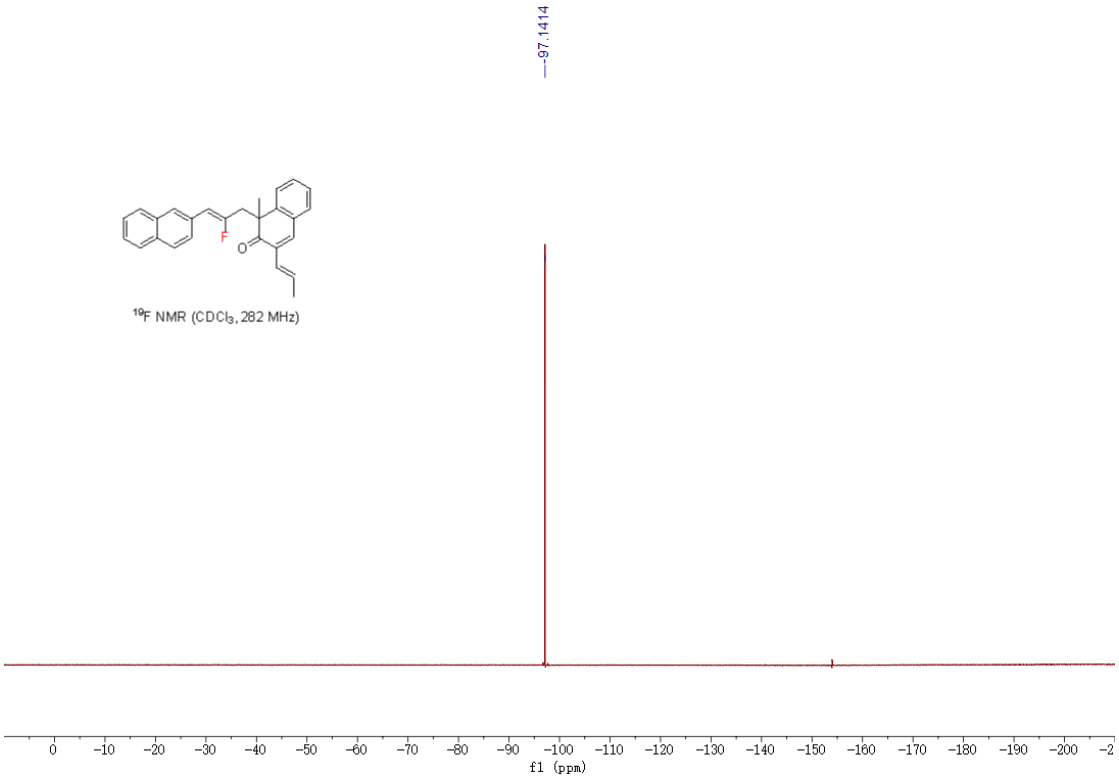



201.854
159.444
155.895
144.006
142.346
139.194
135.677
133.354
132.324
132.300
130.846
130.811
129.846
129.373
129.272
129.228
128.537
127.988
127.742
127.533
127.365
127.266
127.126
126.636
126.566
126.536
126.274
126.098
125.864
108.790
108.683
50.551
50.528
45.737
45.405
35.409
27.735
F
O
Bn
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

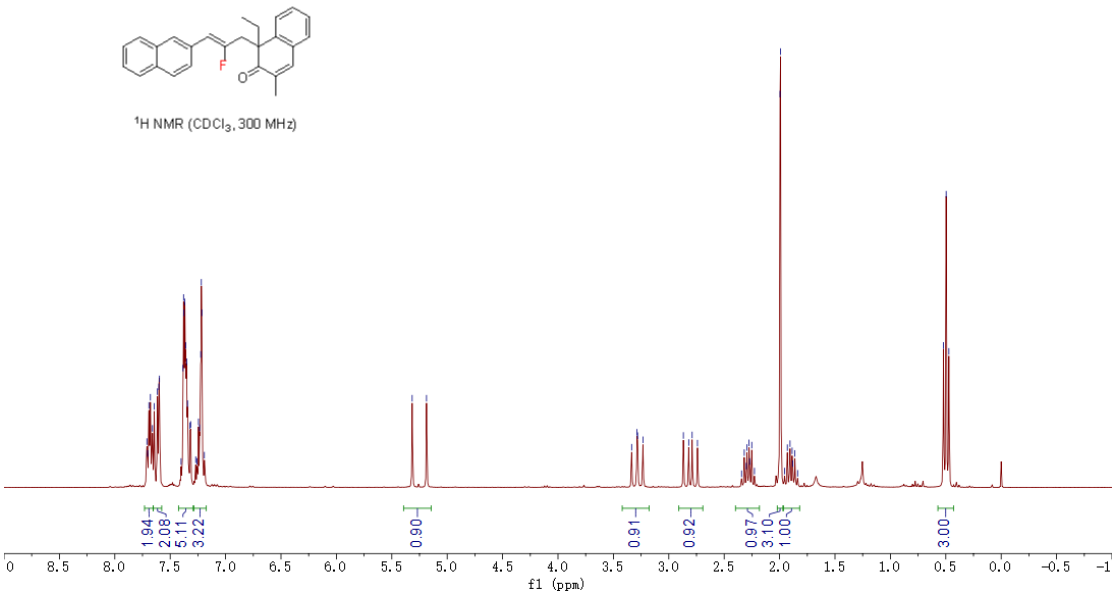

96.8847
F
O
Bn
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

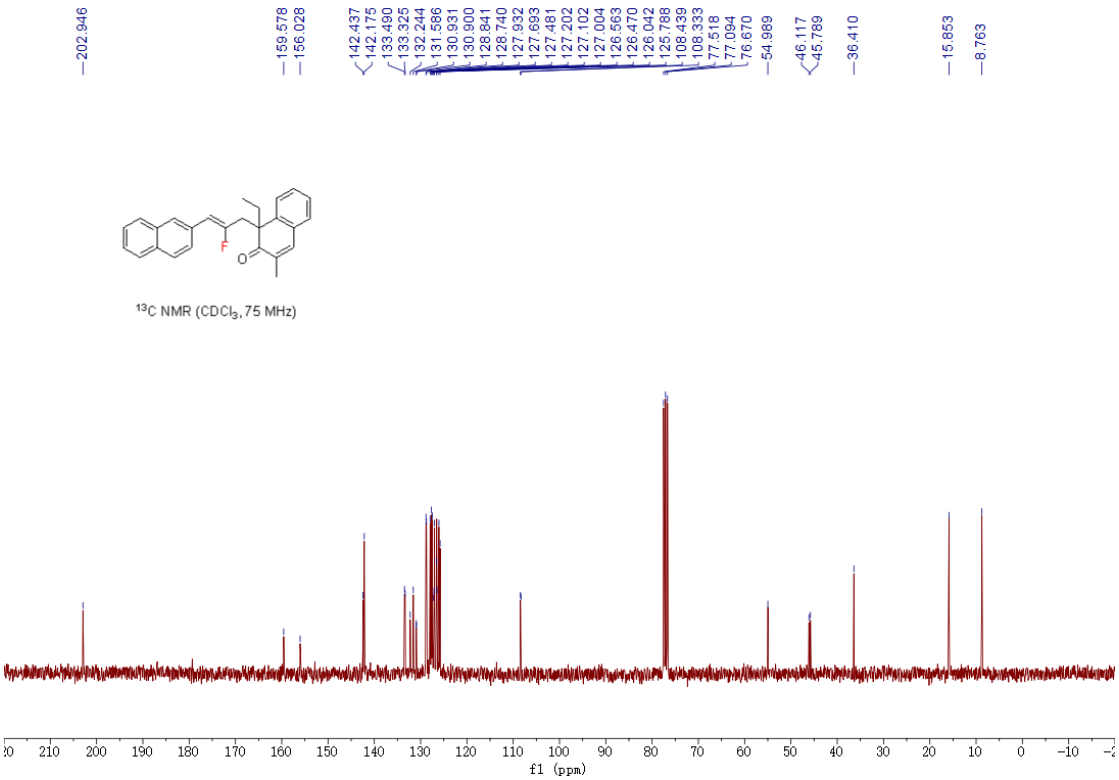

7.7311
7.7242
7.7104
7.7000
7.6848
7.6789
7.6677
7.6379
7.4414
7.4184
7.4136
7.4045
7.4017
7.3963
7.3888
7.3854
7.3784
7.3716
7.3597
7.3560
7.3508
7.3409
7.3338
7.3178
7.3109
7.2929
7.2849
7.2801
7.2632
7.2588
7.2550
7.2501
7.2379
7.2332
6.5064
6.4882
6.4536
6.4409
6.4351
6.4299
6.4134
6.3921
6.3770
6.3607
5.3508
5.2214
3.3407
3.2918
3.2849
3.2362
2.9169
2.8681
2.8408
2.7921
1.8863
1.8818
1.8754
1.8700
1.5509
F
O
1H NMR (CDCl3, 300 MHz)
1.92
2.08
6.29
2.24
1.92
1.00
1.00
1.00
2.95
2.89
0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)

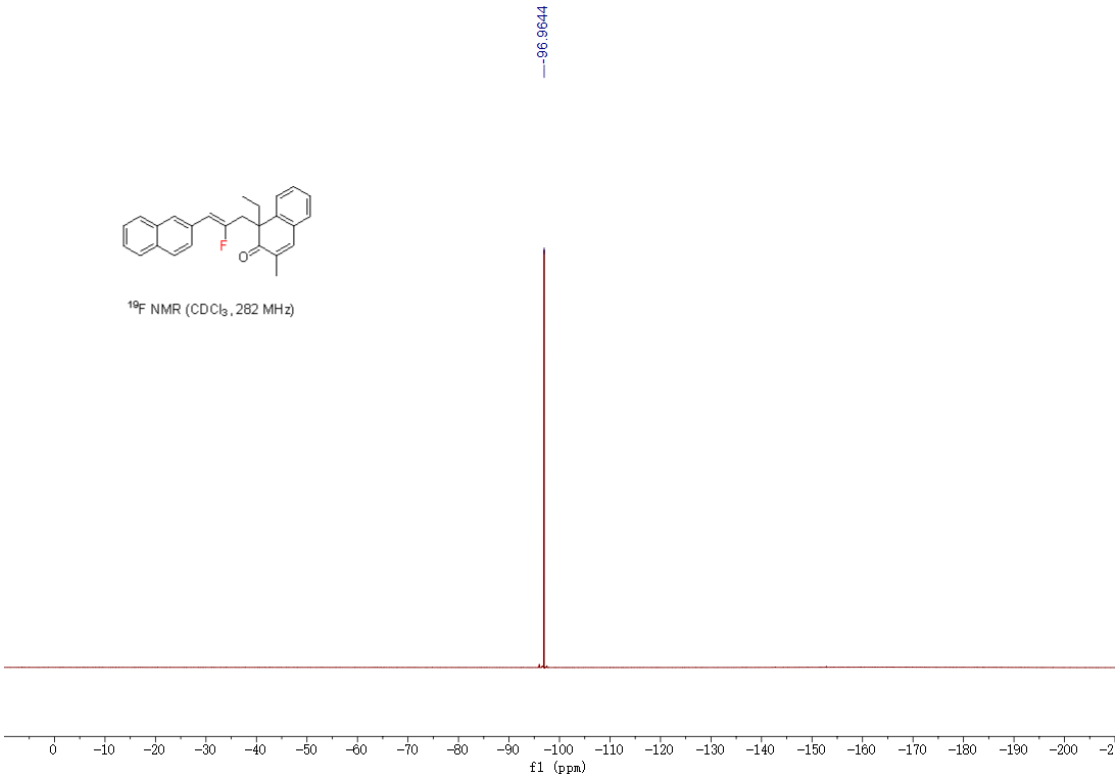

201.564
159.391
155.843
143.734
138.298
133.295
132.252
132.229
131.603
130.819
130.786
130.110
129.530
129.469
129.092
127.926
127.665
127.461
127.276
127.202
127.177
126.584
126.465
126.018
125.780
124.864
108.885
108.778
77.468
77.045
76.621
50.935
50.913
45.450
45.116
27.286
19.110
F
O
13C NMR (CDCl3, 75 MHz)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

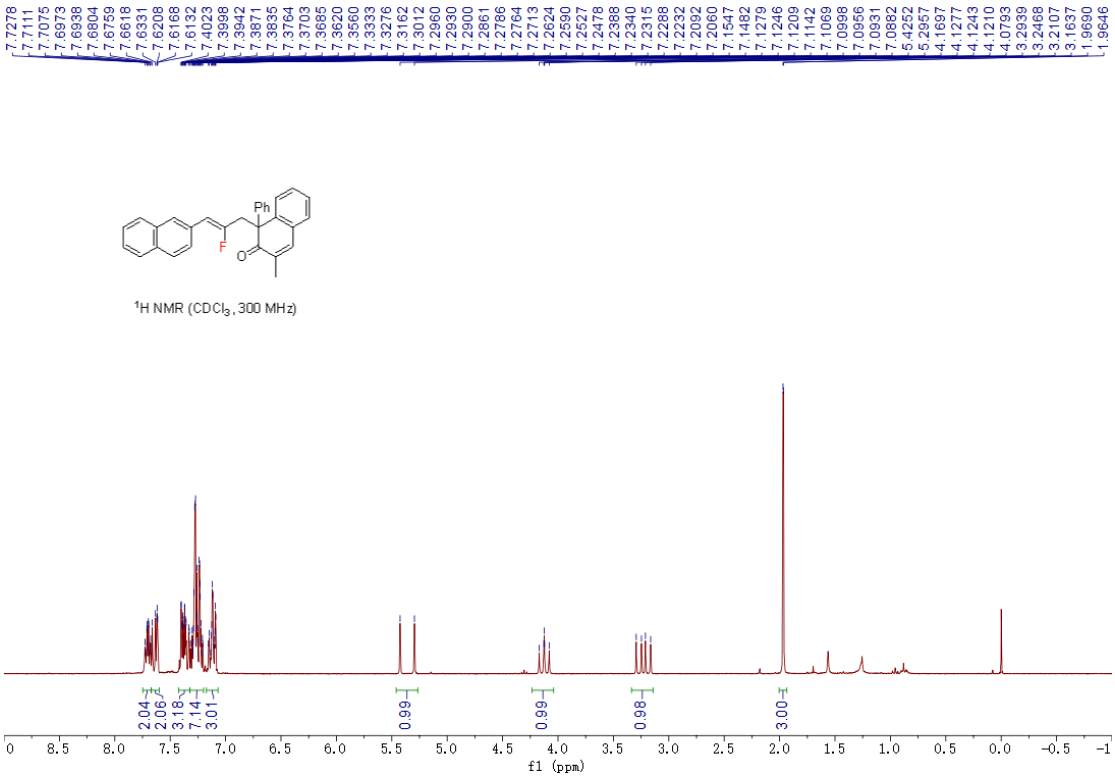

-97.1414
F
O
^{19}F NMR ($CDCl_3$, 282 MHz)
f1 (ppm)

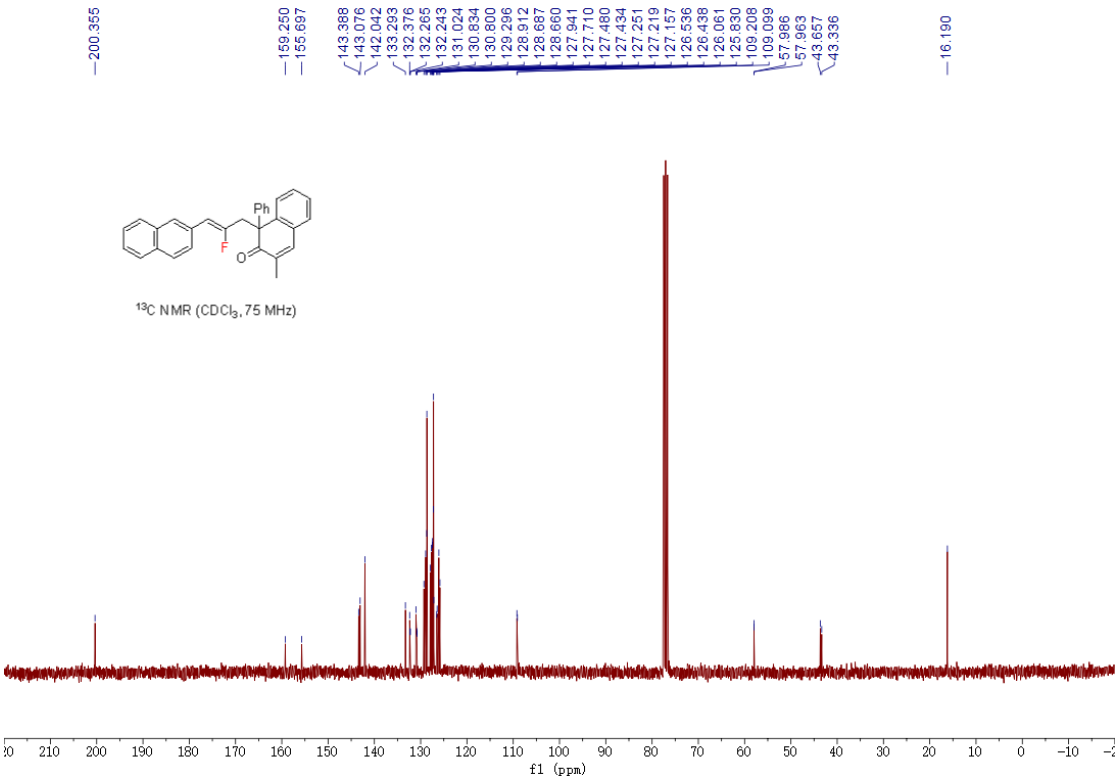

7.7105
7.7037
7.6924
7.6785
7.6604
7.6438
7.6152
7.6024
7.5970
7.4014
7.3842
7.3795
7.3755
7.3682
7.3590
7.3513
7.3436
7.3211
7.3152
7.2699
7.2588
7.2447
7.2353
7.2245
7.2190
7.2149
7.1916
5.3160
5.1866
3.3353
3.2873
3.2815
3.2332
2.8684
2.8203
2.7891
2.7414
2.3432
2.3189
2.3005
2.2946
2.2757
2.2707
2.2511
2.2268
1.9960
1.9915
1.9549
1.9301
1.9056
1.8868
1.8809
1.8620
1.8373
0.5210
0.4966
0.4722

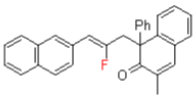

F
O
^{1}H NMR ($CDCl_3$, 300 MHz)
1.94
2.08
5.11
3.22
0.90
0.91
0.92
0.97
3.10
1.00
3.00
f1 (ppm)


202.946
159.578
156.028
142.437
142.175
133.490
133.325
132.244
131.586
130.931
130.900
128.841
128.740
127.932
127.693
127.481
127.202
127.102
127.004
126.563
126.470
126.042
125.788
108.439
108.333
77.518
77.094
76.670
54.989
46.117
45.789
36.410
15.853
8.763
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

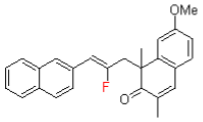

96.9644
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)


7.7278
7.7111
7.7075
7.6973
7.6938
7.6804
7.6759
7.6618
7.6331
7.6208
7.6168
7.6132
7.4023
7.3998
7.3942
7.3871
7.3835
7.3764
7.3703
7.3685
7.3620
7.3560
7.3333
7.3276
7.3162
7.3012
7.2960
7.2930
7.2900
7.2861
7.2786
7.2764
7.2713
7.2624
7.2590
7.2527
7.2478
7.2388
7.2340
7.2315
7.2288
7.2232
7.2092
7.2060
7.1547
7.1482
7.1279
7.1246
7.1209
7.1142
7.1069
7.0998
7.0956
7.0931
7.0882
5.4252
5.2957
4.1697
4.1277
4.1243
4.1210
4.0793
3.2939
3.2468
3.2107
3.1637
1.9690
1.9646
Ph
F
O
1H NMR (CDCl3, 300 MHz)
2.04
2.06
3.18
7.14
3.01
0.99
0.99
0.98
3.00
f1 (ppm)

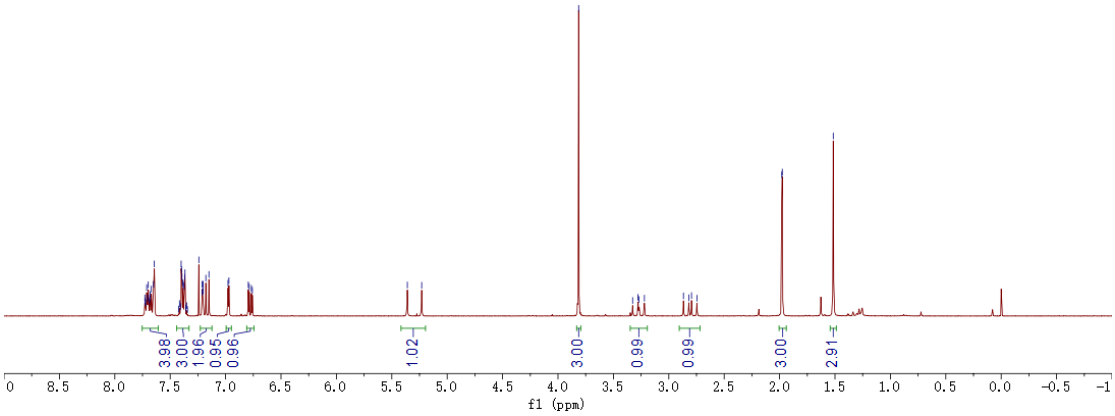

200.355
159.250
155.697
143.388
143.076
142.042
133.293
132.376
132.265
132.243
131.024
130.834
130.800
129.296
128.912
128.687
128.660
127.941
127.710
127.480
127.434
127.251
127.219
127.157
126.536
126.438
126.061
125.830
109.208
109.099
57.986
57.963
43.657
43.336
16.190
Ph
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

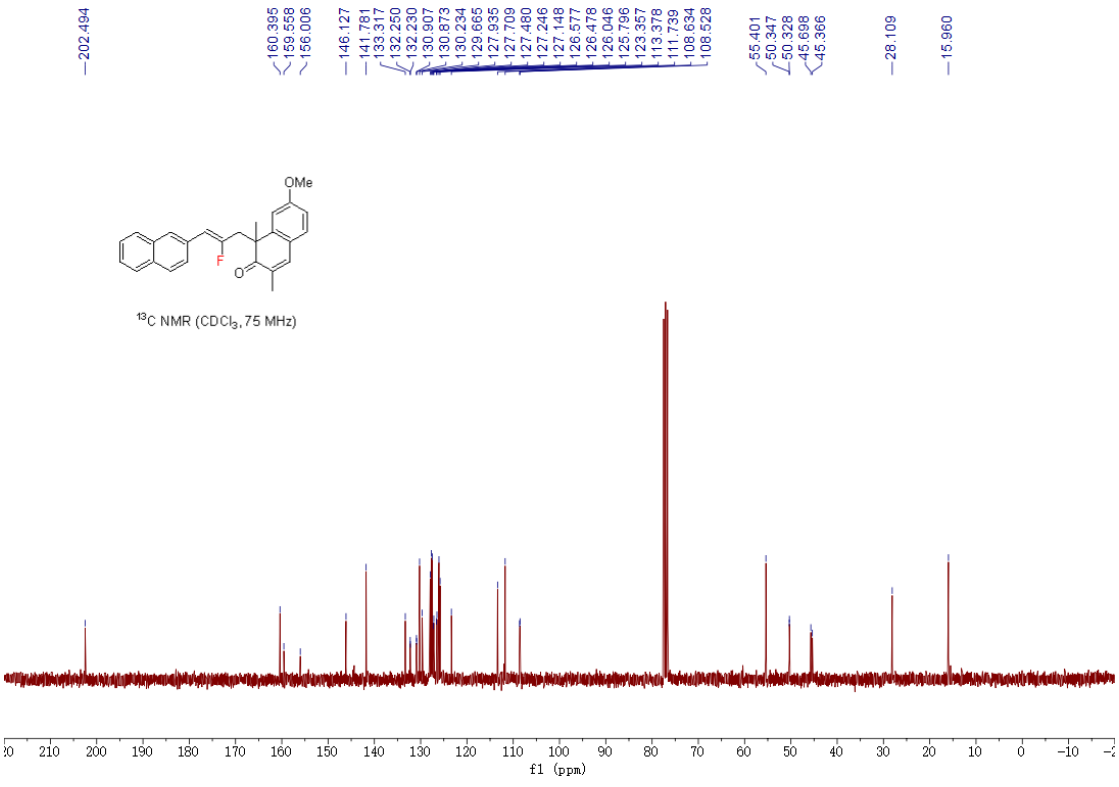


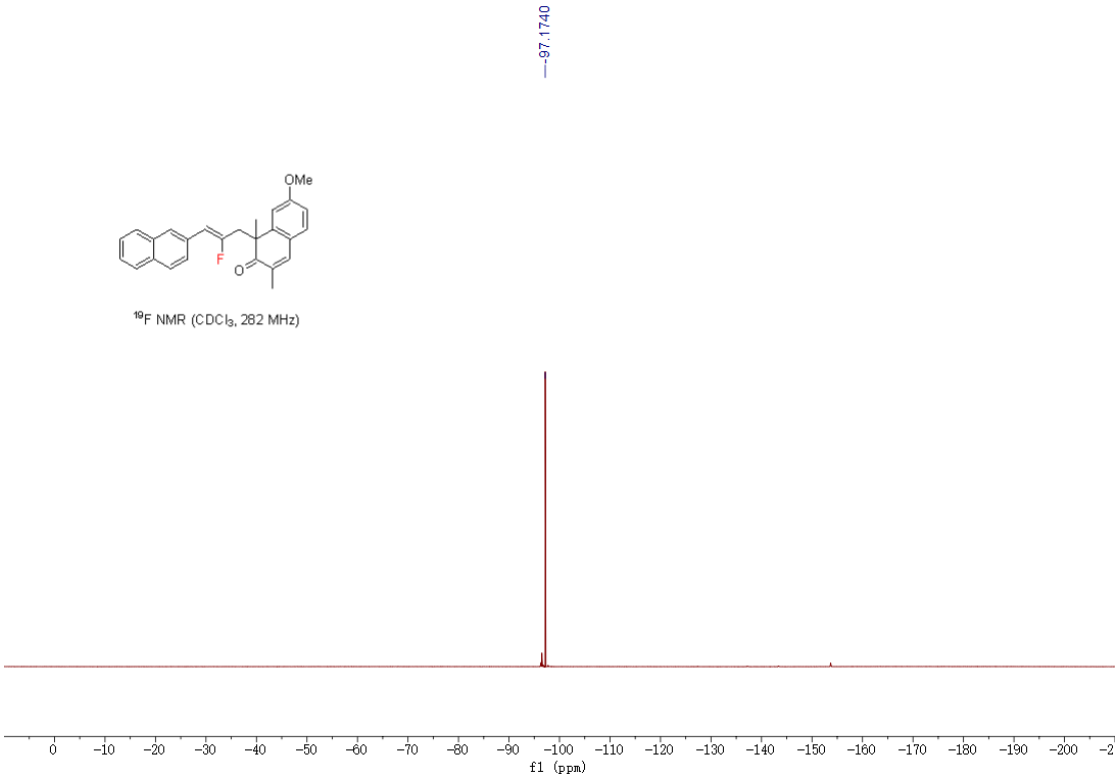
^{19}F NMR ($CDCl_3$, 282 MHz)

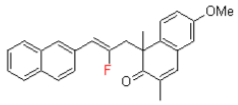


^{1}H NMR ($CDCl_3$, 300 MHz)

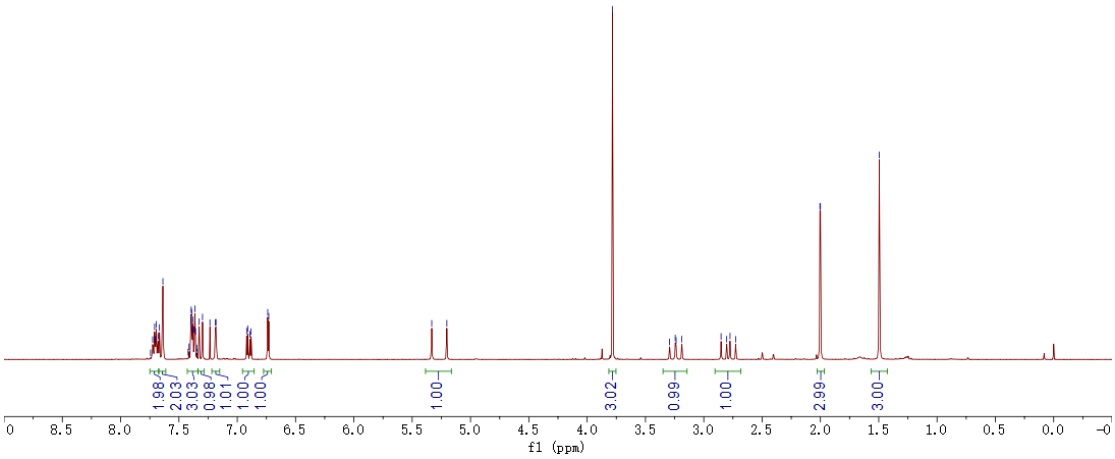


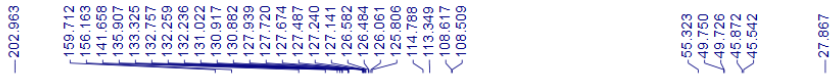

202.494
160.395
159.558
156.006
146.127
141.781
133.317
132.250
132.230
130.907
130.873
130.234
129.665
127.935
127.709
127.480
127.246
127.148
126.577
126.478
126.046
125.796
123.357
113.378
111.739
108.634
108.528
55.401
50.347
50.328
45.698
45.366
28.109
15.960
OMe
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

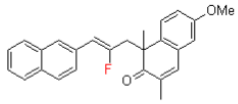

-97.1740
OMe
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)



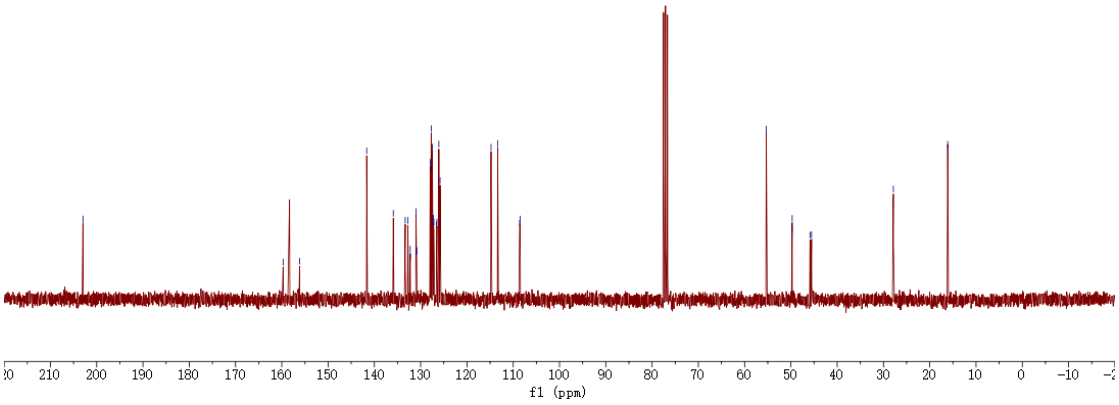
^{1}H NMR ($CDCl_3$, 300 MHz)

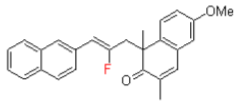




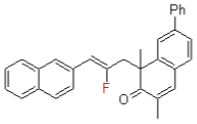


^{13}C NMR ($CDCl_3$, 75 MHz)

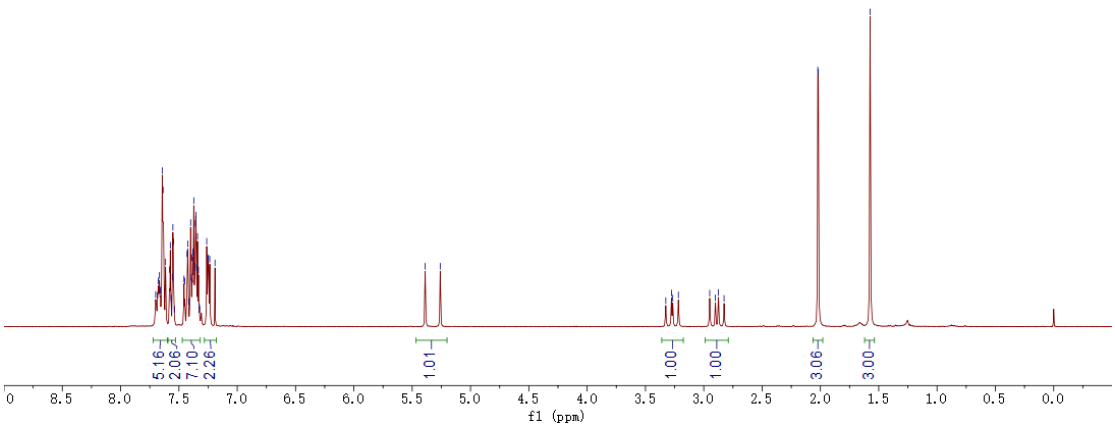


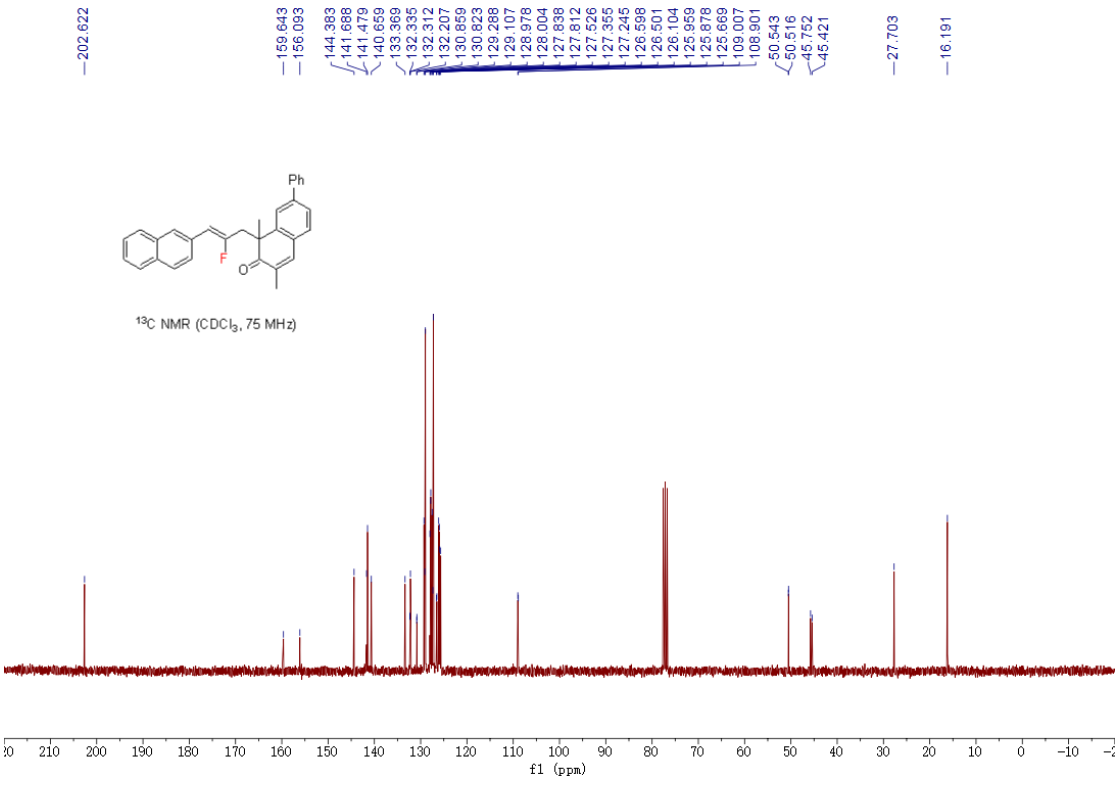


^{19}F NMR ($CDCl_3$, 282 MHz)



^{1}H NMR ($CDCl_3$, 300 MHz)

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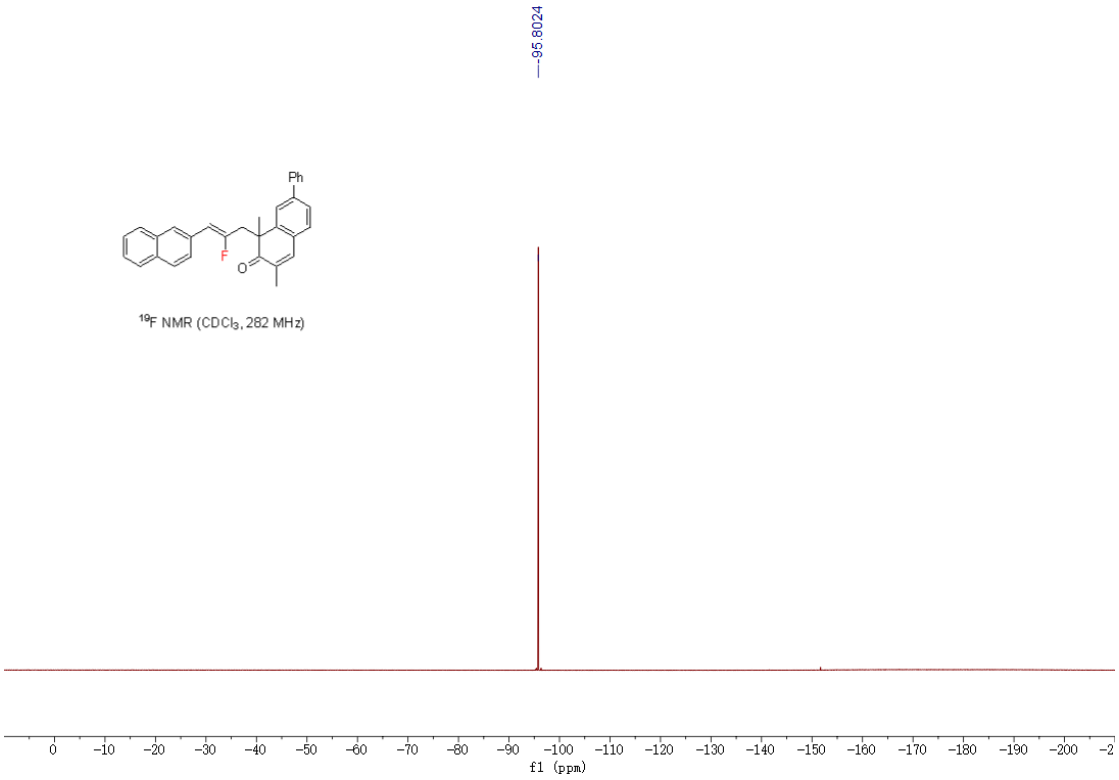
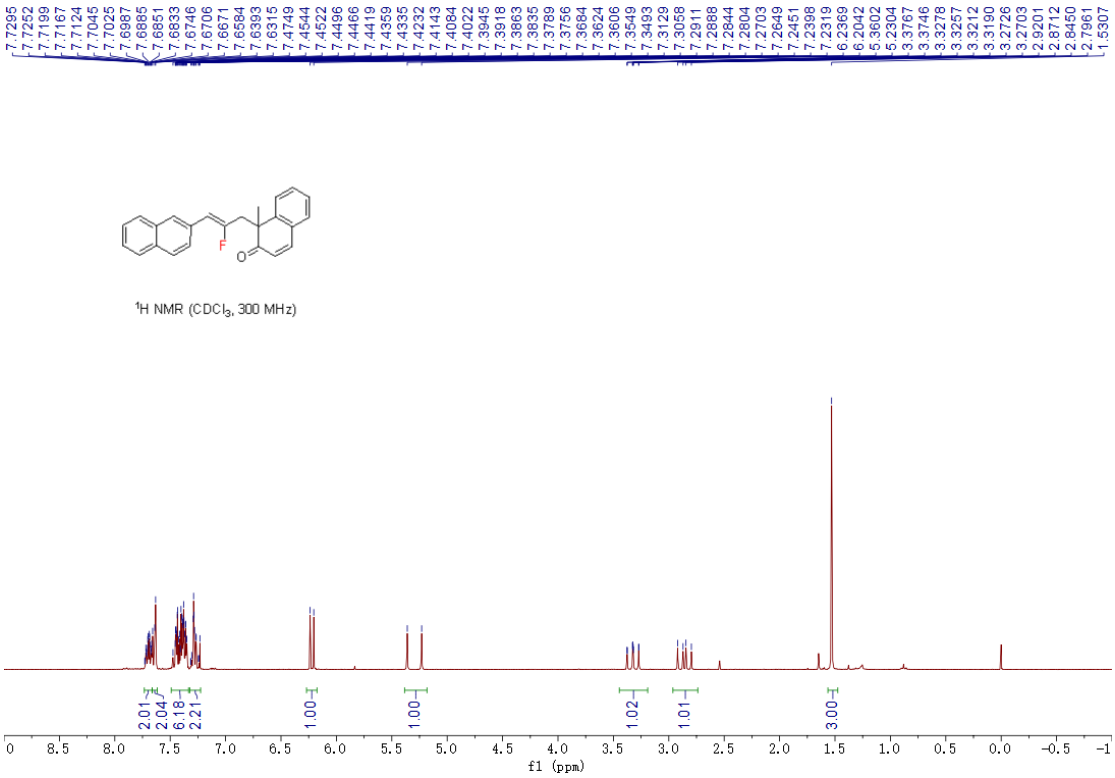
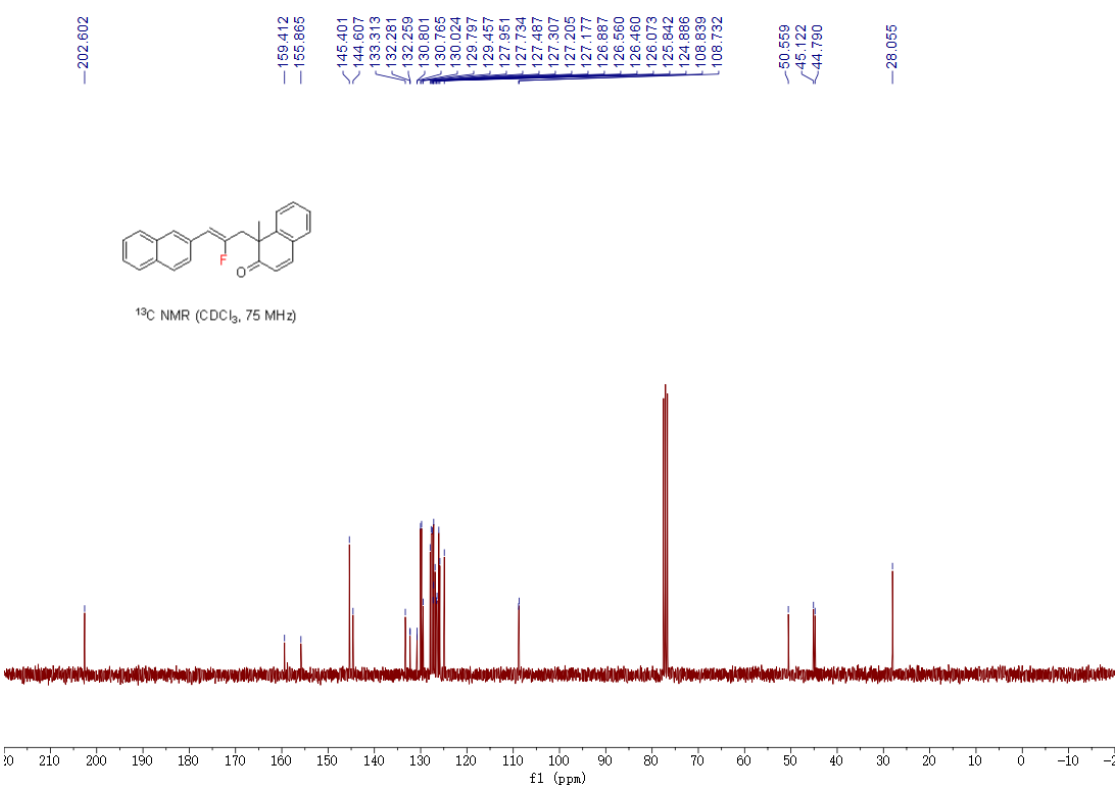
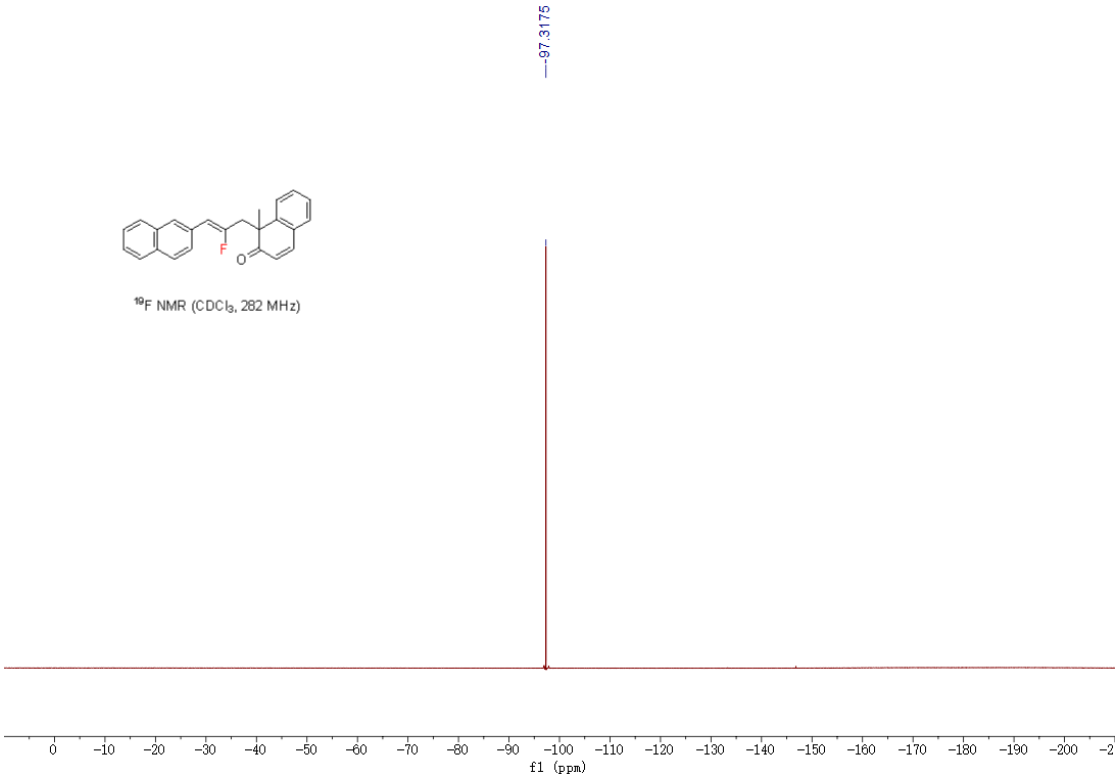
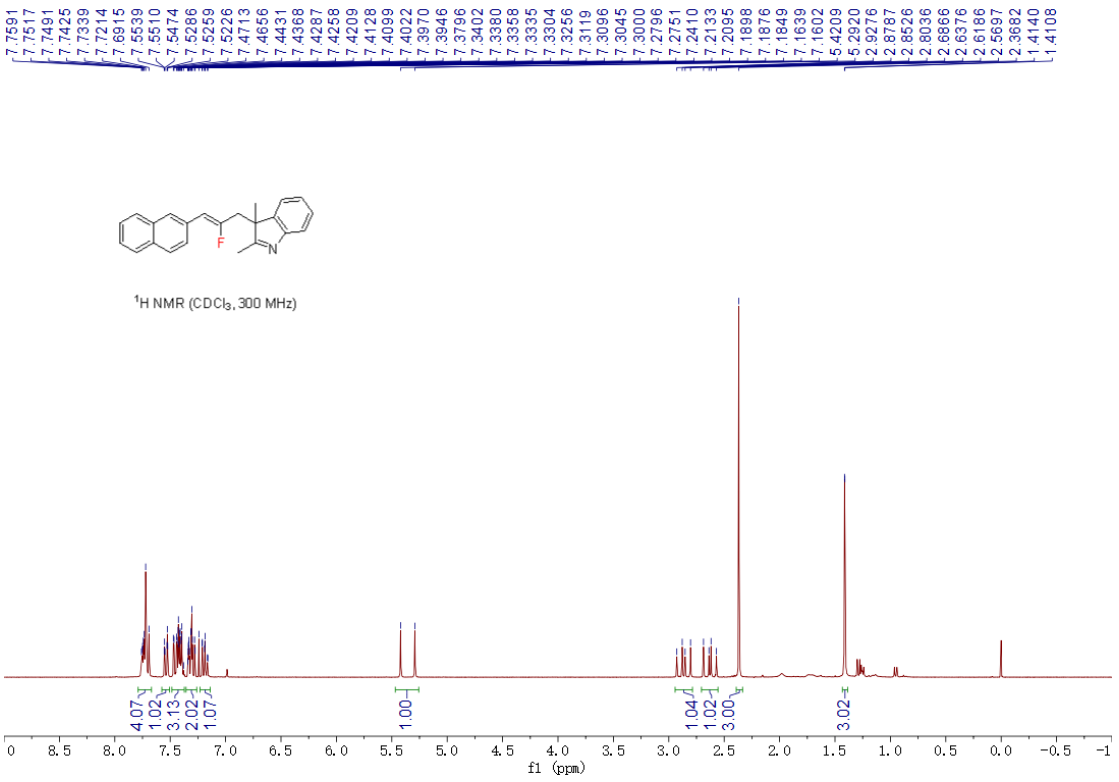
159.643
156.093
144.383
141.688
141.479
140.659
133.369
132.335
132.312
132.207
130.859
130.823
129.288
129.107
128.978
128.004
127.838
127.812
127.526
127.355
127.245
126.598
126.501
126.104
125.959
125.878
125.669
109.007
108.901
50.543
50.516
45.752
45.421
27.703
16.191
Ph
F
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

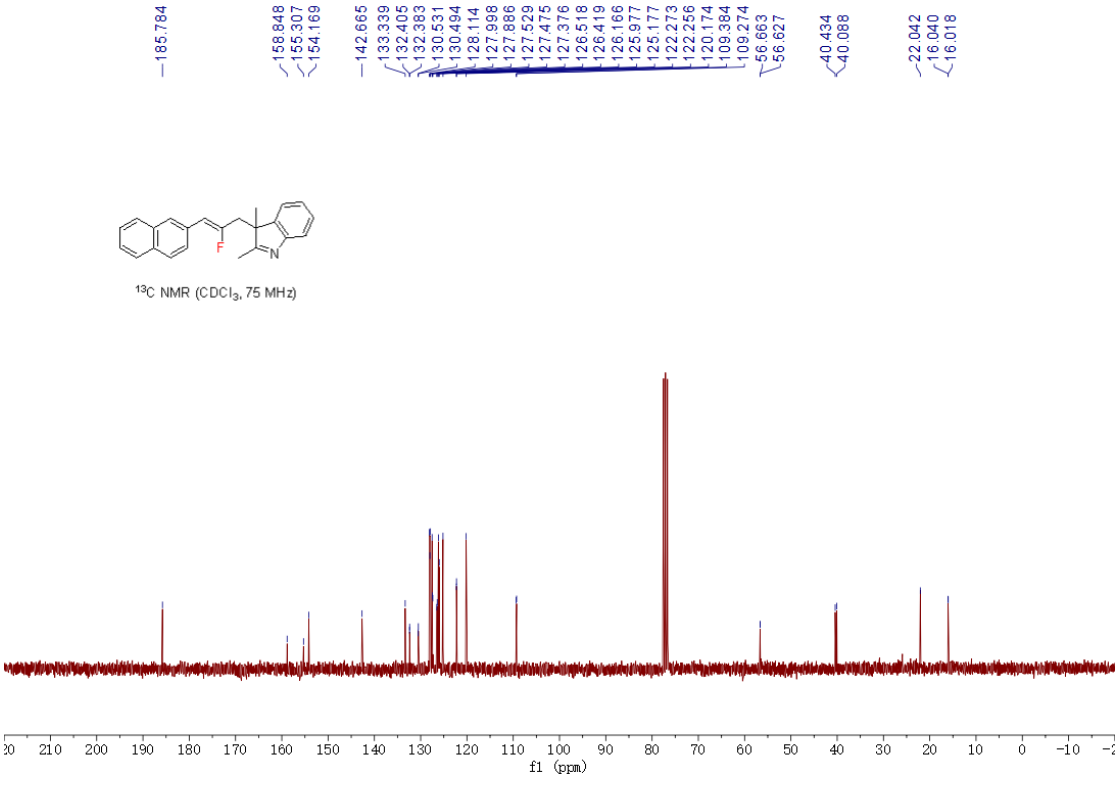

-95.8024
Ph
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

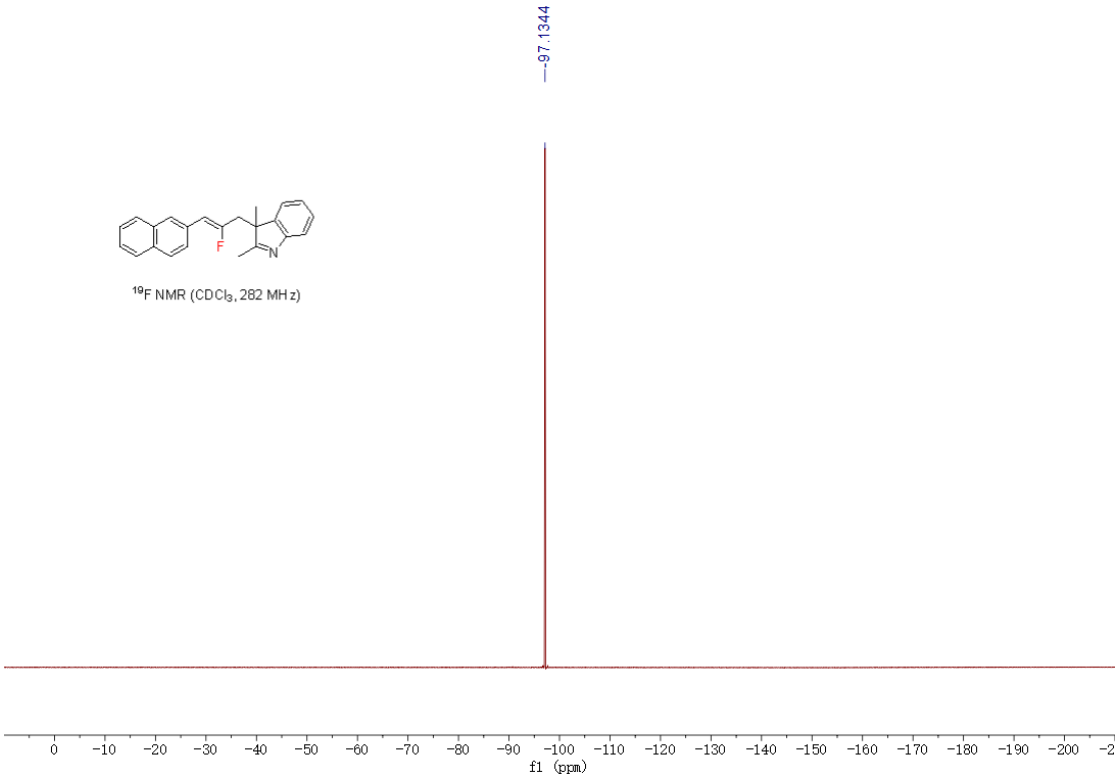

7.7295
7.7252
7.7199
7.7167
7.7124
7.7045
7.7025
7.6987
7.6885
7.6851
7.6833
7.6746
7.6706
7.6671
7.6584
7.6393
7.6315
7.4749
7.4544
7.4522
7.4496
7.4466
7.4419
7.4359
7.4335
7.4232
7.4143
7.4084
7.4022
7.3945
7.3918
7.3863
7.3835
7.3789
7.3756
7.3684
7.3624
7.3606
7.3549
7.3493
7.3129
7.3058
7.2911
7.2888
7.2844
7.2804
7.2703
7.2649
7.2451
7.2398
7.2319
6.2369
6.2042
5.3602
5.2304
3.3767
3.3746
3.3278
3.3257
3.3212
3.3190
3.2726
3.2703
2.9201
2.8712
2.8450
2.7961
1.5307
F
O
^{1}H NMR ($CDCl_3$, 300 MHz)
2.01
2.04
6.18
2.21
1.00
1.00
1.02
1.01
3.00
f1 (ppm)

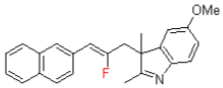

202.602
159.412
155.865
145.401
144.607
133.313
132.281
132.259
130.801
130.765
130.024
129.797
129.457
127.951
127.734
127.487
127.307
127.205
127.177
126.887
126.560
126.460
126.073
125.842
124.886
108.839
108.732
50.559
45.122
44.790
28.055
F
O
^{13}C NMR ($CDCl_3$, 75 MHz)
f1 (ppm)


-97.3175
F
O
^{19}F NMR ($CDCl_3$, 282 MHz)
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -2
f1 (ppm)

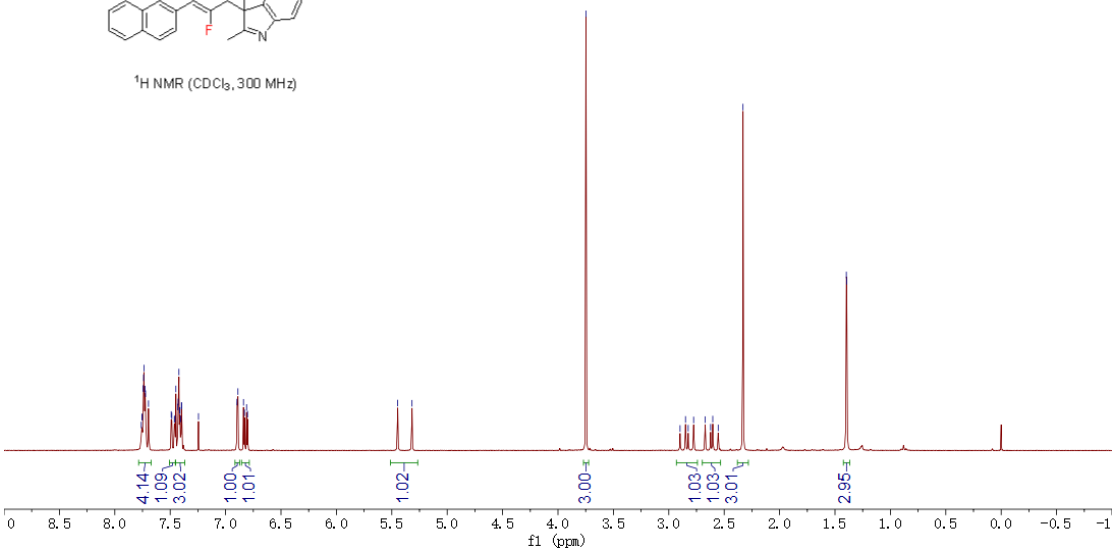

7.7591 7.7517 7.7491 7.7425 7.7339 7.7214 7.6915 7.5539 7.5510 7.5474 7.5286 7.5259 7.5226 7.4713 7.4656 7.4431 7.4368 7.4287 7.4258 7.4209 7.4128 7.4099 7.4022 7.3970 7.3946 7.3796 7.3402 7.3380 7.3358 7.3335 7.3304 7.3256 7.3119 7.3096 7.3045 7.3000 7.2796 7.2751 7.2410 7.2133 7.2095 7.1898 7.1876 7.1849 7.1639 7.1602 5.4209 5.2920 2.9276 2.8787 2.8526 2.8036 2.6866 2.6376 2.6186 2.5697 2.3682 1.4140 1.4108
F
N
^{1}H NMR ($CDCl_3$, 300 MHz)
4.07 1.02 3.13 2.02 1.07 1.00 1.04 1.02 3.00 3.02
0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

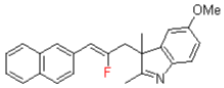

185.784
158.848
155.307
154.169
142.665
133.339
132.405
132.383
130.531
130.494
128.114
127.998
127.886
127.529
127.475
127.376
126.518
126.419
126.166
125.977
125.177
122.273
122.256
120.174
109.384
109.274
56.663
56.627
40.434
40.088
22.042
16.040
16.018
F
N
13C NMR (CDCl3, 75 MHz)
f1 (ppm)


-97.1344
F
N
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

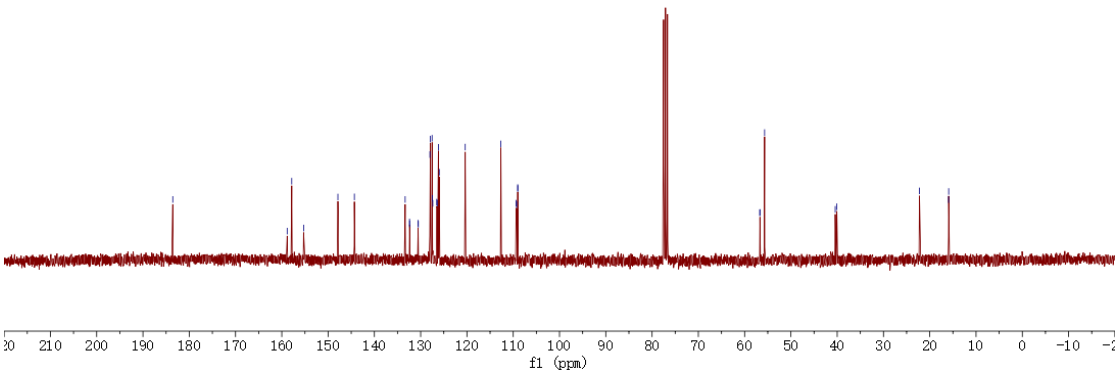


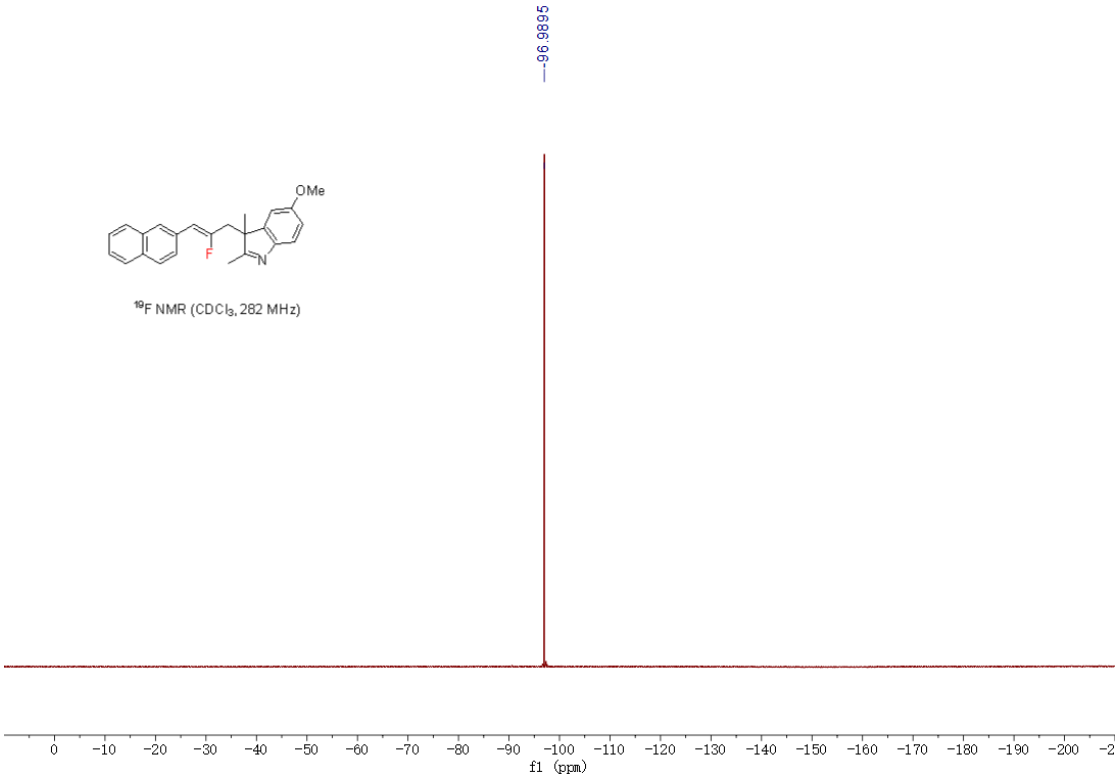
^{1}H NMR ($CDCl_3$, 300 MHz)



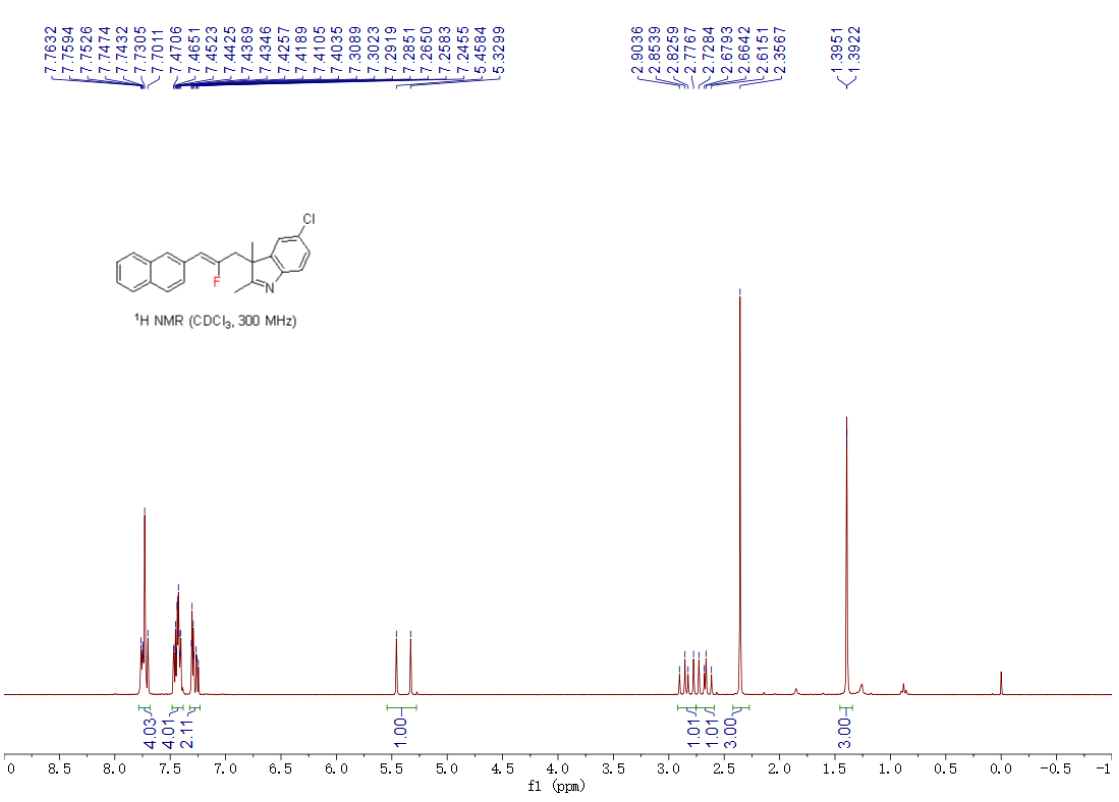


^{13}C NMR ($CDCl_3$, 75 MHz)

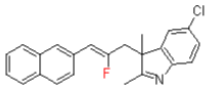




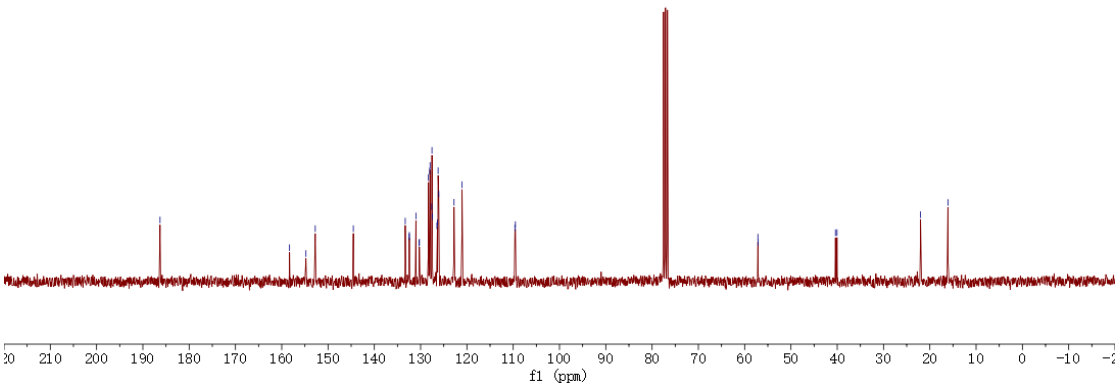
^{19}F NMR ($CDCl_3$, 282 MHz)

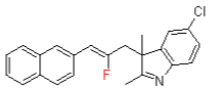


^{1}H NMR ($CDCl_3$, 300 MHz)

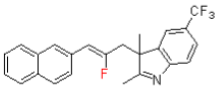


^{13}C NMR ($CDCl_3$, 75 MHz)

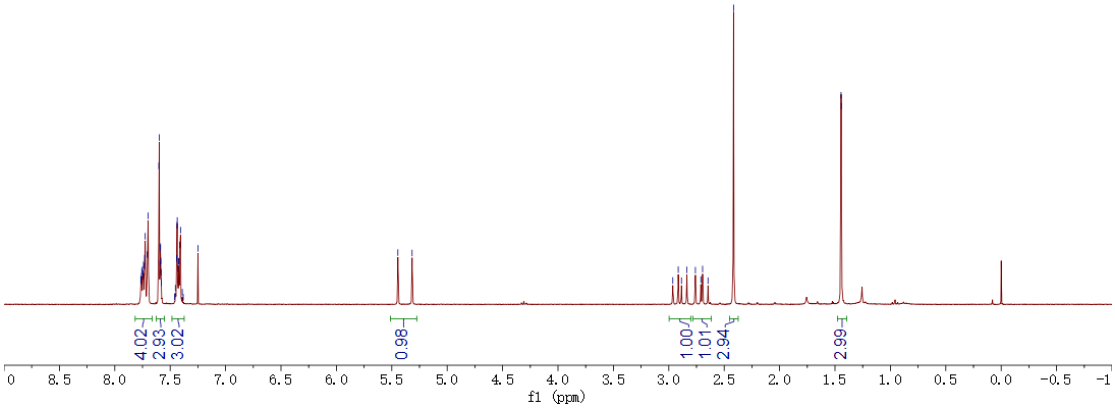


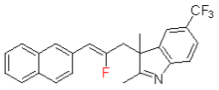


^{19}F NMR ($CDCl_3$, 282 MHz)

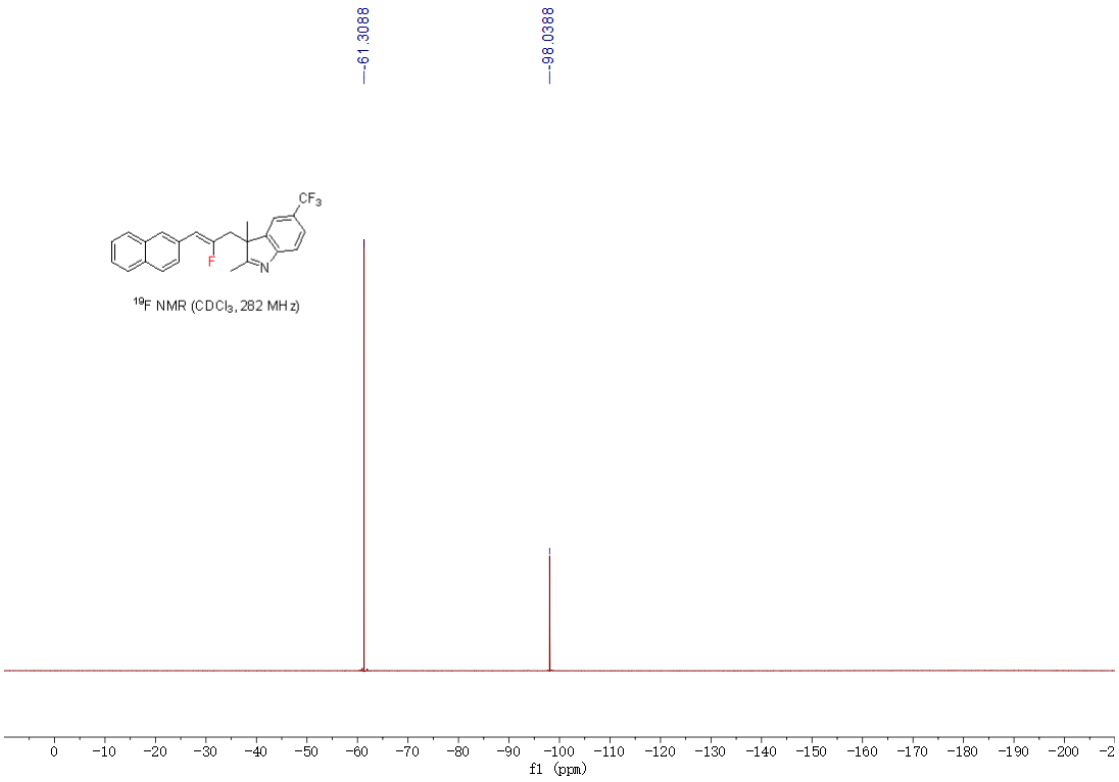


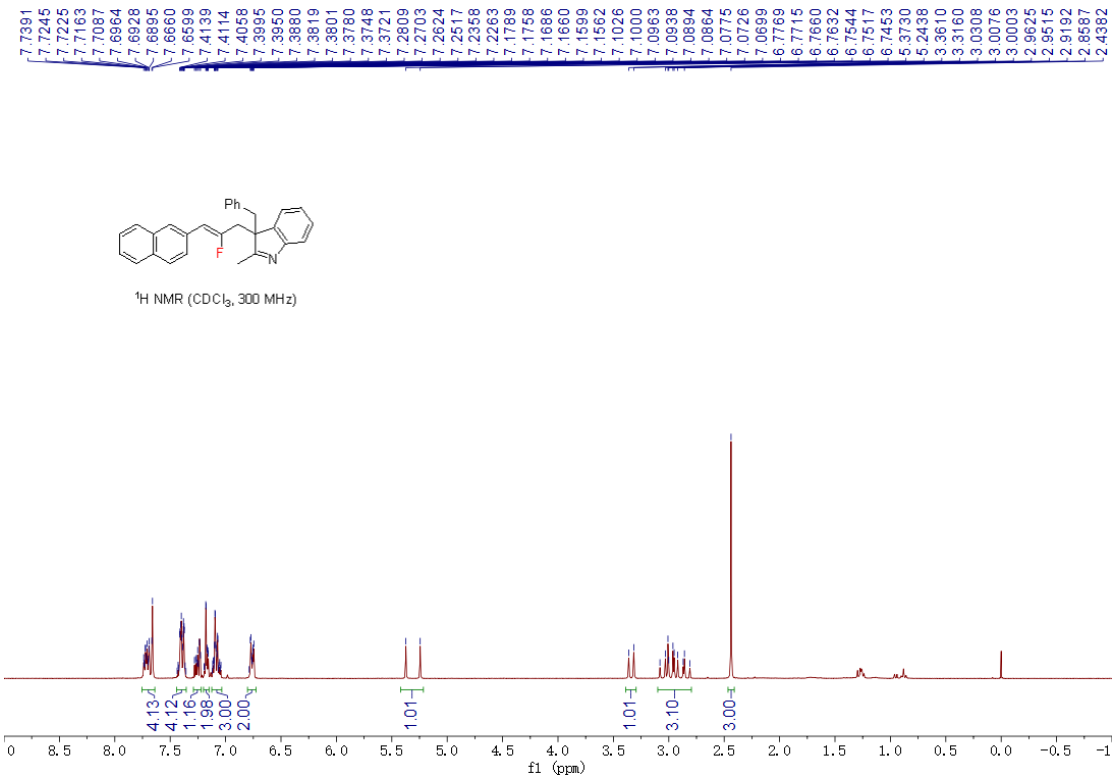
^{1}H NMR ($CDCl_3$, 300 MHz)





^{13}C NMR ($CDCl_3$, 75 MHz)


-61.3088
-98.0388
CF3
F
N
19F NMR (CDCl3, 282 MHz)
f1 (ppm)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7.7245
7.7225
7.7163
7.7087
7.6964
7.6928
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7.6660
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7.4139
7.4114
7.4058
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7.3950
7.3880
7.3819
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7.3748
7.3721
7.2809
7.2703
7.2624
7.2517
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7.1660
7.1599
7.1562
7.1026
7.1000
7.0963
7.0938
7.0894
7.0864
7.0775
7.0726
7.0699
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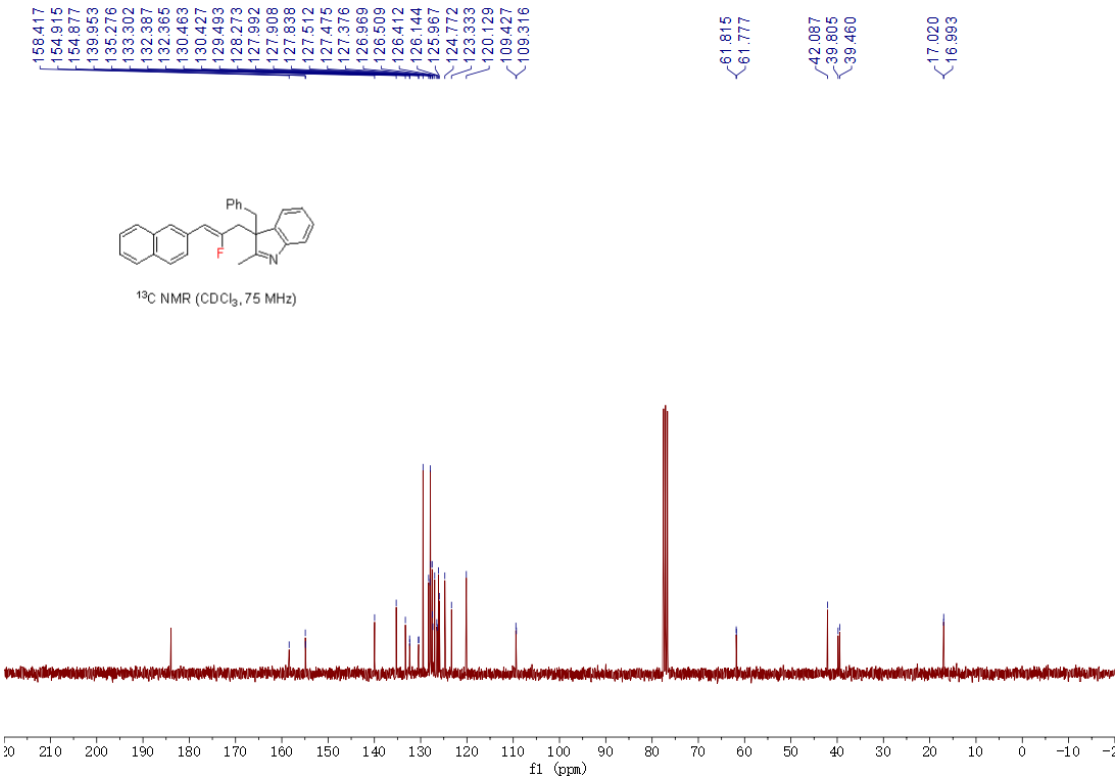
6.7715
6.7660
6.7632
6.7544
6.7517
6.7453
5.3730
5.2438
3.3610
3.3160
3.0308
3.0076
3.0003
2.9625
2.9515
2.9192
2.8587
2.4382
Ph
F
N
1H NMR (CDCl3, 300 MHz)
4.13
4.12
1.16
1.98
3.00
2.00
1.01
1.01
3.10
3.00
f1 (ppm)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135.276
133.302
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132.365
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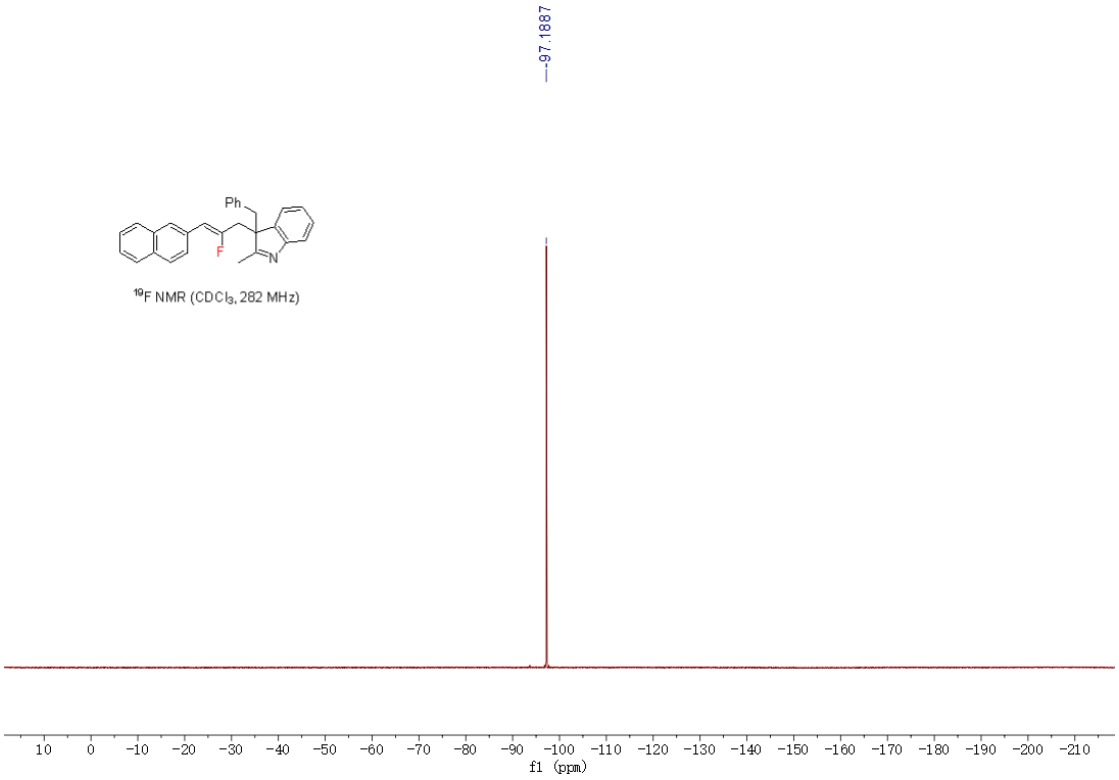
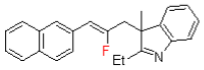
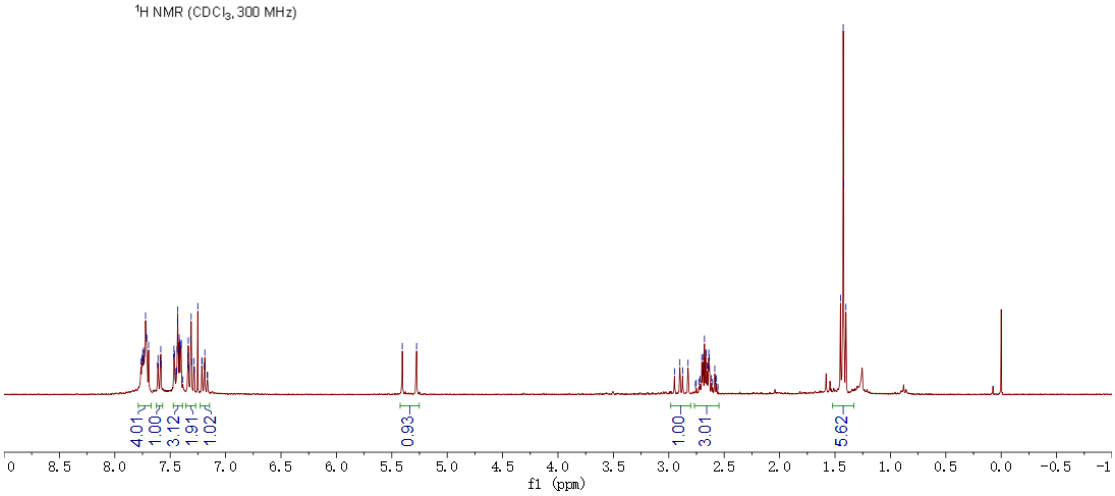
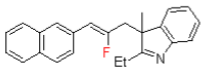
130.427
129.493
128.273
127.992
127.908
127.838
127.512
127.475
127.376
126.969
126.509
126.412
126.144
125.967
124.772
123.333
120.129
109.427
109.316
61.815
61.777
42.087
39.805
39.460
17.020
16.993
Ph
F
N
13C NMR (CDCl3, 75 MHz)
f1 (ppm)


-97.1887
Ph
F
N
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

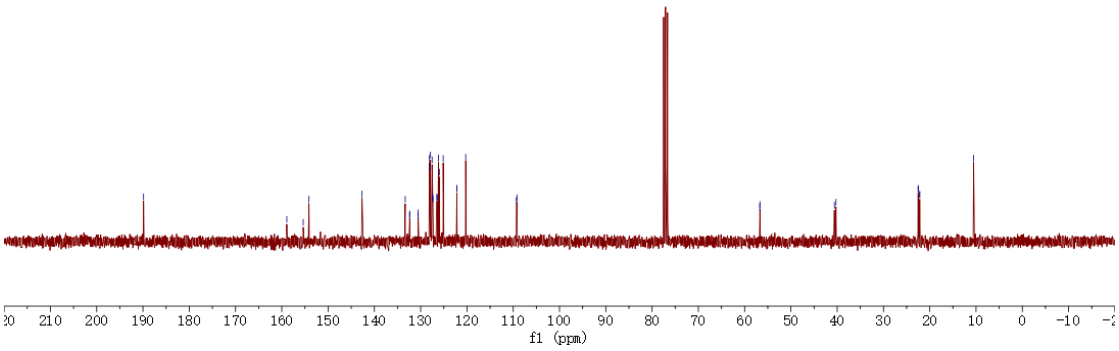


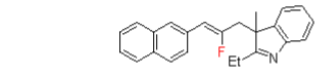
^{1}H NMR ($CDCl_3$, 300 MHz)



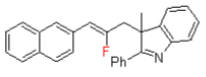


^{13}C NMR ($CDCl_3$, 75 MHz)

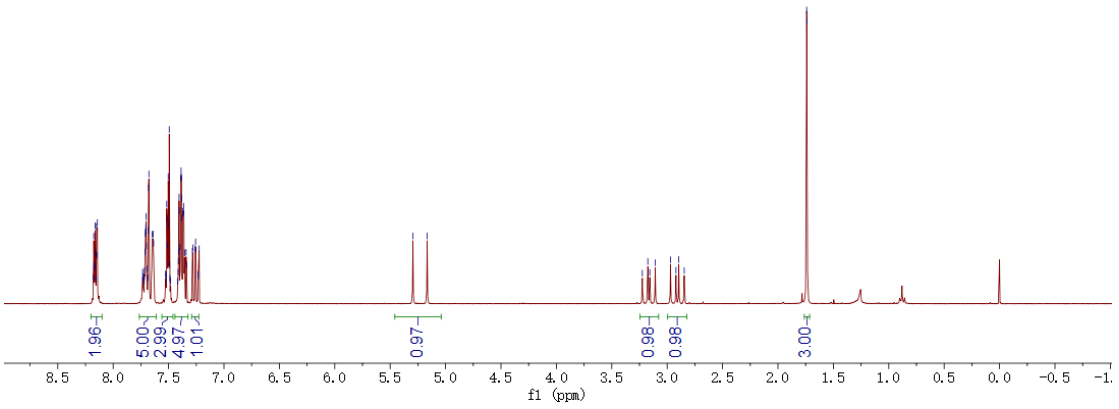


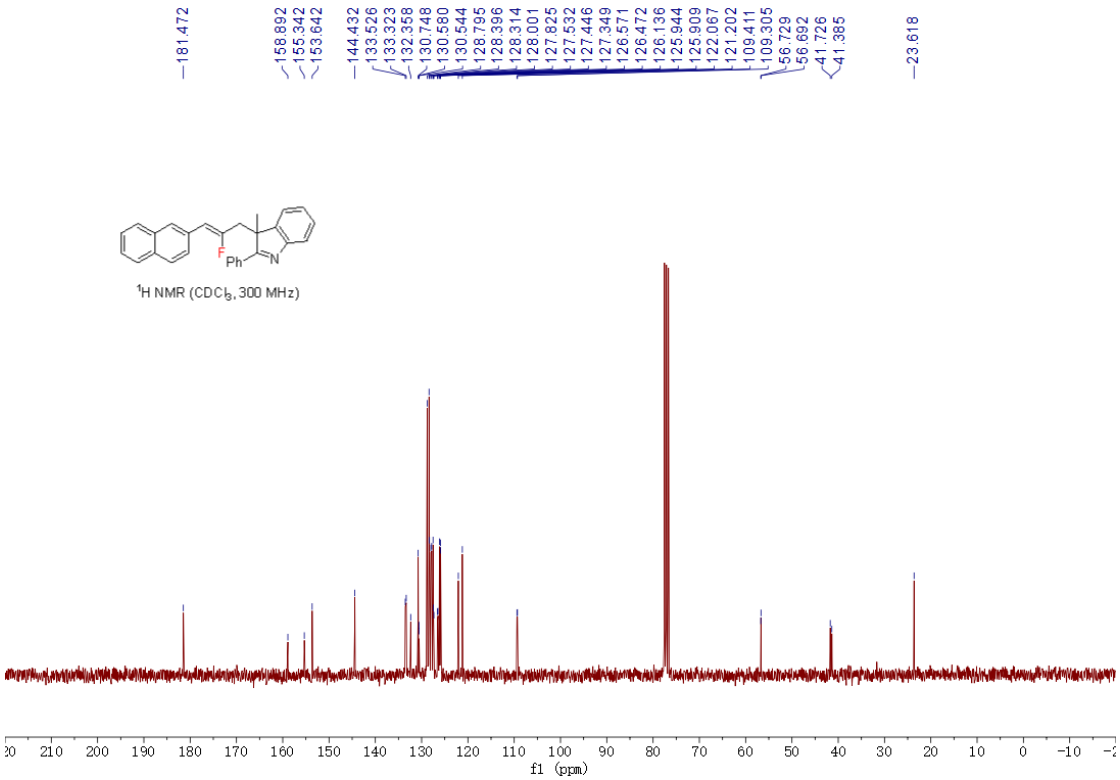


^{19}F NMR ($CDCl_3$, 282 MHz)



^{13}C NMR ($CDCl_3$, 75 MHz)

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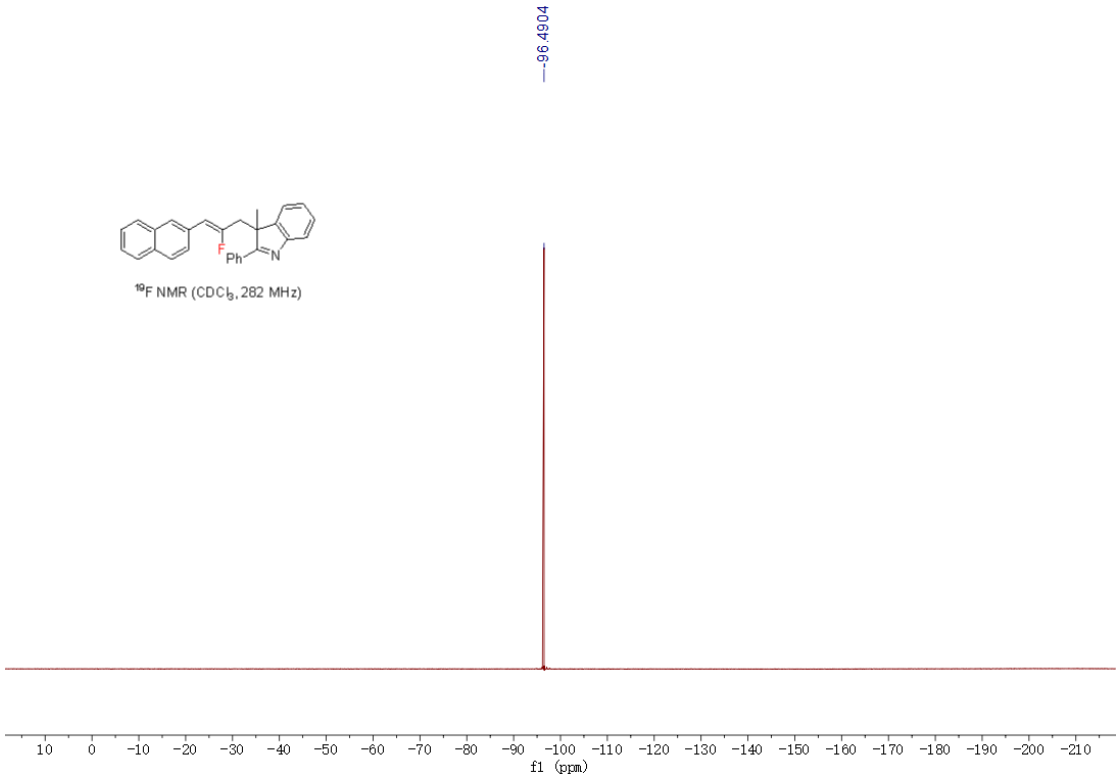
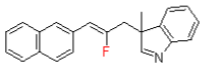
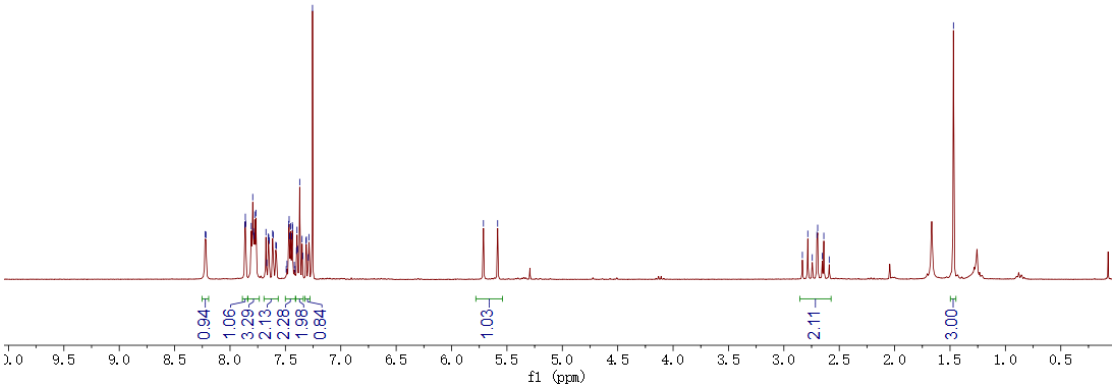
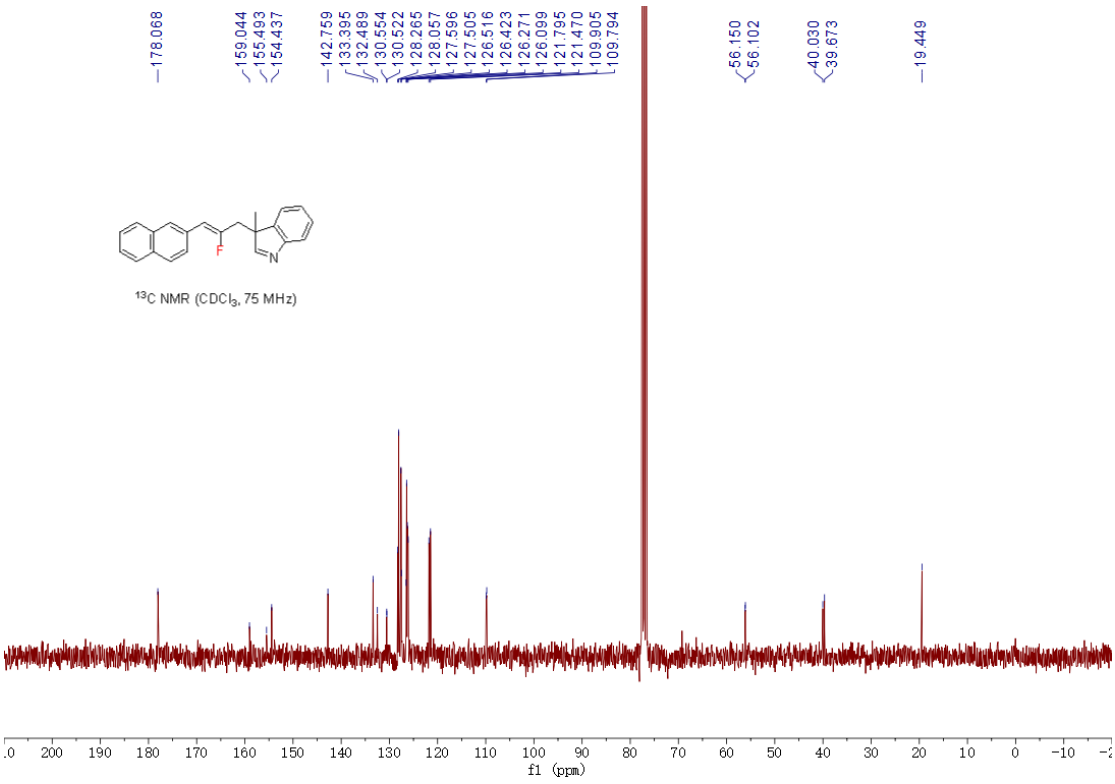
155.342
153.642
144.432
133.526
133.323
132.358
130.748
130.580
130.544
128.795
128.396
128.314
128.001
127.825
127.532
127.446
127.349
126.571
126.472
126.136
125.944
125.909
122.067
121.202
109.411
109.305
56.729
56.692
41.726
41.385
23.618
F
Ph
N
^{1}H NMR (CDCl$_3$, 300 MHz)
f1 (ppm)


96.4904
F
Ph
N
^{19}F NMR (CDCl$_3$, 282 MHz)
f1 (ppm)

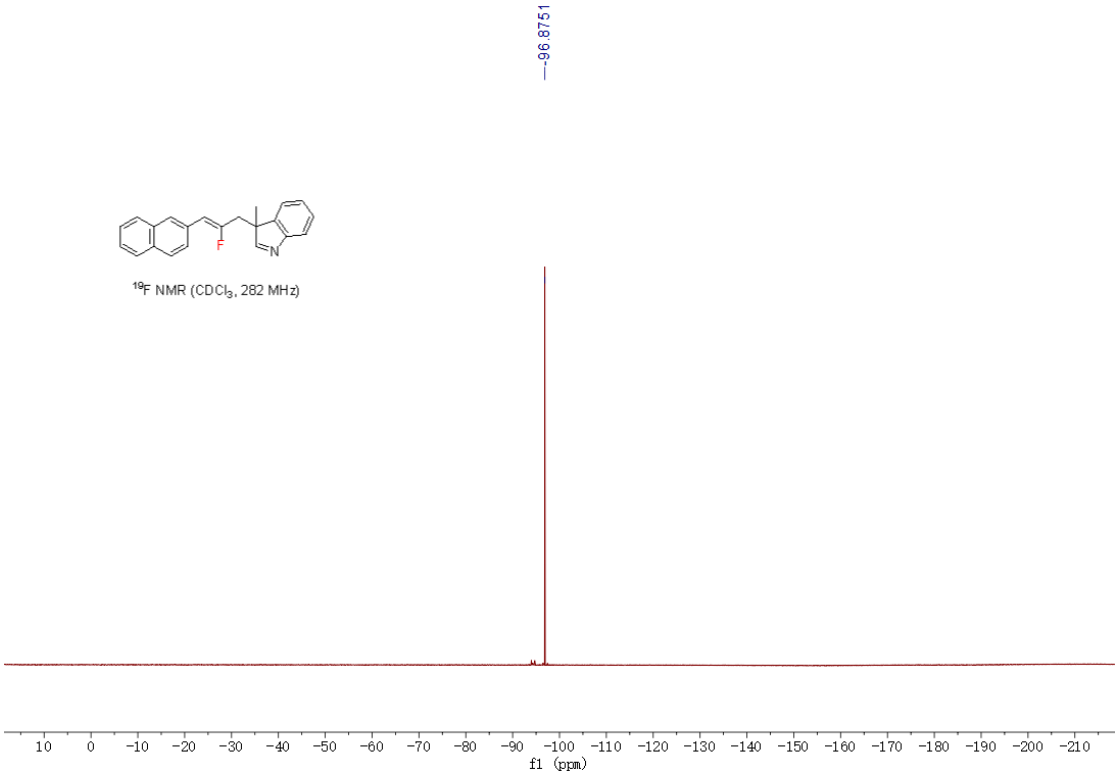


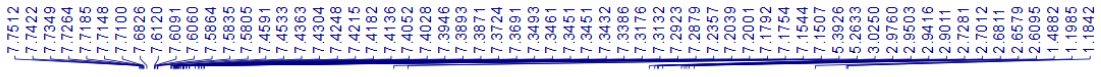
^{1}H NMR ($CDCl_3$, 300 MHz)

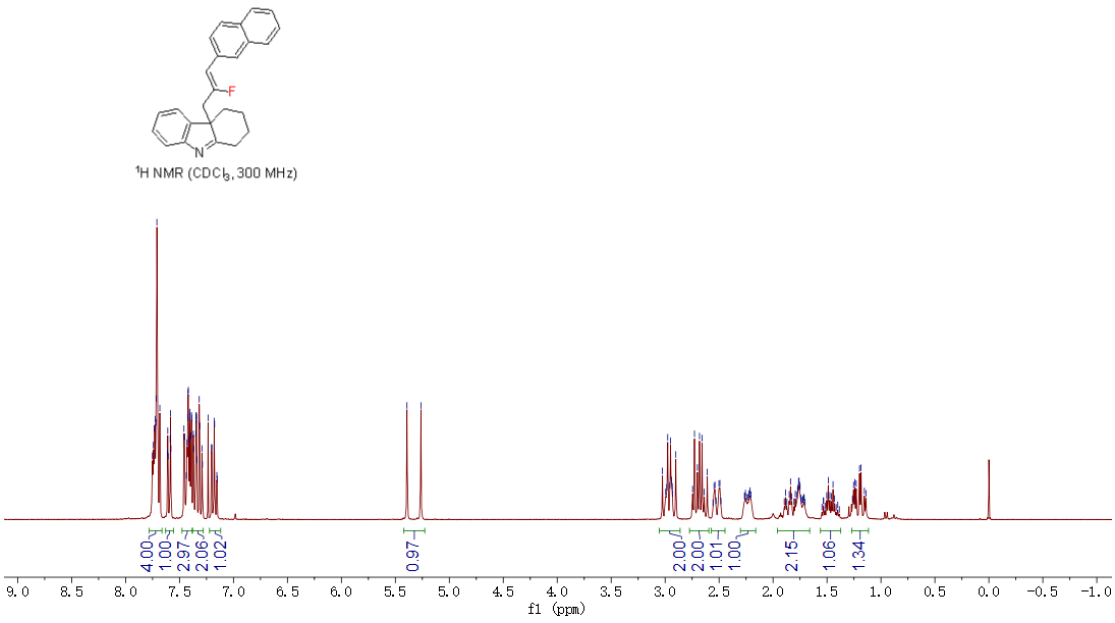


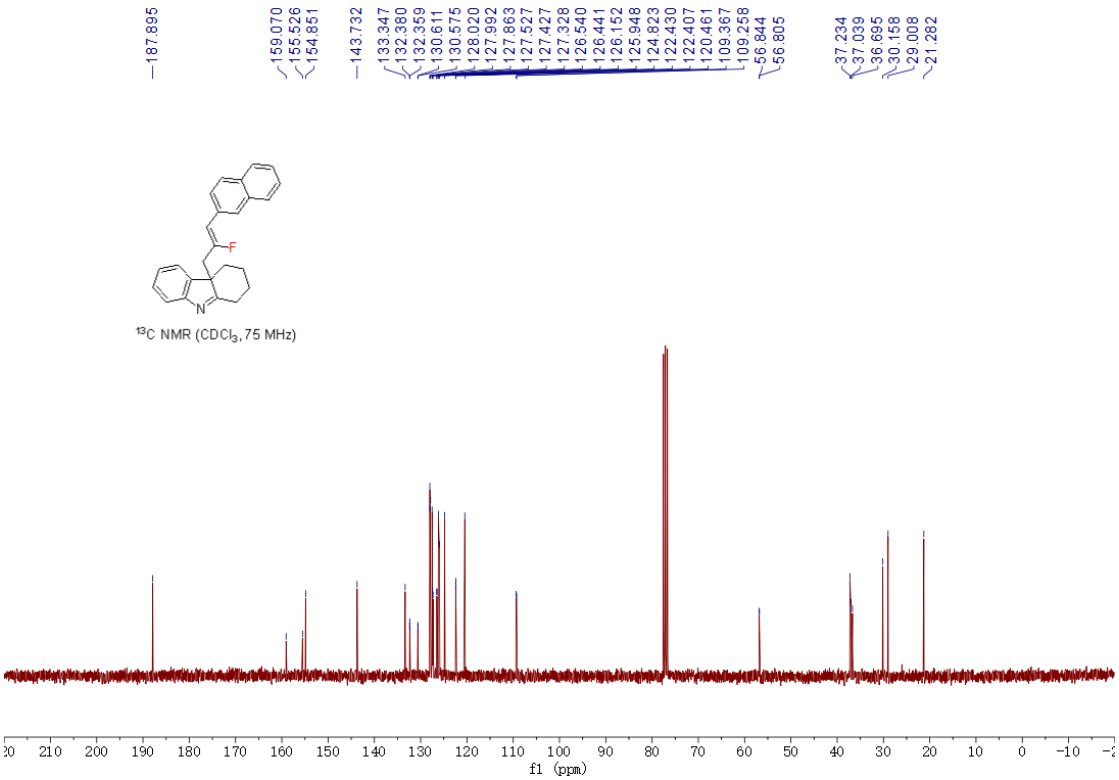


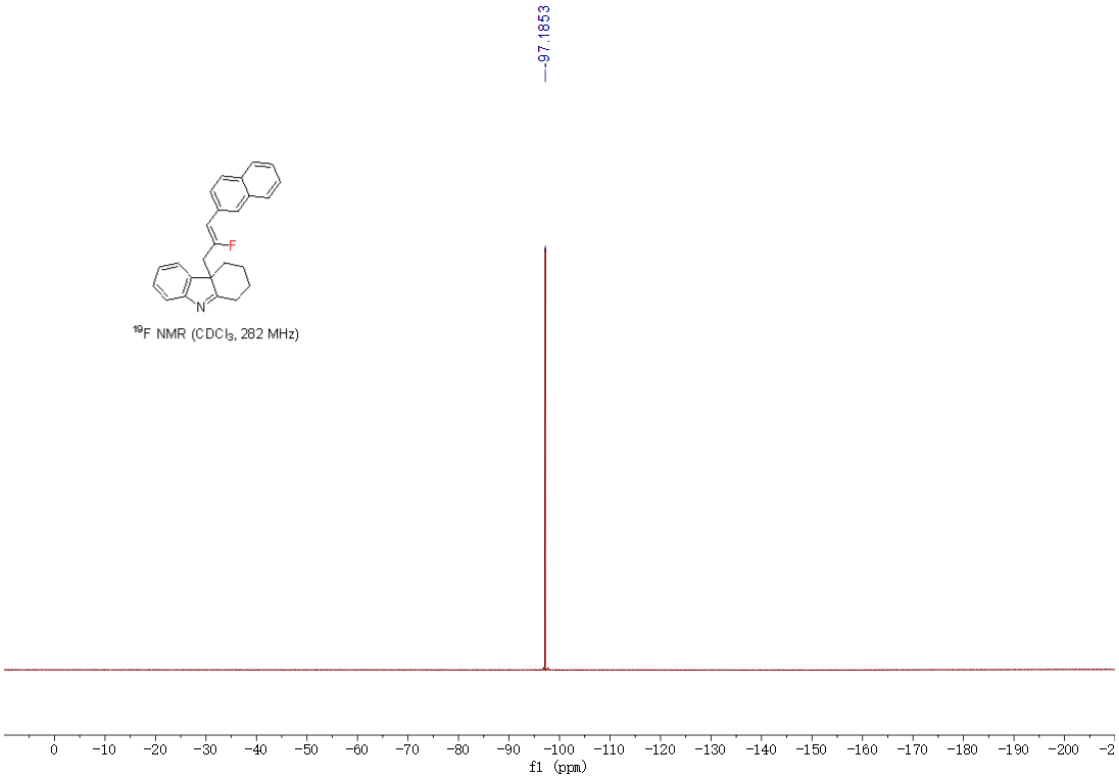
^{13}C NMR ($CDCl_3$, 75 MHz)

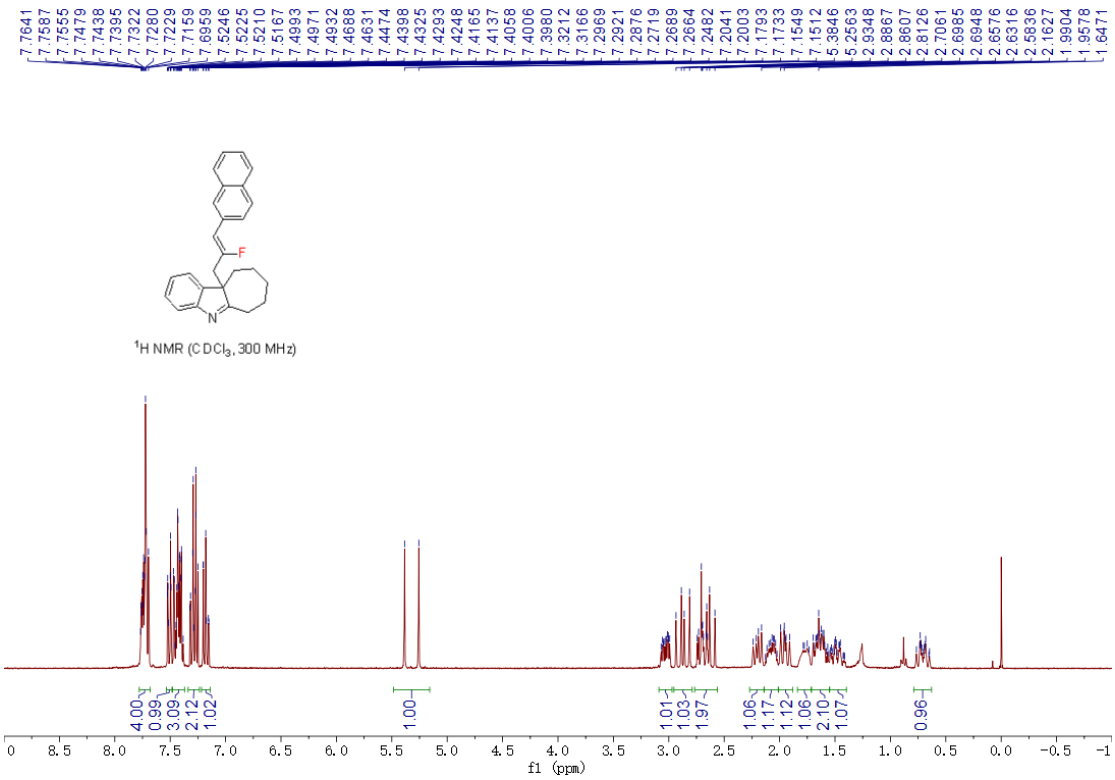

-96.8751
F
N
^{19}F NMR ($CDCl_3$, 282 MHz)
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

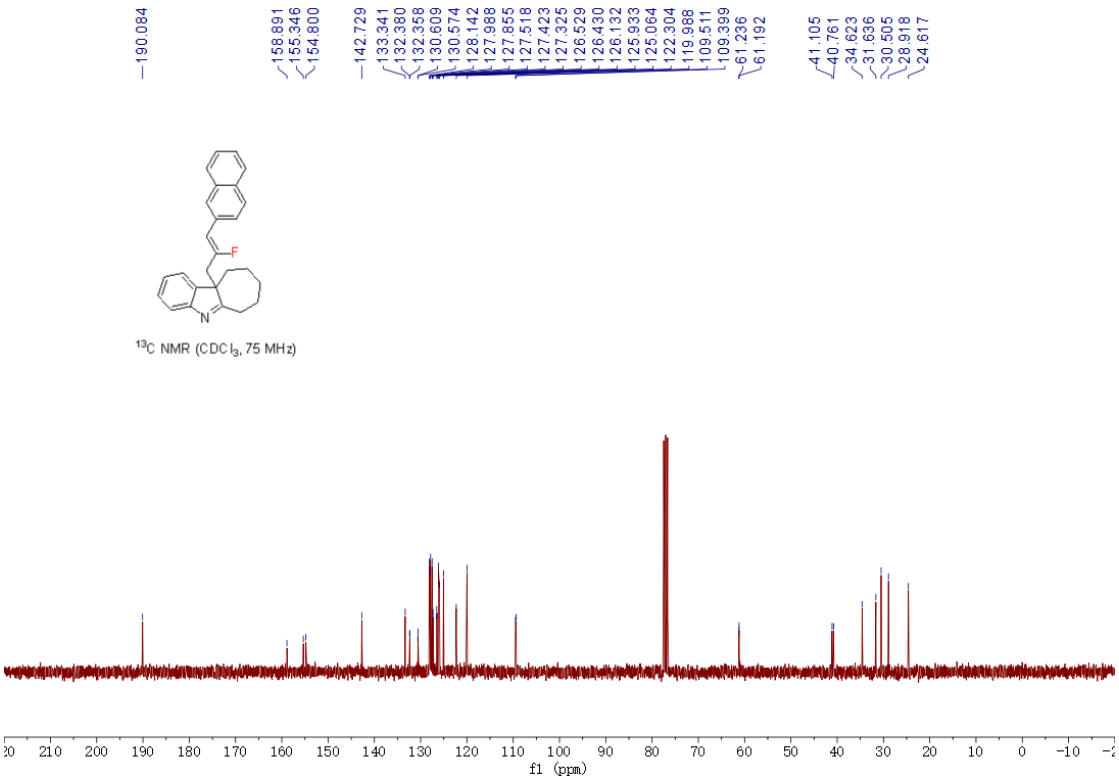

7.7512
7.7422
7.7349
7.7264
7.7185
7.7148
7.7100
7.6826
7.6120
7.6091
7.6060
7.5864
7.5835
7.5805
7.4591
7.4533
7.4363
7.4304
7.4248
7.4215
7.4182
7.4136
7.4052
7.4028
7.3946
7.3893
7.3871
7.3724
7.3691
7.3493
7.3461
7.3451
7.3451
7.3432
7.3386
7.3176
7.3132
7.2923
7.2879
7.2357
7.2039
7.2001
7.1792
7.1754
7.1544
7.1507
5.3926
5.2633
3.0250
2.9760
2.9503
2.9416
2.9011
2.7281
2.7012
2.6811
2.6579
2.6095
1.4882
1.1985
1.1842

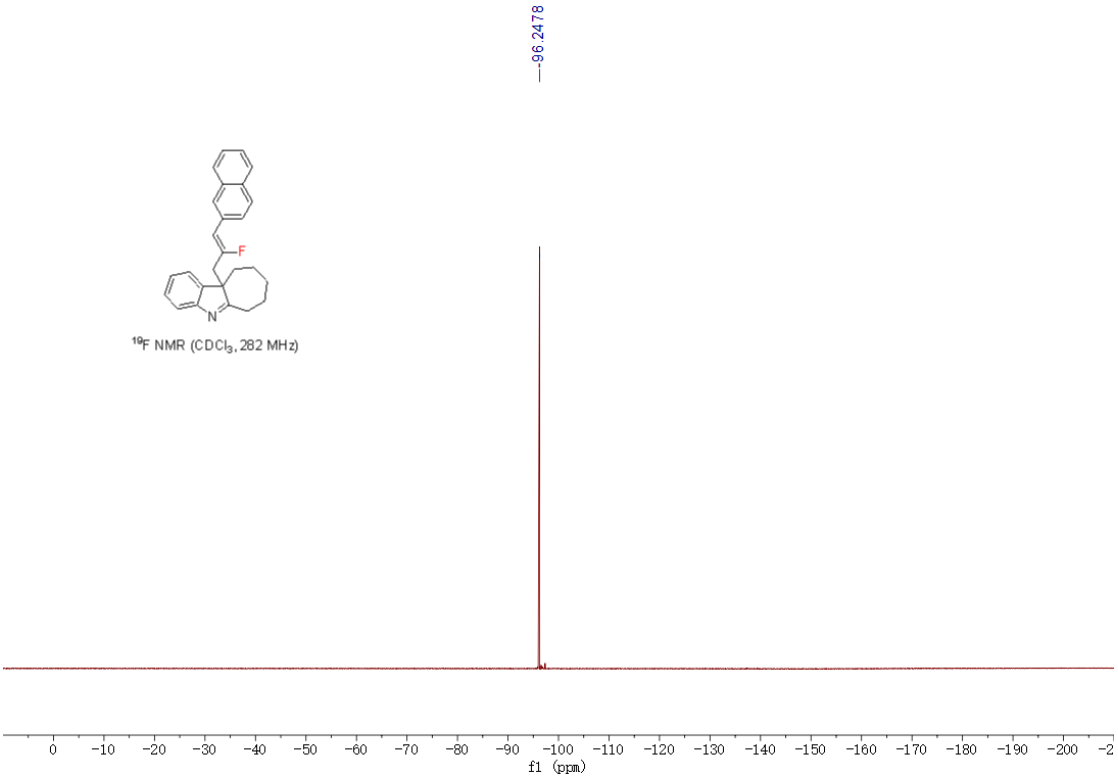

F
N
^{1}H NMR ($CDCl_3$, 300 MHz)
4.00
1.00
2.97
2.06
1.02
0.97
2.00
2.00
1.01
1.00
2.15
1.06
1.34
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


187.895
159.070
155.526
154.851
143.732
133.347
132.380
132.359
130.611
130.575
128.020
127.992
127.863
127.527
127.427
127.328
126.540
126.441
126.152
125.948
124.823
122.430
122.407
120.461
109.367
109.258
56.844
56.805
37.234
37.039
36.695
30.158
29.008
21.282
F
N
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

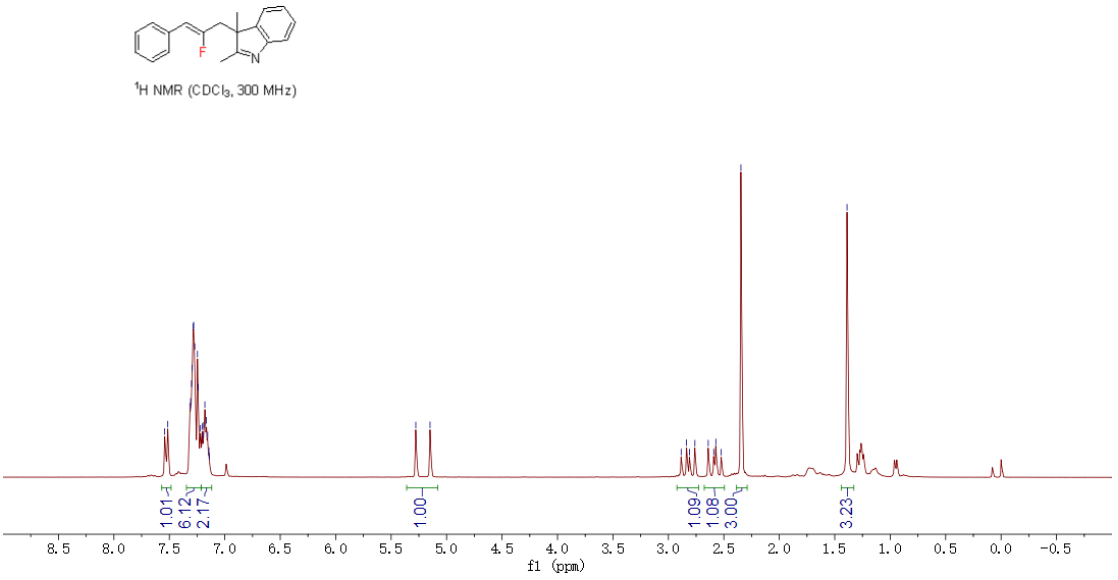

97.1853
F
N
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

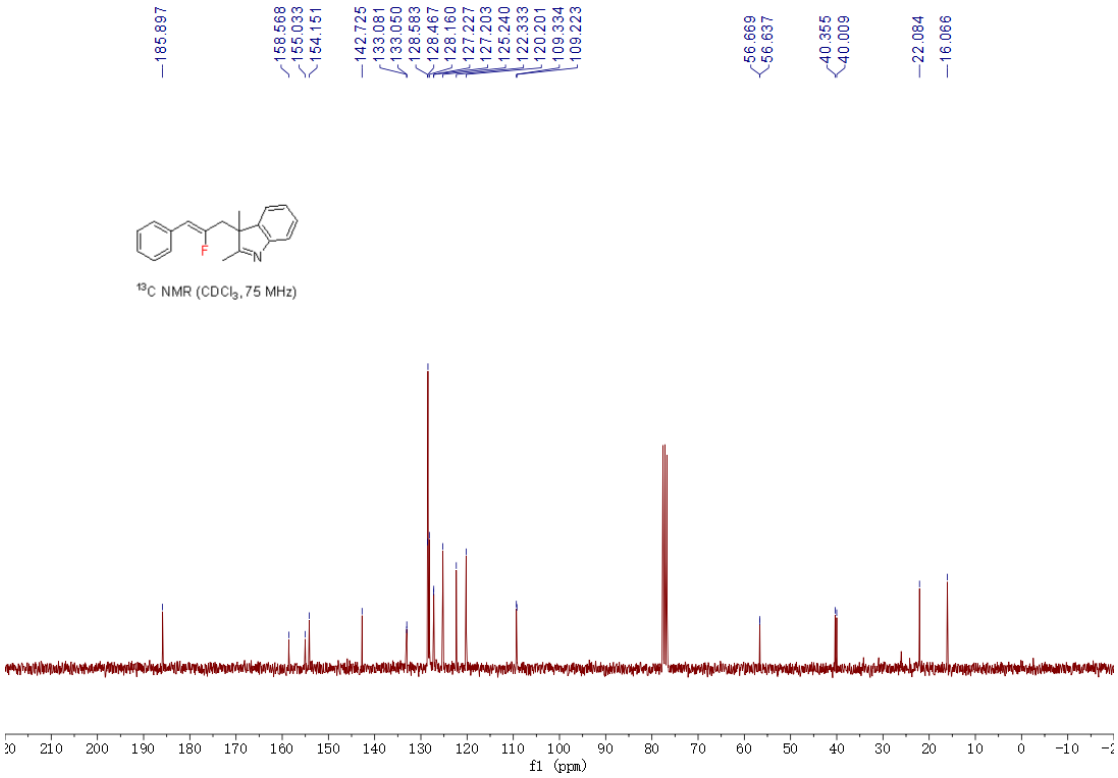

7.7641
7.7587
7.7555
7.7479
7.7438
7.7395
7.7322
7.7280
7.7229
7.7159
7.6959
7.5246
7.5225
7.5210
7.5167
7.4993
7.4971
7.4932
7.4688
7.4631
7.4474
7.4398
7.4325
7.4293
7.4248
7.4165
7.4137
7.4058
7.4006
7.3980
7.3212
7.3166
7.2969
7.2921
7.2876
7.2719
7.2689
7.2664
7.2482
7.2041
7.2003
7.1793
7.1733
7.1549
7.1512
5.3846
5.2563
2.9348
2.8867
2.8607
2.8126
2.7061
2.6985
2.6948
2.6576
2.6316
2.5836
2.1627
1.9904
1.9578
1.6471
F
N
1H NMR (CDCl3, 300 MHz)
4.00
0.99
3.09
2.12
1.02
1.00
1.01
1.03
1.97
1.06
1.17
1.12
1.06
2.10
1.07
0.96
f1 (ppm)

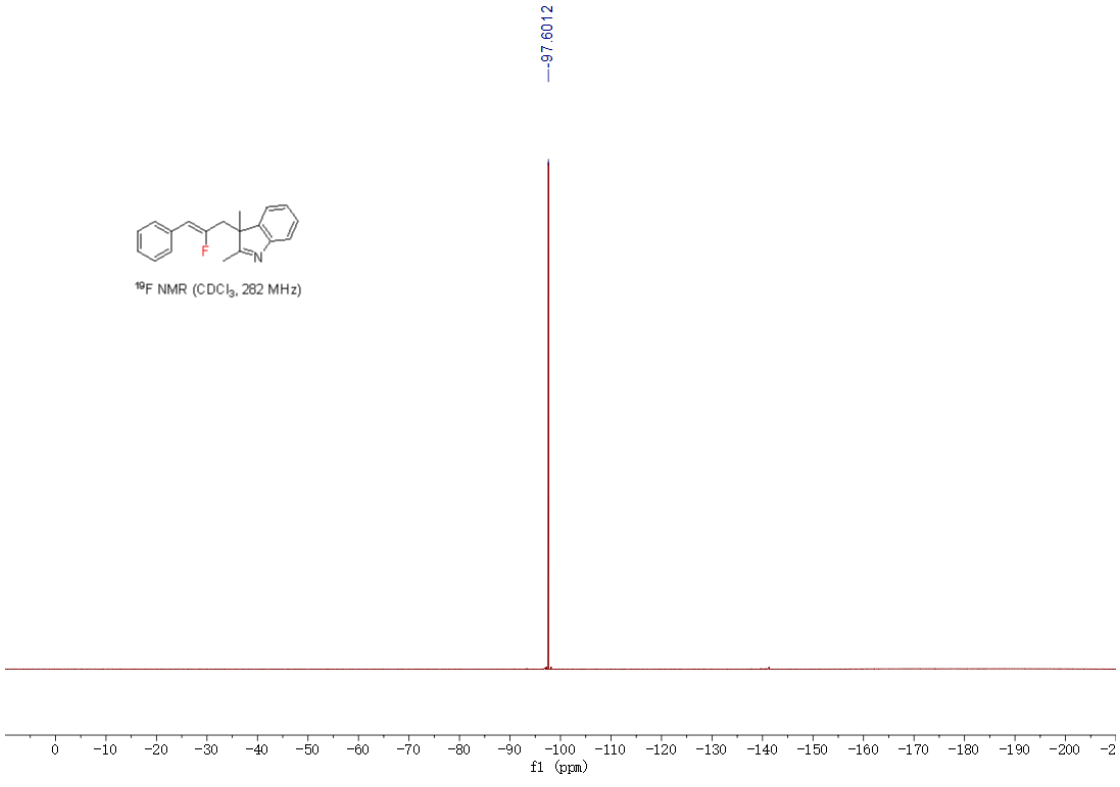

190.084
158.891
155.346
154.800
142.729
133.341
132.380
132.358
130.609
130.574
128.142
127.988
127.855
127.518
127.423
127.325
126.529
126.430
126.132
125.933
125.064
122.304
119.988
109.511
109.399
61.236
61.192
41.105
40.761
34.623
31.636
30.505
28.918
24.617
F
N
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

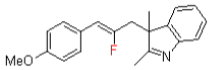

-96.2478
F
N
19F NMR (CDCl3, 282 MHz)
f1 (ppm)


7.5420
7.5143
7.3149
7.3084
7.3000
7.2952
7.2863
7.2807
7.2709
7.2465
7.2405
7.2203
7.2042
7.1956
7.1899
7.1796
7.1659
7.1542
7.1433
7.1385
5.2778
5.1492
2.8846
2.8366
2.8100
2.7612
2.6406
2.5911
2.5722
2.5238
2.3461
1.3891

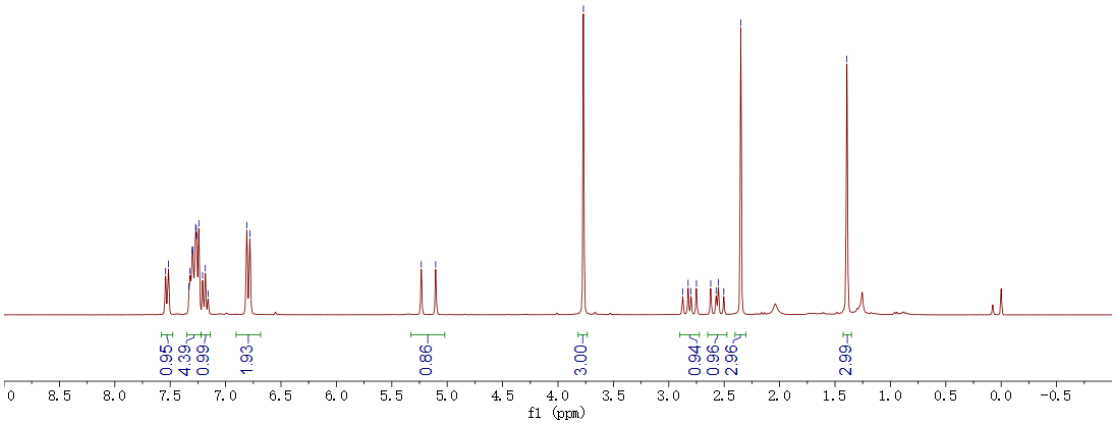

F
N
1H NMR (CDCl3, 300 MHz)
1.01
6.12
2.17
1.00
1.09
1.08
3.00
3.23
f1 (ppm)

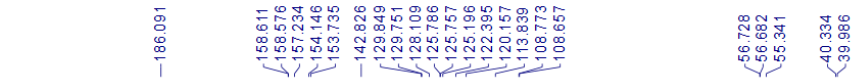

185.897
158.568
155.033
154.151
142.725
133.081
133.050
128.583
128.467
128.160
127.227
127.203
125.240
122.333
120.201
109.334
109.223
56.669
56.637
40.355
40.009
22.084
16.066
F
N
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

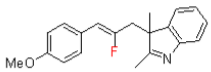

97.6012
F
N
19F NMR (CDCl3, 282 MHz)
f1 (ppm)



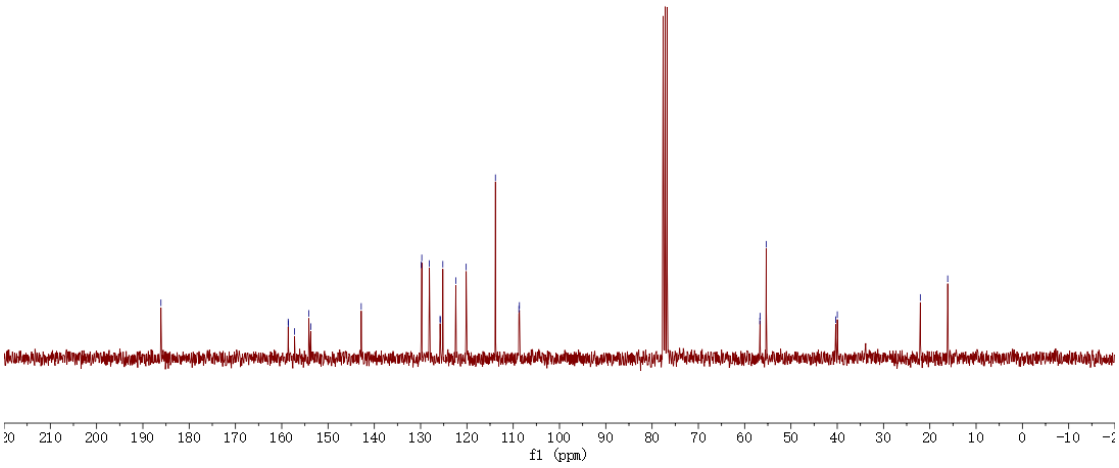
^{1}H NMR ($CDCl_3$, 300 MHz)

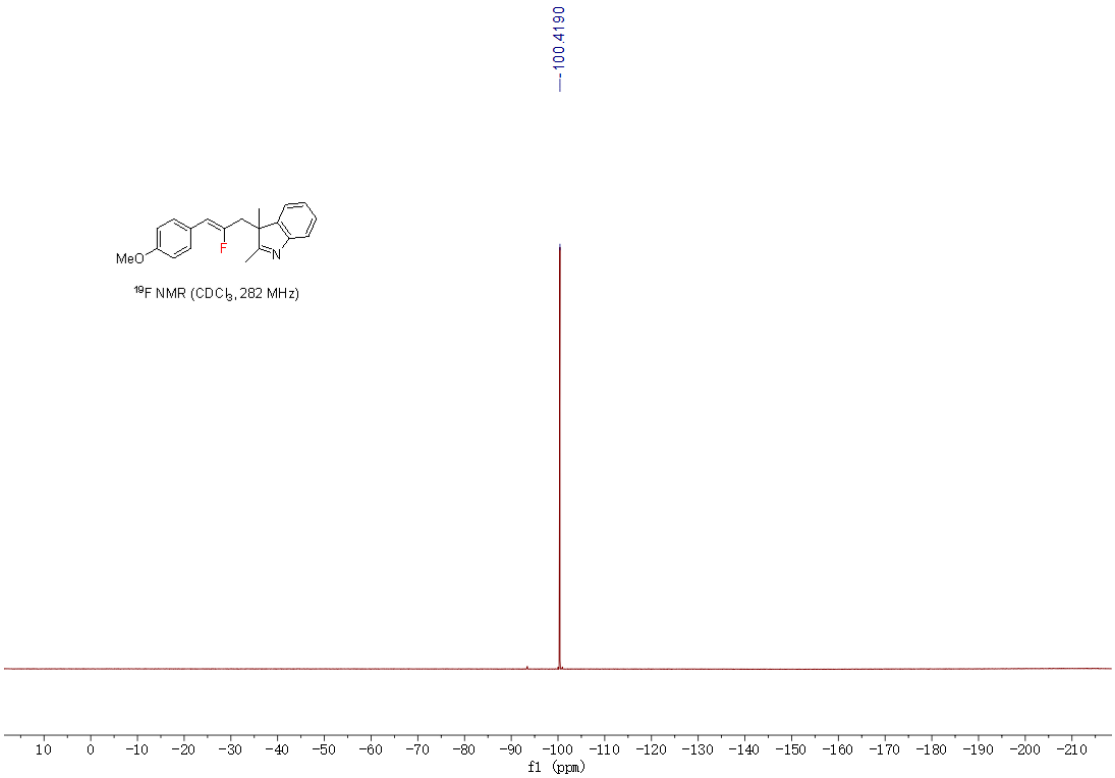


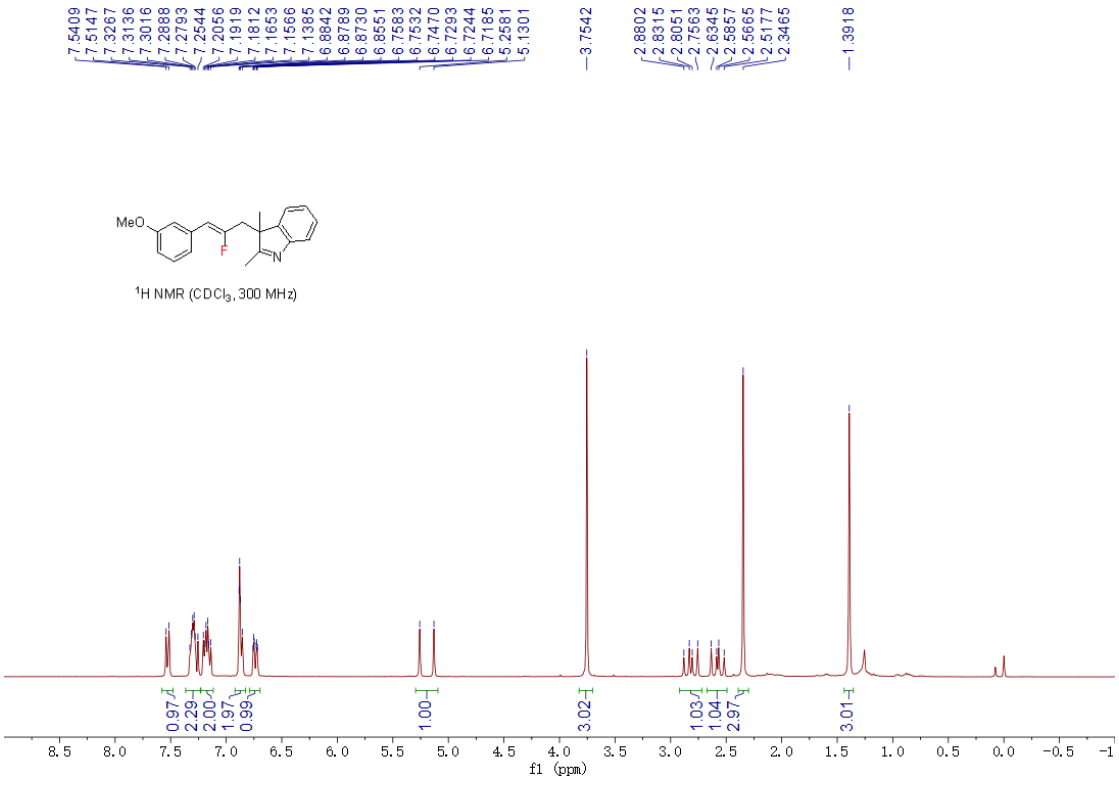


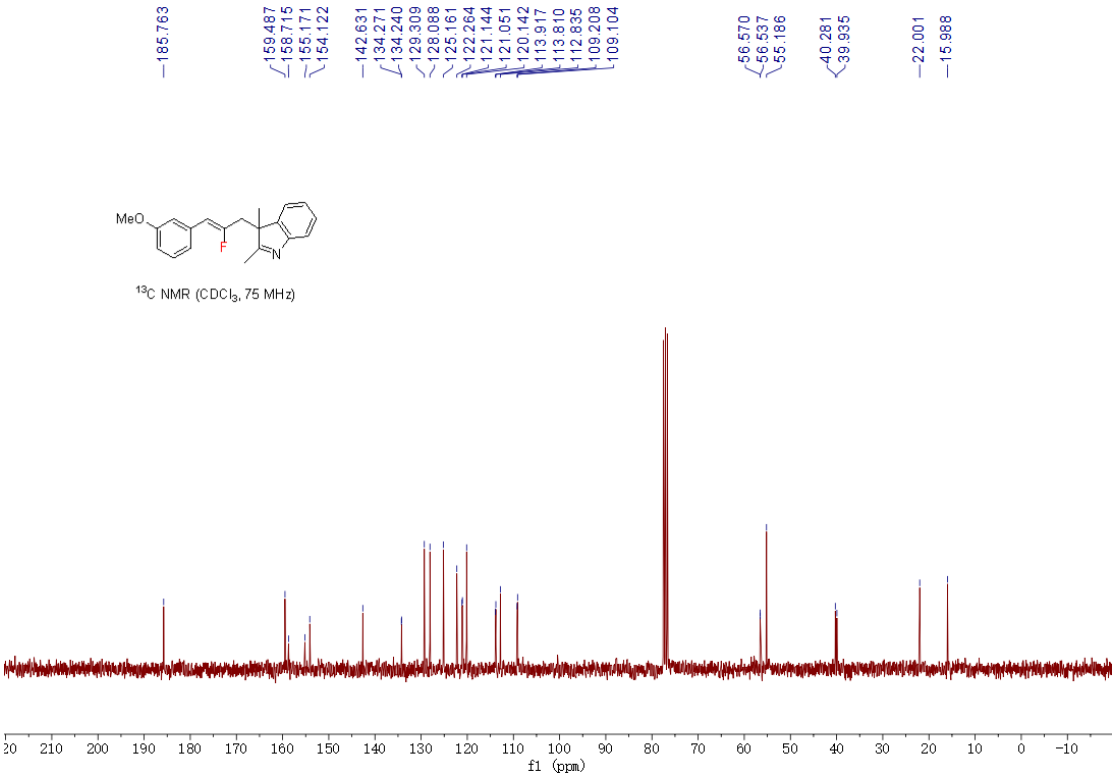


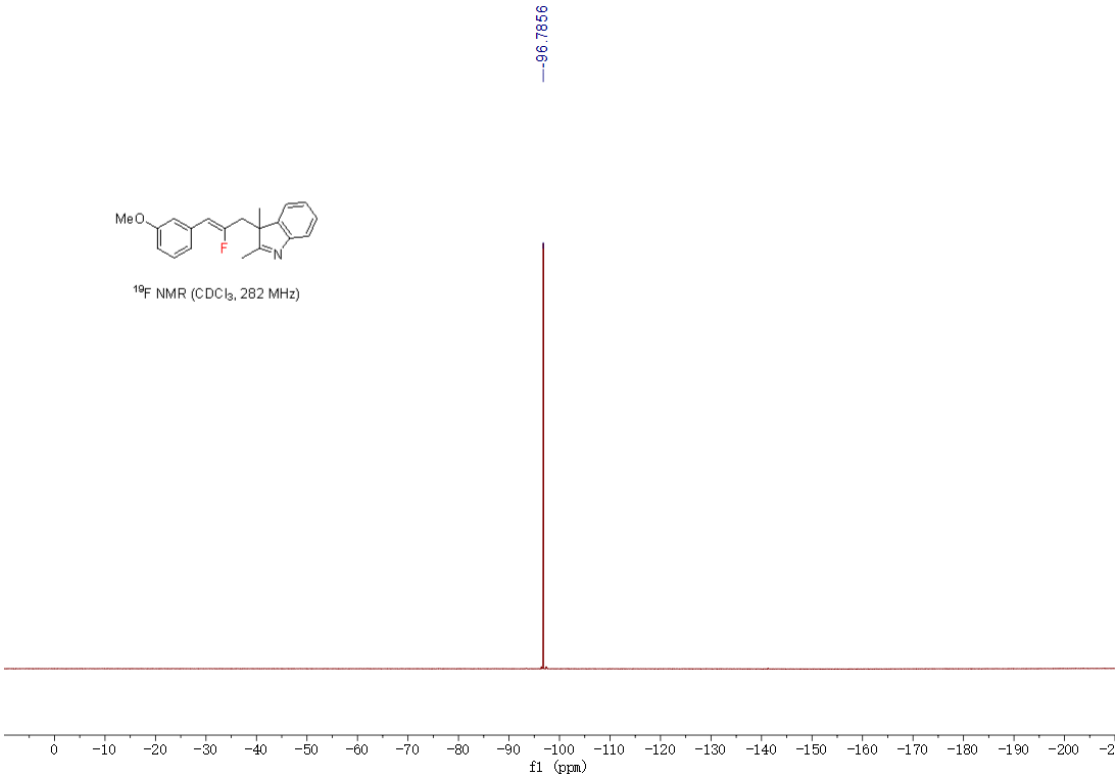
^{13}C NMR ($CDCl_3$, 75 MHz)

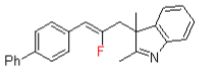



-100.4190
MeO
F
N
^{19}F NMR ($CDCl_3$, 282 MHz)
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

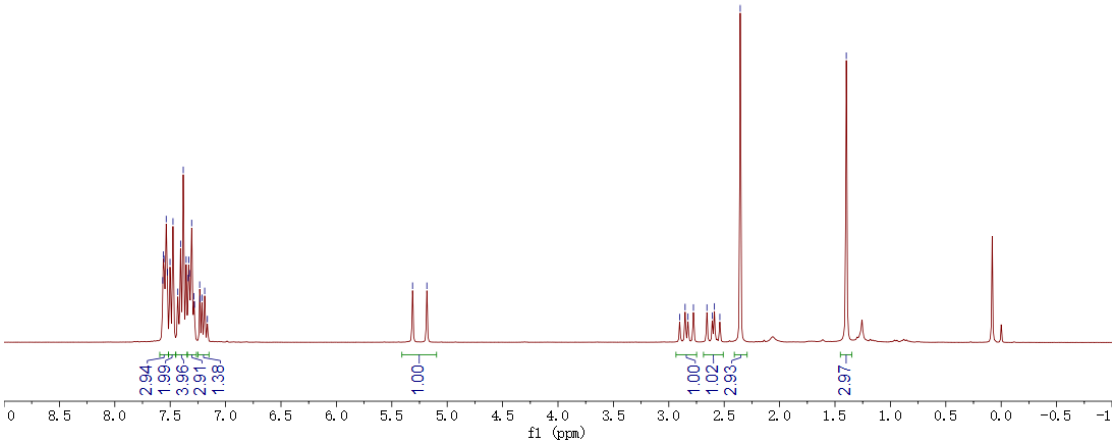

7.5409
7.5147
7.3267
7.3136
7.3016
7.2888
7.2793
7.2544
7.2056
7.1919
7.1812
7.1653
7.1566
7.1385
6.8842
6.8789
6.8730
6.8551
6.7583
6.7532
6.7470
6.7293
6.7244
6.7185
5.2581
5.1301
3.7542
2.8802
2.8315
2.8051
2.7563
2.6345
2.5857
2.5665
2.5177
2.3465
1.3918
MeO
F
N
^{1}H NMR ($CDCl_3$, 300 MHz)
0.97
2.29
2.00
1.97
0.99
1.00
3.02
1.03
1.04
2.97
3.01
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

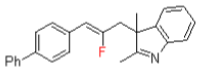

185.763
159.487
158.715
155.171
154.122
142.631
134.271
134.240
129.309
128.088
125.161
122.264
121.144
121.051
120.142
113.917
113.810
112.835
109.208
109.104
56.570
56.537
55.186
40.281
39.935
22.001
15.988
MeO
F
N
13C NMR (CDCl3, 75 MHz)
f1 (ppm)


-96.7856
MeO
F
N
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

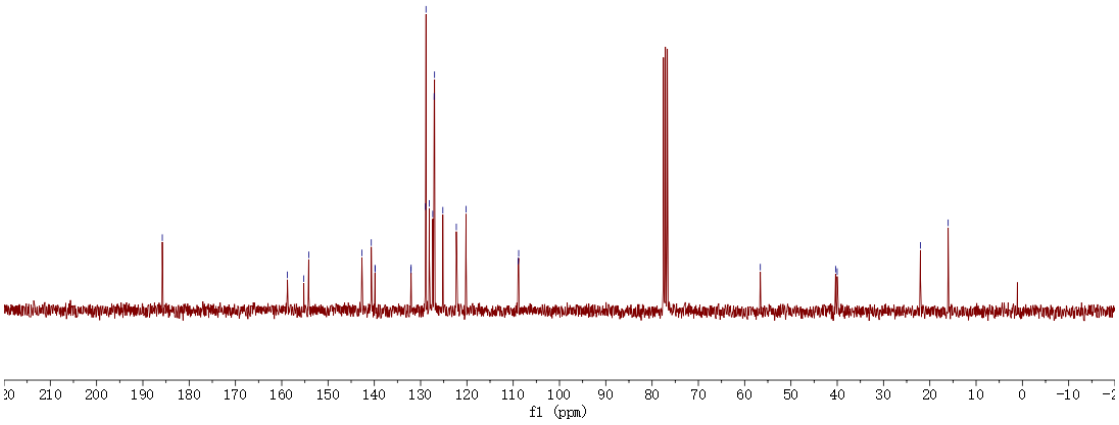


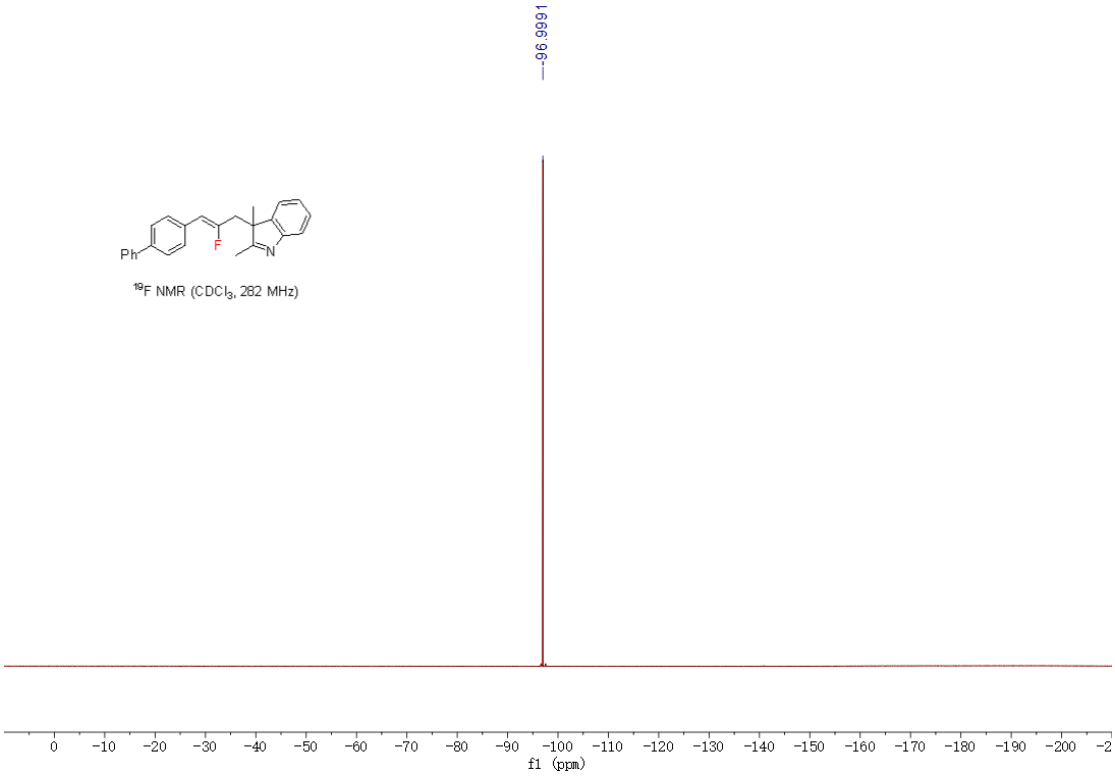
^{1}H NMR ($CDCl_3$, 300 MHz)

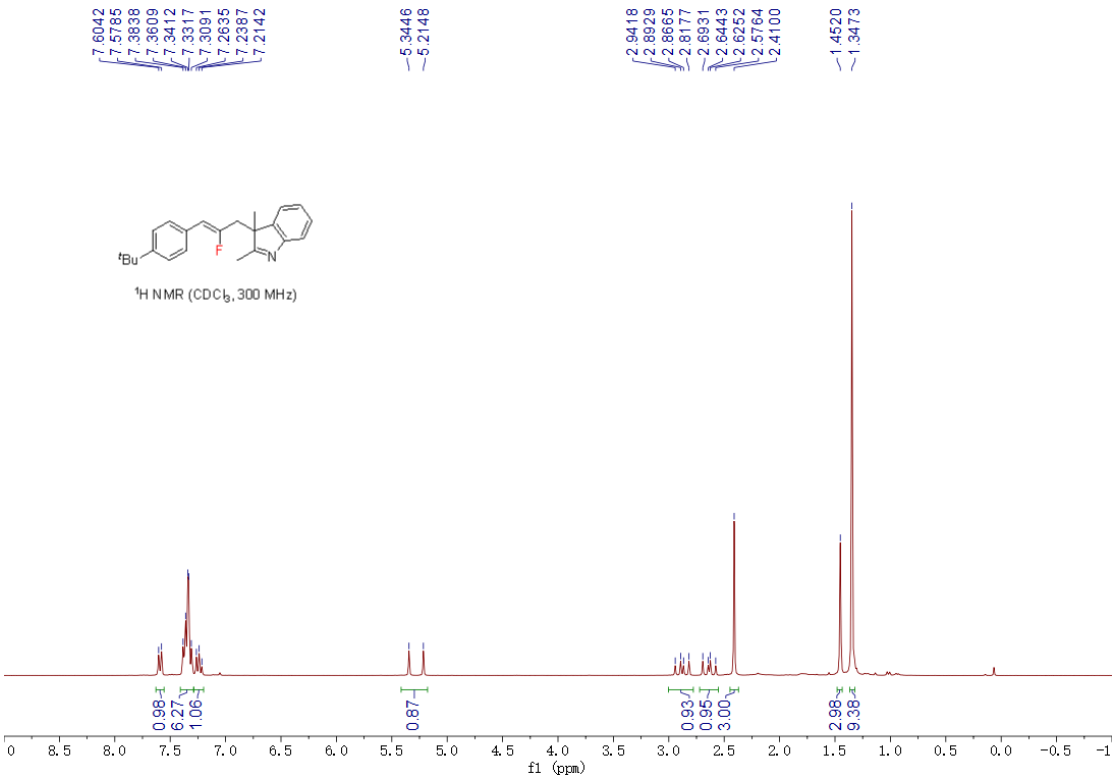


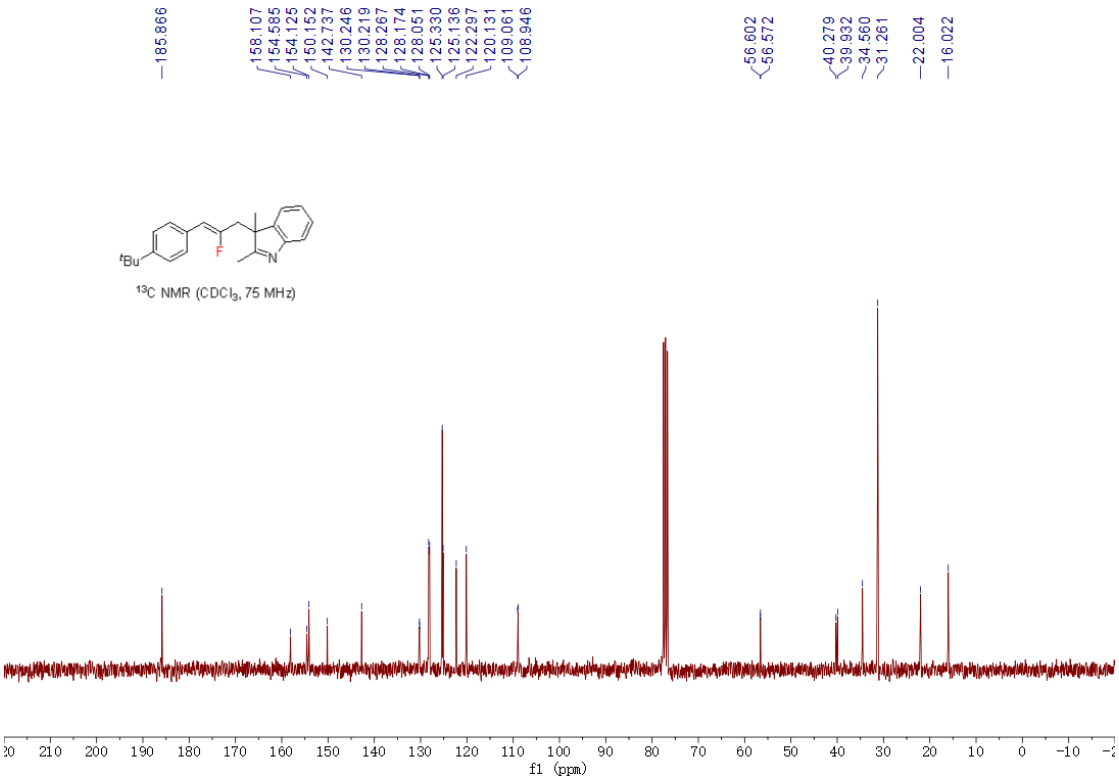


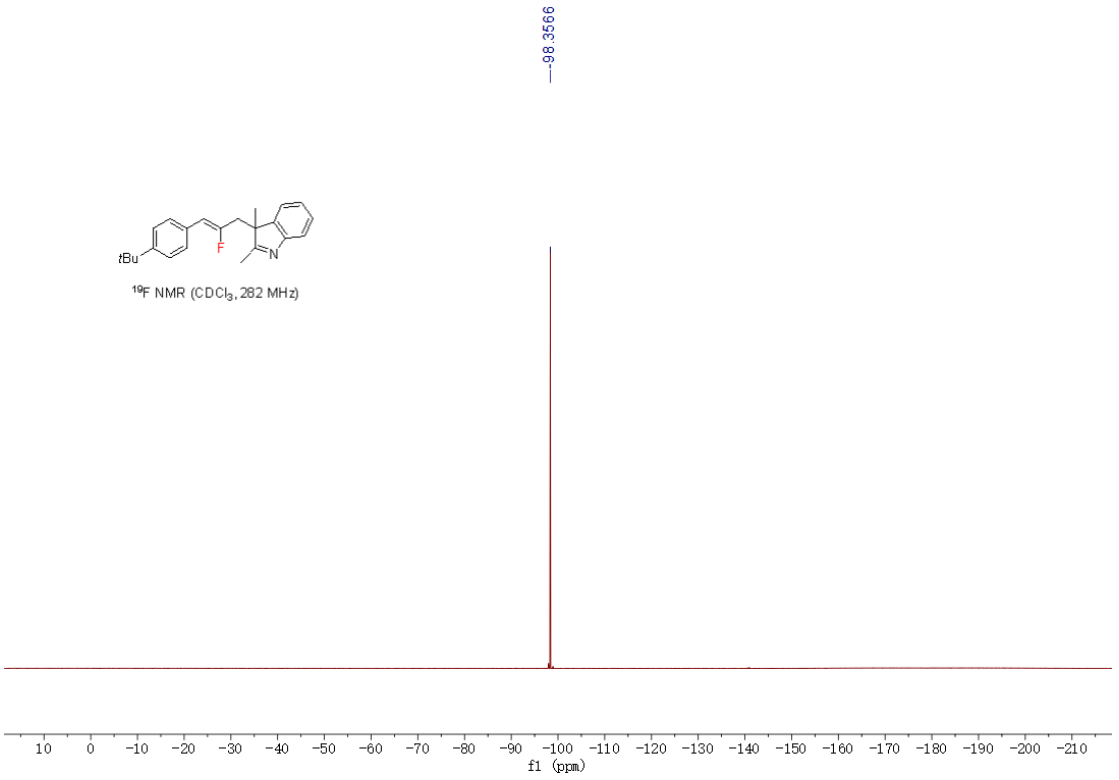
^{13}C NMR ($CDCl_3$, 75 MHz)

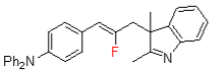



-96.9991
Ph
F
N
^{19}F NMR ($CDCl_3$, 282 MHz)
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -2
f1 (ppm)

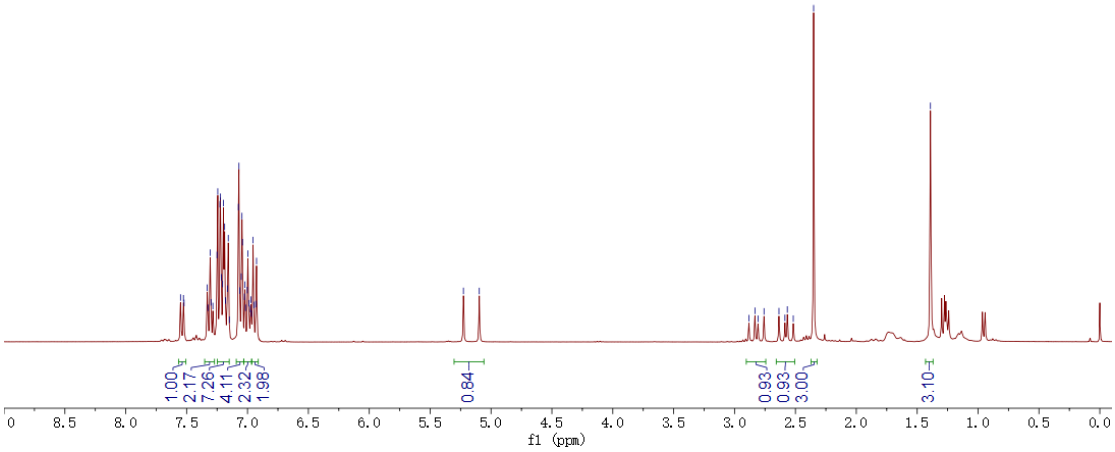

7.6042
7.5785
7.3838
7.3609
7.3412
7.3317
7.3091
7.2635
7.2387
7.2142
5.3446
5.2148
2.9418
2.8929
2.8665
2.8177
2.6931
2.6443
2.6252
2.5764
2.4100
1.4520
1.3473
^{t}Bu
F
N
^{1}H NMR ($CDCl_3$, 300 MHz)
0.98
6.27
1.06
0.87
0.93
0.95
3.00
2.98
9.38
0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

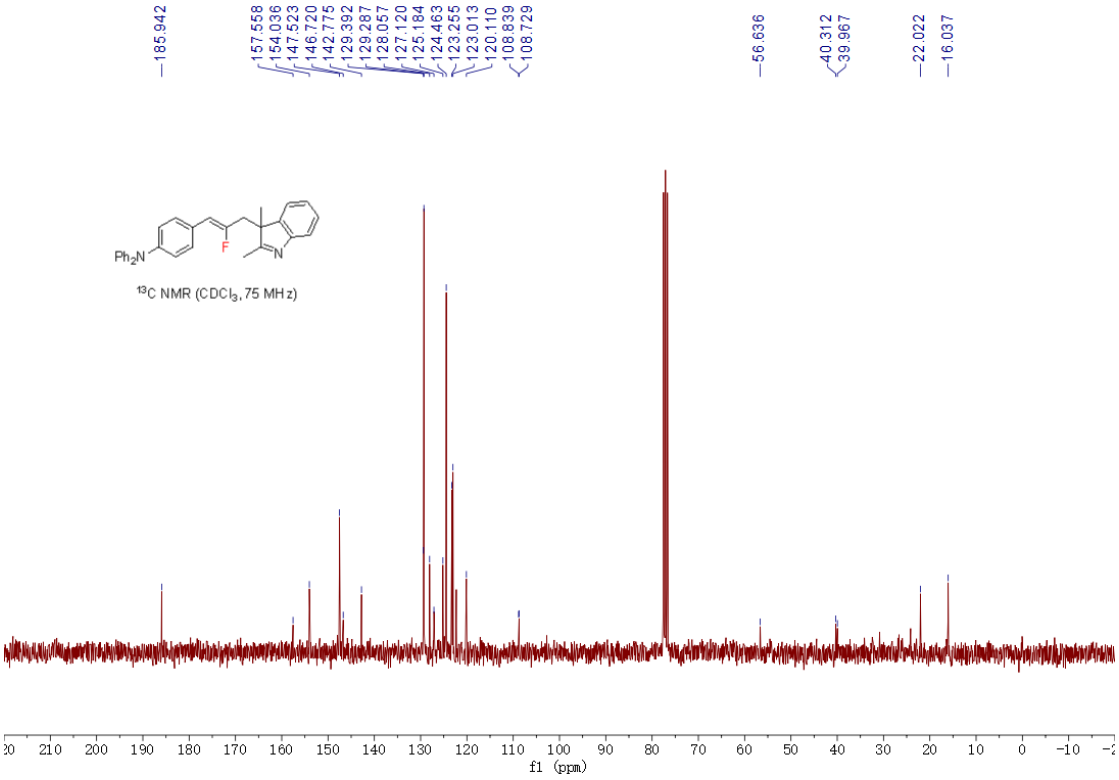

185.866
158.107
154.585
154.125
150.152
142.737
130.246
130.219
128.267
128.174
128.051
125.330
125.136
122.297
120.131
109.061
108.946
56.602
56.572
40.279
39.932
34.560
31.261
22.004
16.022
tBu
F
N
13C NMR (CDCl3, 75 MHz)
f1 (ppm)


98.3566
tBu
F
N
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

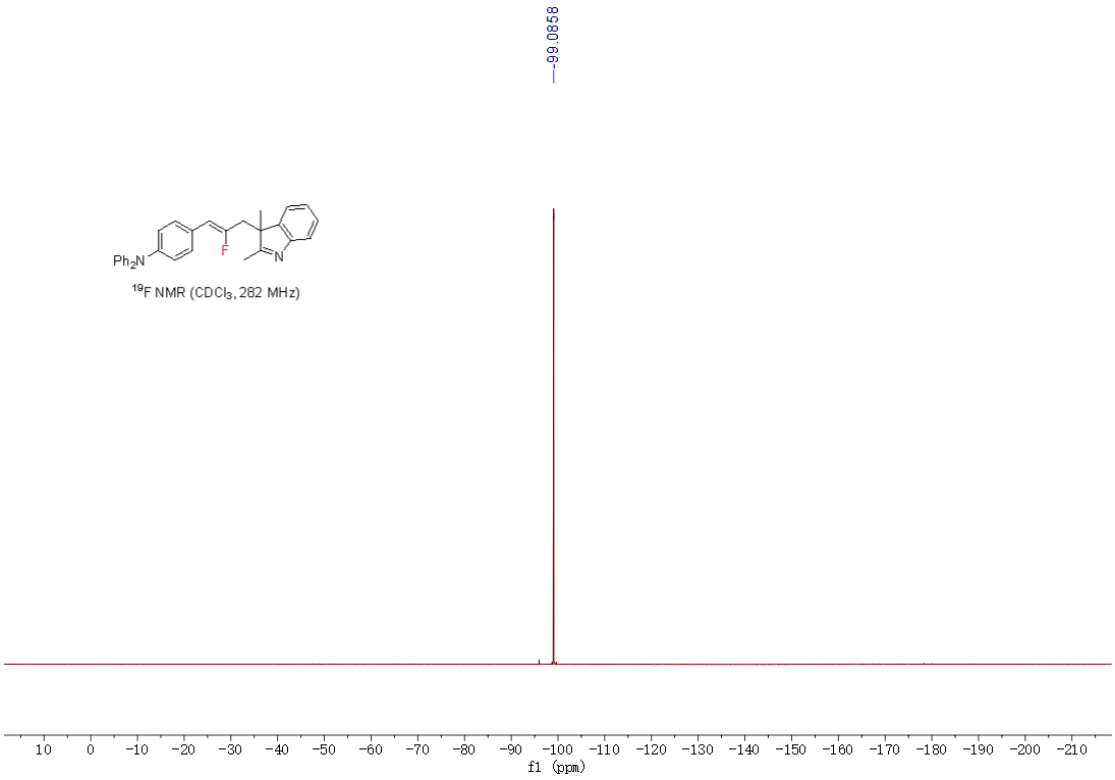


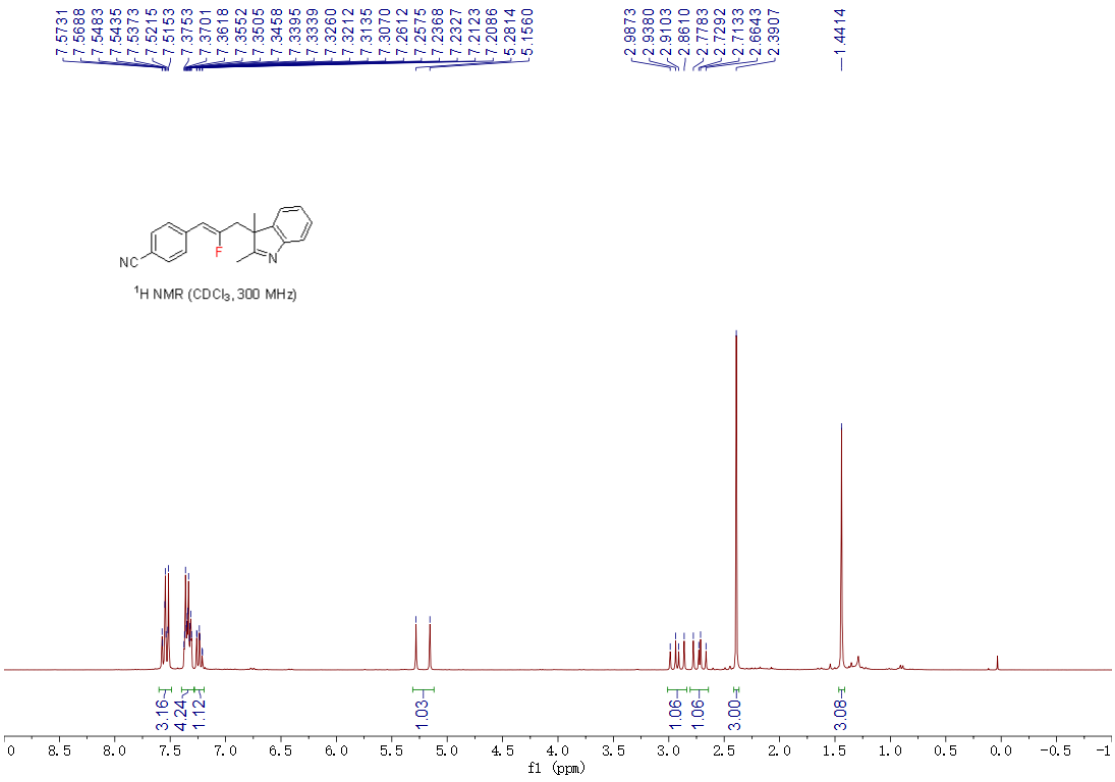
^{1}H NMR ($CDCl_3$, 300 MHz)

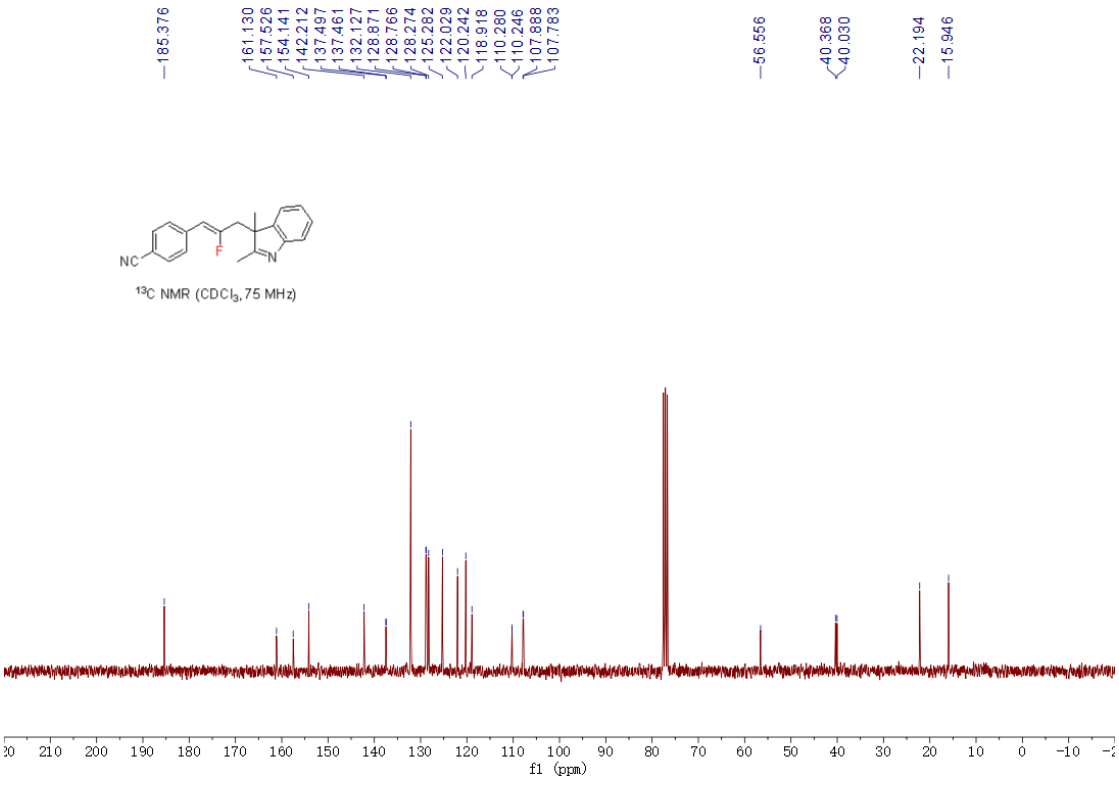


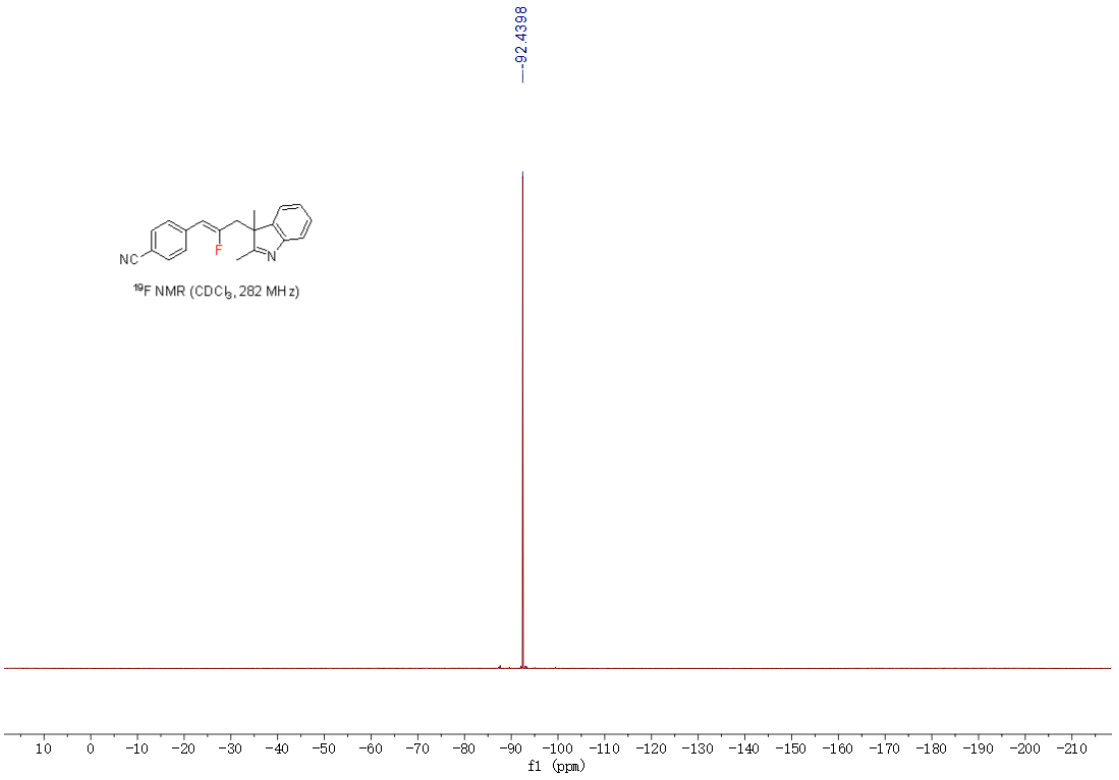


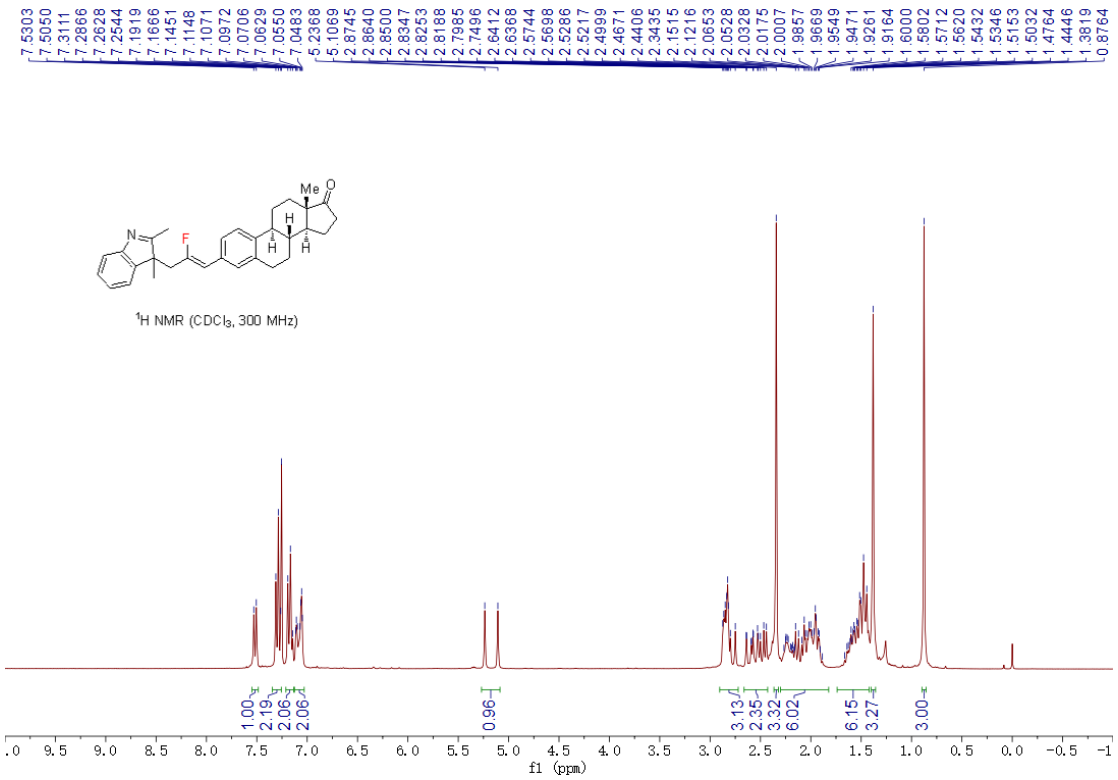
^{13}C NMR ($CDCl_3$, 75 MHz)

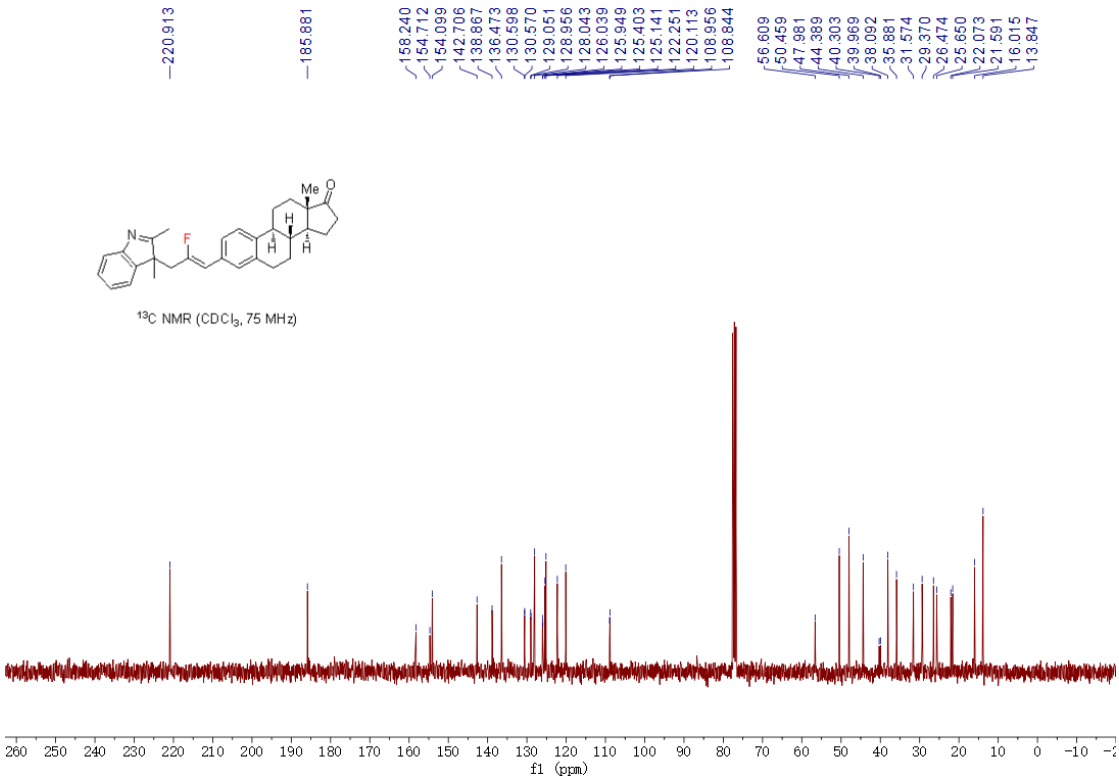

-99.0858
Ph2N
F
N
19F NMR (CDCl3, 282 MHz)
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

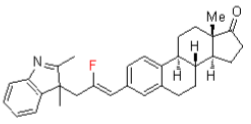

7.5731
7.5688
7.5483
7.5435
7.5373
7.5215
7.5153
7.3753
7.3701
7.3618
7.3552
7.3505
7.3458
7.3395
7.3339
7.3260
7.3212
7.3135
7.3070
7.2612
7.2575
7.2368
7.2327
7.2123
7.2086
5.2814
5.1560
2.9873
2.9380
2.9103
2.8610
2.7783
2.7292
2.7133
2.6643
2.3907
1.4414
NC
F
N
1H NMR (CDCl3, 300 MHz)
3.16
4.24
1.12
1.03
1.06
1.06
3.00
3.08
0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)


185.376
161.130
157.526
154.141
142.212
137.497
137.461
132.127
128.871
128.766
128.274
125.282
122.029
120.242
118.918
110.280
110.246
107.888
107.783
56.556
40.368
40.030
22.194
15.946
NC
F
N
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

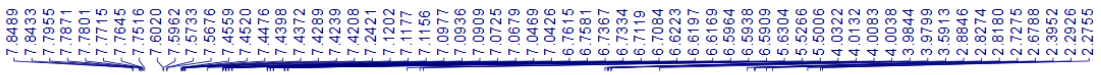

92.4398
NC
F
N
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

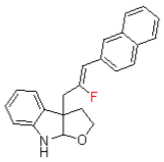

7.5303
7.5050
7.3111
7.2866
7.2628
7.2544
7.1919
7.1666
7.1451
7.1148
7.1071
7.0972
7.0706
7.0629
7.0550
7.0483
5.2368
5.1069
2.8745
2.8640
2.8500
2.8347
2.8253
2.8188
2.7985
2.7496
2.6412
2.6368
2.5744
2.5698
2.5286
2.5217
2.4999
2.4671
2.4406
2.3435
2.1515
2.1216
2.0653
2.0528
2.0328
2.0175
2.0007
1.9857
1.9669
1.9549
1.9471
1.9261
1.9164
1.6000
1.5802
1.5712
1.5620
1.5432
1.5346
1.5153
1.5032
1.4764
1.4446
1.3819
0.8764
Me
O
H
H
H
N
F
1H NMR (CDCl3, 300 MHz)
1.00
2.19
2.06
2.06
0.96
3.13
2.35
3.32
6.02
6.15
3.27
3.00
f1 (ppm)


220.913
185.881
158.240
154.712
154.099
142.706
138.867
136.473
130.598
130.570
129.051
128.956
128.043
126.039
125.949
125.403
125.141
122.251
120.113
108.956
108.844
56.609
50.459
47.981
44.389
40.303
39.969
38.092
35.881
31.574
29.370
26.474
25.650
22.073
21.591
16.015
13.847
Me
O
H
H
H
N
F
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

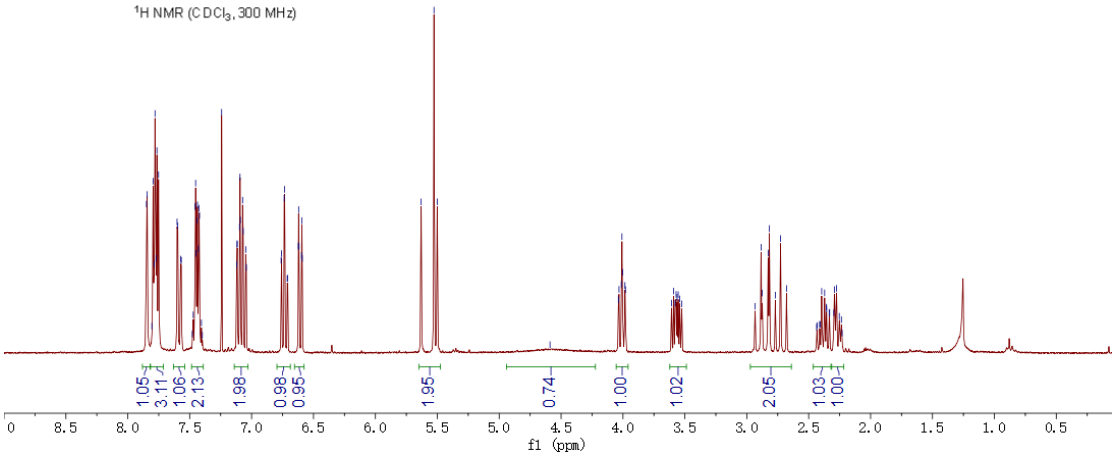


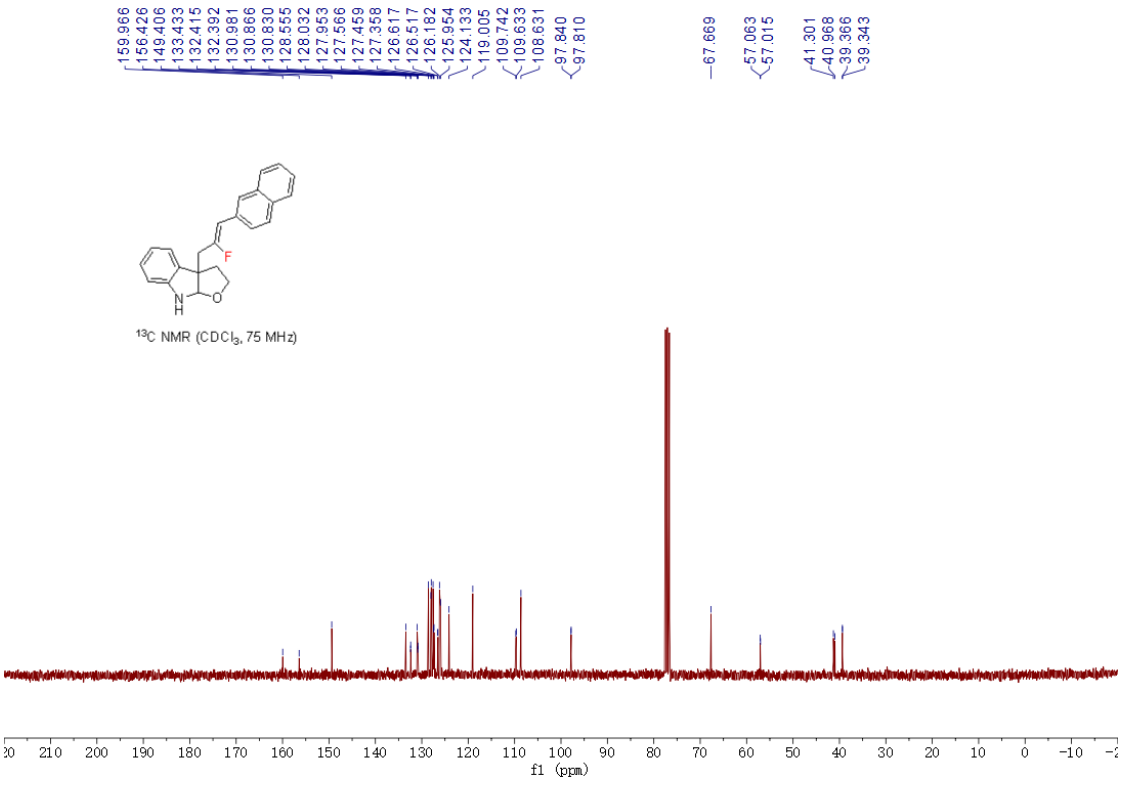
^{19}F NMR ($CDCl_3$, 282 MHz)

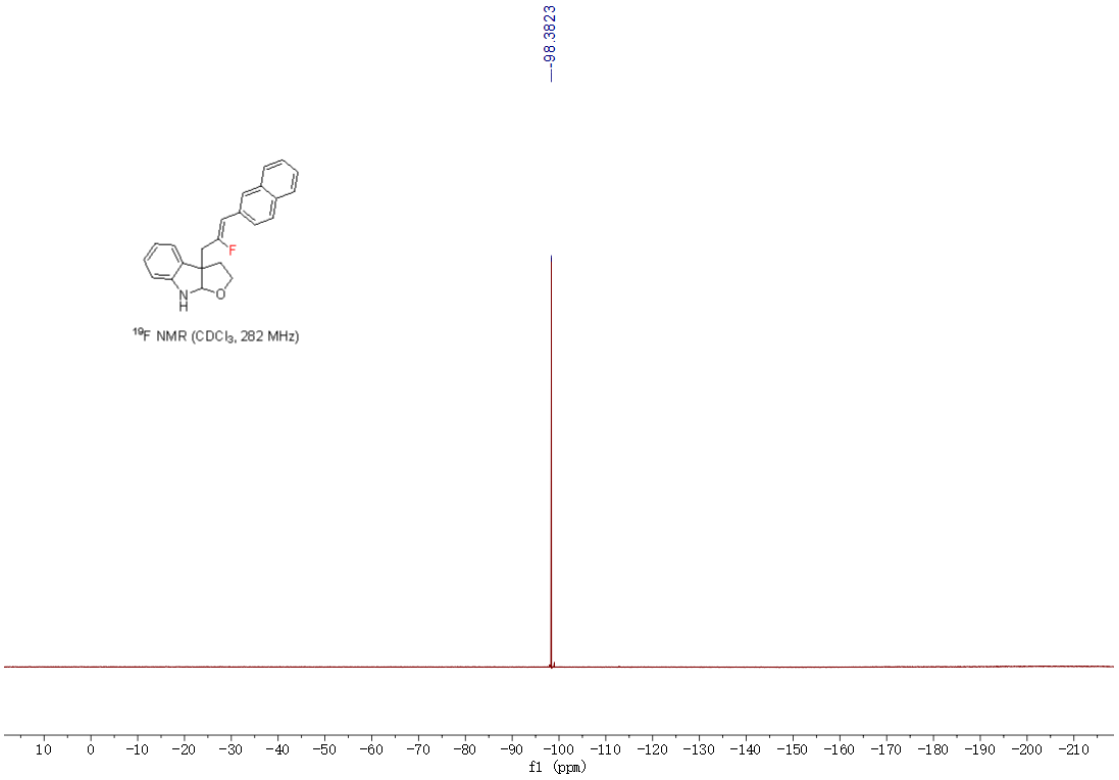


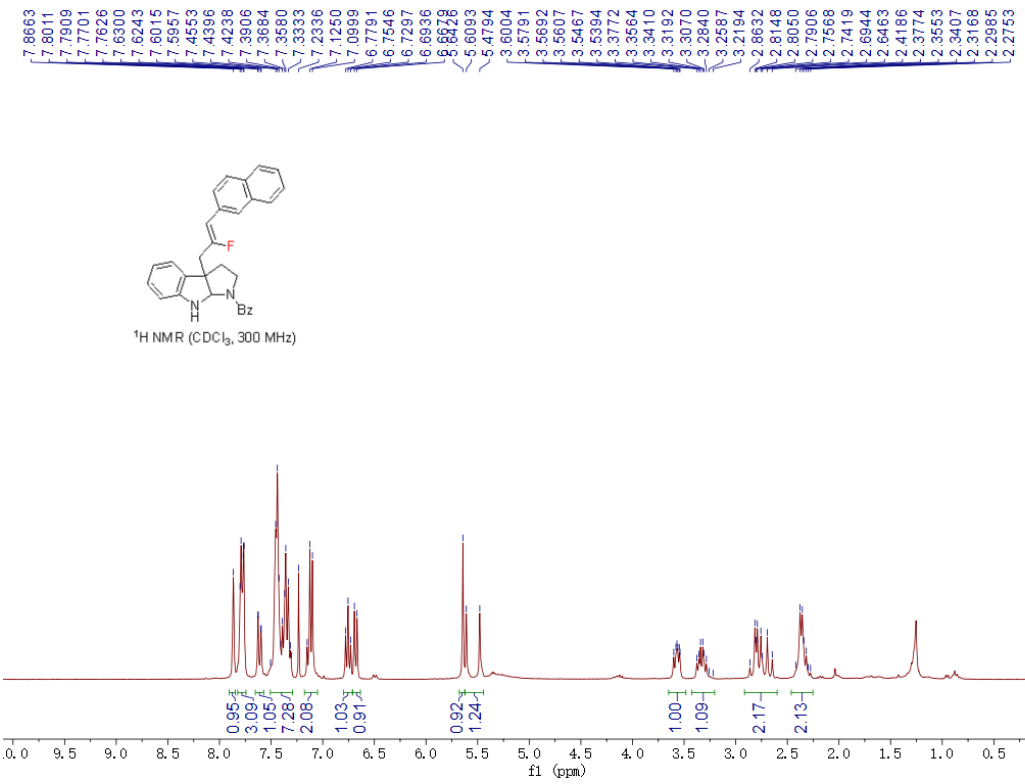


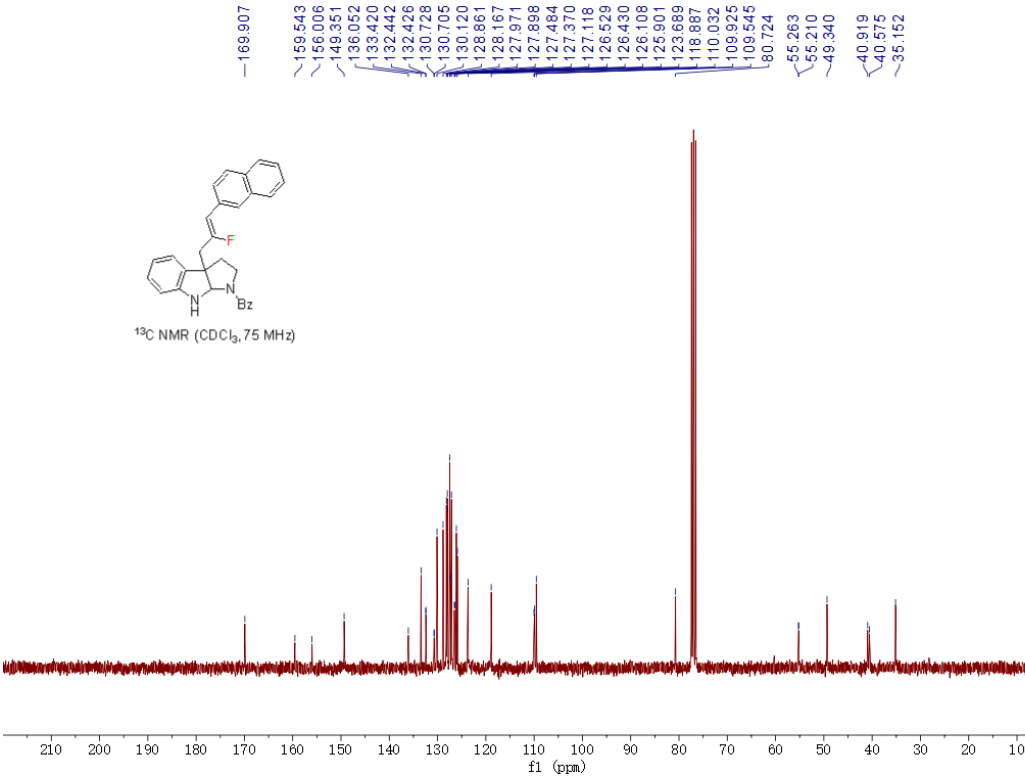
^{1}H NMR ($CDCl_3$, 300 MHz)

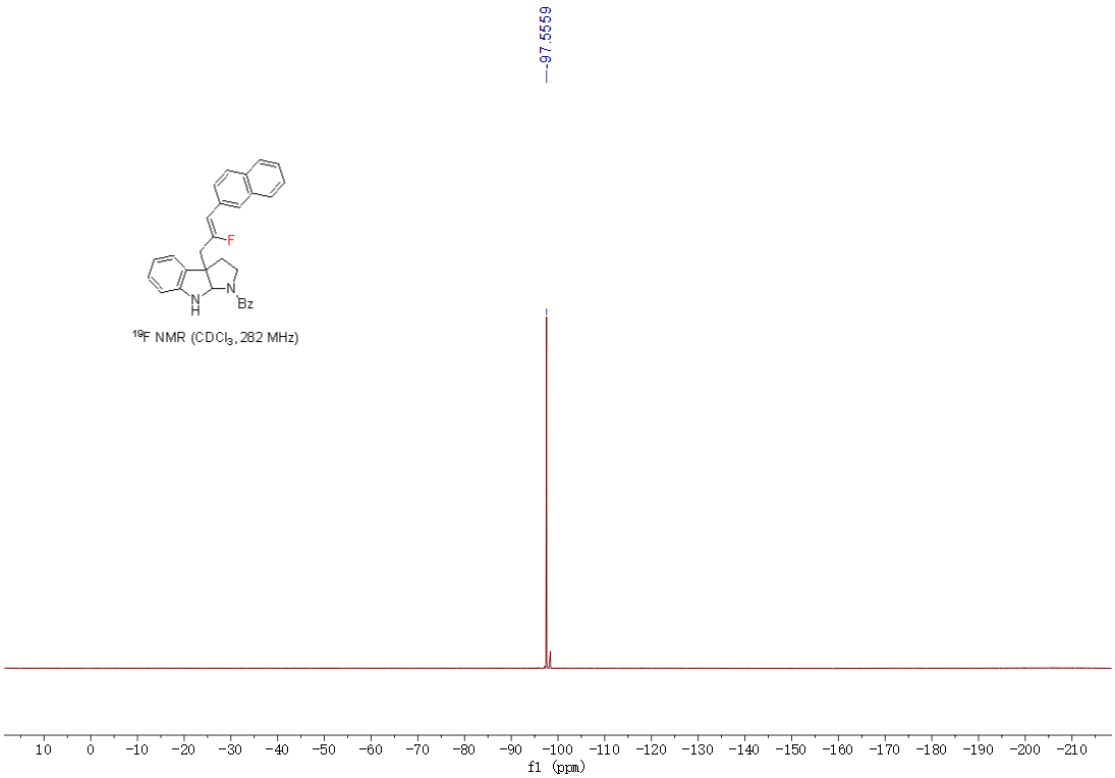


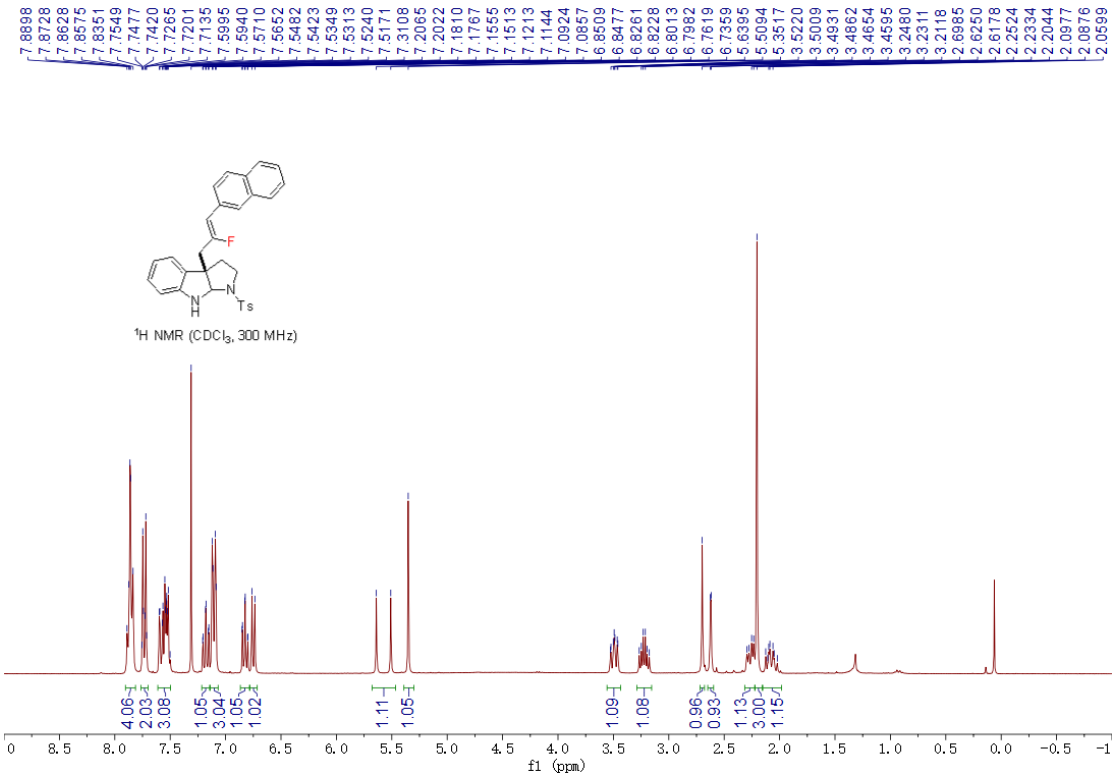

159.966
156.426
149.406
133.433
132.415
132.392
130.981
130.866
130.830
128.555
128.032
127.953
127.566
127.459
127.358
126.617
126.517
126.182
125.954
124.133
119.005
109.742
109.633
108.631
97.840
97.810
67.669
57.063
57.015
41.301
40.968
39.366
39.343
F
N
H
O
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

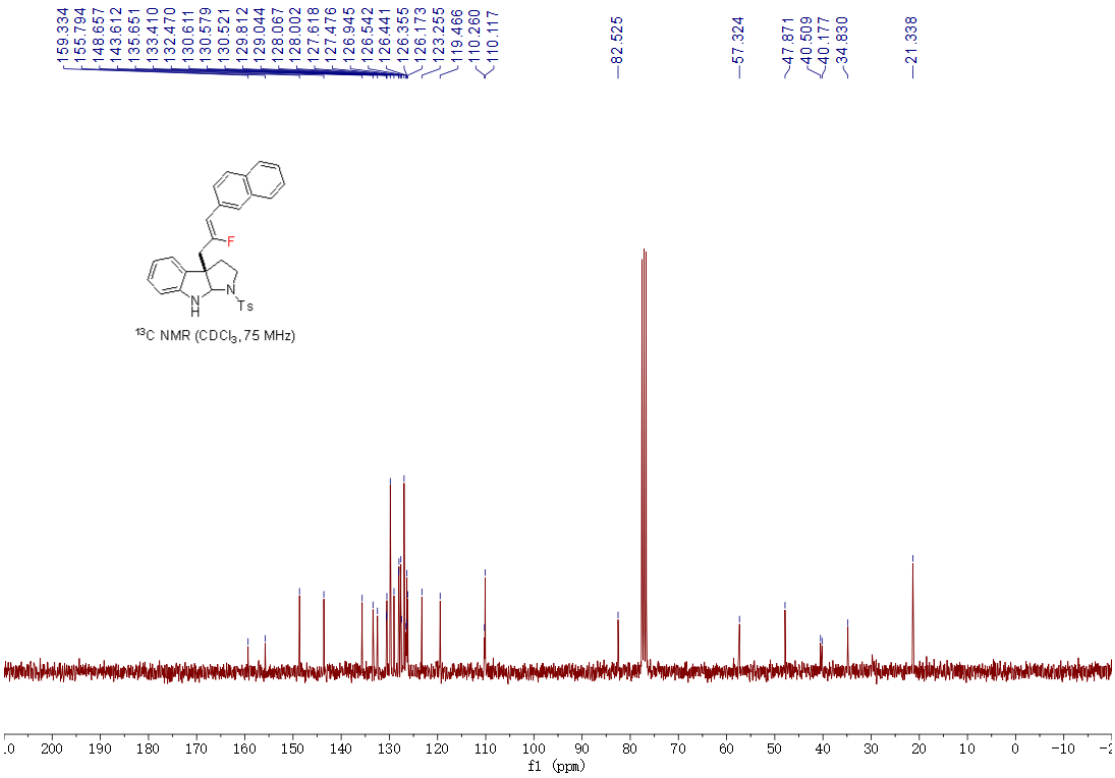

-98.3823
F
N
H
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

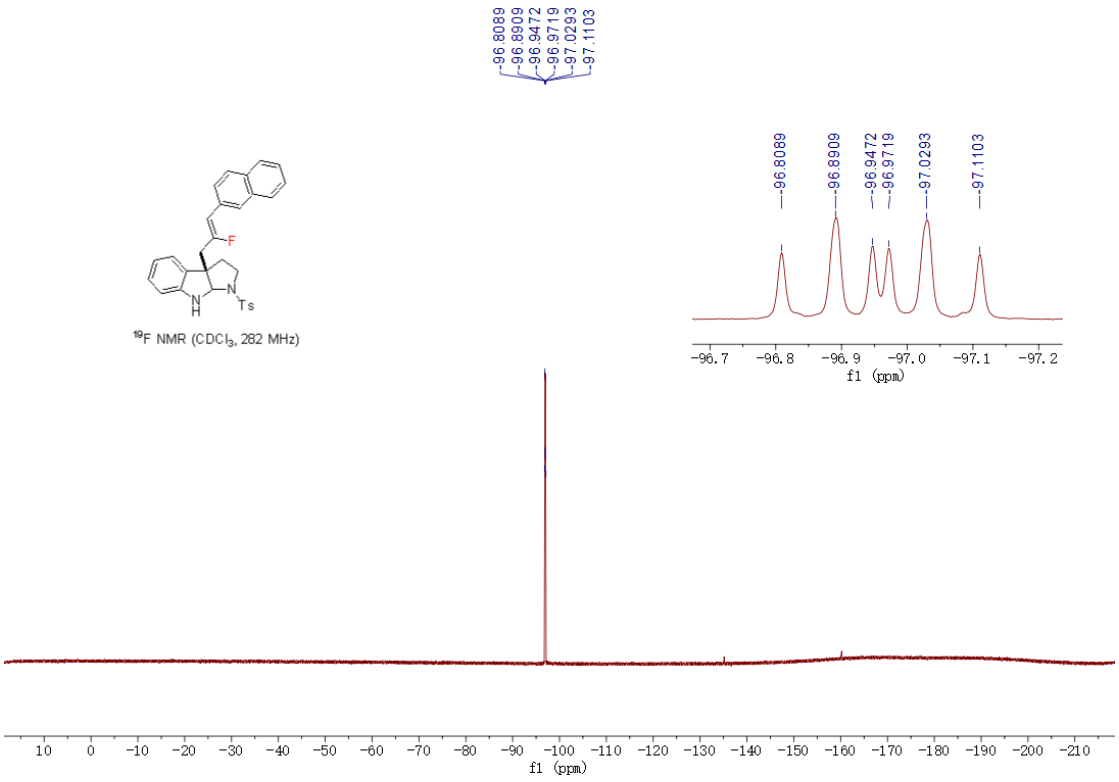

7.8663
7.8011
7.7909
7.7701
7.7626
7.6300
7.6243
7.6015
7.5957
7.4553
7.4396
7.4238
7.3906
7.3684
7.3580
7.3333
7.2336
7.1250
7.0999
6.7791
6.7546
6.7297
6.6936
6.6879
6.6426
5.6093
5.4794
3.6004
3.5791
3.5692
3.5607
3.5467
3.5394
3.3772
3.3564
3.3410
3.3192
3.3070
3.2840
3.2587
3.2194
2.8632
2.8148
2.8050
2.7906
2.7568
2.7419
2.6944
2.6463
2.4186
2.3774
2.3553
2.3407
2.3168
2.2985
2.2753
F
N
H
N
Bz
1H NMR (CDCl3, 300 MHz)
0.95
3.09
1.05
7.28
2.08
1.03
0.91
0.92
1.24
1.00
1.09
2.17
2.13
f1 (ppm)

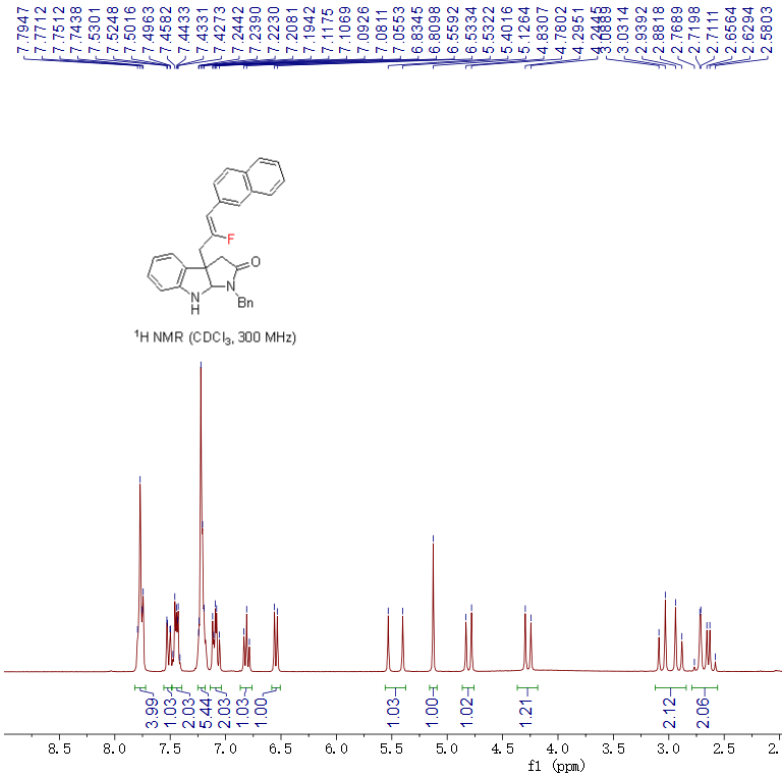

169.907
159.543
156.006
149.351
136.052
133.420
132.442
132.426
130.728
130.705
130.120
128.861
128.167
127.971
127.898
127.484
127.370
127.118
126.529
126.430
126.108
125.901
123.689
118.887
110.032
109.925
109.545
80.724
55.263
55.210
49.340
40.919
40.575
35.152
F
N
H
N
Bz
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

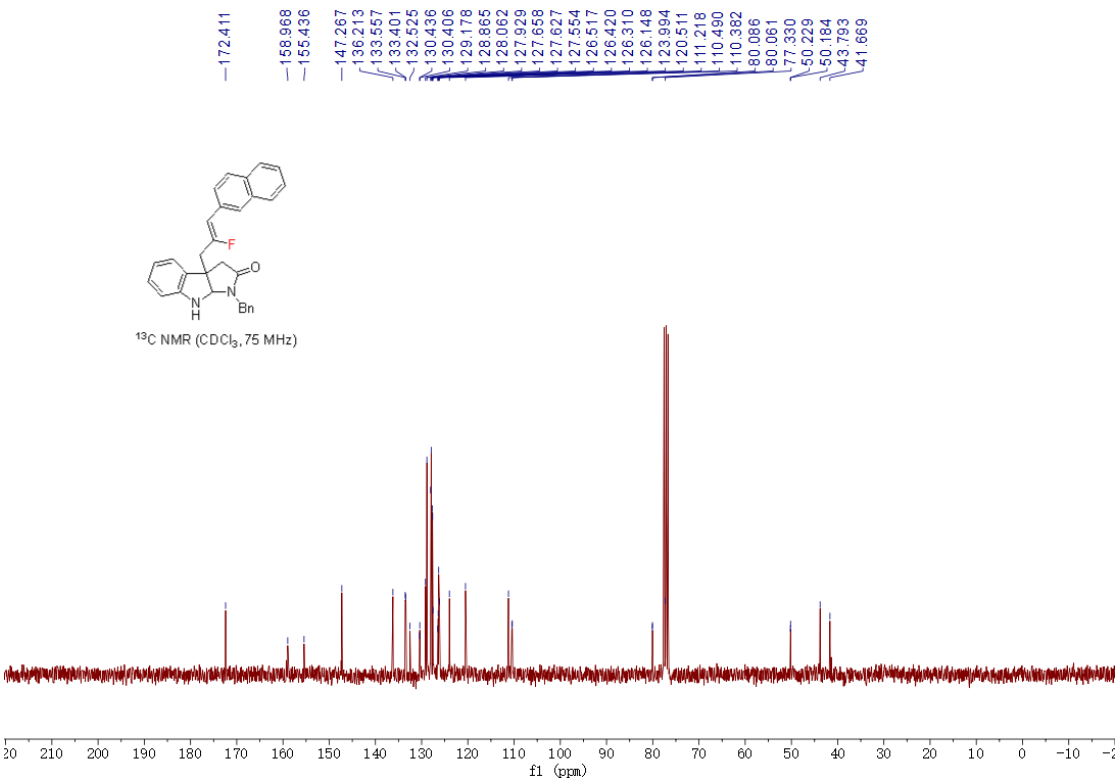

-97.5559
F
N
H
N
Bz
^{19}F NMR ($CDCl_3$, 282 MHz)
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

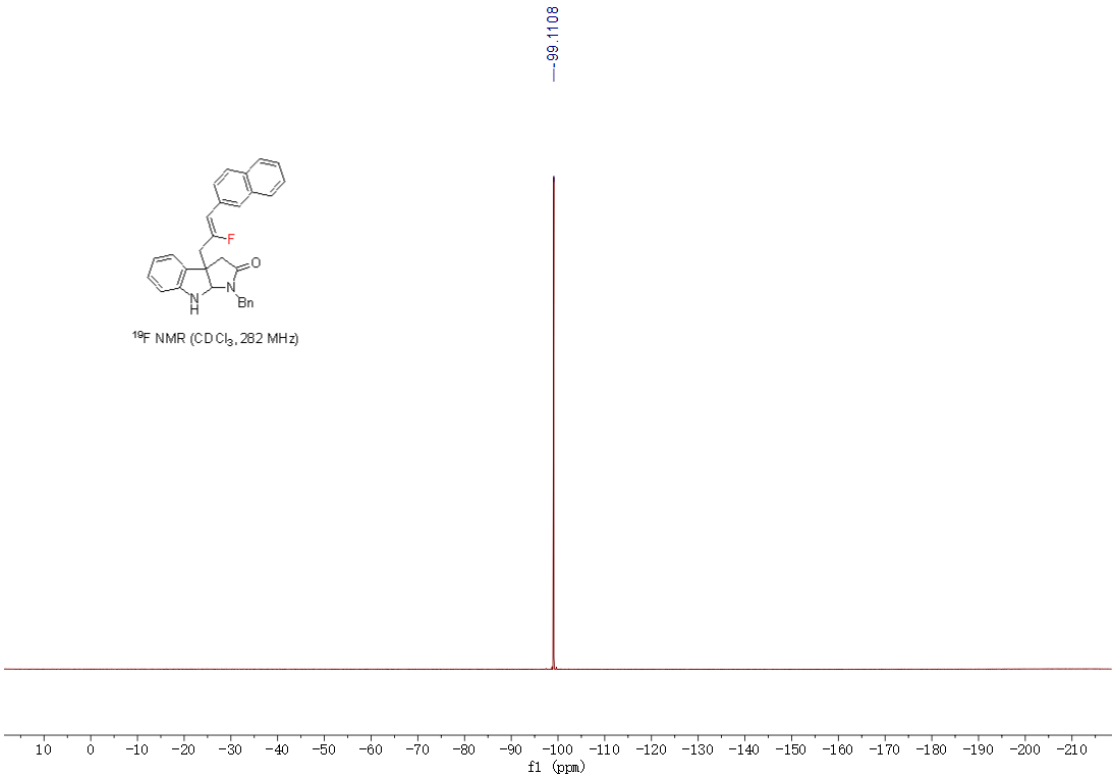

7.8898
7.8728
7.8628
7.8575
7.8351
7.7549
7.7477
7.7420
7.7265
7.7201
7.7135
7.5995
7.5940
7.5710
7.5652
7.5482
7.5423
7.5349
7.5313
7.5240
7.5171
7.3108
7.2065
7.2022
7.1810
7.1767
7.1555
7.1513
7.1213
7.1144
7.0924
7.0857
6.8509
6.8477
6.8261
6.8228
6.8013
6.7982
6.7619
6.7359
6.6395
5.5094
5.3517
3.5220
3.5009
3.4931
3.4862
3.4654
3.4595
3.2480
3.2311
3.2118
2.6985
2.6250
2.6178
2.2524
2.2334
2.2044
2.0977
2.0876
2.0599
F
N
H
N
Ts
^{1}H NMR ($CDCl_3$, 300 MHz)
4.06
2.03
3.08
1.05
3.04
1.05
1.02
1.11
1.05
1.09
1.08
0.96
0.93
1.13
3.00
1.15
0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

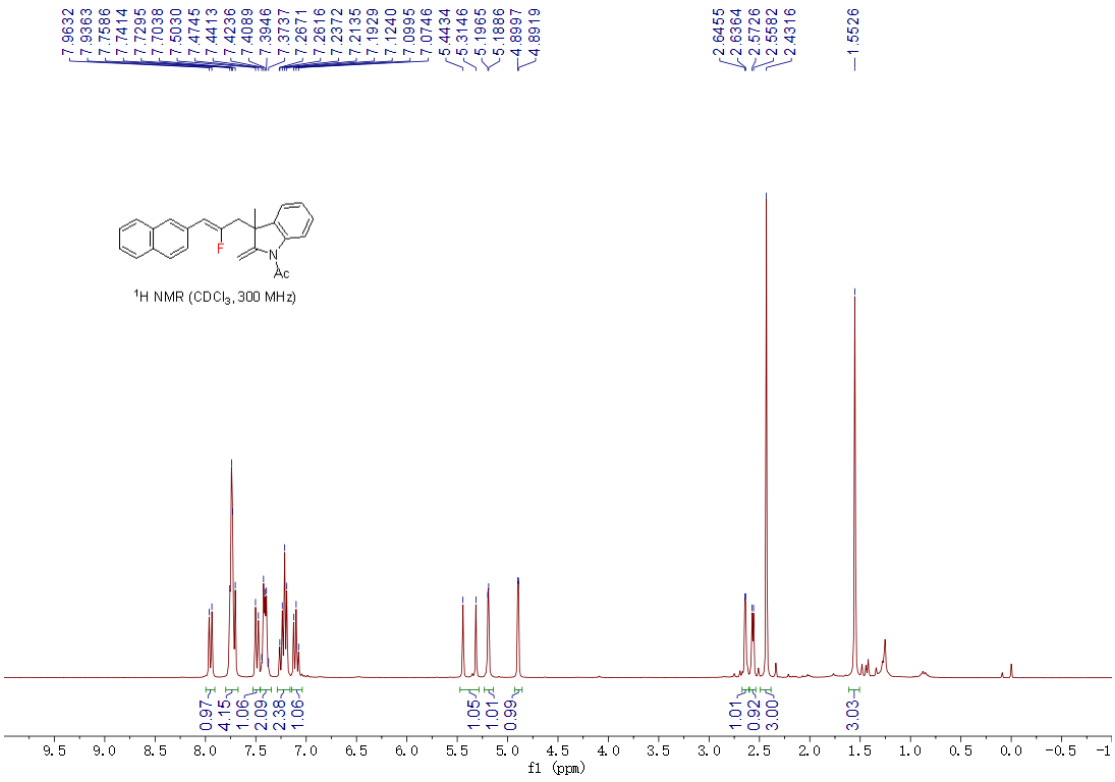

159.334
155.794
148.657
143.612
135.651
133.410
132.470
130.611
130.579
130.521
129.812
129.044
128.067
128.002
127.618
127.476
126.945
126.542
126.441
126.355
126.173
123.255
119.466
110.260
110.117
82.525
57.324
47.871
40.509
40.177
34.830
21.338
F
N
Ts
H
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

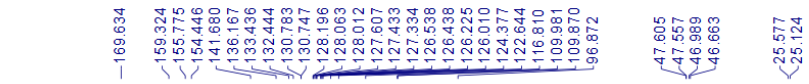

96.8089
96.8909
96.9472
96.9719
97.0293
97.1103
F
N
Ts
H
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

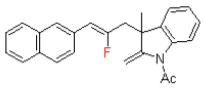

7.7947
7.7712
7.7512
7.7438
7.5301
7.5248
7.5016
7.4963
7.4582
7.4433
7.4331
7.4273
7.2442
7.2390
7.2230
7.2081
7.1942
7.1175
7.1069
7.0926
7.0811
7.0553
6.8345
6.8098
6.6592
6.5334
5.5322
5.4016
5.1264
4.8307
4.7802
4.2951
3.0889
3.0314
2.9392
2.8818
2.7689
2.7198
2.7111
2.6564
2.6294
2.5803
F
O
N
H
N
Bn
1H NMR (CDCl3, 300 MHz)
3.99
1.03
2.03
5.44
2.03
1.03
1.00
1.03
1.00
1.02
1.21
2.12
2.06
f1 (ppm)


172.411
158.968
155.436
147.267
136.213
133.557
133.401
132.525
130.436
130.406
129.178
128.865
128.062
127.929
127.658
127.627
127.554
126.517
126.420
126.310
126.148
123.994
120.511
111.218
110.490
110.382
80.086
80.061
77.330
50.229
50.184
43.793
41.669
F
O
N
H
N
Bn
13C NMR (CDCl3, 75 MHz)
f1 (ppm)

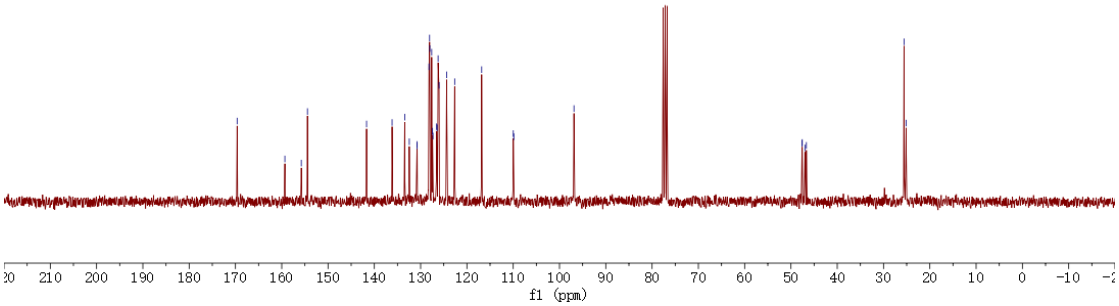

-99.1108
F
O
N
H
N
Bn
^{19}F NMR ($CDCl_3$, 282 MHz)
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

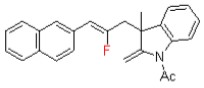

7.9632
7.9363
7.7586
7.7414
7.7295
7.7038
7.5030
7.4745
7.4413
7.4236
7.4089
7.3946
7.3737
7.2671
7.2616
7.2372
7.2135
7.1929
7.1240
7.0995
7.0746
5.4434
5.3146
5.1965
5.1886
4.8997
4.8919
2.6455
2.6364
2.5726
2.5582
2.4316
1.5526
F
N
Ac
^{1}H NMR ($CDCl_3$, 300 MHz)
0.97
4.15
1.06
2.09
2.38
1.06
1.05
1.01
0.99
1.01
0.92
3.00
3.03
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)



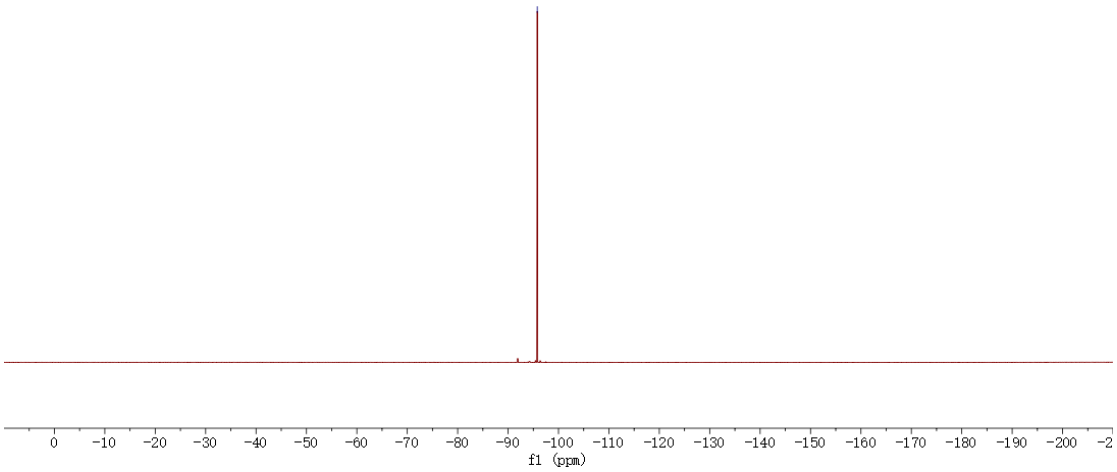


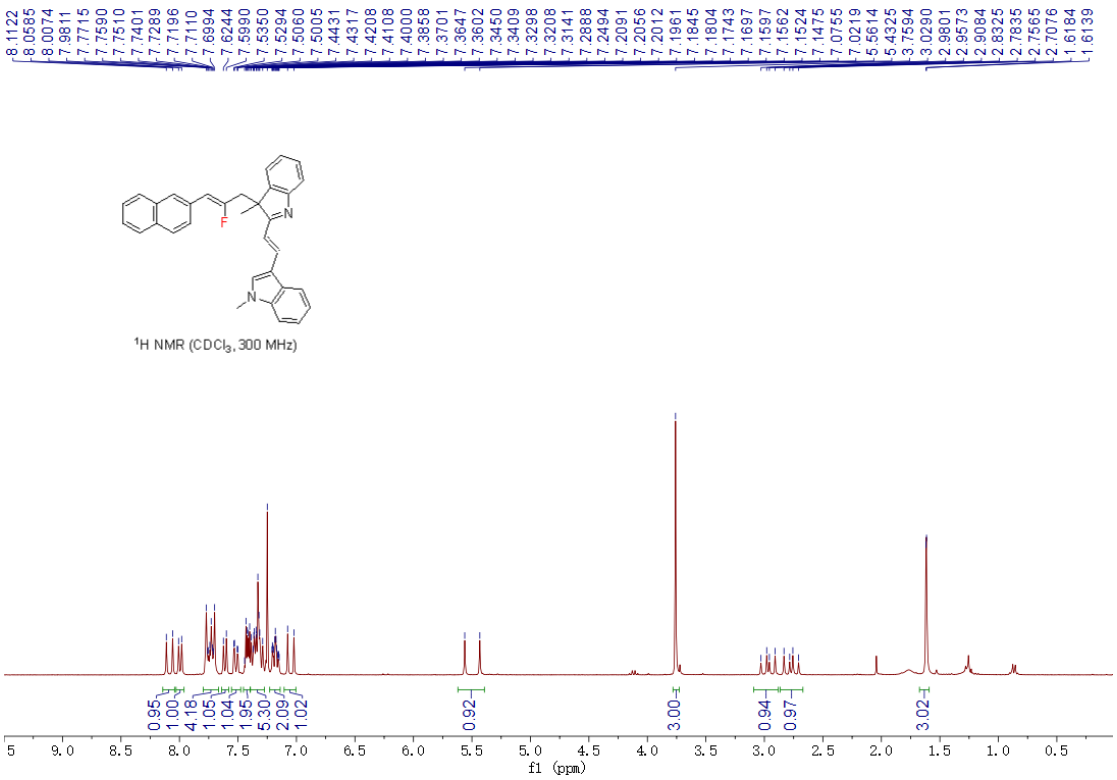
^{13}C NMR ($CDCl_3$, 75 MHz)

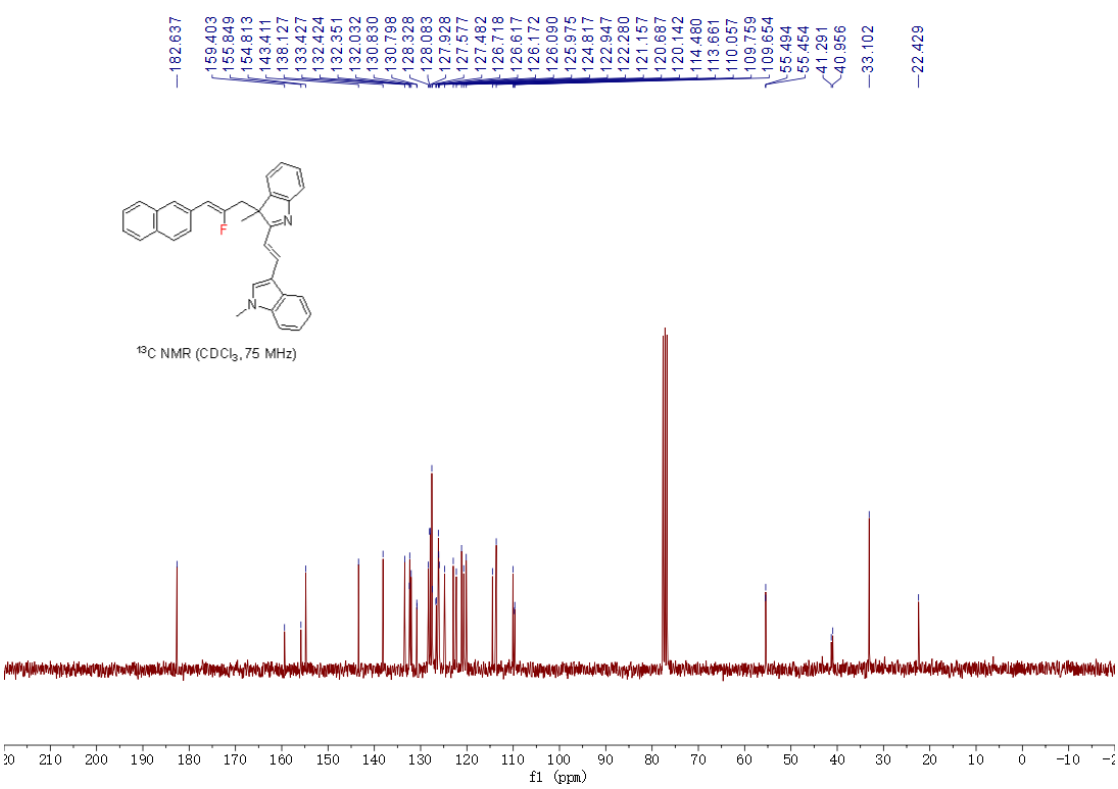


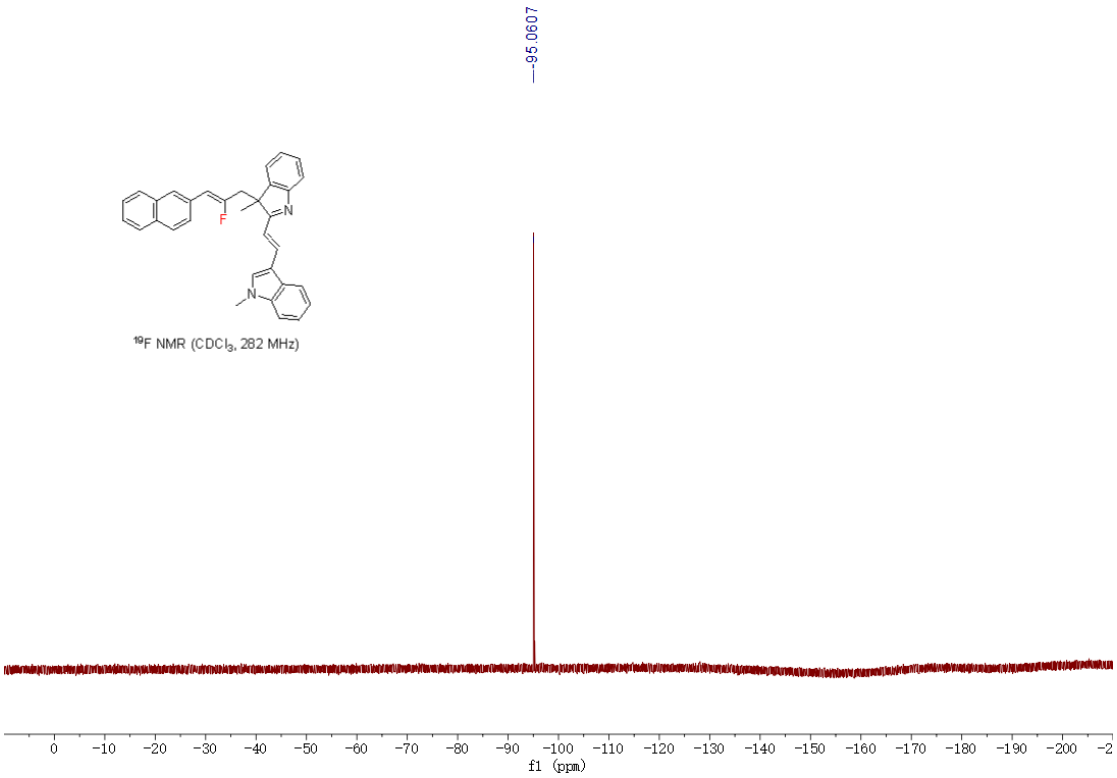


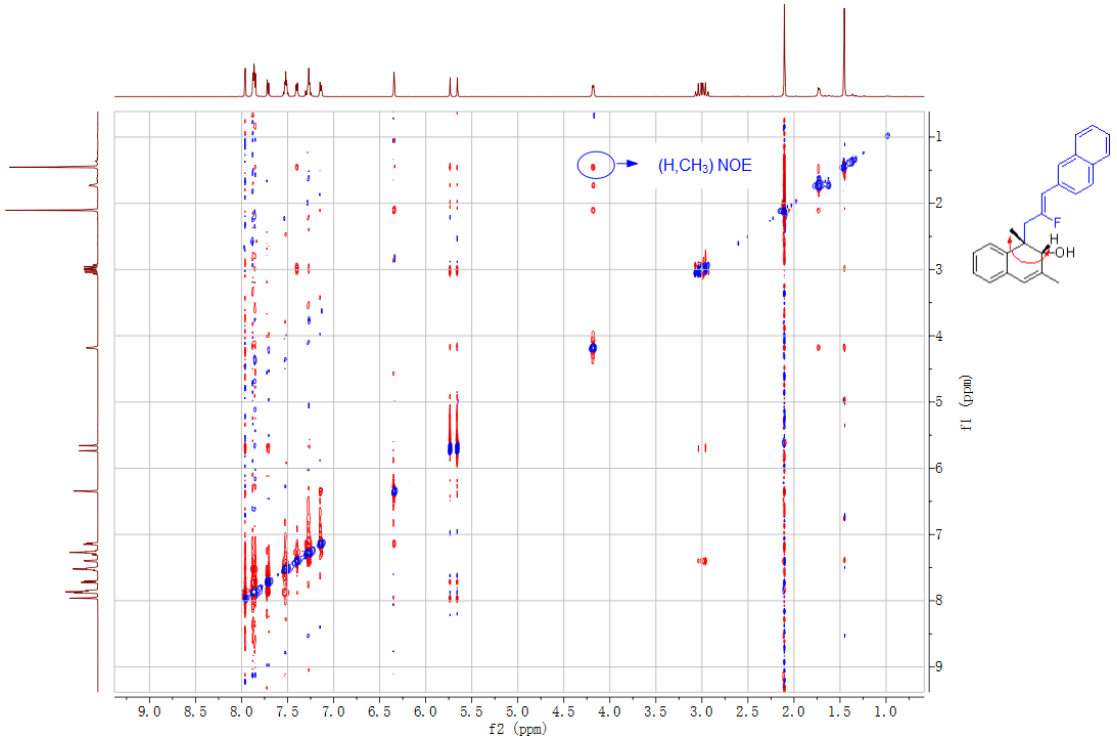
^{19}F NMR ($CDCl_3$, 282 MHz)




8.1122
8.0585
8.0074
7.9811
7.7715
7.7590
7.7510
7.7401
7.7289
7.7196
7.7110
7.6994
7.6244
7.5990
7.5350
7.5294
7.5060
7.5005
7.4431
7.4317
7.4208
7.4108
7.4000
7.3858
7.3701
7.3647
7.3602
7.3450
7.3409
7.3298
7.3208
7.3141
7.2888
7.2494
7.2091
7.2056
7.2012
7.1961
7.1845
7.1804
7.1743
7.1697
7.1597
7.1562
7.1524
7.1475
7.0755
7.0219
5.5614
5.4325
3.7594
3.0290
2.9801
2.9573
2.9084
2.8325
2.7835
2.7565
2.7076
1.6184
1.6139
F
N
N
^{1}H NMR ($CDCl_3$, 300 MHz)
0.95
1.00
4.18
1.05
1.04
1.95
5.30
2.09
1.02
0.92
3.00
0.94
0.97
3.02
f1 (ppm)


182.637
159.403
155.849
154.813
143.411
138.127
133.427
132.424
132.351
132.032
130.830
130.798
128.328
128.083
127.928
127.577
127.482
126.718
126.617
126.172
126.090
125.975
124.817
122.947
122.280
121.157
120.687
120.142
114.480
113.661
110.057
109.759
109.654
55.494
55.454
41.291
40.956
33.102
22.429
F
N
N
^{13}C NMR ($CDCl_3$, 75 MHz)
f1 (ppm)


-95.0607
F
N
N
^{19}F NMR ($CDCl_3$, 282 MHz)
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -2
f1 (ppm)


(H,CH3) NOE
F
H
OH
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
f2 (ppm)
f1 (ppm)