Supporting Information

Palladium-catalyzed intermolecular formal [3+2] cyclization/C-H alkylation of polyfluoroarenes

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1. General Considerations

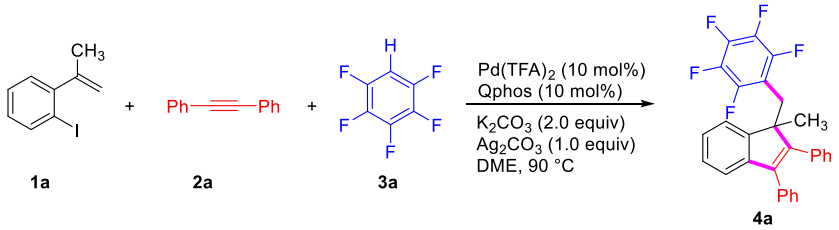
All reactions were carried out under N_2 atmosphere. Materials were obtained from commercial suppliers or prepared according to standard procedures unless otherwise noted. Solvents were purified and dried according to standard methods prior to use. For product purification by flash column chromatography, silica gel (200~300 mesh) and light petroleum ether (bp. 60~90) are used. ^{1}H NMR spectra were recorded on a Bruker advance III 400 MHz in $CDCl_3$ and $^{13}C\{^1H\}$ NMR spectra were recorded on 101 MHz in $CDCl_3$ using TMS as internal standard. Data for ^{1}H NMR are recorded as follows: chemical shift (δ, ppm), multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet or unresolved, br = broad singlet, dd = doublet of doublet, dt = triplet of doublets, ddd = doublet of doublet of doublets, coupling constant (s) in Hz, integration). Data for ^{13}C NMR is reported in terms of chemical shift (δ, ppm). High-resolution mass spectral analysis (HRMS) data were measured on a Bruker Apex II.

2. Preparation of Substrates

Substrates **1** were synthesized according to the known literature.[1-5] Substrates **2** were prepared from the coresponding ternal alkynes via Sonogashira coupling through the known literatures.[6] Polyfluoroarenes **3** or oxanorbornadiene (**5a**) were obtained from commercial suppliers.

3. Optimization of the Reaction Conditions

Table S1: Optimization of Reaction Conditions of the intermolecular formal [3+2] cyclization/C-H alkylation of polyfluoroarenes[a]

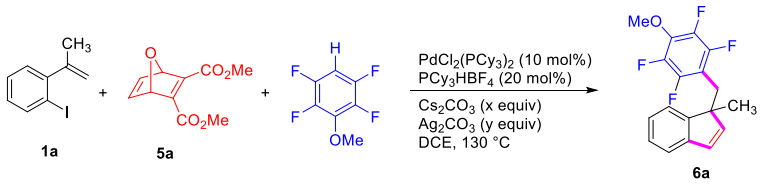


1a 2a 3a 4a

Entry	Variation from the standard conditions	Yield[b] (%)
1	none	71
2	$PdCl_2$ instead of $Pd(TFA)_2$	45
3	$[Pd(C_3H_5)Cl]_2$ instead of $Pd(TFA)_2$	62
4	$PdCl_2(PPh_3)_2$ instead of $Pd(TFA)_2$	50
5	Sphos as ligand	58
6	$P(p\text{-}FC_6H_4)_3$ as ligand	22
7	PPh_3 as ligand	17
8	dppb as ligand	39
9	PCy_3 as ligand	0
10	^{t}BuOK instead of K_2CO_3	36
11	KOAc instead of K_2CO_3	20
12	toluene as solvent	47
13	dioxane as solvent	54
14	AgOAc instead of Ag_2CO_3	<10
15	CuI instead of Ag_2CO_3	<10
16	at 80 ℃ (or 100 ℃)	57 (66)

[a]Reaction conditions unless otherwise noted: **1a** (0.2 mmol), **2a** (0.4 mmol), **3a** (0.6 mmol), $Pd(TFA)_2$ (10 mol %), Qphos (10 mol %), K_2CO_3 (0.4 mmol), Ag_2CO_3 (0.2 mmol), DME (2.0 mL, 0.1 M), 90 ℃, 16 h under a N_2 atmosphere. [b]Isolated yields.

Table S2: Screening the amount of base and Ag salt for [3+2] cyclization/C-H alkylation with ONBD [a]

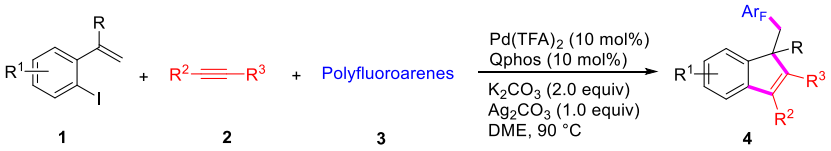


Entry	Cs_2CO_3 (x equiv)	Ag_2CO_3 (y equiv)	Yield[b] (%)
1	1.0	1.0	15
2	1.0	2.0	21
3	2.0	1.0	23
4	2.0	2.0	36
5	2.0	3.0	40
6	**3.0**	**2.0**	**51**
7	3.0	3.0	48

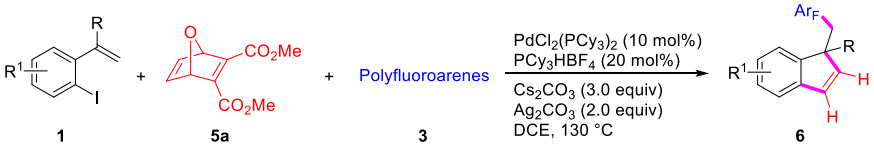
[a]Reaction conditions unless otherwise noted: **1a** (0.2 mmol), **5a** (0.4 mmol), 1,2,4,5-tetrafluoro-3-methoxybenzene (0.4 mmol), $PdCl_2(PCy_3)_2$ (10 mol %), PCy_3HBF_4 (20 mol %), Cs_2CO_3 (x equiv), Ag_2CO_3 (y equiv), DCE (2.0 mL, 0.1 M), 130 ℃, 16 h under a N_2 atmosphere. [b]Isolated yields.

The results of above screening revealed that adequate amounts of Cs_2CO_3 and Ag_2CO_3 may be beneficial for effectively increasing the concentration of polyfluoroarylsilver intermediate involved in the transmetallization process.

4. Experiment Procedure



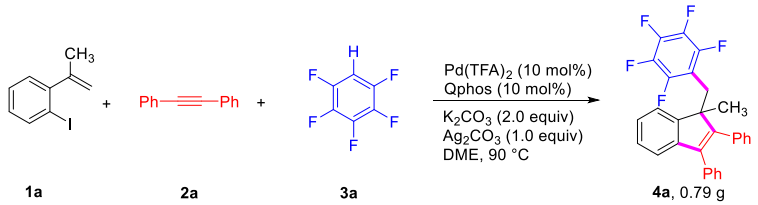
O-iodostyrenes **1** (0.2 mmol, 1.0 equiv), internal alkynes **2** (0.4 mmol, 2.0 equiv), polyfluoroarenes **3** (0.6 mmol, 3.0 equiv), $Pd(TFA)_2$ (10 mol%), Qphos (10 mol%), K_2CO_3 (0.4 mmol, 2.0 equiv), Ag_2CO_3 (0.2 mmol, 1.0 equiv) were added to a sealed tube, DME (2.0 mL, 0.1 M) were added via syringe. The mixture was heated at 90 ℃ in an oil bath about for 16 h until completion (monitored by TLC). After cooling at room temperature, the reaction mixture was filtered through celite. The solvent in the filtrate was evaporated under reduced pressure. The residue was purified through silica gel chromatography to afford the products **4**.



O-iodostyrenes **1** (0.2 mmol, 1.0 equiv), oxanorbornadiene **5a** (0.4 mmol, 2.0 equiv), polyfluoroarenes **3** (0.4 mmol, 2.0 equiv), $PdCl_2(PCy_3)_2$ (10 mol%), PCy_3HBF_4 (20 mol%),

Cs_2CO_3 (0.6 mmol, 3.0 equiv), Ag_2CO_3 (0.4 mmol, 2.0 equiv) were added to a sealed tube, DCE (2.0 mL, 0.1 M) were added via syringe. The mixture was heated at 130 ℃ in an oil bath about for 16 h until completion (monitored by TLC). After cooling at room temperature, the reaction mixture was filtered through celite. The solvent in the filtrate was evaporated under reduced pressure. The residue was purified through silica gel chromatography to afford the products **6**.

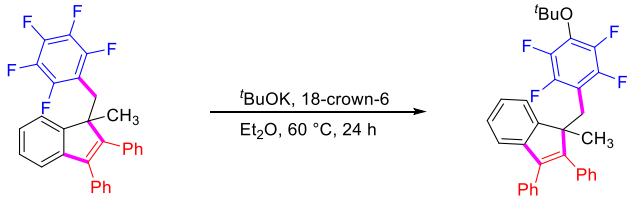
5. Scale-Up Reaction



1a **2a** **3a** **4a**, 0.79 g

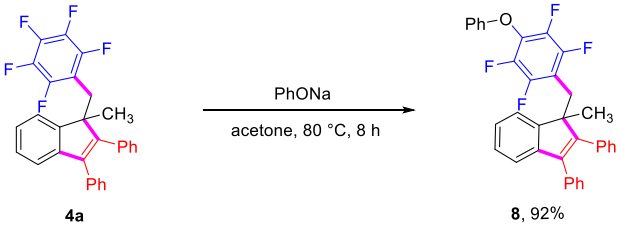
1-iodo-2-(prop-1-en-2-yl)benzene **1a** (3.0 mmol, 1.0 equiv), 1,2-diphenylethyne **2a** (6.0 mmol, 2.0 equiv), 1,2,3,4,5-pentafluorobenzene **3a** (9.0 mmol, 3.0 equiv), $Pd(TFA)_2$ (10 mol%), Qphos (10 mol%), K_2CO_3 (6.0 mmol, 2.0 equiv), Ag_2CO_3 (3.0 mmol, 1.0 equiv) were added to a sealed tube, DME (30.0 mL) were added via syringe. The mixture was heated at 90 ℃ in an oil bath about for 12 h until completion (monitored by TLC). After cooling at room temperature, the reaction mixture was filtered through celite. The solvent in the filtrate was evaporated under reduced pressure. The residue was purified through silica gel chromatography to afford the products **4a** (0.79 g) in 57% yield.

6. Synthetic Transformations



4a **7**, 85%

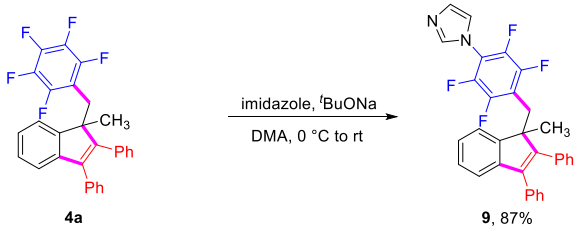
Under nitrogen atmosphere, **4a** (92.4 mg, 0.2 mmol, 1.0 equiv), ^tBuOK (44.8 mg, 0.4 mmol), 18-crown-6 (26.4 mg, 0.1 mmol) and Et_2O (2 mL) were added to a Schlenk flask. The reaction mixture was stirred under 60 ℃ for 24 h. After the indicated time the reaction mixture was quenched with water and extracted with EA. The combined organic phases were washed with brine, dried over anhydrous Na_2SO_4, and concentrated at the reduced pressure. The residue was purified by flash silica gel column chromatography to provide the pure product **7** (85% yield).



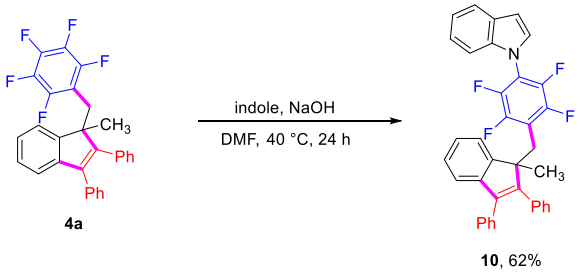
4a **8**, 92%

4a (92.4 mg, 0.2 mmol, 1.0 equiv) and NaOPh (69.6 mg, 0.6 mmol, 3.0 equiv) were suspended in

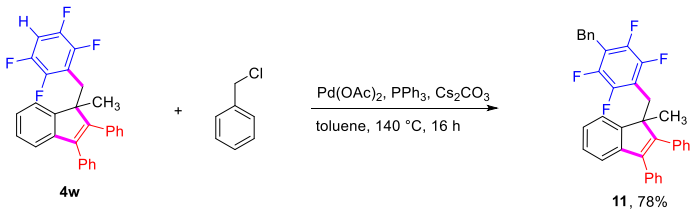
acetone (1 mL). The reaction mixture was stirred under 80 ℃ for 24 h. After the indicated time the reaction mixture was quenched with water and extracted with EA. The combined organic phases were washed with brine, dried over anhydrous Na_2SO_4, and concentrated at the reduced pressure. The residue was purified by flash silica gel column chromatography to provide analytical pure product **8** (92% yield).



NaO^{t}Bu (21 mg, 0.22 mmol) in DMA (1 mL) was added to imidazole (13.6 mg, 0.2 mmol) in DMA (1 mL) and the mixture was cooled down to 0 ℃. A solution of **4a** (92.4 mg, 0.2 mmol, 1.0 equiv) in DMA (1 mL) was added dropwise to the reaction. After 15 min stirring at 0 ℃, the reaction was warmed up to rt. Water was added and the mixture was extracted with ethyl acetate. The organic phase was washed with water, treated with brine, dried over $MgSO_4$, and evaporated. The resultant residue was subjected to purification by column chromatography on silica gel to afford **9** (87% yield).

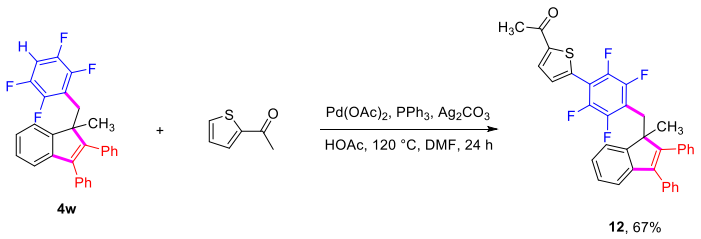


Under nitrogen atmosphere, **4a** (92.4 mg, 0.2 mmol, 1.0 equiv), indole (46.8 mg, 0.4 mmol, 2.0 equiv), NaOH (16 mg, 0.4 mmol) and DMF (2 mL) were added to a Schlenk flask. The reaction mixture was stirred under 40 ℃ for 24 h. After the indicated time the reaction mixture was quenched with water and extracted with EA. The combined organic phases were washed with brine, dried over anhydrous Na2SO4, and concentrated at the reduced pressure. The residue was purified by flash silica gel column chromatography to provide analytical pure product **10** (62% yield).



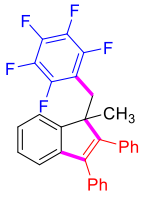
4w (0.2 mmol, 1.0 equiv), BnCl (0.4 mmol, 2.0 equiv), $Pd(OAc)_2$ (10 mol%), PPh_3 (20 mol%),

Cs_2CO_3 (0.6 mmol, 3.0 equiv)were added to a sealed tube, toluene (2.0 mL, 0.1 M) were added via syringe. The mixture was heated at 140 ℃ in an oil bath about for 16 h until completion (monitored by TLC). After cooling at room temperature, the reaction mixture was filtered through celite. The solvent in the filtrate was evaporated under reduced pressure. The residue was purified through silica gel chromatography to afford the products **11** (78% yield).



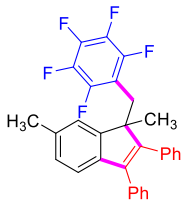
4w (0.2 mmol, 1.0 equiv), 1-(thiophen-2-yl)ethan-1-one (0.4 mmol, 2.0 equiv), $Pd(OAc)_2$ (10 mol%), PPh_3 (20 mol%), Ag_2CO_3 (0.3 mmol, 1.5 equiv), HOAc (0.2 mmol, 1.0 equiv) were added to a sealed tube, DMF (2.0 mL) were added via syringe. The mixture was heated at 120 ℃ in an oil bath about for 24 h until completion (monitored by TLC). After cooling at room temperature, the reaction mixture was filtered through celite. The solvent in the filtrate was evaporated under reduced pressure. The residue was purified through silica gel chromatography to afford the products **12** (67% yield).

7. Spectra Data



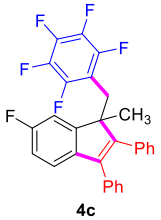
4a

1-methyl-1-((perfluorophenyl)methyl)-2,3-diphenyl-1H-indene (***4a***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale yellow solid, Mp = 123-125 ℃, 66 mg, 71% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35-7.12 (m, 13H), 6.87 (d, *J* = 7.5 Hz, 1H), 3.14 (dd, *J* = 13.6, 1.9 Hz, 1H), 2.93 (dd, *J* = 13.7, 1.9 Hz, 1H), 1.56 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.9, 149.6, 145.5 (dm, *J* = 246.9 Hz), 143.0, 139.9 (dm, *J* = 239.8 Hz), 139.8, 137.3 (dm, *J* = 235.3 Hz), 136.2, 134.9, 130.1, 129.6, 128.4, 128.3, 127.3 (t, *J* = 3.8 Hz), 125.5, 122.2, 121.0, 112.3 (td, *J* = 18.6, 3.1 Hz), 55.0, 31.3, 22.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.3 (m, 2F), -156.3 (t, *J* = 21.0 Hz, 1F), -162.8 (m, 2F). HRMS (ESI-TOF) calcd for $C_{29}H_{20}F_5$ $[M+H]^+$: 463.1480, found: 463.1486.



4b

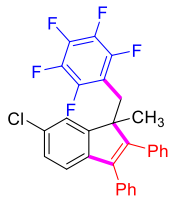
1,6-dimethyl-1-((perfluorophenyl)methyl)-2,3-diphenyl-1H-indene (***4b***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a yellow solid, Mp = 93-95 ℃, 72 mg, 76% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32-7.18 (m, 11H), 7.06 (d, *J* = 7.7 Hz, 1H), 6.68 (s, 1H), 3.13 (dd, *J* = 13.5, 2.1 Hz, 1H), 2.93 (dt, *J* = 13.6, 1.9 Hz, 1H), 2.33 (s, 3H), 1.55 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 149.9, 149.8, 145.6 (dm, *J* = 248.9 Hz), 140.4, 139.9 (dm, *J* = 234.3 Hz), 139.6, 137.4 (dm, *J* = 251.4 Hz), 136.3, 135.3, 135.1, 130.2, 129.6, 128.3, 128.2, 127.9, 127.2 (t, *J* = 2.1 Hz), 123.1, 120.7, 112.4 (td, *J* = 19.2, 3.3 Hz), 54.8, 31.4, 22.0, 21.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.4 (m, 2F), -156.5 (t, *J* = 21.0 Hz, 1F), -163.2 (td, *J* = 22.6, 8.0 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{30}H_{22}F_5$ $[M+H]^+$: 477.1636, found: 477.1636.



4c

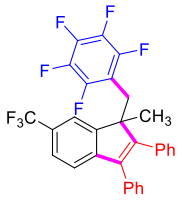
6-fluoro-1-methyl-1-((perfluorophenyl)methyl)-2,3-diphenyl-1H-indene (***4c***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title

compound as a yellow solid, Mp = 117-119 ℃, 64 mg, 67% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29-7.21 (m, 11H), 6.95 (td, *J* = 8.8, 2.4 Hz, 1H), 6.60 (dd, *J* = 8.8, 2.3 Hz, 1H), 3.13 (d, *J* = 13.7 Hz, 1H), 2.93 (d, *J* = 13.7 Hz, 1H), 1.56 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.7 (d, *J* = 245.8 Hz), 151.9 (d, *J* = 7.7 Hz), 150.5 (d, *J* = 4.1 Hz), 145.5 (dm, *J* = 248.2 Hz), 140.0 (dm, *J* = 242.6 Hz), 139.0, 138.9 (d, *J* = 2.3 Hz), 137.3 (dm, *J* = 254.3 Hz), 135.9, 134.6, 130.1, 129.5, 128.4, 128.3, 127.5 (d, *J* = 2.3 Hz), 121.8 (d, *J* = 8.6 Hz), 114.1 (d, *J* = 32.6 Hz), 111.8 (td, *J* = 18.9, 5.3 Hz), 110.0 (d, *J* = 23.6 Hz), 54.9, 31.2, 22.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -116.6 (s, 1F), -138.4 (m, 2F), -155.7 (t, *J* = 21.0 Hz, 1F), -162.5 (m, 2F). HRMS (ESI-TOF) calcd for $C_{29}H_{19}F_6$ $[M+H]^+$: 481.1385, found: 481.1388.



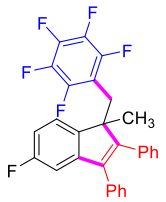
4d

6-chloro-1-methyl-1-((perfluorophenyl)methyl)-2,3-diphenyl-1H-indene ***(4d)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale yellow solid, Mp = 145-147 ℃, 63 mg, 63% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33-7.18 (m, 12H), 6.84 (s, 1H), 3.18-3.08 (m, 1H), 2.93 (dd, *J* = 13.6, 2.1 Hz, 1H), 1.56 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.4, 151.1, 145.6 (dm, *J* = 246.6 Hz), 141.5, 140.0 (dm, *J* = 253.5 Hz), 139.0, 137.5 (dm, *J* = 253.5 Hz), 135.4, 134.4, 131.5, 130.0, 129.5, 128.5, 128.3, 127.6, 127.4, 111.8 (td, *J* = 18.7, 3.2 Hz), 55.0, 31.2, 21.8. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.5 (m, 2F), -155.6 (t, *J* = 21.0 Hz, 1F), -162.5 (m, 2F). HRMS (ESI-TOF) calcd for $C_{29}H_{19}ClF_5$ $[M+H]^+$: 497.1090, found: 497.1088.



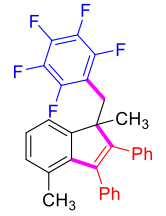
4e

1-methyl-1-((perfluorophenyl)methyl)-2,3-diphenyl-6-(trifluoromethyl)-1H-indene ***(4e)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a pale yellow solid, Mp = 144-145 ℃, 57 mg, 54% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (d, *J* = 8.0 Hz, 1H), 7.39 (d, *J* = 7.9 Hz, 1H), 7.32-7.22 (m, 10H), 7.04 (s, 1H), 3.18 (d, *J* = 13.7 Hz, 1H), 2.99-2.85 (m, 1H), 1.59 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.8, 149.9, 146.5, 145.6 (dm, *J* = 255.1 Hz), 140.2 (dm, *J* = 251.4 Hz), 139.1, 137.5 (dm, *J* = 248.1 Hz), 135.4, 134.1, 129.9, 129.5, 128.6, 128.4 (q, *J* = 2.7 Hz), 127.8, 127.7 (t, *J* = 2.6 Hz), 124.7 (q, *J* = 5.5 Hz), 123.3 (q, *J* = 271.5 Hz), 121.0, 119.2 (q, *J* = 4.4 Hz), 111.8 (td, *J* = 17.3, 4.6 Hz), 55.2, 31.2, 21.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.8 (m, 3F), -138.7 (dt, *J* = 22.6, 13.0 Hz, 2F), -155.5 (m, 1F), -162.4 (td, *J* = 22.8, 22.0, 8.8 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{30}H_{19}F_8$ $[M+H]^+$: 531.1354, found: 531.1357.



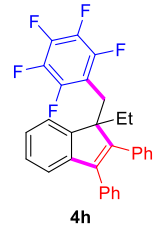
4f

5-fluoro-1-methyl-1-((perfluorophenyl)methyl)-2,3-diphenyl-1H-indene ***(4f)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale yellow solid, Mp = 122-124 ℃, 62 mg, 65% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 (m, 10H), 7.00 (dd, *J* = 9.2, 2.4 Hz, 1H), 6.88-6.76 (m, 2H), 3.18-3.06 (m, 1H), 2.97-2.86 (m, 1H), 1.55 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.9 (d, *J* = 244.3 Hz), 152.8, 145.5 (dm, *J* = 247.0 Hz), 145.1 (d, *J* = 8.6 Hz), 144.9 (d, *J* = 2.4 Hz), 139.1 (d, *J* = 3.1 Hz), 137.4 (dm, *J* = 253.8 Hz), 135.8, 134.3, 130.6, 130.0, 129.4, 128.5, 128.3, 127.6 (t, *J* = 1.8 Hz), 123.0 (d, *J* = 9.0 Hz), 112.0 (d, *J* = 22.9 Hz), 108.3 (t, *J* = 23.9 Hz), 54.6, 31.3, 22.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -115.3 (s, 1F), -138.4 (m, 2F), -155.9 (t, *J* = 20.9 Hz, 1F), -162.5 (td, *J* = 22.6, 8.0 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{29}H_{19}F_6$ $[M+H]^+$: 481.1385, found: 481.1393.



4g

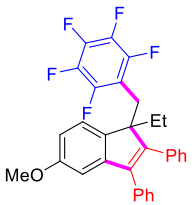
1,4-dimethyl-1-((perfluorophenyl)methyl)-2,3-diphenyl-1H-indene ***(4g)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a colorless solid, Mp = 107-109 ℃, 49 mg, 51% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36-7.26 (m, 2H), 7.23-7.14 (m, 7H), 7.06-6.95 (m, 3H), 6.64 (d, *J* = 7.3 Hz, 1H), 3.09 (dd, *J* = 13.5, 2.3 Hz, 1H), 2.85 (dd, *J* = 13.6, 2.4 Hz, 1H), 1.86 (s, 3H), 1.52 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 152.3, 149.8, 145.6 (dm, *J* = 246.4 Hz), 141.4, 140.6, 140.0 (dm, *J* = 251.3 Hz), 137.6, 137.5 (dm, *J* = 252.2 Hz), 135.9, 132.3, 130.5, 130.1, 130.0, 129.7, 128.0, 127.9, 127.8, 127.1, 127.0, 125.4, 112.5 (td, *J* = 18.3, 4.1 Hz), 54.2, 31.2, 22.0 (t, *J* = 2.1 Hz), 20.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.3 (m, 2F), -156.4 (t, *J* = 20.8 Hz, 1F), -162.8 (dd, *J* = 21.6, 14.6 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{30}H_{22}F_5$ $[M+H]^+$: 477.1636, found: 477.1639.



4h

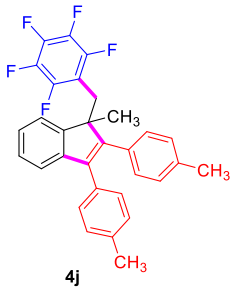
1-ethyl-1-((perfluorophenyl)methyl)-2,3-diphenyl-1H-indene ***(4h)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title

compound as a viscous oil, 73 mg, 77% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30-7.13 (m, 13H), 6.87 (d, *J* = 7.4 Hz, 1H), 3.14 (d, *J* = 13.7 Hz, 1H), 3.01 (d, *J* = 13.7 Hz, 1H), 2.35 (dq, *J* = 14.4, 7.2 Hz, 1H), 2.08 (dq, *J* = 14.3, 7.3 Hz, 1H), 0.55 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.7, 147.6, 145.6 (dm, *J* = 251.7 Hz), 144.3, 141.9, 139.7 (dm, *J* = 243.3 Hz), 137.4 (dm, *J* = 251.9 Hz), 136.2, 135.2, 129.9, 129.7, 128.4, 128.2, 127.3, 127.2 (d, *J* = 3.6 Hz), 125.6, 122.0, 120.9, 112.2 (td, *J* = 19.1, 4.4 Hz), 59.87, 31.31, 28.15, 8.47. ^{19}F NMR (376 MHz, $CDCl_3$) δ -137.8 (m, 2F), -156.5 (t, *J* = 21.1 Hz, 1F), -163.0 (td, *J* = 22.9, 8.0 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{30}H_{22}F_5$ $[M+H]^+$: 477.1636, found: 477.1637.



4i

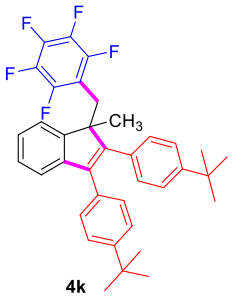
1-ethyl-5-methoxy-1-((perfluorophenyl)methyl)-2,3-diphenyl-1H-indene ***(4i)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a pale red solid, Mp = 106-108 ℃, 71 mg, 70% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24-7.12 (m, 10H), 6.74 (d, *J* = 2.2 Hz, 1H), 6.72-6.58 (m, 2H), 3.68 (s, 3H), 3.02 (d, *J* = 13.7 Hz, 1H), 2.94-2.85 (m, 1H), 2.24 (dq, *J* = 14.3, 7.2 Hz, 1H), 1.94 (m, 1H), 0.47 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.4, 148.9, 145.7, 145.6 (dm, *J* = 237.5 Hz), 141.7, 139.9 (dm, *J* = 251.2 Hz), 139.8, 136.2, 135.2, 129.8, 129.7, 128.5, 128.2, 127.4, 127.3, 122.5, 112.4 (td, *J* = 17.3, 3.9 Hz), 111.0, 106.7, 59.2, 55.5, 31.4, 28.3, 8.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -137.9 (m, 2F), -156.6 (t, *J* = 21.0 Hz, 1F), -163.07 (td, *J* = 22.9, 8.0 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{31}H_{24}OF_5$ $[M+H]^+$: 507.1742, found: 507.1740.



4j

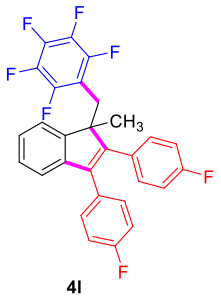
1-methyl-1-((perfluorophenyl)methyl)-2,3-di-p-tolyl-1H-indene ***(4j)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a yellow solid, Mp = 131-133 ℃, 68 mg, 69% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31-7.29 (m, 1H), 7.23-7.06 (m, 10H), 6.85 (d, *J* = 7.4 Hz, 1H), 3.13 (dt, *J* = 13.6, 1.7 Hz, 1H), 2.91 (dd, *J* = 13.6, 1.8 Hz, 1H), 2.32 (s, 6H), 1.54 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.5, 149.6, 145.5 (dm, *J* = 248.5 Hz), 143.3, 139.9 (dm, *J* = 259.1 Hz), 137.3 (dm, *J* = 254.0 Hz), 136.9 (d, *J* = 4.4 Hz), 130.0, 129.5, 129.1, 129.0, 127.3, 125.3, 122.1, 121.0, 112.4 (td, *J* = 17.3, 3.9 Hz), 54.9, 31.4, 22.0, 21.42, 21.35. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.3 (m, 2F), -156.5 (t, *J* = 20.9 Hz, 1F), -163.0 (td, *J* = 22.6, 7.9 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{31}H_{24}F_5$ $[M+H]^+$:

491.1793, found: 491.1795.



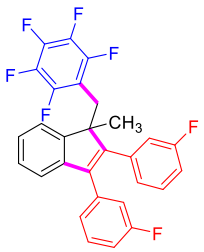
4k

2,3-bis(4-(tert-butyl)phenyl)-1-methyl-1-((perfluorophenyl)methyl)-1H-indene ***(4k)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a colorless solid, Mp = 141-143 ℃, 89 mg, 77% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33-7.21 (m, 8H), 7.18-7.11 (m, 3H), 6.92 (d, *J* = 7.4 Hz, 1H), 3.14 (d, *J* = 13.8 Hz, 1H), 2.99 (dt, *J* = 13.6, 1.9 Hz, 1H), 1.58 (s, 3H), 1.30 (d, *J* = 3.7 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.2, 150.0, 149.93, 149.91, 145.6 (dm, *J* = 250.4 Hz), 143.4, 139.9 (dm, *J* = 254.3 Hz), 139.3, 137.2 (dm, *J* = 248.8 Hz), 133.2, 132.1, 129.7, 129.3, 127.2, 125.3, 125.2, 124.9, 122.0, 121.1, 112.5 (td, *J* = 18.3, 3.2 Hz), 55.0, 34.7, 34.6, 31.5, 31.4, 22.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.2 (m, 2F), -156.7 (t, *J* = 21.0 Hz, 1F), -163.1 (td, *J* = 22.7, 7.9 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{37}H_{36}F_5$ $[M+H]^+$: 575.2732, found: 575.2737.



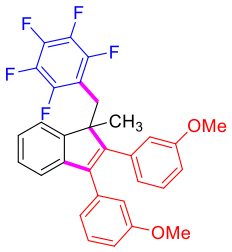
4l

1-methyl-2,3-bis(4-fluorophenyl)-1-((perfluorophenyl)methyl)-1H-indene ***(4l)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale yellow solid, Mp = 146-148 ℃, 52 mg, 52% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28-7.16 (m, 7H), 7.07-6.96 (m, 4H), 6.89 (d, *J* = 7.4 Hz, 1H), 3.12 (d, *J* = 13.6 Hz, 1H), 2.90 (d, *J* = 13.6 Hz, 1H), 1.55 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.4 (d, *J* = 8.9 Hz), 160.9 (d, *J* = 8.4 Hz), 150.0, 149.4, 145.6 (dm, *J* = 248.2 Hz), 142.6, 140.0 (dm, *J* = 258.8 Hz), 139.2, 137.4 (dm, *J* = 243.1 Hz), 131.9 (d, *J* = 3.5 Hz), 131.8 (d, *J* = 8.0 Hz), 131.3 (d, *J* = 8.1 Hz), 130.6 (d, *J* = 3.4 Hz), 127.5, 125.8, 122.3, 120.9, 115.5 (dd, *J* = 21.4, 5.5 Hz),112.1 (td, *J* = 19.0, 3.4 Hz), 55.0, 31.2, 22.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -114.3 (d, *J* = 12.5 Hz, 2F), -138.5 (m, 2F), -156.0 (t, *J* = 20.9 Hz, 1F), -162.7 (dd, *J* = 21.2, 14.8 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{29}H_{18}F_7$ $[M+H]^+$: 499.1291, found: 499.1290.



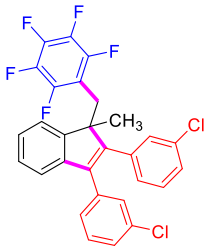
4m

1-methyl-2,3-bis(3-fluorophenyl)-1-((perfluorophenyl)methyl)-1H-indene (***4m***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a yellow solid, Mp = 110-112 ℃, 59 mg, 59% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 (dq, *J* = 10.5, 3.9, 2.9 Hz, 4H), 7.19 (td, *J* = 6.9, 6.4, 2.3 Hz, 1H), 7.06-6.93 (m, 6H), 6.89 (d, *J* = 7.5 Hz, 1H), 3.20-3.10 (m, 1H), 2.92 (dt, *J* = 13.6, 1.9 Hz, 1H), 1.56 (d, *J* = 2.0 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 164.0 (d, *J* = 16.7 Hz), 161.5 (d, *J* = 17.0 Hz), 150.1 (d, *J* = 1.9 Hz), 149.4, 145.5 (dm, *J* = 246.0 Hz), 142.2, 140.0 (dm, *J* = 240.4 Hz), 139.4 (d, *J* = 2.1 Hz), 138.0 (d, *J* = 7.8 Hz), 136.7 (d, *J* = 8.0 Hz), 137.4 (dm, *J* = 258.0 Hz), 130.0 (dd, *J* = 13.6, 8.5 Hz), 127.6, 126.1, 126.0 (d, *J* = 2.9 Hz), 125.3 (dm, *J* = 2.9 Hz), 122.3, 121.1, 116.8 (d, *J* = 21.6 Hz), 116.4 (d, *J* = 22.0 Hz), 114.6 (dd, *J* = 20.9, 1.8 Hz), 111.9 (td, *J* = 18.1, 3.5 Hz), 55.1, 31.2, 22.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -112.8 (s, 1F), -112.9 (s, 1F), -138.4 (m, 2F), -155.9 (t, *J* = 19.9 Hz, 1F), -162.5 (m, 2F). HRMS (ESI-TOF) calcd for $C_{29}H_{18}F_7$ $[M+H]^+$: 499.1291, found: 499.1297.



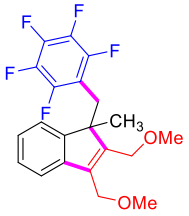
4n

1-methyl-2,3-bis(3-methoxyphenyl)-1-((perfluorophenyl)methyl)-1H-indene (***4n***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~30:1, v/v) affords the title compound as a pale yellow solid, Mp = 117-119 ℃, 70 mg, 67% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25 (d, *J* = 7.5 Hz, 1H), 7.17-7.03 (m, 4H), 6.85-6.68 (m, 7H), 3.57 (s, 6H), 3.08 (d, *J* = 13.6 Hz, 1H), 2.84 (d, *J* = 13.7 Hz, 1H), 1.48 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.5, 159.3, 150.7, 149.5, 145.5 (dm, *J* = 248.2 Hz), 142.8, 139.8 (dm, *J* = 254.0 Hz), 137.5, 137.3 (dm, *J* = 237.6 Hz), 136.2, 129.4, 129.2, 127.4, 125.6, 122.4, 122.2, 122.0, 121.1, 115.9, 114.7, 113.4, 112.7, 112.3 (td, *J* = 19.3, 3.6 Hz), 55.2 (d, *J* = 2.3 Hz), 55.0, 31.3, 22.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.3 (dd, *J* = 23.1, 8.0 Hz, 2F), -156.3 (t, *J* = 21.0 Hz, 1F), -162.8 (td, *J* = 22.8, 8.0 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{31}H_{24}O_2F_5$ $[M+H]^+$: 523.1691, found: 523.1687.



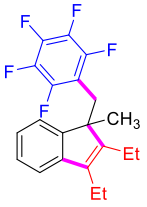
4o

2,3-bis(3-chlorophenyl)-1-methyl-1-((perfluorophenyl)methyl)-1H-indene (***4o***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale red solid, Mp = 105-107 ℃, 74 mg, 70% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32-7.17 (m, 9H), 7.13-7.05 (m, 2H), 6.88 (d, *J* = 7.5 Hz, 1H), 3.12 (d, *J* = 13.6 Hz, 1H), 2.91 (d, *J* = 13.6 Hz, 1H), 1.55 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.1, 149.4, 145.5 (dm, *J* = 248.3 Hz), 142.1, 139.9 (dm, *J* = 253.8 Hz), 139.4, 137.6, 137.4 (dm, *J* = 240.1 Hz), 136.3, 134.4, 134.3, 129.9, 129.70, 129.66, 129.4, 128.5, 127.9 (d, *J* = 1.6 Hz), 127.6, 126.1, 122.3, 121.1, 111.9 (td, *J* = 18.8, 4.1 Hz), 55.2, 31.1, 22.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.4 (m, 2F), -155.8 (t, *J* = 21.0 Hz, 1F), -162.5 (td, *J* = 22.7, 8.1 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{29}H_{18}F_5Cl_2$ $[M+H]^+$: 531.0700, found: 531.0703.



4p

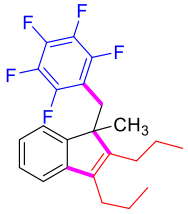
1-methyl-2,3-bis(methoxymethyl)-1-((perfluorophenyl)methyl)-1H-indene (***4p***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~30:1, v/v) affords the title compound as a viscous oil, 55 mg, 69% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (d, *J* = 7.3 Hz, 1H), 7.23-7.08 (m, 3H), 4.53-4.32 (m, 4H), 3.39 (s, 3H), 3.35-3.30 (m, 1H), 3.28 (s, 3H), 2.97 (d, *J* = 13.7 Hz, 1H), 1.47 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 149.0, 147.1, 145.3 (dm, *J* = 246.5 Hz), 142.1, 139.5 (dm, *J* = 254.4 Hz), 138.2, 137.1 (dm, *J* = 252.8 Hz), 127.4, 125.6, 122.1 (t, *J* = 2.0 Hz), 120.6, 111.8 (td, *J* = 19.3, 3.8 Hz), 66.0, 58.4, 57.9, 54.4, 30.6, 22.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -139.3 (m, 2F), -156.5 (t, *J* = 21.0 Hz, 1F), -163.2 (m, 2F). HRMS (ESI-TOF) calcd for $C_{21}H_{20}F_5O_2$ $[M+H]^+$: 399.1378, found: 399.1380.



4q

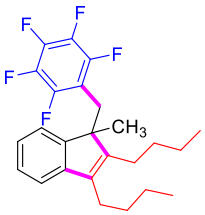
2,3-diethyl-1-methyl-1-((perfluorophenyl)methyl)-1H-indene (***4q***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title

compound as a pale yellow solid, Mp = 98-100 ℃, 44 mg, 60% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.19-7.12 (m, 2H), 7.10-6.91 (m, 2H), 3.17 (dd, *J* = 13.3, 1.7 Hz, 1H), 2.95 (dt, *J* = 13.4, 1.7 Hz, 1H), 2.62-2.26 (m, 4H), 1.43 (s, 3H), 1.12 (t, *J* = 7.6 Hz, 3H), 1.03 (t, *J* = 7.6 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 149.4, 148.6, 145.1 (dm, *J* = 257.0 Hz), 144.0, 139.4 (dm, *J* = 243.8 Hz), 138.6, 136.9 (dm, *J* = 246.8 Hz), 127.0, 124.0, 122.1 (d, *J* = 2.2 Hz), 118.2, 111.9 (td, *J* = 17.5, 3.7 Hz), 54.3, 31.1, 22.2, 18.6 (t, *J* = 3.3 Hz), 18.5, 15.2, 13.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -139.0 (m, 2F), -157.4 (t, *J* = 21.1 Hz, 1F), -163.9 (m, 2F). HRMS (ESI-TOF) calcd for $C_{21}H_{20}F_5$ $[M+H]^+$: 367.1480, found: 367.1481.



4r

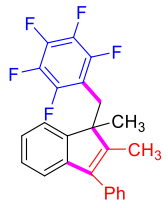
1-methyl-1-((perfluorophenyl)methyl)-2,3-dipropyl-1H-indene ***(4r)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a colorless oil, 43 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16-7.11 (m, 2H), 7.08-7.01 (m, 2H), 3.18 (dt, *J* = 13.3, 1.6 Hz, 1H), 2.95 (dt, *J* = 13.3, 1.7 Hz, 1H), 2.55-2.22 (m, 4H), 1.54-1.39 (m, 7H), 1.03 (t, *J* = 7.3 Hz, 3H), 0.90 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.53, 148.48, 145.2 (dm, *J* = 246.9 Hz), 144.5, 139.5 (dm, *J* = 238.9 Hz), 137.6, 137.0 (dm, *J* = 250.8 Hz), 127.0, 124.0, 122.1 (t, *J* = 2.2 Hz), 118.4, 112.0 (td, *J* = 18.0, 3.1 Hz), 54.4, 31.1, 28.4 (d, *J* = 2.9 Hz), 27.7, 24.0, 22.4, 22.0, 15.2, 14.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.9 (m, 2F), -157.4 (t, *J* = 21.0 Hz, 1F), -163.8 (m, 2F). HRMS (ESI-TOF) calcd for $C_{23}H_{24}F_5$ $[M+H]^+$: 395.1793, found: 395.1797.



4s

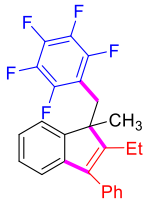
2,3-dibutyl-1-methyl-1-((perfluorophenyl)methyl)-1H-indene ***(4s)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a yellow oil, 49 mg, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.15 (ddd, *J* = 12.0, 6.7, 1.4 Hz, 2H), 7.10-7.00 (m, 2H), 3.18 (dt, *J* = 13.2, 1.7 Hz, 1H), 2.96 (dt, *J* = 13.4, 1.7 Hz, 1H), 2.54-2.21 (m, 4H), 1.47-1.25 (m, 11H), 0.99-0.89 (m, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.5, 148.4, 145.3 (dm, *J* = 252.1 Hz), 144.4, 139.3 (dm, *J* = 239.0 Hz), 137.6, 136.7 (dm, *J* = 251.3 Hz), 127.0, 123.9, 122.1 (t, *J* = 2.2 Hz), 118.3, 112.0 (td, *J* = 18.7, 3.6 Hz), 54.4, 32.9, 31.2, 31.0, 25.8 (t, *J* = 3.0 Hz), 25.4, 23.8, 23.2, 22.5, 14.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.9 (m, 2F), -157.4 (t, *J* = 20.9 Hz, 1F), -163.8 (dd, *J* = 21.2, 15.0 Hz, 2F). HRMS (ESI-TOF) calcd for

$C_{25}H_{28}F_5$ $[M+H]^+$: 423.2106, found: 423.2101.



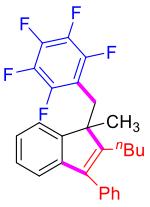
4t, rr = 3.3:1

1,2-dimethyl-1-((perfluorophenyl)methyl)-3-phenyl-1H-indene ***(4t)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale yellow oil, 50 mg, 63% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (dd, *J* = 7.8, 6.2 Hz, 2H), 7.38-7.28 (m, 5H), 7.11 (td, *J* = 7.5, 6.9, 2.3 Hz, 1H), 6.71 (d, *J* = 7.4 Hz, 1H), 3.02 (m, 1H), 2.70 (dt, *J* = 13.5, 2.0 Hz, 1H), 2.00 (s, 3H), 1.44 (t, *J* = 1.9 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.0, 149.3, 145.4 (dm, *J* = 246.4 Hz), 144.1, 139.6 (dm, *J* = 238.4 Hz), 137.2 (dm, *J* = 250.8 Hz), 136.3, 134.4, 129.7, 129.0, 128.5, 128.4, 127.4, 127.2, 125.2, 121.7, 119.5, 54.4, 31.0, 21.5, 11.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.6 (m, 2F), -156.6 (t, *J* = 21.1 Hz, 2F), -162.9 (m, 2F). HRMS (ESI-TOF) calcd for $C_{24}H_{18}F_5$ $[M+H]^+$: 401.1323, found: 401.1325.



4u, rr = 4:1

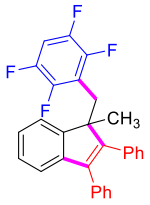
2-ethyl-1-methyl-1-((perfluorophenyl)methyl)-3-phenyl-1H-indene ***(4u)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale yellow oil, 61 mg, 74% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (t, *J* = 7.3 Hz, 2H), 7.37 (dd, *J* = 10.8, 7.4 Hz, 2H), 7.31-7.26 (m, 3H), 7.10 (t, *J* = 7.5 Hz, 1H), 6.72 (d, *J* = 7.5 Hz, 1H), 3.01 (dt, *J* = 13.4, 1.9 Hz, 1H), 2.71 (dd, *J* = 13.9, 2.1 Hz, 1H), 2.41 (qd, *J* = 7.6, 1.6 Hz, 2H), 1.40 (d, *J* = 1.9 Hz, 3H), 1.13 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 149.8, 149.7, 145.6 (dm, *J* = 253.4 Hz), 143.1, 140.4, 140.1 (dm, *J* = 249.9 Hz), 137.3 (dm, *J* = 252.3 Hz), 136.4, 129.8, 128.8, 128.7, 128.5, 127.5, 127.2, 125.1, 122.0, 119.9, 112.7 (td, *J* = 18.0, 4.4 Hz), 54.3, 30.9, 21.6, 19.2, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.5 (m, 2F), -156.6 (t, *J* = 21.0 Hz, 1F), -162.9 (m, 2F). HRMS (ESI-TOF) calcd for $C_{25}H_{20}F_5$ $[M+H]^+$: 415.1480, found: 415.1488.



4v, rr = 3.3:1

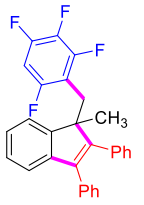
2-butyl-1-methyl-1-((perfluorophenyl)methyl)-3-phenyl-1H-indene ***(4v)***: Purification by column

chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale yellow oil, 51 mg, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (dd, *J* = 8.0, 6.4 Hz, 2H), 7.39-7.33 (m, 2H), 7.31-7.24 (m, 3H), 7.11-7.06 (m, 1H), 6.70 (d, *J* = 7.5 Hz, 1H), 3.00 (dt, *J* = 13.6, 1.9 Hz, 1H), 2.69 (dt, *J* = 13.6, 2.0 Hz, 1H), 2.39 (t, *J* = 7.8 Hz, 2H), 1.56-1.49 (m, 2H), 1.40 (d, *J* = 1.9 Hz, 3H), 1.32-1.21 (m, 2H), 0.82 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.4, 149.6, 145.5 (dm, *J* = 251.2 Hz), 143.4, 139.9 (dm, *J* = 251.2 Hz), 139.0, 137.3 (dm, *J* = 255.7 Hz), 136.4, 129.9, 128.8, 128.6, 128.4, 127.5, 127.2, 125.0, 122.0, 120.1, 112.7 (td, *J* = 19.4, 3.7 Hz), 54.4, 31.3, 31.0, 25.7, 22.9, 21.6, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.5 (m, 2F), -156.7 (t, *J* = 20.9 Hz, 1F), -162.9 (m, 2F). HRMS (ESI-TOF) calcd for $C_{27}H_{24}F_5$ $[M+H]^+$: 443.1793, found: 443.1799.



4w

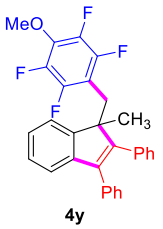
1-methyl-2,3-diphenyl-1-(2,3,5,6-tetrafluorobenzyl)-1H-indene ***(4w)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale red solid, Mp = 109-111 ℃, 55 mg, 62% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25-7.13 (m, 12H), 7.05 (t, *J* = 7.4 Hz, 1H), 6.85-6.73 (m, 2H), 3.09 (dd, *J* = 13.3, 2.2 Hz, 1H), 2.91-2.80 (m, 1H), 1.48 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.2, 149.7, 145.7 (dm, *J* = 247.8 Hz), 145.2 (dm, *J* = 242.3 Hz), 143.0, 139.6, 136.2, 134.9, 130.2, 129.7, 128.3, 128.2, 127.31, 127.25, 125.5, 122.3, 120.9, 118.4 (t, *J* = 18.2 Hz), 104.4 (t, *J* = 22.6 Hz), 55.1, 31.8 (d, *J* = 2.1 Hz), 22.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -139.0 (dd, *J* = 22.5, 12.8 Hz, 2F), -139.9 (dd, *J* = 22.6, 12.8 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{29}H_{21}F_4$ $[M+H]^+$: 445.1574, found: 445.1577.



4x

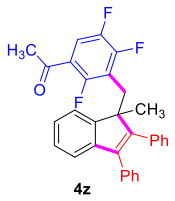
1-methyl-2,3-diphenyl-1-(2,3,4,6-tetrafluorobenzyl)-1H-indene ***(4x)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale yellow solid, Mp = 129-131 ℃, 49 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35-7.21 (m, 12H), 7.13 (t, *J* = 7.4 Hz, 1H), 6.84 (d, *J* = 7.5 Hz, 1H), 6.65 (tdd, *J* = 9.2, 5.9, 2.3 Hz, 1H), 3.10 (d, *J* = 13.6 Hz, 1H), 2.85 (d, *J* = 13.6 Hz, 1H), 1.54 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.0 (dm, *J* = 246.7 Hz), 151.4, 150.4 (dm, *J* = 255.6 Hz), 149.2 (dm, *J* = 254.7 Hz), 143.0, 139.4, 137.1 (dm, *J* = 244.9 Hz), 136.3, 135.0, 130.2, 129.7, 128.3 (d, *J* = 8.7 Hz), 127.3 (d, *J* = 3.9 Hz), 127.2, 125.3, 122.4, 120.9, 112.2 (td, *J* = 22.4, 4.6 Hz), 100.3 (m), 55.1, 31.1, 21.9. ^{19}F NMR (376 MHz, $CDCl_3$) δ -113.7 (d, *J* = 10.9 Hz, 1F), -131.0 (dd, *J* = 21.7, 5.3 Hz, 1F), -134.5 (dd, *J* = 21.5, 5.2 Hz, 1F), -165.5 (td, *J* = 21.4, 10.9 Hz, 1F). HRMS (ESI-TOF) calcd

for $C_{29}H_{21}F_4$ $[M+H]^+$: 445.1574, found: 445.1575.



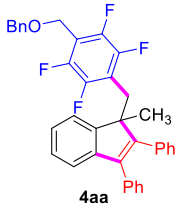
4y

1-methyl-2,3-diphenyl-1-(2,3,5,6-tetrafluoro-4-methoxybenzyl)-1H-indene ***(4y)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a pale yellow solid, Mp = 114-116 ℃, 66 mg, 70% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34-7.22 (m, 12H), 7.15 (t, *J* = 7.4 Hz, 1H), 6.87 (d, *J* = 7.5 Hz, 1H), 4.04 (s, 3H), 3.10 (d, *J* = 13.4 Hz, 1H), 2.87 (d, *J* = 13.4 Hz, 1H), 1.56 (d, *J* = 2.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.3, 149.9, 145.8 (dm, *J* = 246.2 Hz), 143.0, 140.8 (dm, *J* = 256.5 Hz), 139.5, 136.3, 135.0, 130.2, 129.7, 128.3, 128.2, 127.2 (t, *J* = 3.1 Hz), 125.4, 122.4, 120.9, 110.6 (t, *J* = 18.9 Hz), 62.3, 55.1, 31.2, 21.9. ^{19}F NMR (376 MHz, $CDCl_3$) δ -140.2 (m, 2F), -158.7 (m, 2F). HRMS (ESI-TOF) calcd for $C_{30}H_{23}OF_4$ $[M+H]^+$: 475.1680, found: 475.1681.



4z

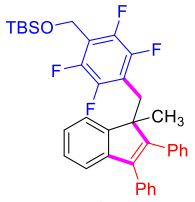
1-(2,4,5-trifluoro-3-((1-methyl-2,3-diphenyl-1H-inden-1-yl)methyl)phenyl)ethan-1-one ***(4z)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~30:1, v/v) affords the title compound as a pale yellow solid, Mp = 121-123 ℃, 59 mg, 63% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (dt, *J* = 9.5, 4.8 Hz, 1H), 7.29-7.17 (m, 12H), 7.05 (d, *J* = 7.4 Hz, 1H), 6.74 (d, *J* = 7.5 Hz, 1H), 3.12 (d, *J* = 13.4 Hz, 1H), 2.87 (d, *J* = 13.2 Hz, 1H), 2.41 (d, *J* = 5.7 Hz, 3H), 1.51 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 194.0, 157.1 (dm, *J* = 264.7 Hz), 152.4 (dm, *J* = 246.8 Hz), 151.3, 149.7, 147.2 (dm, *J* = 247.9 Hz), 143.1, 139.6, 136.2, 134.9, 130.2, 129.6, 128.33, 128.26, 127.4, 127.3, 125.3, 122.4, 121.4 (td, *J* = 17.9, 4.0 Hz), 121.0, 117.9 (dd, *J* = 24.0, 17.0 Hz), 115.9 (qd, *J* = 18.8, 2.5 Hz), 55.1, 31.7, 31.6 (t, *J* = 8.6 Hz), 21.9. ^{19}F NMR (376 MHz, $CDCl_3$) δ -109.2 (dd, *J* = 16.3, 8.2 Hz, 1F), -124.2 (dd, *J* = 22.5, 8.2 Hz, 1F), -140.8 (dd, *J* = 22.4, 16.1 Hz, 1F). HRMS (ESI-TOF) calcd for $C_{31}H_{24}OF_3$ $[M+H]^+$: 469.1774, found: 469.1777.



4aa

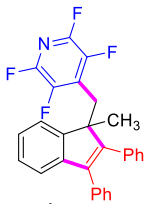
1-(4-((benzyloxy)methyl)-2,3,5,6-tetrafluorobenzyl)-1-methyl-2,3-diphenyl-1H-indene ***(4aa)***:

Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a pale yellow solid, Mp = 132-134 ℃, 80 mg, 71% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44-7.22 (m, 17H), 7.14 (td, *J* = 7.4, 1.2 Hz, 1H), 6.86 (d, *J* = 7.5 Hz, 1H), 4.63 (d, *J* = 1.9 Hz, 2H), 4.55 (s, 2H), 3.30-3.12 (m, 1H), 3.01-2.86 (m, 1H), 1.56 (d, *J* = 2.0 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.2, 149.7, 145.2 (dm, *J* = 254.6 Hz), 143.0, 139.6, 137.6, 136.2, 135.0, 130.2, 129.6, 128.6, 128.3, 128.2, 128.1, 128.0, 127.3, 127.2 (d, *J* = 1.7 Hz), 125.5, 122.4, 121.0, 117.9 (t, *J* = 18.2 Hz), 114.6 (t, *J* = 18.0 Hz), 72.9, 59.4, 55.1, 31.7, 21.9. ^{19}F NMR (376 MHz, $CDCl_3$) δ -139.21 (dd, *J* = 22.9, 13.2 Hz, 2F), -144.41 (dd, *J* = 23.0, 13.0 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{37}H_{29}OF_4$ $[M+H]^+$: 565.2149, found: 565.2150.



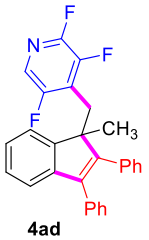
4ab

*tert-butyldimethyl((2,3,5,6-tetrafluoro-4-((1-methyl-2,3-diphenyl-1H-inden-1-yl)methyl)benzyl)oxy)silane (**4ab**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~30:1, v/v) affords the title compound as a pale yellow solid, Mp = 175-177 ℃, 78 mg, 66% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22-7.12 (m, 12H), 7.03 (ddd, *J* = 8.7, 6.8, 1.3 Hz, 1H), 6.74 (d, *J* = 7.6 Hz, 1H), 4.70-4.61 (m, 2H), 3.07 (dt, *J* = 13.5, 1.5 Hz, 1H), 2.86-2.77 (m, 1H), 1.58-1.46 (m, 3H), 0.80 (d, *J* = 1.1 Hz, 9H), 0.00 (d, *J* = 1.1 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.3, 149.7, 145.1 (dm, *J* = 251.2 Hz), 143.0, 139.5, 136.3, 135.0, 130.2, 129.7, 128.3, 128.2, 127.3, 127.2 (d, *J* = 1.5 Hz), 125.4, 122.4, 120.9, 117.3 (dd, *J* = 35.5, 25.0 Hz), 117.2 (d, *J* = 25.7 Hz), 55.1, 53.4, 31.6, 25.9, 21.9, 18.5, -5.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -139.7 (dd, *J* = 23.0, 12.8 Hz, 2F), -145.4 (dd, *J* = 23.0, 12.9 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{36}H_{37}F_4OSi$ $[M+H]^+$: 589.2544, found: 589.2546.



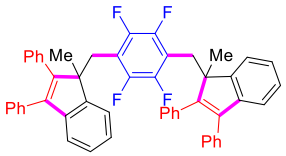
4ac

*2,3,5,6-tetrafluoro-4-((1-methyl-2,3-diphenyl-1H-inden-1-yl)methyl)pyridine (**4ac**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow solid, Mp = 142-144 ℃, 45 mg, 51% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26-7.15 (m, 12H), 7.11 (td, *J* = 7.4, 1.4 Hz, 1H), 6.87 (d, *J* = 7.4 Hz, 1H), 3.23-3.12 (m, 1H), 3.07-2.94 (m, 1H), 1.55 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.2, 149.1, 143.5 (dm, *J* = 240.6 Hz), 142.9, 140.7 (dm, *J* = 239.9 Hz), 140.1, 135.8, 134.6, 132.1 (tm, *J* = 16.9 Hz), 130.1, 129.6, 128.4, 128.3, 127.6 (t, *J* = 10.6 Hz), 125.8, 122.0, 121.2, 54.9, 32.6, 22.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -91.9 (m, 2F), -139.8 (m, 2F). HRMS (ESI-TOF) calcd for $C_{28}H_{20}F_4N$ $[M+H]^+$: 446.1526, found: 446.1526.



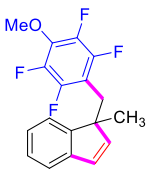
4ad

2,3,5-trifluoro-4-((1-methyl-2,3-diphenyl-1H-inden-1-yl)methyl)pyridine (***4ad***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow solid, Mp = 145-147 ℃, 42 mg, 49% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (t, *J* = 1.6 Hz, 1H), 7.24-7.15 (m, 12H), 7.10-7.06 (m, 1H), 6.82 (d, *J* = 7.5 Hz, 1H), 3.13 (d, *J* = 13.1 Hz, 1H), 2.93 (d, *J* = 13.0 Hz, 1H), 1.52 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.9 (dm, *J* = 252.0 Hz), 150.7, 149.2, 148.5 (dd, *J* = 235.2, 14.7 Hz), 143.9 (dd, *J* = 264.0, 32.9 Hz), 142.9, 139.9, 136.0, 134.7, 130.1, 129.6, 128.4, 128.3, 127.5, 127.4, 125.6, 122.2, 121.1, 54.9, 31.8 (d, *J* = 2.2 Hz), 22.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -90.3 (dd, *J* = 28.9, 26.0 Hz, 1F), -127.9 (dd, *J* = 28.7, 2.4 Hz, 1F), -135.5 (dd, *J* = 26.0, 2.4 Hz, 1F). HRMS (ESI-TOF) calcd for $C_{28}H_{21}F_3N$ $[M+H]^+$: 428.1621, found: 428.1620.



4ae (1:1 dr)

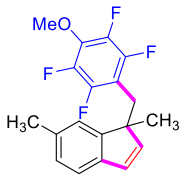
1-methyl-2,3-diphenyl-1-(2,3,5,6-tetrafluoro-4-((1-methyl-2,3-diphenyl-1H-inden-1-yl)methyl)benzyl)-1H-indene (***4ae***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow solid, 69 mg, 47% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.23-7.12 (m, 23H), 7.11-7.06 (m, 2H), 6.82 (t, *J* = 7.4 Hz, 1H), 6.71 (dd, *J* = 18.6, 7.4 Hz, 2H), 3.08 (t, *J* = 13.5 Hz, 2H), 2.89 (t, *J* = 12.7 Hz, 2H), 1.40 (d, *J* = 5.1 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.3, 151.0, 149.7 (d, *J* = 2.5 Hz), 145.0 (dm, *J* = 257.7 Hz), 143.1(d, *J* = 11.5 Hz), 139.6 (d, *J* = 14.1 Hz), 136.3 (d, *J* = 12.1 Hz), 135.0 (d, *J* = 11.2 Hz), 130.2, 129.7 (d, *J* = 10.6 Hz), 128.3 (d, *J* = 1.3 Hz), 128.2 (d, *J* = 5.9 Hz), 127.2, 127.1 (dd, *J* = 12.8, 3.2 Hz), 125.3 (d, *J* = 2.1 Hz), 122.5 (d, *J* = 5.2 Hz), 120.7 (d, *J* = 3.7 Hz), 115.5 (m), 55.2 (d, *J* = 4.8 Hz), 31.5 (d, *J* = 19.4 Hz), 22.0 (d, *J* = 11.2 Hz). ^{19}F NMR (376 MHz, $CDCl_3$) δ -140.1 (d, *J* = 27.7 Hz, 4F). HRMS (ESI-TOF) calcd for $C_{52}H_{39}F_4$ $[M+H]^+$: 739.2982, found: 739.2988.



6a

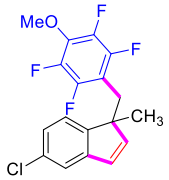
1-methyl-1-(2,3,5,6-tetrafluoro-4-methoxybenzyl)-1H-indene (***6a***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a pale yellow oil, 33 mg, 51% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 (t, *J* = 4.7

Hz, 1H), 7.12 (d, *J* = 2.2 Hz, 3H), 6.52 (d, *J* = 5.5 Hz, 1H), 6.24 (dt, *J* = 5.3, 2.5 Hz, 1H), 3.92 (d, *J* = 1.3 Hz, 3H), 3.07 (dt, *J* = 13.5, 1.8 Hz, 1H), 2.90 (dt, *J* = 13.4, 1.8 Hz, 1H), 1.29 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.3, 145.4 (dm, *J* = 249.0 Hz), 144.0, 143.1, 140.6 (dm, *J* = 247.2 Hz), 136.7 (m), 129.5, 127.1, 125.2, 122.1, 121.3, 110.5 (t, *J* = 18.9 Hz), 62.2, 54.0, 30.8 (t, *J* = 1.7 Hz), 22.9. ^{19}F NMR (376 MHz, $CDCl_3$) δ -141.9 (m, 2F), -158.8 (m, 2F). HRMS (ESI-TOF) calcd for $C_{18}H_{15}F_4O$ $[M+H]^+$: 323.1054, found: 323.1057.



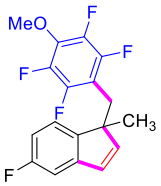
6b

1,6-dimethyl-1-(2,3,5,6-tetrafluoro-4-methoxybenzyl)-1H-indene ***(6b)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a pale yellow oil, 38 mg, 57% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (s, 1H), 7.10 (d, *J* = 7.5 Hz, 1H), 7.02 (d, *J* = 7.6 Hz, 1H), 6.57 (d, *J* = 5.5 Hz, 1H), 6.24 (dd, *J* = 5.4, 2.7 Hz, 1H), 4.01 (t, *J* = 1.3 Hz, 3H), 3.14 (dt, *J* = 13.4, 1.6 Hz, 1H), 2.91 (dt, *J* = 13.4, 1.6 Hz, 1H), 2.40 (s, 3H), 1.34 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.8, 145.6 (dm, *J* = 241.9 Hz), 140.6 (dm, *J* = 249.8 Hz), 143.0 (t, *J* = 1.6 Hz), 140.7 (dm, *J* = 247.3 Hz), 140.4, 136.7 (m), 135.0, 129.2, 127.8, 123.0, 120.9, 110.7 (t, *J* = 19.1 Hz), 62.2 (dm, *J* = 3.6 Hz), 53.7, 30.9, 22.8, 21.7. ^{19}F NMR (376 MHz, $CDCl_3$) δ -142.0 (m, 2F), -158.9 (m, 2F). HRMS (ESI-TOF) calcd for $C_{19}H_{17}F_4O$ $[M+H]^+$: 337.1210, found: 337.1212.



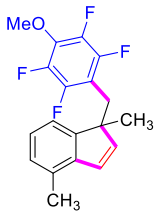
6c

5-chloro-1-methyl-1-(2,3,5,6-tetrafluoro-4-methoxybenzyl)-1H-indene ***(6c)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~30:1, v/v) affords the title compound as a pale green oil, 38 mg, 53% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (d, *J* = 8.5 Hz, 1H), 7.20-7.12 (m, 2H), 6.53 (d, *J* = 5.5 Hz, 1H), 6.40 (dt, *J* = 5.3, 2.5 Hz, 1H), 4.01 (t, *J* = 1.4 Hz, 3H), 3.13 (dt, *J* = 13.5, 1.8 Hz, 1H), 3.06-2.96 (m, 1H), 1.36 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.5, 145.8, 145.4 (dm, *J* = 248.0 Hz), 144.8, 140.6 (dm, *J* = 243.7 Hz), 136.8 (m), 132.9, 128.7, 125.1, 123.1, 121.5, 110.0 (t, *J* = 19.1 Hz), 62.2, 53.9, 30.6 (t, *J* = 1.7 Hz), 23.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -142.0 (m, 2F), -158.6 (m, 2F). HRMS (ESI-TOF) calcd for $C_{18}H_{14}OClF_4$ $[M+H]^+$: 357.0664, found: 357.0665.



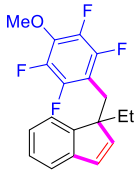
6d

5-fluoro-1-methyl-1-(2,3,5,6-tetrafluoro-4-methoxybenzyl)-1H-indene ***(6d)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a pale yellow oil, 33 mg, 49% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (dd, *J* = 9.0, 4.9 Hz, 1H), 6.87 (ddt, *J* = 9.3, 4.6, 2.4 Hz, 2H), 6.54 (d, *J* = 5.6 Hz, 1H), 6.41 (dt, *J* = 5.3, 2.5 Hz, 1H), 4.01 (t, *J* = 1.2 Hz, 3H), 3.13 (dt, *J* = 13.5, 1.8 Hz, 1H), 3.01 (dt, *J* = 13.6, 1.9 Hz, 1H), 1.37 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.6 (d, *J* = 243.5 Hz), 146.1 (t, *J* = 1.8 Hz), 145.5 (d, *J* = 2.5 Hz), 145.4 (dm, *J* = 245.9 Hz), 144.9 (dm, *J* = 9.1 Hz), 140.7 (dm, *J* = 247.5 Hz), 136.8 (m), 128.8 (d, *J* = 3.0 Hz), 122.9 (d, *J* = 9.3 Hz), 111.6 (d, *J* = 23.0 Hz), 110.1 (t, *J* = 18.9 Hz), 108.3 (d, *J* = 23.2 Hz), 62.2, 53.6, 30.8, 23.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -116.5 (s, 1F), -142.1 (m, 2F), -158.7 (m, 2F). HRMS (ESI-TOF) calcd for $C_{18}H_{14}OF_5$ $[M+H]^+$: 341.0959, found: 341.0957.



6e

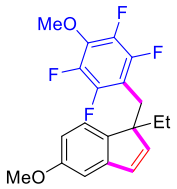
1,4-dimethyl-1-(2,3,5,6-tetrafluoro-4-methoxybenzyl)-1H-indene ***(6e)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a pale yellow oil, 43 mg, 64% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (d, *J* = 7.4 Hz, 1H), 7.11 (t, *J* = 7.4 Hz, 1H), 7.02 (d, *J* = 7.4 Hz, 1H), 6.72 (d, *J* = 5.6 Hz, 1H), 6.31 (dt, *J* = 5.3, 2.5 Hz, 1H), 4.01 (d, *J* = 1.5 Hz, 3H), 3.14 (dt, *J* = 13.5, 1.8 Hz, 1H), 2.91 (dt, *J* = 13.5, 1.9 Hz, 1H), 2.36 (s, 3H), 1.33 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.5, 145.6 (dm, *J* = 242.6 Hz), 143.5 (d, *J* = 1.7 Hz), 141.7, 140.7 (dm, *J* = 247.0 Hz), 136.7 (m), 130.5, 128.3, 127.5, 125.4, 119.43, 110.7 (t, *J* = 18.9 Hz), 62.2, 54.1, 30.8 (t, *J* = 1.5 Hz), 22.8, 18.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -141.9 (m, 2F), -158.8 (m, 2F).. HRMS (ESI-TOF) calcd for $C_{19}H_{17}OF_4$ $[M+H]^+$: 337.1210, found: 337.1211.



6f

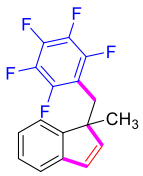
1-ethyl-1-(2,3,5,6-tetrafluoro-4-methoxybenzyl)-1H-indene ***(6f)***: Purification by column

chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a pale green oil, 34 mg, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (q, *J* = 4.2, 3.4 Hz, 1H), 7.22-7.14 (m, 3H), 6.63 (d, *J* = 5.6 Hz, 1H), 6.25 (dt, *J* = 5.4, 2.6 Hz, 1H), 3.98 (d, *J* = 1.3 Hz, 3H), 3.17 (dt, *J* = 13.5, 1.8 Hz, 1H), 3.04 (dt, *J* = 13.4, 1.8 Hz, 1H), 1.93 (qd, *J* = 7.2, 2.7 Hz, 2H), 0.54 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.3, 145.4 (dm, *J* = 244.4 Hz), 144.2, 142.0, 140.5 (dm, *J* = 247.2 Hz), 136.5 (m), 130.9, 127.0, 125.1, 122.3, 121.0, 110.4 (t, *J* = 18.9 Hz), 62.2 (dm, *J* = 3.6 Hz), 58.6, 30.2, 29.6, 8.8. ^{19}F NMR (376 MHz, $CDCl_3$) δ -141.7 (m, 2F), -159.1 (m, 2F). HRMS (ESI-TOF) calcd for $C_{19}H_{17}OF_4$ $[M+H]^+$: 337.1210, found: 337.1210.



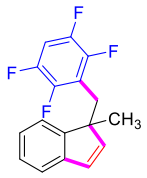
6g

1-ethyl-5-methoxy-1-(2,3,5,6-tetrafluoro-4-methoxybenzyl)-1H-indene (***6g***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~30:1, v/v) affords the title compound as a yellow oil, 35 mg, 48% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24-7.15 (m, 1H), 6.72 (dq, *J* = 5.1, 2.5 Hz, 2H), 6.57 (d, *J* = 5.6 Hz, 1H), 6.28 (dt, *J* = 5.5, 2.6 Hz, 1H), 3.98 (d, *J* = 1.3 Hz, 3H), 3.79 (s, 3H), 3.20-3.10 (m, 1H), 3.08-2.98 (m, 1H), 1.90 (q, *J* = 7.4 Hz, 2H), 0.55 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.2, 145.6, 145.4 (dm, *J* = 245.2 Hz), 143.3 (t, *J* = 1.6 Hz), 140.6 (dm, *J* = 246.8 Hz), 140.3, 136.5 (m), 130.7, 122.8, 110.5 (t, *J* = 18.9 Hz), 110.4, 106.8, 62.1, 57.9, 55.4, 30.3, 29.9, 8.8. ^{19}F NMR (376 MHz, $CDCl_3$) δ -141.7 (m, 2F), -159.1 (m, 2F). HRMS (ESI-TOF) calcd for $C_{20}H_{19}O_2F_4$ $[M+H]^+$: 367.1316, found: 367.1318.



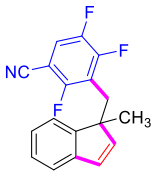
6h

1-methyl-1-((perfluorophenyl)methyl)-1H-indene (***6h***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale yellow solid, Mp = 112-114 ℃, 38 mg, 62% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43-7.36 (m, 1H), 7.19 (t, *J* = 4.0 Hz, 3H), 6.59 (d, *J* = 5.6 Hz, 1H), 6.31 (dt, *J* = 5.4, 2.6 Hz, 1H), 3.18 (dt, *J* = 13.5, 2.0 Hz, 1H), 3.07 (dt, *J* = 13.4, 2.0 Hz, 1H), 1.40 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 149.8, 145.3 (dm, *J* = 246.2 Hz), 143.6 (t, *J* = 1.7 Hz), 143.0, 139.7 (dm, *J* = 253.4 Hz), 136.0 (m), 129.8, 127.3, 125.3, 122.1, 121.3, 112.0 (td, *J* = 20.2 Hz), 53.9, 30.8, 23.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -140.1 (m, 2F), -156.9 (t, *J* = 21.0 Hz, 1F), -163.0 (dd, *J* = 21.2, 14.8 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{17}H_{12}F_5$ $[M+H]^+$: 311.0854, found: 311.0857.



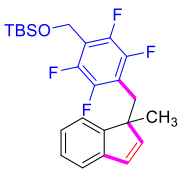
6i

1-methyl-1-(2,3,5,6-tetrafluorobenzyl)-1H-indene (***6i***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale green oil, 31 mg, 53% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 (t, *J* = 4.4 Hz, 1H), 7.20 (d, *J* = 3.1 Hz, 3H), 6.85 (m, 1H), 6.60 (d, *J* = 5.5 Hz, 1H), 6.33 (dt, *J* = 5.6, 2.6 Hz, 1H), 3.22 (m, 1H), 3.05 (m, 1H), 1.39 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.2, 145.7 (dm, *J* = 246.0 Hz), 145.0 (dm, *J* = 249.4 Hz), 143.9 (t, *J* = 1.6 Hz), 143.0, 129.5, 127.2, 125.3, 122.1, 121.3, 118.2 (t, *J* = 18.2 Hz), 104.2 (t, *J* = 22.6 Hz), 54.0, 31.4, 23.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -140.0 (m, 2F), -140.7 (m, 2F). HRMS (ESI-TOF) calcd for $C_{17}H_{13}F_4$ $[M+H]^+$: 293.0948, found: 293.0950.



6j

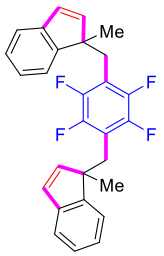
2,4,5-trifluoro-3-((1-methyl-1H-inden-1-yl)methyl)benzonitrile (***6j***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale green oil, 24 mg, 40% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35-7.30 (m, 1H), 7.16-7.07 (m, 4H), 6.51 (d, *J* = 5.5 Hz, 1H), 6.24 (dt, *J* = 5.5, 2.7 Hz, 1H), 3.11 (qt, *J* = 13.3, 1.7 Hz, 2H), 1.35 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 158.5 (dm, *J* = 254.9 Hz), 152.6 (dm, *J* = 260.4 Hz), 149.3, 146.7 (dm, *J* = 250.4 Hz), 143.2, (t, *J* = 1.6 Hz), 142.9, 130.1, 128.9, 127.4, 125.4, 122.2, 121.3, 118.7 (dd, *J* = 20.8, 17.7 Hz), 118.3 (dt, *J* = 21.7, 2.1 Hz), 112.7, 96.5 (m), 54.0, 31.3, 23.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -108.1 (dd, *J* = 14.2, 7.5 Hz, 1F), -122.8 (dd, *J* = 22.1, 7.6 Hz, 1F), -138.7 (dd, *J* = 21.9, 14.3 Hz, 1F). HRMS (ESI-TOF) calcd for $C_{18}H_{13}F_3N$ $[M+H]^+$: 300.0995, found: 300.0997.



6k

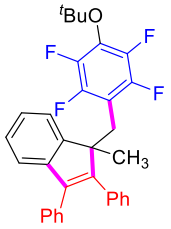
tert-butyldimethyl((2,3,5,6-tetrafluoro-4-((1-methyl-1H-inden-1-yl)methyl)benzyl)oxy)silane (***6k***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1, v/v) affords the title compound as a pale yellow oil, 59 mg, 67% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 (m, 1H), 7.16-7.04 (m, 3H), 6.52 (d, *J* = 5.6 Hz, 1H), 6.26 (dt, *J* = 5.3, 2.5 Hz, 1H), 4.65 (t, *J* = 1.6 Hz, 2H), 3.14 (dt, *J* = 13.3, 1.8 Hz, 1H), 2.95 (dt, *J* = 13.2, 1.8 Hz, 1H), 1.31 (s, 3H), 0.81 (s,

9H), -0.00 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.3, 144.7 (dm, *J* = 247.2 Hz), 143.9, 143.0, 129.5, 127.2, 125.3, 122.1, 121.3, 117.0 (td, *J* = 17.8, 6.5 Hz), 54.0, 53.4 (t, *J* = 2.6 Hz), 31.3 (t, *J* = 1.9 Hz), 25.8 (d, *J* = 3.6 Hz), 22.9, 18.5, -5.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -141.3 (dd, *J* = 23.0, 13.1 Hz, 2F), -145.5 (dd, *J* = 22.8, 13.1 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{24}H_{29}OSiF_4$ $[M+H]^+$: 437.1918, found: 437.1922.



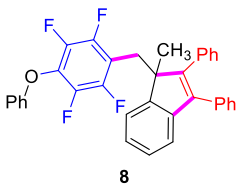
6l (1:1 dr)

1-methyl-1-(2,3,5,6-tetrafluoro-4-((1-methyl-1H-inden-1-yl)methyl)benzyl)-1H-indene ***(6l)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow oil, 28 mg, 32% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (dd, *J* = 8.9, 6.4 Hz, 2H), 7.22-7.13 (m, 6H), 6.56 (dd, *J* = 17.1, 5.6 Hz, 2H), 6.27 (d, *J* = 5.5 Hz, 2H), 3.10 (dd, *J* = 13.3, 6.9 Hz, 2H), 2.96 (dd, *J* = 13.2, 9.5 Hz, 2H), 1.33 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.2 (d, *J* = 34.0 Hz), 144.6 (dm, *J* = 249.7 Hz), 144.1 (d, *J* = 6.0 Hz), 143.0 (d, *J* = 3.3 Hz), 129.3 (d, *J* = 2.7 Hz), 127.1 (d, *J* = 4.3 Hz), 125.2, 122.1 (d, *J* = 7.0 Hz), 121.2 (d, *J* = 7.0 Hz), 115.2 (m), 54.0 (d, *J* = 2.4 Hz), 31.2, 22.7 (d, *J* = 4.0 Hz). ^{19}F NMR (376 MHz, $CDCl_3$) δ -141.9 (d, *J* = 18.5 Hz, 4F). HRMS (ESI-TOF) calcd for $C_{28}H_{23}F_4$ $[M+H]^+$: 435.1730, found: 435.1739.



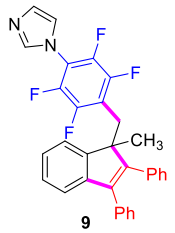
7

1-(4-(tert-butoxy)-2,3,5,6-tetrafluorobenzyl)-1-methyl-2,3-diphenyl-1H-indene ***(7)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a pale yellow solid, Mp = 123-125 ℃, 88 mg, 85% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29-7.20 (m, 12H), 7.12 (td, *J* = 7.4, 1.3 Hz, 1H), 6.87 (d, *J* = 7.5 Hz, 1H), 3.14 (dt, *J* = 13.6, 1.6 Hz, 1H), 2.98 (dt, *J* = 13.5, 1.7 Hz, 1H), 1.58 (s, 3H), 1.35 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.1, 149.9, 145.6 (dm, *J* = 243.2 Hz), 143.3 (dm, *J* = 244.3 Hz), 143.1, 139.6, 136.3, 135.0, 132.5 (t, *J* = 13.8 Hz), 130.2, 129.6, 128.3, 128.2, 127.23 (d, *J* = 2.6 Hz), 127.17, 125.4, 122.3, 120.8, 112.2 (t, *J* = 18.8 Hz), 84.7, 55.2, 31.5, 28.4 (t, *J* = 1.8 Hz), 22.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -140.5 (m, 2F), -152.6 (m, 2F). HRMS (ESI-TOF) calcd for $C_{33}H_{29}OF_4$ $[M+H]^+$: 517.2149, found: 517.2151.



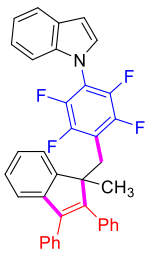
8

1-methyl-2,3-diphenyl-1-(2,3,5,6-tetrafluoro-4-phenoxybenzyl)-1H-indene ***(8)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a colorless solid, Mp = 162-164 ℃, 99 mg, 92% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25-7.05 (m, 15H), 6.97 (t, *J* = 7.4 Hz, 1H), 6.88 (d, *J* = 7.4 Hz, 1H), 6.76 (d, *J* = 8.1 Hz, 2H), 3.09 (d, *J* = 13.5 Hz, 1H), 2.95 (d, *J* = 13.5 Hz, 1H), 1.52 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.3, 150.8, 149.9, 145.8 (dm, *J* = 238.5 Hz), 143.1, 141.3 (dm, *J* = 250.8 Hz), 139.8, 136.2, 134.9, 131.8 (t, *J* = 13.1 Hz), 130.1, 129.7 (d, *J* = 26.0 Hz), 128.2 (d, *J* = 18.2 Hz), 127.3, 125.5, 123.7, 122.3, 120.9, 115.4, 113.5 (t, *J* = 18.6 Hz), 55.2, 31.6, 22.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.6 (m, 2F), -155.2 (m, 2F). HRMS (ESI-TOF) calcd for $C_{35}H_{25}F_4O$ $[M+H]^+$: 537.1836, found: 537.1837.



9

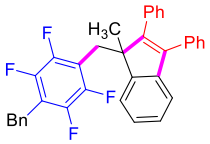
1-(2,3,5,6-tetrafluoro-4-((1-methyl-2,3-diphenyl-1H-inden-1-yl)methyl)phenyl)-1H-imidazole ***(9)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a yellow solid, Mp = 125-127 ℃, 89 mg, 87% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (s, 1H), 7.27-7.06 (m, 15H), 6.89 (d, *J* = 7.4 Hz, 1H), 3.12 (d, *J* = 13.5 Hz, 1H), 3.01-2.90 (m, 1H), 1.54 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.5, 149.7, 145.7 (dm, *J* = 252.6 Hz), 142.9, 140.7 (dm, *J* = 248.8 Hz), 139.9, 137.7 (t, *J* = 3.2 Hz), 136.0, 134.7, 130.0, 129.5, 128.3, 128.2, 127.4, 127.3 (d, *J* = 3.6 Hz), 125.6, 122.0, 121.1, 120.0 (t, *J* = 2.3 Hz), 117.3 (t, *J* = 18.5 Hz), 115.3 (t, *J* = 13.4 Hz), 55.0, 31.7, 22.2, 1.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -136.7 (m, 2F), -149.7 (m, 2F). HRMS (ESI-TOF) calcd for $C_{32}H_{23}N_2F_4$ $[M+H]^+$: 511.1792, found: 511.1797.



10

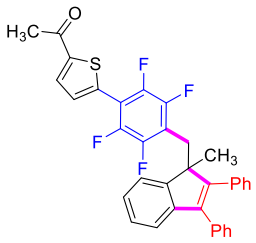
1-(2,3,5,6-tetrafluoro-4-((1-methyl-2,3-diphenyl-1H-inden-1-yl)methyl)phenyl)-1H-indole ***(10)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1,

v/v) affords the title compound as a pale brown solid, Mp = 129-131 ℃, 69 mg, 62% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, *J* = 7.6 Hz, 1H), 7.39-7.16 (m, 16H), 7.04 (d, *J* = 7.6 Hz, 2H), 6.76 (d, *J* = 3.3 Hz, 1H), 3.26 (d, *J* = 13.4 Hz, 1H), 3.12 (d, *J* = 13.4 Hz, 1H), 1.68 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.7, 149.9, 145.9 (dm, *J* = 257.8 Hz), 143.1, 142.7 (dm, *J* = 252.6 Hz), 139.9, 136.4, 136.2, 134.9, 130.2, 129.7, 128.8, 128.4, 128.2, 127.4, 127.3, 125.6, 123.2, 122.2, 121.3 (d, *J* = 5.7 Hz), 121.1, 116.9 (t, *J* = 18.7 Hz), 110.5, 105.4, 55.3, 31.9, 22.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -137.7 (t, *J* = 31.0 Hz, 2F), -147.3 (d, *J* = 25.1 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{37}H_{26}F_4N$ $[M+H]^+$: 560.1996, found: 560.1989.



11

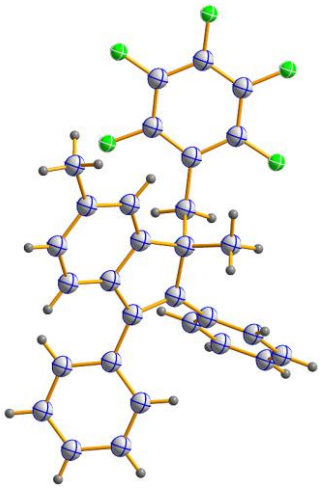
1-(4-benzyl-2,3,5,6-tetrafluorobenzyl)-1-methyl-2,3-diphenyl-1H-indene ***(11)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~50:1, v/v) affords the title compound as a colorless solid, Mp = 112-114 ℃, 83 mg, 78% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31-7.18 (m, 17H), 7.12 (t, *J* = 7.4 Hz, 1H), 6.86 (d, *J* = 7.5 Hz, 1H), 4.00 (s, 2H), 3.13 (d, *J* = 13.4 Hz, 1H), 2.92 (d, *J* = 13.4 Hz, 1H), 1.57 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.2, 149.9, 145.2 (dm, *J* = 248.4 Hz), 144.6 (dm, *J* = 249.4 Hz), 143.0, 139.5, 138.0, 136.3, 135.0, 130.1, 129.7, 128.8, 128.5, 128.3, 128.2, 127.2 (t, *J* = 3.2 Hz), 126.9, 125.4, 122.4, 120.9, 117.8 (t, *J* = 18.7 Hz), 115.6 (t, *J* = 18.4 Hz), 55.2, 31.6, 28.7, 22.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -139.5 (dd, *J* = 22.9, 12.5 Hz, 2F), -144.8 (dd, *J* = 22.9, 12.6 Hz, 2F). HRMS (ESI-TOF) calcd for $C_{36}H_{27}F_4$ $[M+H]^+$: 535.2043, found: 535.2041.



12

1-(5-(2,3,5,6-tetrafluoro-4-((1-methyl-2,3-diphenyl-1H-inden-1-yl)methyl)phenyl)thiophen-2-yl)ethan-1-one ***(12)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 100:1~30:1, v/v) affords the title compound as a yellow solid, Mp = 131-133 ℃, 76 mg, 67% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (d, *J* = 4.1 Hz, 1H), 7.49 (d, *J* = 4.0 Hz, 1H), 7.27-7.15 (m, 12H), 7.09 (t, *J* = 7.4 Hz, 1H), 6.87 (d, *J* = 7.4 Hz, 1H), 3.13 (d, *J* = 13.4 Hz, 1H), 2.91 (d, *J* = 13.4 Hz, 1H), 2.52 (s, 3H), 1.53 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 190.9, 150.9, 149.7, 145.9 (dm, *J* = 244.8 Hz), 145.5, 143.6 (dm, *J* = 247.9 Hz), 142.9, 139.7, 136.2, 134.9, 132.1, 130.8 (t, *J* = 6.3 Hz), 130.1, 139.6, 128.3, 128.2, 127.3 (t, *J* = 2.3 Hz), 125.6, 122.3, 121.0, 117.7 (t, *J* = 18.7 Hz), 111.8 (t, *J* = 14.3 Hz), 55.2, 31.6, 27.1, 22.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -138.4 (q, *J* = 10.2 Hz, 2F), -140.2 (m, 2F). HRMS (ESI-TOF) calcd for $C_{35}H_{25}F_4OS$ $[M+H]^+$: 569.1557, found: 569.1561.

8. Crystallographic Data of 4b

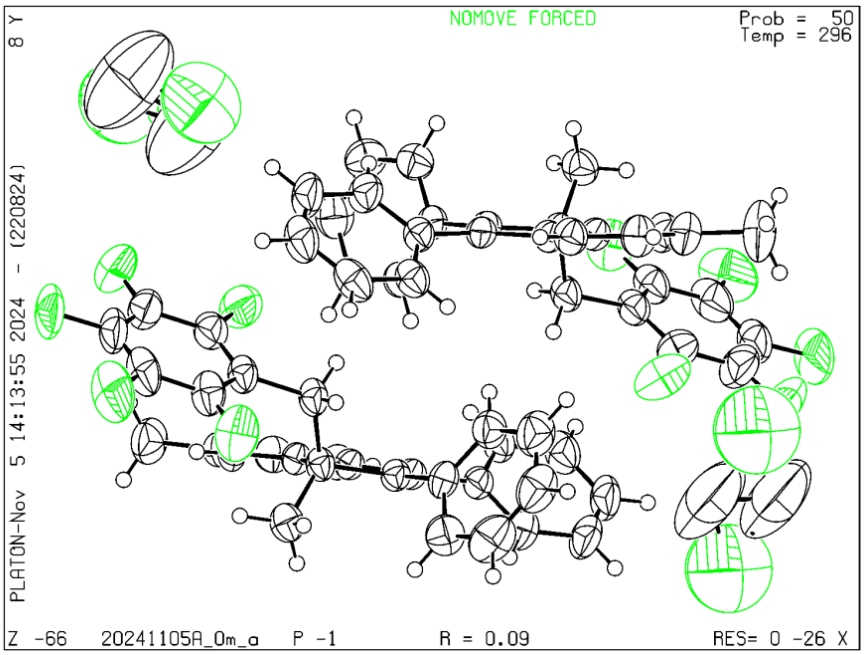


structure of 4b CCDC: 2413247

Datablock:

Bond precision:	C-C = 0.0056 A		Wavelength = 0.71073
Cell:	a = 10.584(2)	b=13.468(3)	c=19.022(4)
	alpha=76.198(4)	beta=85.461(4)	gamma=77.856(4)
Temperature:	296 K		
	Calculated		Reported
Volume	2573.1(9)		2572.9(9)
Space group	p -1		p -1
Hall group	-1 p		-1 p
Moiety formula	2(C30 H21F5), C2C12		
Sum formula	C62 H42 C12 F10		C62 H42 C12 F10
Mr	1047.86		1047.85
Dx,g cm-3	1.352		1.353
Z	2		2
Mu (mm-1)	0.203		0.203
F000	1076.0		1076.0
F000'	1077.23		
h,k,lmax	12,16,22		12,16,22
Nref	9066		9013
Tmin,Tmax			
Tmin'			
Correction method = Not given			
Data completeness = 0.994			Theta (max) = 24.998
R (reflections) = 0.0863(6052)			wR2 (reflections) = 0.2554(9013)
S = 1.423			Npar = 671

Datablock 20241105A_0m_a - ellipsoid plot



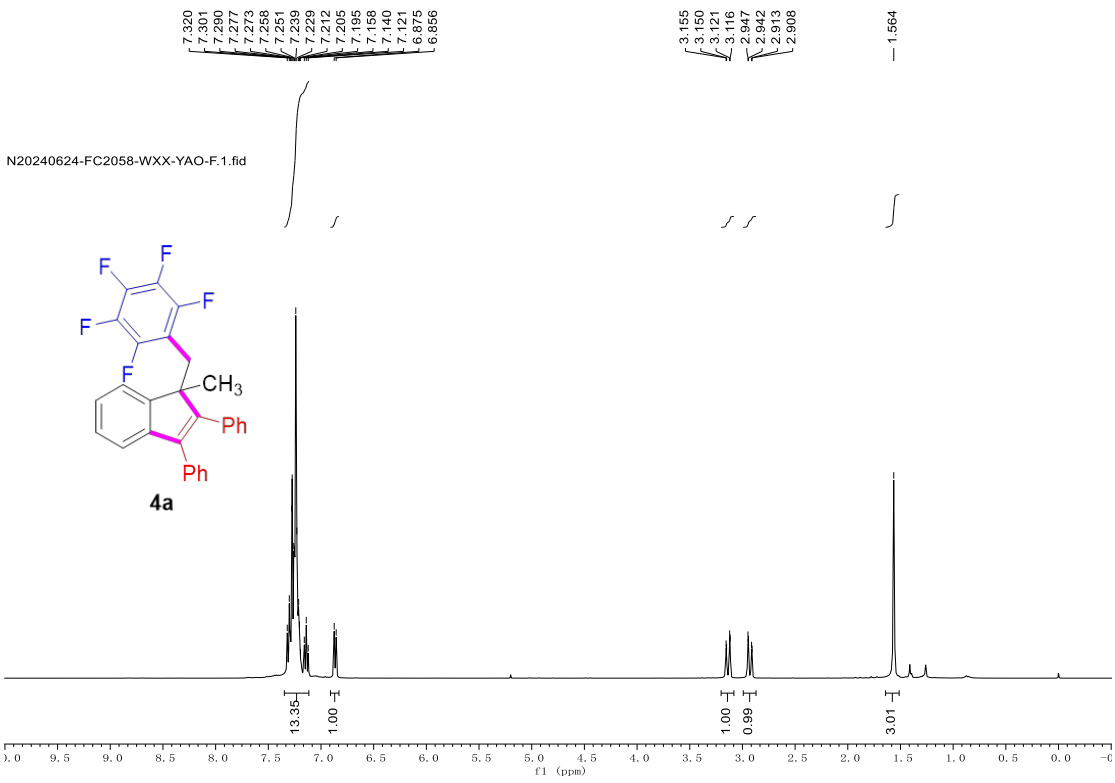
The product **4b** was recrystallized in dichloromethane, and the crystal structure of **4b** containing dichloromethane was confirmed by the X-ray crystallographic analysis. In addition, **4b** contains a quaternary carbon center and is racemic.

9. Reference

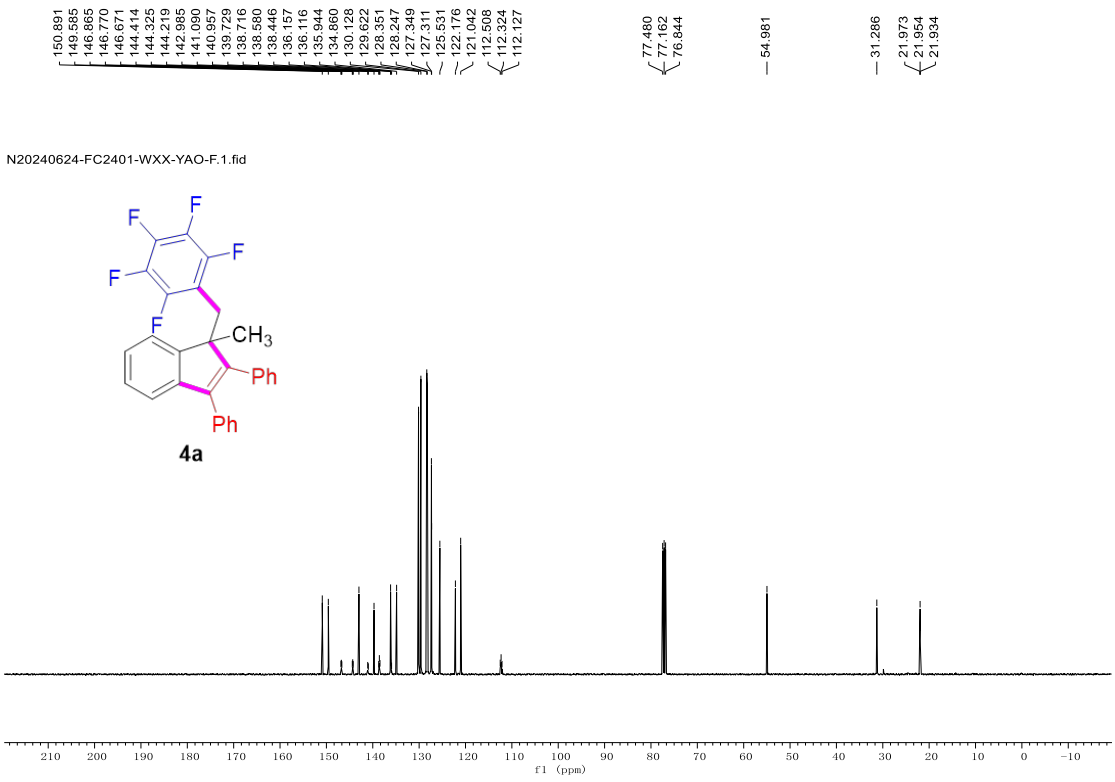
(1) Li, J.; Chen, J.; Wang, L.; Shi, Y. *Org. Lett.* **2021**, *23*, 3646-3651.
(2) Huang, Q.; Larock, R. C. *J. Org. Chem*. **2003**, *68*, 7342.
(3) Yao, T.; Zhang, H.; Zhao, Y. *Org. Lett.* **2016**, *18*, 2532.
(4) Emer, E.; Pfeifer, L.; Brown, J. M.; Gouverneur, V. *Angew. Chem. Int. Ed.* **2014**, *53*, 4181.
(5) Lou, Z.; Zhang, S.; Chen, C.; Pang, X.; Li, M.; Wen, L. *Adv. Synth. Catal.* **2014**, *356*, 153.
(6) Jia, X.; Petrone, D. A.; Lautens, M. *Angew. Chem. Int. Ed.* **2012**, *51*, 9870.

10. NMR Spectra

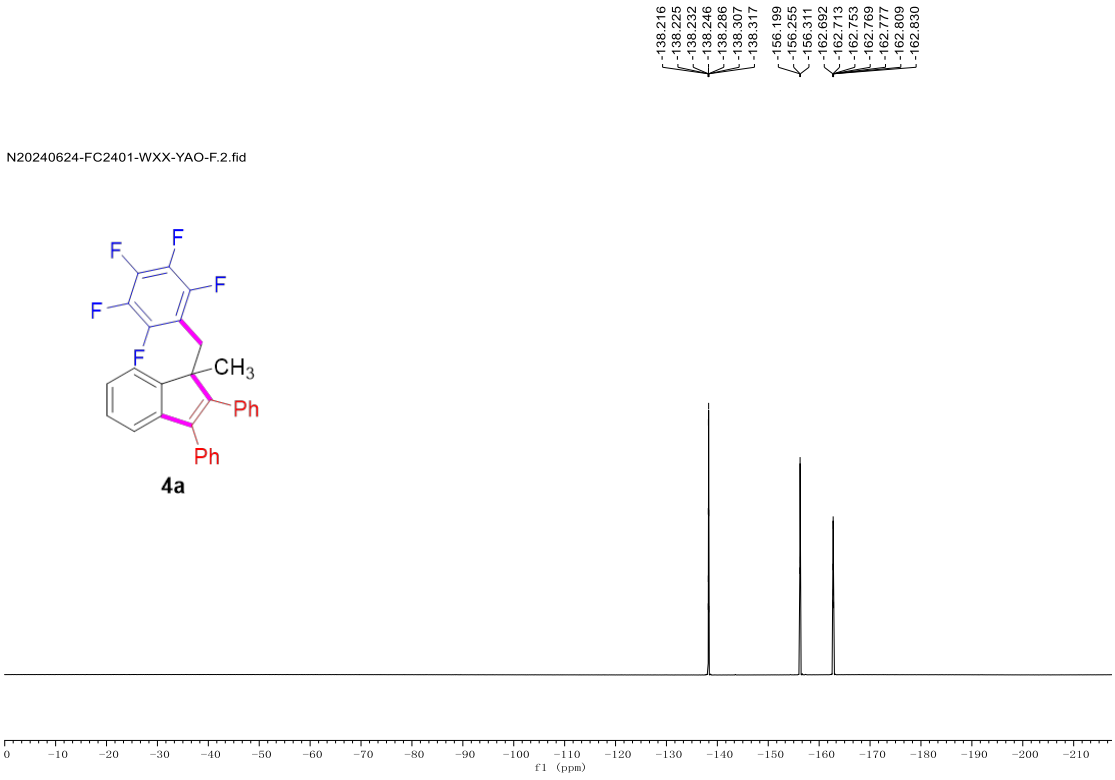
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4a**



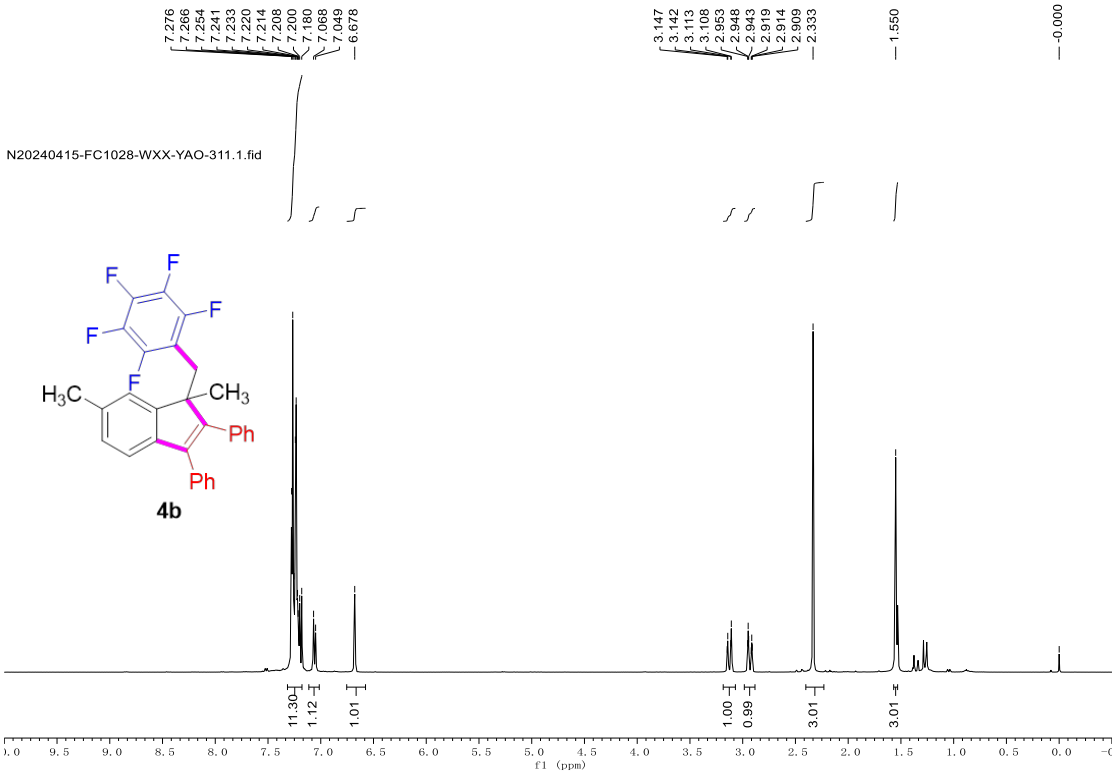
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4a**



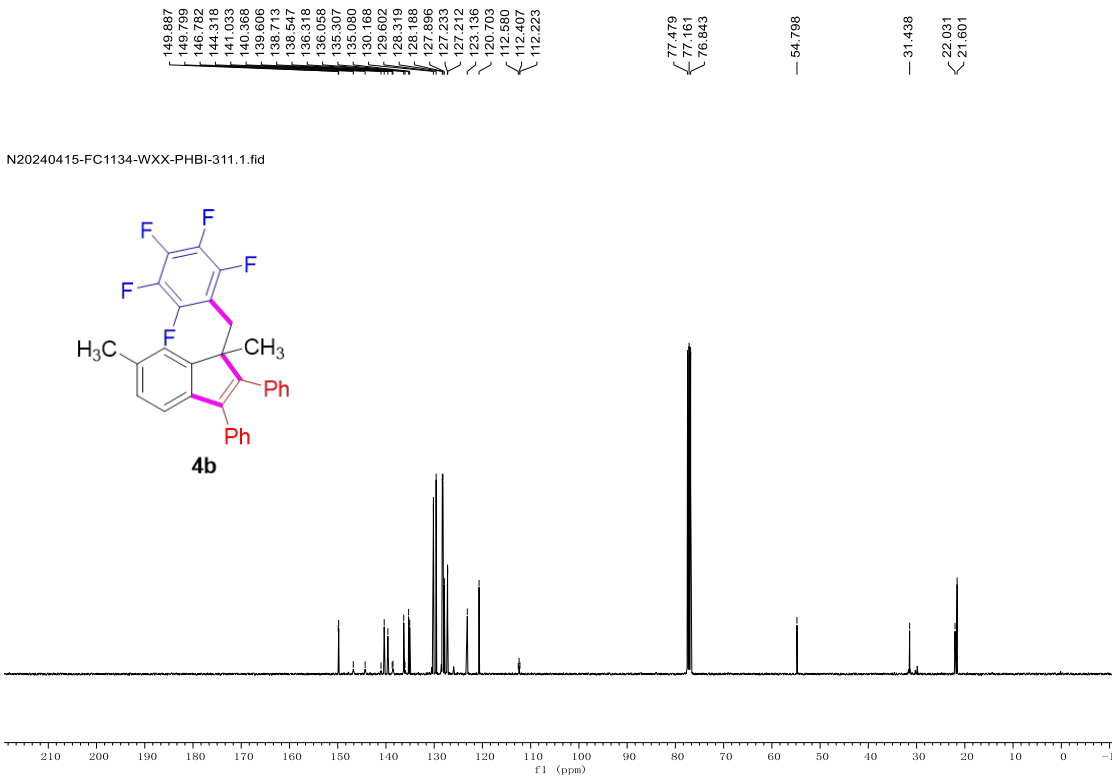
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4a**



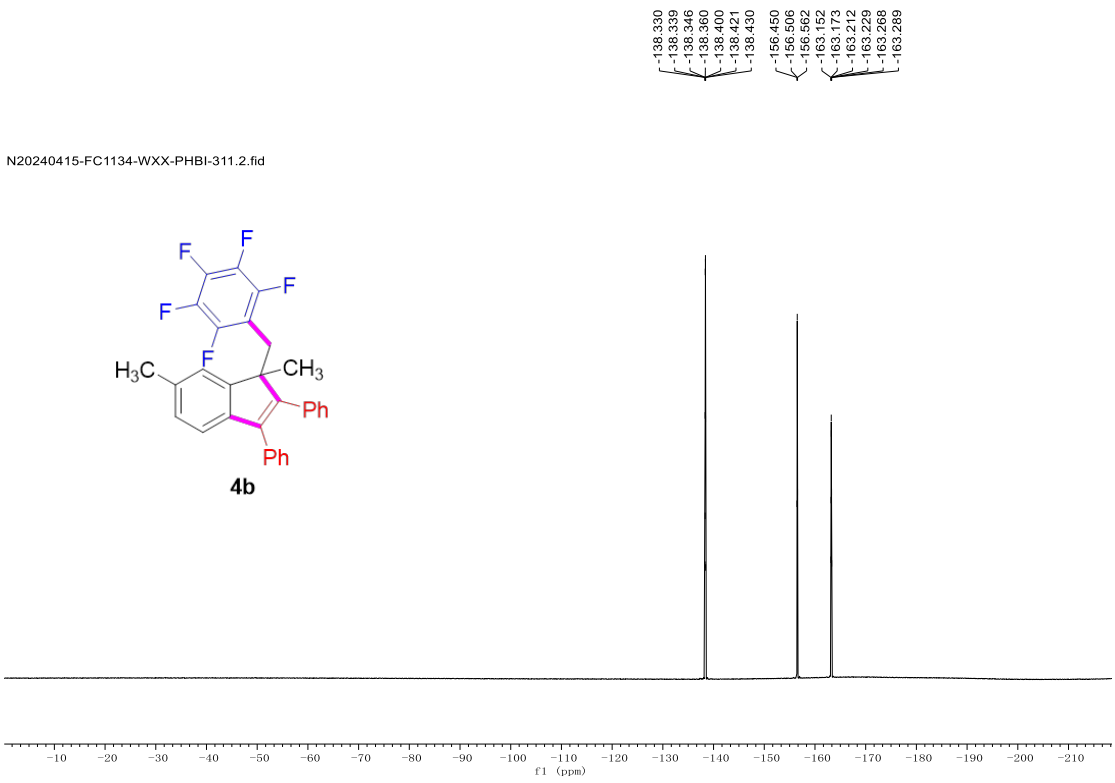
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4b**



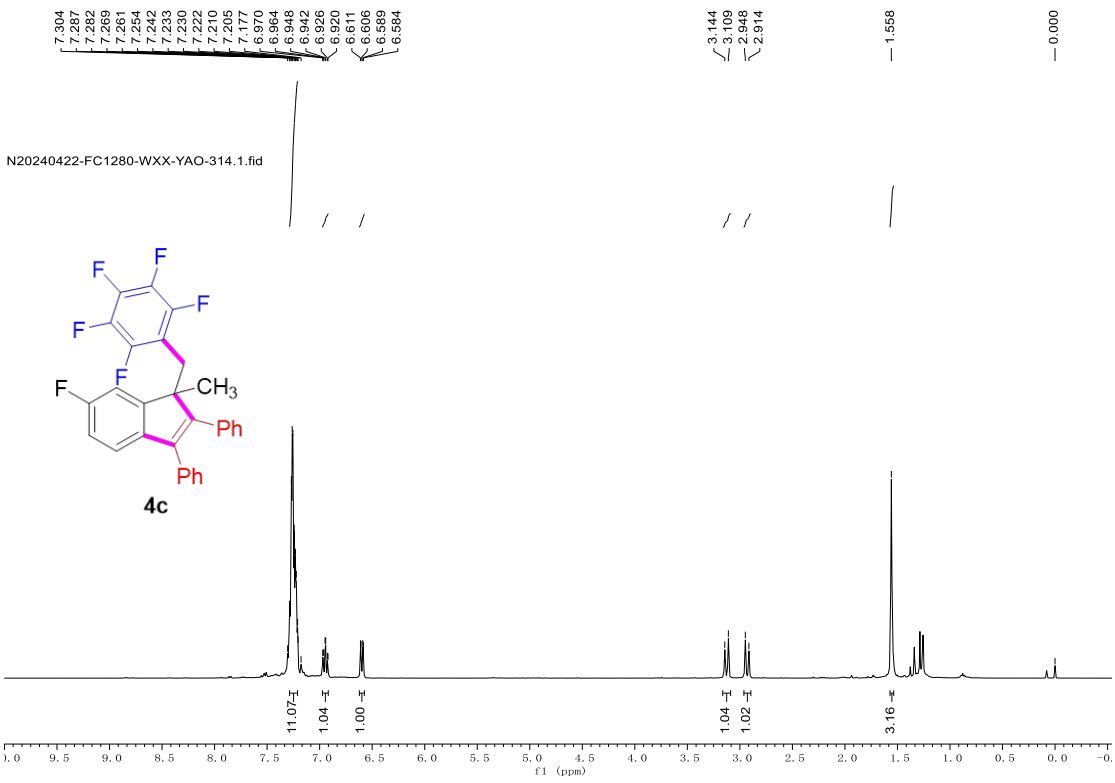
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4b**



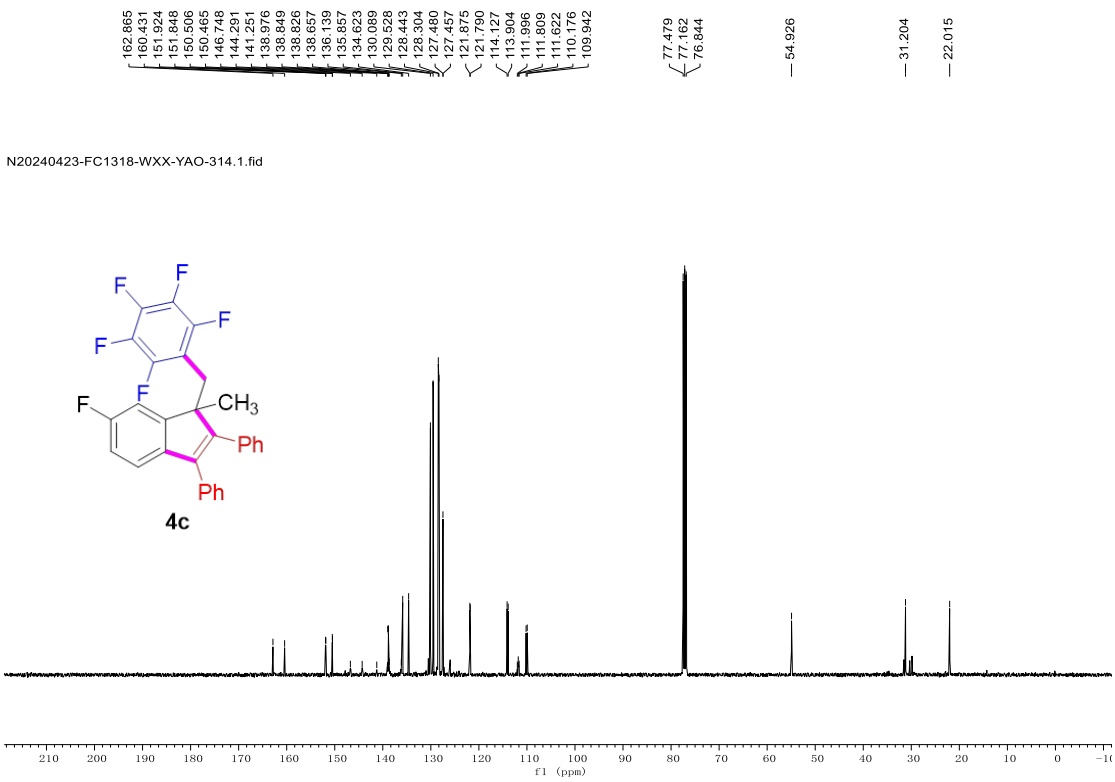
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4b**



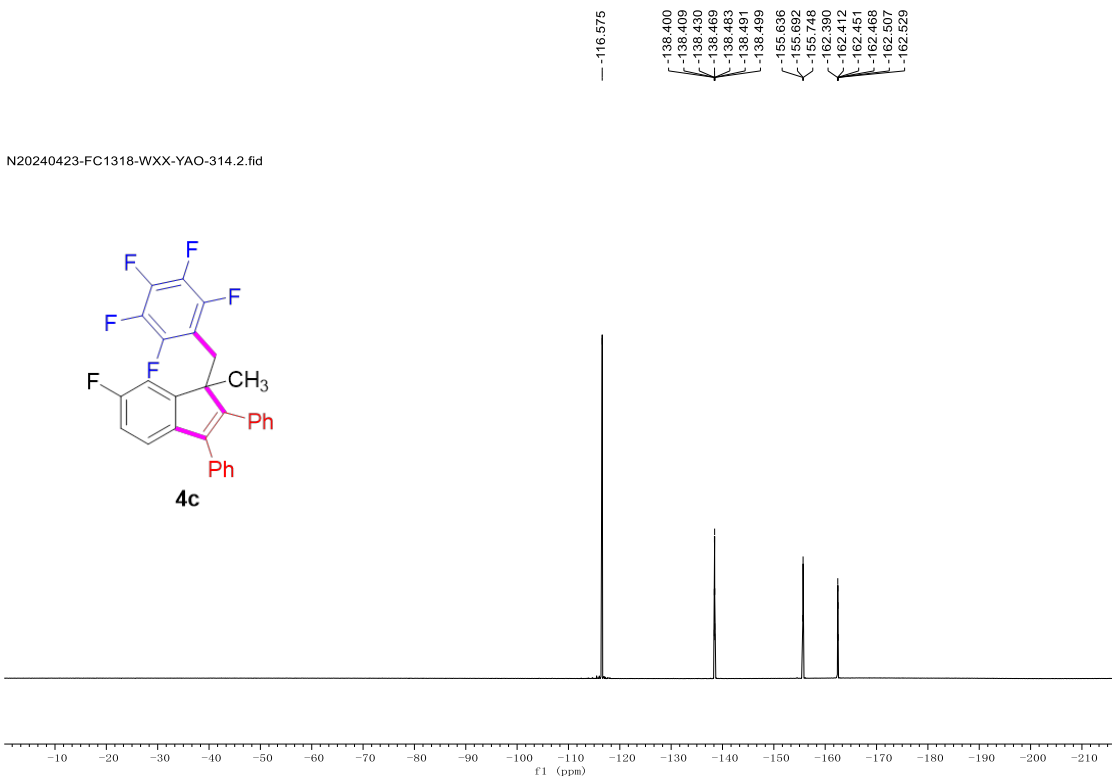
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4c**



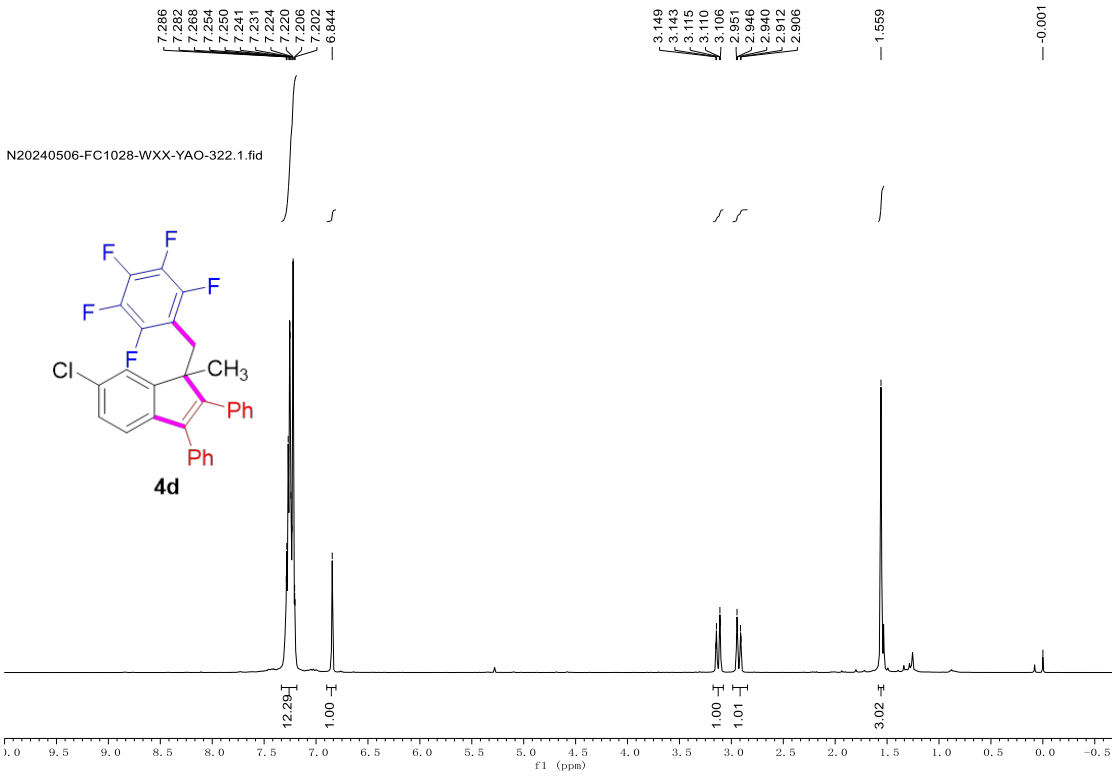
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4c**



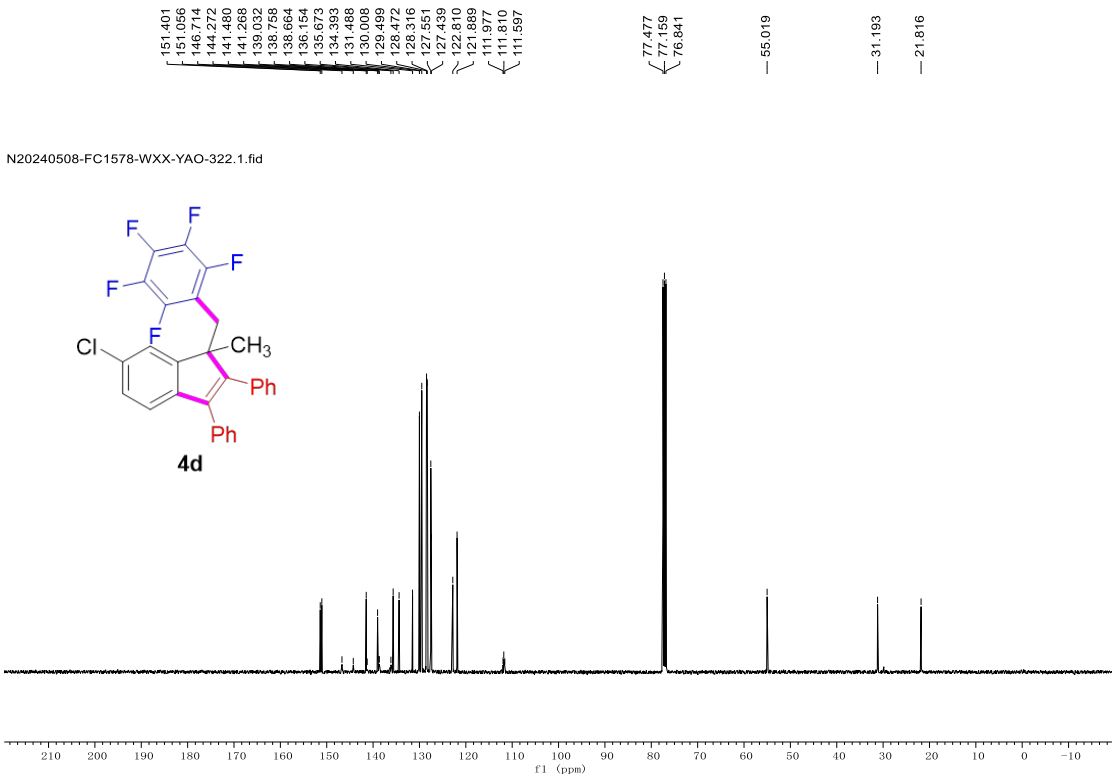
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4c**



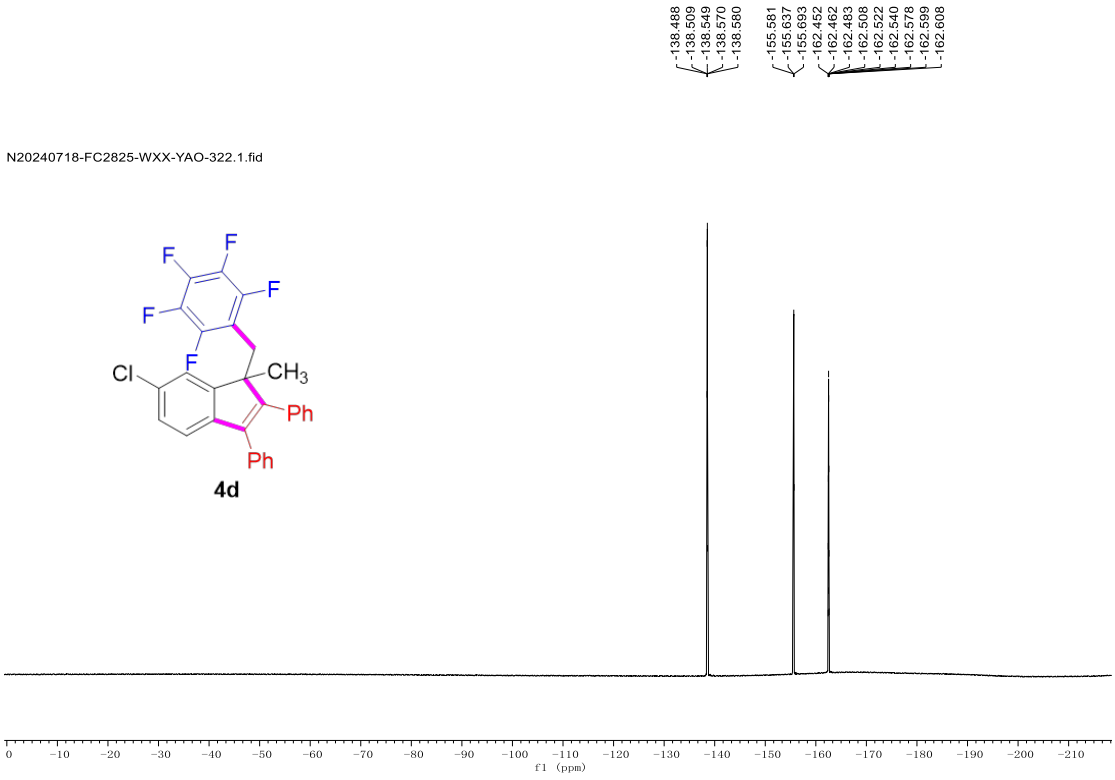
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4d**



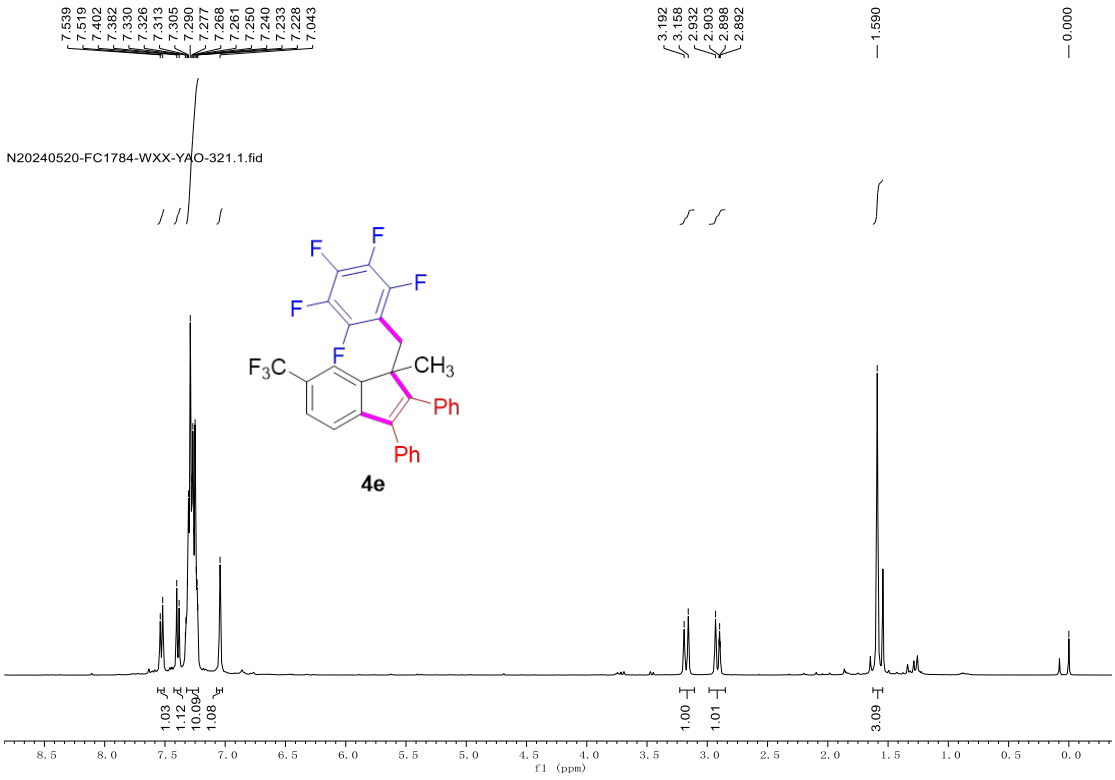
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4d**



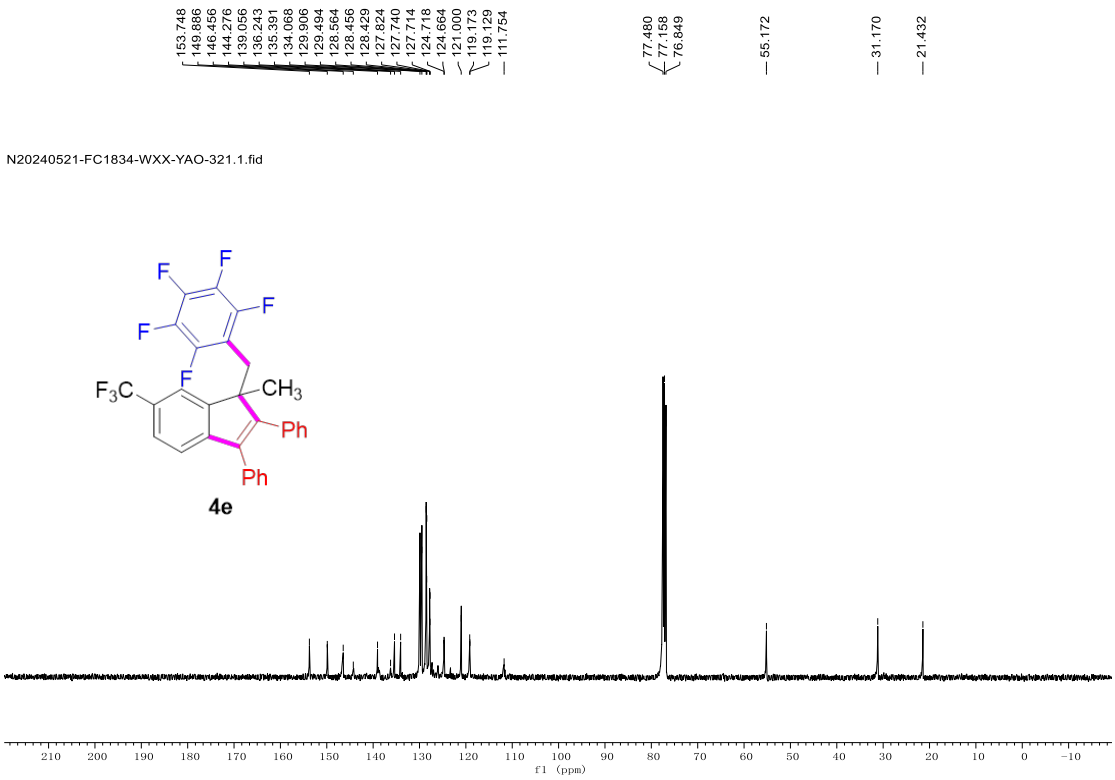
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4d**



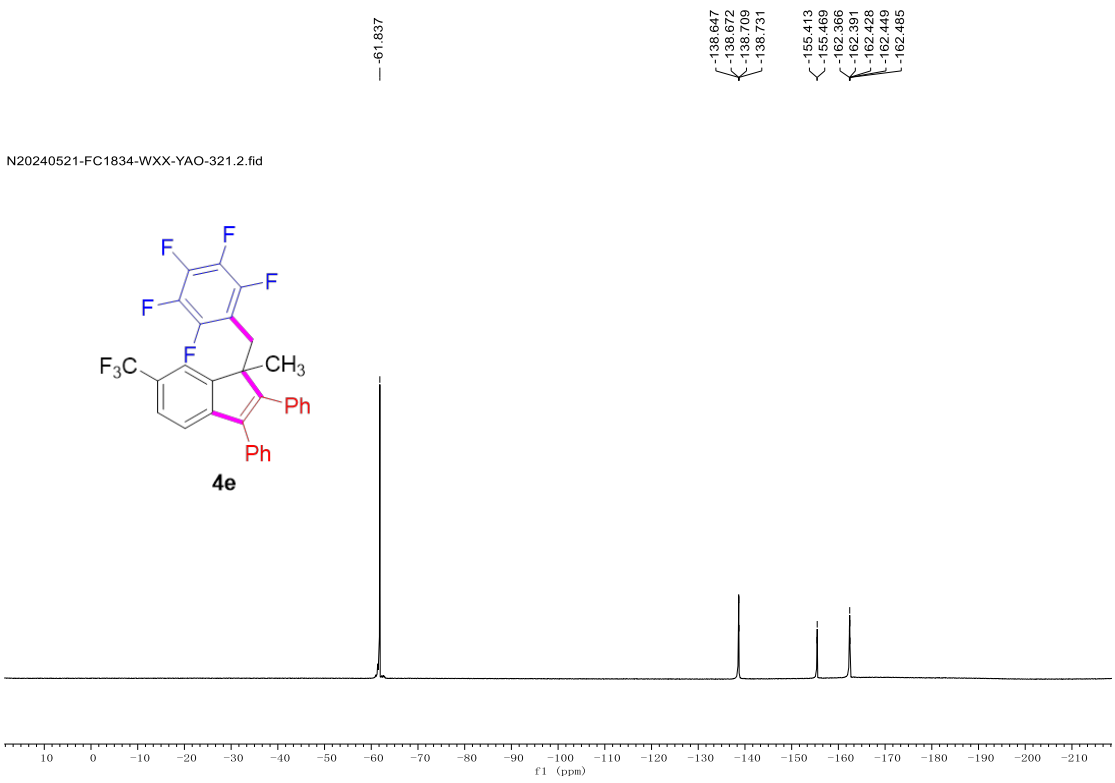
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4e**



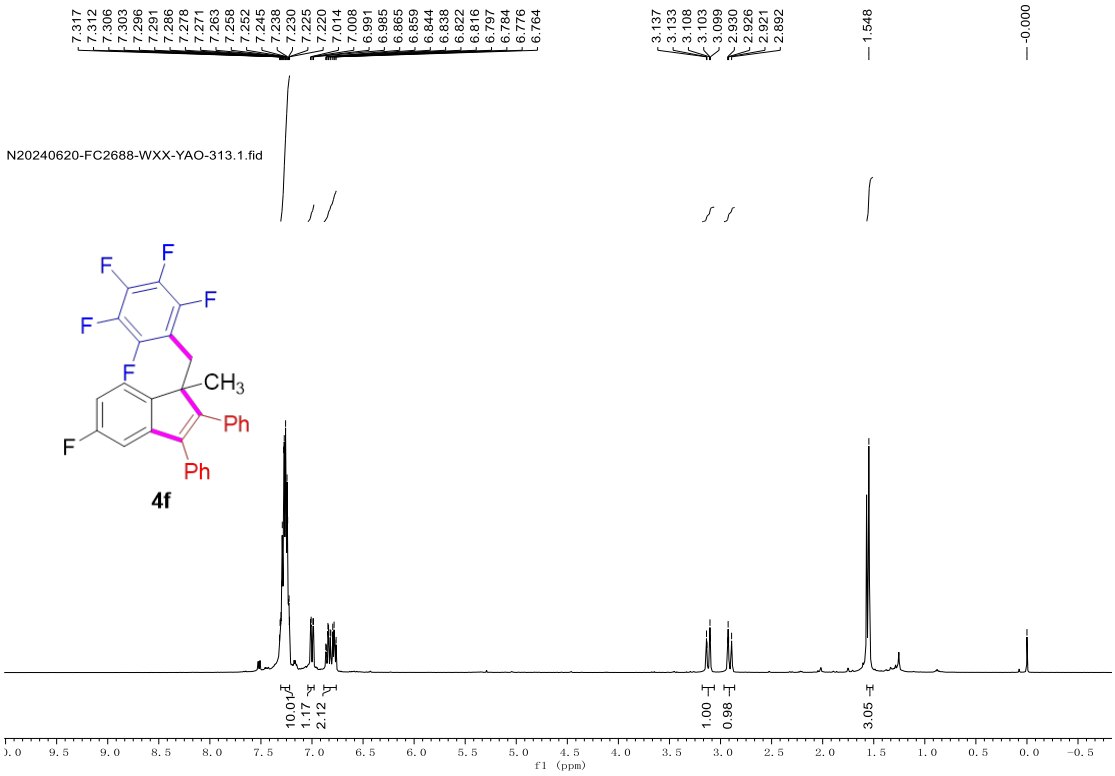
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4e**



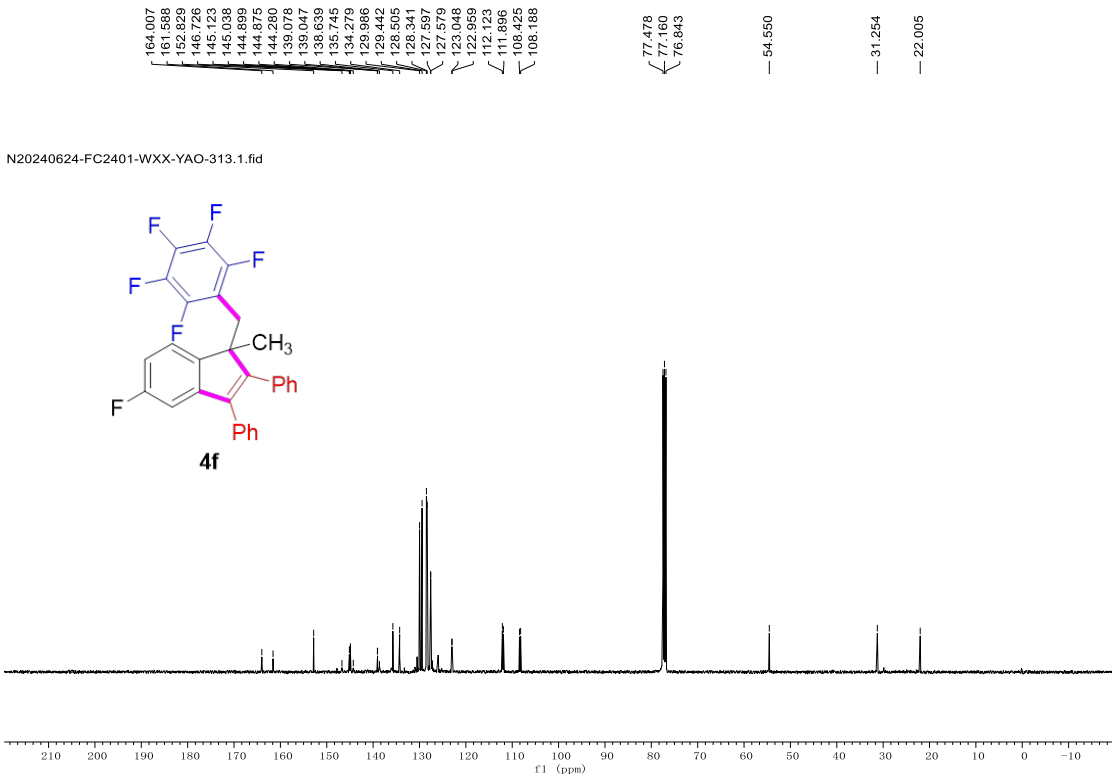
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4e**



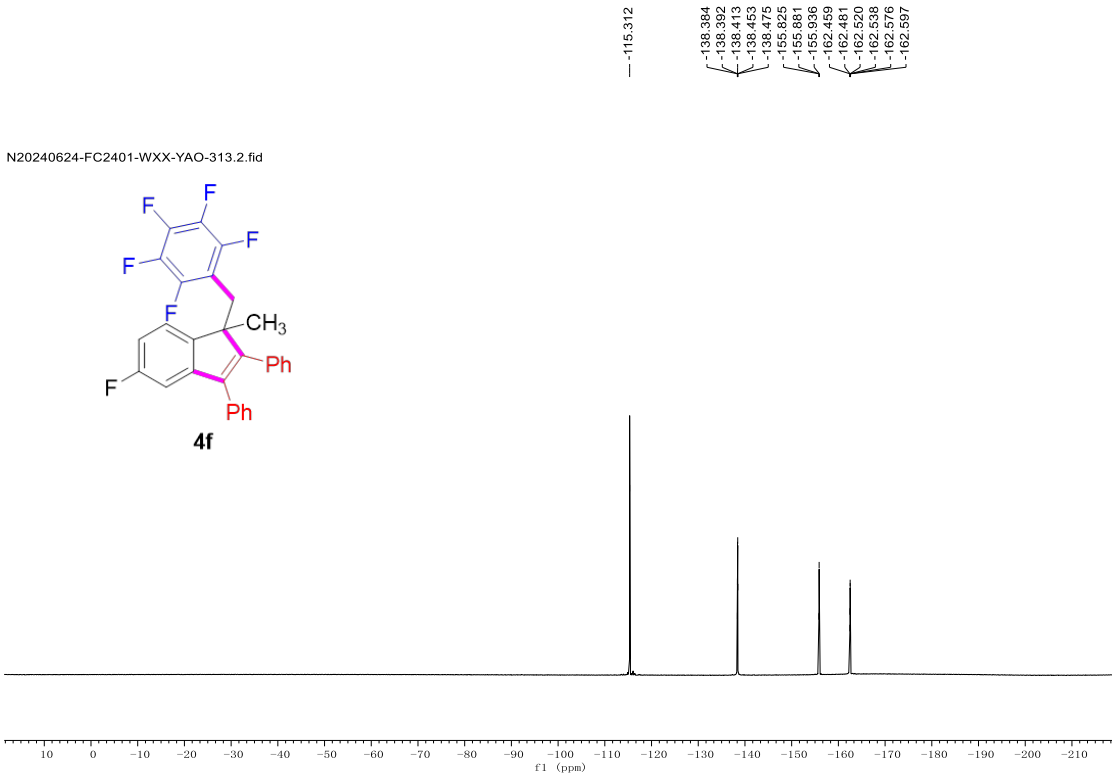
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4f**



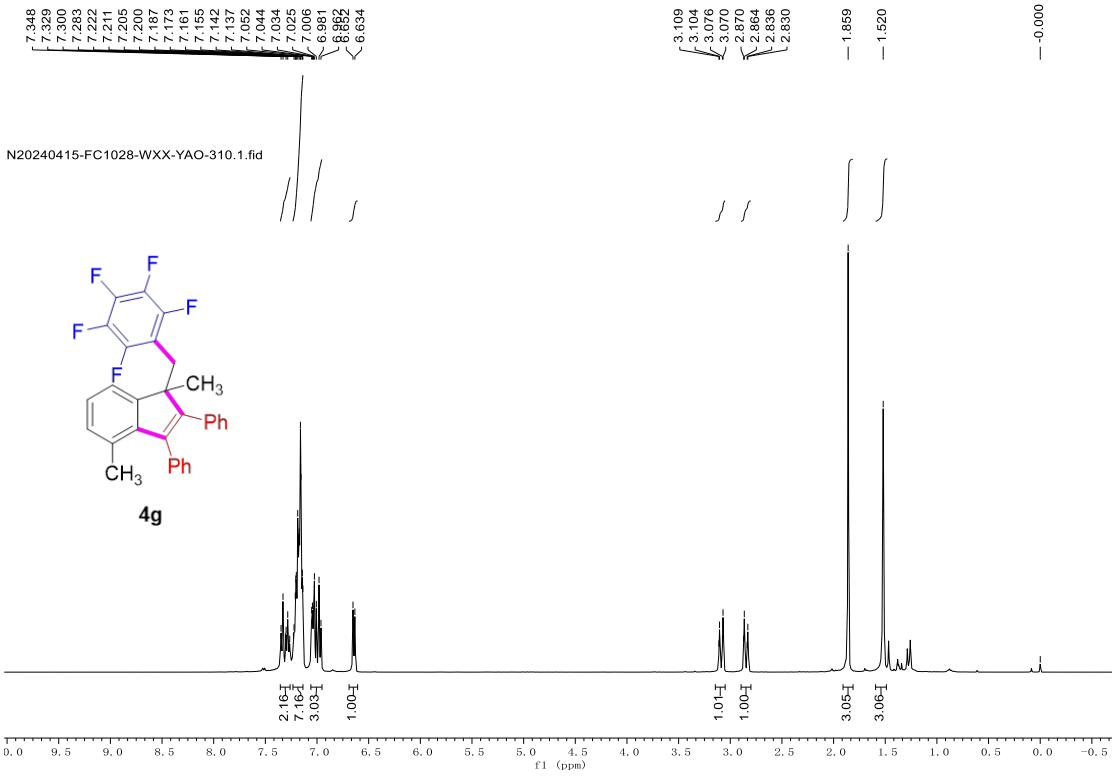
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4f**



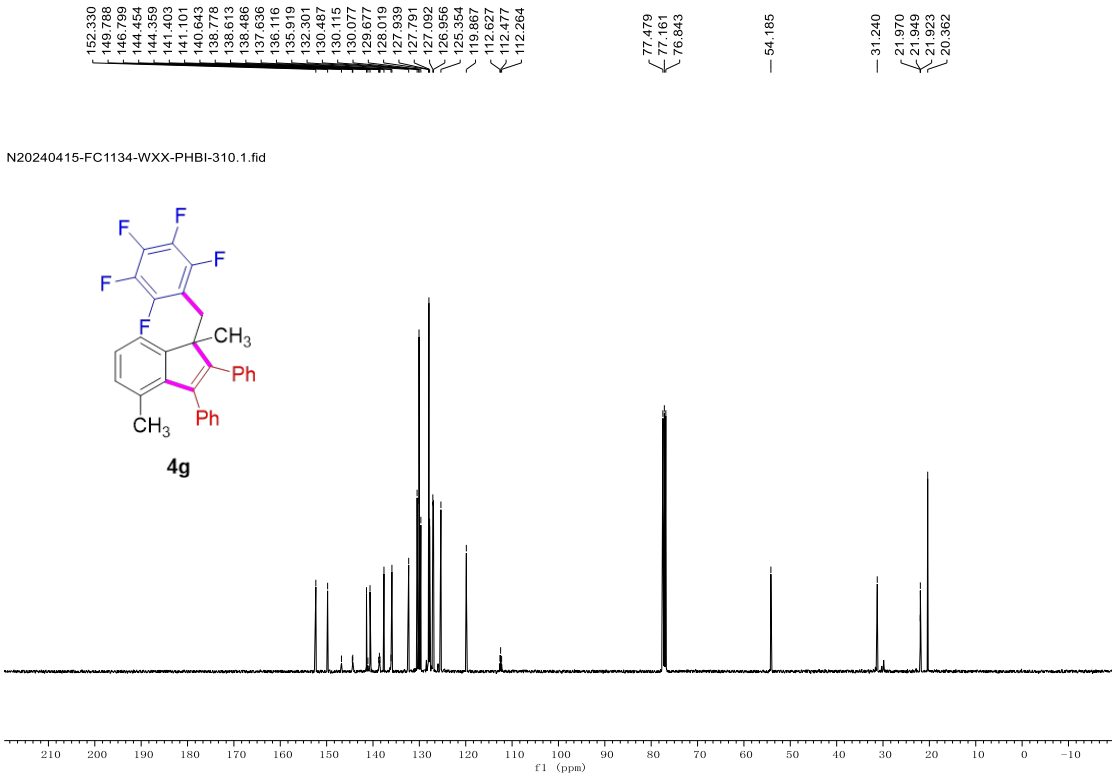
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4f**



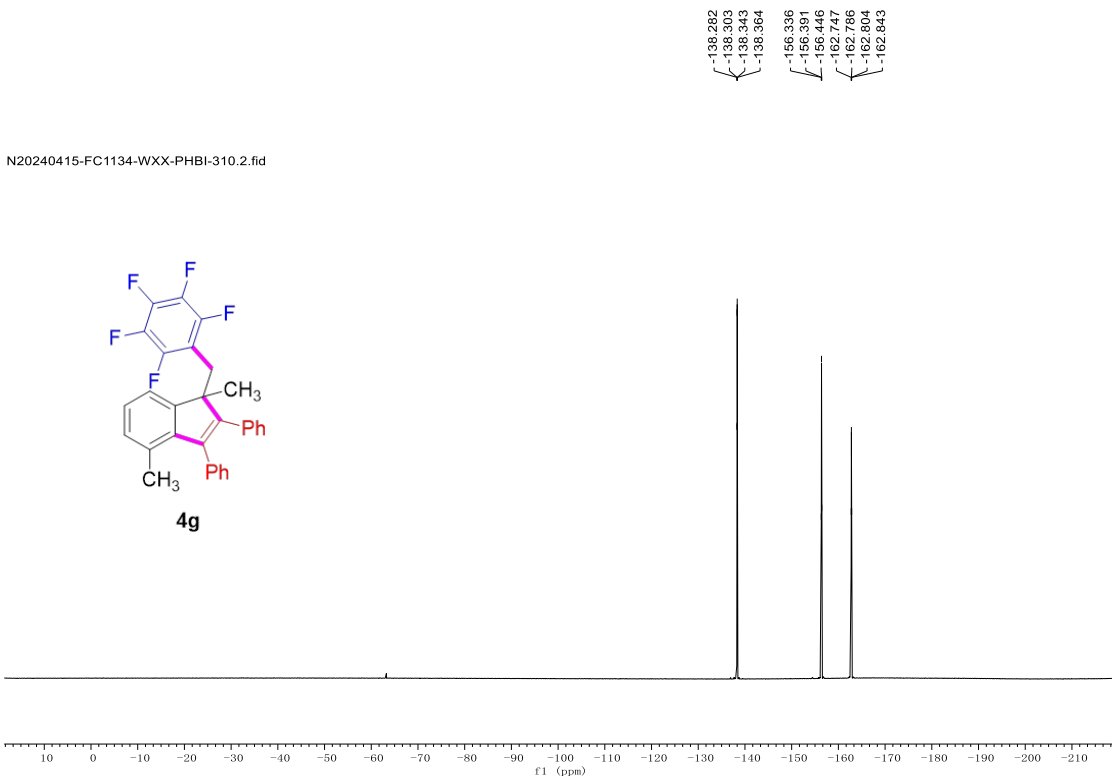
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4g**



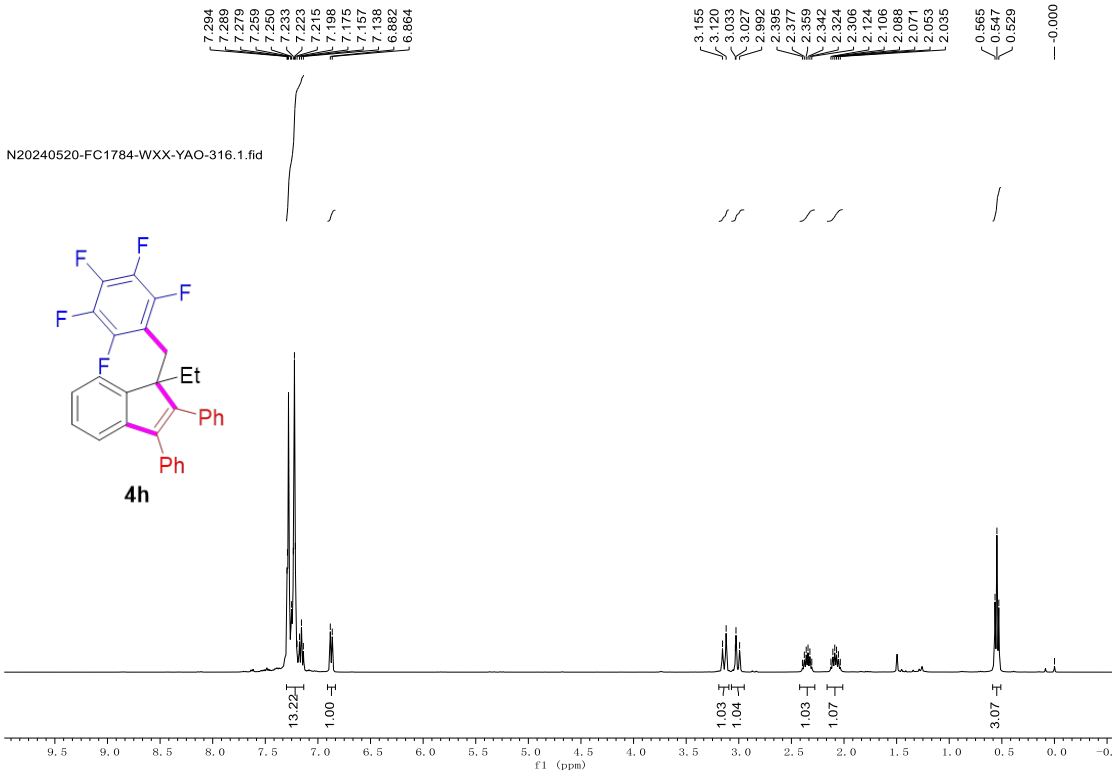
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4g**



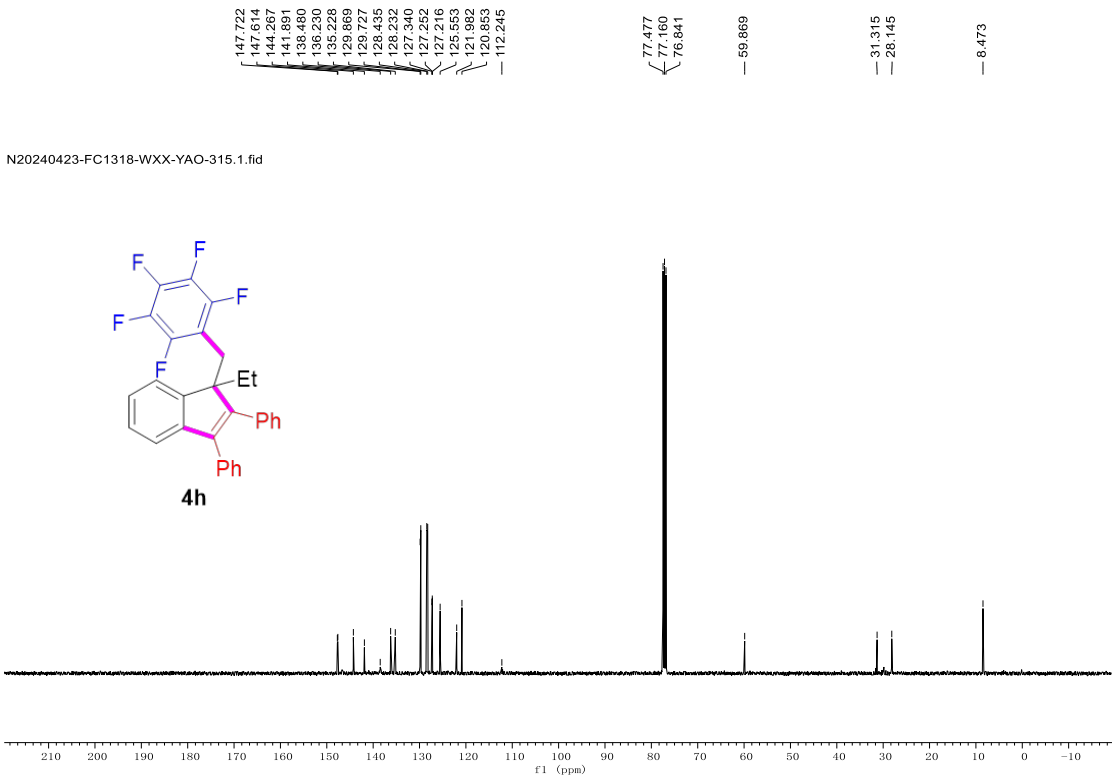
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4g**



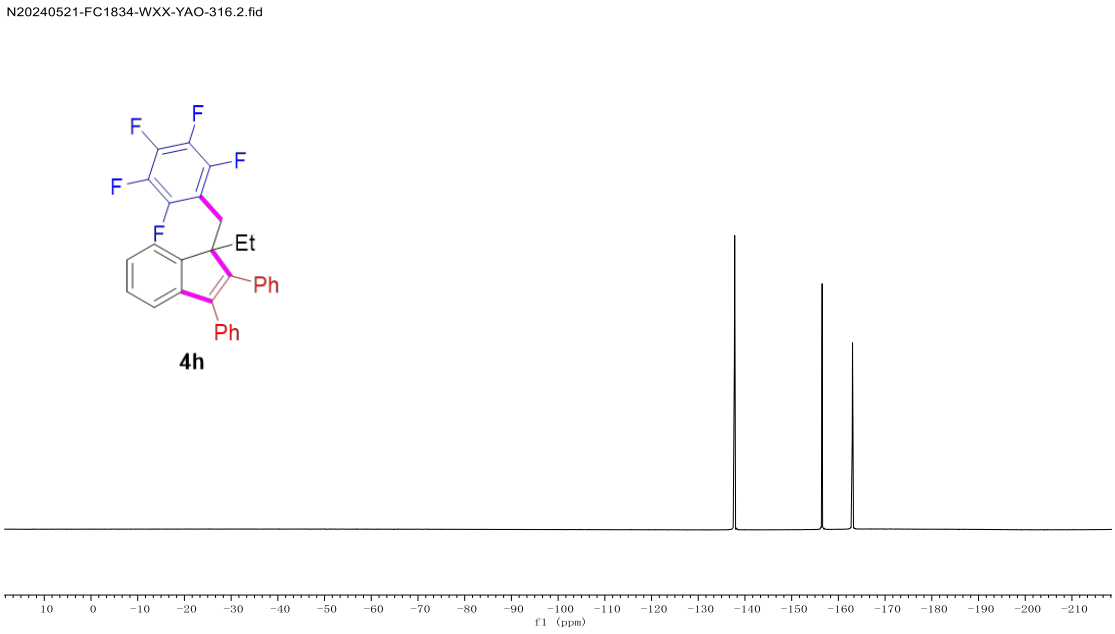
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4h**



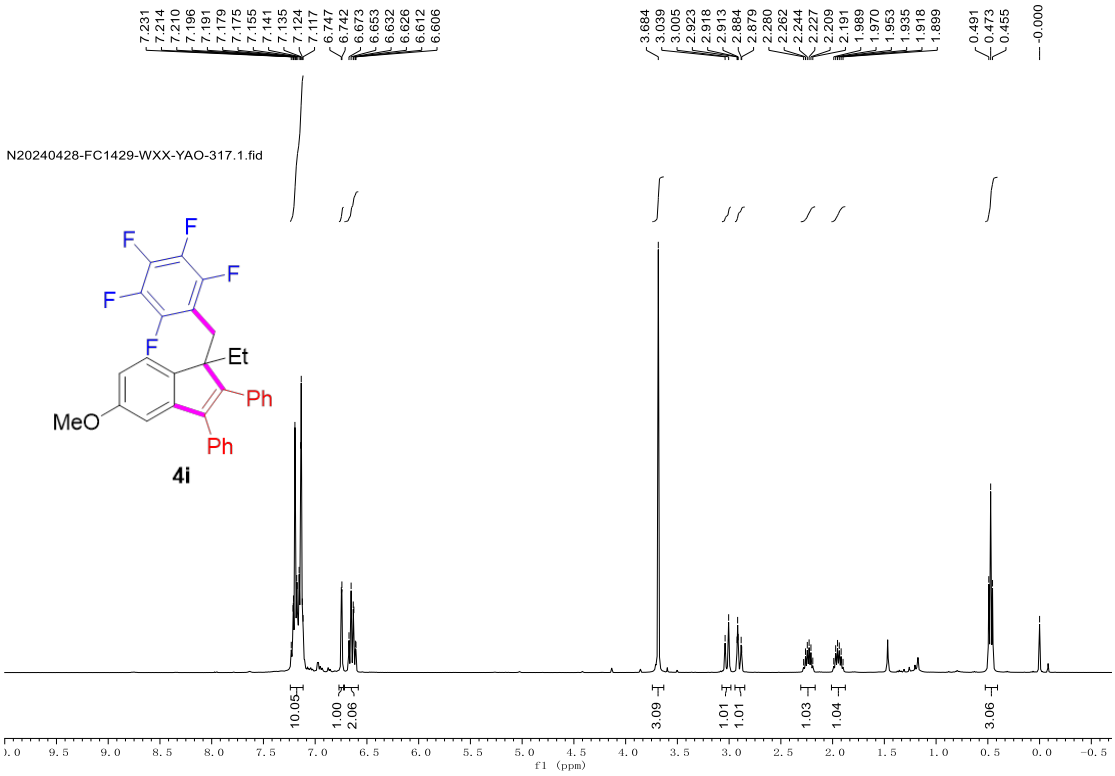
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4h**



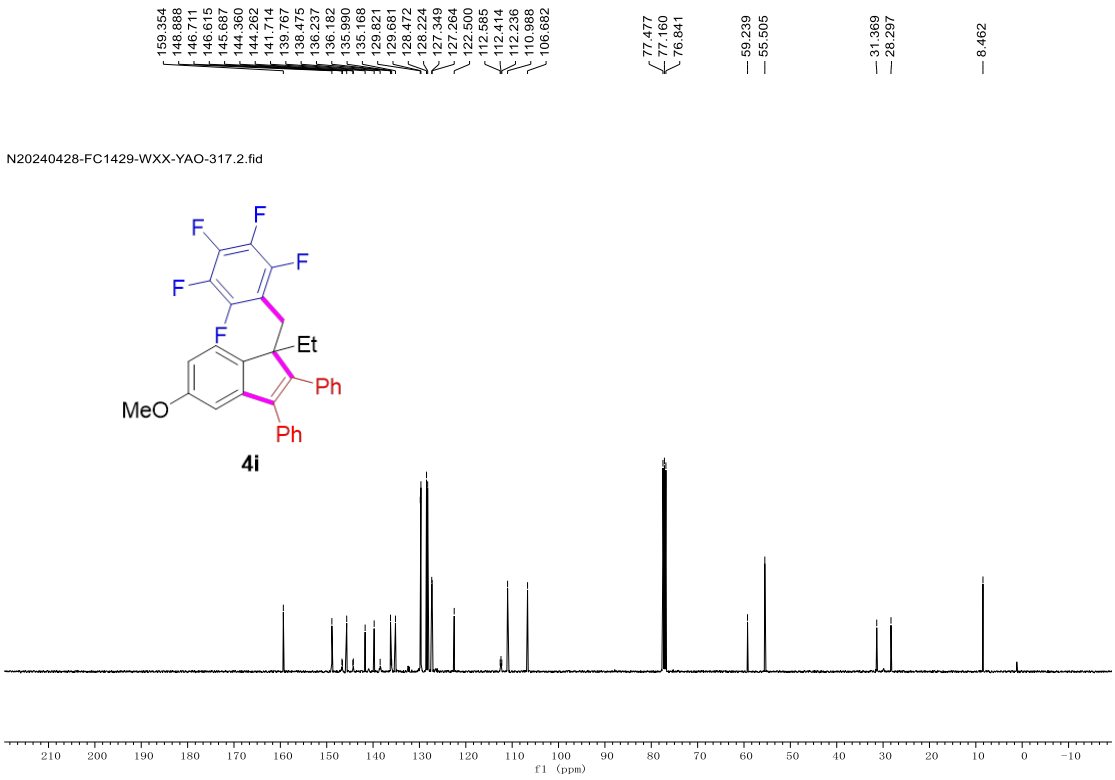
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4h**



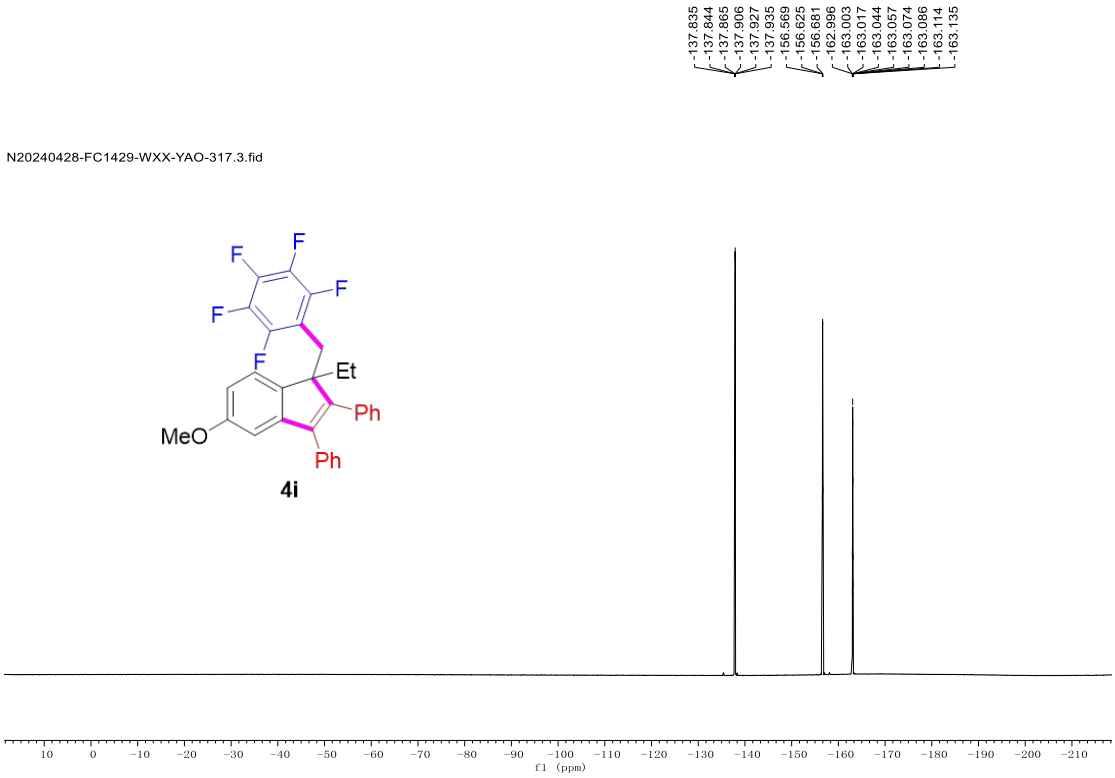
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4i**



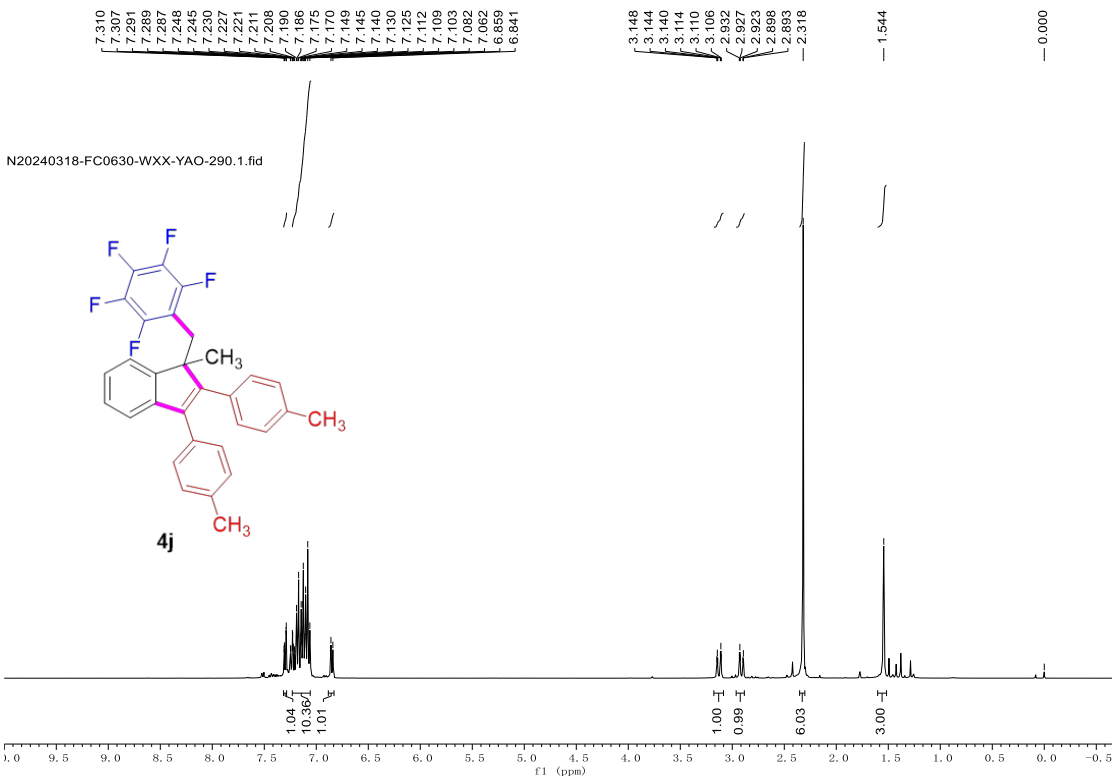
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4i**



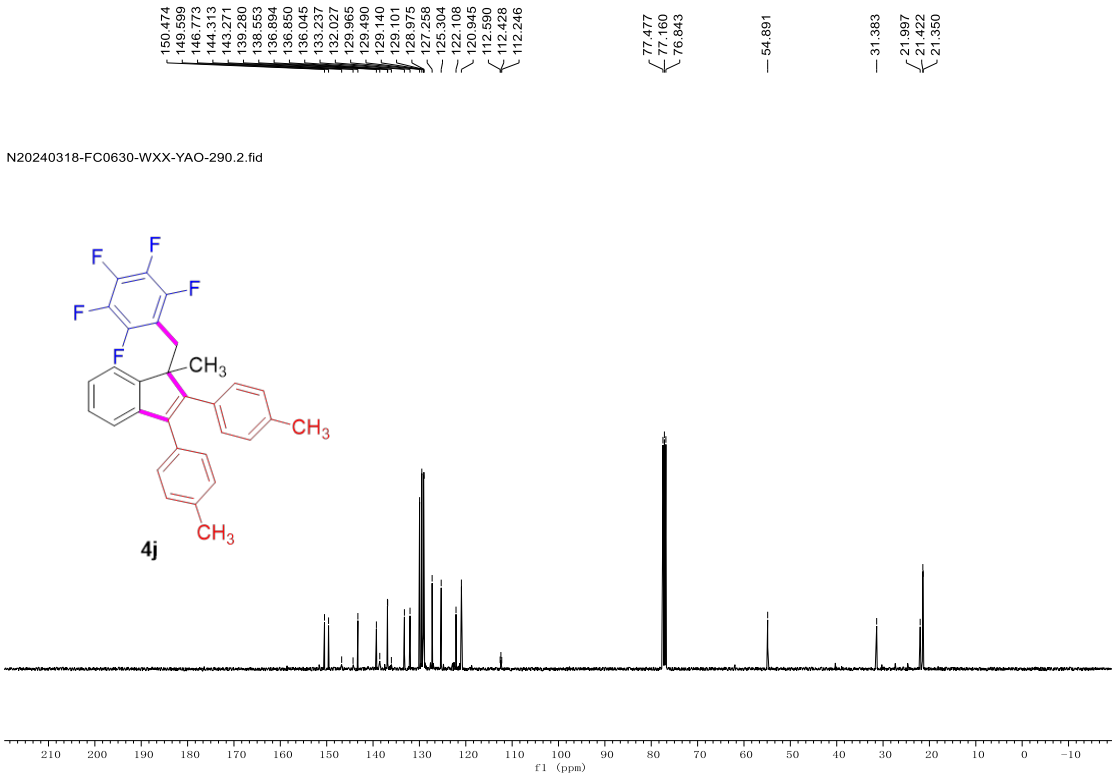
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4i**



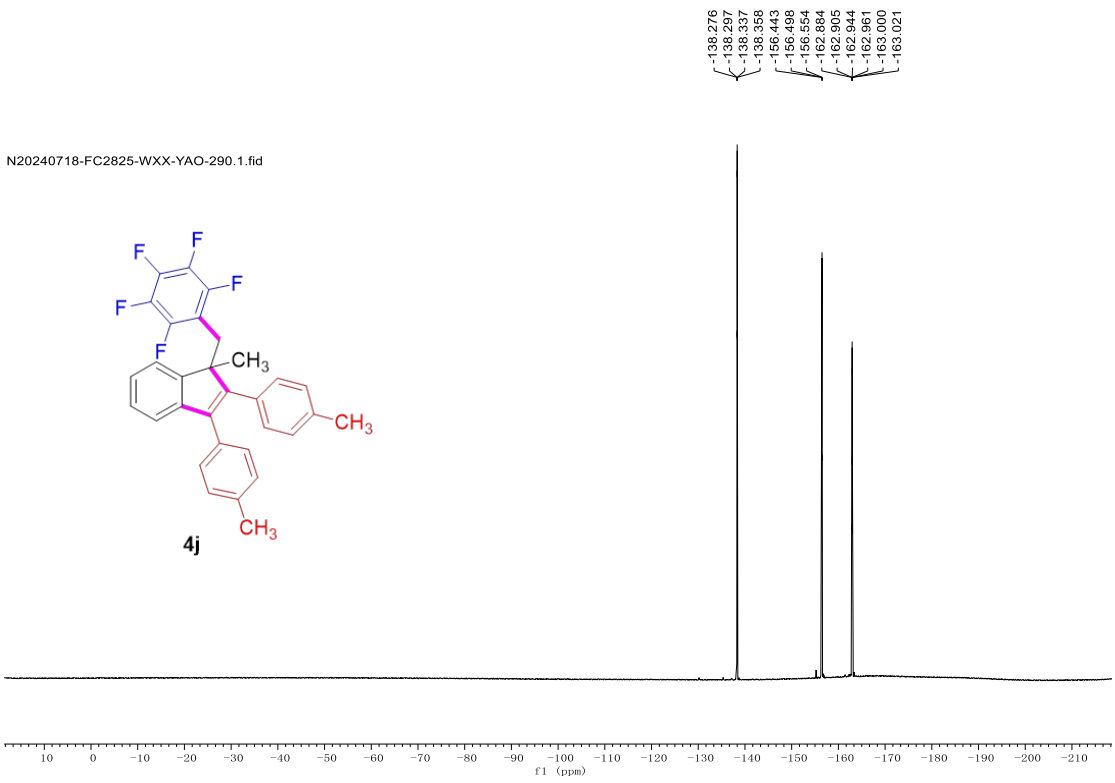
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4j**



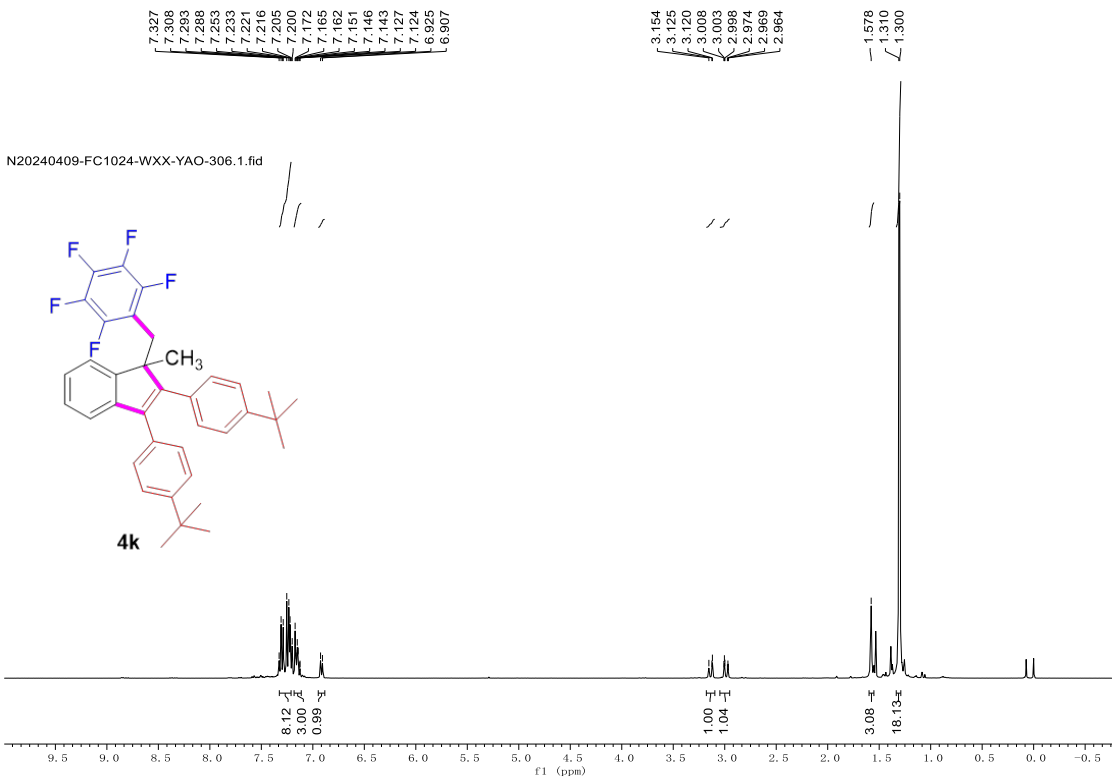
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4j**



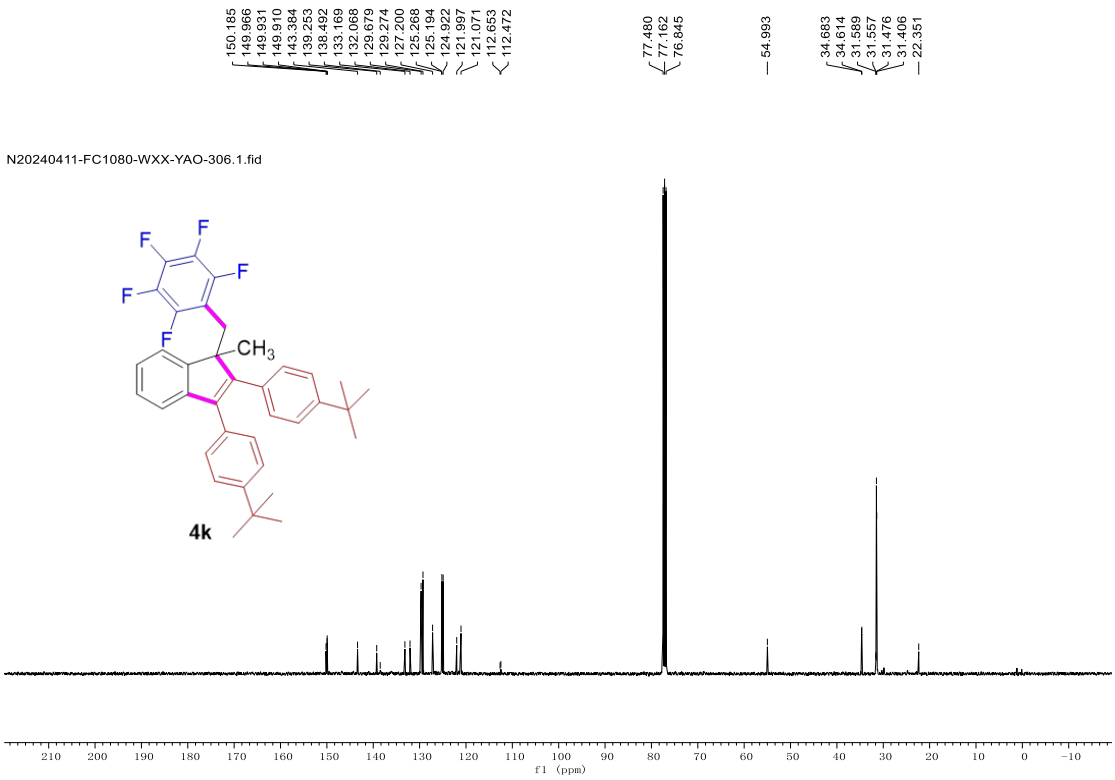
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4j**



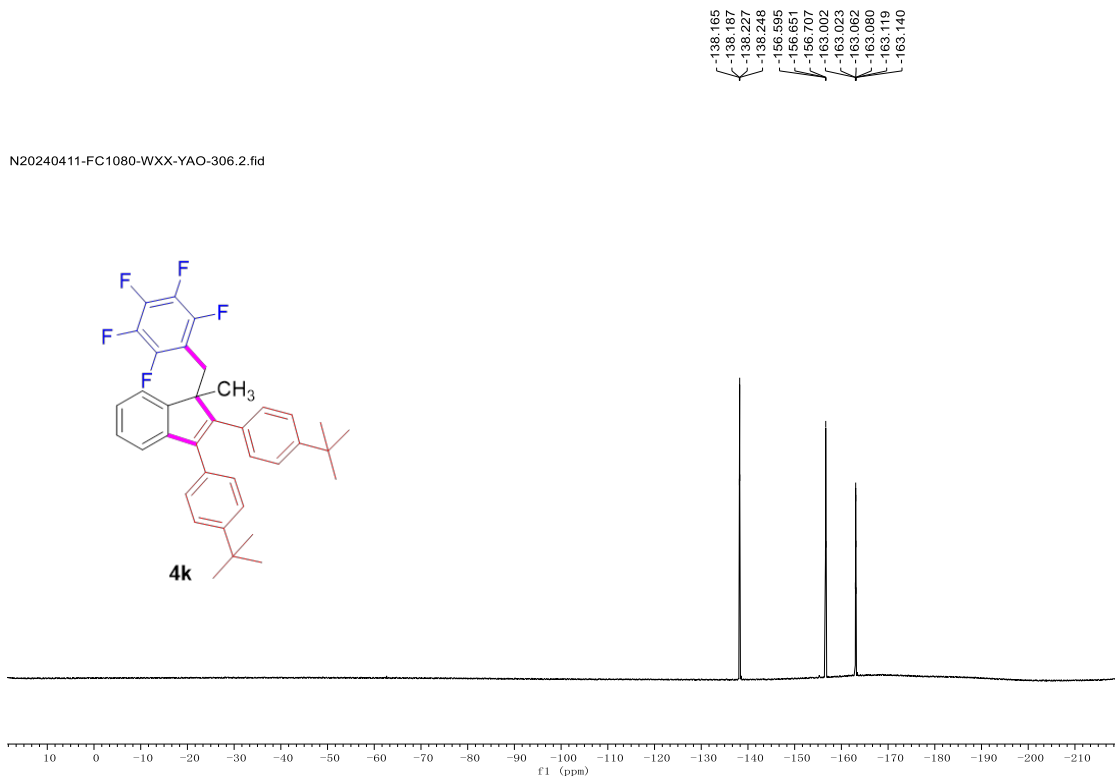
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4k**



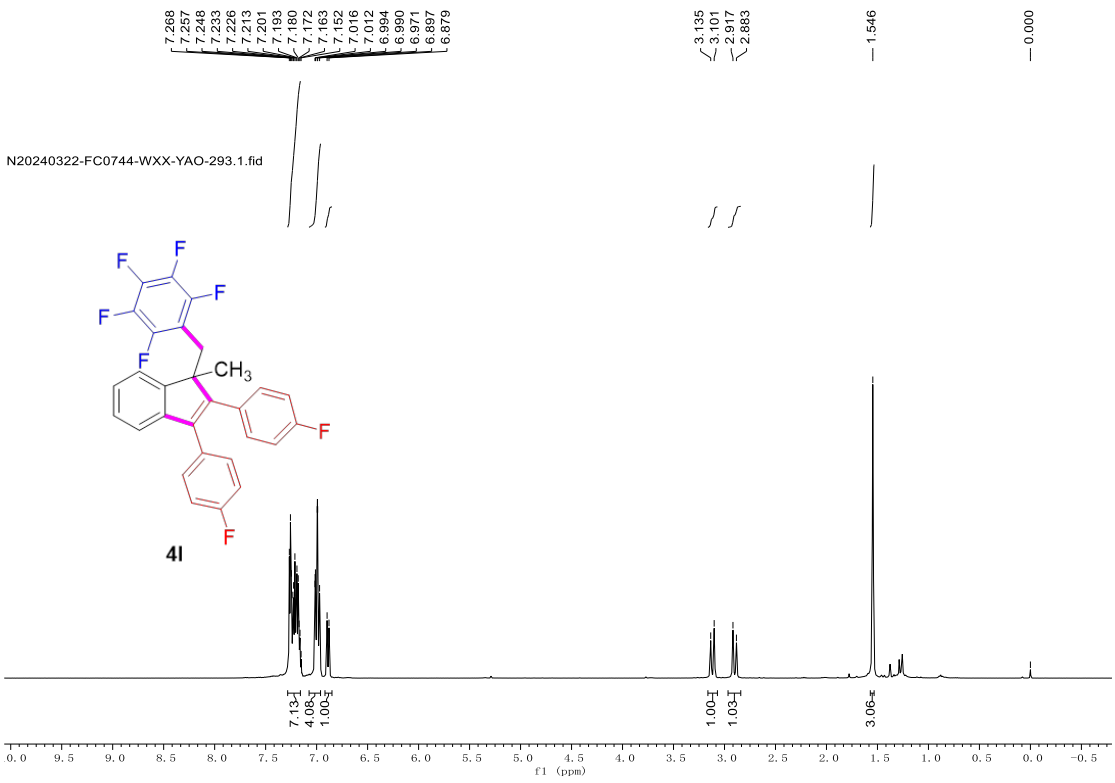
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4k**



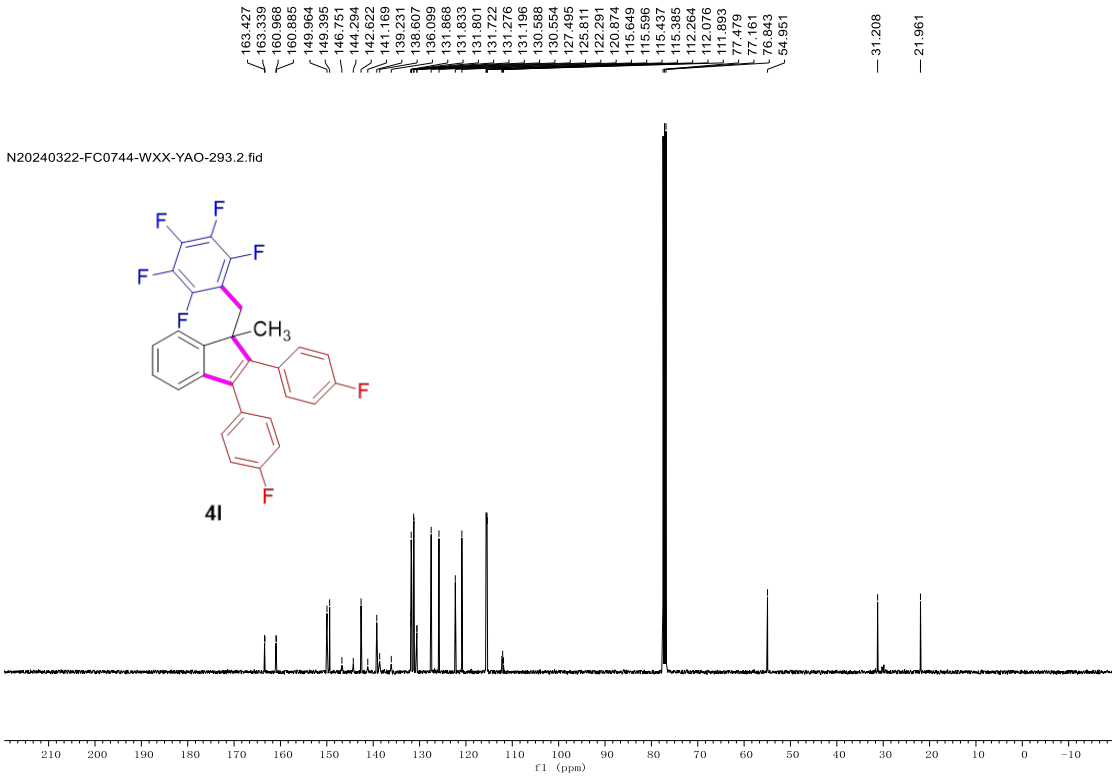
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4k**



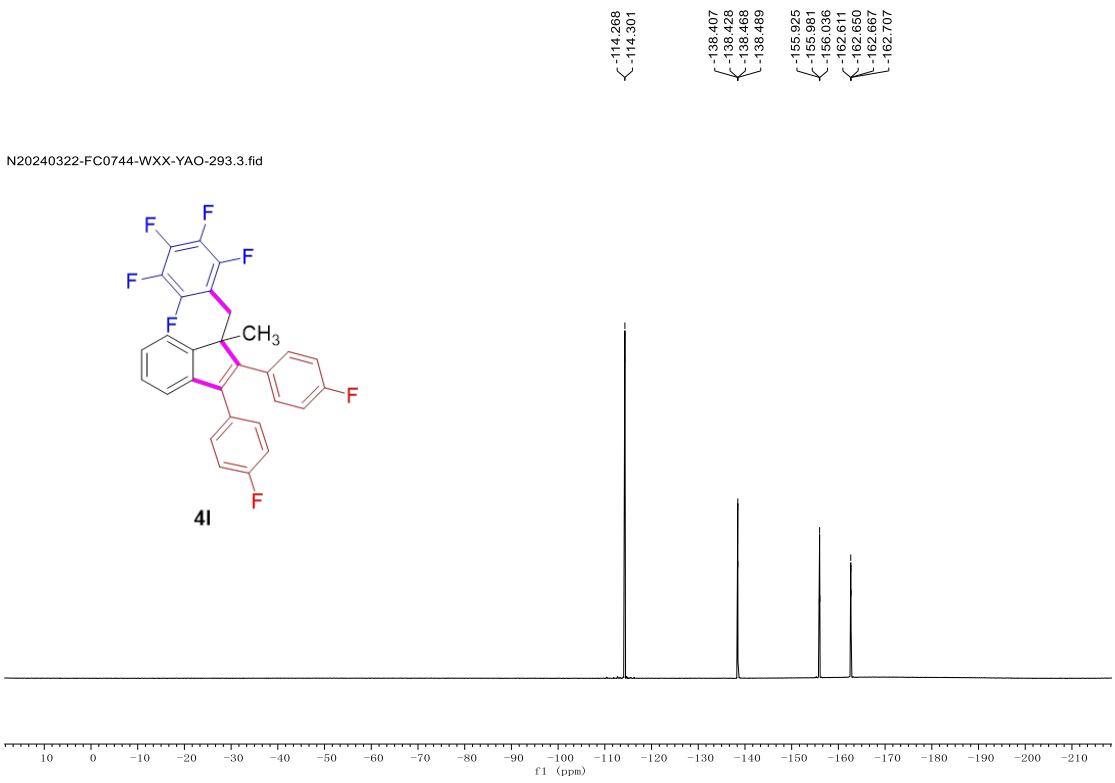
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4l**



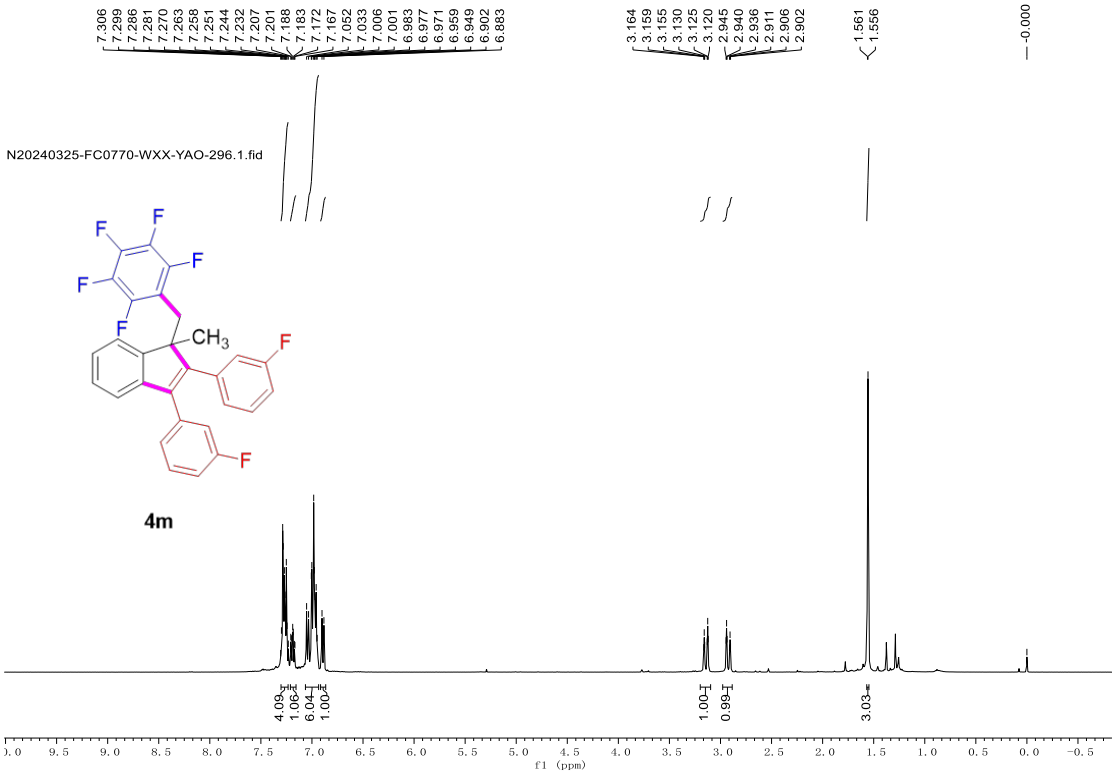
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4l**



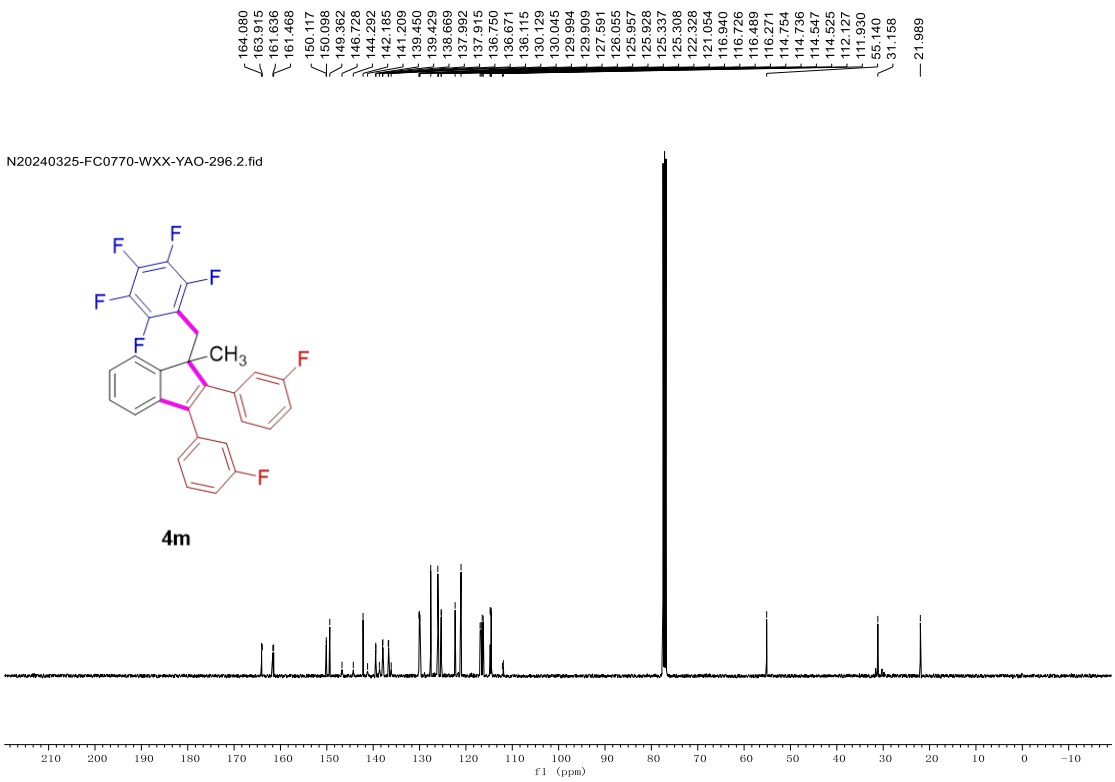
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4l**



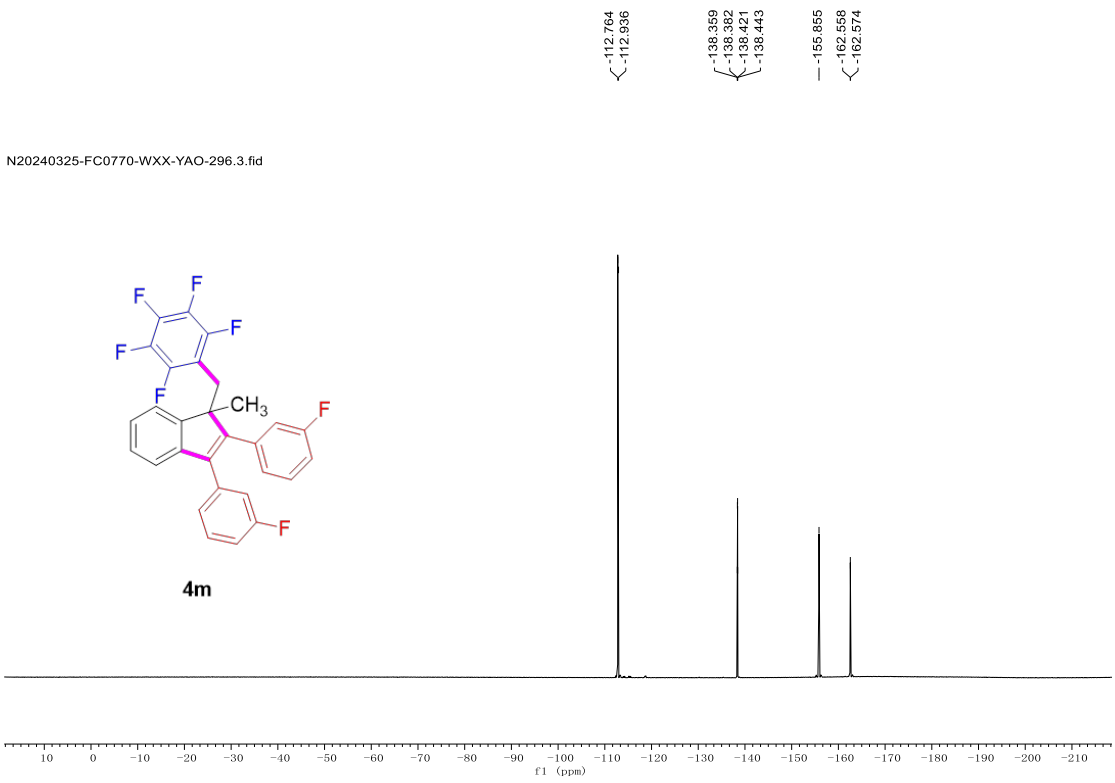
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4m**



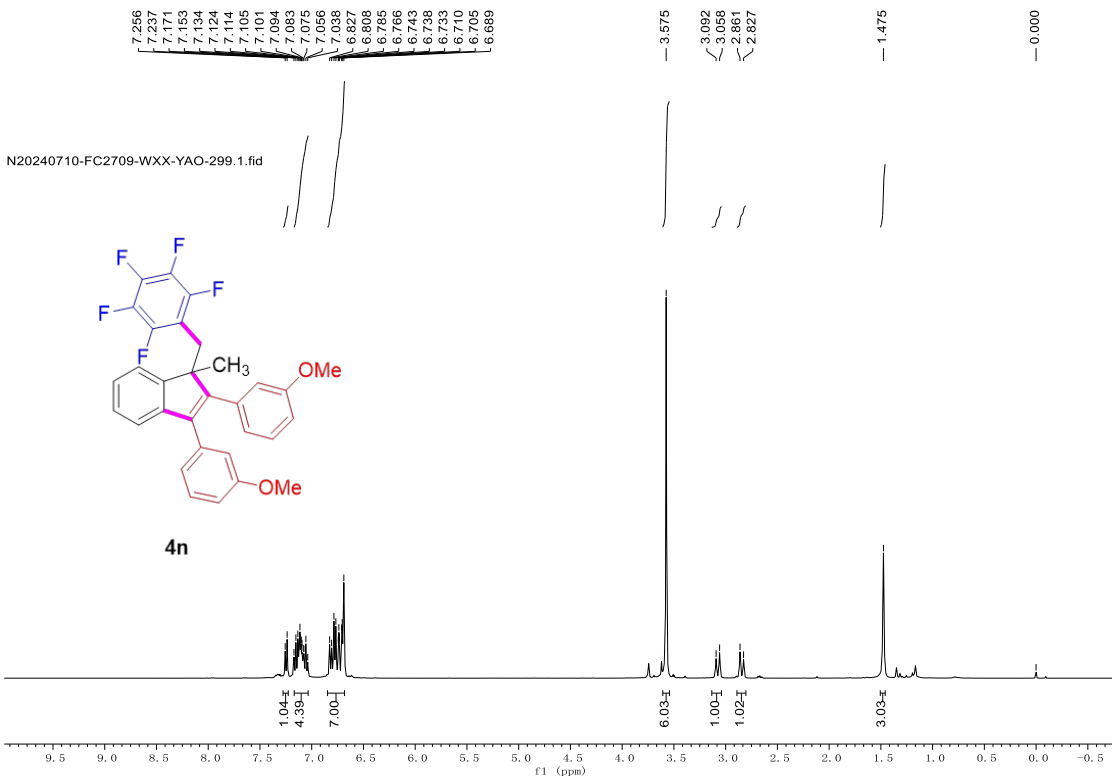
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4m**



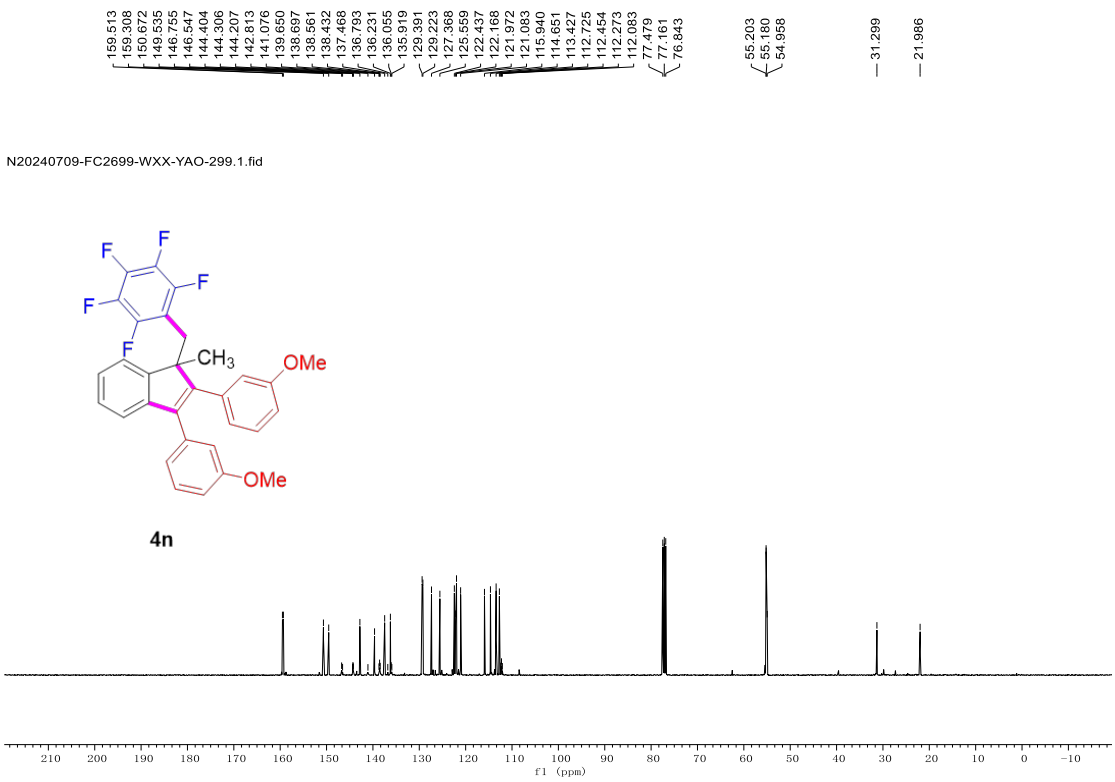
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4m**



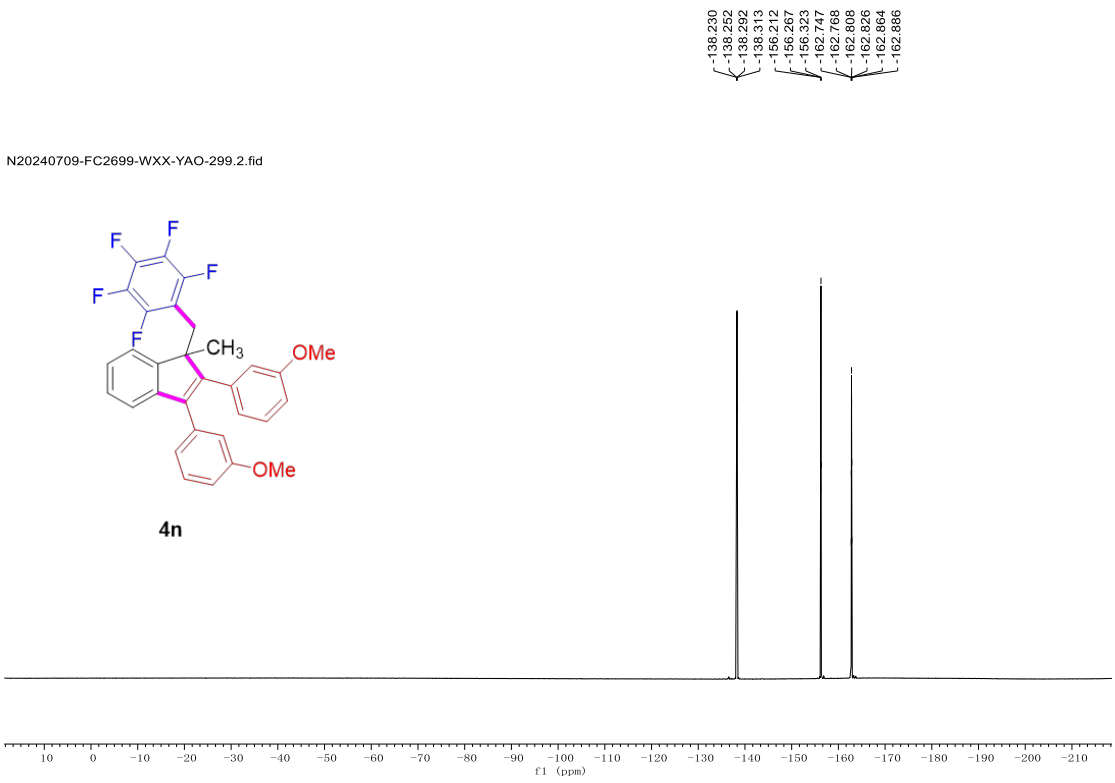
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4n**



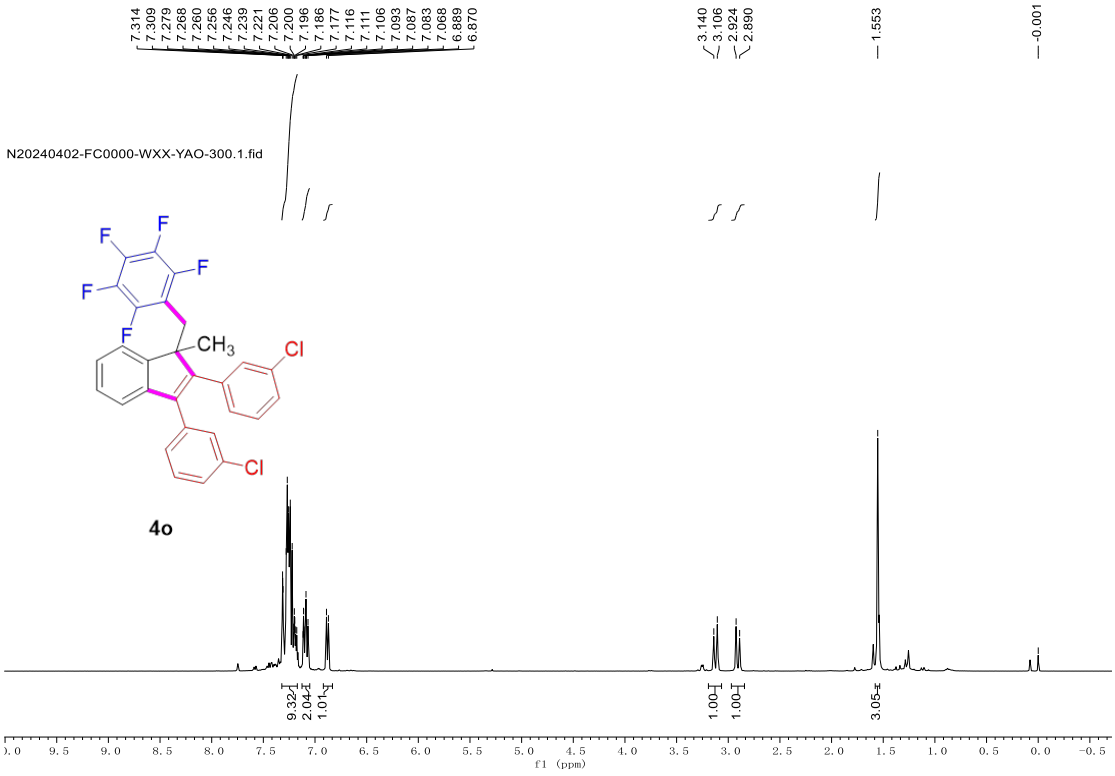
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4n**



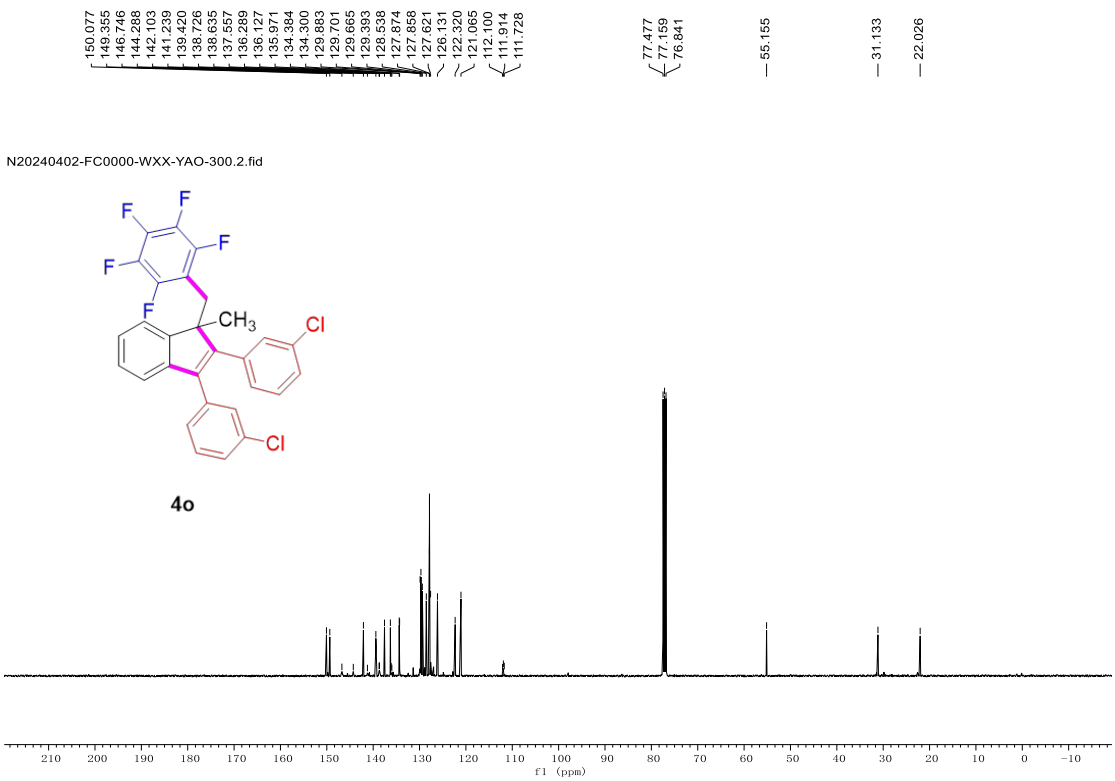
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4n**



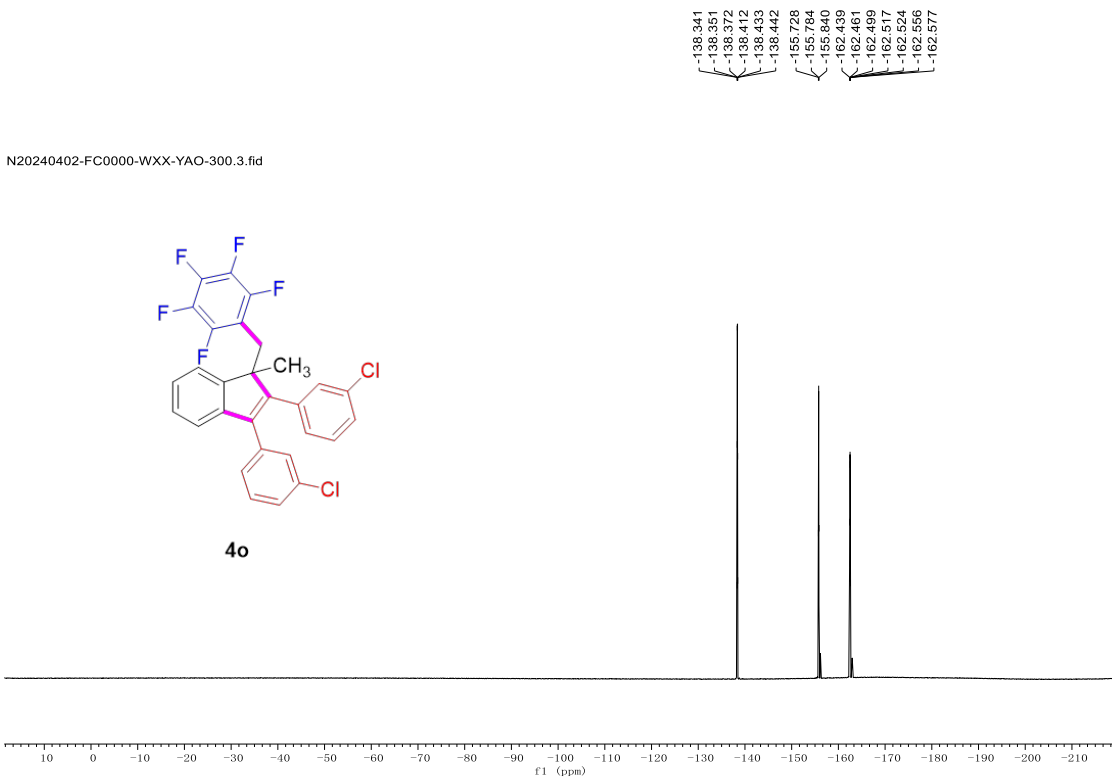
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4o**



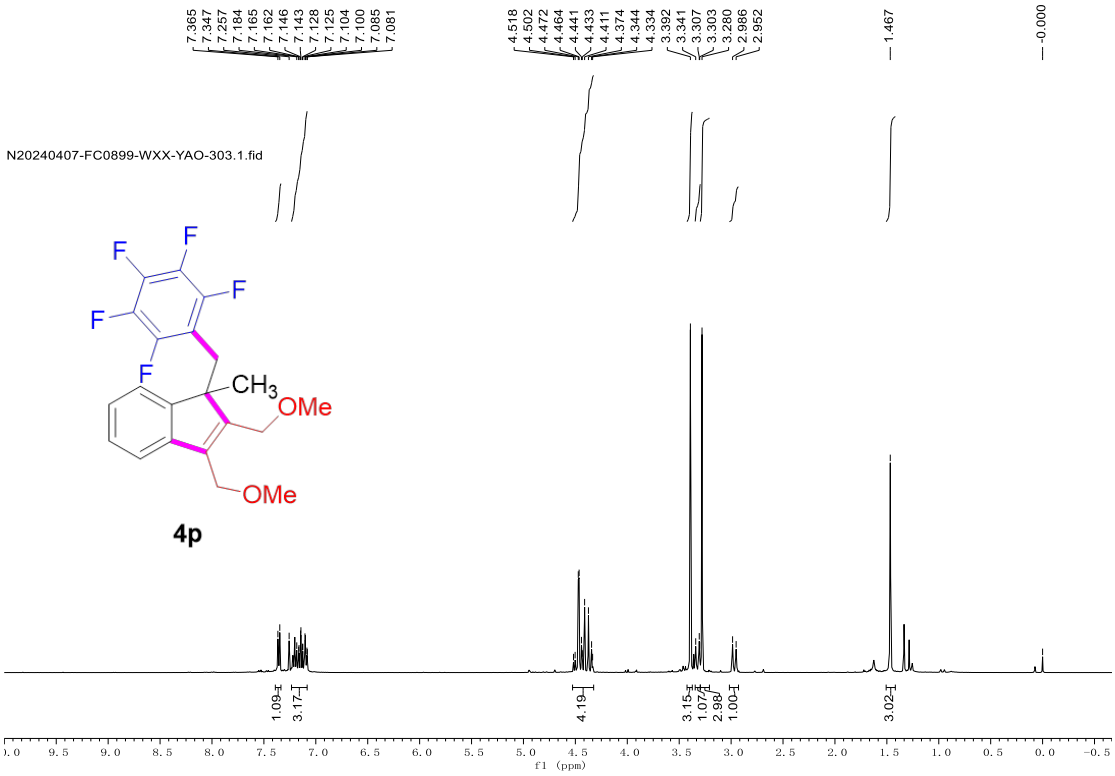
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4o**



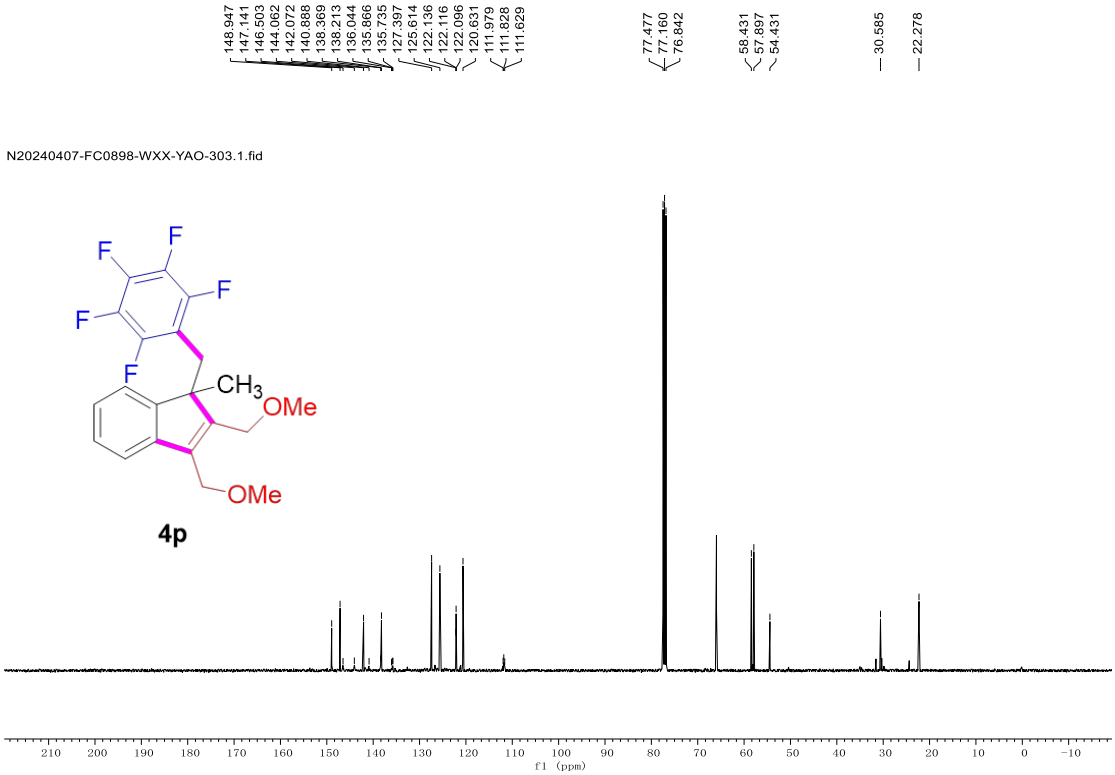
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4o**



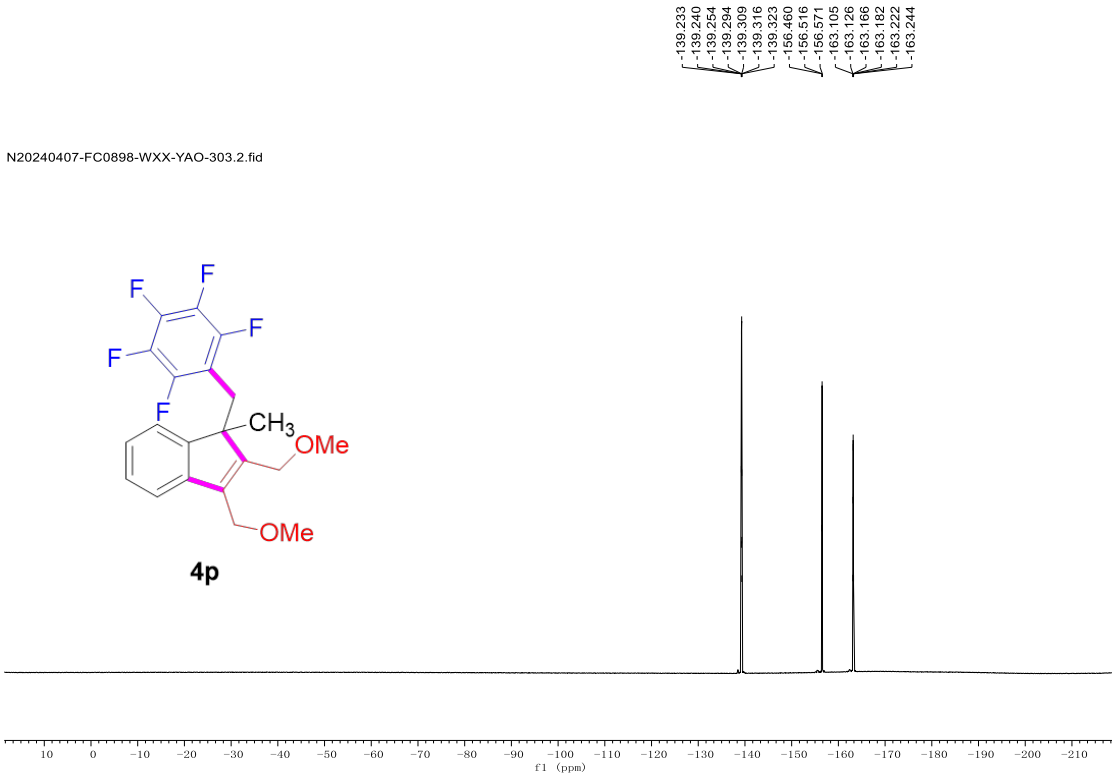
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4p**



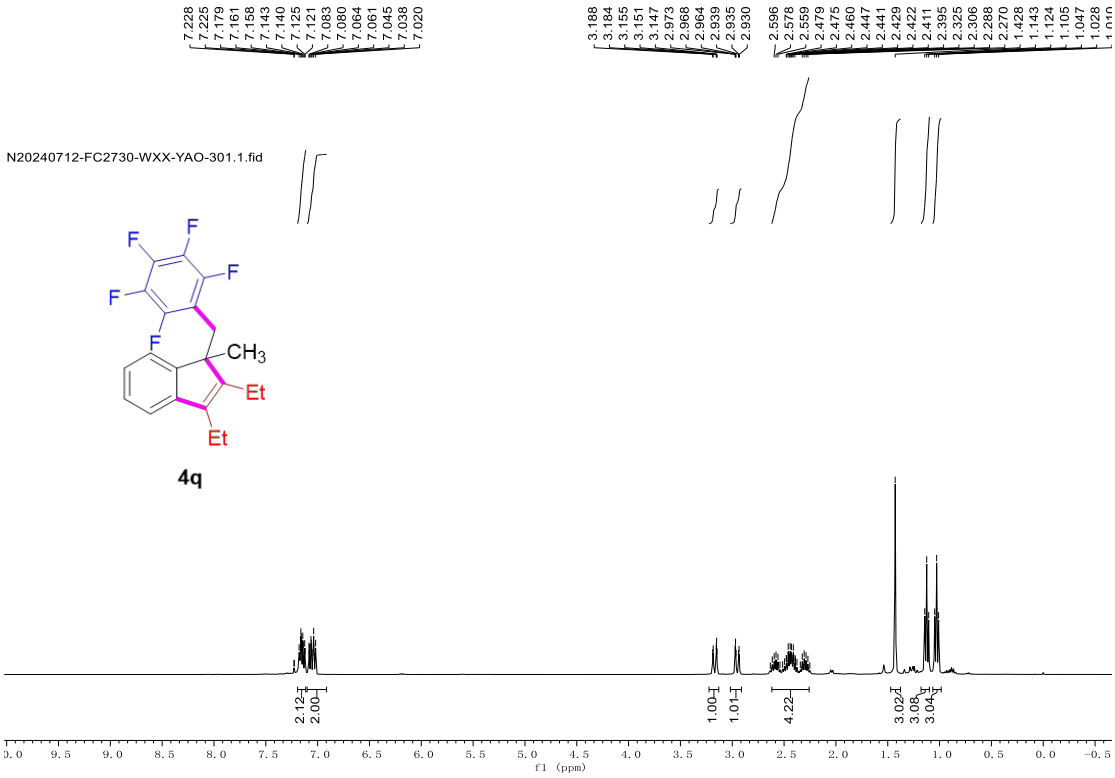
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4p**



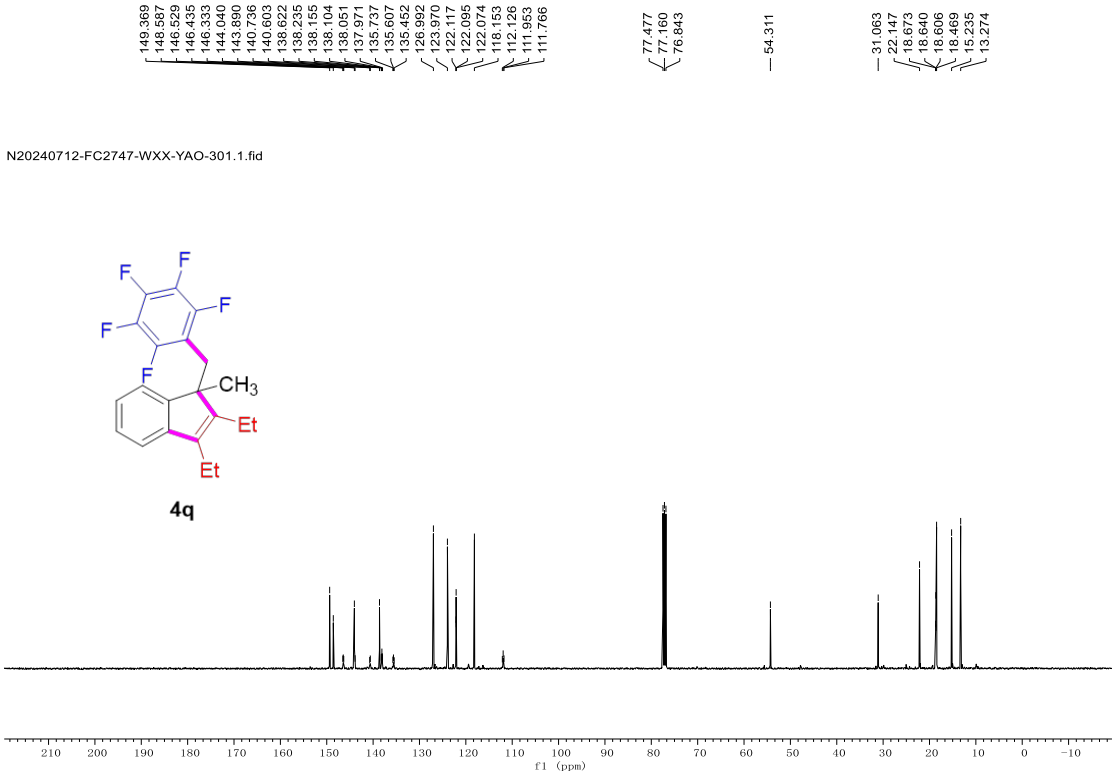
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4p**



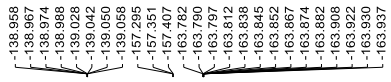
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4q**



^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4q**



^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4q**



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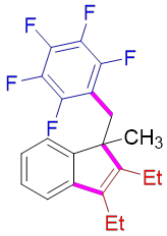
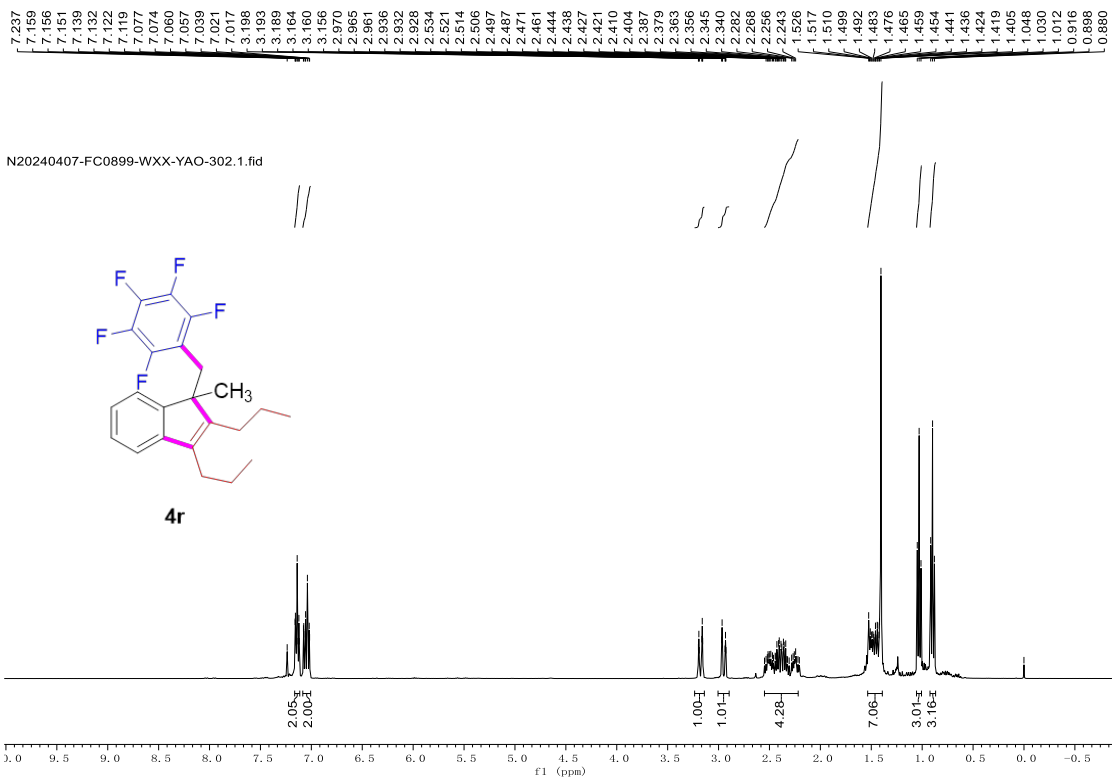
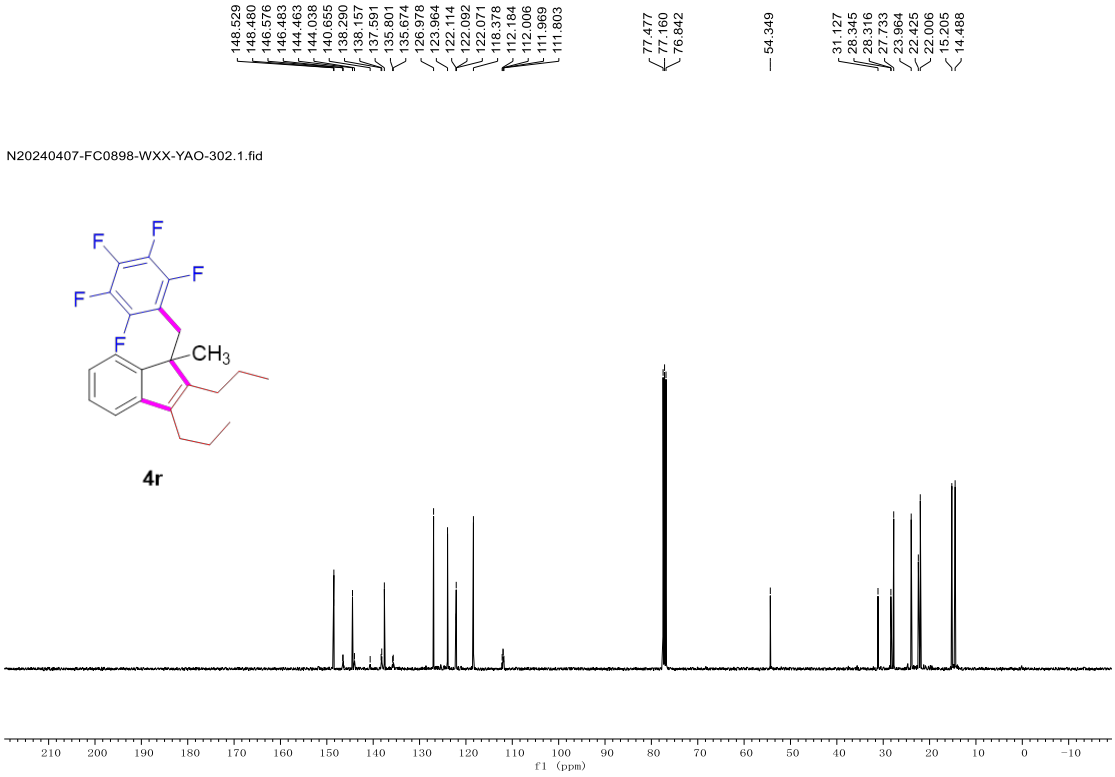


4q

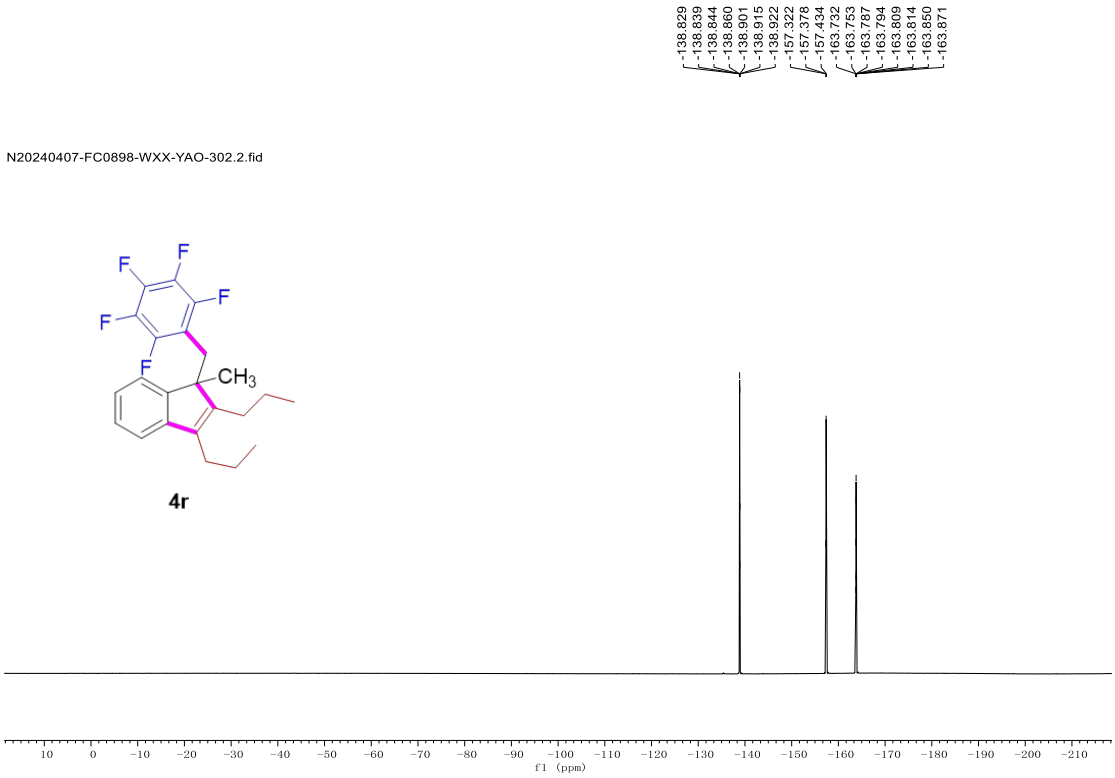
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4r**



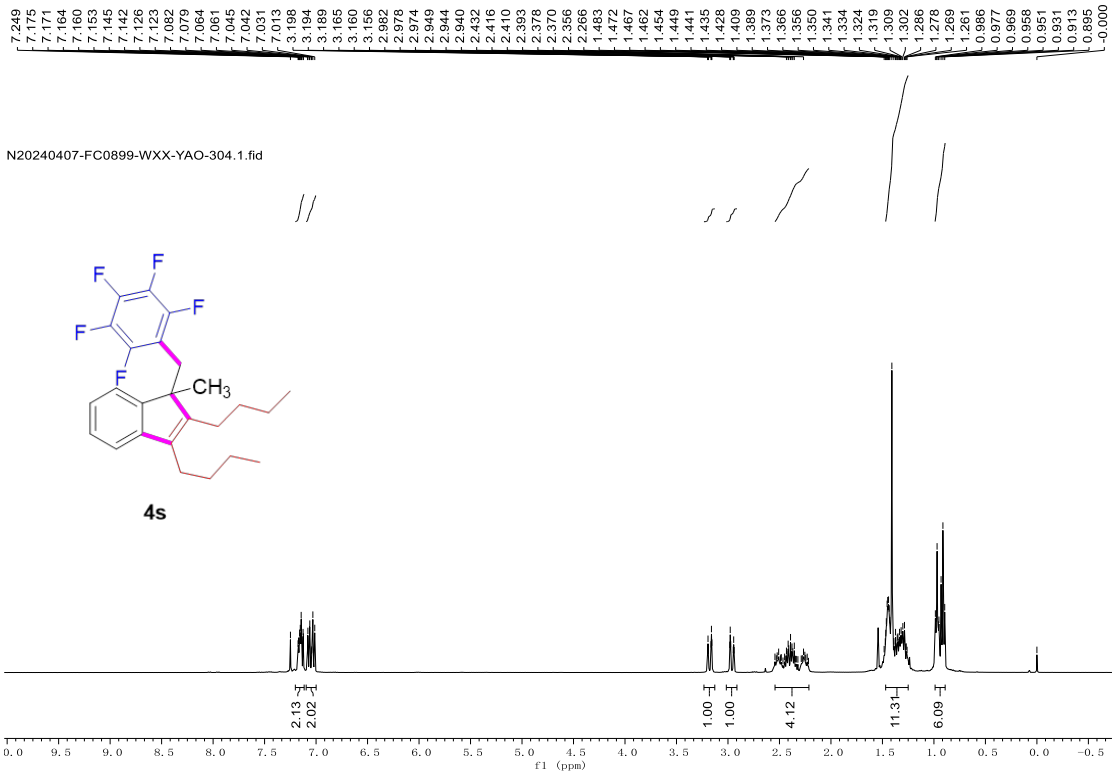
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4r**



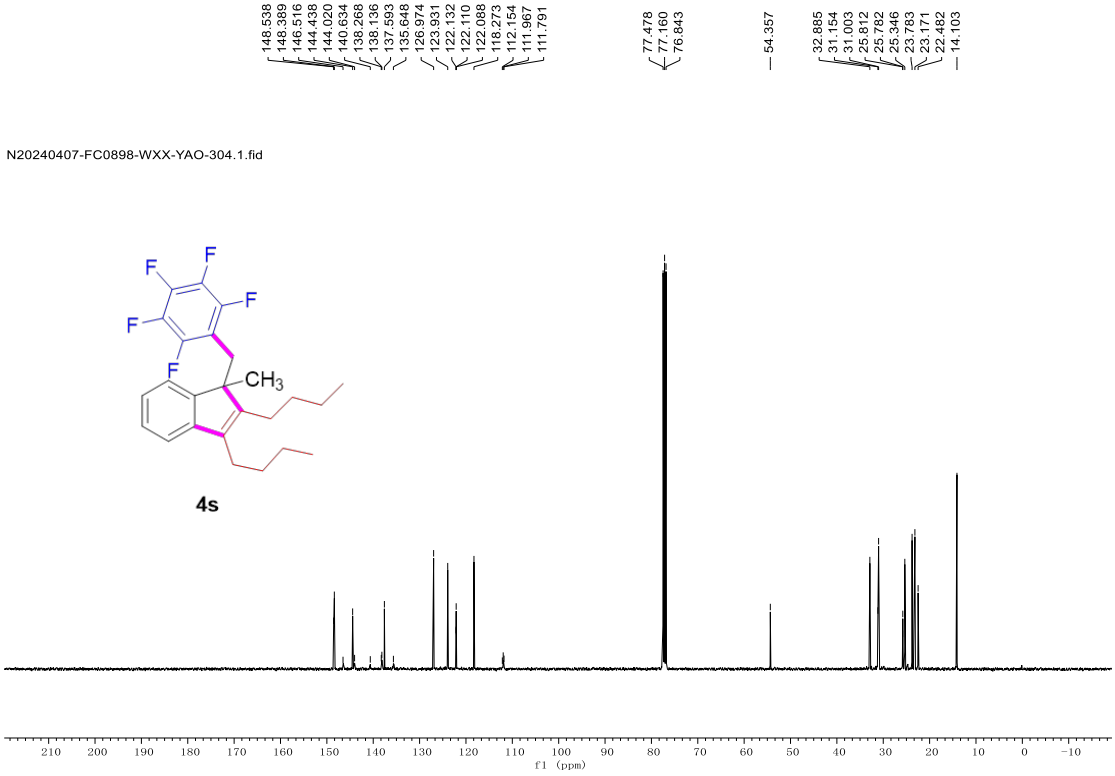
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4r**



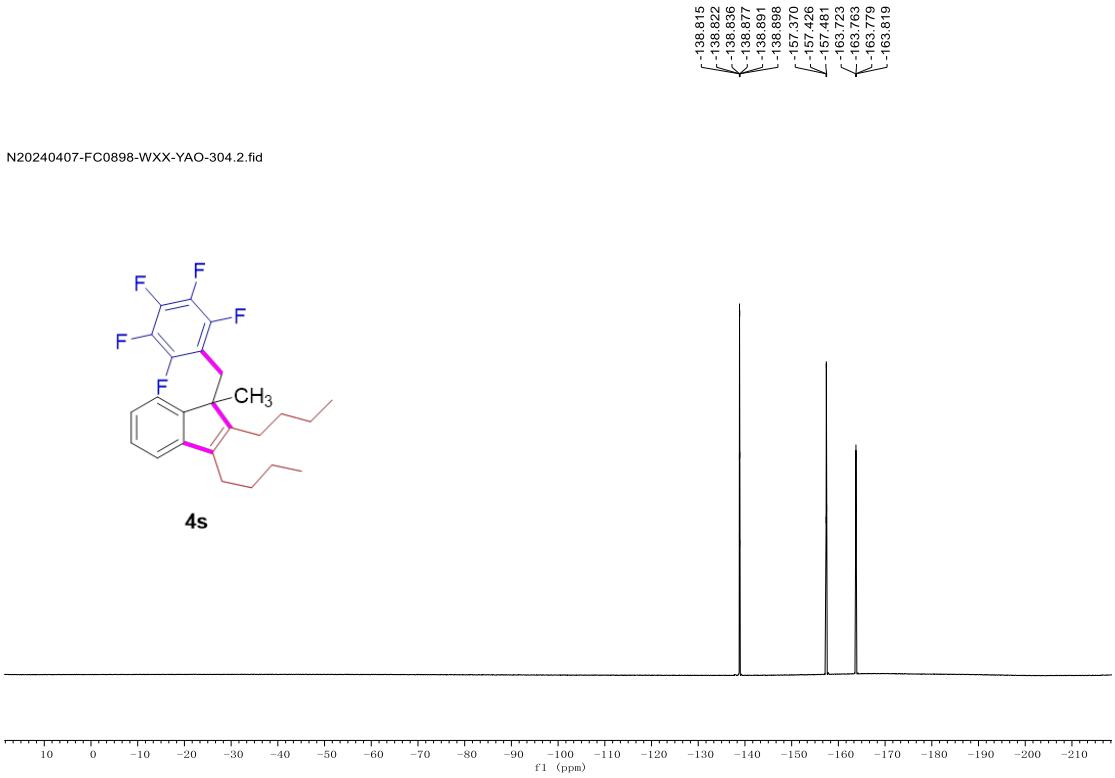
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4s**



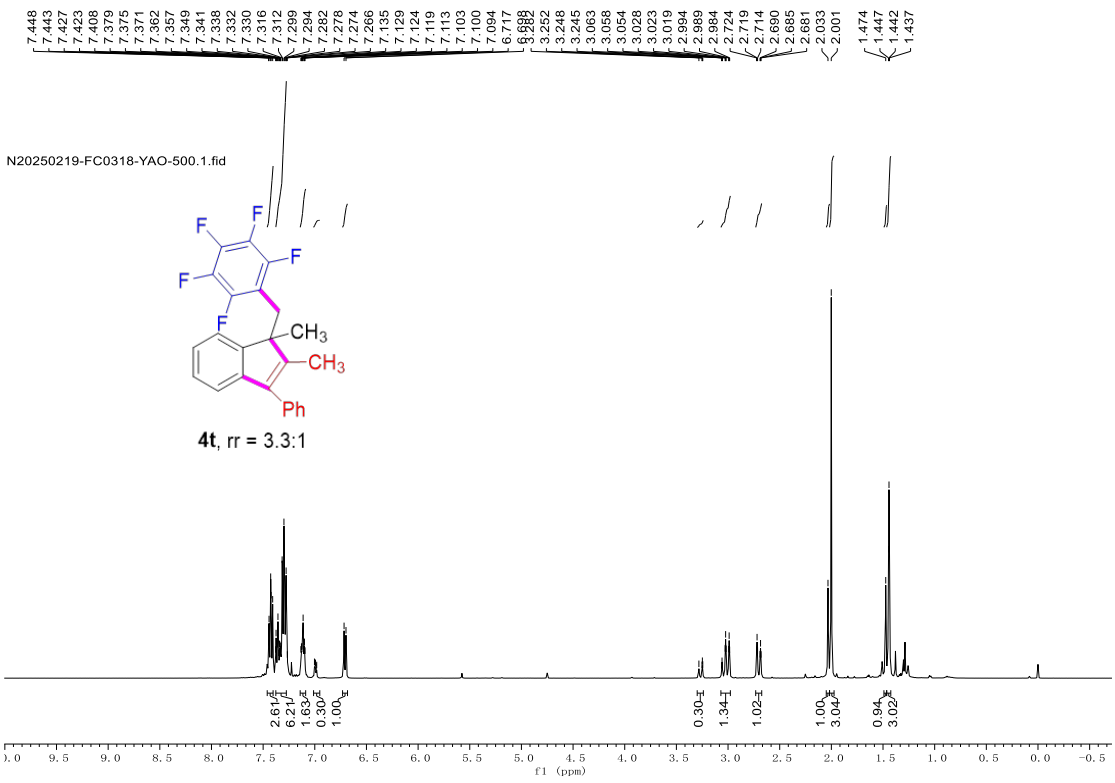
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4s**



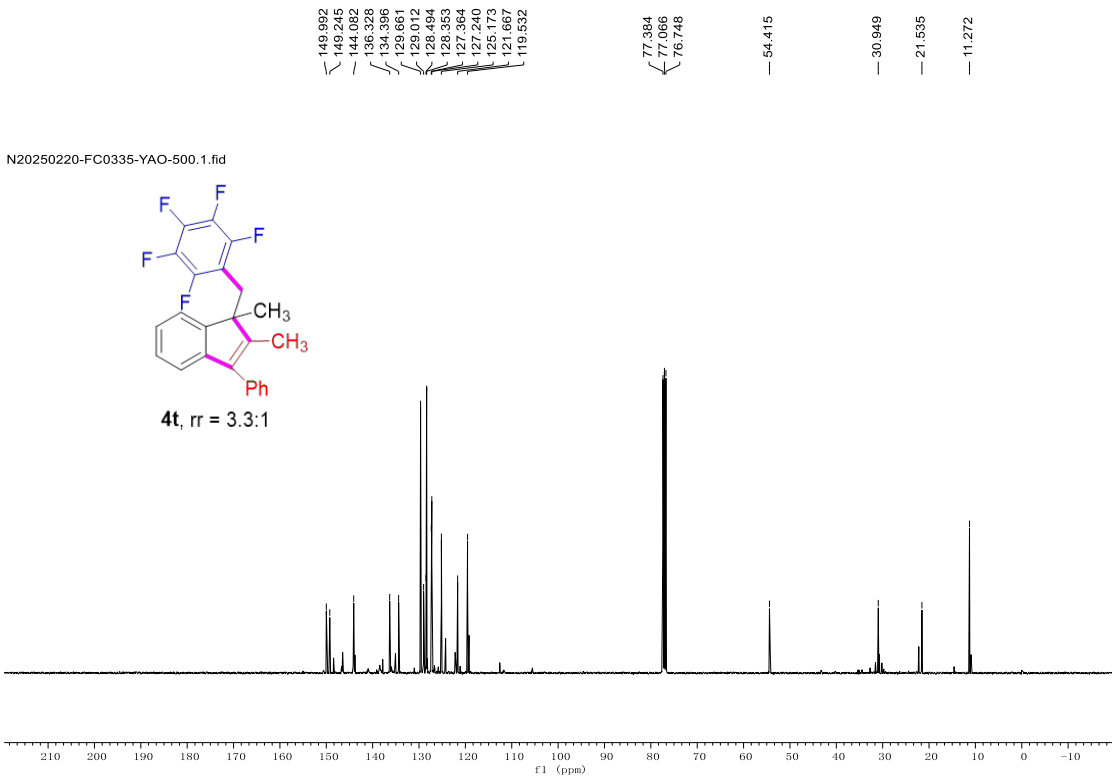
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4s**



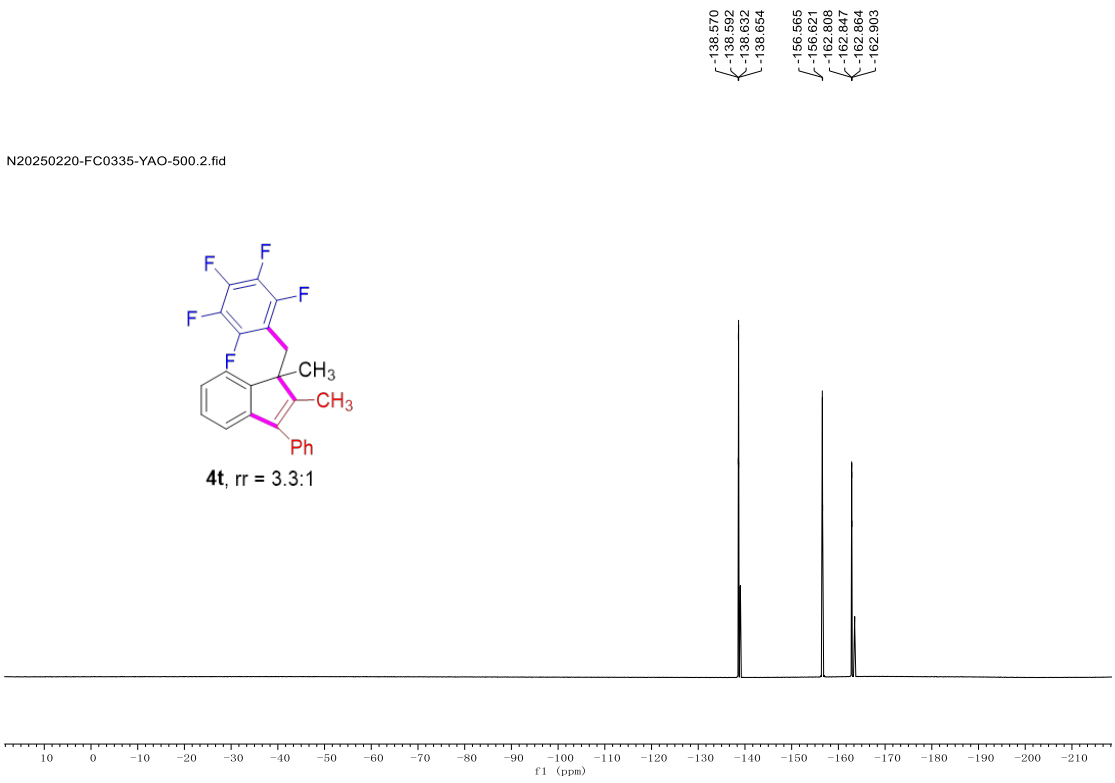
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4t**



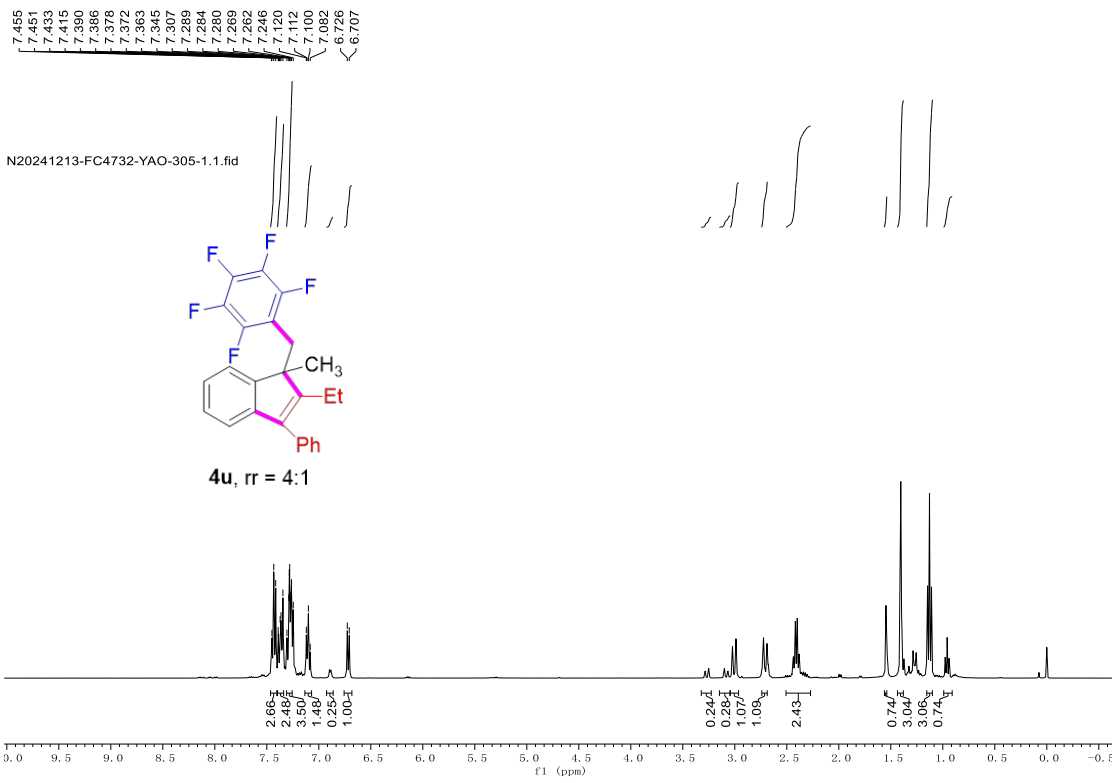
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4t**



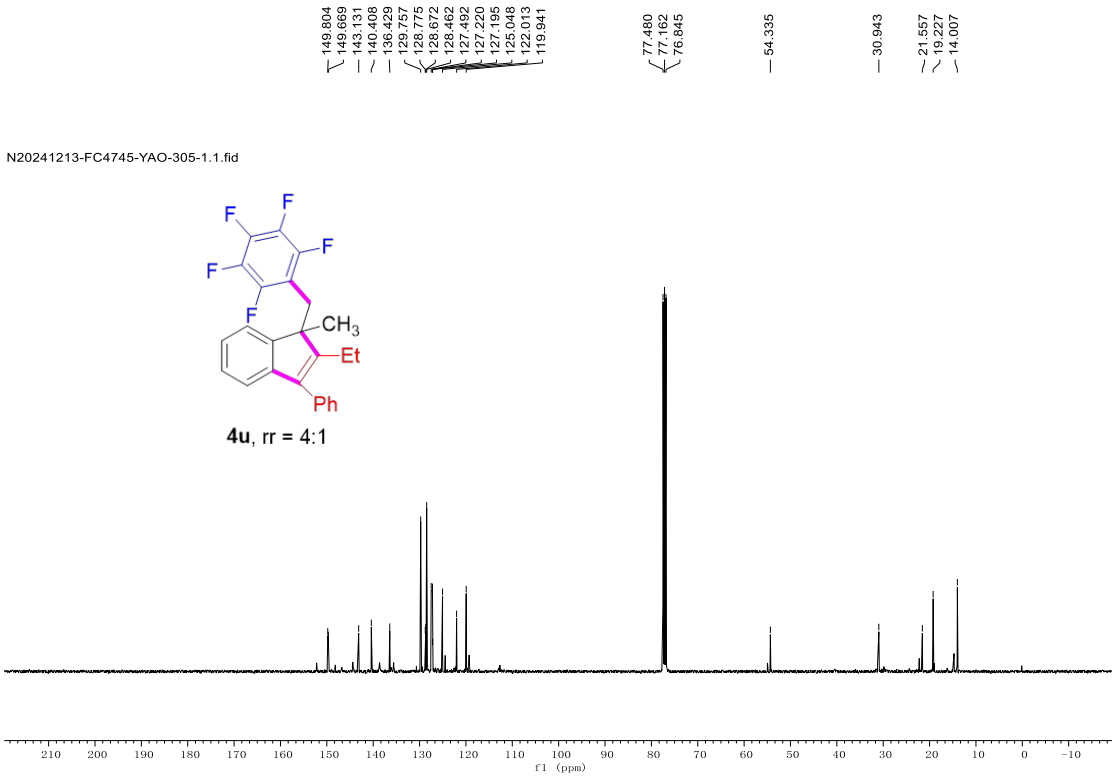
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4t**



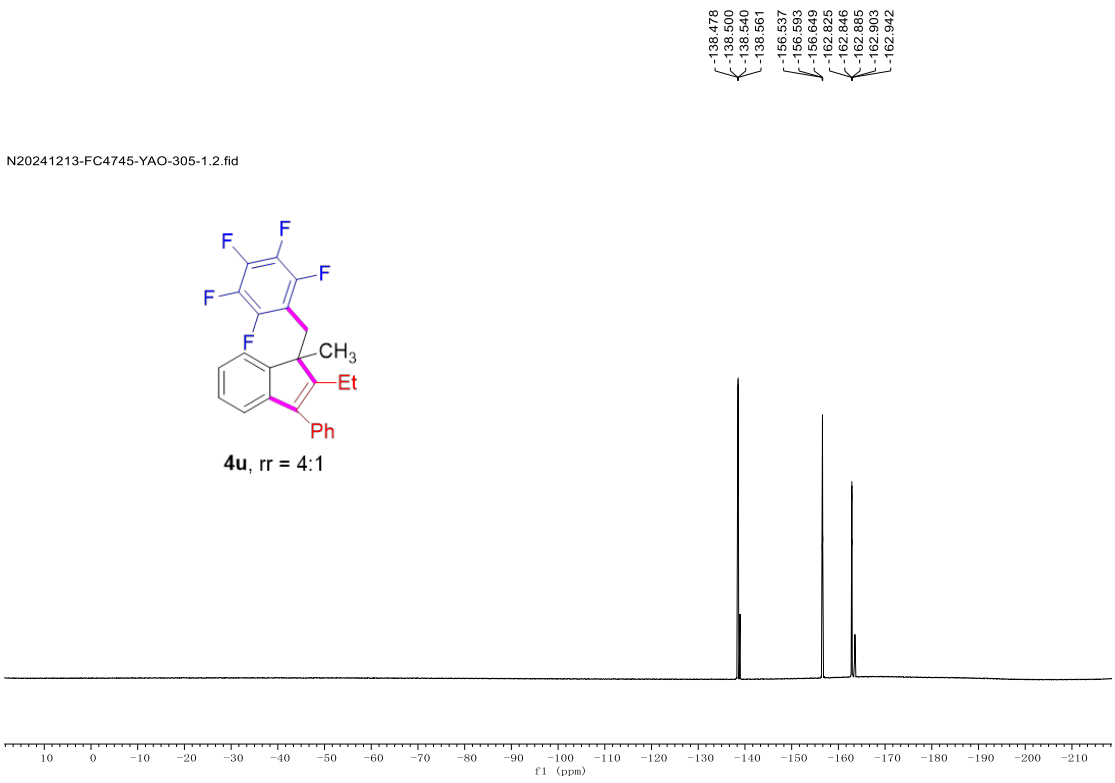
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4u**



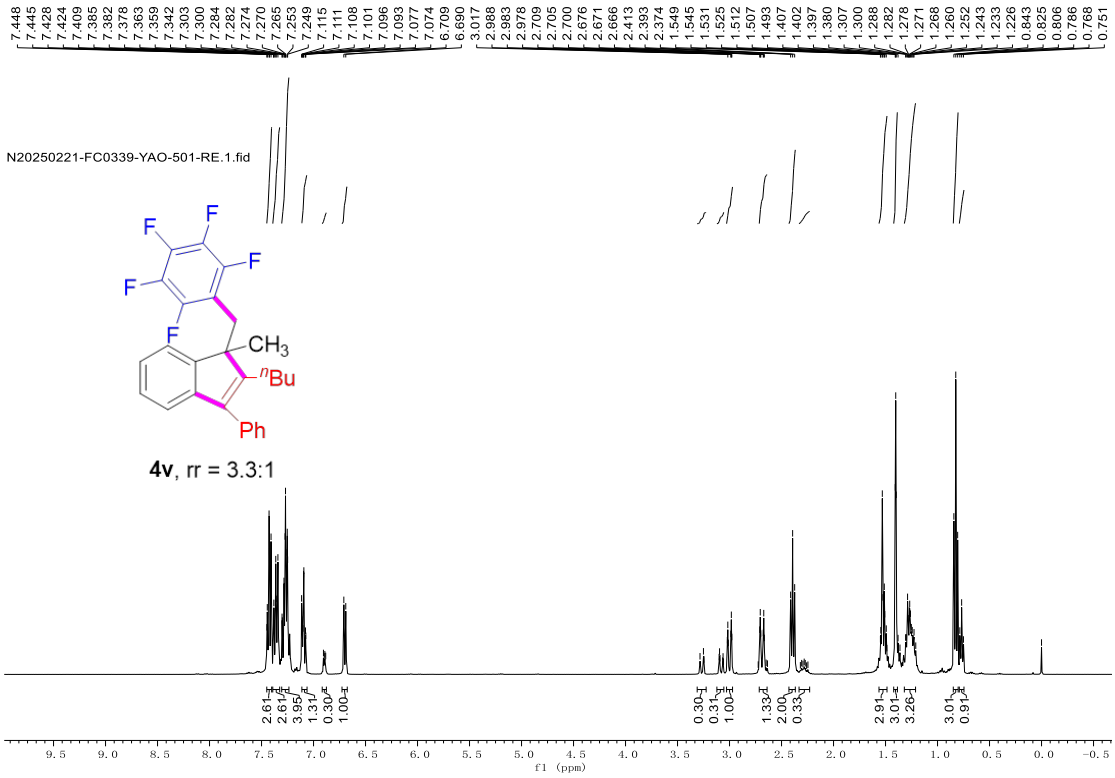
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4u**



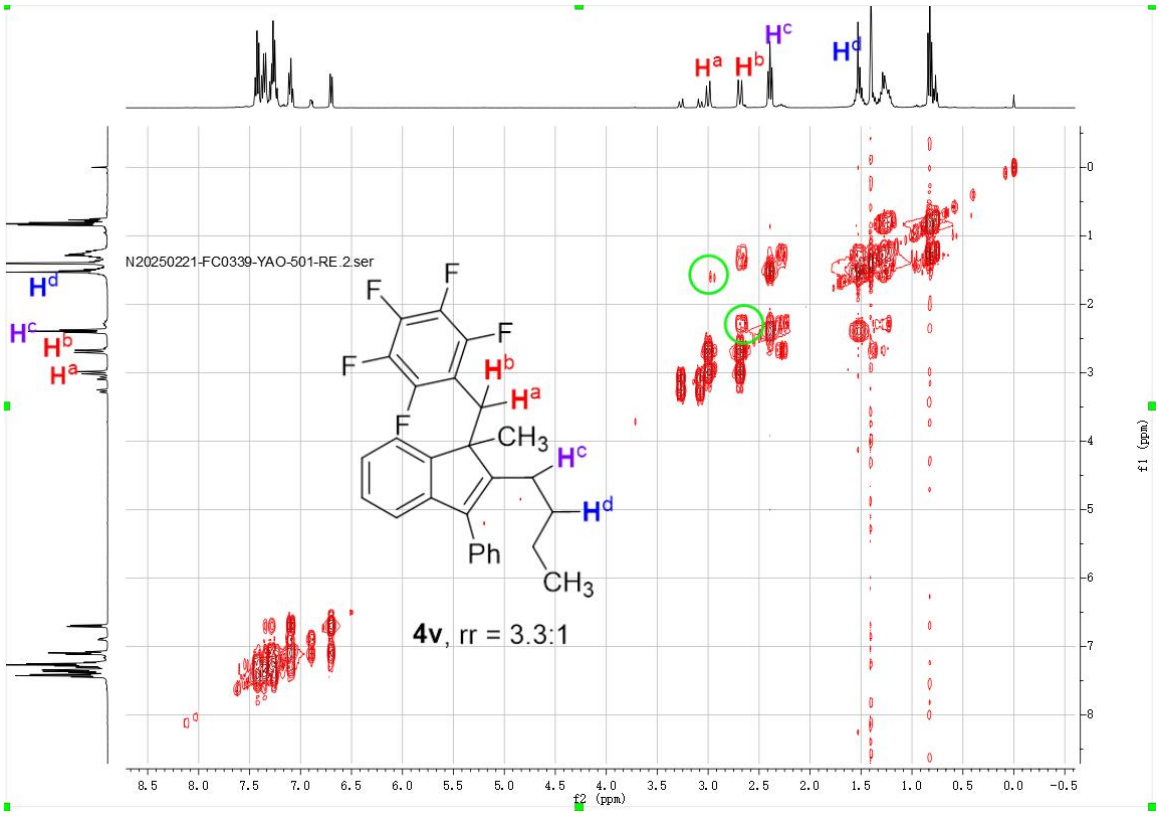
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4u**



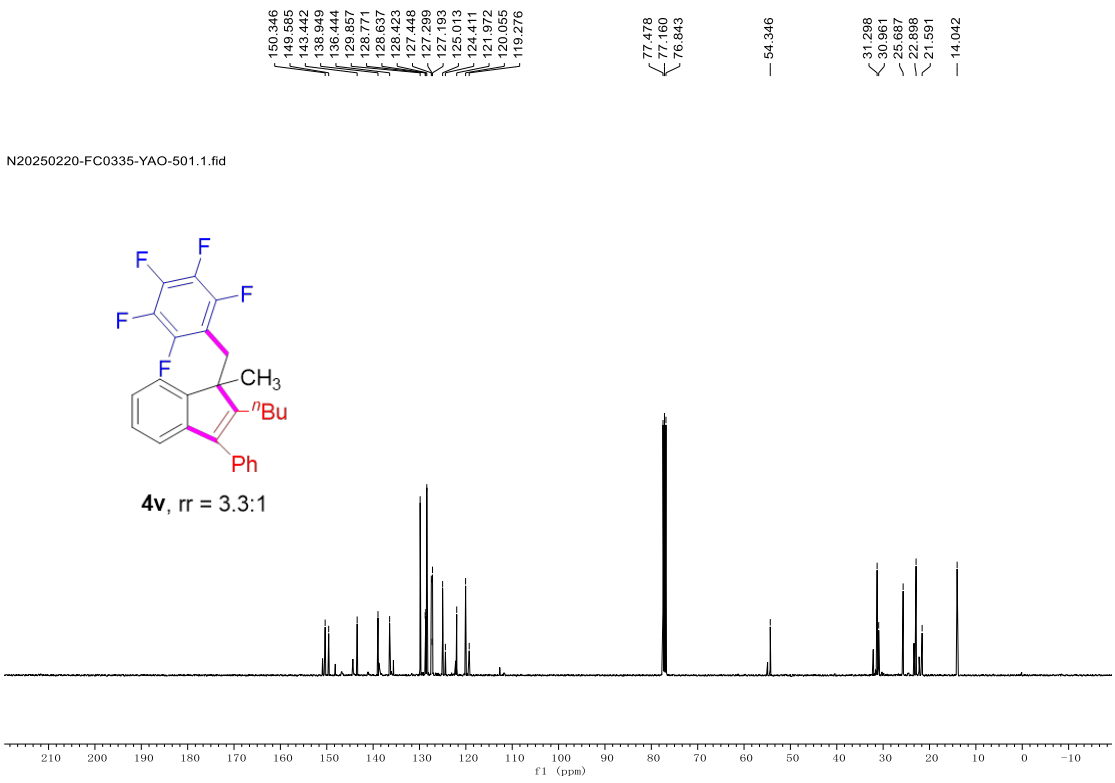
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4v**



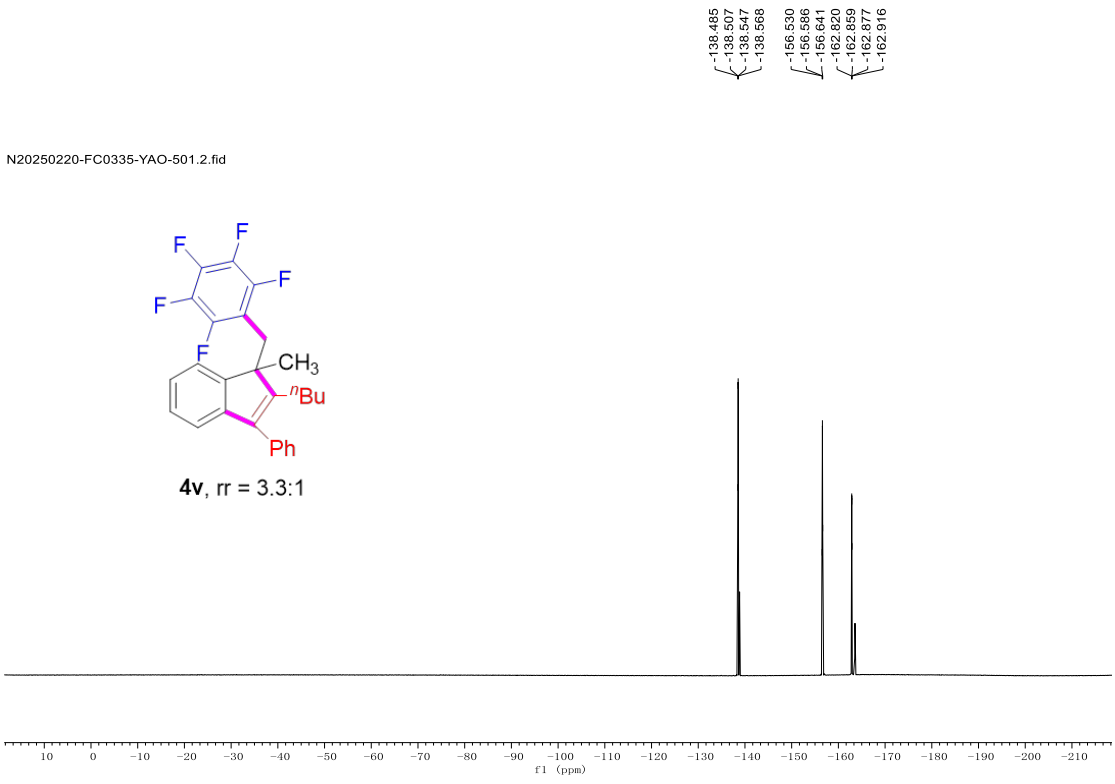
^{1}H-^{1}H NOESY Spectrum of **4v**



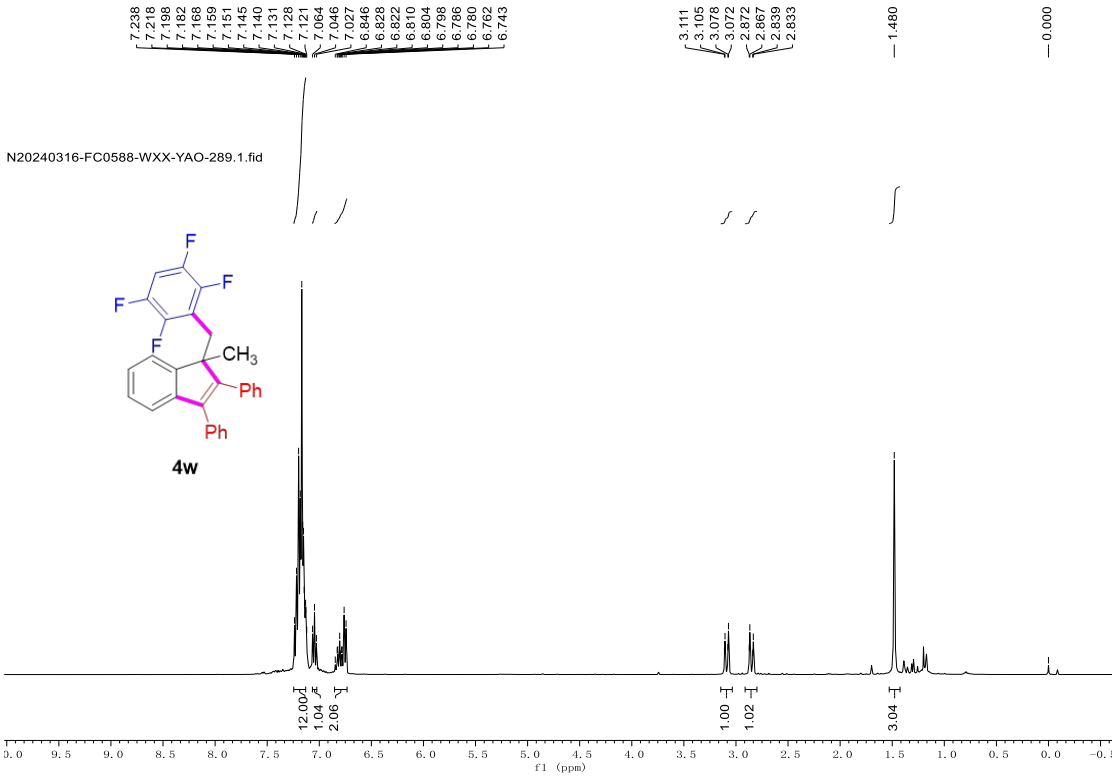
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4v**



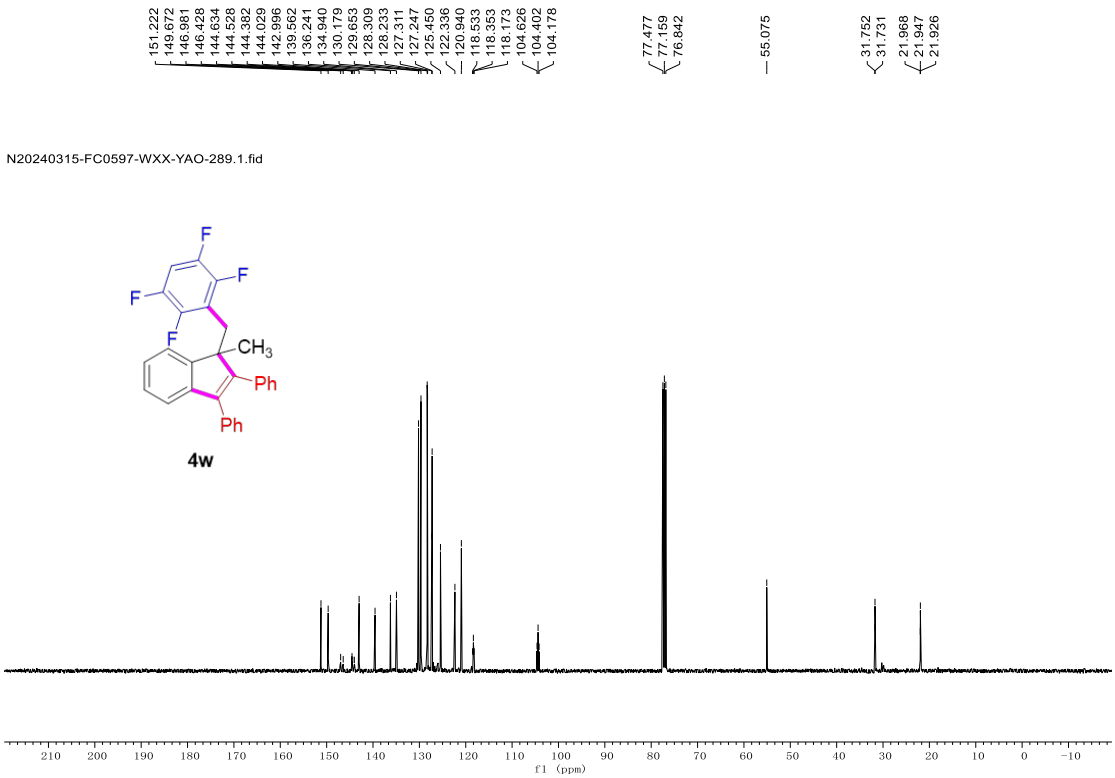
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4v**



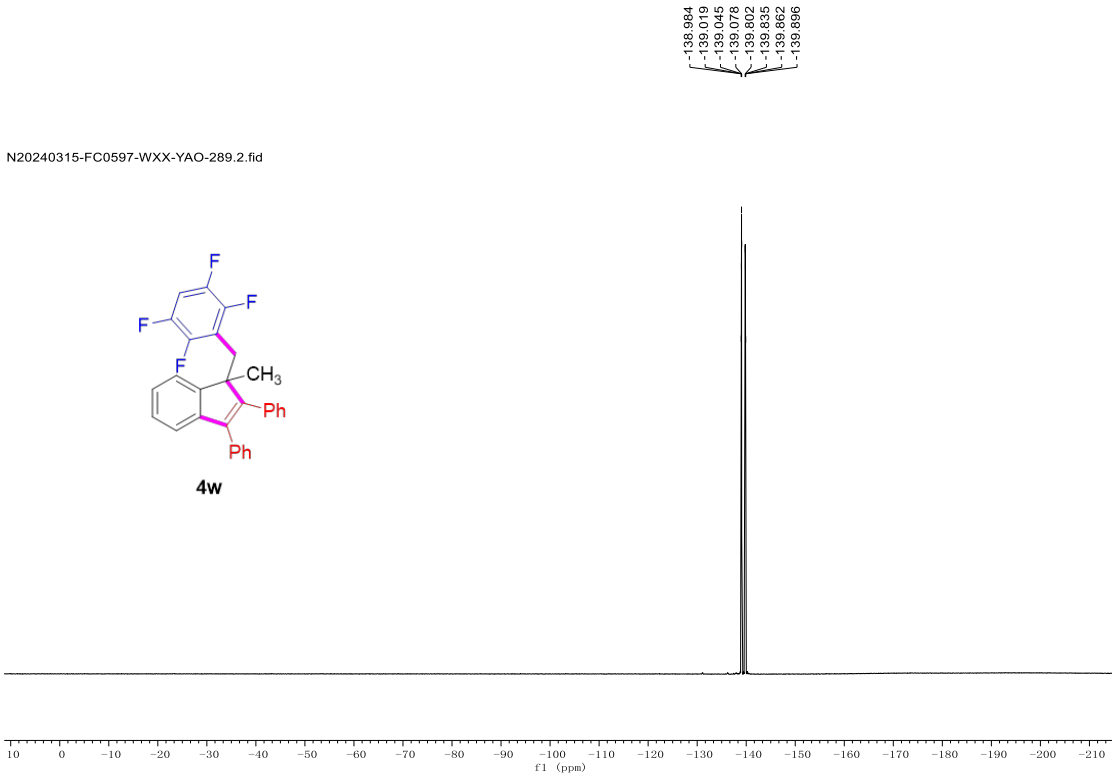
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4w**



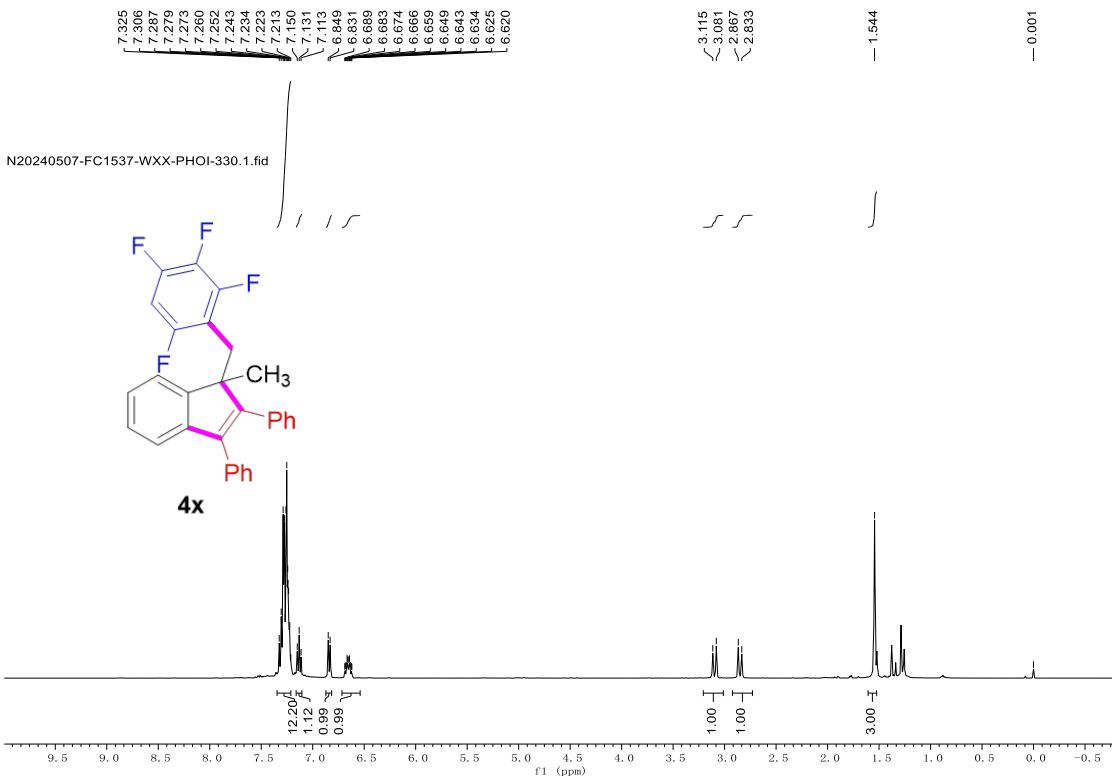
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4w**



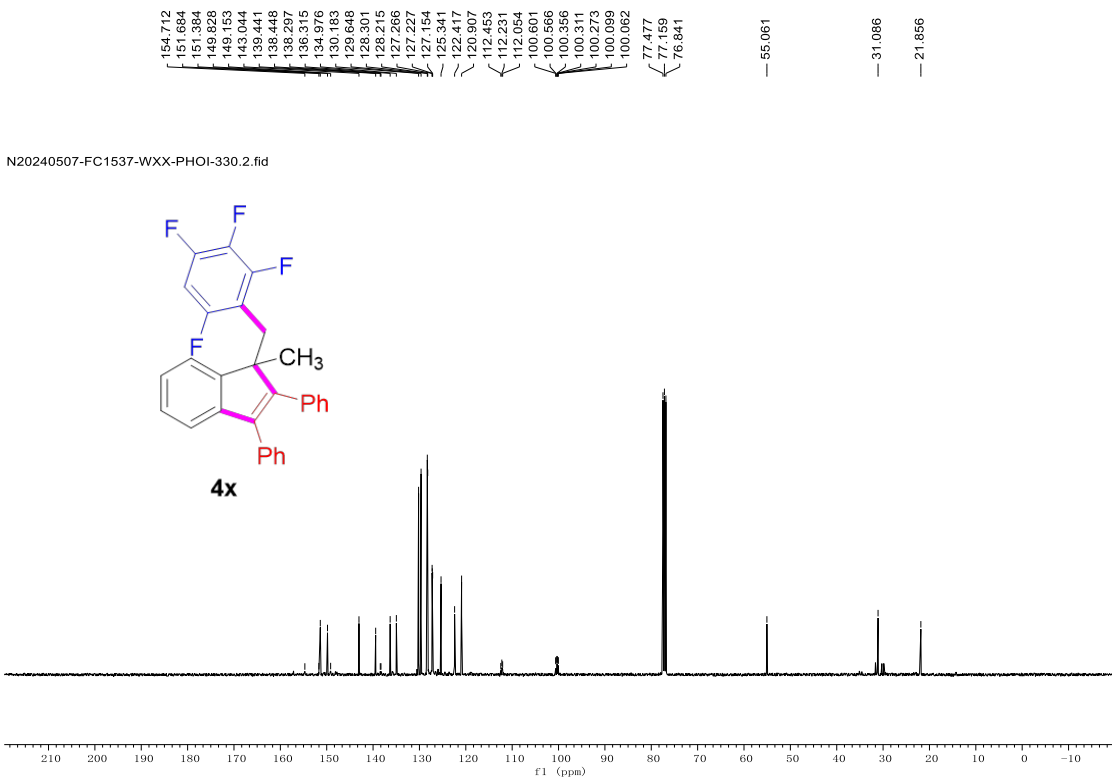
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4w**



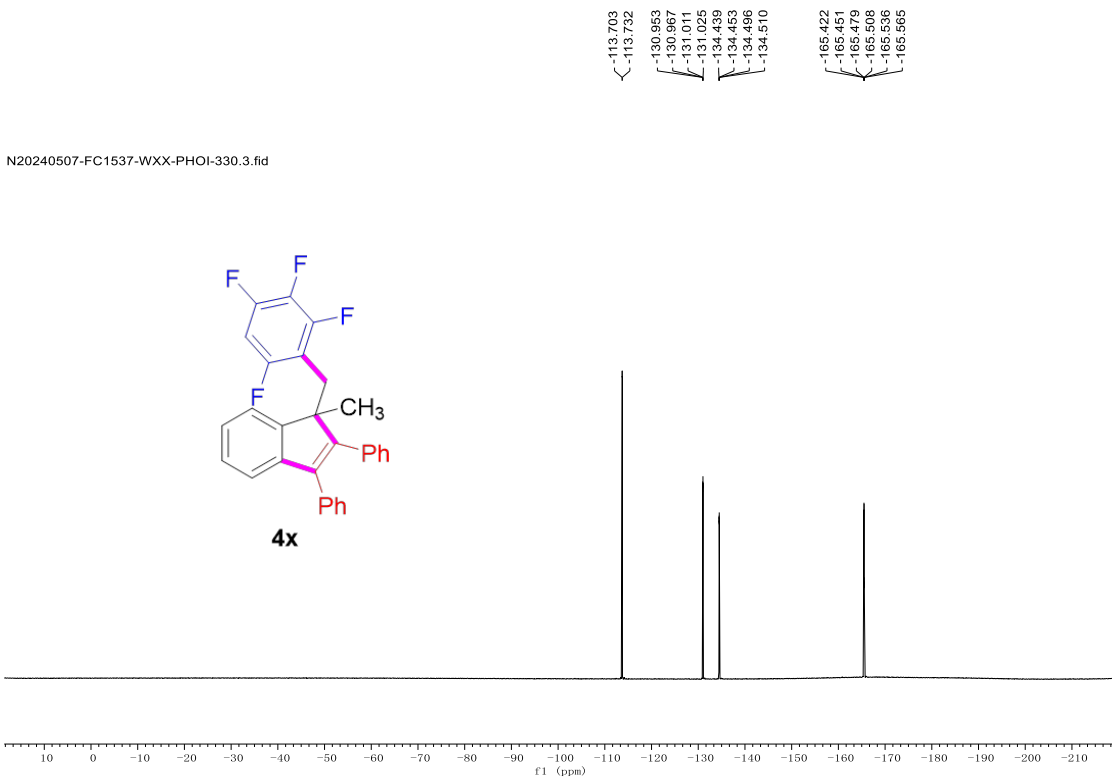
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4x**



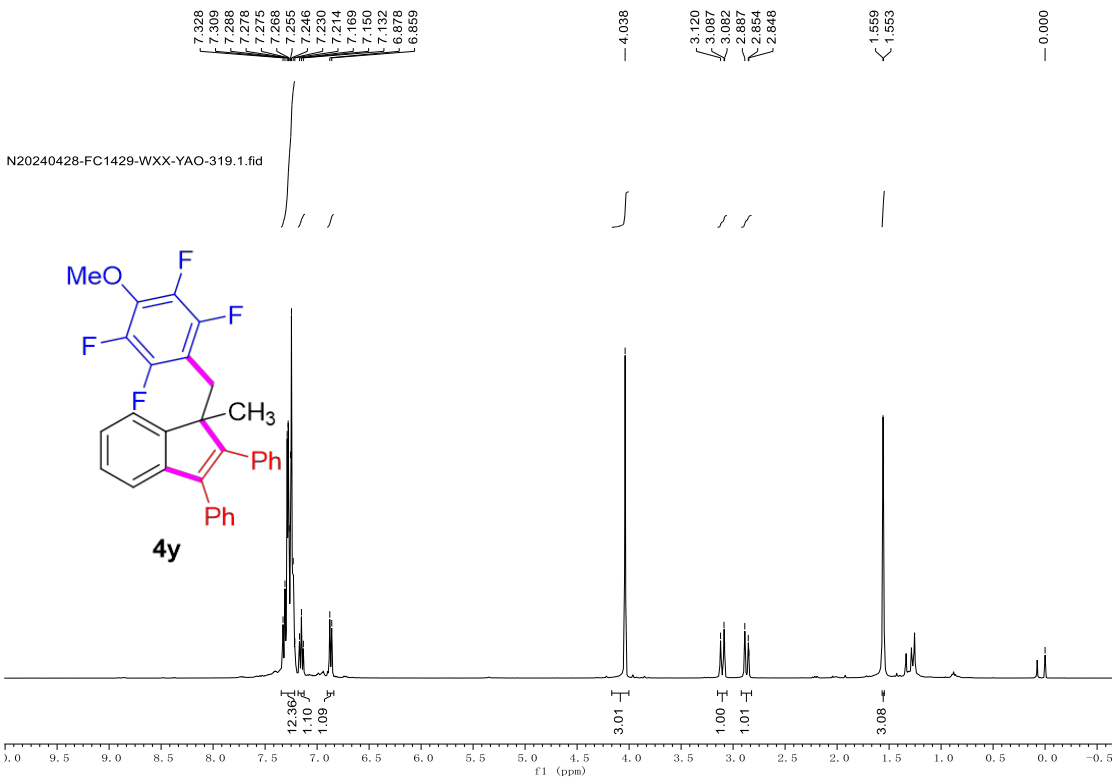
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4x**



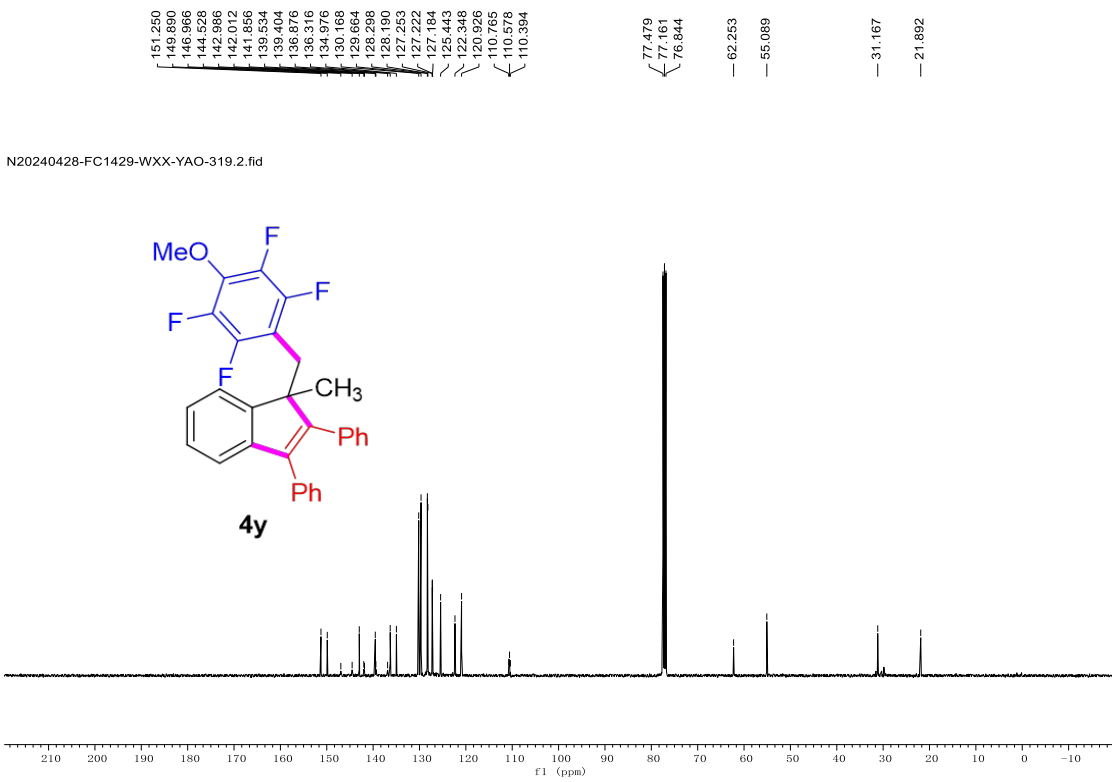
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4x**



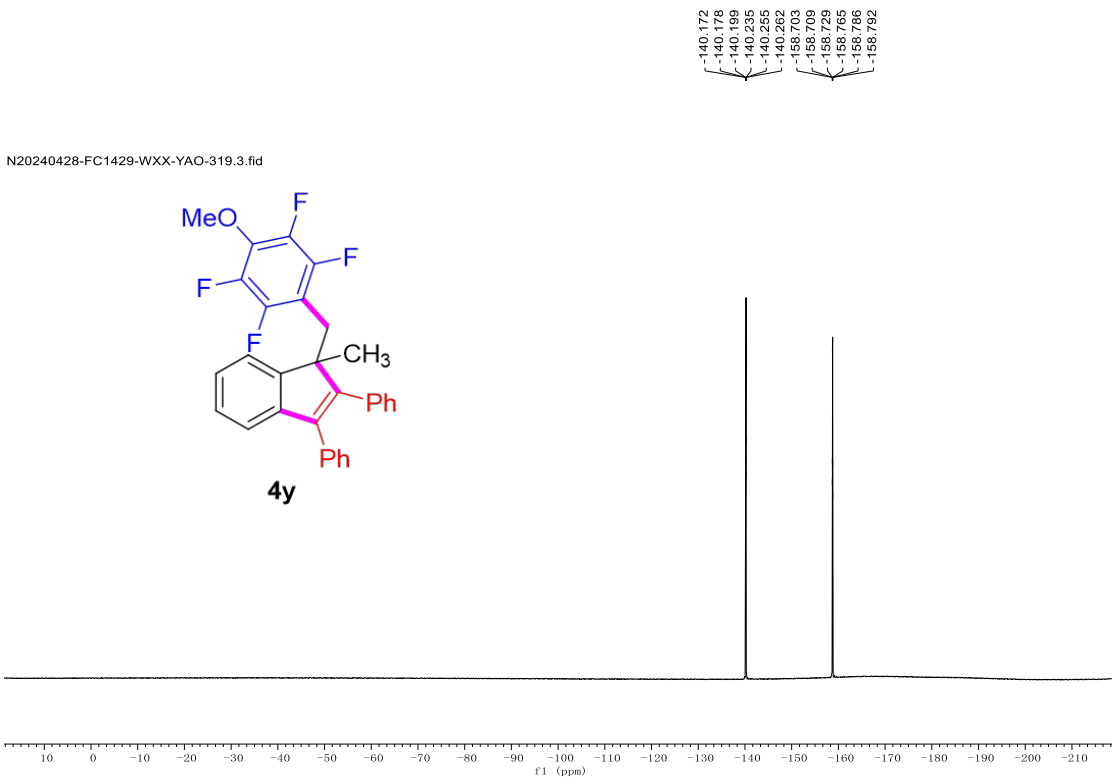
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4y**



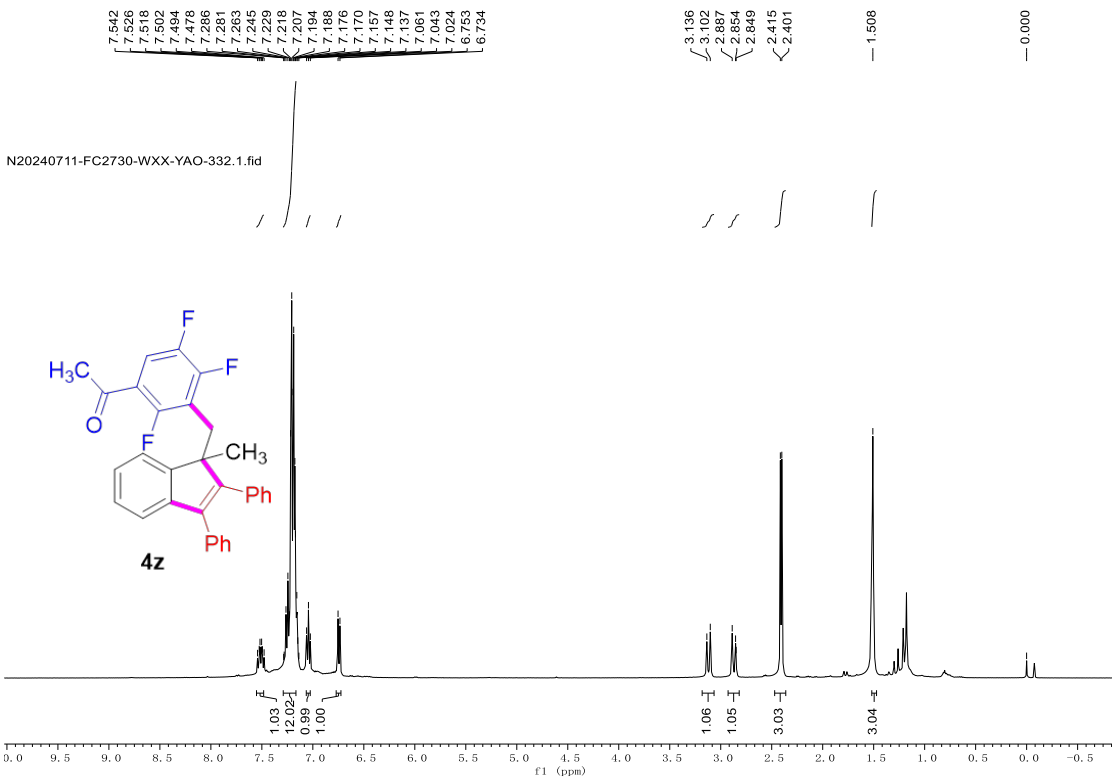
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4y**



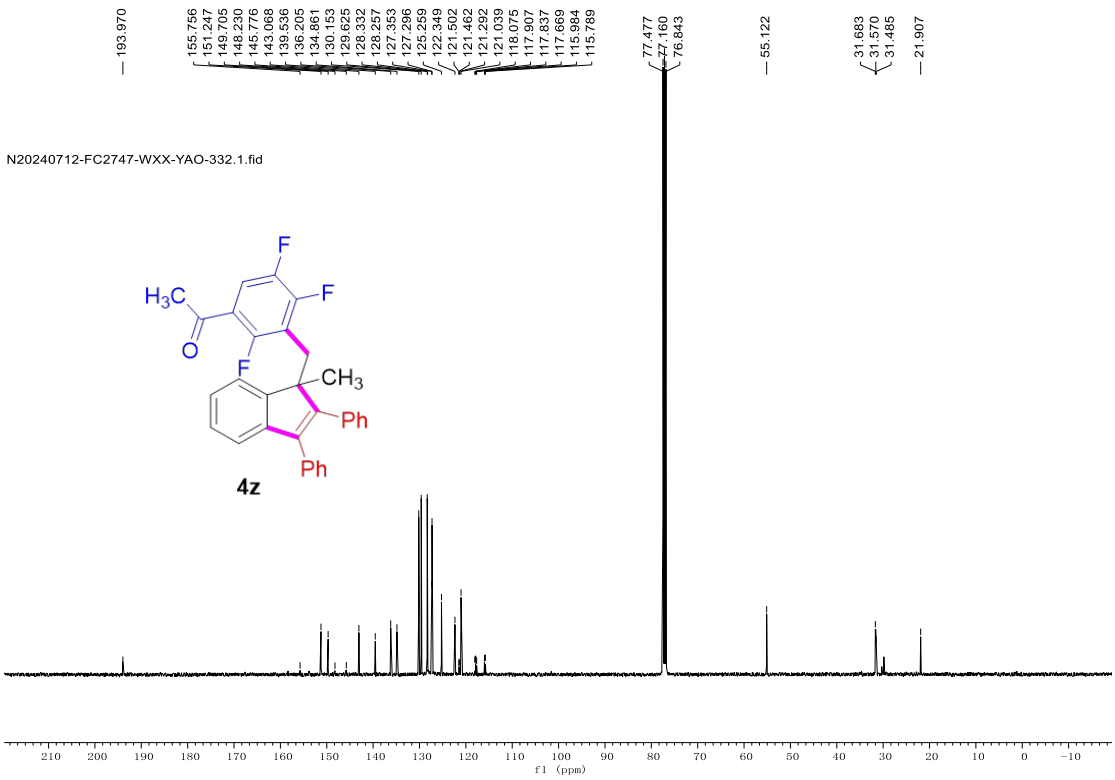
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4y**



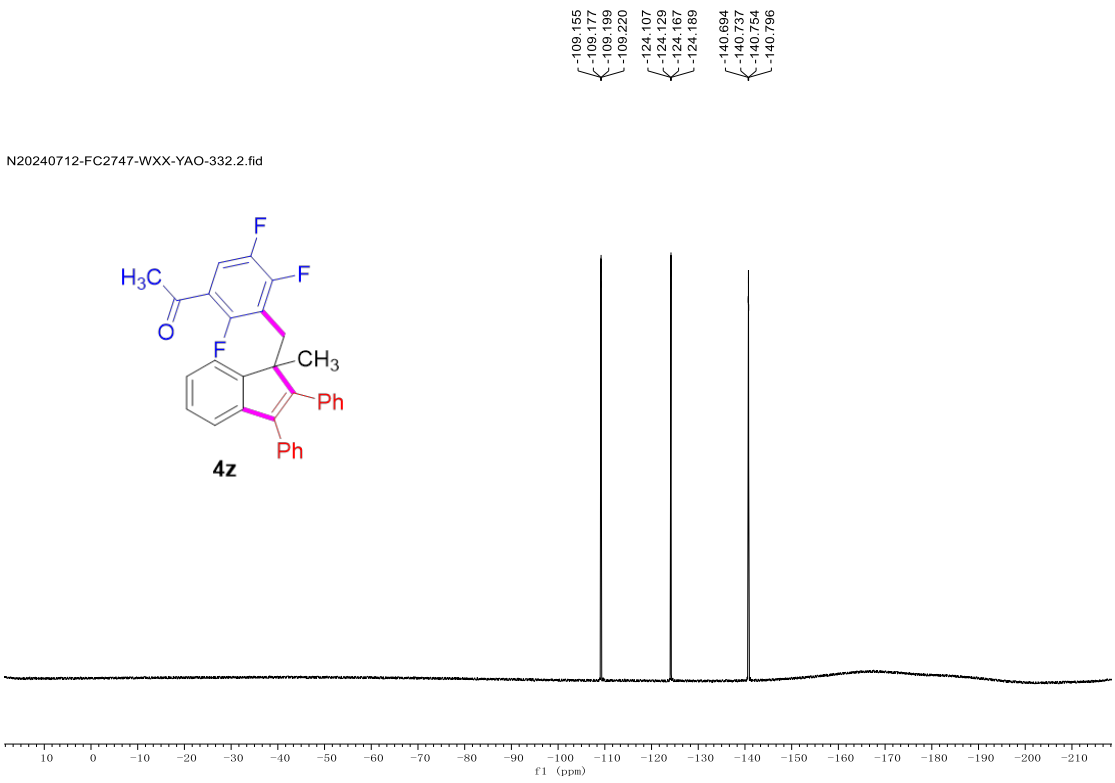
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4z**



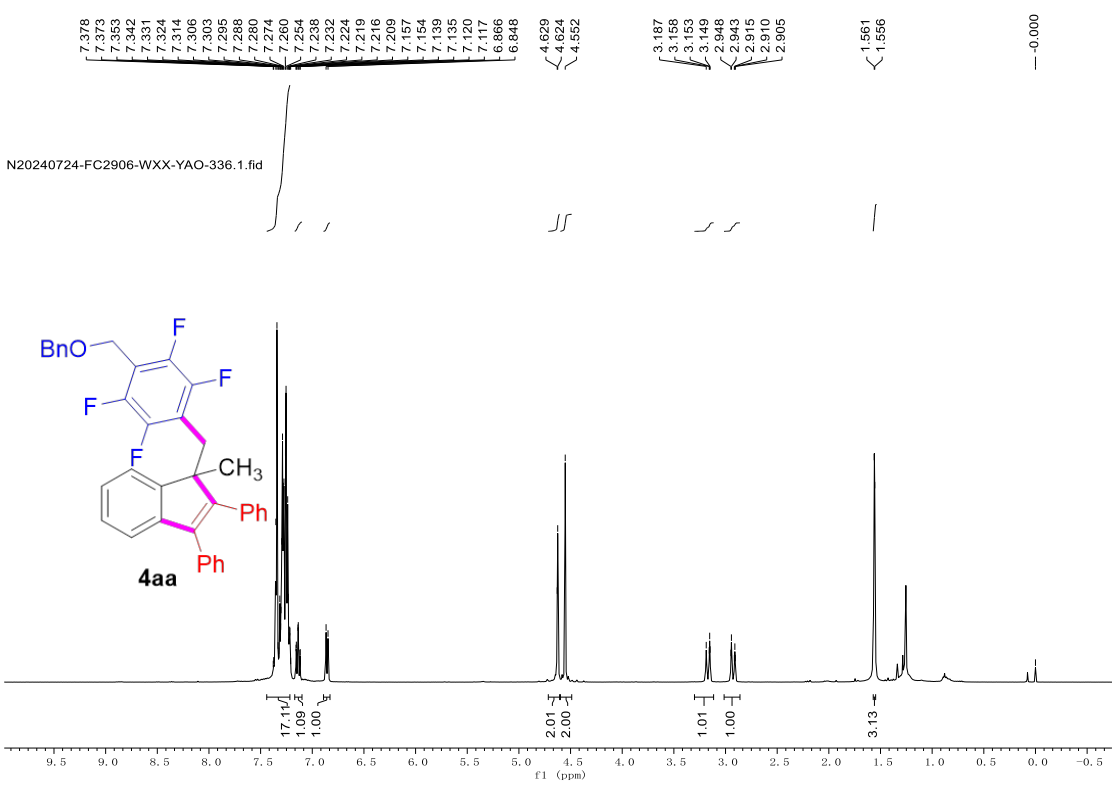
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4z**



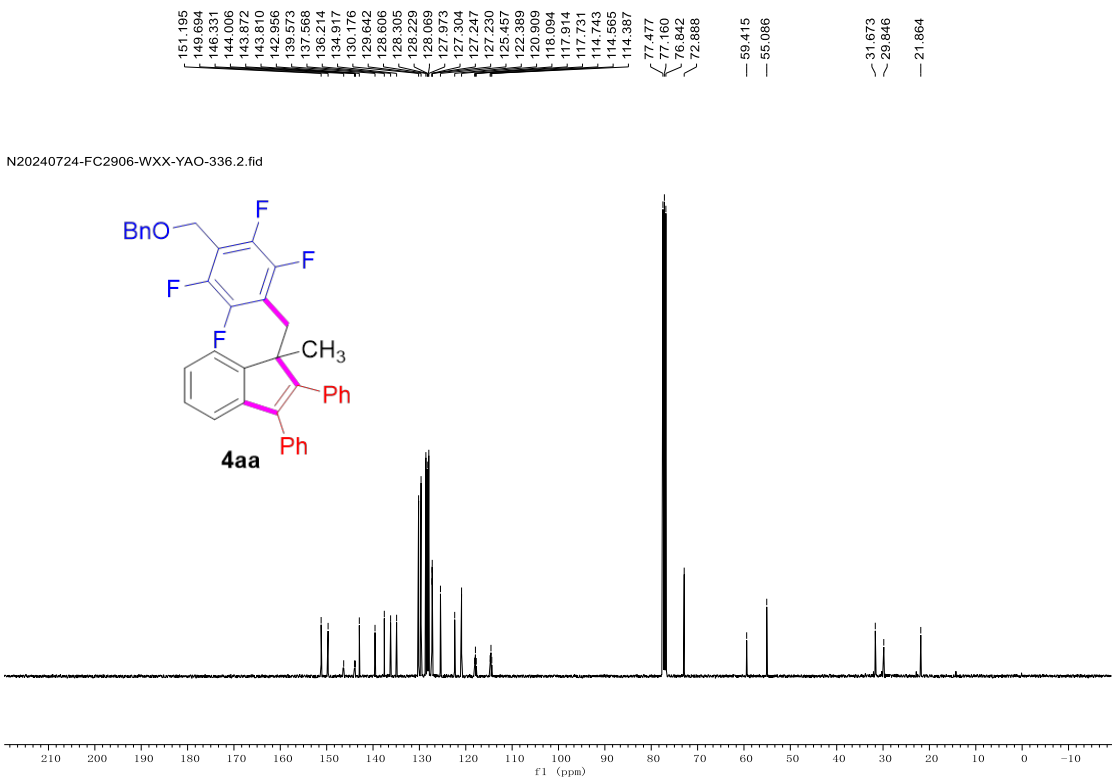
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4z**



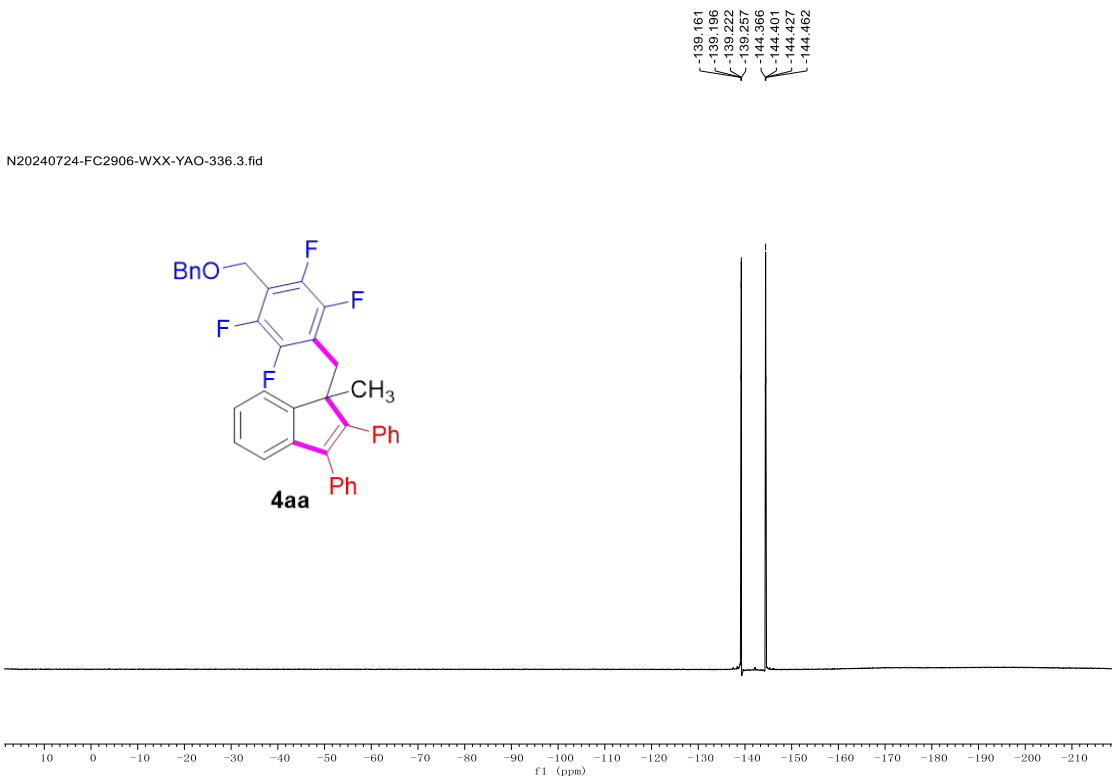
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4aa**



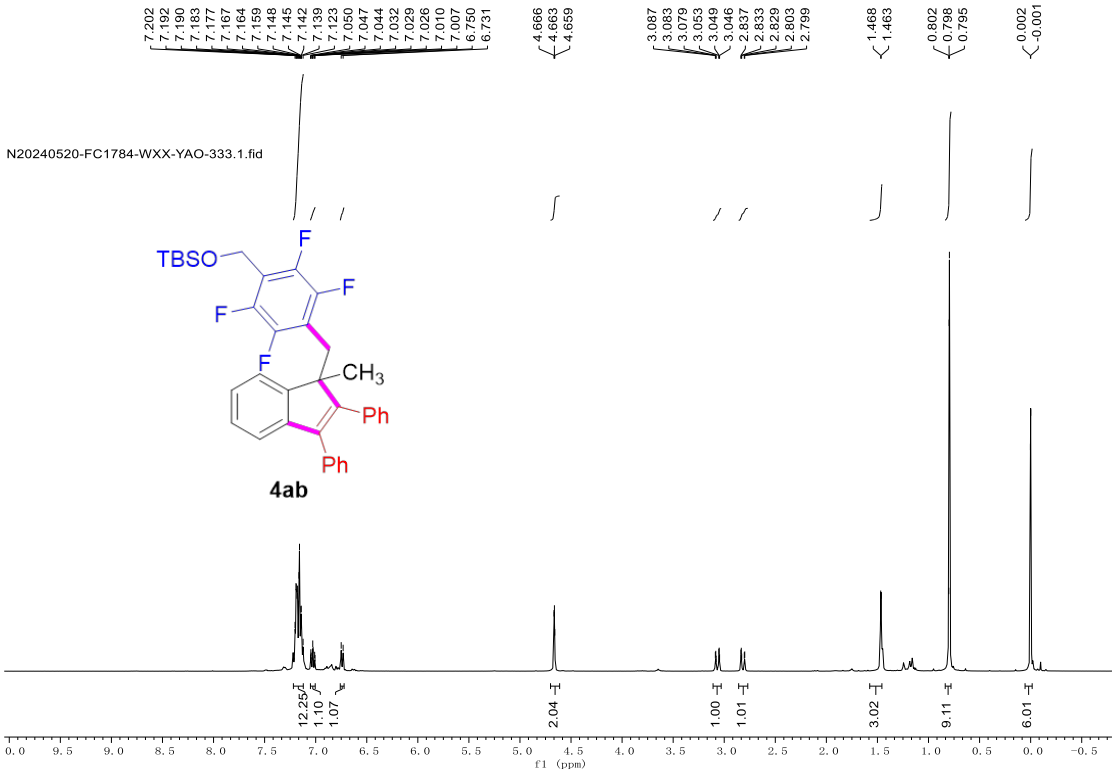
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4aa**



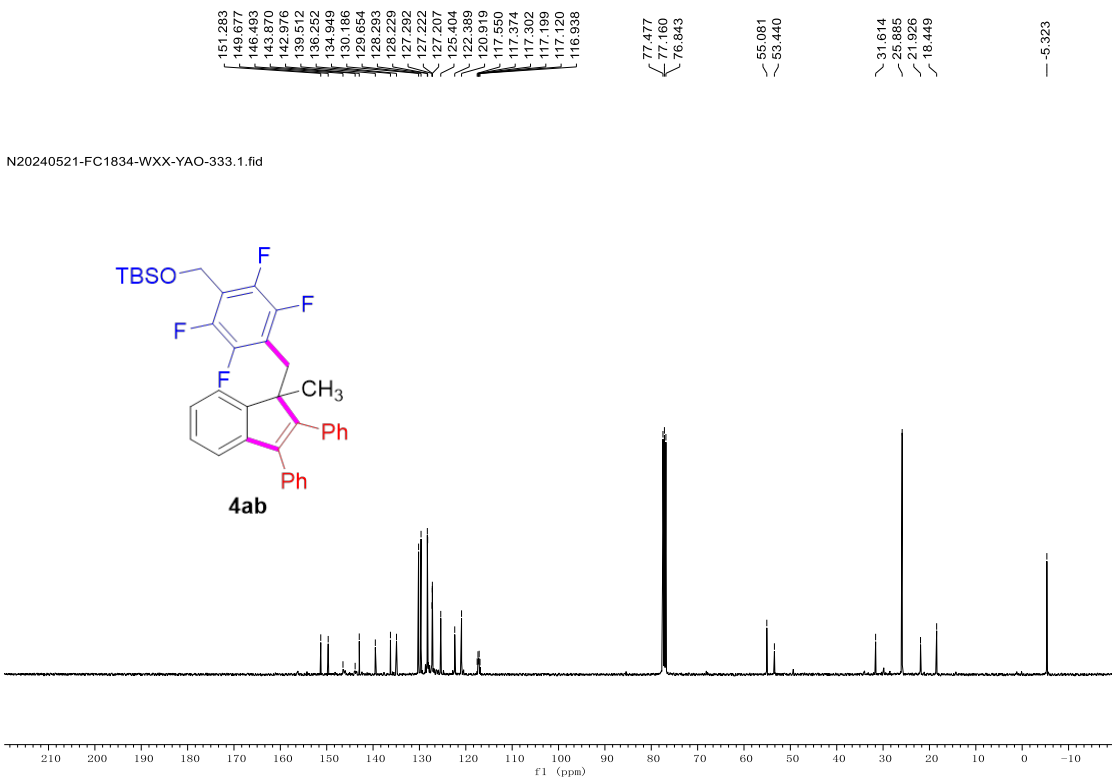
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4aa**



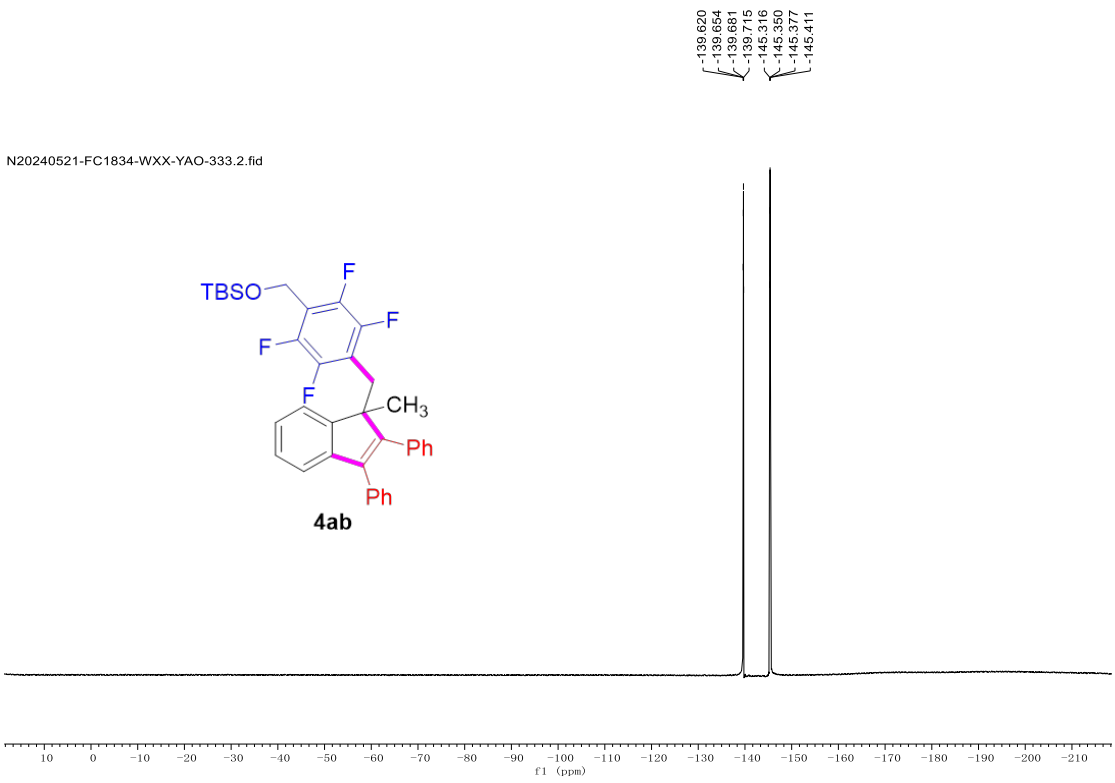
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ab**



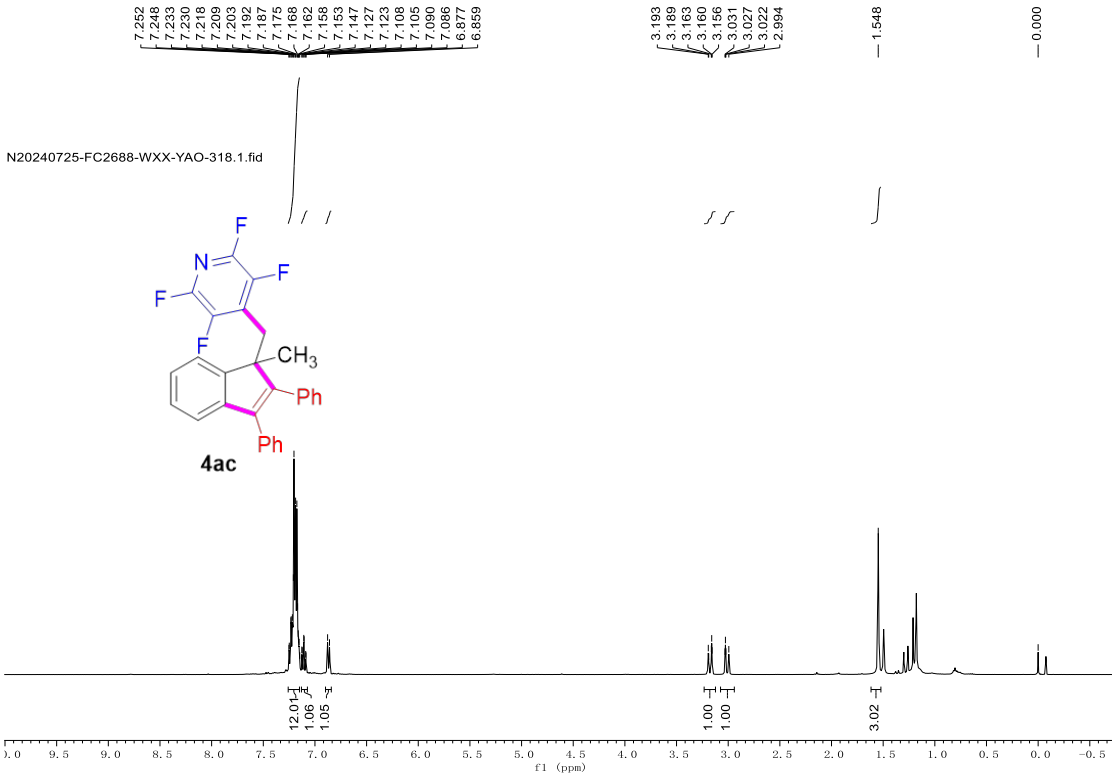
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4ab**



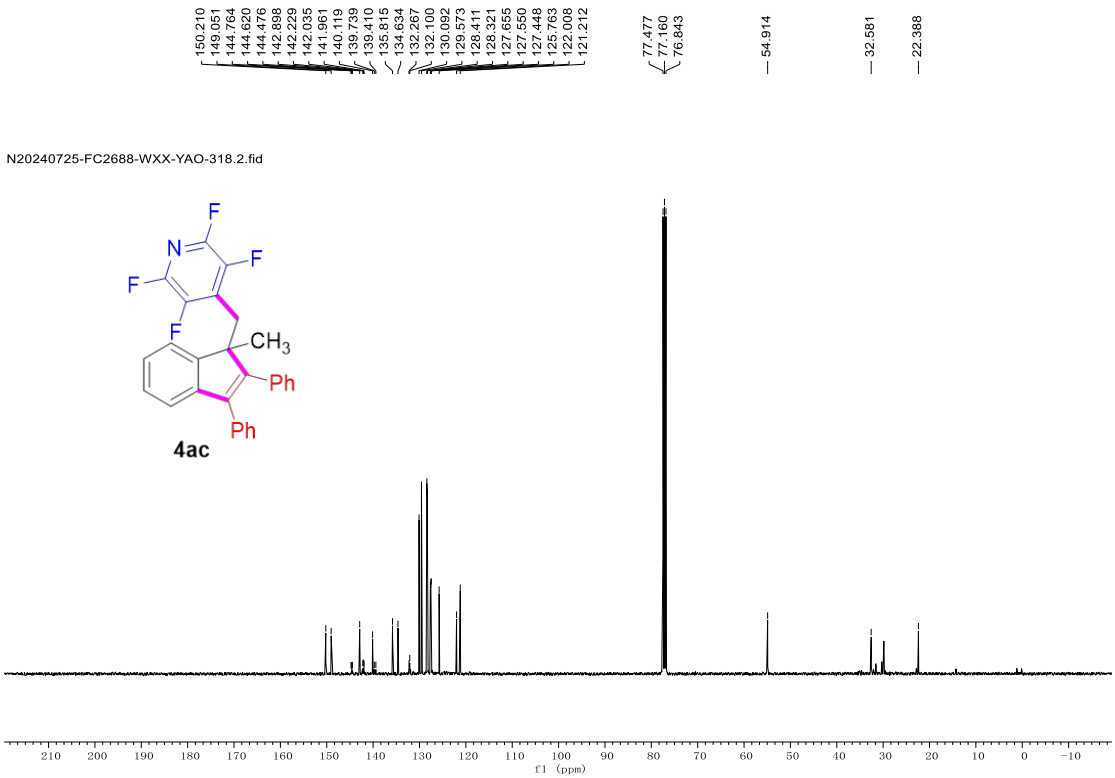
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4ab**



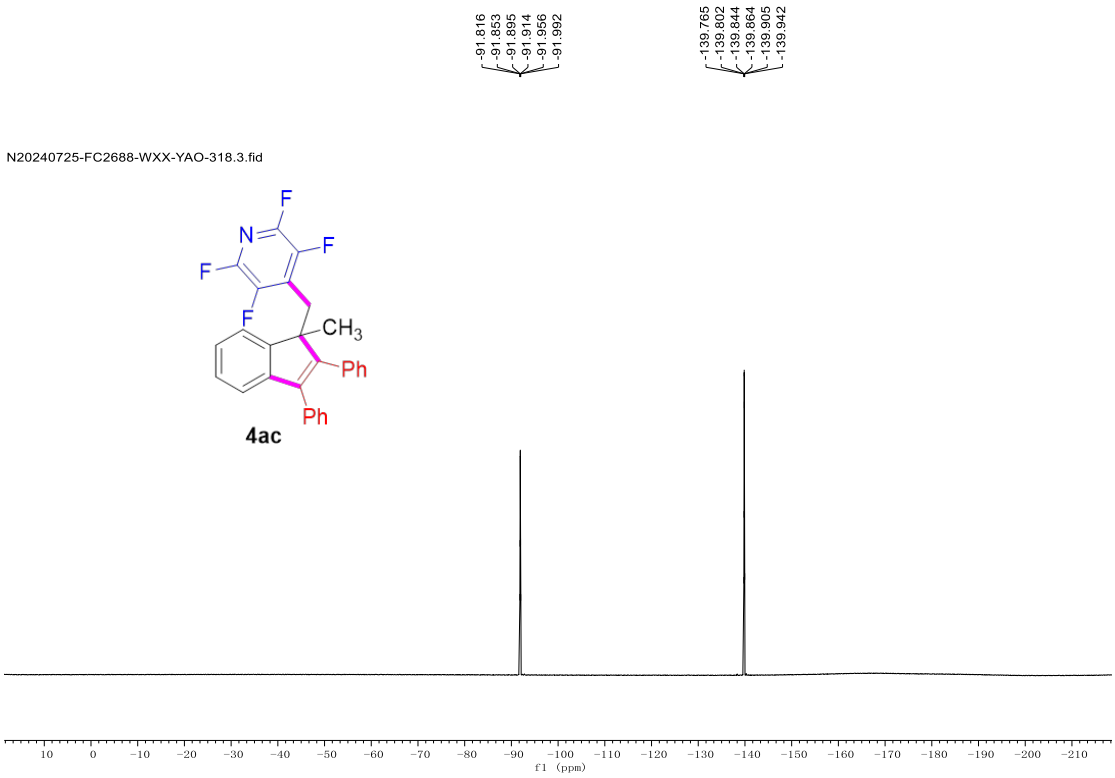
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ac**



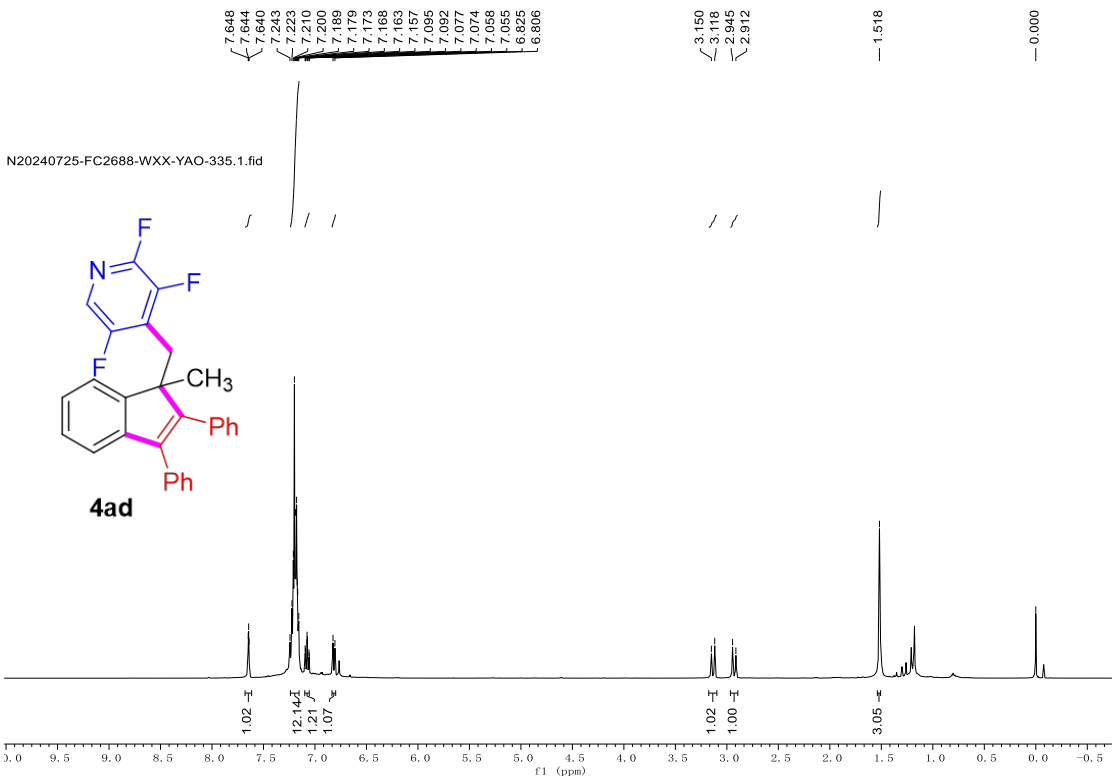
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4ac**



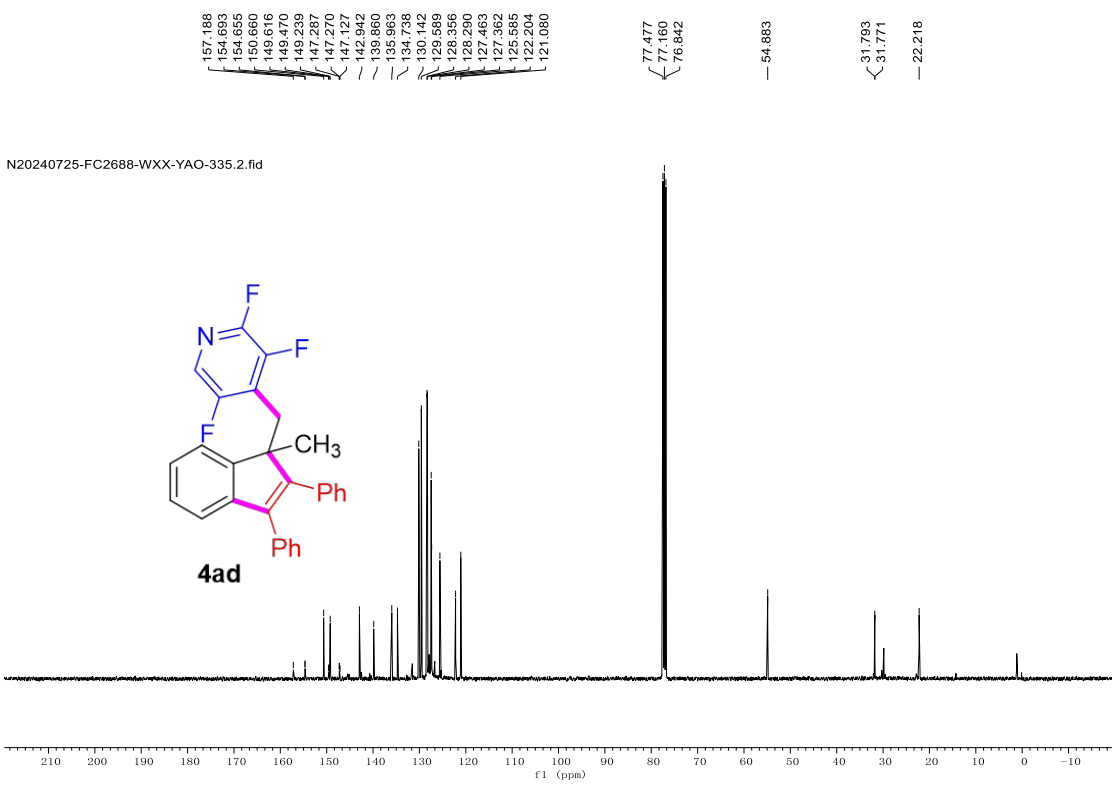
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4ac**



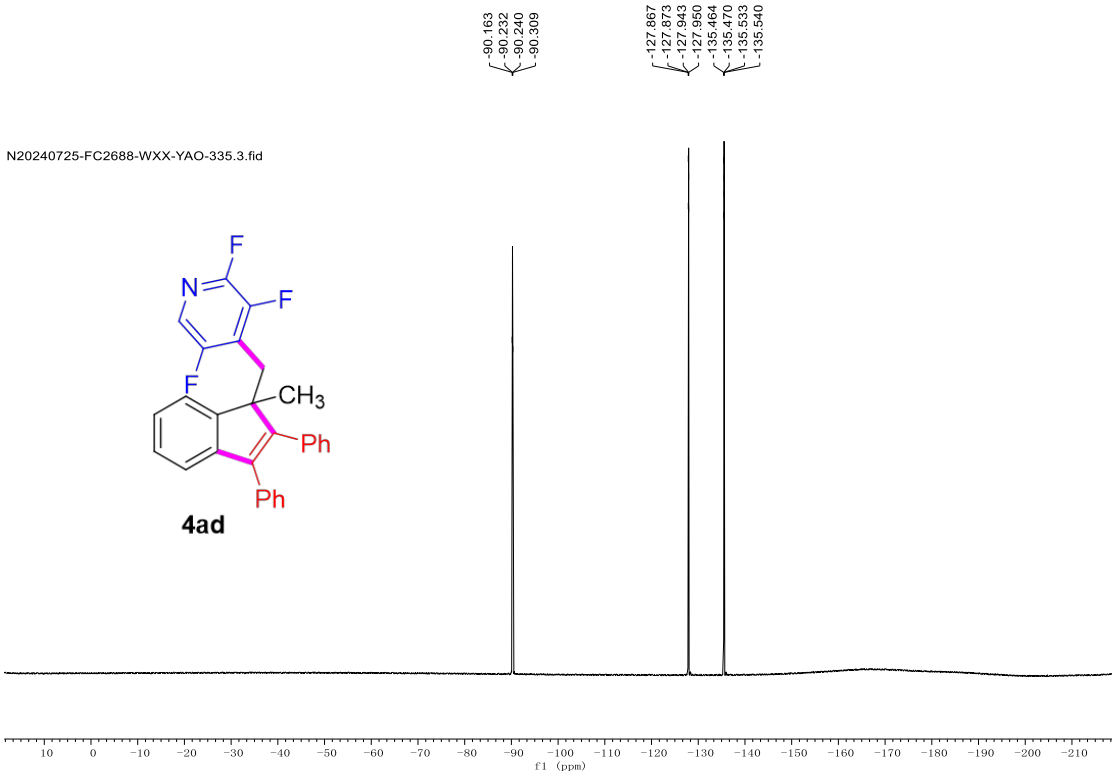
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ad**



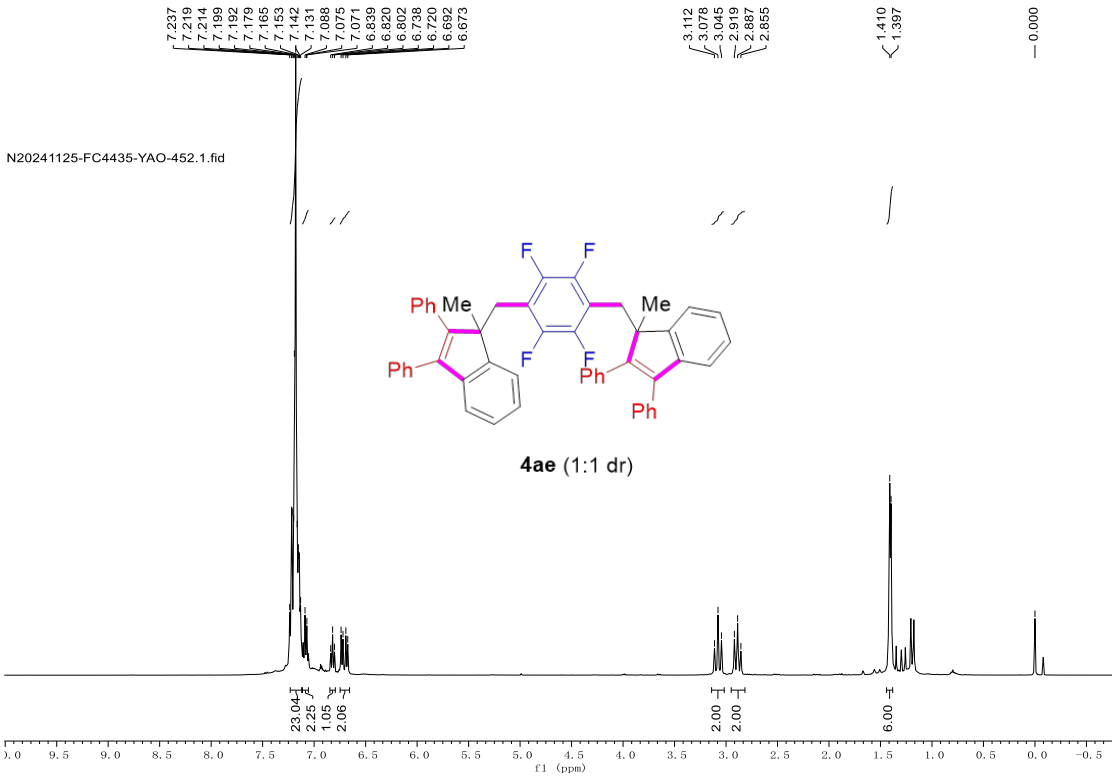
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4ad**



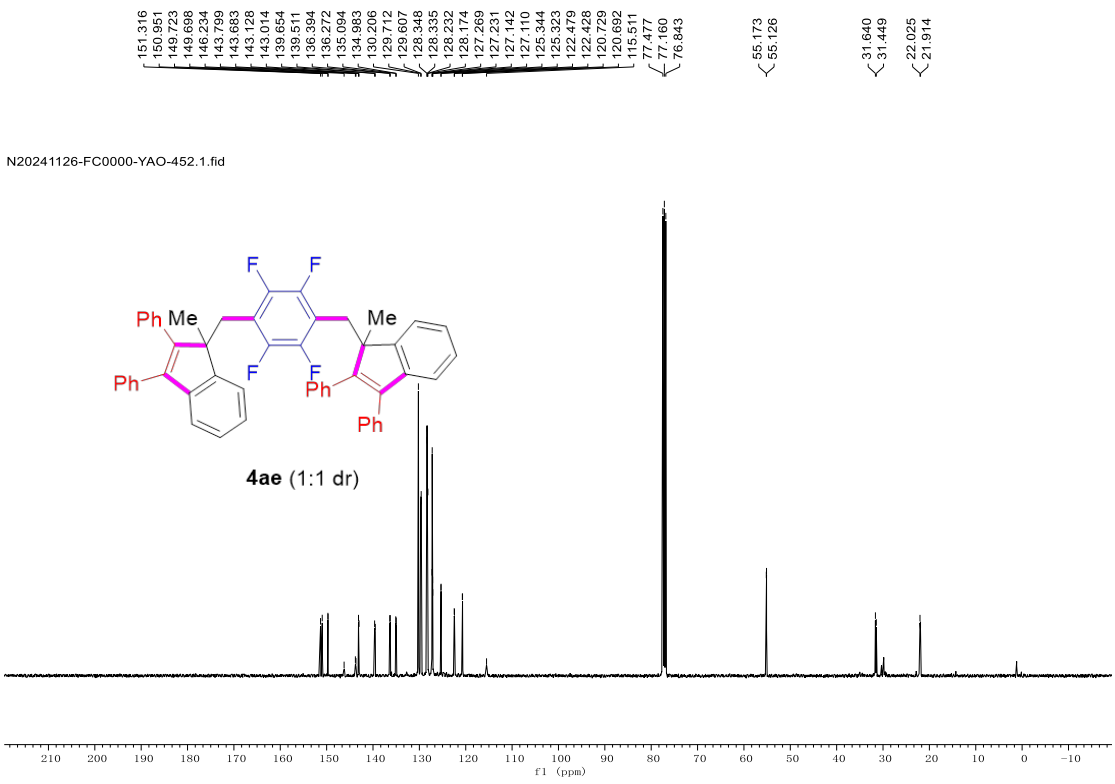
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4ad**



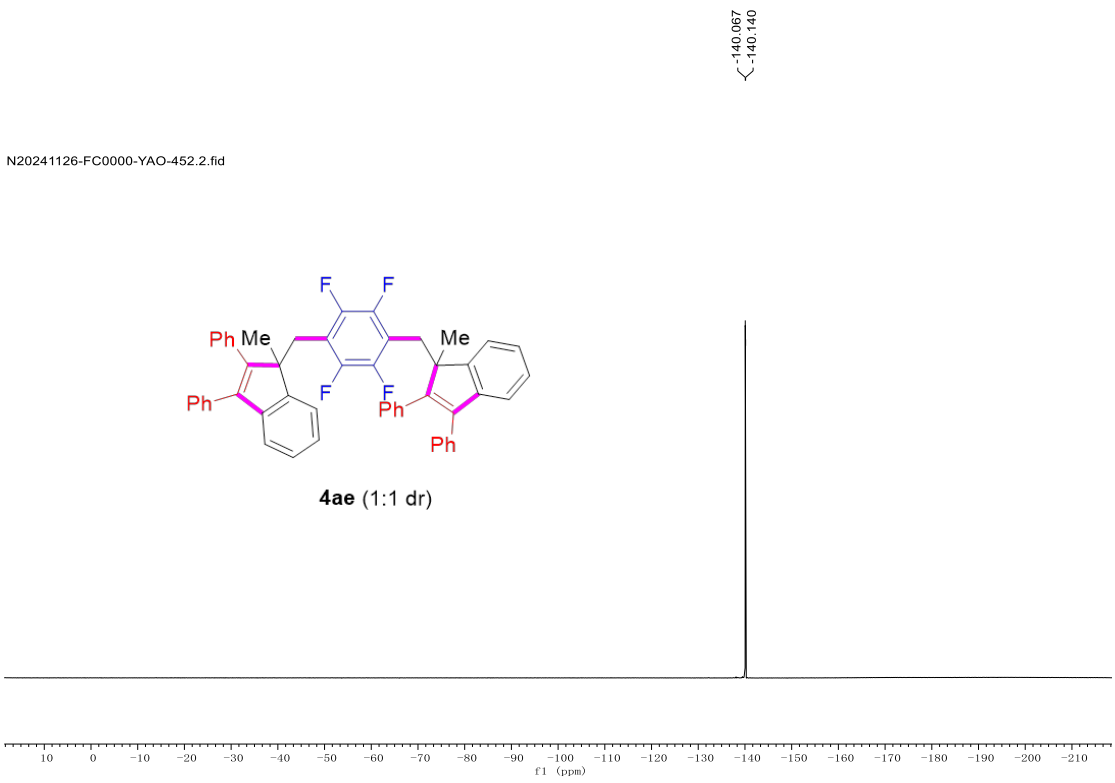
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ae**



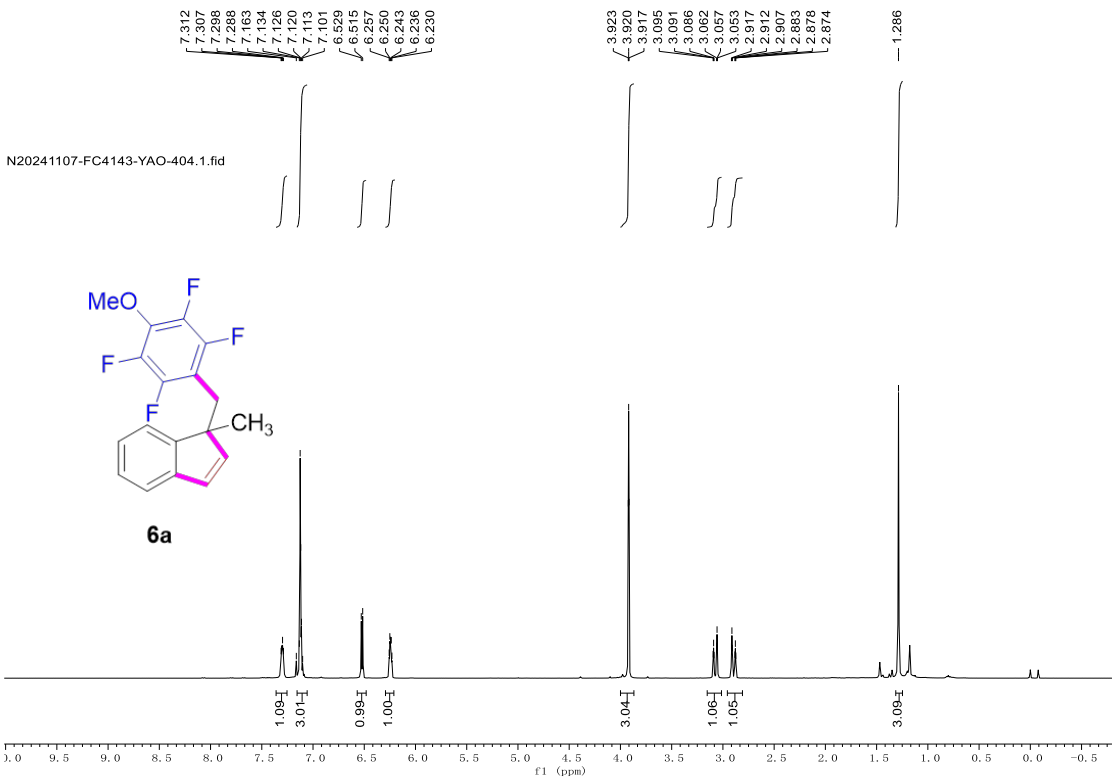
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **4ae**



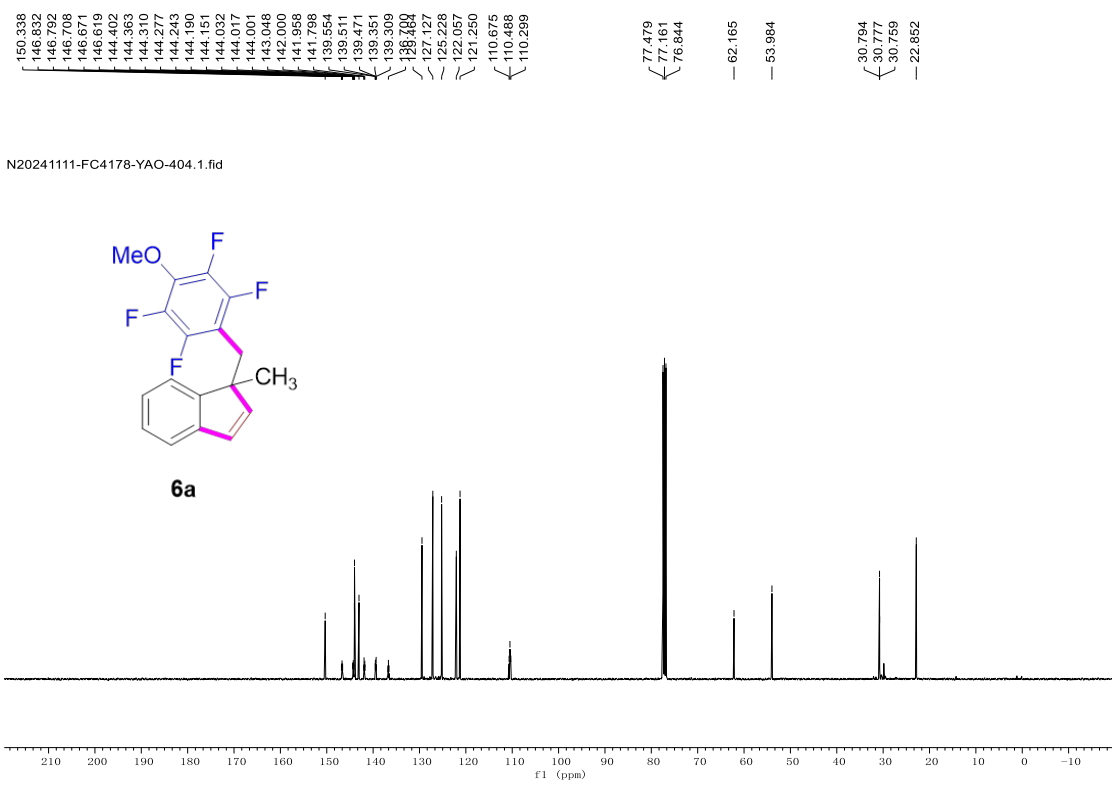
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4ae**



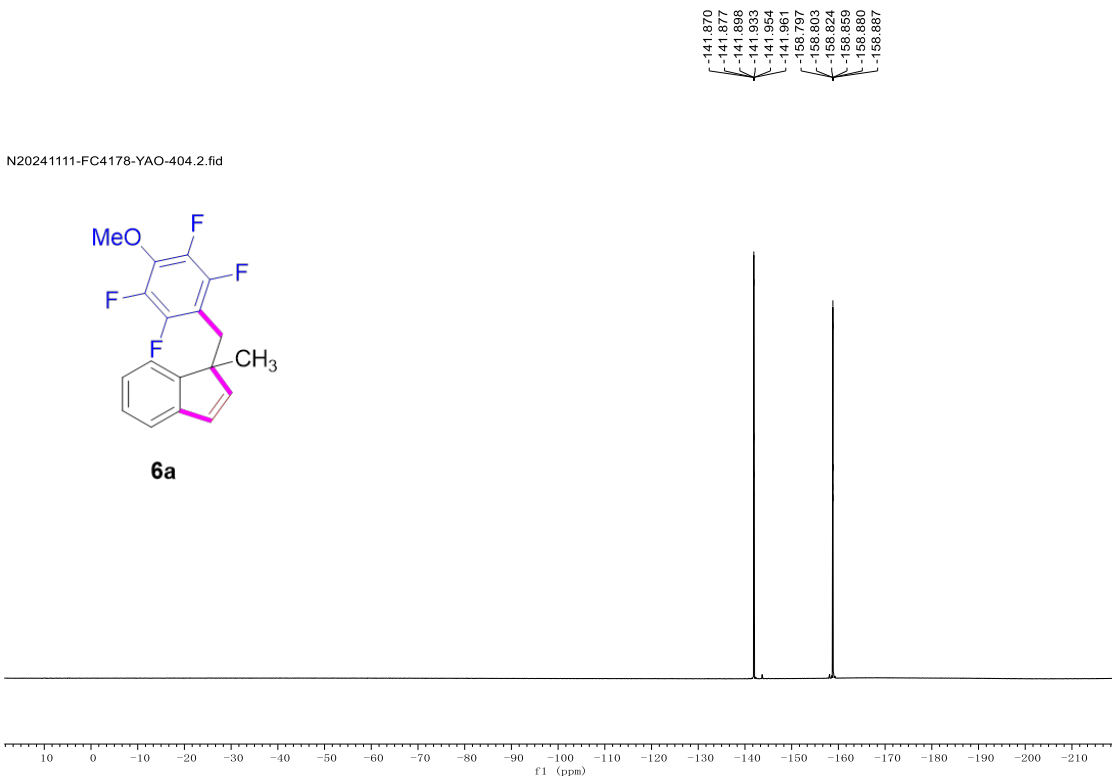
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6a**



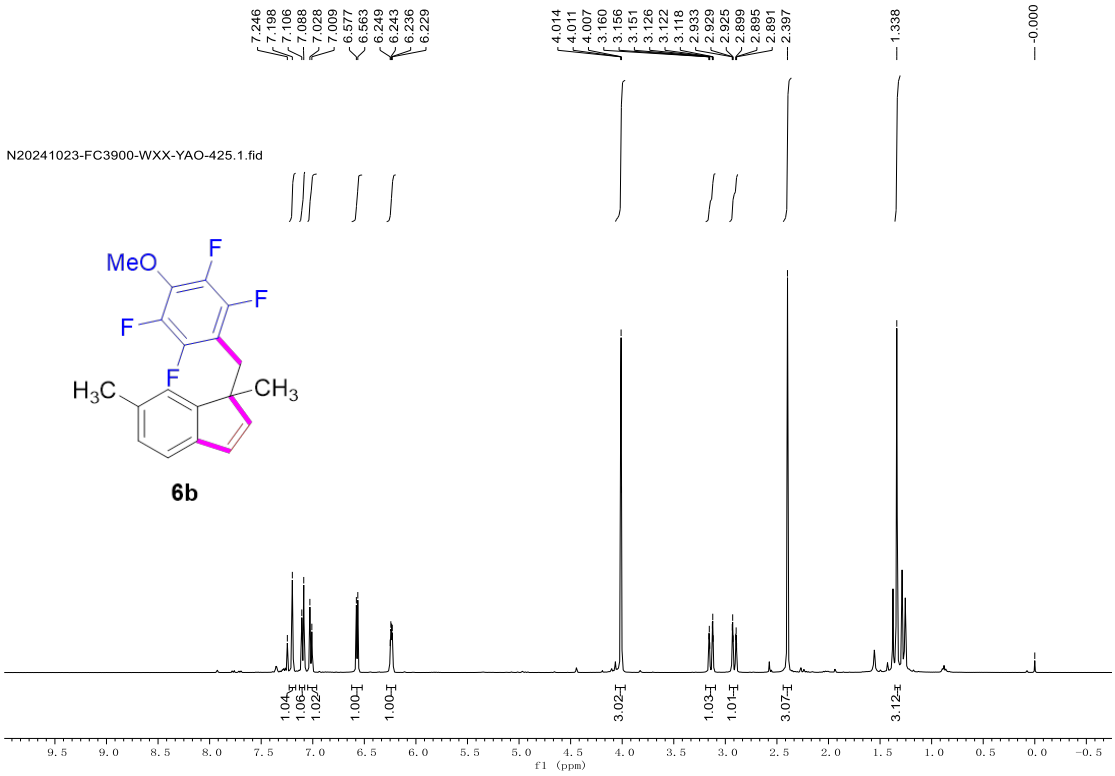
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6a**



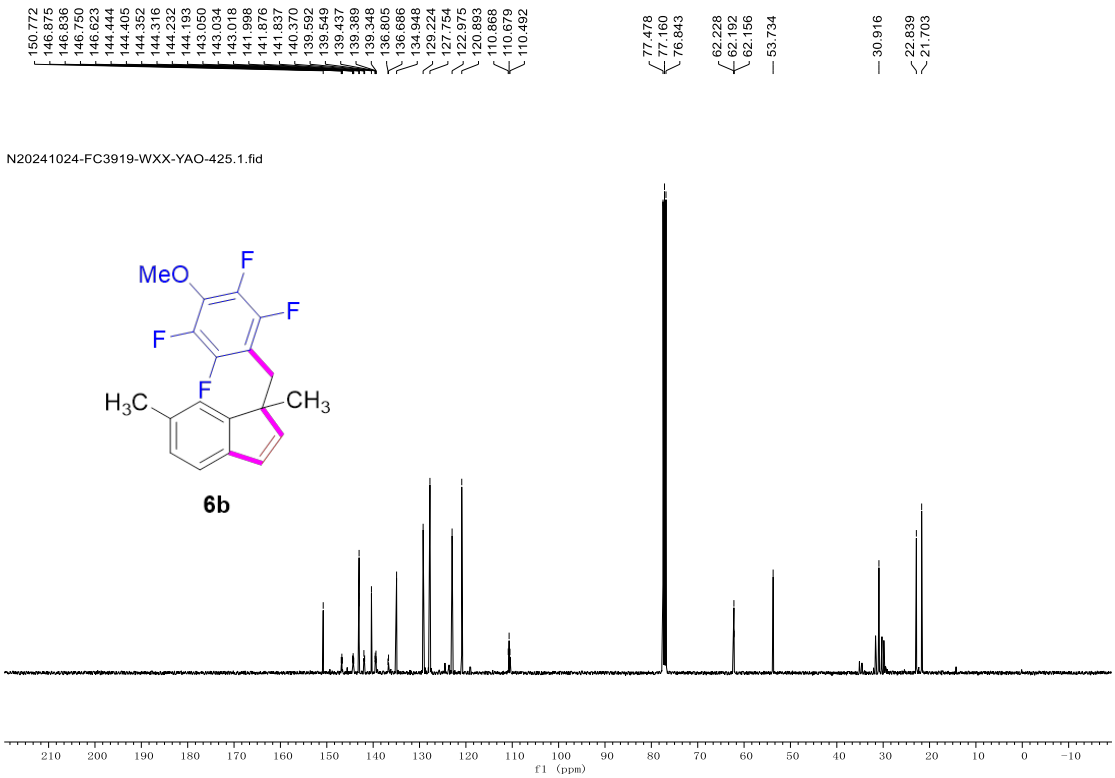
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6a**



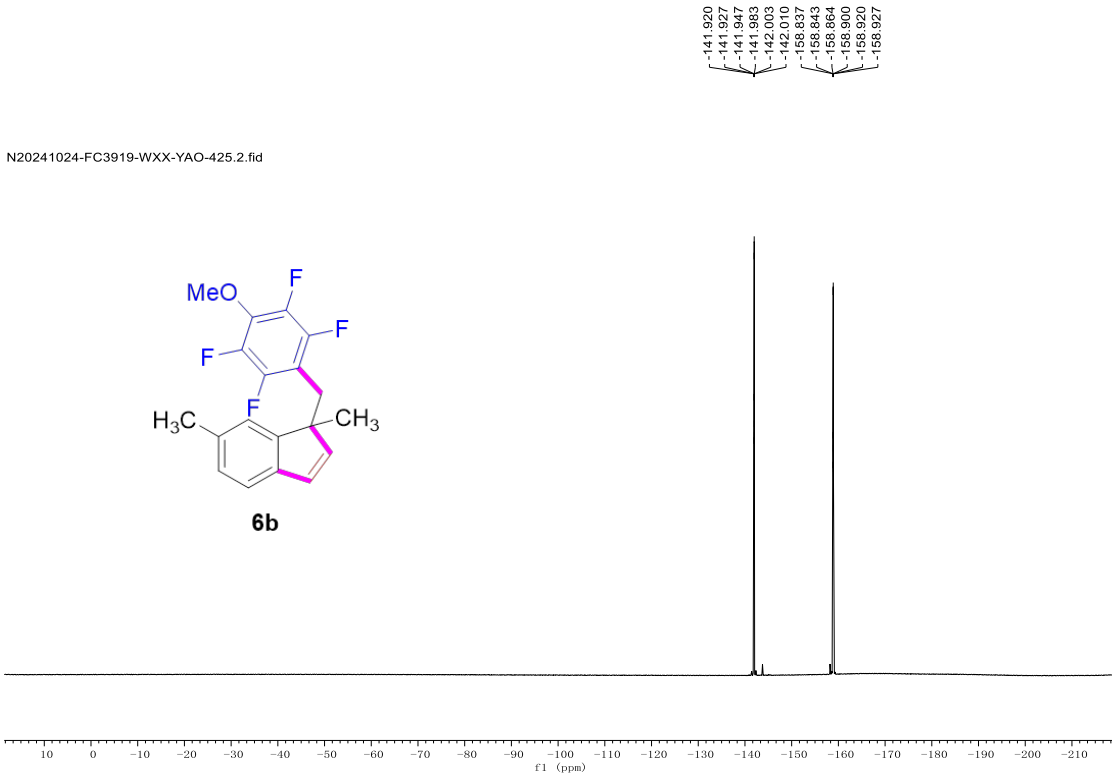
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6b**



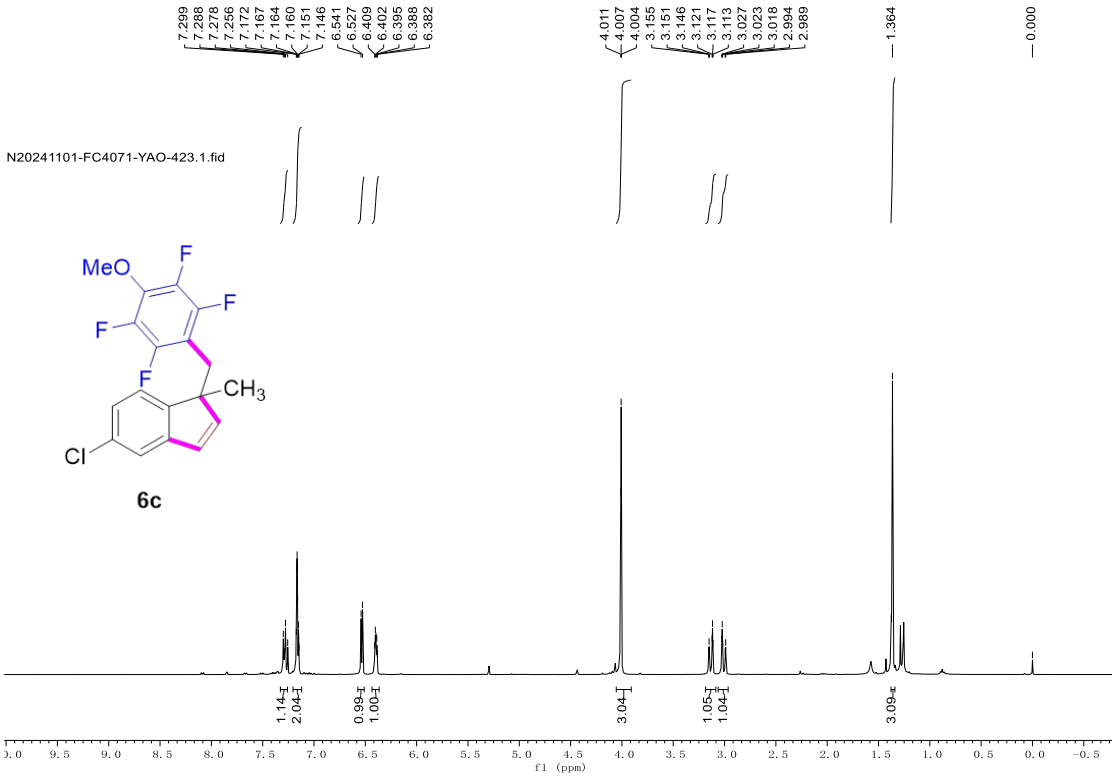
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6b**



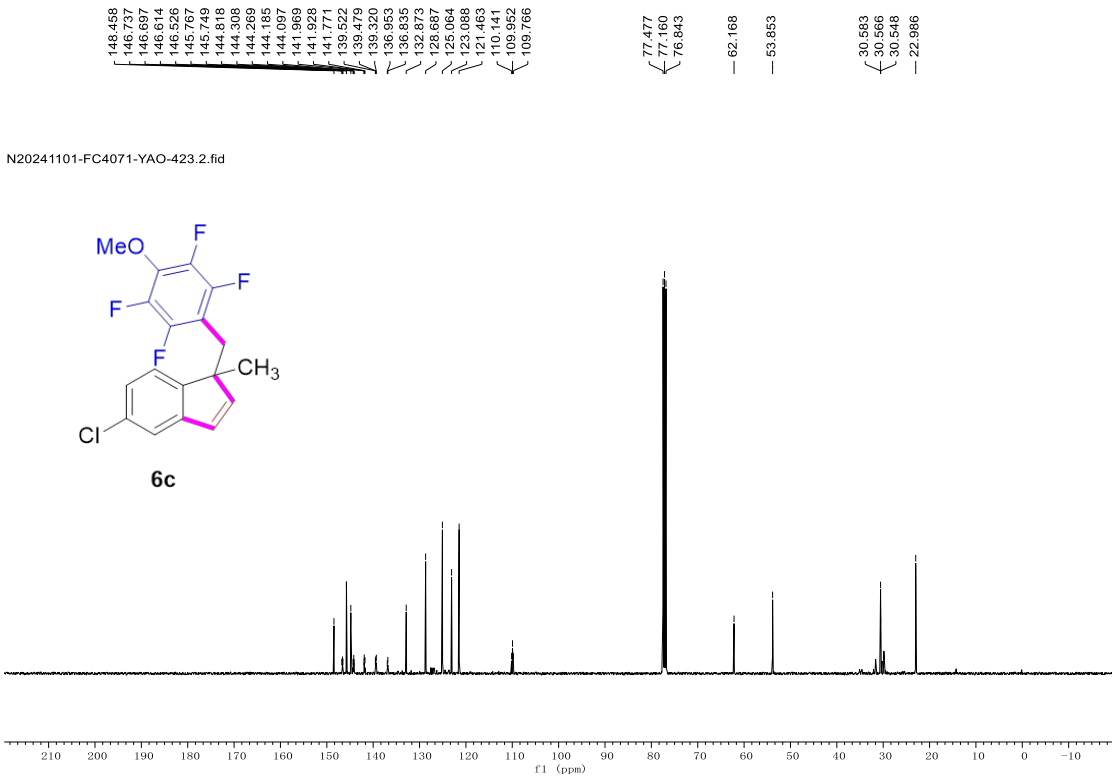
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6b**



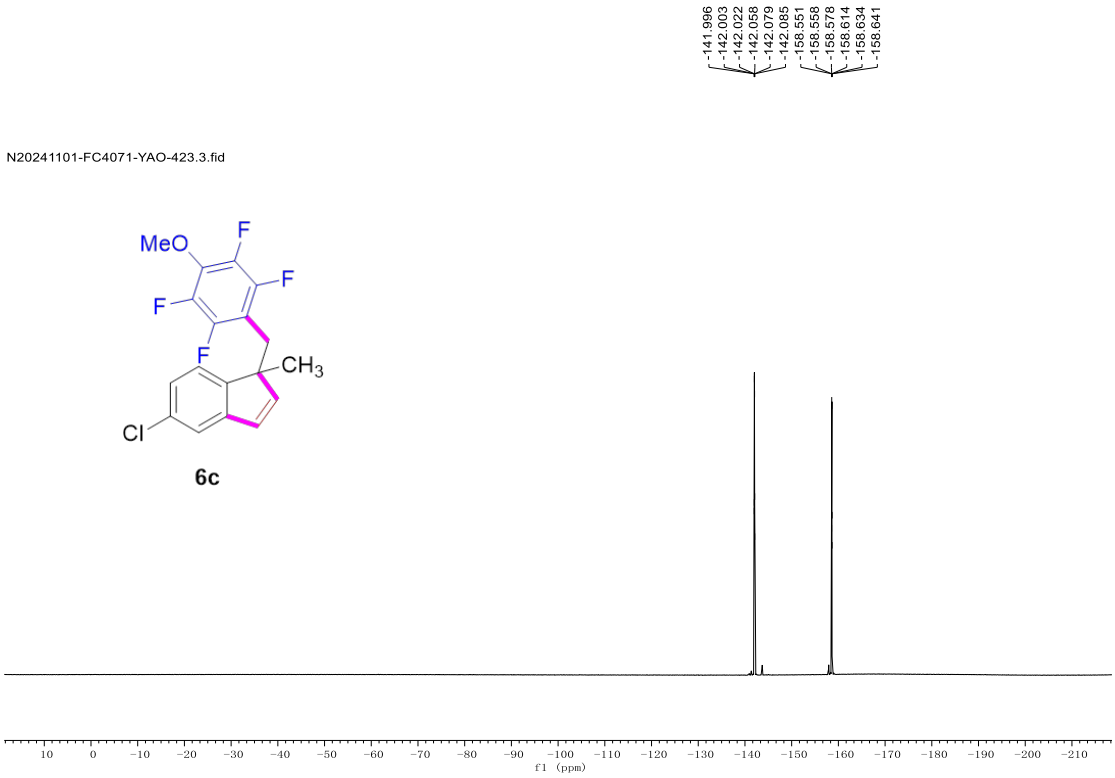
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6c**



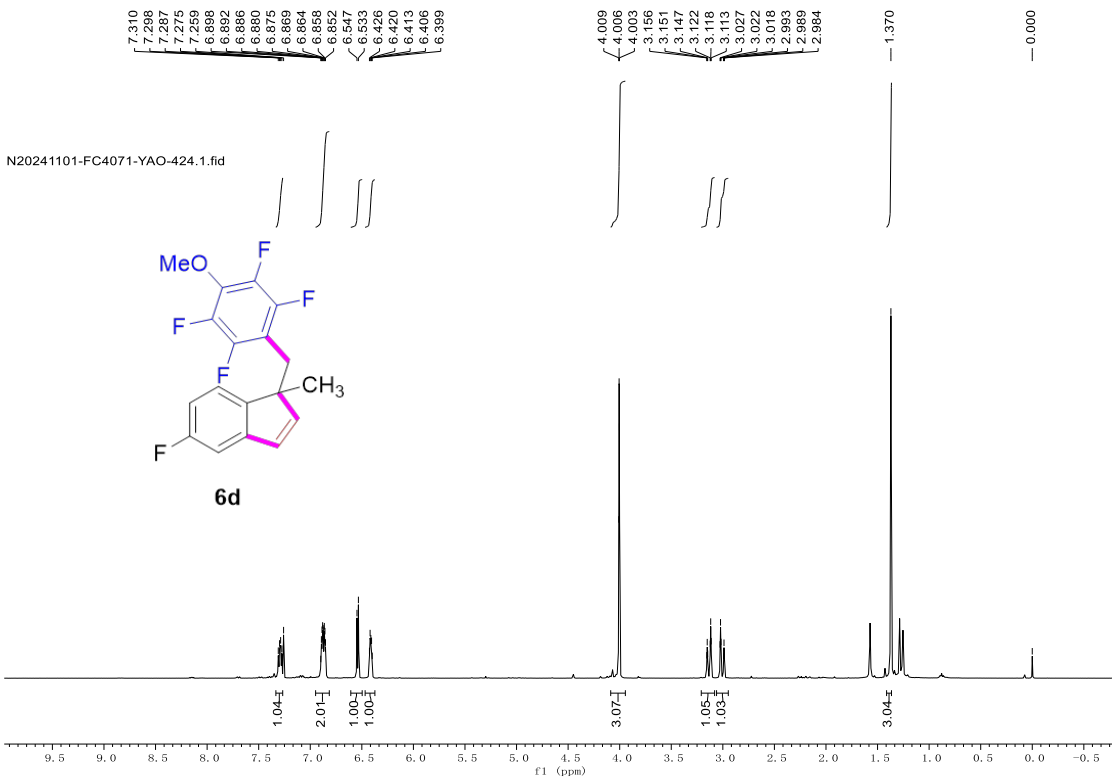
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6c**



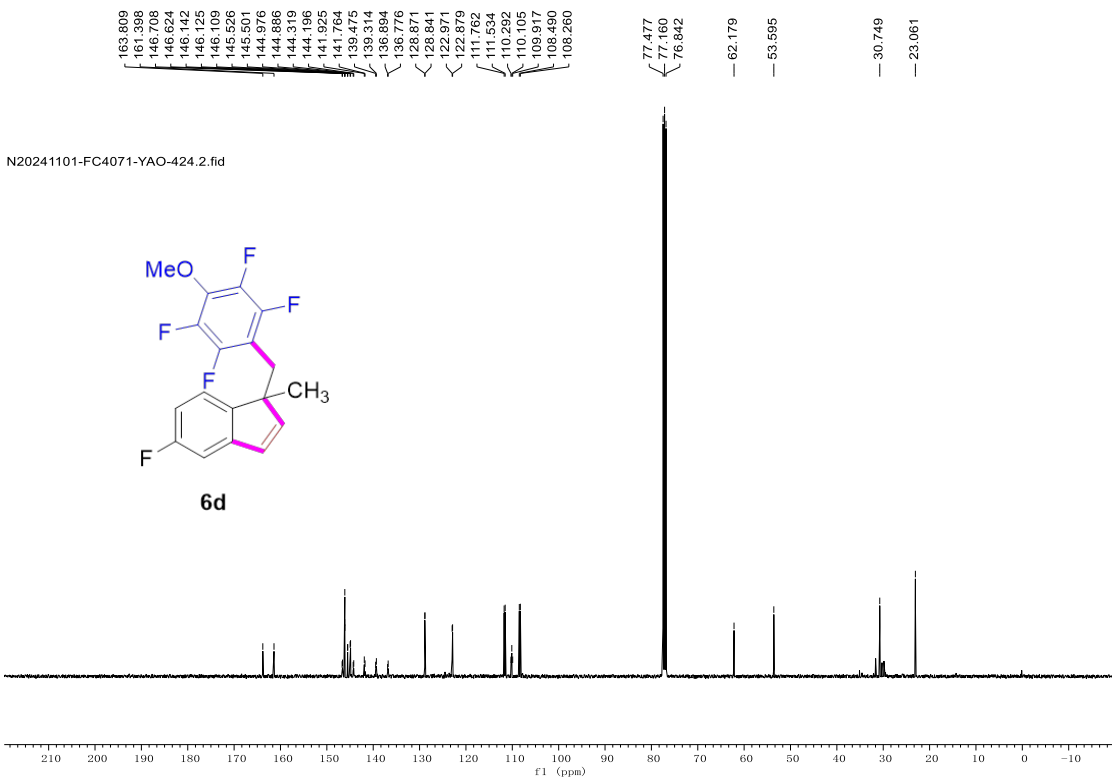
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6c**



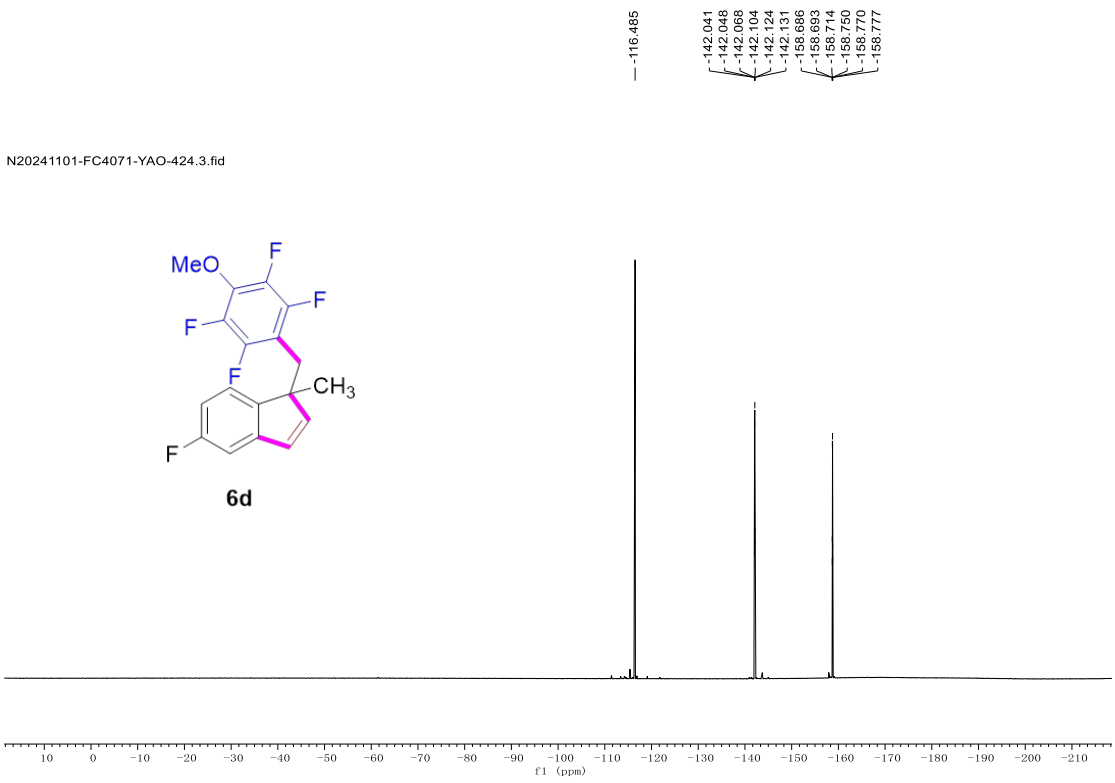
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6d**



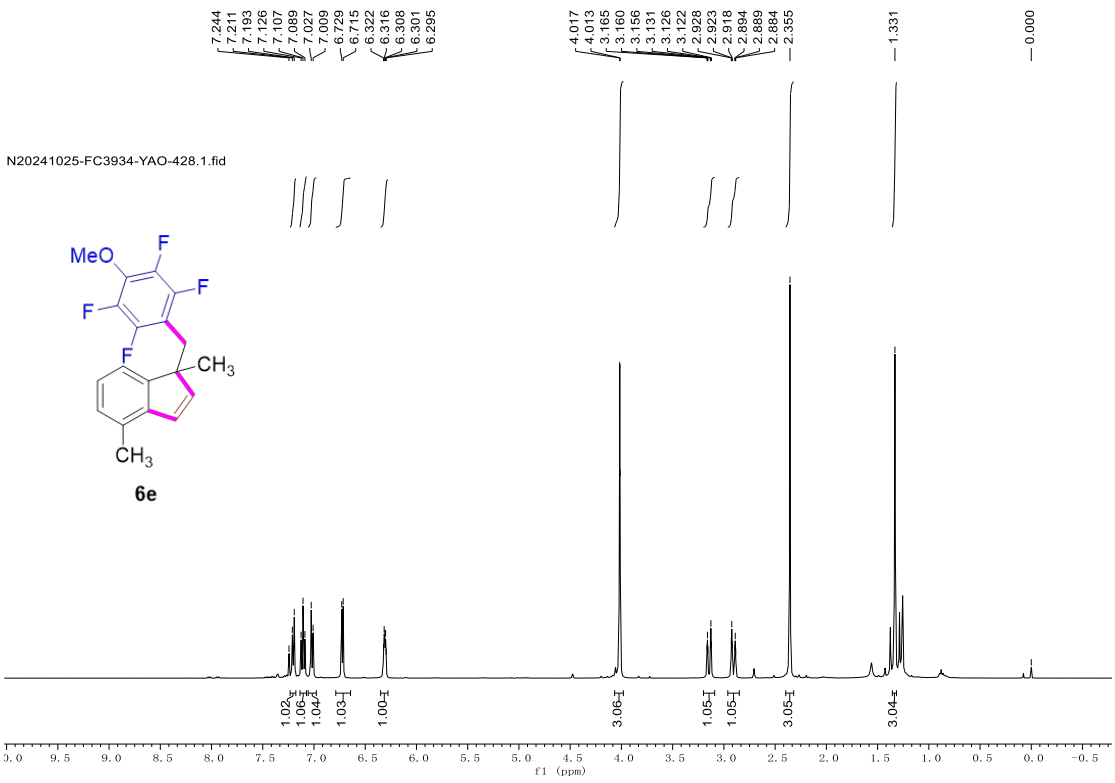
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6d**



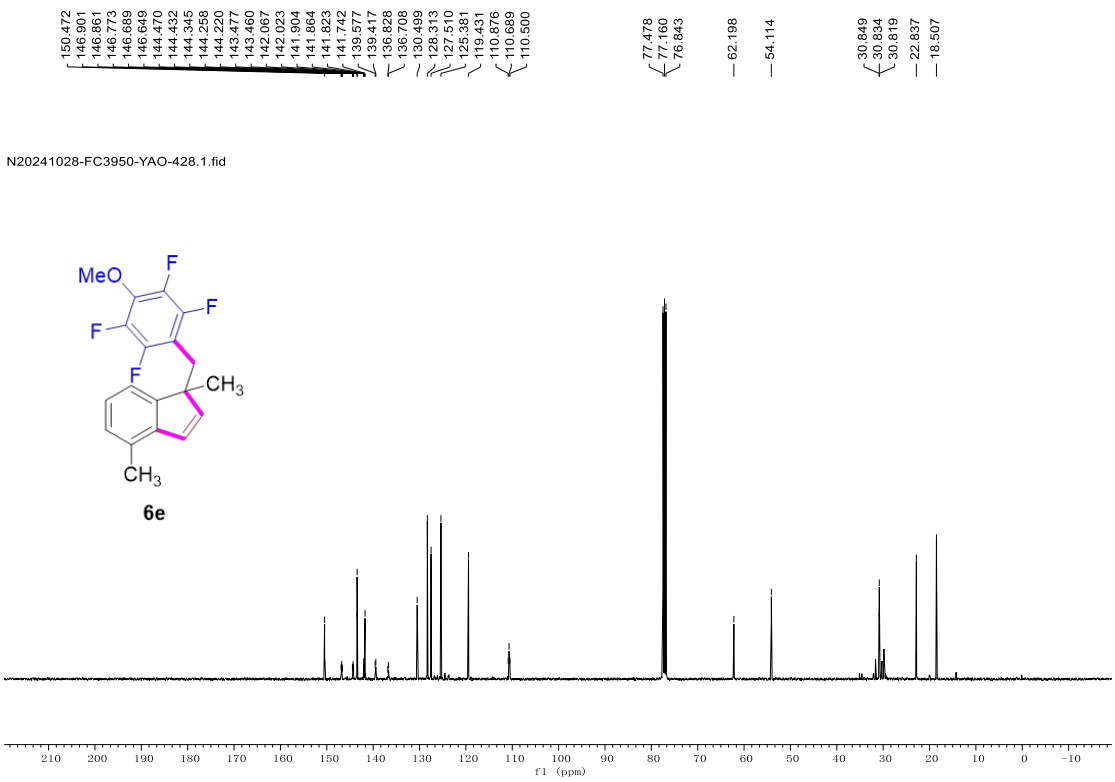
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6d**



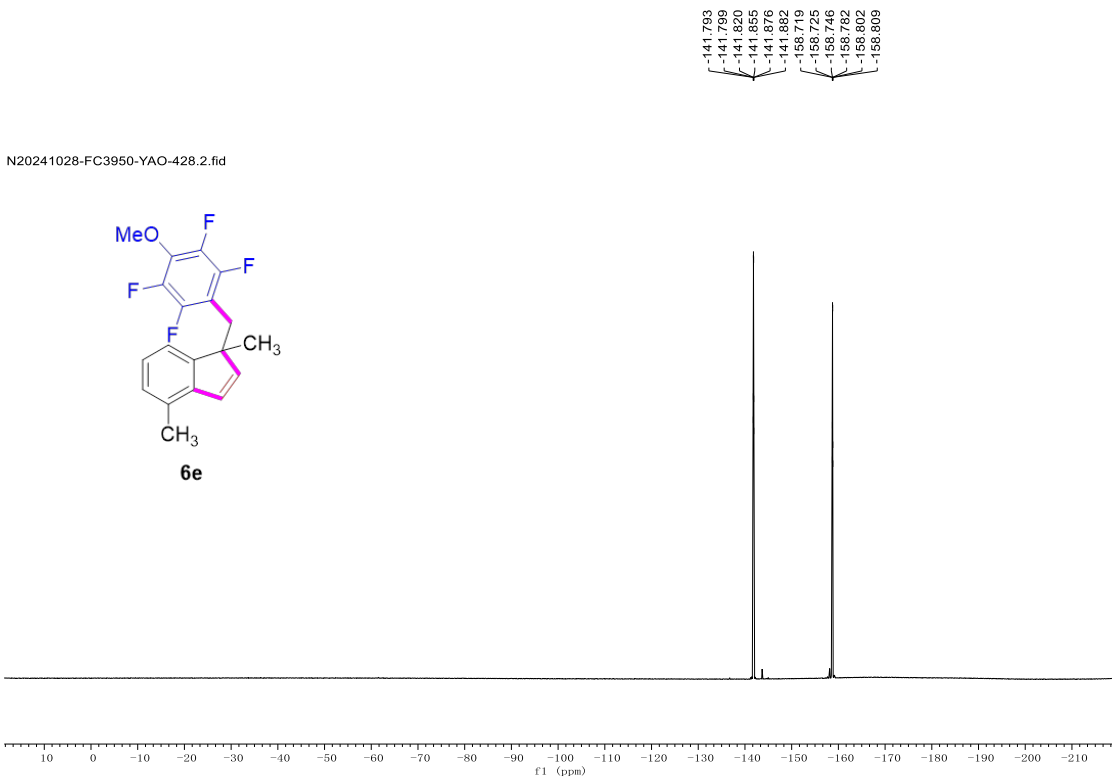
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6e**



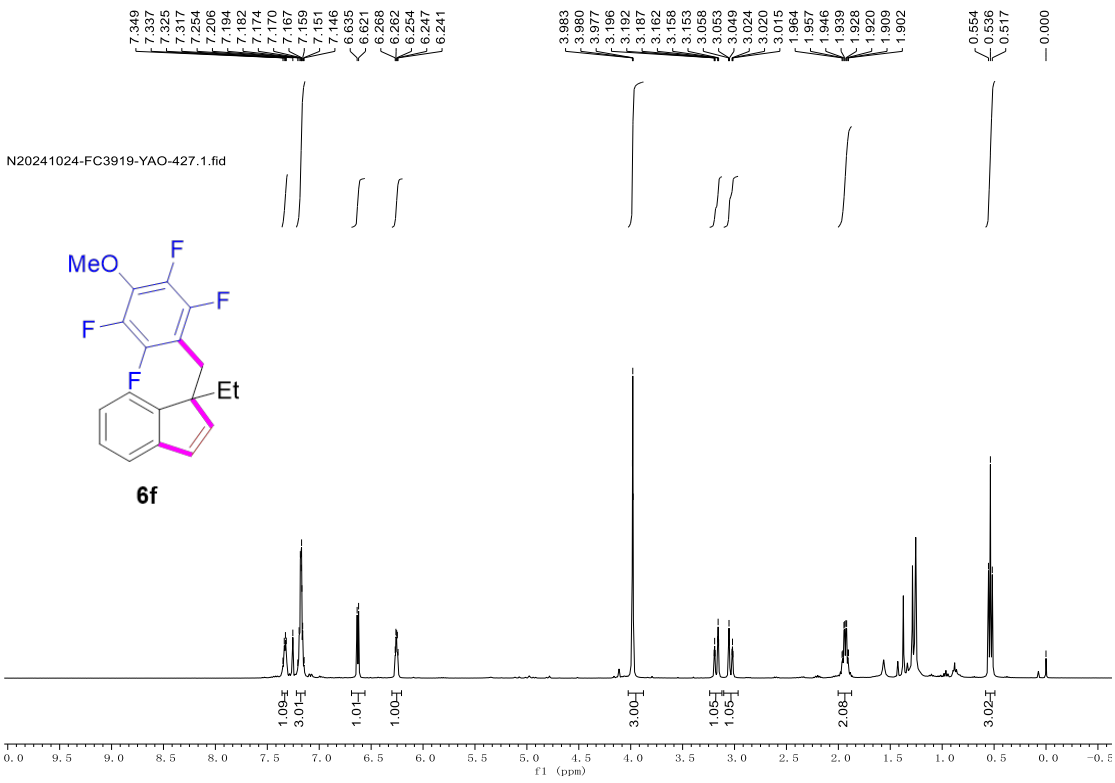
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6e**



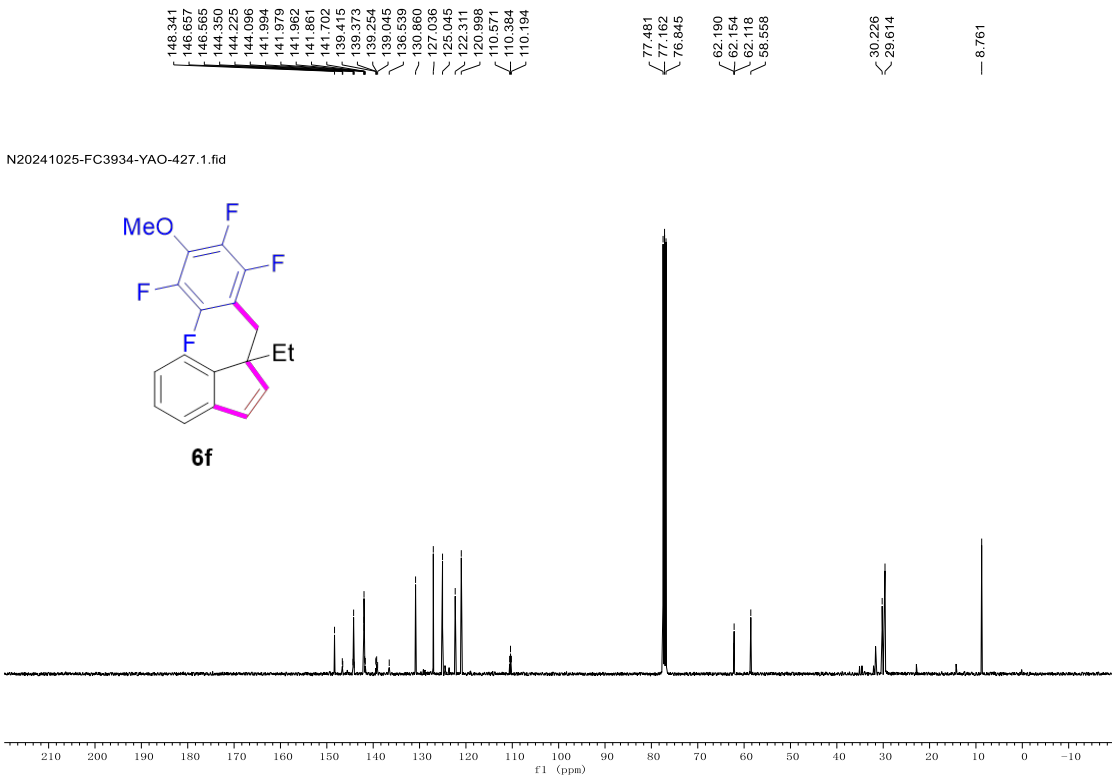
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6e**



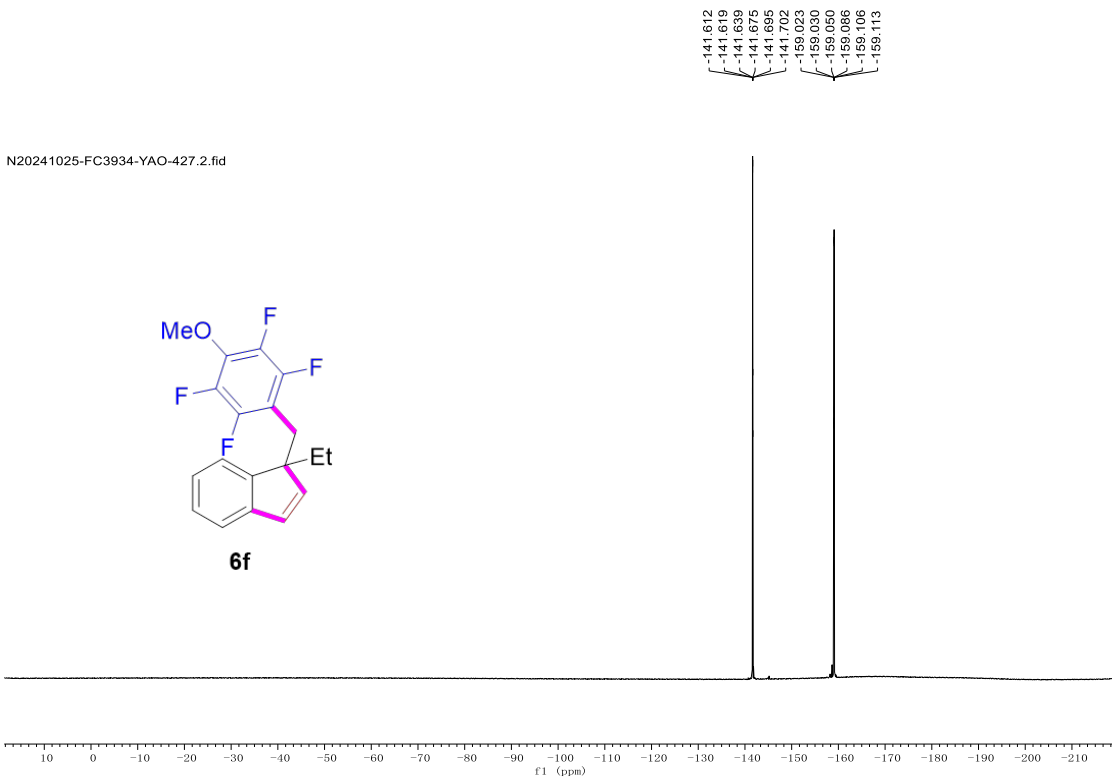
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6f**



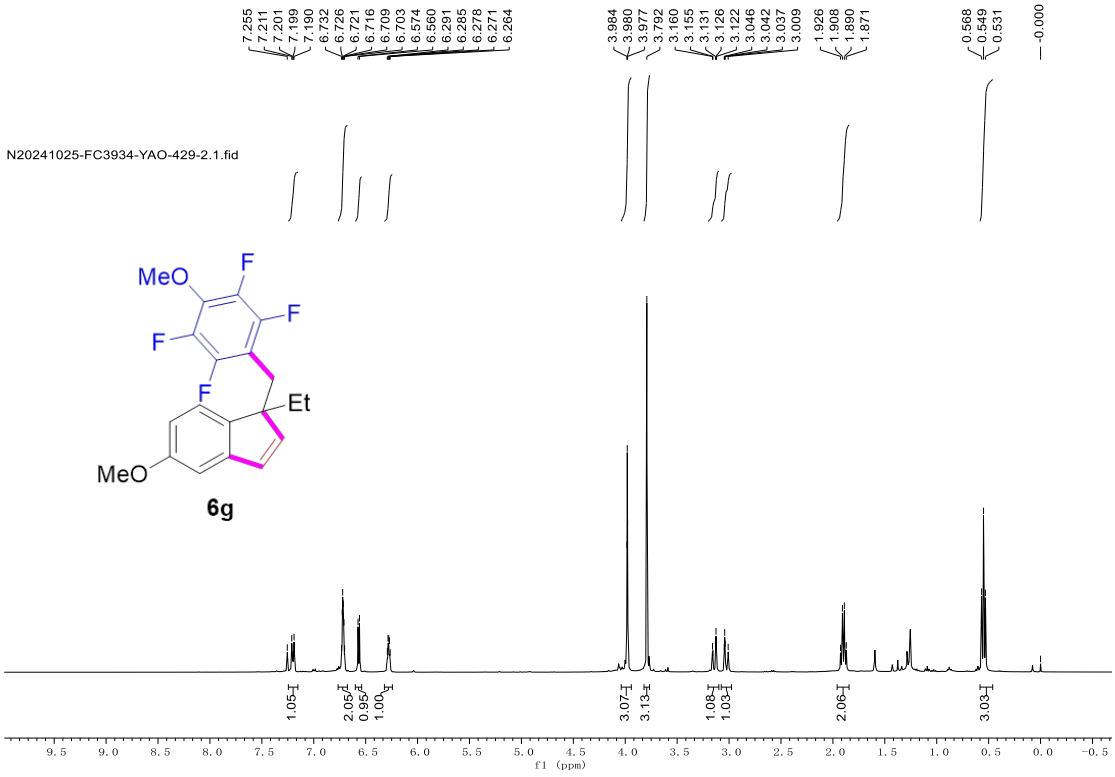
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6f**



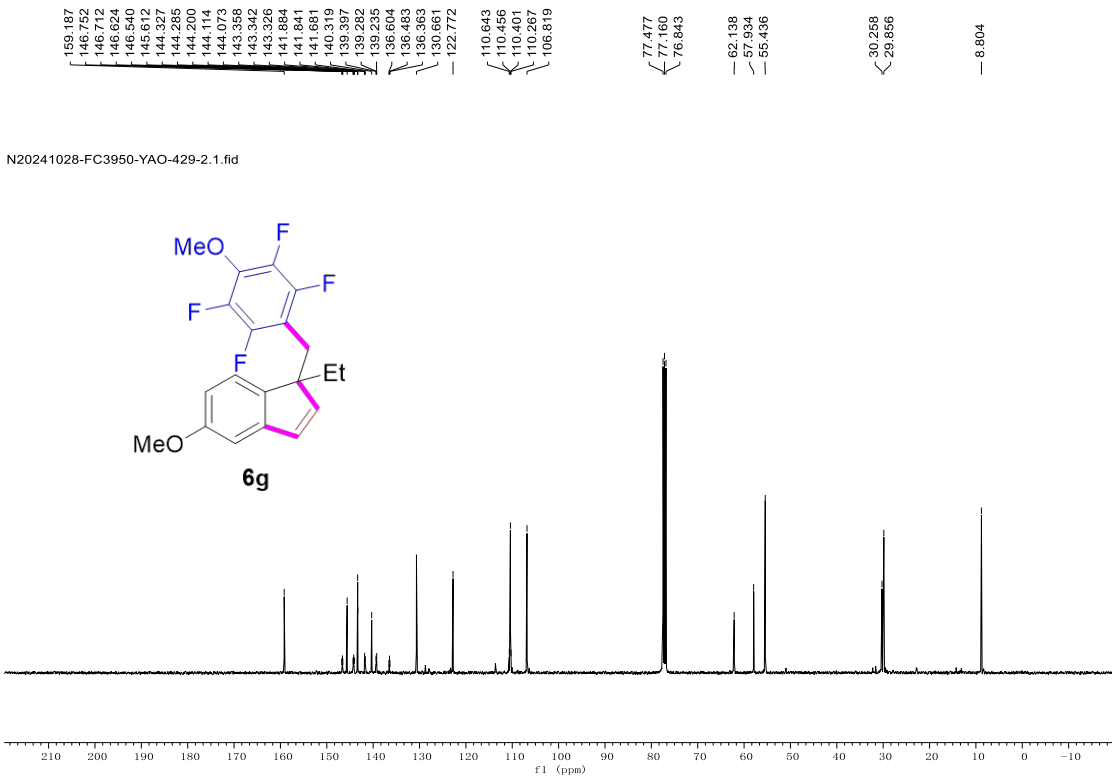
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6f**



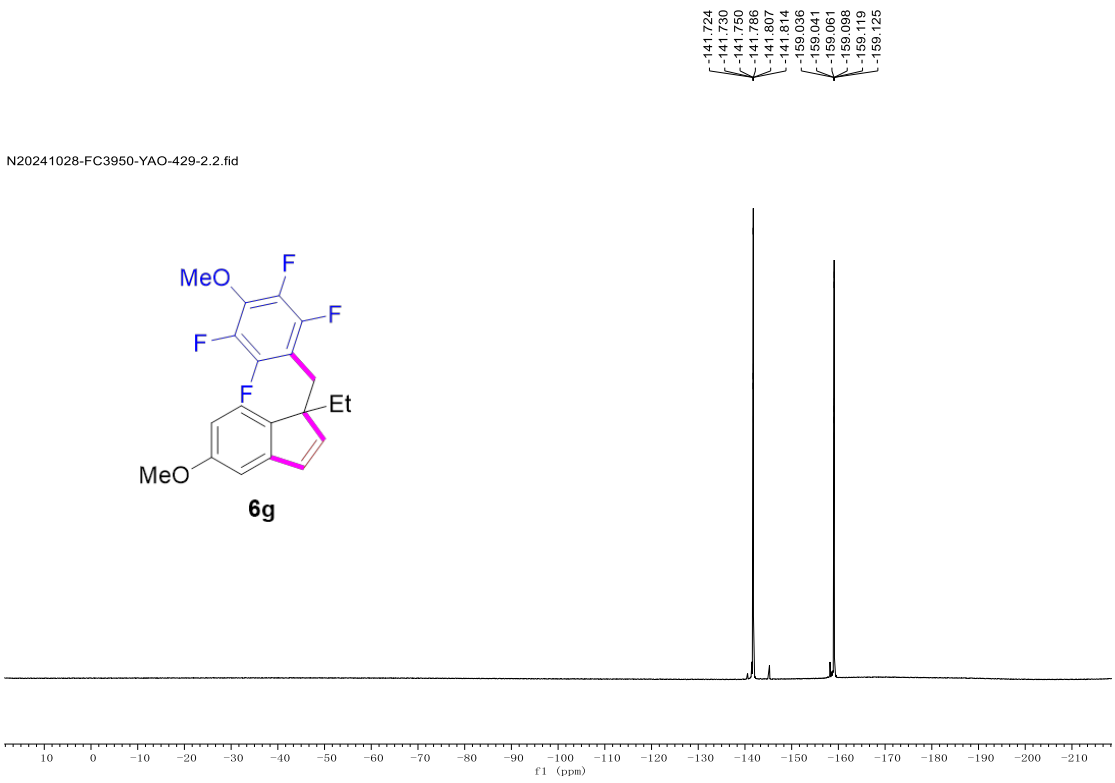
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6g**



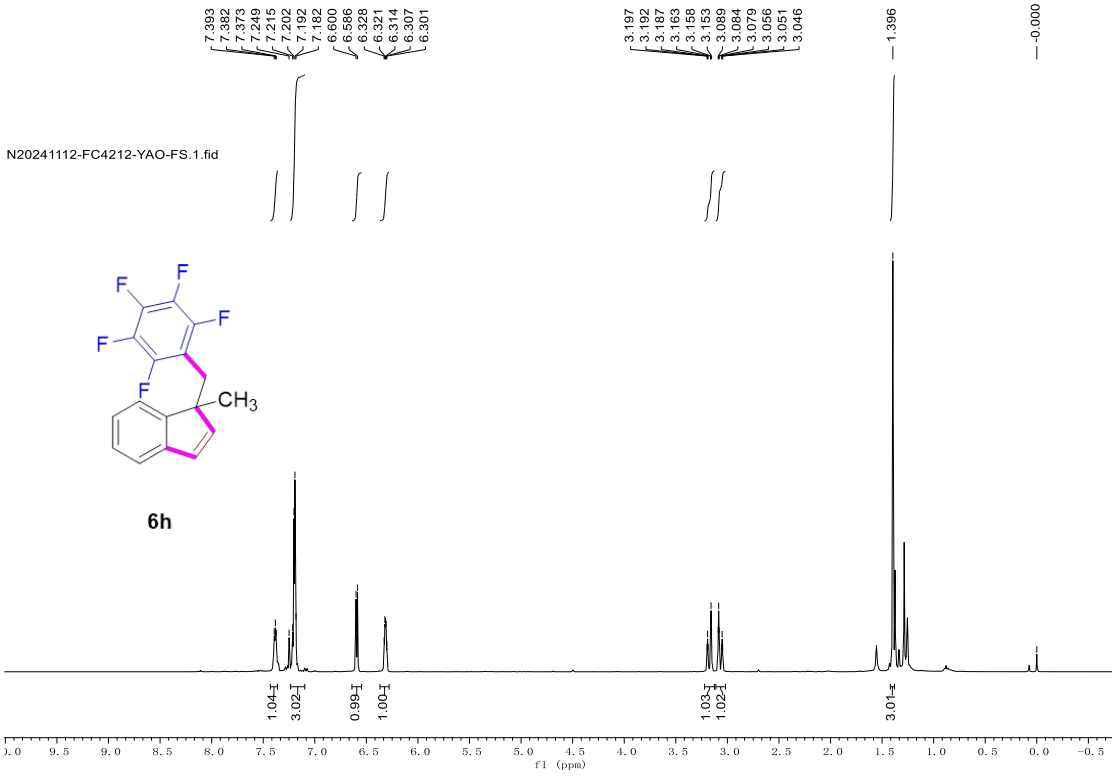
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6g**



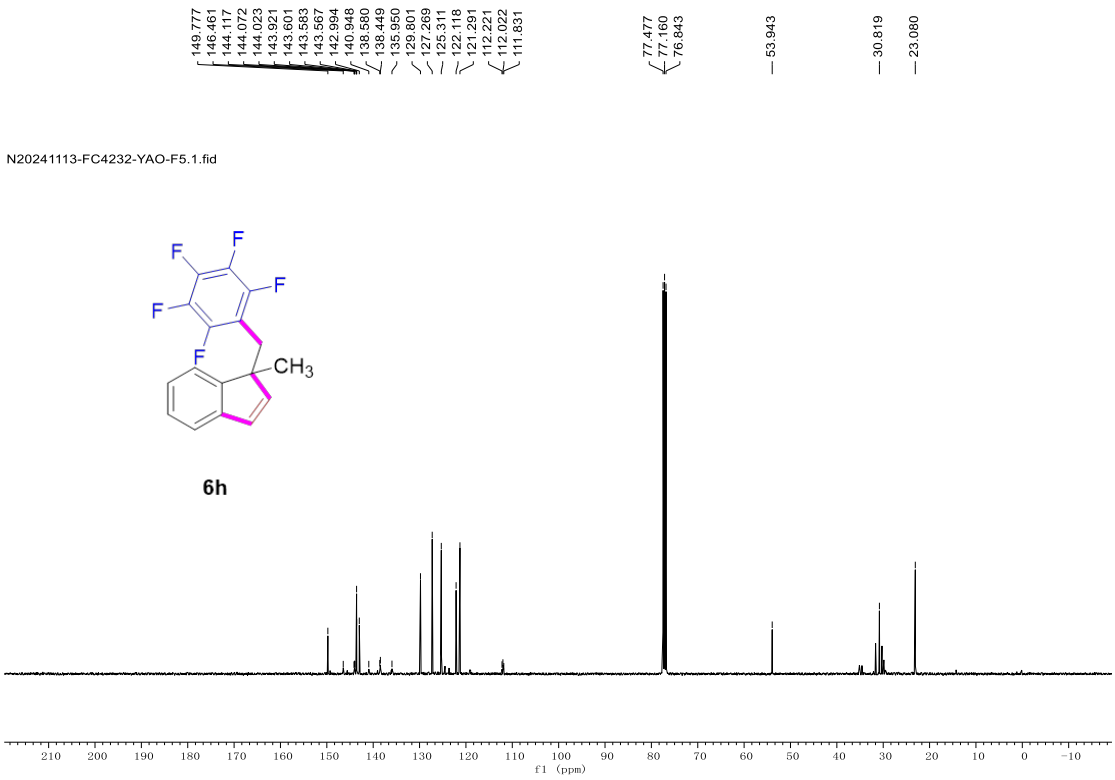
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6g**



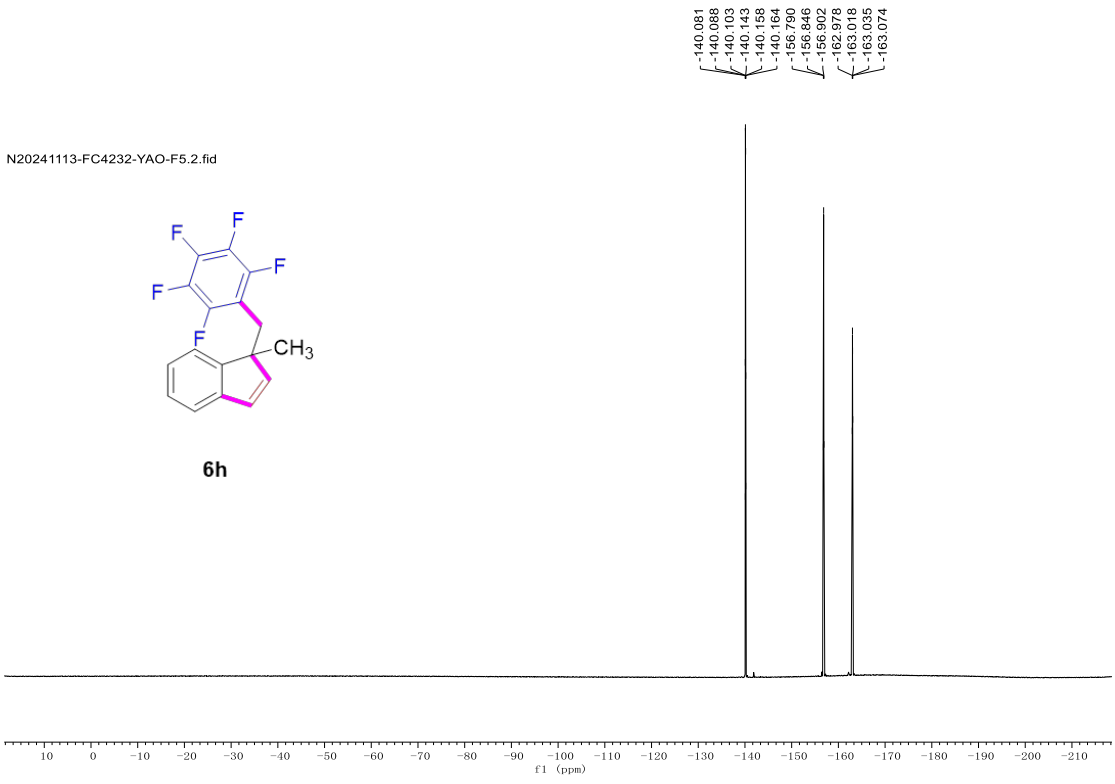
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6h**



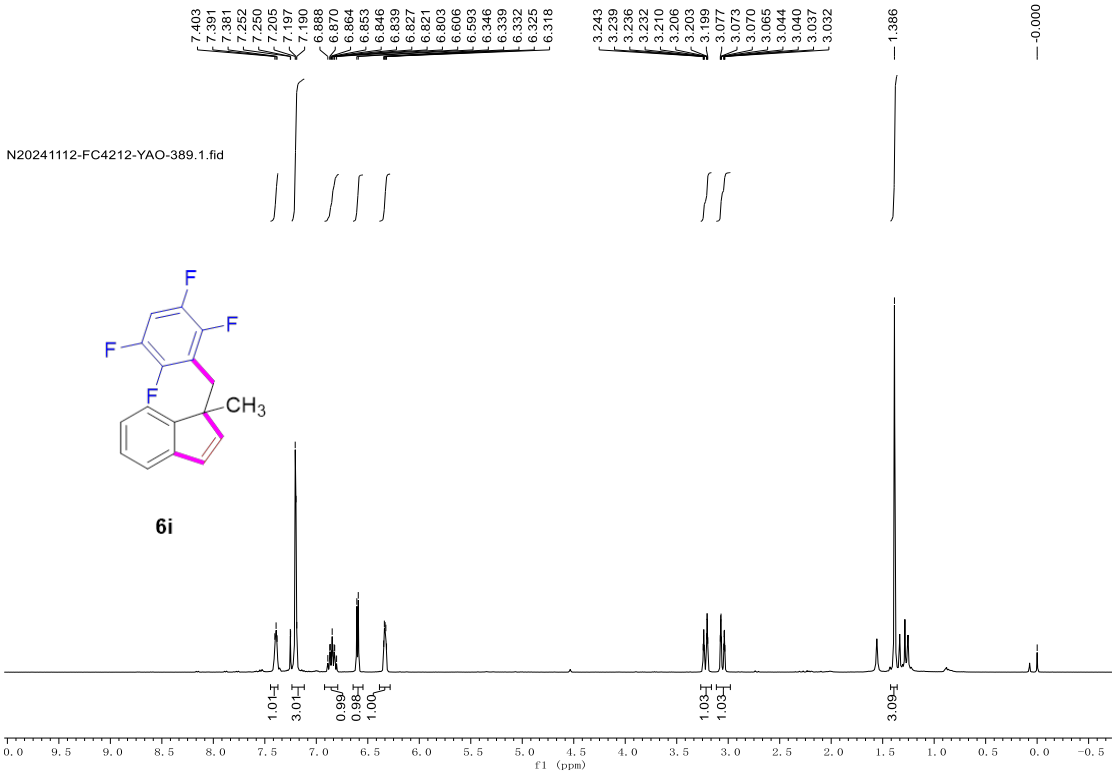
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6h**



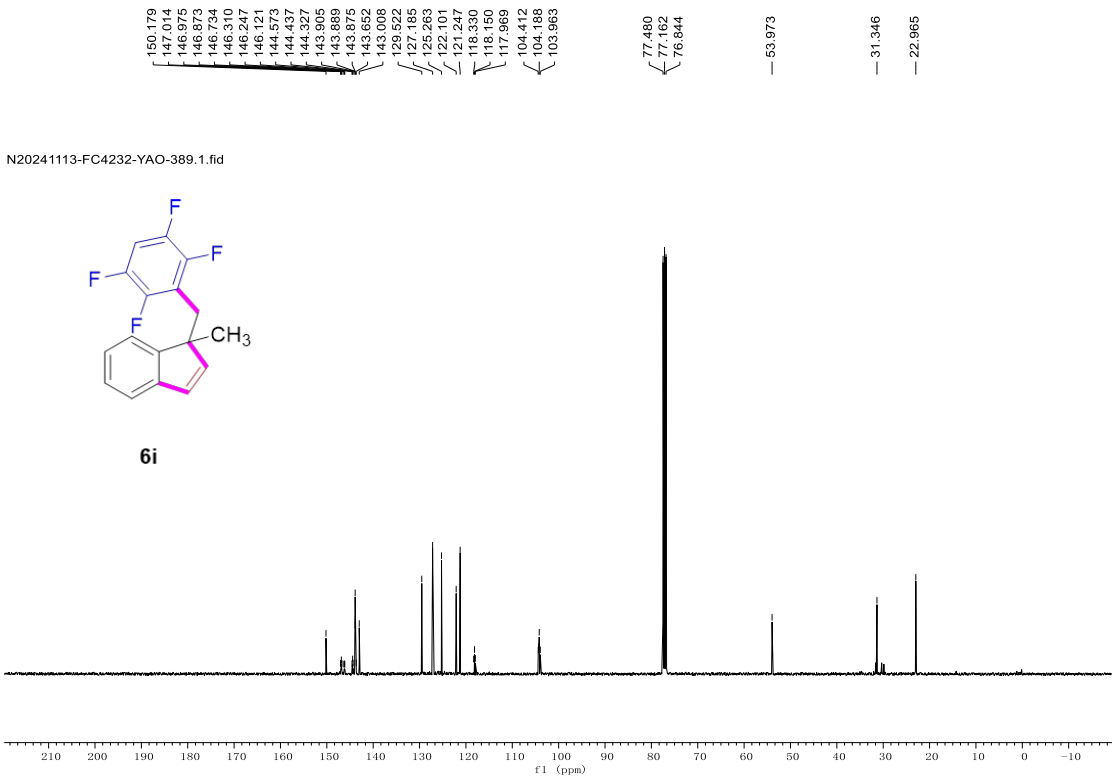
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6h**



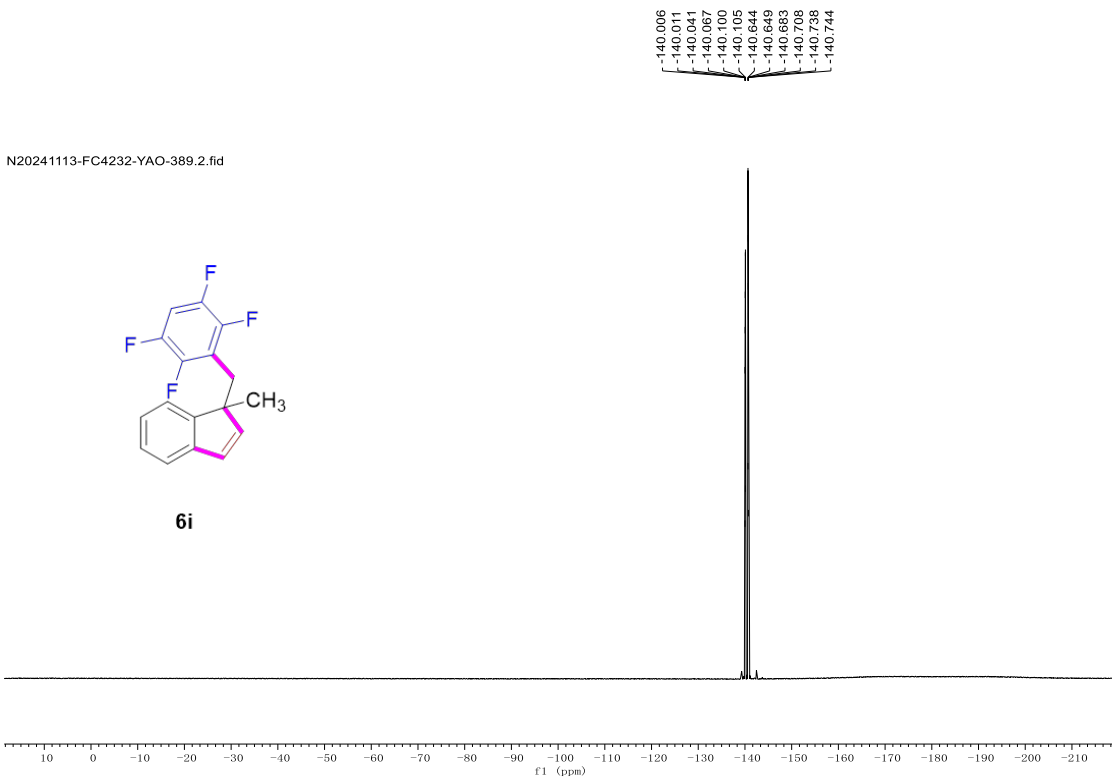
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6i**



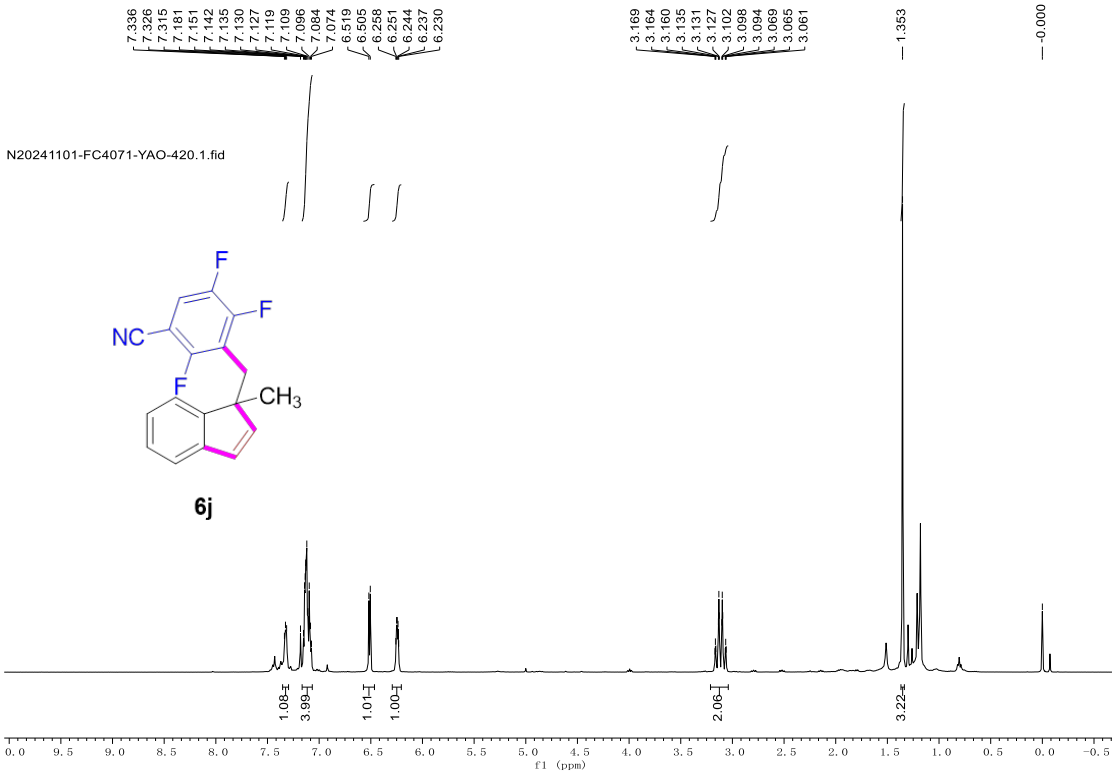
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6i**



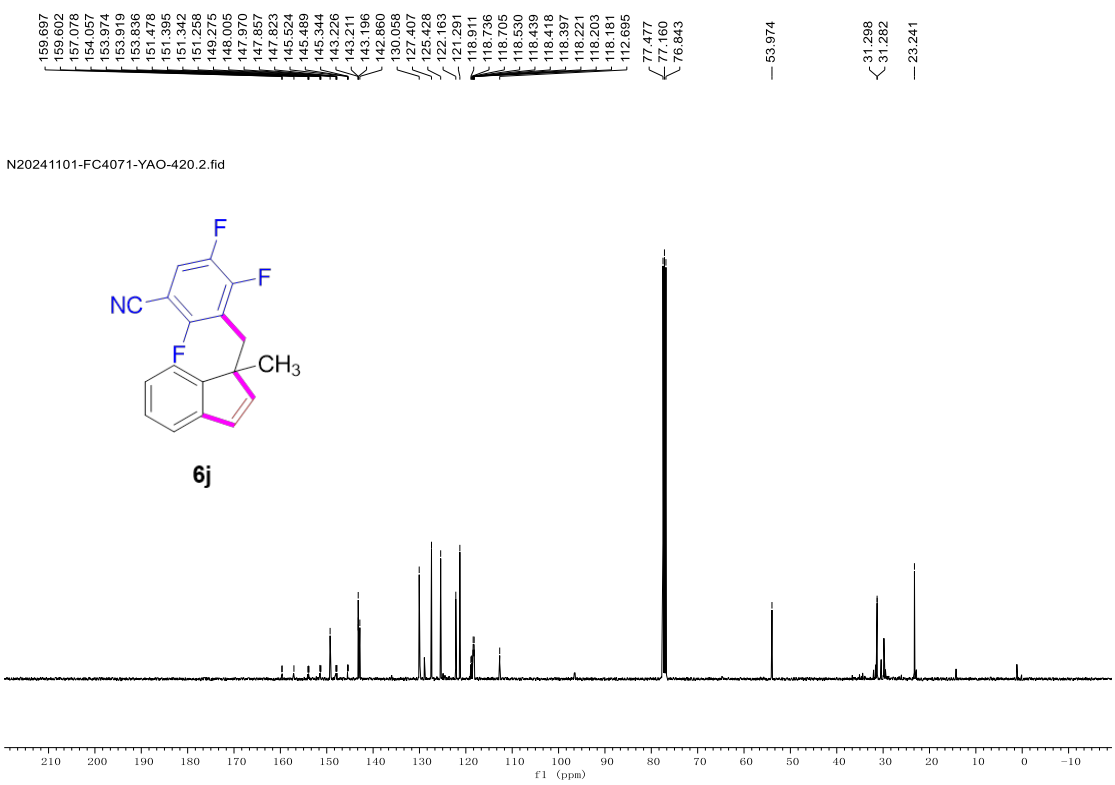
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6i**



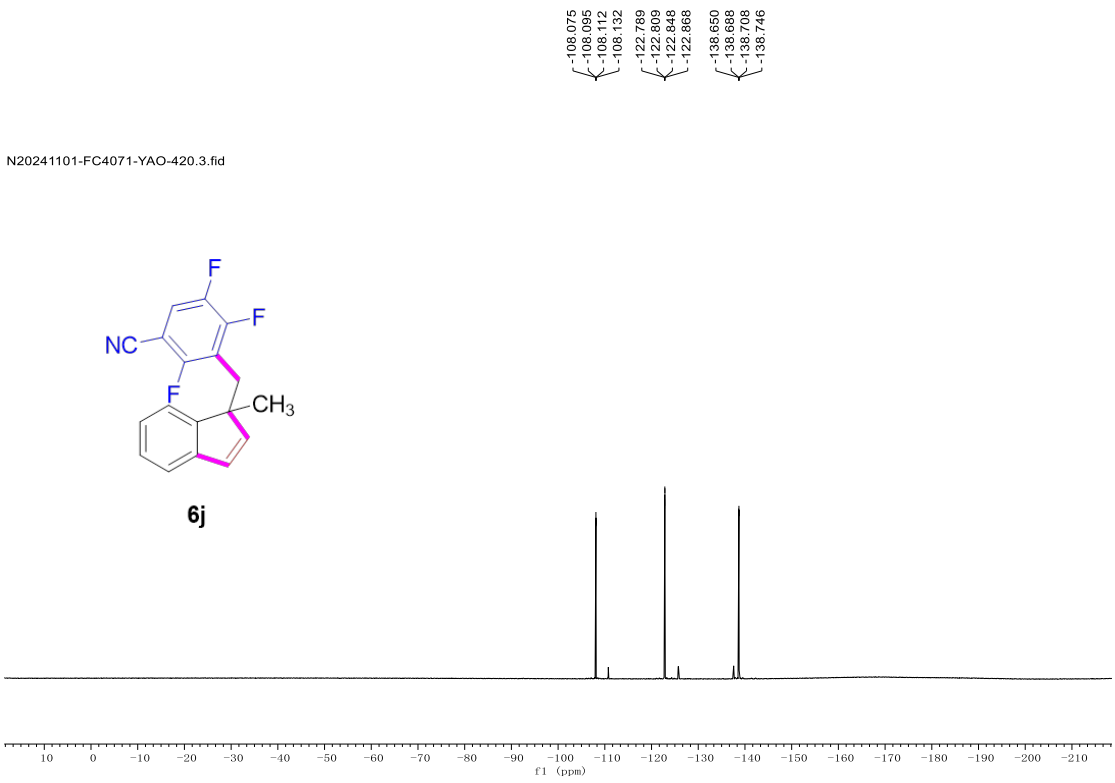
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6j**



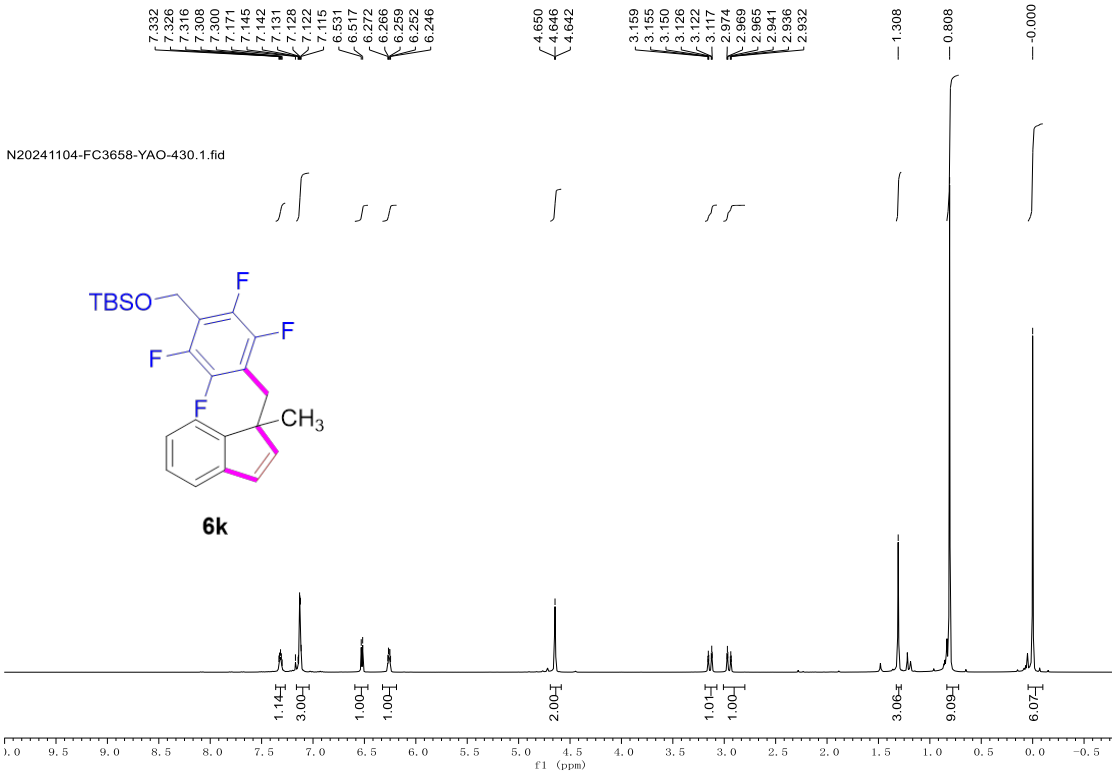
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6j**



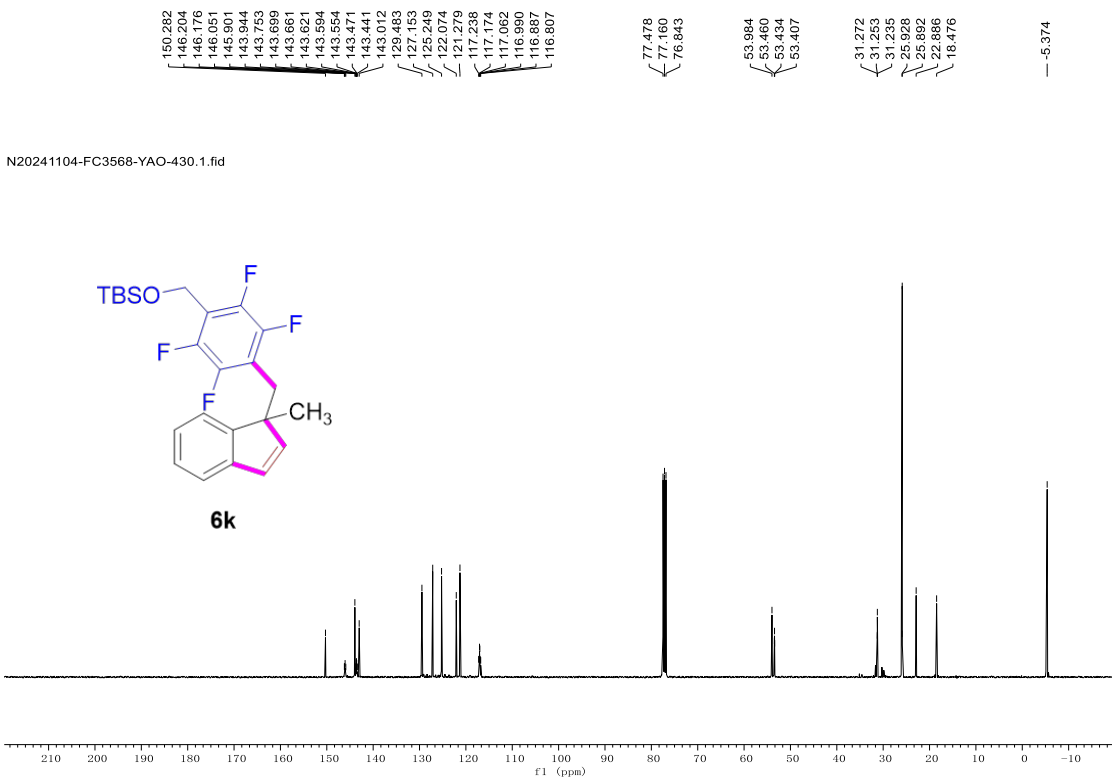
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6j**



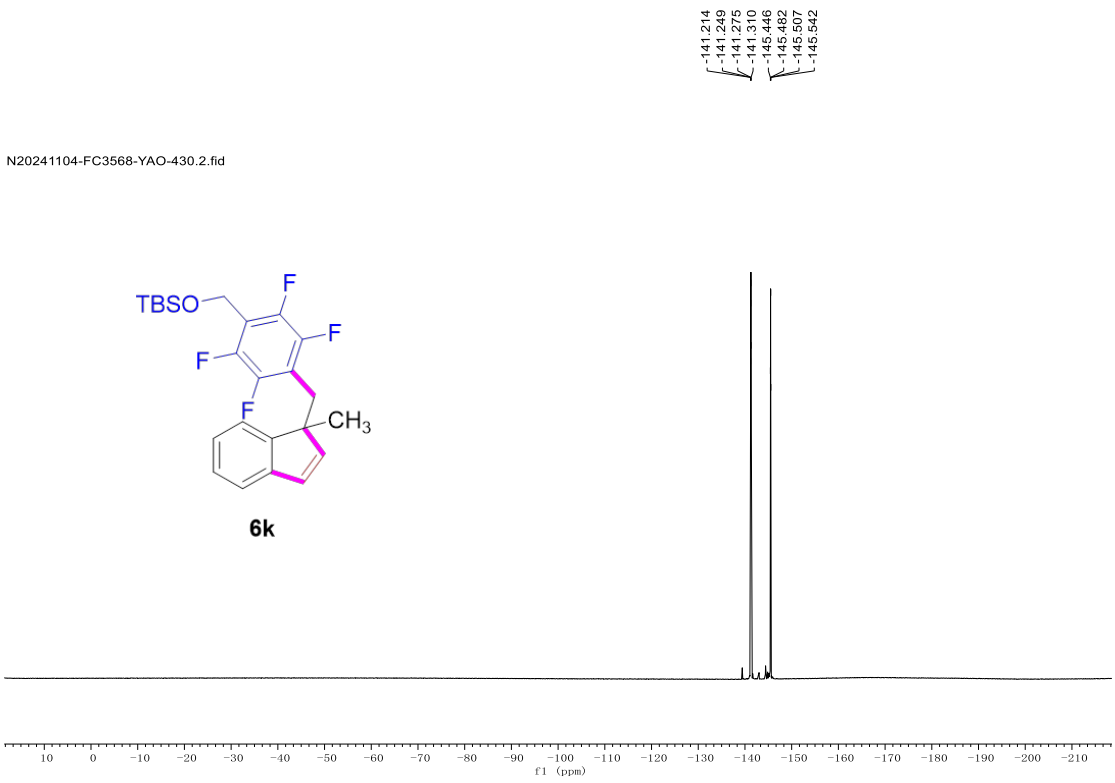
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6k**



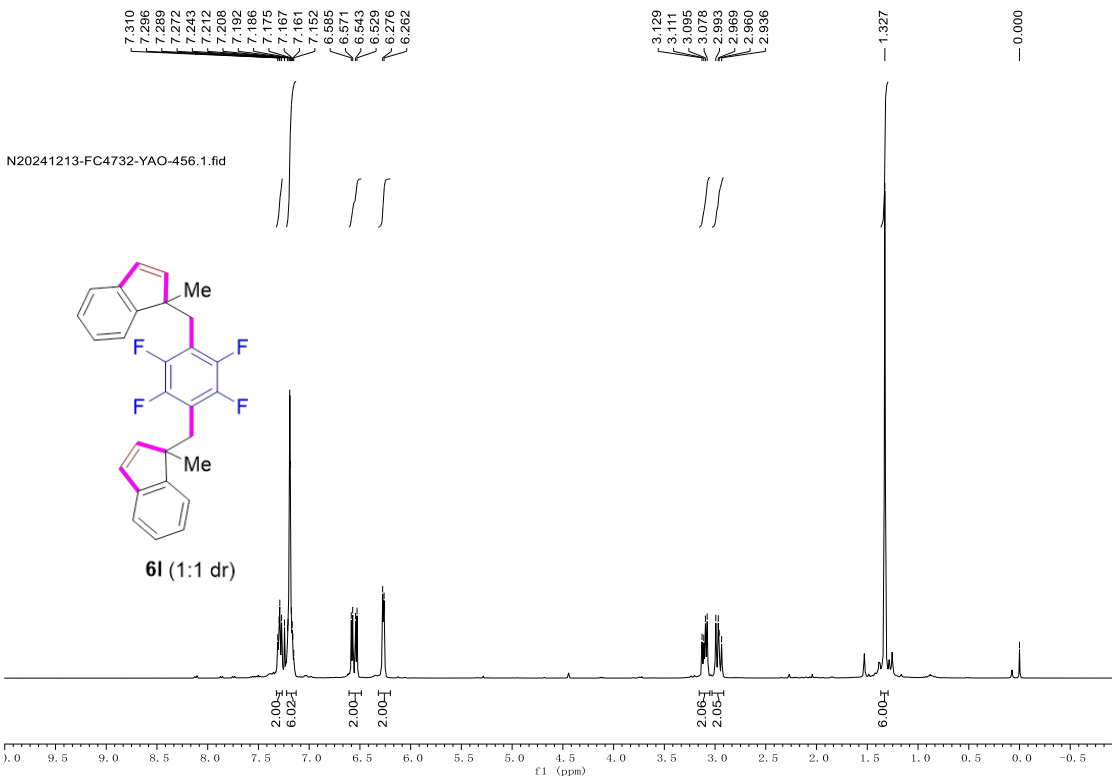
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6k**



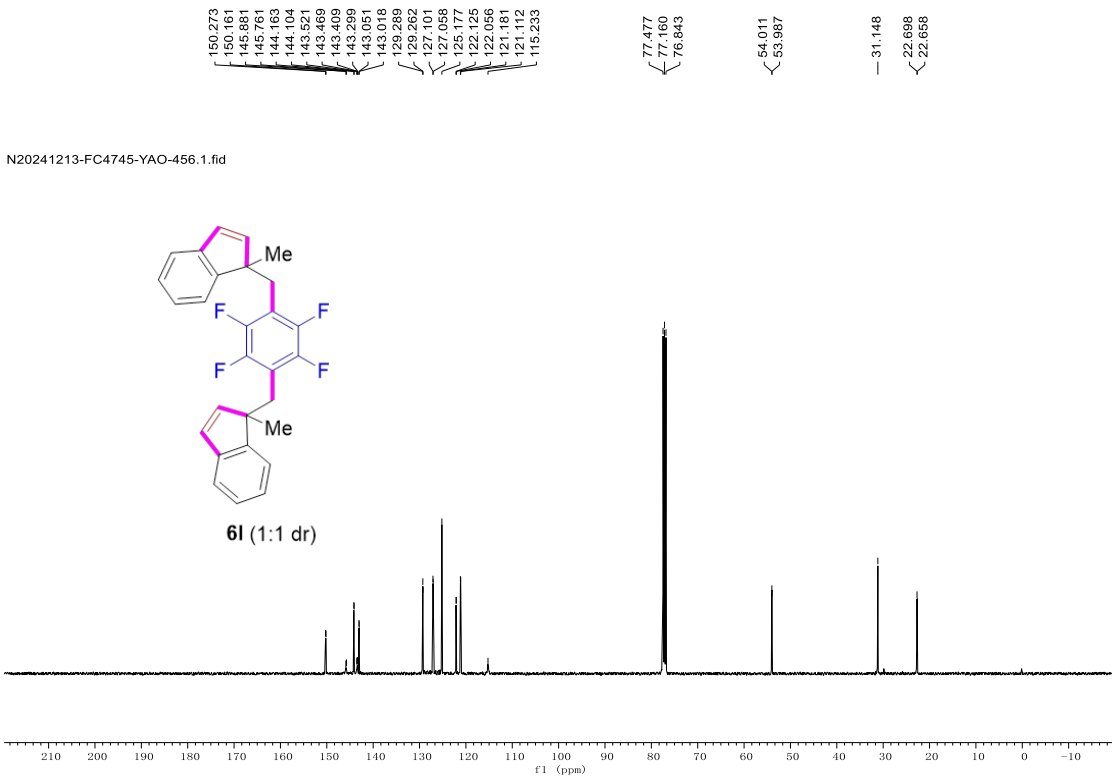
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6k**



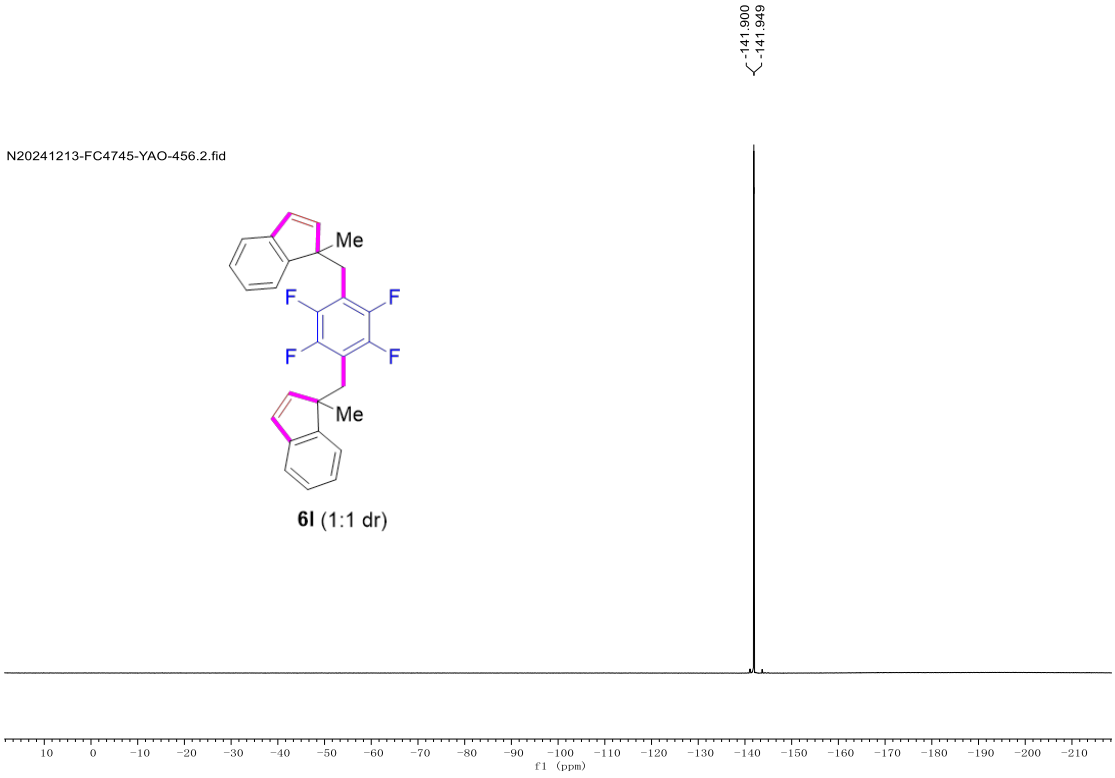
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6l**



^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **6l**

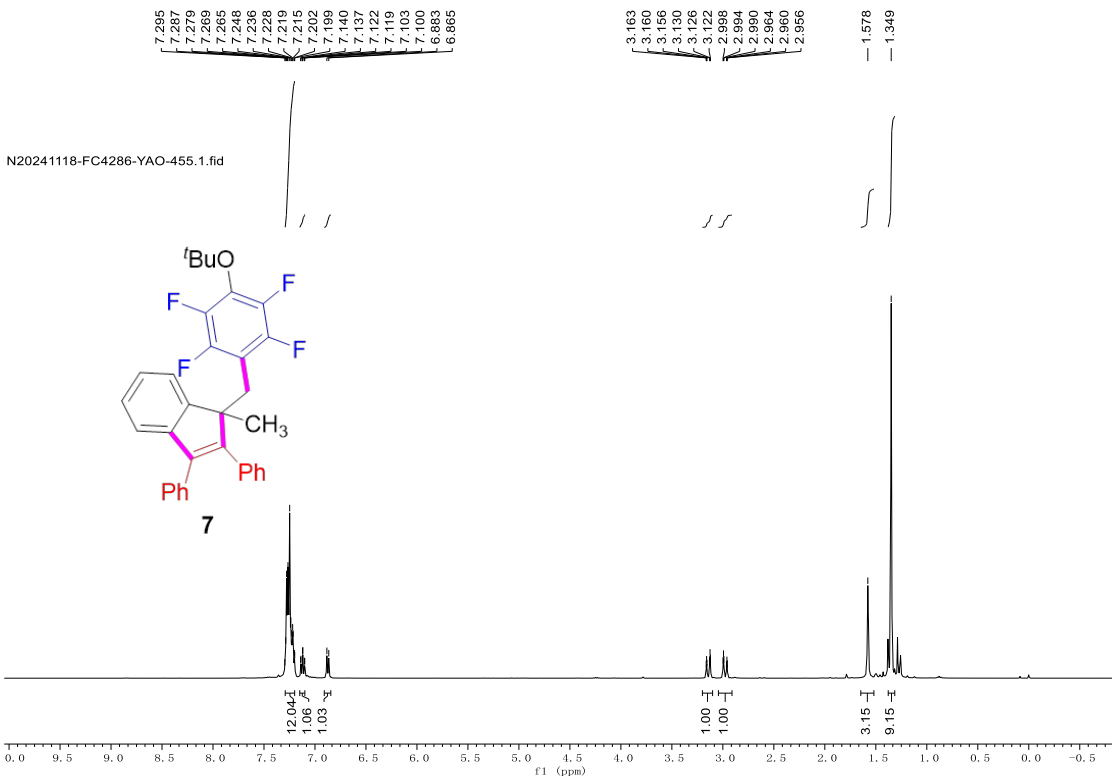


^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **6l**

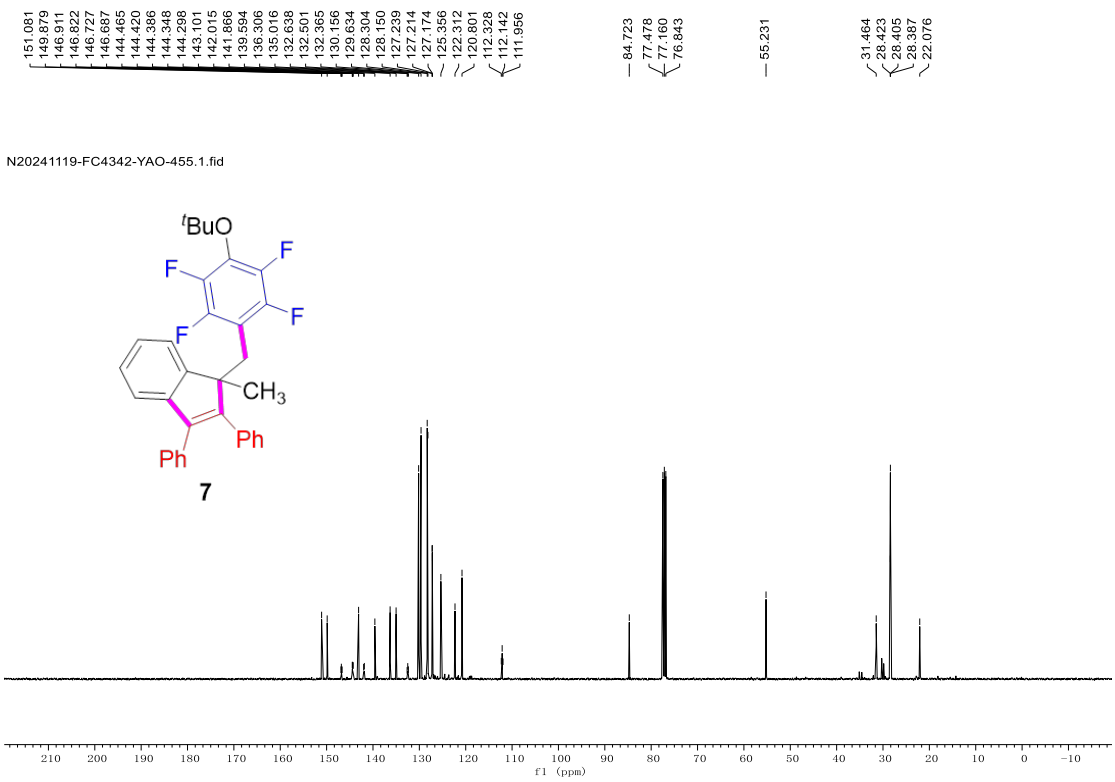


6l (1:1 dr)

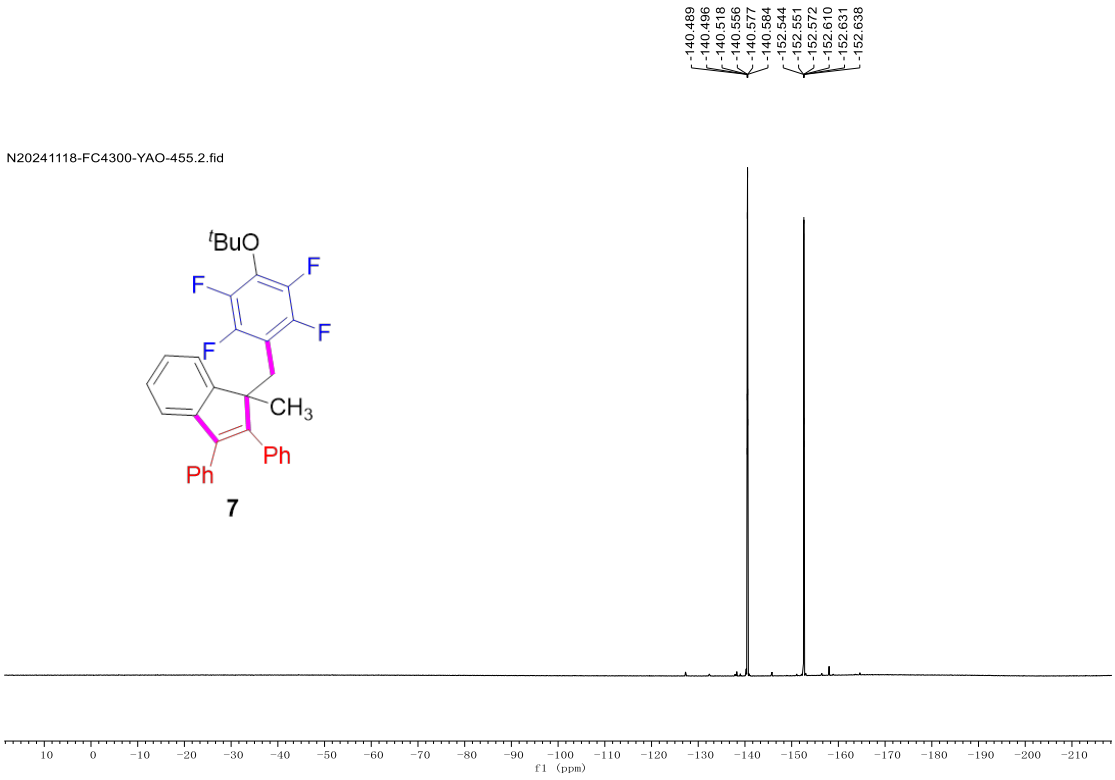
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **7**



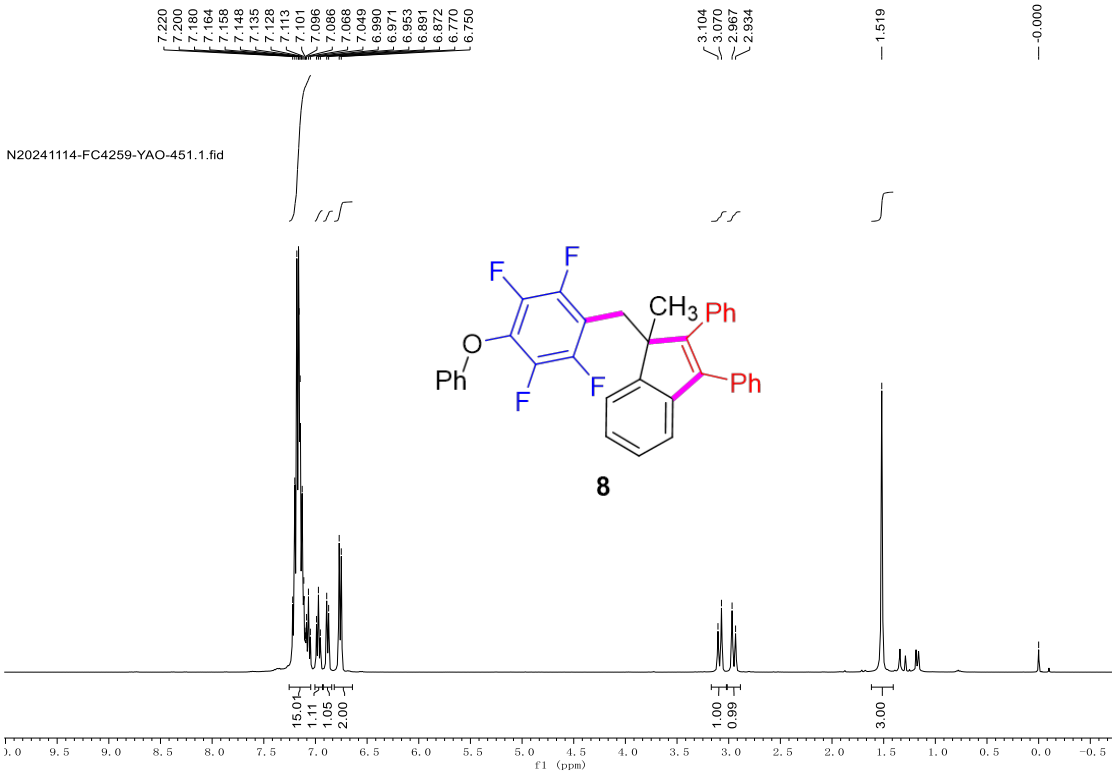
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **7**



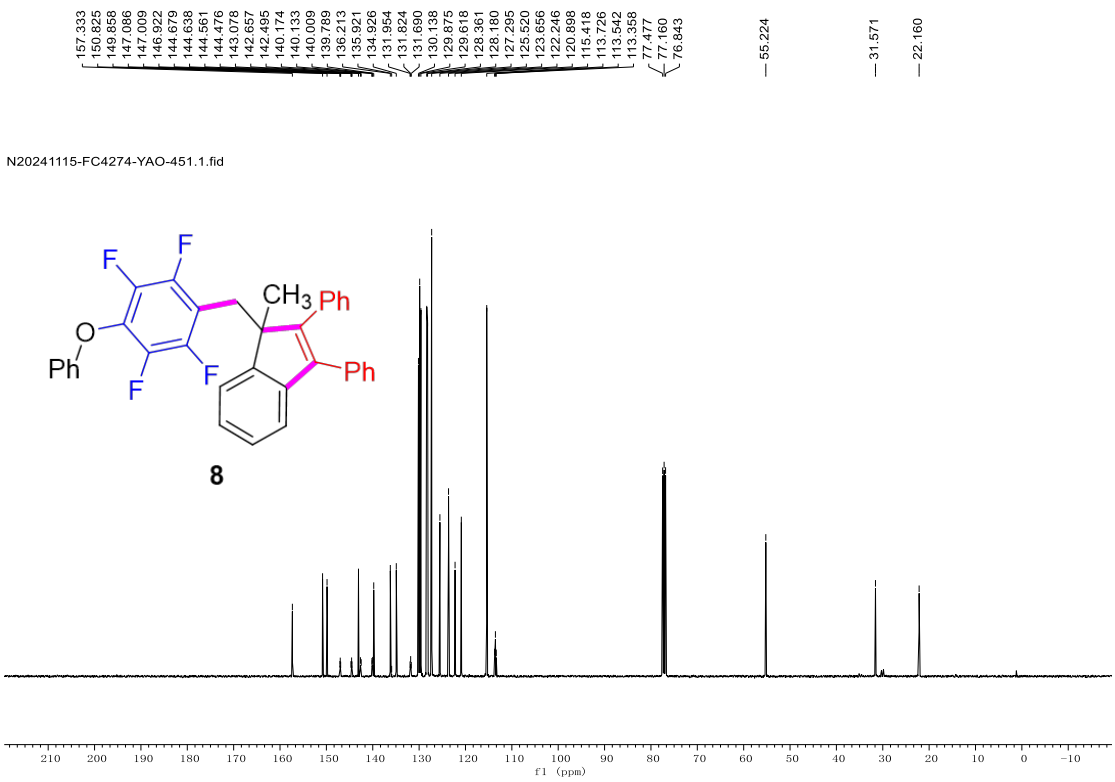
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **7**



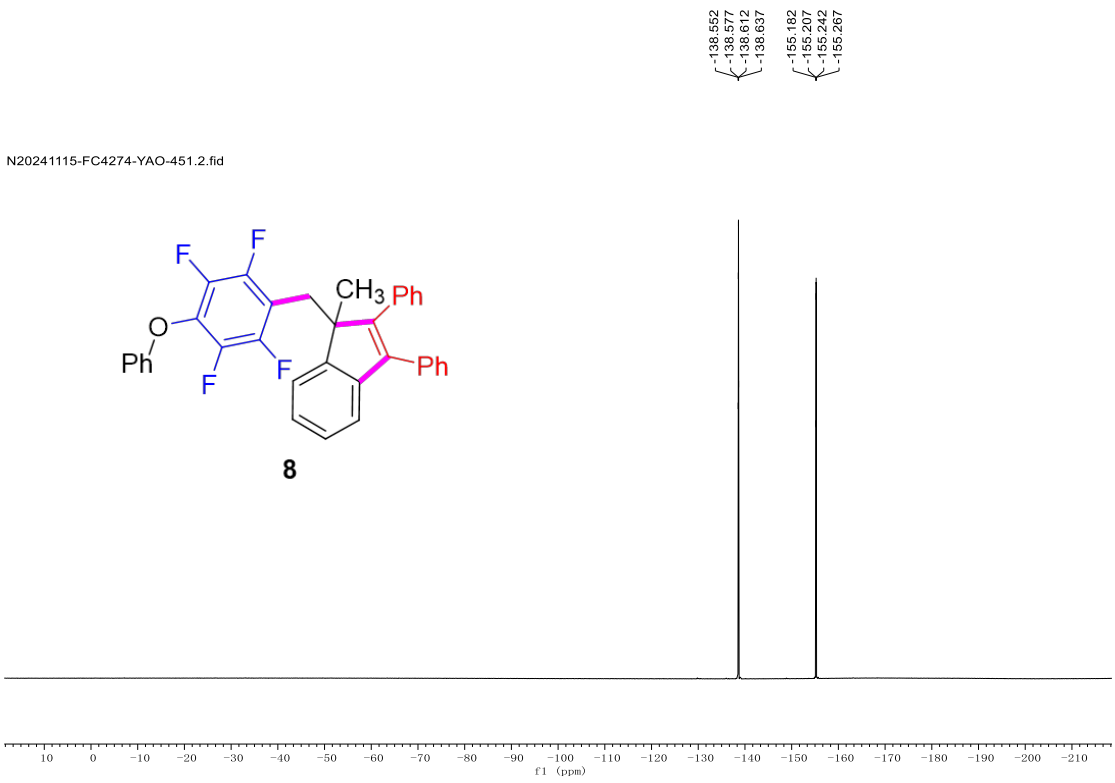
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **8**



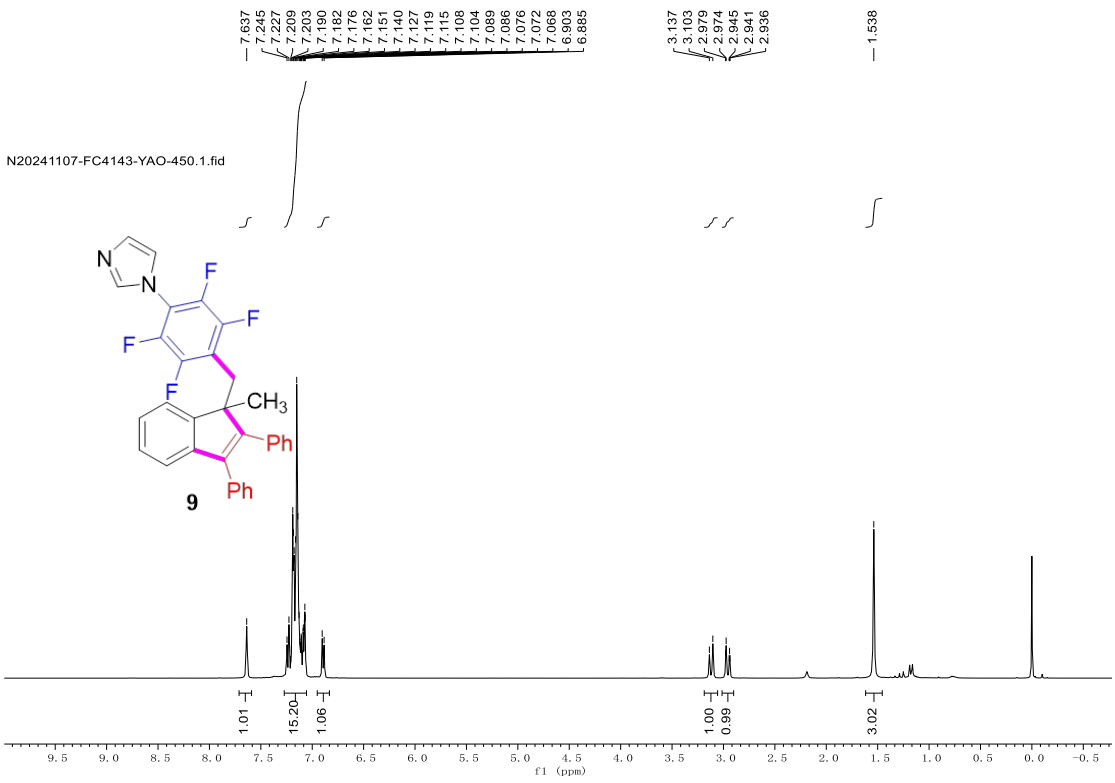
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **8**



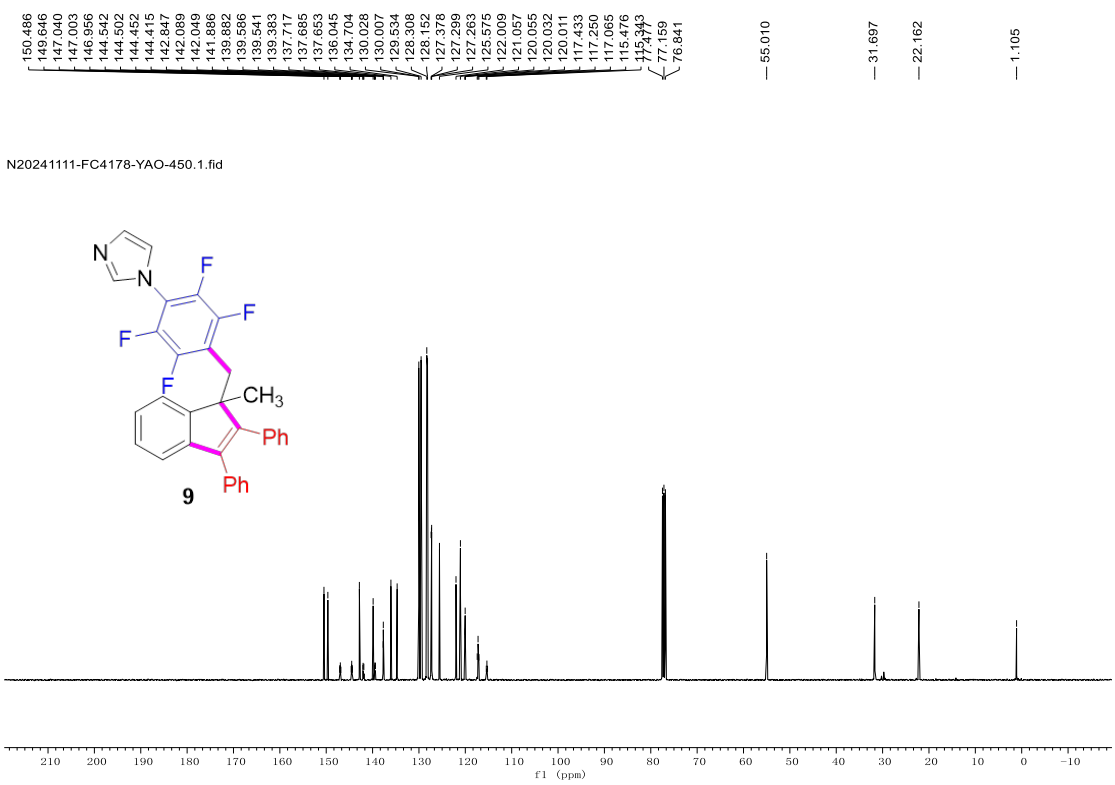
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **8**



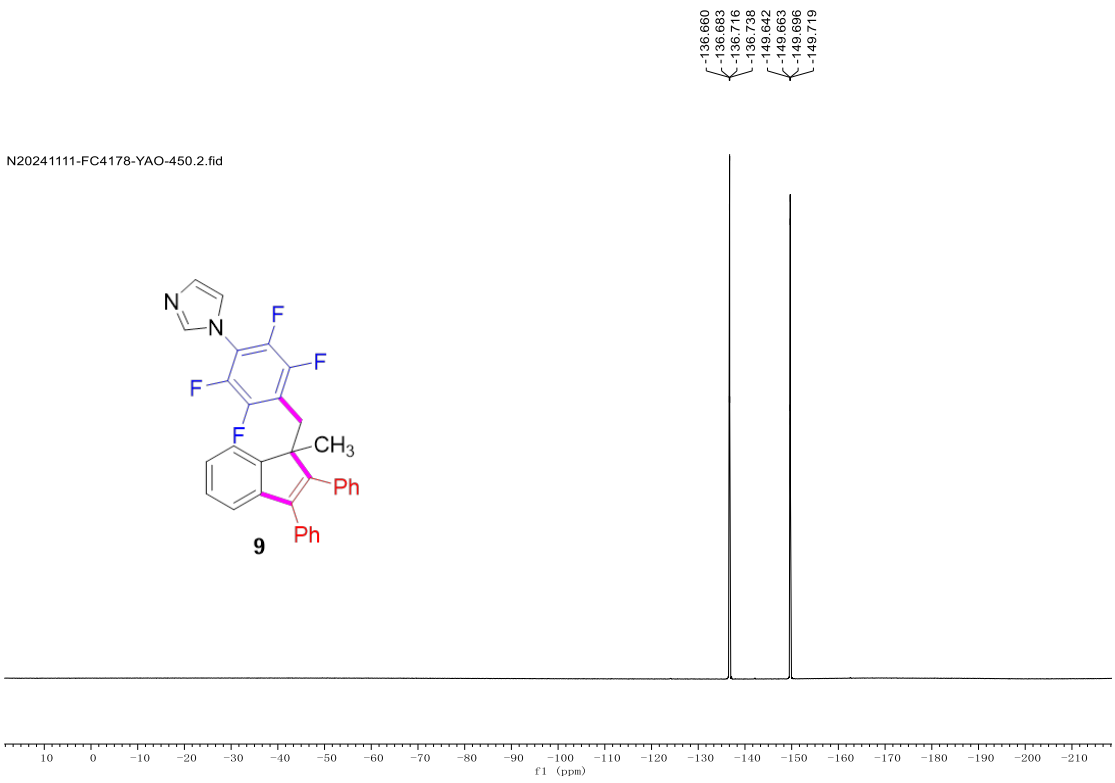
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **9**



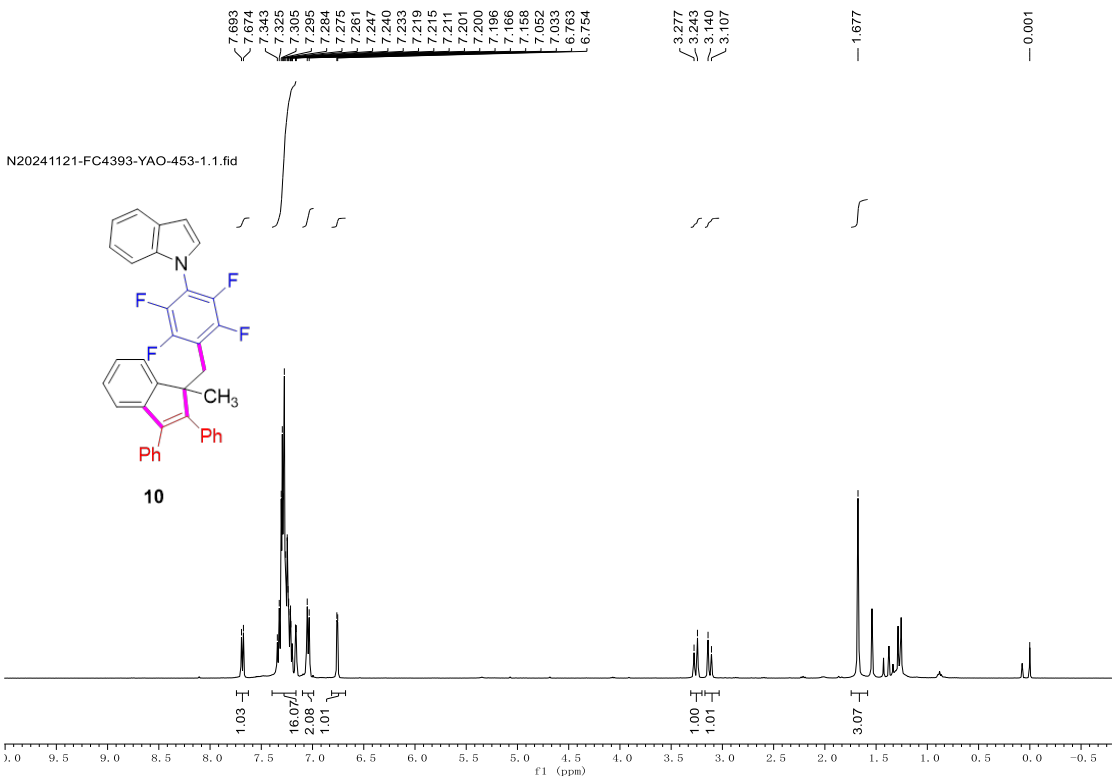
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **9**



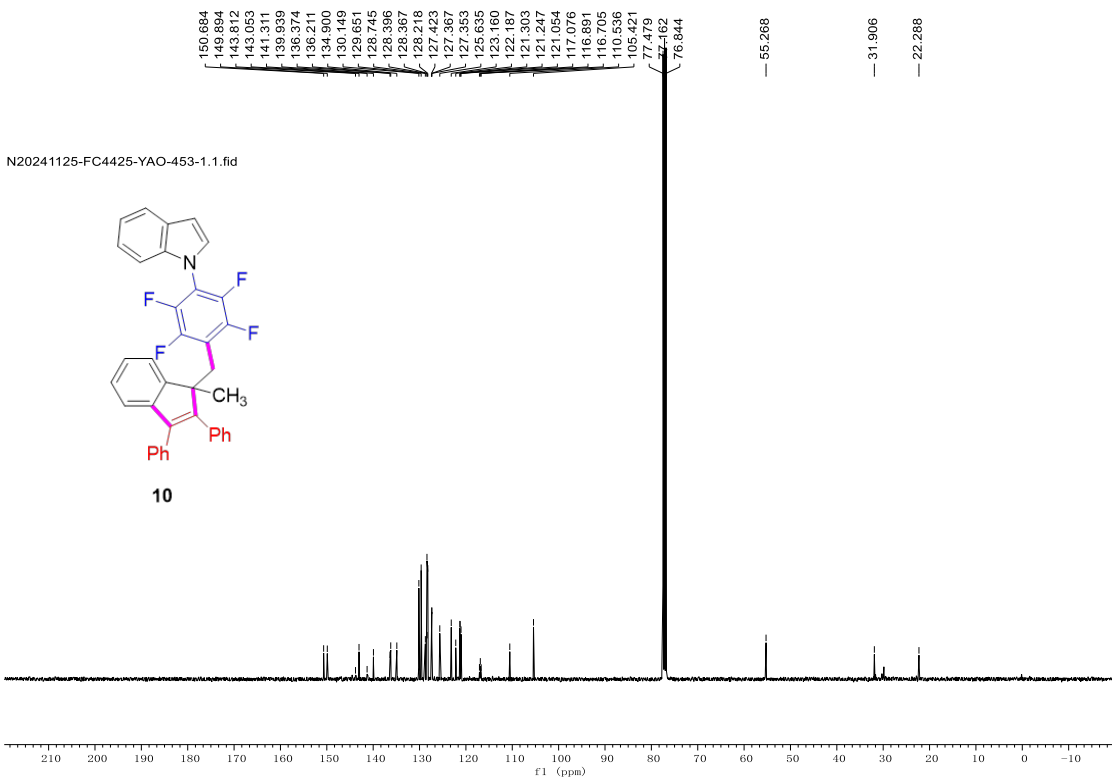
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **9**



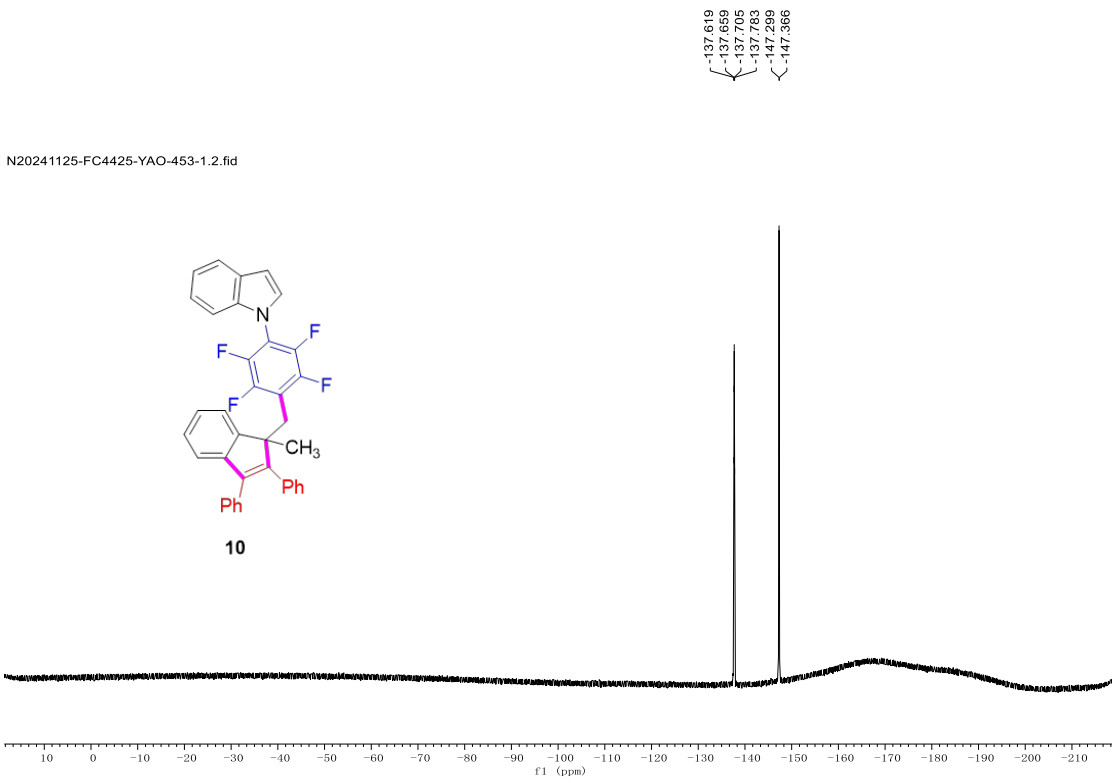
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **10**



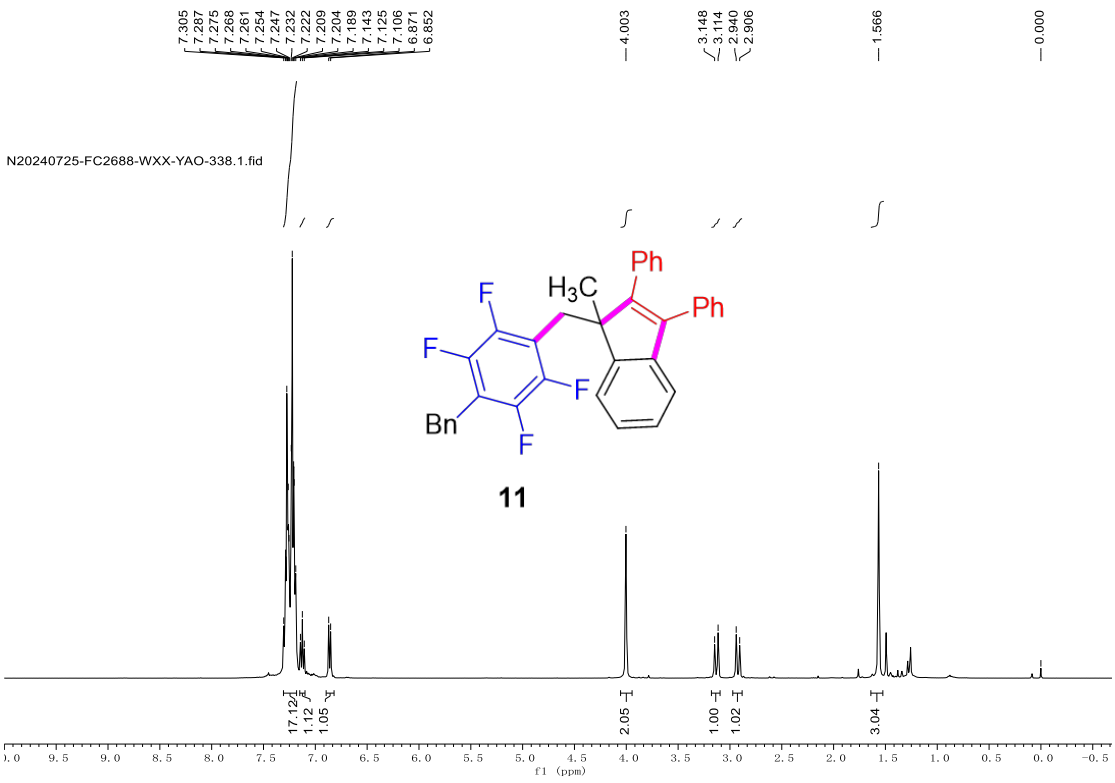
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **10**



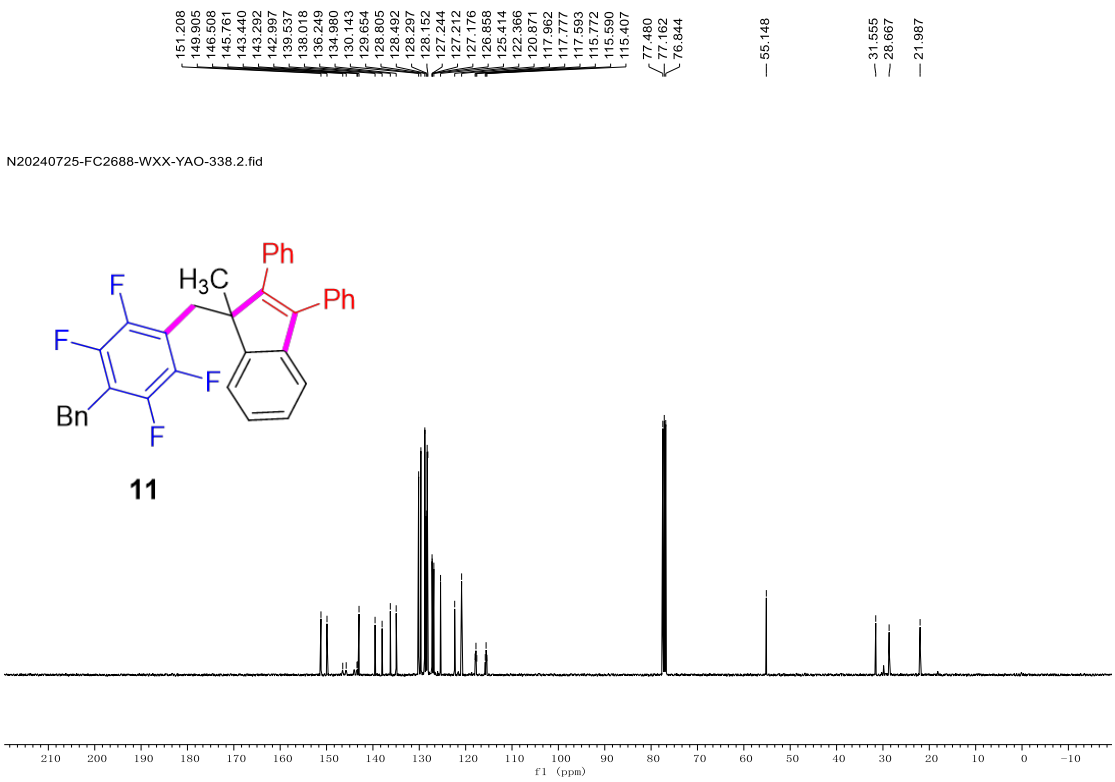
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **10**



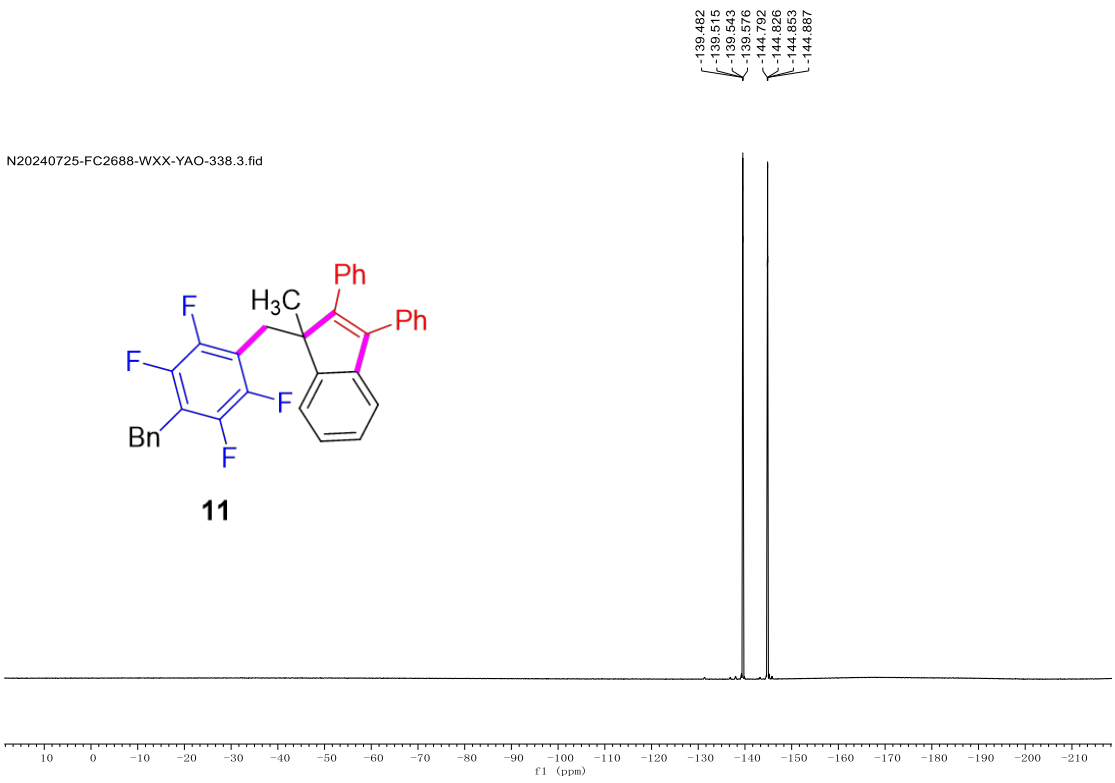
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **11**



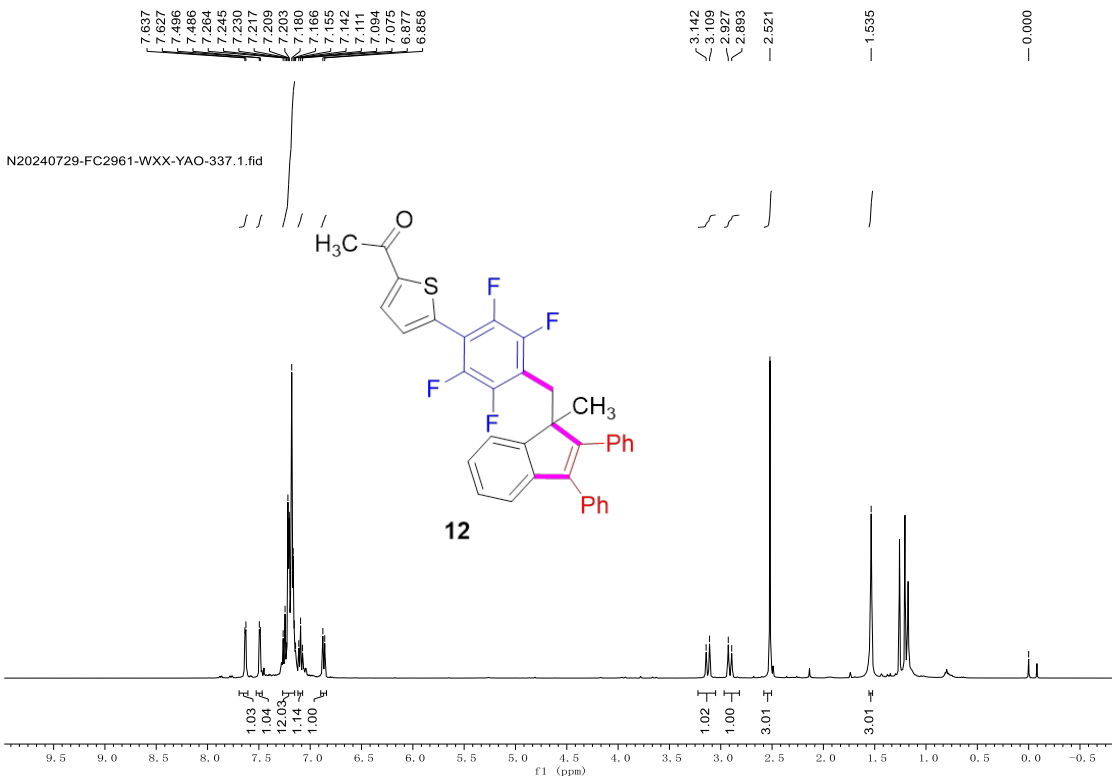
^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **11**



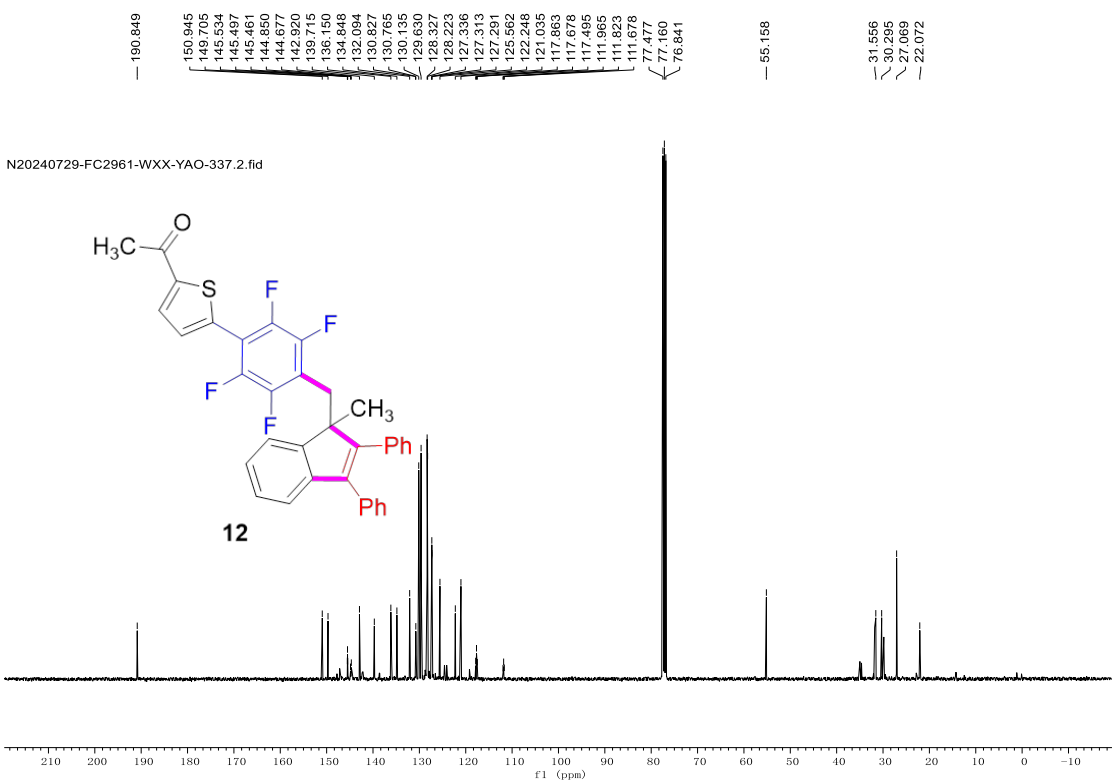
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **11**



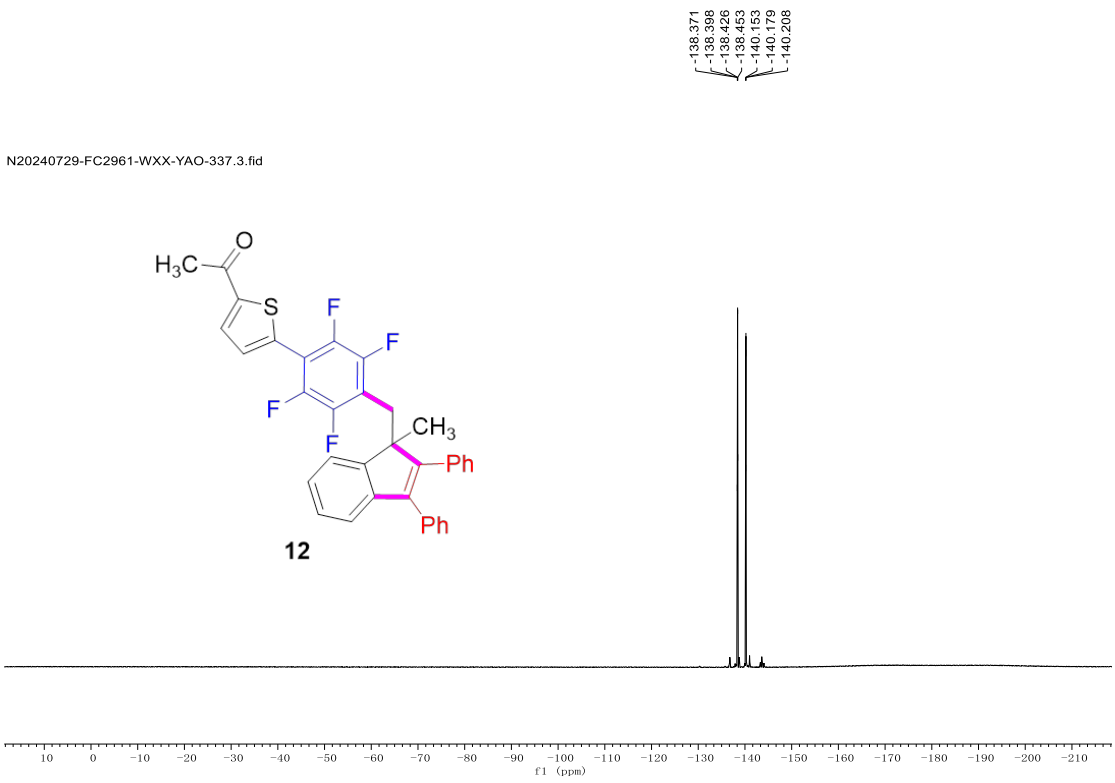
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **12**



^{13}C NMR (101 MHz, $CDCl_3$) Spectrum of **12**



^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **12**



^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of by-product **6'**