Supporting Information

Enantioselective copper-catalysed defluorinative alkylation of polyfluoroarenes with alkenes and 1,3-dienes

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Table of Contents

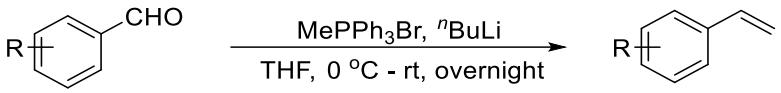
1. General Information

General. All reactions were carried out under nitrogen atmosphere in a glovebox. Reagents were purchased from commercial sources and used without further purification, unless otherwise noted. All of the solvents were anhydrous according distillation. The reactions were monitored with the aid of thin layer chromatography (TLC) on 0.25 mm precoated silica gel plates. Visualization was carried out with UV light and aqueous potassium permanganate stain. Melting points were measured on Büchi B-540 apparatus. ^{1}H, ^{13}C, ^{19}F spectra were recorded with, Varian 500 MHz (Inova-500), or Bruker 600 MHz (Avance-600) instrument. ^{1}H and ^{13}C NMR spectra are reported in parts per million (ppm) downfield from an internal standard, tetramethylsilane (0 ppm for 1H) and Chloroform-*d* (77.0 ppm for ^{13}C), respectively. High resolution mass spectra HRMS (ESI-TOF) were recorded on Bruck microtof. High-pressure liquid chromatography (HPLC) was performed on Agilent 1260 Series chromatographs and Shimadzu LC-2040C Plus Series chromatographs using a chiral column (25 cm) as noted for each compound. Enantiomeric excess was determined by HPLC analysis employing Darcel Chiracel AD-H, AD-3, OD-H, OD-3, OJ-H, OJ-3, IA-3, IF, IG column. Optical rotation was measured on a Perkin–Elmer 341 polarimeter using a sodium lamp (589 nm) as the light source over a path length of 10 cm. UV-Visible Absorption Spectra was measured on an UV-Visible Spectrophotometer (Cary 60).

Materials. The styrenes were synthesized according to existing methods,[1] and polyfluoroarenes and reagents were purchased from Energy-Chemical Limited, Alfa Aesar, and other commercial suppliers and were used as received. Reaction solvents THF, DME, DCM, Dioxane, and Toluene were distilled and stored under nitrogen atmosphere.

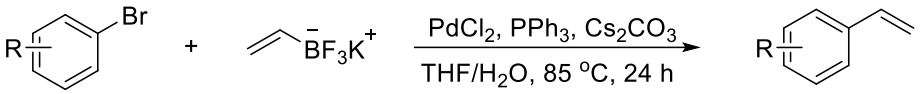
2. Preparation of Starting Materials

General procedure A:



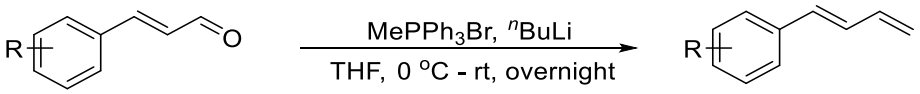
To the solution of methyltriphenylphosphonium bromide (6.0 mmol, 1.2 equiv) suspended in THF (10.0 mL) was added ^{n}BuLi dropwisely (6.0 mmol, 1.2 equiv) under N_2 at 0 °C. The reaction mixture was stirred 15 min at 0 °C before aldehyde (5.0 mmol, 1.0 equiv) was added. Then the reaction was stirred overnight at room temperature. The reaction mixture was filtered by silica gel and washed with PE/EA to afford **1a-1l**, **1k-1q**, **1s**, **1u-1af**.[1]

General procedure B:



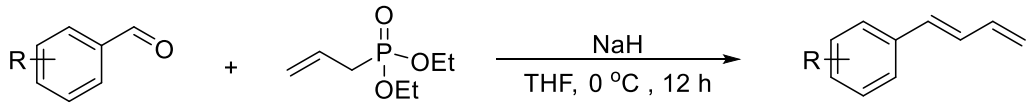
In a 50 mL round bottom flask containing a magnetic stir bar was charged with $PdCl_2$ (0.1 mmol, 2.0 mol%), PPh_3 (0.3 mmol, 6.0 mol%), bromobenzene (5.0 mmol, 1.0 equiv), potassium vinyltrifluoroborate (6.0 mmol, 1.2 equiv), Cs_2CO_3 (15.0 mmol, 3.0 equiv) and 10 mL of 9:1 THF/H_2O. Then the reaction mixture was stirred for 24 h at 85 °C under nitrogen atmosphere until all the bromobenzene was consumed. The reaction mixture was passed through a pad of Celite and washed with diethyl ether. The filtrate was concentrated under reduced pressure The crude mass was purified by silica gel and washed with PE/EA to afford **1j**, **1t**, **1ag-1al**.[2]

General procedure C:



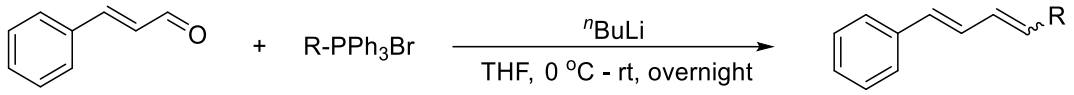
To the solution of methyltriphenylphosphonium bromide (6.0 mmol, 1.2 equiv.) suspended in THF (10.0 mL) was added ^{n}BuLi dropwisely (6.0 mmol, 1.2 equiv.) under N_2 at 0 °C. The reaction mixture was stirred 15 min at 0 °C before enal (5.0 mmol, 1.0 equiv) was added. Then the reaction was stirred overnight at room temperature. The reaction mixture was filtered by silica gel and washed with PE/EA to afford **4a-4e**, **4h-4k**.[3]

General procedure D:



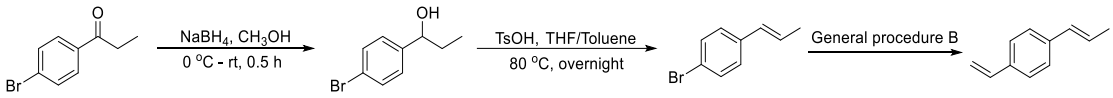
To a solution of diethyl allylphosphonate (7.5 mmol, 1.5 equiv) in anhydrous THF (10 mL) was added NaH (7.5 mmol, 1.5 equiv) at 0 ºC. The reaction mixture was stirred 30 min, then the corresponding aldehyde (5.0 mmol, 1.0 equiv) was added to the solution and the resultant mixture was allowed to stir at 0 ºC for 12 h. The reaction mixture was filtered by silica gel and washed with PE/EA to afford **4f**, **4g**, **4l-4o**.[4]

General procedure E:



To the solution of phosphorus ylide (6.0 mmol, 1.2 equiv.) suspended in THF (10.0 mL) was added ^{n}BuLi dropwisely (6.0 mmol, 1.2 equiv.) under N_2 at 0 °C. The reaction mixture was stirred 15 min at 0 °C before trans-cinnamaldehyde (5.0 mmol, 1.0 equiv) was added. Then the reaction was stirred overnight at room temperature. The reaction mixture was filtered by silica gel and washed with PE/EA to afford **4p-4t**.[5]

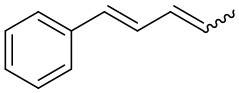
Preparation of (*E*)-1-(prop-1-en-1-yl)-4-vinylbenzene (1r)



To a solution of 4'-Bromopropiophenone (10.0 mmol, 1.0 equiv) in CH_3OH (10 mL) was slowly added $NaBH_4$ (12.0 mmol, 1.2 equiv) at 0 ºC. After stirred 30 min at room temperature, water was added to the reaction mixture and the aqueous layer was extracted twice with CH_2Cl_2. The combined organic layers were concentrated to afford 1-(4-bromophenyl)propan-1-ol. In a 50 mL round bottom flask containing a magnetic stir bar was charged with 1-(4-bromophenyl)propan-1-ol (10.0 mmol, 1.0 equiv), TsOH (15.0 mmol, 1.5 equiv) and 20 mL of 1:1 THF/toluene. Then the reaction mixture was stirred overnight at 80 °C to afford (*E*)-1-bromo-4-(prop-1-en-1-yl)benzene which was followed by General procedure B to obtain (*E*)-1-(prop-1-en-1-yl)-4-vinylbenzene as colorless oil. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.33 (d, *J* = 8.0 Hz, 2H), 7.27 (d, *J* = 8.5 Hz, 2H), 6.68 (dd, *J* = 17.5, 11.0 Hz, 1H), 6.37 (d, *J* = 15.5 Hz, 1H), 6.27 – 6.20 (m, 1H), 5.71 (d, *J* = 17.5 Hz, 1H), 5.20 (d, *J* = 11.0 Hz, 1H), 1.87 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 137.49, 136.54, 136.04,

130.68, 126.35, 125.92, 125.74, 113.13, 18.51. **HRMS** (ESI-TOF) (m/z): Calcd for $C_{11}H_{13}$ ([M + H]$^+$): 145.1012; found: 145.1013.

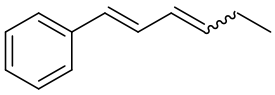
(1-penta-1,3-dien-1-yl)benzene (4p)



Z/E (1.0/1.3)

Following the general procedure E at a 5.0 mmol scale to afford the compound as a colorless oil with 85% yield (0.61 g). NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.42 (d, *J* = 7.2 Hz, 2.63H), 7.37 (d, *J* = 7.2 Hz, 2H), 7.32 – 7.27 (m, 4.63H), 7.22 – 7.17 (m, 2.31H), 7.09 (dd, *J* = 15.6, 10.8 Hz, 1.35H), 6.74 (dd, *J* = 15.6, 10.8 Hz, 1H), 6.52 (d, *J* = 15.6 Hz, 1.3H), 6.42 (d, *J* = 15.6 Hz, 1H), 6.24 – 6.16 (m, 2.35H), 5.86 – 5.80 (m, 1H), 5.62 – 5.57 (m, 1.30H), 1.86 (d, *J* = 7.2 Hz, 3.90H), 1.82 (d, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 137.63, 131.82, 130.28, 129.70, 129.59, 129.30, 128.55, 128.51, 127.30, 127.15, 127.03, 126.28, 126.09, 124.13, 18.35, 13.61. **HRMS** (ESI-TOF) (m/z): Calcd for $C_{11}H_{12}Na$ ([M + Na]$^+$): 167.0831; found: 167.0835.

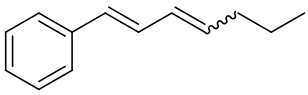
(hexa-1,3-dien-1-yl)benzene (4q)



Z/E (1.0/1.3)

Following the general procedure E at a 5.0 mmol scale to afford the compound as a colorless oil with 87% yield (0.69 g). NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.41 (d, *J* = 7.8 Hz, 2.60H), 7.37 (d, *J* = 7.8 Hz, 2H), 7.30 (q, *J* = 7.8 Hz, 4.66H), 7.22 – 7.17 (m, 2.40H), 7.06 (dd, *J* = 15.6, 10.8 Hz, 1.30H), 6.75 (dd, *J* = 15.6, 10.2 Hz, 1H), 6.52 (d, *J* = 15.6 Hz, 1.30H), 6.44 (d, *J* = 15.6 Hz, 1H), 6.20 (dd, *J* = 15.0, 10.8 Hz, 1H), 6.12 (t, *J* = 10.8 Hz, 1.30H), 5.89 – 5.84 (m, 1H), 5.55 – 5.50 (m, 1.30H), 2.33 – 2.28 (m, 2.60H), 2.19 – 2.14 (m, 2H), 1.06 – 1.03 (m, 6.67H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 137.66, 137.62, 137.36, 134.83, 131.94, 129.94, 129.53, 129.44, 128.54, 128.51, 128.07, 127.30, 127.02, 126.28, 126.09, 124.33, 25.86, 21.33, 14.32, 13.53. **HRMS** (ESI-TOF) (m/z): Calcd for $C_{12}H_{14}Na$ ([M + Na]$^+$): 181.0988; found: 181.0983.

(hepta-1,3-dien-1-yl)benzene (4r)

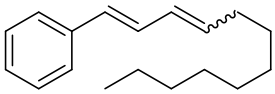


Z/E (1.0/1.4)

Following the general procedure E at a 5.0 mmol scale to afford the compound as a colorless oil with 78% yield (0.67 g). NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.41 (d, *J* = 7.8 Hz, 2.80H), 7.37 (d, *J* = 7.8 Hz, 2H), 7.31 – 7.28 (m, 4.70H), 7.22 – 7.17 (m, 2.38H), 7.07 (dd, *J* = 15.6, 10.2 Hz, 1H), 6.75 (dd, *J* = 15.6, 10.4 Hz, 1H), 6.52

(d, J = 15.6 Hz, 1.40H), 6.44 (d, J = 15.6 Hz, 1H), 6.22 – 6.15 (m, 2.40H), 5.85 – 5.80 (m, 1H), 5.55 – 5.51 (m, 1.39H), 2.27 (q, J = 7.2 Hz, 2.82H), 2.12 (q, J = 7.2 Hz, 2H), 1.49 – 1.42 (m, 4.82H), 0.97 – 0.92 (m, 7.21H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 137.66, 135.75, 133.11, 131.92, 130.63, 129.91, 129.45, 128.84, 128.54, 128.51, 127.29, 127.03, 126.29, 126.09, 124.50, 34.94, 30.03, 22.88, 22.48, 13.80, 13.72. **HRMS** (ESI-TOF) (m/z): Calcd for $C_{13}H_{17}$ ([M + H]$^+$): 173.1325; found: 173.1321.

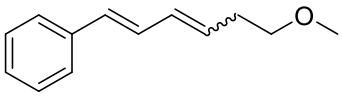
(dodeca-1,3-dien-1-yl)benzene (4s)



Z/E (1.0/2.1)

Following the general procedure E at a 5.0 mmol scale to afford the compound as a colorless oil with 83% yield (1.01 g). NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.41 (d, J = 7.8 Hz, 4.20H), 7.37 (d, J = 7.8 Hz, 2H), 7.32 – 7.27 (m, 6.22H), 7.22 – 7.17 (m, 3H), 7.06 (dd, J = 15.6, 10.8 Hz, 2.10H), 6.75 (dd, J = 15.6, 10.8 Hz, 1H), 6.52 (d, J = 15.6 Hz, 2.10H), 6.43 (d, J = 15.6 Hz, 1H), 6.22 – 6.14 (m, 3.10H), 5.85 – 5.80 (m, 1H), 5.55 – 5.51 (m, 2.10H), 2.28 (q, J = 7.2 Hz, 4.20H), 2.13 (q, J = 7.2 Hz, 2H), 1.45 – 1.39 (m, 6.64H), 1.35 – 1.27 (m, 31.55H), 0.89 – 0.87 (m, 9.30H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 137.67, 136.05, 133.41, 131.88, 130.43, 129.86, 129.47, 128.62, 128.54, 128.51, 127.28, 127.01, 126.28, 126.08, 124.49, 32.88, 31.90, 29.71, 29.49, 29.33, 29.29, 29.24, 28.01, 22.68, 14.11. **HRMS** (ESI-TOF) (m/z): Calcd for $C_{18}H_{26}Na$ ([M + Na]$^+$): 265.1927; found: 265.1920.

(6-methoxyhexa-1,3-dien-1-yl)benzene (4t)

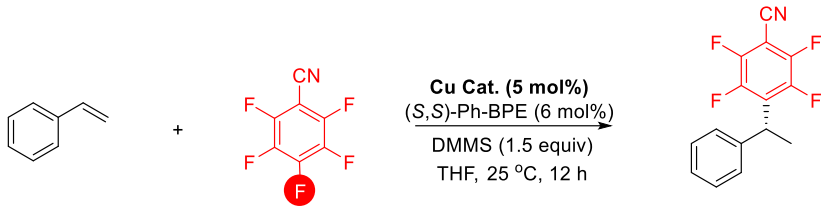


Z/E (1.0/1.3)

Following the general procedure E at a 5.0 mmol scale to afford the compound as a colorless oil with 75% yield (0.71 g). NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.41 (d, J = 7.8 Hz, 2.61H), 7.37 (d, J = 7.2 Hz, 2H), 7.32 – 7.28 (m, 4.90H), 7.23 – 7.18 (m, 2.40H), 7.06 (dd, J = 15.6, 10.8 Hz, 1.30H), 6.75 (dd, J = 15.6, 10.8 Hz, 1H), 6.55 (d, J = 15.6 Hz, 1.30H), 6.46 (d, J = 15.6 Hz, 1H), 6.30 – 6.23 (m, 2.31H), 5.84 – 5.79 (m, 1H), 5.56 – 5.51 (m, 1.30H), 3.46 (t, J = 6.3 Hz, 4.60H), 3.36 (s, 3.90H), 3.36 (s, 3H), 2.58 (q, J = 6.6 Hz, 2.60H), 2.43 (q, J = 6.6 Hz, 2H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 137.46, 137.41, 132.76, 132.26, 131.42, 130.70, 130.43, 129.06, 128.54, 128.50, 128.46, 127.45, 127.17, 126.35, 126.15, 124.04, 72.13, 72.11, 58.64, 58.61, 33.19, 28.56. **HRMS** (ESI-TOF) (m/z): Calcd for $C_{13}H_{16}NaO$ ([M + Na]$^+$): 211.1093; found: 211.1087.

3. Detailed Optimization Studies

Table S1. Cu Catalyst Screening[a]

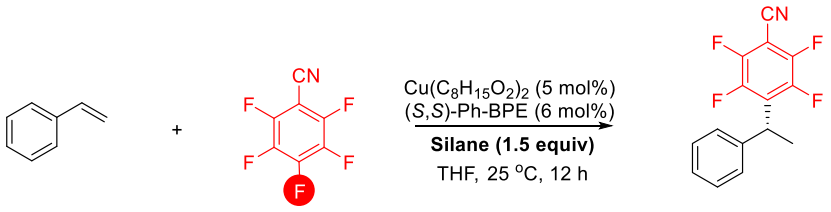


1a 2a 3a

Entry	Cu Cat.	3a/%	ee/%
1	**$Cu(C_8H_{15}O_2)_2$**	**89**	**93**
2	$Cu(OAc)_2$	97	86
3	CuOAc	88	86
4	$Cu(CF_3SO_3)_2$	N.R.	--
5[b]	CuCl	40	96
6[c]	CuCl	29	98
7	$[(PPh_3)CuH]_6$	28	90

[a] Reaction condition: **1a** (0.3 mmol, 1.5 equiv), **2a** (0.2 mmol), DMMS (0.3 mmol, 1.5 equiv), Cu Cat. (5 mol%), (*S*,*S*)-Ph-BPE (6 mol%) in dry THF (2.0 mL). The yield of **3a** was determined via ^{1}H NMR analysis of the crude reaction mixture using CH_2Br_2 as an internal standard, and ee value was determined by HPLC analysis. DMMS = $(MeO)_2MeSiH$. [b] NaO^{t}Bu (0.04 mmol, 20 mol%). [c] NaO^{t}Bu (0.1 mmol, 50 mol%).

Table S2. Silane Screening[a]

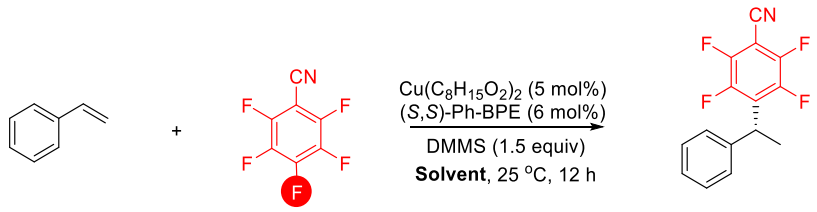


1a 2a 3a

Entry	Silane	3a/%	ee/%
1	**DMMS**	**89**	**93**
2	PMHS	86	91
3	Et_3SiH	52	69
4	Ph_2MeSiH	58	56
5	TMDS	90	88
6	$PhSiH_3$	58	98

[a] Reaction condition:**1a** (0.3 mmol, 1.5 equiv), **2a** (0.2 mmol), silane (0.3 mmol, 1.5 equiv), $Cu(C_8H_{15}O_2)_2$ (5 mol%), (*S*,*S*)-Ph-BPE (6 mol%) in dry THF (2.0 mL). The yield of **3a** was determined via ^{1}H NMR analysis of the crude reaction mixture using CH_2Br_2 as an internal standard, and ee value was determined by HPLC analysis.

Table S3. Solvent Screening[a]

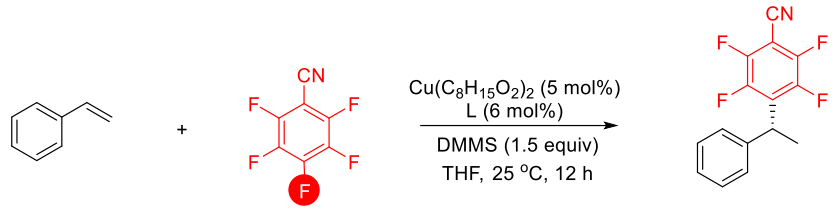


1a **2a** **3a**

Entry	Silane	3a/%	ee/%
1	**THF**	**89**	**93**
2	MTBE	78	81
3	DME	81	83
4	1,4-Dioxane	81	93
5	Toluene	76	94
6	DCM	82	85

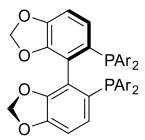
[a] Reaction condition: **1a** (0.3 mmol, 1.5 equiv), **2a** (0.2 mmol), DMMS (0.3 mmol, 1.5 equiv), $Cu(C_8H_{15}O_2)_2$ (5 mol%), (*S*,*S*)-Ph-BPE (6 mol%) in dry solvent (2.0 mL). The yield of **3a** was determined via ^{1}H NMR analysis of the crude reaction mixture using CH_2Br_2 as an internal standard, and ee value was determined by HPLC analysis.

Table S4. Chiral Ligand Screening[a]

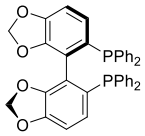


1a **2a** **3a**

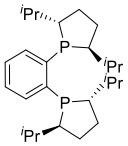
Entry	Ligand	3a/%	ee/%
1	**L1**	N.R.	--
2	**L2**	N.R.	--
3	**L3**	N.R.	--
4	**L4**	N.R.	--
5	**L5**	N.R.	--
6	**L6**	N.D.	--
7	**L7**	N.D.	--
8	**L8**	N.D.	--
9	**L9**	N.D.	--
10	**L10**	89	93
11[b]	**L10**	**97**	**96**



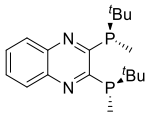
L1, Ar: 3,5-^{t}Bu-4-OMe-C_6H_2



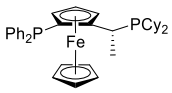
L2



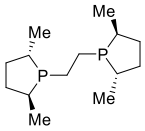
L3



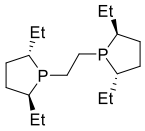
L4



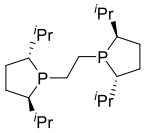
L5



L6



L7



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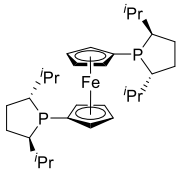
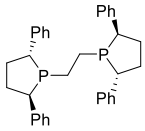


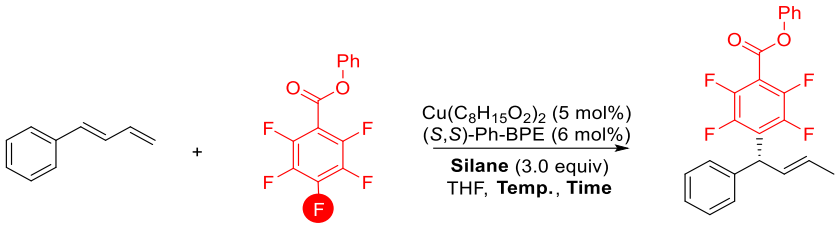
L9



L10

[a] Reaction condition: **1a** (0.3 mmol, 1.5 equiv), **2a** (0.2 mmol), DMMS (0.3 mmol, 1.5 equiv), $Cu(C_8H_{15}O_2)_2$ (5 mol%), ligand (6 mol%) in dry THF (2.0 mL). The yield of **3a** was determined via ^{1}H NMR analysis of the crude reaction mixture using CH_2Br_2 as an internal standard, and ee value was determined by HPLC analysis. [b] **1a** (0.4 mmol, 2.0 equiv).

Table S5. Optimization of 1,3-Dienes Reaction Conditions[a]



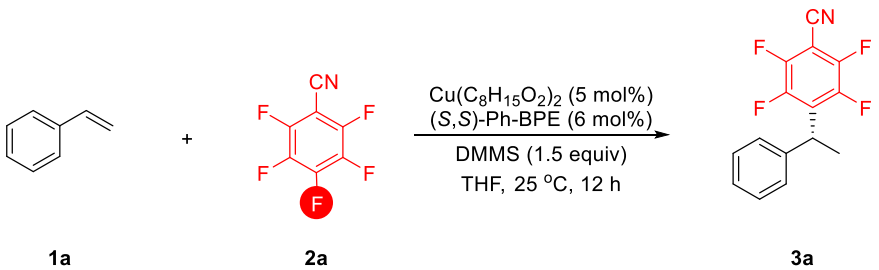
4a 2b 5a

Entry	Silane	T/°C	Time/h	3b/%	ee/%
1	DMMS	0	12	83	95
2	Ph_2MeSiH	0	12	68	92
3	PMHS	0	12	67	90
4	TMDS	0	12	77	93
5	Ph_2SiH_2	0	12	50	88
6	$PhSiH_3$	0	12	92	99
7[b]	$PhSiH_3$	0	12	95	99
8	$PhSiH_3$	0	24	95	99
9	$PhSiH_3$	0	6	95	99
10[b]	$PhSiH_3$	25	6	85	97
11[b]	$PhSiH_3$	-10	6	98	99
12[b]	**$PhSiH_3$**	**0**	**6**	**98**	**99**

[a] Reaction condition: **4a** (0.4 mmol, 2.0 equiv), **2b** (0.2 mmol, 1.0 equiv), silane (0.6 mmol, 3.0 equiv), $Cu(C_8H_{15}O_2)_2$ (5 mol%), (*S*,*S*)-Ph-BPE (6 mol%) in dry THF (2.0 mL). The yield of **5a** was determined via ^1H NMR analysis of the crude reaction mixture using CH_2Br_2 as an internal standard, and ee value was determined by HPLC analysis. [b] $PhSiH_3$ (0.3 mmol, 1.5 equiv).

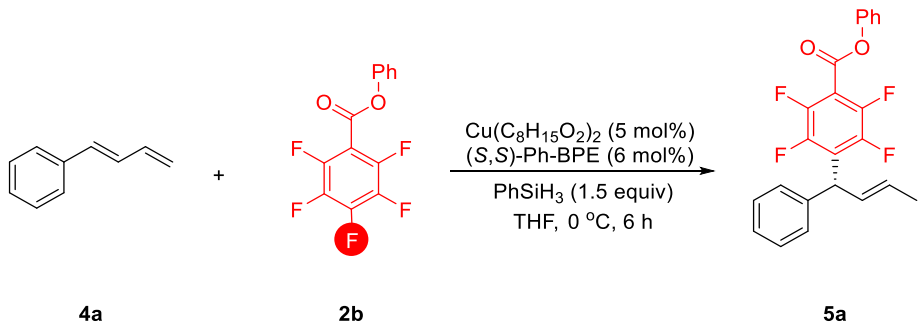
4. Experimental Procedures

General procedure F:



Taking 3a as an example: In a nitrogen-filled glovebox, a flame-dried screw-cap reaction tube equipped with a Teflon-coated magnetic stir bar were charged with $Cu(C_8H_{15}O_2)_2$ (3.5 mg, 10 μmol), (*S*, *S*)-Ph-BPE (6.1 mg, 12 μmol) and dry THF (2.0 mL). The resulting mixture was stirred for 10 min, then dimethoxymethylsilane (DMMS, 38 μL, 1.5 equiv) was added and stirring was continued for another 5 min at room temperature. The reaction solution typically turned a yellow or orange color at this time, then styrene **1a** (41.6 mg, 2.0 equiv) and pentafluorobenzonitrile **2a** (38.6 mg, 0.2 mmol) were added. The reaction was removed from the glovebox and stirred at 25 °C for 12 h, until the reaction was complete as indicated by TLC. And the reaction mixture were concentrated in vacuo. The resulting crude product was purified by flash column chromatography on silica gel (petroleum ether : dichloromethane = 10:1) to obtain product **3a**. The details and characterization data of the products were stated below.

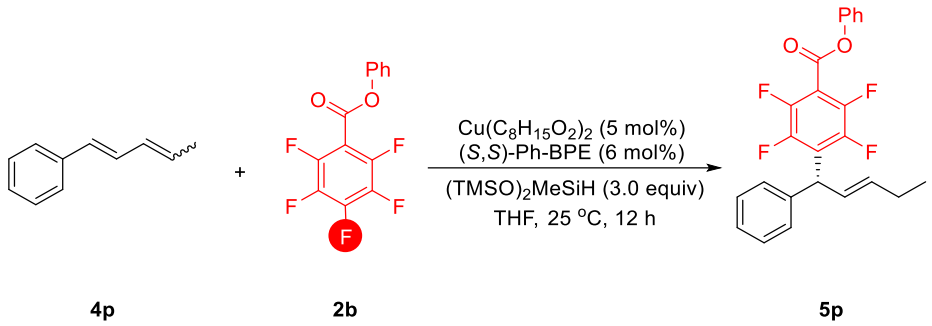
General procedure G:



Taking 5a as an example: In a nitrogen-filled glovebox, a flame-dried screw-cap reaction tube equipped with a Teflon-coated magnetic stir bar were charged with $Cu(C_8H_{15}O_2)_2$ (3.5 mg, 10 μmol), (*S*, *S*)-Ph-BPE (6.1 mg, 12 μmol) and dry THF (2.0 mL). The resulting mixture was stirred for 10 min, then phenylsilane (37 μL, 1.5 equiv) was added and stirring was continued for another 3 min at room temperature. The reaction solution typically turned a yellow or orange color at this time, then 1-

phenyl-1,3-butadiene **4a** (52.1 mg, 2.0 equiv) and pentafluorobenzoate **2b** (57.6 mg, 0.2 mmol) were added. The reaction was removed from the glovebox and stirred at 0 °C for 6 h, until the reaction was complete as indicated by TLC. And the reaction mixture were concentrated in vacuo. The resulting crude product was purified by flash column chromatography on silica gel (petroleum ether : dichloromethane = 10:1) to obtain product **5a**. The details and characterization data of the products were stated below.

General procedure H:

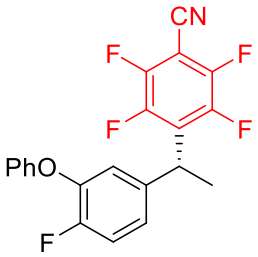


Taking 5p as an example: In a nitrogen-filled glovebox, a flame-dried screw-cap reaction tube equipped with a Teflon-coated magnetic stir bar were charged with $Cu(C_8H_{15}O_2)_2$ (3.5 mg, 10 μmol), (*S*, *S*)-Ph-BPE (6.1 mg, 12 μmol) and dry THF (2.0 mL). The resulting mixture was stirred for 10 min, then 1,1,1,3,5,5,5-heptamethyltrisiloxane (163 μL, 3.0 equiv) was added and stirring was continued for another 3 min at room temperature. Then (1-penta-1,3-dien-1-yl)benzene **4p** (57.7 mg, 2.0 equiv) and pentafluorobenzoate **2b** (57.6 mg, 0.2 mmol) were added. The reaction was removed from the glovebox and stirred at 25 °C for 12 h, until the reaction was complete as indicated by TLC. And the reaction mixture were concentrated in vacuo. The resulting crude product was purified by flash column chromatography on silica gel (petroleum ether : dichloromethane = 10:1) to obtain product **5p**. The details and characterization data of the products were stated below.

5. Absolute Stereochemistry Determination

Structure Analysis X-Ray Crystallography of 3y

For the stereochemistry configuration of the hydroamination compounds, the X-ray crystallography of **3y** showed that the structure of compound, X-ray quality crystals were grown from PE/DCM. Crystallographic data (excluding structure factors) for the structure has been deposited with the Cambridge Crystallographic Data Center as supplementary publication number **(CCDC 2378635)**. These data can be obtained free of charge from the Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif



X-Ray Crystallographic Data

A single crystal of **3y** suitable for X-ray crystallography was obtained by crystallization *via* evaporation from its PE/DCM solution. And the crystal structure of compound **3y** has been deposited at the Cambridge Crystallographic Data Centre (**CCDC 2378635**).

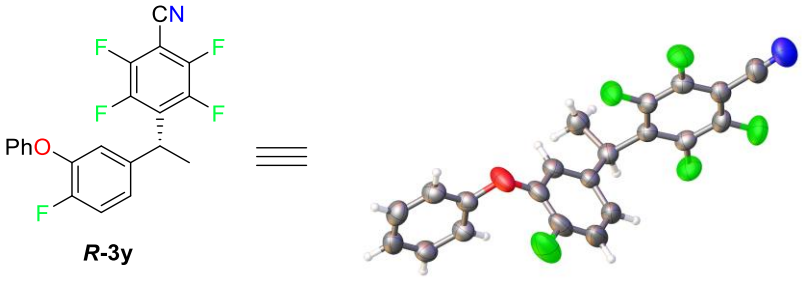
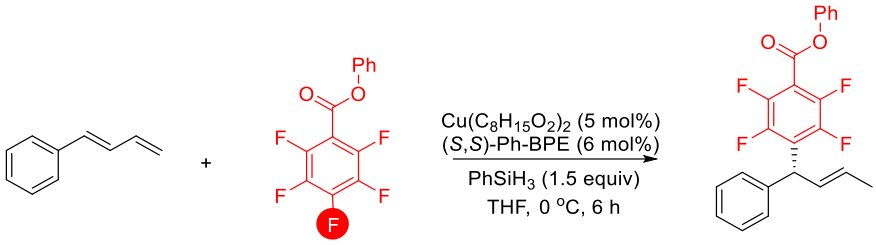


Table S6. Crystal data for **3y**

CCDC	2378635
Empirical formula	$C_{21}H_{12}F_5NO$
Formula weight	389.32
Temperature/K	293
Crystal system	orthorhombic
Space group	P 21 21 21
a/Å	5.7489(9)
b/Å	15.981(3)

c/Å	19.362(3)
α/°	90
β/°	90
γ/°	90
Volume/Å^3	1778.9(5)
Z	4
ρ_{calc}g/cm^3	1.454
μ/mm^{-1}	1.093
F(000)	792.0
Crystal size/mm^3	0.20 × 0.20 × 0.20
Radiation	CuK\a (λ = 1.54184)
2Θ range for data collection/°	7.172 to 127.63
Index ranges	$-6 \leq h \leq 5$, $-18 \leq k \leq 18$, $-22 \leq l \leq 22$
Reflections collected	15788
Independent reflections	2922 [R_{int} = 0.0341, R_{sigma} = 0.0267]
Data/restraints/parameters	2922/0/257
Goodness-of-fit on F^2	1.083
Final R indexes [I>=2σ (I)]	R_1 = 0.0341, wR_2 = 0.0776
Final R indexes [all data]	R_1 = 0.0399, wR_2 = 0.0815
Largest diff. peak/hole / e Å^{-3}	0.13/-0.16
Flack parameter	-0.04(19)

6. Gram-Scale Reaction



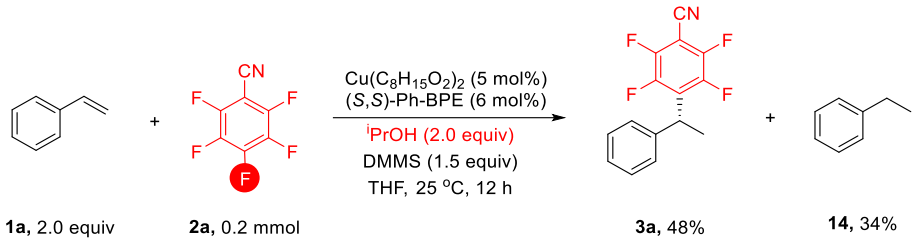
4a, 2.0 equiv **2b**, 3 mmol **5a**

Following the general procedure G: In a nitrogen-filled glovebox, a flame-dried screw-cap reaction tube equipped with a Teflon-coated magnetic stir bar were charged with $Cu(C_8H_{15}O_2)_2$ (52.5 mg, 0.15 mmol, 5 mol%), (*S,S*)-Ph-BPE (91.2 mg, 0.18 mmol, 6 mol%), $PhSiH_3$ (486.9 mg, 4.5 mmol, 1.5 equiv), **4a** (781.2 mg, 6 mmol, 2.0 equiv.), **2b** (864.6 mg, 3 mmol, 1.0 equiv.) and anhydrous THF (15 mL). After stirring at 0 °C for 12 h, the reaction mixture was quenched with water (20.0 mL). The mixture was extracted with dichloromethane (3 × 20.0 mL). The combined organic layers were dried over Na_2SO_4, and concentrated under reduced pressure. The crude mixture was purified by column chromatography on silica gel (n-hexane : dichloromethane, 15:1) to give the product **5a** (1.11 g, 92% isolated yield, >99% ee) as colorless oil.

7. Mechanism Studies

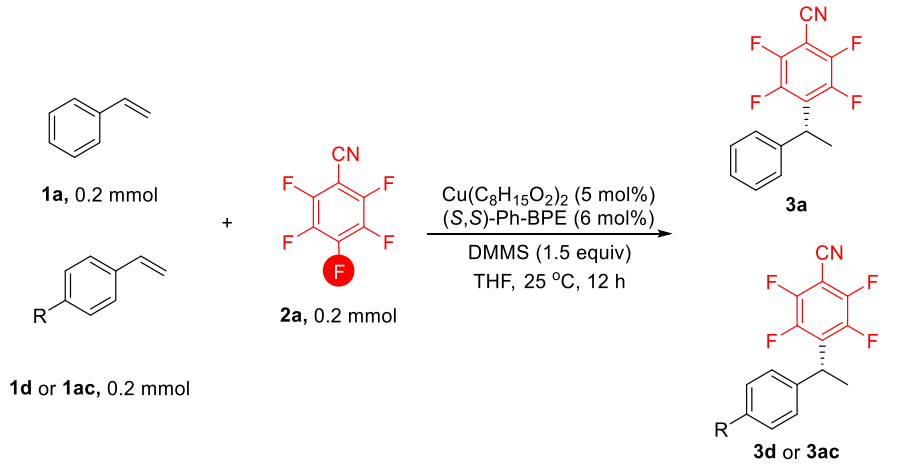
a) Control experiments

In a nitrogen-filled glovebox, a flame-dried screw-cap reaction tube equipped with a Teflon-coated magnetic stir bar were charged with $Cu(C_8H_{15}O_2)_2$ (3.5 mg, 10 μmol), (*S*, *S*)-Ph-BPE (6.1 mg, 12 μmol) and dry THF (2.0 mL). The resulting mixture was stirred for 10 min, then dimethoxymethylsilane (38 μL, 1.5 equiv) was added and stirring was continued for another 5 min at room temperature. The reaction solution typically turned a yellow or orange color at this time, then styrene **1a** (41.6 mg, 2.0 equiv), pentafluorobenzonitrile **2a** (38.6 mg, 0.2 mmol) and ^{i}PrOH (2.0 equiv) were added. The reaction was removed from the glovebox and stirred at 25 °C for 12 h, until the reaction was complete as indicated by TLC. Yields were analyzed by ^{1}H NMR spectroscopy of the crude mixture with CH_2Br_2 as an internal standard.



b) Competitive reaction of styrenes

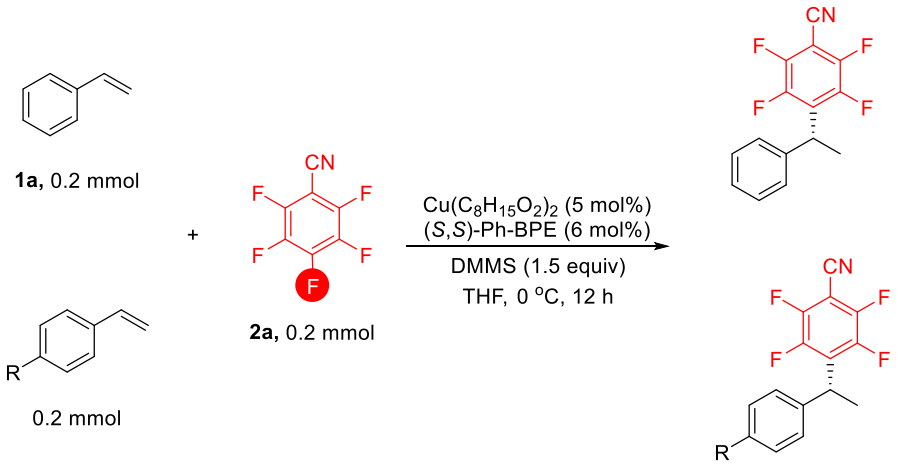
In a nitrogen-filled glovebox, a flame-dried screw-cap reaction tube equipped with a Teflon-coated magnetic stir bar were charged with $Cu(C_8H_{15}O_2)_2$ (3.5 mg, 10 μmol), (*S*, *S*)-Ph-BPE (6.1 mg, 12 μmol) and dry THF (2.0 mL). The resulting mixture was stirred for 10 min, then dimethoxymethylsilane (38 μL, 1.5 equiv) was added and stirring was continued for another 5 min at room temperature. The reaction solution typically turned a yellow or orange color at this time, then styrene **1a** and **1d** or **1ac** (20.8 mg and 23.6 mg or 37.6 mg, 0.2 mmol), pentafluorobenzonitrile **2a** (38.6 mg, 0.2 mmol) were added. The reaction was removed from the glovebox and stirred at 25 °C for 12 h, until the reaction was complete as indicated by TLC. Yields were analyzed by ^{19}F NMR spectroscopy of the crude mixture with α,α,α-trifluorotoluene as an internal standard.



R	Yield of **3a** (%)	Yield of **3d** or **3ac** (%)
Me	62	20
OCF_3	16	65

c) Hammett analysis in the case of the styrene

The reactions were very fast under the standard conditions. The reactions were then carried out at 0 °C.



This procedure was performed on the relative kinetic data when R = *p*-Me, *p*-Ph, *p*-F and *p*-OCF_3 substituted alkene in comparison to the standard substrate (where R = H) to obtain the log(k_R/k_H) for each substrate. The log(k_R/k_H) for each substrate was then plotted against the corresponding σ- values taken from the literature.[6]

Table S7. The summary of Hammett analysis

R	**σ**	**σ^+**	**σ^-**	**log(k_R/k_H)**
p-H	0	0	0	0
p-Me	-0.17	-0.31	-0.17	-0.20

p-Ph	-0.01	-0.18	0.02	0.04
p-F	0.06	-0.07	-0.03	0.01
p-OCF3	0.35	--	0.27	0.27

Figure S1. Hammett plots obtained from correlation of log(k_R/k_H) versus: (A) σ^- (B) σ (C) σ^+

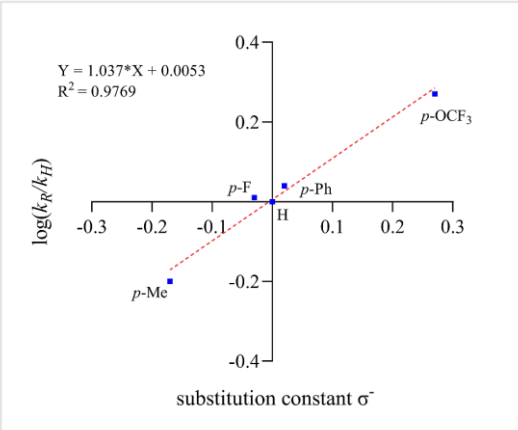


Fig. S1-(A) log(k_R/k_H) versus σ^-

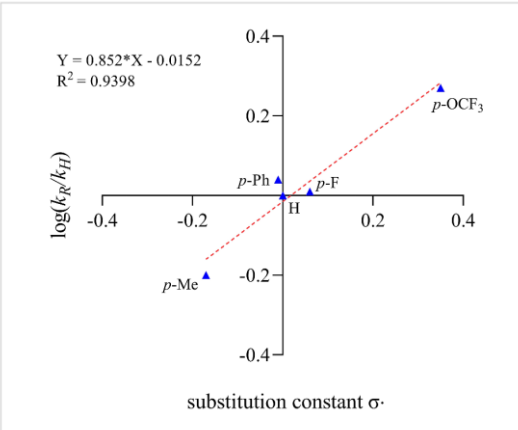


Fig. S1-(B) log(k_R/k_H) versus σ

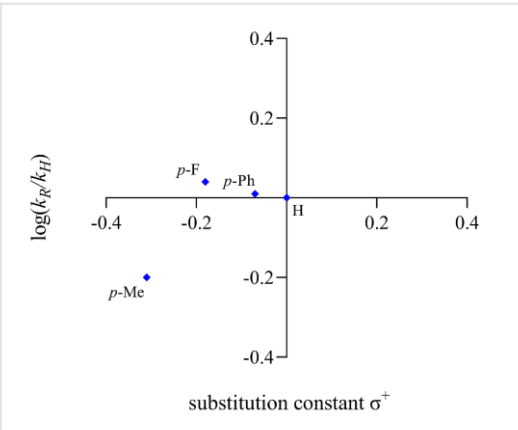
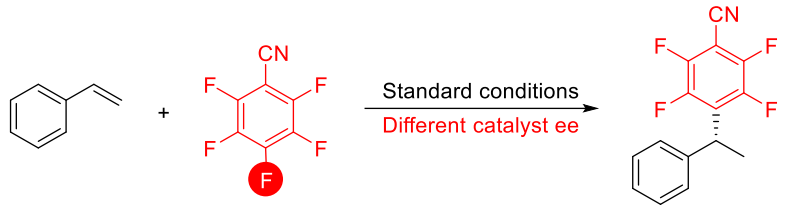


Fig. S1-(C) log(k_R/k_H) versus σ^+

d) Nonlinear effect studies

We investigated the dependence of product enantiomeric excess on catalyst e.e. To perform this study we prepared ligand (*S,S*)-Ph-BPE, and mixed it with ligand (*R,R*)-Ph-BPE to afford 99%, 80%, 60%, 40%, 20% and 0% e.e. of the catalyst. According to the general procedure we separated the product **3a** and determined its enantioselectivity by chiral HPLC analysis. Finally, the catalyst enantiomeric composition on reaction enantioselectivity was plotted (**Fig. S2**).



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

Catalyst ee (%)	0	20	40	60	80	99
ee of **3a** (%)	0	20	42	61	75	96

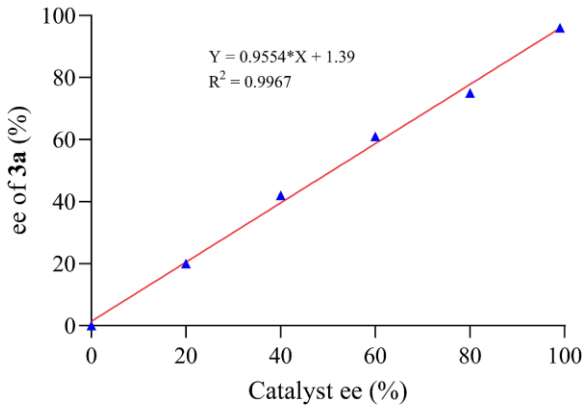
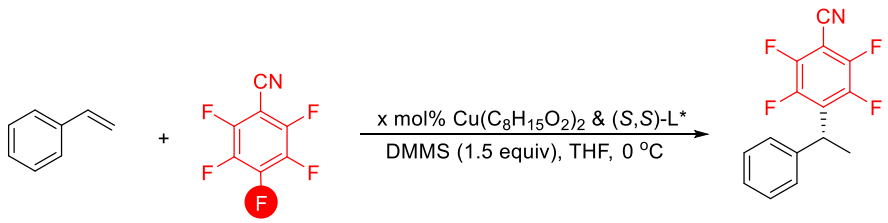


Figure S2. Linear correlation between the ee of Ph-BPE and **3a**

e) Initial-rate kinetic studies

The reactions were very fast under the standard conditions. The reactions were then carried out at 0 °C.



1a, 2.0 equiv **2a,** 1.0 equiv **3a**

Order in $Cu(C_8H_{15}O_2)_2$ & (*S,S*)-Ph-BPE. The order in donor was determined by studying the initial rate of reactions using different concentrations of $Cu(C_8H_{15}O_2)_2$ & (*S,S*)-Ph-BPE. Rate on the concentration of $Cu(C_8H_{15}O_2)_2$ & (*S,S*)-Ph-BPE from the reaction of **1a** (0.1 M), **2a** (0.05 M), DMMS (0.075 M) with 1×10^{-3} M, 2×10^{-3} M, 2.5×10^{-3} M, 3×10^{-3} M, 4×10^{-3} M of $Cu(C_8H_{15}O_2)_2$. The reaction was used 1,3,5-trimethoxybenzene as an internal standard. After addition of DMMS, the stopwatch was started. The aliquots of the reaction mixture (40 μL) were taken out by syringe after initiation period at about every 10 minutes. The product composition was analyzed by GC-MS.

$Cu(C_8H_{15}O_2)_2$ (M)	1×10^{-3}	2×10^{-3}	2.5×10^{-3}	3×10^{-3}	4×10^{-3}
Rate (M/min)	1×10^{-4}	2.05×10^{-4}	2.8×10^{-4}	3.55×10^{-4}	4.5×10^{-4}

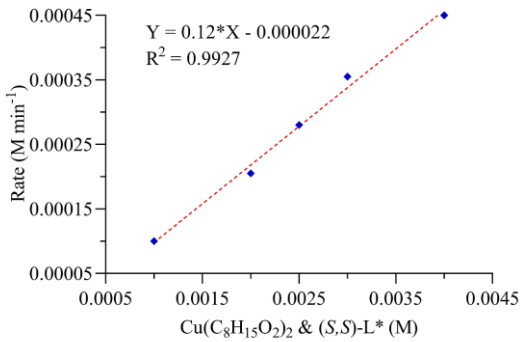
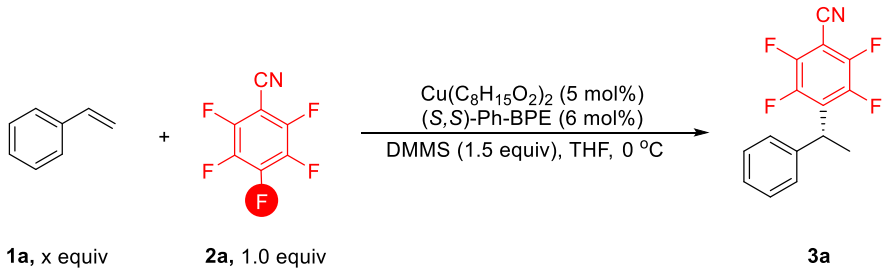


Figure S3. Plot indicates first order dependence on $Cu(C_8H_{15}O_2)_2$ & (*S,S*)-Ph-BPE for the model system



Order in 1a. The order in donor was determined by studying the initial rate of reactions using different concentrations of **1a**. Rate on the concentration of **1a** from the reaction of $Cu(C_8H_{15}O_2)_2$ & (*S,S*)-Ph-BPE (2.5×10^{-3} M), **2a** (0.05 M), DMMS (0.075 M) with 0.05 M, 0.075 M, 0.1 M, 0.125 M, 0.15 M of **1a**. The reaction was used 1,3,5-trimethoxybenzene as an internal standard. After addition of DMMS, the stopwatch was started. The aliquots of the reaction mixture (40 μL) were taken out by syringe after

initiation period at about every 10 minutes. The product composition was analyzed by GC-MS.

1a (M)	0.05	0.075	0.1	0.125	0.15
Rate (M/min)	1.45×10^{-4}	2.15×10^{-4}	2.8×10^{-4}	3.2×10^{-4}	3.65×10^{-4}

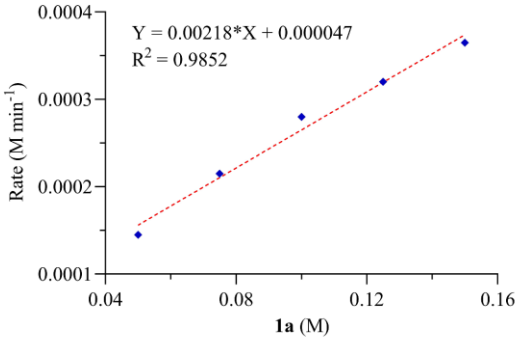
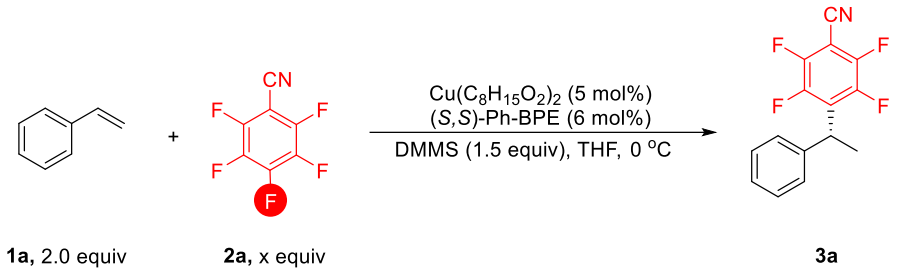


Figure S4. Plot indicates first order dependence on **1a** for the model system



Order in 2a. The order in donor was determined by studying the initial rate of reactions using different concentrations of **2a**. Rate on the concentration of **2a** from the reaction of $Cu(C_8H_{15}O_2)_2$ & (*S,S*)-Ph-BPE (2.5×10^{-3} M), **1a** (0.1 M), DMMS (0.075 M) with 0.025 M, 0.0375 M, 0.05 M, 0.0625 M, 0.075 M of **2a**. The reaction was used 1,3,5-trimethoxybenzene as an internal standard. After addition of DMMS, the stopwatch was started. The aliquots of the reaction mixture (40 μL) were taken out by syringe after initiation period at about every 10 minutes. The product composition was analyzed by GC-MS.

2a (M)	0.025	0.0375	0.05	0.0625	0.075
Rate (M/min)	2.5×10^{-4}	2.65×10^{-4}	2.8×10^{-4}	2.9×10^{-4}	3.0×10^{-4}

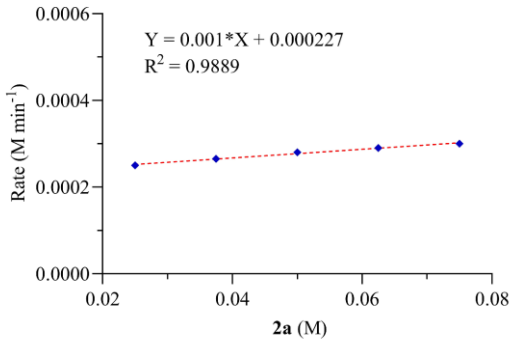
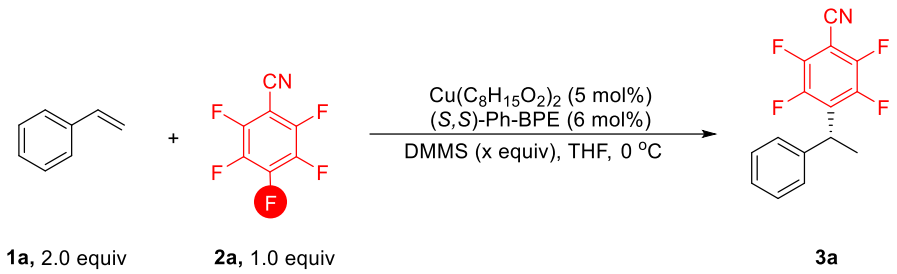


Figure S5. Plot indicates zero order dependence on **2a** for the model system



Order in DMMS. The order in donor was determined by studying the initial rate of reactions using different concentrations of DMMS. Rate on the concentration of DMMS from the reaction of $Cu(C_8H_{15}O_2)_2$ & (*S,S*)-Ph-BPE (2.5×10^{-3} M), **1a** (0.1 M), **2a** (0.05 M) with 0.025 M, 0.05 M, 0.075 M, 0.1 M, 0.125 M of DMMS. The reaction was used 1,3,5-trimethoxybenzene as an internal standard. After addition of DMMS, the stopwatch was started. The aliquots of the reaction mixture (40 μL) were taken out by syringe after initiation period at about every 10 minutes. The product composition was analyzed by GC-MS.

DMMS (M)	0.025	0.05	0.075	0.1	0.125
Rate (M/min)	2.6×10^{-4}	2.7×10^{-4}	2.8×10^{-4}	2.9×10^{-4}	2.95×10^{-4}

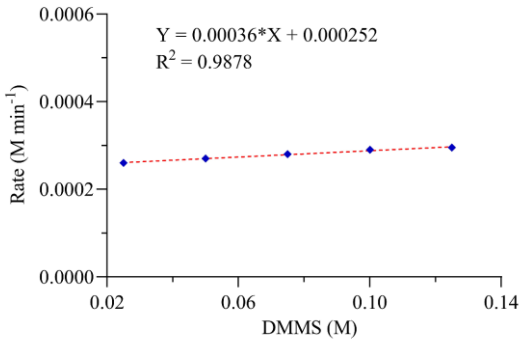


Figure S6. Plot indicates zero order dependence on DMMS for the model system

f) Calculation details

All calculations were performed using the Gaussian16 package.[7] The B3LYP functional[8] including Grimme empirical dispersion correction (D3BJ) was used for the geometry optimization of all structures. The SDD[9-10] basis set and pseudopotential were employed for the Cu, and the 6-31G(d)[11-12] was applied for other atoms. This combination of functional and basis sets has been recommended in mechanistic investigations of organic reactions catalyzed by transition-metal such as Cu[13]. Frequency calculations at the same level of theory as the geometry optimizations were carried out to verify that all stationary points were either local minima (no imaginary frequencies) or transition states (one imaginary frequency)[14]. To confirm the correct connectivity between reactants and products, intrinsic reaction coordinate (IRC) calculations were performed for each transition state[15-16]. Single-point energy calculations were performed at the M06 level of theory, employing the SDD basis set for cobalt and iodine, and the 6-311+G(d,p) basis set[17-18] for all other atoms. The solvation model density model (SMD)[19-20] is conducted for optimized structure and single-point energy calculations to evaluate the solvent effects (THF). The ball stick models in this work were drawn by using CYLView[21]. The non-covalent interactions between molecular fragments were analyzed using the independent gradient model based on Hirshfeld partition (IGMH) method[22], as implemented in Multiwfn[23-24] and visualized with VMD[25] software.

The enantiomeric excess (% ee) is calculated by using the Bolzmann distribution of diastereomeric transition states with the expression

$$\mathrm{ee} = \frac{1 - e^{-\Delta G^{\ddagger}_{R/S}/RT}}{1 + e^{-\Delta G^{\ddagger}_{R/S}/RT}} \times 100$$

Where $\Delta G^{\ddagger}$ is the difference in the Gibbs free energies between the competing diastereomeric transition states.

$$ee = \frac{1 - e^{-(2.6*1000)/(1.98715*298.15)}}{1 + e^{-(2.6*1000)/(1.98715*298.15)}} = 97.5\%$$

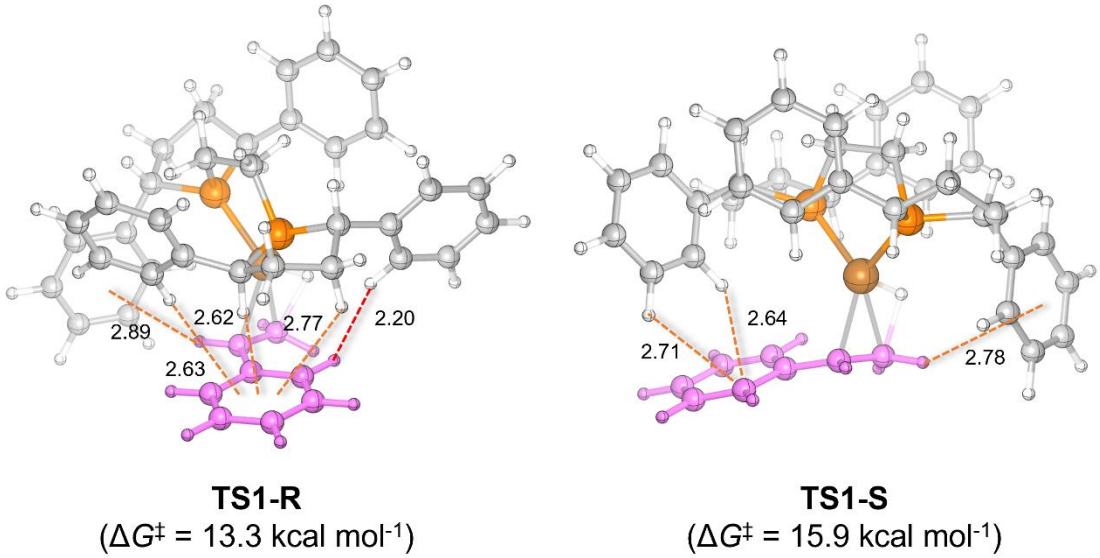


Figure S7. Optimized geometries of **TS1-R** and **TS1-S** and visualization of noncovalent interactions.

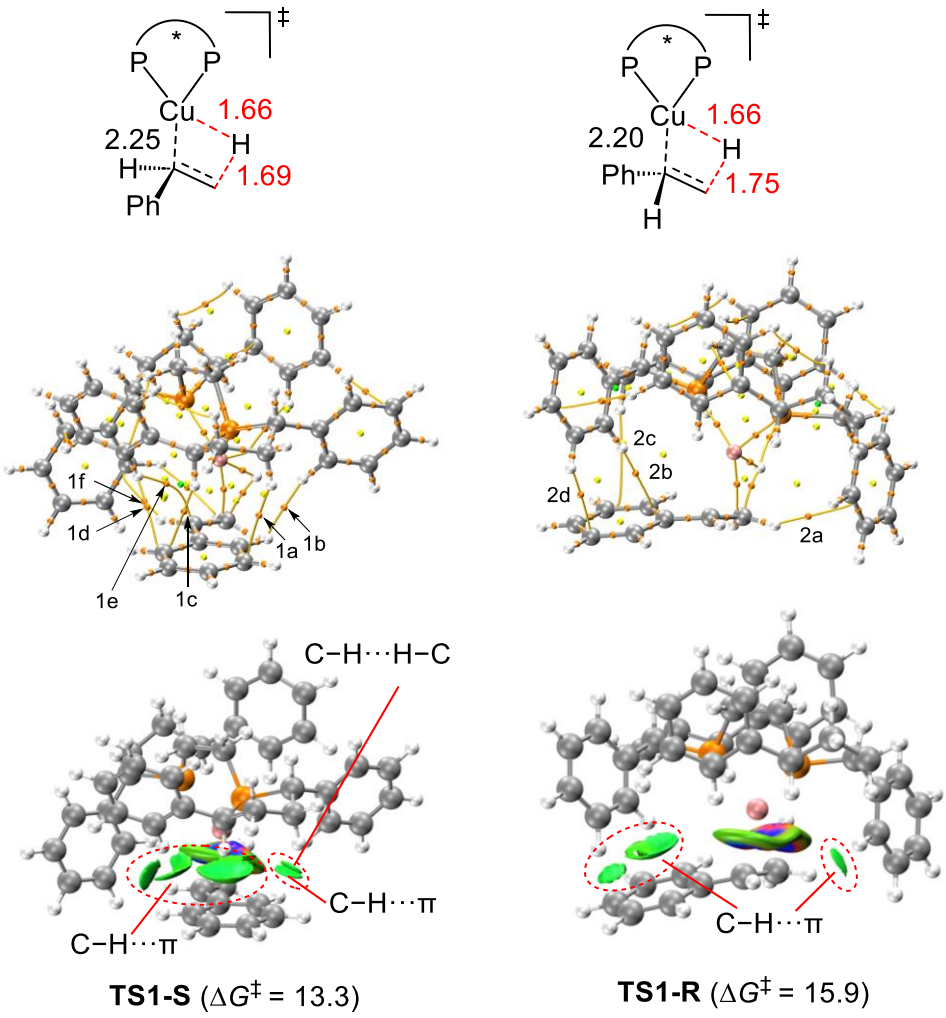
Table S8. The electronic energy and the number of imaginary frequencies.

Stationary Points	G_correction	E (SCF)	Number of imaginary frequencies
Cat	0.551345	-2197.34	0
1a	0.102291	-309.477	0
TS1-R	0.67923	-2506.82	1
TS1-S	0.678262	-2506.82	1
IM1-R	0.685197	-2506.87	0
IM1-S	0.684464	-2506.87	0
2a	0.021646	-820.49	0
TS2R	0.729362	-3327.36	1
TS2'	0.728046	-3327.36	1
IM2R	0.735457	-3327.41	0
IM2'	0.737055	-3327.41	0
IM3R	0.733578	-3327.45	0

IM3'	0.736019	-3327.46	0
Cat	0.547969	-2296.66	0
Pr-R	0.158522	-1030.78	0
Pr-S	0.158815	-1030.78	0

Table S9. The estimation of noncovalent interaction energies (E_{HB}) for transition states **TS1-S** and **TS1-R** was performed based on the Espinosa equation ($E_{HB} = 1/2V(r_{cp})$).

TS1-S							
Bond Id	Noncovalent Interactions	Distance	a.u				E_{NCI}
			ρ	$\Delta_2\rho$	V	K	
1a	C−H···π	2.76	0.0065	0.0199	-0.0029	-0.0010	-0.9
1b	C−H···H−C	2.20	0.0068	0.025	-0.0033	-0.0014	-1.0
1c	C−H···π	2.61	0.0098	0.033	-0.0054	-0.0014	-1.7
1d	C−H···π	2.62	0.0085	0.030	-0.0044	-0.0015	-1.4
1e	C−H···π	2.87	0.0064	0.017	-0.0030	-0.0007	-0.9
1f	C−H···π	2.89	0.0057	0.017	-0.0024	-0.0009	-0.8
E_{NCI}							-6.7
TS1-R							
2a	C−H···π	2.77	0.0067	0.021	-0.0030	-0.0011	-0.9
2b	C−H···π	2.63	0.0045	0.030	-0.0049	-0.0013	-1.5
2c	C−H···π	2.71	0.0031	0.0090	-0.0011	-0.0005	-0.3
2d	C−H···π	3.27	0.0072	0.023	-0.0034	-0.0012	-1.1
E_{NCI}							-3.9



TS1-S ($\Delta G^{\ddagger}$ = 13.3) **TS1-R** ($\Delta G^{\ddagger}$ = 15.9)

Figure S8. AIM analysis of key transition states **TS1-S** and **TS1-R**.

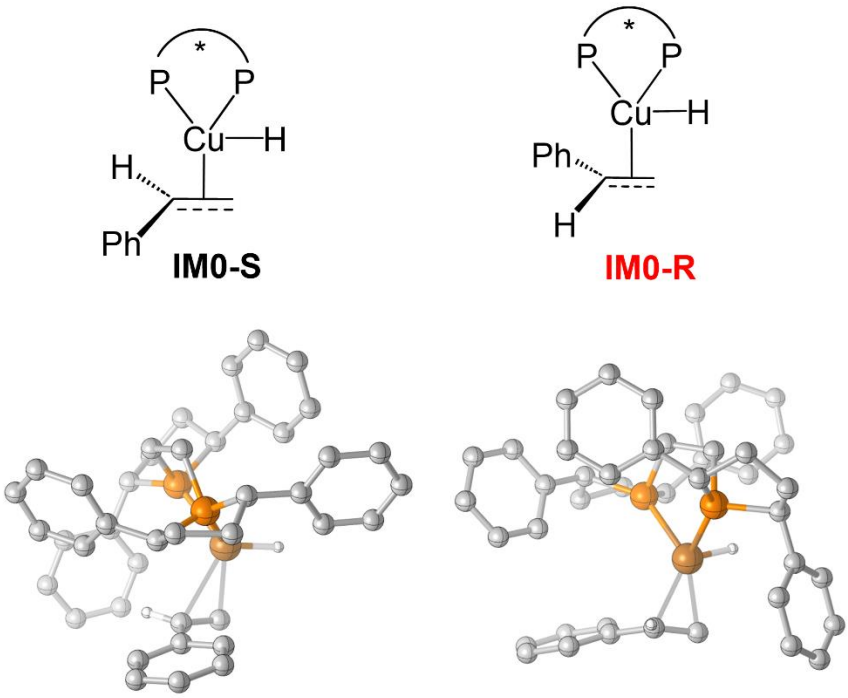


Figure S9. The optimized structures of **IM0-S** and **IM0-R**.

Table S10. The optimized coordinates for key structures in the manuscript.

Cat

Zero-point correction= 0.616038 (Hartree/Particle)
Thermal correction to Energy= 0.651069
Thermal correction to Enthalpy= 0.652013
Thermal correction to Gibbs Free Energy= 0.547974
Sum of electronic and zero-point Energies= -2295.652938
Sum of electronic and thermal Energies= -2295.617908
Sum of electronic and thermal Enthalpies= -2295.616963
Sum of electronic and thermal Free Energies= -2295.721002

F	-0.58757000	0.19290800	-3.17839200
C	-0.63054000	0.35147800	1.84994100
C	0.74228400	-0.34571800	1.78288300
H	-0.63008100	1.08953800	2.66057000
H	-1.40944300	-0.38389800	2.07396800
H	1.53980700	0.38865700	1.93629500
H	0.82424400	-1.08961200	2.58427900
C	-2.91060600	1.66016800	0.55622700
C	-0.46100000	2.87568900	0.28366100
C	-2.87215300	3.21092900	0.48403400
H	-3.14714900	1.37166600	1.58812500
C	-1.52215200	3.68036500	1.04549700
H	-0.48798300	3.19540900	-0.76617700
H	-2.96021100	3.52013000	-0.56472900
H	-3.72431400	3.64312600	1.02017900
H	-1.37667400	4.76067400	0.92503500
H	-1.47686100	3.46242000	2.12038000
C	2.90922400	-1.72546000	0.45878500
C	0.41715600	-2.87941300	0.22670900
C	2.83498000	-3.26605100	0.30892400
H	3.11372300	-1.50217700	1.51327300
C	1.49967200	-3.72653600	0.91036400

H	0.36464100	-3.18847300	-0.82453400
H	2.87344600	-3.52893300	-0.75571100
H	3.69861000	-3.73885600	0.78942400
H	1.32401300	-4.79820200	0.76102900
H	1.50916100	-3.54581300	1.99264200
P	-1.14111600	1.11793500	0.23054300
P	1.14595900	-1.14046900	0.14045300
C	3.96555700	-1.05012000	-0.38134600
C	5.16584100	-0.64079800	0.21158700
C	3.77827900	-0.81409900	-1.75034000
C	6.15584100	-0.00389500	-0.53760900
H	5.31820700	-0.81079400	1.27484100
C	4.76318600	-0.17374100	-2.50156300
H	2.84283600	-1.09777600	-2.22454300
C	5.95486900	0.23604400	-1.89799900
H	7.07802500	0.31182200	-0.05752100
H	4.59324000	0.01408400	-3.55785800
H	6.71844500	0.74036600	-2.48322100
C	-0.98606700	-2.84314700	0.77516700
C	-2.01780800	-2.39288200	-0.06554500
C	-1.28987500	-3.13387600	2.10972400
C	-3.31319200	-2.21995500	0.41558500
H	-1.79553400	-2.15170400	-1.10229600
C	-2.58875100	-2.95912800	2.59677800
H	-0.51420500	-3.49245200	2.77936700
C	-3.60062000	-2.49498500	1.75544100
H	-4.09031300	-1.86271300	-0.25054300
H	-2.80601200	-3.18667900	3.63698300
H	-4.60827700	-2.35303200	2.13529300
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C	1.95409900	2.43436500	-0.17489200
C	1.36534700	3.15301500	2.04833300
C	3.27900800	2.26656000	0.21776100
H	1.66252600	2.20053800	-1.19650200
C	2.69570800	2.98683200	2.44655400

H	0.63173400	3.49994200	2.76955000
C	3.65297500	2.53458600	1.53780100
H	4.01390200	1.91846200	-0.49951000
H	2.97990000	3.21022300	3.47145300
H	4.68424400	2.39524100	1.84878300
C	-3.92247600	1.01467200	-0.36733300
C	-5.20821900	0.74719200	0.12044000
C	-3.61616600	0.66759300	-1.69314500
C	-6.17147400	0.13871100	-0.68439900
H	-5.44963700	1.00449200	1.14958800
C	-4.58046200	0.05557100	-2.49606500
H	-2.62054300	0.81296400	-2.10872200
C	-5.85720900	-0.21377500	-1.99839300
H	-7.16016800	-0.06790400	-0.28333300
H	-4.31855700	-0.22285000	-3.51279600
H	-6.59934400	-0.69813800	-2.62699100
Cu	0.04343000	-0.04140400	-1.48796400

Com1

Zero-point correction= 0.619393 (Hartree/Particle)
Thermal correction to Energy= 0.653720
Thermal correction to Enthalpy= 0.654664
Thermal correction to Gibbs Free Energy= 0.551345
Sum of electronic and zero-point Energies= -2196.350535
Sum of electronic and thermal Energies= -2196.316208
Sum of electronic and thermal Enthalpies= -2196.315264
Sum of electronic and thermal Free Energies= -2196.418583

H	0.08677200	-0.60821500	-3.19388700
C	0.59907600	0.28747400	1.74834300
C	-0.88039700	0.67324400	1.58718300
H	0.71462800	-0.34883000	2.63082700
H	1.19752500	1.18866600	1.90995900
H	-1.52045700	-0.17196500	1.85976200

H	-1.12894700	1.50336500	2.25910200
C	3.12583400	-0.65146400	0.82625100
C	1.02230800	-2.36785500	0.40343300
C	3.08589000	-1.87197400	1.78233200
H	3.36408200	0.25804800	1.38851300
C	2.26338000	-2.97954900	1.10672600
H	0.98409400	-2.72745300	-0.62937900
H	4.09896600	-2.21618500	2.02112200
H	2.61536200	-1.56990800	2.72561800
H	2.88479300	-3.45844500	0.34301700
H	1.97606900	-3.76018000	1.81860700
C	-3.22045300	1.40826800	0.06373700
C	-0.96045500	2.91869600	-0.39668300
C	-3.41511800	2.85827700	-0.44115300
H	-3.39766300	1.41035600	1.14677100
C	-2.21640500	3.67628700	0.06043700
H	-0.88231800	3.02644700	-1.48548700
H	-3.44010100	2.86348800	-1.53823100
H	-4.37287700	3.26112400	-0.09357200
H	-2.22438100	4.70431100	-0.32012400
H	-2.25732100	3.73388200	1.15541500
P	1.35454300	-0.50290500	0.22919500
P	-1.37858600	1.08705200	-0.15867000
C	-4.12292300	0.37113400	-0.55959300
C	-5.22501200	-0.10835200	0.15869000
C	-3.88274800	-0.14024700	-1.84268400
C	-6.06888800	-1.07807400	-0.38418900
H	-5.41470400	0.27378700	1.15913100
C	-4.72132200	-1.11280400	-2.38610500
H	-3.01318200	0.18957900	-2.40420600
C	-5.81659900	-1.58666800	-1.65943800
H	-6.91576600	-1.44139800	0.19154500
H	-4.50906000	-1.50860400	-3.37513400
H	-6.46490900	-2.34880500	-2.08241300
C	0.38342300	3.24297200	0.20426700

C	1.53757800	2.83001900	-0.48243800
C	0.53410900	3.82783600	1.46670800
C	2.80111700	2.96309800	0.08858400
H	1.43659000	2.36912400	-1.46198900
C	1.80126000	3.97176600	2.03907700
H	-0.33811500	4.16645100	2.01690600
C	2.93721000	3.53043900	1.35904500
H	3.67434100	2.60980100	-0.45237100
H	1.89709700	4.42556300	3.02168500
H	3.92001900	3.63502900	1.80968400
C	-0.34114200	-2.58982100	1.00854900
C	-1.46677600	-2.52275200	0.17114100
C	-0.54354100	-2.75195400	2.38438900
C	-2.75734100	-2.59043300	0.69191400
H	-1.32583700	-2.39589500	-0.90015000
C	-1.83613200	-2.82165000	2.91112300
H	0.31038900	-2.81325200	3.05338100
C	-2.94628200	-2.73231200	2.06919500
H	-3.61022200	-2.52478300	0.02514800
H	-1.97300000	-2.94193300	3.98255800
H	-3.95110400	-2.77791100	2.47934600
C	4.14457100	-0.81170900	-0.28748600
C	5.49848700	-0.59530600	0.01075200
C	3.80268600	-1.19324900	-1.59107200
C	6.48447700	-0.76035400	-0.96006700
H	5.77817500	-0.29245400	1.01769500
C	4.78911400	-1.36057500	-2.56577900
H	2.76156700	-1.32998700	-1.87033800
C	6.13149800	-1.14756300	-2.25501200
H	7.52646600	-0.58272300	-0.70780400
H	4.49890200	-1.65052900	-3.57159800
H	6.89675100	-1.27470000	-3.01553100
Cu	-0.09120300	-0.08090200	-1.72250000

IM1-R

Zero-point correction=	0.760621 (Hartree/Particle)
Thermal correction to Energy=	0.802261
Thermal correction to Enthalpy=	0.803205
Thermal correction to Gibbs Free Energy=	0.685197
Sum of electronic and zero-point Energies=	-2505.949925
Sum of electronic and thermal Energies=	-2505.908285
Sum of electronic and thermal Enthalpies=	-2505.907341
Sum of electronic and thermal Free Energies=	-2506.025348

C	1.16089200	-4.56232000	-0.86754500
C	-0.05780400	-5.02853100	-0.36864500
C	-1.22986300	-4.35911700	-0.74290400
C	-1.17507200	-3.23548200	-1.56014900
C	0.05215300	-2.70999100	-2.03843600
C	1.21583000	-3.43828600	-1.69260000
H	2.08254100	-5.08641200	-0.62233900
H	-2.19455600	-4.71438700	-0.38761600
H	-2.09606600	-2.71901900	-1.82693600
C	0.08611300	-1.43632700	-2.78499600
C	1.30526300	-1.18879900	-3.67262700
H	-0.83693000	-1.31919400	-3.36519400
H	2.17652800	-3.11742200	-2.08191300
H	1.48773400	-2.00730400	-4.39177800
H	1.17123400	-0.26735600	-4.25177000
H	2.23091100	-1.05946000	-3.09780200
C	-0.70097100	1.75072600	1.57845300
C	0.65302800	1.11411600	1.93976900
H	-0.71869300	2.80248100	1.88766700
H	-1.50628100	1.23715300	2.11195700
H	1.46435100	1.82345500	1.74469400
H	0.67446100	0.87309000	3.00875800
C	-2.91569400	2.24660100	-0.23445100
C	-0.44332700	3.14793100	-1.03961600

C	-2.86027200	3.51902000	-1.11907500
H	-3.12398000	2.56370600	0.79512600
C	-1.52331000	4.22039700	-0.84301500
H	-0.41467100	2.89451300	-2.10688800
H	-2.91381100	3.22606000	-2.17523900
H	-3.72361900	4.16326100	-0.91901500
H	-1.36112200	5.08105200	-1.50259200
H	-1.51637900	4.59417900	0.18872700
C	2.78117500	-0.83237600	1.61311200
C	0.22598000	-1.86309200	1.74401500
C	2.63220600	-2.32035400	2.00682100
H	2.90473800	-0.24939200	2.53491000
C	1.27156000	-2.46717400	2.69665500
H	0.08169400	-2.56943900	0.92124400
H	2.65546500	-2.94249400	1.10452400
H	3.46487100	-2.63346200	2.64689900
H	1.03139000	-3.51370700	2.91593300
H	1.29366200	-1.92789300	3.65165400
P	-1.14752900	1.59644400	-0.22622400
P	1.08403000	-0.38791300	0.91754200
C	3.93113700	-0.52518500	0.68948200
C	5.03349600	0.20651700	1.14407800
C	3.91964500	-0.96362600	-0.64152600
C	6.10158100	0.49624600	0.29242700
H	5.05074500	0.55951600	2.17245600
C	4.98134800	-0.67513300	-1.49627900
H	3.06303500	-1.51798000	-1.00840900
C	6.07772400	0.05851600	-1.03265200
H	6.94828900	1.06765700	0.66310300
H	4.94879300	-1.01746300	-2.52698600
H	6.90434200	0.28700500	-1.69935600
C	-1.12892600	-1.49122000	2.28842400
C	-2.22830700	-1.49731100	1.41539600
C	-1.32791600	-1.04674200	3.60201600
C	-3.48303600	-1.05834800	1.83164100

H	-2.08929300	-1.84906200	0.39945100
C	-2.58344700	-0.60015300	4.02230200
H	-0.50121400	-1.03910500	4.30552700
C	-3.66351600	-0.59671900	3.13786900
H	-4.31416800	-1.07320800	1.13527400
H	-2.71502600	-0.25501900	5.04448000
H	-4.63902300	-0.24756800	3.46474300
C	0.96903000	3.38837000	-0.57461500
C	1.98563500	2.56329200	-1.08448400
C	1.29707900	4.31286400	0.42262000
C	3.28667100	2.63983800	-0.59622000
H	1.74239300	1.83262900	-1.85339200
C	2.60404700	4.39505000	0.91341200
H	0.53387600	4.97017400	0.82760900
C	3.59860200	3.55443400	0.41365600
H	4.05075300	1.98059500	-0.99192600
H	2.83974300	5.11685300	1.69087400
H	4.61101900	3.60697900	0.80295800
C	-3.97185600	1.24437300	-0.64165500
C	-5.23693600	1.30207900	-0.04379300
C	-3.73098600	0.25505400	-1.60504200
C	-6.23559700	0.38974100	-0.38572400
H	-5.43381700	2.06022500	0.71079500
C	-4.72444900	-0.66386200	-1.94348700
H	-2.74980500	0.17522500	-2.06449000
C	-5.97951500	-0.60278300	-1.33368600
H	-7.20781100	0.44694600	0.09608000
H	-4.51214900	-1.43365400	-2.68033200
H	-6.74982600	-1.32313300	-1.59367100
Cu	-0.02963900	-0.19164700	-1.19912900
H	-0.09868200	-5.90325100	0.27361300

IM1-S

Zero-point correction= 0.760452 (Hartree/Particle)

Thermal correction to Energy= 0.802165
Thermal correction to Enthalpy= 0.803110
Thermal correction to Gibbs Free Energy= 0.684464
Sum of electronic and zero-point Energies= -2505.943082
Sum of electronic and thermal Energies= -2505.901369
Sum of electronic and thermal Enthalpies= -2505.900425
Sum of electronic and thermal Free Energies= -2506.019070

C	-1.80987200	-3.82405200	-2.04198700
C	-3.11531800	-3.56038500	-1.60657200
C	-3.57500200	-2.24231000	-1.64060900
C	-2.75603500	-1.20473400	-2.08671700
C	-1.43058300	-1.44333500	-2.52466700
C	-0.99174800	-2.79296900	-2.49010300
H	-1.43142000	-4.84412400	-2.03597500
H	-4.58672600	-2.00872300	-1.31739800
H	-3.14540800	-0.19356800	-2.09146900
C	-0.50579500	-0.35856900	-2.92219500
C	-1.13619300	0.91983300	-3.46710300
H	0.25233500	-0.74277800	-3.61399600
H	0.02107900	-3.01421600	-2.82436100
H	-1.78629000	0.74172700	-4.34242900
H	-0.35722700	1.62862400	-3.77515500
H	-1.75397400	1.43194500	-2.72003000
C	-0.03374200	0.84696300	2.24341400
C	1.36139600	0.21087400	2.11155300
H	0.04510700	1.76259900	2.83837200
H	-0.69570300	0.16184600	2.78126800
H	2.11521200	0.98952300	1.95856700
H	1.61992700	-0.31986400	3.03566800
C	-2.57416900	1.75995700	1.29500700
C	-0.37771200	2.92876900	0.14650900
C	-2.28690300	3.18871200	1.81928200
H	-2.82298200	1.10118200	2.13279700
C	-1.31576700	3.93057300	0.87471500

H	-0.57463800	2.97429400	-0.92964500
H	-3.21921700	3.75019900	1.94866200
H	-1.83141400	3.09741800	2.81171200
H	-1.88458000	4.48544400	0.12255400
H	-0.74461800	4.68067200	1.42896600
C	3.37516100	-1.39070500	0.76583700
C	0.93907800	-2.61414900	1.19576700
C	3.35561500	-2.93351700	0.90277900
H	3.73736300	-0.97409000	1.71406000
C	2.17018200	-3.30101200	1.80554400
H	0.69570200	-3.12041300	0.25369600
H	3.22122000	-3.38402300	-0.08877600
H	4.31226600	-3.29572200	1.29511600
H	2.02544300	-4.38494500	1.88085200
H	2.36134600	-2.92699100	2.81924100
P	-0.91571300	1.16886800	0.61659600
P	1.55720400	-0.91651600	0.64613200
C	4.23728500	-0.85587200	-0.35117500
C	5.45850500	-0.23883800	-0.05693400
C	3.84176100	-0.95521400	-1.69269800
C	6.26685300	0.27440700	-1.07235200
H	5.77169800	-0.14858900	0.98051000
C	4.64461600	-0.44090600	-2.70980500
H	2.88268300	-1.40098400	-1.94073300
C	5.85961700	0.17805700	-2.40392700
H	7.20907000	0.75448300	-0.82259000
H	4.31465800	-0.51509800	-3.74219900
H	6.48155700	0.58320700	-3.19701800
C	-0.33151400	-2.49034200	1.99607900
C	-1.53199100	-2.28146400	1.29934800
C	-0.35469600	-2.46942800	3.39586200
C	-2.72035500	-2.03937400	1.98368000
H	-1.53721900	-2.30143100	0.21571400
C	-1.54606800	-2.22264100	4.08352900
H	0.55761700	-2.63944900	3.95947000

C	-2.73174700	-1.99860700	3.38059300
H	-3.63013300	-1.88653600	1.41250600
H	-1.54558100	-2.20786100	5.17011100
H	-3.65719700	-1.80946800	3.91779100
C	1.11509000	3.06232300	0.33078200
C	1.95960800	2.51907200	-0.65226100
C	1.69959100	3.59310000	1.48673900
C	3.34058900	2.47713500	-0.47457500
H	1.52060700	2.10054100	-1.55591100
C	3.08579800	3.56248900	1.66485800
H	1.07472900	4.02024500	2.26551200
C	3.90948300	2.99516900	0.69160800
H	3.96867900	2.03243800	-1.23875300
H	3.51838000	3.97687100	2.57166300
H	4.98534100	2.95695900	0.83434100
C	-3.67814900	1.64353700	0.26995600
C	-4.74202600	0.76279700	0.50530500
C	-3.67223400	2.36000500	-0.93616000
C	-5.76049400	0.59008800	-0.43157700
H	-4.76591200	0.20204800	1.43547400
C	-4.68842000	2.19120400	-1.87660900
H	-2.86171500	3.04334800	-1.16128900
C	-5.73508300	1.30157500	-1.63160000
H	-6.57128100	-0.10302900	-0.22469200
H	-4.65176000	2.74672600	-2.80920100
H	-6.52028700	1.16289100	-2.36873700
Cu	0.30014800	-0.18666800	-1.09465800
H	-3.75508100	-4.36454200	-1.25482100

IM2'

Zero-point correction= 0.823920 (Hartree/Particle)
Thermal correction to Energy= 0.877094
Thermal correction to Enthalpy= 0.878039
Thermal correction to Gibbs Free Energy= 0.735457

Sum of electronic and zero-point Energies= -3326.577878
Sum of electronic and thermal Energies= -3326.524703
Sum of electronic and thermal Enthalpies= -3326.523759
Sum of electronic and thermal Free Energies= -3326.666340

C	-1.01951300	-0.21372100	-4.47281200
C	-0.67365300	-1.52166000	-4.11916700
C	-1.12031500	-2.03988900	-2.90532000
C	-1.94290400	-1.27940900	-2.06648400
C	-2.32512800	0.02349500	-2.42352400
C	-1.81969300	0.54835800	-3.62550600
H	-0.66797000	0.20956400	-5.41021900
H	-0.86171100	-3.04976800	-2.60305200
H	-2.31954100	-1.74306100	-1.16530000
C	-3.37488600	0.84634600	-1.69799000
C	-4.73841400	0.64694500	-2.39645200
H	-3.09801000	1.89957800	-1.81648900
H	-2.10081500	1.55810300	-3.91393400
H	-5.03086600	-0.40441900	-2.39947700
H	-5.50832300	1.22763400	-1.88638300
H	-4.66966100	0.98514900	-3.43523000
C	-2.24883000	1.19447300	0.54761300
C	-2.15499700	0.91124300	1.93423600
C	-2.69020500	-0.22587100	2.51711500
C	-3.50198400	-1.03108300	1.64513300
C	-3.77226400	-0.68210100	0.37057400
C	-3.46238500	0.67384500	-0.16522600
F	-1.44125800	1.75422500	2.69923300
F	-1.98661000	2.51894300	0.22983200
F	-4.54877000	-1.50762200	-0.38057200
F	-3.93466800	-2.21479600	2.12438200
F	-4.57697500	1.53526200	0.19489600
C	2.70109000	-0.61744600	0.71279600
C	2.77868000	0.72722100	-0.02708000
H	3.48639100	-0.67453300	1.47297600

H	2.85655100	-1.44451400	0.01424400
H	2.65558800	1.55333500	0.68052100
H	3.75895900	0.84330800	-0.50116100
C	1.07451200	-2.70631700	1.95796500
C	1.21470700	-0.25882500	3.26342600
C	0.76510600	-2.69456500	3.47031600
H	2.11156400	-3.03639000	1.81763500
C	1.54250300	-1.52385700	4.08341000
H	0.21574400	0.07645300	3.54976500
H	-0.30400700	-2.54746700	3.64695500
H	1.04058300	-3.65296000	3.92384000
H	1.27984400	-1.37173200	5.13518100
H	2.61480300	-1.74727100	4.03677100
C	1.67158000	2.65557000	-1.93409300
C	2.16417500	0.09957300	-2.85827000
C	1.80626600	2.47141200	-3.45529000
H	2.65134400	2.96769500	-1.54901800
C	2.74129000	1.27814100	-3.66671900
H	1.28853000	-0.27217600	-3.38988000
H	0.83033900	2.24442700	-3.89907300
H	2.17861100	3.38696700	-3.92793900
H	2.83818800	1.00554600	-4.72392300
H	3.74246200	1.54503200	-3.30952600
P	1.02789800	-0.88588400	1.48161400
P	1.42400900	0.89500500	-1.29574300
C	0.63645200	3.62989600	-1.43111500
C	0.82400100	4.22834400	-0.17781100
C	-0.51764000	3.94697400	-2.15601200
C	-0.11560000	5.11653100	0.34026800
H	1.71594600	3.99108600	0.39654700
C	-1.45444900	4.84529400	-1.64458500
H	-0.69097600	3.49560700	-3.12724900
C	-1.25896000	5.43227300	-0.39501300
H	0.04601600	5.56550600	1.31665600
H	-2.34390200	5.08069000	-2.22244300

H	-1.99402500	6.12395900	0.00537500
C	3.07735700	-1.06902700	-2.58690900
C	2.52412100	-2.35230900	-2.45272100
C	4.46138300	-0.92612400	-2.41560100
C	3.32644300	-3.45466200	-2.16333000
H	1.45267100	-2.47889900	-2.55971200
C	5.26496300	-2.02638800	-2.11216600
H	4.92559500	0.04899000	-2.52041400
C	4.70234000	-3.29660800	-1.98552600
H	2.87439600	-4.43846700	-2.08016300
H	6.33465000	-1.88884600	-1.98110600
H	5.32901600	-4.15384700	-1.75749500
C	2.15653800	0.91997000	3.35600100
C	1.67613300	2.20518600	3.05251400
C	3.51714300	0.78190100	3.66230900
C	2.52695400	3.30951300	3.05366000
H	0.63015300	2.33579800	2.80319100
C	4.37226200	1.88618900	3.65682000
H	3.92238500	-0.19232900	3.91485600
C	3.88313200	3.15533900	3.34989300
H	2.12585700	4.29381400	2.82767600
H	5.42272800	1.75069300	3.89920500
H	4.54717100	4.01487600	3.35095500
C	0.17458100	-3.53114700	1.07346600
C	0.71740700	-4.38021800	0.10306700
C	-1.21850100	-3.41269100	1.15424700
C	-0.11001400	-5.08765300	-0.77195600
H	1.79642400	-4.48217900	0.03227300
C	-2.05038600	-4.10929300	0.28012800
H	-1.65819200	-2.77385300	1.90806000
C	-1.49730100	-4.94929800	-0.69076600
H	0.32939200	-5.74856100	-1.51489600
H	-3.12550100	-3.98122500	0.35678300
H	-2.14282300	-5.49404900	-1.37372300
Cu	-0.47611000	0.15019900	-0.06149300

H	-0.05172700	-2.12179500	-4.77756200
C	-2.35841800	-0.63305600	3.82570900
N	-2.03697400	-0.97672000	4.89455600

IM2

Zero-point correction= 0.824421 (Hartree/Particle)
Thermal correction to Energy= 0.877332
Thermal correction to Enthalpy= 0.878276
Thermal correction to Gibbs Free Energy= 0.737055
Sum of electronic and zero-point Energies= -3326.574687
Sum of electronic and thermal Energies= -3326.521775
Sum of electronic and thermal Enthalpies= -3326.520831
Sum of electronic and thermal Free Energies= -3326.662052

C	0.89967800	0.77397500	-4.53112200
C	0.46966600	1.97015300	-3.95528600
C	0.90989900	2.29805600	-2.67441600
C	1.80341300	1.46442200	-1.99513200
C	2.28034400	0.27311700	-2.57443200
C	1.77711400	-0.06449700	-3.84366400
H	0.55745400	0.49120500	-5.52327100
H	0.59270400	3.21790900	-2.19519900
H	2.16387200	1.79891700	-1.03296300
C	3.40299700	-0.56606900	-1.96429500
C	3.44008700	-2.00536900	-2.50932300
H	4.33764100	-0.08121700	-2.27496400
H	2.10307900	-0.97741200	-4.32605700
H	3.74848600	-2.01009700	-3.55916600
H	4.16708000	-2.58802500	-1.94585000
H	2.46735900	-2.49142600	-2.42150800
C	2.35101200	-1.15338600	0.33319200
C	2.30164100	-0.91591500	1.73114800
C	2.82300500	0.21748000	2.33639900
C	3.57596700	1.08094300	1.46649400

C	3.80295900	0.78535800	0.17133300
C	3.50117400	-0.55252800	-0.41466900
F	1.64155700	-1.80724300	2.49019800
F	2.10555800	-2.47358100	-0.01348500
F	4.53207600	1.64068200	-0.59069100
F	3.99366400	2.25889400	1.97379100
F	4.68602400	-1.35984100	-0.15958800
C	-2.63282800	0.55764400	0.81247900
C	-2.72426100	-0.77857100	0.05904900
H	-3.38949200	0.59482200	1.60187000
H	-2.82683600	1.39077800	0.13152600
H	-2.57141100	-1.60956200	0.75466700
H	-3.71857900	-0.89697000	-0.38337300
C	-1.01972600	2.65198900	2.04840100
C	-1.03757700	0.17236000	3.29689200
C	-0.63461400	2.61419200	3.54326400
H	-2.07385200	2.94639800	1.96847700
C	-1.34587100	1.40954000	4.16663200
H	-0.02231000	-0.15497600	3.52910800
H	0.44607400	2.49419300	3.66056100
H	-0.91229800	3.55463400	4.03178300
H	-1.01710600	1.23553300	5.19609800
H	-2.42395400	1.60588100	4.19044400
C	-1.64321000	-2.64443600	-1.95697600
C	-2.14535600	-0.05569200	-2.78244600
C	-1.65385400	-2.38848000	-3.47231300
H	-2.65584900	-2.95164000	-1.66017300
C	-2.59968500	-1.20623100	-3.70549200
H	-1.27993200	0.41974900	-3.24289700
H	-0.64644700	-2.12009100	-3.81454900
H	-1.96295300	-3.28375000	-4.02327000
H	-2.60073900	-0.87609600	-4.75039100
H	-3.62196500	-1.51915600	-3.46593300
P	-0.93589800	0.84579800	1.52211600
P	-1.40786700	-0.91303500	-1.25166400

C	-0.65676500	-3.65072100	-1.41513000
C	-0.75280200	-4.03835700	-0.07090300
C	0.35954500	-4.20657400	-2.19763200
C	0.15224300	-4.93925100	0.48151000
H	-1.54299300	-3.62772100	0.55034400
C	1.26482700	-5.11682500	-1.64723700
H	0.45288500	-3.93420600	-3.24379000
C	1.16880800	-5.48281000	-0.30652000
H	0.06835400	-5.21516100	1.52926900
H	2.05144300	-5.53267400	-2.27042800
H	1.88026700	-6.18195400	0.12259800
C	-3.15495200	1.01873900	-2.46383600
C	-2.71207300	2.33486700	-2.25604800
C	-4.52153700	0.75126200	-2.30203600
C	-3.60137700	3.34738700	-1.89982400
H	-1.65598400	2.55670100	-2.35302900
C	-5.41342700	1.76138700	-1.93789300
H	-4.90191000	-0.25322600	-2.45807900
C	-4.95858900	3.06455900	-1.73440400
H	-3.23074300	4.35774800	-1.75288400
H	-6.46733900	1.52731100	-1.81617000
H	-5.65405700	3.85062200	-1.45512300
C	-1.95921900	-1.01904100	3.41639700
C	-1.45855800	-2.30355700	3.14836900
C	-3.32139500	-0.89557500	3.72498000
C	-2.29139200	-3.42148600	3.18195300
H	-0.41044000	-2.42198100	2.90109900
C	-4.15830100	-2.01277700	3.75189700
H	-3.74200500	0.07806500	3.95367200
C	-3.64896700	-3.28155700	3.47708100
H	-1.87705200	-4.40522800	2.97876900
H	-5.21011900	-1.88807600	3.99413500
H	-4.29859800	-4.15160900	3.50225300
C	-0.19321700	3.55074400	1.16516600
C	-0.80637100	4.46239300	0.29848900

C	1.20510100	3.46848300	1.16918200
C	-0.04101000	5.27589100	-0.54088000
H	-1.89057100	4.53640200	0.28570200
C	1.97434000	4.26856100	0.32733200
H	1.69853900	2.77889200	1.84090800
C	1.35203300	5.17869700	-0.53205000
H	-0.53373600	5.98520000	-1.20079100
H	3.05507900	4.16742300	0.34289600
H	1.94827500	5.80463200	-1.18953500
Cu	0.51501100	-0.13570300	-0.11942700
H	-0.20924800	2.62751300	-4.49120500
C	2.52746400	0.56728700	3.66946700
N	2.23755300	0.86382700	4.76144600

IM3'

Zero-point correction= 0.823558 (Hartree/Particle)
Thermal correction to Energy= 0.877147
Thermal correction to Enthalpy= 0.878091
Thermal correction to Gibbs Free Energy= 0.733578
Sum of electronic and zero-point Energies= -3326.626498
Sum of electronic and thermal Energies= -3326.572910
Sum of electronic and thermal Enthalpies= -3326.571966
Sum of electronic and thermal Free Energies= -3326.716479

C	0.03170400	0.24763700	-3.92949400
C	0.44650700	-0.94503700	-3.33190300
C	-0.47184600	-1.71775700	-2.60355000
C	-1.79681900	-1.28553600	-2.48464700
C	-2.20936600	-0.07815900	-3.05667500
C	-1.28434700	0.67902600	-3.78070400
H	0.74192400	0.85423800	-4.48355100
H	-0.17896600	-2.66582500	-2.16125800
H	-2.48894800	-1.88292300	-1.90653900
C	-3.61756300	0.45778900	-2.81566200

C	-4.71894700	-0.45600200	-3.37948800
H	-3.69036100	1.41356800	-3.34044900
H	-1.58929400	1.63258700	-4.20198900
H	-4.65107400	-1.47401800	-2.99458100
H	-5.71244600	-0.06388100	-3.13628400
H	-4.62292700	-0.49763300	-4.46901600
C	-4.06085500	-0.14160500	-0.34356400
C	-3.97891500	0.16223600	1.00470700
C	-3.58866700	1.43793200	1.43278100
C	-3.28671900	2.38699100	0.45104800
C	-3.35968200	2.05597800	-0.89422200
C	-3.74557700	0.78930100	-1.33496800
F	-4.24048600	-0.79446300	1.91213900
F	-4.41718600	-1.40817900	-0.66347100
F	-3.01694100	2.99466400	-1.78749700
F	-2.86215000	3.59885400	0.80961800
F	-0.92979700	1.32529000	-0.85557300
C	2.10665300	-1.19999700	1.89035500
C	2.89680300	-0.01473000	1.30591900
H	2.19919600	-1.19937600	2.98292700
H	2.51987500	-2.14586600	1.52475700
H	2.65073200	0.89934700	1.85297700
H	3.97146800	-0.19081900	1.42944800
C	-0.33978200	-2.80224700	2.17258100
C	-0.52648100	-0.09948100	2.67367000
C	-1.32936500	-2.34048800	3.27240000
H	0.52168100	-3.28179600	2.65235100
C	-0.80967400	-1.02512600	3.86426000
H	-1.48229800	0.14457700	2.20332900
H	-2.31765700	-2.16489700	2.83634200
H	-1.44737600	-3.12269000	4.03026300
H	-1.53064300	-0.56643100	4.55005300
H	0.10922300	-1.21770200	4.43174500
C	3.42334400	1.99587800	-0.70744500
C	3.78494600	-0.62959600	-1.45812200

C	4.45007300	1.70012500	-1.82784200
H	3.99080500	2.14202700	0.22186400
C	5.00621600	0.29396100	-1.57723900
H	3.34388800	-0.72172300	-2.45763600
H	3.94423800	1.73739800	-2.80151800
H	5.23538200	2.46376900	-1.84449000
H	5.68345300	-0.03932900	-2.37267100
H	5.58014800	0.30056000	-0.64241400
P	0.30643700	-1.20289000	1.39623700
P	2.50197600	0.36573200	-0.48057200
C	2.59405500	3.24385500	-0.94330300
C	3.21275100	4.48677300	-0.73794700
C	1.25041600	3.22186200	-1.33361700
C	2.51139000	5.67778100	-0.91749800
H	4.25209700	4.51950000	-0.41689800
C	0.54299400	4.41553500	-1.50070300
H	0.68524800	2.30027200	-1.41697500
C	1.16722300	5.64608400	-1.30008100
H	3.00883700	6.62860500	-0.74506500
H	-0.51245100	4.36022700	-1.75271100
H	0.61226700	6.57238300	-1.42205600
C	3.95094400	-2.01304700	-0.88669400
C	2.97633400	-2.98317600	-1.17021900
C	4.98419800	-2.35324600	-0.00457500
C	3.02341700	-4.24671600	-0.58673900
H	2.16245800	-2.73551300	-1.84370900
C	5.03198500	-3.61741000	0.58782900
H	5.75928100	-1.63041200	0.22814700
C	4.05092000	-4.56800900	0.30380500
H	2.25290100	-4.97275500	-0.82429900
H	5.84168700	-3.85829300	1.27109700
H	4.09145000	-5.55132800	0.76362600
C	0.22588700	1.18741600	2.90425100
C	0.18069900	2.18790400	1.91746700
C	1.02966000	1.38612800	4.03301400

C	0.93475900	3.35226500	2.06081100
H	-0.39911300	2.03120500	1.00919100
C	1.78840500	2.55118100	4.17041100
H	1.06866800	0.63446800	4.81484700
C	1.74642300	3.53584200	3.18320400
H	0.89321800	4.11123900	1.28742400
H	2.40770600	2.68734900	5.05317000
H	2.33583400	4.44261300	3.28785700
C	-0.89492100	-3.73411800	1.12482000
C	-0.17689900	-4.87275300	0.74169500
C	-2.09682700	-3.44994700	0.46113200
C	-0.63602900	-5.70157200	-0.28411300
H	0.75687800	-5.10402900	1.24734500
C	-2.56346100	-4.27956800	-0.55691500
H	-2.67537300	-2.57479200	0.73338700
C	-1.83135700	-5.40578600	-0.94086100
H	-0.06311200	-6.58178200	-0.56413600
H	-3.50094400	-4.04054700	-1.05075600
H	-2.19371100	-6.04971700	-1.73692300
Cu	0.21165700	-0.19947400	-0.64530500
H	1.46950200	-1.28658500	-3.45274900
C	-3.46412400	1.72613400	2.82171500
N	-3.35163800	1.92204600	3.96198900

IM3

Zero-point correction= 0.824453 (Hartree/Particle)
Thermal correction to Energy= 0.877846
Thermal correction to Enthalpy= 0.878790
Thermal correction to Gibbs Free Energy= 0.736019
Sum of electronic and zero-point Energies= -3326.632499
Sum of electronic and thermal Energies= -3326.579106
Sum of electronic and thermal Enthalpies= -3326.578162
Sum of electronic and thermal Free Energies= -3326.720933

C	5.32890900	1.48297100	-2.03299200
C	4.46862600	0.89938400	-2.95959300
C	3.10579400	1.20444300	-2.91507700
C	2.60040700	2.08773200	-1.96217900
C	3.47606300	2.72298000	-1.06609500
C	4.83585100	2.39911900	-1.10027900
H	6.38715900	1.23800700	-2.03799400
H	2.42839700	0.75448800	-3.63467400
H	1.52550900	2.25145000	-1.88562100
C	2.92534200	3.82091300	-0.15521100
C	3.96518200	4.48987000	0.76077700
H	2.53586700	4.59850400	-0.81943800
H	5.52681300	2.86376100	-0.40526500
H	4.76778500	4.93703100	0.16639200
H	3.49185000	5.28691700	1.34227800
H	4.40707200	3.77368600	1.45884100
C	0.48507700	3.93627000	0.51274600
C	-0.60243000	3.55577900	1.28627700
C	-0.47101600	2.55038000	2.24821700
C	0.78430700	1.93985000	2.39697800
C	1.85551800	2.33080500	1.61175000
C	1.73969100	3.34971200	0.66387500
F	-1.79190900	4.13236100	1.09340100
F	0.29947500	4.89694600	-0.39985200
F	3.03844700	1.71828400	1.79836500
F	0.94798900	0.99114600	3.33155700
F	-0.30195000	1.95886400	-1.11846300
C	-2.01100500	-2.55280700	-0.23255300
C	-0.59604900	-3.00569000	-0.61845700
H	-2.52704000	-3.35776500	0.30410000
H	-2.59263200	-2.33437700	-1.13343600
H	-0.13006600	-3.53142600	0.21949400
H	-0.65528900	-3.71351600	-1.45374900
C	-3.95835200	-0.75304900	0.87482400
C	-1.91160100	-1.53127000	2.56430200

C	-4.25553500	-0.78076000	2.39408600
H	-4.38859400	-1.66184100	0.43515500
C	-3.34650300	-1.85034000	3.01780900
H	-1.58544500	-0.63184500	3.09550300
H	-4.03370600	0.19632900	2.83403200
H	-5.31726500	-0.98802500	2.56819900
H	-3.41768000	-1.86396300	4.11108800
H	-3.65419600	-2.83997500	2.65705700
C	2.16122800	-2.64551300	-1.29089400
C	0.32789200	-1.35577600	-2.89851100
C	2.52349700	-2.45870000	-2.78471100
H	1.85570300	-3.68887500	-1.14568500
C	1.21523900	-2.40501900	-3.58355200
H	0.76429000	-0.36731700	-3.07149900
H	3.07399100	-1.52024500	-2.90102700
H	3.18418200	-3.26691000	-3.11900300
H	1.38386500	-2.15638200	-4.63842200
H	0.73627400	-3.39171200	-3.55803300
P	-2.09462100	-0.98653200	0.76774700
P	0.58709000	-1.62289400	-1.04218600
C	3.28880500	-2.34748200	-0.33400100
C	3.63989700	-1.03551800	0.01037100
C	4.02189100	-3.40567600	0.21797200
C	4.69410300	-0.79229400	0.89006500
H	3.08749400	-0.19851300	-0.40379900
C	5.07658300	-3.16602200	1.09923500
H	3.75196600	-4.42791700	-0.03708400
C	5.41339400	-1.85494500	1.44108100
H	4.94543000	0.23174800	1.14283500
H	5.62911200	-4.00090700	1.52185000
H	6.23015100	-1.66272500	2.13126700
C	-1.13982300	-1.27883200	-3.23665700
C	-1.82446000	-0.08239600	-2.95562600
C	-1.86943800	-2.37658200	-3.70791300
C	-3.20913700	-0.00768800	-3.09460900

H	-1.27347100	0.78290300	-2.59045100
C	-3.25706500	-2.29551400	-3.86021500
H	-1.36327200	-3.30617500	-3.94958600
C	-3.93268100	-1.11755600	-3.53903900
H	-3.72179100	0.91462200	-2.84310500
H	-3.80777000	-3.15905900	-4.22415500
H	-5.01275500	-1.05849700	-3.63761800
C	-0.83133800	-2.57716200	2.68753000
C	0.50816300	-2.15945700	2.62578600
C	-1.09671700	-3.94990900	2.74797400
C	1.55194100	-3.08003000	2.59901700
H	0.73061600	-1.09975500	2.58739400
C	-0.05162000	-4.87852800	2.72119700
H	-2.12041300	-4.30523300	2.80887100
C	1.27330000	-4.44909300	2.63582700
H	2.57672700	-2.73047600	2.53717000
H	-0.27841000	-5.94045900	2.76440100
H	2.08423500	-5.17111000	2.60519400
C	-4.50042300	0.43486300	0.11808900
C	-5.65852900	0.29452000	-0.65598800
C	-3.87083200	1.68482400	0.15683200
C	-6.17294500	1.37188400	-1.37825700
H	-6.15299600	-0.67295800	-0.70254500
C	-4.37353600	2.76232400	-0.56946500
H	-2.96472900	1.81269800	0.73457500
C	-5.52723800	2.60940000	-1.34184100
H	-7.07057200	1.24159100	-1.97668900
H	-3.85223000	3.71367300	-0.53602300
H	-5.91768400	3.44683000	-1.91309500
Cu	-0.53360200	0.35795400	-0.16043300
H	4.85277000	0.20682700	-3.70335200
C	-1.56453600	2.16614400	3.07161600
N	-2.45194900	1.83941000	3.74808800

Pr-R

Zero-point correction=	0.204924 (Hartree/Particle)
Thermal correction to Energy=	0.222102
Thermal correction to Enthalpy=	0.223046
Thermal correction to Gibbs Free Energy=	0.158522
Sum of electronic and zero-point Energies=	-1030.938278
Sum of electronic and thermal Energies=	-1030.921100
Sum of electronic and thermal Enthalpies=	-1030.920156
Sum of electronic and thermal Free Energies=	-1030.984680

C	-4.00126900	1.29855200	-1.02732500
C	-4.23033300	0.17482400	-1.82038200
C	-3.51081600	-0.99751500	-1.58004500
C	-2.57201700	-1.04787100	-0.55130800
C	-2.34232600	0.07415400	0.25549500
C	-3.06011800	1.24691300	0.00166900
H	-4.55239300	2.21700200	-1.20847100
H	-3.67931900	-1.87573800	-2.19694900
H	-2.01006900	-1.96033200	-0.38189800
C	-1.31826900	0.04594000	1.38657800
C	-1.60845100	-1.03948800	2.43833000
H	-1.38863200	1.00922000	1.89773500
H	-2.87684900	2.12710600	0.61258900
H	-1.65105400	-2.03903500	2.00549800
H	-0.84070500	-1.03649200	3.21948400
H	-2.57532000	-0.82880100	2.90502200
C	0.74893400	-1.16762600	0.41474000
C	2.02216100	-1.14606200	-0.14180700
C	2.69877400	0.06435400	-0.33703600
C	2.04910000	1.24509300	0.04489600
C	0.77663400	1.20019300	0.59808500
C	0.09051900	-0.00058300	0.80945900
F	2.60283300	-2.29390200	-0.49566100

F	0.16090000	-2.37160800	0.55242600
F	0.19919300	2.36522700	0.93919800
F	2.65577400	2.42086900	-0.12420600
H	-4.96173400	0.21169200	-2.62253700
C	4.00431900	0.09352900	-0.90608800
N	5.06953200	0.11766500	-1.36969400

Pr-S

Zero-point correction= 0.204937 (Hartree/Particle)
Thermal correction to Energy= 0.222072
Thermal correction to Enthalpy= 0.223016
Thermal correction to Gibbs Free Energy= 0.158815
Sum of electronic and zero-point Energies= -1030.938565
Sum of electronic and thermal Energies= -1030.921430
Sum of electronic and thermal Enthalpies= -1030.920486
Sum of electronic and thermal Free Energies= -1030.984687

C	-4.01511000	1.11174300	-0.81517800
C	-4.17731600	0.17695600	-1.83690900
C	-3.41681600	-0.99409200	-1.82721200
C	-2.50412300	-1.22205700	-0.80013000
C	-2.33607800	-0.28907400	0.23137100
C	-3.09742900	0.88255600	0.21159000
H	-4.60280900	2.02541900	-0.81474500
H	-3.53717600	-1.73059400	-2.61661500
H	-1.91020600	-2.13337500	-0.79271600
C	-1.29725700	-0.58334200	1.31146200
C	-1.54790400	0.10010800	2.66514900
H	-1.32342200	-1.66179000	1.48670800
H	-2.97973100	1.62215400	0.99569800
H	-2.54990900	-0.15181300	3.02582700
H	-0.81864800	-0.25075900	3.40203000
H	-1.46610900	1.18654400	2.60321000
C	0.97384200	-1.31972900	0.45469300

C	2.23637200	-1.08469500	-0.07552200
C	2.66865400	0.22360900	-0.32558700
C	1.78885800	1.27400000	-0.02987400
C	0.53015900	1.01614500	0.49653500
C	0.09052300	-0.28323400	0.76382200
F	3.04071100	-2.11336700	-0.34854600
F	0.60458700	-2.59769100	0.65749200
F	-0.27232900	2.06537300	0.74369100
F	2.16197500	2.53406500	-0.25940200
H	-4.89185000	0.35784500	-2.63469200
C	3.96168900	0.47929100	-0.86593700
N	5.01671100	0.68740400	-1.30620600

1a

Zero-point correction= 0.133831 (Hartree/Particle)
Thermal correction to Energy= 0.140601
Thermal correction to Enthalpy= 0.141545
Thermal correction to Gibbs Free Energy= 0.102291
Sum of electronic and zero-point Energies= -309.542013
Sum of electronic and thermal Energies= -309.535243
Sum of electronic and thermal Enthalpies= -309.534298
Sum of electronic and thermal Free Energies= -309.573553

C	-1.78043700	-1.04444300	-0.00008700
C	-2.26210500	0.26403600	-0.00007200
C	-1.35765700	1.33012300	0.00003500
C	0.01222500	1.09080900	0.00012200
C	0.51467100	-0.22253500	0.00009000
C	-0.40709600	-1.28184000	0.00000000
H	-2.47304000	-1.88153200	-0.00016100
H	-3.33150300	0.45459900	-0.00013500
H	-1.72427900	2.35298600	0.00007000
H	0.69964000	1.93115500	0.00025000
H	-0.03606400	-2.30398200	-0.00001400

C	1.95201700	-0.53182900	0.00013900
C	2.97082300	0.33595800	-0.00018800
H	2.18428200	-1.59669300	0.00043300
H	3.99925800	-0.01105600	-0.00011600
H	2.82706200	1.41285000	-0.00056000

2a

Zero-point correction= 0.058204 (Hartree/Particle)
Thermal correction to Energy= 0.068879
Thermal correction to Enthalpy= 0.069823
Thermal correction to Gibbs Free Energy= 0.021646
Sum of electronic and zero-point Energies= -820.581774
Sum of electronic and thermal Energies= -820.571100
Sum of electronic and thermal Enthalpies= -820.570156
Sum of electronic and thermal Free Energies= -820.618332

C	0.91102000	-1.21089500	-0.00004100
C	-0.47866800	-1.20553900	-0.00085500
C	-1.19526600	0.00024100	-0.00053500
C	-0.47830500	1.20574100	-0.00079400
C	0.91144200	1.21068600	-0.00002000
C	1.60363900	-0.00018600	-0.00020100
F	-1.13249700	-2.36525200	-0.00014900
F	1.58411900	-2.36213400	0.00050000
F	1.58478400	2.36177100	0.00038700
F	-1.13162700	2.36573100	-0.00006500
F	2.93378600	-0.00051000	0.00019800
C	-2.61980400	0.00039800	-0.00006000
N	-3.78163300	0.00012500	0.00103100

TS1-R

Zero-point correction= 0.754865 (Hartree/Particle)

Thermal correction to Energy= 0.796215
Thermal correction to Enthalpy= 0.797159
Thermal correction to Gibbs Free Energy= 0.679230
Sum of electronic and zero-point Energies= -2505.906099
Sum of electronic and thermal Energies= -2505.864749
Sum of electronic and thermal Enthalpies= -2505.863805
Sum of electronic and thermal Free Energies= -2505.981735

C	1.18031600	-4.46961400	-1.28579100
C	0.35783100	-5.31537400	-0.53382500
C	-0.99089900	-4.97802100	-0.38431500
C	-1.50050100	-3.81661000	-0.95750600
C	-0.68092700	-2.93110400	-1.69608700
C	0.67653700	-3.30295300	-1.85330600
H	2.22969600	-4.71826800	-1.42735200
H	-1.65277000	-5.62471800	0.18638900
H	-2.55276500	-3.57336400	-0.83270100
C	-1.22496000	-1.69604900	-2.23059800
C	-0.56013200	-0.89350700	-3.19534300
H	-2.26081900	-1.46427300	-2.00161200
H	1.34441300	-2.65710500	-2.41422600
H	0.24599500	-1.33241000	-3.77564800
H	-1.16496100	-0.19091000	-3.75965400
H	0.51947600	0.32761500	-2.73198500
C	-0.56169600	1.58170700	1.66838600
C	0.78767800	0.87080300	1.85829500
H	-0.53779000	2.56406400	2.15437400
H	-1.35973700	0.99938500	2.13718900
H	1.60919800	1.56312700	1.65087600
H	0.88863900	0.53881300	2.89794800
C	-2.82080900	2.41043200	0.02047200
C	-0.34255400	3.42815700	-0.63134100
C	-2.75566100	3.85178200	-0.54837800
H	-3.04685800	2.46924000	1.09162700
C	-1.39275000	4.44993500	-0.17581900

H	-0.35042800	3.39382600	-1.72785700
H	-2.85137100	3.81147600	-1.64060500
H	-3.59361000	4.45096100	-0.17517500
H	-1.23124500	5.43010700	-0.64014700
H	-1.34579700	4.59438300	0.91081600
C	2.85200200	-0.98975400	1.11333500
C	0.37567500	-2.08399000	1.60636600
C	2.80032500	-2.49012300	1.48420000
H	3.08045600	-0.43651800	2.03390900
C	1.56527800	-2.68214000	2.37413300
H	0.12049300	-2.77289900	0.79818200
H	2.69856900	-3.09117600	0.57395100
H	3.72780500	-2.79462200	1.98254700
H	1.38541900	-3.73711100	2.60847200
H	1.72784500	-2.15660200	3.32362300
P	-1.05375500	1.75301400	-0.12251900
P	1.06081100	-0.57077300	0.70543200
C	3.88403100	-0.61382900	0.07886600
C	5.12706100	-0.12243000	0.49890900
C	3.64847000	-0.74632500	-1.29548500
C	6.11215500	0.22738700	-0.42465200
H	5.31857100	-0.00429600	1.56300900
C	4.62810500	-0.39200000	-2.22264400
H	2.67918000	-1.08609300	-1.64086200
C	5.86407100	0.09574600	-1.79252500
H	7.06780300	0.61044200	-0.07706600
H	4.41928900	-0.48778300	-3.28468700
H	6.62456000	0.37524300	-2.51622100
C	-0.89064600	-1.73554700	2.34398900
C	-2.06711600	-1.55335200	1.59690700
C	-0.93531400	-1.48849600	3.72118500
C	-3.24823200	-1.13539400	2.20549300
H	-2.03715600	-1.71532500	0.52604500
C	-2.11760600	-1.06429000	4.33419600
H	-0.04543500	-1.62565300	4.32746000

C	-3.27736400	-0.88328400	3.57995300
H	-4.13901500	-0.99757100	1.60103600
H	-2.12909600	-0.87738900	5.40473000
H	-4.19592100	-0.55510500	4.05880700
C	1.08623300	3.56016900	-0.16958600
C	2.07794900	2.83518200	-0.85232900
C	1.45244400	4.28058700	0.97328800
C	3.39185800	2.80940500	-0.39157000
H	1.79910100	2.24813200	-1.72297700
C	2.77167700	4.25891400	1.43559900
H	0.71017000	4.85921300	1.51437300
C	3.74222600	3.51702000	0.76159200
H	4.13620300	2.22761900	-0.92410200
H	3.03634400	4.82190300	2.32675900
H	4.76504300	3.49069400	1.12671700
C	-3.83894200	1.51652000	-0.64299200
C	-4.98358100	1.10482100	0.04780300
C	-3.65754600	1.07099900	-1.96047700
C	-5.92128400	0.26230000	-0.55381600
H	-5.13581900	1.44111800	1.07055200
C	-4.58998400	0.23064300	-2.56562400
H	-2.76523300	1.36487100	-2.50697100
C	-5.72490000	-0.18088700	-1.86185400
H	-6.80192600	-0.04875300	0.00152500
H	-4.42489700	-0.11262600	-3.58298100
H	-6.44832500	-0.84173100	-2.33044500
Cu	-0.09367400	-0.03370800	-1.23028400
H	0.75628100	-6.22063000	-0.08571100

TS1-S

Zero-point correction= 0.754579 (Hartree/Particle)
Thermal correction to Energy= 0.795916
Thermal correction to Enthalpy= 0.796860
Thermal correction to Gibbs Free Energy= 0.678262

Sum of electronic and zero-point Energies= -2505.895292
Sum of electronic and thermal Energies= -2505.853955
Sum of electronic and thermal Enthalpies= -2505.853011
Sum of electronic and thermal Free Energies= -2505.971609

C	-3.99932100	3.52390600	-1.71818100
C	-4.20427400	3.97239500	-0.40999800
C	-3.12286500	3.97663600	0.47524200
C	-1.86378400	3.54757000	0.06355000
C	-1.63597500	3.09494300	-1.25802000
C	-2.74471700	3.08436600	-2.13135000
H	-4.82657400	3.51729300	-2.42436300
H	-3.26235400	4.31421200	1.49971500
H	-1.04351800	3.53761600	0.77567500
C	-0.31693500	2.67877400	-1.71628700
C	0.86950300	3.06727400	-1.04564800
H	-0.23940200	2.26616800	-2.71879400
H	-2.60297500	2.73849400	-3.15295500
H	0.82007100	3.88134100	-0.32960000
H	1.81282100	2.99735800	-1.57521800
H	1.49073800	2.09258300	0.27318200
C	1.36036900	-1.95063900	0.48288300
C	-0.02638400	-1.86052000	1.13312600
H	1.59664200	-2.99455800	0.24517800
H	2.11944300	-1.59027200	1.18488800
H	-0.76574100	-2.39861600	0.53119600
H	-0.00199800	-2.32873200	2.12294800
C	3.40555000	-1.04954700	-1.35653300
C	1.07714000	-2.02008700	-2.46107700
C	3.51404700	-1.83769800	-2.68484700
H	3.79221500	-1.68137000	-0.54855200
C	2.34744600	-2.83256500	-2.74403400
H	0.91061600	-1.34005300	-3.30676700
H	3.44320500	-1.14438200	-3.53142200
H	4.48865300	-2.33258000	-2.75963700

H	2.29279100	-3.34776500	-3.71053700
H	2.48953200	-3.60178900	-1.97493400
C	-2.40023700	-0.46961200	1.95555600
C	-0.06825400	0.61683600	2.90372800
C	-2.55044900	0.61404100	3.04323600
H	-2.30574400	-1.43263500	2.47631500
C	-1.26325100	0.55432900	3.87765500
H	0.10747200	1.66353400	2.63913200
H	-2.66681500	1.59777500	2.57045800
H	-3.44561100	0.43362700	3.64899600
H	-1.20409200	1.36527800	4.61235500
H	-1.25659200	-0.38653800	4.43995300
P	1.54844100	-0.87462000	-1.03219400
P	-0.68510900	-0.12256500	1.25779500
C	-3.53746800	-0.58582700	0.97551200
C	-4.41922200	-1.67014900	1.07870600
C	-3.76386200	0.37274200	-0.02010500
C	-5.51146300	-1.79383000	0.22003600
H	-4.24510200	-2.42563700	1.84145400
C	-4.85461200	0.25045200	-0.88109500
H	-3.08753300	1.21180500	-0.12951700
C	-5.73322900	-0.82937800	-0.76459100
H	-6.18427500	-2.64158000	0.31861200
H	-5.00902000	1.00613700	-1.64327800
H	-6.58087300	-0.92025600	-1.43832100
C	1.24660700	0.02140100	3.33786200
C	2.44144400	0.60352500	2.88387400
C	1.32973900	-1.15336800	4.09888700
C	3.67627700	0.02359700	3.17191700
H	2.39018400	1.49445000	2.26558000
C	2.56510900	-1.73549200	4.38812600
H	0.42500900	-1.62664200	4.46857100
C	3.74462300	-1.15234900	3.92234600
H	4.58397300	0.49533300	2.80660300
H	2.60394900	-2.64647400	4.97930200

H	4.70577400	-1.60541500	4.14900100
C	-0.21434800	-2.73095800	-2.15469200
C	-1.40613400	-1.98681200	-2.16914900
C	-0.26770900	-4.06950400	-1.74970100
C	-2.61269700	-2.55797800	-1.77544900
H	-1.37464000	-0.93869500	-2.45580200
C	-1.47852600	-4.64572900	-1.35457700
H	0.63586000	-4.67077100	-1.73640200
C	-2.65145200	-3.89140600	-1.35937100
H	-3.51655900	-1.96056100	-1.77614400
H	-1.49929500	-5.68597300	-1.04053500
H	-3.59149100	-4.33158900	-1.04013500
C	4.12643100	0.27319000	-1.31738000
C	5.03649600	0.55110400	-0.29232200
C	3.87271800	1.26723200	-2.27226000
C	5.67668400	1.78906200	-0.21655800
H	5.23553000	-0.20855500	0.45912200
C	4.51468000	2.50220200	-2.20583900
H	3.15137800	1.08125100	-3.06412800
C	5.41798800	2.76974200	-1.17407000
H	6.37851500	1.98545500	0.58954300
H	4.30492500	3.25981000	-2.95606600
H	5.91504200	3.73393000	-1.11940300
Cu	0.40680000	1.04232900	-0.42885100
H	-5.18542400	4.30699400	-0.08724500

TS2'

Zero-point correction= 0.819911 (Hartree/Particle)
Thermal correction to Energy= 0.873436
Thermal correction to Enthalpy= 0.874381
Thermal correction to Gibbs Free Energy= 0.729362
Sum of electronic and zero-point Energies= -3326.525401
Sum of electronic and thermal Energies= -3326.471876
Sum of electronic and thermal Enthalpies= -3326.470932

Sum of electronic and thermal Free Energies= -3326.615950

C	-1.76380100	-1.72736900	2.55586900
C	-2.30590100	-0.46024600	2.82556100
C	-2.40544200	0.46868600	1.79123100
C	-1.99958000	0.14127500	0.49636600
C	-1.47302200	-1.15634400	0.18396600
C	-1.35772000	-2.07295600	1.27579600
H	-1.69148000	-2.46246400	3.35317100
H	-2.84330600	1.44707100	1.97059600
H	-2.15710900	0.85242700	-0.30345400
C	-1.31363700	-1.56904500	-1.19638700
C	-0.58818300	-2.84814000	-1.56776600
H	-1.24921400	-0.76014700	-1.92523900
H	-0.99175400	-3.07523700	1.08029700
H	-1.06165800	-3.72188700	-1.11087100
H	-0.63437000	-2.99670800	-2.64980800
H	0.46799500	-2.86298900	-1.27021400
C	-4.02878400	-0.71598300	-1.52265100
C	-4.81878000	-0.41411700	-0.44195600
C	-5.15285900	-1.37147800	0.53815800
C	-4.60184700	-2.66112400	0.35190000
C	-3.82342800	-2.97471700	-0.73342000
C	-3.36357200	-1.97308200	-1.64603800
F	-5.27443600	0.84546100	-0.29860400
F	-3.67031900	0.26627000	-2.39552600
F	-3.33664000	-4.23265800	-0.86844100
F	-4.87313700	-3.61421200	1.25665200
F	-3.09285000	-2.39527100	-2.92651000
C	2.73003900	2.24481100	-0.26133900
C	3.45004600	1.06454600	0.41672800
H	3.42533500	2.75460000	-0.93860000
H	2.42087100	2.97356900	0.49391700
H	4.01216200	0.49221600	-0.32769500
H	4.17082200	1.44880400	1.14792400

C	0.53879200	3.50739200	-1.70534100
C	1.74083700	1.33828500	-2.90485300
C	0.74357200	3.54725600	-3.24426300
H	1.22189700	4.22672500	-1.23921000
C	1.95897600	2.68470000	-3.60633700
H	0.86545900	0.85588500	-3.35983500
H	-0.14897100	3.13986700	-3.73305900
H	0.84894600	4.58286800	-3.58430200
H	2.06607400	2.55962800	-4.68996200
H	2.87553600	3.16582200	-3.24318900
C	3.55407400	-1.50239800	1.77764300
C	2.01750900	0.45125400	2.97722000
C	3.38116300	-1.56070800	3.31603200
H	4.54757200	-1.08912200	1.56371500
C	3.16749800	-0.12723400	3.81477200
H	1.08909600	-0.05202200	3.27542300
H	2.50445100	-2.17433800	3.55795300
H	4.24993000	-2.04263600	3.77721000
H	2.93580400	-0.08933600	4.88514500
H	4.08807700	0.44895700	3.66022100
P	1.16152600	1.80112600	-1.17361700
P	2.32594100	-0.18189200	1.22470500
C	3.42684100	-2.83449600	1.08367700
C	4.56718700	-3.48715200	0.60258800
C	2.17981600	-3.45066700	0.92061700
C	4.46688400	-4.72335500	-0.03744700
H	5.54001100	-3.01610800	0.72026800
C	2.07385500	-4.68291900	0.27718300
H	1.28373600	-2.95195000	1.27739500
C	3.21763900	-5.32273000	-0.20738800
H	5.36240700	-5.21376700	-0.40875500
H	1.09658000	-5.13752000	0.14444200
H	3.13434800	-6.28028600	-0.71284900
C	1.77017300	1.93698000	2.96991500
C	0.49684300	2.39293400	2.59558600

C	2.77670800	2.88057700	3.20716200
C	0.24004300	3.75228000	2.43597300
H	-0.29460100	1.67084000	2.42173200
C	2.52138100	4.24569900	3.04984900
H	3.76755600	2.55825100	3.51148200
C	1.25719900	4.68565900	2.65393100
H	-0.74912200	4.07787800	2.13301300
H	3.31417600	4.96445800	3.23800300
H	1.06179900	5.74712700	2.53008500
C	2.85727300	0.33040700	-2.83137700
C	2.53223300	-0.98980400	-2.47921000
C	4.20525400	0.66946900	-2.98559800
C	3.52401100	-1.93881100	-2.25071200
H	1.48771000	-1.26654900	-2.37377800
C	5.20505300	-0.28371400	-2.76485500
H	4.48464800	1.67861600	-3.27150400
C	4.86942900	-1.58328300	-2.38451500
H	3.25059300	-2.94804100	-1.96239300
H	6.24778600	-0.00443100	-2.88886700
H	5.64530400	-2.32006200	-2.20039000
C	-0.86871400	3.81338100	-1.25631200
C	-1.12982100	4.93106500	-0.45714700
C	-1.93920200	2.98471200	-1.61952400
C	-2.42558300	5.20600200	-0.01389000
H	-0.30884300	5.58370800	-0.17043700
C	-3.23354300	3.24861300	-1.17490500
H	-1.76530700	2.10692900	-2.23684700
C	-3.47835200	4.35993200	-0.36409300
H	-2.60896100	6.07777200	0.60836800
H	-4.03678900	2.57239900	-1.44036800
H	-4.48483100	4.56223000	-0.01016700
Cu	0.37981100	-0.04415700	0.00138900
H	-2.65309200	-0.21261600	3.82329600
C	-5.91402000	-1.03382100	1.67839200
N	-6.54208300	-0.74657800	2.61866300

TS2

Zero-point correction=	0.819306 (Hartree/Particle)
Thermal correction to Energy=	0.872942
Thermal correction to Enthalpy=	0.873886
Thermal correction to Gibbs Free Energy=	0.728046
Sum of electronic and zero-point Energies=	-3326.522870
Sum of electronic and thermal Energies=	-3326.469234
Sum of electronic and thermal Enthalpies=	-3326.468289
Sum of electronic and thermal Free Energies=	-3326.614130

C	1.85742200	1.51209000	2.27961000
C	1.92763100	0.11528600	2.46360600
C	1.87407500	-0.70781600	1.34315000
C	1.76166000	-0.16897800	0.04285400
C	1.75077600	1.25725600	-0.17272800
C	1.77071100	2.06351800	1.01615700
H	1.91645200	2.16975300	3.14278300
H	1.97556000	-1.78553300	1.44118200
H	1.91403300	-0.83252100	-0.79728200
C	1.94660700	1.82764500	-1.45064700
C	1.62554800	1.10164800	-2.73242600
H	1.85775400	2.91226800	-1.50170600
H	1.79708400	3.14369400	0.89827900
H	0.54291600	1.07733000	-2.94917200
H	2.11260700	1.59206000	-3.58045200
H	1.97334100	0.06465300	-2.72286800
C	4.55758700	0.35534600	-1.42619100
C	4.91313900	-0.31038200	-0.27838900
C	5.09162400	0.35736300	0.95114800
C	4.87895600	1.75615600	0.93587500
C	4.54150000	2.43137200	-0.21024000
C	4.20463500	1.73372500	-1.40357600
F	5.10274600	-1.64320600	-0.33006300

F	4.39768600	-0.33528000	-2.58374400
F	4.28334800	3.75767300	-0.16718000
F	5.00001000	2.43653700	2.08588900
F	4.30539200	2.41541500	-2.58058400
C	-3.16561500	-1.80981400	-0.24823400
C	-3.59806300	-0.52383200	0.48398400
H	-3.99048200	-2.17219500	-0.87237400
H	-2.93890300	-2.59346700	0.48201700
H	-4.05335500	0.17472200	-0.22493000
H	-4.35599800	-0.76811400	1.23657600
C	-1.19545100	-3.35822200	-1.83077100
C	-2.19865400	-1.05440300	-2.94995600
C	-1.57038000	-3.39640300	-3.33899400
H	-1.85011300	-4.03675900	-1.27252800
C	-2.66623200	-2.35541100	-3.61683800
H	-1.28609500	-0.71592700	-3.45915700
H	-0.68510800	-3.15210700	-3.93577800
H	-1.87910300	-4.40586700	-3.62936300
H	-2.83552700	-2.21925900	-4.69133700
H	-3.61509200	-2.68994700	-3.17971200
C	-3.06410500	1.99811500	1.83841700
C	-1.98977000	-0.25432000	3.01773700
C	-2.75304900	2.05777500	3.35378000
H	-4.13831200	1.80264900	1.72558400
C	-2.88335200	0.63134200	3.90150300
H	-0.94391400	-0.02532900	3.25383500
H	-1.72930100	2.42497500	3.49934900
H	-3.42568500	2.76365300	3.85277500
H	-2.58790200	0.56023500	4.95425900
H	-3.93198600	0.31651500	3.83548300
P	-1.60830200	-1.60836900	-1.25842600
P	-2.19811400	0.42826000	1.26788500
C	-2.72158800	3.25078200	1.06975900
C	-3.72878300	4.16957700	0.75260500
C	-1.40709100	3.52956200	0.67593200

C	-3.43346600	5.33892300	0.05019700
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H	2.05258200	-0.30678300	3.45511100
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IM0-S

Zero-point correction= 0.755696 (Hartree/Particle)
Thermal correction to Energy= 0.796850
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Thermal correction to Gibbs Free Energy= 0.681417
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H	0.56669200	1.23059700	-3.77048600

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C	-0.92812200	-0.69025700	1.76314300
H	0.14552100	-2.53502700	2.15363100
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H	2.23287600	-4.22670400	-1.62351900
H	2.90175800	-4.94151800	-0.15805200
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H	0.67714000	-4.75576400	0.95836600
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C	-0.06983400	2.17576500	1.50807300
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H	-2.16484700	3.43656600	0.21419800
H	-3.28492800	3.44297100	1.58250800
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H	-1.49127900	2.66359600	3.09841100
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C	-2.01862900	-4.05911700	1.10932200
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H	-3.60248600	-4.35349000	2.53696900
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C	3.53642000	-2.04454900	-0.60529500
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C	4.57224500	-1.02727100	-2.55688000
H	2.78175500	-2.21349300	-2.61856000

C	5.56905900	-0.46739100	-1.75295500
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H	4.57186300	-0.84674500	-3.62804300
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IM0-R

Zero-point correction= 0.755217 (Hartree/Particle)
Thermal correction to Energy= 0.797270
Thermal correction to Enthalpy= 0.798214
Thermal correction to Gibbs Free Energy= 0.677436
Sum of electronic and zero-point Energies= -2505.906119
Sum of electronic and thermal Energies= -2505.864066
Sum of electronic and thermal Enthalpies= -2505.863122
Sum of electronic and thermal Free Energies= -2505.983900

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C	-1.54632200	2.94041800	2.21505400
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P	-0.81731000	-0.78988700	0.93935500
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C	-5.32674200	-0.70425400	-1.71650400
H	-4.52009600	-2.36698500	-0.61251400
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H	-2.72307600	1.44907600	0.17721600
C	-5.25433400	0.66906200	-1.95664200
H	-6.05306400	-1.31475500	-2.24641100

H	-4.23865900	2.50564200	-1.44884900
H	-5.92468500	1.13577300	-2.67319200
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C	-0.09233500	-3.89641500	2.63702600
C	2.57789500	-3.42155900	3.25337300
H	2.01812200	-1.34043300	3.33354500
C	0.80691700	-4.96104700	2.70858200
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C	2.14794500	-4.72851600	3.01601900
H	3.61900300	-3.22607800	3.49671700
H	0.45723700	-5.97300900	2.52223300
H	2.84857700	-5.55690200	3.07324700
C	0.21681300	-1.03265000	-3.39854800
C	-0.92867200	-0.24023400	-3.21589900
C	0.04771000	-2.36040800	-3.80780900
C	-2.20314800	-0.76136700	-3.41419200
H	-0.81407900	0.78735600	-2.88016400
C	-1.23137000	-2.88703900	-4.00916900
H	0.91379800	-2.99482600	-3.96586900
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H	-1.34085200	-3.92215500	-4.32183300
H	-3.35514500	-2.50441600	-3.94630500
C	4.14562900	1.07505500	-0.69431400
C	4.77215900	1.11982600	0.55553000
C	3.98122000	2.27809600	-1.39703800
C	5.23826000	2.32437100	1.08328000
H	4.87832600	0.20240400	1.12679400
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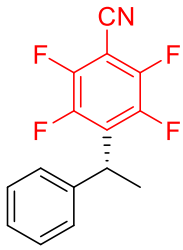
H	3.47497300	2.27640200	-2.35912600
C	5.08123300	3.51254900	0.36814300
H	5.72028000	2.33390800	2.05687000
H	4.30967800	4.40408800	-1.43920100
H	5.44400400	4.45123500	0.77697100

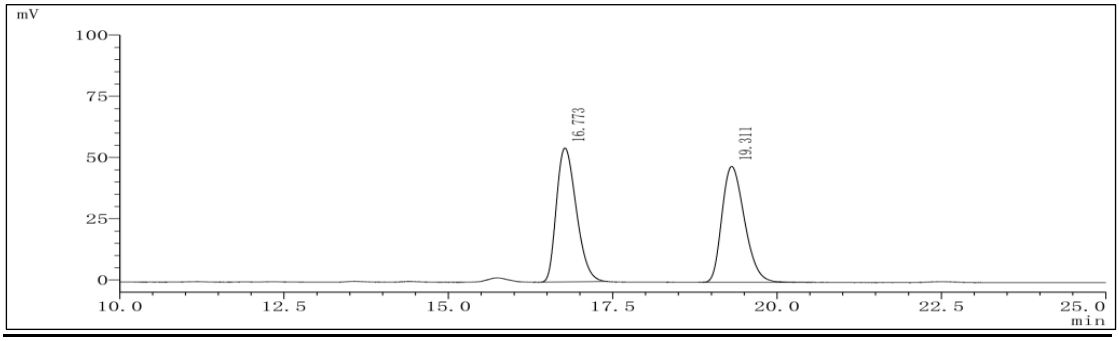
Cu	0.79613300	0.96871300	0.71680500
H	-4.77389300	4.02856900	2.23215600

8. Compound Characterization

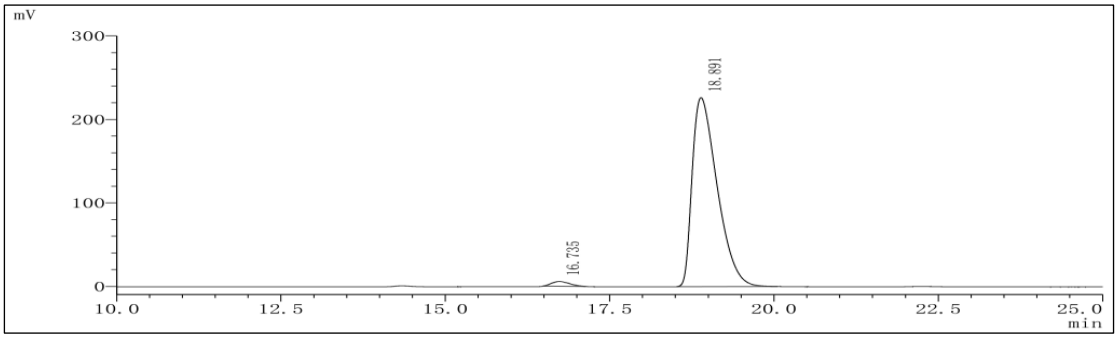
(*R*)-2,3,5,6-tetrafluoro-4-(1-phenylethyl)benzonitrile (3a)



This compound was obtained in 95% (53.0 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.34 – 7.32 (m, 2H), 7.29 (d, *J* = 7.2 Hz, 2H), 7.26 (t, *J* = 6.9 Hz, 1H), 4.68 (q, *J* = 7.2 Hz, 1H), 1.79 (d, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.21 (dm, *J* = 260.3 Hz), 144.74 (dm, *J* = 247.5 Hz), 140.66, 131.71 (t, *J* = 15.5 Hz), 128.81, 127.37, 127.11, 107.48 (t, *J* = 3.8 Hz), 92.31, 35.48, 17.73 (t, *J* = 3.1 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.56 – -132.63 (m, 2F), -139.16 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{15}H_{10}F_4N$ ([M + H]$^+$): 280.0744; found: 280.0741. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 96% ee, t_R (minor) = 16.74 min, t_R (major) = 18.89 min. $[\alpha]_D^{25}$ = + 9.67 (c = 1.0, CH_2Cl_2).

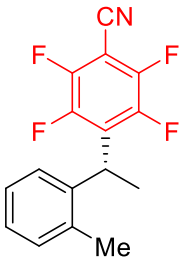


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	16.773	M	0.5440	1151101	54700	50.3200
2	19.311	M	0.6330	1136440	47338	49.6800

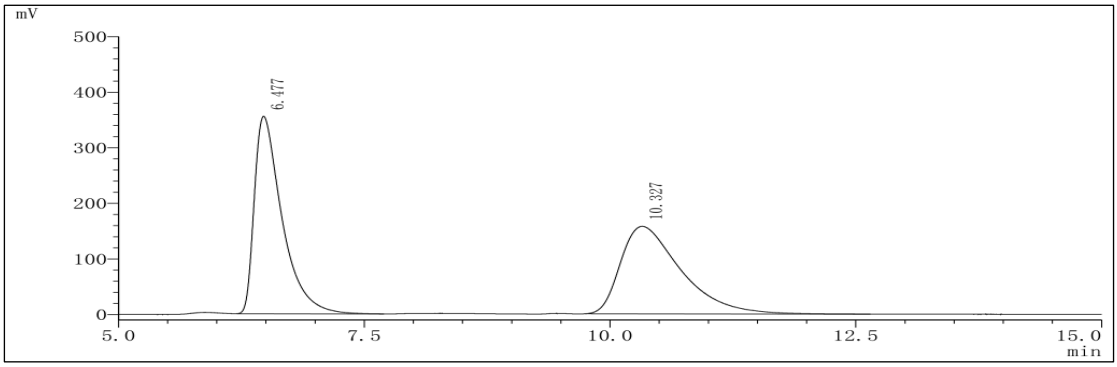


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	16.735	M	0.5180	107354	5630	1.7640
2	18.891	M	0.6950	5979375	226430	98.2360

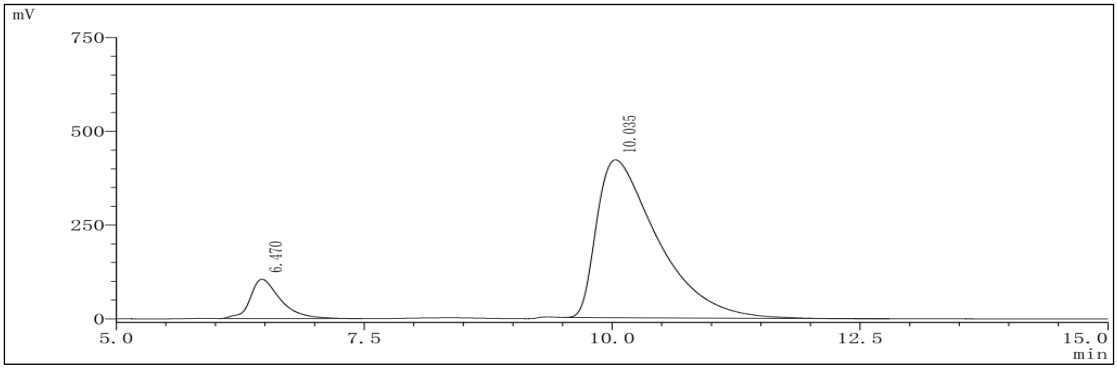
(*R*)-2,3,5,6-Tetrafluoro-4-(1-(o-tolyl)ethyl)benzonitrile (3b)



This compound was obtained in 76% (44.5 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.44 (d, *J* = 7.5 Hz, 1H), 7.24 (t, *J* = 7.0 Hz, 1H), 7.19 (t, *J* = 7.3 Hz, 1H), 7.14 (d, *J* = 7.5 Hz, 1H), 4.72 (q, *J* = 7.3 Hz, 1H), 2.23 (s, 3H), 1.75 (d, *J* = 7.5 Hz, 3H).**^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.15 (dm, *J* = 260.1 Hz), 144.85 (dm, *J* = 247.7 Hz), 138.62, 135.83, 131.14 (t, *J* = 15.3 Hz), 130.68, 127.41, 126.83 (t, *J* = 2.9 Hz), 126.38, 107.47 (t, *J* = 3.8 Hz), 92.26, 32.84, 19.26, 18.81. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.71 (td, *J* = 16.4, 7.3 Hz, 2F), -138.83 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{16}H_{12}F_4N$ ([M + H]$^+$): 294.0900; found: 294.0900. **HPLC** analysis (OJ-H, Hexane/IPA = 99.5/0.5, 1.0 mL/min, 254 nm) indicated 78% ee, t_R (minor) = 6.47 min, t_R (major) = 10.04 min. $[\alpha]_D^{25}$ = + 11.35 (c = 1.0, CH_2Cl_2).

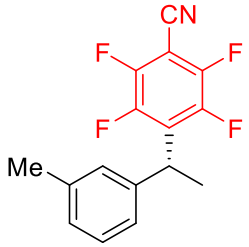


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	6.477	M	0.4910	6977314	355220	50.8540
2	10.327	M	1.1110	6742862	157494	49.1460

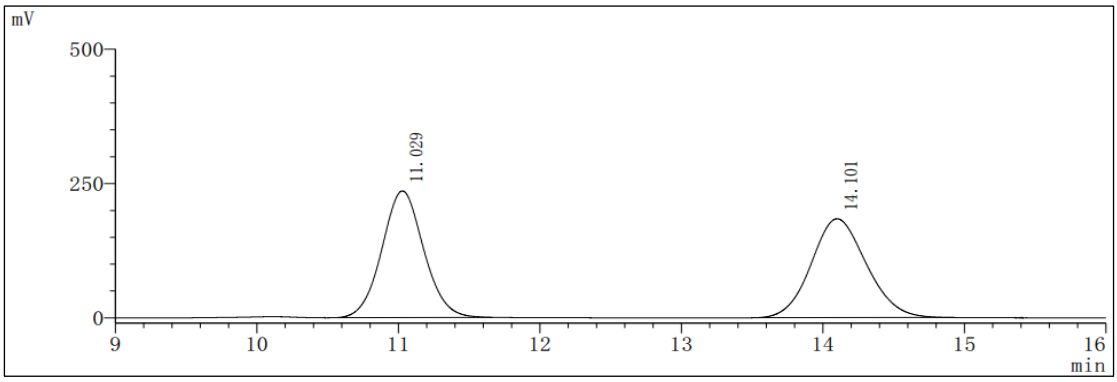


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	6.470	M	0.5180	2207146	104692	10.882
2	10.035	M	1.1130	18075958	421199	89.118

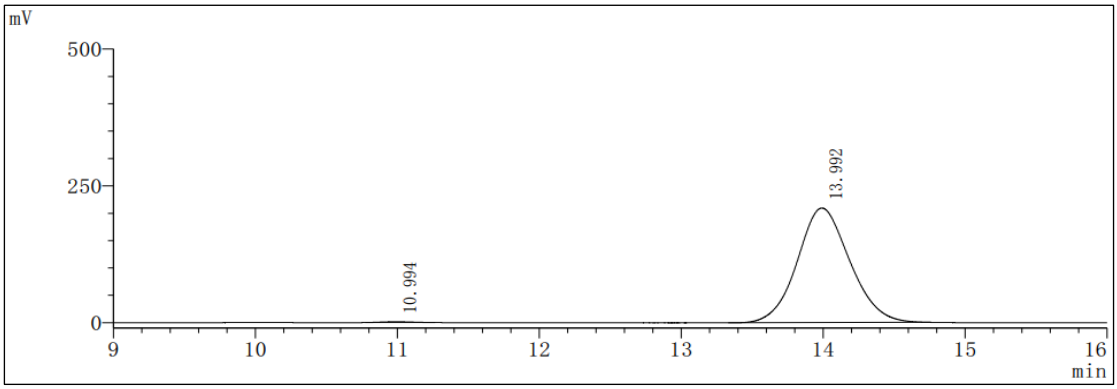
(*R*)-2,3,5,6-Tetrafluoro-4-(1-(m-tolyl)ethyl)benzonitrile (3c)



This compound was obtained in 93% (54.5 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.22 (t, *J* = 7.5 Hz, 1H), 7.11 – 7.06 (m, 3H), 4.63 (q, *J* = 7.5Hz, 1H), 2.33 (s, 3H), 1.77 (d, *J* = 7.5 z, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.18 (dm, *J* = 260.3 Hz), 144.72 (dm, *J* = 247.5 Hz), 140.61, 138.50, 131.82 (t, *J* = 15.6 Hz), 128.66, 128.11, 127.90, 124.06, 107.54, 92.19, 35.41, 21.43, 17.72 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.65 (td, *J* = 16.4, 7.3 Hz, 2F), -139.12 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{16}H_{12}F_4N$ ([M + H]$^+$): 294.0900; found: 294.0900. **HPLC** analysis (OD-3, Hexane/IPA = 98/0.5, 0.5 mL/min, 254 nm) indicated 99% ee, t_R (minor) = 10.99 min, t_R (major) = 13.99 min. $[\alpha]_D^{25}$ = + 15.51 (c = 1.0, CH_2Cl_2).

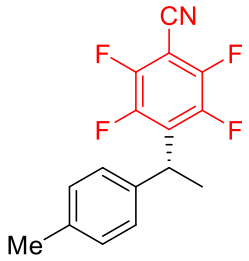


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.029	M	0.5394	4838328	235569	49.2218
2	14.101	M	0.7167	4991321	184046	50.7782

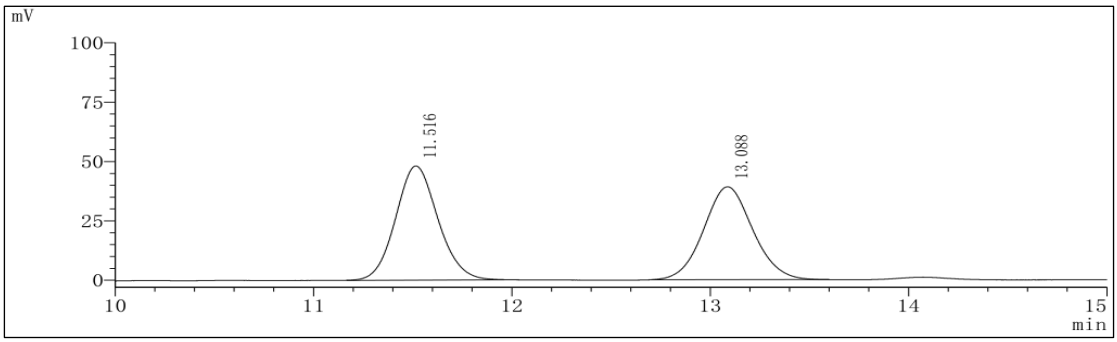


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.994	M	0.4315	22571	1459	0.4173
2	13.992	M	0.6806	5385745	209290	99.5827

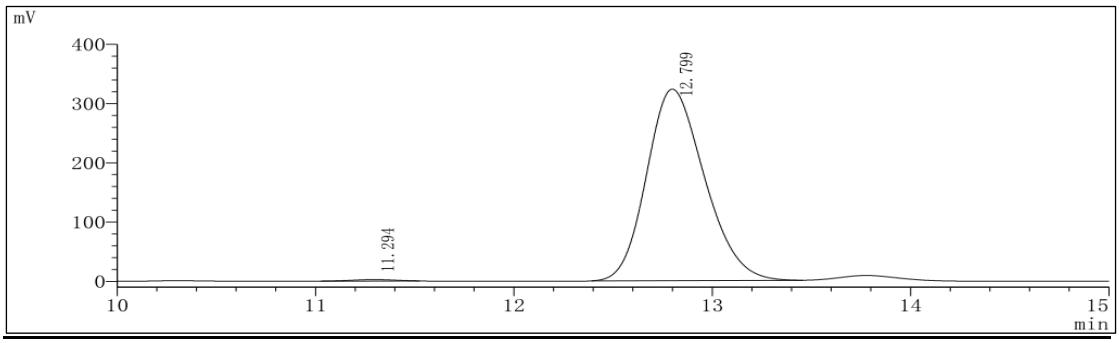
(*R*)-2,3,5,6-Tetrafluoro-4-(1-(p-tolyl)ethyl)benzonitrile (3d)



This compound was obtained in 67% (39.3 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.18 (d, *J* = 7.8 Hz, 2H), 7.13 (d, *J* = 7.8 Hz, 2H), 4.64 (q, *J* = 7.2 Hz, 1H), 2.32 (s, 3H), 1.77 (d, *J* = 7.8 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.17 (dm, *J* = 260.0 Hz), 144.69 (dm, *J* = 247.7 Hz), 137.68, 137.11, 131.94 (t, *J* = 15.5 Hz), 129.45, 126.98, 107.54, 92.12, 35.12, 20.98, 17.75 (t, *J* = 3.1 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.64 (td, *J* = 16.4, 6.8 Hz, 2F), -139.23 (td, *J* = 15.8, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{16}H_{12}F_4N$ ($[M+H]^+$): 294.0900; found: 294.0900. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 99% ee, t_R (minor) = 11.29 min, t_R (major) = 12.80 min. $[\alpha]_D^{25}$ = + 2.83 (c = 1.0, CH_2Cl_2).

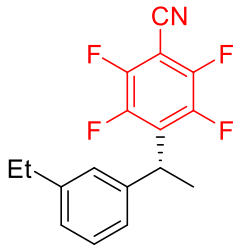


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.516	M	0.3904	714922	48066	51.4416
2	13.088	M	0.4523	674851	39143	48.5584

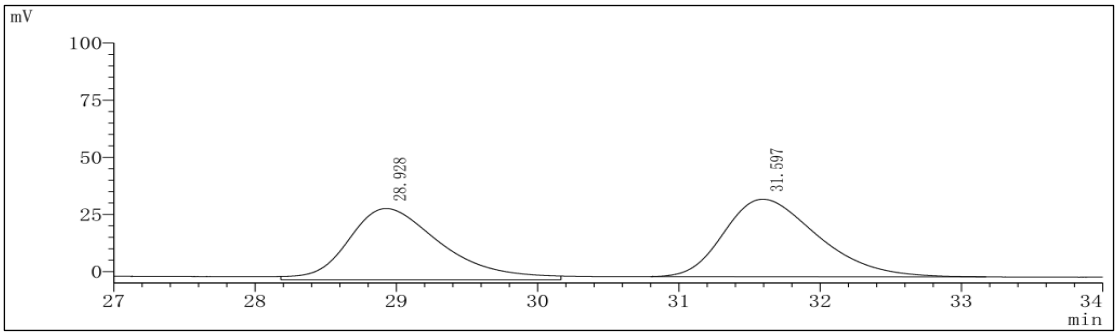


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.294	M	0.4146	34909	2315	0.5286
2	12.799	M	0.5391	6568984	323400	99.4714

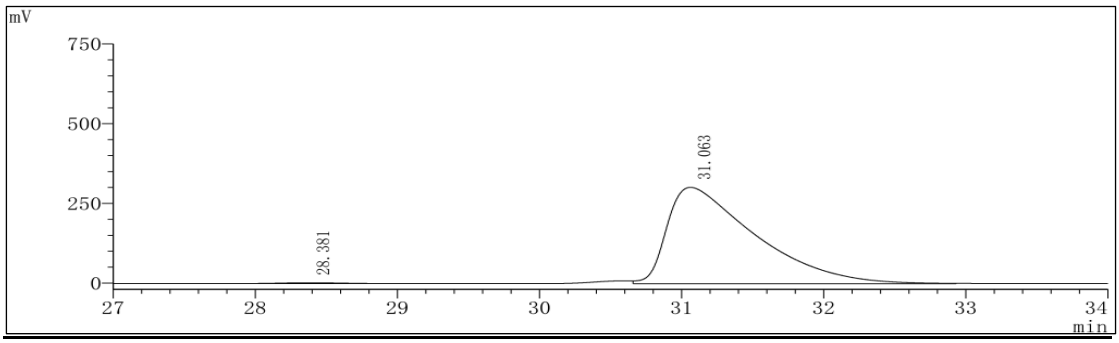
(*R*)-4-(1-(3-ethylphenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3e)



This compound was obtained in 90% (55.3 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.26 – 7.22 (m, 1H), 7.12 – 7.09 (m, 3H), 4.65 (q, *J* = 7.5 Hz, 1H), 2.63 (q, *J* = 7.7 Hz, 2H), 1.78 (d, *J* = 7.0 Hz, 3H), 1.22 (t, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.20 (dm, *J* = 260.3 Hz), 144.89, 144.75 (dm, *J* = 247.5 Hz), 140.65, 131.85 (t, *J* = 15.6 Hz), 128.75, 126.88, 126.76, 124.37, 107.51 (t, *J* = 3.7 Hz), 92.20, 35.53, 28.83, 17.78 (t, *J* = 3.1 Hz), 15.50. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.68 (td, *J* = 16.4, 7.3 Hz, 2F), -139.12 (td, *J* = 15.8, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_{13}F_4NNa$ ([M + Na]$^+$): 330.0876; found: 330.0882. **HPLC** analysis (OD-H, Hexane/IPA = 100.0/0.0, 0.3 mL/min, 254 nm) indicated 99% ee, t_R (minor) = 28.38 min, t_R (major) = 31.06 min. $[\alpha]_D^{25}$ = + 5.85 (c = 1.0, CH_2Cl_2).

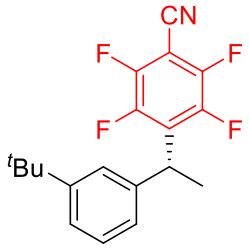


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	28.928	M	1.1770	1448071	31192	48.1230
2	31.597	M	1.2125	1561035	33864	51.8770

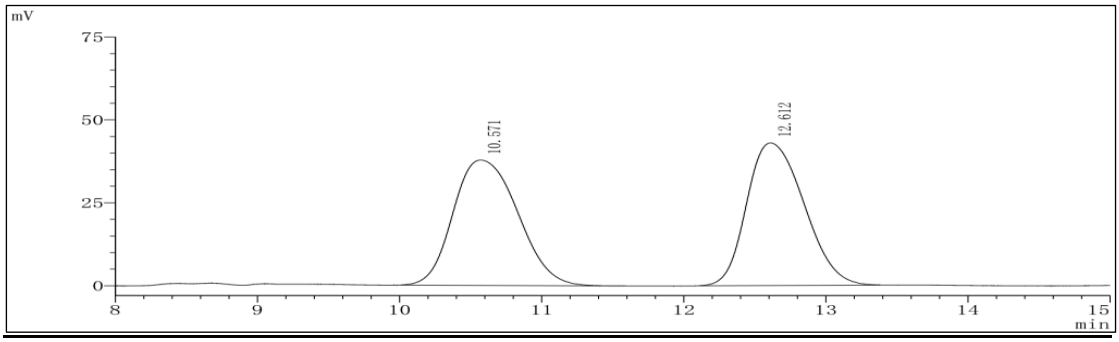


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	28.381	M	0.7783	69734	2393	0.5319
2	31.063	M	1.1483	13041008	302416	99.4681

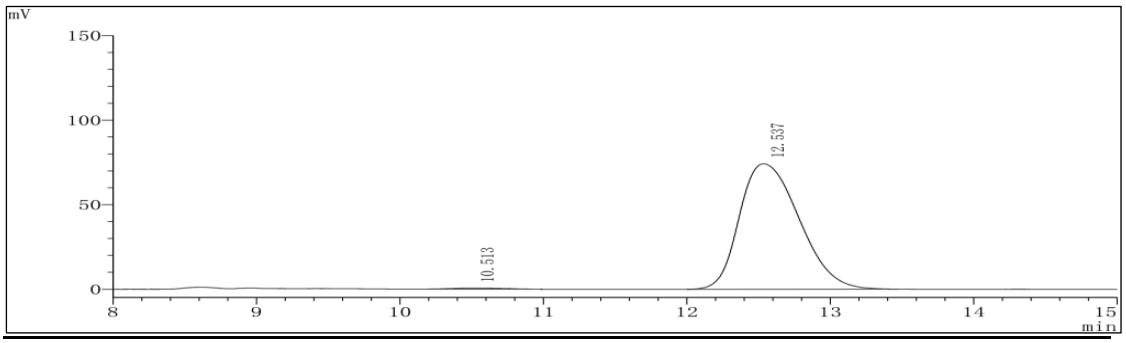
(*R*)-4-(1-(3-(Tert-butyl)phenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3f)



This compound was obtained in 89% (59.6 mg) yield as white solid by the General procedure F. **m.p.** 78 – 79 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.35 (s, 1H), 7.30 (d, *J* = 8.0 Hz, 1H), 7.26 (t, *J* = 7.8 Hz, 1H), 7.11 (d, *J* = 7.5 Hz, 1H), 4.66 (q, *J* = 7.3 Hz, 1H), 1.80 (d, *J* = 7.5 Hz, 3H), 1.31 (s, 9H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 151.80, 147.18 (dm, *J* = 259.9 Hz), 144.72 (dm, *J* = 247.4 Hz), 140.29, 131.86 (t, *J* = 15.6 Hz), 128.46, 124.42, 124.28, 124.12, 107.55 (t, *J* = 3.7 Hz), 92.14, 35.85, 34.73, 31.28, 17.88 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.62 (td, *J* = 16.4, 7.3 Hz, 2F), -139.13 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{19}H_{17}F_4NNa$ ([M + Na]$^+$): 358.1189; found: 358.1182. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 99% ee, t_R (minor) = 10.51 min, t_R (major) = 12.54 min. $[\alpha]_D^{25}$ = + 7.24 (c = 1.0, CH_2Cl_2).

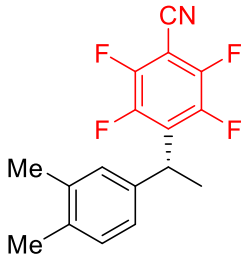


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.571	M	0.8090	1193273	37759	49.8050
2	12.612	M	0.7270	1202595	42958	50.1950

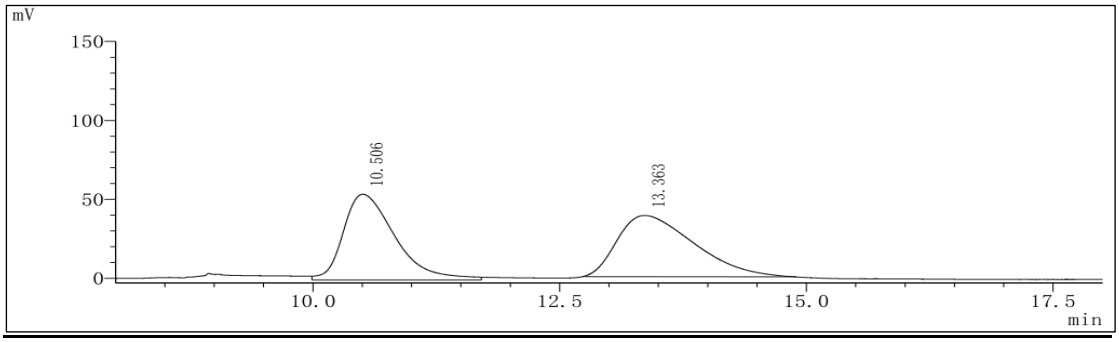


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.513	M	0.6770	12571	514	0.5830
2	12.537	M	0.7460	2143144	74151	99.4170

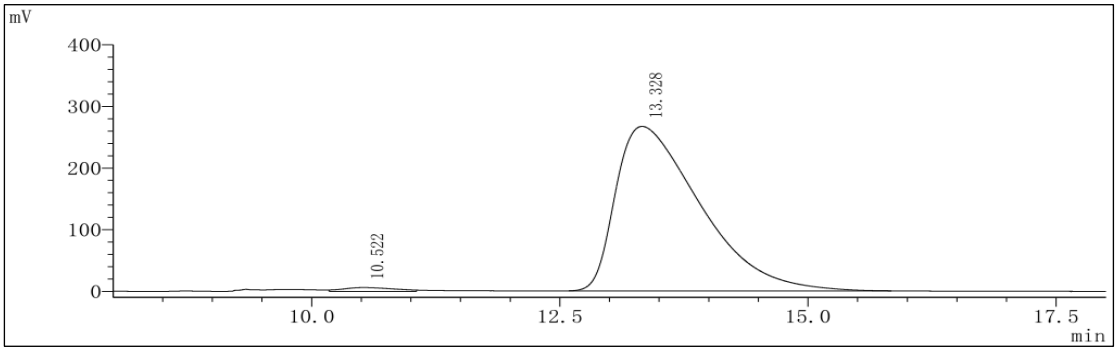
(*R*)-4-(1-(3,4-dimethylphenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3g)



This compound was obtained in 82% (50.4 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.09 (d, *J* = 8.0 Hz, 1H), 7.04 – 7.03 (m, 2H), 4.60 (q, *J* = 7.3 Hz, 1H), 2.23 (d, *J* = 5.5 Hz, 6H), 1.76 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.19 (dm, *J* = 260.1 Hz), 144.73 (dm, *J* = 247.5 Hz), 138.17, 137.04, 135.78, 132.05 (t, *J* = 15.5 Hz), 129.98, 128.45, 124.34, 107.55 (t, *J* = 3.7 Hz), 92.08, 35.17, 19.82, 19.32, 17.81 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.74 (td, *J* = 16.4, 7.3 Hz, 2F), -139.18 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_{14}F_4N$ ([M + H]$^+$): 308.1057; found: 308.1048. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 97% ee, t_R (minor) = 10.52 min, t_R (major) = 13.33 min. $[\alpha]_D^{25}$ = + 6.19 (c = 1.0, CH_2Cl_2).

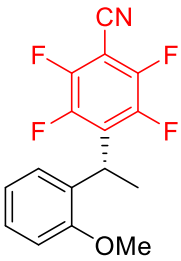


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.506	M	0.9207	1984308	54321	48.6867
2	13.363	M	1.4570	2091356	38753	51.3133

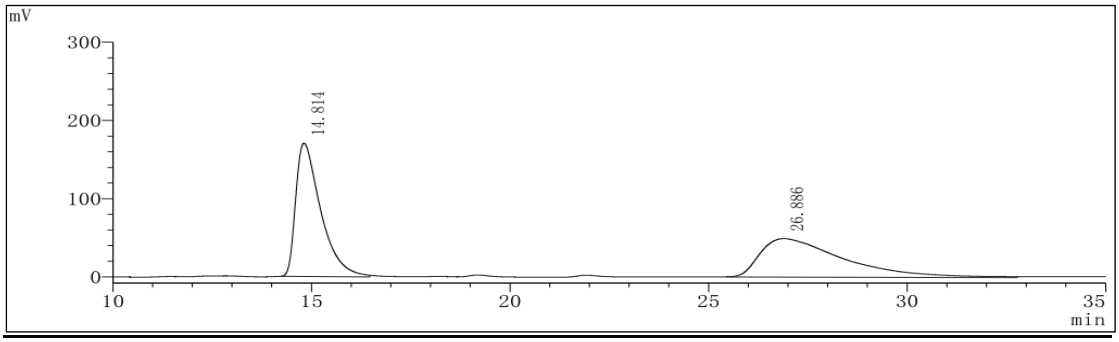


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.522	M	1.0761	219859	6070	1.3706
2	13.328	M	1.5629	15820661	266979	98.6294

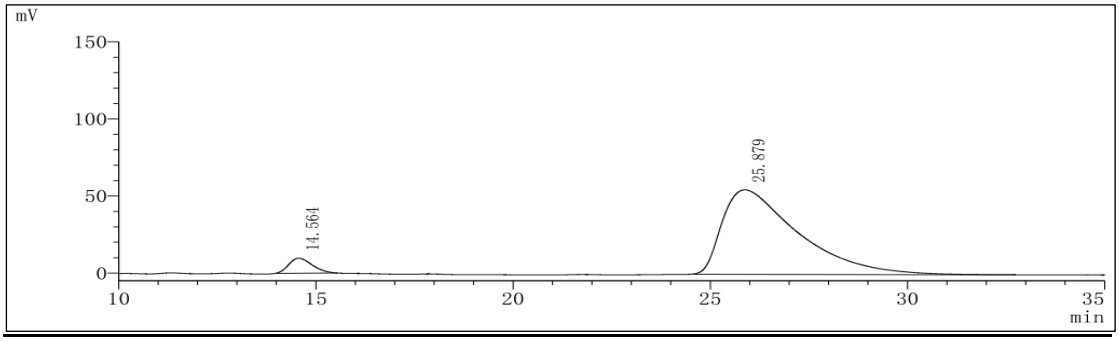
(*R*)-2,3,5,6-tetrafluoro-4-(1-(2-methoxyphenyl)ethyl)benzonitrile (3h)



This compound was obtained in 70% (43.3 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.45 (d, *J* = 7.5 Hz, 1H), 7.29 – 7.26 (m, 1H), 7.00 (t, *J* = 7.5 Hz, 1H), 6.81 (d, *J* = 8.0 Hz, 1H), 4.83 (q, *J* = 7.5 Hz, 1H), 3.72 (s, 3H), 1.71 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 156.82, 146.90 (dm, *J* = 259.3 Hz), 144.93 (dm, *J* = 248.0 Hz), 132.09 (t, *J* = 15.2 Hz), 128.53, 127.26 (t, *J* = 2.5 Hz), 120.48, 110.18, 107.80 (t, *J* = 3.7 Hz), 91.56, 55.24, 29.58, 16.99 (t, *J* = 2.0 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -133.95 (td, *J* = 16.4, 7.9 Hz, 2F), -139.67 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{16}H_{12}F_4NO$ ([M + H]$^+$): 310.0850; found: 310.0855. **HPLC** analysis (OJ-H, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 90% ee, t_R (minor) = 14.56 min, t_R (major) = 25.88 min. $[\alpha]_D^{25}$ = + 9.21 (c = 1.0, CH_2Cl_2).

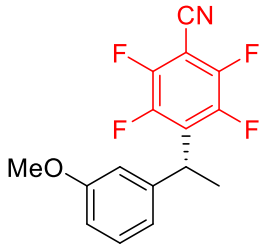


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	14.814	M	1.1277	7475705	170616	51.0633
2	26.886	M	3.6690	7164368	49221	48.9367

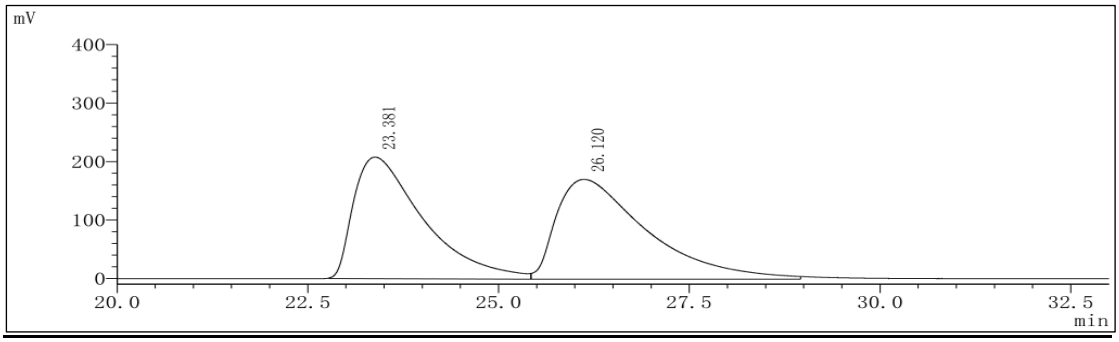


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	14.564	M	1.0936	401573	9745	5.2104
2	25.879	M	3.4439	7305517	54731	94.7896

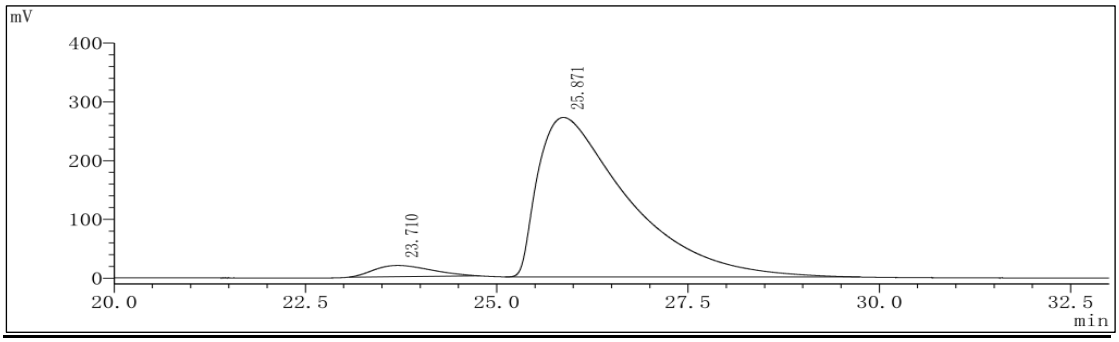
(*R*)-2,3,5,6-Tetrafluoro-4-(1-(3-methoxyphenyl)ethyl)benzonitrile (3i)



This compound was obtained in 88% (54.4 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.24 (t, *J* = 7.5 Hz, 1H), 6.87 (d, *J* = 8.0 Hz, 1H), 6.84 (s, 1H), 6.80 (d, *J* = 8.5 Hz, 1H), 4.64 (q, *J* = 7.3 Hz, 1H), 3.80 (s, 3H), 1.77 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 159.84, 147.19 (dm, *J* = 260.4 Hz), 144.73 (dm, *J* = 247.5 Hz), 142.23, 131.55 (t, *J* = 15.5 Hz), 129.80, 119.47, 113.54, 112.01, 107.50 (t, *J* = 3.7 Hz), 92.30, 55.24, 35.40, 17.68. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.53 (td, *J* = 16.4, 7.3 Hz, 2F), -139.05 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{16}H_{12}F_4NO$ ([M + H]$^+$): 310.0850; found: 310.0858. **HPLC** analysis (OJ-H, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 92% ee, t_R (minor) = 23.71 min, t_R (major) = 25.87 min. $[\alpha]_D^{25}$ = + 15.38 (c = 1.0, CH_2Cl_2).

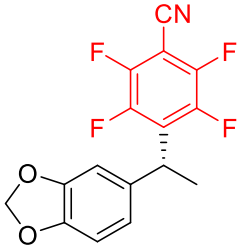


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	23.381	M	1.6238	13246760	208005	48.5019
2	26.120	M	2.0875	14065054	170802	51.4981

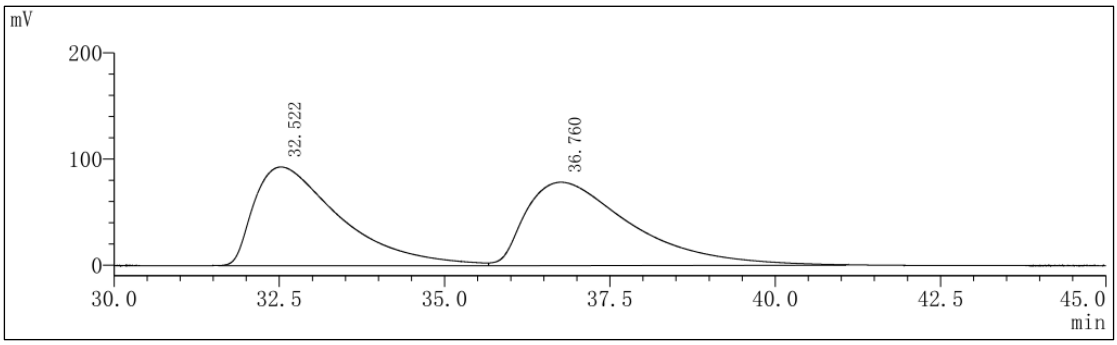


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	23.710	M	1.4010	993076	19088	4.2420
2	25.871	M	2.1047	22417228	271513	95.7580

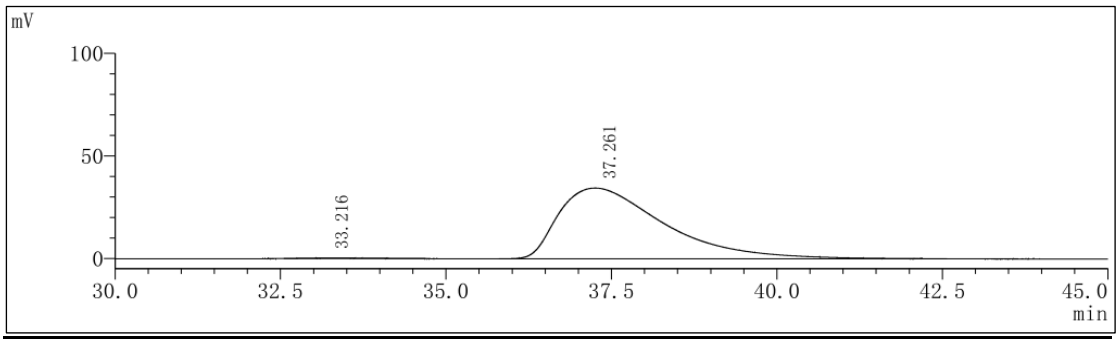
(*R*)-4-(1-(benzo[d][1,3]dioxol-5-yl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3j)



This compound was obtained in 56% (36.2 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 6.79 (s, 1H), 6.75 (s, 2H), 5.94 (s, 2H), 4.59 (q, *J* = 7.5 Hz, 1H), 1.74 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.99, 147.19 (dm, *J* = 262.1 Hz), 146.76, 144.62 (dm, *J* = 247.4 Hz), 134.48, 131.73 (t, *J* = 15.5 Hz), 120.39, 108.36, 107.59, 107.49 (t, *J* = 3.6 Hz), 101.20, 92.22, 35.20, 17.92 (t, *J* = 3.1 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.50 (td, *J* = 16.4, 6.8 Hz, 2F), -139.38 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{16}H_9F_4NNaO_2$ ([M + Na]$^+$): 346.0462; found: 346.0454. **HPLC** analysis (OJ-H, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 99% ee, t_R (minor) = 33.22 min, t_R (major) = 37.26 min. $[\alpha]_D^{25}$ = + 31.27 (c = 1.0, CH_2Cl_2).

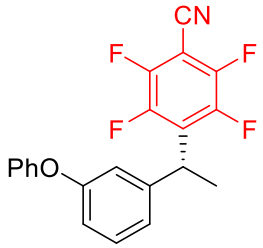


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	32.522	M	2.3353	8453746	93031	49.0556
2	36.760	M	2.8582	8779235	78578	50.9444

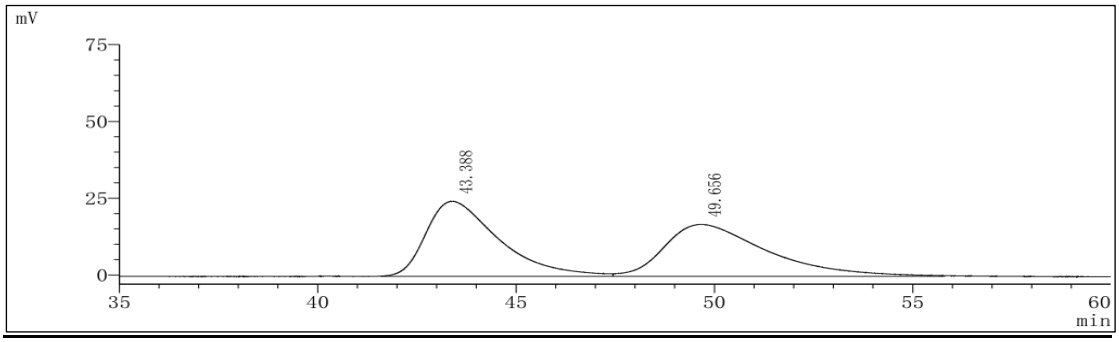


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	33.216	M	1.2691	19038	281	0.4956
2	37.261	S	2.7883	3822164	34506	99.5044

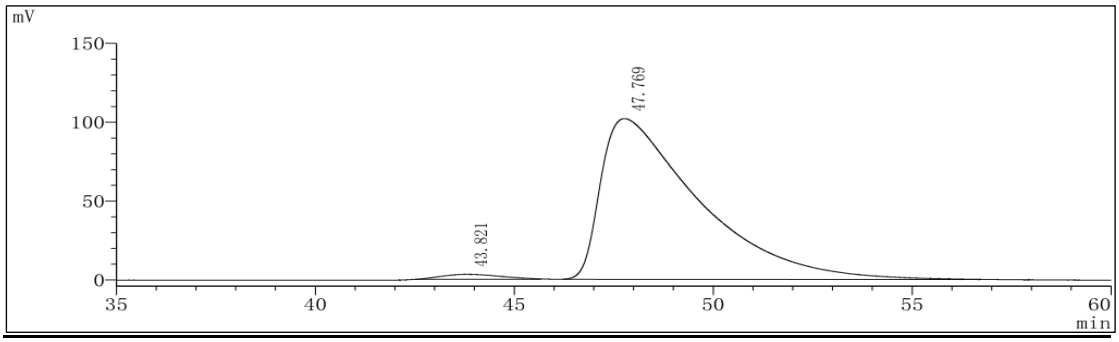
(*R*)-2,3,5,6-Tetrafluoro-4-(1-(3-phenoxyphenyl)ethyl)benzonitrile (3k)



This compound was obtained in 62% (46.0 mg) yield as white solid by the General procedure F. **m.p.** 97 – 98 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.34 (t, *J* = 8.0 Hz, 2H), 7.26 (t, *J* = 7.3 Hz, 1H), 7.12 (t, *J* = 7.3 Hz, 1H), 7.01 – 6.98 (m, 4H), 6.86 (d, *J* = 9.0 Hz, 1H), 4.65 (q, *J* = 7.3 Hz, 1H), 1.76 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 157.62, 156.80, 147.21 (dm, *J* = 260.5 Hz), 144.72 (dm, *J* = 247.8 Hz), 142.66, 131.31 (t, *J* = 15.5 Hz), 130.00, 129.79, 123.50, 121.92, 118.87, 117.72, 117.34, 107.44, 92.47, 35.24, 17.69 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.42 (td, *J* = 17.0, 7.3 Hz, 2F), -139.07 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{21}H_{13}F_4NNaO$ ([M + Na]$^+$): 394.0825; found: 394.0830. **HPLC** analysis (OJ-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 96% ee, t_R (minor) = 43.82 min, t_R (major) = 47.77 min. $[\alpha]_D^{25}$ = + 12.77 (c = 1.0, CH_2Cl_2).

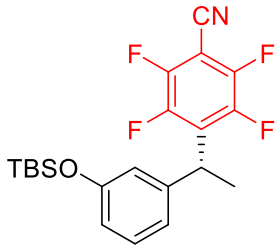


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	43.388	M	3.1777	3114060	24396	50.6928
2	49.656	M	4.1528	3028939	16871	49.3072

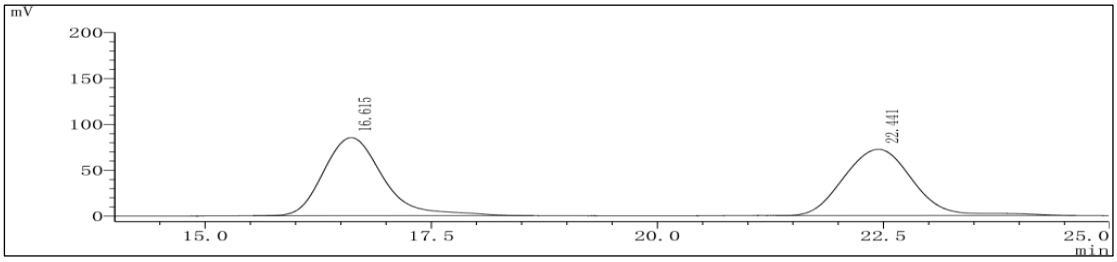


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	43.821	M	2.4715	318530	3112	1.7870
2	47.769	M	4.4309	17506566	101908	98.2130

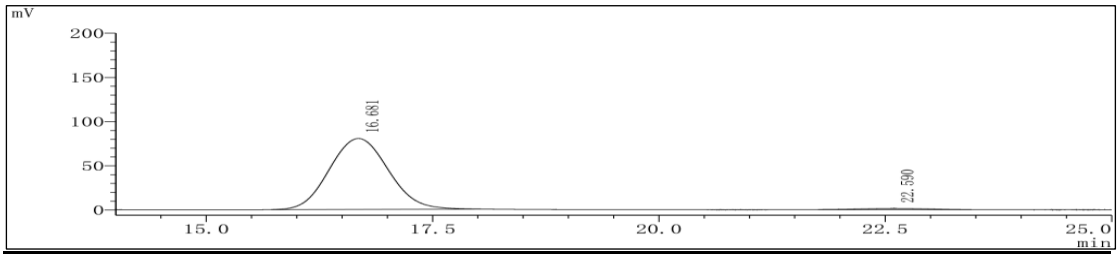
(*R*)-4-(1-(3-((tert-butyldimethylsilyl)oxy)phenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3l)



This compound was obtained in 66% (54.0 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.17 (t, *J* = 8.0 Hz, 1H), 6.85 (d, *J* = 8.0 Hz, 1H), 6.78 (s, 1H), 6.73 (d, *J* = 8.0 Hz, 1H), 4.61 (q, *J* = 7.3 Hz, 1H), 1.76 (d, *J* = 7.5 Hz, 3H), 0.97 (s, 9H), 0.18 (s, 6H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 155.99, 147.18 (dm, *J* = 260.3 Hz), 144.71 (dm, *J* = 247.5 Hz), 142.12, 131.68 (t, *J* = 15.5 Hz), 129.66, 120.13, 118.95, 118.87, 107.50 (t, *J* = 3.8 Hz), 92.23, 35.27, 25.64, 18.21, 17.63 (t, *J* = 2.9 Hz), -4.46. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.64 (td, *J* = 16.4, 6.8 Hz), -139.16 (td, *J* = 16.4, 6.8 Hz). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{21}H_{23}F_4NNaOSi$ ([M + Na]$^+$): 432.1377; found: 432.1371. **HPLC** analysis The enantiomeric excess value of compound **3l** was detected by the corresponding phenol (OD-3, Hexane/IPA = 95.0/5.0, 1.0 mL/min, 254 nm) indicated 96% ee, t_R (major) = 16.68 min, t_R (minor) = 22.59 min. $[\alpha]_D^{25}$ = + 12.38 (c = 1.0, CH_2Cl_2).

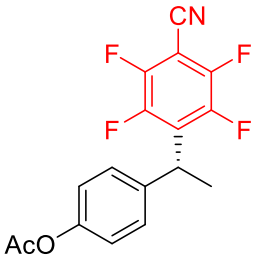


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	16.615	M	1.1530	3890366	85120	50.3518
2	22.441	M	1.3778	3836011	72128	49.6482

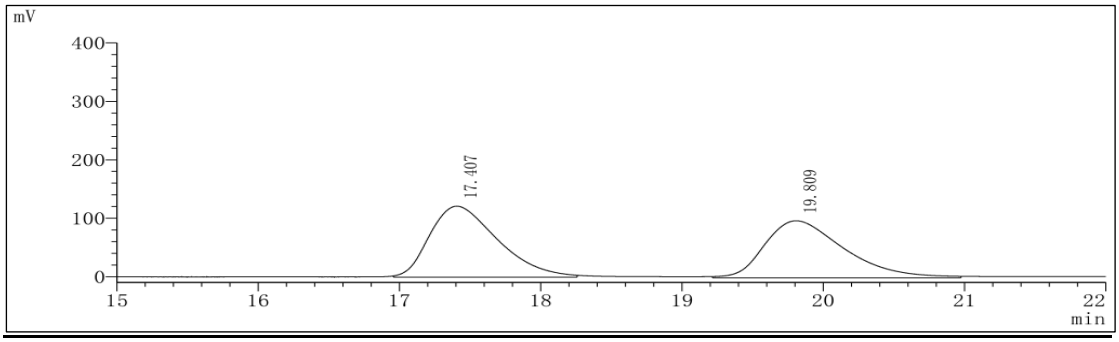


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	16.681	M	1.1962	3640019	80295	98.1257
2	22.590	M	1.3314	69527	1371	1.8743

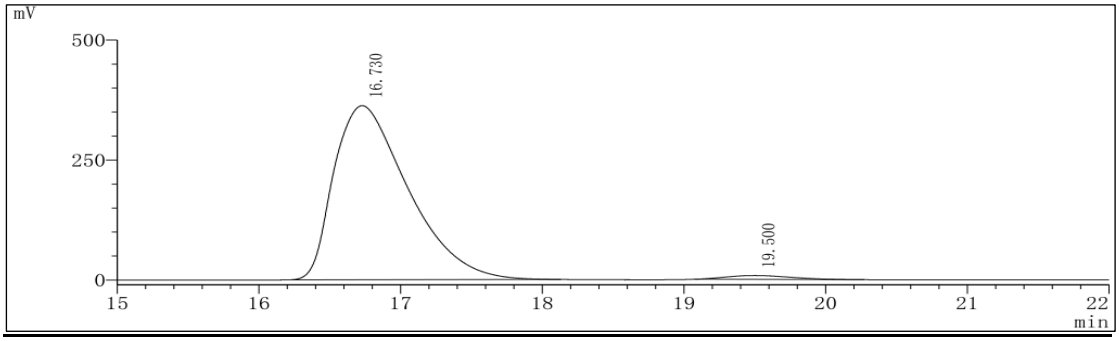
(*R*)-4-(1-(4-cyano-2,3,5,6-tetrafluorophenyl)ethyl)phenyl acetate (3m)



This compound was obtained in 88% (59.3 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.31 (d, *J* = 8.5 Hz, 2H), 7.05 (d, *J* = 8.5 Hz, 2H), 4.66 (q, *J* = 7.3 Hz, 1H), 2.29 (s, 3H), 1.78 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 169.40, 149.72, 147.18 (dm, *J* = 260.3 Hz), 144.63 (dm, *J* = 247.4 Hz), 138.07, 131.26 (t, *J* = 15.5 Hz), 128.22, 121.88, 107.44 (t, *J* = 3.6 Hz), 92.38, 34.93, 21.08, 17.77 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.39 (td, *J* = 15.8, 6.8 Hz, 2F), -139.16 (td, *J* = 15.8, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_{11}F_4NNaO_2$ ([M + Na]$^+$): 360.0618; found: 360.0625. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 1.0 mL/min, 254 nm) indicated 96% ee, t_R (major) = 16.73 min, t_R (minor) = 19.50 min. $[\alpha]_D^{25}$ = + 7.64 (c = 1.0, CH_2Cl_2).

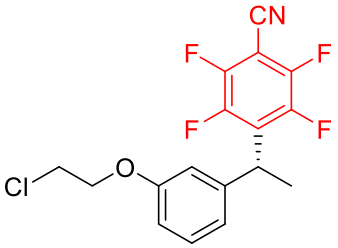


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	17.407	M	0.8969	4058759	121351	51.4254
2	19.809	M	1.0301	3833754	97755	48.5746

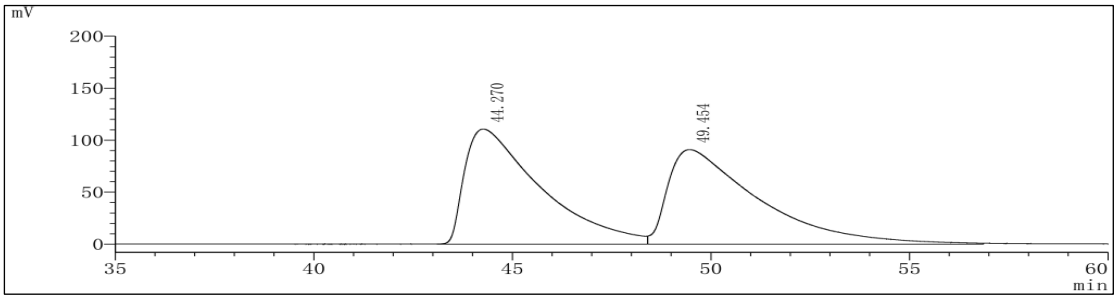


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	16.730	M	0.9546	13231556	362823	98.0353
2	19.500	M	0.8915	265174	8114	1.9647

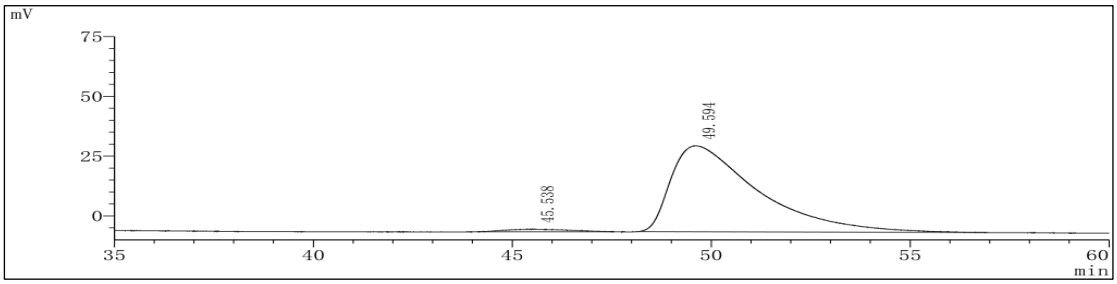
(*R*)-4-(1-(3-(2-Chloroethoxy)phenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3n)



This compound was obtained in 96% (68.6 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.25 (t, *J* = 8.0 Hz, 1H), 6.91 (d, *J* = 8.0 Hz, 1H), 6.87 (s, 1H), 6.80 (d, *J* = 8.0 Hz, 1H), 4.64 (q, *J* = 7.3 Hz, 1H), 4.22 (t, *J* = 5.8 Hz, 2H), 3.81 (t, *J* = 5.8 Hz, 2H), 1.77 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.48, 147.19 (dm, *J* = 260.4 Hz), 144.71 (dm, *J* = 247.7 Hz), 142.43, 131.41 (t, *J* = 15.5 Hz), 129.89, 120.20, 114.37, 112.67, 107.47 (t, *J* = 3.6 Hz), 92.37, 68.01, 41.85, 35.31, 17.65 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.44 (td, *J* = 16.4, 9.6 Hz, 2F), -139.05 (td, *J* = 15.8, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_{12}ClF_4NNaO$ ([M + Na]$^+$): 380.0436; found: 380.0443. **HPLC** analysis (OJ-H, Hexane/IPA = 99.0/1.0, 0.5 mL/min, 254 nm) indicated 96% ee, t_R (minor) = 45.54 min, t_R (major) = 49.59 min. $[\alpha]_D^{25}$ = − 15.42 (c = 1.0, CH_2Cl_2).

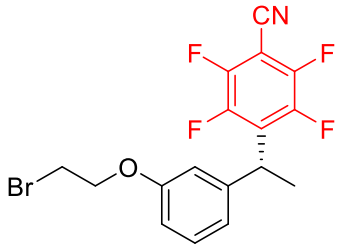


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	44.270	M	3.5762	14725860	110787	50.4755
2	49.454	M	4.0033	14448393	91016	49.5245

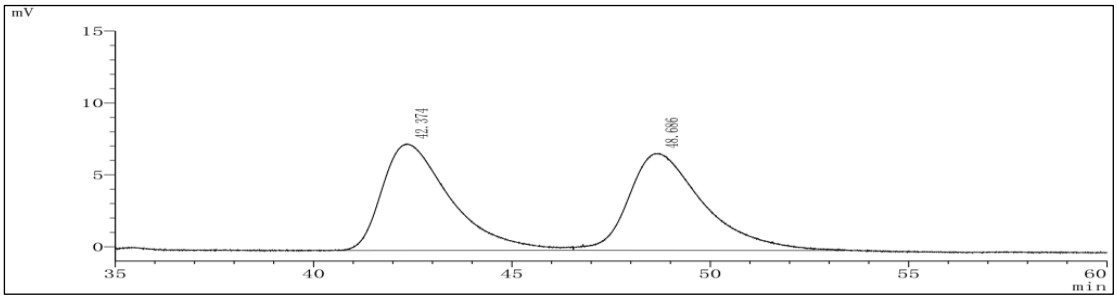


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	45.538	M	2.1899	113749	1029	2.0383
2	49.594	M	3.7853	5466874	35913	97.9617

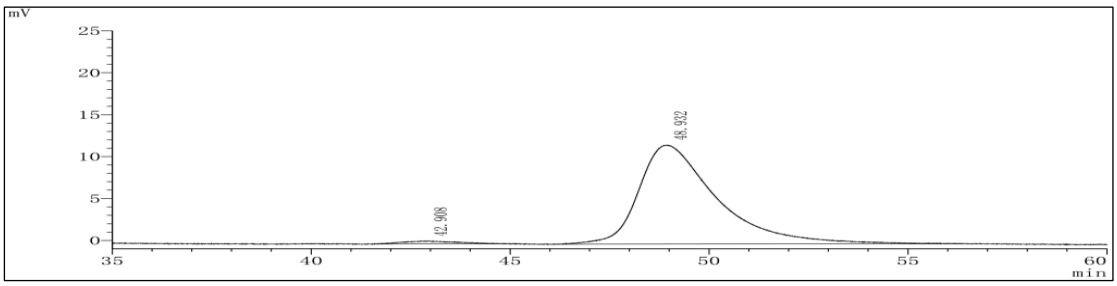
(*R*)-4-(1-(3-(2-Bromoethoxy)phenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3o)



This compound was obtained in 72% (57.7 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.25 (t, *J* = 7.6 Hz, 1H), 6.91 (d, *J* = 8.0 Hz, 1H), 6.86 (s, 1H), 6.80 (d, *J* = 8.5 Hz, 1H), 4.64 (q, *J* = 7.3 Hz, 1H), 4.28 (t, *J* = 6.3 Hz, 2H), 3.63 (t, *J* = 6.3 Hz, 2H), 1.77 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.40, 147.20 (dm, *J* = 260.3 Hz), 144.70 (dm, *J* = 247.7 Hz), 142.45, 131.40 (t, *J* = 15.5 Hz), 129.91, 120.24, 114.42, 112.78, 107.45 (t, *J* = 3.5 Hz), 92.40, 67.89, 35.34, 28.97, 17.68 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.45 (td, *J* = 15.8, 6.8 Hz, 2F), -139.06 (dt, *J* = 24.9, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_{12}BrF_4NNaO$ ([M + Na]$^+$): 423.9931; found: 423.9942. **HPLC** analysis (OJ-H, Hexane/IPA = 99.0/1.0, 0.5 mL/min, 254 nm) indicated 96% ee, t_R (minor) = 42.91 min, t_R (major) = 48.93 min. $[\alpha]_D^{25}$ = − 16.18 (c = 1.0, CH_2Cl_2).

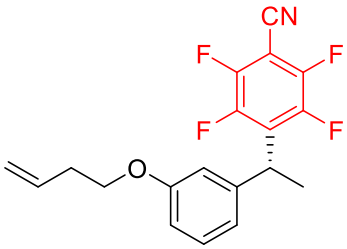


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	42.374	M	2.8190	884530	7387	50.1700
2	48.686	M	2.8810	878522	6722	49.8300

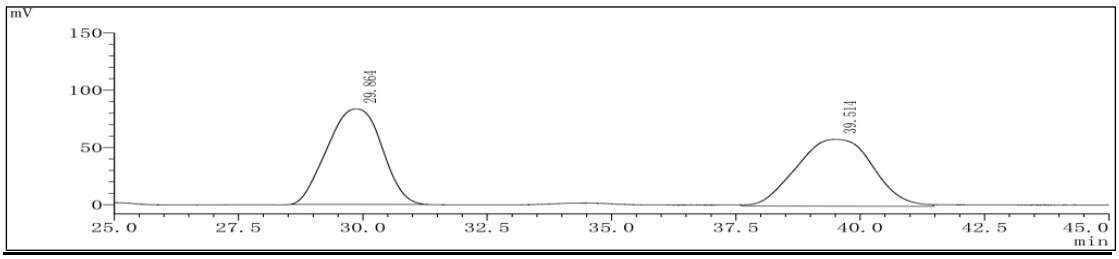


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	42.908	M	1.7200	31359	316	1.9200
2	48.932	M	3.4330	1601609	11786	98.0800

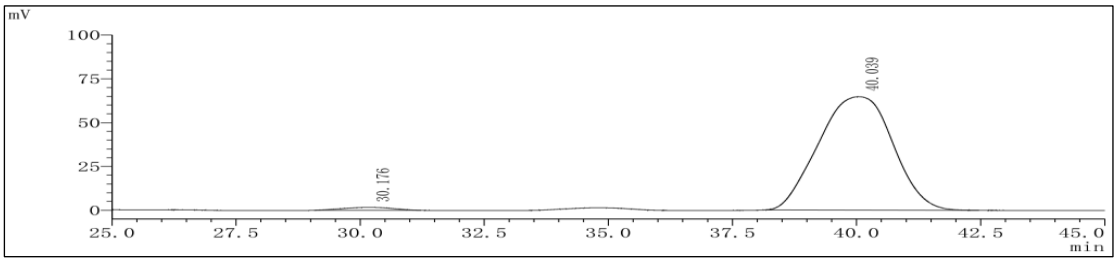
(*R*)-4-(1-(3-(but-3-en-1-yloxy)phenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3p)



This compound was obtained in 75% (52.4 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.26 – 7.21 (m, 1H), 6.86 (d, *J* = 8.0 Hz, 1H), 6.83 (s, 1H), 6.79 (d, *J* = 8.0 Hz, 1H), 5.94 – 5.86 (m, 1H), 5.14 (dd, *J* = 32.0, 17.0 Hz, 2H), 4.63 (q, *J* = 7.5 Hz, 1H), 3.99 (t, *J* = 6.8 Hz, 2H), 2.54 (q, *J* = 6.7 Hz, 2H), 1.77 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 159.20, 147.19 (dm, *J* = 260.3 Hz), 144.74 (dm, *J* = 247.5 Hz), 142.22, 134.29, 131.58 (t, *J* = 15.5 Hz), 129.76, 119.47, 117.10, 114.17, 112.67, 107.48 (t, *J* = 3.6 Hz), 92.29, 67.23, 35.40, 33.60, 17.68 (t, *J* = 3.1 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.57 (td, *J* = 15.8, 6.8 Hz, 2F), -139.04 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{19}H_{16}F_4NO$ ([M + H]$^+$): 350.1163; found: 350.1171. **HPLC** analysis (OD-3, Hexane/IPA = 95.0/5.0, 0.5 mL/min, 254 nm) indicated 97% ee, t_R (minor) = 30.18 min, t_R (major) = 40.04 min. $[\alpha]_D^{25}$ = + 13.75 (c = 1.0, CH_2Cl_2).

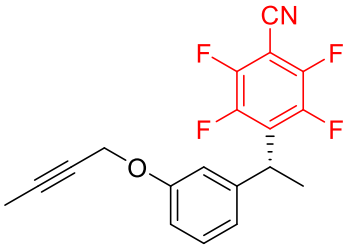


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	29.864	M	2.0015	6390207	83521	50.5990
2	39.514	M	2.7013	6238903	58329	49.4010

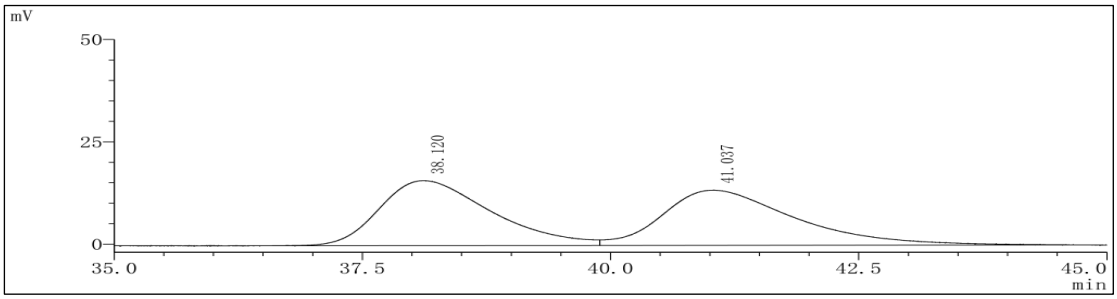


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	30.176	M	1.8166	114064	1619	1.6612
2	40.039	M	2.6705	6752381	64709	98.3388

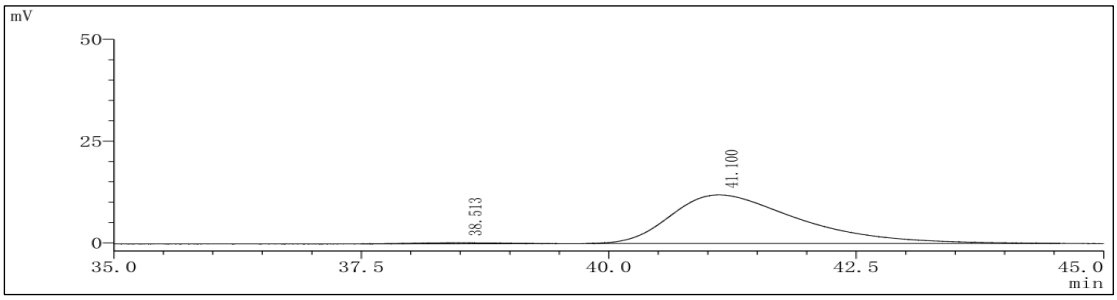
(*R*)-4-(1-(3-(but-2-yn-1-yloxy)phenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3q)



This compound was obtained in 47% (32.6 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.25 (t, *J* = 7.8 Hz, 1H), 6.91 – 6.89 (m, 2H), 6.85 (d, *J* = 7.5 Hz, 1H), 4.66 – 4.63 (m, 3H), 1.85 (s, 3H), 1.77 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.09, 147.18 (dm, *J* = 260.1 Hz), 144.74 (dm, *J* = 247.7 Hz), 142.21, 131.49 (t, *J* = 15.6 Hz), 129.72, 119.99, 114.35, 113.07, 107.45 (t, *J* = 3.7 Hz), 92.29, 83.97, 73.71, 56.42, 35.40, 17.63 (t, *J* = 3.1 Hz), 3.58. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.62 (td, *J* = 16.4, 6.8 Hz, 2F), -139.01 (td, *J* = 15.8, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{19}H_{14}F_4NO$ ([M + H]$^+$): 348.1006; found: 348.1015. **HPLC** analysis (OJ-3, Hexane/IPA = 98.5/1.5, 0.5 mL/min, 254 nm) indicated 97% ee, t_R (minor) = 38.51 min, t_R (major) = 41.10 min. $[\alpha]_D^{25}$ = + 8.37 (c = 1.0, CH_2Cl_2).

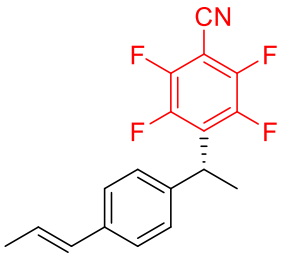


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	38.120	V	2.0154	1246607	15892	50.0359
2	41.037	SV	2.2950	1244817	13469	49.9641

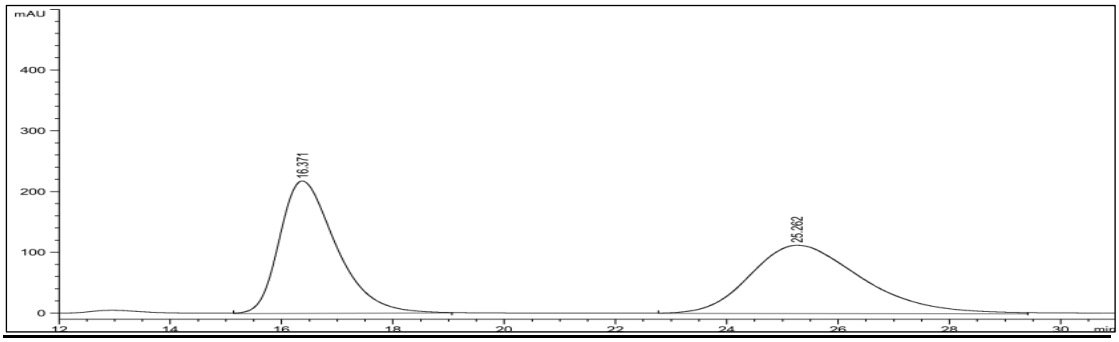


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	38.513	M	1.2650	15443	248	1.4130
2	41.100	M	2.3292	1077448	11951	98.5870

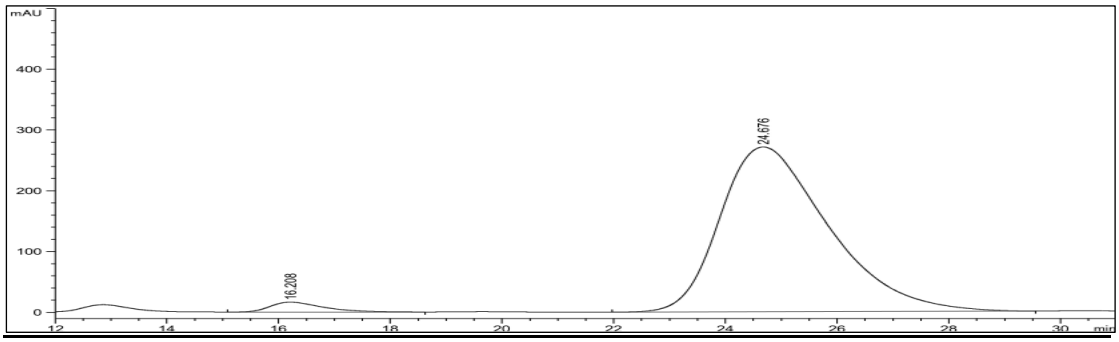
(*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-(4-(prop-1-en-1-yl)phenyl)ethyl)benzonitrile (3r)



This compound was obtained in 83% (53.0 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.26 (t, *J* = 7.2 Hz, 2H), 7.20 (d, *J* = 7.8 Hz, 2H), 6.36 (d, *J* = 16.2 Hz, 1H), 6.24 – 6.18 (m, 1H), 4.64 (q, *J* = 7.4 Hz, 1H), 1.87 (d, *J* = 6.0 Hz, 3H), 1.77 (d, *J* = 9.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.18 (dm, *J* = 260.6 Hz), 144.70 (dm, *J* = 247.5 Hz), 138.97, 137.19, 131.74 (t, *J* = 15.5 Hz), 130.24, 127.24, 126.27, 126.14, 107.50 (t, *J* = 3.8 Hz), 92.21, 35.19, 18.45, 17.69 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.64 (td, *J* = 16.4, 7.3 Hz, 2F), -139.22 (td, *J* = 17.0, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{18}H_{14}F_4N$ ([M + H]$^+$): 320.1057; found: 320.1061. **HPLC** analysis (OJ-H, Hexane/IPA = 97.0/3.0, 0.8 mL/min, 254 nm) indicated 94% ee, t_R (minor) = 16.21 min, t_R (major) = 24.68 min. $[\alpha]_D^{25}$ = + 13.75 (c = 1.0, CH_2Cl_2).

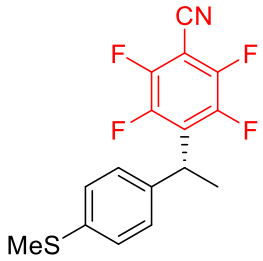


Peak	RetTime	Type	Width(min)	Area(mAU*S)	Hight(mAU)	Area%
1	16.371	MM R	1.1755	1.53662e4	217.87373	49.3191
2	25.262	MM R	2.3407	1.57905e4	112.43182	50.6809

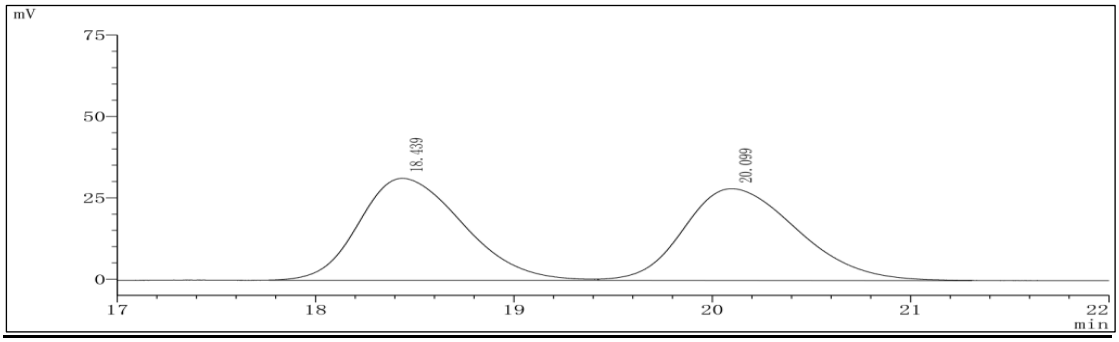


Peak	RetTime	Type	Width(min)	Area(mAU*S)	Hight(mAU)	Area%
1	16.208	BB	0.9852	1061.04163	16.21976	2.8156
2	24.676	BB	1.9782	3.66237e4	271.25278	97.1844

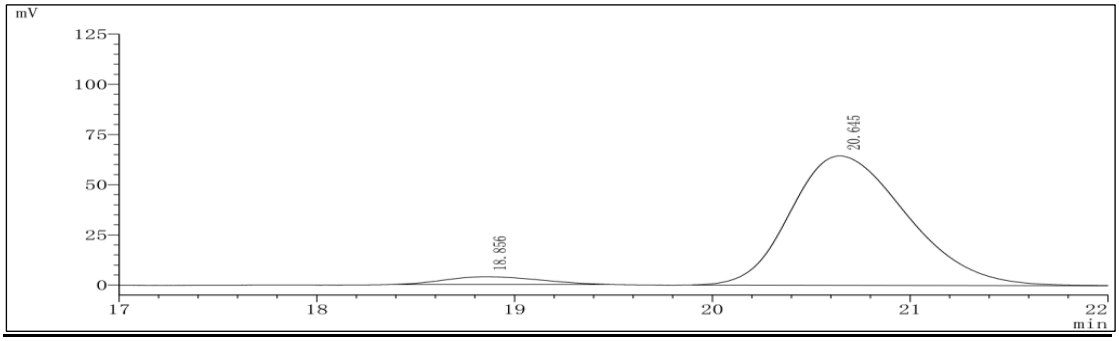
(*R*)-2,3,5,6-Tetrafluoro-4-(1-(4-(methylthio)phenyl)ethyl)benzonitrile (3s)



This compound was obtained in 90% (58.5 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.21 (s, 4H), 4.63 (q, *J* = 7.5 Hz, 1H), 2.46 (s, 3H), 1.77 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.17 (dm, *J* = 260.8 Hz), 144.65 (dm, *J* = 247.5 Hz), 137.76, 137.37, 131.53 (t, *J* = 15.5 Hz), 127.59, 126.80, 107.46 (t, *J* = 3.8 Hz), 92.28, 34.97, 17.66 (t, *J* = 2.9 Hz), 15.74. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.47 (td, *J* = 16.4, 7.3 Hz, 2F), -139.23 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{16}H_{12}F_4NS$ ([M + H]$^+$): 326.0621; found: 326.0627. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 91% ee, t_R (minor) = 18.86 min, t_R (major) = 20.65 min. $[\alpha]_D^{25}$ = + 10.49 (c = 1.0, CH_2Cl_2).

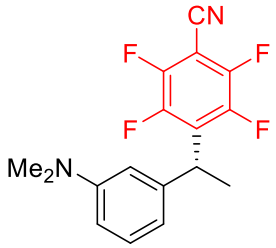


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	18.439	M	0.9470	1140220	31286	50.3760
2	20.099	M	1.0400	1123193	28169	49.6240

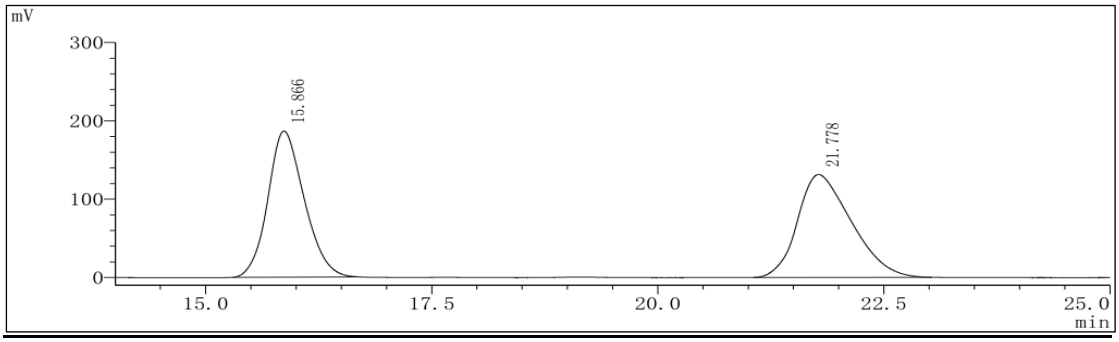


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	18.856	M	0.9030	128516	3835	4.6640
2	20.645	M	1.0700	2626737	64378	95.3360

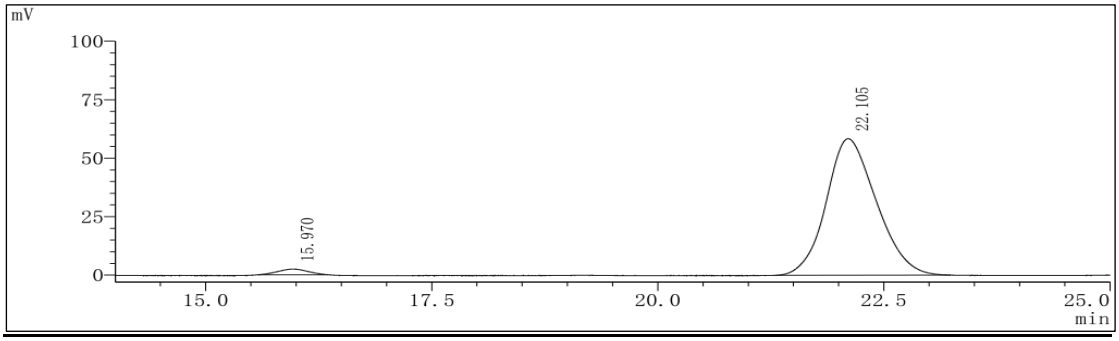
(*R*)-4-(1-(3-(Dimethylamino)phenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3t)



This compound was obtained in 82% (52.8 mg) yield as light yellow oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.17 (t, *J* = 8.0 Hz, 1H), 6.65 – 6.61 (m, 3H), 4.61 (q, *J* = 7.3 Hz, 1H), 2.94 (s, 6H), 1.78 (d, *J* = 8.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 150.82, 147.16 (dm, *J* = 260.0 Hz), 144.78 (dm, *J* = 247.2 Hz), 141.64, 132.04 (t, *J* = 15.7 Hz), 129.43, 115.19, 111.49, 111.11, 107.56 (t, *J* = 3.8 Hz), 91.98, 40.46, 36.04, 17.80 (t, *J* = 3.2 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.77 – -132.85 (m, 2F), -138.99 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_{14}F_4N_2Na$ ([M + Na]$^+$): 345.0985; found: 345.0972. **HPLC** analysis (OD-3, Hexane/IPA = 99.0/1.0, 0.5 mL/min, 254 nm) indicated 95% ee, t_R (minor) = 15.97 min, t_R (major) = 22.11 min. $[\alpha]_D^{25}$ = + 10.18 (c = 1.0, CH_2Cl_2).

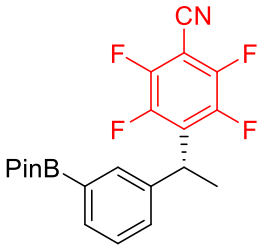


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.866	M	0.7412	5232755	186769	49.0580
2	21.778	M	1.1162	5433706	131312	50.9420

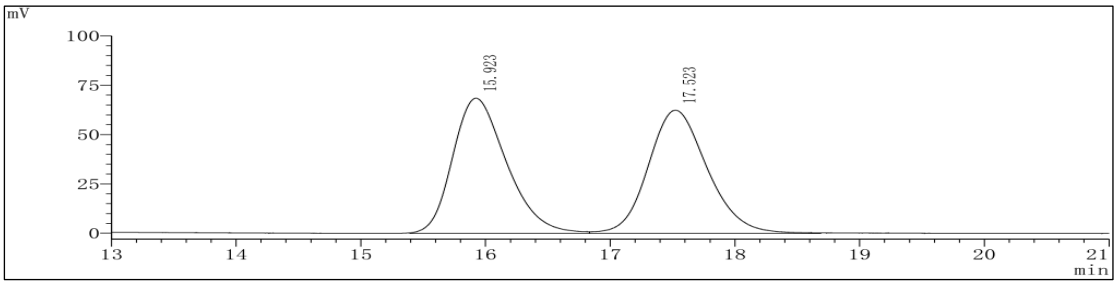


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.970	M	0.6301	56929	2415	2.4604
2	22.105	M	1.0223	2256893	58397	97.5396

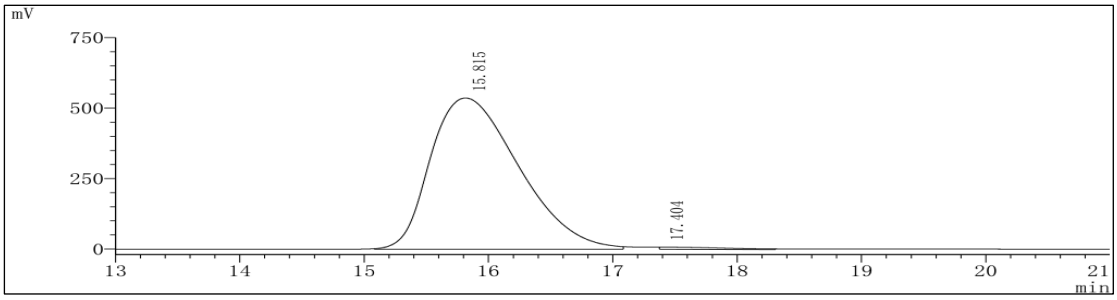
(*R*)-2,3,5,6-Tetrafluoro-4-(1-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)ethyl)benzonitrile (3u)



This compound was obtained in 61% (49.4 mg) yield as yellow oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.72 – 7.69 (m, 2H), 7.39 (d, *J* = 8.0 Hz, 1H), 7.34 (t, *J* = 7.5 Hz, 1H), 4.68 (q, *J* = 7.5 Hz, 1H), 1.79 (d, *J* = 7.5 Hz, 3H), 1.34 (s, 12H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.21 (dm, *J* = 259.8 Hz), 144.75 (dm, *J* = 248.1 Hz), 139.89, 133.89, 133.45, 131.77 (t, *J* = 15.2 Hz), 129.83, 128.19, 107.55 (t, *J* = 4.0 Hz), 83.95, 35.48, 24.88, 24.84, 17.93 (t, *J* = 3.2 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.62 (td, *J* = 16.4, 7.3 Hz, 2F), -138.91 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{21}H_{21}BF_4NO_2$ ([M + H]$^+$): 406.1600; found: 406.1591. **HPLC** analysis (OD-3, Hexane/IPA = 99.8/0.2, 0.5 mL/min, 254 nm) indicated 98% ee, t_R (major) = 15.82 min, t_R (minor) = 17.40 min. $[\alpha]_D^{25}$ = + 9.26 (c = 1.0, CH_2Cl_2).

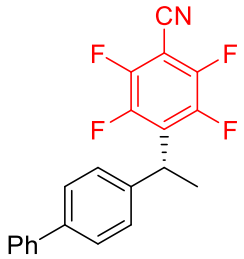


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.923	M	0.7921	2056043	68438	50.0507
2	17.523	M	0.8528	2051877	62379	49.9493

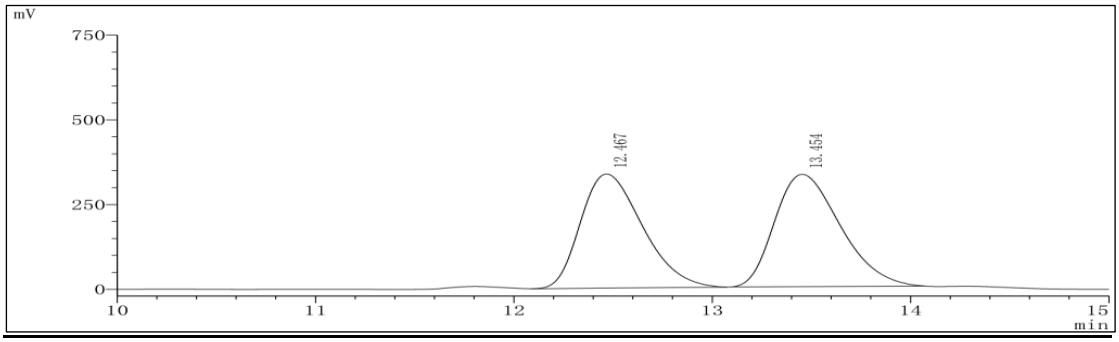


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.815	M	1.2931	26484862	536561	98.9233
2	17.404	M	3.6420	288258	7316	1.0767

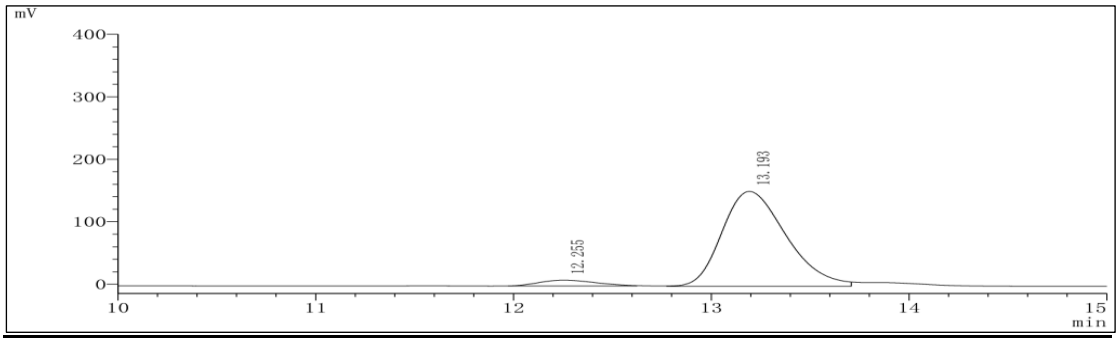
(*R*)-4-(1-([1,1'-biphenyl]-4-yl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3v)



This compound was obtained in 98% (69.6 mg) yield as white solid by the General procedure F. **m.p.** 82 – 83 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.55 (d, *J* = 8.0 Hz, 4H), 7.43 (t, *J* = 7.5 Hz, 2H), 7.37 – 7.33 (m, 3H), 4.71 (q, *J* = 7.5 Hz, 1H), 1.82 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.23 (dm, *J* = 260.3 Hz), 144.75 (dm, *J* = 247.5 Hz), 140.38, 139.65, 131.58 (t, *J* = 15.6 Hz), 128.79, 127.55, 127.49, 127.44, 127.01, 107.48 (t, *J* = 3.8 Hz), 92.35, 35.21, 17.76 (t, *J* = 2.5 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.46 (td, *J* = 15.8, 6.8 Hz, 2F), -139.08 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{21}H_{13}F_4NNa$ ([M + Na]$^+$): 378.0876; found: 378.0883. **HPLC** analysis (AD-H, Hexane/IPA = 98.0/2.0, 0.5 mL/min, 254 nm) indicated 90% ee, t_R (minor) = 12.26 min, t_R (major) = 13.19 min. $[\alpha]_D^{25}$ = − 17.65 (c = 1.0, CH_2Cl_2).

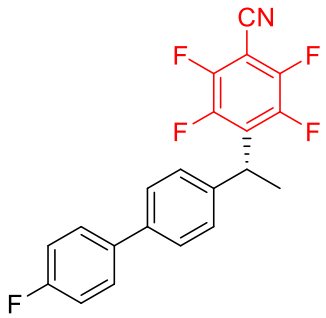


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	12.467	M	0.5750	7288224	336568	48.8770
2	13.454	M	0.6100	7623251	331523	51.1230

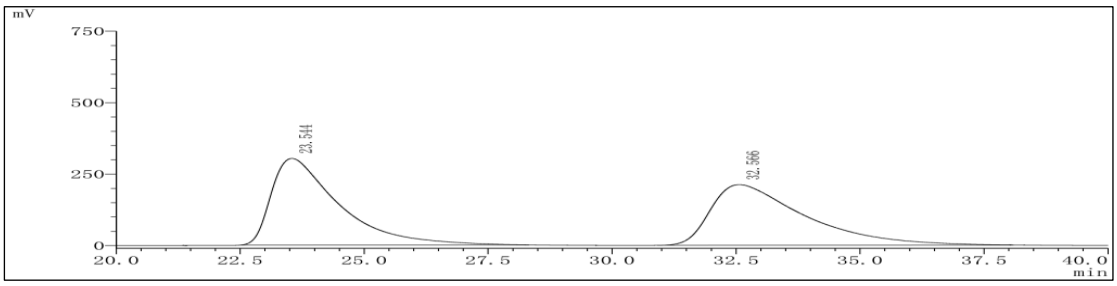


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	12.255	M	0.5400	189878	9361	5.2410
2	13.193	M	0.5920	3432983	151905	94.7590

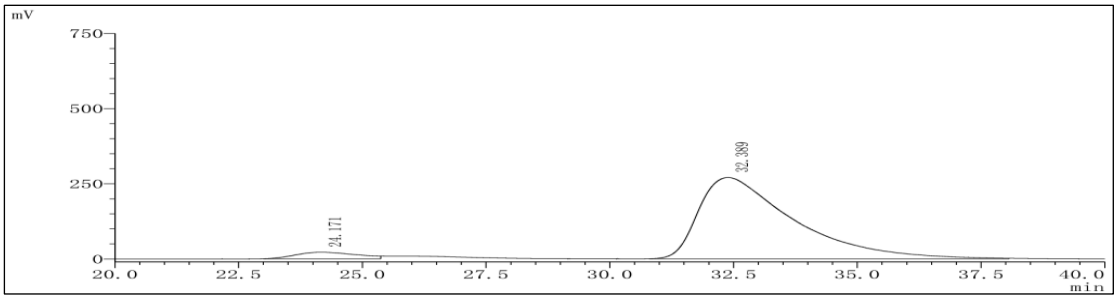
(*R*)-2,3,5,6-tetrafluoro-4-(1-(4'-fluoro-[1,1'-biphenyl]-4-yl)ethyl)benzonitrile (3w)



This compound was obtained in 84% (62.7 mg) yield as white solid by the General procedure F. **m.p.** 76 – 77 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.52 – 7.49 (m, 4H), 7.36 (d, *J* = 8.0 Hz, 2H), 7.11 (t, *J* = 8.8 Hz, 2H), 4.71 (q, *J* = 7.5 Hz, 1H), 1.82 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 162.52 (d, *J* = 245.3 Hz), 147.22 (dm, *J* = 260.2 Hz), 144.73 (dm, *J* = 246.8 Hz), 139.68, 139.38, 136.50 (d, *J* = 3.1 Hz), 131.52 (t, *J* = 15.6 Hz), 128.56 (d, *J* = 8.1 Hz), 127.61, 127.34, 115.67 (d, *J* = 21.3 Hz), 107.46 (t, *J* = 3.5 Hz), 92.38, 35.16, 17.74 (t, *J* = 3.0 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -115.36 – -115.41 (m, 1F), -132.38 – -132.46 (m, 2F), -139.07 – -139.14 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{21}H_{13}F_5N$ ([M + H]$^+$): 374.0963; found: 374.0966. **HPLC** analysis (OJ-H, Hexane/IPA = 97.0/3.0, 1.0 mL/min, 254 nm) indicated 90% ee, t_R (minor) = 24.17 min, t_R (major) = 32.39 min. $[\alpha]_D^{25}$ = − 22.17 (c = 1.0, CH_2Cl_2).

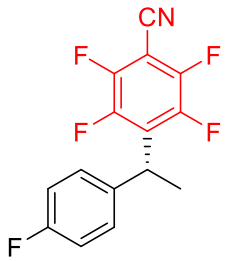


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	23.544	M	2.3860	28670380	303177	50.6450
2	32.566	M	3.4550	27940523	212541	49.3550

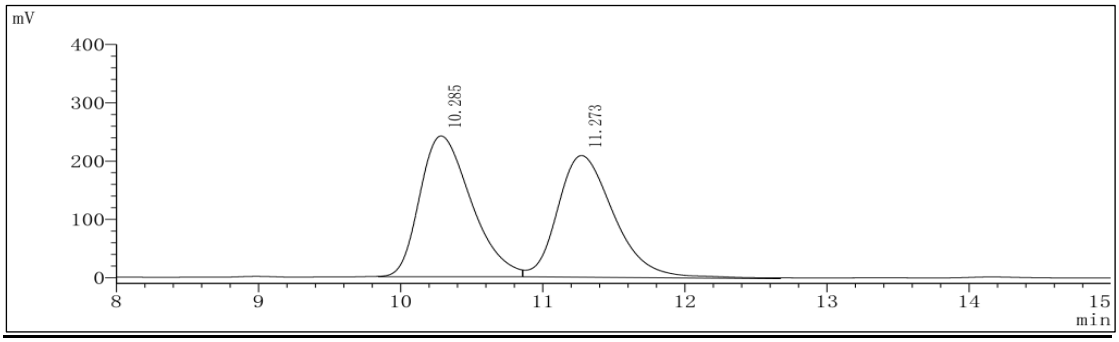


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	24.171	M	2.5820	1911676	22120	5.0300
2	32.389	M	3.4350	36091088	270419	94.9700

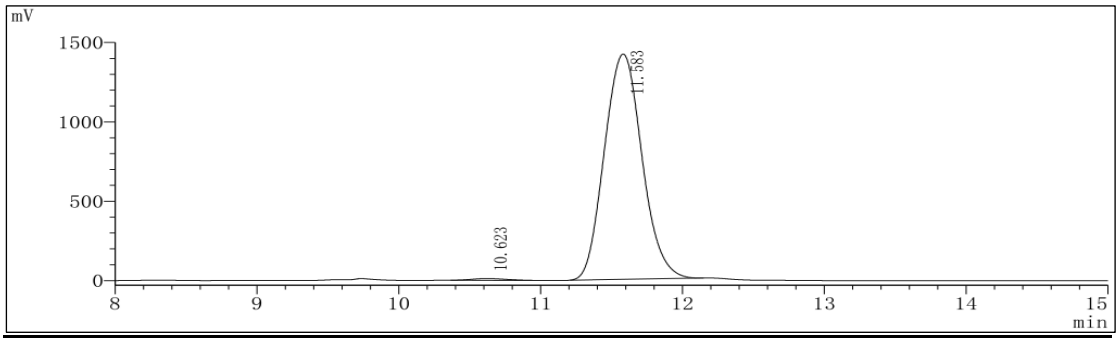
(*R*)-2,3,5,6-Tetrafluoro-4-(1-(4-fluorophenyl)ethyl)benzonitrile (3x)



This compound was obtained in 52% (30.9 mg) yield as light yellow oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.28 – 7.25 (m, 2H), 7.04 – 6.99 (m, 2H), 4.66 (q, *J* = 7.3 Hz, 1H), 1.78 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 161.89 (d, *J* = 245.1 Hz), 147.22 (dm, *J* = 260.6 Hz), 144.63 (dm, *J* = 247.5 Hz), 136.34 (d, *J* = 3.3 Hz), 131.41 (t, *J* = 15.5 Hz), 128.74 (d, *J* = 8.1 Hz), 115.66 (d, *J* = 21.3 Hz), 107.41 (t, *J* = 3.8 Hz), 92.47, 34.76, 17.88 (t, *J* = 3.1 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -114.91 (td, *J* = 9.0, 5.7 Hz, 1F), -132.29 – -132.37 (m, 2F), -139.37 – -139.44 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{15}H_8F_5NNa$ ([M + Na]$^+$): 320.0469; found: 320.0462. **HPLC** analysis (AD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 99% ee, t_R (minor) = 10.62 min, t_R (major) = 11.58 min. $[\alpha]_D^{25}$ = − 3.47 (c = 1.0, CH_2Cl_2).

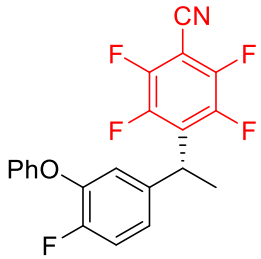


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.285	M	0.6632	6091524	241535	51.3825
2	11.273	M	0.7080	5763736	208655	48.6175

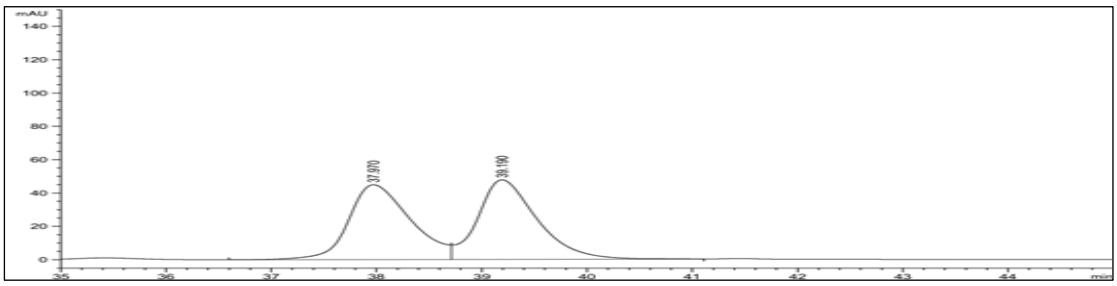


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.623	M	0.4494	175765	10552	0.6660
2	11.583	M	0.4839	26214466	1419193	99.3340

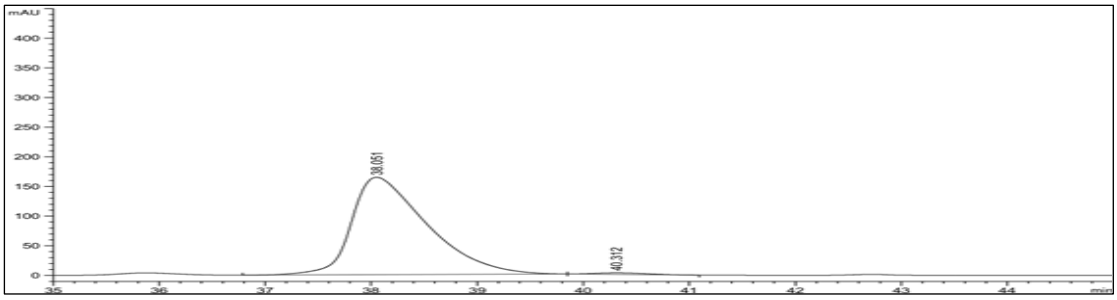
(*R*)-2,3,5,6-tetrafluoro-4-(1-(4-fluoro-3-phenoxyphenyl)ethyl)benzonitrile (3y)



This compound was obtained in 84% (65.4 mg) yield as white solid by the General procedure F. **m.p.** 92 – 93 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.32 (t, *J* = 7.8 Hz, 2H), 7.14 – 7.08 (m, 2H), 7.03 (d, *J* = 6.0 Hz, 2H), 6.93 (d, *J* = 8.0 Hz, 2H), 4.61 (q, *J* = 7.3 Hz, 1H), 1.72 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 157.19, 153.46 (d, *J* = 248.1 Hz), 147.21 (dm, *J* = 260.9 Hz), 144.59 (dm, *J* = 248.1 Hz), 143.45 (d, *J* = 11.9 Hz), 137.44 (d, *J* = 3.9 Hz), 130.99 (t, *J* = 15.5 Hz), 129.72, 123.61 (d, *J* = 6.9 Hz), 123.21, 120.94, 117.31 (d, *J* = 18.5 Hz), 116.84, 107.36 (t, *J* = 3.8 Hz), 92.62, 34.68, 17.82 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -131.62 – -131.66 (m, 1F), -132.10 – -132.17 (m, 2F), -139.34 (td, *J* = 15.8, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{21}H_{13}F_5NO$ ([M + H]$^+$): 390.0912; found: 390.0916. **HPLC** analysis (IA-3, Hexane/IPA = 99.5/0.5, 0.3 mL/min, 254 nm) indicated 98% ee, t_R (major) = 38.05 min, t_R (minor) = 40.31 min. $[\alpha]_D^{25}$ = + 8.85 (c = 1.0, CH_2Cl_2).

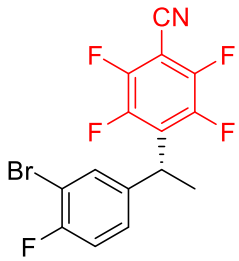


Peak	RetTime	Type	Width(min)	Area(mAU*S)	Hight(mAU)	Area%
1	37.970	BV	0.6152	1827.47583	44.87010	49.6109
2	39.190	VB	0.5839	1856.14124	47.71013	50.3891

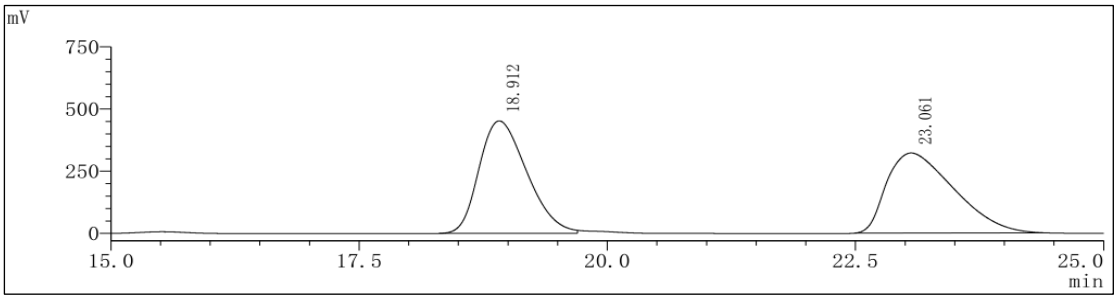


Peak	RetTime	Type	Width(min)	Area(mAU*S)	Hight(mAU)	Area%
1	38.051	BB	0.6980	8119.93457	164.18326	98.9122
2	40.312	BB	0.5252	89.29829	2.59047	1.0878

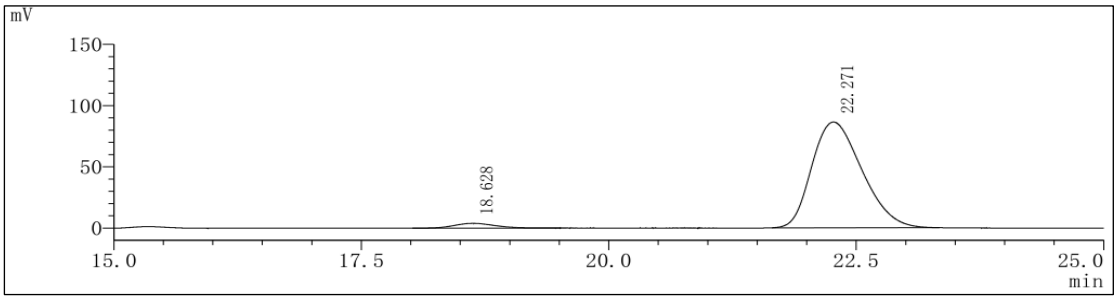
(*R*)-4-(1-(3-Bromo-4-fluorophenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3z)



This compound was obtained in 84% (63.0 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.48 (d, *J* = 5.0 Hz, 1H), 7.23 – 7.20 (m, 1H), 7.08 (t, *J* = 8.5 Hz, 1H), 4.63 (q, *J* = 7.5 Hz, 1H), 1.77 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.24 (d, *J* = 246.5 Hz), 147.25 (dm, *J* = 260.7 Hz), 144.57 (dm, *J* = 247.7 Hz), 137.92 (d, *J* = 3.9 Hz), 132.26, 130.61 (t, *J* = 15.4 Hz), 127.73 (d, *J* = 7.2 Hz), 116.68 (d, *J* = 22.4 Hz), 109.37 (d, *J* = 21.2 Hz), 107.30 (t, *J* = 3.7 Hz), 92.82, 34.42, 17.77 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -108.82 – -108.85 (m, 1F), -131.88 – -131.96 (m, 2F), -139.27 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{15}H_8BrF_5N$ ([M + H]$^+$): 375.9755; found: 375.9761. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 93% ee, t_R (minor) = 18.63 min, t_R (major) = 22.27 min. $[\alpha]_D^{25}$ = − 16.63 (c = 1.0, CH_2Cl_2).

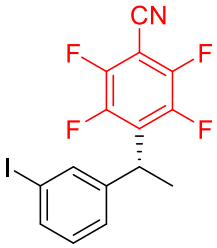


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	18.912	M	0.8903	15152460	452519	49.9458
2	23.061	M	1.2712	15185350	322295	50.0542

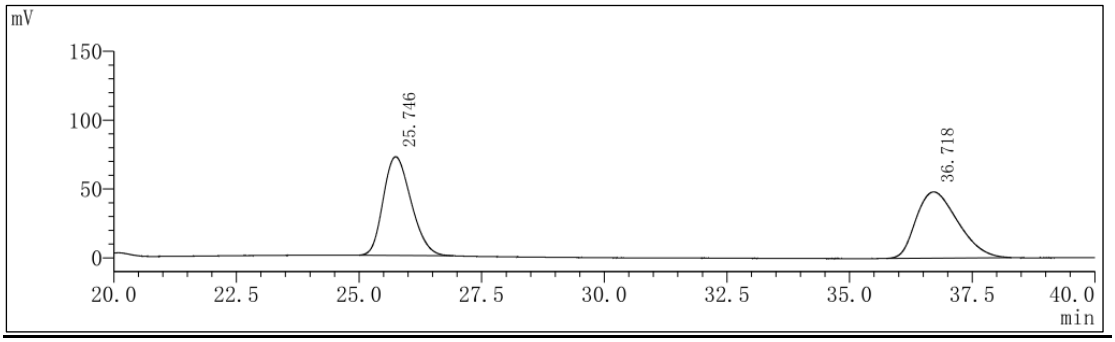


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	18.628	SV	0.7226	109730	3860	3.4832
2	22.271	M	0.9398	3040570	86390	96.5168

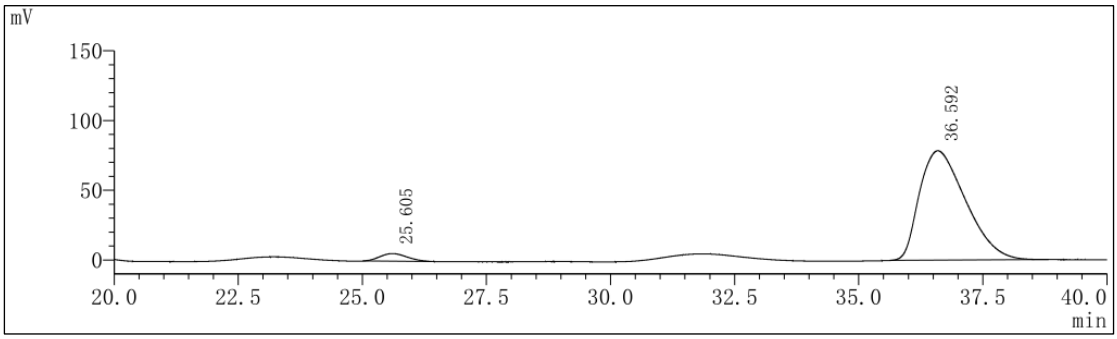
(*R*)-2,3,5,6-Tetrafluoro-4-(1-(3-iodophenyl)ethyl)benzonitrile (3aa)



This compound was obtained in 90% (72.9 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.62 – 7.59 (m, 2H), 7.26 (d, *J* = 7.5 Hz, 1H), 7.07 (t, *J* = 7.8 Hz, 1H), 4.61 (q, *J* = 7.3 Hz, 1H), 1.76 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.23 (dm, *J* = 260.6 Hz), 144.64 (dm, *J* = 247.7 Hz), 142.85, 136.54, 136.20, 130.79 (t, *J* = 15.6 Hz), 130.47, 126.40, 107.37 (t, *J* = 3.6 Hz), 94.71, 92.69, 34.93, 17.59 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.08 (td, *J* = 15.8, 6.8 Hz, 2F), -139.05 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{15}H_8F_4INNa$ ([M + Na]$^+$): 427.9530; found: 427.9538. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 92% ee, t_R (minor) = 25.61 min, t_R (major) = 36.59 min. $[\alpha]_D^{25}$ = − 20.19 (c = 1.0, CH_2Cl_2).

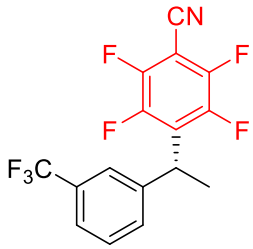


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	25.746	M	1.0461	2830519	71646	49.9342
2	36.718	M	1.5842	2837982	48086	50.0658

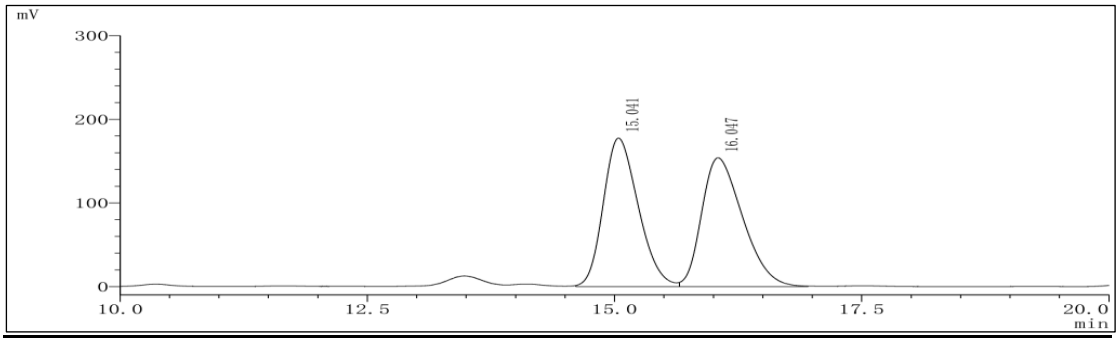


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	25.605	M	0.9883	207157	5449	3.9162
2	36.592	M	1.7517	5082592	78488	96.0838

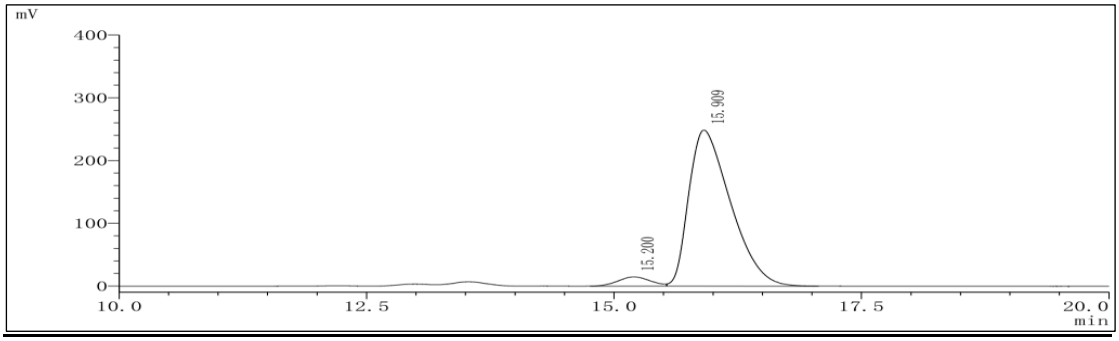
(*R*)-2,3,5,6-tetrafluoro-4-(1-(3-(trifluoromethyl)phenyl)ethyl)benzonitrile (3ab)



This compound was obtained in 85% (59.0 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.55 – 7.52 (m, 2H), 7.49 – 7.44 (m, 2H), 4.74 (q, *J* = 7.3 Hz, 1H), 1.82 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.29 (dm, *J* = 260.6 Hz), 144.68 (dm, *J* = 248.0 Hz), 141.53, 131.26 (q, *J* = 32.2 Hz), 130.63, 129.35, 124.40 – 123.32 (m), 123.91 – 123.86 (m), 123.87 (q, *J* = 270.7 Hz), 107.30 (t, *J* = 3.8 Hz), 92.90, 35.19, 17.66 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -62.69 (s, 3F), -132.00 (td, *J* = 16.4, 7.3 Hz, 2F), -139.20 (dt, *J* = 24.9, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{16}H_9F_7N$ ($[M + H]^+$): 348.0618; found: 348.0629. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 91% ee, t_R (minor) = 15.20 min, t_R (major) = 15.91 min. $[\alpha]_D^{25}$ = + 9.28 (c = 1.0, CH_2Cl_2).

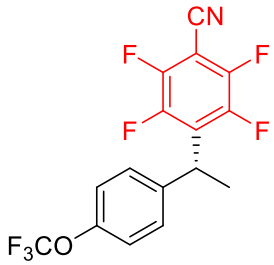


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.041	M	0.6560	4377549	177485	49.6820
2	16.047	M	0.7700	4433630	153934	50.3180

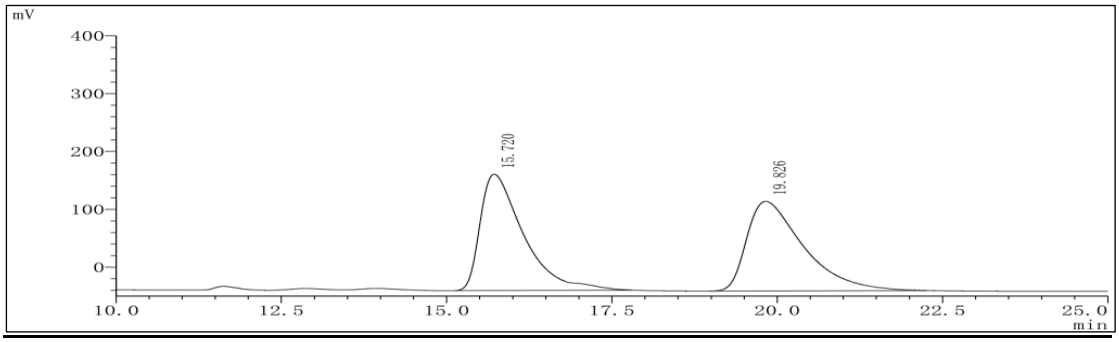


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.200	M	0.6130	333310	14647	4.3670
2	15.909	M	0.7970	7299456	248609	95.6330

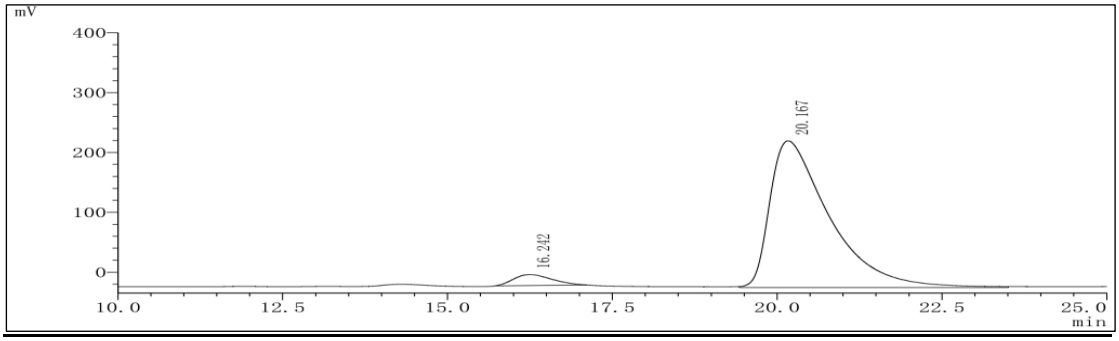
(*R*)-2,3,5,6-tetrafluoro-4-(1-(4-(trifluoromethoxy)phenyl)ethyl)benzonitrile (3ac)



This compound was obtained in 60% (43.6 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.33 (d, *J* = 8.5 Hz, 2H), 7.18 (d, *J* = 8.5 Hz, 2H), 4.68 (q, *J* = 7.5 Hz, 1H), 1.79 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 148.35, 147.25 (dm, *J* = 260.9 Hz), 144.66 (dm, *J* = 247.8 Hz), 139.24, 130.96 (t, *J* = 15.5 Hz), 128.59, 121.27, 120.37 (q, *J* = 255.7 Hz), 107.36 (t, *J* = 3.7 Hz), 92.67, 34.86, 17.78 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -57.95 (s, 3F), -132.17 (td, *J* = 16.4, 6.8 Hz, 2F), -139.26 (dt, *J* = 24.9, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{16}H_9F_7NO$ ([M + H]$^+$): 364.0567; found: 364.0568. **HPLC** analysis (OJ-H, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 91% ee, t_R (minor) = 16.24 min, t_R (major) = 20.17 min. $[\alpha]_D^{25}$ = + 13.46 (c = 1.0, CH_2Cl_2).

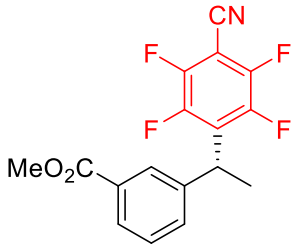


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.720	M	1.1500	9173551	201026	49.8590
2	19.826	M	1.5450	9225292	154757	50.1410

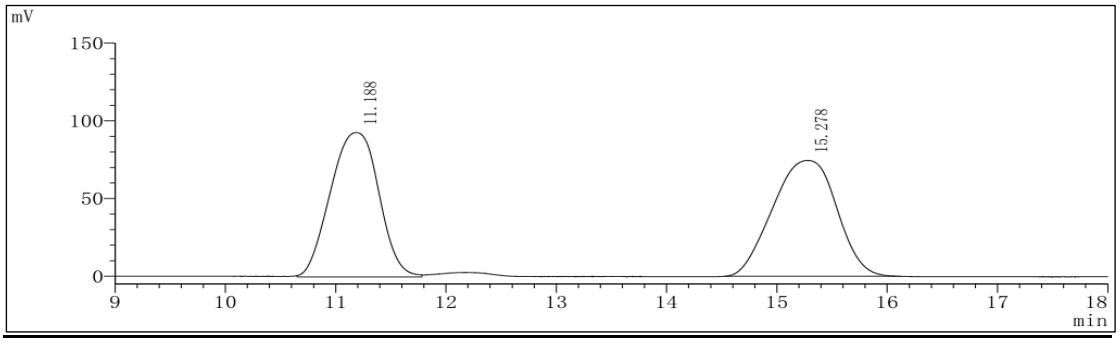


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	16.242	M	1.0850	744064	18441	4.5950
2	20.167	M	1.6070	15449441	245072	95.4050

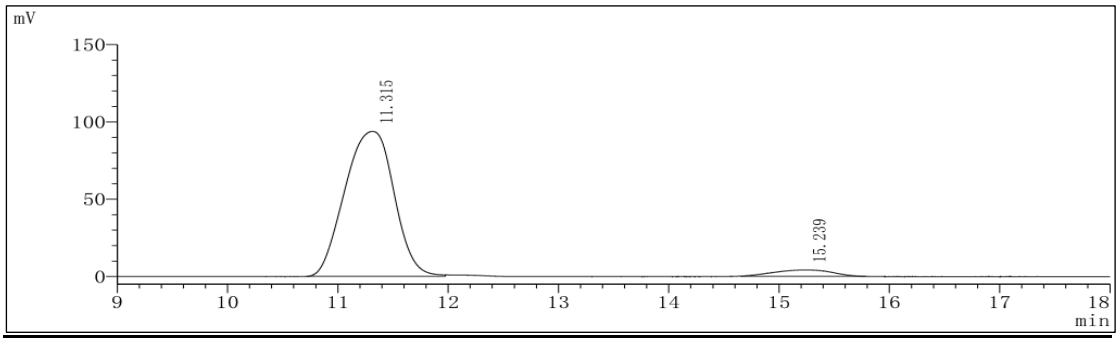
(*R*)-Methyl-3-(1-(4-cyano-2,3,5,6-tetrafluorophenyl)ethyl)benzoate (3ad)



This compound was obtained in 95% (64.0 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.97 – 7.93 (m, 2H), 7.49 (d, *J* = 8.0 Hz, 1H), 7.42 (t, *J* = 7.8 Hz, 1H), 4.73 (q, *J* = 7.3 Hz, 1H), 3.92 (s, 3H), 1.82 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 166.64, 147.22 (dm, *J* = 260.9 Hz), 144.67 (dm, *J* = 247.8 Hz), 140.97, 131.59, 131.05 (t, *J* = 15.5 Hz), 130.73, 128.88, 128.59, 128.23, 107.36 (t, *J* = 3.8 Hz), 92.64, 52.23, 35.16, 17.68 (t, *J* = 2.8 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.22 (td, *J* = 17.0, 7.3 Hz, 2F), -139.10 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_{11}F_4NNaO_2$ ([M + Na]$^+$): 360.0618; found: 360.0623. **HPLC** analysis (OD-3, Hexane/IPA = 93.0/7.0, 1.0 mL/min, 254 nm) indicated 90% ee, t_R (major) = 11.32 min, t_R (minor) = 15.24 min. $[\alpha]_D^{25}$ = + 8.35 (c = 1.0, CH_2Cl_2).

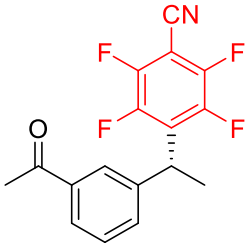


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.188	M	0.7810	2833523	92832	48.4713
2	15.278	M	1.0373	3012254	74608	51.5287

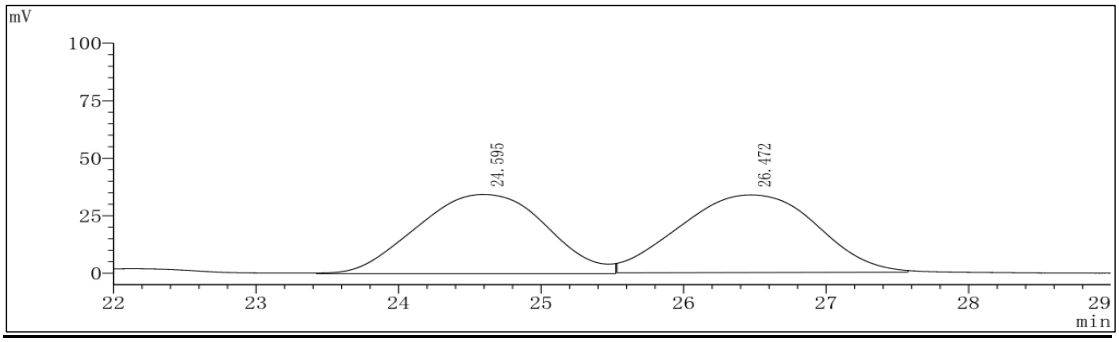


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.315	M	0.7961	2913603	93816	95.0124
2	15.239	M	0.9041	152947	4130	4.9876

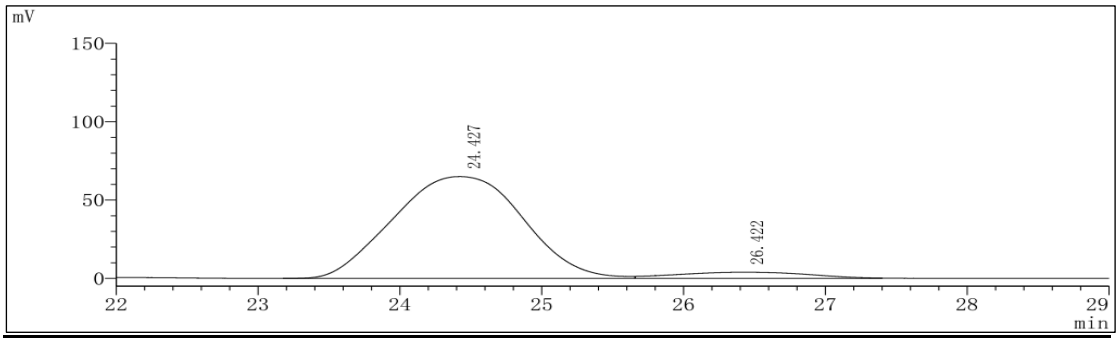
(*R*)-4-(1-(3-acetylphenyl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3ae)



This compound was obtained in 95% (61.0 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.90 (s, 1H), 7.85 (d, *J* = 7.5 Hz, 1H), 7.50 (d, *J* = 8.0 Hz, 1H), 7.45 (t, *J* = 7.5 Hz, 1H), 4.74 (q, *J* = 7.5 Hz, 1H), 2.60 (s, 3H), 1.83 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 197.65, 147.23 (dm, *J* = 260.6 Hz), 144.68 (dm, *J* = 248.0 Hz), 141.26, 137.61, 131.75, 130.99 (t, *J* = 15.5 Hz), 129.08, 127.61, 126.66, 107.34 (t, *J* = 3.8 Hz), 92.68, 35.26, 26.64, 17.73 (t, *J* = 2.7 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.15 (td, *J* = 16.4, 6.8 Hz, 2F), -139.10 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_{11}F_4NNaO$ ([M + Na]$^+$): 344.0669; found: 344.0676. **HPLC** analysis (OD-3, Hexane/IPA = 95.0/5.0, 0.5 mL/min, 254 nm) indicated 88% ee, t_R (major) = 24.43 min, t_R (minor) = 26.42 min. $[\alpha]_D^{25}$ = + 8.40 (c = 1.0, CH_2Cl_2).

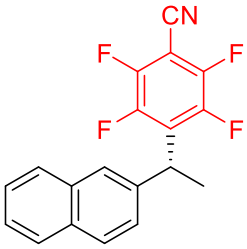


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	24.595	M	1.6342	2178854	34446	49.0555
2	26.472	M	1.7437	2262758	33768	50.9445

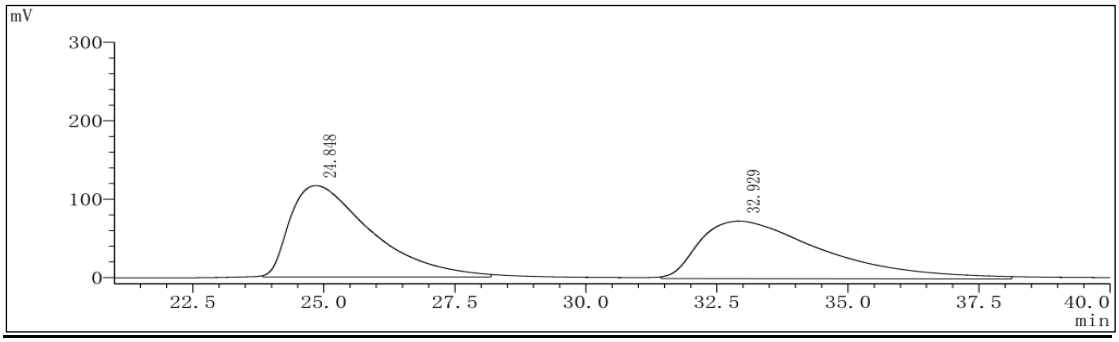


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	24.427	M	1.6546	4153227	65088	94.0452
2	26.422	M	1.7541	262974	3997	5.9548

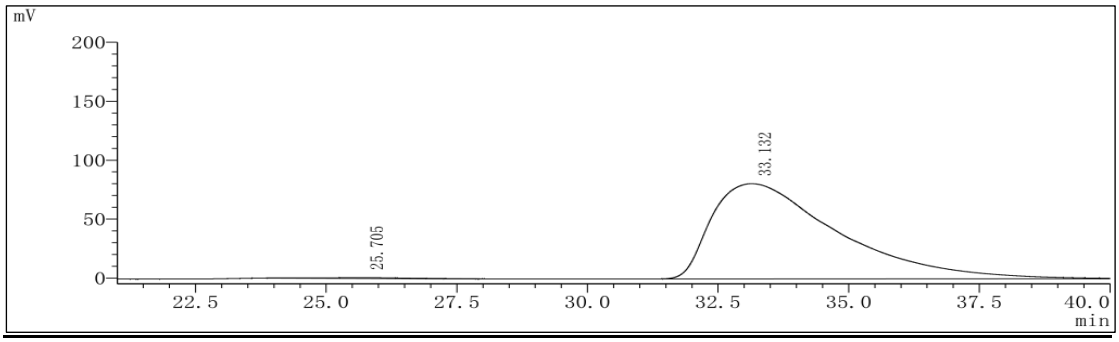
(*R*)-2,3,5,6-tetrafluoro-4-(1-(naphthalen-2-yl)ethyl)benzonitrile (3af)



This compound was obtained in 83% (54.6 mg) yield as white solid by the General procedure F. **m.p.** 81 – 82 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.81 – 7.76 (m, 4H), 7.50 – 7.44 (m, 2H), 7.35 (d, *J* = 8.5 Hz, 1H), 4.82 (q, *J* = 7.3 Hz, 1H), 1.88 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.19 (dm, *J* = 260.2 Hz), 144.76 (dm, *J* = 248.0 Hz), 137.95, 133.30, 132.46, 131.53 (t, *J* = 15.5 Hz), 128.58, 127.80, 127.57, 126.46, 126.15, 125.58, 125.36, 107.47 (t, *J* = 3.8 Hz), 92.35, 35.59, 17.72 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.48 (td, *J* = 16.4, 7.3 Hz, 2F), -139.05 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{19}H_{11}F_4NNa$ ([M + Na]$^+$): 352.0720; found: 352.0723. **HPLC** analysis (OJ-H, Hexane/IPA = 99.5/0.5, 1.0 mL/min, 254 nm) indicated 99% ee, t_R (minor) = 25.71 min, t_R (major) = 33.13 min. $[\alpha]_D^{25}$ = + 18.93 (c = 1.0, CH_2Cl_2).

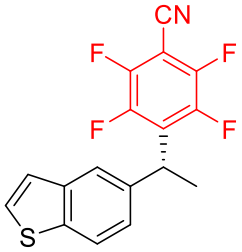


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	24.848	M	2.7929	12575533	116599	50.9331
2	32.929	M	4.2036	12114760	73321	49.0669

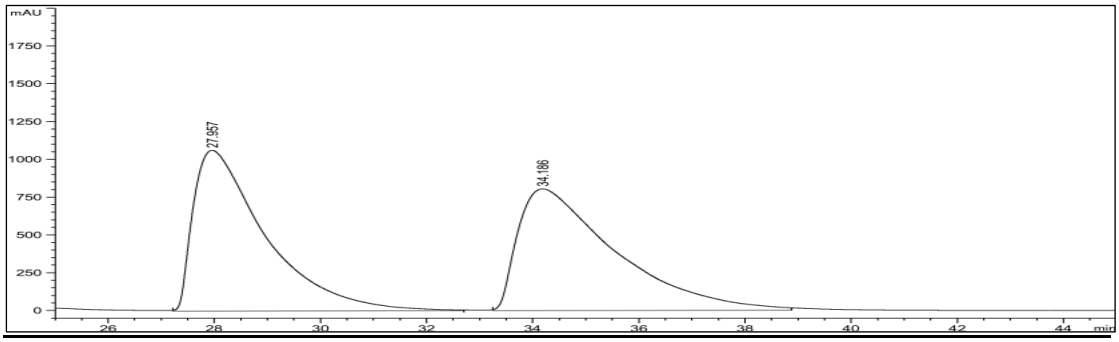


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	25.705	M	1.6413	68297	627	0.5004
2	33.132	M	4.3179	13580078	80789	99.4996

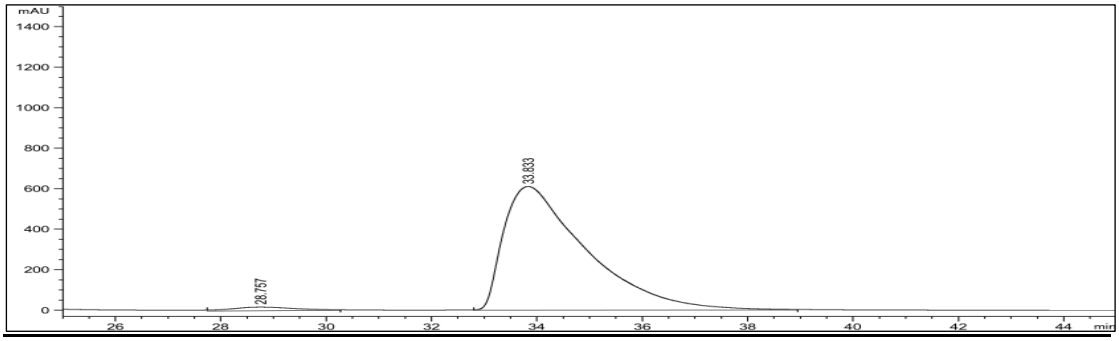
(*R*)-4-(1-(benzo[b]thiophen-5-yl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3ag)



This compound was obtained in 92% (61.6 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.83 (s, 1H), 7.75 (d, *J* = 8.0 Hz, 1H), 7.43 (d, *J* = 5.5 Hz, 1H), 7.30 – 7.26 (m, 2H), 4.80 (q, *J* = 7.5 Hz, 1H), 1.86 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.19 (dm, *J* = 260.5 Hz), 144.68 (dm, *J* = 247.7 Hz), 140.23, 138.72, 136.87, 131.60 (t, *J* = 15.5 Hz), 126.92, 123.82, 123.79, 123.47, 120.67, 107.47 (t, *J* = 3.8 Hz), 92.32, 35.51, 17.88 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.41 (td, *J* = 16.4, 7.3 Hz, 2F), -139.14 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_9F_4NNaS$ ([M + Na]$^+$): 358.0284; found: 358.0270. **HPLC** analysis (OJ-H, Hexane/IPA = 99.0/1.0, 0.5 mL/min, 254 nm) indicated 95% ee, t_R (minor) = 28.76 min, t_R (major) = 33.83 min. $[\alpha]_D^{25}$ = + 21.82 (c = 1.0, CH_2Cl_2).

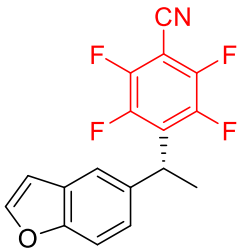


Peak	RetTime	Type	Width(min)	Area(mAU*S)	Hight(mAU)	Area%
1	27.957	MM R	1.5708	1.00267e5	1063.87061	49.5296
2	34.186	MM R	2.1161	1.02172e5	804.70892	50.4704

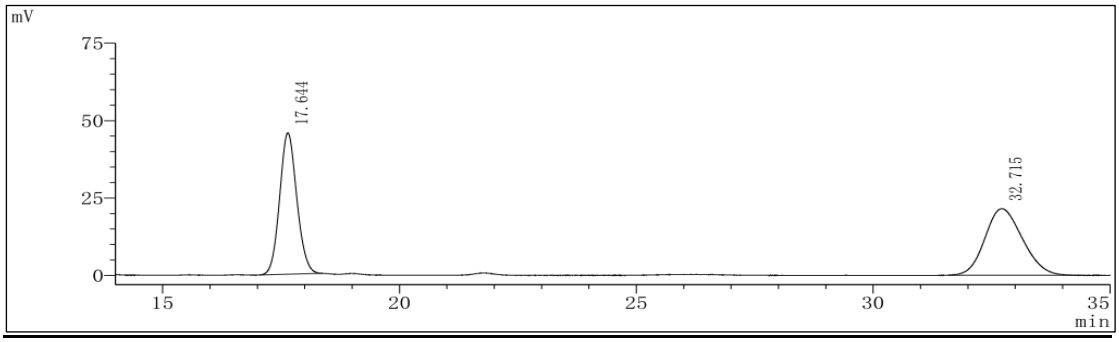


Peak	RetTime	Type	Width(min)	Area(mAU*S)	Hight(mAU)	Area%
1	28.757	MM R	1.4847	1607.41663	18.04471	2.3591
2	33.833	MM R	1.8140	6.65280e4	611.25665	97.6409

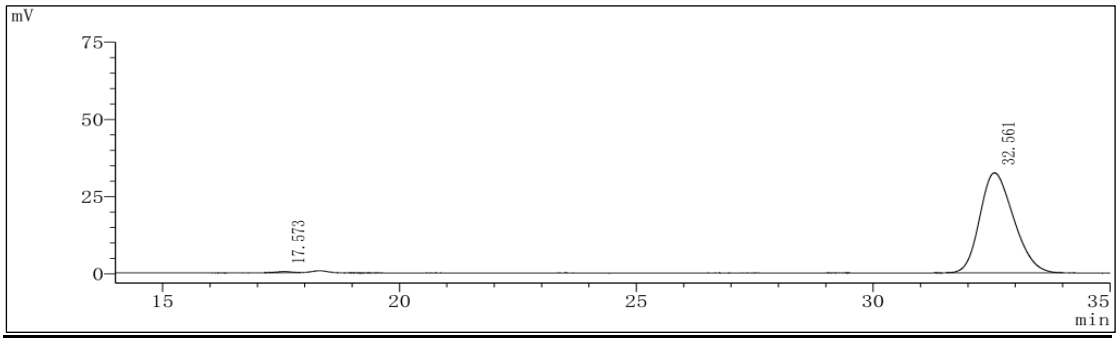
(*R*)-4-(1-(benzofuran-5-yl)ethyl)-2,3,5,6-tetrafluorobenzonitrile (3ah)



This compound was obtained in 44% (28.1 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.62 (d, *J* = 2.0 Hz, 1H), 7.56 (s, 1H), 7.44 (d, *J* = 8.5 Hz, 1H), 7.21 (d, *J* = 8.6 Hz, 1H), 6.74 (s, 1H), 4.78 (q, *J* = 7.5 Hz, 1H), 1.85 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 154.02, 147.20 (dm, *J* = 260.3 Hz), 145.77, 144.67 (dm, *J* = 247.5 Hz), 135.34, 132.06 (t, *J* = 15.5 Hz), 127.80, 123.62, 119.51, 111.59, 107.52 (t, *J* = 3.8 Hz), 106.51, 92.20, 35.47, 18.16 (t, *J* = 3.1 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.51 – -132.58 (m, 2F), -139.32 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_{10}F_4NO$ ([M + H]$^+$): 320.0693; found: 320.0696. **HPLC** analysis (OD-3, Hexane/IPA = 99.0/1.0, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (minor) = 17.57 min, t_R (major) = 32.56 min. $[\alpha]_D^{25}$ = + 11.23 (c = 1.0, CH_2Cl_2).

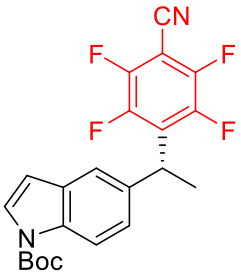


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	17.644	M	0.6638	1150232	45669	49.2417
2	32.715	M	1.4358	1185658	21522	50.7583

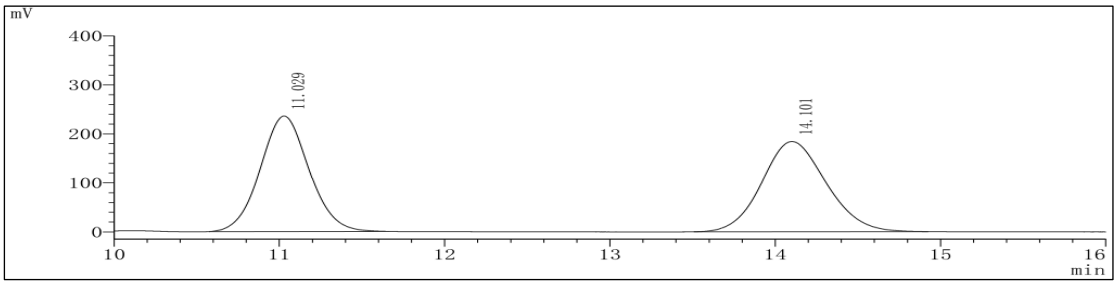


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	17.573	M	0.5724	7413	339	0.4594
2	32.561	M	1.3130	1606445	32378	99.5406

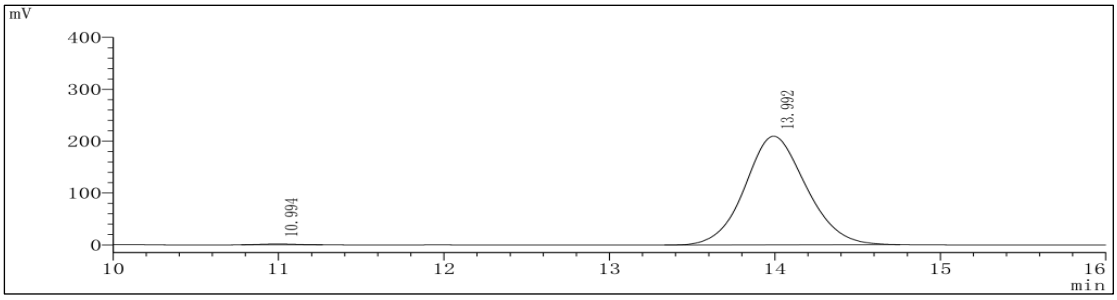
(*R*)-tert-butyl-5-(1-(4-cyano-2,3,5,6-tetrafluorophenyl)ethyl)-1H-indole-1-carboxylate (3ai)



This compound was obtained in 43% (36.0 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.06 (s, 1H), 7.60 (s, 1H), 7.50 (s, 1H), 7.21 (d, *J* = 8.5 Hz, 1H), 6.54 (d, *J* = 3.5 Hz, 1H), 4.78 (q, *J* = 7.3 Hz, 1H), 1.84 (d, *J* = 7.5 Hz, 3H), 1.66 (s, 9H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 149.58, 147.20 (dm, *J* = 262.1 Hz), 144.68 (dm, *J* = 251.6 Hz), 135.09, 134.24, 132.21 (t, *J* = 15.5 Hz), 130.88, 126.68, 123.46, 119.18, 115.39, 107.54, 107.09, 92.13, 83.88, 35.41, 28.15, 18.02 (t, *J* = 9.5 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.68 (td, *J* = 16.4, 7.3 Hz, 2F), -139.30 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{22}H_{19}F_4N_2O_2$ ([M + H]$^+$): 419.1377; found: 419.1389. **HPLC** analysis (OD-3, Hexane/IPA = 98.0/2.0, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (minor) = 10.99 min, t_R (major) = 13.99 min. $[\alpha]_D^{25}$ = + 29.23 (c = 1.0, CH_2Cl_2).

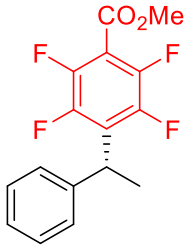


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.029	M	0.5394	4838328	235569	49.2218
2	14.101	M	0.7167	4991321	184046	50.7782

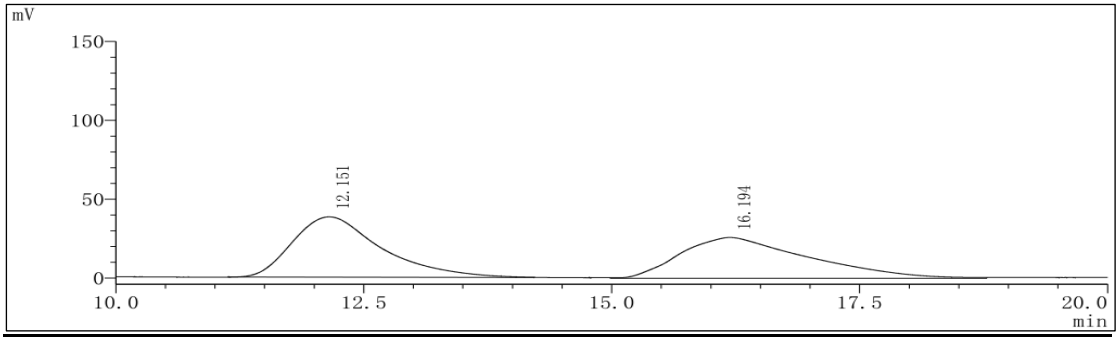


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.994	M	0.4315	22571	1459	0.4173
2	13.992	M	0.6806	5385745	209290	99.5827

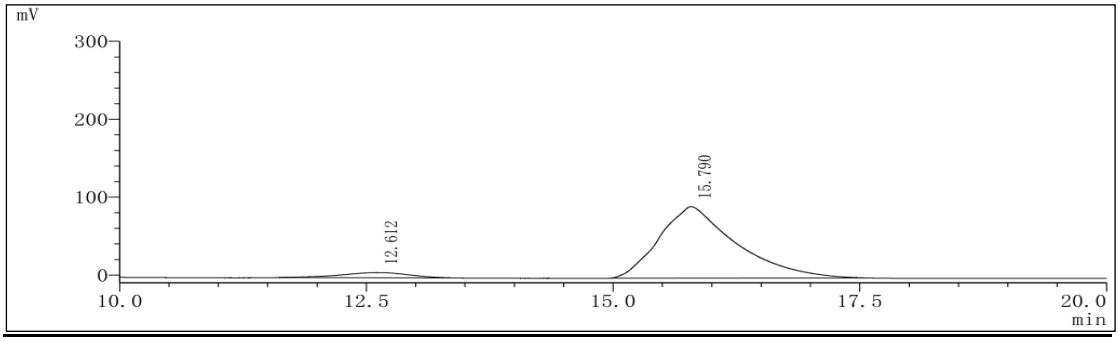
methyl (*R*)-2,3,5,6-tetrafluoro-4-(1-phenylethyl)benzoate (3aj)



This compound was obtained in 40% (24.9 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.33 – 7.29 (m, 4H), 7.25 – 7.22 (m, 1H), 4.64 (q, *J* = 7.3 Hz, 1H), 3.95 (s, 3H), 1.77 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 160.29, 144.82 (dm, *J* = 254.9 Hz), 141.52, 128.61, 127.95 (t, *J* = 15.8 Hz), 127.12, 127.00, 110.49 (t, *J* = 15.7 Hz), 53.17, 35.04, 17.95 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -139.68 – -139.75 (m, 2F), -141.54 – -141.61 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{16}H_{13}F_4O_2$ ([M + H]$^+$): 313.0846; found: 313.0847. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 88% ee, t_R (minor) = 12.61 min, t_R (major) = 15.79 min. $[\alpha]_D^{25}$ = + 16.46 (c = 1.0, CH_2Cl_2).

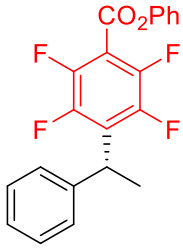


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	12.151	M	1.6142	2374672	38253	50.4502
2	16.194	M	2.3722	2332290	25957	49.5498

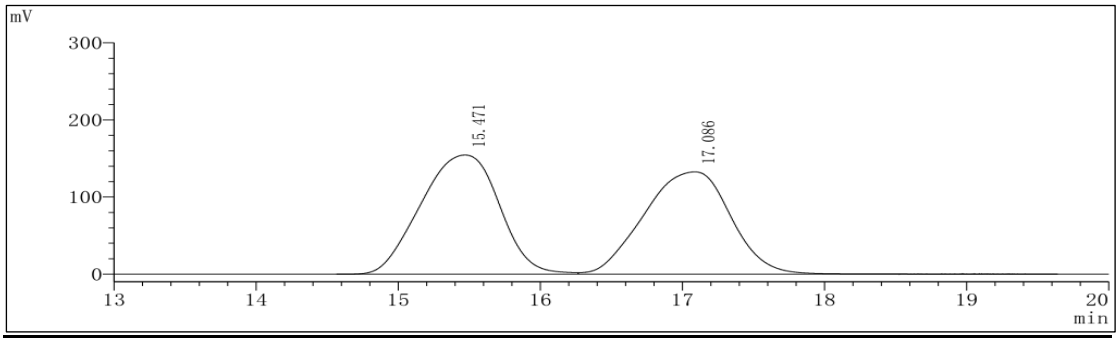


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	12.612	M	1.2432	325902	6710	6.1769
2	15.790	M	1.4504	4950234	91836	93.8231

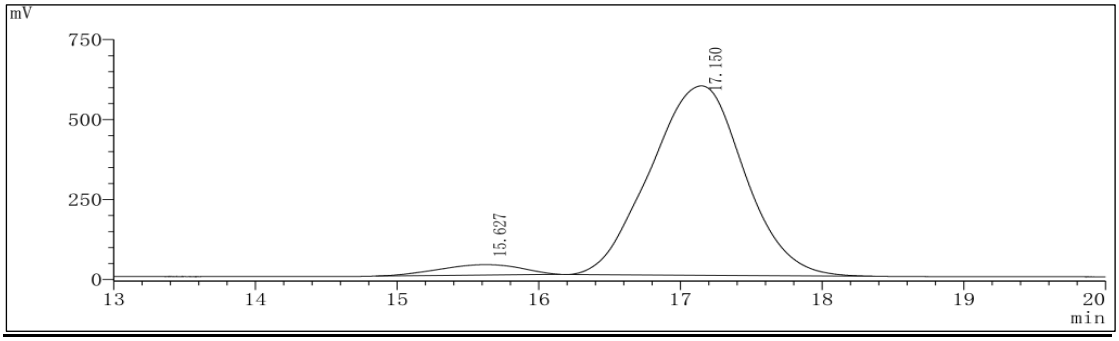
phenyl (*R*)-2,3,5,6-tetrafluoro-4-(1-phenylethyl)benzoate (3ak)



This compound was obtained in 82% (61.4 mg) yield as white solid by the General procedure F. **m.p.** 78 – 79 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.43 (t, *J* = 8.0 Hz, 2H), 7.33 (d, *J* = 4.5 Hz, 4H), 7.31 – 7.22 (m, 4H), 4.68 (q, *J* = 7.5 Hz, 1H), 1.80 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.21, 150.10, 145.09 (dm, *J* = 256.4 Hz), 144.97 (dm, *J* = 252.3 Hz), 141.41, 129.63, 128.68 (t, *J* = 15.8 Hz), 128.66, 127.13, 127.07, 126.56, 121.32, 110.07 (t, *J* = 15.2 Hz), 35.13, 17.92 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.82 – -138.90 (m, 2F), -141.18 (td, *J* = 15.8, 5.1 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{21}H_{14}F_4NaO_2$ ([M + Na]$^+$): 397.0822; found: 397.0827. **HPLC** analysis (OD-3, Hexane/IPA = 99.8/0.5, 0.5 mL/min, 254 nm) indicated 91% ee, t_R (minor) = 15.63 min, t_R (major) = 17.15 min. $[\alpha]_D^{25}$ = + 7.27 (c = 1.0, CH_2Cl_2).

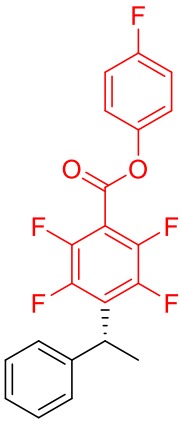


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.471	V	1.0020	5942868	154539	51.3373
2	17.086	SV	1.0892	5633259	132672	48.6627

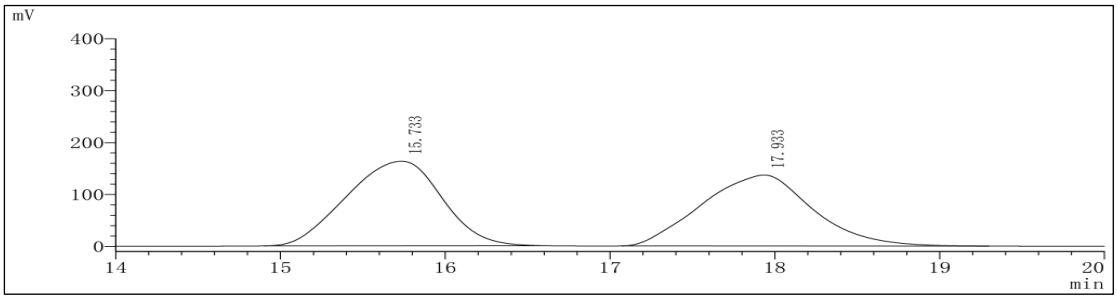


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.627	M	1.0983	1303310	32348	4.5573
2	17.150	M	1.2166	27295291	591985	95.4427

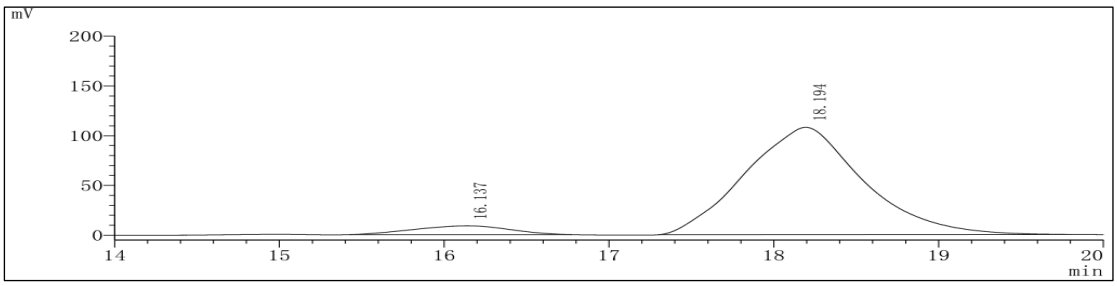
4-fluorophenyl (*R*)-2,3,5,6-tetrafluoro-4-(1-phenylethyl)benzoate (3al)



This compound was obtained in 85% (66.7 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.33 (d, *J* = 4.5 Hz, 4H), 7.28 – 7.23 (m, 1H), 7.21 – 7.19 (m, 2H), 7.11 (t, *J* = 8.5 Hz, 2H), 4.68 (q, *J* = 7.3 Hz, 1H), 1.80 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 160.62 (d, *J* = 243.8 Hz), 158.22, 145.90 (d, *J* = 2.9 Hz), 145.14 (dm, *J* = 256.7 Hz), 144.95 (dm, *J* = 253.4 Hz), 141.37, 128.92 (t, *J* = 15.8 Hz), 128.67, 127.11 (d, *J* = 5.3 Hz), 122.82 (d, *J* = 8.6 Hz), 116.40, 116.25, 109.77 (t, *J* = 15.0 Hz), 35.18, 17.92 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -115.69 – -115.74 (m, 1F), -138.70 – -138.77 (m, 2F), -141.02 – -141.09 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{21}H_{13}F_5NaO_2$ ([M + Na]$^+$): 415.0728; found: 415.0739. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 88% ee, t_R (minor) = 16.14 min, t_R (major) = 18.19 min. $[\alpha]_D^{25}$ = + 9.80 (c = 1.0, CH_2Cl_2).

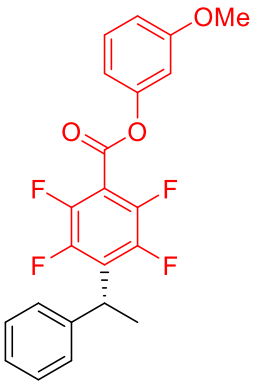


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.733	M	1.0804	6578948	163156	50.6908
2	17.933	M	1.2457	6399625	136868	49.3092

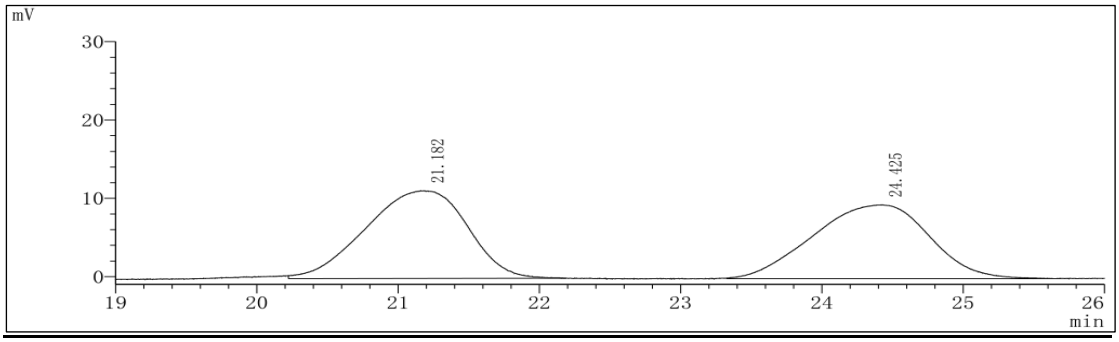


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	16.137	M	1.0837	352647	8750	6.1429
2	18.194	M	1.3551	5388123	107919	93.8571

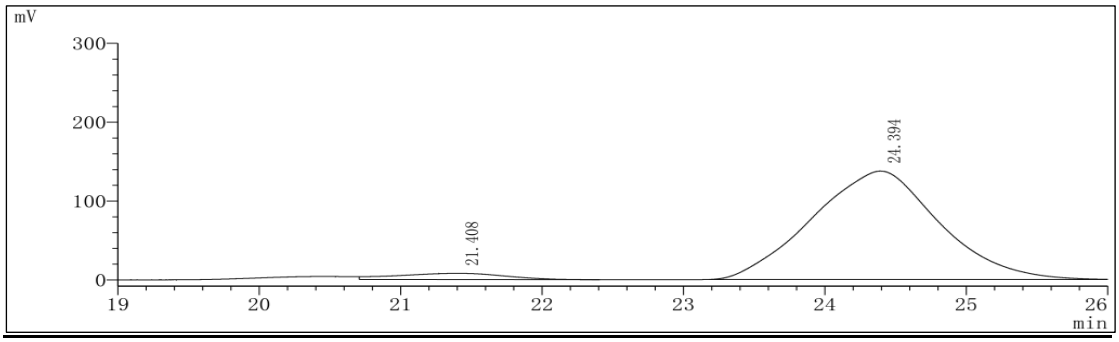
3-methoxyphenyl (*R*)-2,3,5,6-tetrafluoro-4-(1-phenylethyl)benzoate (3am)



This compound was obtained in 73% (59.0 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.35 – 7.31 (m, 5H), 7.28 – 7.23 (m, 1H), 6.85 – 6.82 (m, 2H), 6.78 – 6.77 (m, 1H), 4.68 (q, *J* = 7.5 Hz, 1H), 3.82 (s, 3H), 1.80 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 160.61, 158.08, 151.00, 145.10 (dm, *J* = 256.2 Hz), 144.99 (dm, *J* = 256.4 Hz), 141.42, 130.01, 128.71 (t, *J* = 15.7 Hz), 128.66, 127.12, 127.07, 113.46, 112.44, 110.07 (t, *J* = 15.2 Hz), 107.33, 55.49, 35.15, 17.93 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.80 – -138.87 (m, 2F), -141.18 (td, *J* = 15.8, 5.7 Hz). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{22}H_{17}F_4O_3$ ([M + H]$^+$): 405.1108; found: 405.1110. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 90% ee, t_R (minor) = 21.41 min, t_R (major) = 24.39 min. $[\alpha]_D^{25}$ = + 17.13 (c = 1.0, CH_2Cl_2).

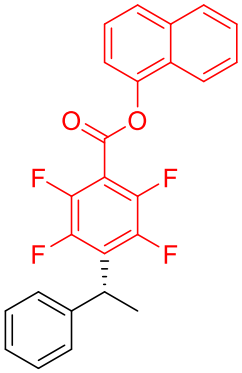


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	21.182	M	1.2813	560685	11182	51.0118
2	24.425	M	1.5660	538442	9410	48.9882

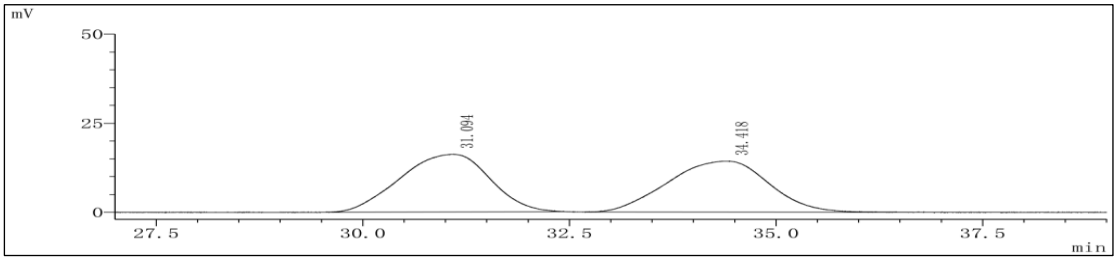


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	21.408	M	1.5612	432681	7996	4.7921
2	24.394	M	1.6957	8596447	137574	95.2079

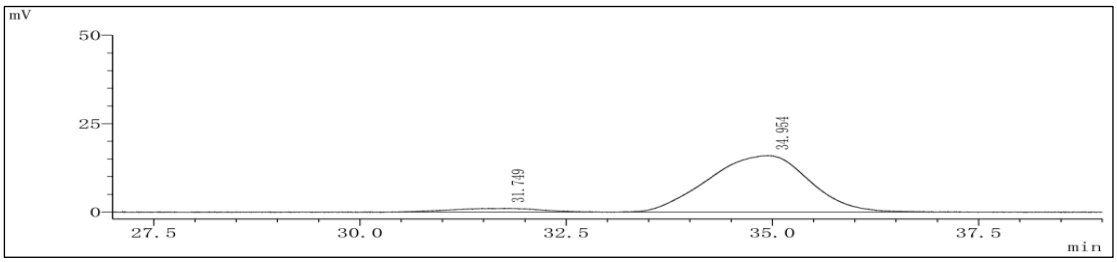
naphthalen-1-yl (*R*)-2,3,5,6-tetrafluoro-4-(1-phenylethyl)benzoate (3an)



This compound was obtained in 91% (77.2 mg) yield as white solid by the General procedure F. **m.p.** 96 – 97 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.01 – 7.99 (m, 1H), 7.90 – 7.88 (m, 1H), 7.79 (d, *J* = 8.5 Hz, 1H), 7.56 – 7.48 (m, 3H), 7.42 (d, *J* = 7.5 Hz, 1H), 7.36 – 7.32 (m, 4H), 7.28 – 7.24 (m, 1H), 4.71 (q, *J* = 7.5 Hz, 1H), 1.82 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.26, 146.06, 145.20 (dm, *J* = 257.4 Hz), 145.09 (dm, *J* = 254.6 Hz), 141.41, 134.72, 128.83 (t, *J* = 15.9 Hz), 128.69, 128.03, 127.16, 127.10, 126.88, 126.76, 126.67, 126.29, 125.28, 121.07, 118.00, 110.09 (t, *J* = 15.5 Hz), 35.20, 17.95 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.38 – -138.45 (m, 2F), -140.92 (td, *J* = 15.8, 5.1 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{25}H_{16}F_4NaO_2$ ([M + Na]$^+$): 447.0979; found: 447.0973. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 90% ee, t_R (minor) = 31.75 min, t_R (major) = 34.95 min. $[\alpha]_D^{25}$ = + 25.39 (c = 1.0, CH_2Cl_2).

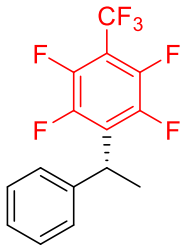


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	31.094	M	1.9962	1224413	16187	50.1641
2	34.418	M	2.0991	1216403	14320	49.8359

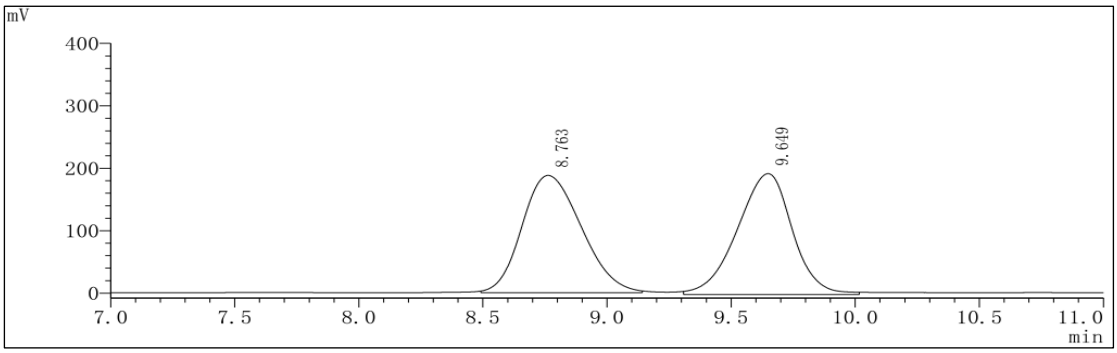


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	31.749	M	1.6913	72831	998	5.1281
2	34.954	M	2.1919	1347394	15919	94.8719

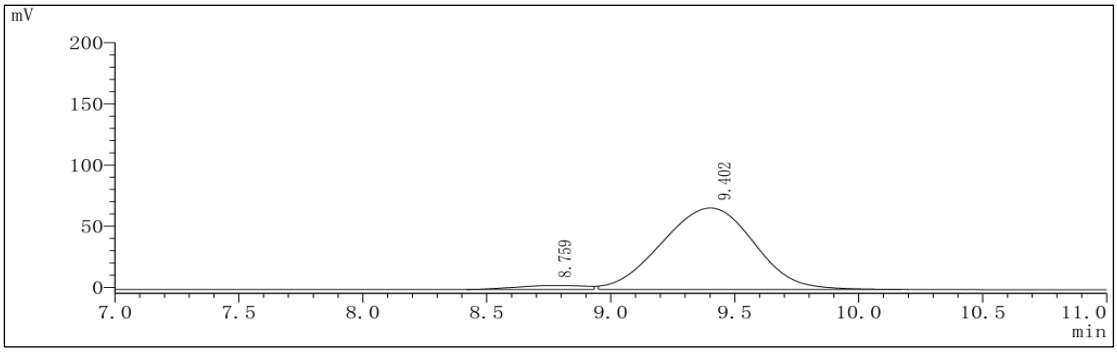
(*R*)-1,2,4,5-tetrafluoro-3-(1-phenylethyl)-6-(trifluoromethyl)benzene (3ao)



This compound was obtained in 41% (26.4 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.35 – 7.30 (m, 4H), 7.27 – 7.24 (m, 1H), 4.66 (q, *J* = 7.5 Hz, 1H), 1.79 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 145.02 (dm, *J* = 235.1 Hz), 144.14 (dm, *J* = 256.2 Hz), 141.15, 129.05 (t, *J* = 15.7 Hz), 128.72, 127.19, 127.14, 107.79, 35.14, 17.85 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -56.31 (t, *J* = 21.2 Hz, 3F), -140.57 (dt, *J* = 24.3, 6.8 Hz, 2F), -140.76 – -140.95 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{15}H_{10}F_7$ ([M + H]$^+$): 323.0665; found: 323.0661. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 93% ee, t_R (minor) = 8.76 min, t_R (major) = 9.40 min. $[\alpha]_D^{25}$ = − 25.43 (c = 1.0, CH_2Cl_2).

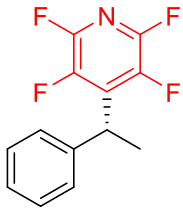


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	8.763	M	0.4420	3124503	187775	50.9736
2	9.649	M	0.4024	3005144	193724	49.0264

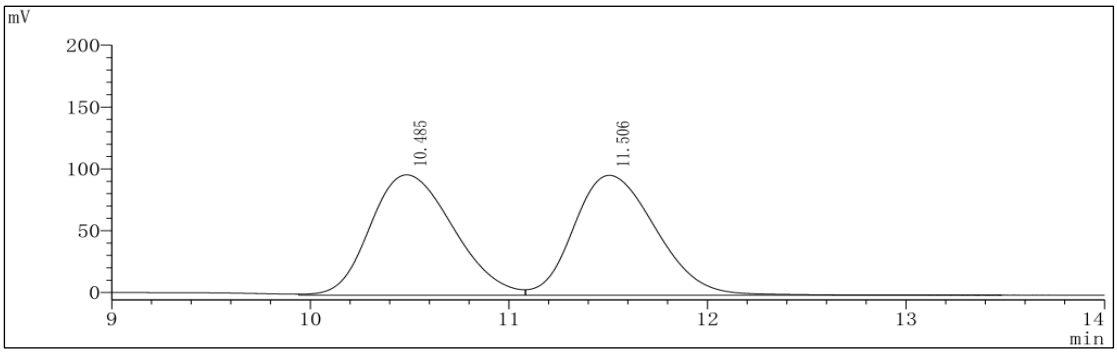


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	8.759	M	0.6912	62835	3180	3.4968
2	9.402	M	0.6948	1734097	66587	96.5032

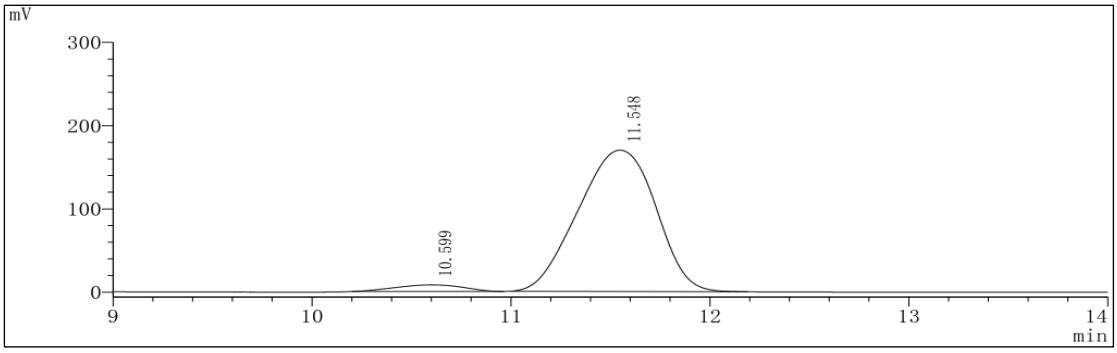
(*R*)-2,3,5,6-tetrafluoro-4-(1-phenylethyl)pyridine (3ap)



This compound was obtained in 72% (36.7 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.35 – 7.31 (m, 4H), 7.28 – 7.25 (m, 1H), 4.67 (q, *J* = 7.5 Hz, 1H), 1.80 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 143.66 (dm, *J* = 245.0 Hz), 140.47, 140.24 (dm, *J* = 256.2 Hz), 138.46, 138.36 (t, *J* = 14.3 Hz), 138.27, 128.82, 127.41, 127.18, 35.73, 17.61 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -91.17 – -91.29 (m, 2F), -143.68 – -143.80 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{13}H_9F_4NNa$ ([M + Na]$^+$): 278.0563; found: 278.0567. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 92% ee, t_R (minor) = 10.60 min, t_R (major) = 11.55 min. $[\alpha]_D^{25}$ = − 35.19 (c = 1.0, CH_2Cl_2).

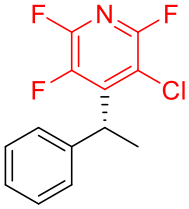


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.485	M	0.7676	2826698	97264	50.4020
2	11.506	SV	0.7504	2781604	96884	49.5980

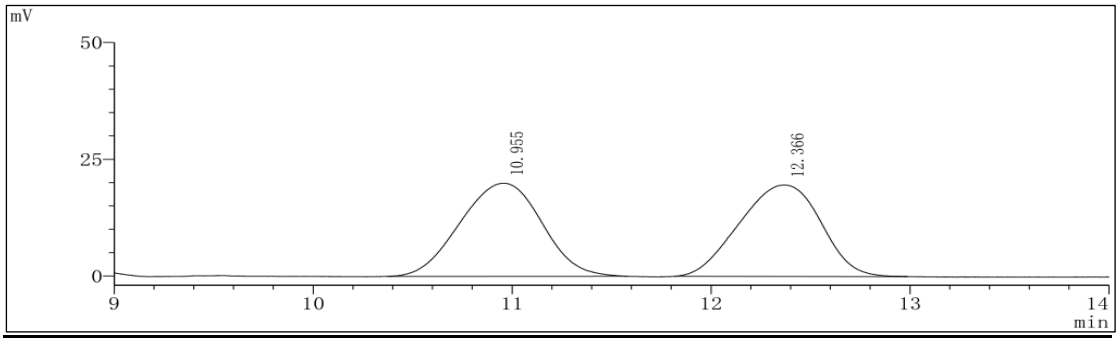


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.599	M	0.6529	187438	7875	3.9010
2	11.548	M	0.7299	4617445	169778	96.0990

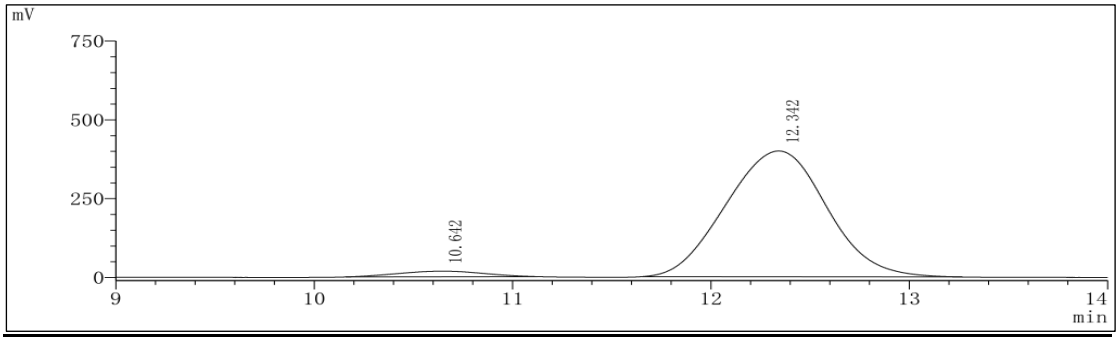
(*R*)-3-chloro-2,5,6-trifluoro-4-(1-phenylethyl)pyridine (3aq)



This compound was obtained in 76% (41.2 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.35 – 7.25 (m, 5H), 4.85 (q, *J* = 7.3 Hz, 1H), 1.79 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 151.12 (dm, *J* = 241.4 Hz), 148.38 (d, *J* = 12.0 Hz), 147.62 (dm, *J* = 245.6 Hz), 141.75 (dm, *J* = 256.8 Hz), 140.25, 128.68, 127.25, 127.18 (d, *J* = 2.1 Hz), 112.62 (dd, *J* = 33.5, 6.2 Hz), 39.15 (t, *J* = 2.3 Hz), 17.02 (t, *J* = 4.7 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -72.78 (dd, *J* = 27.1, 13.0 Hz, 1F), -89.44 (dd, *J* = 22.0, 13.0 Hz, 1F), 143.02 (t, *J* = 24.3 Hz, 1F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{13}H_{10}ClF_3N$ ([M + H]$^+$): 272.0448; found: 272.0451. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 93% ee, t_R (minor) = 10.64 min, t_R (major) = 12.34 min. $[\alpha]_D^{25}$ = − 19.67 (c = 1.0, CH_2Cl_2).

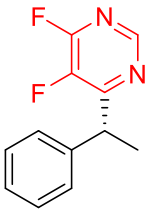


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.955	M	0.7514	569860	19937	50.4905
2	12.366	M	0.7629	558788	19596	49.5095

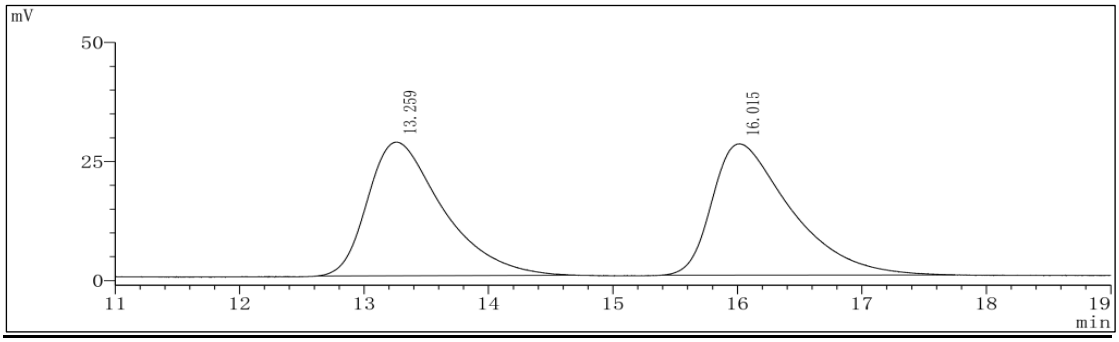


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.642	M	0.8266	531386	17678	3.6259
2	12.342	M	0.9420	14124046	399153	96.3741

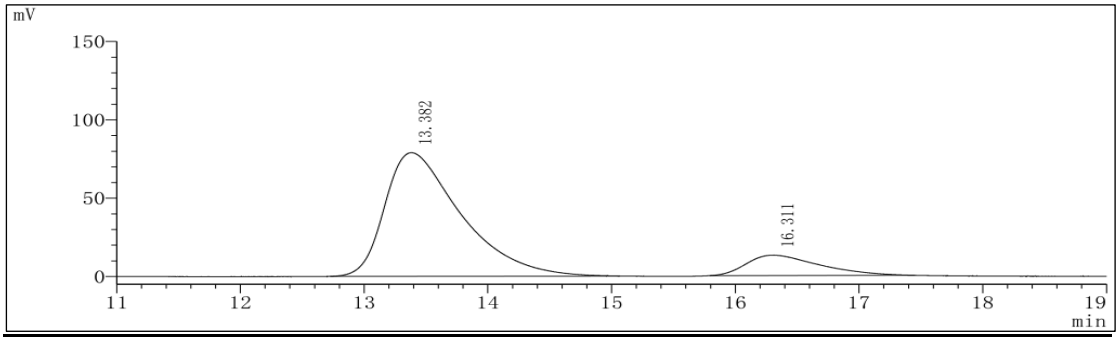
(*R*)-4,6-difluoro-5-(1-phenylethyl)pyrimidine (3ar)



This compound was obtained in 51% (22.5 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.61 (s, 1H), 7.36 (d, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.26 – 7.23 (m, 1H), 4.61 (q, *J* = 6.8 Hz, 1H), 1.73 (d, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 163.66 (dd, *J* = 9.8, 3.9 Hz), 157.42 (dd, *J* = 253.2, 13.2 Hz), 152.40 (dd, *J* = 13.2, 11.4 Hz), 141.98 (dd, *J* = 266.3, 21.2 Hz), 141.60, 128.75, 127.67, 127.25, 39.93 (d, *J* = 3.5 Hz), 19.12. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -82.00 (d, *J* = 23.7 Hz, 1F), -153.41 (d, *J* = 23.7 Hz, 1F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{12}H_{11}F_2N_2$ ([M + H]$^+$): 221.0885; found: 221.0884. **HPLC** analysis (OJ-H, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 73% ee, t_R (minor) = 13.38 min, t_R (major) = 16.31 min. $[\alpha]_D^{25}$ = − 8.42 (c = 1.0, CH_2Cl_2).

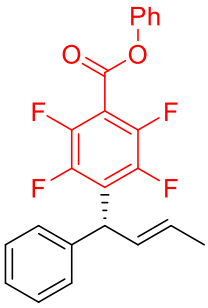


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	13.259	M	1.0902	1178472	28065	49.3261
2	16.015	M	1.1509	1210671	27565	50.6739

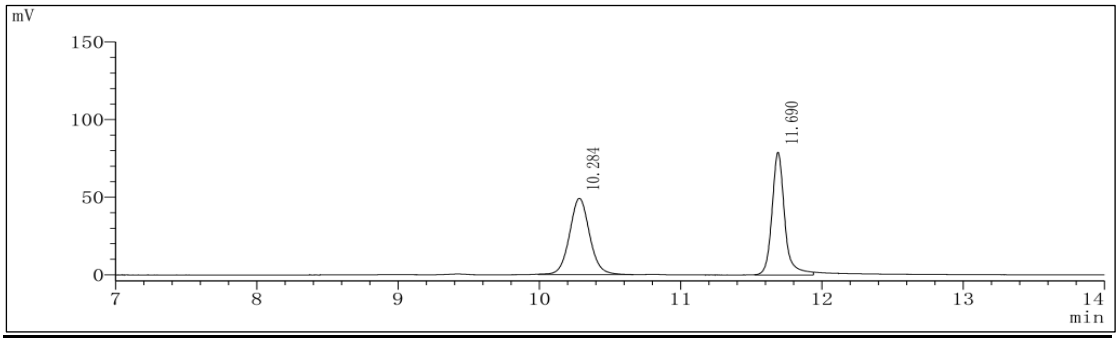


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	13.382	M	1.1055	3375254	78917	86.3985
2	16.311	M	1.0579	531359	13035	13.6015

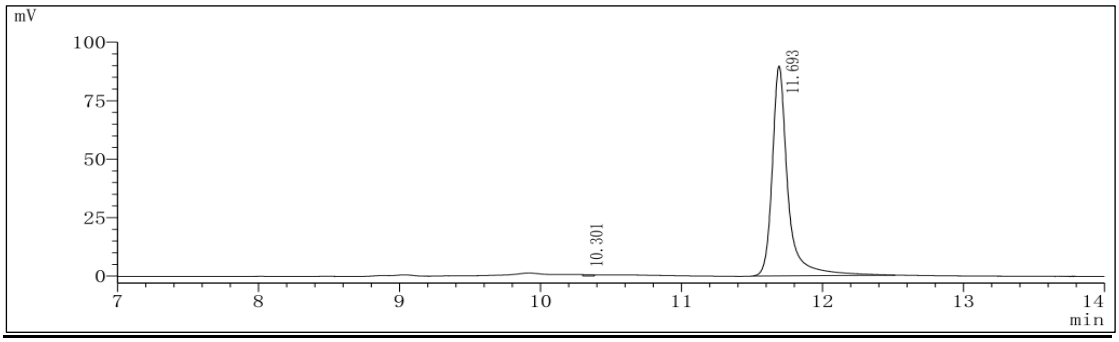
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-phenylbut-2-en-1-yl)benzoate (5a)



This compound was obtained in 96% (76.8 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.43 (t, *J* = 7.8 Hz, 2H), 7.34 – 7.28 (m, 3H), 7.26 – 7.23 (m, 5H), 6.07 (dd, *J* = 15.5, 9.0 Hz, 1H), 5.78 – 5.71 (m, 1H), 5.18 (d, *J* = 8.5 Hz, 1H), 1.78 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.20, 150.15, 145.08 (dm, *J* = 256.5 Hz), 144.64 (dm, *J* = 246.6 Hz), 140.24, 130.07, 129.63, 128.64, 128.00 (t, *J* = 2.3 Hz), 127.32, 127.07, 127.01 (t, *J* = 16.1 Hz), 126.56, 121.32, 110.28 (t, *J* = 15.2 Hz), 44.17, 17.86. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.66 – -138.73 (m, 2F), -140.34 – -140.40 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{23}H_{17}F_4O_2$ ($[M + H]^+$): 401.1159; found: 401.1156. **HPLC** analysis (IF, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (minor) = 10.30 min, t_R (major) = 11.69 min. $[\alpha]_D^{25}$ = − 24.59 (c = 1.0, CH_2Cl_2).

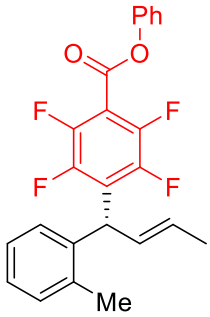


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.284	M	0.2552	487460	49075	49.5837
2	11.690	M	0.1542	495646	78929	50.4163

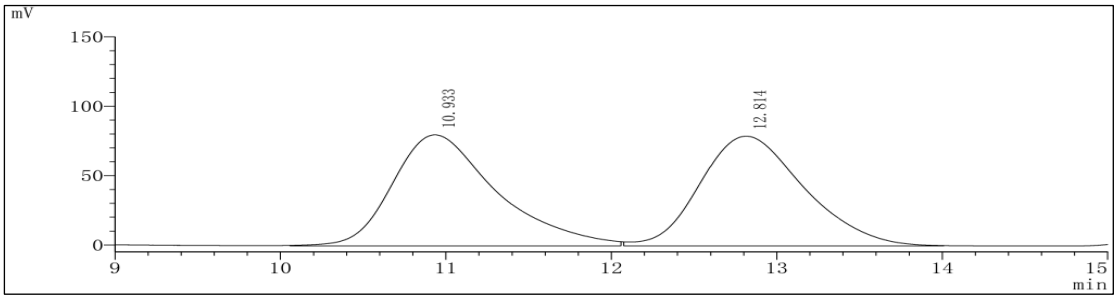


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.301	M	0.3119	2941	647	0.4233
2	11.693	M	0.1775	691961	89161	99.5767

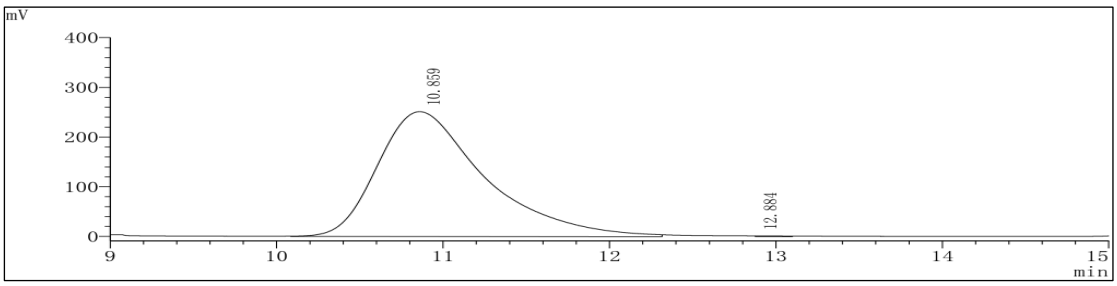
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-(o-tolyl)but-2-en-1-yl)benzoate (5b)



This compound was obtained in 89% (73.7 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.43 (t, *J* = 7.8 Hz, 2H), 7.38 (d, *J* = 7.5 Hz, 1H), 7.29 (t, *J* = 7.5 Hz, 1H), 7.24 – 7.21 (m, 3H), 7.18 – 7.14 (m, 2H), 6.00 (dd, *J* = 14.0, 6.0 Hz, 1H), 5.59 – 5.52 (m, 1H), 5.23 (d, *J* = 7.5 Hz, 1H), 2.26 (s, 3H), 1.76 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.22, 150.13, 145.02 (dm, *J* = 256.4 Hz), 144.82 (dm, *J* = 248.0 Hz), 138.13, 135.98, 130.67, 129.64, 128.62, 128.42, 128.05 (t, *J* = 2.6 Hz), 127.27, 126.57, 126.31 (t, *J* = 15.5 Hz), 126.17, 121.33, 110.24 (t, *J* = 15.2 Hz), 41.55, 19.34, 17.86. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.84 – -138.92 (m, 2F), -139.79 (td, *J* = 15.3, 5.1 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{24}H_{19}F_4O_2$ ([M + H]$^+$): 415.1316; found: 415.1322. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (major) = 10.86 min, t_R (minor) = 12.88 min. $[\alpha]_D^{25}$ = − 22.75 (c = 1.0, CH_2Cl_2).

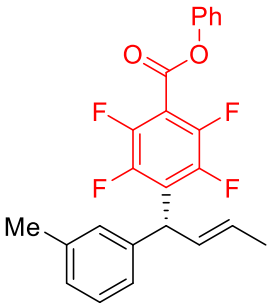


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.933	M	1.1148	3510853	80070	50.3276
2	12.814	M	1.1638	3465140	79120	49.6724

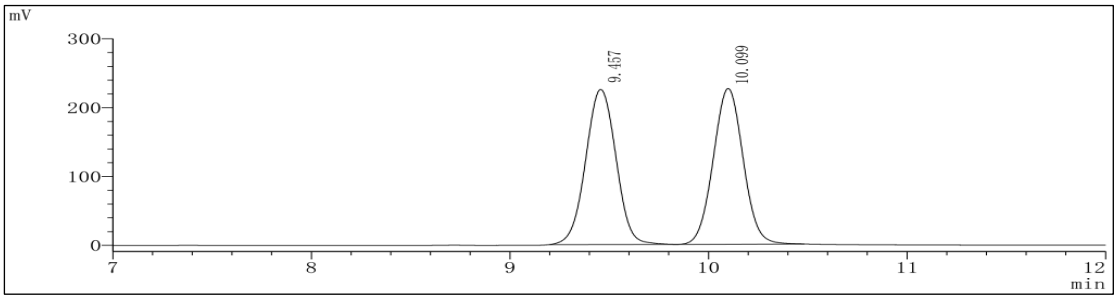


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.859	M	1.1275	11234808	250978	99.8543
2	12.884	M	--	16388	1400	0.1457

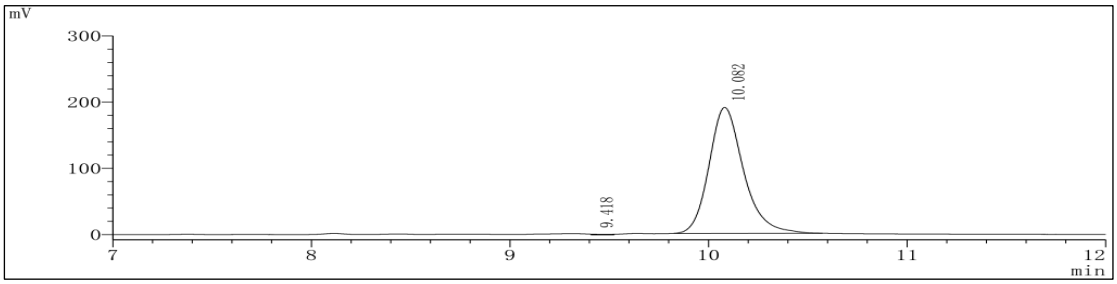
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-(m-tolyl)but-2-en-1-yl)benzoate (5c)



This compound was obtained in 93% (77.0 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.43 (t, *J* = 7.8 Hz, 2H), 7.30 (t, *J* = 7.5 Hz, 1H), 7.22 (dd, *J* = 19.5, 8.0 Hz, 3H), 7.07 – 7.04 (m, 3H), 6.06 (dd, *J* = 13.5, 9.0 Hz, 1H), 5.76 – 5.69 (m, 1H), 5.13 (d, *J* = 8.5 Hz, 1H), 2.33 (s, 3H), 1.78 (d, *J* = 6.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.25, 150.15, 145.08 (dm, *J* = 256.5 Hz), 144.64 (dm, *J* = 246.6 Hz), 140.19, 138.34, 129.90, 129.64, 128.52, 128.12 (t, *J* = 2.4 Hz), 128.02, 127.85, 127.16 (t, *J* = 16.1 Hz), 126.56, 124.33, 121.33, 110.18 (t, *J* = 15.2 Hz), 44.14, 21.45, 17.87. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.71 – -138.79 (m, 2F), -140.35 (td, *J* = 15.8, 5.1 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{24}H_{19}F_4O_2$ ([M + H]$^+$): 415.1316; found: 415.1320. **HPLC** analysis (IF, Hexane/IPA = 99.9/0.1, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (minor) = 9.42 min, t_R (major) = 10.08 min. $[\alpha]_D^{25}$ = − 19.82 (c = 1.0, CH_2Cl_2).

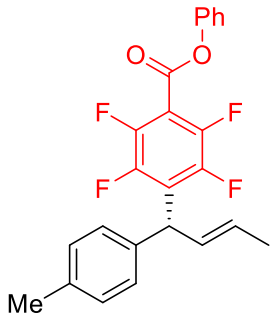


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	9.457	M	0.2774	2392076	225107	50.2628
2	10.099	M	0.2754	2367065	225919	49.7372

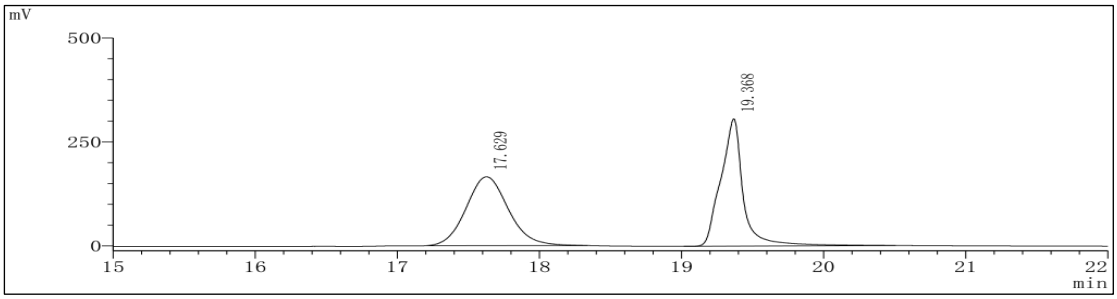


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	9.418	M	--	7584	1296	0.3288
2	10.082	M	0.3077	2299060	190136	99.6712

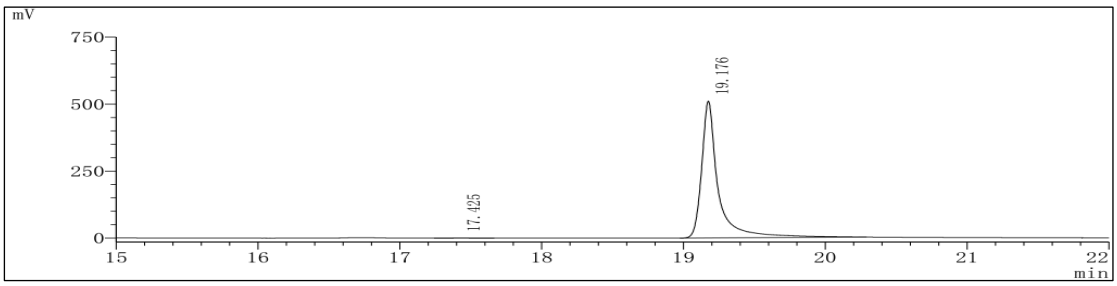
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-(p-tolyl)but-2-en-1-yl)benzoate (5d)



This compound was obtained in 96% (79.5 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.43 (t, *J* = 8.0 Hz, 2H), 7.32 – 7.26 (m, 1H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.13 (s, 4H), 6.05 (dd, *J* = 14.0, 9.0 Hz, 1H), 5.76 – 5.69 (m, 1H), 5.14 (d, *J* = 8.5 Hz, 1H), 2.32 (s, 3H), 1.77 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.26, 150.16, 145.09 (dm, *J* = 256.3 Hz), 144.64 (dm, *J* = 248.4 Hz), 137.28, 136.78, 129.83, 129.65, 129.34, 128.22 (t, *J* = 7.8 Hz), 127.25 (t, *J* = 16.1 Hz), 127.22, 126.58, 121.35, 110.16 (t, *J* = 14.9 Hz), 43.87, 21.00, 17.89. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.74 – -138.81 (m, 2F), -140.44 (td, *J* = 16.4, 5.1 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{24}H_{18}F_4NaO_2$ ([M + Na]$^+$): 437.1135; found: 437.1128. **HPLC** analysis (IF, Hexane/IPA = 99.9/0.1, 0.3 mL/min, 254 nm) indicated >99% ee, t_R (minor) = 17.43 min, t_R (major) = 19.18 min. $[\alpha]_D^{25}$ = − 24.38 (c = 1.0, CH_2Cl_2).

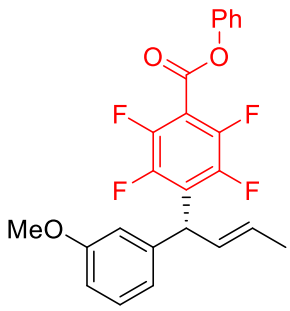


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	17.629	M	0.5340	3434080	165788	50.4091
2	19.368	M	0.2570	3378340	305583	49.5909

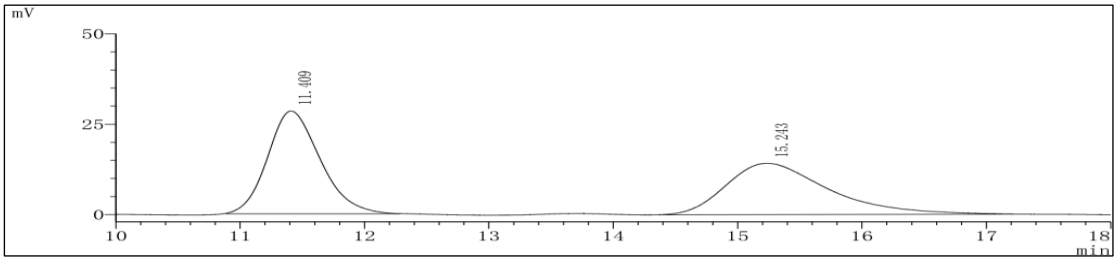


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	17.425	M	0.4500	8610	595	0.2065
2	19.176	M	0.1732	4160621	506668	99.7935

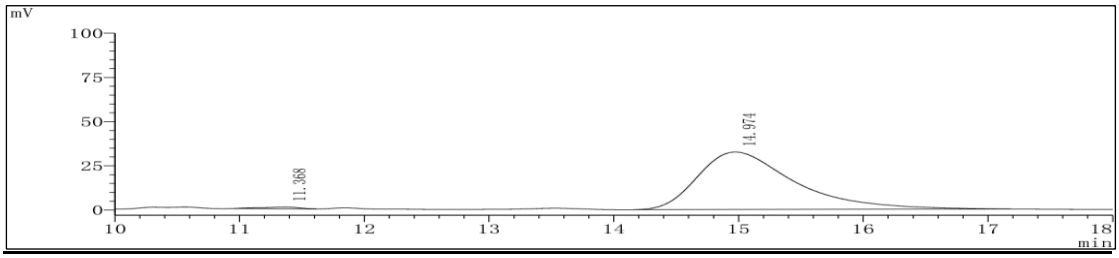
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-(3-methoxyphenyl)but-2-en-1-yl)benzoate (5e)



This compound was obtained in 86% (74.0 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.43 (t, *J* = 7.8 Hz, 2H), 7.29 (t, *J* = 7.5 Hz, 1H), 7.25 – 7.22 (m, 3H), 6.82 – 6.78 (m, 3H), 6.05 (dd, *J* = 14.5, 8.5 Hz, 1H), 5.78 – 5.71 (m, 1H), 5.14 (d, *J* = 8.5 Hz, 1H), 3.79 (s, 3H), 1.78 (d, *J* = 6.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 159.79, 158.19, 150.13, 145.07 (dm, *J* = 256.5 Hz), 144.63 (dm, *J* = 248.9 Hz), 141.84, 130.17, 129.62, 127.86 (t, *J* = 2.3 Hz), 126.89 (t, *J* = 16.1 Hz), 126.55, 121.31, 119.67, 113.75, 111.82, 110.27 (t, *J* = 15.2 Hz), 55.21, 44.09, 17.85. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.63 – -138.70 (m, 2F), -140.29 – -140.35 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{24}H_{18}F_4NaO_3$ ([M + Na]$^+$): 453.1084; found: 453.1078. **HPLC** analysis (IF, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 98% ee, t_R (minor) = 11.37 min, t_R (major) = 14.97 min. $[\alpha]_D^{25}$ = − 21.36 (c = 1.0, CH_2Cl_2).

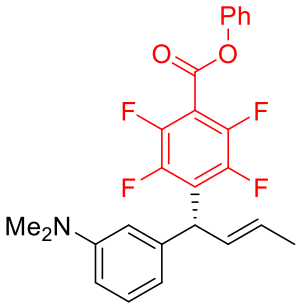


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.409	M	0.7755	837701	28425	50.7868
2	15.243	M	1.4668	811745	14205	49.2132

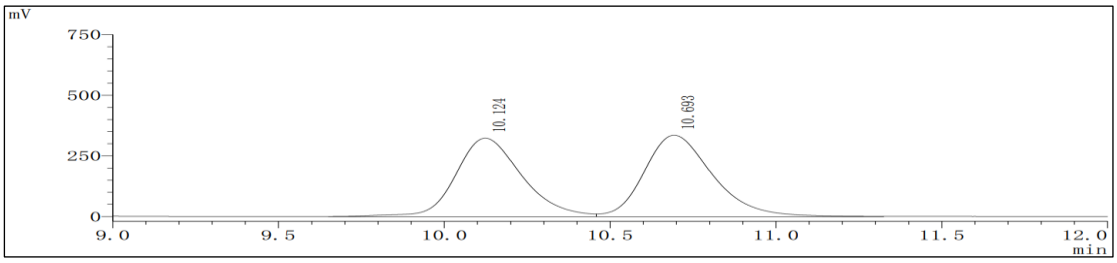


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.368	M	0.6851	21191	960	1.1905
2	14.974	M	1.3698	1758826	32536	98.8095

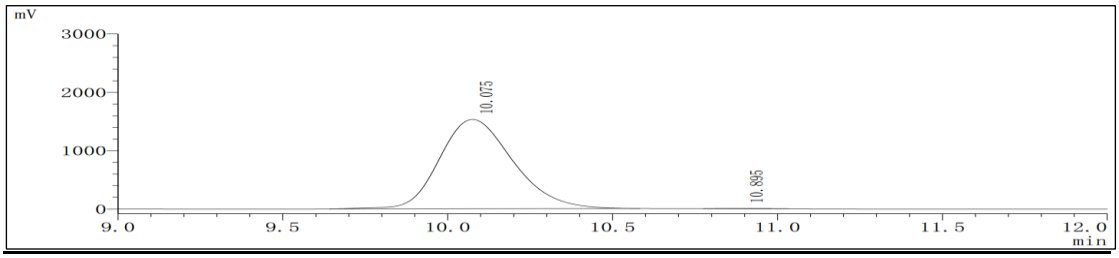
phenyl (*R*,*E*)-4-(1-(3-(dimethylamino)phenyl)but-2-en-1-yl)-2,3,5,6-tetrafluorobenzoate (5f)



This compound was obtained in 70% (60.6 mg) yield as light yellow oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.43 (t, *J* = 7.8 Hz, 2H), 7.29 (t, *J* = 7.2 Hz, 1H), 7.24 (d, *J* = 8.4 Hz, 2H), 7.19 – 7.16 (m, 1H), 6.63 – 6.59 (m, 3H), 6.09 (dd, *J* = 13.8, 9.0 Hz, 1H), 5.75 – 5.69 (m, 1H), 5.12 (d, *J* = 8.4 Hz, 1H), 2.93 (s, 6H), 1.77 (d, *J* = 6.6 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.29, 150.82, 150.15, 145.12 (dm, *J* = 255.9 Hz), 144.69 (dm, *J* = 239.4 Hz), 141.17, 129.63, 129.60, 129.30, 128.35, 127.46 (t, *J* = 15.8 Hz), 126.54, 121.35, 115.54, 111.52, 111.34, 109.98, 44.67, 40.54, 17.88. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.82 – -138.89 (m, 2F), -140.24 (q, *J* = 10.7 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{25}H_{21}F_4NNaO_2$ ([M + Na]$^+$): 466.1401; found: 466.1406. **HPLC** analysis (IF, Hexane/IPA = 98.0/2.0, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (major) = 10.08 min, t_R (minor) = 10.90 min. $[\alpha]_D^{25}$ = − 7.82 (c = 1.0, CH_2Cl_2).

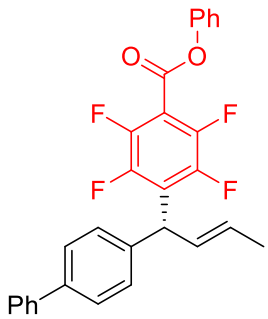


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.124	M	0.3552	4508108	323626	48.2815
2	10.693	M	0.3685	4829025	335678	51.7185

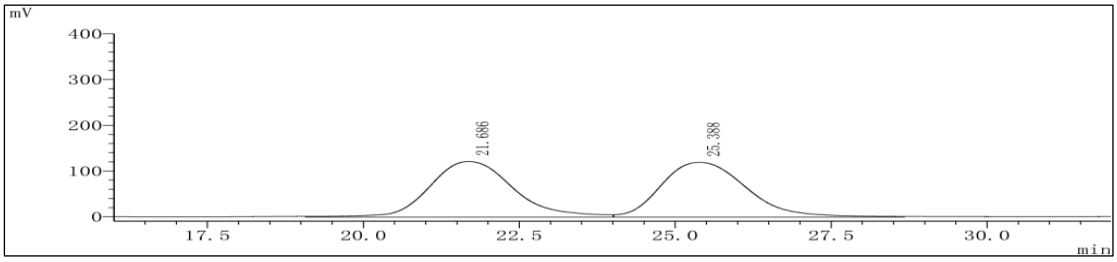


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.075	M	0.4035	23734645	1527637	99.8018
2	10.895	M	0.2663	47147	4886	0.1982

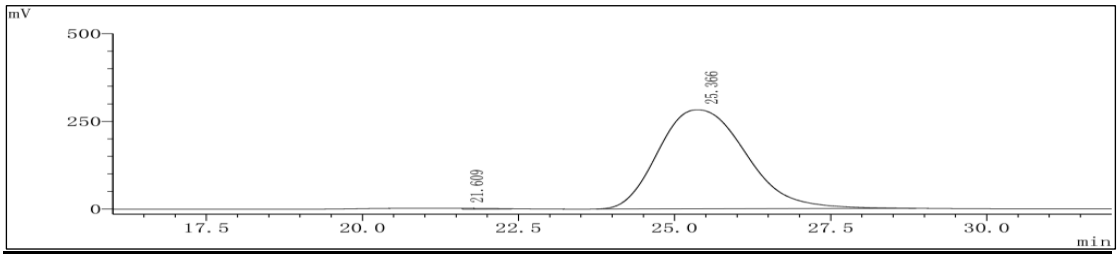
phenyl (*R*,*E*)-4-(1-([1,1'-biphenyl]-4-yl)but-2-en-1-yl)-2,3,5,6-tetrafluorobenzoate (5g)



This compound was obtained in 92% (87.6 mg) yield as white solid by the General procedure G. **m.p.** 101 – 102 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.55 (t, *J* = 8.5 Hz, 4H), 7.44 – 7.40 (m, 4H), 7.34 – 7.27 (m, 4H), 7.24 (d, *J* = 8.0 Hz, 2H), 6.10 (dd, *J* = 14.5, 9.5 Hz, 1H), 5.81 – 5.74 (m, 1H), 5.21 (d, *J* = 8.5 Hz, 1H), 1.80 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.19, 150.13, 145.12 (dm, *J* = 256.5 Hz), 144.65 (dm, *J* = 246.2 Hz), 140.57, 140.08, 139.26, 130.17, 129.63, 128.75, 127.95, 127.75, 127.36, 127.32, 127.04, 126.56, 121.32, 110.32 (t, *J* = 15.1 Hz), 43.91, 17.89. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.74 (td, *J* = 15.8, 5.1 Hz, 2F), -140.26 – -140.31 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{29}H_{20}F_4NaO_2$ ([M + Na]$^+$): 499.1292; found: 499.1280. **HPLC** analysis (AD-3, Hexane/IPA = 99.0/1.0, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (minor) = 21.61 min, t_R (major) = 25.37 min. $[\alpha]_D^{25}$ = − 17.58 (c = 1.0, CH_2Cl_2).

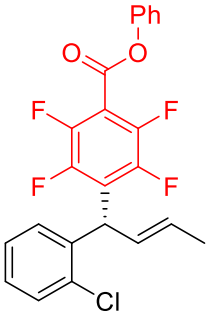


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	21.686	M	2.2887	11377340	121450	50.0408
2	25.388	M	2.3855	11358778	119633	49.9592

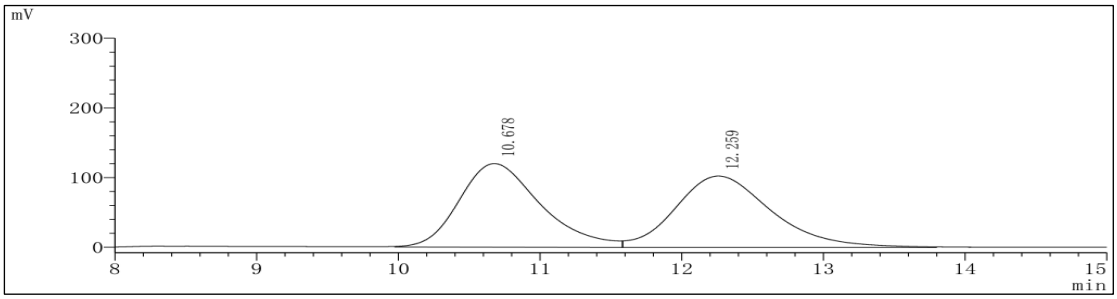


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	21.609	M	--	79771	2123	0.2887
2	25.366	M	2.4745	27547451	282506	99.7113

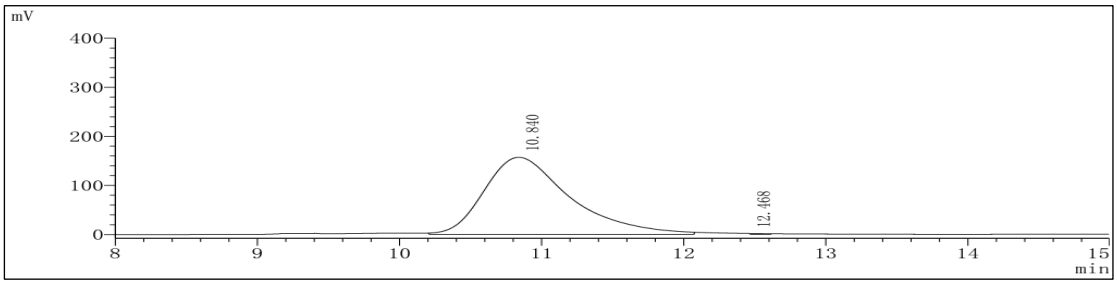
phenyl (*R*,*E*)-4-(1-(2-chlorophenyl)but-2-en-1-yl)-2,3,5,6-tetrafluorobenzoate (5h)



This compound was obtained in 90% (78.1 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.53 (d, *J* = 8.0 Hz, 1H), 7.43 (t, *J* = 7.8 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 1H), 7.29 (t, *J* = 7.0 Hz, 2H), 7.24 – 7.21 (m, 3H), 5.97 (dd, *J* = 15.0, 7.0 Hz, 1H), 5.66 – 5.59 (m, 1H), 5.41 (d, *J* = 7.0 Hz, 1H), 1.79 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.23, 150.13, 145.00 (dm, *J* = 255.8 Hz), 144.89 (dm, *J* = 255.3 Hz), 137.61, 133.80, 129.96 (t, *J* = 2.8 Hz), 129.77, 129.69, 129.63, 128.65, 126.99, 126.73, 126.56, 125.29 (t, *J* = 15.3 Hz), 121.32, 110.40 (t, *J* = 15.1 Hz), 41.59, 17.93. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -139.11 – -139.18 (m, 2F), -139.85 (td, *J* = 15.8, 5.7 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{23}H_{15}ClF_4NaO_2$ ([M + Na]$^+$): 457.0589; found: 457.0593. **HPLC** analysis (OD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (major) = 10.84 min, t_R (minor) = 12.47 min. $[\alpha]_D^{25}$ = + 7.47 (c = 1.0, CH_2Cl_2).

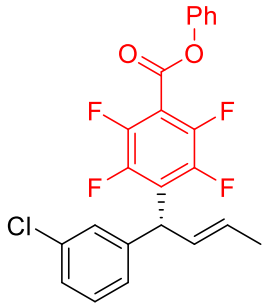


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.678	M	1.0417	4807938	120194	49.8126
2	12.259	M	1.2211	4844115	102550	50.1874

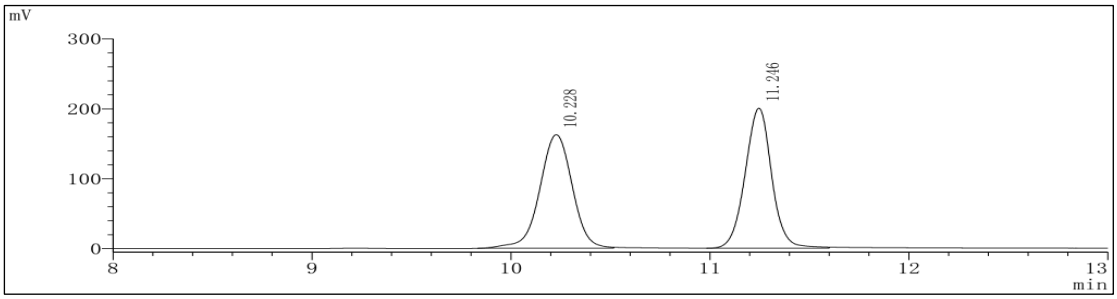


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.840	M	1.0701	6603027	157065	99.8070
2	12.468	M	--	12767	1720	0.1930

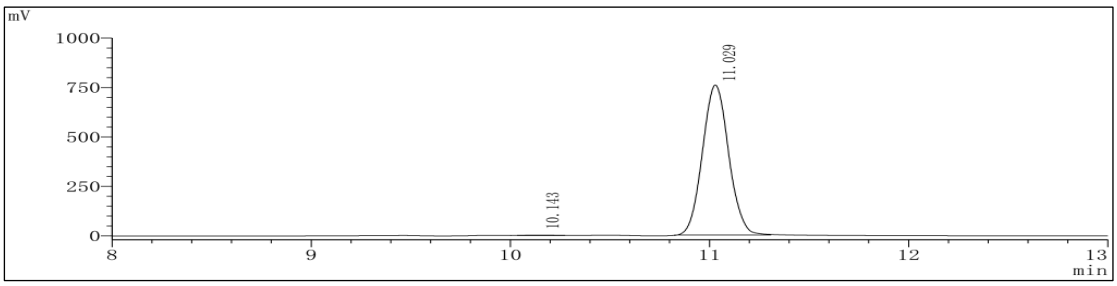
phenyl (*R*,*E*)-4-(1-(3-chlorophenyl)but-2-en-1-yl)-2,3,5,6-tetrafluorobenzoate (5i)



This compound was obtained in 91% (79.0 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.44 (t, *J* = 8.0 Hz, 2H), 7.30 (t, *J* = 7.5 Hz, 1H), 7.25 (d, *J* = 7.0 Hz, 5H), 7.11 (d, *J* = 6.5 Hz, 1H), 6.00 (dd, *J* = 14.5, 9.0 Hz, 1H), 5.79 – 5.73 (m, 1H), 5.14 (d, *J* = 8.5 Hz, 1H), 1.80 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.10, 150.11, 145.10 (dm, *J* = 256.9 Hz), 144.57 (dm, *J* = 247.1 Hz), 142.24, 134.57, 130.90, 129.86, 129.66, 127.53, 127.33, 127.19, 126.61, 126.17 (t, *J* = 16.1 Hz), 125.50, 121.30, 110.64 (t, *J* = 15.2 Hz), 43.73, 17.89. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.28 – -138.35 (m, 2F), -140.32 (td, *J* = 15.3, 5.1 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{23}H_{15}ClF_4NaO_2$ ([M + Na]$^+$): 457.0589; found: 457.0587. **HPLC** analysis (IF, Hexane/IPA = 99.8/0.2, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (minor) = 10.14 min, t_R (major) = 11.03 min. $[\alpha]_D^{25}$ = + 9.86 (c = 1.0, CH_2Cl_2).

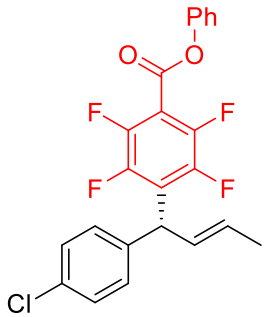


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.228	M	0.2913	1850640	162527	49.7586
2	11.246	M	0.2373	1868594	200291	50.2414

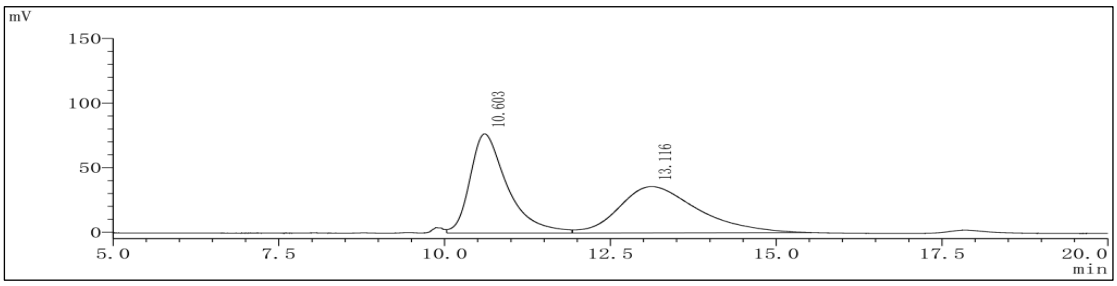


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.143	M	0.2335	12367	1446	0.1773
2	11.029	M	0.2387	6961853	758568	99.8227

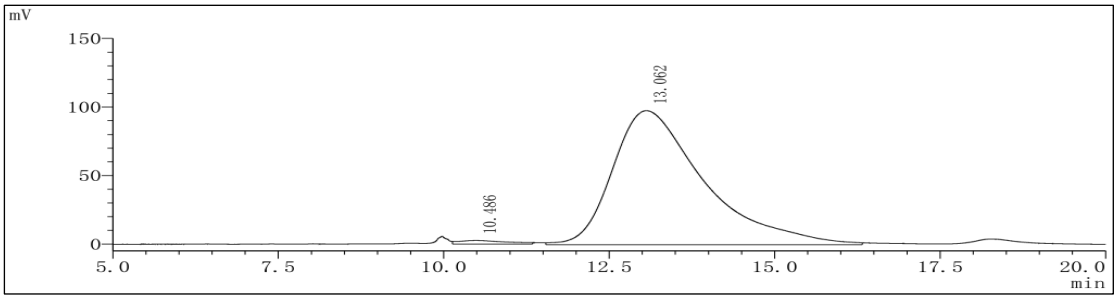
phenyl (*R*,*E*)-4-(1-(4-chlorophenyl)but-2-en-1-yl)-2,3,5,6-tetrafluorobenzoate (5j)



This compound was obtained in 91% (79.0 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.44 (t, *J* = 7.8 Hz, 2H), 7.31 – 7.28 (m, 3H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.17 (d, *J* = 8.5 Hz, 2H), 6.00 (dd, *J* = 14.0, 10.5 Hz, 1H), 5.78 – 5.71 (m, 1H), 5.13 (d, *J* = 8.5 Hz, 1H), 1.78 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.10, 150.10, 145.08 (dm, *J* = 257.2 Hz), 144.56 (dm, *J* = 243.9 Hz), 138.72, 132.98, 130.59, 129.64, 128.75, 128.70, 127.48 (t, *J* = 2.2 Hz), 126.60, 126.42 (t, *J* = 16.0 Hz), 121.29, 110.54 (t, *J* = 15.2 Hz), 43.50, 17.86. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.37 – -138.44 (m, 2F), -140.42 (td, *J* = 15.3, 5.1 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{23}H_{16}ClF_4O_2$ ([M + H]$^+$): 435.0769; found: 435.0773. **HPLC** analysis (IF, Hexane/IPA = 99.9/0.1, 0.5 mL/min, 254 nm) indicated 97% ee, t_R (minor) = 10.49 min, t_R (major) = 13.06 min. $[\alpha]_D^{25}$ = + 15.71 (c = 1.0, CH_2Cl_2).

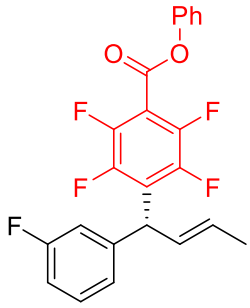


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.603	M	0.9945	3008310	76773	50.3799
2	13.116	M	2.1482	2962940	35834	49.6201

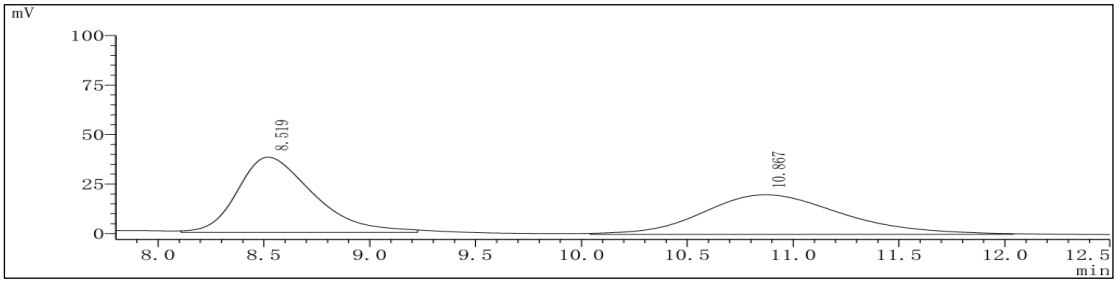


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.486	M	2.9114	134004	2587	1.4028
2	13.062	M	2.4250	9418772	97810	98.5972

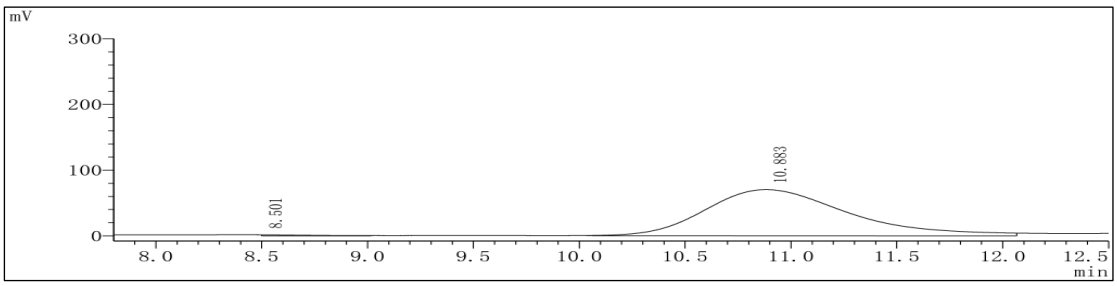
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-(3-fluorophenyl)but-2-en-1-yl)benzoate (5k)



This compound was obtained in 86% (71.9 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.44 (t, *J* = 8.0 Hz, 2H), 7.31 – 7.23 (m, 4H), 7.00 – 6.93 (m, 3H), 6.01 (dd, *J* = 14.5, 9.5 Hz, 1H), 5.80 – 5.73 (m, 1H), 5.15 (d, *J* = 9.0 Hz, 1H), 1.79 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 162.94 (d, *J* = 245.0 Hz), 158.10, 150.12, 145.09 (dm, *J* = 256.7 Hz), 144.60 (dm, *J* = 246.5 Hz), 142.75 (d, *J* = 6.9 Hz), 130.82, 130.08 (d, *J* = 8.4 Hz), 129.65, 127.31 (t, *J* = 2.4 Hz), 126.59, 126.28 (t, *J* = 16.1 Hz), 122.94 (d, *J* = 3.5 Hz), 121.30, 114.44 (d, *J* = 22.2 Hz), 114.03 (d, *J* = 21.0 Hz), 110.60 (t, *J* = 15.2 Hz), 43.75, 17.85. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -112.51 (td, *J* = 9.0, 6.2 Hz, 1F), -138.35 – -138.43 (m, 2F), -140.37 (q, *J* = 10.2 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{23}H_{15}F_5NaO_2$ ([M + Na]$^+$): 441.0884; found: 441.0876. **HPLC** analysis (IF, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 98% ee, t_R (minor) = 8.50 min, t_R (major) = 10.88 min. $[\alpha]_D^{25}$ = − 8.95 (c = 1.0, CH_2Cl_2).

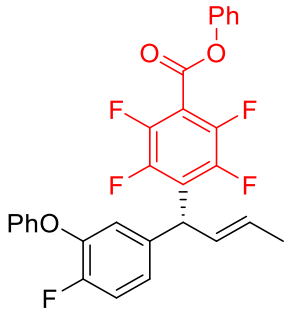


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	8.519	M	0.6495	953390	38065	50.7460
2	10.867	M	1.1875	925359	20026	49.2540

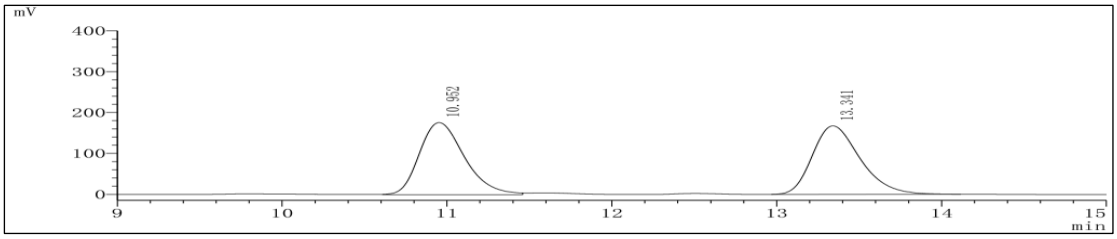


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	8.501	M	--	31305	1800	0.9385
2	10.883	M	1.1955	3304240	70239	99.0615

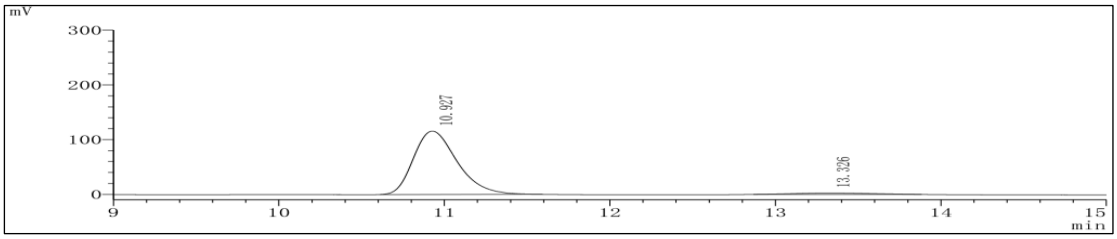
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-(4-fluoro-3-phenoxyphenyl)but-2-en-1-yl)benzoate (5l)



This compound was obtained in 91% (92.8 mg) yield as white solid by the General procedure G. **m.p.** 83 – 84 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.43 (t, *J* = 7.8 Hz, 2H), 7.33 – 7.28 (m, 3H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.14 – 7.06 (m, 2H), 7.02 – 6.97 (m, 2H), 6.94 (d, *J* = 8.0 Hz, 2H), 5.95 (dd, *J* = 14.5, 9.5 Hz, 1H), 5.76 – 5.69 (m, 1H), 5.11 (d, *J* = 8.0 Hz, 1H), 1.75 (d, *J* = 6.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.06, 157.42, 153.46 (d, *J* = 247.7 Hz), 150.11, 145.08 (dm, *J* = 256.8 Hz), 144.52 (dm, *J* = 247.2 Hz), 143.16 (d, *J* = 11.9 Hz), 137.12 (d, *J* = 3.8 Hz), 130.74, 129.65, 127.39, 126.60, 126.32 (t, *J* = 15.8 Hz), 123.83 (d, *J* = 6.9 Hz), 123.00, 121.51, 121.29, 117.13 (d, *J* = 18.6 Hz), 116.65, 110.60 (t, *J* = 15.2 Hz), 43.34, 17.82. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.03 (t, *J* = 10.7 Hz, 1F), -138.29 – -138.37 (m, 2F), -140.47 – -140.53 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{29}H_{19}F_5NaO_3$ ([M + Na]$^+$): 533.1147; found: 533.1159. **HPLC** analysis (AD-3, Hexane/IPA = 98.5/1.5, 0.5 mL/min, 254 nm) indicated 93% ee, t_R (major) = 10.93 min, t_R (minor) = 13.33 min. $[\alpha]_D^{25}$ = − 29.87 (c = 1.0, CH_2Cl_2).

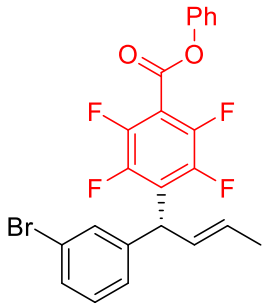


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.952	M	0.4920	3356485	176371	49.8589
2	13.341	M	0.5264	3375481	167403	50.1411

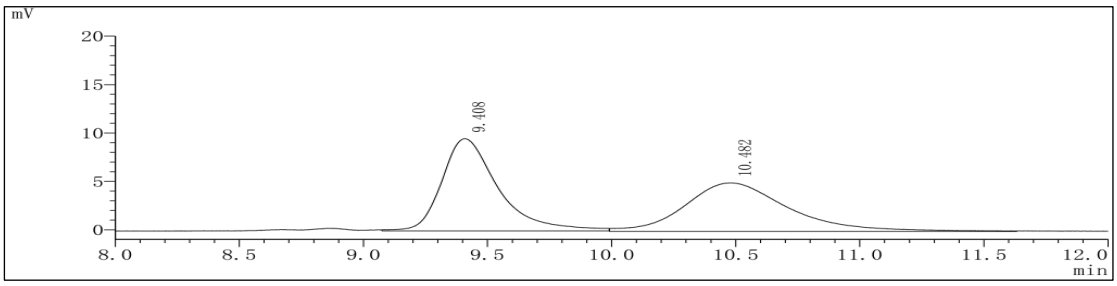


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.927	M	0.4749	2122306	115808	96.3370
2	13.326	M	0.9063	80696	2574	3.6630

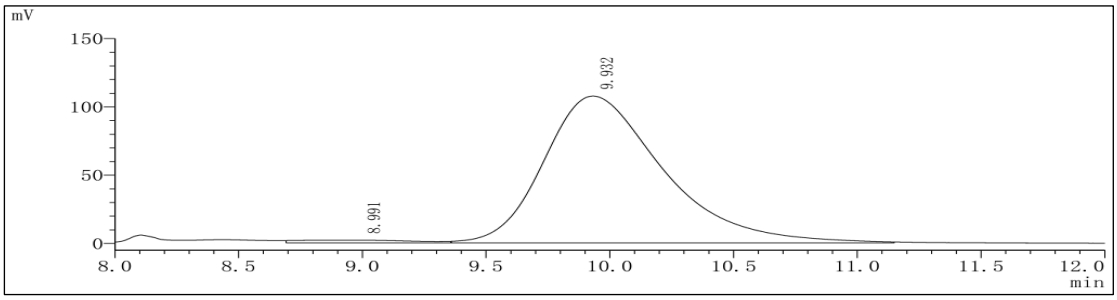
phenyl (*R*,*E*)-4-(1-(3-bromophenyl)but-2-en-1-yl)-2,3,5,6-tetrafluorobenzoate (5m)



This compound was obtained in 92% (88.0 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.44 (t, *J* = 8.0 Hz, 2H), 7.39 (d, *J* = 6.5 Hz, 2H), 7.30 (t, *J* = 7.5 Hz, 1H), 7.25 (d, *J* = 8.0 Hz, 2H), 7.21 – 7.15 (m, 2H), 6.00 (dd, *J* = 14.0, 8.5 Hz, 1H), 5.79 – 5.72 (m, 1H), 5.14 (d, *J* = 8.5 Hz, 1H), 1.80 (d, *J* = 6.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.08, 150.10, 145.09 (dm, *J* = 256.7 Hz), 144.55 (dm, *J* = 246.9 Hz), 142.50, 130.91, 130.41, 130.26, 130.14, 129.64, 127.16 (t, *J* = 2.3 Hz), 126.59, 126.13 (t, *J* = 16.1 Hz), 125.96, 122.78, 121.29, 110.65 (t, *J* = 15.2 Hz), 43.69, 17.88. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.24 – -138.31 (m, 2F), -140.29 (td, *J* = 15.3, 4.5 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{23}H_{15}BrF_4NaO_2$ ([M + Na]$^+$): 501.0084; found: 501.0075. **HPLC** analysis (IF, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 96% ee, t_R (minor) = 8.99 min, t_R (major) = 9.93 min. $[\alpha]_D^{25}$ = + 6.43 (c = 1.0, CH_2Cl_2).

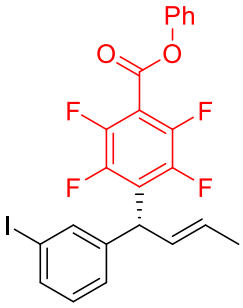


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	9.408	M	0.3869	150776	9509	50.6996
2	10.482	M	0.7184	146615	5021	49.3004

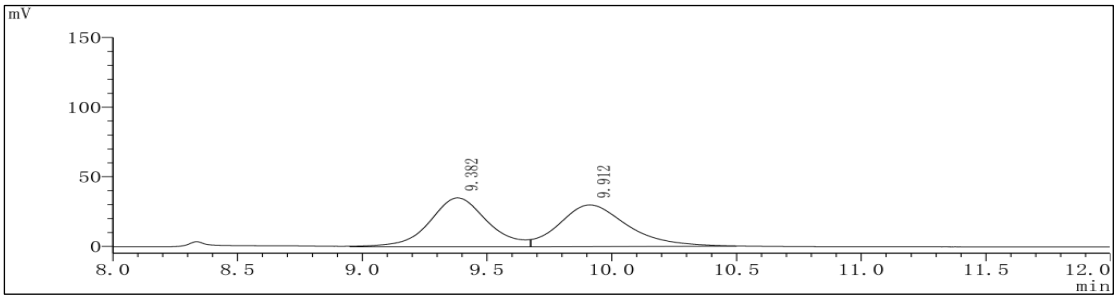


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	8.991	M	1.3939	67911	2017	1.8399
2	9.932	M	0.8628	3623125	107567	98.1601

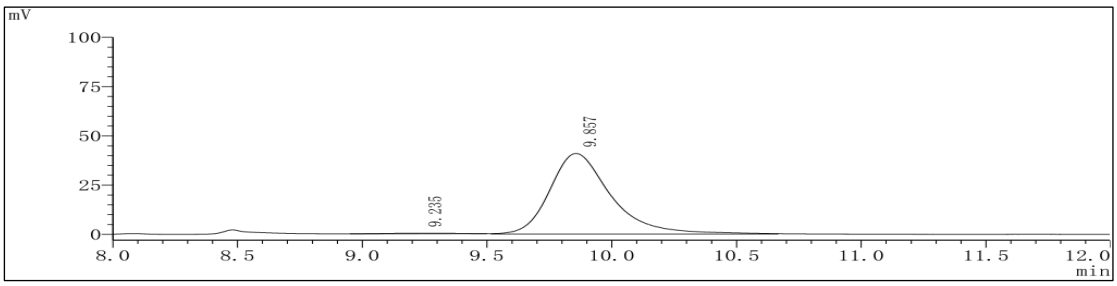
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-(3-iodophenyl)but-2-en-1-yl)benzoate (5n)



This compound was obtained in 88% (92.6 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.60 (d, *J* = 5.5 Hz, 2H), 7.44 (t, *J* = 7.8 Hz, 2H), 7.30 (t, *J* = 7.5 Hz, 1H), 7.25 (d, *J* = 8.0 Hz, 2H), 7.20 (d, *J* = 7.5 Hz, 1H), 7.06 (t, *J* = 8.0 Hz, 1H), 6.01 (dd, *J* = 15.5, 8.5 Hz, 1H), 5.79 – 5.72 (m, 1H), 5.12 (d, *J* = 8.5 Hz, 1H), 1.80 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.07, 150.09, 145.08 (dm, *J* = 256.8 Hz), 144.52 (dm, *J* = 247.1 Hz), 142.54, 136.30, 136.23, 130.83, 130.28, 129.63, 127.15 (t, *J* = 2.3 Hz), 126.58, 126.12 (t, *J* = 16.0 Hz), 121.28, 110.61 (t, *J* = 15.2 Hz), 94.64, 43.57, 17.88. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.25 (td, *J* = 15.8, 5.7 Hz, 2F), -140.23 – -140.29 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{23}H_{16}F_4IO_2$ ([M + H]$^+$): 527.0126; found: 527.0136. **HPLC** analysis (IF, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated 99% ee, t_R (minor) = 9.24 min, t_R (major) = 9.86 min. $[\alpha]_D^{25}$ = + 12.19 (c = 1.0, CH_2Cl_2).

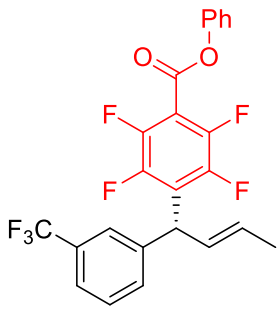


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	9.382	M	0.4102	568975	35127	50.0198
2	9.912	M	0.4940	568524	29941	49.9802

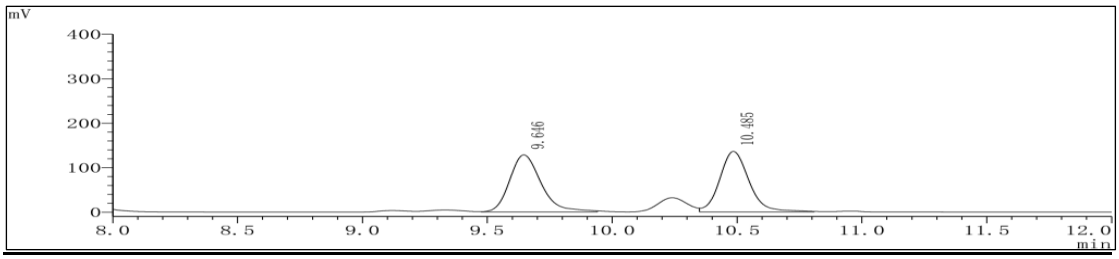


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	9.235	M	0.4343	4746	252	0.6755
2	9.857	M	0.4240	697897	40852	99.3245

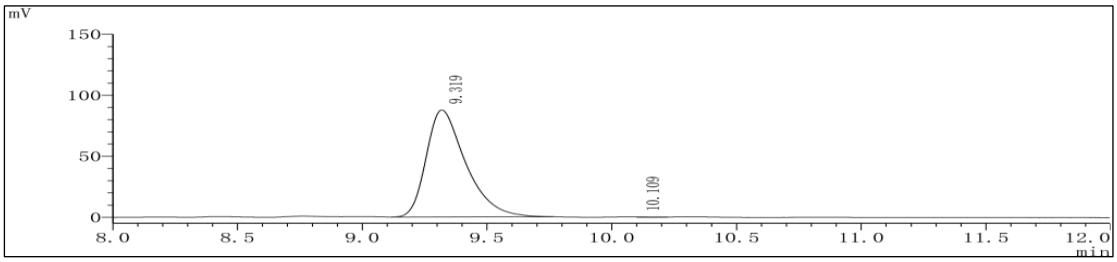
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-(3-(trifluoromethyl)phenyl)but-2-en-1-yl)benzoate (5o)



This compound was obtained in 86% (80.5 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.53 (d, *J* = 7.0 Hz, 2H), 7.45 – 7.41 (m, 4H), 7.30 (t, *J* = 7.5 Hz, 1H), 7.24 (d, *J* = 8.0 Hz, 2H), 6.03 (dd, *J* = 14.0, 8.5 Hz, 1H), 5.82 – 5.75 (m, 1H), 5.21 (d, *J* = 8.5 Hz, 1H), 1.81 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.06, 150.11, 145.12 (dm, *J* = 257.0 Hz), 144.84 (dm, *J* = 246.8 Hz), 141.24, 131.17, 130.74, 129.66, 129.13, 127.03 (t, *J* = 2.2 Hz), 126.62, 125.98 (t, *J* = 15.9 Hz), 124.16 – 124.01 (m), 123.98 (q, *J* = 270.8 Hz), 121.29, 110.80 (t, *J* = 15.1 Hz), 43.84, 17.88. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -62.57 (s, 3F), -138.15 – -138.22 (m, 2F), -140.35 – -140.41 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{24}H_{16}F_7O_2$ ([M + H]$^+$): 469.1033; found: 469.1039. **HPLC** analysis (AD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (major) = 9.32 min, t_R (minor) = 10.11 min. $[\alpha]_D^{25}$ = + 9.43 (c = 1.0, CH_2Cl_2).

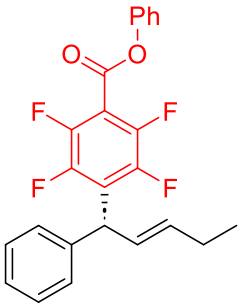


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	9.646	M	0.2237	1122253	127988	50.2460
2	10.485	M	0.2083	1111265	135586	49.7540

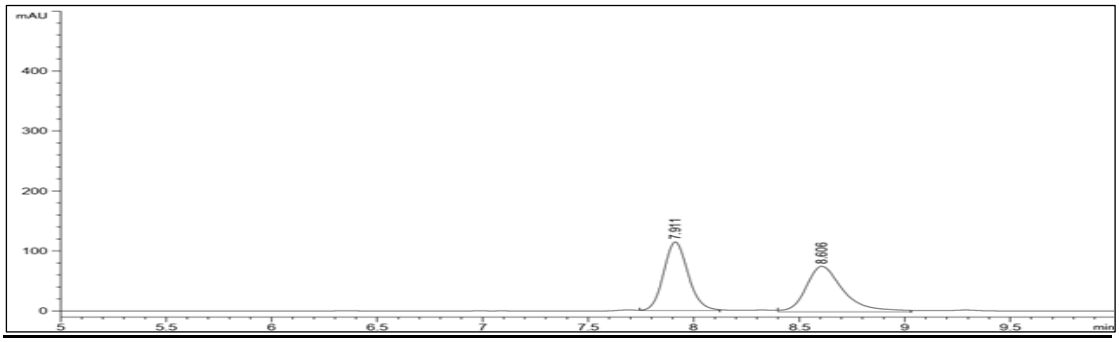


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	9.319	M	0.2836	970429	87645	99.9030
2	10.109	M	0.5686	942	210	0.0970

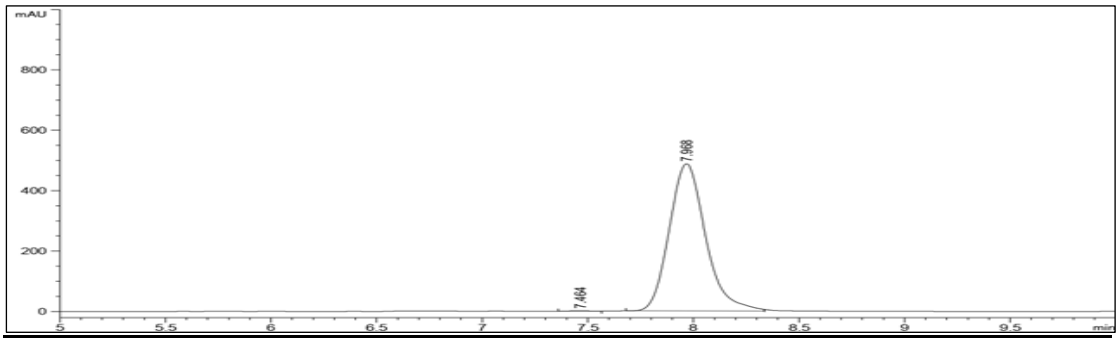
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-phenylpent-2-en-1-yl)benzoate (5p)



This compound was obtained in 75% (62.1 mg) yield as colorless oil by the General procedure H. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.44 (t, *J* = 7.8 Hz, 2H), 7.34 – 7.29 (m, 3H), 7.26 – 7.23 (m, 5H), 6.03 (dd, *J* = 15.0, 9.0 Hz, 1H), 5.80 – 5.75 (m, 1H), 5.18 (d, *J* = 8.4 Hz, 1H), 2.17 – 2.12 (m, 2H), 1.04 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.25, 150.11, 145.08 (dm, *J* = 256.2 Hz), 144.63 (dm, *J* = 246.9 Hz), 140.29, 136.99, 129.65, 128.63, 127.32, 127.09 (t, *J* = 16.4 Hz), 127.06, 126.58, 125.79, 121.33, 110.23 (t, *J* = 15.2 Hz), 44.10, 25.47, 13.41. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.61 – -138.68 (m, 2F), -140.28 – -140.34 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{24}H_{18}F_4NaO_2$ ([M + Na]$^+$): 437.1135; found: 437.1130. **HPLC** analysis (IF, Hexane/IPA = 99.0/1.0, 1.0 mL/min, 254 nm) indicated >99% ee, tR (minor) = 7.46 min, tR (major) = 7.97 min. $[\alpha]_D^{25}$ = − 18.10 (c = 1.0, CH_2Cl_2).

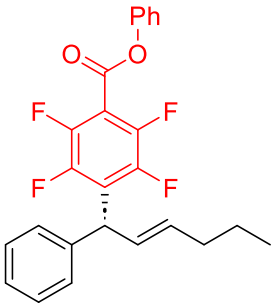


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	7.911	MM R	0.1342	922.01996	114.47403	49.8531
2	8.606	MM R	0.2039	927.45471	75.79124	50.1469

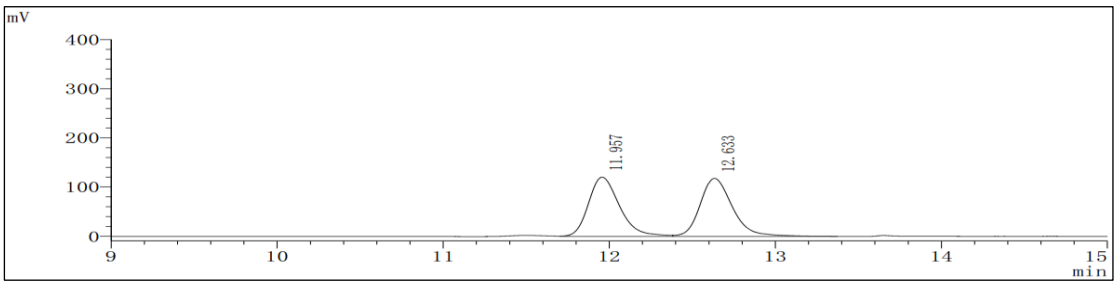


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	7.464	MM R	0.1414	15.38862	1.81406	0.2639
2	7.968	MF R	0.1990	5816.44727	487.14172	99.7361

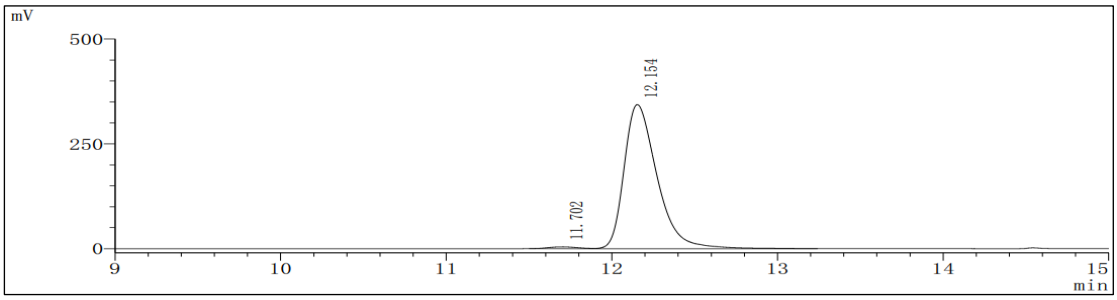
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-phenylhex-2-en-1-yl)benzoate (5q)



This compound was obtained in 86% (73.6 mg) yield as colorless oil by the General procedure H. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.44 (t, *J* = 7.8 Hz, 2H), 7.34 – 7.29 (m, 3H), 7.26 – 7.23 (m, 5H), 6.04 (dd, *J* = 15.0, 8.4 Hz, 1H), 5.74 – 5.70 (m, 1H), 5.19 (d, *J* = 8.4 Hz, 1H), 2.10 (q, *J* = 7.2 Hz, 2H), 1.48 – 1.42 (m, 2H), 0.93 (t, *J* = 7.2Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.28, 150.14, 145.11(dm, *J* = 256.5 Hz), 144.66 (dm, *J* = 246.6 Hz), 140.32, 135.38, 129.68, 128.67, 127.36, 127.12(t, *J* = 16.1 Hz), 127.09, 126.93, 126.61, 121.36, 110.27 (t, *J* = 15.0 Hz), 44.17, 34.50, 22.28, 13.71. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.59 – -138.66 (m, 2F), -140.29 – -140.34 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{25}H_{20}F_4NaO_2$ ([M + Na]$^+$): 451.1292; found: 451.1281. **HPLC** analysis (OD-H, Hexane/IPA = 99.9/0.1, 0.5 mL/min, 254 nm) indicated 98% ee, tR (minor) = 11.70 min, tR (major) = 12.15 min. $[\alpha]_D^{25}$ = + 25.83 (c = 1.0, CH_2Cl_2).

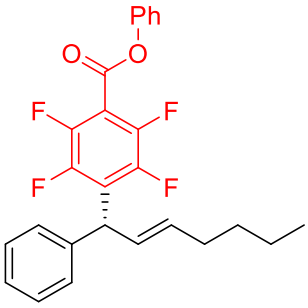


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.957	M	0.3350	1580124	120728	49.6750
2	12.633	M	0.3433	1600798	118061	50.3250

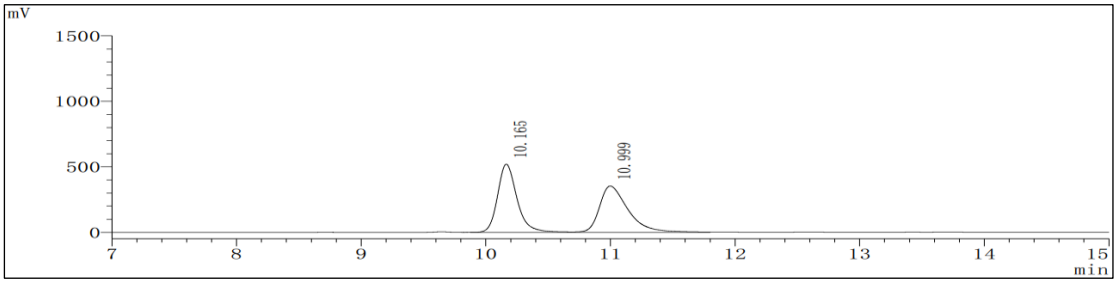


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.702	M	0.3357	51492	4164	1.0689
2	12.154	M	0.3525	4765679	343571	98.9311

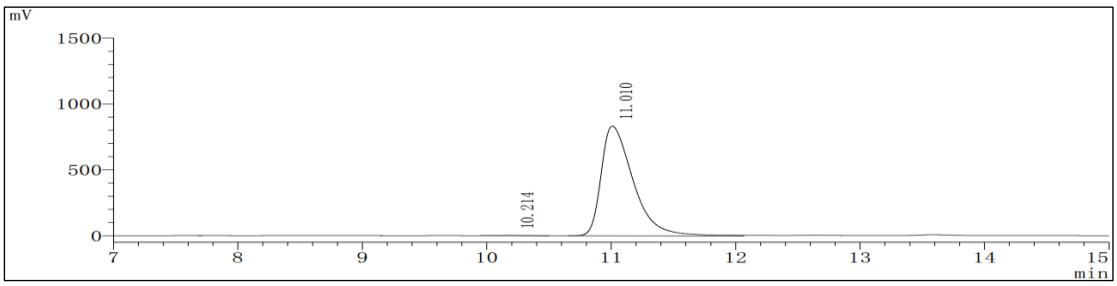
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-phenylhept-2-en-1-yl)benzoate (5r)



This compound was obtained in 81% (71.6 mg) yield as colorless oil by the General procedure H. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.44 (t, *J* = 7.8 Hz, 2H), 7.34 – 7.29 (m, 3H), 7.26 – 7.23 (m, 5H), 6.03 (dd, *J* = 15.6, 8.4 Hz, 1H), 5.74 – 5.70 (m, 1H), 5.18 (d, *J* = 8.4 Hz, 1H), 2.12 (q, *J* = 7.2 Hz, 2H), 1.43 – 1.38 (m, 2H), 1.37 – 1.31 (m, 2H), 0.91 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.25, 150.11, 145.08(dm, *J* = 256.5 Hz), 144.63 (dm, *J* = 246.6 Hz), 140.30, 135.57, 129.65, 128.63, 127.32, 127.09 (t, *J* = 42.6 Hz), 127.06, 126.65, 126.58, 121.33, 110.23 (t, *J* = 15.2 Hz), 44.13, 32.11, 31.23, 22.24, 13.90. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ --138.59 – -138.66 (m, 2F), -140.32 (dd, *J* = 20.9, 11.9 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{26}H_{22}F_4NaO_2$ ([M + Na]$^+$): 465.1448; found: 465.1455. **HPLC** analysis (IF, Hexane/IPA = 99.8/0.2, 0.5 mL/min, 254 nm) indicated >99% ee, tR (minor) = 10.21 min, tR (major) = 11.01 min. $[\alpha]_D^{25}$ = − 7.26 (c = 1.0, CH_2Cl_2).

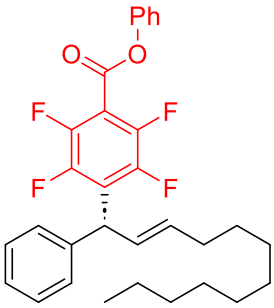


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.165	M	0.2729	5632111	520112	49.8843
2	10.999	M	0.4024	5658238	353152	50.1157

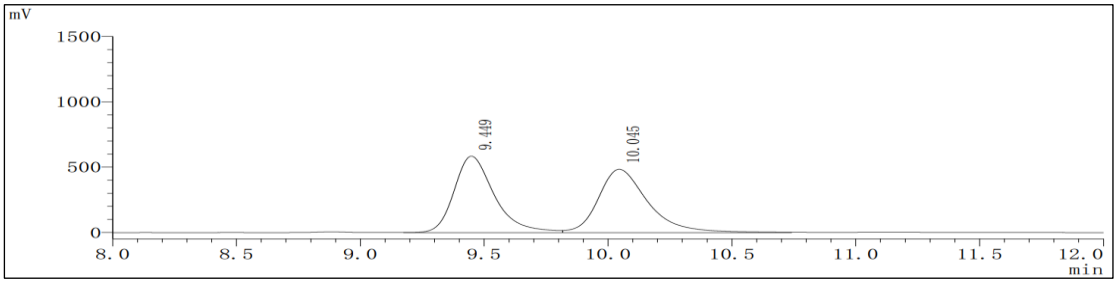


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.214	M	0.3930	26312	1713	0.1765
2	11.010	M	0.4539	14885585	831375	99.8235

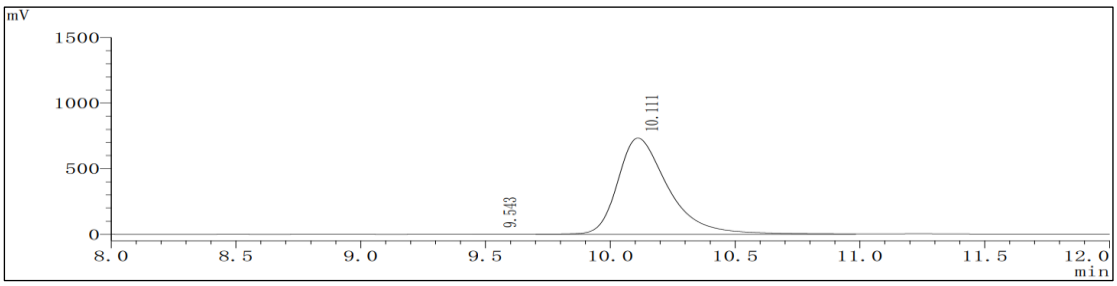
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-phenyldodec-2-en-1-yl)benzoate (5s)



This compound was obtained in 84% (86.0 mg) yield as colorless oil by the General procedure H. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.44 (t, *J* = 7.8 Hz, 2H), 7.34 – 7.29 (m, 3H), 7.26 – 7.23 (m, 5H), 6.03 (dd, *J* = 15.0, 8.4 Hz, 1H), 5.74 – 5.70 (m, 1H), 5.18 (d, *J* = 8.4 Hz, 1H), 2.11 (q, *J* = 7.2 Hz, 2H),1.43 – 1.39 (m, 2H), 1.31 – 1.27 (m, 12H), 0.88 (t, *J* = 6.9 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.24, 150.11, 145.08 (dm, *J* = 256.4 Hz), 144.63 (dm, *J* = 246.0 Hz), 140.30, 135.62, 129.64, 128.63, 127.33, 127.09 (t, *J* = 16.1 Hz), 127.05, 126.66, 126.57, 121.33, 110.22 (t, *J* = 15.1 Hz), 44.13, 32.41, 31.89, 29.57, 29.43, 29.30, 29.17, 29.06, 22.68, 14.11. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.60 – -138.67 (m, 2F), -140.27 – -140.33 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{31}H_{33}F_4O_2$ ([M + H]$^+$): 513.2411; found: 513.2423. **HPLC** analysis (IF, Hexane/IPA = 99.8/0.2, 0.5 mL/min, 254 nm) indicated >99% ee, tR (minor) = 9.54 min, tR (major) = 10.11 min. $[\alpha]_D^{25}$ = − 24.11 (c = 1.0, CH_2Cl_2).

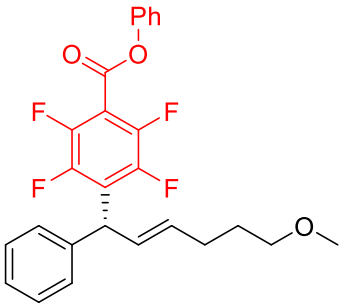


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	9.449	M	0.2852	6616862	584009	49.5673
2	10.045	M	0.3471	6732379	484060	50.4327

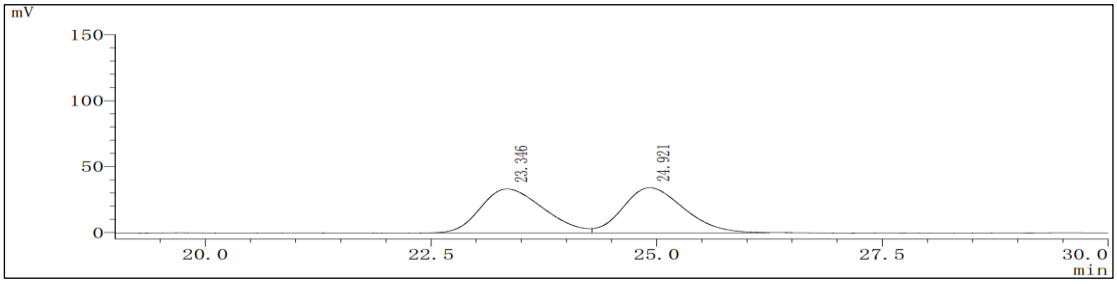


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	9.543	M	0.2014	6218	814	0.0602
2	10.111	M	0.3521	10326864	732598	99.9398

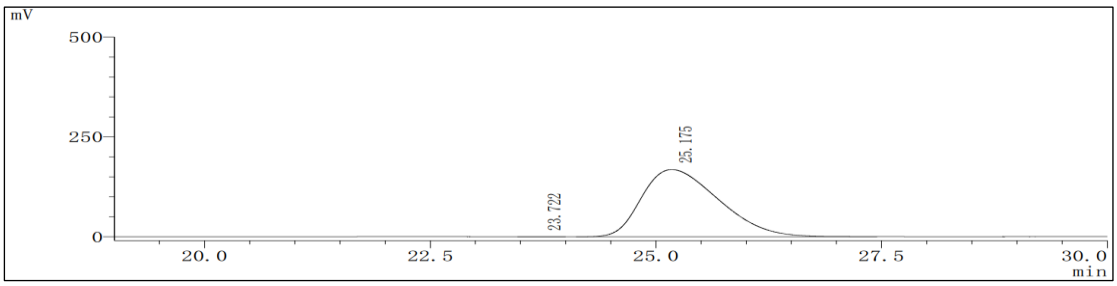
phenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(6-methoxy-1-phenylhex-2-en-1-yl)benzoate (5t)



This compound was obtained in 83% (76.1 mg) yield as colorless oil by the General procedure H. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.41 (t, *J* = 7.8 Hz, 2H), 7.30 – 7.25 (m, 3H), 7.23 – 7.20 (m, 5H), 6.04 (dd, *J* = 15.0, 8.4 Hz, 1H), 5.72 – 5.67 (m, 1H), 5.15 (d, *J* = 8.4 Hz, 1H), 3.36 (t, *J* = 6.6 Hz, 2H), 3.30 (s, 3H), 2.17 (q, *J* = 7.8 Hz, 2H), 1.69 – 1.65 (m, 2H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.20, 150.10, 145.07 (dm, *J* = 256.7 Hz), 144.61 (dm, *J* = 246.9 Hz), 140.15, 134.62, 129.63, 128.65, 127.32, 127.10, 126.92 (t, *J* = 16.2 Hz), 126.57, 121.31, 110.29 (t, *J* = 15.0 Hz), 71.95, 58.55, 44.08, 29.01, 28.96. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.55 – -138.62 (m, 2F), -140.26 – -140.31 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{26}H_{22}F_4NaO_3$ ([M + Na]$^+$): 481.1397; found: 481.1391. **HPLC** analysis (OD-H, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated >99% ee, tR (minor) = 23.72 min, tR (major) = 25.18 min. $[\alpha]_D^{25}$ = − 16.37 (c = 1.0, CH_2Cl_2).

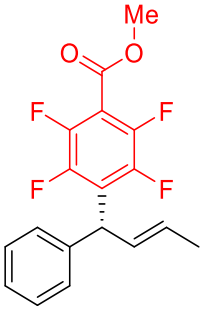


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	23.346	M	1.2895	1618451	33329	50.0400
2	24.921	M	1.2416	1615861	34263	49.9600

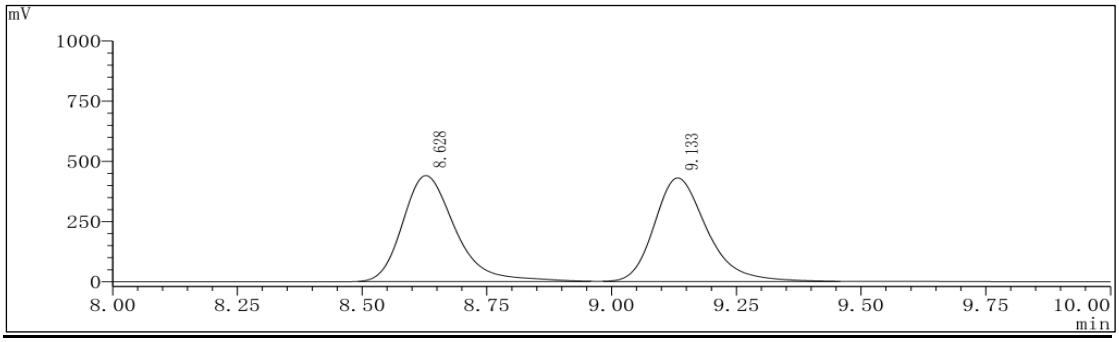


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	23.722	M	0.3409	1820	103	0.0182
2	25.175	M	1.5793	10000963	168471	99.9818

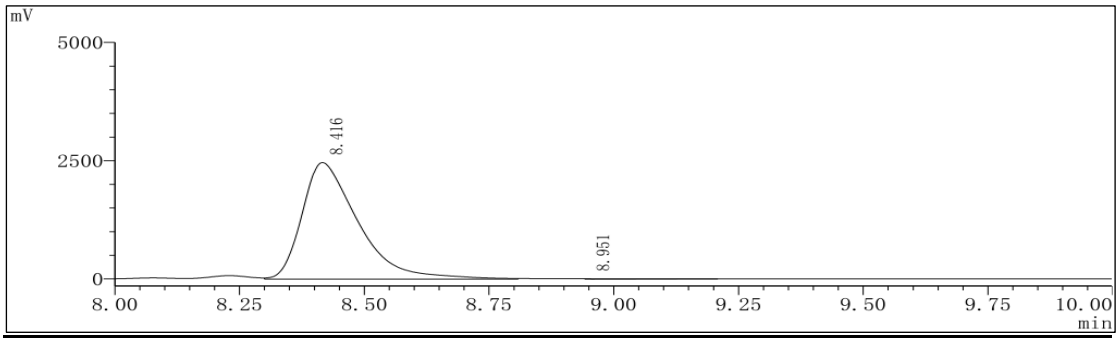
methyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-phenylbut-2-en-1-yl)benzoate (5u)



This compound was obtained in 97% (65.6 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.31 (t, *J* = 7.5 Hz, 2H), 7.23 (t, *J* = 8.5 Hz, 3H), 6.04 (dd, *J* = 14.0, 9.5 Hz, 1H), 5.75 – 5.68 (m, 1H), 5.14 (d, *J* = 8.5 Hz, 1H), 3.96 (s, 3H), 1.77 (d, *J* = 6.0 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 160.27, 144.81 (dm, *J* = 255.4 Hz), 144.51 (dm, *J* = 246.2 Hz), 140.31, 129.93, 128.58, 128.07 (t, *J* = 2.5 Hz), 127.29, 127.00, 126.26 (t, *J* = 16.1 Hz), 110.67 (t, *J* = 15.7 Hz), 53.16, 44.07, 17.84. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -139.49 – -139.56 (m, 2F), -140.74 – -140.80 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{18}H_{15}F_4O_2$ ([M + H]$^+$): 339.1003; found: 339.1007. **HPLC** analysis (AD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (major) = 8.42 min, t_R (minor) = 8.95 min. $[\alpha]_D^{25}$ = − 10.17 (c = 1.0, CH_2Cl_2).

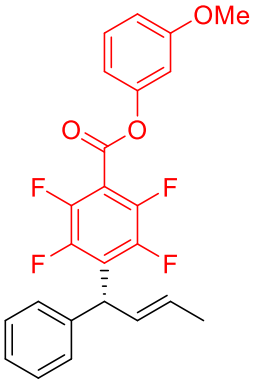


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	8.628	M	0.1868	3256518	439754	50.5774
2	9.133	M	0.1878	3182159	429712	49.4226

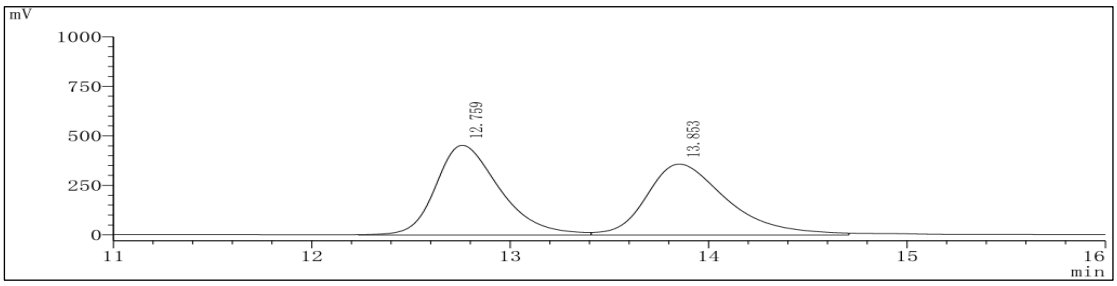


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	8.416	M	0.2028	19239984	2457693	99.6848
2	8.951	M	--	60840	5846	0.3152

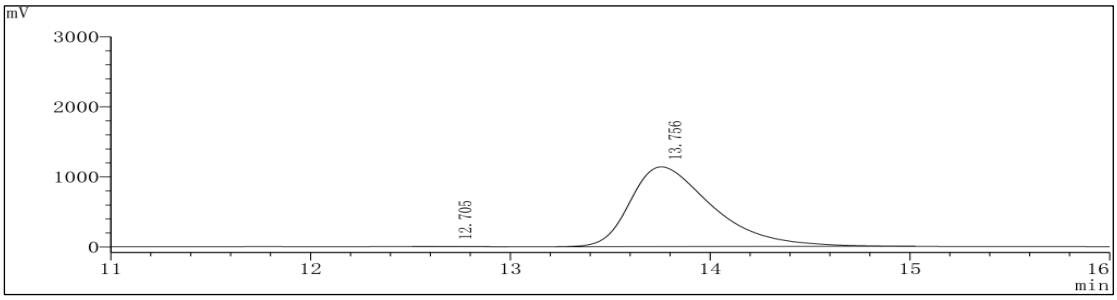
3-methoxyphenyl (*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-phenylbut-2-en-1-yl)benzoate (5v)



This compound was obtained in 90% (77.4 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.32 (t, *J* = 8.5 Hz, 3H), 7.25 (t, *J* = 6.0 Hz, 3H), 6.85 – 6.83 (m, 2H), 6.78 (t, *J* = 2.3 Hz, 1H), 6.09 – 6.04 (m, 1H), 5.78 – 5.71 (m, 1H), 5.18 (d, *J* = 8.5 Hz, 1H), 3.82 (s, 3H), 1.79 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 160.59, 158.11, 150.98, 145.07 (dm, *J* = 256.7 Hz), 144.61 (dm, *J* = 246.6 Hz), 140.21, 130.10, 130.03, 128.63, 127.95 (t, *J* = 2.3 Hz), 127.30, 127.07, 127.03 (t, *J* = 16.1 Hz), 113.46, 112.44, 110.20 (t, *J* = 15.1 Hz), 107.32, 55.49, 44.14, 17.89. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.61 – -138.68 (m, 2F), -140.33 – -140.39 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{24}H_{18}F_4NaO_3$ ([M + Na]$^+$): 453.1084; found: 453.1075. **HPLC** analysis (IF, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated >99% ee, t_R (minor) = 12.71 min, t_R (major) = 13.76 min. $[\alpha]_D^{25}$ = + 10.04 (c = 1.0, CH_2Cl_2).

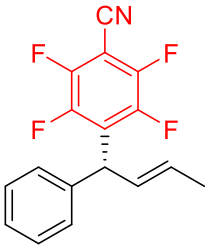


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	12.759	M	0.5779	10203025	452977	50.1575
2	13.853	M	0.7155	10138956	358214	49.8425

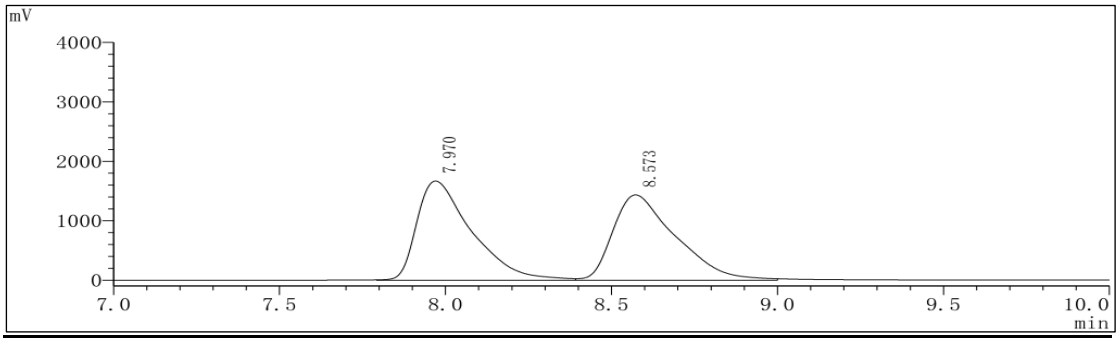


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	12.705	M	0.3994	21971	1303	0.0671
2	13.756	M	0.7331	32700259	1137878	99.9329

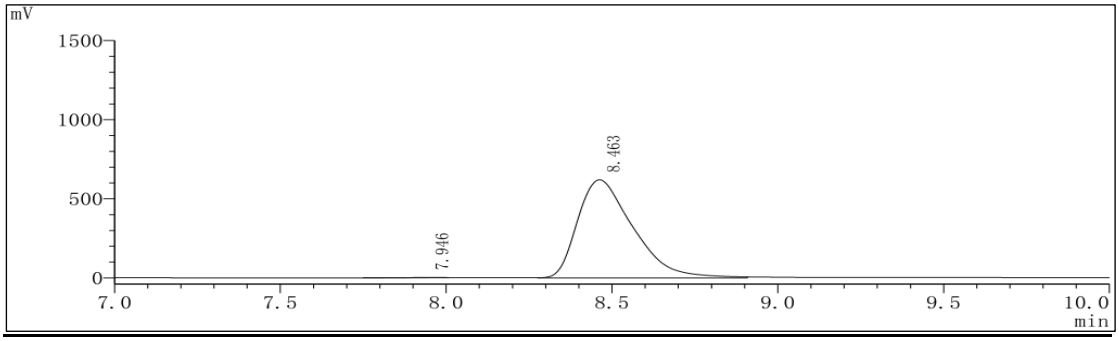
(*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-phenylbut-2-en-1-yl)benzonitrile (5w)



This compound was obtained in 37% (22.6 mg) yield as colorless oil by the General procedure G. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.32 (t, *J* = 7.3 Hz, 2H), 7.26 (t, *J* = 7.0 Hz, 1H), 7.21 (d, *J* = 7.5 Hz, 2H), 6.03 (dd, *J* = 15.5, 9.0 Hz, 1H), 5.78 – 5.71 (m, 1H), 5.17 (d, *J* = 8.5 Hz, 1H), 1.78 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.24 (dm, *J* = 260.6 Hz), 144.43 (dm, *J* = 247.8 Hz), 139.56, 130.80, 130.08 (t, *J* = 16.0 Hz), 128.77, 127.34, 127.24, 107.53 (t, *J* = 3.7 Hz), 92.41 (t, *J* = 17.0 Hz), 44.42, 17.90. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.36 (td, *J* = 16.4, 7.3 Hz), -138.35 (td, *J* = 16.4, 7.3 Hz). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{17}H_{12}F_4N$ ([M + H]$^+$): 306.0900; found: 306.0901. **HPLC** analysis (AD-3, Hexane/IPA = 99.5/0.5, 0.5 mL/min, 254 nm) indicated >99% ee, tR (minor) = 7.95 min, tR (major) = 8.46 min. $[\alpha]_D^{25}$ = − 5.39 (c = 1.0, CH_2Cl_2).

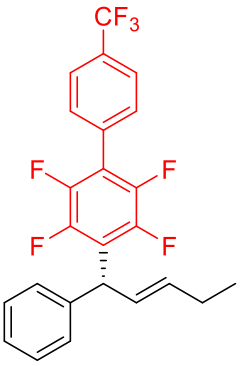


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	7.970	M	0.2832	19148896	1666525	50.4299
2	8.573	M	0.3343	18822383	1435330	49.5701

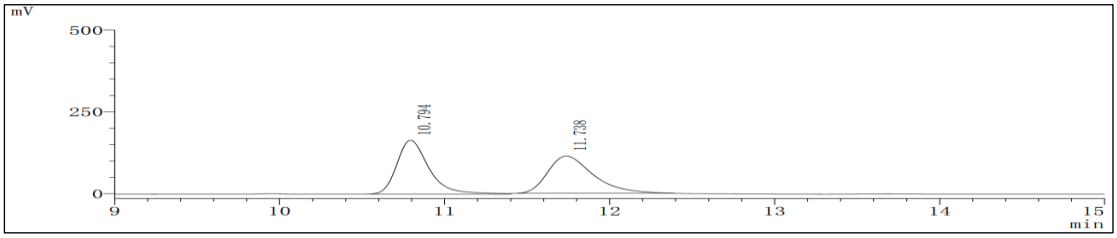


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	7.946	M	0.1337	7321	1252	0.1014
2	8.463	M	0.3028	7213569	619795	99.8986

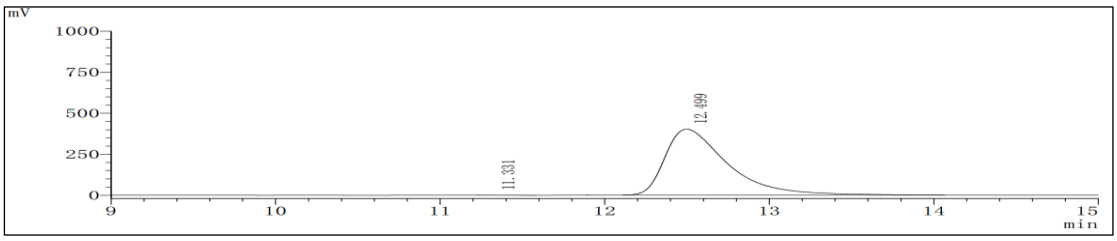
(*R*,*E*)-2,3,5,6-tetrafluoro-4-(1-phenylpent-2-en-1-yl)-4'-(trifluoromethyl)-1,1'-biphenyl (5x)



This compound was obtained in 87% (76.2 mg) yield as colorless oil by the General procedure H. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.74 (d, *J* = 7.8 Hz, 2H), 7.59 (d, *J* = 7.8 Hz, 2H), 7.35 – 7.30 (m, 4H), 7.26 – 7.24 (m, 1H), 6.08 (dd, *J* = 15.0, 8.4 Hz, 1H), 5.81 – 5.76 (m, 1H), 5.18 (d, *J* = 8.4 Hz, 1H), 2.17 (p, *J* = 7.2 Hz, 2H), 1.05 (t, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 144.80 (dm, *J* = 245.1 Hz), 143.84 (dm, *J* = 246.8 Hz), 140.99, 136.43, 131.26, 131.06 (q, *J* = 32.6 Hz), 130.58 (t, *J* = 2.3 Hz), 128.57, 127.44, 126.90, 126.43, 125.53 (q, *J* = 3.8 Hz), 123.86 (q, *J* = 270.6 Hz), 122.86 (t, *J* = 16.4 Hz), 117.34 (t, *J* = 16.4 Hz), 44.00, 25.48, 13.46. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -62.85 (s, 3F), -141.67 (dd, *J* = 22.0, 11.9 Hz, 2F), -144.08 (dd, *J* = 22.0, 11.9 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{24}H_{17}F_7Na$ ([M + Na]$^+$): 461.1111; found: 461.1127. **HPLC** analysis (IF, Hexane/IPA = 99.8/0.2, 0.5 mL/min, 254 nm) indicated >99% ee, tR (minor) = 11.33 min, tR (major) = 12.50 min. $[\alpha]_D^{25}$ = − 35.68 (c = 1.0, CH_2Cl_2).

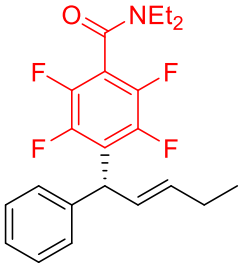


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.794	M	0.3401	2244438	164702	50.7798
2	11.738	M	0.4954	2175508	113593	49.2202

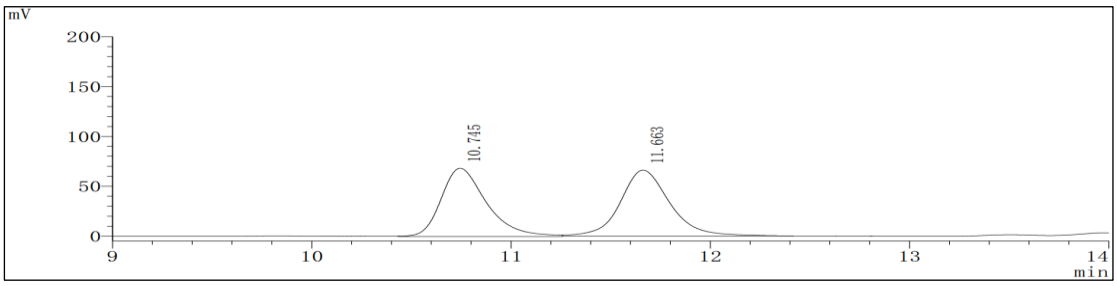


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	11.331	M	0.2848	6512	574	0.0615
2	12.499	M	0.6559	10575859	401924	99.9385

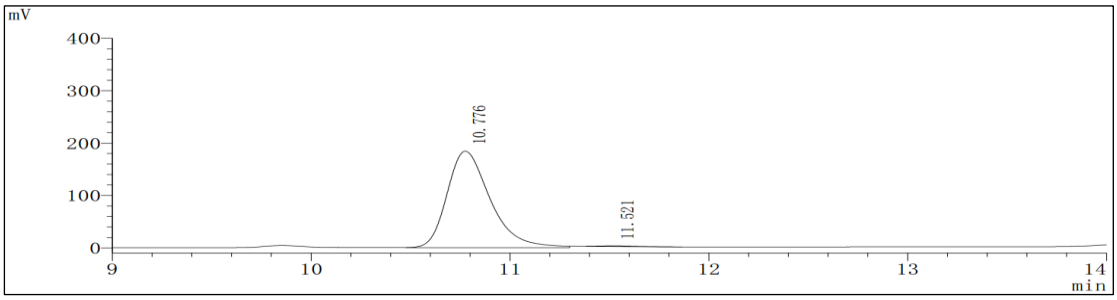
(*R*,*E*)-N,N-diethyl-2,3,5,6-tetrafluoro-4-(1-phenylpent-2-en-1-yl)benzamide (5y)



This compound was obtained in 76% (59.8 mg) yield as colorless oil by the General procedure H. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.32 (t, *J* = 7.8 Hz, 2H), 7.25 (d, *J* = 7.8 Hz, 3H), 6.02 (dd, *J* = 15.0, 9.0 Hz, 1H), 5.77 – 5.72 (m, 1H), 5.12 (d, *J* = 8.4 Hz, 1H), 3.59 (q, *J* = 7.2 Hz, 2H), 3.25 (q, *J* = 7.2 Hz, 2H), 2.16 – 2.11 (m, 2H), 1.26 (t, *J* = 7.2 Hz, 3H), 1.14 (t, *J* = 7.2 Hz, 3H), 1.04 (t, *J* = 7.8 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.76, 144.47 (dm, *J* = 246.6 Hz), 142.41 (dm, *J* = 247.5 Hz), 140.71, 136.50, 128.54, 127.42, 126.90, 126.23, 123.63 (t, *J* = 16.1 Hz), 115.02 (t, *J* = 22.1 Hz), 43.94, 43.20, 39.57, 25.44, 14.03, 13.41, 12.72. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -140.47 (td, *J* = 23.2, 13.0 Hz, 2F), -142.29 – -142.41 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{22}H_{23}F_4NNaO$ ([M + Na]$^+$): 416.1608; found: 416.1623. **HPLC** analysis (OD-H, Hexane/IPA = 98.0/2.0, 0.5 mL/min, 254 nm) indicated 99% ee, tR (major) = 10.78 min, tR (minor) = 11.52 min. $[\alpha]_D^{25}$ = − 27.43 (c = 1.0, CH_2Cl_2).

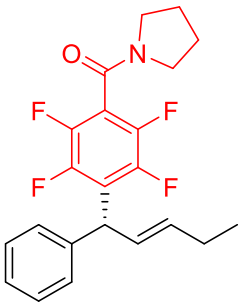


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.745	M	0.4029	1088369	68532	48.9295
2	11.663	M	0.4346	1135991	65980	51.0705

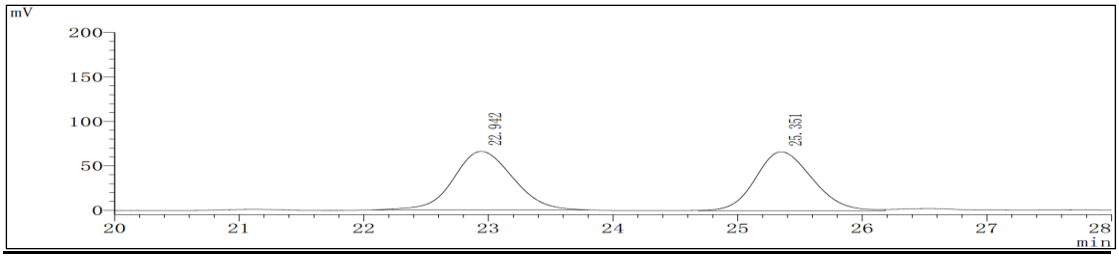


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	10.776	M	0.3846	2785266	184175	99.4146
2	11.521	M	0.3293	16401	1271	0.5854

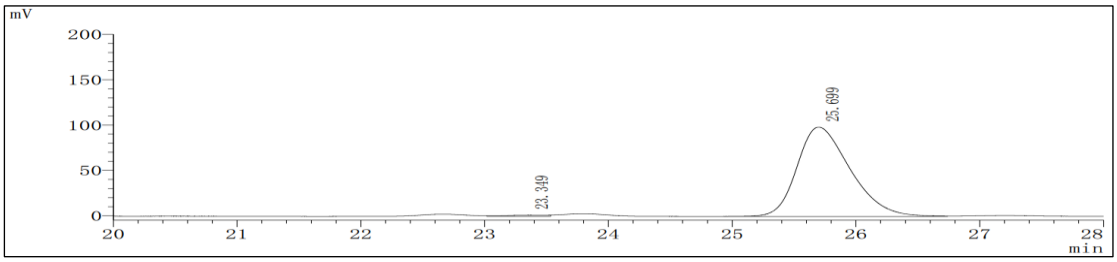
(*R*,*E*)-pyrrolidin-1-yl(2,3,5,6-tetrafluoro-4-(1-phenylpent-2-en-1-yl)phenyl)methanone (5z)



This compound was obtained in 72% (56.3 mg) yield as colorless oil by the General procedure H. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.31 (t, *J* = 7.2 Hz, 2H), 7.24 (t, *J* = 6.3 Hz, 3H), 6.01 (dd, *J* = 15.6, 9.0 Hz, 1H), 5.76 – 5.72 (m, 1H), 5.12 (d, *J* = 8.4 Hz, 1H), 3.67 (t, *J* = 6.9 Hz, 2H), 3.34 (t, *J* = 7.2 Hz, 2H), 2.15 – 2.10 (m, 2H), 2.02 – 1.93 (m, 4H), 1.04 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 157.75, 144.56 (dm, *J* = 246.3 Hz), 142.55 (dm, *J* = 248.0 Hz), 140.65, 136.54, 128.54, 127.38, 126.90, 126.18, 123.96 (t, *J* = 16.1 Hz), 115.42 (t, *J* = 21.2 Hz), 47.57, 45.91, 43.90, 25.65, 25.44, 24.45, 13.42. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -140.38 – -140.52 (m, 2F), -142.00 – -142.13 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{22}H_{21}F_4NNaO$ ([M + Na]$^+$): 414.1451; found: 414.1461. **HPLC** analysis (IF, Hexane/IPA = 95.0/5.0, 0.5 mL/min, 254 nm) indicated 98% ee, tR (major) = 10.78 min, tR (minor) = 11.52 min. $[\alpha]_D^{25}$ = − 27.43 (c = 1.0, CH_2Cl_2).

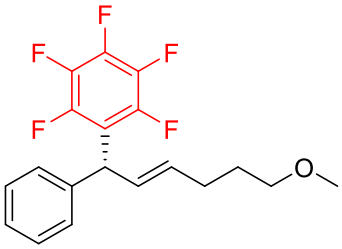


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	22.942	M	0.8608	2184200	65874	50.9598
2	25.351	M	0.8286	2101920	66297	49.0402

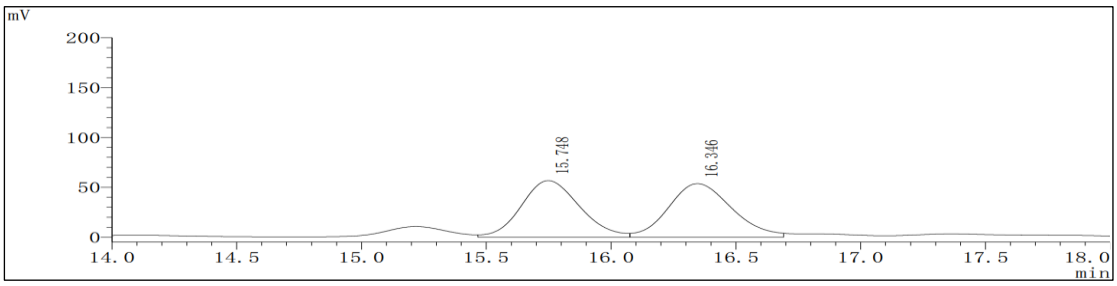


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	23.349	M	3.9176	29792	1219	1.0018
2	25.699	M	0.7831	2944190	98602	98.9982

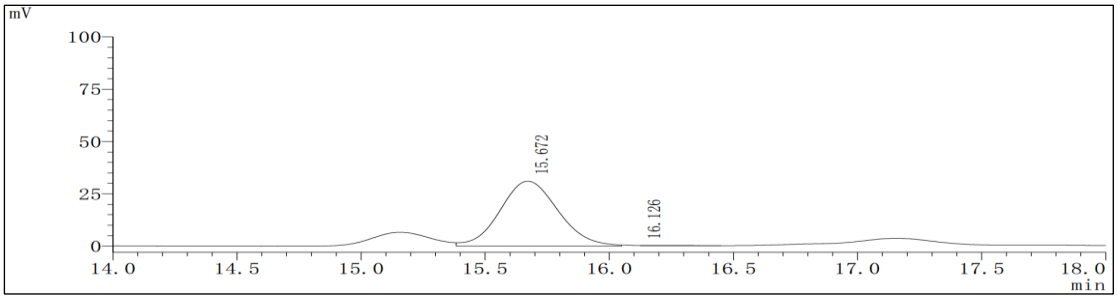
(*R*,*E*)-1,2,3,4,5-pentafluoro-6-(6-methoxy-1-phenylhex-2-en-1-yl)benzene (5aa)



This compound was obtained in 56% (39.9 mg) yield as colorless oil by the General procedure H. NMR Spectroscopy: **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.30 (t, *J* = 7.5 Hz, 2H), 7.24 (d, *J* = 7.2 Hz, 1H), 7.21 (d, *J* = 7.8 Hz, 2H), 6.03 (dd, *J* = 15.0, 8.4 Hz, 1H), 5.69 – 5.65 (m, 1H), 5.08 (d, *J* = 8.4 Hz, 1H), 3.38 (t, *J* = 6.3 Hz, 2H), 3.33 (s, 3H), 2.18 (q, *J* = 7.2 Hz, 2H), 1.71 – 1.66 (m, 2H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 144.75 (dm, *J* = 244.7 Hz), 140.69, 137.64 (dm, *J* = 243.5 Hz), 134.03, 128.56, 127.94, 127.29, 126.93, 117.59, 71.99, 58.56, 43.39, 29.05, 28.91. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -141.54 (dd, *J* = 22.0, 6.2 Hz), -156.87 (t, *J* = 20.9 Hz), -162.00 – -162.09 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{19}H_{17}F_5NaO$ ([M + Na]$^+$): 379.1092; found: 379.1092. **HPLC** analysis (IG, Hexane/IPA = 99.9/0.1, 0.3 mL/min, 254 nm) indicated >99% ee, tR (major) = 15.67 min, tR (minor) = 16.13 min. $[\alpha]_D^{25}$ = − 9.86 (c = 1.0, CH_2Cl_2).

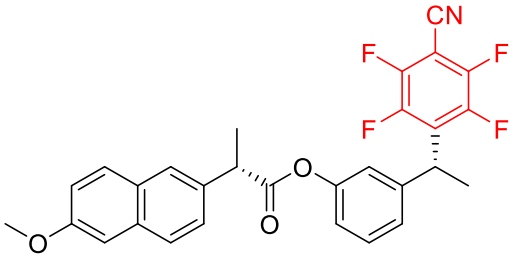


Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.748	M	0.4309	928186	56802	49.4368
2	16.346	M	0.4638	949333	53790	50.5632



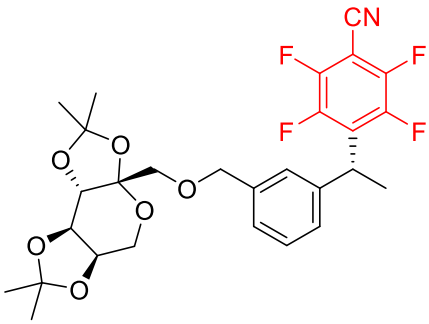
Peak	RetTime	Type	Width(min)	Area(mV*S)	Hight(mV)	Area%
1	15.672	M	0.4269	504070	31019	99.7074
2	16.126	M	--	1479	108	0.2926

3-((*R*)-1-(4-cyano-2,3,5,6-tetrafluorophenyl)ethyl)phenyl (*S*)-2-(6-methoxynaphthalen-2-yl)propanoate (6)



This compound was obtained in 83% (84.2 mg) yield as white solid by the General procedure F. **m.p.** 134 – 135 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.75 – 7.70 (m, 3H), 7.48 (d, *J* = 8.5 Hz, 1H), 7.28 – 7.24 (m, 1H), 7.17 – 7.09 (m, 3H), 6.92 – 6.88 (m, 2H), 4.61 (q, *J* = 7.3 Hz, 1H), 4.08 (q, *J* = 7.2 Hz, 1H), 3.91 (s, 3H), 1.70 (dd, *J* = 17.5, 7.0 Hz, 6H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 173.02, 157.77, 151.11, 147.15 (dm, *J* = 260.6 Hz), 144.62 (dm, *J* = 247.4 Hz), 142.10 (d, *J* = 2.7 Hz), 134.93, 133.80, 131.00 (t, *J* = 15.5 Hz), 129.61, 129.22, 128.93, 127.35, 126.11, 126.00, 124.46 (d, *J* = 3.5 Hz), 120.48 (d, *J* = 2.0 Hz), 120.22, 119.13, 107.39 (t, *J* = 3.6 Hz), 105.59, 92.47, 55.28, 45.55, 35.09, 18.47, 17.57 – 17.64 (m). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.33 (td, *J* = 16.4, 6.8 Hz, 2F), -138.97 – -139.09 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{29}H_{22}F_4NO_3$ ([M + H]$^+$): 508.1530; found: 508.1536. $[\alpha]_D^{25}$ = + 19.26 (c = 1.0, CH_2Cl_2).

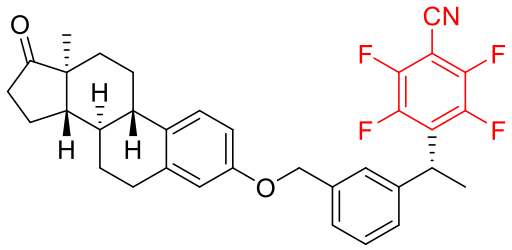
2,3,5,6-tetrafluoro-4-((*R*)-1-(3-((((3a*S*,5a*R*,8a*R*,8b*S*)-2,2,7,7-tetramethyltetrahydro-3aH-bis([1,3]dioxolo)[4,5-b:4',5'-d]pyran-3a-yl)methoxy)methyl)phenyl)ethyl)benzonitrile (7)



This compound was obtained in 76% (83.8 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.31 – 7.27 (m, 2H), 7.21 (t, *J* = 7.0 Hz, 2H), 4.69 – 4.62 (m, 2H), 4.59 – 4.56 (m, 2H), 4.38 (d, *J* = 2.5 Hz, 1H), 4.23 (d, *J* = 8.0 Hz, 1H), 3.91 (d, *J* = 12.5 Hz, 1H), 3.73 (d, *J* = 13.0 Hz, 1H), 3.61 – 3.55 (m, 2H), 1.78 (d, *J* = 7.5 Hz, 3H), 1.55 (s, 3H), 1.40 (s, 6H), 1.33 (s, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 147.18 (dm, *J* = 260.3 Hz), 144.69 (dm, *J* = 247.7 Hz), 140.72, 138.83, 131.66 (t, *J* = 15.5 Hz), 128.69, 126.43, 126.14, 126.11, 108.86, 108.48, 107.47 (t, *J* = 3.6 Hz), 102.56, 92.31, 73.25, 71.60, 70.95, 70.18, 60.93, 35.31, 26.53, 25.75, 25.29, 23.97, 17.65 (t, *J* = 2.8 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.56 (td, *J* = 15.8, 6.8 Hz, 2F), -139.18 (td, *J* = 16.4, 6.8 Hz, 2F).

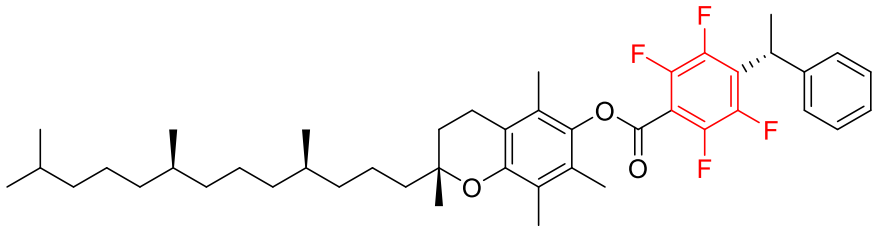
HRMS (ESI-TOF) (m/z): Calcd for $C_{28}H_{29}F_4NNaO_6$ ([M + Na]$^+$): 574.1823; found: 574.1836. $[\alpha]_D^{25}$ = + 35.58 (c = 1.0, CH_2Cl_2).

2,3,5,6-tetrafluoro-4-((*R*)-1-(3-((((8*R*,9*S*,13*S*,14*S*)-13-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-3-yl)oxy)methyl)phenyl)ethyl)benzonitrile (8)



This compound was obtained in 85% (95.4 mg) yield as white solid by the General procedure F. **m.p.** 178 – 179 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.36 – 7.32 (m, 3H), 7.26 (d, *J* = 5.0 Hz, 1H), 7.20 (d, *J* = 8.5 Hz, 1H), 6.75 (d, *J* = 8.5 Hz, 1H), 6.70 (s, 1H), 5.00 (s, 2H), 4.68 (q, *J* = 7.3 Hz, 1H), 2.90 – 2.87 (m, 2H), 2.50 (dd, *J* = 19.0, 9.0 Hz, 1H), 2.41 – 2.37 (m, 1H), 2.28 – 2.23 (m, 1H), 2.18 – 2.11 (m, 1H), 2.08 – 1.99 (m, 2H), 1.97 – 1.94 (m, 1H), 1.79 (d, *J* = 7.5 Hz, 3H), 1.67 – 1.40 (m, 6H), 0.91 (s, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 220.82, 156.65, 147.18 (dm, *J* = 260.3 Hz), 144.70 (dm, *J* = 247.5 Hz), 140.95, 137.92, 137.82, 132.51, 131.49 (t, *J* = 15.6 Hz), 129.04, 126.56, 126.50, 126.33, 126.24, 114.85, 112.32, 107.45 (t, *J* = 3.7 Hz), 92.33, 69.70, 50.40, 47.97, 43.96, 38.33, 35.84, 35.39, 31.56, 29.62, 26.50, 25.89, 21.56, 17.71 (t, *J* = 3.0 Hz), 13.83. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.47 (td, *J* = 16.4, 7.3 Hz, 2F), -139.03 (td, *J* = 16.4, 7.3 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{34}H_{32}F_4NO_2$ ([M + H]$^+$): 562.2364; found: 562.2355. $[\alpha]_D^{25}$ = + 17.83 (c = 1.0, CH_2Cl_2).

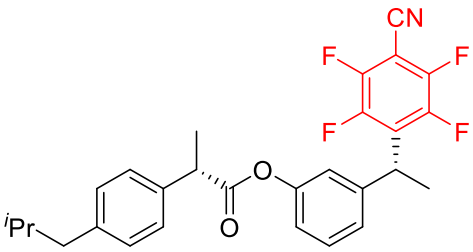
(*R*)-2,5,7,8-tetramethyl-2-((4*R*,8*R*)-4,8,12-trimethyltridecyl)chroman-6-yl 2,3,5,6-tetrafluoro-4-((*R*)-1-phenylethyl)benzoate (9)



This compound was obtained in 75% (106.6 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.33 (d, *J* = 4.5 Hz, 4H), 7.27 – 7.23 (m, 1H), 4.68 (q, *J* = 7.3 Hz, 1H), 2.62 (t, *J* = 6.8 Hz, 2H), 2.11 (d, *J* = 9.0 Hz, 6H), 2.06 (s, 3H), 1.86 – 1.74 (m, 5H), 1.58 – 1.49 (m,

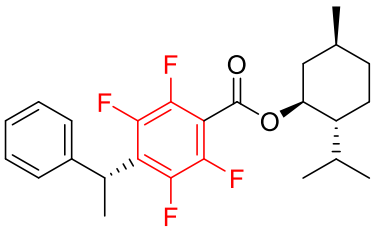
3H), 1.44 – 1.35 (m, 4H), 1.32 – 1.20 (m, 11H), 1.15 – 1.11 (m, 3H), 1.09 – 1.02 (m, 3H), 0.87 – 0.84 (m, 12H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 158.59, 149.93, 144.95 (dm, *J* = 246.3 Hz), 144.76 (dm, *J* = 252.4 Hz), 141.53, 140.29, 128.65, 128.04 (t, *J* = 15.7 Hz), 127.15, 127.04, 126.49, 124.79, 123.38, 117.64, 110.74 (t, *J* = 16.5 Hz), 75.22, 39.38, 37.46, 37.44, 37.42, 37.29, 35.12, 32.80, 32.71, 27.98, 24.80, 24.45, 22.71, 22.62, 21.02, 20.65, 19.75, 19.66, 17.96 (t, *J* = 3.0 Hz), 12.95, 12.10, 11.86. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -138.92 – -138.99 (m, 2F), -141.21 – -141.28 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{44}H_{58}F_4NaO_3$ ([M + Na]$^+$): 733.4214; found: 733.4222. $[\alpha]_D^{25}$ = − 26.75 (c = 1.0, CH_2Cl_2).

3-((*R*)-1-(4-cyano-2,3,5,6-tetrafluorophenyl)ethyl)phenyl (*S*)-2-(4-isobutylphenyl) propanoate (10)



This compound was obtained in 92% (88.9 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.30 – 7.27 (m, 3H), 7.13 (dd, *J* = 16.0, 8.0 Hz, 3H), 6.92 – 6.90 (m, 2H), 4.63 (q, *J* = 7.3 Hz, 1H), 3.92 (q, *J* = 7.2 Hz, 1H), 2.47 (d, *J* = 7.5 Hz, 2H), 1.91 – 1.82 (m, 1H), 1.74 (d, *J* = 7.5 Hz, 3H), 1.60 (d, *J* = 7.0 Hz, 3H), 0.91 (d, *J* = 7.0 Hz, 6H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 173.08, 151.16, 147.19 (dm, *J* = 260.5 Hz), 144.66 (dm, *J* = 247.8 Hz), 142.08, 140.89, 137.06, 131.06 (t, *J* = 15.5 Hz), 129.60, 129.50, 127.17, 124.45, 120.52, 120.23, 107.40 (t, *J* = 3.7 Hz), 92.51, 53.39, 45.25, 45.01, 35.12, 30.16, 22.33 (d, *J* = 2.7 Hz), 18.47, 17.60 (t, *J* = 2.9 Hz). **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -132.32 – -132.39 (m, 2F), -139.07 (td, *J* = 16.4, 6.8 Hz, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{28}H_{25}F_4NNaO_2$ ([M + Na]$^+$): 506.1714; found: 506.1721. $[\alpha]_D^{25}$ = + 32.59 (c = 1.0, CH_2Cl_2).

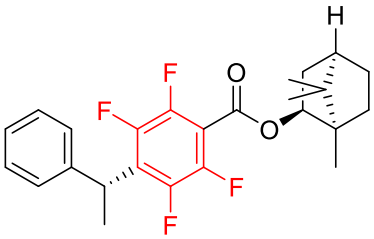
(1*S*,2*R*,5*S*)-2-isopropyl-5-methylcyclohexyl 2,3,5,6-tetrafluoro-4-((*R*)-1-phenyleth yl)benzoate (11)



This compound was obtained in 43% (37.5 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.33 – 7.29 (m, 4H), 7.26 – 7.22 (m, 1H), 4.97 (td, *J* = 11.0, 4.5 Hz, 1H), 4.63 (q, *J* = 7.3 Hz, 1H), 2.17 – 2.13 (m, 1H), 2.01 – 1.95 (m, 1H), 1.77 (d, *J* = 7.5 Hz, 3H), 1.74 – 1.69 (m, 2H), 1.54 – 1.44

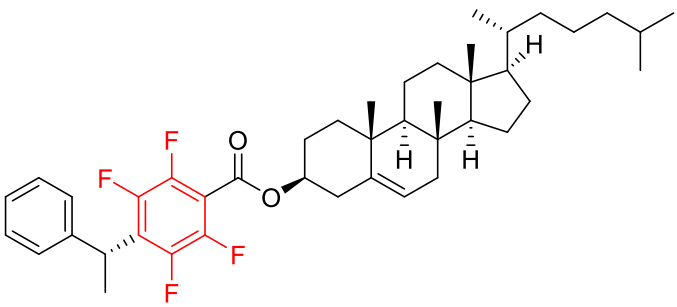
(m, 2H), 1.15 – 1.05 (m, 2H), 0.92 (dd, J = 16.5, 6.5 Hz, 7H), 0.80 (d, J = 70 Hz, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 159.45, 141.64, 144.74 (dm, J = 245.6 Hz), 144.40 (dm, J = 253.5 Hz), 128.59, 127.27 (t, J = 15.8 Hz), 127.11, 126.96, 111.63 (t, J = 16.7 Hz), 77.30, 46.89, 40.62, 34.99, 34.10, 31.49, 25.86, 23.07, 21.95, 20.80, 17.97 (t, J = 3.0 Hz), 15.86. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -140.38 – -140.45 (m, 2F), -141.72 – -141.79 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{25}H_{29}F_4O_2$ ([M + H]$^+$): 437.2098; found: 437.2093. $[\alpha]_D^{25}$ = − 9.94 (c = 1.0, CH_2Cl_2).

(1*R*,2*S*,4*R*)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-yl 2,3,5,6-tetrafluoro-4-((*R*)-1-phenylethyl)benzoate (12)



This compound was obtained in 49% (42.6 mg) yield as colorless oil by the General procedure F. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.32 (d, J = 4.5 Hz, 4H), 7.26 – 7.22 (m, 1H), 5.18 – 5.14 (m, 1H), 4.65 (q, J = 7.3 Hz, 1H), 2.50 – 2.44 (m, 1H), 2.01 – 1.96 (m, 1H), 1.79 – 1.72 (m, 5H), 1.36 – 1.31 (m, 1H), 1.28 – 1.23 (m, 1H), 1.13 (dd, J = 13.5, 3.0 Hz, 1H), 0.94 (s, 3H), 0.90 (s, 6H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 160.10, 144.83 (dm, J = 254.9 Hz), 141.62, 128.61, 127.55 (t, J = 15.8 Hz), 127.13, 126.98, 111.27 (t, J = 15.9 Hz), 82.93, 48.99, 47.90, 44.88, 36.74, 35.04, 27.93, 27.11, 19.67, 18.85, 17.96 (t, J = 2.9 Hz), 13.36. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -139.93 – -140.00 (m, 2F), -141.72 – -141.79 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{25}H_{27}F_4O_2$ ([M + H]$^+$): 435.1942; found: 435.1948. $[\alpha]_D^{25}$ = − 15.71 (c = 1.0, CH_2Cl_2).

(3*S*,8*S*,9*S*,10*R*,13*R*,14*R*,17*R*)-8,10,13-trimethyl-17-((*R*)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthren-3-yl 2,3,5,6-tetrafluoro-4-((*R*)-1-phenylethyl)benzoate (13)

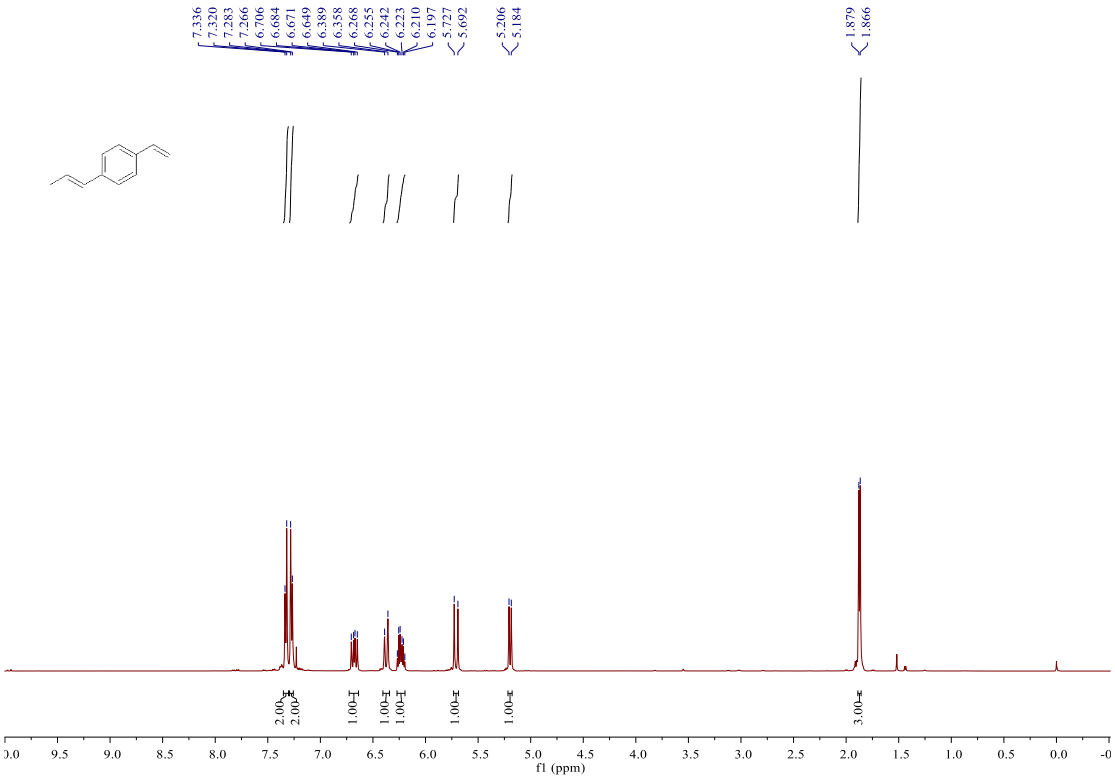


This compound was obtained in 45% (61.2 mg) yield as white solid by the General procedure F. **m.p.** 126 – 127 °C. NMR Spectroscopy: **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 7.33 – 7.29 (m, 4H), 7.25 – 7.22 (m,

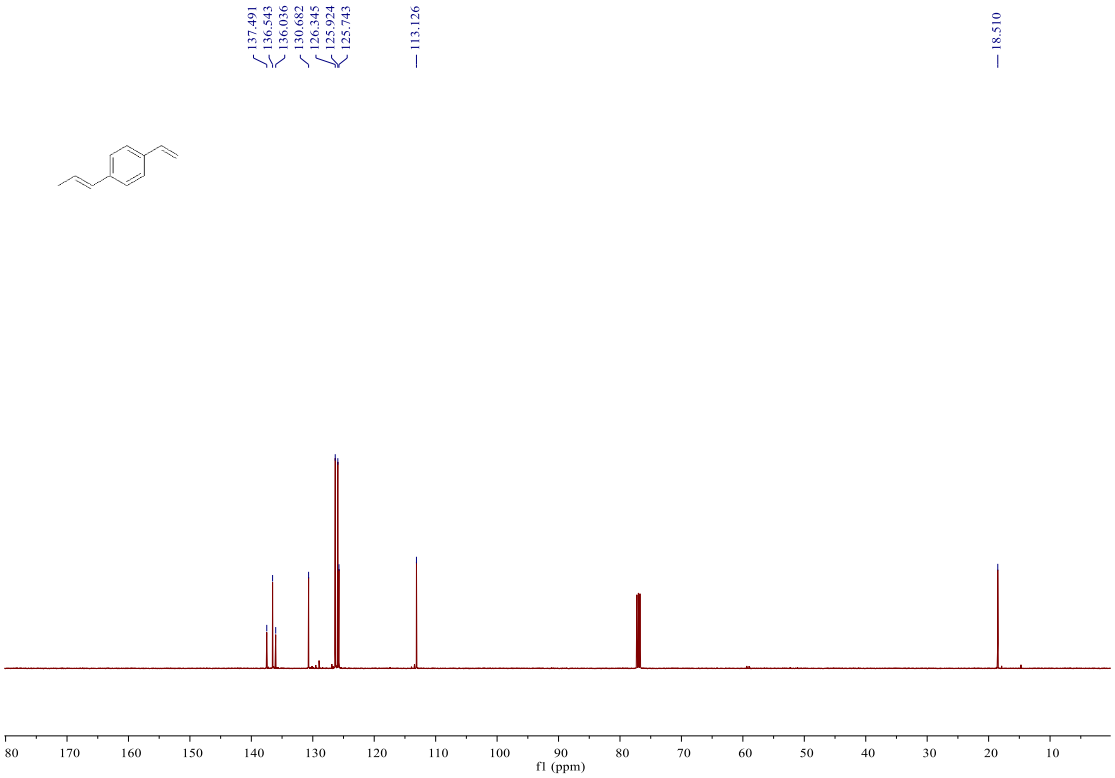
1H), 5.42 (d, *J* = 5.0 Hz, 1H), 4.93 – 4.87 (m, 1H), 4.63 (q, *J* = 7.3 Hz, 1H), 2.48 – 2.43 (m, 2H), 2. 04 – 1.96 (m, 3H), 1.93 – 1.89 (m, 1H), 1.86 – 1.81 (m, 1H), 1.77 (d, *J* = 7.0 Hz, 3H), 1.72 – 1.67 (m, 1H), 1.61 – 1.55 (m, 3H), 1.53 – 1.44 (m, 4H), 1.40 – 1.31 (m, 3H), 1.28 – 1.20 (m, 2H), 1.19 – 1.07 (m, 7H), 1.03 – 0.97 (m, 6H), 0.92 (d, *J* = 6.5 Hz, 3H), 0.87 (dd, *J* = 6.5, 2.5 Hz, 6H), 0.68 (s, 3H). **^{13}C NMR** (151 MHz, Chloroform-*d*) δ 159.15, 144.75 (dm, *J* = 245.7 Hz), 144.53 (dm, *J* = 254.4 Hz), 141.61, 139.13, 128.59, 127.45 (t, *J* = 15.7 Hz), 127.10, 126.96, 123.22, 111.43 (t, *J* = 16.2 Hz), 76.69, 56.68, 56.15, 50.01, 42.32, 39.72, 39.52, 37.89, 36.91, 36.59, 36.19, 35.79, 35.00, 31.91, 31.85, 28.22, 28.01, 27.65, 24.28, 23.84, 22.81, 22.56, 21.04, 19.28, 18.72, 17.97 (t, *J* = 2.9 Hz), 11.86. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -140.26 – -140.33 (m, 2F), -141.72 – -141.79 (m, 2F). **HRMS** (ESI-TOF) (m/z): Calcd for $C_{43}H_{57}F_4O_2$ ($[M + H]^+$): 681.4289; found: 681.4297. $[\alpha]_D^{25}$ = − 26.77 (c = 1.0, CH_2Cl_2).

9. NMR Spectra of Compounds

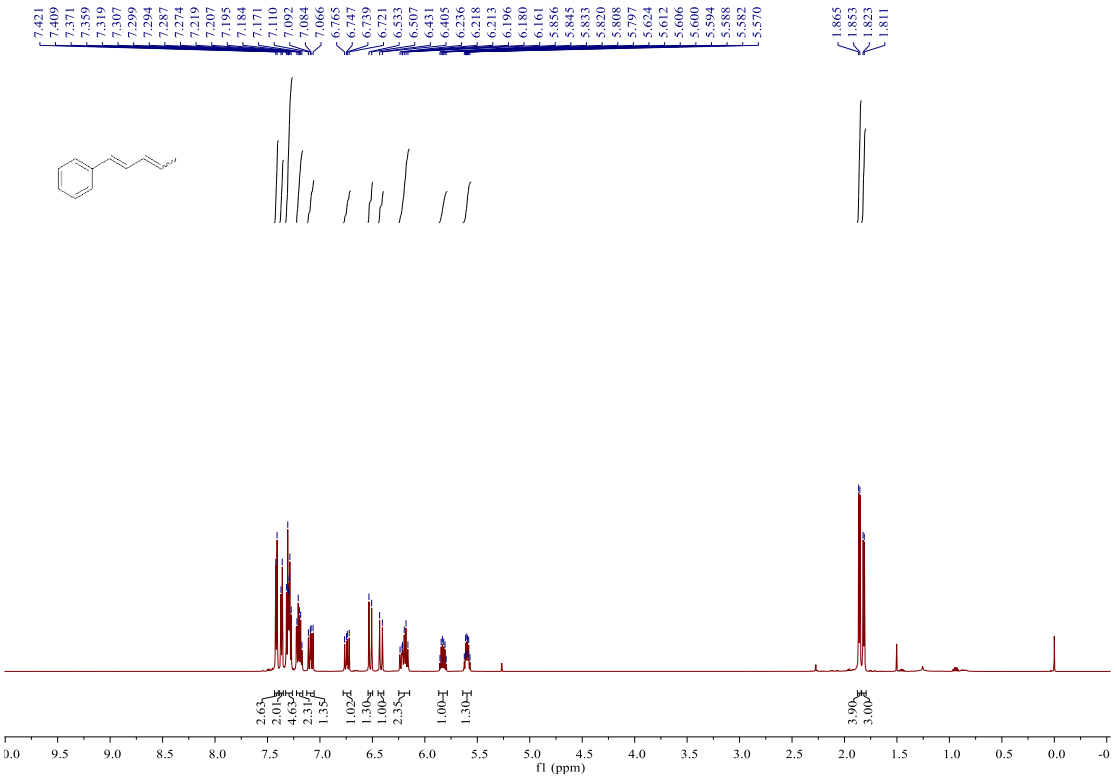
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 1r



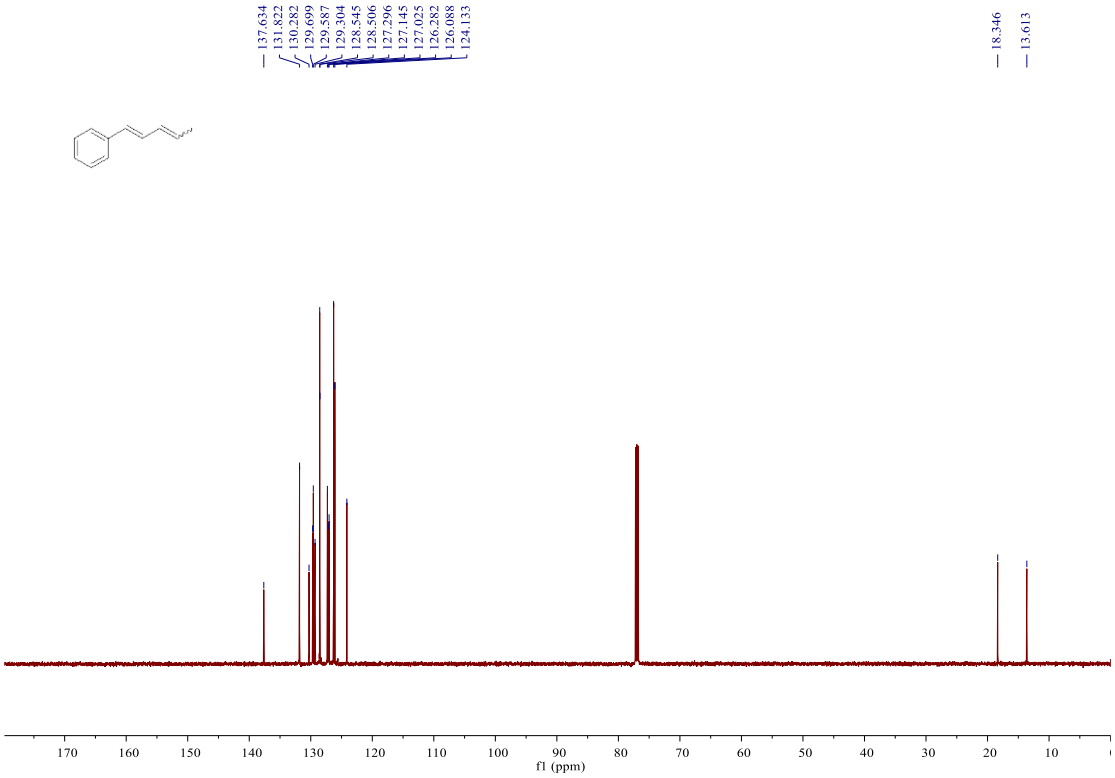
^{13}C NMR (126 MHz, Chloroform-*d)* spectrum of 1r



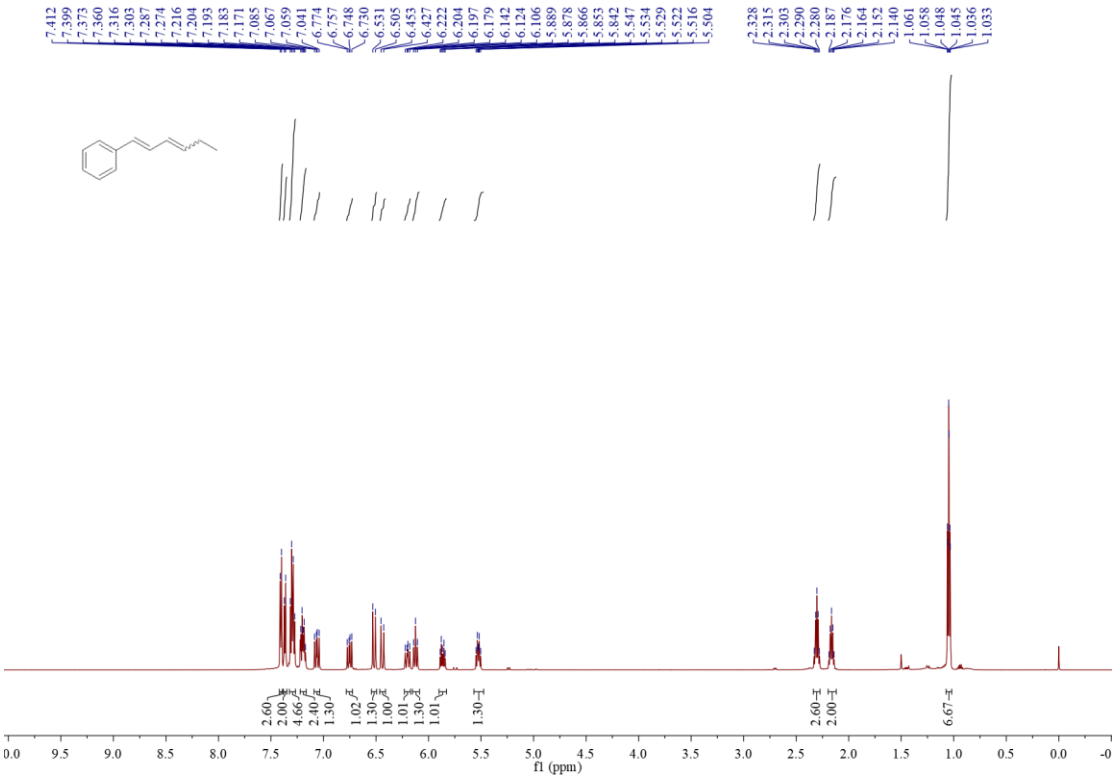
^{1}H NMR (600 MHz, Chloroform-*d)* spectrum of 4p



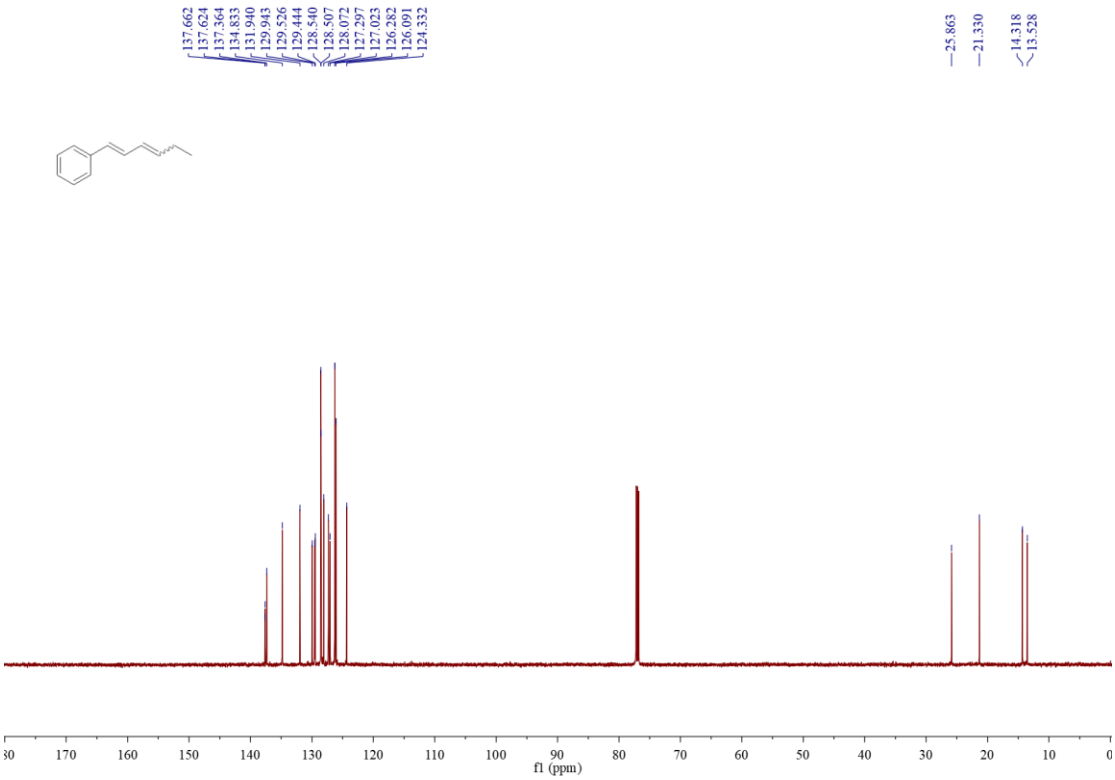
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 4p



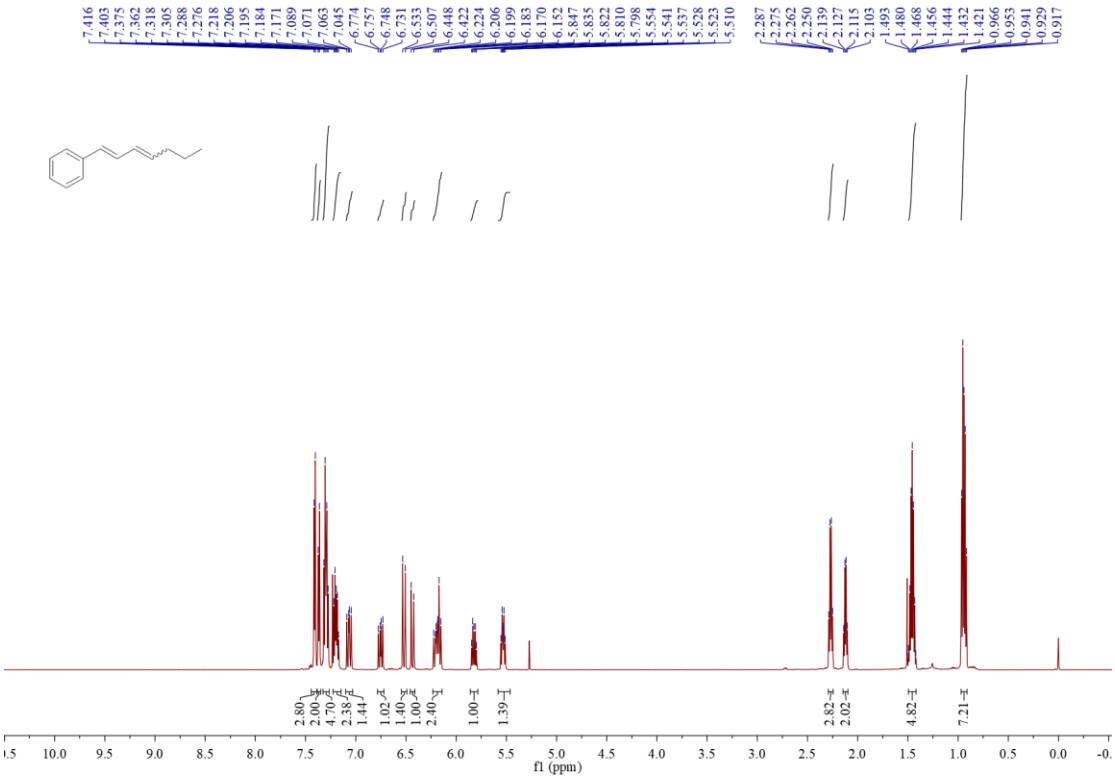
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 4q



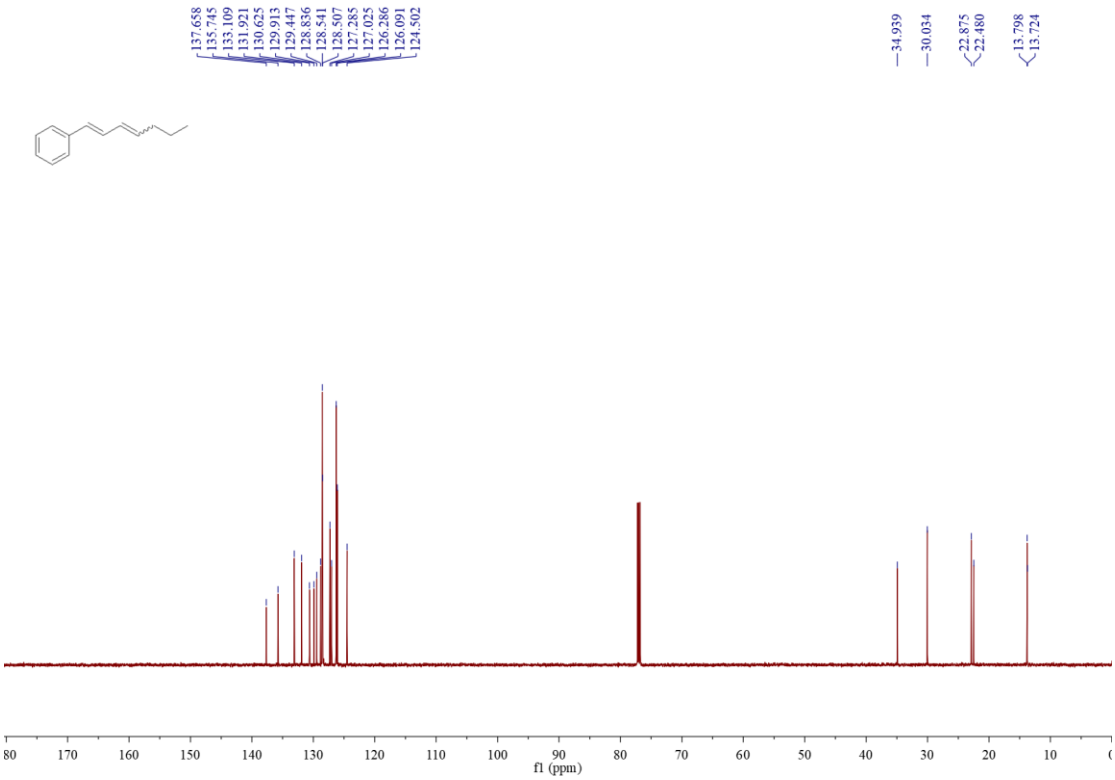
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 4q



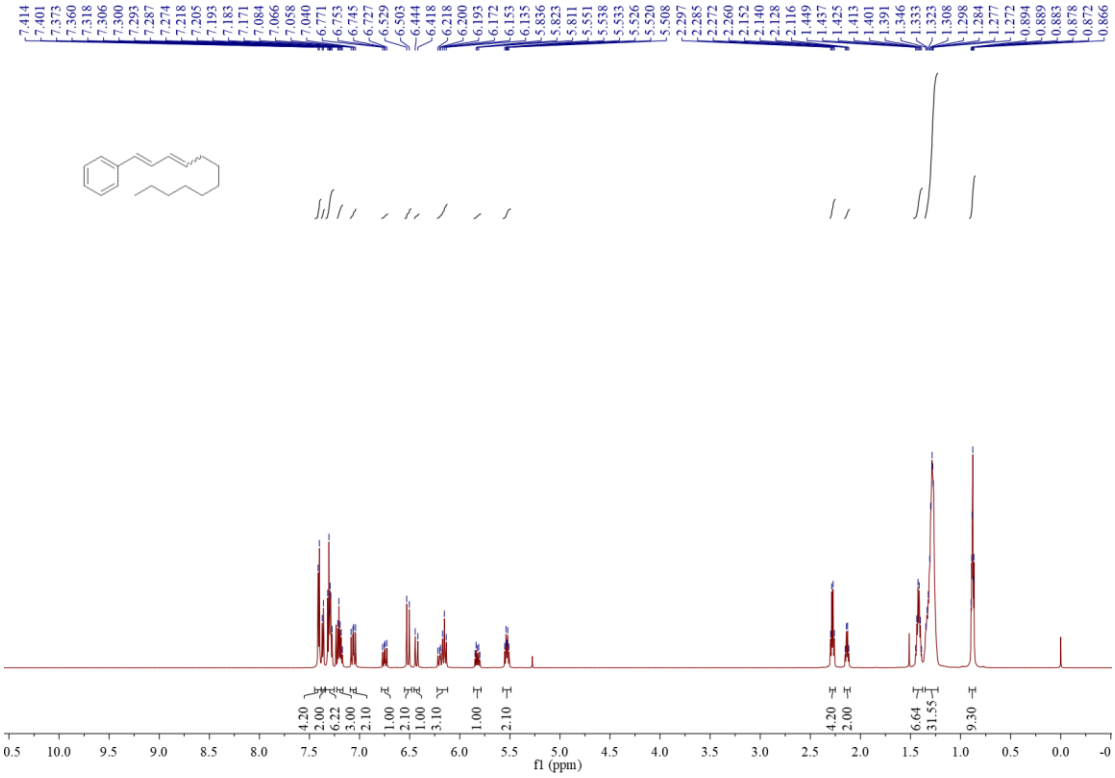
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 4r



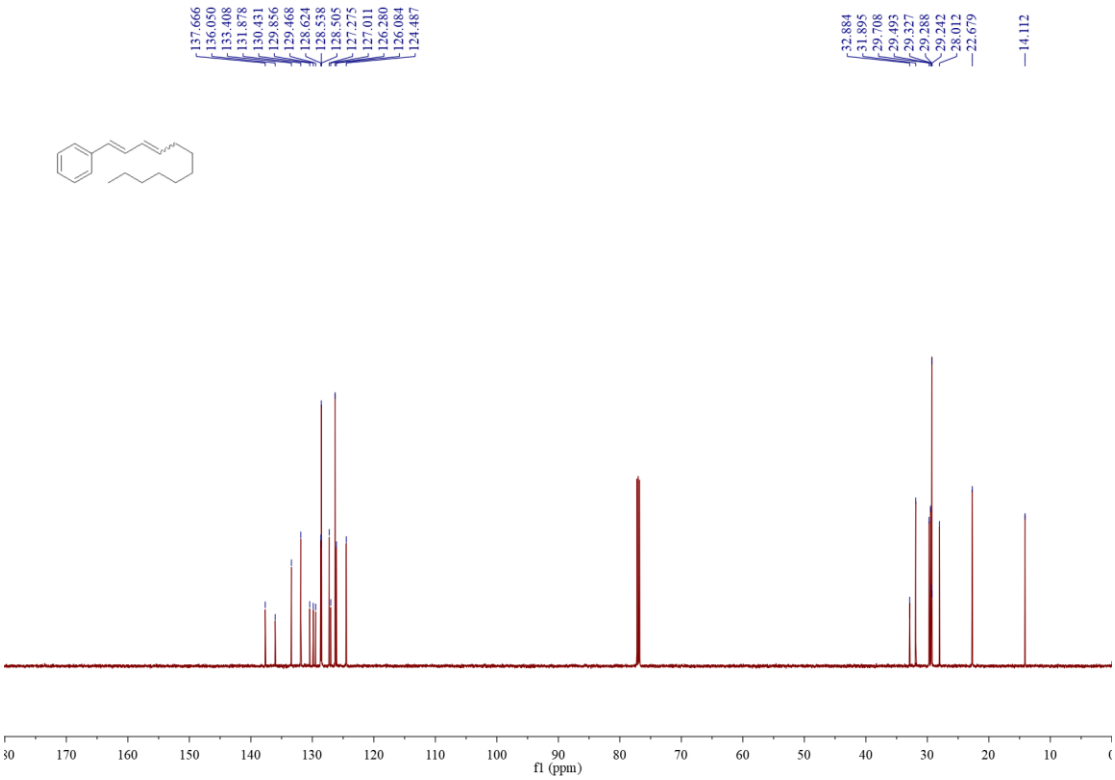
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 4r



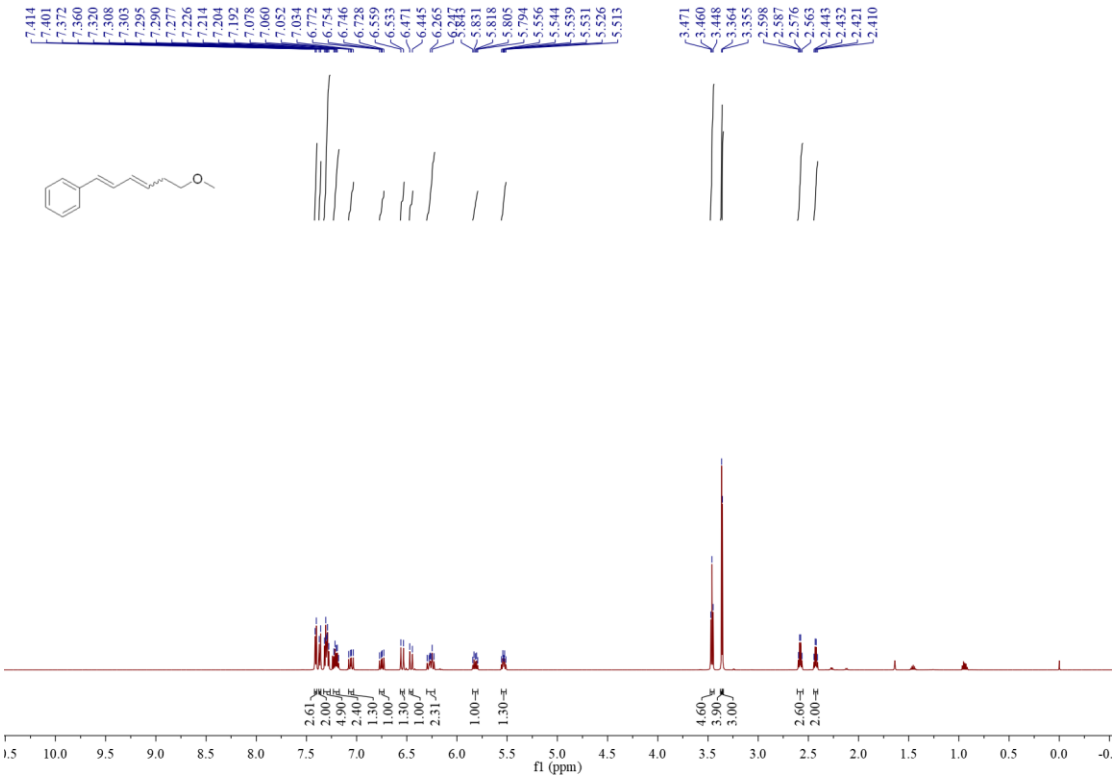
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 4s



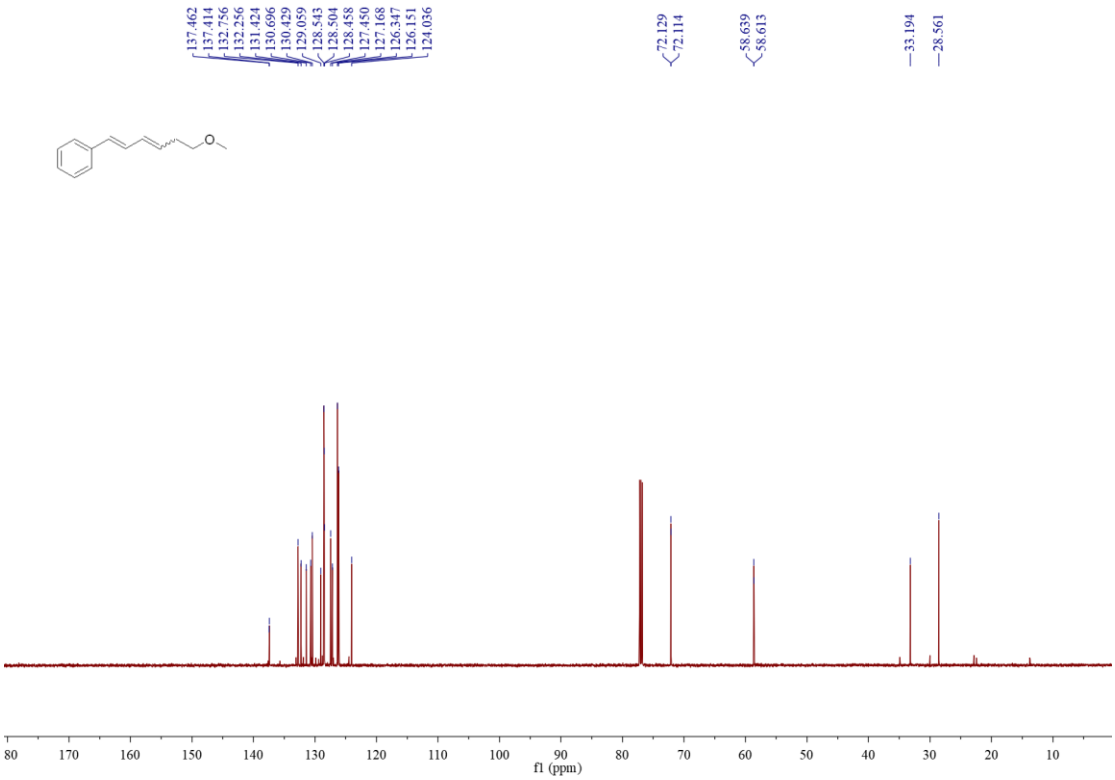
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 4s



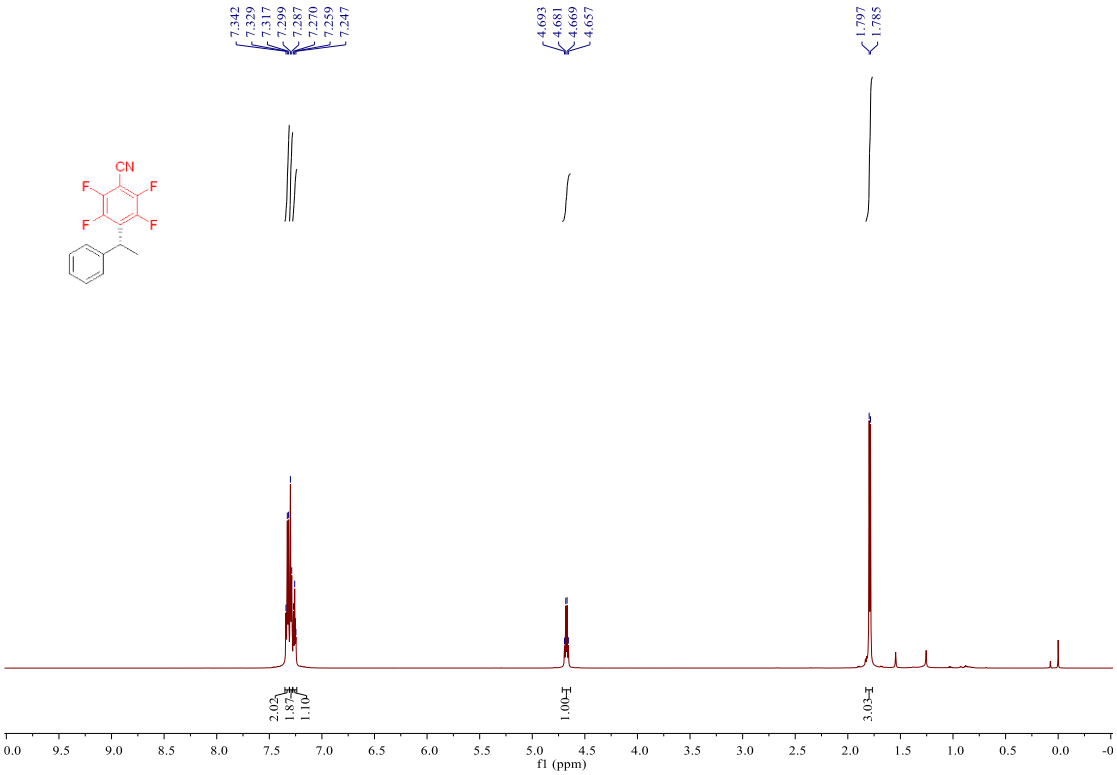
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 4t



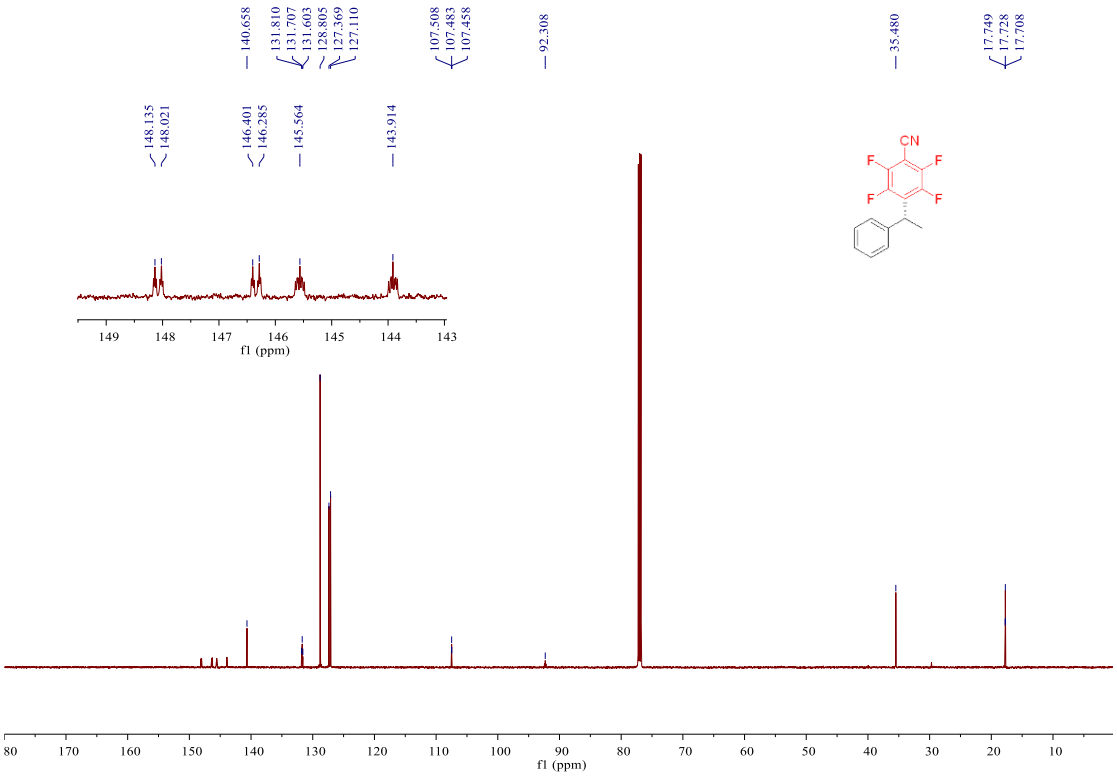
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 4t



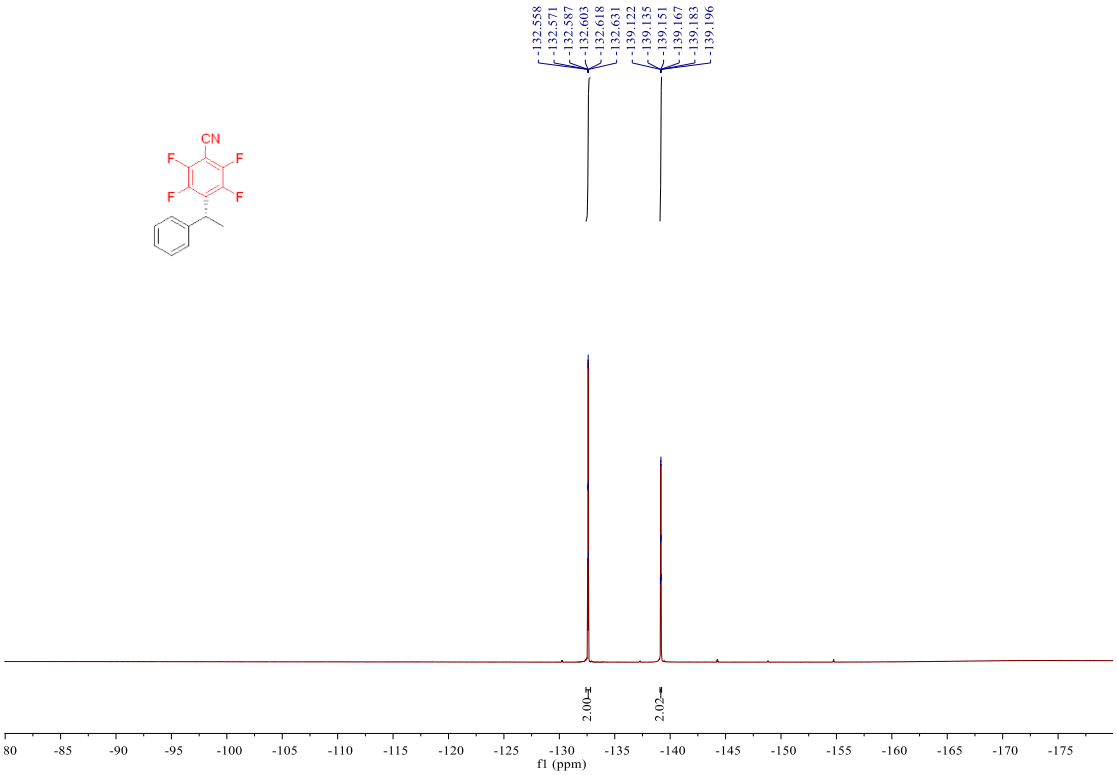
^{1}H NMR (600 MHz, Chloroform-*d)* spectrum of 3a



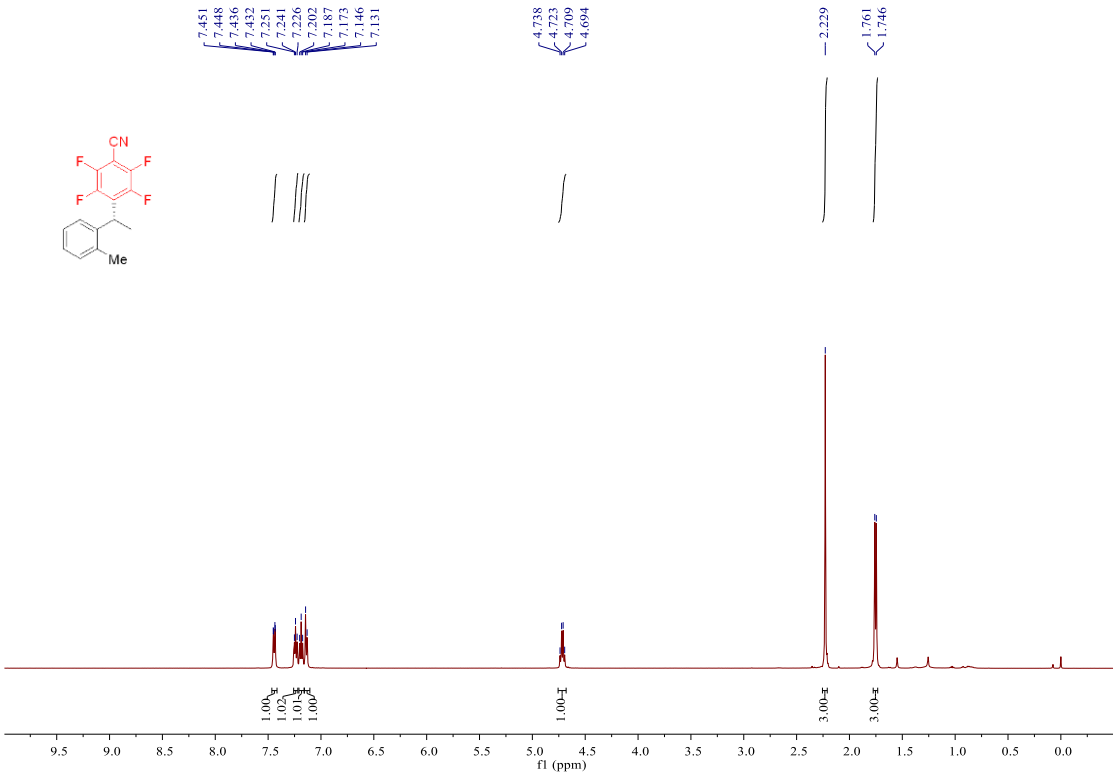
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3a



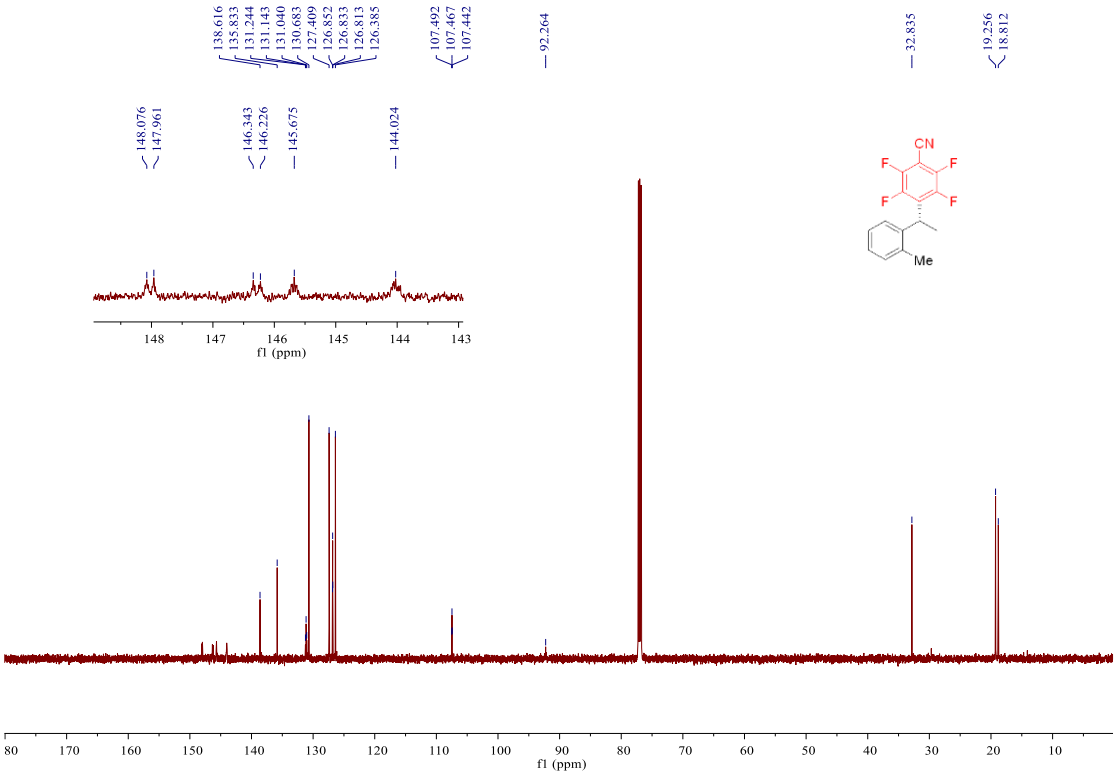
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3a



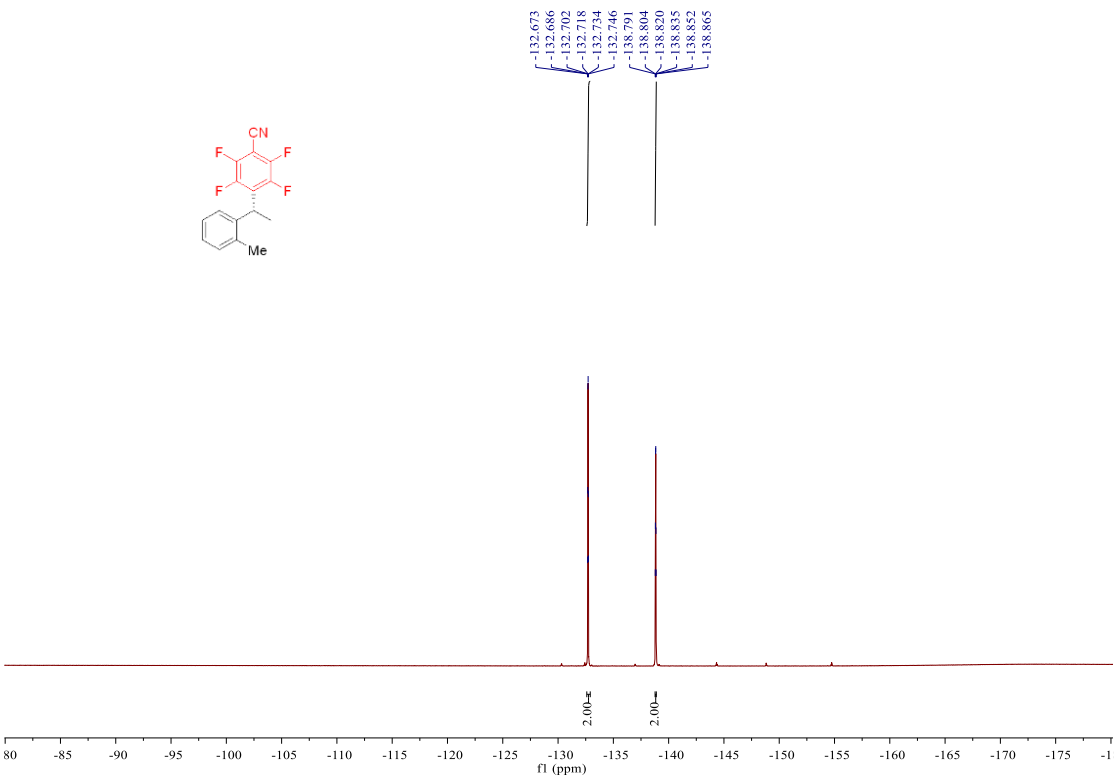
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3b



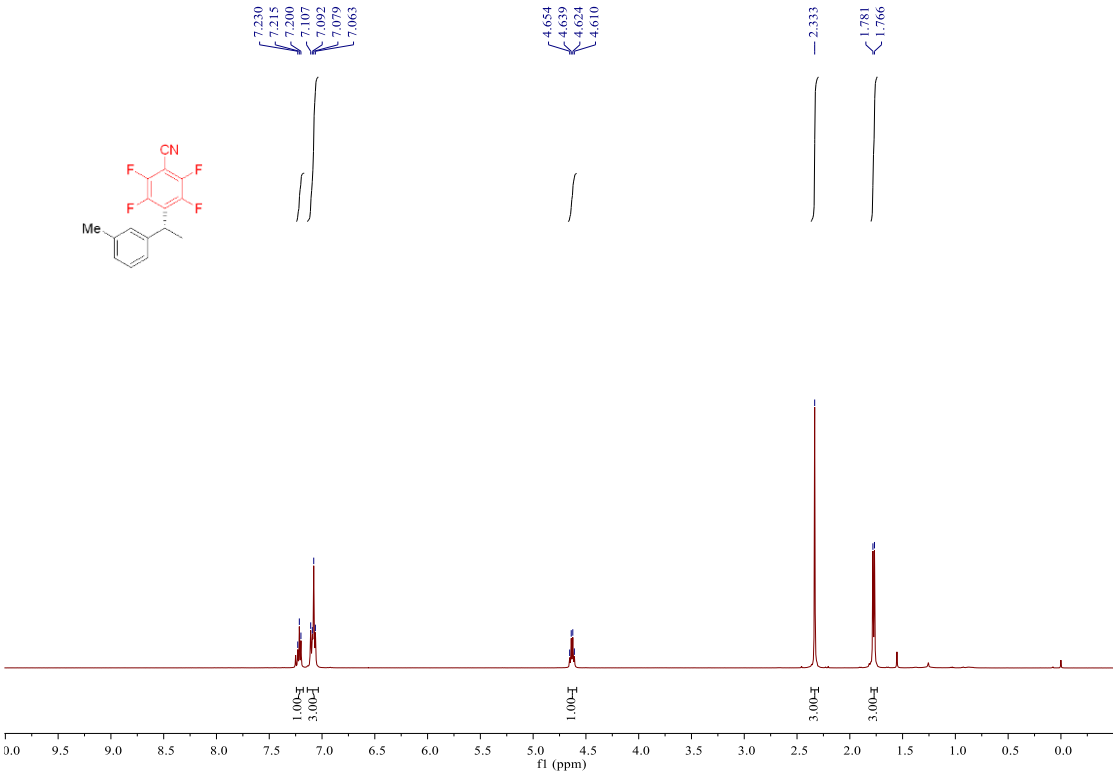
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3b



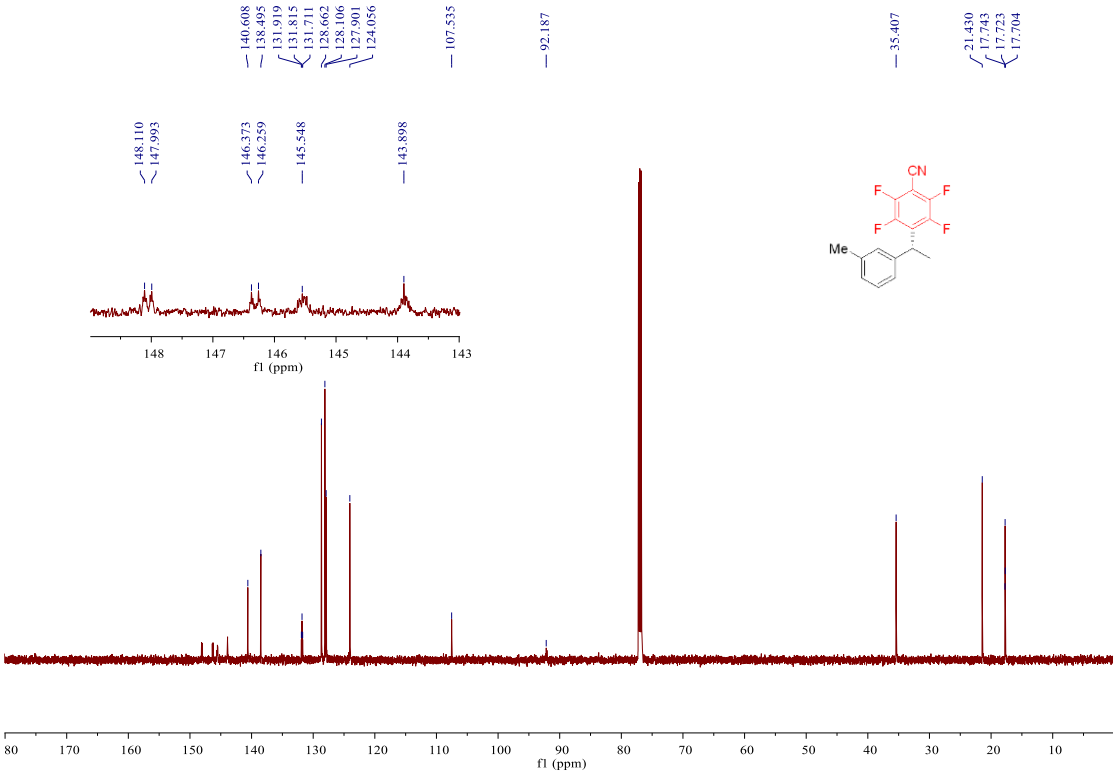
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3b



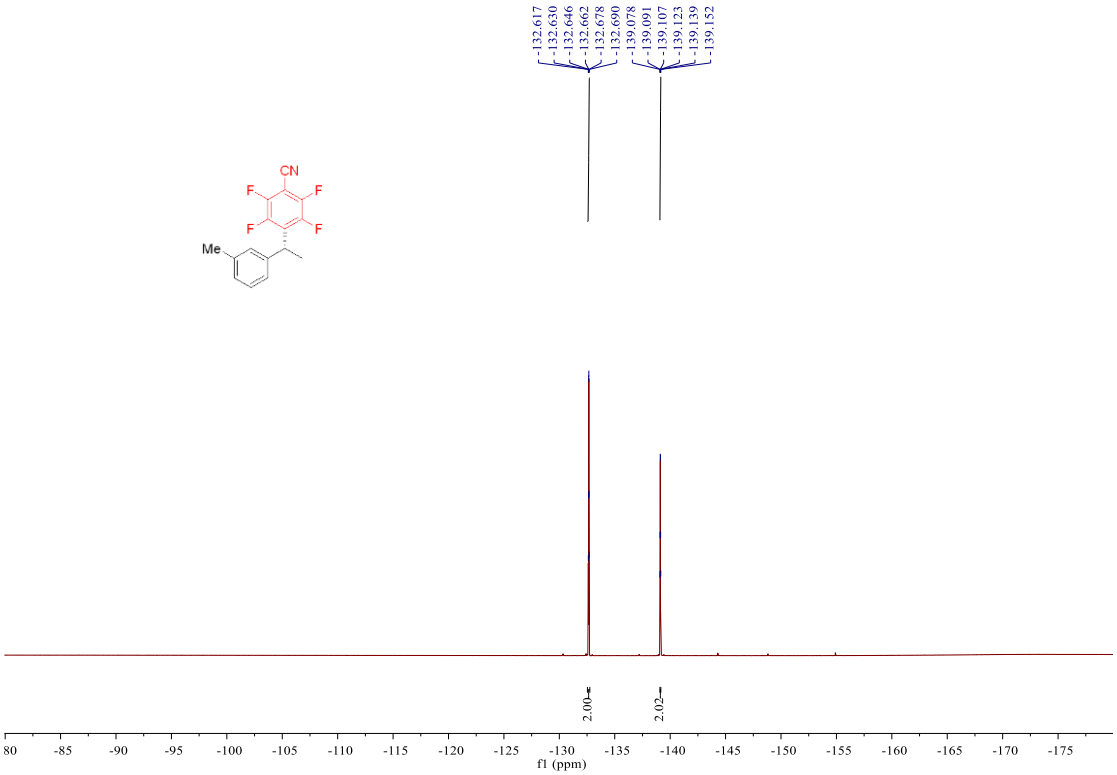
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 3c



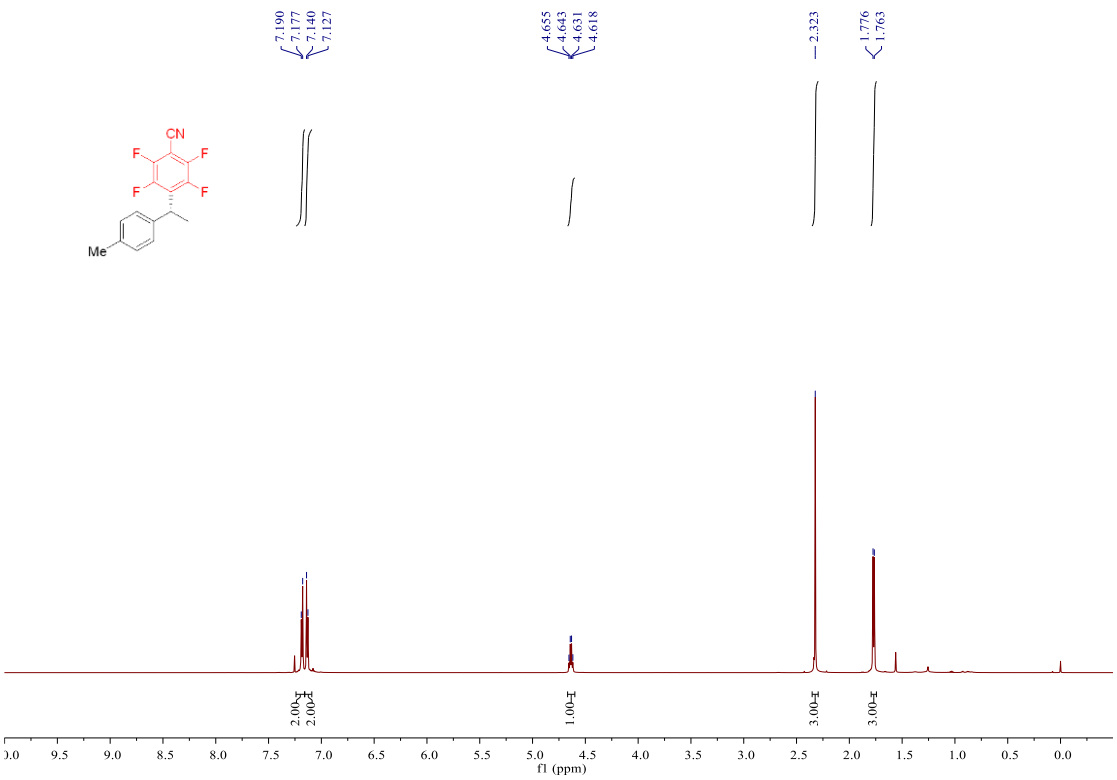
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3c



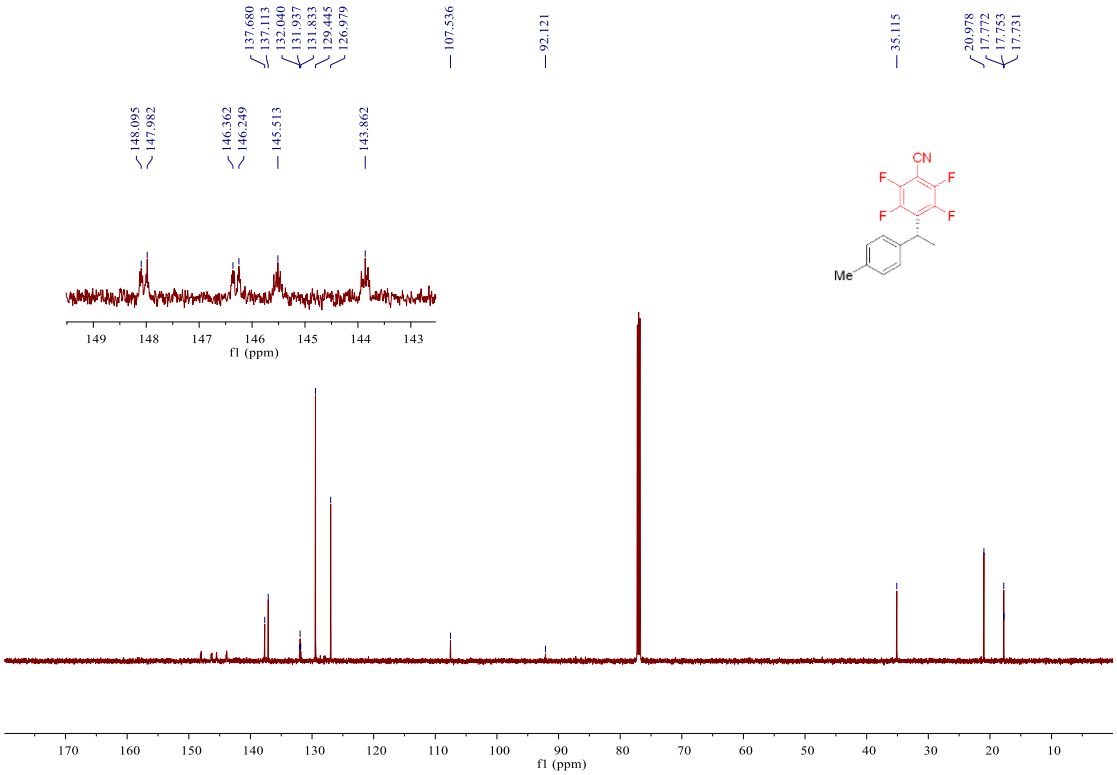
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3c



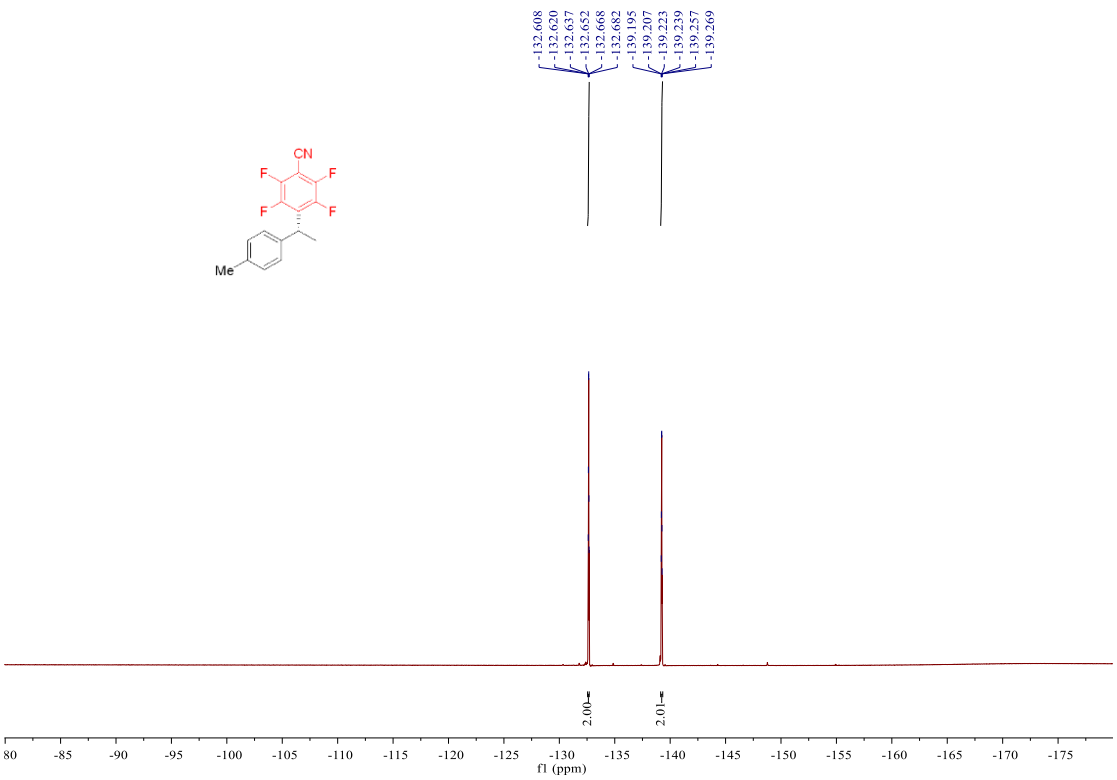
^{1}H NMR (600 MHz, Chloroform-*d)* spectrum of 3d



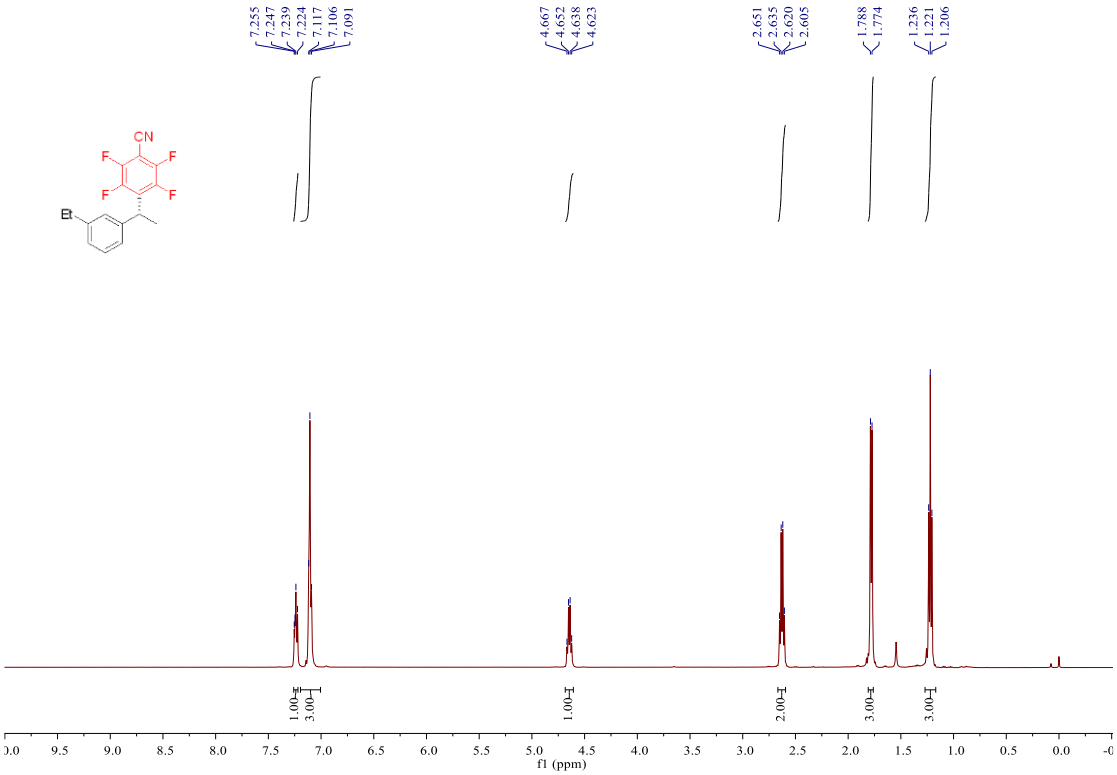
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3d



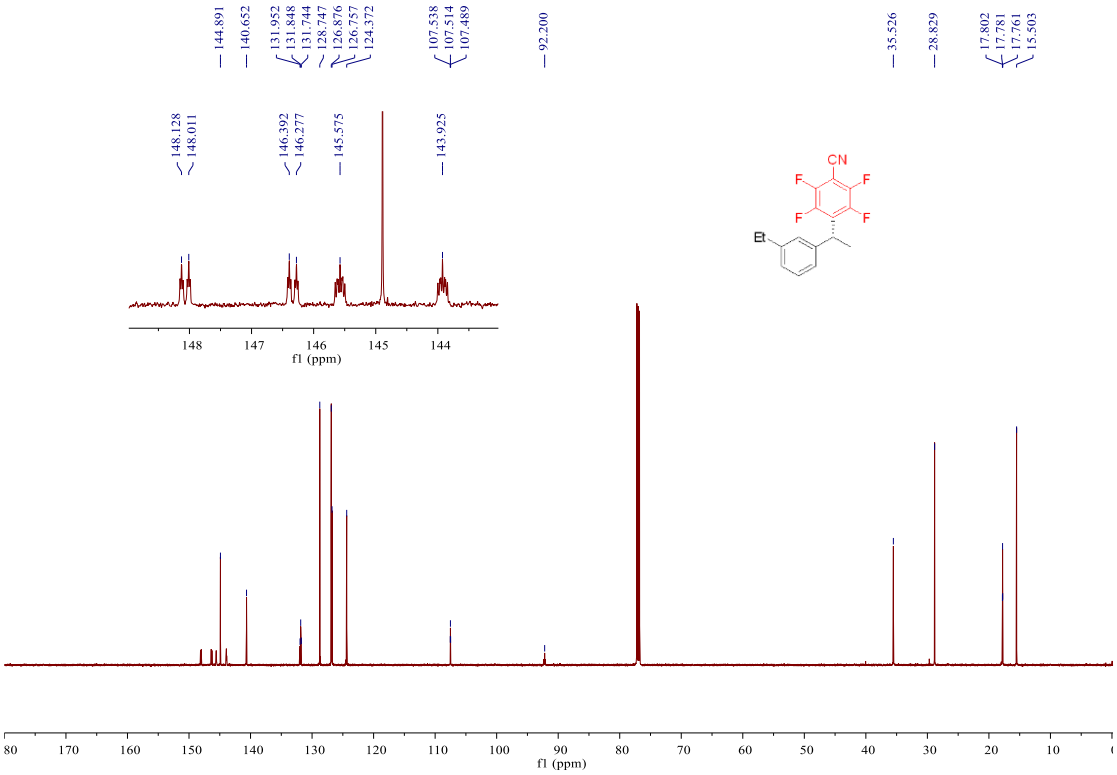
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 3d



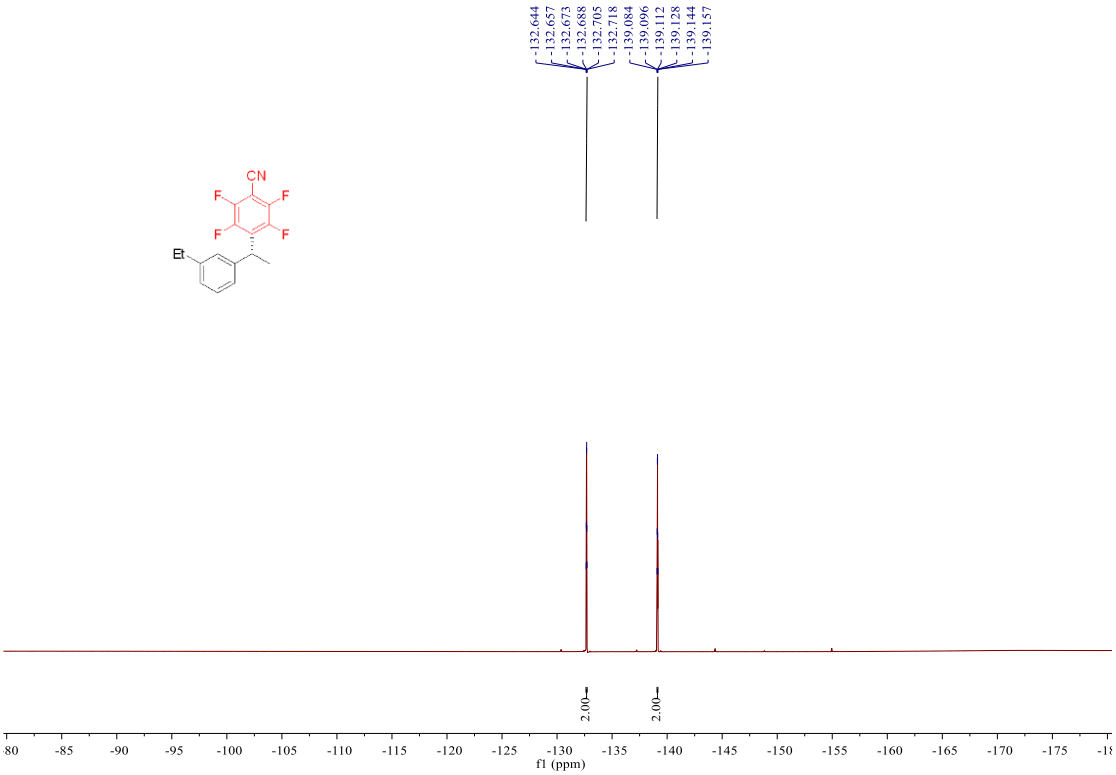
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 3e



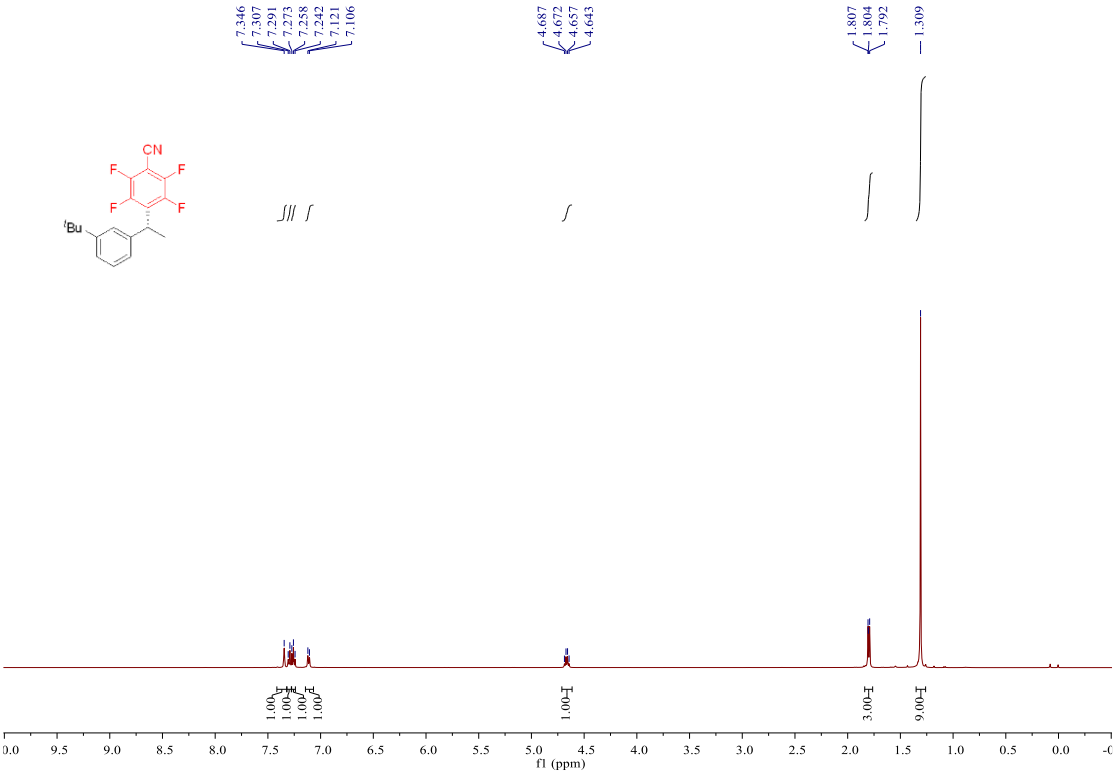
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3e



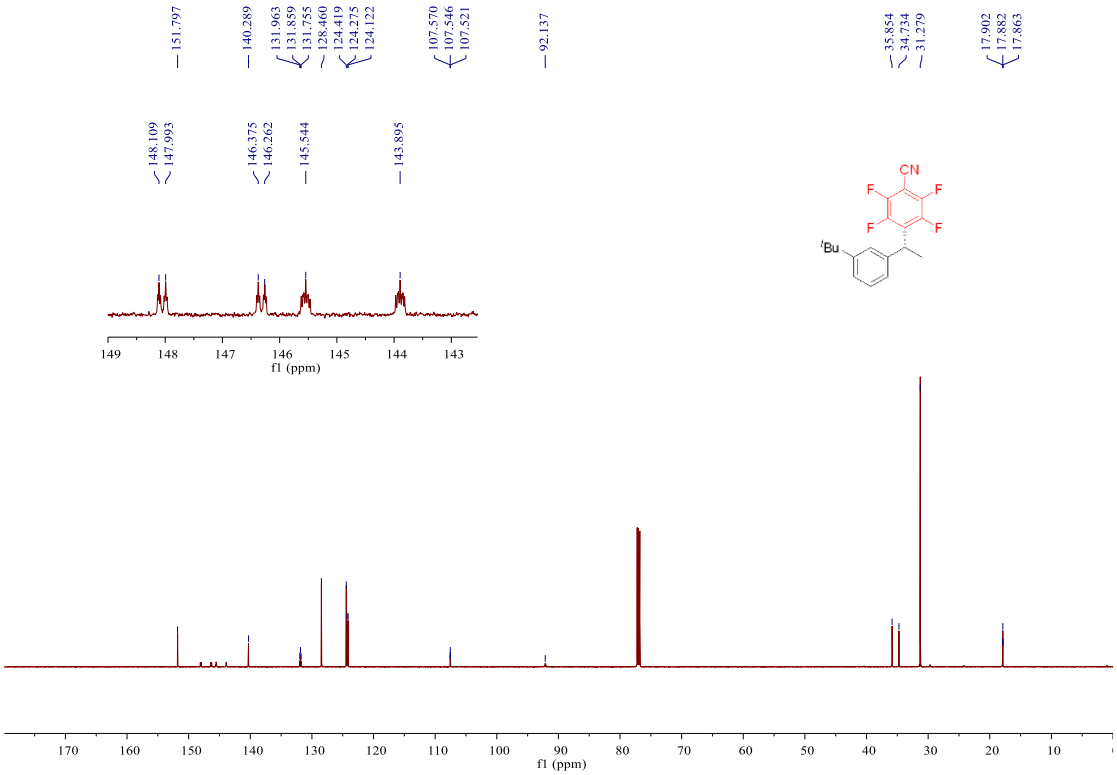
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3e



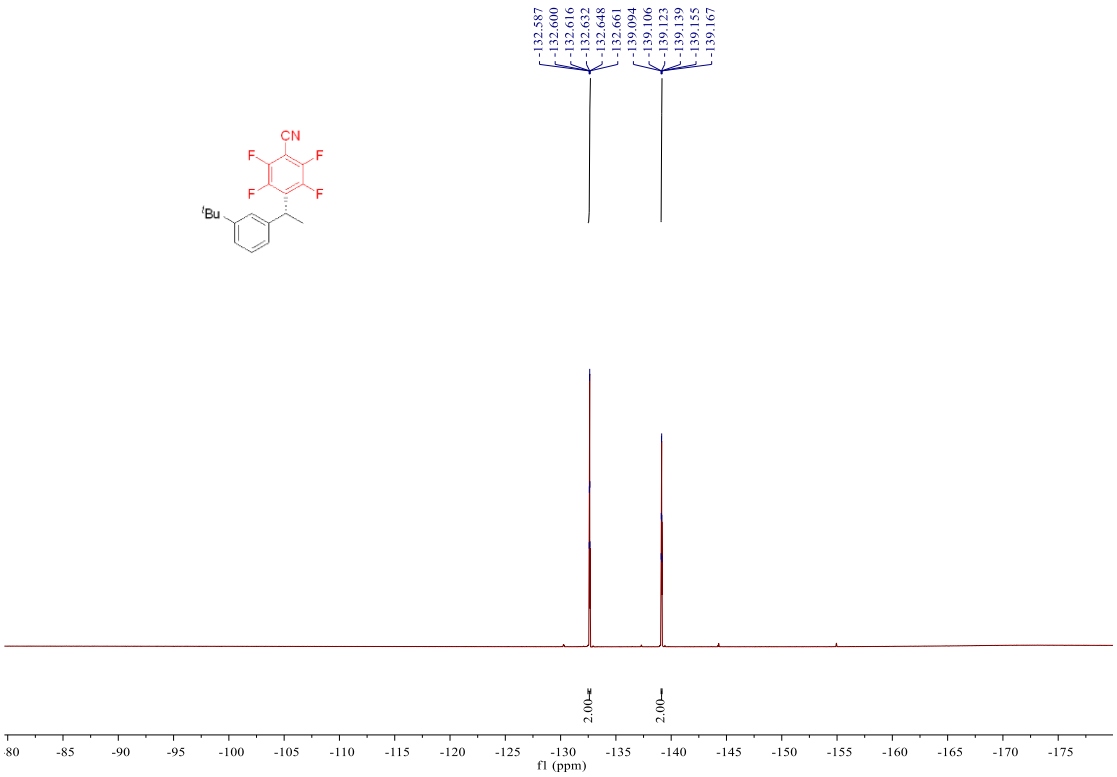
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3f



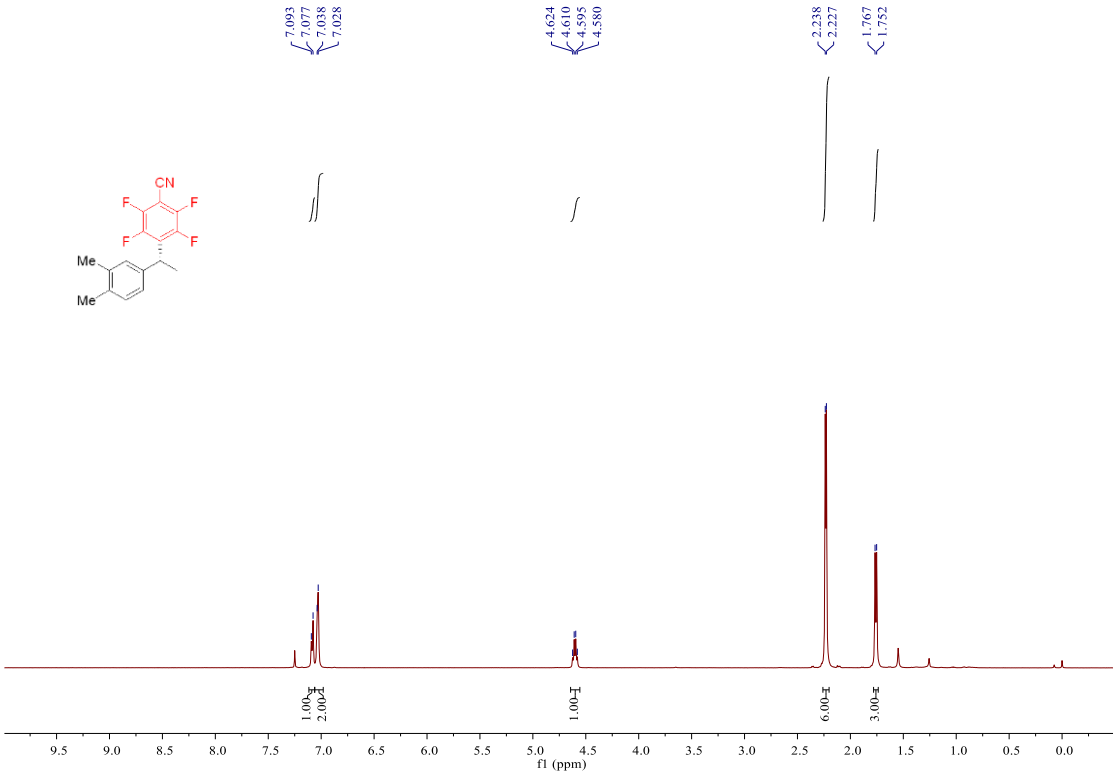
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3f



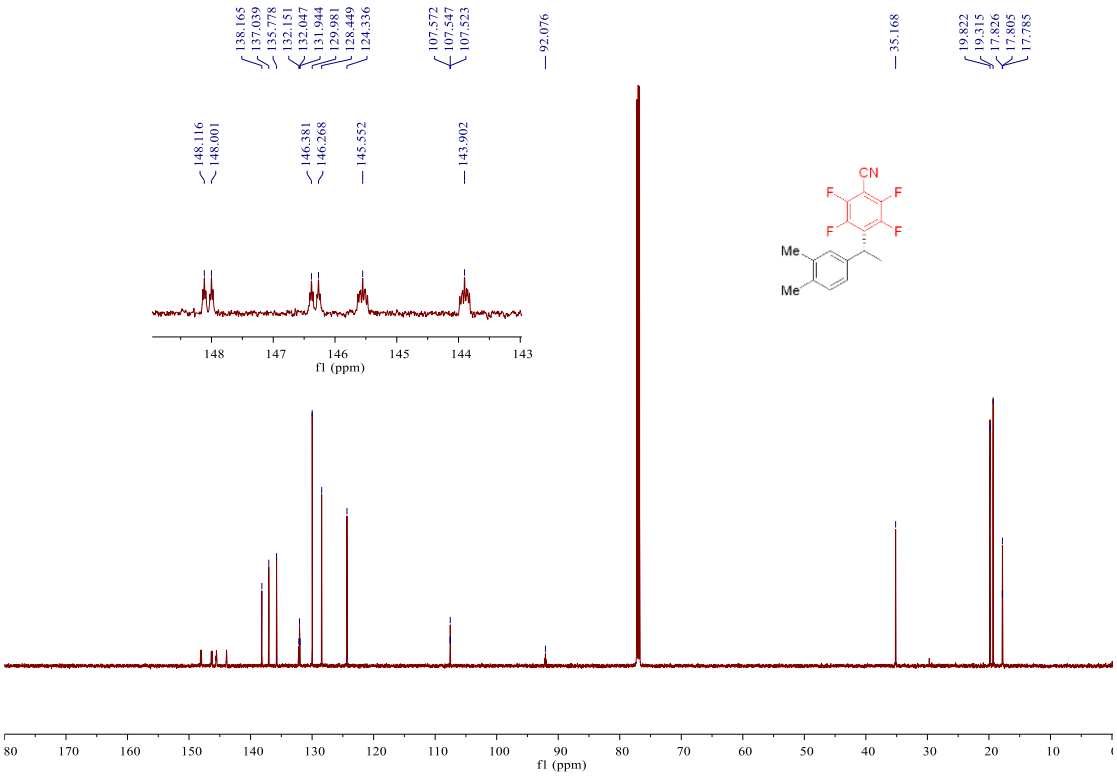
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3f



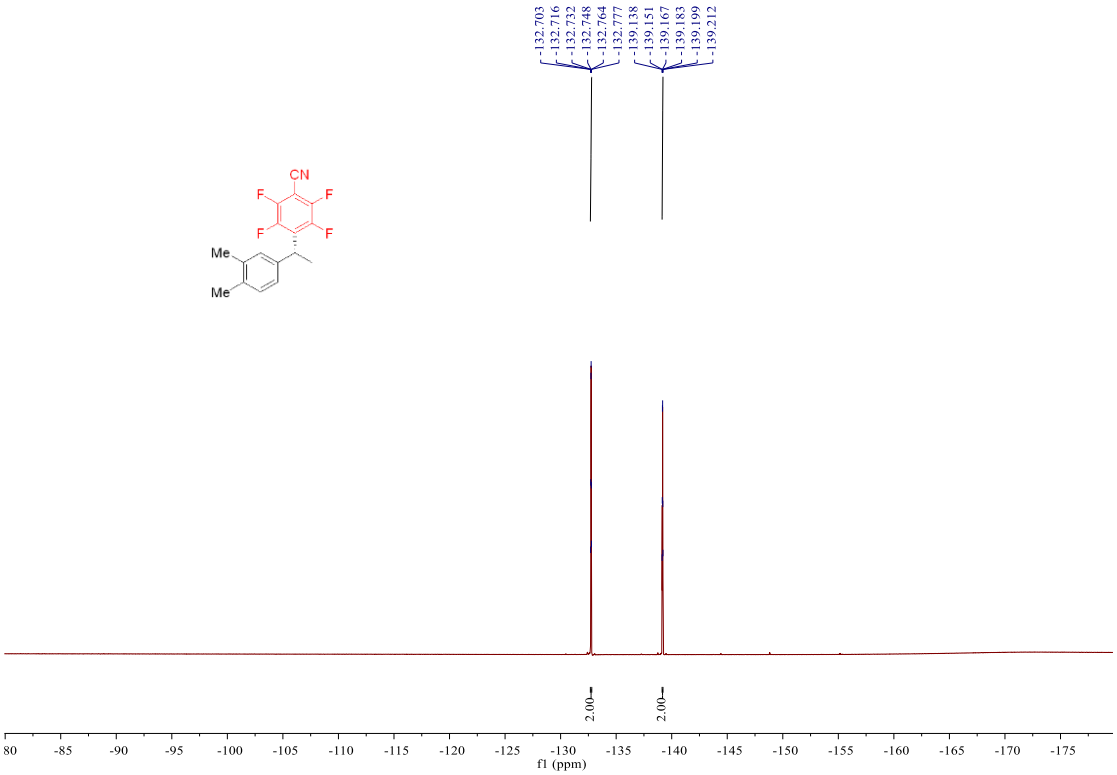
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3g



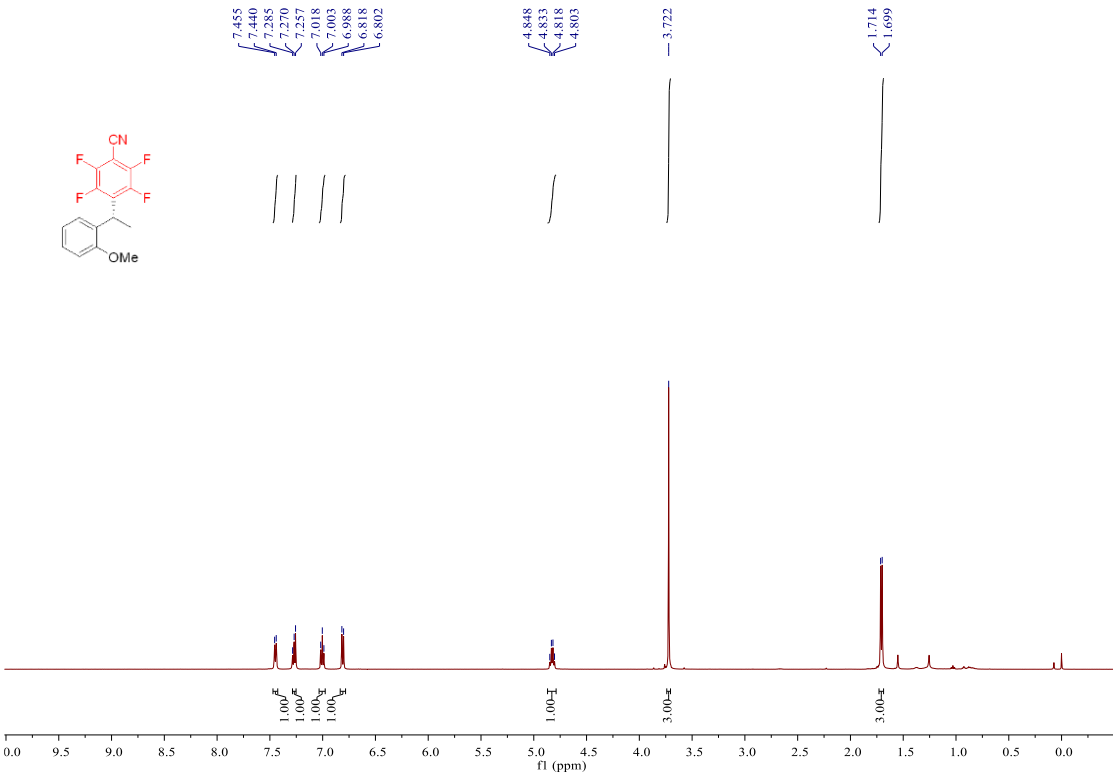
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3g



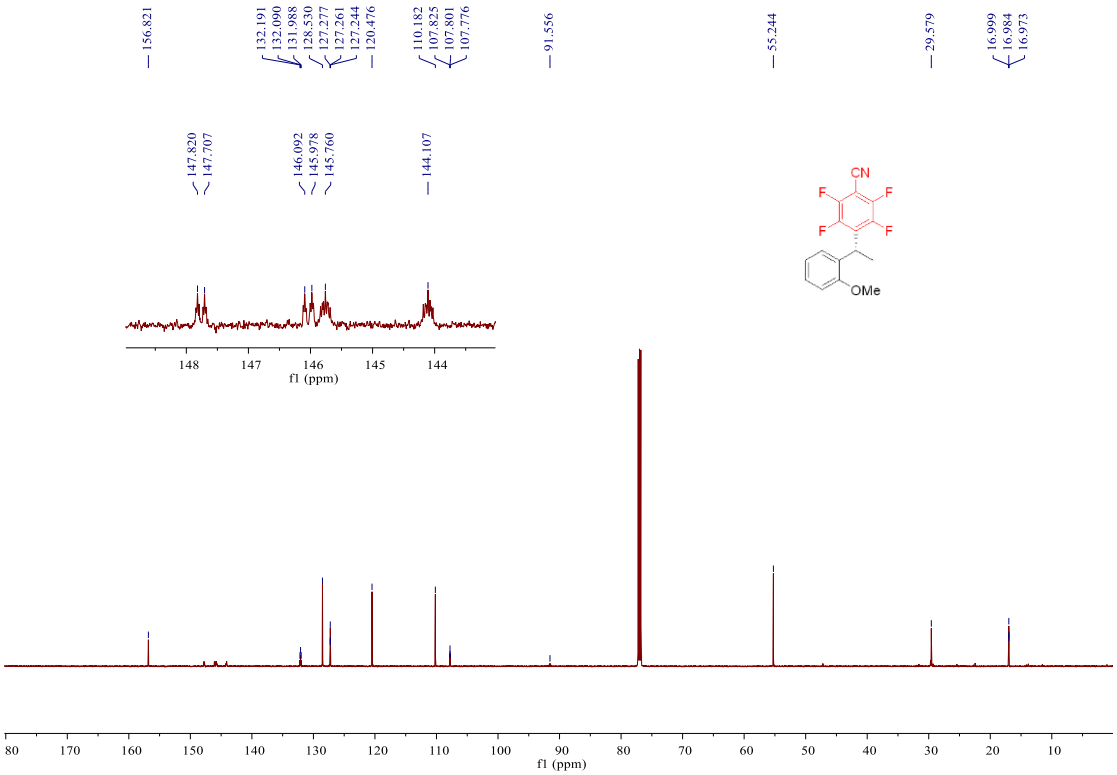
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3g



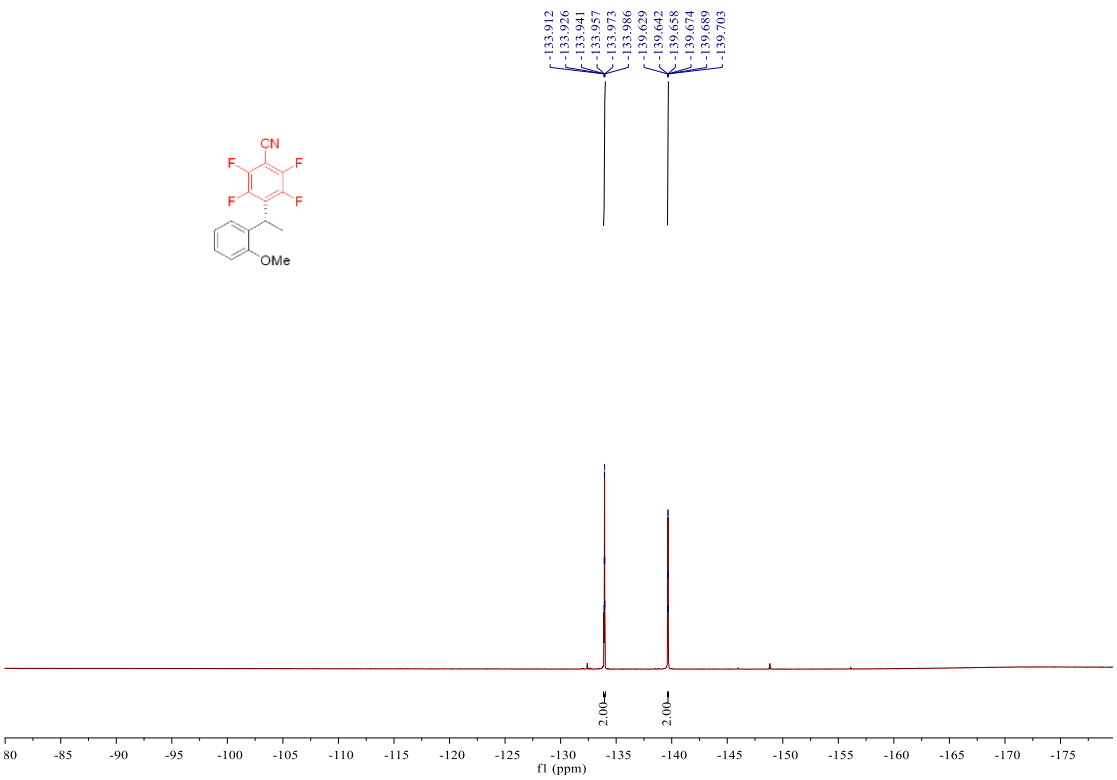
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3h



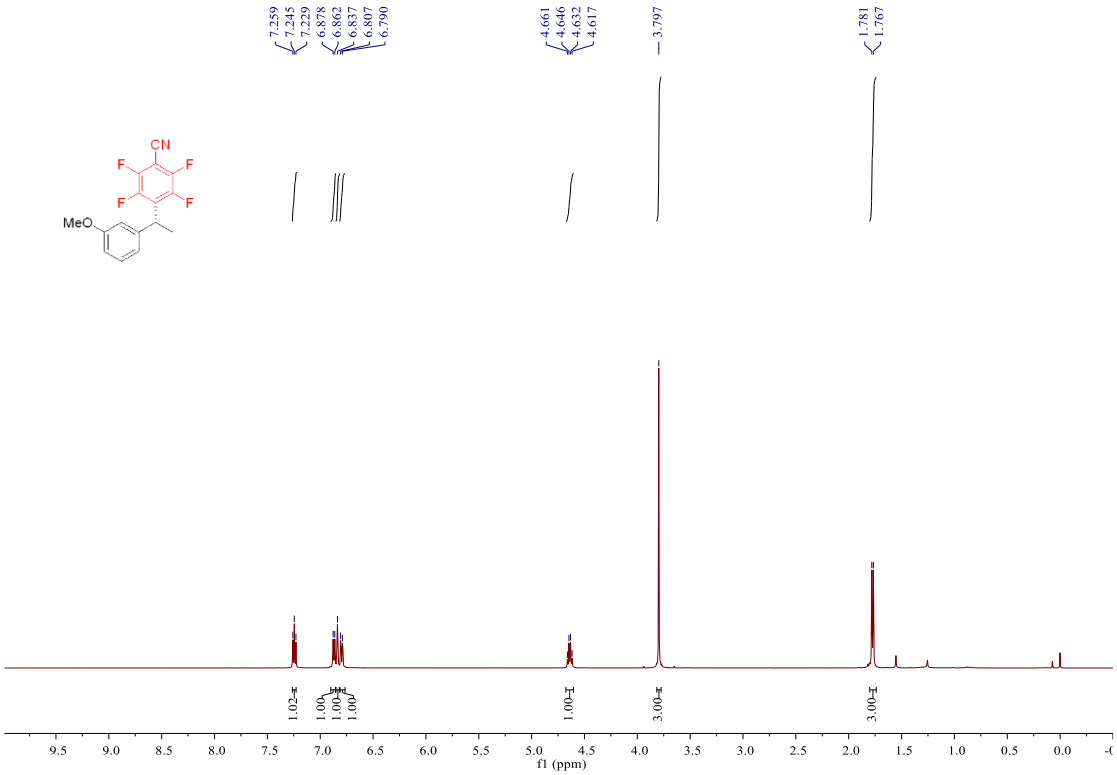
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3h



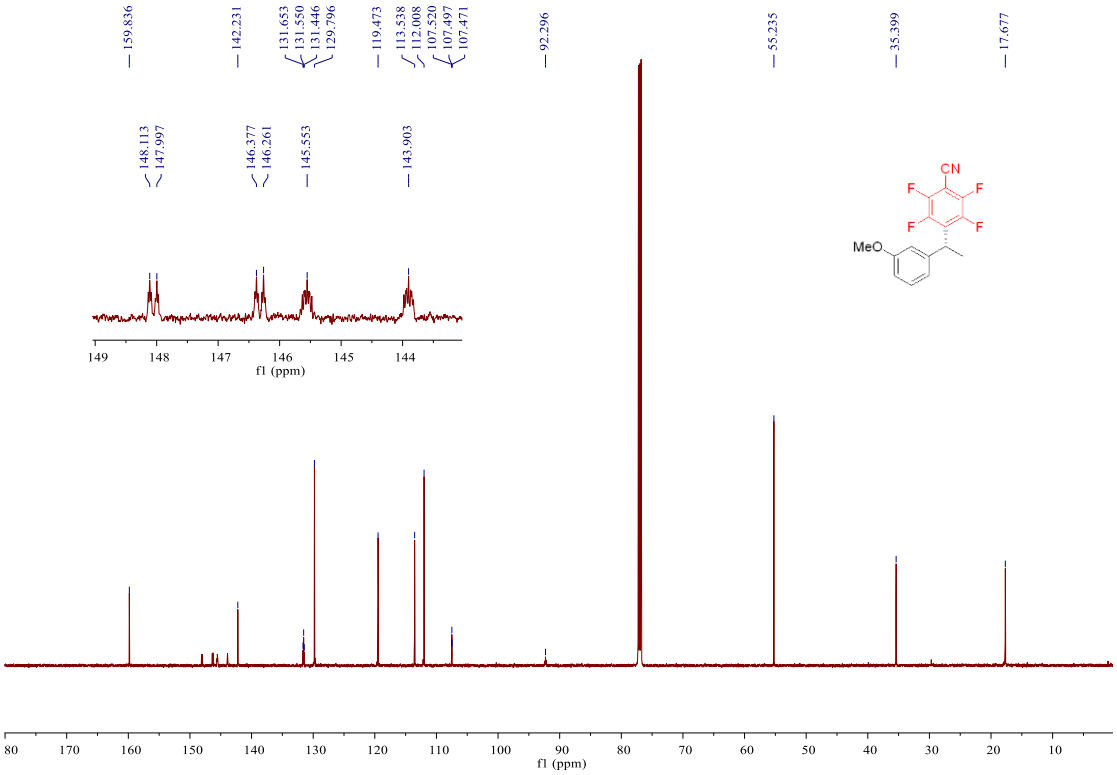
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3h



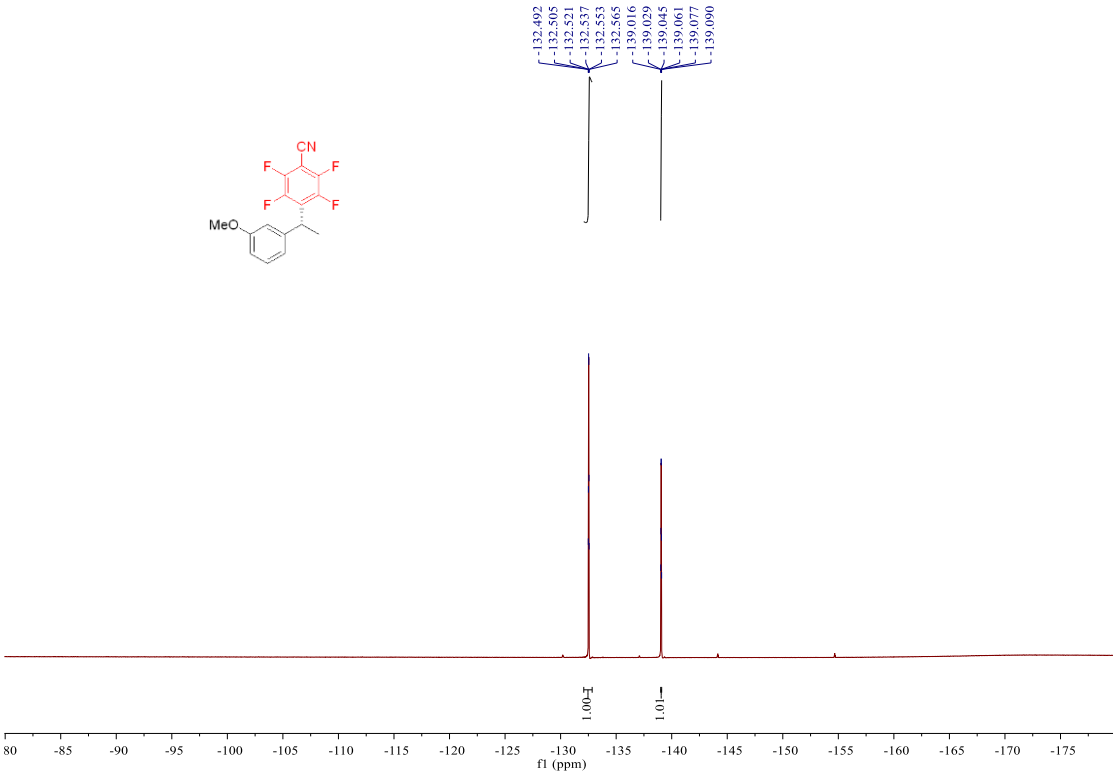
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3i



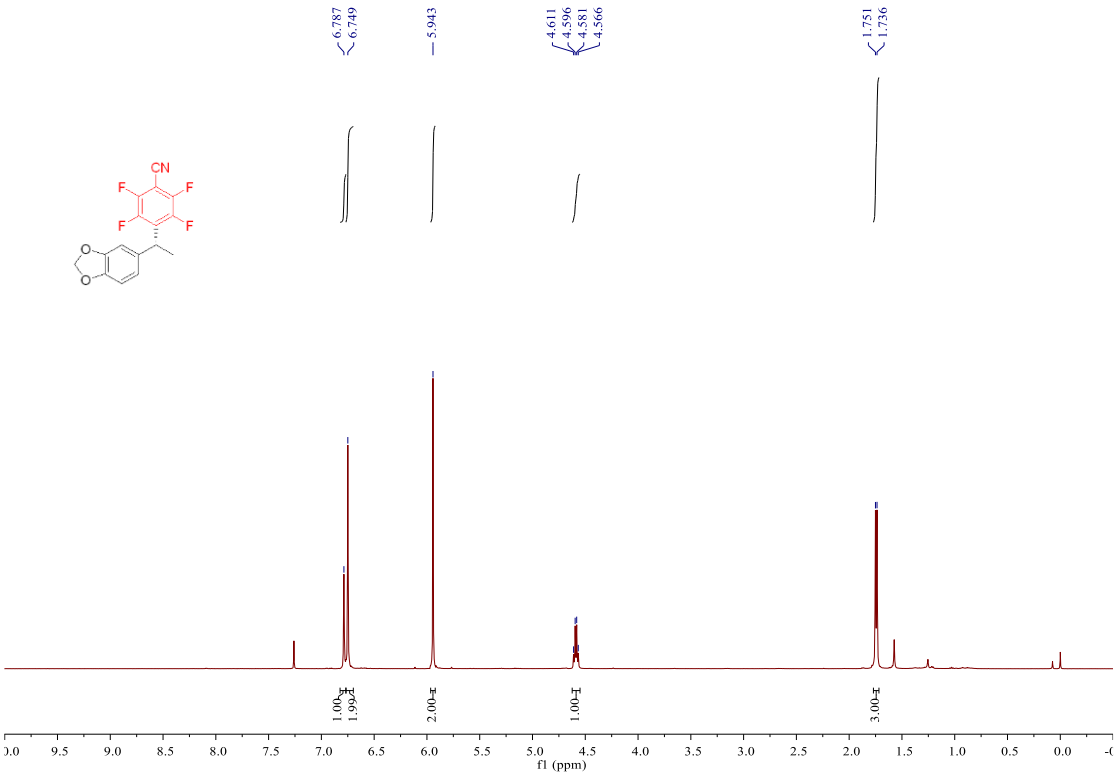
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3i



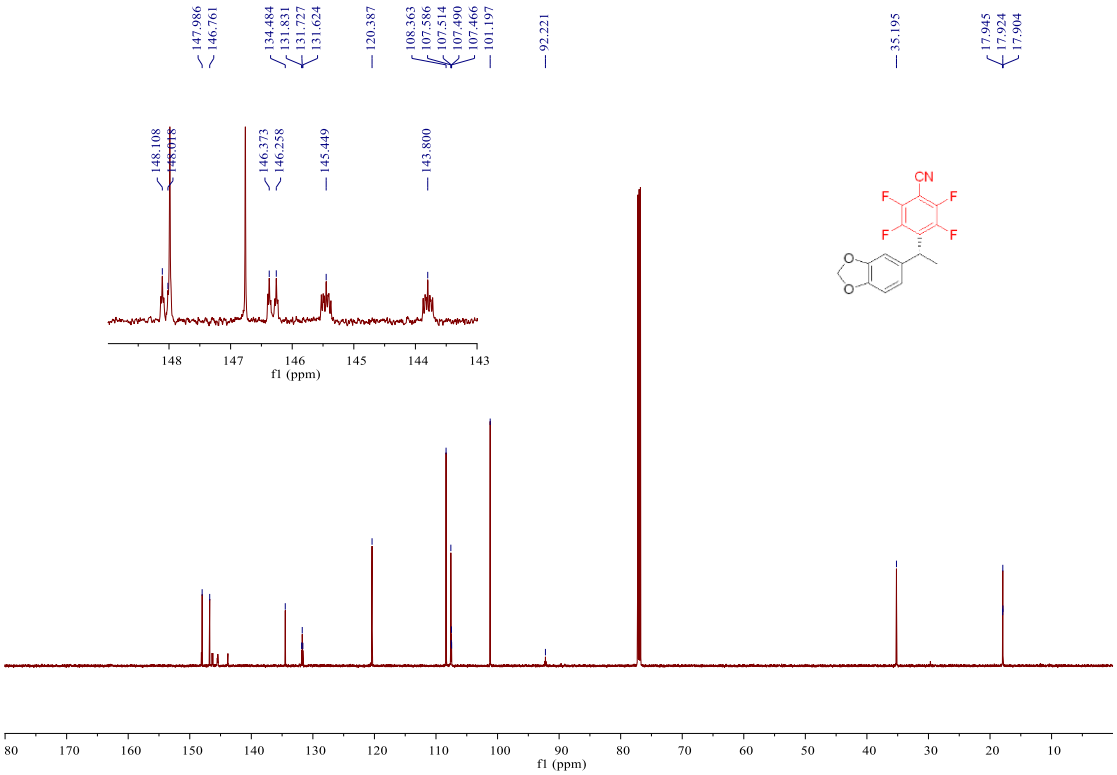
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3i



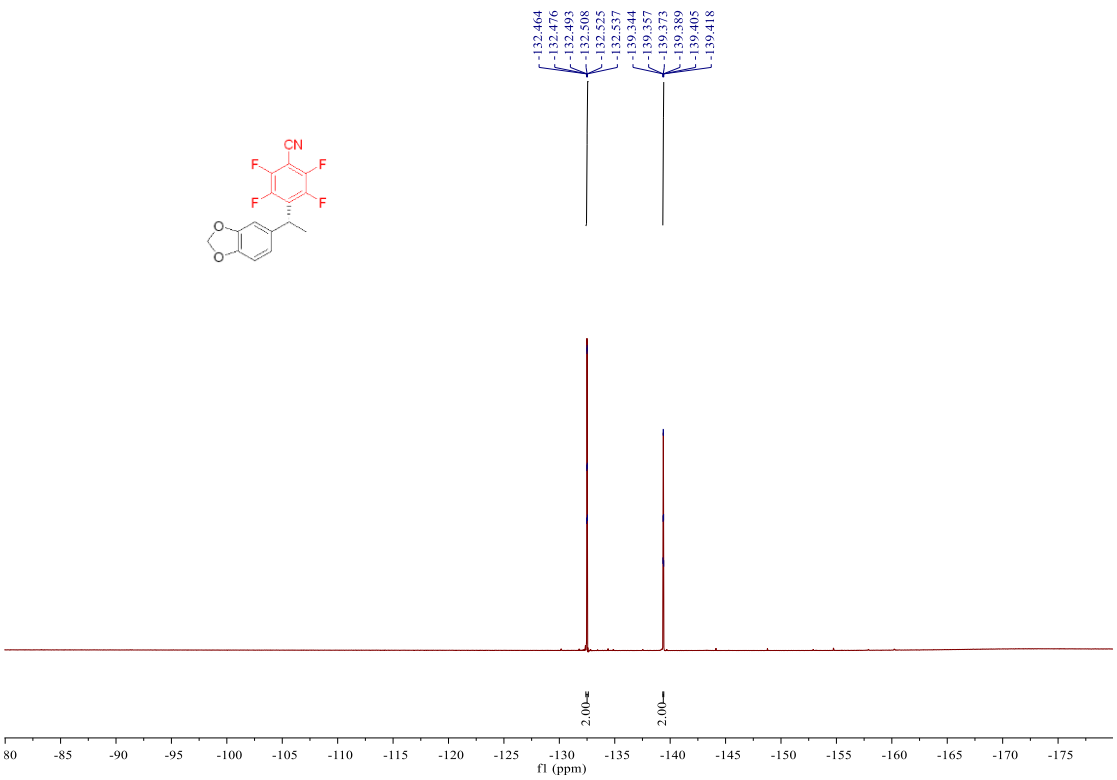
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3j



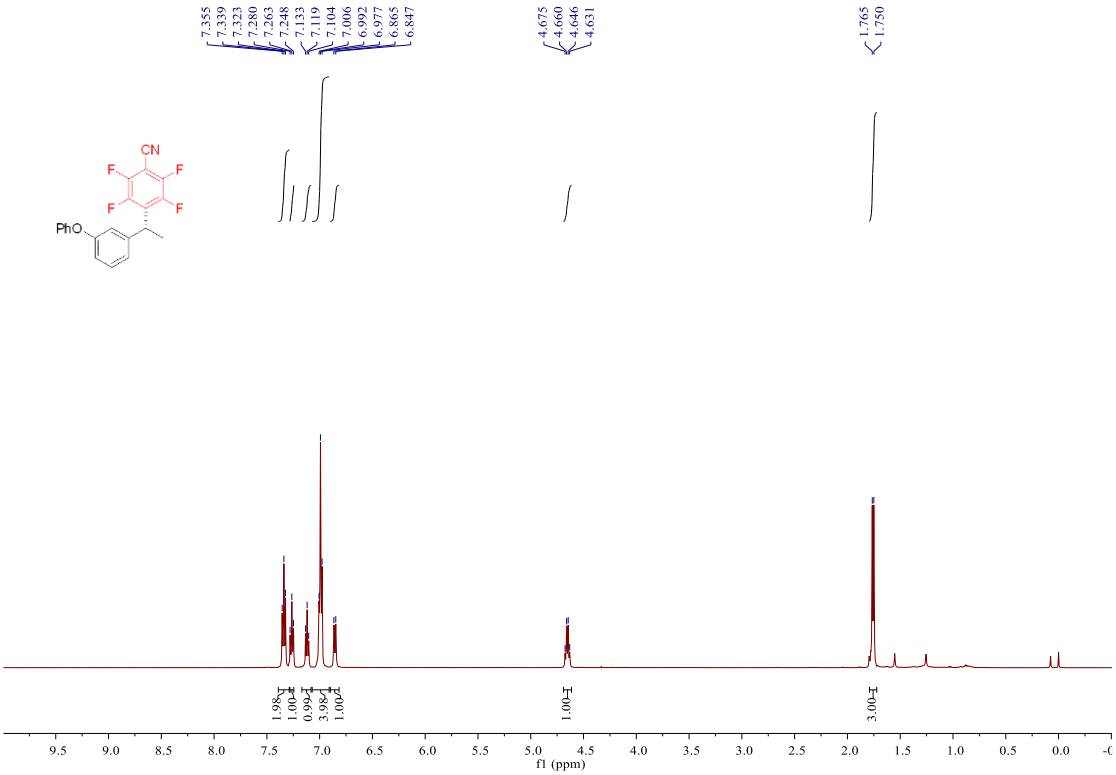
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3j



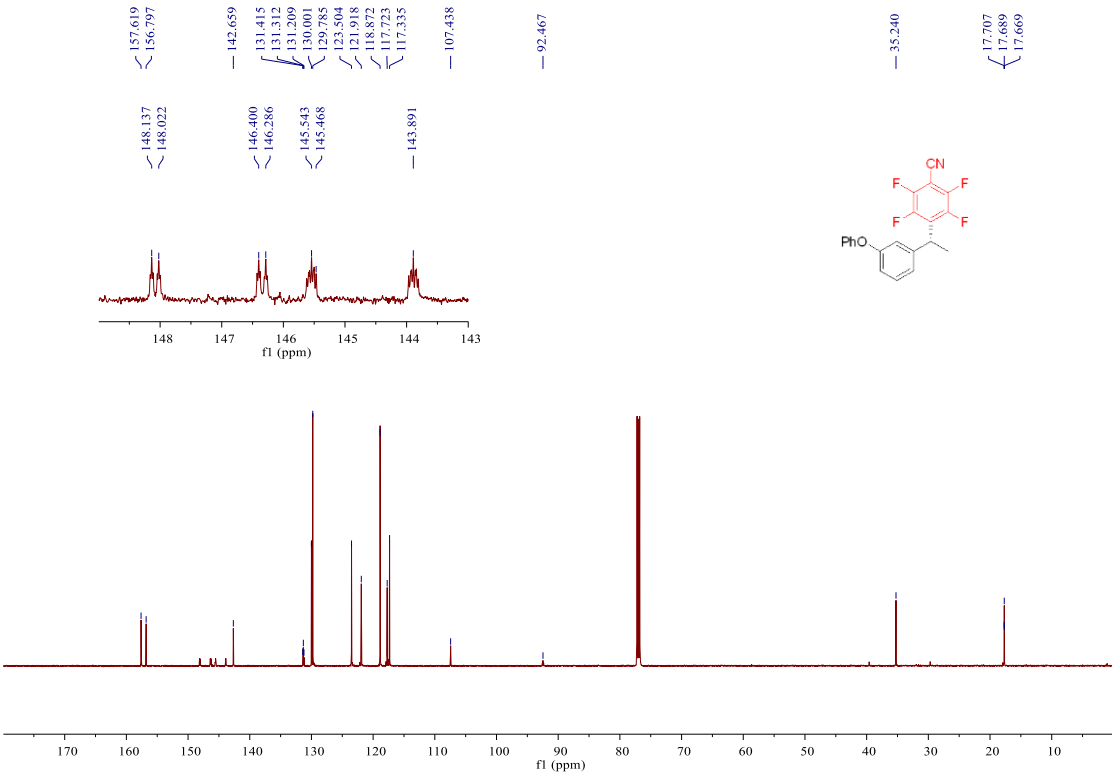
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3j



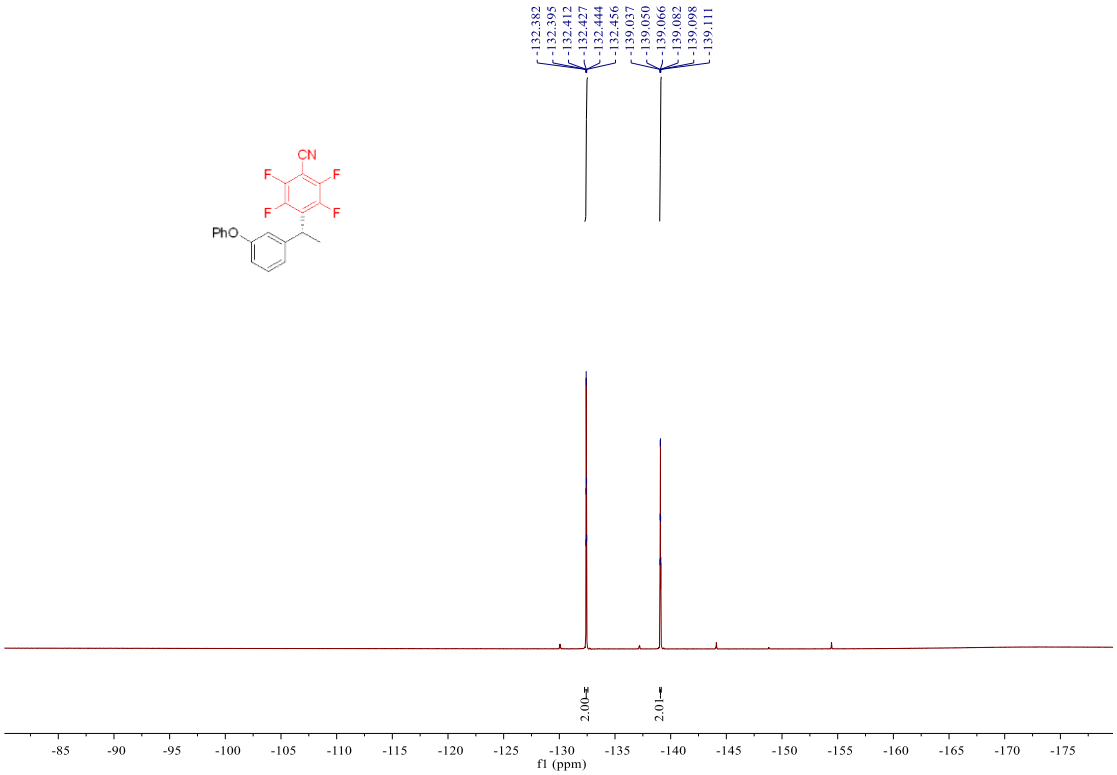
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3k



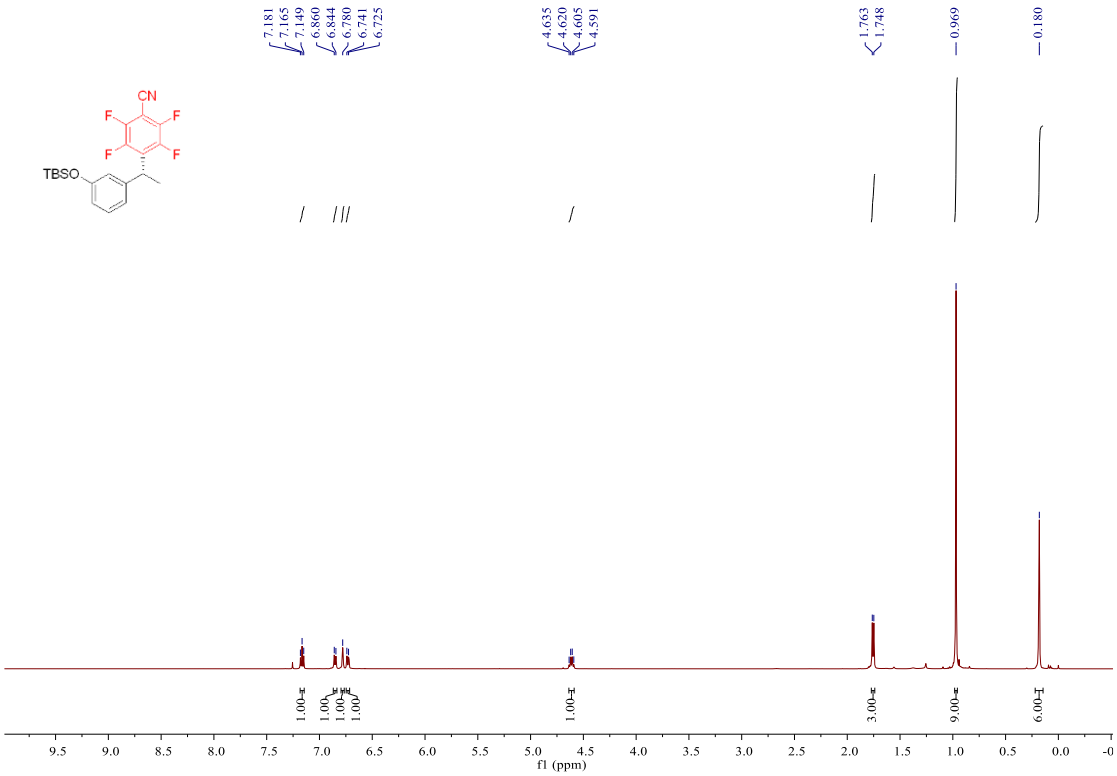
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3k



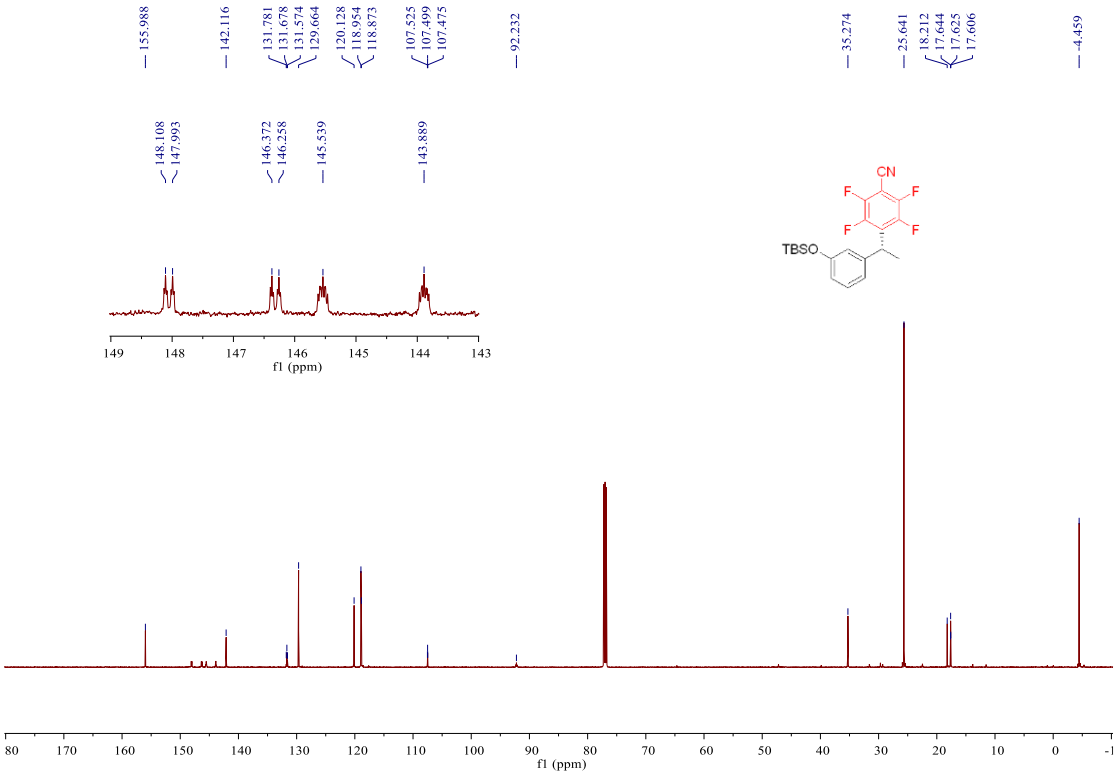
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3k



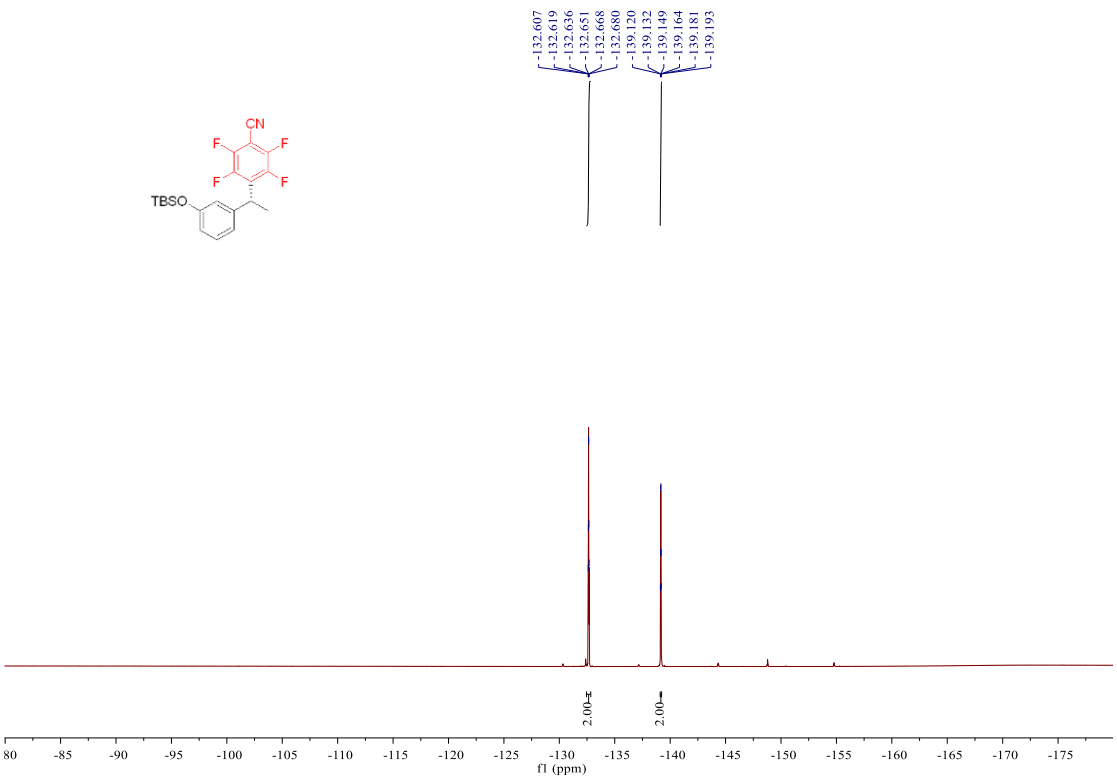
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3l



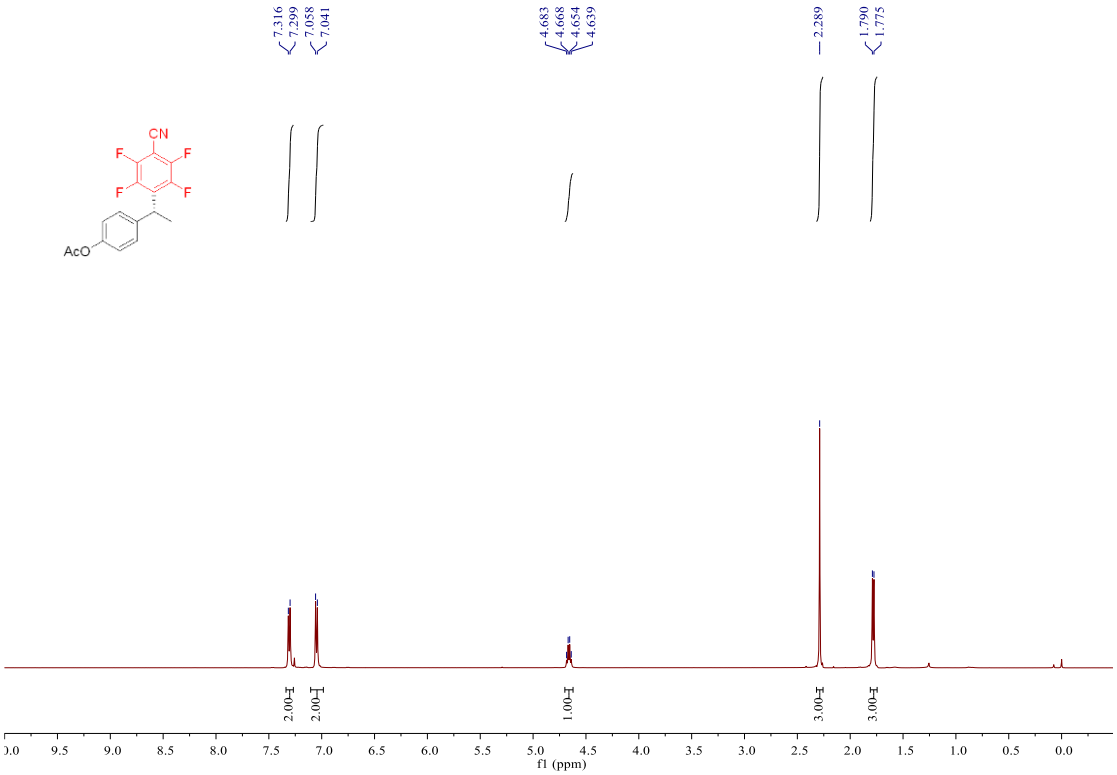
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3l



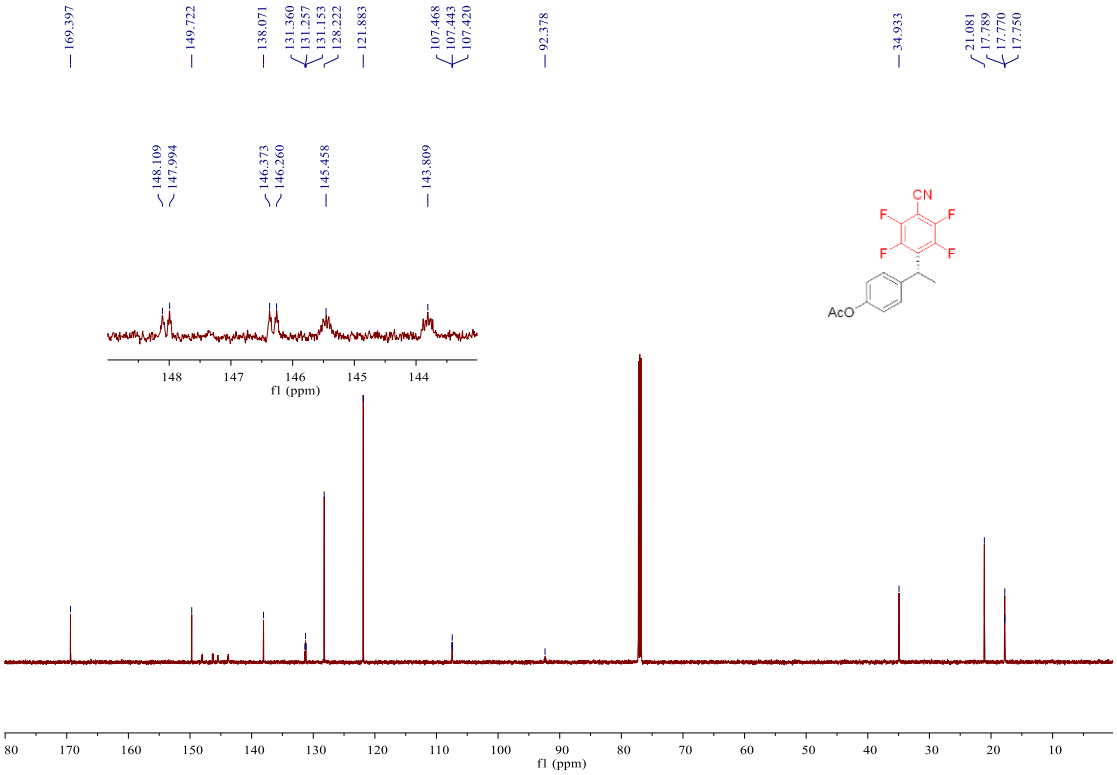
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3l



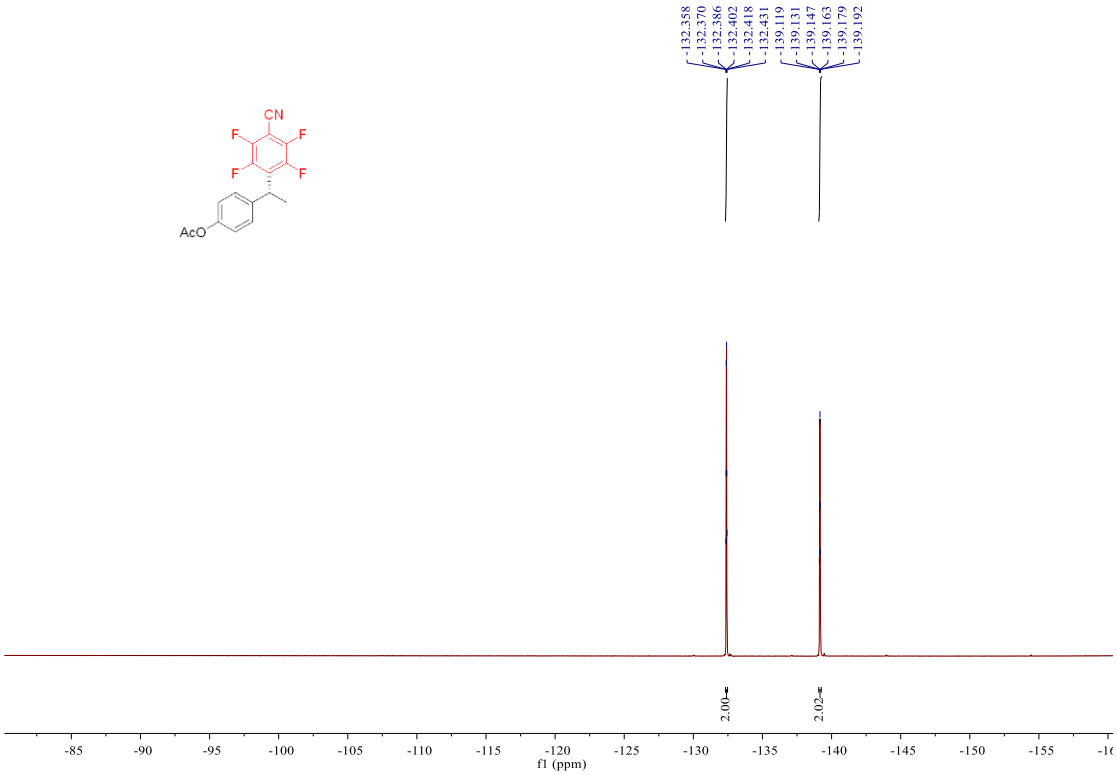
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 3m



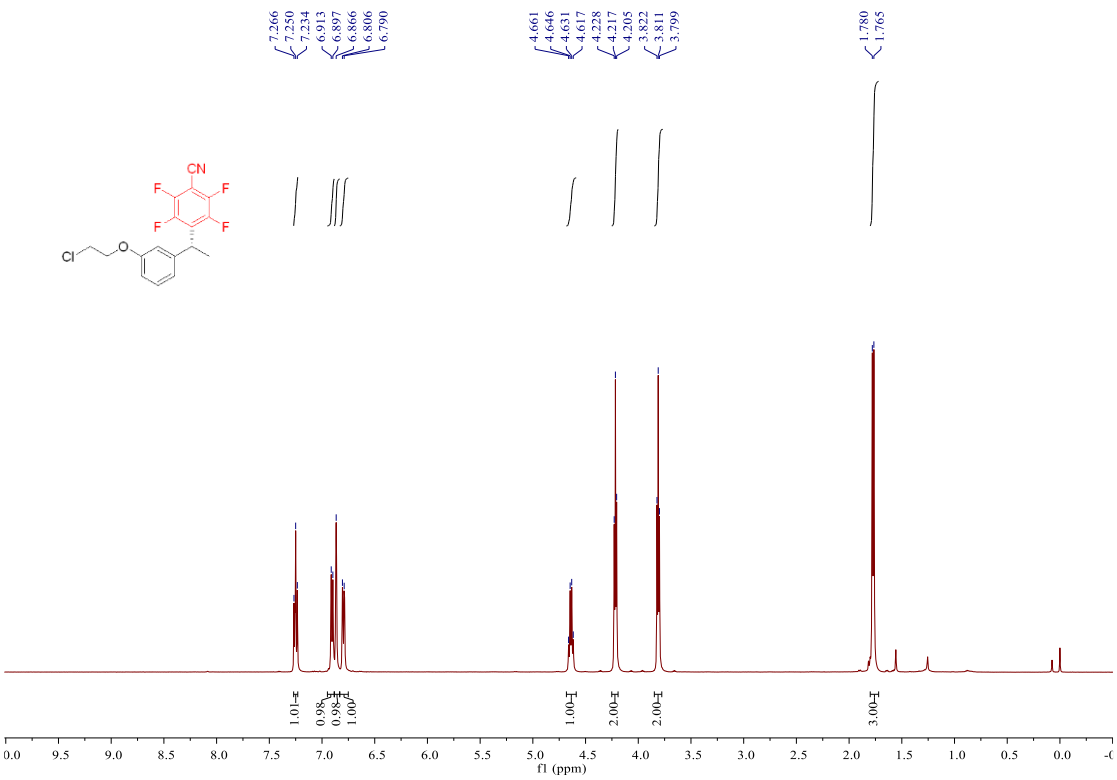
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3m



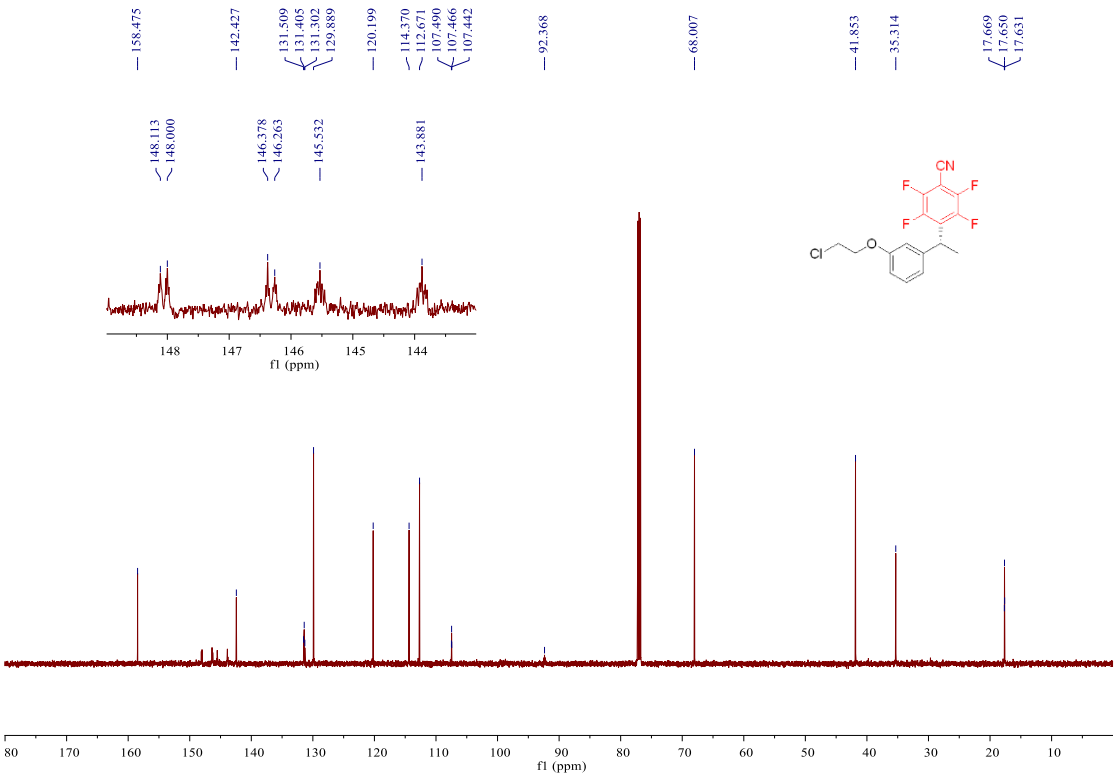
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3m



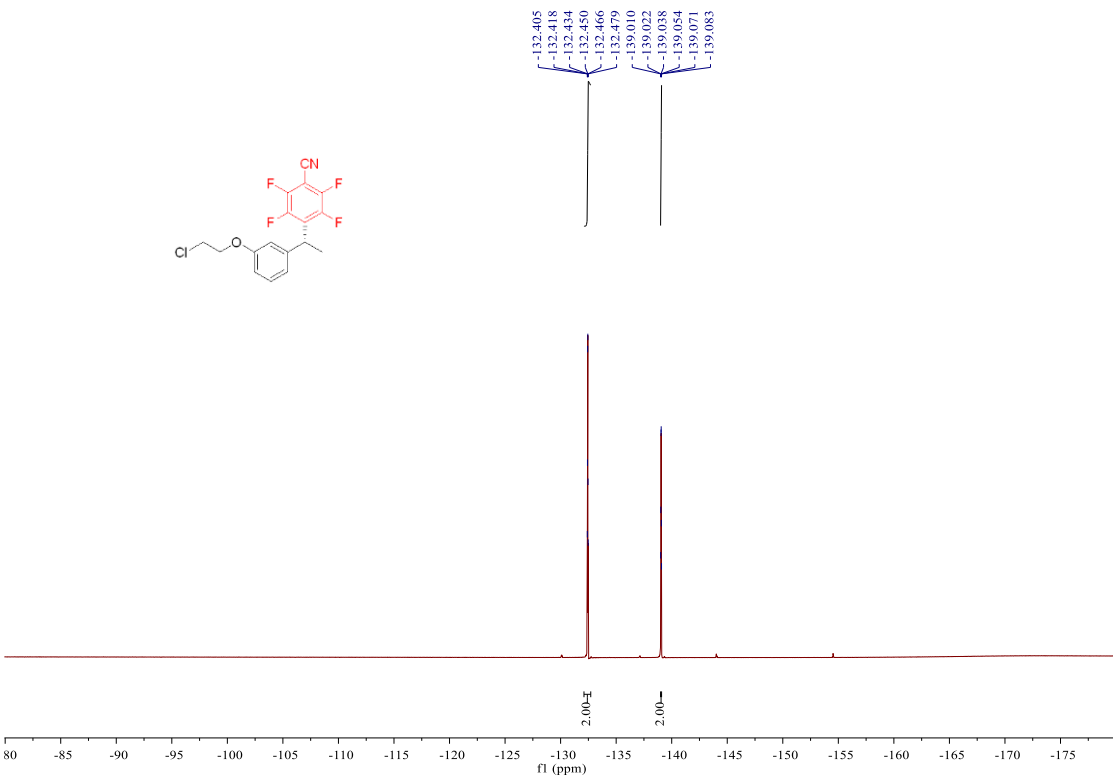
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3n



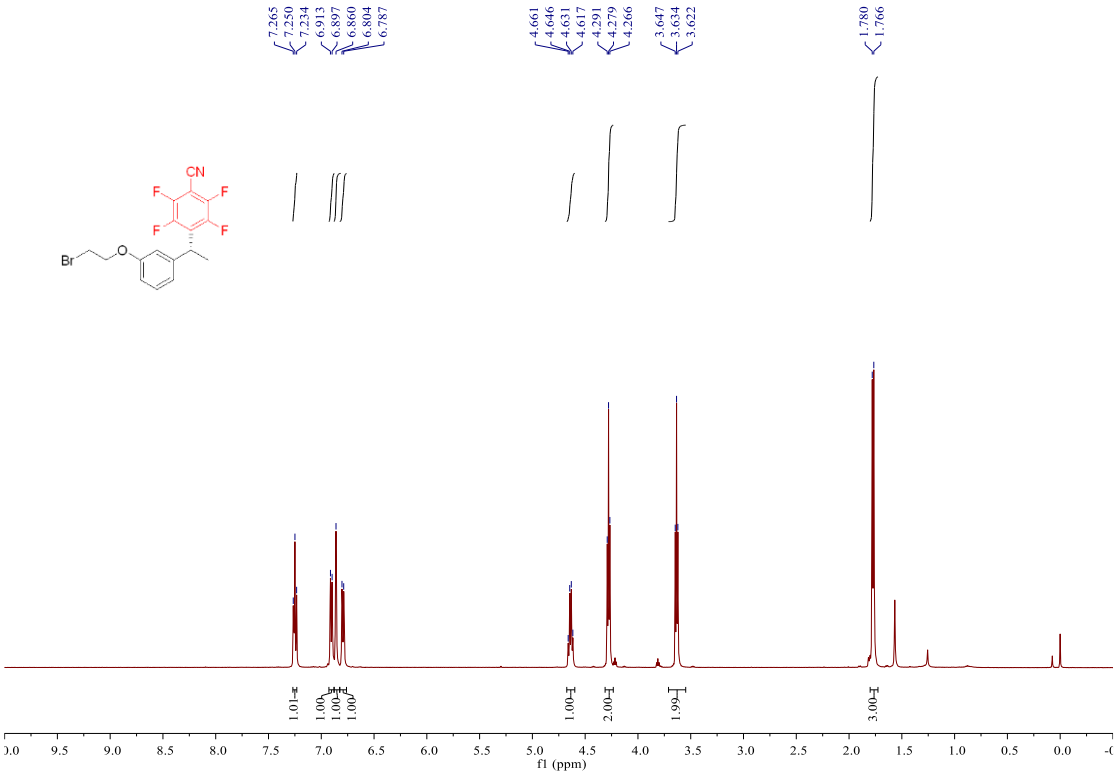
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3n



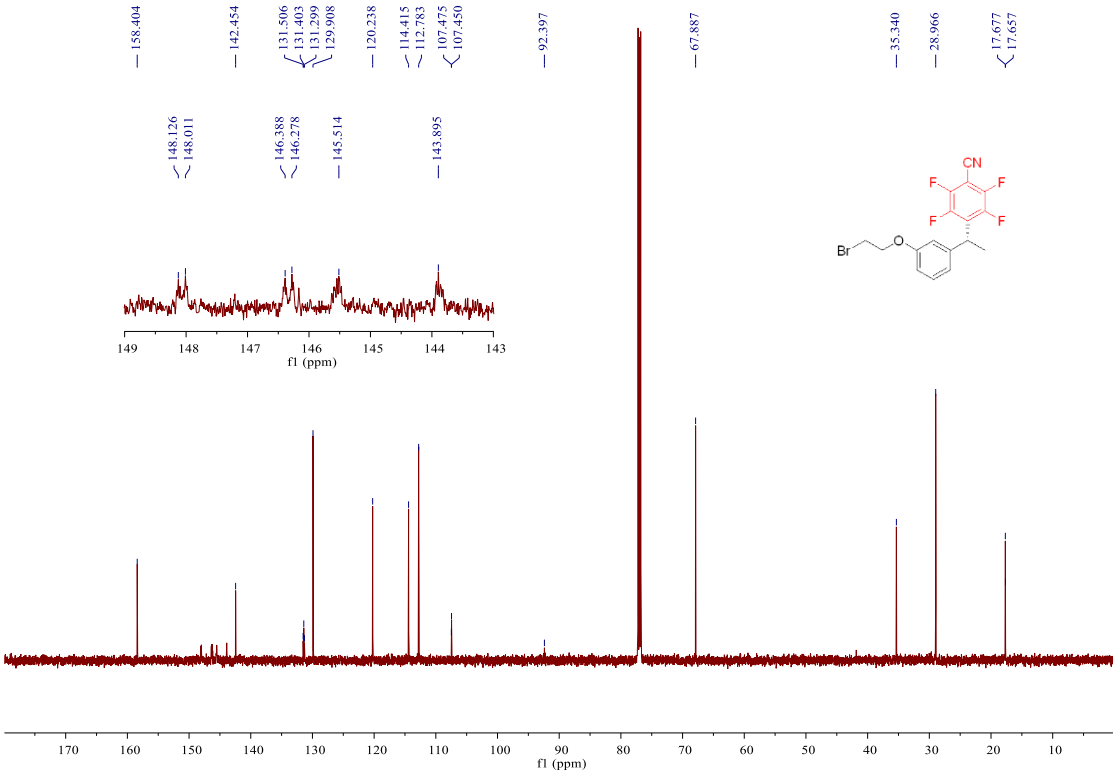
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3n



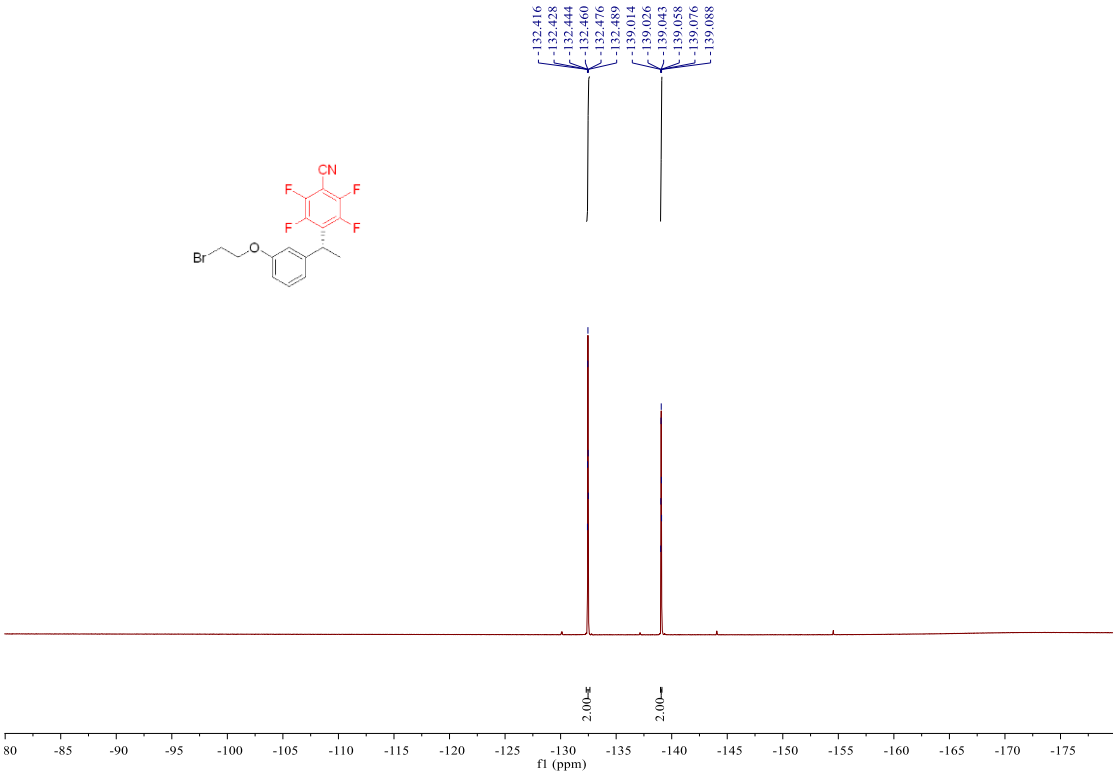
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 3o



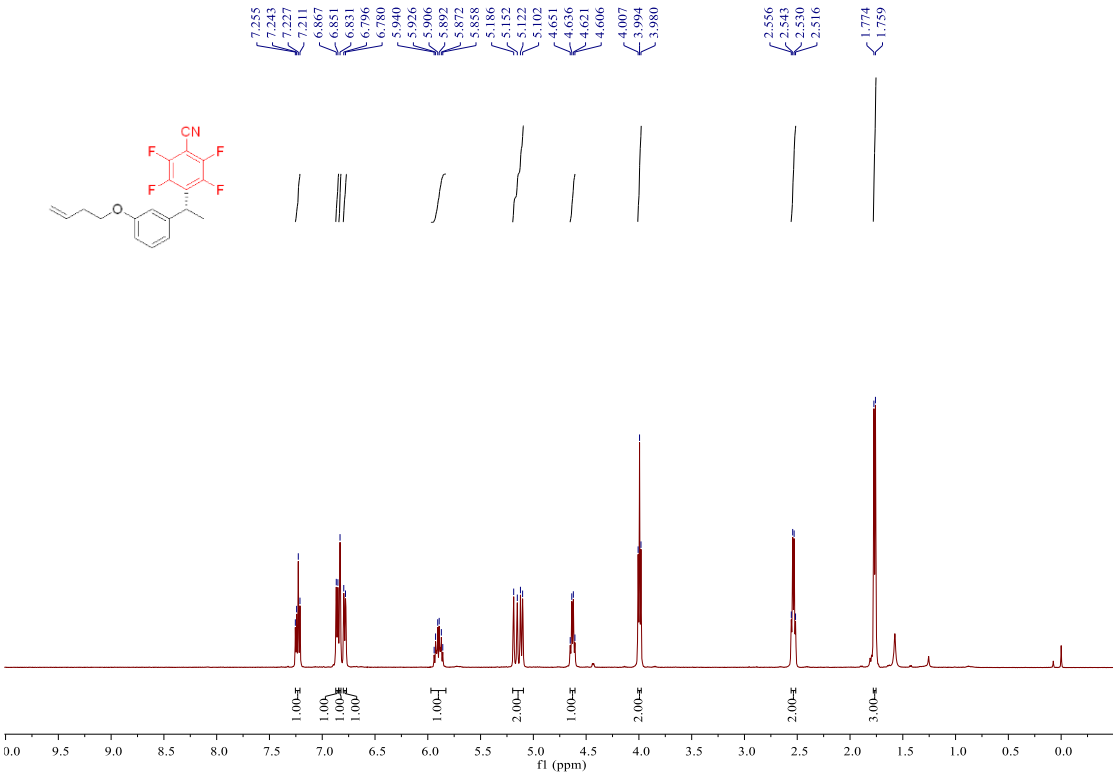
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3o



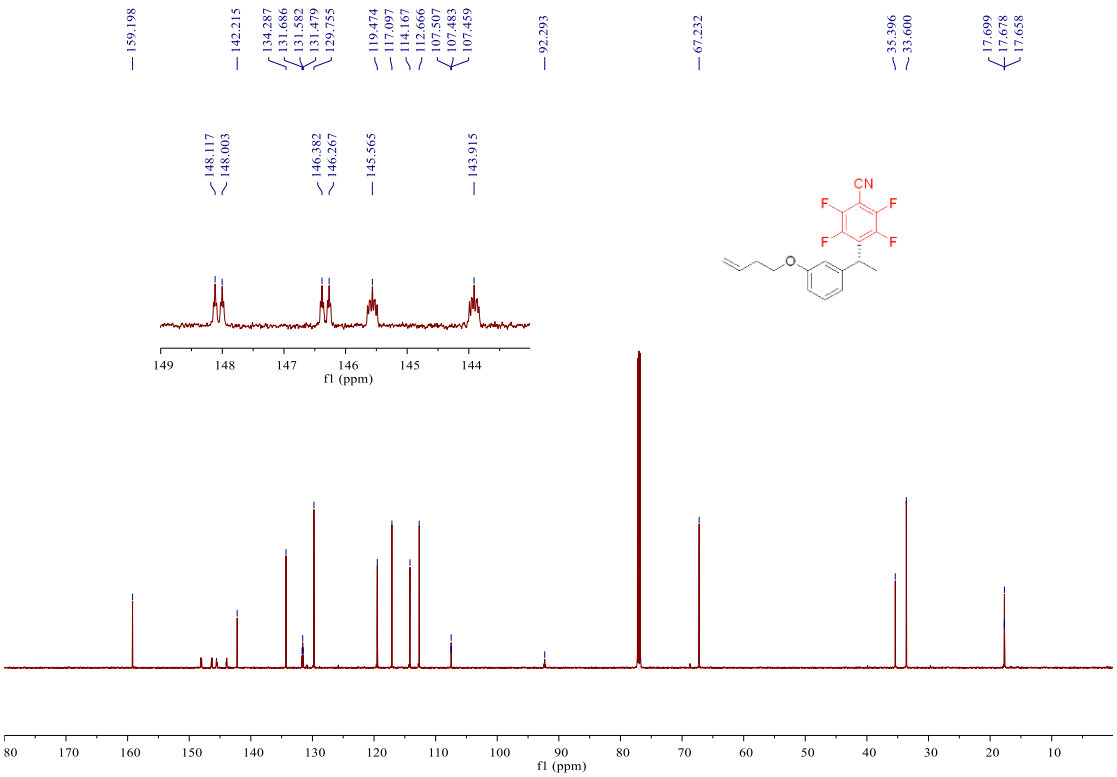
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3o



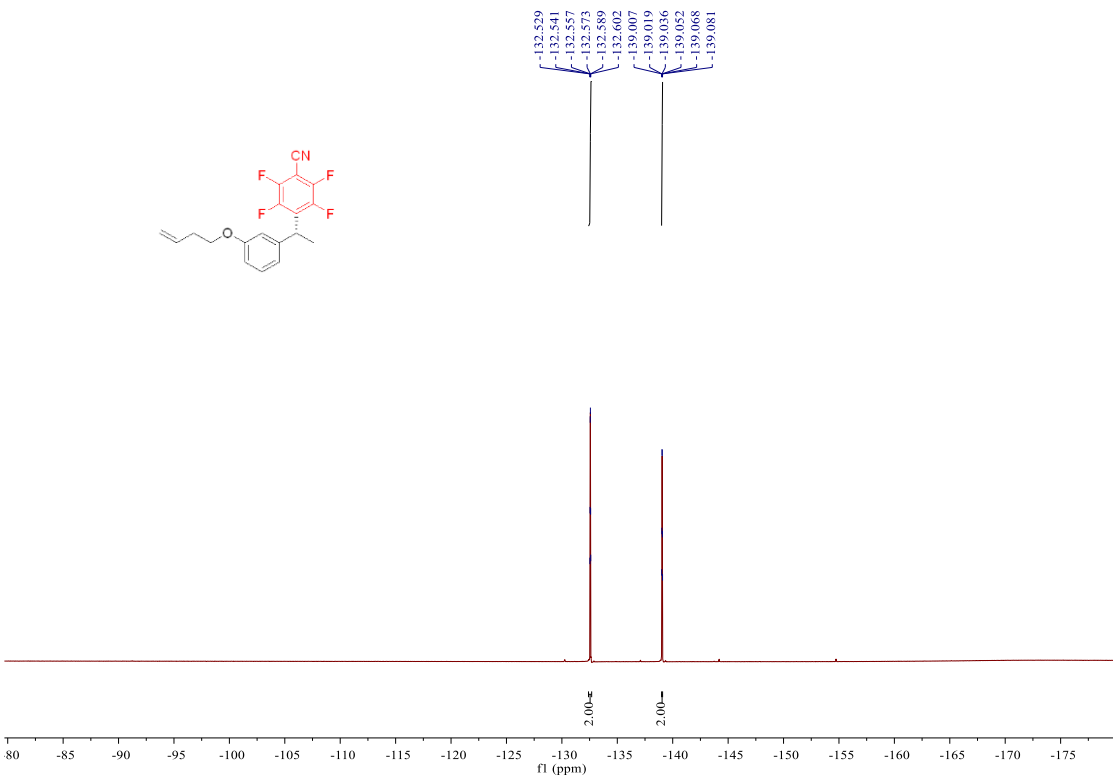
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3p



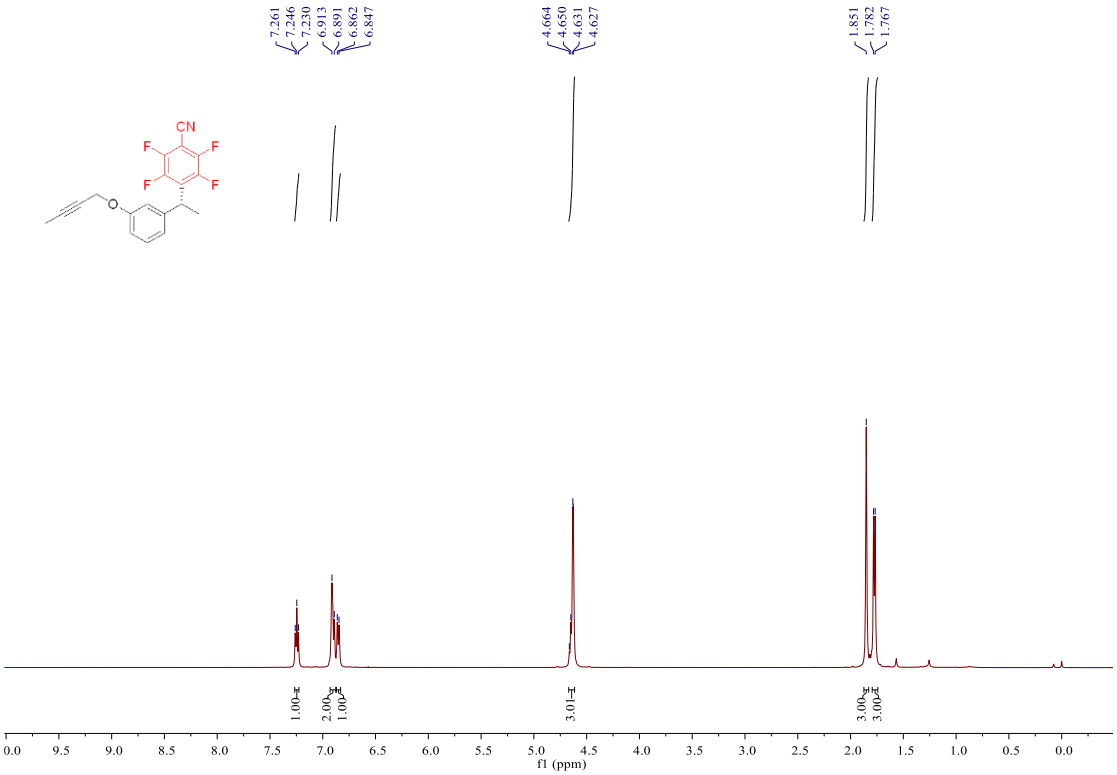
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3p



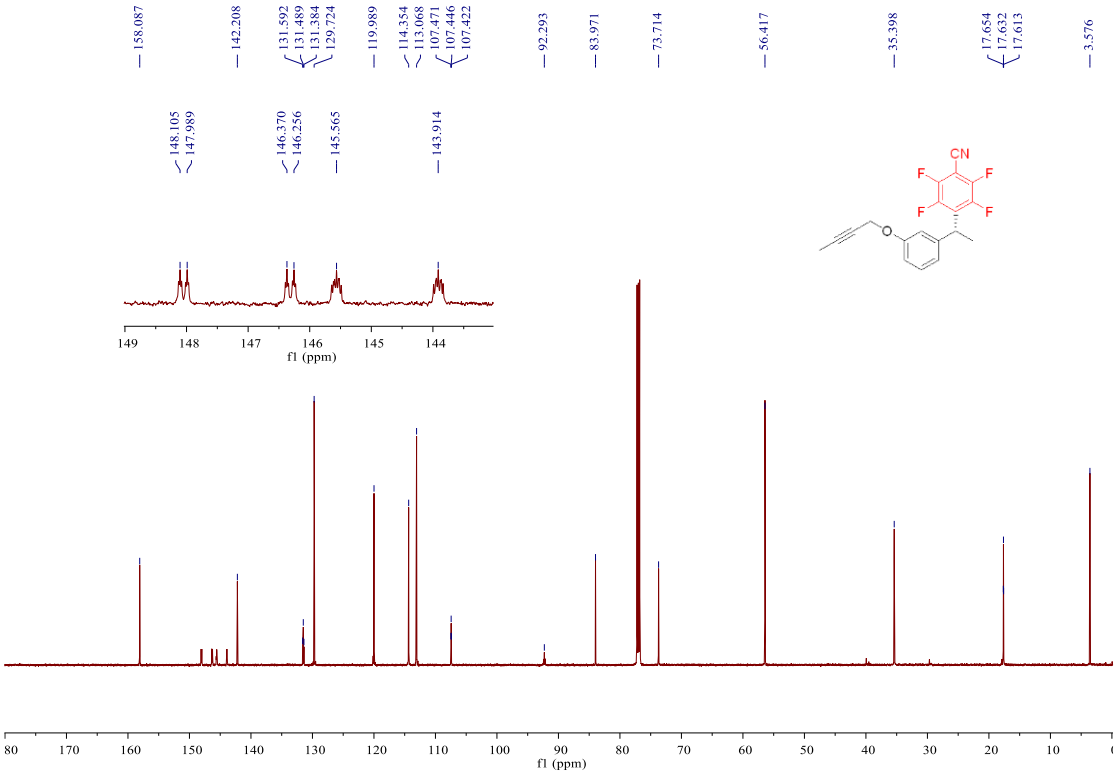
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3p



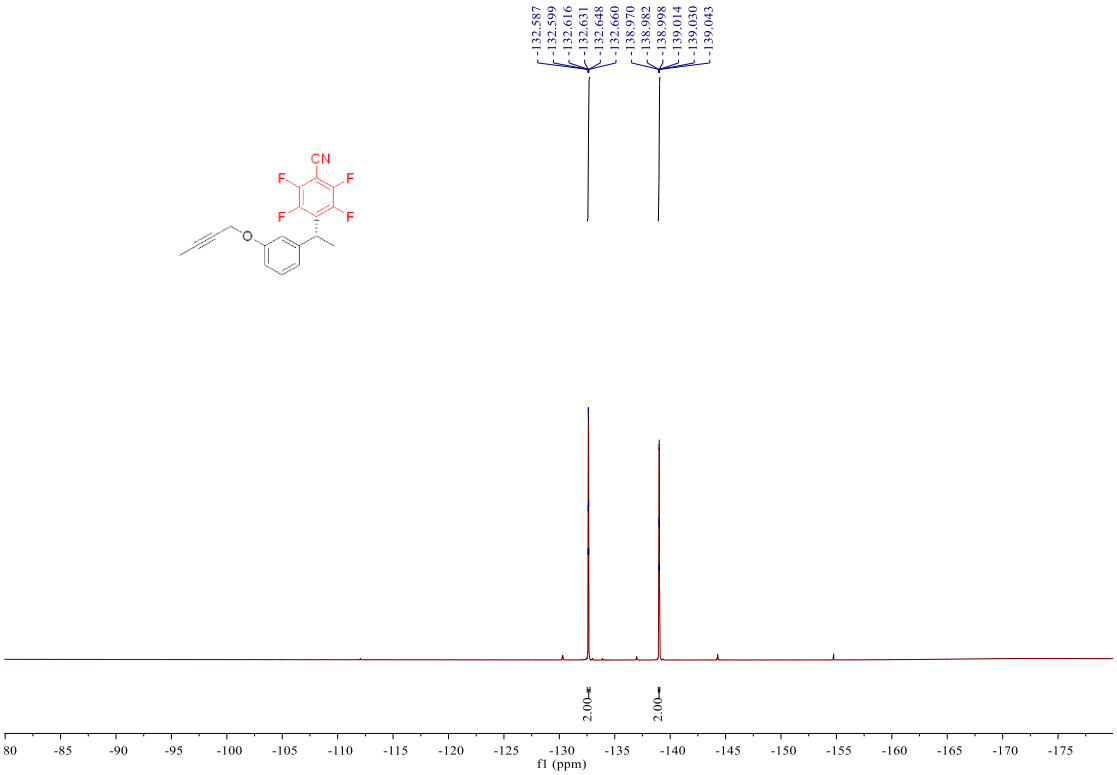
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3q



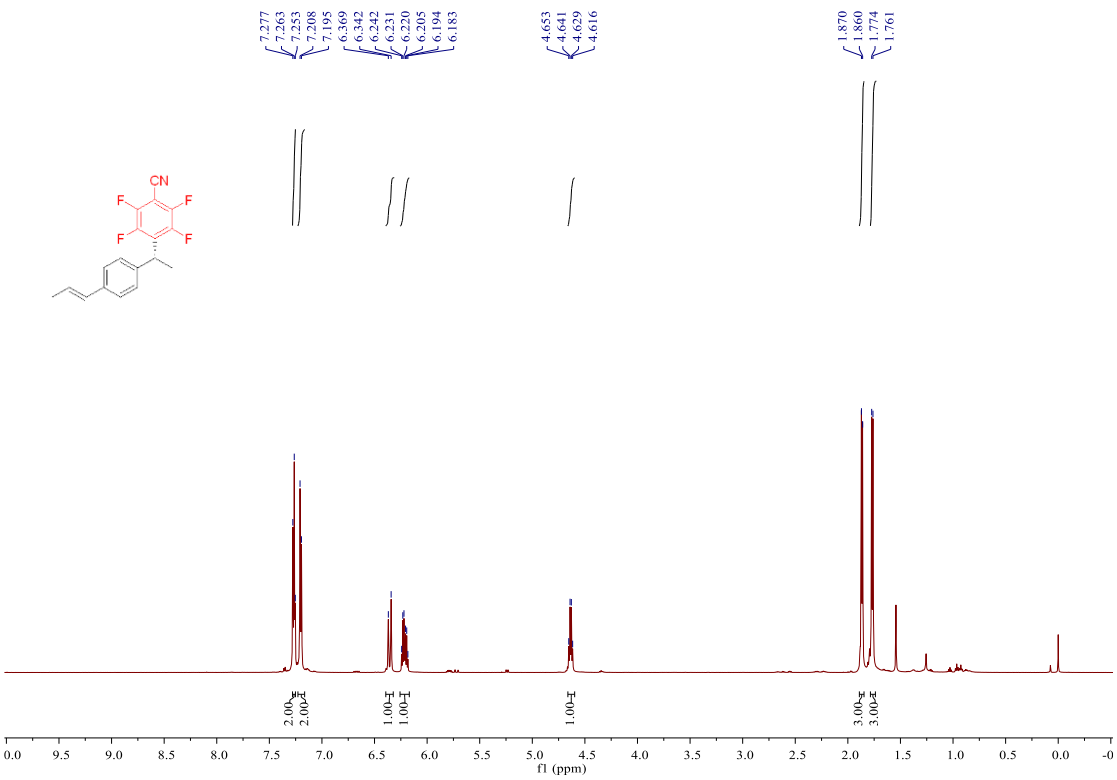
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3q



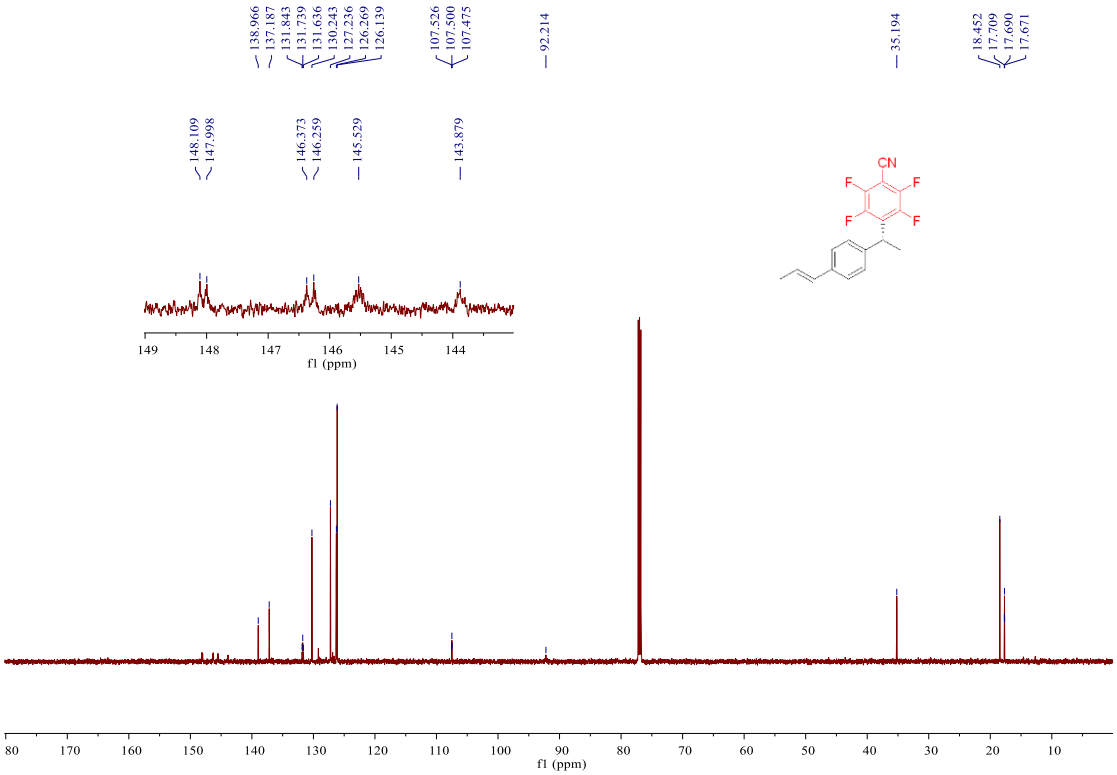
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3q



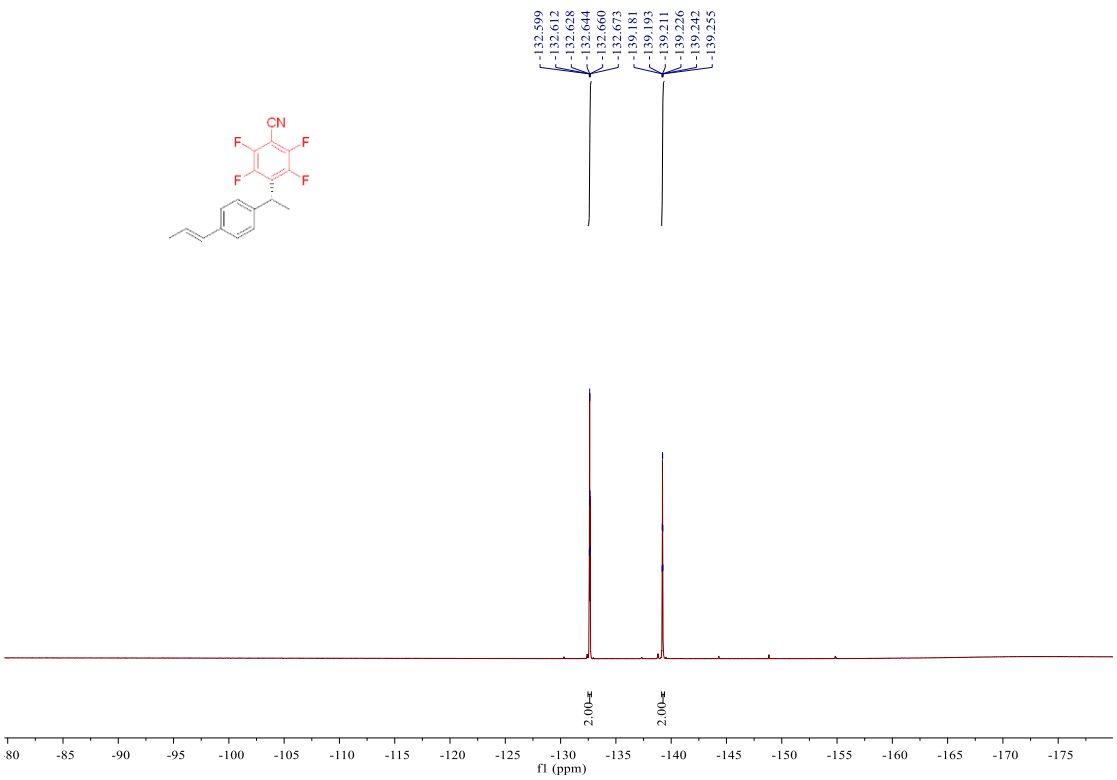
^{1}H NMR (600 MHz, Chloroform-*d)* spectrum of 3r



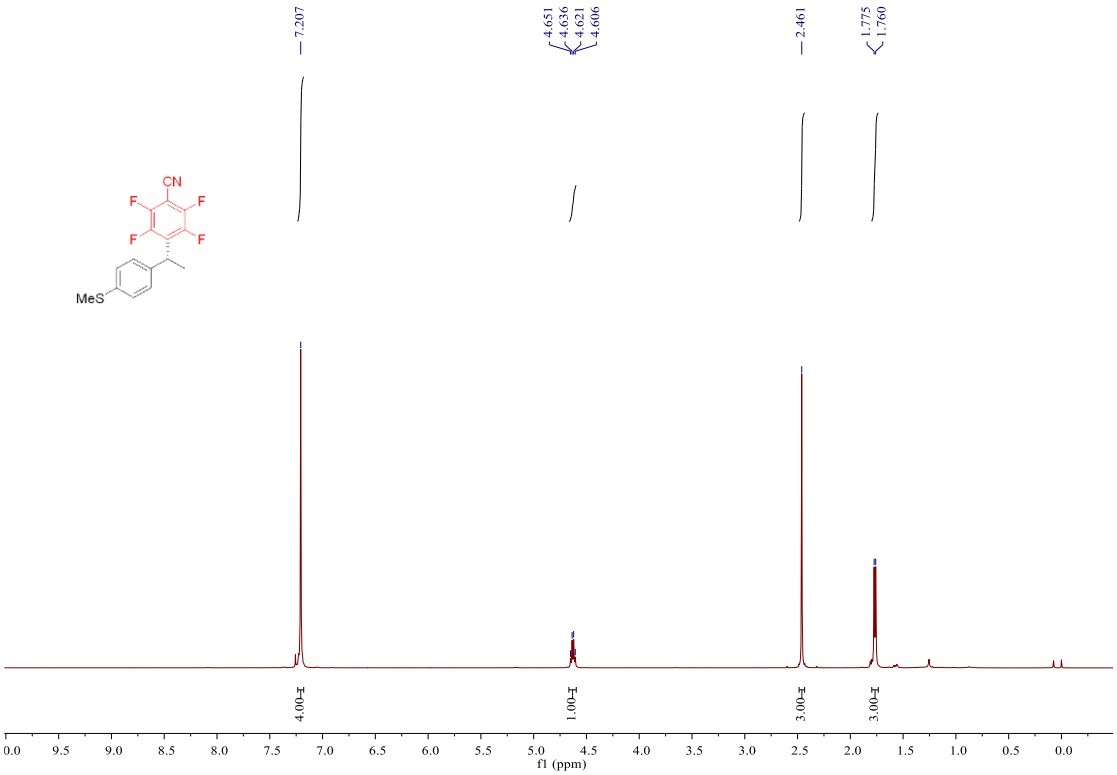
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3r



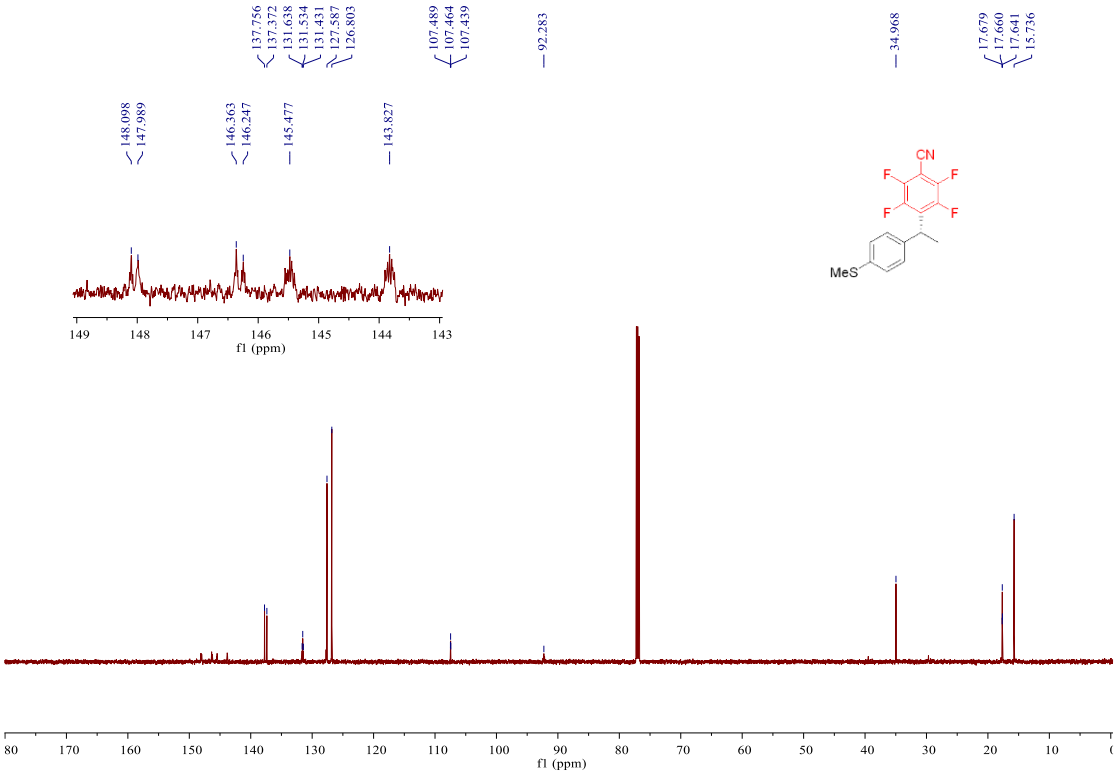
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3r



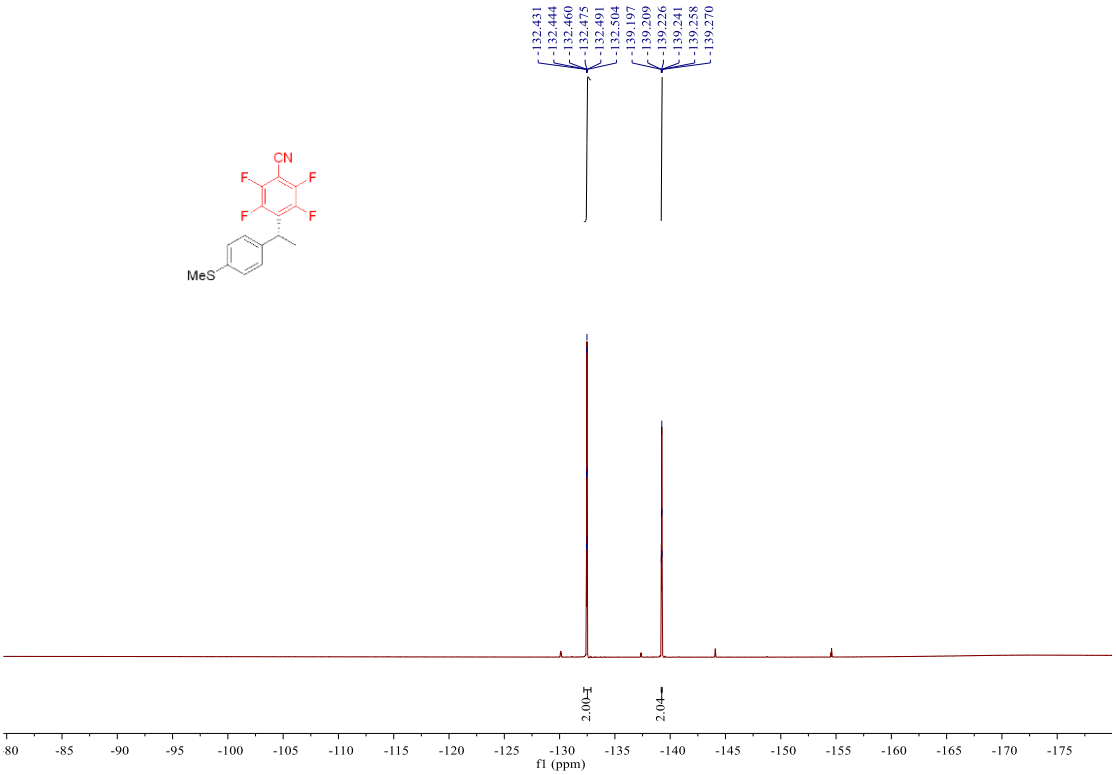
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3s



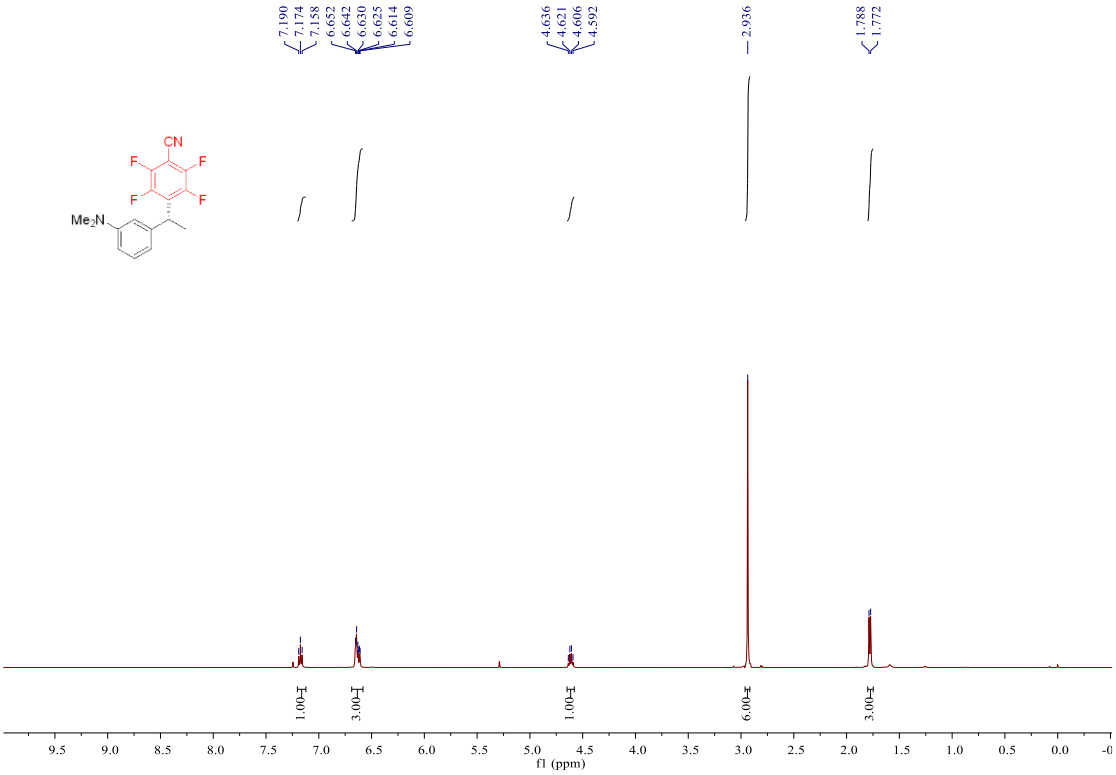
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3s



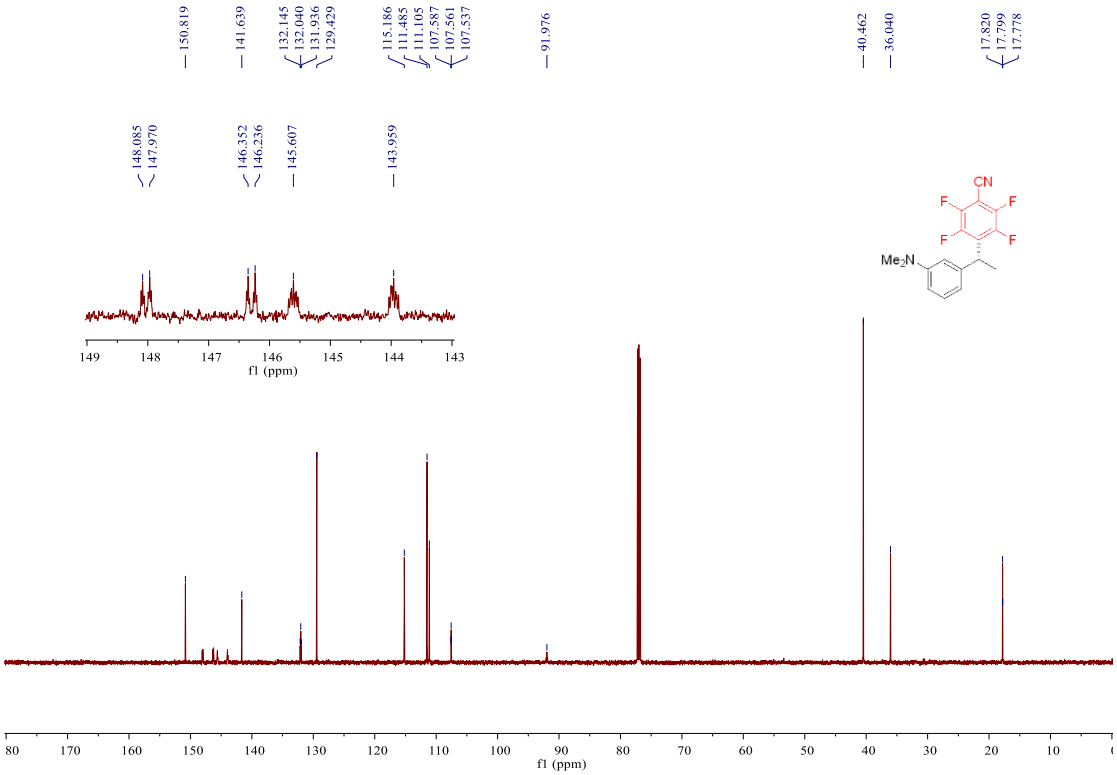
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3s



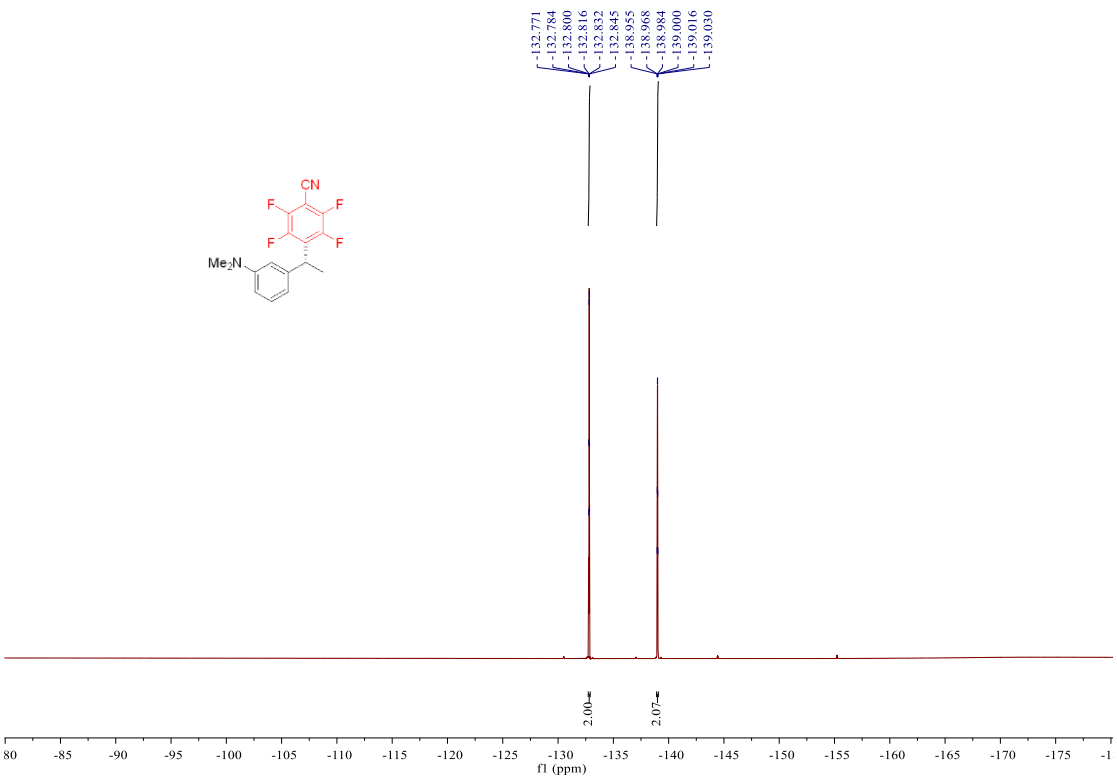
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3t



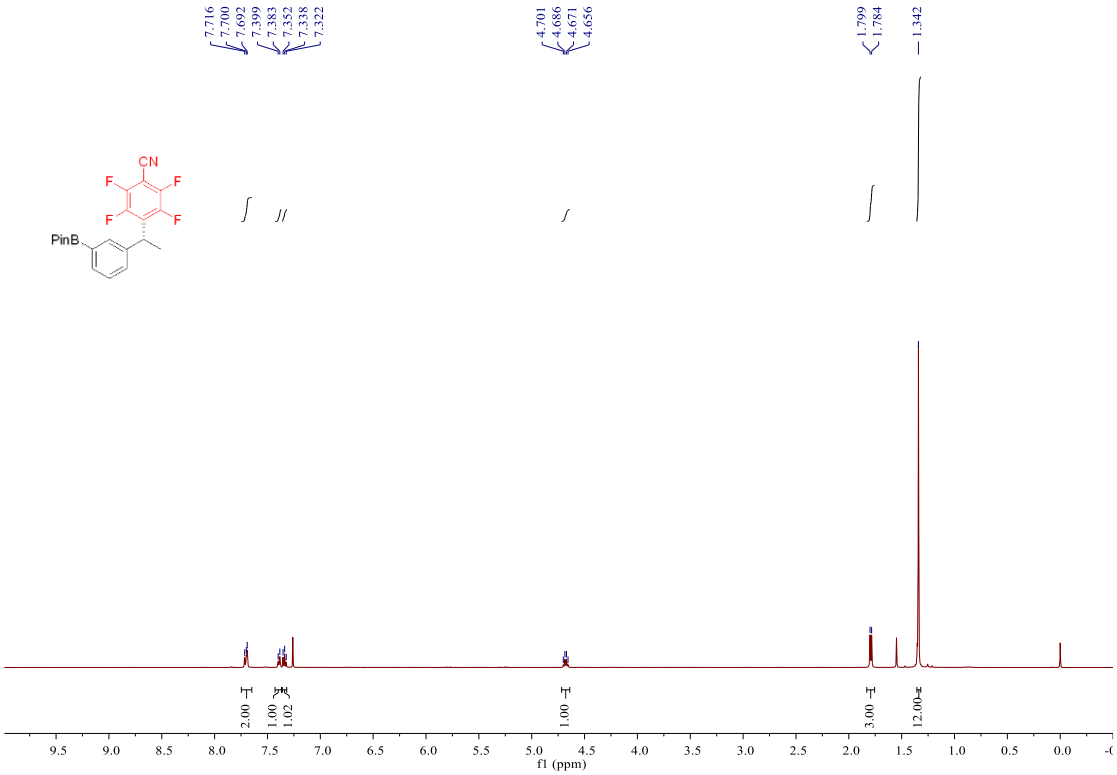
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3t



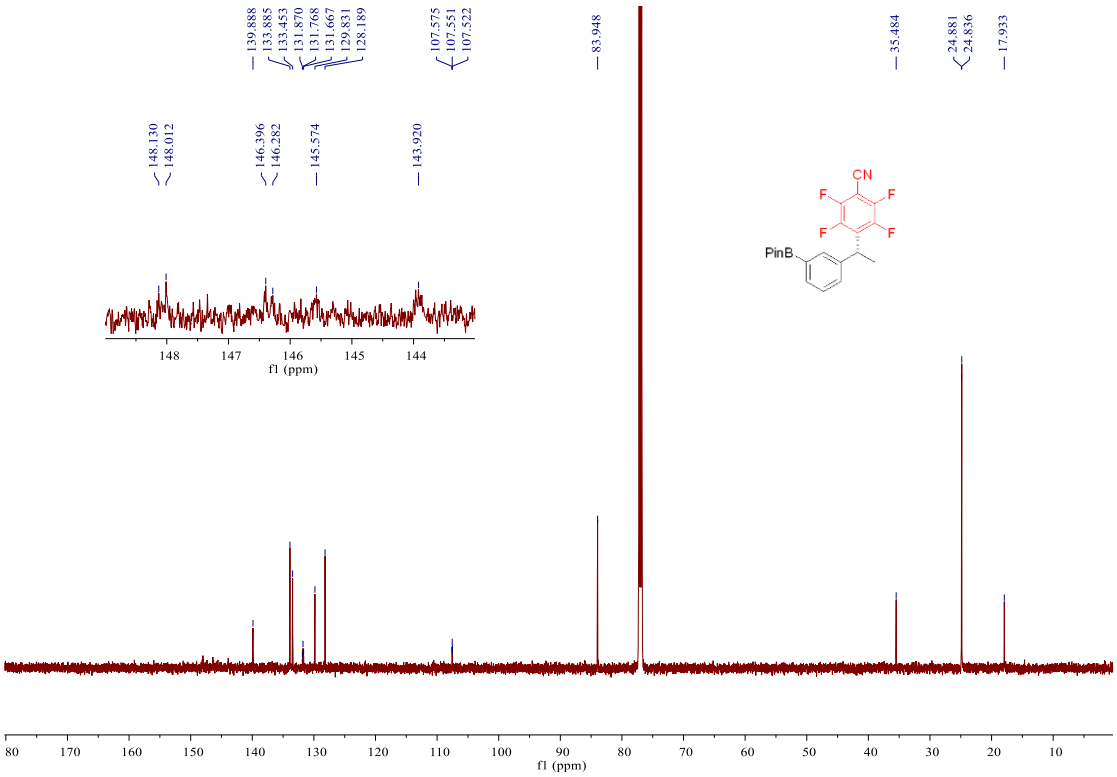
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3t



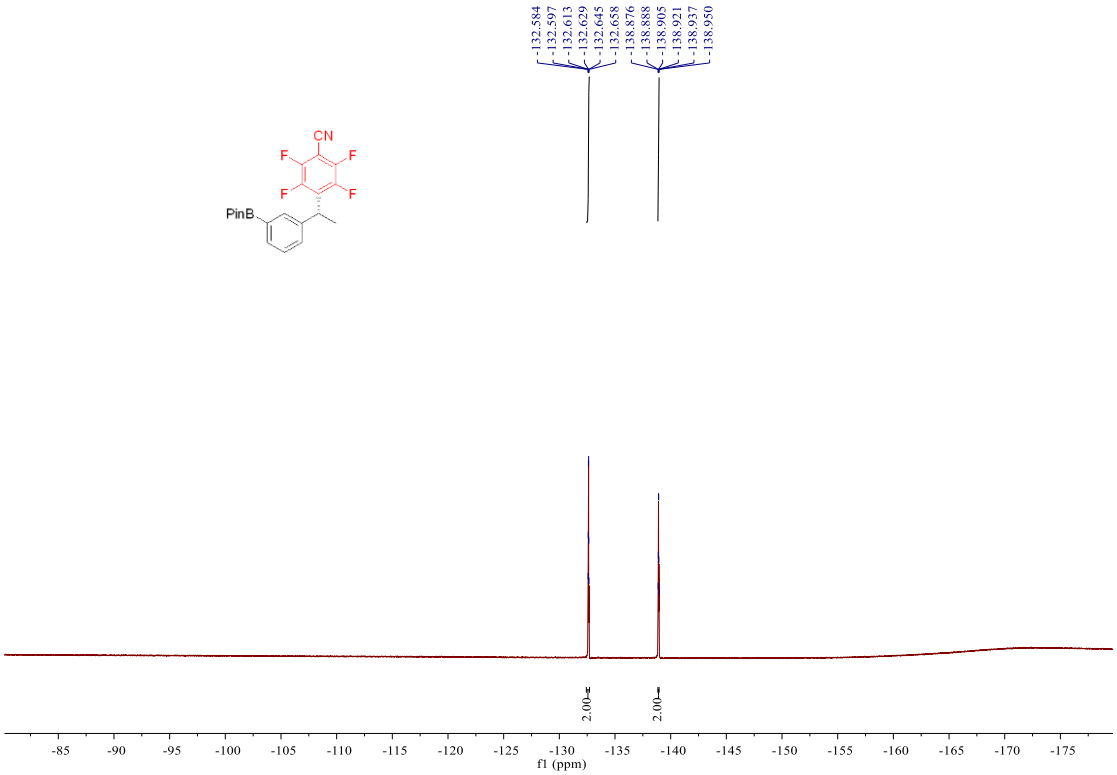
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3u



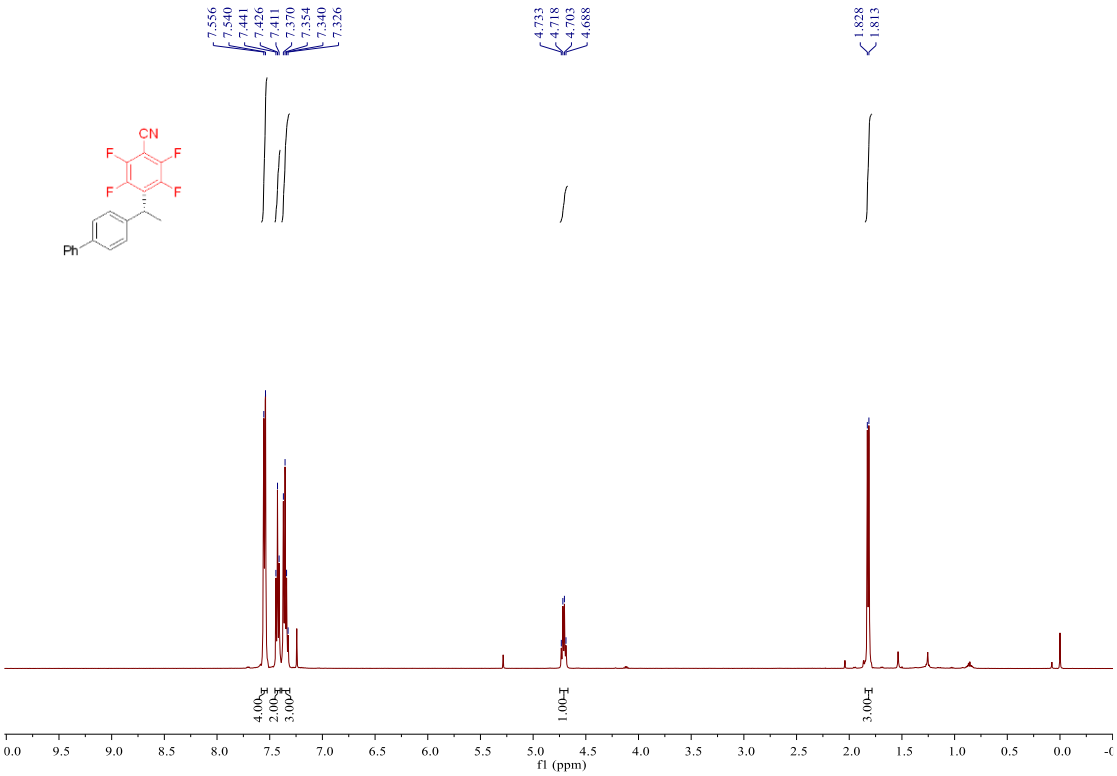
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3u



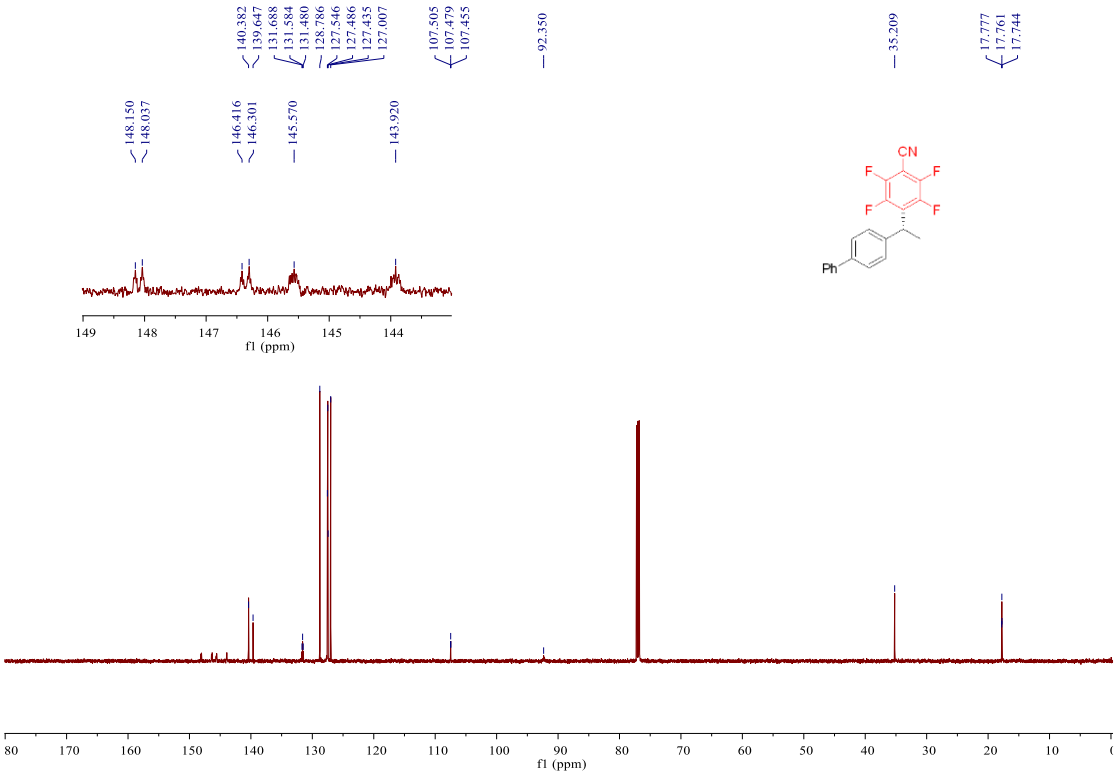
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3u



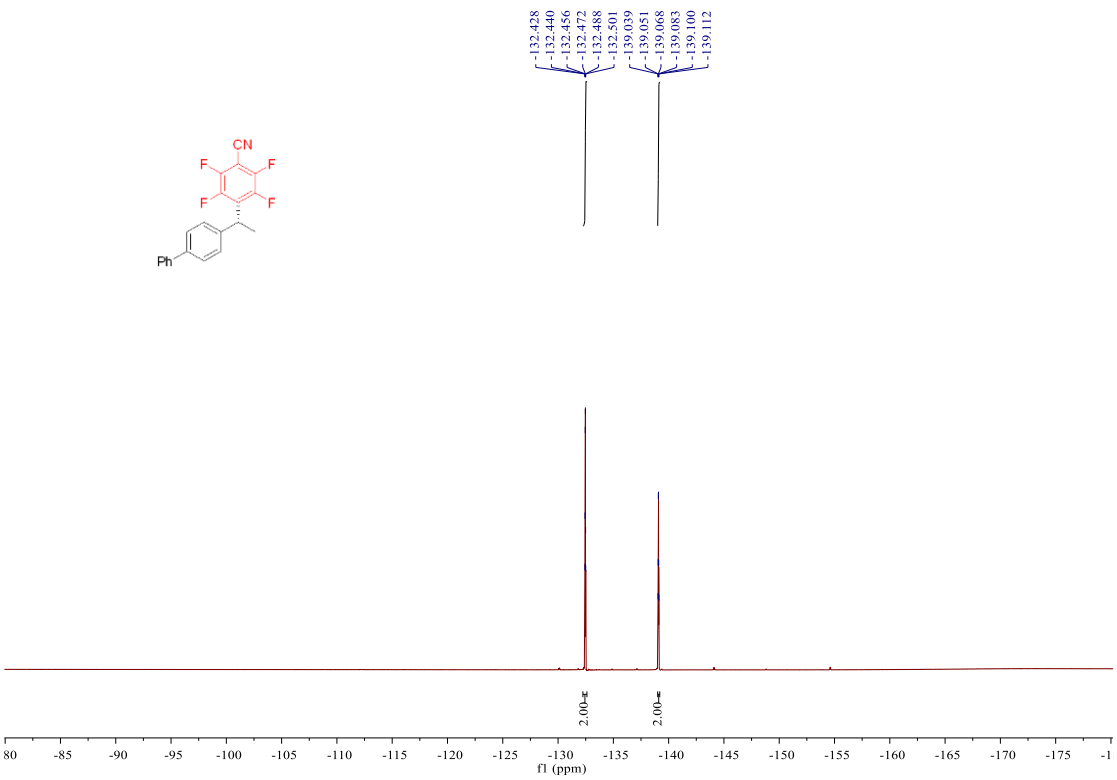
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3v



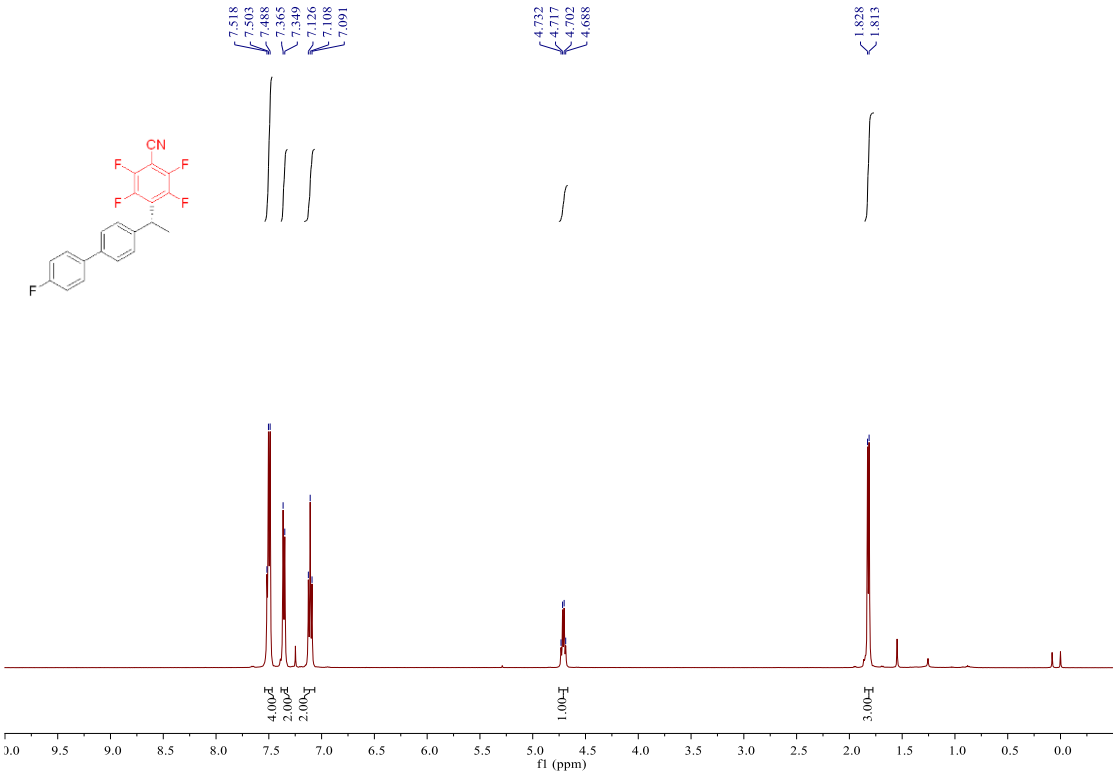
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3v



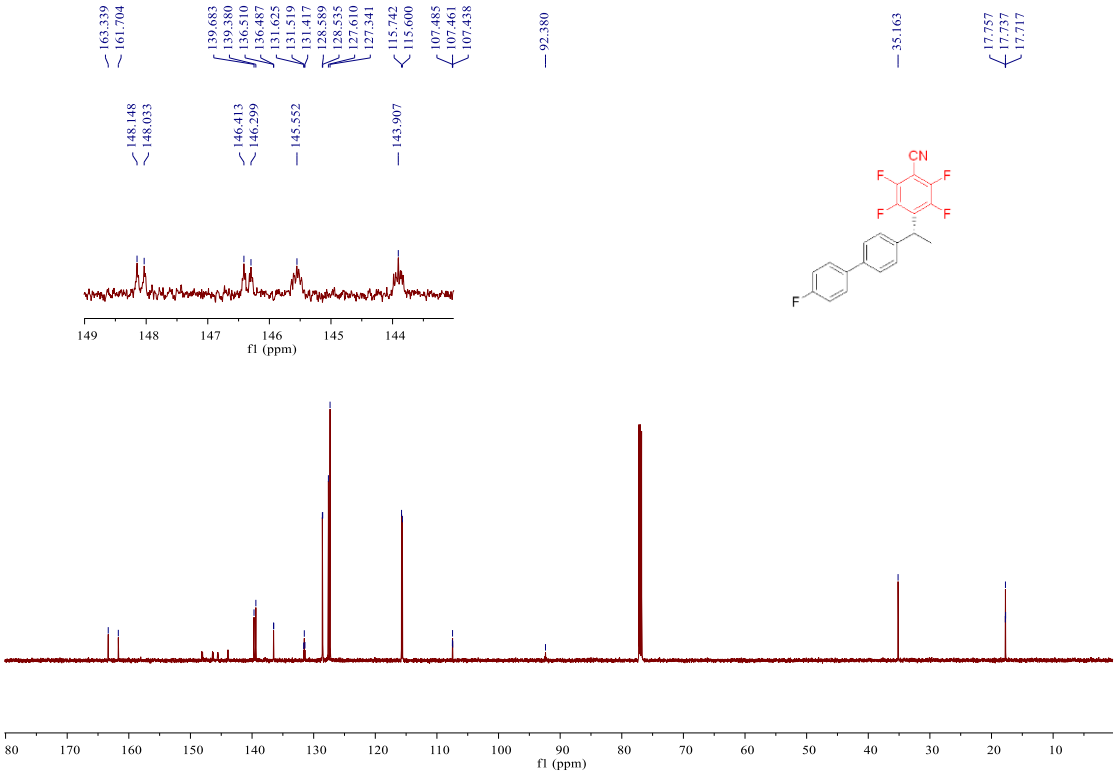
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3v



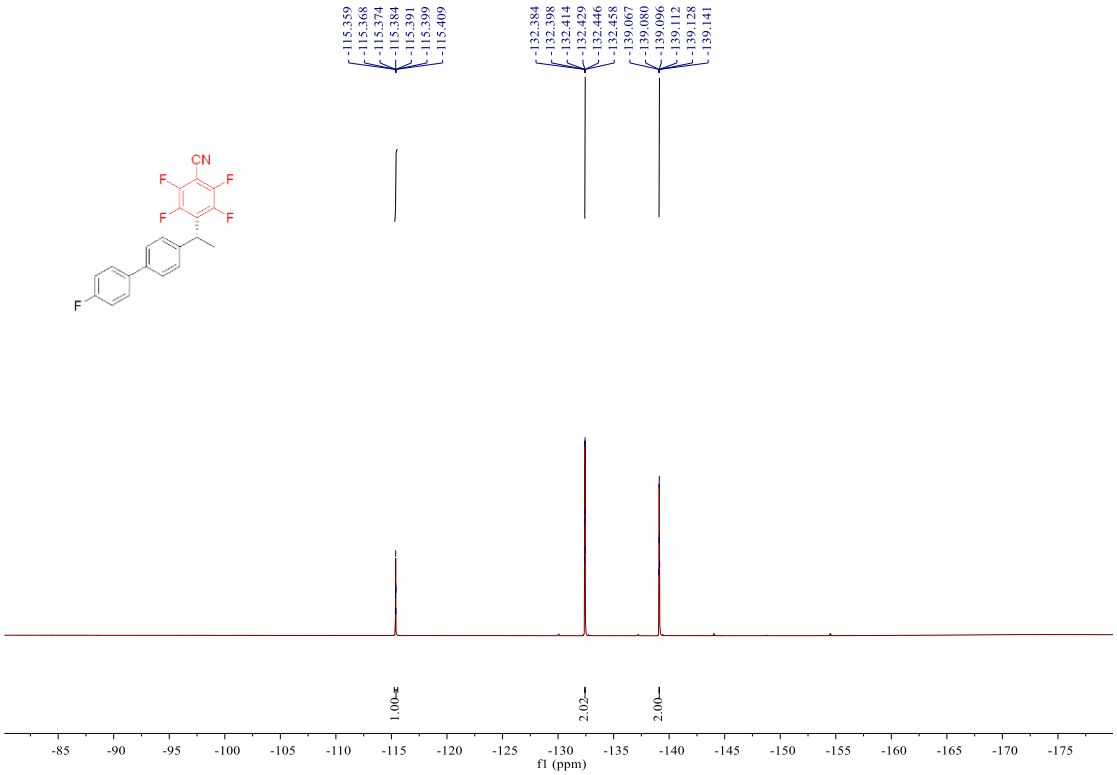
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 3w



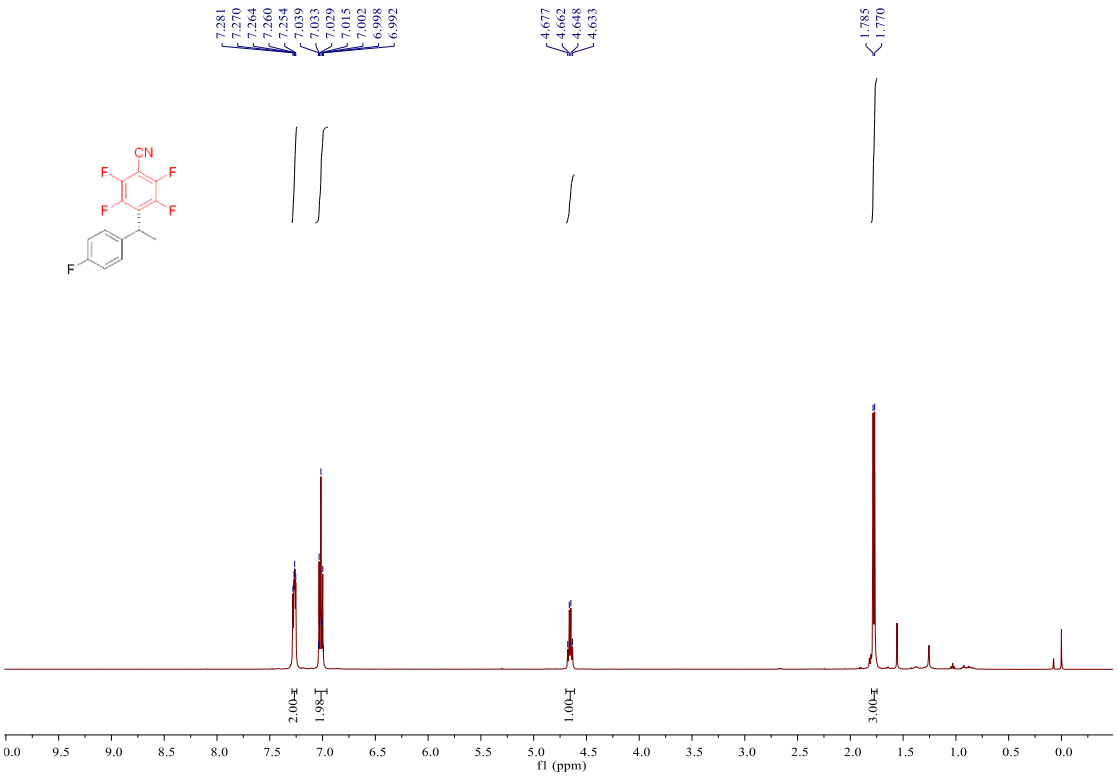
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3w



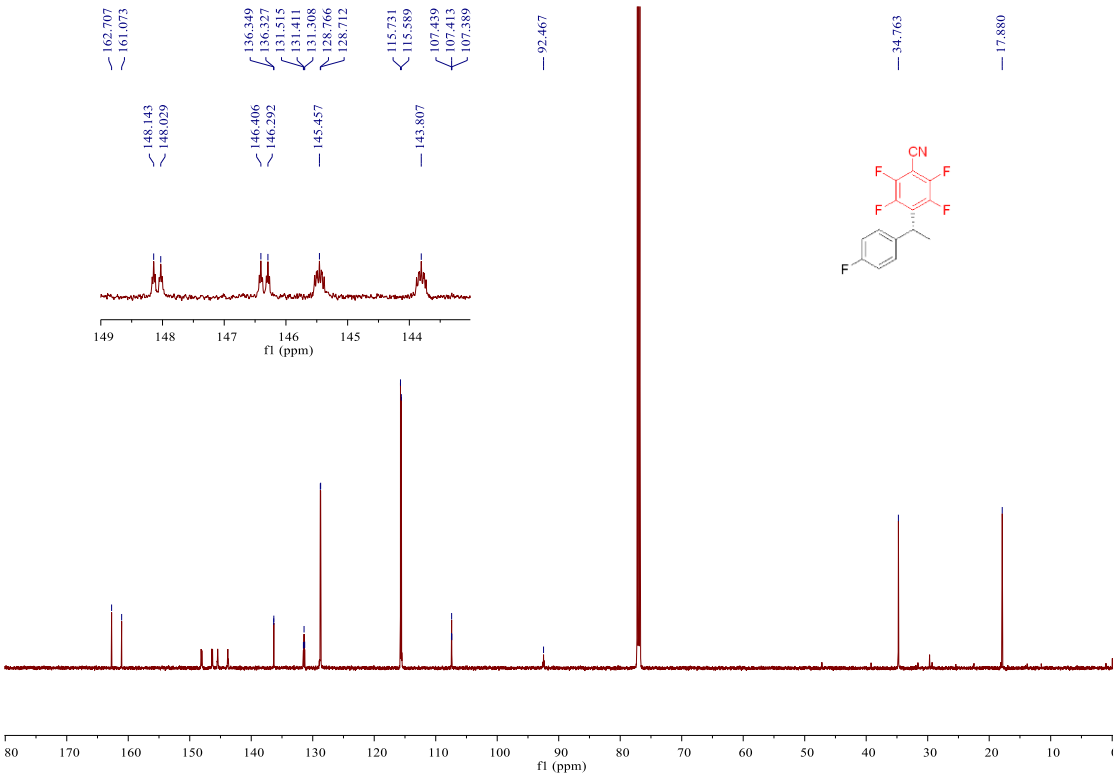
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3w



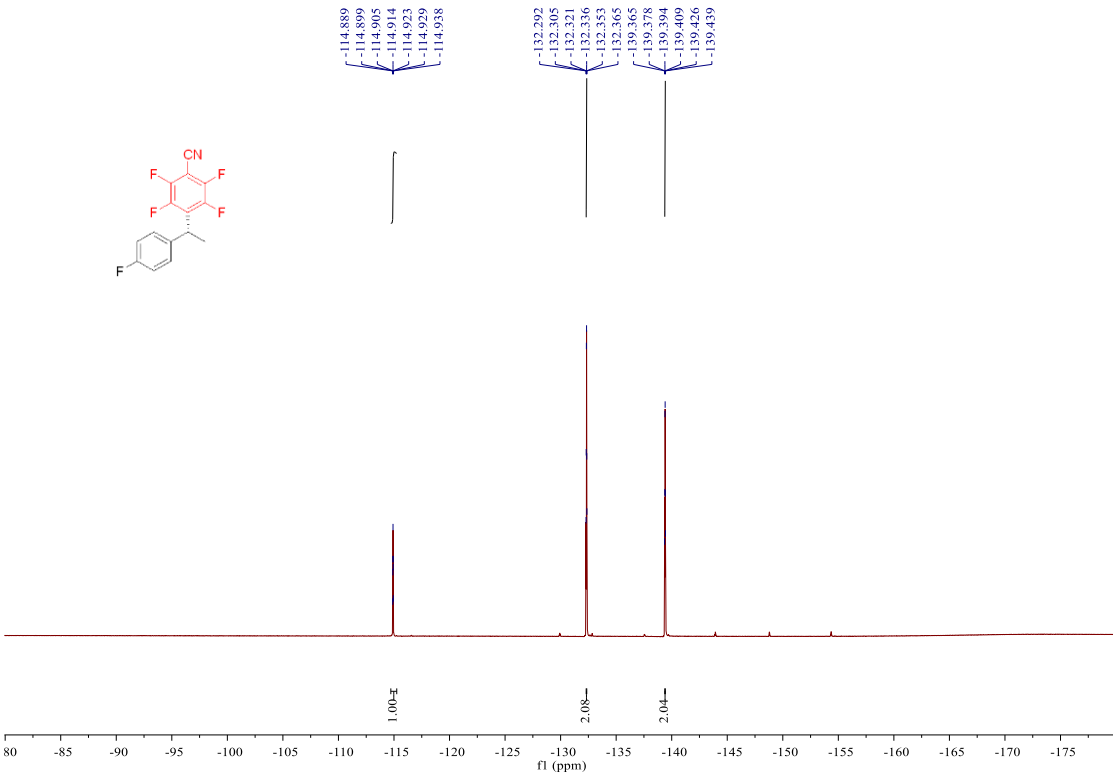
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3x



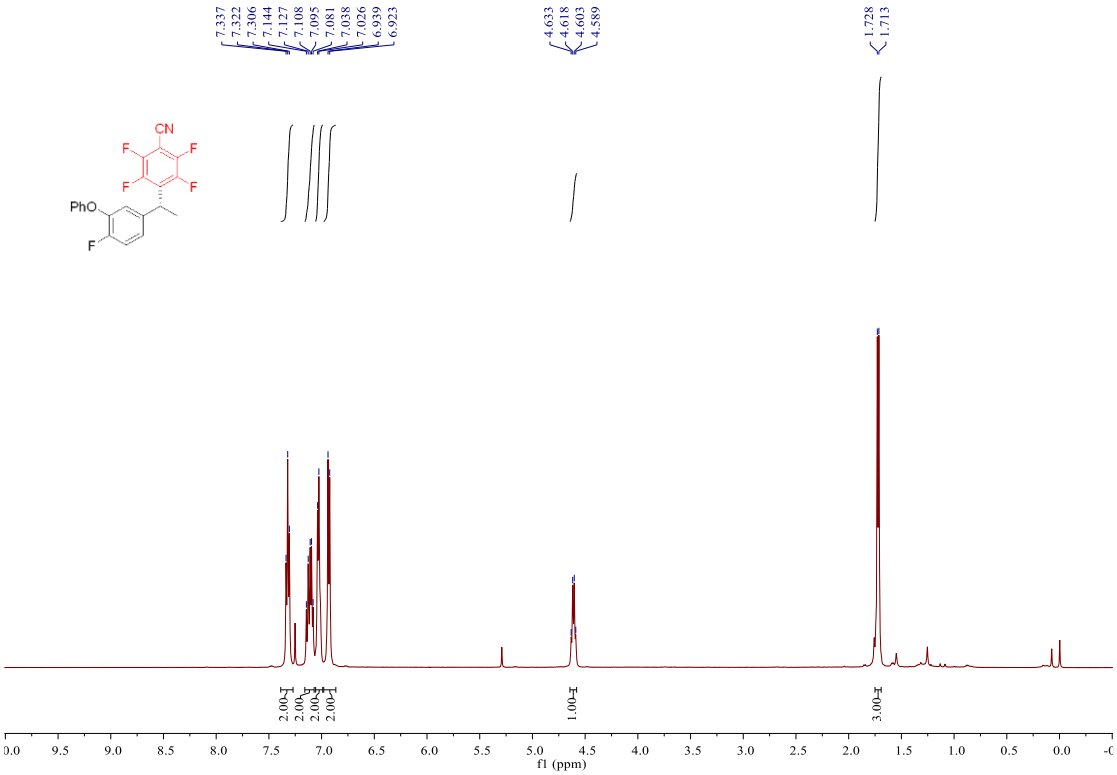
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3x



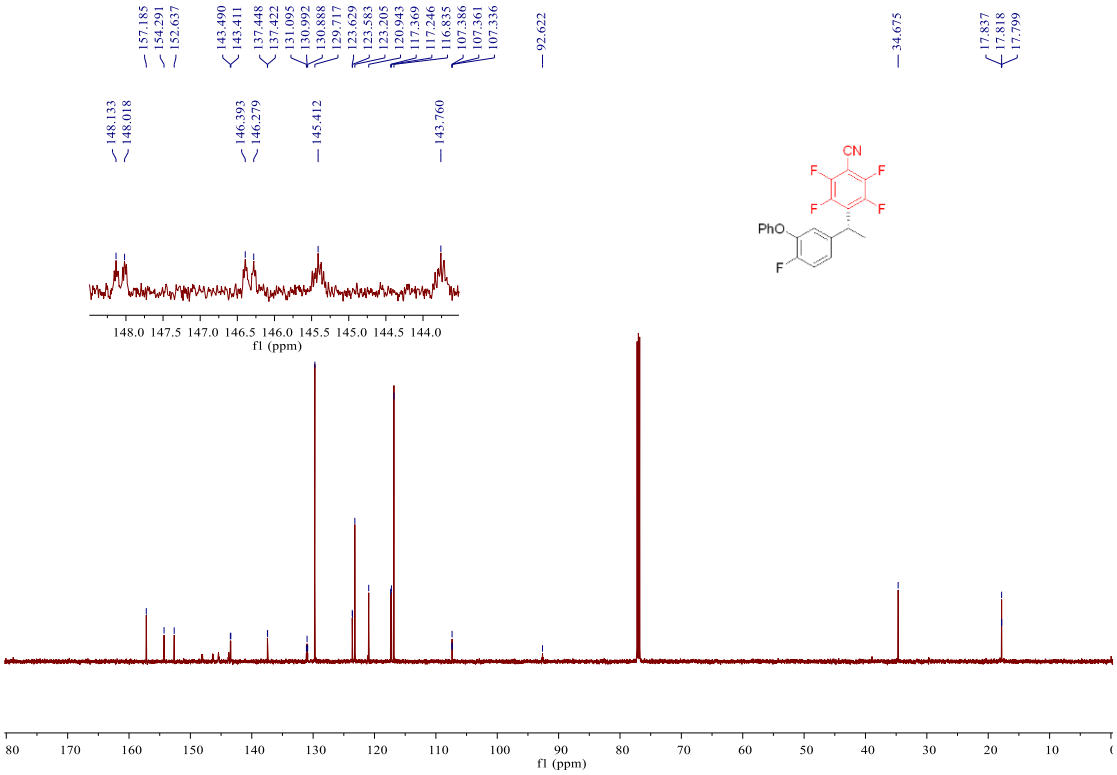
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3x



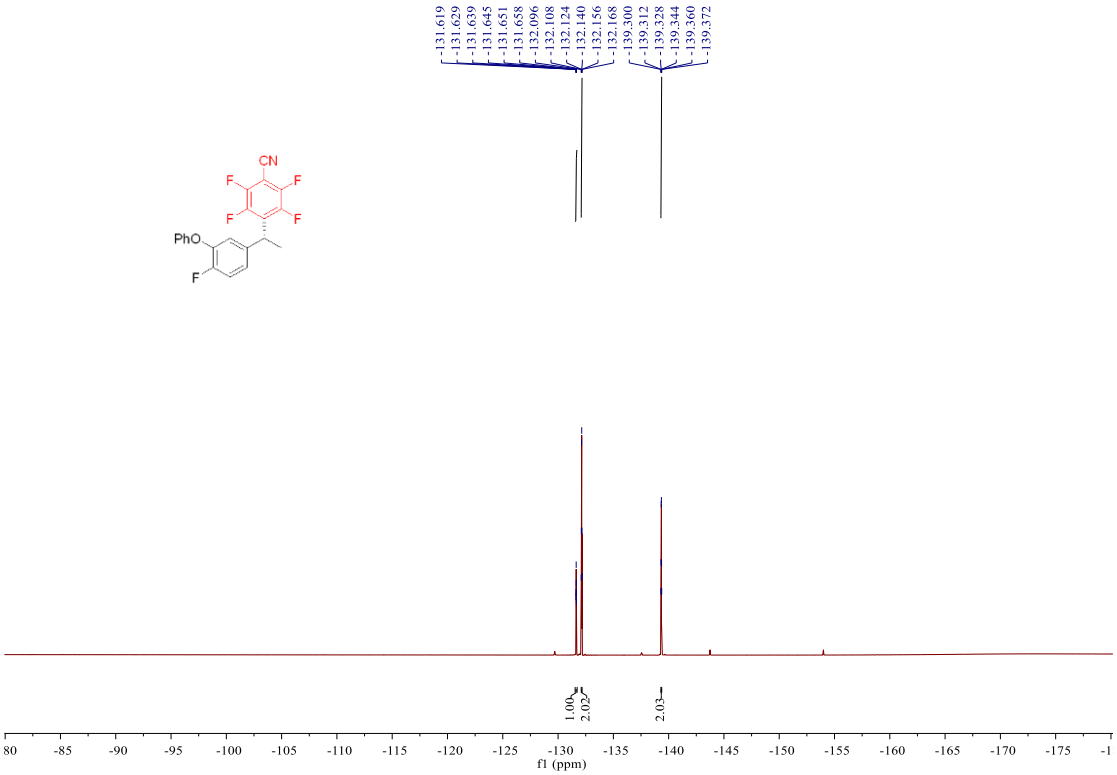
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3y



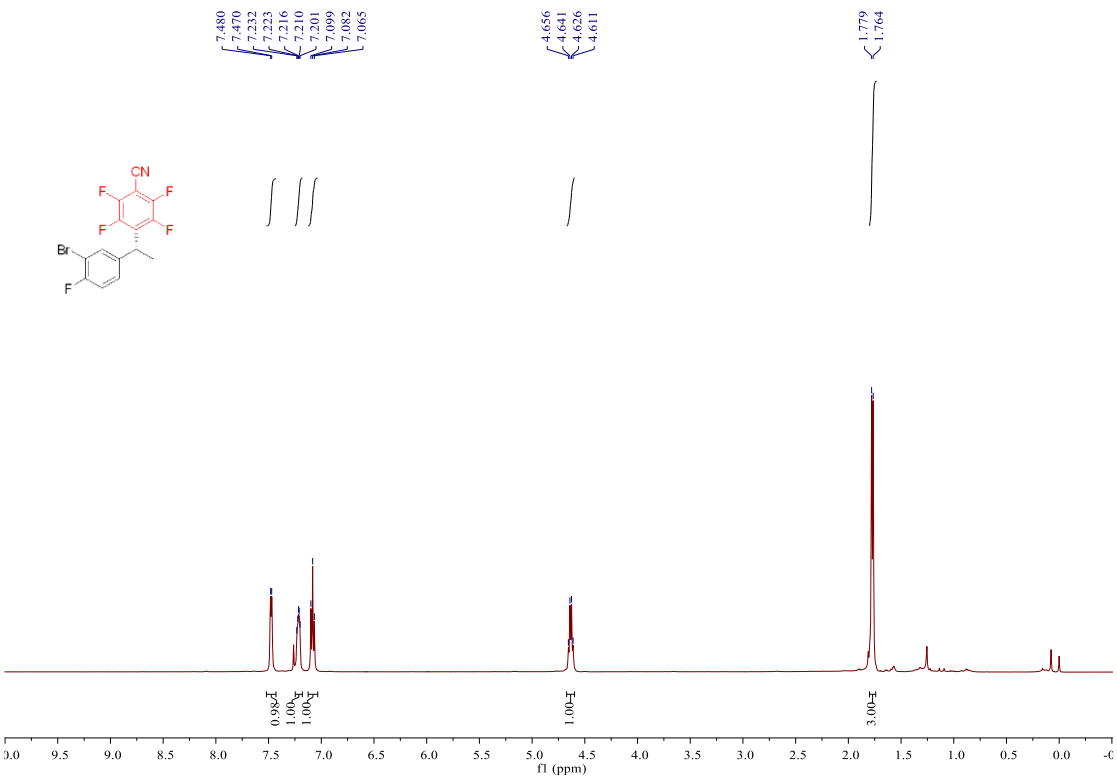
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3y



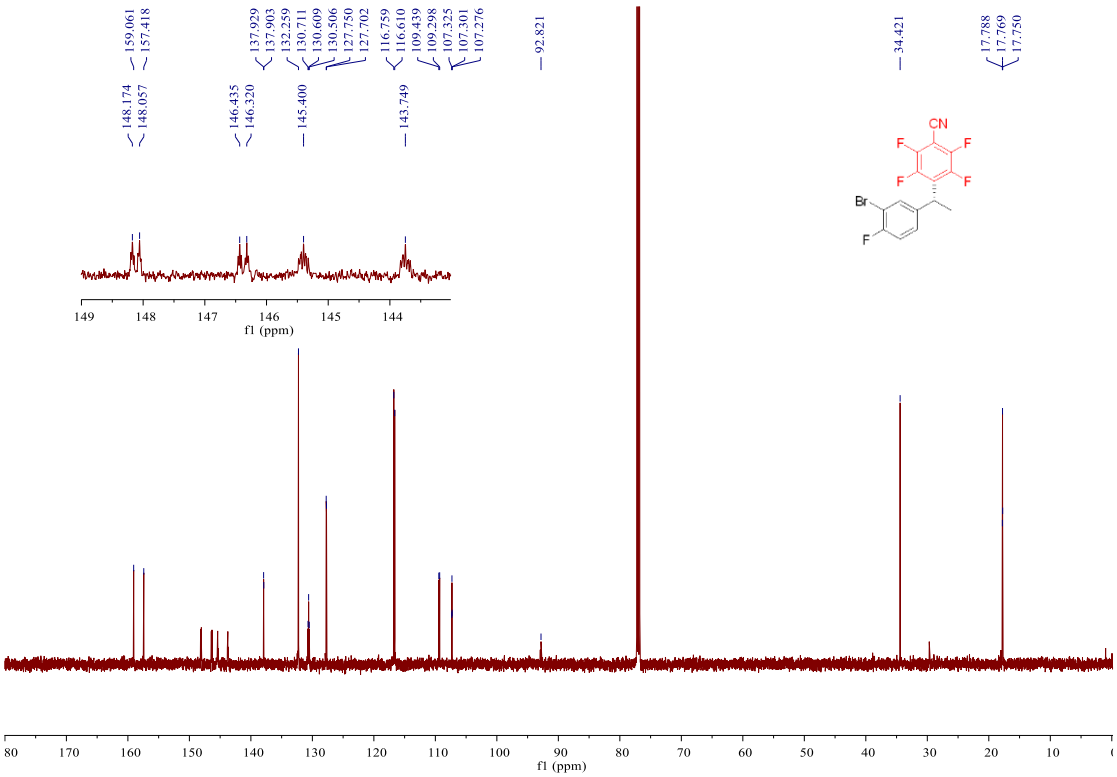
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3y



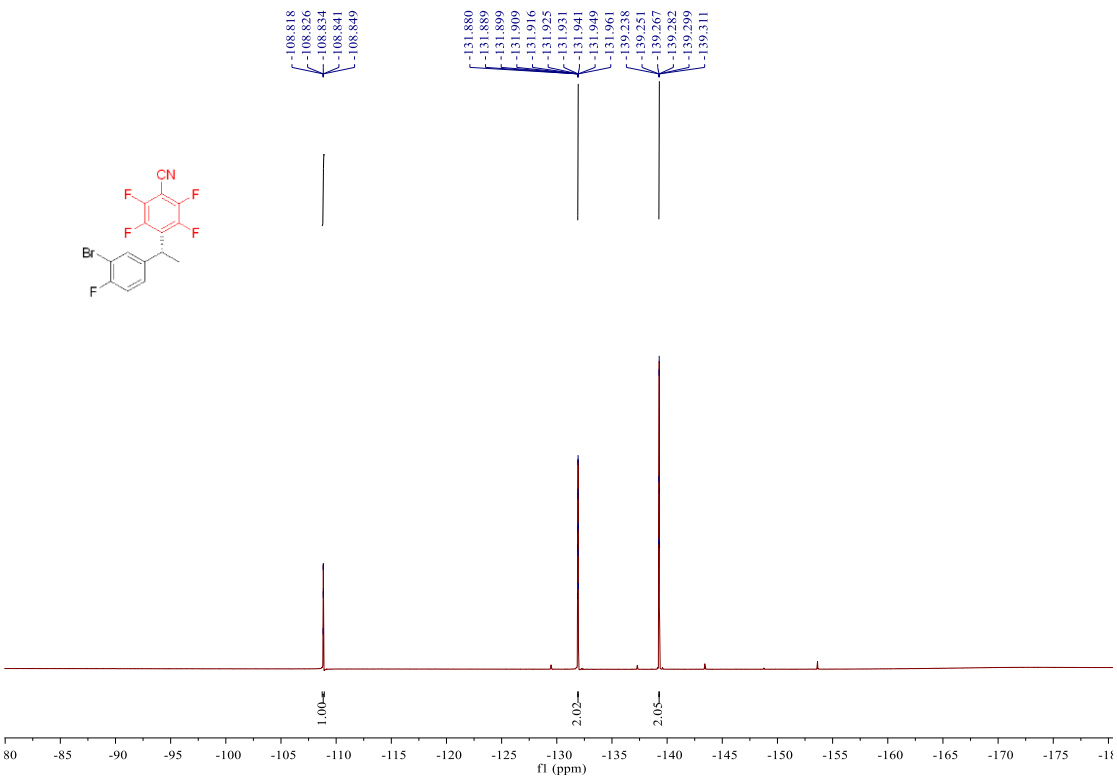
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3z



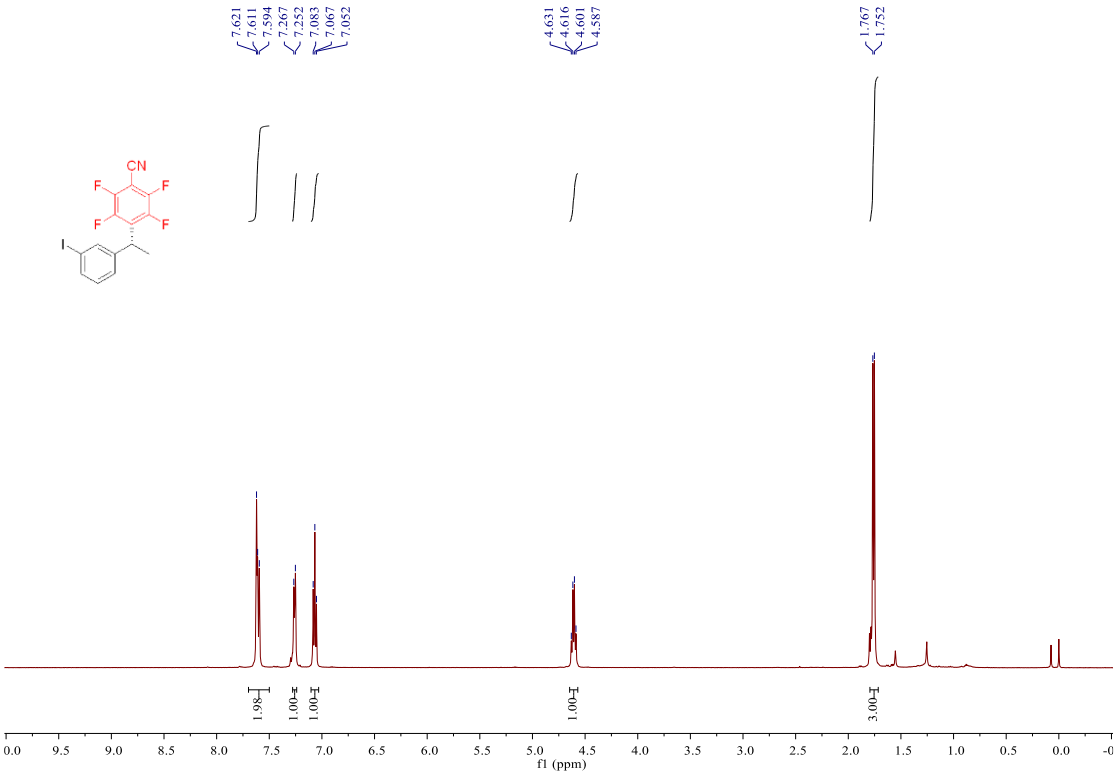
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3z



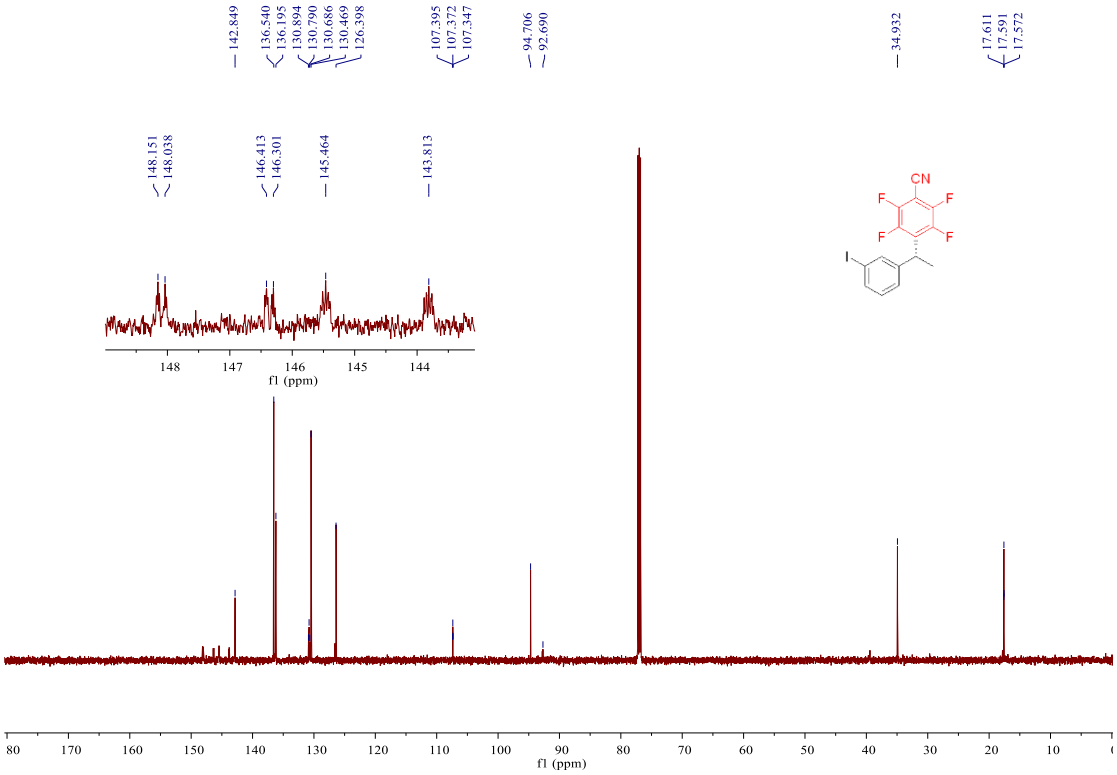
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3z



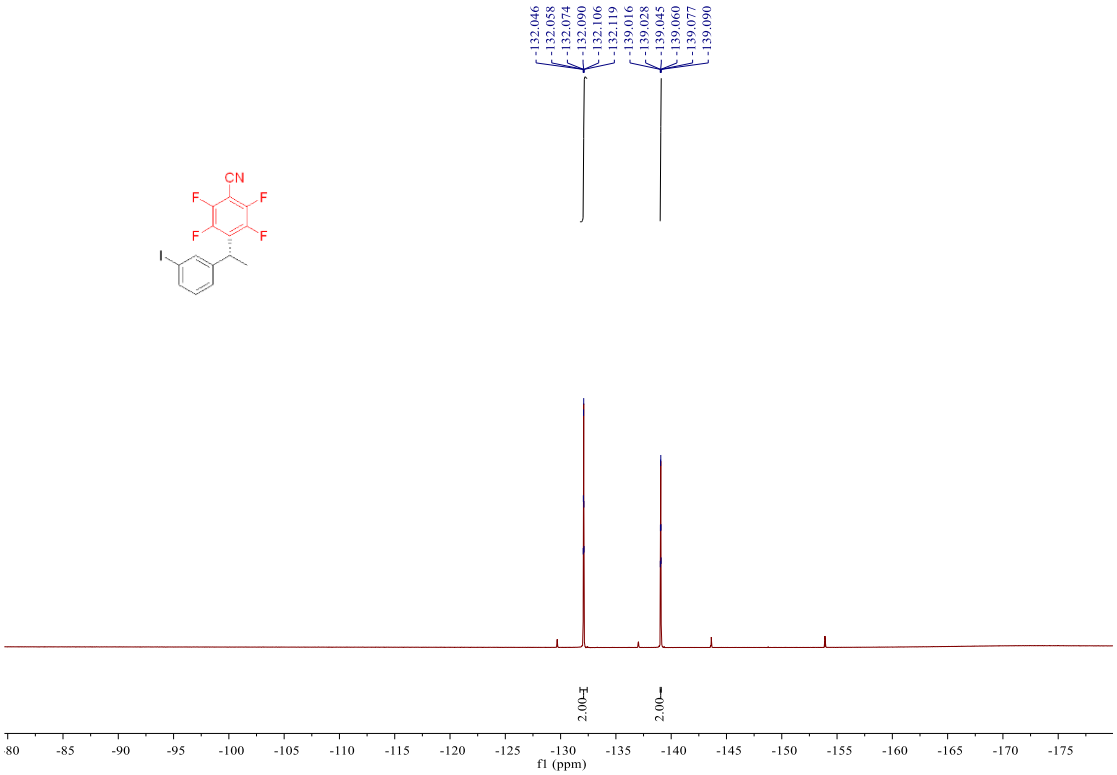
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 3aa



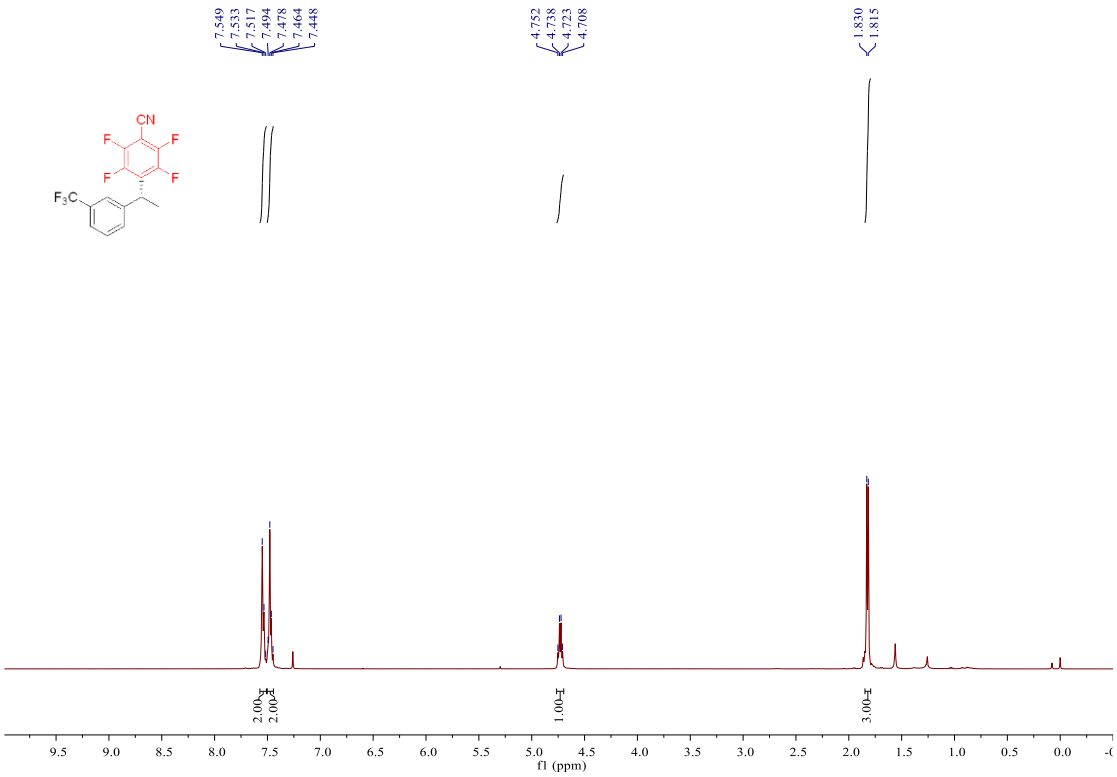
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3aa



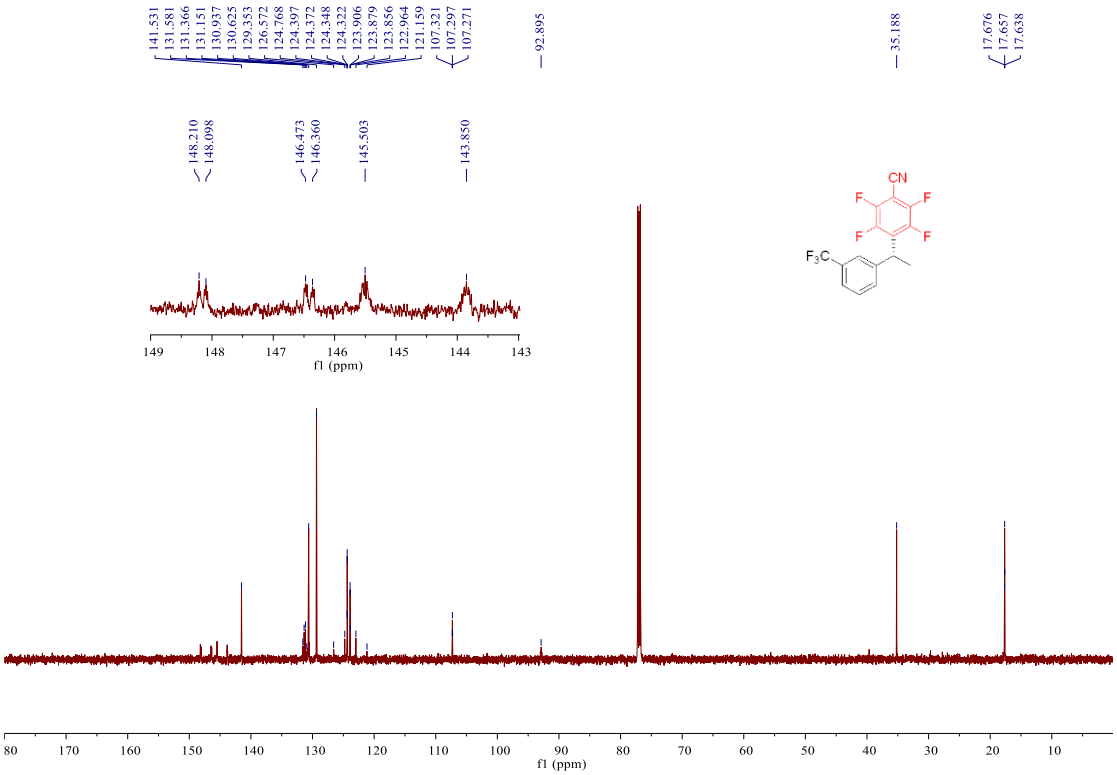
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3aa



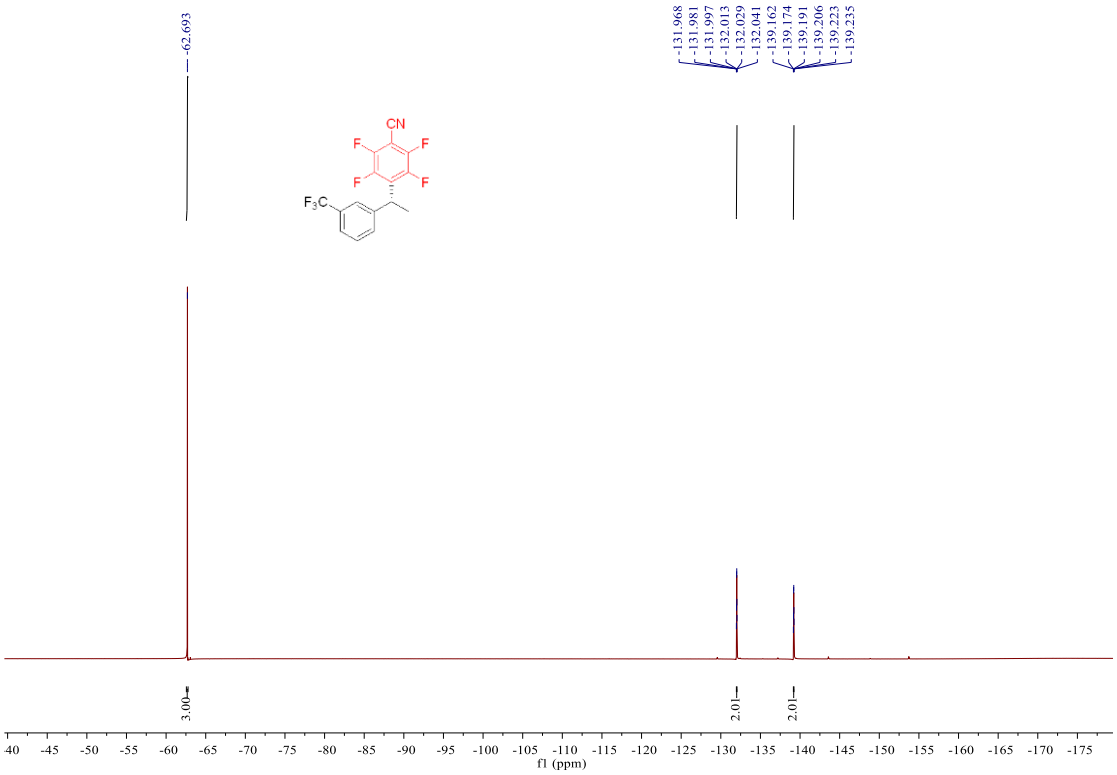
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3ab



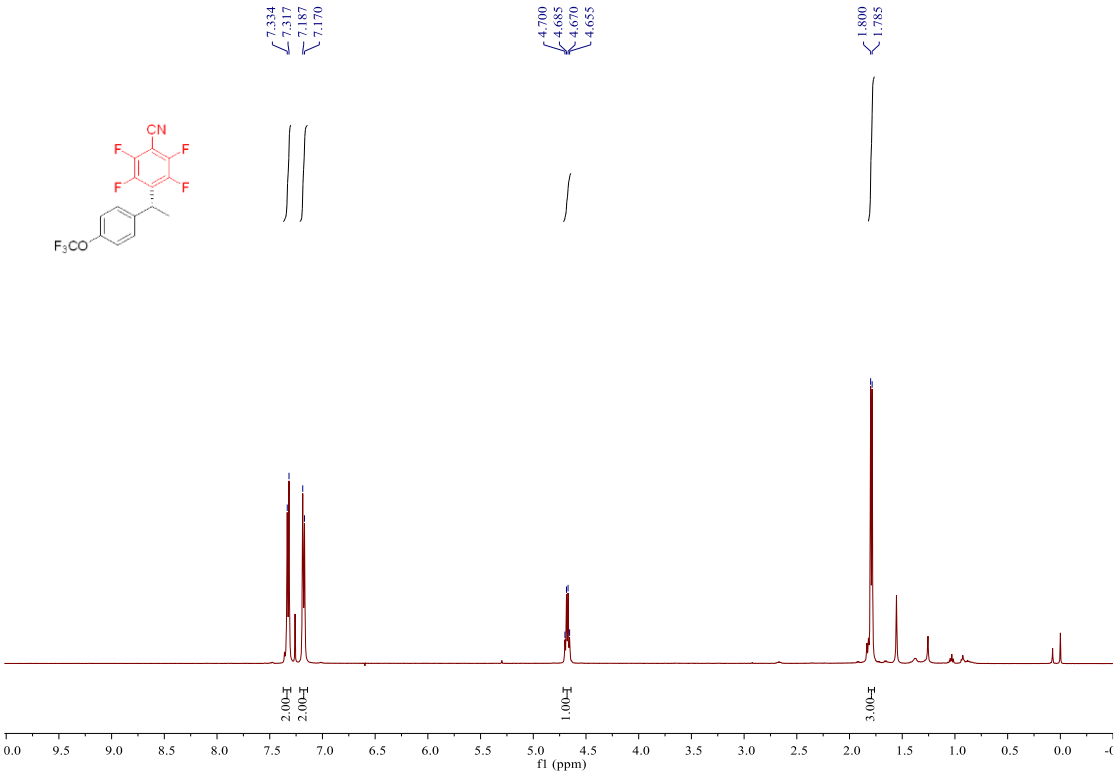
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3ab



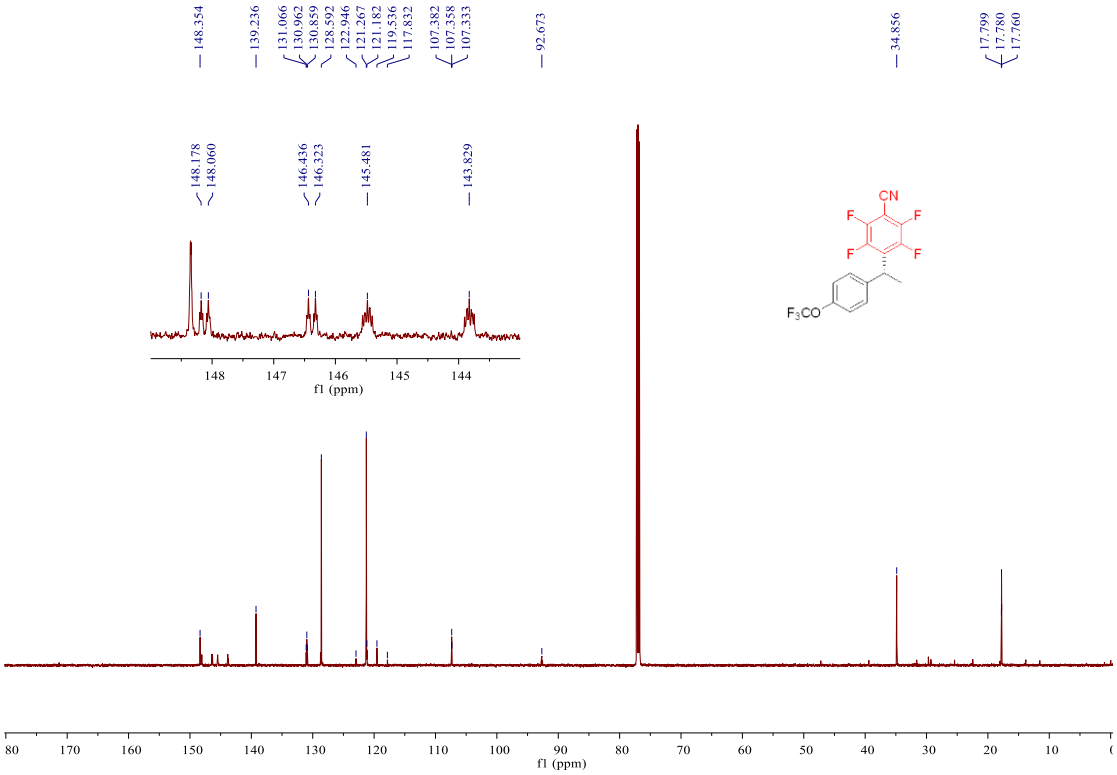
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3ab



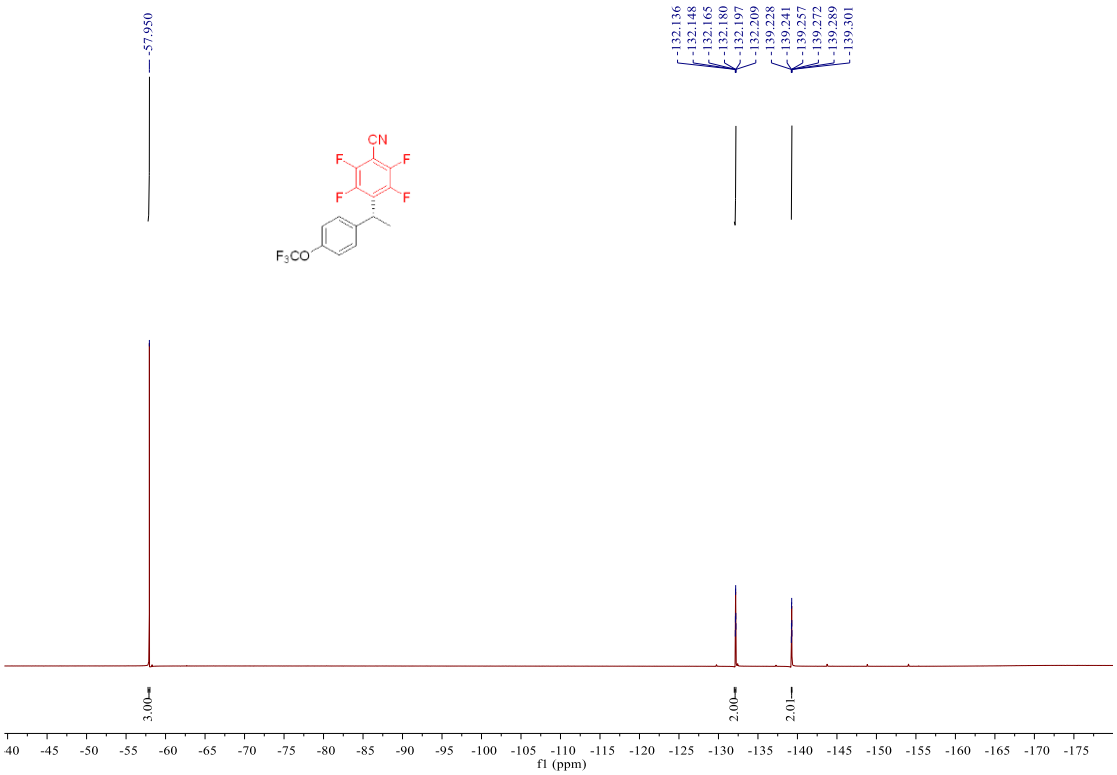
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3ac



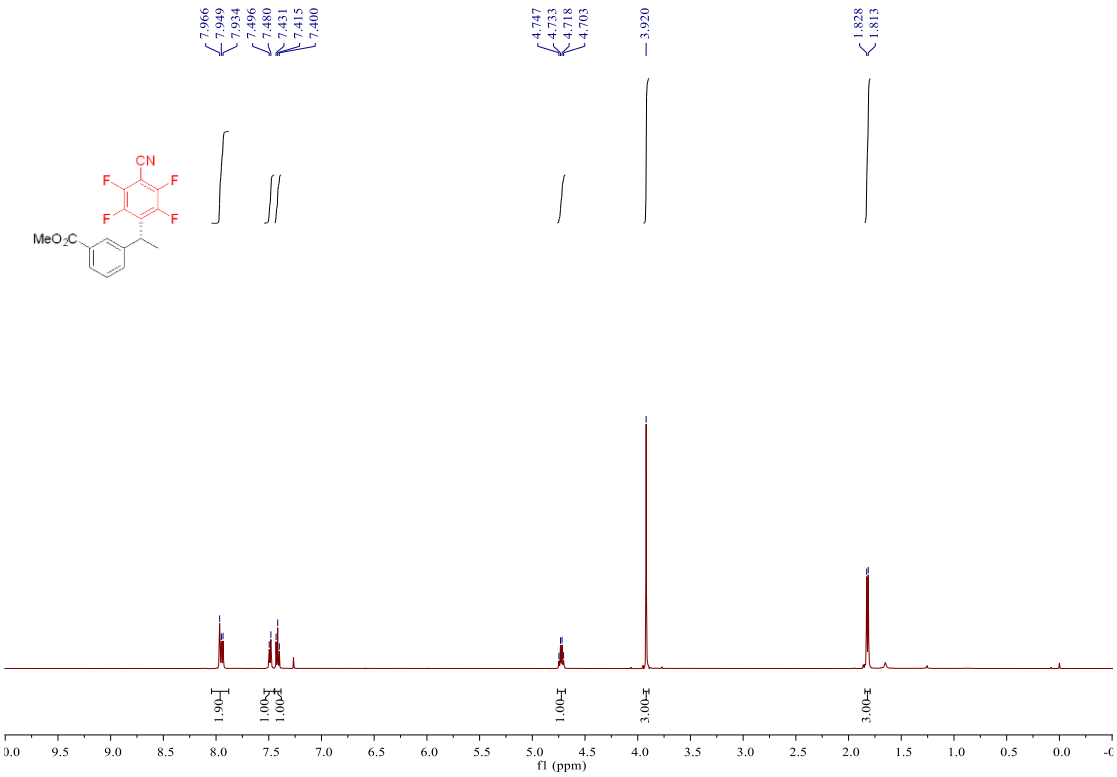
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3ac



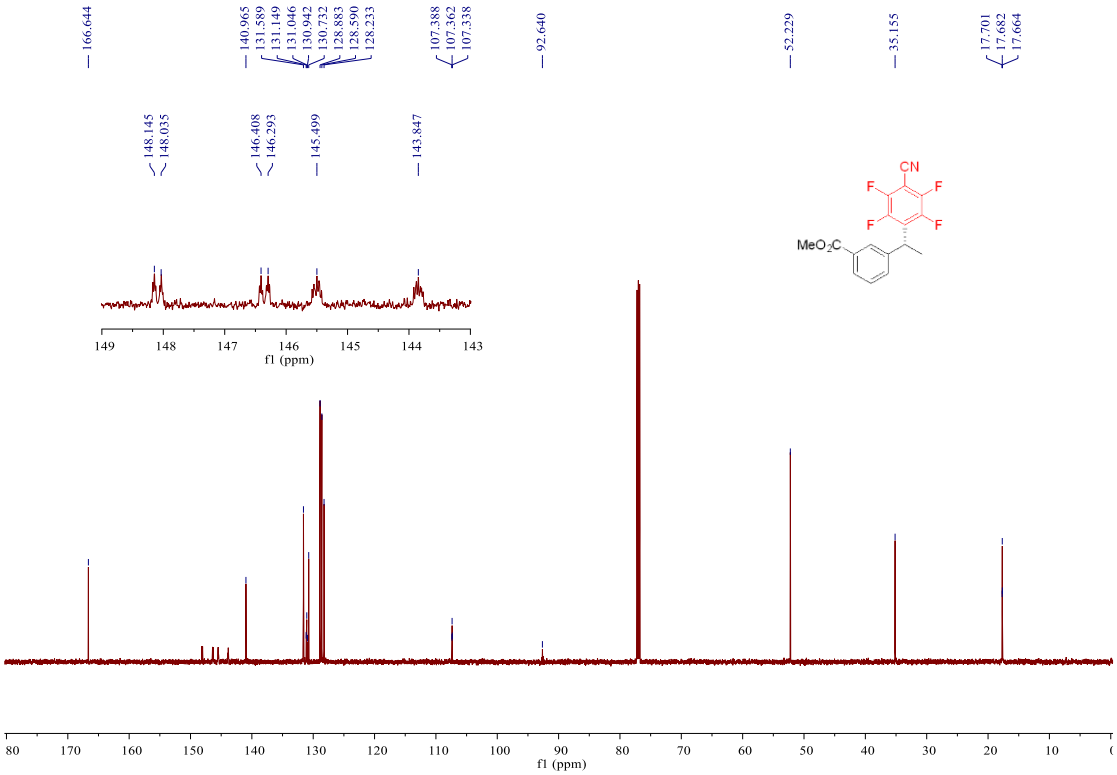
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3ac



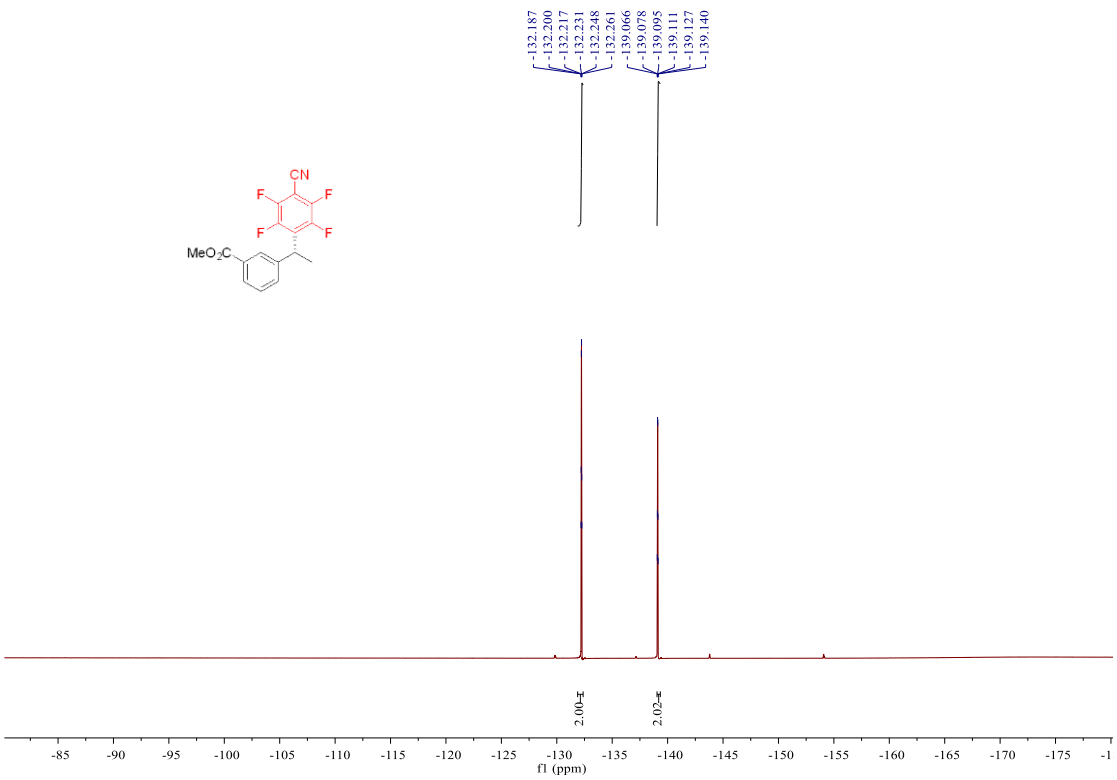
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3ad



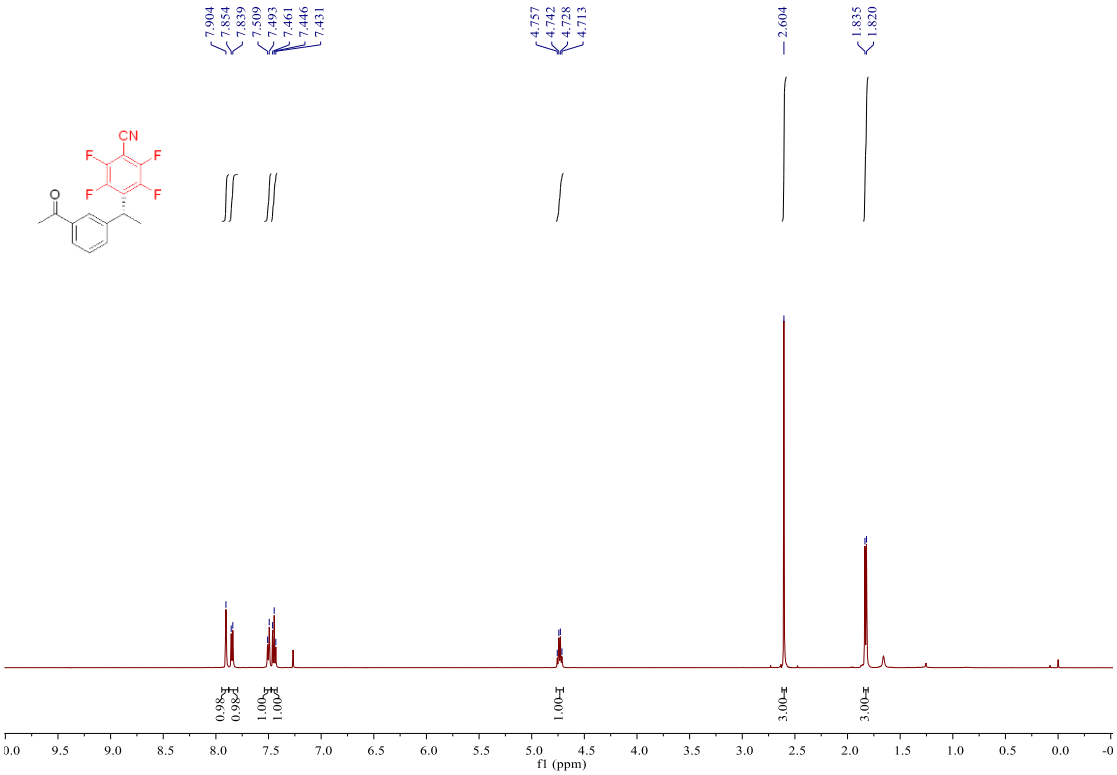
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3ad



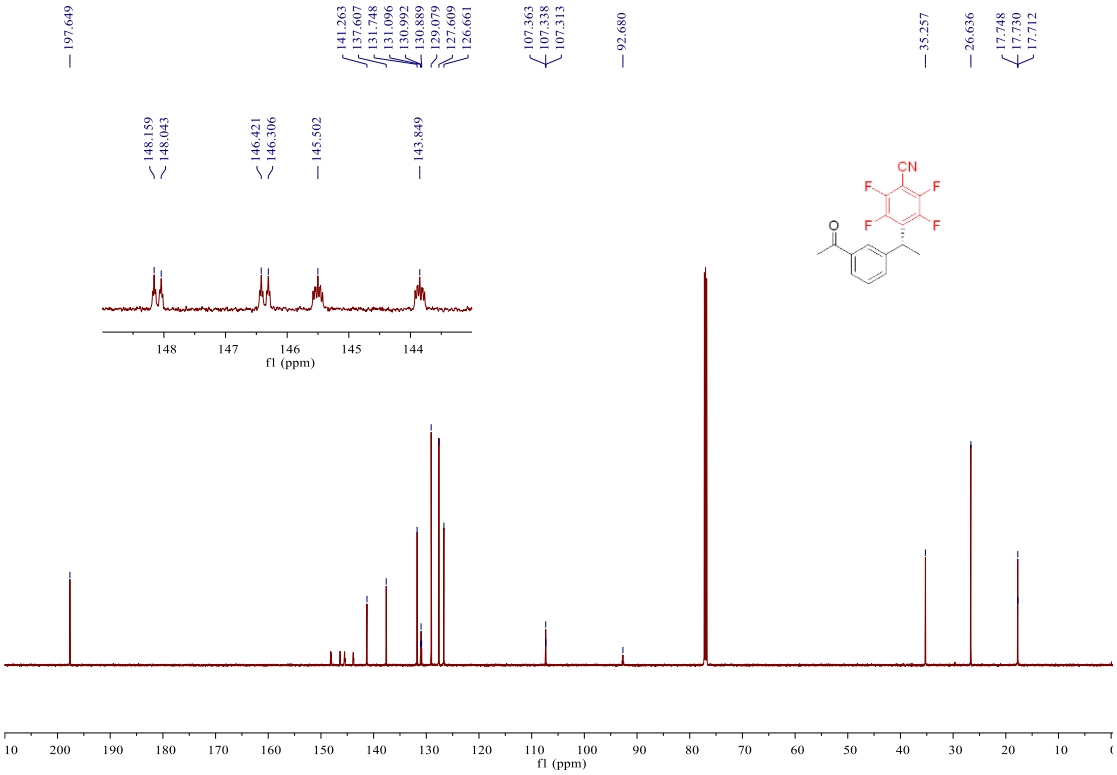
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 3ad



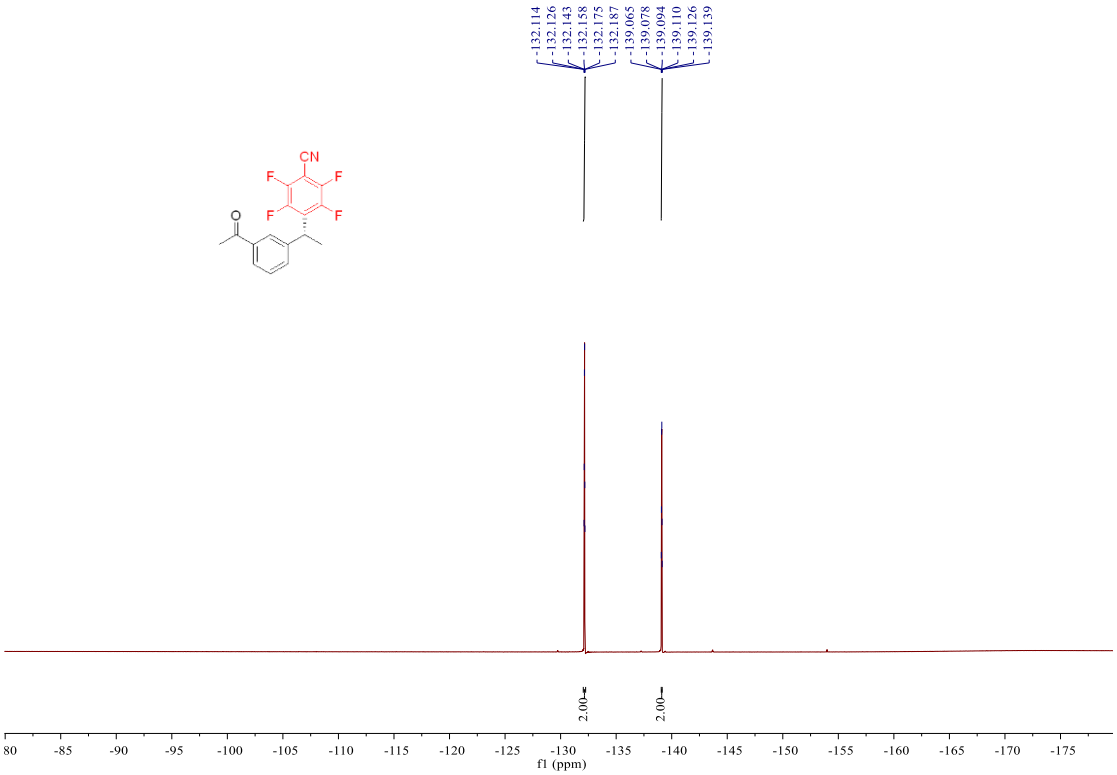
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3ae



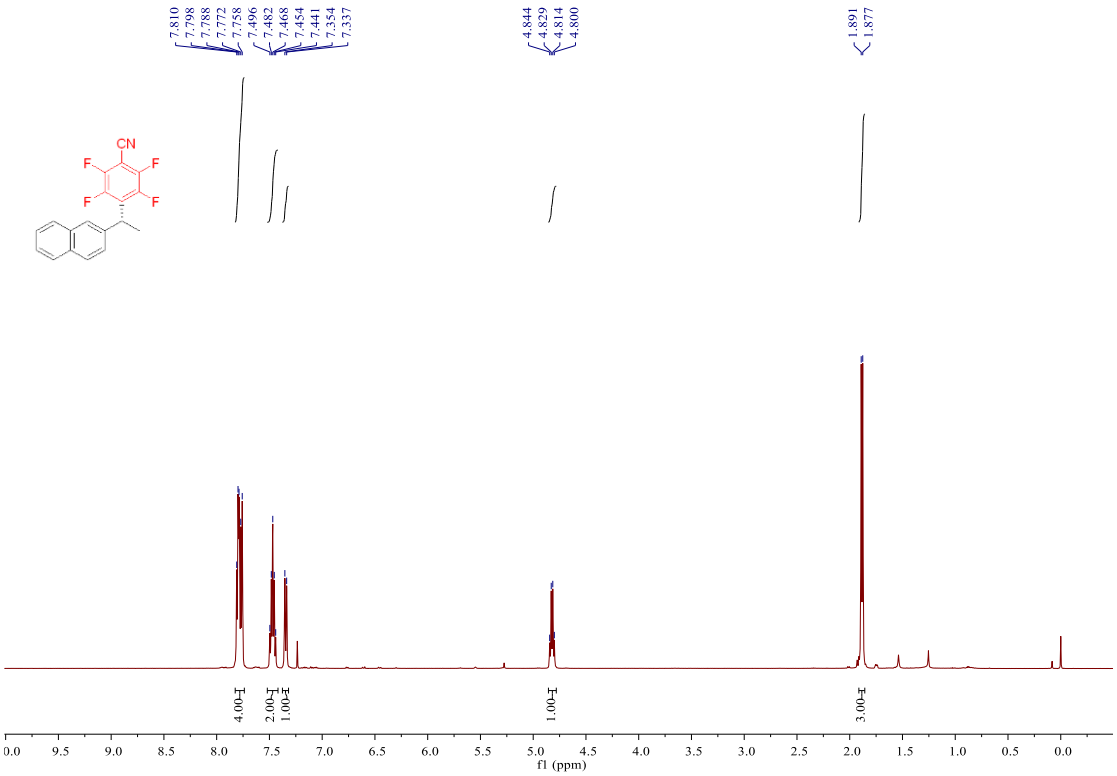
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3ae



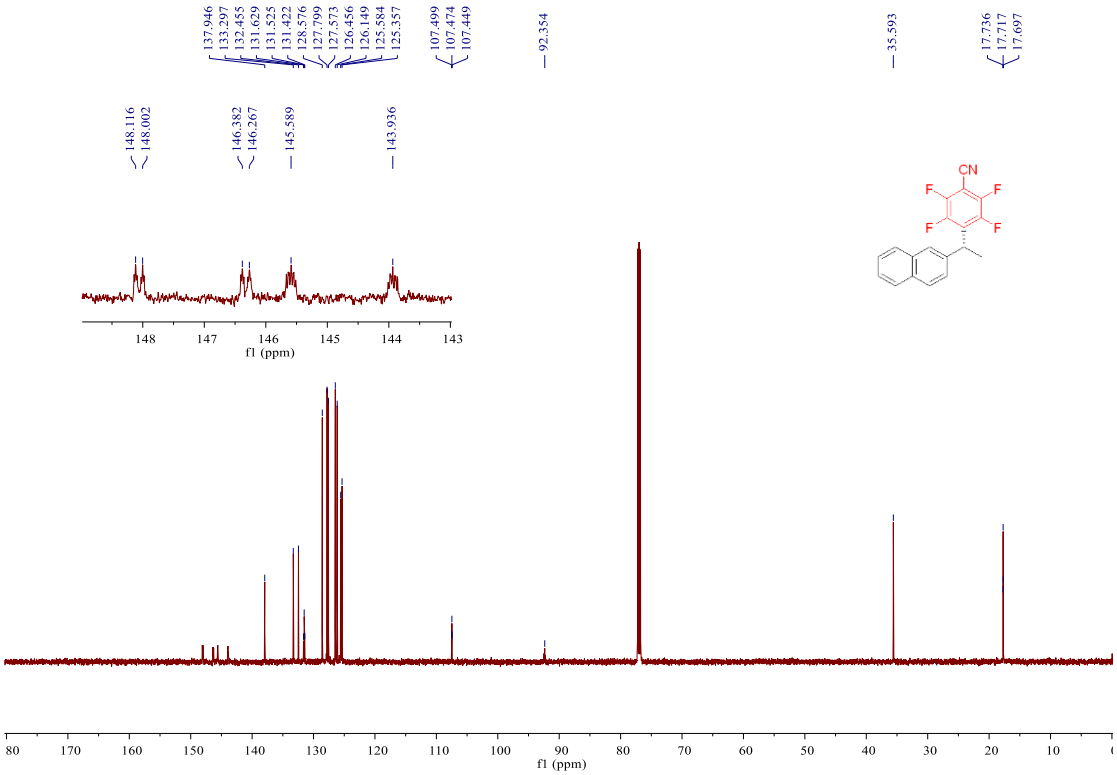
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3ae



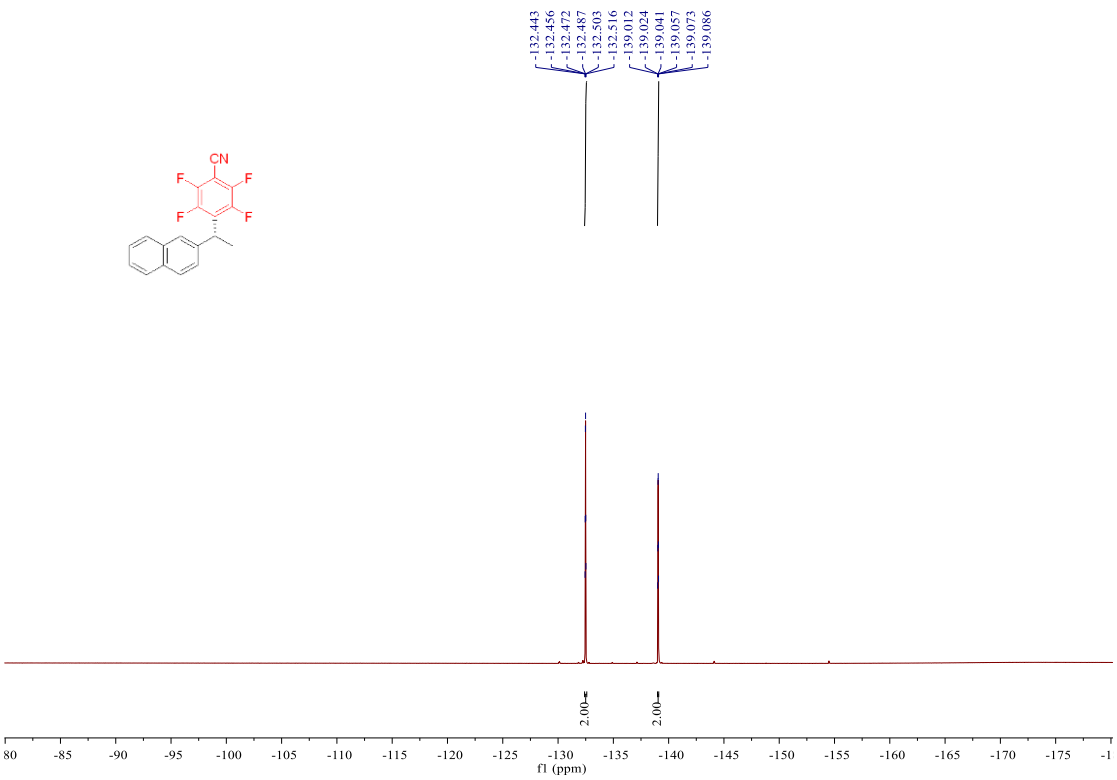
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3af



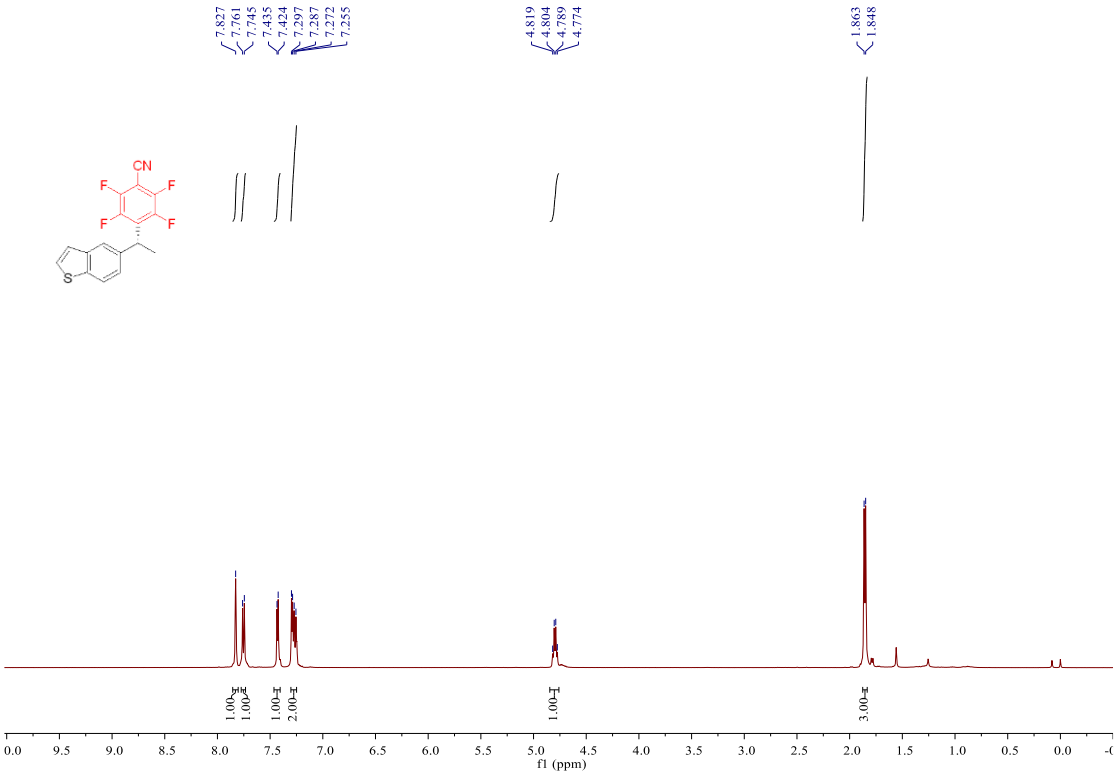
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3af



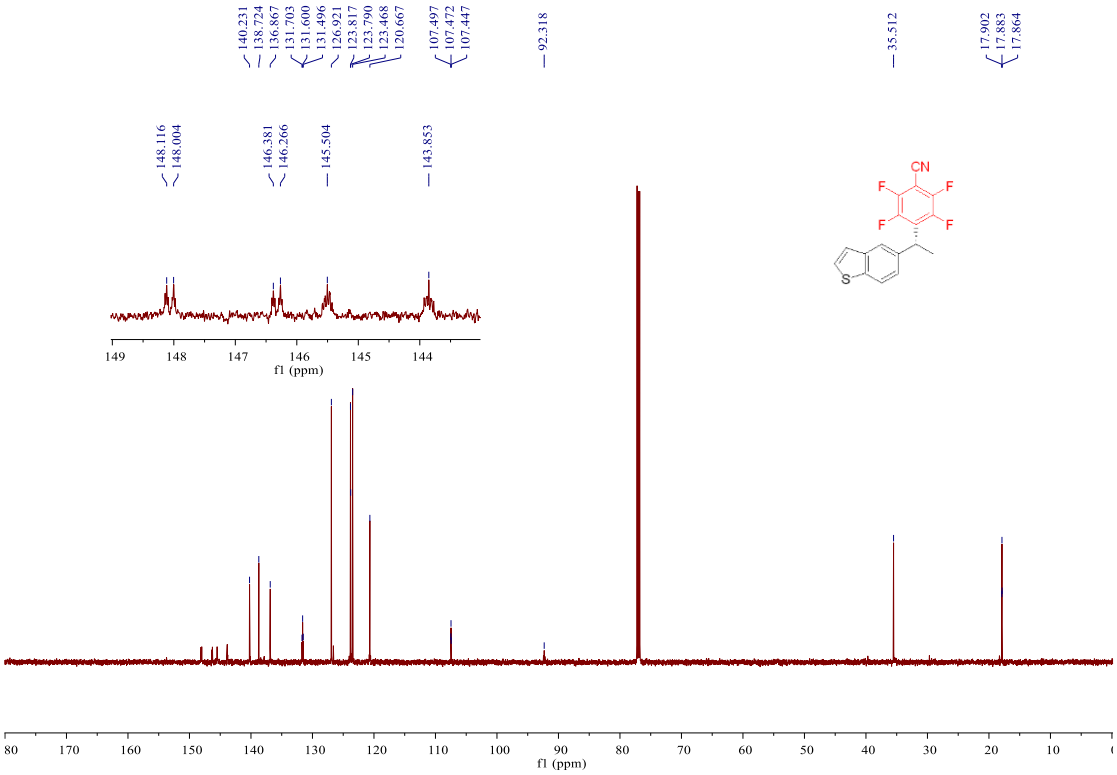
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 3af



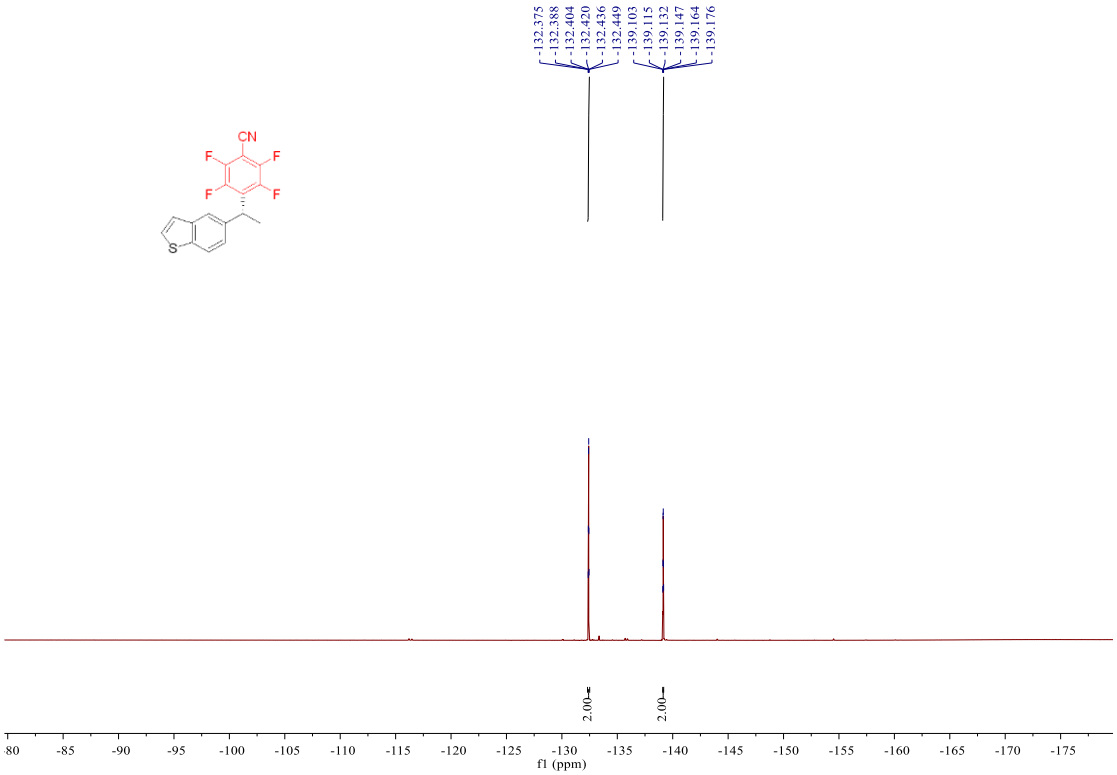
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3ag



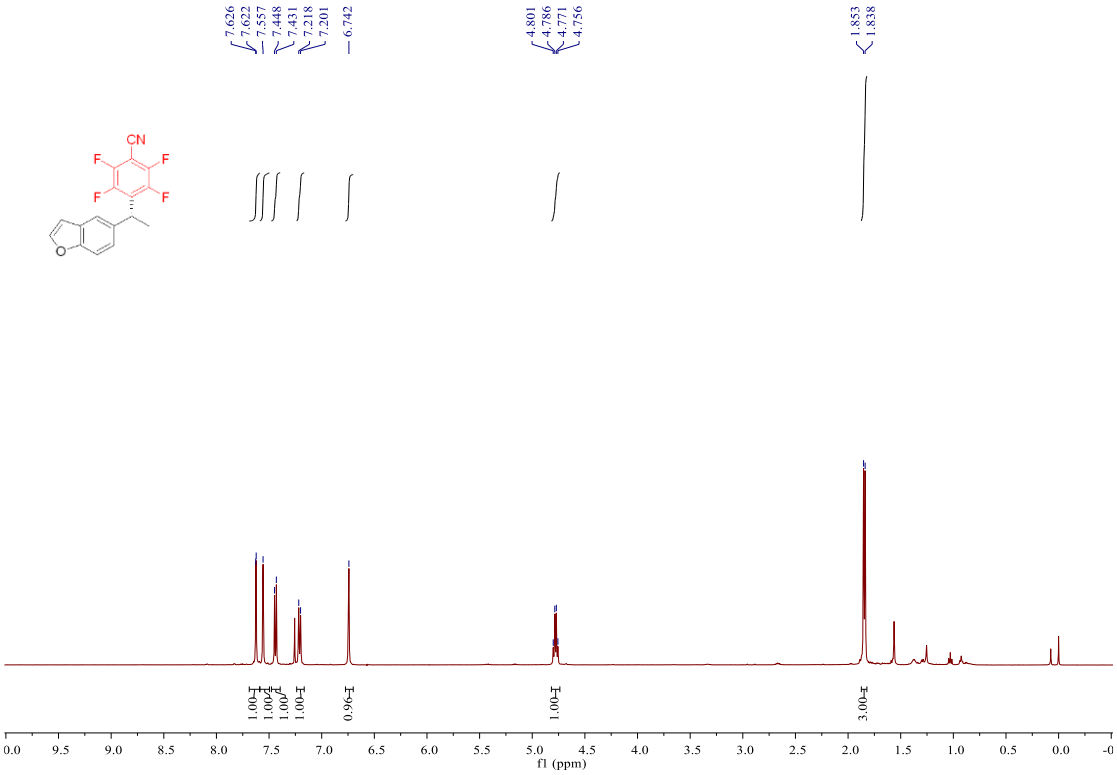
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3ag



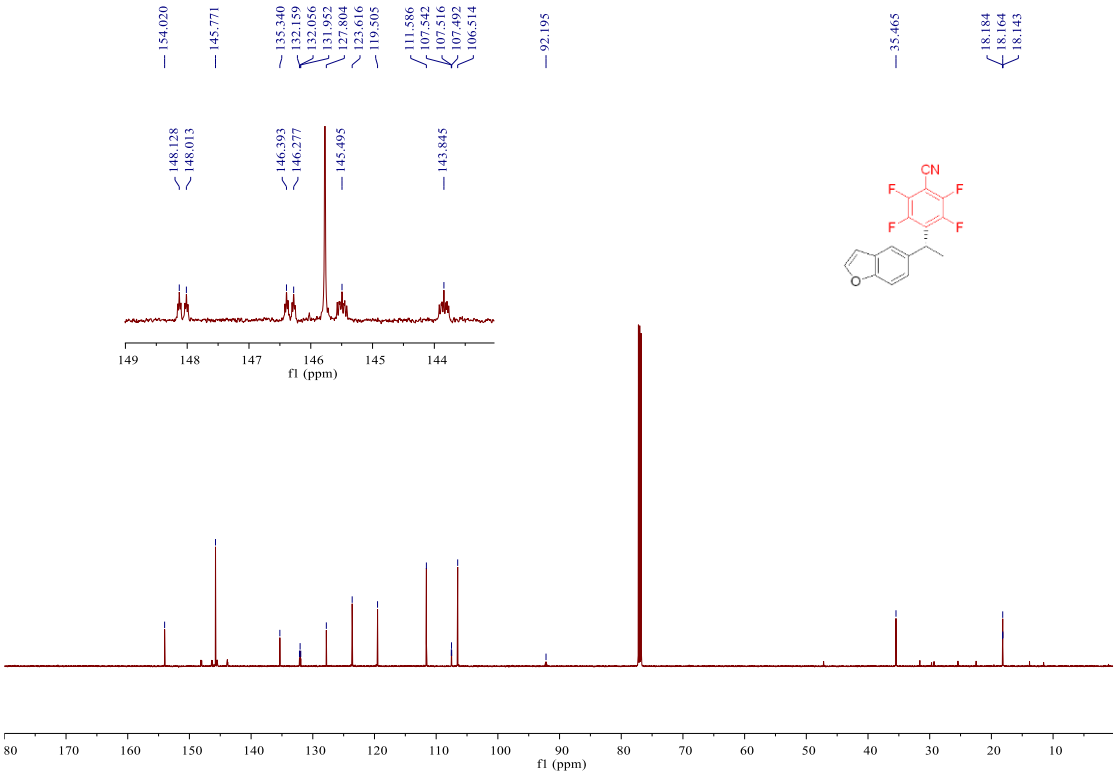
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3ag



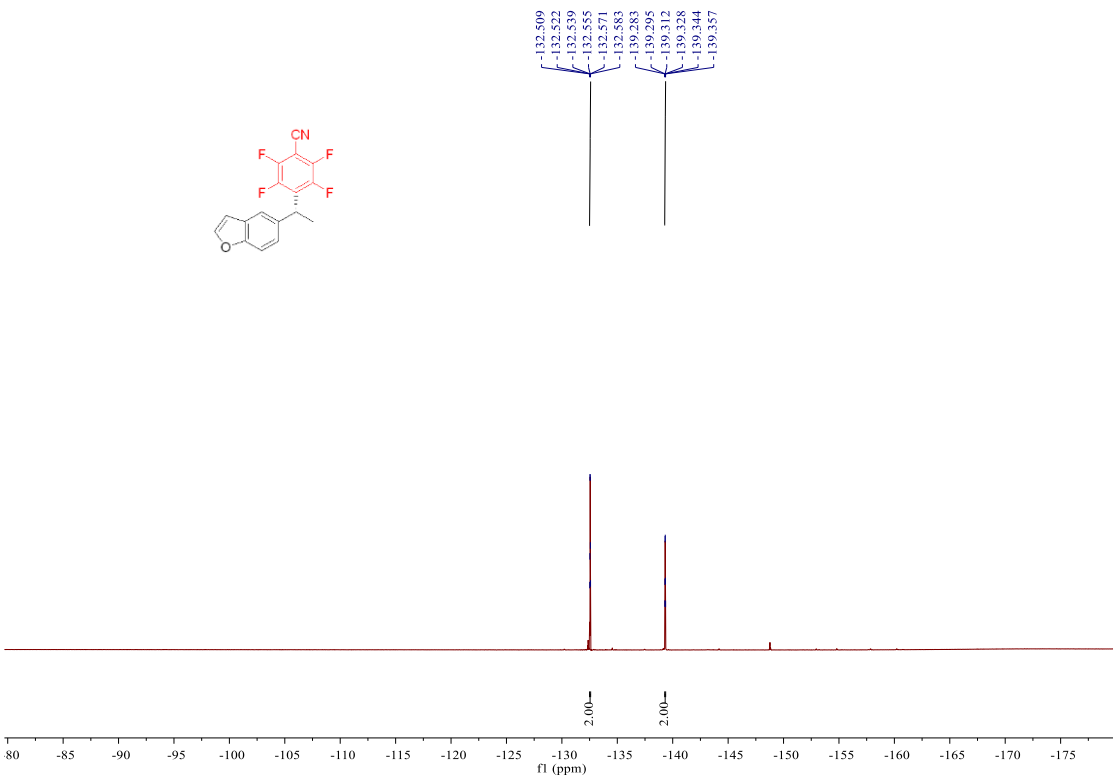
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3ah



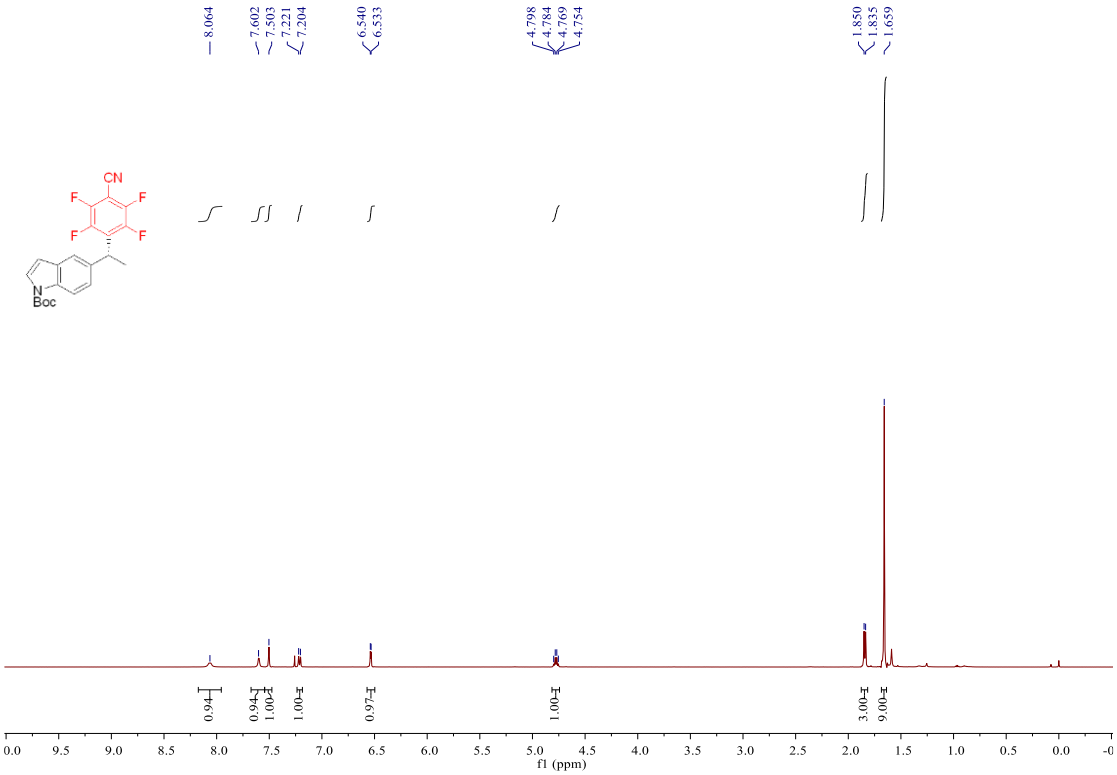
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3ah



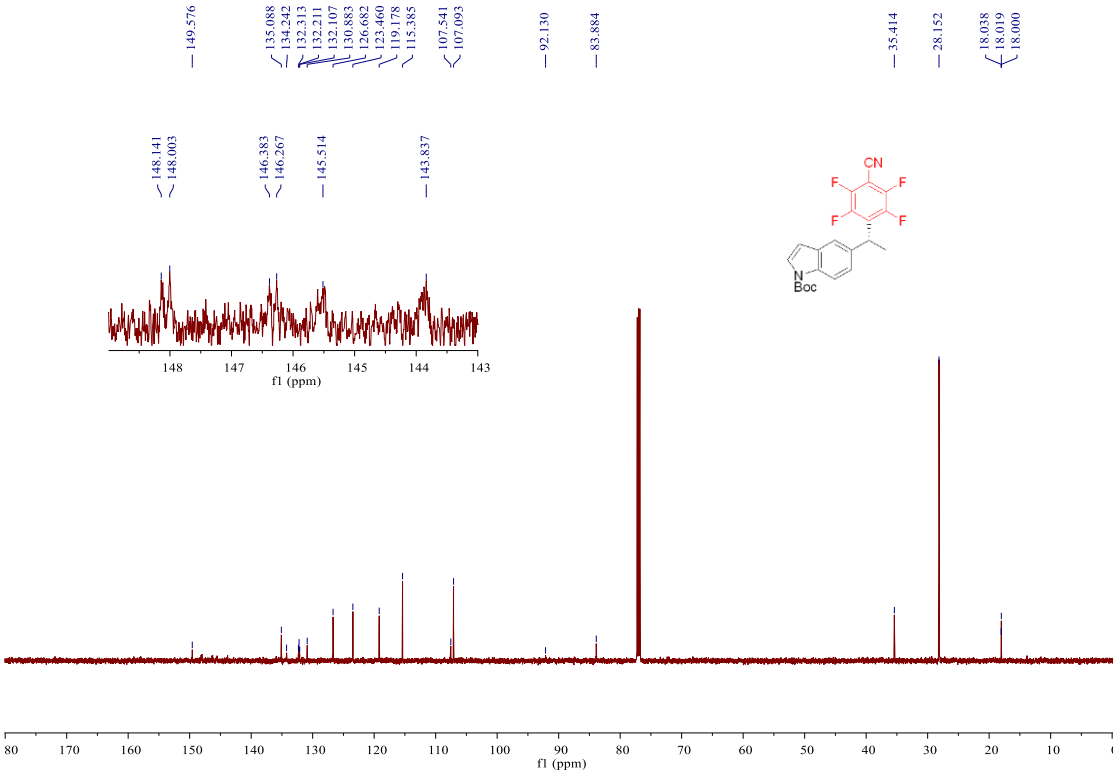
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 3ah



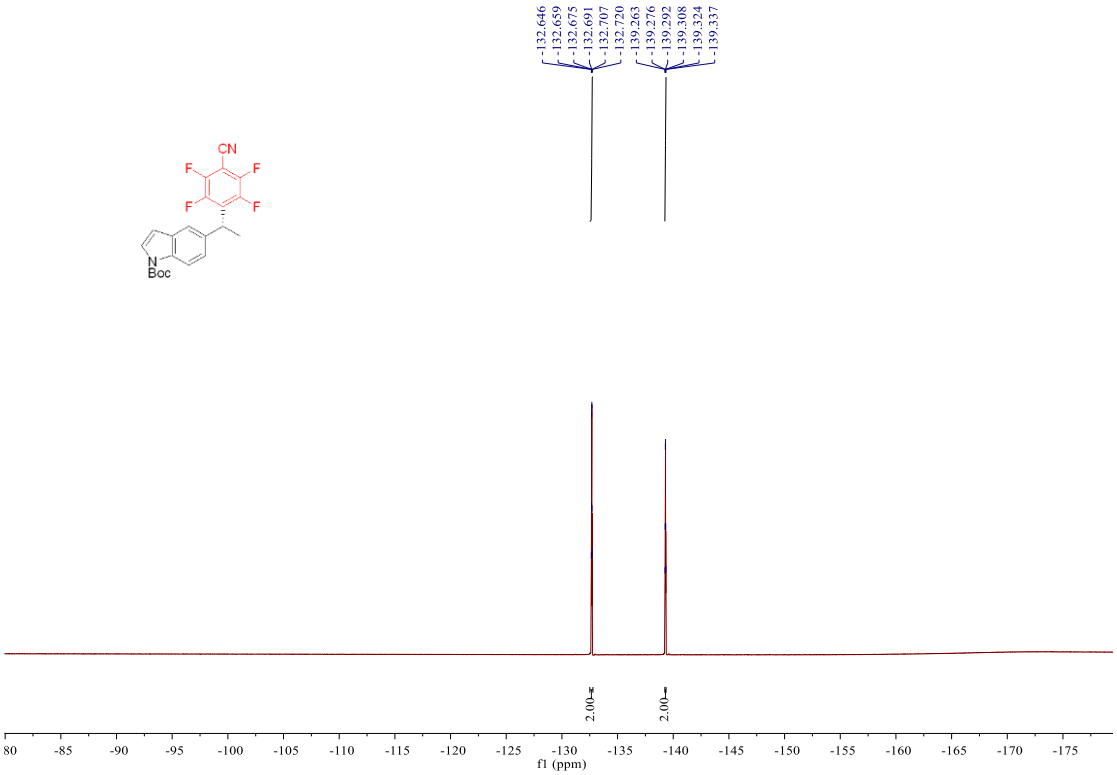
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 3ai



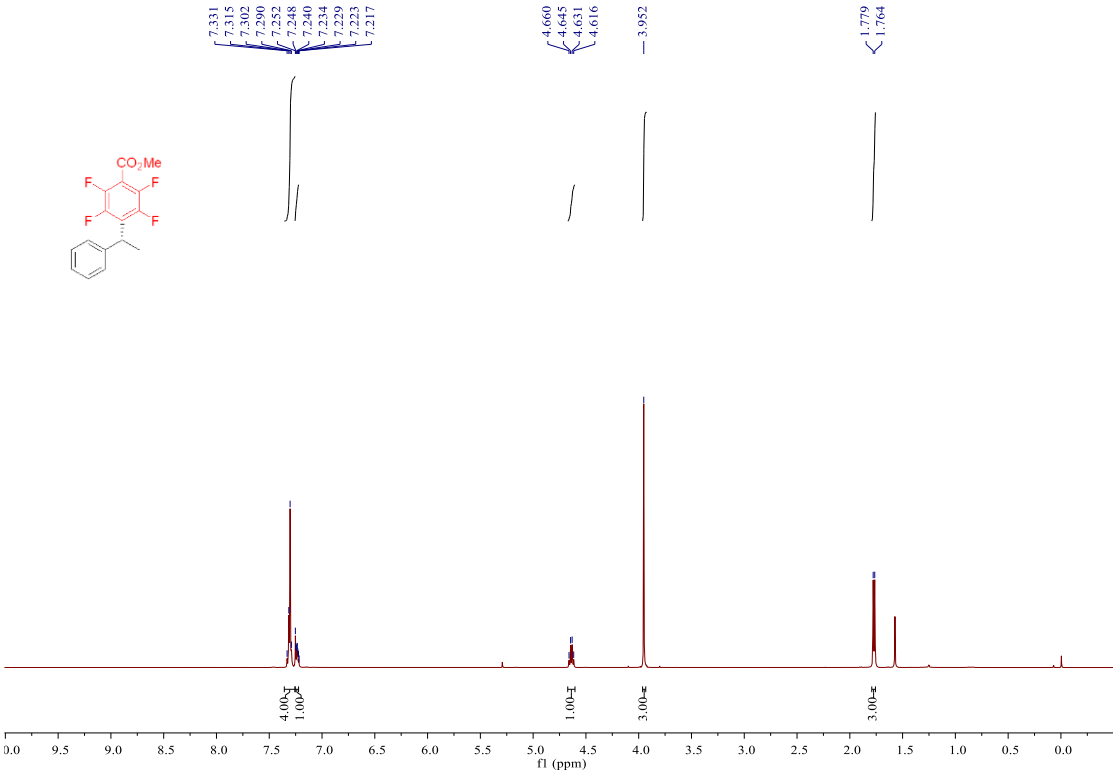
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 3ai



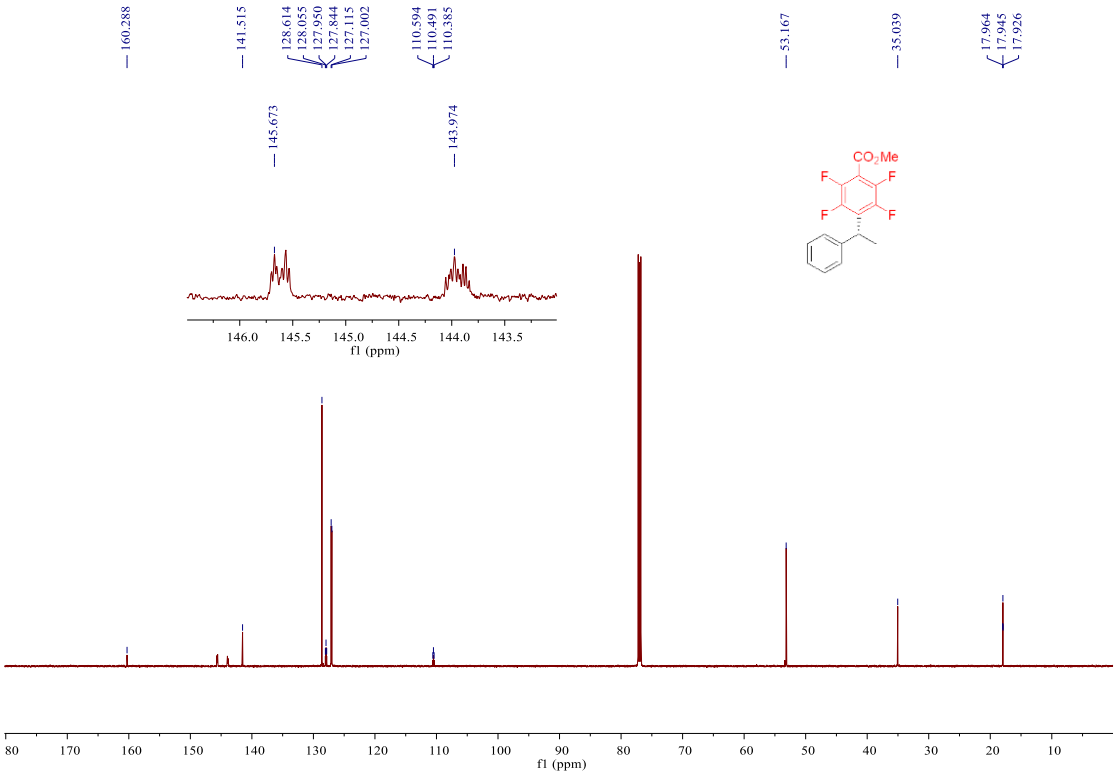
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3ai



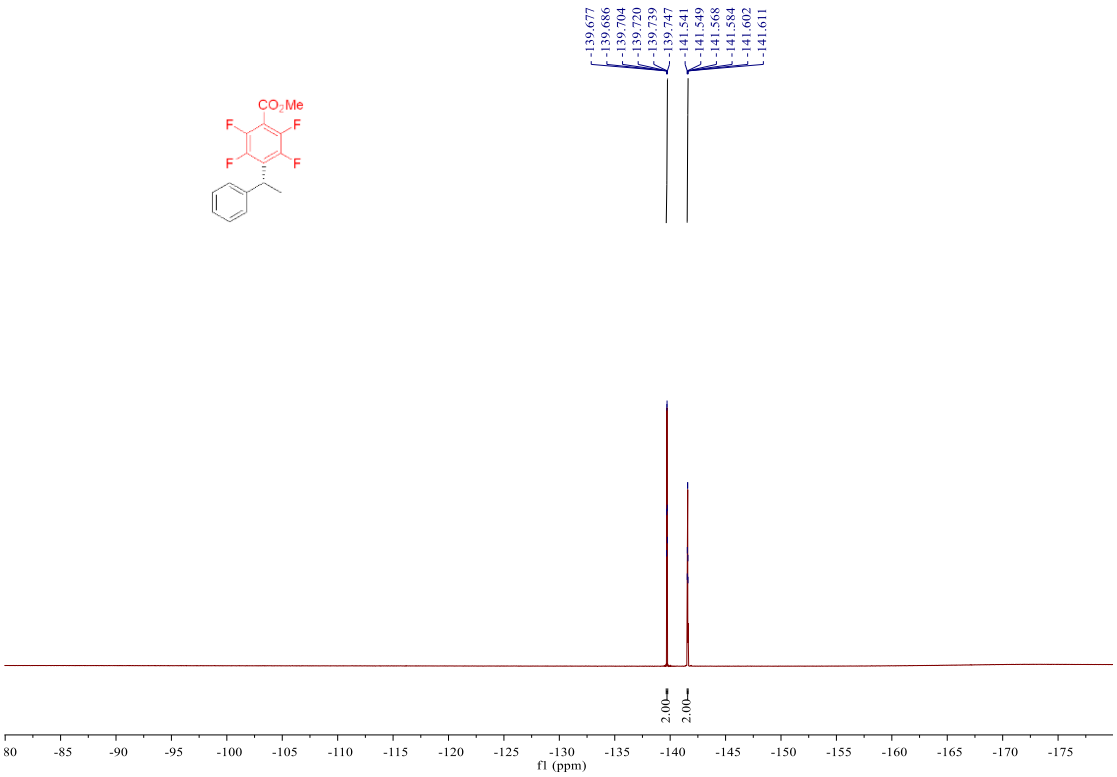
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3aj



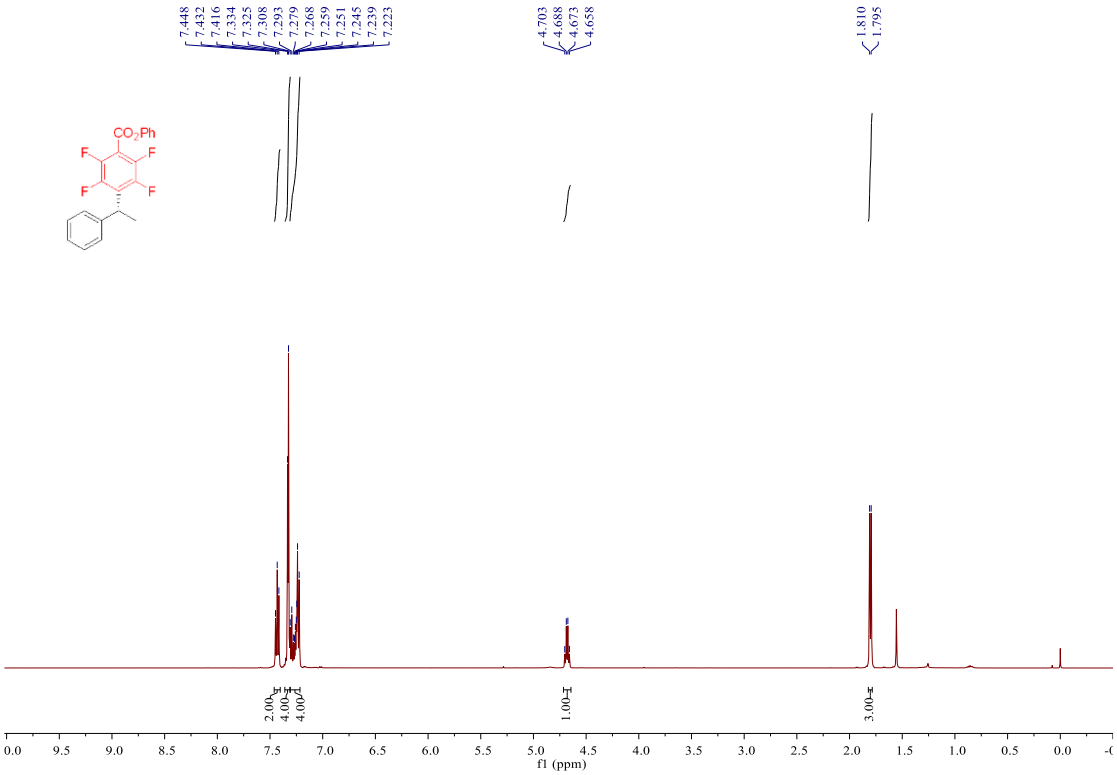
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3aj



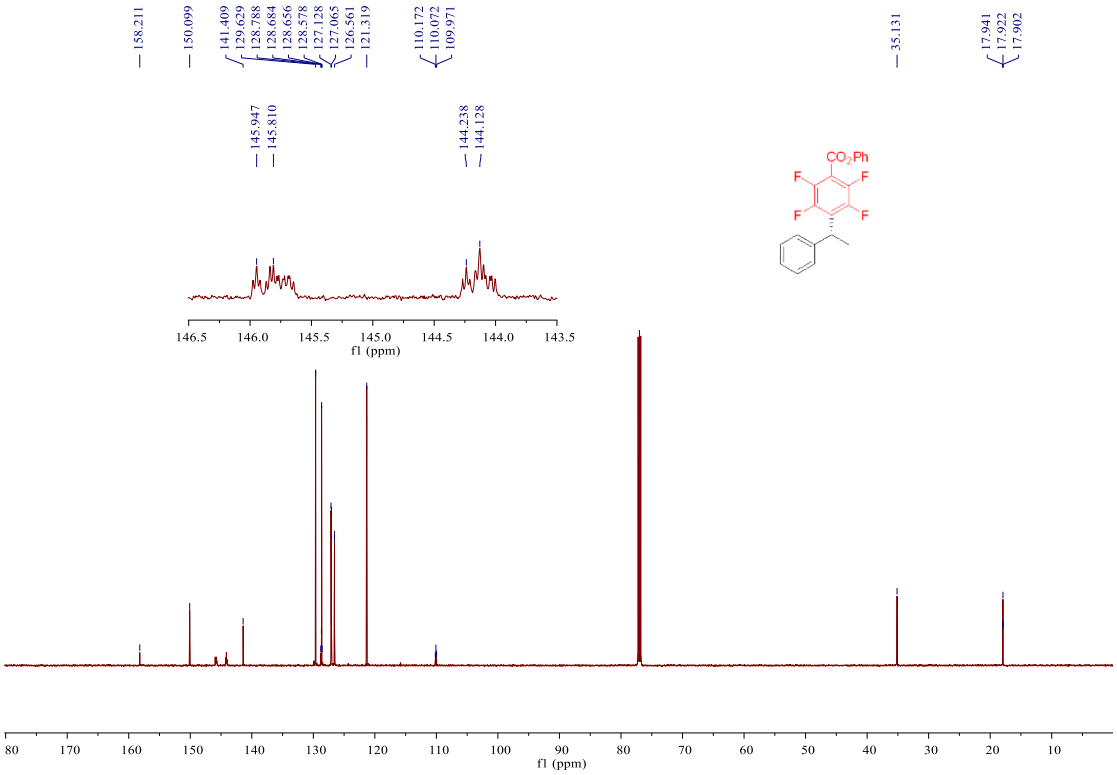
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3aj



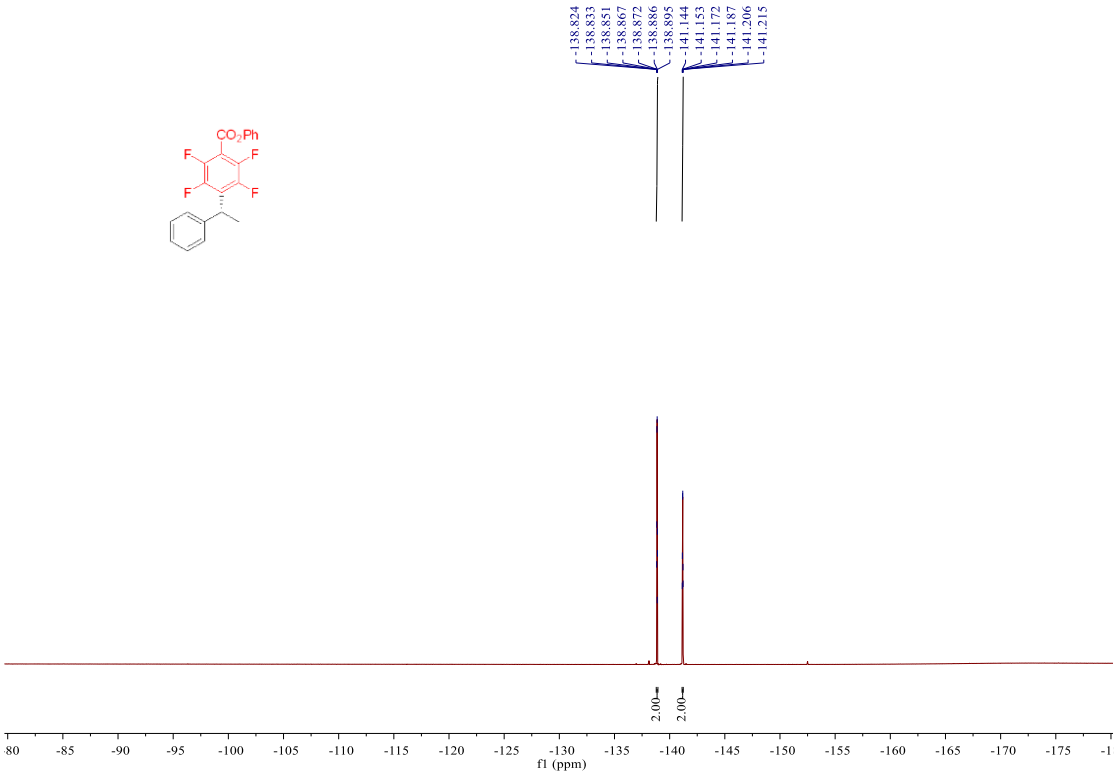
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3ak



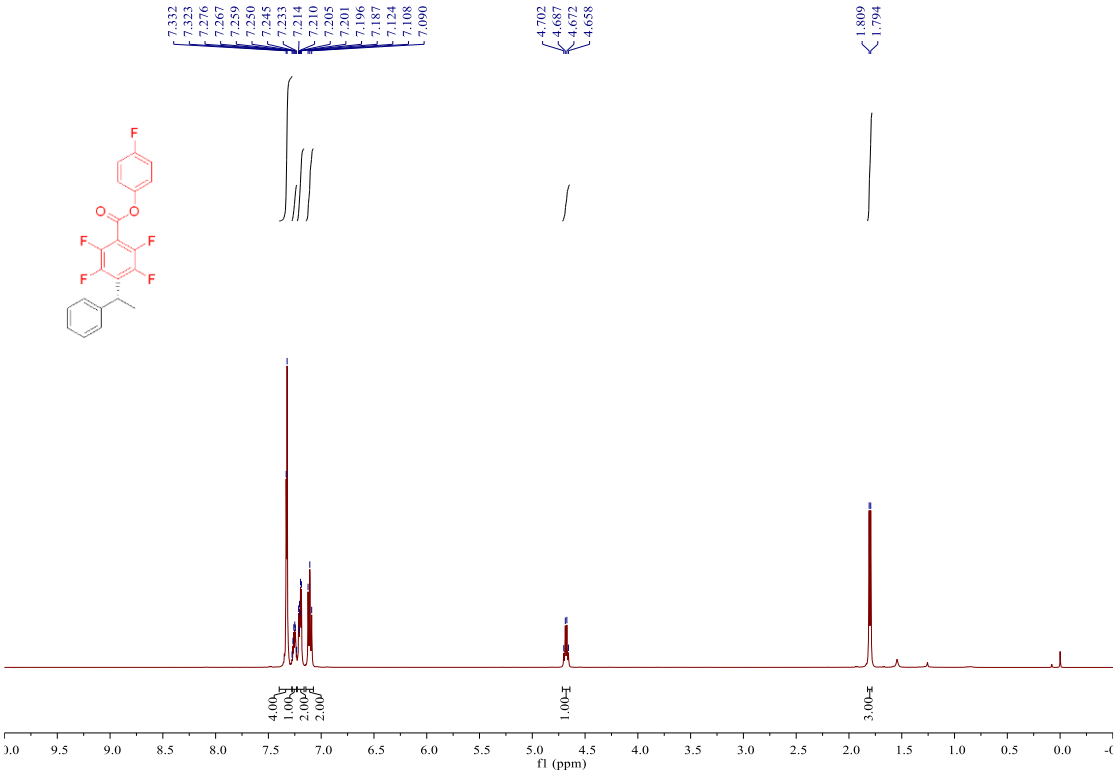
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3ak



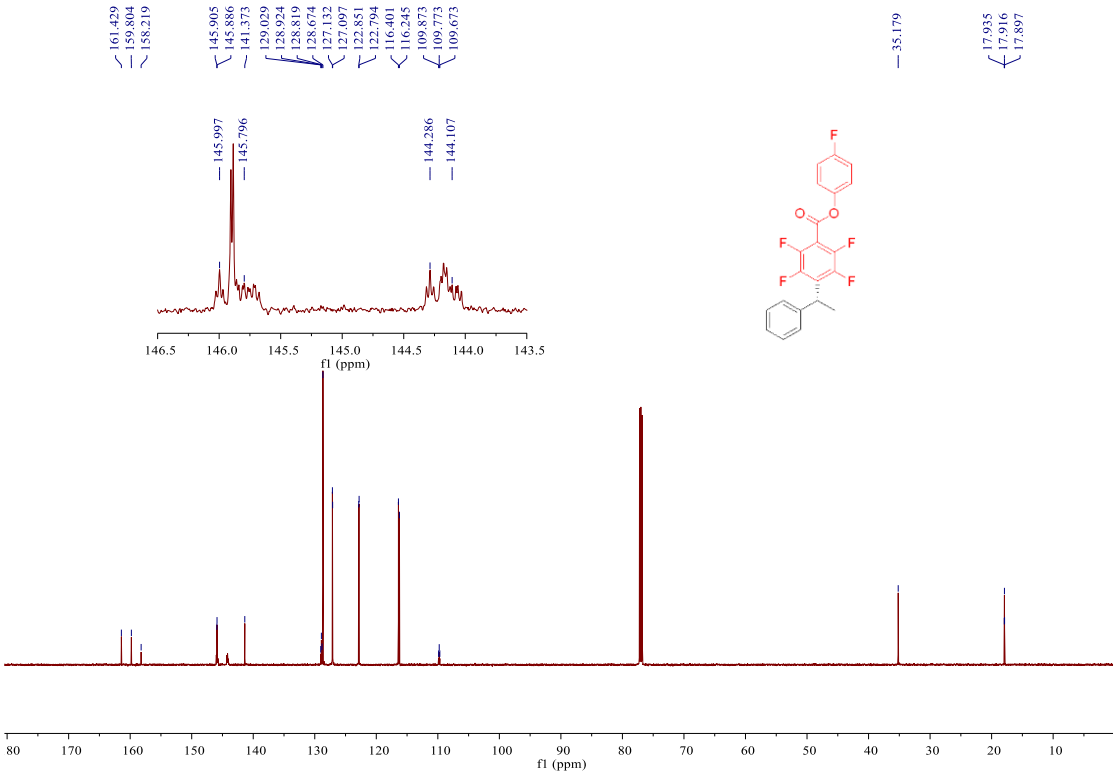
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3ak



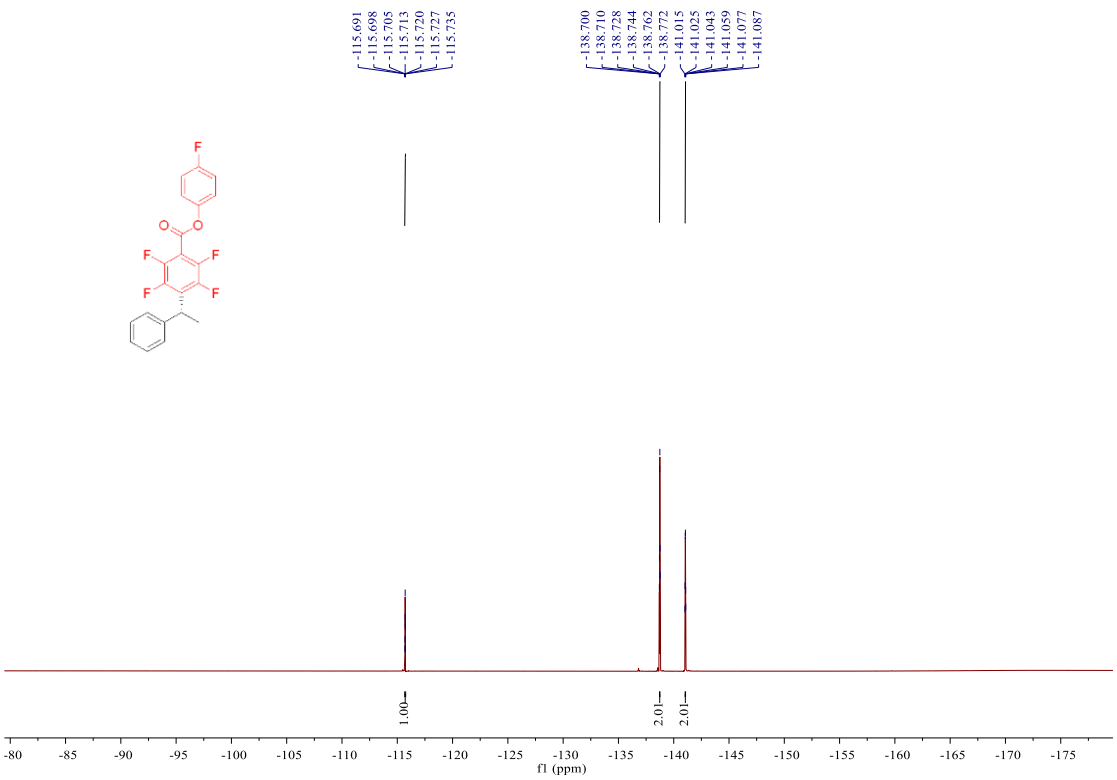
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3al



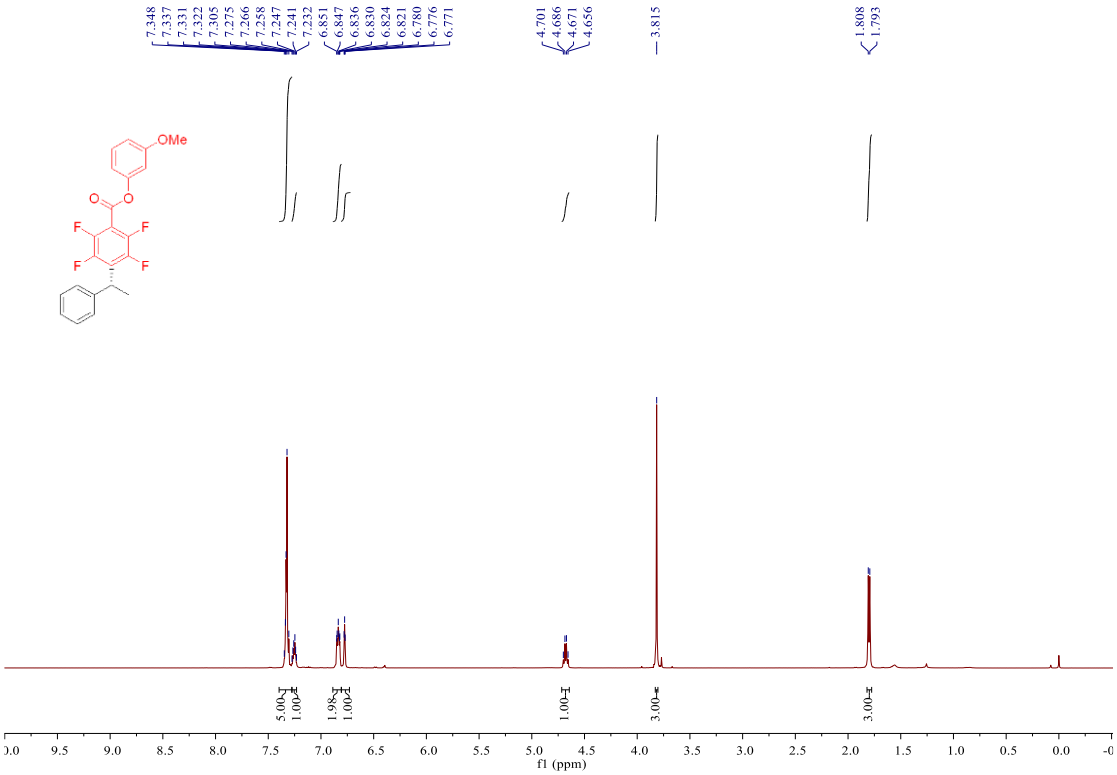
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3al



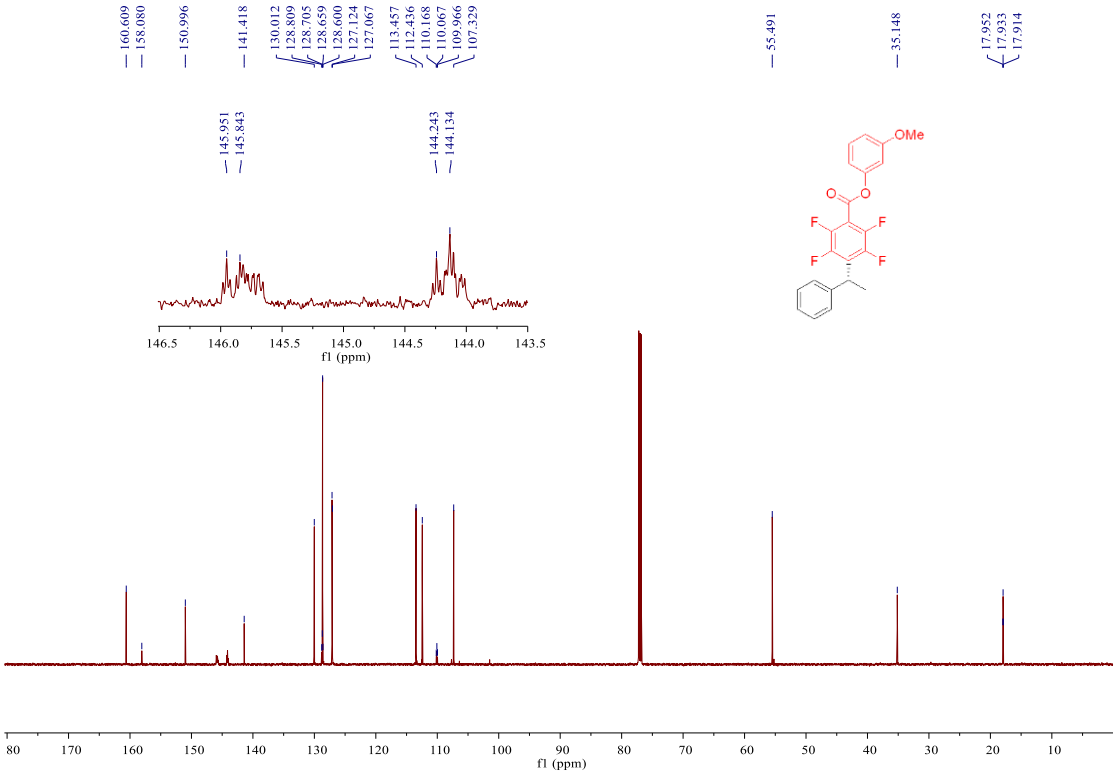
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3al



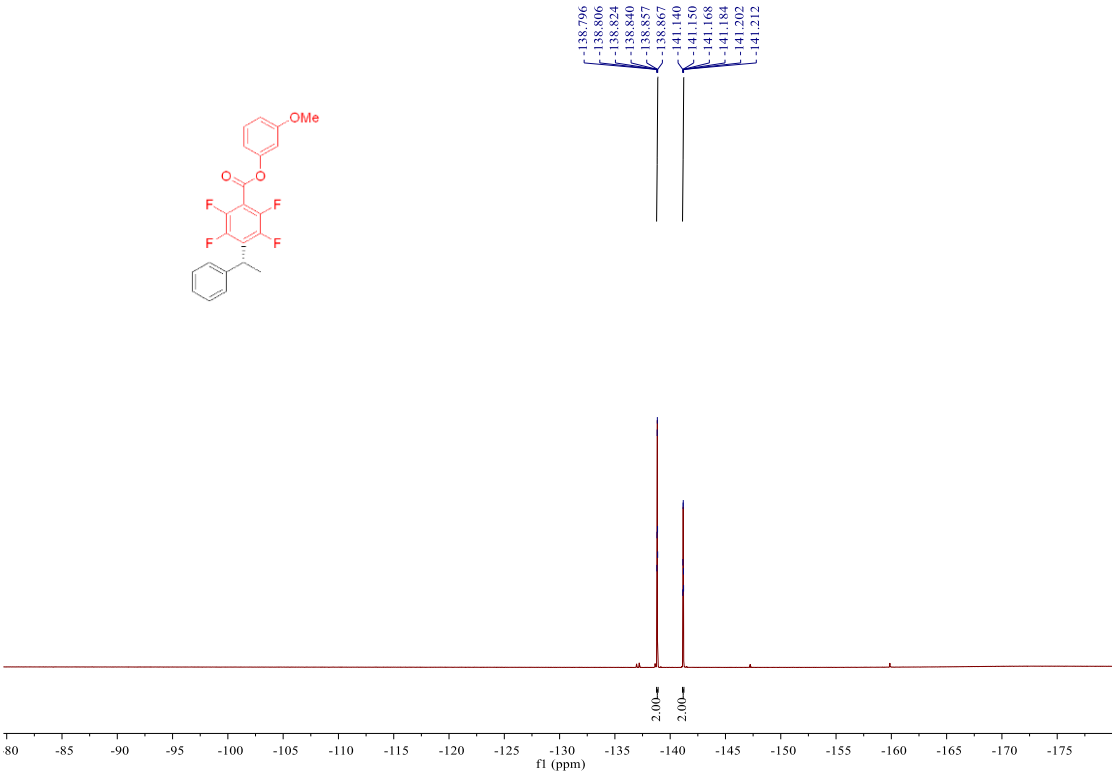
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3am



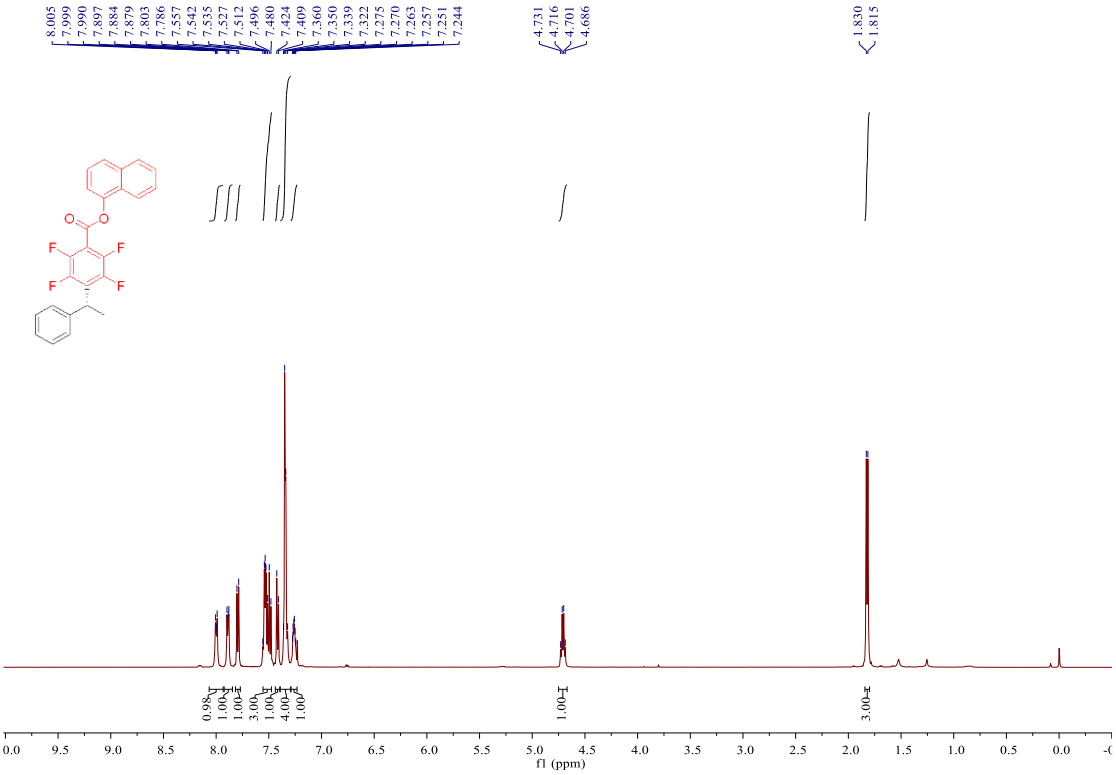
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3am



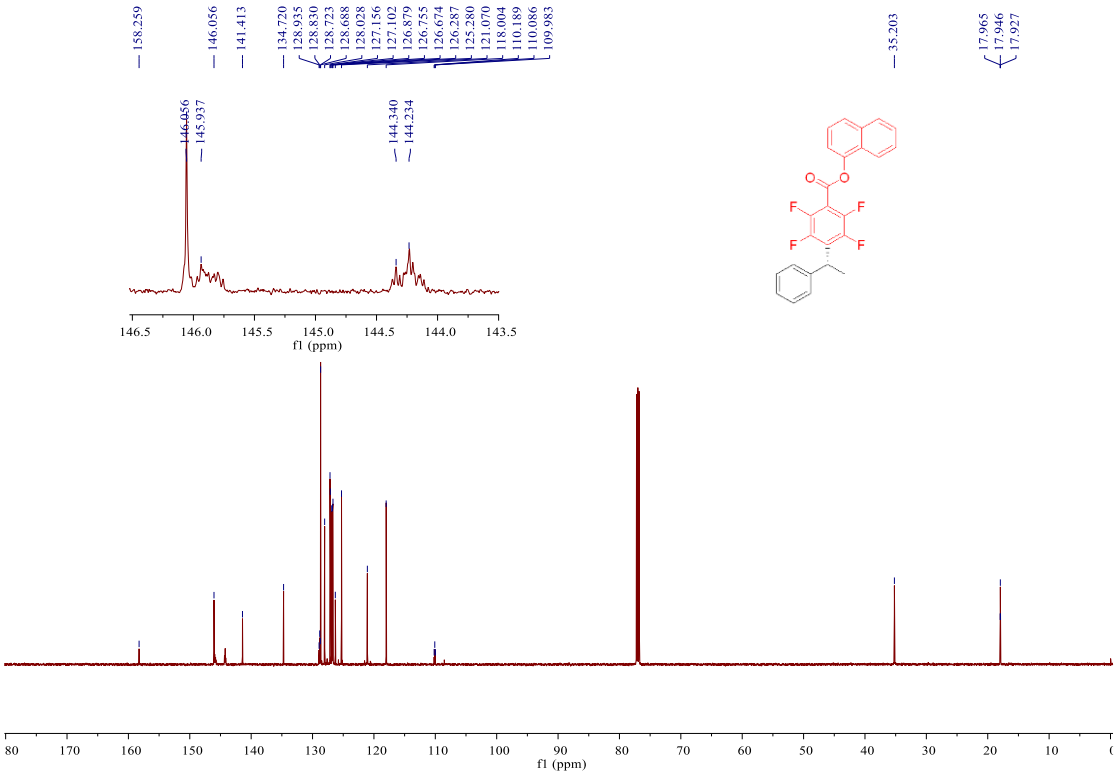
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3am



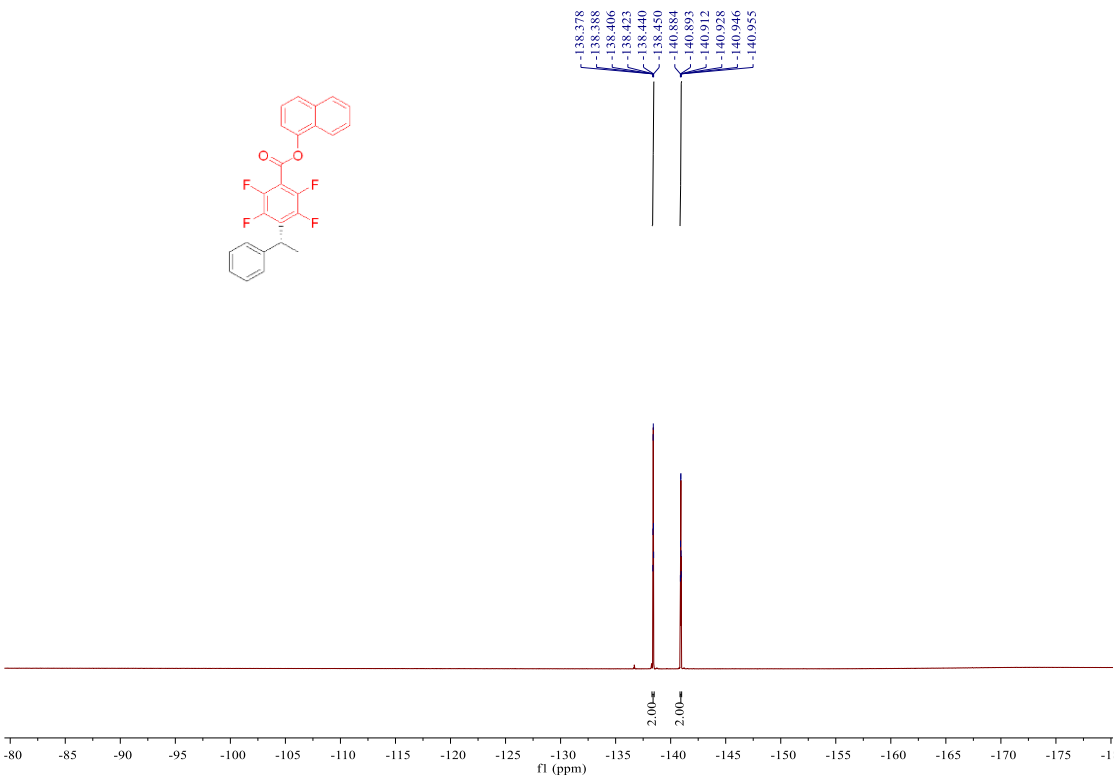
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3an



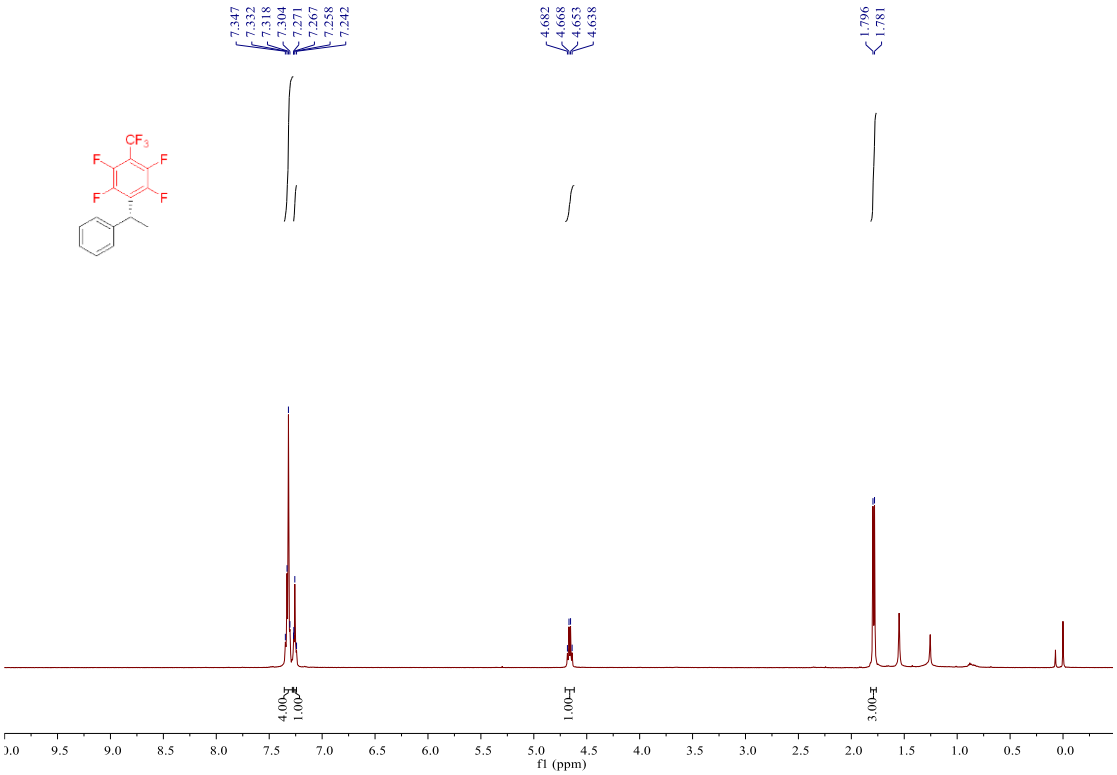
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3an



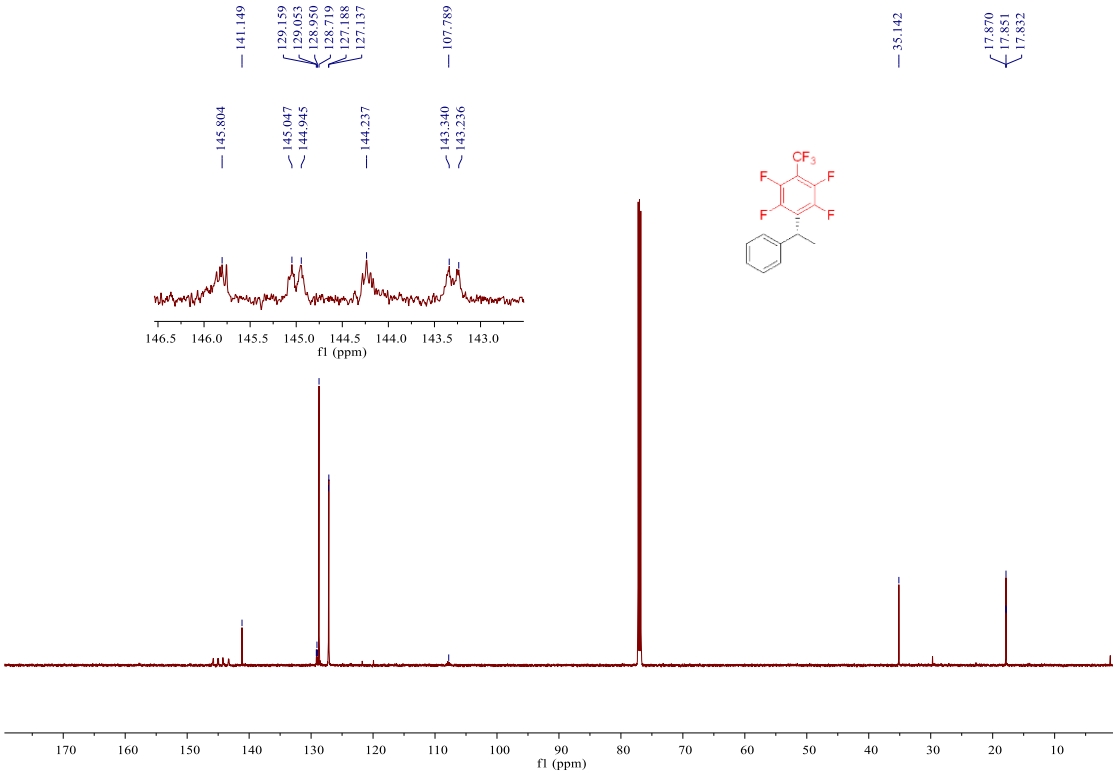
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3an



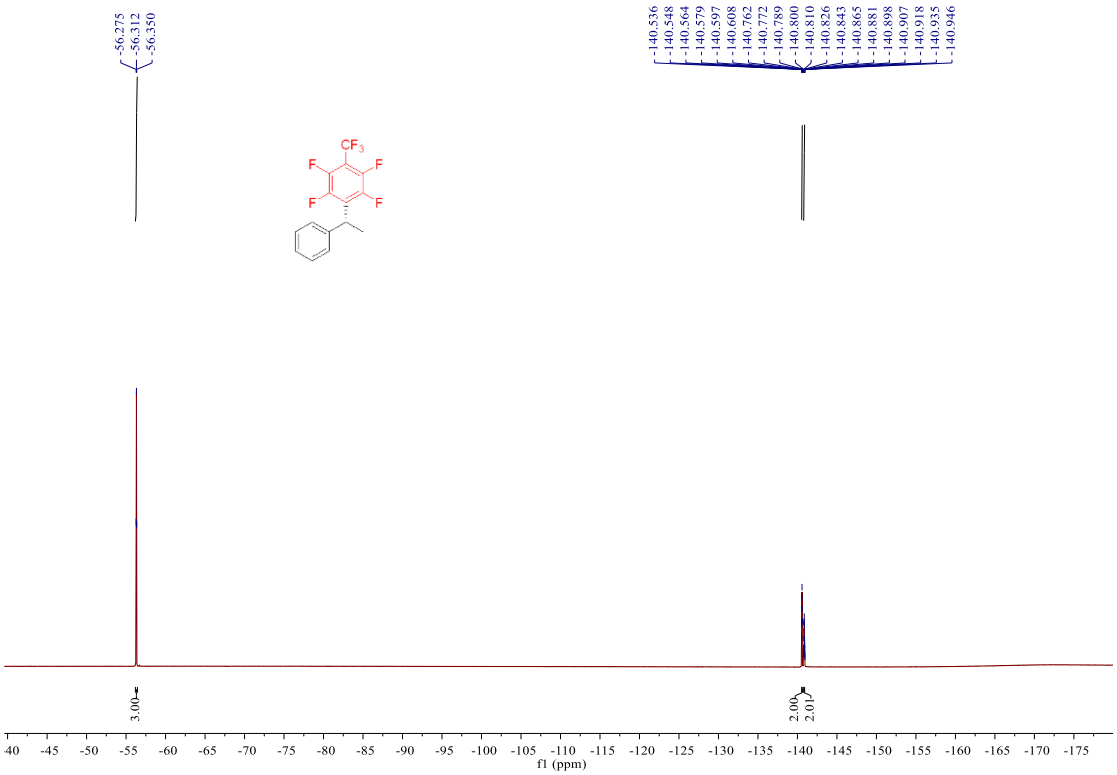
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3ao



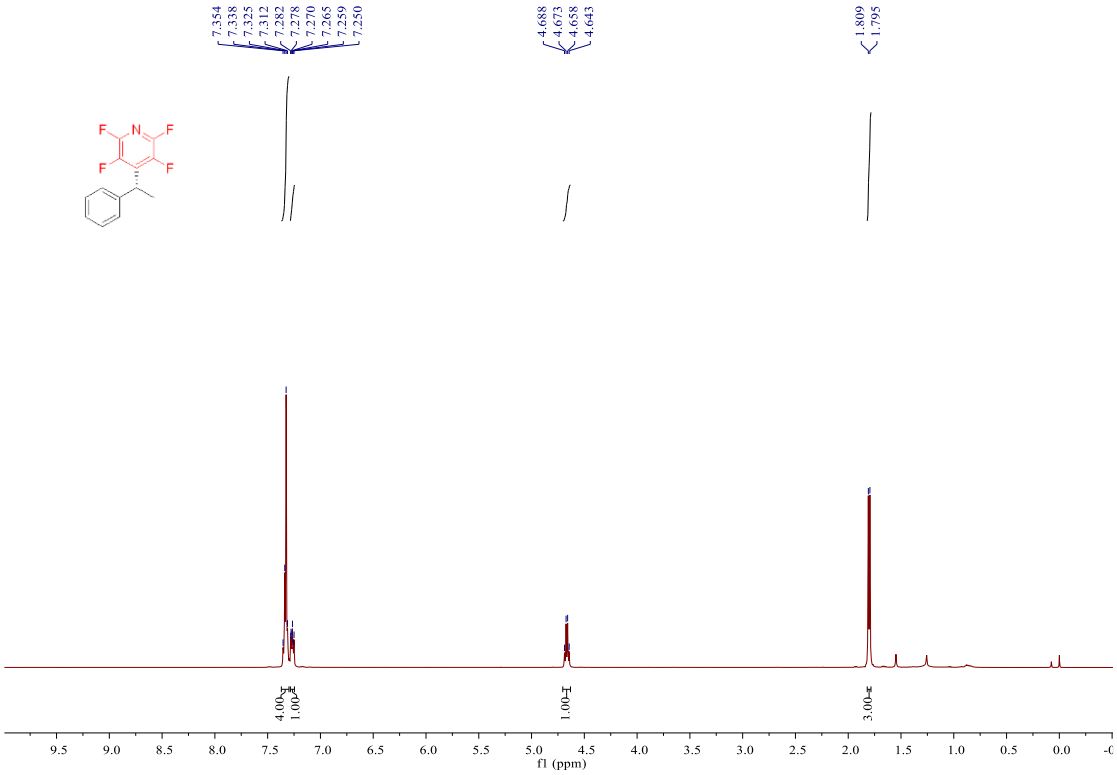
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3ao



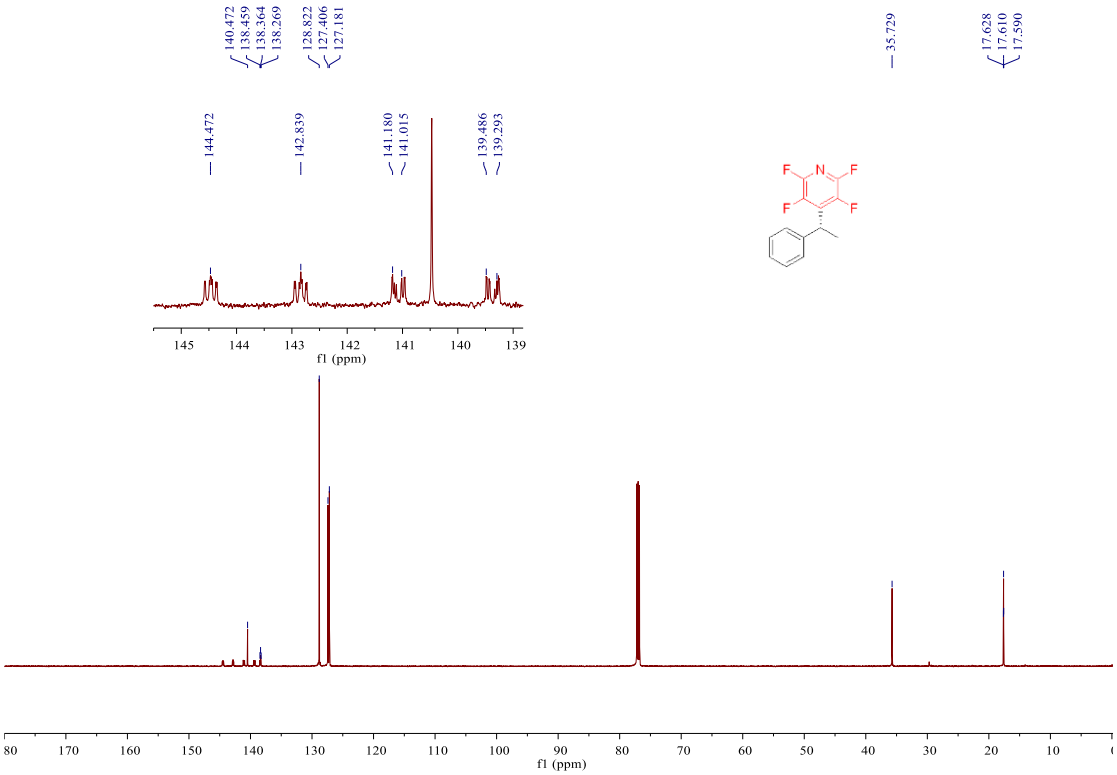
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3ao



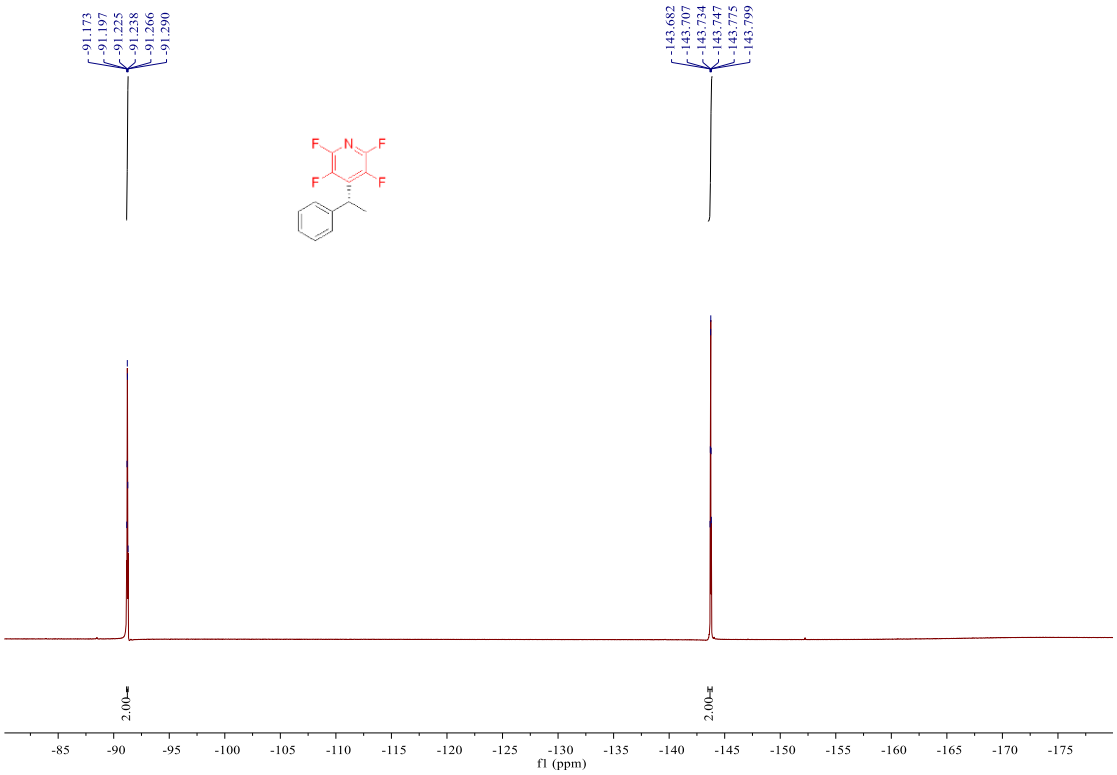
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3ap



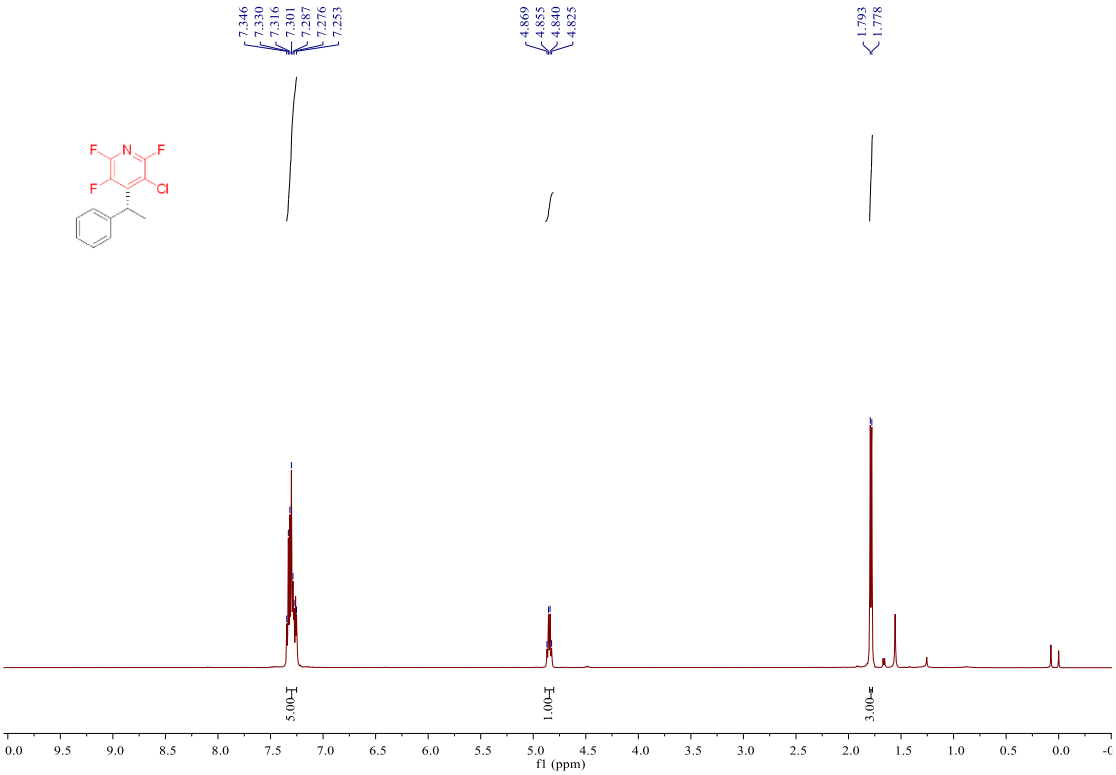
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3ap



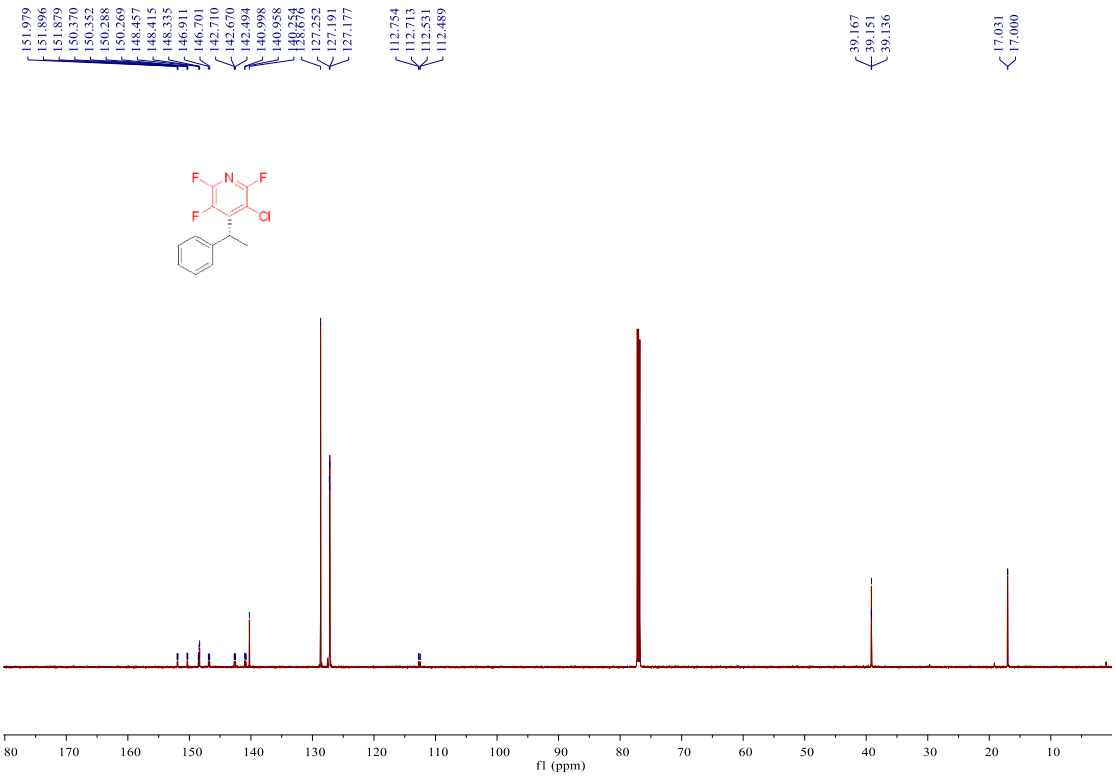
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3ap



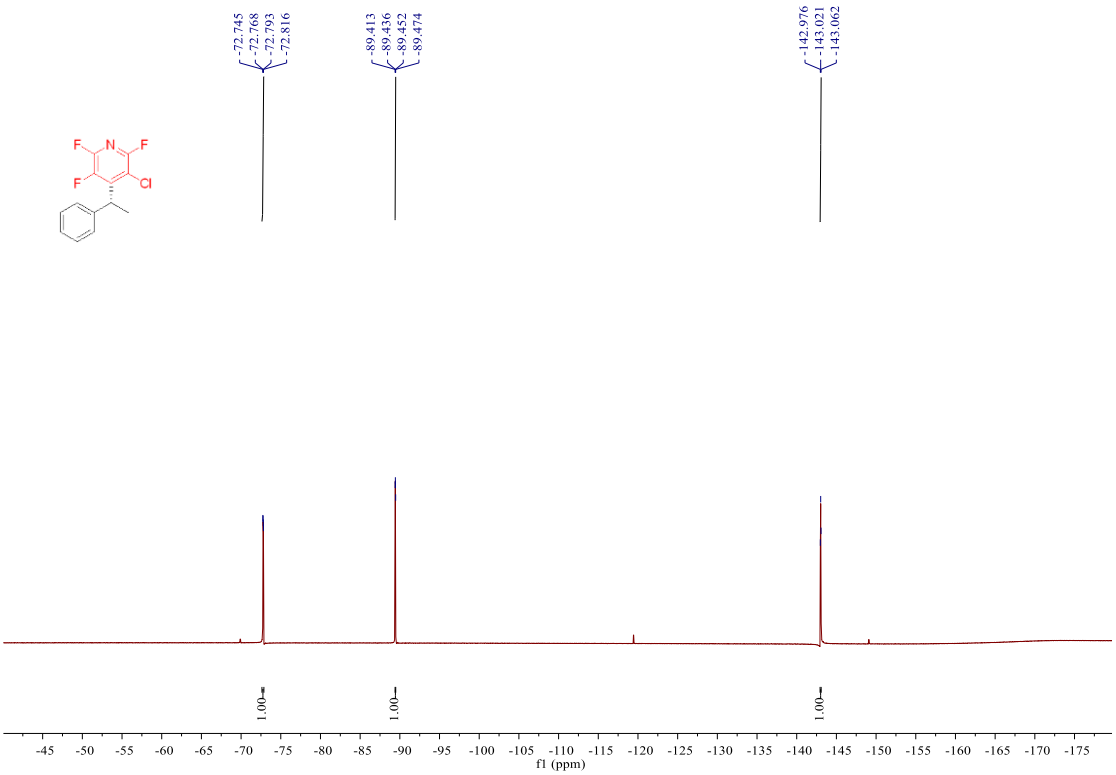
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3aq



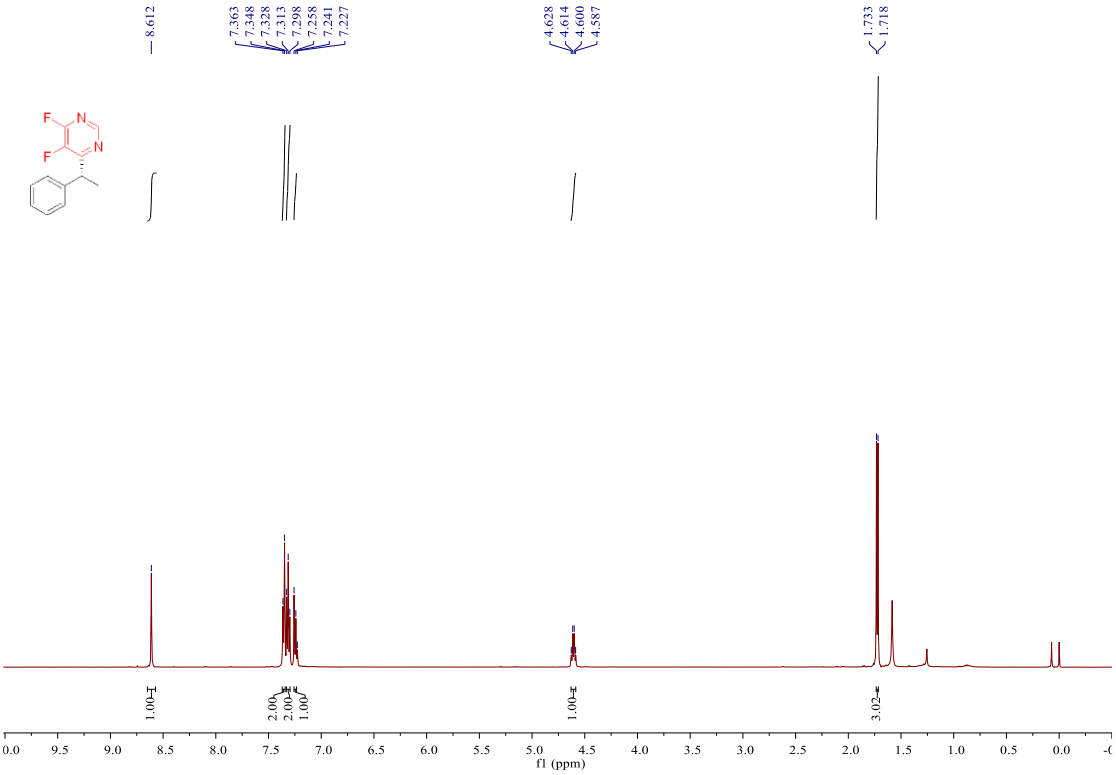
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3aq



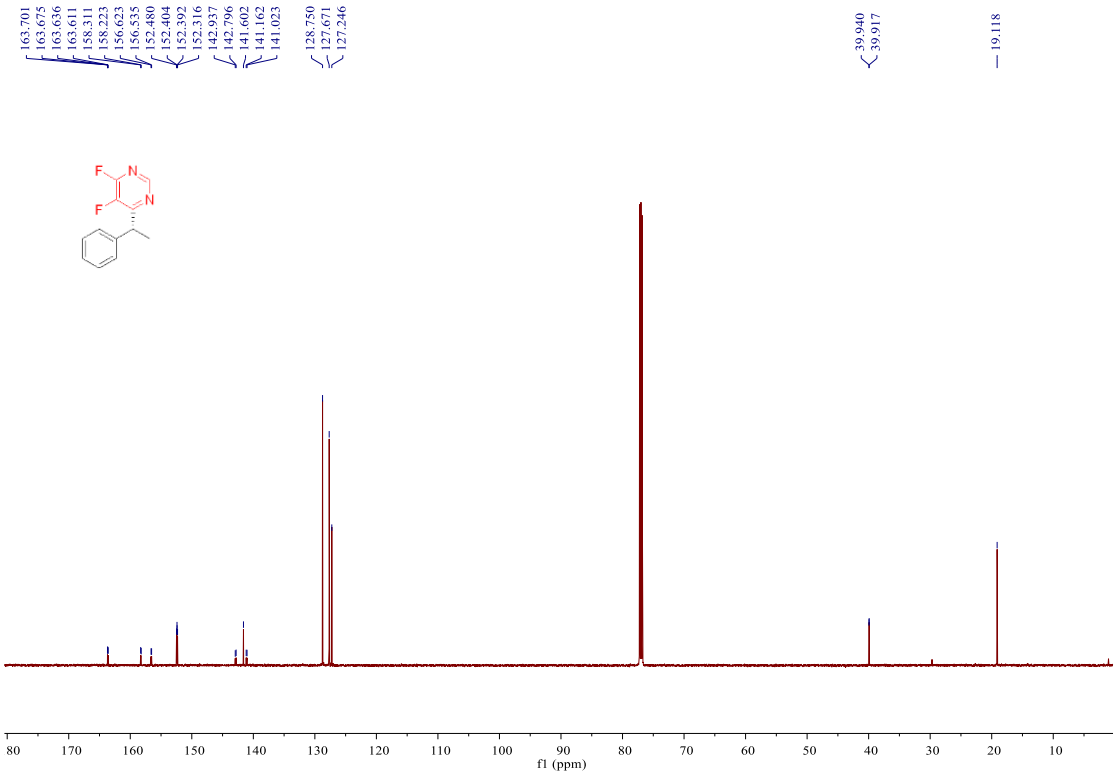
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3aq



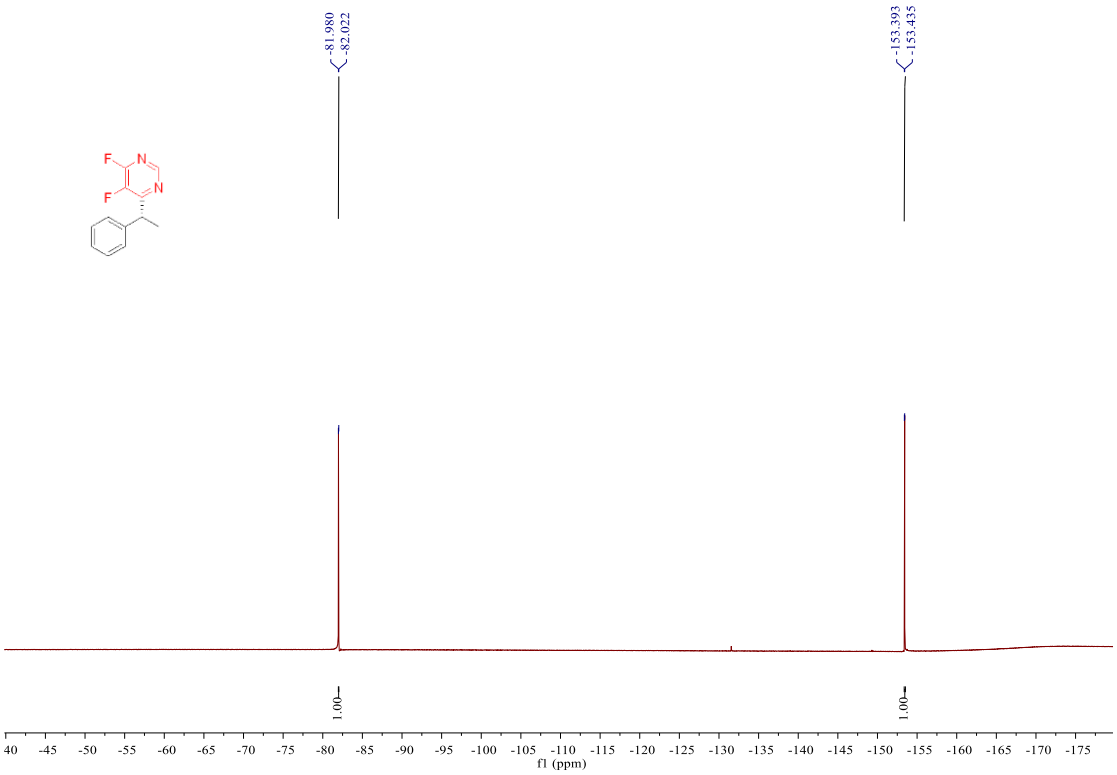
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 3ar



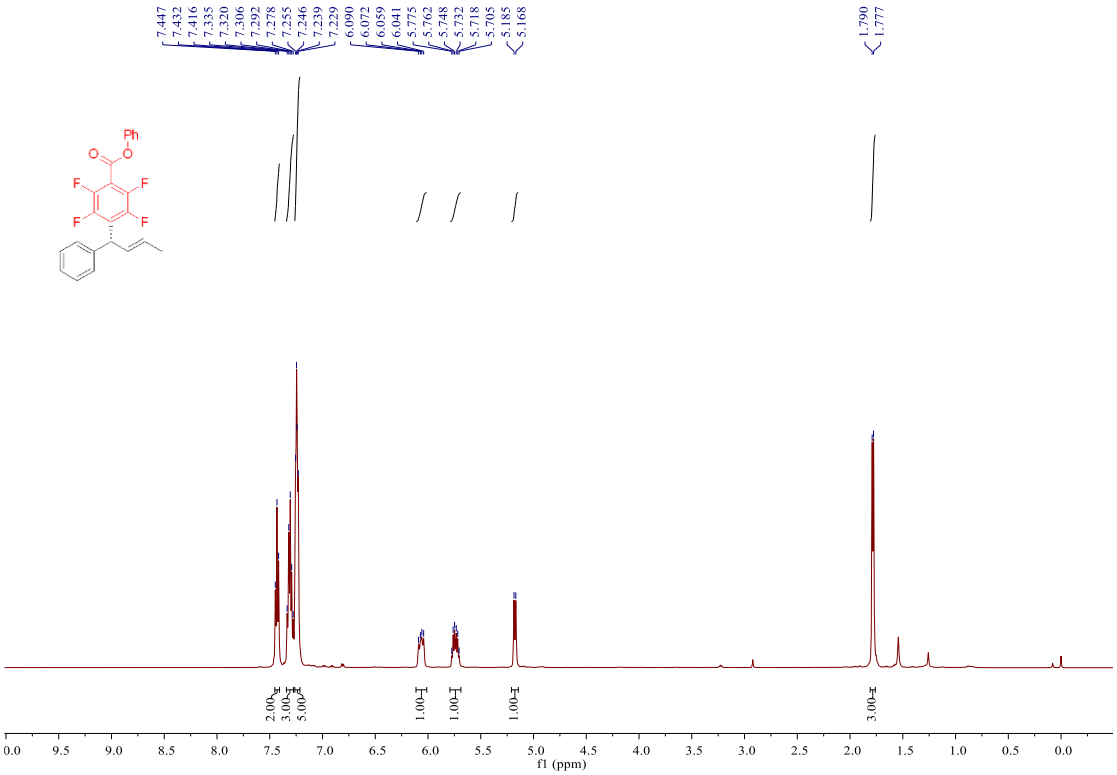
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 3ar



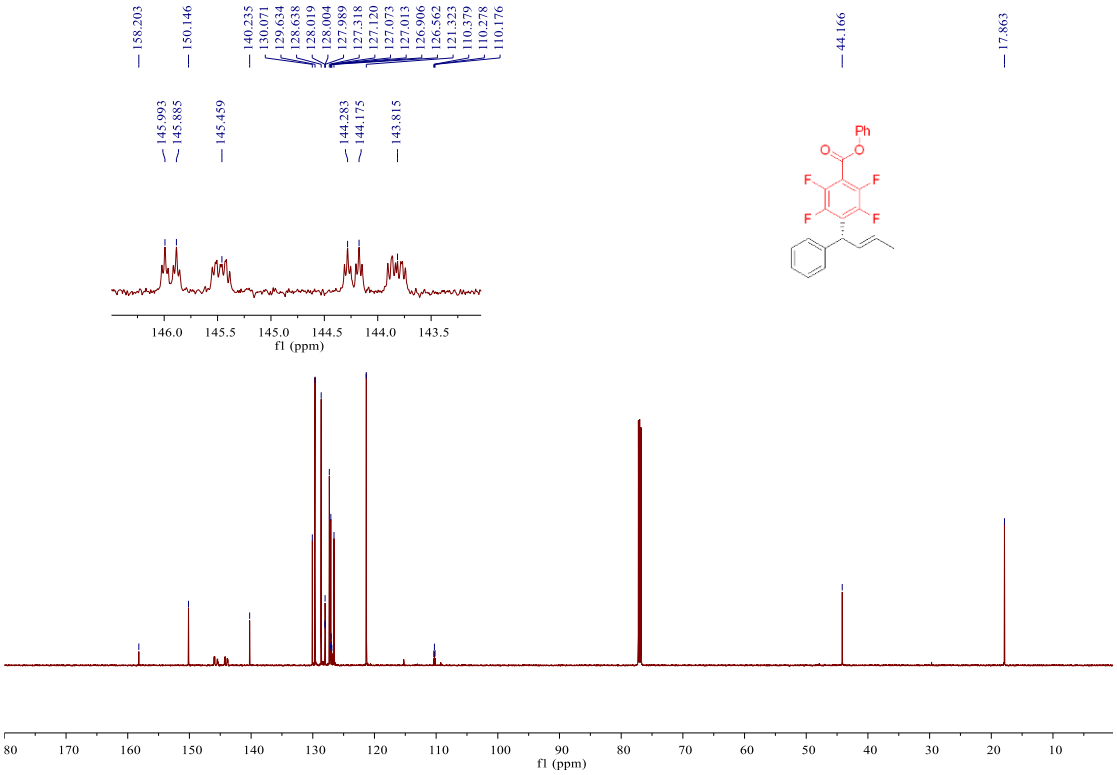
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 3ar



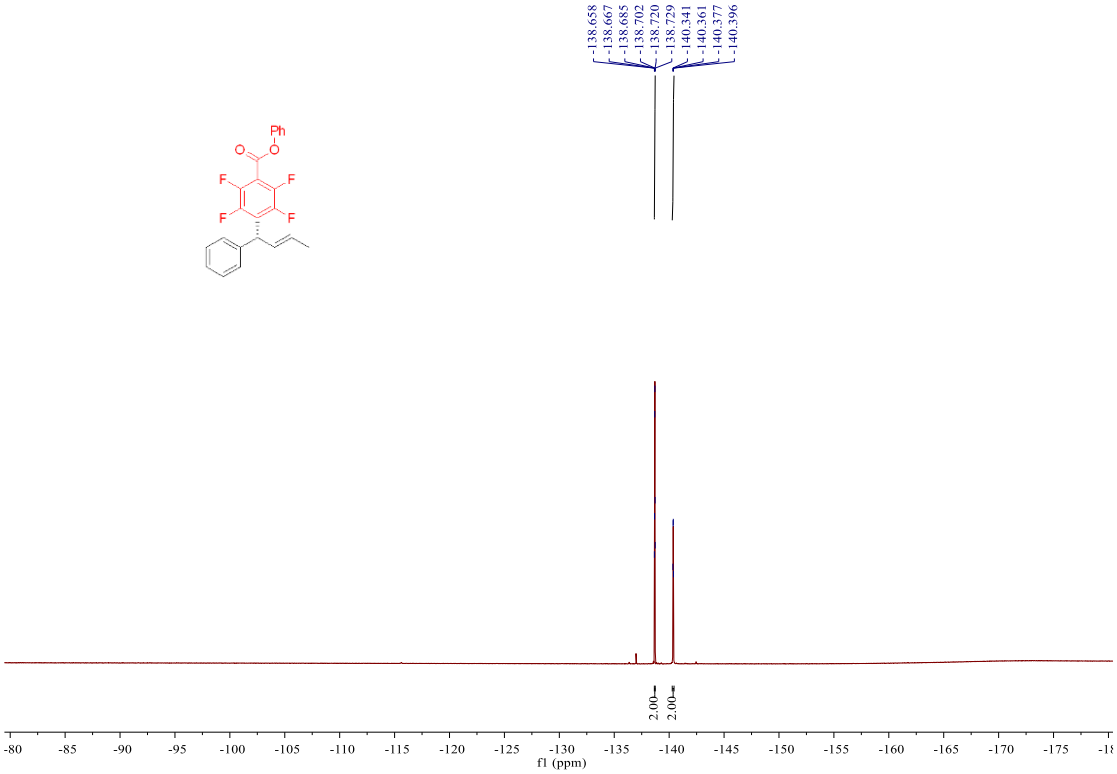
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5a



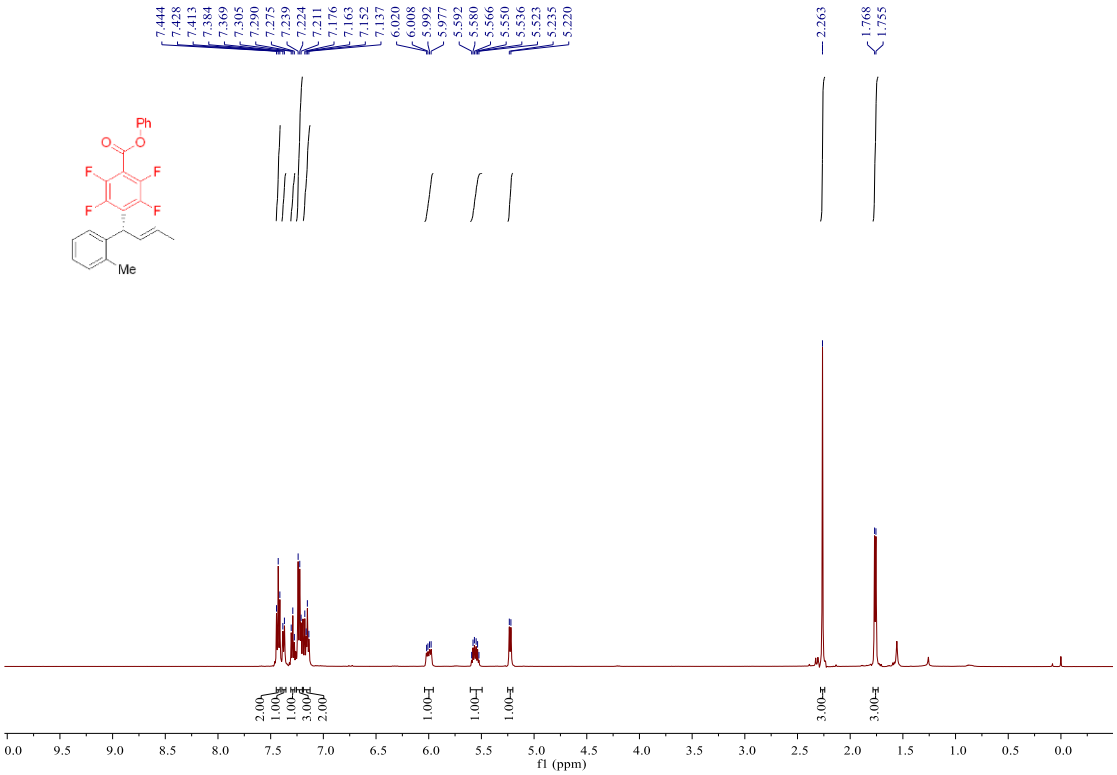
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5a



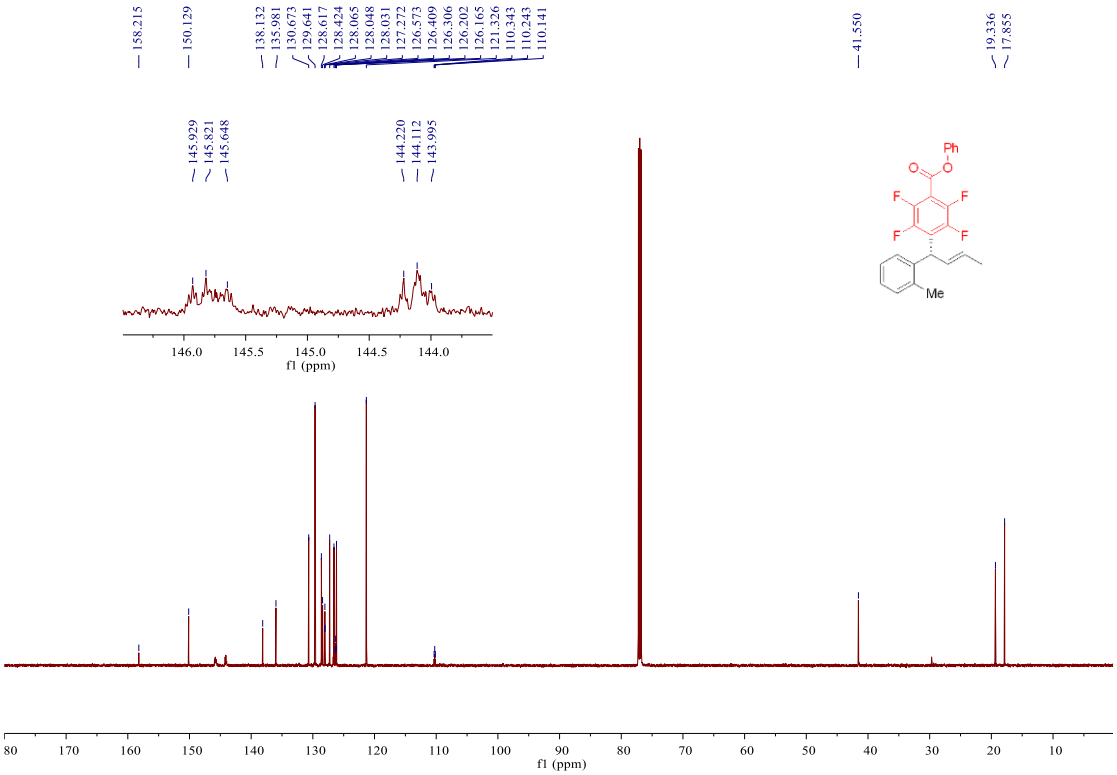
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5a



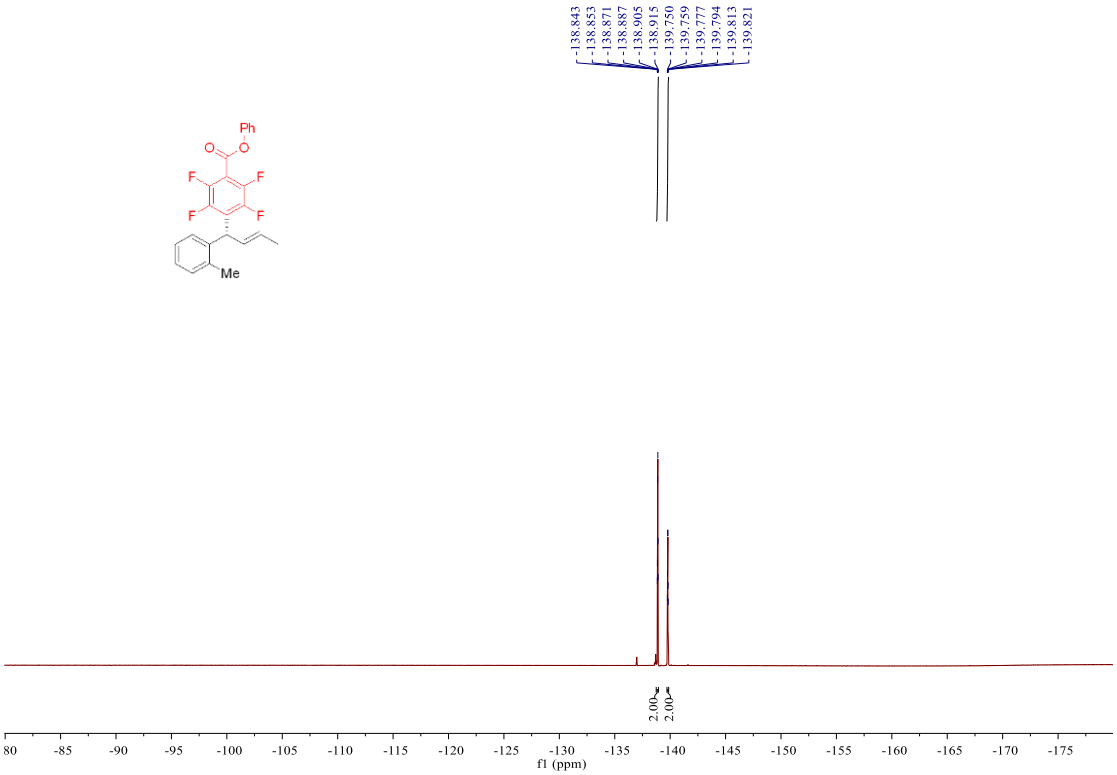
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5b



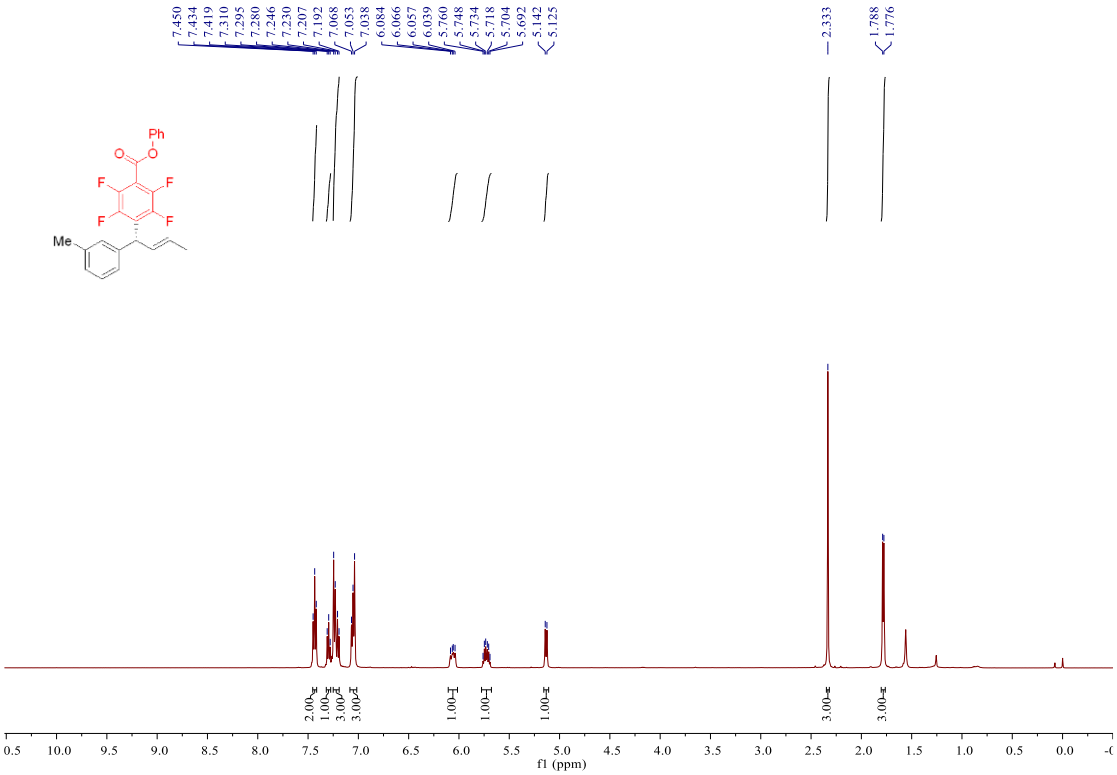
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5b



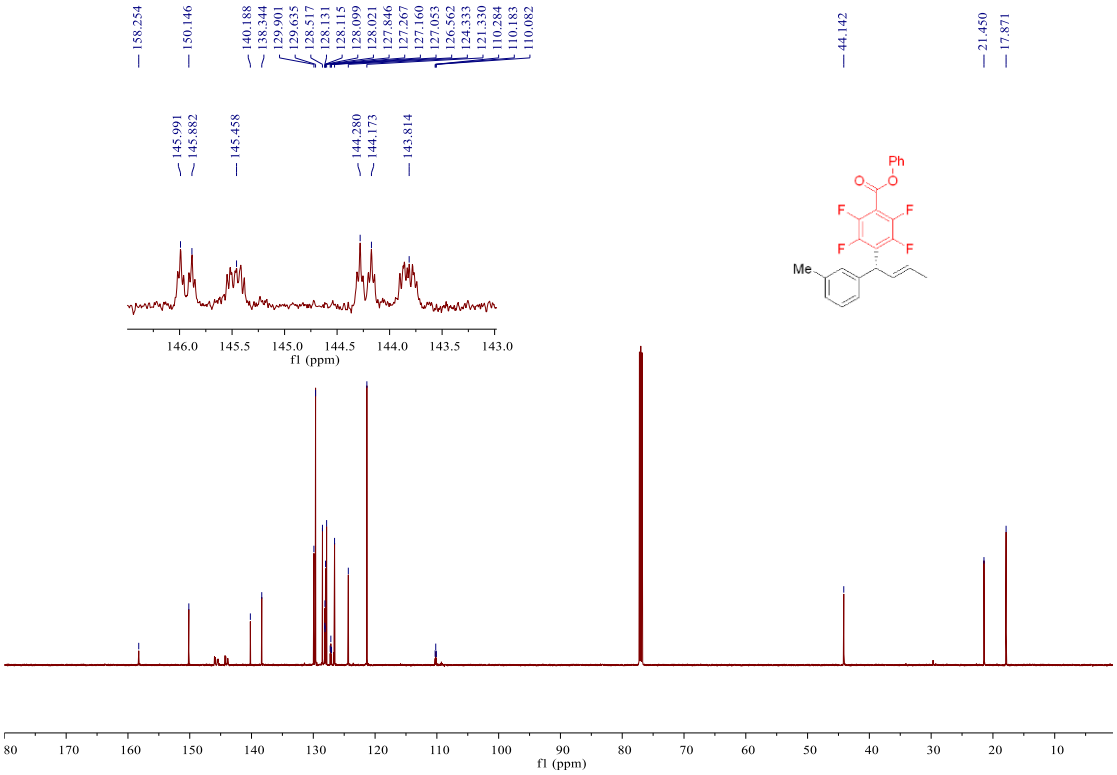
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5b



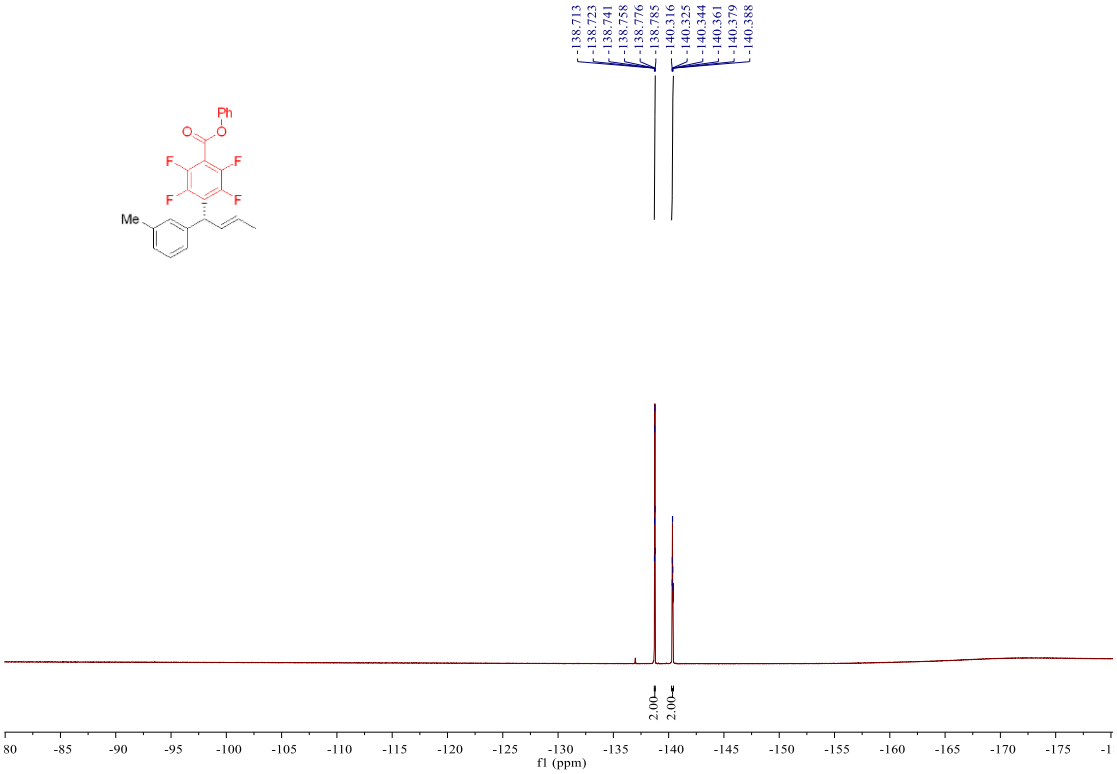
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5c



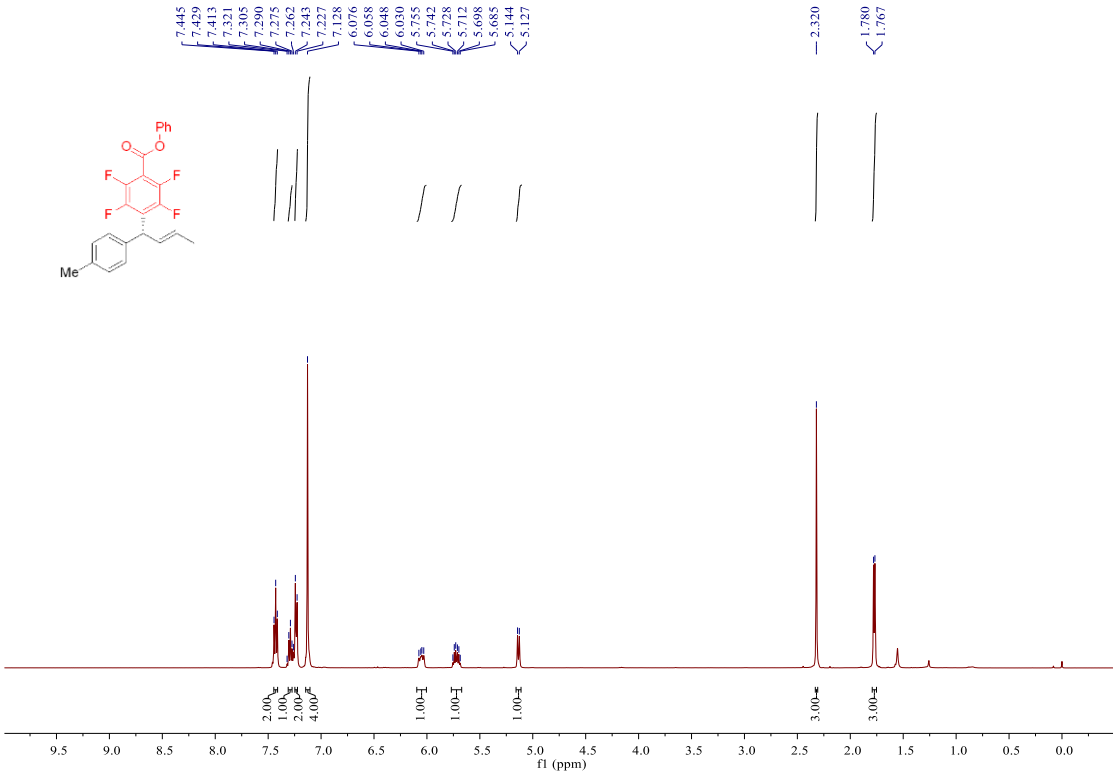
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5c



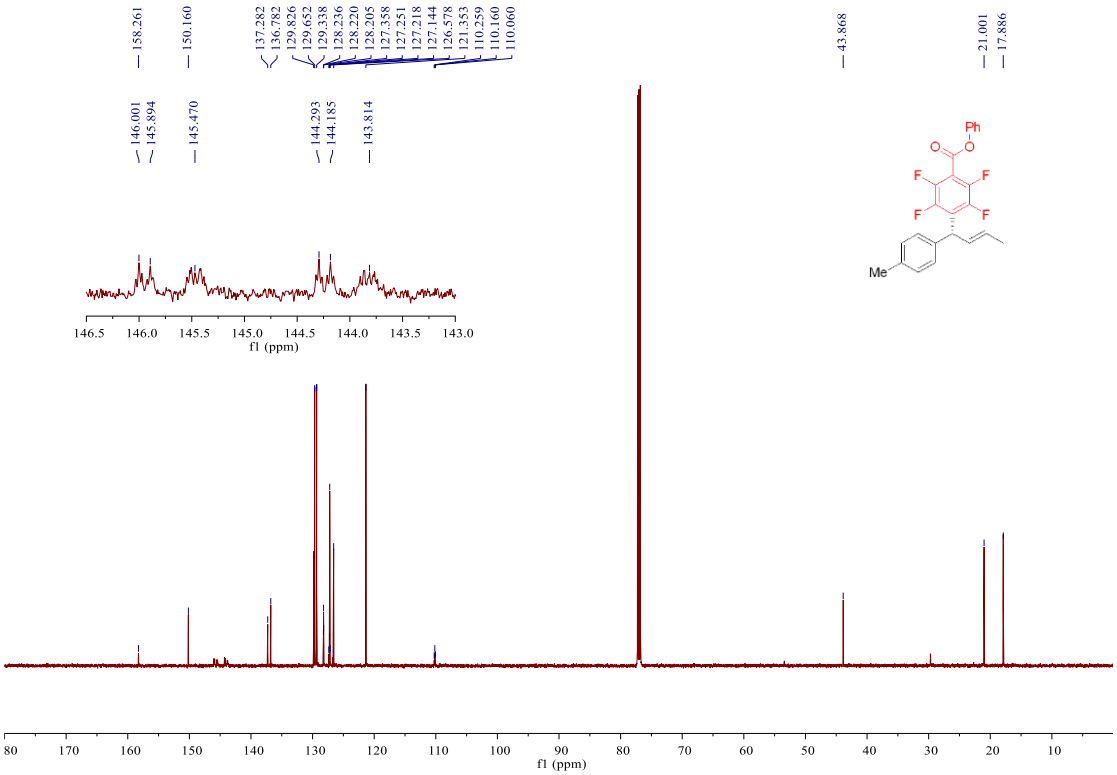
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5c



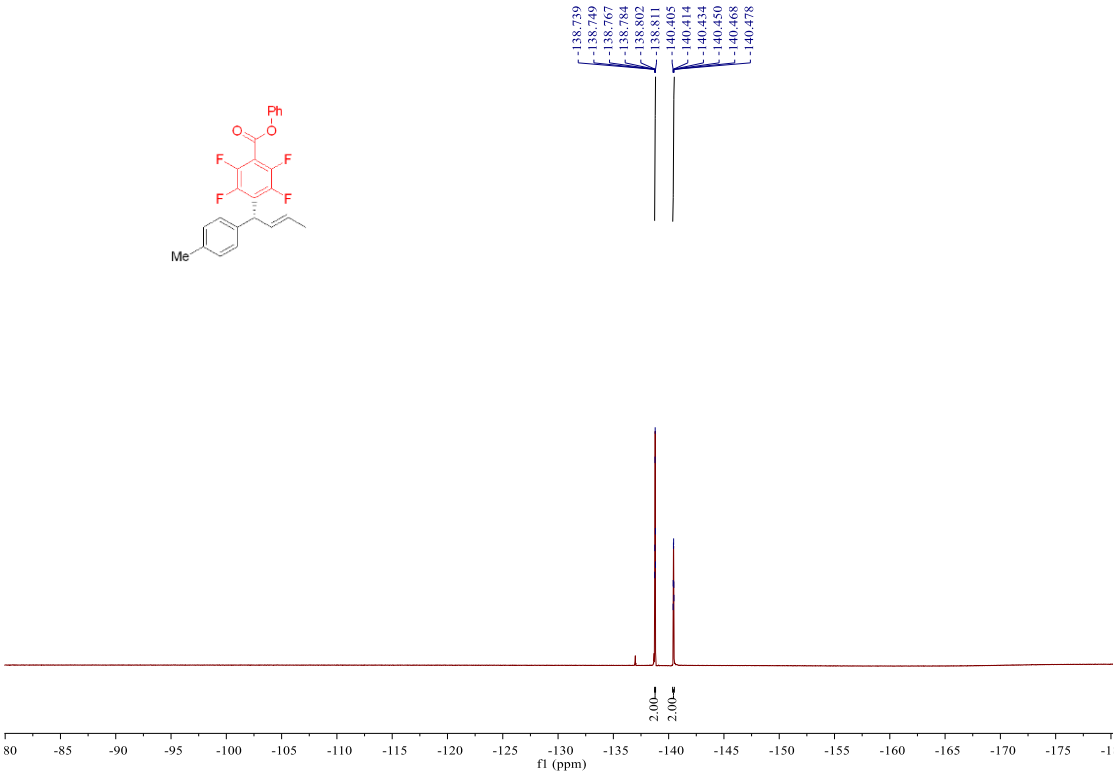
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5d



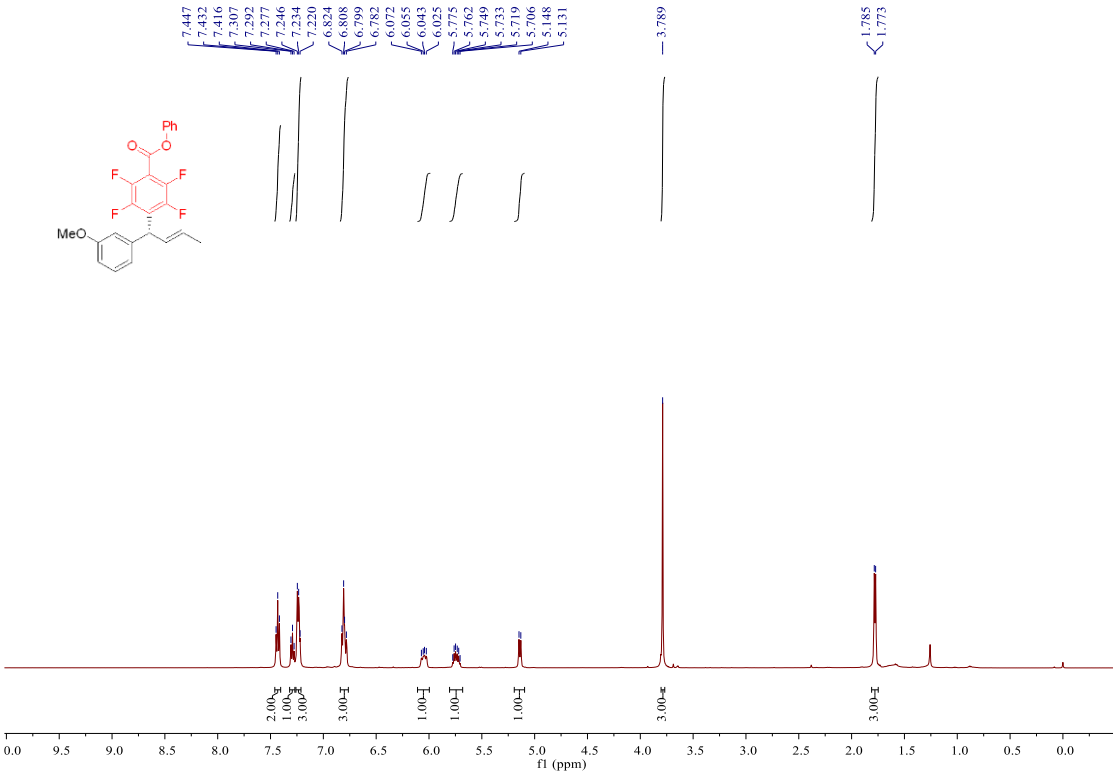
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5d



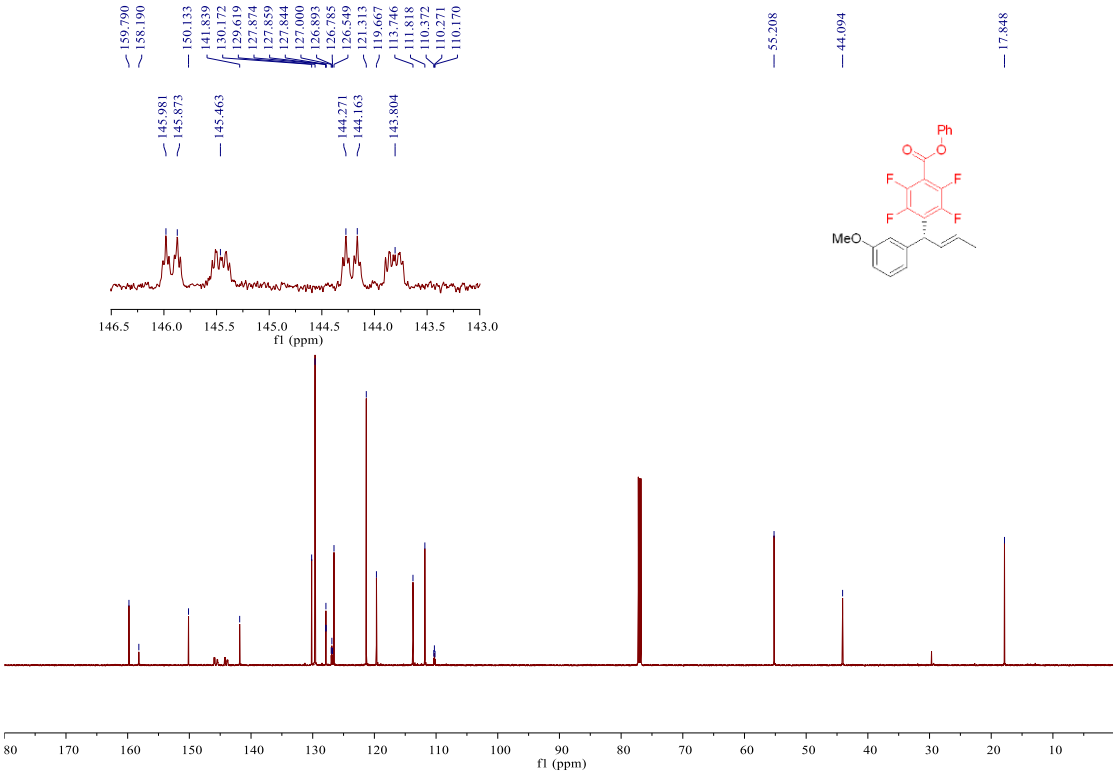
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5d



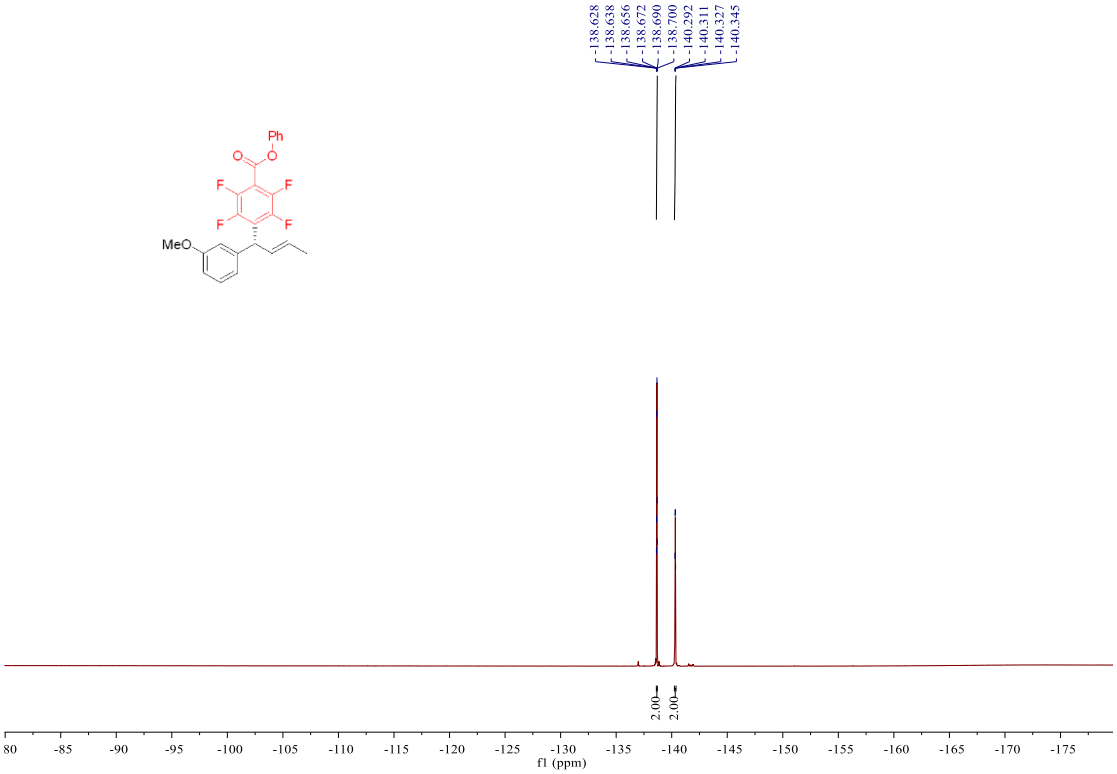
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 5e



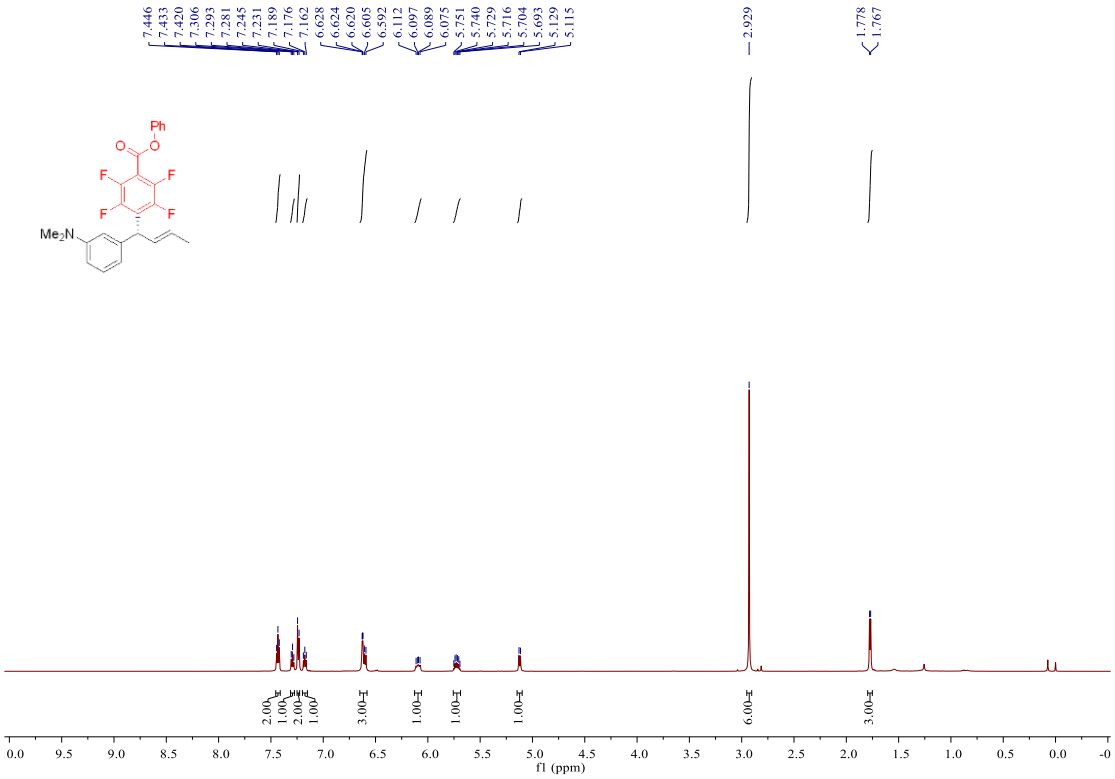
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5e



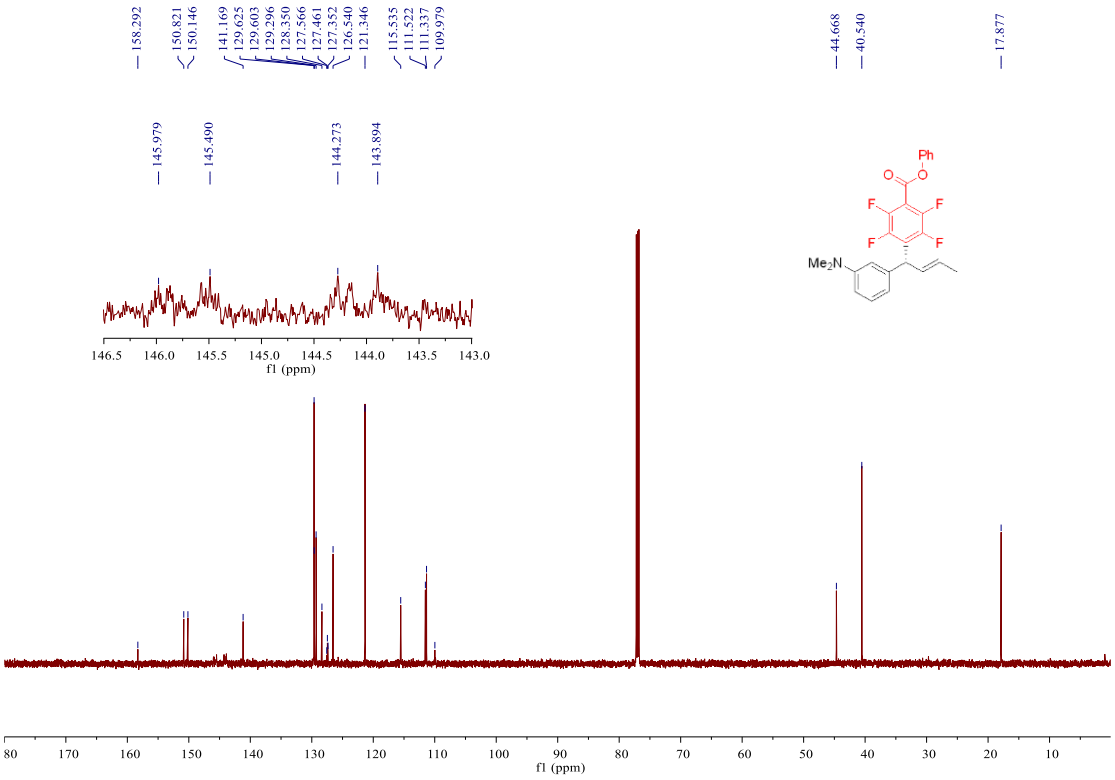
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5e



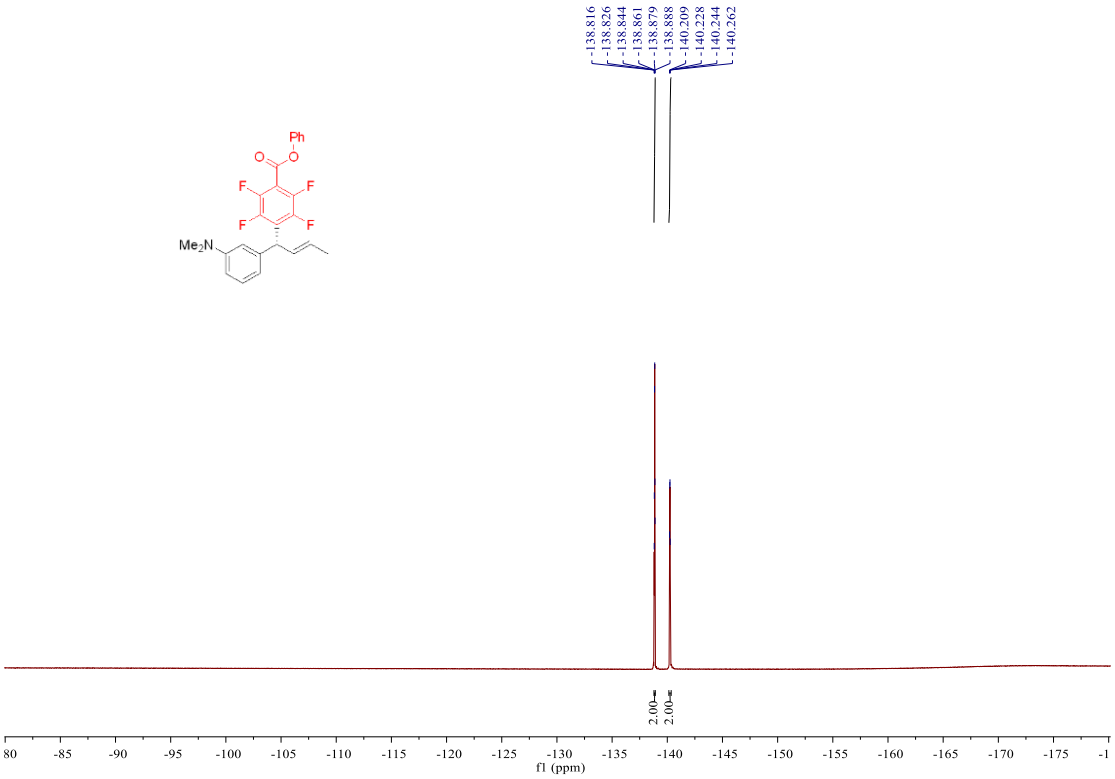
^{1}H NMR (600 MHz, Chloroform-*d)* spectrum of 5f



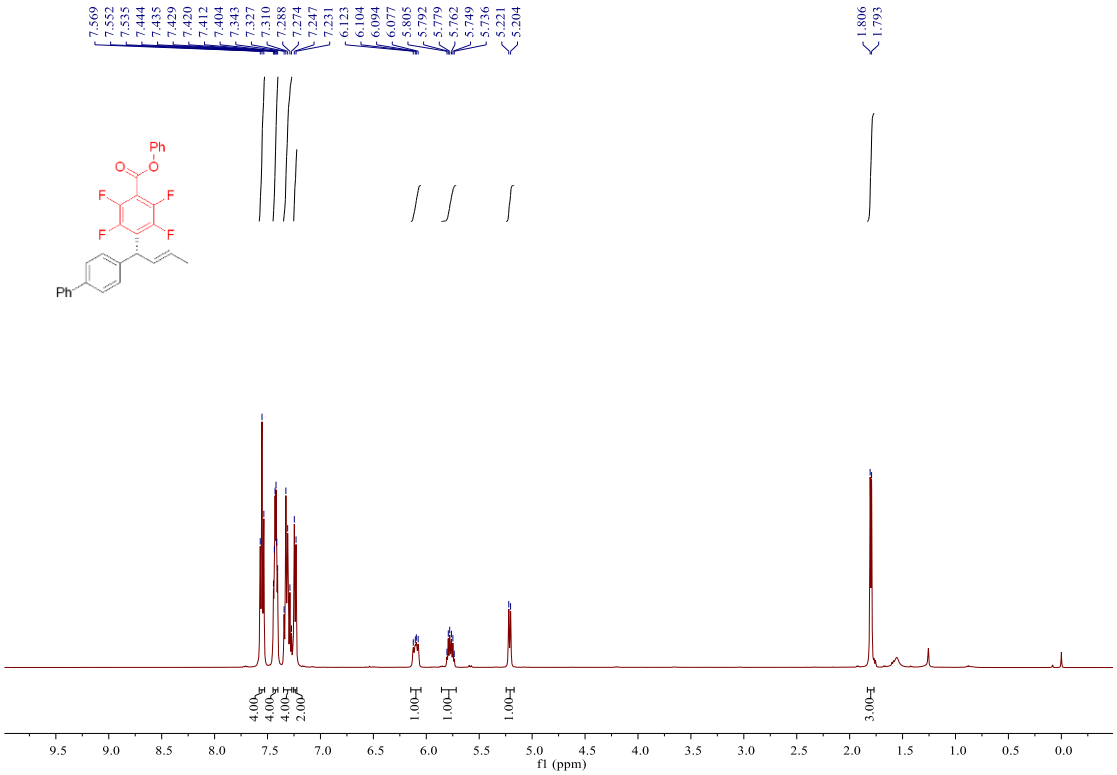
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5f



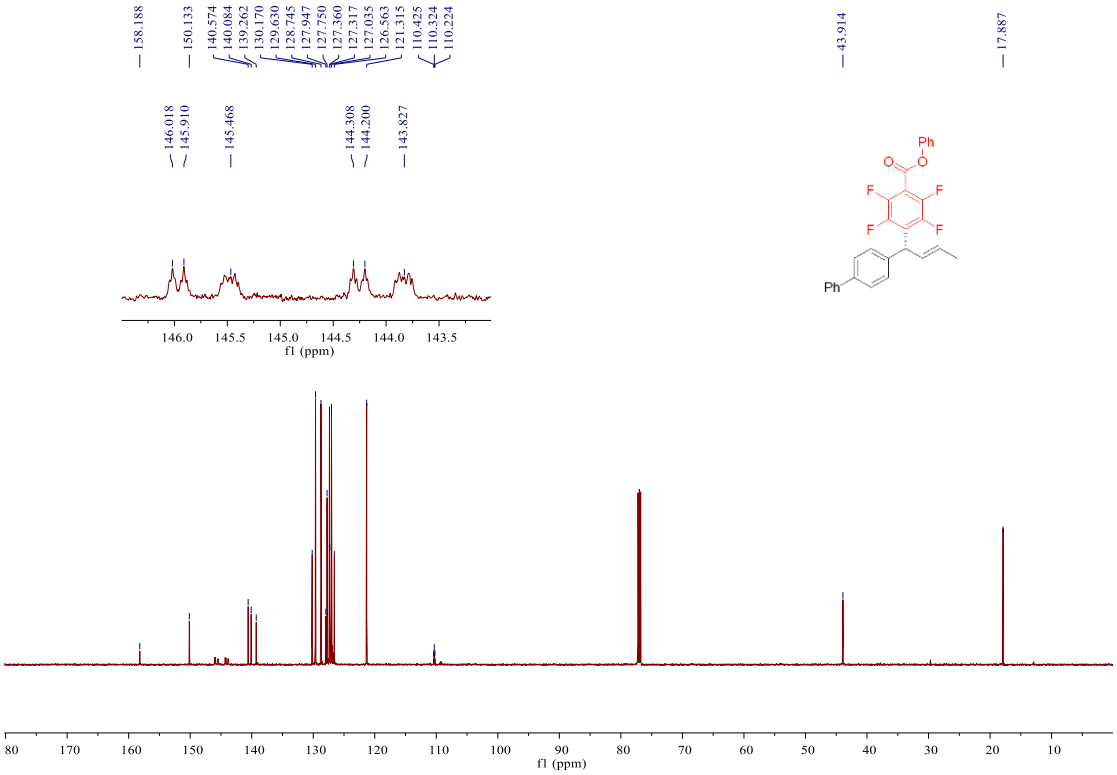
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5f



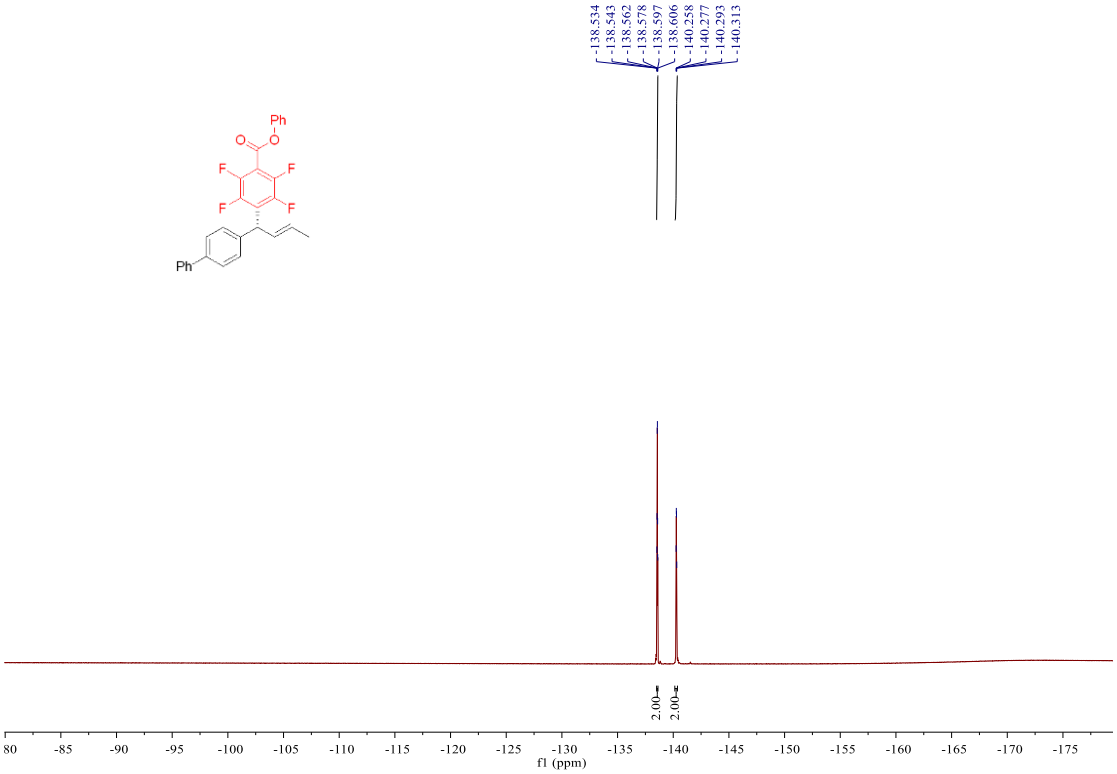
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 5g



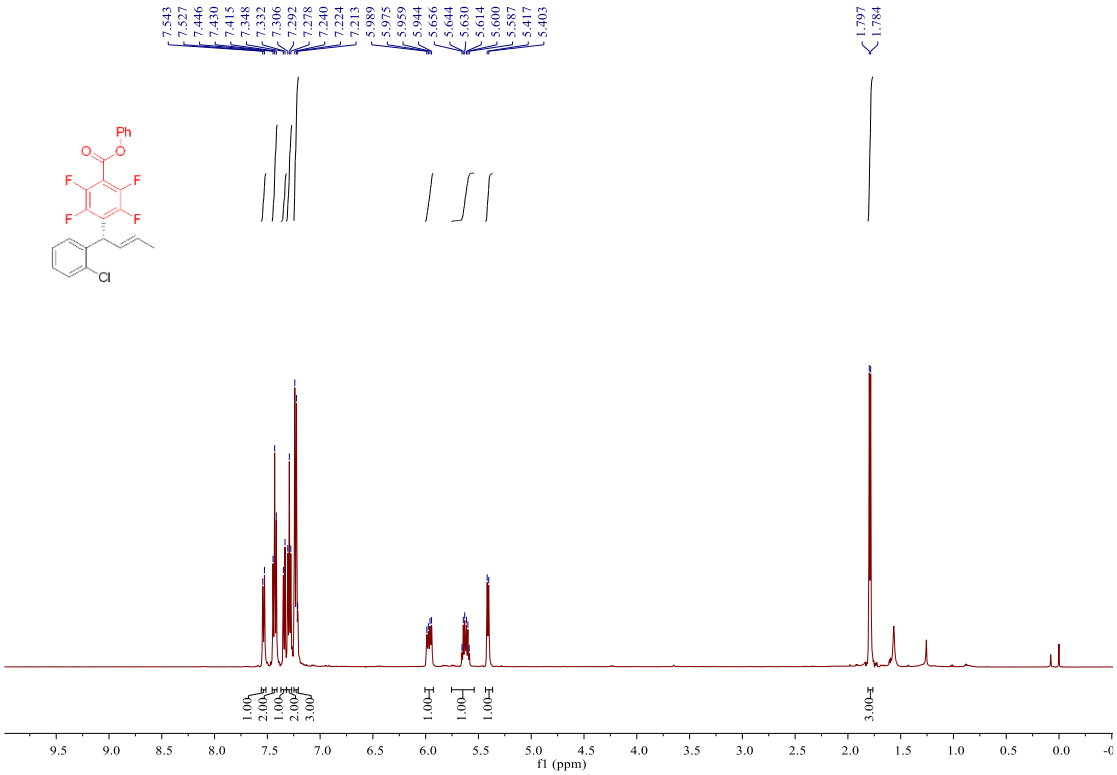
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5g



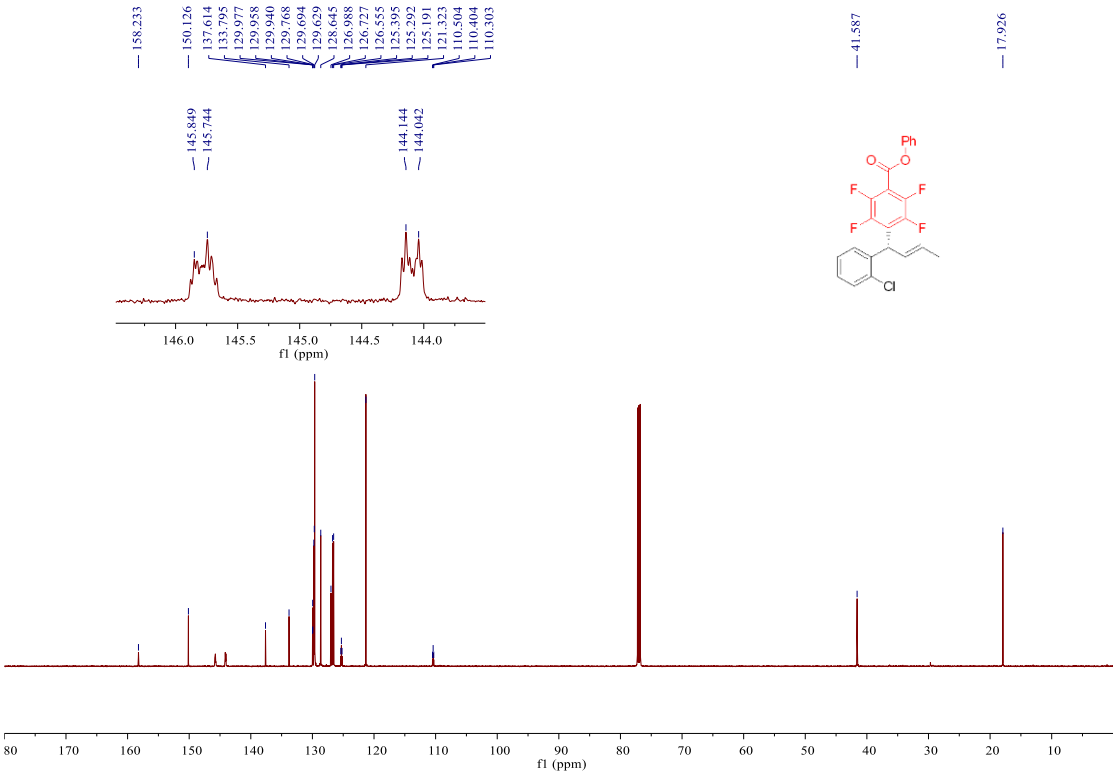
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5g



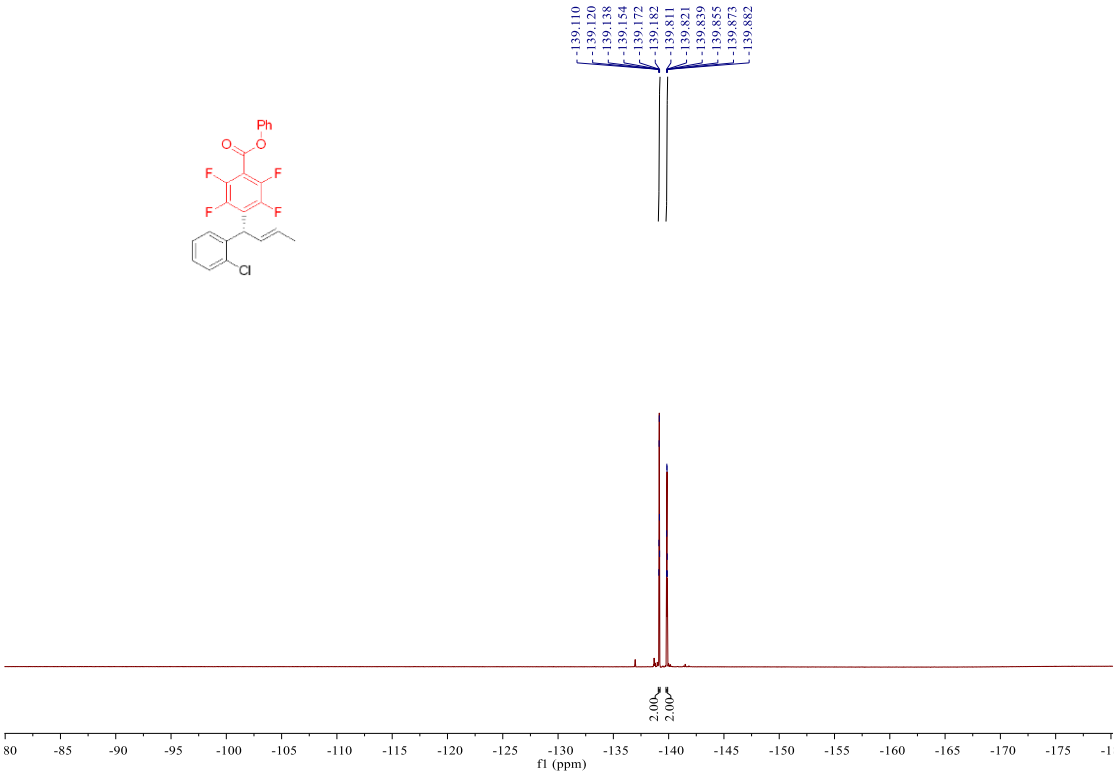
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5h



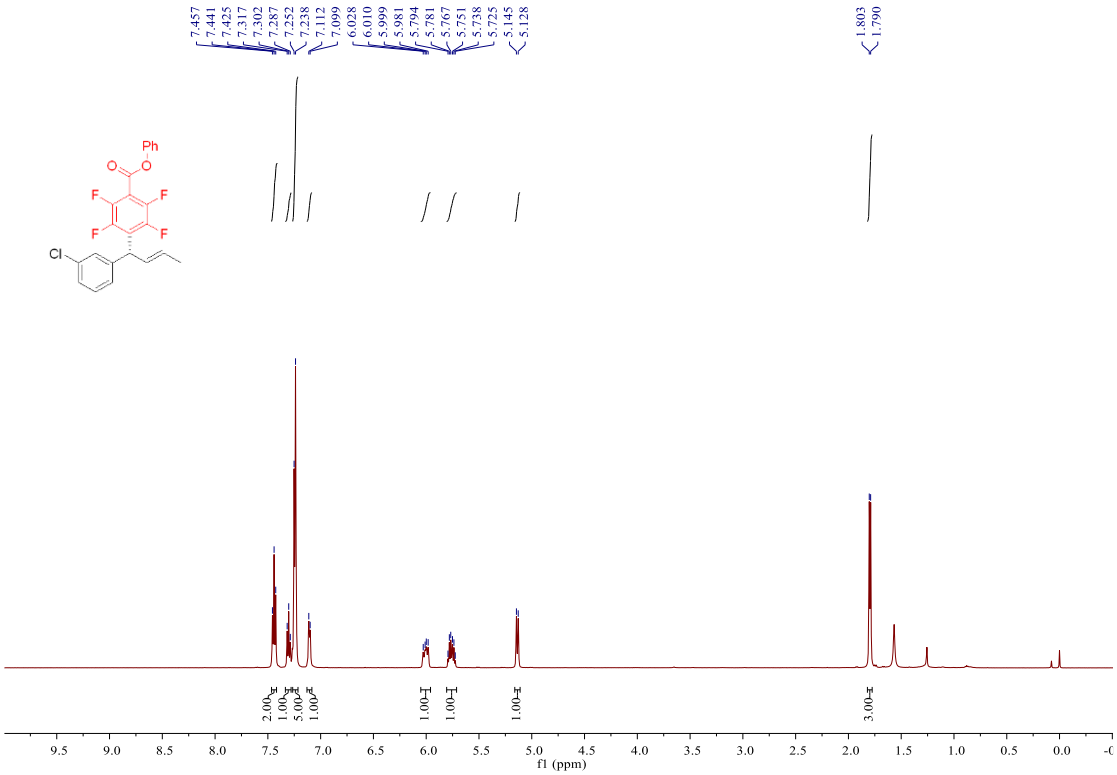
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5h



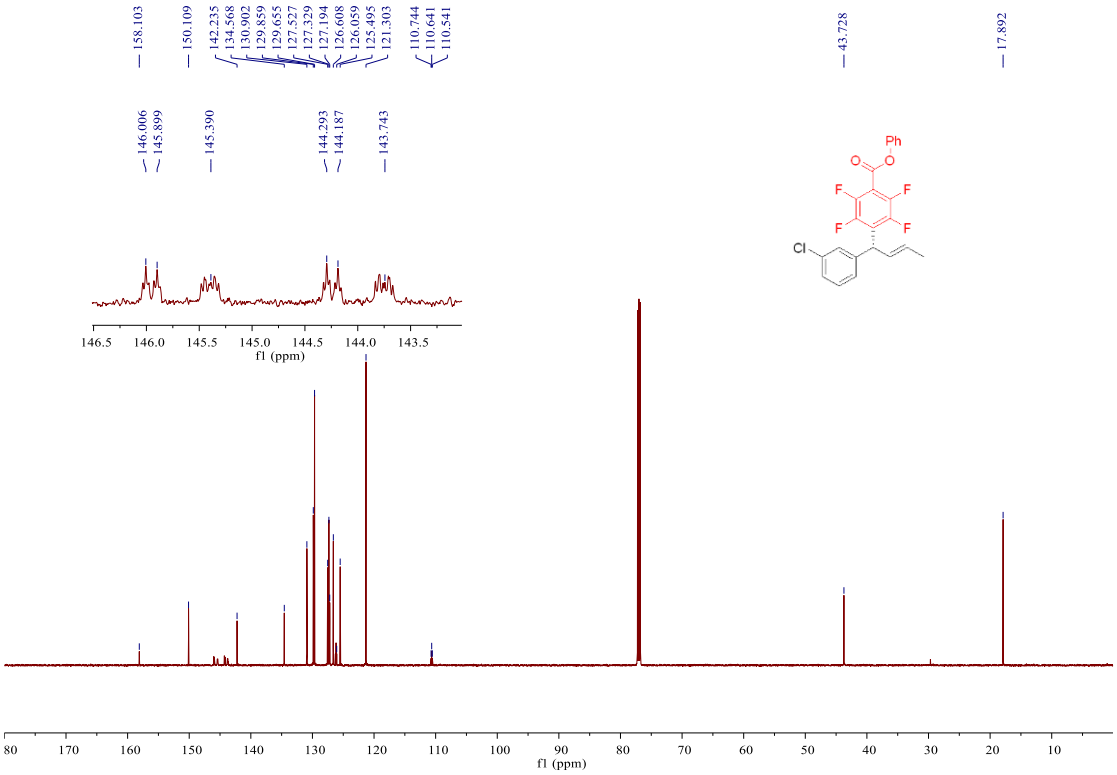
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5h



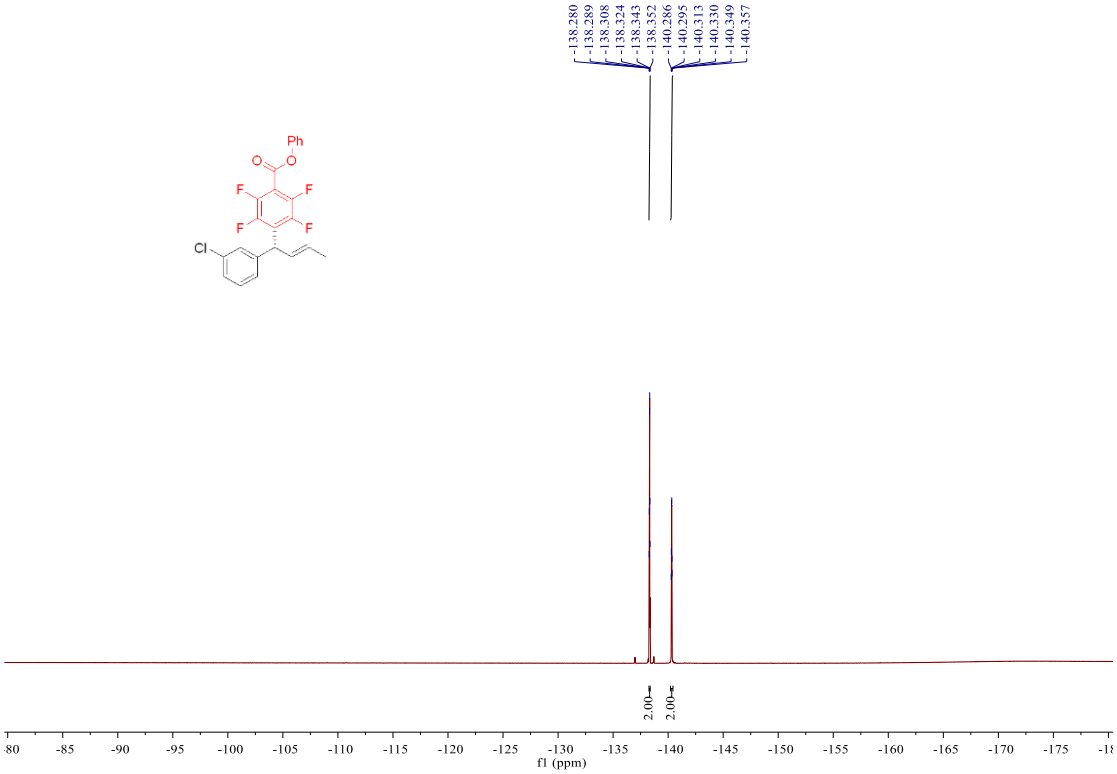
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 5i



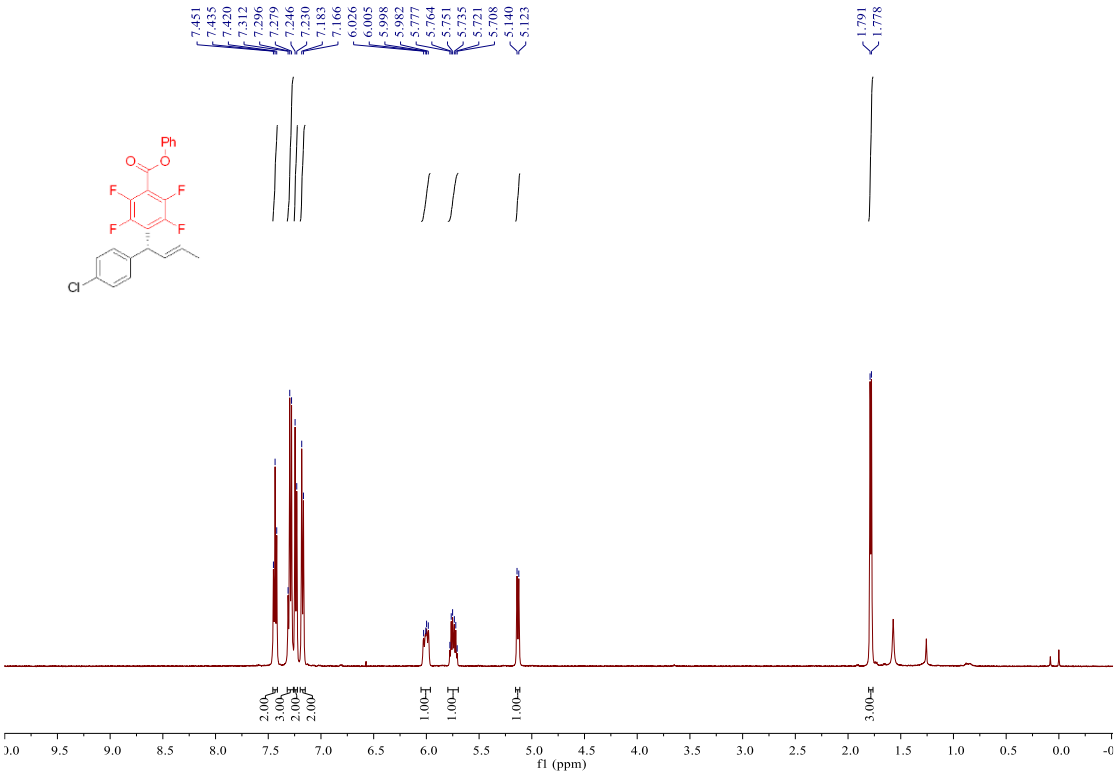
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5i



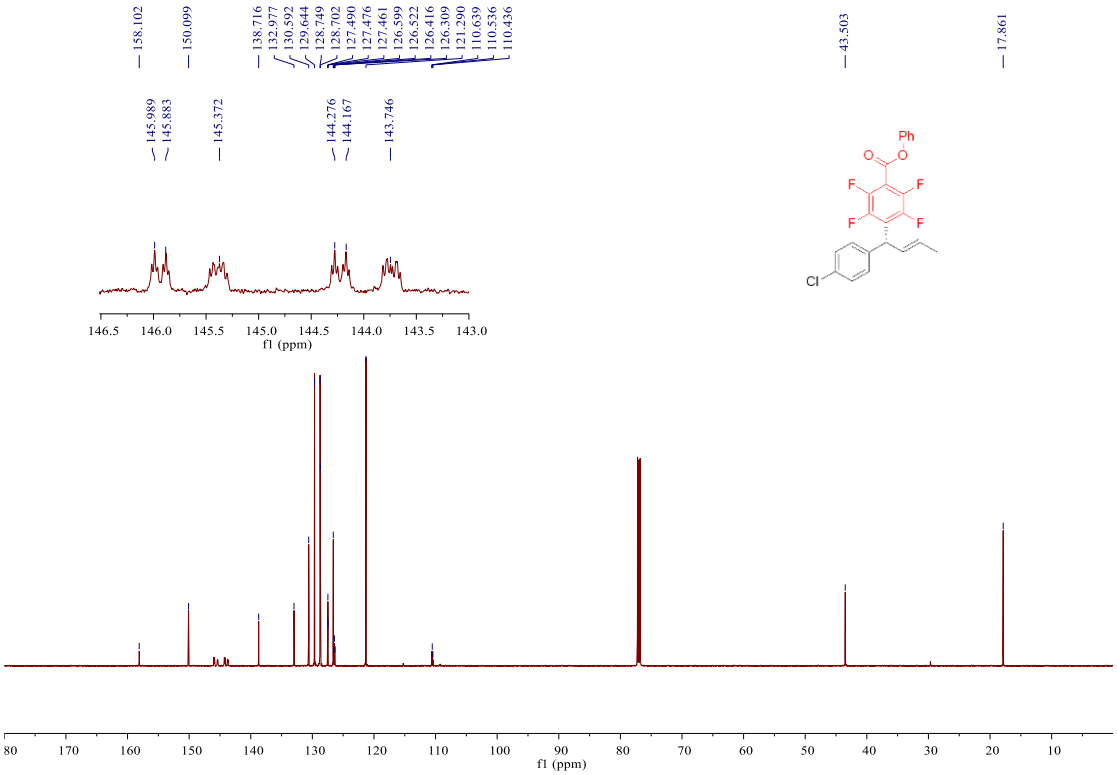
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5i



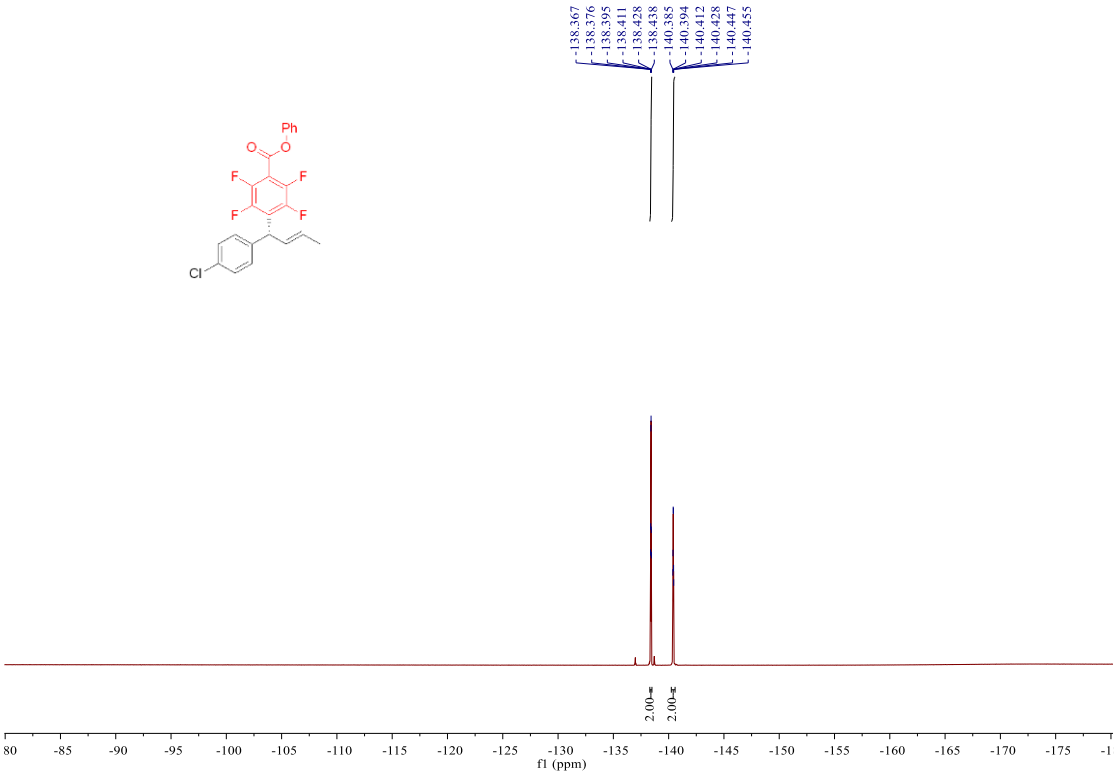
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5j



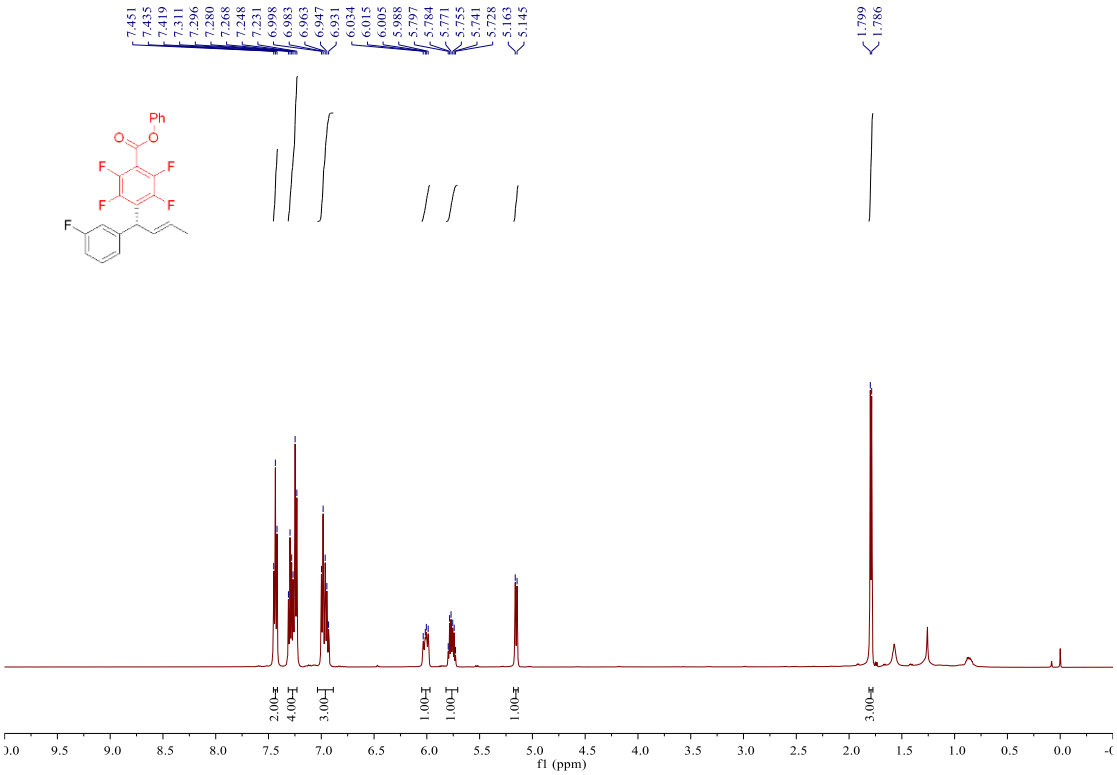
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5j



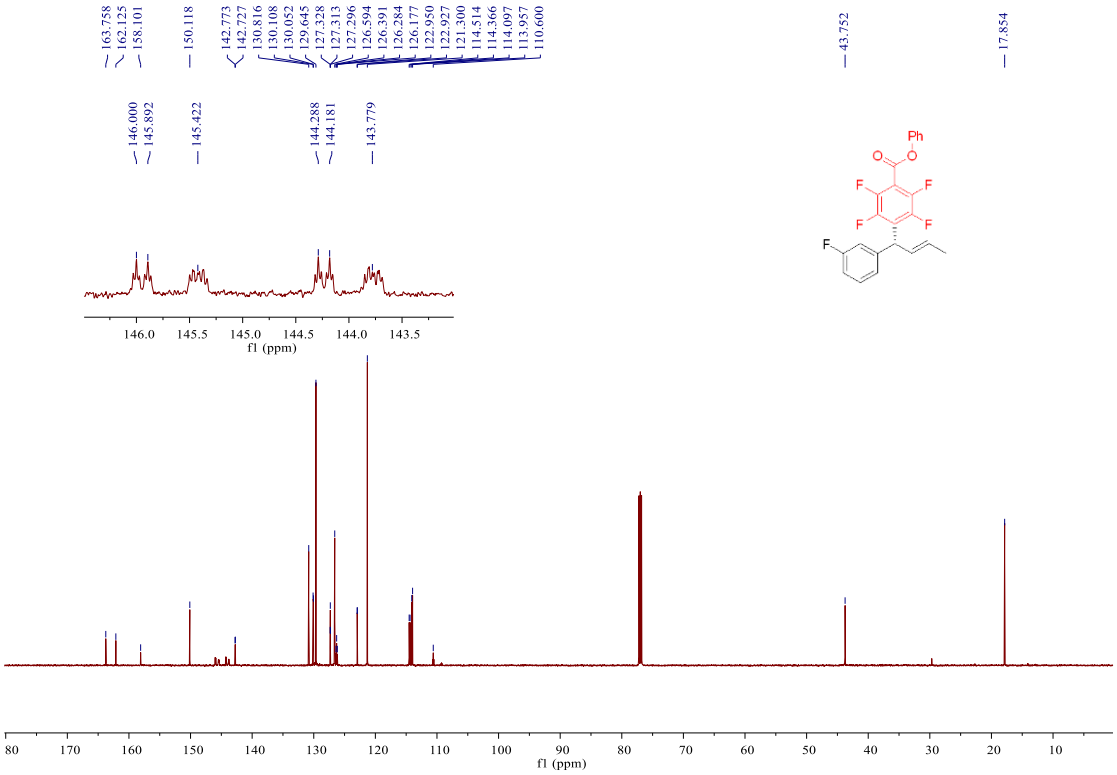
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5j



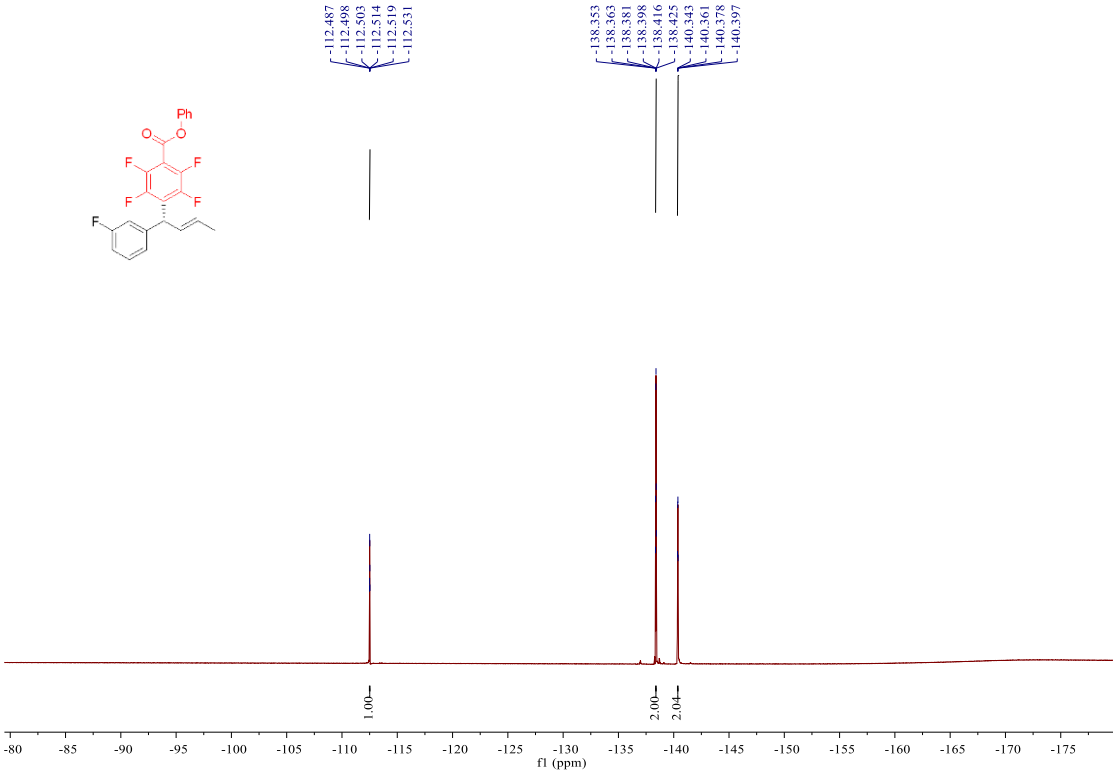
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 5k



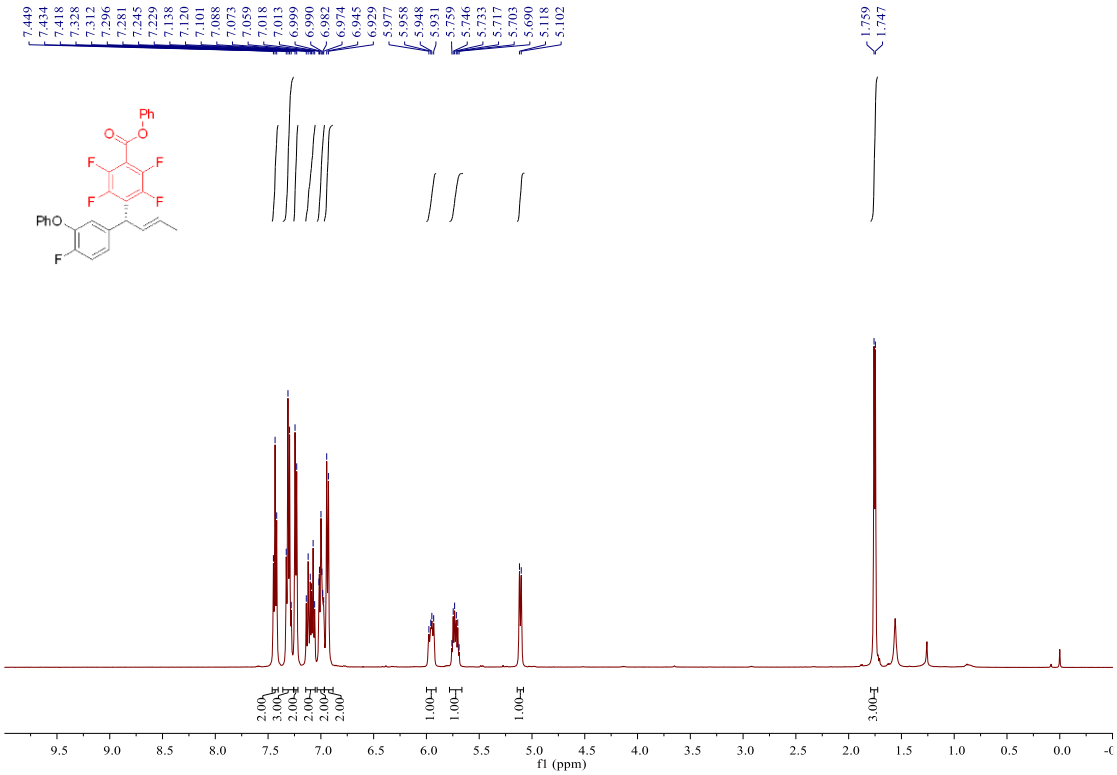
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5k



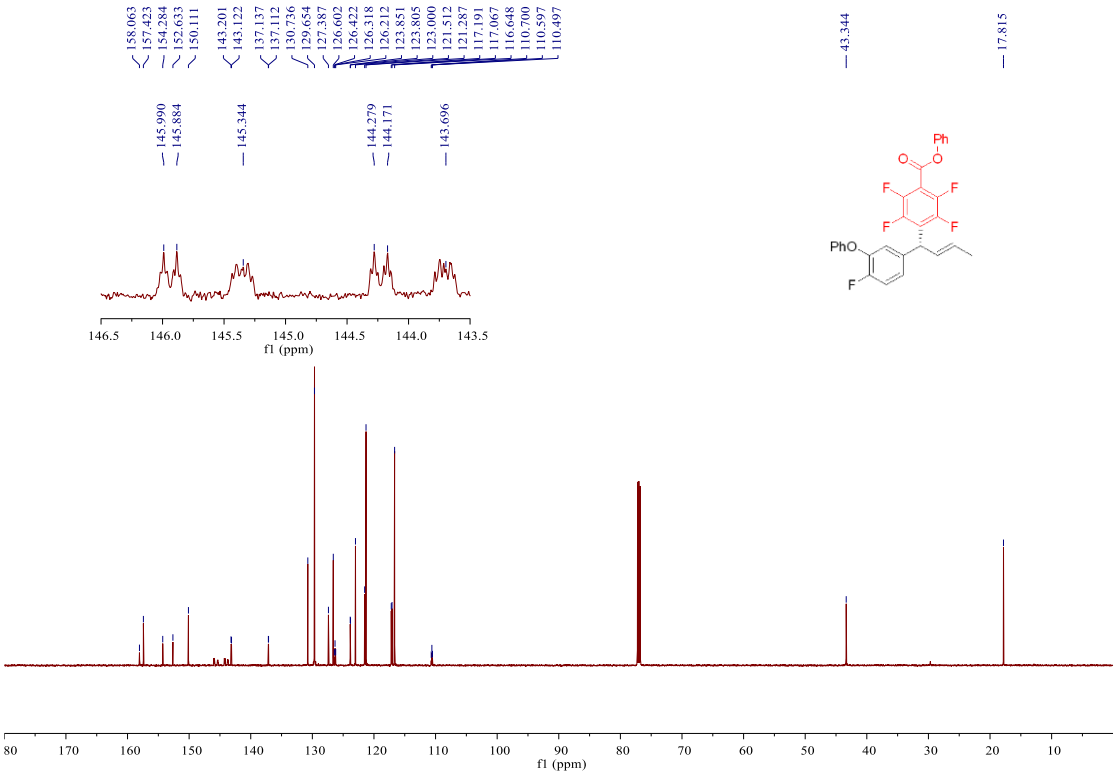
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5k



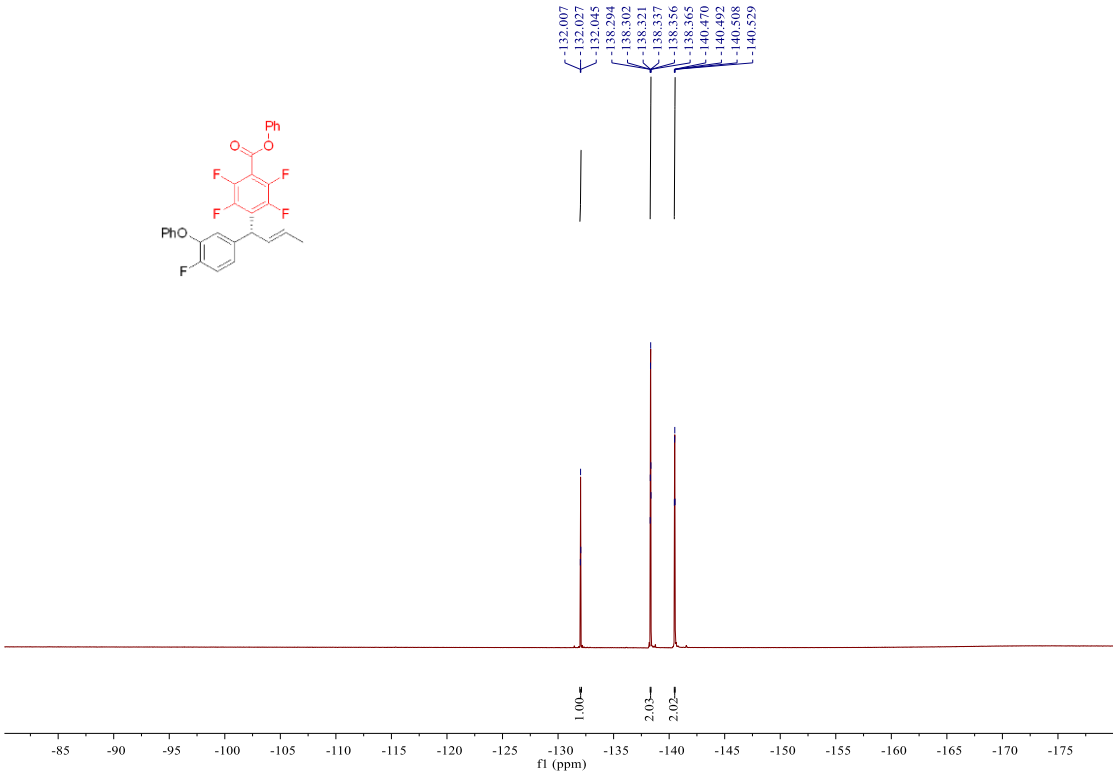
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5l



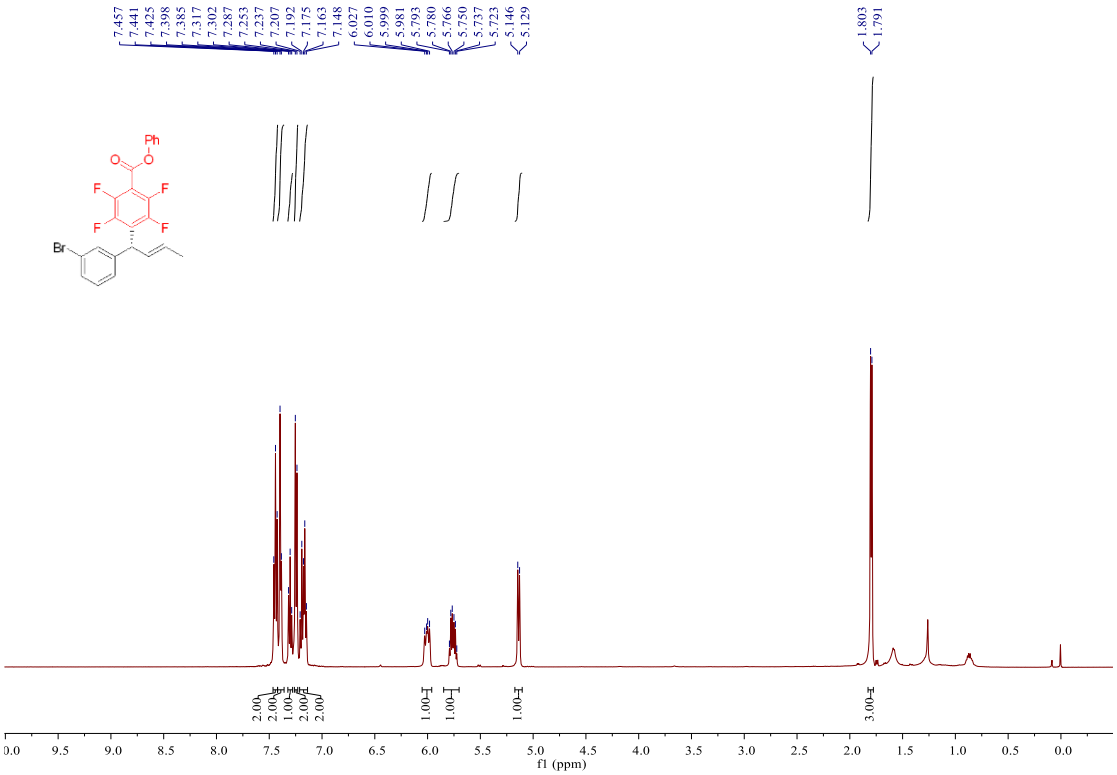
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5l



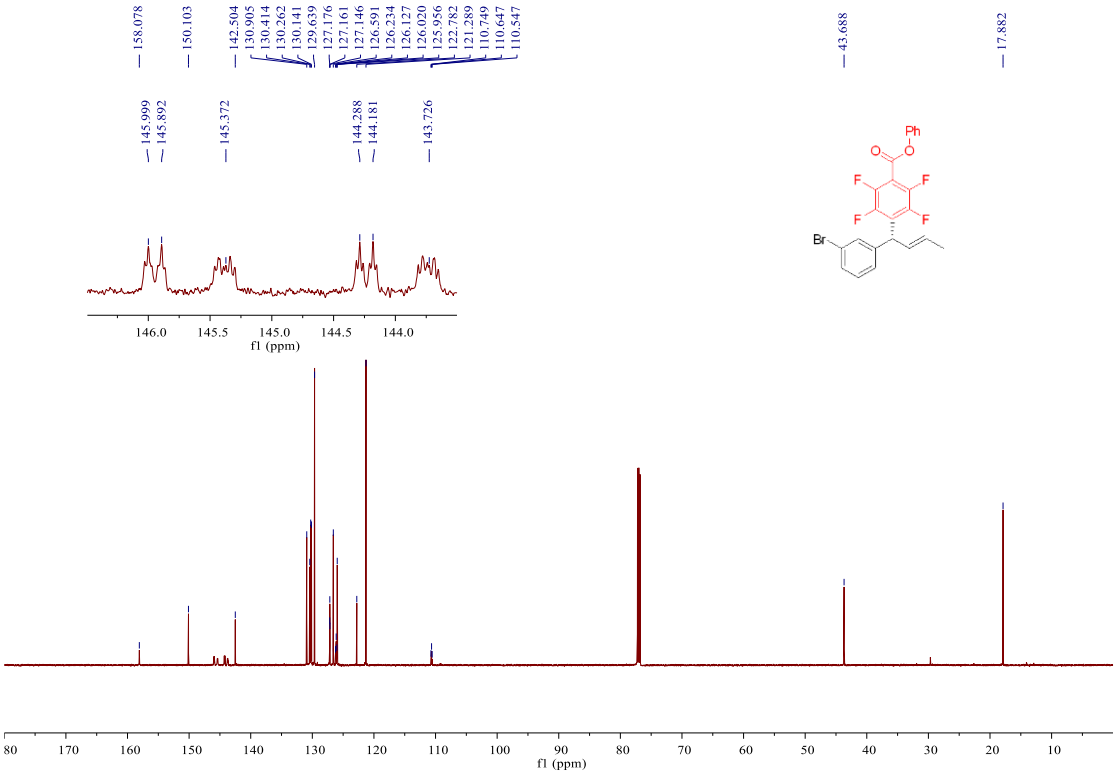
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5l



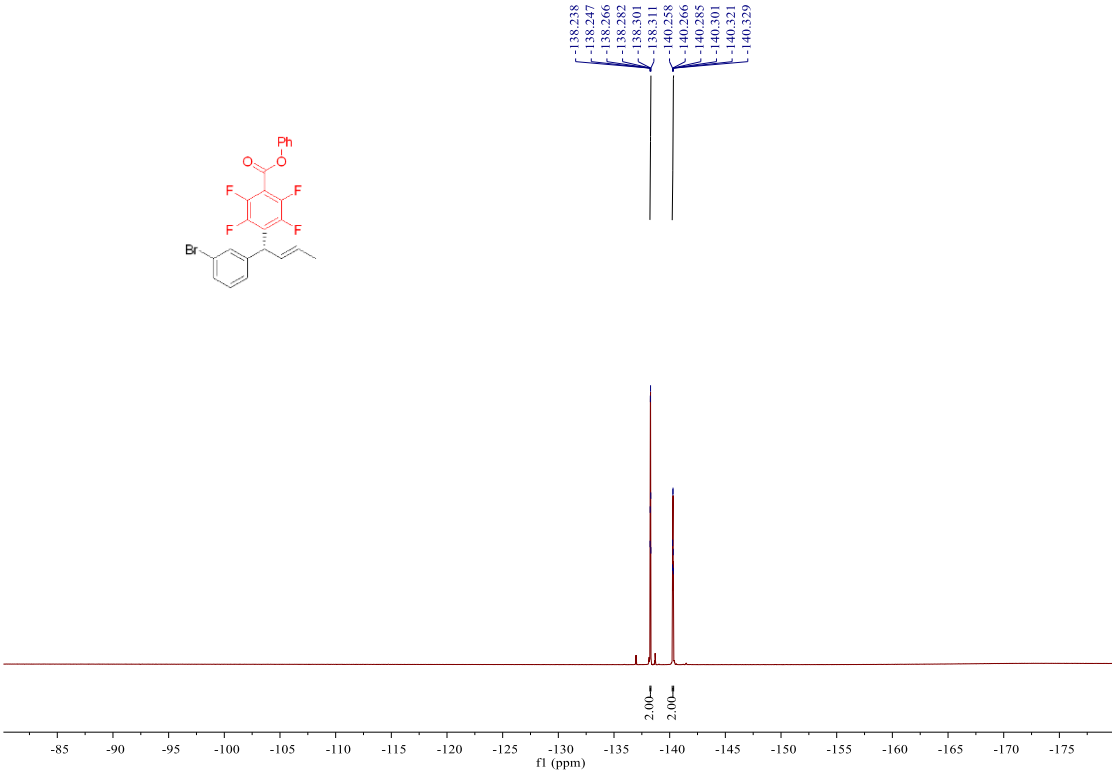
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5m



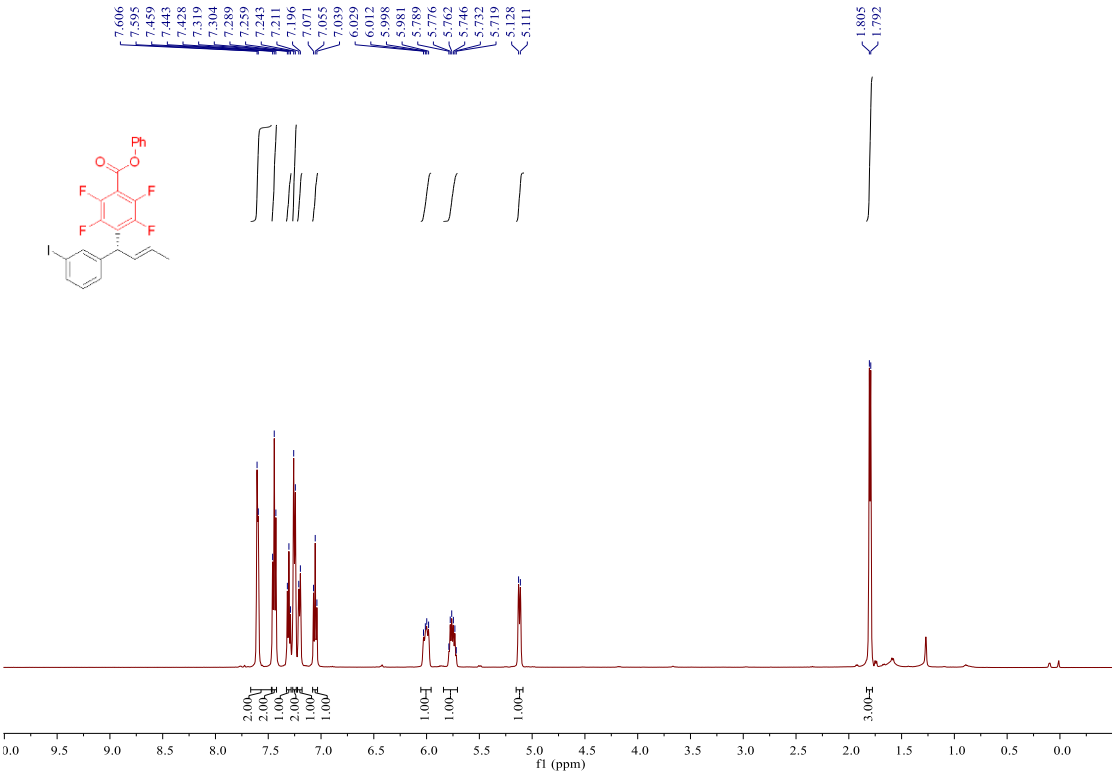
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5m



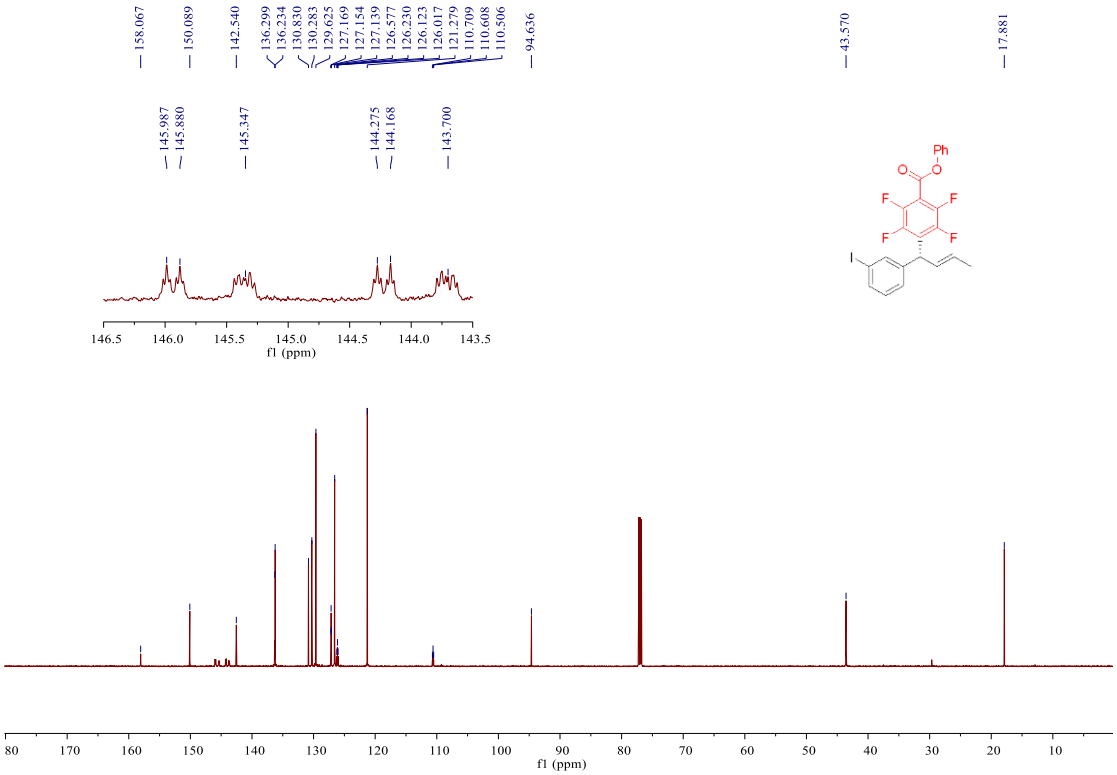
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5m



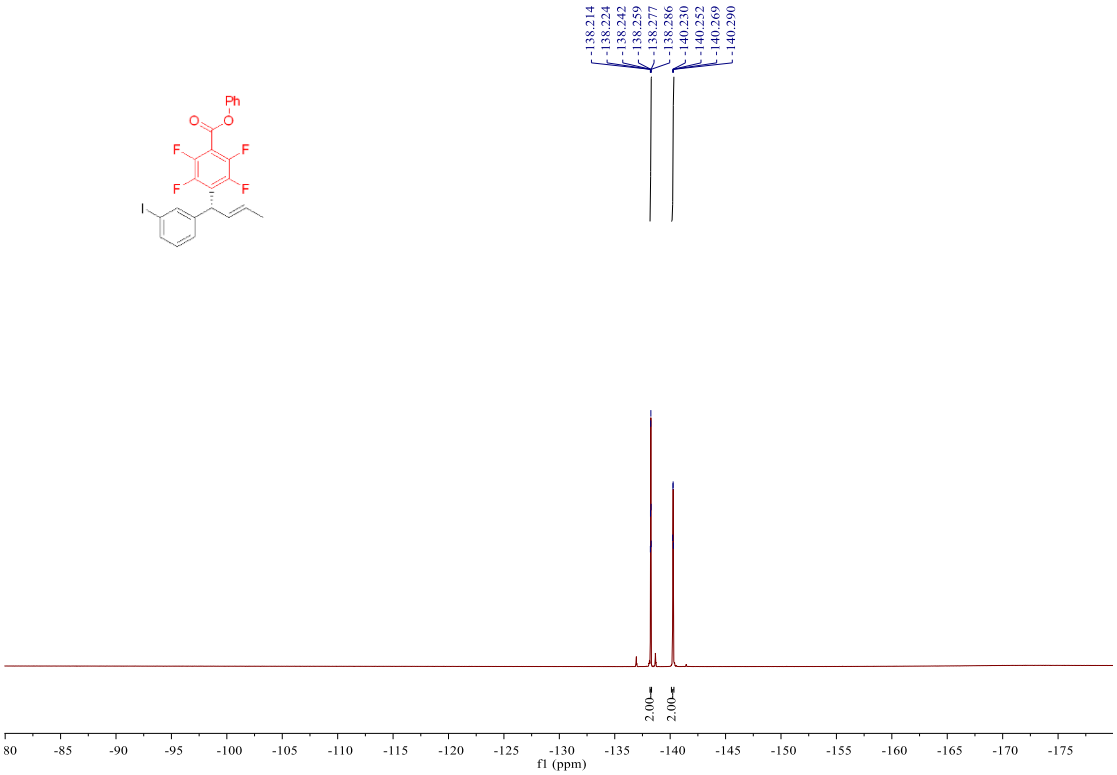
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5n



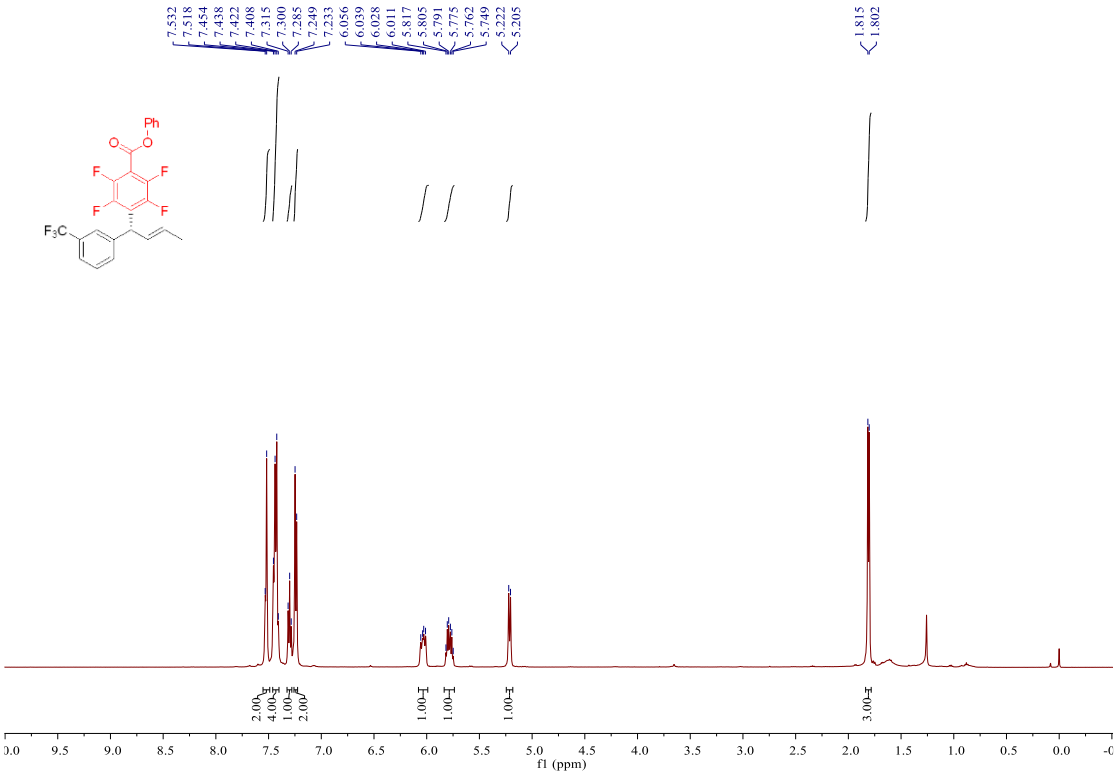
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5n



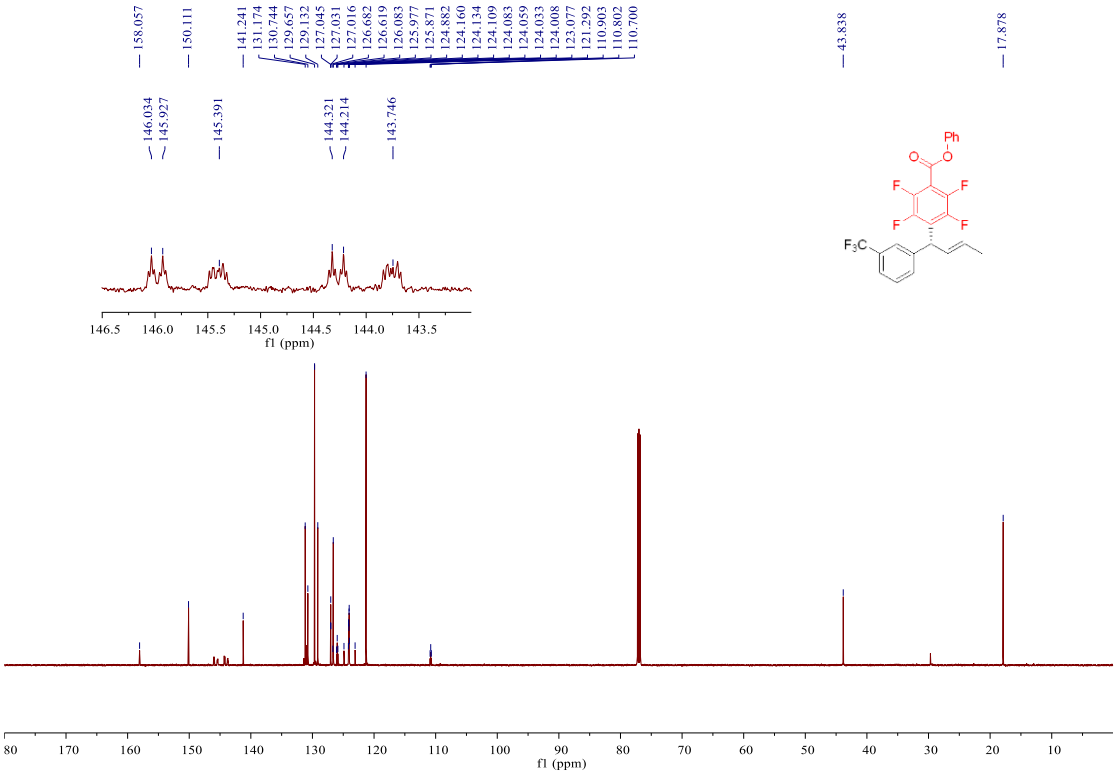
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5n



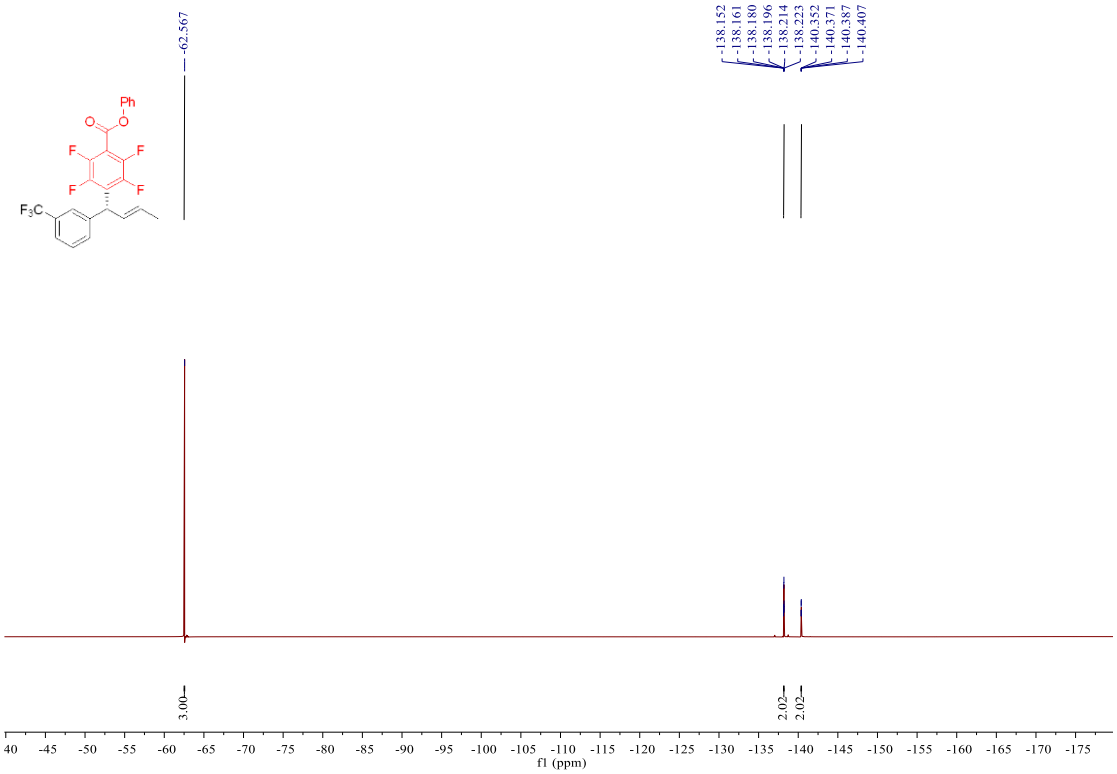
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 5o



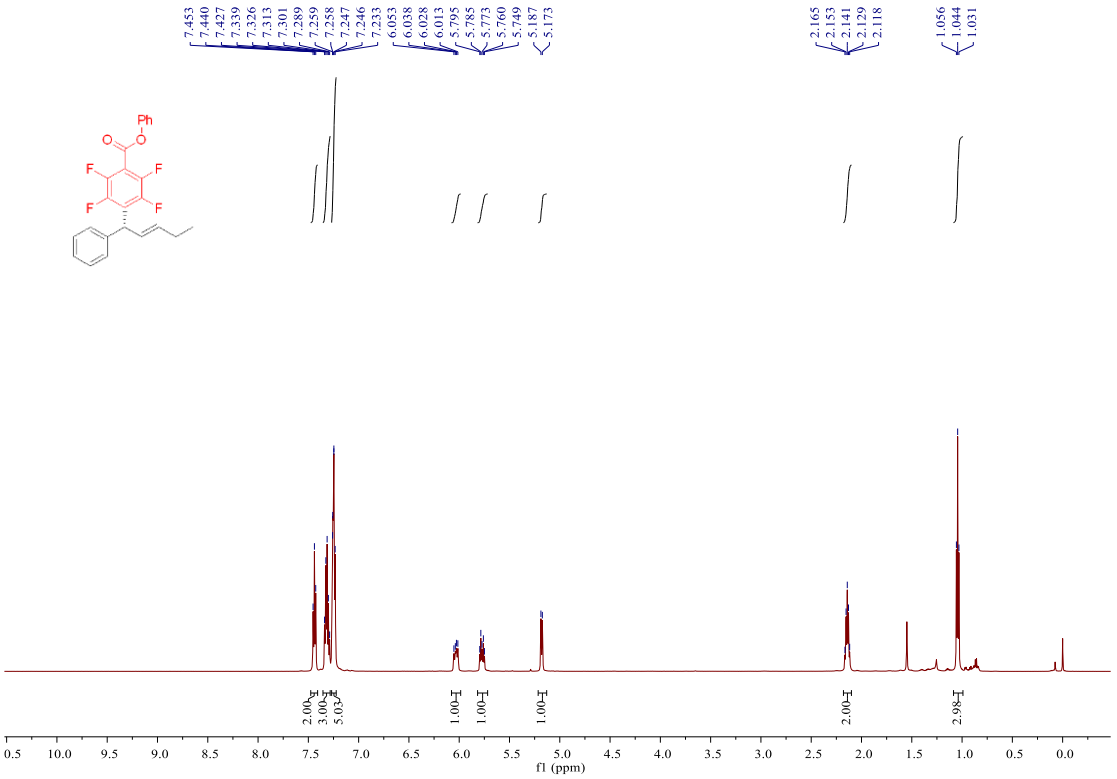
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5o



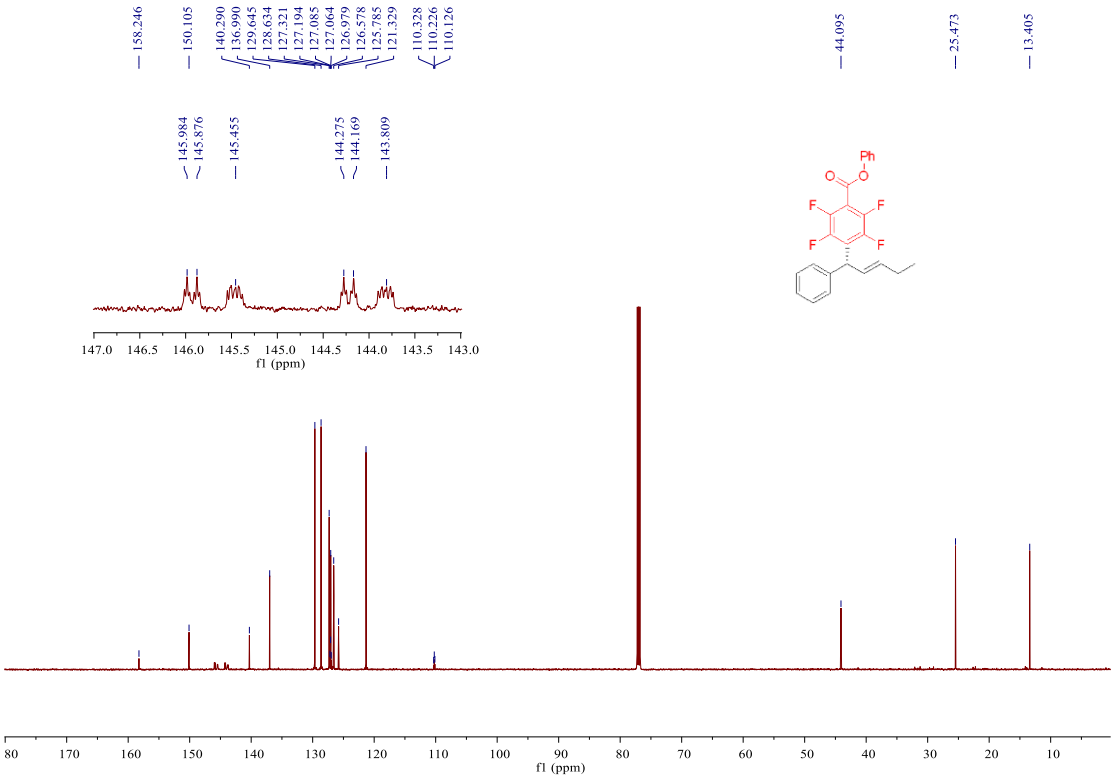
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5o



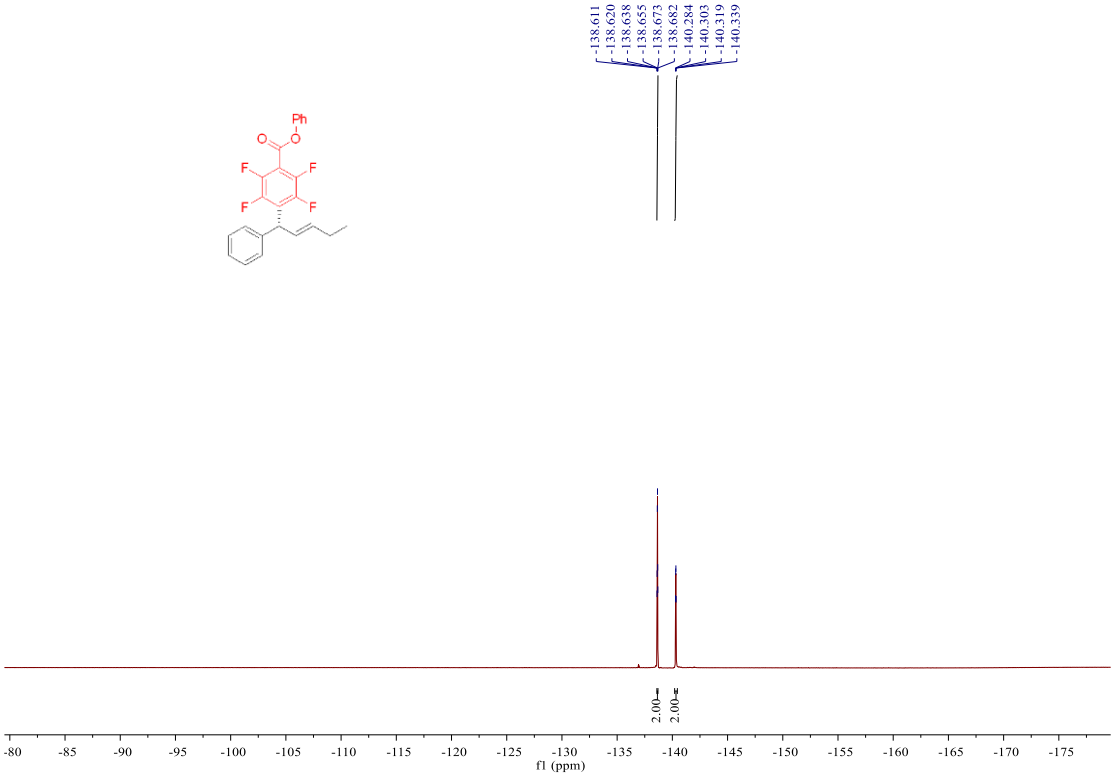
^{1}H NMR (600 MHz, Chloroform-*d)* spectrum of 5p



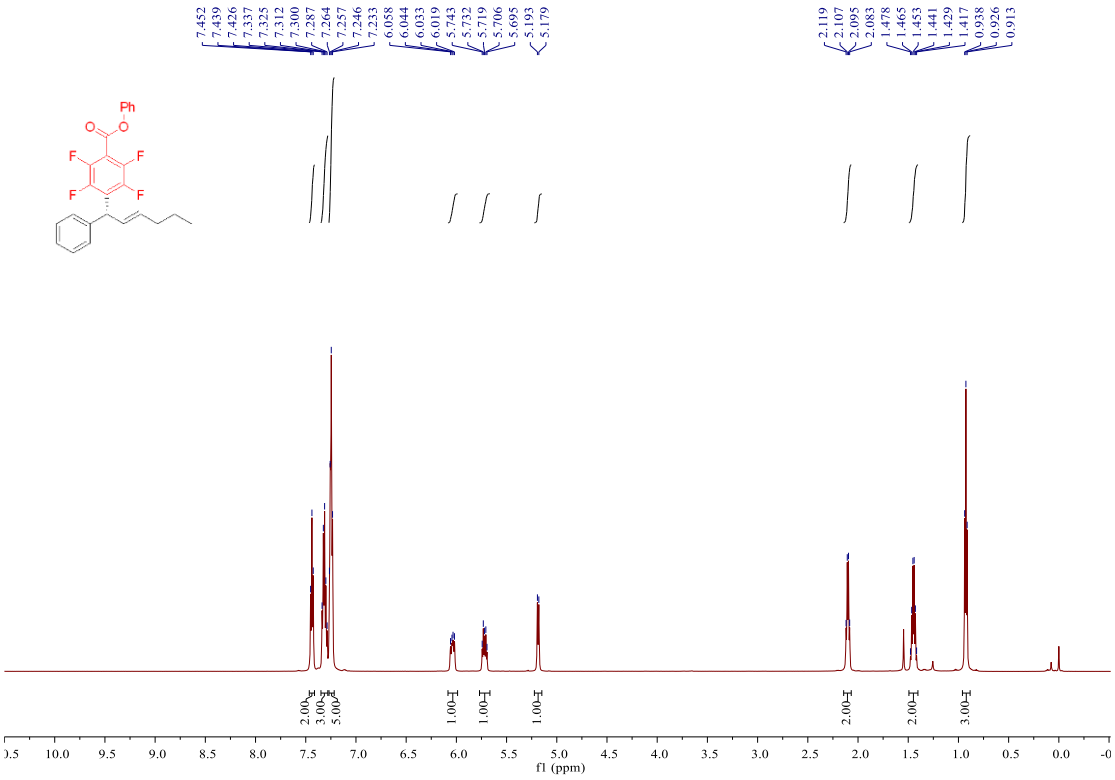
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5p



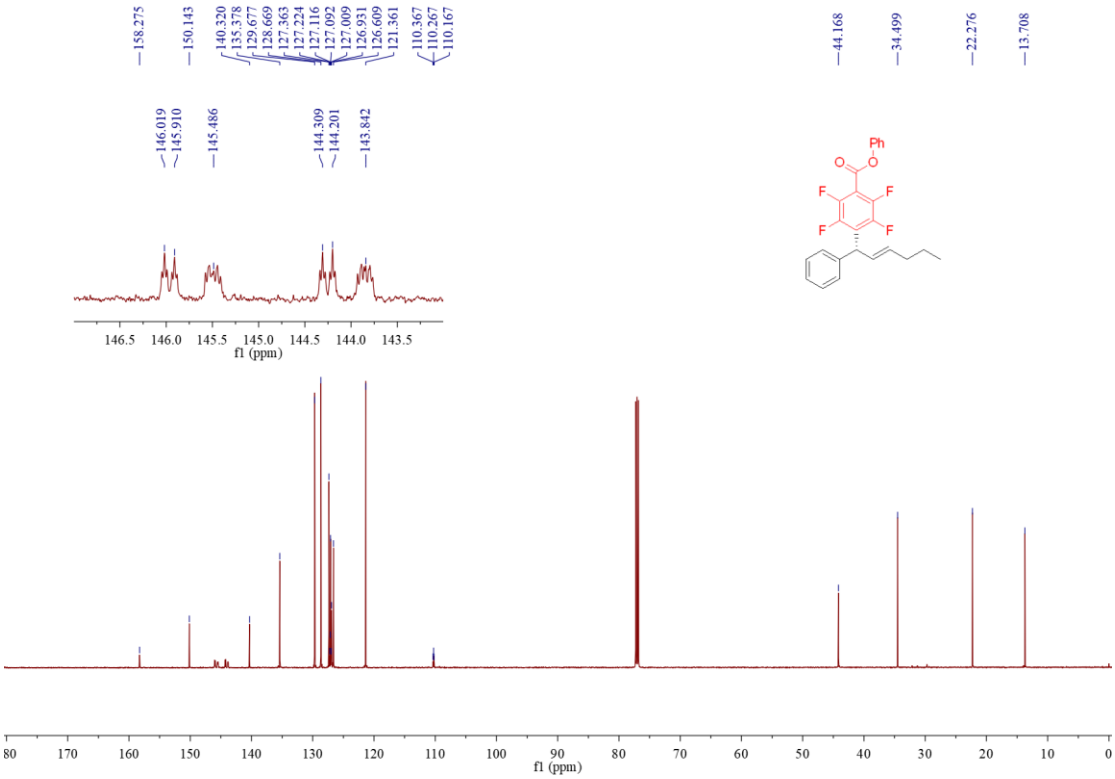
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5p



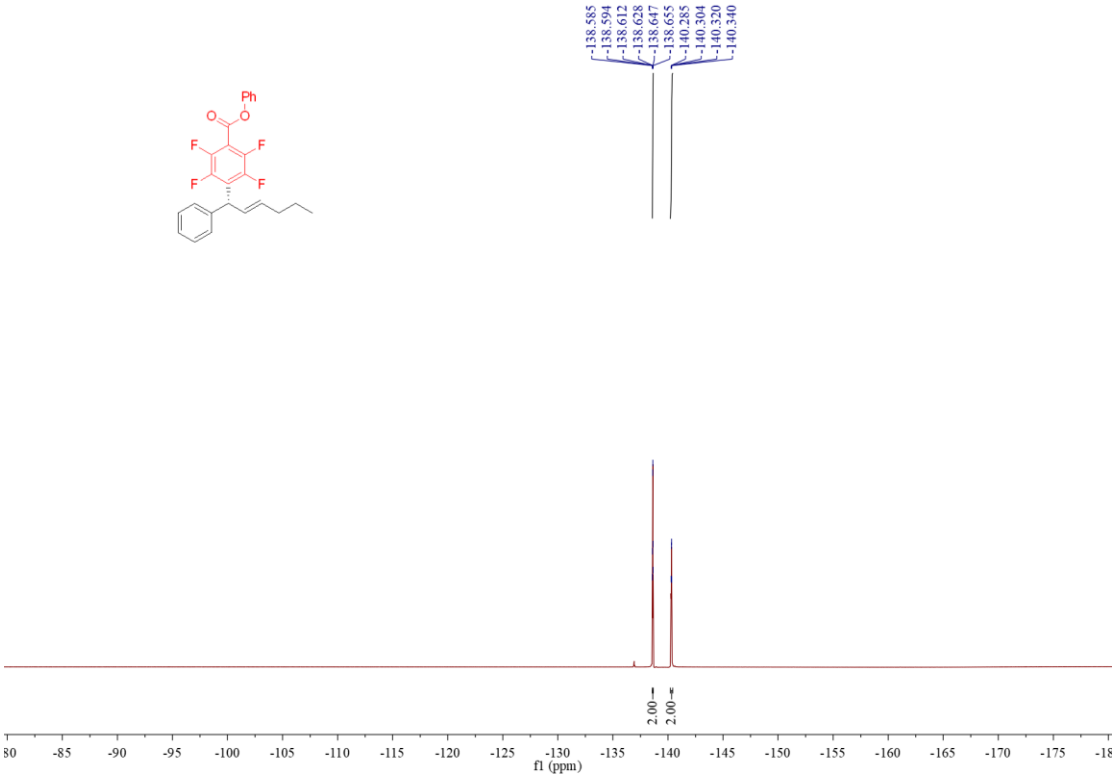
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 5q



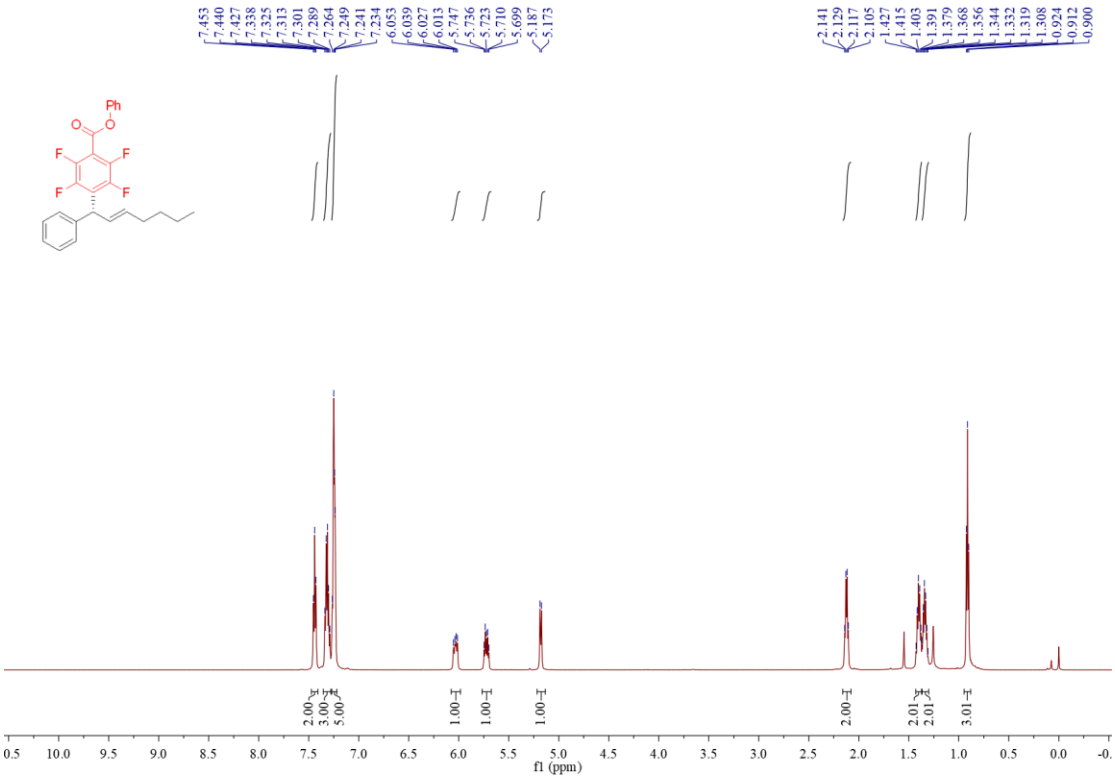
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5q



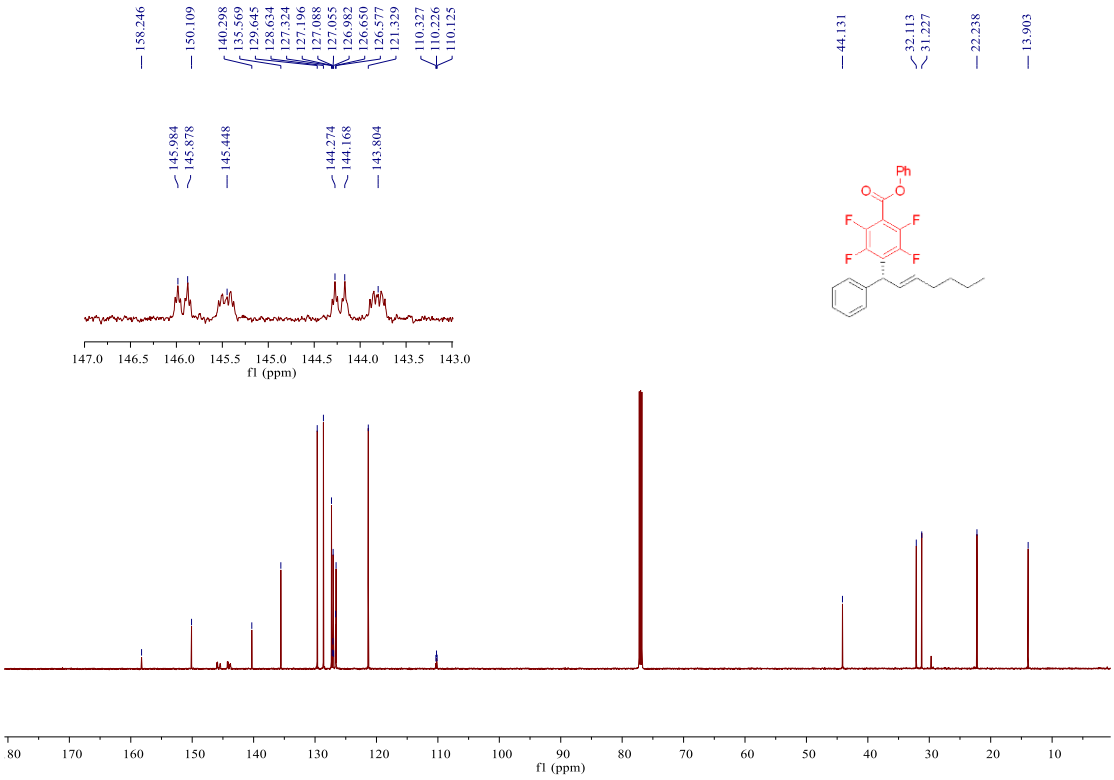
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 5q



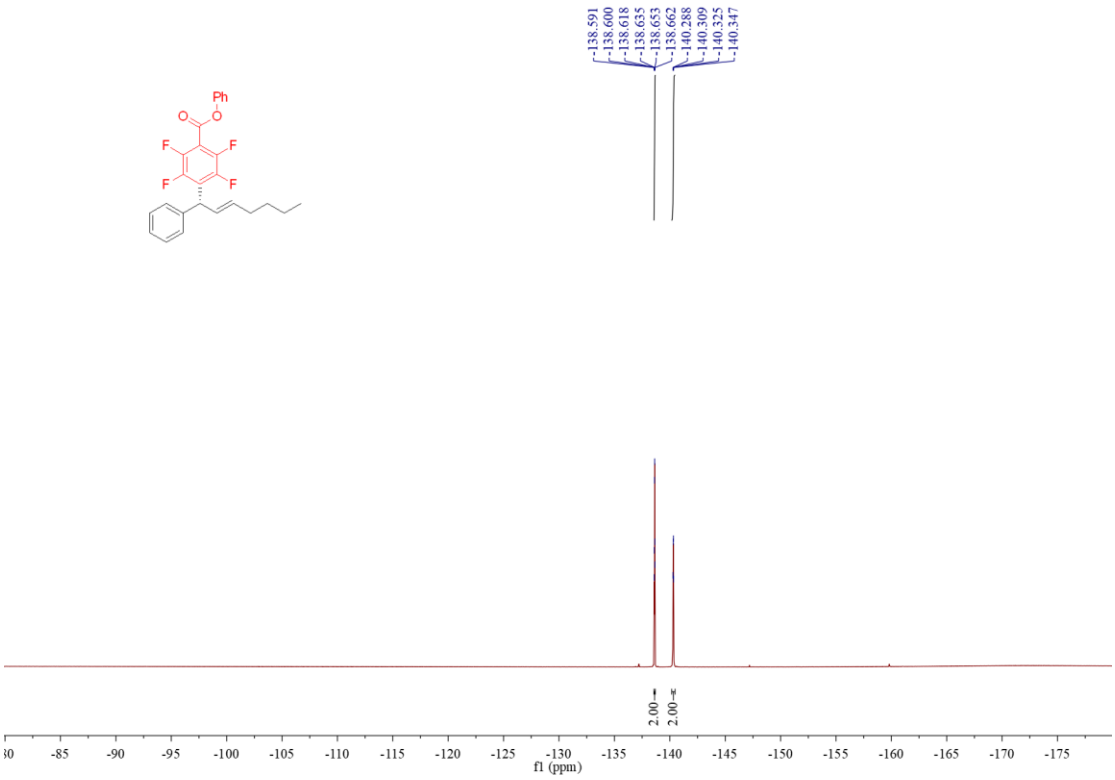
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 5r



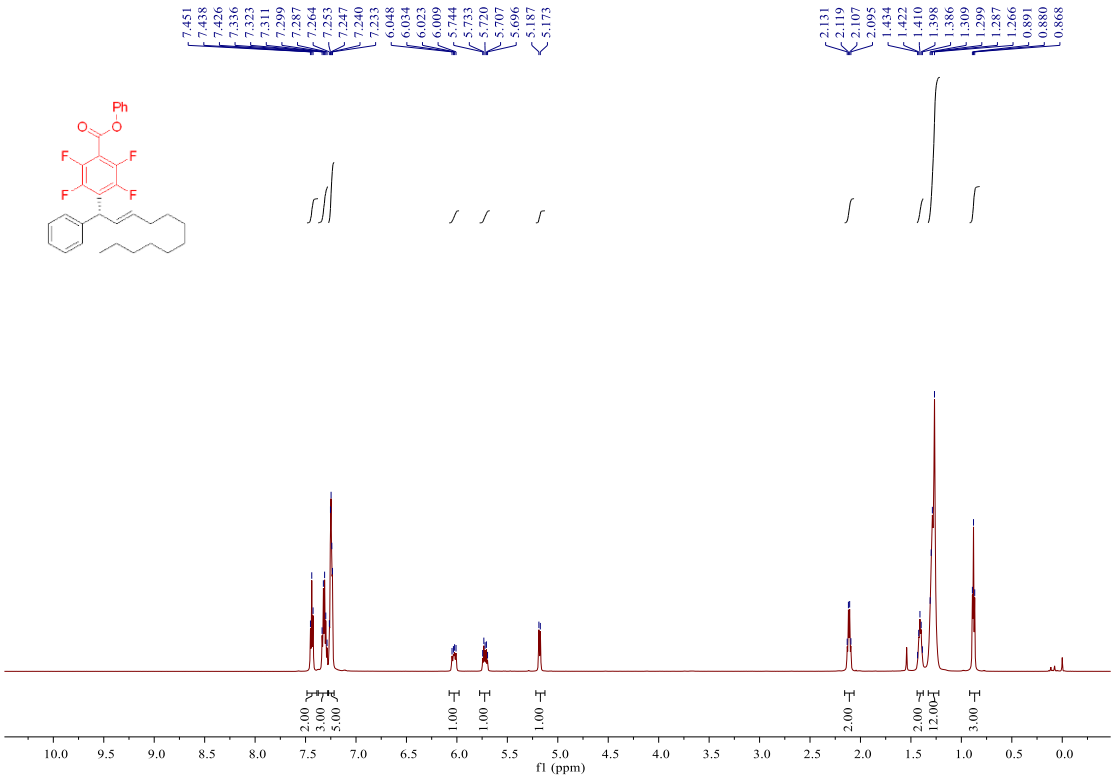
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5r



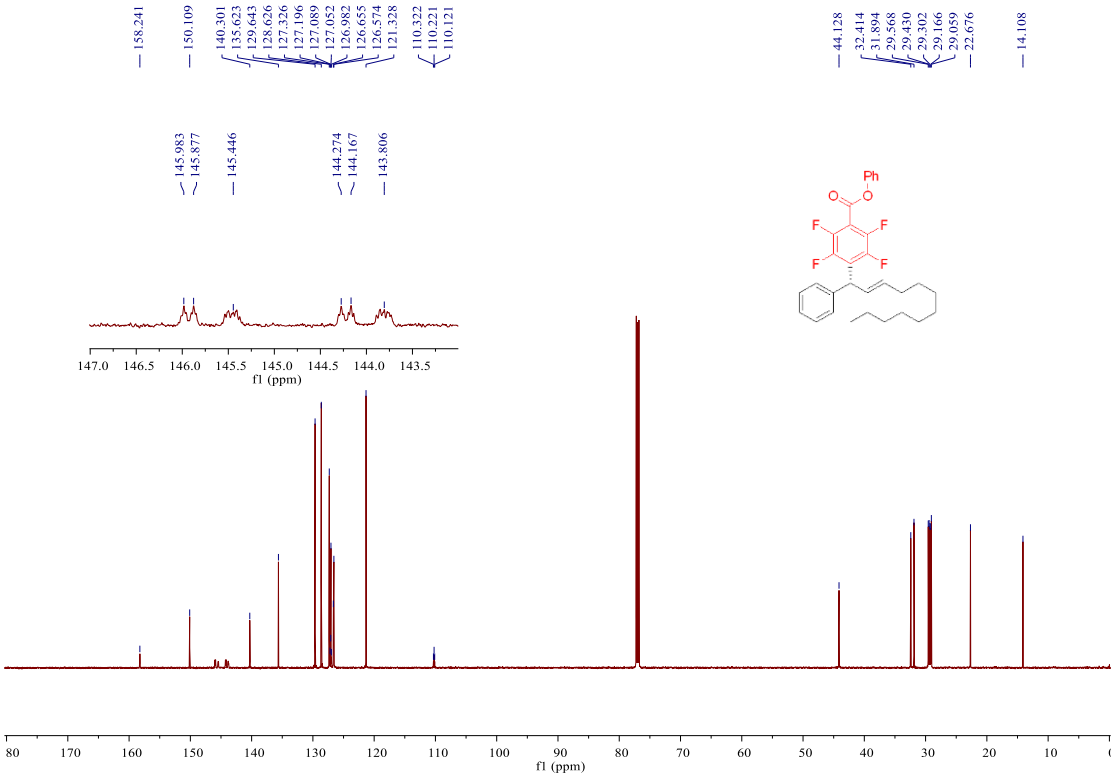
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5r



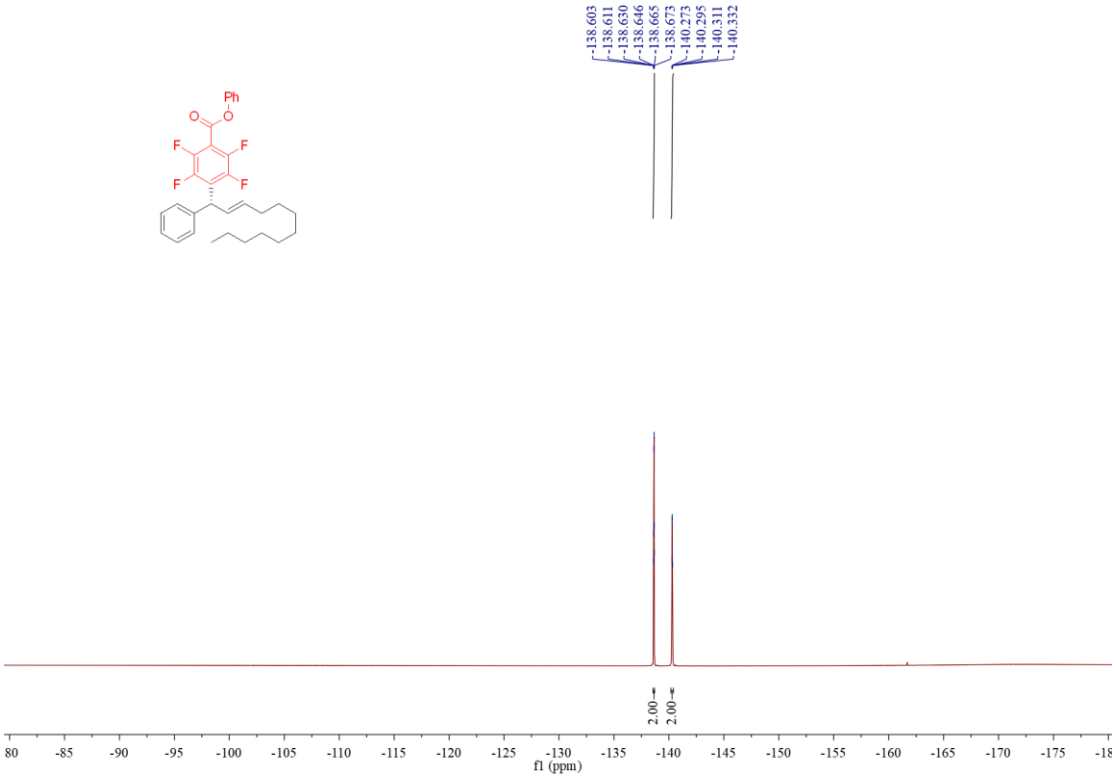
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 5s



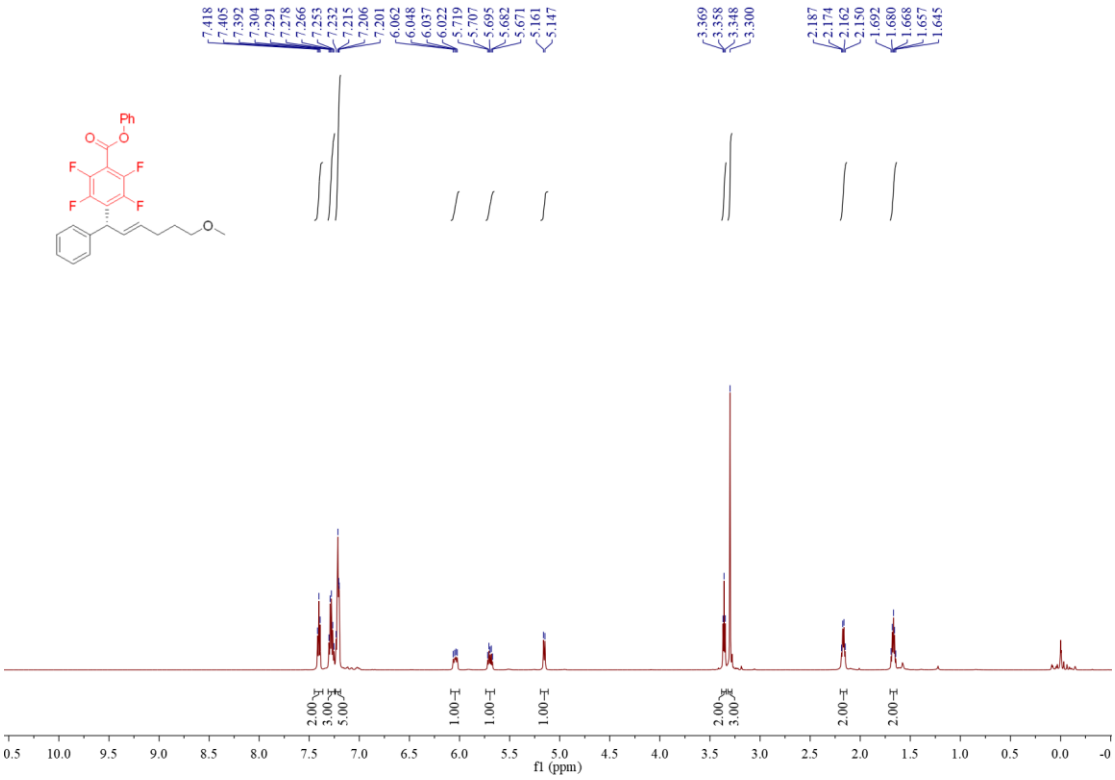
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5s



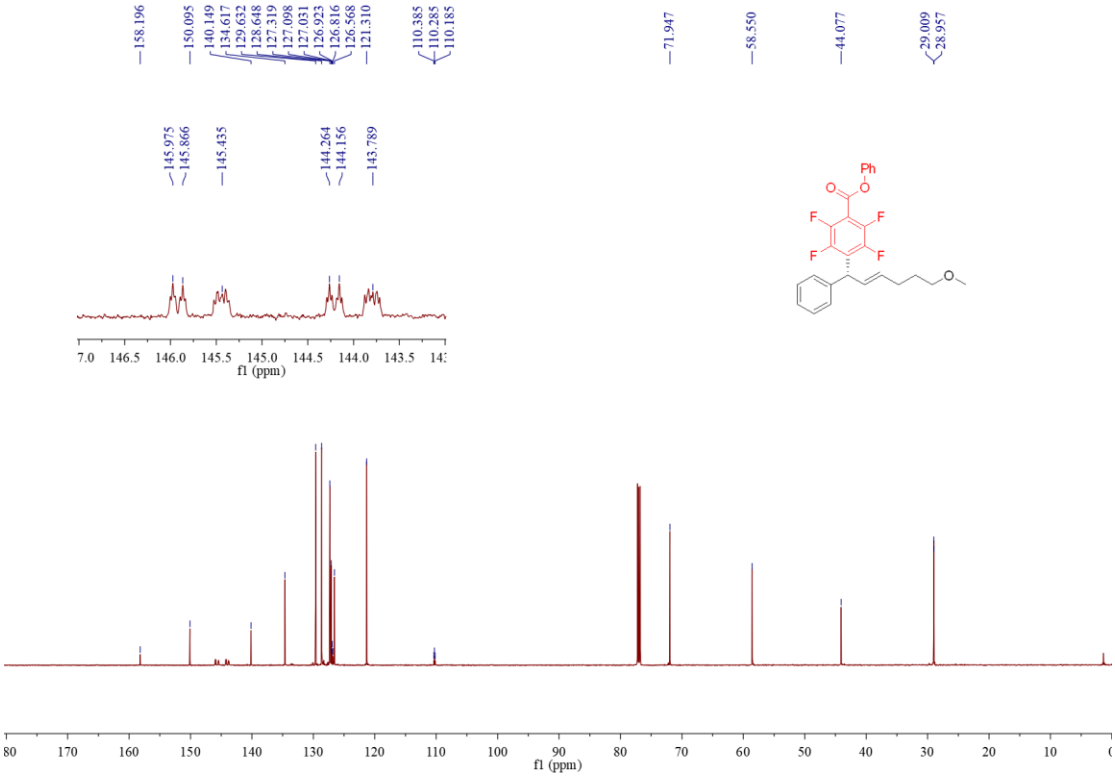
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 5s



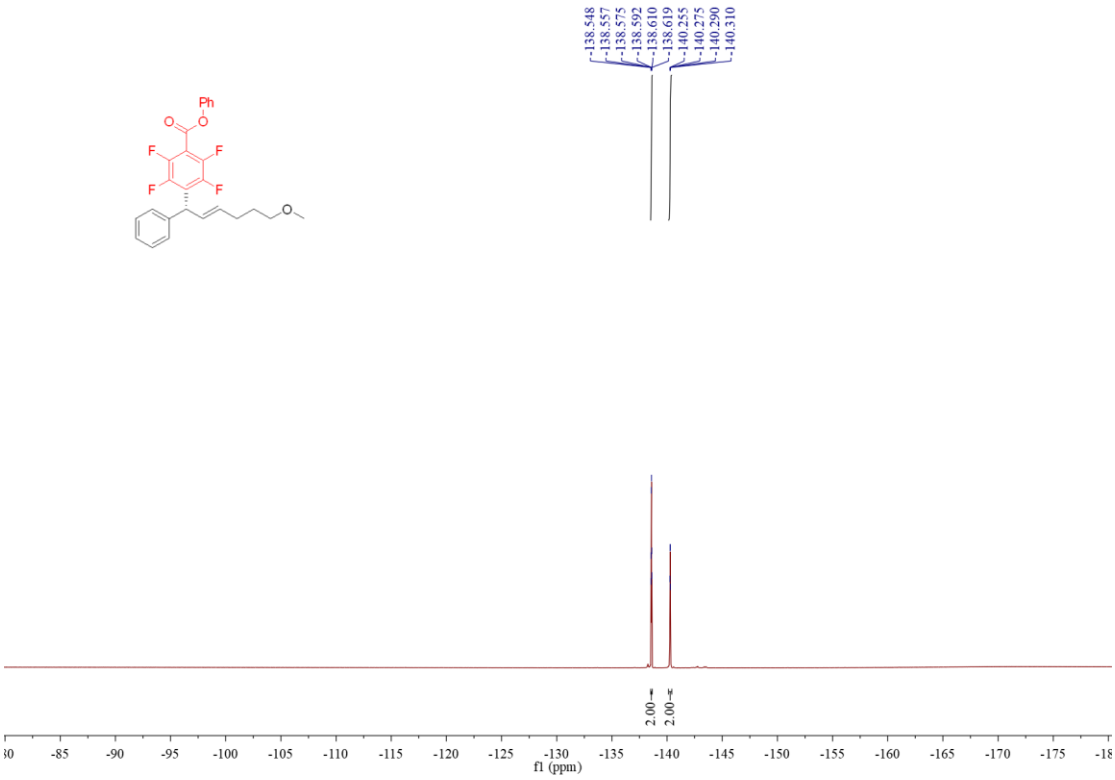
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 5t



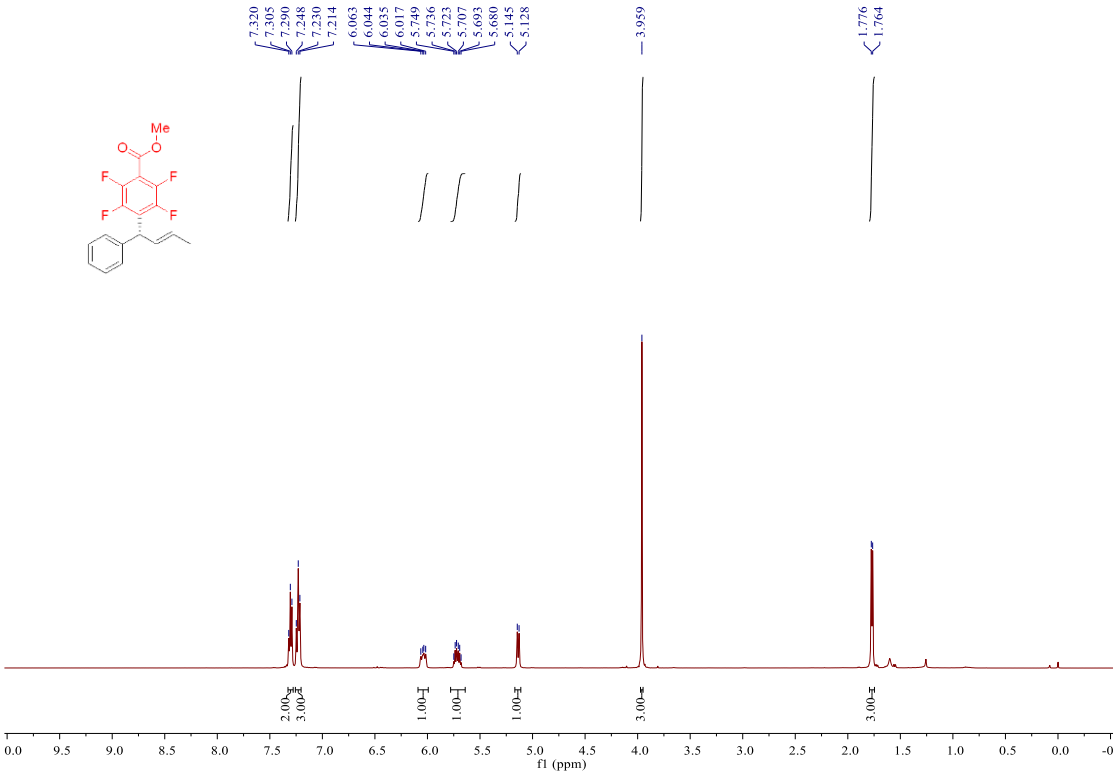
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5t



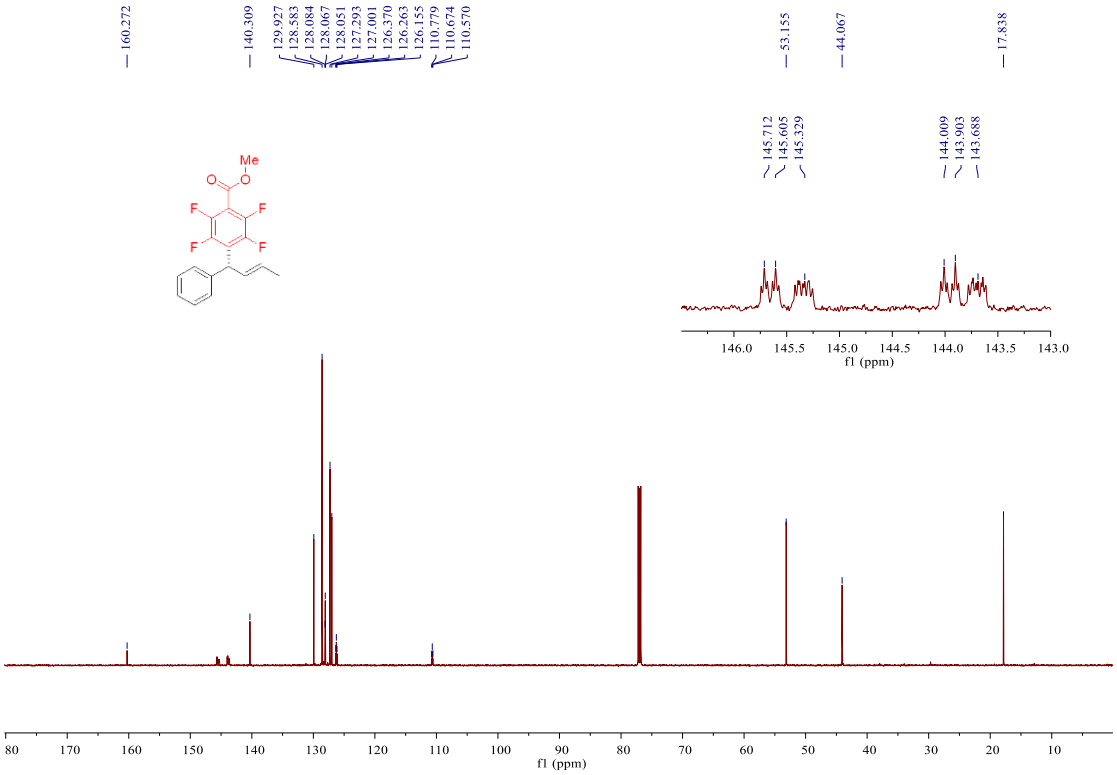
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 5t



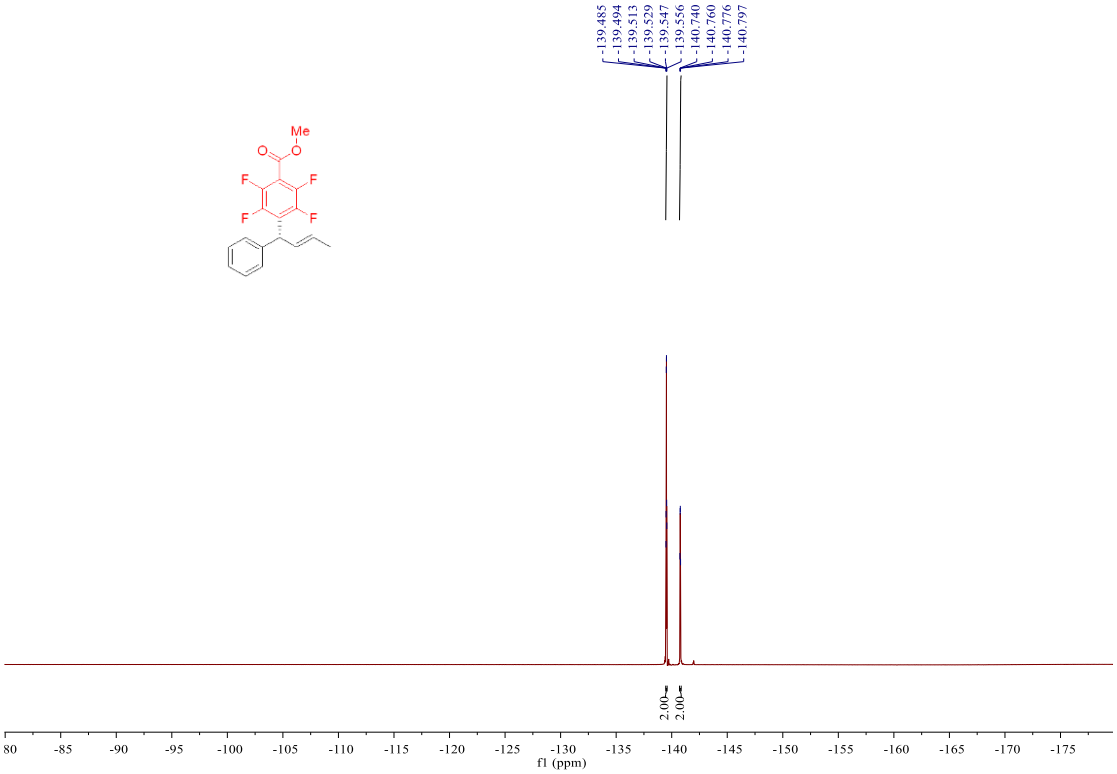
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5u



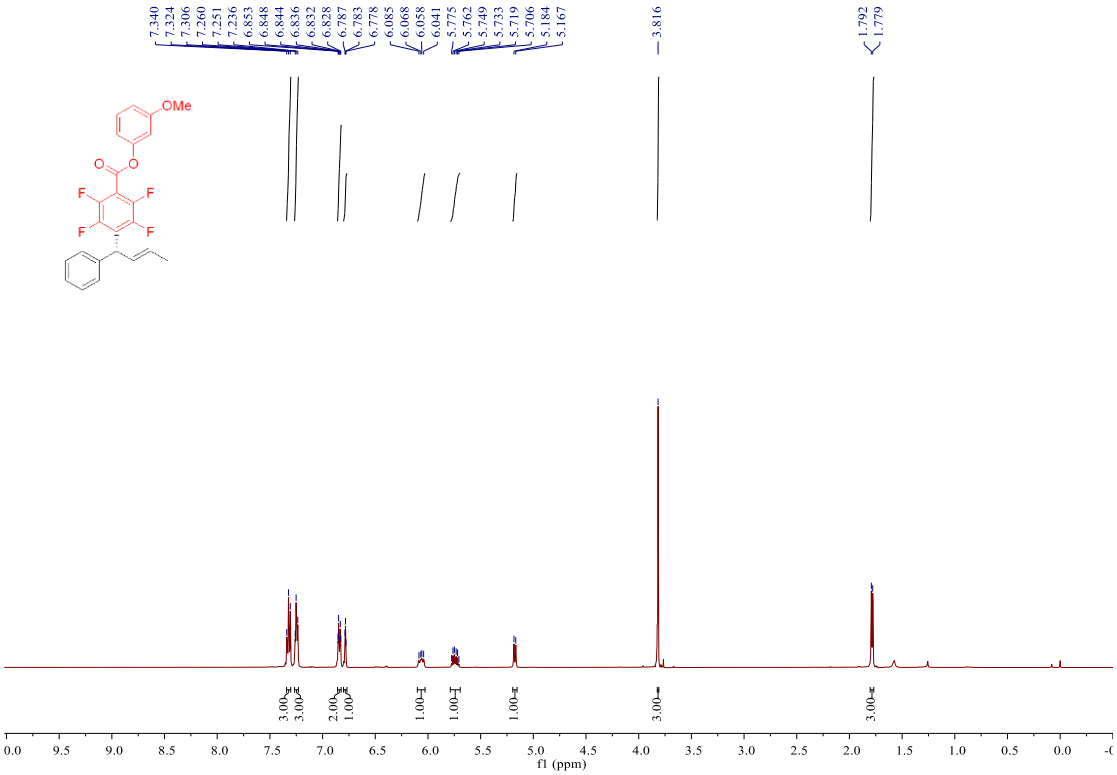
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5u



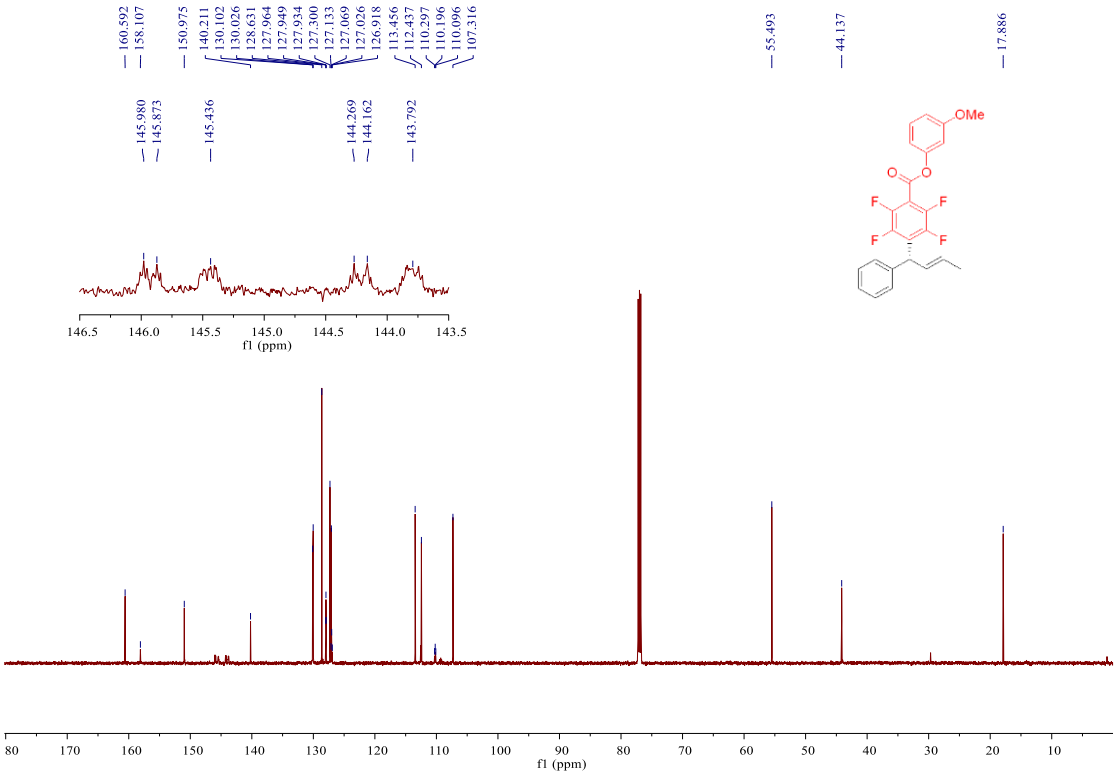
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5u



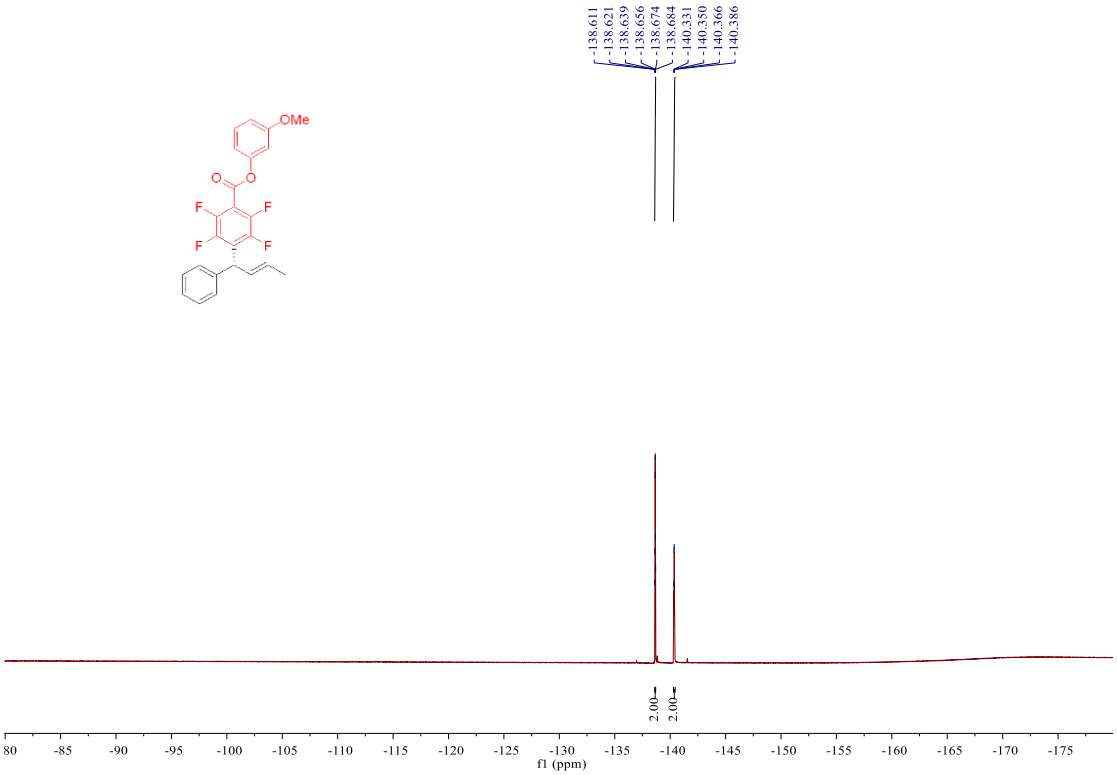
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5v



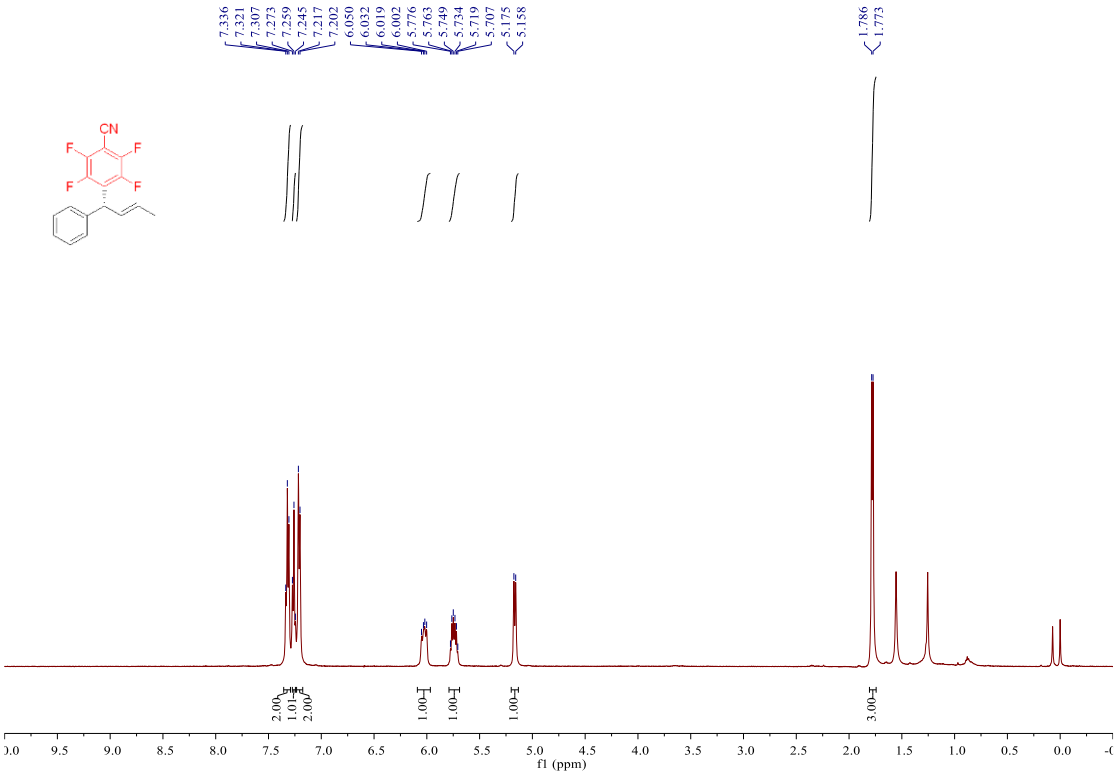
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5v



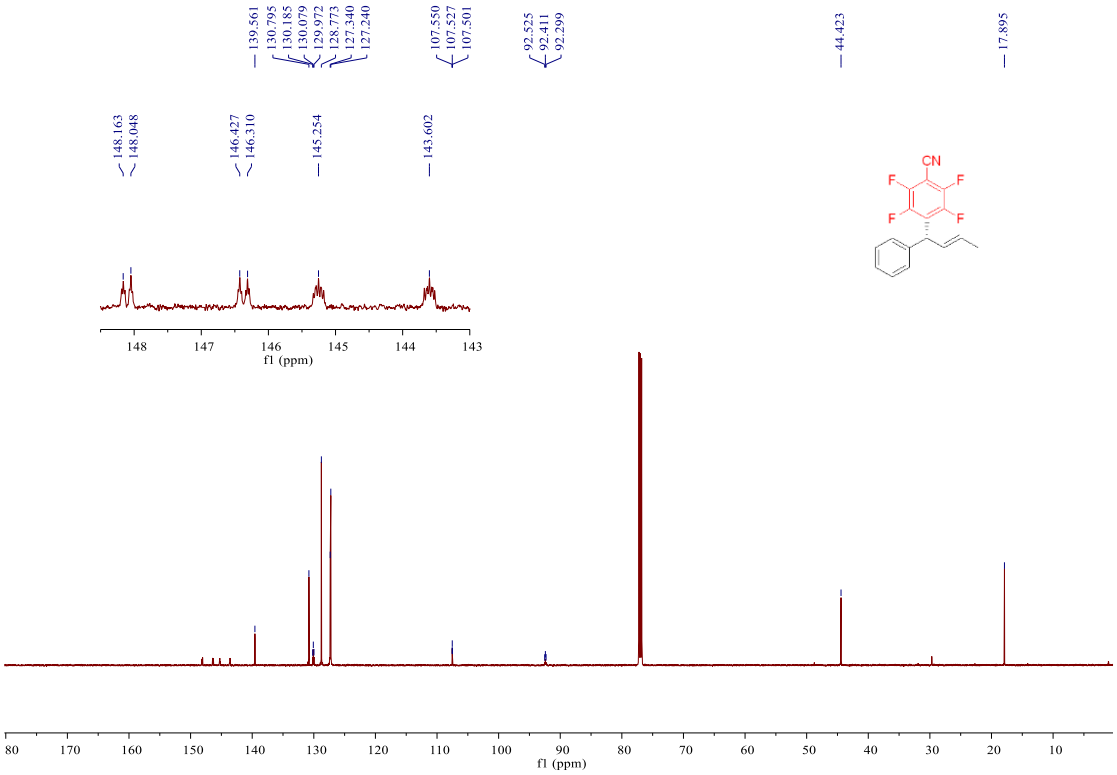
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5v



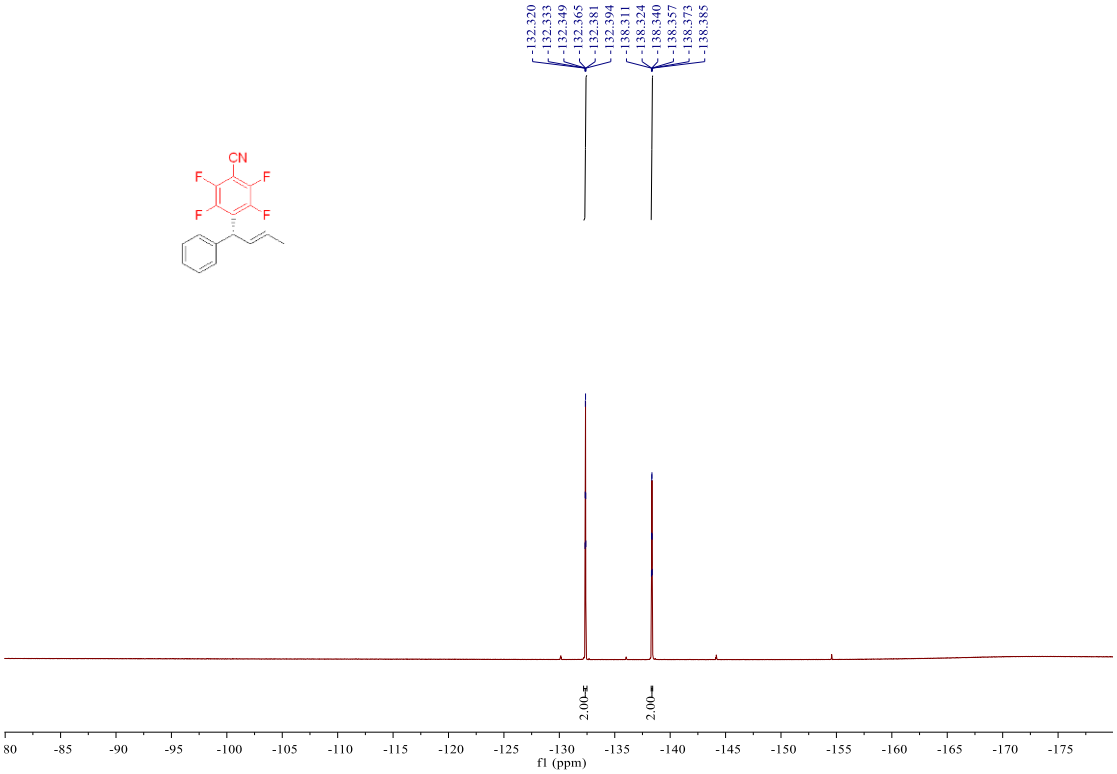
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 5w



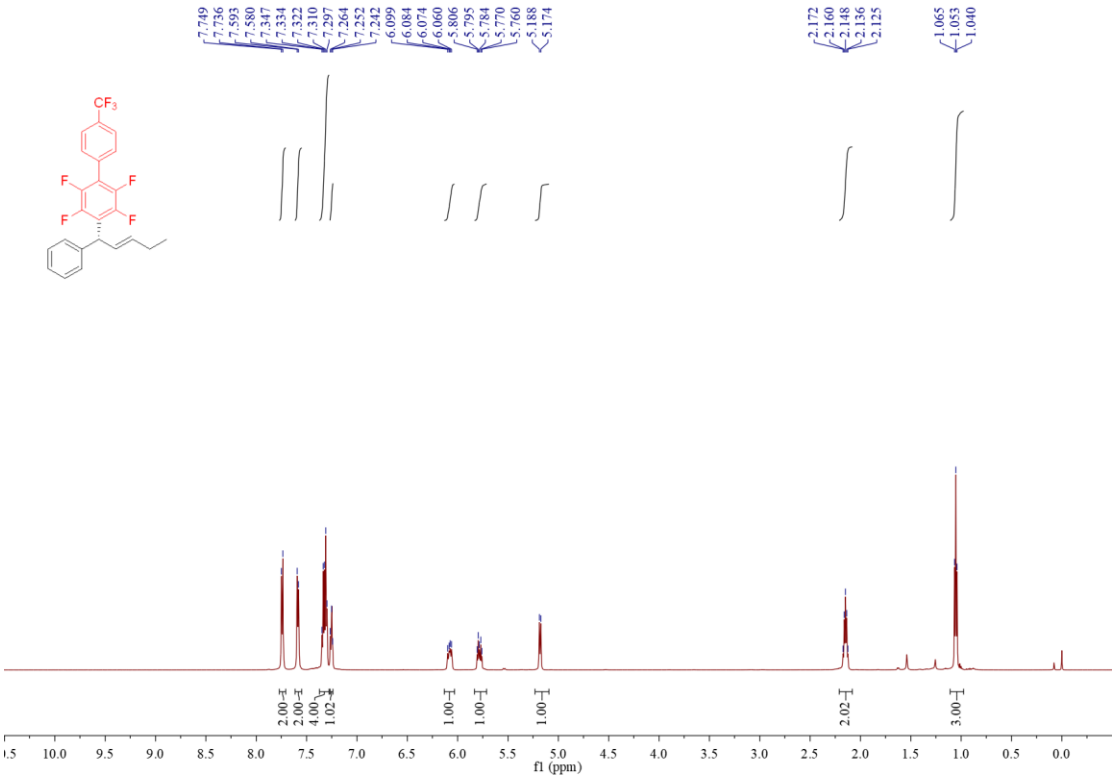
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5w



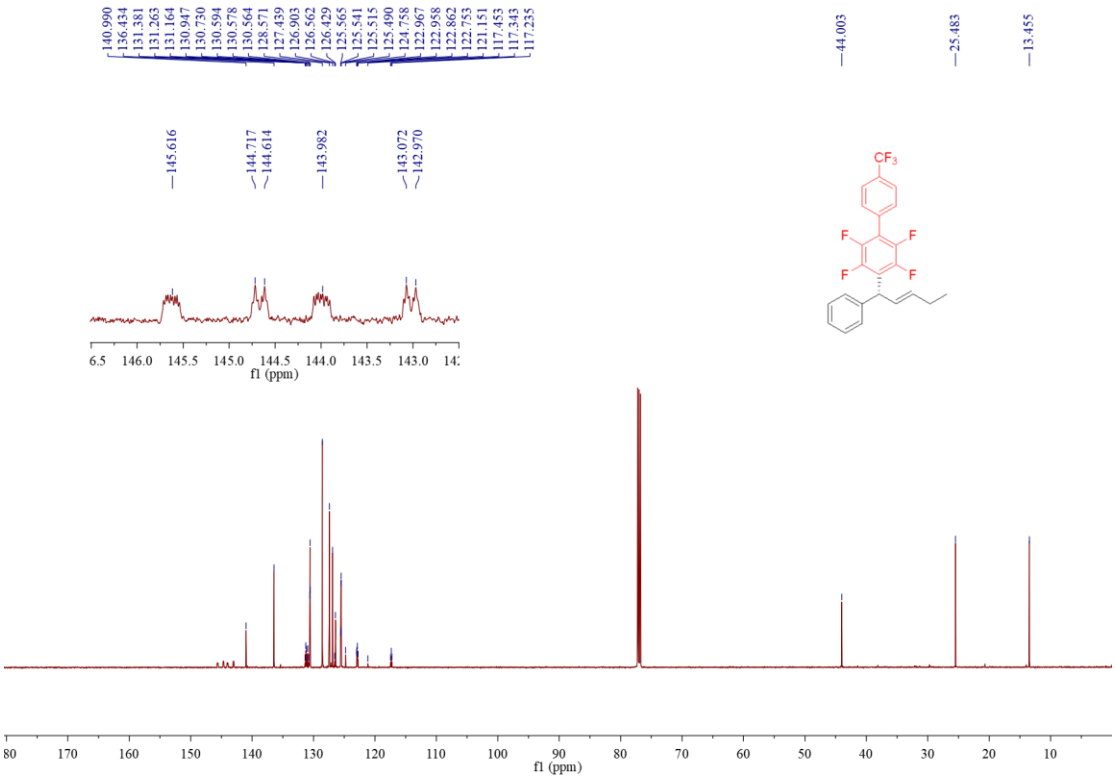
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 5w



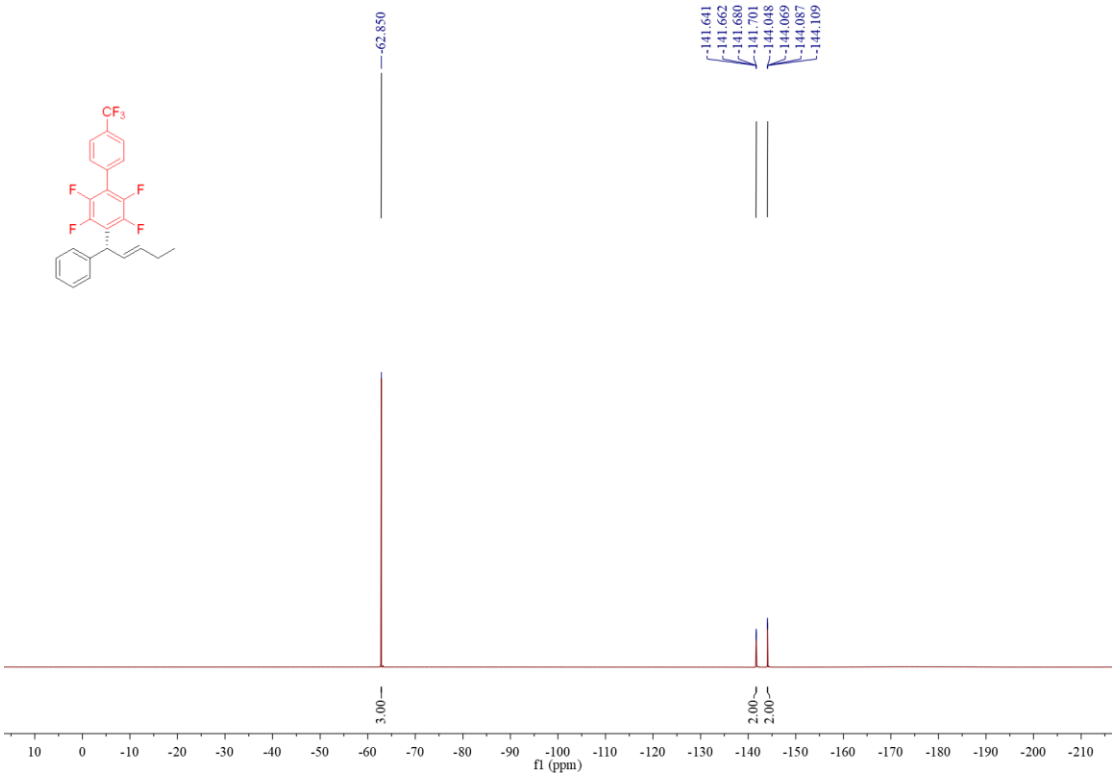
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 5x



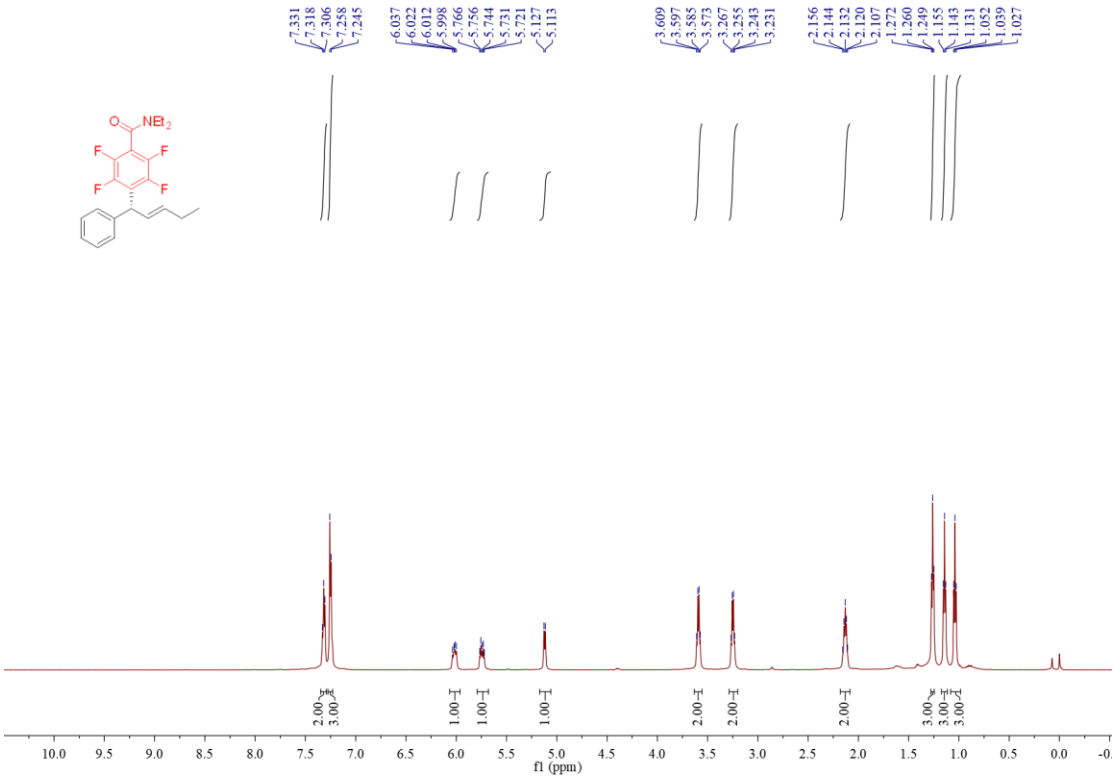
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 5x



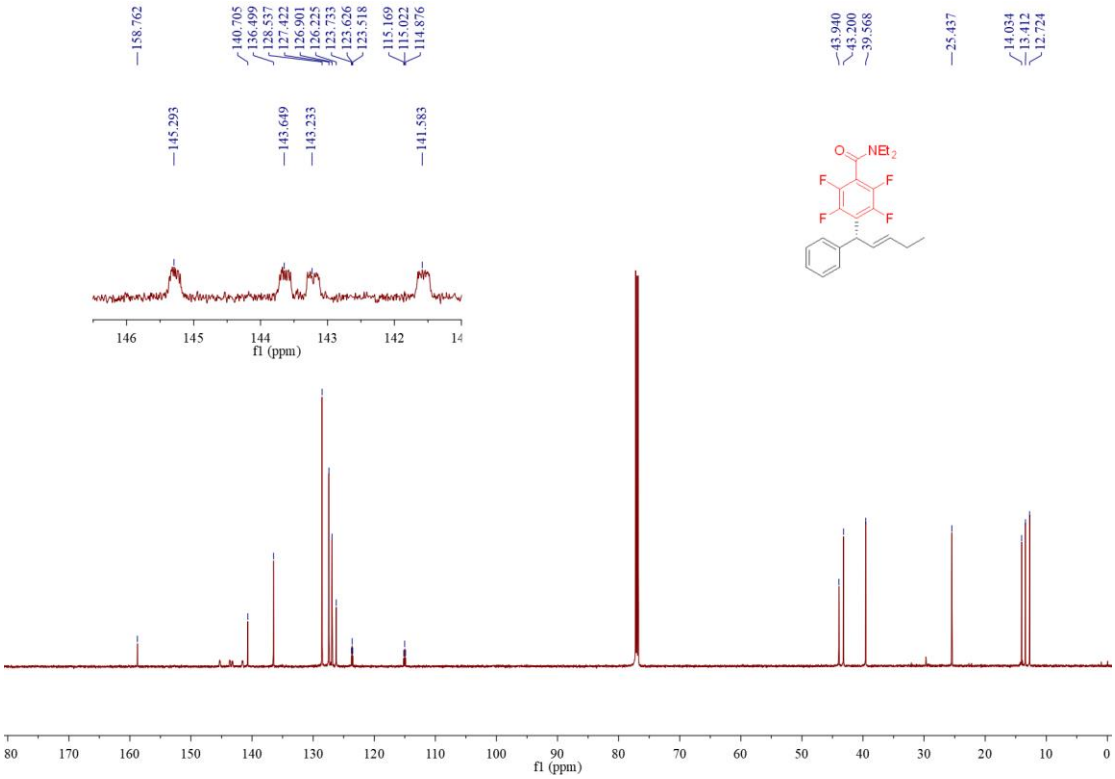
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 5x



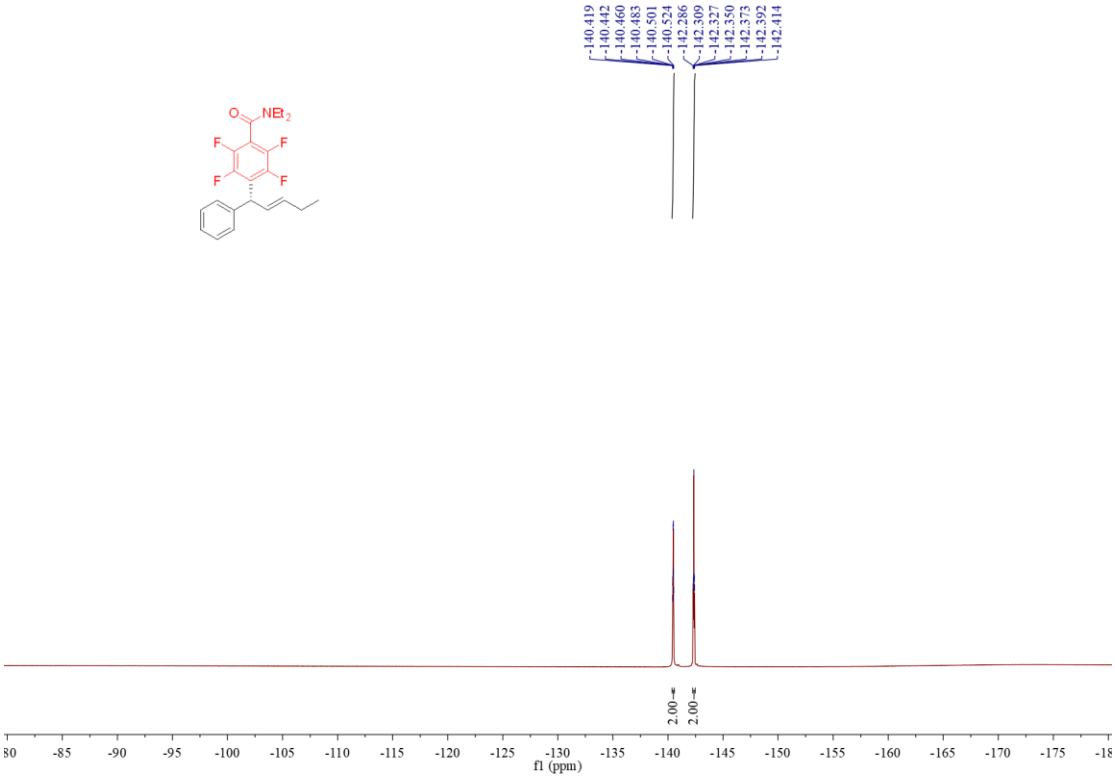
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 5y



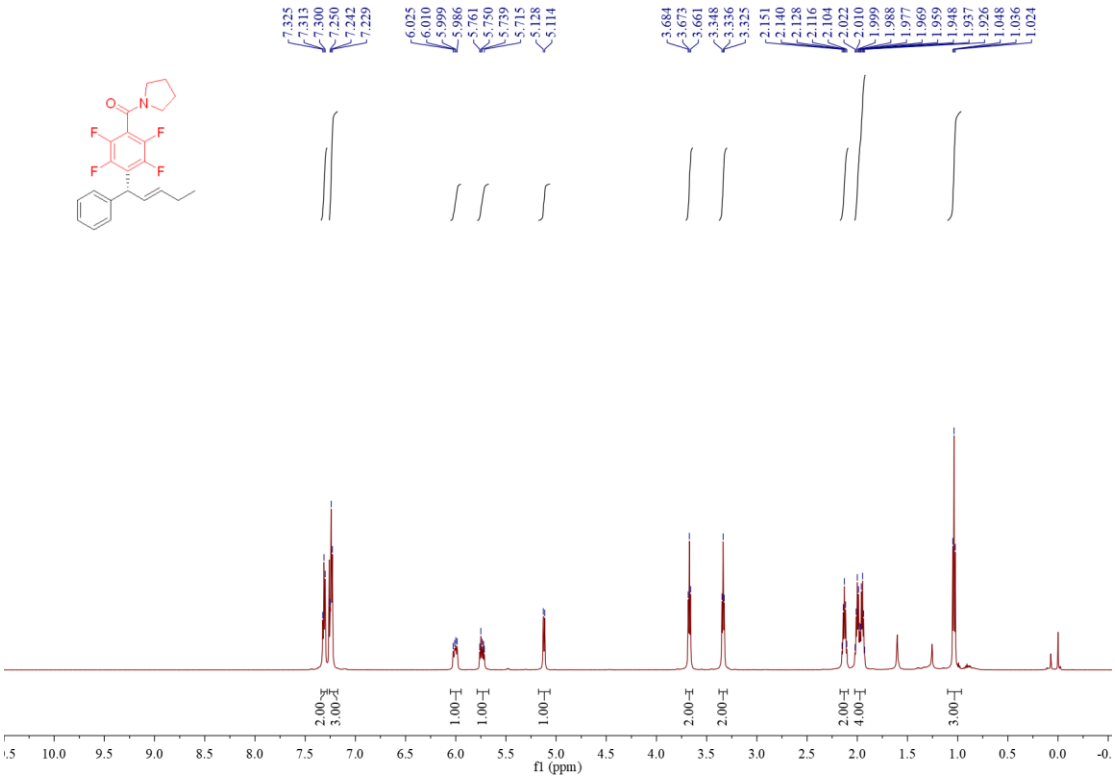
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5y



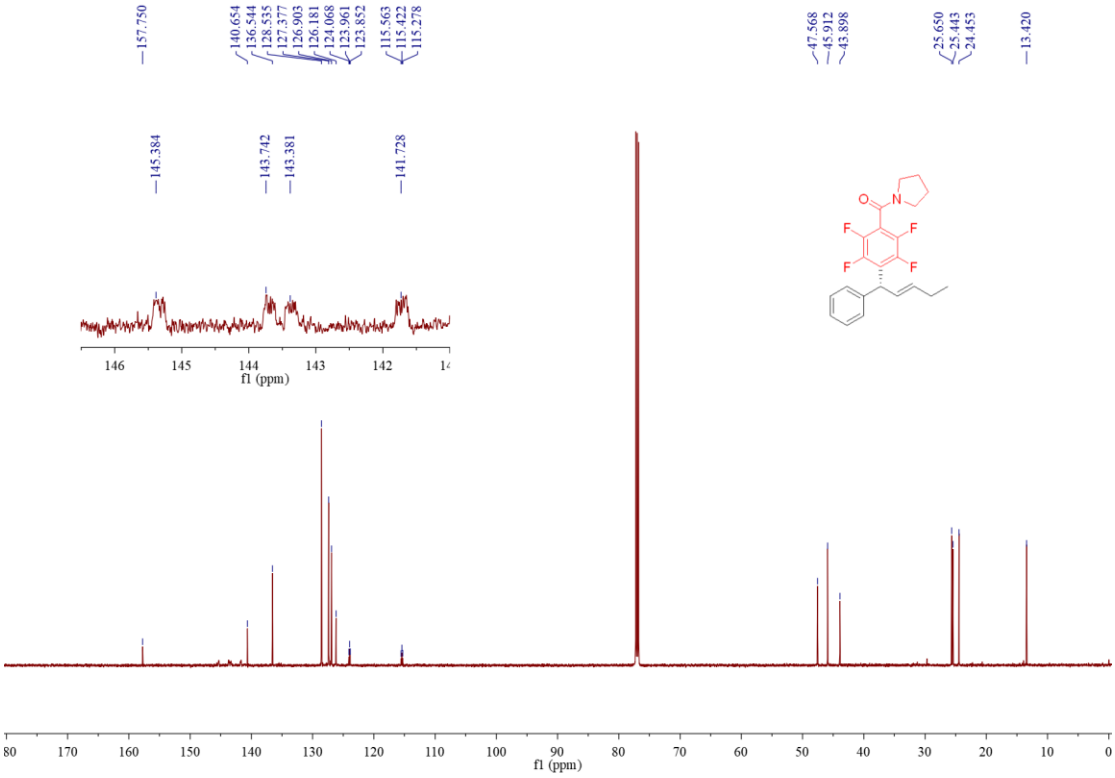
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 5y



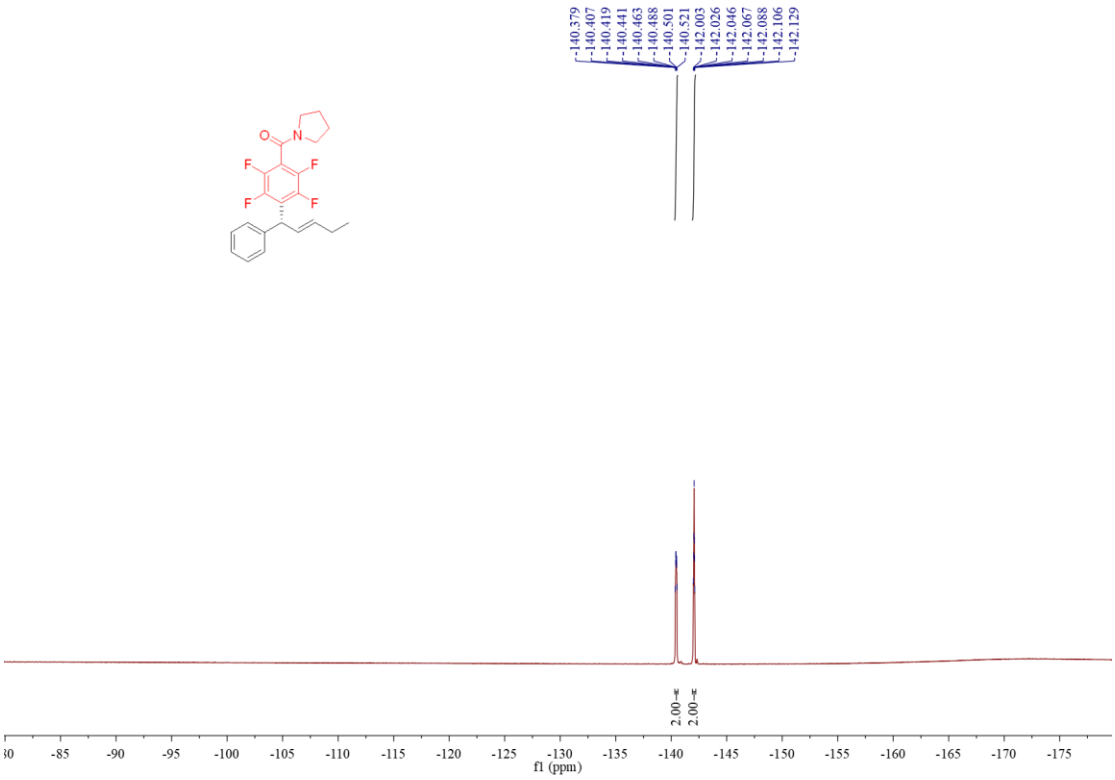
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 5z



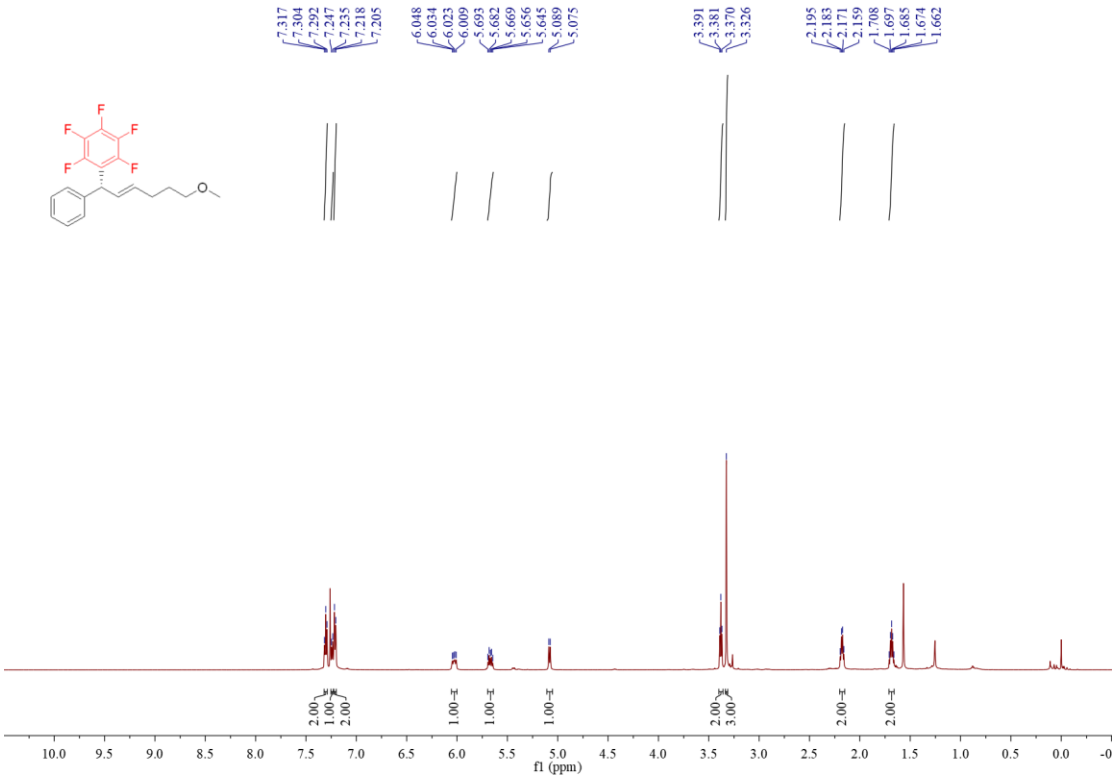
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5z



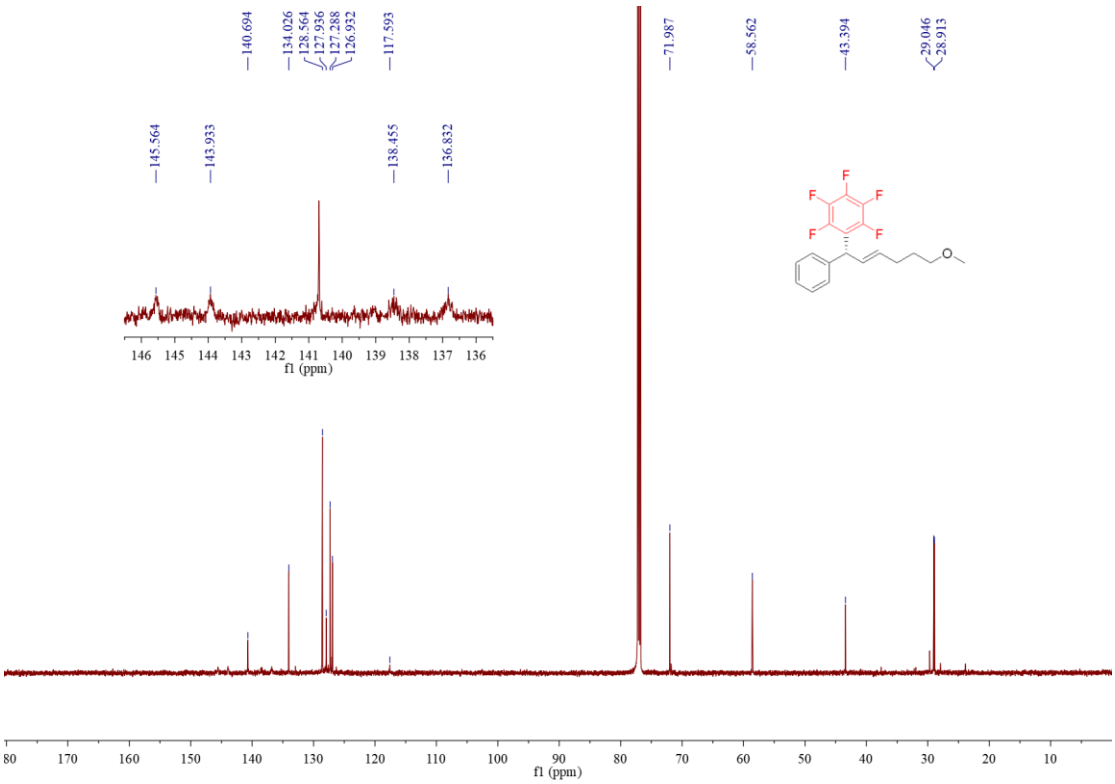
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 5z



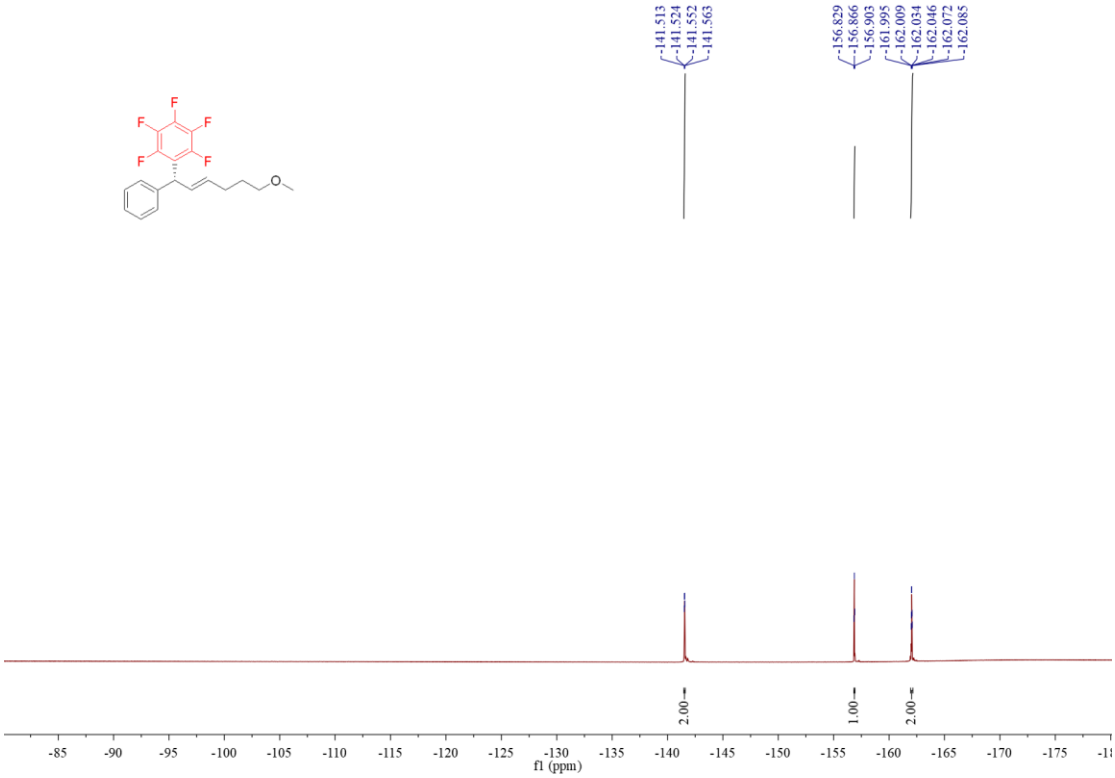
^{1}H NMR (600 MHz, Chloroform-*d*) spectrum of 5aa



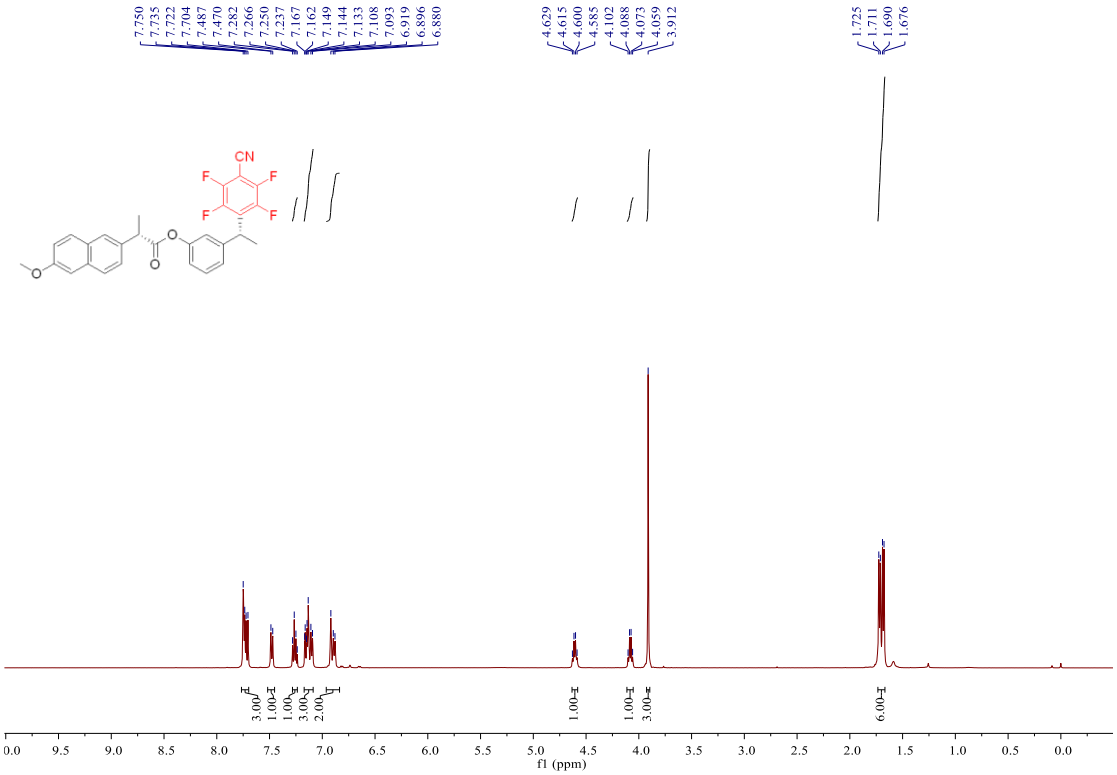
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 5aa



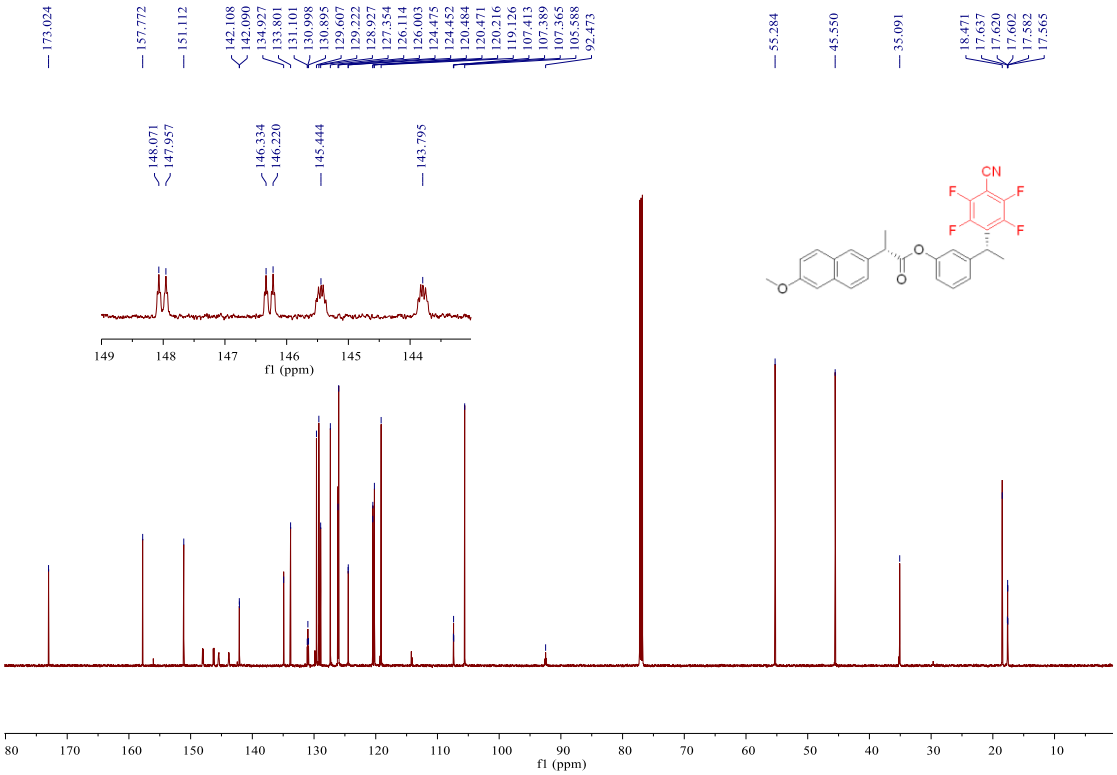
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 5aa



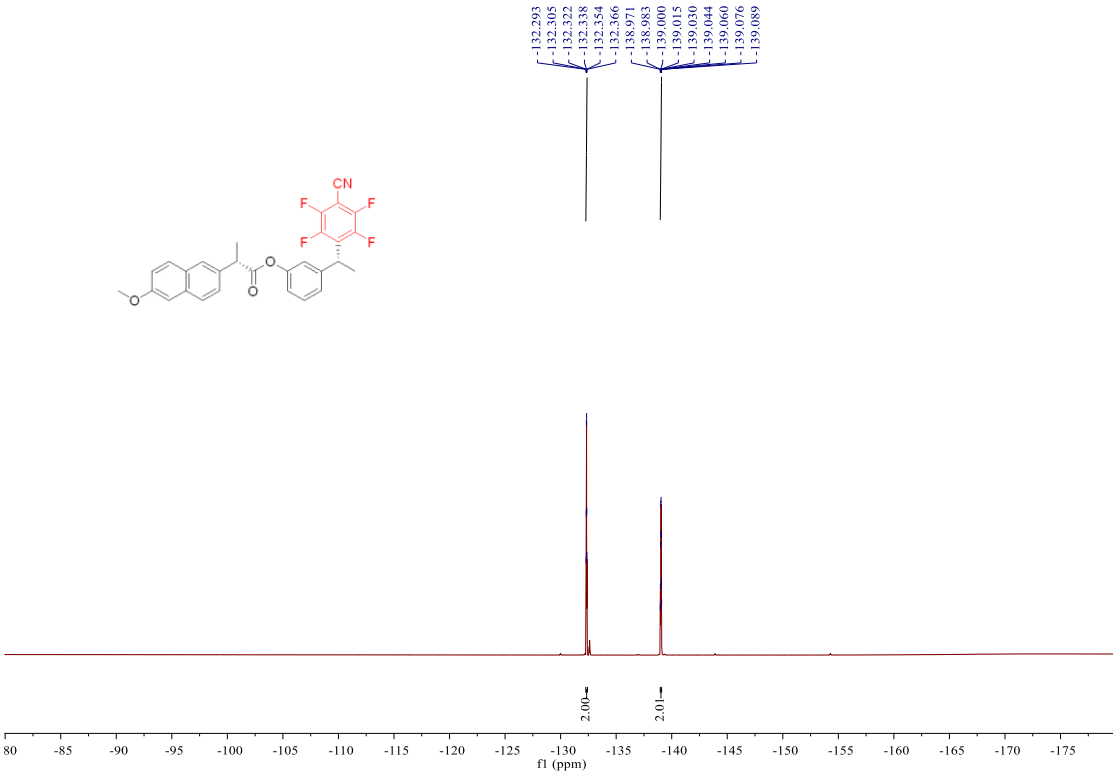
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 6



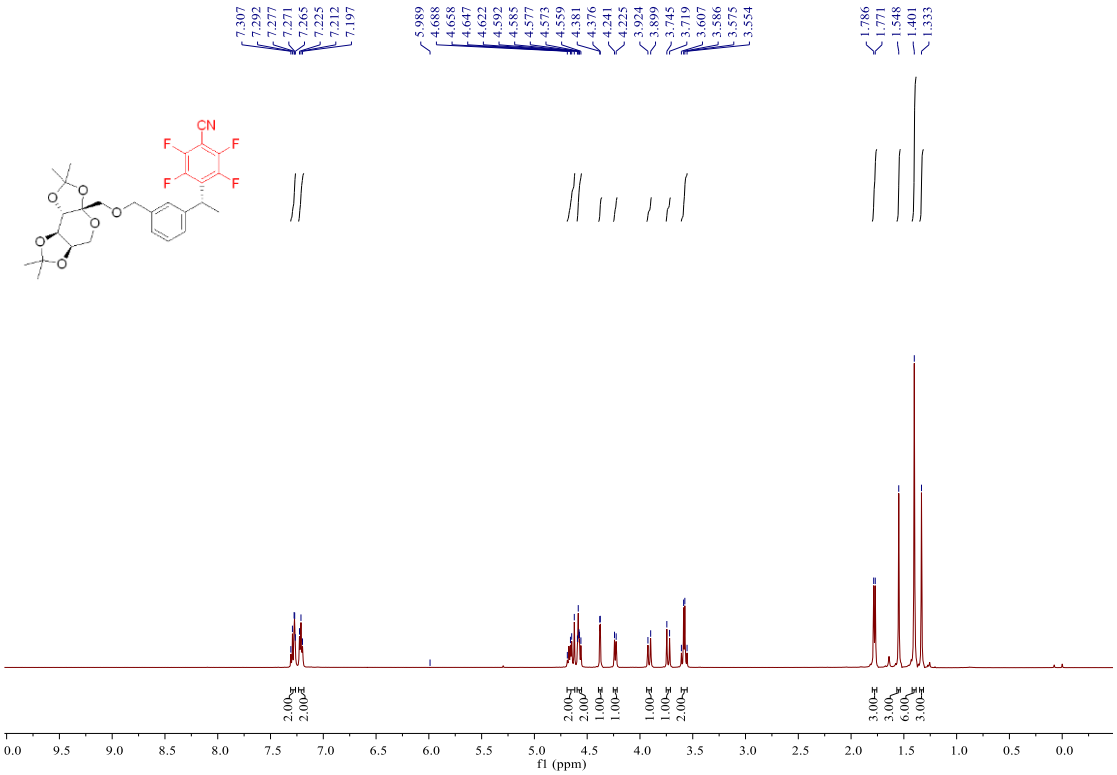
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 6



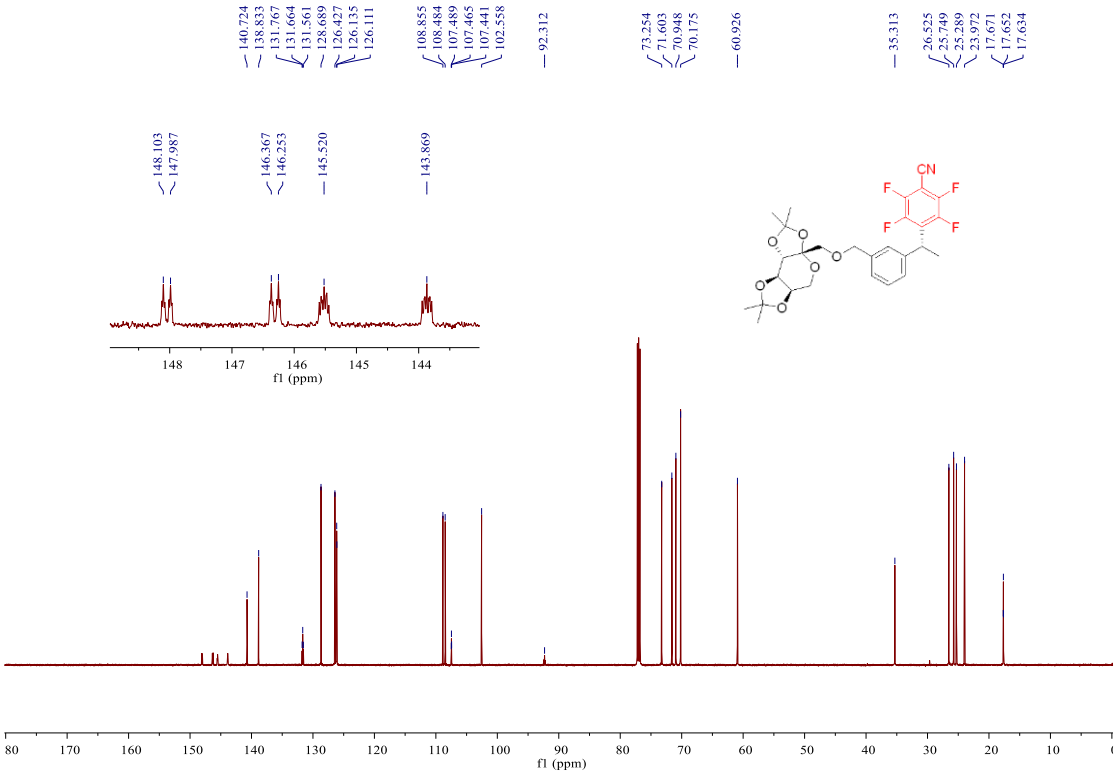
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 6



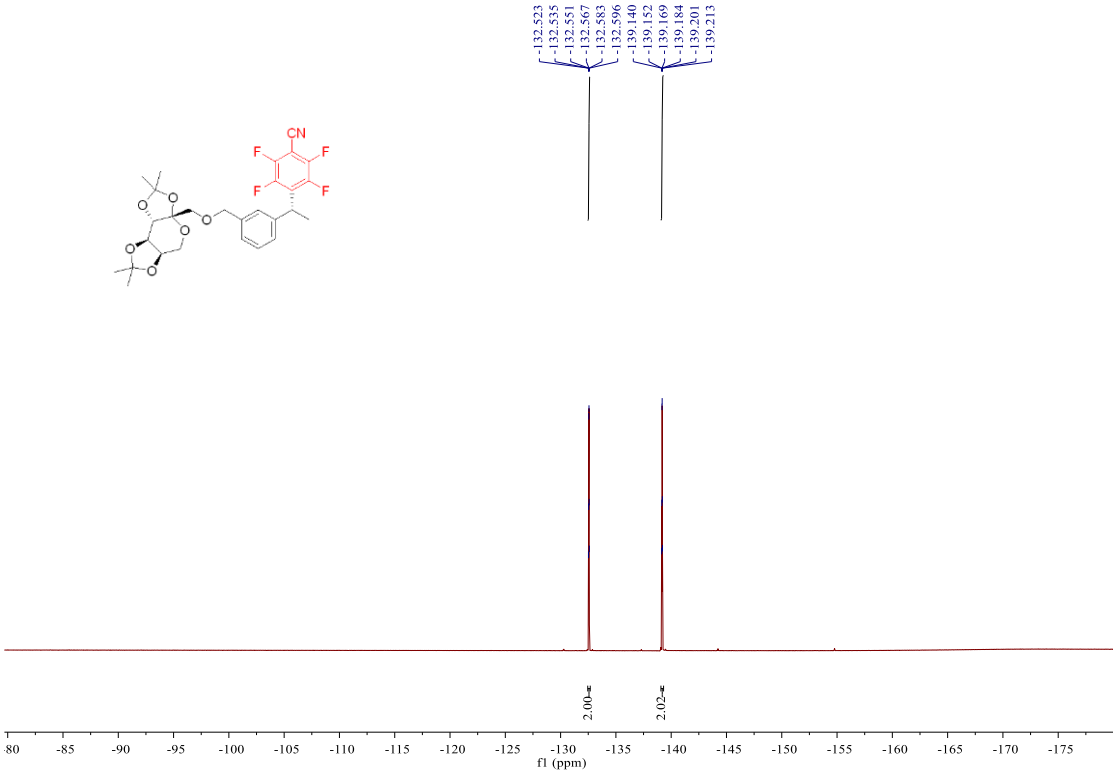
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 7



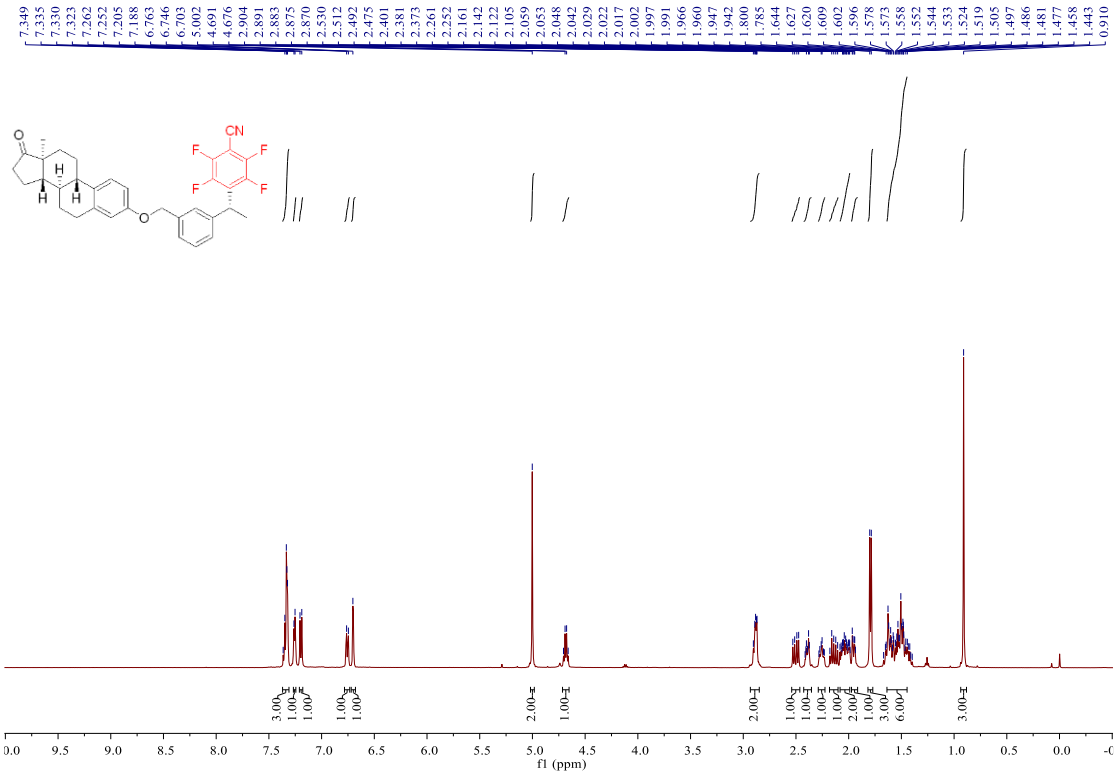
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 7



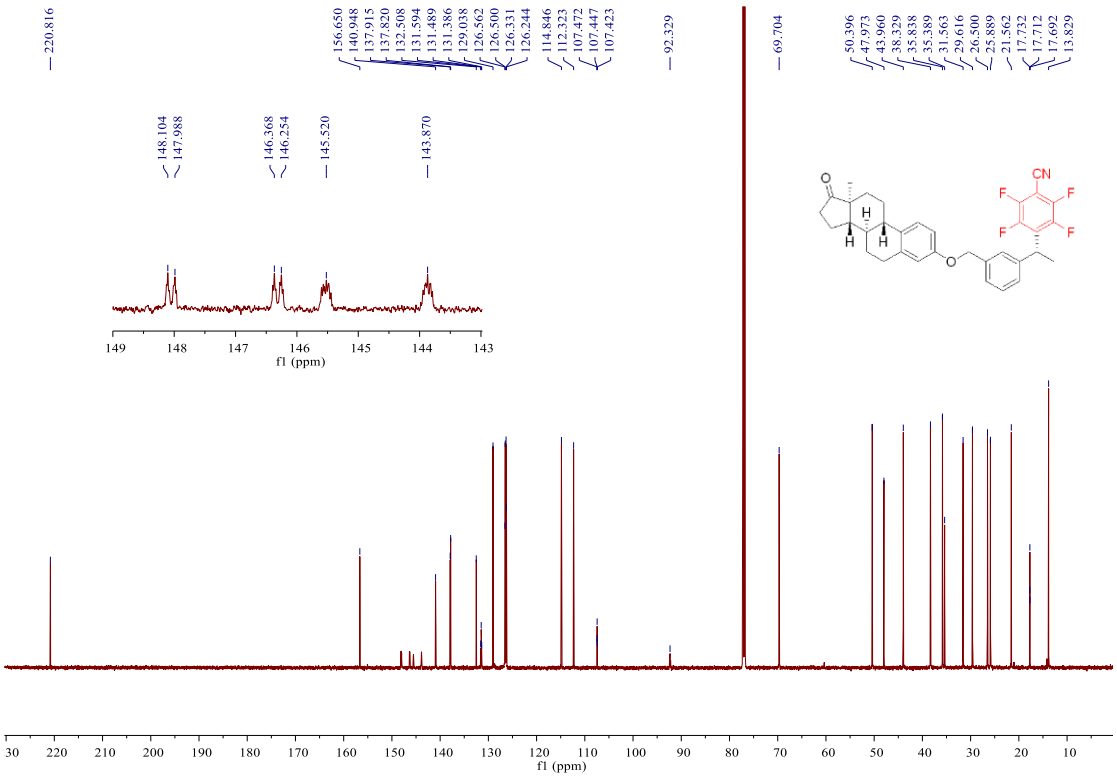
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 7



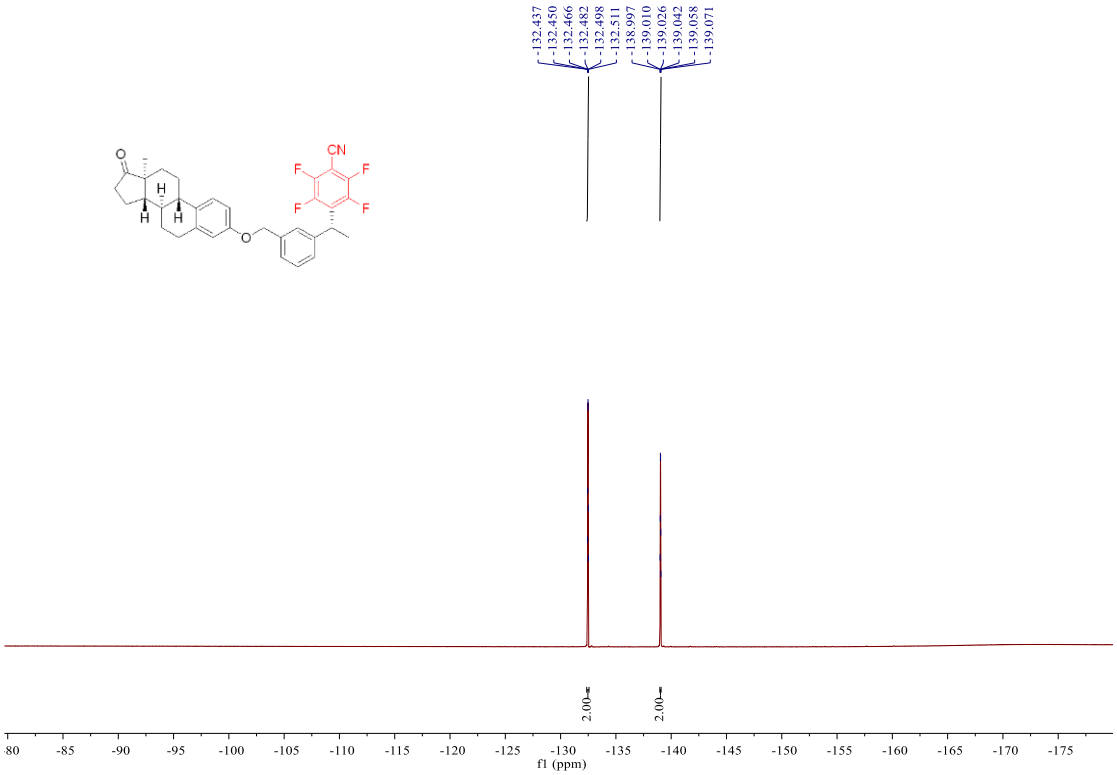
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 8



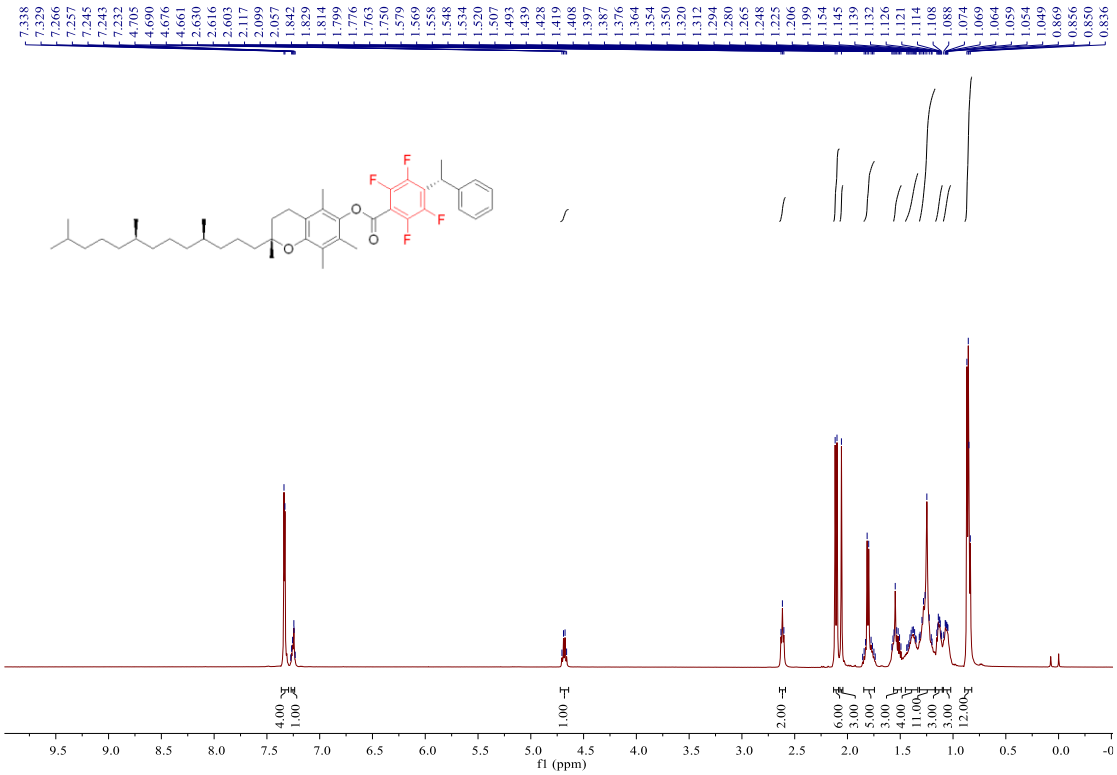
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 8



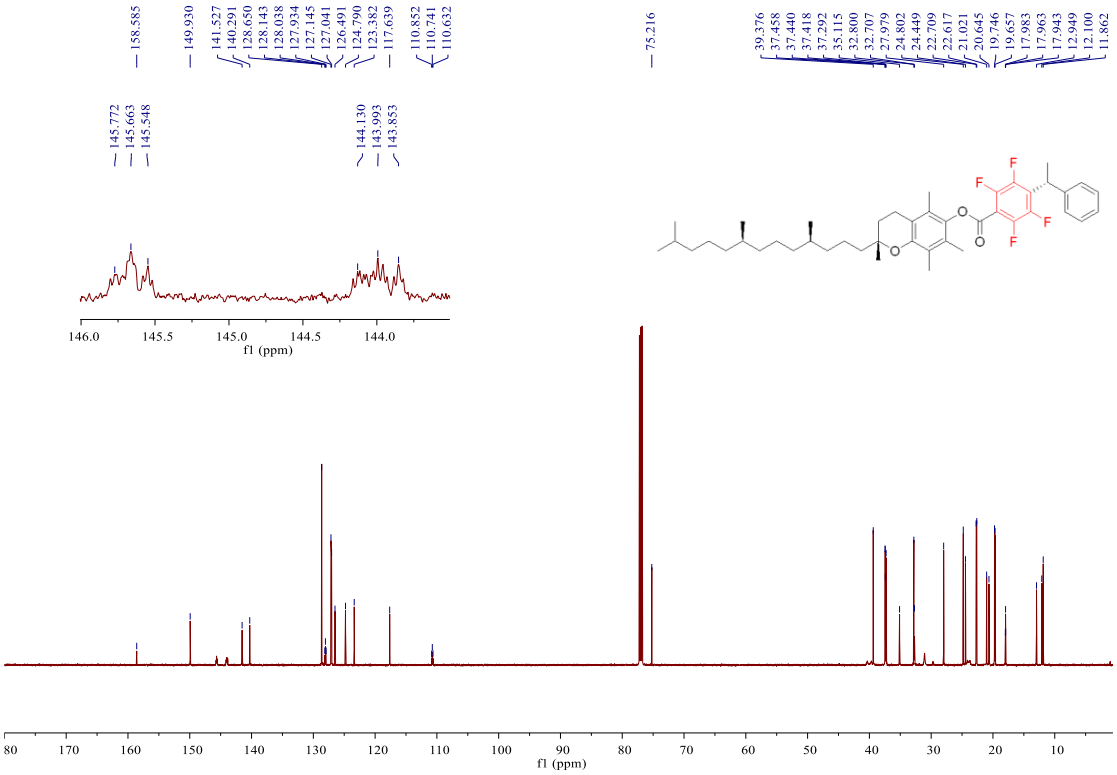
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 8



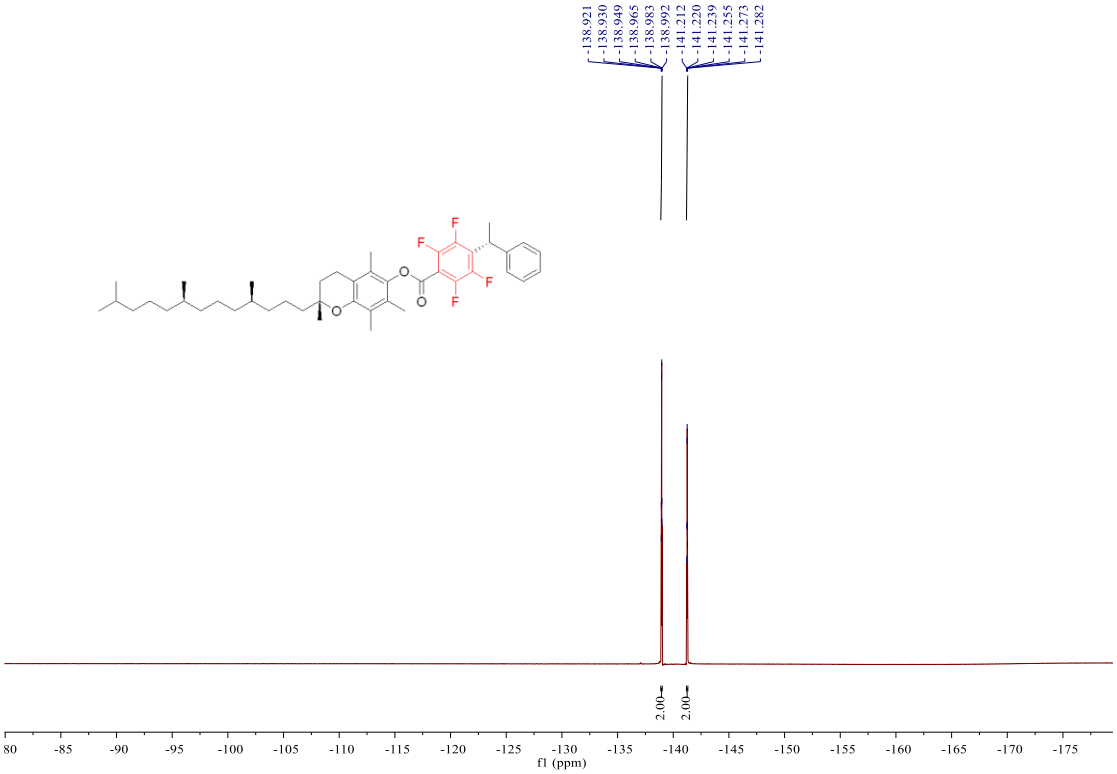
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 9



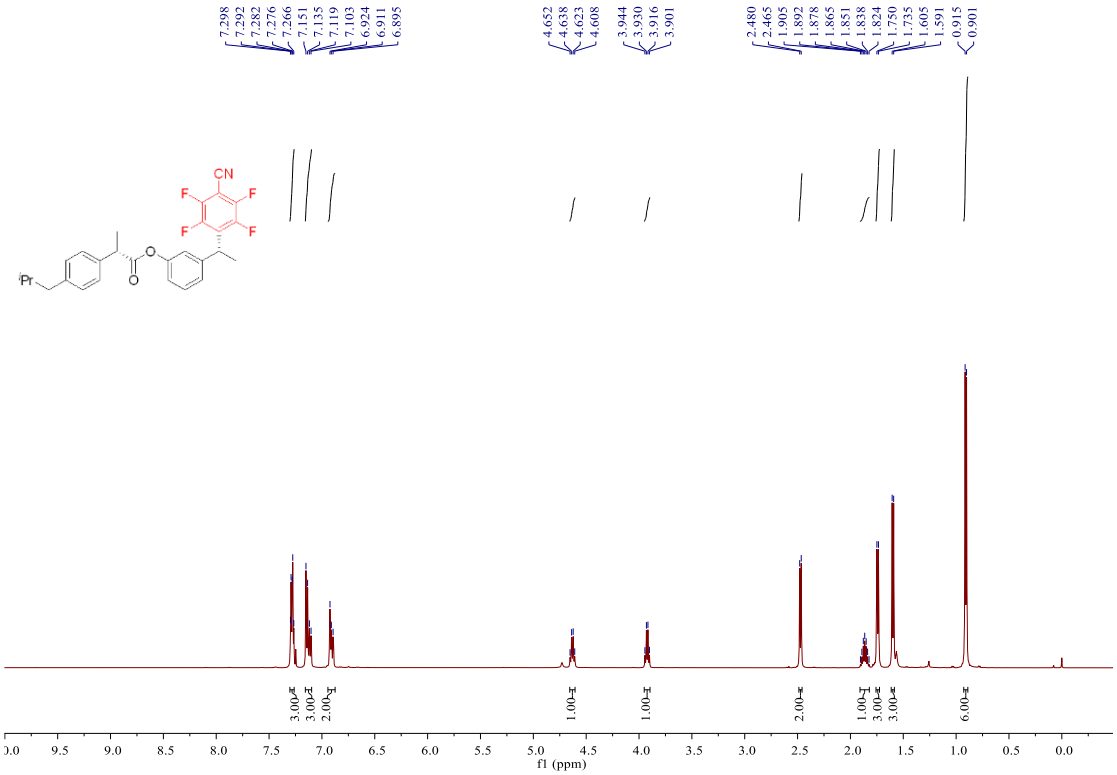
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 9



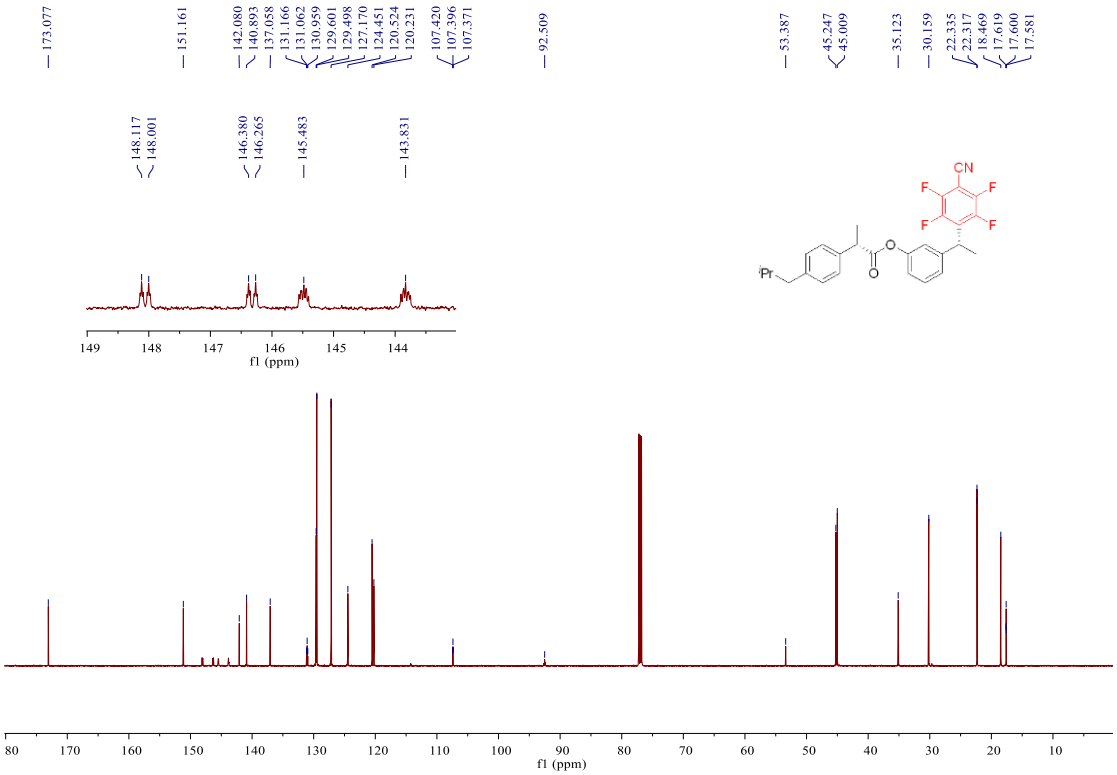
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 9



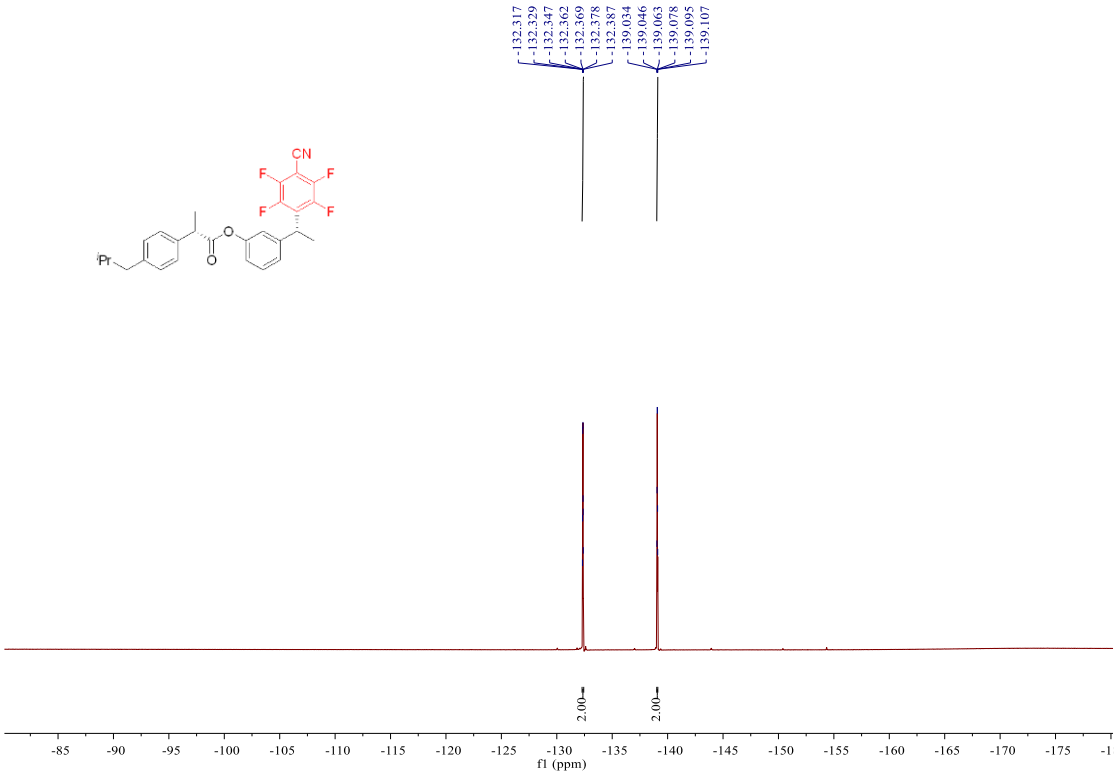
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 10



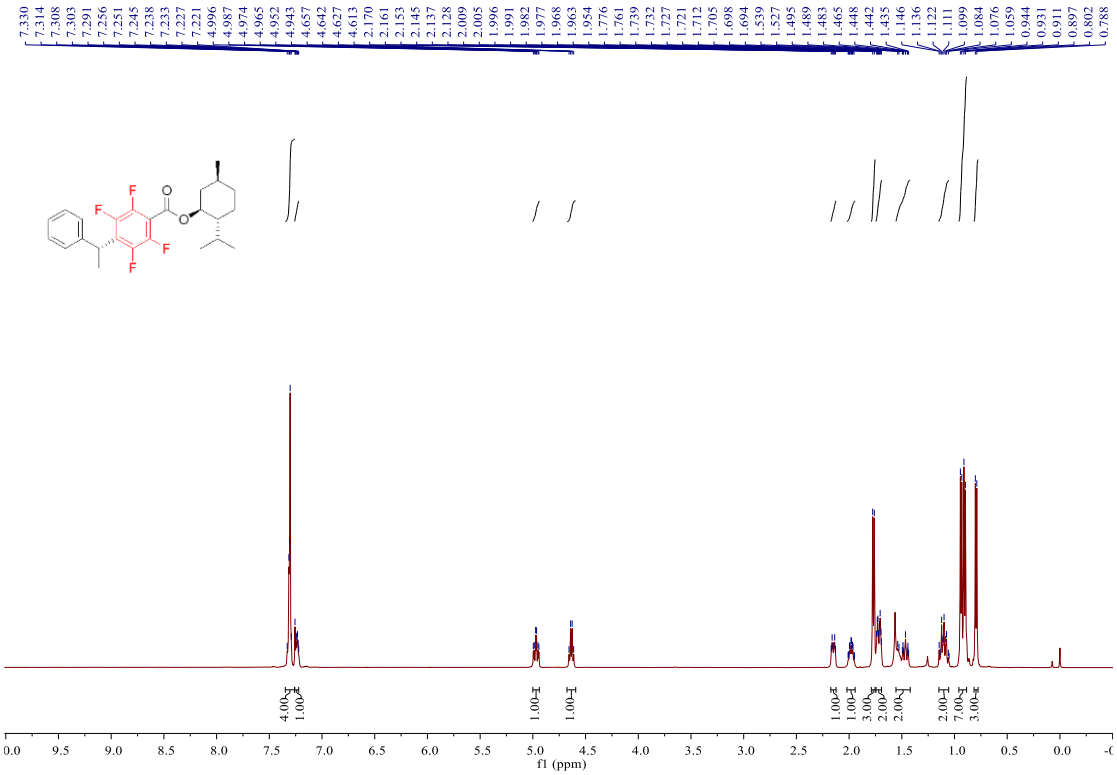
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 10



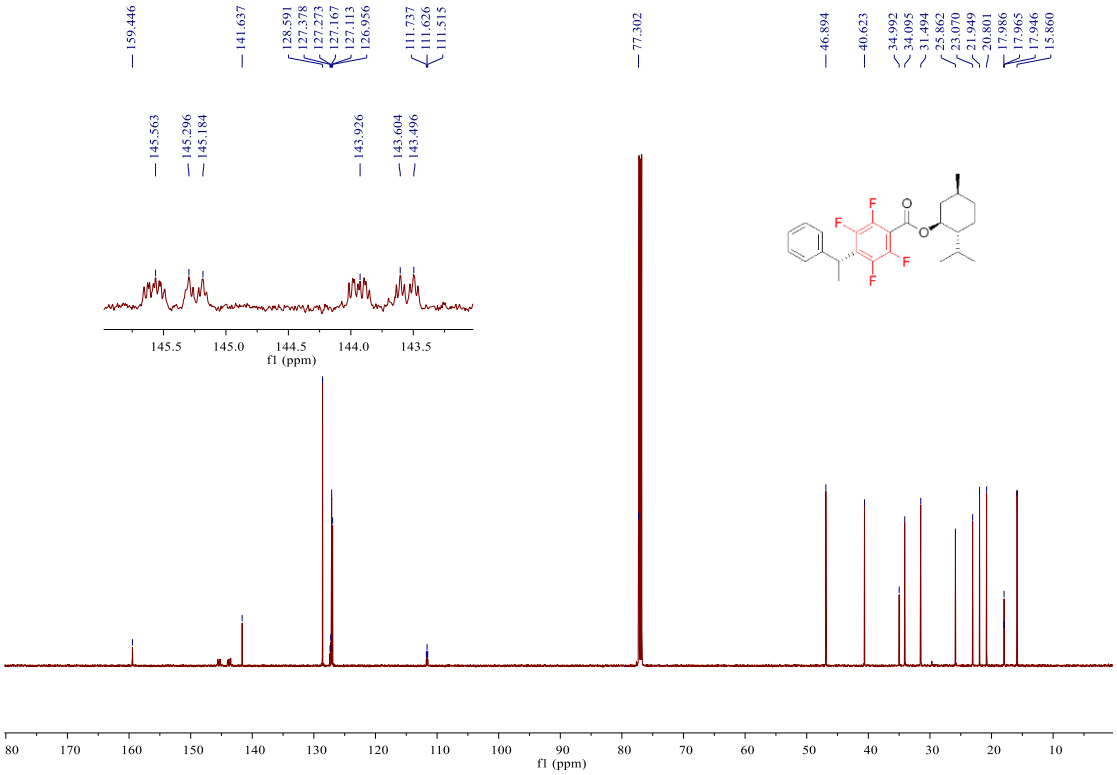
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 10



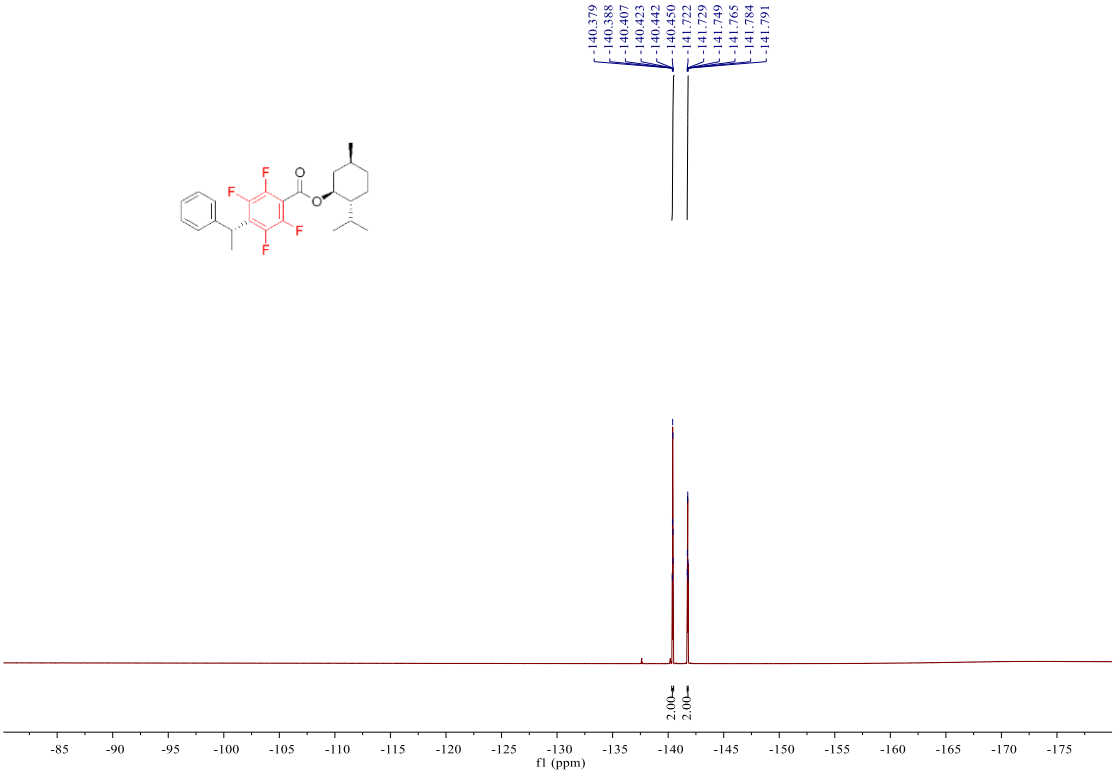
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 11



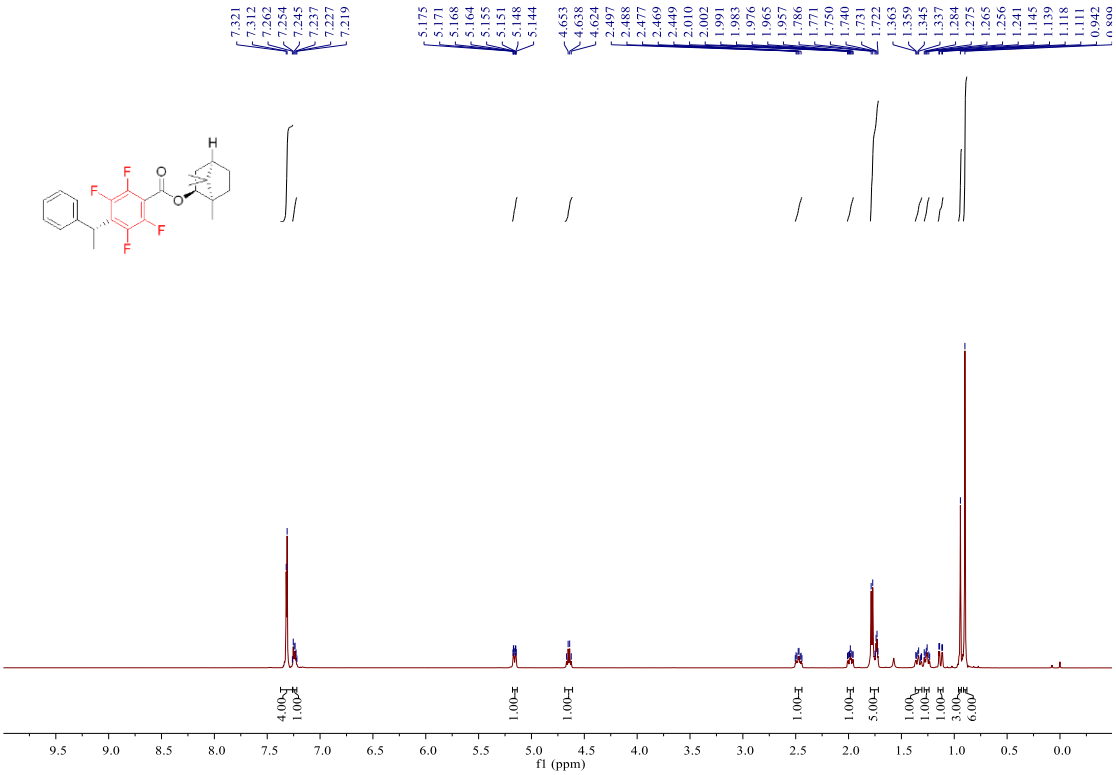
^{13}C NMR (151 MHz, Chloroform-*d*) spectrum of 11



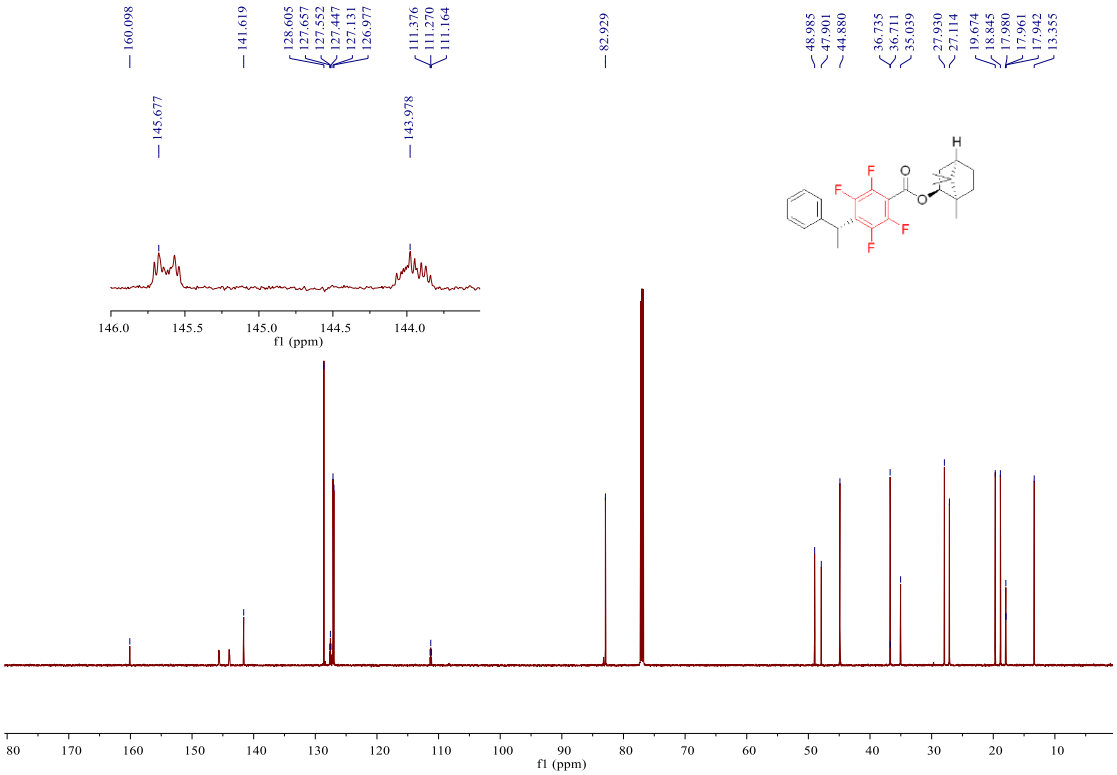
^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 11



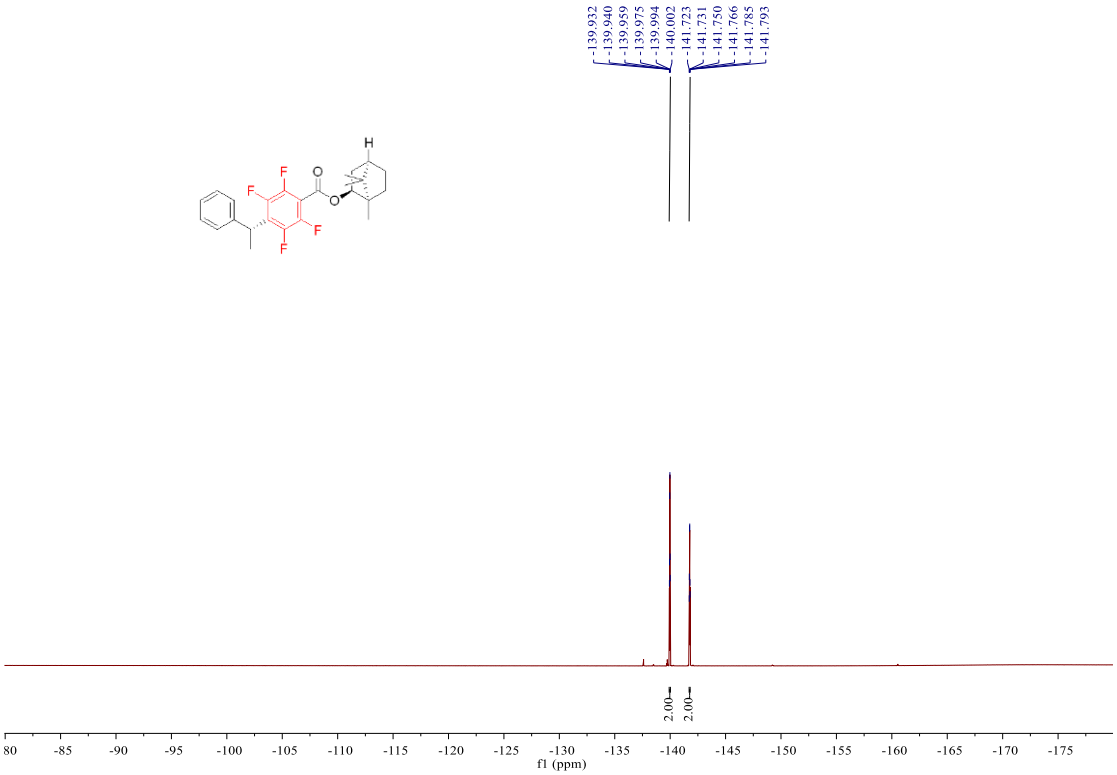
^{1}H NMR (500 MHz, Chloroform-*d*) spectrum of 12



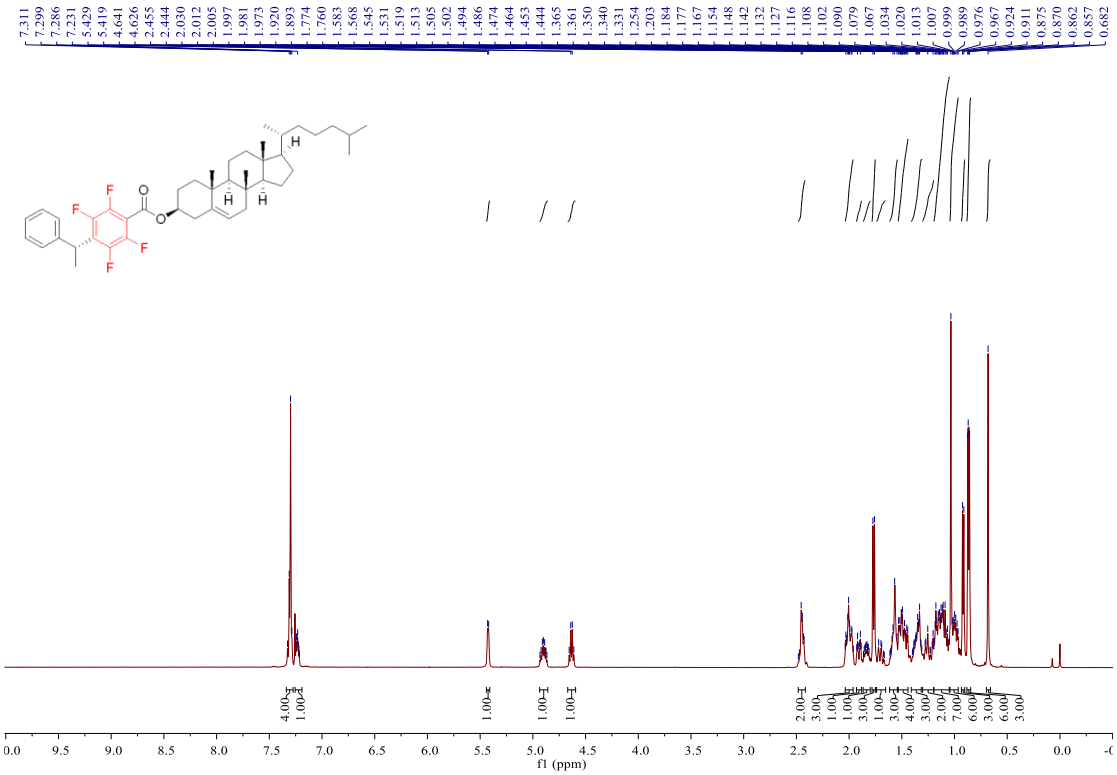
^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 12



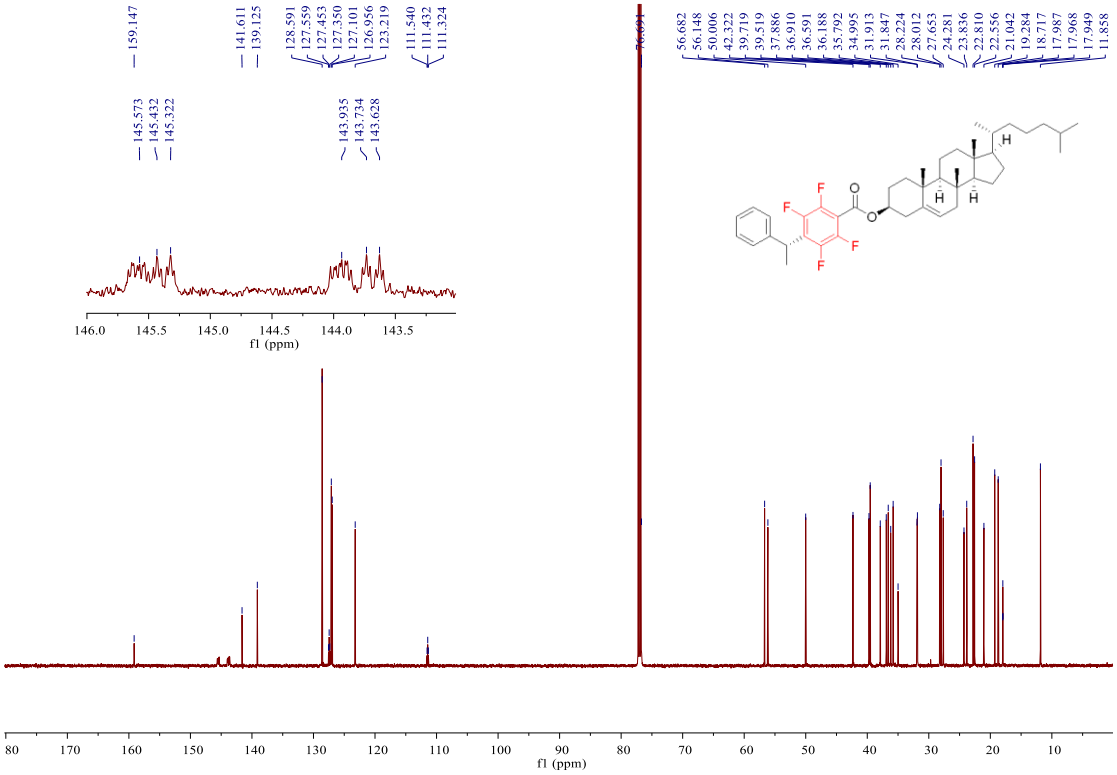
^{19}F NMR (565 MHz, Chloroform-*d)* spectrum of 12



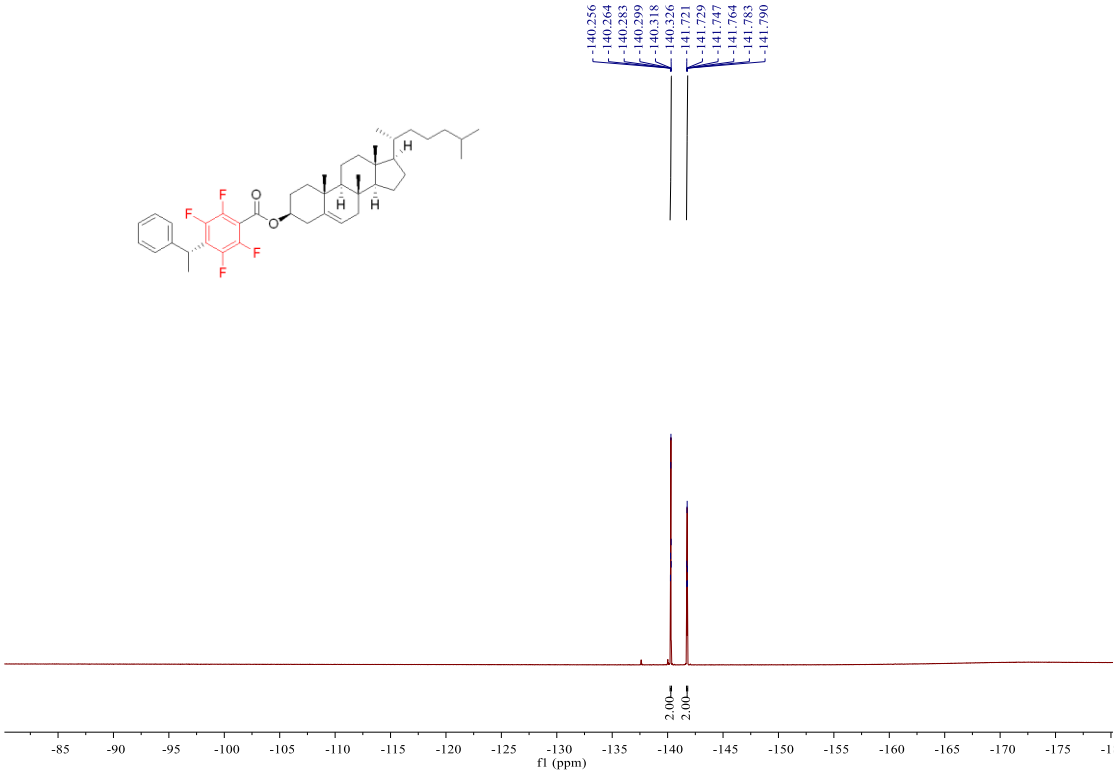
^{1}H NMR (500 MHz, Chloroform-*d)* spectrum of 13



^{13}C NMR (151 MHz, Chloroform-*d)* spectrum of 13



^{19}F NMR (565 MHz, Chloroform-*d*) spectrum of 13



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