Three-component reaction of *gem*-difluorinated cyclopropanes with alkenes and B_2pin_2 for the synthesis of monofluoroalkenes

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1. General Information:

1.1 Materials

Pd $(OTFA)_2$ and other palladium salts were covered from Aldrich and J &K. All phosphor ligands were purchased from Aldrich. As received the following chemicals were used: Na_2CO_3, NaO^tBu, K_2CO_3 and Cs_2CO_3 (Acros, J&K). All anhydrous solvents were purchased from Acros and used without more purification. CH_3CN was stored over 4 Å molecular sieves under an argon atmosphere in a septum-capped bottle. *gem*-difluorinated cyclopropanes substrates were prepared and NMR data have been conformed according to previous procedure in literatures.[1-6]

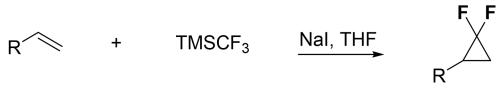
Other reagents and solvents were mentioned in this text bought from commercial sources and used without purification.

1.2 Analytical Methods

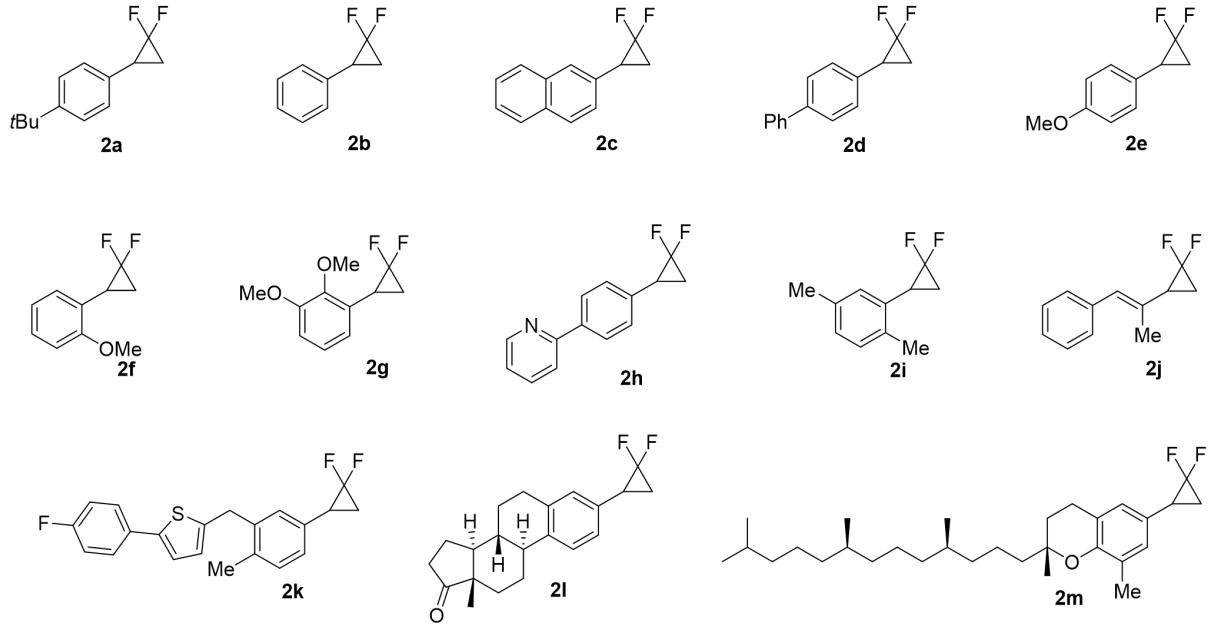
NMR (^1H, ^{13}C, ^{11}B ^{19}F) spectra were recorded on a Bruker Avance 400 MHz spectrometer at ambient in $CDCl_3$. ^1H-NMR data are reported as chemical shift (δ ppm), multiplicity, integration and coupling constant (Hz). Where ^{13}C-NMR data are reported in terms of chemical shift (δ ppm), multiplicity and coupling constant (Hz). Gas Chromatography-Mass Spectrometry (GC-MS) analysis was acquired on Thermo Scientific AS 3000 Series GC-MS System. Gas Chromatography (GC) analysis was performed on Shimadzu GC-2014 Series GC System equipped with a flame-ionization detector. High Resolution-Mass Spectra (HRMS) were recorded on Finnigan LCQ advantage Max Series MS System. Analytical High-Performance Liquid Chromatography (HPLC) was achieved on Waters-Breez (2487 Dual Absorbance Detector and 1525 Binary HPLC pump). Organic solutions were concentrated in vacuo using a Buchi rotary evaporate. Thin Layer Chromatography (TLC) were used for monitoring the reactions by glass 0.25 mm Silica gel. Flash Column Chromatography purification for products was performed using forced-flow Chromatography on Silica Gel (200-300 mesh).

2. Synthesis of gem-difluorinated cyclopropanes.

2.1 Experimental procedure of synthesis of *gem*-difluorinated cyclopropanes.[1-6]

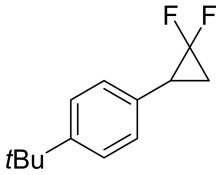


A three-necked around-bottom flask (100 mL) with stir bar, anhydrous NaI (0.5 equiv.) was added with corresponding alkene (1 equiv.). The vessel refilled three times with Ar after evacuation. 20 mL of freshly distilled THF was added under inert gas. Then, the vessel removed to oil bath which sit at 90 °C and in dropwise manner $TMSCF_3$ (3 equiv.) was added. Afterward, refluxing for 8 hours. After the mixture cooled to romm temperature, the crude was extracted with ether (15 ml) and washed with water (15 ml), saturated sodium sulfite solution (15 ml), saturated sodium bicarbonate solution (15 ml). After drying the combined organic layers over anhydrous sodium sulfite and filtering the mixture, the solvent was removed under reduced pressure to obtain a dark red residue. Purify by flash column chromatography (SiO_2, PE/ EtOAc (V/V) to obtain the pure *gem*-difluorocyclopropane.

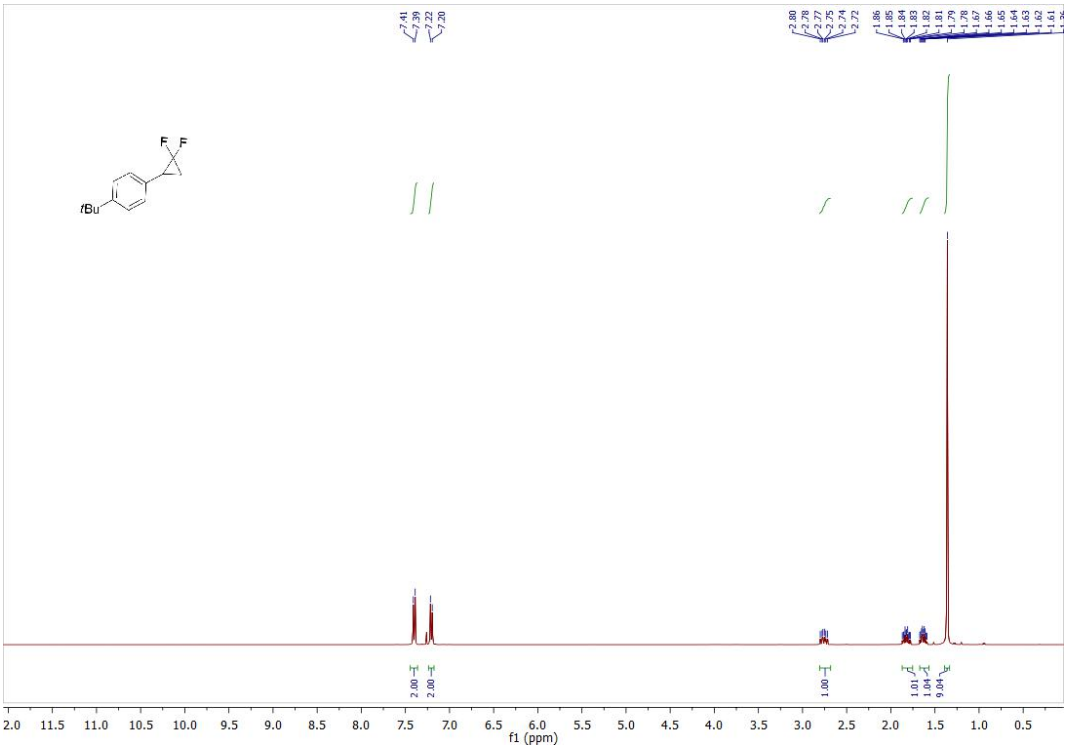


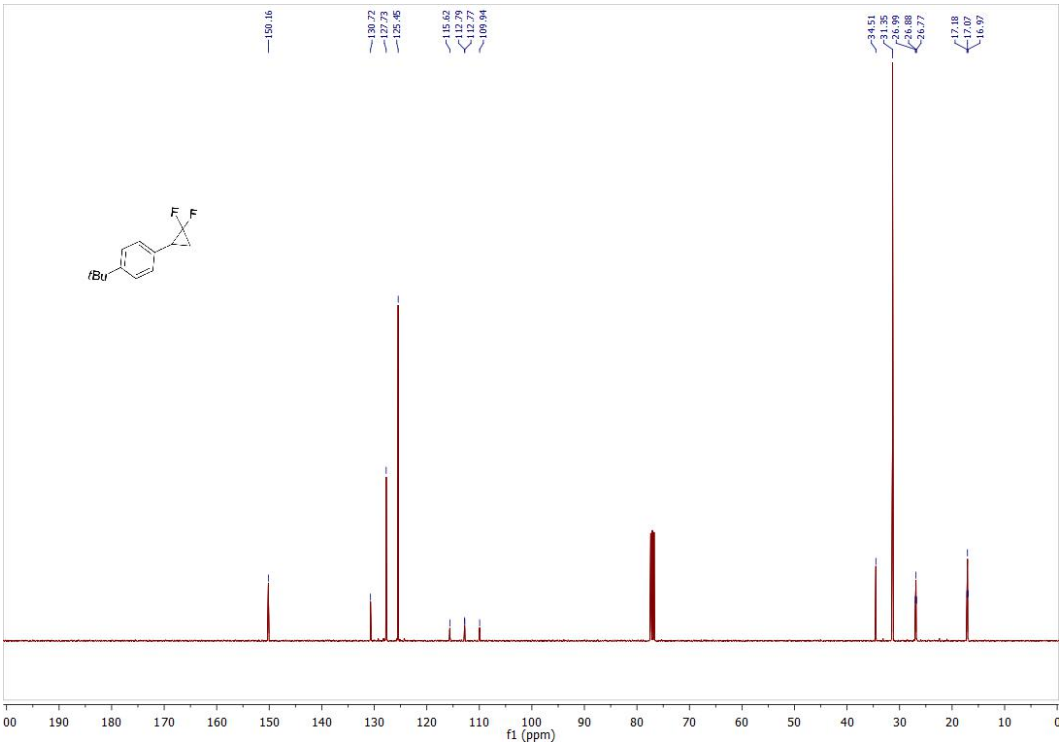
2.2 Characterization of *gem*-difluorinated cyclopropanes.

1-(tert-butyl)-4-(2,2-difluorocyclopropyl) benzene (2a):



(1.9 g, colorless oil, pure petroleum ether as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.40 (d, *J* = 8.4 Hz, 2H), 7.21 (d, *J* = 8.4 Hz, 2H), 2.81-2.70 (m, 1H), 1.82 (m, 1H), 1.63 (m, 1H), 1.36 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 150.1, 130.7, 127.7, 125.4, 115.6, 112.7, 109.9, 34.5, 31.3, 26.8, 17.0.**^{13}C NMR** (101 MHz, $CDCl_3$) δ 150.1, 130.7, 127.7, 125.4, 112.7 (dd, *J* = 286.7, 284.2 Hz), 34.5, 31.3, 26.8 (t, *J* = 11.5 Hz), 17.0 (t, *J* = 10.5 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -125.79, -142.32.

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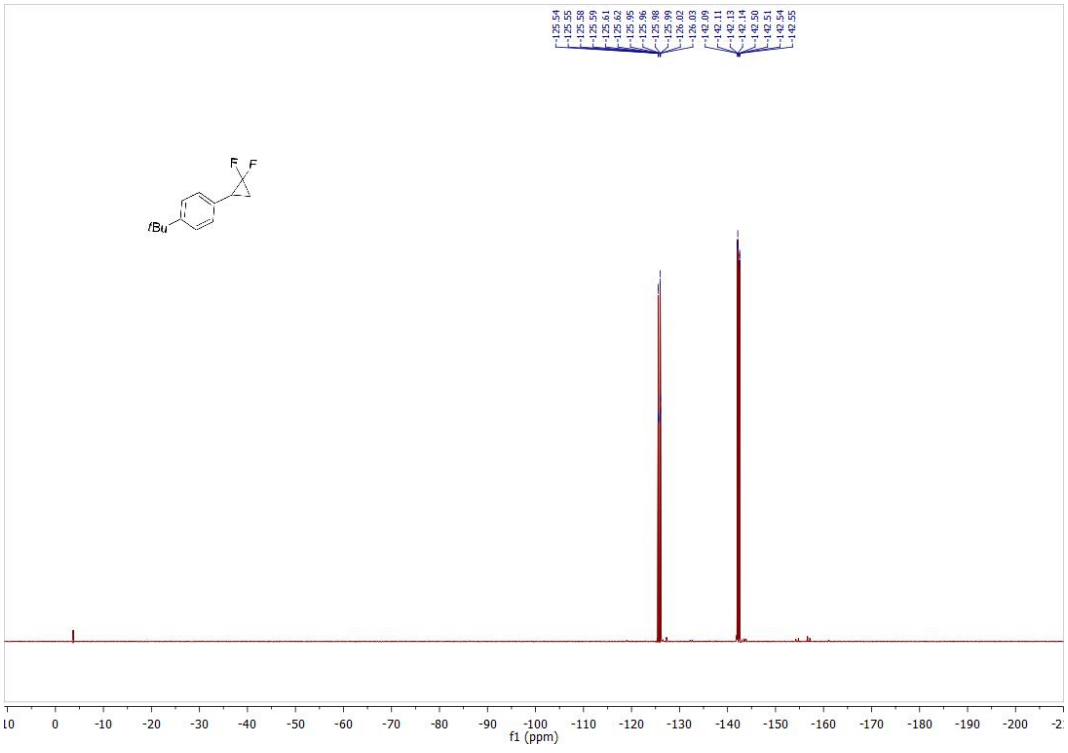
127.73
125.45
115.62
112.79
111.77
109.64
34.51
31.35
26.99
26.88
26.77
17.18
17.07
16.97
F
F
tBu
f1 (ppm)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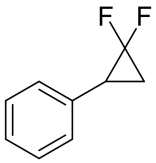
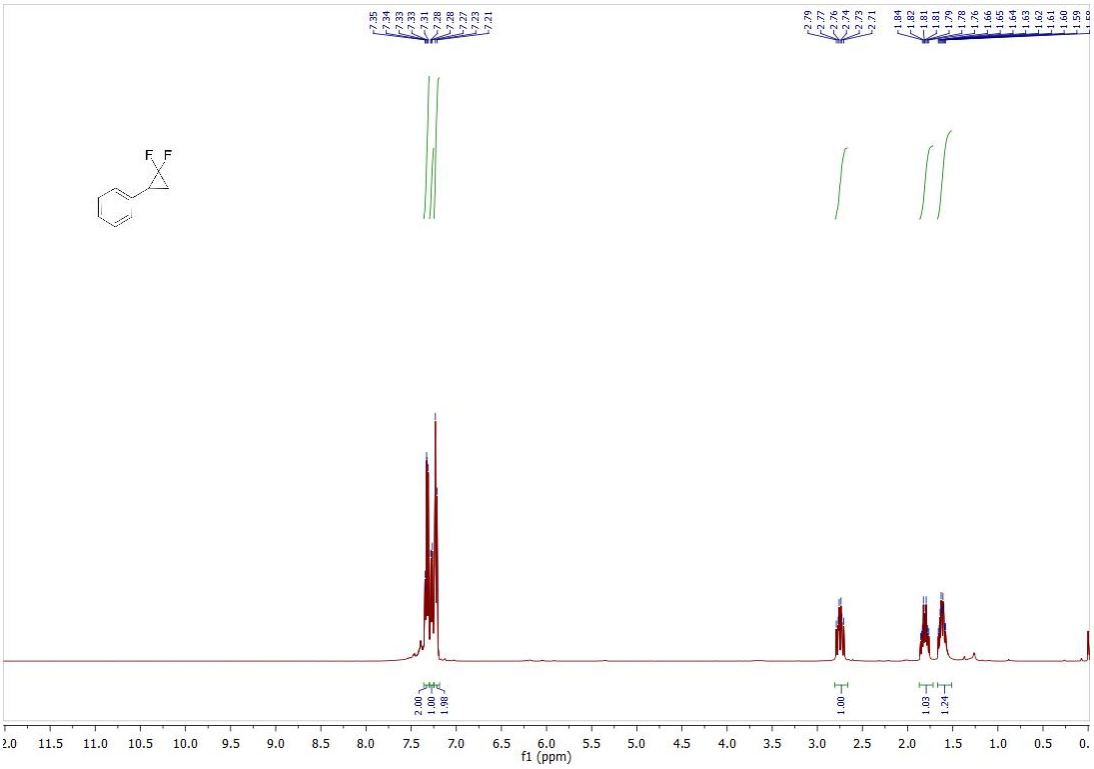
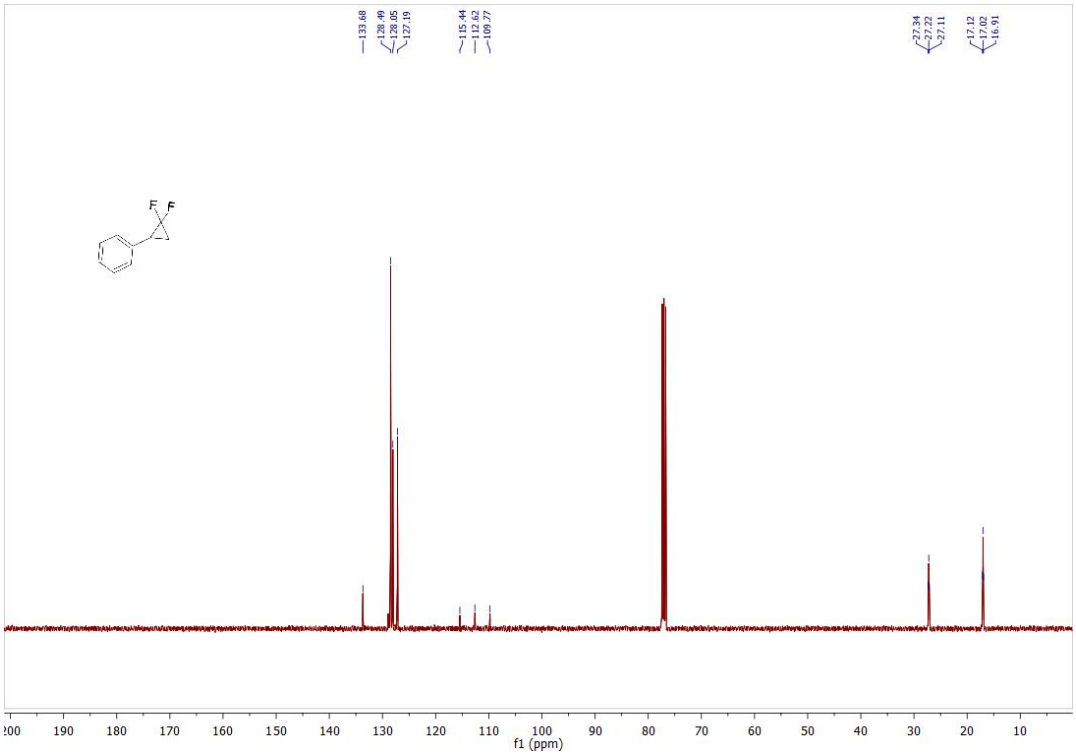
125.55
125.58
125.59
125.61
125.62
125.95
125.96
125.98
125.99
126.02
126.03
142.09
142.11
142.13
142.14
142.50
142.51
142.54
142.55
F
F
tBu
f1 (ppm)

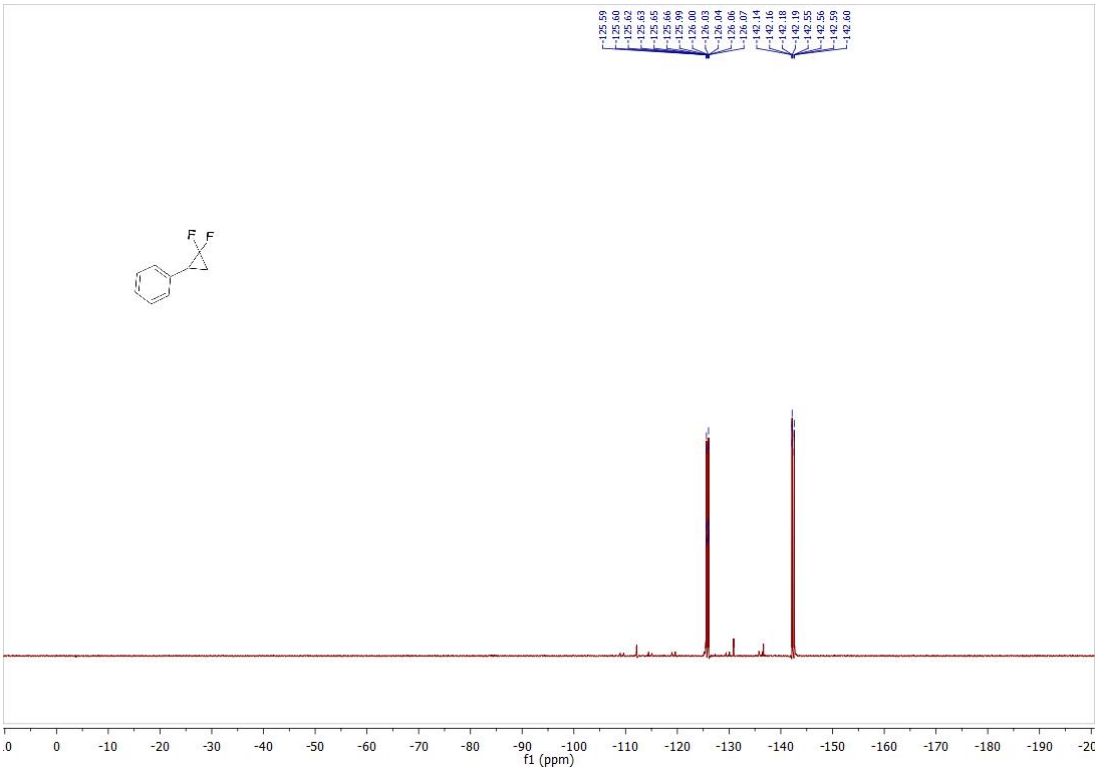
(2,2-difluorocyclopropyl) benzene (2b):



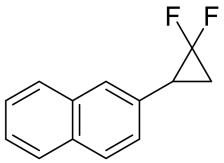
(1.4 g, colorless oil, pure petroleum ether as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.35-7.30 (m, 2H), 7.29-7.26 (m, 1H), 7.22 (d, *J* = 7.4 Hz, 2H), 2.75 (td, *J* = 12.5, 8.3 Hz, 1H), 1.86-1.74 (m, 1H), 1.62 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 133.6, 128.4, 128.0, 127.1, 112.6 (dd, *J* = 286.6, 284.0 Hz), 27.2 (t, *J* = 11.5 Hz), 17.0 (t, *J* = 10.5 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -125.83, -142.37.



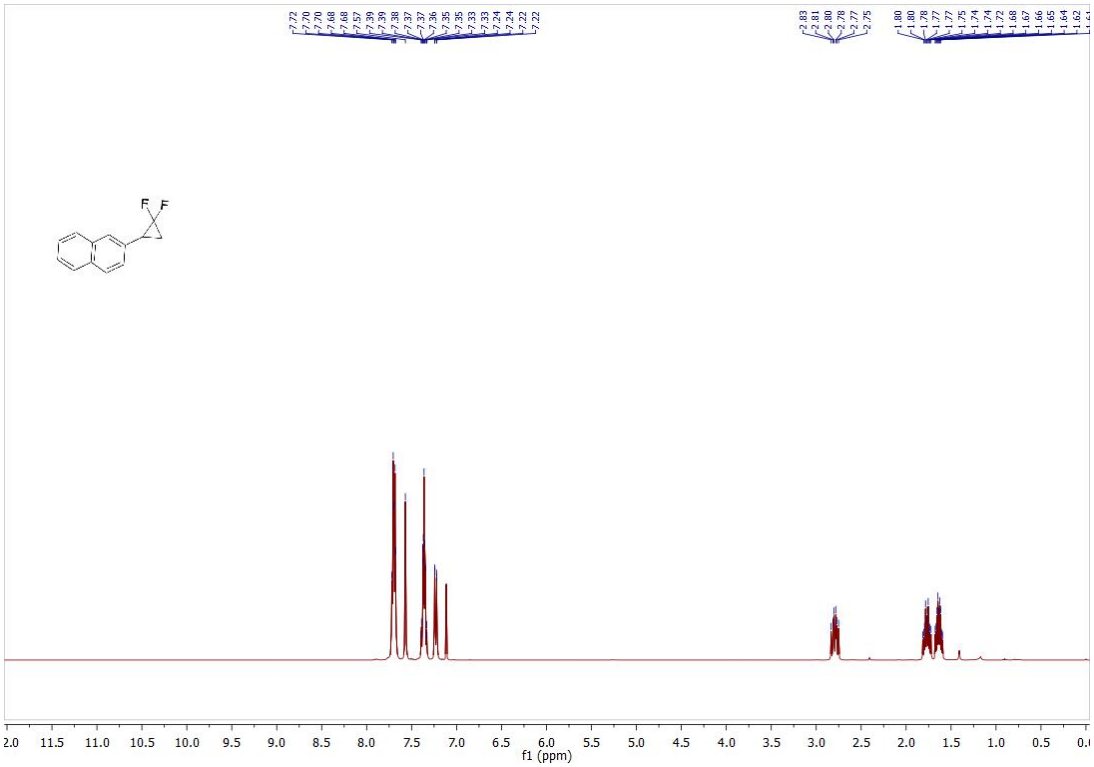

133.68
128.49
128.05
127.19
115.44
112.62
109.77
27.34
27.22
27.11
17.12
17.02
16.91
F
F
f1 (ppm)

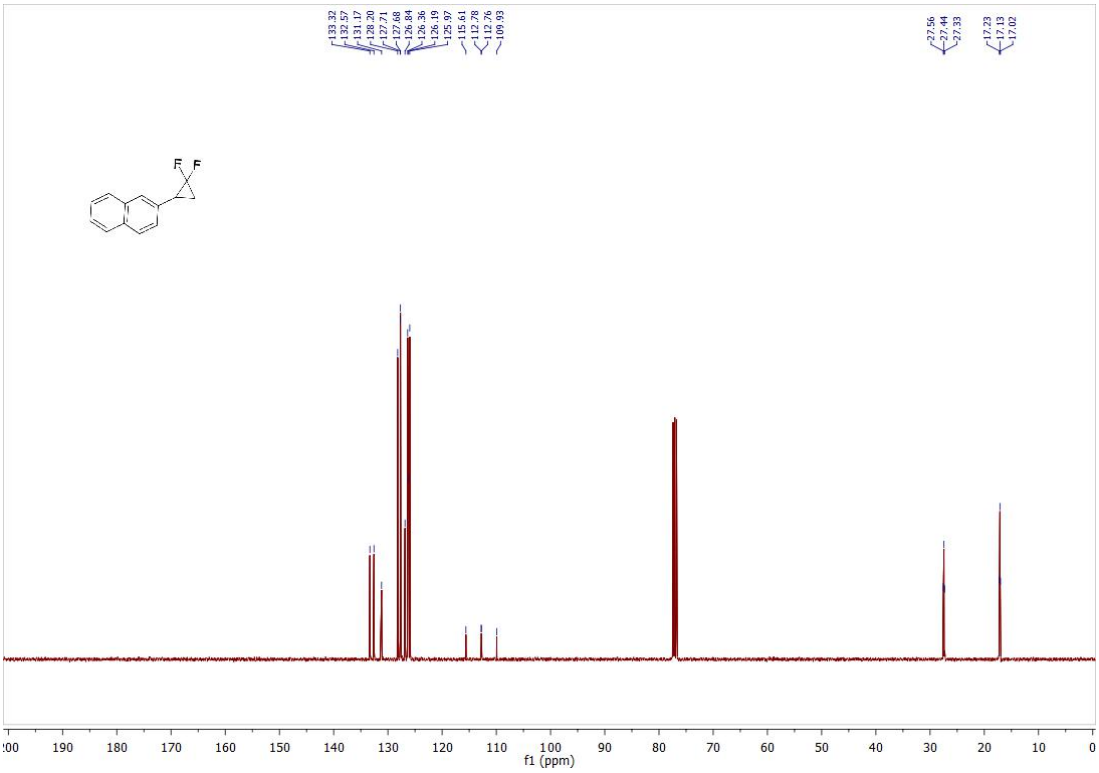

F
F
f1 (ppm)

2-(2,2-difluorocyclopropyl) naphthalene (2c):



(2 g, colorless oil, pure petroleum ether as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.73-7.67 (m, 1H), 7.57 (s, 1H), 7.36 (m, 1H), 7.23 (dd, *J* = 8.5, 1.3 Hz, 1H), 2.84-2.73 (m, 1H), 1.77 (m, 1H), 1.64 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 133.3, 132.5, 131.1, 128.2, 127.7, 127.6, 126.8, 126.3, 126.1, 125.9, 112.7 (dd, *J* = 287.0, 284.2 Hz), 27.4 (t, *J* = 11.4 Hz), 17.1 (t, *J* = 10.5 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -125.53, -141.98.

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132.57
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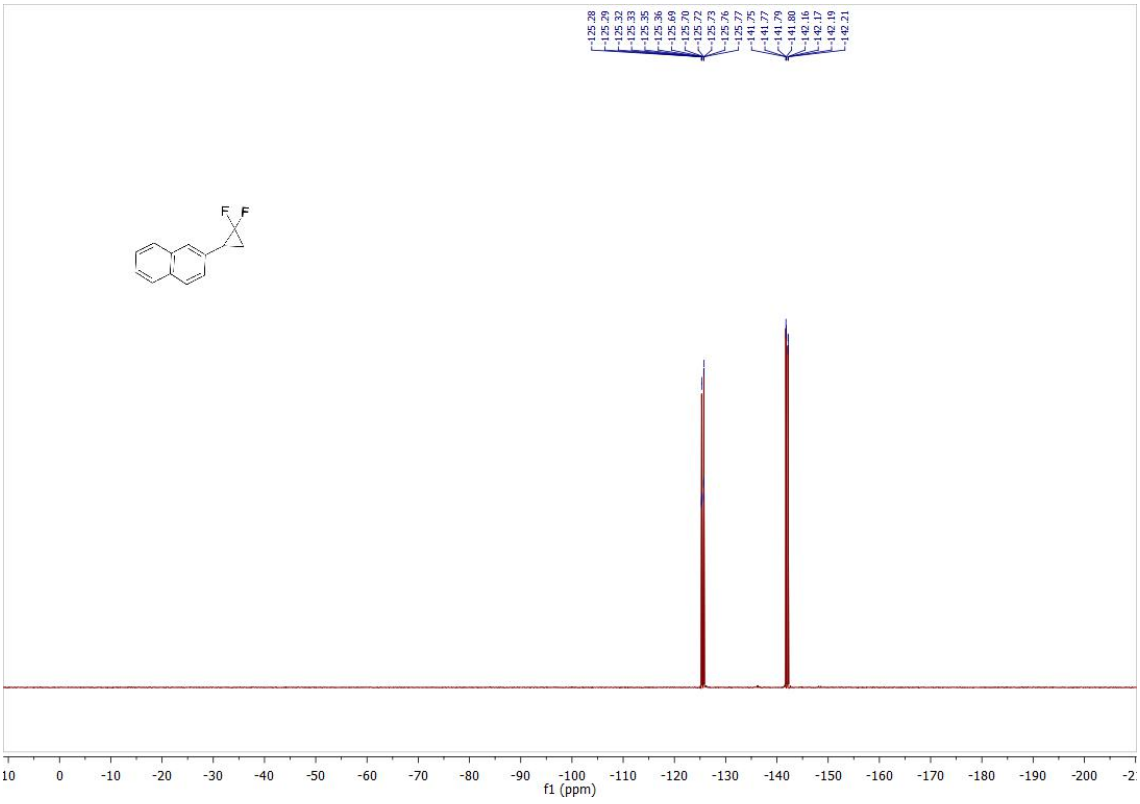
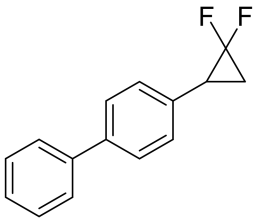
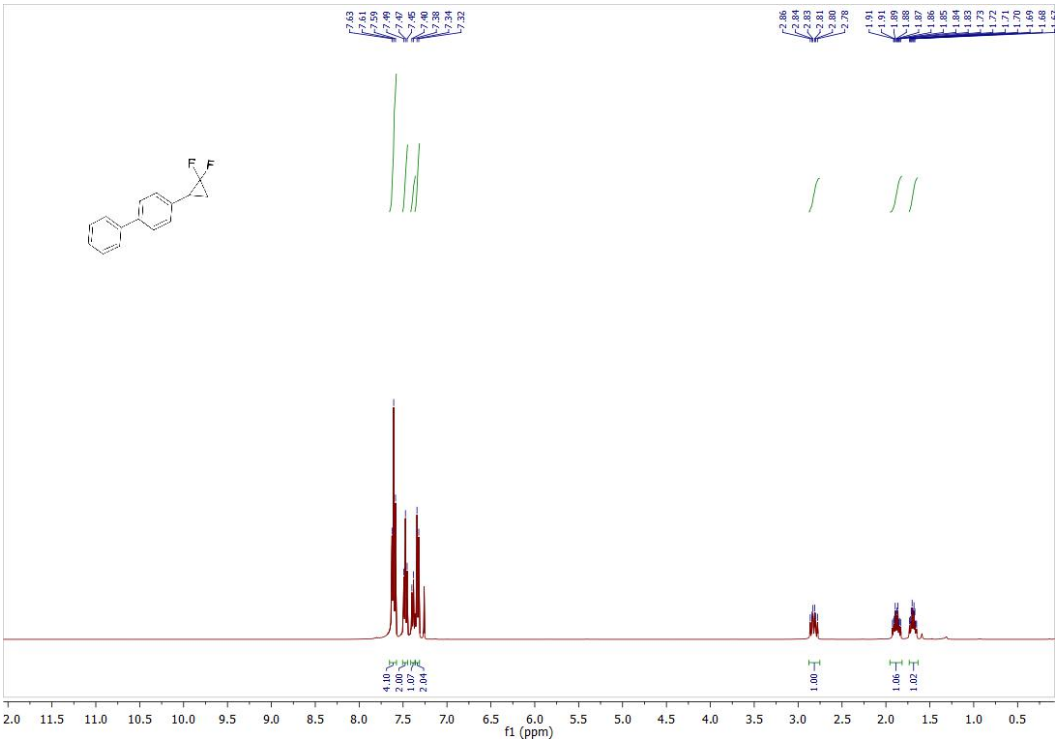
127.71
127.68
126.84
126.36
126.19
125.97
115.41
112.78
112.76
109.93
27.56
27.44
27.33
17.23
17.13
17.02
F
F
f1 (ppm)

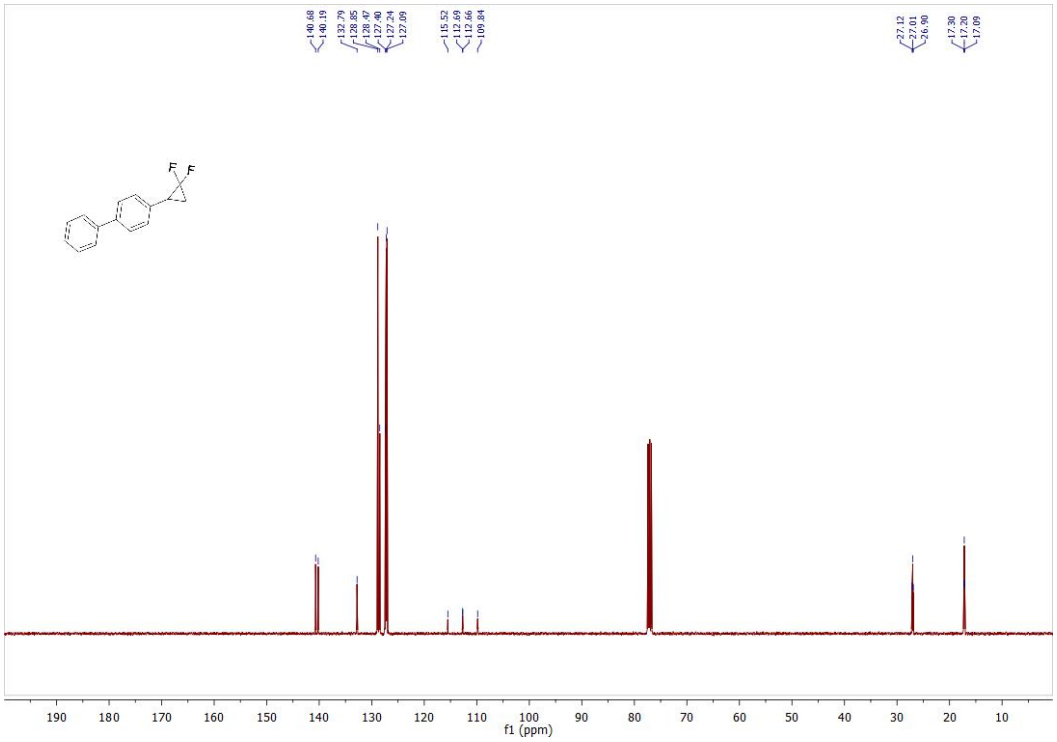

125.28
125.29
125.32
125.33
125.35
125.36
125.69
125.70
125.72
125.73
125.76
125.77
141.75
141.77
141.79
141.80
142.16
142.17
142.19
142.21
F
F
f1 (ppm)

4-(2,2-difluorocyclopropyl)-1,1'-biphenyl (2d):



(2 g, white solid, pure petroleum ether as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.61 (t, *J* = 8.0 Hz, 4H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.39 (d, *J* = 7.3 Hz, 1H), 7.33 (d, *J* = 8.1 Hz, 2H), 2.82 (td, *J* = 12.5, 8.2 Hz, 1H), 1.88 (m, 1H), 1.69 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 140.6, 140.1, 132.7, 128.8, 128.4, 127.4, 127.2, 127.0, 112.6 (dd, *J* = 287.1, 284.1 Hz), 27.0 (t, *J* = 11.5 Hz), 17.2 (t, *J* = 10.5 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -125.70, -142.16.

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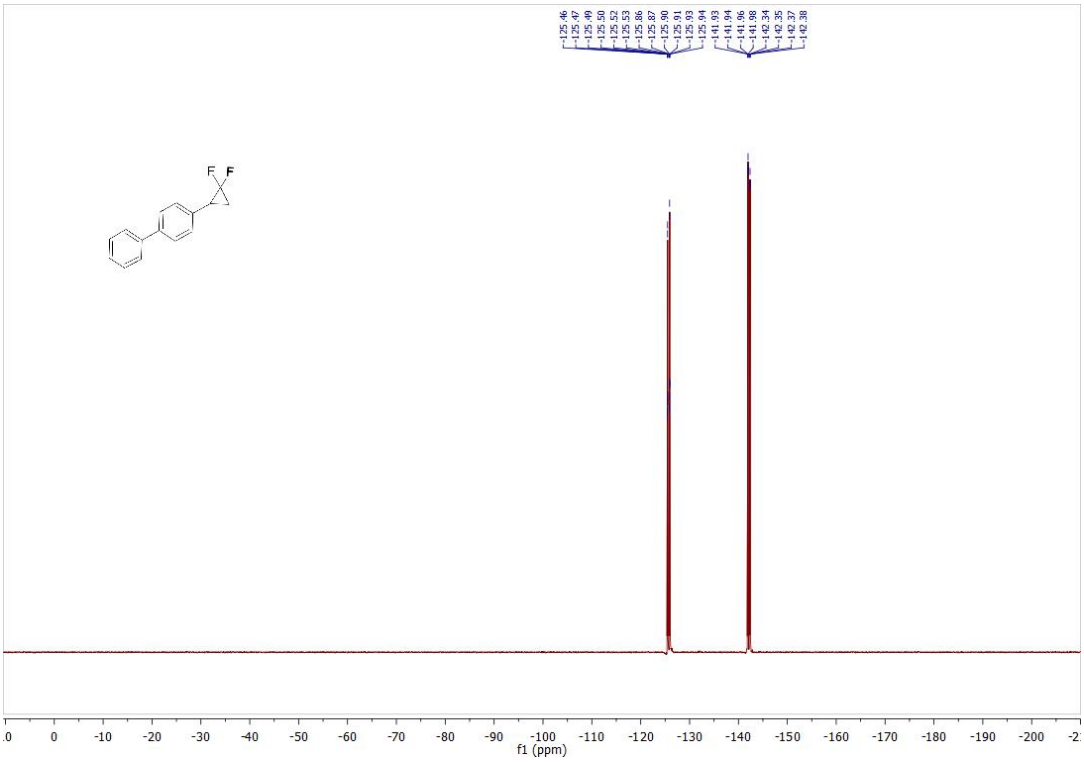
127.09
115.52
112.69
112.66
109.84
27.12
27.01
26.90
17.30
17.20
17.09
F
F
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)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125.47
125.49
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125.52
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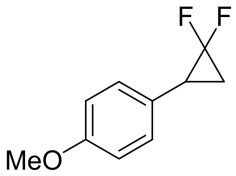
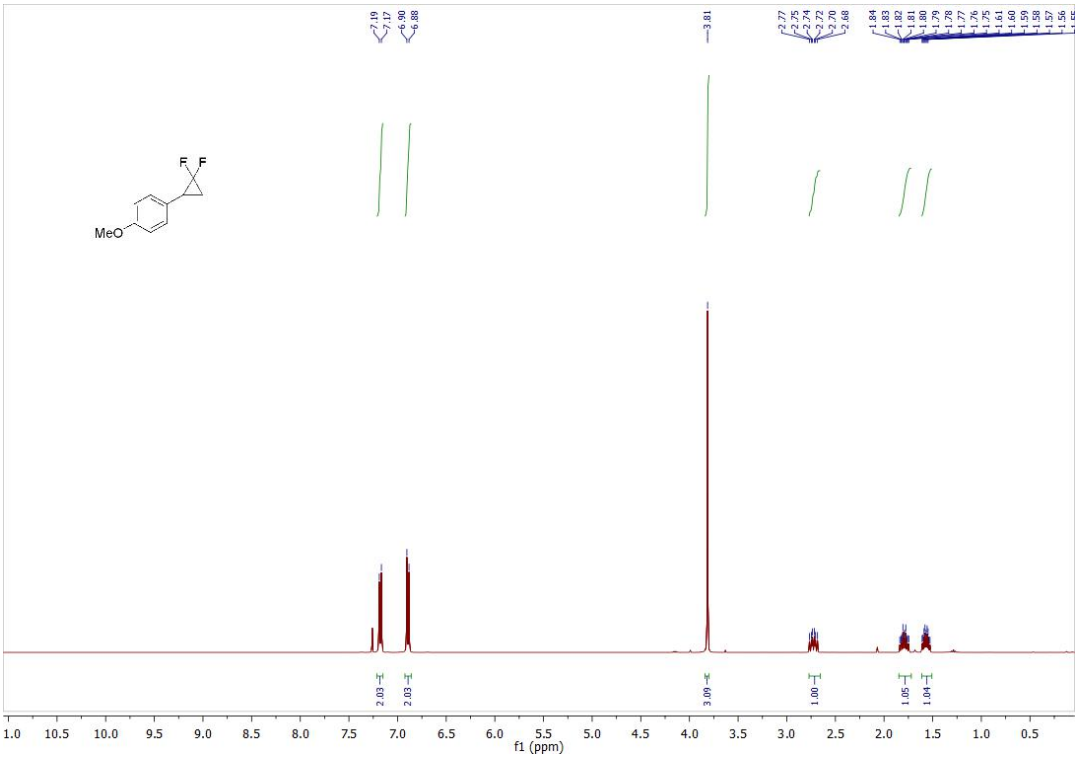
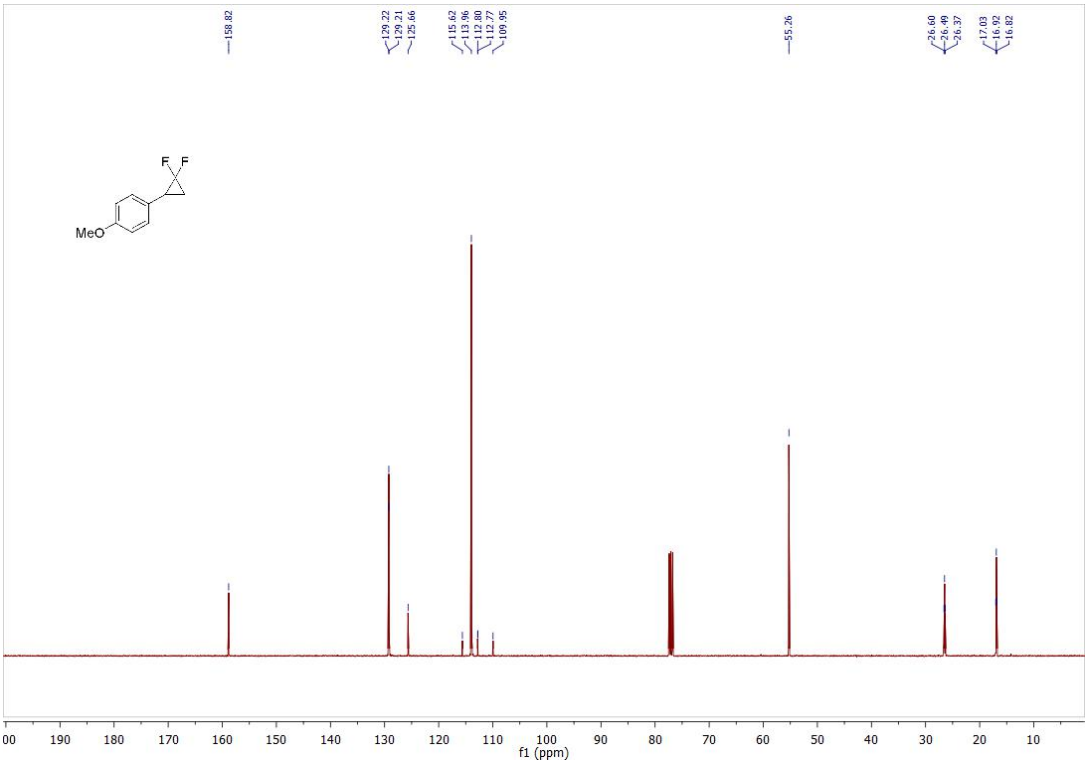
125.87
125.90
125.91
125.93
125.94
141.93
141.94
141.96
141.98
142.34
142.35
142.37
142.38
F
F
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)

1-(2,2-difluorocyclopropyl)-4-methoxybenzene (2e):



(1.7 g, colorless oil, petroleum ether /ethyl acetate 50: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.18 (d, *J* = 8.6 Hz, 2H), 6.89 (d, *J* = 8.7 Hz, 2H), 3.81 (s, 3H), 2.78-2.67 (m, 1H), 1.79 (m, 1H), 1.57 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.8, 129.2 (d, *J* = 1.3 Hz), 125.6, 113.9, 112.7 (dd, *J* = 286.6, 283.7 Hz), 55.2, 26.4 (t, *J* = 11.5 Hz), 16.9 (t, *J* = 10.5 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -126.17, -142.33.

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113.96
112.80
112.77
109.95
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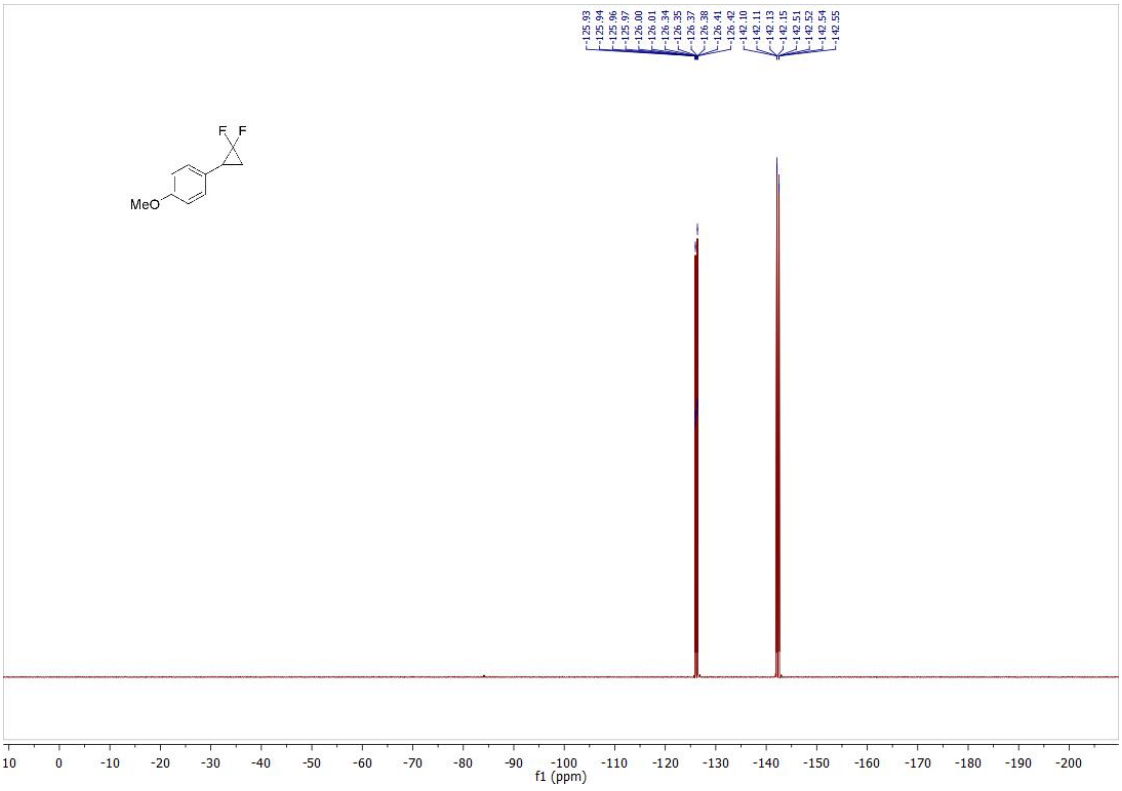
26.37
17.03
16.92
16.82
F
F
MeO
f1 (ppm)


-125.93
-125.94
-125.96
-125.97
-126.00
-126.01
-126.34
-126.35
-126.37
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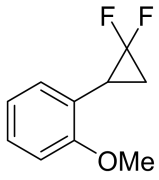
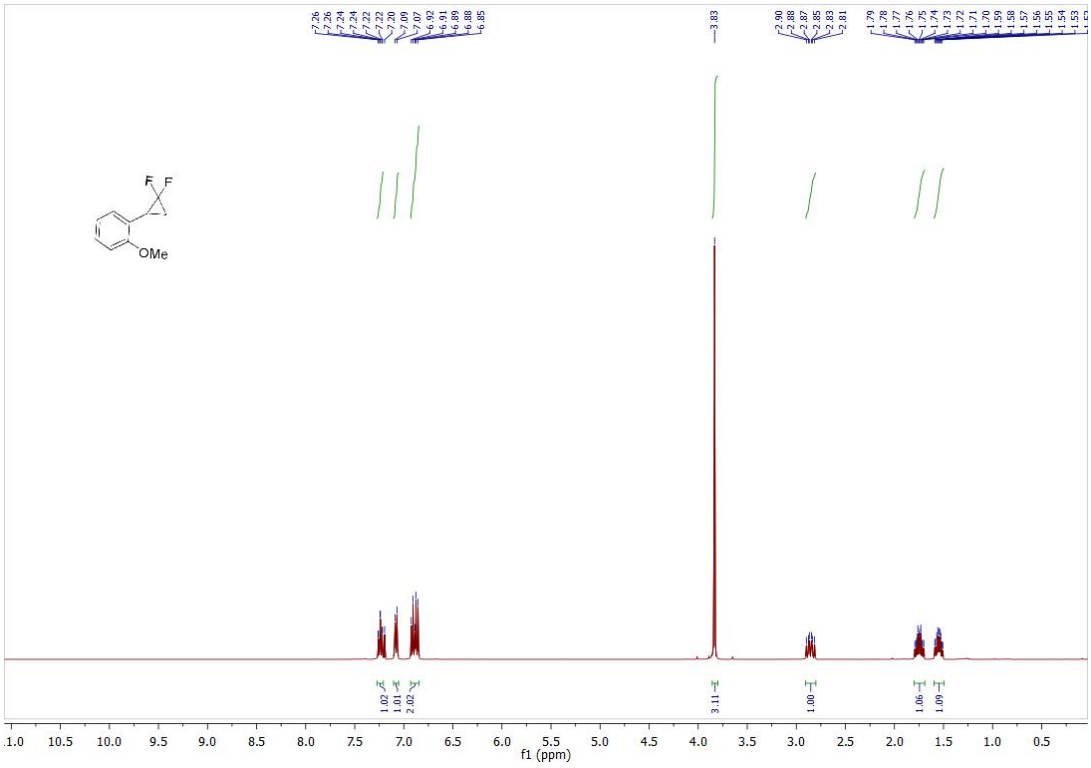
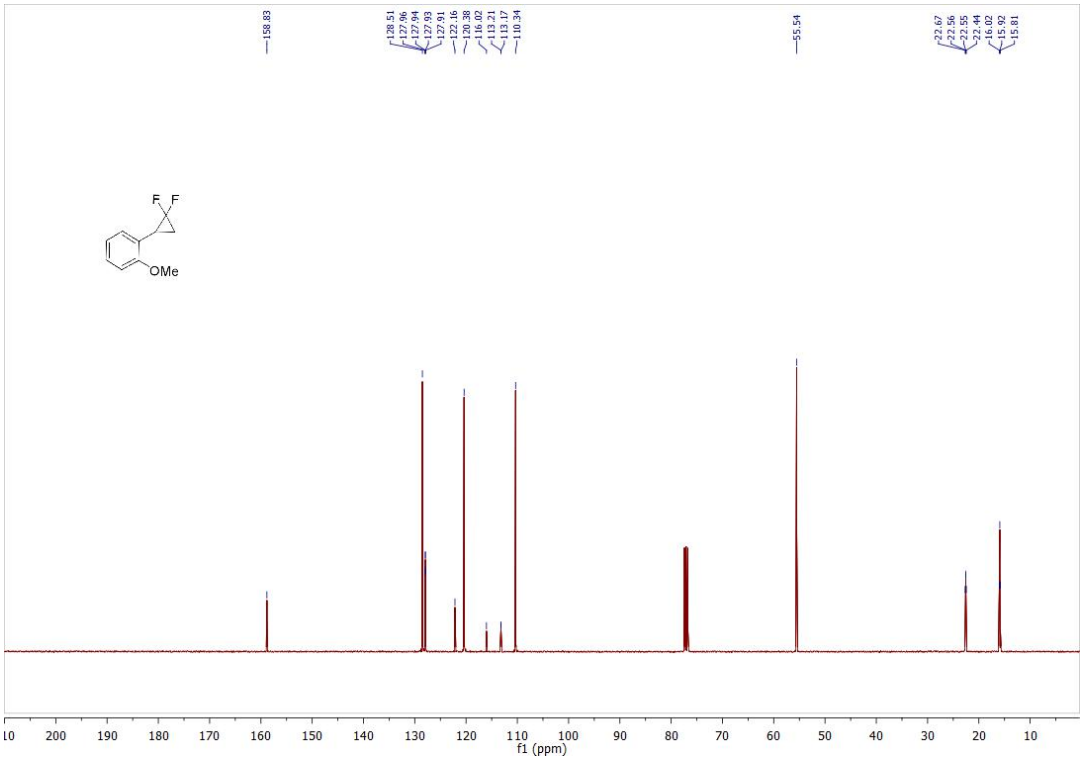
-126.41
-126.42
-142.10
-142.11
-142.13
-142.15
-142.51
-142.52
-142.54
-142.55
F
F
MeO
f1 (ppm)

1-(2,2-difluorocyclopropyl)-2-methoxybenzene (2f):



(1.5 g, colorless oil, petroleum ether /ethyl acetate 50: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.27-7.17 (m, 1H), 7.08 (d, *J* = 7.5 Hz, 1H), 6.94-6.79 (m, 2H), 3.83 (s, 3H), 2.91-2.79 (m, 1H), 1.80-1.68 (m, 1H), 1.61-1.48 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.8, 128.5, 127.9 (dd, *J* = 2.9, 2.1 Hz), 122.1, 120.3, 113.2 (dd, *J* = 285.6, 282.7 Hz), 110.3, 55.5, 22.5 (dd, *J* = 11.9, 10.9 Hz), 15.9 (t, *J* = 10.6 Hz). ^{19}F NMR (376 MHz, $CDCl_3$) δ -126.82, -142.07.

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128.51
127.96
127.94
127.93
127.91
123.16
120.38
116.02
113.21
113.17
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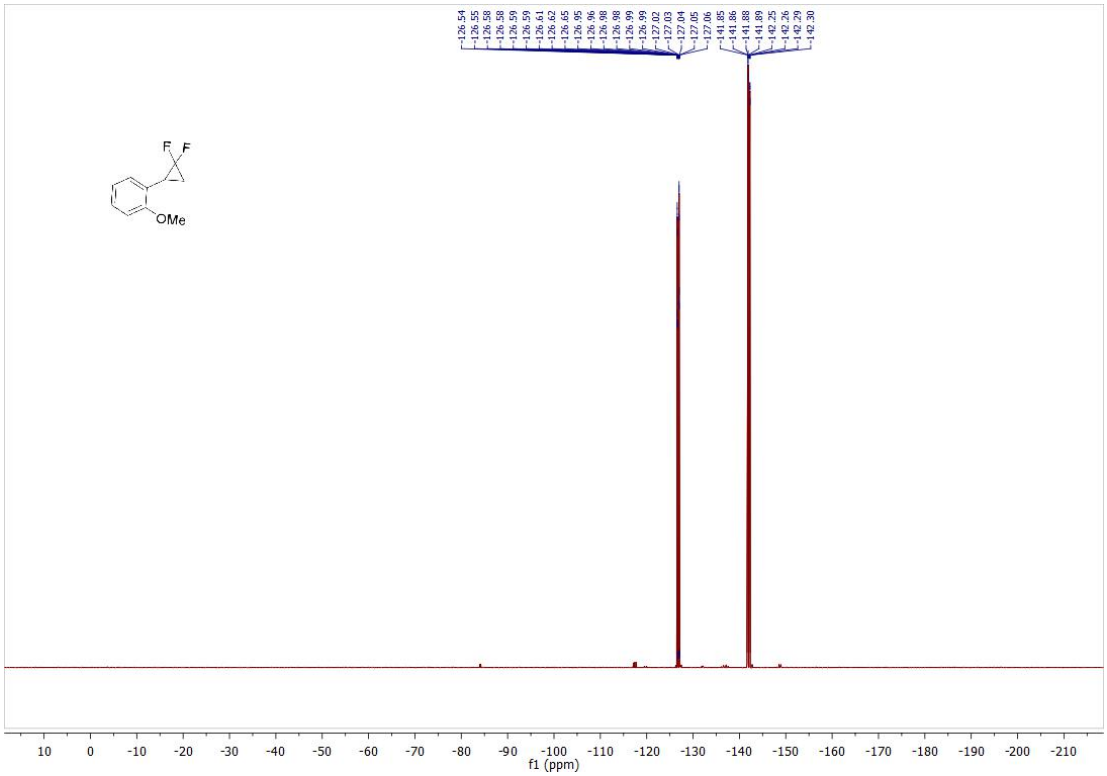
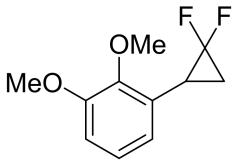
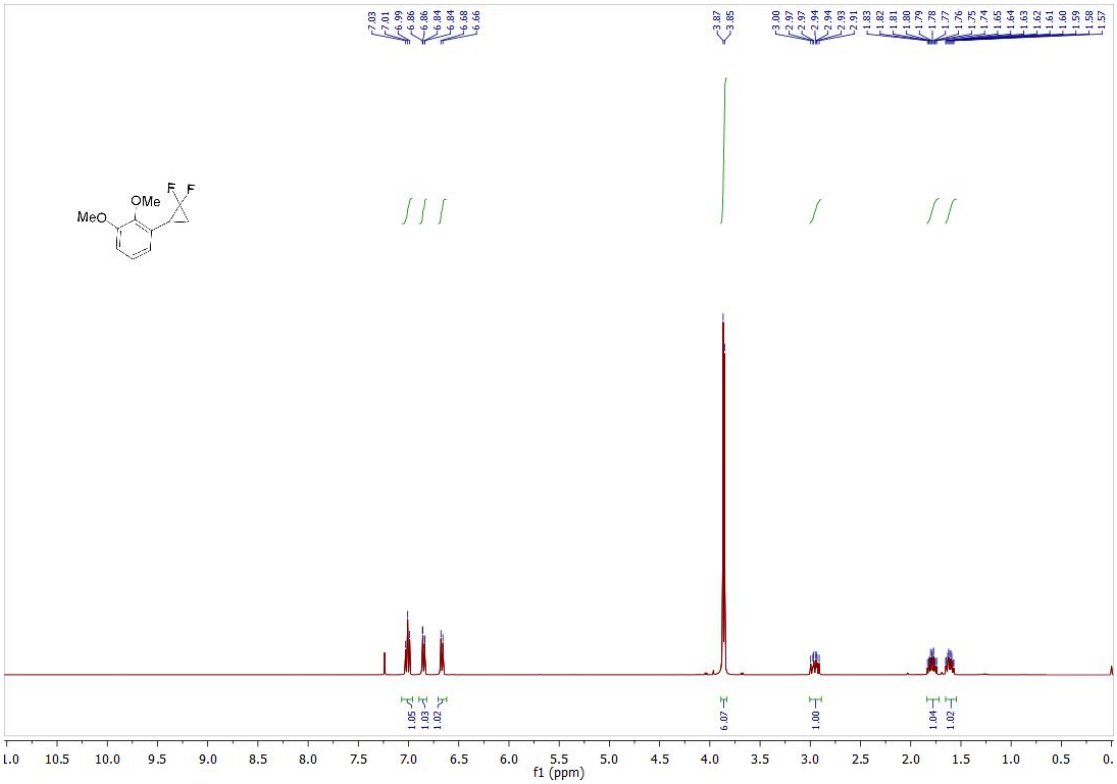
22.67
22.56
22.55
22.44
16.02
15.92
15.61
F F
OMe
f1 (ppm)

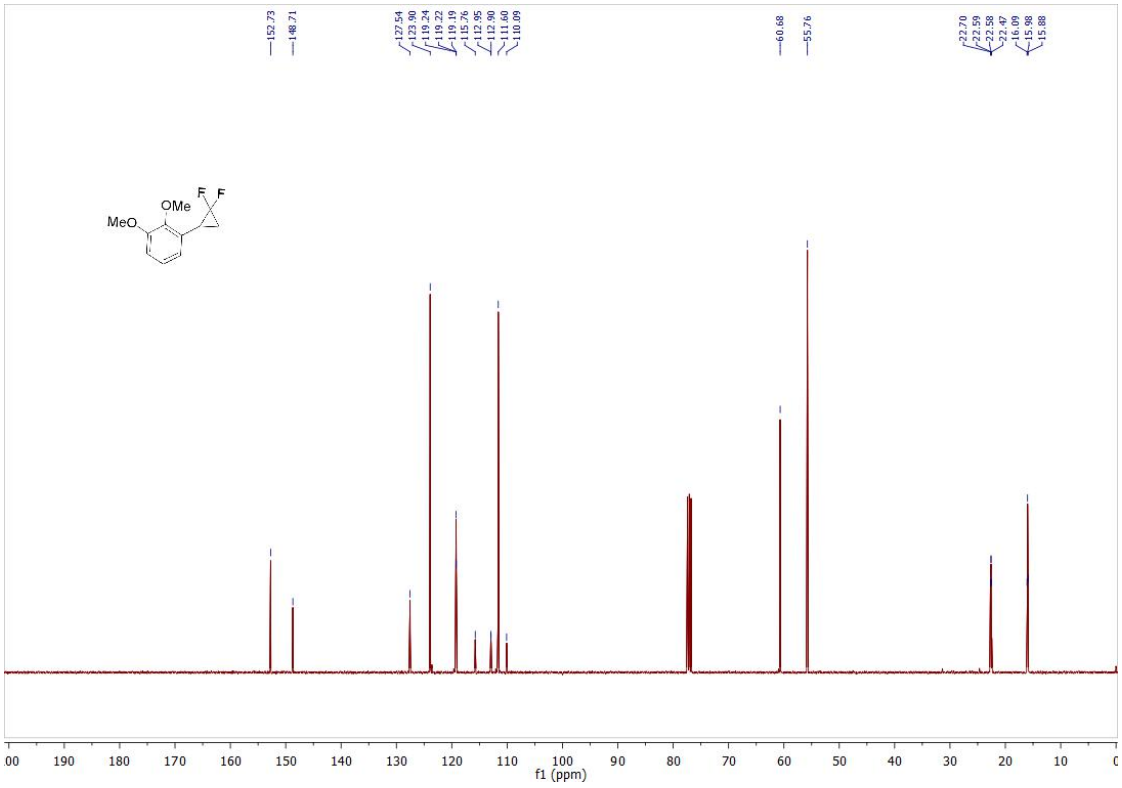

F F
OMe
f1 (ppm)

1-(2,2-difluorocyclopropyl)-2,3-dimethoxybenzene (2g):



(1.6 g, colorless oil, petroleum ether /ethyl acetate 50: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.01 (t, *J* = 8.0 Hz, 1H), 6.85 (dd, *J* = 8.2, 1.0 Hz, 1H), 6.67 (d, *J* = 7.8 Hz, 1H), 3.86 (d, *J* = 5.7 Hz, 6H), 3.02-2.89 (m, 1H), 1.85-1.71 (m, 1H), 1.66-1.55 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 152.7, 148.7, 127.5, 123.9, 120.1, 112.9 (dd, *J* = 287.5, 282.7 Hz), 111.6, 60.6, 55.7, 22.5 (dd, *J* = 12.0, 11.0 Hz), 15.9 (t, *J* = 10.6 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -125.82, -141.60.

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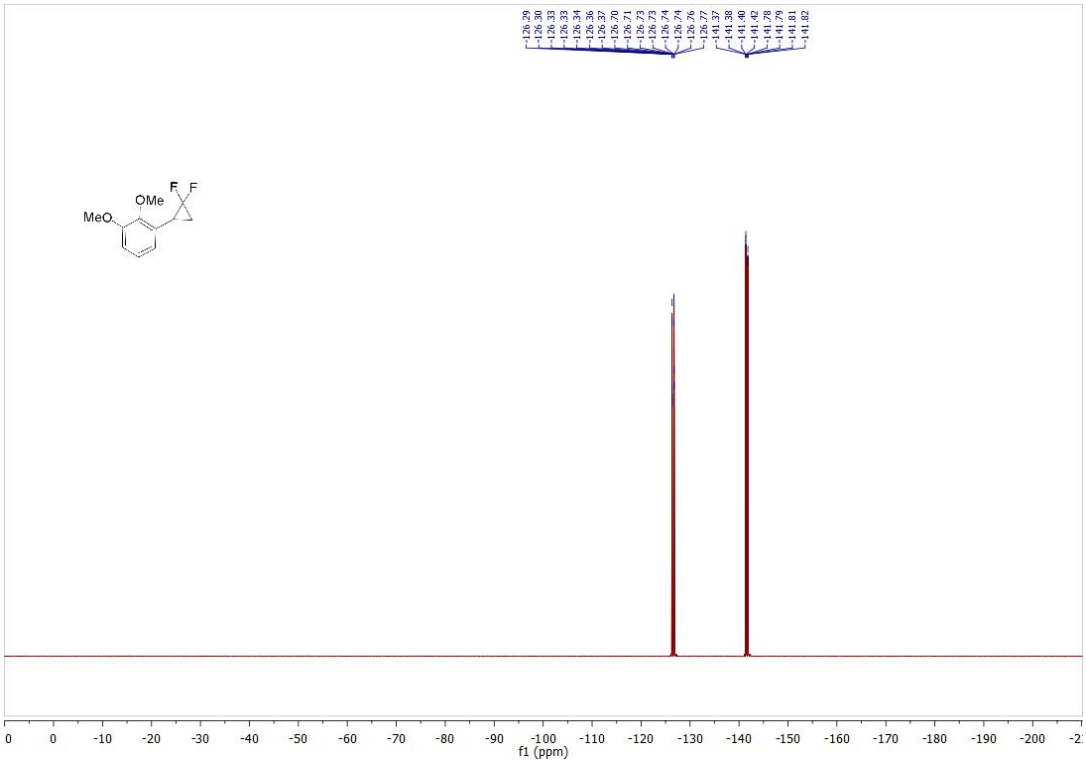
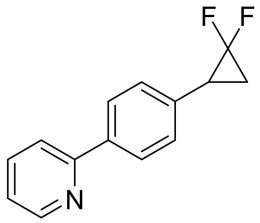
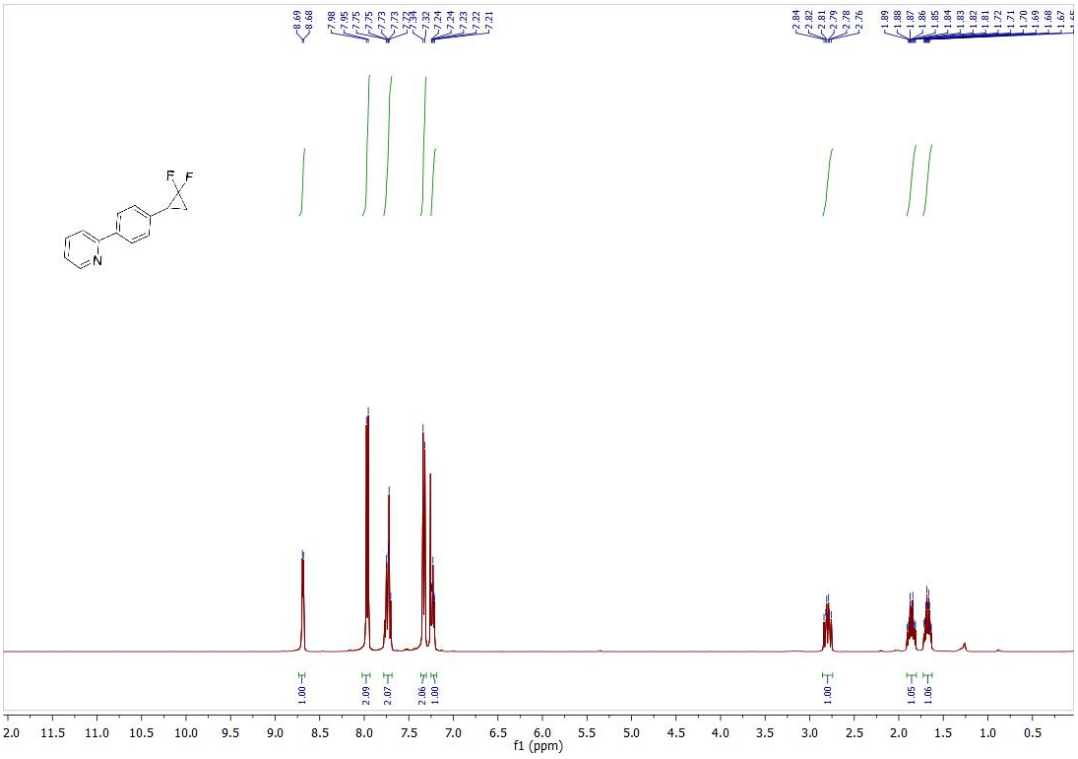
127.54
123.90
119.24
119.22
119.19
115.76
112.95
112.90
111.60
110.09
60.68
55.76
22.70
22.59
22.58
22.47
16.09
15.98
15.88
OMe
MeO
F
F
f1 (ppm)

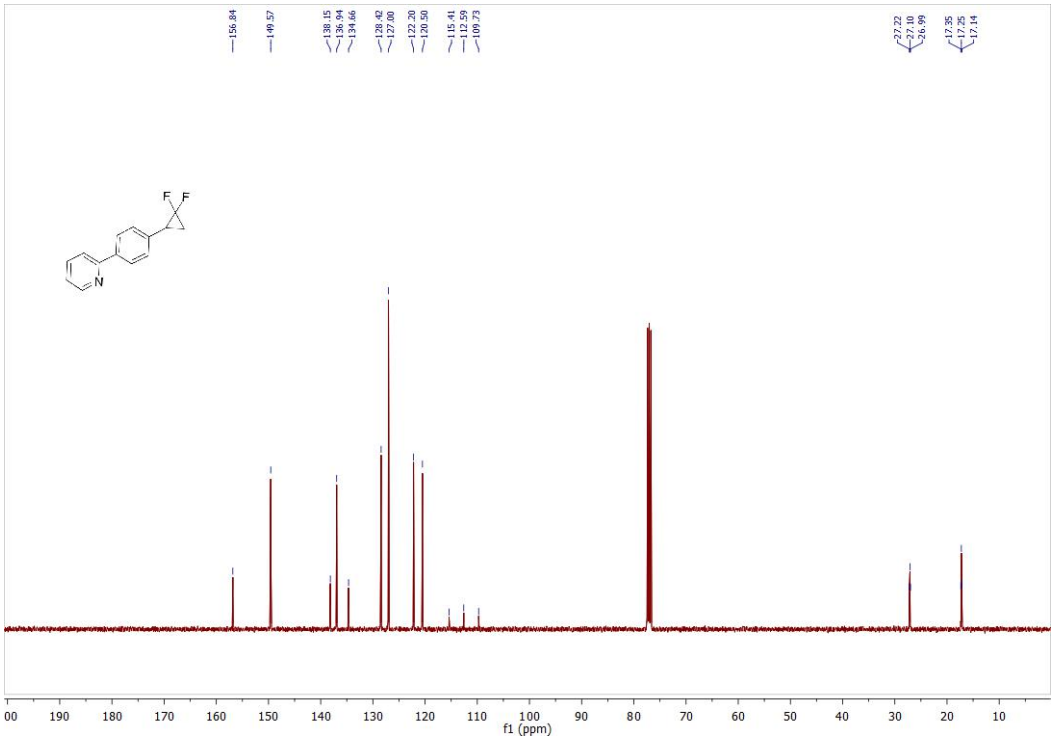

OMe
MeO
F
F
f1 (ppm)

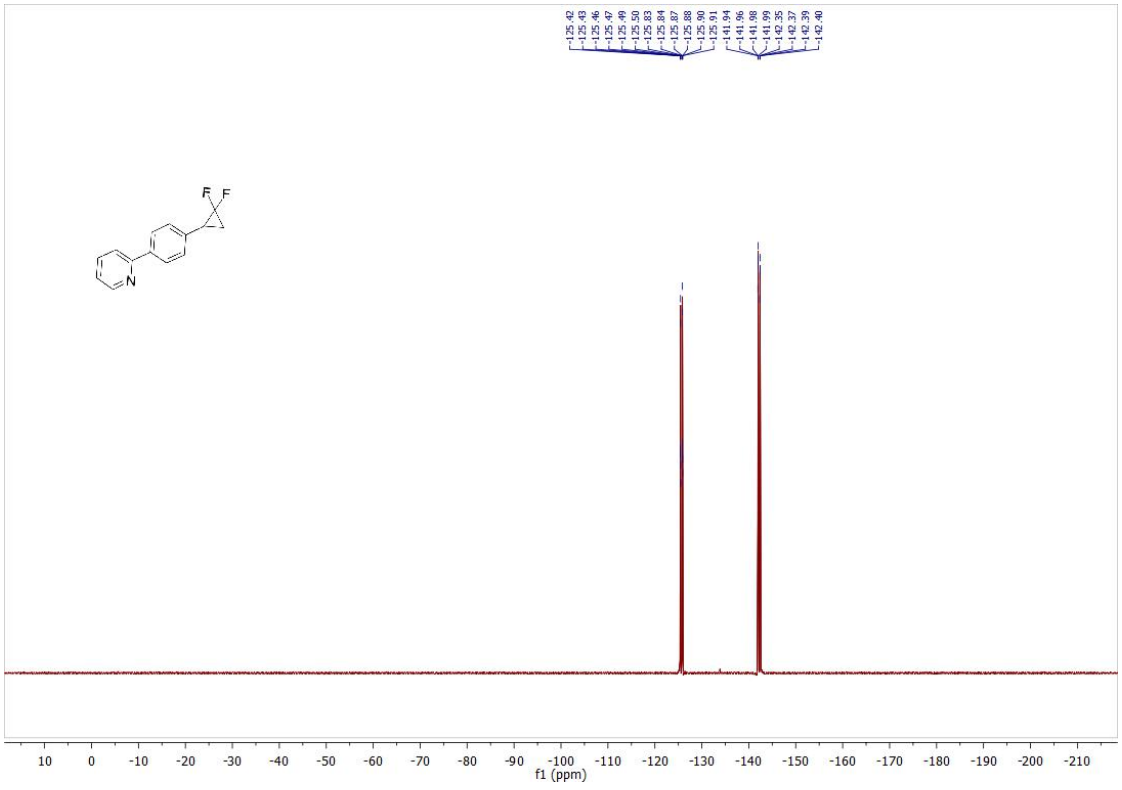
2-(4-(2,2-difluorocyclopropyl) phenyl) pyridine (2h):



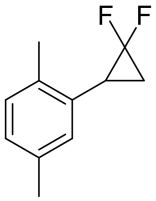
(1.9 g, brown solid, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.69 (d, *J* = 4.7 Hz, 1H), 7.97 (d, *J* = 8.2 Hz, 2H), 7.73 (dt, *J* = 10.6, 4.2 Hz, 2H), 7.33 (d, *J* = 8.2 Hz, 2H), 7.25-7.19 (m, 1H), 2.80 (td, *J* = 12.4, 8.2 Hz, 1H), 1.92-1.79 (m, 1H), 1.68 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 156.8, 149.5, 138.1, 136.9, 134.6, 128.4, 127.0, 122.2, 120.5, 112.5 (dd, *J* = 286.2, 283.1 Hz), 27.1 (t, *J* = 11.5 Hz), 17.2 (t, *J* = 10.5 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -125.67, -142.17.



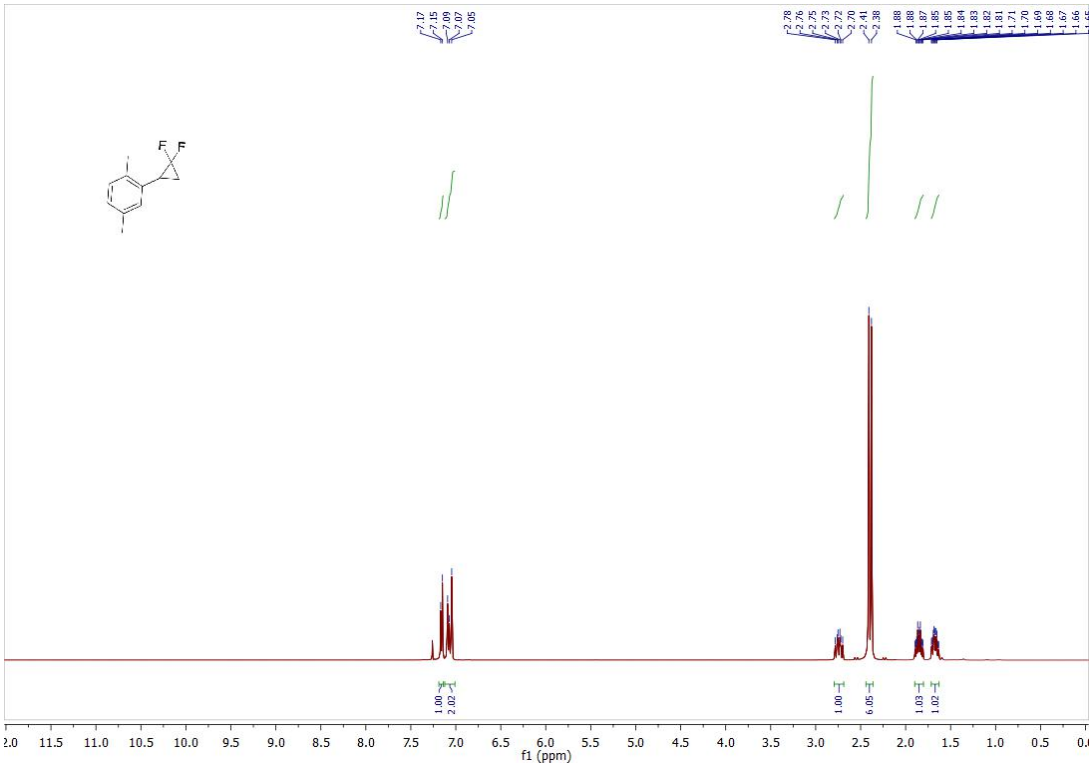

156.84
149.57
138.15
136.94
134.66
128.42
127.00
122.20
120.50
115.41
112.59
109.73
27.22
27.10
26.99
17.35
17.25
17.14
F
F
N
f1 (ppm)

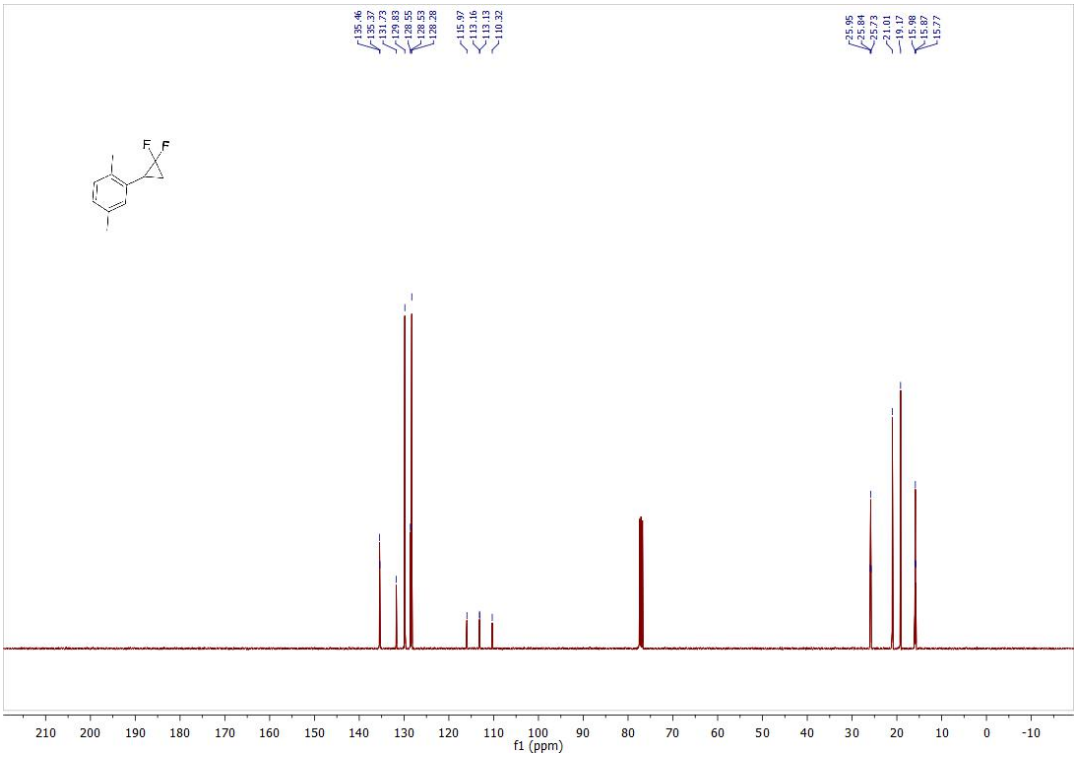

125.42
125.43
125.46
125.47
125.49
125.50
125.83
125.84
125.87
125.88
125.90
125.91
141.94
141.96
141.98
141.99
142.35
142.37
142.39
142.40
F
F
N
f1 (ppm)

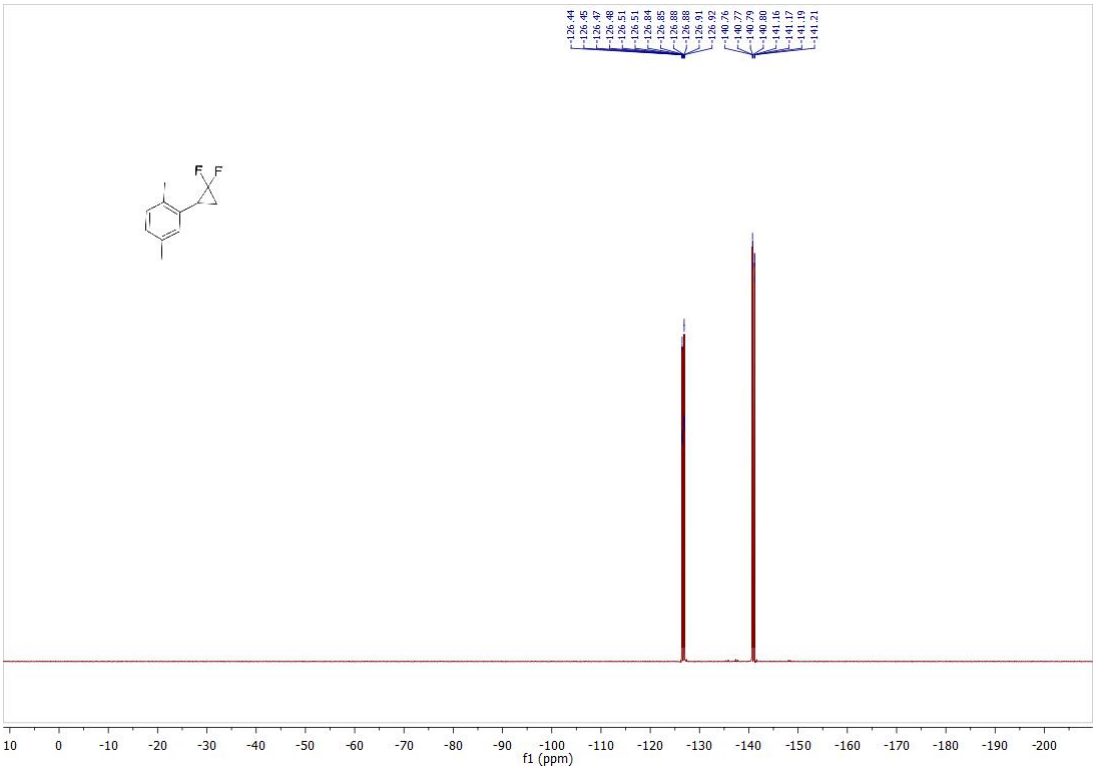
2-(2,2-difluorocyclopropyl)-1,4-dimethylbenzene (2i):



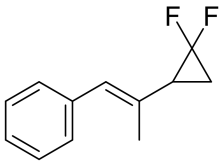
(1.78 g, colorless oil, pure petroleum ether as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.16 (d, *J* = 7.6 Hz, 1H), 7.10-7.03 (m, 2H), 2.74 (td, *J* = 12.4, 8.5 Hz, 1H), 2.41 (s, 3H), 2.38 (s, 3H), 1.90-1.79 (m, 1H), 1.72-1.62 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 135.4 (d, *J* = 8.6 Hz), 131.7, 129.8, 128.5 (d, *J* = 2.7 Hz), 128.2, 113.1 (dd, *J* = 285.7, 282.7 Hz), 25.8 (t, *J* = 11.2 Hz), 21.0, 19.1, 15.8 (t, *J* = 10.6 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -125.95, -140.98.



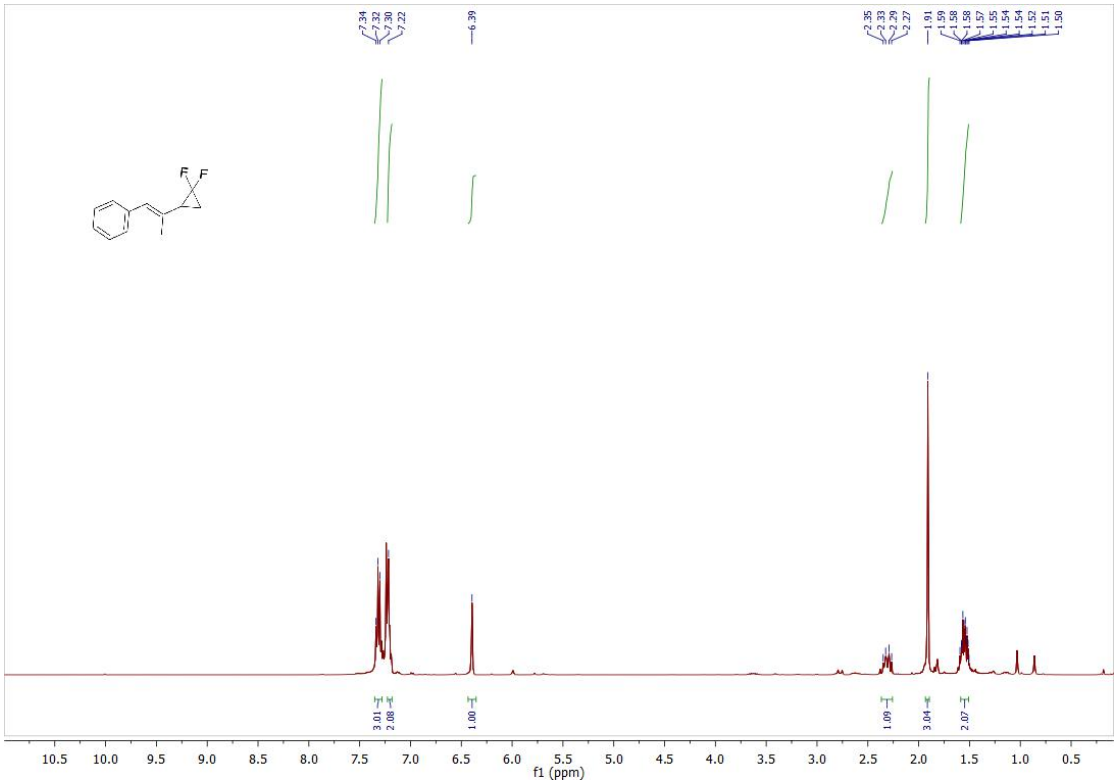

135.46
135.37
131.73
129.83
128.55
128.53
128.28
115.97
113.16
113.13
110.32
25.95
25.84
25.73
21.01
19.17
15.98
15.87
15.77
F
F
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

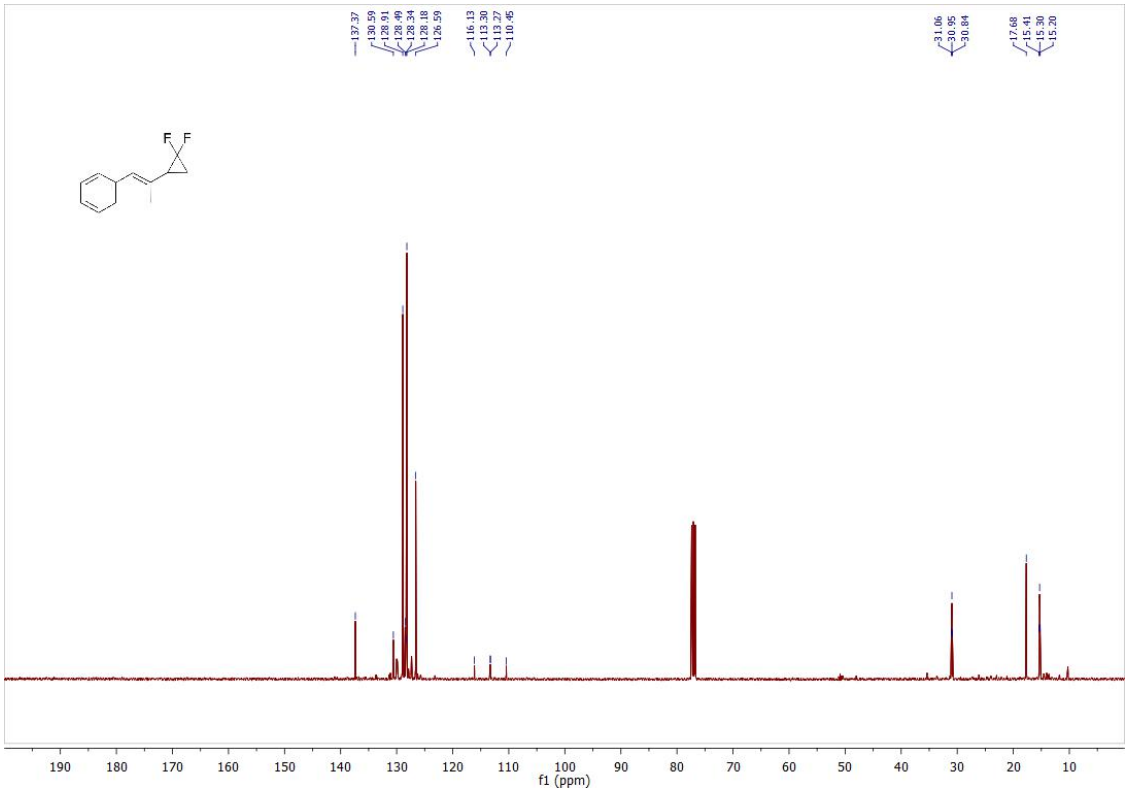

126.44
126.45
126.47
126.48
126.51
126.51
126.84
126.85
126.88
126.88
126.91
126.92
140.76
140.77
140.79
140.80
141.16
141.17
141.19
141.21
F
F
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)

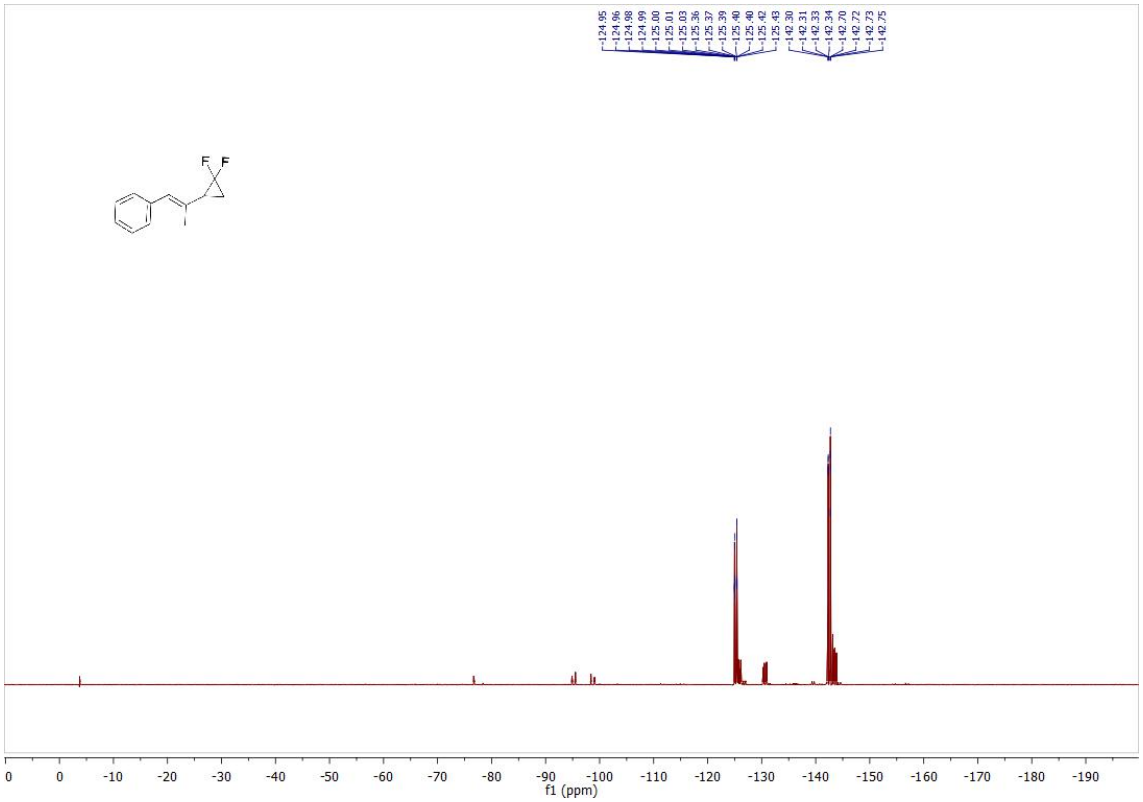
(E)-(2-(2,2-difluorocyclopropyl) prop-1-en-1-yl) benzene (2j):



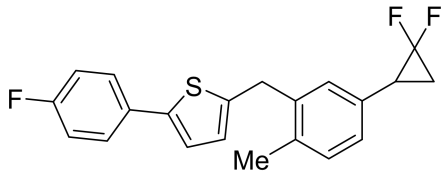
(1.5 g, colorless oil, pure petroleum ether as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.32 (t, *J* = 7.6 Hz, 3H), 7.22 (s, 2H), 6.39 (s, 1H), 2.31 (dd, *J* = 23.3, 9.9 Hz, 1H), 1.91 (s, 3H), 1.60-1.48 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 137.3, 130.5, 129.9 (d, *J* = 14.8 Hz), 128.9, 128.4, 128.1, 127.3 (d, *J* = 5.6 Hz), 126.5, 113.2 (dd, *J* = 287.1, 284.3 Hz), 30.9 (t, *J* = 10.9 Hz), 17.6, 15.3 (t, *J* = 10.4 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -123.93, -142.52.



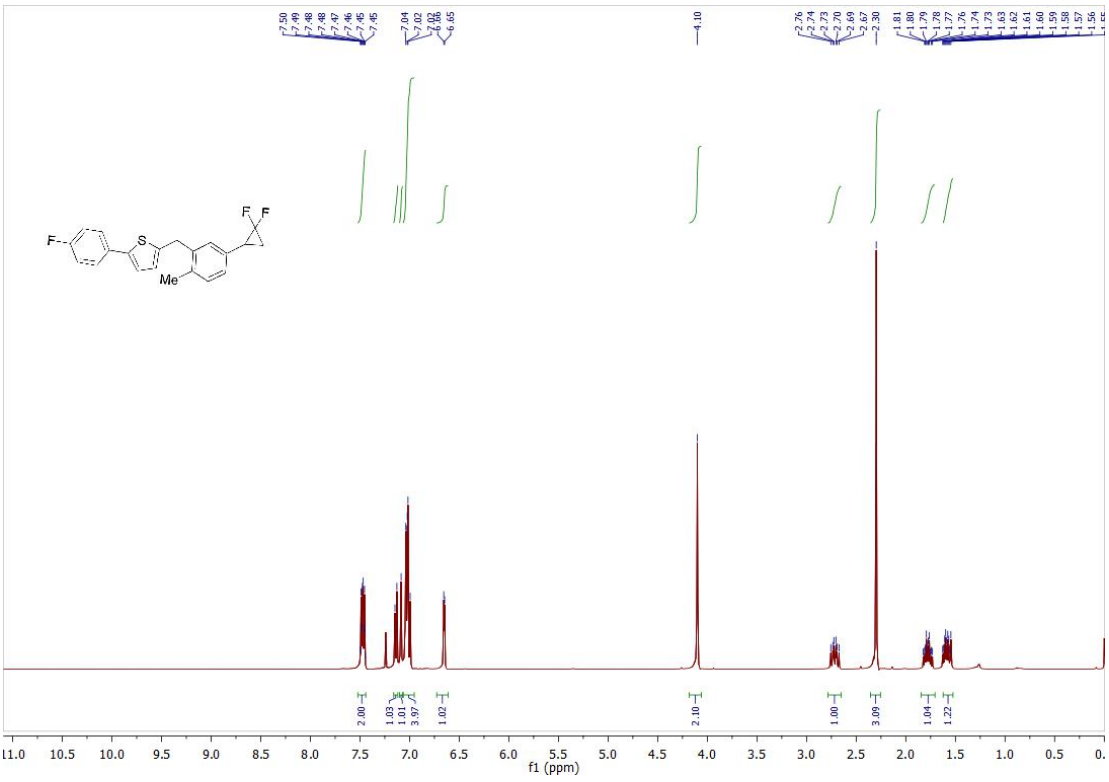

137.37
130.59
128.91
128.49
128.34
128.18
126.59
116.13
113.30
113.27
110.45
31.06
30.95
30.84
17.68
15.41
15.30
15.20
F F
f1 (ppm)

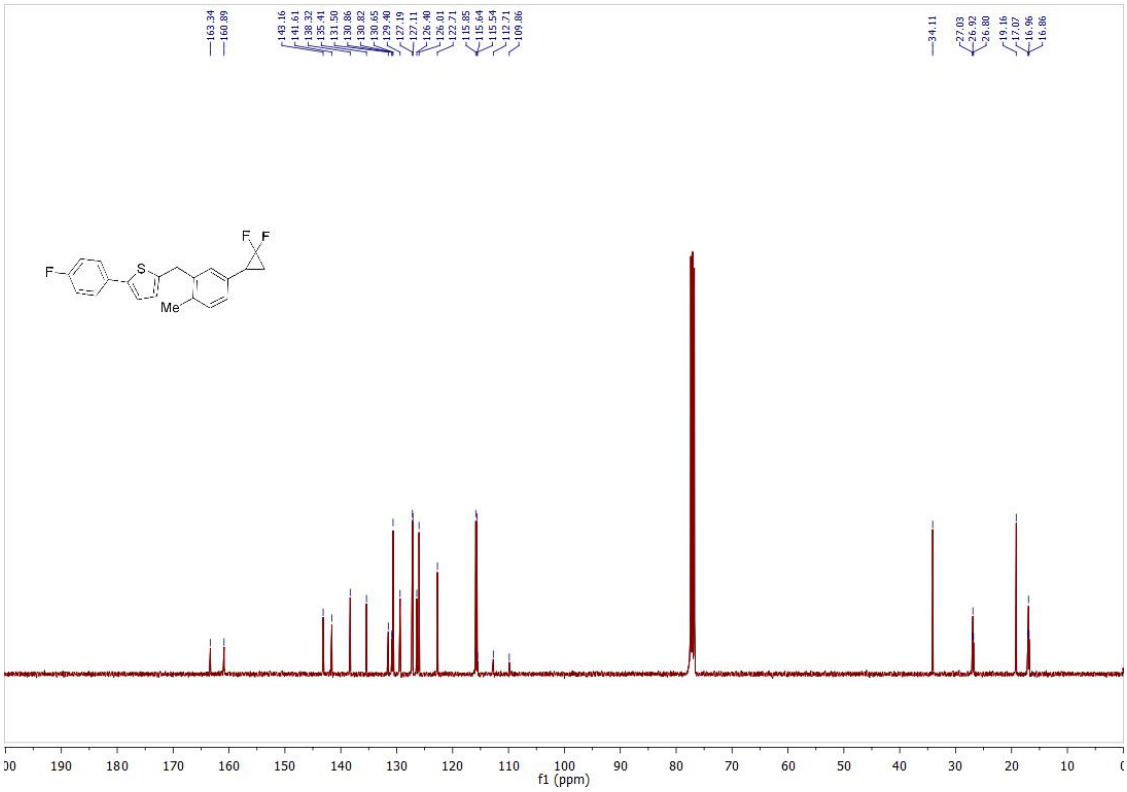

-124.95
-124.96
-124.98
-124.99
-125.00
-125.01
-125.03
-125.36
-125.37
-125.39
-125.40
-125.42
-125.43
-142.30
-142.31
-142.33
-142.34
-142.70
-142.72
-142.73
-142.75
F F
f1 (ppm)

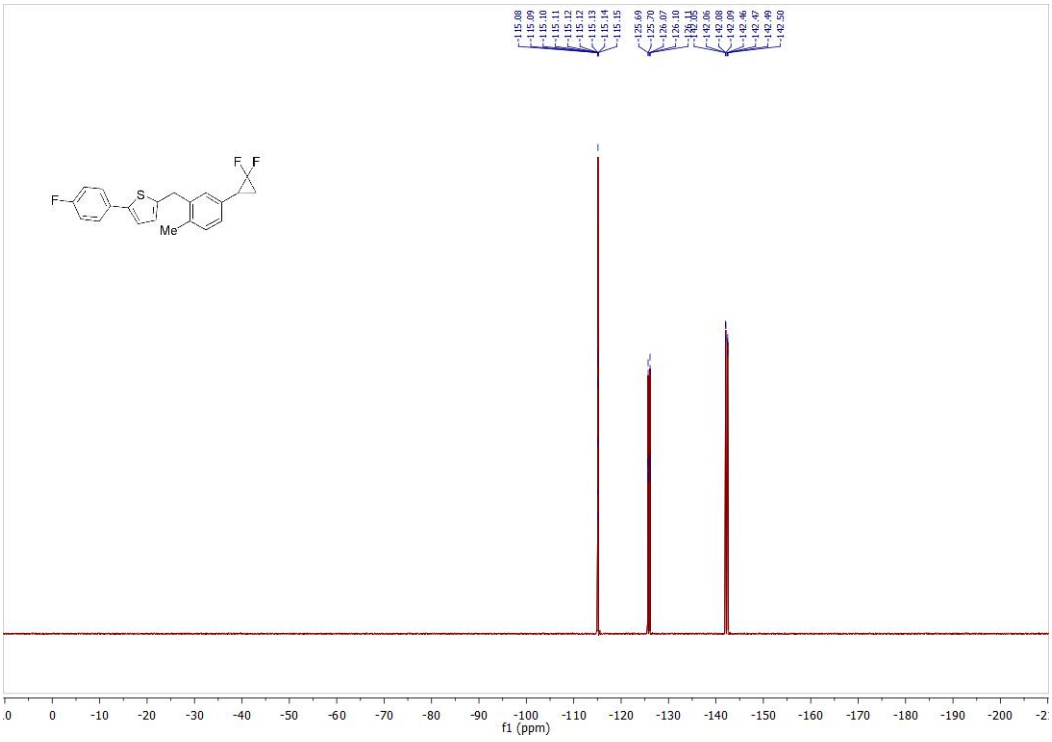
2-(5-(2,2-difluorocyclopropyl)-2-methylbenzyl)-5-(4-fluorophenyl)thiophene (2k):



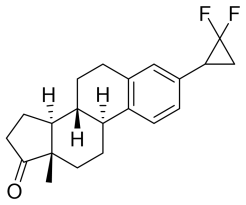
(2.8 g, white solid, petroleum ether /ethyl acetate 50: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.50-7.44 (m, 2H), 7.14 (d, *J* = 7.8 Hz, 1H), 7.09 (s, 1H), 7.06-6.98 (m, 4H), 6.65 (d, *J* = 3.6 Hz, 1H), 4.10 (s, 2H), 2.79-2.64 (m, 1H), 2.30 (s, 3H), 1.78 (tdd, *J* = 12.4, 7.8, 4.9 Hz, 1H), 1.65-1.51 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.1 (d, *J* = 246.7 Hz), 143.1, 141.6, 138.3, 135.4, 131.5, 130.8 (d, *J* = 3.3 Hz), 130.6, 129.4, 127.1 (d, *J* = 8.0 Hz), 126.4, 126.0, 122.7, 115.7 (d, *J* = 21.7 Hz), 112.7 (dd, *J* = 286.9, 284.0 Hz)., 34.1, 26.9 (t, *J* = 11.4 Hz), 19.1, 16.9 (t, *J* = 10.5 Hz). **^{19}F NMR** (377 MHz, $CDCl_3$) δ -115.12, -125.90, -142.27.



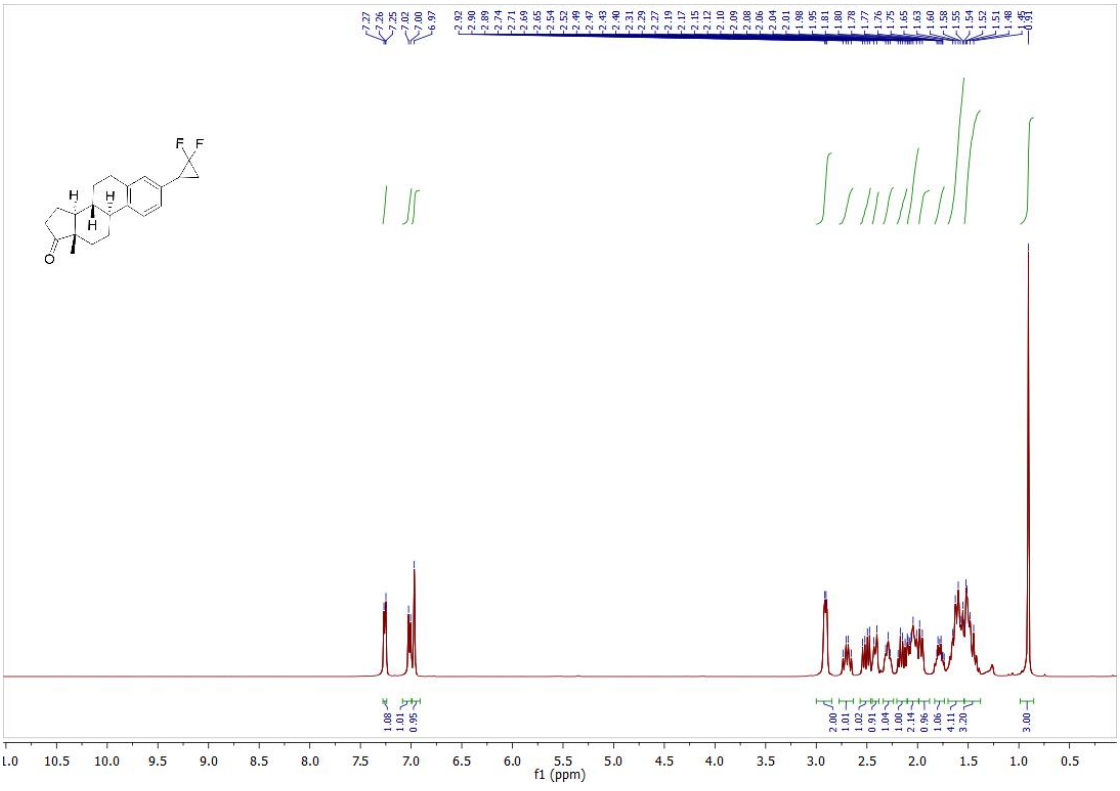

163.34
160.89
148.16
141.61
138.32
135.41
131.50
130.86
130.82
130.65
129.40
127.19
127.11
126.40
126.01
122.71
115.85
115.64
115.54
112.71
109.86
34.11
27.03
26.92
26.80
19.16
17.07
16.96
16.86
F
S
Me
F F
f1 (ppm)

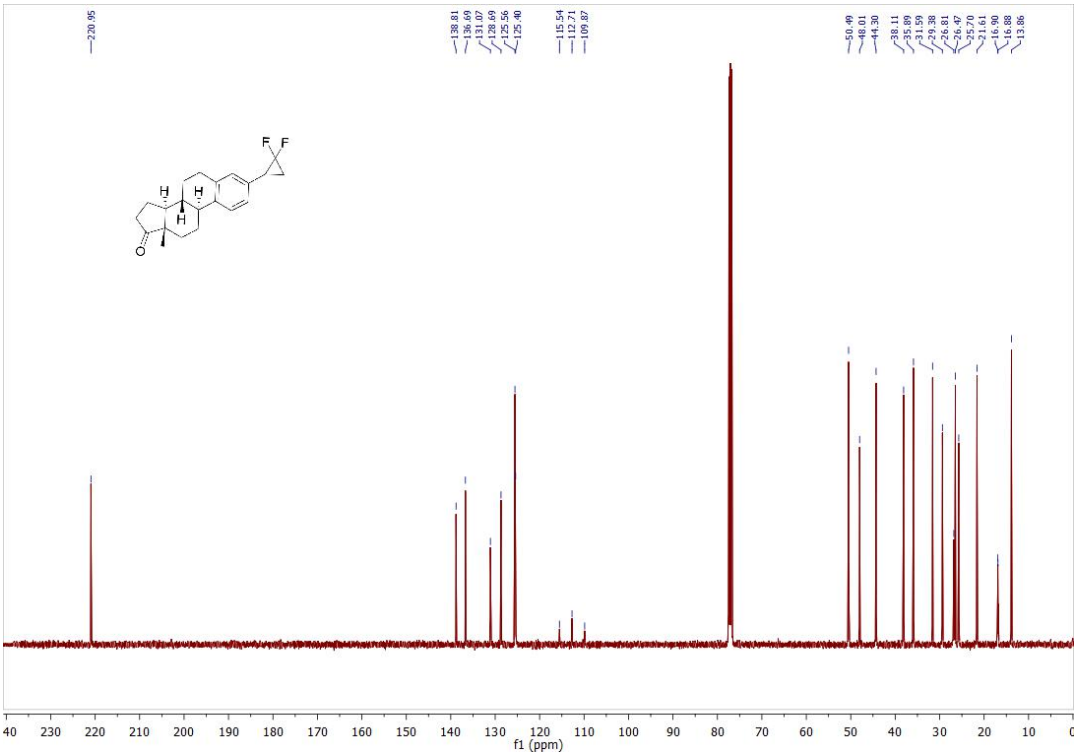

F
S
Me
F F
f1 (ppm)

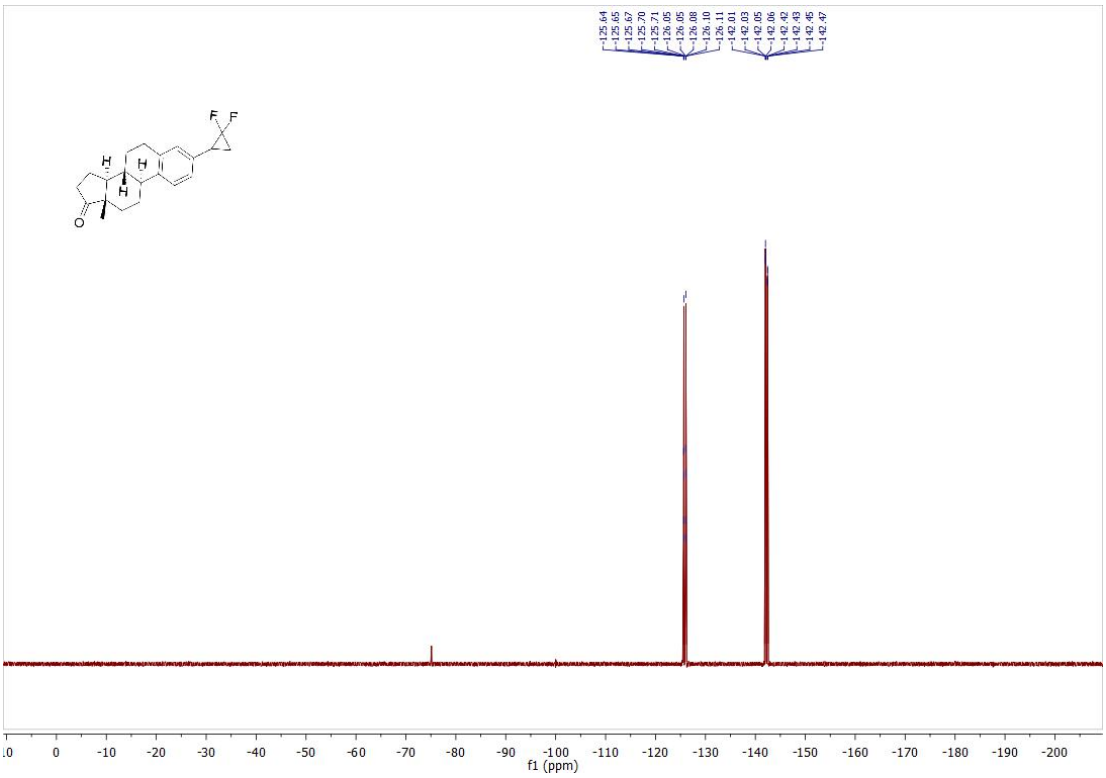
(8R,9S,13S,14S)-3-(2,2-difluorocyclopropyl)-13-methyl-6,7,8,9,11,12,13,14,15,16-decahydro-17H-cyclopenta[a]phenanthren-17-one (2l):



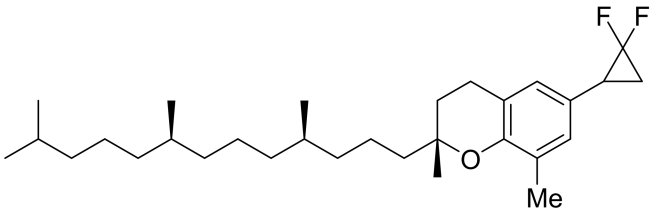
(2.5 g, yellow solid, petroleum ether /ethyl acetate 10: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.30-7.23 (m, 1H), 7.01 (d, *J* = 8.1 Hz, 1H), 6.97 (s, 1H), 2.95-2.87 (m, 2H), 2.70 (dd, *J* = 20.8, 12.4 Hz, 1H), 2.51 (dd, *J* = 18.8, 8.7 Hz, 1H), 2.42 (d, *J* = 11.7 Hz, 1H), 2.29 (t, *J* = 8.5 Hz, 1H), 2.16 (dd, *J* = 18.5, 9.3 Hz, 1H), 2.11-1.99 (m, 2H), 1.97 (d, *J* = 10.8 Hz, 1H), 1.84-1.73 (m, 1H), 1.70-1.54 (m, 4H), 1.54-1.37 (m, 3H), 0.91 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 220.9, 138.8, 136.6, 131.0, 128.6, 125.4 (d, *J* = 16.0 Hz), 112.7 (t, *J* = 285.4 Hz), 50.4, 48.0, 44.3, 38.1, 35.8, 31.5, 29.3, 26.8 (t, *J* = 11.4 Hz), 26.4, 25.7, 21.6, 16.9 (t, *J* = 10.5 Hz), 13.8. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -125.45, -142.24.



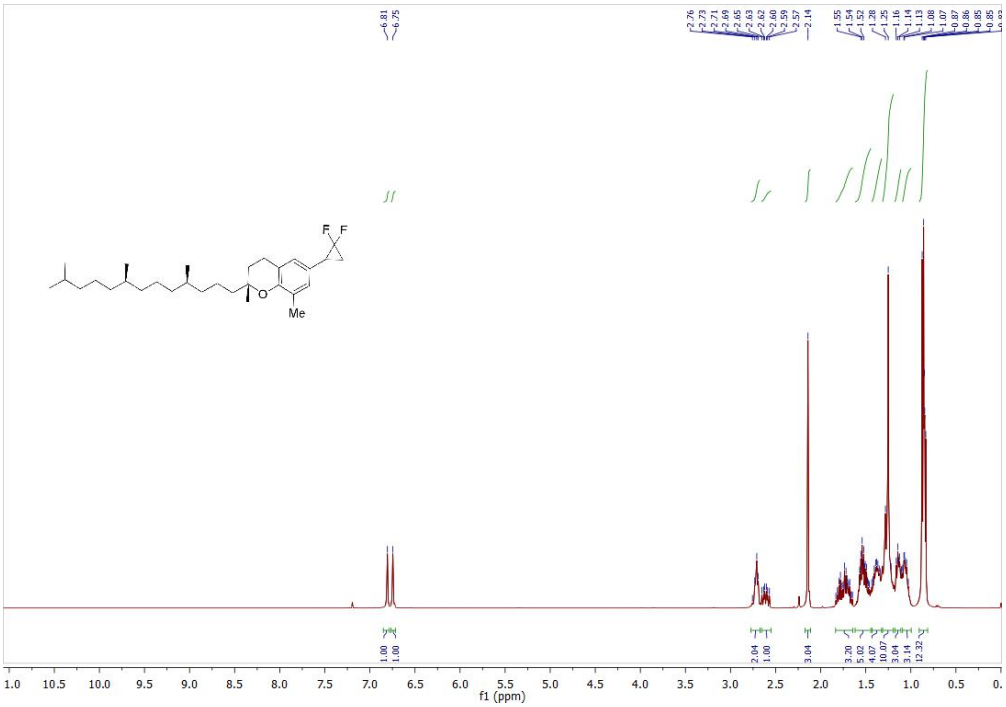

220.95
138.81
136.69
131.07
128.69
125.56
125.40
115.54
112.71
109.87
50.49
48.01
44.30
38.11
35.89
31.59
29.38
26.81
26.47
25.70
21.61
16.90
16.88
13.86
F F
H
H
H
O
40 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

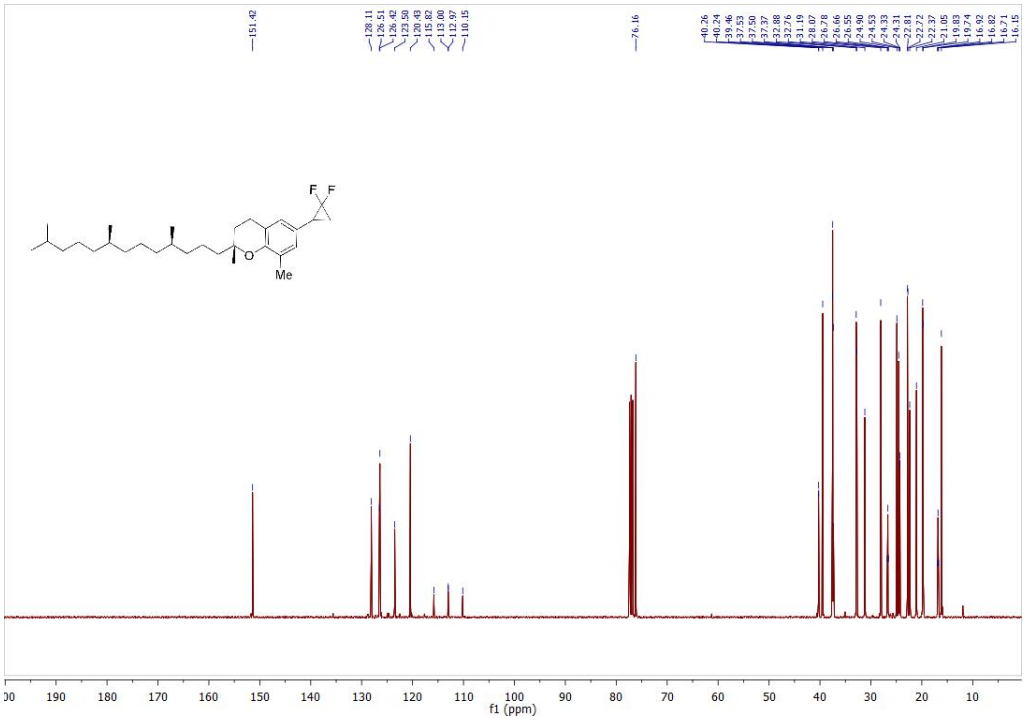

-125.64
-125.65
-125.67
-125.70
-125.71
-126.05
-126.05
-126.08
-126.10
-126.11
-142.01
-142.03
-142.05
-142.06
-142.42
-142.43
-142.45
-142.47
F F
H
H
H
O
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)

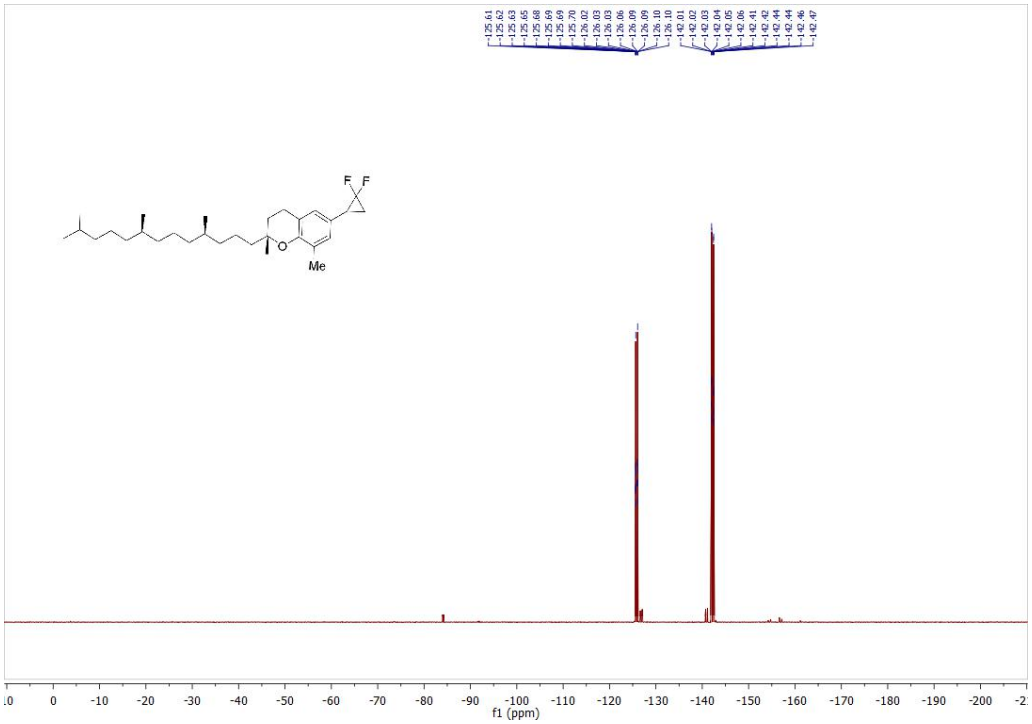
(2R)-6-(2,2-difluorocyclopropyl)-2,8-dimethyl-2-((4R,8R)-4,8,12-trimethyltridecyl)chromane (2m):



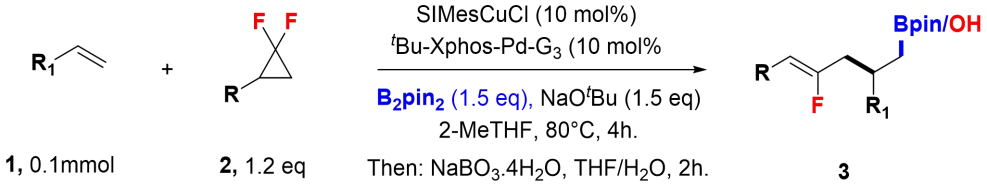
(3 g, colorless oil, petroleum ether /ethyl acetate 100: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.81 (s, 1H), 6.75 (s, 1H), 2.72 (dd, *J* = 16.9, 8.0 Hz, 2H), 2.66-2.56 (m, 1H), 2.14 (s, 3H), 1.73 (qdd, *J* = 12.3, 10.6, 5.7 Hz, 3H), 1.62-1.44 (m, 5H), 1.39 (ddd, *J* = 19.9, 10.6, 4.6 Hz, 4H), 1.32-1.20 (m, 10H), 1.19-1.10 (m, 3H), 1.06 (dt, *J* = 12.6, 6.6 Hz, 3H), 0.91-0.82 (m, 12H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.4, 128.1, 126.4 (d, *J* = 9.6 Hz), 123.5, 120.4, 112.9 (dd, *J* = 286.6, 284.0 Hz), 76.1, 40.2 (d, *J* = 2.4 Hz), 39.4, 37.8, 32.8 (d, *J* = 11.8 Hz), 31.1, 28.0, 26.6 (t, *J* = 11.4 Hz), 24.9, 24.5, 24.3 (d, *J* = 2.0 Hz), 22.7 (d, *J* = 9.6 Hz), 22.3, 21.0, 19.7 (d, *J* = 9.5 Hz), 16.8 (t, *J* = 10.5 Hz), 16.1. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -125.86, -142.24.




F F
O
Me
f1 (ppm)

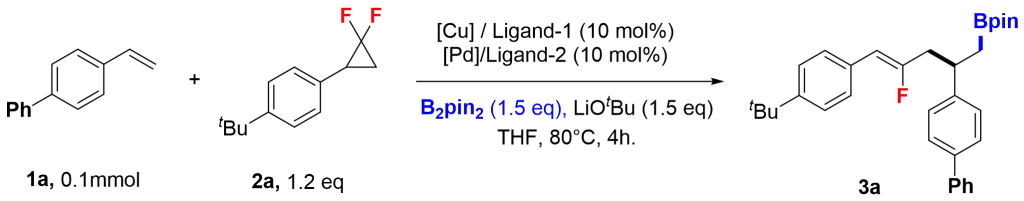

F F
O
Me
f1 (ppm)

3. General Experimental Procedure



A Schlenk tube (10 mL) was charged with B_2pin_2 (0.15 mmol, 1.5 equiv.), [Cu] (10 mol%), [Pd] (10 mol %), and base (0.15 mmol, 1.5 equiv.). The tube equipped with a stirring bar and then evacuated and backfilled with argon three times, followed by substrate (**2**) (0.12 mmol, 1.2 equiv.), alkene (**1**) (0.1 mmol, 1 equiv.) and 1 mL of the solvent. The sealed tube was removed to oil bath and heated to 80 ℃ for 4 hours. The reaction cooled to room temperature, then extracted with ethyl acetate and the combined organic layer was dried over anhydrous Na_2SO_4, the solvent was removed under reduced pressure to obtain a mixture residue. The mixture residue then dissolved in (2 mL) THF and (2 mL) H_2O, $NaBO_3$•$4H_2O$ (0.5 mmol, 5 was added. The reaction was stirred at room temperature for 2 h, then extracted with ethyl acetate and the combined organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduce pressure. Then, purified by thin layer chromatography plate (SiO_2, petroleum ether/ ethyl acetate (V/V) as eluent) to afford the desired products.

3.1 Screening of Cu/Pd Catalysts:

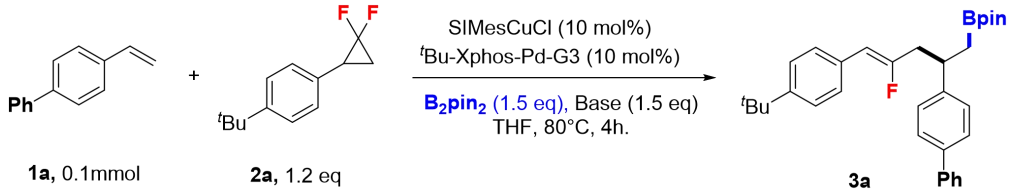


Entry	[Cu]/Ligand-1	[Pd]/Ligand-2	Yield%[b]
1	IMesCuCl	$Pd(dppf)Cl_2$	-
2	IMesCuCl	Xphos-Pd-G_3	47
3	IMesCuCl	tBu-Xphos-Pd-G_3	62

4	IMesCuCl	Davephos-Pd-G_3	-
5	IMesCuCl	Sphos-Pd-G_3	-
6	SIMesCuCl	tBu-Xphos-Pd-G_3	68
7	IPrCuCl	tBu-Xphos-Pd-G_3	17
8	PCy3/CuCl	tBu-Xphos-Pd-G_3	-
9	IMesCuCl	Xphos-Pd-G_2	23

[a] **1a** (0.1 mmol), **2a** (0.12 mmol), B_2pin_2 (0.15 mmol), LiO^tBu (0.15 mmol), [Cu]/Ligand-1 (10 mol%), and [Pd]/Ligand-2 (10 mol%) in THF (1 mL) under an Argon atmosphere at 80 ℃ for 4 hours. [b] Yield was determined by ^{19}F NMR using $PhCF_3$ as an internal standard.

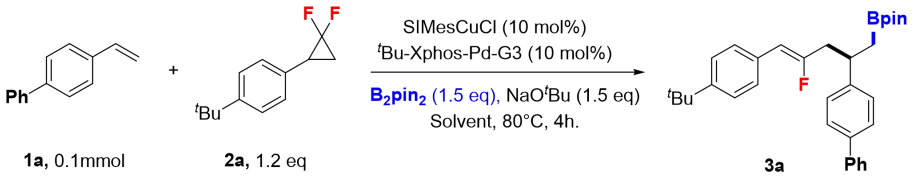
3.2 Screening of Bases:



Entry	Base	Yield % [b]
1	NaOMe	trace
2	LiOMe	43
3	NaO^tBu	77
4	KOtBu	61
5	KOMe	30
6	KOTMS	39

[a] **1a** (0.1 mmol), **2a** (0.12 mmol), B_2pin_2 (0.15 mmol), base (0.15 mmol), SIMesCuCl (10 mol%), and ^{t}Bu-Xphos-Pd-G_3 (10 mol%) in (1 mL) of THF under an Argon atmosphere at 80 ℃ for 4 hours. [b] Yield was determined by ^{19}F NMR using $PhCF_3$ as an internal standard.

3.3 Screening of Solvents:

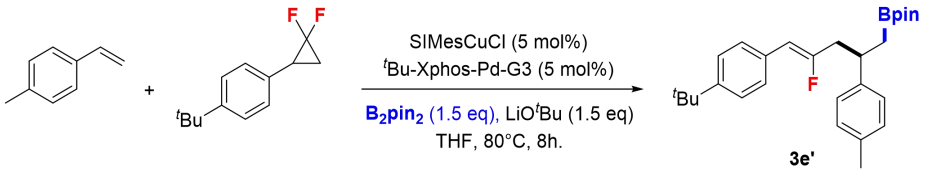


Entry	Solvent	Yield%[b]
1	Toluene	60
2	**2-MeTHF**	**85, (80)**[c]
3	MeCN	27
4	Toluene/THF=10:1	58
5	Toluene/MeCN=10:1	44
6	2-MeTHF/THF=2:1	80

[a] **1a** (0.1 mmol), **2a** (0.12 mmol), B_2pin_2 (0.15 mmol), NaO^{t}Bu (0.15 mmol), SIMesCuCl (10 mol%), and ^{t}Bu-Xphos-Pd-G_3 (10 mol%) in (1 mL) of solvent under an Argon atmosphere at 80 ℃ for 4 hours. [b] Yield was determined by ^{19}F NMR using $PhCF_3$ as an internal standard. [c] Isolated yield of **3a**.

3.4 Gram Scale synthesis and Applications:

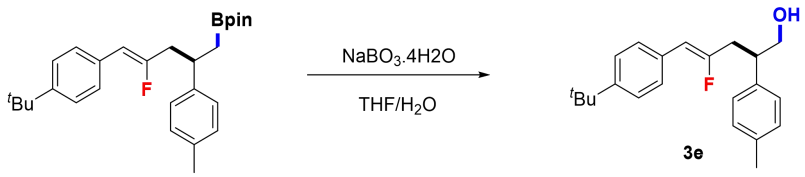
3.4.1 Gram-scale synthesis (**3e'**):



A Schlenk tube (100 mL) was charged with B_2pin_2 (4.5 mmol, 1.5 equiv), [SIMesCuCl] (5 mol%), [^{t}Bu-xphos-Pd-G3] (5 mol %), and NaO^{t}Bu (4.5 mmol, 1.5 equiv). The tube equipped with a stirring bar and then evacuated and backfilled with argon three times, followed by **2a** (3.6 mmol, 1.2 equiv), 1-methyl-4-vinylbenzene (3 mmol) and 20 mL of 2-MeTHF. The sealed tube was removed to oil bath and heated to 80 ℃ for 8 hours. Then the reaction cooled to room temperature and diluted by water (15 mL) and ethyl acetate (30 mL). The organic layer was

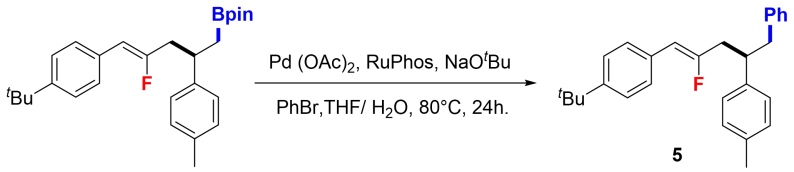
collected, dried over anhydrous Na_2SO_4 and concentrated under reduce pressure. then, purified by thin layer chromatography plate (SiO_2, petroleum ether/ ethyl acetate 50:1 (V/V) as eluent) to afford the desired product **3e'** as colorless oil (1.2g, 92%).

3.4.2 Oxidation (**3e**):[7]



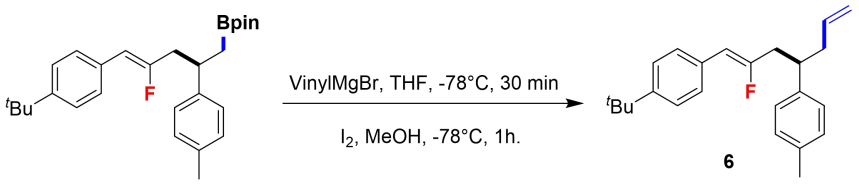
A Schlenk tube (100 mL) was charged with **3e'** (1.5 mmol, 1 equiv.), $NaBO_3 \cdot 4H_2O$ (7.5 mmol, 5 equiv.), then 10 mL of THF and 10 mL H_2O were added, the mixture stirred at room temperature for 2 hours. Then extracted with ethyl acetate and the combined organic layer was dried over Na_2SO_4. The organic layer concentrated under vacuo and purified by thin layer chromatography plate (SiO_2, petroleum ether /ethyl acetate 5:1 (V/V) as eluent) to afford the desired product **3e** as colorless oil (0.46 g, 94%).

3.4.3 **arylation** (**5**): [9]



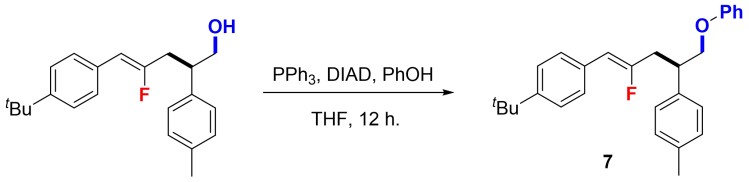
A Schlenk tube (10 mL) was charged with Pd $(OAc)_2$ (2.5 mol%, 0.005 mmol), RuPhos (5 mol%, 0.01 mmol) and NaO^{t}Bu (0.6 mmol, 3 equiv.). The tube equipped with a stirring bar and then evacuated and backfilled with argon three times, substrate **3e'** (0.1 mmol, 1 equiv.), bromobenzene (0.12 mmol, 1.2 equiv.), 0.1 mL H_2O and 1 mL of THF were added in order. The sealed tube was removed to oil bath and heated to 80 ºC for 24 hours. Then the reaction cooled to room temperature, diluted by water (2 mL) and ethyl acetate (3 mL). The organic layer was collected, dried over anhydrous Na_2SO_4 and concentrated under reduce pressure, then purified through thin layer chromatography plate (SiO_2, petroleum ether/ ethyl acetate 50:1 (V/V) as eluent) to afford the desired product **5** as colorless oil **(**25.3 mg, 66%).

3.4.4 Allylation (**6**):[11]



A Schlenk tube (10 mL) with a stir bar was charged with a solution of **3e'** (0.1 mmol, 1 equiv.) in THF (1 mL), then vinyl magnesium bromide (0.4 mmol, 4 equiv. 1.0 M solution in THF) was added to tube. The reaction mixture was stirred at -78 ºC for 30 min. A solution of iodine (0.4 mmol, 4 equiv.) in 1 mL MeOH was added slowly, after addition 30 min the reaction warmup to 0 ºC until completion of the reaction. The reaction was quenched with a saturated aqueous solution of $Na_2S_2O_3$ (2 mL) and extracted with ethyl acetate. The organic layer concentrated under vacuo and purified by thin layer chromatography plate (SiO_2, petroleum ether /ethyl acetate 100:1 (V/V) as eluent) to afford the desired product **6** as colorless oil (28.5 mg, 85%).

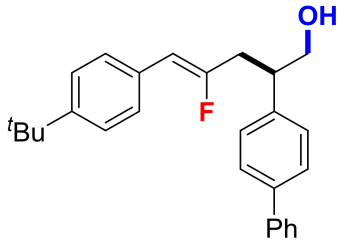
3.4.5 Mitsunobu Reaction (**7**):[10]



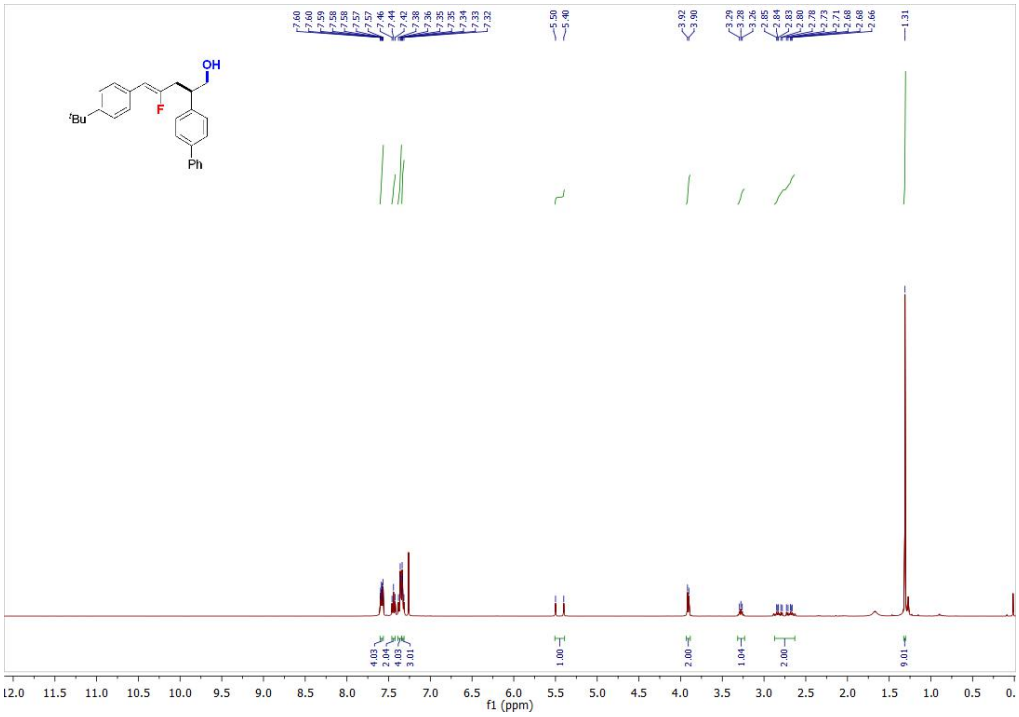
A Schlenk tube (10 mL) with a stir bar was charged with PPh_3 (0.2 mmol, 2 equiv.), then evacuated and backfilled with argon 3 times, followed by **3e'** (0.1 mmol, 1 equiv. 0.1 M solution in THF) was added. The mixture was cooled in ice/ water bath and the DIAD (0.2 mmol, 2 equiv.) was added slowly, after 30 min the phenol (0.15mmol, 1.5 equiv.) was added and the reaction stirred at room temperature for 12 hours. the reaction mixture was concentrated in vacuo. and purified by thin layer chromatography plate (SiO_2, petroleum ether /ethyl acetate 50:1 (V/V) as eluent) to afford the desired product **7** as colorless oil (33 mg, 82%).

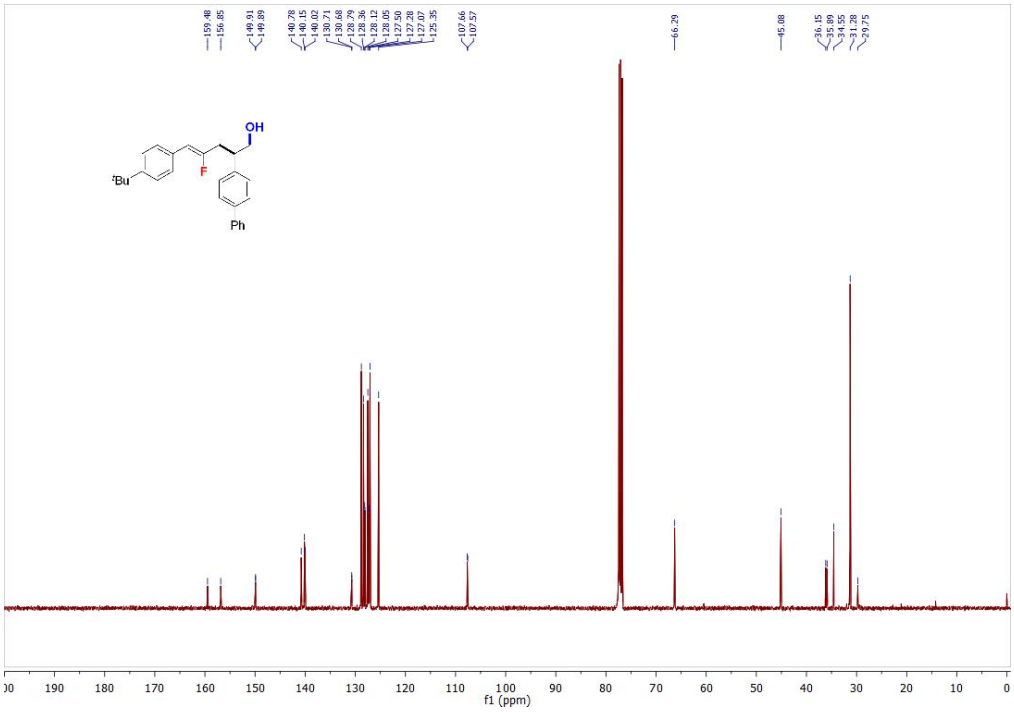
4. NMR Data and Spectra:

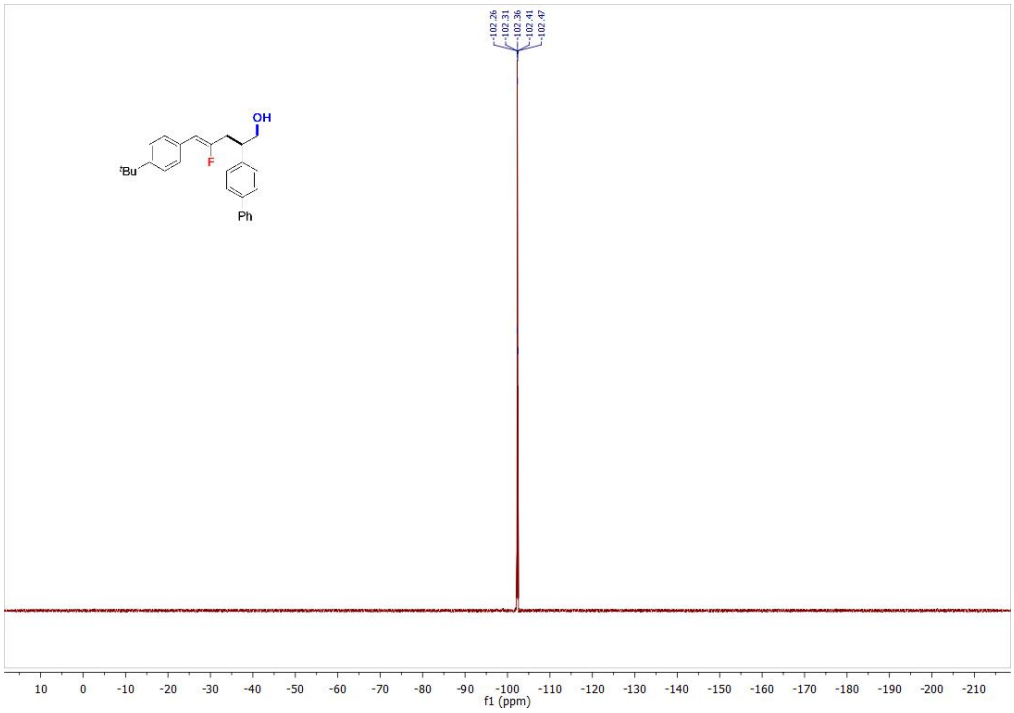
(*R*,*Z*)-2-([1,1'-biphenyl]-4-yl)-5-(4-(tert-butyl)phenyl)-4-fluoropent-4-en-1-ol (3a):



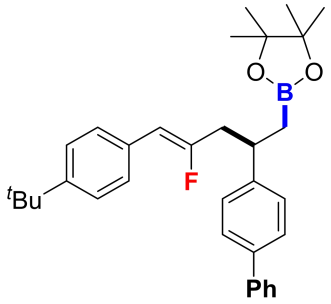
(32 mg, 83% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.60-7.55 (m, 4H), 7.46-7.41 (m, 2H), 7.38-7.34 (m, 4H), 7.34-7.30 (m, 3H), 5.45 (d, *J* = 39.6 Hz, 1H), 3.91 (d, *J* = 6.2 Hz, 2H), 3.32-3.23 (m, 1H), 2.88-2.60 (m, 2H), 1.31 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.1 (d, *J* = 265.2 Hz), 149.9 (d, *J* = 2.0 Hz), 140.7, 140.1, 140.0, 130.7 (d, *J* = 2.4 Hz), 128.7, 128.3, 128.0 (d, *J* = 7.2 Hz), 127.5, 127.2, 127.0, 125.3, 107.6 (d, *J* = 8.8 Hz), 66.2, 45.0, 36.0 (d, *J* = 26.6 Hz), 34.5, 31.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -102.36 (dt, *J* = 39.7, 19.9 Hz). **HRMS (ESI)** calcd for $C_{27}H_{30}FO^{+}$[M+H^{+}]: 389.2275 found 389.2270.



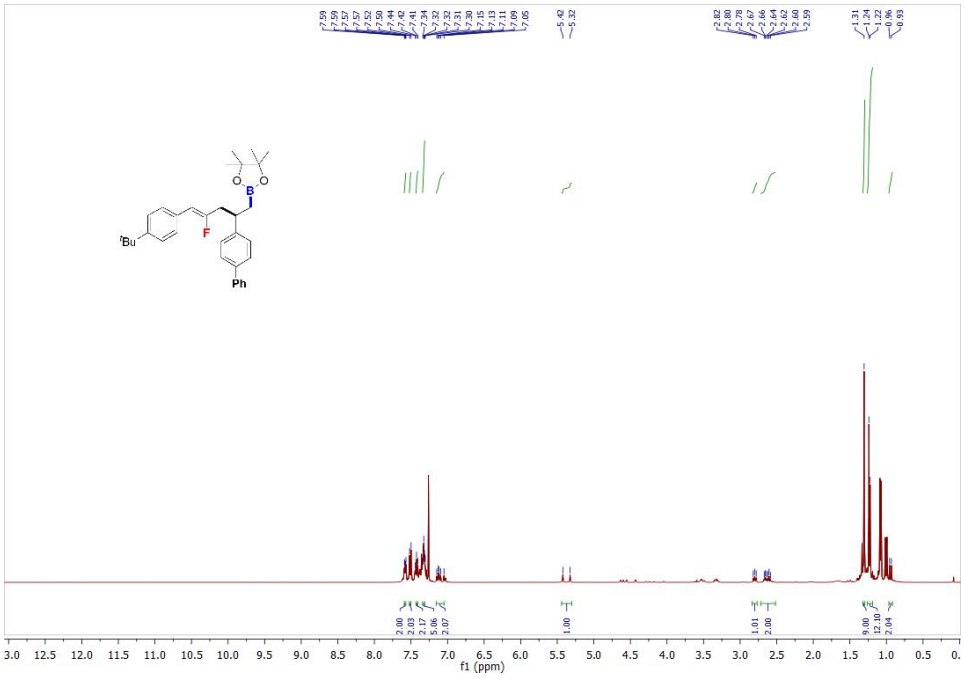

159.48
156.85
149.91
149.89
140.78
140.15
140.02
130.71
130.68
128.79
128.36
128.12
128.05
127.50
127.28
127.07
125.35
107.66
107.57
66.29
45.08
36.15
35.89
34.55
31.28
29.75
OH
F
tBu
Ph
f1 (ppm)

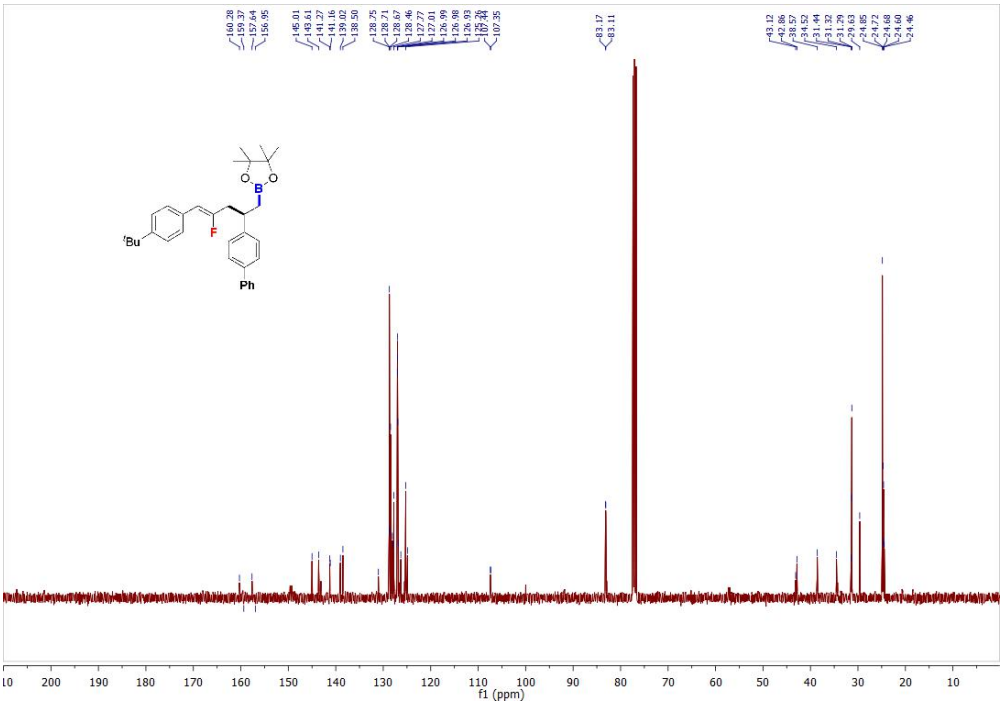

102.26
102.31
102.36
102.41
102.47
OH
F
tBu
Ph
f1 (ppm)

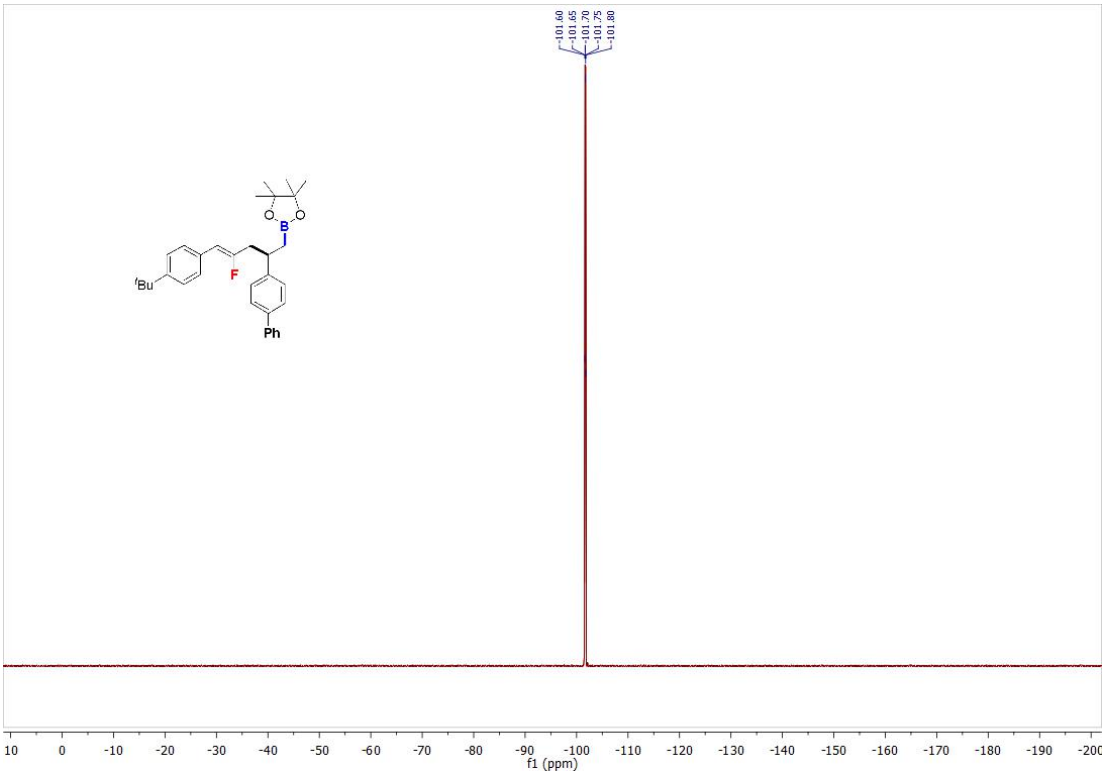
([1,1'-biphenyl]-4-yl)-5-(4-(tert-butyl)phenyl)-4-fluoropent-4-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3a'):

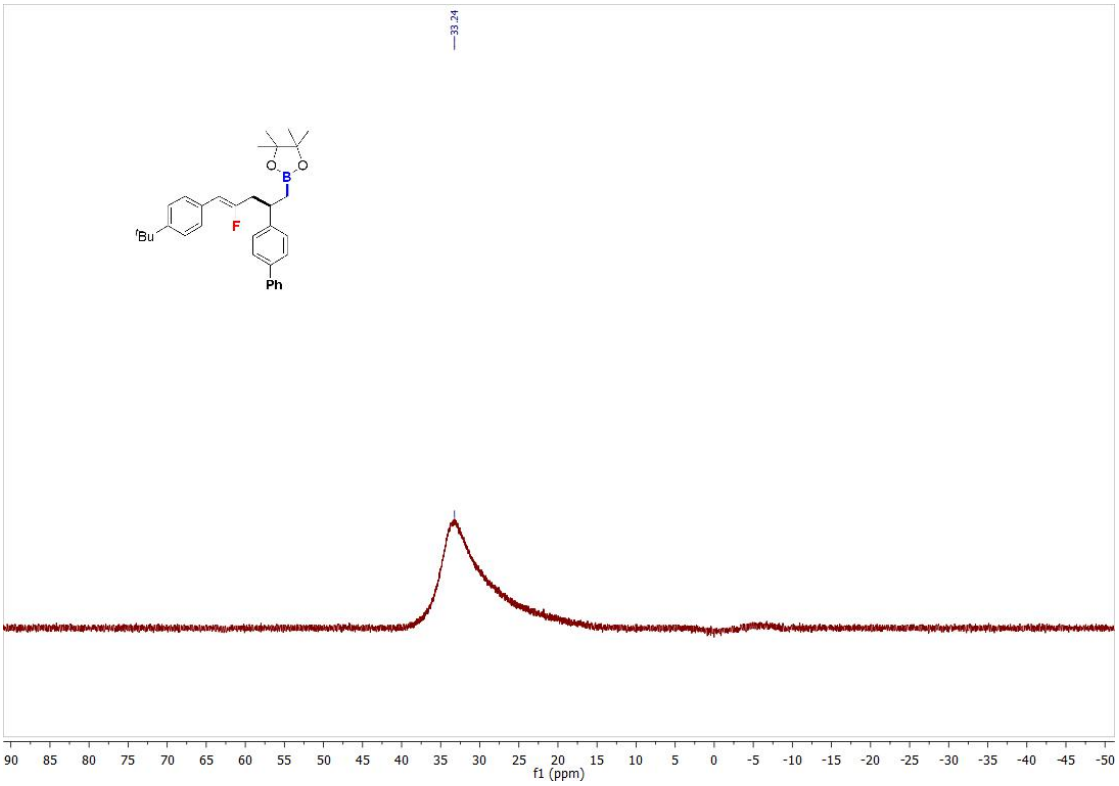


(40mg, 80% colorless oil, petroleum ether /ethyl acetate 50: 1 (V/V) as eluent),**^{1}H_NMR** (400 MHz, $CDCl_3$) δ 7.61-7.56 (m, 2H), 7.52-7.49 (m, 2H), 7.44-7.40 (m, 2H), 7.34-7.30 (m, 5H), 7.15-7.08 (m, 2H), 5.37 (d, 1H), 2.84-2.76 (m, 1H), 2.67-2.54 (m, 2H), 1.31 (s, 9H), 1.26-1.21 (m, 12H), 0.94 (d, *J* = 9.9 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.9 (d, *J* = 265.7 Hz), 145.0, 143.6, 141.2, 139.0, 138.5, 131.0, 128.7, 128.4, 127.7, 127.0, 125.2, 124.9, 107.3 (d, *J* = 8.7 Hz), 83.1, 42.9 (d, *J* = 26.3 Hz), 38.5, 34.5, 31.2, 29.6, 24.8. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -101.70. **^{11}B NMR** (128 MHz, $CDCl_3$) δ 33.24. **HRMS (ESI)** calcd for $C_{33}H_{41}BFO_2^+$[M+H$^+$]: 499.3178 found 499.31741.

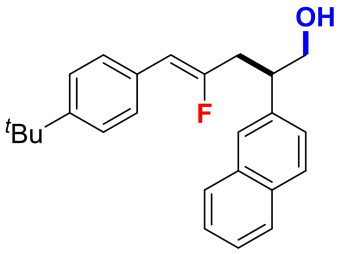



160.28
159.37
157.64
156.95
145.01
143.61
141.27
141.16
139.02
138.50
128.75
128.71
128.67
128.46
127.77
127.01
126.98
126.98
126.93
125.26
125.24
107.35
83.17
83.11
43.12
42.86
38.57
34.52
31.44
31.32
31.29
29.63
24.85
24.72
24.68
24.60
24.46
tBu
F
B
O
O
Ph
f1 (ppm)

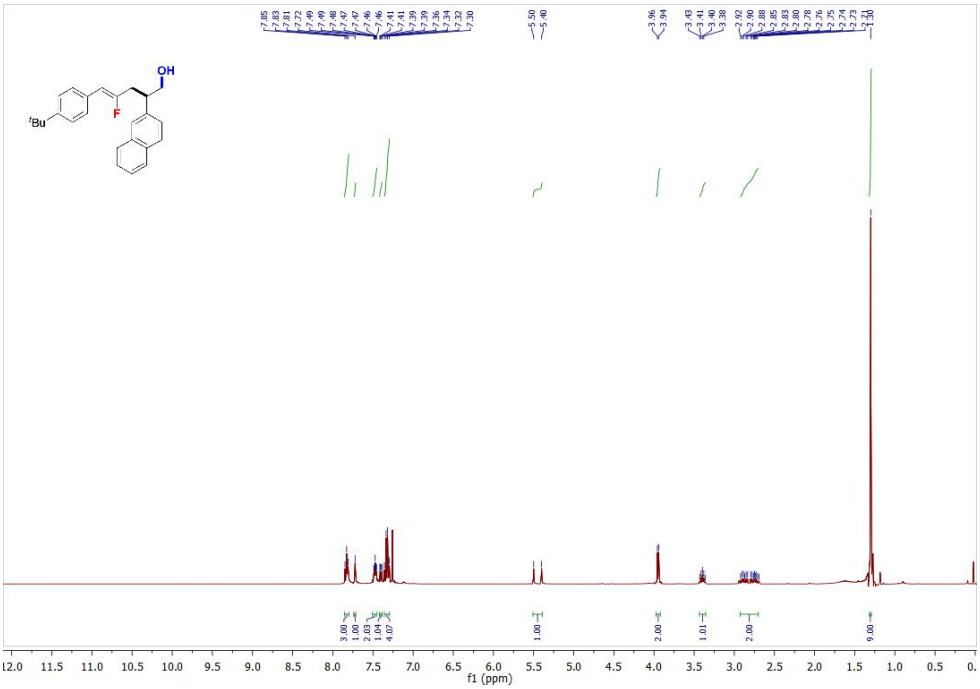

101.60
101.65
101.70
101.75
101.80
tBu
F
B
O
O
Ph
f1 (ppm)

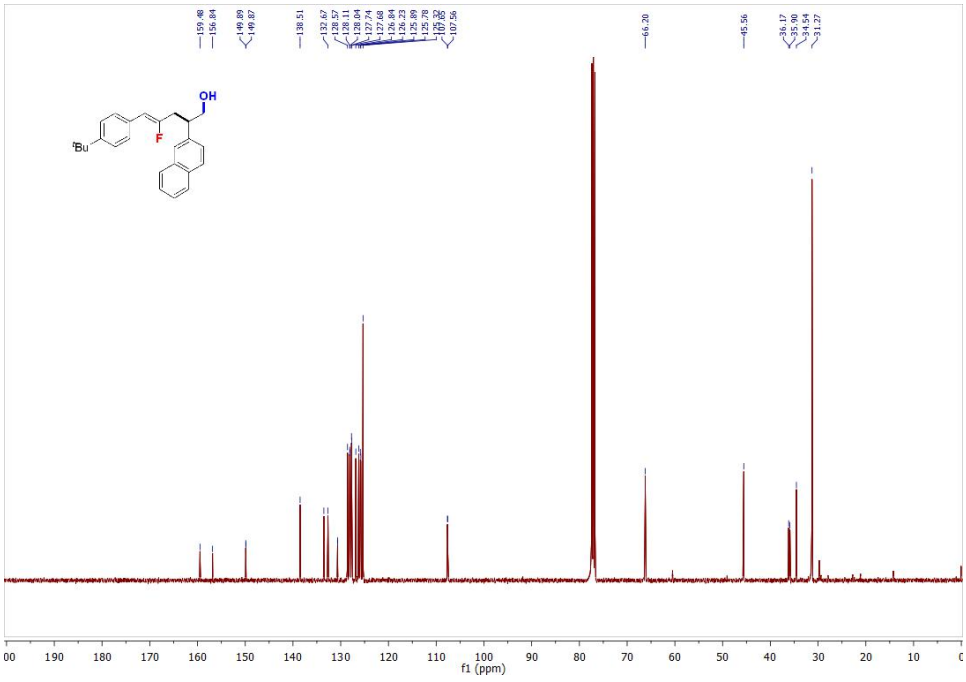


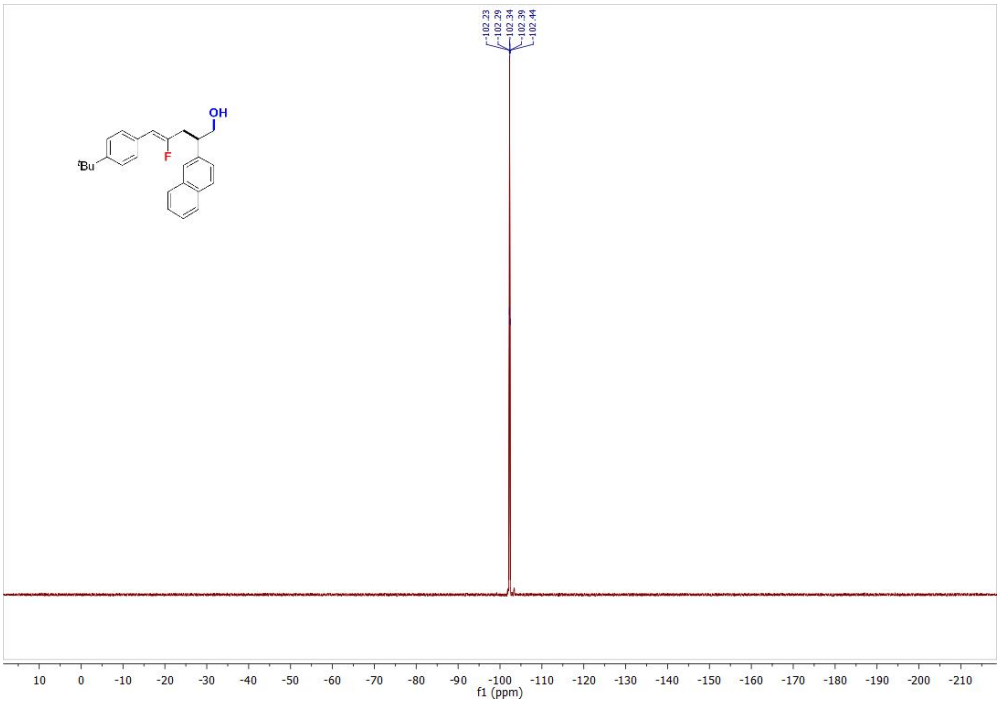
(*R*,*Z*)-5-(4-(tert-butyl)phenyl)-4-fluoro-2-(naphthalen-2-yl)pent-4-en-1-ol (3b):



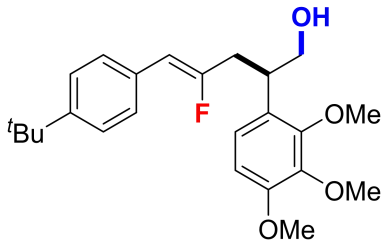
(31 mg, 85% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87-7.78 (m, 3H), 7.72 (s, 1H), 7.49-7.45 (m, 2H), 7.42-7.38 (m, 1H), 7.37-7.28 (m, 4H), 5.44 (d, 1H), 3.95 (d, *J* = 6.2 Hz, 2H), 3.44-3.34 (m, 1H), 2.94-2.66 (m, 2H), 1.29 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.1 (d, *J* = 265.2 Hz), 149.8 (d, *J* = 2.0 Hz), 138.5, 133.5, 132.6, 130.6 (d, *J* = 2.4 Hz), 128.5, 128.0 (d, *J* = 7.2 Hz), 127.7, 127.68, 126.8, 126.2, 125.8, 125.7, 125.3, 107.6 (d, *J* = 8.8 Hz), 66.2, 45.5, 36.0 (d, *J* = 26.6 Hz), 34.5, 31.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -102.34 (dt, *J* = 39.6, 19.9 Hz). **HRMS (ESI)** calcd for $C_{25}H_{28}FO^{+}$[M+H^{+}]: 363.2119 found 363.2115.


OH
F
tBu
f1 (ppm)

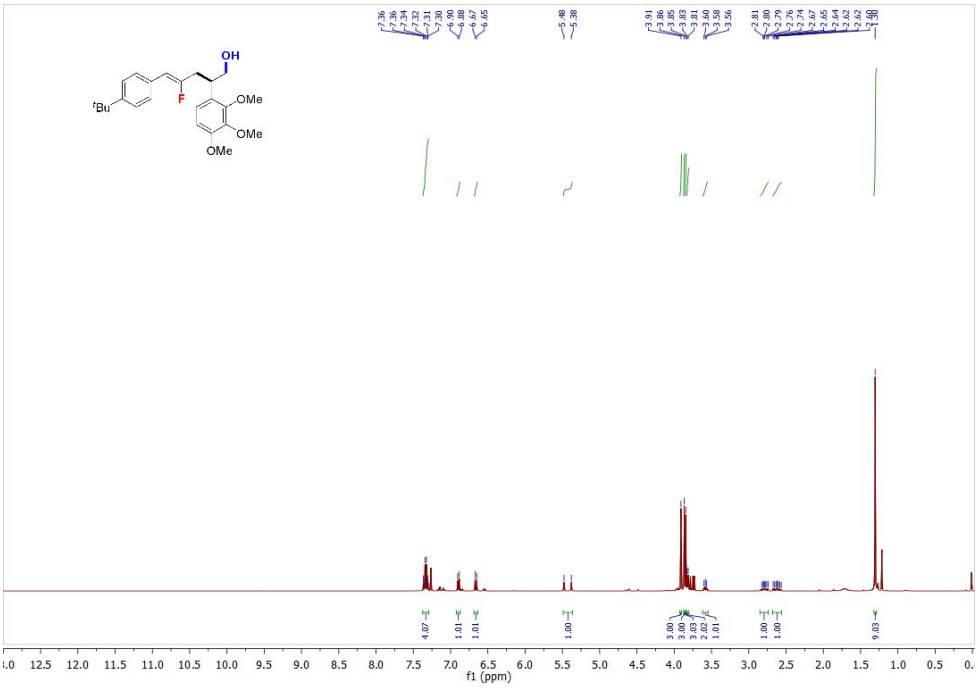

OH
F
tBu
f1 (ppm)

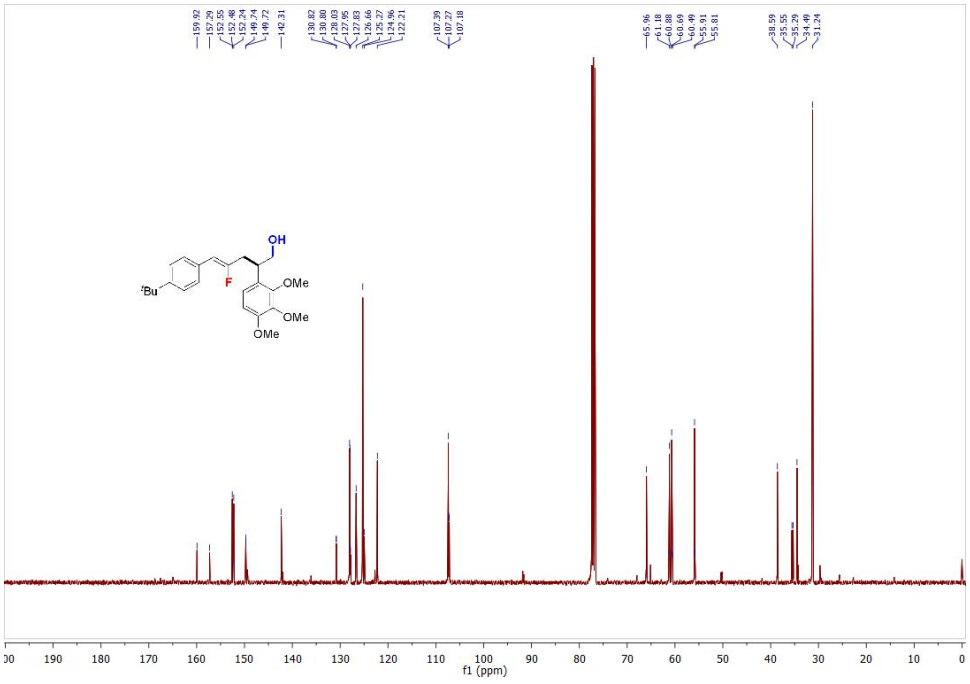


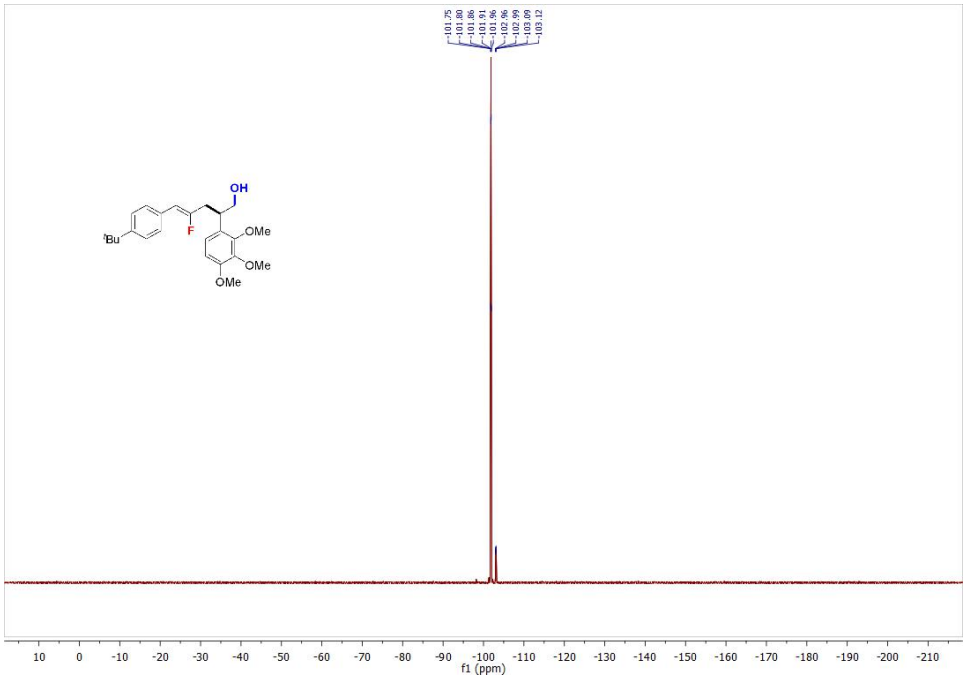
(*R*,*Z*)-5-(4-(tert-butyl)phenyl)-4-fluoro-2-(2,3,4-trimethoxyphenyl)pent-4-en-1-ol (3c):



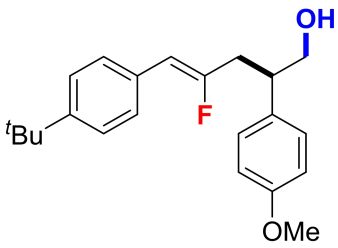
(32 mg, 80% colorless oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37-7.29 (m, 4H), 6.91-6.87 (m, 1H), 6.68-6.64 (m, 1H), 5.43 (d, J = 39.7 Hz, 1H), 3.91 (s, 3H), 3.86 (s, 3H), 3.85 (s, 3H), 3.82 (d, J = 6.1 Hz, 2H), 3.62-3.55 (m, 1H), 2.85-2.72 (m, 1H), 2.66-2.54 (m, 1H), 1.30 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.6 (d, *J* = 265.4 Hz), 152.5, 152.2, 149.7 (d, *J* = 2.1 Hz), 142.3, 130.8 (d, *J* = 2.4 Hz), 127.9 (d, *J* = 7.2 Hz), 126.6, 125.2, 124.9, 122.2, 107.3, 107.2 (d, *J* = 8.8 Hz), 65.9, 60.9, 55.9, 38.5, 35.4 (d, *J* = 26.4 Hz), 34.4, 31.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -101.86 (dt, *J* = 39.7, 19.9 Hz). **HRMS (ESI)** calcd for $C_{24}H_{32}FO_4^+$[M+H$^+$]: 403.2279 found 403.2276.


OH
F
tBu
OMe
OMe
OMe
f1 (ppm)

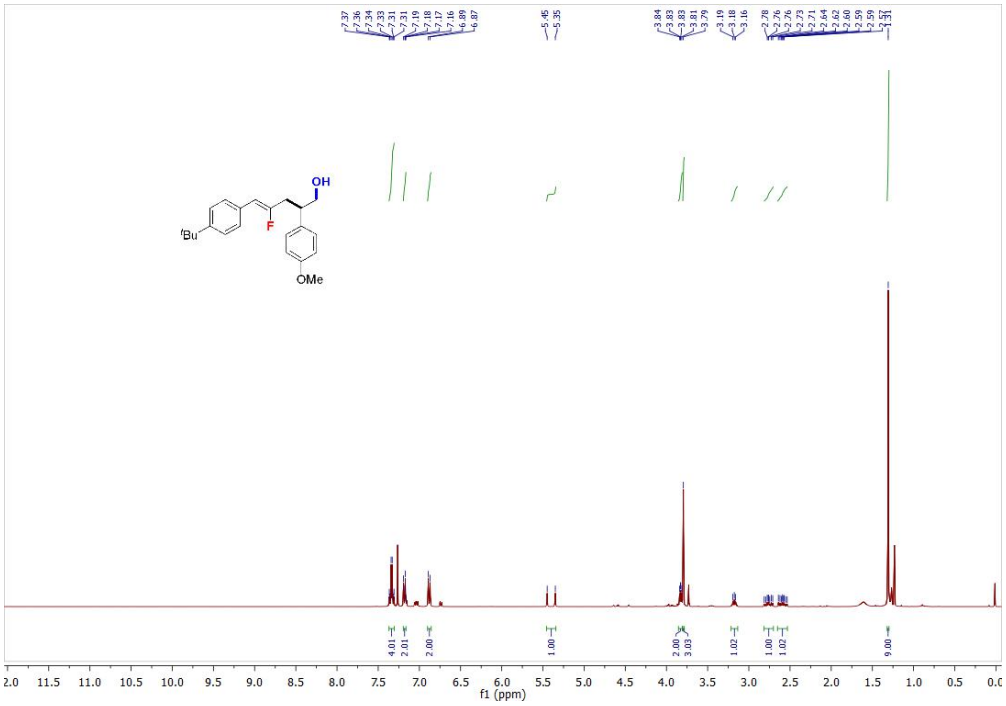

OH
F
tBu
OMe
OMe
OMe
f1 (ppm)

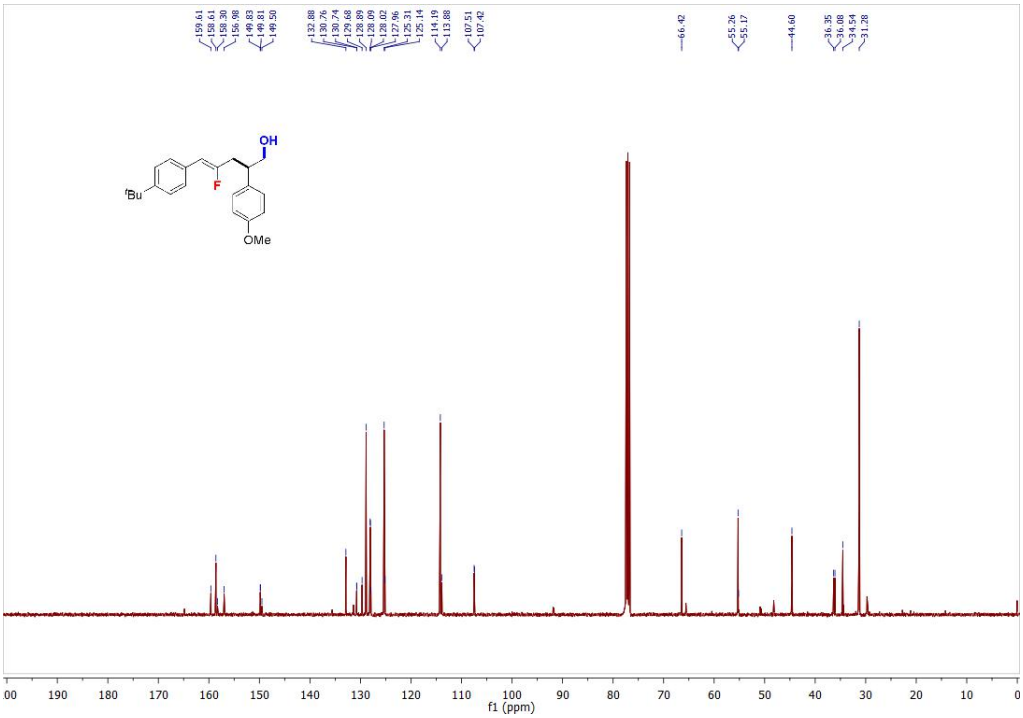


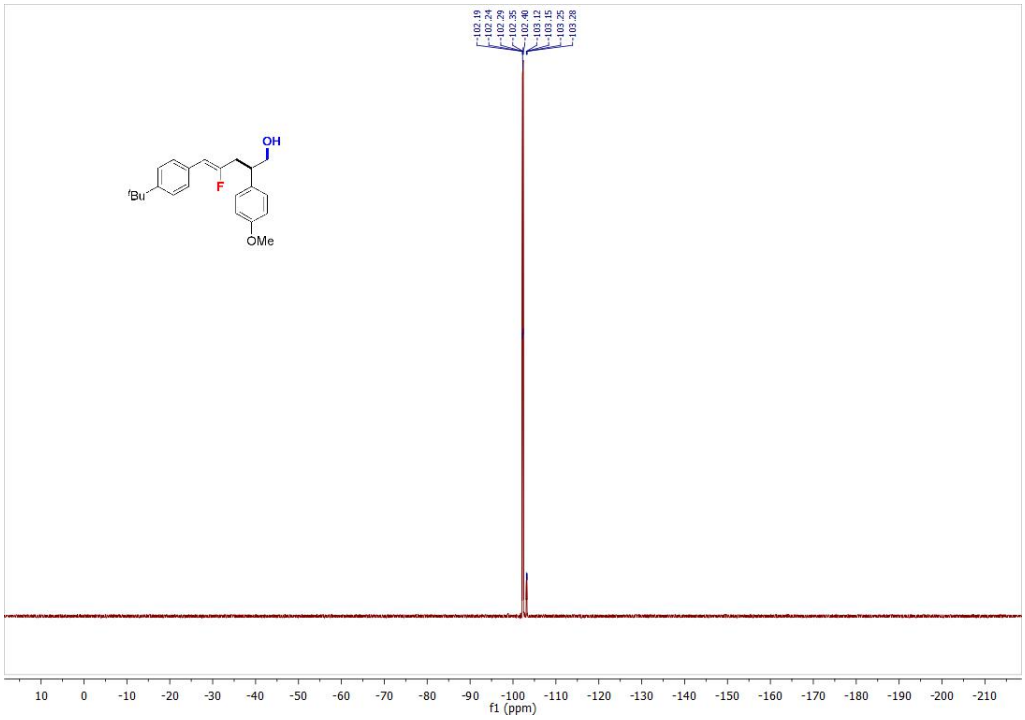
(*R*,*Z*)-5-(4-(tert-butyl)phenyl)-4-fluoro-2-(4-methoxyphenyl)pent-4-en-1-ol (3d):



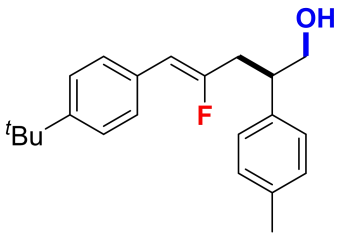
(30 mg, 87% colorless oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37-7.29 (m, 4H), 7.20-7.14 (m, 2H), 6.90-6.84 (m, 2H), 5.40 (d, *J* = 39.6 Hz, 1H), 3.84-3.80 (m, 2H), 3.79 (s, 3H), 3.23-3.06 (m, 1H), 2.82-2.69 (m, 1H), 2.64-2.52 (m, 1H), 1.31 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.6, 158.3 (d, *J* = 265.2 Hz), 149.8 (d, *J* = 2.0 Hz), 132.8, 129.6, 128.8, 128.0 (t, *J* = 6.2 Hz), 125.3, 114.1, 107.4 (d, *J* = 8.8 Hz), 66.4, 55.2, 44.6, 36.2 (d, *J* = 26.6 Hz), 34.5, 31.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -102.29 (dt, *J* = 39.7, 19.9 Hz). **HRMS (ESI)** calcd for $C_{22}H_{28}FO_2^+$[M+H$^+$]: 343.2068 found 343.2062.


OH
F
tBu
OMe
f1 (ppm)

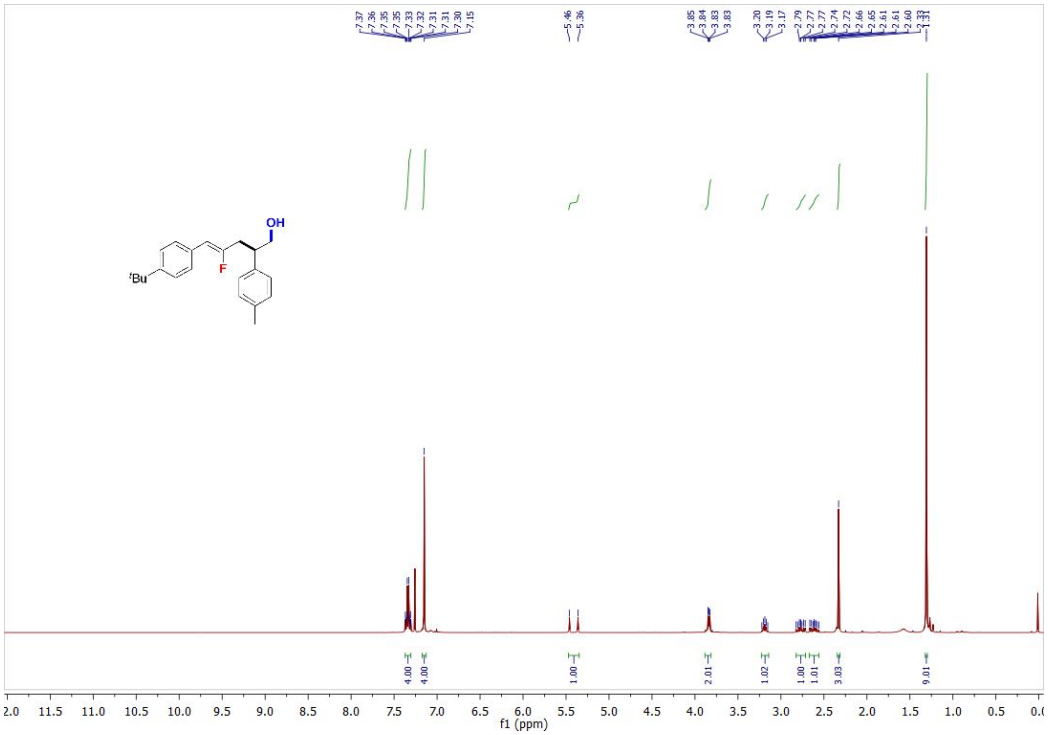

OH
F
tBu
OMe
f1 (ppm)

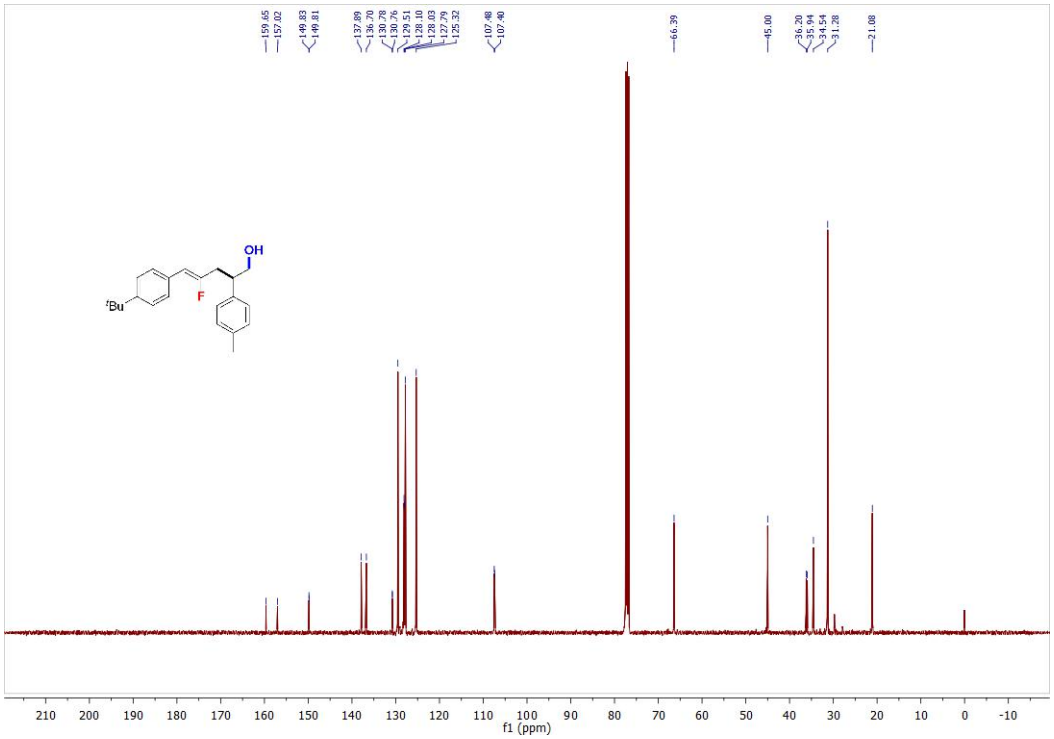


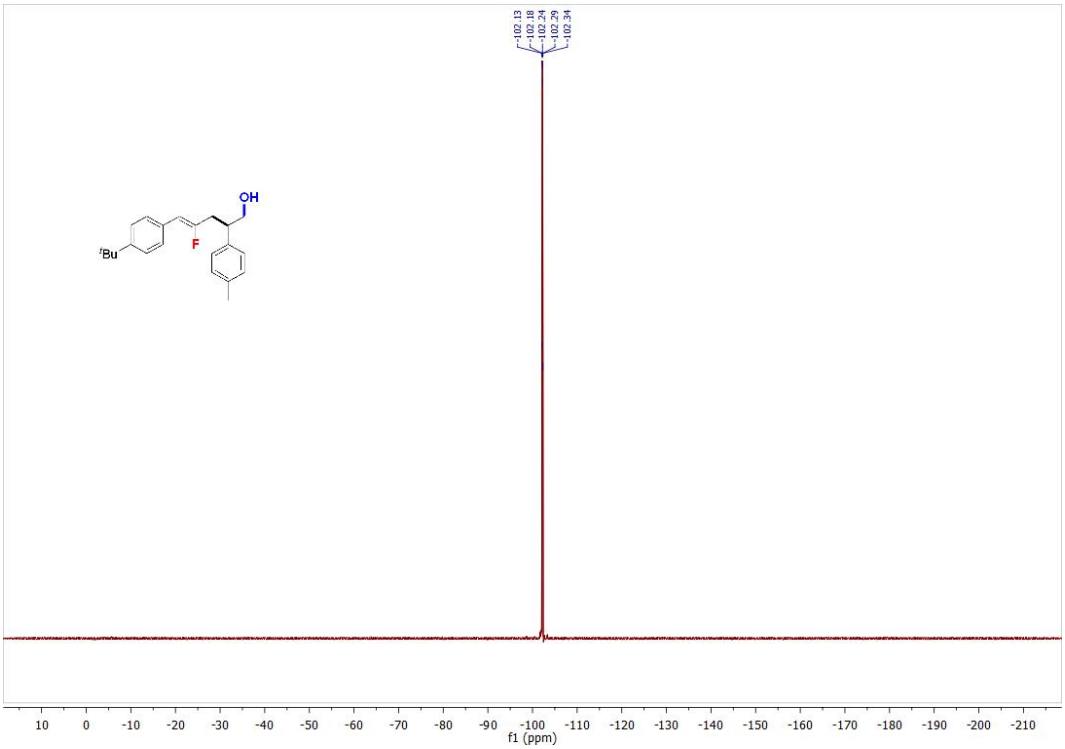
(*R*,*Z*)-5-(4-(tert-butyl)phenyl)-4-fluoro-2-(p-tolyl)pent-4-en-1-ol (3e):



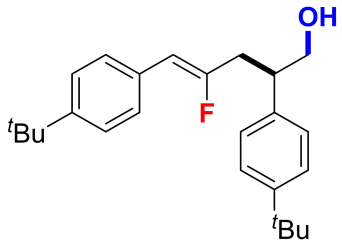
(30.4 mg, 93% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.38-7.30 (m, 4H), 7.15 (s, 4H), 5.40 (d, 1H), 3.86-3.82 (m, 2H), 3.23-3.15 (m, 1H), 2.84-2.71 (m, 1H), 2.67-2.55 (m, 1H), 2.33 (s, 3H), 1.31 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.3 (d, J = 265.3 Hz), 149.8 (d, J = 2.1 Hz), 137.8, 136.7, 130.7 (d, J = 2.3 Hz), 129.5, 128.0 (d, J = 7.2 Hz), 127.7, 125.3, 107.4 (d, J = 8.8 Hz), 66.3, 45.0, 36.0 (d, J = 26.6 Hz), 34.5, 31.2, 21.0. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -102.24 (dt, J = 39.6, 19.9 Hz). **HRMS (ESI)** calcd for $C_{22}H_{28}FO^+$[M+H$^+$]: 327.2119 found 327.2117.


OH
F
tBu
f1 (ppm)

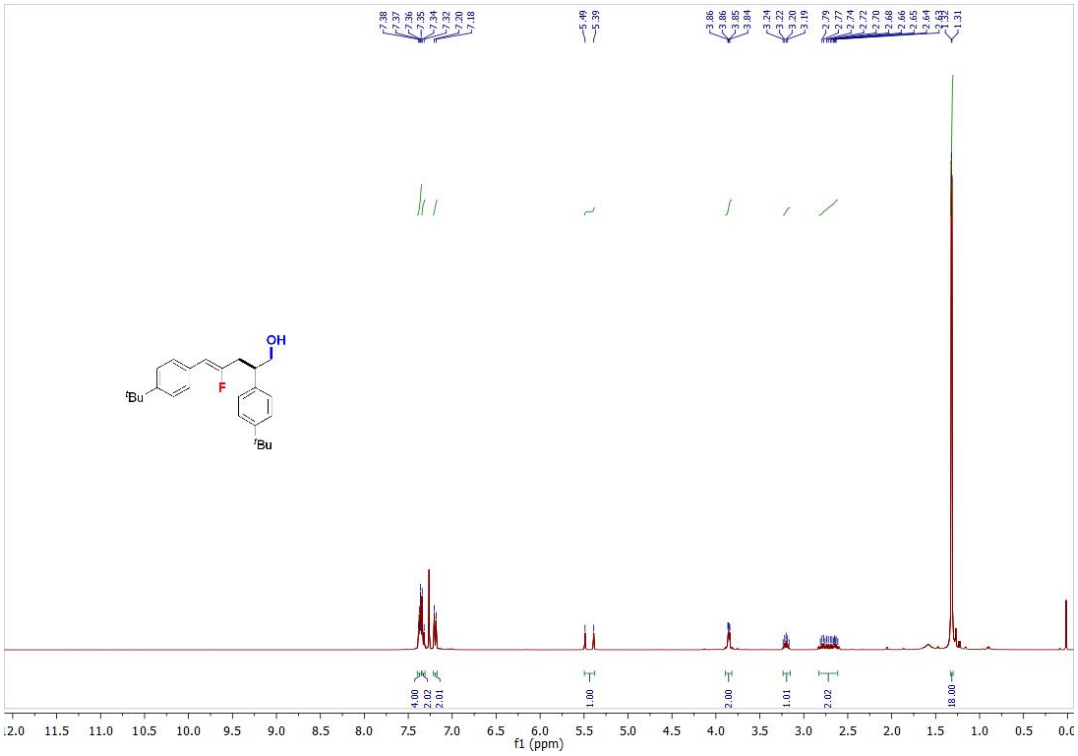

OH
F
tBu
f1 (ppm)

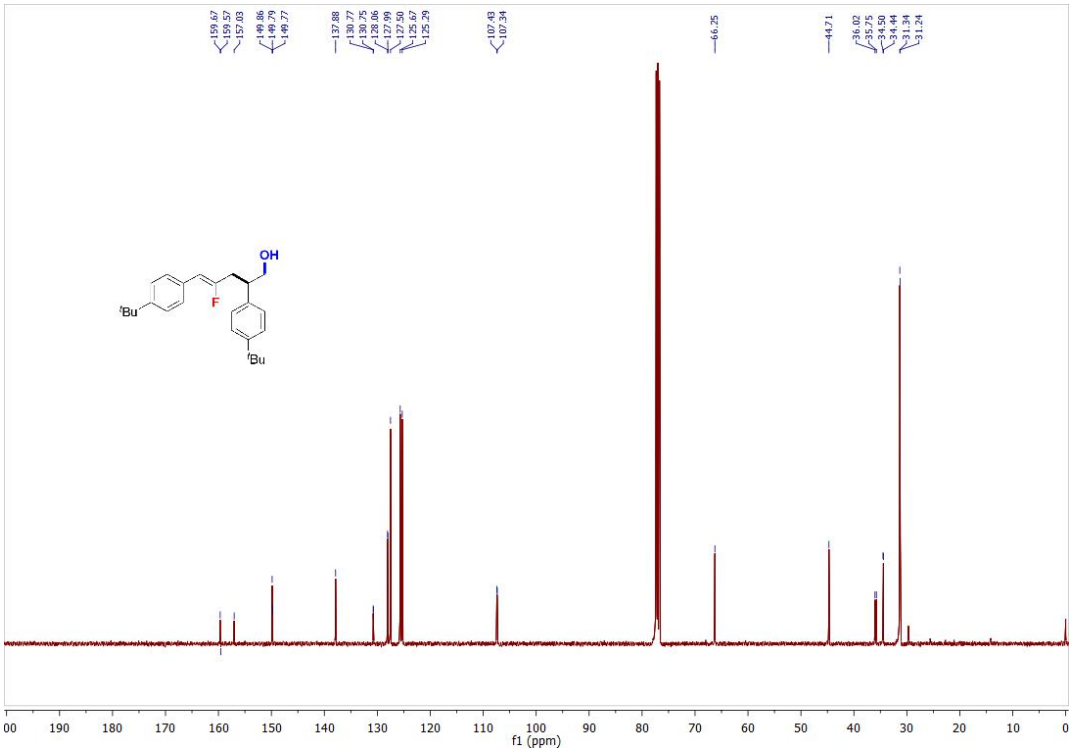


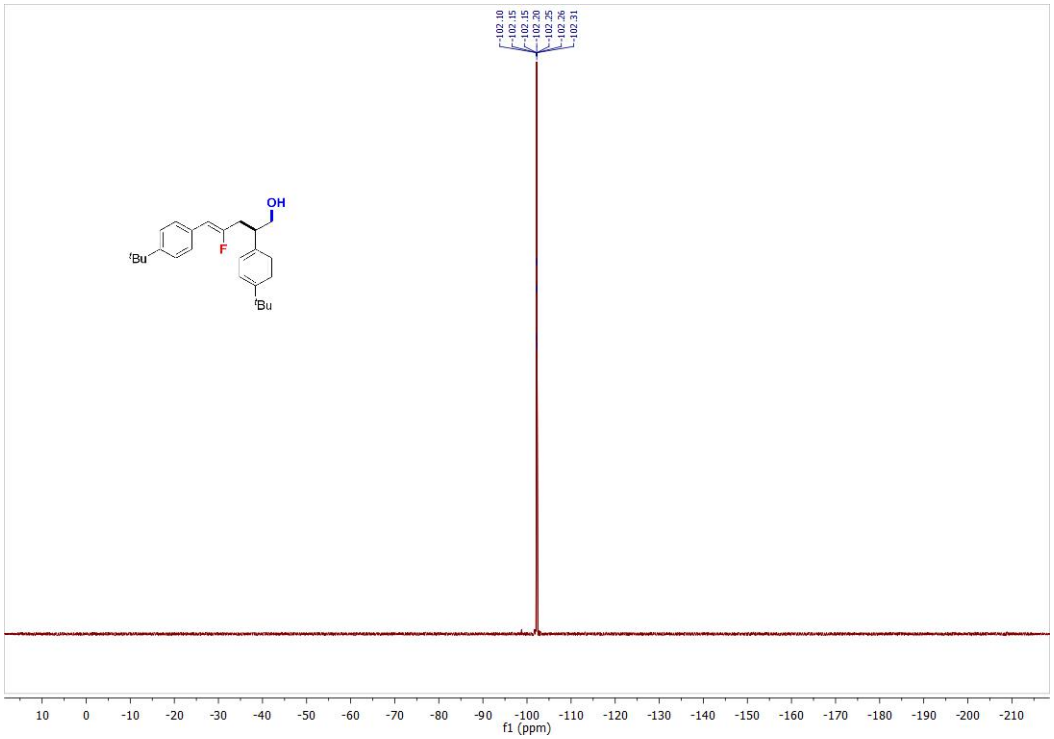
(*R*,*Z*)-2,5-bis(4-(tert-butyl)phenyl)-4-fluoropent-4-en-1-ol (3f):



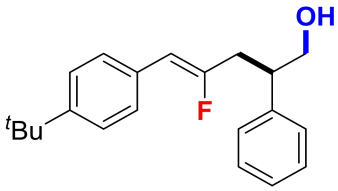
(33.5 mg, 91% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.35 (m, 4H), 7.35-7.31 (m, 2H), 7.21-7.17 (m, 2H), 5.44 (d, *J* = 39.6 Hz, 1H), 3.86-3.82 (m, 2H), 3.23-3.15 (m, 1H), 2.82-2.58 (m, 2H), 1.34-1.29 (m, 18H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.3 (d, *J* = 265.3 Hz), 149.8, 149.7 (d, *J* = 2.0 Hz), 137.8, 130.7 (d, *J* = 2.4 Hz), 128.0 (d, *J* = 7.2 Hz), 127.5, 125.6, 125.2, 107.3 (d, *J* = 8.8 Hz), 66.2, 44.7, 35.8, 34.5, 34.4, 31.3, 31.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -102.20 (ddd, *J* = 39.7, 20.9, 18.8 Hz). **HRMS (ESI)** calcd for $C_{25}H_{34}FO^{+}$[M+H^{+}]: 369.2588 found 369.2585.


OH
F
tBu
tBu
f1 (ppm)

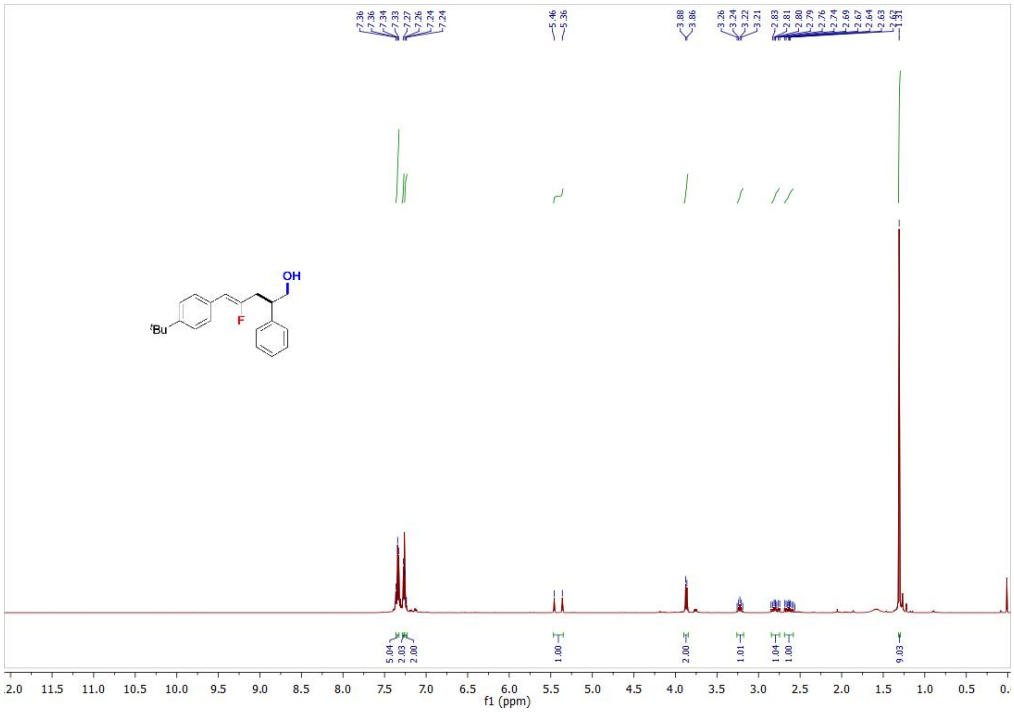

OH
F
tBu
tBu
f1 (ppm)

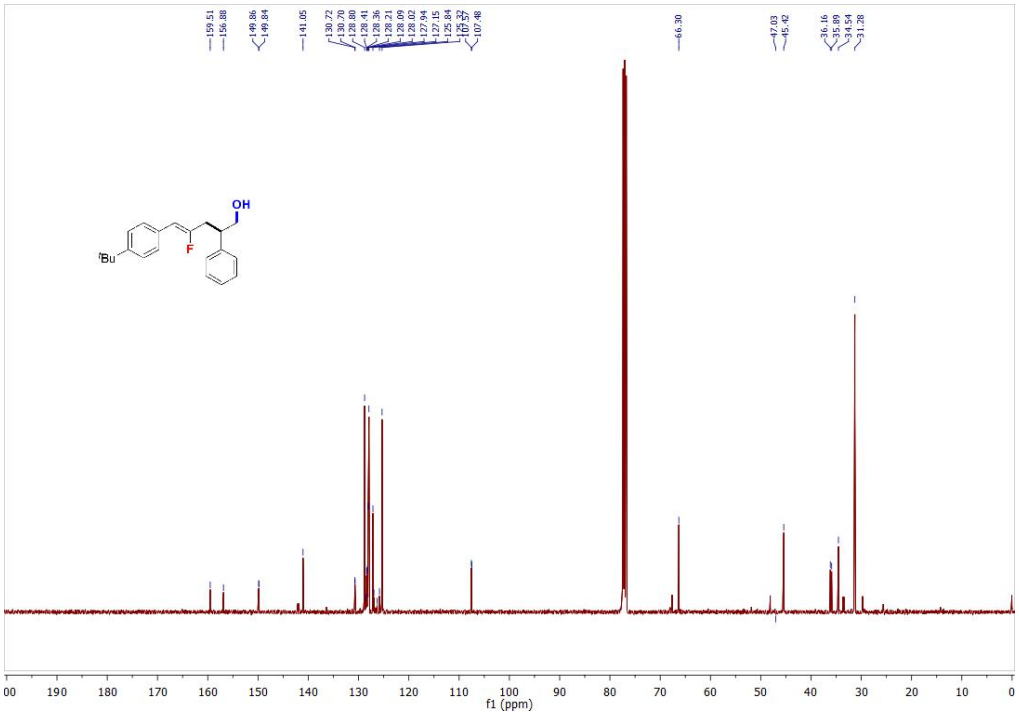


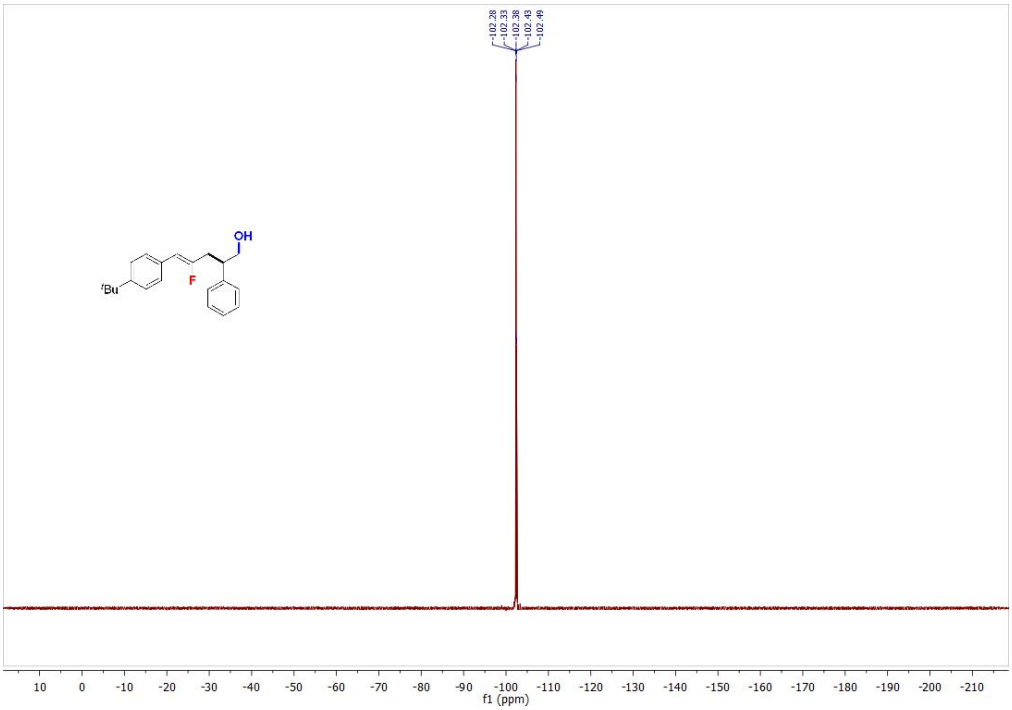
(*R*,*Z*)-5-(4-(tert-butyl)phenyl)-4-fluoro-2-phenylpent-4-en-1-ol (3g):



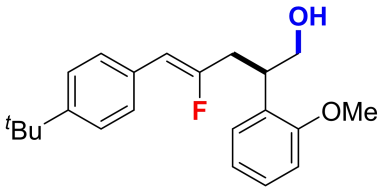
(28 mg, 90% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.35-7.32 (m, 5H), 7.27 (s, 2H), 7.25 (s, 2H), 5.41 (d, *J* = 39.6 Hz, 1H), 3.87 (d, *J* = 6.2 Hz, 2H), 3.25-3.17 (m, 1H), 2.84-2.74 (m, 1H), 2.68-2.58 (m, 1H), 1.31 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.3 (d, *J* = 265.3 Hz), 149.8, 149.7 (d, *J* = 2.0 Hz), 137.8, 130.7 (d, *J* = 2.4 Hz), 128.0 (d, *J* = 7.2 Hz), 127.5, 125.6, 125.2, 107.3 (d, *J* = 8.8 Hz), 66.2, 44.7, 35.8 (d, *J* = 26.7 Hz), 34.4, 31.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -102.38 (dt, *J* = 39.7, 19.9 Hz). **HRMS (ESI)** calcd for $C_{21}H_{26}FO^+$[M+H$^+$]: 313.1962 found 313.1963.


OH
F
tBu
f1 (ppm)

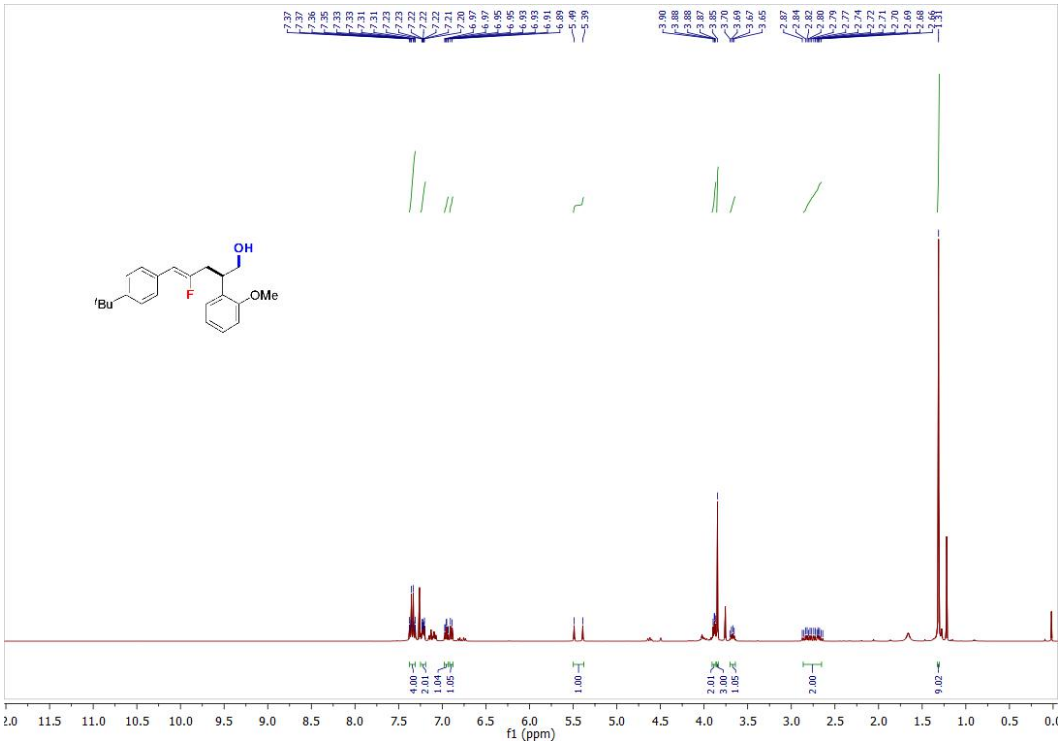

OH
F
tBu
f1 (ppm)

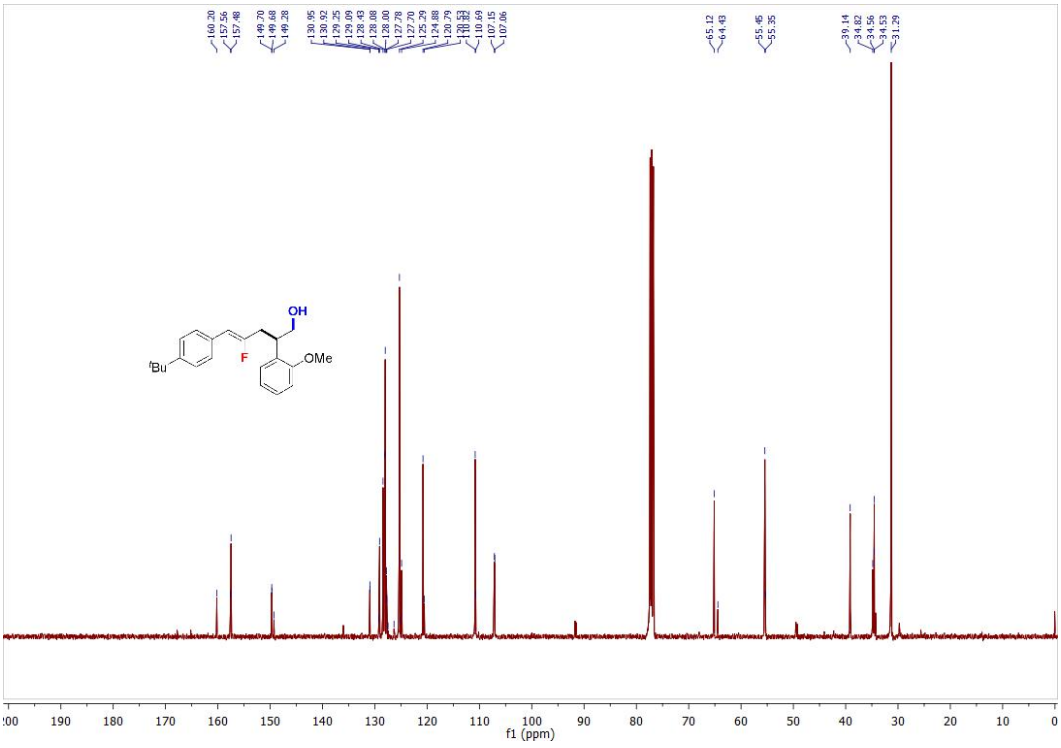


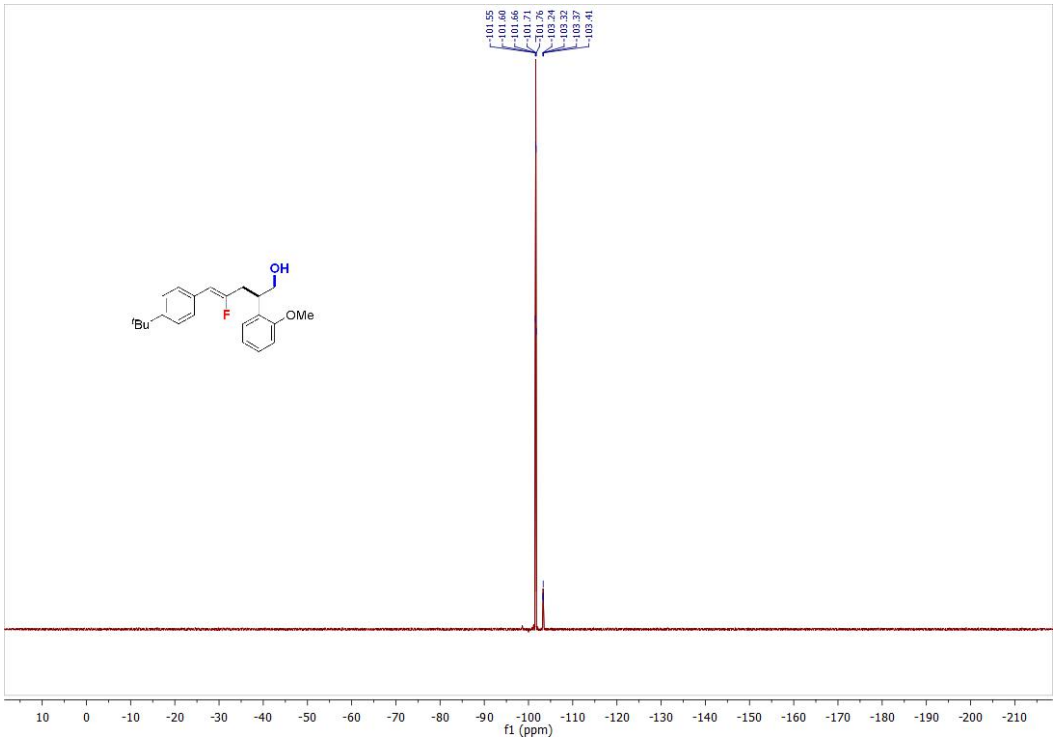
(*R*,*Z*)-5-(4-(tert-butyl)phenyl)-4-fluoro-2-(2-methoxyphenyl)pent-4-en-1-ol (3h):



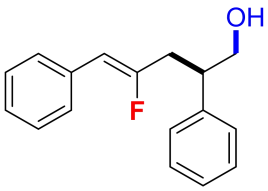
(29 mg, 85% colorless oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37-7.30 (m, 4H), 7.23-7.19 (m, 2H), 6.97-6.92 (m, 1H), 6.91-6.87 (m, 1H), 5.44 (d, *J* = 39.6 Hz, 1H), 3.89-3.86 (m, 2H), 3.84 (s, 3H), 3.70-3.62 (m, 1H), 2.85-2.64 (m, 2H), 1.31 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.8 (d, *J* = 265.5 Hz), 157.4, 149.6 (d, *J* = 2.0 Hz), 130.9 (d, *J* = 2.4 Hz), 129.0, 128.4, 128.0 (d, *J* = 7.5 Hz), 125.2, 120.7, 110.8, 107.1 (d, *J* = 8.9 Hz), 91.6, 65.1, 55.4, 49.3 (d, *J* = 24.1 Hz), 39.1, 34.5, 31.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -101.66 (dt, *J* = 39.7, 19.9 Hz). **HRMS (ESI)** calcd for $C_{22}H_{28}FO_2^+$[M+H$^+$]: 343.2068 found 343.2067.


OH
F
OMe
tBu
f1 (ppm)

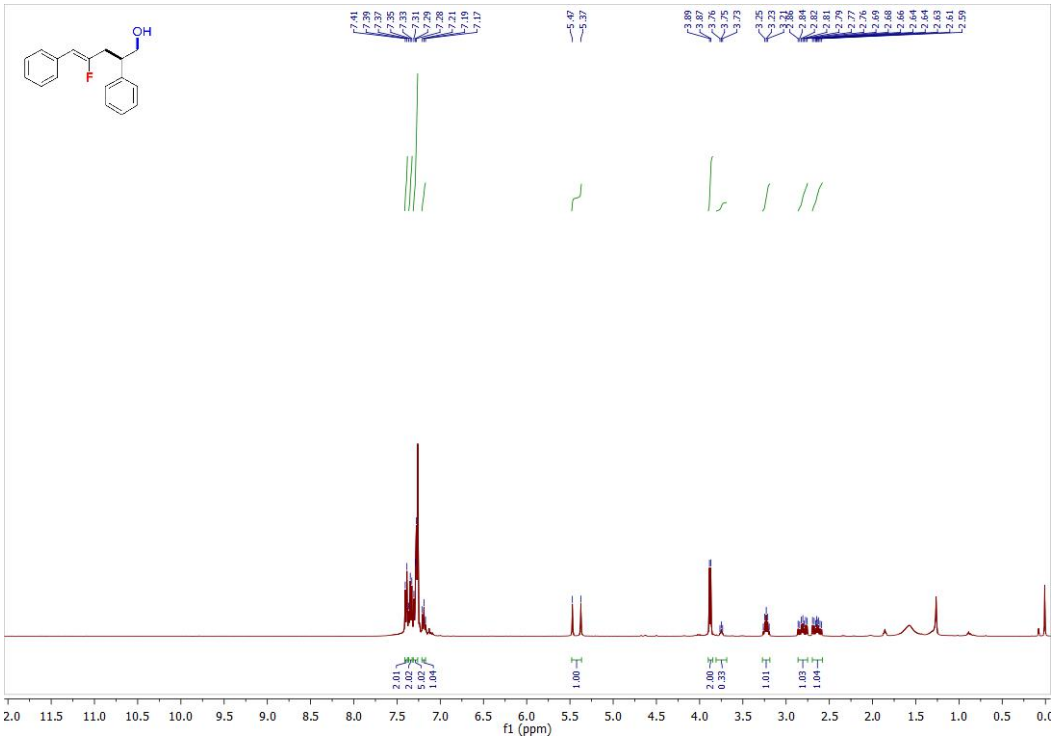

OH
F
OMe
tBu
f1 (ppm)

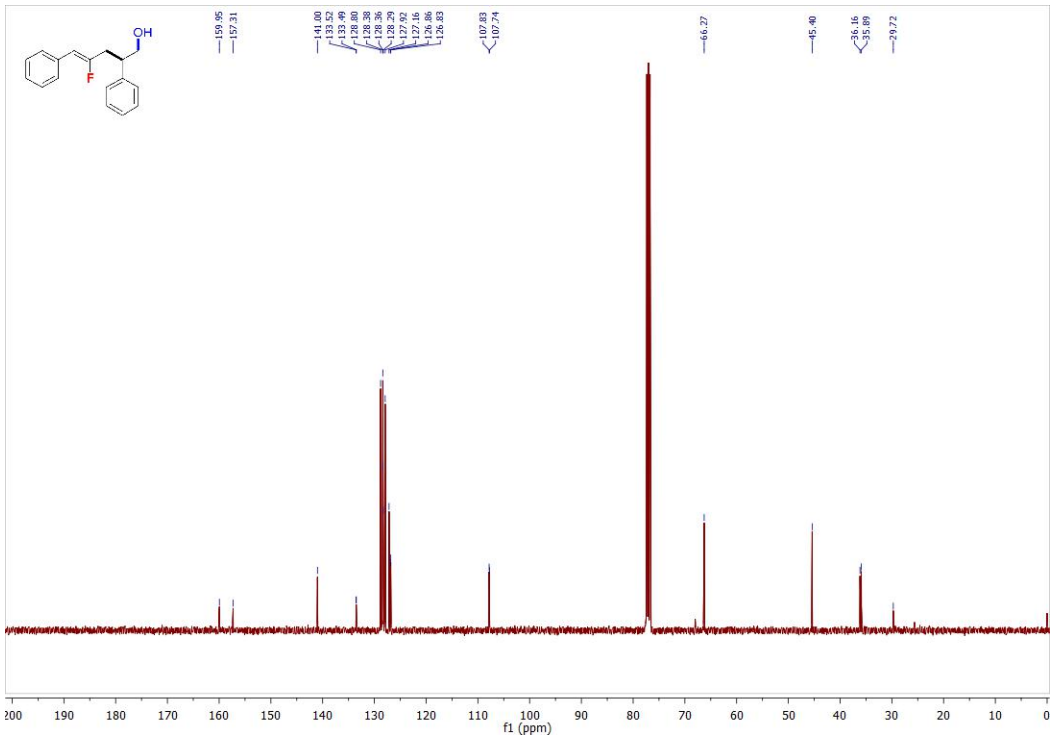


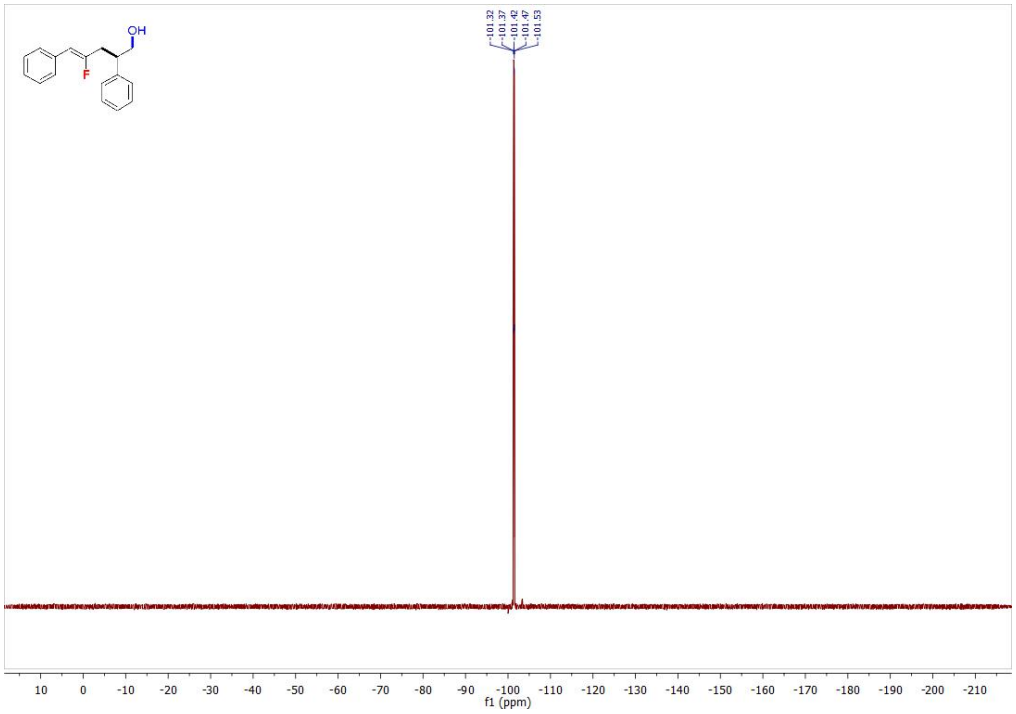
(*R*,*Z*)-4-fluoro-2,5-diphenylpent-4-en-1-ol (3i):



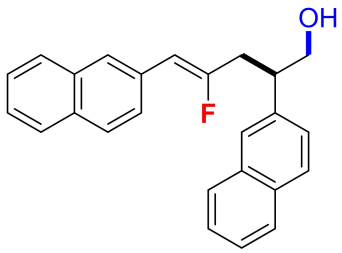
(23 mg, 90% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.42-7.38 (m, 2H), 7.37-7.32 (m, 2H), 7.31-7.26 (m, 5H), 7.22-7.16 (m, 1H), 5.42 (d, *J* = 39.3 Hz, 1H), 3.87 (d, *J* = 8.6 Hz, 2H), 3.77-3.70 (m, 1H), 3.28-3.17 (m, 1H), 2.87-2.72 (m, 1H), 2.71-2.55 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.6 (d, *J* = 266.2 Hz), 141.0, 133.5 (d, *J* = 2.5 Hz), 128.8, 128.3, 128.2, 127.9, 127.1, 126.8 (d, *J* = 2.2 Hz), 107.7 (d, *J* = 8.6 Hz), 66.2, 45.4, 36.0 (d, *J* = 26.6 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -101.42 (dt, *J* = 39.5, 19.9 Hz). **HRMS (ESI)** calcd for $C_{17}H_{18}FO^+$[M+H$^+$]: 257.1336 found 257.1336.


OH
F
f1 (ppm)

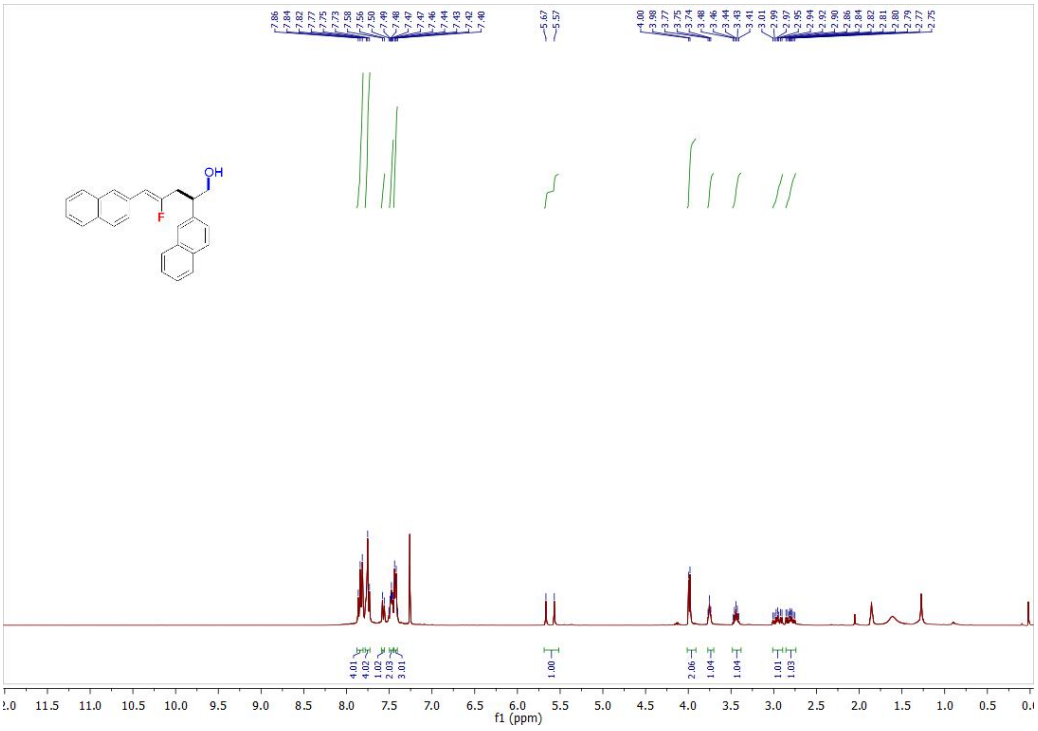

OH
F
f1 (ppm)

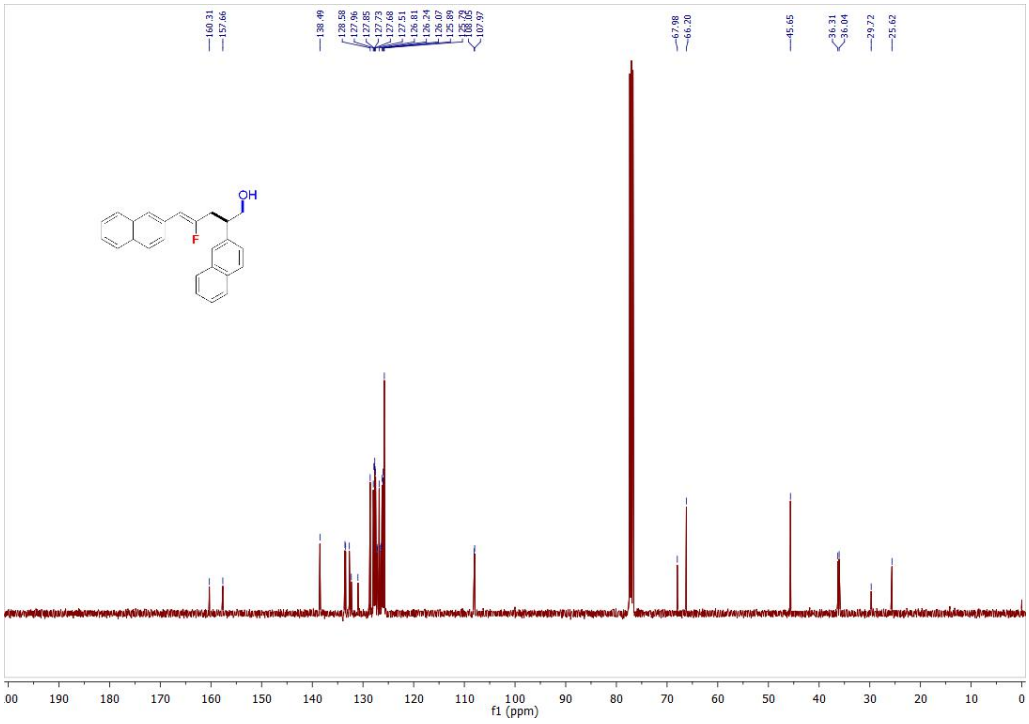


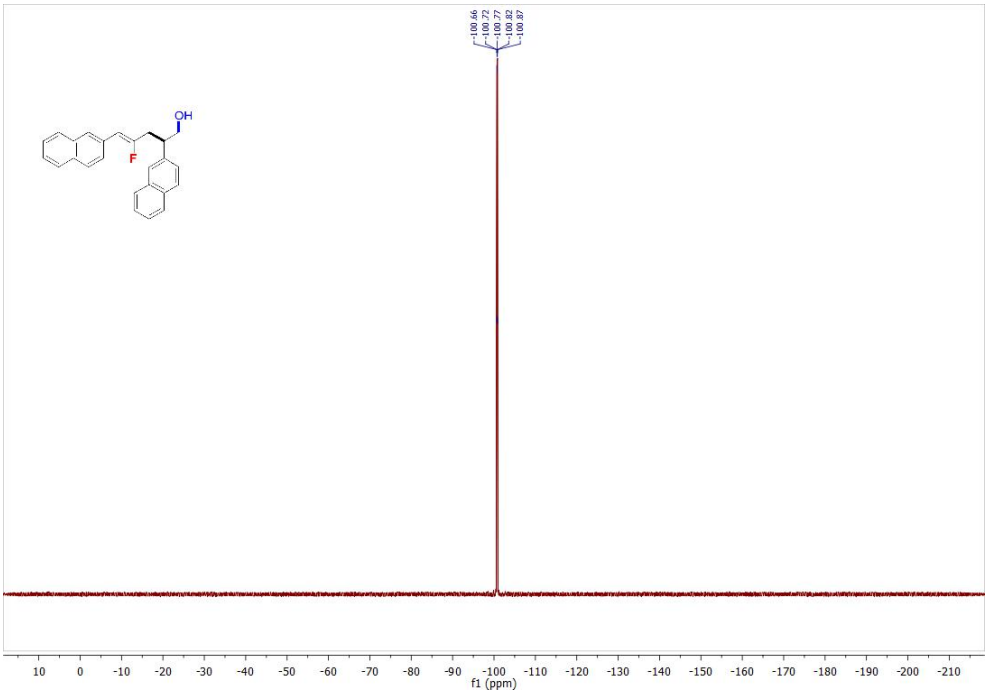
(*R*,*Z*)-4-fluoro-2,5-di(naphthalen-2-yl)pent-4-en-1-ol (3j):



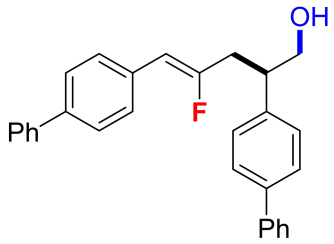
(30 mg, 84% white solid, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.88-7.80 (m, 4H), 7.78-7.71 (m, 4H), 7.59-7.54 (m, 1H), 7.50-7.45 (m, 2H), 7.45-7.41 (m, 3H), 5.62 (d, *J* = 39.2 Hz, 1H), 4.00-3.96 (m, 2H), 3.77-3.71 (m, 1H), 3.47-3.41 (m, 1H), 3.01-2.88 (m, 1H), 2.87-2.73 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.9 (d, *J* = 266.7 Hz), 138.4, 133.4, 132.6, 132.3, 131.0, 128.5, 127.9, 127.8, 127.7, 127.5, 127.1 (d, *J* = 7.3 Hz), 126.8, 126.5, 126.2, 126.0, 125.8, 125.7, 108.0 (d, *J* = 8.5 Hz), 67.9, 66.2, 45.6, 36.1 (d, *J* = 26.6 Hz), 29.7, 25.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -100.77 (dt, *J* = 39.5, 19.9 Hz). **HRMS (ESI)** calcd for $C_{25}H_{22}FO^+$[M+H$^+$]: 357.1649 found 357.1650.


OH
F
f1 (ppm)

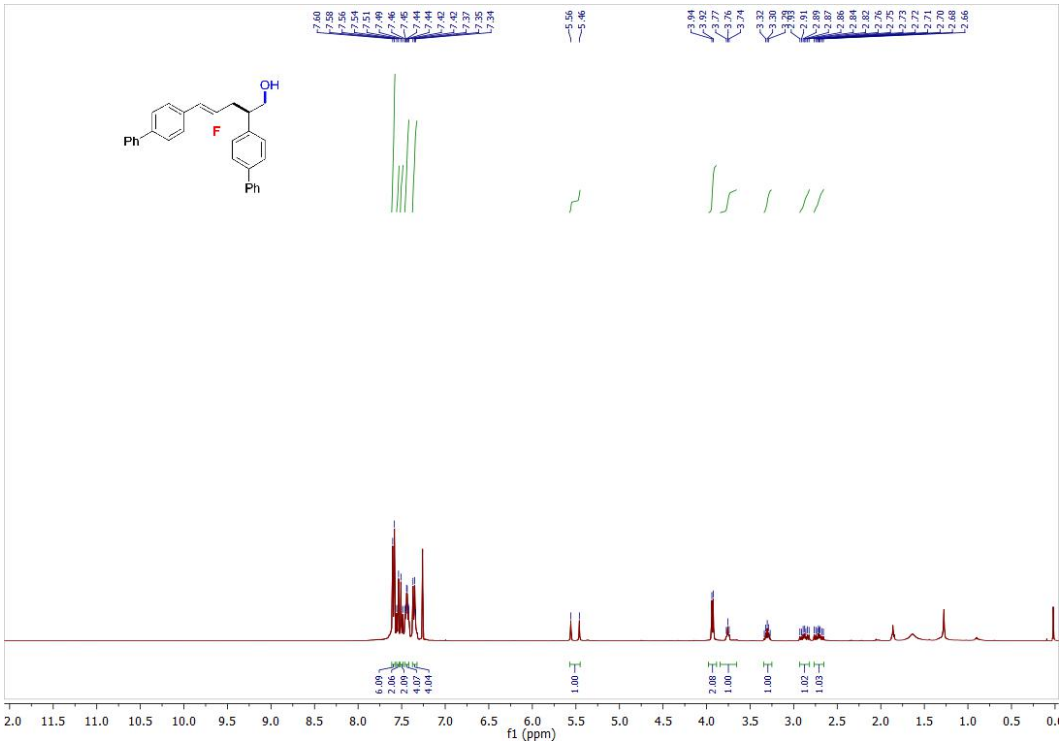

OH
F
f1 (ppm)

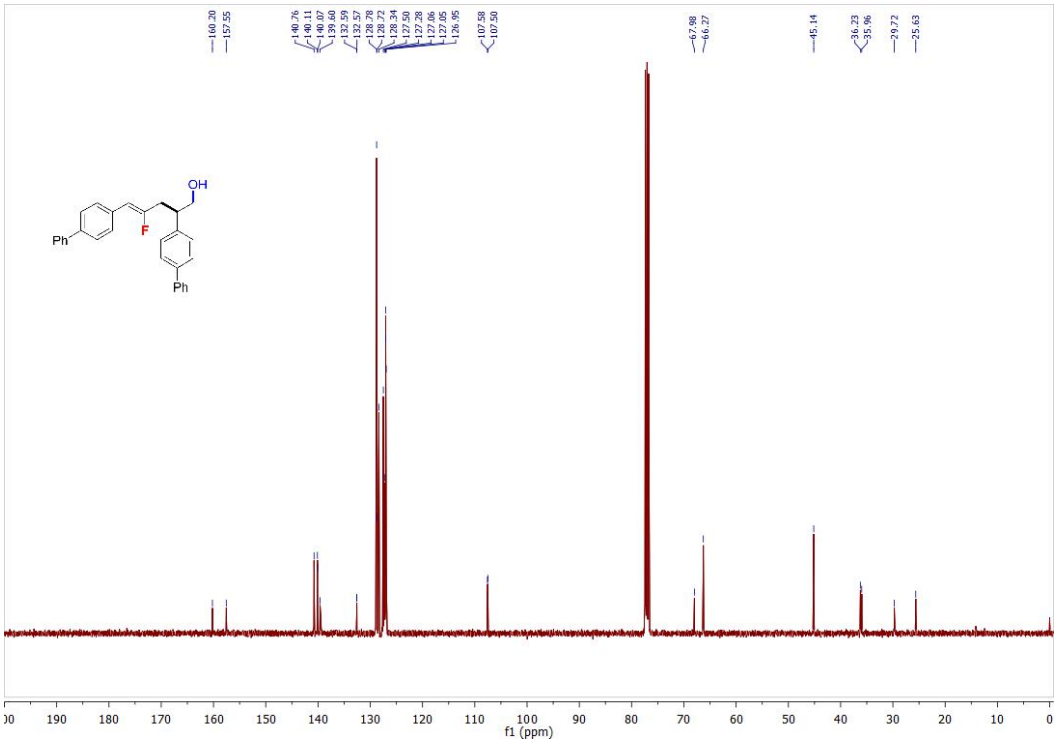


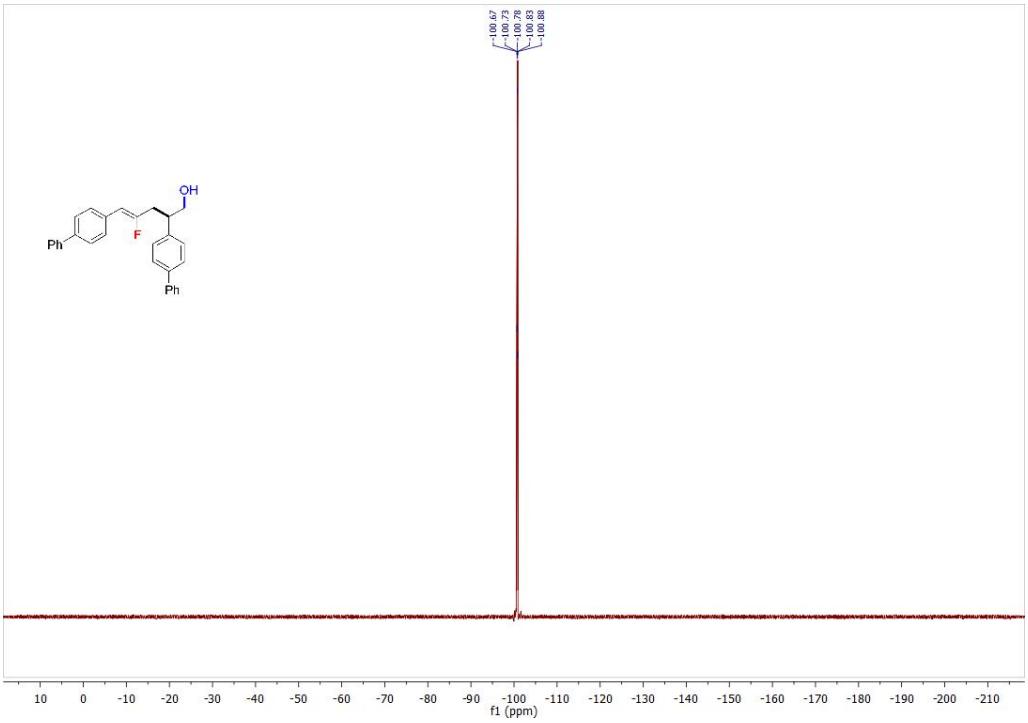
(*R*,*Z*)-2,5-di([1,1'-biphenyl]-4-yl)-4-fluoropent-4-en-1-ol (3k):



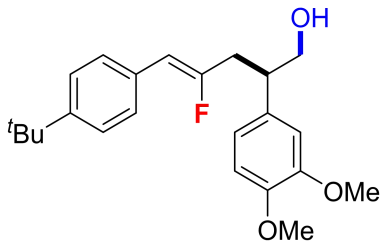
(35.6 mg, 87% white solid, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.61-7.58 (m, 6H), 7.56-7.53 (m, 2H), 7.52-7.48 (m, 2H), 7.46-7.41 (m, 4H), 7.38-7.33 (m, 4H), 5.51 (d, *J* = 39.3 Hz, 1H), 3.92 (d, *J* = 8.6 Hz, 2H), 3.79-3.72 (m, 1H), 3.34-3.25 (m, 1H), 2.93-2.81 (m, 1H), 2.77-2.64 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.8 (d, *J* = 266.5 Hz), 140.7, 140.1, 140.0, 139.6, 132.5 (d, *J* = 2.5 Hz), 128.7, 128.7, 128.3, 127.5, 127.2, 127.0, 126.9, 107.5 (d, *J* = 8.6 Hz), 67.9, 66.2, 45.1, 36.0 (d, *J* = 26.6 Hz), 29.7, 25.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -100.78 (dt, *J* = 39.5, 19.9 Hz). **HRMS (ESI)** calcd for $C_{29}H_{26}FO^{+}$[M+H^{+}]: 409.1962 found 409.1958.


OH
F
Ph
Ph
f1 (ppm)

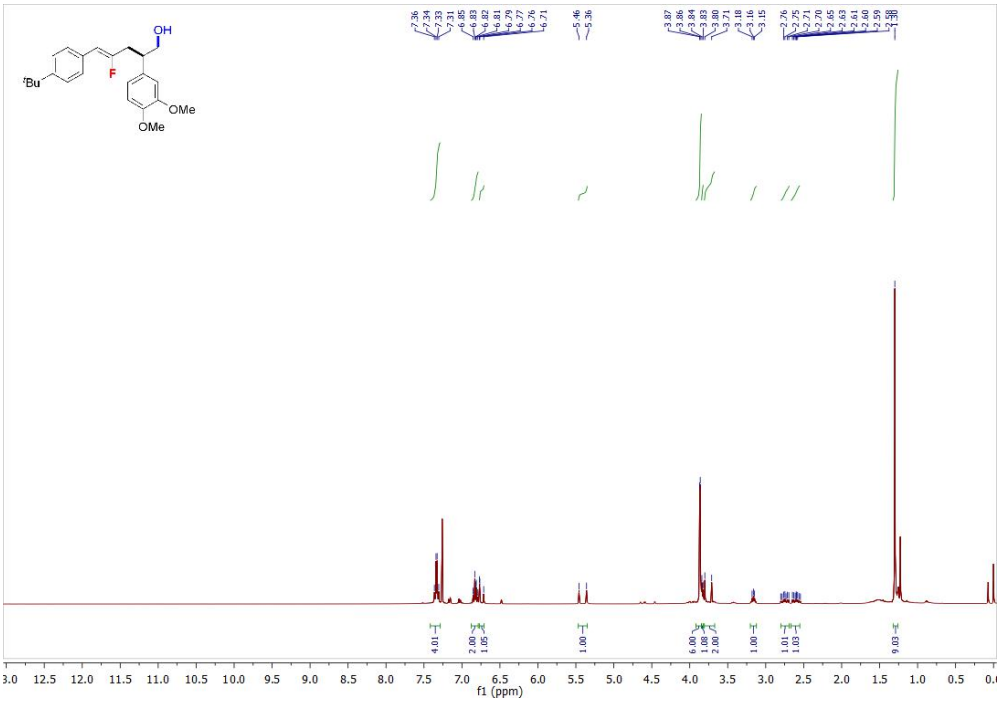

OH
F
Ph
Ph
f1 (ppm)

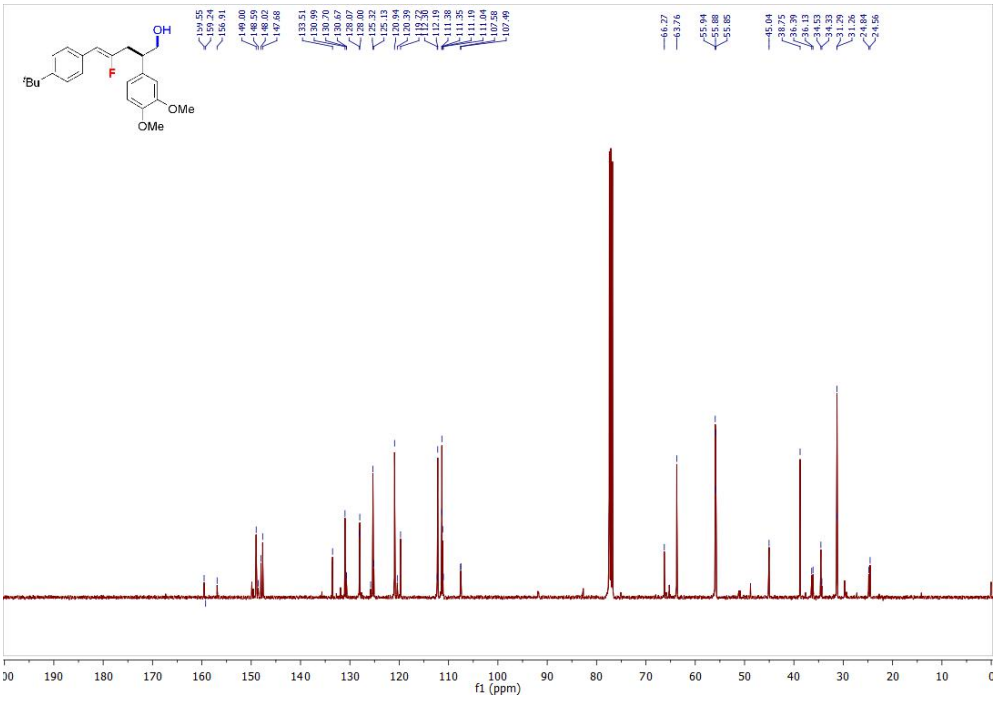


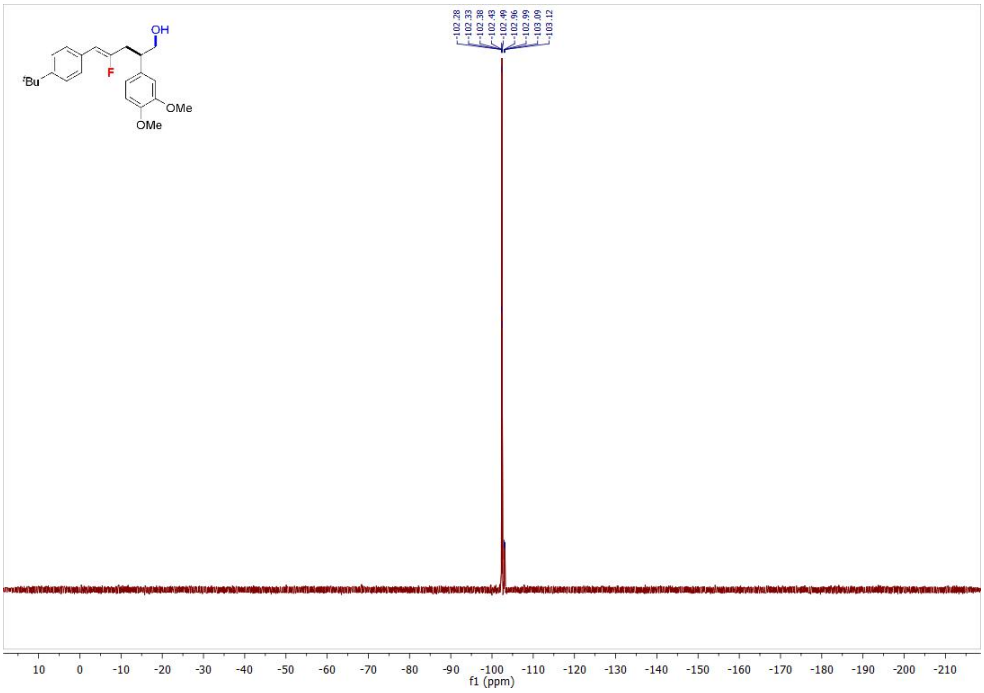
(*R*,*Z*)-5-(4-(tert-butyl)phenyl)-2-(3,4-dimethoxyphenyl)-4-fluoropent-4-en-1-ol (3l):



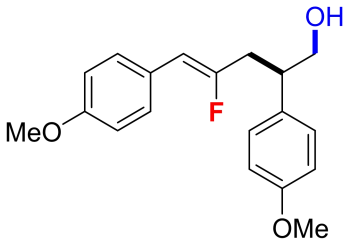
(31.3 mg, 84% colorless oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.33 (d, 4H), 6.87-6.78 (m, 2H), 6.78-6.69 (m, 1H), 5.41 (d, *J* = 39.6 Hz, 1H), 3.90-3.85 (m, 6H), 3.85-3.82 (m, 1H), 3.81-3.69 (m, 2H), 3.20-3.10 (m, 1H), 2.81-2.68 (m, 1H), 2.65-2.53 (m, 1H), 1.30 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.2 (d, *J* = 265.1 Hz), 149.0, 147.6, 133.5, 130.9, 128.0 (d, *J* = 7.2 Hz), 125.3, 120.9, 119.7, 112.1, 111.3, 107.5 (d, *J* = 8.8 Hz), 66.2, 63.7, 56.2, 45.0, 38.7, 36.2 (d, *J* = 26.6 Hz), 31.2, 24.7. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -102.38 (dt, *J* = 39.8, 20.0 Hz). **HRMS (ESI)** calcd for $C_{23}H_{30}FO_3^+$[M+H$^+$]: 373.2173 found 373.2176.


OH
F
tBu
OMe
OMe
f1 (ppm)

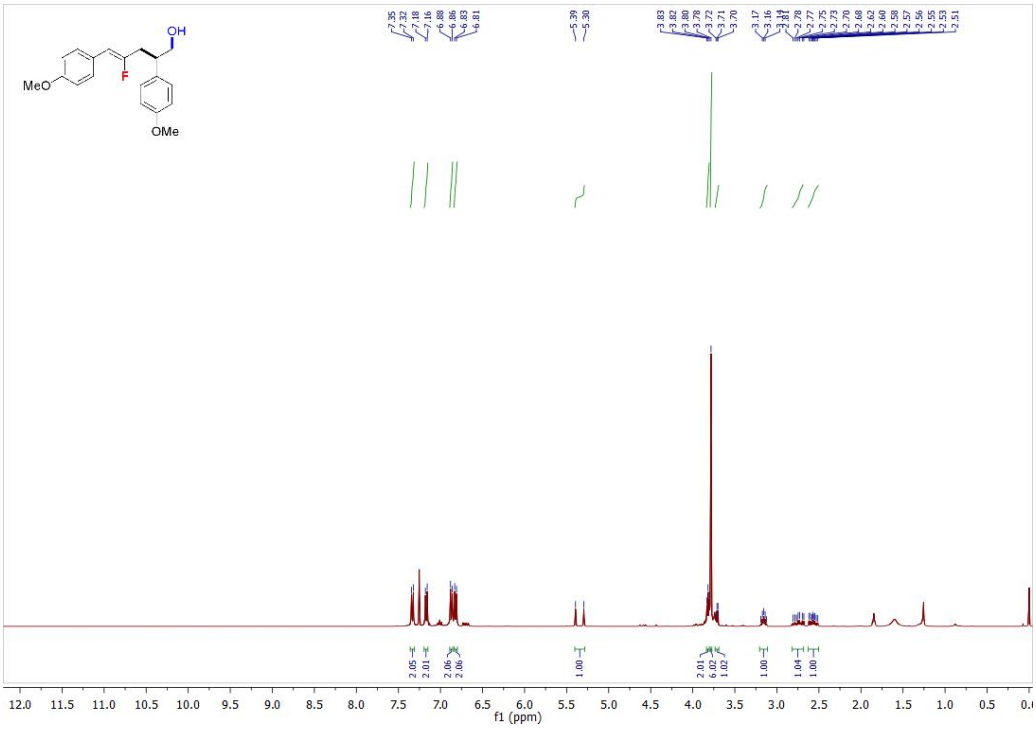

OH
F
tBu
OMe
OMe
f1 (ppm)

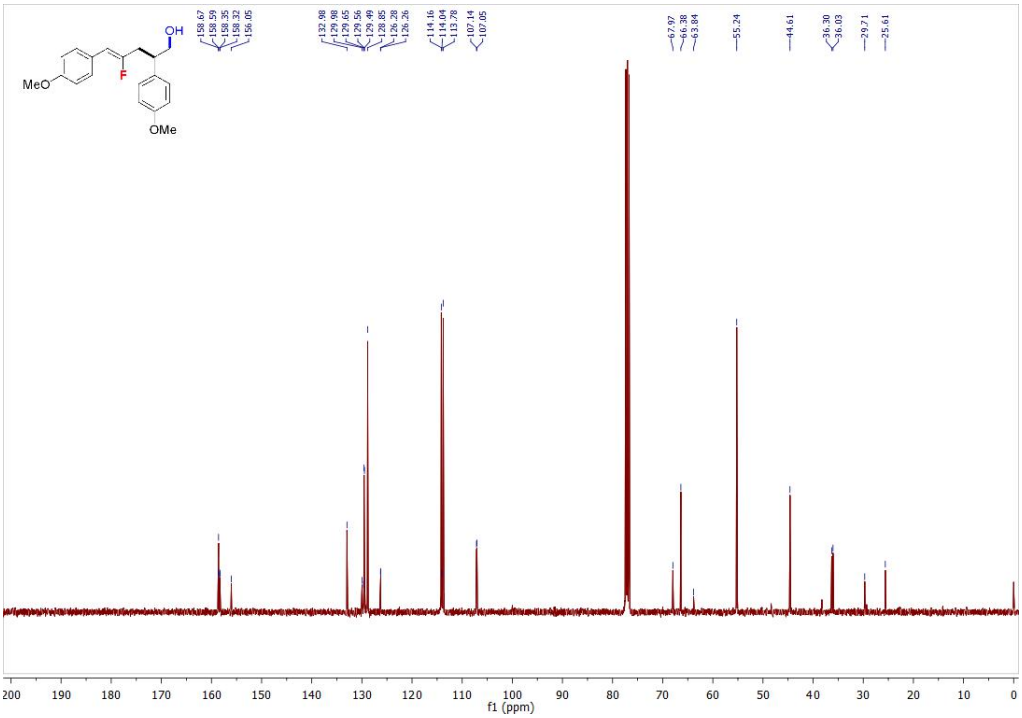


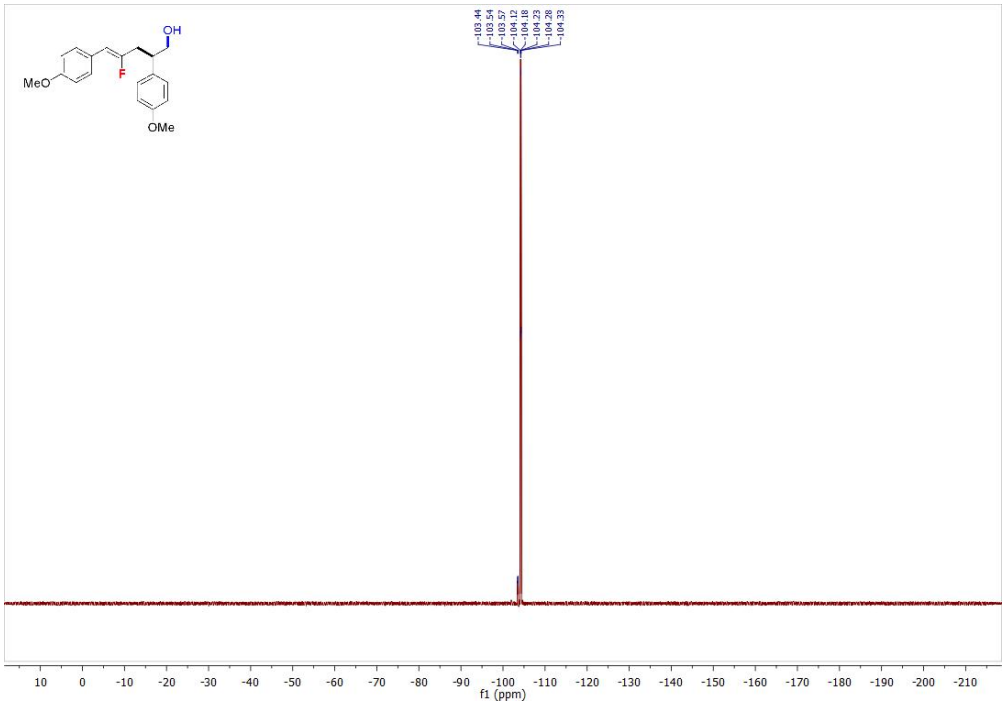
(*R*,*Z*)-4-fluoro-2,5-bis(4-methoxyphenyl)pent-4-en-1-ol (3m):



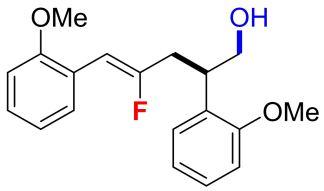
(27 mg, 85% colorless oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.35-7.32 (m, 2H), 7.19-7.15 (m, 2H), 6.89-6.85 (m, 2H), 6.83-6.80 (m, 2H), 5.35 (d, 1H), 3.84-3.80 (m, 2H), 3.78 (s, 6H), 3.74-3.69 (m, 1H), 3.20-3.09 (m, 1H), 2.79-2.67 (m, 1H), 2.61-2.51 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.5, 158.5 (d, *J* = 32.4 Hz), 156.0, 132.9, 129.5 (d, *J* = 7.4 Hz), 128.8, 126.2 (d, *J* = 2.5 Hz), 113.9 (d, *J* = 38.4 Hz), 107.0 (d, *J* = 9.0 Hz), 66.3, 55.2, 44.6, 36.1 (d, *J* = 26.7 Hz), 25.6. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -104.23 (dt, *J* = 39.8, 20.0 Hz). **HRMS (ESI)** calcd for $C_{19}H_{22}FO_3^+$[M+H$^+$]: 317.1547 found 317.1544.


OH
MeO
F
OMe
f1 (ppm)

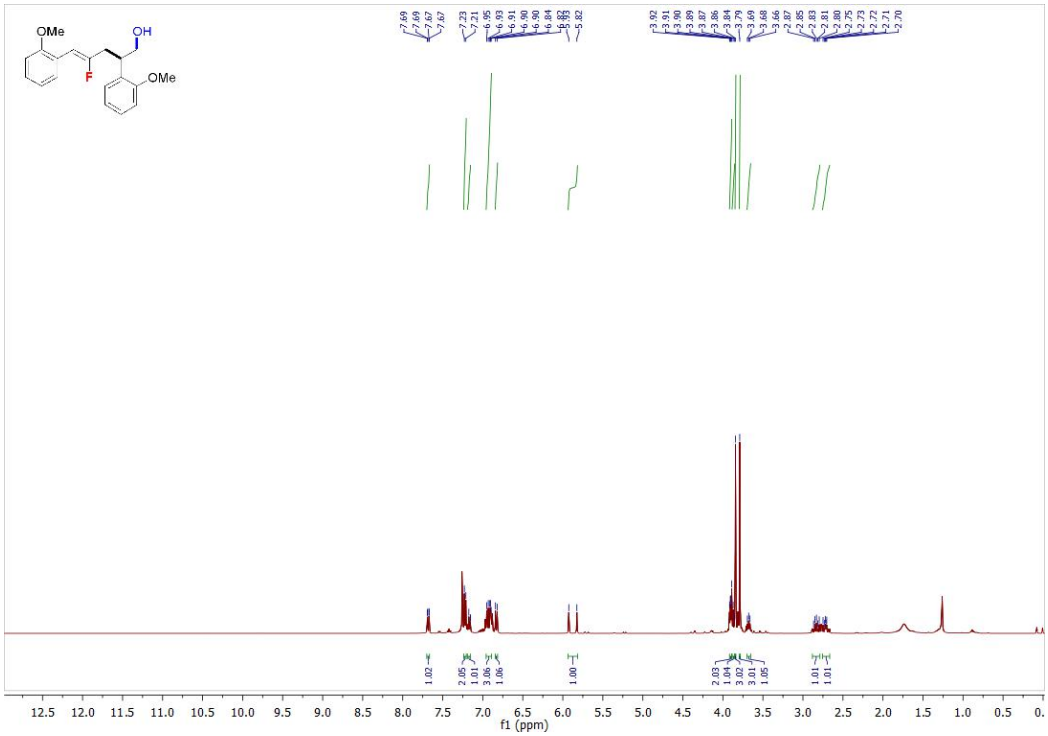

OH
MeO
F
OMe
f1 (ppm)

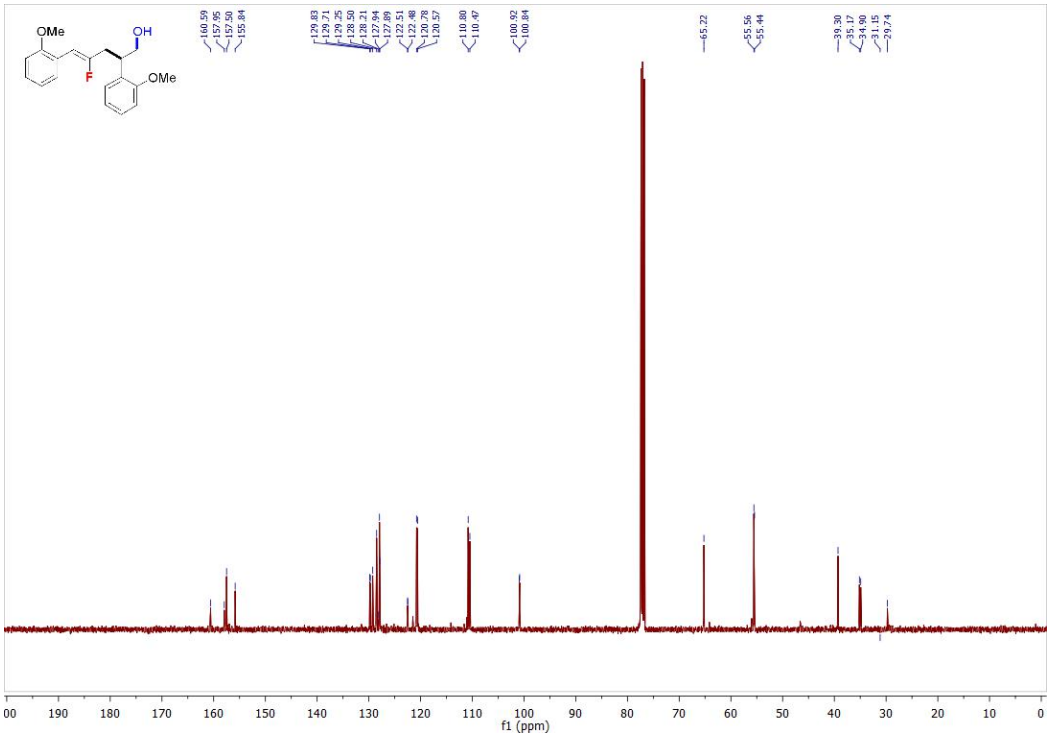


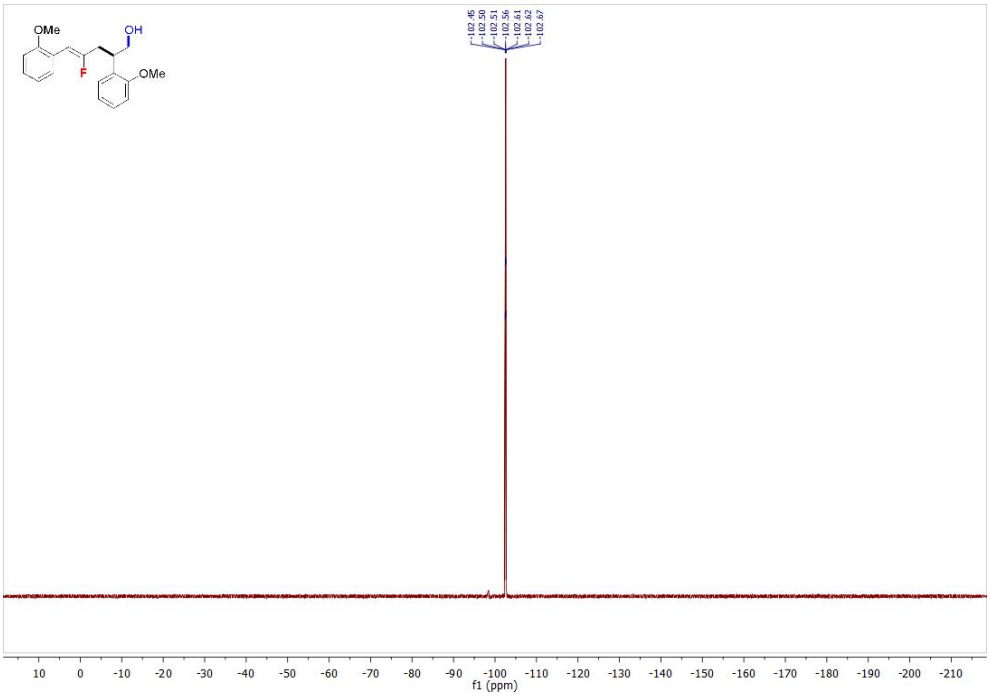
(*R*,*Z*)-4-fluoro-2,5-bis(2-methoxyphenyl)pent-4-en-1-ol (3n):



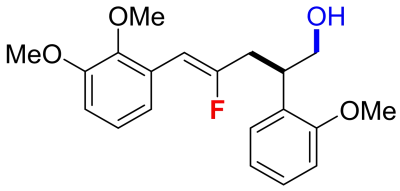
(25.5 mg, 81% colorless oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.70-7.66 (m, 1H), 7.23-7.20 (m, 2H), 7.18-7.14 (m, 1H), 6.96-6.89 (m, 3H), 6.84-6.81 (m, 1H), 5.93-5.81 (m, 1H), 3.92-3.89 (m, 2H), 3.88-3.85 (m, 1H), 3.84 (s, 3H), 3.79 (s, 3H), 3.70-3.66 (m, 1H), 2.87-2.78 (m, 1H), 2.75-2.69 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.2 (d, J = 265.9 Hz), 157.5, 155.8, 129.7, 129.2, 128.5, 127.9, 127.8, 122.5 (d, J = 2.7 Hz), 120.7, 120.5, 110.8, 110.4, 100.8 (d, J = 7.3 Hz), 65.2, 55.5, 39.3, 35.0 (d, J = 26.6 Hz), 29.7. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -102.56 (ddd, J = 40.1, 21.2, 18.8 Hz). **HRMS (ESI)** calcd for $C_{19}H_{22}FO_3^+$[M+H$^+$]: 317.1547 found 317.1541.


OMe
OH
F
OMe
f1 (ppm)

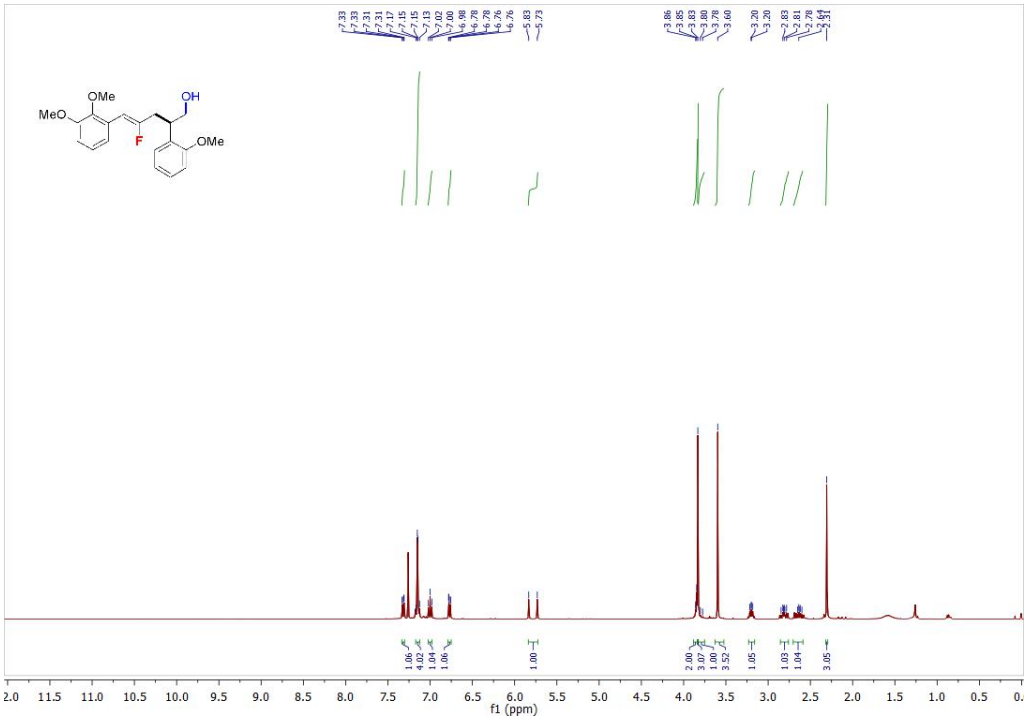

OMe
OH
F
OMe
f1 (ppm)

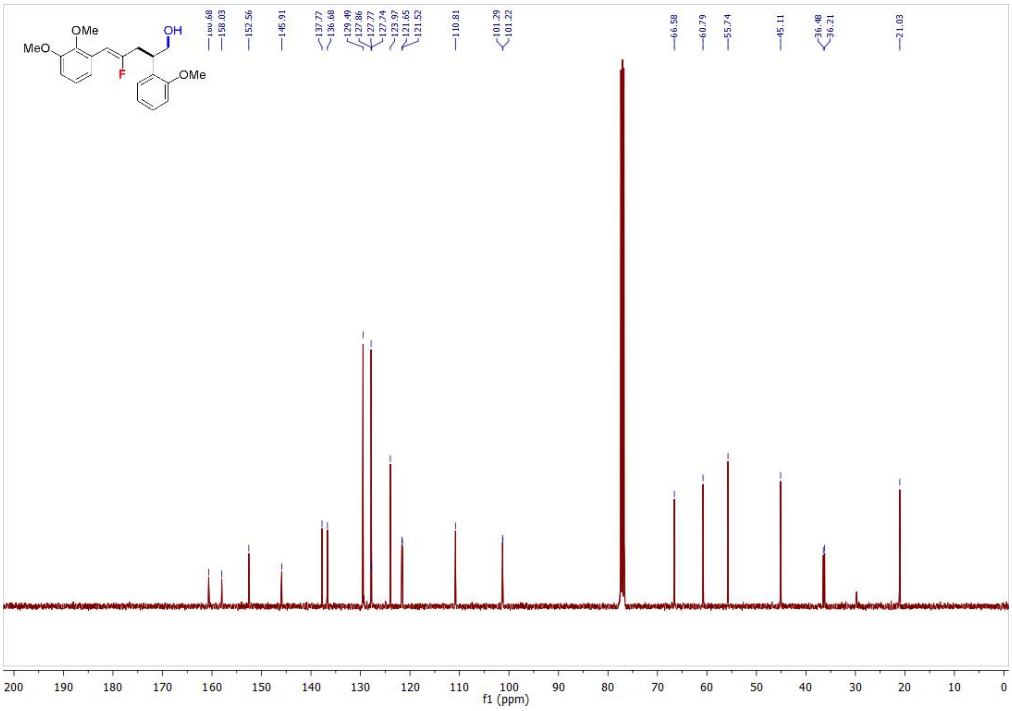


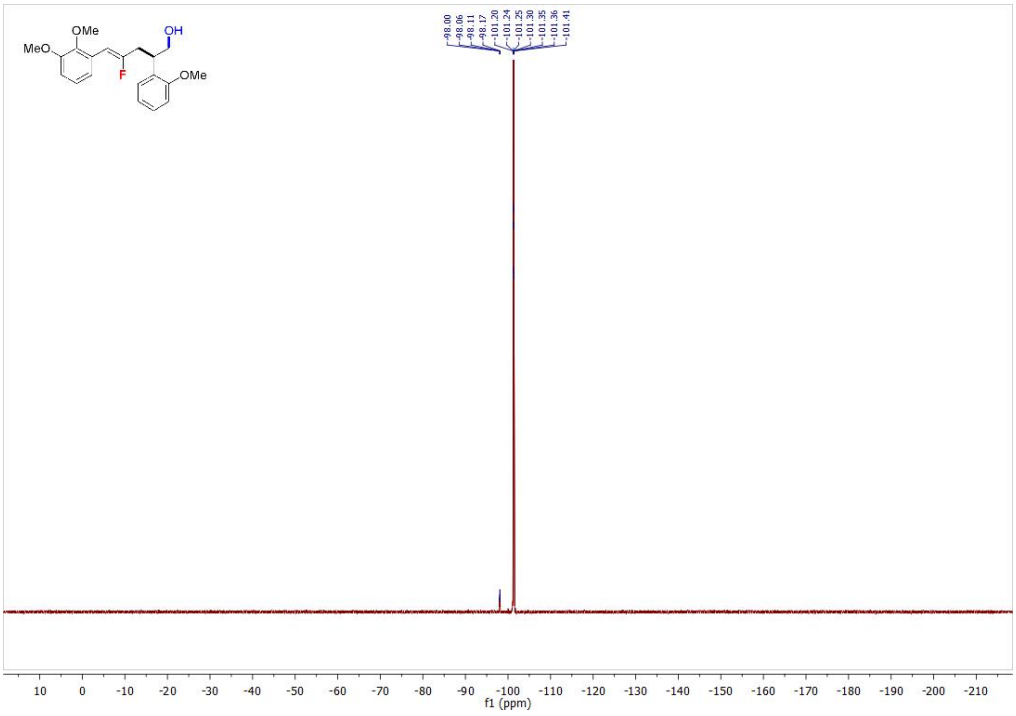
(*R*,*Z*)-5-(2,3-dimethoxyphenyl)-4-fluoro-2-(2-methoxyphenyl)pent-4-en-1-ol (3o):



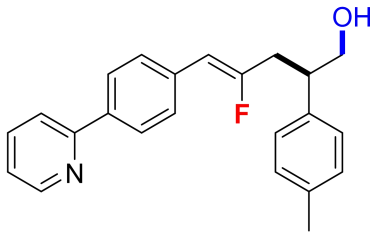
(27.7 mg, 80% colorless oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.34-7.30 (m, 1H), 7.17-7.12 (m, 4H), 7.02-6.96 (m, 1H), 6.79-6.74 (m, 1H), 5.77 (d, 1H), 3.86-3.84 (m, 2H), 3.83 (s, 3H), 3.83-3.77 (m, 1H), 3.60 (s, 3H), 3.22-3.15 (m, 1H), 2.83-2.76 (m, 1H), 2.65-2.60 (m, 1H), 2.31 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.3 (d, J = 266.7 Hz), 152.5, 145.9, 137.7, 136.6, 129.4, 127.8, 127.7, 123.9, 121.5 (d, J = 12.6 Hz), 110.8, 101.2 (d, J = 7.0 Hz), 66.5, 60.7, 55.7, 45.1, 36.3 (d, J = 26.8 Hz), 29.7, 21.0. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -101.17. **HRMS (ESI)** calcd for $C_{20}H_{24}FO_4^+$[M+H$^+$]: 347.1653 found 347.1651.


OMe
MeO
OH
F
OMe
f1 (ppm)

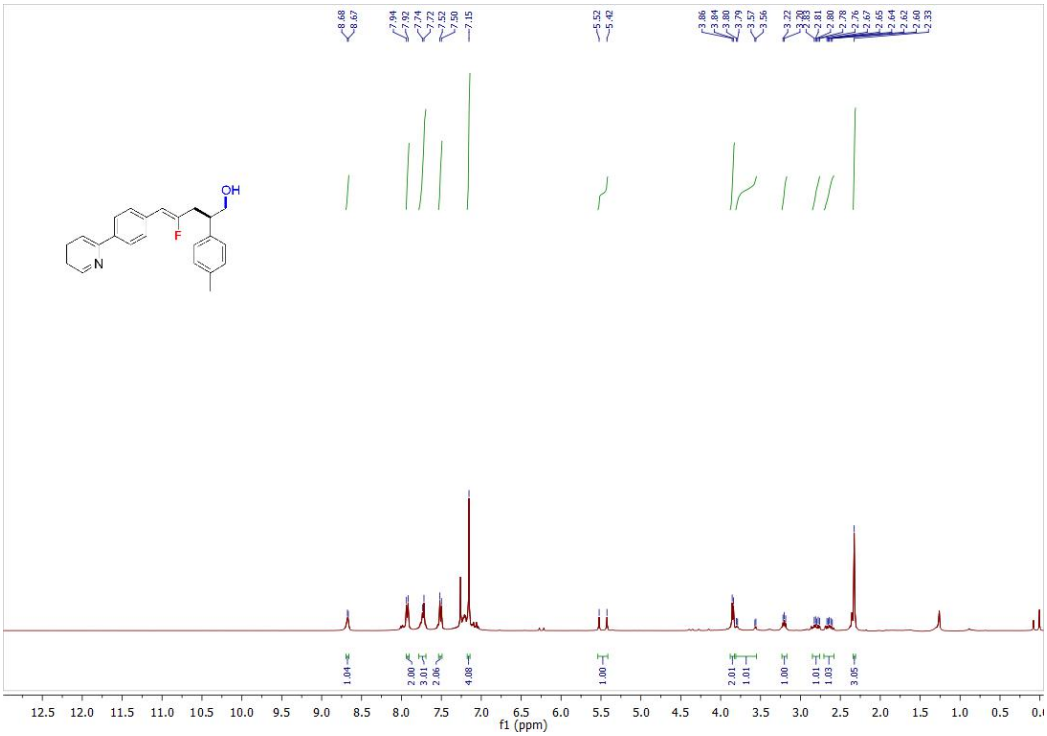

OMe
MeO
OH
F
OMe
f1 (ppm)

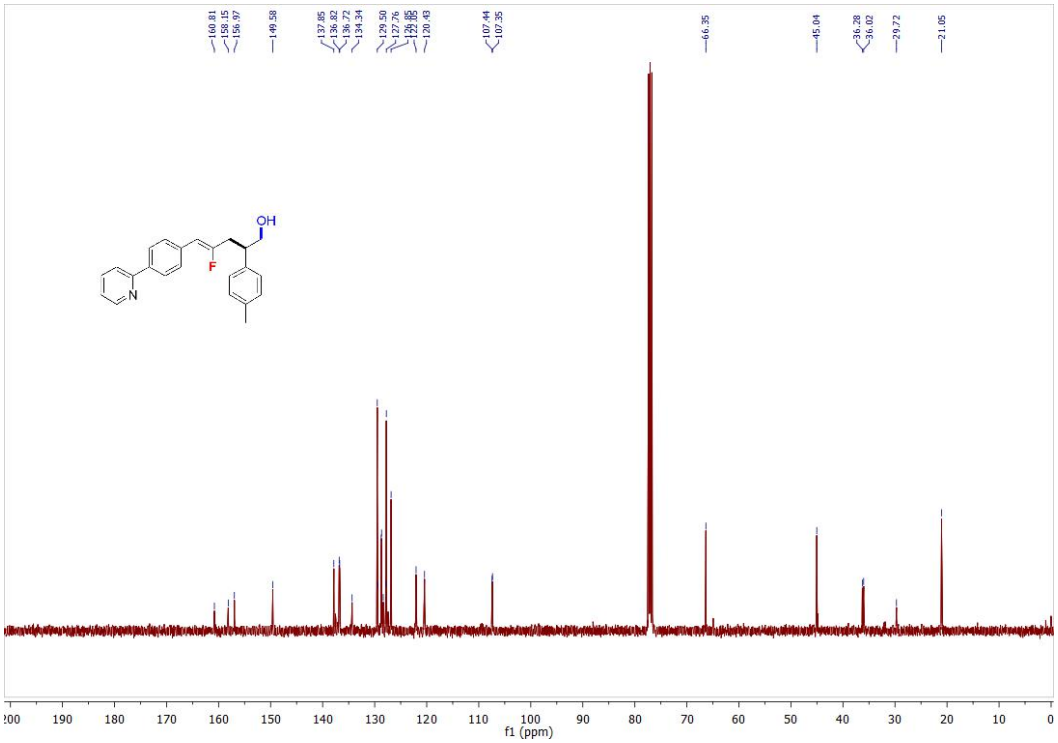


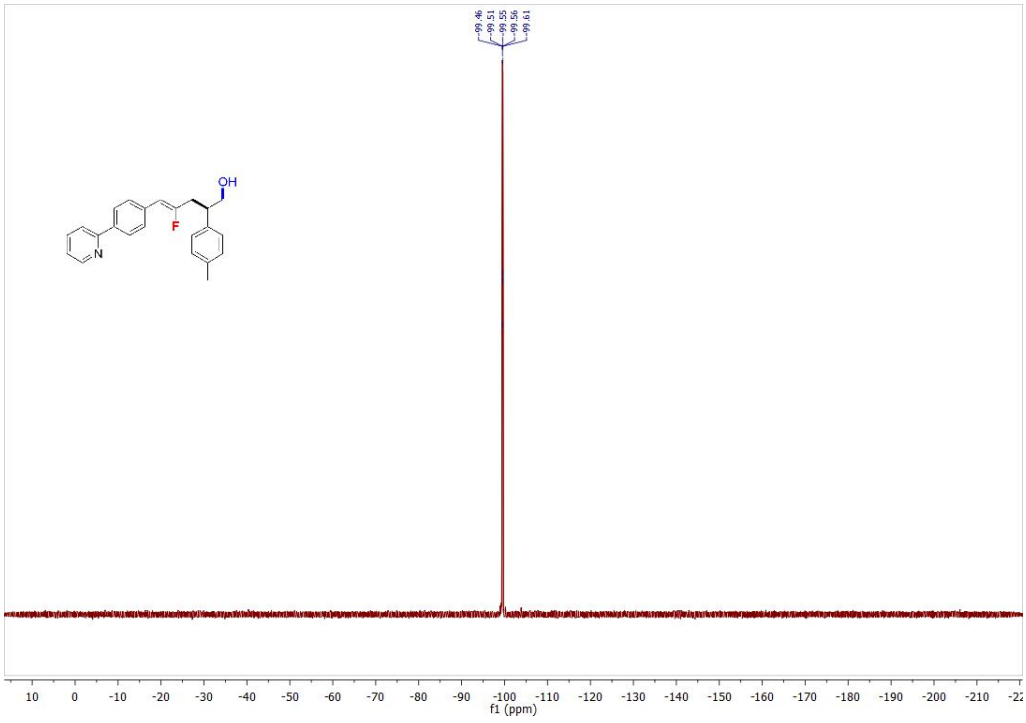
(*R*,*Z*)-4-fluoro-5-(4-(pyridin-2-yl)phenyl)-2-(p-tolyl)pent-4-en-1-ol (3p):



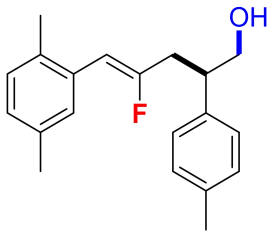
(26 mg, 75% colorless oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.69-8.63 (m, 1H), 7.95-7.90 (m, 2H), 7.74-7.70 (m, 3H), 7.53-7.48 (m, 2H), 7.15 (s, 4H), 5.47 (d, *J* = 39.2 Hz, 1H), 3.85 (d, *J* = 6.2 Hz, 2H), 3.81-3.53 (m, 1H), 3.25-3.15 (m, 1H), 2.83-2.75 (m, 1H), 2.67-2.59 (m, 1H), 2.33 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.4 (d, *J* = 267.7 Hz), 156.9, 149.5, 137.8, 136.7 (d, *J* = 10.1 Hz), 134.3, 129.5, 128.7 (d, *J* = 7.5 Hz), 128.3, 127.7, 126.8, 122.0, 120.4, 107.4 (d, *J* = 8.6 Hz), 66.3, 45.0, 36.1 (d, *J* = 26.4 Hz), 29.7, 21.0. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -99.55 (dt, *J* = 39.4, 19.8 Hz). **HRMS (ESI)** calcd for $C_{23}H_{23}FNO^+$[M+H$^+$]: 348.1758 found 348.1757.


OH
F
N
f1 (ppm)

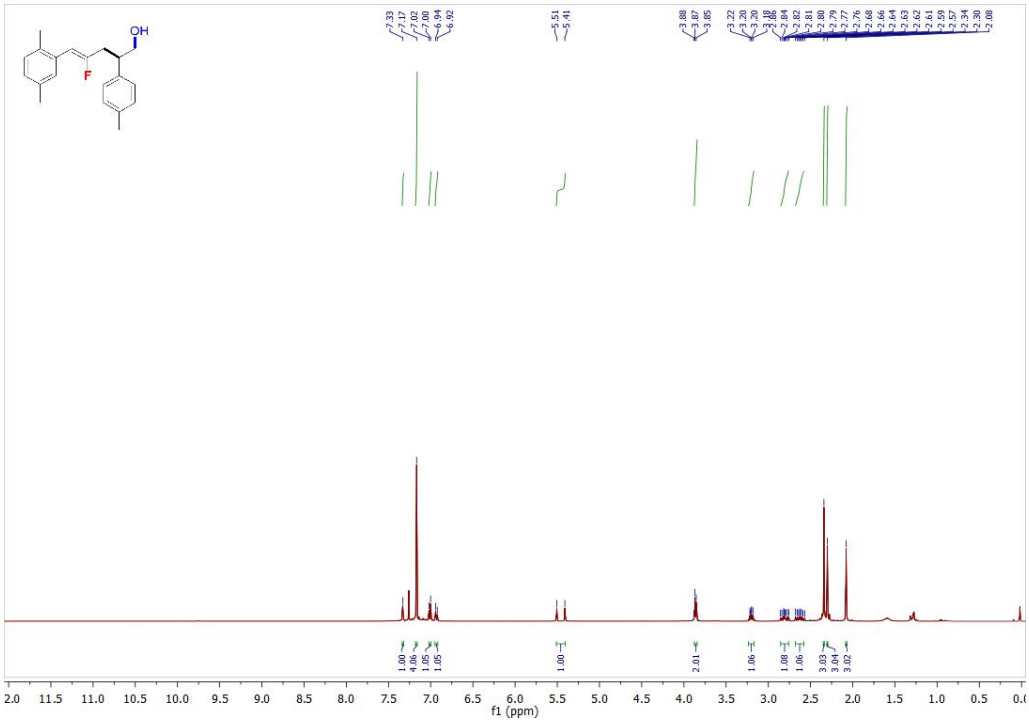

OH
F
N
f1 (ppm)

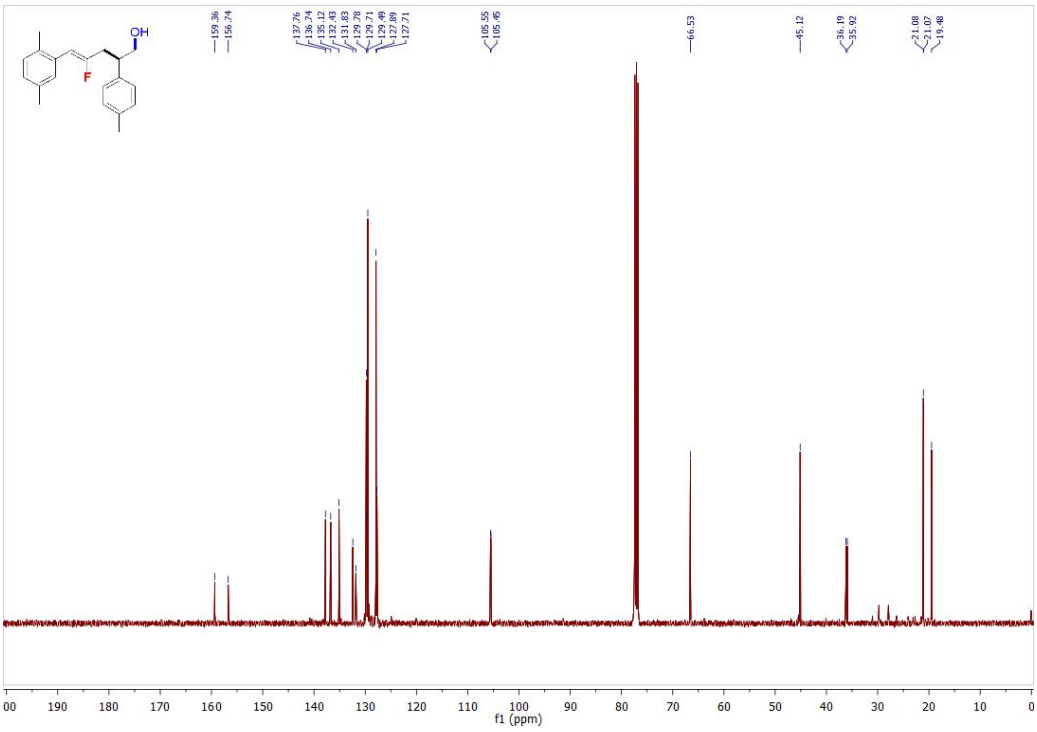


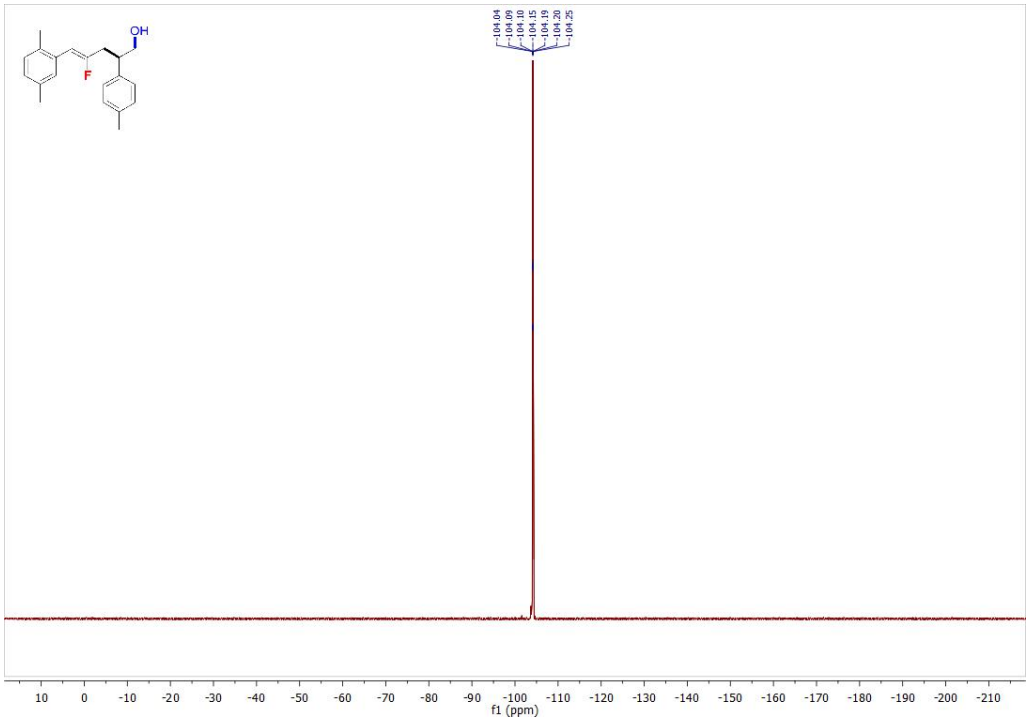
(*R*,*Z*)-5-(2,5-dimethylphenyl)-4-fluoro-2-(p-tolyl)pent-4-en-1-ol (3q):



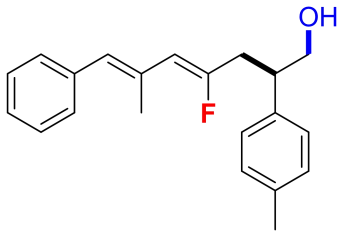
(26 mg, 91% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.33 (s, 1H), 7.17 (s, 4H), 7.03-6.99 (m, 1H), 6.95-6.91 (m, 1H), 5.46 (d, 1H), 3.88-3.84 (m, 2H), 3.24-3.15 (m, 1H), 2.84-2.76 (m, 1H), 2.67-2.58 (m, 1H), 2.33 (s, 3H), 2.30 (s, 3H), 2.07 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.0 (d, J = 264.2 Hz), 137.7, 136.7, 135.1, 132.4, 131.8, 129.7, 129.7, 129.4, 127.8, 127.7, 105.5, 66.5, 45.1, 36.0 (d, J = 27.1 Hz), 28.8, 21.0, 19.4. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -104.15 (ddd, J = 38.7, 20.3, 18.5 Hz). **HRMS (ESI)** calcd for $C_{20}H_{24}FO^{+}$[M+H^{+}]: 299.1806 found 299.1801.


OH
F
f1 (ppm)

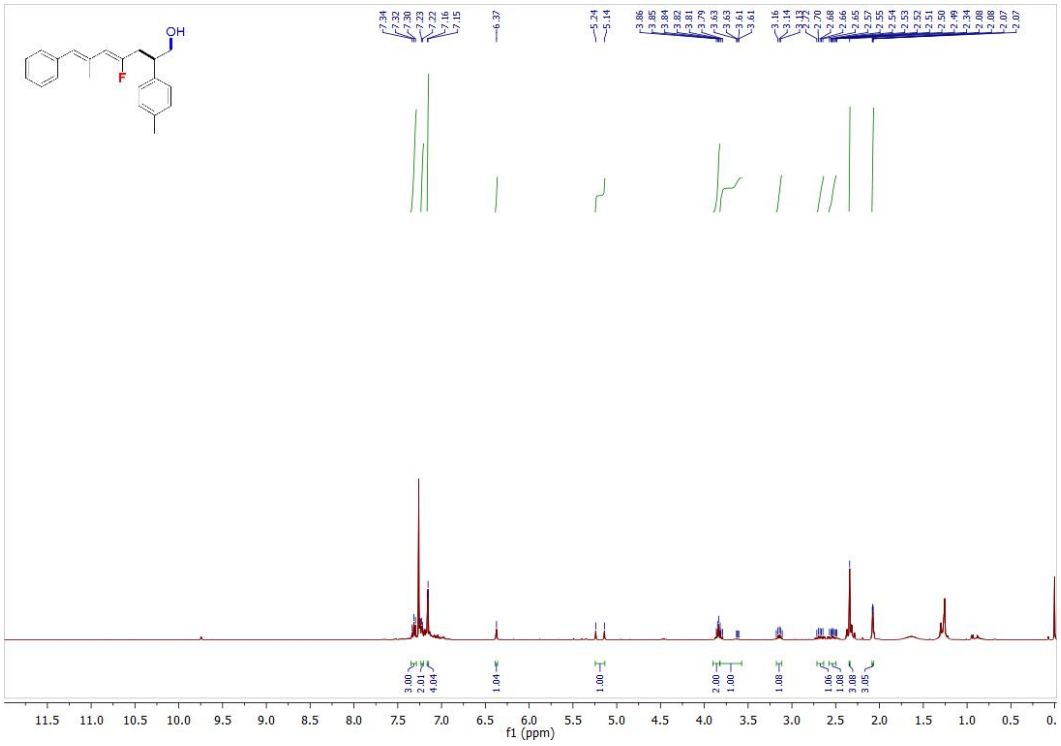

OH
F
f1 (ppm)

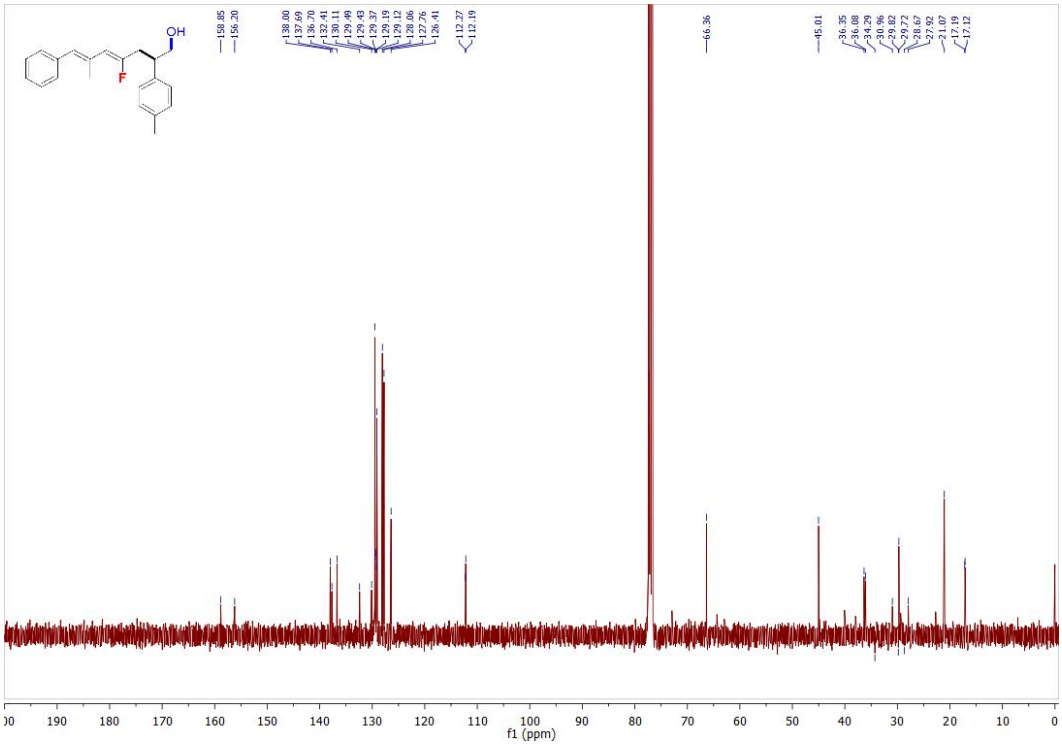


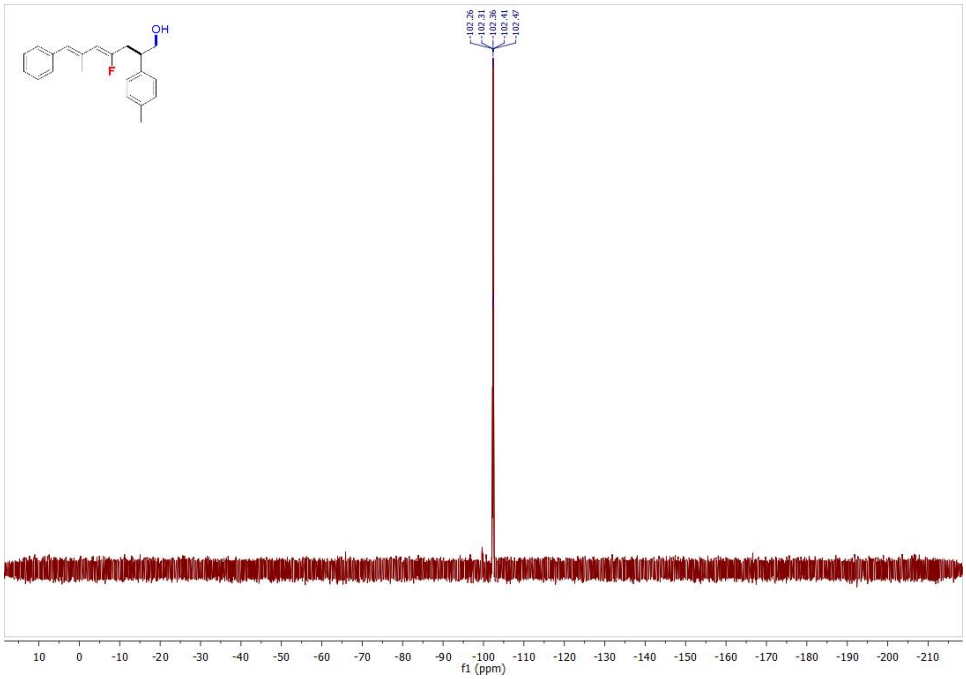
(*R,4Z,6E*)-4-fluoro-6-methyl-7-phenyl-2-(p-tolyl)hepta-4,6-dien-1-ol (3r):



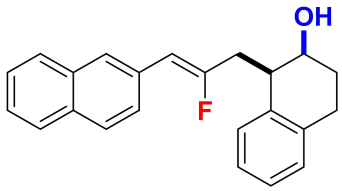
(26 mg, 63% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.34-7.29 (m, 3H), 7.23-7.21 (m, 2H), 7.16-7.15 (m, 4H), 6.37 (s, 1H), 5.19 (d, *J* = 39.5 Hz, 1H), 3.86-3.82 (m, 2H), 3.81-3.59 (m, 1H), 3.18-3.11 (m, 1H), 2.72-2.63 (m, 1H), 2.58-2.49 (m, 1H), 2.34 (s, 3H), 2.09-2.06 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.5 (d, *J* = 265.9 Hz), 138.0, 136.7, 132.4, 129.4, 129.1, 128.0, 127.7, 126.4, 112.2 (d, *J* = 7.8 Hz), 66.3, 45.0, 36.2 (d, *J* = 27.1 Hz), 29.7, 21.0, 17.1. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -102.20. **HRMS (ESI)** calcd for $C_{21}H_{24}FO^+$[M+H$^+$]: 311.1806 found 311.1808.


OH
F
f1 (ppm)

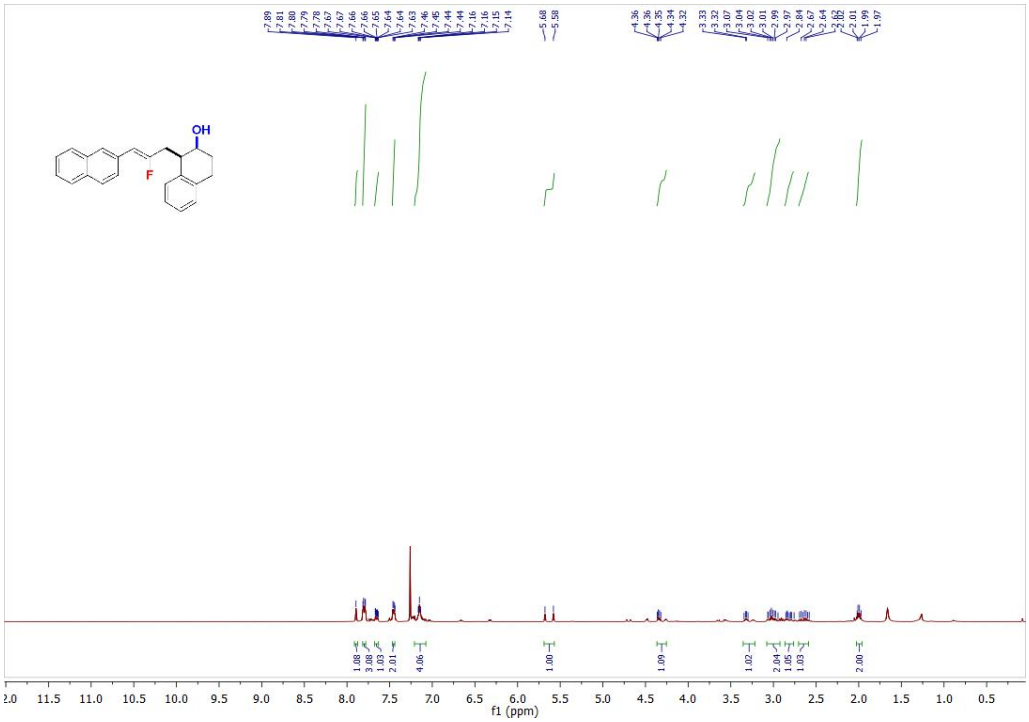

OH
F
f1 (ppm)

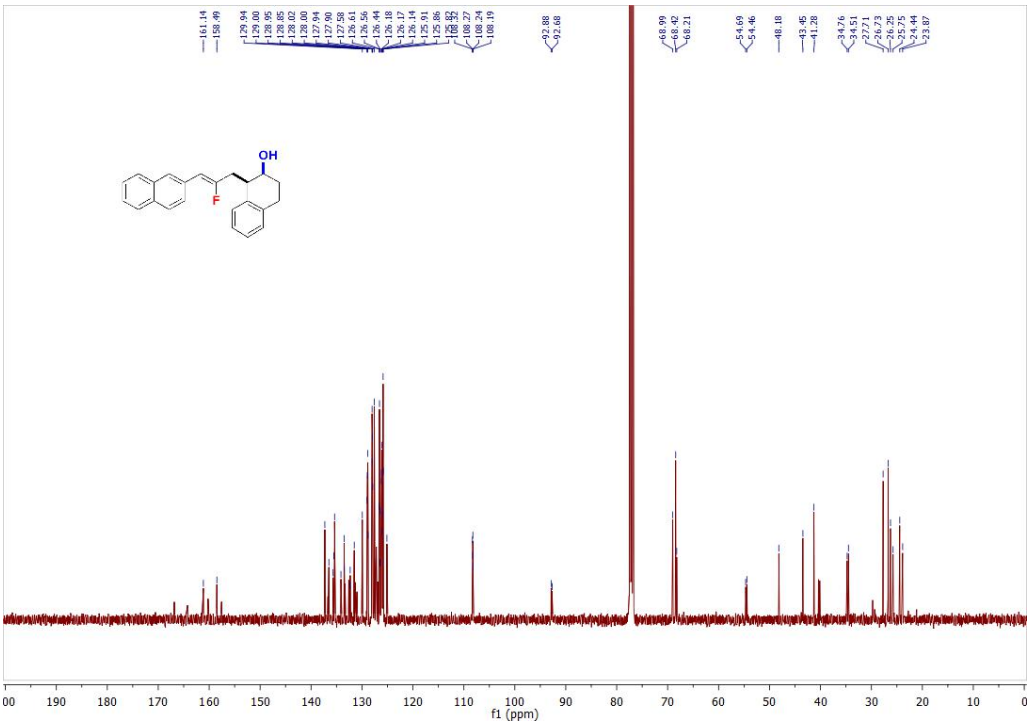


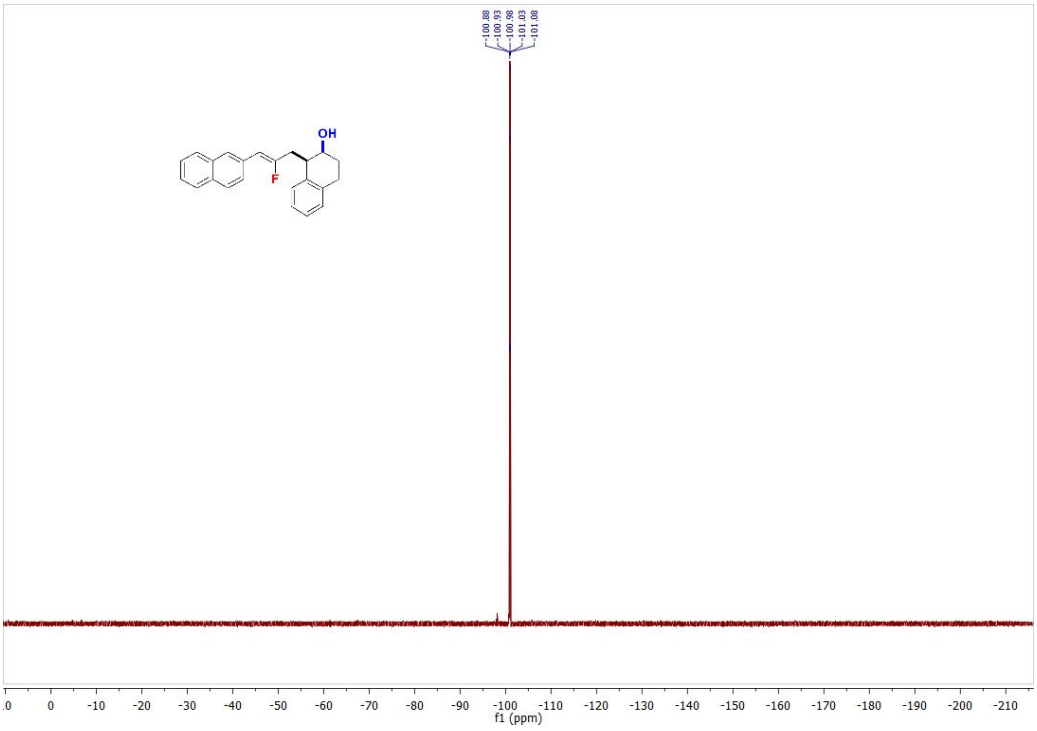
(*1R,2S*)-1-((*Z*)-2-fluoro-3-(naphthalen-2-yl)allyl)-1,2,3,4-tetrahydronaphthalen -2-ol (3s):



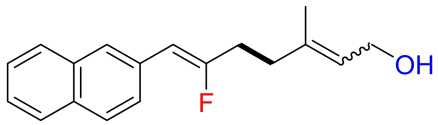
(25 mg, 75% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent, *Z/E* = 10:1; dr = 3:1), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.89 (s, 1H), 7.82-7.77 (m, 3H), 7.67-7.62 (m, 1H), 7.47-7.43 (m, 2H), 7.18-7.09 (m, 4H), 5.63 (d, *J* = 39.6 Hz, 1H), 4.38-4.28 (m, 1H), 3.35-3.26 (m, 1H), 3.07-2.95 (m, 2H), 2.87-2.77 (m, 1H), 2.70-2.56 (m, 1H), 2.05-1.93 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.8 (d, *J* = 266.4 Hz), 137.3, 135.3, 133.4, 131.5, 129.9, 128.8, 127.5, 126.5, 126.1, 125.8, 125.1, 108.2 (d, *J* = 8.4 Hz), 92.7, 68.9, 68.4, 54.5, 48.1, 43.4, 41.2, 40.2 (d, *J* = 25.8 Hz), 34.6, 27.71.**^{19}F NMR** (376 MHz, $CDCl_3$) δ -100.87. **HRMS (ESI)** calcd for $C_{23}H_{22}FO_2^+$[M+H$^+$]: 333.1649 found 333.164571.


OH
F
f1 (ppm)

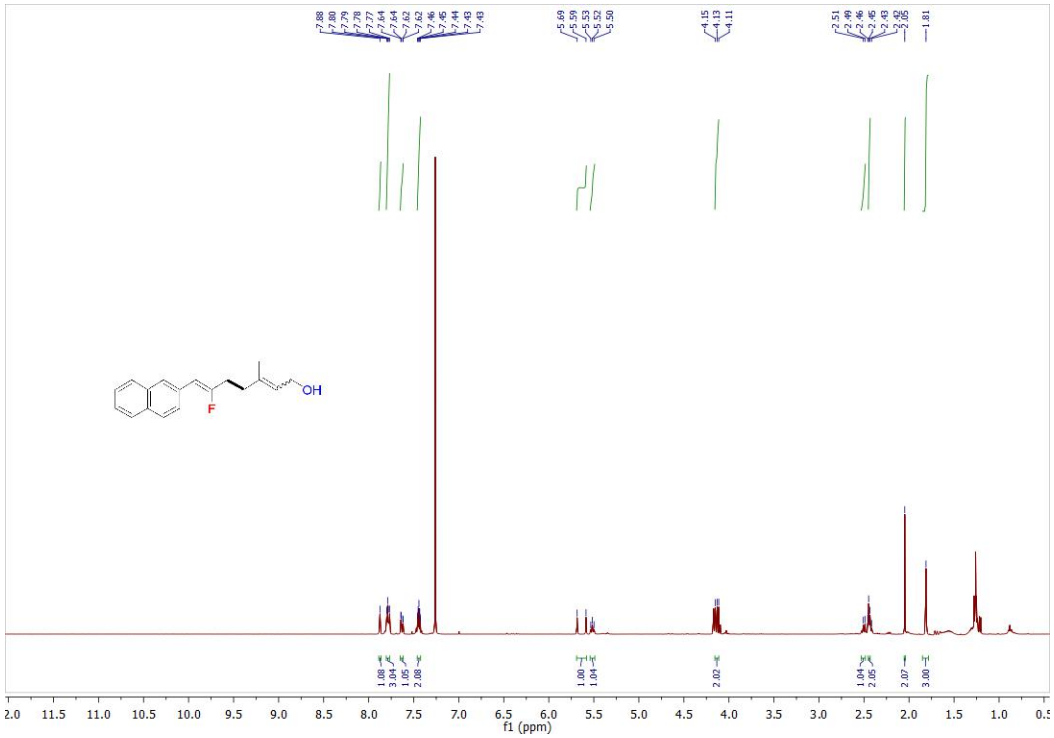

OH
F
f1 (ppm)

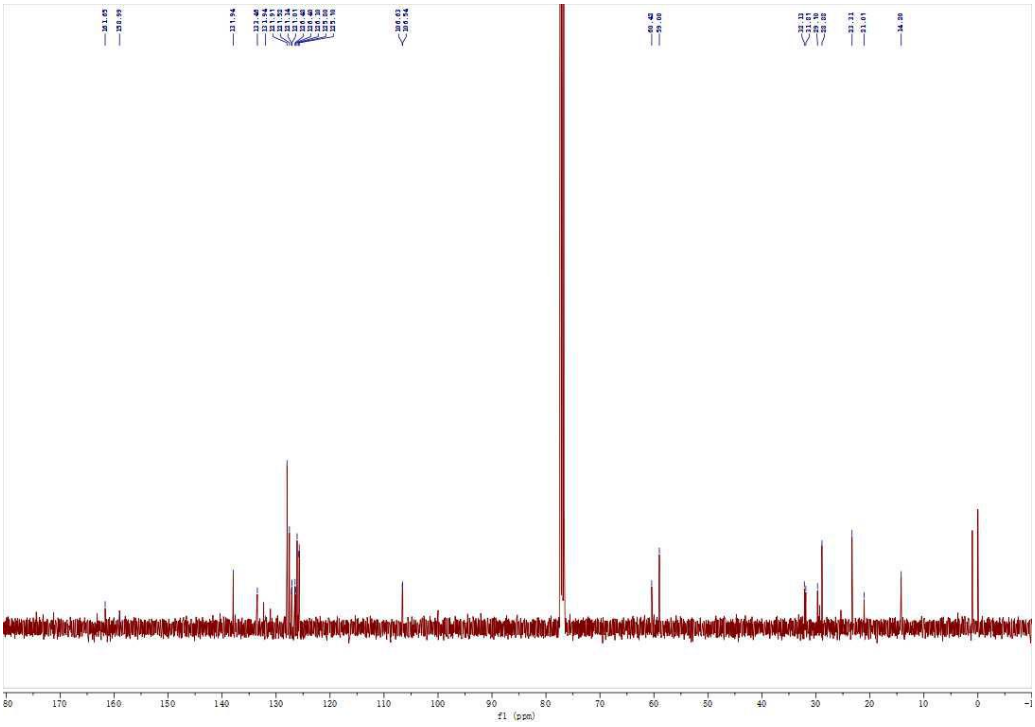


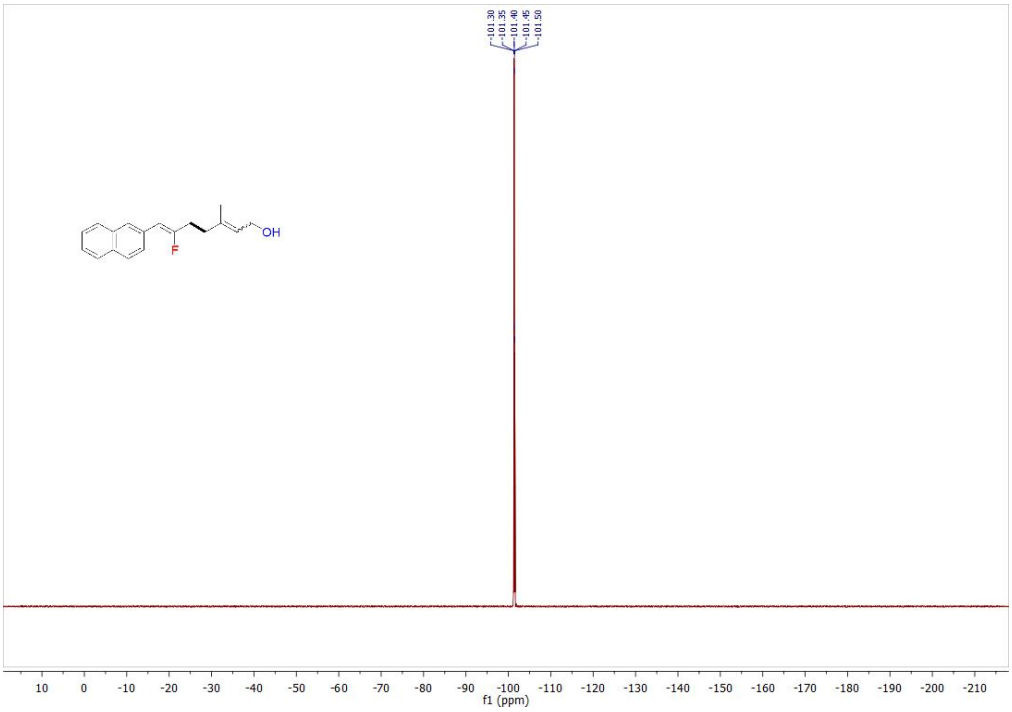
(*6Z*)-6-fluoro-3-methyl-7-(naphthalen-2-yl) hepta-2,6-dien-1-ol (3t):



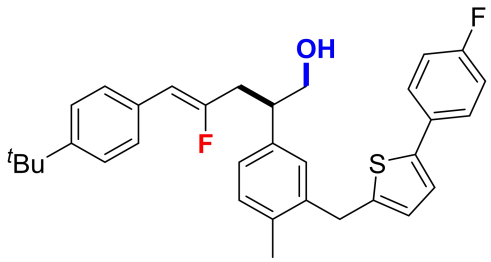
(12.2 mg, 45% white solid, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent, E/Z = 2:1), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.88 (s, 1H), 7.82-7.75 (m, 3H), 7.65-7.60 (m, 1H), 7.46-7.42 (m, 2H), 5.64 (d, *J* = 39.4 Hz, 1H), 5.55-5.49 (m, 1H), 4.14-4.11 (m, 2H), 2.51-2.48 (m, 1H), 2.46-2.42 (m, 2H), 2.05 (s, 2H), 1.81 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.3 (d, *J* = 269.9 Hz), 137.9, 133.4, 131.9, 127.9, 127.5, 127.1, 127.0, 126.5, 126.4, 126.1, 125.8, 125.7, 106.5 (d, *J* = 8.3 Hz), 60.4, 59.0, 32.0 (d, *J* = 26.7 Hz), 29.7, 28.8, 23.3, 21.0, 14.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -101.40 (dt, *J* = 37.4, 18.7 Hz). **HRMS (ESI)** calcd for $C_{18}H_{20}FO^{+}[M+H^{+}]$: 271.1493 found 271.1489.


OH
F
f1 (ppm)


f1 (ppm)

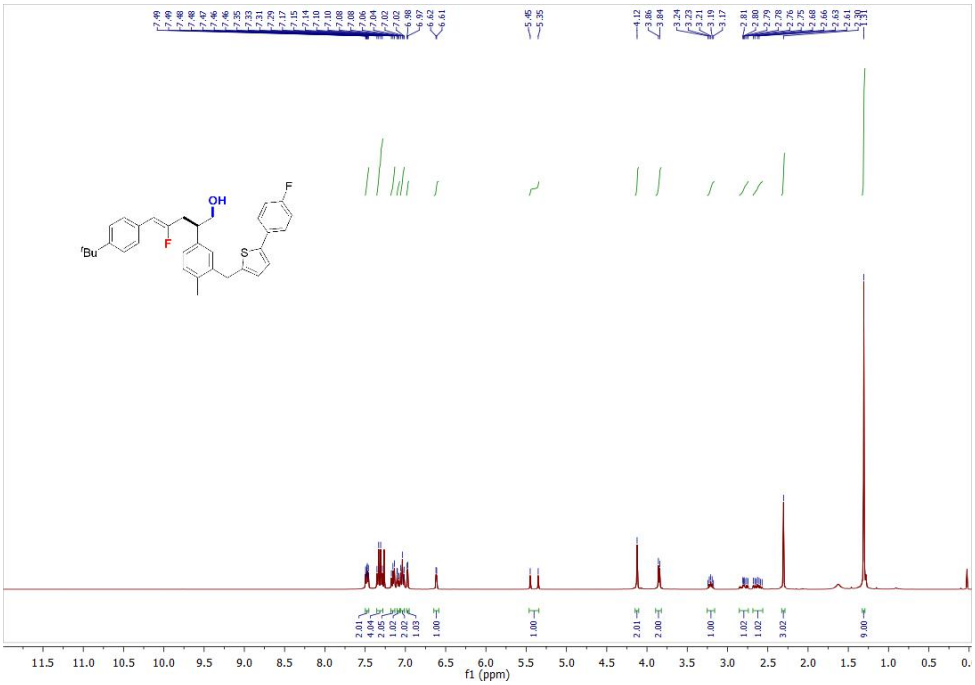


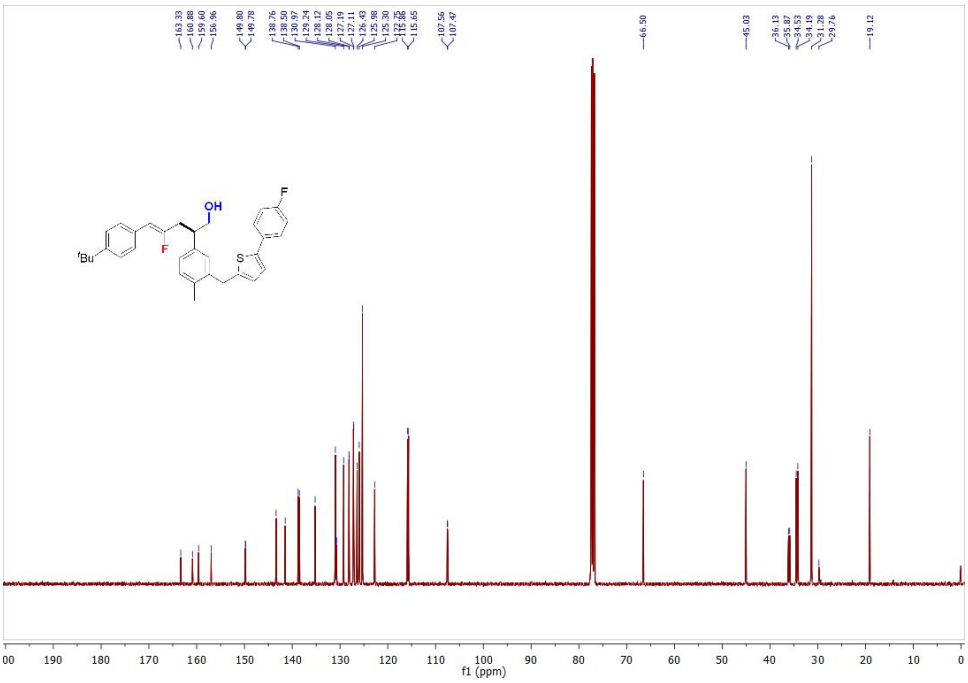
(*R*,*Z*)-5-(4-(tert-butyl)phenyl)-4-fluoro-2-(3-((5-(4-fluorophenyl)thiophen-2-yl)methyl)-4-methylphenyl)pent-4-en-1-ol (4a):

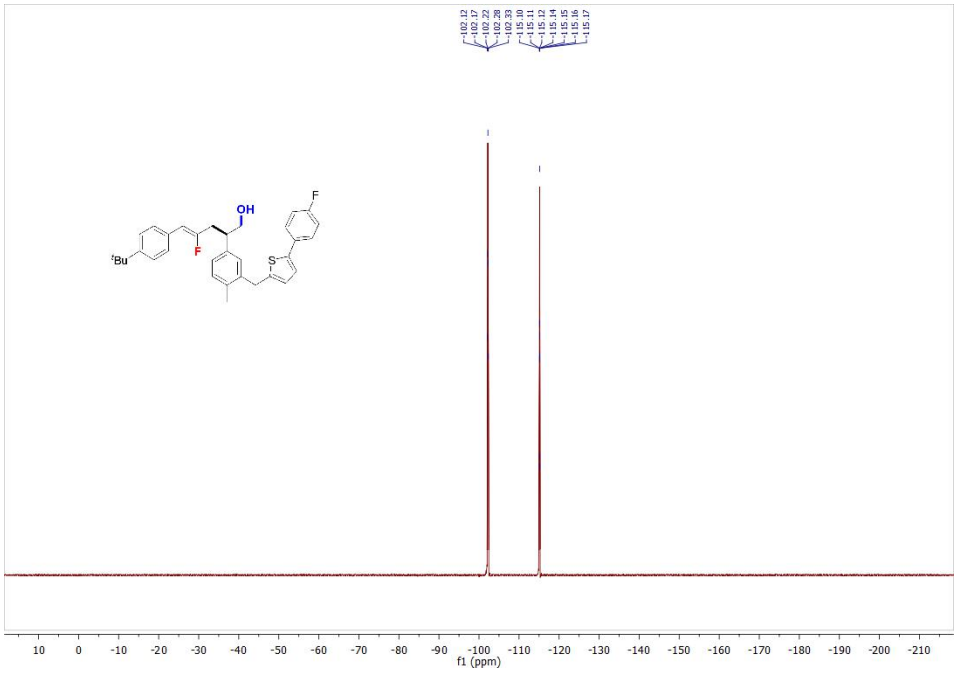


(43.7 mg, 85% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.50-7.45 (m, 2H), 7.36-7.27 (m, 4H), 7.18-7.12 (m, 2H), 7.11-7.07 (m, 1H), 7.06-7.00 (m, 2H), 6.97 (d, *J* = 3.6 Hz, 1H), 6.62-6.60 (m, 1H), 5.40 (d, *J* = 39.6 Hz, 1H), 4.12 (s, 2H), 3.87-3.81 (m, 2H), 3.23-3.15 (m, 1H), 2.84-2.71 (m, 1H), 2.69-2.54 (m, 1H), 2.30 (s, 3H), 1.30 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.1 (d, *J* = 246.7 Hz), 159.6, 156.9, 149.7 (d, *J* = 2.0 Hz), 143.3, 141.4, 138.7, 138.5, 135.2, 130.9, 130.8, 130.7 (d, *J* = 2.3 Hz), 129.2, 128.0 (d, *J* = 7.2 Hz), 127.1 (d, *J* = 8.0 Hz), 126.4, 125.9, 125.3, 122.7, 115.7, 107.5 (d, *J* = 8.7 Hz), 66.5,

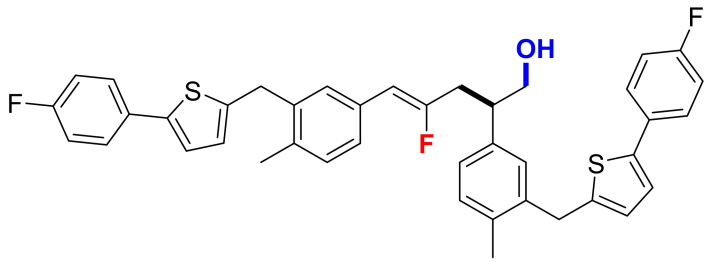
45.0, 36.0 (d, J = 26.6 Hz), 34.3, 31.2, 19.1. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -102.07, -114.93. **HRMS (ESI)** calcd for $C_{33}H_{35}F_2OS^+$[M+H$^+$]: 517.2371 found 517.2370.





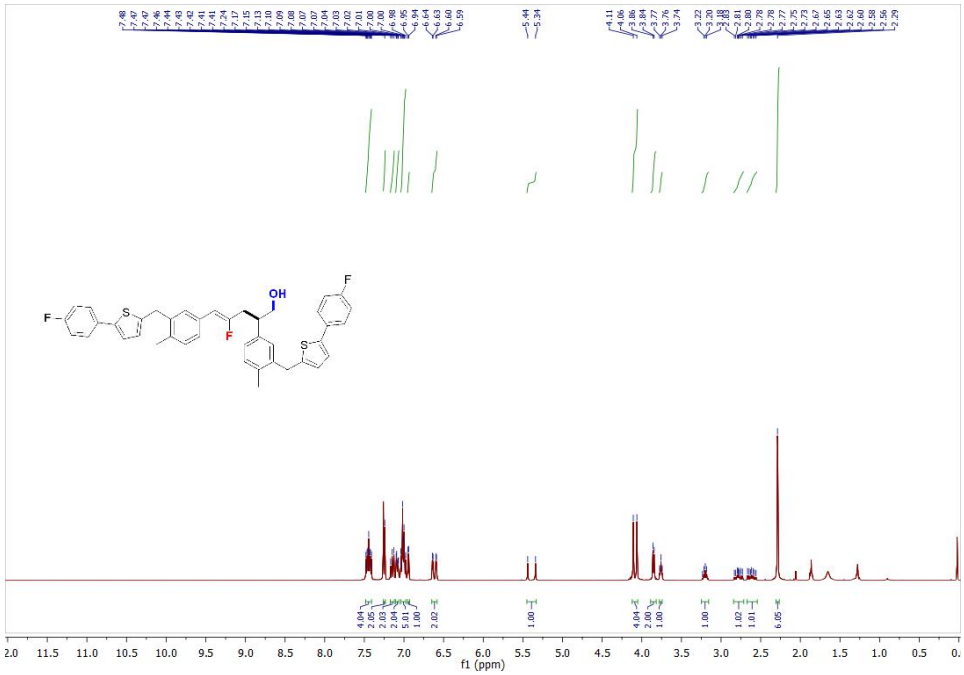


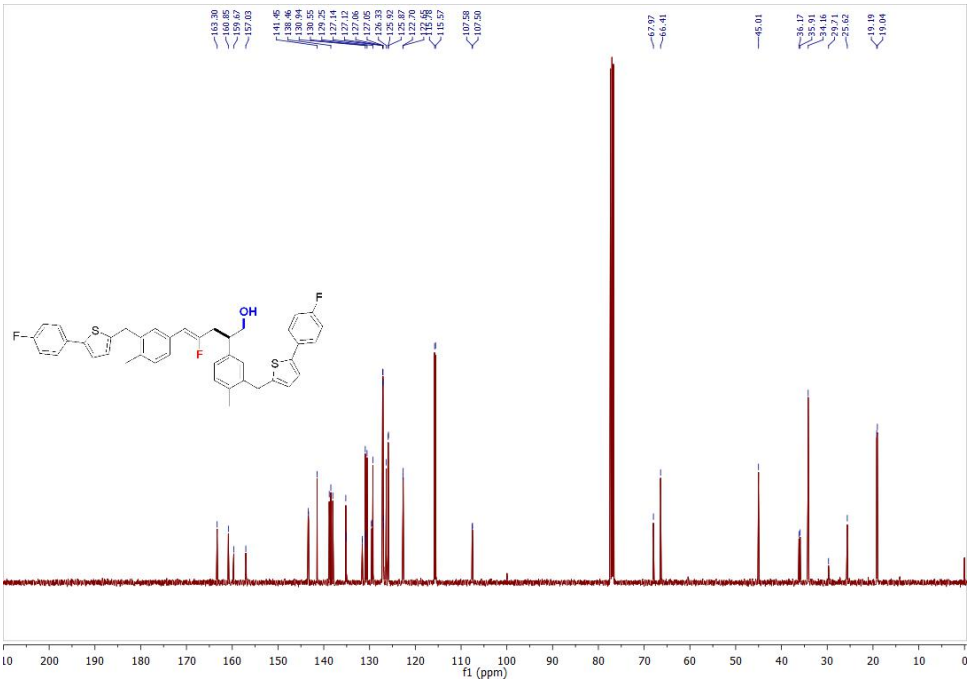
(*R*,*Z*)-4-fluoro-2,5-bis(3-((5-(4-fluorophenyl)thiophen-2-yl)methyl)-4-methylphenyl)pent-4-en-1-ol (4b):

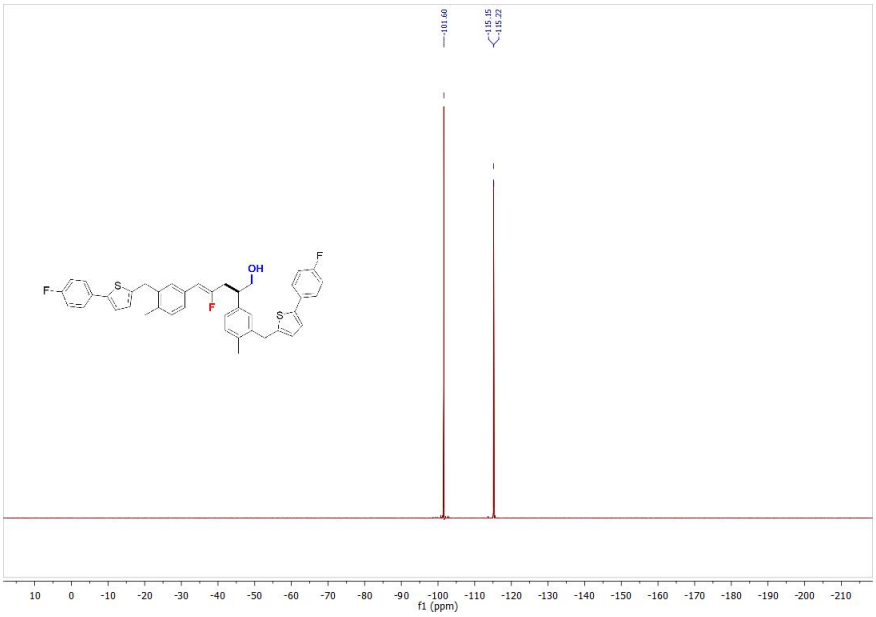


(55 mg, 83% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.49-7.40 (m, 4H), 7.23 (s, 2H), 7.17-7.11 (m, 2H), 7.10-7.05 (m, 2H), 7.04-6.97 (m, 5H), 6.94 (d, *J* = 3.6 Hz, 1H), 6.65-6.56 (m, 2H), 5.38 (d, 1H), 4.08 (d, *J* = 18.2 Hz, 4H), 3.87-3.81 (m, 2H), 3.78-3.72 (m, 1H), 3.24-3.14 (m, 1H), 2.83-2.70 (m, 1H), 2.66-2.55 (m, 1H), 2.29 (s, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.3, 160.8, 158.3 (d, *J* = 265.5 Hz), 143.3 (d, *J* = 9.3 Hz), 141.4, 138.8, 138.4, 138.0, 135.1, 135.0 (d, *J* = 2.1 Hz), 131.5 (d, *J* = 2.3 Hz), 130.9, 130.8, 130.5, 129.5, 129.2, 127.1, 127.0, 126.9 (d, *J* = 7.7 Hz), 126.3, 125.8, 122.6, 115.7, 115.5, 107.5 (d, *J* = 8.7 Hz), 67.9, 66.4, 45.0, 36.0 (d, *J* = 26.5 Hz), 34.1, 29.7, 25.6, 19.1. **^{19}F NMR**

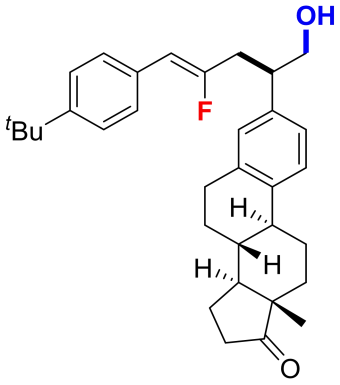
(376 MHz, $CDCl_3$) δ -101.6, -115.1, -115.2. **HRMS (ESI)** calcd for $C_{41}H_{36}F_3OS_2$ $^+$[M+H$^+$]: 665.2154 found 665.2158.





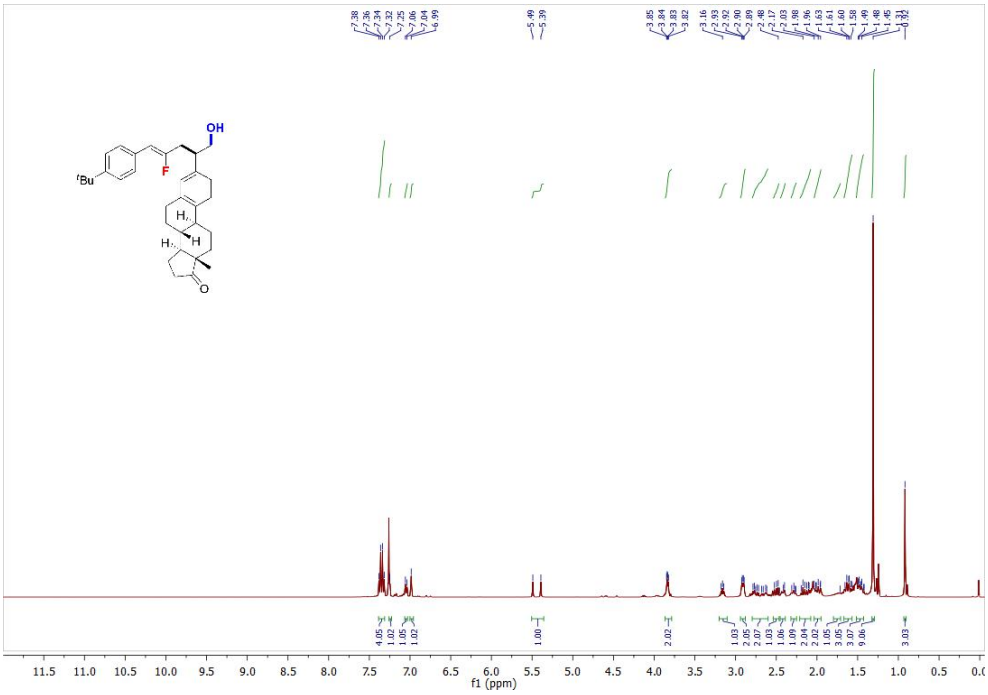


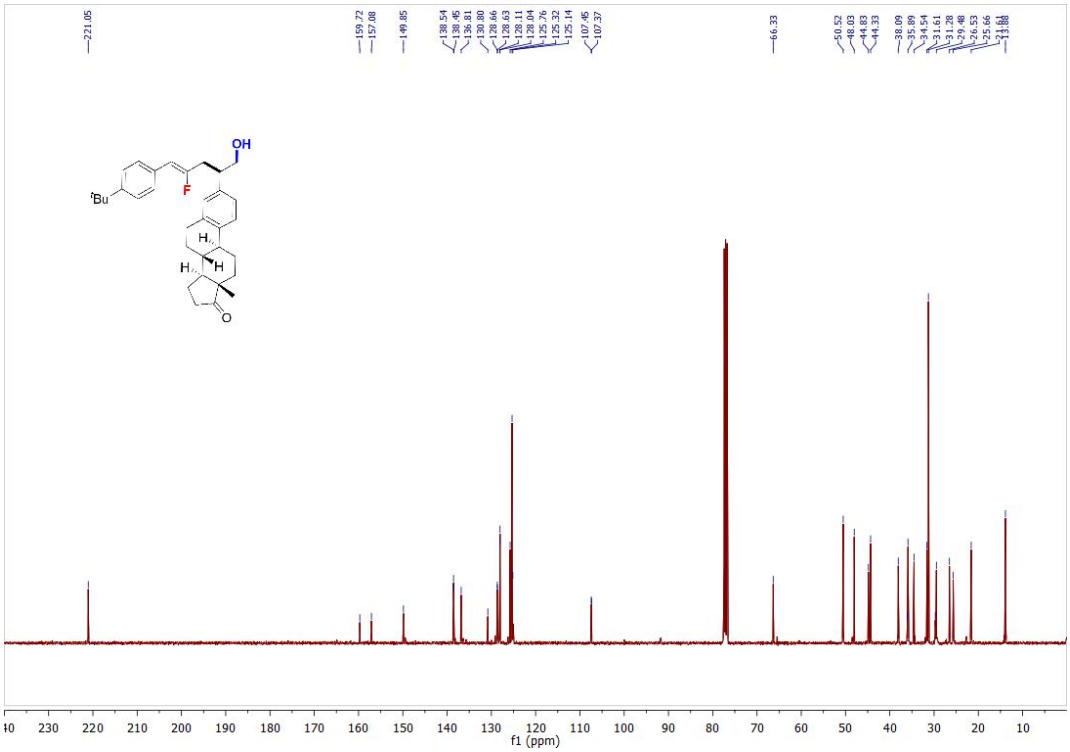
(8R,9S,13S,14S)-3-((*R*,*Z*)-5-(4-(tert-butyl)phenyl)-4-fluoro-1-hydroxypent-4-en-2-yl)-13-methyl-6,7,8,9,11,12,13,14,15,16-decahydro-17*H*-cyclopenta[a]phenanthren-17-one (4c):

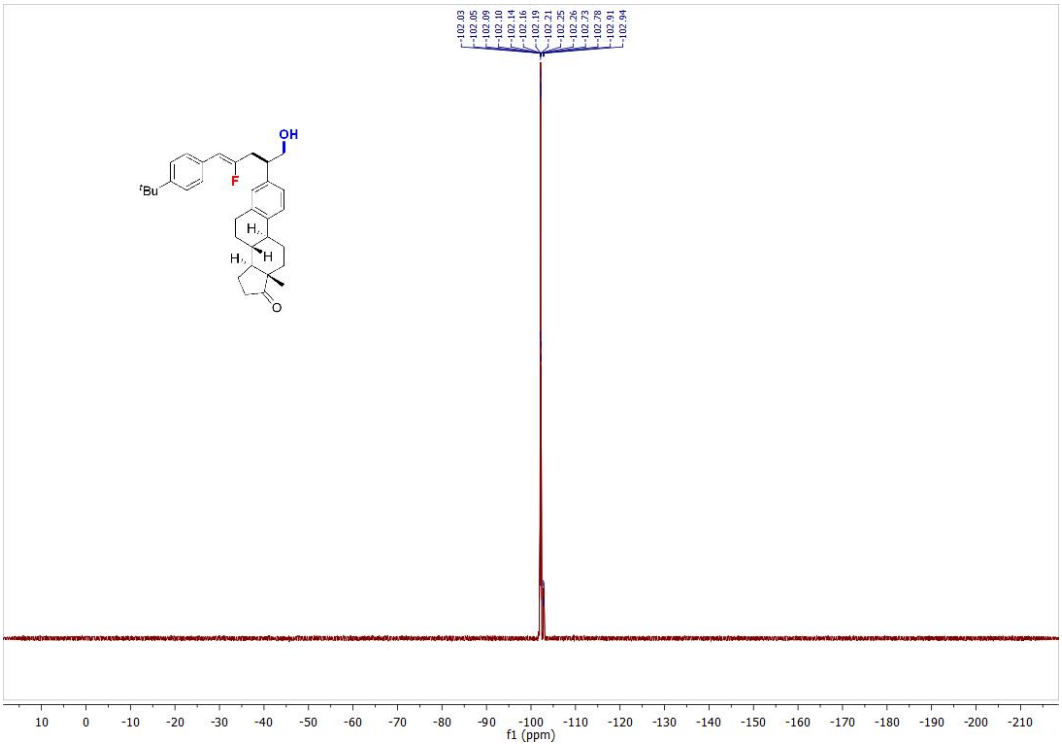


(39 mg, 85% yellow oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.31 (m, 4H), 7.25 (s, 1H), 7.07-7.02 (m, 1H), 6.99 (s, 1H), 5.44 (d, *J* = 39.6 Hz, 1H), 3.86-3.81 (m, 2H), 3.19-3.11 (m, 1H), 2.94-2.86 (m, 2H), 2.80-2.60 (m, 2H), 2.55-2.44 (m, 1H), 2.44-2.36 (m, 1H), 2.32-2.22 (m, 1H), 2.20-2.06 (m, 2H), 2.06-1.90 (m, 2H), 1.71 (s, 1H), 1.67-1.57 (m, 3H), 1.50-1.41 (m, 3H), 1.31 (s, 9H), 0.92 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 221.0, 158.4 (d, *J* = 265.3 Hz), 149.8, 138.5 (d, *J* = 9.3 Hz), 136.8, 130.8, 128.6 (d, *J* = 3.6 Hz), 128.0 (d, *J* = 7.2 Hz), 125.7, 125.3, 125.1, 107.4 (d, *J* = 8.8 Hz), 66.3, 50.5, 48.0, 44.8, 44.3, 38.0, 36.0 (d, *J* = 5.4 Hz), 35.8, 34.5, 31.6, 31.2, 29.7, 29.4, 26.5, 25.6, 21.6, 13.8.

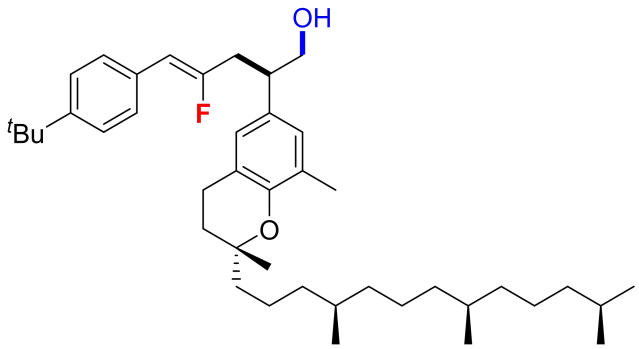
^{19}F NMR (376 MHz, $CDCl_3$) δ -102.15 (dtd, *J* = 25.5, 19.8, 5.8 Hz). **HRMS (ESI)** calcd for $C_{33}H_{42}FO_2^+$[M+H$^+$]: 489.3163 found 489.3159.





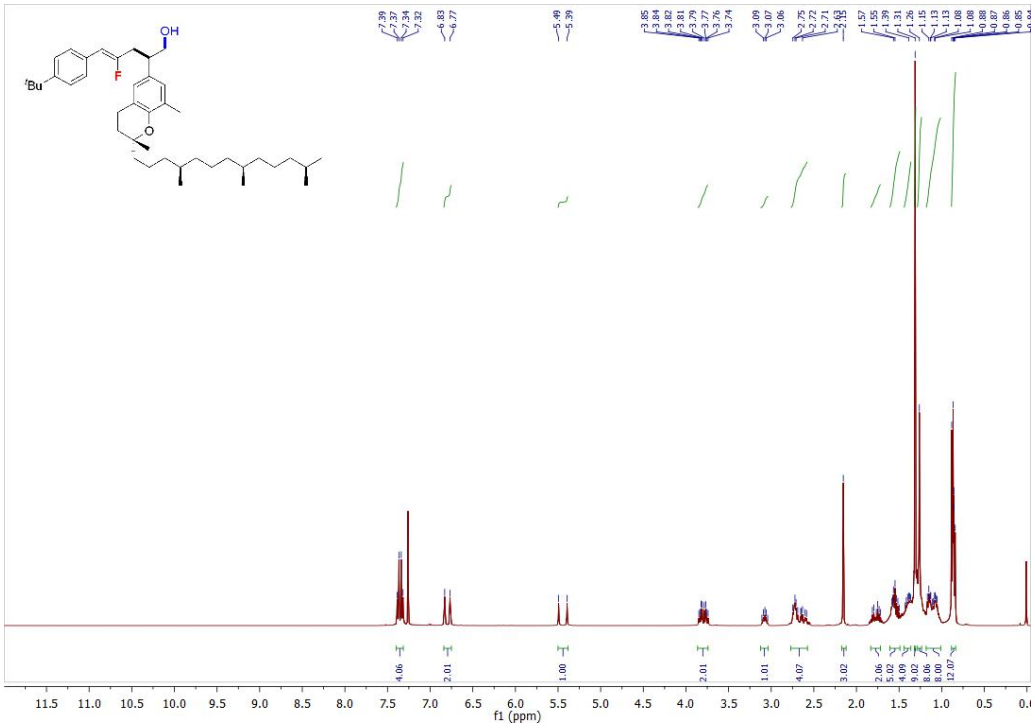


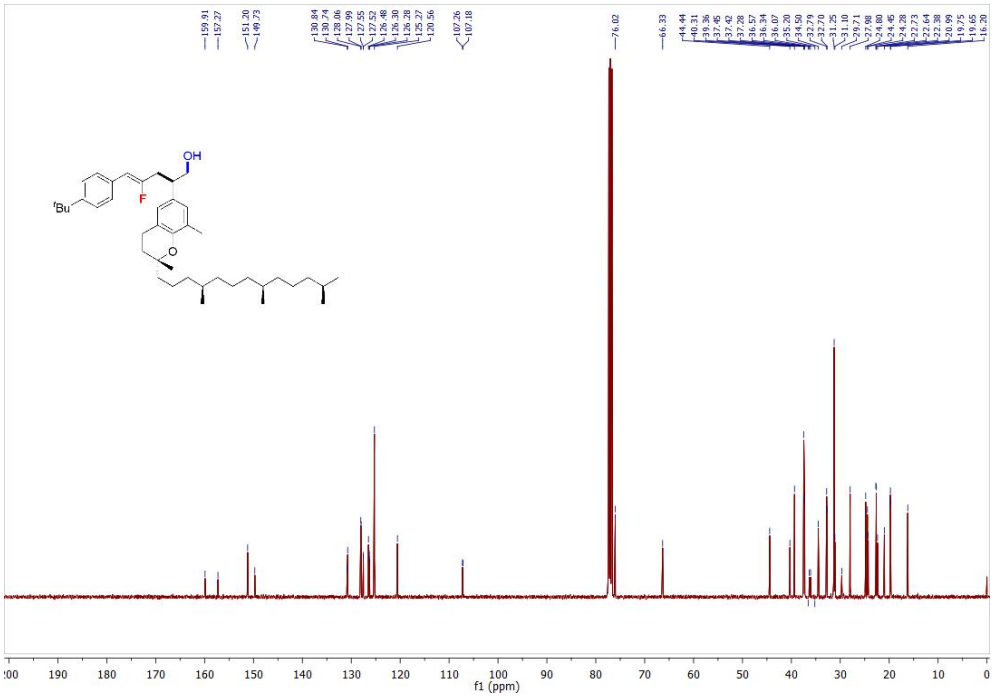
(*R*,*Z*)-5-(4-(tert-butyl)phenyl)-2-((*R*)-2,8-dimethyl-2-((*4R*,*8R*)-4,8,12-trimethyltridecyl)chroman-6-yl)-4-fluoropent-4-en-1-ol (4d):

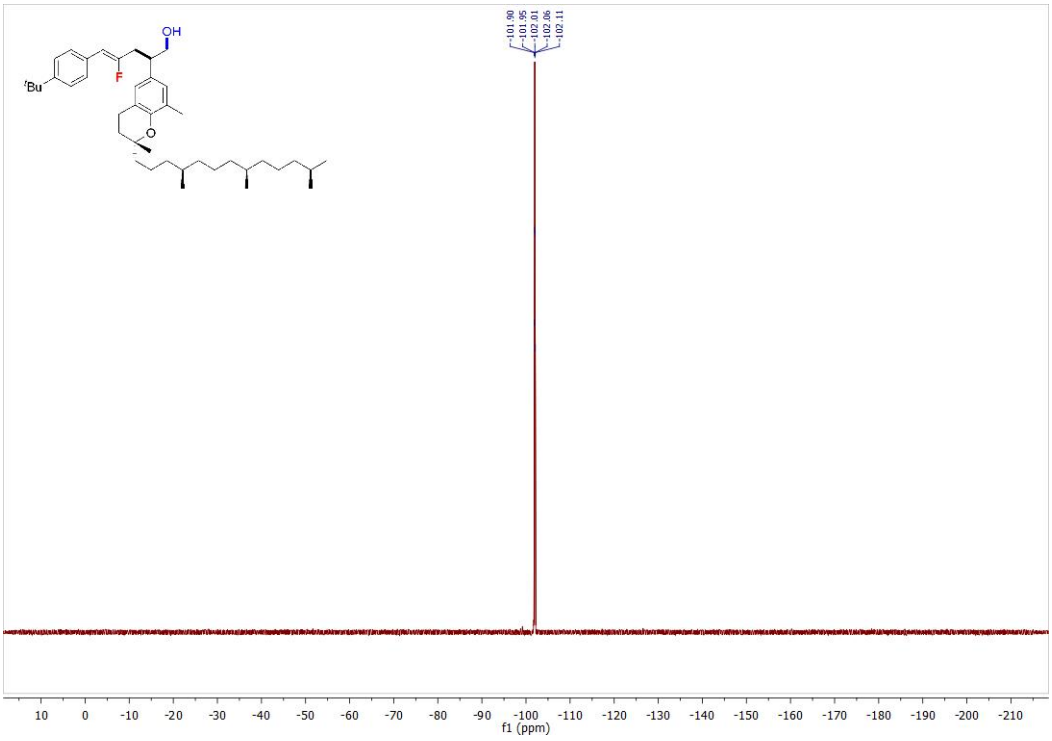


(47.3 mg, 76% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39-7.30 (m, 4H), 6.80 (d, *J* = 24.9 Hz, 2H), 5.44 (d, *J* = 39.6 Hz, 1H), 3.86-3.72 (m, 2H), 3.11-3.01 (m, 1H), 2.77-2.57 (m, 4H), 2.15 (s, 3H), 1.84-1.69 (m, 2H), 1.60-1.49 (m, 5H), 1.44-1.34 (m, 4H), 1.32 (s, 9H), 1.25 (s, 8H), 1.18-1.00 (m, 8H), 0.91-0.82 (m, 12H).

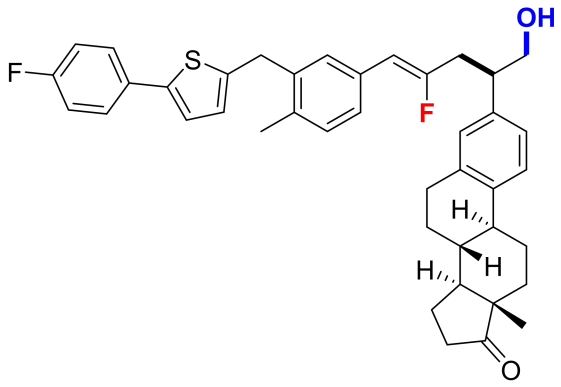
^{13}C NMR (101 MHz, $CDCl_3$) δ 158.5 (d, *J* = 265.4 Hz), 151.2, 149.7, 130.8, 130.7, 128.0 (d, *J* = 7.1 Hz), 127.5 (d, *J* = 2.9 Hz), 126.4, 126.2 (d, *J* = 2.9 Hz), 125.2, 120.5, 107.2 (d, *J* = 8.9 Hz), 76.0, 66.3, 44.4, 40.3, 39.3, 37.4, 37.2, 36.2 (d, *J* = 26.6 Hz), 34.5, 32.7, 31.1, 31.1, 29.7, 27.9, 24.8, 24.4, 24.2, 22.6, 22.3, 20.9, 19.7, 16.2. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -101.85. **HRMS (ESI)** calcd for $C_{42}H_{66}FO_2^+$[M+H$^+$]: 621.5041 found 621.5043.



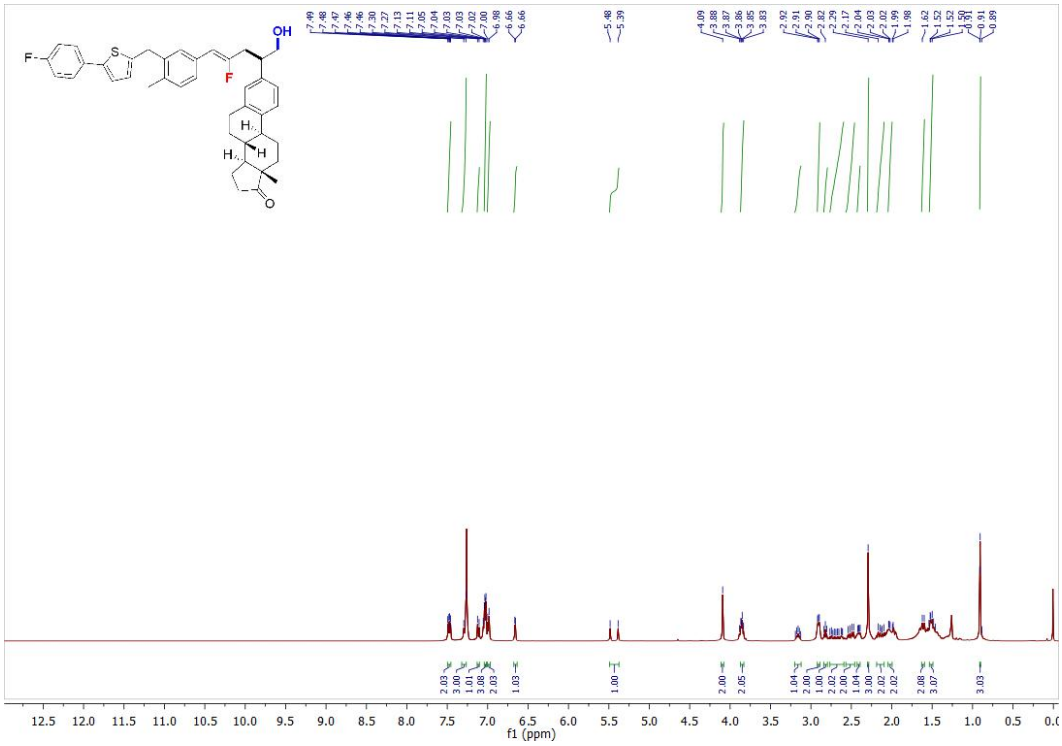


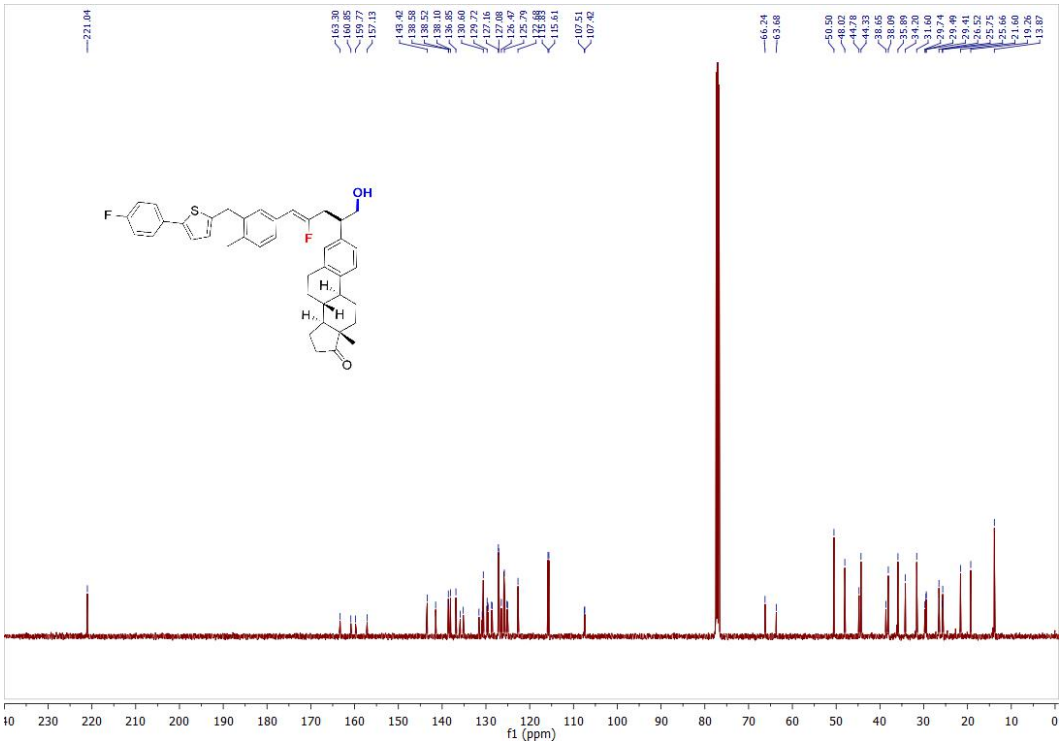


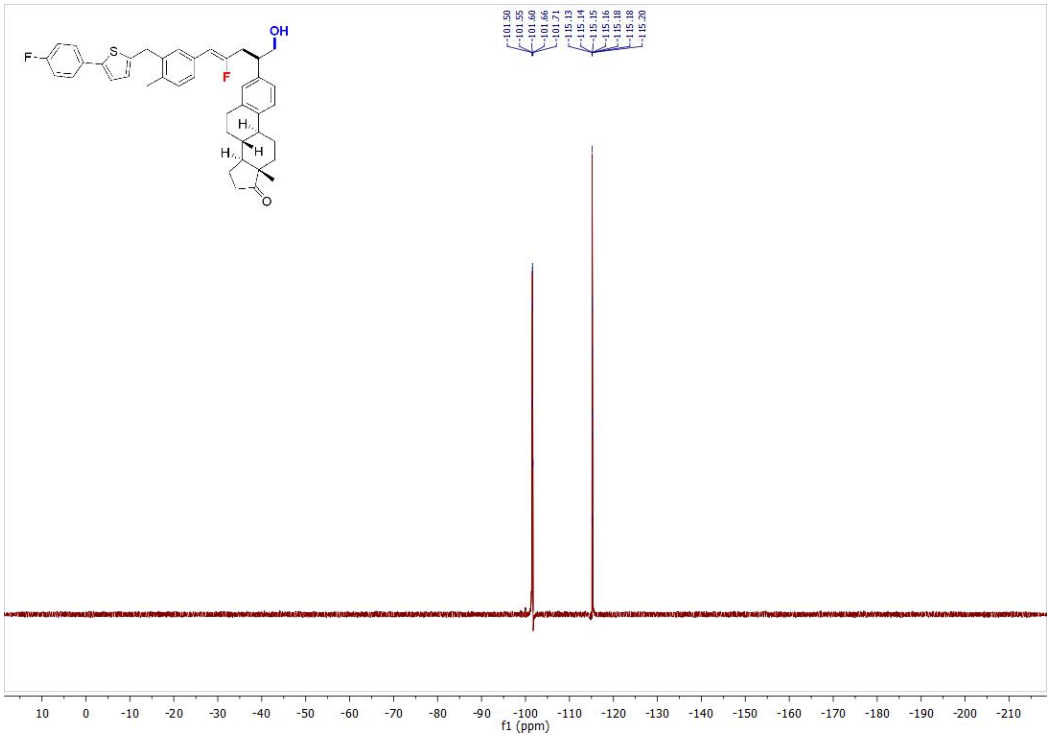
(*8R,9S,13S,14S*)-3-((*R,Z*)-4-fluoro-5-(3-((5-(4-fluorophenyl)thiophen-2-yl)methyl)-4-methylphenyl)-1-hydroxypent-4-en-2-yl)-13-methyl-6,7,8,9,11,12,13,14,15,16-decahydro-17H-cyclopenta[a]phenanthren-17-one (4e):



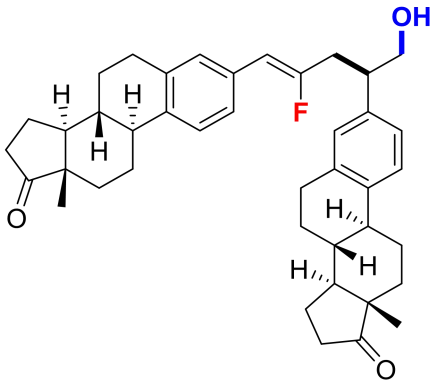
(48 mg, 75% yellow oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.50-7.45 (m, 2H), 7.30-7.26 (m, 3H), 7.14-7.10 (m, 1H), 7.06-7.01 (m, 3H), 7.00-6.97 (m, 2H), 6.67-6.64 (m, 1H), 5.44 (d, *J* = 39.5 Hz, 1H), 4.09 (s, 2H), 3.91-3.79 (m, 2H), 3.19-3.10 (m, 1H), 2.94-2.87 (m, 2H), 2.85-2.78 (m, 1H), 2.75-2.62 (m, 2H), 2.55-2.45 (m, 2H), 2.43-2.35 (m, 1H), 2.29 (s, 3H), 2.18-2.08 (m, 2H), 2.04-1.95 (m, 2H), 1.64-1.57 (m, 2H), 1.54-1.44 (m, 3H), 0.91-0.90 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 221.0, 163.3, 160.8, 158.4 (d, *J* = 265.6 Hz), 143.4, 141.4, 138.5, 138.1, 136.8, 135.8, 135.1, 131.6, 130.8, 130.6, 129.7, 129.5, 128.7, 128.5, 127.1, 126.9, 126.4, 125.9, 125.8, 125.6, 125.2, 125.0, 122.6, 115.7 (d, *J* = 21.8 Hz), 107.4 (d, *J* = 8.7 Hz), 66.2, 63.6, 50.5, 48.0, 44.7, 44.3, 38.6, 38.0, 35.8, 34.2, 31.6, 29.4 (d, *J* = 8.2 Hz), 26.5, 25.7, 21.6, 19.2, 13.8. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -101.61 (dt, *J* = 39.6, 19.8 Hz), -115.16 (ddd, *J* = 13.7, 8.7, 5.3 Hz). **HRMS (ESI)** calcd for $C_{41}H_{43}F_2O_2S^+$[M+H$^+$]: 637.2946 found 637.2941.


OH
F
S
F
H
H
O
f1 (ppm)

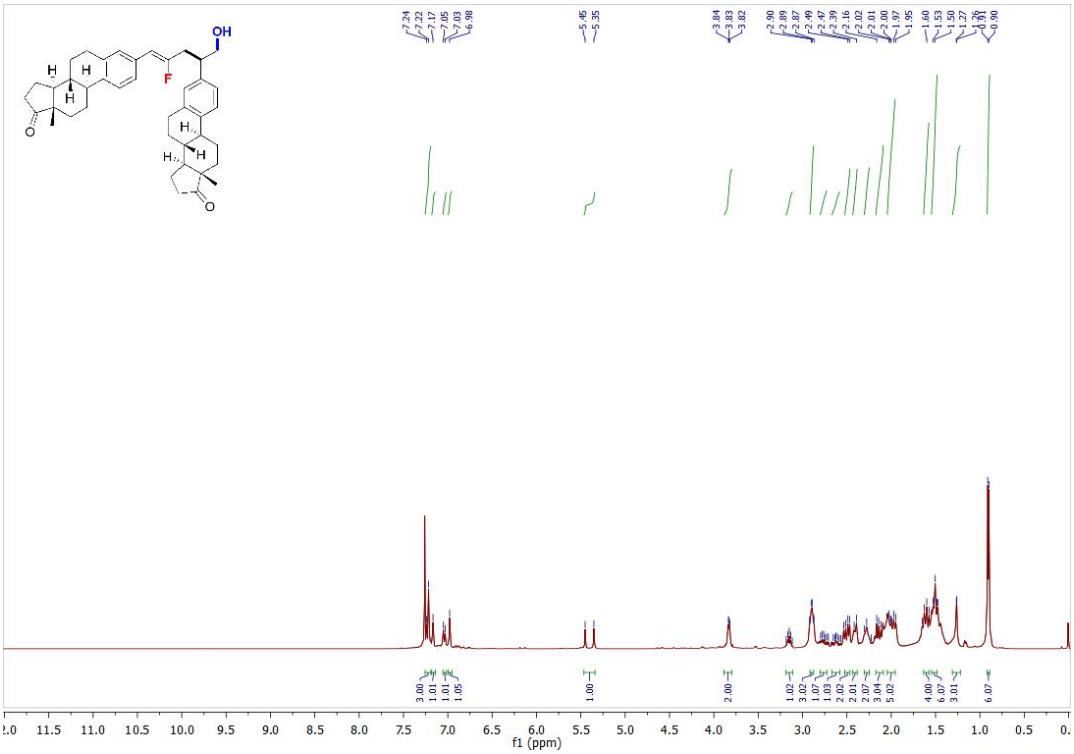

OH
F
S
F
H
H
O
f1 (ppm)

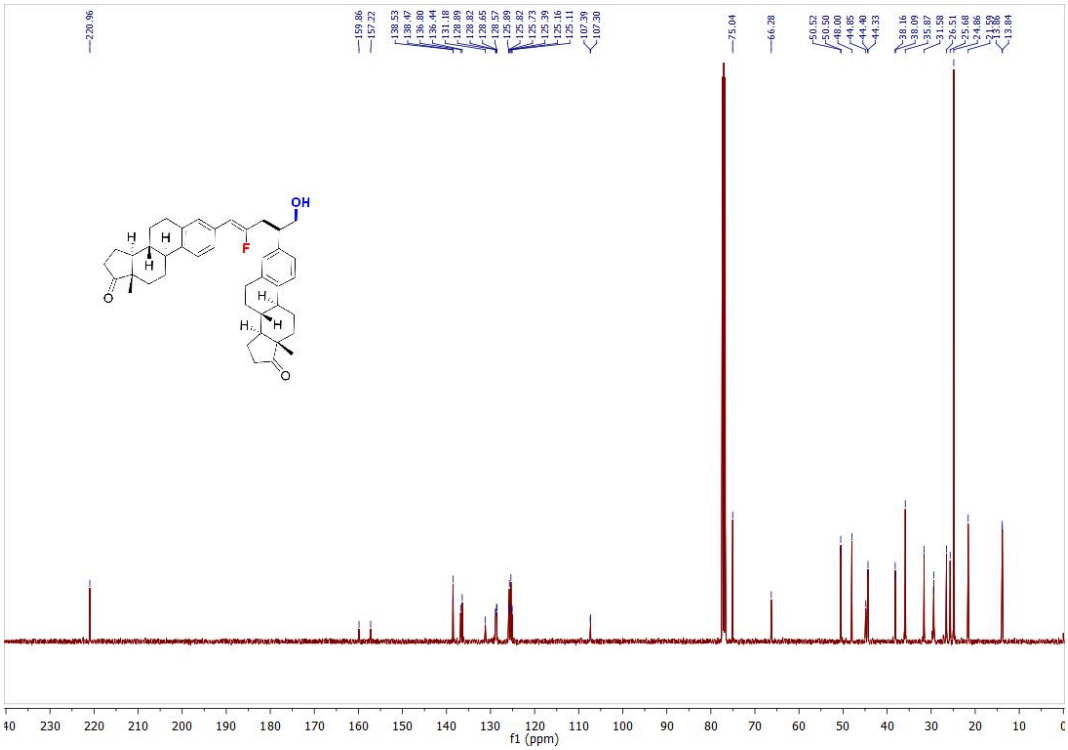


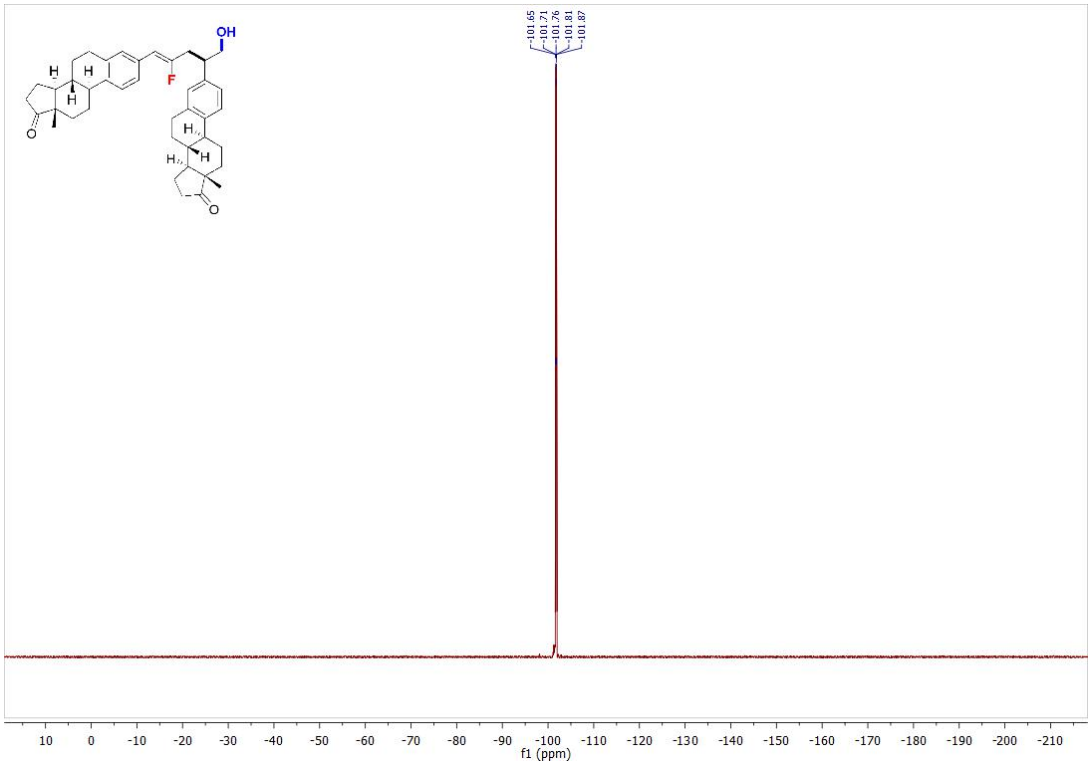
(*8R,8'R,9S,9'S,13S,13'S,14S,14'S*)-3,3'-((*R,Z*)-2-fluoro-5-hydroxypent-1-ene-1,4-diyl)bis(13-methyl-6,7,8,9,11,12,13,14,15,16-decahydro-17H-cyclopenta[a]phenanthren-17-one) (4f):



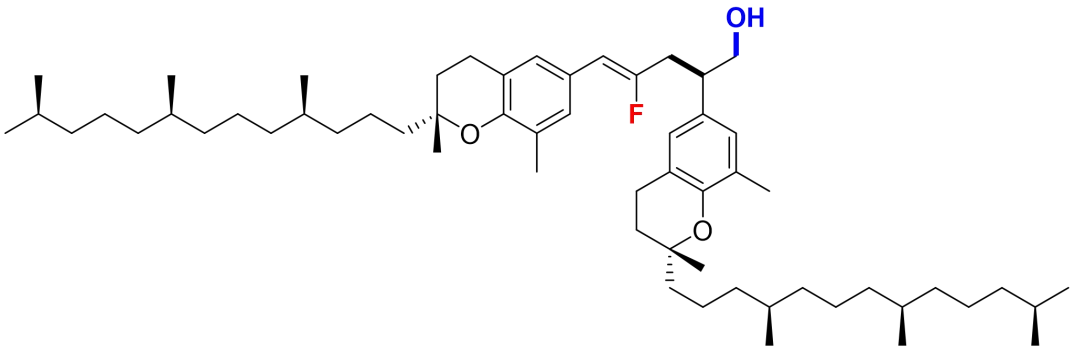
(47.4 mg, 78% white solid, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.25-7.19 (m, 3H), 7.17 (s, 1H), 7.06-7.02 (m, 1H), 6.98 (s, 1H), 5.40 (d, *J* = 39.6 Hz, 1H), 3.87-3.77 (m, 2H), 3.20-3.07 (m, 1H), 2.95-2.85 (m, 3H), 2.82-2.70 (m, 1H), 2.68-2.58 (m, 1H), 2.54-2.46 (m, 2H), 2.43-2.36 (m, 2H), 2.30-2.23 (m, 2H), 2.18-2.08 (m, 3H), 2.05-1.94 (m, 5H), 1.65-1.56 (m, 4H), 1.54-1.44 (m, 6H), 1.26 (d, *J* = 2.0 Hz, 3H), 0.91 (d, *J* = 4.9 Hz, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 220.9 (2C), 158.5 (d, *J* = 265.6 Hz), 138.5, 138.5, 136.8, 136.4, 131.2, 128.9, 128.8, 128.6 (d, *J* = 7.6 Hz), 125.8, 125.7, 125.4, 125.1, 107.3 (d, *J* = 8.3 Hz), 66.3, 50.6, 50.5, 48.00 (2C), 44.9, 44.8, 44.4, 44.3, 38.2, 38.1, 35.9 (2C), 31.6, 31.6, 29.5, 29.4, 26.5 (2C), 25.7 (2C), 21.6 (2C), 13.9, 13.8. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -101.76 (dt, *J* = 39.5, 19.8 Hz). **HRMS (ESI)** calcd for $C_{41}H_{50}FO_3^+$[M+H$^+$]: 609.3739 found 609.3738.



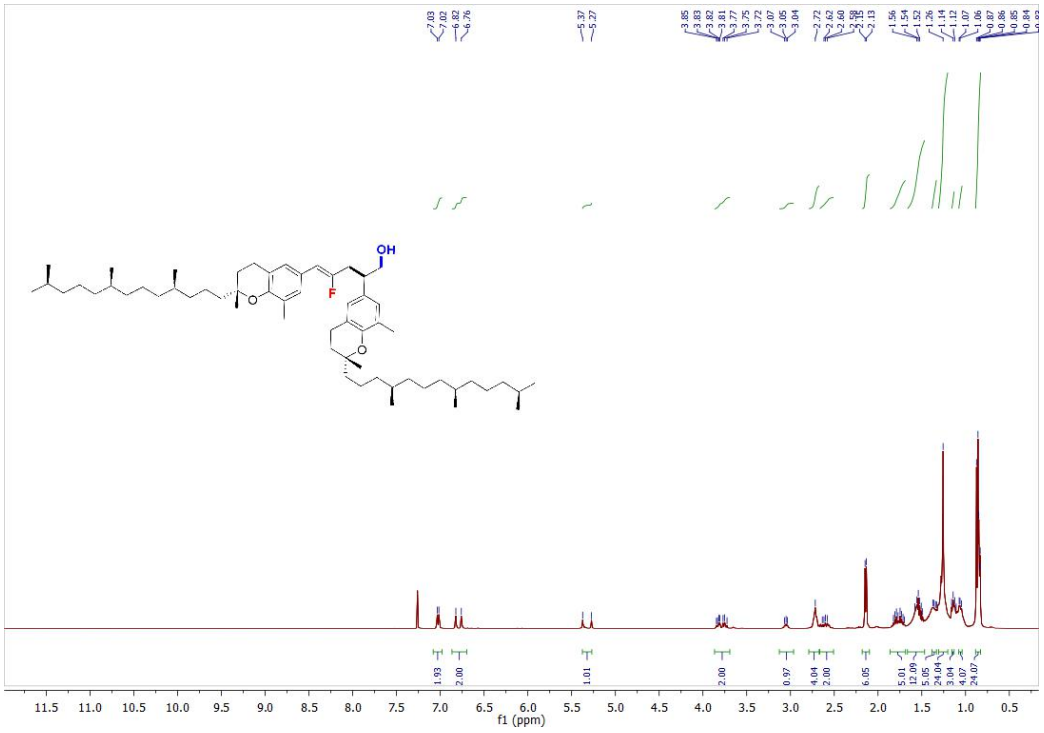

OH
F
O
f1 (ppm)

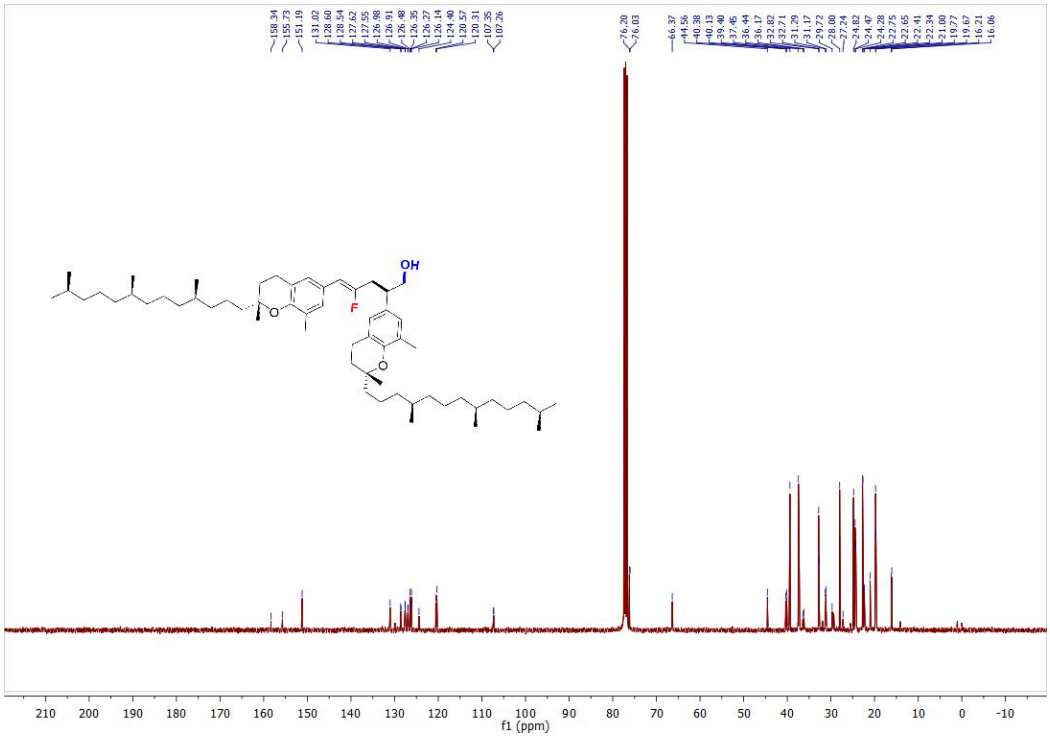

OH
F
O
f1 (ppm)

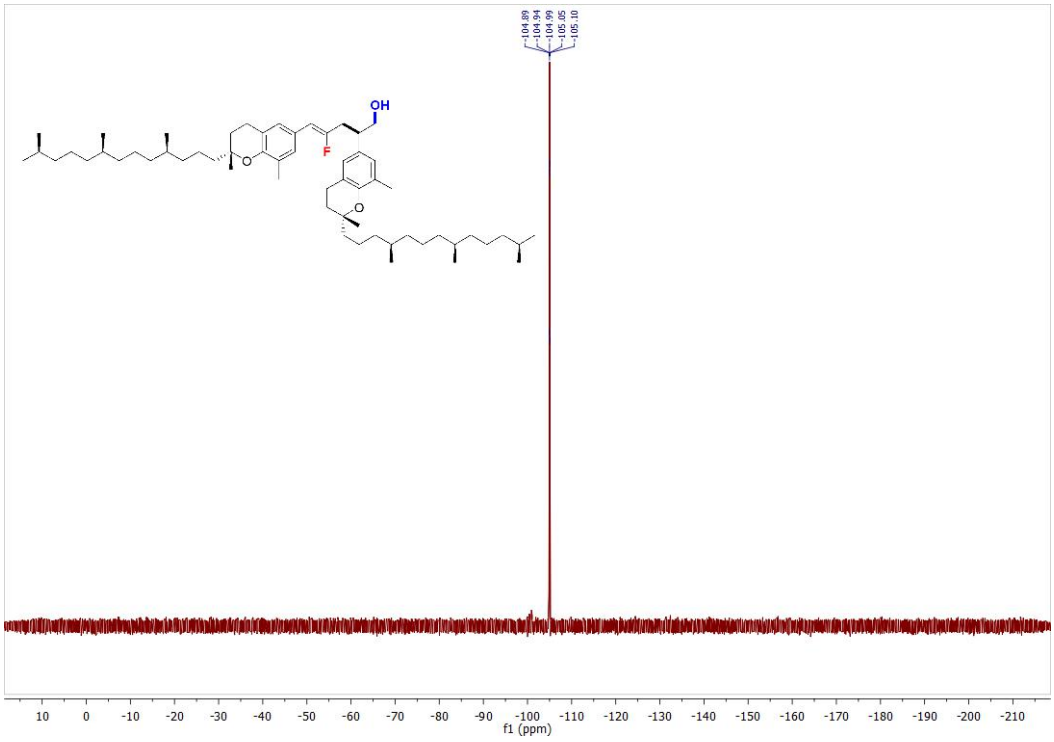
(*R*,*Z*)-2,5-bis((R)-2,8-dimethyl-2-((*4R*,*8R*)-4,8,12-trimethyltridecyl)chroman-6-yl)-4-fluoropent-4-en-1-ol (4g):



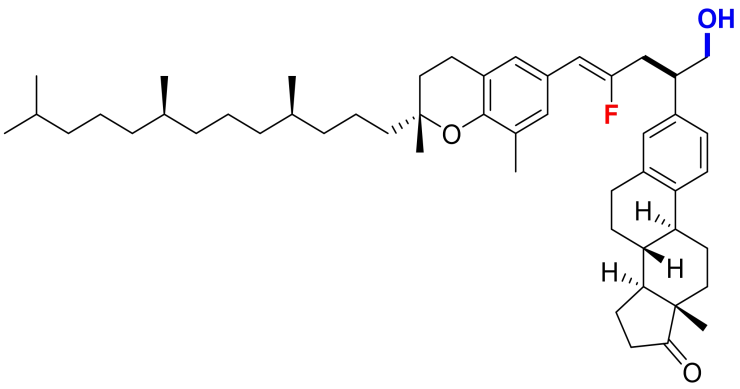
(62.4 mg, 72% colorless oil, petroleum ether /ethyl acetate 5: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.07-6.98 (m, 2H), 6.79 (d, *J* = 25.0 Hz, 2H), 5.32 (d, *J* = 40.1 Hz, 1H), 3.87-3.67 (m, 2H), 3.09-3.00 (m, 1H), 2.72 (s, 4H), 2.61 (dd, *J* = 14.8, 8.1 Hz, 2H), 2.14 (d, *J* = 5.9 Hz, 6H), 1.83-1.69 (m, 5H), 1.58-1.47 (m, 12H), 1.39-1.31 (m, 5H), 1.26 (s, 24H), 1.16-1.10 (m, 3H), 1.08-1.04 (m, 4H), 0.89-0.82 (m, 24H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.0 (d, *J* = 262.7 Hz), 151.1, 131.0, 128.5, 127.5, 126.9, 126.4, 126.3, 126.1, 124.3, 120.5, 120.3, 107.3, 76.1, 67.9, 66.3, 44.5, 40.2, 39.3, 37.4, 37.3, 36.2 (d, *J* = 26.9 Hz), 32.8, 32.7, 31.2, 31.1, 29.7, 28.0, 25.6, 24.8, 24.4, 24.2, 22.7, 22.3, 20.9, 19.7, 19.6, 16.2, 16.0. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -104.86. **HRMS (ESI)** calcd for $C_{59}H_{98}FO_3^+$[M+H$^+$]: 873.7495 found 873.7490.


OH
F
O
O
f1 (ppm)


OH
F
O
O
f1 (ppm)

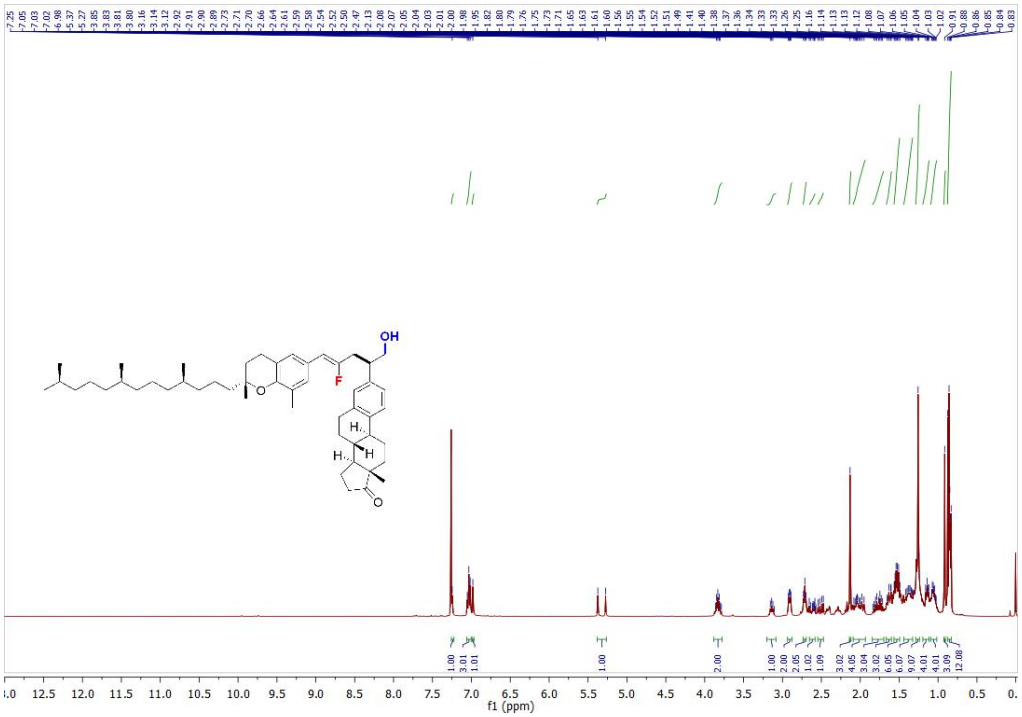


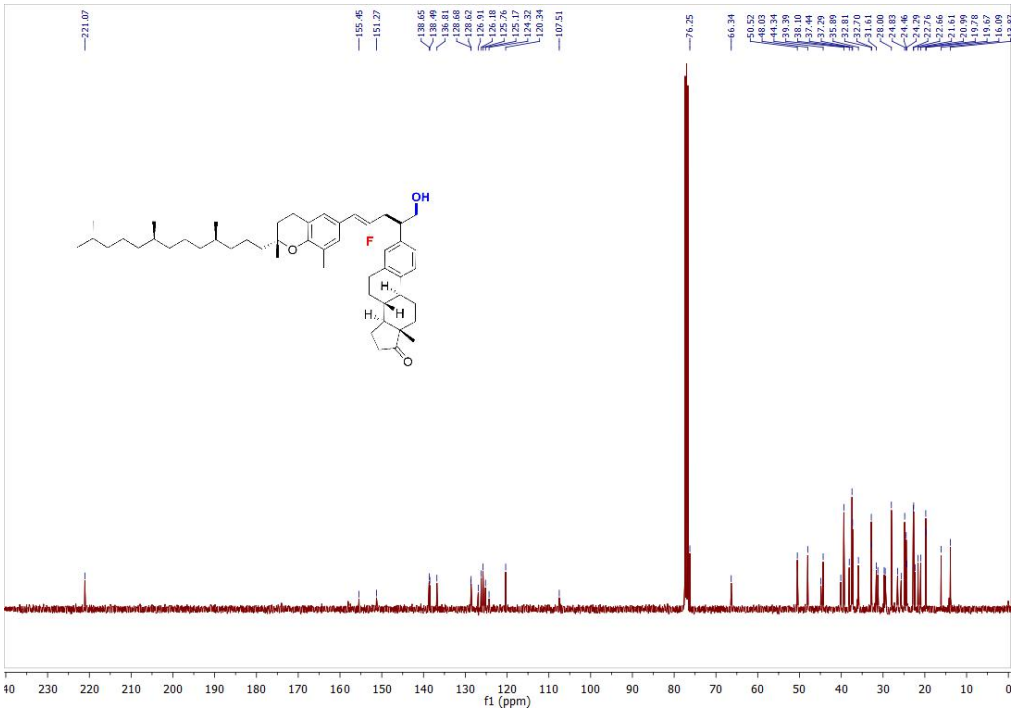
(*8R,9S,13S,14S*)-3-((*R,Z*)-5-((R)-2,8-dimethyl-2-((*4R,8R*)-4,8,12-trimethyltridecyl)chroman-6-yl)-4-fluoro-1-hydroxypent-4-en-2-yl)-13-methyl-6,7,8,9,11,12,13,14,15,16-decahydro-17H-cyclopenta[a]phenanthren-17-one (4h):

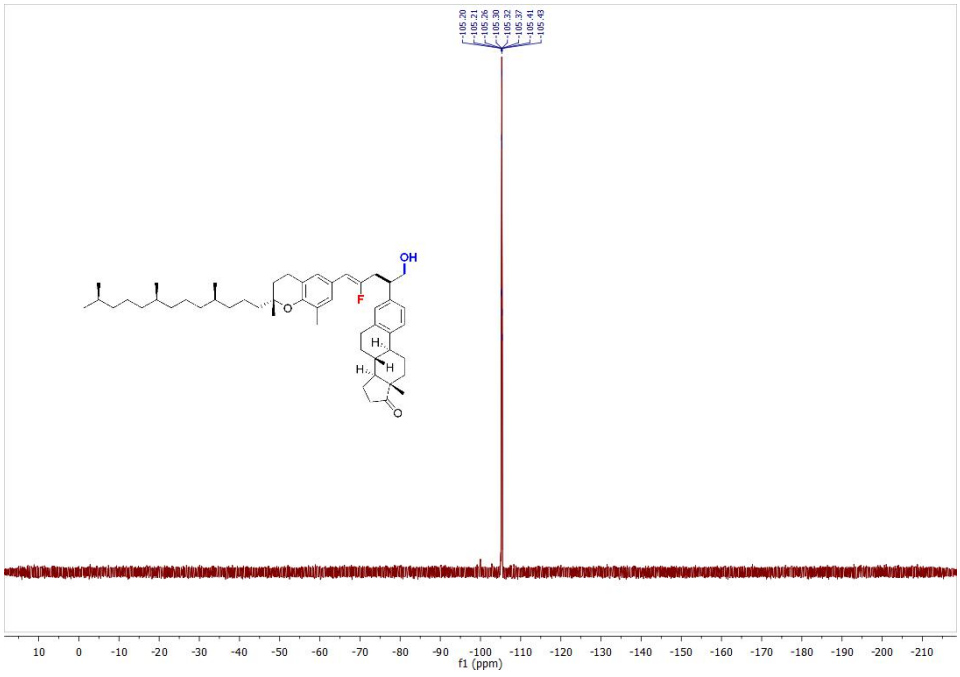


(49.8 mg, 67% colorless oil, petroleum ether /ethyl acetate 2: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.25 (s, 1H), 7.06-7.00 (m, 3H), 6.98 (s, 1H), 5.33 (d, 1H), 3.88-3.76 (m, 2H), 3.17-3.10 (m, 1H), 2.93-2.87 (m, 2H), 2.74-2.68 (m, 2H), 2.65-2.58 (m, 1H), 2.55-2.46 (m, 1H),

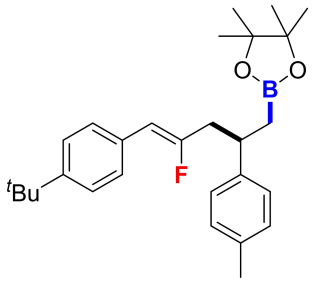
2.13 (s, 3H), 2.09-1.94 (m, 4H), 1.85-1.70 (m, 3H), 1.66-1.59 (m, 3H), 1.57-1.49 (m, 6H), 1.44-1.33 (m, 6H), 1.26 (s, 9H), 1.17-1.11 (m, 4H), 1.09-1.02 (m, 4H), 0.91 (s, 3H), 0.88-0.81 (m, 12H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 221.0, 156.7 (d, J = 262.7 Hz), 151.2, 138.6, 138.5, 136.8, 128.6, 128.6, 128.5, 126.9, 126.9, 126.1, 125.7, 125.1, 124.3, 120.3, 107.4, 76.2, 66.3 , 50.5, 48.0, 44.8, 44.3, 40.1, 39.3, 38.1, 37.4, 37.3, 36.1, 35.9, 32.8, 32.7, 31.6, 31.2, 29.7, 29.4, 28.0, 26.5, 25.6, 24.8, 24.4, 24.2, 22.7, 22.3, 21.6, 20.9, 19.7, 16.1, 13.8. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -105.31 (ddd, J = 40.0, 22.6, 5.4 Hz). **HRMS (ESI)** calcd for $C_{50}H_{74}FO_3$ $^+$[M+H$^+$]: 741.5617 found 741.5620.



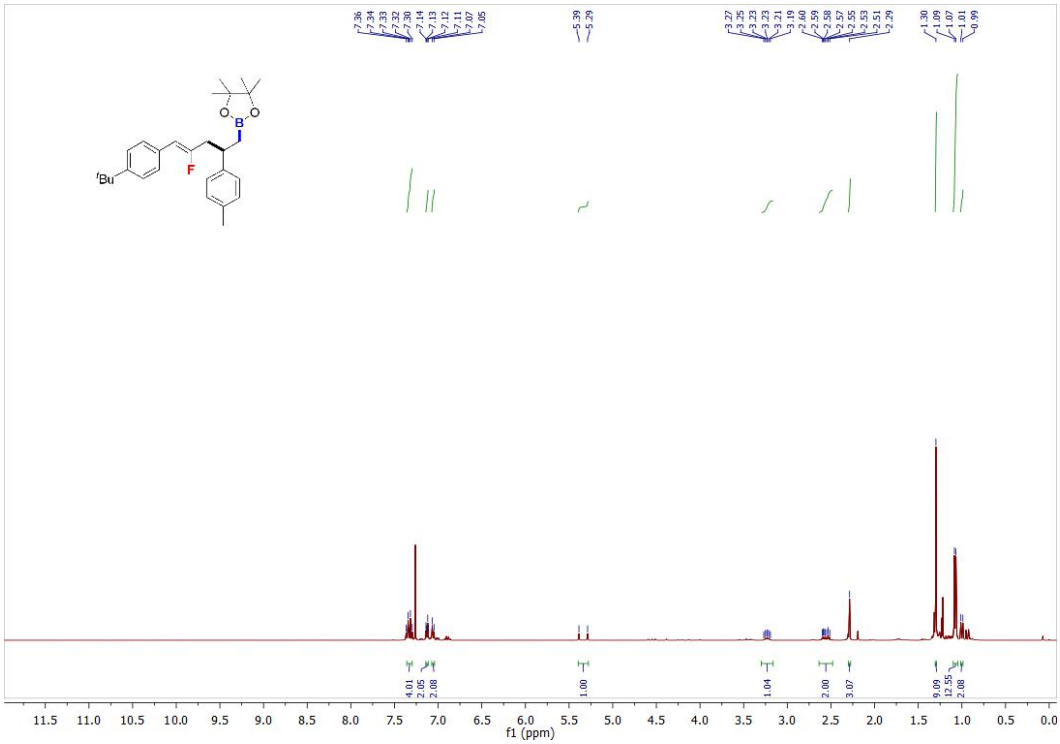

OH
F
H
O
f1 (ppm)

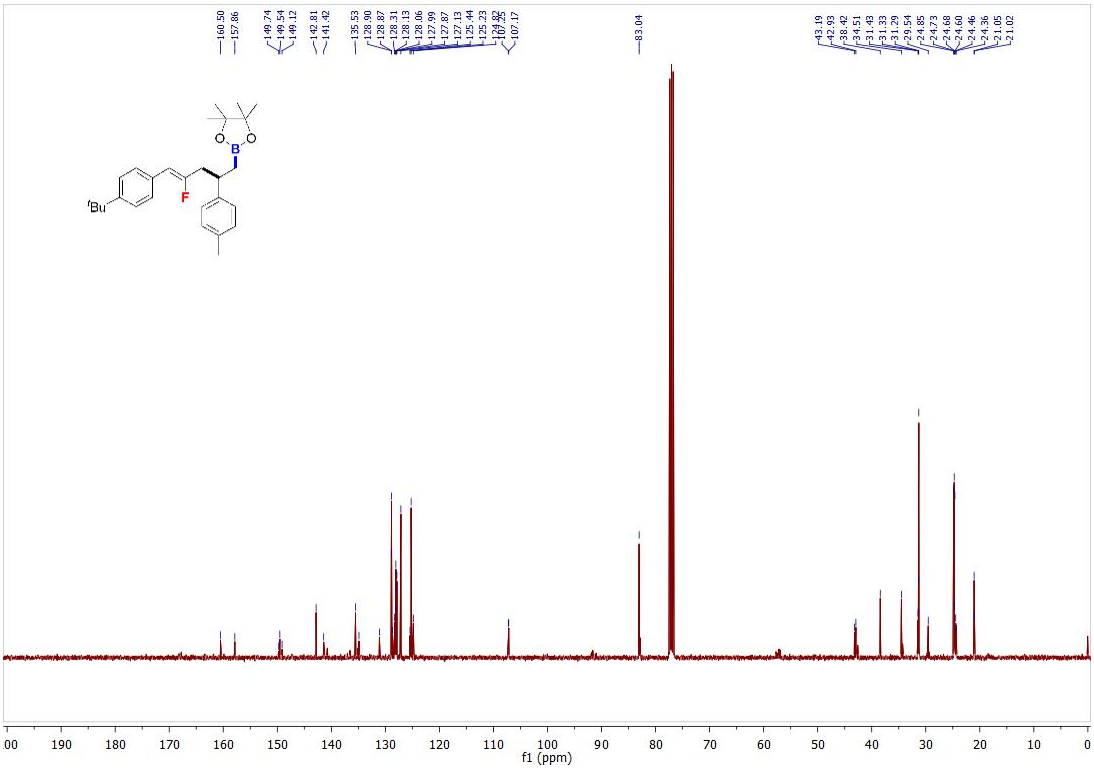

OH
F
H
O
f1 (ppm)

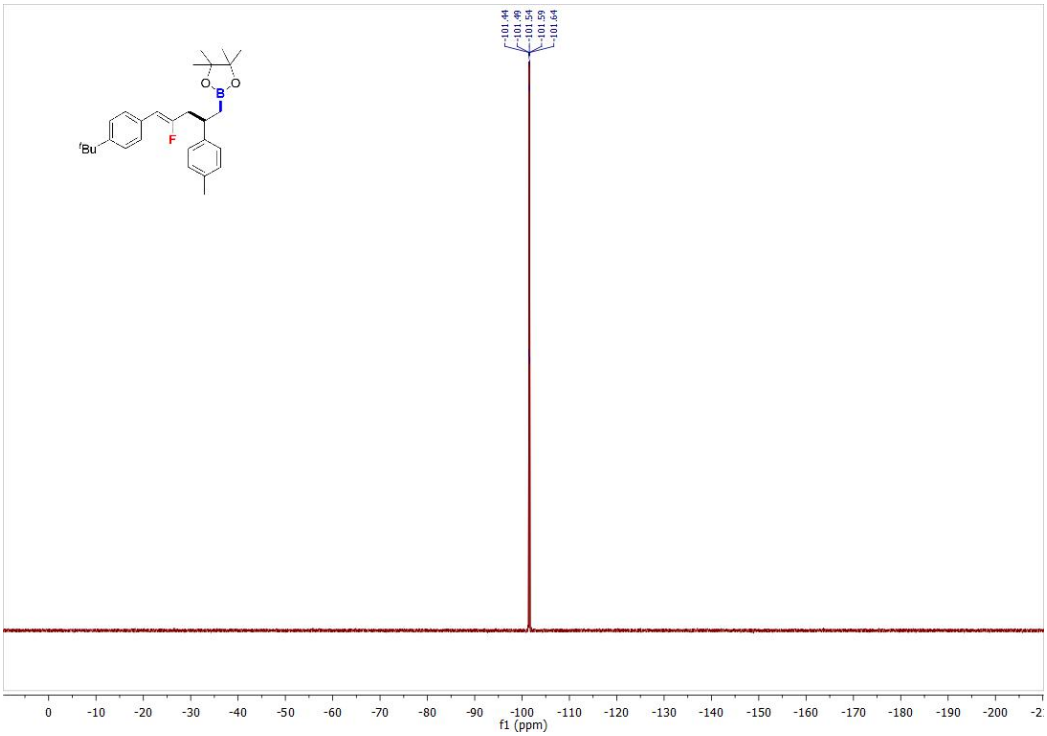
(R,Z)-2-(2-(*R,Z*)-2-(5-(4-(tert-butyl)phenyl)-4-fluoro-2-(p-tolyl)pent-4-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3e'):

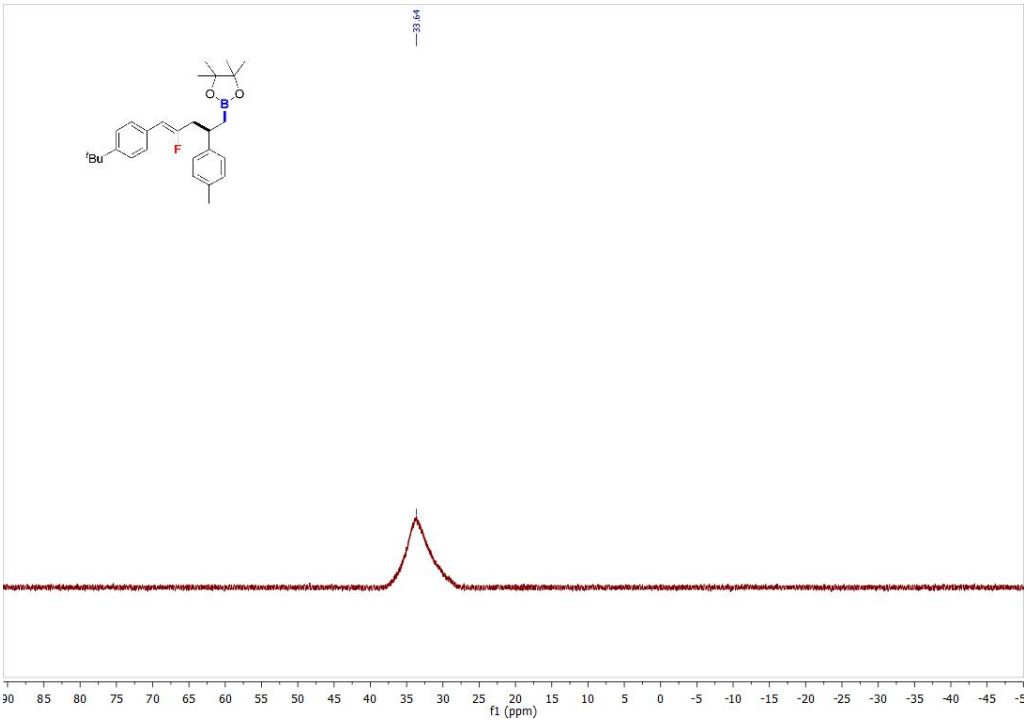


(1.2 g, 92% colorless oil, petroleum ether /ethyl acetate 50: 1 (V/V) as eluent),**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37-7.29 (m, 4H), 7.15-7.11 (m, 2H), 7.07-7.04 (m, 2H), 5.34 (d, *J* = 39.6 Hz, 1H), 3.27-3.18 (m, 1H), 2.60-2.50 (m, 2H), 2.29 (s, 3H), 1.30 (s, 9H), 1.08 (d, *J* = 6.9 Hz, 12H), 1.00 (d, *J* = 9.3 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.1 (d, *J* = 265.9 Hz), 149.5, 142.8, 135.5, 128.8, 128.0, 127.1, 125.2, 124.8, 107.2 (d, *J* = 8.8 Hz), 83.0, 42.0 (d, *J* = 26.0 Hz), 38.4, 34.5, 31.2, 29.5, 24.7, 21.0. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -101.54 (dt, *J* = 37.5, 18.8 Hz).**^{11}B NMR** (128 MHz, $CDCl_3$) δ 33.64. **HRMS (ESI)** calcd for $C_{28}H_{39}BFO_2^+$[M+H$^+$]: 437.3022 found 437.3018.

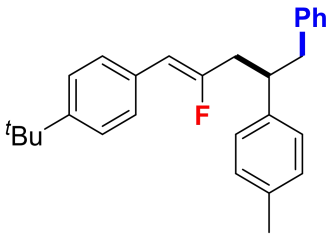

f1 (ppm)


f1 (ppm)

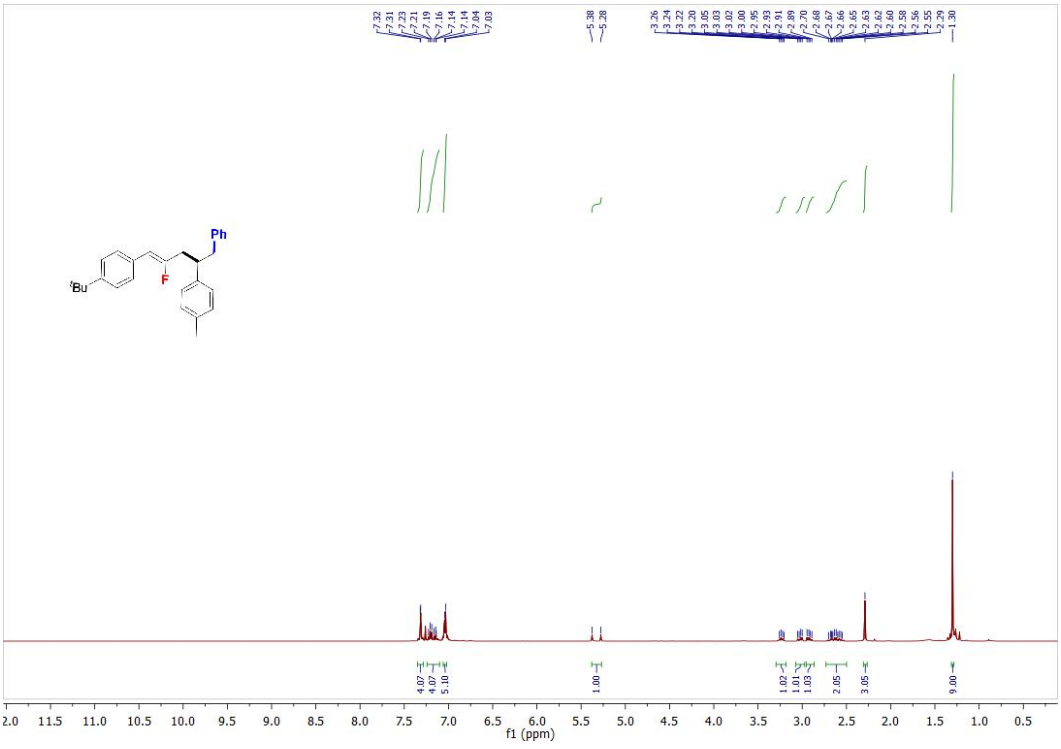

-101.44
-101.49
-101.54
-101.59
-101.64
f1 (ppm)

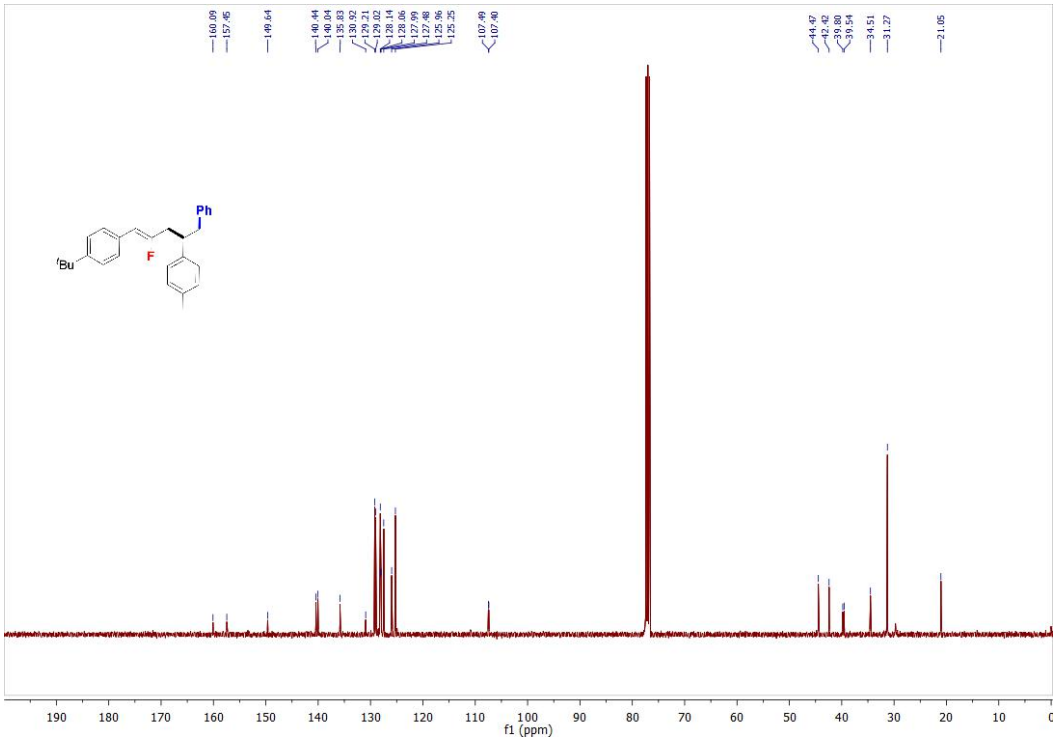

33.64
f1 (ppm)

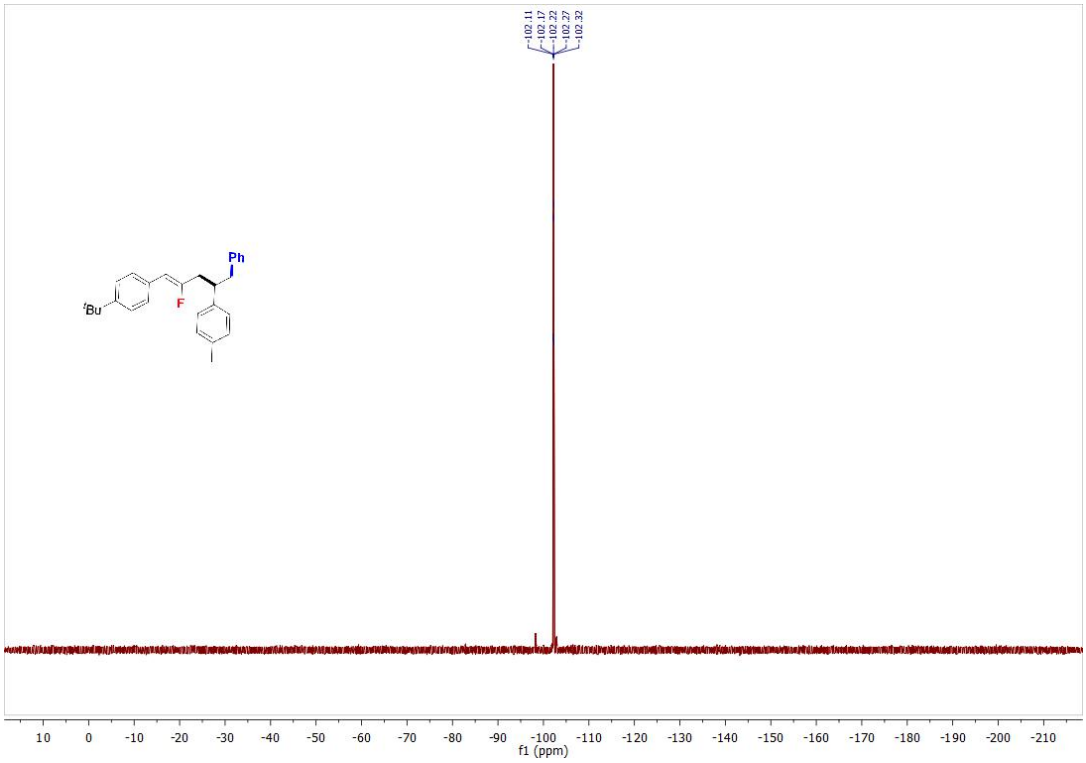
(*R*,*Z*)-1-(tert-butyl)-4-(2-fluoro-5-phenyl-4-(p-tolyl)pent-1-en-1-yl)benzene (5):



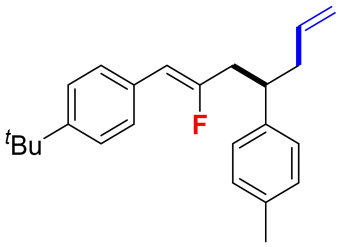
(25.3 mg, 66% colorless oil, petroleum ether /ethyl acetate 50: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.32 (d, *J* = 2.2 Hz, 4H), 7.23-7.13 (m, 4H), 7.05-7.02 (m, 5H), 5.33 (d, *J* = 39.7 Hz, 1H), 3.28-3.18 (m, 1H), 3.06 – 2.97 (m, 1H), 2.95-2.86 (m, 1H), 2.71-2.51 (m, 2H), 2.29 (s, 3H), 1.30 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.7 (d, *J* = 265.3 Hz), 149.6, 140.4, 140.0, 135.8, 130.92, 129.2, 129.0, 128.1, 128.0 (d, *J* = 7.1 Hz), 127.4, 125.9, 125.2, 107.4 (d, *J* = 8.9 Hz), 44.4, 42.4, 39.6 (d, *J* = 26.2 Hz), 34.5, 31.2, 21.0. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -102.22 (dt, *J* = 39.5, 19.6 Hz). **HRMS (ESI)** calcd for $C_{28}H_{32}F^{+}$[M+H^{+}]: 387.2483 found 387.2482.



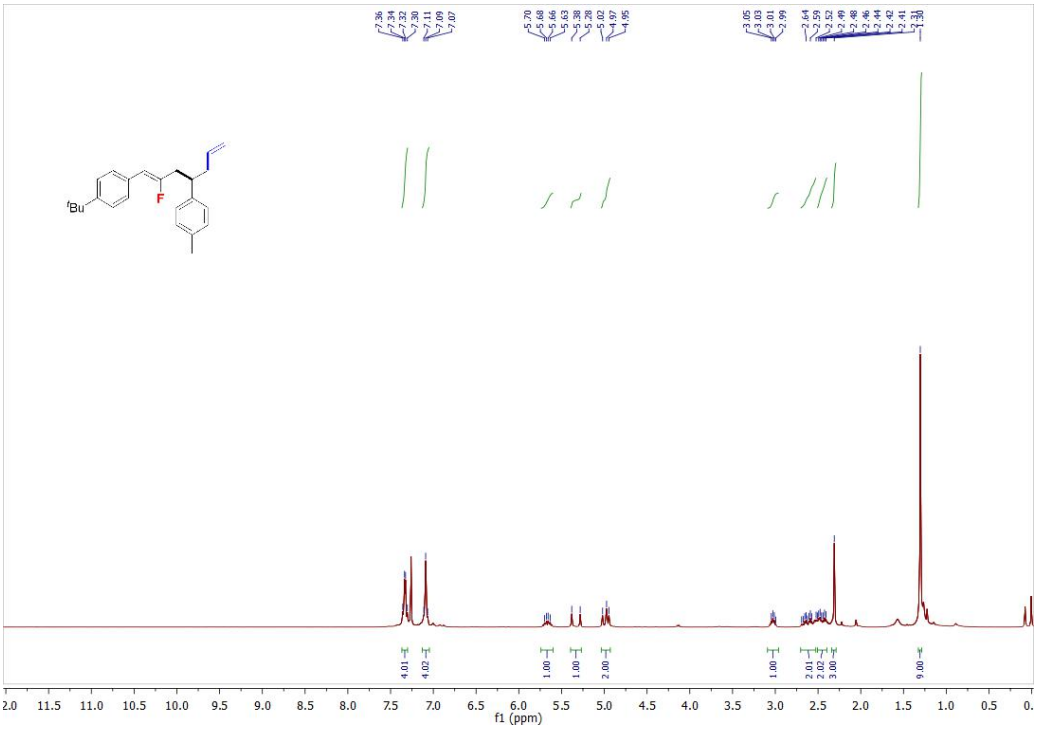

160.09
157.45
149.64
140.44
140.04
135.83
130.92
129.21
129.02
128.14
128.06
127.99
127.68
125.96
125.25
107.49
107.40
44.47
42.42
39.80
39.54
34.51
31.27
21.05
Ph
F
tBu
f1 (ppm)

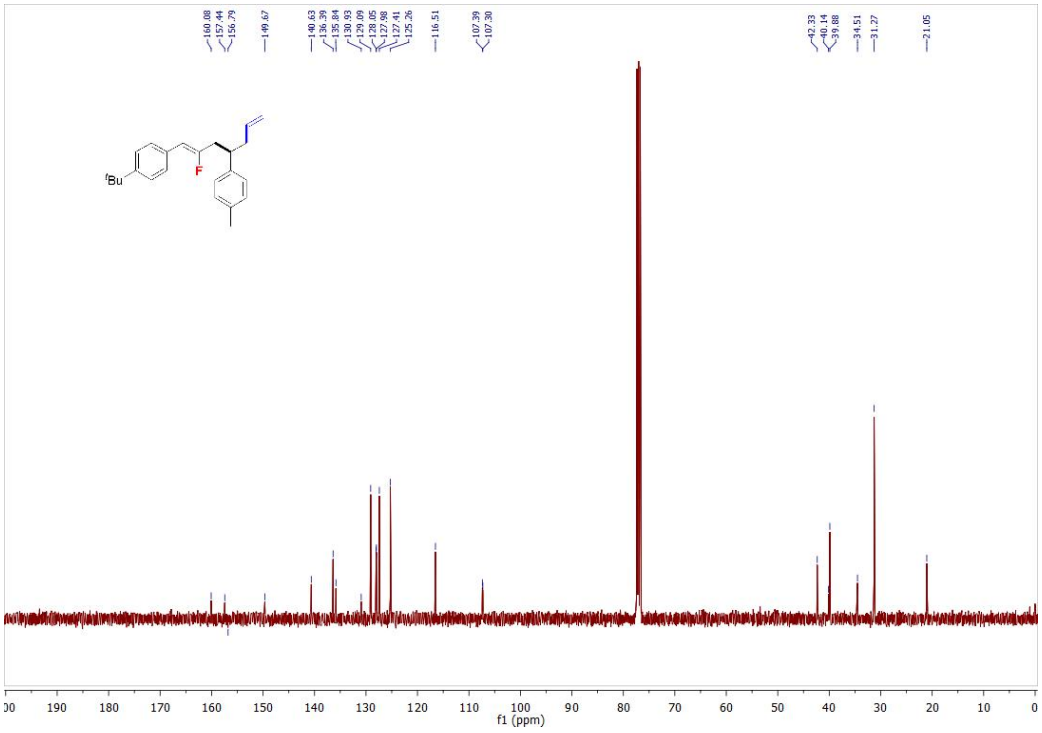

102.11
102.17
102.22
102.27
102.32
Ph
F
tBu
f1 (ppm)

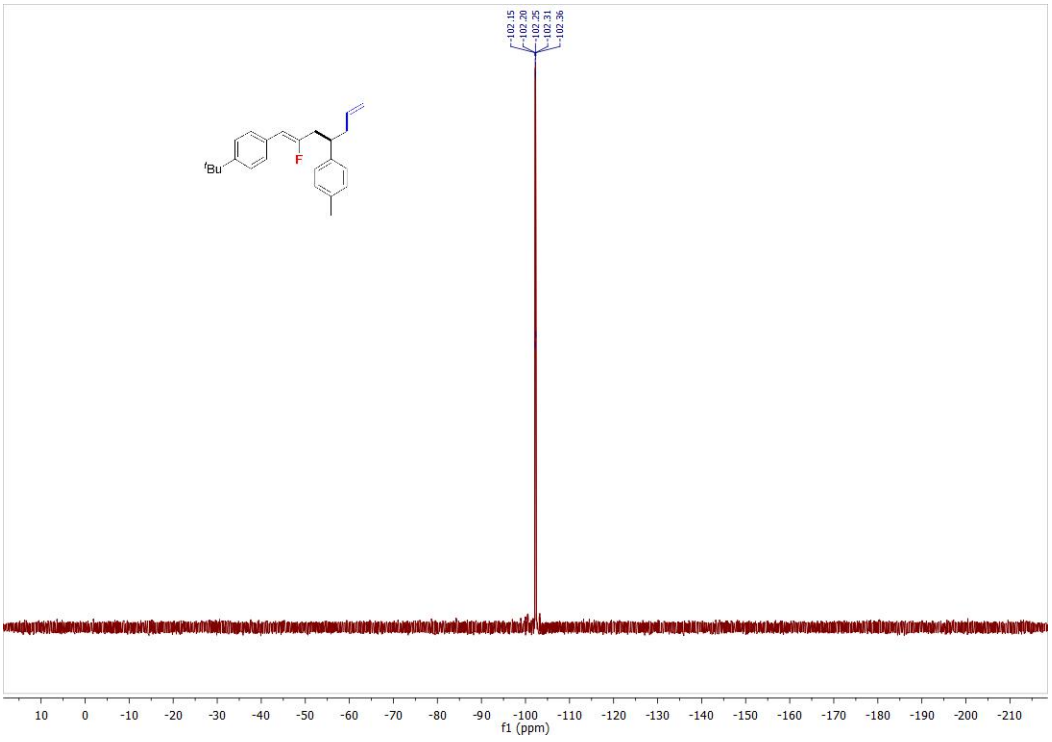
(*R*,*Z*)-1-(tert-butyl)-4-(2-fluoro-4-(p-tolyl)hepta-1,6-dien-1-yl)benzene (6):



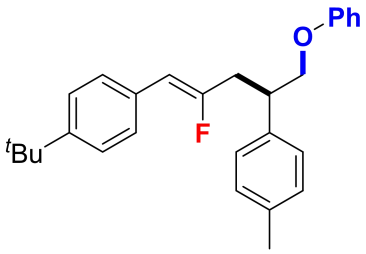
(28.5 mg, 85% colorless oil, petroleum ether /ethyl acetate 100: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36-7.29 (m, 4H), 7.12-7.06 (m, 4H), 5.73-5.60 (m, 1H), 5.33 (d, *J* = 39.6 Hz, 1H), 5.03-4.93 (m, 2H), 3.08-2.97 (m, 1H), 2.70-2.55 (m, 2H), 2.50-2.37 (m, 2H), 2.31 (s, 3H), 1.30 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.7 (d, *J* = 265.4 Hz), 149.6, 140.6, 136.3, 135.8, 130.9, 129.0, 128.0 (d, *J* = 7.2 Hz), 127.4, 125.2, 116.5, 107.3 (d, *J* = 9.0 Hz), 42.3, 40.1, 39.8, 34.5, 31.2, 21.0. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -102.25 (dt, *J* = 40.0, 20.1 Hz). **HRMS (ESI)** calcd for $C_{24}H_{30}F^{+}$[M+H^{+}]: 337.2326 found 337.2327.



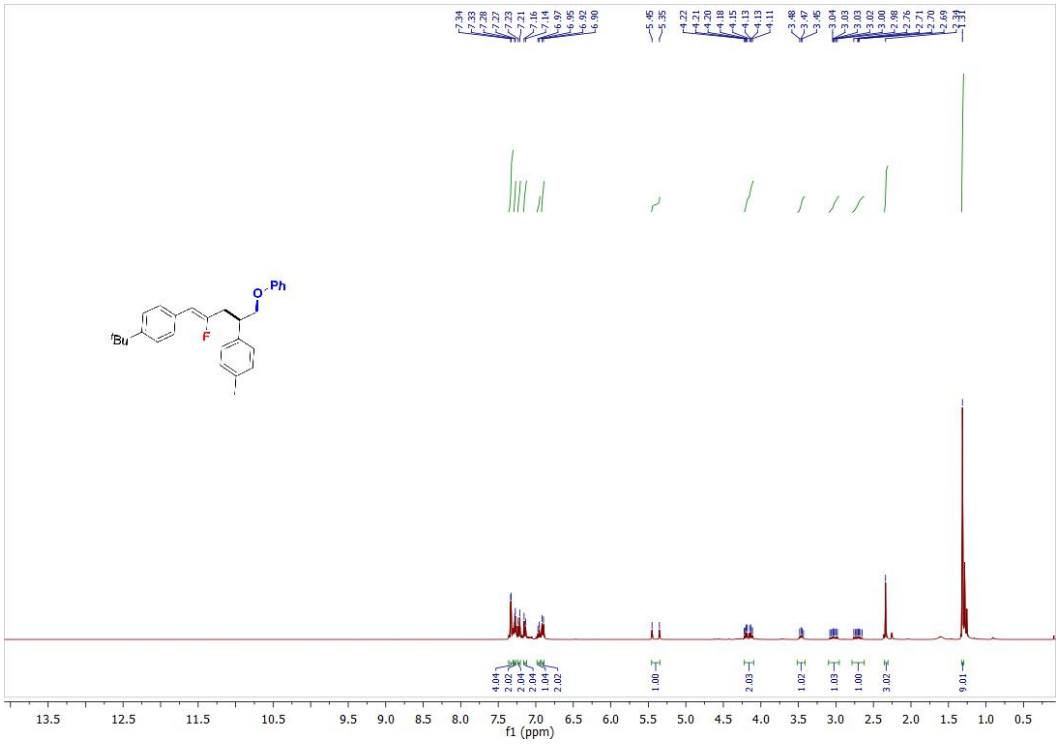

160.08
157.44
156.79
149.67
140.63
136.39
135.84
130.65
129.09
128.05
127.98
127.41
125.26
116.51
107.39
107.30
42.33
40.14
39.88
34.51
31.27
21.05
tBu
F
f1 (ppm)

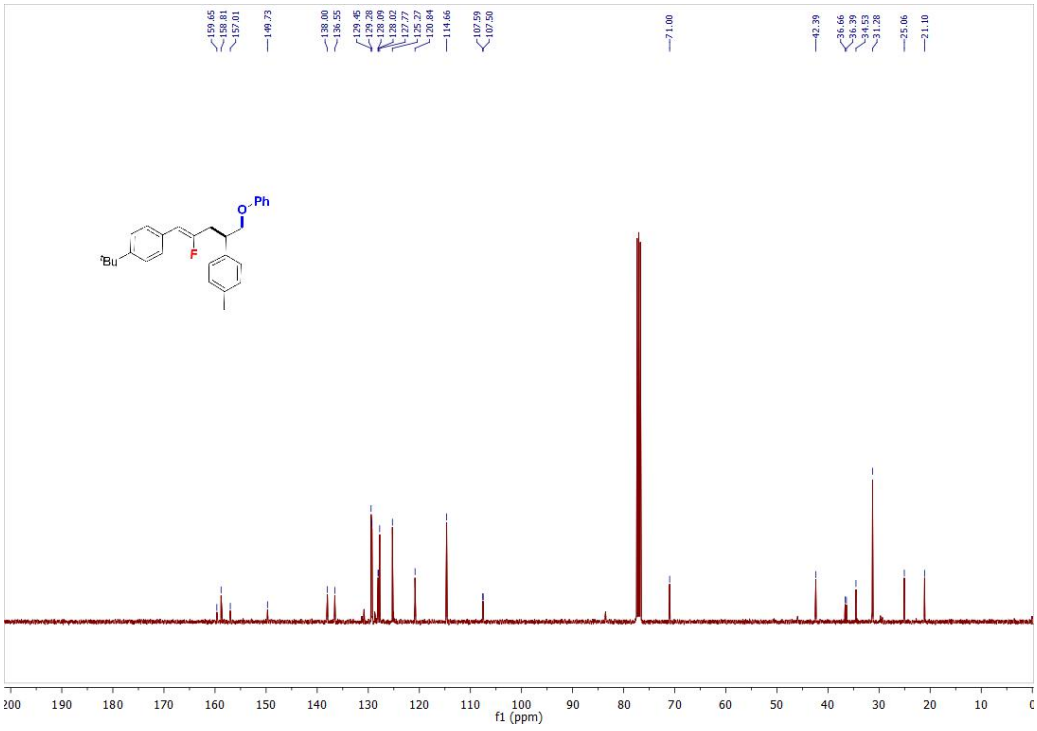

-102.15
-102.20
-102.25
-102.31
-102.36
tBu
F
f1 (ppm)

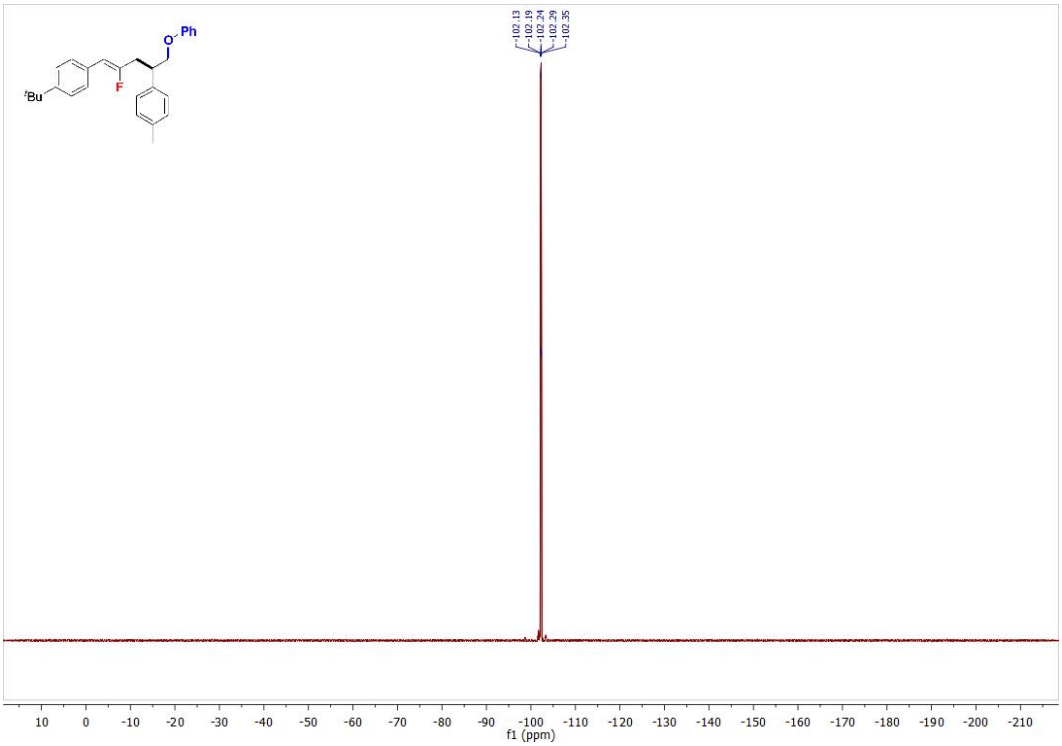
(*R*,*Z*)-1-(tert-butyl)-4-(2-fluoro-5-phenoxy-4-(p-tolyl)pent-1-en-1-yl)benzene (7):



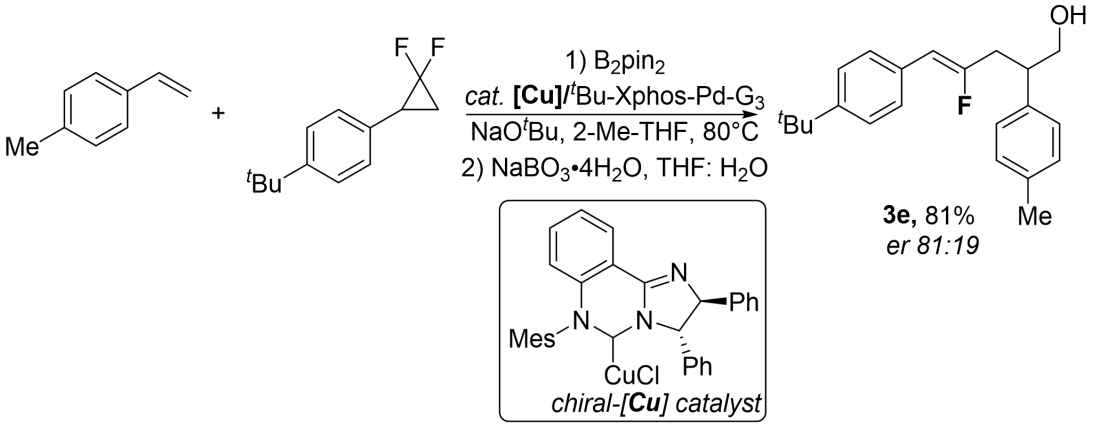
(33 mg, 82% colorless oil, petroleum ether /ethyl acetate 50: 1 (V/V) as eluent), **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 2.7 Hz, 4H), 7.28 (m , 2H), 7.24-7.20 (m, 2H), 7.17-7.12 (m, 2H), 6.99-6.94 (m, 1H), 6.91 (d, *J* = 7.9 Hz, 2H), 5.40 (d, *J* = 39.6 Hz, 1H), 4.24-4.08 (m, 2H), 3.50-3.39 (m, 1H), 3.10-2.96 (m, 1H), 2.78-2.63 (m, 1H), 2.34 (s, 3H), 1.31 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.8, 158.3 (d, *J* = 265.3 Hz), 149.7, 138.0, 136.5, 129.4, 129.2, 128.0 (d, *J* = 7.2 Hz), 127.7, 125.2, 120.8, 114.6, 107.5 (d, *J* = 8.7 Hz), 71.0, 42.3, 36.5 (d, *J* = 26.4 Hz), 34.5, 31.2, 25.0, 21.1. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -102.24 (dt, *J* = 39.6, 19.8 Hz). **HRMS (ESI)** calcd for $C_{28}H_{32}FO^+$[M+H$^+$]: 403.2432 found 403.2430.



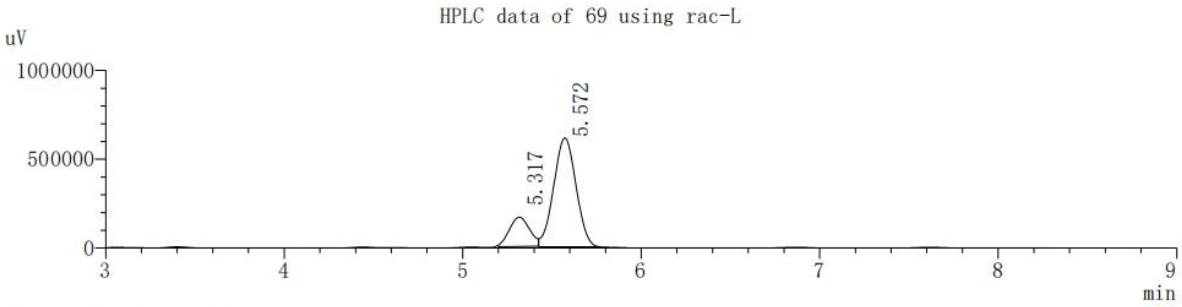

159.65
158.81
157.01
149.73
138.00
136.55
129.45
129.28
128.09
128.02
127.77
125.27
120.84
114.66
107.59
107.50
71.00
42.39
36.66
36.39
34.53
31.28
25.06
21.10
Ph
O
F
tBu
f1 (ppm)


-102.13
-102.19
-102.24
-102.29
-102.35
Ph
O
F
tBu
f1 (ppm)

HPLC Data:

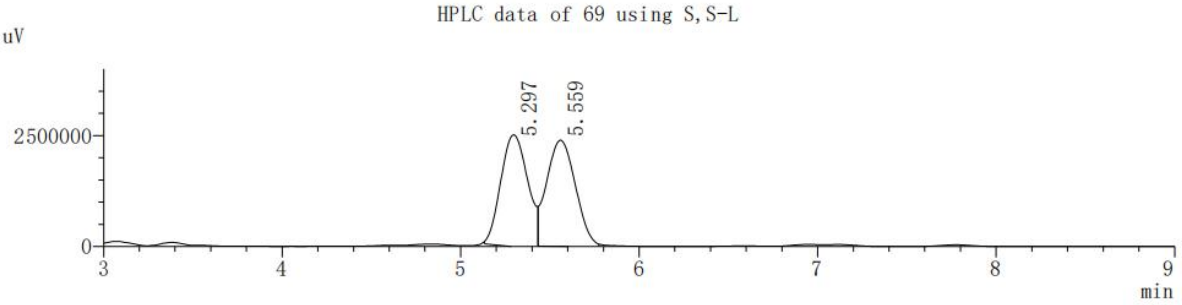


A Schlenk tube (10 mL) was charged with B_2pin_2 (0.15 mmol, 1.5 equiv.), chiral-[Cu] (10 mol%), [Pd] (10 mol %), and NaO*t*Bu (0.15 mmol, 1.5 equiv.). The tube equipped with a stirring bar and then evacuated and backfilled with argon 3 times, followed by substrate (**2a**) (0.12 mmol, 1.2 equiv.), alkene (**1**) (0.1 mmol, 1 equiv.) and 1 mL of the 2-MeTHF. The sealed tube was removed to oil bath and heated to 80 ℃ for 4 hours. The reaction cooled to room temperature, then extracted with ethyl acetate and the combined organic layer was dried over anhydrous Na_2SO_4, the solvent was removed under reduced pressure to obtain a mixture residue. The mixture residue then dissolved in (2 mL) THF and (2 mL) H_2O, $NaBO_3$•$4H_2O$ (0.5 mmol, 5 was added. The reaction was stirred at room temperature for 2 h, then extracted with ethyl acetate and the combined organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduce pressure. Then, purified by thin layer chromatography plate (SiO_2, petroleum ether/ ethyl acetate (V/V) as eluent) to afford the desired products. The ee values were determined by HPLC on Chiralpak OD-H column (hexane: isopropanol = 95:5, flow rate = 1.0 mL/min, UV detection at 254 nm).



检测器A Ch1 254nm

Peak[#]	RetTime[min]	Height[uV]	Width[min]	Area[uV*s]	Area[%]
1	5.317	165885	0.129	1320221	19.805
2	5.572	613419	0.137	5345960	80.195



检测器A Ch1 214nm

Peak[#]	RetTime[min]	Height[uV]	Width[min]	Area[uV*s]	Area[%]
1	5.297	2522783	0.175	26809219	50.088
2	5.559	2393961	0.186	26714956	49.912

5. References:

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