Supporting Information

The dual role of $BrCF_2CO_2Et$: difluorocarbene-enabled access to α-trifluoromethyl ketones from sulfoxonium ylides

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1.General information

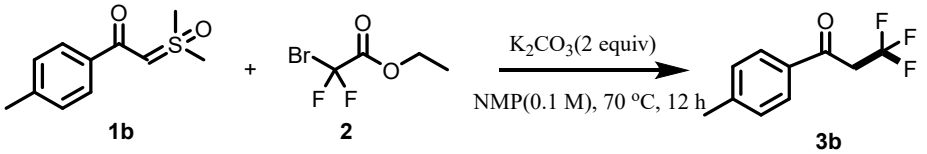
All substrates and reagents were commercially available and used without further purification. TLC analysis was performed using pre-coated glass plates. Column chromatography was performed using silica gel (200–300 mesh). ^{1}H spectra were recorded in $CDCl_3$ on 600/400 MHz NMR spectrometers and resonances (δ) are given in parts per million relative to tetramethylsilane. Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet), coupling constants (Hz) and integration. ^{13}C spectra were recorded in $CDCl_3$ on 150/100 MHz NMR spectrometers and resonances (δ) are given in ppm. HRMS were obtained on a Bruker 7-tesla FT-ICR MS equipped with an electrospray source. The X-ray crystal-structure determinations were obtained on a Bruker SMART APEX CCD system. Sulfoxonium ylides **1** were known compounds, and prepared according to the reported procedures.[1] $BrCF_2COOEt$ was commercially available and used without further purification.

2.General procedure for the synthesis of 3

A 25 mL Schlenk-type tube (with a Teflon screw cap and a side arm) equipped with a magnetic stir bar was charged with the mixture of sulfoxonium ylide (1 mmol), $BrCF_2COOEt$ (3 mmol), K_2CO_3 (2 mmol) and H_2O (0.5 mmol) in NMP (10 mL). The mixture was stirred at 70 °C for 5 hours. After cooling to room temperature, the mixture was quenched with water (25 mL), extracted with EtOAc (3 × 50 mL), the combined organic layers were washed with brine, dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (eluent: PE/EtOAc) to afford the products.

3. Optimization of the reaction conditions

Table S1. The influence of solvents

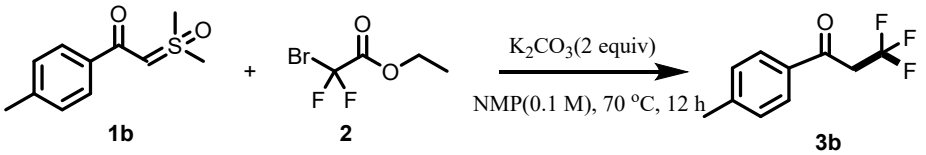


1b 2 3b

entry	solvent[a]	yields[b]
1	**NMP**	**50%**
2	CH_3CN	12%
3	THF	20%
4	DMSO	10%
5	DMF	15%

[a]Standard conditions: reactions were carried out with **1b** (1 equiv.), **2** (2 equiv.) and K_2CO_3 (2 equiv.) in NMP (0.1 M) at 70 ℃ for 12 h. [b]Isolated yields.

Table S2. The influence of protonic additives



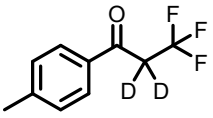
1b 2 3b

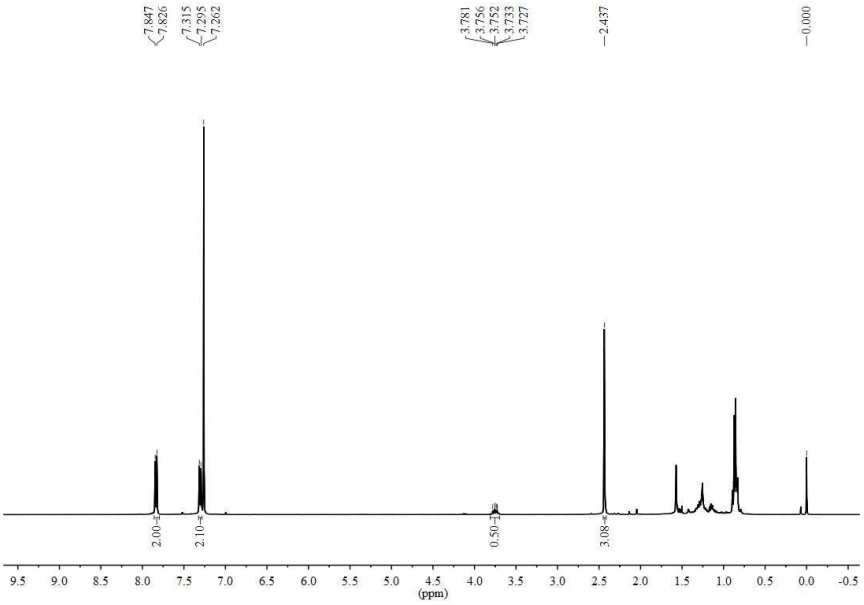
entry	protonic additives[a]	Yields[b]
1	EtOH	56%
2	MeOH	60%
3	HFIP	36%
4	*n*-BuOH	34%
5	*i*-PrOH	12%
6	$HOCH_2CH_2OH$	63%
7	H_2O	**68%**

[a]Standard conditions: reactions were carried out with **1b** (1 equiv.), **2** (3 equiv.) and K_2CO_3 (2 equiv.) in NMP (0.1 M) at 70 ℃ for 5 h. [b]Isolated yields.

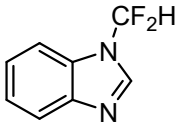
4. Characterization data for compounds in mechanistic study

The deuterium labeling experiment

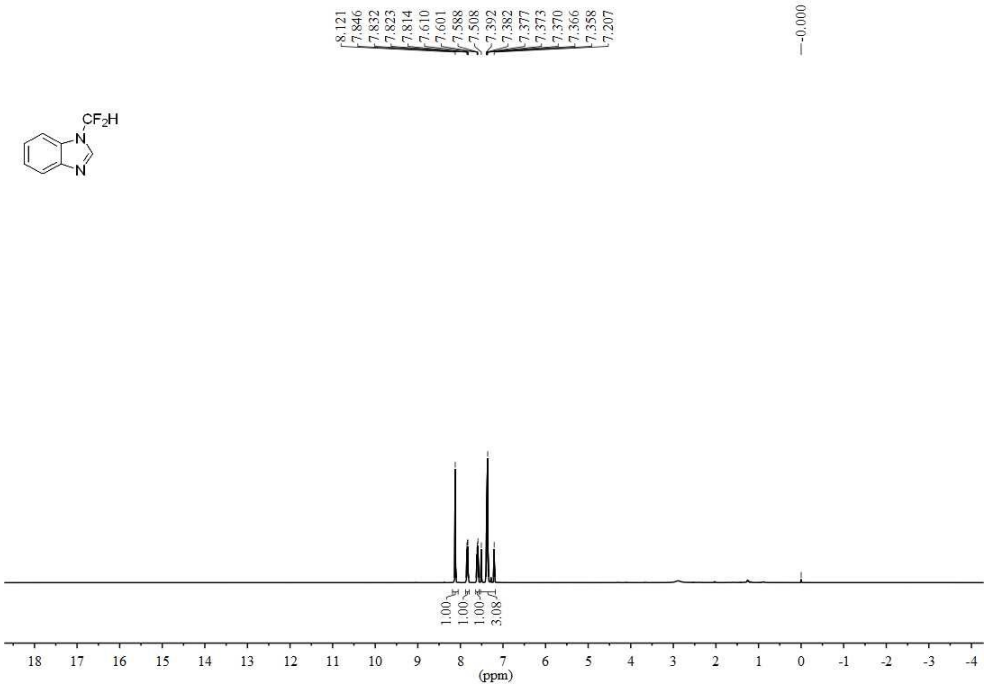




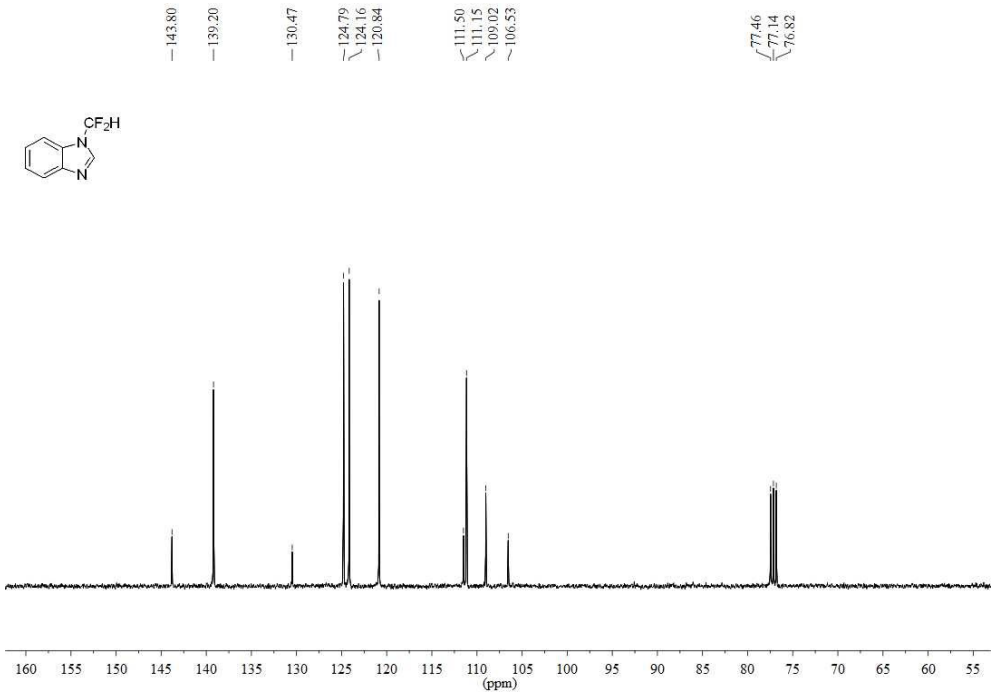
conpound **13**



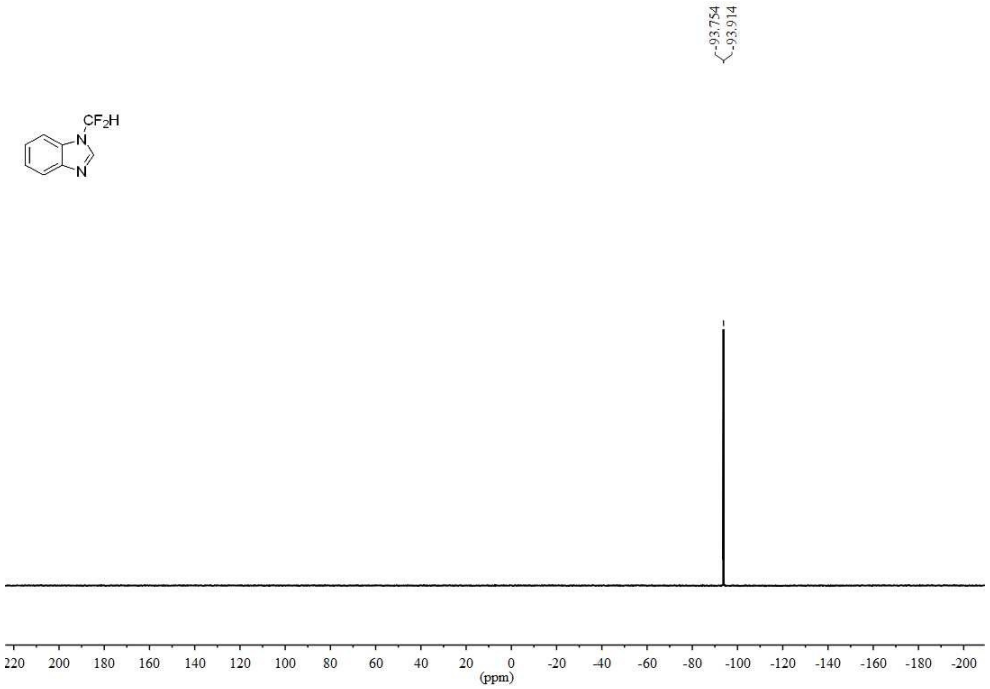
^{1}H NMR (400 MHz, $CDCl_3$) of compound 13



$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **13**



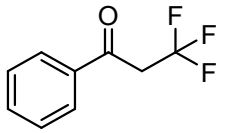
^{19}F NMR (376 MHz, $CDCl_3$) of compound **13**



1-(difluoromethyl)-1H-benzo[d]imidazole (13)

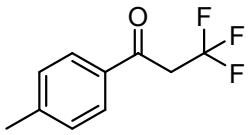
^1H NMR (400 MHz, $CDCl_3$) δ 8.12 (s, 1H), 7.83 (dd, J = 8.0, 4.8 Hz, 1H), 7.64–7.56 (m, 1H), 7.53–7.18 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.7, 139.1, 130.3, 124.7, 124.0, 120.7, 111.0, 108.9(t, J = 248.0 Hz, $^1J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -97.8.

5. Characterization data for compounds



3,3,3-trifluoro-1-phenylpropan-1-one (3a):

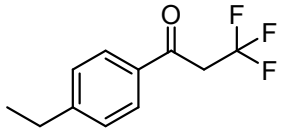
Yield 73%; 137.0 mg; yellow soild; mp 55-56 ℃; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^1H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, J = 7.6 Hz, 2H), 7.64 (t, J = 7.6 Hz, 1H), 7.51 (t, J = 7.6 Hz, 2H), 3.81 (q, J = 10.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.7(q, J = 3.0 Hz, $^3J_{CF}$), 135.7(q, J = 1.0 Hz, $^4J_{CF}$), 134.3, 129.0(q, J = 275.0 Hz, $^1J_{CF}$), 124.0, 42.141.8(q, J = 28.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.05. HRMS (ESI) m/z calcd for $C_9H_7F_3ONa^+$ $(M+Na)^+$ 211.0341, found 211.0343.



3,3,3-trifluoro-1-(p-tolyl)propan-1-one (3b):

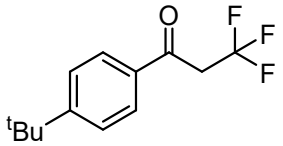
Yield 75%; 151 mg; white solid; mp 51-52 ℃; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.3; ^1H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, J = 8.0 Hz, 2H), 7.29 (d, J = 8.0 Hz, 2H), 3.76 (q, J =

10.0 Hz, 2H), 2.43 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.3(q, J = 3.0 Hz, $^3J_{CF}$), 145.3, 133.3(q, J = 2.0 Hz, $^4J_{CF}$), 129.6, 128.4, 124.1(q, J = 275.0 Hz, $^1J_{CF}$), 41.9(q, J = 28.0 Hz, $^2J_{CF}$), 21.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.03. HRMS (ESI) m/z calcd for $C_{10}H_{10}F_3O^+$ $(M+H)^+$ 203.0678, found 203.0676.



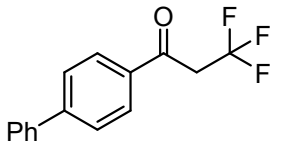
1-(4-ethylphenyl)-3,3,3-trifluoropropan-1-one (3c)

Yield 74%; 160 mg; yellow oil; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, J = 8.4 Hz, 2H), 7.32 (d, J = 8.0 Hz, 2H), 3.77 (q, J = 10.0 Hz, 2H), 2.72 (q, J = 7.6 Hz, 2H), 1.26 (t, J = 7.6 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.3(q, J = 3.0 Hz, $^3J_{CF}$), 151.4, 133.5(q, J = 1.0 Hz, $^4J_{CF}$), 128.6, 128.4, 124.1(q, J = 275.0 Hz, $^1J_{CF}$), 41.9(q, J = 28.0 Hz, $^2J_{CF}$), 28.9, 15.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.03. HRMS (ESI) m/z calcd for $C_{11}H_{11}F_3ONa^+$ $(M+Na)^+$ 239.0654, found 239.0651.



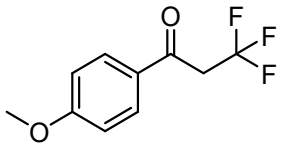
1-(4-(tert-butyl)phenyl)-3,3,3-trifluoropropan-1-one (3d):

Yield 70%; 170 mg; yellow oil; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.11–7.76 (m, 2H), 7.67–7.37 (m, 2H), 3.82 (q, J = 10.0 Hz, 2H), 1.61–1.22 (m, 10H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.4, 158.2, 133.4, 128.4, 125.9, 124.1(q, J = 276.0 Hz, $^1J_{CF}$), 41.9(q, J = 28.0 Hz, $^2J_{CF}$), 35.3, 31.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.97.



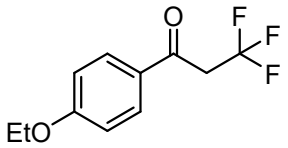
1-([1,1'-biphenyl]-4-yl)-3,3,3-trifluoropropan-1-one (3e):

Yield 69%; 182 mg; yellow solid; mp 120-122 ℃; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, J = 8.4 Hz, 2H), 7.71 (d, J = 8.4 Hz, 2H), 7.62 (d, J = 7.2 Hz, 2H), 7.48 (t, J = 7.2 Hz, 2H), 7.43 (d, J = 7.2 Hz, 1H), 3.82 (q, J = 10.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.3(q, J = 3.0 Hz, $^3J_{CF}$), 146.8, 139.3, 134.4(q, J = 2.0 Hz, $^4J_{CF}$), 129.02, 128.96, 128.6, 127.5, 127.3,124.0(q, J = 276.0 Hz, $^1J_{CF}$), 42.0(q, J = 28.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.51. HRMS (ESI) m/z calcd for $C_{15}H_{11}F_3ONa^+$ $(M+Na)^+$ 287.0654, found 287.0656.



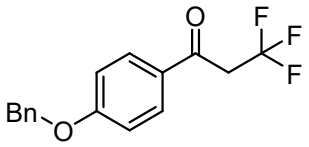
3,3,3-trifluoro-1-(4-methoxyphenyl)propan-1-one (3f):

Yield 67%; 146 mg; white solid; mp 50-51 ℃; TLC (PE:EtOAc, 100:1 v/v): R_f= 0.1; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, *J* = 8.8 Hz, 2H), 6.96 (d, *J* = 8.8 Hz, 2H), 3.88 (s, 3H), 3.74 (q, *J* = 10.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.12(q, *J* = 3.0 Hz, $^3J_{CF}$), 164.3, 130.7, 128.8(q, *J* = 1.0 Hz, $^4J_{CF}$), 124.2(q, *J* = 306.0 Hz, $^1J_{CF}$), 114.0, 55.5, 41.6(q, *J* = 28.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.01. HRMS (ESI) m/z calcd for $C_{10}H_9F_3O_2Na^+$ $(M+Na)^+$ 241.0447, found 241.0443.



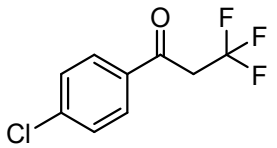
1-(4-ethoxyphenyl)-3,3,3-trifluoropropan-1-one (3g):

Yield 64%; 149 mg; yellow solid; mp 56-57 ℃; TLC (PE:EtOAc, 50:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.8 Hz, 2H), 6.94 (d, *J* = 8.8 Hz, 2H), 4.11 (q, *J* = 7.2 Hz, 2H), 3.73 (q, *J* = 10.0 Hz, 2H), 1.45 (t, *J* = 7.2 Hz, 3H).; ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.1(q, *J* = 3.0 Hz, $^3J_{CF}$), 163.8, 130.8, 128.67(q, *J* = 1.0 Hz, $^4J_{CF}$), 124.2(q, *J* = 275.0 Hz, $^1J_{CF}$), 114.4, 63.9,41.6(q, *J* = 28.0 Hz, $^2J_{CF}$), 14.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.99. HRMS (ESI) m/z calcd for $C_{11}H_{12}F_3O_2^+$ $(M+H)^+$ 233.0784, found 233.0781.



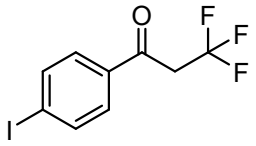
1-(4-(benzyloxy)phenyl)-3,3,3-trifluoropropan-1-one (3h):

Yield 73%; 214 mg; white solid; mp 118-120 ℃; TLC (PE:EtOAc, 50:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.8 Hz, 2H), 7.38 (m, 5H), 7.02 (d, *J* = 8.8 Hz, 2H), 5.12 (s, 2H), 3.71 (q, *J* = 10.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.1(q, *J* = 2.0 Hz, $^3J_{CF}$), 163.4, 135.8, 130.8, 129.0, 128.7, 128.3, 127.4, 124.1(q, *J* = 275.0 Hz, $^1J_{CF}$), 114.8, 70.2, 41.7(q, *J* = 28.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.90. HRMS (ESI) m/z calcd for $C_{16}H_{13}F_3O_2Na^+$ $(M+Na)^+$ 317.0760, found 317.0758.



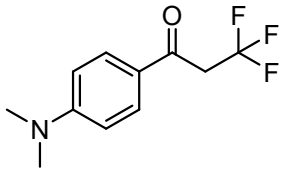
1-(4-chlorophenyl)-3,3,3-trifluoropropan-1-one (3i):

Yield 70%; 133 mg; yellow solid; mp 54-55 ℃; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.8 Hz, 2H), 7.47 (d, *J* = 8.8 Hz, 2H), 3.79 (q, *J* = 10.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.6(q, *J* = 3.0 Hz, $^3J_{CF}$), 140.8, 134.0(q, *J* = 1.0 Hz, $^4J_{CF}$), 129.7, 129.2, 123.9(q, *J* = 275.0 Hz, $^1J_{CF}$), 42.0(q, *J* = 28.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.07. HRMS (ESI) m/z calcd for $C_9H_6ClF_3ONa^+$ $(M+Na)^+$ 244.9952, found 244.9952.



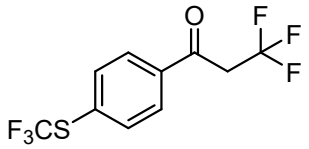
3,3,3-trifluoro-1-(4-iodophenyl)propan-1-one (3j):

Yield 57%; 179 mg; white solid; mp 93-94 °C; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, *J* = 8.4 Hz, 2H), 7.63 (d, *J* = 8.4 Hz, 2H), 3.76 (q, *J* = 10.0 Hz, 2H).; ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.1(q, *J* = 2.0 Hz, $^{3}J_{CF}$), 138.3, 134.9(q, *J* = 1.0 Hz, $^{4}J_{CF}$), 129.6, 123.8(q, *J* = 276.0 Hz, $^{1}J_{CF}$), 102.6, 42.0(q, *J* = 29.0 Hz, $^{2}J_{CF}$). ^{19}F NMR (376 MHz, CDCl3) δ -62.07. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.98. HRMS (ESI) m/z calcd for $C_9H_6F_3IONa^+$ $(M+Na)^+$ 336.9308, found 336.9303.



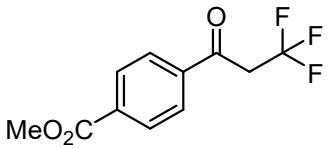
1-(4-(dimethylamino)phenyl)-3,3,3-trifluoropropan-1-one (3k):

Yield 71%; 164 mg; yellow solid; mp 104-105 °C; TLC (PE:EtOAc, 50:1 v/v): Rf= 0.23; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 9.2 Hz, 2H), 6.65 (d, *J* = 9.2 Hz, 2H), 3.67 (q, *J* = 10.4 Hz, 2H), 3.07 (s, 6H).; ^{13}C NMR (100 MHz, $CDCl_3$) δ 187.2(q, *J* = 3.0 Hz, $^{3}J_{CF}$), 153.9, 130.8, 124.4(q, *J* = 306.0 Hz, $^{1}J_{CF}$), 123.76(q, *J* = 2.0 Hz, $^{4}J_{CF}$), 110.7, 41.4(q, *J* = 27.0 Hz, $^{2}J_{CF}$), 39.9. ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.84. HRMS (ESI) m/z calcd for $C_{11}H_{12}F_3NONa^+$ $(M+Na)^+$ 254.0763, found 254.0760.



3,3,3-trifluoro-1-(4-((trifluoromethyl)thio)phenyl)propan-1-one (3l):

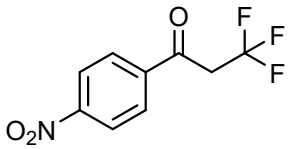
Yield 42%; 121 mg; yellow solid; mp 51-52 °C; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.4 Hz, 2H), 7.79 (d, *J* = 8.4 Hz, 2H), 3.82 (q, *J* = 10.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.88(q, *J* = 2.0 Hz, $^{3}J_{CF}$), 137.0(q, *J* = 1.0 Hz, $^{4}J_{CF}$), 135.7, 133.7, 131.6(q, *J* = 2.0 Hz, $^{3}J_{CF}$), 130.4,129.13(q, *J* = 306.0 Hz, $^{1}J_{CF}$), 129.1, 124.5(q, *J* = 275.0 Hz, $^{1}J_{CF}$), 42.3(q, *J* = 28.0 Hz, $^{2}J_{CF}$); ^{19}F NMR (376 MHz, $CDCl_3$) δ -41.50, -61.94. HRMS (ESI) m/z calcd for $C_{10}H_6F_6OSNa^+$ $(M+Na)^+$ 310.9936, found 310.9933.



methyl 4-(3,3,3-trifluoropropanoyl)benzoate (3m):

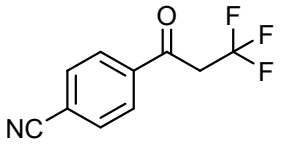
Yield 50%; 123 mg; yellow solid; mp 97-99 °C; TLC (PE:EtOAc, 50:1 v/v): Rf= 0.1; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 (d, *J* = 8.4 Hz, 2H), 7.99 (d, *J* = 8.4 Hz, 2H), 3.96 (s, 3H), 3.87 (q, *J* = 10.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.31(q, *J* = 2.0 Hz, $^{3}J_{CF}$), 165.8,

138.7(q, J = 1.0 Hz, $^4J_{CF}$), 134.7, 130.0, 128.2, 123.8(q, J = 275.0 Hz, $^1J_{CF}$), 52.5, 42.3(q, J = 28.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.1.



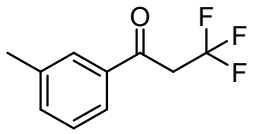
3,3,3-trifluoro-1-(4-nitrophenyl)propan-1-one (3n):

Yield 32%; 74 mg; yellow solid; mp 97-99 ℃; TLC (PE:EtOAc, 10:1 v/v): Rf= 0.3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 (d, J = 8.4 Hz, 2H), 8.14 (d, J = 8.4 Hz, 2H), 3.91 (q, J = 9.6 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.5(q, J = 3.0 Hz, $^3J_{CF}$), 150.9, 139.93, 139.92, 129.5, 124.2,123.6(q, J = 275.0 Hz, $^1J_{CF}$) 42.7(q, J = 29.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.0.



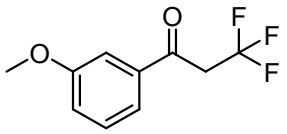
4-(3,3,3-trifluoropropanoyl)benzonitrile (3o):

Yield 29%; 61 mg; white solid; mp 128-129 ℃; TLC (PE:EtOAc, 10:1 v/v): Rf= 0.25; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (d, J = 8.0 Hz, 2H), 7.84 (d, J = 8.0 Hz, 2H), 3.85 (q, J = 9.6 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.6(q, J = 2.0 Hz, $^3J_{CF}$), 138.5, 132.8, 128.8, 123.6(q, J = 275.0 Hz, $^1J_{CF}$), 117.6, 117.5, 42.4(q, J = 29.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.1.



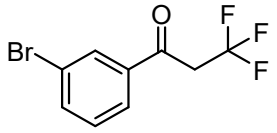
3,3,3-trifluoro-1-(m-tolyl)propan-1-one (3p):

Yield 70%; 141 mg; yellow oil; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77–7.69 (m, 2H), 7.45 (d, J = 7.6 Hz, 1H), 7.39 (t, J = 7.6 Hz, 1H), 3.79 (q, J = 10.0 Hz, 2H), 2.43 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.9(q, J = 3.0 Hz, $^3J_{CF}$), 138.9, 135.8, 135.0, 128.80, 128.77, 125.6, 124.0(q, J = 275.0 Hz, $^1J_{CF}$)119.9, 42.1(q, J = 28.0 Hz, $^2J_{CF}$), 21.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.51. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.05. HRMS (ESI) m/z calcd for $C_{10}H_9F_3ONa^+$ $(M+Na)^+$ 225.0498, found 225.0498.



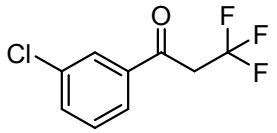
3,3,3-trifluoro-1-(3-methoxyphenyl)propan-1-one (3q):

Yield 62%; 135 mg; yellow oil; TLC (PE:EtOAc, 50:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (dd, *J* = 6.8, 5.2 Hz, 2H), 7.40 (t, *J* = 8.0 Hz, 1H), 7.16 (dd, *J* = 8.0, 2.4 Hz, 1H), 3.84 (s, 3H), 3.79 (q, *J* = 10.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.6(q, *J* = 3.0 Hz, $^3J_{CF}$), 160.0, 137.1(q, *J* = 2.0 Hz, $^4J_{CF}$), 129.9, 124.1(q, *J* = 276.0 Hz, $^1J_{CF}$), 120.9, 120.7, 112.5, 55.44, 55.37, 42.1(q, *J* = 28.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.14. HRMS (ESI) m/z calcd for $C_{10}H_9F_3O_2Na^+$ $(M+Na)^+$ 241.0447, found 241.0447.



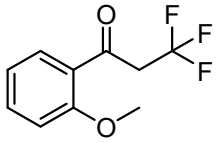
1-(3-bromophenyl)-3,3,3-trifluoropropan-1-one (3r):

Yield 44%; 117mg; yellow oil; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.86 (d, *J* = 8.0 Hz, 1H), 7.77 (dd, *J* = 8.0, 0.8 Hz, 1H), 7.40 (t, *J* = 8.0 Hz, 1H), 3.78 (q, *J* = 10.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.4(q, *J* = 2.0 Hz, $^3J_{CF}$), 137.40(q, *J* = 2.0 Hz, $^4J_{CF}$), 137.1, 131.4, 130.5, 126.9, 123.8(q, *J* = 275.0 Hz, $^1J_{CF}$), 123.3, 42.2(q, *J* = 29.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.03.



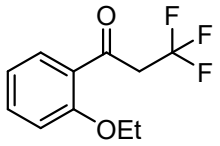
1-(3-chlorophenyl)-3,3,3-trifluoropropan-1-one (3s):

Yield 48%; 106 mg; yellow oil; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (s, 1H), 7.81 (d, *J* = 8.0 Hz, 1H), 7.61 (d, *J* = 8.0 Hz, 1H), 7.47 (t, *J* = 8.0 Hz, 1H), 3.79 (q, *J* = 10.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.5(q, *J* = 3.0 Hz, $^3J_{CF}$), 137.2(q, *J* = 1.0 Hz, $^4J_{CF}$), 135.4, 134.1, 130.3, 128.4, 126.4, 123.7(q, *J* = 276.0 Hz, $^1J_{CF}$), 42.2(q, *J* = 29.0 Hz, $^2J_{CF}$); ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.05. HRMS (ESI) m/z calcd for $C_9H_6ClF_3ONa^+$ $(M+Na)^+$ 244.9952, found 244.9950.



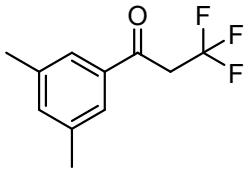
3,3,3-trifluoro-1-(2-methoxyphenyl)propan-1-one (3t):

Yield 56 %; 122 mg; yellow solid; mp 50-51 ℃; TLC (PE:EtOAc, 50:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.57–7.48 (m, 1H), 7.06–6.97 (m, 2H), 3.94 (s, 3H), 3.88 (q, *J* = 10.4 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.0(q, *J* = 2.0 Hz, $^3J_{CF}$), 158.9, 134.9, 130.9, 126.3,124.2(q, *J* = 275.0 Hz, $^1J_{CF}$), 121.0, 111.6, 55.6, 46.8(q, *J* = 27.0 Hz, $^2J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.50. HRMS (ESI) m/z calcd for $C_{10}H_9F_3O_2Na^+$ $(M+Na)^+$ 241.0447, found 241.0447.



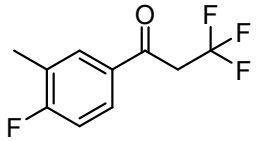
1-(2-ethoxyphenyl)-3,3,3-trifluoropropan-1-one (3u):

Yield 68%; 158 mg; white solid; mp 51-53 ℃; TLC (PE:EtOAc, 50:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 7.6 Hz, 1H), 7.51 (t, *J* = 8.0 Hz, 1H), 7.08–6.90 (m, 2H), 4.17 (q, *J* = 6.8 Hz, 2H), 3.92 (q, *J* = 10.4 Hz, 2H), 1.51 (t, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.16(q, *J* = 2.0 Hz, $^{3}J_{CF}$), 158.4, 135.0, 130.9, 126.44(q, *J* = 2.0 Hz, $^{4}J_{CF}$), 124.2(q, *J* = 275.0 Hz, $^{1}J_{CF}$), 120.8, 112.3, 64.3, 46.9(q, *J* = 27.0 Hz, $^{2}J_{CF}$), 14.7. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.51. HRMS (ESI) m/z calcd for $C_{11}H_{11}F_3O_2Na^+$ $(M+H)^+$ 233.0784, found 233.0788.



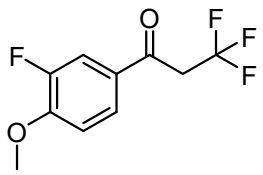
1-(3,5-dimethylphenyl)-3,3,3-trifluoropropan-1-one (3v):

Yield 68%; 147 mg; yellow oil; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (s, 2H), 7.26 (s, 1H), 3.77 (q, *J* = 10.0 Hz, 2H), 2.38 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 190.11(q, *J* = 2.0 Hz, $^{3}J_{CF}$), 138.7, 135.94(q, *J* = 2.0 Hz, $^{4}J_{CF}$), 135.88, 126.1, 124.1(q, *J* = 275.0 Hz, $^{1}J_{CF}$), 42.0(q, *J* = 29.0 Hz, $^{2}J_{CF}$), 21.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.09. HRMS (ESI) m/z calcd for $C_{11}H_{11}F_3ONa^+$ $(M+Na)^+$ 239.0654, found 239.0654.



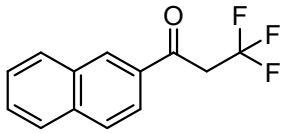
3,3,3-trifluoro-1-(4-fluoro-3-methylphenyl)propan-1-one (3w):

Yield 53%;117 mg; yellow solid; mp 61-62 ℃; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86–7.72 (m, 2H), 7.11 (t, *J* = 8.8 Hz, 1H), 3.77 (q, *J* = 10.0 Hz, 2H), 2.34 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.4(q, *J* = 2.0 Hz, $^{3}J_{CF}$), 164.9(q, *J* = 255.0 Hz, $^{1}J_{CF}$), 132.3, 132.1(q, *J* = 8.0 Hz, $^{3}J_{CF}$), 128.5, 128.4(q, *J* = 10.0 Hz, $^{3}J_{CF}$), 126.0(q, *J* = 18.0 Hz, $^{2}J_{CF}$), 123.9(q, *J* = 275.0 Hz, $^{1}J_{CF}$), 115.6(q, *J* = 24.0 Hz, $^{2}J_{CF}$), 41.9(q, *J* = 27.0 Hz, $^{2}J_{CF}$), 14.48(q, *J* = 3.0 Hz, $^{3}J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.02, -107.00.



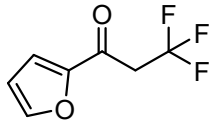
1-([1,1'-biphenyl]-4-yl)-3,3,3-trifluoropropan-1-one (3x):

Yield 58%; 136 mg; white solid; mp 85-86 °C; TLC (PE:EtOAc, 50:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 8.4 Hz, 2H), 7.71 (d, *J* = 8.4 Hz, 2H), 7.62 (d, *J* = 7.2 Hz, 2H), 7.48 (t, *J* = 7.2 Hz, 2H), 7.43 (d, *J* = 7.2 Hz, 1H), 3.82 (q, *J* = 10.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.3(q, *J* = 3.0 Hz, $^{3}J_{CF}$), 146.8, 139.3, 134.4(q, *J* = 2.0 Hz, $^{4}J_{CF}$), 129.02, 128.96, 128.6, 127.5, 127.3,124.0(q, *J* = 276.0 Hz, $^{1}J_{CF}$), 42.0(q, *J* = 28.0 Hz, $^{2}J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.51. HRMS (ESI) m/z calcd for $C_{15}H_{11}F_3ONa^+$ $(M+Na)^+$ 287.0654, found 287.0656.



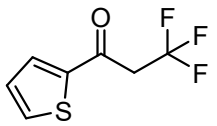
3,3,3-trifluoro-1-(naphthalen-2-yl)propan-1-one (3y):

Yield 66%; 157 mg; yellow solid; mp 83-84 °C; TLC (PE:EtOAc, 100:1 v/v): R_f= 0.15; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (s, 1H), 7.98 (t, *J* = 9.6 Hz, 2H), 7.94–7.87 (m, 2H), 7.64 (t, *J* = 7.6 Hz, 1H), 7.58 (t, *J* = 7.6 Hz, 1H), 3.92 (q, *J* = 10.0 Hz, 2H).; ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.61(q, *J* = 3.0 Hz, $^{3}J_{CF}$), 135.9, 133.2(q, *J* = 2.0 Hz, $^{4}J_{CF}$), 132.3, 130.5, 129.7, 129.2, 128.9, 127.8, 127.2, 124.08(q, *J* = 275.0 Hz, $^{1}J_{CF}$), 123.4, 42.1(q, *J* = 28.0 Hz, $^{2}J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.90. HRMS (ESI) m/z calcd for $C_{13}H_{10}F_3O^+$ $(M+H)^+$ 239.0678, found 239.0674.



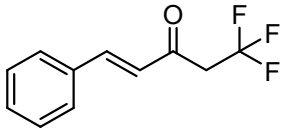
3,3,3-trifluoro-1-(furan-2-yl)propan-1-one (3z):

Yield 74%; 132 mg; yellow oil; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.24; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (s, 1H), 7.32 (d, *J* = 3.6 Hz, 1H), 6.67–6.53 (m, 1H), 3.67 (q, *J* = 10.4 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.2(q, *J* = 3.0 Hz, $^{3}J_{CF}$), 151.9(q, *J* = 2.0 Hz, $^{4}J_{CF}$), 147.4, 123.7(q, *J* = 276.0 Hz, $^{1}J_{CF}$), 118.8, 113.0, 42.2(q, *J* = 29.0 Hz, $^{2}J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.95.



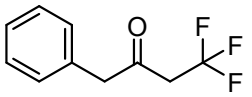
3,3,3-trifluoro-1-(thiophen-2-yl)propan-1-one (3aa):

Yield 72%; 139 mg; yellow oil; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.24; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (dd, *J* = 9.2, 4.4 Hz, 2H), 7.18 (t, *J* = 4.4 Hz, 1H), 3.72 (q, *J* = 10.0 Hz, 2H).; ^{13}C NMR (100 MHz, $CDCl_3$) δ 182.1(q, *J* = 3.0 Hz, $^{3}J_{CF}$), 143.2(q, *J* = 2.0 Hz, $^{4}J_{CF}$), 135.7, 133.4, 128.5, 123.6(q, *J* = 275.0 Hz, $^{1}J_{CF}$), 43.0(q, *J* = 28.0 Hz, $^{2}J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.94. HRMS (ESI) m/z calcd for $C_7H_5F_3OSNa^+$ $(M+Na)^+$ 216.9905, found 216.9906.



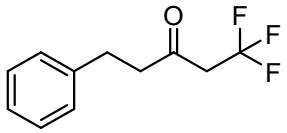
(E)-5,5,5-trifluoro-1-phenylpent-1-en-3-one (3ab):

Yield 62%; 133 mg; white solid; mp 55-56 ℃; TLC (PE): Rf= 0.1; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, J = 16.0 Hz, 1H), 7.58–7.51 (m, 2H), 7.42 (t, J = 6.0 Hz, 3H), 6.80 (d, J = 16.0 Hz, 1H), 3.47 (q, J = 10.4 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.13(q, J = 3.0 Hz, $^{3}J_{CF}$), 145.3, 133.7, 131.2, 129.0, 128.6, 124.66(q, J = 2.0 Hz, $^{4}J_{CF}$), 123.9(q, J = 276.0 Hz, $^{1}J_{CF}$), 44.5(q, J = 28.0 Hz, $^{2}J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.02. HRMS (ESI) m/z calcd for $C_{11}H_9F_3ONa^+$ $(M+Na)^+$ 237.0498, found 237.0493.



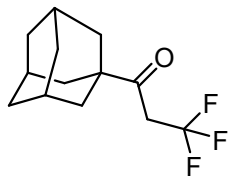
4,4,4-trifluoro-1-phenylbutan-2-one (3ac):

Yield 62%; 125 mg; white oil; TLC (PE): Rf= 0.1; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40–7.30 (m, 3H), 7.20 (d, J = 6.8 Hz, 2H), 3.80 (s, 2H), 3.23 (q, J = 10.4 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.69(q, J = 2.0 Hz, $^{3}J_{CF}$), 132.4, 129.5, 129.1, 127.7, 123.6(q, J = 275.0 Hz, $^{1}J_{CF}$), 50.60(q, J = 2.0 Hz, $^{4}J_{CF}$), 45.0(q, J = 29.0 Hz, $^{2}J_{CF}$). ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.37. HRMS (ESI) m/z calcd for $C_{10}H_9F_3ONa^+$ $(M+Na)^+$ 225.0498, found 225.0497.



4,4,4-trifluoro-1-phenylbutan-2-one (3ad):

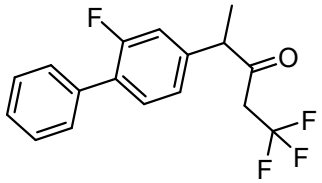
Yield 68%; 145 mg; yellow oil; TLC (PE): Rf= 0.1; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (t, J = 7.2 Hz, 2H), 7.24–7.15 (m, 3H), 3.18 (q, J = 10.4 Hz, 2H), 2.92 (dd, J = 11.2, 4.4 Hz, 2H), 2.87–2.81 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.3(q, J = 2.0 Hz, $^{3}J_{CF}$), 140.2, 128.7, 128.3, 126.4, 123.6(q, J = 275.0 Hz, $^{1}J_{CF}$), 46.4(q, J = 28.0 Hz, $^{2}J_{CF}$), 45.00, 44.98, 29.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.37. HRMS (ESI) m/z calcd for $C_{11}H_{11}F_3ONa^+$ $(M+Na)^+$ 239.06542, found 239.06544.



1-((1r,3R,5S)-adamantan-1-yl)-3,3,3-trifluoropropan-1-one (3ae):

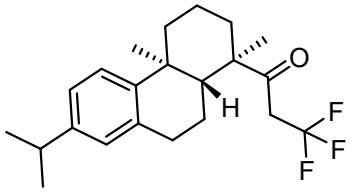
Yield 67%; 164 mg; white solid; mp 59-61 ℃; TLC (PE): Rf= 0.1; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.30 (q, J = 10.0 Hz, 2H), 2.08 (s, 3H), 1.79 (dd, J = 14.0, 8.0 Hz, 9H), 1.69 (d, J = 12.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 204.9(q, J = 2.0 Hz, $^{3}J_{CF}$), 124.3(q, J = 275.0 Hz, $^{1}J_{CF}$), 47.0(q, J = 1.0 Hz, $^{4}J_{CF}$), 39.1(q, J = 28.0 Hz, $^{2}J_{CF}$), 37.6, 36.3, 27.6. ^{19}F NMR (376 MHz,

$CDCl_3$) δ -62.27. HRMS (ESI) m/z calcd for $C_{13}H_{17}F_3ONa^+$ $(M+Na)^+$ 269.1124, found 269.1124.



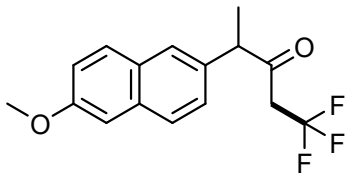
1,1,1-trifluoro-4-(2-fluoro-[1,1'-biphenyl]-4-yl)pentan-3-one (3af):

Yield 68%; 210 mg; yellow oil; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (d, J = 8.0 Hz, 2H), 7.48–7.42 (m, 3H), 7.38 (t, J = 7.2 Hz, 1H), 7.09–6.97 (m, 2H), 3.84 (q, J = 6.8 Hz, 1H), 3.21 (dd, J = 22.4, 10.4 Hz, 2H), 1.46 (d, J = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.43(q, J = 2.0 Hz, $^3J_{CF}$), 160.0(q, J = 248.0 Hz, $^1J_{CF}$), 140(d, J = 8.0 Hz, $^2J_{CF}$), 135.0, 131.7(d, J = 4.0 Hz, $^3J_{CF}$), 128.9(d, J = 3.0 Hz, $^3J_{CF}$), 128.7(d, J = 13.0 Hz, $^2J_{CF}$), 128.57, 128.0, 123.9(d, J = 3.0 Hz, $^3J_{CF}$), 123.6(q, J = 276.0 Hz, $^1J_{CF}$), 115.6(d, J = 24.0 Hz, $^2J_{CF}$), 53.1, 44.2(q, J = 28.0 Hz, $^2J_{CF}$), 17.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.38, -116.26. HRMS (ESI) m/z calcd for $C_{17}H_{14}F_4O_3Na^+$ $(M+Na)^+$ 333.0873, found 333.0885.



3,3,3-trifluoro-1-((1R,4aS,10aR)-7-isopropyl-1,4a-dimethyl-1,2,3,4,4a,9,10,10a-octahydrophenanthren-1-yl)propan-1-one (3ag):

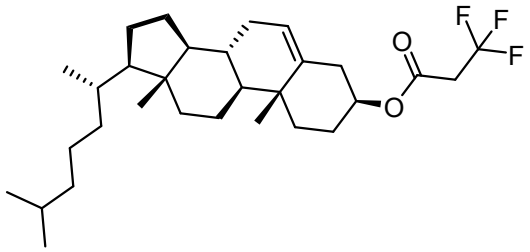
Yield 62%; 227 mg; colorless oil; TLC (PE): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17 (d, J = 8.4 Hz, 1H), 7.02 (d, J = 8.0 Hz, 1H), 6.90 (s, 1H), 3.49–3.16 (m, 2H), 2.96–2.74 (m, 3H), 2.36 (d, J = 13.2 Hz, 1H), 2.06 (dd, J = 12.4, 1.6 Hz, 1H), 1.85–1.72 (m, 3H), 1.58–1.47 (m, 3H), 1.23 (t, J = 6.8 Hz, 13H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 205.3(q, J = 1.0 Hz, $^3J_{CF}$), 146.5, 146.1, 134.4, 127.1, 124.3(q, J = 276.0 Hz, $^1J_{CF}$), 124.12, 124.07, 53.1(q, J = 1.0 Hz, $^4J_{CF}$), 43.5, 39.8(q, J = 28.0 Hz, $^2J_{CF}$), 37.8, 36.9, 35.0, 33.5, 29.8, 25.2, 24.01, 23.99, 21.5, 18.3, 15.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.2. HRMS (ESI) m/z calcd for $C_{30}H_{30}F_3O_2Na^+$ $(M+Na)^+$ 405.1802, found 405.1810.



3-(2-fluorophenyl)-1-(2-hydroxyphenyl)-3-(2-methyl-6-(trimethylgermyl)phenyl) propan-1-one (3ah):

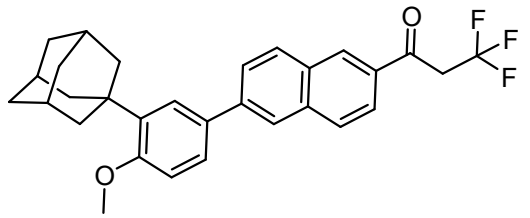
Yield 64%; 189 mg; white solid; mp 54-56 ℃ ; TLC (PE:EtOAc, 50:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (dd, J = 14.0, 8.8 Hz, 2H), 7.59 (s, 1H), 7.26–7.22 (m, 1H), 7.18 (dd, J = 8.8, 2.4 Hz, 1H), 7.13 (d, J = 2.4 Hz, 1H), 3.91 (s, 3H), 3.26–3.04 (m, 2H), 1.49

(d, J = 6.8 Hz, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.3(q, J = 2.0 Hz, $^3J_{CF}$), 158.0, 134.0, 133.9, 129.24, 129.15, 128.2, 126.9, 126.0, 123.7(q, J = 275.0 Hz, $^1J_{CF}$), 119.6, 105.6, 55.4, 53.8, 43.9(q, J = 28.0 Hz, $^2J_{CF}$), 17.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.4. HRMS (ESI) m/z calcd for $C_{16}H_{15}F_3O_2Na^+$ $(M+Na)^+$ 319.0916, found 319.0927.



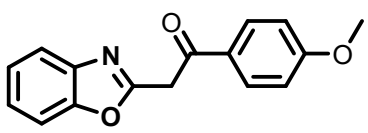
(3S,8S,9S,10R,13R,14S,17R)-10,13-dimethyl-17-((S)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a] phenanthren-3-yl 3,3,3-trifluoropropanoate (3ai):

Yield 71%; 352 mg; white solid; mp 99-100℃; TLC (PE); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.39 (d, J = 4.0 Hz, 1H), 4.79–4.57 (m, 1H), 3.15 (q, J = 10.0 Hz, 2H), 2.35 (d, J = 8.0 Hz, 2H), 2.07–1.93 (m, 2H), 1.92–1.77 (m, 3H), 1.66–1.42 (m, 7H), 1.39–0.97 (m, 17H), 0.91 (d, J = 6.4 Hz, 3H), 0.86 (dd, J = 6.8, 1.6 Hz, 6H), 0.68 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.5(q, J = 4.0 Hz, $^3J_{CF}$), 139.1,123.5(q, J = 275.0 Hz, $^1J_{CF}$), 123.1, 75.7, 56.7, 56.1, 50.0, 42.3, 40.0(q, J = 30.0 Hz, $^2J_{CF}$), 39.7, 39.5, 37.8, 36.9, 36.5, 36.2, 35.8, 31.9, 31.8, 28.3, 28.0, 27.5, 24.3, 23.9, 22.9, 22.6, 21.0, 19.3, 18.7, 11.9. ^{19}F NMR (376 MHz, $CDCl_3$) δ -63.48. HRMS (ESI) m/z calcd for $C_{30}H_{47}F_3O_2Na^+$ $(M+Na)^+$ 519.3420, found 519.3423.



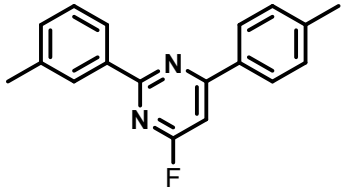
1-(6-(3-((3r,5r,7r)-adamantan-1-yl)-4-methoxyphenyl)naphthalen-2-yl)-3,3,3-trifluoropropan-1-one (3aj):

Yield 65%; 310 mg; white solid; mp 186-187 ℃; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (s, 1H), 8.07–7.96 (m, 3H), 7.93 (d, J = 8.8 Hz, 1H), 7.82 (d, J = 8.4 Hz, 1H), 7.60 (s, 1H), 7.54 (dd, J = 8.4, 1.2 Hz, 1H), 6.99 (d, J = 8.4 Hz, 1H), 3.99–3.84 (m, 5H), 2.18 (s, 6H), 2.11 (s, 3H), 1.80 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.5(q, J = 2.0 Hz, $^3J_{CF}$), 159.2, 142.4, 139.1, 136.5, 132.7(q, J = 1.0 Hz, $^4J_{CF}$), 132.2, 131.0, 130.4, 130.1, 129.0, 127.0, 126.0, 125.6, 124.7, 124.2(q, J = 275.0 Hz, $^1J_{CF}$), 123.9, 112.1, 55.2,42.2(q, J = 28.0 Hz, $^2J_{CF}$), 40.6, 37.3, 37.1, 29.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.8. HRMS (ESI) m/z calcd for $C_{30}H_{30}F_3O_2Na^+$ $(M+Na)^+$ 479.2192, found 419.2191.



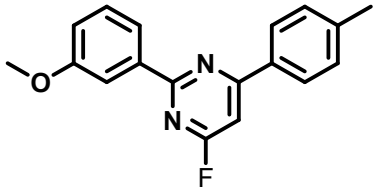
2-(benzo[d]oxazol-2-yl)-1-(4-methoxyphenyl)ethan-1-one (8):

Yield 85%; 227mg; white solid; mp 86-88℃; TLC (PE:EtOAc, 5:1 v/v): Rf= 0.3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.4 Hz, 2H), 7.71 (dd, *J* = 5.2, 3.2 Hz, 1H), 7.53–7.46 (m, 1H), 7.32 (dd, *J* = 5.6, 3.2 Hz, 2H), 6.96 (d, *J* = 8.4 Hz, 2H), 4.59 (s, 2H), 3.86 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 190.9, 164.2, 160.9, 151.3, 141.2, 131.1, 128.8, 125.0, 124.4, 120.0, 114.1, 110.7, 55.6, 39.5. HRMS (ESI) m/z calcd for $C_{16}H_{14}NO_3^+$ $(M+H)^+$ 268.0968, found 268.0964.



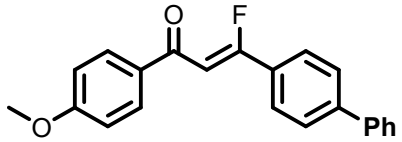
4-fluoro-2-(m-tolyl)-6-(p-tolyl)pyrimidine (9):

Yield 83%; 230 mg; white solid; mp 57-58 ℃; TLC (PE): Rf= 0.3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.35 (d, *J* = 6.8 Hz, 2H), 8.07 (d, *J* = 8.0 Hz, 2H), 7.39 (t, *J* = 8.0 Hz, 1H), 7.32 (d, *J* = 8.0 Hz, 3H), 7.11 (s, 1H), 2.46 (s, 3H), 2.43 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3(d, *J* = 248.0 Hz), 168.6(d, *J* = 8.0 Hz), 165.4(d, *J* = 14.0 Hz), 142.0, 138.3, 136.5, 133.3(d, *J* = 4.0 Hz), 129.8, 129.1, 128.5, 127.3, 125.9, 99.0(d, *J* = 32.0 Hz), 21.6, 21.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.2. HRMS (ESI) m/z calcd for $C_{18}H_{16}FN_2^+$ $(M+H)^+$ 279.1292, found 279.1301.



4-fluoro-2-(3-methoxyphenyl)-6-(p-tolyl)pyrimidine (10):

Yield 85%; 250 mg; white solid; mp 71-72℃; TLC (PE:EtOAc, 100:1 v/v): Rf= 0.3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 (d, *J* = 7.6 Hz, 1H), 8.07 (d, *J* = 8.4 Hz, 3H), 7.41 (t, *J* = 8.0 Hz, 1H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.13 (s, 1H), 7.06 (dd, *J* = 8.0, 2.4 Hz, 1H), 3.91 (s, 3H), 2.43 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3(d, *J* = 247.0 Hz), 168.5(d, *J* = 7.0 Hz), 165.0(d, *J* = 14.0 Hz), 159.9, 142.1, 138.0, 133.3(d, *J* = 5.0 Hz), 129.8, 129.6, 127.3, 121.2, 117.7, 113.3, 99.2(d, *J* = 31.0 Hz), 55.5, 21.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.2. HRMS (ESI) m/z calcd for $C_{18}H_{16}FO^+$ $(M+H)^+$ 295.1241, found 295.1242.



(Z)-3-([1,1'-biphenyl]-4-yl)-3-fluoro-1-(4-methoxyphenyl)prop-2-en-1-one (11):

Yield 64%; 212 mg; white solid; mp 131-133℃; TLC (PE:EtOAc, 5:1 v/v): Rf= 0.3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.8 Hz, 2H), 7.79 (d, *J* = 8.4 Hz, 2H), 7.67 (d, *J* = 8.4 Hz, 2H), 7.61 (d, *J* = 7.6 Hz, 2H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.40 (d, *J* = 7.2 Hz, 1H), 6.96

(d, J = 8.8 Hz, 2H), 6.79 (d, J = 34.4 Hz, 1H), 3.86 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 187.3, 164.4(d, J = 275.0 Hz, $^1J_{CF}$), 163.4, 144.1, 139.6, 131.4, 130.7, 129.7(d, J = 27.0 Hz), 128.9, 128.1, 127.4(d, J = 2.0 Hz), 127.0, 126. (d, J = 8.0 Hz), 113.7, 101.6(d, J = 8.0 Hz), 55.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -98.4. HRMS (ESI) m/z calcd for $C_{22}H_{18}FO_2^+$ $(M+H)^+$ 333.1285, found 333.1281.

Crystallographic data and molecular structure of 3i

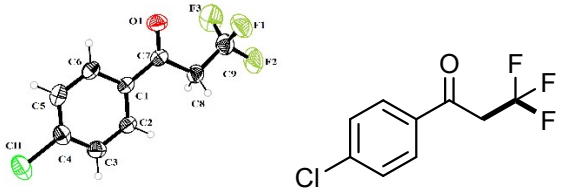


Figure S1. X-ray crystal structure of **3i** with 30% probability ellipsoids (ORTEP)

Crystal Data for Compound **3i**: CCDC 2182469 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic.

Sample preparation: In a 10 mL glass bottle, 15 mg of pure **3i** was completely dissolved in the mixed solvent of 3 mL $CHCl_2$, and then 2 mL of n-hexane was added slowly. After a week of solvent evaporation, some yellow transparent crystals were obtained. The crystals were mounted on a glass fiber for diffraction experiments. Intensity data were collected on a Bruker SMART APEX CCD diffractometer with Mo Kα radiation (0.71073 Å) at room temperature.

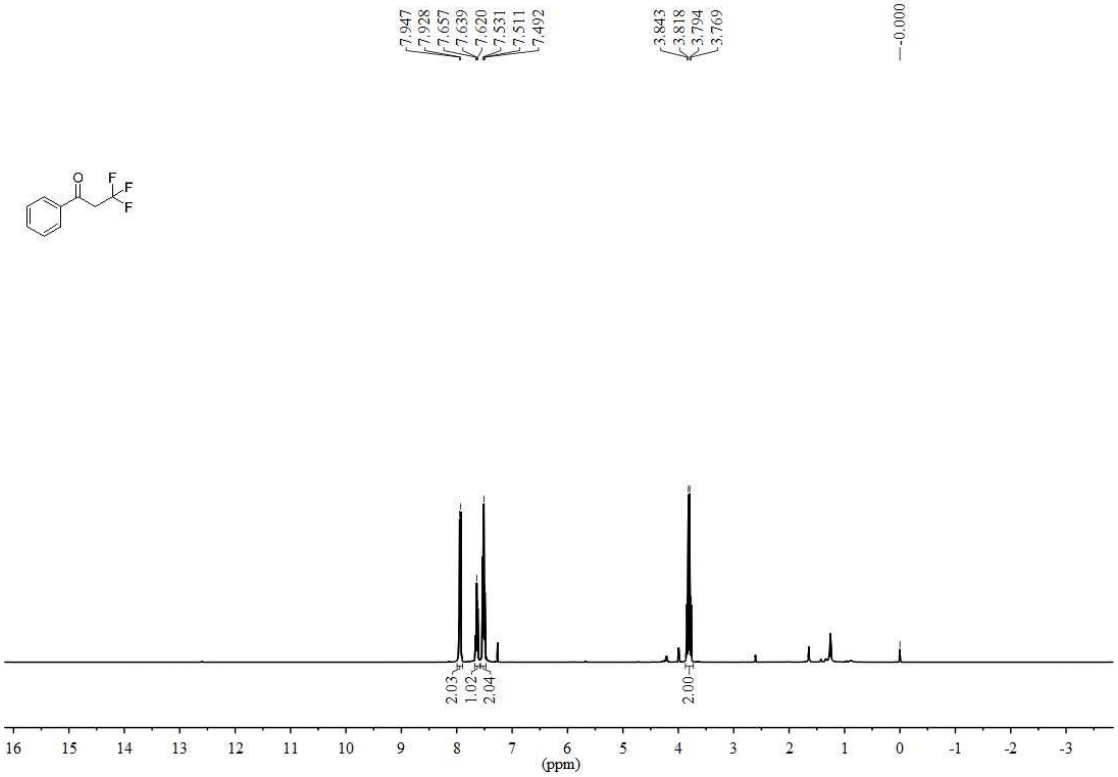
```
Bond precision:   C-C = 0.0037 A          Wavelength=0.71073

Cell:              a=15.120(3)      b=5.9966(13)      c=20.980(4)
                   alpha=90         beta=90           gamma=90
Temperature:       296 K

                  Calculated                Reported
Volume            1902.2(7)                 1902.3(7)
Space group       P b c a                   P b c a
Hall group        -P 2ac 2ab                -P 2ac 2ab
Moiety formula    C9 H6 Cl F3 O             C9 H6 Cl F3 O
Sum formula       C9 H6 Cl F3 O             C9 H6 Cl F3 O
Mr                222.59                    222.59
Dx,g cm-3         1.554                     1.554
Z                 8                         8
Mu (mm-1)         0.409                     0.409
F000              896.0                     896.0
F000'             897.84
h,k,lmax          18,7,25                   18,7,25
Nref              1867                      1861
Tmin,Tmax         0.943,0.960               0.561,0.746
Tmin'             0.940

Correction method= # Reported T Limits: Tmin=0.561 Tmax=0.746
AbsCorr = MULTI-SCAN

Data completeness= 0.997          Theta(max)= 25.991

R(reflections)= 0.0534( 1527)                    wR2(reflections)=
                                                 0.1467( 1861)
S = 1.067                 Npar= 128
```

References

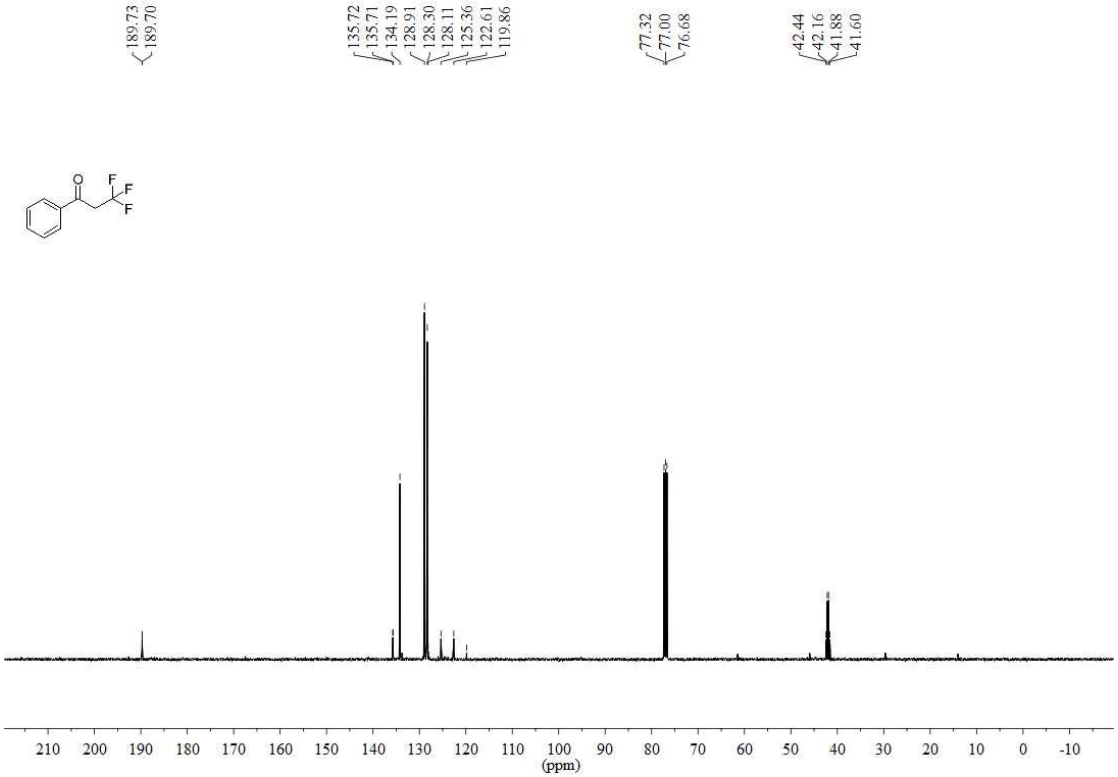
(1) 1. (a) J. Vaitla, A. Bayer and K. H. Hopmann, Angew. Chem. Int. Ed., 2017, 56, 4277; (b) M. Barday, C. Janot, N. R. Halcovitch, J. Muir and C. Aïssa, Angew. Chem. Int. Ed., 2017, 56, 13117; (c) Y. Xu, X. Zhou, G. Zheng and X. Li, Org. Lett., 2017, 19, 5256; (d) C. Janot, P. Palamini, B. C. Dobson, J. Muir and C. Aïssa, Org. Lett., 2018, 21, 296.

NMR spectra of compounds

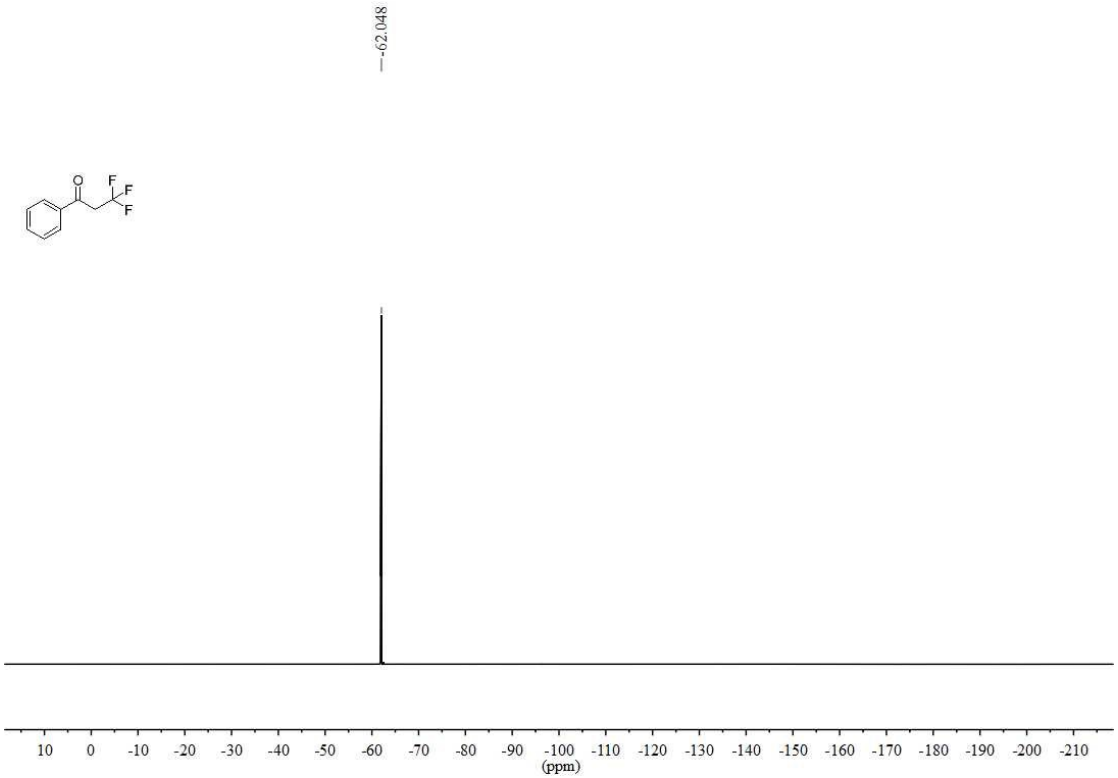
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3a**



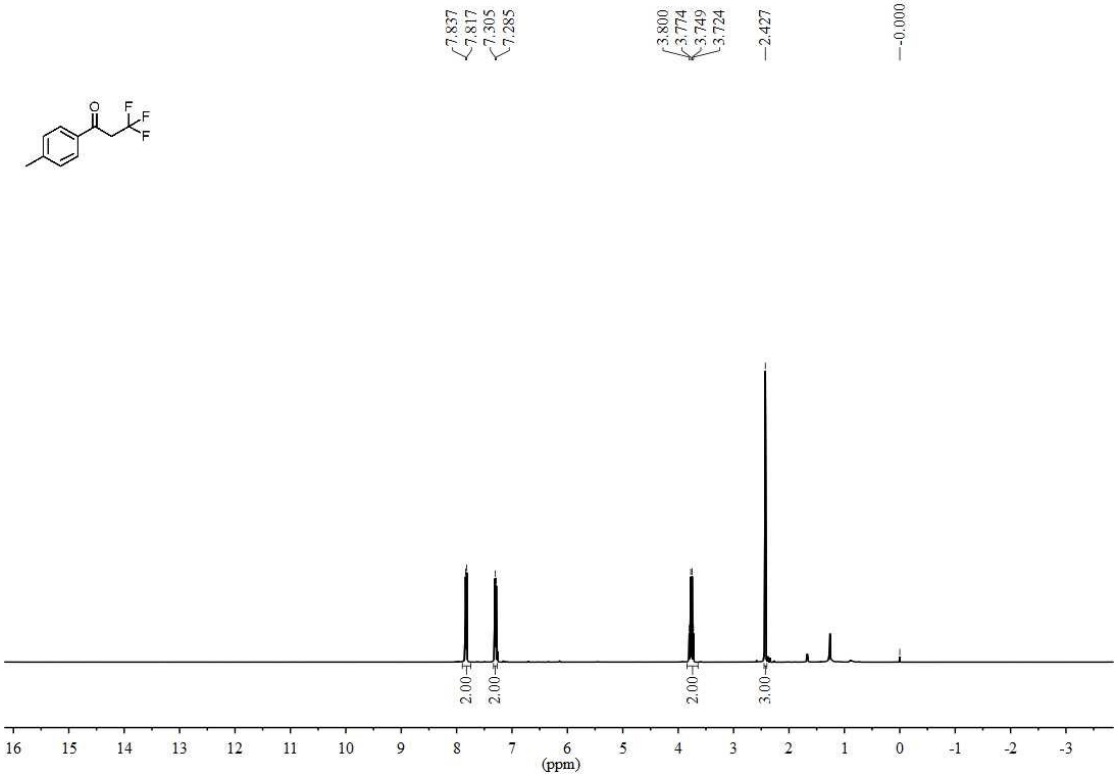
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3a**



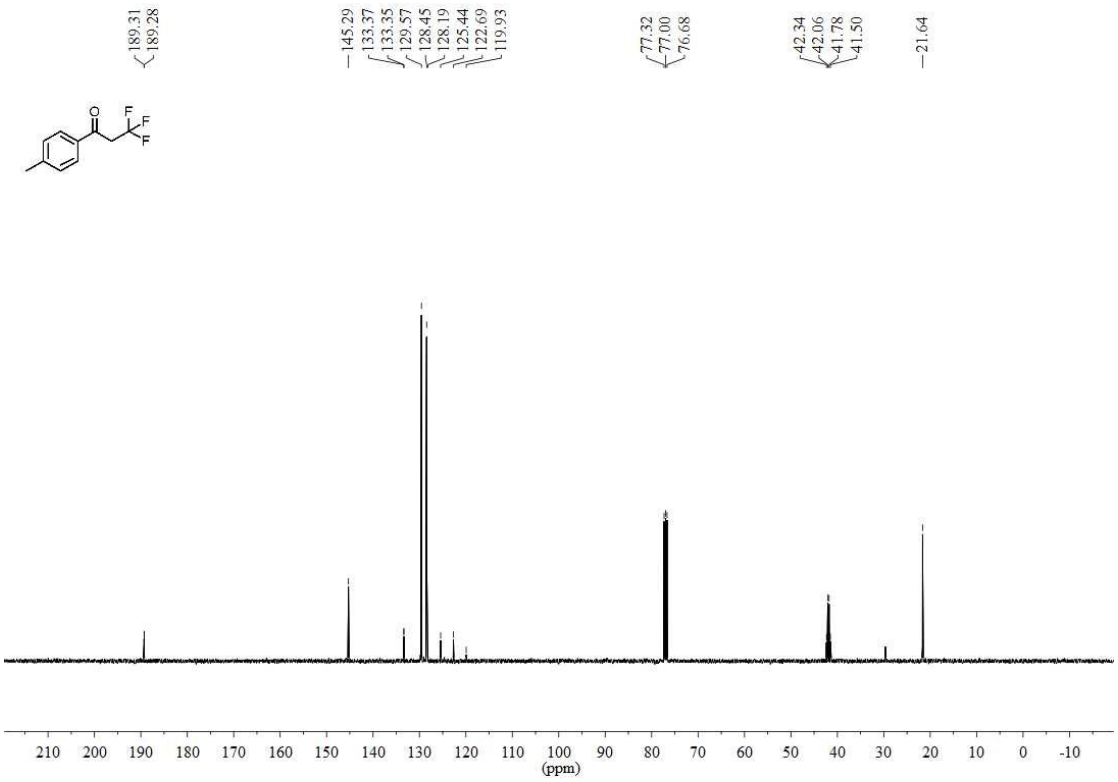
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3a**



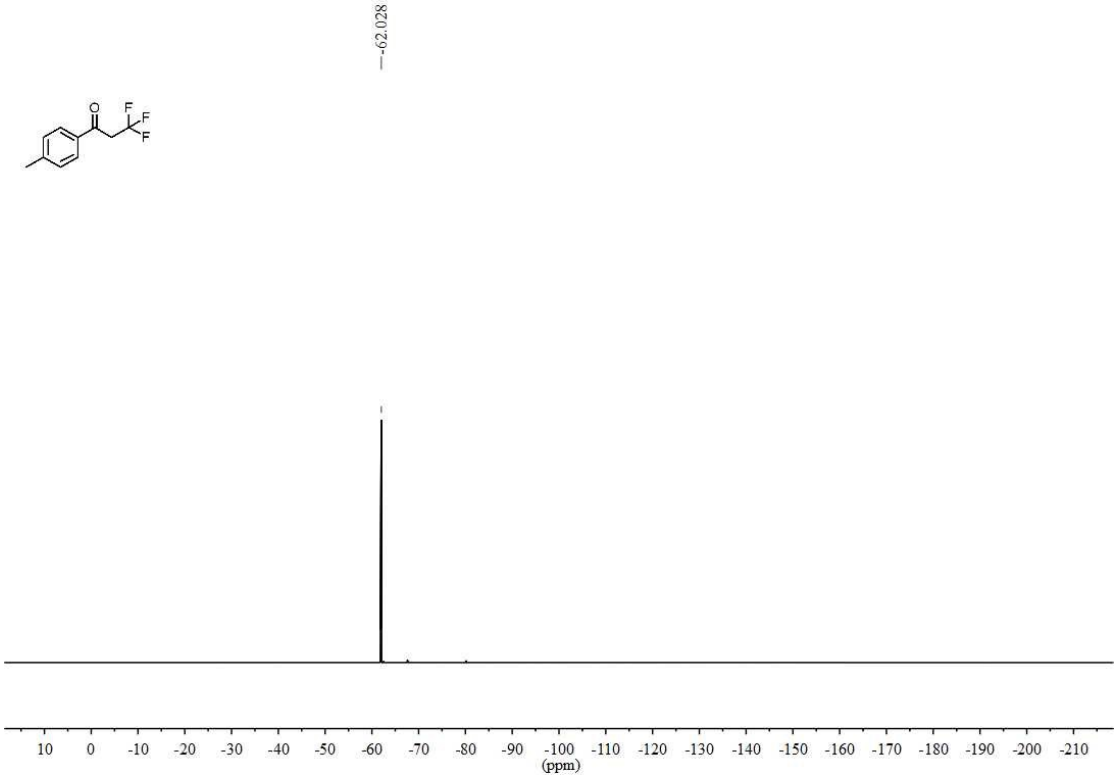
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3b**



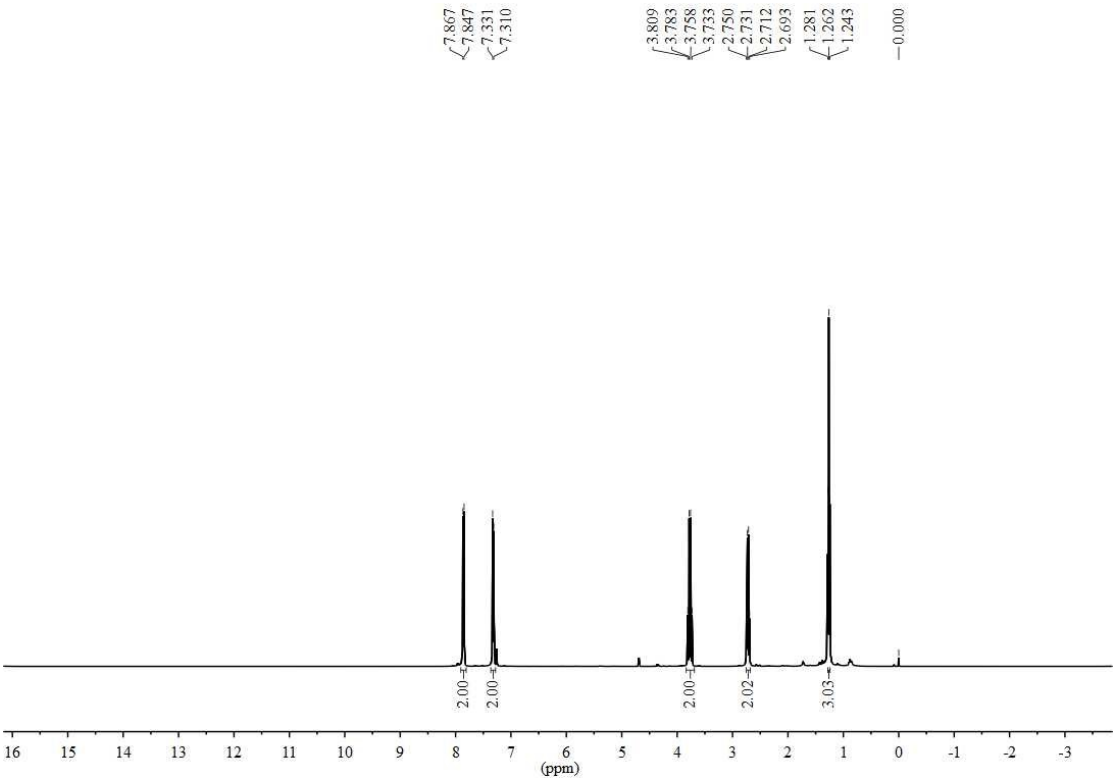
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3b**



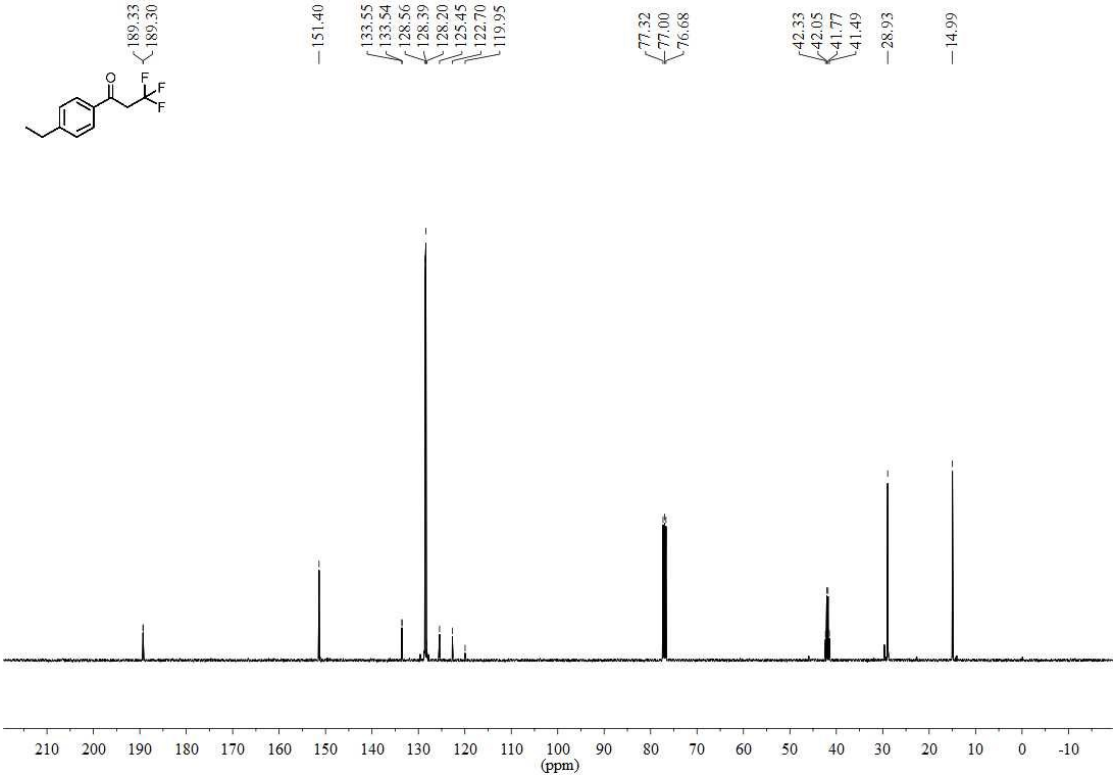
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3b**



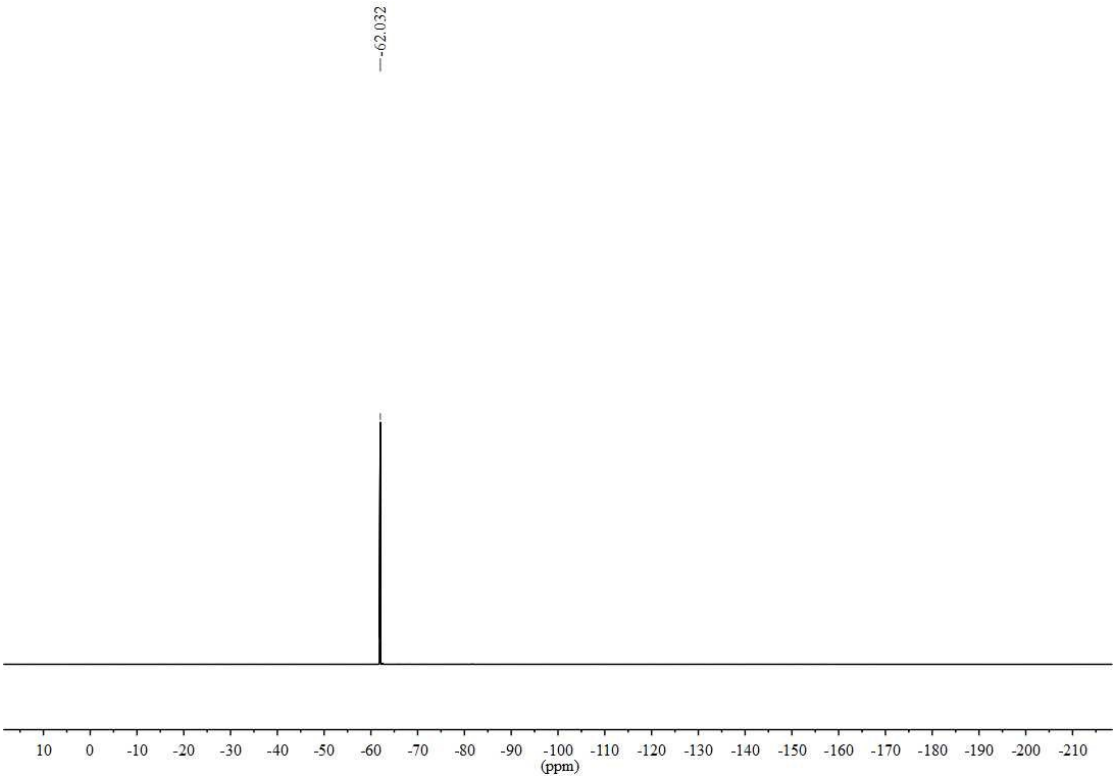
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3c**



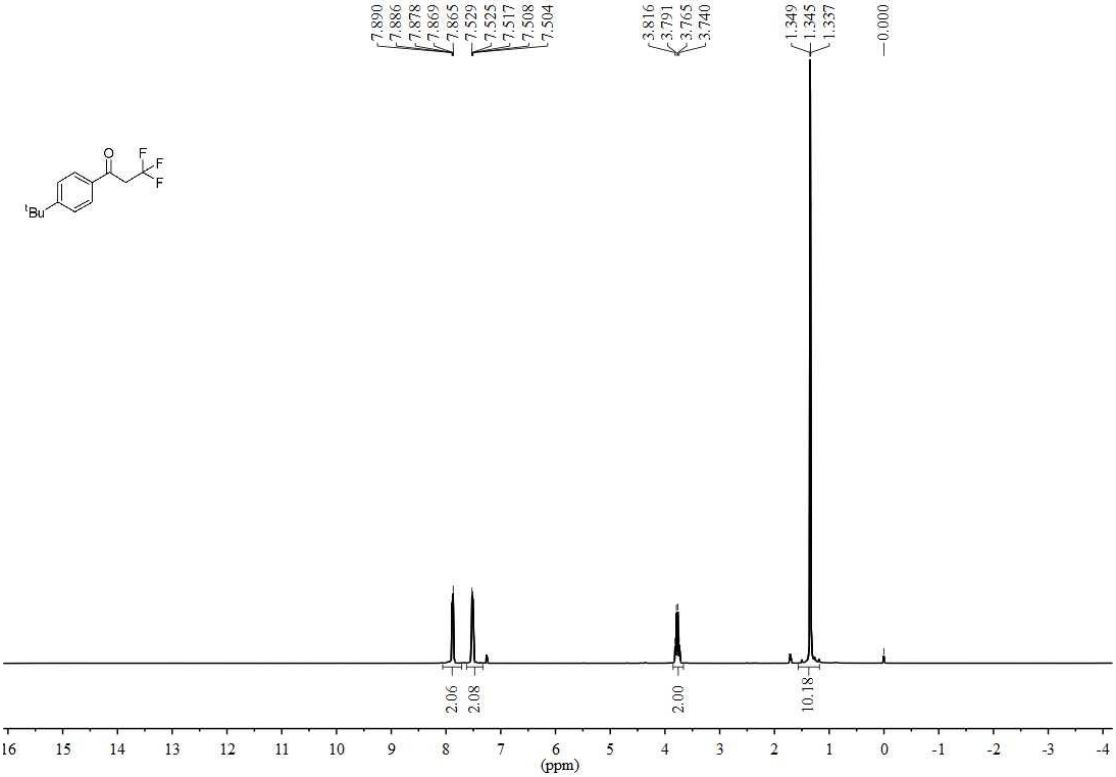
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3c**



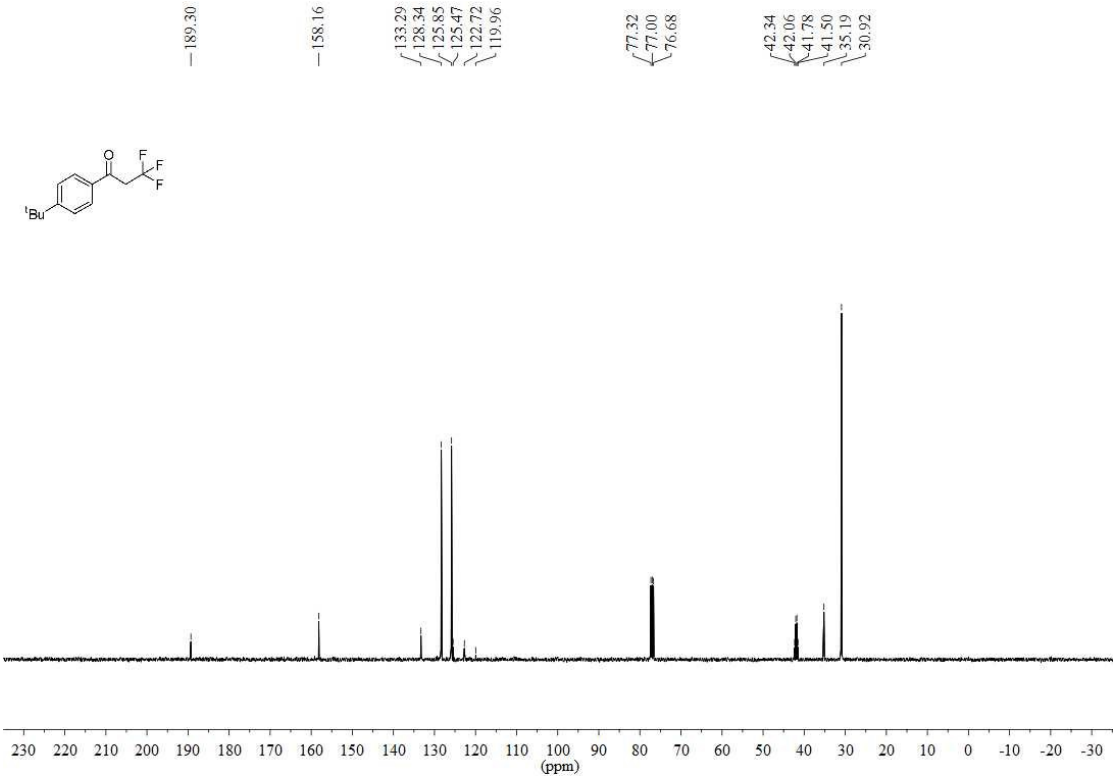
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3c**



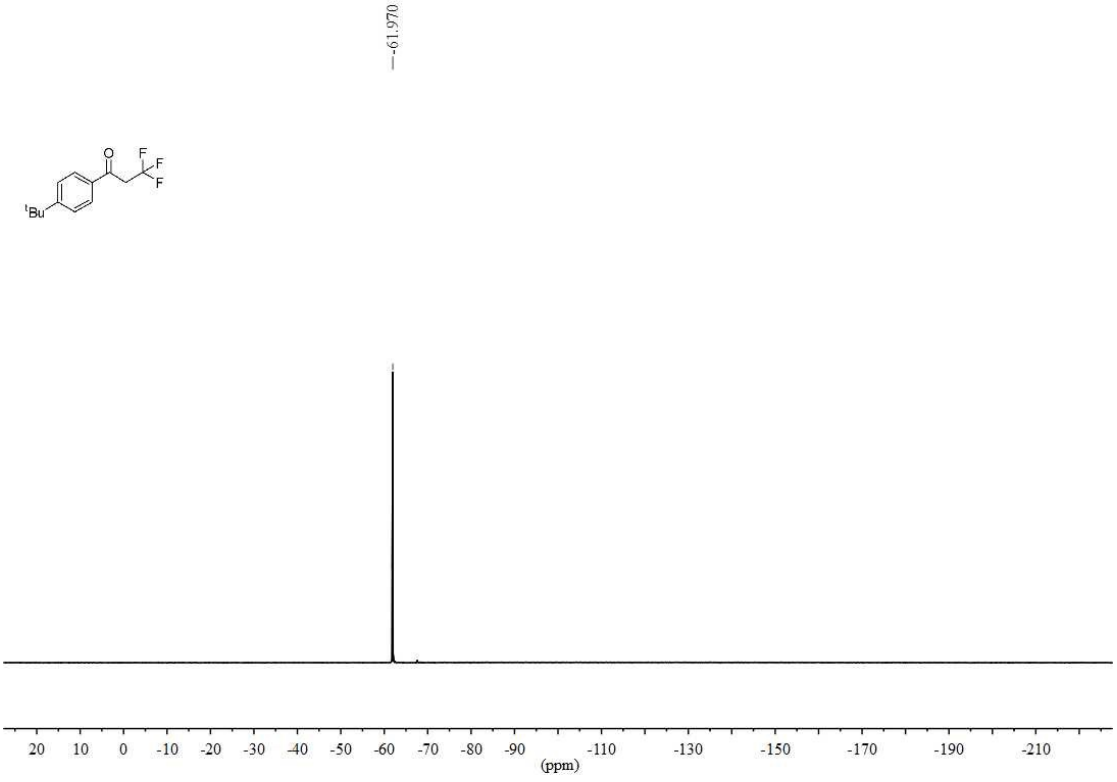
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3d**



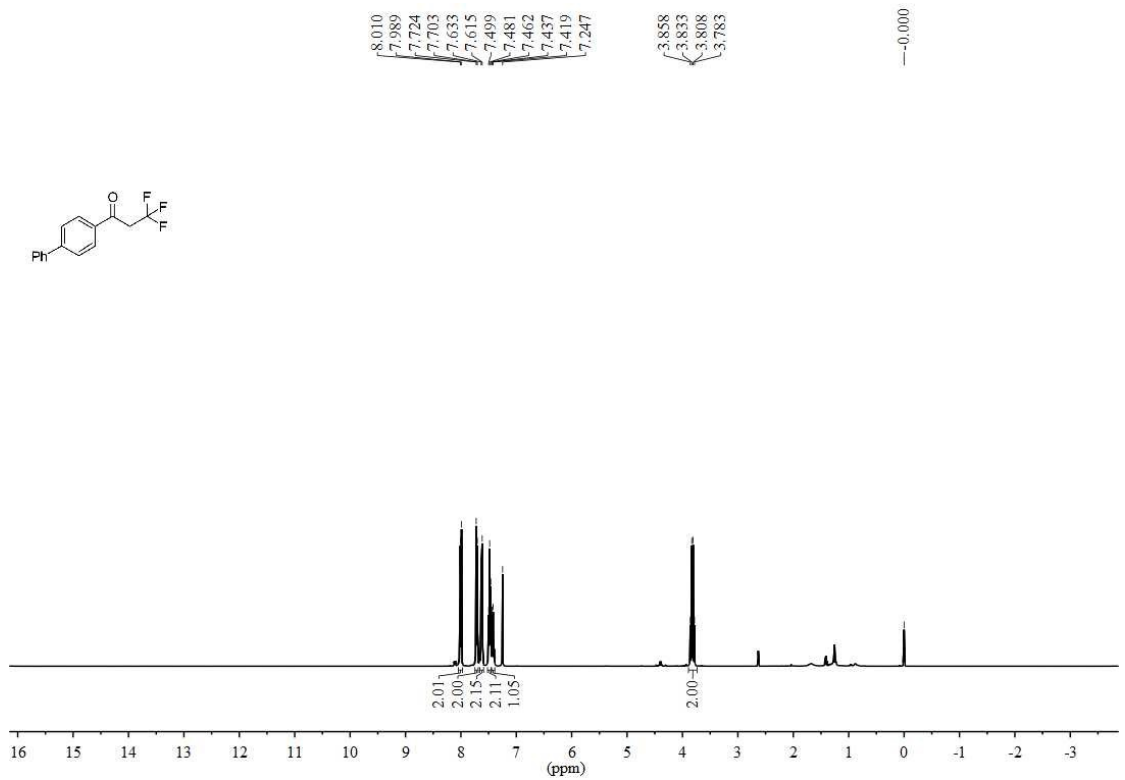
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3d**



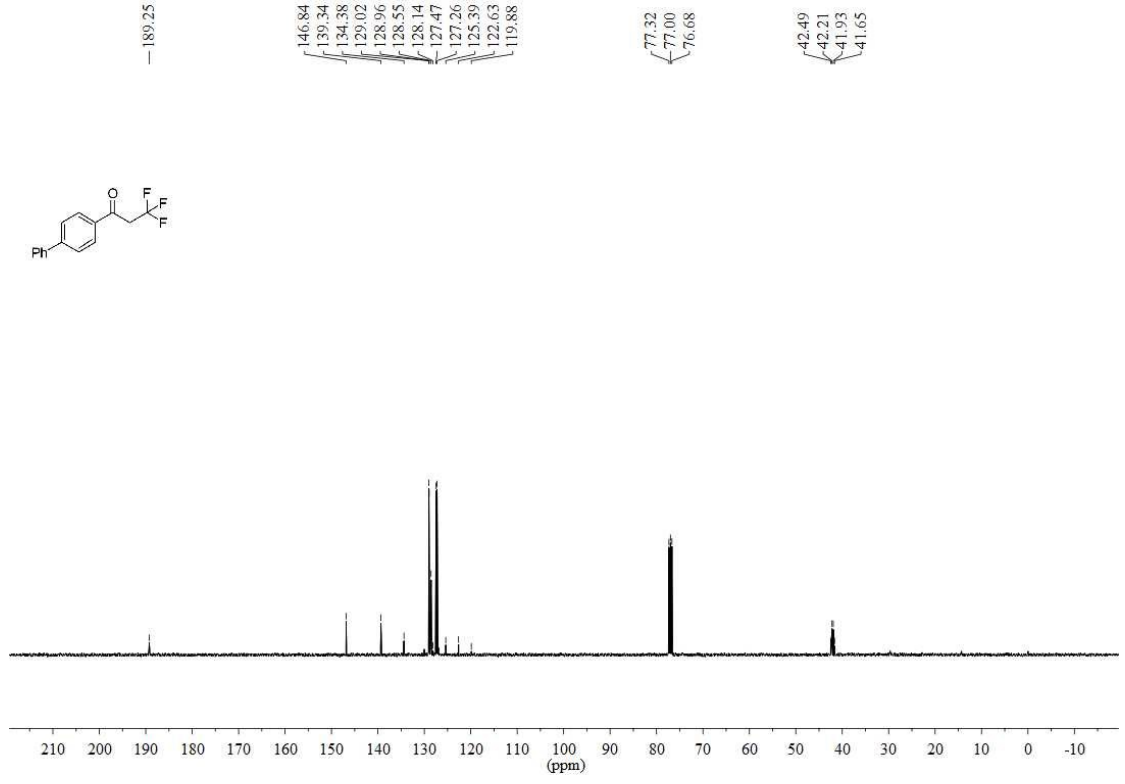
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3d**



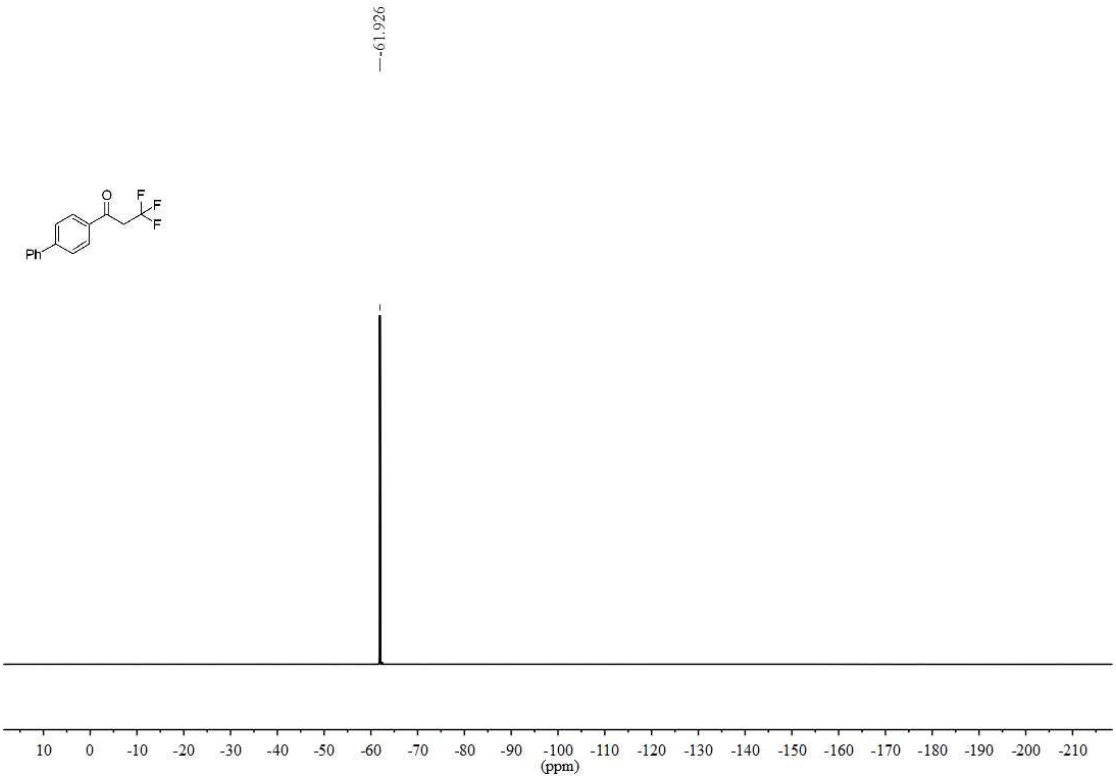
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3e**



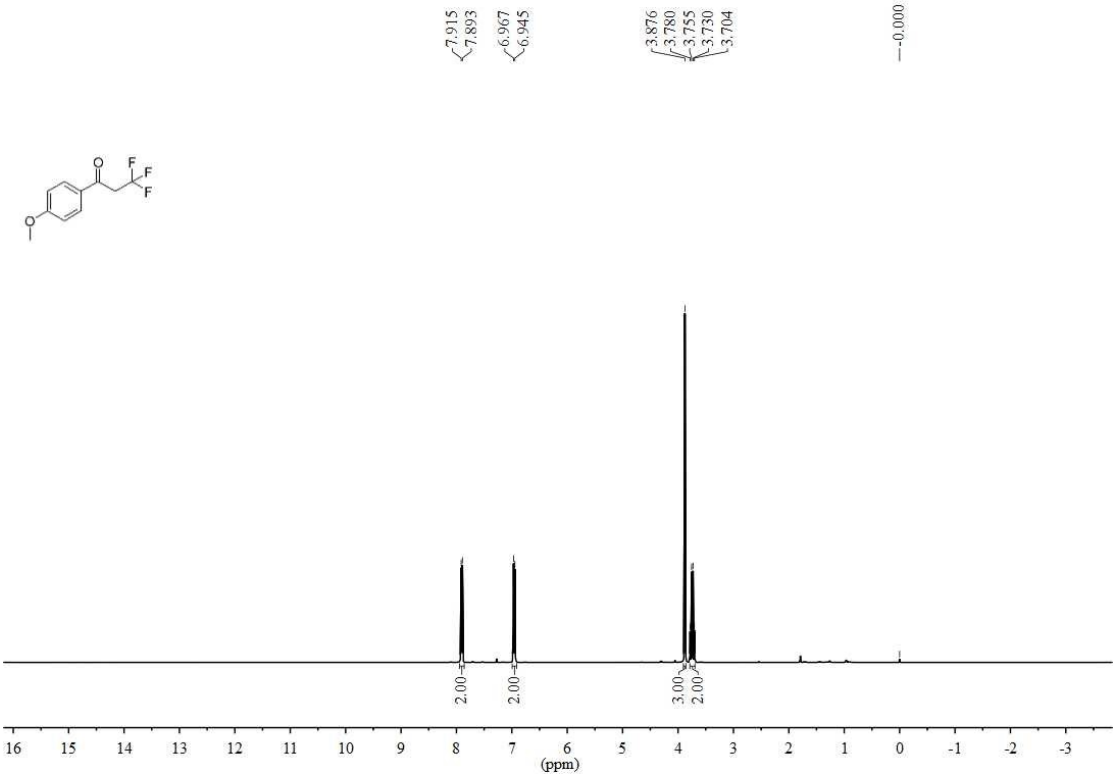
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3e**



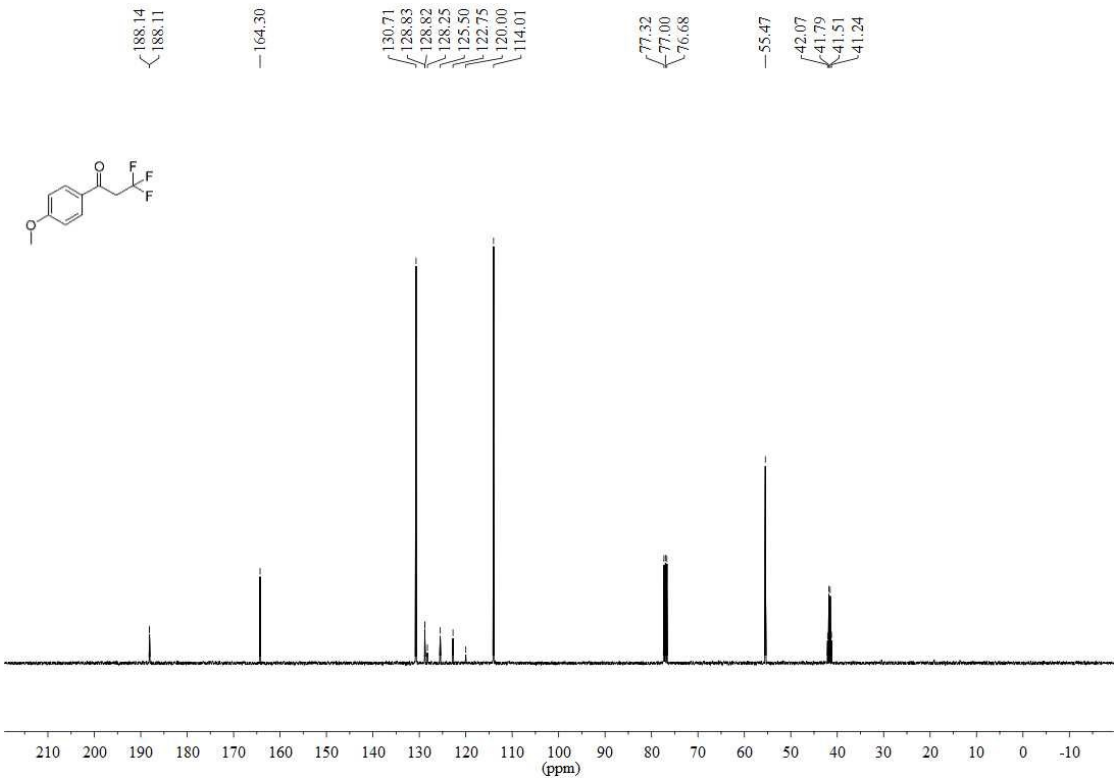
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3e**



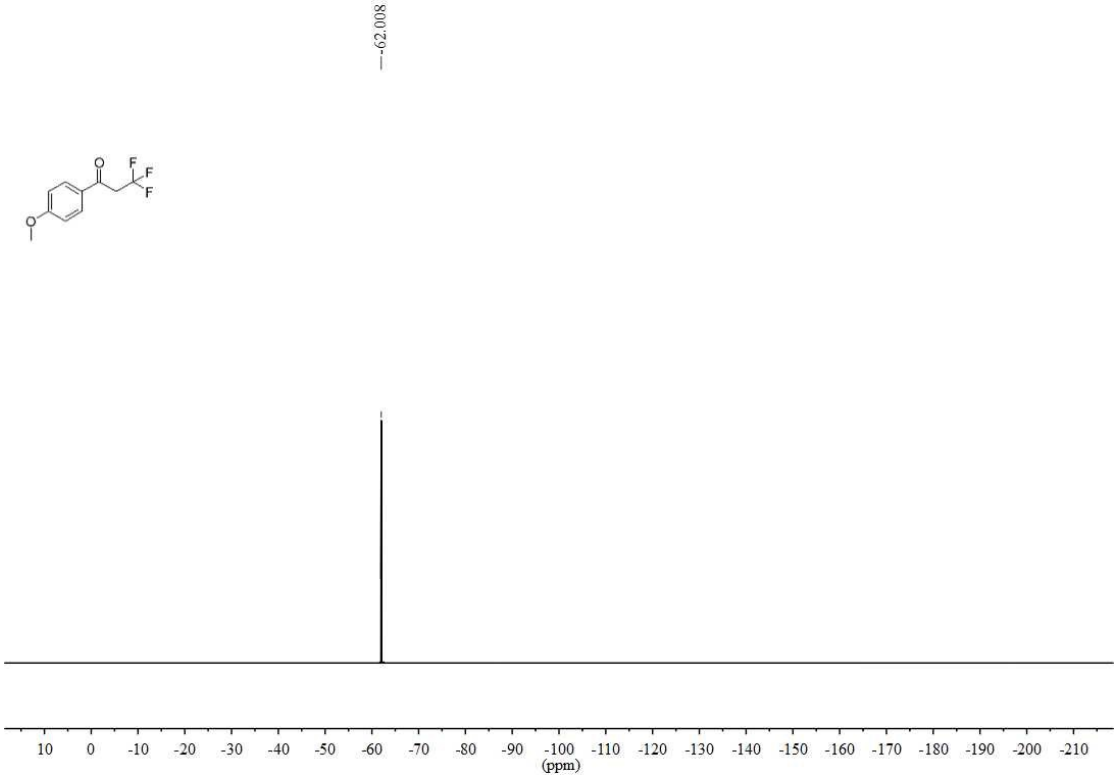
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3f**



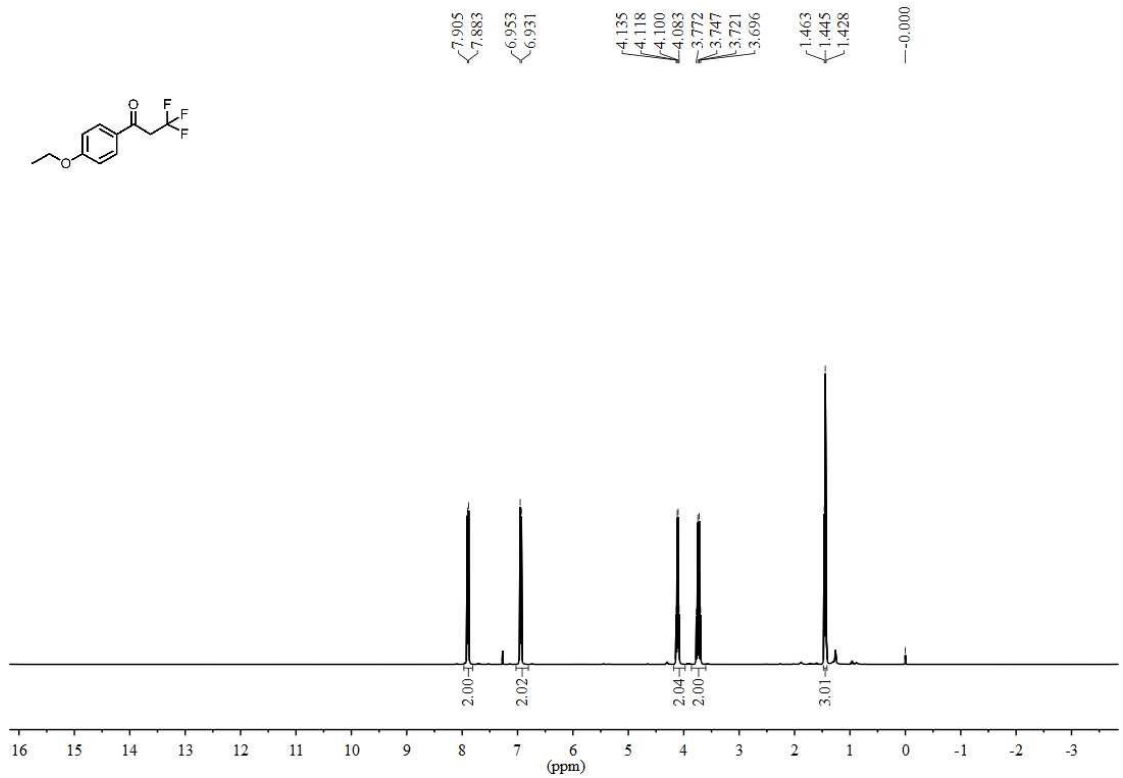
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3f**



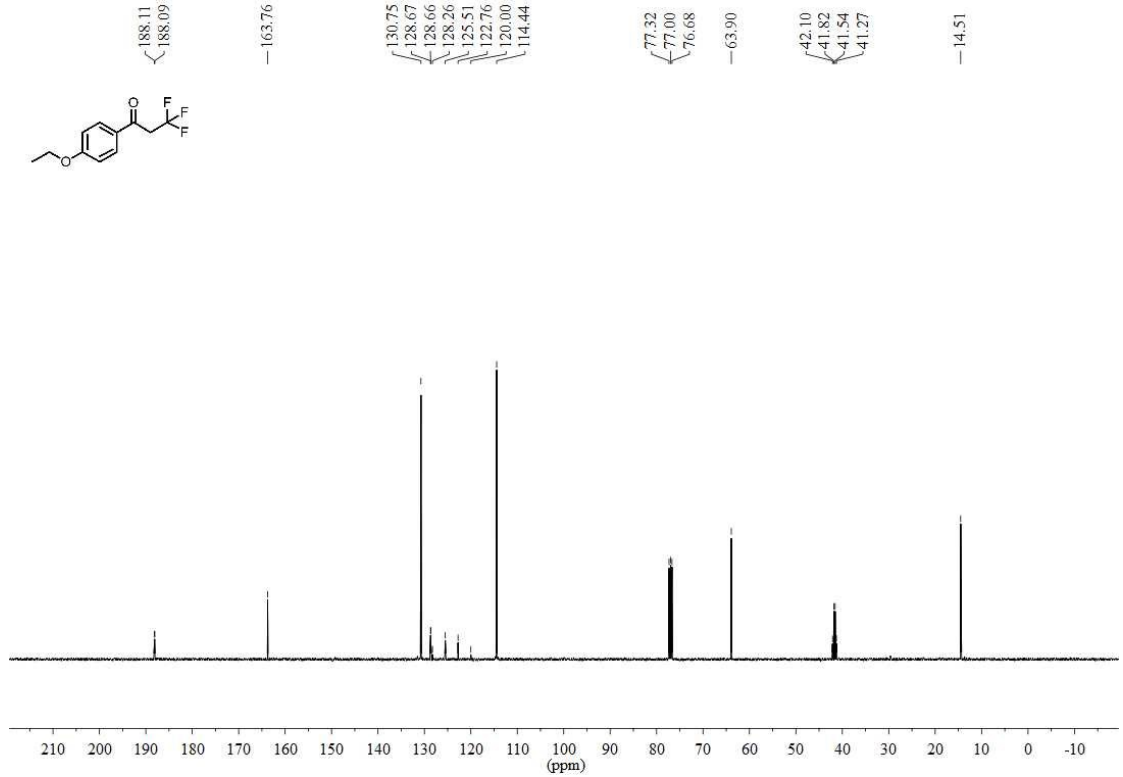
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3f**



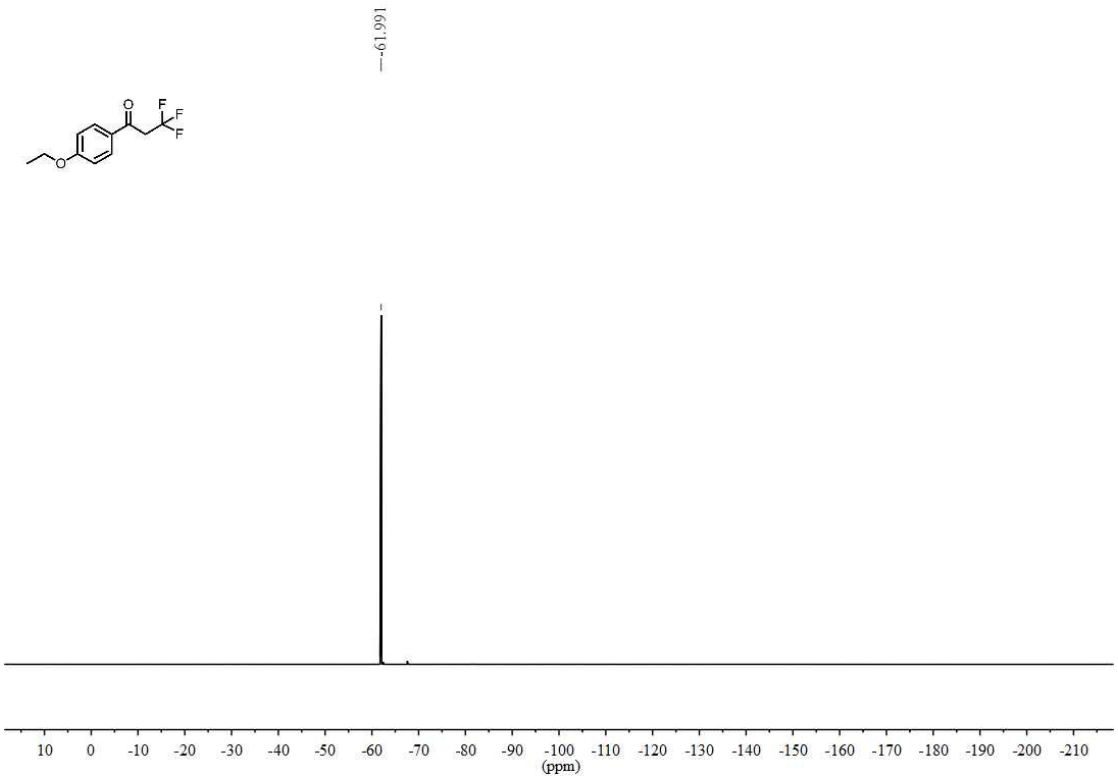
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3g**



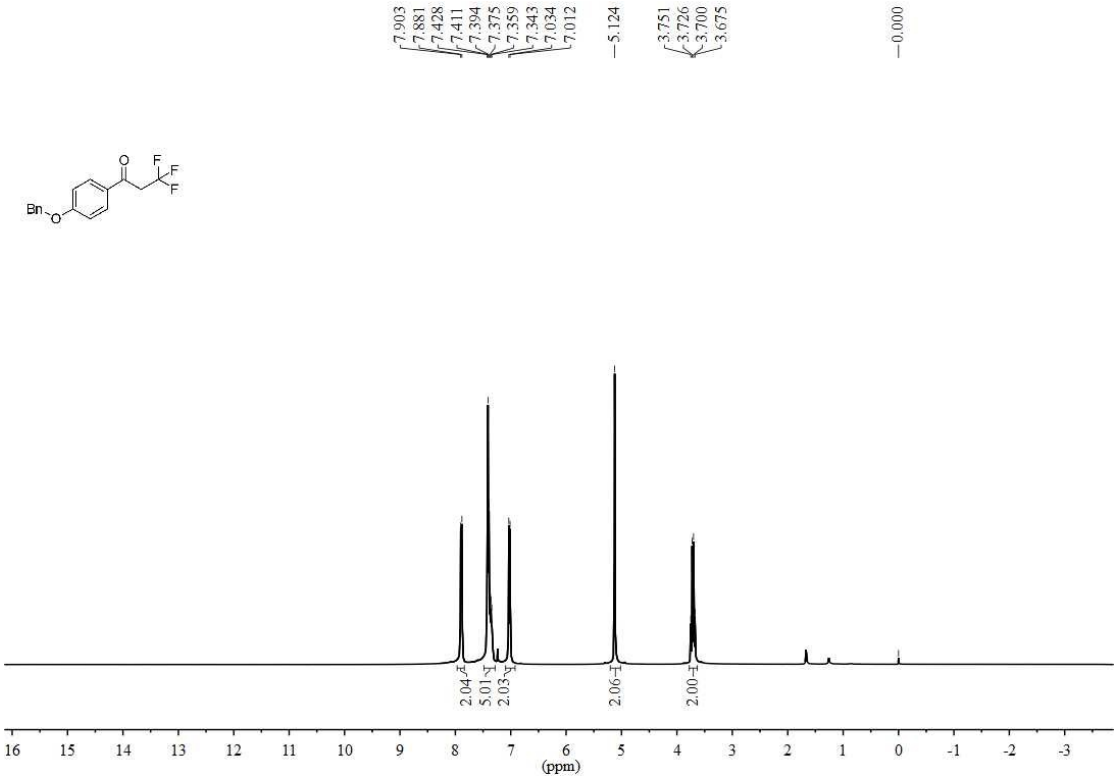
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3g**



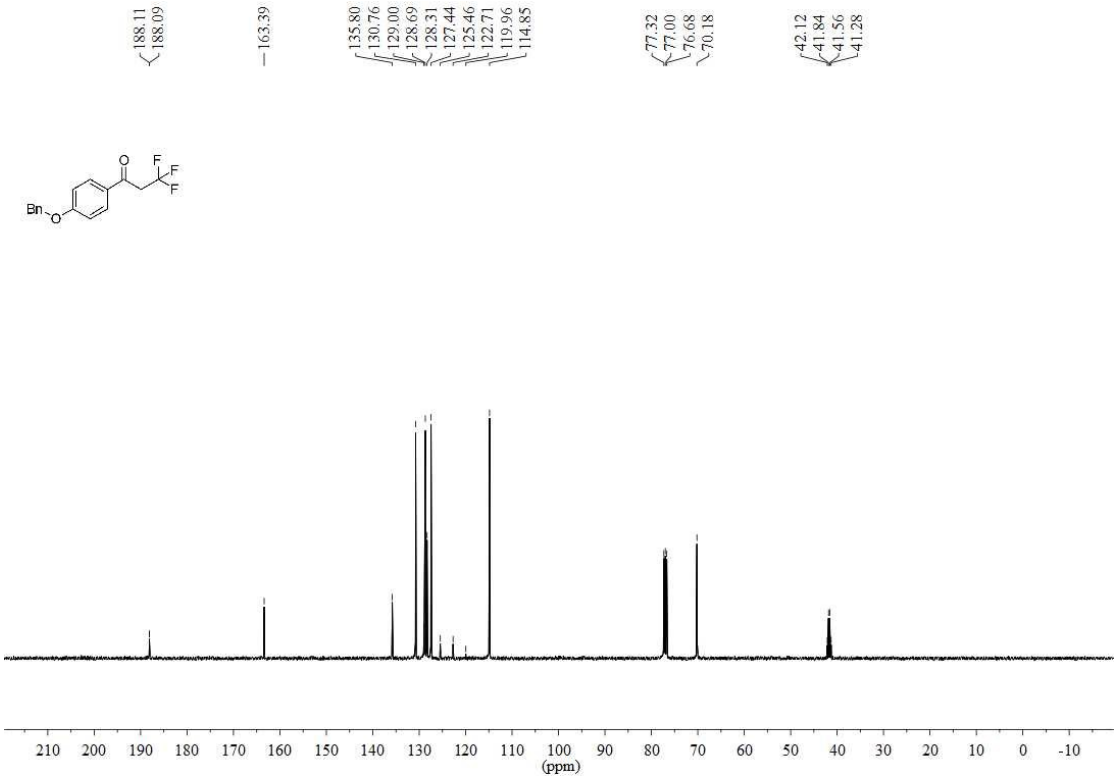
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3g**



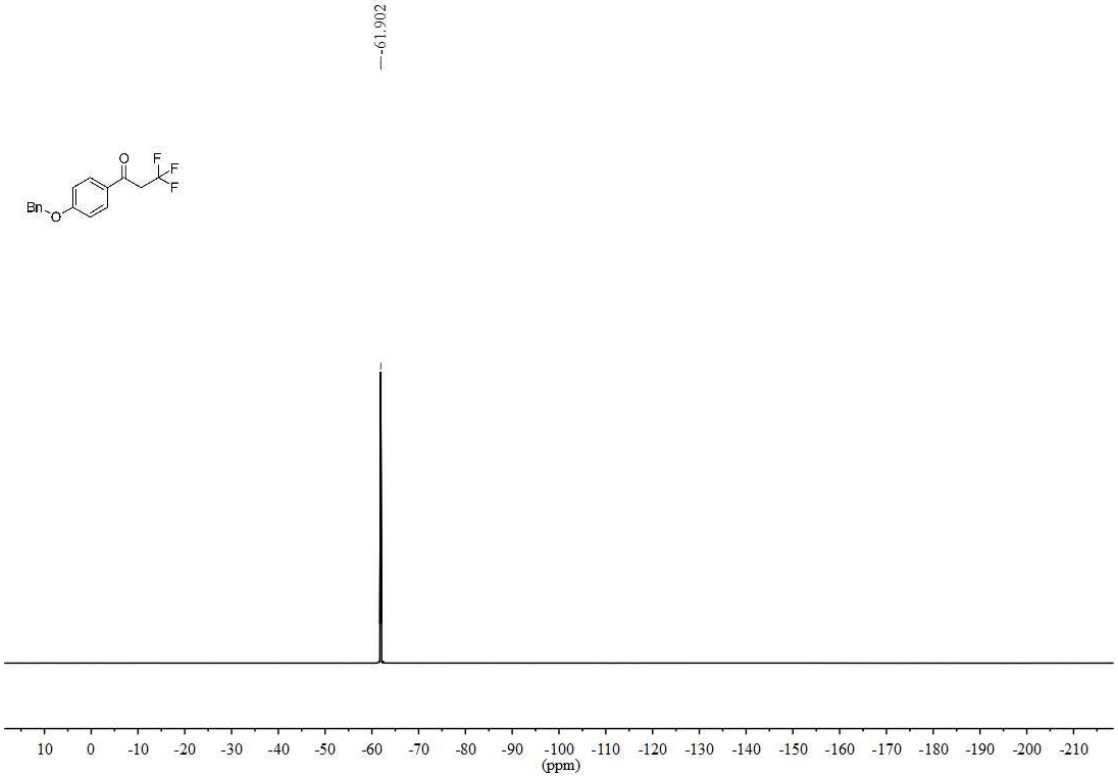
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3h**



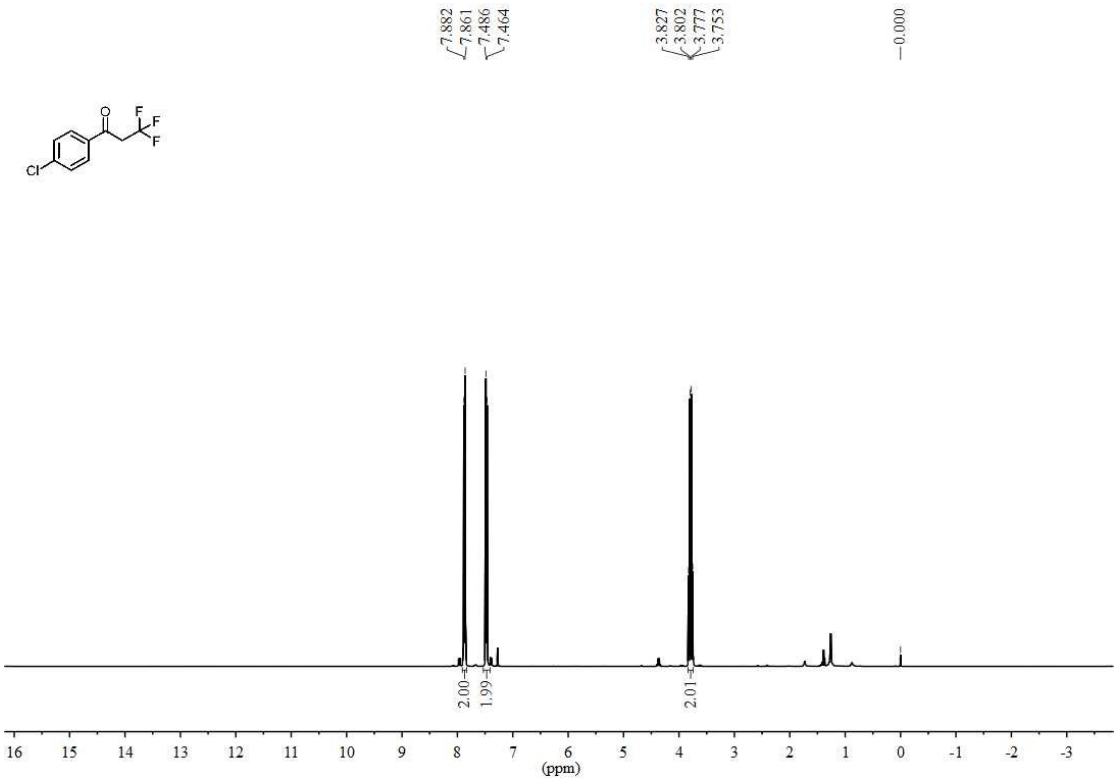
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3h**



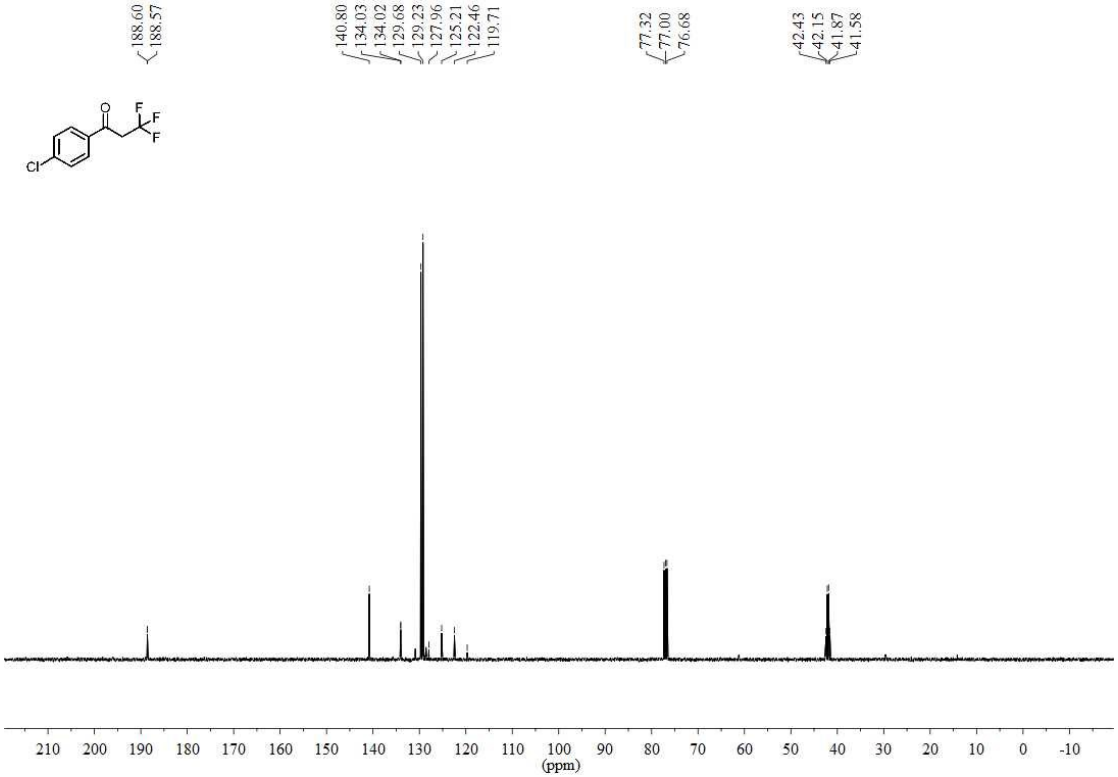
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3h**



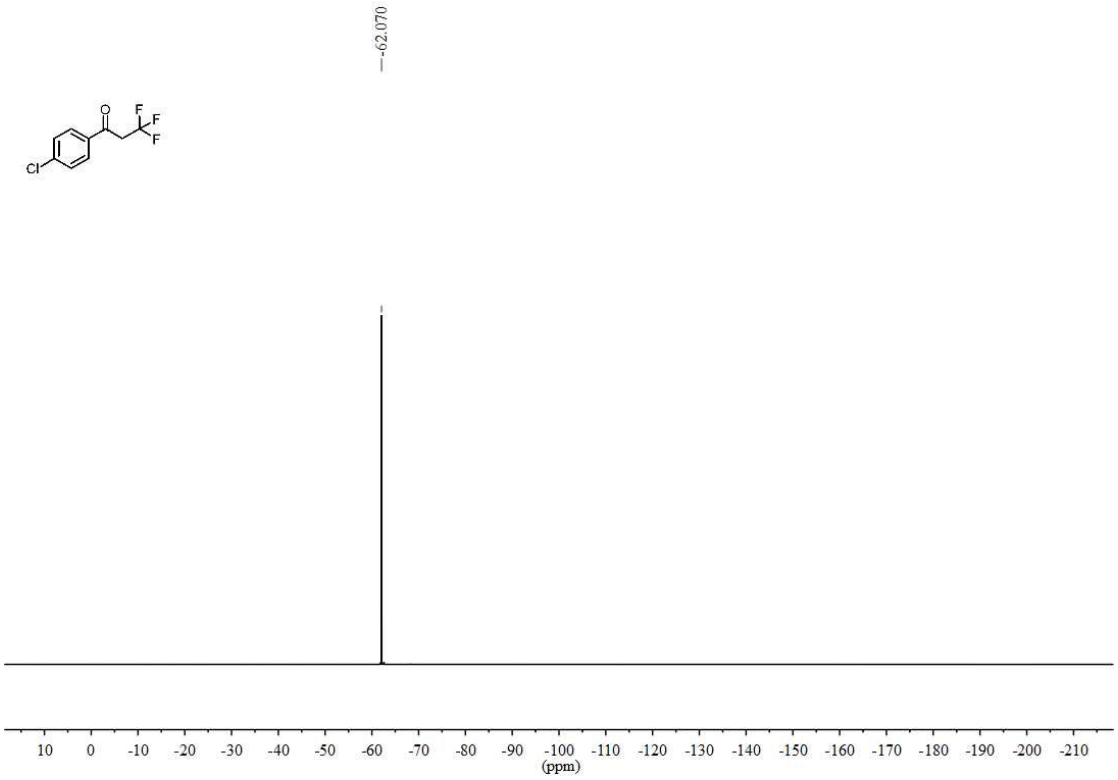
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3i**



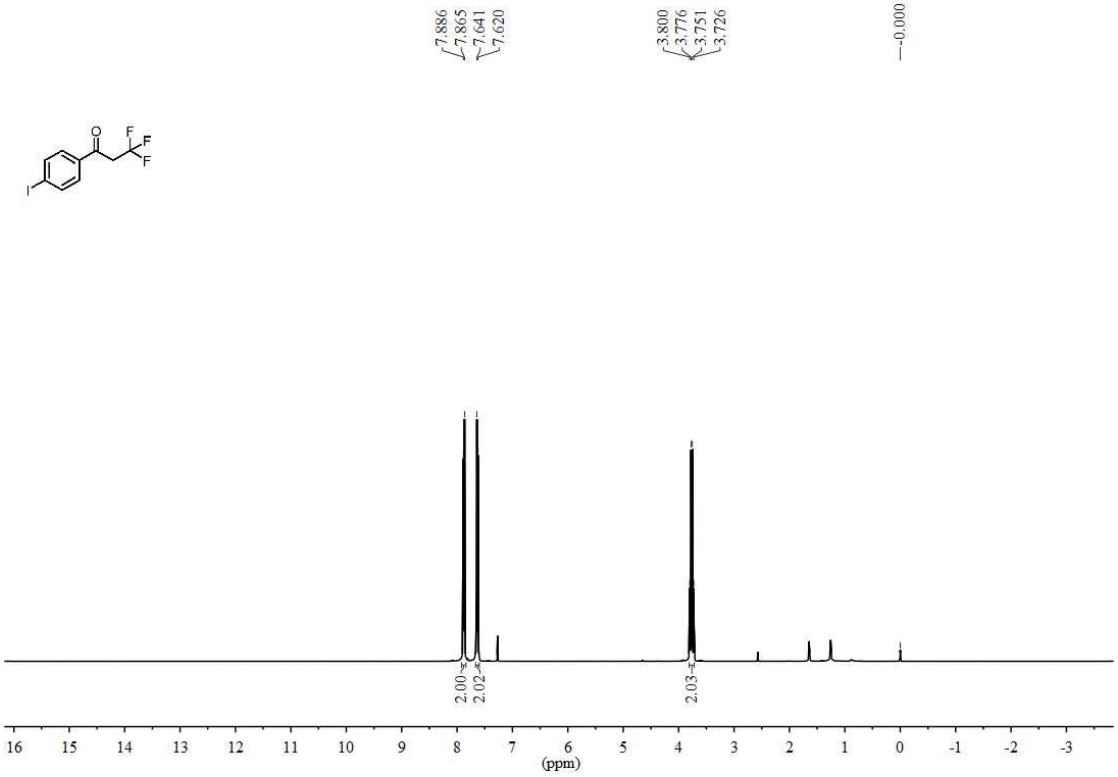
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3i**



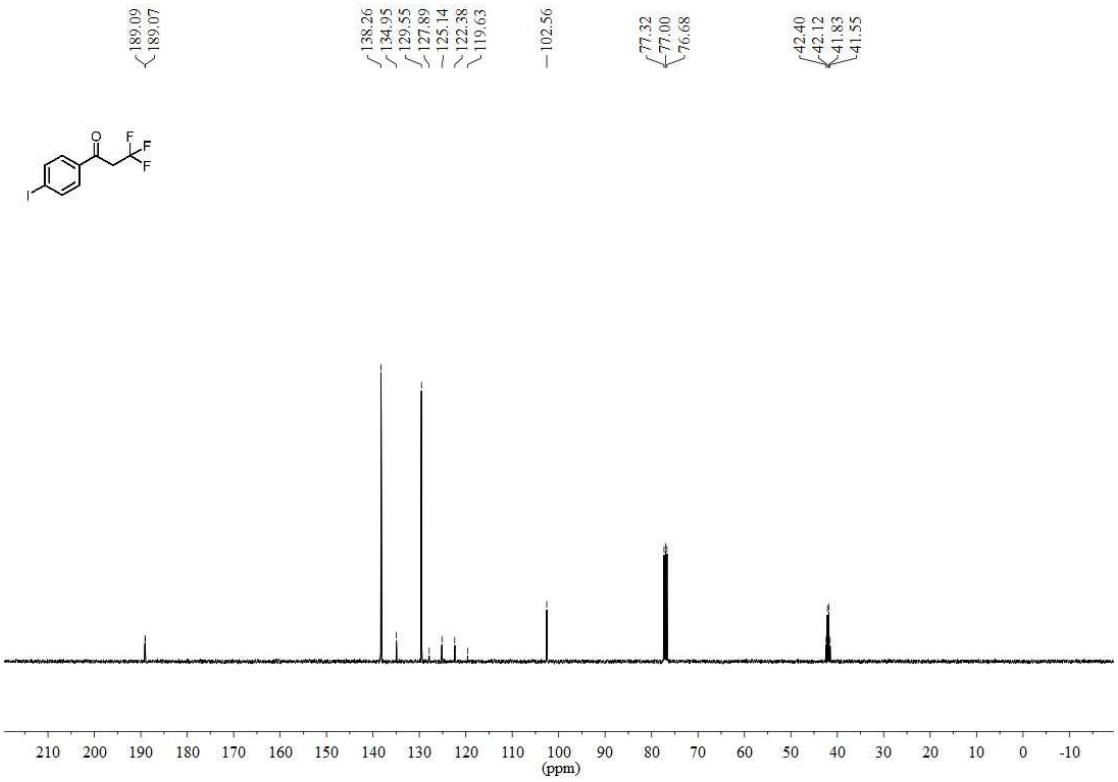
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3i**



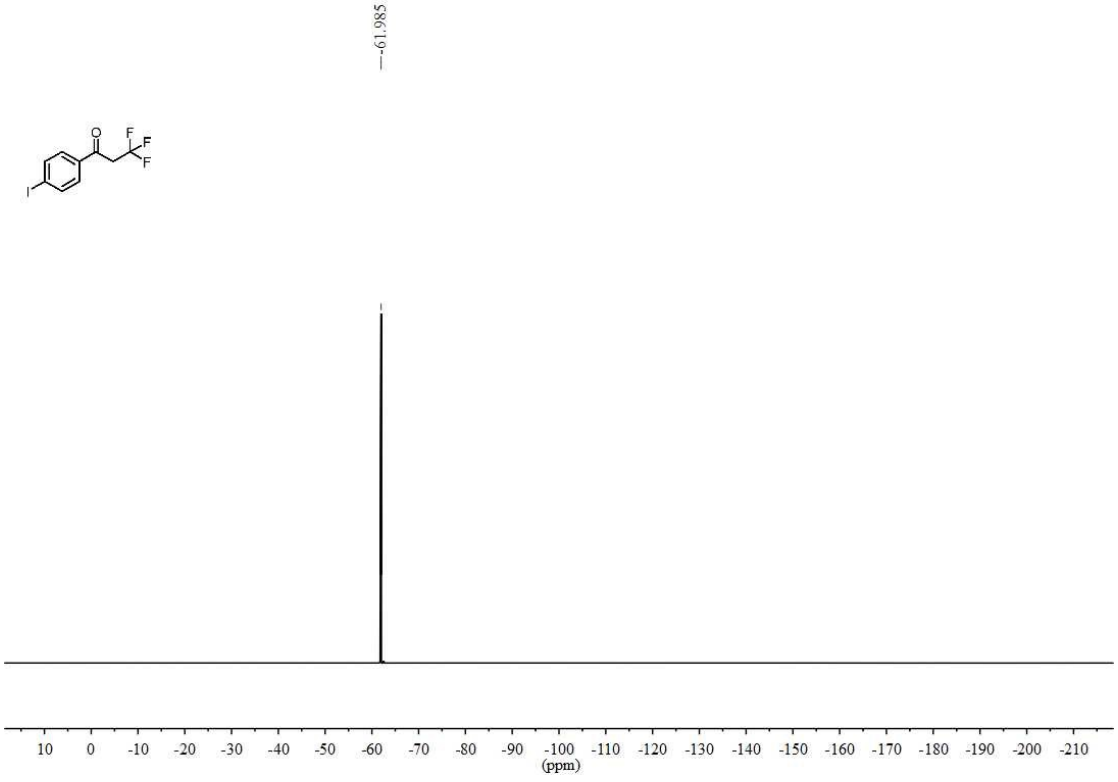
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3j**



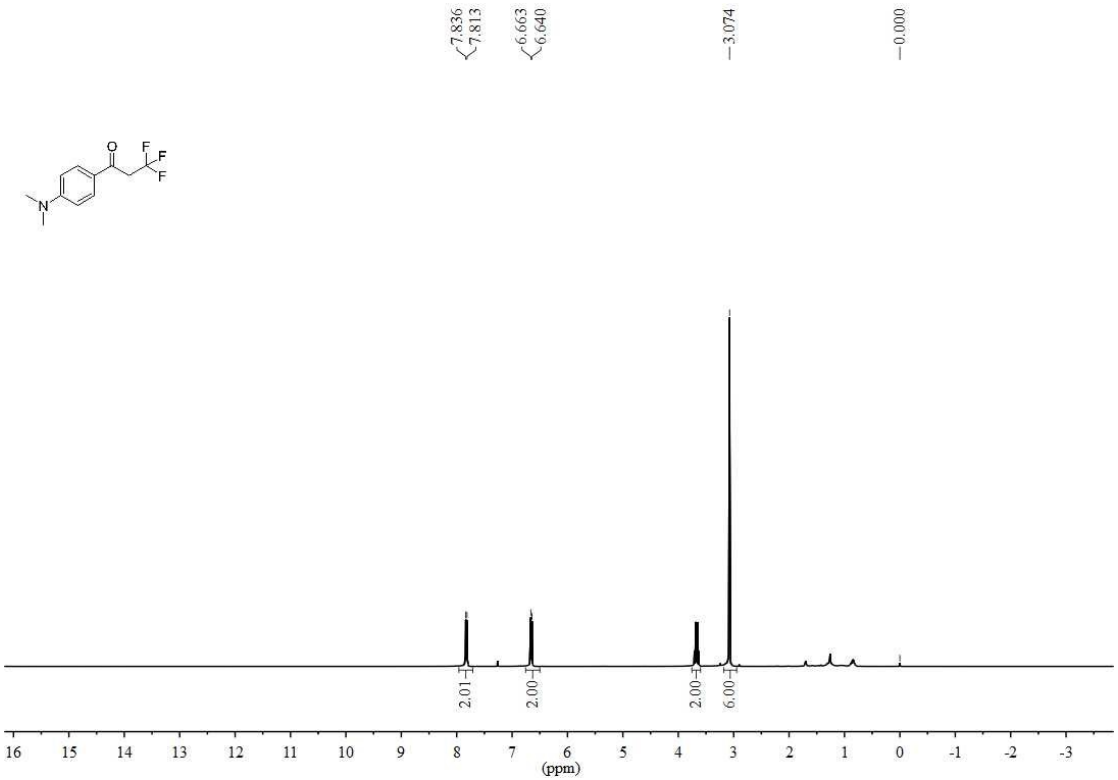
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3j**



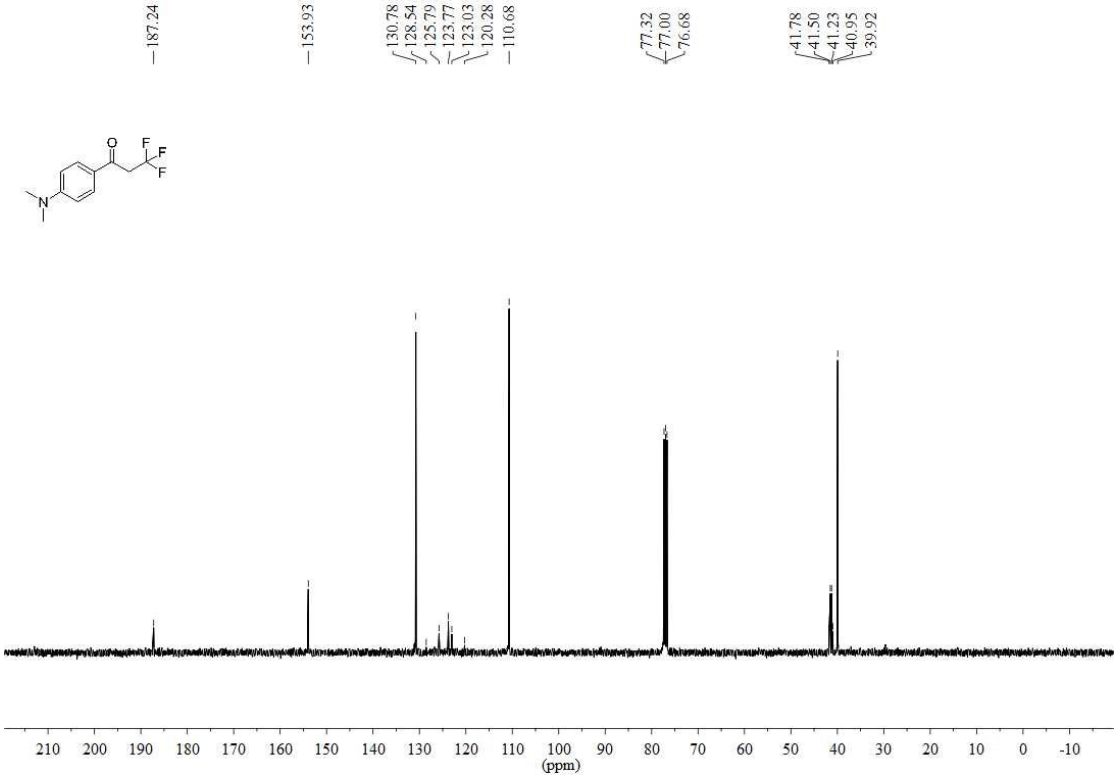
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3j**



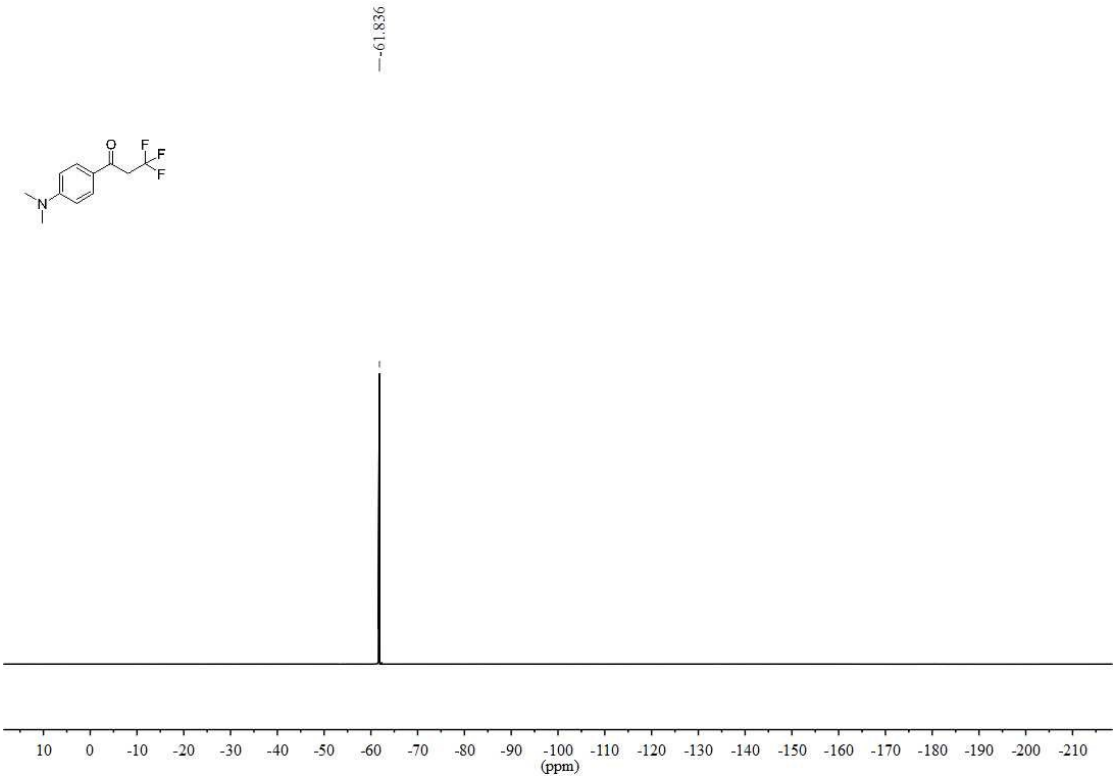
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3k**



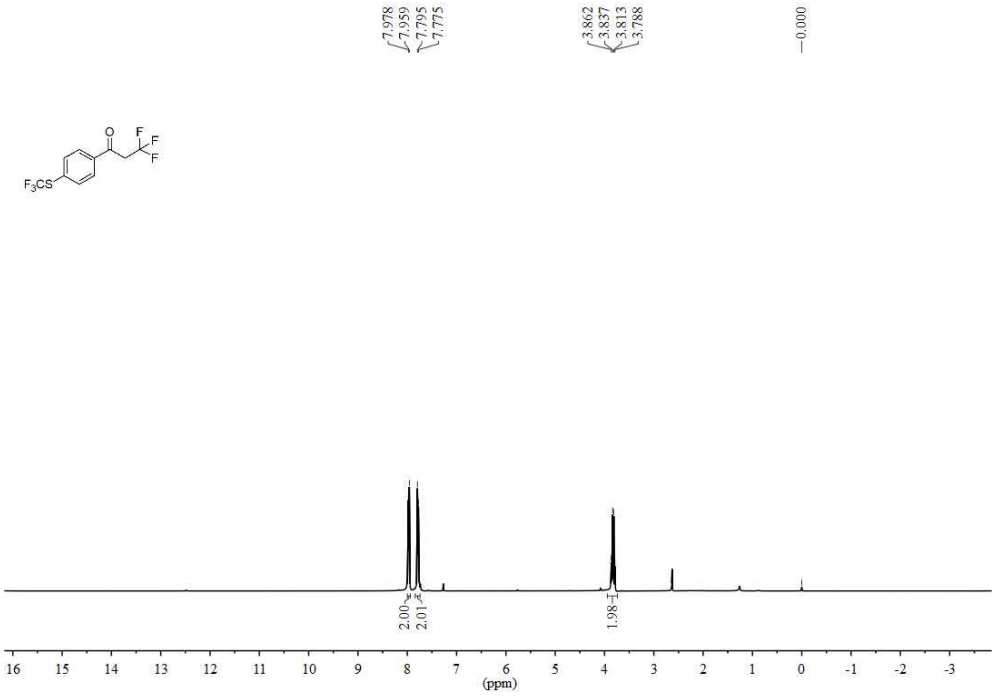
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3k**



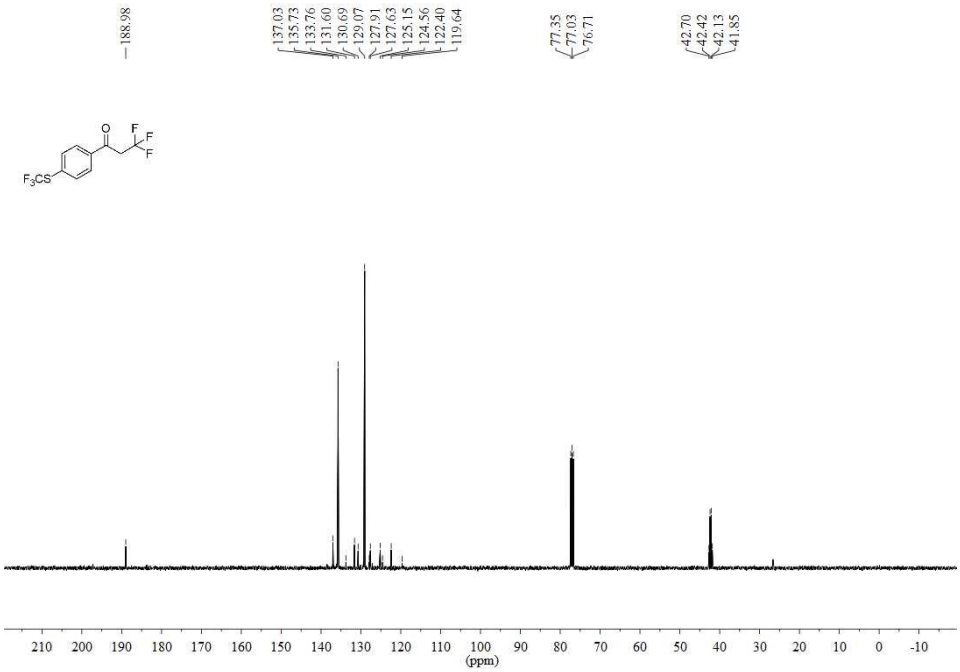
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3k**



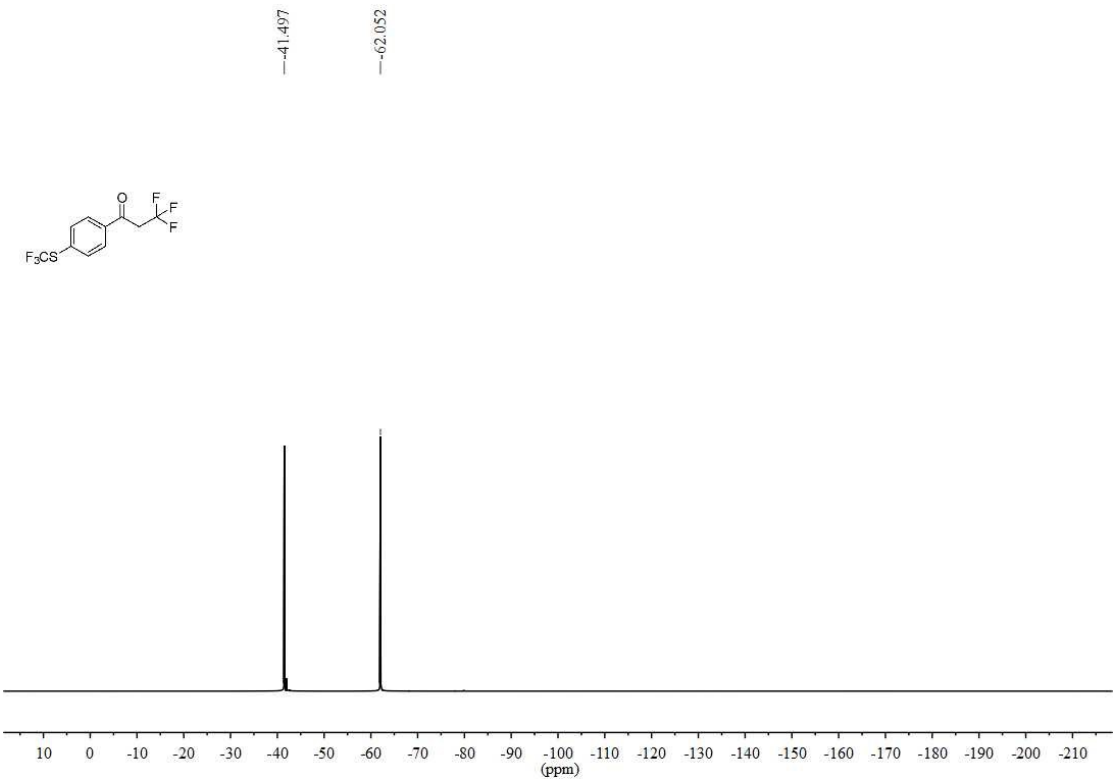
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3l**



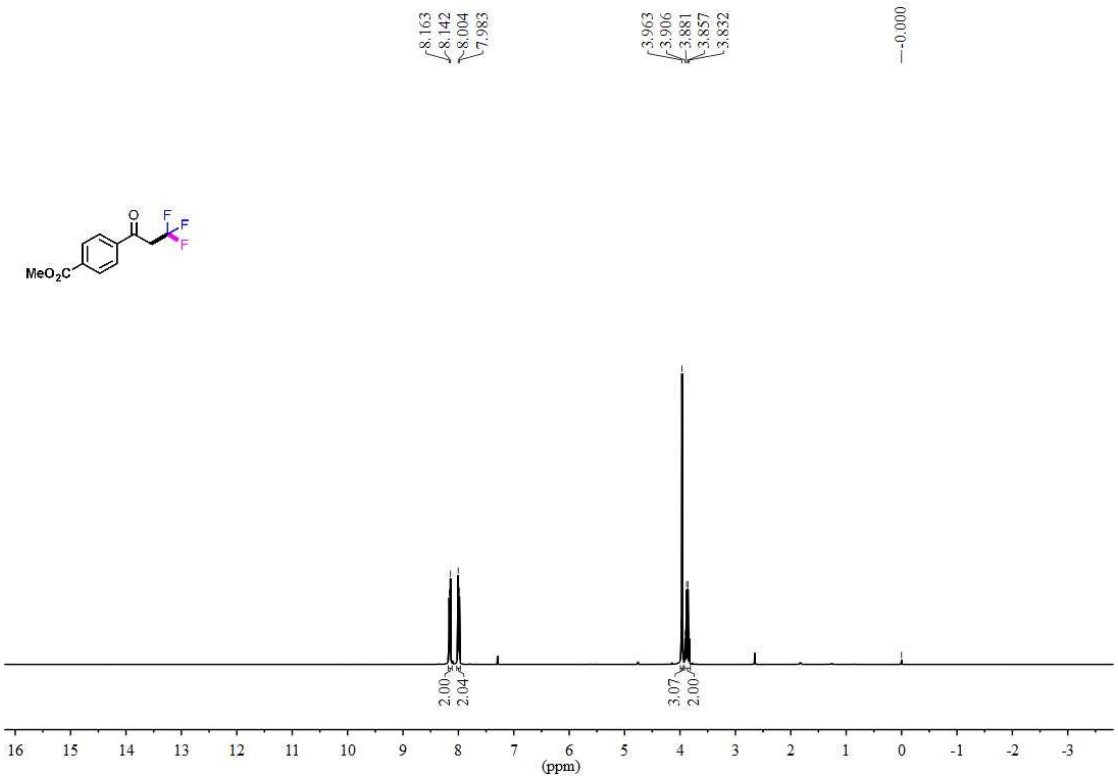
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3l**



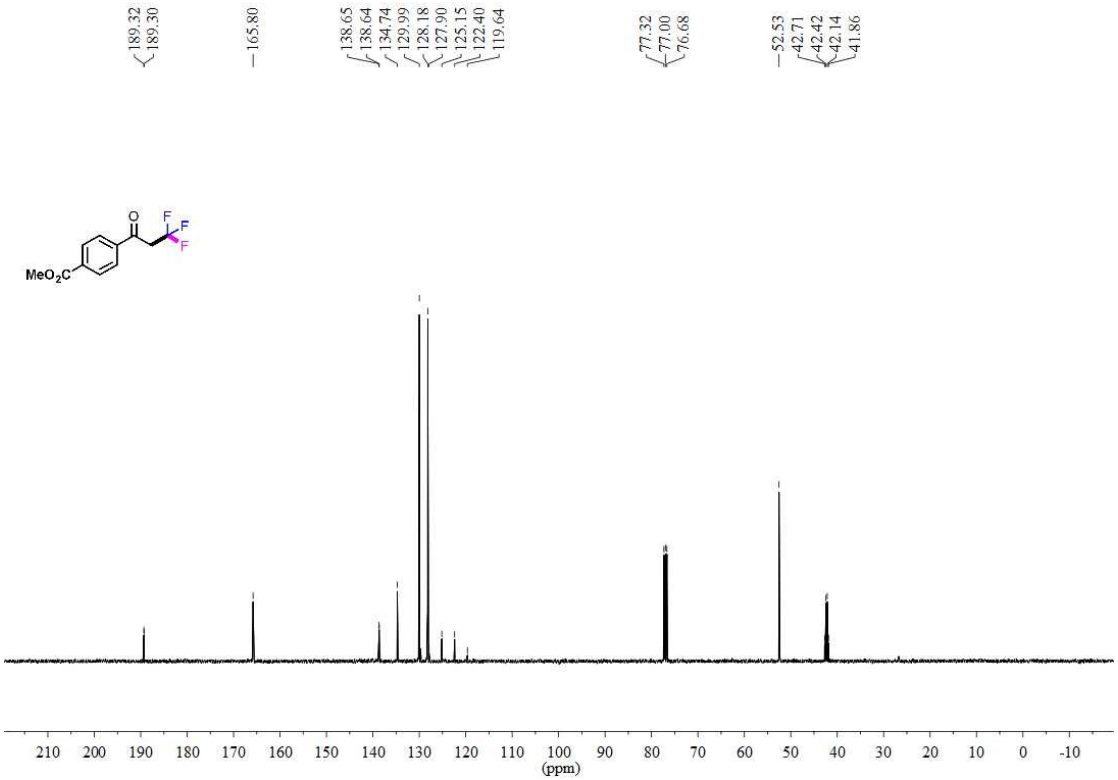
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3l**



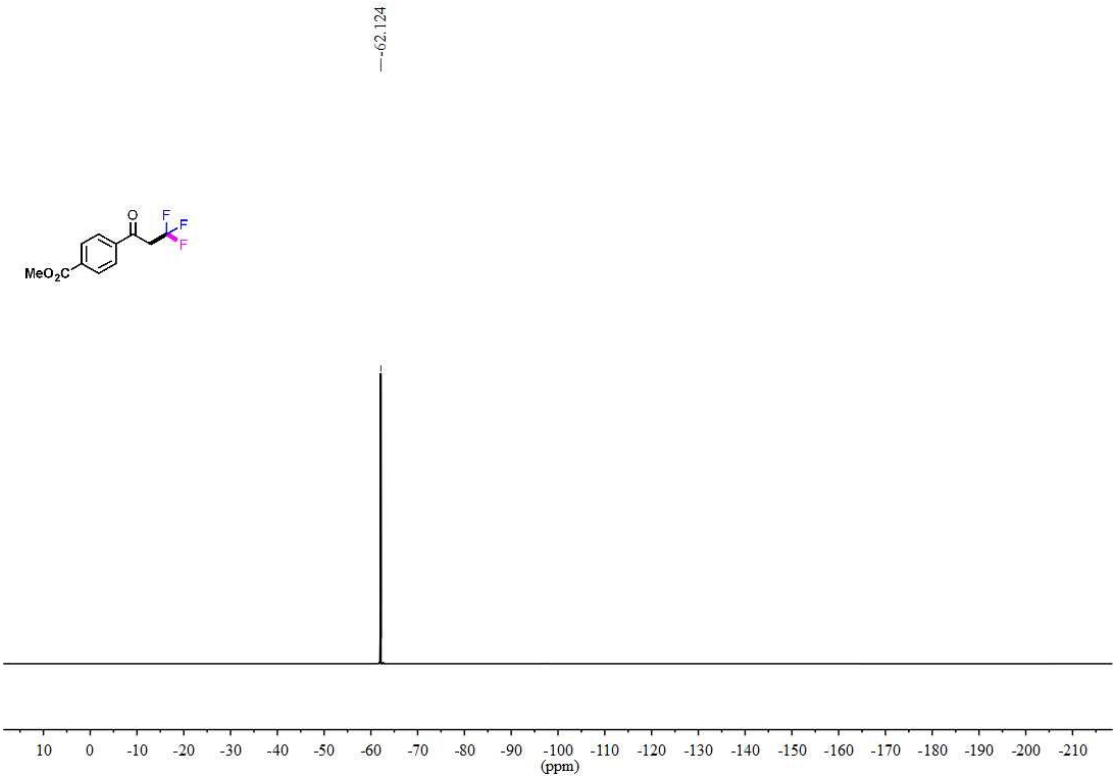
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3m**



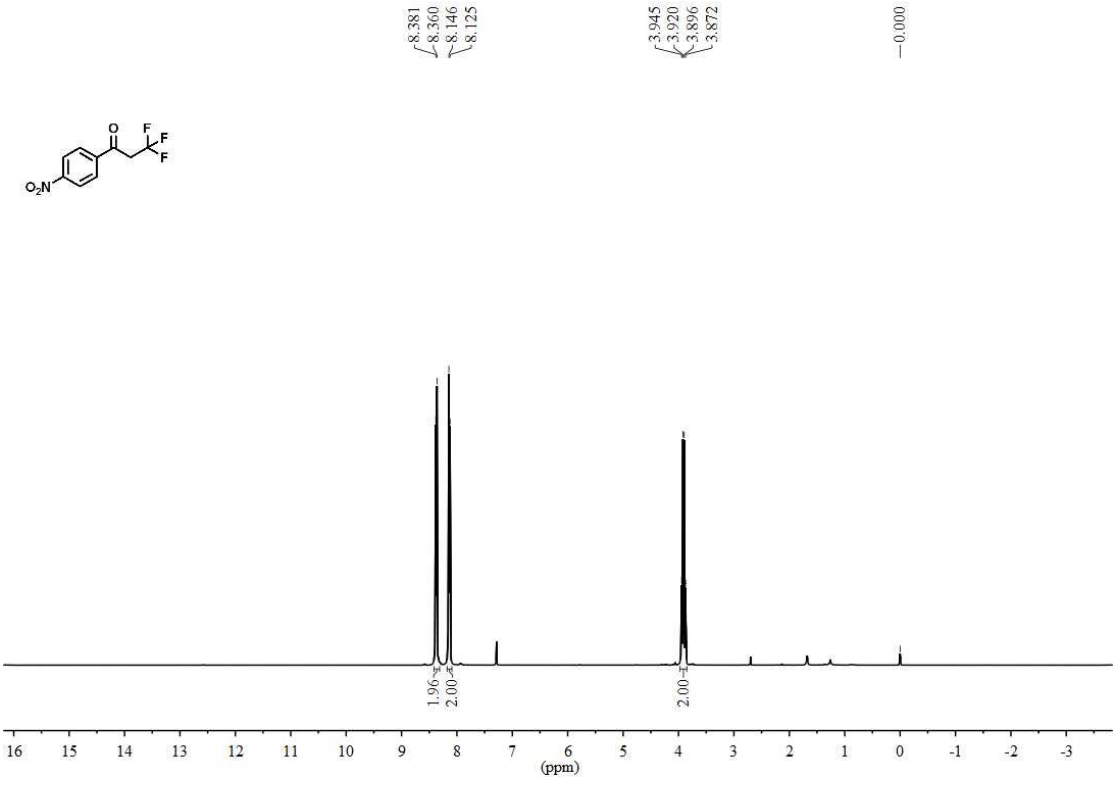
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3m**



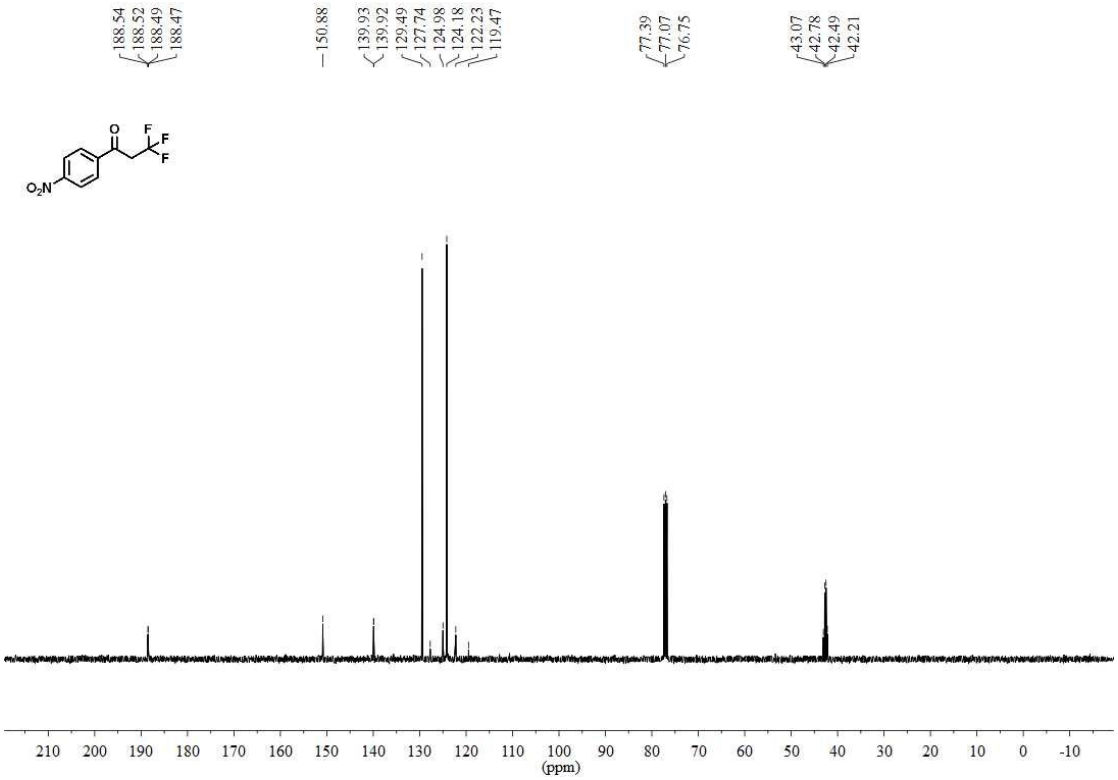
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3m**



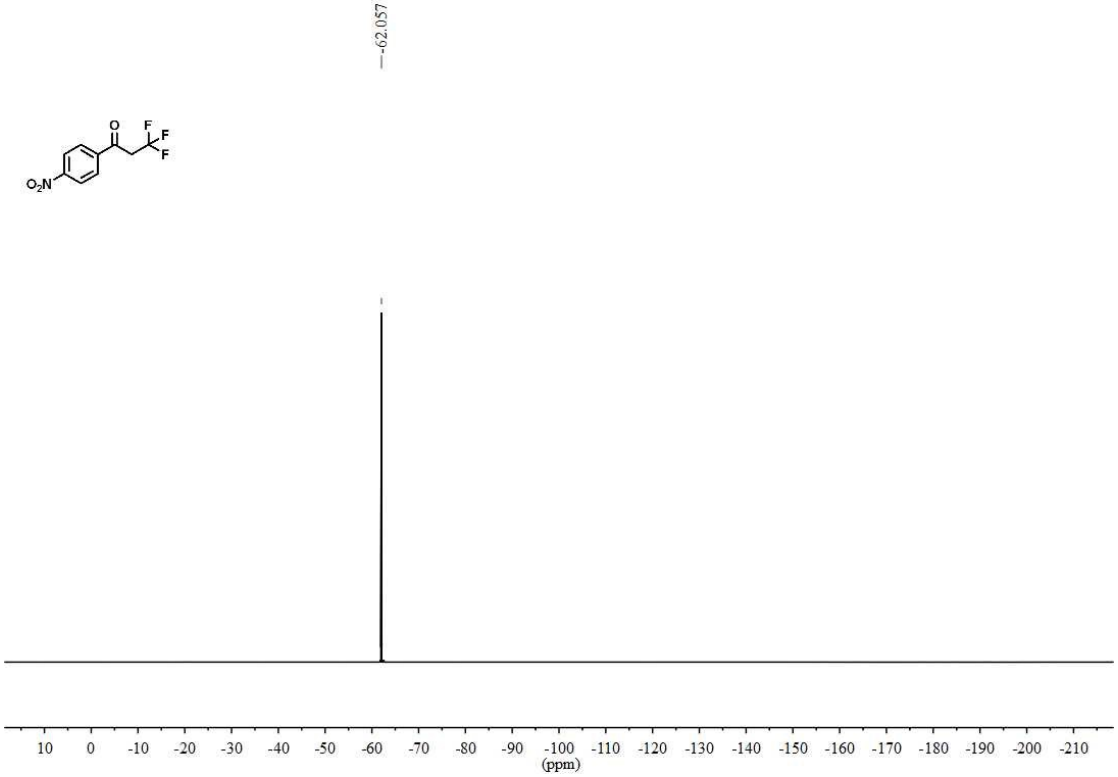
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3n**



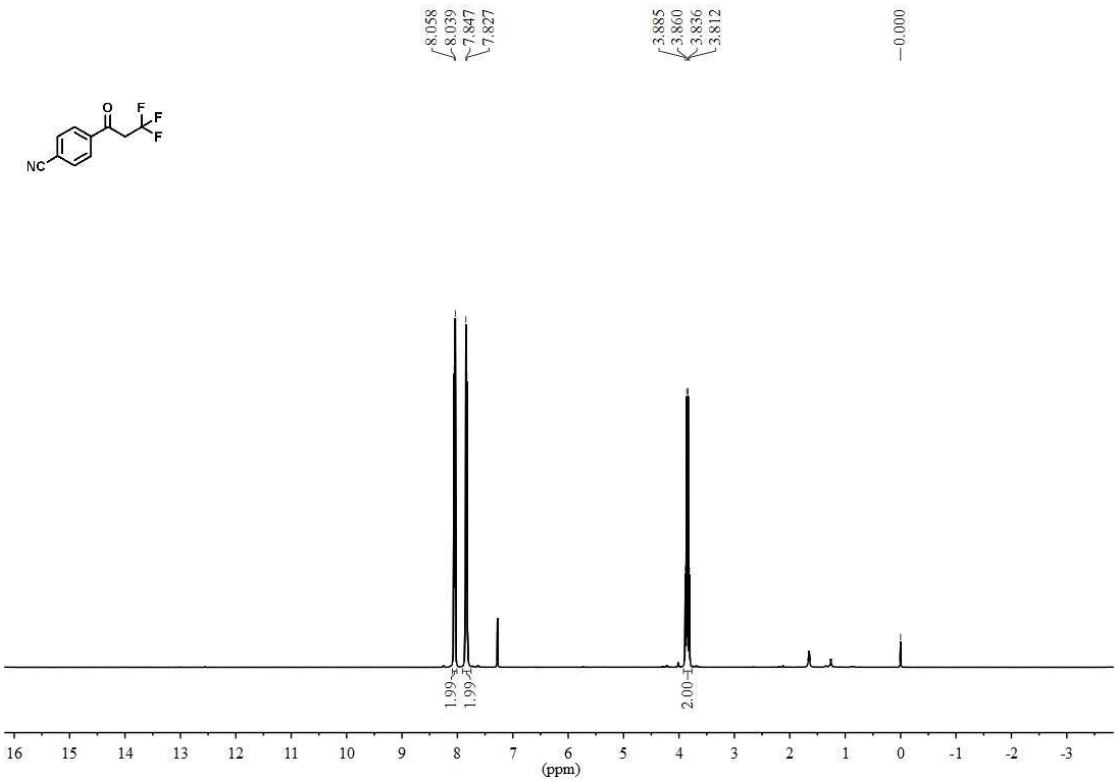
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3n**



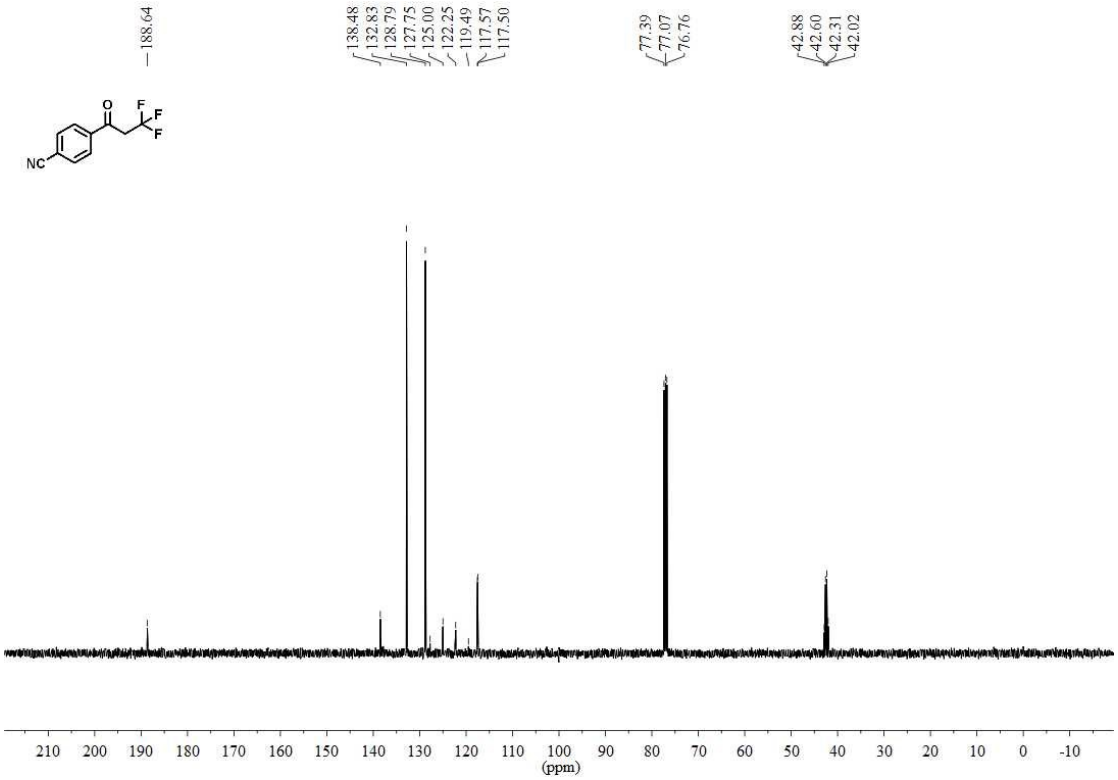
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3n**



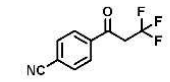
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3o**

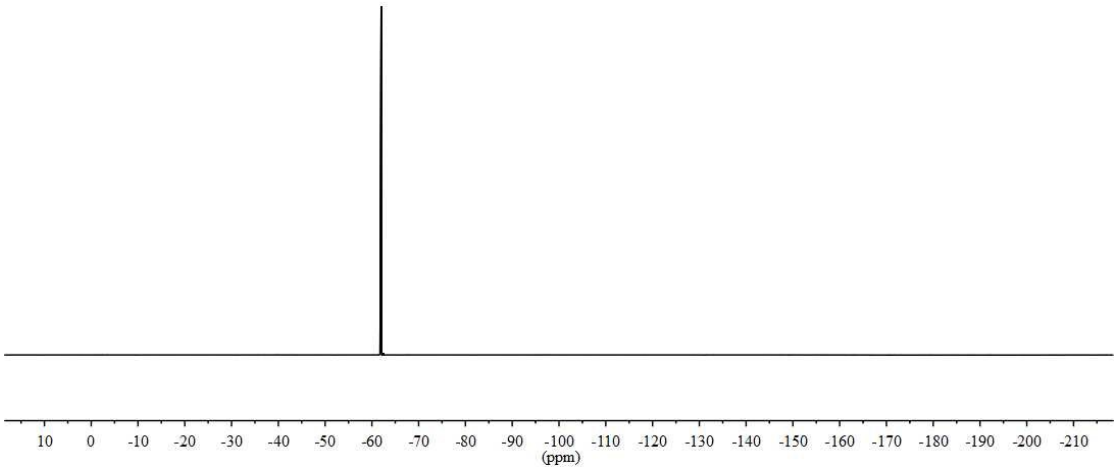


$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3o**

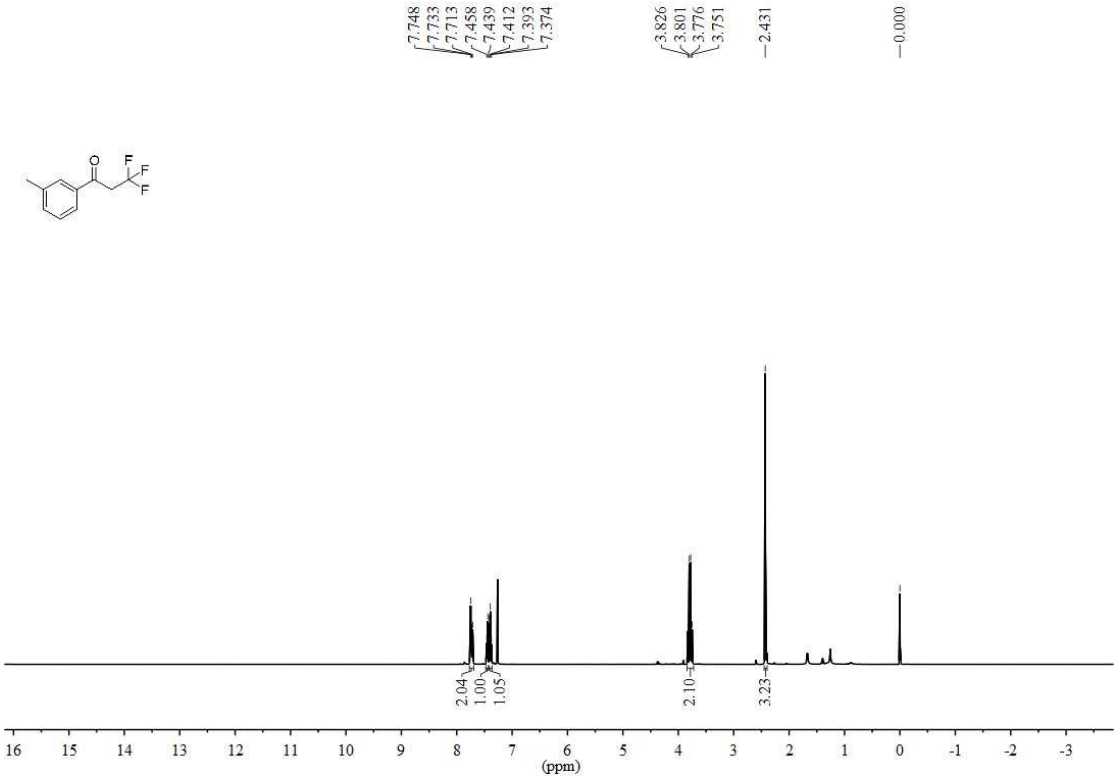


^{19}F NMR (376 MHz, $CDCl_3$) of compound **3o**

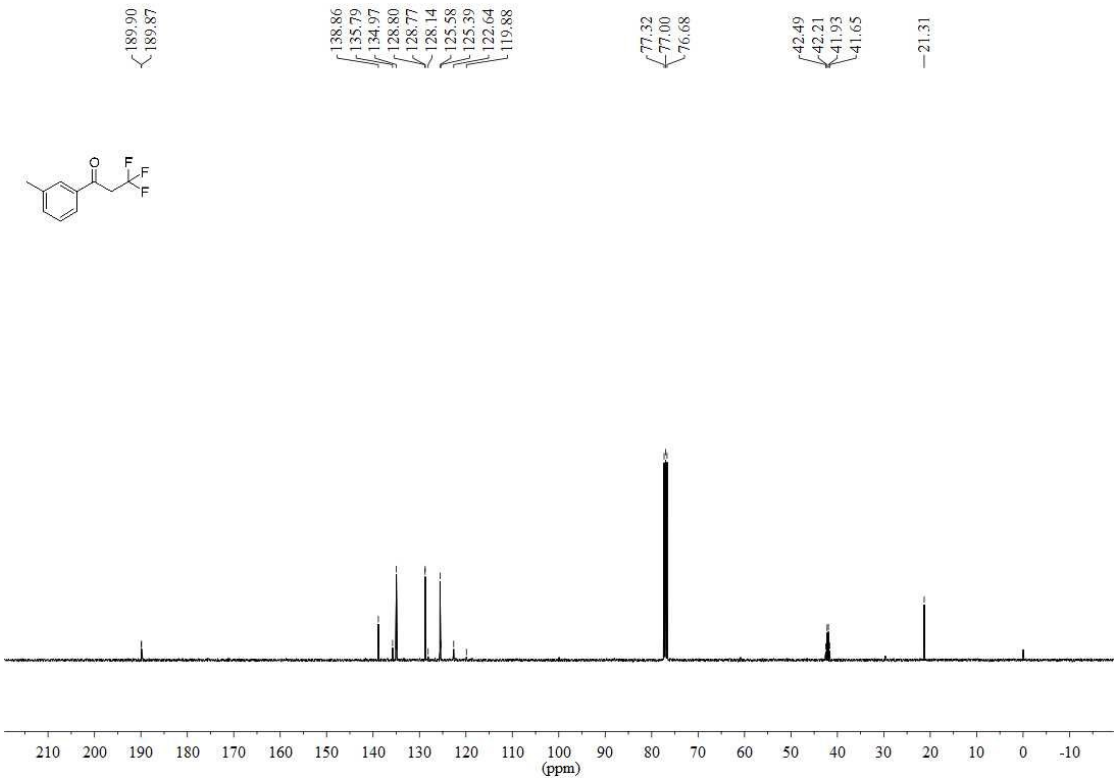




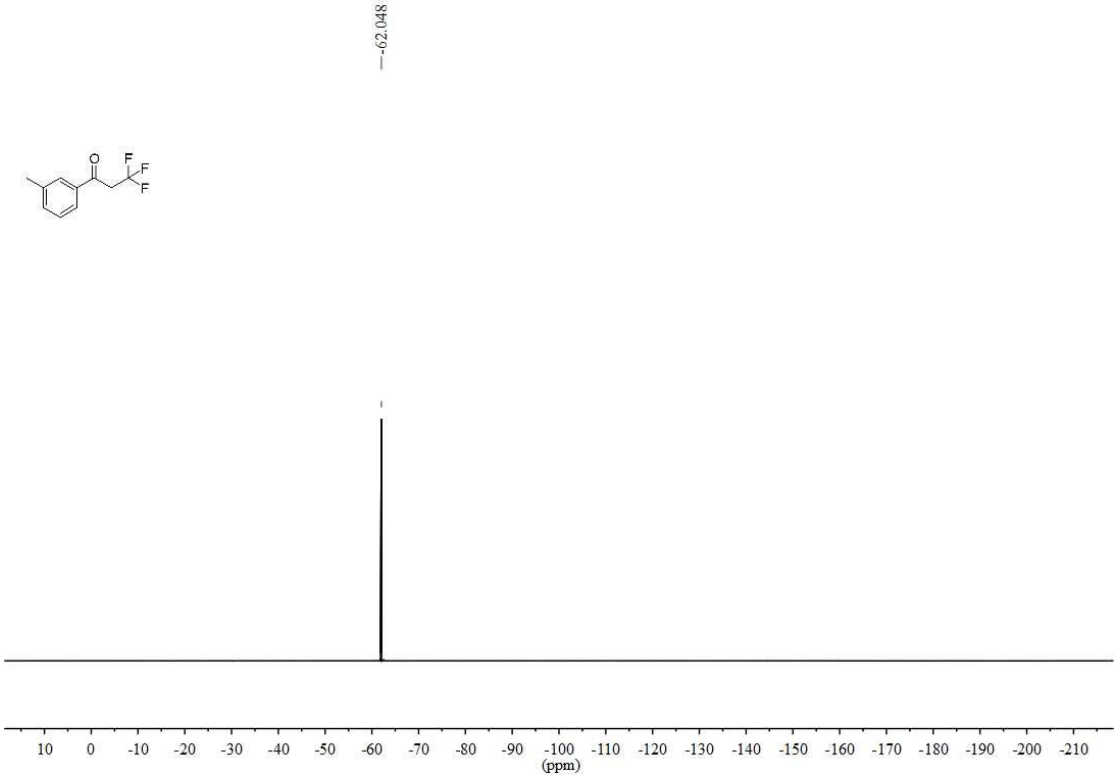
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3p**



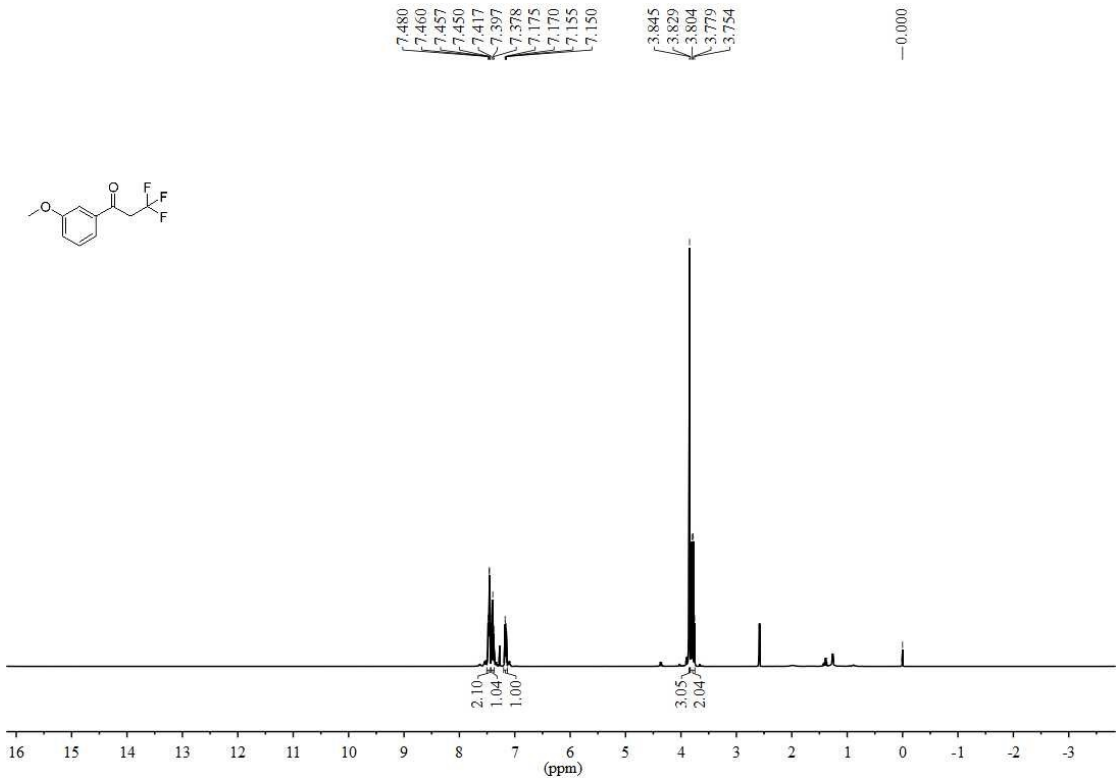
^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) of compound **3p**



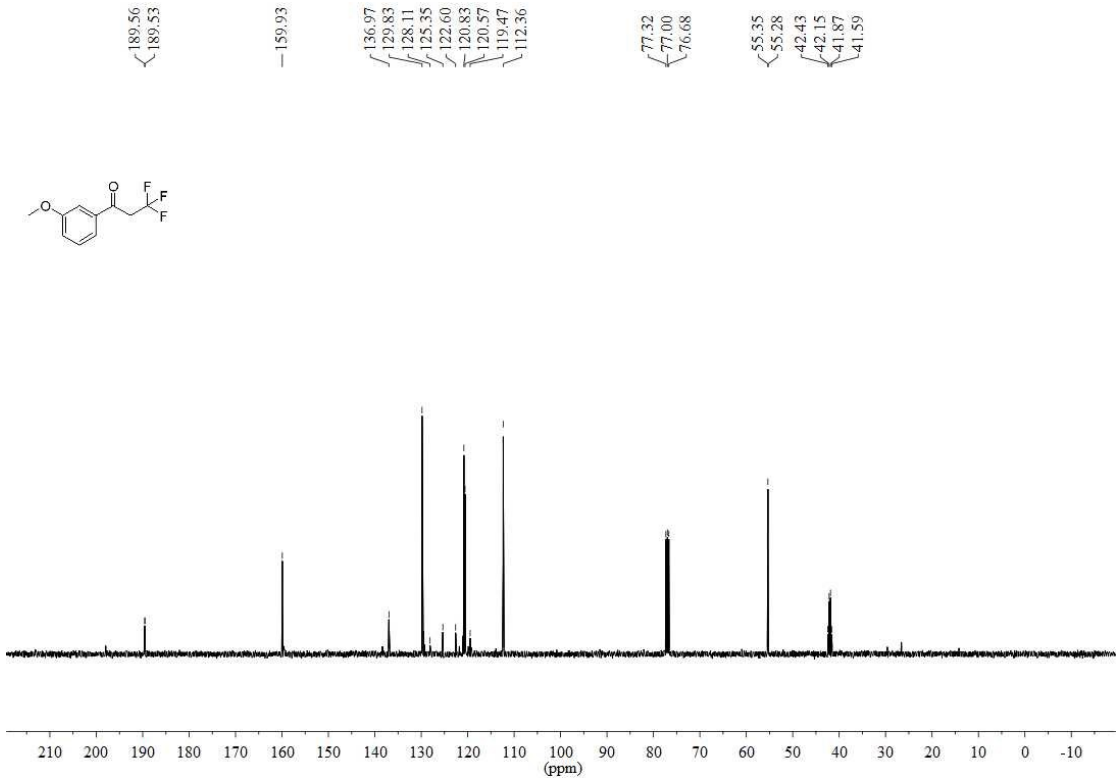
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3p**



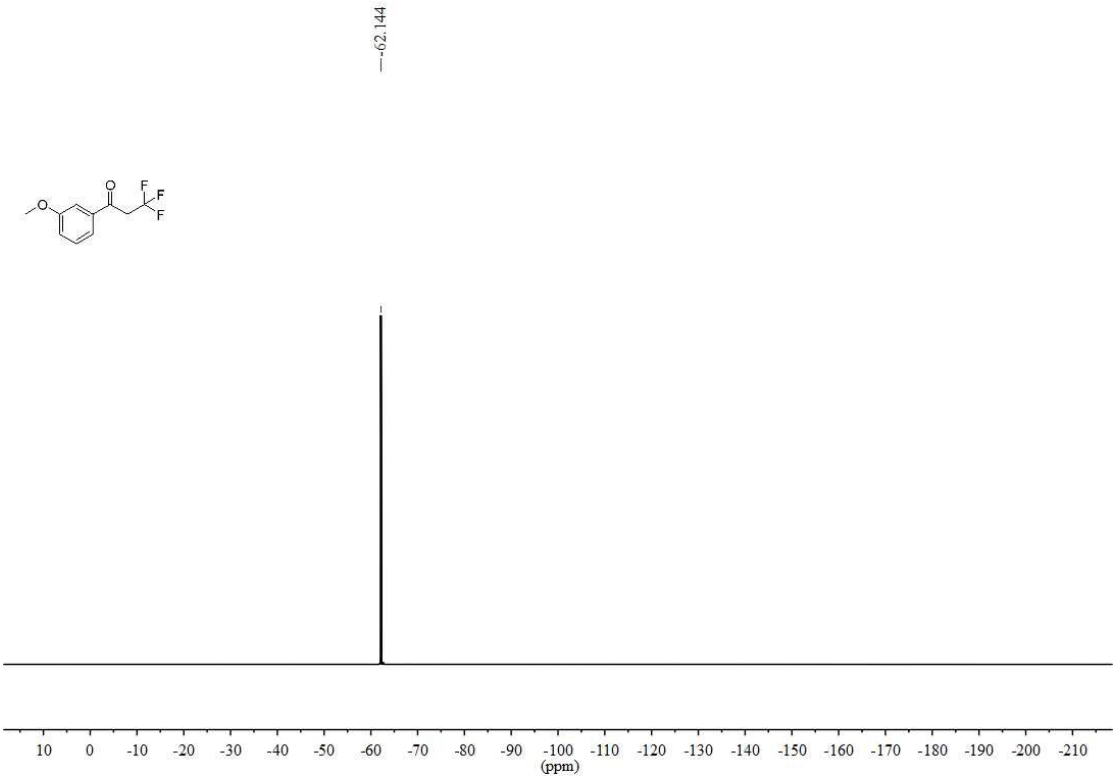
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3q**



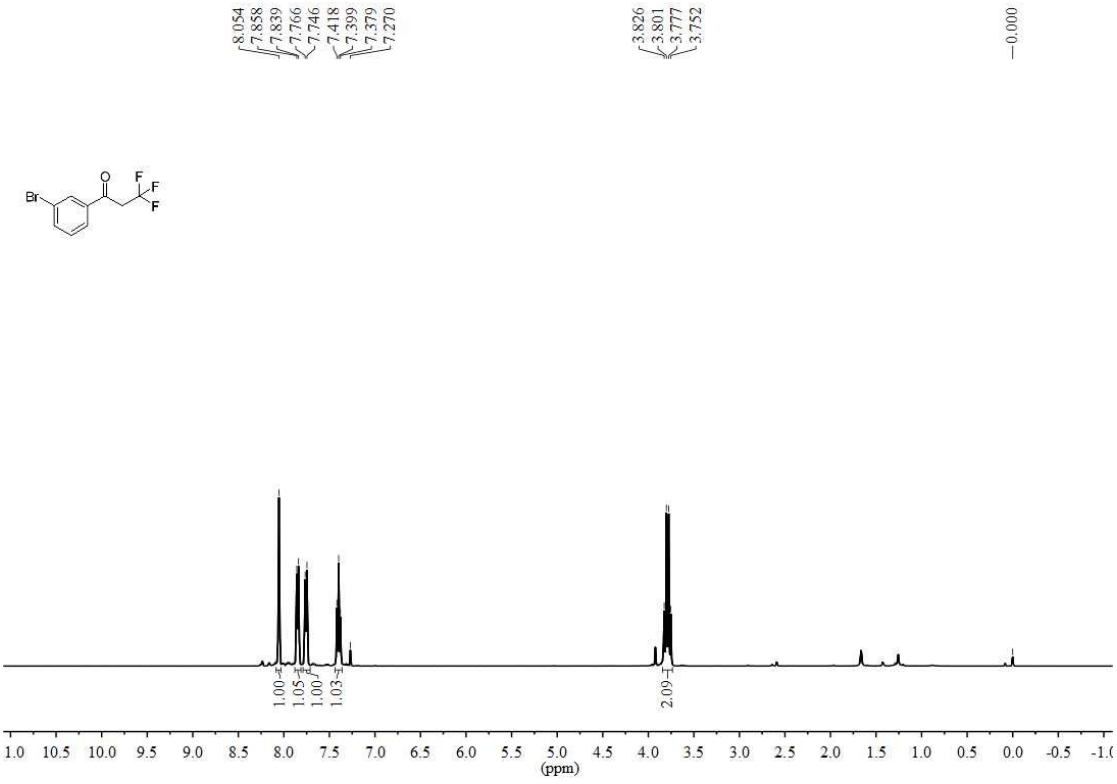
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3q**



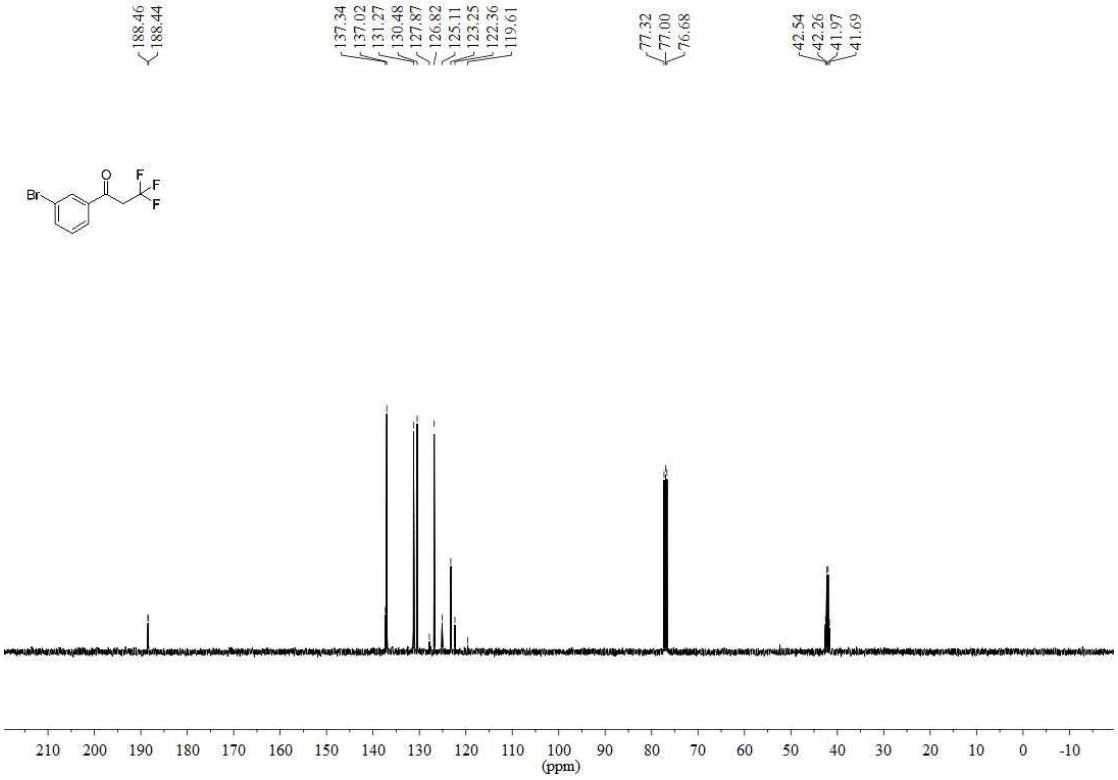
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3q**



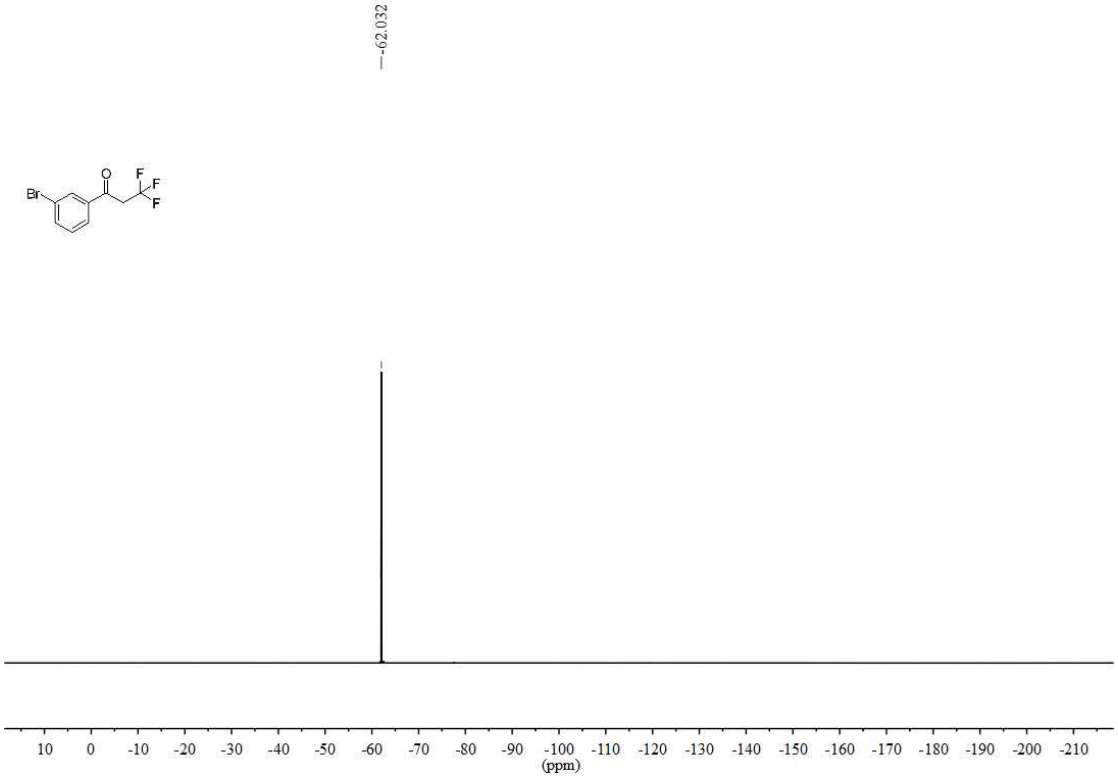
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3r**



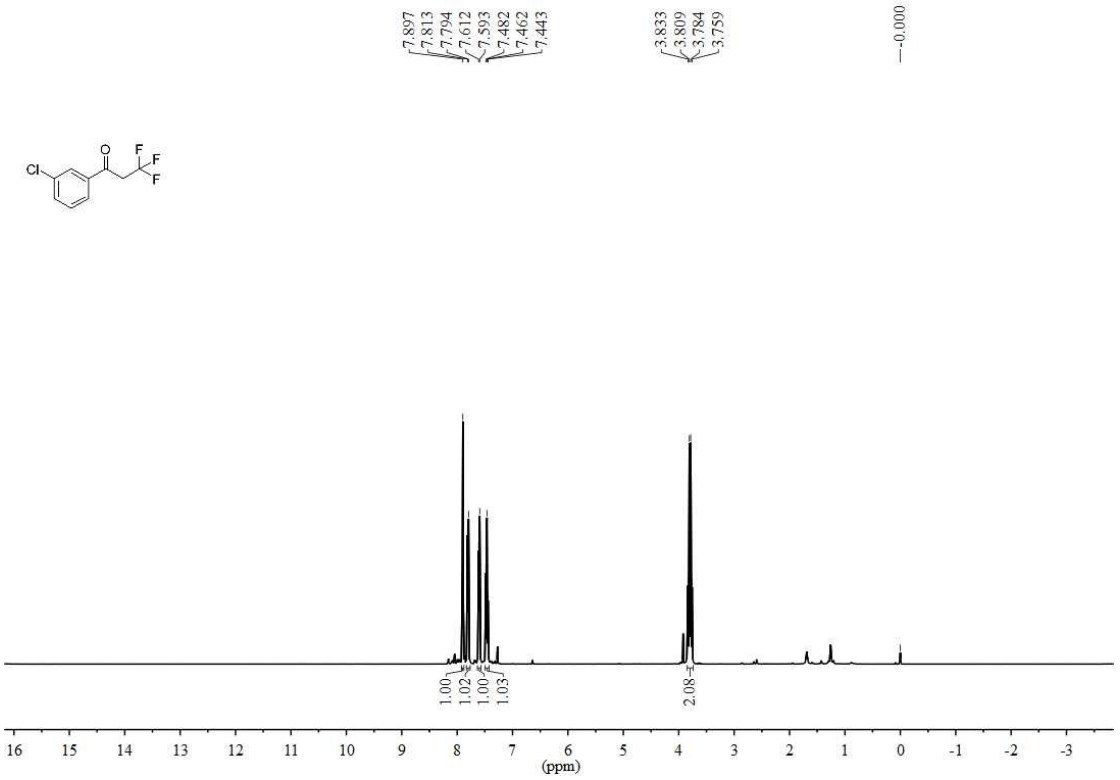
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3r**



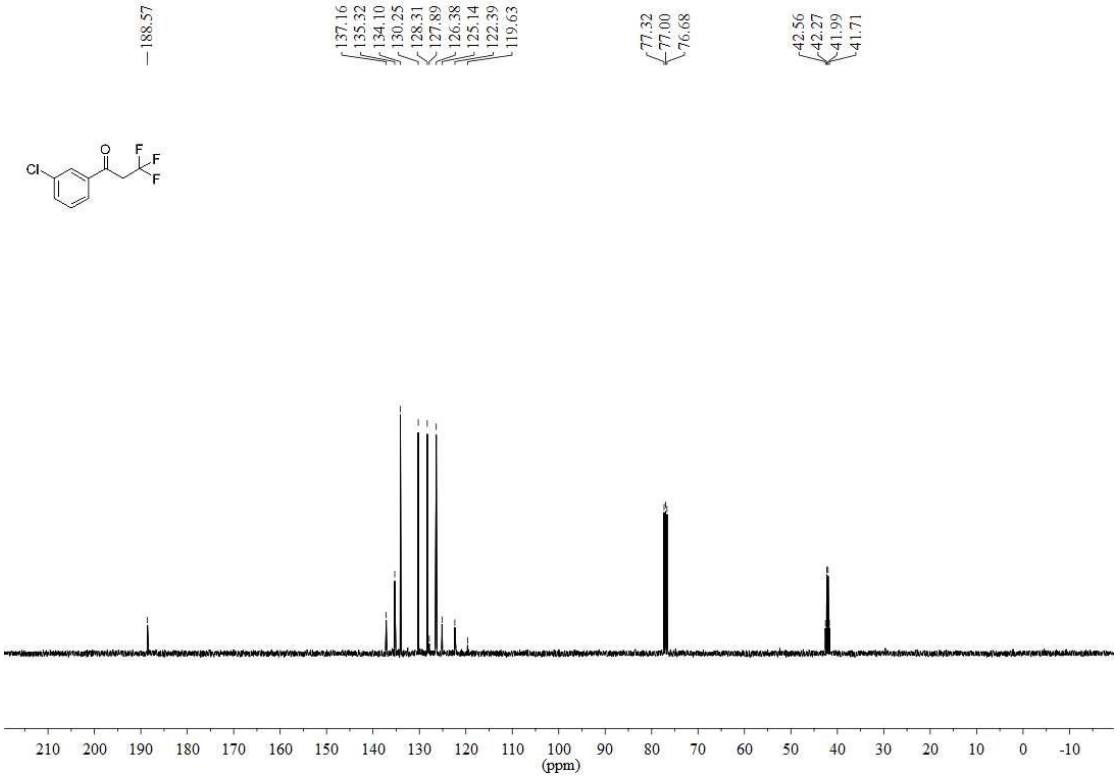
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3r**



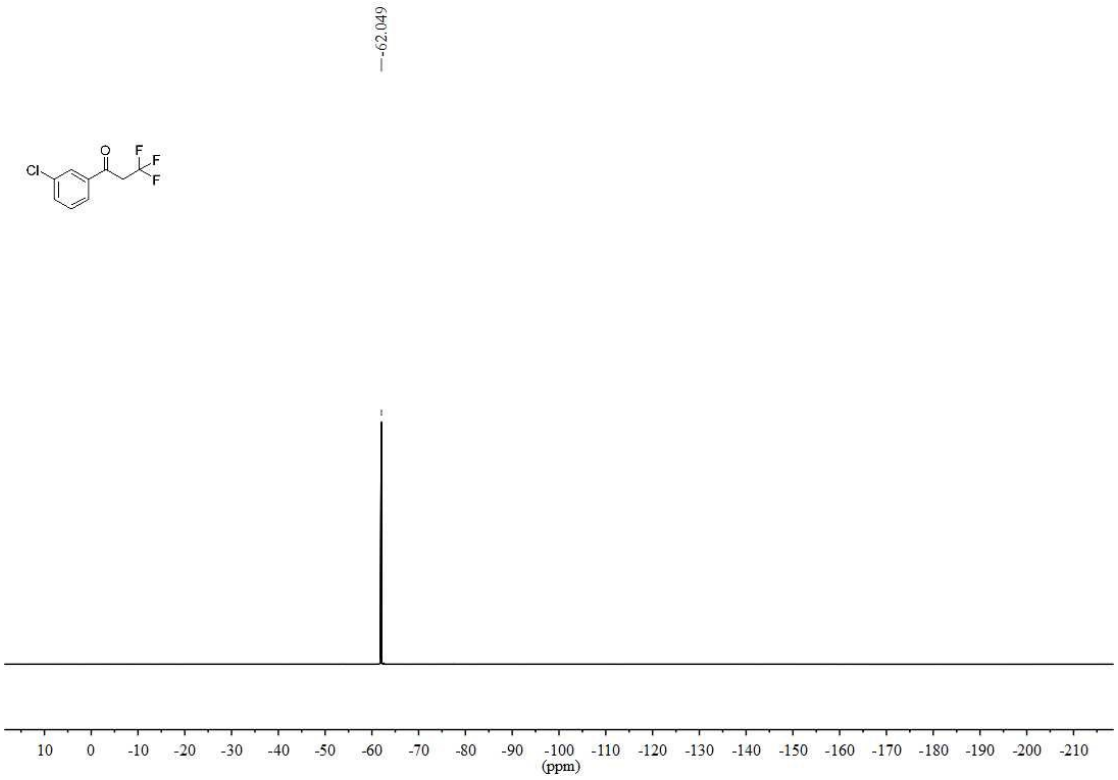
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3s**



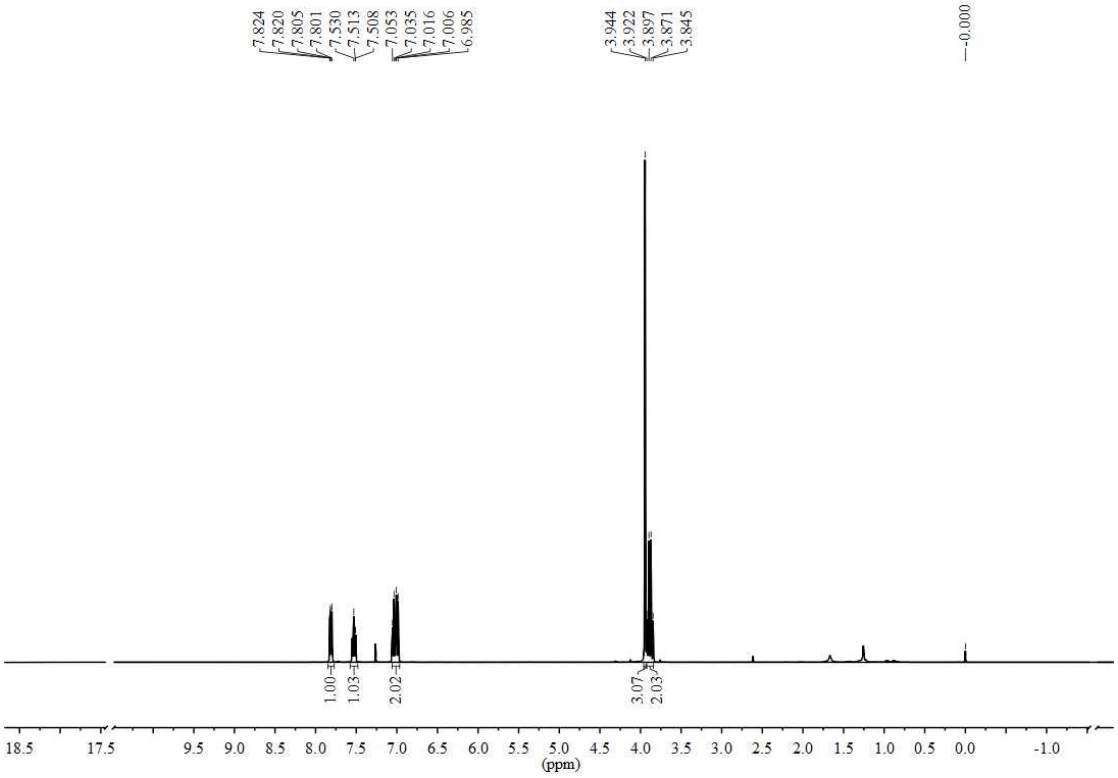
^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) of compound **3s**



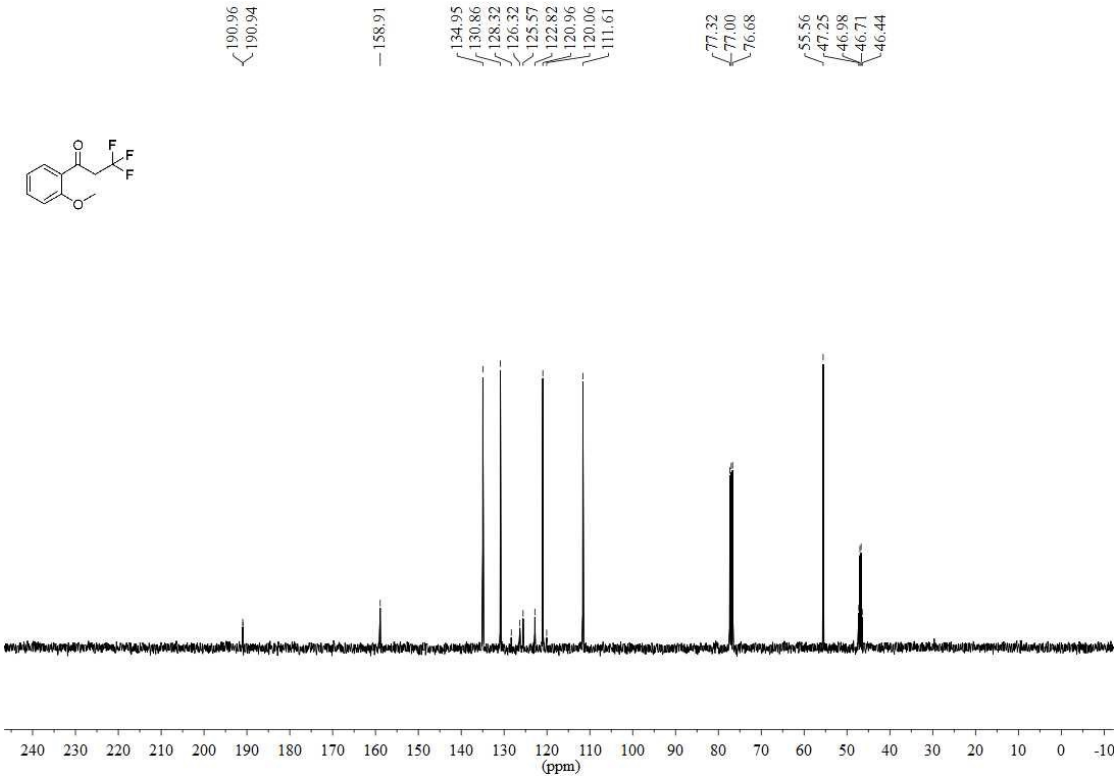
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3s**



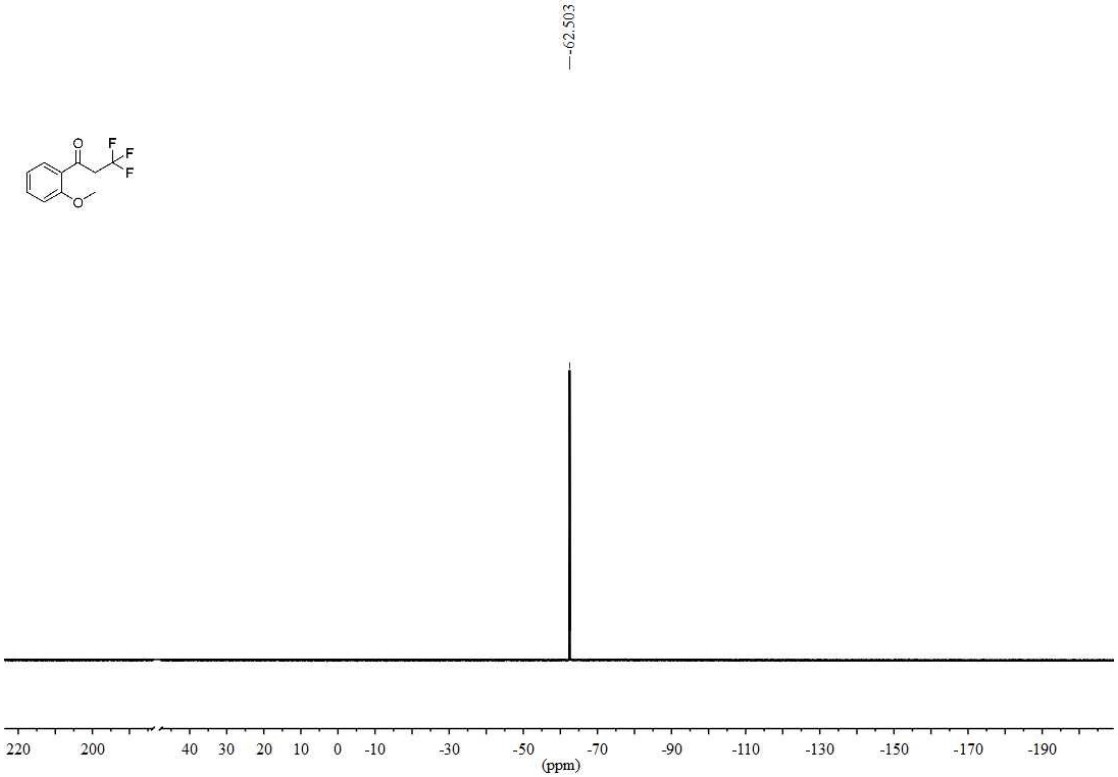
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3t**



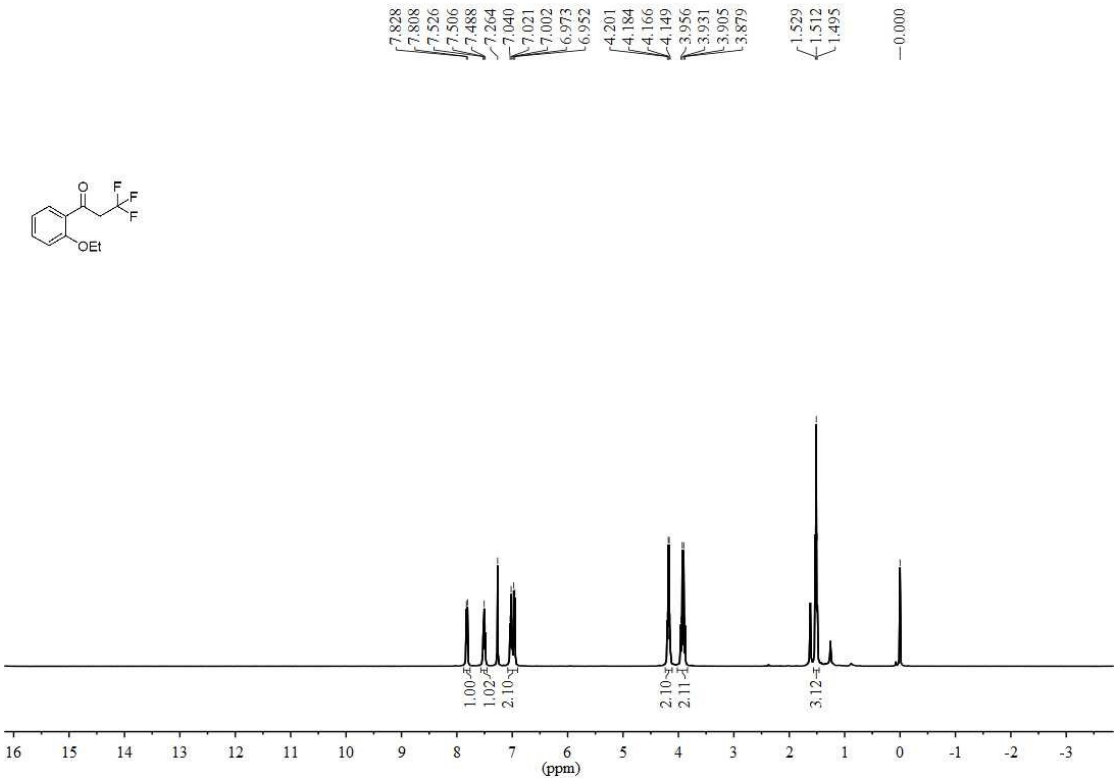
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3t**



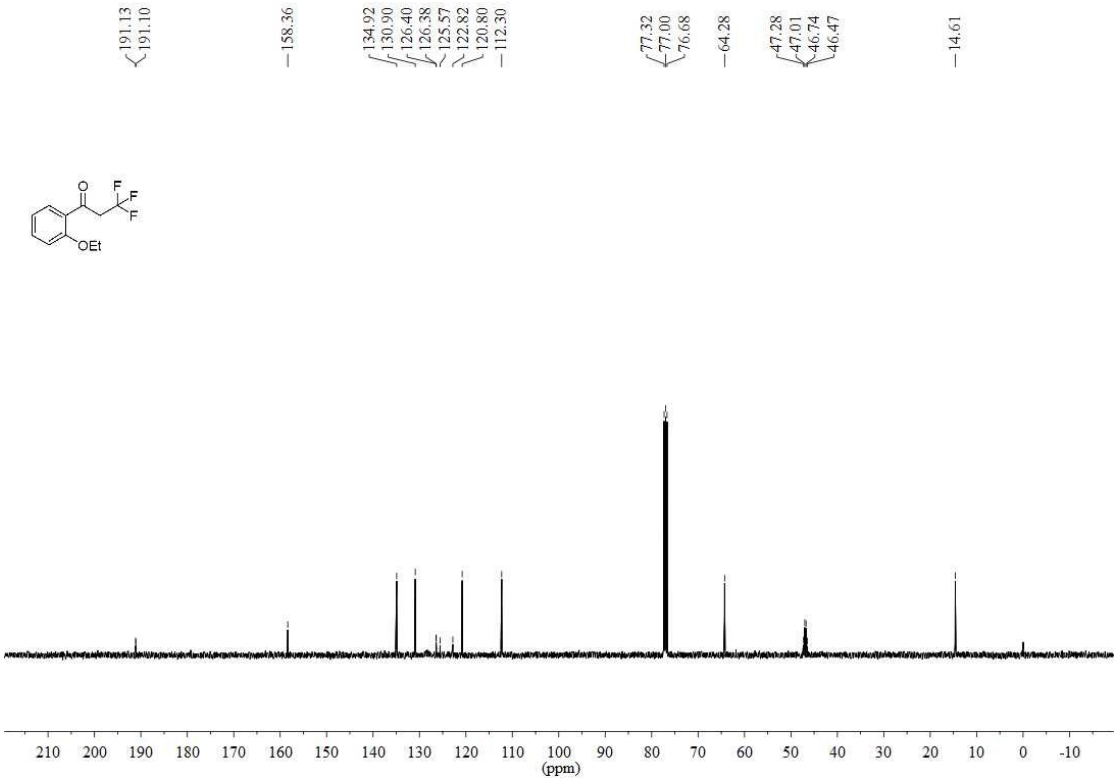
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3t**



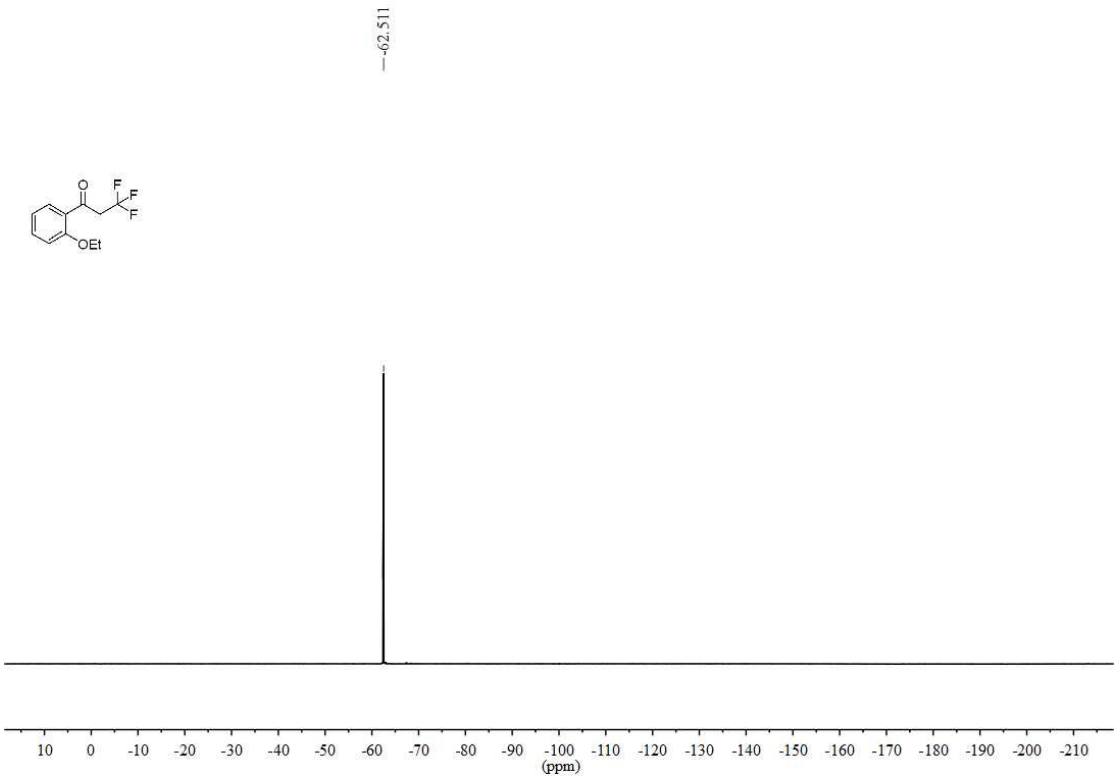
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3u**



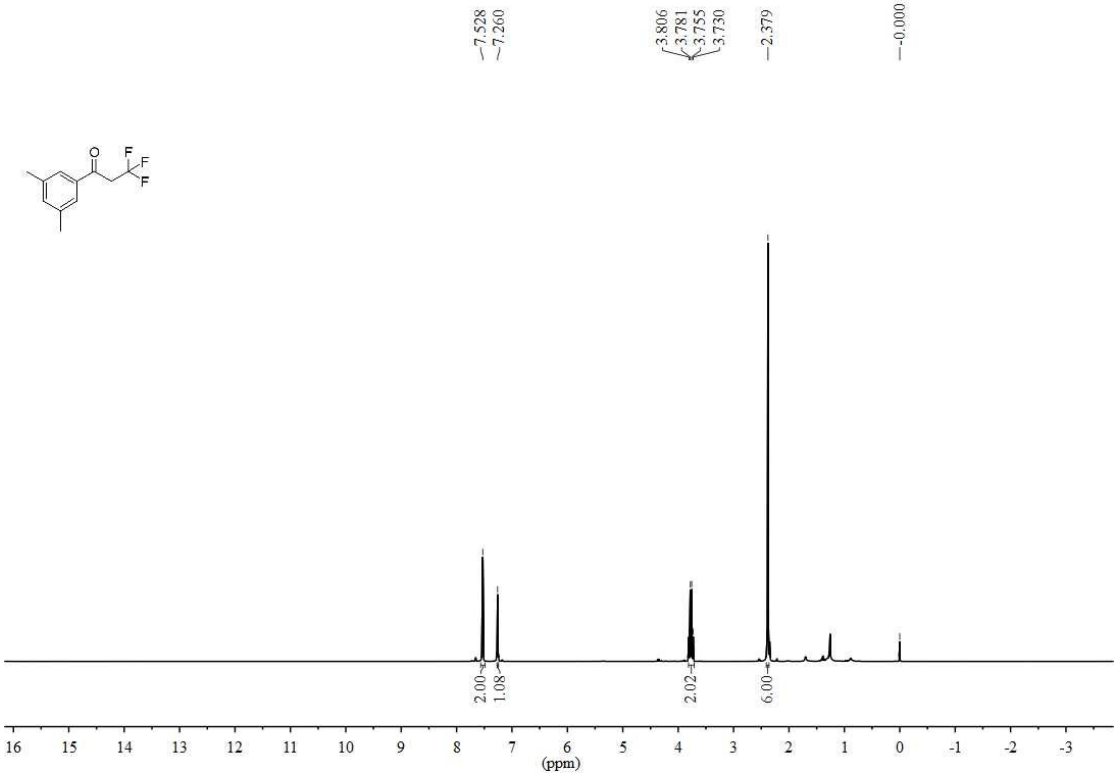
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3u**



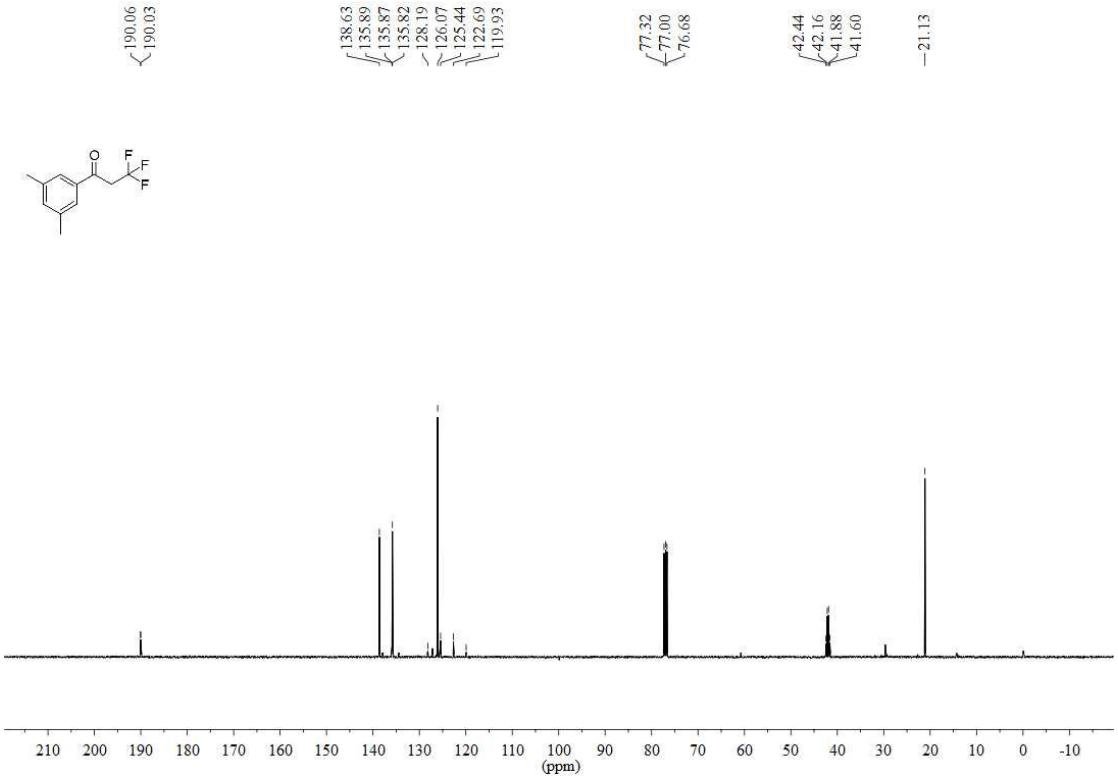
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3u**



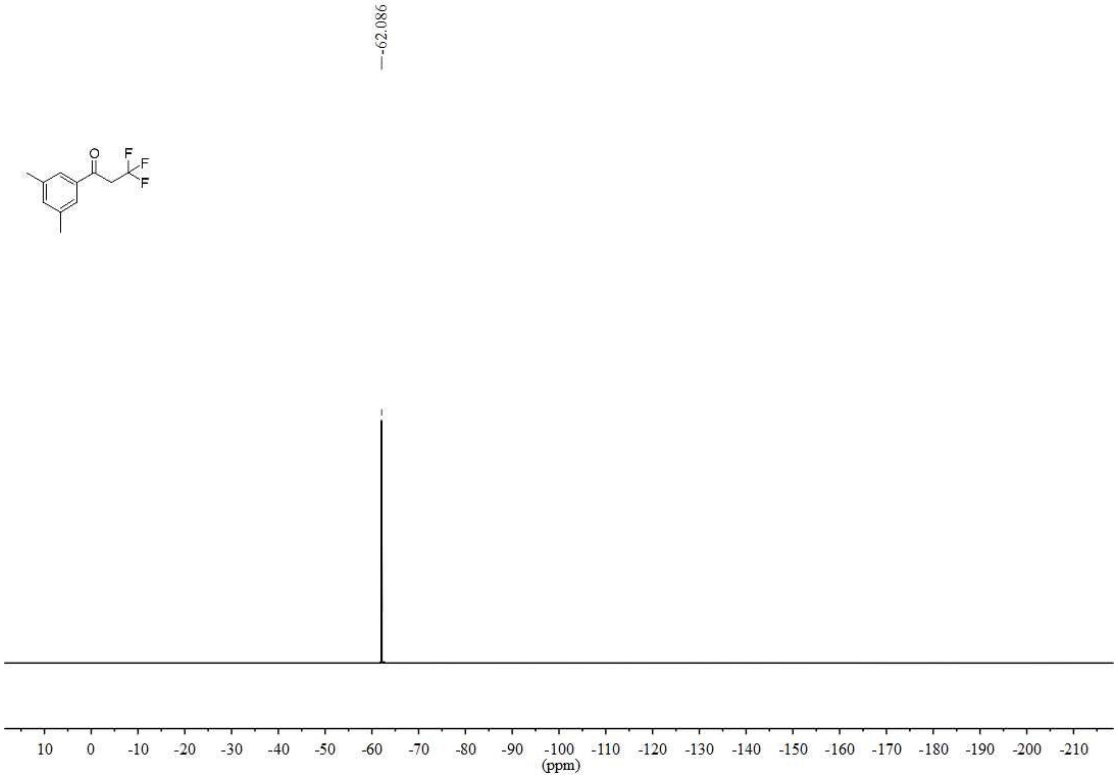
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3v**



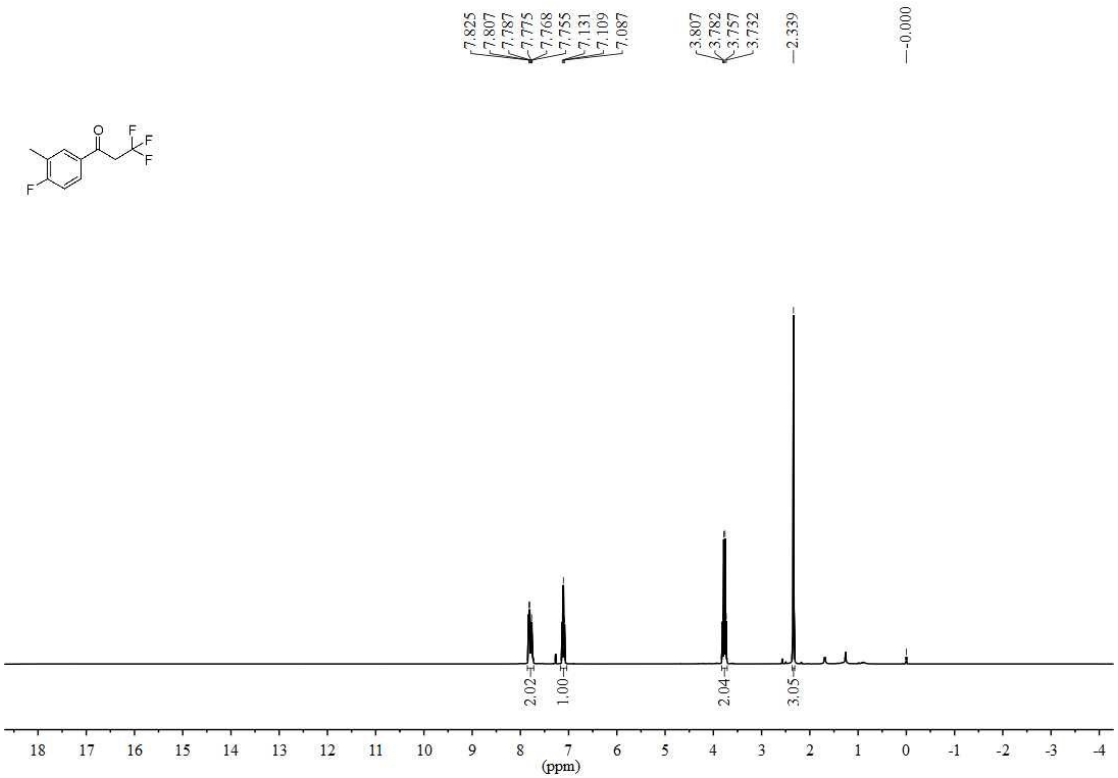
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3v**



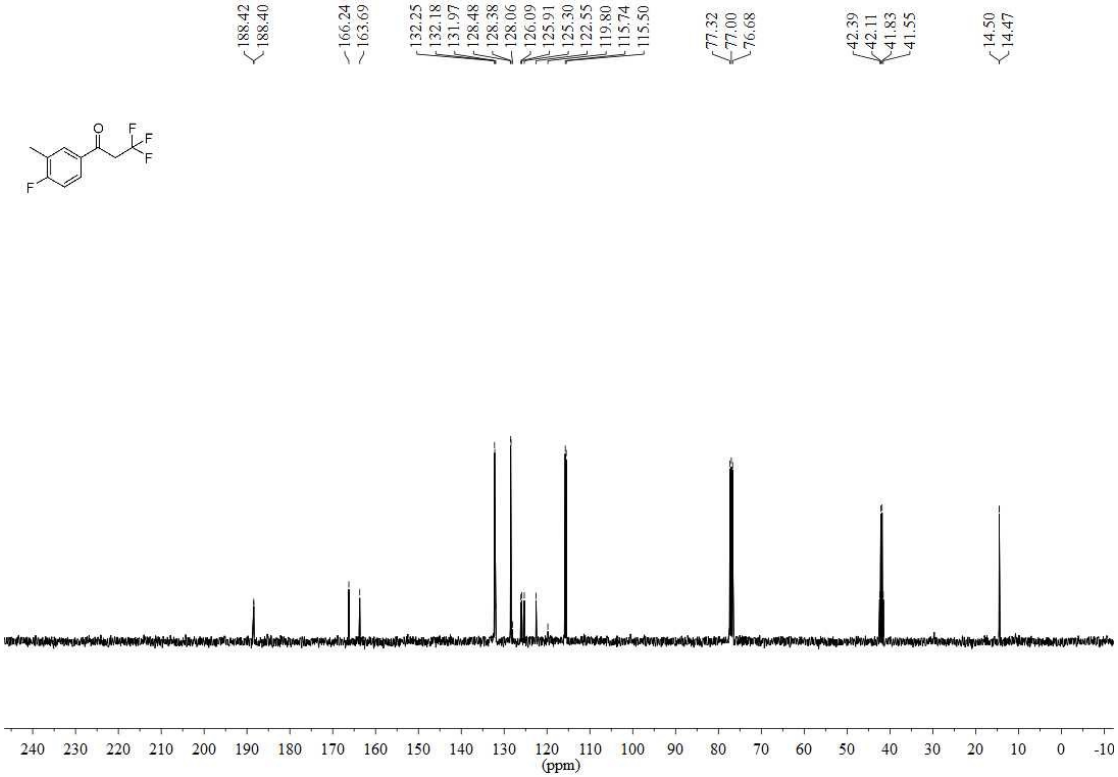
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3v**



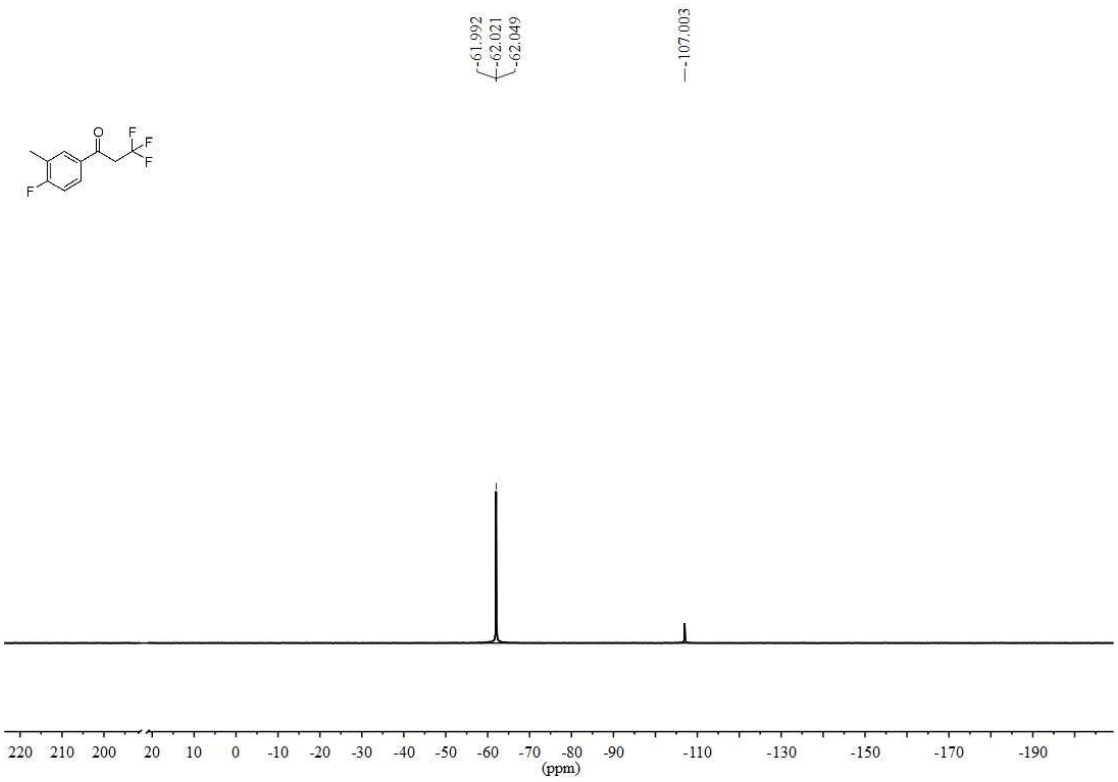
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3w**



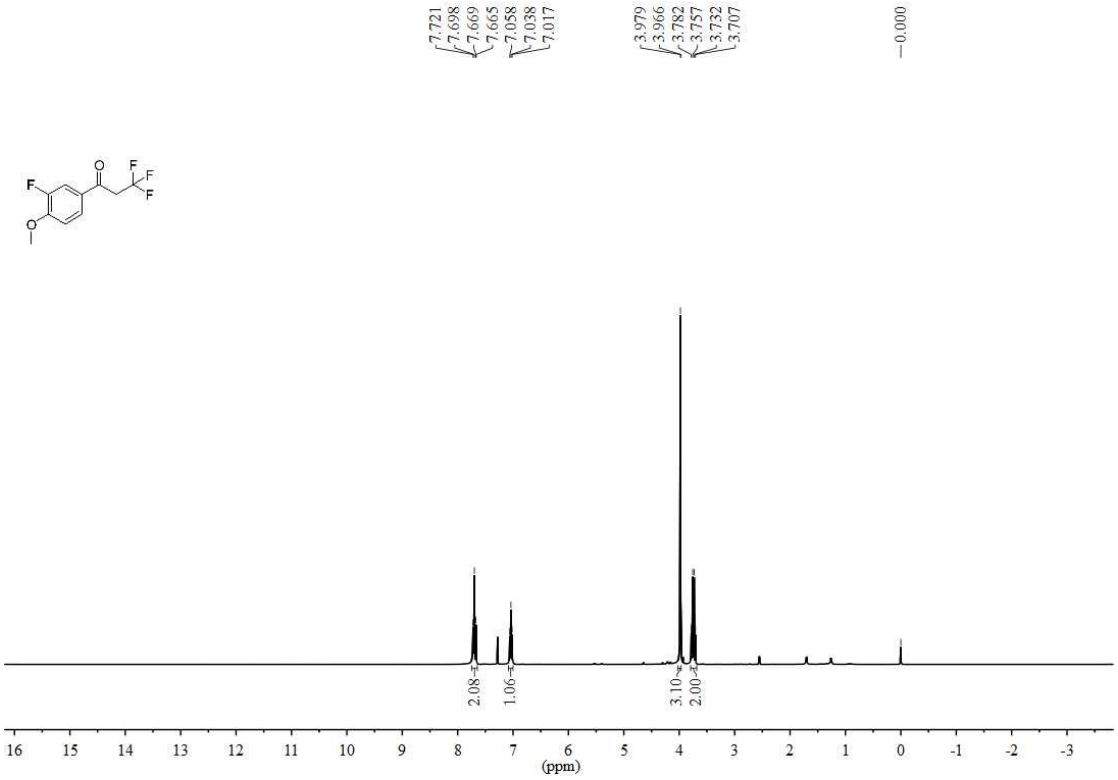
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3w**



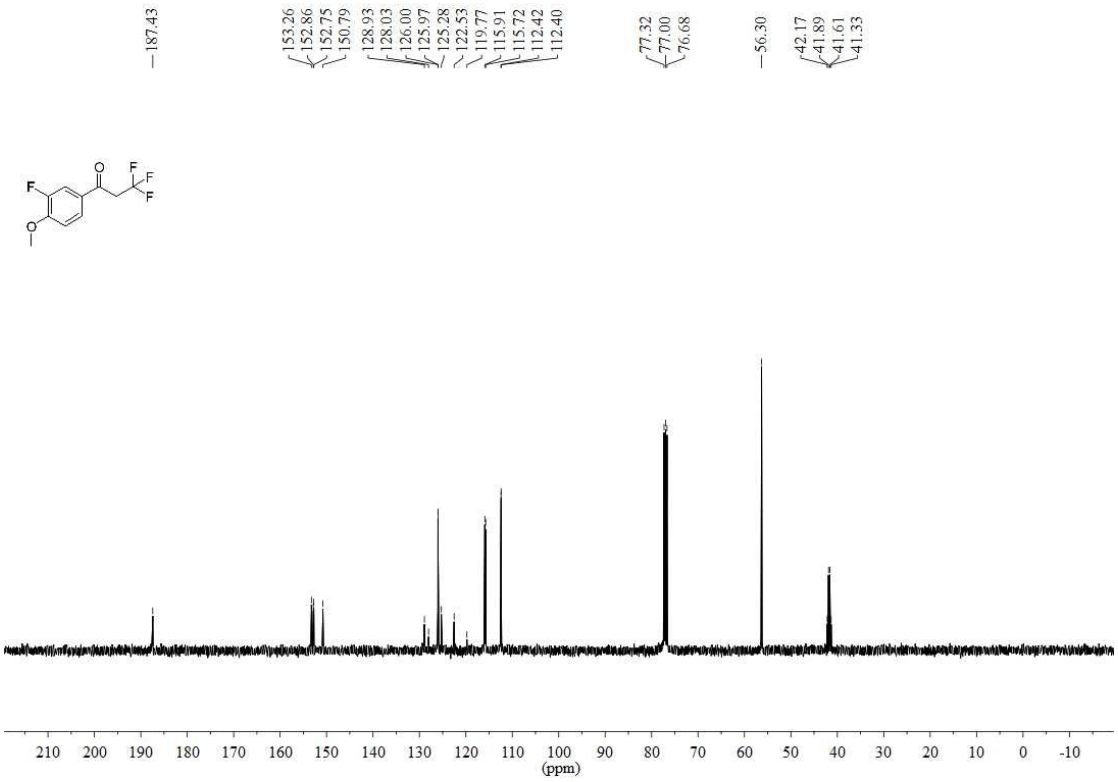
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3w**



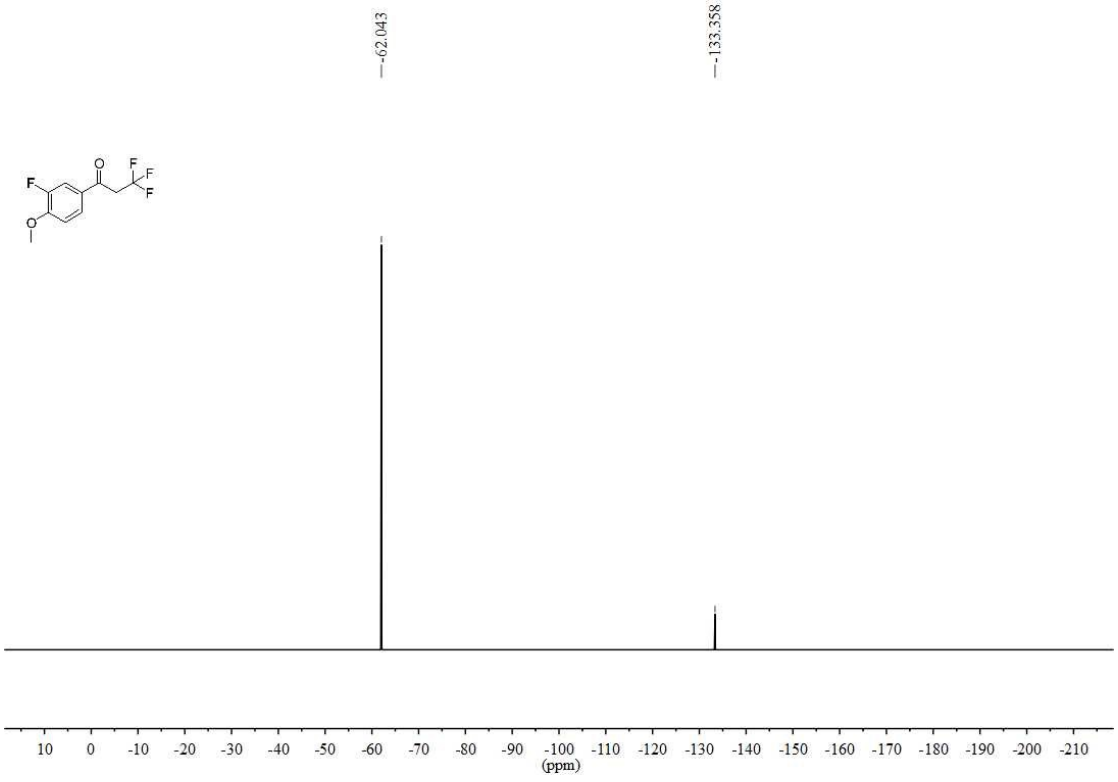
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3x**



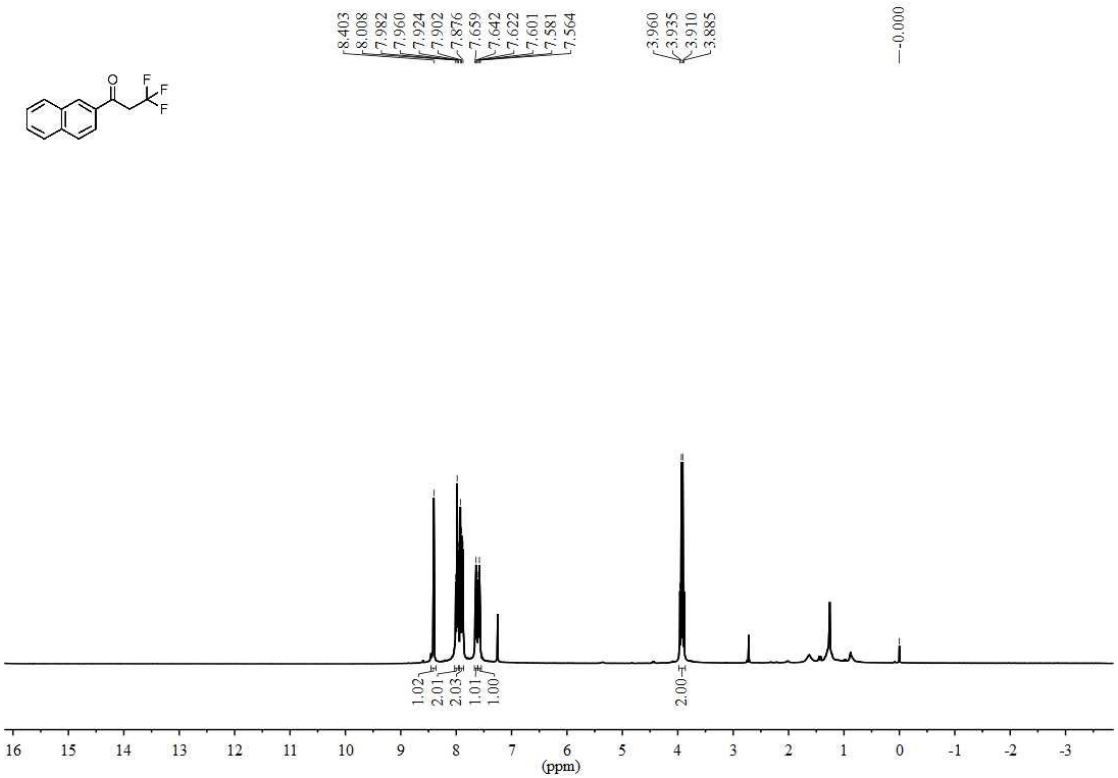
^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) of compound **3x**



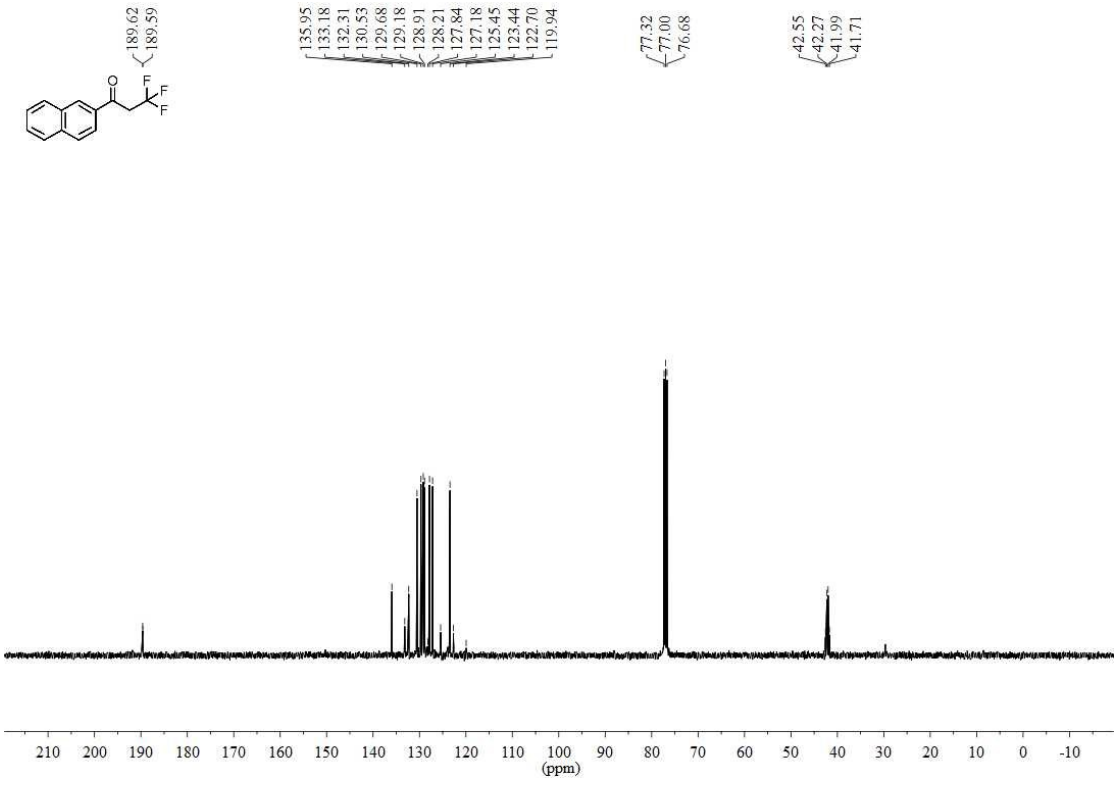
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3x**



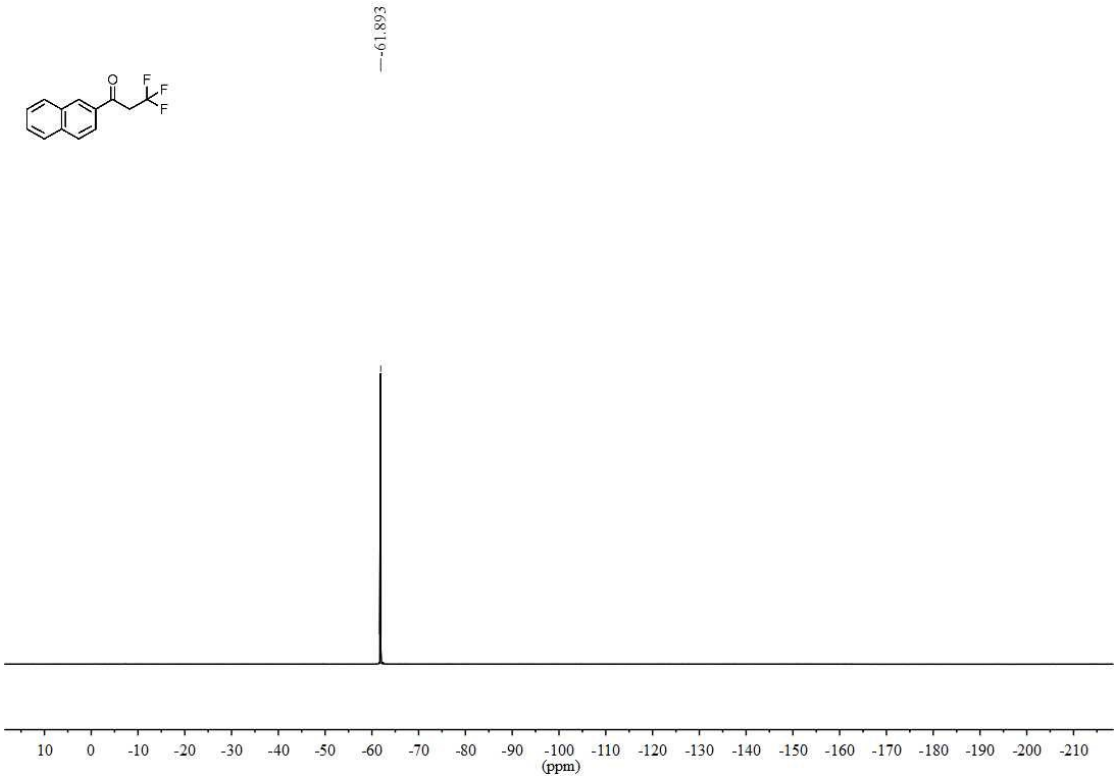
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3y**



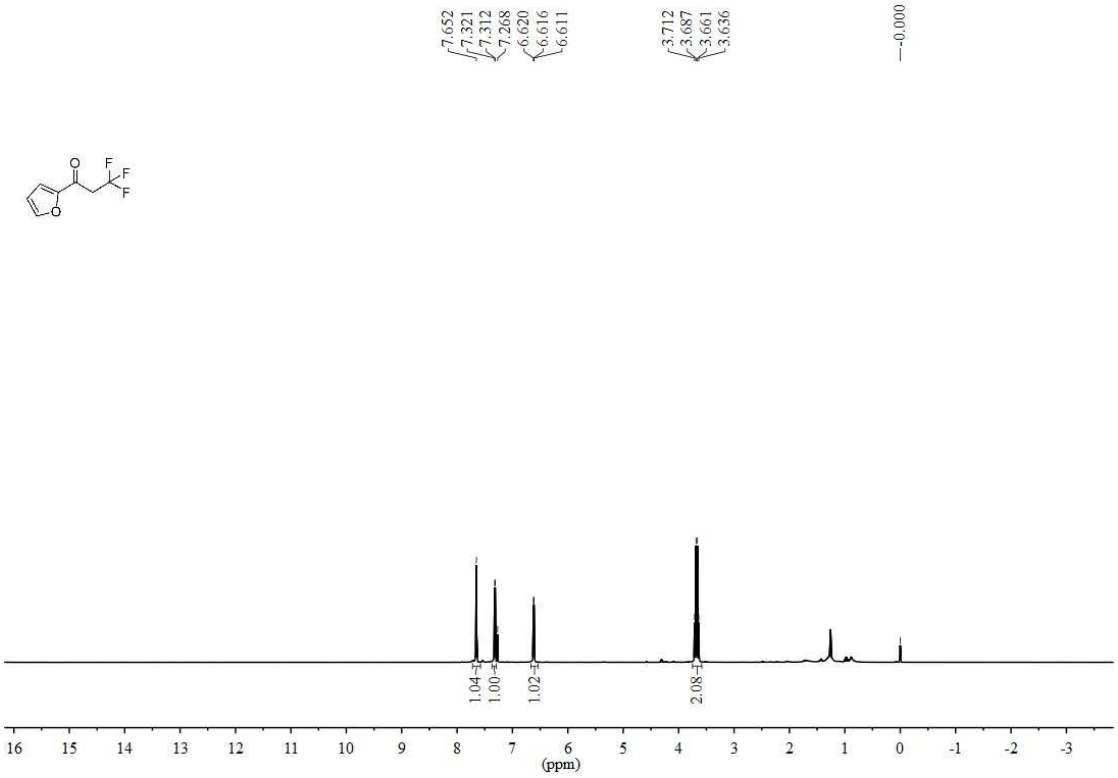
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3y**



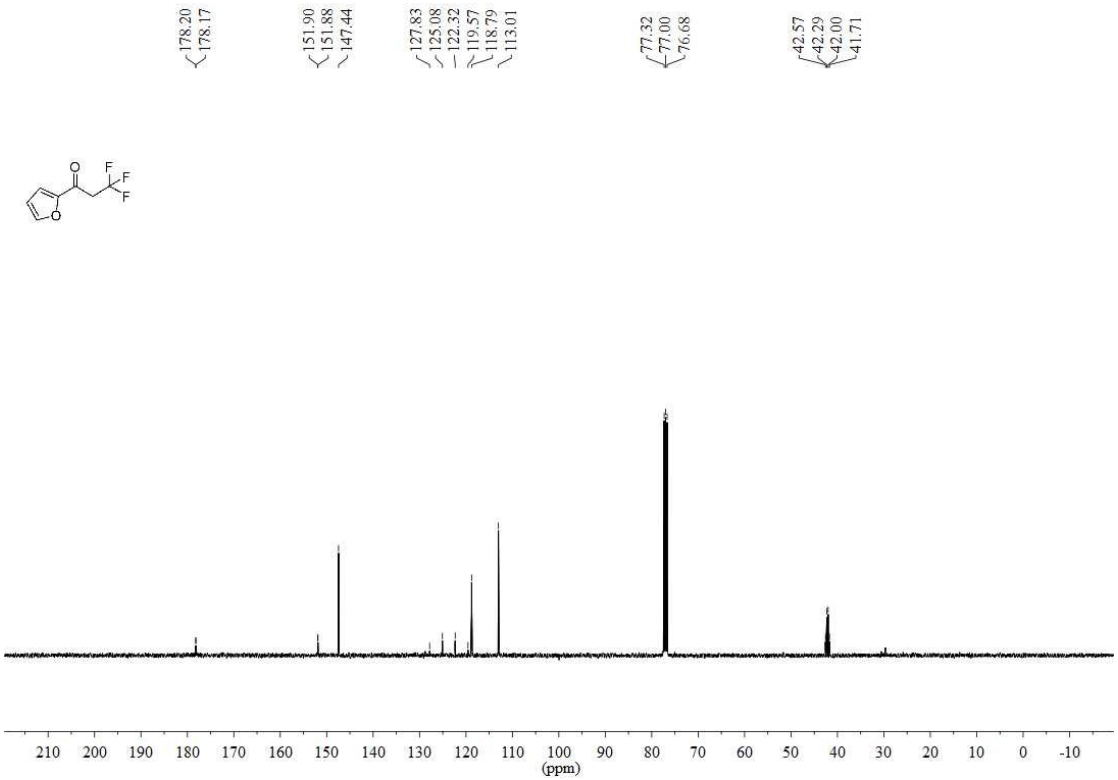
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3y**



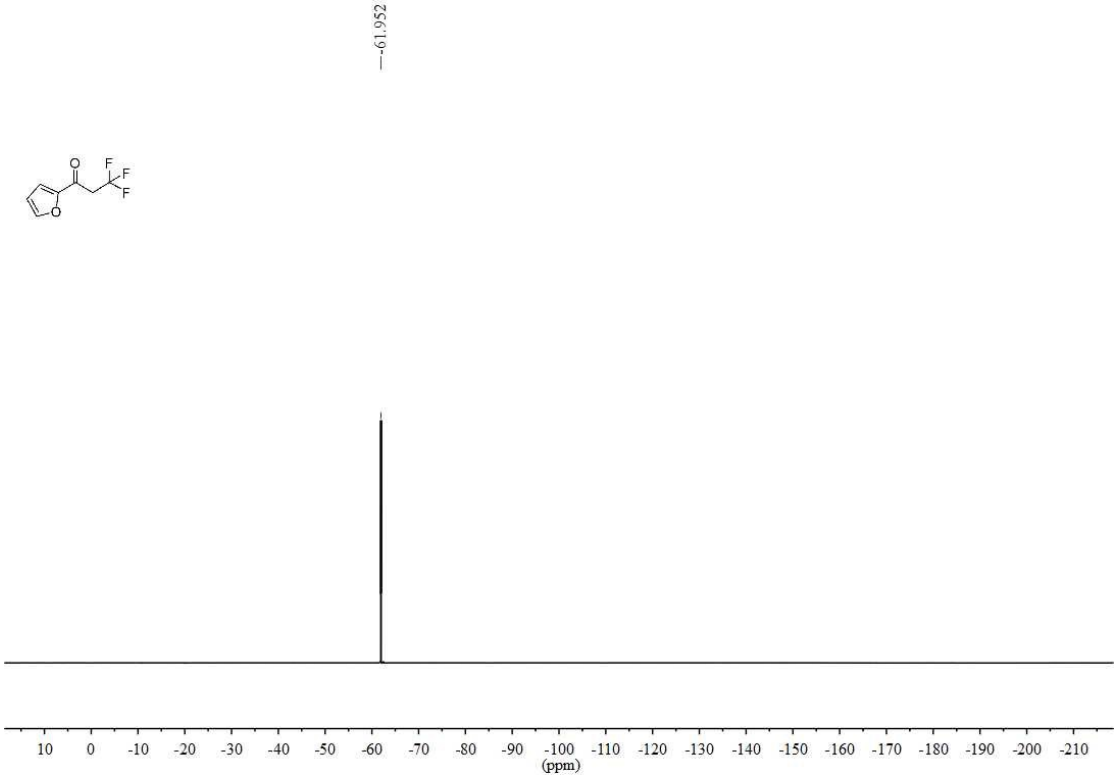
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3z**



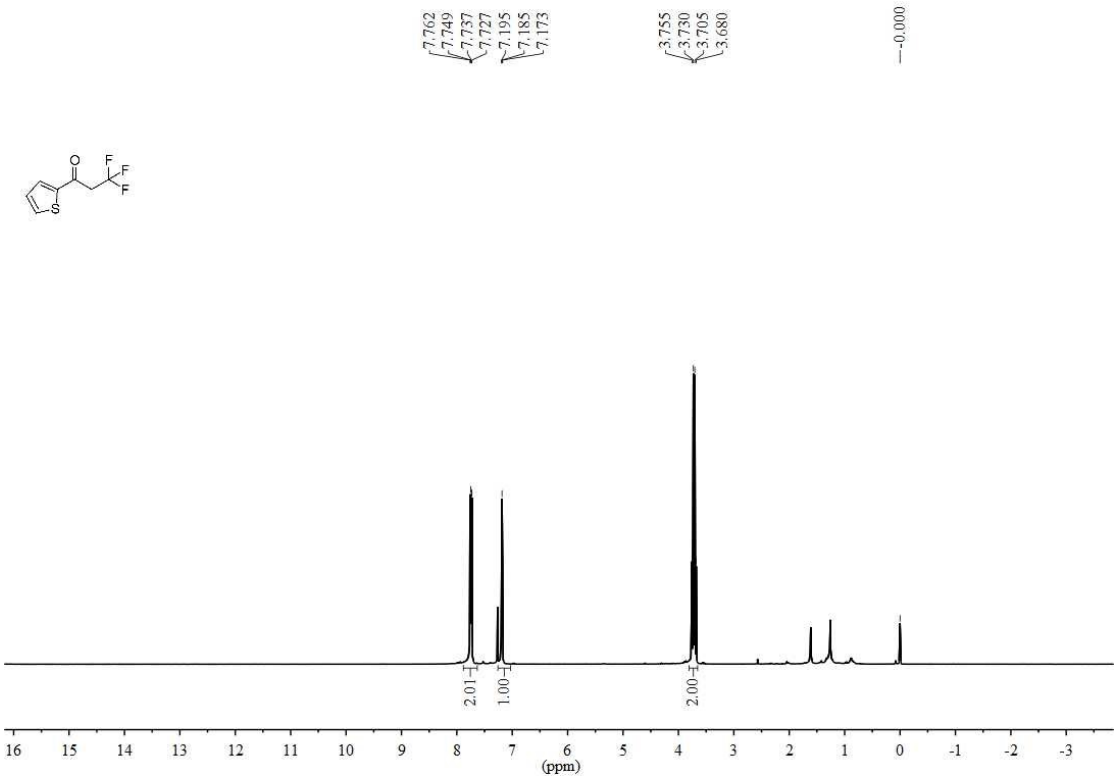
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3z**



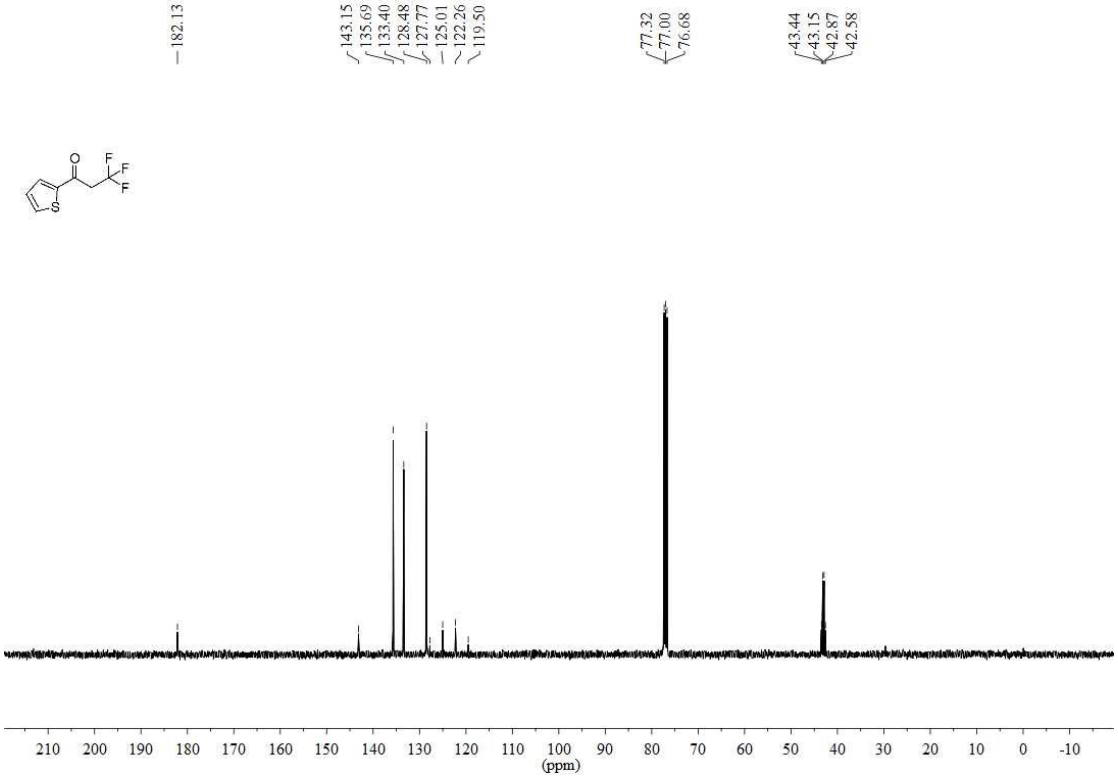
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3z**



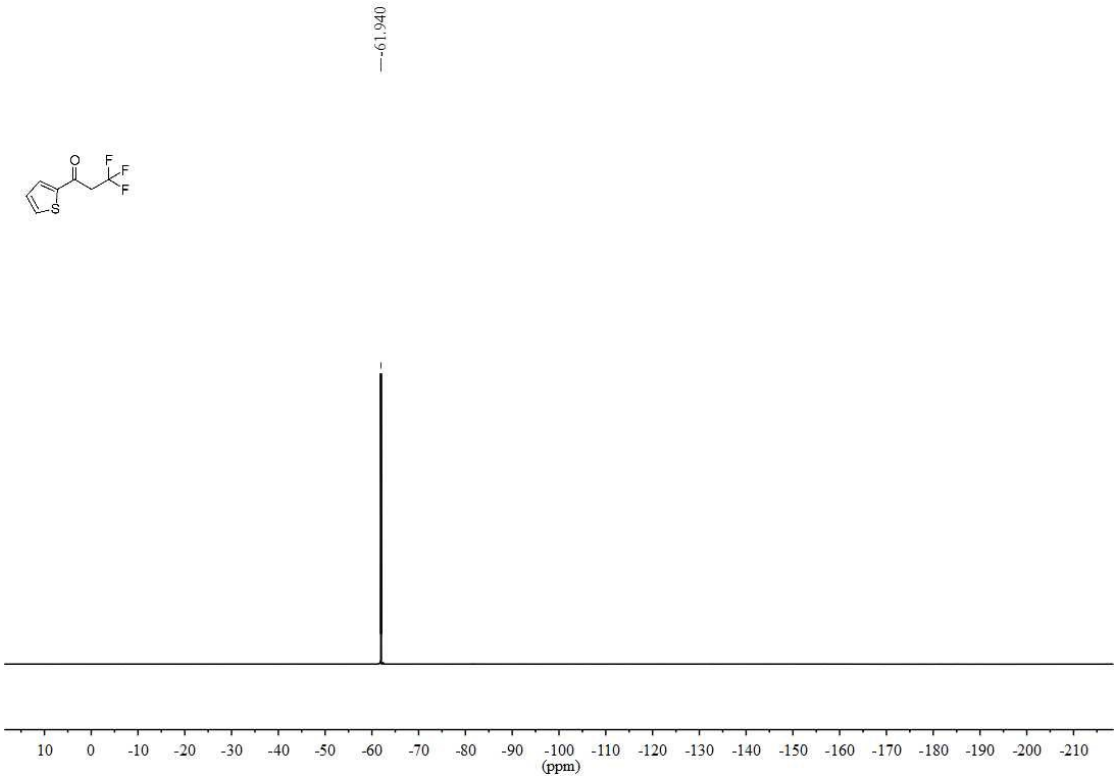
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3aa**



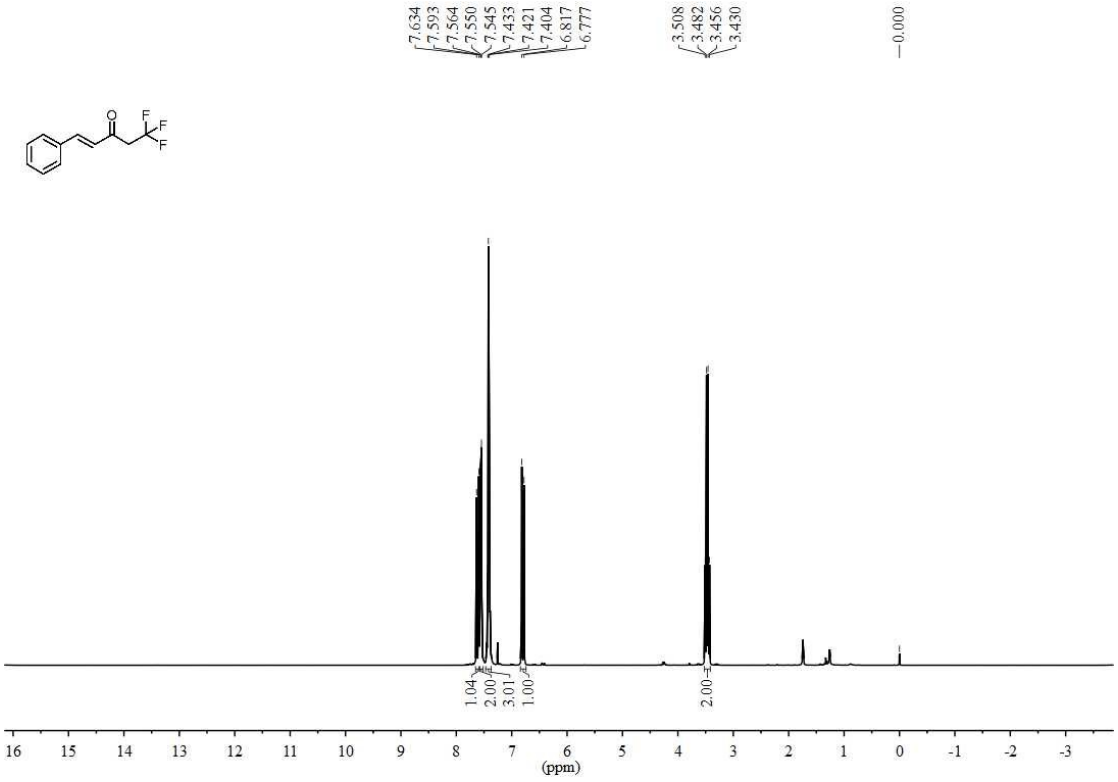
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3aa**



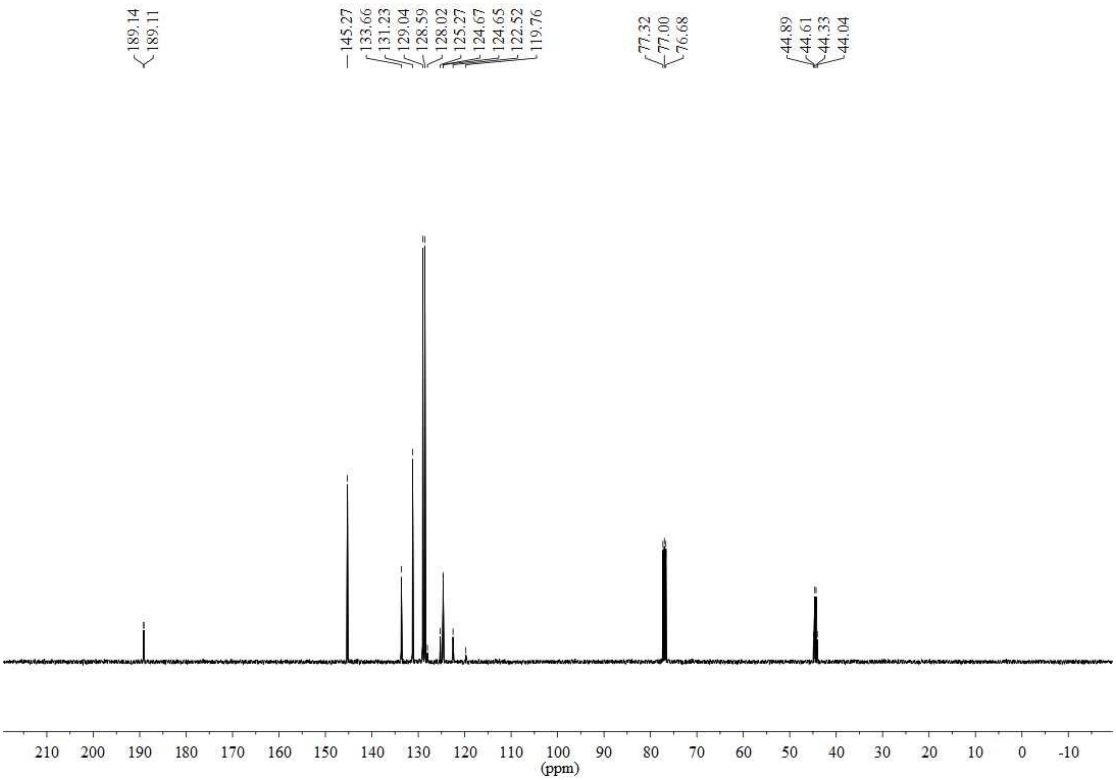
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3aa**



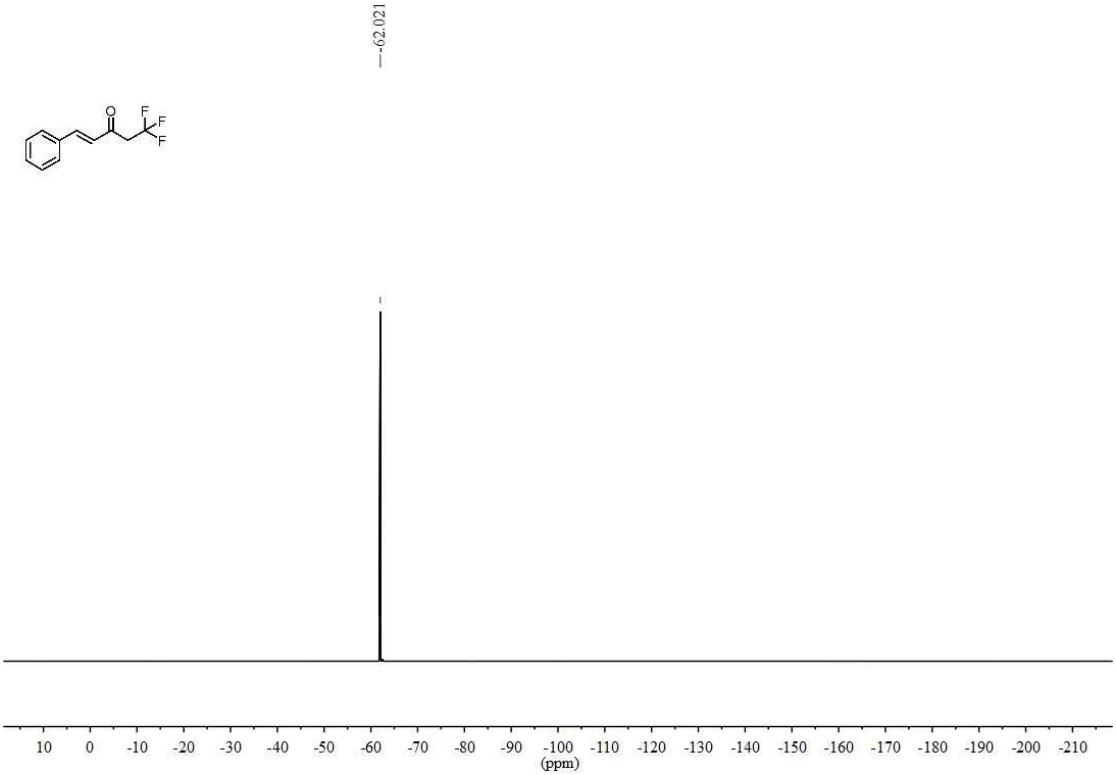
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3ab**



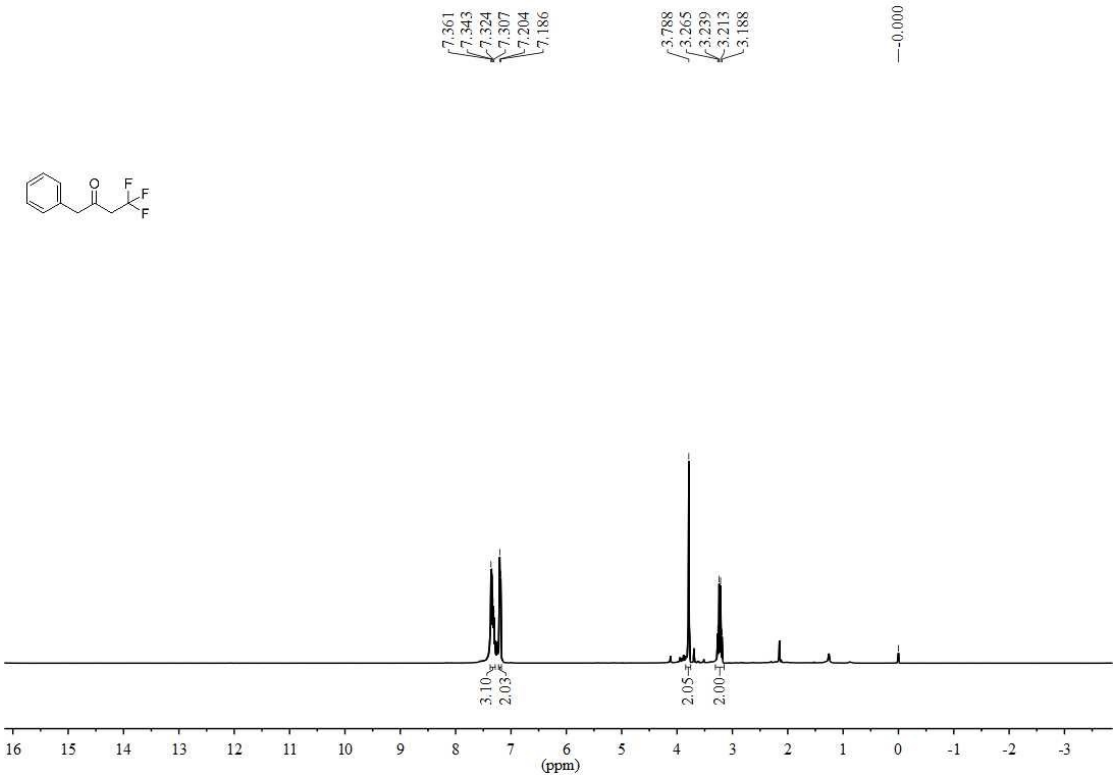
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3ab**



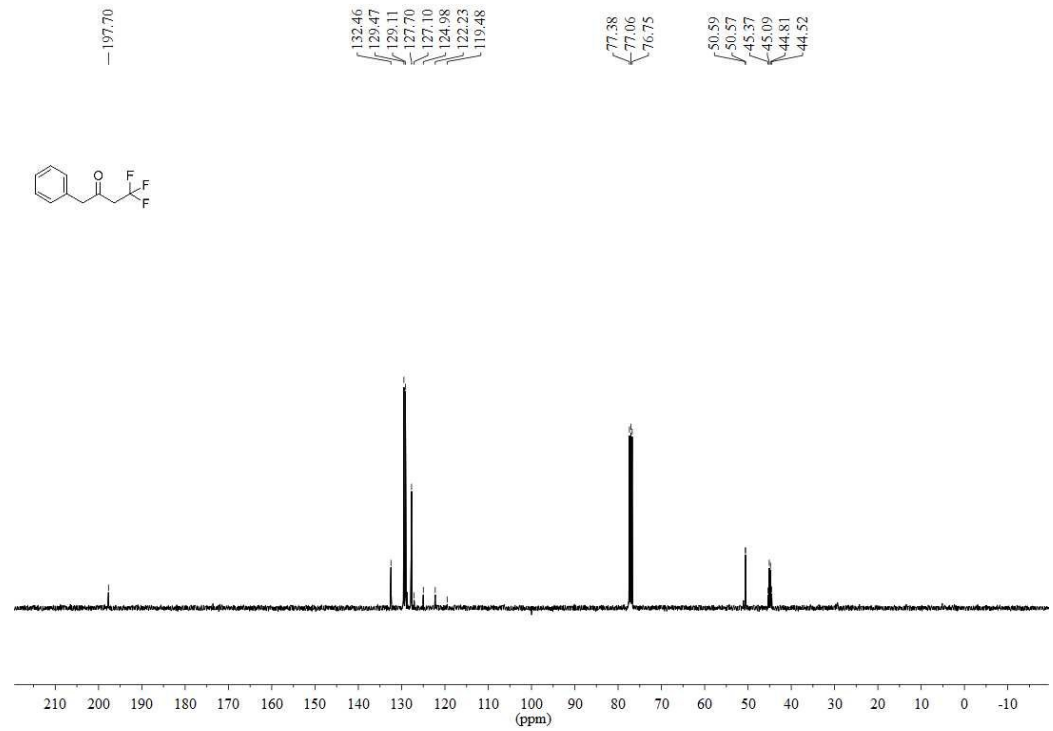
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3ab**



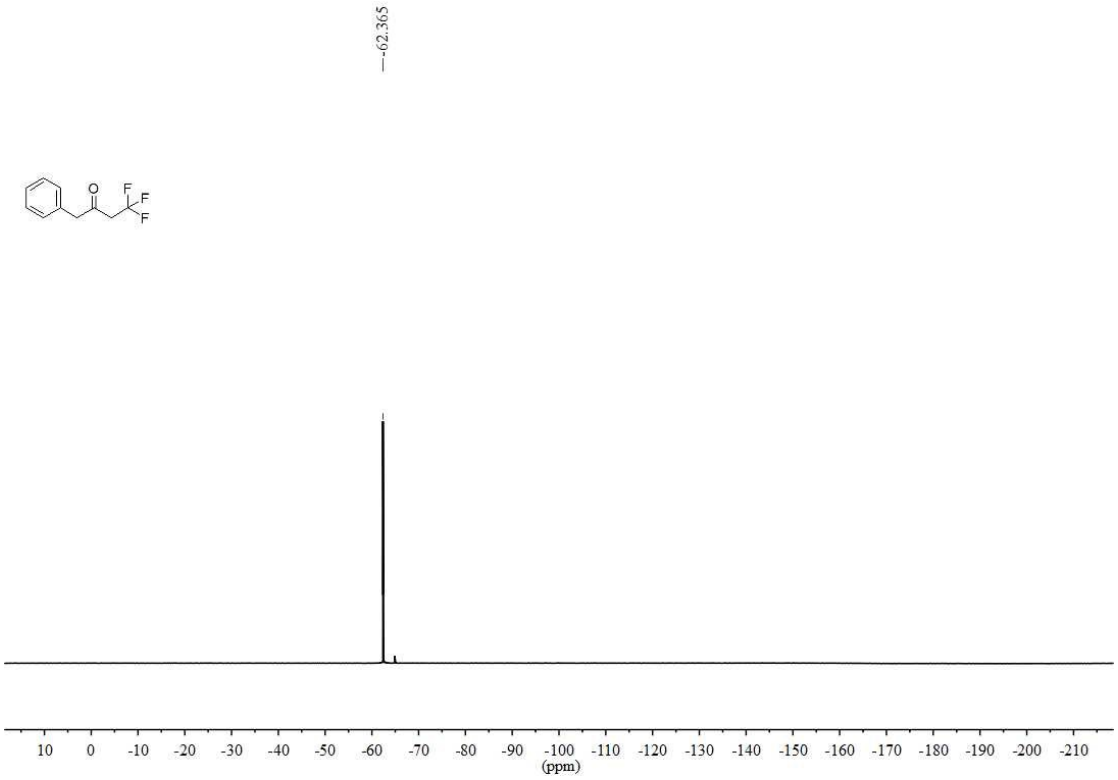
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3ac**



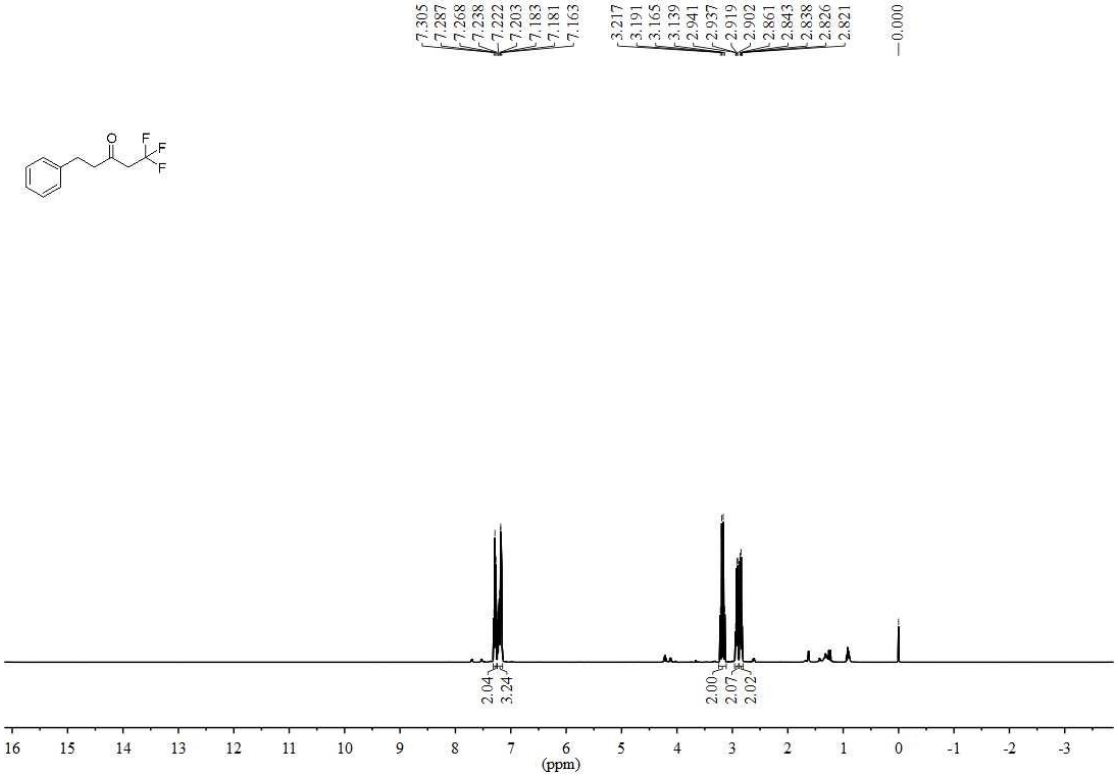
^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) of compound **3ac**



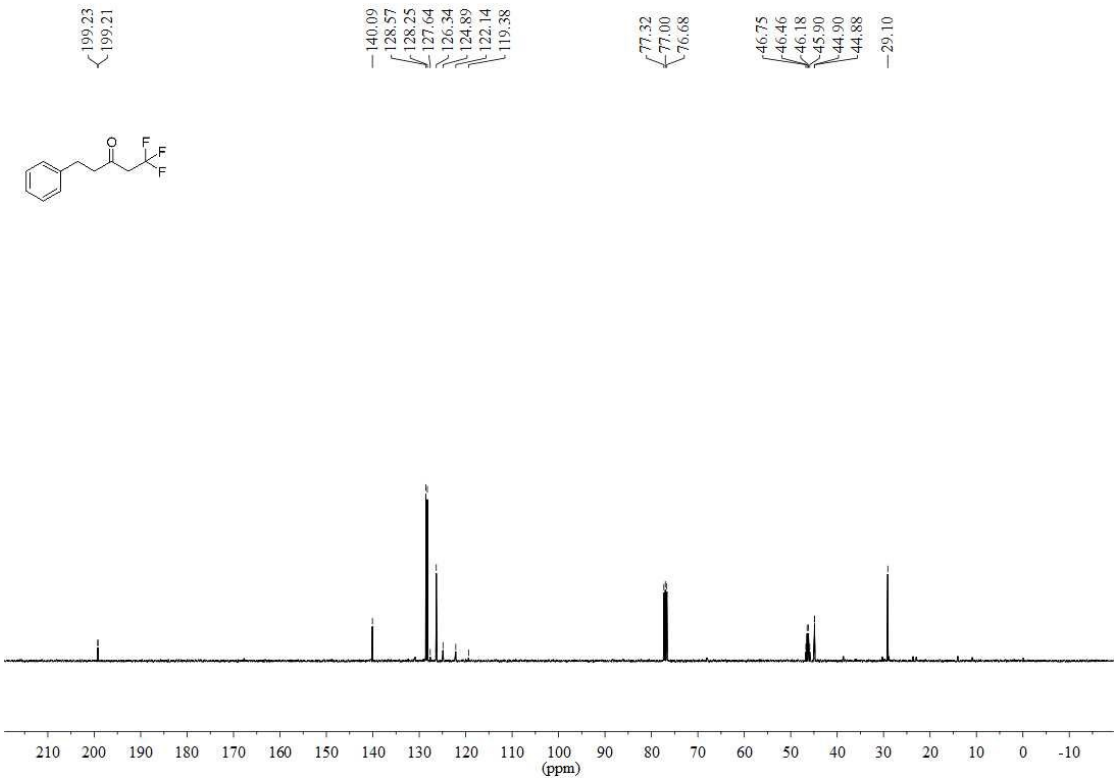
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3ac**



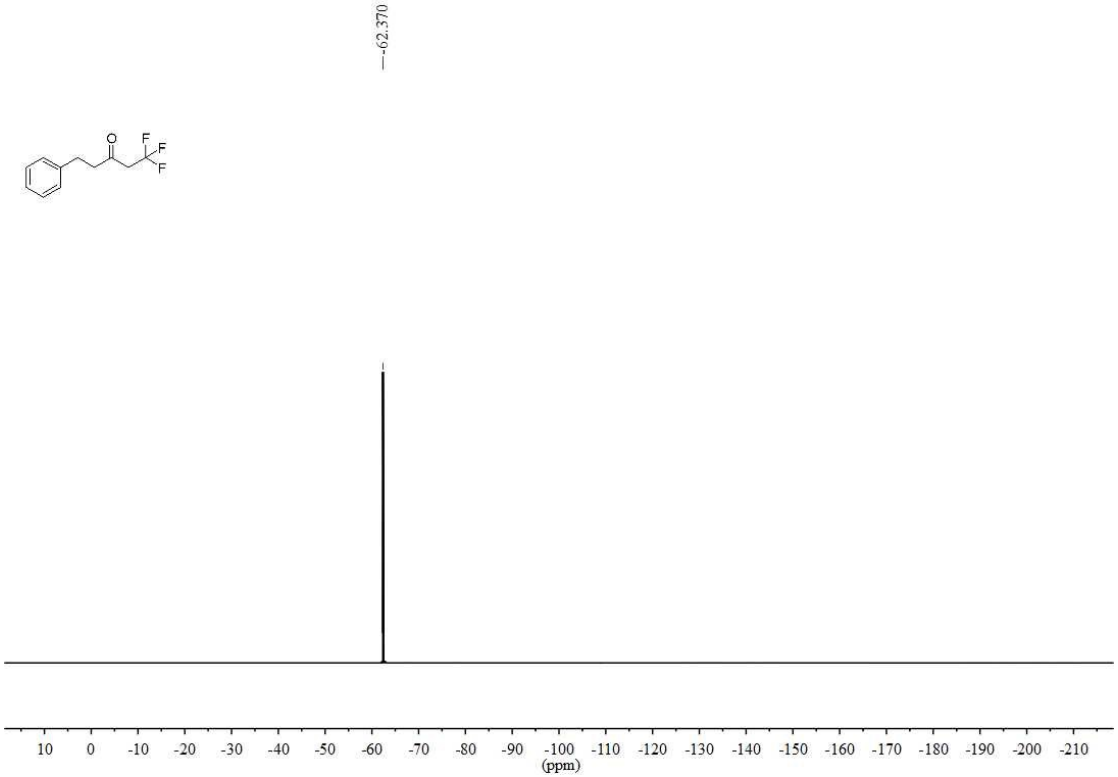
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3ad**



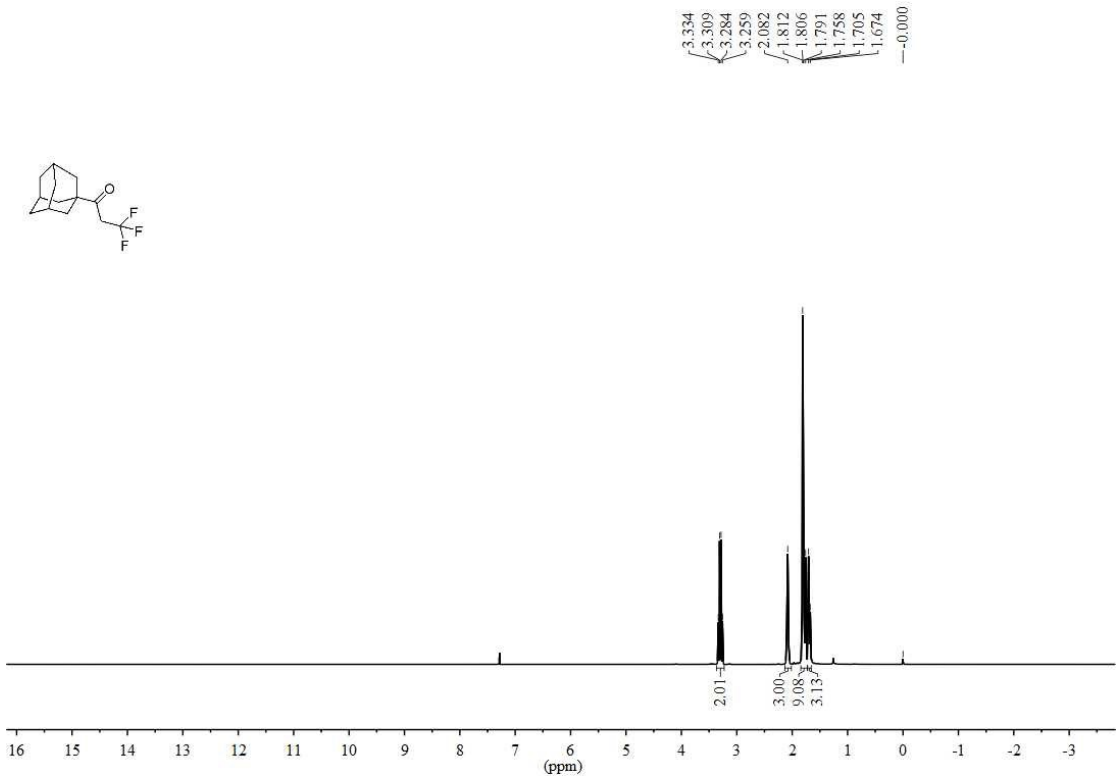
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3ad**



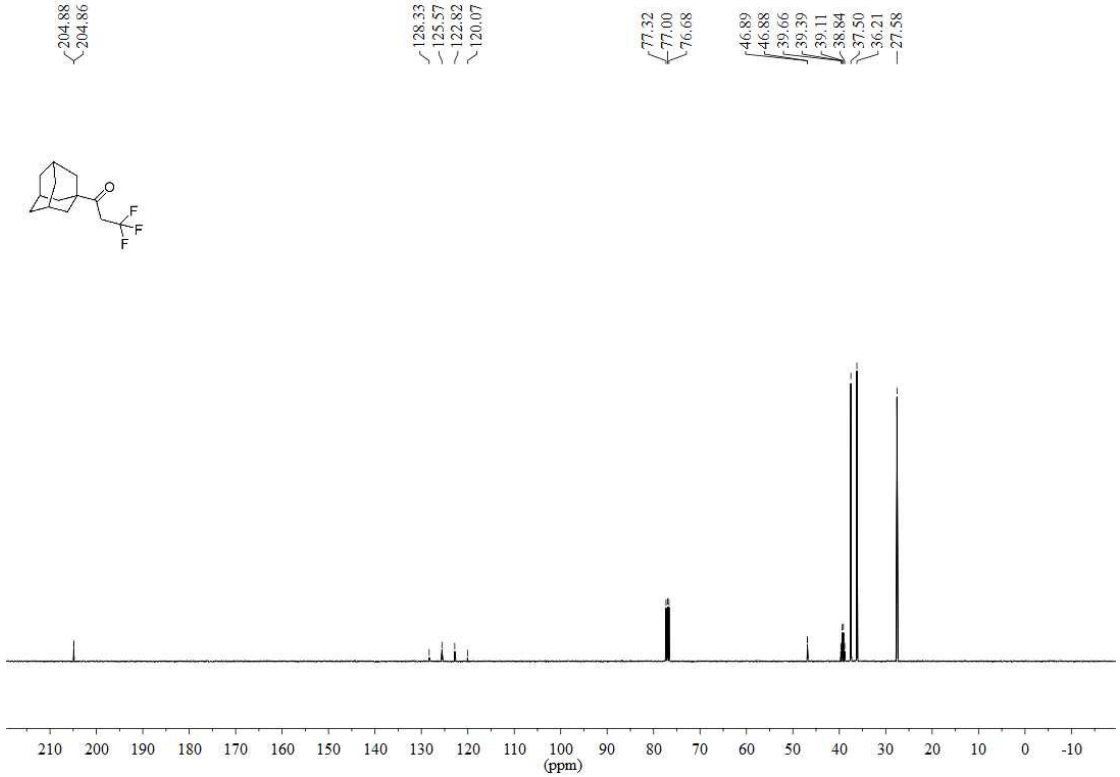
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3ad**



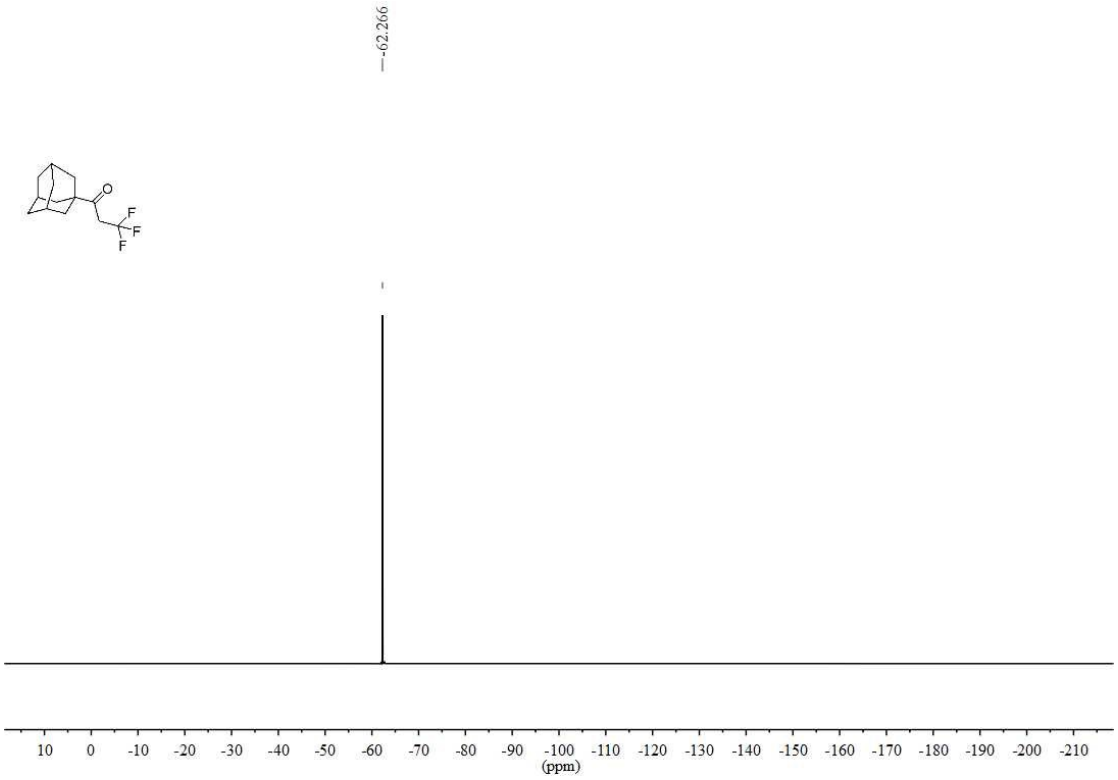
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3ae**



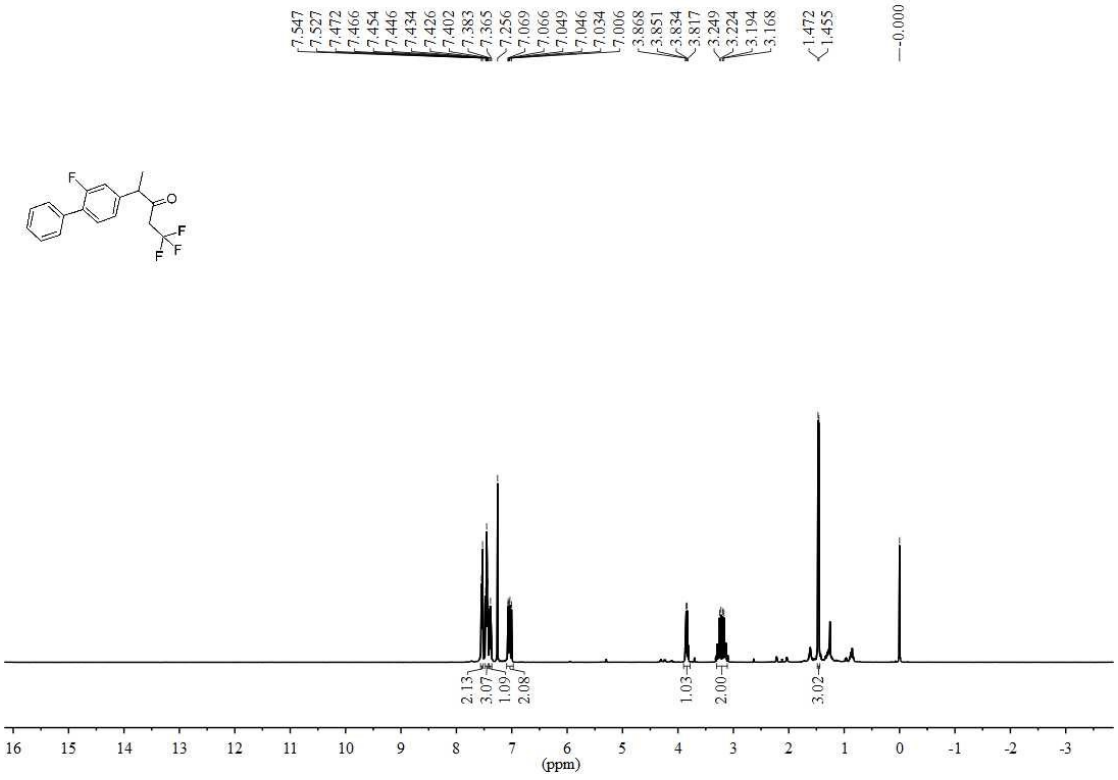
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3ae**



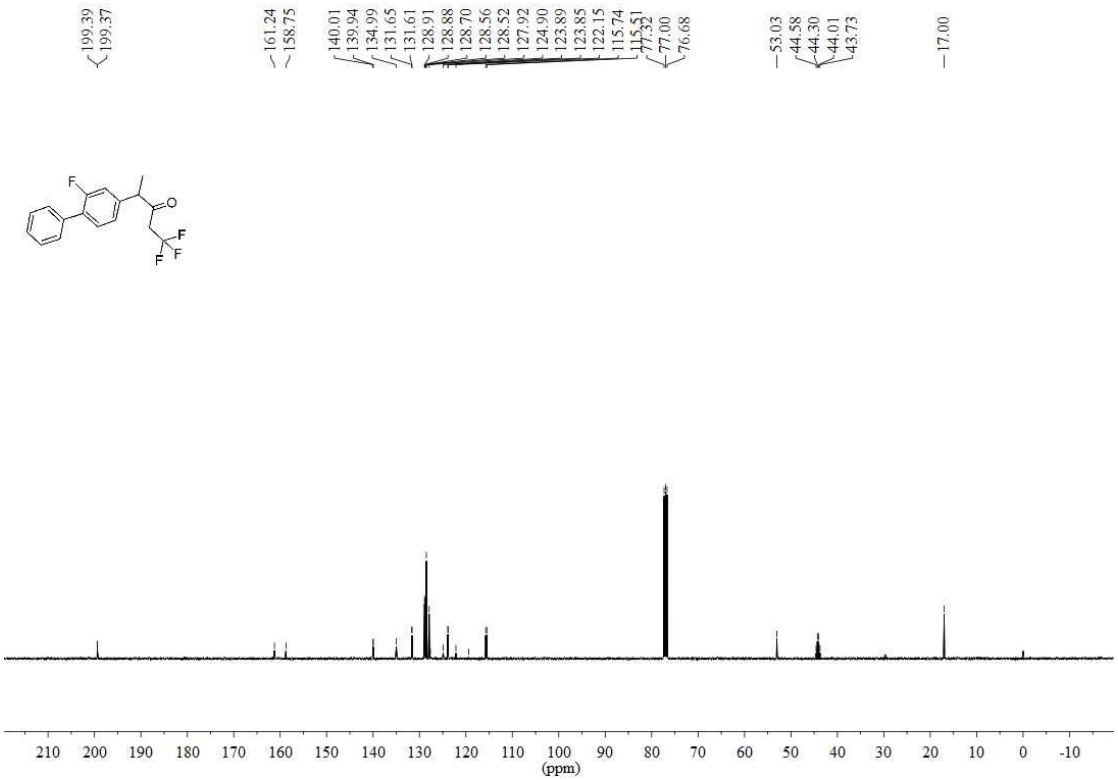
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3ae**



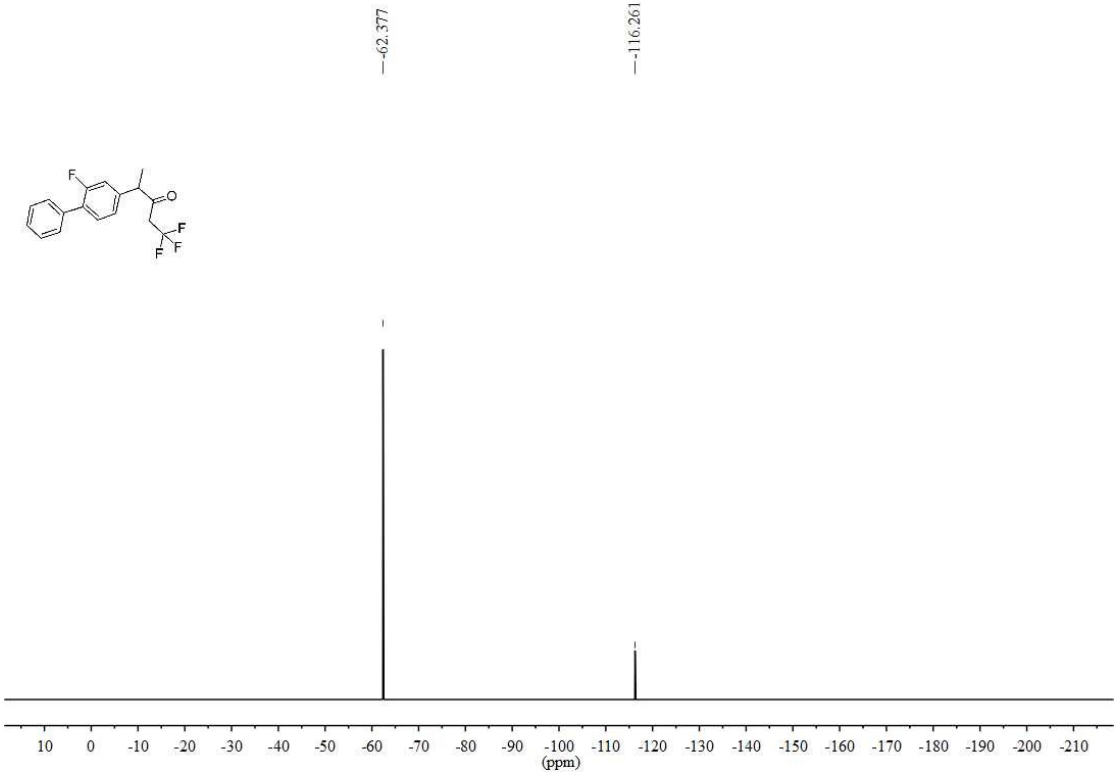
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3af**



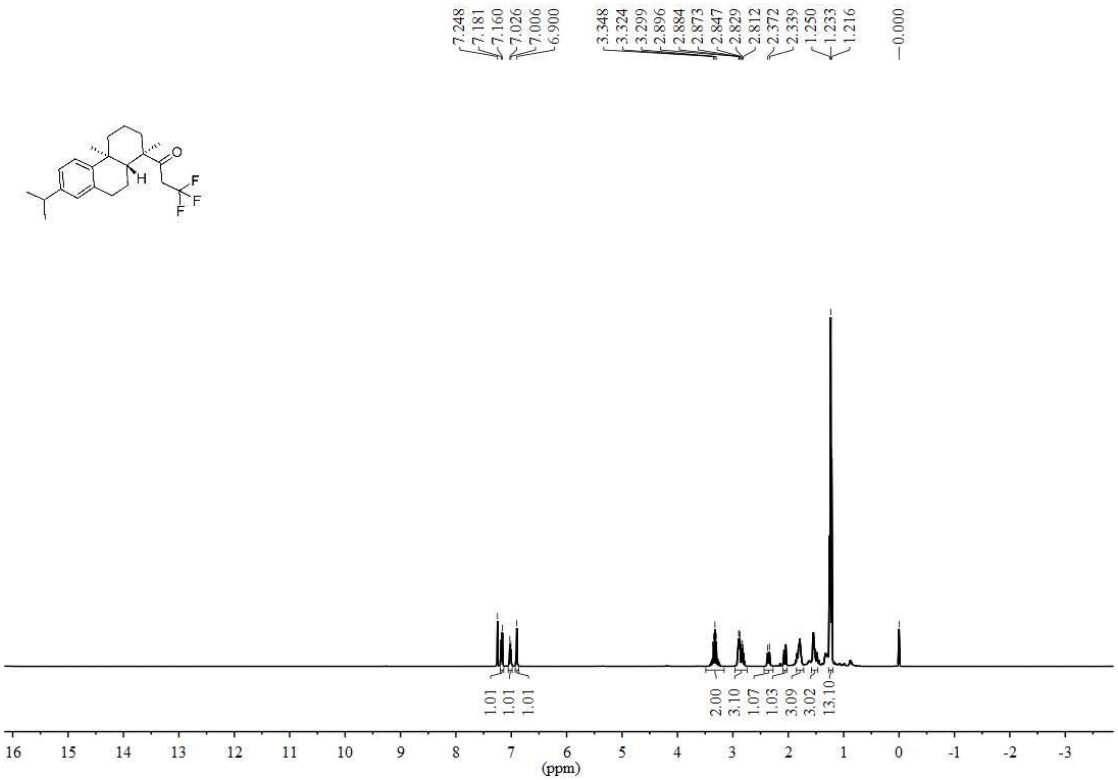
^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) of compound **3af**



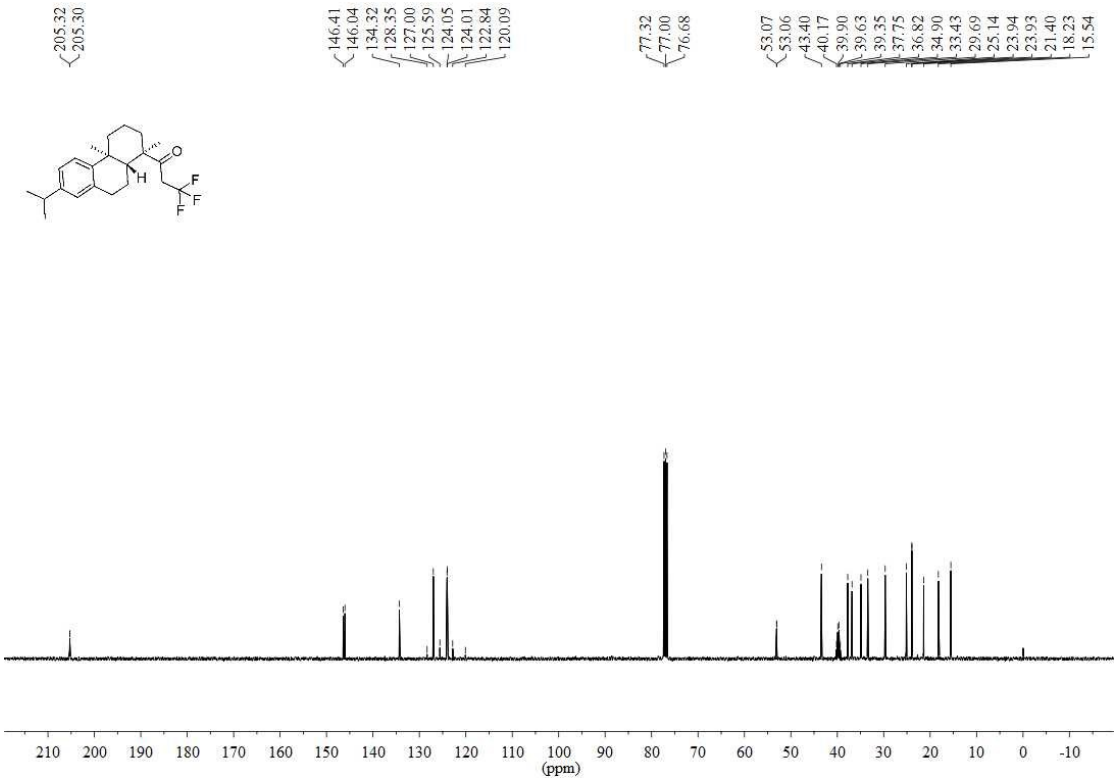
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3af**



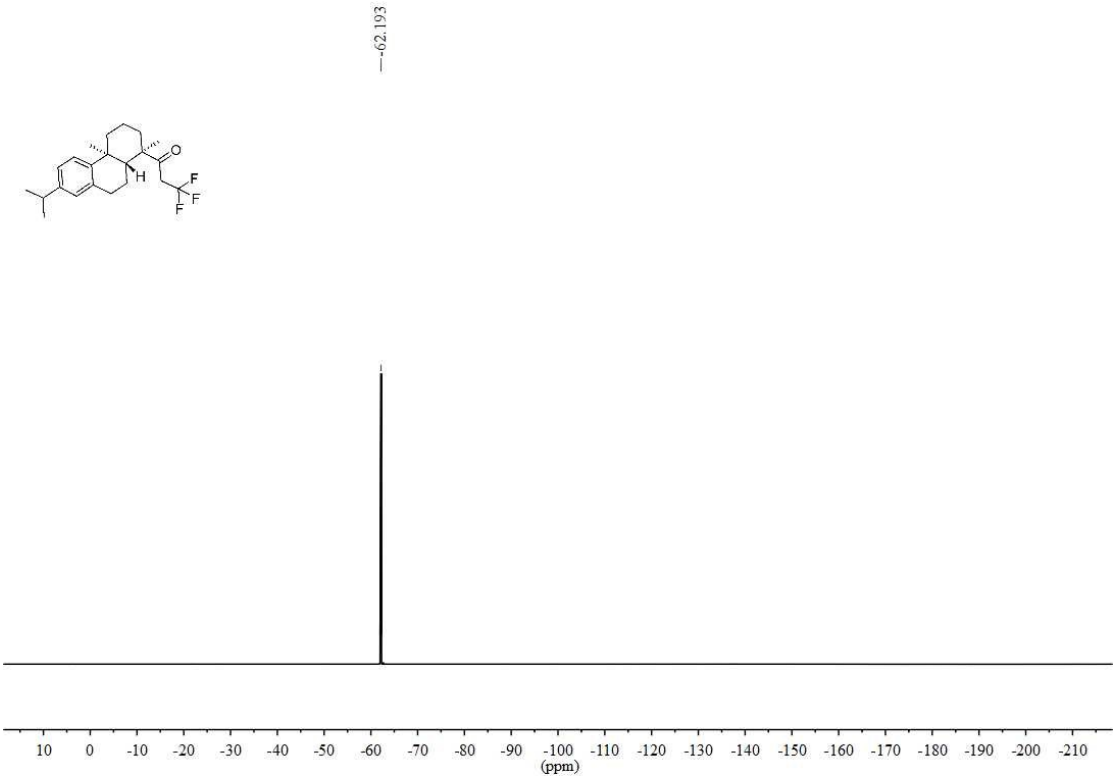
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3ag**



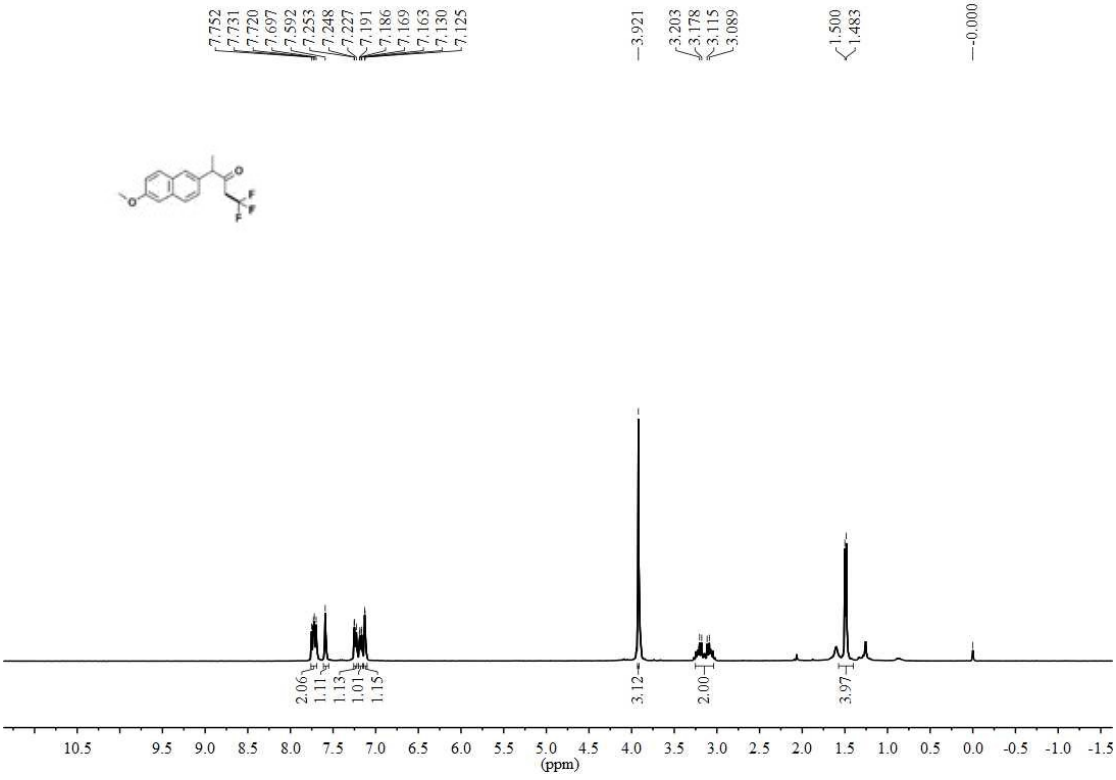
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3ag**



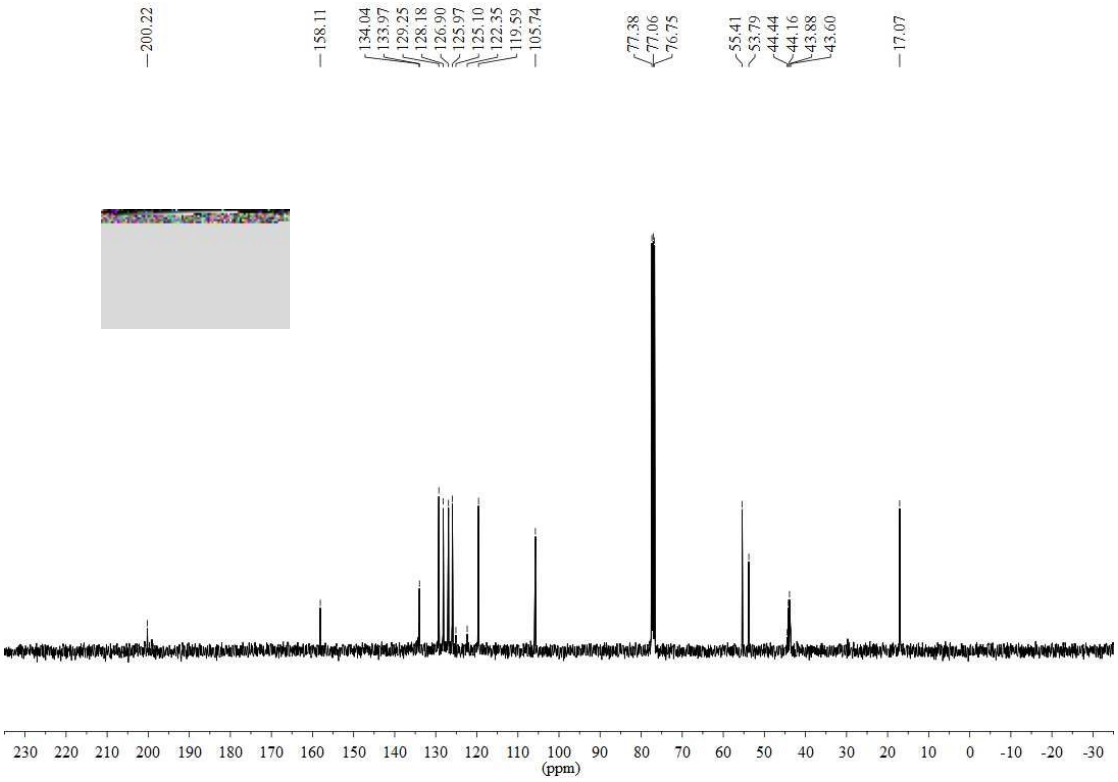
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3ag**



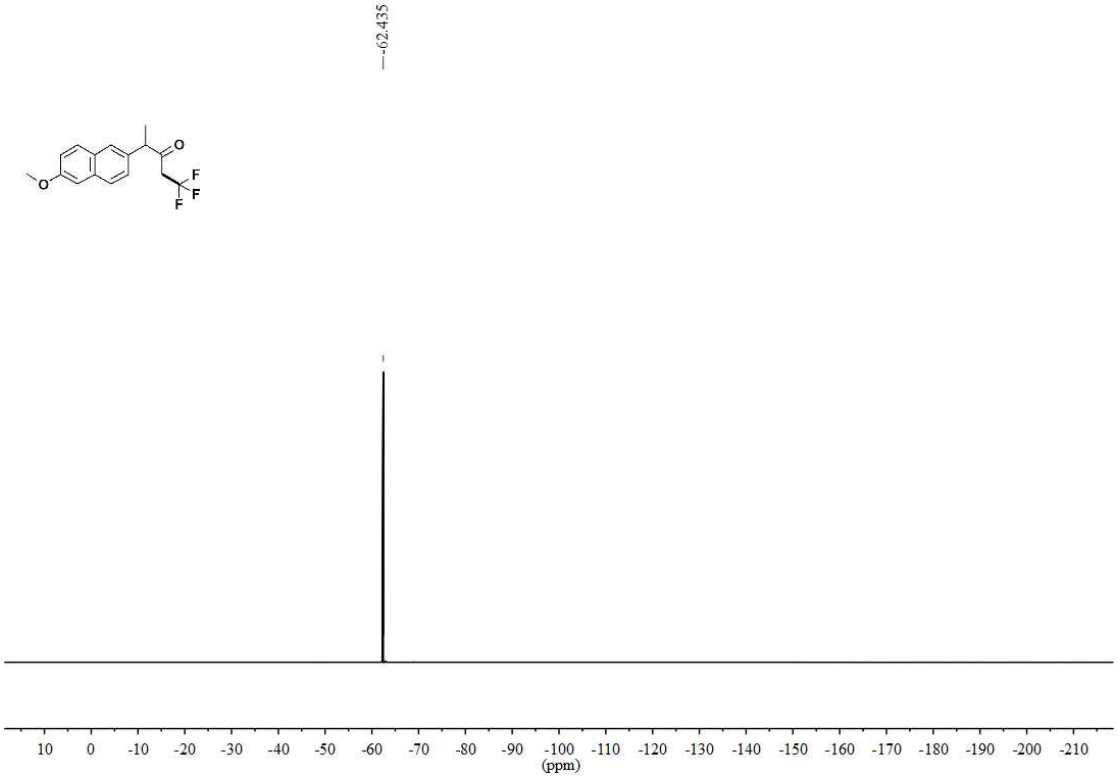
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3ah**



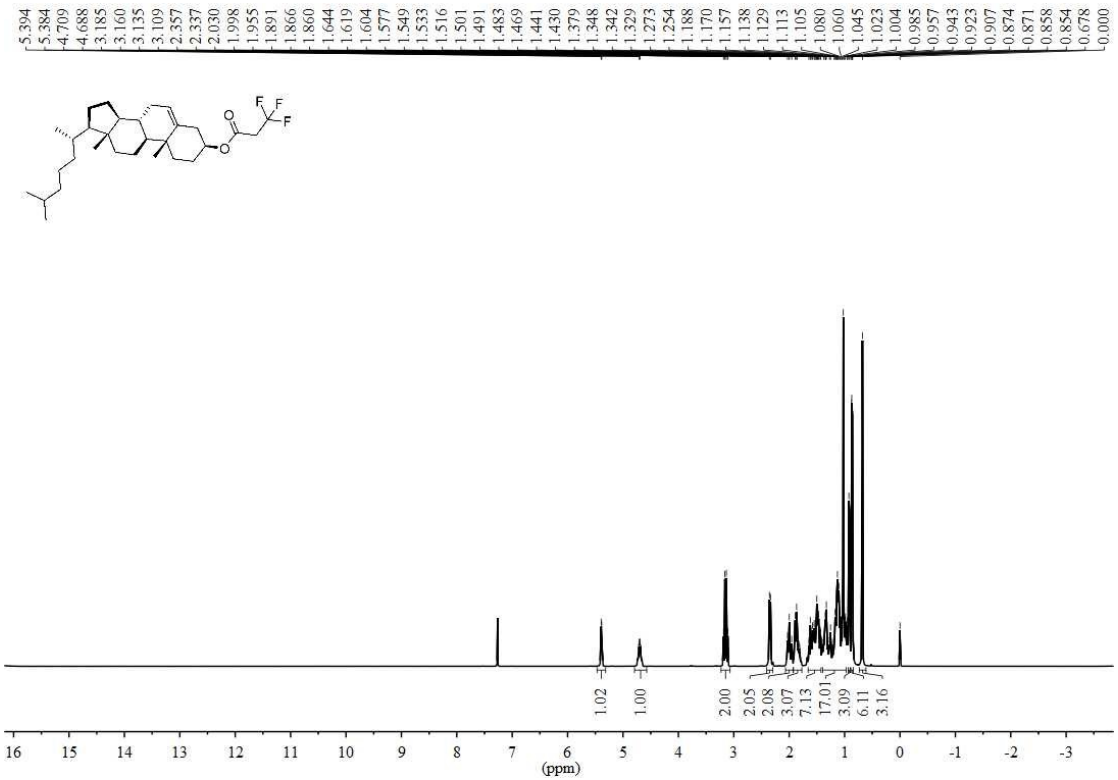
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3ah**



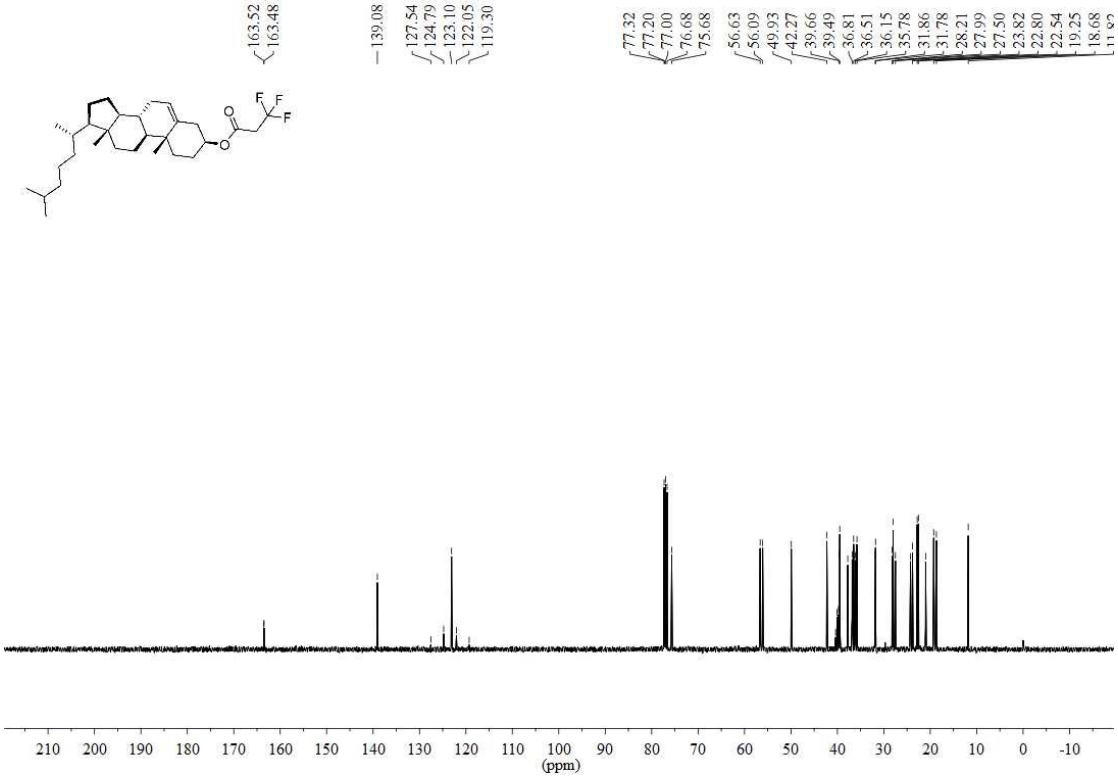
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3ah**



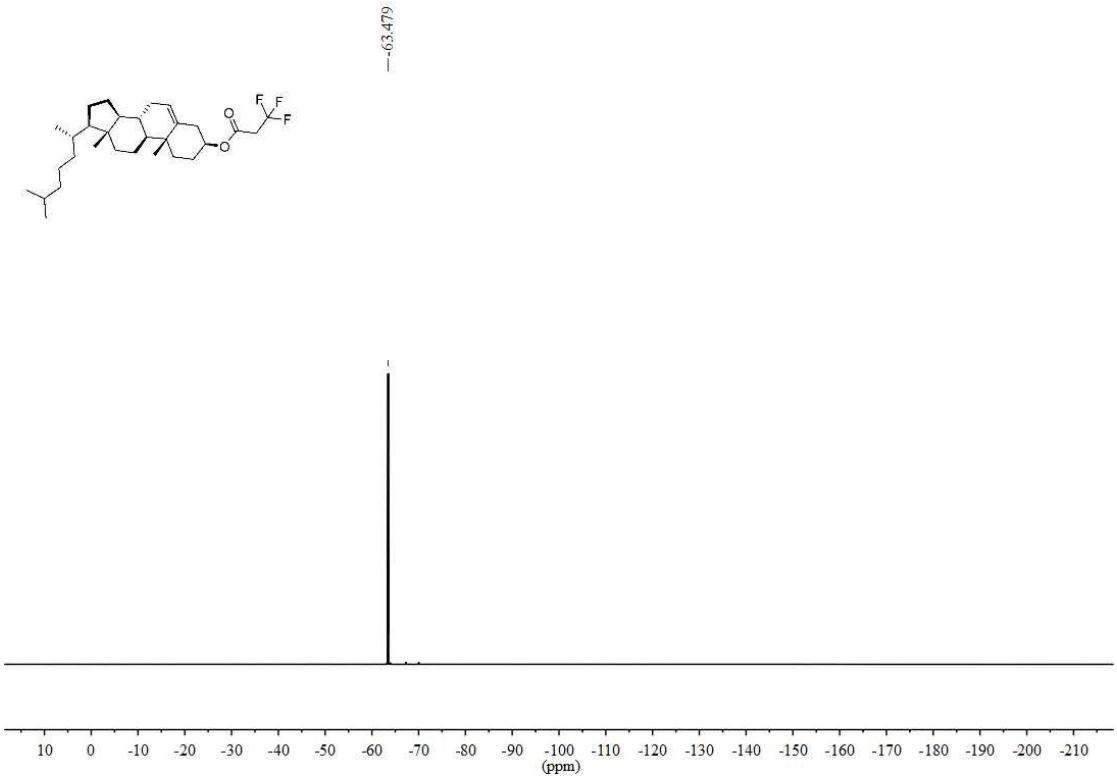
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3ai**



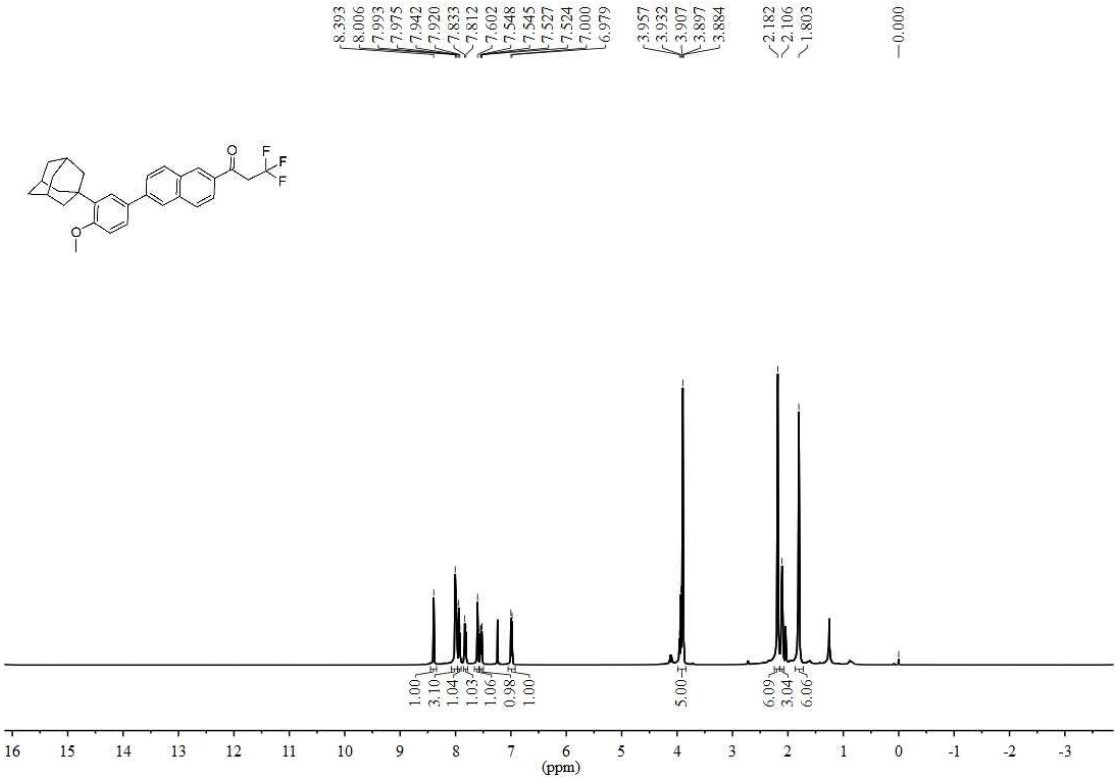
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **3ai**



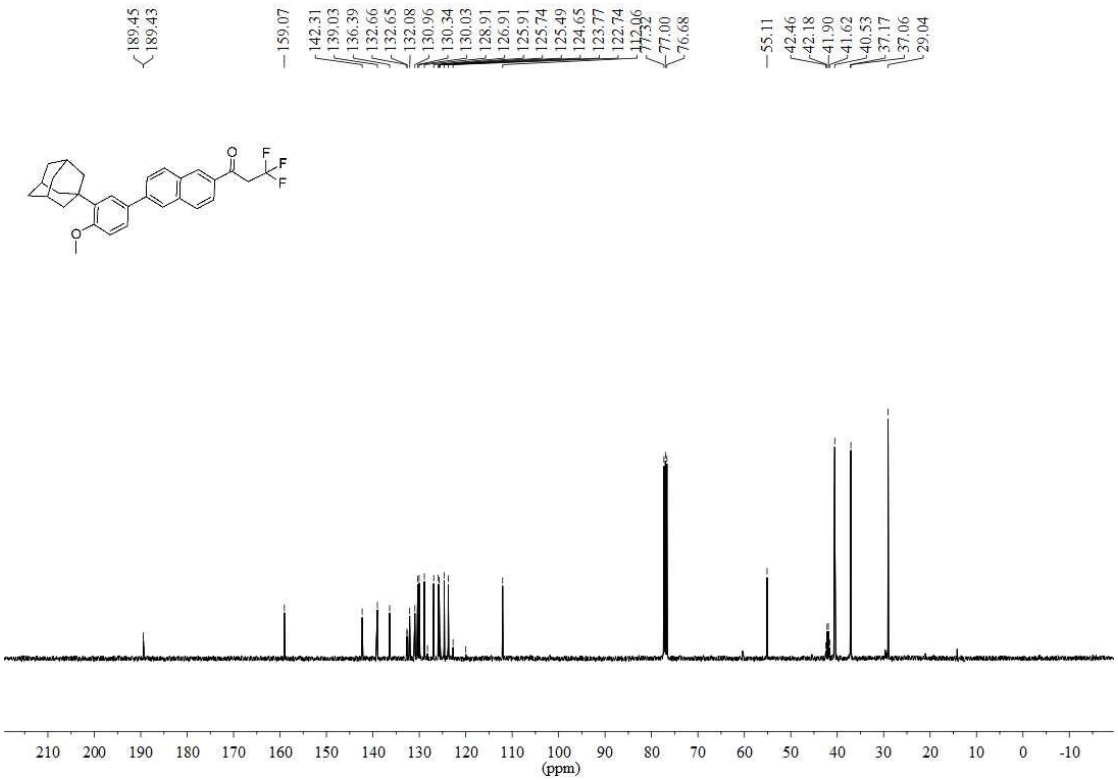
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3ai**



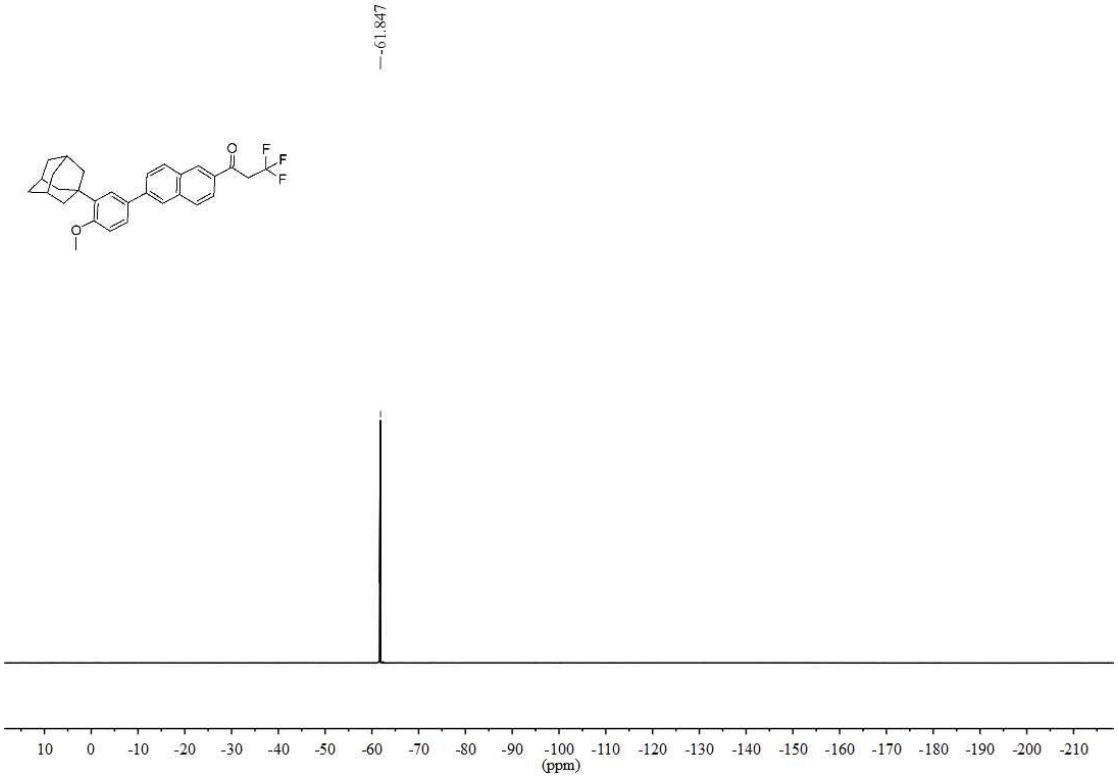
^{1}H NMR (400 MHz, $CDCl_3$) of compound **3aj**



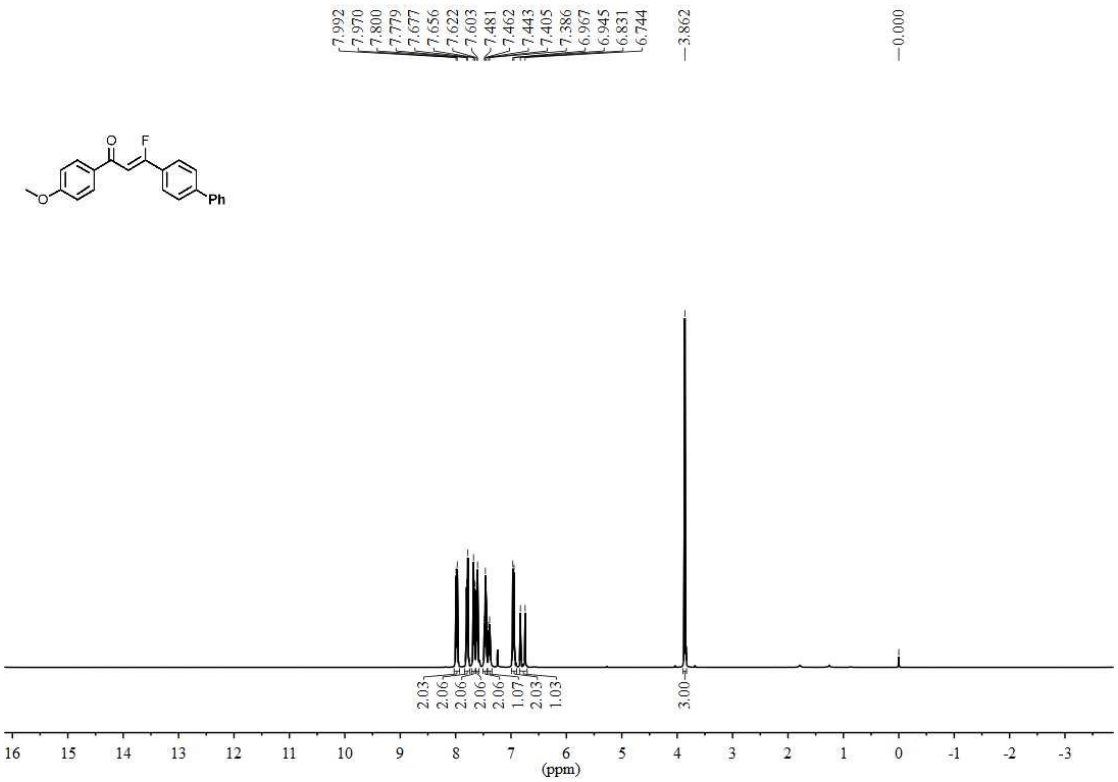
^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) of compound **3aj**



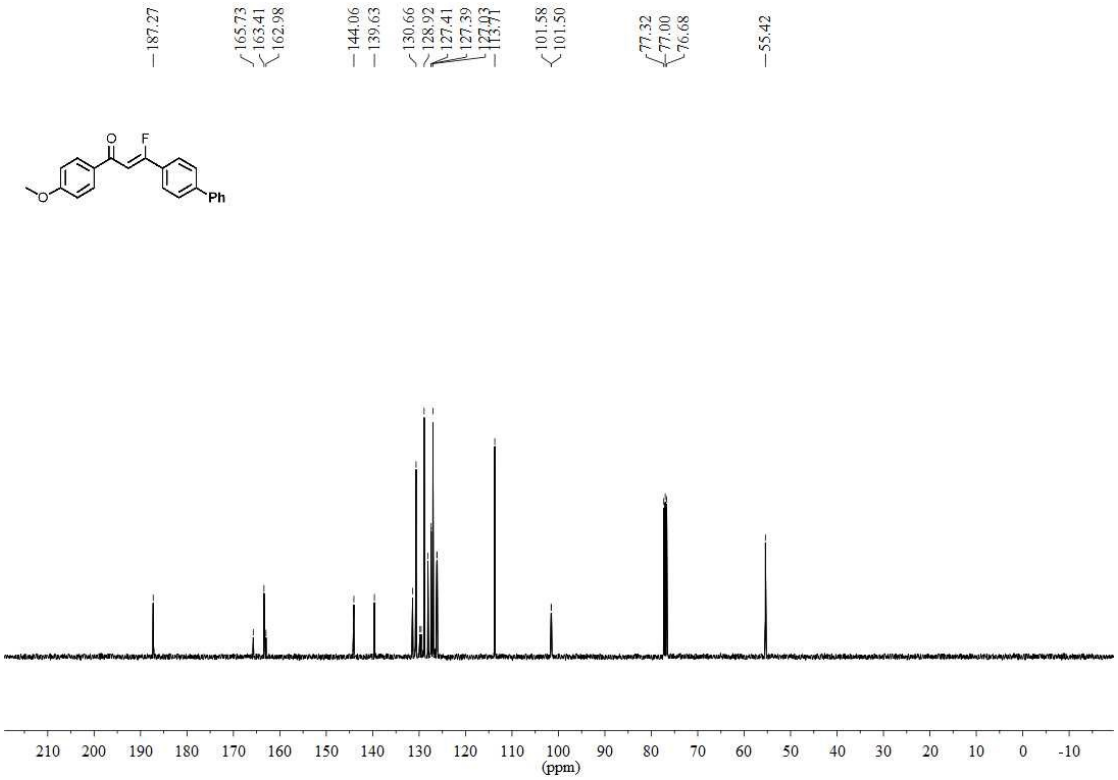
^{19}F NMR (376 MHz, $CDCl_3$) of compound **3aj**



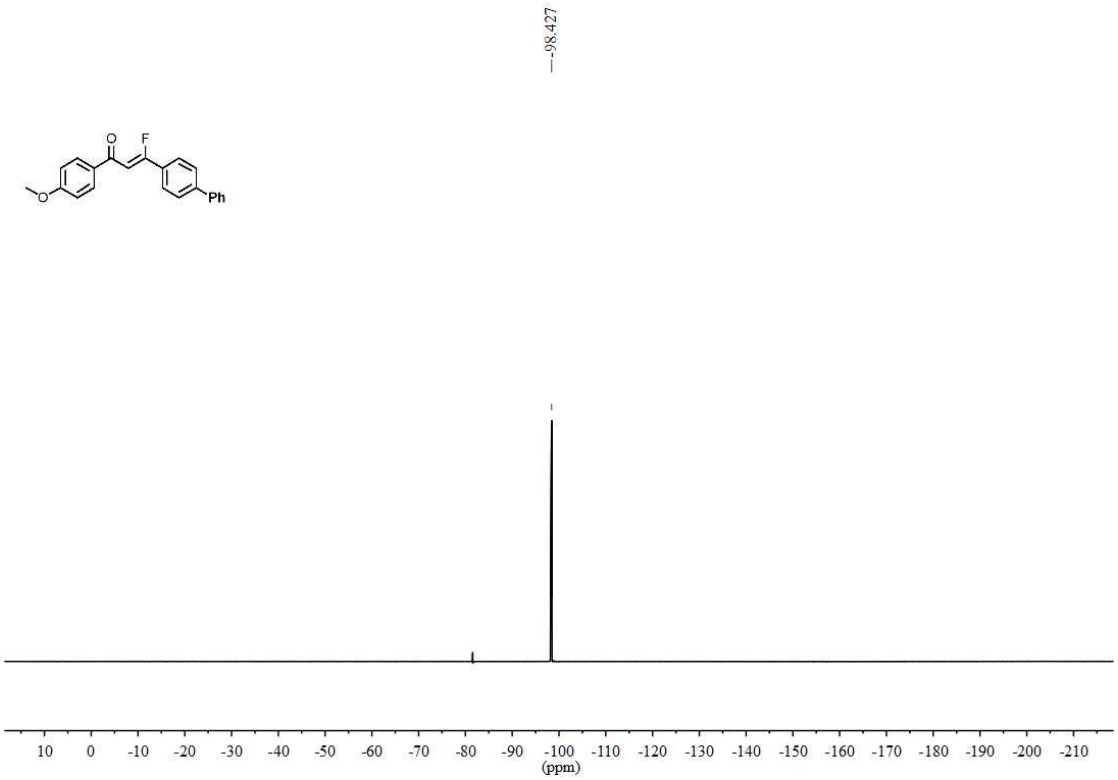
^{1}H NMR (400 MHz, $CDCl_3$) of compound **11**



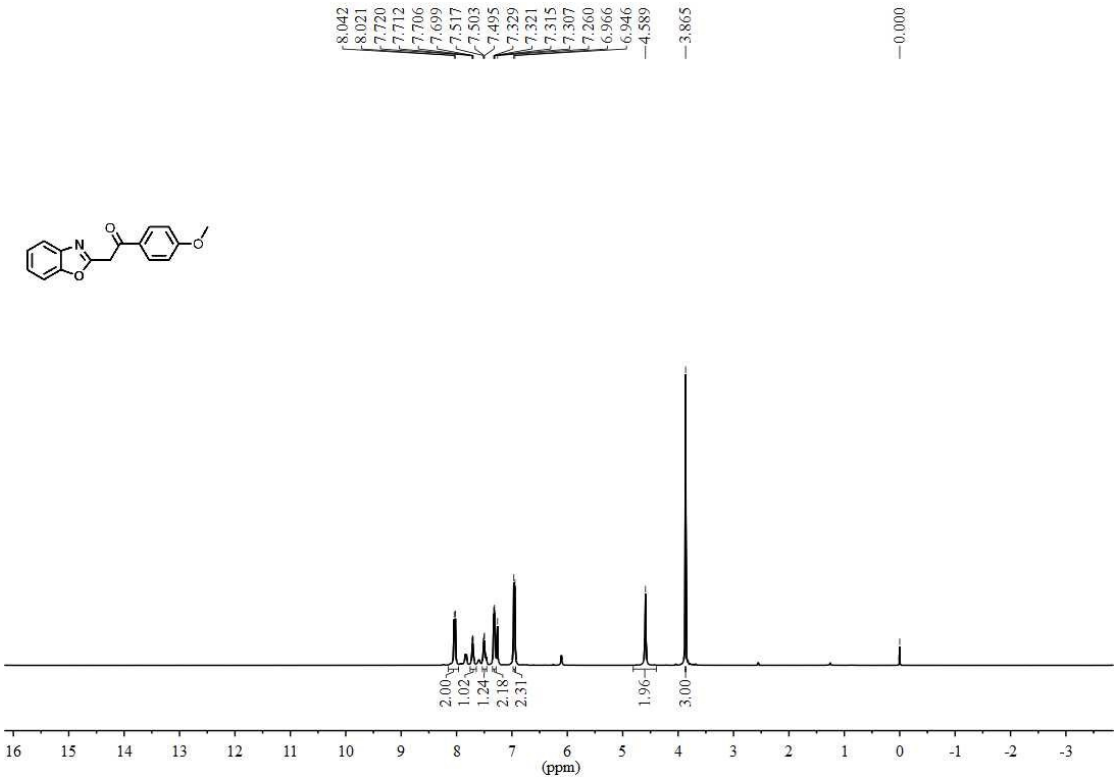
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **11**



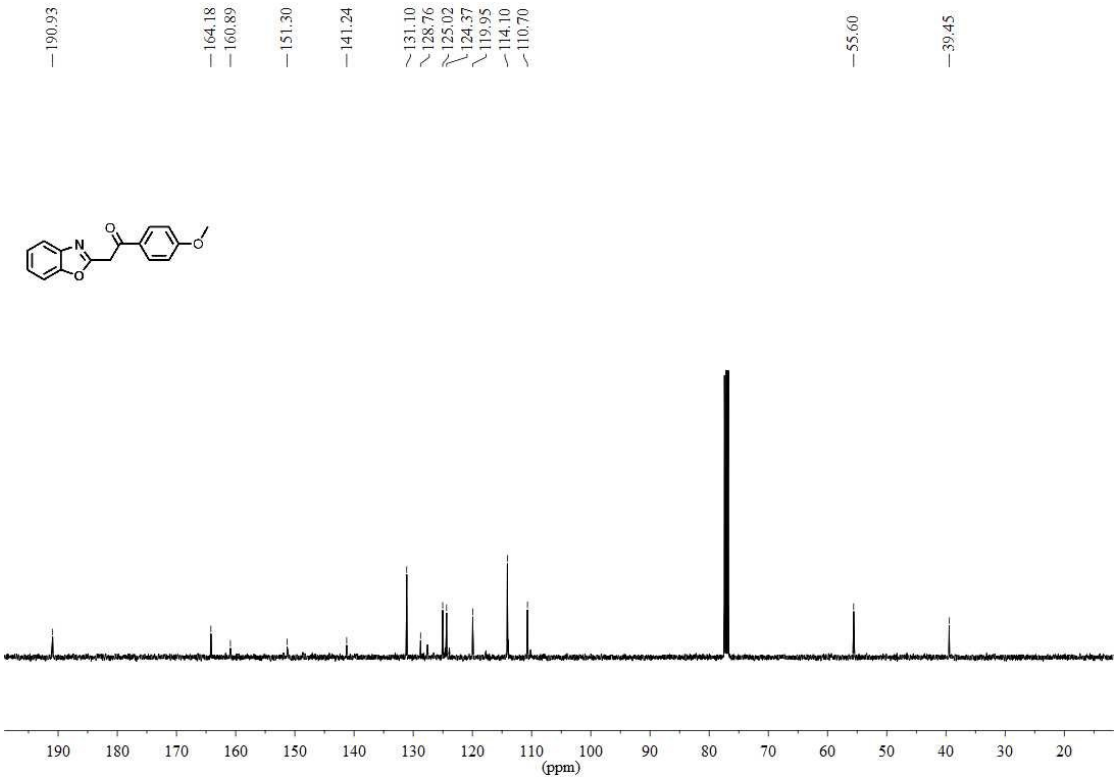
^{19}F NMR (376 MHz, $CDCl_3$) of compound **11**



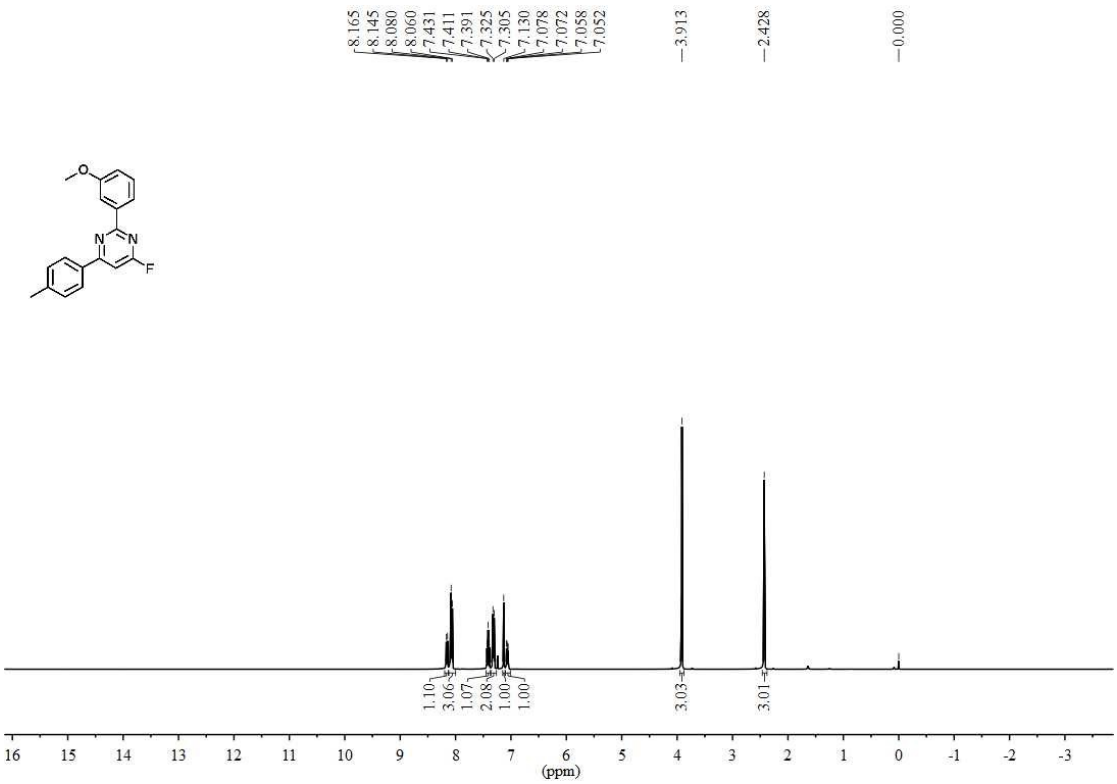
^{1}H NMR (400 MHz, $CDCl_3$) of compound **8**



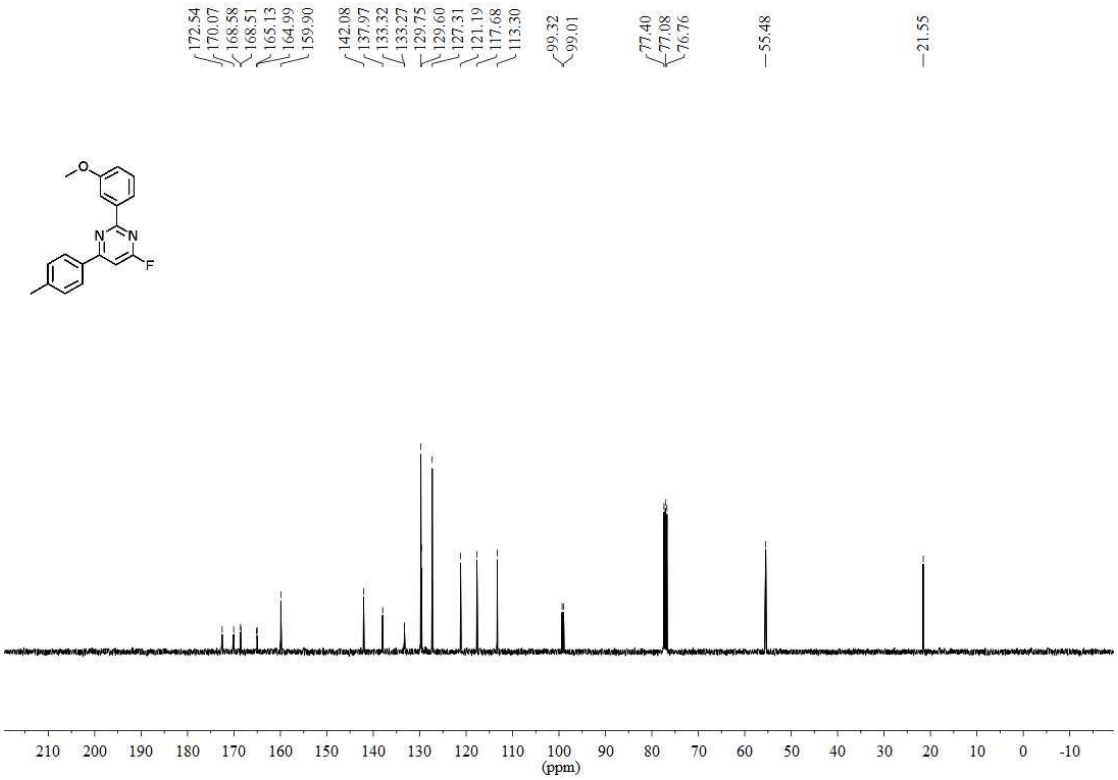
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **8**



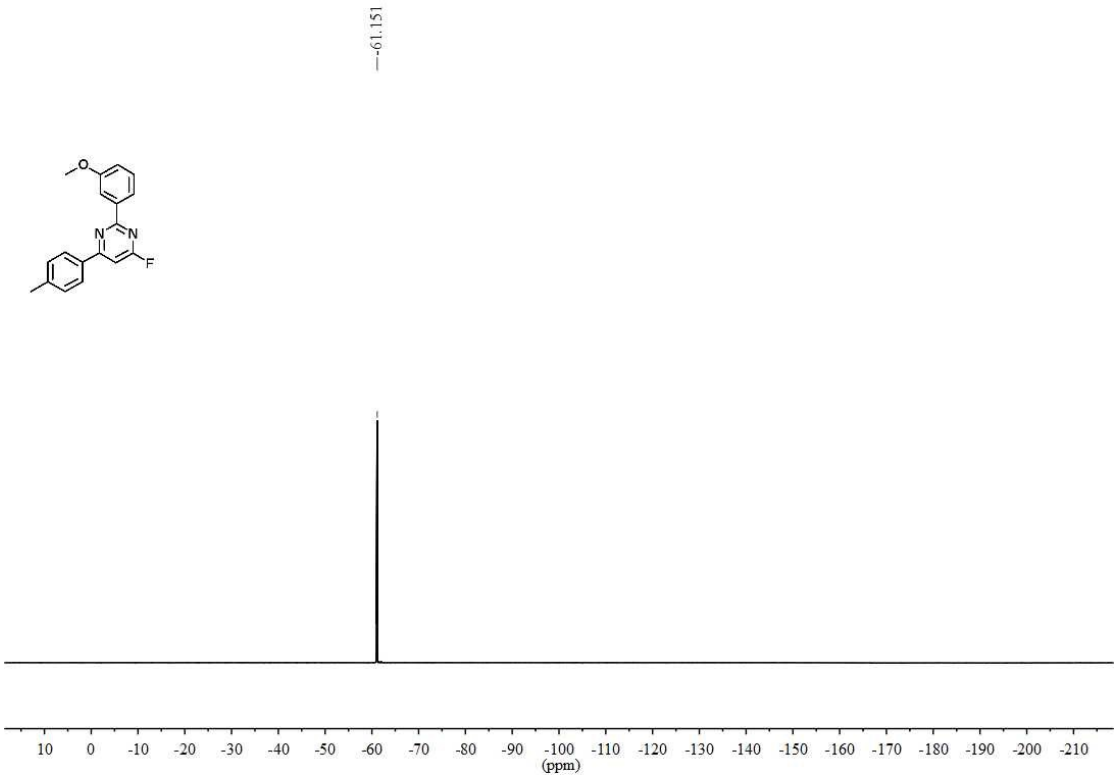
^{1}H NMR (400 MHz, $CDCl_3$) of compound **10**



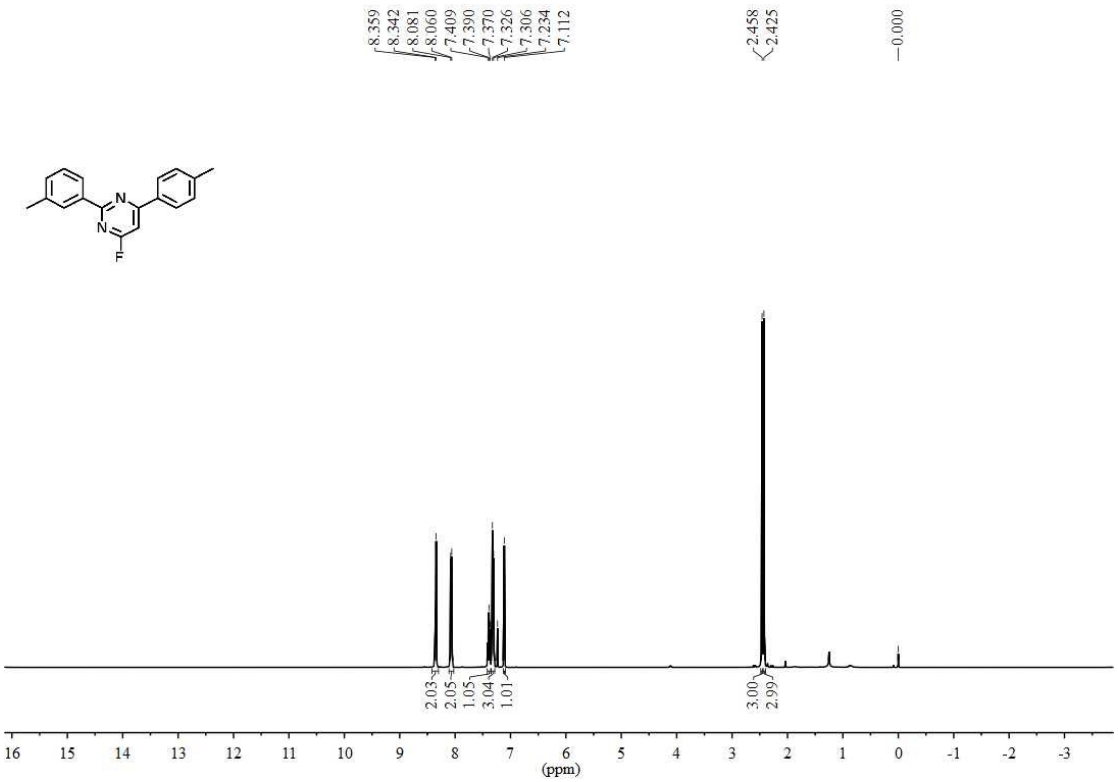
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **10**



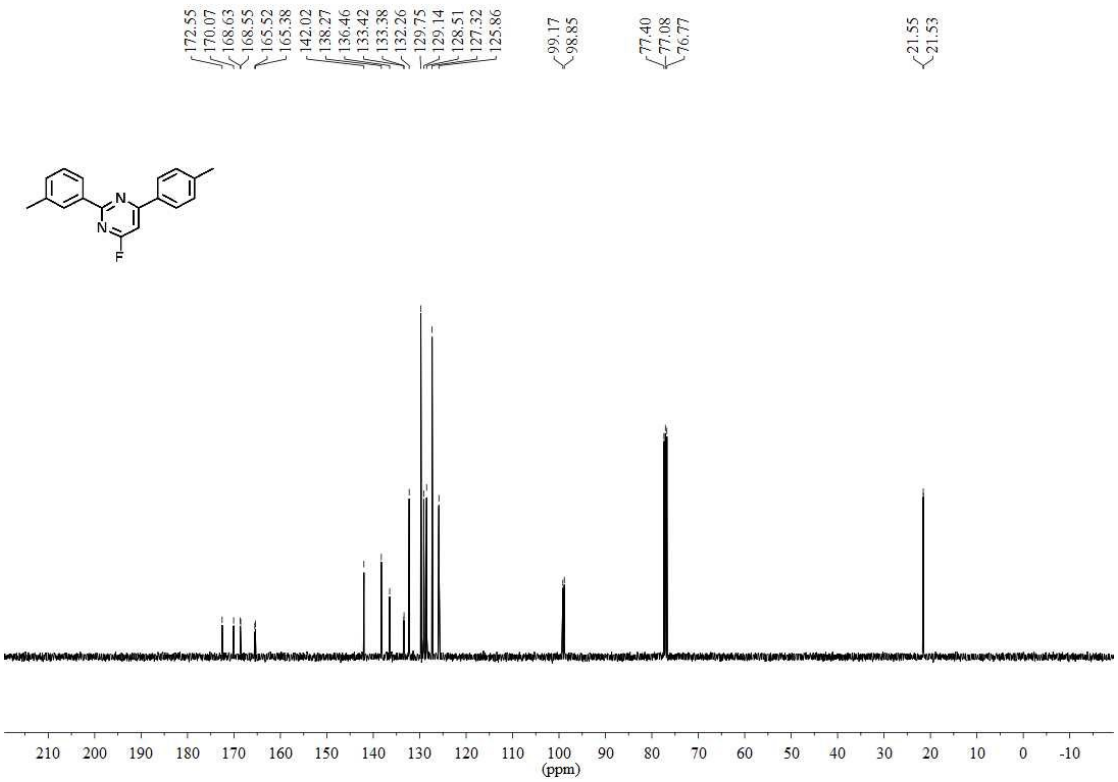
^{19}F NMR (376 MHz, $CDCl_3$) of compound **10**



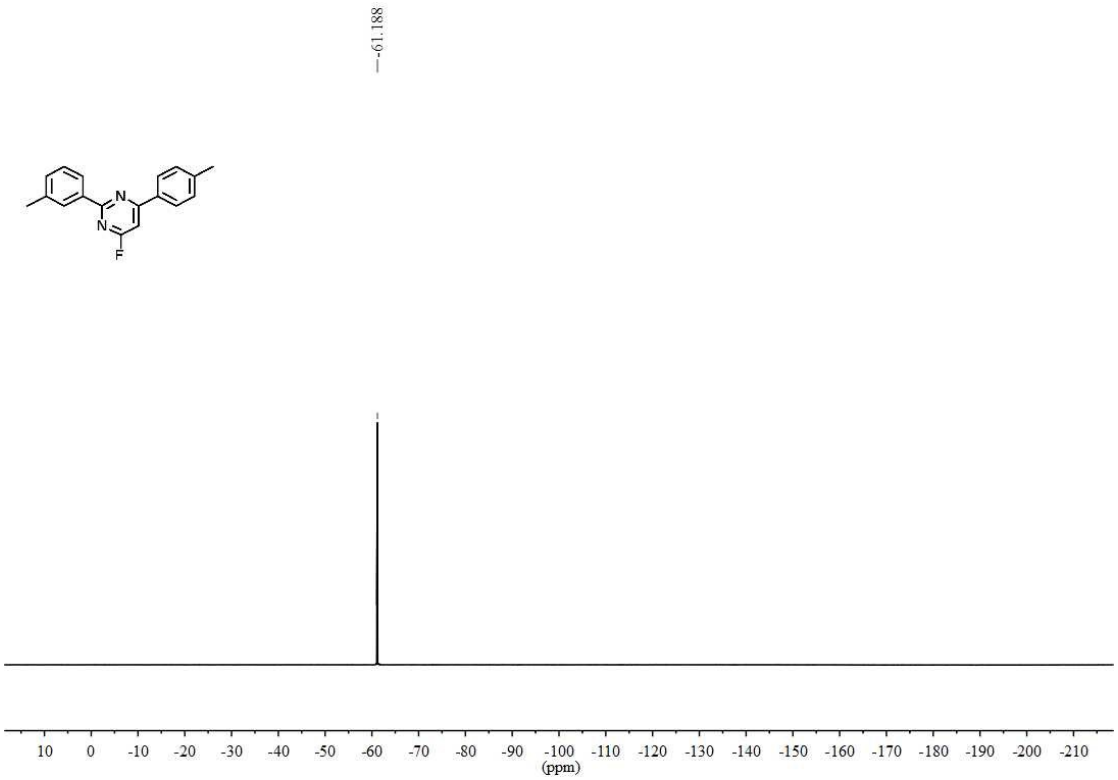
^{1}H NMR (400 MHz, $CDCl_3$) of compound **9**



$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) of compound **9**



^{19}F NMR (376 MHz, $CDCl_3$) of compound **9**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N
N
F
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
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-110
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-200
-210
(ppm)