Supporting Information for

Rhodium(III)-Catalyzed Aromatic and Olefinic C-H Additions to CF_3-Substituted Unsaturated Ketones

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Experimental procedures and analytical data

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1. General considerations

The solvents were dried and distilled prior to use by the literature methods. ^{1}H and $^{13}C\{^{1}H\}$ NMR spectra were recorded on a Bruker DRX-400 spectrometer and all chemical shift values refer to $CDCl_3$ ($\delta(^{1}H)$, 7.26 ppm; $\delta(^{13}C)$, 77.16 ppm). The HRMS analysis was obtained on a Waters GC-TOF CA156 mass spectrometer. All the melting points were uncorrected. Analytical TLC plates, Sigma-Aldrich silica gel 60_{F200} were viewed by UV light (254 nm). Column chromatographic purifications were performed on SDZF silica gel 160. All the chemical reagents were purchased from commercial sources and used as received unless otherwise indicated. Starting materials 2-phenylpyridine derivatives,[1,2] 2-(cyclopent-1-en-1-yl)pyridine (**5a**), 2-(Cyclohex-1-en-1-yl)pyridine (**5b**) and 2-(cyclohept-1-en-1-yl)pyridine (**5c**),[3] were prepared by the reported procedures.

References

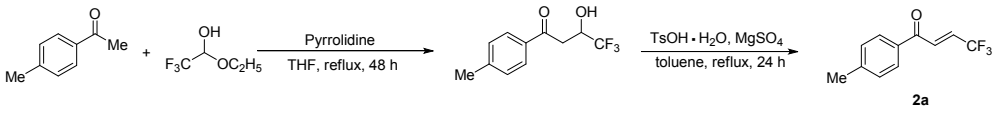
1 C. Liu and W. Yang, *Chem. Commun.*, 2009, 6267.

2 J. Yang, S. Liu, J.-F. Zheng and J. Zhou, *Eur. J. Org. Chem.*, 2012, 6248.

3 M. Kang, J.-W. Kang, J. W. Park, S. O. Jung, S.-H. Lee, H.-D. Park, Y.-H. Kim, S. C. Shin, J.-J. Kim and S.-K. Kwon, *Adv. Mater.*, 2008, **20**, 2003.

2. Experimental procedure

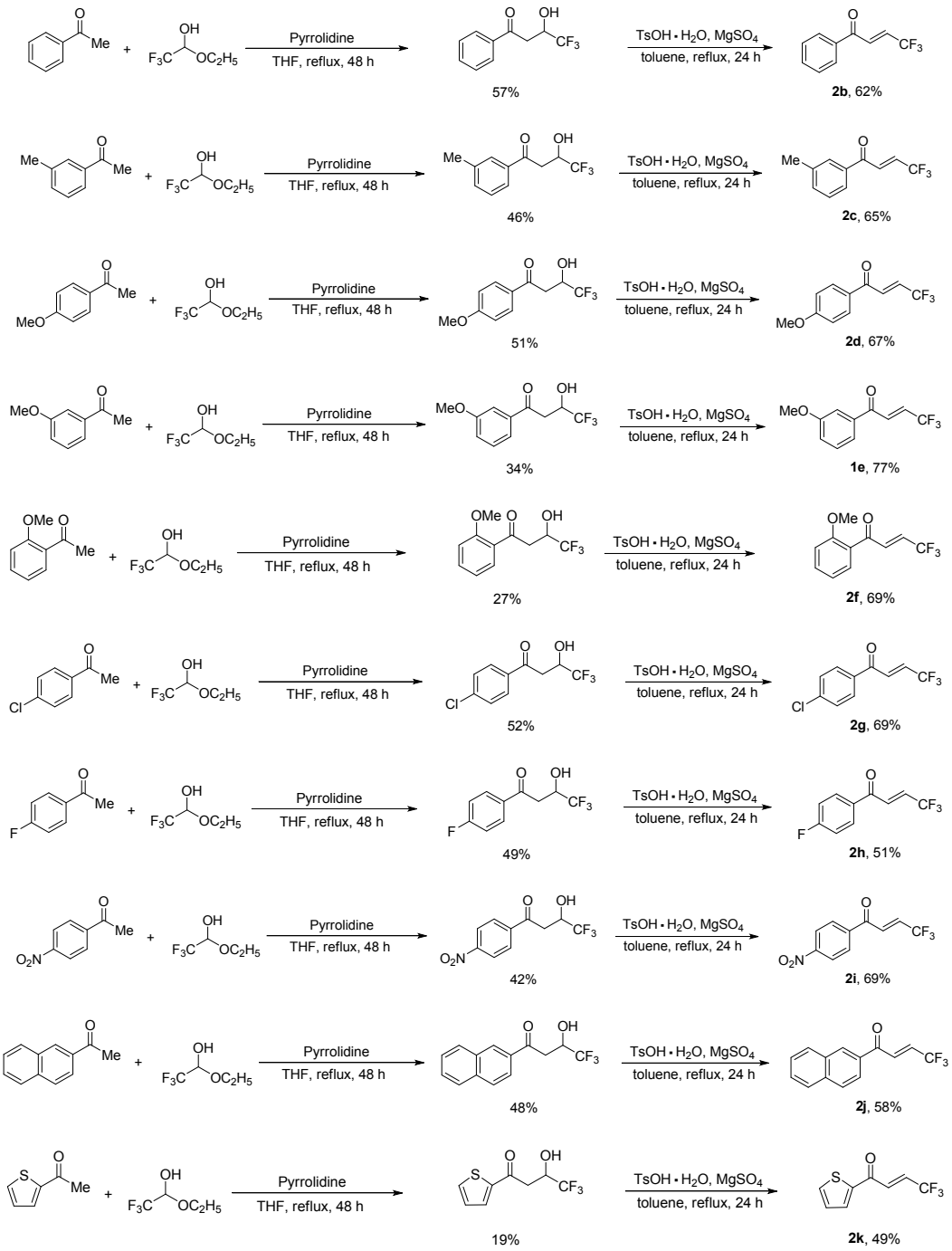
2.1 Synthesis of *β*-trifluoromethyl-*α*,*β*-unsaturated ketones



S*ynthesis of* (*E*)-4,4,4-trifluoro-1-p-tolylbut-2-en-1-one *(2a)*: To a solution of the trifluoroacetaldehyde ethyl hemiacetal (1.44 g, 10.0 mmol) in THF (20 mL), pyrrolidine (0.49 g, 7.0 mmol) was added and the resulting mixture was stirred at room temperature for 30 min. Then 1-*p*-tolylethanone (1.34 g, 10.0 mmol) was poured into the solution. The reaction mixture was stirred at reflux for 48 h. After cooled to ambient temperature, all the volatiles were removed under reduced pressure. The resulting residue was purification by silica gel column chromatography (eluent: petroleum ether (60-90 ^{o}C)/EtOAc = 10:1) to afford 4,4,4-trifluoro-3-hydroxy-1- p-tolylbutan-1-one as white liquid (1.24 g, 53%).

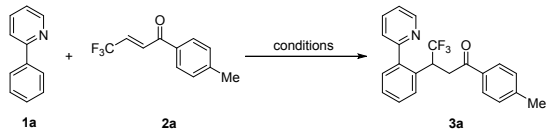
4,4,4-Trifluoro-3-hydroxy-1-p-tolylbutan-1-one (1.05 g, 4.5 mmol) was dissolved

in toluene (30 mL) and *p*-toluenesulfonic acid (0.60 g, 3.15 mmol), anhydrous $MgSO_4$ (ca. 5 g) was added. The mixture was stirred at reflux for 24 h. After cooled to ambient temperature, the reaction mixture was filtered. All the volatiles were removed under reduced pressure, the resulting residue was purified by silica gel column chromatography (eluent: petroleum ether (60-90 ^oC)/EtOAc = 100:1, v/v) to afford **2a** as a yellow solid (0.55 g, 57%). Compounds **2b**-**2k** were synthesized in a similar fashion.



2.2 Screening of conditions for the reaction of 1a with 2a

Table S1 Screening of reaction conditions[a]



1a 2a 3a

Entry	Catalyst (mol %)	Solvent	Yield[b] (%)
1	$[Cp^*RhCl_2]_2$ (2.5)/$AgSbF_6$ (10)	DCE	86
2	$[Cp^*RhCl_2]_2$ (2.5)/$AgSbF_6$ (10)	1,4-dioxane	94
3	$[Cp^*RhCl_2]_2$ (2.5)/$AgSbF_6$ (10)	toluene	99 (96)[c]
4[d]	$[Cp^*RhCl_2]_2$ (2.5)/$AgSbF_6$ (10)	toluene	94
5	Rh(COD)BF_4/5.0	toluene	<5
6	[Ru(*p*-cymene)$Cl_2]_2$ (2.5/)$AgSbF_6$ (10)	toluene	18
7	$[Cp^*RhCl_2]_2$ (1.25)/$AgSbF_6$ (5)	toluene	10
8[e]	$[Cp^*RhCl_2]_2$ (2.5)/$AgSbF_6$ (10)	toluene	88

[a] Conditions: **1a** (0.3 mmol), **2a** (0.2 mmol), solvent (2 mL), 80 °C, 20 h, 0.1 MPa N_2.[b] Yield was determined by ^1H NMR analysis by using CH_2Br_2 as an internal standard. [c] Isolated yield given in parentheses. [d] 60 °C. [e] **1a** (0.24 mmol). DCE = 1,2-dichloroethane.

2.3 A typical procedure for C-H additon to *β*-trifluoromethyl-*α,β*-enones

***Synthesis of 3a*:** Under nitrogen atmosphere, a mixture of $[Cp^*RhCl_2]_2$ (3.1 mg, 0.005 mmol), $AgSbF_6$ (6.9 mg, 0.02 mmol), 2-phenylpyridine (**1a**; 46 mg, 0.3 mmol), (*E*)-4,4,4-trifluoro-1-p-tolylbut-2-en-1-one (**2a**; 43 mg, 0.2 mmol) in toluene (2 mL) was stirred at 80 °C for 20 h. After cooled to ambient temperature, all the volatiles were removed under reduced pressure. The resulting residue was purified by silica gel column chromatography (eluent: petroleum ether (60-90 °C)/EtOAc = 10:1, v/v) to afford **3a** as a Colorless liquid. (71 mg, 96%).

3. X-Ray crystallographic studies

Single crystals for X-ray diffraction studies for compounds **3f** were carried out on a SMART APEX diffractometer with graphite-monochromated Mo-K_α radiation (λ = 0.71073 Å). Cell parameters were obtained by global refinement of the positions of all collected reflections. Intensities were corrected for Lorentz and polarization effects and empirical absorption. The structures were solved by direct methods and refined by full-matrix least squares on F^2. All non-hydrogen atoms were refined anisotropically. All hydrogen atoms were placed in calculated positions. Structure solution and refinement were performed by using the SHELXL-97 package. The X-ray crystallographic files, in CIF format, are available from the Cambridge Crystallographic Data Centre on quoting the deposition numbers CCDC 1417798 for **3f**. Copies of this information may be obtained free of charge from The Director,

CCDC, 12 Union Road, Cambridge CB2 IEZ, UK (Fax: +44-1223-336033; e-mail: deposit@ccdc.cam.ac.uk or www: http://www. ccdc.cam.ac.uk).

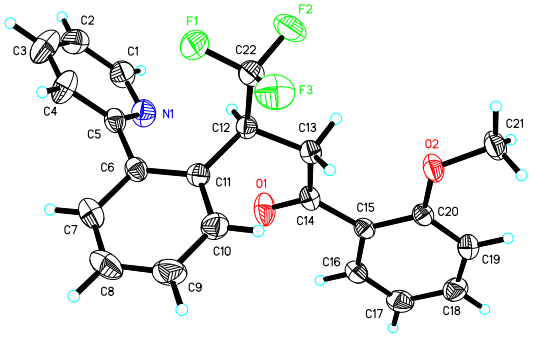


Figure 1 Molecular structure of **3f**.

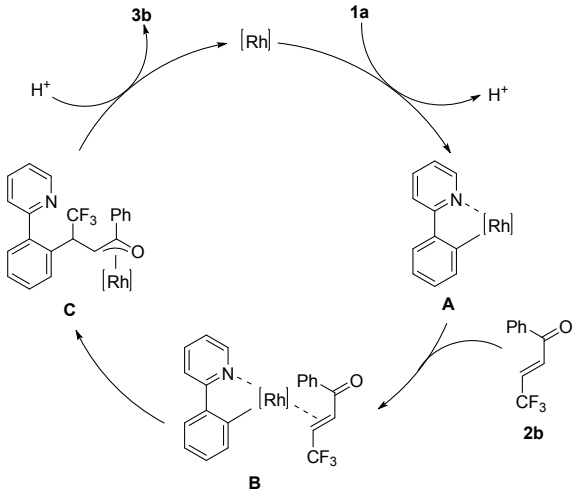
Table S2 Crystal data and structure refinement for **3f**

Empirical formula	$C_{22}H_{18}F_3NO_2$	
Formula weight	385.37	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system, space group	Monoclinic, P 21/c	
Unit cell dimensions	a = 13.9588(19) Å	alpha = 90°
	b = 8.5515(11) Å	beta = 104.782(14)°
	c = 16.218(2) Å	gamma = 90°
Volume	1871.9(5) $Å^3$	
Z, Calculated density	4, 1.367 Mg/m^3	
Absorption coefficient	0.108 mm^{-1}	
F(000)	800	
Crystal size	0.211 x 0.167 x 0.123 mm^3	
Theta range for data collection	3.262 to 26.000°	
Limiting indices	-15<=h<=17, -10<=k<=10, -18<=l<=20	
Reflections collected	9988	
Independent reflections	3671 [R(int) = 0.0316]	
Completeness to theta = 25.242°	99.8 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	1.0000 and 0.7915	
Refinement method	Full-matrix least-squares on F^2	
Data/restraints/parameters	3671 / 5 / 255	
Goodness-of-fit on F^2	1.021	

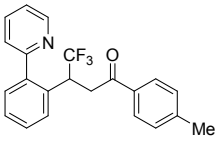
Final R indices [I > 2 sigma(I)]	R1 = 0.0463, wR2 = 0.1103
R indices (all data)	R1 = 0.0717, wR2 = 0.1266
Extinction coefficient	0.0157(16)
Largest diff. peak and hole	0.233 and -0.218 e.Å^{-3}

4. Proposed mechanism

A plausible mechanism is proposed. Initial interaction of the rhodium(III) precatalyst with 2-phenylpyridine (**1a**) generates arylrhodium species **A** and one equivalent of proton. Coordination of the C=C bond of *β*-trifluoromethyl-*α,β*-unsaturated ketone (**2b**) to the metal center of **A** leads to arylrhodium species **B**, which is followed by subsequent conjugate addition to produce oxa-π-allylrhodium species **C**. Protonation of **C** with the in situ generated proton affords the desired product **3b** and regenerates the catalytically active rhodium species.

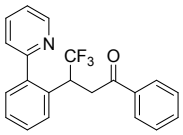


5. Analytical data

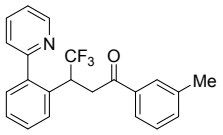


4,4,4-trifluoro-3-(2-(pyridin-2-yl)phenyl)-1-p-tolylbutan-1-one (3a): Colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1 H, aromatic CH), 7.81-7.76 (m, 3 H, aromatic CH), 7.60-7.54 (m, 2 H, aromatic CH), 7.44-7.36 (m, 3 H, aromatic CH), 7.28 (ddd, *J* = 7.6, 4.9, 1.1 Hz, 1 H, aromatic CH), 7.22 (d, *J* = 8.0 Hz, 2 H, aromatic CH), 4.90-4.79 (m, 1 H, CH), 3.68-3.56 (m, 2 H, CH_2), 2.39 (s,

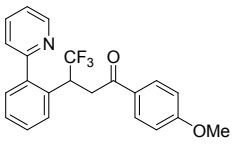
3 H, CH_3); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 195.1 (Cq, C=O), 159.2, 144.3, 142.4, 134.0, 132.8 (Cq each), 149.4, 136.5, 130.7, 129.4, 128.8, 128.3, 128.2, 127.7, 124.6, 122.1 (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 278.5 Hz, CF_3), 39.9 (q, $J_{C\text{-}F}$ = 27.0 Hz, CH), 39.2 (CH_2), 21.7 (CH_3); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.5 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{22}H_{19}F_3NO$: 370.1419; Found: 370.1413.



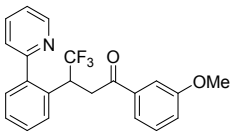
4,4,4-trifluoro-1-phenyl-3-(2-(pyridin-2-yl)phenyl)butan-1-one (3b): white solid, m.p.: 42-44 °C. ^1H NMR (400 MHz, $CDCl_3$) δ 8.68-8.67 (m, 1 H, aromatic CH), 7.90-7.89 (m, 2 H, aromatic CH), 7.81-7.77 (m, 1 H, aromatic CH), 7.59-7.53 (m, 3 H , aromatic CH), 7.45-7.37 (m, 5 H, aromatic CH), 7.28 (ddd, J = 7.6, 5.0, 0.9 Hz, 1 H, aromatic CH), 4.91-4.81 (m, 1 H, CH), 3.70-3.59 (m, 2 H, CH_2); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 195.5 (Cq, C=O), 159.2, 142.3, 136.5, 132.8 (Cq each), 149.4, 136.6, 133.4, 130.7, 128.8, 128.7, 128.2, 127.7, 124.6, 122.2, (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 278.6 Hz, CF_3), 39.9 (q, $J_{C\text{-}F}$ = 27.1 Hz, CH), 39.4 (CH_2); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.5 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{21}H_{17}F_3NO$: 356.1262; Found: 356.1259.



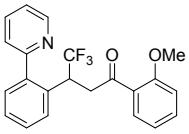
4,4,4-trifluoro-3-(2-(pyridin-2-yl)phenyl)-1-m-tolylbutan-1-one (3c): Pale yellow liquid. ^1H NMR (400 MHz, $CDCl_3$) ^1H NMR (400 MHz, $CDCl_3$) δ 8.68 (ddd, J = 4.8, 1.5, 0.8 Hz, 1 H, aromatic CH), 7.81-7.77 (m, 1 H, aromatic CH), 7.70-7.68 (m, 2 H, aromatic CH), 7.59-7.54 (m, 2 H, aromatic CH), 7.44-7.27 (m, 6 H, aromatic CH), 4.89-4.79 (m, 1 H, CH), 3.68-3.57 (m, 2 H, CH_2), 2.38 (s, 3 H, CH_3); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 195.6 (Cq, C=O), 159.2, 142.4, 138.6, 132.8, 129.0 (Cq each), 149.4, 136.5, 134.2, 130.7, 128.8, 128.7, 128.6, 128.2, 127.7, 125.4, 124.6, 122.1 (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 278.4 Hz, CF_3), 39.9 (q, $J_{C\text{-}F}$ = 27.1 Hz, CH), 39.4 (CH_2), 21.4 (CH_3); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.5 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{22}H_{19}F_3NO$: 370.1419; Found: 370.1424.



4,4,4-trifluoro-1-(4-methoxyphenyl)-3-(2-(pyridin-2-yl)phenyl)butan-1-one (3d): Pale yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.68 (ddd, J = 4.8, 1.6, 0.8 Hz, 1 H, aromatic CH), 7.90-7.86 (m, 2 H, aromatic CH), 7.80-7.76 (m, 1 H, aromatic CH), 7.59-7.54 (m, 2 H, aromatic CH), 7.43-7.36 (m, 3 H, aromatic CH), 7.29-7.26 (m, 1 H, aromatic CH), 6.91-6.87 (m, 2 H, aromatic CH), 4.88-4.78 (m, 1 H, CH), 3.85 (s, 3 H, OCH_3), 3.64-3.52 (m, 2 H, CH_2); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 194.0 (Cq, C=O), 163.7, 159.2, 142.4, 132.8, 129.5 (Cq each), 149.4, 136.5, 130.7, 130.5, 128.7, 128.1, 127.7, 124.6, 122.1, 113.9 (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 278.6 Hz, CF_3), 55.6 (OCH_3), 40.0 (q, $J_{C\text{-}F}$ = 27.1 Hz, CH), 39.4 (CH_2); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.5 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{22}H_{19}F_3NO_2$: 386.1368; Found: 386.1371.

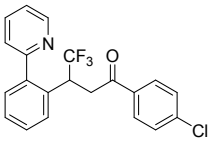


4,4,4-trifluoro-1-(3-methoxyphenyl)-3-(2-(pyridin-2-yl)phenyl)butan-1-one (3e): Yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.68 (d, J = 4.7 Hz, 1 H, aromatic CH), 7.80-7.76 (m, 1 H, aromatic CH), 7.58-7.54 (m, 2 H, aromatic CH), 7.49 (d, J = 7.6 Hz, 1 H, aromatic CH), 7.44-7.26 (m, 6 H, aromatic CH), 7.09 (dd, J = 8.2, 2.4 Hz, 1 H, aromatic CH), 4.91-4.80 (m, 1 H, CH), 3.81 (s, 3 H, OCH_3), 3.69- 3.57 (m, 2 H, CH_2); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.3 (Cq, C=O), 160.0, 159.2, 142.4, 137.8, 132.7 (Cq each), 149.4, 136.5, 130.7, 129.7, 128.8, 128.2, 127.7, 124.6, 122.2, 120.8, 120.0, 112.4 (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 278.7 Hz, CF_3), 55.5 (OCH_3), 40.0 (q, $J_{C\text{-}F}$ = 27.0 Hz, CH), 39.5 (CH_2); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.5 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{22}H_{19}F_3NO_2$: 386.1368; Found: 386.1367.

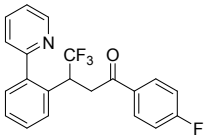


4,4,4-trifluoro-1-(2-methoxyphenyl)-3-(2-(pyridin-2-yl)phenyl)butan-1-one (3f): white solid, m.p.: 42-44 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.64 (d, J = 4.5 Hz, 1 H, aromatic CH), 7.75-7.71 (m, 1 H, aromatic CH), 7.56-7.49 (m, 3 H, aromatic CH), 7.45-7.35 (m, 4 H, aromatic CH), 7.26-7.23 (m, 1 H, aromatic CH), 6.95-6.88 (m, 2 H, aromatic CH), 4.86-4.76 (m, 1 H, CH), 3.85 (s, 3 H, OCH_3), 3.72- 3.60 (m, 2 H, CH_2); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 197.6 (Cq, C=O), 159.2, 158.6, 142.3, 132.8, 127.5 (Cq each), 149.3, 136.4, 133.9, 130.8, 130.5, 128.6, 128.03, 127.98, 124.6,

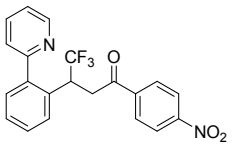
122.0, 120.8, 111.5 (aromatic CH), 127.3 (Cq, J_{C-F} = 271.3 Hz, CF_3), 55.5 (OCH_3), 44.3 (CH_2), 39.9 (q, J_{C-F} = 26.9 Hz, CH); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.8 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{22}H_{19}F_3NO_2$: 386.1368; Found: 386.1367.



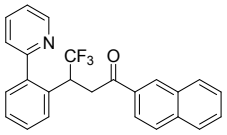
1-(4-chlorophenyl)-4,4,4-trifluoro-3-(2-(pyridin-2-yl)phenyl)butan-1-one (3g): Pale yellow liquid. ^1H NMR (400 MHz, $CDCl_3$) δ 8.65 (ddd, J = 4.9, 1.7, 0.9 Hz, 1 H, aromatic CH), 7.84-7.76 (m, 3 H, aromatic CH), 7.56-7.53 (m, 2 H, aromatic CH), 7.44-7.37 (m, 5 H, aromatic CH), 7.29 (ddd, J = 7.5, 4.9, 1.0 Hz, 1 H, aromatic CH), 4.90-4.79 (m, 1 H, CH), 3.64-3.54 (m, 2 H, CH_2); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 194.4 (Cq, C=O), 159.1, 142.3, 139.9, 134.7, 132.6 (Cq each), 149.3, 136.6, 130.7, 129.7, 129.1, 128.9, 128.3, 127.7, 124.6, 122.2 (aromatic CH), 127.1 (Cq, J_{C-F} = 278.3 Hz, CF_3), 40.0 (q, J_{C-F} = 27.1 Hz, CH), 39.5 (CH_2); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.4 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{21}H_{16}ClF_3NO$: 390.0873; Found: 390.0878.



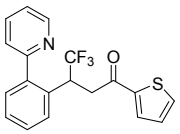
4,4,4-trifluoro-1-(4-fluorophenyl)-3-(2-(pyridin-2-yl)phenyl)butan-1-one (3h): Pale yellow liquid. ^1H NMR (400 MHz, $CDCl_3$) δ 8.66 (ddd, J = 4.9, 1.7, 0.9 Hz, 1 H, aromatic CH), 7.94-7.89 (m, 2 H, aromatic CH), 7.81-7.77 (m, 1 H, aromatic CH), 7.56-7.54 (m, 2 H, aromatic CH), 7.44-7.37 (m, 3 H, aromatic CH), 7.28 (ddd, J = 7.6, 4.9, 1.1 Hz, 1 H, aromatic CH), 7.12-7.06 (m, 2 H, aromatic CH), 4.90-4.80 (m, 1 H, CH), 3.67-3.55 (m, 2 H, CH_2); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 193.9 (Cq, C=O), 165.9 (Cq and d, J_{C-F} = 253.6 Hz, C-F), 159.2, 142.3, 132.7 (Cq each), 149.4, 136.6, 130.9 (d, J_{C-F} = 9.4 Hz), 130.7, 128.8, 128.3, 127.7, 124.6, 122.2, 115.9 (d, J_{C-F} = 21.8 Hz) (aromatic CH), 132.9 (Cq and d, J_{C-F} = 2.7 Hz, *i*-C of C_6H_4F), 127.2 (Cq, J_{C-F} = 278.6 Hz, CF_3), 40.0 (q, J_{C-F} = 27.1 Hz, CH), 39.4 (CH_2); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.4 (CF_3), -104.7 (C-F). HRMS [ESI] Calcd for $[M+H]^+$ $C_{21}H_{16}F_4NO$: 374.1168; Found: 374.1167.



4,4,4-trifluoro-1-(4-nitrophenyl)-3-(2-(pyridin-2-yl)phenyl)butan-1-one (3i): Yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.61 (d, *J* = 4.9 Hz, 1 H, aromatic CH), 8.27 (d, *J* = 8.8 Hz, 2 H, aromatic CH), 8.04 (d, *J* = 8.8 Hz, 2 H, aromatic CH), 7.82-7.78 (m, 1 H, aromatic CH), 7.57-7.51 (m, 2 H, aromatic CH), 7.46-7.39 (m, 3 H, aromatic CH), 7.30 (dd, *J* = 7.2, 5.2 Hz, 1 H, aromatic CH), 4.93-4.83 (m, 1 H, CH), 3.66 (d, *J* = 6.7 Hz, 2 H, CH_2); δ 194.2 (Cq, C=O), 159.1, 150.5, 142.1, 140.8, 132.4 (Cq each), 149.2, 136.8, 130.7, 129.3, 129.0, 128.5, 127.7, 124.6, 123.9, 122.3 (aromatic CH), 127.0 (Cq, $J_{C\text{-}F}$ = 278.7 Hz, CF_3), 40.2 (CH_2); 39.9 (q, $J_{C\text{-}F}$ = 27.3 Hz, CH); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.3 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{21}H_{16}F_3N_2O_3$: 401.1113; Found: 401.1118.

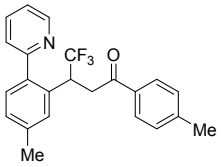


4,4,4-trifluoro-1-(naphthalen-2-yl)-3-(2-(pyridin-2-yl)phenyl)butan-1-one (3j): Yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.64 (d, *J* = 4.8 Hz, 1 H, aromatic CH), 8.42 (s, 1 H, aromatic CH), 7.95-7.93 (d, *J* = 7.6 Hz, 2 H, aromatic CH), 7.86-7.84 (m, 2 H, aromatic CH), 7.76-7.72 (m, 1 H, aromatic CH), 7.64-7.53 (m, 4 H, aromatic CH), 7.46-7.38 (m, 3 H, aromatic CH), 7.23 (dd, *J* = 7.1, 5.3 Hz, 1 H, aromatic CH), 5.00-4.90 (m, 1 H, CH), 3.84-3.73 (m, 2 H, CH_2); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.4 (Cq, C=O), 159.2, 142.4, 135.7, 133.8, 132.8, 132.5 (Cq each), 149.3, 136.5, 130.7, 129.9, 129.7, 128.8, 128.7, 128.6, 128.2, 127.9, 127.7, 127.0, 124.6, 123.9, 122.1 (aromatic CH), 127.3 (Cq, $J_{C\text{-}F}$ = 278.5 Hz, CF_3), 40.1 (q, $J_{C\text{-}F}$ = 27.1 Hz, CH), 39.5 (CH_2); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.4 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{25}H_{19}F_3NO$: 406.1419; Found: 406.1419.

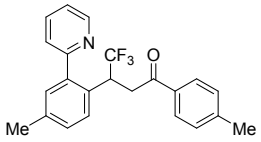


4,4,4-trifluoro-3-(2-(pyridin-2-yl)phenyl)-1-(thiophen-2-yl)butan-1-one (3k): Colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.68 (dd, *J* = 4.8, 0.6 Hz, 1 H, aromatic CH), 7.80-7.76 (m, 1 H, aromatic CH), 7.70 (dd, *J* = 3.8, 0.9 Hz, 1 H, thienyl

CH), 7.61 (dd, J = 5.0, 0.9 Hz, 1 H, thienyl CH), 7.57-7.54 (m, 2 H, aromatic CH), 7.44-7.37 (m, 3 H, aromatic CH), 7.29-7.26 (m, 1 H, aromatic CH), 7.09 (dd, J = 4.9, 3.9 Hz, 1 H, thienyl CH), 4.89-4.78 (m, 1 H, CH), 3.61-3.51 (m, 2 H, CH_2); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 188.3 (Cq, C=O), 159.1, 143.6, 142.3, 132.5 (Cq each), 149.4, 136.6, 134.1, 132.2, 130.7, 128.8, 128.3, 128.2, 127.7, 124.6, 122.2 (aromatic CH), 127.1 (Cq, $J_{C\text{-}F}$ = 278.7 Hz, CF_3), 40.1 (q, $J_{C\text{-}F}$ = 27.2 Hz, CH), 39.9 (CH_2); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.5 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{19}H_{15}F_3NOS$: 362.0826; Found: 362.0829.

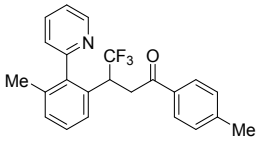


4,4,4-trifluoro-3-(5-methyl-2-(pyridin-2-yl)phenyl)-1-p-tolylbutan-1-one (4a): Colorless liquid. ^1H NMR (400 MHz, $CDCl_3$) δ 8.66 (ddd, J = 4.8, 1.6, 0.8 Hz, 1 H, aromatic CH), 7.81 (d, J = 8.2 Hz, 2 H, aromatic CH), 7.78-7.74 (m, 1 H, aromatic CH), 7.55 (dd, J = 7.9, 0.8 Hz, 1 H, aromatic CH), 7.34-7.30 (m, 2 H, aromatic CH), 7.27-7.18 (m, 4 H, aromatic CH), 4.91-4.80 (m, 1 H, CH), 3.60 (d, J = 6.7 Hz, 2 H, CH_2), 2.40 (s, 6 H, 2×CH_3); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 195.1 (Cq, C=O), 159.3, 144.2, 139.6, 138.5, 134.0, 132.6 (Cq each), 149.4, 136.5, 130.6, 129.4, 129.0, 128.4, 128.3, 124.6, 121.9 (aromatic CH), 127.3 (Cq, $J_{C\text{-}F}$ = 278.6 Hz, CF_3), 39.8 (q, $J_{C\text{-}F}$ = 27.0 Hz, CH), 39.3 (CH_2), 21.7 and 21.5 (2×CH_3); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.4 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{23}H_{21}F_3NO$: 384.1575; Found: 384.1574.

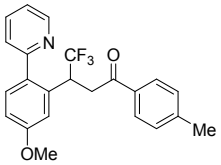


4,4,4-trifluoro-3-(4-methyl-2-(pyridin-2-yl)phenyl)-1-p-tolylbutan-1-one (4b): Colorless liquid. ^1H NMR (400 MHz, $CDCl_3$) δ 8.69 (d, J = 4.4 Hz, 1 H, aromatic CH), 7.82-7.75 (m, 3 H, aromatic CH), 7.61 (d, J = 7.8 Hz, 1 H, aromatic CH), 7.43 (d, J = 8.0 Hz, 1 H, aromatic CH), 7.29-7.21 (m, 5 H, aromatic CH), 4.82-4.71 (m, 1 H, CH), 3.68-3.54 (m, 2 H, CH_2), 2.39 and 2.36 (s each, 3:3 H, 2×CH_3); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 195.1 (Cq, C=O), 159.2, 144.2, 142.2, 137.9, 134.0, 129.6 (Cq each), 149.4, 136.4, 131.3, 129.5, 129.4, 128.3, 127.5, 124.5, 122.0 (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 278.5 Hz, CF_3), 39.7 (q, $J_{C\text{-}F}$ = 26.9 Hz, CH), 39.1 (CH_2), 21.7 and 21.1 (2×CH_3); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.7 (CF_3). HRMS [ESI]

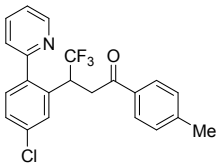
Calcd for $[M+H]^+$ $C_{23}H_{21}F_3NO$: 384.1575; Found: 384.1580.



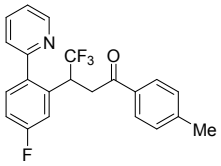
4,4,4-trifluoro-3-(3-methyl-2-(pyridin-2-yl)phenyl)-1-p-tolylbutan-1-one (4c): Colorless liquid, a pair of diastereomers. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.74 (d, J = 12.9 Hz, 2 H, aromatic CH), 7.82-7.78 (m, 6 H, aromatic CH), 7.63-7.20 (m, 14 H, aromatic CH), 4.15-4.00 (m, 2 H, 2×CH), 3.78-3.58 and 3.46-3.36 (m each, 2:2 H, 2×CH_2), 2.39, 2.04, 2.02 (s each, 6:6 H, 4×CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.2 and 194.5 (Cq each, C=O), 158.4, 144.4, 144.1, 142.4, 141.8, 137.2, 136.9, 133.9, 133.5, 132.3 (Cq each), 149.8, 149.7, 136.4, 136.2, 130.2, 130.0, 129.4, 129.3, 128.4, 128.31, 128.25, 125.3, 125.1, 124.4, 122.3, 122.2 (aromatic CH), 127.1 (Cq, $J_{C\text{-}F}$ = 280.3 Hz, CF_3), 41.0 and 40.6 (q each, 2×CH, $J_{C\text{-}F}$ = 28.1 Hz and 26.1 Hz), 39.7 and 38.6 (2×CH_2), 21.7 and 20.7 (4×CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.3 and -69.0 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{23}H_{21}F_3NO$: 384.1575; Found: 384.1582.



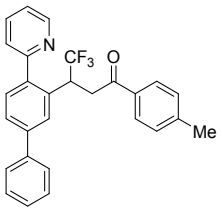
4,4,4-trifluoro-3-(5-methoxy-2-(pyridin-2-yl)phenyl)-1-p-tolylbutan-1-one (4d): Pale yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.66 (d, J = 4.3 Hz, 1 H, aromatic CH), 7.80 (d, J = 8.2 Hz, 2 H, aromatic CH), 7.76 (td, J = 7.7, 1.8 Hz, 1 H, aromatic CH), 7.56 (d, J = 7.8 Hz, 1 H, aromatic CH), 7.38 (d, J = 8.5 Hz, 1 H, aromatic CH), 7.26-7.21 (m, 3 H, aromatic CH), 7.07 (s, 1 H, aromatic CH), 6.92 (dd, J = 8.5, 2.6 Hz, 1 H, aromatic CH), 4.96-4.86 (m, 1 H, CH), 3.83 (s, 3 H, OCH_3), 3.66-3.54 (m, 2 H, CH_2), 2.39 (s, 3 H, CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.0 (Cq, C=O), 159.7, 159.0, 144.2, 135.0, 134.3, 134.0 (Cq each), 149.3, 136.5, 131.9, 129.4, 128.3, 124.6, 121.8, 114.1, 112.8 (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 278.6 Hz, CF_3), 55.4 (OCH_3), 40.0 (q, $J_{C\text{-}F}$ = 27.0 Hz, CH), 39.2 (CH_2), 21.7 (CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.4 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{23}H_{21}F_3NO_2$: 400.1524; Found: 400.1525.



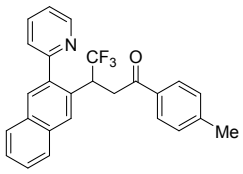
3-(5-chloro-2-(pyridin-2-yl)phenyl)-4,4,4-trifluoro-1-p-tolylbutan-1-one (4e): White solid, m.p.: 98-100 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69 (d, *J* = 4.7 Hz, 1 H, aromatic CH), 7.81-7.78 (m, 3 H, aromatic CH), 7.59 (d, *J* = 7.8 Hz, 1 H, aromatic CH), 7.51 (s, 1 H, aromatic CH), 7.37 (s, 2 H, aromatic CH), 7.30 (dd, *J* = 7.4, 5.0 Hz, 1 H, aromatic CH), 7.24 (d, *J* = 8.1 Hz, 2 H, aromatic CH), 4.90-4.80 (m, 1 H, CH), 3.60 (d, *J* = 6.6 Hz, 2 H, CH_2), 2.40 (s, 3 H, CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 194.6 (Cq, C=O), 158.2, 144.5, 140.9, 134.9, 134.7, 133.8 (Cq each), 149.6, 136.7, 132.0, 129.5, 128.4, 128.3, 127.9, 124.6, 122.4 (aromatic CH), 127.0 (Cq, $J_{C\text{-}F}$ = 278.6 Hz, CF_3), 39.9 (q, $J_{C\text{-}F}$ = 27.3 Hz, CH), 39.0 (CH_2), 21.8 (CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.5 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{22}H_{18}ClF_3NO$: 404.1029; Found: 404.1027.



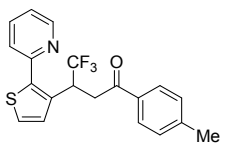
4,4,4-trifluoro-3-(5-fluoro-2-(pyridin-2-yl)phenyl)-1-p-tolylbutan-1-one (4f): Pale yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69-8.67 (m, 1 H, aromatic CH), 7.81-7.77 (m, 3 H, aromatic CH), 7.58 (d, *J* = 7.8 Hz, 1 H, aromatic CH), 7.41 (dd, *J* = 8.6, 6.0 Hz, 1 H, aromatic CH), 7.29 (ddd, *J* = 7.5, 4.9, 1.0 Hz, 1 H, aromatic CH), 7.25-7.22 (m, 3 H, aromatic CH), 7.11-7.06 (m, 1 H, aromatic CH), 4.90-4.80 (m, 1 H, CH), 3.59 (d, *J* = 6.7 Hz, 2 H, CH_2), 2.40 (s, 3 H, CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 194.7 (Cq, C=O), 162.7 (Cq and d, $J_{C\text{-}F}$ = 246.2 Hz, C-F), 158.3, 144.5, 133.9 (Cq each), 138.6 (d, $J_{C\text{-}F}$ = 3.3 Hz) and 135.3 (d, $J_{C\text{-}F}$ = 6.1 Hz, Cq each), 149.5, 136.6, 132.5 (d, *J* = 8.4 Hz), 129.5, 128.3, 124.6, 122.3, 115.3 (d, *J* = 20.9 Hz), 114.8 (d, *J* = 22.0 Hz) (aromatic CH), 127.0 (Cq, $J_{C\text{-}F}$ = 278.7 Hz, CF_3), 40.1 (q, $J_{C\text{-}F}$ = 27.4 Hz, CH), 39.1 (CH_2), 21.8 (CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.6 (CF_3), -112.5 (C-F). HRMS [ESI] Calcd for $[M+H]^+$ $C_{22}H_{18}F_4NO$: 388.1325; Found: 388.1325.



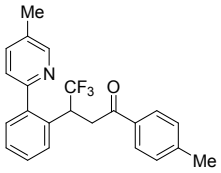
4,4,4-trifluoro-3-(4-(pyridin-2-yl)biphenyl-3-yl)-1-p-tolylbutan-1-one (4g): Colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73-8.71 (m, 1 H, aromatic CH), 7.84-7.80 (m, 3 H, aromatic CH), 7.76 (s, 1 H, aromatic CH), 7.65-7.59 (m, 4 H, aromatic CH), 7.53-7.45 (m, 3 H, aromatic CH), 7.39 (ddd, J = 7.3, 3.8, 1.1 Hz, 1 H, aromatic CH), 7.31 (ddd, J = 7.6, 4.9, 1.0 Hz, 1 H, aromatic CH), 7.23 (d, J = 8.0 Hz, 2 H, aromatic CH), 5.02-4.92 (m, 1 H, CH), 3.74-3.62 (m, 2 H, CH_2), 2.40 (s, 3 H, CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.1 (Cq, C=O), 159.0, 144.3, 141.7, 140.6, 134.0, 133.4 (Cq each), 149.5, 136.6, 131.2, 129.4, 129.0, 128.4, 127.8, 127.4, 127.0, 126.7, 124.6, 122.2 (aromatic CH), 127.3 (Cq, $J_{C\text{-}F}$ = 278.5 Hz, CF_3), 40.0 (q, $J_{C\text{-}F}$ = 27.0 Hz, CH), 39.3 (CH_2), 21.7 (CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.3 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{28}H_{23}F_3NO$: 446.1732; Found: 446.1726.



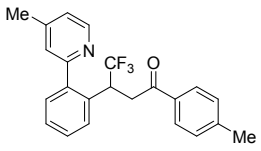
4,4,4-trifluoro-3-(3-(pyridin-2-yl)naphthalen-2-yl)-1-p-tolylbutan-1-one (4h): Colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.74 (d, J = 4.5 Hz, 1 H, aromatic CH), 8.03 and 7.92 (s each, 1:1 H, aromatic CH), 7.87-7.81 (m, 5 H, aromatic CH), 7.73 (d, J = 7.8 Hz, 1 H, aromatic CH), 7.52-7.49 (m, 2 H, aromatic CH), 7.32 (dd, J = 6.8, 5.1 Hz, 1 H, aromatic CH), 7.23 (d, J = 8.0 Hz, 2 H, aromatic CH), 5.09-5.00 (m, 1 H, CH), 3.85-3.70 (m, 2 H, CH_2), 2.39 (s, 3 H, CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.1 (Cq, C=O), 159.4, 144.3, 140.0, 134.0, 133.0, 132.7, 131.2 (Cq each), 149.4, 136.6, 130.1, 129.4, 128.4, 128.0, 127.8, 127.5, 126.9, 126.8, 124.9, 122.1 (aromatic CH), 127.3 (Cq, $J_{C\text{-}F}$ = 278.6 Hz, CF_3), 39.9 (q, $J_{C\text{-}F}$ = 27.1 Hz, CH), 39.7 (CH_2), 21.7 (CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.5 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{26}H_{21}F_3NO$: 420.1575; Found: 420.1578.



4,4,4-trifluoro-3-(2-(pyridin-2-yl)thiophen-3-yl)-1-p-tolylbutan-1-one (4i): Colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.61 (d, *J* = 4.8 Hz, 1 H, aromatic CH), 7.79 (d, *J* = 8.2 Hz, 2 H, aromatic CH), 7.76-7.72 (m, 1 H, aromatic CH), 7.69 (d, *J* = 7.8 Hz, 1 H, , aromatic CH), 7.33 (d, *J* = 5.3 Hz, 1 H, aromatic CH), 7.22-7.20 (m, 3 H, aromatic CH), 7.16 (d, *J* = 5.3 Hz, 1 H, aromatic CH), 5.46-5.36 (m, 1 H, CH), 3.61-3.49 (m, 2 H, CH_2), 2.38 (s, 3 H, CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.2 (Cq, C=O), 152.7, 144.3, 142.1, 134.0, 132.2 (Cq each), 149.7, 136.9, 129.4, 128.3, 127.8, 126.3, 123.0, 122.3 (aromatic CH), 127.1 (Cq, $J_{C\text{-}F}$ = 278.4 Hz, CF_3), 39.0 (CH_2), 38.3 (q, $J_{C\text{-}F}$ = 27.8 Hz, CH), 21.7 (CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.3 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{20}H_{17}F_3NOS$: 376.0983; Found: 376.0987.

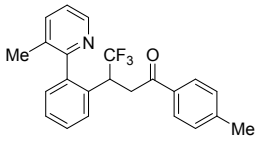


4,4,4-trifluoro-3-(2-(5-methylpyridin-2-yl)phenyl)-1-p-tolylbutan-1-one (4j): Pale yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.51 (dd, *J* = 1.4, 0.7 Hz, 1 H, aromatic CH), 7.79 (d, *J* = 8.2 Hz, 2 H, aromatic CH), 7.58 (dd, *J* = 7.9, 1.7 Hz, 1 H, aromatic CH), 7.54 (d, *J* = 7.1 Hz, 1 H, aromatic CH), 7.46 (d, *J* = 7.9 Hz, 1 H, aromatic CH), 7.42-7.34 (m, 3 H, aromatic CH), 7.22 (d, *J* = 8.0 Hz, 2 H, aromatic CH), 4.90-4.80 (m, 1 H, CH), 3.67-3.55 (m, 2 H, CH_2), 2.39 (s, 6 H, 2×CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.1 (Cq, C=O), 156.3, 144.2, 142.4, 134.0, 132.8, 131.6 (Cq each), 149.9, 137.1, 130.7, 129.4, 128.6, 128.4, 128.1, 127.6, 124.0 (aromatic CH), 127.3 (Cq, $J_{C\text{-}F}$ = 278.7 Hz, CF_3), 40.0 (q, $J_{C\text{-}F}$ = 27.0 Hz, CH), 39.3 (CH_2), 21.7 and 18.4 (2×CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.5 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{23}H_{21}F_3NO$: 384.1575; Found: 384.1577.

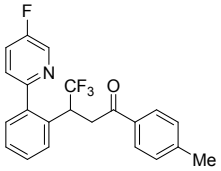


4,4,4-trifluoro-3-(2-(4-methylpyridin-2-yl)phenyl)-1-p-tolylbutan-1-one (4k): Pale yellow liquid. δ 8.52 (d, *J* = 5.0 Hz, 1 H, aromatic CH), 7.80 (d, *J* = 8.2 Hz, 2 H, aromatic CH), 7.56 (d, *J* = 7.8 Hz, 1 H, aromatic CH), 7.42-7.35 (m, 4 H, aromatic CH), 7.22 (d, *J* = 8.1 Hz, 2 H, aromatic CH), 7.10-7.09 (m, 1 H, aromatic CH), 4.92-

4.82 (m, 1 H, CH), 3.60 (d, J = 6.7 Hz, 2 H, CH_2), 2.41 and 2.39 (s each, 3:3 H, 2×CH_3); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 195.1 (Cq, C=O), 159.0, 147.6, 144.2, 142.4, 134.0, 132.9 (Cq each), 149.1, 130.6, 129.4, 128.6, 128.4, 128.1, 127.7, 125.5, 123.1 (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 278.6 Hz, CF_3), 40.0 (q, $J_{C\text{-}F}$ = 27.0 Hz, CH), 39.3 (CH_2), 21.7 and 21.3 (2×CH_3); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.4 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{23}H_{21}F_3NO$: 384.1575; Found: 384.1577.

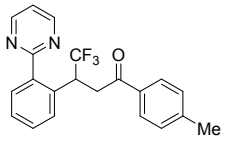


4,4,4-trifluoro-3-(2-(3-methylpyridin-2-yl)phenyl)-1-p-tolylbutan-1-one (4l): Pale yellow solid, m.p.: 86-88□°C. ^1H NMR (400 MHz, $CDCl_3$) δ 8.46 (s, 1 H, aromatic CH), 7.80 (d, J = 7.3 Hz, 2 H, aromatic CH), 7.64-7.61 (m, 2 H, aromatic CH), 7.46-7.36 (m, 2 H, aromatic CH), 7.26-7.22 (m, 4 H, aromatic CH), 4.33 (s, 1 H, CH), 3.65 (s) and 3.42 (dd, J = 16.9, 4.5 Hz, 1:1 H, CH_2), 2.39 and 2.14 (s each, 3:3 H, 2×CH_3); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 194.8 (Cq, C=O), 158.2, 144.2, 138.4, 133.9, 132.4, 129.8 (Cq each), 146.7, 129.4, 128.6, 128.4, 128.2, 127.9, 122.8 (aromatic CH), 127.1 (Cq, $J_{C\text{-}F}$ = 278.8 Hz, CF_3), 40.3 (q, $J_{C\text{-}F}$ = 27.8 Hz, CH), 39.6 (CH_2), 21.7 and 19.3 (2×CH_3); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.3 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{23}H_{21}F_3NO$: 384.1575; Found: 384.1575.

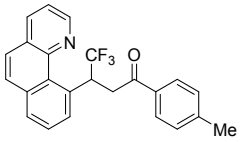


4,4,4-trifluoro-3-(2-(5-fluoropyridin-2-yl)phenyl)-1-p-tolylbutan-1-one (4m): Pale yellow liquid. ^1H NMR (400 MHz, $CDCl_3$) δ 8.53 (d, J = 2.7 Hz, 1 H, aromatic CH), 7.79 (d, J = 8.0 Hz, 2 H, aromatic CH), 7.61 (dd, J = 8.6, 4.4 Hz, 1 H, aromatic CH), 7.55-7.48 (m, 2 H, aromatic CH), 7.43-7.35 (m, 3 H, aromatic CH), 7.23 (d, J = 8.0 Hz, 2 H, aromatic CH), 4.80-4.70 (m, 1 H, CH), 3.62 (qd, J = 17.3, 6.7 Hz, 2 H, CH_2), 2.40 (s, 3 H, CH_3); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 195.1 (Cq, C=O), 158.7 (Cq and d, $J_{C\text{-}F}$ = 254.9 Hz, C-F), 155.4, 144.4, 141.4, 133.9, 132.8 (Cq each), 137.6 (d, $J_{C\text{-}F}$ = 23.3 Hz), 130.7, 129.4, 128.9, 128.3, 128.2, 127.7, 125.6 (d, J = 4.2 Hz), 123.4 (d, J = 18.3 Hz) (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 278.3 Hz, CF_3), 40.0 (q, $J_{C\text{-}F}$ = 27.0 Hz, CH), 39.1 (CH_2), 21.7 (CH_3); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -

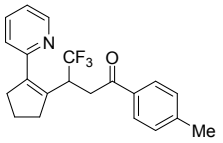
68.6 (CF_3), -129.2 (C-F). HRMS [ESI] Calcd for $[M+H]^+$ $C_{22}H_{18}F_4NO$: 388.1325; Found: 388.1324.



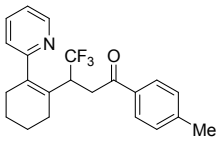
4,4,4-trifluoro-3-(2-(pyrimidin-2-yl)phenyl)-1-p-tolylbutan-1-one (4n): Pale yellow solid, m.p.: 65-67 °C.. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.87 (d, *J* = 4.9 Hz, 2 H, aromatic CH), 7.93 (dd, *J* = 7.3, 1.8 Hz, 1 H, aromatic CH), 7.81 (d, *J* = 8.1 Hz, 2 H, aromatic CH), 7.62 (d, *J* = 7.5 Hz, 1 H, aromatic CH), 7.50-7.43 (m, 2 H, aromatic CH), 7.28 (d, *J* = 5.1 Hz, 1 H, aromatic CH), 7.23 (d, *J* = 8.1 Hz, 2 H, aromatic CH), 5.78-5.67 (m, 1 H, CH), 3.71-3.59 (m, 2 H, CH_2), 2.41 (s, 3 H, CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.1 (Cq, C=O), 166.9, 144.2, 139.5, 134.1 (Cq each), 157.1, 131.6, 129.9, 129.3, 128.3, 128.1, 128.0, 118.9 (aromatic CH), 127.5 (Cq, $J_{C\text{-}F}$ = 278.6 Hz, CF_3), 39.5 (CH_2), 39.1 (q, $J_{C\text{-}F}$ = 26.9 Hz, CH), 21.7 (CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.1 (CF_3); HRMS [ESI] Calcd for $[M+H]^+$ $C_{21}H_{18}F_3N_2O$: 371.1371; Found: 371.1369.



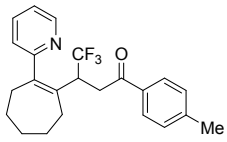
3-(benzo[h]quinolin-10-yl)-4,4,4-trifluoro-1-p-tolylbutan-1-one (4o): Yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.91 (dd, *J* = 4.2, 1.7 Hz, 1 H, aromatic CH), 8.69-8.59 (m, 1 H, CH), 8.15 (dd, *J* = 8.0, 1.6 Hz, 1 H, aromatic CH), 7.89-7.83 (m, 4 H, aromatic CH), 7.78 (d, *J* = 8.7 Hz, 1 H, aromatic CH), 7.66-7.61 (m, 2 H, aromatic CH), 7.48 (dd, *J* = 8.0, 4.3 Hz, 1 H, aromatic CH), 7.20 (d, *J* = 8.0 Hz, 2 H, aromatic CH), 3.94-3.83 (m, 2 H, CH_2), 2.38 (s, 3 H, CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 196.1 (Cq, C=O), 148.3, 144.0, 135.6, 135.3, 134.4, 129.8, 128.0 (Cq each), 147.0, 136.1, 129.32, 129.29, 129.0, 128.3, 128.2, 127.2, 126.1, 121.4 (aromatic CH), 128.3 (Cq, $J_{C\text{-}F}$ = 278.6 Hz, CF_3), 40.1 (CH_2), 39.6 (q, $J_{C\text{-}F}$ = 26.0 Hz, CH), 21.7 (CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -67.9 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{24}H_{19}F_3NO$: 394.1419; Found: 394.1421.



4,4,4-trifluoro-3-(2-(pyridin-2-yl)cyclopent-1-enyl)-1-p-tolylbutan-1-one (6a): Colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 (d, *J* = 4.6 Hz, 1 H, aromatic CH), 7.81 (d, *J* = 8.2 Hz, 2 H, aromatic CH), 7.63-7.59 (m, 1 H, aromatic CH), 7.26 (d, *J* = 7.9 Hz, 1 H, aromatic CH), 7.21 (d, *J* = 8.1 Hz, 2 H, aromatic CH), 7.08 (dd, *J* = 7.4, 4.9 Hz, 1 H, aromatic CH), 5.41-5.30 (m, 1 H, CH), 3.32 (qd, *J* = 16.0, 7.0 Hz, 2 H, $COCH_2$), 2.87-2.72, 2.69-2.55, 2.02-1.85 (m each, 2:2:2 H, 3×CH_2), 2.39 (s, 3 H, CH_3); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.9 (Cq, C=O), 155.8, 144.1, 141.4, 135.0, 134.1 (Cq each), 149.0, 136.2, 129.4, 128.4, 122.4, 121.7 (aromatic CH), 127.3 (Cq, $J_{C\text{-}F}$ = 279.4 Hz, CF_3), 39.1 (q, $J_{C\text{-}F}$ = 27.2 Hz, CH), 36.5 ($COCH_2$), 36.2, 34.2, 22.0 (3×CH_2), 21.7 (CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -67.9 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{21}H_{21}F_3NO$: 360.1575; Found: 360.1574.

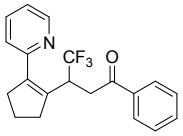


4,4,4-trifluoro-3-(2-(pyridin-2-yl)cyclohex-1-enyl)-1-p-tolylbutan-1-one (6b): Colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.54 (d, *J* = 4.8 Hz, 1 H, aromatic CH), 7.77 (d, *J* = 8.1 Hz, 2 H, aromatic CH), 7.63-7.59 (m, 1 H, aromatic CH), 7.26-7.21 (m, 3 H, aromatic CH), 7.13 (dd, *J* = 7.4, 5.0 Hz, 1 H, aromatic CH), 4.04-3.94 (m, 1 H, CH), 3.30-3.18 (m, 2 H, $COCH_2$), 2.43-2.32 (m, 5 H, CH_3 and CH_2 overlapped), 2.25-2.11, 1.78-1.65 (m each, 2:4 H, 3×CH_2); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 195.5 (Cq, C=O), 160.9, 144.2, 140.7, 134.0, 127.3 (Cq each), 149.5, 136.4, 129.4, 128.4, 123.2, 121.7 (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 279.9 Hz, CF_3), 42.1 (q, $J_{C\text{-}F}$ = 26.7 Hz, CH), 35.7 ($COCH_2$), 31.5, 25.1, 22.7, 22.6 (4×CH_2), 21.8 (CH_3); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -67.2 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{22}H_{23}F_3NO$: 374.1732; Found: 374.1740.

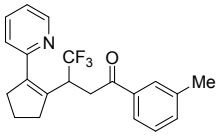


4,4,4-trifluoro-3-(2-(pyridin-2-yl)cyclohept-1-enyl)-1-p-tolylbutan-1-one (6c): Pale yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.55-8.54 (m, 1 H, aromatic CH), 7.75 (d, *J* = 8.2 Hz, 2 H, aromatic CH), 7.63-7.59 (m, 1 H, aromatic CH), 7.23-7.19 (m, 3 H, aromatic CH), 7.11 (ddd, *J* = 7.5, 4.9, 0.9 Hz, 1 H, aromatic CH), 4.05-3.95 (m, 1 H, CH), 3.28-3.17 (m, 2 H, $COCH_2$), 2.59-2.51, 1.90-1.71, 1.67-1.54 (m each,

2:2:4 H, 4×CH_2), 2.50-2.36 (m, 5 H, CH_2 and CH_3 overlapped); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 195.4 (Cq, C=O), 161.8, 146.7, 144.1, 134.0, 133.5 (Cq each), 149.5, 136.3, 129.4, 128.4, 123.0, 121.6 (aromatic CH), 127.3 (Cq, $J_{C\text{-}F}$ = 279.6 Hz, CF_3), 42.7 (q, $J_{C\text{-}F}$ = 26.5 Hz, CH), 35.9 (CO*C*H_2), 35.4, 32.6, 29.0, 26.1, 26.0 (5×CH_2), 21.8 (CH_3); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -67.3 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{23}H_{25}F_3NO$: 388.1888; Found: 388.1888.

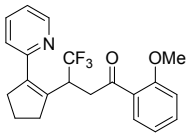


4,4,4-trifluoro-1-phenyl-3-(2-(pyridin-2-yl)cyclopent-1-enyl)butan-1-one (6d): Pale yellow liquid. ^1H NMR (400 MHz, $CDCl_3$) δ 8.42 (d, *J* = 4.7 Hz, 1 H, aromatic CH), 7.91 (d, *J* = 7.6 Hz, 2 H, aromatic CH), 7.64-7.60 (m, 1 H, aromatic CH), 7.56-7.52 (m, 1 H, aromatic CH), 7.44-7.41 (m, 2 H, aromatic CH), 7.25 (d, *J* = 7.4 Hz, 1 H, aromatic CH), 7.07 (dd, *J* = 7.4, 4.9 Hz, 1 H, aromatic CH), 5.44-5.34 (m, 1 H, CH), 3.43-3.26 (m, 2 H, $COCH_2$), 2.87-2.73, 2.69-2.56, 2.03-1.85 (m each, 2:2:2 H, 3×CH_2); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 196.4 (Cq, C=O), 155.7, 141.4, 136.6, 135.0 (Cq each), 149.0, 136.3, 133.3, 128.7, 128.3, 122.4, 121.8 (aromatic CH), 127.3 (Cq, $J_{C\text{-}F}$ = 279.4 Hz, CF_3), 39.1 (q, $J_{C\text{-}F}$ = 27.2 Hz, CH), 36.7 (CO*C*H_2), 36.2, 34.2, 22.1 (3×CH_2); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.0 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{20}H_{19}F_3NO$: 346.1419; Found: 346.1420.

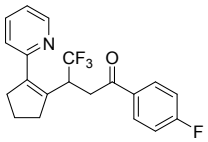


4,4,4-trifluoro-3-(2-(pyridin-2-yl)cyclopent-1-enyl)-1-m-tolylbutan-1-one (6e): Pale yellow liquid. ^1H NMR (400 MHz, $CDCl_3$) δ 8.44-8.43 (m, 1 H, aromatic CH), 7.72-7.68 (m, 2 H, aromatic CH), 7.64-7.60 (m, 1 H, aromatic CH), 7.36-7.29 (m, 2 H, aromatic CH), 7.27-7.26 (m, 1 H, aromatic CH), 7.08 (dd, *J* = 7.5, 4.8 Hz, 1 H, aromatic CH), 5.41-5.30 (m, 1 H, CH), 3.41-3.25 (m, 2 H, $COCH_2$), 2.87-2.73, 2.68-2.53, 2.02-1.85 (m each, 2:2:2 H, 3×CH_2), 2.38 (s, 3 H, CH_3); $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 196.5 (Cq, C=O), 155.8, 141.5, 138.5, 136.6, 135.0 (Cq each), 149.0, 136.2, 134.0, 128.8, 128.6, 125.5, 122.4, 121.7 (aromatic CH), 127.3 (Cq, $J_{C\text{-}F}$ = 279.4 Hz, CF_3), 39.1 (q, $J_{C\text{-}F}$ = 27.2 Hz, CH), 36.7 (CO*C*H_2), 36.3, 34.2, 22.1 (3×CH_2), 21.5 (CH_3); $^{19}F\{^1H\}$ NMR (376 MHz, $CDCl_3$) δ -68.0 (CF_3). HRMS [ESI] Calcd for

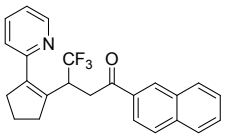
$[M+H]^+$ $C_{21}H_{21}F_3NO$: 360.1575; Found: 360.1575.



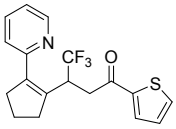
4,4,4-trifluoro-1-(2-methoxyphenyl)-3-(2-(pyridin-2-yl)cyclopent-1-enyl)butan-1-one (6f): Pale yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (d, *J* = 4.1 Hz, 1 H, aromatic CH), 7.59-7.52 (m, 2 H, aromatic CH), 7.39-7.34 (m, 1 H, aromatic CH), 7.19 (d, *J* = 7.9 Hz, 1 H, aromatic CH), 7.04 (dd, *J* = 6.9, 5.1 Hz, 1 H, aromatic CH), 6.89-6.84 (m, 2 H, aromatic CH), 5.30-5.19 (m, 1 H, CH), 3.86 (s, 3 H, OCH_3), 3.47 (dd, *J* = 15.7, 4.6 Hz) and 3.25 (dd, *J* = 15.7, 9.7 Hz, 1:1 H, $COCH_2$), 2.77 (t, *J* = 7.3 Hz) and 2.61 (t, *J* = 7.4 Hz, 2:2 H, 2×CH_2), 1.99-1.84 (m, 2 H, CH_2); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 198.5 (Cq, C=O), 158.4, 155.9, 141.3, 127.6, 115.1 (Cq each), 148.9, 136.1, 133.7, 130.7, 122.4, 121.6, 120.8, 111.3 (aromatic CH), 127.4 (Cq, $J_{C\text{-}F}$ = 279.4 Hz, CF_3), 55.5 (OCH_3), 41.6 ($CO\mathit{C}H_2$), 39.0 (q, $J_{C\text{-}F}$ = 27.1 Hz, CH), 36.3, 34.2, 22.1 (3×CH_2); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.1 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{21}H_{21}F_3NO_2$: 376.1524; Found: 376.1526.



4,4,4-trifluoro-1-(4-fluorophenyl)-3-(2-(pyridin-2-yl)cyclopent-1-enyl)butan-1-one (6g): Pale yellow liquid. δ 8.40 (d, *J* = 4.4 Hz, 1 H, aromatic CH), 7.95-7.91 (m, 2 H, aromatic CH), 7.64-7.60 (m, 1 H, aromatic CH), 7.23 (d, *J* = 7.9 Hz, 1 H, aromatic CH), 7.11-7.06 (m, 3 H, aromatic CH), 5.47-5.36 (m, 1 H, CH), 3.38 (dd, *J* = 15.8, 5.2 Hz) and 3.24 (dd, *J* = 15.7, 8.9 Hz, 1:1 H, $COCH_2$), 2.86-2.72, 2.68-2.56, 2.03-1.86 (m each, 2:2:2 H, 3×CH_2); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 194.9 (Cq, C=O), 165.9 (Cq and d, $J_{C\text{-}F}$ = 253.4 Hz, C-F), 155.7, 141.3, 135.0 (Cq each), 133.0 (Cq and d, *J* = 2.8 Hz), 148.9, 136.3, 131.0 (d, $J_{C\text{-}F}$ = 9.4 Hz), 122.4, 121.8, 115.8 (d, $J_{C\text{-}F}$ = 21.7 Hz) (aromatic CH), 127.2 (Cq, $J_{C\text{-}F}$ = 279.2 Hz, CF_3), 39.2 (q, $J_{C\text{-}F}$ = 27.2 Hz, CH), 36.7 ($CO\mathit{C}H_2$), 36.2, 34.2, 22.1 (3×CH_2); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -67.9 (CF_3), -105.1 (C-F). HRMS [ESI] Calcd for $[M+H]^+$ $C_{20}H_{18}F_4NO$: 364.1325; Found: 364.1324.



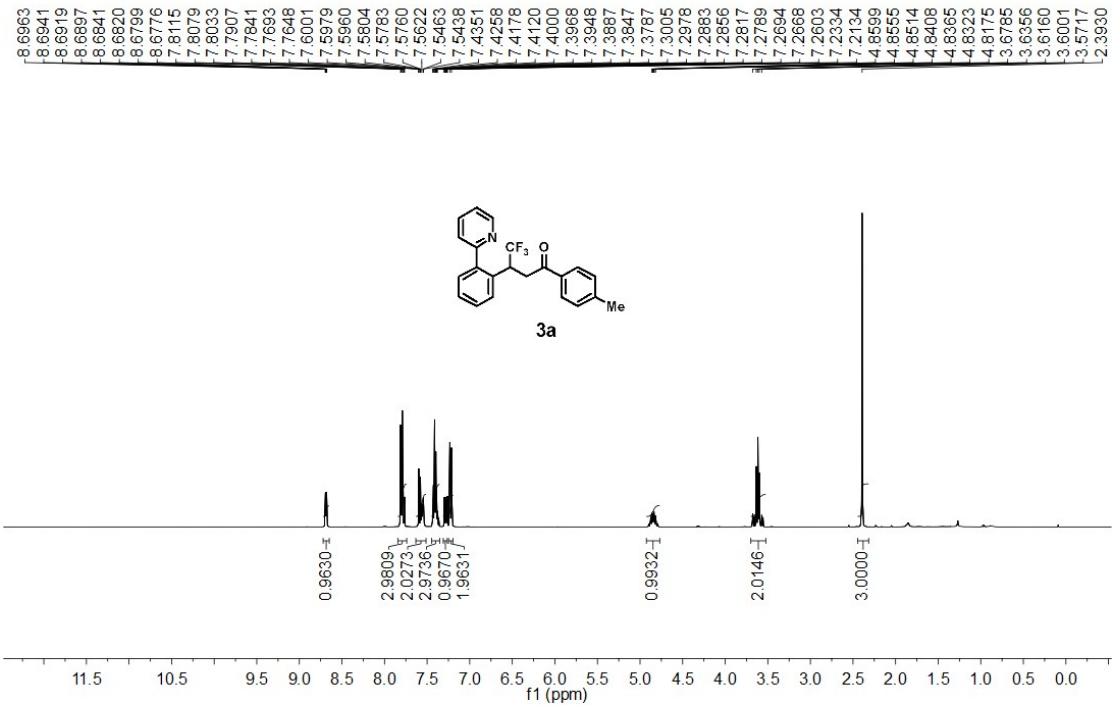
4,4,4-trifluoro-1-(naphthalen-2-yl)-3-(2-(pyridin-2-yl)cyclopent-1-enyl)butan-1-one (6h): Pale yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (s, 1 H, aromatic CH), 8.31 (d, J = 4.2 Hz, 1 H, aromatic CH), 7.96-7.92 (m, 2 H, aromatic CH), 7.86-7.83 (m, 2 H, aromatic CH), 7.62-7.52 (m, 3 H, aromatic CH), 7.22 (d, J = 7.9 Hz, 1H), 6.97-6.94 (m, 1 H, aromatic CH), 5.54-5.43 (m, 1 H, CH), 3.55 (dd, J = 15.8, 4.9 Hz) and 3.42 (dd, J = 15.8, 9.1 Hz, 1:1 H, $COCH_2$), 2.80-2.63 and 2.03-1.86 (m each, 4:2 H, 3×CH_2); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 196.3 (Cq, C=O), 155.7, 141.5, 135.7, 134.9, 133.9, 132.5 (Cq each), 148.9, 136.1, 129.9, 129.7, 128.6, 128.5, 127.8, 126.9, 124.0, 122.2, 121.6 (aromatic CH), 127.3 (Cq, $J_{C\text{-}F}$ = 279.1 Hz, CF_3), 39.2 (q, $J_{C\text{-}F}$ = 27.2 Hz, CH), 36.7 (CO*C*H_2), 36.2, 34.2, 22.0 (3×CH_2); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -67.9 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{24}H_{21}F_3NO$: 396.1575; Found: 396.1576.



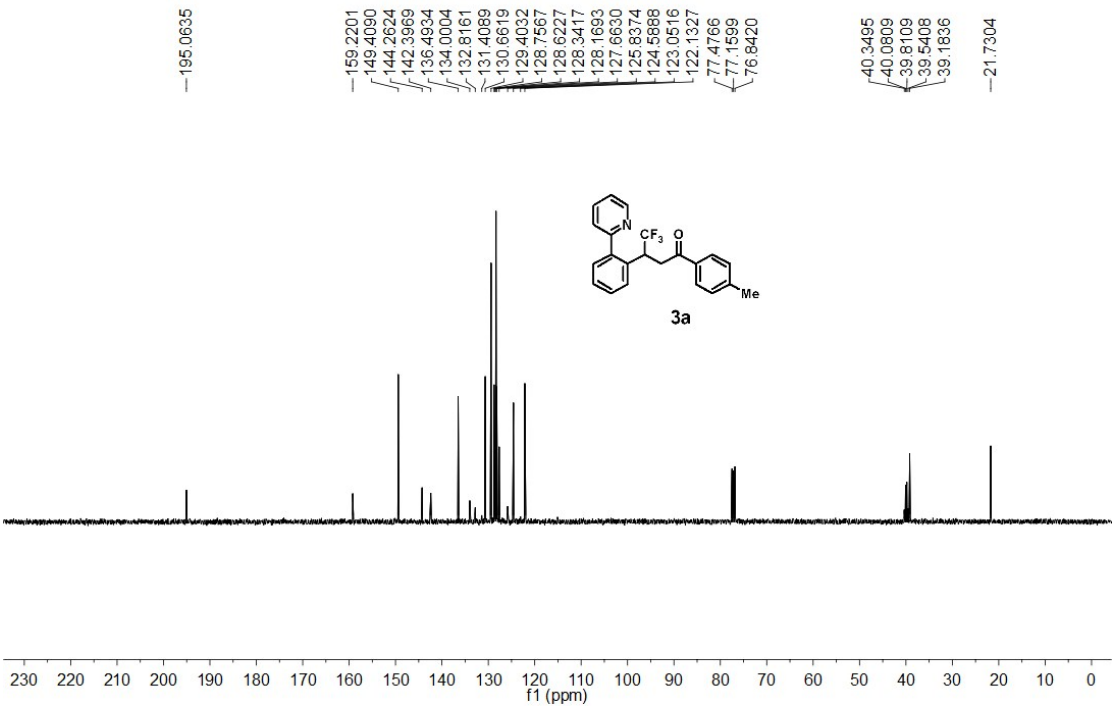
4,4,4-trifluoro-3-(2-(pyridin-2-yl)cyclopent-1-enyl)-1-(thiophen-2-yl)butan-1-one (6i): Pale yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.49-8.48 (m, 1 H, aromatic CH), 7.77 (dd, J = 3.7, 0.7 Hz, 1 H, aromatic CH), 7.67-7.63 (m, 2 H, aromatic CH), 7.28 (d, J = 8.0 Hz, 1 H, aromatic CH), 7.14-7.10 (m, 2 H, aromatic CH), 5.49-5.38 (m, 1 H, CH), 3.36 (dd, J = 15.5, 5.2 Hz) and 3.25 (dd, J = 15.5, 8.9 Hz, 1:1 H, $COCH_2$), 2.90-2.75, 2.72-2.61, 2.06-1.89 (m each, 2:2:2 H, 3×CH_2); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 189.1 (Cq, C=O), 155.7, 143.9, 141.5, 134.8 (Cq each), 148.9, 136.3, 134.0, 132.2, 128.2, 122.3, 121.8 (aromatic CH), 127.1 (Cq, $J_{C\text{-}F}$ = 279.4 Hz, CF_3), 39.4 (q, $J_{C\text{-}F}$ = 27.2 Hz, CH), 37.3 (CO*C*H_2), 36.2, 34.2, 22.1 (3×CH_2); ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.0 (CF_3). HRMS [ESI] Calcd for $[M+H]^+$ $C_{18}H_{17}F_3NOS$: 352.0983; Found: 352.0980.

6. Copies of NMR spectra

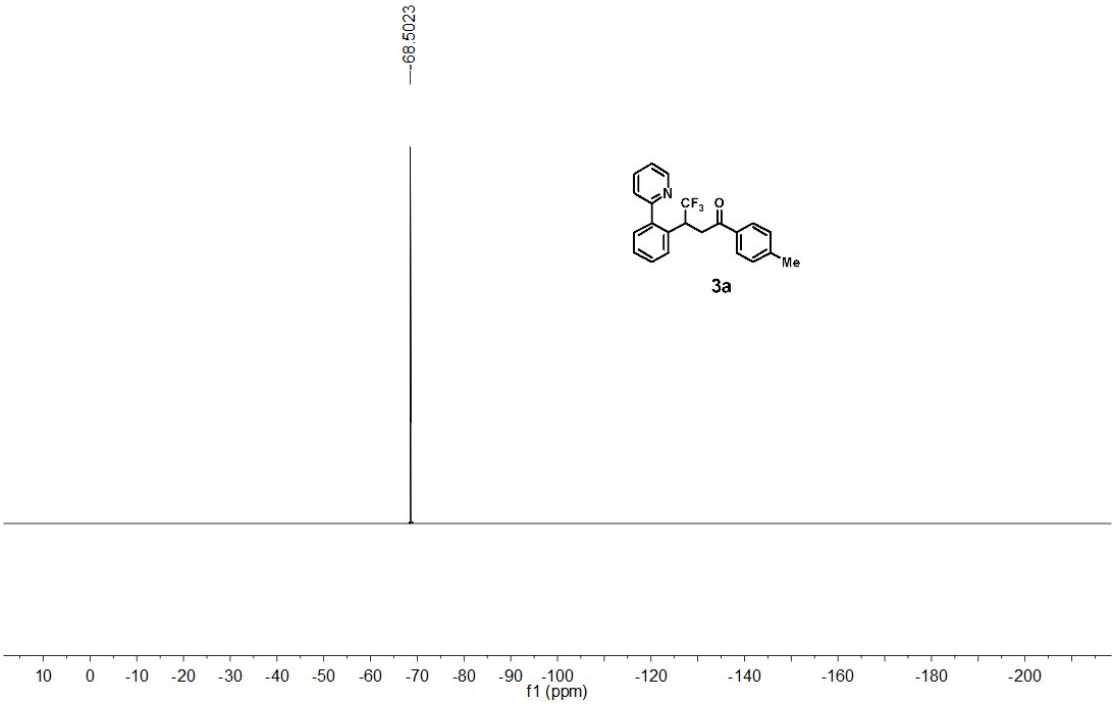
^{1}H NMR in $CDCl_3$



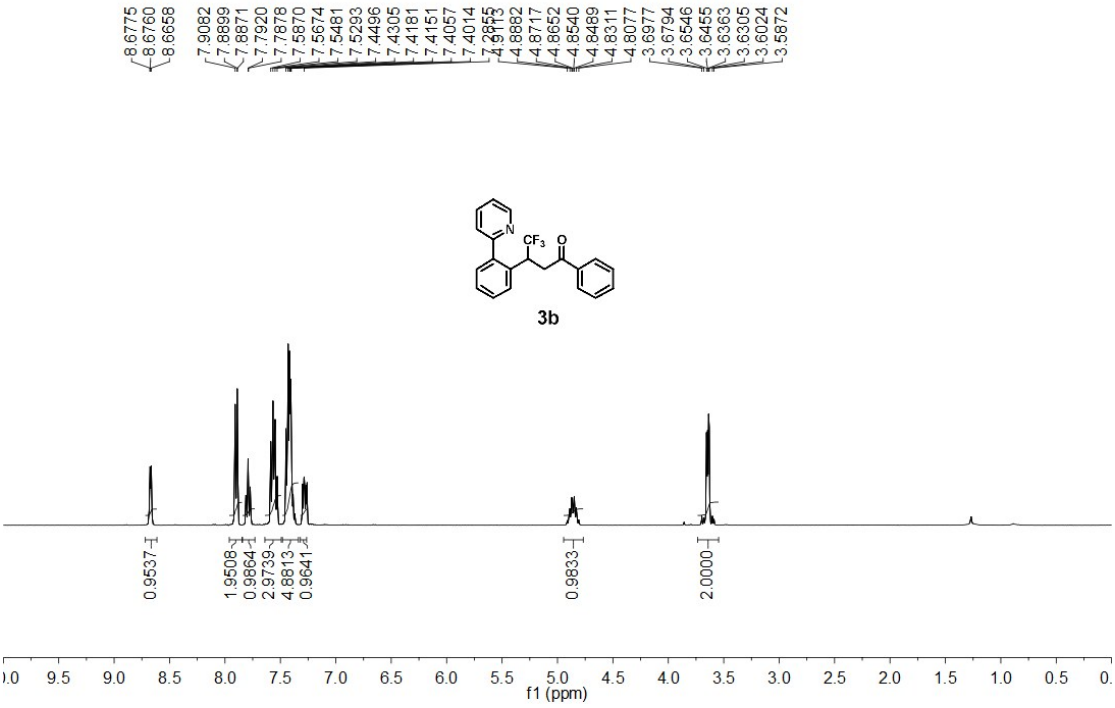
^{13}C NMR in $CDCl_3$



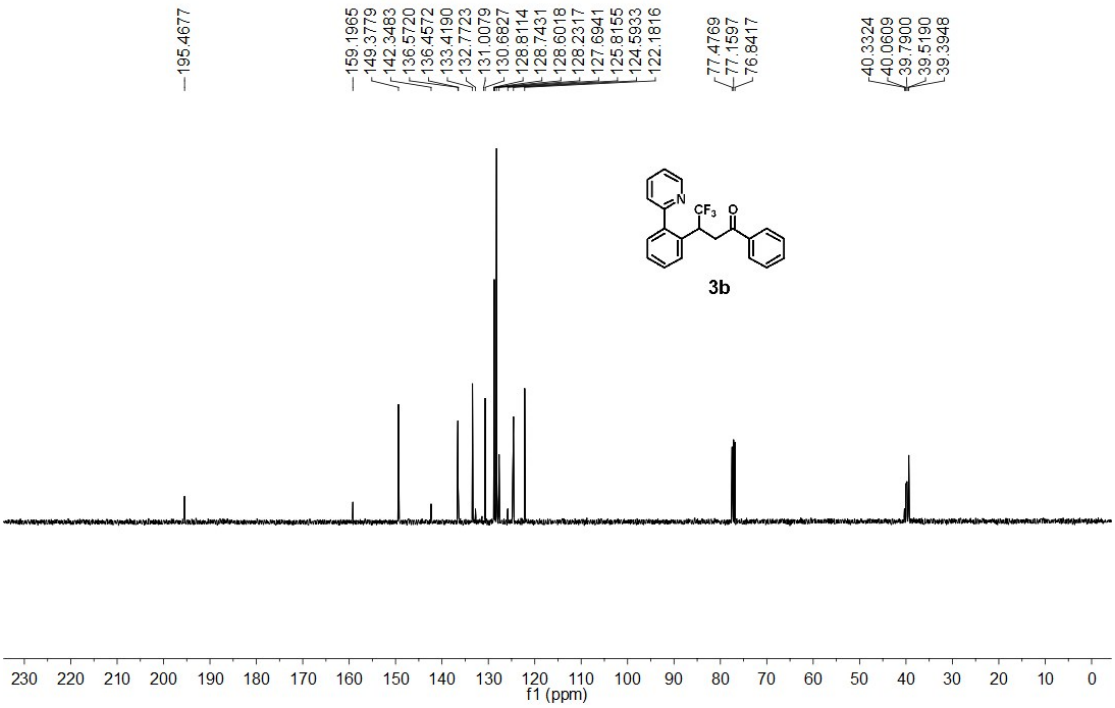
^{19}F NMR in $CDCl_3$



^{1}H NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



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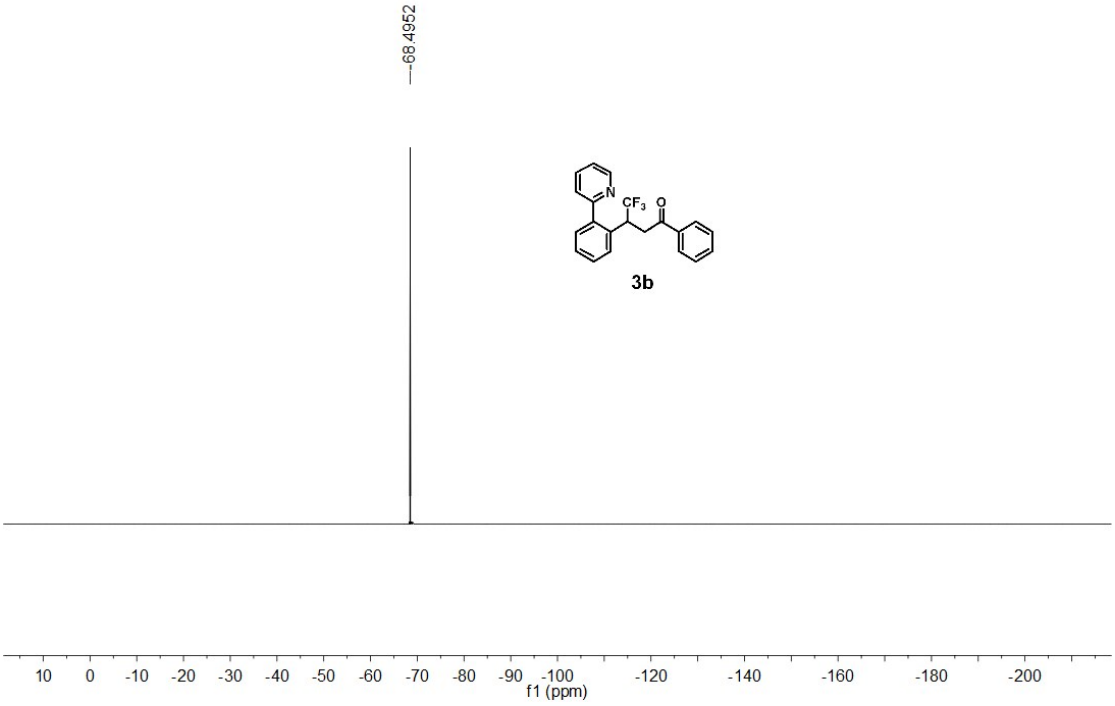
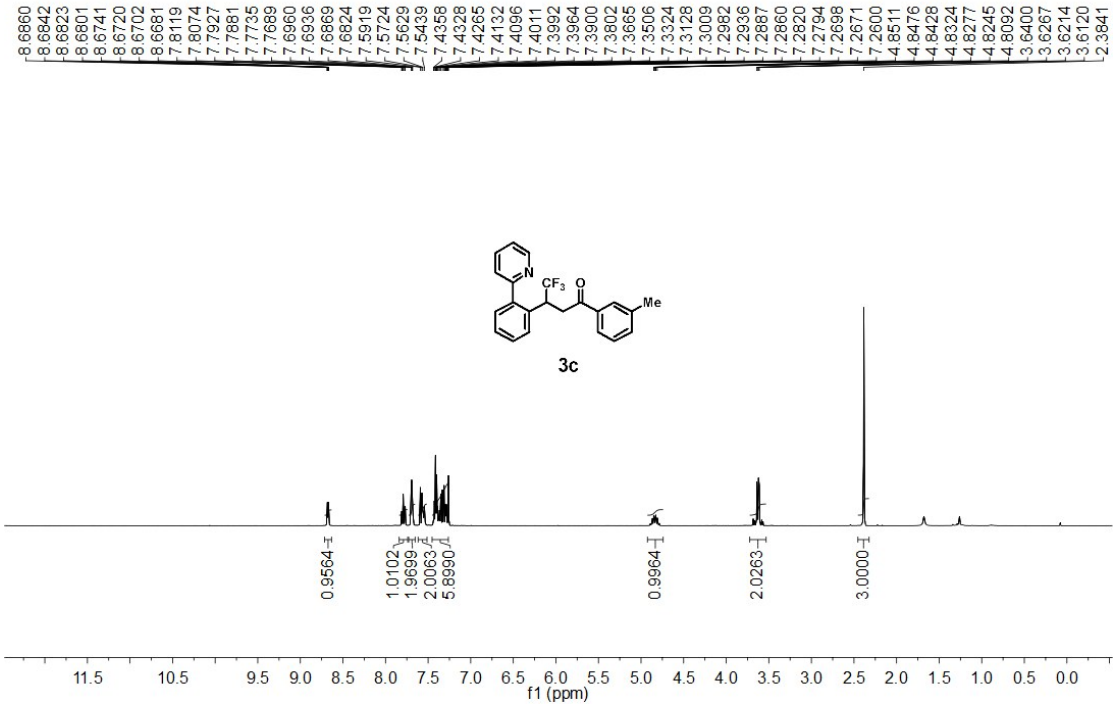
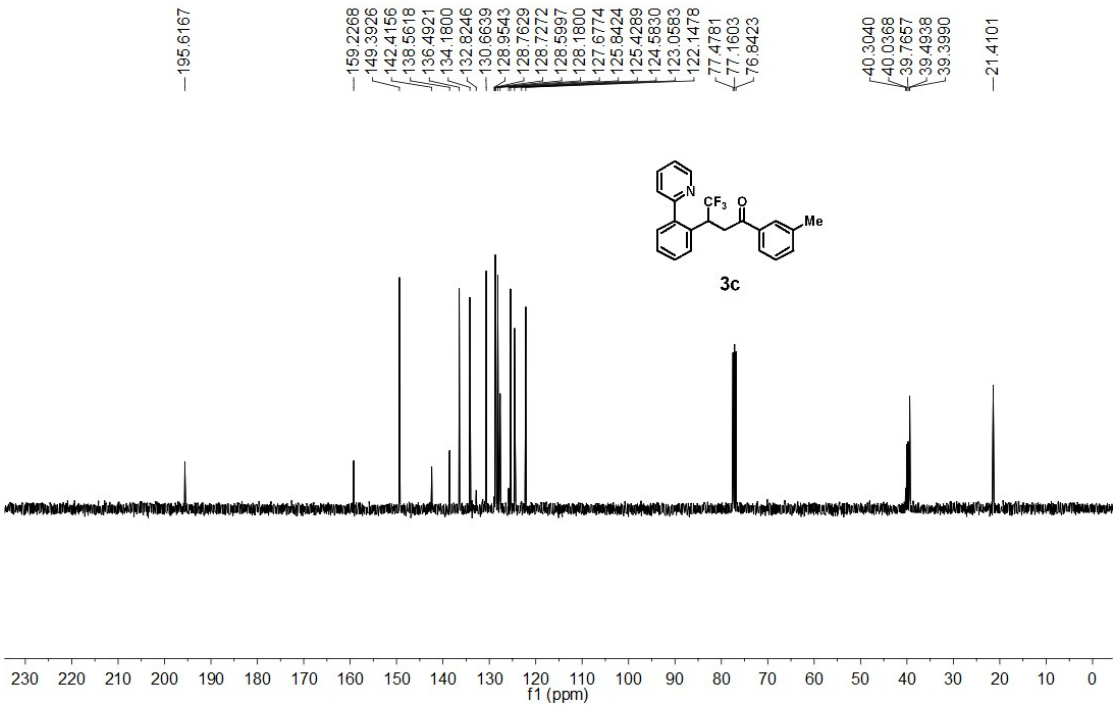


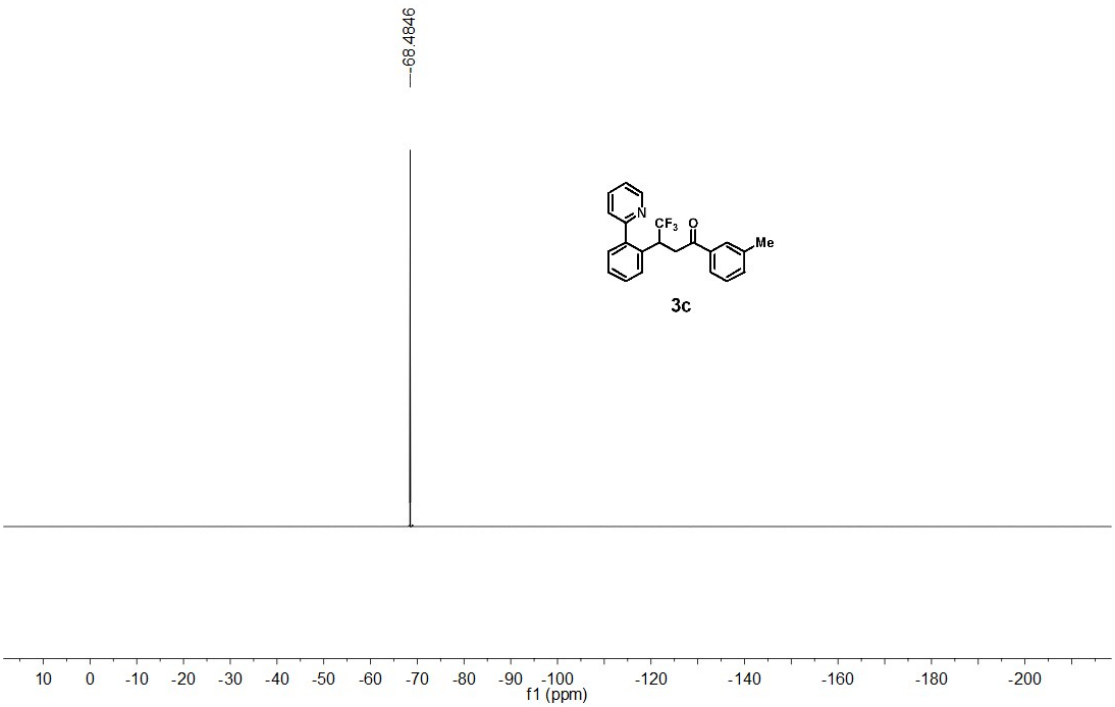
^{1}H NMR in $CDCl_3$



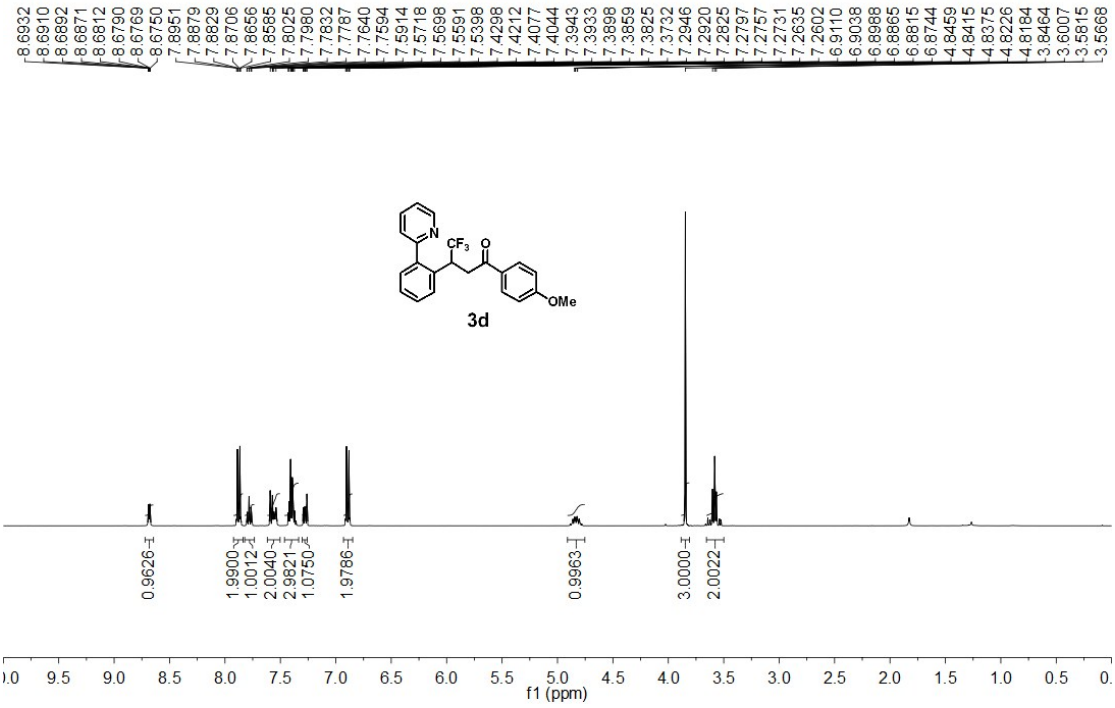
^{13}C NMR in $CDCl_3$



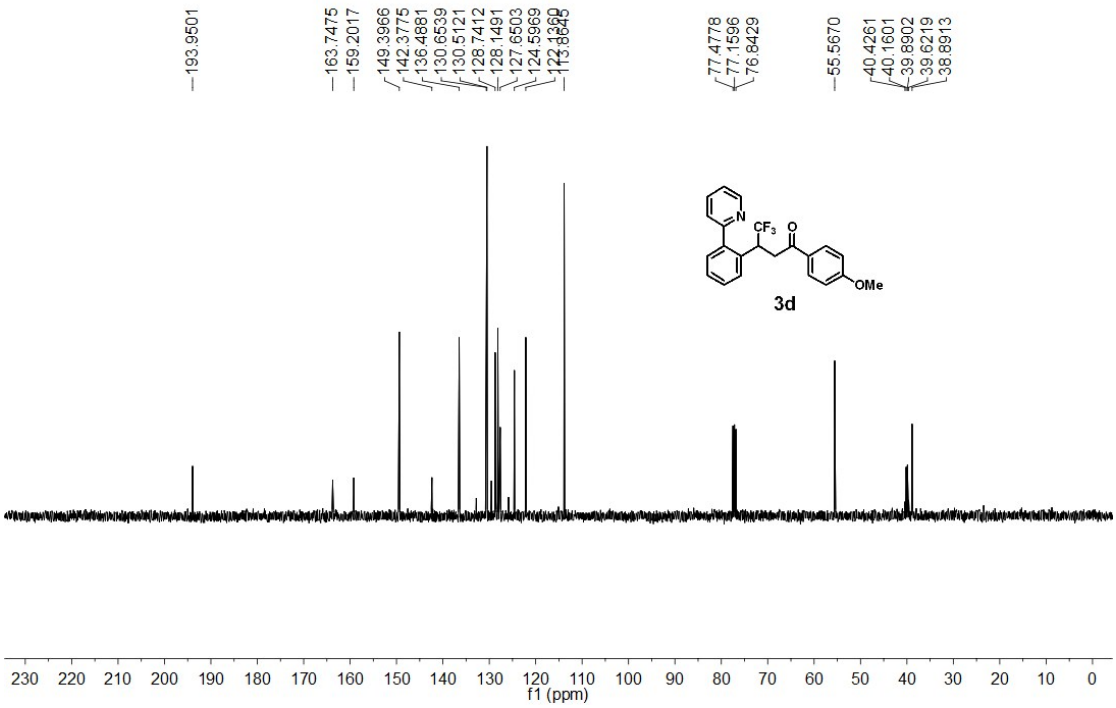
^{19}F NMR in $CDCl_3$



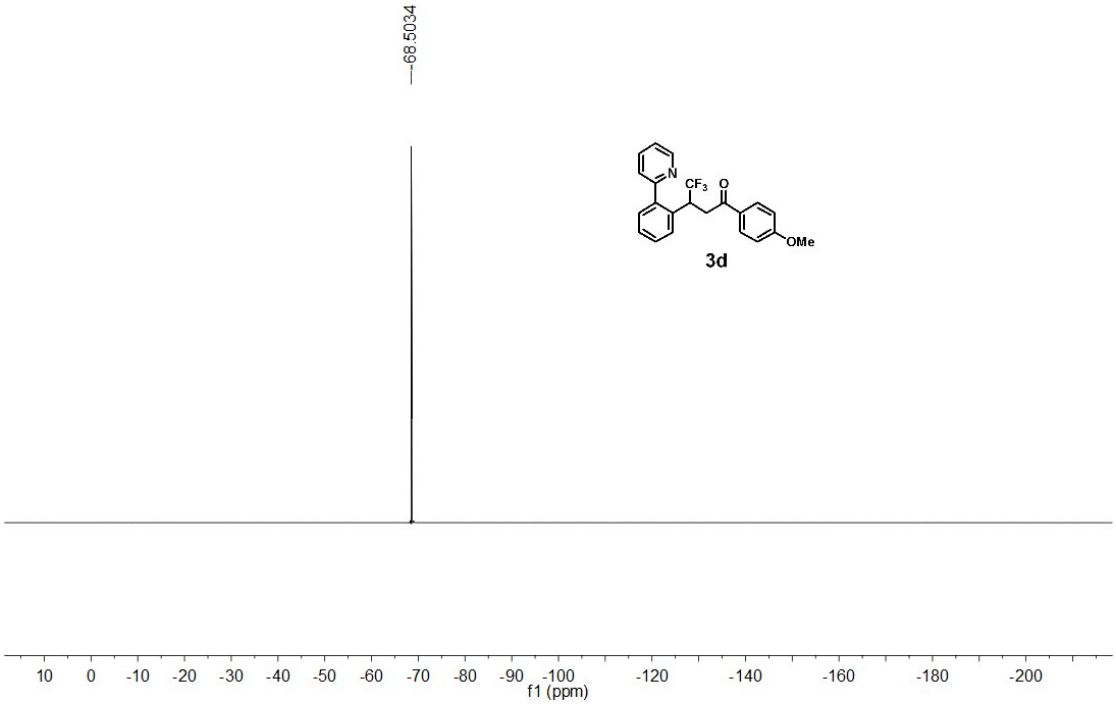
^{1}H NMR in $CDCl_3$ 1



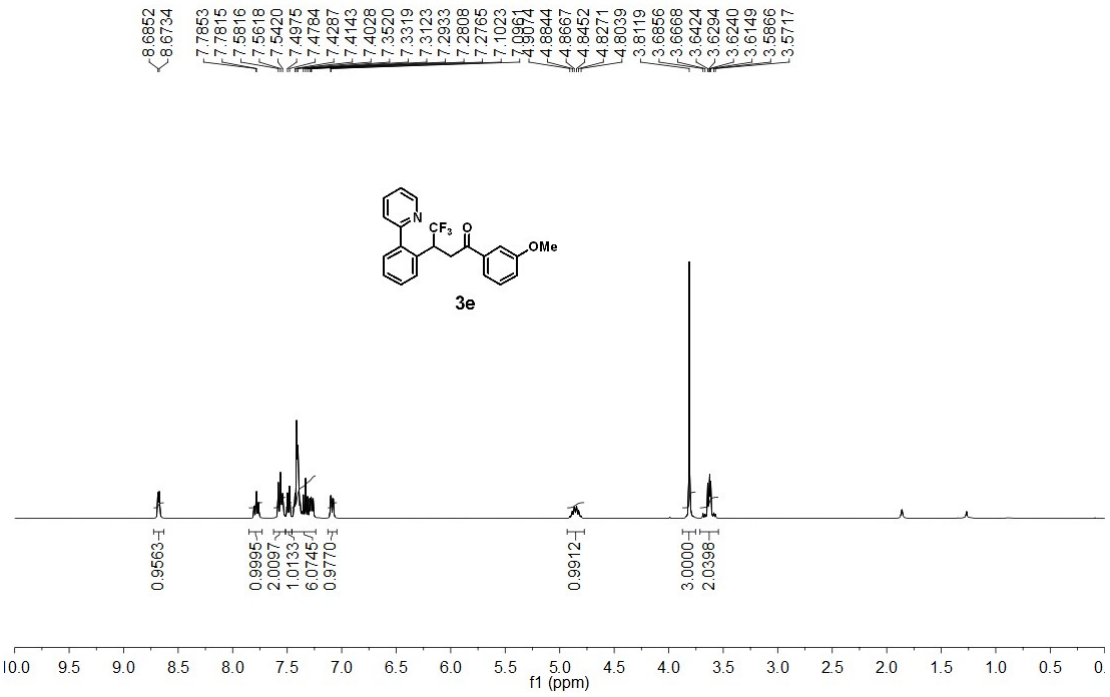
^{13}C NMR in $CDCl_3$



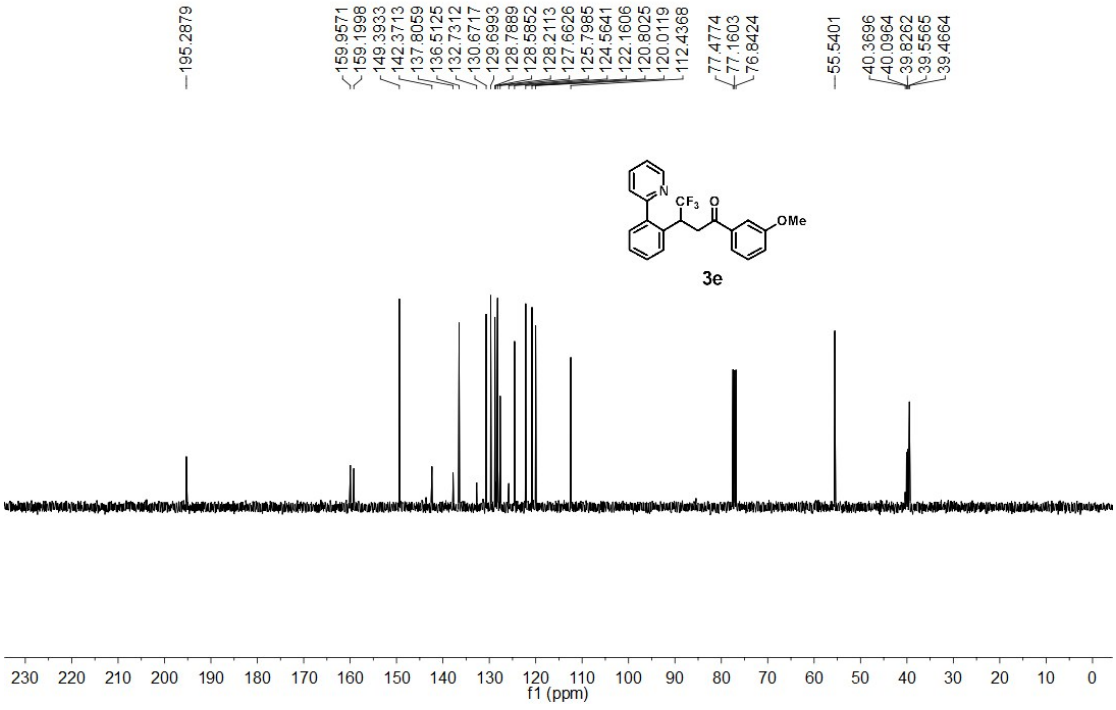
^{19}F NMR in $CDCl_3$



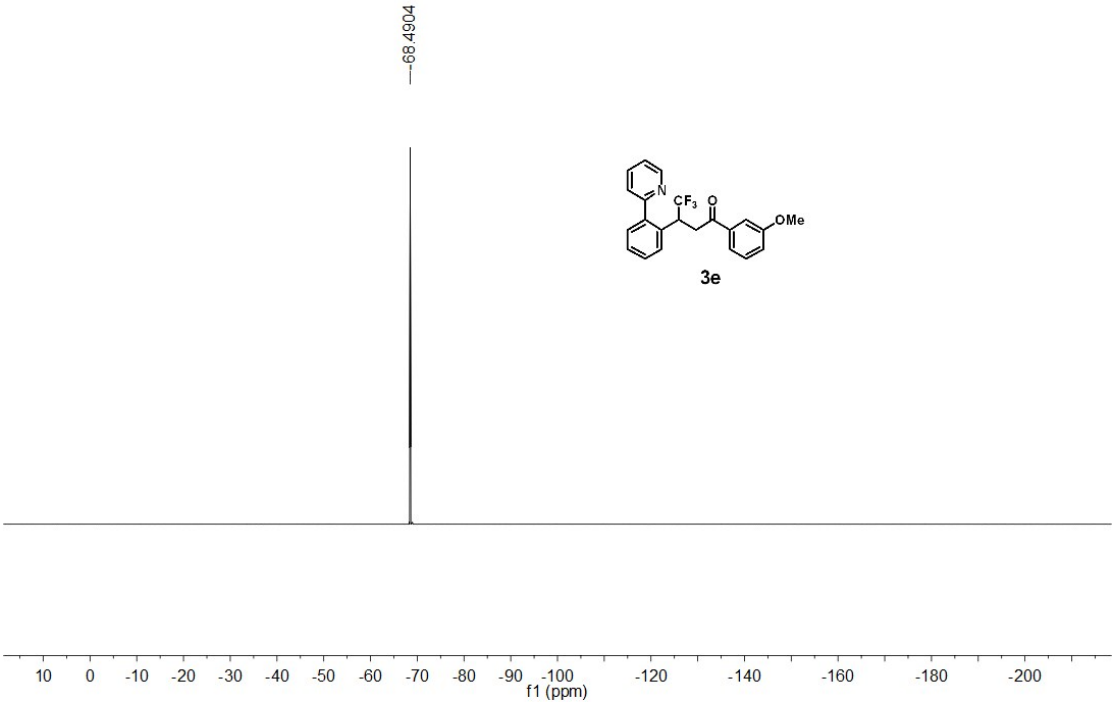
^{1}H NMR in $CDCl_3$



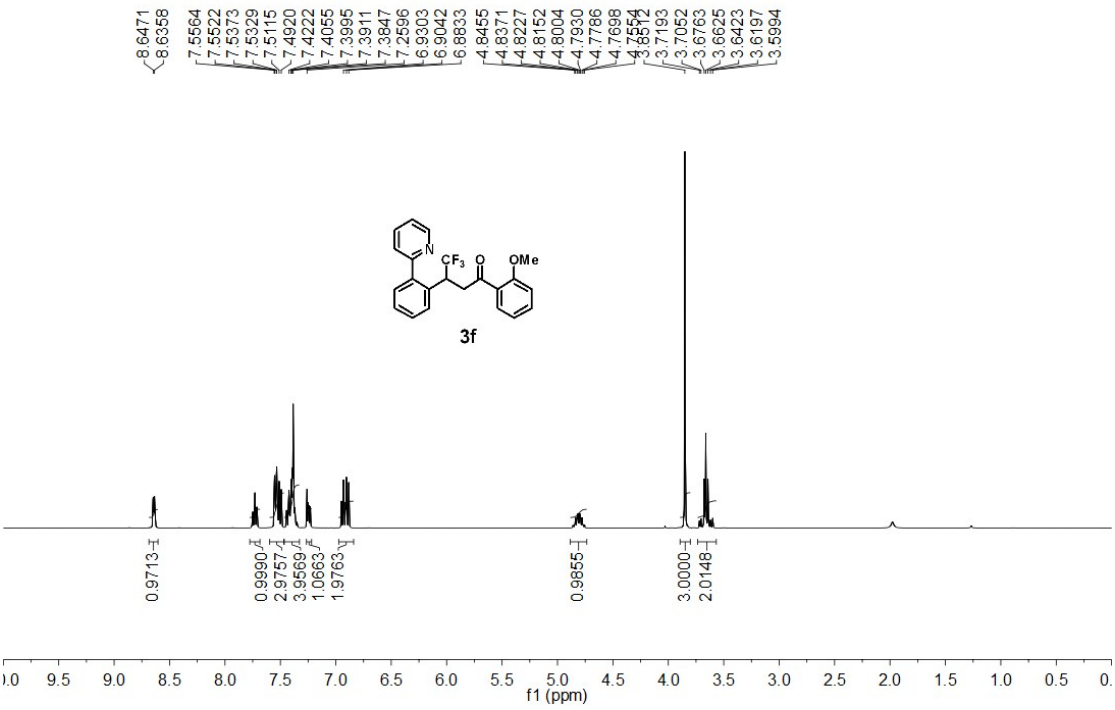
^{13}C NMR in $CDCl_3$



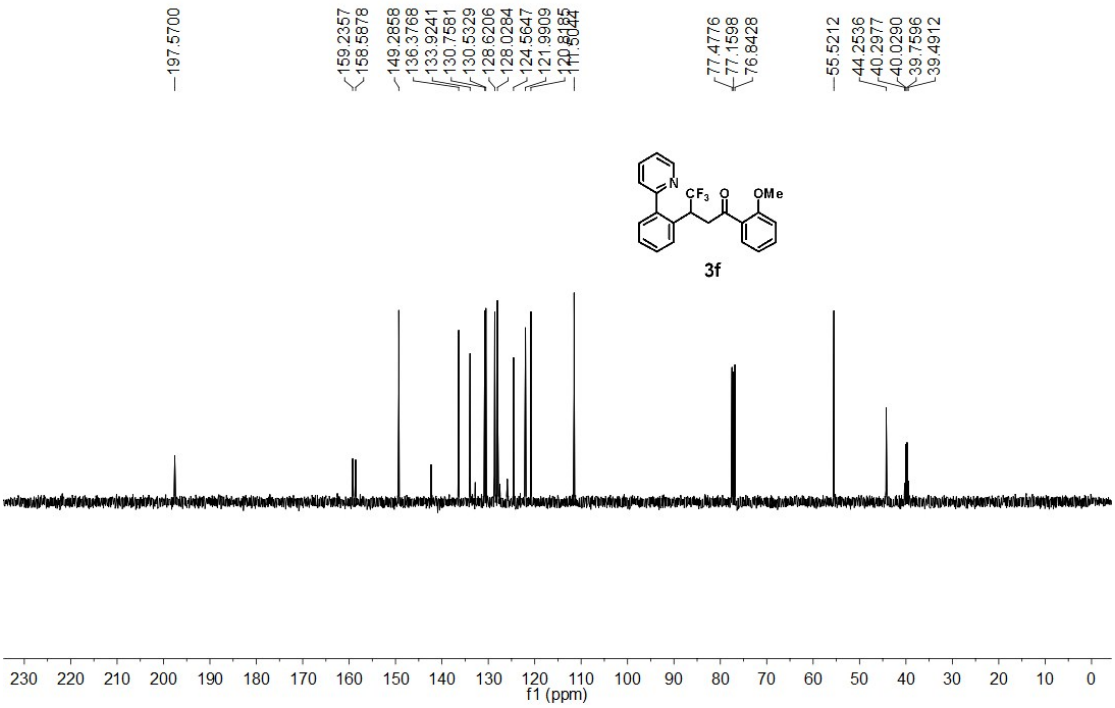
^{19}F NMR in $CDCl_3$



^{1}H NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



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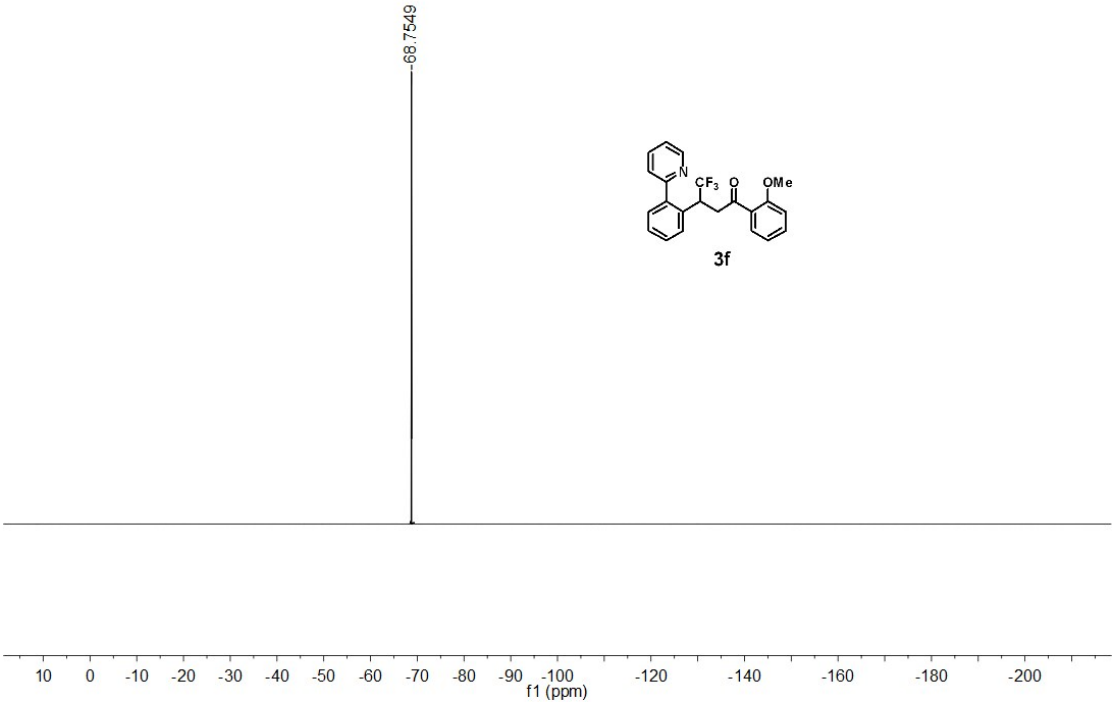
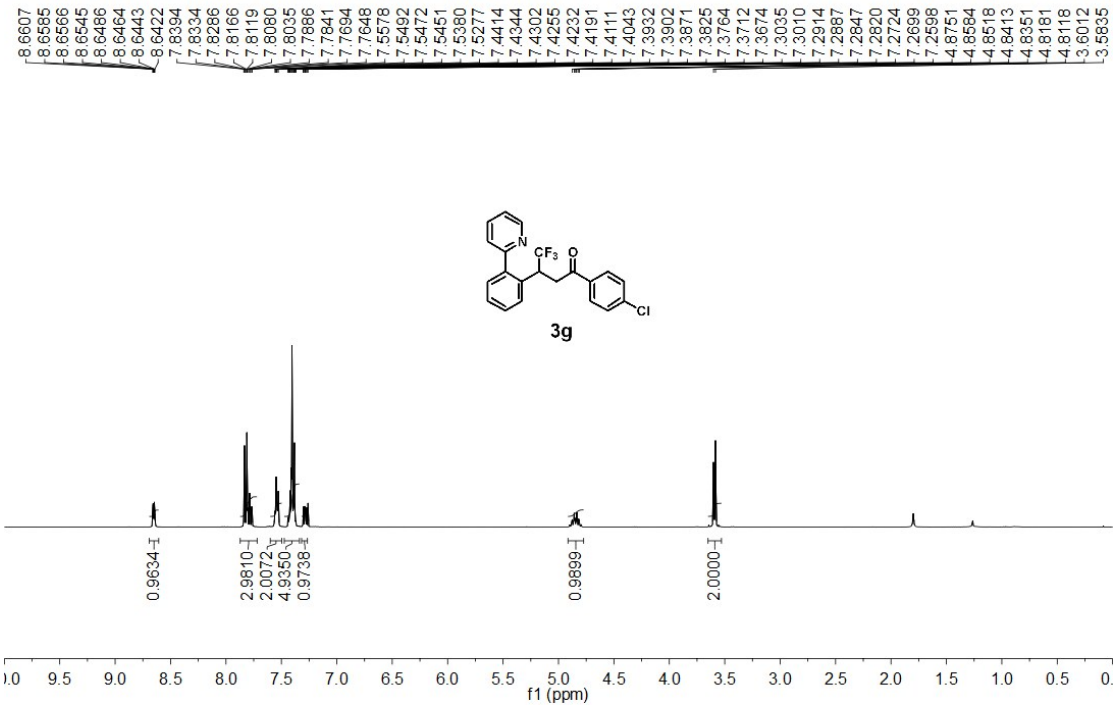
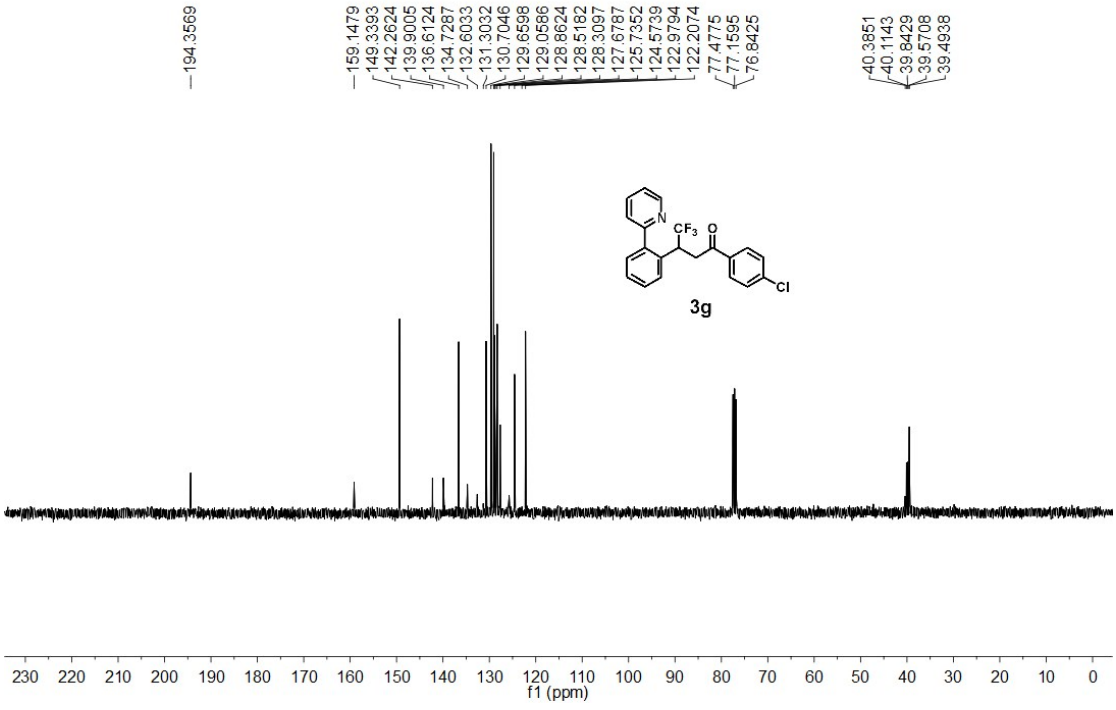


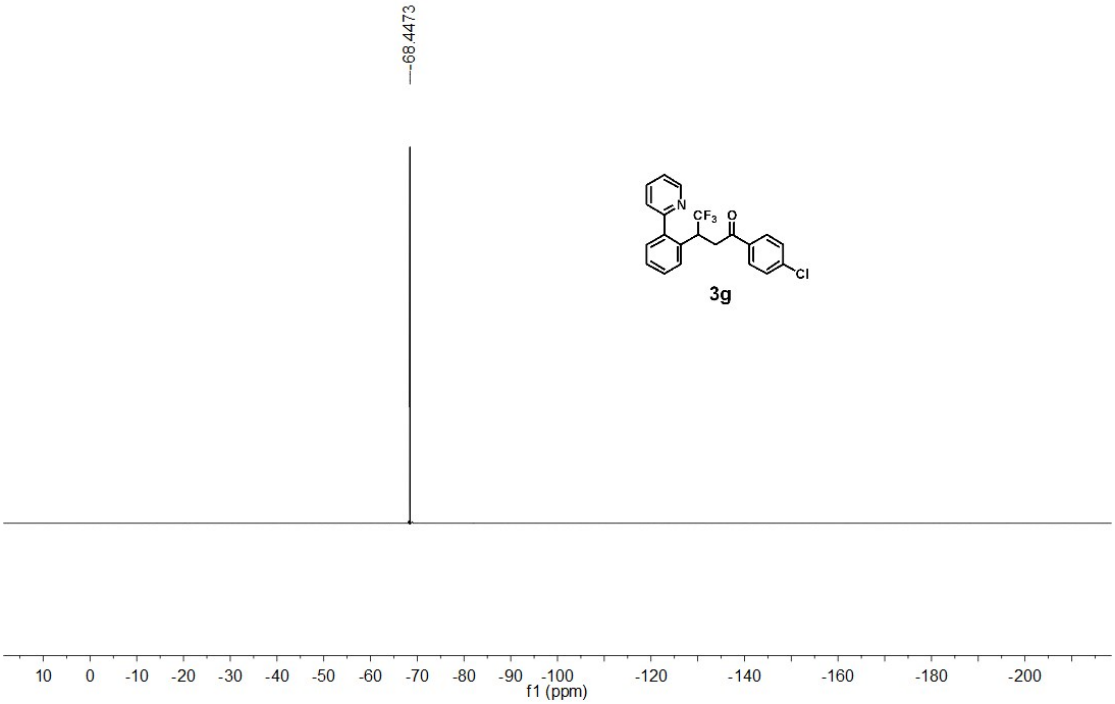
^{1}H NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$

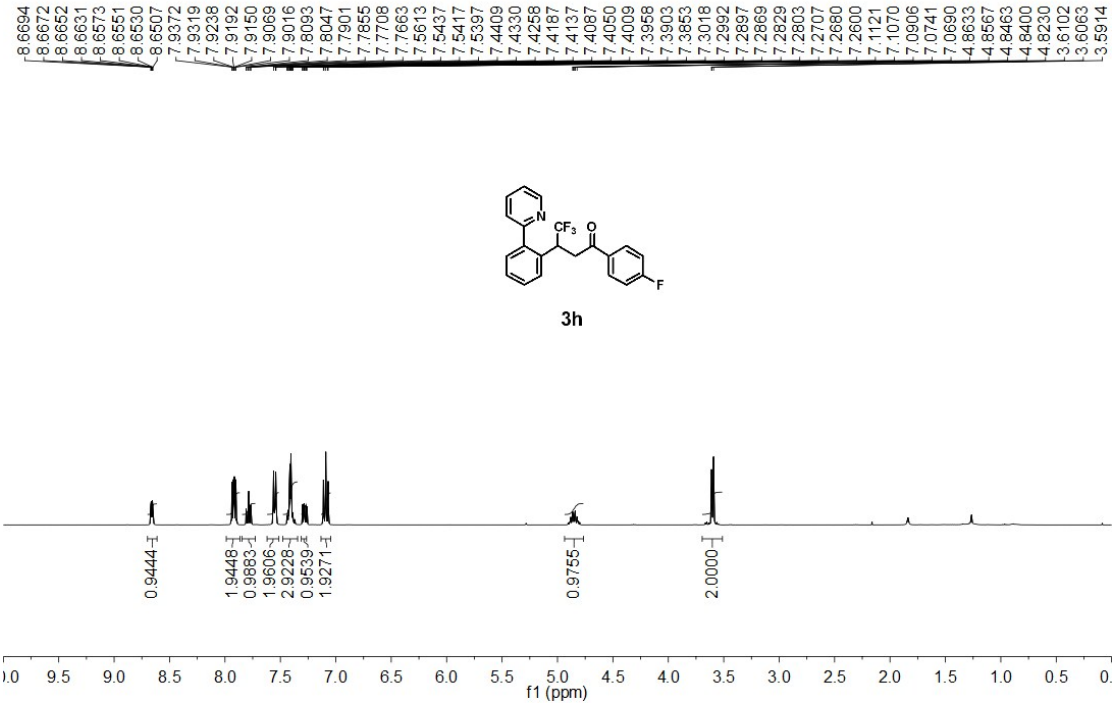


^{19}F NMR in $CDCl_3$



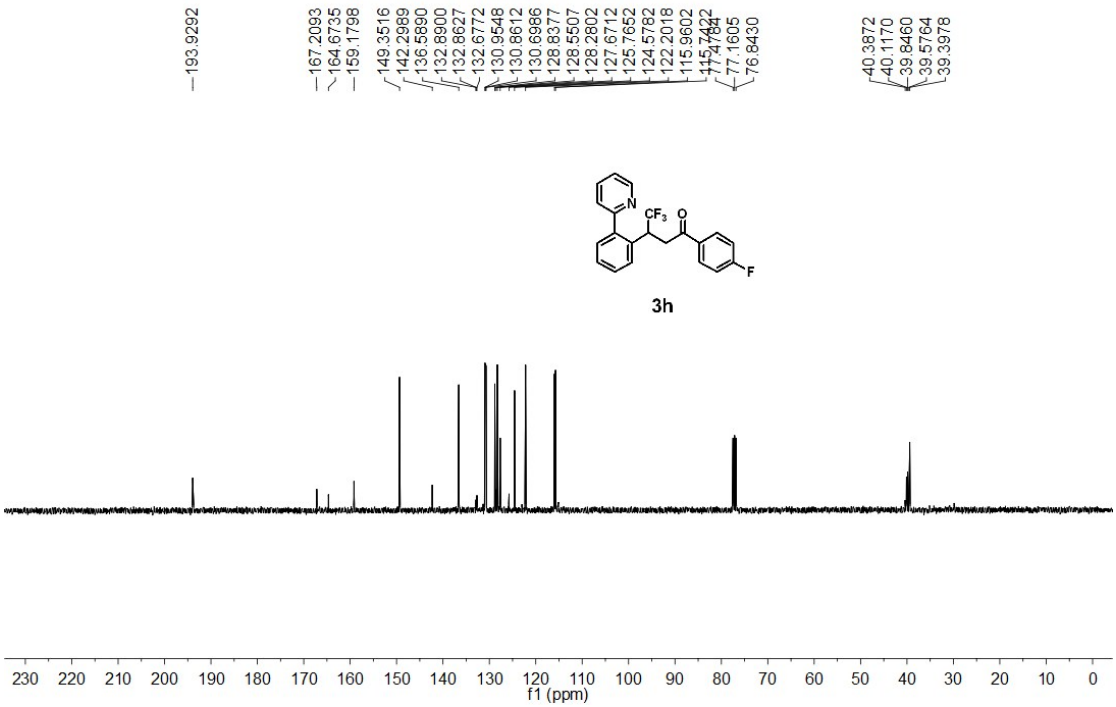
3g

^{1}H NMR in $CDCl_3$

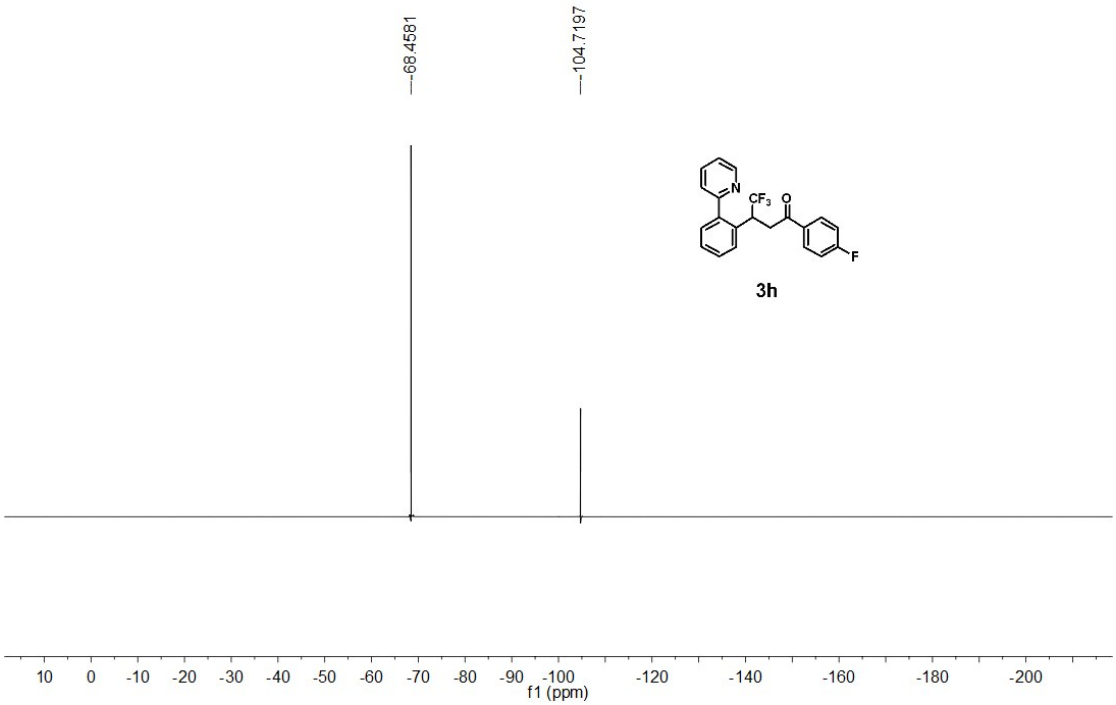


3h

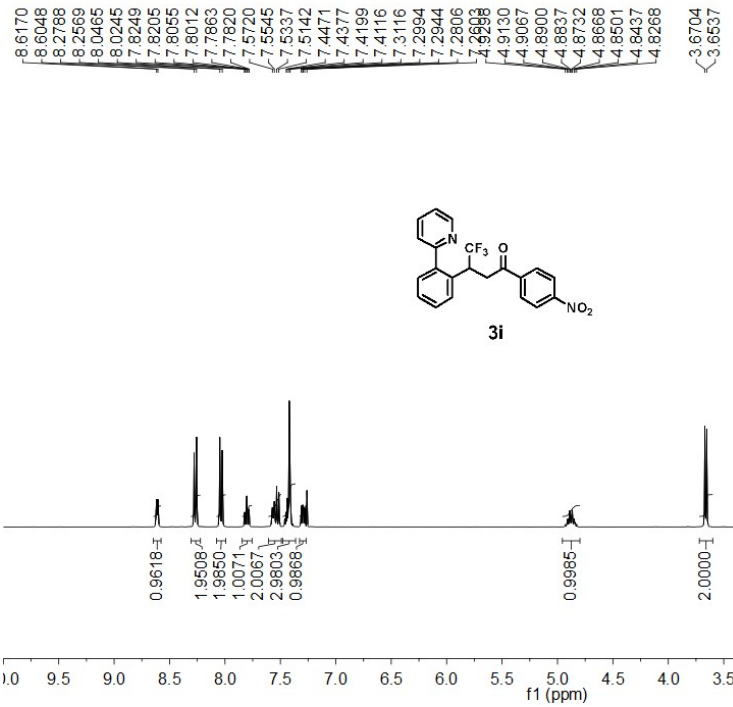
^{13}C NMR in $CDCl_3$



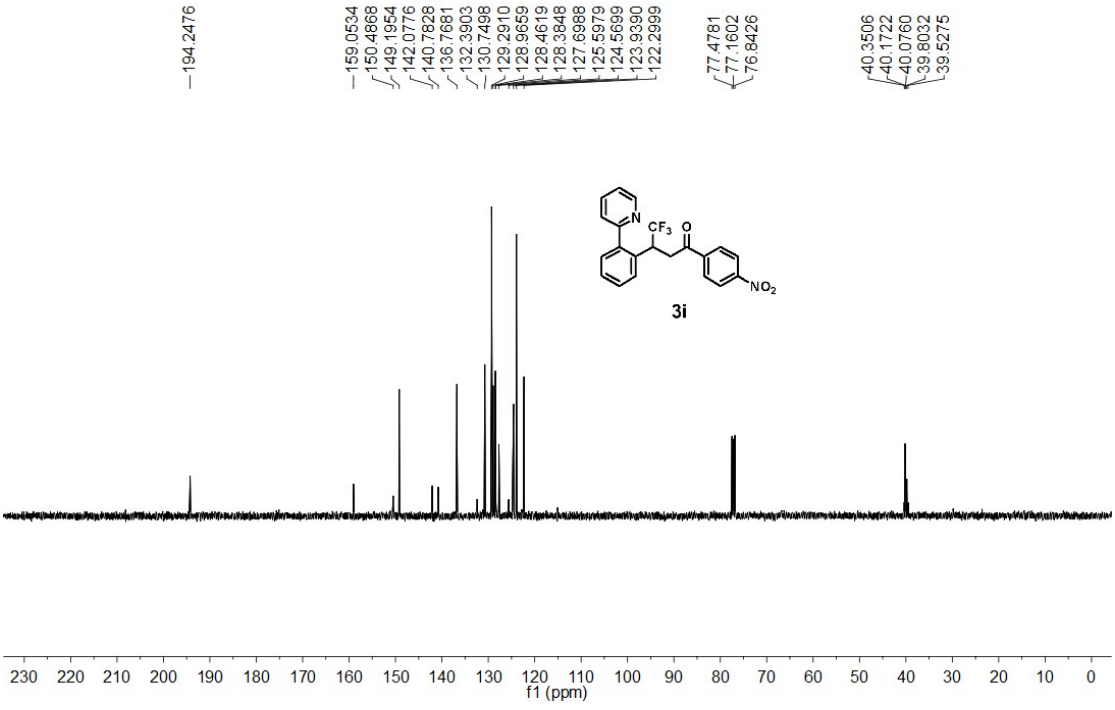
^{19}F NMR in $CDCl_3$



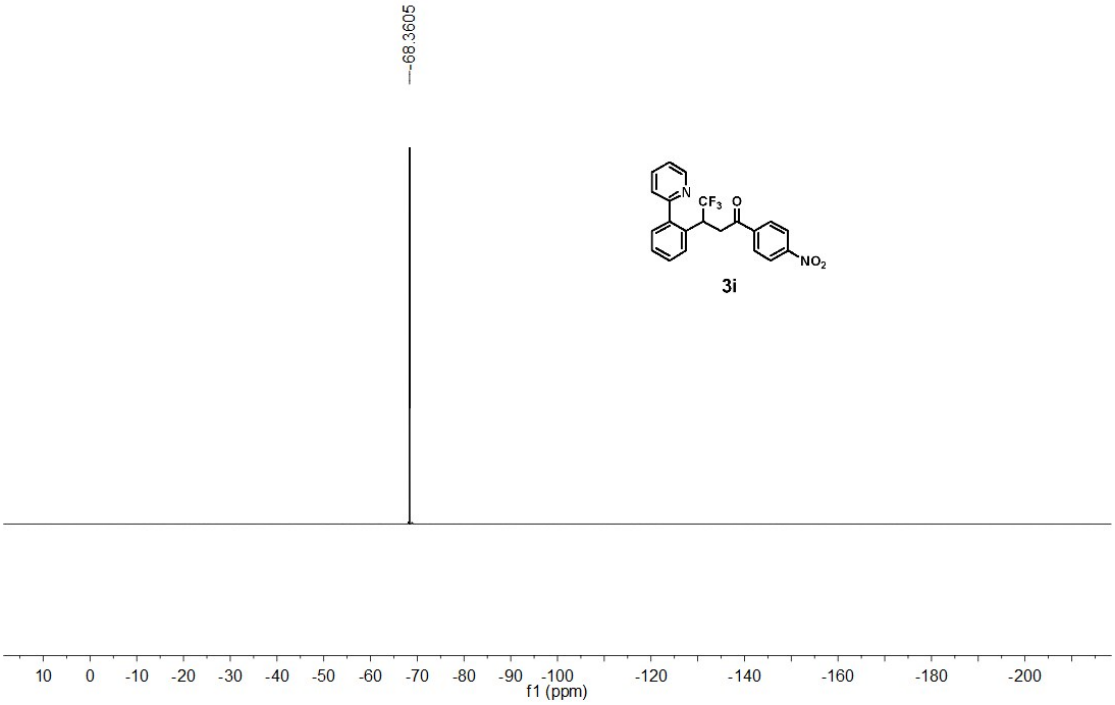
^{1}H NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



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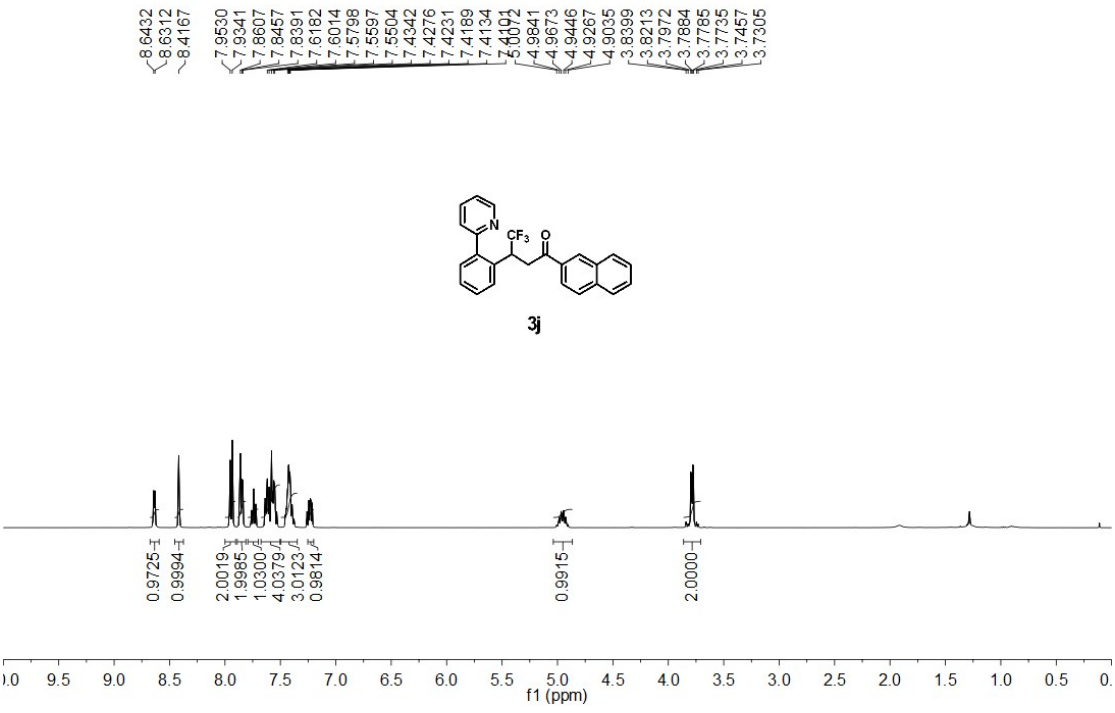
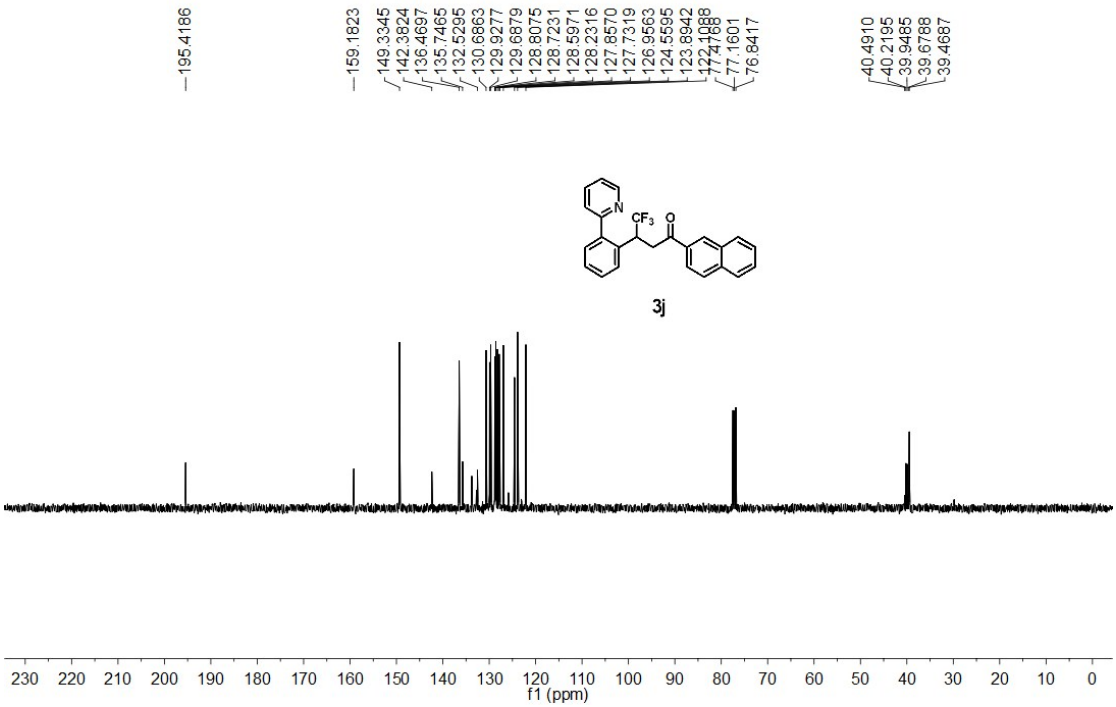
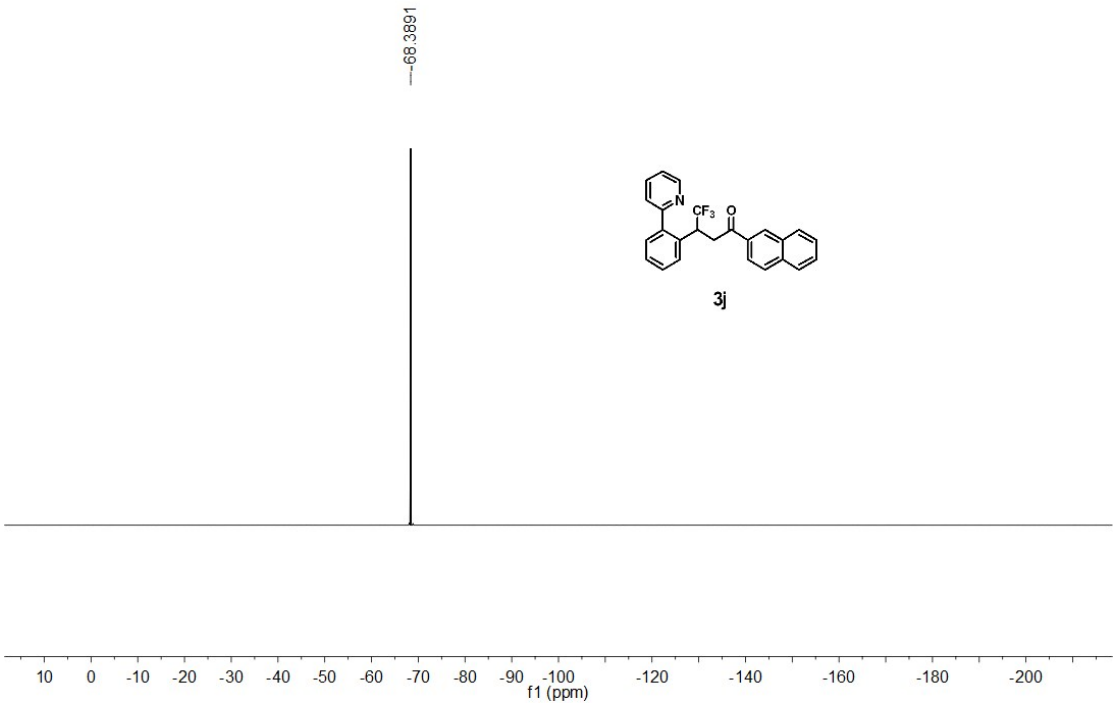


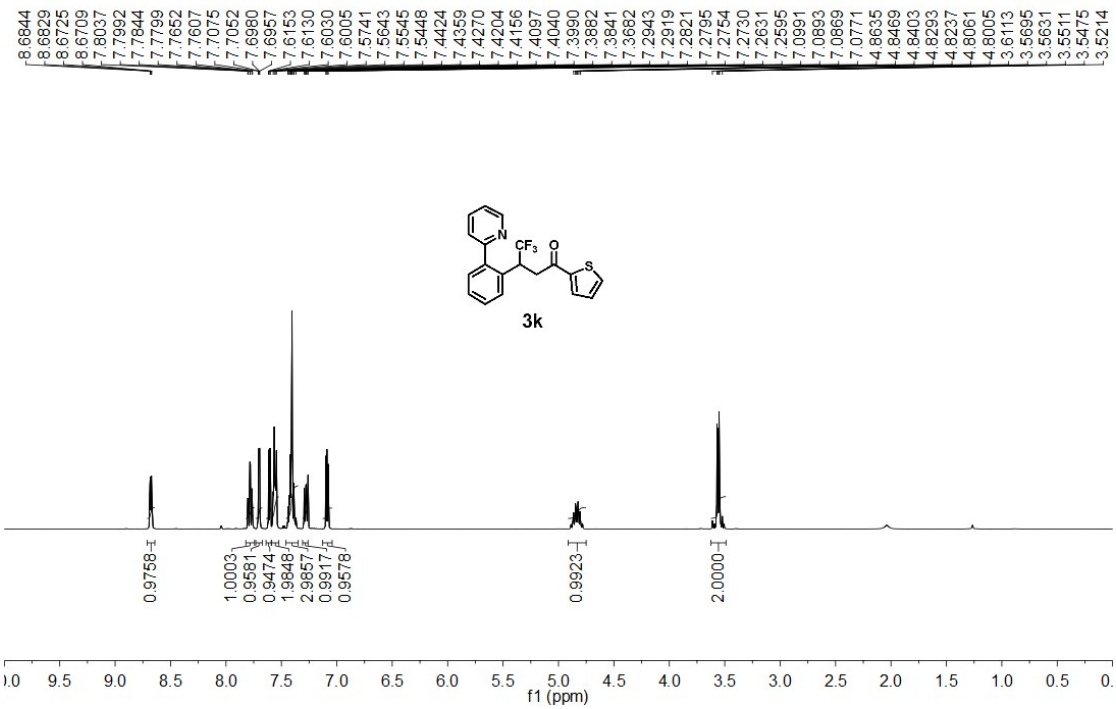
^{13}C NMR in $CDCl_3$



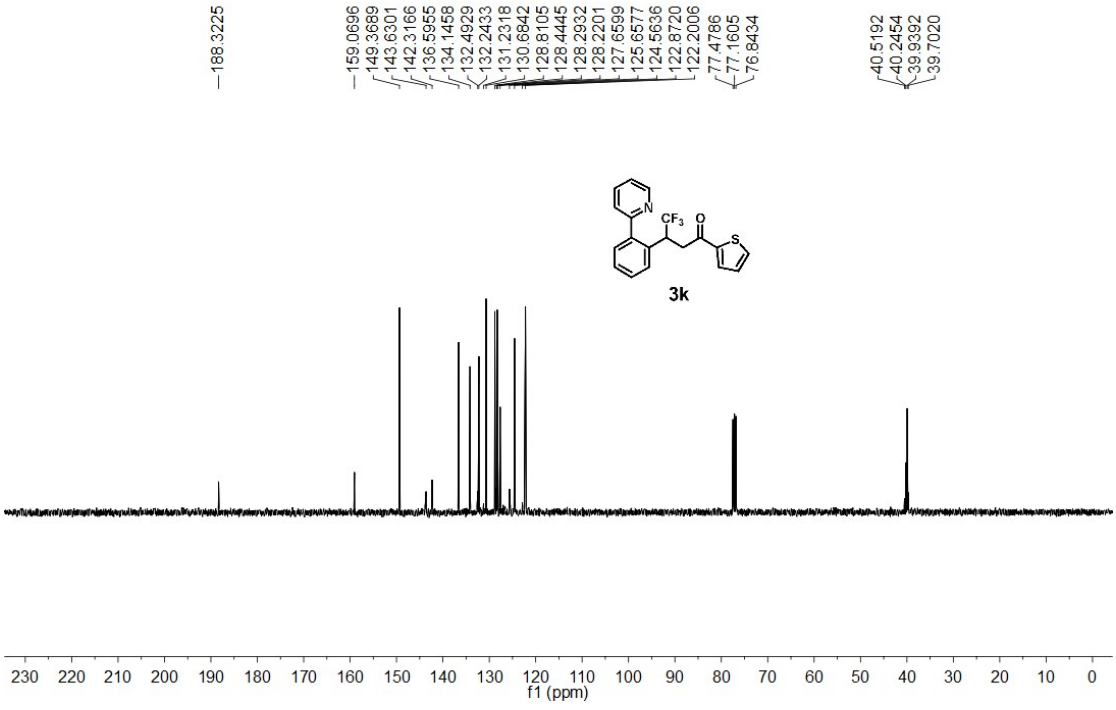
^{19}F NMR in $CDCl_3$



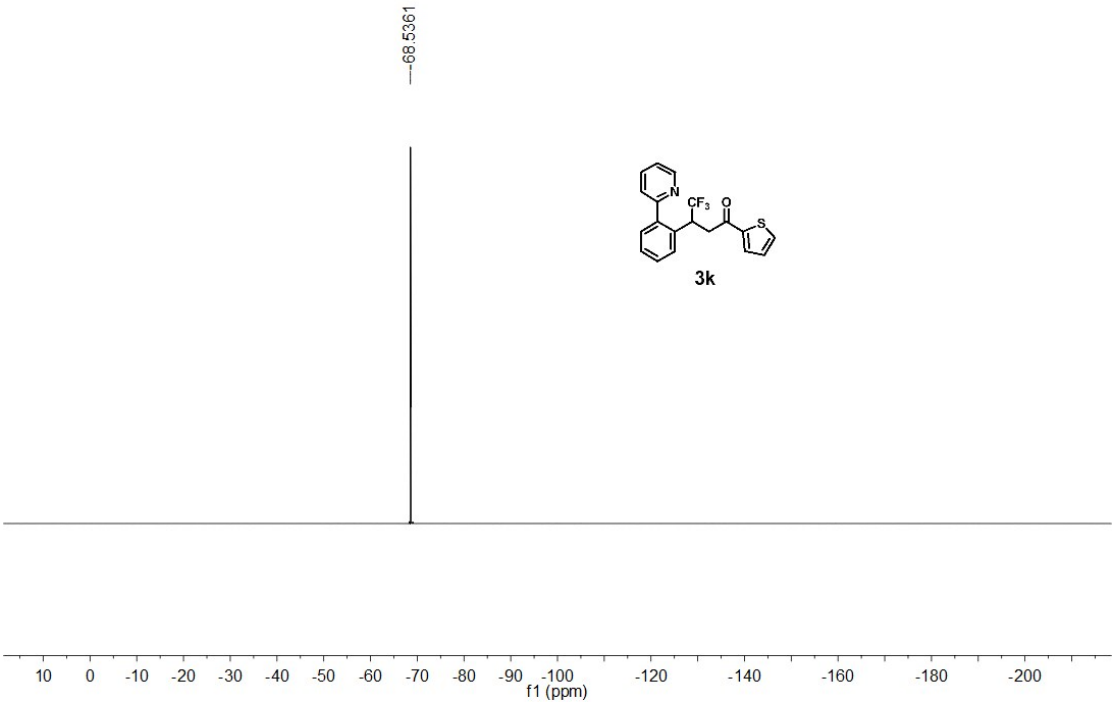
^{1}H NMR in $CDCl_3$



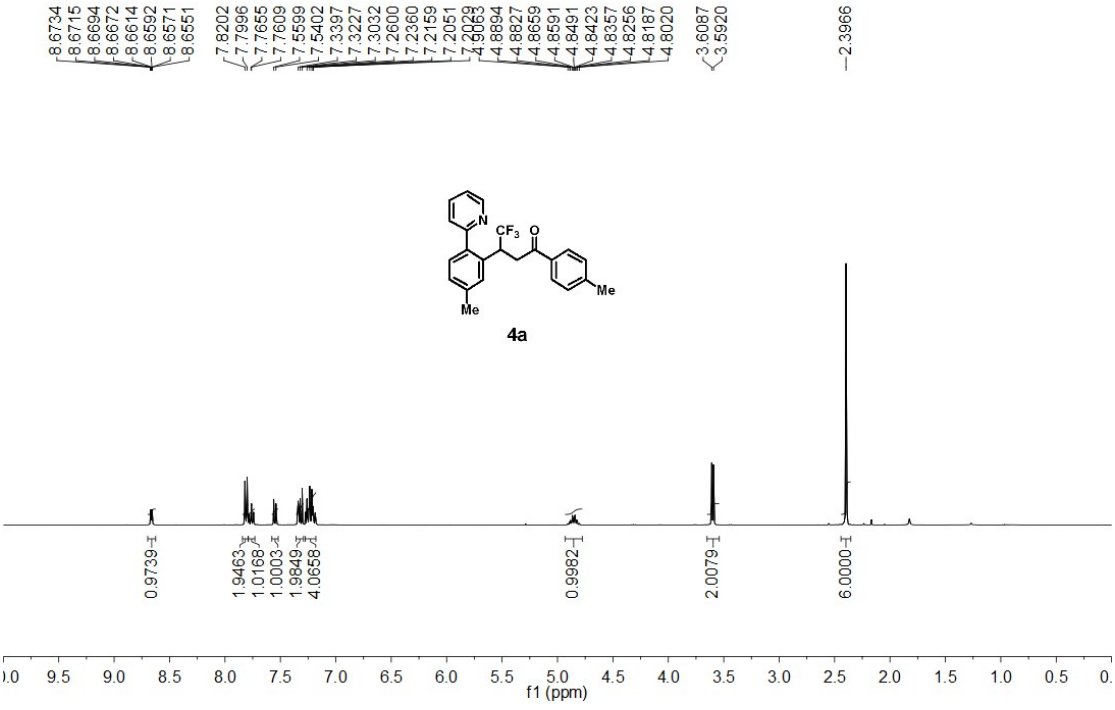
^{13}C NMR in $CDCl_3$



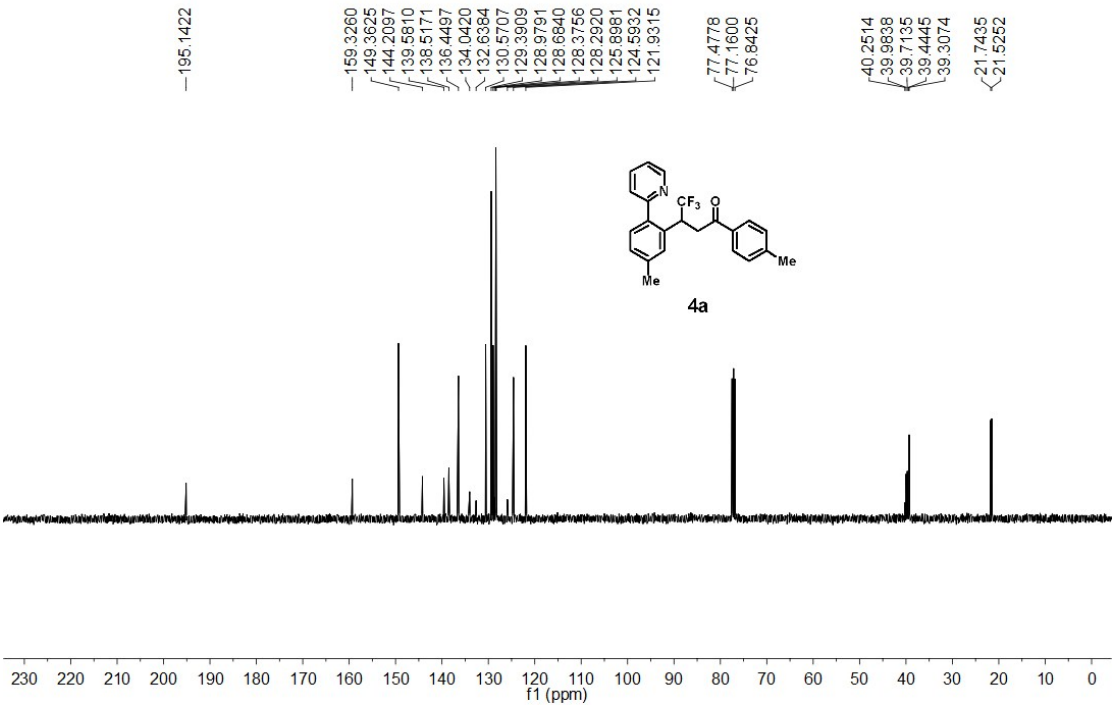
^{19}F NMR in $CDCl_3$



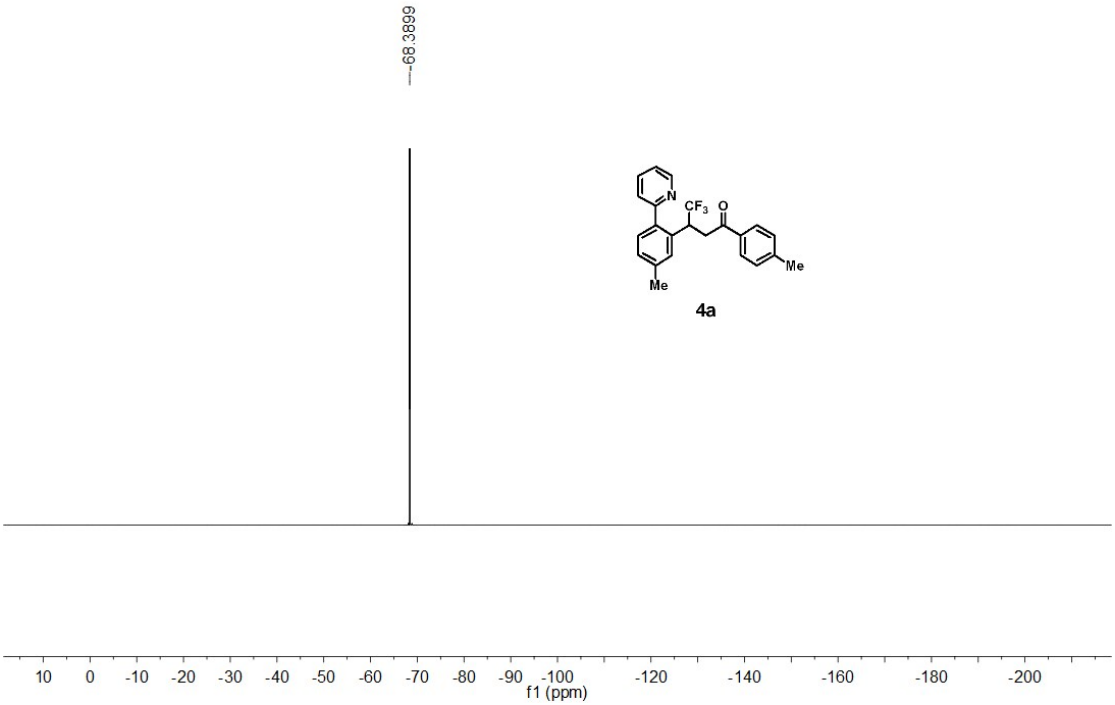
^{1}H NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



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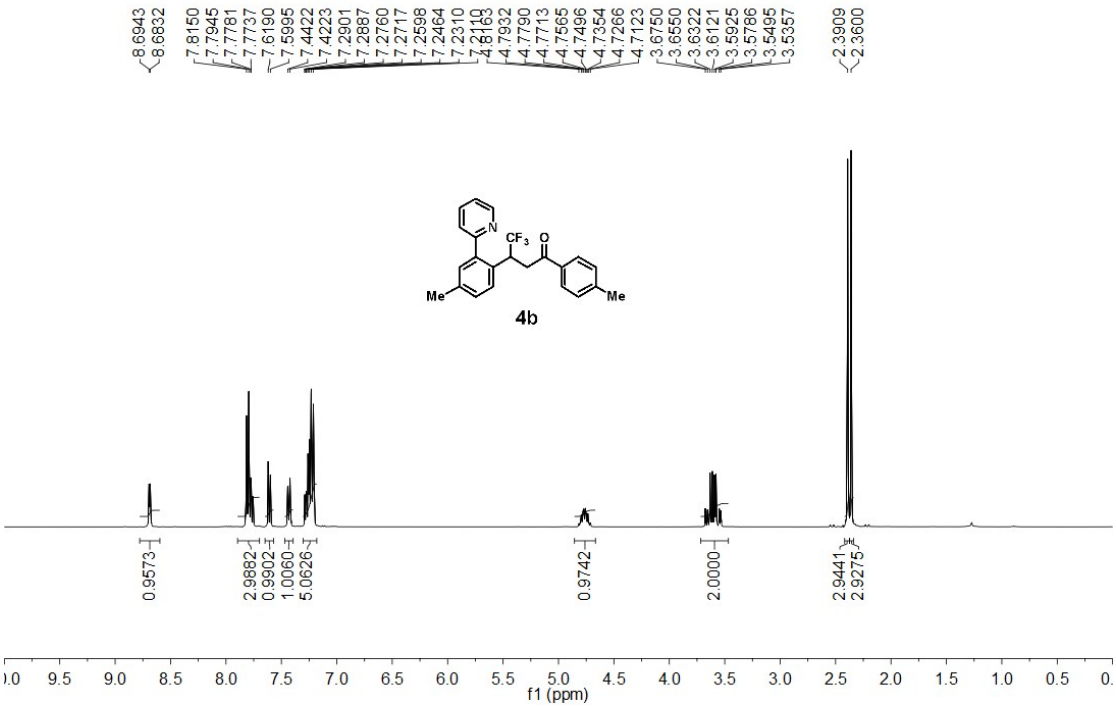
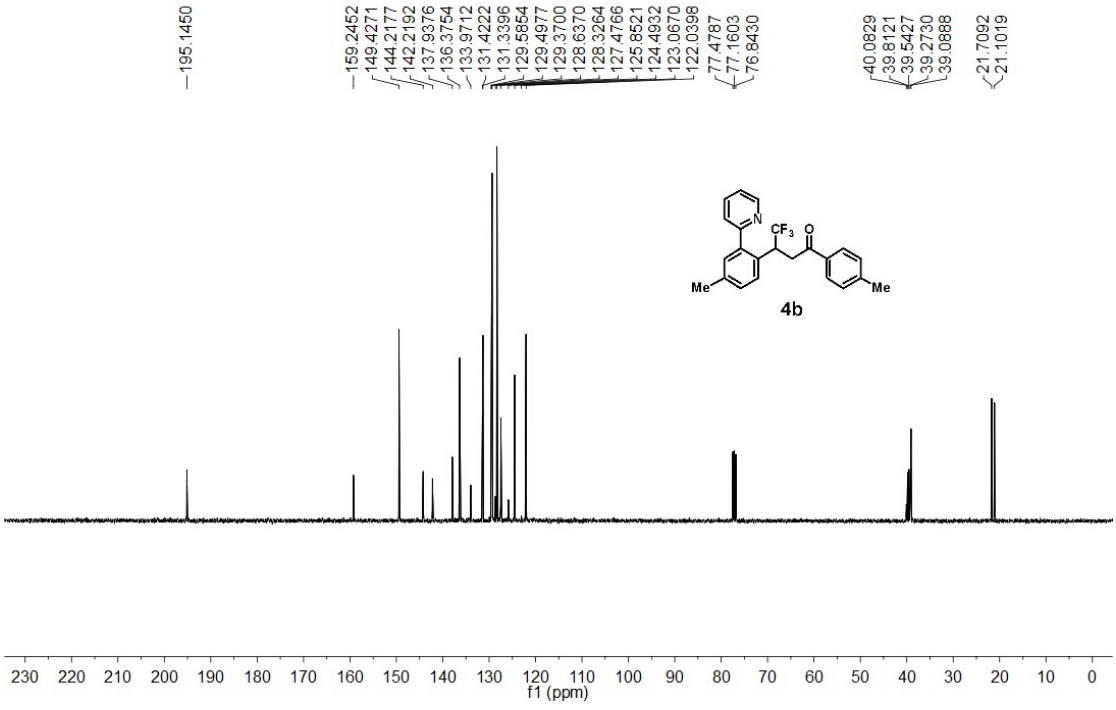


^{13}C NMR in $CDCl_3$



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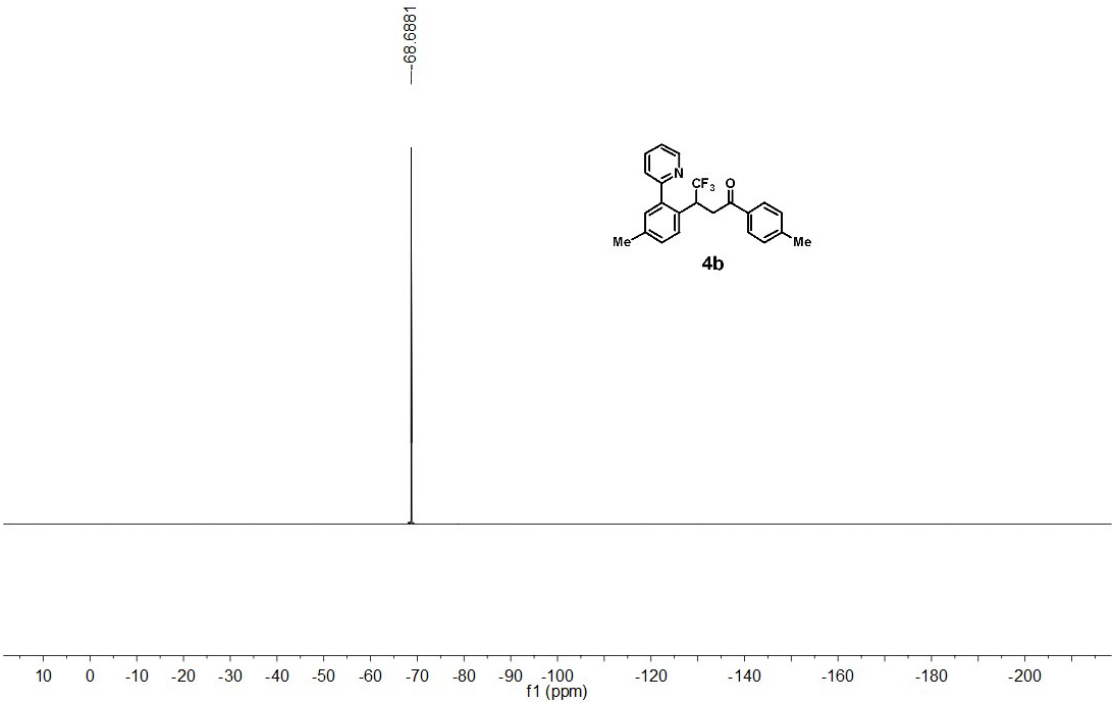

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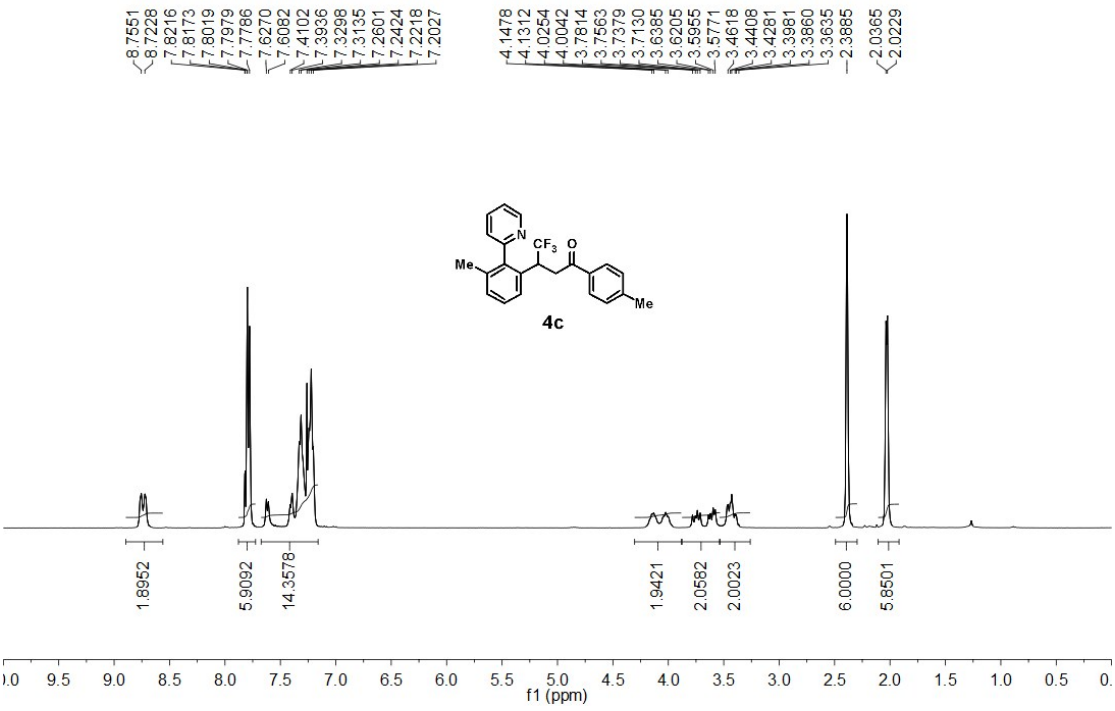

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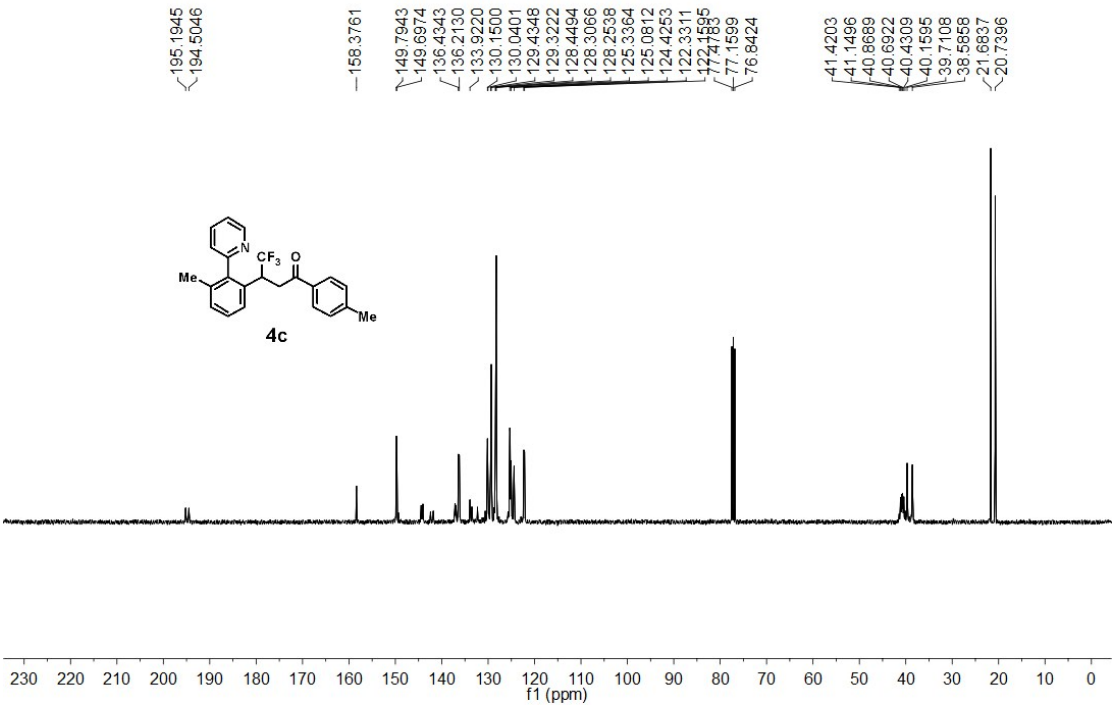

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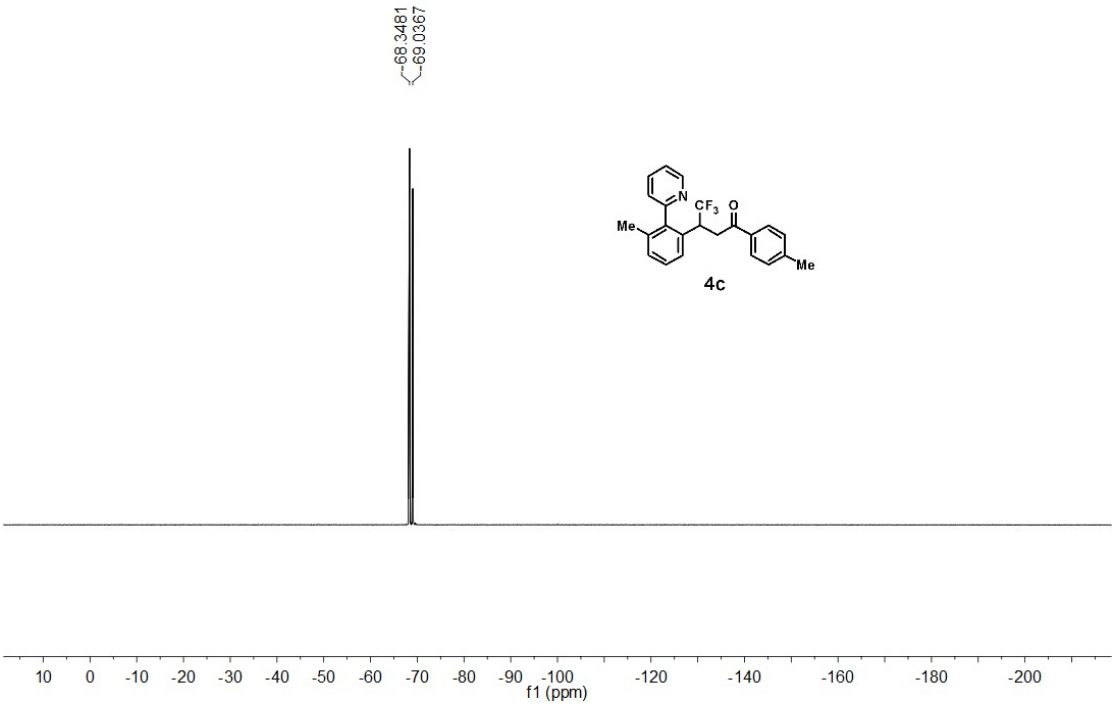

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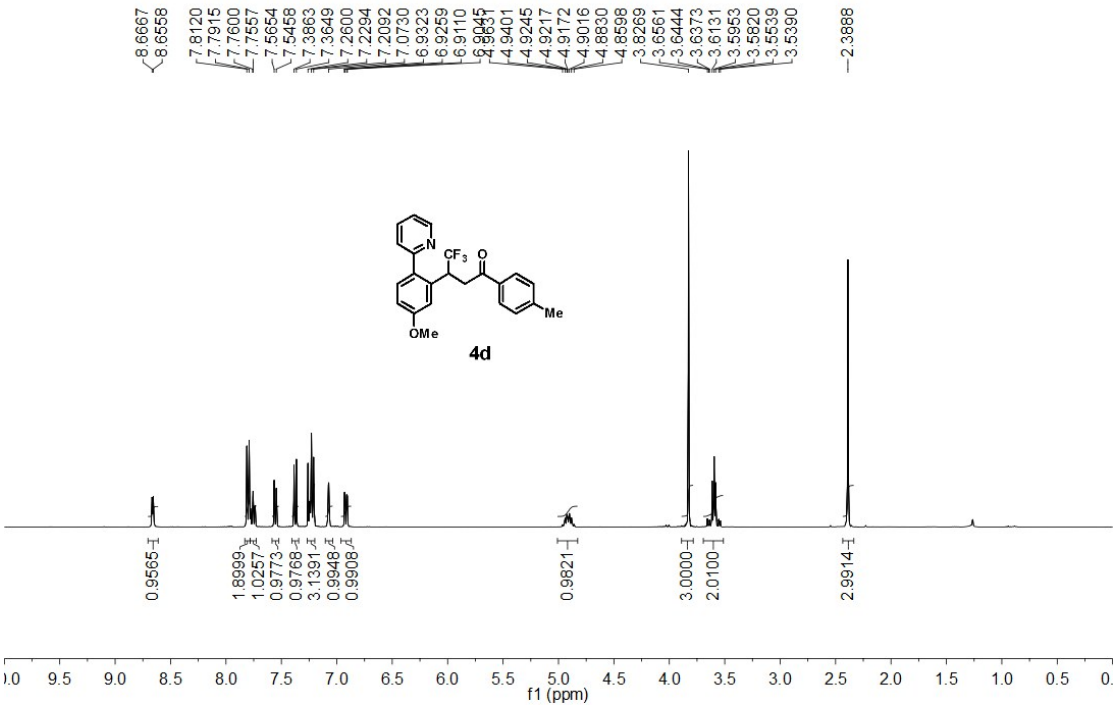
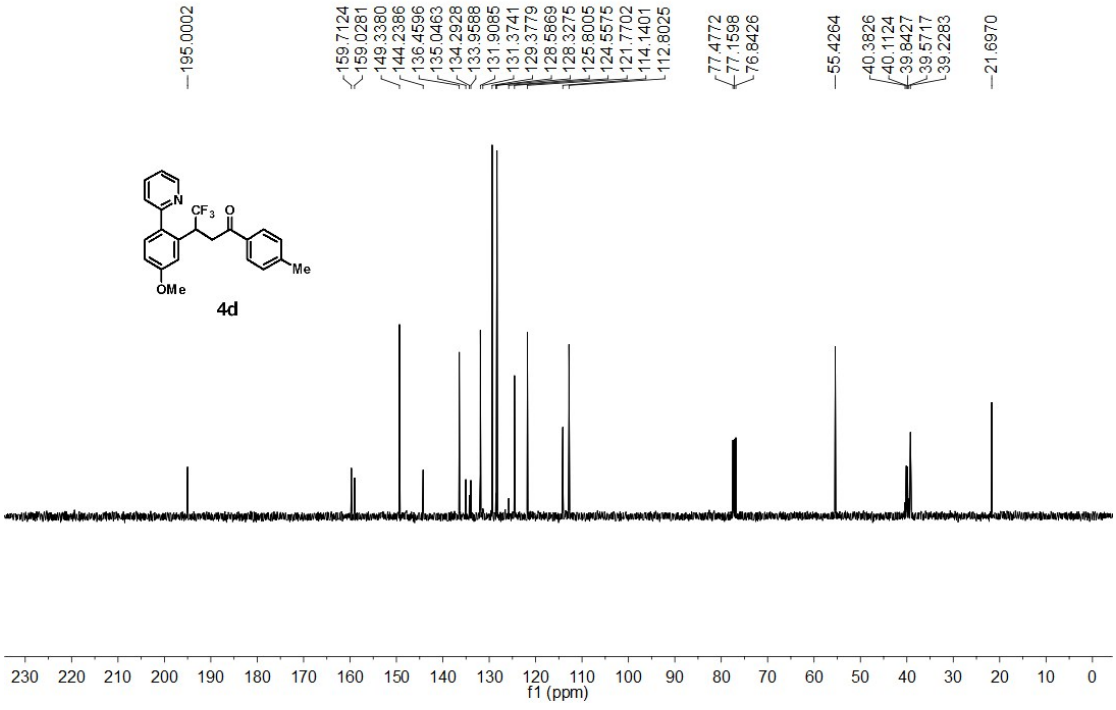


4d

^{13}C NMR in $CDCl_3$



4d

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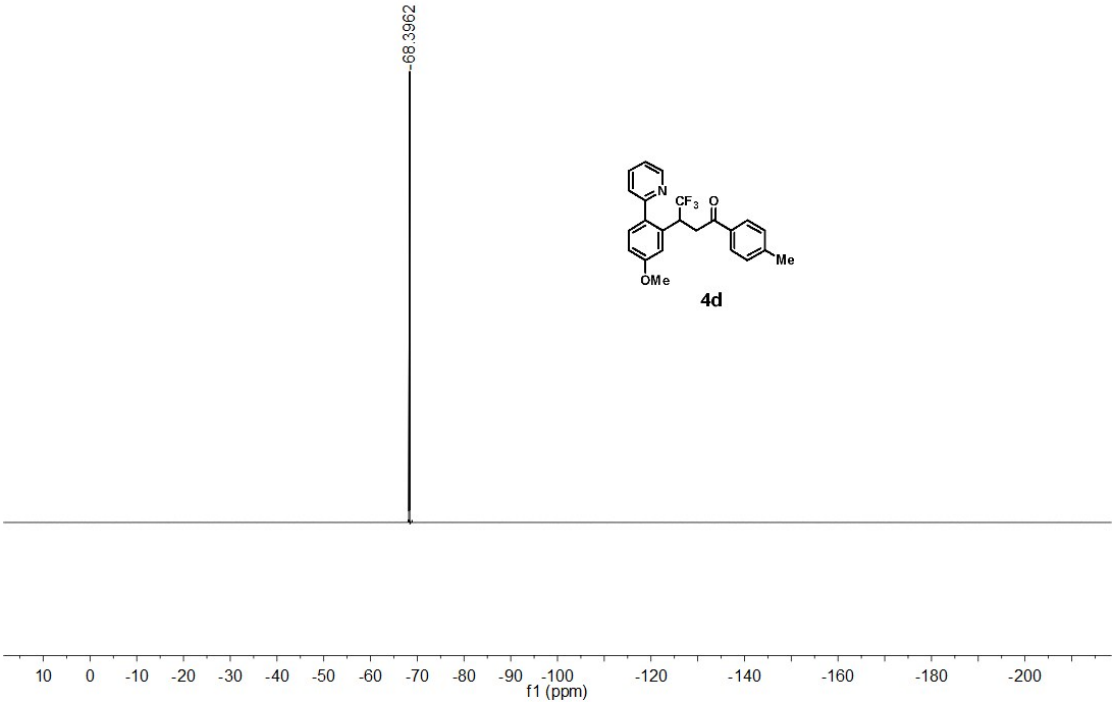
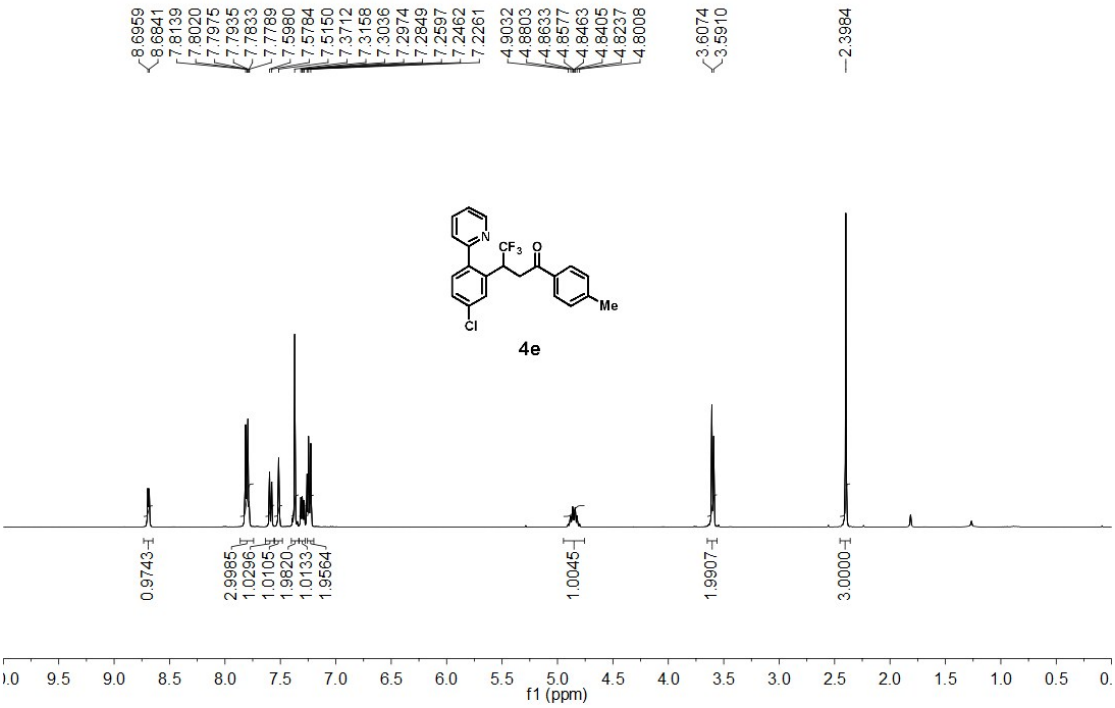


^{1}H NMR in $CDCl_3$



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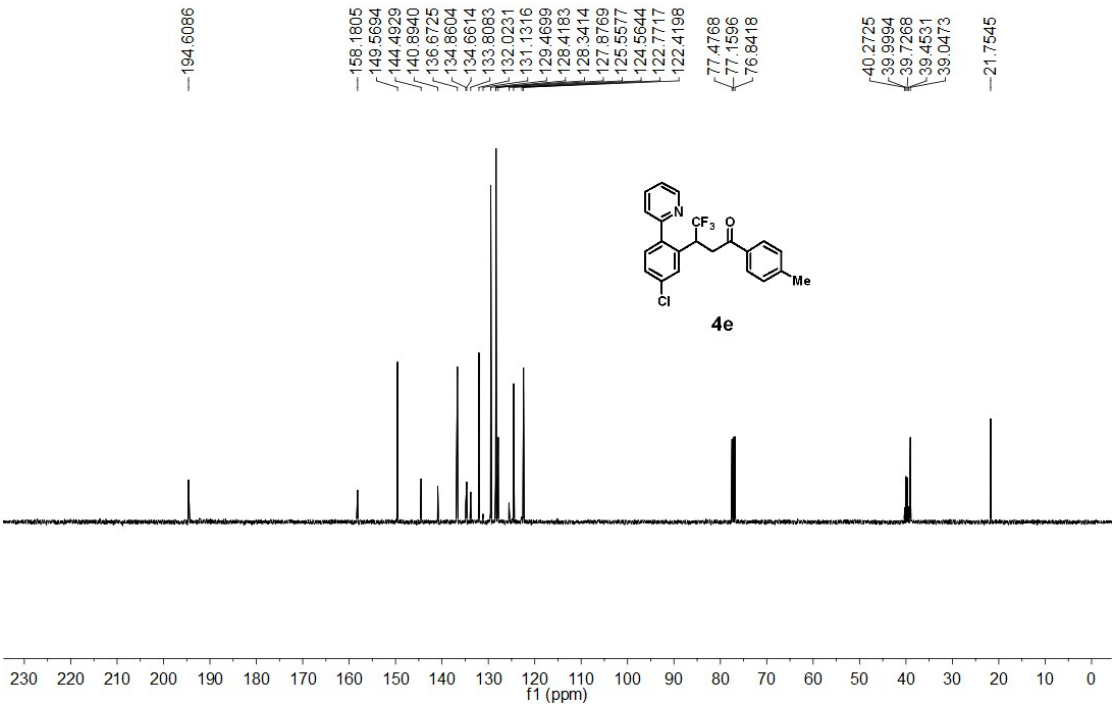

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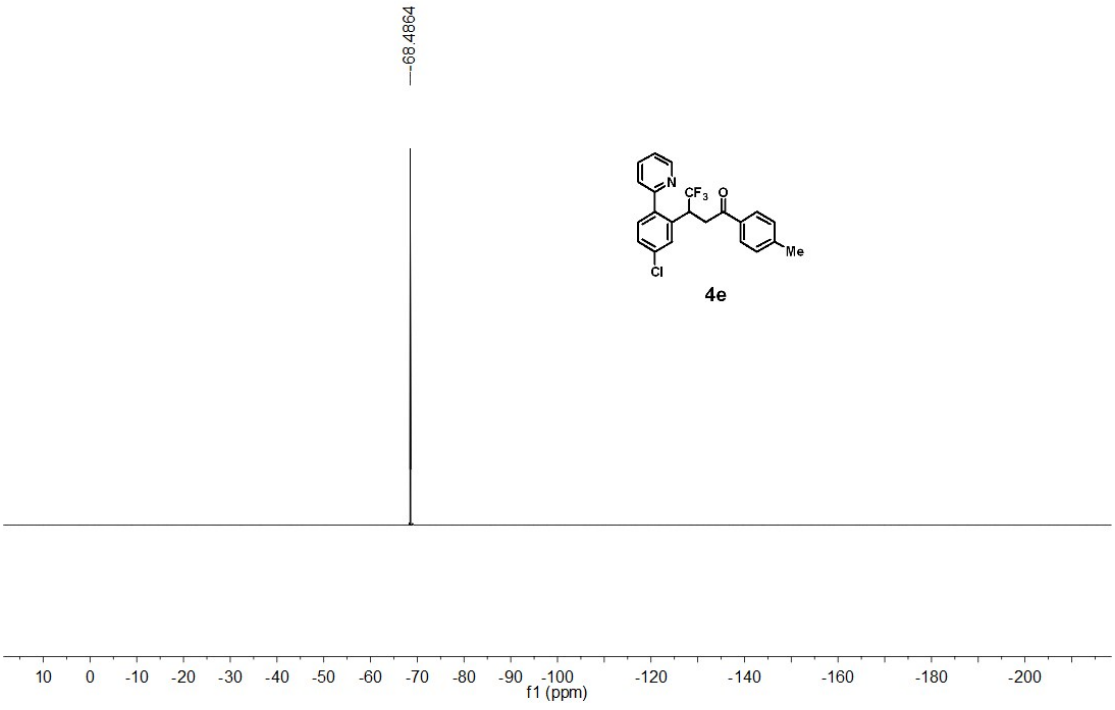

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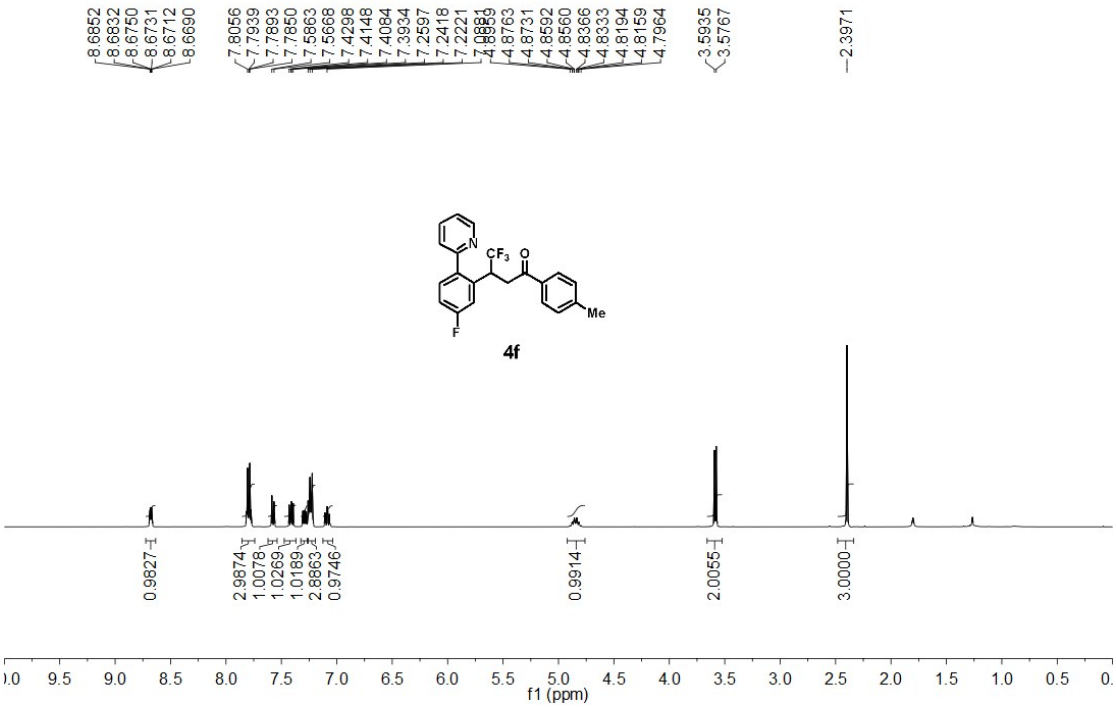

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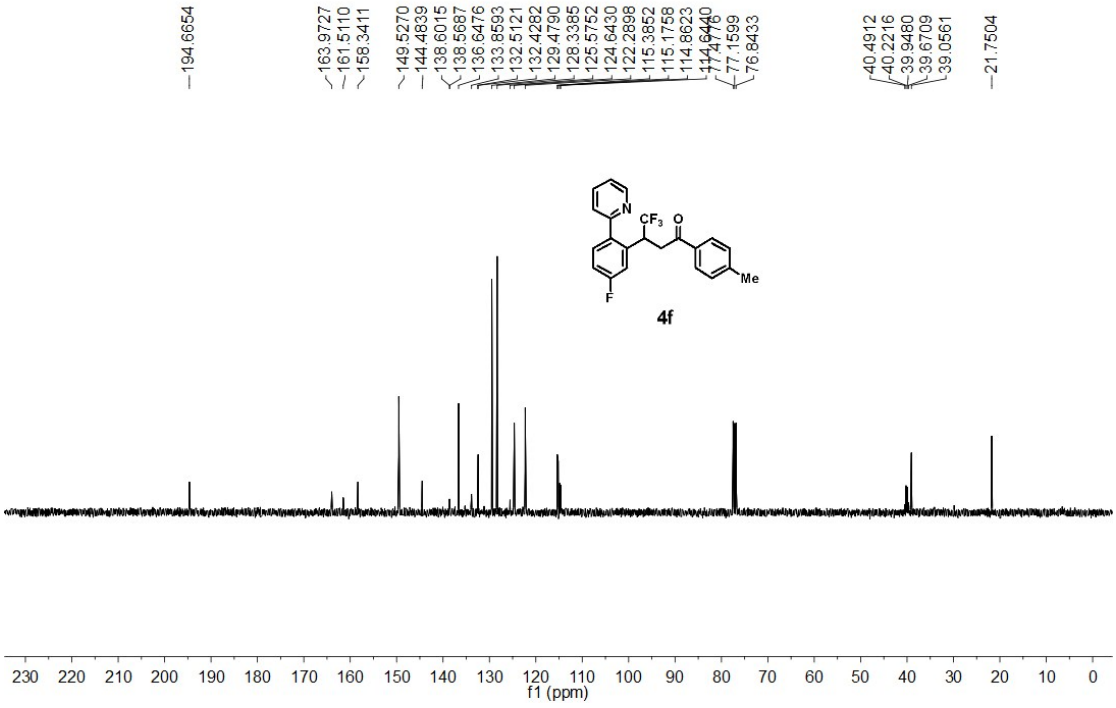

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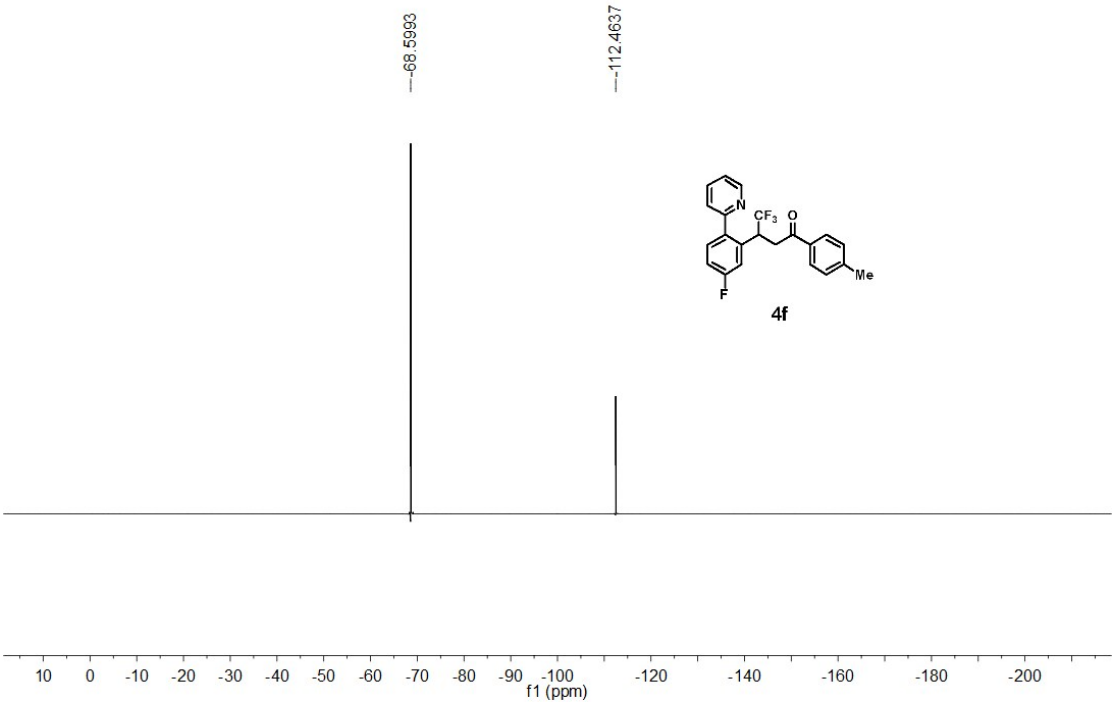

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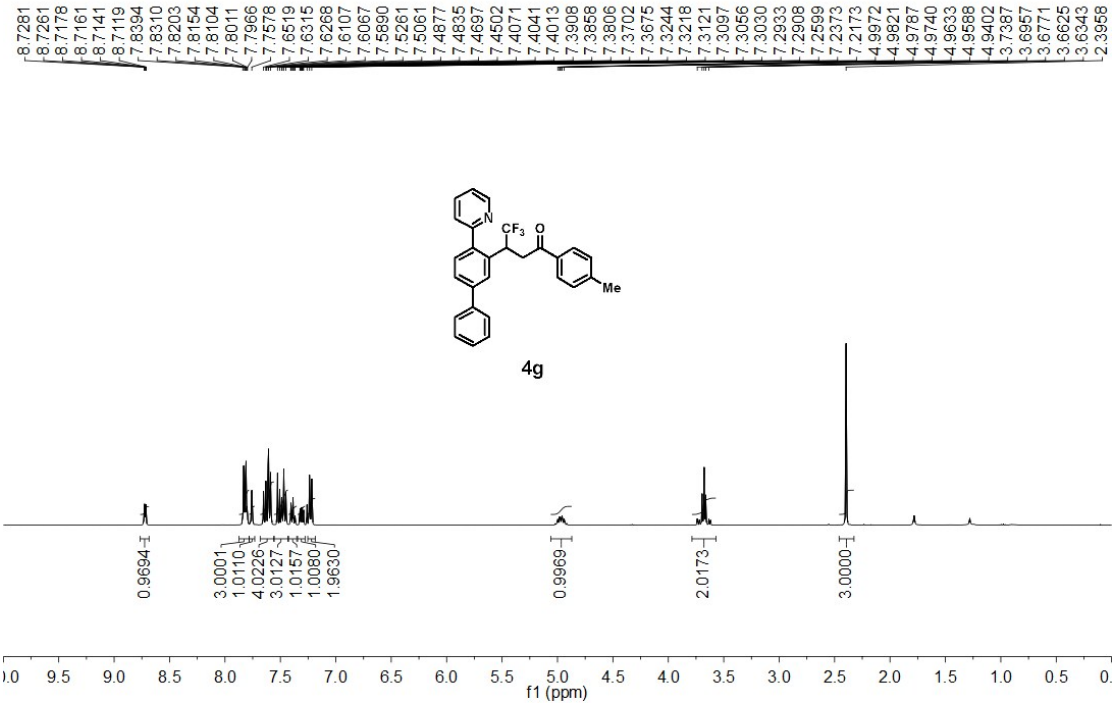

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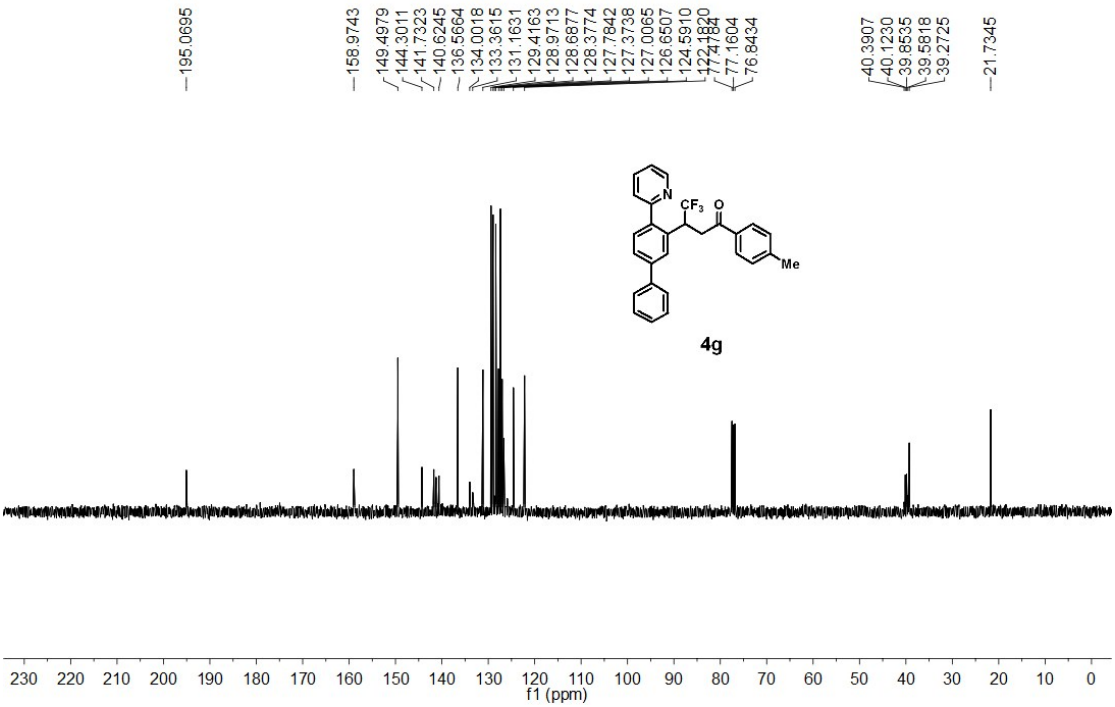

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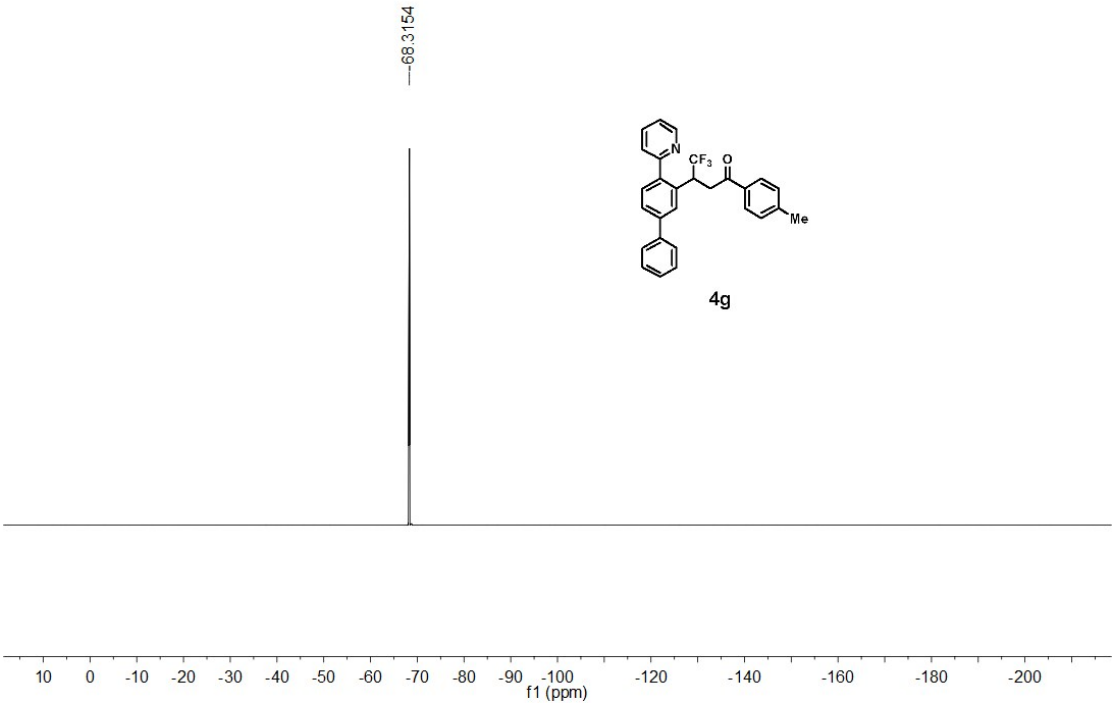

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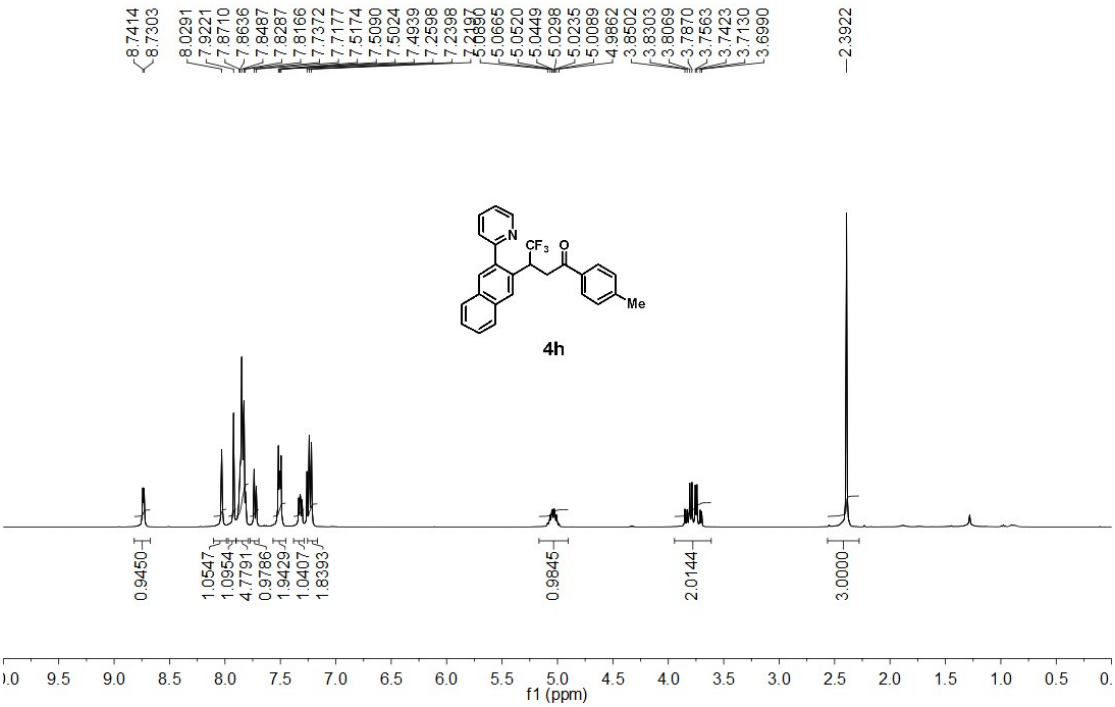

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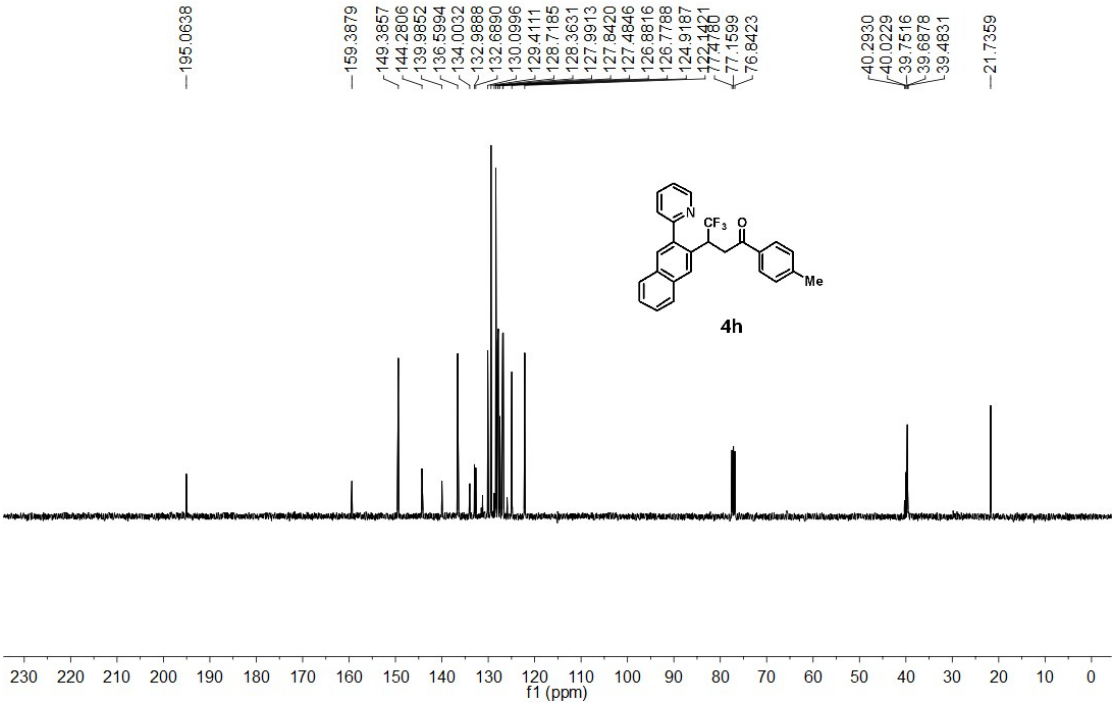

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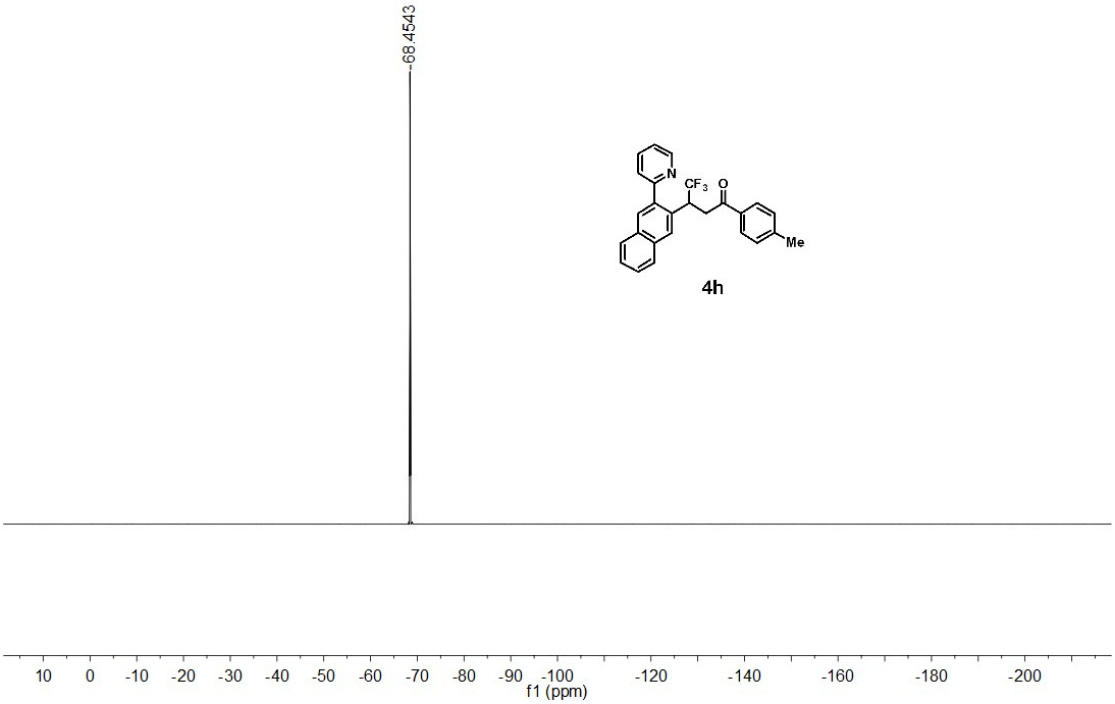
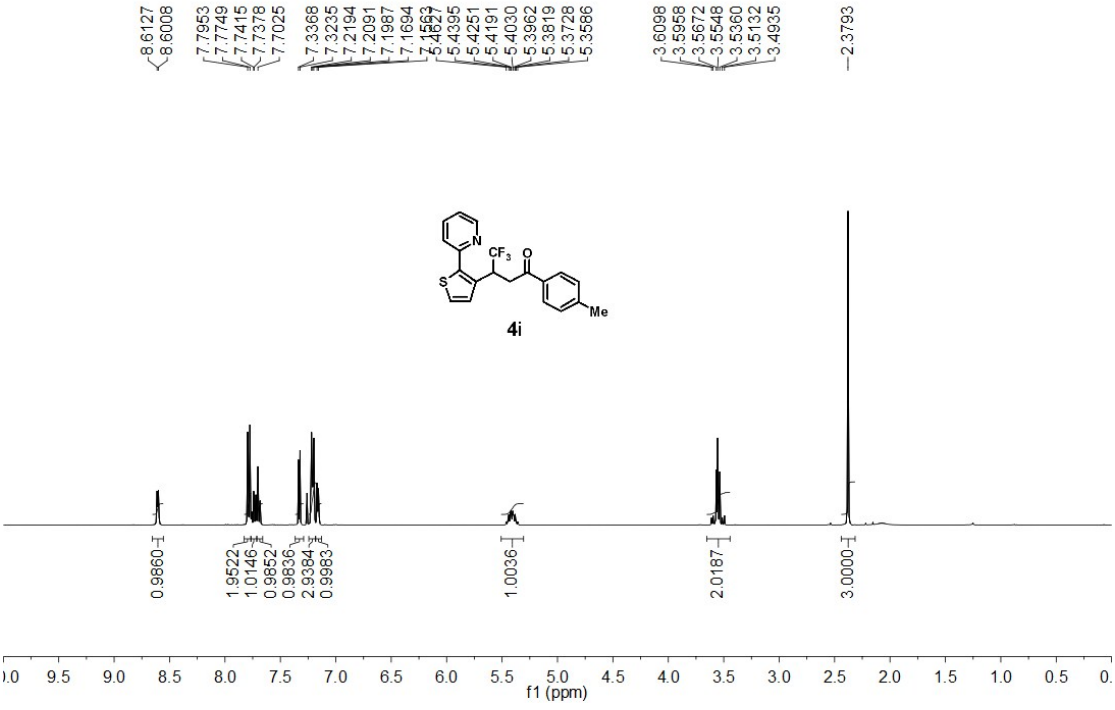


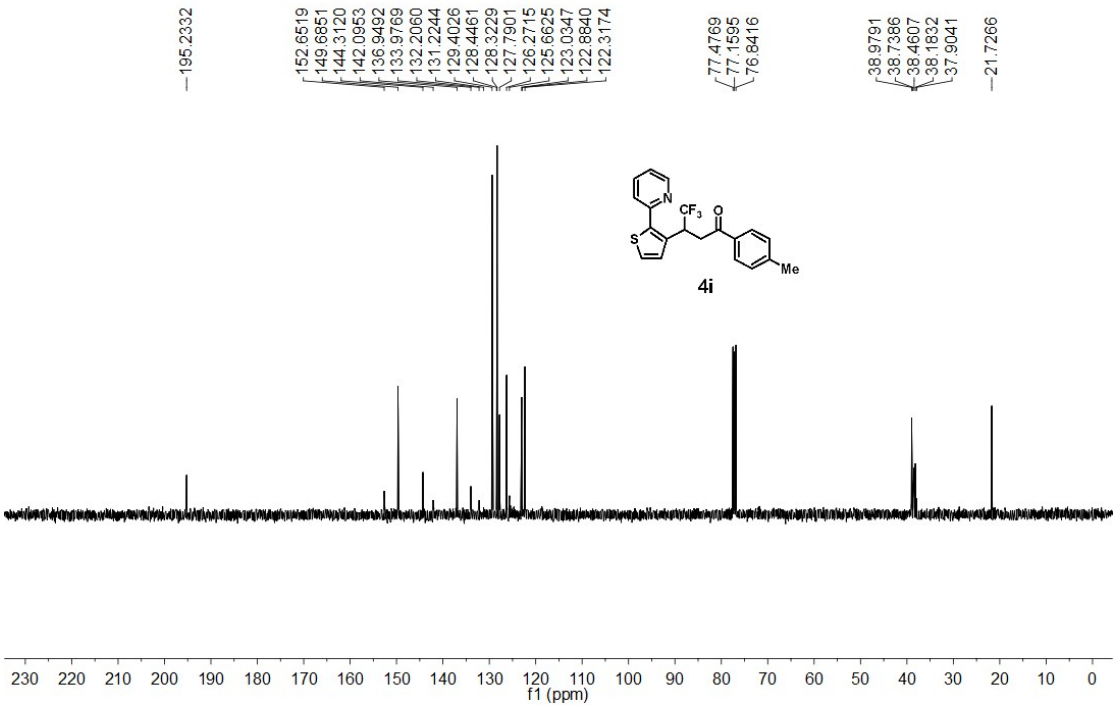
4h

^{1}H NMR in $CDCl_3$

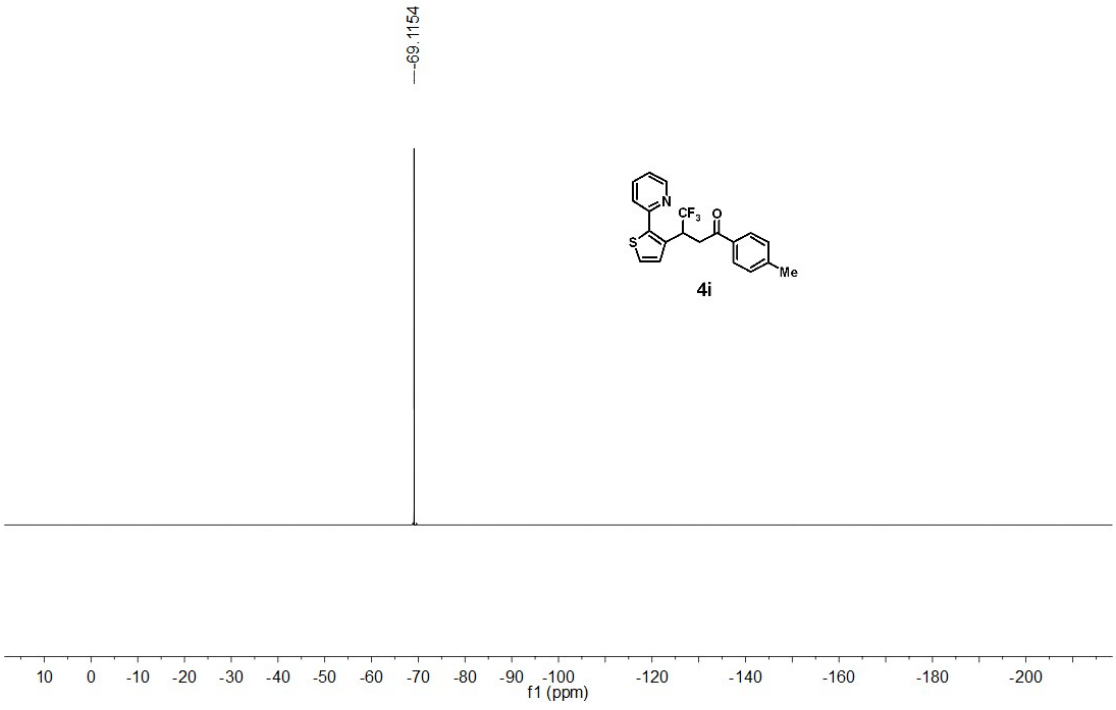


4i

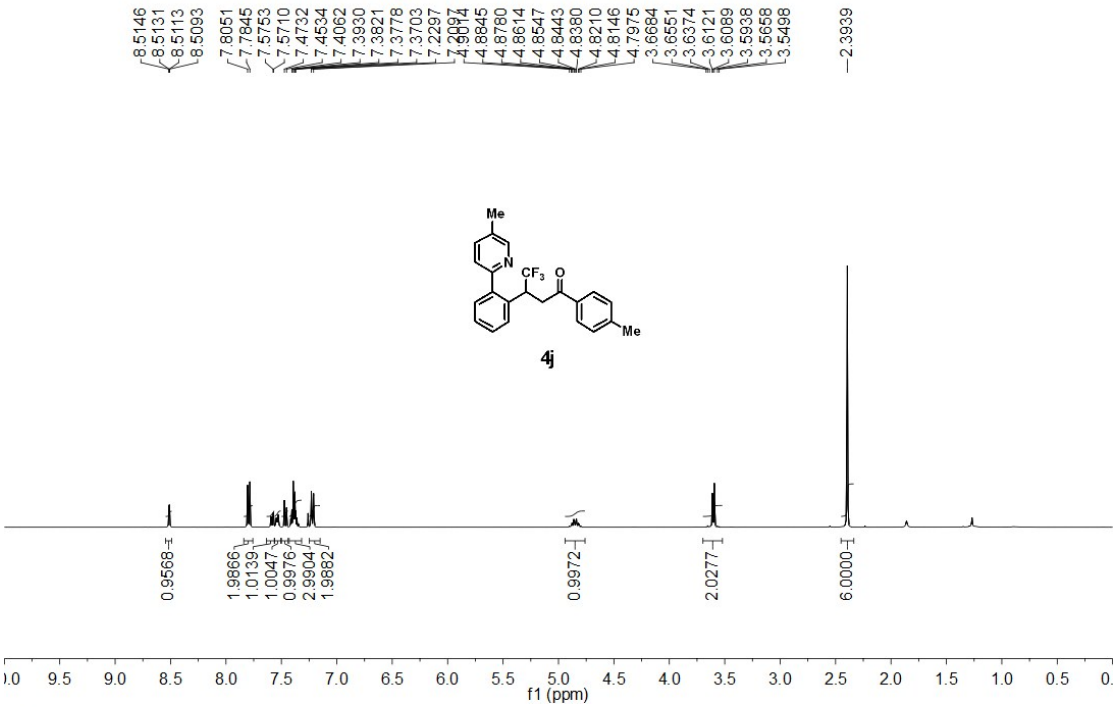
^{13}C NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



^{1}H NMR in $CDCl_3$



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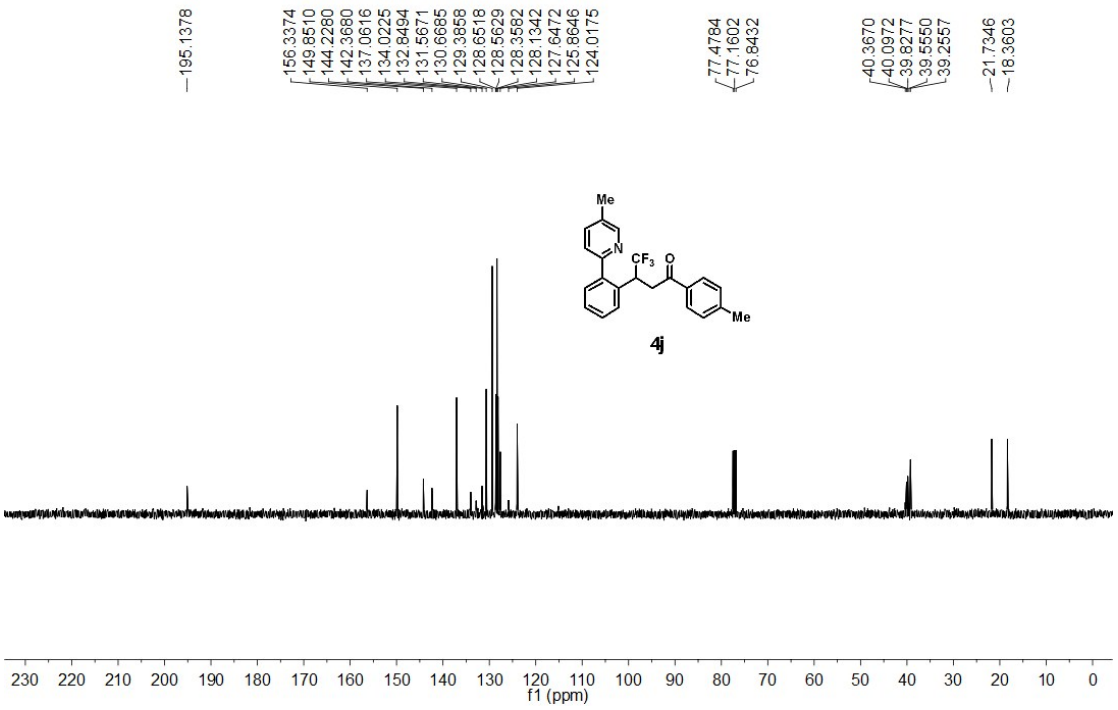

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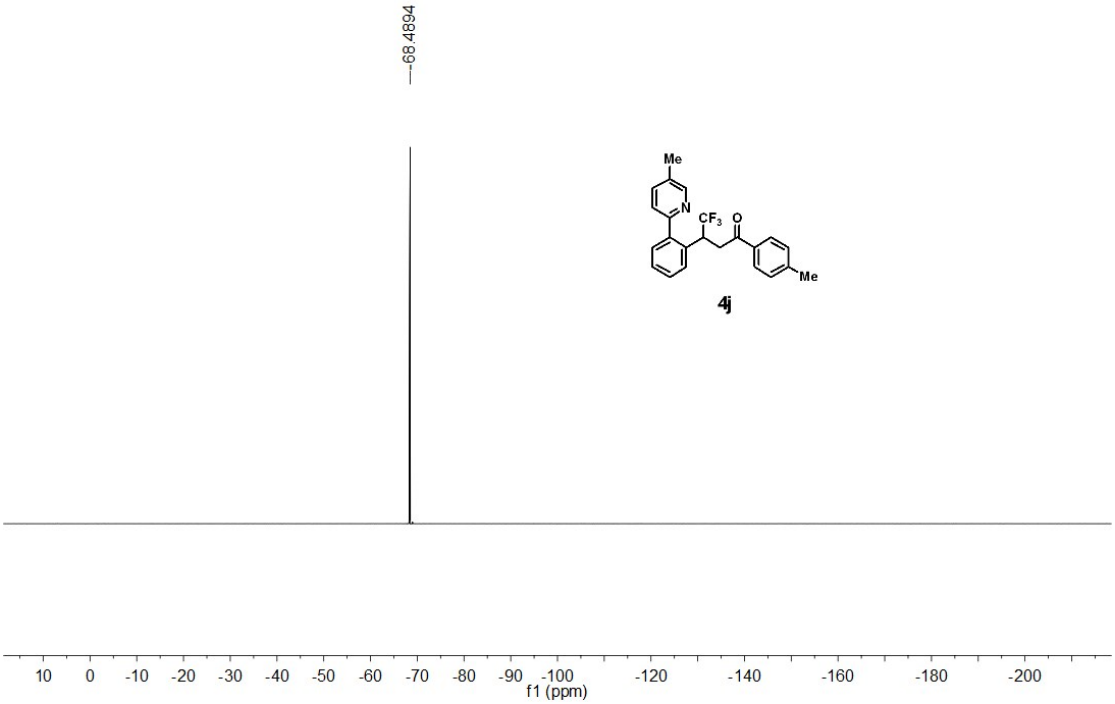

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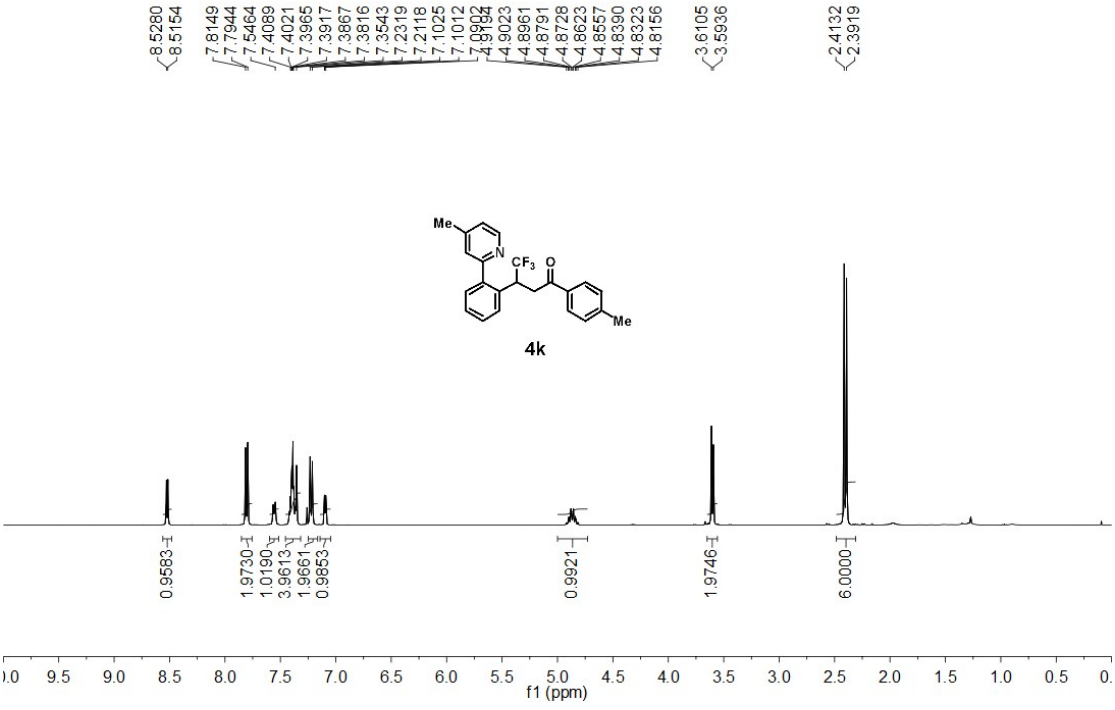

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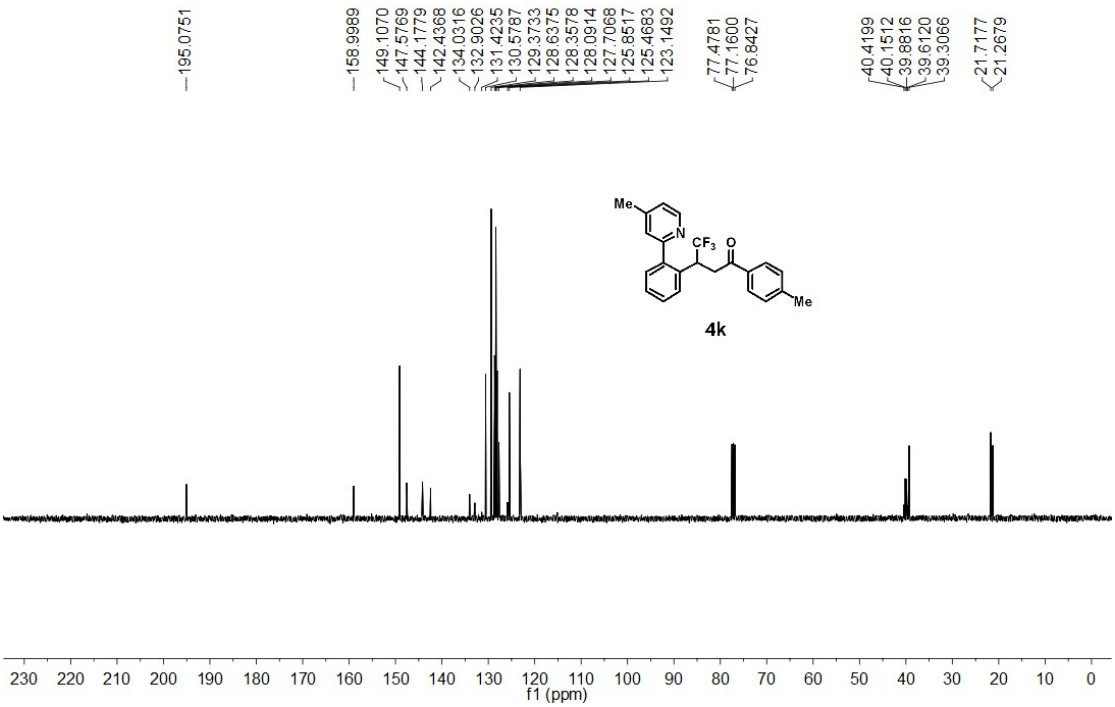

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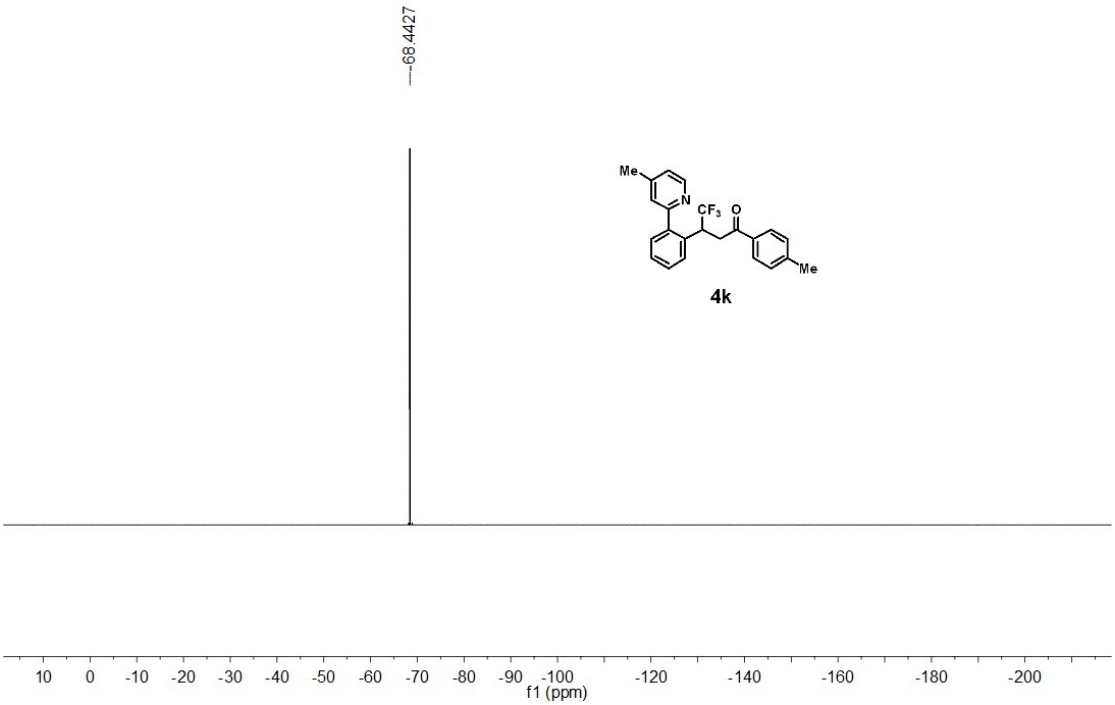

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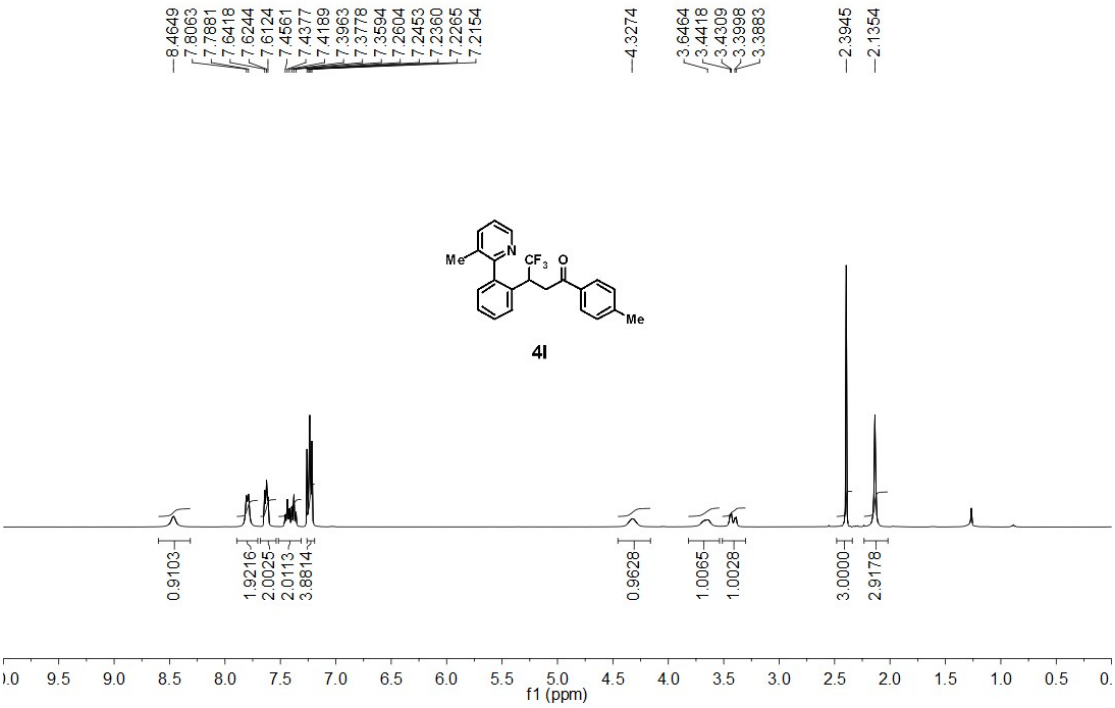

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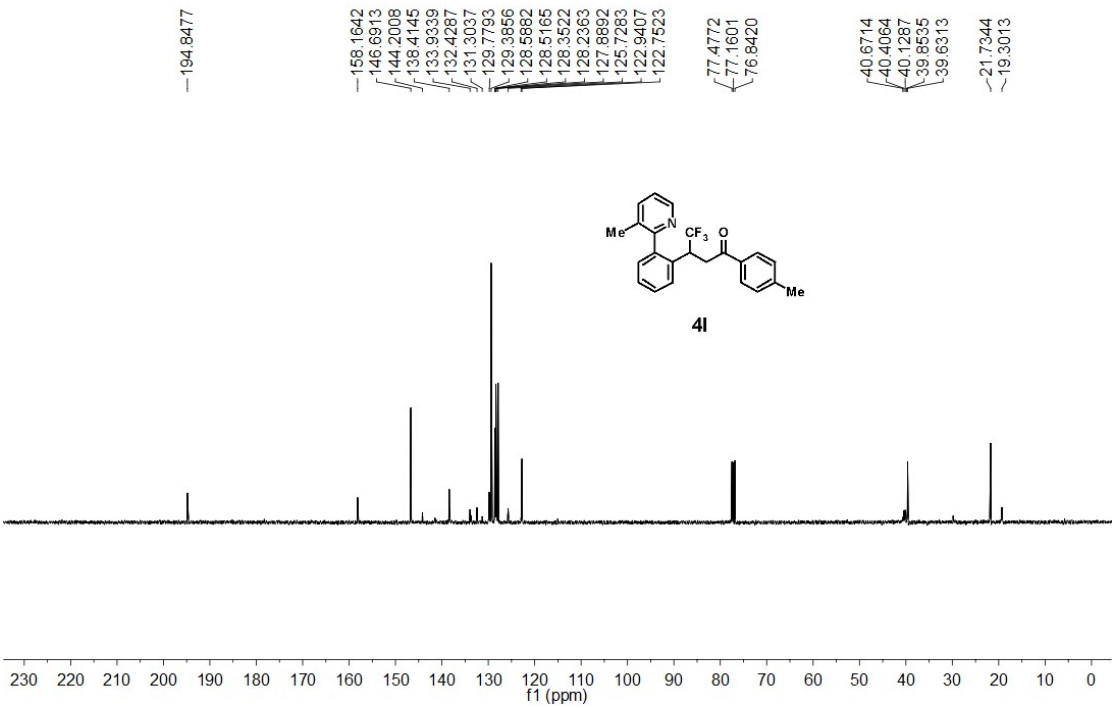

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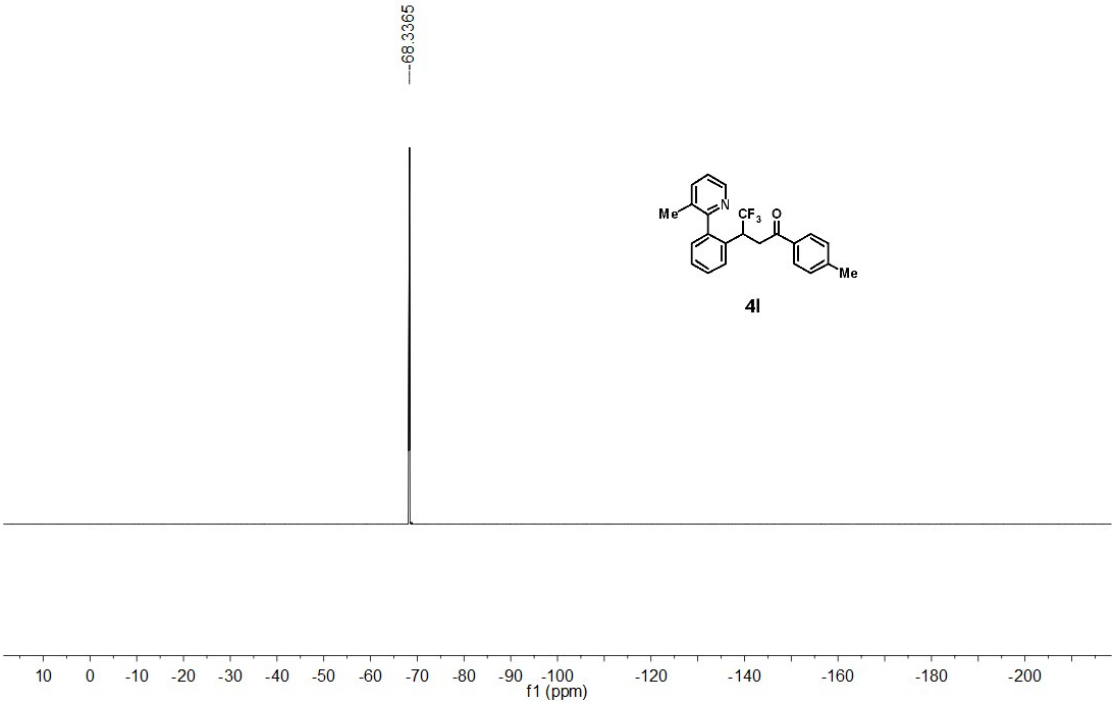

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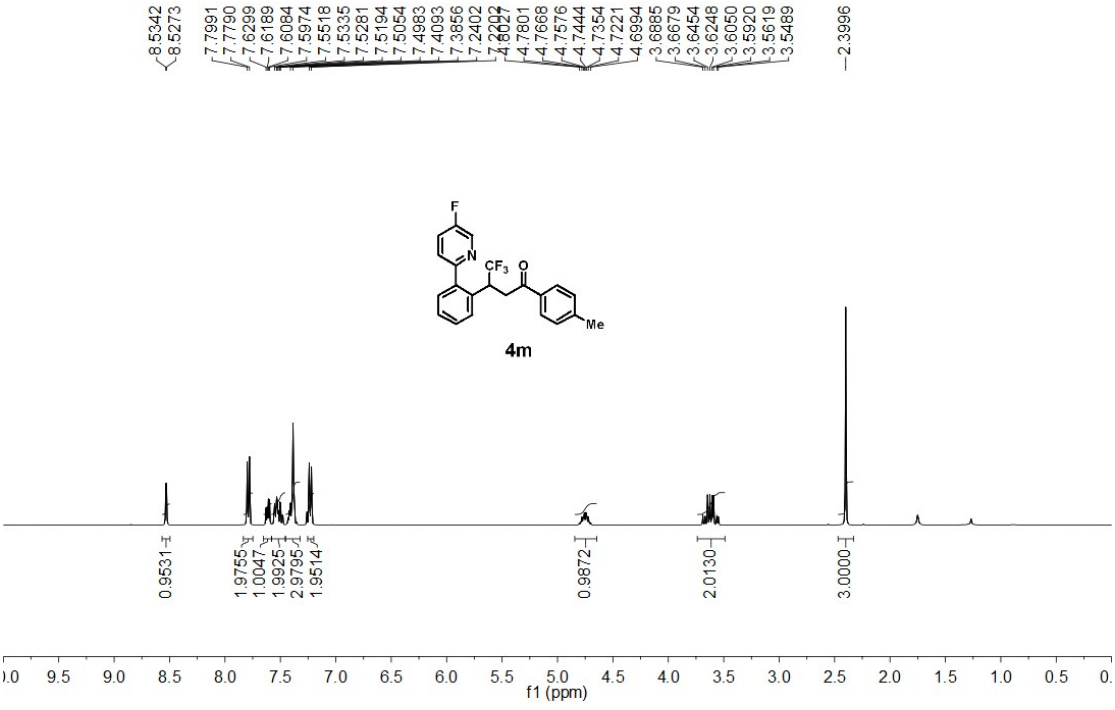

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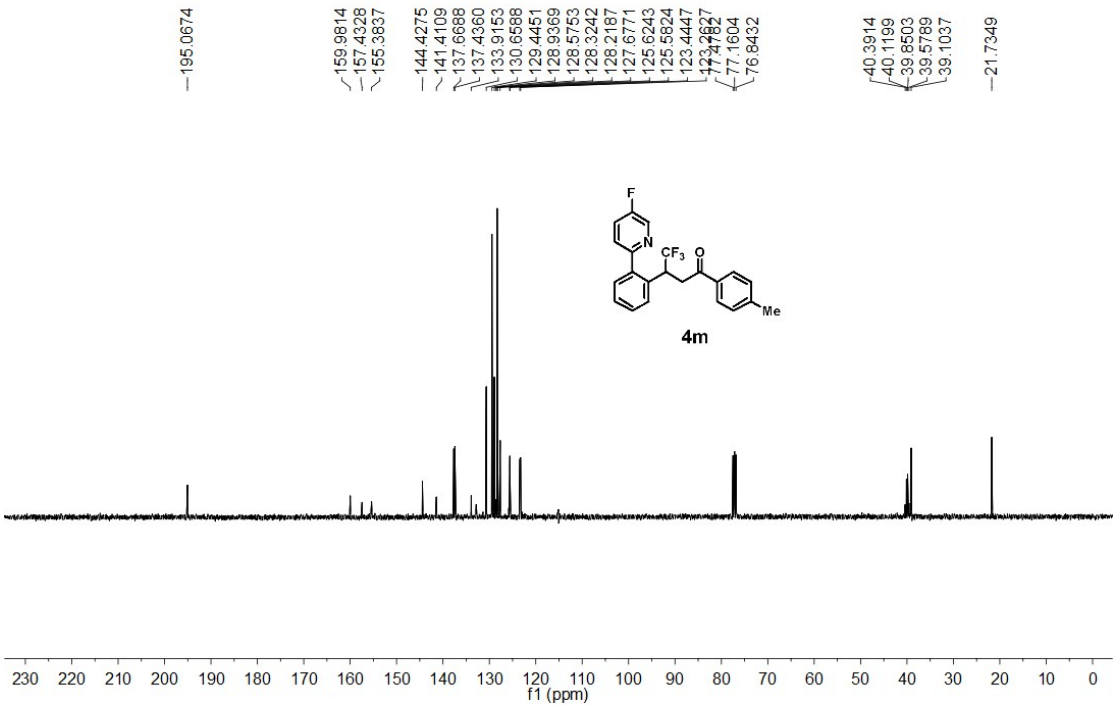

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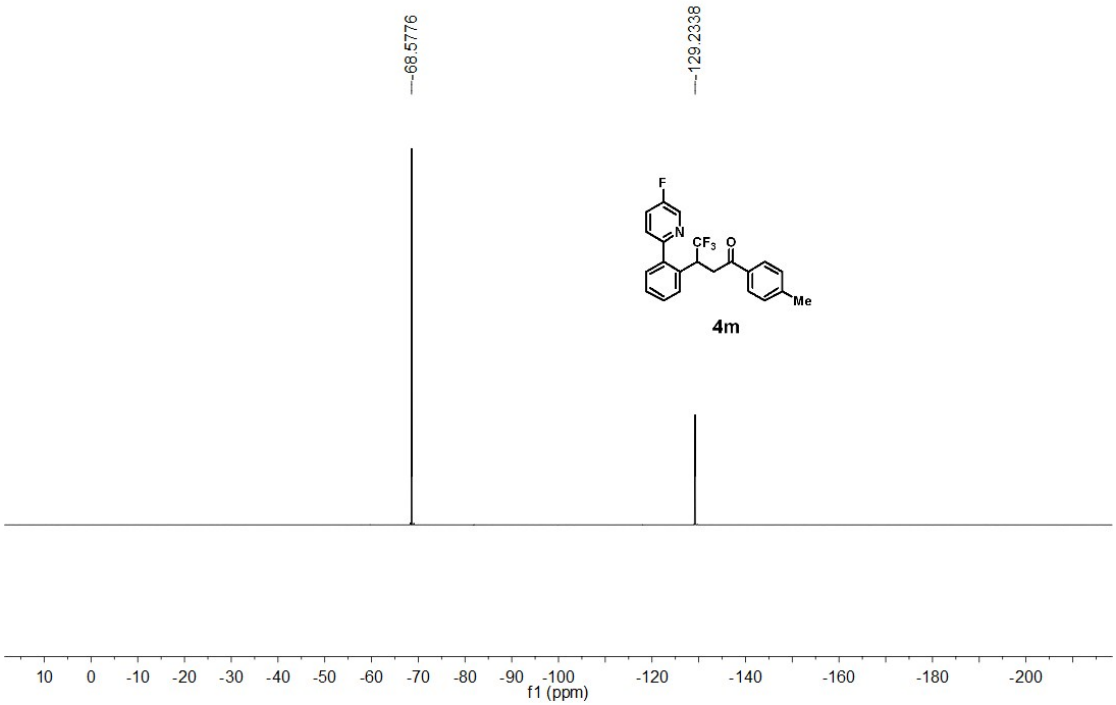

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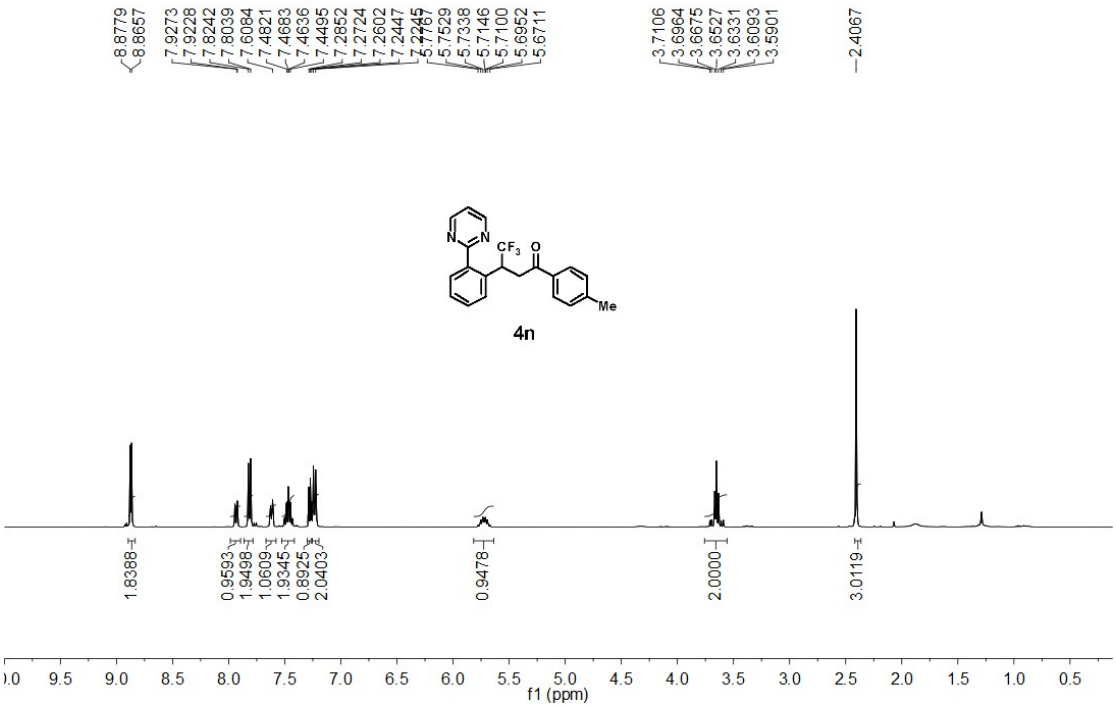
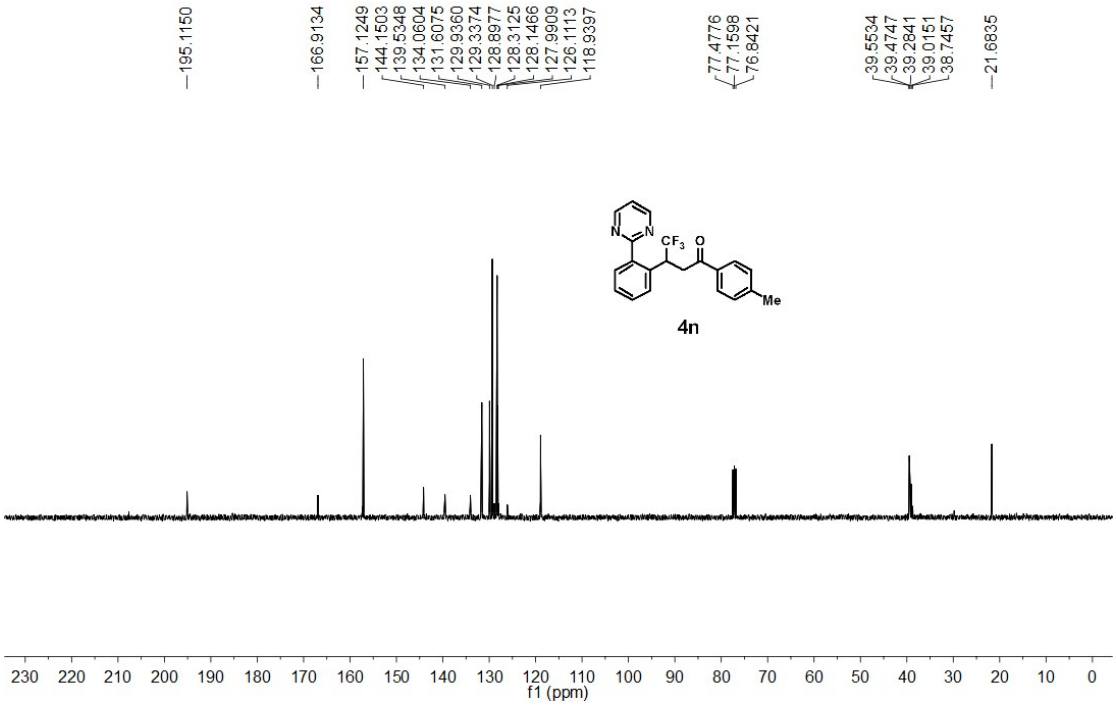
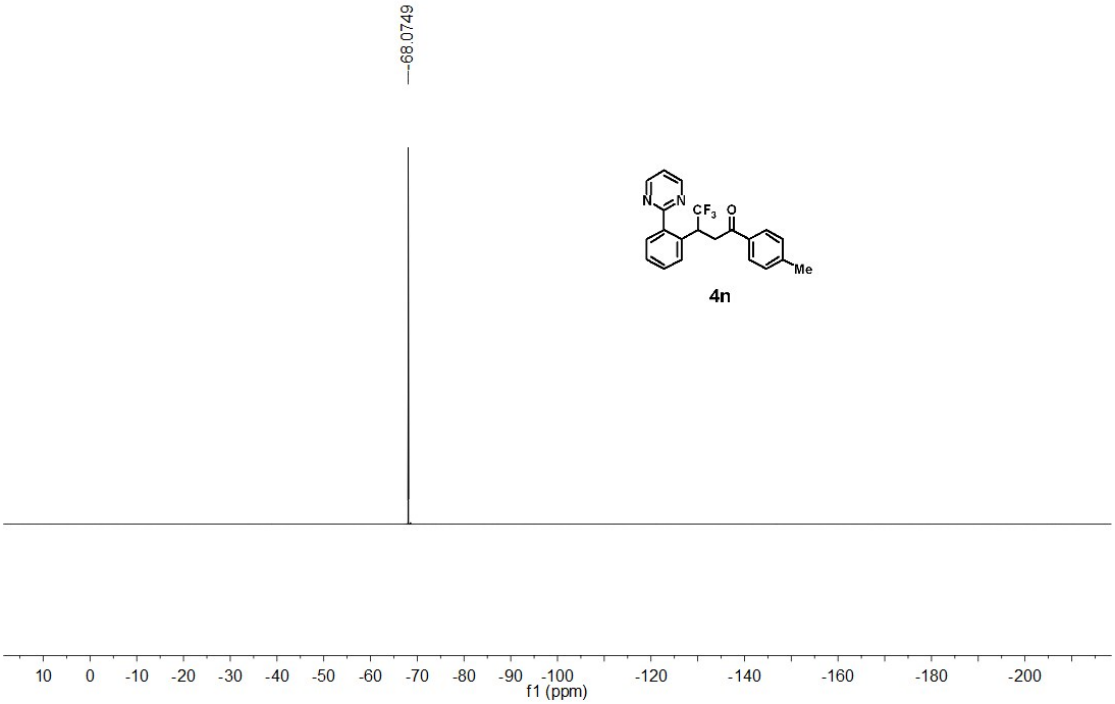


^{13}C NMR in $CDCl_3$

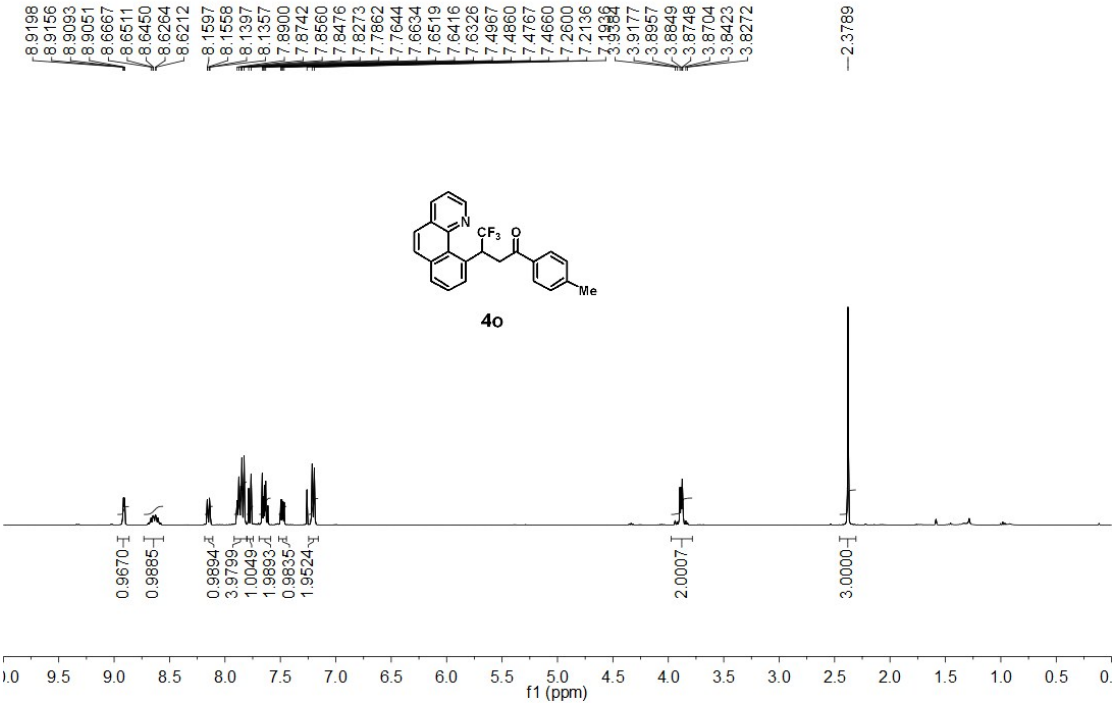


^{19}F NMR in $CDCl_3$



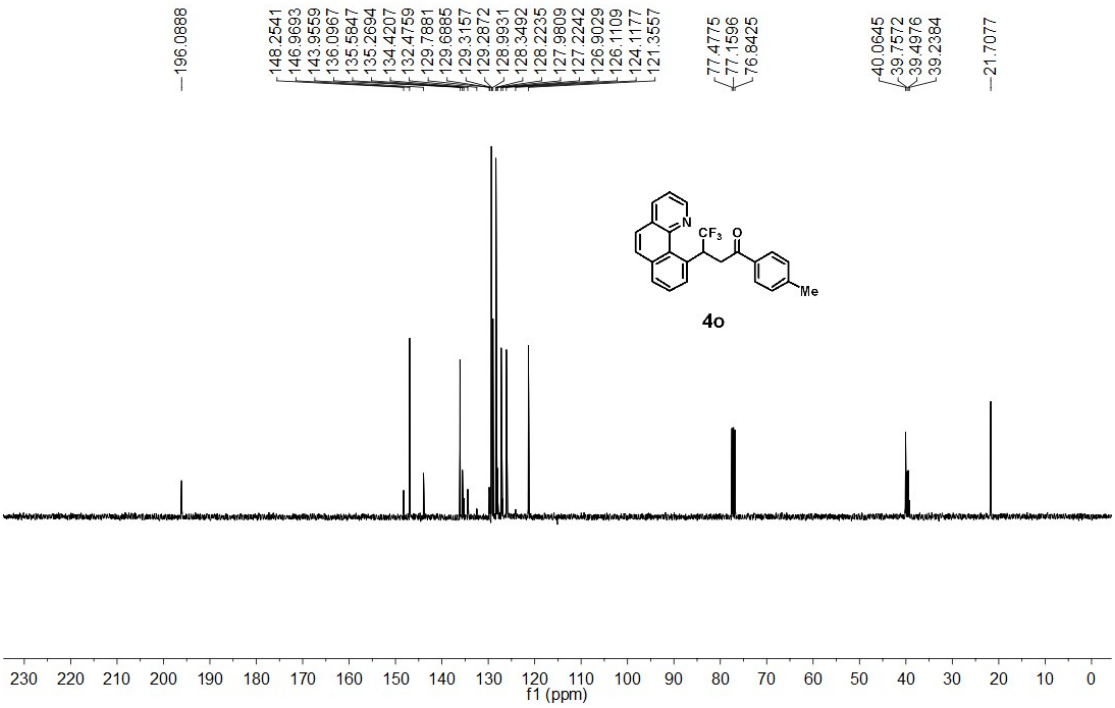
4n

^{1}H NMR in $CDCl_3$

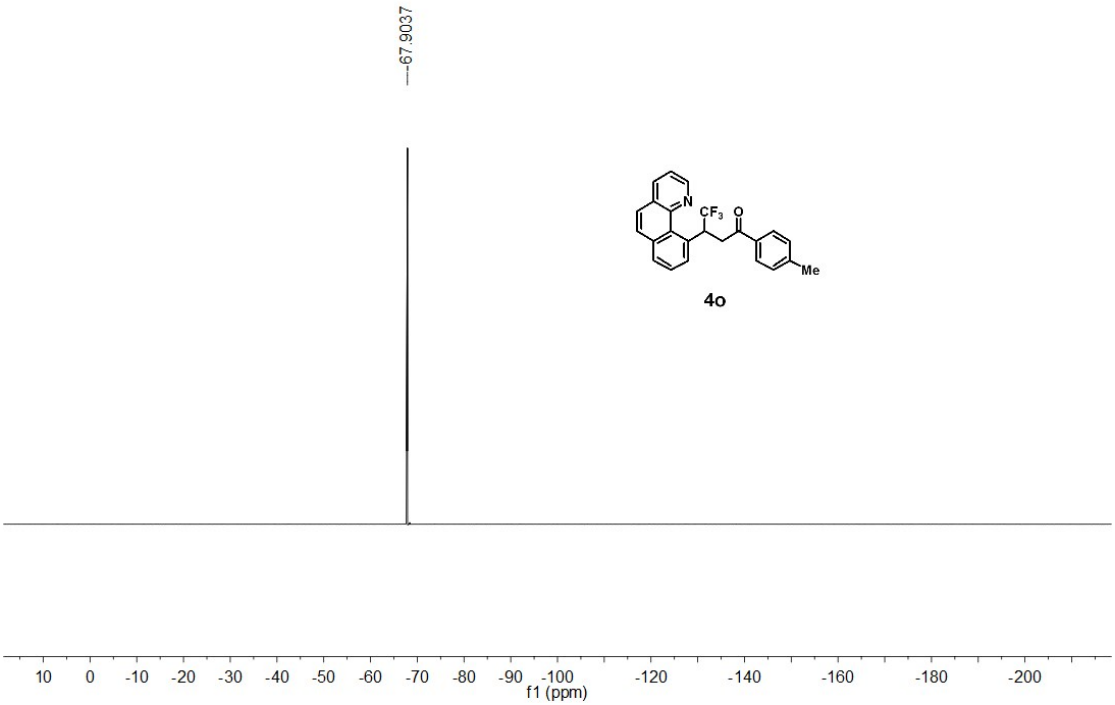


4o

^{13}C NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



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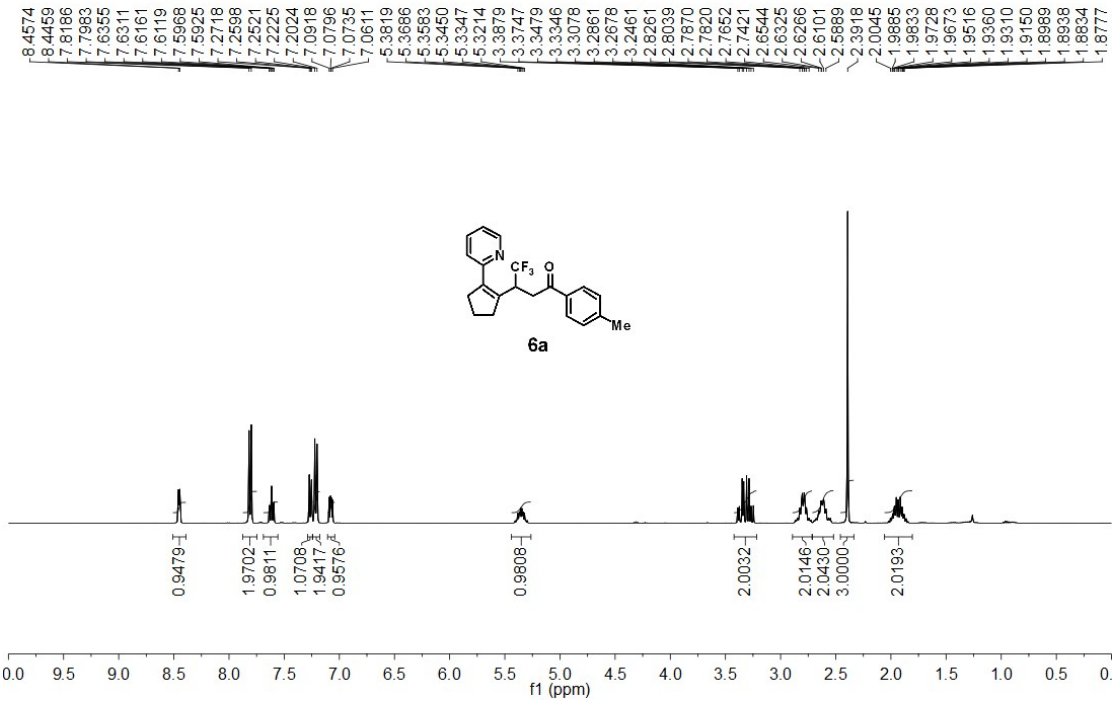

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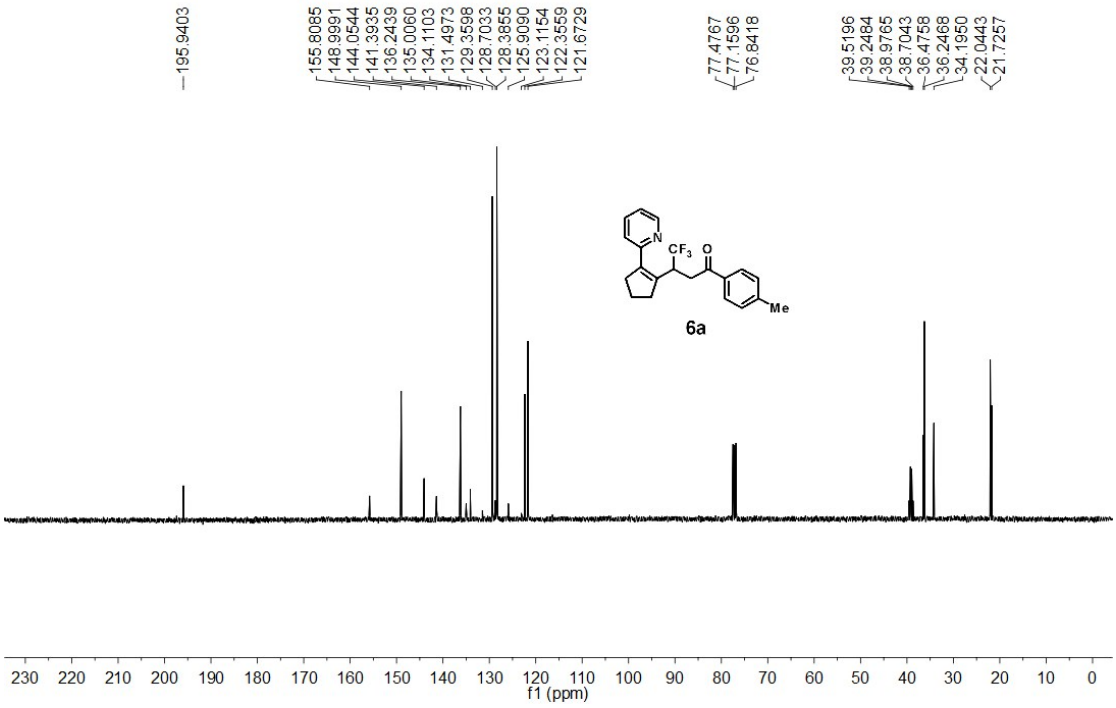

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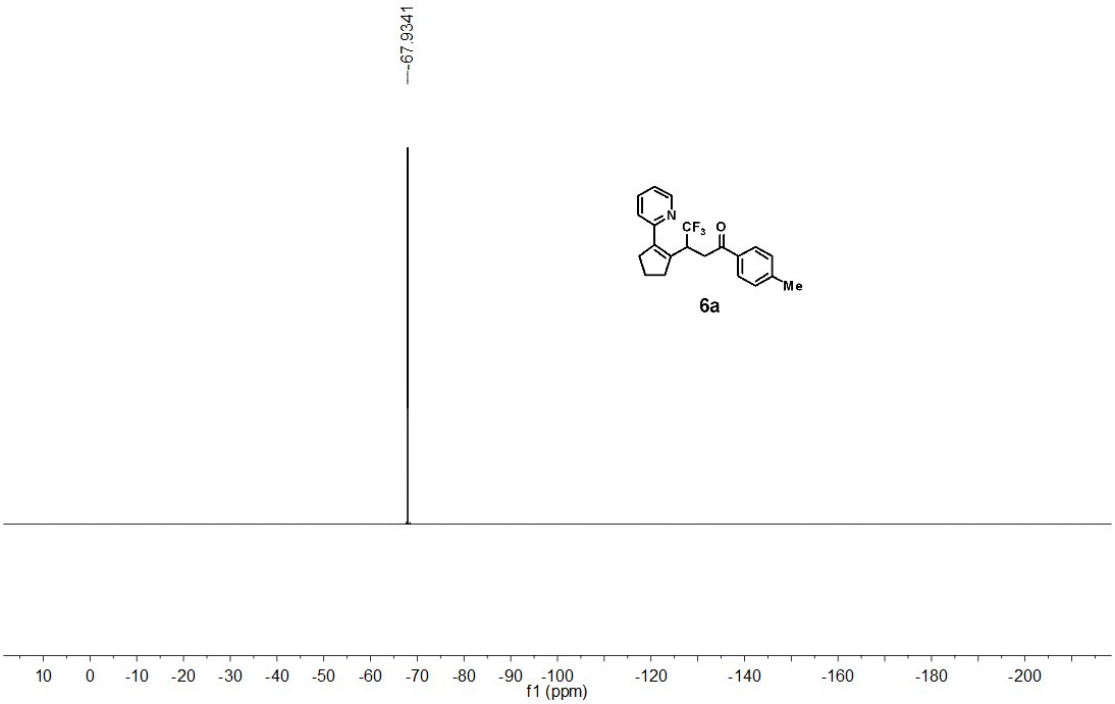

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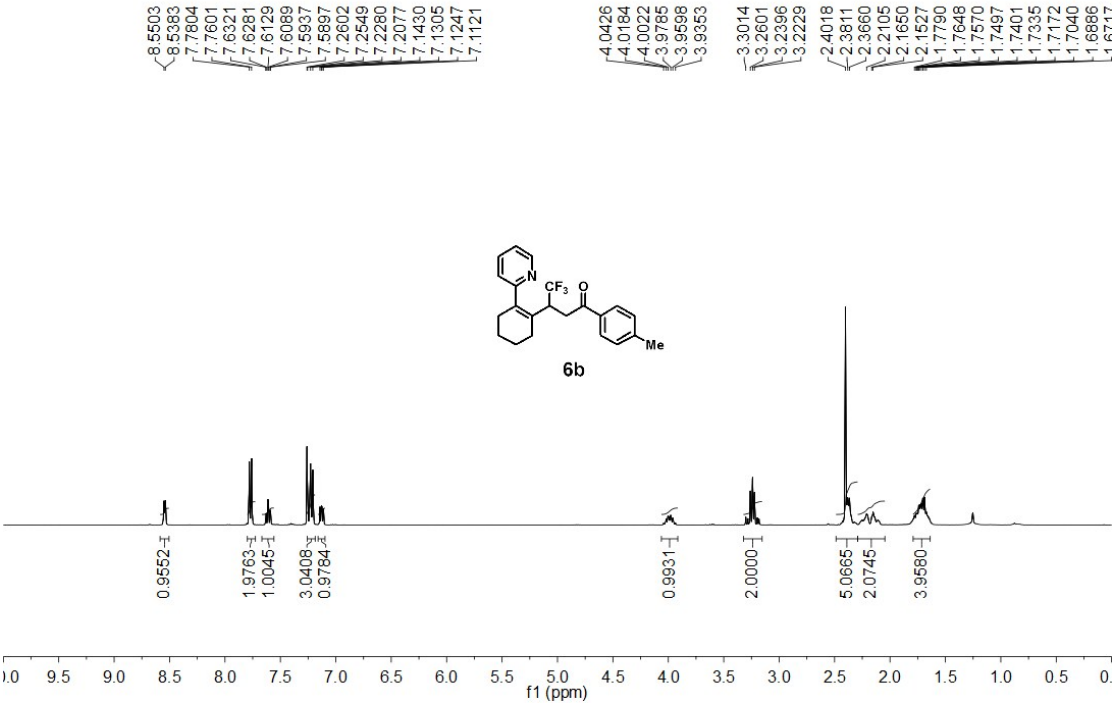

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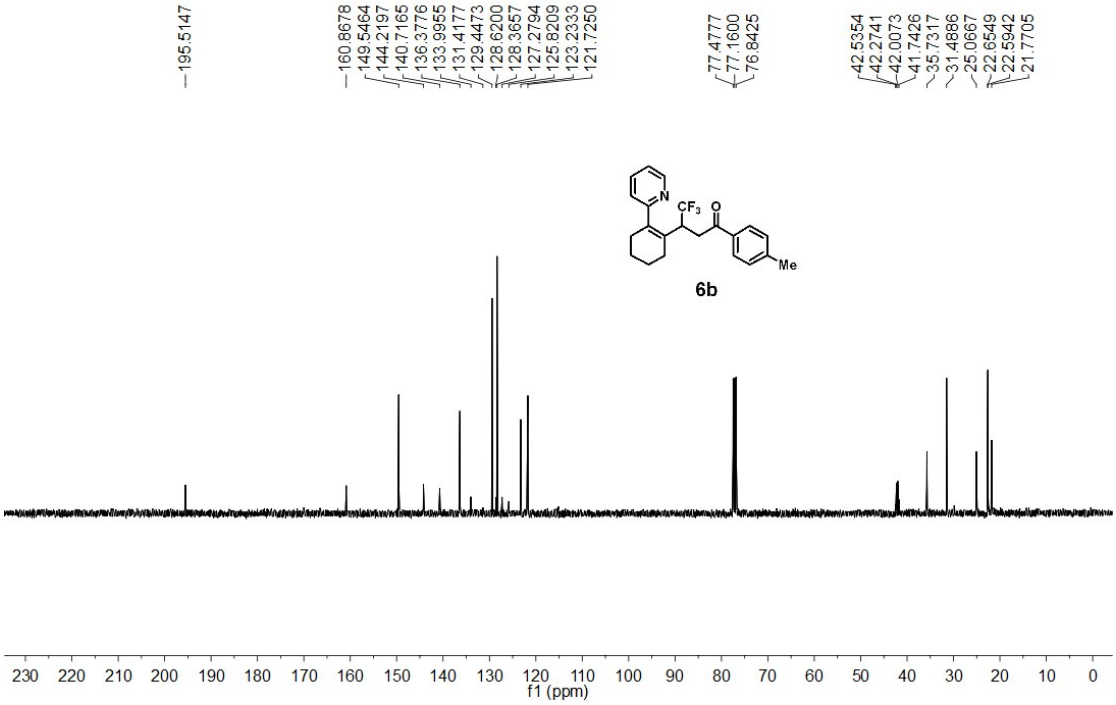

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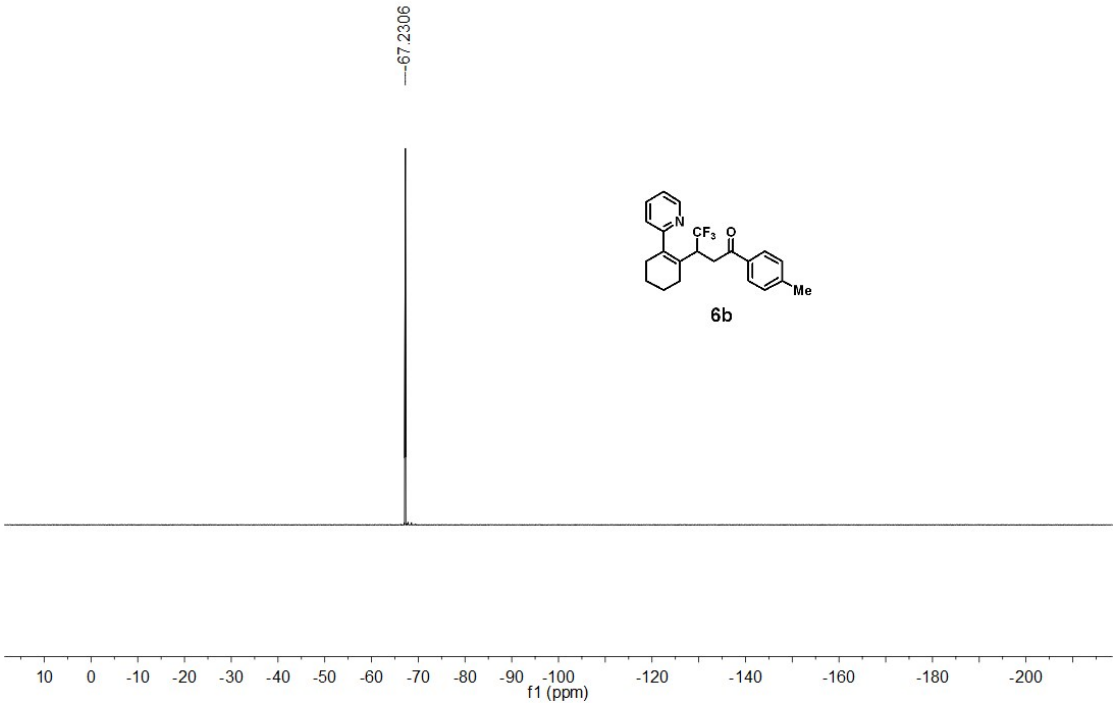

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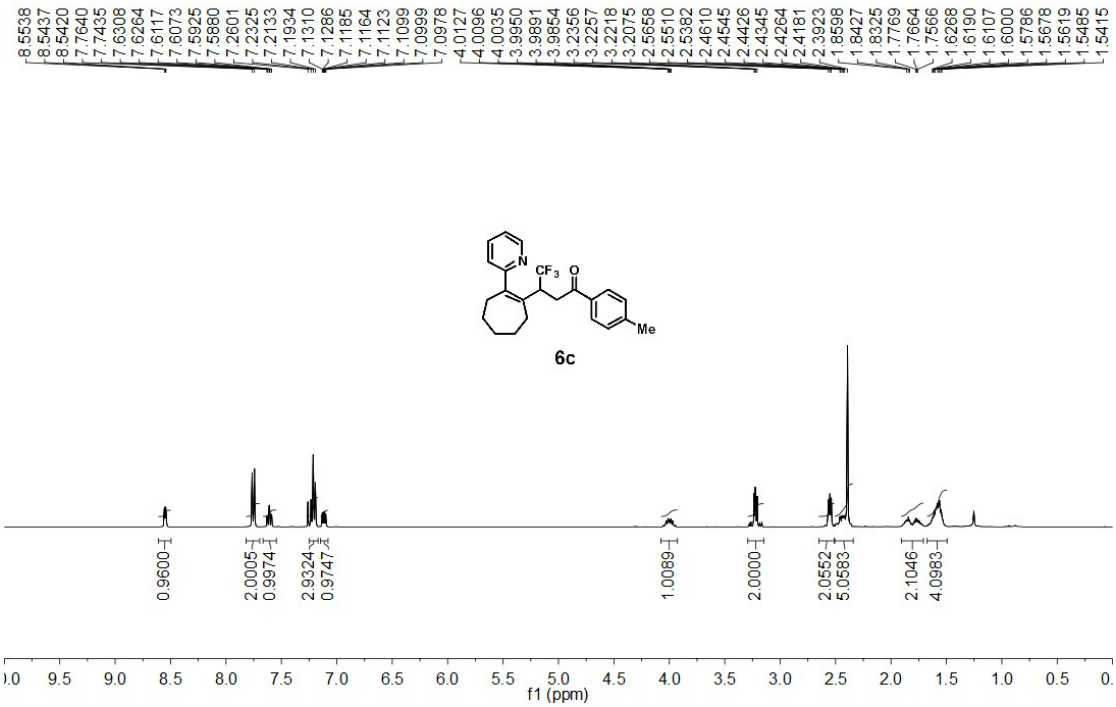

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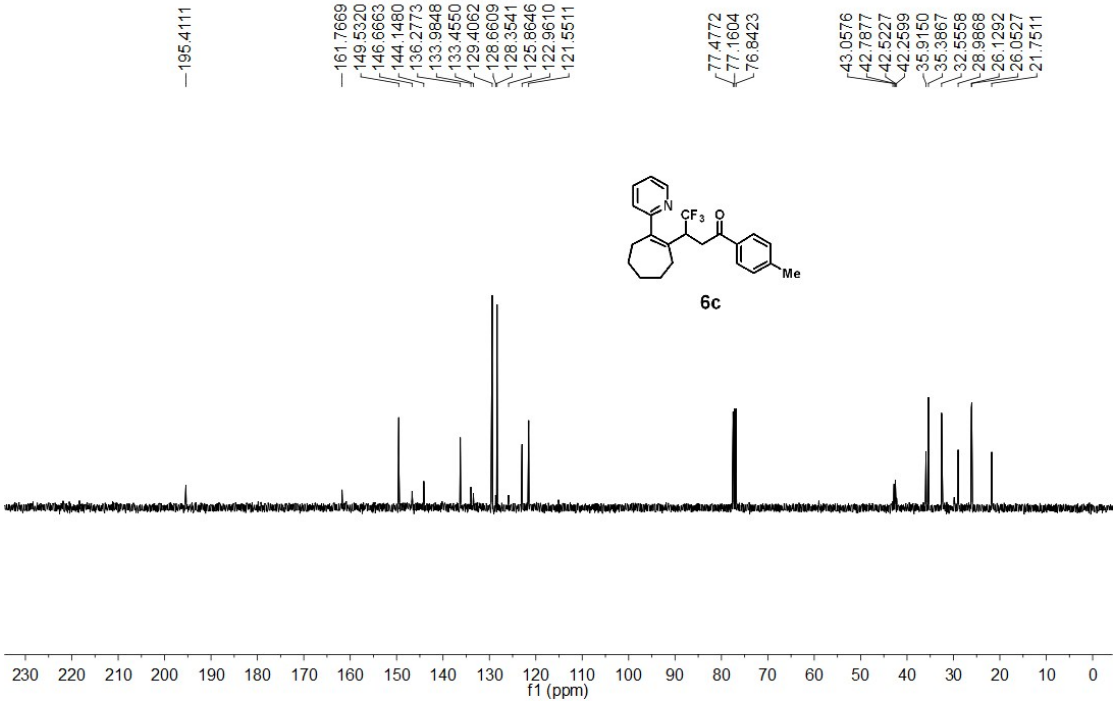

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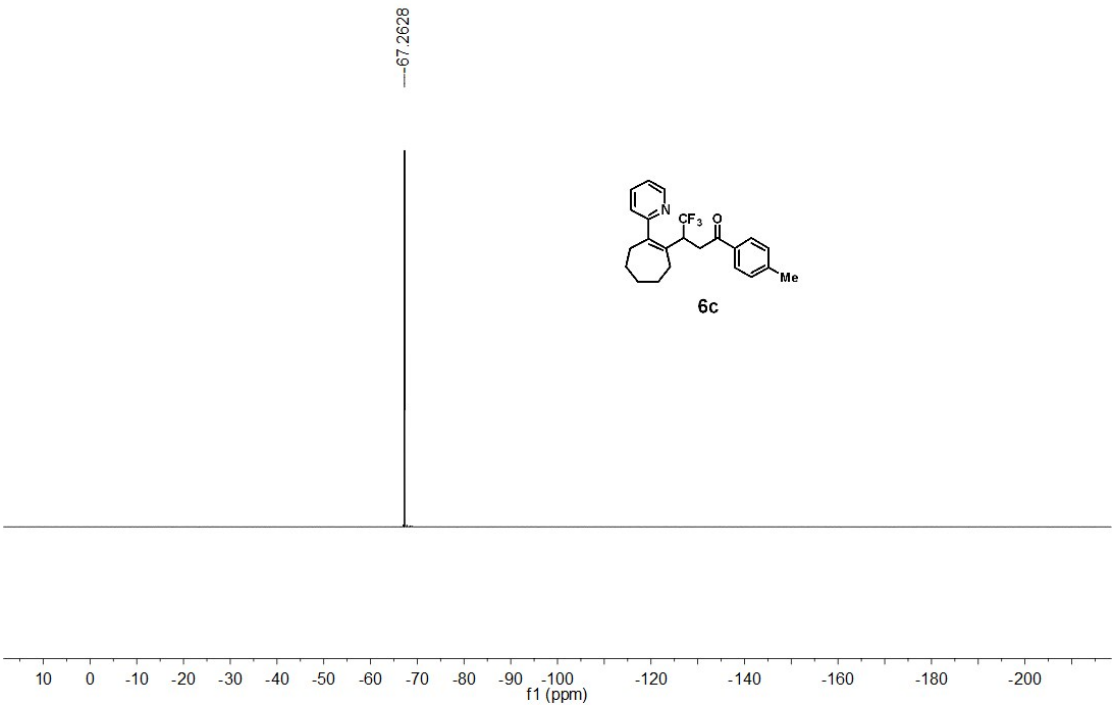

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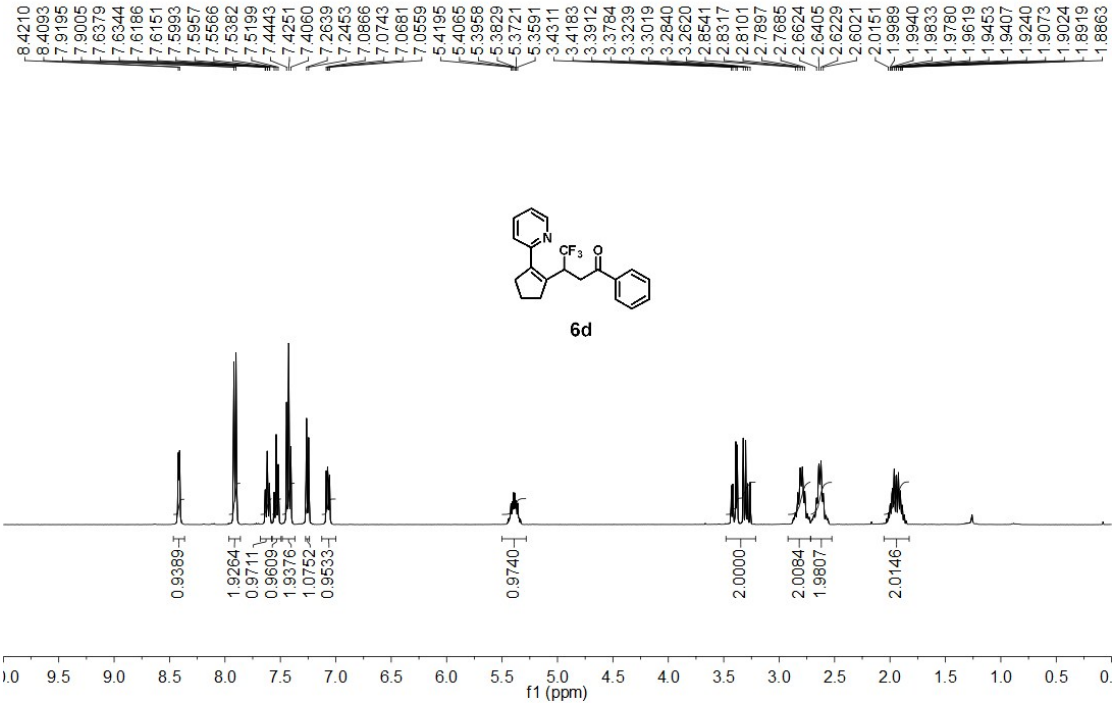
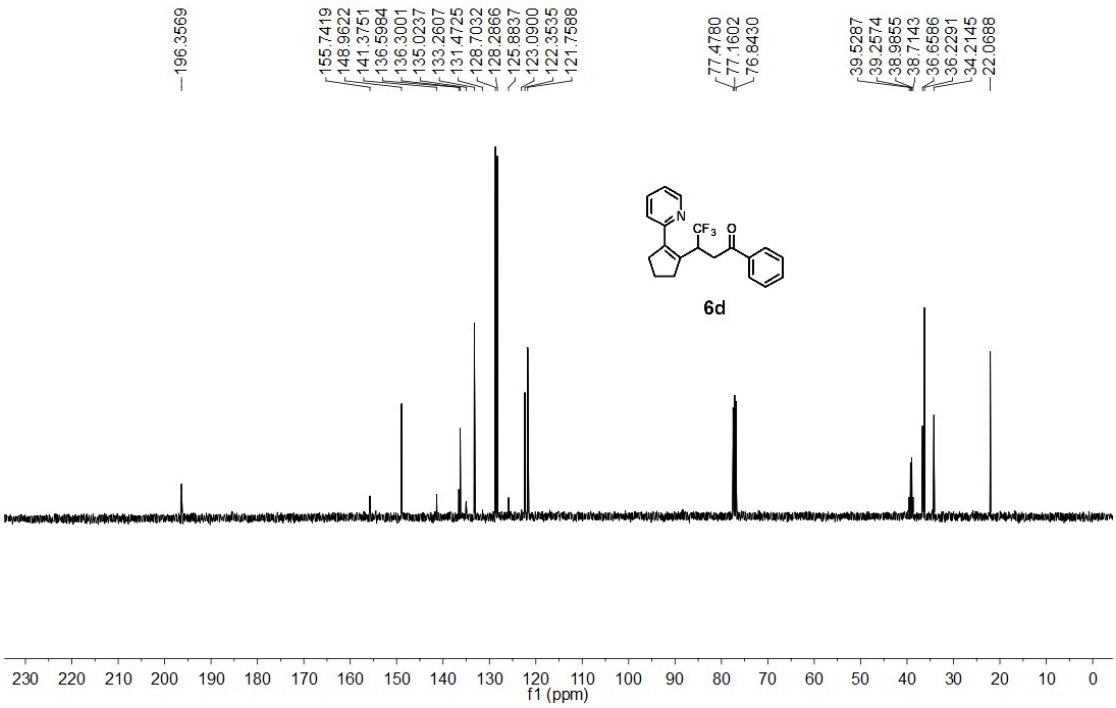
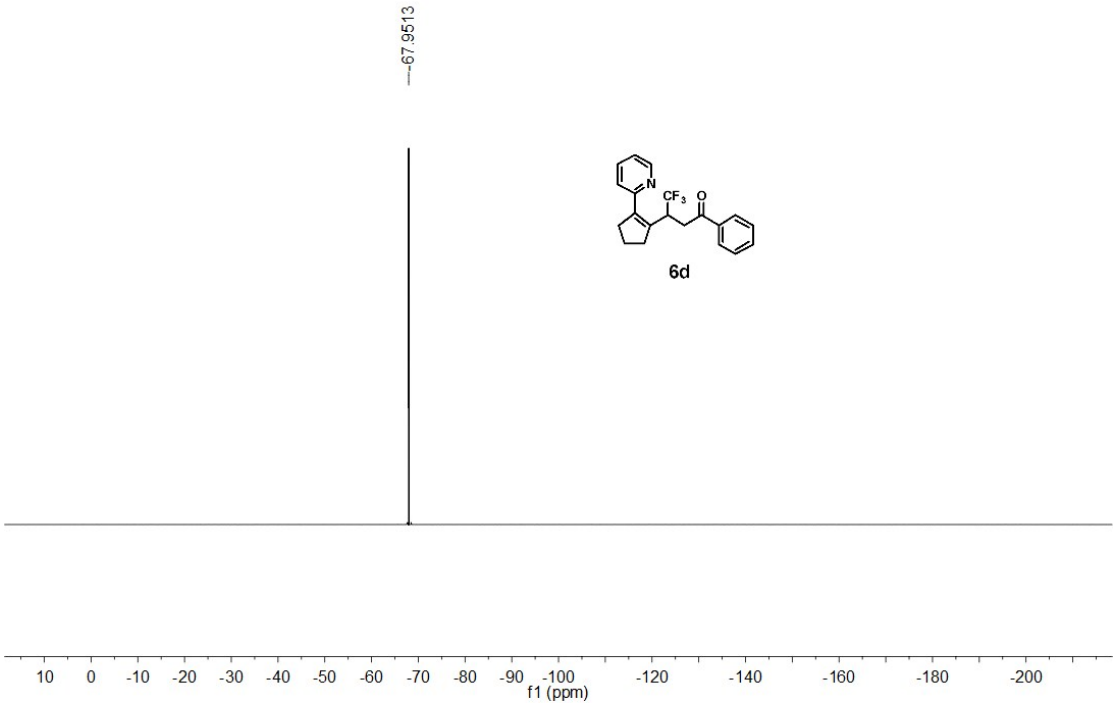


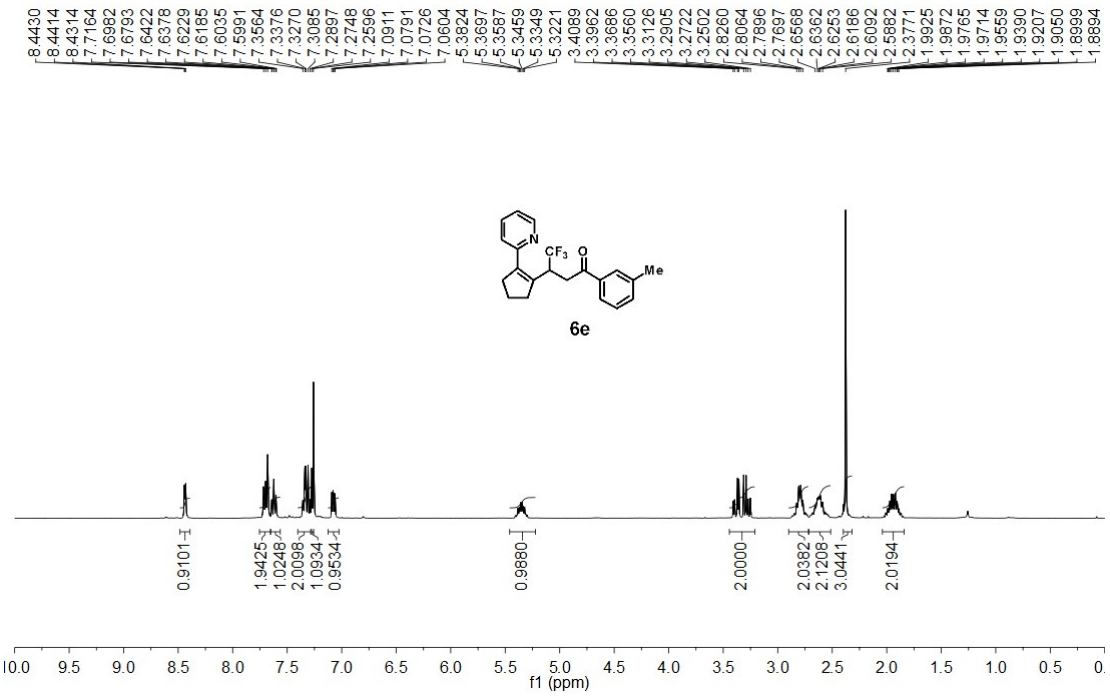
^{13}C NMR in $CDCl_3$



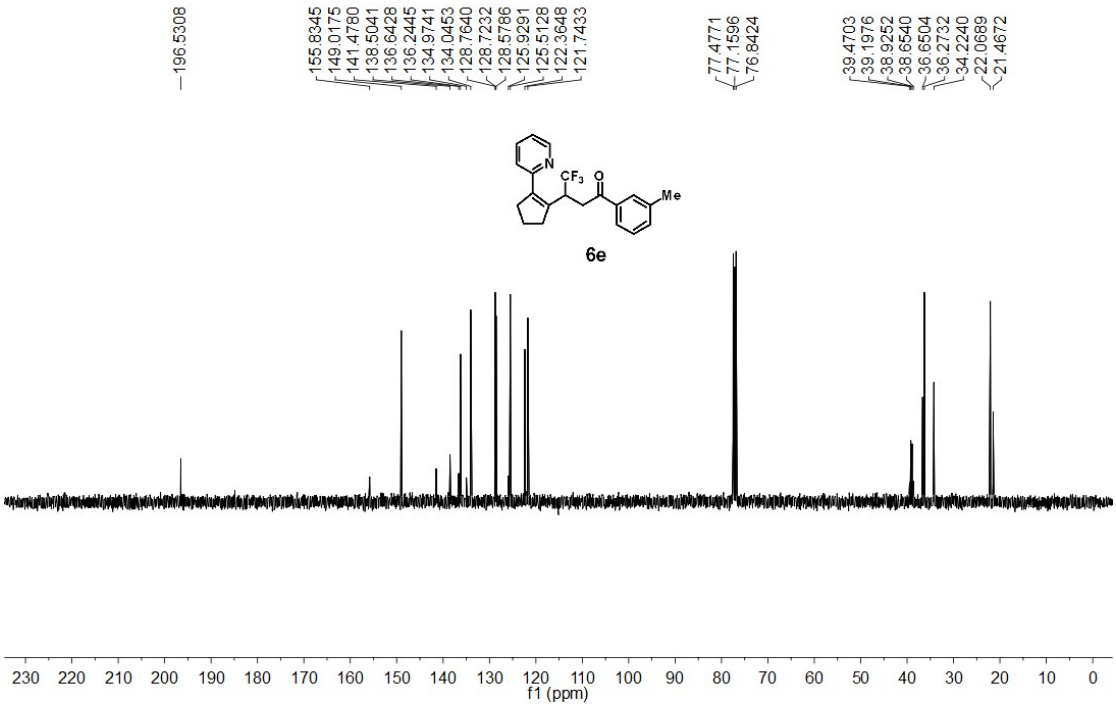
^{19}F NMR in $CDCl_3$



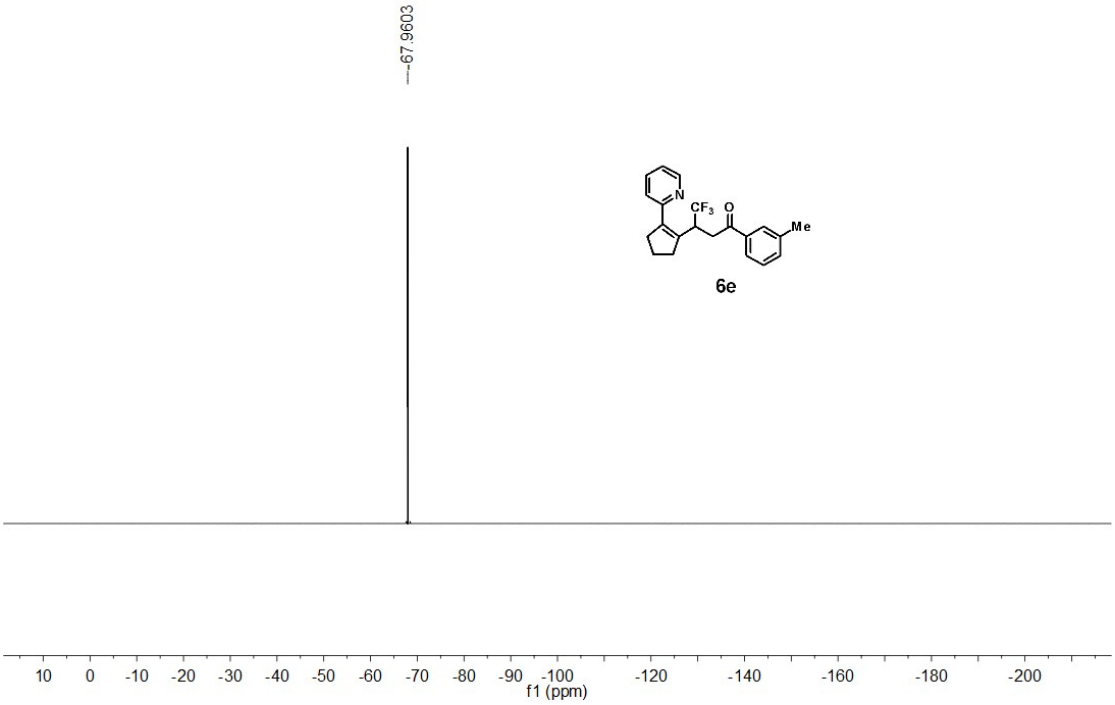
^{1}H NMR in $CDCl_3$



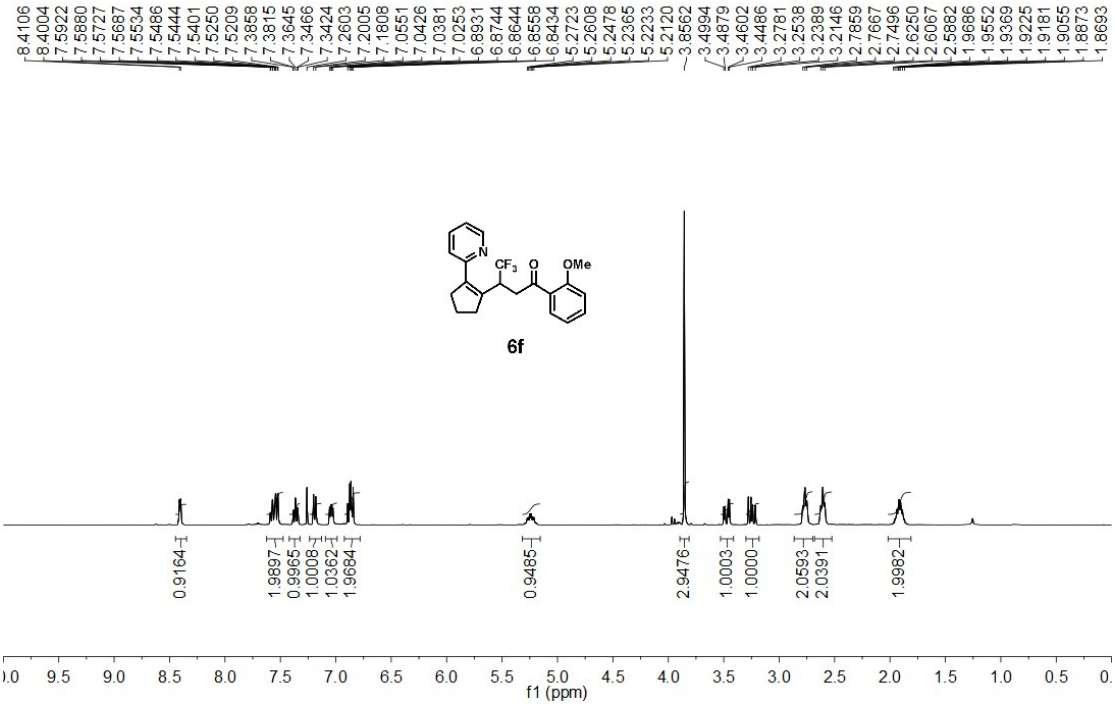
^{13}C NMR in $CDCl_3$



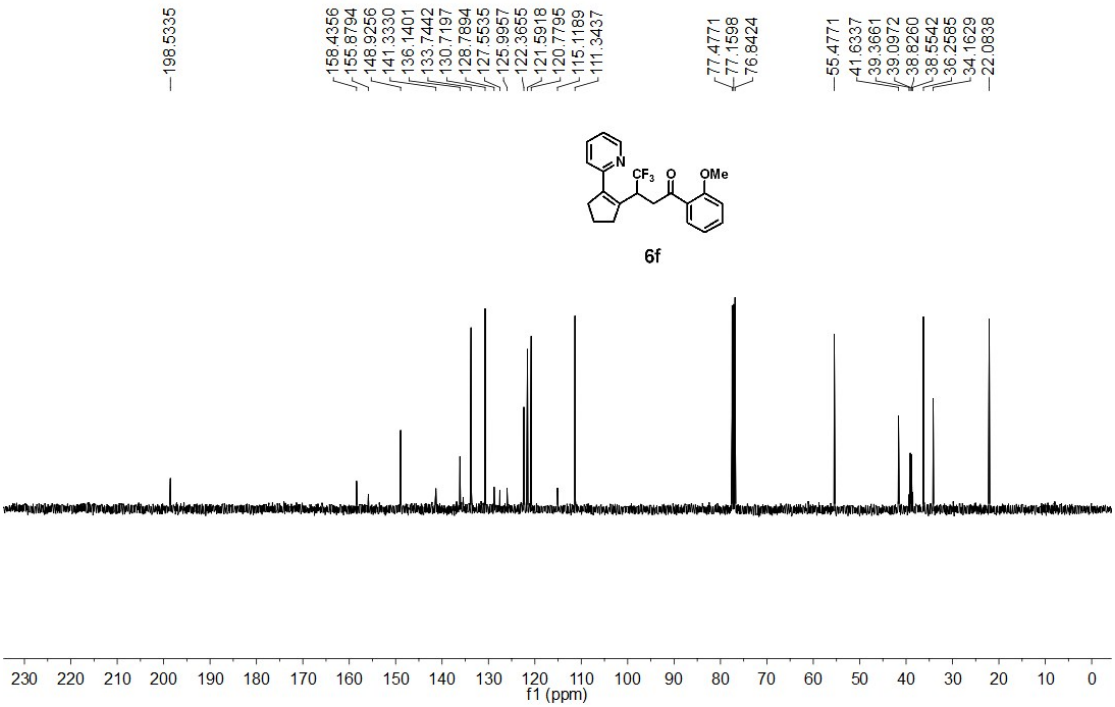
^{19}F NMR in $CDCl_3$



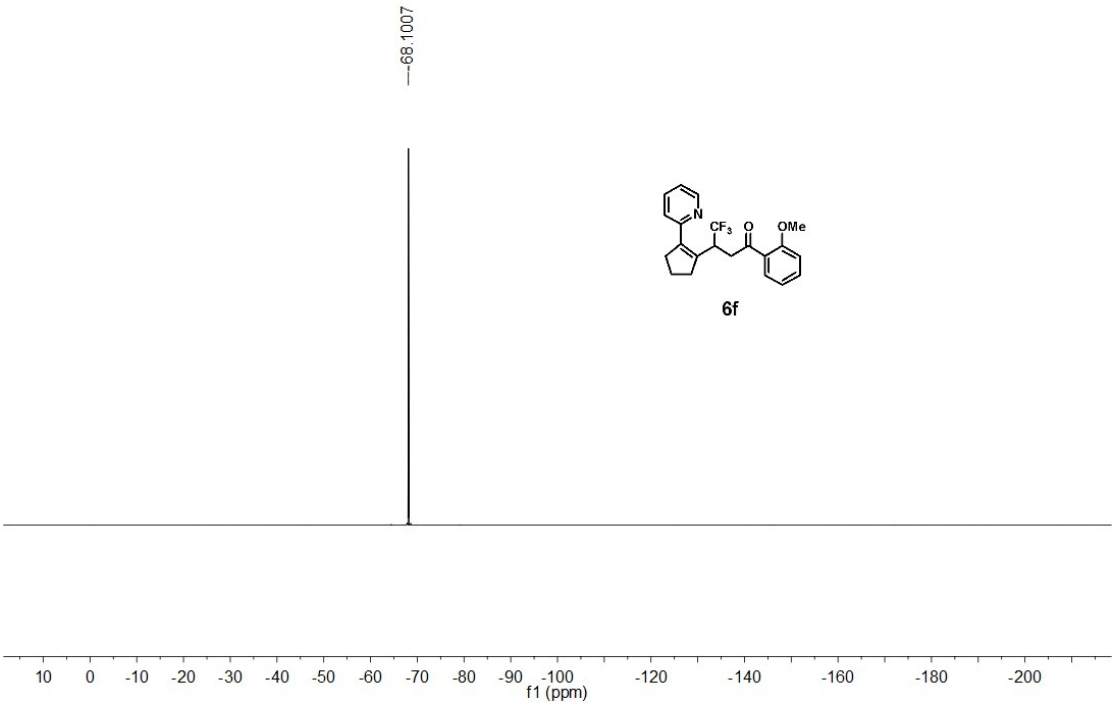
^{1}H NMR in $CDCl_3$



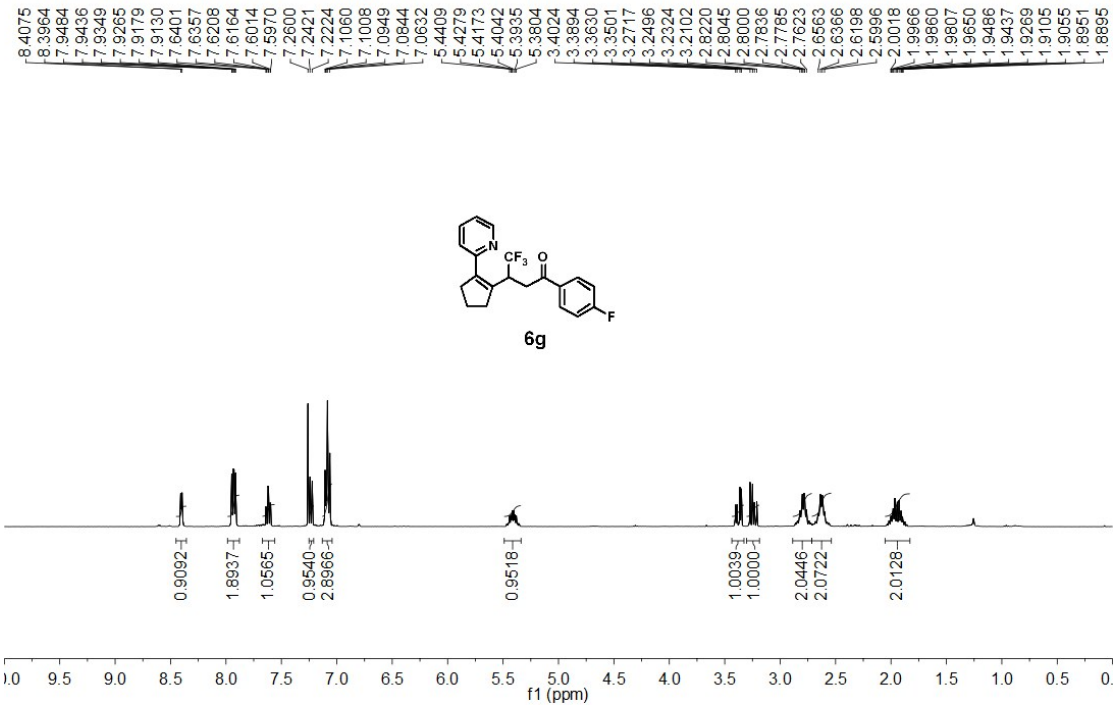
^{13}C NMR in $CDCl_3$



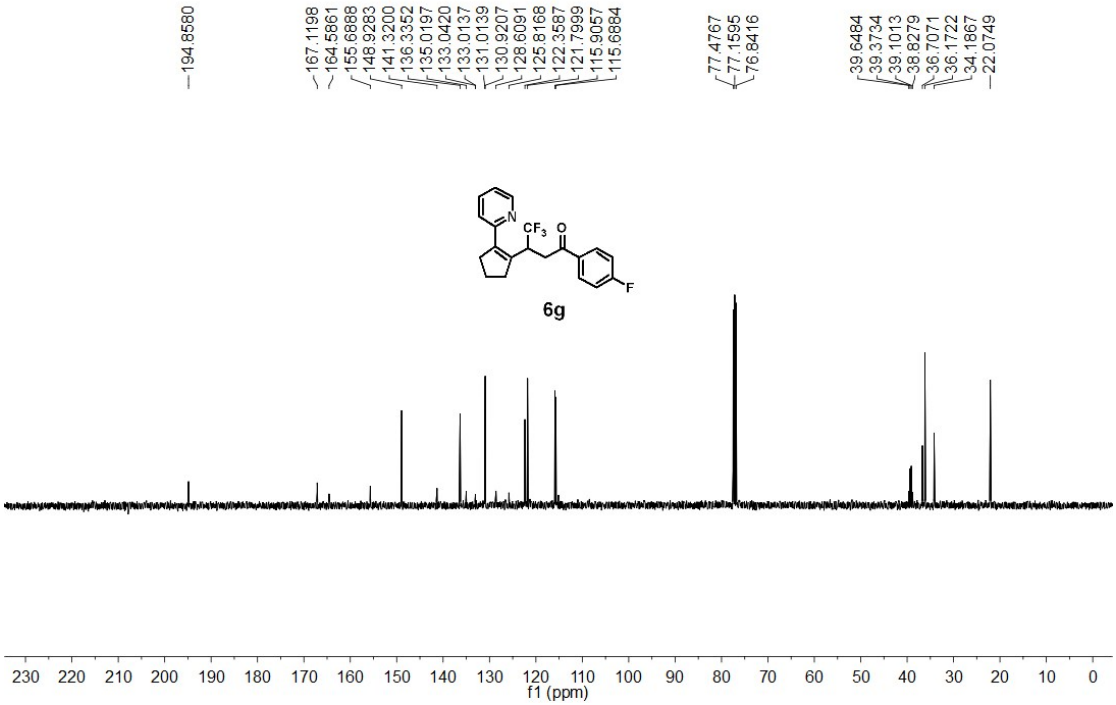
^{19}F NMR in $CDCl_3$



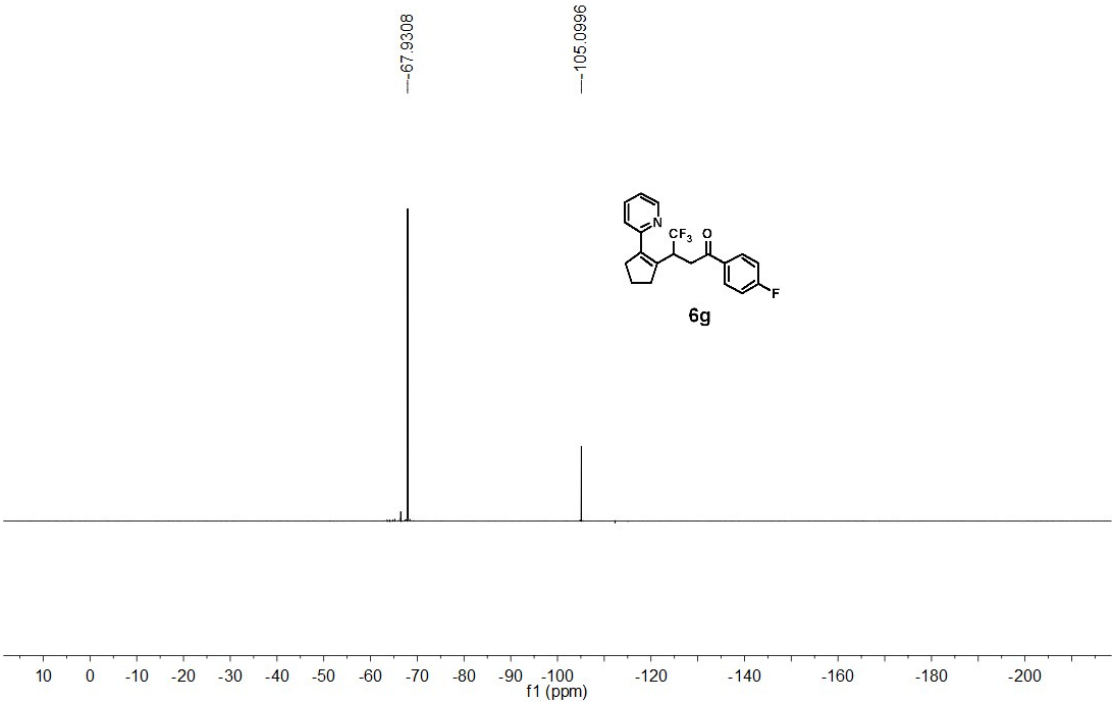
^{1}H NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



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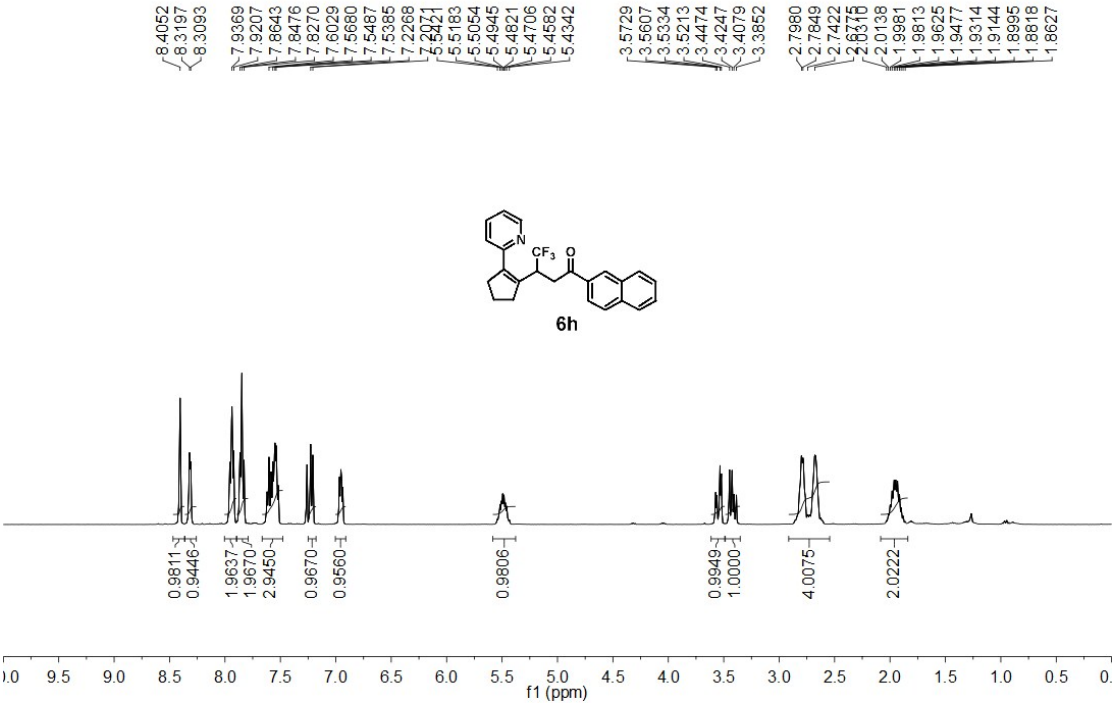
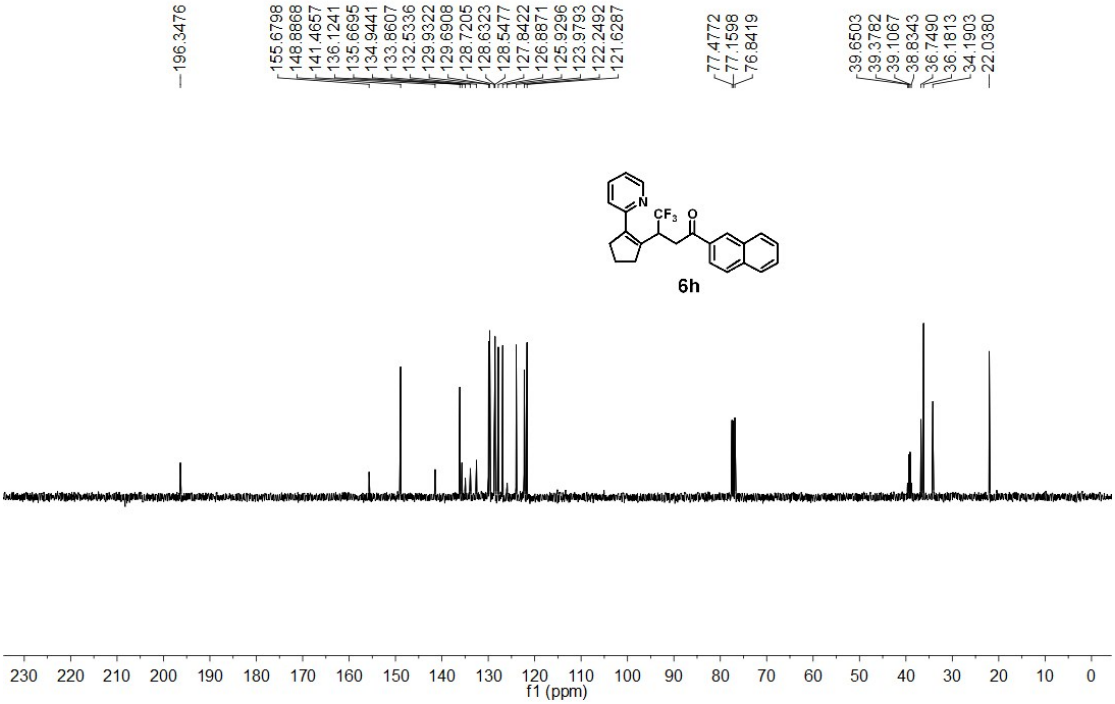
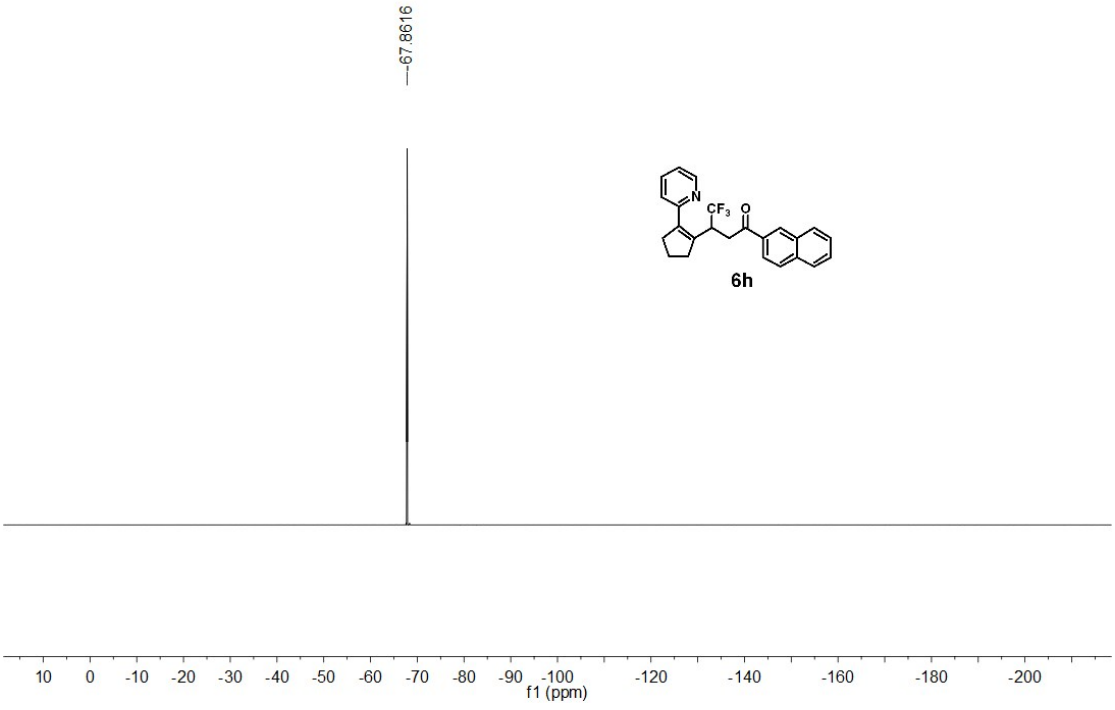


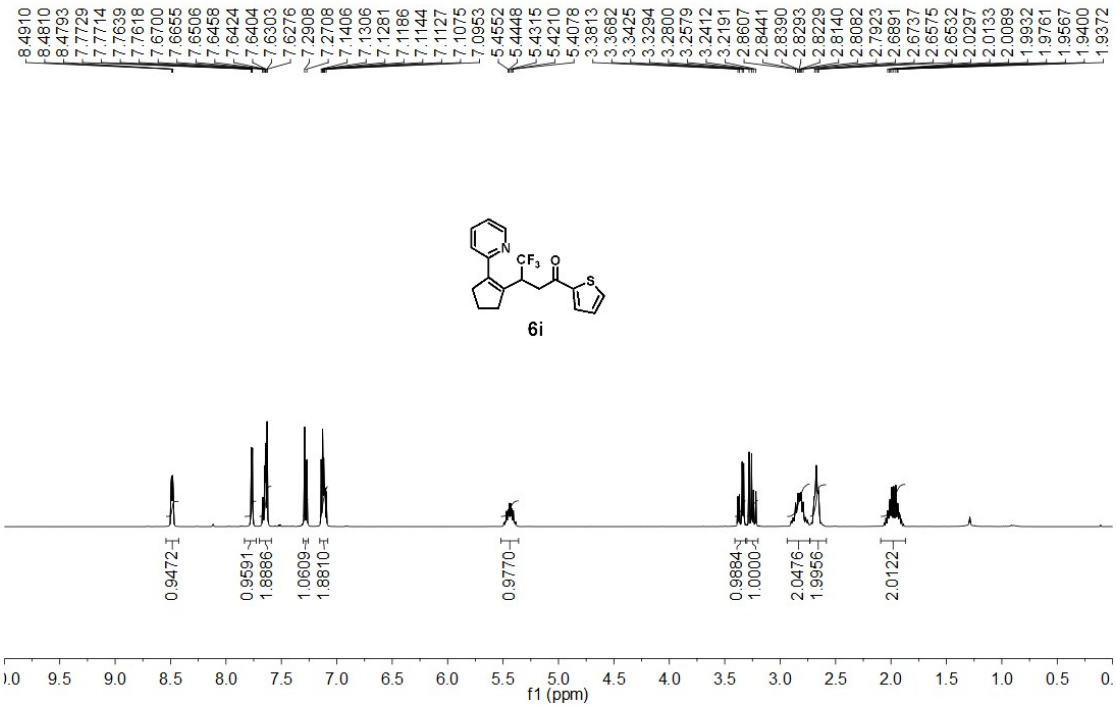
^{13}C NMR in $CDCl_3$



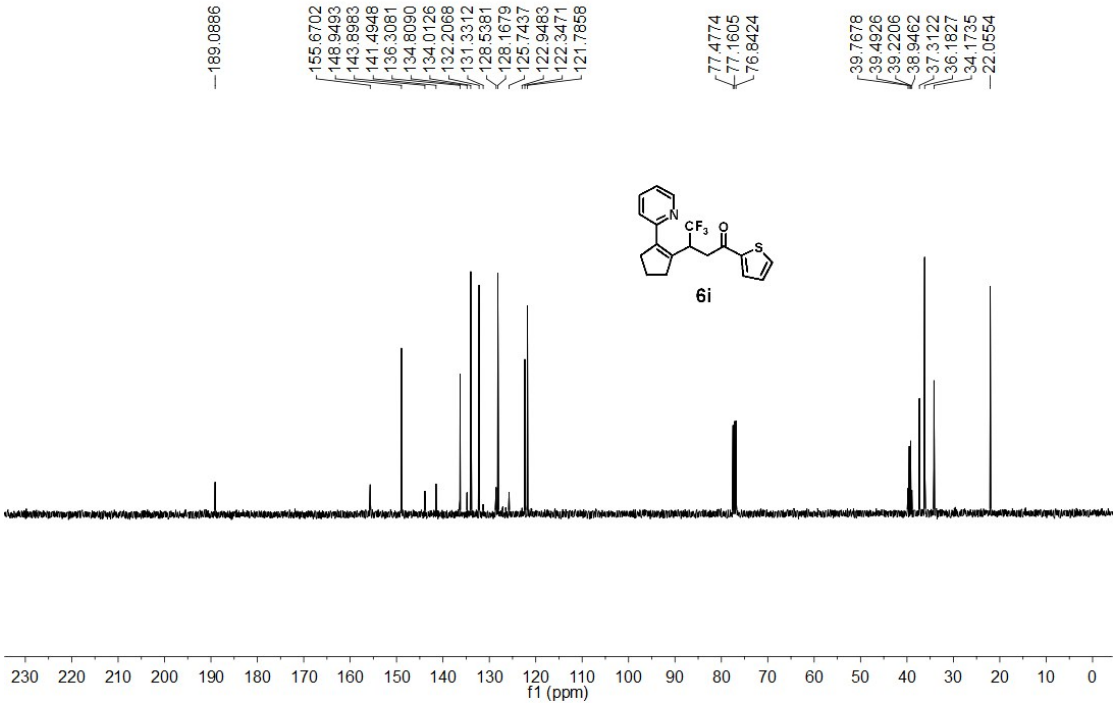
^{19}F NMR in $CDCl_3$



^{1}H NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$