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Supporting Information

Deoxyfluorination of (Hetero)aryl Aldehydes Using Tetramethylammonium Fluoride and Perfluorobutanesulfonyl Fluoride or Trifluoromethanesulfonic Anhydride

Devin M. Ferguson, Patrick R. Melvin, and Melanie S. Sanford*

Supporting Information for:

Deoxyfluorination of (Hetero)aryl Aldehydes Using Tetramethylammonium Fluoride and Perfluorobutanesulfonyl Fluoride or Trifluoromethanesulfonic Anhydride

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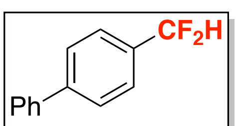
1. General Information

NMR spectra were obtained on a Varian MR400 (400.52 MHz for ^{1}H, 376.87 MHz for ^{19}F), Varian VNMRS 500 (470.47 MHz for ^{19}F), Varian Inova 500 (499.91 MHz for ^{1}H), or a Varian VNMRS 700 (699.75 MHz for ^{1}H, 175.97 MHz for ^{13}C) spectrometer. ^{1}H and ^{13}C NMR chemical shifts are reported in parts per million (ppm) relative to tetramethylsilane (TMS), with the residual NMR solvent peak used as an internal reference. ^{19}F NMR chemical shifts are reported in ppm and are referenced to the solvent lock. Abbreviations used to report the NMR data: app, apparent; s, singlet; d, doublet; t, triplet; dd, doublet of doublets; ddd, doublet of doublets of doublets; m, multiplet. ^{19}F NMR yields were obtained on a Varian MR400 spectrometer (376.87 MHz for ^{19}F) using (trifluoromethoxy)benzene (–58.3 ppm) as an internal standard with a relaxation delay of 5 s. High-resolution mass spectra were recorded on a Micromass AutoSpec Ultima Magnetic Sector mass spectrometer. Melting points were obtained using a Thomas Hoover Capillary Melting Point Apparatus and are uncorrected.

2. Materials and Methods

All commercial reagents were used as received unless stated otherwise. Black open-top caps (thread size: 13-425) and Teflon/silicone septa (for 13-425 open top caps) were purchased from Thermo Scientific. The solvents Et_2O (Alfa Aesar), DCM (Fisher Scientific) and THF (Alfa Aesar) used in the glovebox were deaerated by sparging with N_2 and were dried using an Innovative Technology, Inc. (now rebranded to Inert) solvent purification system. EtOAc used in the glovebox was purchased from Fisher Scientific and distilled from CaH_2. 5-bromo-2-pyridinecarboxaldehyde and 4-isoquinolinecarboxaldehyde were purchased from Alfa Aesar. 3-methoxy-pyridine-2-carbaldehyde was purchased from TCI America. Dibenzofuran-4-carboxaldehyde was purchased from Chem-Impex International, Inc. 4-cyanobenzaldehyde, *N*-methyl-2-pyrrolidone (NMP, extra dry over molecular sieves in an AcroSeal™ bottle), DMSO (anhydrous in an AcroSeal™ bottle, stored over activated 3Å molecular sieves) were purchased from Acros Organics. 1-naphthaldehyde was purchased from AK Scientific, Inc. 2-phenylbenzaldehyde was purchased from Ark Pharm. Perfluorobutanesulfonyl fluoride (stored in a nitrogen-filled glovebox), trifluoromethanesulfonic anhydride (stored in the freezer of a nitrogen-filled glovebox at –35 °C), and 4-phenylbenzaldehyde were purchased from Oakwood Chemical. Tetramethylammonium fluoride (anhydrous, 97%, stored in a nitrogen-filled glovebox), 4-bromobenzaldehyde, 4-nitrobenzaldehyde, 4-(2-pyridyl)benzaldehyde, 4-quinolinecarboxaldehyde (recrystallized from EtOAc/hexanes), and anhydrous *N,N*-DMF in a Sure/Seal™ bottle were purchased from Aldrich. $CDCl_3$ was purchased from Cambridge Isotope Laboratories, Inc. All glassware used in the glovebox was dried in an oven at 150 °C for at least 3 h and cooled under an inert atmosphere. DCM (Fisher Scientific), Et_2O (EMD Millipore), and pentane (Fisher Scientific) used on the bench top were used as received. Silica (SiliaFlash F60) used on the bench top was purchased from SiliCycle, Inc. and used as received.

3. Characterization of Products Isolated from (Hetero)aryl Aldehydes using PBSF



1

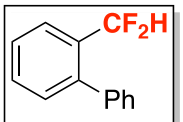
This reaction was performed with 4-phenylbenzaldehyde according to the general procedure using PBSF. Product **1** was obtained as a white solid (15 mg, 37% yield, R_f = 0.26 in 100% pentane, mp = 76-77 °C). The NMR spectra are consistent with those reported in the literature.[1]

^{1}H NMR (499.91 MHz, $CDCl_3$): δ 7.68 (app d, *J* = 8.0 Hz, 2H), 7.61-7.58 (m, 4H), 7.48-7.45 (m, 2H), 7.41-7.37 (m, 1H), 6.70 (t, *J* = 56.4 Hz, 1H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –110.42 (d, *J* = 56.4 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 143.85 (t, *J* = 2.0 Hz), 140.33, 133.35 (t, *J* = 22.4 Hz), 129.06, 128.04, 127.58, 127.39, 126.17 (t, *J* = 6.0 Hz), 114.88 (t, *J* = 238.5 Hz).

HRMS calcd. for $C_{13}H_{10}F_2$: 204.0751; Found: 204.0755



2

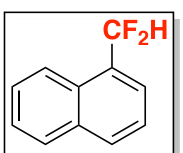
This reaction was performed with 2-phenylbenzaldehyde according to the general procedure using PBSF. Product **2** was obtained as a colorless oil (20 mg, 49% yield, R_f = 0.39 in 100% pentane). The NMR spectra are consistent with those reported in the literature.[2]

^{1}H NMR (499.91 MHz, $CDCl_3$): δ 7.80 (app d, *J* = 7.3 Hz, 1H), 7.54-7.35 (multiple peaks, 8H), 6.54 (t, *J* = 55.0 Hz, 1H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –107.44 (d, *J* = 55.0 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 141.53 (t, *J* = 6.6 Hz), 138.80, 131.89 (t, *J* = 22.1 Hz), 130.59 (t, *J* = 2.0 Hz), 130.35, 129.59, 128.55, 128.01, 127.99, 125.74 (t, *J* = 5.2 Hz), 113.27 (t, *J* = 236.0).

HRMS calcd. for $C_{13}H_{10}F_2$: 204.0751; Found: 204.0758



3

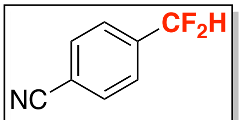
This reaction was performed with 1-naphthaldehyde according to the general procedure using PBSF. 1-naphthaldehyde is an oil and the order of addition of reagents changed to accommodate this: 1-naphthaldehyde was added to the vial first, followed by THF, TMAF, and finally PBSF. Product **3** was obtained as a colorless oil (13 mg, 37% yield, R_f = 0.31 in 100% pentane). The NMR spectra are consistent with those reported in the literature.[1]

^1H NMR (499.91 MHz, $CDCl_3$): δ 8.18 (d, J = 8.3 Hz, 1H), 7.97 (d, J = 8.3 Hz, 1 H), 7.92 (app d, J = 8.0 Hz, 1H), 7.70 (app d, J = 7.0 Hz, 1H), 7.62-7.50 (multiple peaks, 3H), 7.14 (t, J = 55.2 Hz, 1H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –110.95 (d, J = 55.2 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 133.93, 131.64 (t, J = 1.7 Hz), 129.88 (t, J = 2.6 Hz), 129.71 (t, J = 20.8 Hz), 128.92, 127.31, 126.52, 124.94 (t, J = 8.7 Hz), 124.82, 123.71 (t, J = 1.3 Hz), 115.55 (t, J = 238.4 Hz).

HRMS calcd. for $C_{11}H_8F_2$: 178.0594; Found: 178.0596



5

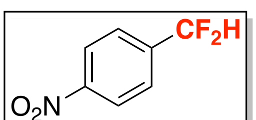
This reaction was performed with 4-cyanobenzaldehyde according to the general procedure using PBSF. Product **5** was obtained as a colorless oil (26 mg, 85% yield, R_f = 0.54 in 20% Et_2O / 80% pentane). The NMR spectra are consistent with those reported in the literature.[1]

^1H NMR (499.91 MHz, $CDCl_3$): δ 7.77 (d, J = 8.0 Hz, 2H), 7.64 (d, J = 8.0 Hz, 2H), 6.69 (t, J = 55.8 Hz, 1H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –113.19 (d, J = 55.8 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 138.71 (t, J = 22.8 Hz), 132.74, 126.55 (t, J = 6.1 Hz), 118.02, 114.97 (t, J = 2.1 Hz), 113.45 (t, J = 240.7).

HRMS calcd. for $C_8H_5F_2N$: 153.0390; Found: 153.0394



6

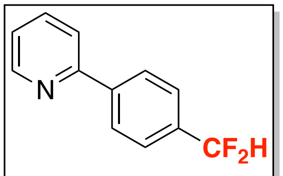
This reaction was performed with 4-nitrobenzaldehyde according to the general procedure using PBSF. Product **6** was obtained as a yellow oil and was pure after filtration through a silica plug using Et_2O (33 mg, 95% yield). The yield reported is an average of two independent runs (95% and 83%). The NMR spectra are consistent with those reported in the literature.[1]

^1H NMR (499.91 MHz, $CDCl_3$): δ 8.33 (d, J = 8.2 Hz, 2H), 7.72 (d, J = 8.2 Hz, 2H), 6.74 (t, J = 55.8 Hz, 1H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –113.00 (d, *J* = 55.8 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 149.55, 140.34 (t, *J* = 22.9 Hz), 126.99 (t, *J* = 6.0 Hz), 124.15, 113.31 (t, *J* = 241.1 Hz).

HRMS calcd. for $C_7H_5F_2NO_2$: 173.0288; Found: 173.0290



7

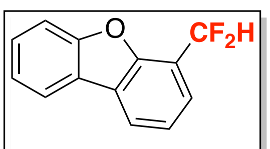
This reaction was performed with 4-(2-pyridyl)benzaldehyde according to the general procedure using PBSF. Product **7** was obtained as a white solid (21 mg, 51% yield, R_f = 0.48 in 30% Et_2O / 70% pentane, mp = 39-40 °C). The NMR spectra are consistent with those reported in the literature.[3]

^{1}H NMR (499.91 MHz, $CDCl_3$): δ 8.73-8.72 (m, 1H), 8.09 (d, *J* = 8.1 Hz, 2H), 7.81-7.75 (multiple peaks, 2H), 7.62 (d, *J* = 8.1 Hz, 2H), 7.28 (app ddd, *J* = 6.7, 4.8, 1.5 Hz, 1H), 6.71 (t, *J* = 56.5 Hz, 1H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –110.96 (d, *J* = 56.5 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 156.51, 150.01, 141.86 (t, *J* = 1.9 Hz), 137.04, 134.88 (t, *J* = 22.3 Hz), 127.34, 126.14 (t, *J* = 6.1 Hz), 122.83, 120.92, 114.76 (t, *J* = 238.7 Hz).

HRMS calcd. for $C_{12}H_9F_2N$ [M+H]+: 206.0776; Found: 206.0783



8

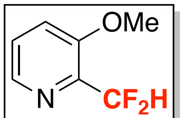
This reaction was performed with dibenzofuran-4-carboxaldehyde according to the general procedure using PBSF. Product **8** was obtained as a colorless oil (32 mg, 73% yield, R_f = 0.28 in 100% pentane). The yield reported is an average of two independent runs (73% and 52%). The NMR spectra are consistent with those reported in the literature.[4]

^{1}H NMR (499.91 MHz, $CDCl_3$): δ 8.06 (d, *J* = 7.7 Hz, 1H), 7.98 (d, *J* = 7.7 Hz, 1H), 7.67 (app d, *J* = 7.6 Hz, 1H), 7.63 (app d, *J* = 8.3 Hz, 1H), 7.53-7.49 (m, 1H), 7.44-7.37 (multiple peaks, 2H), 7.22 (t, *J* = 55.1 Hz, 1H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –113.12 (d, *J* = 55.1 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 156.49, 153.19 (t, *J* = 5.1 Hz), 127.97, 125.32, 123.87 (t, *J* = 5.8 Hz), 123.53, 123.40, 123.24 (t, *J* = 1.5 Hz), 122.88, 120.93, 118.64 (t, *J* = 23.8 Hz), 112.10, 112.02 (t, *J* = 237.4 Hz).

HRMS calcd. for $C_{13}H_8F_2O$: 218.0543; Found: 218.0544



9

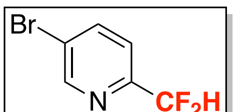
This reaction was performed with 3-methoxy-pyridine-2-carbaldehyde according to the general procedure using PBSF. Product **9** was obtained as a colorless oil (27 mg, 85% yield, R_f = 0.31 in 40% Et_2O / 60% pentane).[5]

^{1}H NMR (499.91 MHz, $CDCl_3$): δ 8.28 (app d, *J* = 4.4 Hz, 1H), 7.40-7.39 (m, 1H), 7.31 (app d, *J* = 8.4 Hz, 1H), 6.90 (t, *J* = 54.2 Hz, 1H), 3.91 (s, 3H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –119.51 (d, *J* = 54.2 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 154.37 (t, *J* = 2.5 Hz), 141.28, 141.11 (t, *J* = 22.7 Hz), 126.53 (t, *J* = 1.7 Hz), 119.15, 111.66 (t, *J* = 238.7 Hz), 55.87.

HRMS calcd. for $C_7H_7F_2NO$ [M+H]+: 160.0568; Found: 160.0570



10

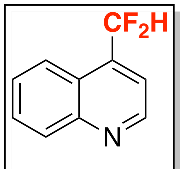
This reaction was performed with 5-bromo-2-pyridinecarboxaldehyde according to the general procedure using PBSF. Product **10** was obtained as a white solid (30 mg, 72% yield, R_f = 0.32 in 2% Et_2O / 98% pentane, mp = 40-41 °C). The yield reported is an average of two independent runs (72% and 68%). The NMR spectra are consistent with those reported in the literature.[6]

^{1}H NMR (499.91 MHz, $CDCl_3$): δ 8.72 (d, *J* = 2.0 Hz, 1H), 7.98 (dd, *J* = 8.3, 2.0 Hz, 1H), 7.55 (d, *J* = 8.3 Hz, 1H), 6.61 (t, *J* = 55.3 Hz, 1H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –115.68 (d, *J* = 55.3 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 151.46 (t, *J* = 26.4 Hz), 150.90, 140.10, 122.97 (t, *J* = 2.0 Hz), 121.57 (t, *J* = 2.7 Hz), 113.62 (t, *J* = 240.8).

HRMS calcd. for $C_6H_4BrF_2N$ [M+H]+: 207.9568; Found: 207.9565



11

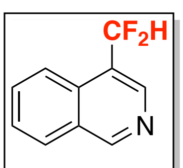
This reaction was performed with 4-quinolinecarboxaldehyde according to the general procedure using PBSF. Product **11** was obtained as a white solid and was pure after filtration through a silica plug using Et_2O (34 mg, 95% yield, mp = 55-56 °C). The yield reported is an average of two independent runs (95% and 84%). The NMR spectra are consistent with those reported in the literature.[5]

^{1}H NMR (499.91 MHz, $CDCl_3$): δ 9.03 (d, *J* = 4.3 Hz, 1H), 8.21 (d, *J* = 8.5 Hz, 1H), 8.10 (d, *J* = 8.5 Hz, 1H), 7.82-7.79 (m, 1H), 7.69-7.65 (m, 1H), 7.60 (d, *J* = 4.3 Hz, 1H), 7.17 (t, *J* = 54.6 Hz, 1H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –115.13 (d, *J* = 54.6 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 150.14, 148.79, 137.96 (t, *J* = 21.7 Hz), 130.60, 130.08, 127.97, 124.30 (t, *J* = 3.1 Hz), 123.45-123.43 (m), 118.09 (t, *J* = 7.7 Hz), 113.44 (t, *J* = 240.4 Hz).

HRMS calcd. for $C_{10}H_7F_2N$ [M+H]+: 180.0619; Found: 180.0623



12

This reaction was performed with 4-isoquinolinecarboxaldehyde according to the general procedure using PBSF. Product **12** was obtained as a colorless oil (28 mg, 78% yield, R_f = 0.33 in 50% Et_2O / 50% pentane). The NMR spectra are consistent with those reported in the literature.[5]

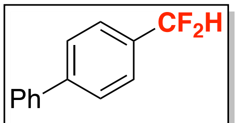
^{1}H NMR (499.91 MHz, $CDCl_3$): δ 9.35 (s, 1H), 8.69 (s, 1H), 8.20 (app d, *J* = 8.5 Hz, 1H), 8.06 (app d, *J* = 8.2 Hz, 1H), 7.84-7.81 (m, 1H), 7.71 (app t, *J* = 7.6 Hz, 1H), 7.07 (t, *J* = 54.4 Hz, 1H).

^{19}F NMR (470.47 MHz, $CDCl_3$): δ –110.95 (d, J = 54.4 Hz, 2F).

^{13}C NMR (175.97 MHz, $CDCl_3$): δ 156.21-156.19 (m), 141.88 (t, J = 9.4 Hz), 132.33 (t, J = 1.6 Hz), 131.80, 128.58, 128.07, 123.41 (t, J = 21.6 Hz), 123.32 (t, J = 1.7 Hz), 115.22 (t, J = 238.5 Hz).

HRMS calcd. for $C_{10}H_7F_2N$ [M+H]+: 180.0619; Found: 180.0621

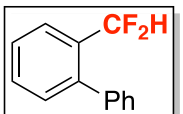
4. Characterization of Products Isolated from (Hetero)aryl Aldehydes using Tf_2O



1

This reaction was performed with 4-phenylbenzaldehyde according to the general procedure using Tf_2O. Product **1** was obtained as a white solid (23 mg, 56% yield, R_f = 0.26 in 100% pentane). The yield reported is an average of two independent runs (56% and 59%).

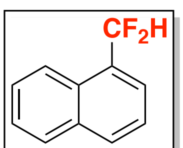
^1H and ^{19}F NMR spectral data were consistent with the spectral data obtained for **1** isolated from the general procedure using PBSF.



2

This reaction was performed with 2-phenylbenzaldehyde according to the general procedure using Tf_2O. Product **2** was obtained as a colorless oil (19 mg, 47% yield, R_f = 0.39 in 100% pentane).

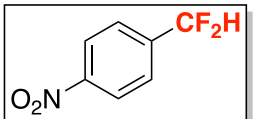
^1H and ^{19}F NMR spectral data were consistent with the spectral data obtained for **2** isolated from the general procedure using PBSF.



3

This reaction was performed with 1-naphthaldehyde according to the general procedure using Tf_2O. 1-naphthaldehyde is an oil and the order of addition of reagents changed to accommodate this: 1-naphthaldehyde was added to the vial first, followed by DCM, TMAF, and finally Tf_2O. Product **3** was obtained as a colorless oil (21 mg, 59% yield, R_f = 0.31 in 100% pentane). The yield reported is an average of two independent runs (59% and 72%).

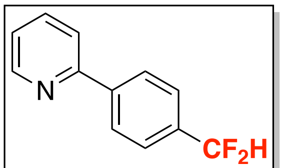
^1H and ^{19}F NMR spectral data were consistent with the spectral data obtained for **3** isolated from the general procedure using PBSF.



6

This reaction was performed with 4-nitrobenzaldehyde according to the general procedure using Tf_2O. Product **6** was obtained as a colorless oil (17 mg, 49% yield, R_f = 0.36 in 6% Et_2O / 94% pentane).

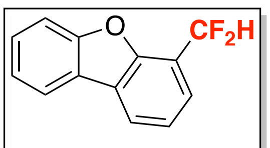
^1H and ^{19}F NMR spectral data were consistent with the spectral data obtained for **6** isolated from the general procedure using PBSF.



7

This reaction was performed with 4-(2-pyridyl)benzaldehyde according to the general procedure using Tf_2O. Product **7** was obtained as a white solid (26 mg, 63% yield, R_f = 0.48 in 30% Et_2O / 70% pentane).

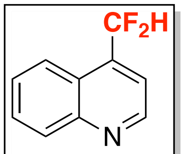
^1H and ^{19}F NMR spectral data were consistent with the spectral data obtained for **7** isolated from the general procedure using PBSF.



8

This reaction was performed with dibenzofuran-4-carboxaldehyde according to the general procedure using Tf_2O. Product **8** was obtained as a colorless oil (34 mg, 78% yield, R_f = 0.28 in 100% pentane). The yield reported is an average of two independent runs (78% and 50%).

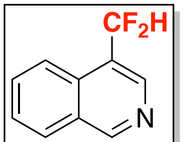
^{1}H and ^{19}F NMR spectral data were consistent with the spectral data obtained for **8** isolated from the general procedure using PBSF.



11

This reaction was performed with 4-quinolinecarboxaldehyde according to the general procedure using Tf_2O. Product **11** was obtained as an orange oil (14 mg, 39% yield R_f = 0.46 in 50% Et_2O / 50% pentane).

^{1}H and ^{19}F NMR spectral data were consistent with the spectral data obtained for **11** isolated from the general procedure using PBSF.



12

This reaction was performed with 4-isoquinolinecarboxaldehyde according to the general procedure using Tf_2O. Product **12** was obtained as a colorless oil (25 mg, 70% yield, R_f = 0.33 in 50% Et_2O / 50% pentane).

^{1}H and ^{19}F NMR spectral data were consistent with the spectral data obtained for **12** isolated from the general procedure using PBSF.

5. References

[1] Motohashi, H.; Mikami, K. *Org. Lett.* **2018**, *20*, 5340.
[2] Pan, F.; Boursalian, G. B.; Ritter, T. *Angew. Chem. Int. Ed.* **2018**, *57*, 16871.
[3] Miao, W.; Zhao, Y.; Ni, C.; Gao, B.; Zhang, W.; Hu, J. *J. Am. Chem. Soc.* **2018**, *140*, 880.
[4] Hori, K.; Motohashi, H.; Saito, D.; Mikami, K. *ACS Catal.* **2019**, *9*, 417.
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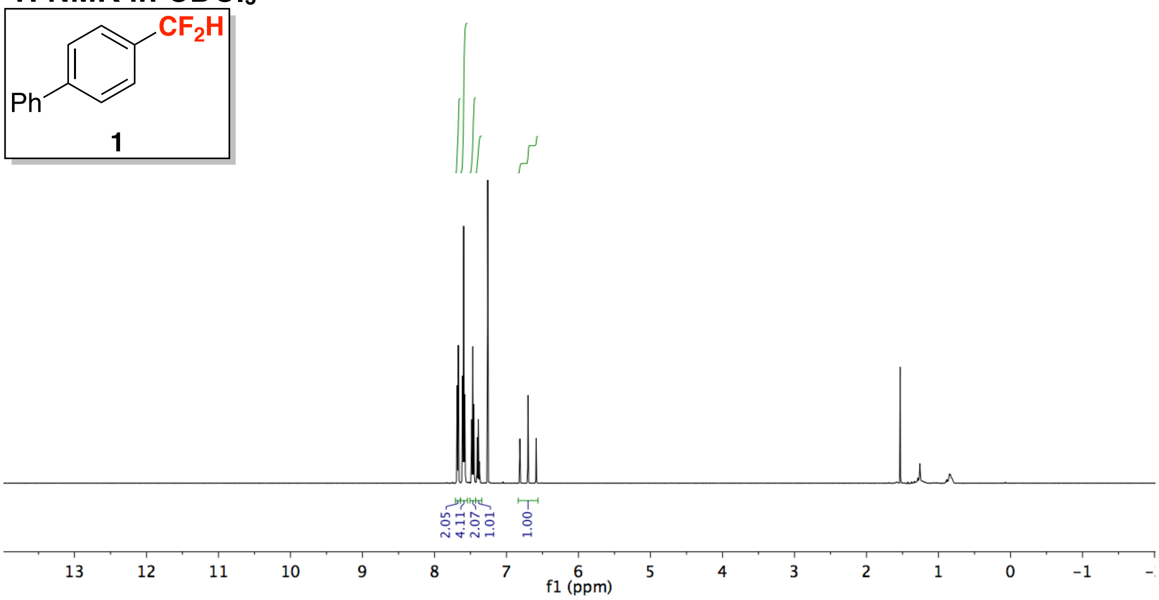
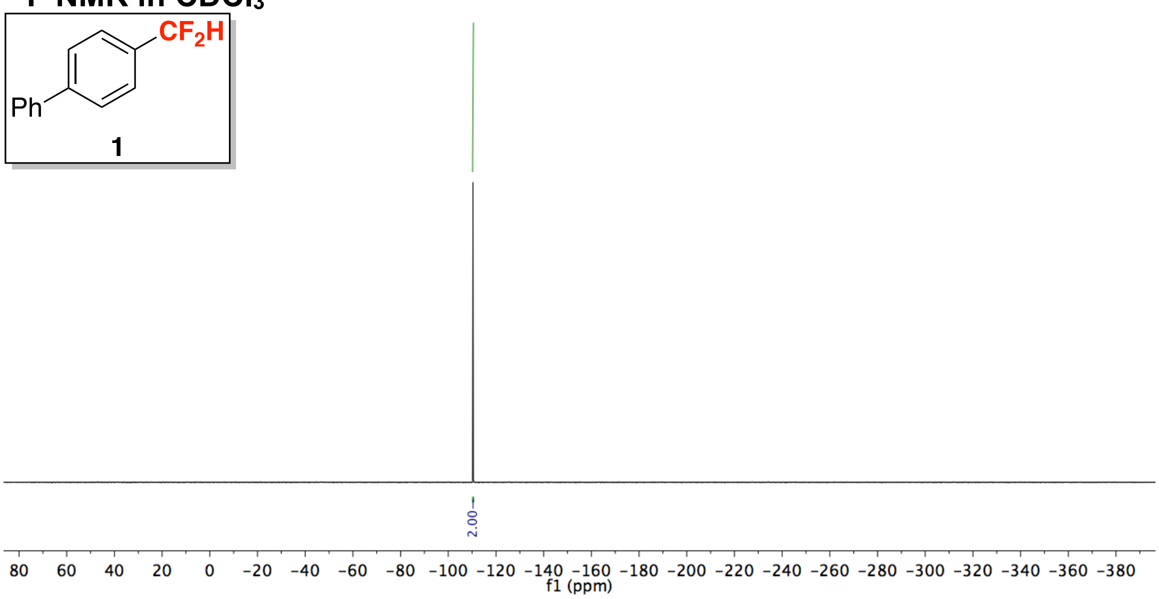
6. NMR Spectra

i. ***1 Synthesized Using PBSF***

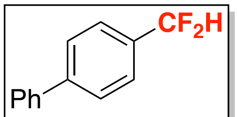
^{1}H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



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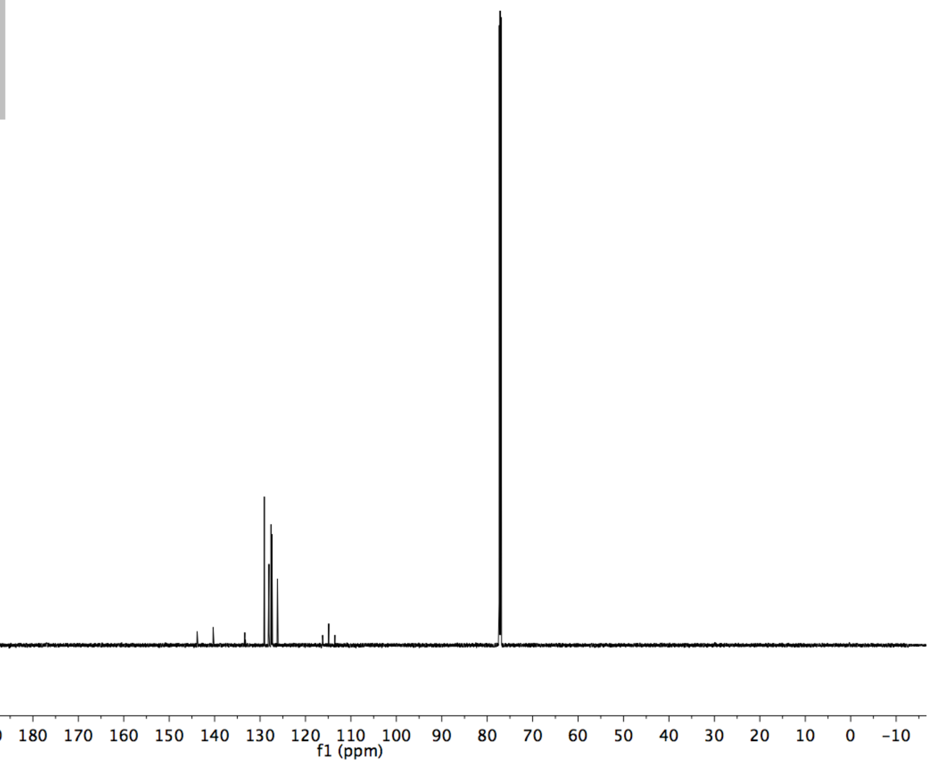
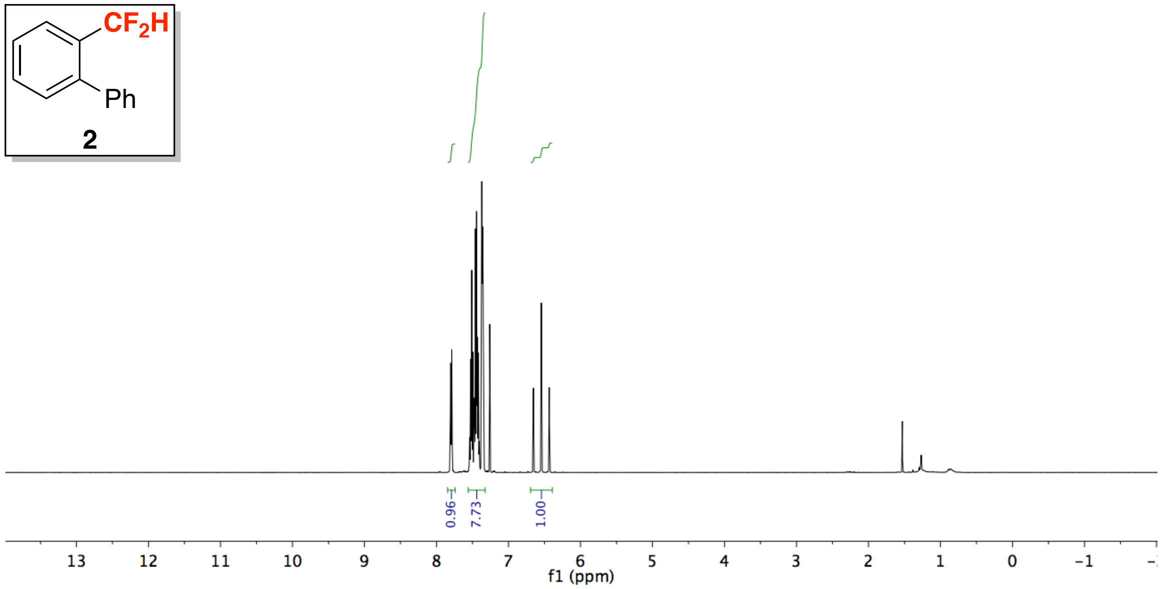
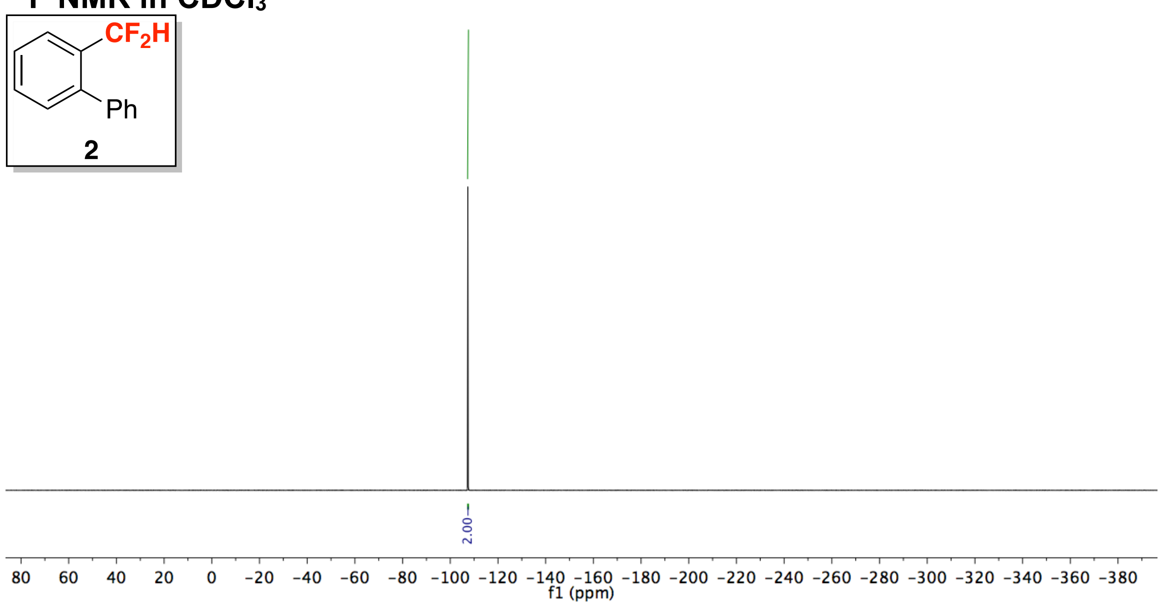


ii. ***2 Synthesized Using PBSF***

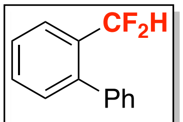
^{1}H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



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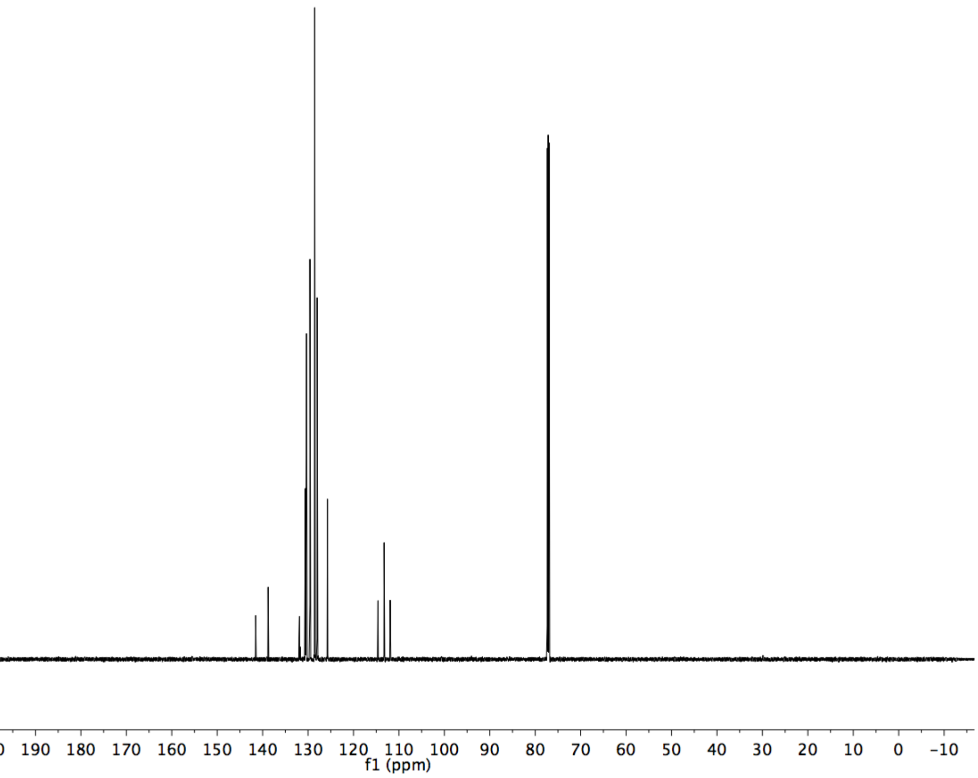
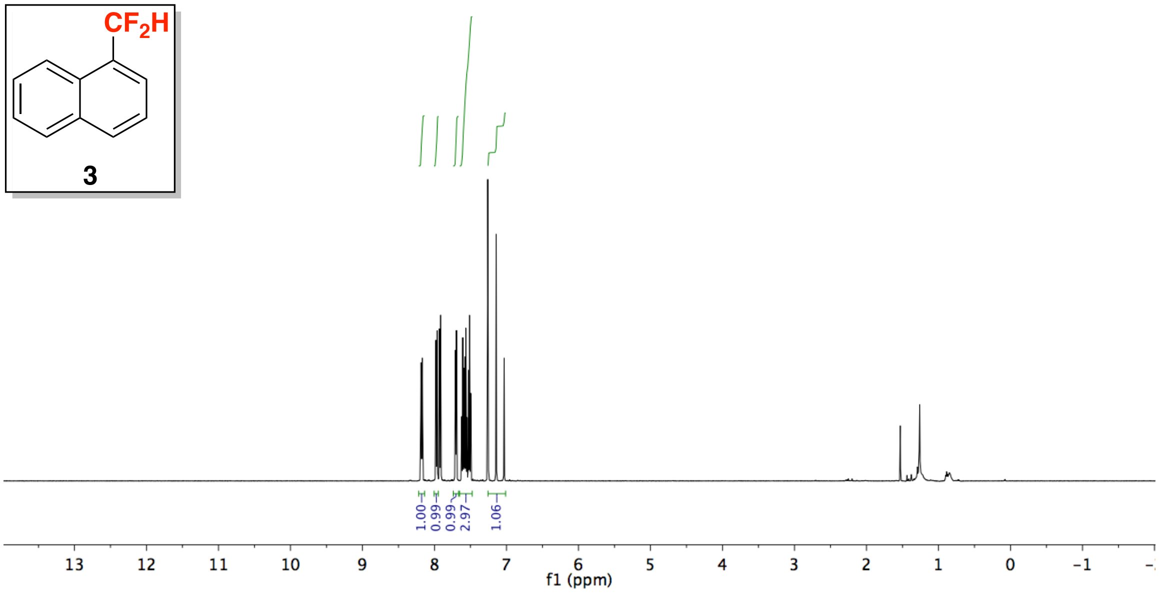
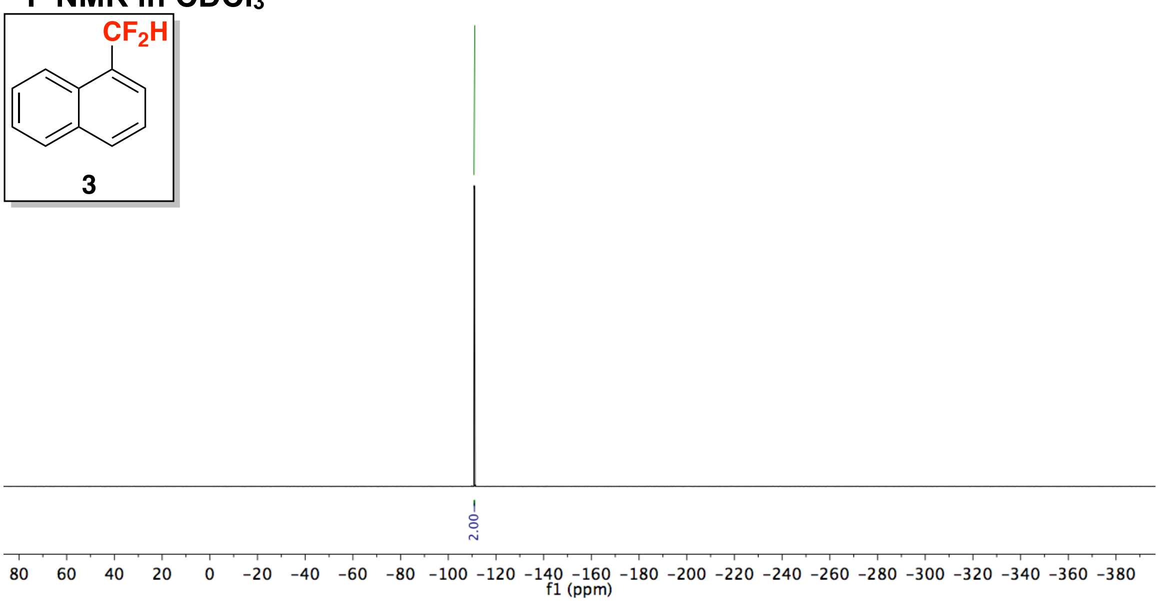


iii. ***3 Synthesized Using PBSF***

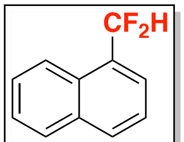
^{1}H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



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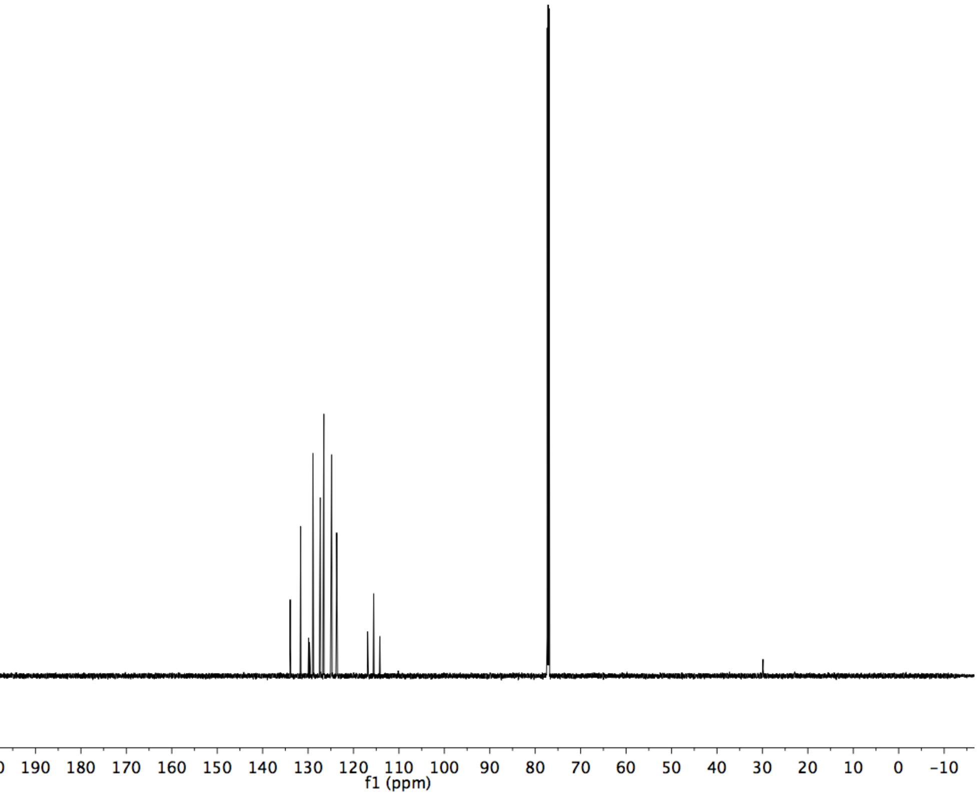
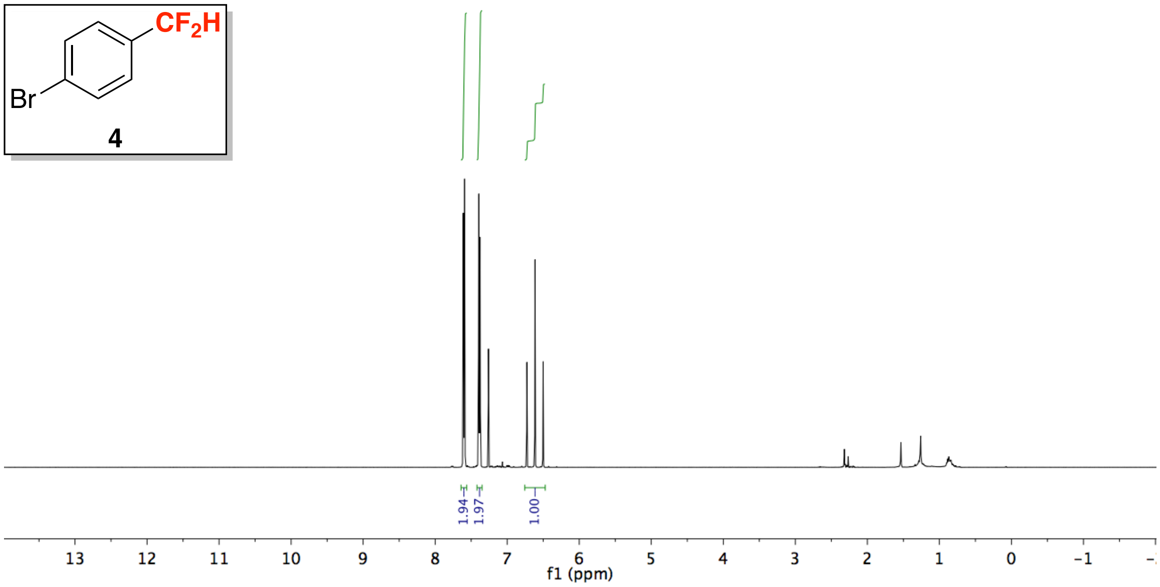
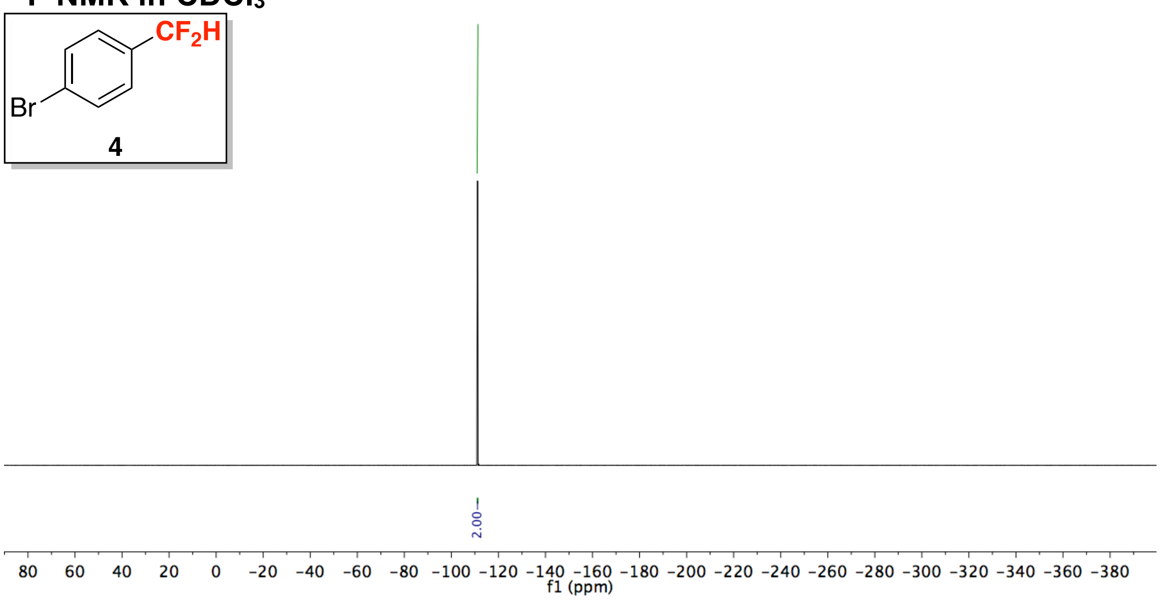


iv. ***4 Synthesized Using PBSF***

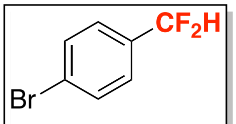
^{1}H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



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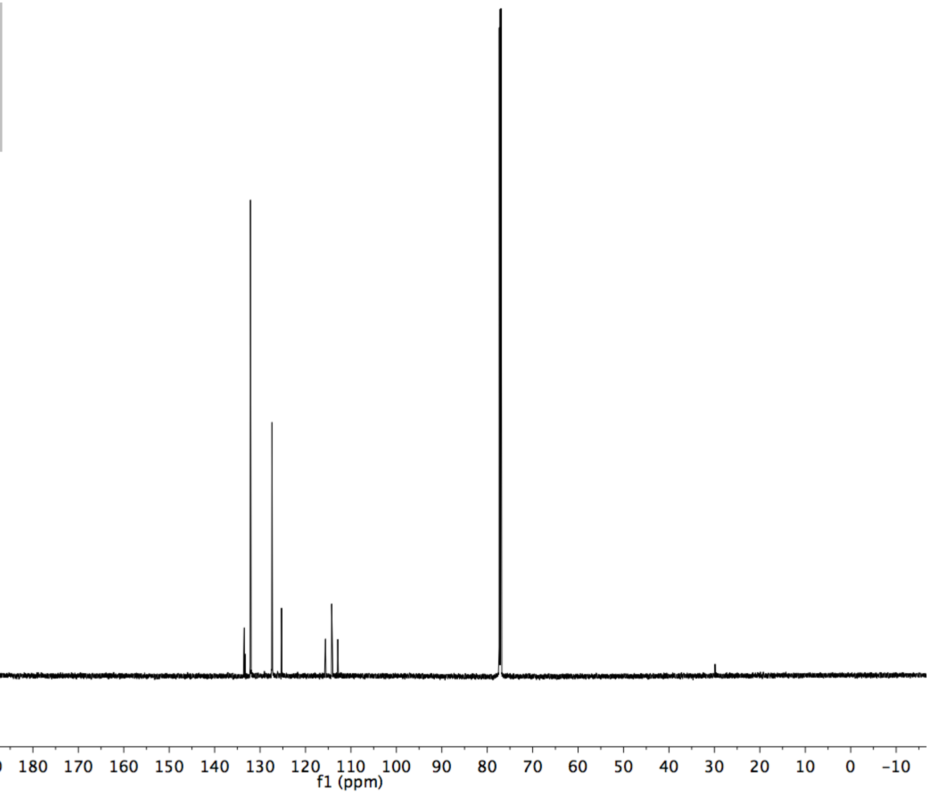
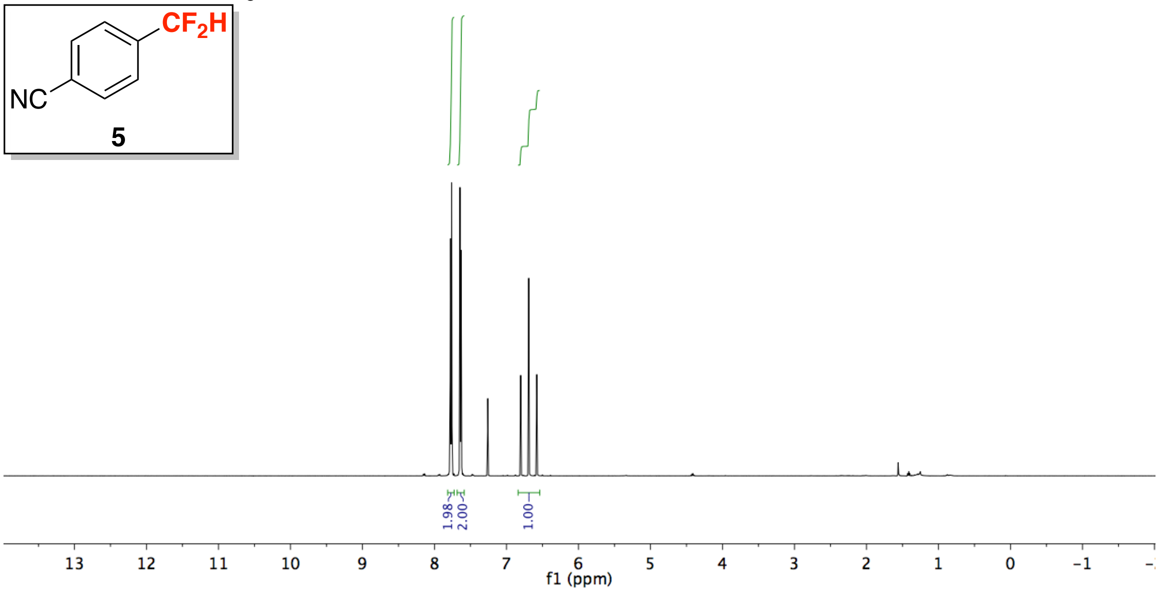
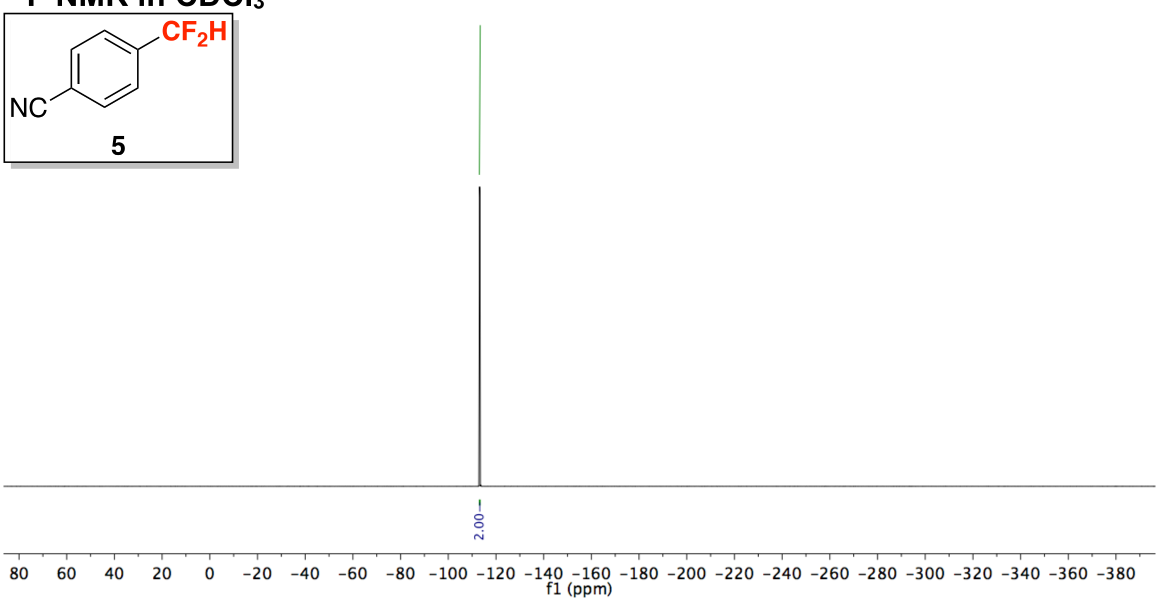


v. *5 Synthesized Using PBSF*

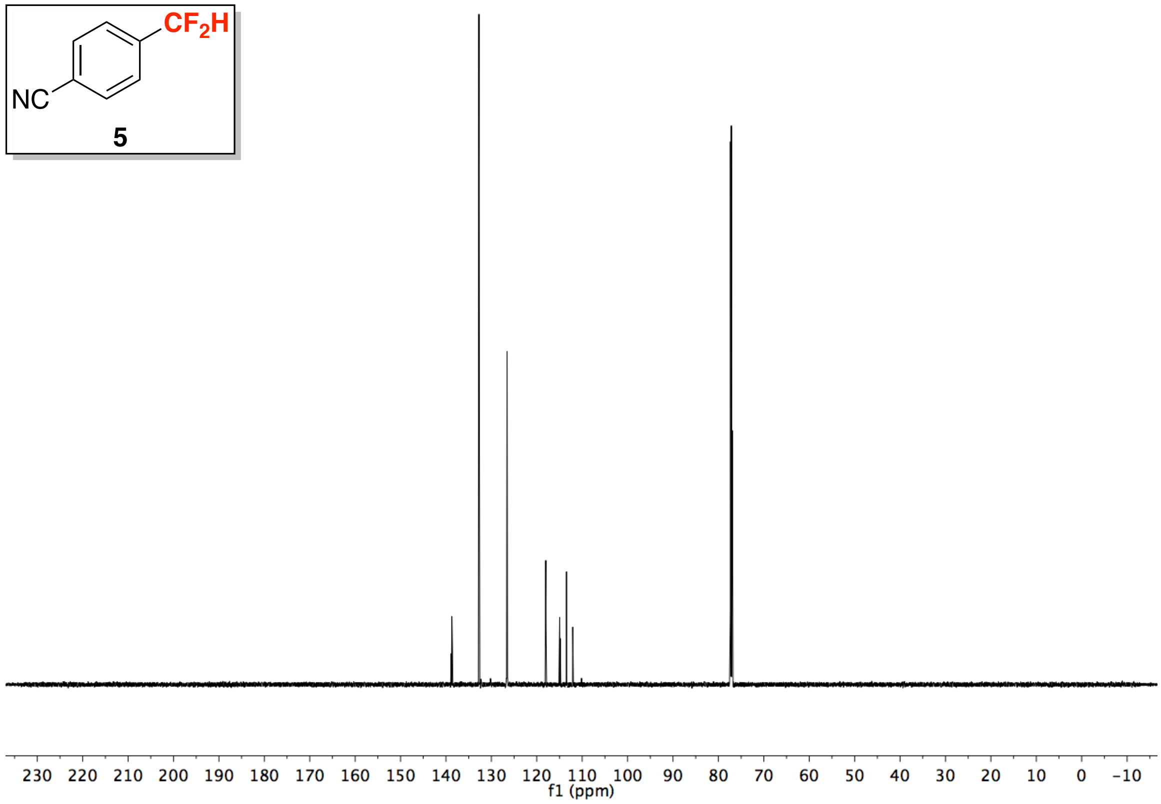
^{1}H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$

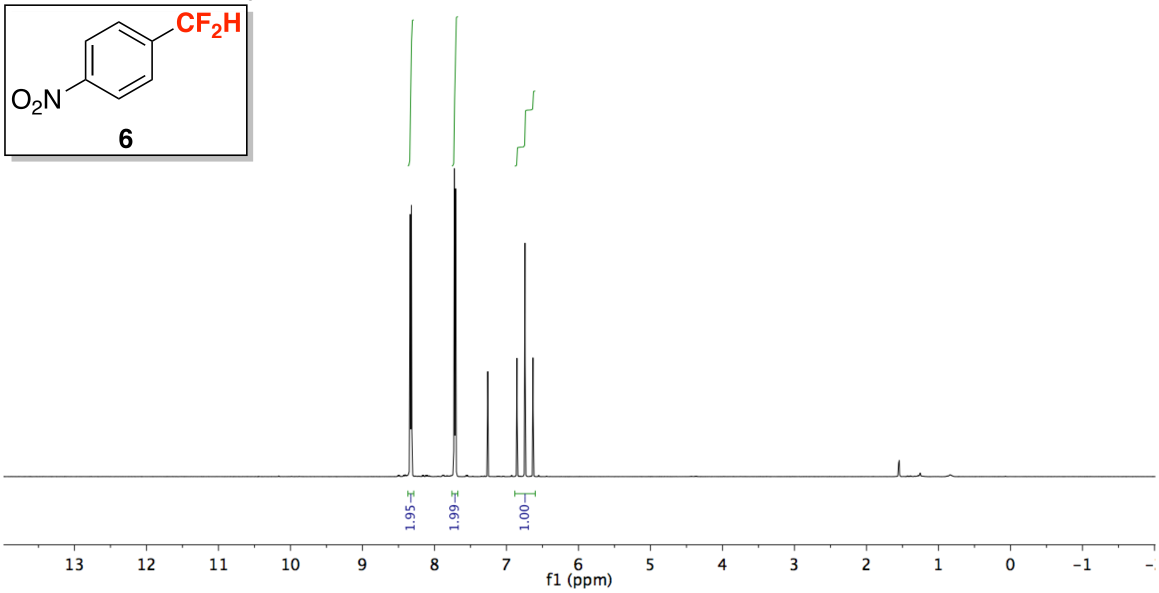


^{13}C NMR in $CDCl_3$

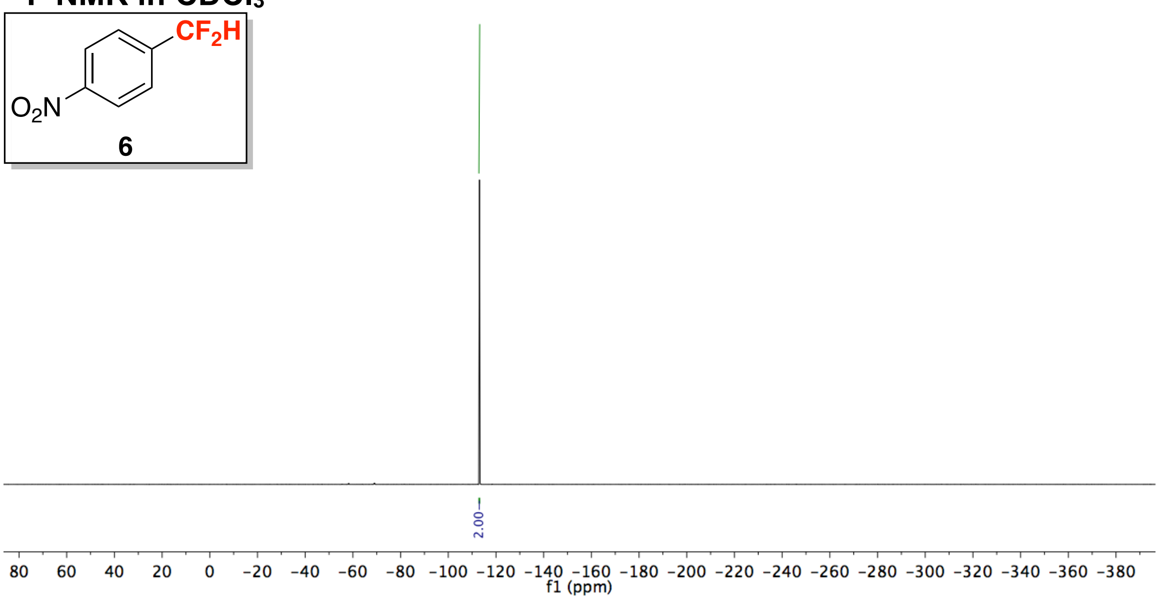


vi. *6 Synthesized Using PBSF*

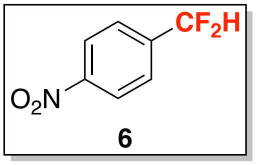
^{1}H NMR in CDCl$_3$

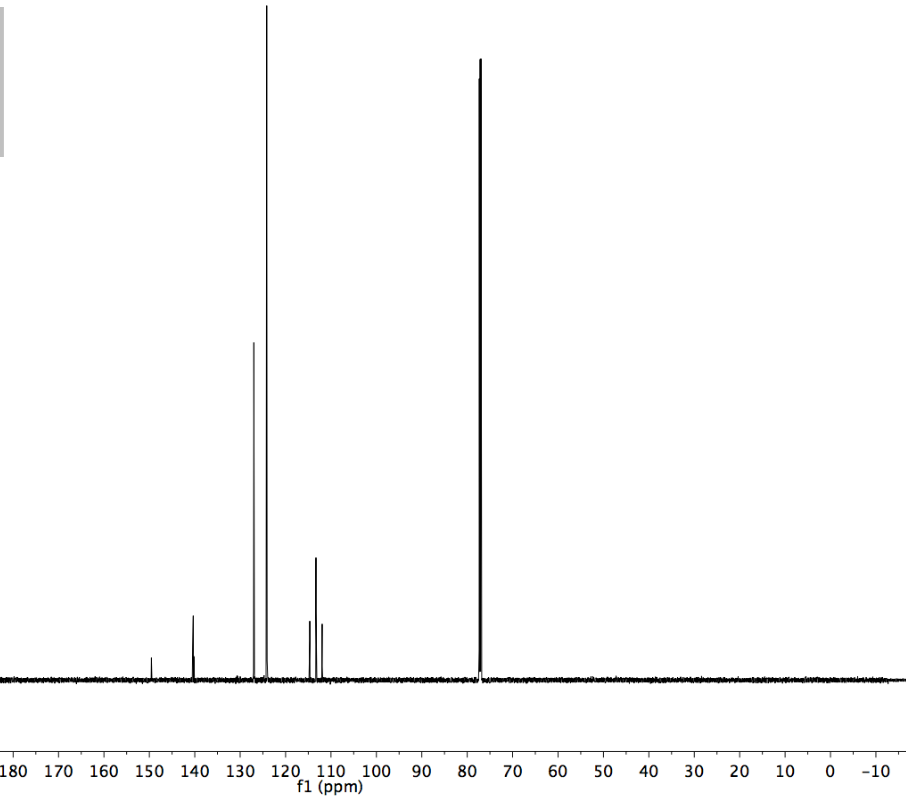


^{19}F NMR in CDCl$_3$



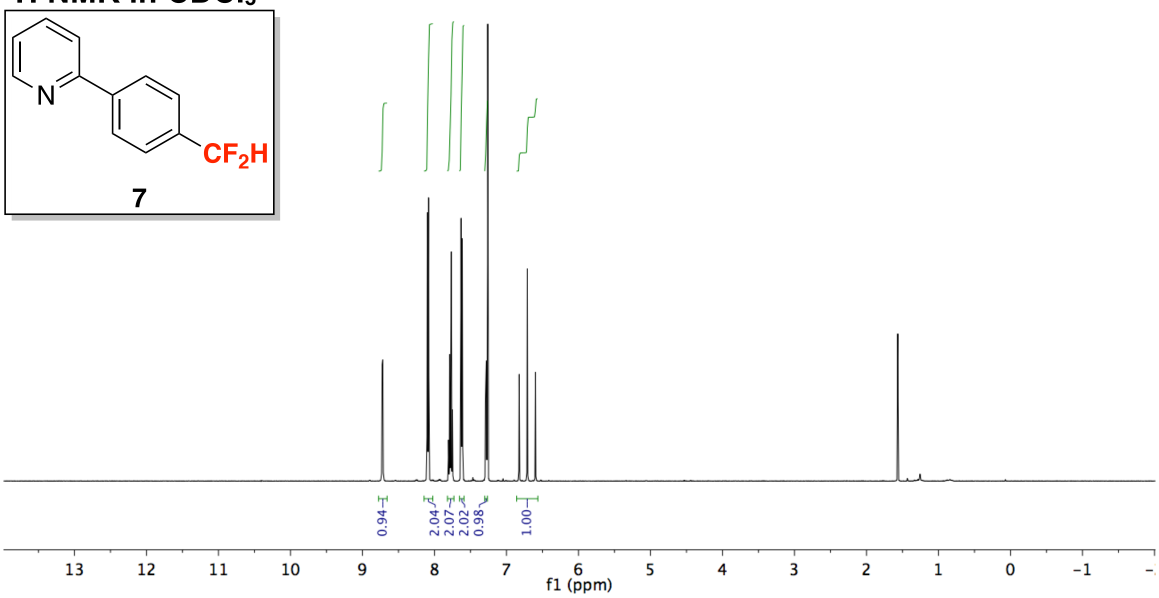
^{13}C NMR in $CDCl_3$



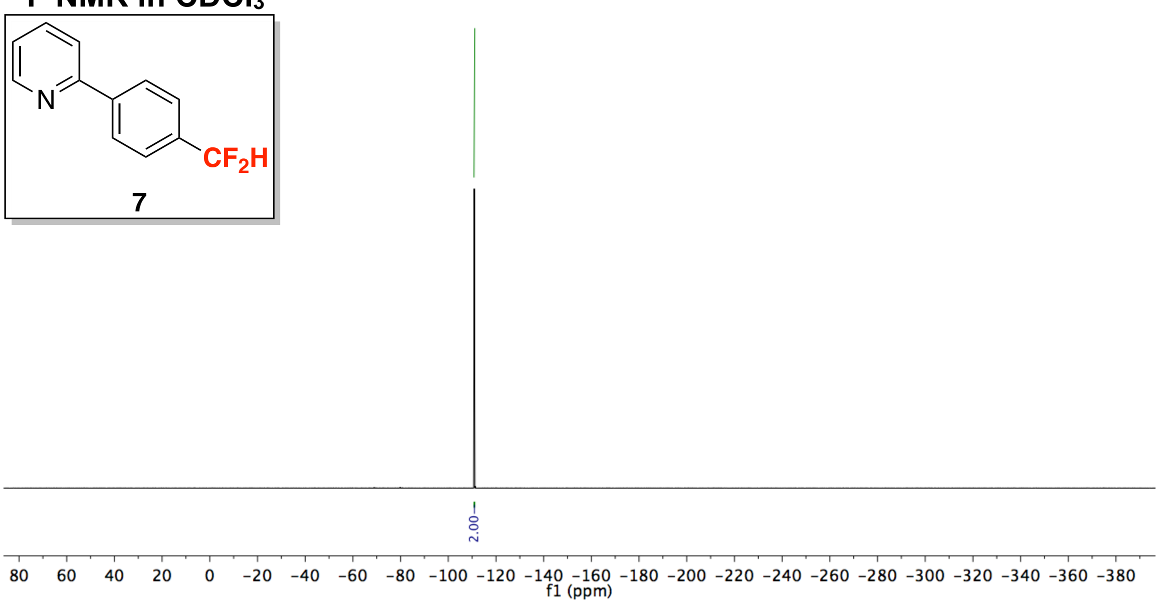


vii. ***7 Synthesized Using PBSF***

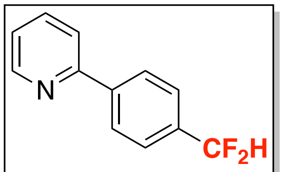
^{1}H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$



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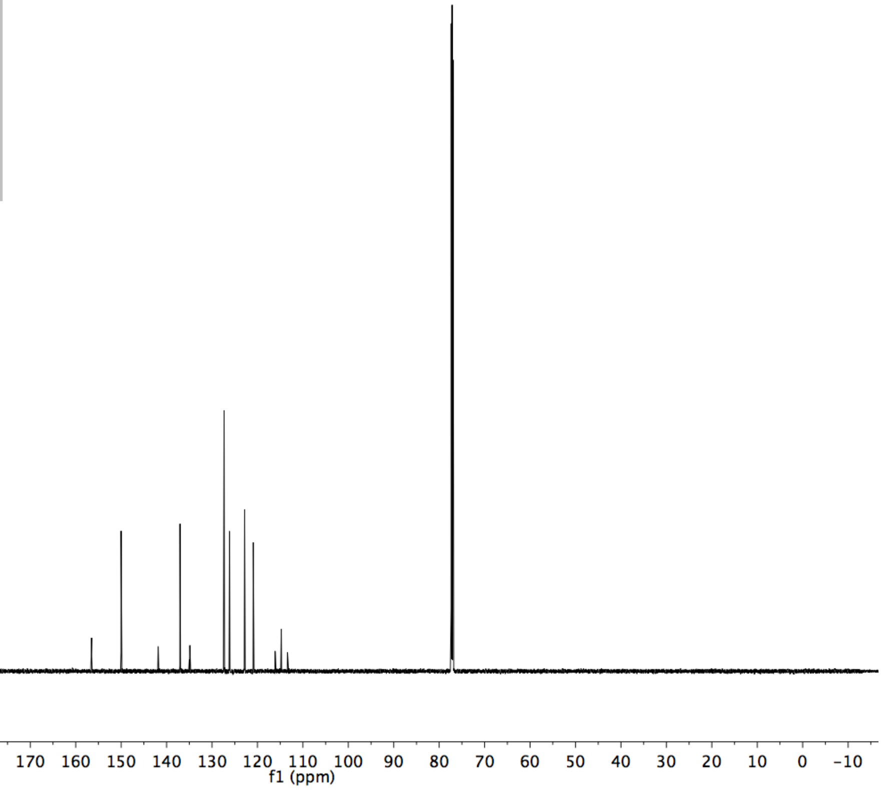
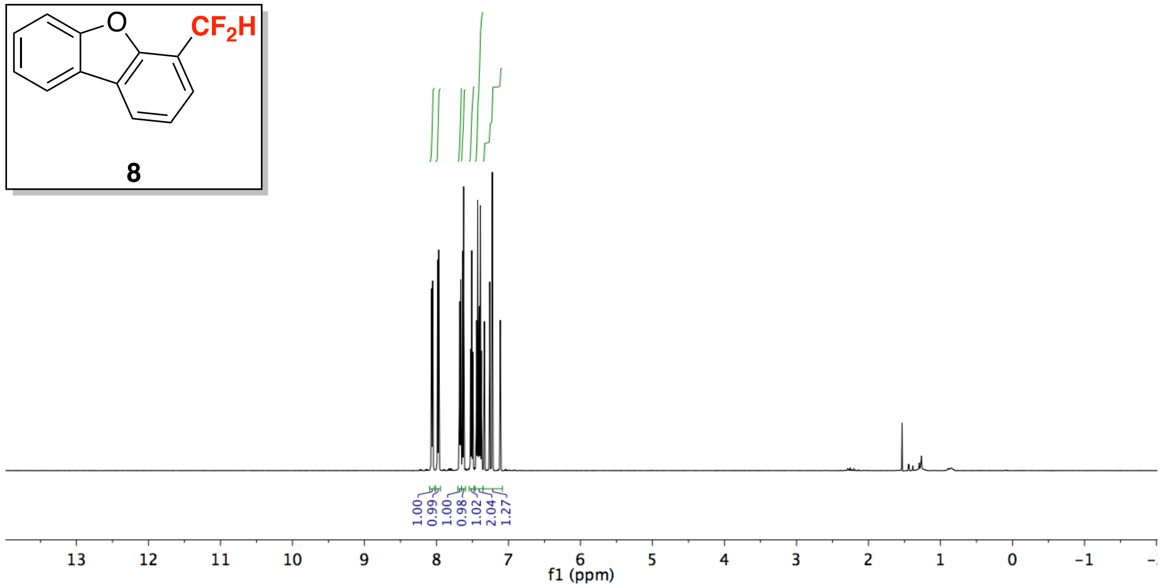
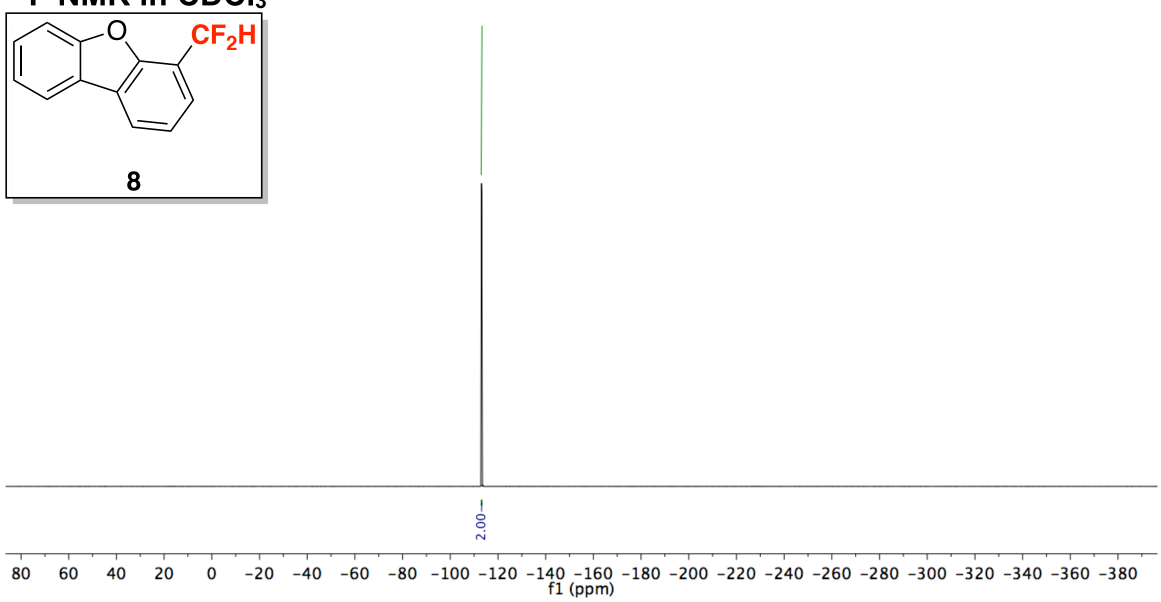


viii. ***8 Synthesized Using PBSF***

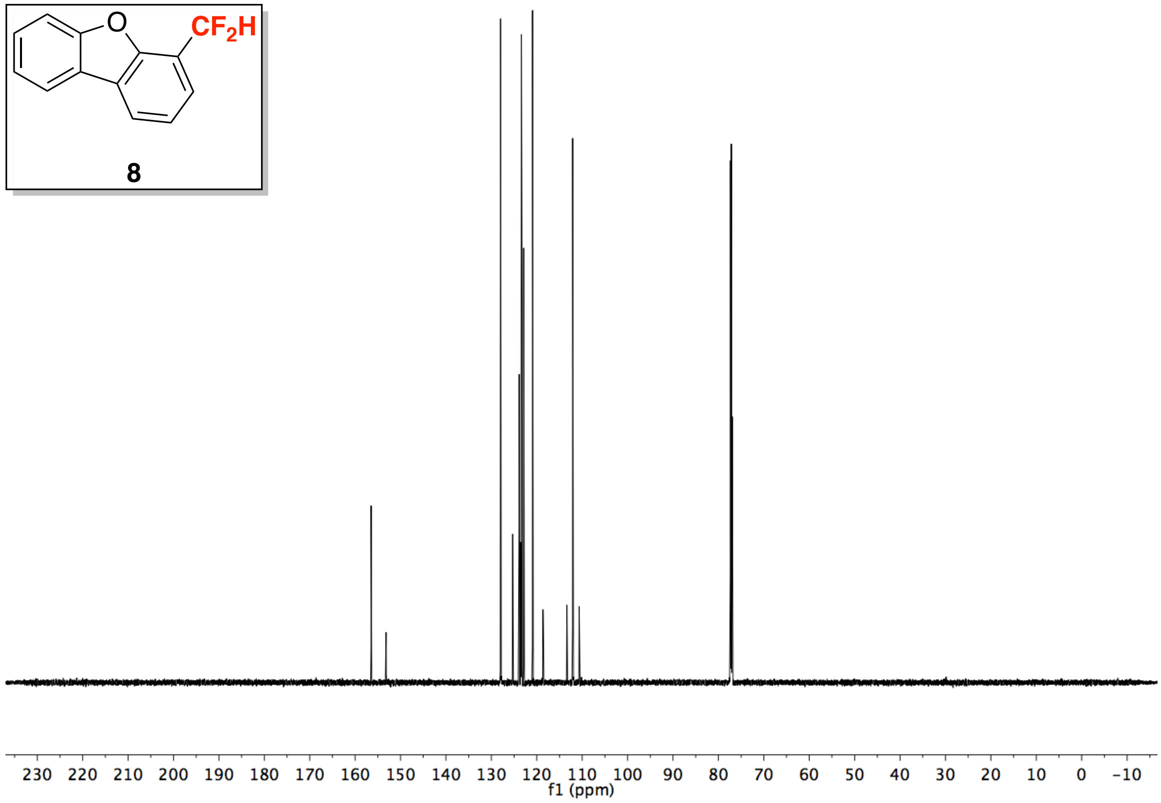
^1H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$

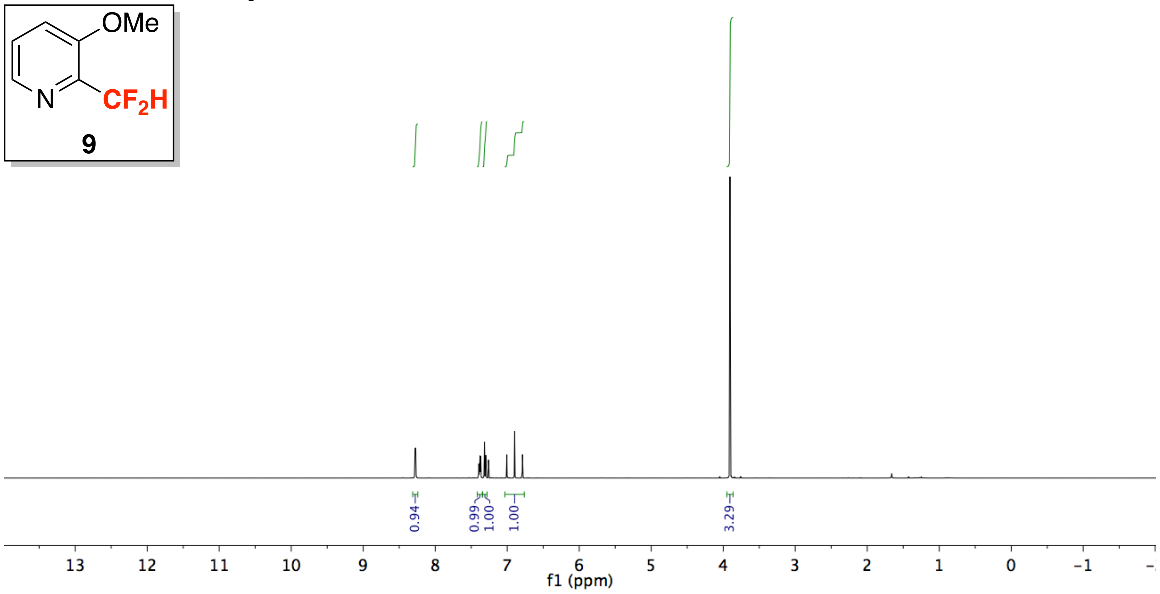


^{13}C NMR in $CDCl_3$

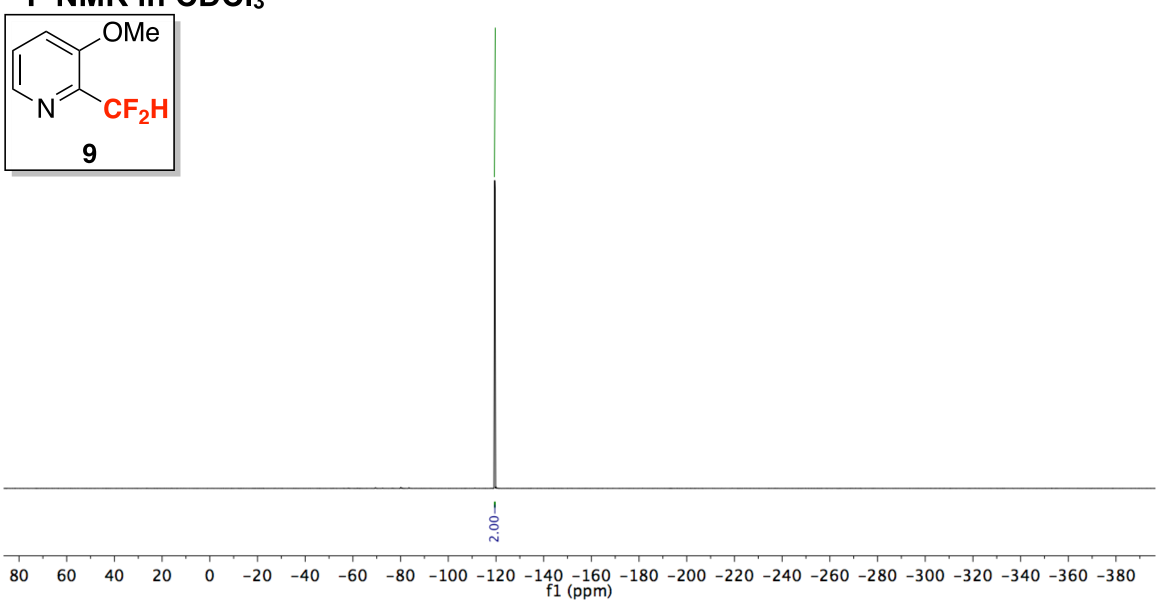


ix. ***9 Synthesized Using PBSF***

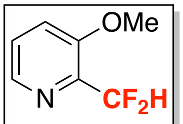
^{1}H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$



^{13}C NMR in CDCl$_3$



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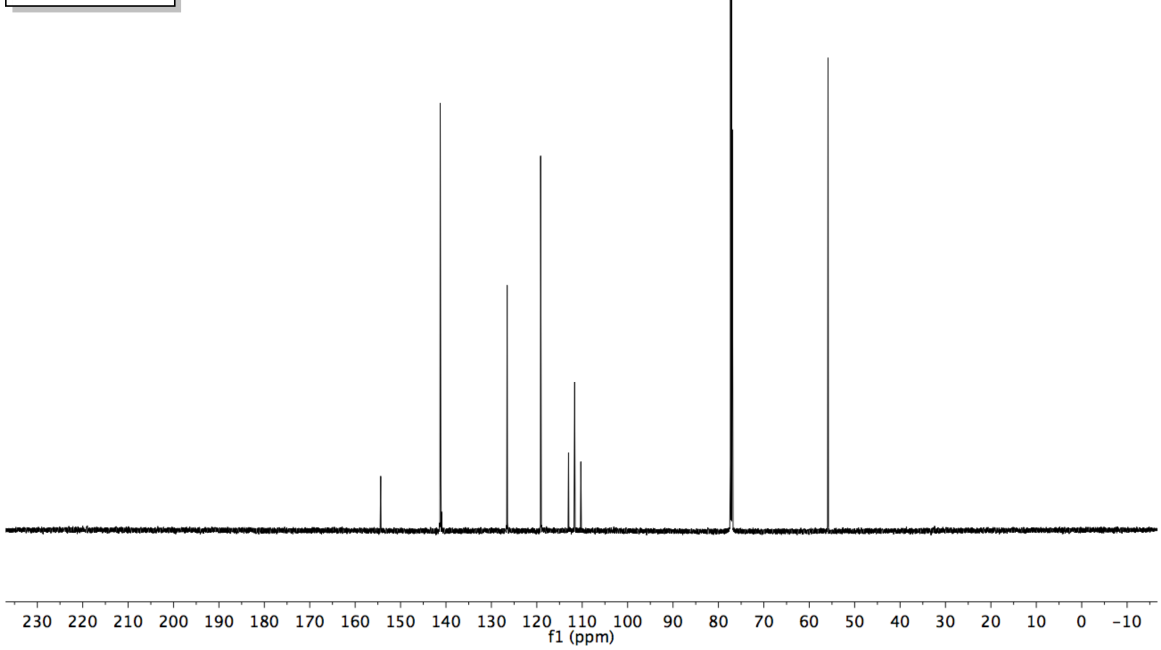
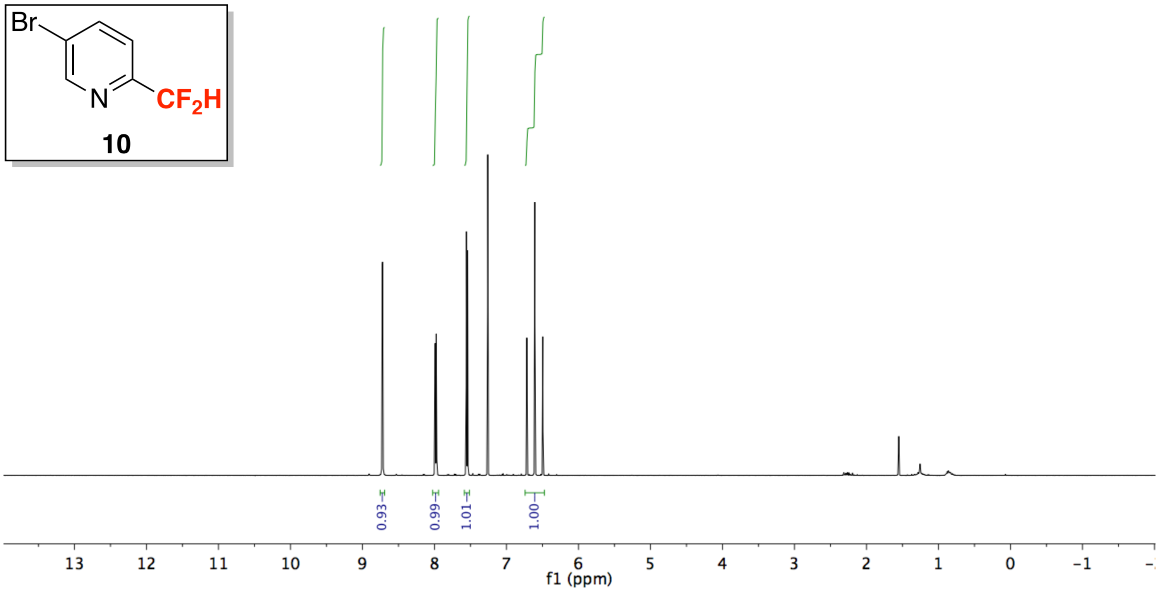
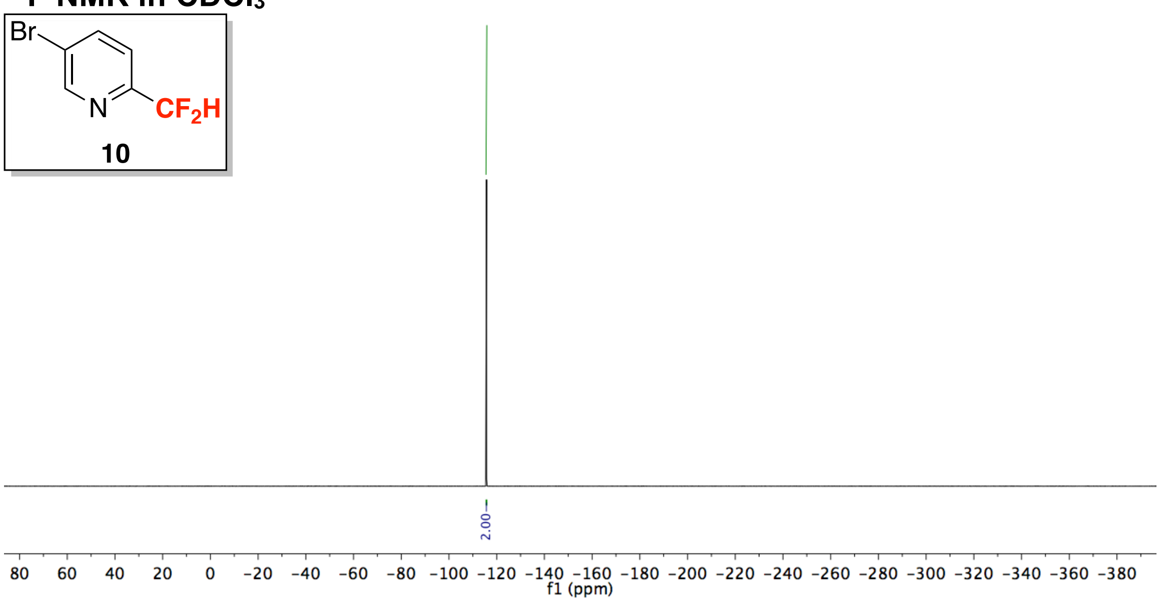


x. ***10 Synthesized Using PBSF***

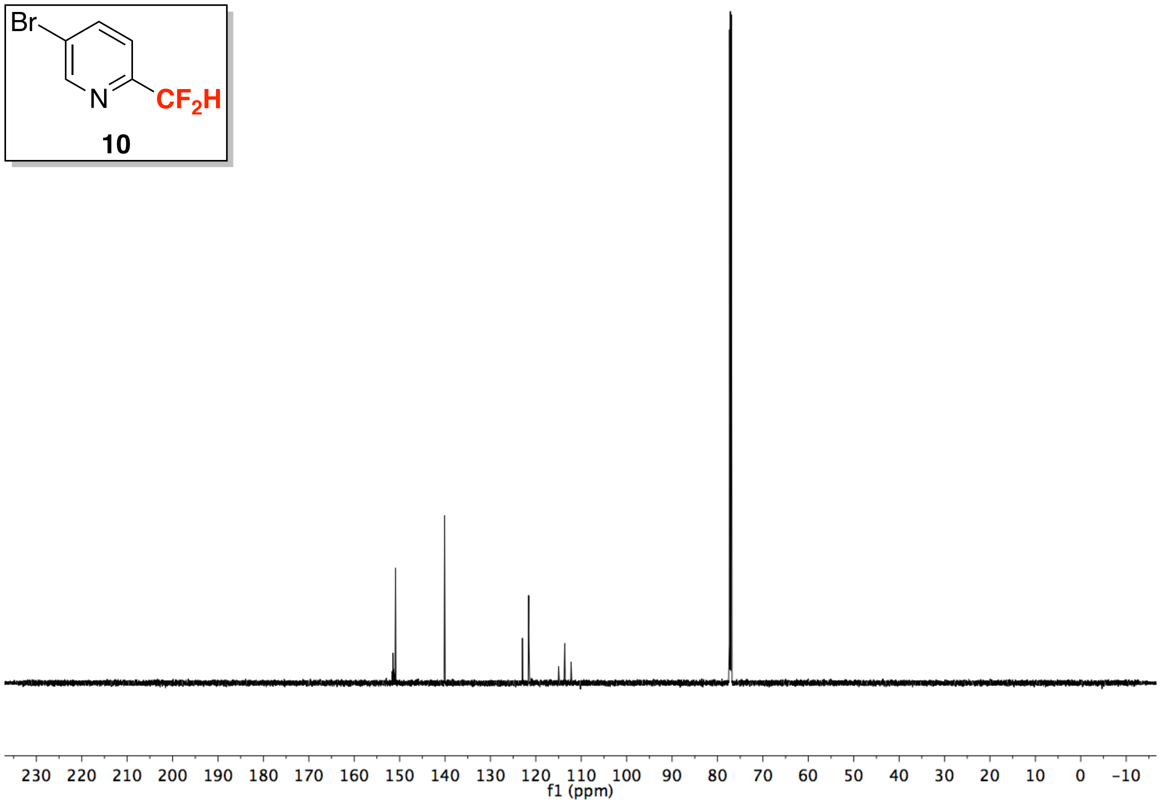
^{1}H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$

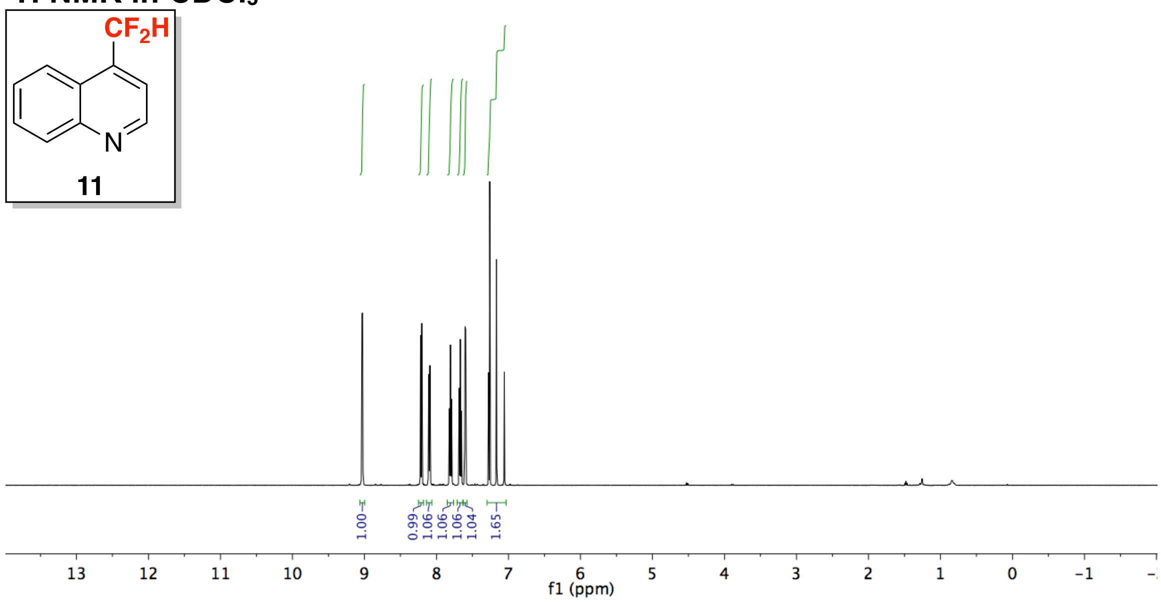


^{13}C NMR in $CDCl_3$

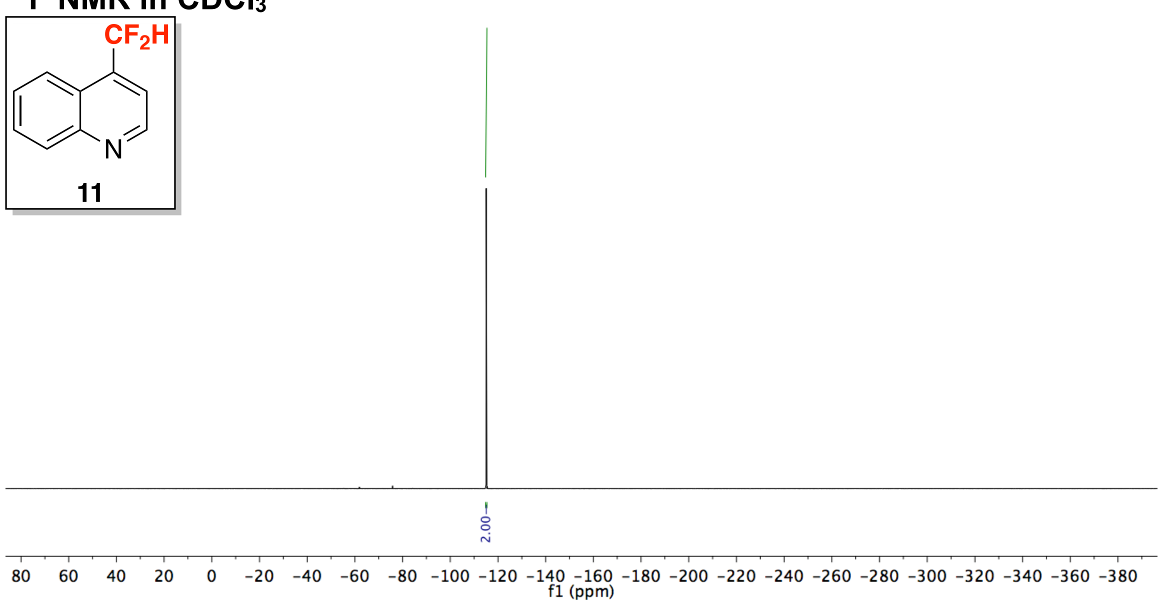


xi. ***11 Synthesized Using PBSF***

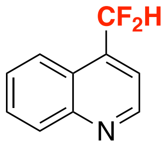
^1H NMR in $CDCl_3$



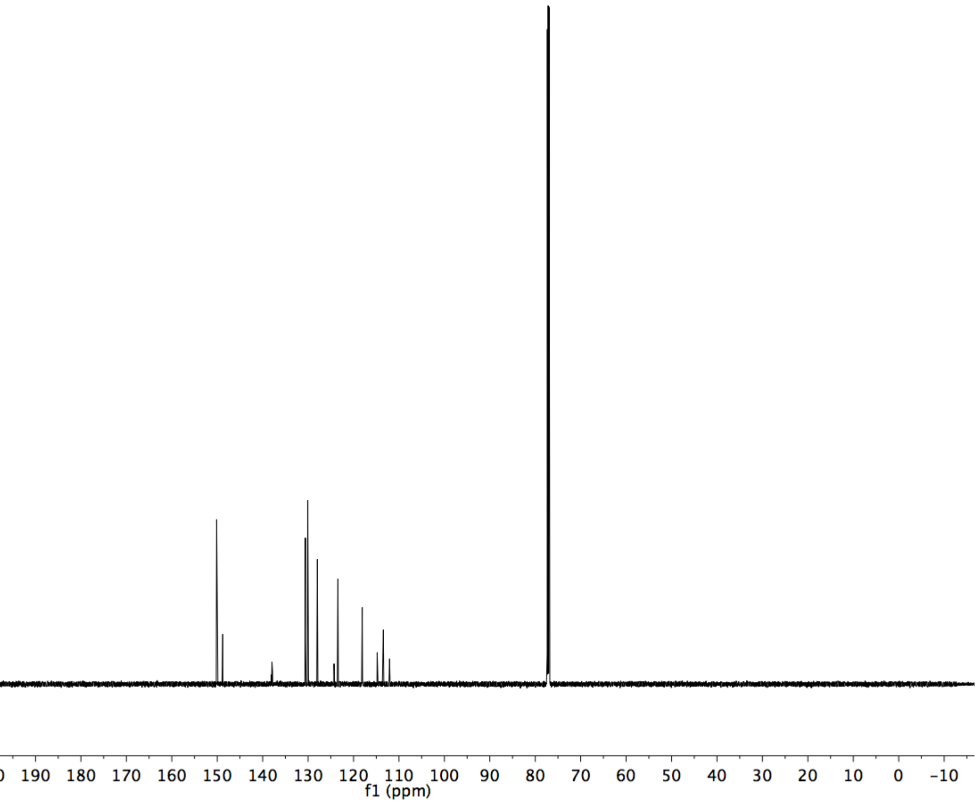
^{19}F NMR in $CDCl_3$



^{13}C NMR in $CDCl_3$

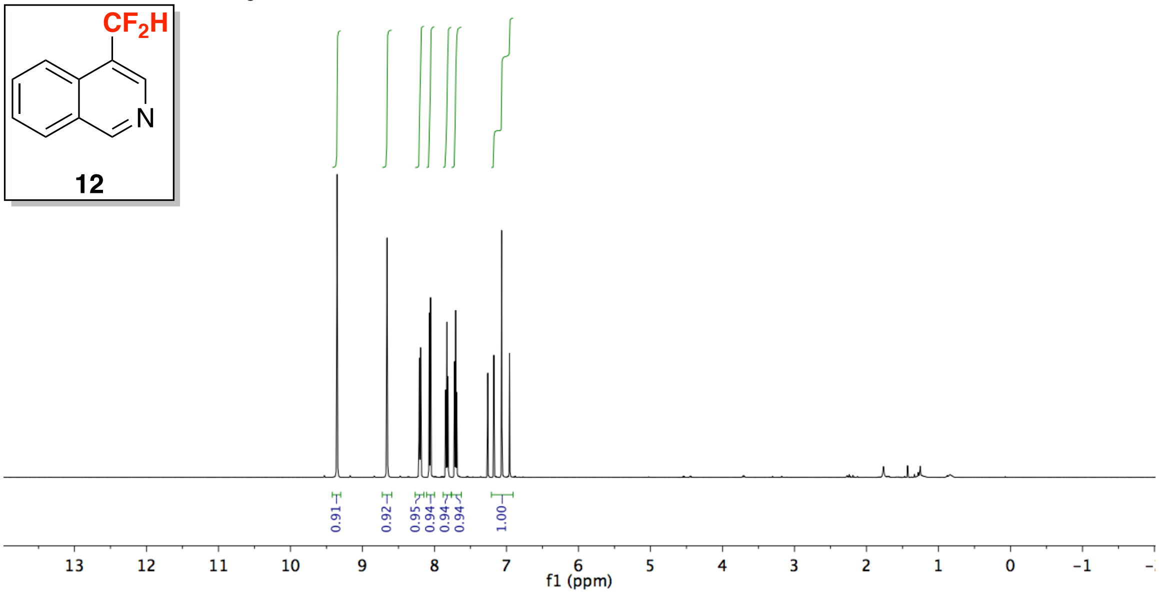


11

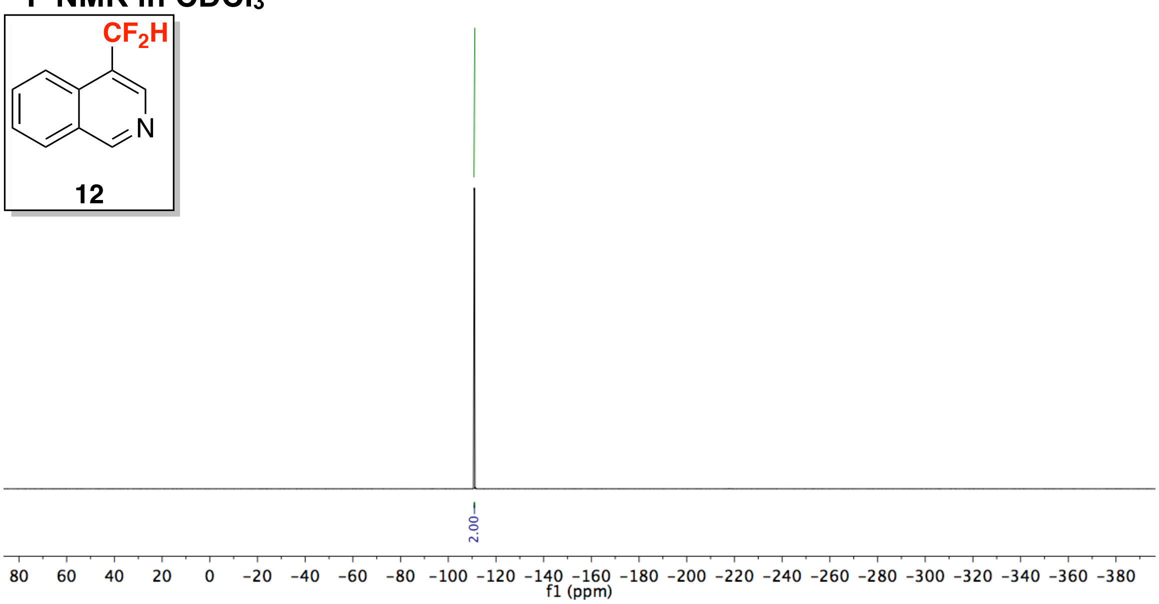


xii. ***12 Synthesized Using PBSF***

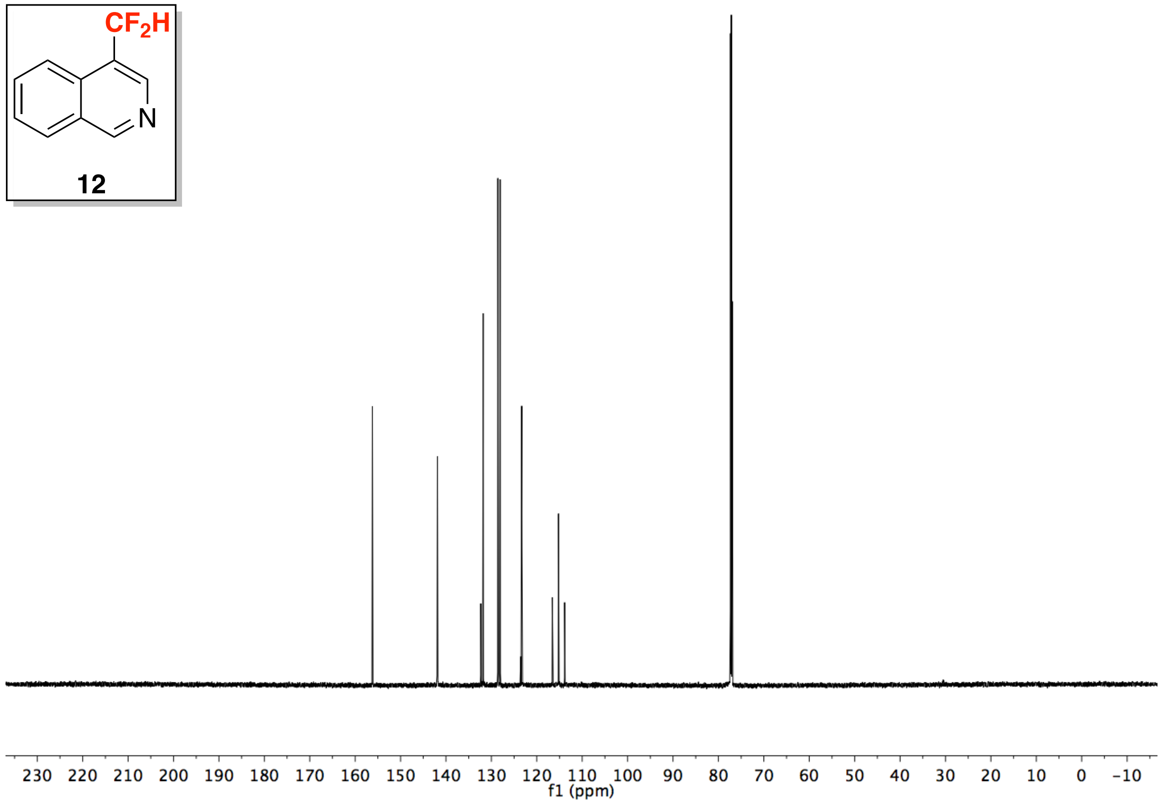
^{1}H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$

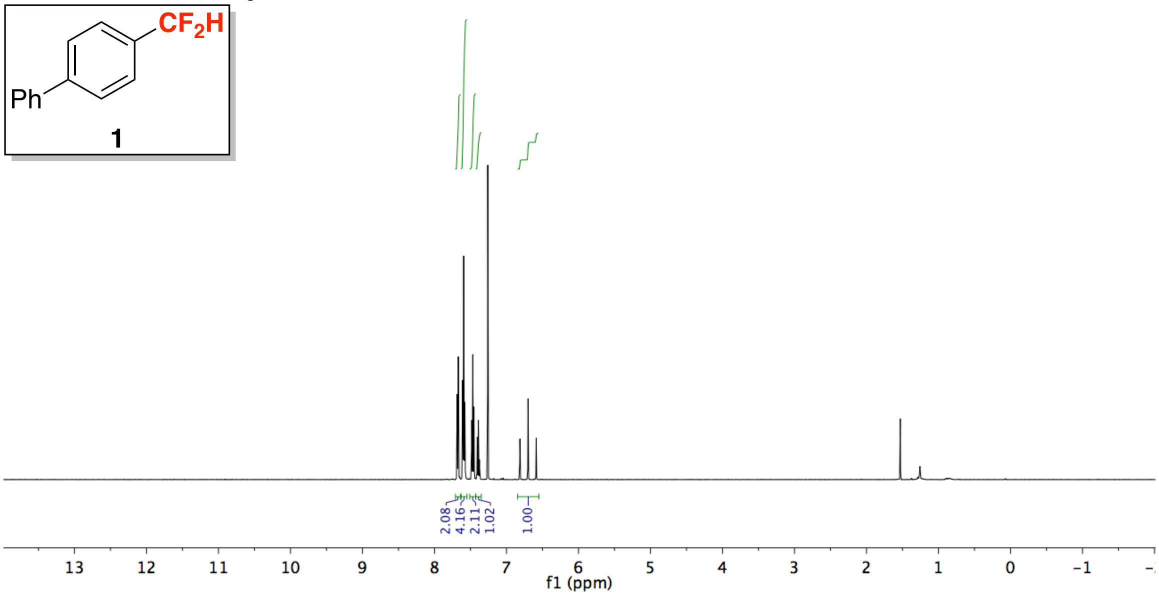


^{13}C NMR in $CDCl_3$

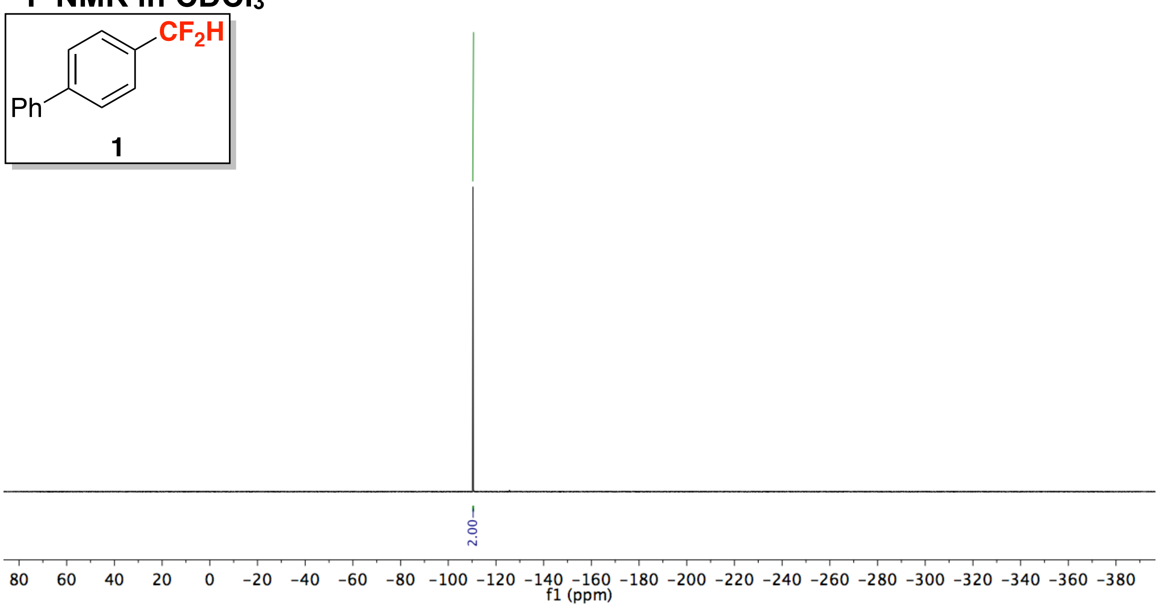


xiii. ***1 Synthesized Using Tf_2O***

^1H NMR in $CDCl_3$

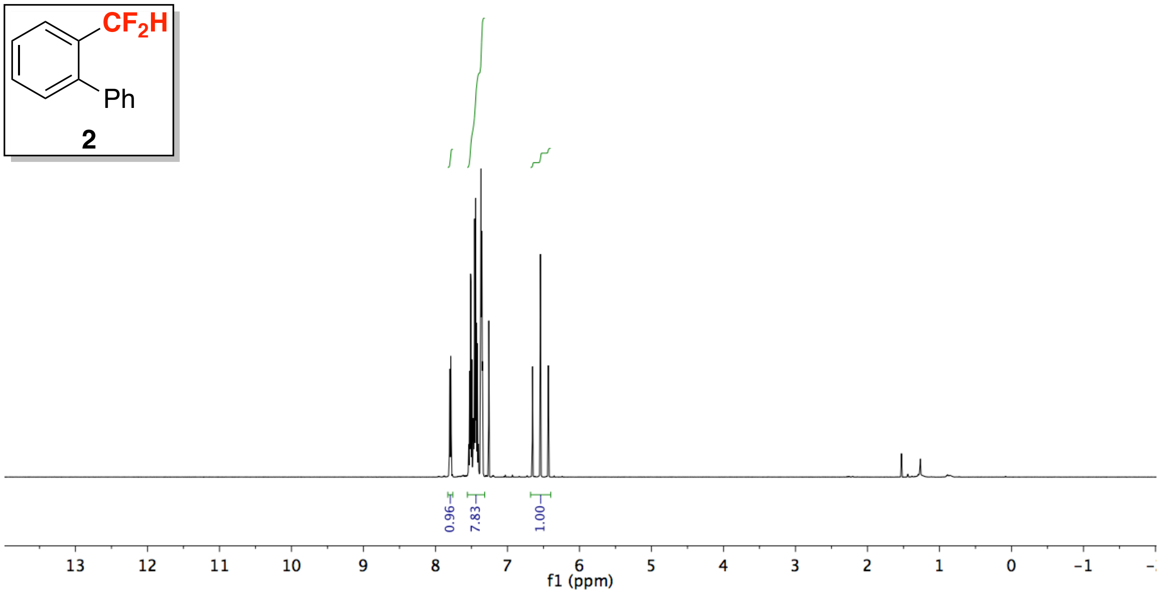


^{19}F NMR in $CDCl_3$

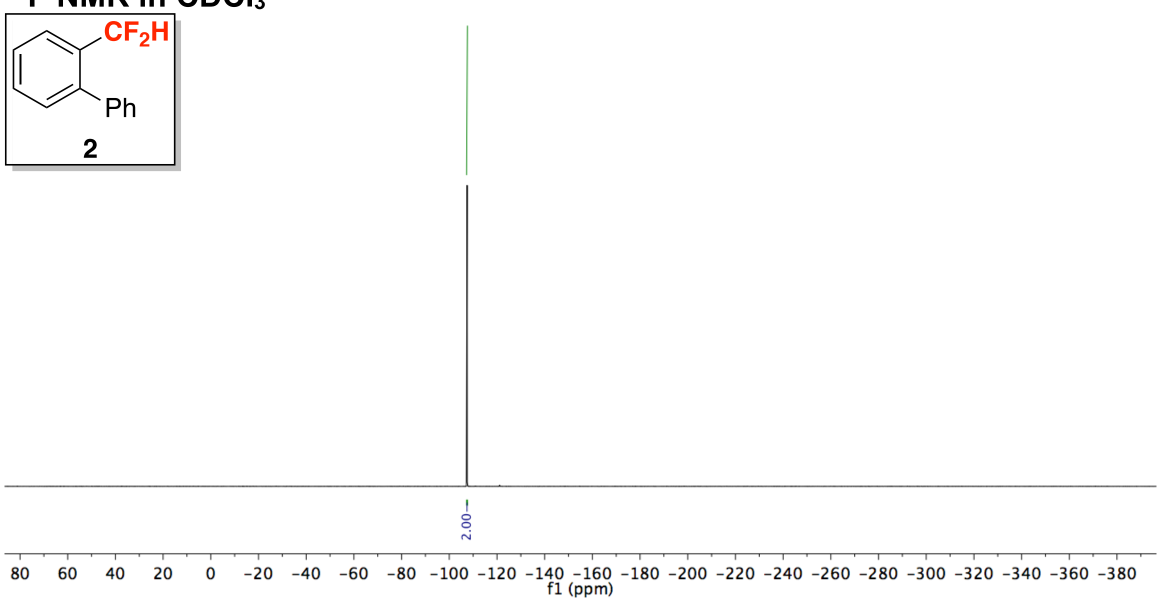


xiv. ***2 Synthesized Using Tf_2O***

^{1}H NMR in $CDCl_3$

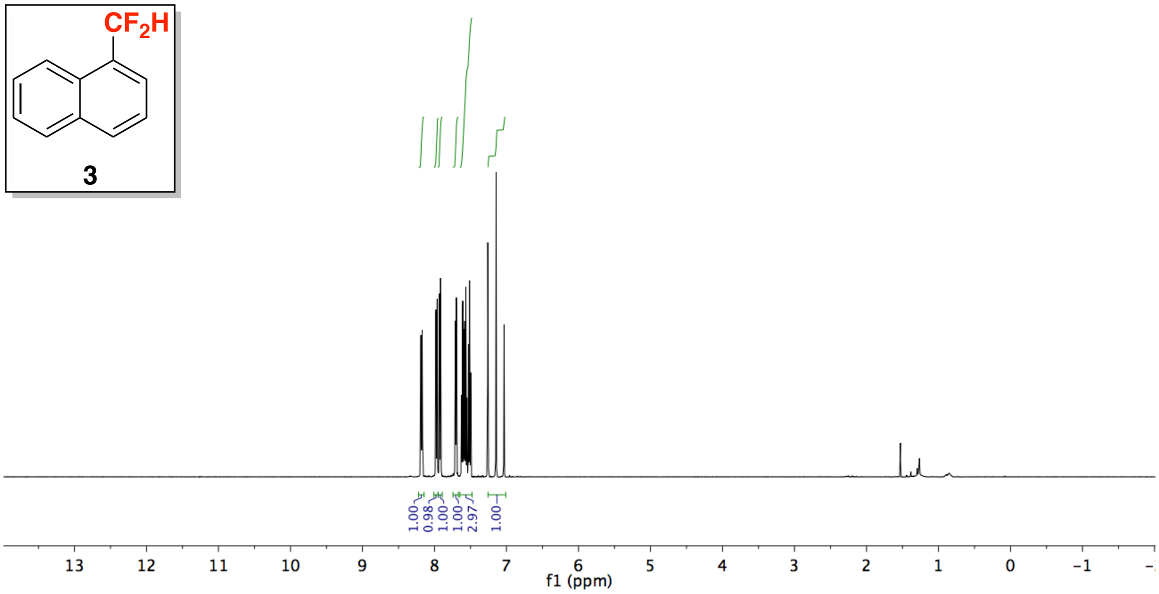


^{19}F NMR in $CDCl_3$

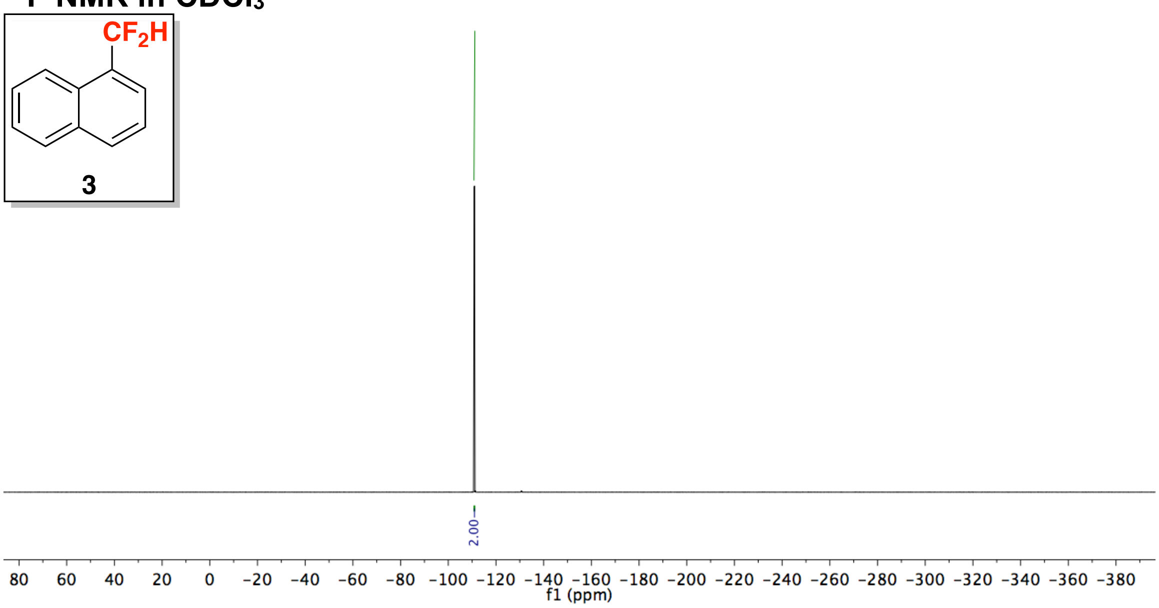


xv. ***3 Synthesized Using Tf_2O***

^1H NMR in $CDCl_3$

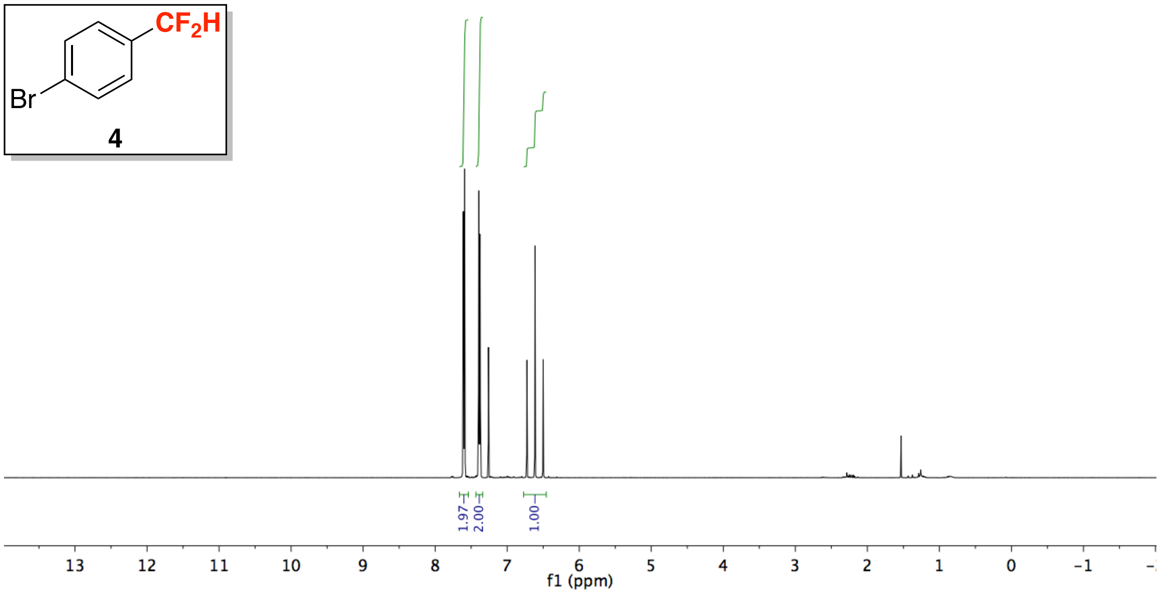


^{19}F NMR in $CDCl_3$

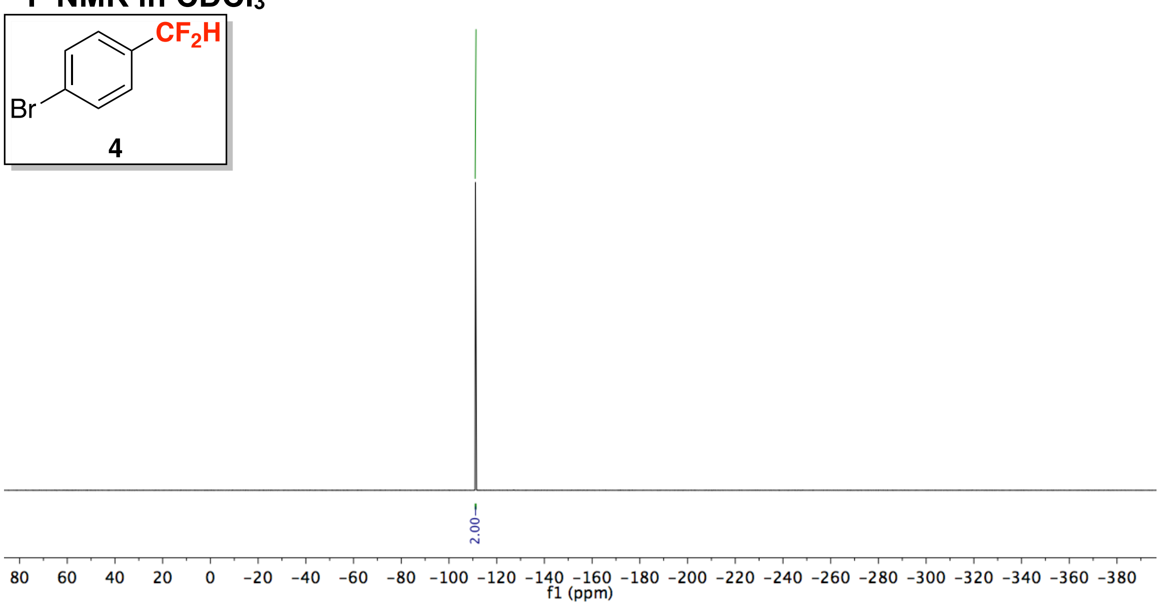


xvi. ***4 Synthesized Using*** $\boldsymbol{Tf_2O}$

^{1}H NMR in $CDCl_3$

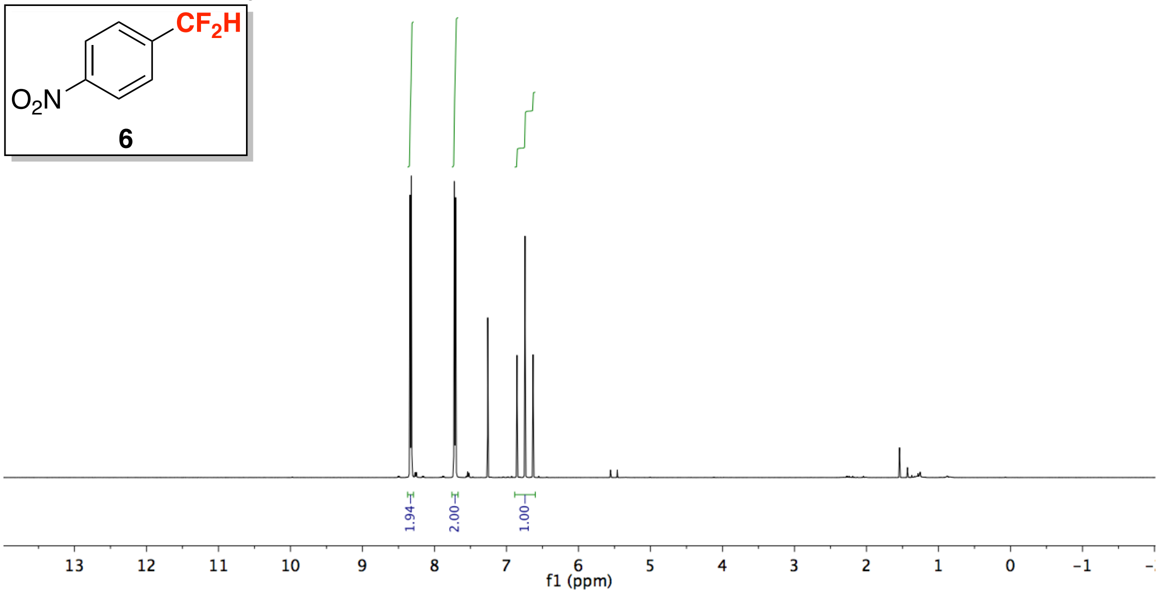


^{19}F NMR in $CDCl_3$

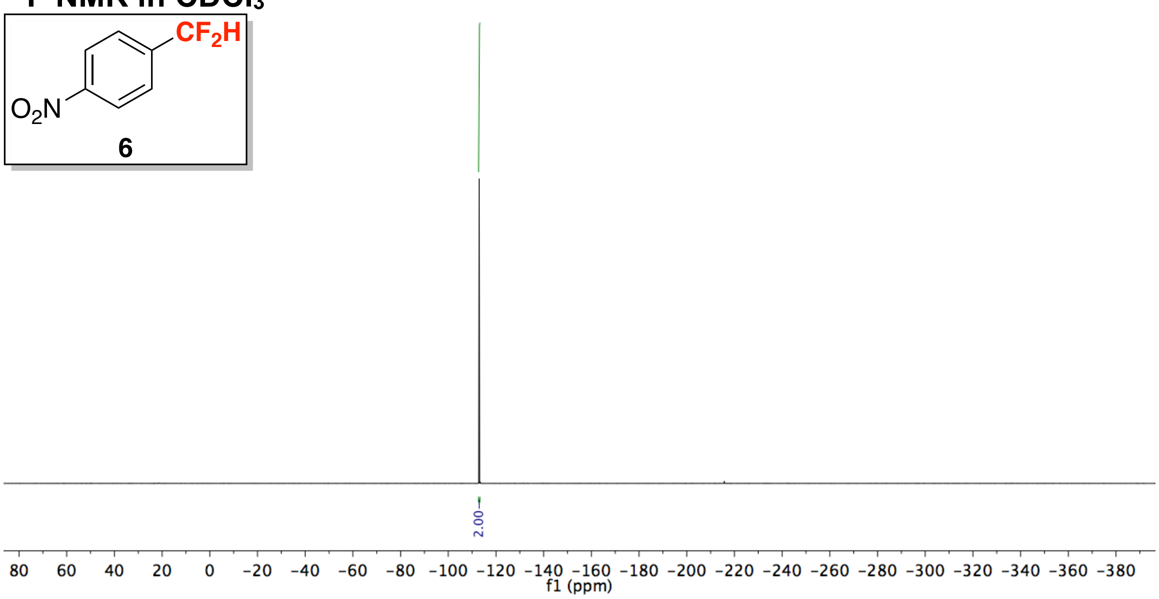


xvii. ***6 Synthesized Using Tf_2O***

^{1}H NMR in $CDCl_3$

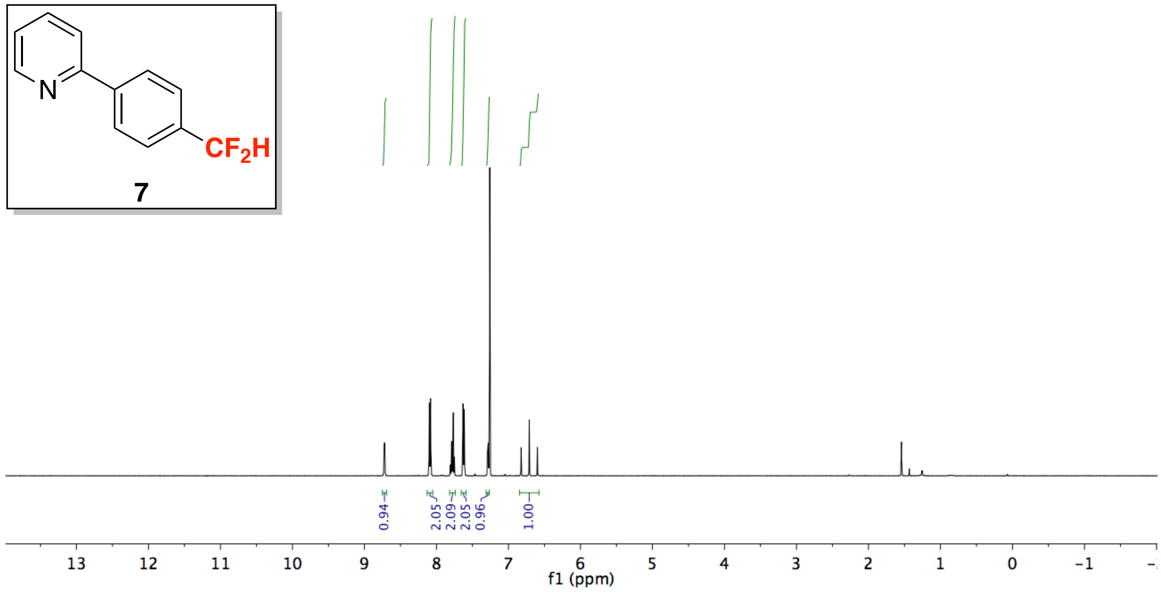


^{19}F NMR in $CDCl_3$

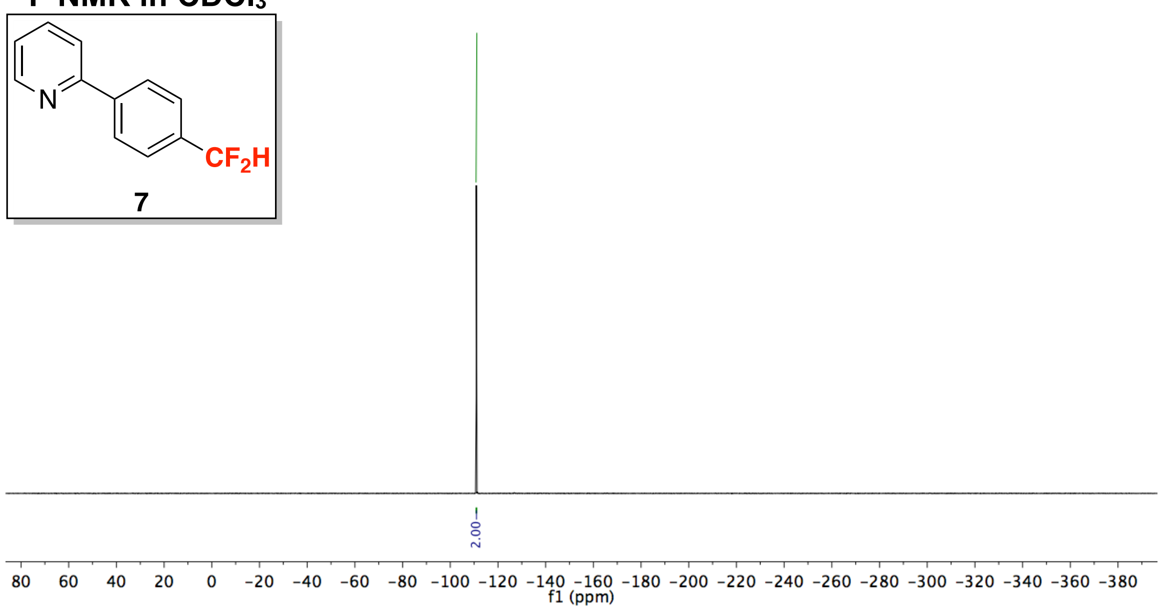


xviii. ***7 Synthesized Using Tf_2O***

^{1}H NMR in $CDCl_3$

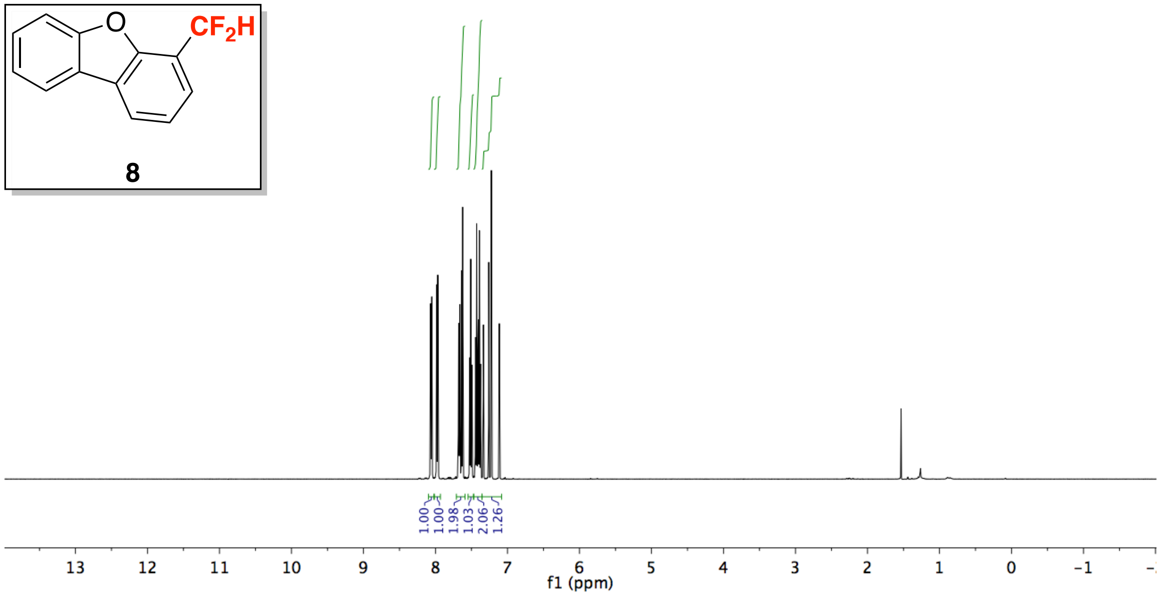


^{19}F NMR in $CDCl_3$

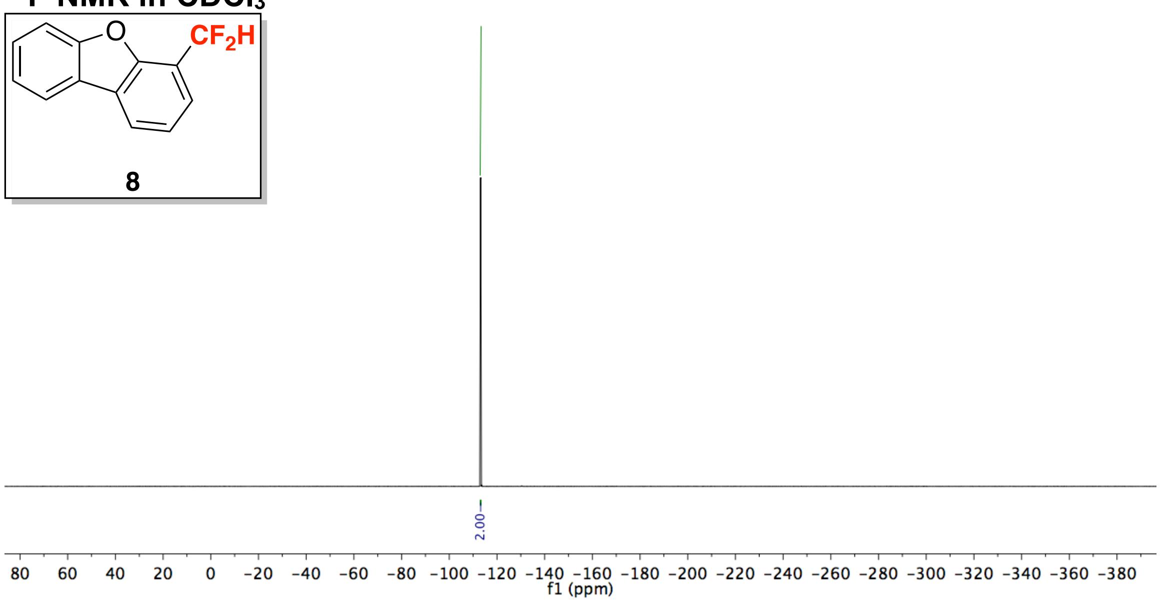


xix. ***8 Synthesized Using Tf₂O***

^{1}H NMR in CDCl$_3$

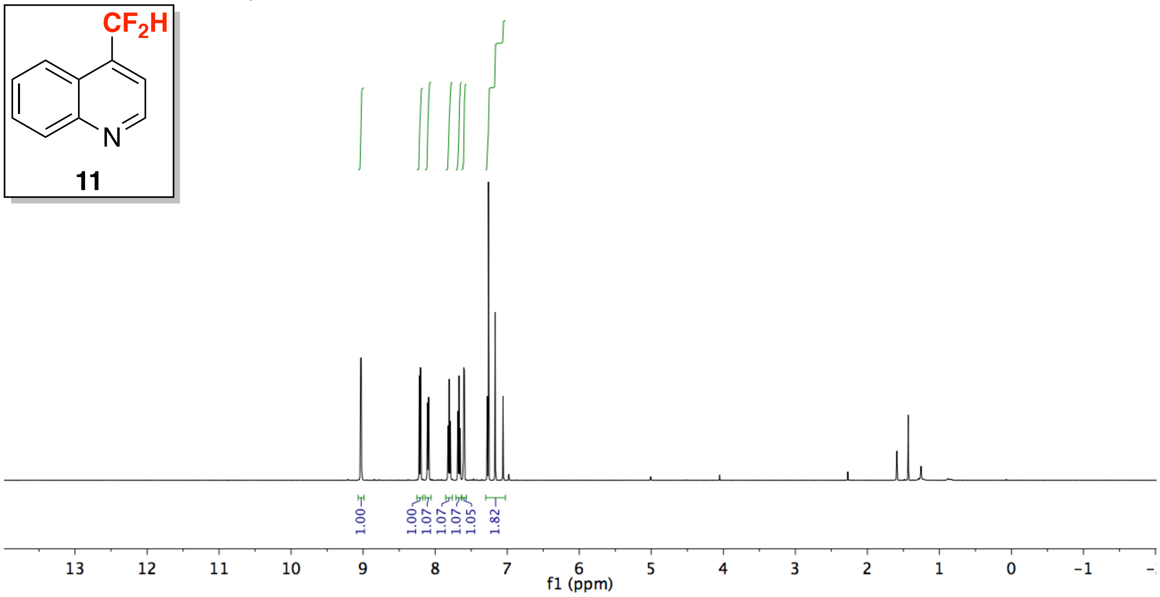


^{19}F NMR in CDCl$_3$

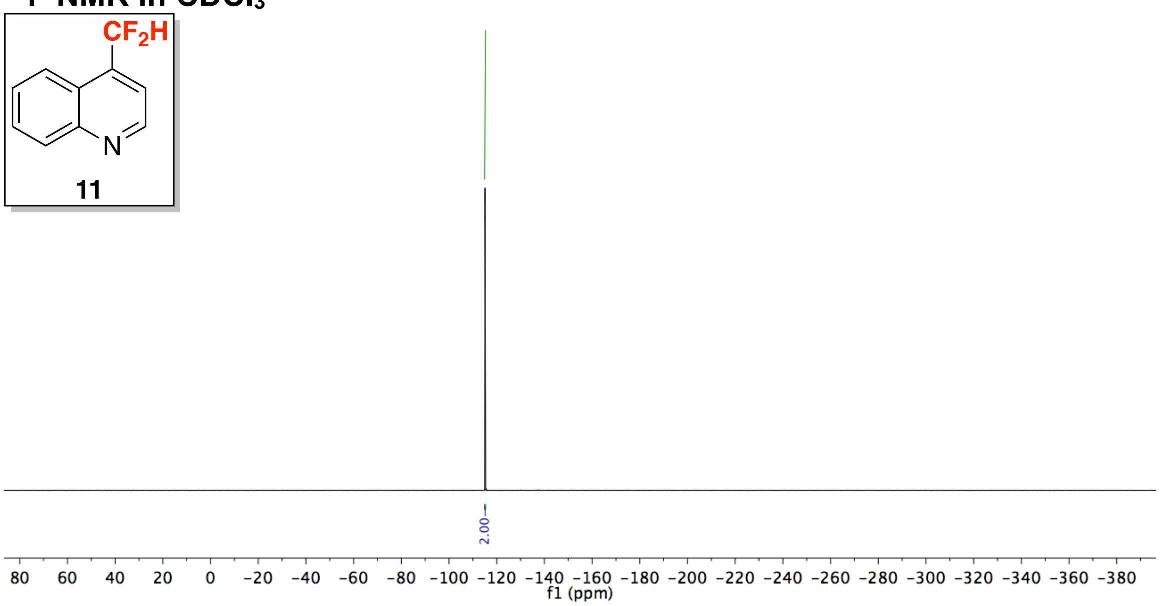


xx. ***11 Synthesized Using Tf_2O***

^{1}H NMR in $CDCl_3$

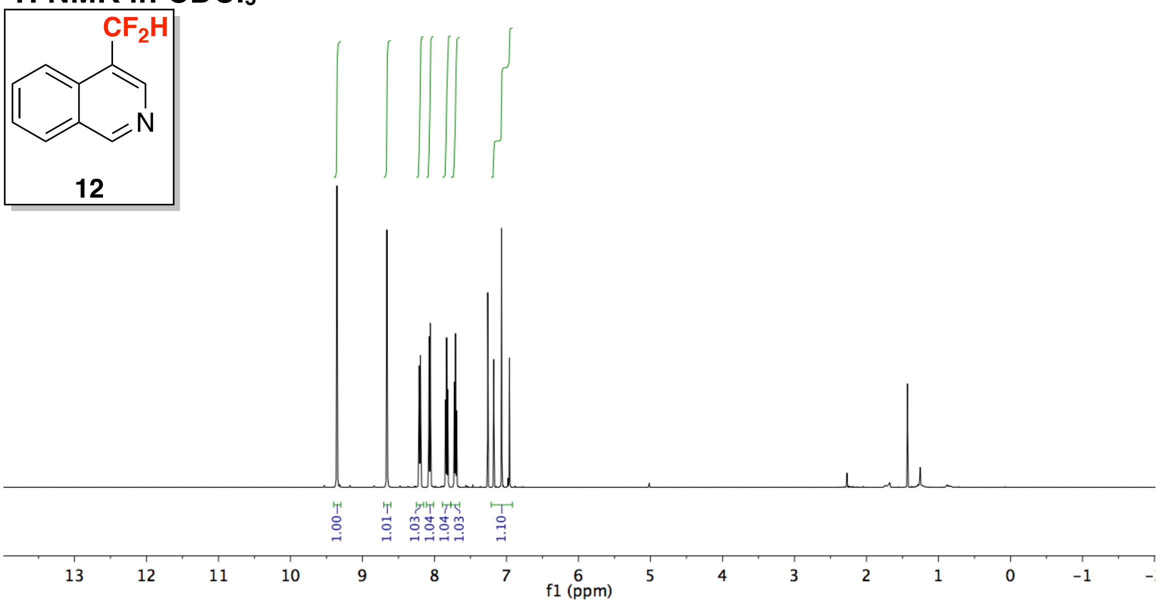


^{19}F NMR in $CDCl_3$



xxi. ***12 Synthesized Using Tf_2O***

^1H NMR in $CDCl_3$



^{19}F NMR in $CDCl_3$