Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Ligand-induced reactivity of β-diketiminate magnesium complexes for regioselective functionalization of fluoroarenes via C-H or C-F bond activations

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Table of Contents

Expertimental Section

General remarks

All the experiments were performed under protective argon inert atmosphere and using standard Schlenk techniques. The use of a glovebox has also been required. Hexane, toluene and THF were dried by heating to reflux over sodium, benzophenone ketyl and distilled under nitrogen prior to use. The [(^{Dip}Nacnac)Mg(TMP)] (^{Dip}Nacnac= ArNC(Me)CHC(Me)NAr; Ar = 2,6-^{i}Pr$_2$-C$_6$H$_3$ and TMP = 2,2,6,6-tetramethylpiperidide) base **1**, **2, 3e** and **6** were synthesized according to literature method.[1,2,3] All reagents were purchased from Sigma-Aldrich, Alfa Aesar or Fluorochem (1,2-difluorobenzene, 1,3,5-trifluorobenzene, 1,2,4,5-tetrafluorobenzene, pentafluorobenzene and 2-(2,4-difluorophenyl)pyridine) and were dried before use where applicable.

All NMR spectra were recorded on a Bruker AV3 or AV 400 MHz, or on a AV 600 MHz spectrometer, operating at 400.13 MHz for ^{1}H, 100.61 MHz for ^{13}C and 376.40 MHz for ^{19}F. All ^{13}C NMR spectra were proton decoupled. ^{1}H, ^{13}C{^{1}H} and ^{19}F{^{1}H} chemical shifts are expressed in parts per million (δ, ppm) and referenced to residual solvent peaks. Elemental analyses were performed using a Perkin Elmer 2400 elemental analyzer.

X-ray crystallography

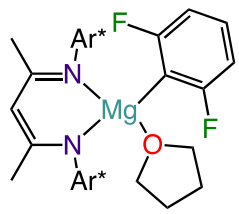
Data for samples **3c** and **8** were collected on Oxford Diffraction Gemini S or Xcalibur E instruments with graphite-monochromated Mo Kα (λ = 0.71073 Å) or Cu Kα (λ = 1.54180 Å) radiation. Data collection and processing used Rigaku and Bruker software.[4,5] All structures were solved and refined to convergence on F^2 for all independent reflections by the full-matrix least squares method using SHELXL-2014/7[3,4] or by the GaussNewton algorithm using OLEX2.[6] Selected crystallographic data are shown in Table S1 and full details in .cif format are available from the CCDC (1567107-1567108).

Table S 1: Selected crystallographic and refinement parameters.

	3c	**8**
CCDC code	1567107	1567108
Empirical formula	$C_{39}H_{50}F_4MgN_2O$	$C_{41}H_{54}MgN_2O_2$
Mol. Mass	663.14	576.77
Crystal system	Monoclinic	Triclinic
Space group	P 2_1/n	P-1
a/ Å	12.4430(4)	9.1082(8)
b/ Å	16.6363(6)	11.6359(9)
c/ Å	18.2241(6)	18.2169(17)
A	90	72.767(7)
B	97.499(3)	86.724(7)
Γ	90	84.098(7)
V/ Å^3	3740.2(2)	1833.5(3)
Z	4	2
λ / Å	1.54184	0.71073
μ mm^{-1}	1.1776	1.0446
2θmax °	146.34	58
Measured reflections	15184	18824
Unique reflections	7339	9403
R_{int}	0.0246	0.0310
Observed rflns [I>2σ(I)]	6085	6415
GooF	1.0423	0.9380
R [on *F*, obs rflns only]	0.0539	0.0906
ωR [on F^2, all data]	0.1603	0.3118
Largest diff. Peak/hole. e/Å^{-3}	0.4161/-0.2267	0.9639/-0.3915

Synthesis of compounds (3a-3e)

- **Synthesis of [(^{Dipp}Nacnac)Mg($C_6H_3F_2$)(THF)] (3a)**



To a solution of **1** (0.56 g, 1 mmol) in THF (5 mL), 1,3-difluorobenzene (0.1 mL, 1 mmol) was added. The yellow solution was stirred for 2 hours at room temperature. The solvent was concentrated to 1 mL and 2 mL of hexane were added. The resulting yellow solution was stored at -15 ^{o}C. After 48 hours a white solid precipitated, and was isolated and placed in a glovebox (0.417 g, 66%). Quantitative formation of **3a** is observed after two hours, as evidenced by following the reaction by ^{1}H and ^{19}F NMR spectroscopy in d_8-THF in a J. Young NMR tube.

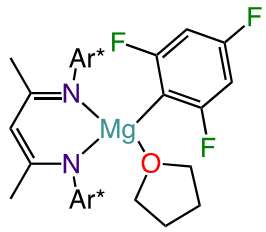
^{1}H NMR (400.13 MHz, d_8-THF, 298 K) δ 7.06 [s, 6H, Ar of ^{Dipp}Nacnac], 6.89 [q, 1H, *J* = 7.6 Hz, $C_6H_3F_2$], 6.40 [dd, 2H *J* = 3.6 Hz, *J* = 8.4 Hz, $C_6H_3F_2$], 4.97 [s, 1H, C*H* of ^{Dipp}Nacnac], 3.27 [m, 4H, C*H*, ^{i}Pr, Ar of ^{Dipp}Nacnac], 1.72 [s, 6H, CH_3 of ^{Dipp}Nacnac], 1.30 [m, 4H, C*H*, ^{i}Pr, Ar of ^{Dipp}Nacnac], 1.13 [d, 12 H, *J* = 4, CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 0.94 [d, 12H, *J* = 8 CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac].

^{13}C NMR {^{1}H} (100.62 MHz, d_8-THF, 298 K) δ 172.2 [dd, *J* = 230, *J* = 30, $C_6H_3F_2$], 168.9 [C_q, CH*C*(Me) of ^{Dipp}Nacnac], 146.1 [*C*, Ar of ^{Dipp}Nacnac], 143.1 [*C*, Ar of ^{Dipp}Nacnac], 128.7 [t, *J* = 8, $C_6H_3F_2$], 125.3 [*C*H, Ar of ^{Dipp}Nacnac], 123.9 [*C*H, Ar of ^{Dipp}Nacnac], 108.7 [dd, *J* = 35, *J* = 4, $C_6H_3F_2$], 95.3 [*C*H of ^{Dipp}Nacnac], 49.9 [*C*H, ^{i}Pr, Ar of ^{Dipp}Nacnac], 28.4 [*C*H, ^{i}Pr, Ar of ^{Dipp}Nacnac], 24.6 [*C*H_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 24.5 [*C*H_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 19.1 [*C*H_3, ^{i}Pr, Ar of ^{Dipp}Nacnac].

^{19}F NMR {^{1}H} (376.40 MHz, d_8-THF, 298 K) δ -82.2 [s, $C_6H_3F_2$].

Elemental analysis: ($C_{39}H_{52}F_2MgN_2O$) *Calculated:* C: 74.69 % H: 8.36 % N: 4.47 %. *Found:* C: 74.55 % H: 8.26 % N: 4.55 %.

- **Synthesis of [(^{Dipp}Nacnac)Mg($C_6H_2F_3$)(THF)] (3b)**



To a solution of **1** (0.28 g, 0.5 mmol) in THF (5 mL), 1,3,5-trifluorobenzene (0.05 mL, 0.5 mmol) was added. The yellow solution was stirred for 2 hours at room temperature. The solvent was removed and 5 mL of hexane were added obtaining a yellow solution that was stored at -70 ^{o}C. After 48 hours a white solid precipitated, and was isolated and placed in a glovebox (0.14 g, 43%). Quantitative formation of **3b** is observed after two hours, as evidenced by following the reaction by ^{1}H and ^{19}F NMR spectroscopy in d_8-THF in a J. Young NMR tube.

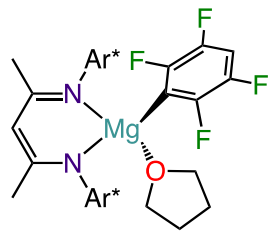
^{1}H NMR (400.13 MHz, d_8-THF, 298 K) δ 7.07 [s, 6H, Ar of ^{Dipp}Nacnac] 6.21 [dd, *J* = 9.8, *J* = 3.4 Hz, 2H, $C_6H_2F_3$], 4.97 [s, 1H, C*H* of ^{Dipp}Nacnac], 3.62 [m, 4H, OCH_2, THF], 3.24 [sept, 4H, *J* = 6.8 Hz, C*H*, ^{i}Pr, Ar of ^{Dipp}Nacnac], 1.77 [m, 4H, CH_2, THF], 1.72 [s, 6H, CH_3 of ^{Dipp}Nacnac], 1.14 [d, 12H, *J* = 6.8 Hz, CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 0.96 [d, 12H, *J* = 5.9 Hz, CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac].

^{13}C NMR {^{1}H} (100.62 MHz, d_8-THF, 298 K) 169.1 [C_q, CH*C*(Me) of ^{Dipp}Nacnac], 146.0 [*C*H, Ar of ^{Dipp}Nacnac], 143.1 [*C*H, Ar of ^{Dipp}Nacnac], 125.4 [*C*H, Ar of ^{Dipp}Nacnac], 124.0 [*C*H, Ar of ^{Dipp}Nacnac], 95.3 [*C*H of ^{Dipp}Nacnac], 68.0 [O*C*H_2, THF], 28.4 [*C*H, ^{i}Pr, Ar of ^{Dipp}Nacnac], 26.3 [*C*H_2, THF], 24.6 [*C*H_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 24.4 [*C*H_3, ^{i}Pr, Ar of ^{Dipp}Nacnac] (C_q of *C*-Mg and $C_6H_2F_3$ were not observed in the spectrum).

^{19}F NMR {^{1}H} (376.40 MHz, d_8-THF, 298 K) δ -82.0 [br, 2F, $C_6H_2F_3$], -116 [s, 1F, $C_6H_2F_3$].

Elemental analysis: ($C_{35}H_{43}F_3MgN_2$) *Calculated:* C: 72.61 % H: 7.97 % N: 4.34 %. *Found:* C: 72.38 % H: 8.42 % N: 5.47 %.

- **Synthesis of [(^{Dipp}Nacnac)Mg(C_6HF_4)(THF)] (3c)**



To a solution of **1** (0.28 g, 0.5 mmol) in THF (5 mL), 1,2,4,5-tetrafluorobenzene (0.056 mL, 0.5 mmol) was added. The yellow solution was stirred for 1 hour at room temperature. The solvent was reduced to 1 mL of THF and the solution was stored at -70 ^{o}C. After 48 hours a crop of colorless crystals yielded the title compound as colourless crystals. In order to obtain a good yield of the compound, after 1 hour of reaction the solvent was removed and 5 mL of hexane were added. A white solid precipitated, and was isolated and placed in a glovebox (0.22 g, 66%). Quantitative formation of **3c** is observed after two hours, as evidenced by following the reaction by ^{1}H and ^{19}F NMR spectroscopy in d_8-THF in a J. Young NMR tube.

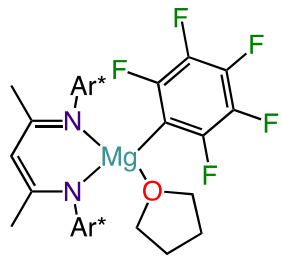
^{1}H NMR (400.13 MHz, d_8-THF, 298 K) δ 7.10 [s, 6H, Ar of ^{Dipp}Nacnac] 6.74 [m, 1H, C_6HF_4], 5.01 [s, 1H, C*H* of ^{Dipp}Nacnac], 3.62 [m, 4H, OCH_2, THF], 3.23 [sept, 4H, *J* = 6.8 Hz, C*H*, ^{i}Pr, Ar of ^{Dipp}Nacnac], 1.77 [m, 4H, CH_2, THF], 1.74 [s, 6H, CH_3 of ^{Dipp}Nacnac], 1.15 [d, 12 H, *J* = 6.8 Hz, CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 0.95 [d, 12H, *J* = 6.4 Hz, CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac].

^{13}C NMR {^{1}H} (100.62 MHz, d_8-THF, 298 K) δ 169.4 [C_q, CH*C*(Me) of ^{Dipp}Nacnac], 145.9 [*C*, Ar], 143.2 [*C*, Ar], 125.6 [*C*H, Ar of ^{Dipp}Nacnac], 124.2 [*C*H, Ar of ^{Dipp}Nacnac], 104.0 [t, *J* = 23 Hz C_6HF_4], 95.5 [*C*H of ^{Dipp}Nacnac], 28.4 [*C*H, ^{i}Pr, Ar of ^{Dipp}Nacnac], 26.3 [*C*H_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 24.2 [*C*H_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], (C_q of *C*-Mg was not observed).

^{19}F NMR {^{1}H} (376.40 MHz, d_8-THF, 298 K) δ -113.5 [br, 2F, C_6HF_4], -140.0 [m, 2F, C_6HF_4].

Elemental analysis: ($C_{35}H_{42}F_4MgN_2$) *Calculated:* C: 70.64 % H: 7.60 % N: 4.22 %. *Found:* C: 70.75 % H: 7.48 % N: 4.60 %.

- **Synthesis of [(^{Dipp}Nacnac)Mg(C_6F_5)(THF)] (3d)**



To a solution of **1** (0.28 g, 0.5 mmol) in THF (5 mL), pentafluorobenzene (0.056 mL, 0.5 mmol) was added. The yellow solution was stirred for 1 hour at room temperature. The solvent was removed and 10 mL of hexane were added obtaining a yellow suspension that was stored at -30 ^{o}C. After 48 hours a white solid precipitated, and was isolated and placed in a glovebox (0.19 g, 56%). Quantitative formation of **3d** is observed after two hours, as evidenced by following the reaction by ^{1}H and ^{19}F NMR spectroscopy in d_8-THF in a J. Young NMR tube.

^{1}H NMR (400.13 MHz, d_8-THF, 298 K) δ 7.10 [s, 6H, Ar of ^{Dipp}Nacnac], 5.02 [s, 1H, C*H* of ^{Dipp}Nacnac], 3.61 [m, 4H, OCH_2, THF], 3.20 [sept, 4H, *J* = 6.8 Hz, C*H*, ^{i}Pr, Ar of ^{Dipp}Nacnac], 1.77 [m, 4H, CH_2, THF], 1.74 [s, 6H, CH_3 of ^{Dipp}Nacnac], 1.15 [d, 12H, *J* = 7.9 Hz, CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 0.96 [d, 12H, *J* = 7.1 Hz, CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac].

^{13}C NMR {^{1}H} (100.62 MHz, d_8-THF, 298 K) δ 169.6 [C_q, CH*C*(Me) of ^{Dipp}Nacnac], 145.7 [*C*H, Ar of ^{Dipp}Nacnac], 143.1 [*C*H, Ar of ^{Dipp}Nacnac], 125.7 [*C*H, Ar of ^{Dipp}Nacnac], 124.2 [*C*H, Ar of ^{Dipp}Nacnac], 95.5 [*C*H of ^{Dipp}Nacnac], 68.1 [O*C*H_2, THF], 28.5 [*C*H, ^{i}Pr, Ar of ^{Dipp}Nacnac], 26.2 [*C*H_2, THF], 24.7 [*C*H_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 24.5 [*C*H_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 24.2 [*C*H_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], (C_q of *C*-Mg and C_6F_5 were not observed in the spectrum.

^{19}F NMR (376.40 MHz, d_8-THF, 298 K) δ -112.8 [br. s, C_6F_5], -160.3 [t, *J* = 19.5Hz $C_6H_2F_3$], -163.6 [m, $C_6H_2F_3$].

Elemental analysis: ($C_{35}H_{41}F_5MgN_2$) *Calculated:* C: 68.77 % H: 7.25 % N: 4.11 %. *Found:* C: 68.86 % H: 7.27 % N: 4.26 %.

DOSY NMR Studies

- **Reaction of [(^{Dipp}Nacnac)MgTMP] (1) with 1,3,5-trifluorobenzene**

In a J. Young's NMR tube, 1,3,5-trifluorobenzene (2.13 µL, 0.02 mmol) was added to a solution of **1** (0.0112 g, 0.02 mmol) in d_8-THF (0.5 mL). 2.75 µL of TMS (tetramethylsilane) were added in order to use as internal standard in the DOSY experiment.[7]

Table S 2: Possible species formed in d_8-THF and the corresponding diffusion coefficient (D), molecular weights (MW) and errors MW_{est}=524 g mol^{-1}.

Compound	D ($m^2 s^{-1}$)	MW_{calc} (g mol^{-1})	Error (%)
[(^{Dipp}Nacnac)Mg($C_6H_2F_3$)] *(a)*	1.373E-9	572	9
[(^{Dipp}Nacnac)Mg($C_6H_2F_3$)(THF)] *(b)*	5.7503E-10	644	23
[(^{Dipp}Nacnac)Mg($C_6H_2F_3$)]$_2$ *(c)*	5.7503E-10	1144	118
(a) ⇌ *(b)*	5.7503E-10	608	16

This experiment suggests that 3b in d_8-THF solution exists as a monomer without THF solvation**.** The findings estimate a molecular weight of 524 g mol^{-1} with an error of 9% for the anticipated monomeric compound where the magnesium atom is coordinated to the β-diketiminate fragment and to the terminal trifluorobenzene ligand (Table S.2). A higher aggregation state, such as a dimeric unit would be inconsistent with the obtained results, as the error value would increase to 118%. Similarly, a THF solvated magnesium β-diketiminate complex would increase the error value to 23%. A lower error of 16% would be obtained for an equilibrium of solvation/desolvation of THF, however, the error of the predicted MW in ECC DOSY method has a maximum of ±9% which would indicate that this equilibrium is not present in solution.

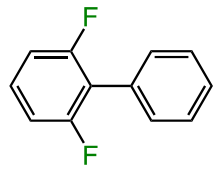
General Experimental Procedure for Metallation Reactions at NMR Tube Scale

Metallation reactions were performed in a J. Young's NMR tube at NMR scale following the following procedure. In a glovebox, the NMR tube was filled with 0.2 mmol of base **1**, 10 mol% of ferrocene (0.0035 g, 0.02 mmol) as internal standard and 0.409 g of d_8-THF. The initial ratio of base calculated by integration in ^{1}H NMR relative to the ferrocene. 0.2 mmol of fluoroaromatic derivative, was introduced and the reactions times were measured from this point in regular intervals of time until full conversion by ^{1}H NMR spectrum. All the yields were calculated by integration of the products relative to the ferrocene in the ^{1}H NMR spectrum. The NMR spectra of the compounds correspond to the isolated species obtained for compounds **3a** to **3e**.

General Experimental Procedure for Negishi Cross-Coupling Reactions

To an oven dried Schlenk **1** (0.56 g, 1 mmol) and the fluoroaromatic derivative (1 mmol) were dissolved in THF (5 mL) during 2 hours at room temperature. $ZnCl_2$ (0.14 g, 1 mmol) was then added and the solution was stirred at room temperature during one hour. 5 mol% of $Pd(PPh_3)_4$ (0.058 g) and iodobenzene (1.25 or 2 mmol) were added and the solution was refluxed during 18 hours. After this time the solution was opened to air. NH_4Cl was added and the solution was extracted with ethyl acetate (30 mL x 2) and brine (20 mL x 3). The solution was then dried over $MgSO_4$, and the filtrate was evaporated *in vacuo*. The compound was purified by chromatographic column (silica gel, petroleum ether 40 – 60 ^{o}C).

- **Synthesis of 2,6-difluorobiphenyl (4a)**



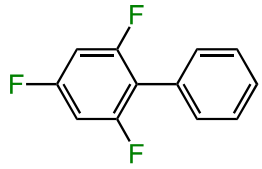
The reaction was performed starting from **3a** (0.627 g, 1 mmol). 10 mol% of $Pd(PPh_3)_4$ (0.1167 g) and iodobenzene (0.416 g, 2 mmol) were also employed. 64% isolated yield (0.122 g) was obtained for compound **4a**. Spectra are in agreement with those previously reported.[8]

^{1}H NMR (400.13 MHz, $CDCl_3$, 298 K) δ 7.45 [m, 5H, C_6H_5], 7.30 [m, 1H, C*H*CH_2CF of $C_6H_3F_2$], 7.02 [m, 2H, C*H*CF of $C_6H_3F_2$].

^{13}C NMR {^{1}H} (100.6 MHz, $CDCl_3$, 298 K) δ 160.3 [dd, *J* = 10.8 Hz, *J* = 249.9, C_q, *C*F of $C_6H_3F_2$], 130.4 [*C*H], 129.3 [C_q, *C*CF of C_6H_5], 129.0 [*C*H], 128.4 [*C*H], 128.3 [*C*H], 118.6 [C_q, *C*CF of $C_6H_3F_2$], 111.8 [m, *C*H, *C*HCF of $C_6H_3F_2$].

^{19}F NMR {^{1}H} (376.40 MHz, $CDCl_3$, 298 K) δ -114.5 [s, 2F].

- **Synthesis of 2,4,6-trifluorobiphenyl (4b)**



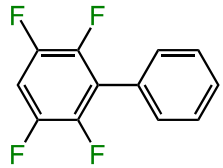
In this reaction 2 equivalents of iodobenzene (0.416 g, 2 mmol) were employed. 63% isolated yield (0.129 g) was obtained for compound **4b**. Spectra are in agreement with those previously reported.[8]

^{1}H NMR (400.13 MHz, $CDCl_3$, 298 K) δ 7.45 [m, 5H, C_6H_5], 6.76 [m, 2H, $C_6H_2F_3$].

^{13}C NMR {^{1}H} (100.6 MHz, $CDCl_3$, 298 K) δ 161.7 [dt *C*F of $C_6H_2F_3$, *J* = 250.0 and 14.9 Hz], 160.3 [dm *C*F of $C_6H_2F_3$, *J* = 248.7 Hz], 130.4 [*C*H of C_6H_5], 128.5 [*C*H of C_6H_5], 115.1 [m C_q of $C_6H_2F_3$] 100.6 [m, *C*H of $C_6H_2F_3$].

^{19}F NMR (376.40 MHz, $CDCl_3$, 298 K) δ -109.0 [m, 2F, $C_6H_2F_3$], -101.3 [t, 1F, *J* = 6.5 Hz $C_6H_2F_3$].

- **Synthesis of 2,3,5,6-tetrafluorobiphenyl (4c)**



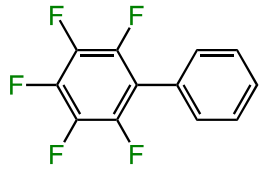
In this reaction 1.25 equivalents of iodobenzene (0.260 g, 1.25 mmol) were employed. 65% isolated yield (0.145 g) was obtained for compound **4c**. Spectra are in agreement with those previously reported.[8]

^{1}H NMR (400.13 MHz, $CDCl_3$, 298 K) δ 7.49 [m, 5H, C_6H_5], 7.07 [m, 1H, C_6HF_4].

^{13}C NMR {^{1}H} (100.6 MHz, $CDCl_3$, 298 K) δ 146.4 [dm *C*F of $C_6H_2F_3$, *J* = 241.4 Hz], 143.2 [dm *C*F of $C_6H_2F_3$, *J* = 238.9 Hz], 130.2 [*C*H of C_6H_5], 129.3 [*C*H of C_6H_5], 128.7 [*C*H of C_6H_5], 127.6 [C_q], 121.6 [C_q], 104.9 [t, *C*H of C_6HF_4, *J* = 24.6 Hz].

^{19}F NMR (376.40 MHz, $CDCl_3$, 298 K) δ -139.2 [m, 2F, C_6HF_4], -143.9 [m, 2F, C_6HF_4].

- **Synthesis of 2,3,4,5,6-pentafluorobiphenyl (4d)**



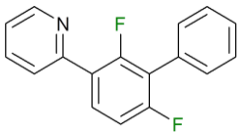
In this reaction 1.25 equivalents of iodobenzene (0.260 g, 1.25 mmol) were employed. 68% isolated yield (0.166 g) was obtained for compound **4d**. Spectra are in agreement with those previously reported.[8]

^{1}H NMR (400.13 MHz, $CDCl_3$, 298 K) δ 7.54-7.39 [m, 5H, C_6H_5].

^{13}C NMR {^{1}H} (100.6 MHz, $CDCl_3$, 298 K) δ 144.3 [dm *C*F of $C_6H_2F_3$, *J* = 255.3 Hz], 140.5 [dm *C*F of $C_6H_2F_3$, *J* = 253.2 Hz], 138.9 [dm *C*F of $C_6H_2F_3$, *J* = 242.5 Hz] 130.2 [*C*H of C_6H_5], 129.4 [*C*H of C_6H_5], 128.9 [*C*H of C_6H_5], 126.6 [C_q of C_6H_5], 116.1 [t, C_q of C_6F_5].

^{19}F NMR {^{1}H} (376.40 MHz, $CDCl_3$, 298 K) δ -143.2 [m, C_6F_5], -155.6 [m, C_6F_5], -162.2 [m, C_6F_5].

- **Synthesis of 2-(2,4-difluoro-3-phenyl-phenyl)pyridine (4e)**



In this reaction 2 equivalents of iodobenzene (0.416 g, 2 mmol) were employed. 68% isolated yield (0.182 g) was obtained for compound **4e**.

^{1}H NMR (400.13 MHz, $CDCl_3$, 298 K) δ 8.75 [dt, 1H, Ar-*H*], 7.98 [td, 1H, Ar-*H*], 7.78 [m, 2H, 2Ar-*H*], 7.48 [m, 5H, 5Ar-*H*], 7.29 [m, 1H, Ar-*H*] and 7.14 ppm [dt, 1H, Ar-*H*].

^{13}C NMR {^{1}H} (100.6 MHz, $CDCl_3$, 298 K) δ 160.4 [dd, *C*F of ArCF], 157.7 0 [dd, Ar*C*F], 153.1 [quaternary C], 150.0 [ArCH], 136.6 [ArCH], 132.2 [t, quaternary C], 130.7 [ArCH], 130.5 [ArCH], 129.4 [quaternary C], 128.4 [ArCH], 124.5 [d ArCH], 122.6 [ArCH], 118.9 [quaternary C], 112.1 [dd ArCH].

^{19}F NMR {^{1}H} (376.40 MHz, $CDCl_3$, 298 K) δ -113.1 [m, C_6F_2], -117.6 [m, C_6F_2].

C-F Activation 2-(2,4-difluorophenyl)pyridine

To a solution of **2** (0.28 g, 0.5 mmol) in toluene (5 mL), 2-(2,4-difluorophenyl)pyridine (0.1 g, 0.5 mmol) was added. The yellow solution was stirred for 24 hours at room temperature. The solvent was removed and 5 mL of hexane were added obtaining a white solid precipitate **5**, which was isolated and placed in a glovebox. The solvent from the filtrate was removed and placed into the glovebox. C_6D_6 was then added as well as ferrocene (9.5 mg, 0.05 mmol). The ^{1}H NMR spectrum suggests the presence of a 92% of compound **7a** from the integration versus ferrocene. ^{1}H, ^{13}C and ^{19}F NMR experiments are in agreement with the literature.[9,10]

- **Synthesis of [^{Dipp}NacnacMg(F)] (5)**[9]

^{1}H NMR (400.13 MHz, C_6D_6, 298K) δ 7.06 [br. m, 12H, Ar of ^{Dipp}Nacnac], 4.84 [s, 2H, C*H* of ^{Dipp}Nacnac], 3.01 [m, 8H, C*H*, ^{i}Pr, Ar of ^{Dipp}Nacnac], 1.49 [s, 12H, C*H*3 of ^{Dipp}Nacnac], 1.10 [d, 24H, , *J* = 6.8 Hz, C*H*3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 0.96 [d, 24H, , *J* = 7.6 Hz, C*H*3, ^{i}Pr, Ar of ^{Dipp}Nacnac].
^{19}F {^{1}H} NMR (376.40 MHz, C_6D_6, 298K) δ -188.1 [s, 2F].

- **Synthesis of 2-(2-butyl-4-fluorophenyl)pyridine (7a)**[10]

^{1}H NMR (400.13 MHz, $CDCl_3$, 298K) δ 8.67 [d, *J* = 5.1 Hz, 1H], 7.72 [td, *J* = 1.9 Hz, *J* = 7.6 Hz, 1H], 7.32 [m, 2H], 7.23 [m, 1H], 7.00 [m, 1H], 6.95 [m, 1H], 2.68 [m, 2H, CH_2 of Bu], 1.43 [m, 2H, CH_2 of Bu], 1.21 [m, 2H, CH_2 of Bu], 0.78 (t, *J* = 7.5 Hz, 3H, CH_3 of Bu]. In agreement with reported data.[8]
^{19}F {^{1}H} NMR (376.40 MHz, C_6D_6, 298K) δ -114.4 [s, 1F]. In agreement with reported data.[10]

- **Synthesis of 2-(2-phenyl-4-fluorophenyl)pyridine (7b)**[10]

In a similar experiment [^{Dipp}NacnacMg(C_6H_5)THF] (**13**) (74 mg, 0.125 mmol) was reacted with ppf (25 mg, 0.125 mmol) in deuterated toluene (0.5 mL) in a J. Young NMR tube at 60°C for 72 hours, and reaction was monitored by ^{1}H and ^{19}F NMR spectroscopy. Comparison of the resulting resonances in the ^{1}H NMR spectrum, against ferrocene as an internal standard reveal formation of **7b** in an 82% yield.**^{1}H NMR (400.13 MHz, *d*$_8$-toluene, 298K)** ; δ 8.50 [d, *J* = 5.4 Hz, 1H], 7.74 [m, 1H], 7.13 [m, 1H], 7.0 [m, 5H], 6.90 [td, *J* = 8.4 and 3.1 Hz, 1H], 6.80 [td, *J* = 7.7 and 1.50 Hz, 1H], 6.66 [dt; *J* = 8.4 Hz, 1H], 6.57 [m, 1H]. In agreement with reported data.[8]
^{19}F {^{1}H} NMR (376.40 MHz, *d*$_8$-toluene, 298K) δ -114.0 [s, 1F]. In agreement with reported data.[10]

- **Synthesis of 2-(2-{C_8H_5O}-4-fluorophenyl)pyridine (7c)**

[^{Dipp}NacnacMgTMP] (**1**) (140 mg, 0.25 mmol) and 2,3-benzofuran (28 μL, 0.25 mmol) was stirred in THF 2 mL for 2 hours. All volatiles were removed *in vacuo* and the resulting residue stirred in pentane, before solvent removal to ensure all remaining THF is removed. A solution of **ppf** (46 mg 0.25 mol) in toluene (3 mL) was added and then reacted at 60 ^{o}C for 72 hours. The reaction was

quenched with water and **7c** was isolated as a viscous pale yellow oil in 71% yield (43 mg) after purification via flash column chromatography, eluting with hexane:EtOAc (10:1).

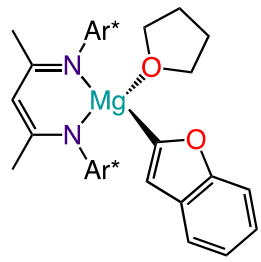
^{1}H NMR (400.13 MHz, $CDCl_3$, 298 K): δ 8.73 [m, 1H, Ar-H], 7.68 [m, 2H, Ar-H], 7.54 [dd, 1H, *J* = 8.5 and 5.4 Hz, Ar-H], 7.44 [d, 1H, *J* = 7.2 Hz, Ar-H], 7.40 [d, 1H, *J* = 8.1 Hz, Ar-H], 7.30 [m, 3H,Ar-H], 7.20 [2H. m, Ar-H], 6.17 [s, 1H, Ar-H of C_5H_5O]

^{13}C NMR {^{1}H} (100.62 MHz, $CDCl_3$, 298 K): δ 161.7 [d Ar-CF], 157.8 [quaternary-C], 153.5 [quaternary-C], 152.7 [quaternary-C], 148.7 [Ar-CH], 135.3 [Ar-CH], 134.5 [d, *J* = 3.4 Hz, quaternary-C], 131.6 [d, *J* = 8.9 Hz, Ar-CH], 130.1 [d, *J* = 8.9 Hz, quaternary-C], 127.8 [quaternary-C], 123.8 [Ar-CH], 123.5 [Ar-CH], 122.0 [Ar-CH], 121.4 [Ar-CH], 120.2 [Ar-CH], 114.6 [d, *J* = 21.3 Hz, Ar-CH], 114.2 [d, *J* = 23.9 Hz, Ar-CH], 110.2 [Ar-CH], 105.1 [CH of C_8H_5O].

^{19}F NMR (376.40 MHz, d_8-toluene, 298K): δ -113.2 [s, 1F].

HR-MS (ESI): *m/z* calcd. for $[M]^+$ $C_{19}H_{12}FNO$ = 290.0976. Found 290.0974

- **Synthesis of [{(^{Dipp}Nacnac)MgTHF{C_8H_5O}] (8)**



To a solution of compound **1** (0.56 g, 1 mmol) in THF (10 mL), benzofuran (0.11 mL, 1 mmol) was added. The dark yellow solution was stirred for 2 hours at room temperature. The solvent was removed and a mixture of 3 mL of hexane and 4 mL of toluene were added. The suspension was warmed until a solution was obtained, then placed at -33 ^{o}C. After 48 hours a crop of colourless crystals were isolated and placed in a glovebox (0.329g, 59%). In order to improve yield of the compound, after 5 hours of reaction the solvent was removed and 10 mL of hexane were added, the suspension was placed at -33 ^{o}C. The resulting solid was isolated and placed in a glovebox (0.413g, 74%).

^{1}H NMR (400.13 MHz, C_6D_6, 298 K) δ 7.55 [br. d, 1H, C_8H_5O], 7.45 [br. d, 1H, C_8H_5O], 7.13 [s, 6H, Ar of ^{Dipp}Nacnac], 7.07 [m, 2H, C_8H_5O], 6.64 [d, 1H, *J* = 4 Hz, C_8H_5O], 4.90 [s, 1H,C*H*], 3.45 [br. m, 4H, C*H*, ^{i}Pr, Ar of ^{Dipp}Nacnac], 1.72 [s, 6H, CH_3 of ^{Dipp}Nacnac], 1.21 [d, 12 H, *J* = 8 Hz, CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 1.18 [br. m, 6H, CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 1.09 [br. m, 6H, CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac].

^{13}C NMR {^{1}H} (100.62 MHz, C_6D_6, 298 K) δ 192.8 [C_q, Mg-C_α of C_8H_5O], 168.9 [C_q, CH*C*(Me) of ^{Dipp}Nacnac], 159.9 [C_q of C_8H_5O], 145.4 [*C*H, Ar of ^{Dipp}Nacnac], 142.9 [*C*, Ar of ^{Dipp}Nacnac], 130.6 [C_q of C_8H_5O], 125.5 [*C*H, Ar of ^{Dipp}Nacnac], 124.0 [*C*H, Ar of ^{Dipp}Nacnac], 121.2 [*C*H of C_8H_5O], 120.9 [*C*H of C_8H_5O], 119.6 [*C*H of C_8H_5O], 119.1 [*C*H of C_8H_5O], 110.4 [*C*H of C_8H_5O], 94.7 [*C*H of ^{Dipp}Nacnac], 69.8 [C_q, ^{i}Pr, Ar of ^{Dipp}Nacnac], 28.4 [*C*H, ^{i}Pr, Ar of ^{Dipp}Nacnac], 25.2 [CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 25.0 [CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 24.6 [CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac], 24.1 [CH_3, ^{i}Pr, Ar of ^{Dipp}Nacnac].

Elemental analysis: ($C_{37}H_{46}MgN_2O$) *Calculated:* C: 79.49 % H: 8.29 % N: 4.35 %. *Found:* C: 79.53 % H: 9.06 % N: 4.70 %.

NMR spectra of compounds

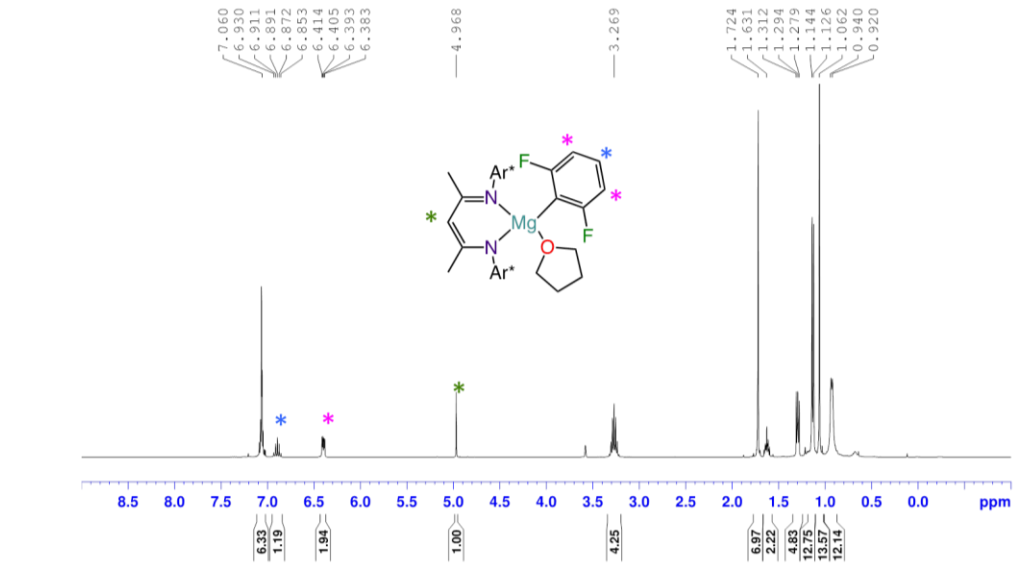


Figure 1: ^{1}H NMR spectrum of **3a** in d_8-THF.

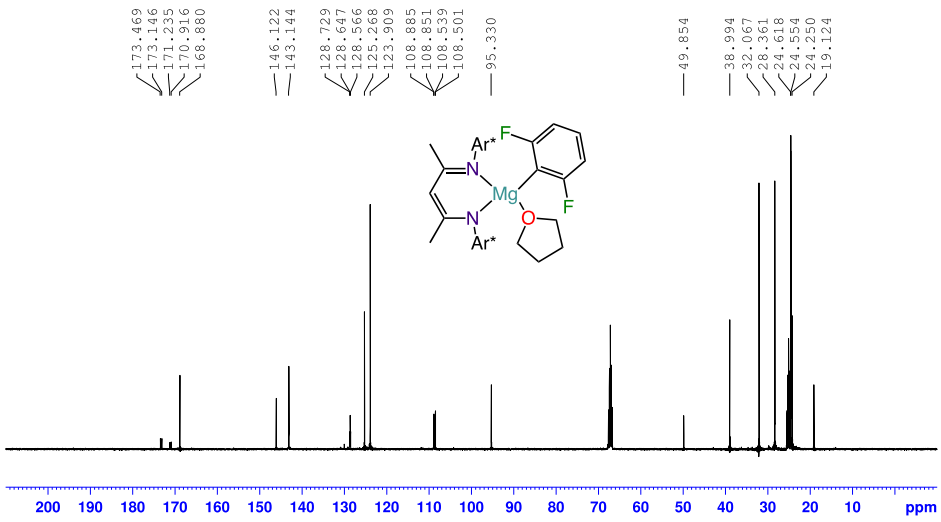


Figure 2: ^{13}C NMR spectrum of **3a** in d_8-THF.

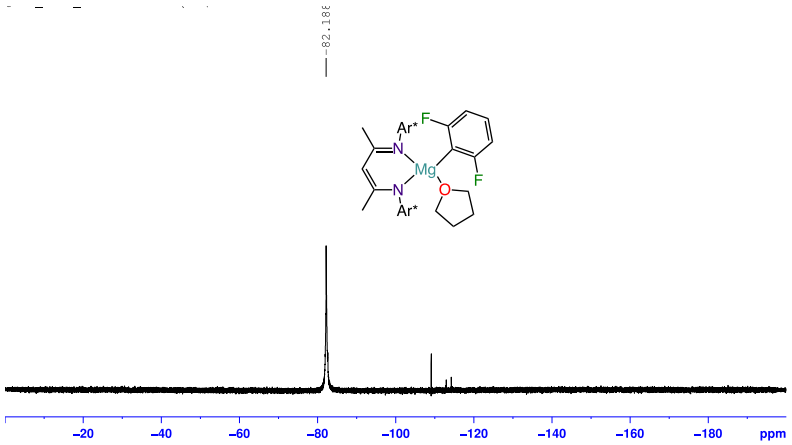


Figure 3: ^{19}F NMR spectrum of **3a** in d_8-THF.

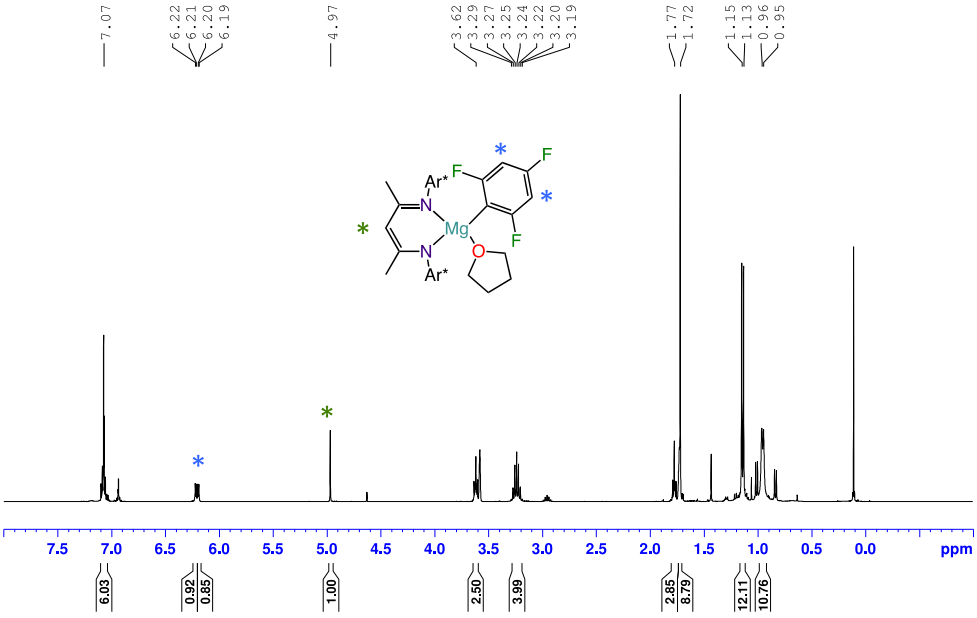


Figure 4: ^{1}H NMR spectrum of **3b** in d_8-THF

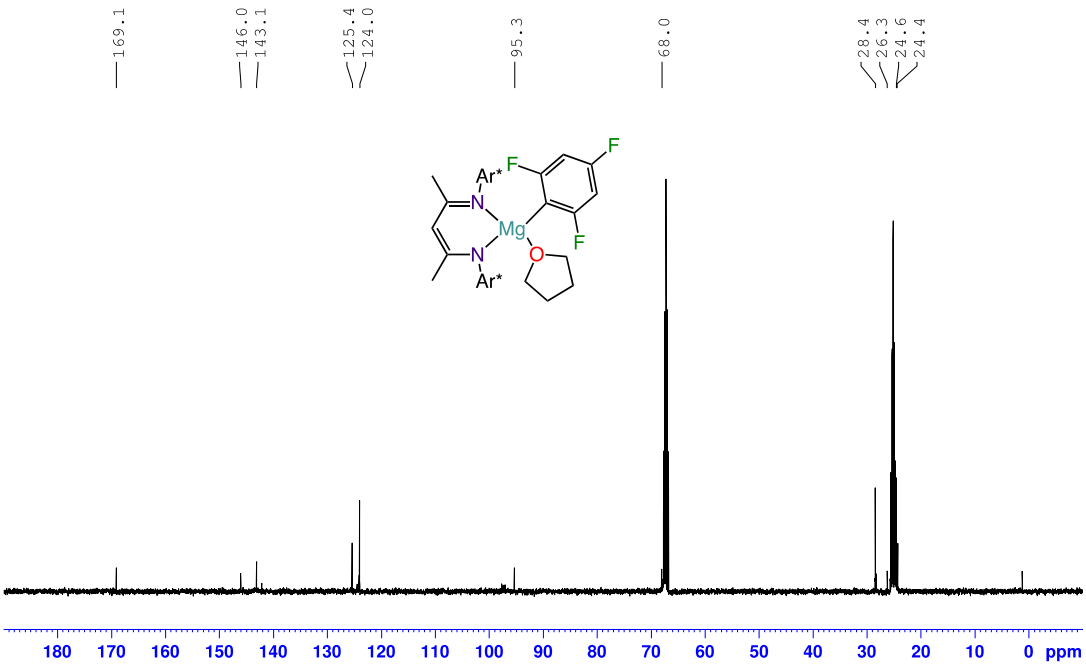


Figure 5: ^{13}C NMR spectrum of **3b** in d_8-THF.

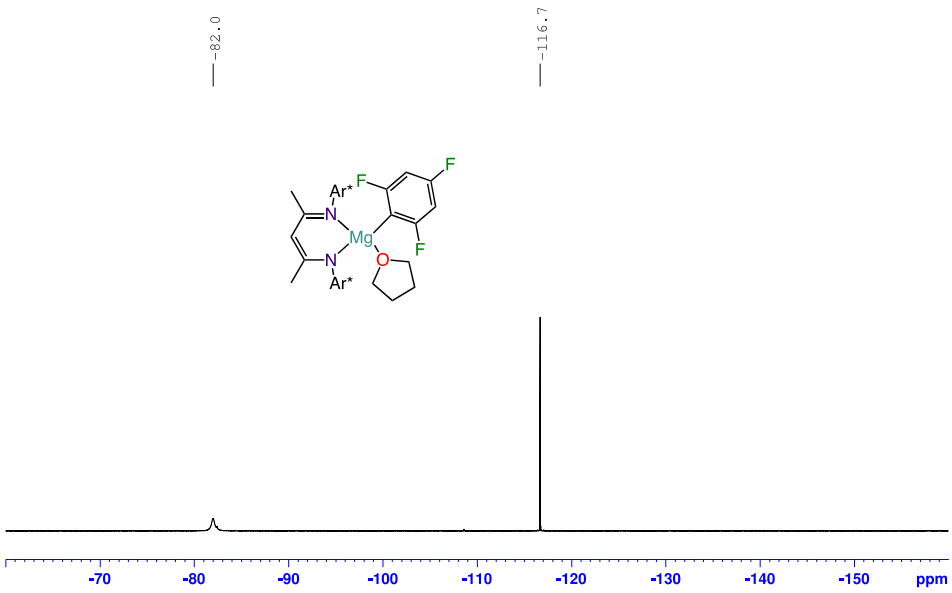


Figure 6: ^{19}F NMR spectrum of **3b** in d_8-THF.

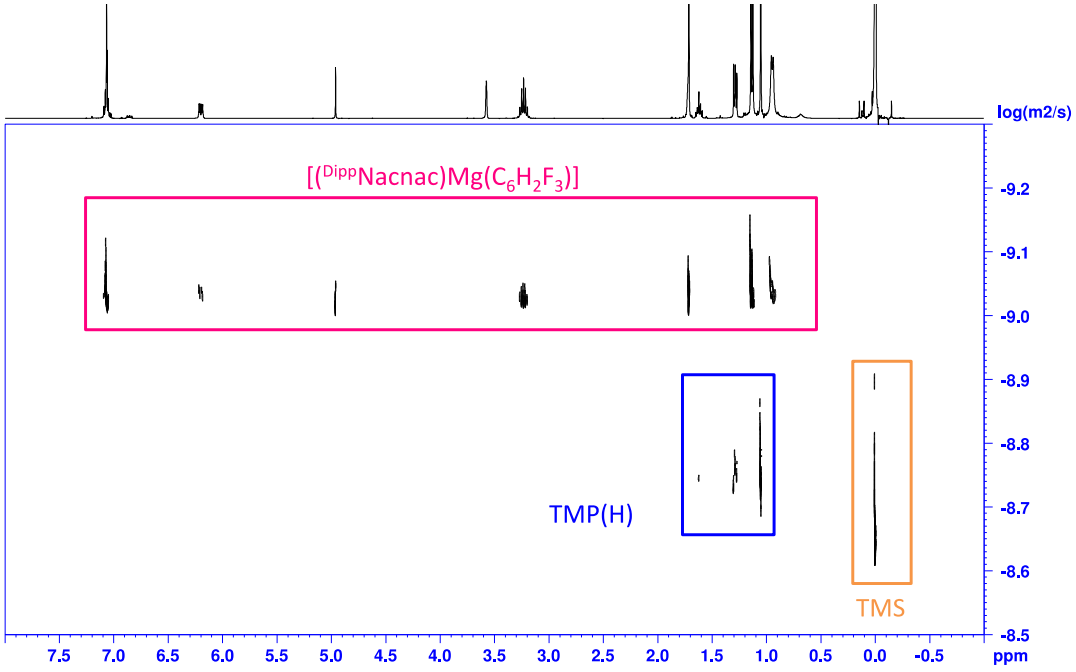


Figure 7: ^{1}H DOSY NMR spectrum of 3b in d_8-THF.

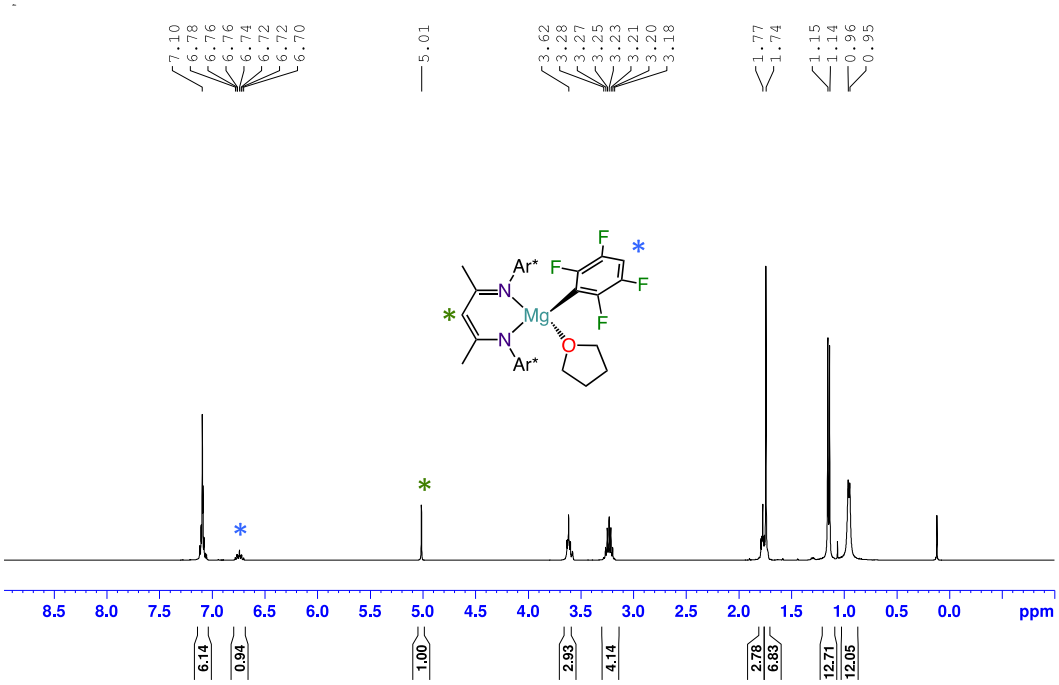


Figure 8: ^{1}H NMR spectrum of 3c in d_8-THF.

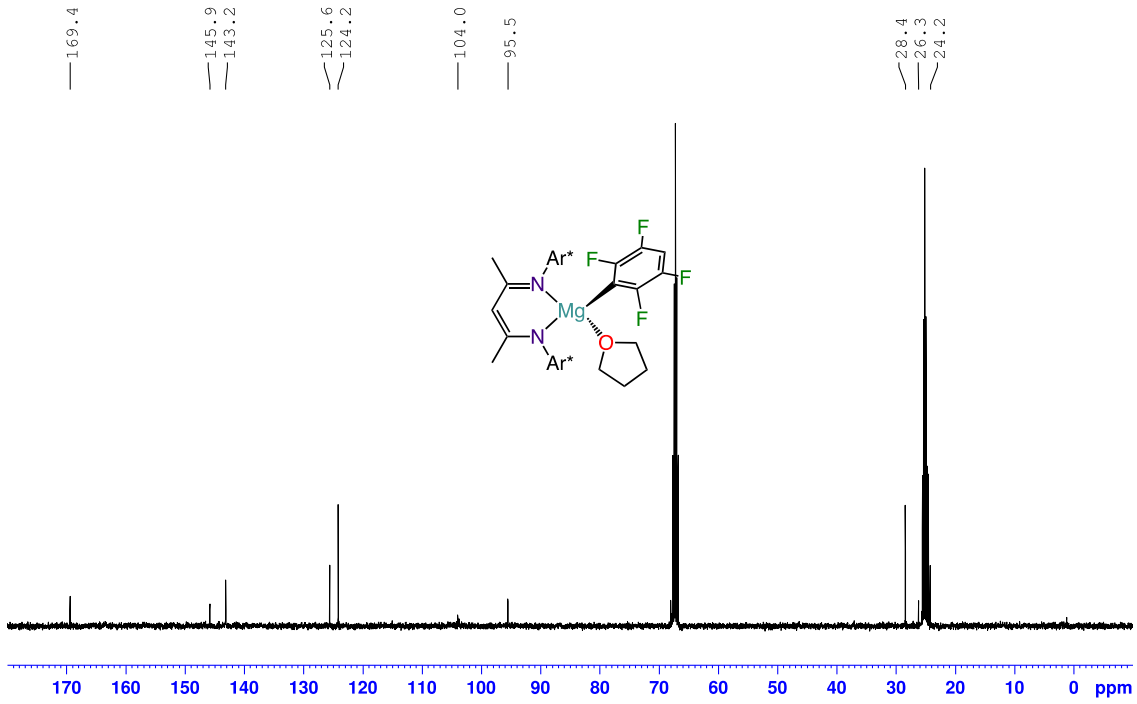


Figure 9: ^{13}C NMR spectrum of **3c** in d_8-THF.

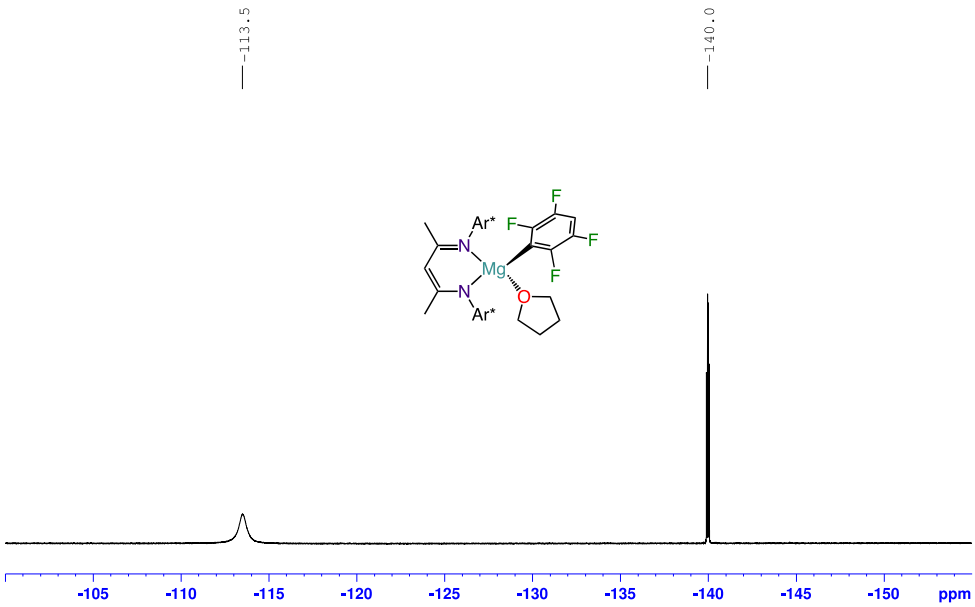


Figure 10: ^{19}F NMR spectrum of **3c** in d_8-THF.

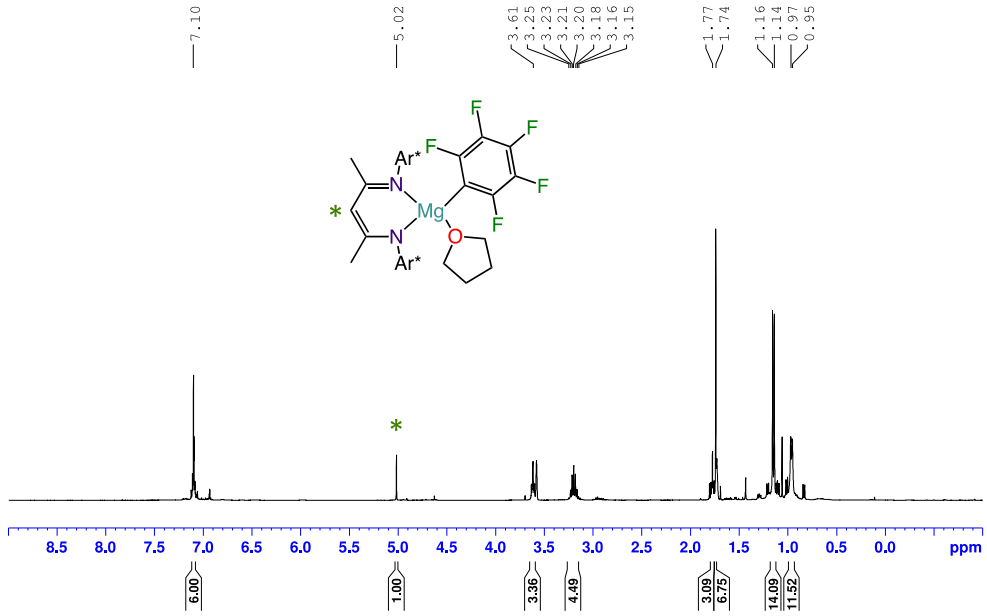


Figure 11: ^{1}H NMR spectrum of **3d** in d_8-THF.

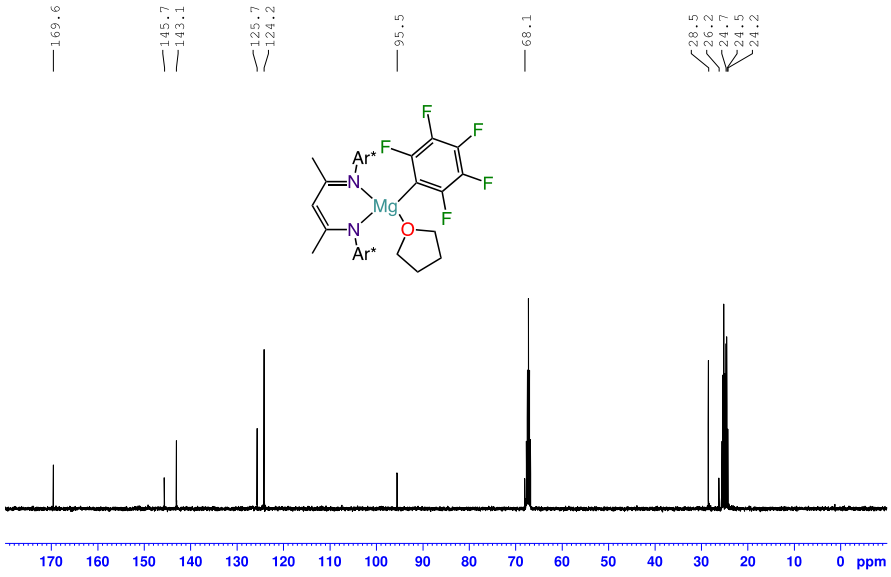


Figure 12: ^{13}C NMR spectrum of **3d** in d_8-THF.

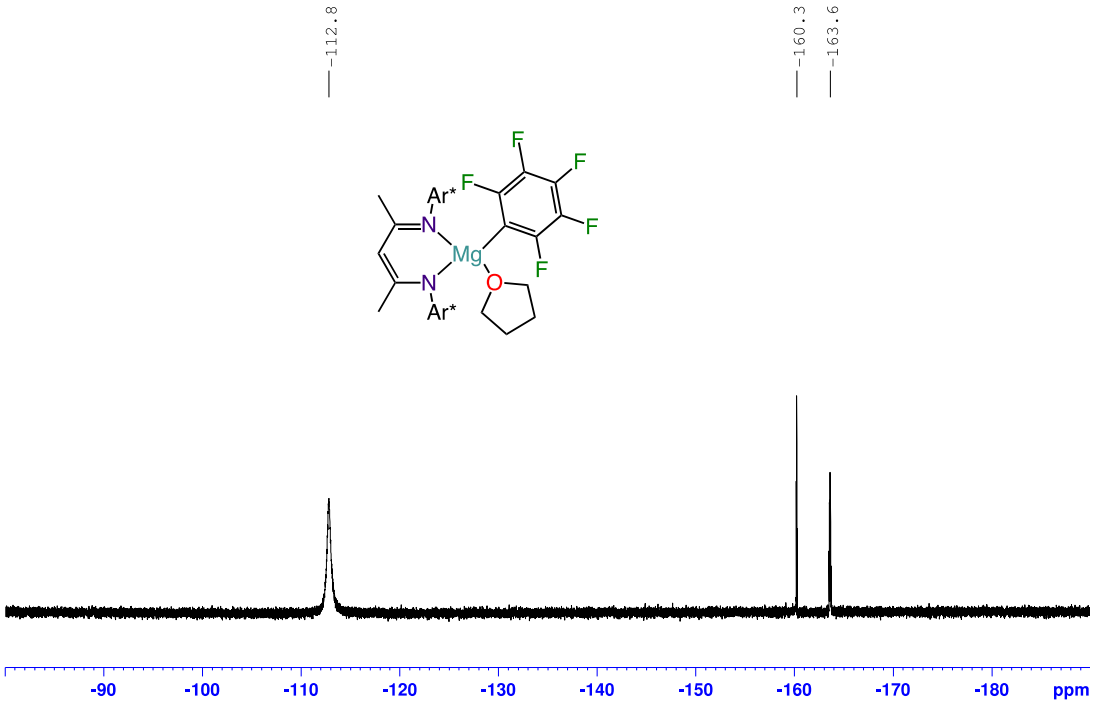


Figure 13: ^{19}F NMR spectrum of **3d** in d_8-THF.

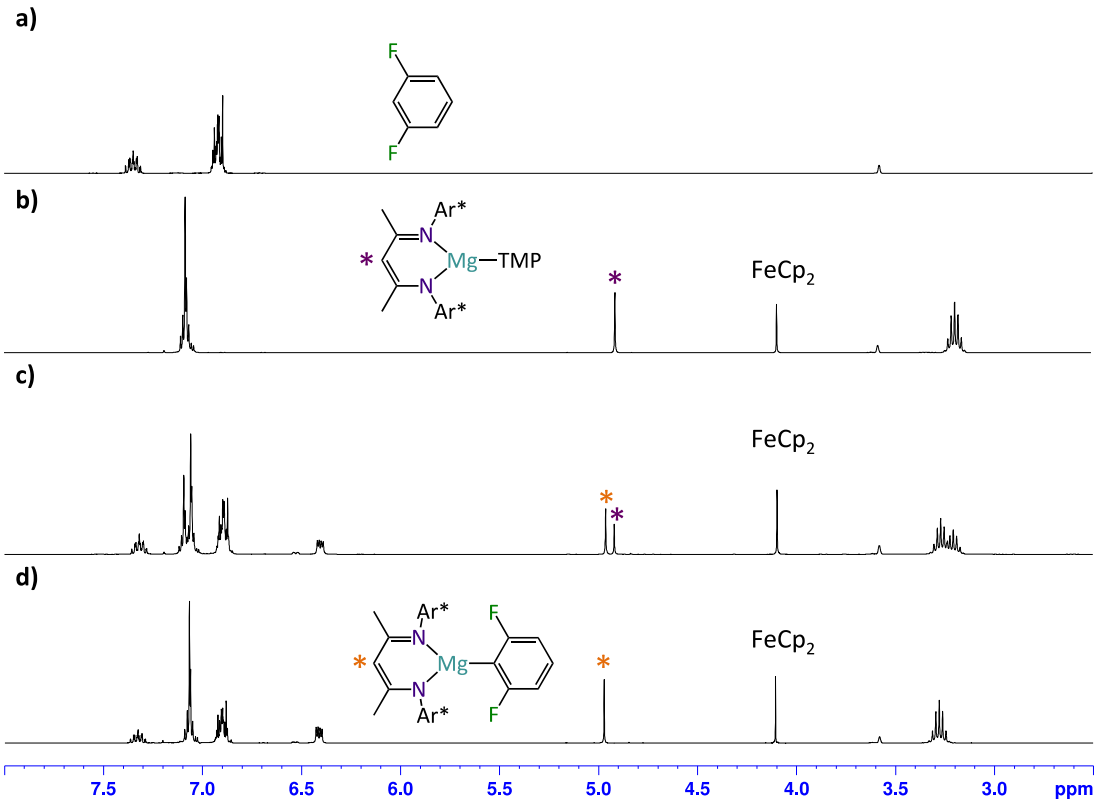


Figure 14: a) ^{1}H NMR spectrum of 1,3-difluorobenzene in d_8-THF. b) ^{1}H NMR spectrum of base **1** in d_8-THF. c) ^{1}H NMR spectrum for the reaction of **1** (0.2 mmol) and 1 equivalent of $C_6H_4F_2$ (0.2 mmol) at RT in d_8-THF after 30 min, mixture of **1** and **3a**. d) ^{1}H NMR spectrum for the reaction of **1** (0.2 mmol) and 1 equivalent of $C_6H_4F_2$ (0.2 mmol) at RT in d_8-THF after 2 hours, formation of **3a**.

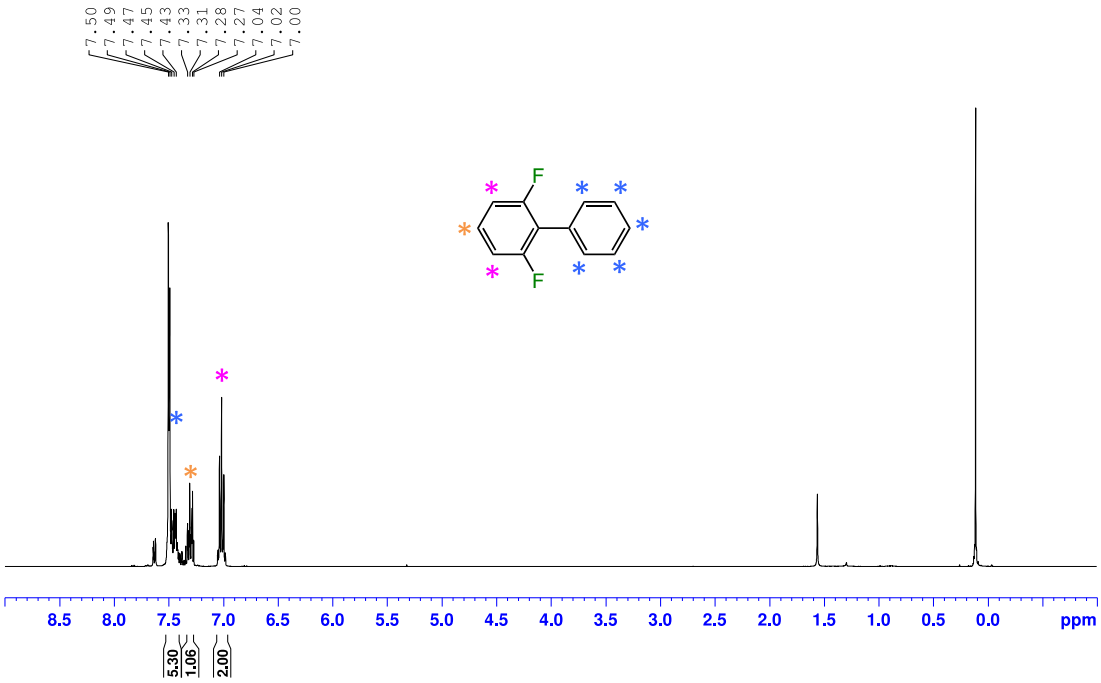


Figure 15: ^{1}H NMR spectrum of **4a** in $CDCl_3$.

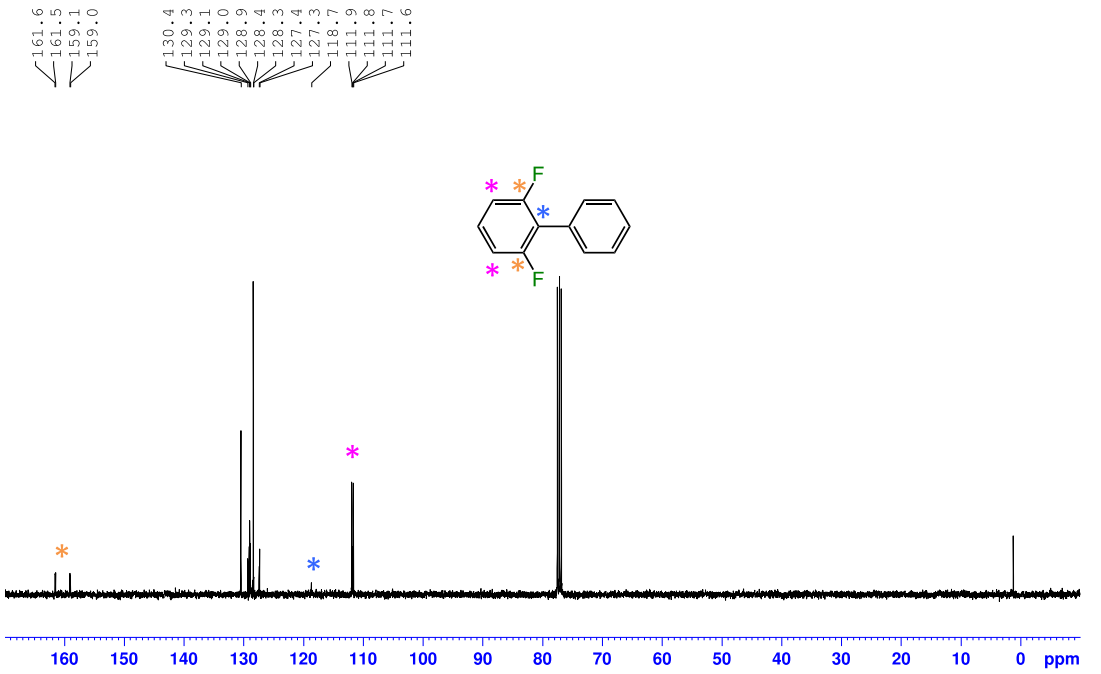


Figure 16: ^{13}C NMR spectrum of **4a** in $CDCl_3$.

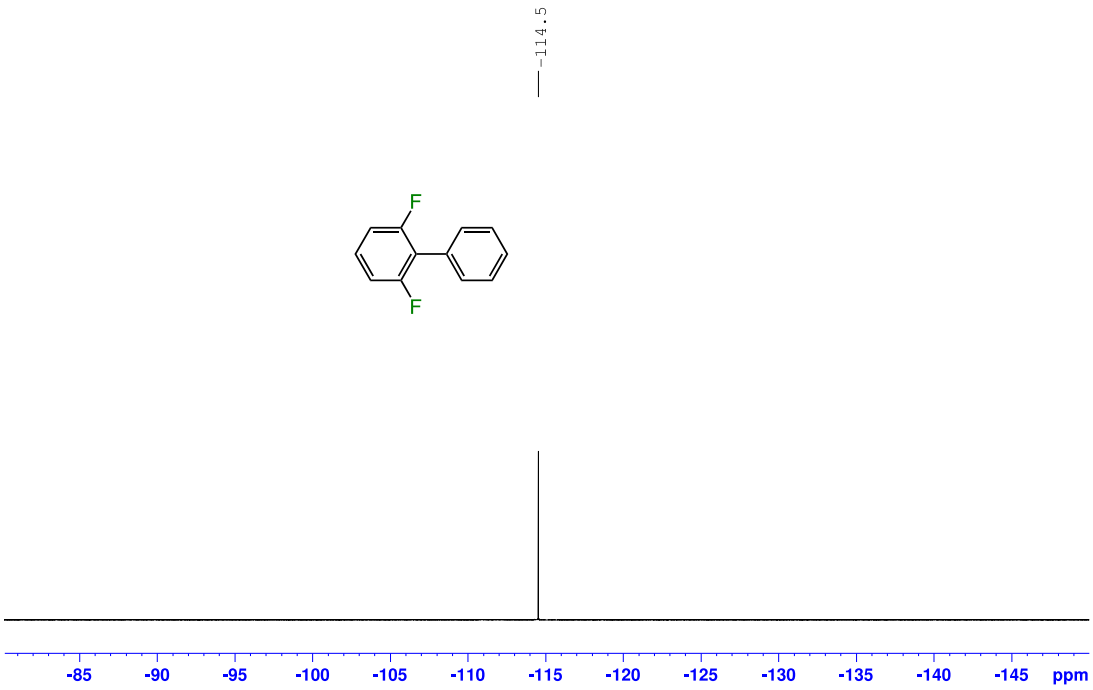


Figure 17: ^{19}F NMR spectrum of **4a** in $CDCl_3$.

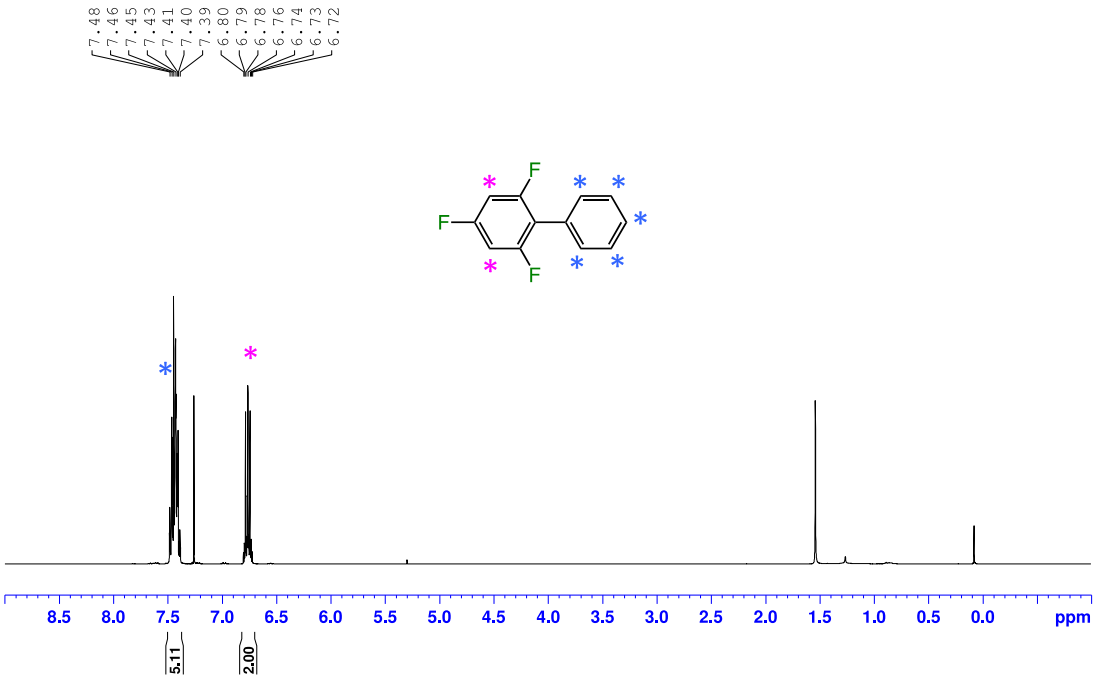


Figure 18: ^{1}H NMR spectrum of **4b** in $CDCl_3$.

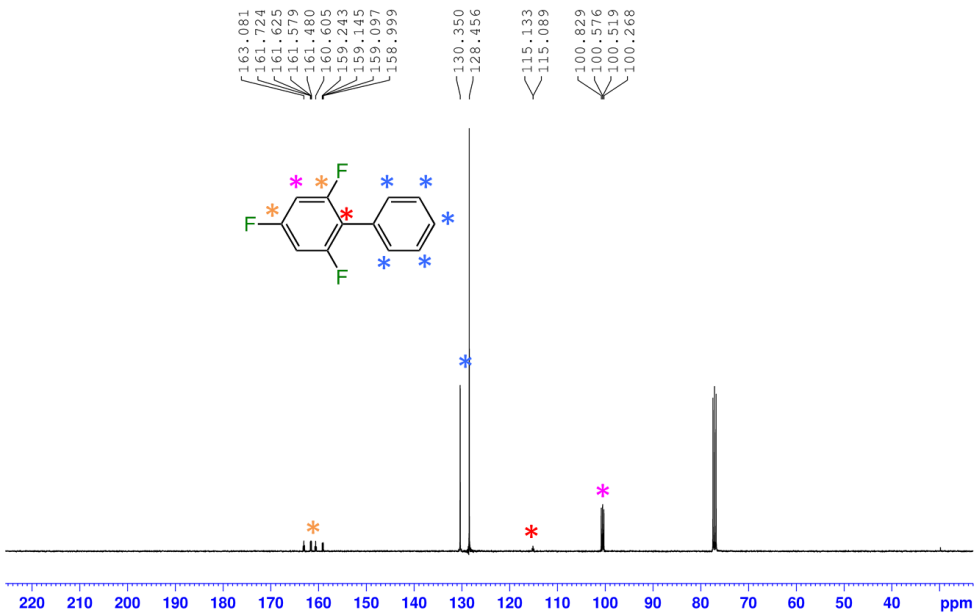


Figure 19: ^{13}C NMR spectrum of **4b** in $CDCl_3$.

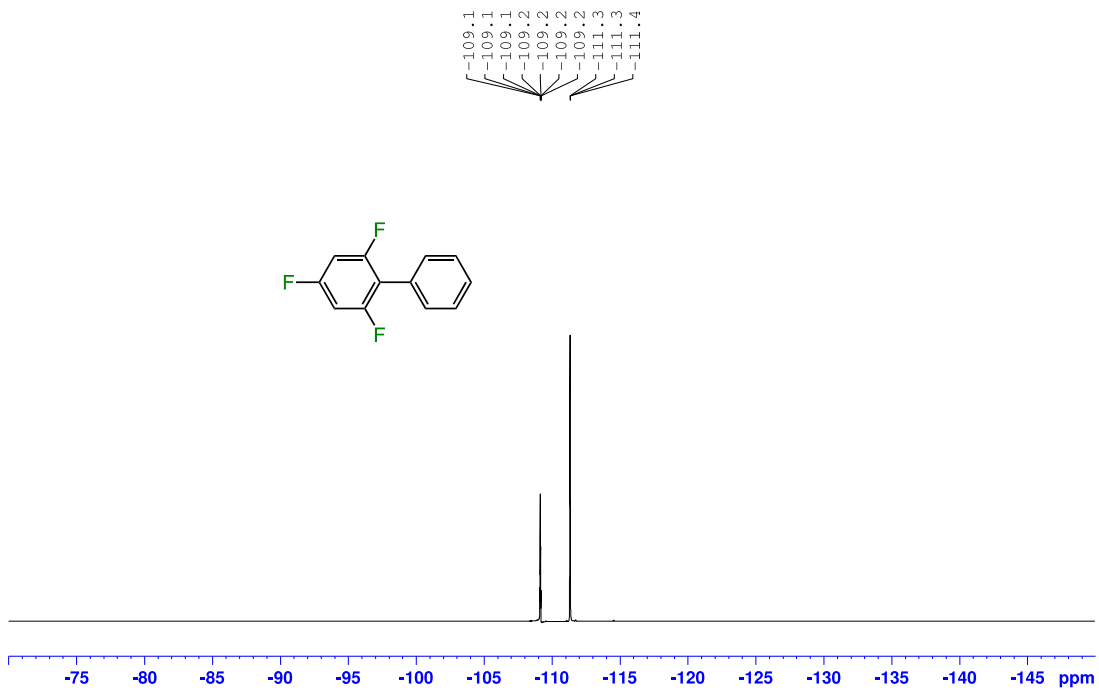


Figure 20: ^{19}F NMR spectrum of **4b** in $CDCl_3$.

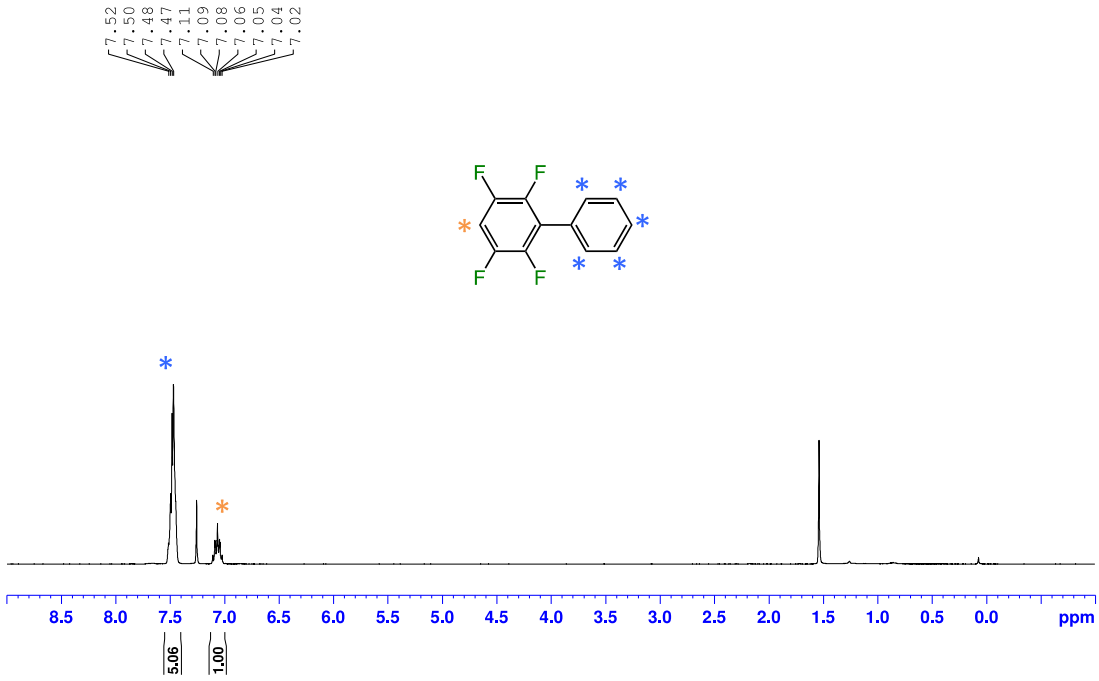


Figure 21: ^{1}H NMR spectrum of **4c** in $CDCl_3$.

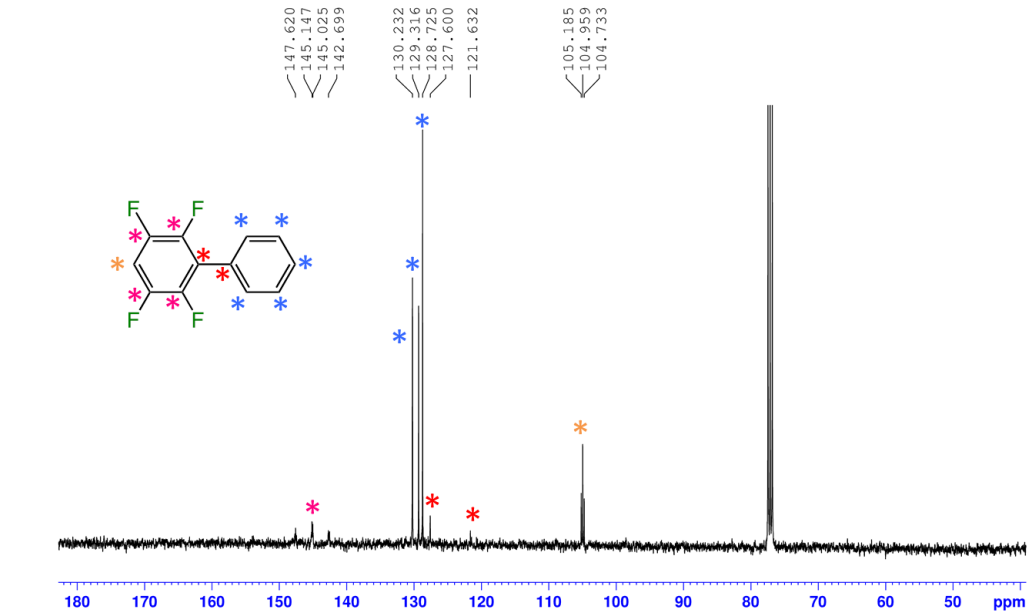


Figure 22: ^{13}C NMR spectrum of **4c** in $CDCl_3$.

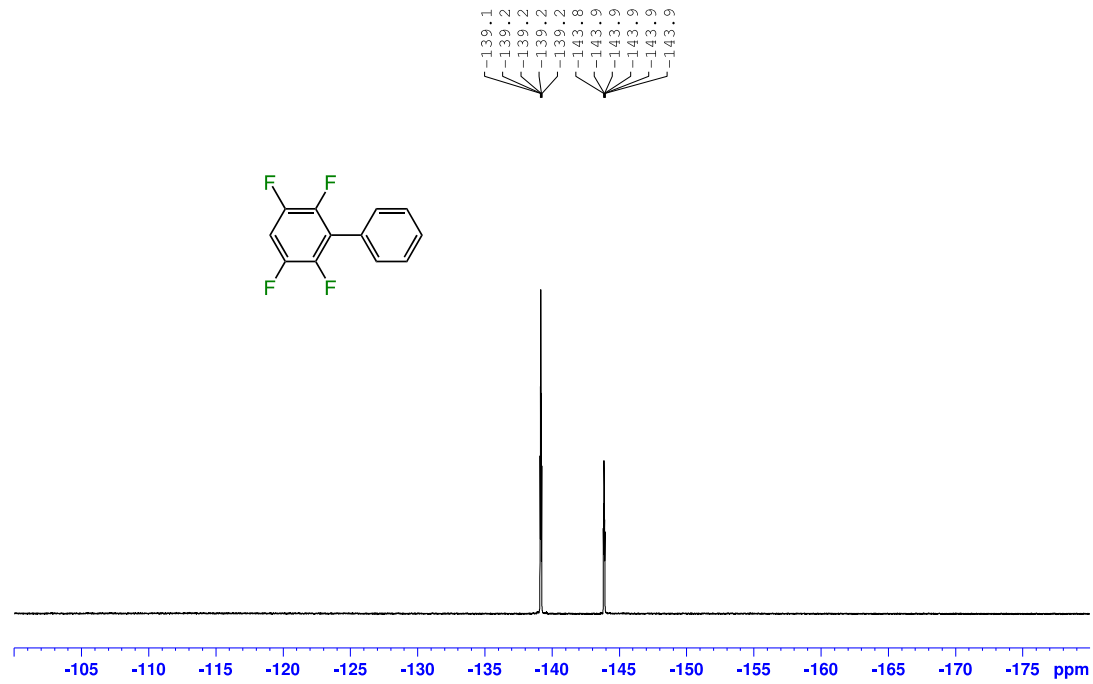


Figure 23: ^{19}F NMR spectrum of **4c** in $CDCl_3$.

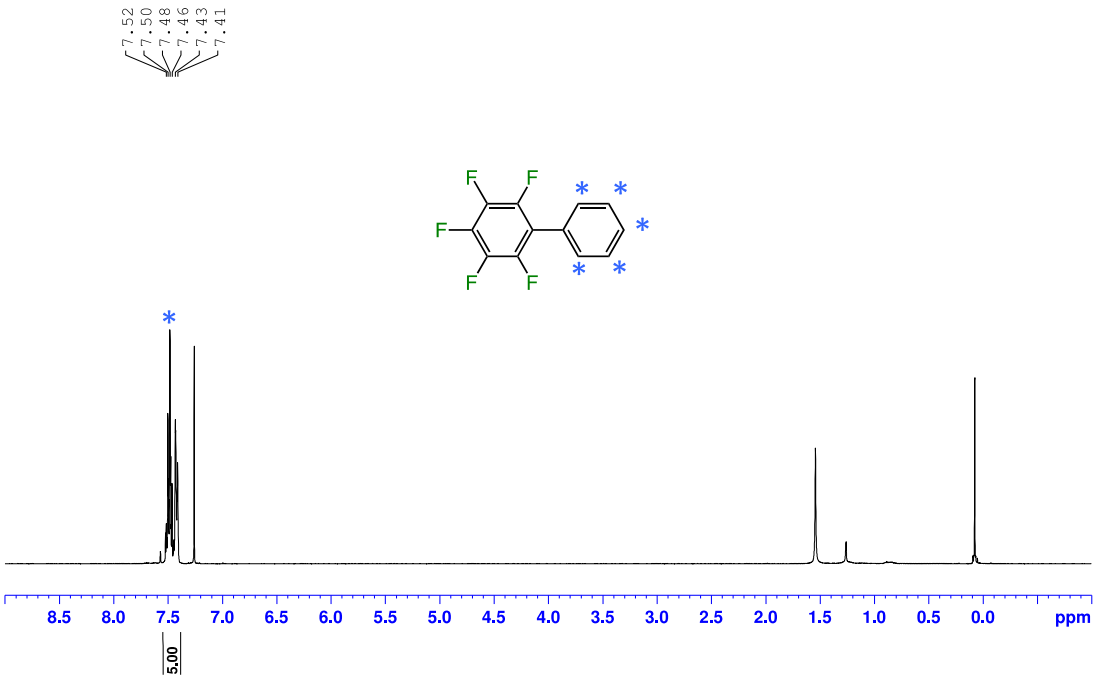


Figure 24: ^{1}H NMR spectrum of **4d** in $CDCl_3$.

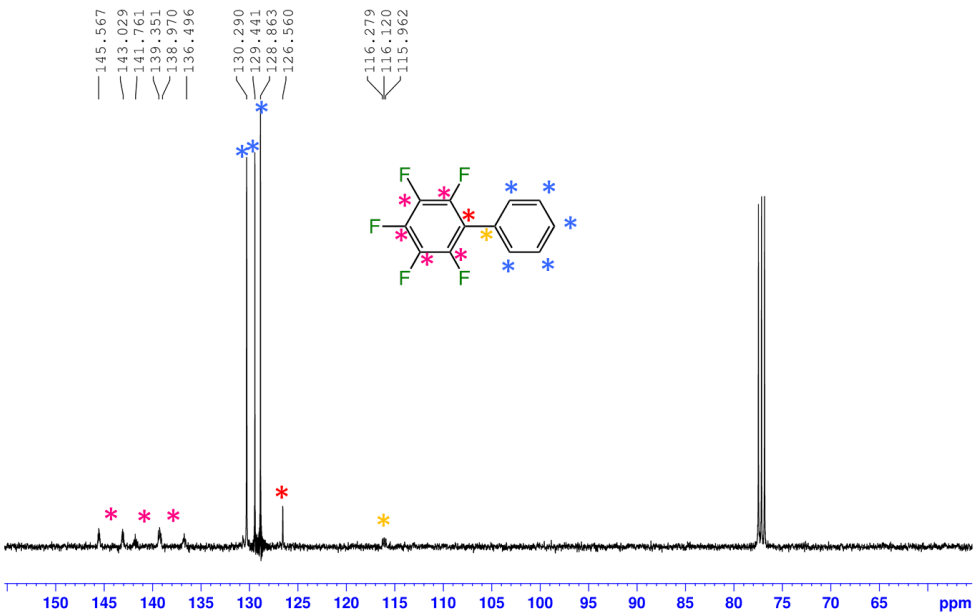


Figure 25: ^{13}C NMR spectrum of **4d** in $CDCl_3$.

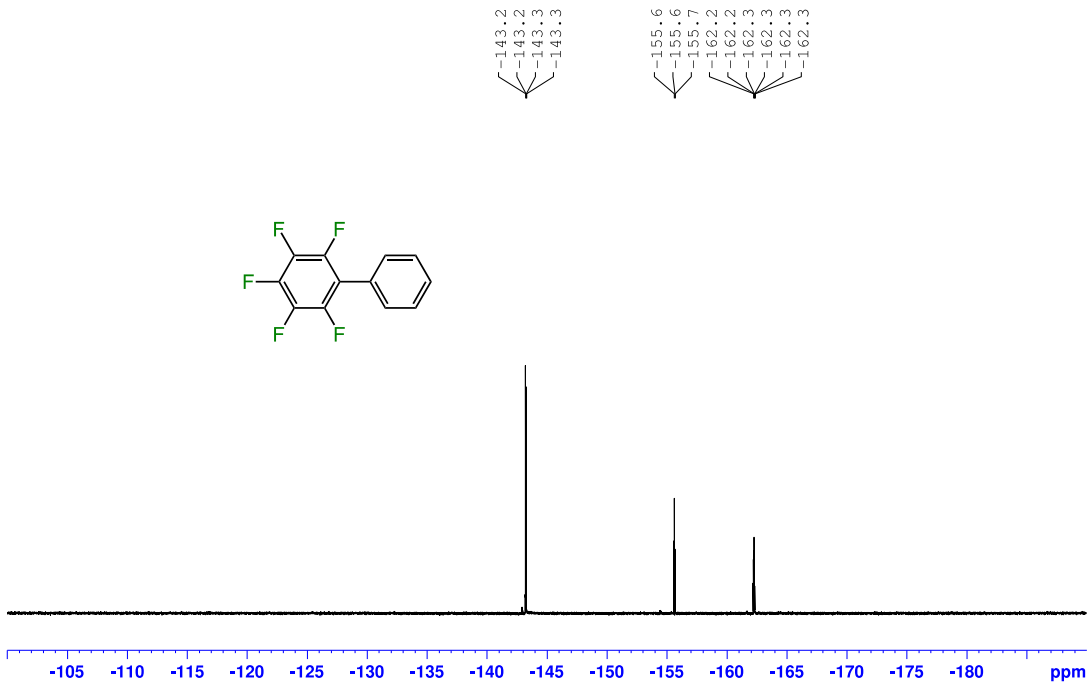


Figure 26: ^{19}F NMR spectrum of **4d** in $CDCl_3$.

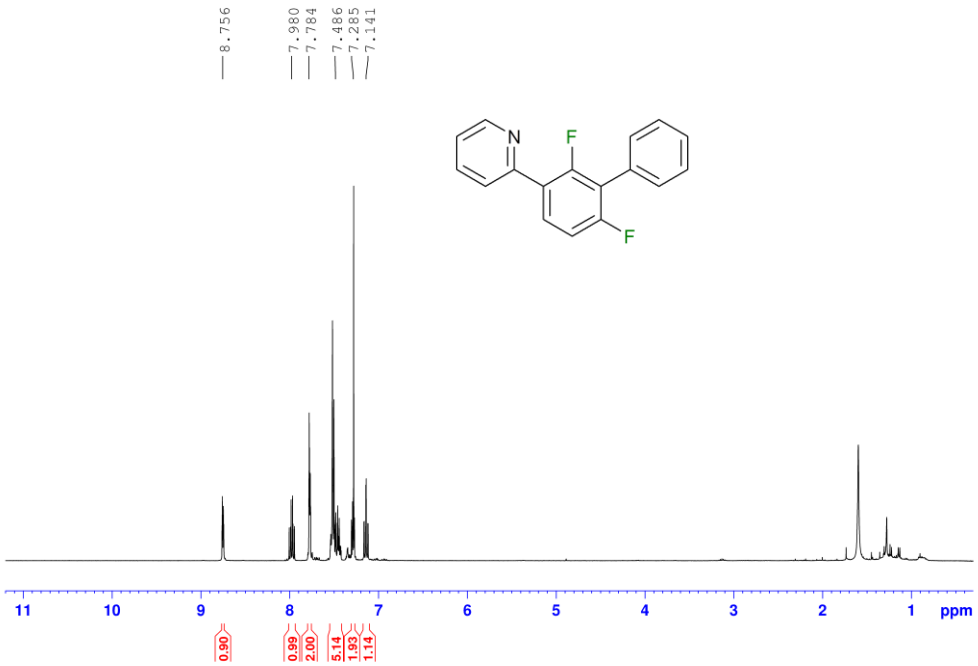


Figure 27: ^{1}H NMR spectrum of **4e** in $CDCl_3$.

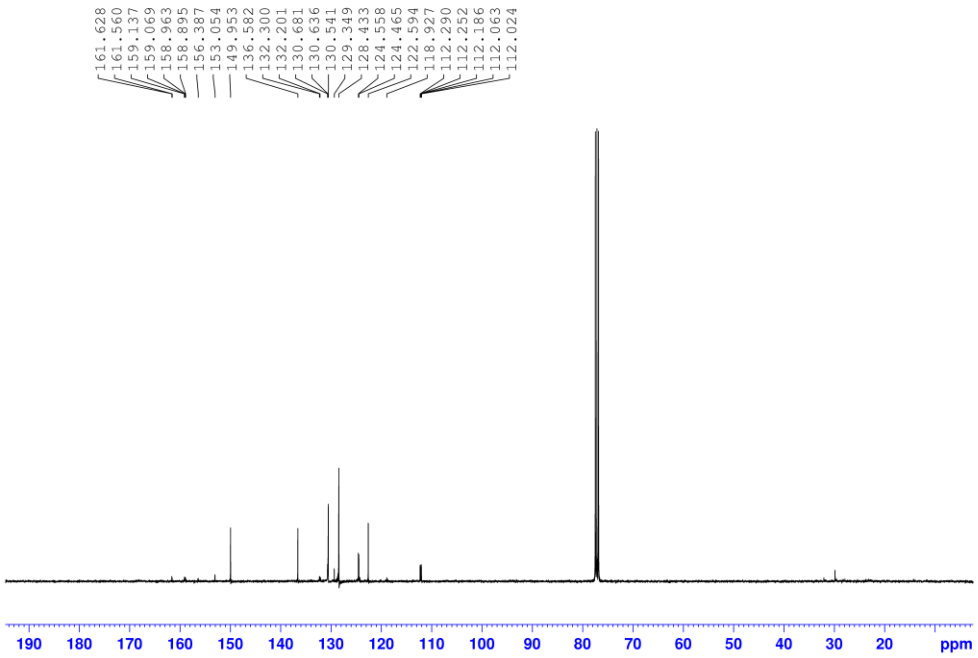


Figure 28: ^{13}C NMR spectrum of **4e** in $CDCl_3$.

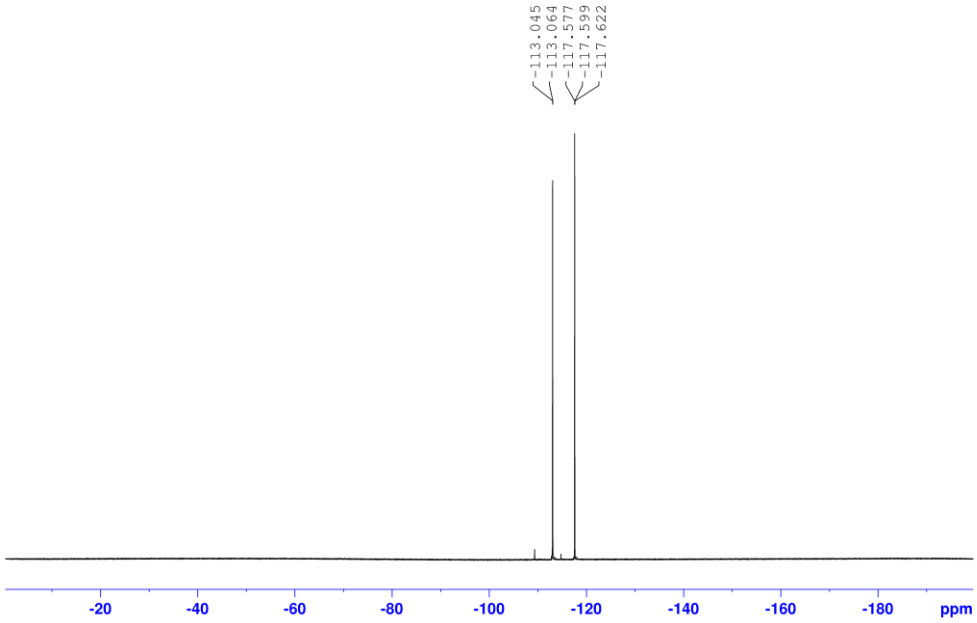


Figure 29: ^{19}F NMR spectrum of **4e** in $CDCl_3$.

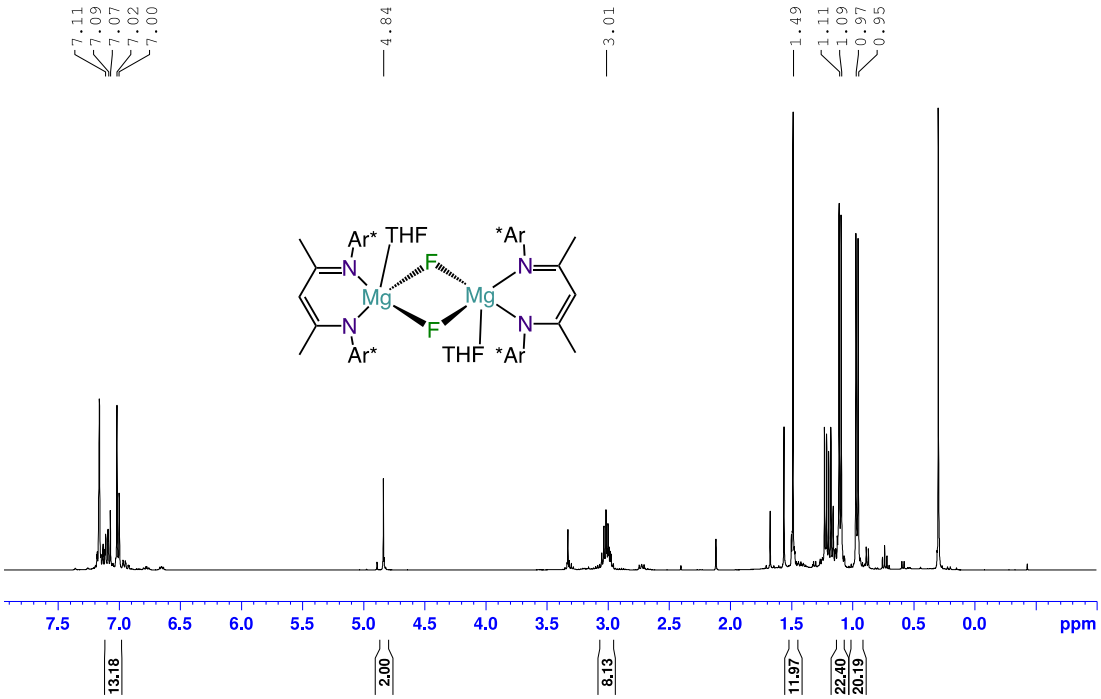


Figure 30: ^{1}H NMR spectrum of **5** in C_6D_6.

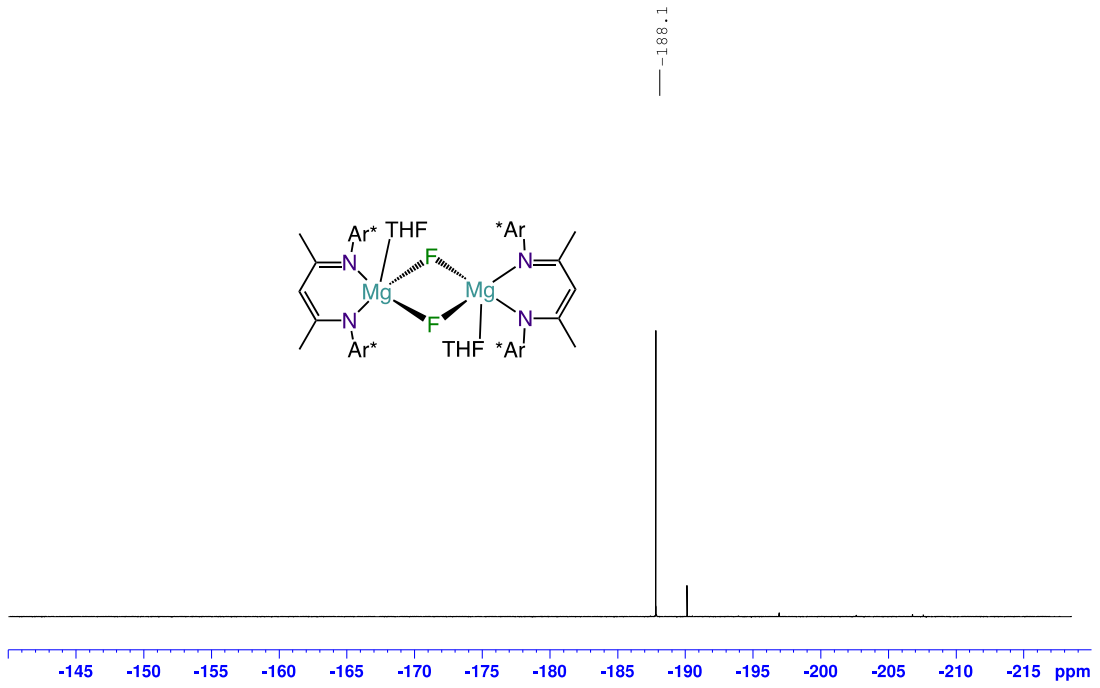


Figure 31: ^{19}F NMR spectrum of **5** in C_6D_6.

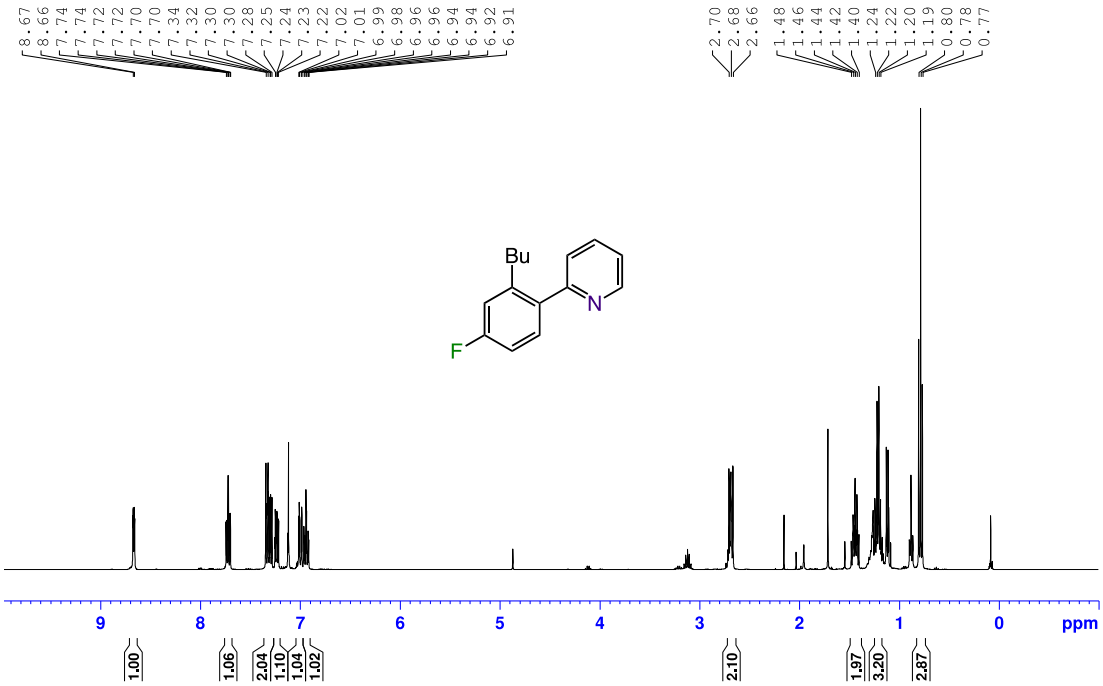


Figure 32: ^{1}H NMR spectrum of **7a** in $CDCl_3$.

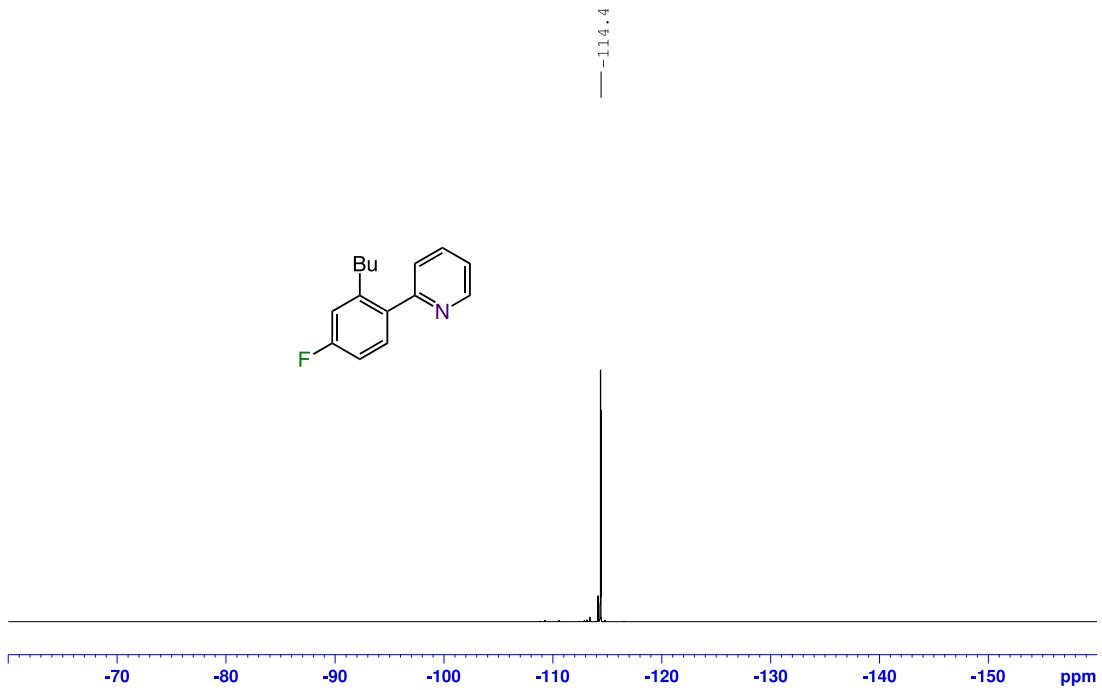


Figure 33: ^{19}F NMR spectrum of **7a** in $CDCl_3$.

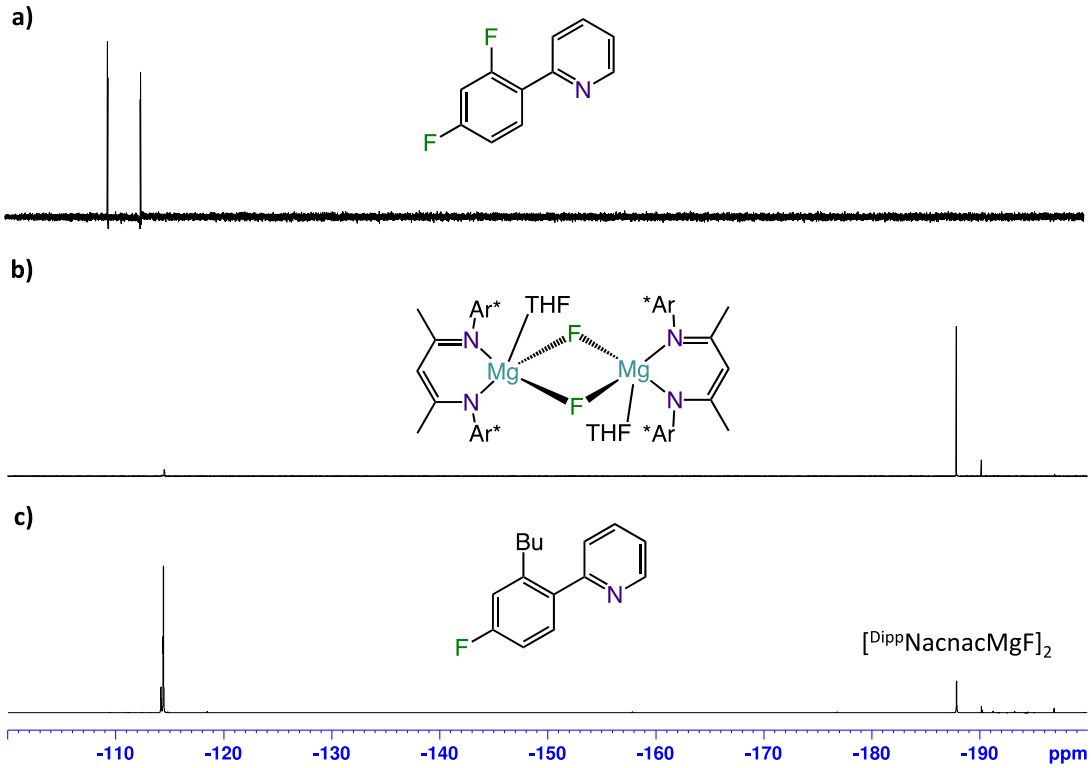


Figure 34: a) ^{19}F NMR spectrum of 2-(2,4-difluorophenyl)pyridine in C_6D_6. b) ^{19}F NMR spectrum of **5** in C_6D_6. c) ^{19}F NMR spectrum of **7a** in C_6D_6 (presence of an impurity of **5**).

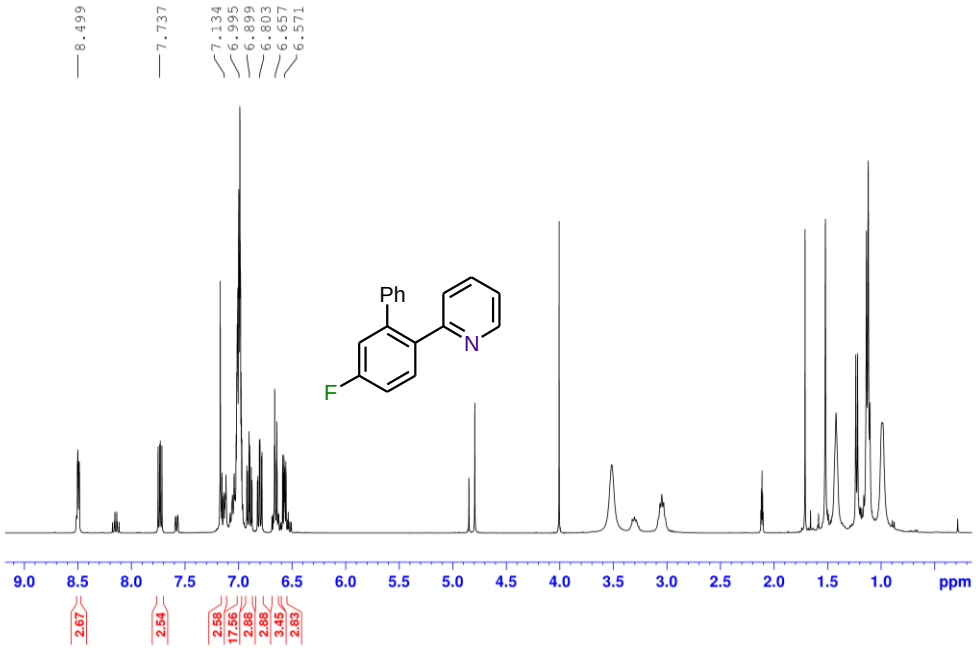


Figure 35: ^{1}H NMR spectrum of **7b** in d_8-toluene.

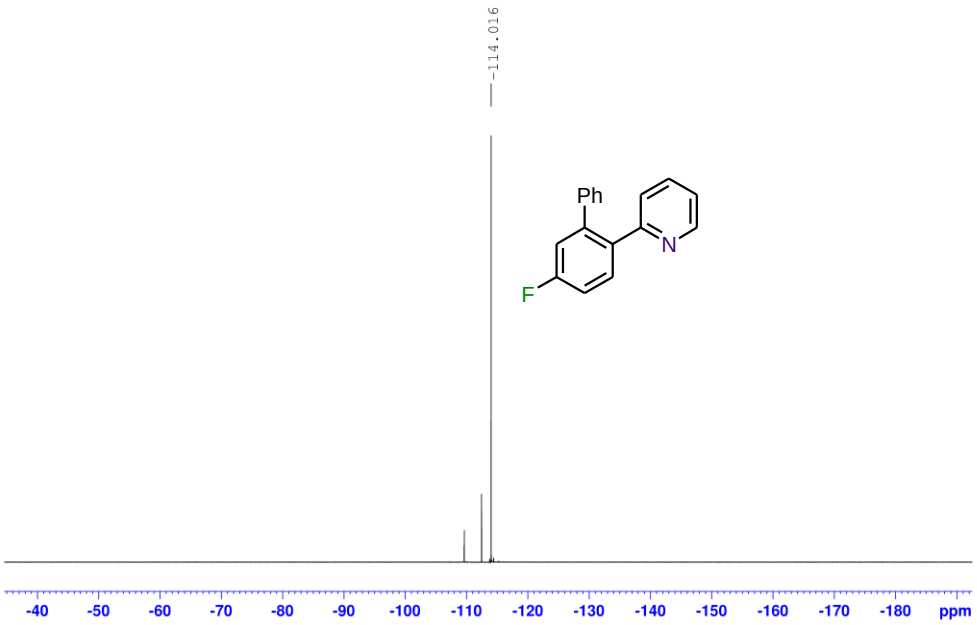


Figure 36: ^{19}F NMR spectrum of **7b** in d_8-toluene. Minor signals correspond to unreacted **ppf**.

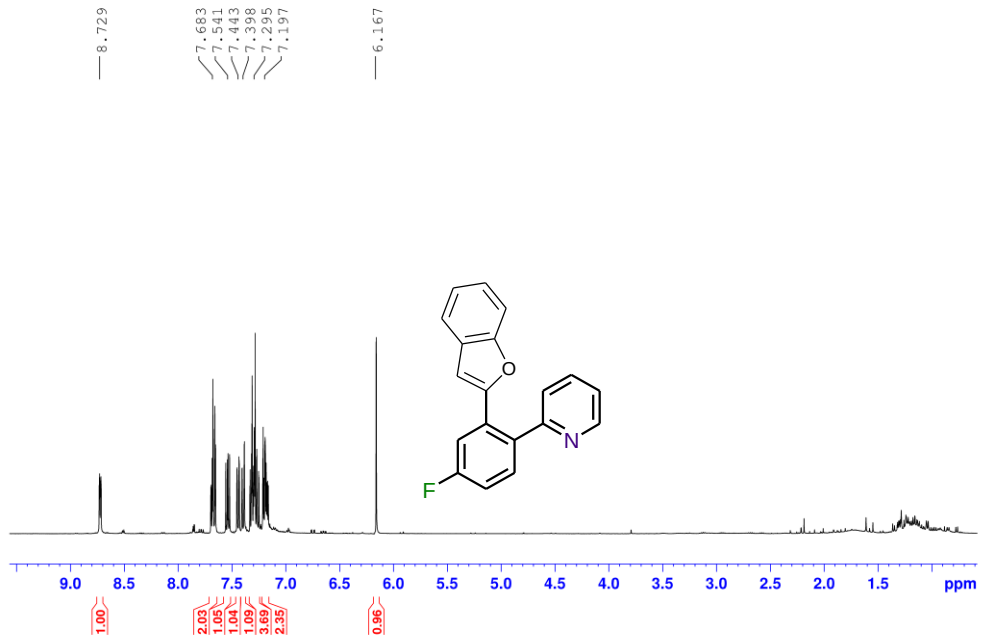


Figure 37: ^{1}H NMR spectrum of **7c** in $CDCl_3$.

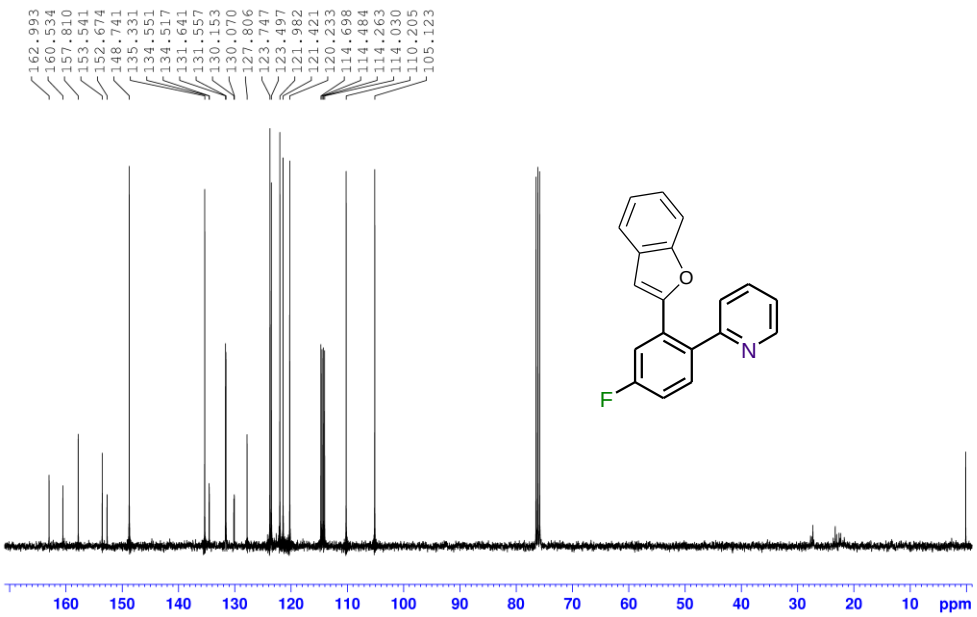


Figure 38: ^{13}C NMR spectrum of **7c** in $CDCl_3$.

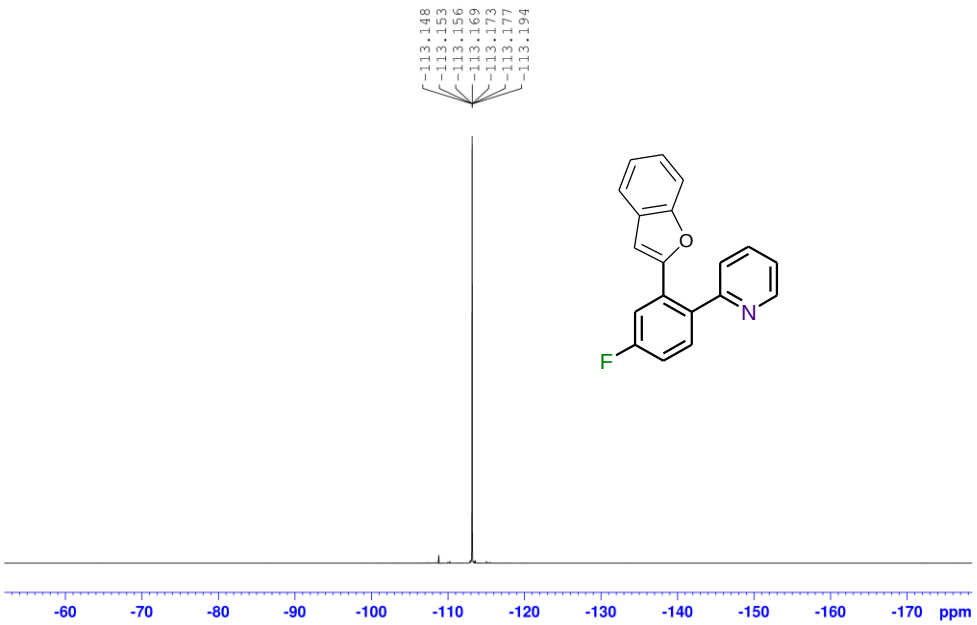


Figure 39: ^{19}F NMR spectrum of **7c** in $CDCl_3$.

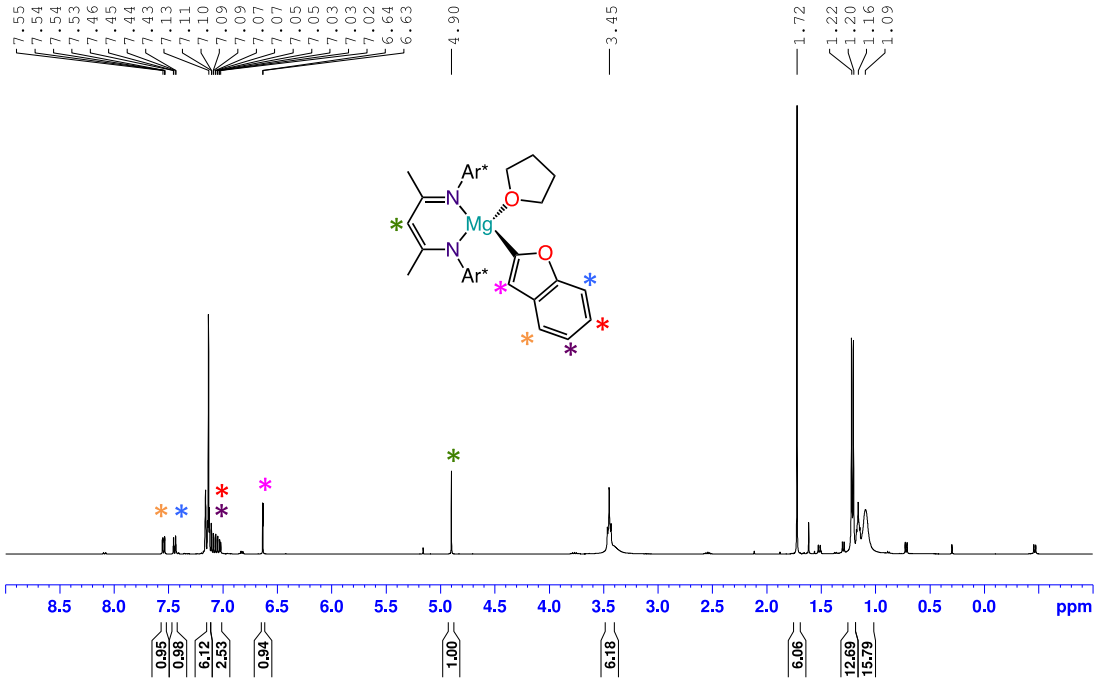


Figure 40: ^{1}H NMR spectrum of **8** in C_6D_6.

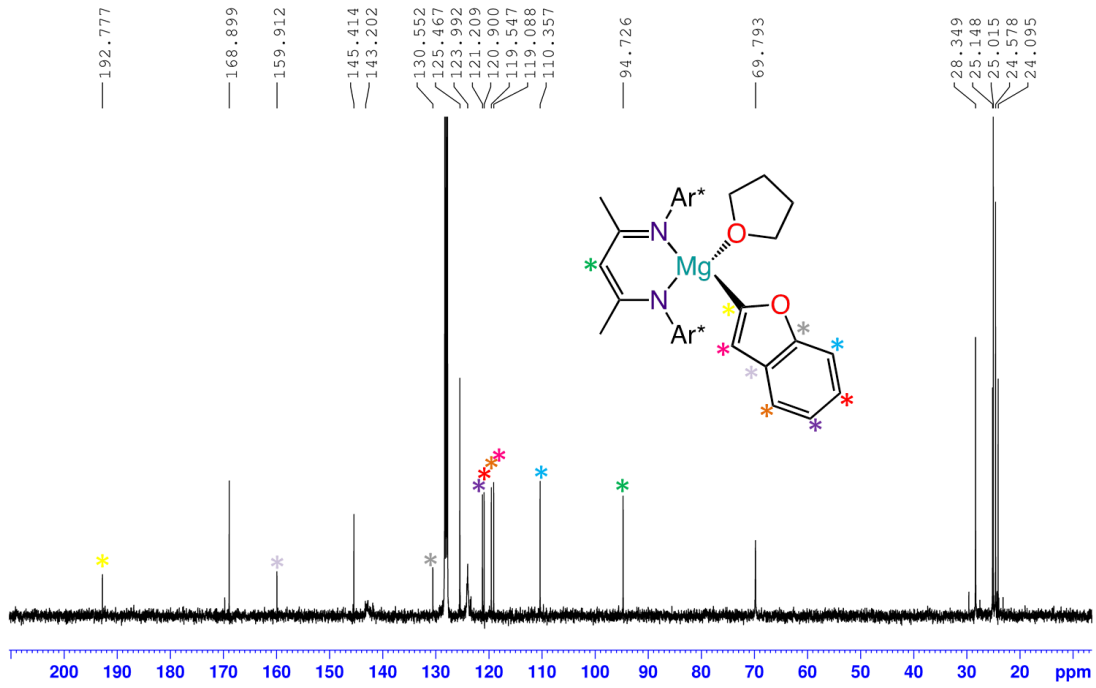


Figure 41: ^{13}C NMR spectrum of **8** in C_6D_6.

Presence of TEMPO in synthesis of 7a

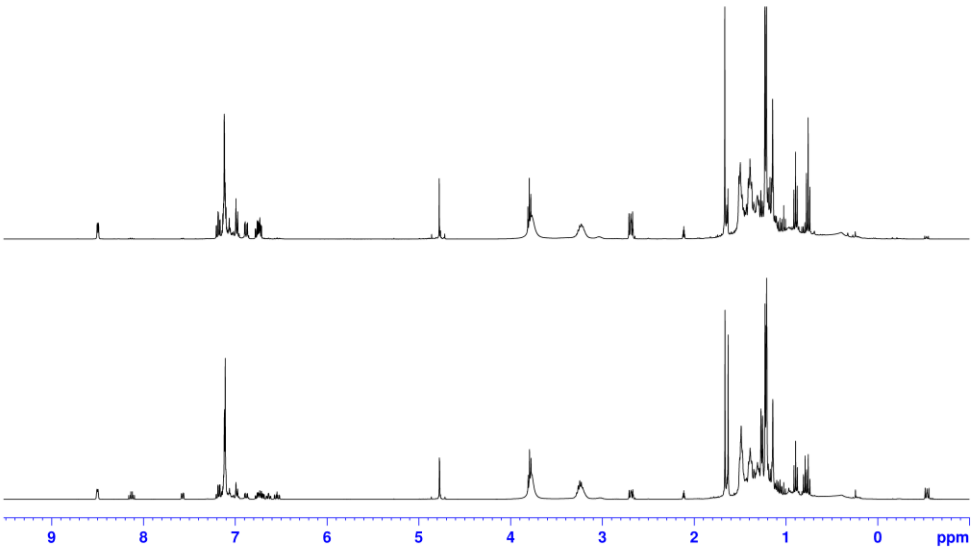


Figure 42: ^{1}H NMR spectra of reaction between **2** and **ppf** in d_8-toluene. Lower spectrum after one hour at room temperature, and upper spectrum recorded after 24 hours at room temperature. The results demonstrate that formation of **7b** is unaffected by the presence of the radical trap TEMPO. Indicating that the reaction likely proceeds via nucleophilic substitution.

Competition experiments

Reaction between 1, 2 and ppf: 1 (56 mg, 0.1 mmol), **2** (56 mg, 0.1 mmol) **ppf** (20 mg, 0.1 mmol) were added to a J. Young NMR tube and dissolved in d_8-THF (0.5 mL). The reaction maintained at room temperature and was monitored periodically over 72 hours, via ^{1}H and ^{19}F NMR spectroscopy.

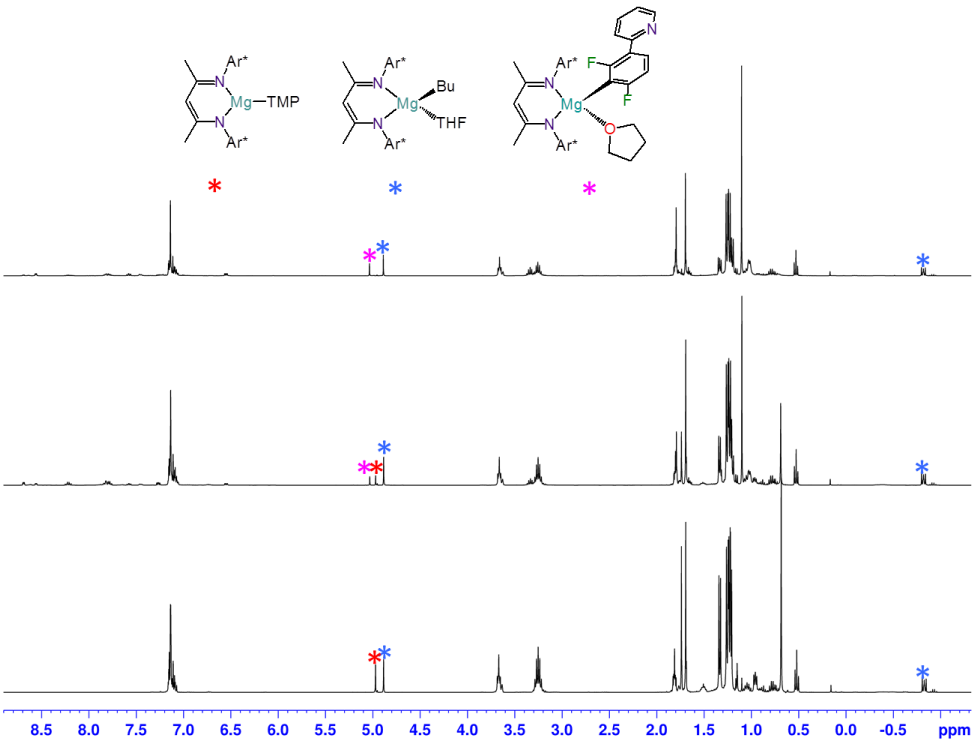


Figure 43: Competition experiment between **1**, **2** and **ppf** in d_8-THF. Bottom spectrum contains only **1** and **2**. Middle spectrum recorded after 15 minutes indicates metalation has already begun. Upper spectrum after 72 hours at room temperature indicates metalation occurs preferentially over C-F activation. Analysis of resonance relating to the proton present on the backbone of the NACNAC ligand provides diagnostic information in this regard. After 15 minutes three singlets are present at *ca.* δ 5 ppm, these correspond to **1**, **2 and 3e**. The top spectrum, after 72 hours, only displays resonances corresponding to **2** and **3e**.

Reaction between 2, TMPH and ppf: 2 (112 mg, 0.2 mmol), TMPH (34 μL, 0.2 mmol) and **ppf** (40 mg, 0.2 mmol) were added to a J. Young NMR tube and dissolved in d_8-THF (0.5 mL). The reaction maintained was heated at 80 °C and was monitored periodically over 24 hours, via ^{1}H and ^{19}F NMR spectroscopy.

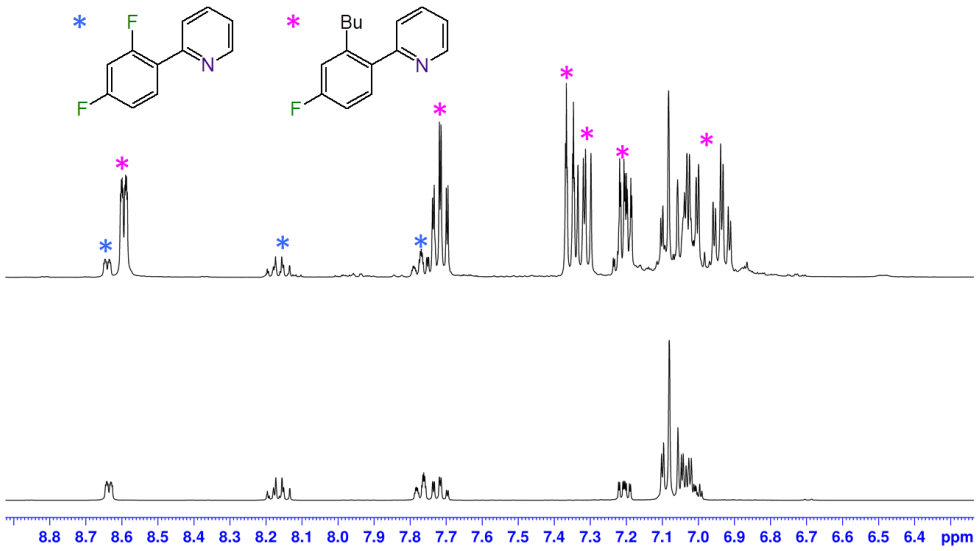


Figure 44: Competition experiment between **1**, TMPH and **ppf** in d_8-THF. Lower spectrum is recorded after 15 minutes at room temperature and indicates no reaction has occured. Upper spectrum recorded after 24 hours at 80 °C after reveals that only C-F activation, and not metalation occurs.

A competition experiment of an equimolar mixture of **1** and **2** with 1,3,5 trifluorobenzene showed the formation of metallation product **3b** and unreacted **2**. When **2** is refluxed with this fluoroarene product **3b** only occurs at elevated temperatures (60 °C for 138 hours).

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