TMPZnOPiv•LiCl: A New Base for the Preparation of Air-Stable Solid Zinc Pivalates of Sensitive Aromatics and Heteroaromatics.

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Supporting Information

Experimental Details

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General: All reactions were carried out under argon atmosphere in flame-dried glassware. Syringes, which were used to transfer anhydrous solvents or reagents, were purged with argon prior to use. THF was continuously refluxed and freshly distilled from sodium benzophenone ketyl under nitrogen. Diethyl ether was predried over calcium hydride and dried with the solvent purification system SPS-400-2 from INNOVATIVE TECHNOLOGIES INC (Al_2O_3, 1-3 mm, ICN, Eschwege, Germany). TMPH, liquid acid chlorides and $BF_3{\cdot}OEt_2$ were distilled under argon prior to use. Yields refer to isolated yields of compounds estimated to be > 95 % pure as determined by ^{1}H-NMR (25 °C) and capillary-GC analysis. NMR spectra were recorded on solutions in deuterated chloroform ($CDCl_3$) with residual chloroform (δ 7.26 ppm for ^{1}H-NMR and δ 77.0 ppm for ^{13}C-NMR). Column chromatographical purifications were performed using SiO_2 (0.040 – 0.063 mm, 230 – 400 mesh ASTM) from Merck if not indicated otherwise.

Preparation of $Zn(OPiv)_2$

Pivalic acid (20.4 g, 22.6 mL, 200 mmol) was placed in a dry and argon-flushed 500 mL three-necked round-bottom flask, equipped with a magnetic stirring bar, a septum and a pressure equalizer, and was dissolved in dry THF (120 mL). The mixture was cooled at 0 °C, and a solution of Et_2Zn (13.0 g, 10.8 mL, 105 mmol) in dry THF (120 mL) was cannulated to it over a period of 30 min under vigorous stirring. Then, the ice-bath was removed and stirring continued at 25 °C for one additional hour at which point bubbling was ceased (a thick slurry was formed). The solvent was removed *in vacuo* and the solid residue was dried for at least 4 h longer. $Zn(OPiv)_2$ was received in quantitative yield, as a puffy amorphous white solid.

Preparation of TMPZnOPiv·Mg(OPiv)Cl·LiCl (4)

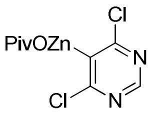
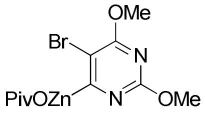
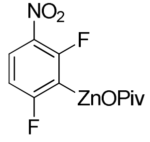
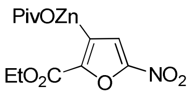
A dry and argon flushed 250-mL Schlenk-flask, equipped with a magnetic stirring bar, was charged with a solution of TMPMgCl·LiCl (**1**, 87.7 mL, 100 mmol) and cooled at 0 °C. Then, solid $Zn(OPiv)_2$ (28.1 g, 105 mmol, dried *in vacuo* at 400 °C prior to use) was added in one portion and the mixture was allowed to slowly warm up to 25 °C over ca. 1.5 h. Then THF (ca. 10-20 mL) was added to give **4** as a bright yellow solution. The freshly prepared TMPZnOPiv·Mg(OPiv)Cl·LiCl was titrated prior to use at 0 °C with benzoic acid using 4-(phenylazo)diphenylamine as indicator.

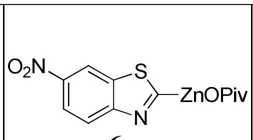
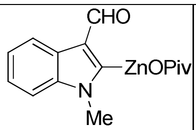
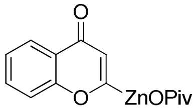
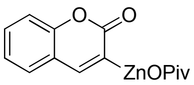
Titration of organozinc reagents using GC-analysis

First of all, the iodinated compounds of all organic zinc pivalates (**6a-h**) were isolated. Stock solutions of the iodides (0.1 M) and of an internal standard (0.1 M,) were prepared. As internal standard for all calibration curves *n*-octadacane was used, with exception of **6d** where *n*-tetradecane was used, since the iodinated product had the same GC-retention time as *n*-octadecane. For each iodinated compound GC-samples of different iodide/internal standard ratios were prepared and measured (at least eight for each iodide) and these ratios were plotted against the area ratios of the corresponding GC-analysis to give a linear graph with a determined equation. With these equations the amount of iodinated substance of the zinc pivalates (**6a-h**) could be calculated.

Stability studies of organozinc reagents towards air

To evaluate the stability of organozinc reagents towards air, accurately weighted aliquots of the solid organo-zinc pivalate were placed at 25 °C in open *Schlenk*-flasks. After exposure to air for a given time, the flasks were closed, evacuated, filled with argon and the organozink pivalate was dissolved in dry THF. Then, an excess of iodine was added and the solution stirred for 10 min at 25 °C followed by addition of 100 µL of a 0.1 M stock-solution of *n*-octadecane in toluene (*n*-tetradecane for **6d**). An aliquot (ca. 0.1 mL) of this reaction mixture was then quenched with sat. aqueous $Na_2S_2O_3$ solution (ca. 0.5 mL) and extracted with EtOAc (ca. 1 mL). The molar *n*-octadecane/iodinated heteroarene ratio was determined via GC-analysis.

Sub-strate	 **6a**	 **6b**	 **6c**	 **6d**
t on air (h)	Percentage of the active heteroarylzinc species			
0	74	72	83	77
1	73 (99 of t_0)	72 (= t_0)	83 (= t_0)	75 (97 of t_0)
2	72 (97 of t_0)	70 (97 of t_0)	82 (98 of t_0)	74 (96 of t_0)
4	70 (95 of t_0)	68 (94 of t_0)	80 (97 of t_0)	73 (95of t_0)
24	51 (69 of t_0)	52 (72 of t_0)	-	-

Sub-strate	 **6e**	 **6f**	 **6g**	 **6h**
t on air (h)	Percentage of the active heteroarylzinc species			
0	79	88	55	82
1	79 (= t_0)	87 (99 of t_0)	54 (98 of t_0)	77 (93 of t_0)
2	76 (96 of t_0)	86 (98 of t_0)	52 (95 of t_0)	75 (91 of t_0)
4	74 (94 of t_0)	85 (96 of t_0)	49 (90 of t_0)	71 (88 of t_0)
24	41 (52 of t_0)	42 (48 of t_0)	23 (42 of t_0)	41 (51 of t_0)

Typical Procedure for the metalation of heteroaromatics with TMPZnOPiv·Mg(OPiv)Cl·LiCl (4) (TP1)

A dry and argon flushed 20-mL Schlenk-tube, equipped with a magnetic stirring bar, was charged with a 0.5 M solution of the corresponding *N*-heteroarene in dry THF. The solution was brought to the given temperature followed by dropwise addition of TMPZnOPiv·Mg(OPiv)Cl·LiCl (**4**, 0.85 M in THF, 1.1 – 2.0 equiv.) and stirred at the indicated temperature for the given time. Complete metalation was monitored by GC analysis of reaction aliquots, quenched with iodine in dry THF using tetradecane as internal standard. The solvent was carefully removed *in vacuo* and the content of active zinc species was determined as described above.

Typical Procedure for the BF_3·OEt_2-triggered metalation of heteroaromatics with TMPZnOPiv·Mg(OPiv)Cl·LiCl (4) (TP2)

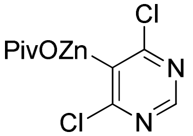
A dry and argon flushed 20-mL Schlenk-tube, equipped with a magnetic stirring bar, was charged with a solution of the corresponding heteroarene (1.0 mmol) in dry THF (2 mL) and cooled to -20 °C. BF_3·OEt_2 (156 mg, 1.1 mmol) was slowly added and stirred for 30 min at the same temperature. The reaction mixture was cooled down to -30 °C and after dropwise addition of TMPZnOPiv·Mg(OPiv)Cl·LiCl (**4**, 0.85 M in THF, 1.1 equiv.) the mixture was stirred for 1 h at -30 °C.

Typical Procedure for the metalation of benzylic N-heterocycles with TMPZnOPiv·Mg(OPiv)Cl·LiCl (4) (TP3)

A dry and argon flushed 10-mL Schlenk-tube, equipped with a magnetic stirring bar, was charged with a 0.5 M solution of the corresponding *N*-heteroarene in dry THF. The solution was brought to the given temperature followed by dropwise addition of TMPZnOPiv·Mg(OPiv)Cl·LiCl (**4**, 0.85 M in THF, 1.1 equiv.) and stirred at the indicated temperature for the given time. Complete metalation was monitored by GC analysis of reaction aliquots, quenched with iodine in dry THF using tetradecane as internal standard. Due to the brownish color of the benzylic zinc pivalates titration against iodine was not possible. Also determination of the active zinc species *via* GC-analysis was not possible, because of the low stability of the corresponding benzylic iodides. Therefore all yields concerning benzylic zinc pivalates are given over two steps (metalation and reaction with electrophile).

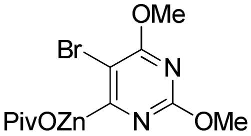
Preparation of organozinc pivalates 6a-h

5-(4,6-Dichloropyrimidinyl)zinc pivalate (6a)



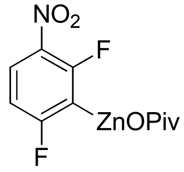
According to **TP1** 4,6-dichloropyrimidine (**5a**; 298 mg, 2.0 mmol) in 4 mL dry THF reacted with TMPZnOPiv•LiCl (**4**; 2.6 mL, 0.85 M, 2.2 mmol) at 25 °C and stirred at this temperature for 0.5 h. After solvent removal *in vacuo* **6a** (2.06 g) was obtained as a yellow solid. GC-analysis of an iodinated sample (see above) gave a concentration of the active zinc species of 0.81 mmol/g, which corresponds to a yield of 78 %.

(5-Bromo-2,6-dimethoxypyrimidin-4-yl)zinc pivalate (6b)



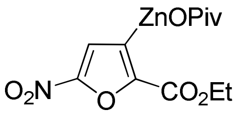
According to **TP1** 5-bromo-2,4-dimethoxypyrimidine (**5a**; 438 mg, 2.0 mmol) in 4 mL THF reacted with TMPZnOPiv•LiCl (**4**; 2.6 mL, 0.85 M, 2.2 mmol) at 25 °C and stirred at this temperature for 3 h. After solvent removal *in vacuo* **6b** (1.83 g) was obtained as a orange-brown solid. GC-analysis of an iodinated sample (see above) gave a concentration of the active zinc species of 0.79 mmol/g, which corresponds to a yield of 72 %.

(2,6-Difluoro-3-nitrophenyl)zinc pivalate (6c)



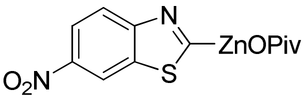
According to **TP1** 2,4-difluoro-1-nitrobenzene (**5c**; 318 mg, 2.0 mmol) in 4 mL dry THF reacted with TMPZnOPiv•LiCl (**4**; 2.6 mL, 0.85 M, 2.2 mmol) at 25 °C and stirred at this temperature for 45 min. After solvent removal *in vacuo* **6c** (2.05 g) was obtained as a light brown solid. GC-analysis of an iodinated sample (see above) gave a concentration of the active zinc species of 0.81 mmol/g, which corresponds to a yield of 83 %.

3-(2-Ethoxycarbonyl-5-nitrofuranyl)zinc pivalate (6d)



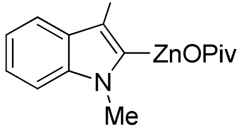
According to **TP1** ethyl 5-nitrofuran-2-carboxylate (**5d**; 370 mg, 2.0 mmol) in 4 mL dry THF reacted with TMPZnOPiv•LiCl (**4**; 4.7 mL, 0.85 M, 4.0 mmol) at -10 °C and stirred at this temperature for 1 h. After warming to 25 °C and solvent removal *in vacuo* **6d** (2.04 g) was obtained as a dark red-brown solid. GC-analysis of an iodinated sample (see above) gave a concentration of the active zinc species of 0.75 mmol/g, which corresponds to a yield of 77 %.

(6-Nitrobenzo[*d*]thiazol-2-yl)zinc pivalate (6e)



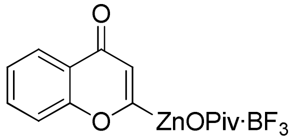
According to **TP1** ethyl 6-nitrobenzothiazol (**5e**; 360 mg, 2.0 mmol) in 4 mL dry THF reacted with TMPZnOPiv•LiCl (**4**; 2.6 mL, 0.85 M, 2.2 mmol) at 25 °C and stirred at this temperature for 10 min. After solvent removal *in vacuo* **6e** (1.98 g) was obtained as a dark red-brown solid. GC-analysis of an iodinated sample (see above) gave a concentration of the active zinc species of 0.75 mmol/g, which corresponds to a yield of 74 %.

(3-Formyl-1-methyl-1*H*-indol-2-yl)zinc pivalate (6f)



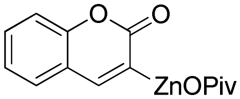
According to **TP1** 1-methyl-1*H*-indole-3-carbaldehyde (**5e**; 318 mg, 2.0 mmol) in 4 mL THF reacted with TMPZnOPiv•LiCl (**4**; 2.6 mL, 0.85 M, 2.2 mmol) at 25 °C and stirred at this temperature for 0.5 h. After solvent removal *in vacuo* **6f** (2.06 g) was obtained as a yellow solid. GC-analysis of an iodinated sample (see above) gave a concentration of the active zinc species of 0.85 mmol/g, which corresponds to a yield of 88 %.

(4-Oxo-4*H*-chromen-2-yl) zinc pivalate (6g)



According to **TP2** chromone (**5g**; 292 mg, 2.0 mmol) in 4 mL THF reacted with $BF_3 \cdot OEt_2$ (312 mg, 2.2 mmol) and TMPZnOPiv•LiCl (**4**; 2.6 mL, 0.85 M, 2.2 mmol). After solvent removal *in vacuo* **6g** (1.89 g) was obtained as a dark red solid. GC-analysis of an iodinated sample (see above) gave a concentration of the active zinc species of 0.60 mmol/g, which corresponds to a yield of 55 %. However, when used as a solution overall yields higher than 55 % were obtained, indicating, that the BF_3 containing zinc pivalate **6g** decomposes during the solvent removal. Therefore all yields are referring over two steps (metalation and reaction with electrophile).

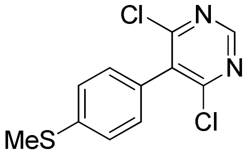
(2-Oxo-2*H*-chromen-3-yl)zinc pivalate (6h)



According to **TP1** coumarin (**5h**, 438 mg, 2.0 mmol) in 4 mL dry THF reacted with TMPZnOPiv•LiCl (**4**, 2.6 mL, 0.85 M, 2.2 mmol) at 25 °C and stirred at 80 °C in the microwave for 1 h. After cooling to 25 °C and solvent removal *in vacuo* **6h** (2.23 g) was obtained as a orange solid. GC-analysis of an iodinated sample (see above) gave a concentration of the active zinc species of 1.11 mmol/g, which corresponds to a yield of 82 %.

Synthesis of compounds 8a-w

4,6-Dichloro-5-(4-(methylthio)phenyl)pyrimidine (8a)



To a solution of 5-(4,6-dichloropyrimidinyl)zinc pivalate (**6a**; 1.23 g, 1.0 mmol) in THF (3 mL) Pd(dba)$_2$ (17 mg, 3 mol%), P(*o*-fur)$_3$ (14 mg, 6 mol%) and 4-iodothioanisole (200 mg, 0.8 mmol) were added sequentially at 25 °C. The reaction mixture was stirred at 25 °C for 2 h and then quenched with a sat. aqueous NH$_4$Cl solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na$_2$SO$_4$ and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 15:1) afforded the product **8a** (197 mg, 91%) as white solid.

M.p. (°C): 88.7-90.4.

^{1}H-NMR (300 MHz, CDCl$_3$): δ / ppm = 8.76 (s, 1H), 7.36 (d, *J* = 8.2 Hz, 2H), 7.23 (d, *J* = 8.2 Hz, 2H), 2.54 (s, 3H).

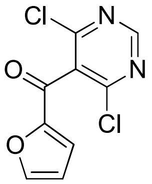
^{13}C-NMR (75 MHz, CDCl$_3$): δ / ppm = 161.5, 156.6, 140.8, 133. 6, 129.5, 128.8, 125.9, 15.2.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = cm-1, 3050, 2992, 2925, 1916, 1713, 1652, 1594, 1552, 1539, 1504, 1434, 1424, 1406, 1398, 1389, 1372, 1362, 1346, 1322, 1296, 1270, 1230, 1215, 1204, 1189, 1163, 1114, 1093, 1020, 994, 969, 959, 951, 824, 801, 796, 780, 732, 721, 704.

MS (EI, 70 eV): m/z (%) = 271 [M$^+$] (32), 257 (20), 255 (30), 192 (16), 173 (15), 91 (16), 61 (20), 43 (100).

HRMS (EI) for **C$_{11}$H$_9$Cl$_2$N$_2$S$^+$** (270.9858): 270.9860.

(4,6-Dichloropyrimidin-5-yl)(furan-2-yl)methanone (8b)



A solution of 5-(4,6-dichloropyrimidinyl)zinc pivalate (**6a**; 1.23 g, 1.0 mmol) in THF (3 mL) was cooled to -20 °C and CuCN·2LiCl (1.1 mmol, 1.1 mL, 1.0 M in THF) was added dropwise. After stirring at this temperature for 20 min, 2-furoyl chloride (392 mg, 3.0 mmol) was added and the mixture was left to reach 0 °C and stirred there for 3 h. Then, sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) were used to quench the reaction, followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 12:1) afforded the product **8b** (233 mg, 96 %) as brown solid.

M.p. (°C): 143.6–145.4.

^{1}H-NMR (600 MHz, $CDCl_3$): δ / ppm = 8.87 (s, 1H), 7.69 (d, *J* = 0.9 Hz, 1H), 7.28 (br s, 1H), 6.65 (dd, *J* = 3.7, 1.7 Hz, 1H).

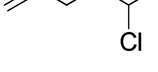
^{13}C-NMR (150 MHz, $CDCl_3$): δ / ppm = 175.6, 158.8, 158.4, 150.9, 149.0, 130.9, 121.4, 113.5.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3133, 2969, 2359, 2340, 1738, 1636, 1558, 1540, 1512, 1450, 1403, 1375, 1361, 1297, 1230, 1216, 1168, 1123, 1083, 1032, 956, 904, 888, 878, 815, 789, 781, 746, 738, 668, 626, 615, 609.

MS (EI, 70 eV): m/z (%) = 242 [M$^+$] (48), 167 (49), 95 (100), 58 (21), 43 (33).

HRMS (EI) for **$C_9H_4Cl_2N_2O_2$** (241.9650): 241.9653.

5-Allyl-4,6-dichloropyrimidine (8c)



A solution of 5-(4,6-dichloropyrimidinyl)zinc pivalate (**6a**; 1.23 g, 1.0 mmol) in THF (3 mL) was cooled to -20 °C and CuCN·2LiCl (0.05 mmol, 0.05 mL, 1.0 M in THF) was added. After stirring for 20 min the mixture was cooled further at -60 °C and allyl bromide (145 mg, 1.2 mmol) was added. The reaction mixture was allowed to warm to up to -30 °C over 1 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) followed by extraction with ethyl acetate (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 10:1) afforded the product **8c** (166 mg, 88%) as colourless oil.

^{1}H-NMR (300 MHz, $CDCl_3$): δ / ppm = 8.62 (s, 1H), 5.84 (ddd, *J* = 16.5, 11.1, 6.0 Hz, 1H), 5.27 – 4.95 (m, 2H), 3.63 (dd, *J* = 6.2, 1.5 Hz, 2H).

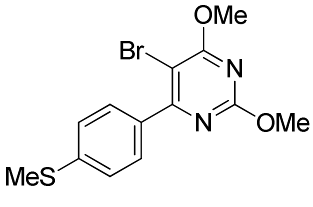
^{13}C-NMR (75 MHz, $CDCl_3$): δ / ppm = 162.0, 155.8, 130.9, 130.6, 118.1, 34.0.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 2969, 2360, 1739, 1639, 1539, 1513, 1435, 1406, 1375, 1348, 1313, 1290, 1200, 1162, 1129, 1090, 989, 929, 906, 839, 777, 687, 668, 627, 621, 616.

MS (EI, 70 eV): m/z (%) = 188 [M$^+$] (70), 125 (22), 117 (44), 90 (59), 64 (35), 49 (43), 41 (100).

HRMS (EI) for **$C_7H_6Cl_2N_2$** (187.9908): 187.9913.

5-Bromo-2,4-dimethoxy-6-(4-(methylthio)phenyl)pyrimidine (8d)



To a solution of (5-bromo-2,6-dimethoxypyrimidin-4-yl)zinc pivalate (**6b**; 1.27 g, 1.0 mmol) in THF (3 mL) $Pd(dba)_2$ (17 mg, 3 mol%), P(*o*-fur)$_3$ (14 mg, 6 mol%) and 4-iodothioanisole (200 mg, 0.8 mmol) were added sequentially at 25 °C. The reaction mixture was stirred at 25 °C over 12 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et_2O = 5:1) afforded the product **8d** (276 mg, 81%) as white solid.

M.p. (°C): 121.6-123.4.

^{1}H-NMR (300 MHz, $CDCl_3$): δ / ppm = 7.75 (d, *J* = 8.50 Hz, 2H), 7.31 (d, *J* = 8.43 Hz, 2H), 4.10 (s, 3H), 4.02 (s, 3H), 2.53 (s, 3H).

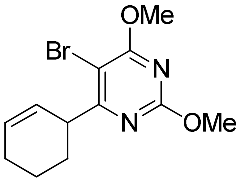
^{13}C-NMR (75 MHz, $CDCl_3$): δ / ppm = 168.1, 165.2, 163.4, 141.2, 134.0, 129.8, 125.2, 96.5, 55.3, 55.2, 15.2.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3021, 2988, 2953, 2882, 2211, 1596, 1562, 1535, 1499, 1477, 1448, 1420, 1401, 1383, 1350, 1324, 1301, 1240, 1196, 1151, 1111, 1092, 1034, 1020, 1011, 977, 964, 949, 934, 900, 887, 863, 828, 814, 786, 736, 727, 681, 661.

MS (EI, 70 eV): m/z (%) = 342 [^{81}Br, M^+] (100), 340 [^{79}Br, M^+] (92), 231 (29), 174 (11), 43 (14).

HRMS (EI) for **$C_{13}H_{13}BrN_2O_2S$** (339.9881): 339.9857.

5-Bromo-4-(cyclohex-2-en-1-yl)-2,6-dimethoxypyrimidine (8e)



A solution of (5-bromo-2,6-dimethoxypyrimidin-4-yl)zinc pivalate (**6b**; 1.27 g, 1.0 mmol) in THF (3 mL) was cooled to -20 °C. CuCN·2LiCl (0.1 mmol, 0.1 mL, 1 M in THF) and 3-bromocyclohex-1-ene (242 mg, 1.5 mmol) were added sequentially. The reaction mixture was allowed to warm up to 25 °C over 12 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et_2O = 10:1) afforded the product **8e** (266 mg, 89%) as colorless oil.

^{1}H-NMR (300 MHz, $CDCl_3$): δ / ppm = 5.82 – 5.93 (m, 1H), 5.57 – 7.70 (m, 1H), 4.04 (s, 3H), 3.95 – 4.02 (m, 4H) 1.61 – 2.17 (m, 6H).

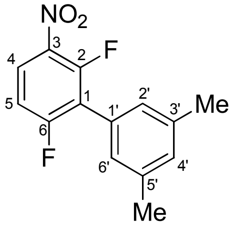
^{13}C-NMR (75 MHz, CDCl$_3$): δ / ppm = 172.7, 167.1, 163.5, 128.5, 126.9, 97.6, 55.0, 54.9, 41.6, 27.3, 24.6, 21.5.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3024, 2989, 2940, 2867, 2836, 1563, 1546, 1479, 1452, 1381, 1352, 1299, 1285, 1258, 1239, 1200, 1156, 1138, 1109, 1084, 1069, 1042, 1026, 997, 956, 943, 926, 896, 885, 864, 854, 791, 761, 743, 722, 700, 680, 658.

MS (EI, 70 eV): m/z (%) = 298 [M$^+$] (72), 271 (100), 259 (18), 234 (37), 219 (40), 72 (17), 43 (16).

HRMS (EI) for **$C_{12}H_{15}BrN2O_2$** (298.0317): 298.0314.

2,6-Difluoro-3',5'-dimethyl-3-nitro-1,1'-biphenyl (8f)



To a solution of (2,6-difluoro-3-nitrophenyl)zinc pivalate (**6c**; 1.23 g, 1.0 mmol) in THF (3 mL) Pd(dba)$_2$ (17 mg, 3 mol%), P(*o*-fur)$_3$ (14 mg, 6 mol%) and 1-iodo-3,5-dimethylbenzene (185 mg, 0.8 mmol) were added sequentially at 25 °C. The reaction mixture was stirred at 25 °C over 3 h and then quenched with a sat. aqueous NH$_4$Cl solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na$_2$SO$_4$ and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 20:1) afforded the product **8f** (206 mg, 98 %) as off-white solid.

M.p. (°C): 71.8-72.8

^{1}H-NMR (300 MHz, CDCl$_3$): δ / ppm = 8.07 (ddd, $^3J_{HH}$ = 9.2, $^4J_{HF}$ = 8.1, $^4J_{HF}$ = 5.5 Hz, 1H, 4-H), 7.10 (ddd, $^3J_{HH}$ = 9.2, $^3J_{HF}$ = 8.1, $^5J_{HF}$ = 1.8 Hz, 1H, 5-H), 7.10 (s, br, 1H, 4'-H), 7.04 (s, br, 2H, 2',6'-H), 2.36 - 2.38 (m, 6H, Me).

^{13}C-NMR (75 MHz, CDCl$_3$): δ / ppm = 162.8 (dd, J_{CF} = 259, 6 Hz, C-6), 153.9 (dd, J_{CF} = 259, 9 Hz, C-2), 138.2, 134.7, 131.0 (C-4'), 127.7 (t, J_{CF} = 2 Hz, C-2',6'), 126.6, 125.7 (dd, J_{CF} = 11, 2 Hz, C-4), 121.5 (dd, J = 21, 19 Hz), 111.9 (dd, J_{CF} = 25, 4 Hz, C-5), 21.3 (Me).

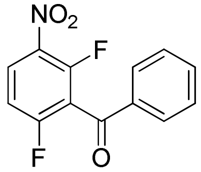
^{19}F-NMR (254 MHz, CDCl$_3$): δ / ppm = -115.20 (dddt, $^4J_{FF}$ = 14.6, $^4J_{HF}$ = 8.0, $^5J_{HF}$ = 1.6, $^5J_{HF}$ = 1.4 Hz, 1F, 2-F), -100.84 (dddt, $^4J_{FF}$ = 14.6, $^3J_{HF}$ = 8.1, $^4J_{HF}$ = 5.6, $^5J_{HF}$ = 1.4 Hz, 1F, 6-F).

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3098, 2949, 2916, 2863, 1863, 1618, 1602, 1586, 1526, 1479, 1447, 1416, 1378, 1347, 1304, 1278, 1219, 1204, 1173, 1147, 1106, 1032, 996, 975, 941, 919, 908, 892, 859, 830, 820, 766, 731, 699, 674.

MS (EI, 70 eV): m/z (%) = 263 [M$^+$] (55), 202 (20), 70 (10), 61 (14), 43 (100).

HRMS (EI) for **$C_{14}H_{11}F_2NO_2$** (263.0758): 263.0752.

(2,6-Difluoro-3-nitrophenyl)(phenyl)methanone (8g)



A solution of (2,6-difluoro-3-nitrophenyl)zinc pivalate (**6c**; 1.23 g, 1.0 mmol) in THF (3 mL) was cooled to -20 °C and CuCN·2LiCl (1.1 mmol, 1.1 mL, 1.0 M in THF) was added dropwise. After stirring at this temperature for 20 min, benzoyl chloride (281 mg, 2.0 mmol) was added and the mixture was warmed up slowly to reach 25 °C and stirred there for 2 h. The reaction was quenched using sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 10:1) afforded the product **8g** (156 mg, 59 %) as a colourless solid.

^{1}H-NMR (400 MHz, CDCl$_3$): 8.28 (td, *J* = 8.77, 5.55 Hz, 1H), 7.87 (dd, *J* = 7.84, 0.60 Hz, 2H), 7.64 - 7.75 (m, 1H), 7.48 - 7.61 (m, 2H), 7.11 - 7.23 (m, 1H).

The physical and spectroscopical data of compound **8g** were in perfect agreement with the one reported in the literature.[1]

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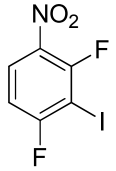
[1] Mosrin, M.; Knochel, P. *Org. Lett.* **2009**, *11*, 1837.

1,3-Difluoro-2-iodo-4-nitrobenzene (8h)

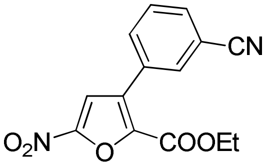


A solution of (2,6-difluoro-3-nitrophenyl)zinc pivalate (**6c**; 1.23 g, 1.0 mmol) in THF (3 mL) was cooled down to 0 °C and I_2 (380 mg, 1.5 mmol) was added. The stirred reaction mixture was allowed to come to 25 °C (over 30 min) and then quenched with a sat. aqueous $Na_2S_2O_3$ solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 12:1) afforded the product **8h** (278 mg, 98%) as an off-white solid.

^{1}H-NMR (400 MHz, $CDCl_3$): 8.16 (ddd, *J* = 9.24, 8.17, 5.61 Hz, 1H), 7.07 (ddd, *J* = 9.24, 6.38, 1.88 Hz, 1H).

The physical and spectroscopical data of compound **8h** were in perfect agreement with the one reported in the literature.[1]

Ethyl 3-(3-cyanophenyl)-5-nitrofuran-2-carboxylate (8i)



To a solution of 3-(2-ethoxycarbonyl-5-nitrofuranyl)zinc pivalate (**6d**; 1.33 g, 1.0 mmol) in THF (3 mL) at 25 °C Pd(dba)$_2$ (17 mg, 3 mol%), P(*o*-fur)$_3$ (14 mg, 6 mol%) and 3-iodobenzonitrile (183 mg, 0.8 mmol) were added sequentially. The reaction mixture was stirred for 6 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 8:1) afforded the product **8i** (189 mg, 66%) as off-white solid.

M.p. (°C): 133.9-136.5

^{1}H-NMR (400 MHz, CDCl$_3$): δ / ppm = 7.86 (td, *J* = 1.8, 0.6 Hz, 1H), 7.81 (ddd, *J* = 7.9, 1.8, 1.2 Hz, 1H), 7.79 – 7.75 (m, 1H), 7.62 (td, *J* = 7.9, 0.6 Hz, 1H), 7.36 (s, 1H), 4.46 (q, *J* = 7.1 Hz, 2H), 1.42 (t, *J* = 7.1 Hz, 3H).

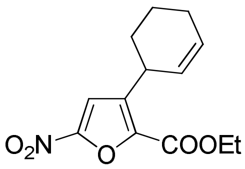
^{13}C-NMR (100 MHz, CDCl$_3$): δ / ppm = 156.7, 157.7, 143.6, 133.7, 133.3, 132.8, 129.8, 129.6, 125.3, 120.4, 117.8, 113.2, 62.7, 14.2.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3098, 3066, 2997, 2910, 2238, 1746, 1612, 1591, 1532, 1509, 1481, 1463, 1447, 1420, 1398, 1362, 1348, 1336, 1324, 1301, 1262, 1244, 1224, 1186, 1180, 1155, 1123, 1111, 1096, 1011, 968, 934, 925, 891, 870, 848, 820, 799, 767, 744, 692, 680, 665.

MS (EI, 70 eV): m/z (%) = 286 [M$^+$] (100), 241 (18), 213 (32), 200 (39), 172 (37), 139 (32), 130 (20), 127 (59).

HRMS (ESI) for **$C_{14}H_{10}N_2O_5$** (286.0590): 286.0585.

Ethyl 3-(cyclohex-2-enyl)-5-nitrofuran-2-carboxylate (8j)



A solution of 3-(2-ethoxycarbonyl-5-nitrofuranyl)zinc pivalate (**6d**; 1.33 g, 1.0 mmol) in THF (3 mL) was cooled to -20 °C. CuCN·2LiCl (0.1 mmol, 0.1 mL, 1 M in THF) and 3-bromocyclohex-1-ene (242 mg, 1.5 mmol) were added sequentially. The reaction mixture was allowed to warm to 25 °C over 12 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) followed by extraction with ethyl acetate (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 10:1) afforded the product **8j** (187 mg, 70 %) as reddish oil.

^{1}H-NMR (400 MHz, CDCl$_3$): δ / ppm = 7.20 (d, *J* = 0.5 Hz, 1H), 5.97 (dtd, *J* = 9.8, 3.7, 2.2 Hz, 1H), 5.64 – 5.54 (m, 1H), 4.41 (q, *J* = 7.1 Hz, 2H), 4.14 (ddd, *J* = 10.6, 5.5, 2.7 Hz, 1H), 2.17 – 1.99 (m, 3H), 1.77 – 1.64 (m, 2H), 1.61 – 1.48 (m, 1H), 1.40 (t, *J* = 7.1 Hz, 3H)

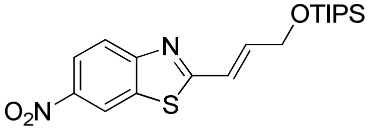
^{13}C-NMR (100 MHz, CDCl$_3$): δ / ppm = 157.2, 147.9, 143.0, 134.0, 130.5, 126.4, 119.9, 62.3, 32.3, 29.1, 24.7, 20.6, 14.2.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3127, 3025, 2984, 2936, 2864, 2838, 1737, 1724, 1629, 1595, 1532, 1502, 1475, 1465, 1447, 1433, 1402, 1390, 1367, 1337, 1286, 1251, 1226, 1197, 1156, 1140, 1106, 1092, 1015, 981, 965, 932, 883, 851, 818, 764, 746, 725, 671.

MS (EI, 70 eV): m/z (%) = 265 [M$^+$] (2), 248 (100), 231 (49), 220 (15), 146 (20), 91 (19), 77 (16).

HRMS (ESI) for **$C_{13}H_{15}NO_5$** (265.0950): 265.0943.

(*E*)-6-nitro-2-(3-(triisopropylsilyloxy)prop-1-enyl)benzo[*d*]thiazole (8k)



To a solution of (6-nitrobenzo[d]thiazol-2-yl)zinc pivalate (**6e**; 1.33 g, 1.0 mmol) in THF (3 mL) at 25 °C Pd(dba)$_2$ (17 mg, 3 mol%), P(*o*-fur)$_3$ (14 mg, 6 mol%) and (*E*)-(3-iodoallyloxy)triisopropylsilane (272 mg, 0.8 mmol) were added sequentially. The reaction mixture was stirred for 2 h and then quenched with a sat. aqueous NH$_4$Cl solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na$_2$SO$_4$ and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 25:1) afforded the product **8k** (298 mg, 95 %) as orange crystals.

M.p. (°C): 50.5-52.6.

^{1}H-NMR (400 MHz, CDCl$_3$): δ / ppm = 8.76 (dd, *J* = 2.3, 0.5 Hz, 1H), 8.32 (dd, *J* = 9.0, 2.3 Hz, 1H), 8.04 (dd, *J* = 9.0, 0.4 Hz, 1H), 7.11 (dt, *J* = 15.6, 2.2 Hz, 1H), 6.96 (dt, *J* = 15.6, 3.4 Hz, 1H), 4.56 (dd, *J* = 3.4, 2.2 Hz, 2H), 1.24 – 1.13 (m, 3H), 1.13 – 1.07 (m, 18H).

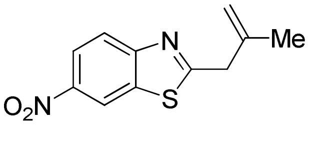
^{13}C-NMR (100 MHz, CDCl$_3$): δ / ppm = 172.6, 157.5, 144.8, 143.1, 134.7, 122.9, 122.1, 121.8, 118.0, 62.7, 18.0, 11.9.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3112, 2957, 2942, 2890, 2864, 2839, 2718, 1646, 1601, 1567, 1514, 1491, 1462, 1440, 1411, 1384, 1371, 1335, 1290, 1278, 1270, 1261, 1238, 1136, 1126, 1120, 1096, 1073, 1046, 1016, 994, 964, 949, 919, 908, 882, 846, 824, 816, 793, 781, 764, 751, 716, 687, 663.

MS (EI, 70 eV): m/z (%) = 392 [M$^+$] (7), 349 (100), 173 (27), 103 (11), 75 (14), 43 (38).

HRMS (ESI) for **$C_{19}H_{28}N_2O_3SSi$** (392.1590): 392.1584.

2-(2-Methylallyl)-6-nitrobenzo[*d*]thiazole (8l)



A solution of (6-nitrobenzo[*d*]thiazol-2-yl)zinc pivalate (**6e**; 1.33 g, 1.0 mmol) in THF (3 mL) was cooled to -40 °C. CuCN·2LiCl (0.1 mmol, 0.1 mL, 1 M in THF) and 3-bromo-2-methylprop-1-ene (162 mg, 1.2 mmol) were added sequentially. The reaction mixture was stirred for 45 min at the same temperature and then quenched with a sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) and allowed to warm up to 25 °C (prolonged reaction time or quenching at higher temperature led to partial migration of the double bond to conjugation) followed by extraction with ethyl acetate (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 15:1) afforded the product **8l** (205 mg, 88 %) as orange solid.

M.p. (°C): 88.5-90.1.

^{1}H-NMR (600 MHz, $CDCl_3$): δ / ppm = 8.78 (dd, *J* = 2.3, 0.4 Hz, 1H), 8.33 (dd, *J* = 9.0, 2.3 Hz, 1H), 8.07 (dd, *J* = 9.0, 0.3 Hz, 1H), 5.07 – 5.04 (m, 1H), 5.04 – 5.02 (m, 1H), 3.88 (d, *J* = 1.0 Hz, 2H), 1.84 (t, *J* = 1.1 Hz, 3H).

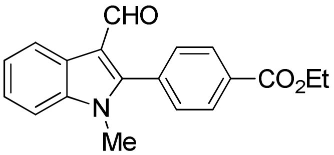
^{13}C-NMR (150 MHz, $CDCl_3$): δ / ppm = 176.6, 157.1, 144.8, 140.8, 136.0, 123.0, 121.5, 118.1, 115.6, 43.3, 22.1.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3094, 3063, 3002, 2980, 2933, 2906, 1944, 1833, 1812, 1738, 1650, 1601, 1567, 1511, 1447, 1418, 1384, 1366, 1344, 1335, 1328, 1310, 1277, 1246, 1196, 1131, 1113, 1047, 1022, 976, 914, 896, 845, 754, 743, 723, 681, 654.

MS (EI, 70 eV): m/z (%) = 234 [M$^+$] (23), 219 (29), 194 (15), 70 (15), 61 (18), 44 (17), 43 (100).

HRMS (ESI) for **$C_{11}H_{10}N_2O_2S$** (234.0463): 234.0458

Ethyl 4-(3-formyl-1-methyl-1*H*-indol-2-yl)benzoate (8m)



To a solution of (3-formyl-1-methyl-1*H*-indol-2-yl)zinc pivalate (**6f**; 1.18 g, 1.0 mmol) in THF (3 mL) at 25 °C Pd(dba)$_2$ (17 mg, 3 mol%), P(*o*-fur)$_3$ (14 mg, 6 mol%) and ethyl 4-iodobenzoate (220 mg, 0.8 mmol) were added sequentially. The reaction mixture was stirred at 25 °C over 3 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et_2O = 1:1) afforded the product **8m** (281 mg, 91%) as off-white solid.

M.p. (°C): 161.4-163.0.

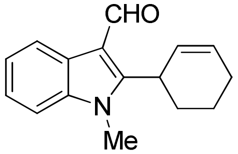
^{1}H-NMR (300 MHz, $CDCl_3$): δ / ppm = 9.75 (s, 1H), 8.44 (d, *J* = 5.73 Hz, 1H), 8.18 – 8.30 (m, 2H), 7.49 – 7.72 (m, 2H), 7.30 – 7.52 (m, 3H), 4.46 (q, *J* = 7.06 Hz, 2H), 3.69 (s, 3H), 1.45 (t, *J* = 7.17 Hz, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$): δ / ppm = 186.0, 165.7, 149.7, 137.5, 133.0, 131.8, 130.9, 129.7, 125.1, 124.3, 123.4, 122.2, 116.0, 109.8, 61.4, 31.1, 14.3.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3034, 2988, 2978, 2886, 2803, 2770, 2730, 1712, 1649, 1608, 1578, 1567, 1537, 1507, 1467, 1442, 1416, 1371, 1366, 1339, 1327, 1313, 1289, 1280, 1255, 1183, 1155, 1128, 1107, 1082, 1072, 1049, 1028, 1018, 990, 977, 951, 901, 884, 874, 861, 848, 812, 760, 741, 714, 700, 694, 682, 662.

HRMS (ESI) for **$C_{19}H_{18}NO_3^+$** (308.1281): 308.1280.

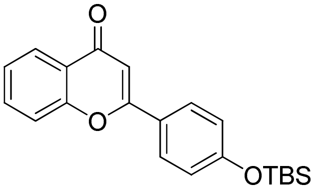
2-(Cyclohex-2-en-1-yl)-1-methyl-1*H*-indole-3-carbaldehyde (8n)



A solution of (3-formyl-1-methyl-1*H*-indol-2-yl)zinc pivalate (**6f**; 1.18 g, 1.0 mmol) in THF (3 mL) was cooled to -20 °C. CuCN·2LiCl (0.1 mmol, 0.1 mL, 1 M in THF) and 3-bromocyclohex-1-ene (242 mg, 1.5 mmol) were added sequentially. The reaction mixture was allowed to warm to 25 °C over 12 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) followed by extraction with ethyl acetate (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et_2O = 2:1) afforded the product **8n** (234 mg, 98%) as orange resin.

^{1}H-NMR (300 MHz, $CDCl_3$): δ / ppm = 10.34 (s, 1H), 8.35 (s, 1H), 7.25 – 7.40 (m, 3H), 5.96 – 6.05 (m, 1H), 5.80 – 5.88 (m, 1H), 4.22 – 4.37 (m, 1H), 3.80 (s, 3H), 2.11 – 2.26 (m, 3H), 1.74 – 2.04 (m, 3H).
^{13}C-NMR (75 MHz, $CDCl_3$): δ / ppm = 185.2, 153.7, 137.2, 129.4, 127.5, 125.7, 123.3, 123.0, 121.6, 114.3, 109.2, 34.0, 30.7, 27.0, 24.6, 22.2.
IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3054, 3024, 2932, 2862, 1713, 1641, 1612, 1580, 1513, 1468, 1446, 1413, 1393, 1372, 1336, 1322, 1291, 1246, 1223, 1186, 1126, 1082, 1048, 1016, 980, 933, 890, 859, 818, 801, 746, 729, 701, 683, 671.
HRMS (ESI) for **$C_{16}H_{18}NO^+$** (240.1383): 240.1383.

2-(4-(tert-butyldimethylsilyloxy)phenyl)-4*H*-chromen-4-one (8o)



According to **TP2** chromone (**5g**; 146 mg, 1.0 mmol) in 2 mL THF reacted with $BF_3{\cdot}OEt_2$ (156 mg, 1.1 mmol) and TMPZnOPiv·LiCl (**4**; 1.3 mL, 0.85 M, 1.1 mmol) to give (4-oxo-4*H*-chromen-2-yl)zinc pivalate (**6g**) as a deep red solution. To this solution $Pd(dba)_2$ (17 mg, 3 mol%), P(*o*-fur)$_3$ (14 mg, 6 mol%) and tert-butyl(4-iodophenoxy)dimethylsilane (267 mg, 0.8 mmol) were added sequentially at 25 °C. The reaction mixture was stirred for 2 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 25:1) afforded the product **8o** (218 mg, 78 %) as red-brown solid.

M.p. (°C): 94.7-96.3.

^{1}H-NMR (400 MHz, CDCl$_3$): δ / ppm = 8.23 (ddd, *J* = 7.9, 1.7, 0.4 Hz, 1H), 7.89 – 7.79 (m, 2H), 7.73 – 7.65 (m, 1H), 7.55 (ddd, *J* = 8.4, 1.1, 0.4 Hz, 1H), 7.41 (ddd, *J* = 8.1, 7.1, 1.1 Hz, 1H), 7.00 – 6.92 (m, 2H), 6.78 (s, 1H), 1.00 (s, 9H), 0.25 (s, 6H).

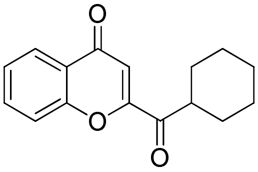
^{13}C-NMR (100 MHz, CDCl$_3$): δ / ppm = 178.5, 163.6, 159.1, 156.2, 133.6, 128.0, 125.7, 125.1, 124.5, 123.8, 120.6, 117.9, 106.2, 25.6, 18.3, -4.3.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3060, 2955, 2928, 2857, 2769, 2703, 2641, 1642, 1632, 1620, 1600, 1576, 1509, 1467, 1420, 1376, 1337, 1298, 1274, 1252, 1226, 1176, 1133, 1114, 1043, 1017, 1009, 918, 908, 873, 836, 823, 806, 771, 752, 733, 726, 716, 673.

MS (EI, 70 eV): m/z (%) = 253 [M$^+$] (76), 297 (22), 296 (100), 295 (20), 175 (11), 121 (29).

HRMS (ESI) for **$C_{21}H_{24}O_3Si$** (352.1495): 352.1494.

2-(Cyclohexanecarbonyl)-4*H*-chromen-4-one (8p)



According to **TP2** chromone (**5g**; 146 mg, 1.0 mmol) in 2 mL THF reacted with $BF_3 \cdot OEt_2$ (156 mg, 1.1 mmol) and TMPZnOPiv·LiCl (**4**; 1.3 mL, 0.85 M, 1.1 mmol) to give (4-oxo-4*H*-chromen-2-yl)zinc pivalate (**6g**) as a deep red solution. This solution was cooled to -20 °C and CuCN·2LiCl (1.1 mmol, 1.1 mL, 1 M in THF) was added. After stirring for 20 min at this temperature, cyclohexanecarbonyl chloride (292 mg, 2.0 mmol) were added dropwise and the reaction mixture was warmed to 25 °C and stirred there for 2 h. Then a sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) were added followed by extraction with ethyl acetate (3×10 mL). The combined organic layers were washed with a 15 % w/w aqueous solution K_2CO_3 (2×20 mL) and brine (1×20 mL) dried over Na_2SO_4. After filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / ethyl acetate = 15:1) afforded the product **8p** (179 mg, 70 %) as colourless crystals.

M.p. (°C): 137.3-140.9.

^{1}H-NMR (400 MHz, CDCl$_3$): δ / ppm = 8.20 (ddd, *J* = 8.0, 1.7, 0.4 Hz, 1H), 7.75 (ddd, *J* = 8.8, 7.1, 1.7 Hz, 1H), 7.58 (ddd, *J* = 8.5, 1.0, 0.4 Hz, 1H), 7.45 (ddd, *J* = 8.1, 7.2, 1.0 Hz, 1H), 6.97 (s, 1H), 3.27 (tt, *J* = 11.2, 3.3 Hz, 1H), 1.95 (dd, *J* = 14.3, 1.3 Hz, 2H), 1.91 – 1.81 (m, 2H), 1.81 – 1.70 (m, 1H), 1.44 (dtdd, *J* = 19.3, 16.0, 9.7, 3.3 Hz, 4H), 1.33 – 1.22 (m, 1H).

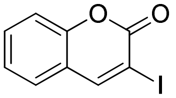
^{13}C-NMR (100 MHz, CDCl$_3$): δ / ppm = 197.9, 178.6, 156.5, 155.56, 134.7, 125.9, 125.8, 124.5, 118.6, 112.0, 45.6, 28.4, 25.7, 25.5.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3074, 2923, 2852, 1693, 1642, 1616, 1570, 1464, 1450, 1398, 1367, 1352, 1331, 1315, 1294, 1272, 1254, 1240, 1224, 1190, 1169, 1148, 1136, 1114, 1103, 1084, 1075, 1057, 1040, 1030, 1020, 996, 962, 924, 896, 878, 866, 839, 784, 771, 755, 744, 721, 676.

MS (EI, 70 eV): m/z (%) = 256 [M$^+$] (37), 83 (17), 70 (15), 61 (17), 55 (21), 43 (100).

HRMS (ESI) for **$C_{16}H_{16}O_3$** (256.1099): 256.1085

3-Iodo-2*H*-chromen-2-one (8q)



A solution of oxo(2-oxo-2*H*-chromen-3-yl)zinc pivalate (**6h**; 0.91 g, 1.0 mmol) in THF (3 mL) was cooled down to 0 °C and I_2 (380 mg, 1.5 mmol) was added. The stirred reaction mixture was allowed to come to 25 °C (over 30 min) and then quenched with a sat. aqueous $Na_2S_2O_3$ solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et_2O = 4:1) afforded the product **8q** (252 mg, 92%) as a white solid.

M.p. (°C): 90.2-91.6.

^{1}H-NMR (300 MHz, CDCl$_3$): δ / ppm = 8.36 (s, 1H), 7.52 - 7.63 (m, 1H), 7.44 (d, *J* = 7.67 Hz, 1H), 7.27 - 7.37 (m, 2H).

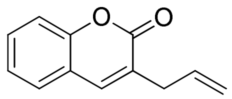
^{13}C-NMR (75 MHz, CDCl$_3$): δ / ppm = 157.4, 153.9, 152.1, 132.3, 126.8, 124.7, 120.1, 116.8, 86.2.

R (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3069, 3047, 3027, 1720, 1706, 1687, 1669, 1602, 1564, 1553, 1508, 1483, 1448, 1440, 1418, 1400, 1363, 1350, 1342, 1329, 1274, 1245, 1212, 1157, 1132, 1119, 1083, 1049, 1026, 986, 958, 948, 934, 913, 860, 802, 782, 763, 750, 724, 700, 682**.**

MS (EI, 70 eV): m/z (%) = 272 [M$^+$] (100), 244 (29), 145 (44), 89 (61), 63 (28), 43 (18).

HRMS (EI) for **$C_9H_5IO_2$** (271.9334): 271.9333.

3-Allyl-2*H*-chromen-2-one (8r)



A solution of (2-oxo-2*H*-chromen-3-yl)zinc pivalate (**6h**; 0.91 g, 1.0 mmol) in THF (3 mL) was cooled to -20 °C. CuCN·2LiCl (0.1 mmol, 0.1 mL, 1.0 M in THF) and allyl bromide (182 mg, 1.5 mmol) were added sequentially. The reaction mixture was allowed to warm to 25 °C over 12 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) followed by extraction with ethyl acetate (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et_2O = 4:1) afforded the product **8r** (182 mg, 98%) as a white solid.

M.p. (°C): 41.4-45.9.

^{1}H-NMR (300 MHz, $CDCl_3$): δ / ppm = 7.38 - 7.61 (m, 3H), 7.16-7.37 (m, 2H), 5.80 - 6.14 (m, 1H), 5.04 - 5.43 (m, 2H), 3.32 (d, *J* = 6.77 Hz, 2H)

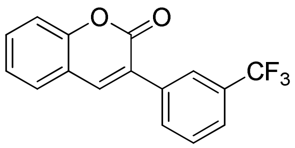
^{13}C-NMR (75 MHz, $CDCl_3$): δ / ppm = 161.5, 153.1, 138.8, 133.7, 130.7, 128.0, 127.2, 124.2, 119.4, 118.1, 116.4, 34.5.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3068, 3016, 2976, 2905, 1707, 1633, 1608, 1578, 1568, 1508, 1484, 1472, 1457, 1429, 1416, 1400, 1382, 1363, 1326, 1291, 1282, 1253, 1232, 1185, 1150, 1124, 1082, 1050, 1026, 1006, 946, 932, 901, 864, 844, 787, 754, 744, 727, 712, 702, 682, 662.

MS (EI, 70 eV): m/z (%) = 186 [M$^+$] (49), 171 (20), 157 (24), 131 (23), 61 (19), 43 (100)..

HRMS (ESI) for **$C_{12}H_{10}O_2$** (186.0681): 186.0674.

3-(3-(Trifluoromethyl)phenyl)-2*H*-chromen-2-one (8s)



To a solution of (2-oxo-2*H*-chromen-3-yl)zinc pivalate (**6h**; 0.91 g, 1.0 mmol) in THF (3 mL) at 25 °C, Pd(dba)$_2$ (17 mg, 3 mol%), P(*o*-fur)$_3$ (14 mg, 6 mol%) and 1-iodo-3-(trifluoromethyl)benzene (217 mg, 0.8 mmol) were added sequentially. The reaction mixture was stirred at 25 °C for 1.5 h and then quenched with a sat. aqueous NH$_4$Cl solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na$_2$SO$_4$ and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et$_2$O = 5:1) afforded the product **8h** (226 mg, 96%) as white solid.

M.p. (°C): 122.9-124.4.

^{1}H-NMR (300 MHz, CDCl$_3$): δ / ppm = 7.90 - 8.01 (m, 2H), 7.89 (s, 1H), 7.64 - 7.73 (m, 1H), 7.58 (t, *J* = 7.36 Hz, 3H), 7.28 - 7.45 (m, 2H).

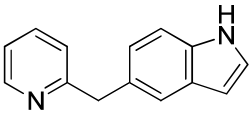
^{13}C-NMR (75 MHz, CDCl$_3$): δ / ppm = 160.2, 153.7, 140.7, 135.4, 132.0, 131.9 (q, *J* = 1.3 Hz), 131.0 (q, *J* = 32.5 Hz), 128.9, 128.1, 126.9, 125.5 (q, *J* = 3.8 Hz), 125.2 (q, *J* = 3.8 Hz), 124.7, 123.9 (q, *J* = 272 Hz), 119.3, 116.6.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3038, 2979, 2889, 1710, 1658, 1608, 1567, 1508, 1492, 1458, 1430, 1400, 1356, 1343, 1332, 1289, 1285, 1261, 1232, 1180, 1165, 1150, 1108, 1076, 1026, 1001, 986, 968, 956, 940, 924, 904, 859, 808, 774, 758, 736, 691, 654.

MS (EI, 70 eV): m/z (%) = 290 [M$^+$] (100), 262 (88), 233 (9), 165 (29), 43 (10)..

HRMS (EI) for **C$_{16}$H$_9$F$_3$O$_2$** (290.0555): 290.0548.

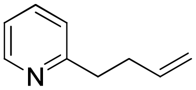
5-(Pyridin-2-ylmethyl)-1*H*-indole (8t)



According to **TP3** 2-picolin (**5i**; 93 mg, 1.0 mmol) reacted with **4** at 25 °C for 1 h to give (pyridin-2-ylmethyl)zinc pivalate (**6i**) as a brownish solution. To this solution Pd(OAc)$_2$ (9 mg, 4 mol%), SPhos (33 mg, 8 mol%) and 5-bromoindole (156 mg, 0.8 mmol) were added sequentially at 25 °C. The reaction mixture was stirred at 50 °C for 12 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et_2O = 5:1 -> 1:1) afforded the product **8t** (123 mg, 74%) as colorless oil.

^{1}H-NMR (300 MHz, $CDCl_3$): δ / ppm = 8.56 (d, *J* = 4.2 Hz, 1H), 8.37 (br s, 1H), 7.47 - 7.67 (m, 2H), 7.33 (d, *J* = 8.3 Hz, 1H), 7.01 - 7.25 (m, 4H), 6.50 (s, 1H), 4.29 (s, 2H).
^{13}C-NMR (75 MHz, $CDCl_3$): δ / ppm = 162.1, 148.9, 136.6, 134.6, 130.7, 128.2, 124.5, 123.4, 123.2, 121.0, 120.9, 111.1, 102.3, 44.7.
IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3114, 3097, 3028, 2852, 2361, 1739, 1592, 1474, 1344, 1218, 1138, 1093, 998, 889, 793, 755, 736, 655.
MS (EI, 70 eV): m/z (%) = 208 [M$^+$] (70), 207 (100), 130 (48), 127 (18), 44 (62).
HRMS (EI) for **$C_{14}H_{12}N_2$:** (208.1000): 208.0933.

2-(But-3-enyl)pyridine (8u)



According to **TP3** 2-picolin (**5i**; 93 mg, 1.0 mmol) reacted with **4** at 25 °C for 1 h to give (pyridin-2-ylmethyl)zinc pivalate (**6i**) as a brownish solution which was cooled to -60 °C. CuCN·2LiCl (0.05 mmol, 0.05 mL, 1.0 M in THF) and allyl bromide (145 mg, 1.2 mmol) were added sequentially. The reaction mixture was allowed to warm slowly up to 0 °C over 6 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) followed by extraction with ethyl acetate (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et_2O = 4:1) afforded the product **8u** (105 mg, 79 %) as a colourless oil.

^{1}H-NMR (300 MHz, $CDCl_3$): δ / ppm = 8.54 (dd, *J* = 5.9, 0.9 Hz, 1H), 7.60 (td, *J* = 7.7, 1.8 Hz, 1H), 7.22 – 7.02 (m, 2H), 5.86 (ddt, *J* = 16.9, 10.2, 6.6 Hz, 1H), 5.04 (ddd, *J* = 17.1, 3.4, 1.6 Hz, 1H), 5.00 – 4.94 (m, 1H), 2.90 (dd, *J* = 8.8, 6.8 Hz, 2H), 2.55 – 2.43 (m, 2H).

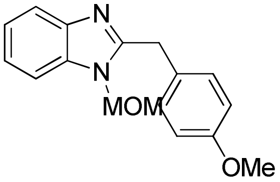
^{13}C-NMR (75 MHz, CDCl$_3$): δ / ppm = 161.2, 148.9, 137.6, 136.5, 122.9, 121.1, 115.2, 37.4, 33.7.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3739, 3412, 3026, 3001, 2925, 1873, 1591, 1474, 1435, 1376, 1355, 1217, 1147, 1069, 991, 748, 676, 662.

MS (EI, 70 eV): m/z (%) = 133 [M$^+$] (39), 132 (100), 118 (49), 93 (20), 79 (22), 65 (18), 43 (46).

HRMS (EI) for **$C_9H_{11}N$** (133.0892): 133.0864

2-(4-Methoxybenzyl)-1-(methoxymethyl)-1*H*-benzo[*d*]imidazole (8v)



According to **TP3** 1-(methoxymethyl)-2-methyl-1*H*-benzo[*d*]imidazole (**5j**; 176 mg, 1.0 mmol) reacted with **4** at 25 °C for 1 h to give ((1-(methoxymethyl)-1*H*-benzo[*d*]imidazol-2-yl)methyl)zinc pivalate (**6j**) as a brownish solution. To this solution Pd(OAc)$_2$ (9 mg, 4 mol%), SPhos (33 mg, 8 mol%) and 4-bromoanisole (150 mg, 0.8 mmol) were added sequentially at 25 °C. The reaction mixture was stirred at 50 °C for 12 h and then quenched with a sat. aqueous NH$_4$Cl solution (9 mL) followed by extraction with diethyl ether (3×10 mL). The combined organic layers were dried over Na$_2$SO$_4$ and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et$_2$O = 5:1) afforded the product **8v** (165 mg, 73 %) as colourless oil.

^{1}H-NMR (600 MHz, CDCl$_3$): δ / ppm = 7.78 (ddd, *J* = 4.9, 2.4, 0.8 Hz, 1H), 7.40 (ddd, *J* = 4.4, 2.6, 0.8 Hz, 1H), 7.30 – 7.25 (m, 2H), 7.22 – 7.17 (m, 2H), 6.86 – 6.79 (m, 2H), 5.32 (s, 2H), 4.32 (s, 2H), 3.76 (s, 3H), 3.17 (s, 3H).

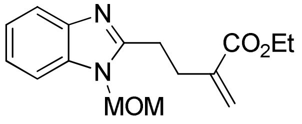
^{13}C-NMR (150 MHz, CDCl$_3$): δ / ppm = 158.6, 153.9, 142.2, 135.5, 129.6, 128.0, 122.9, 122.5, 119.5, 114.2, 109.5, 74.4, 56.1, 55.2, 33.5.

IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3059, 2934, 2835, 1708, 1647, 1612, 1597, 1510, 1480, 1456, 1442, 1425, 1412, 1388, 1364, 1328, 1302, 1279, 1245, 1202, 1173, 1153, 1119, 1095, 1063, 1031, 1009, 966, 916, 899, 846, 831, 815, 776, 741, 726, 703, 666, 660**.**

MS (EI, 70 eV): m/z (%) = 282 [M$^+$] (55), 267 (61), 253 (28), 251 (30), 239 (100), 237 (41), 219 (25), 206 (23), 151 (47), 135 (28), 131 (52), 121 (65), 77 (23), 45 (59).

HRMS (EI) for **$C_{17}H_{18}N_2O_2$** (282.1368): 282.1349.

Ethyl 4-(1-(methoxymethyl)-1*H*-benzo[*d*]imidazol-2-yl)-2-methylenebutano-ate (8w)



According to **TP3** 1-(methoxymethyl)-2-methyl-1*H*-benzo[*d*]imidazole (**5j**; 176 mg, 1.0 mmol) reacted with **4** at 25 °C for 1 h to give ((1-(methoxymethyl)-1*H*-benzo[*d*]imidazol-2-yl)methyl)zinc pivalate (**6j**) as a brownish solution which was cooled to -60 °C. CuCN·2LiCl (0.05 mmol, 0.05 mL, 1.0 M in THF) and ethyl 2-(bromomethyl)acrylate (232 mg, 1.2 mmol) were added sequentially. The reaction mixture was allowed to warm up to 25 °C over 2 h and then quenched with a sat. aqueous NH_4Cl solution (9 mL) and NH_3 (conc.) (1 mL) followed by extraction with ethyl acetate (3×10 mL). The combined organic layers were dried over Na_2SO_4 and after filtration the solvents were evaporated *in vacuo*. Purification by flash chromatography (silica gel, isohexane / Et_2O = 8:1) afforded the product **8w** (219 mg, 76 %) as colourless oil.

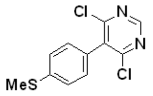
^{1}H-NMR (600 MHz, CDCl$_3$): δ / ppm = 7.77 – 7.71 (m, 1H), 7.42 (dt, *J* = 4.9, 2.9 Hz, 1H), 7.30 – 7.22 (m, 2H), 6.20 (d, *J* = 1.3 Hz, 1H), 5.68 (q, *J* = 1.3 Hz, 1H), 5.49 (s, 2H), 4.22 (q, *J* = 7.1 Hz, 2H), 3.30 (s, 3H), 3.18 – 3.12 (m, 2H), 2.94 – 2.87 (m, 2H), 1.30 (t, *J* = 7.1 Hz, 3H).

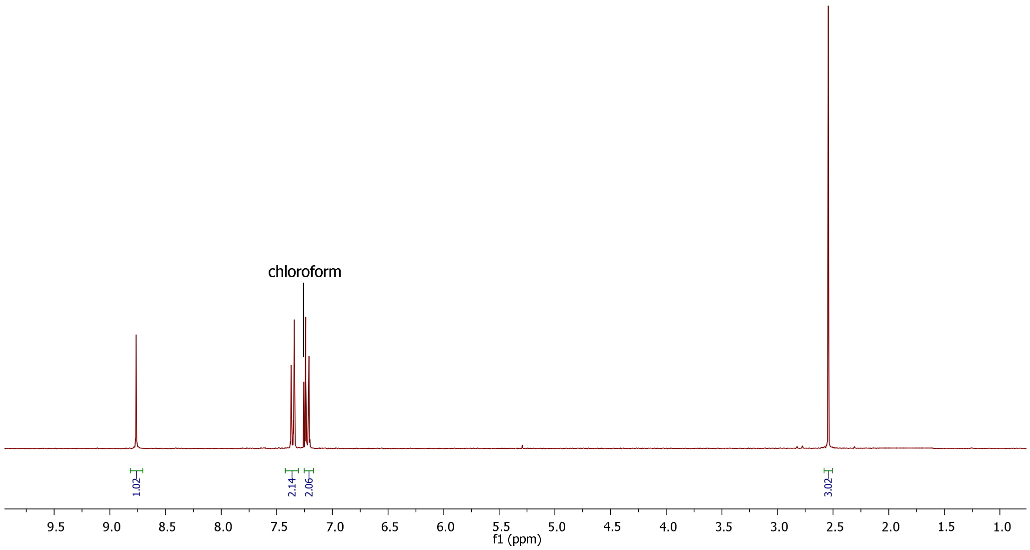
^{13}C-NMR (100 MHz, CDCl$_3$): δ / ppm = 166.7, 154.6, 142.2, 139.1, 135.20, 126.5, 122.8, 122.5, 119.3, 109.4, 74.1, 60.8, 56.3, 30.8, 26.9, 14.2.

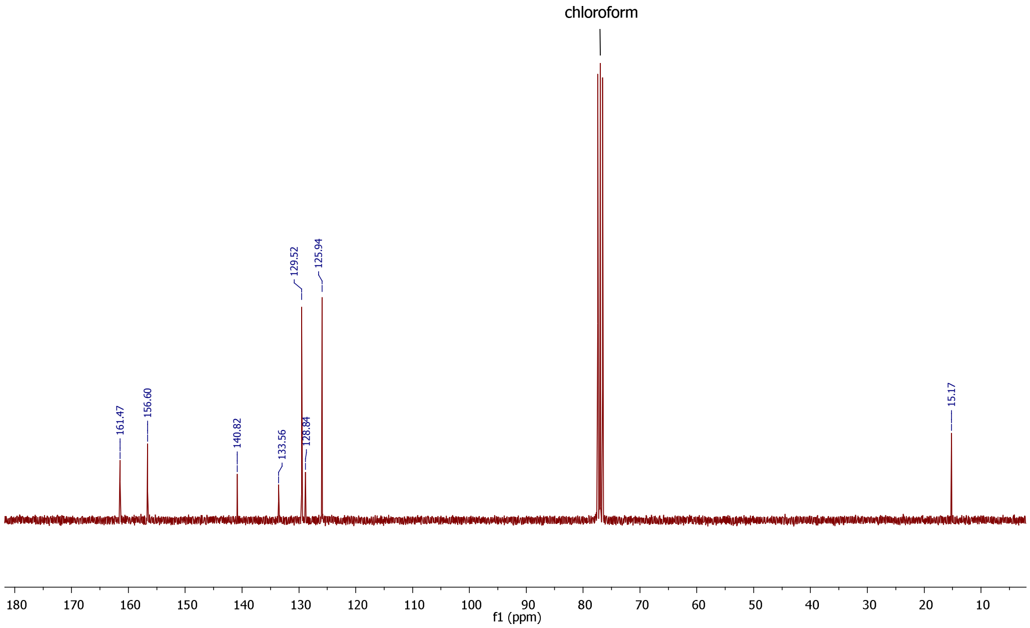
IR (Diamond-ATR, neat): $\tilde{\nu}$ / cm^{-1} = 3061, 2981, 2937, 2906, 2826, 1710, 1631, 1616, 1520, 1458, 1414, 1391, 1370, 1325, 1288, 1275, 1255, 1242, 1186, 1152, 1138, 1119, 1095, 1065, 1027, 1010, 950, 914, 865, 818, 767, 729.

HRMS (ESI) for **$C_{16}H_{21}N_2O_3^+$** (289.1547): 289.1546.

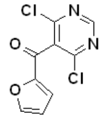
4,6-dichloro-5-(4-(methylthio)phenyl)pyrimidine **8a**

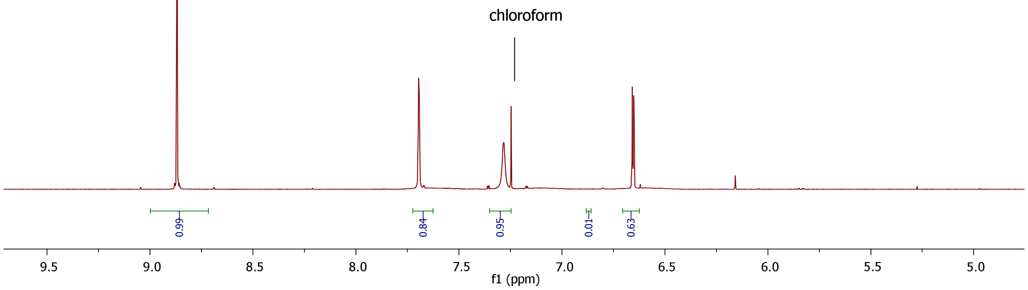


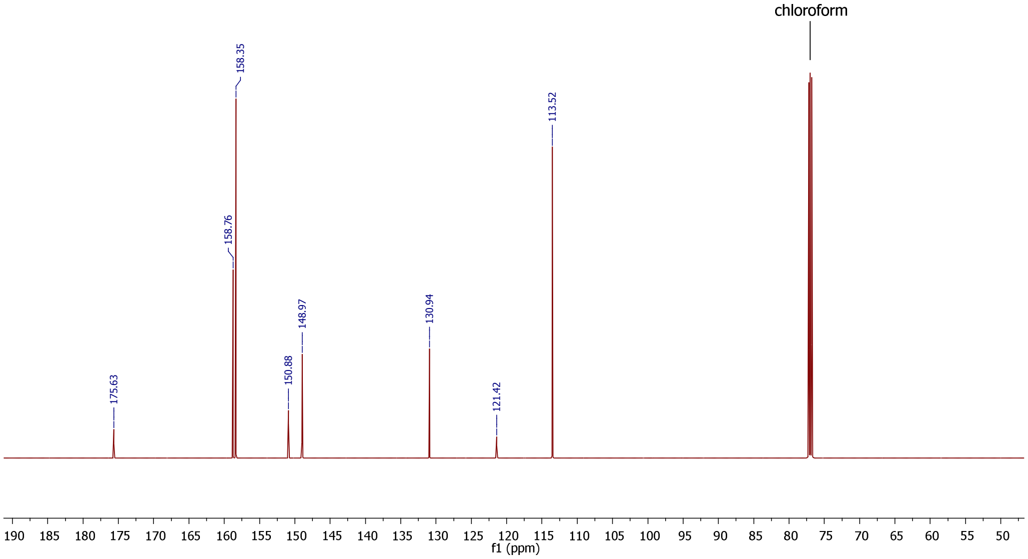




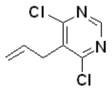
(4,6-dichloropyrimidin-5-yl)(furan-2-yl)methanone **8b**

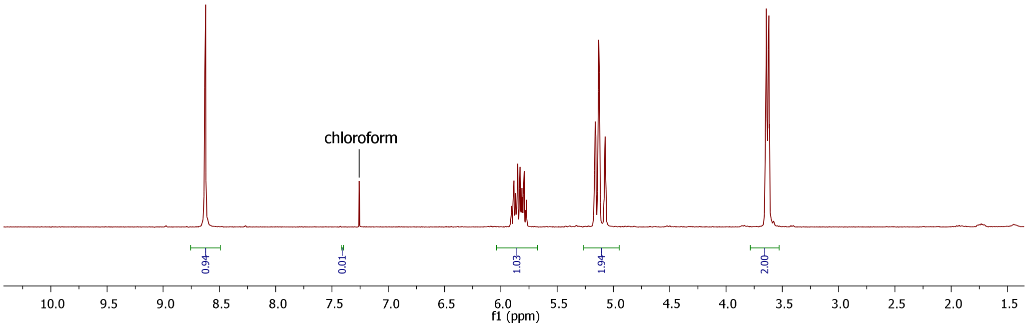


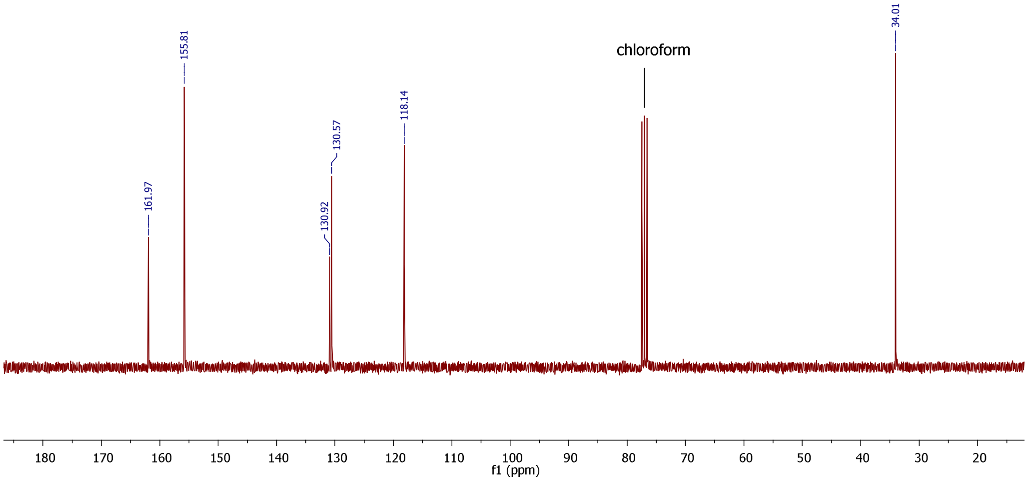




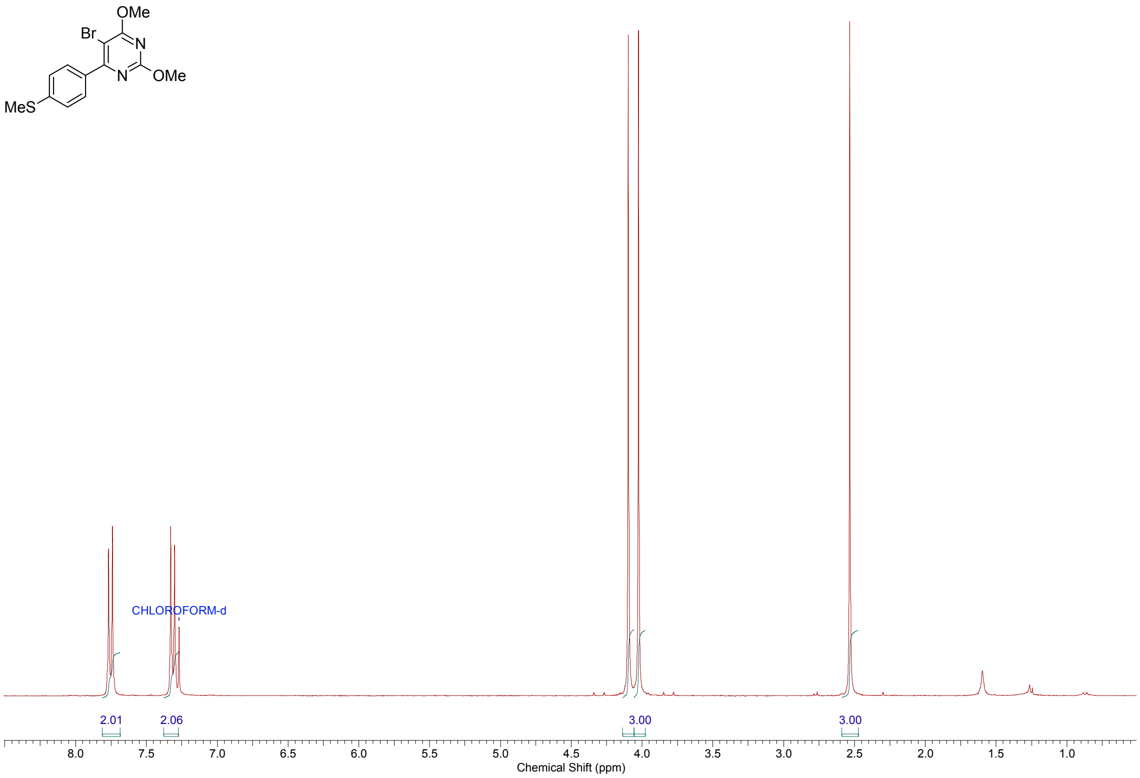
5-allyl-4,6-dichloropyrimidine **8c**

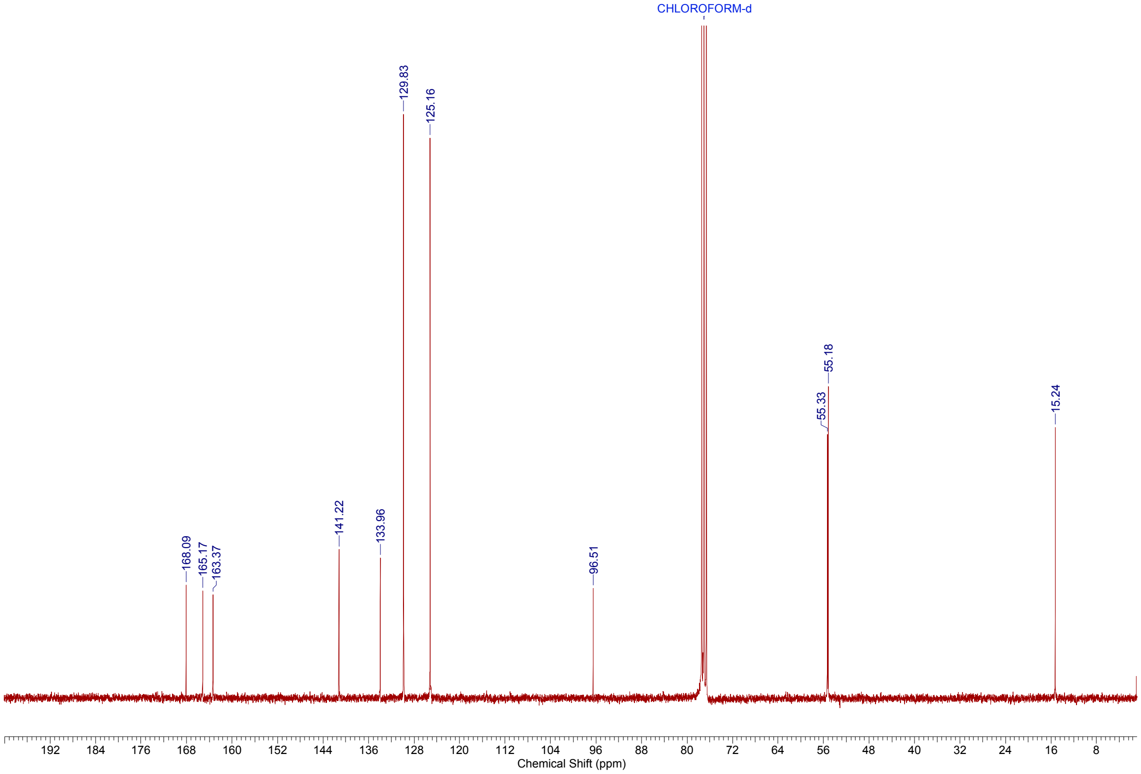




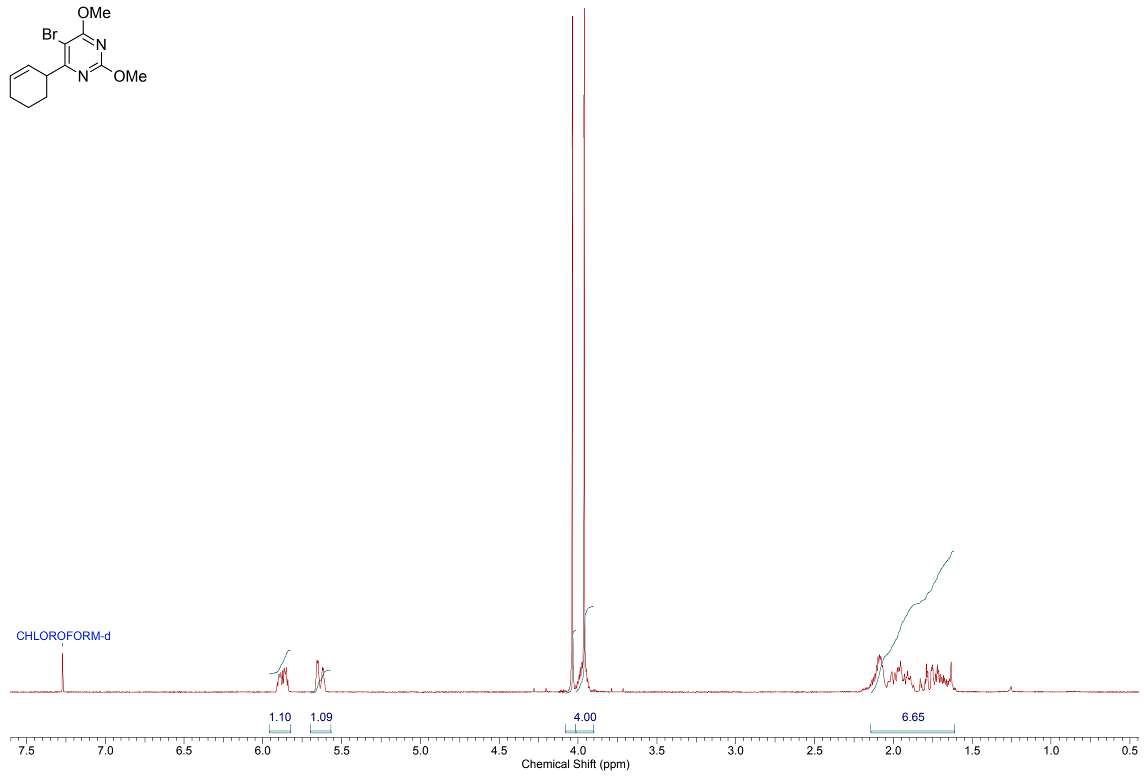


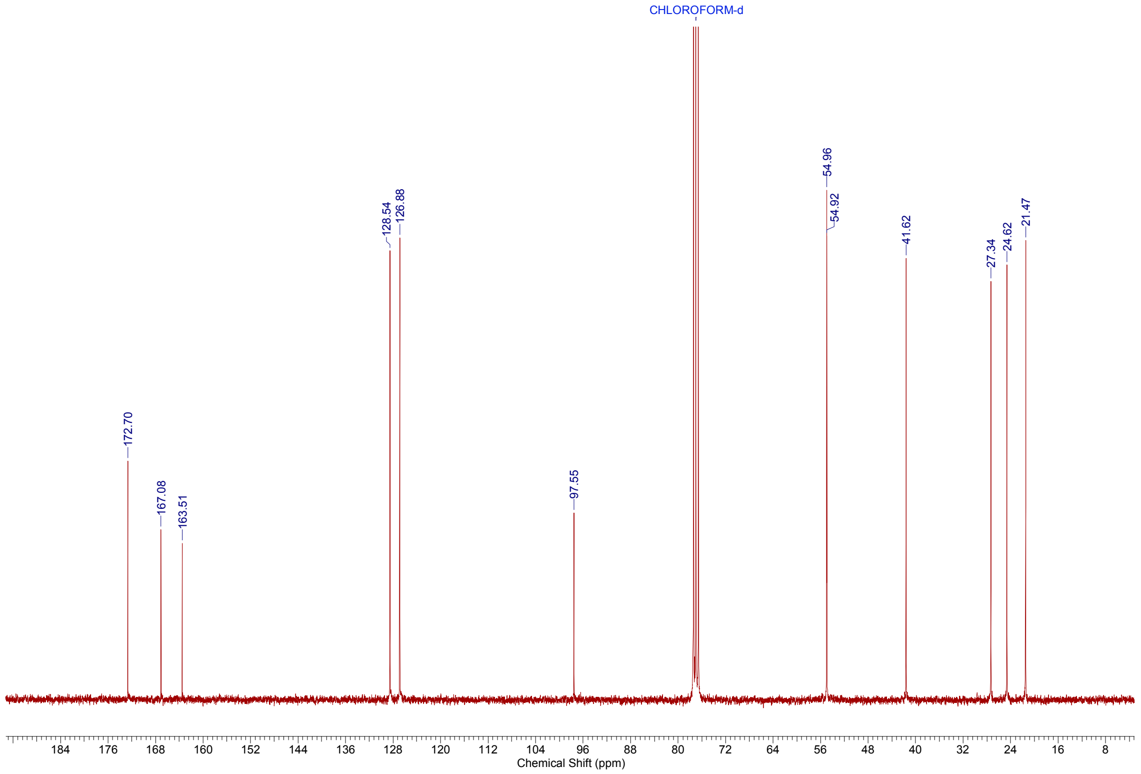
5-Bromo-2,4-dimethoxy-6-(4-(methylthio)phenyl)pyrimidine **8d**



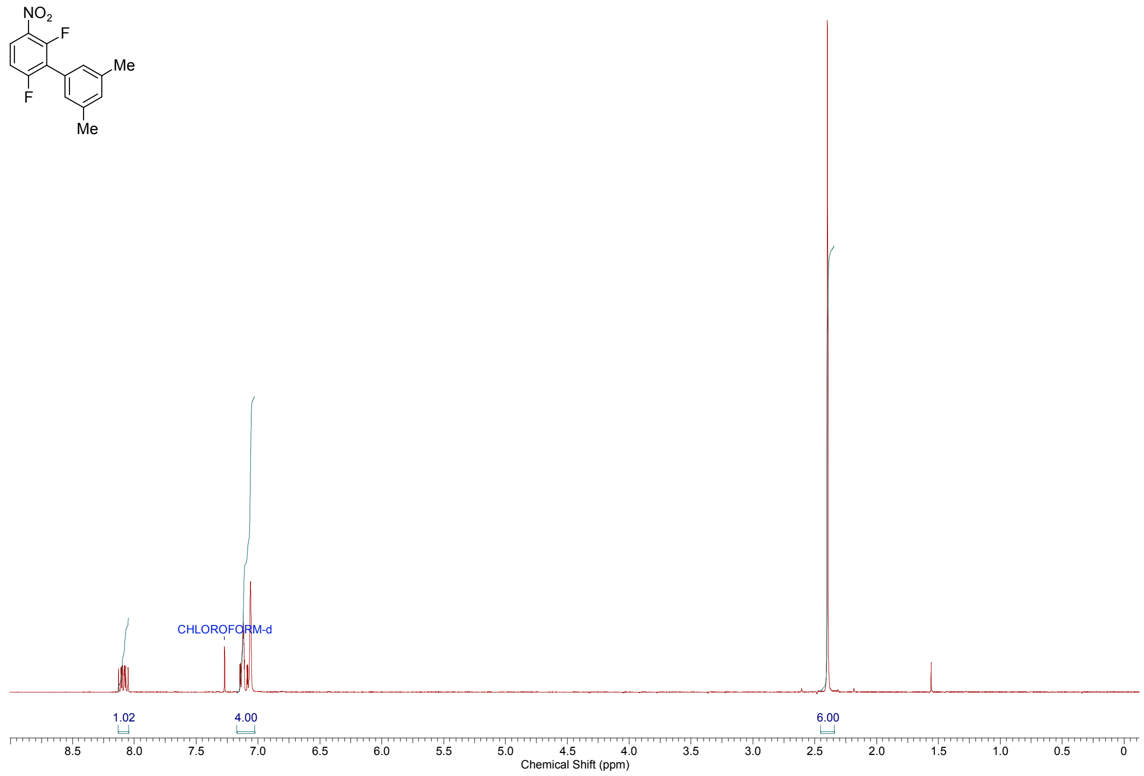


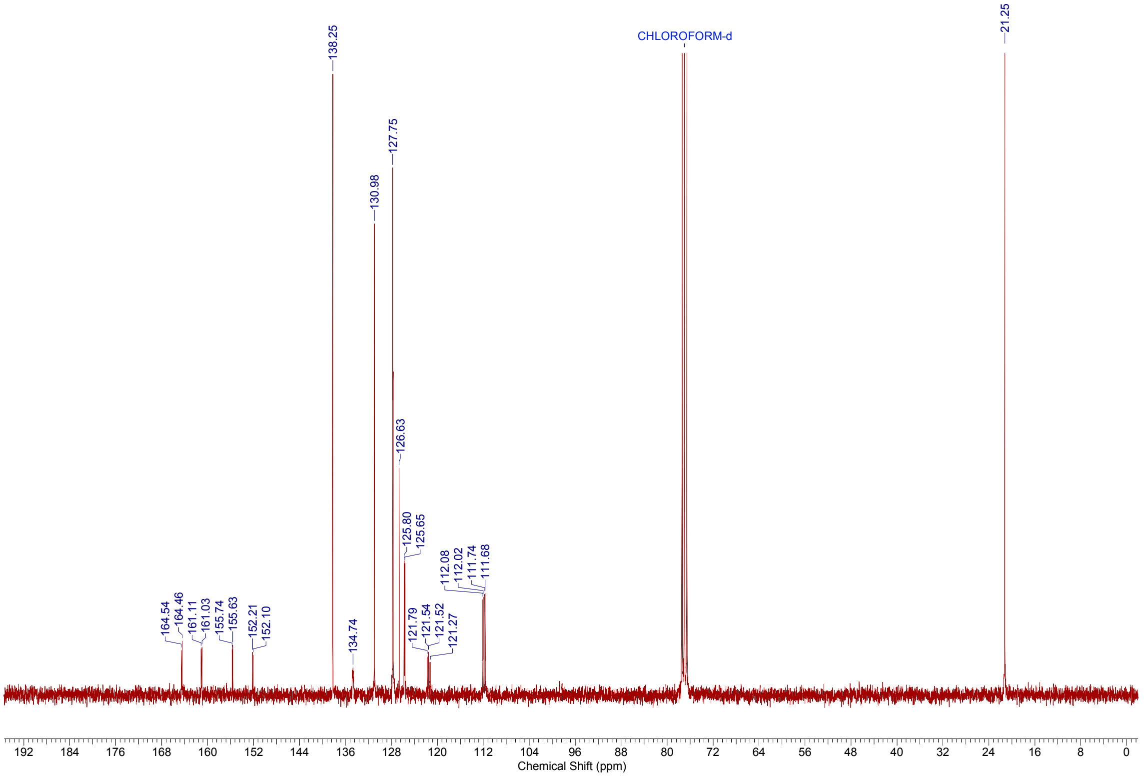
5-Bromo-4-(cyclohex-2-en-1-yl)-2,6-dimethoxypyrimidine **8e**



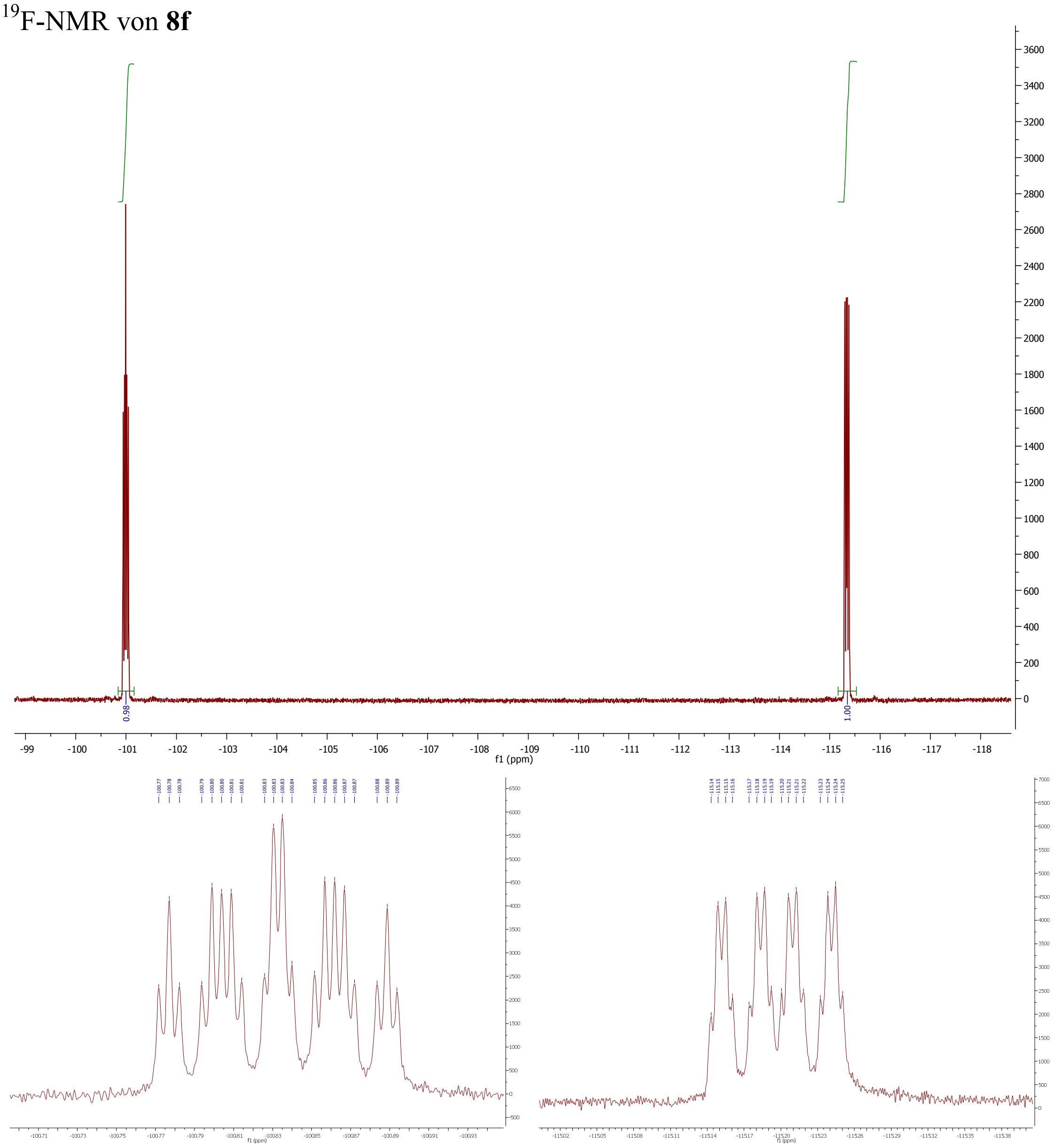


2,6-Difluoro-3',5'-dimethyl-3-nitro-1,1'-biphenyl **8f**

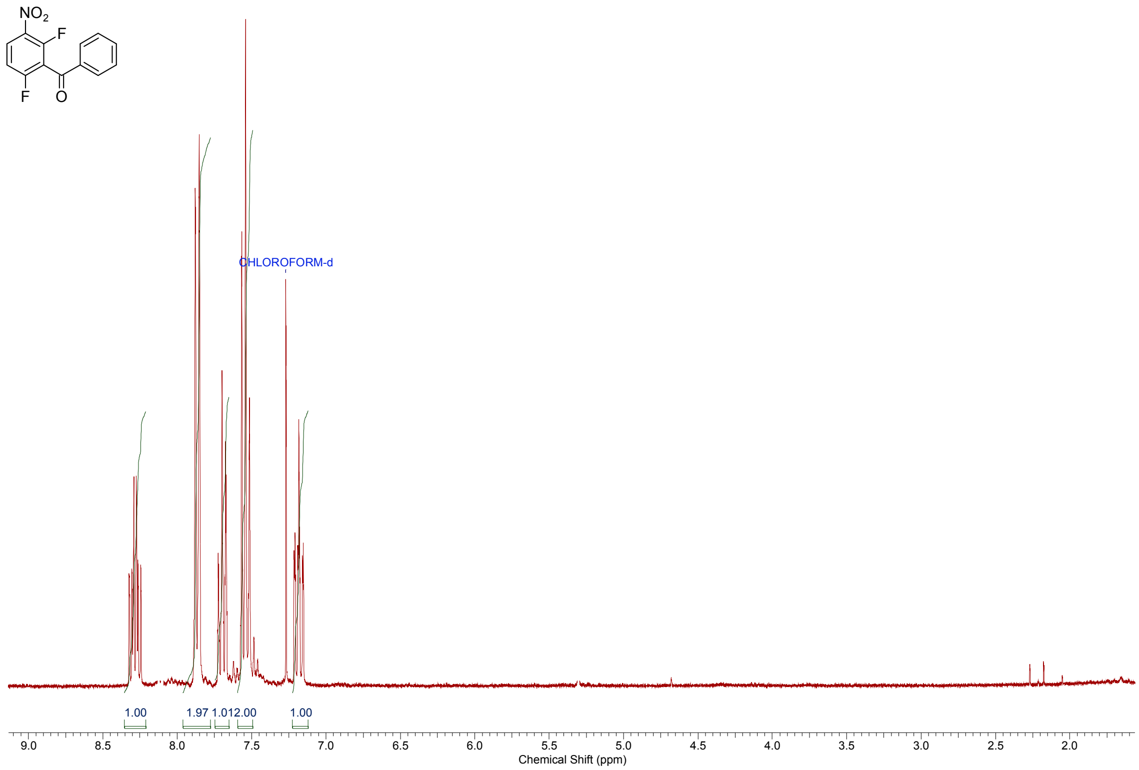




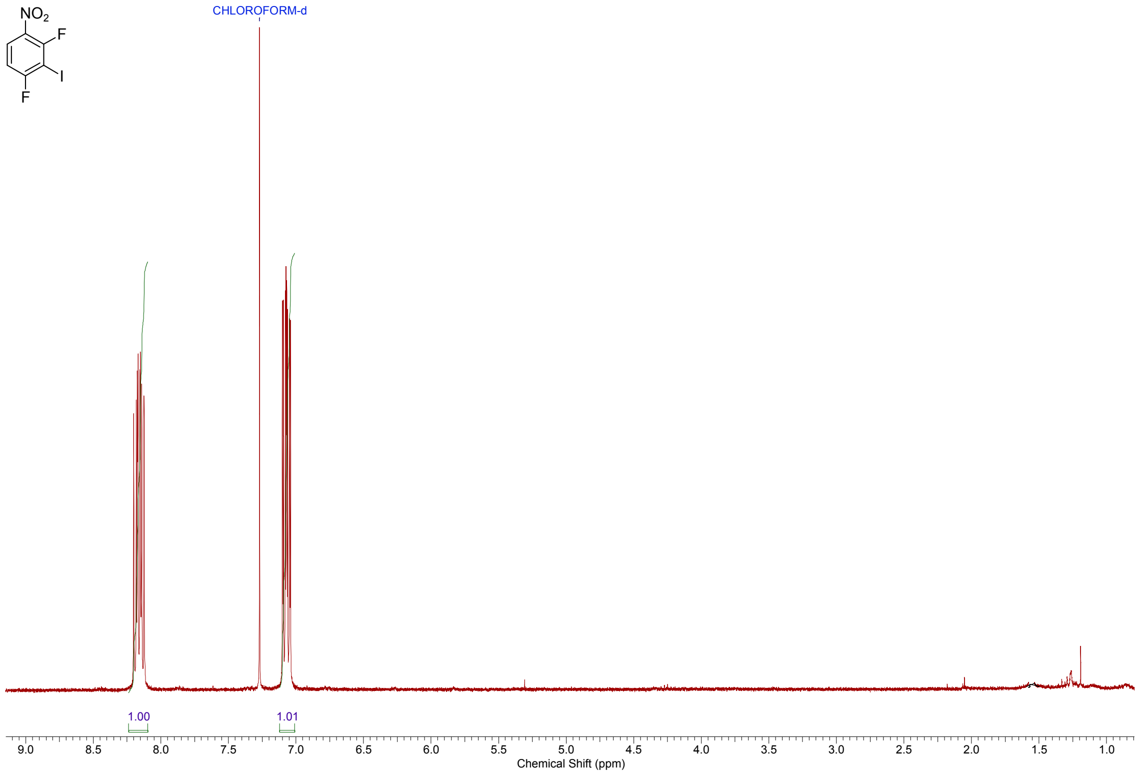
^{19}F-NMR von **8f**



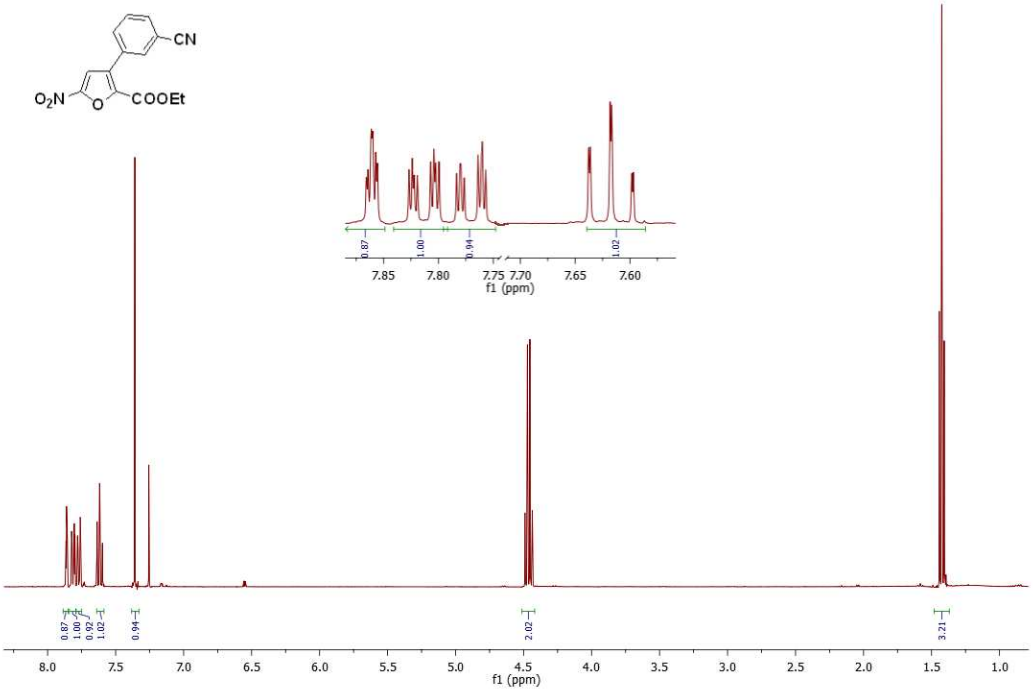
(2,6-Difluoro-3-nitrophenyl)(phenyl)methanone **8g**

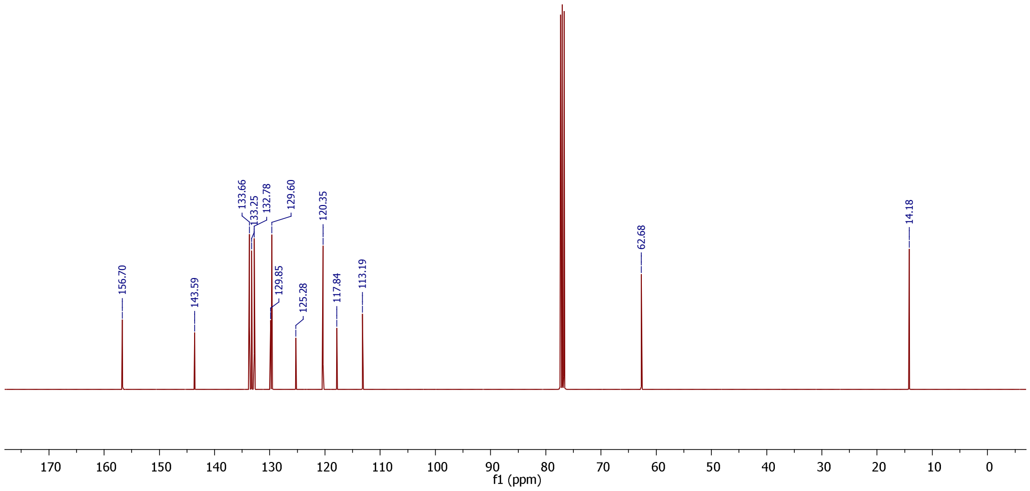


1,3-Difluoro-2-iodo-4-nitrobenzene **8h**

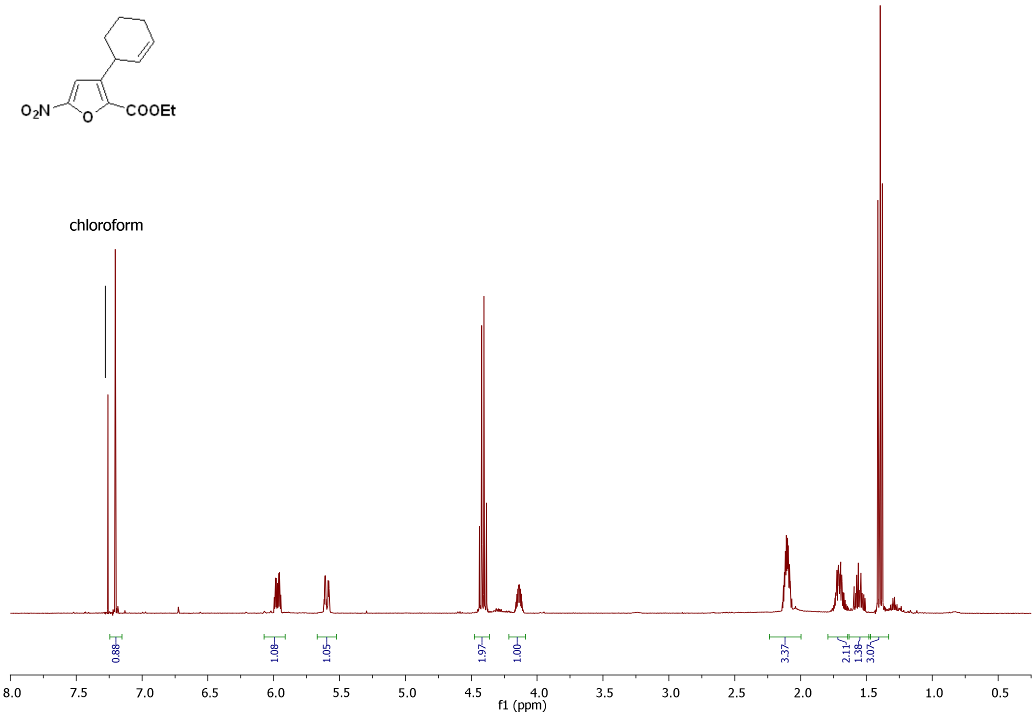


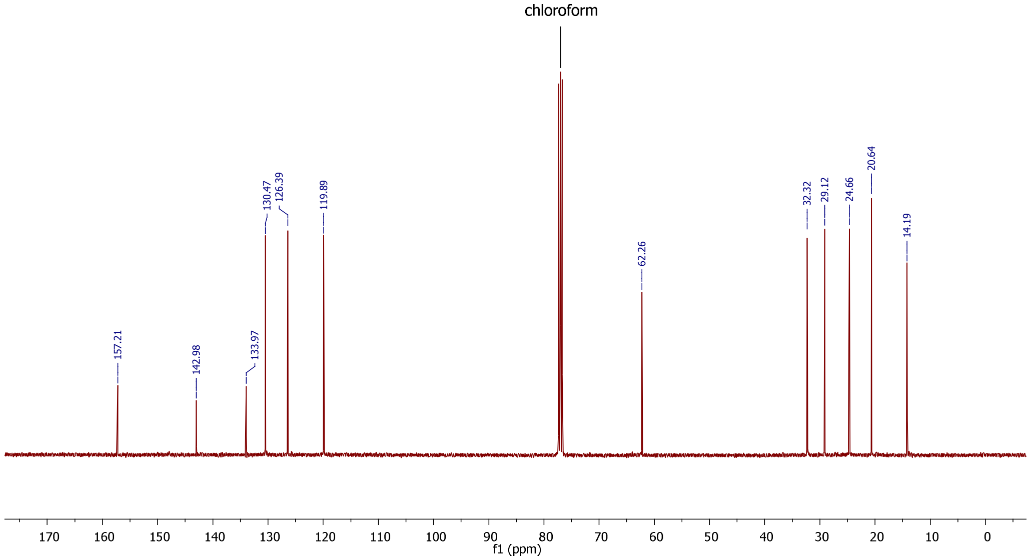
Ethyl 3-(3-cyanophenyl)-5-nitrofuran-2-carboxylate **8i**



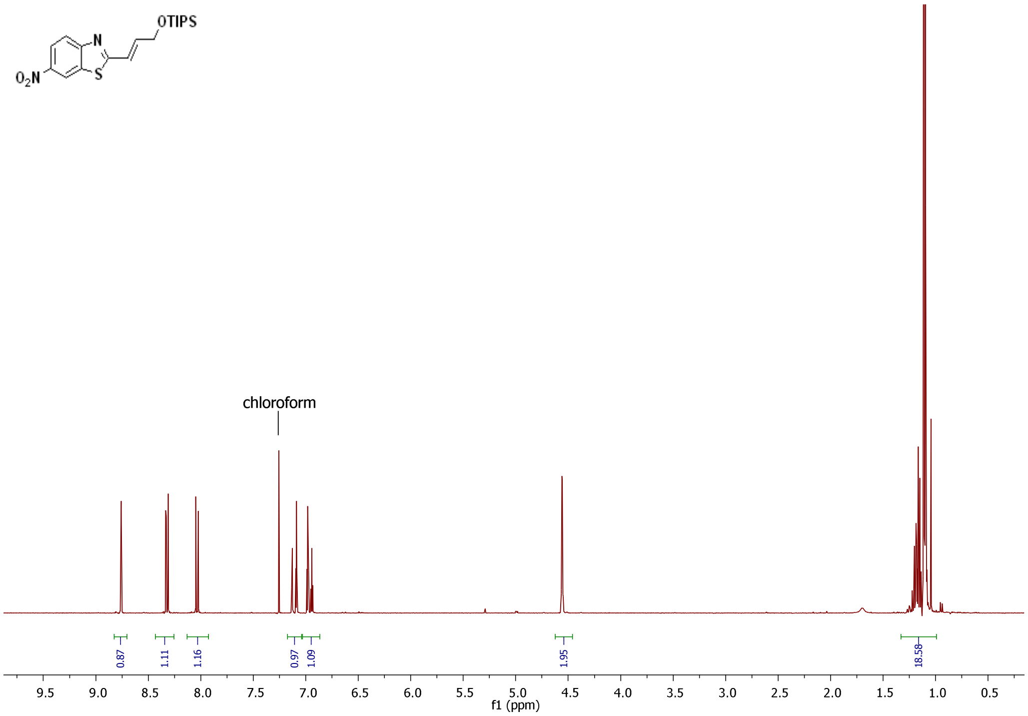


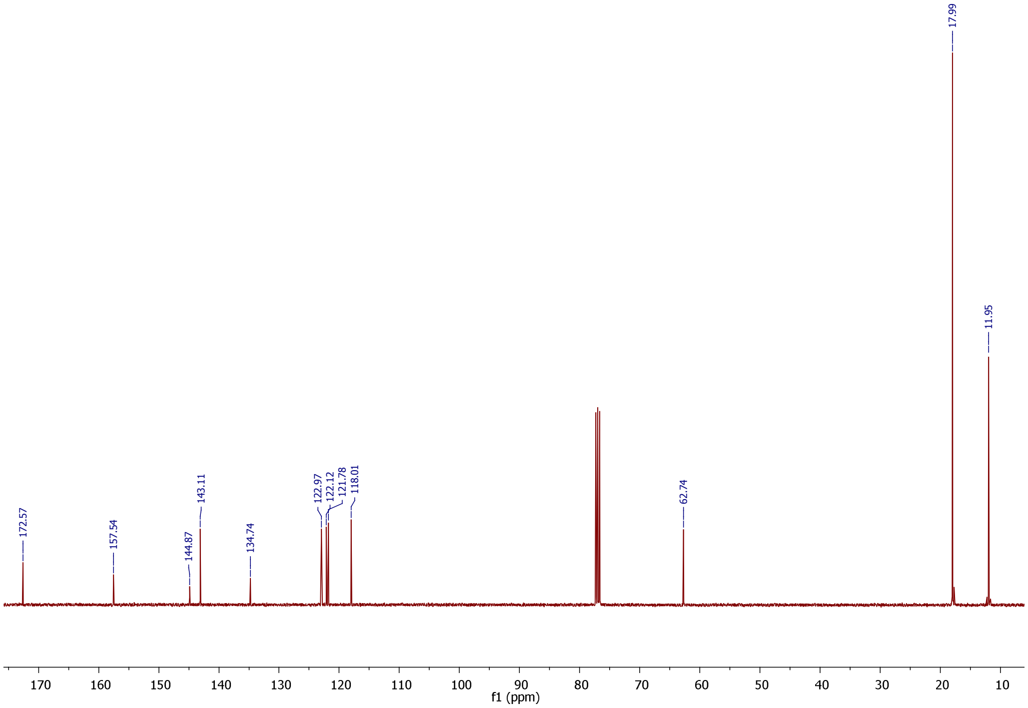
Ethyl 3-(cyclohex-2-enyl)-5-nitrofuran-2-carboxylate **8j**



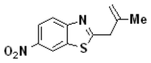


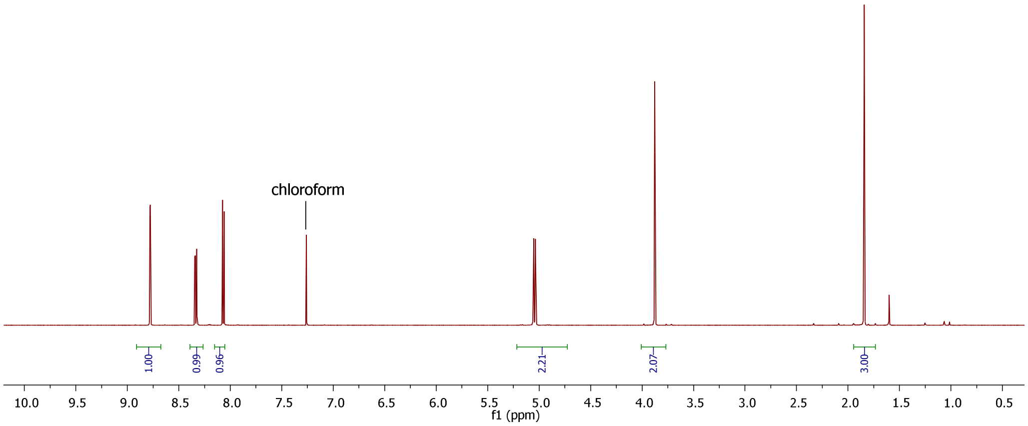
(*E*)-6-nitro-2-(3-(triisopropylsilyloxy)prop-1-enyl)benzothiazole **8k**

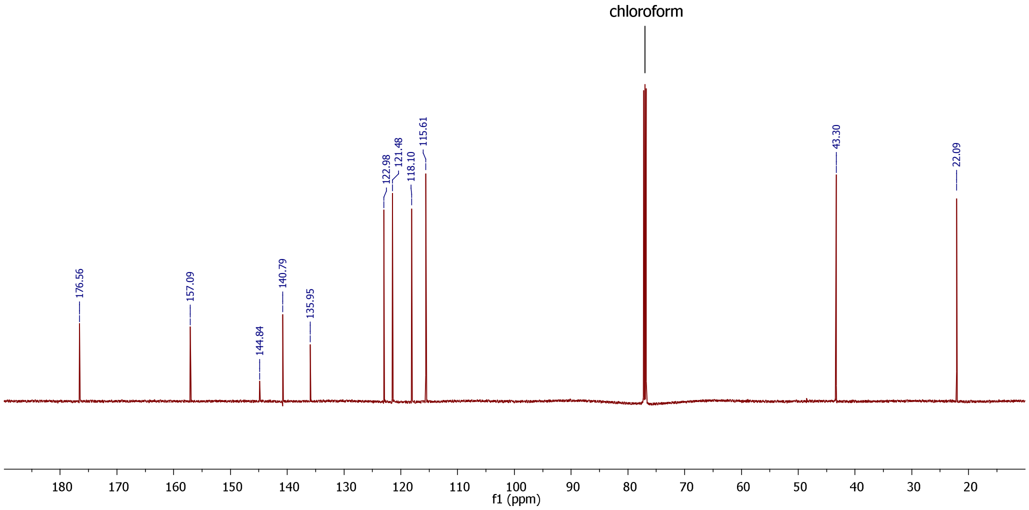




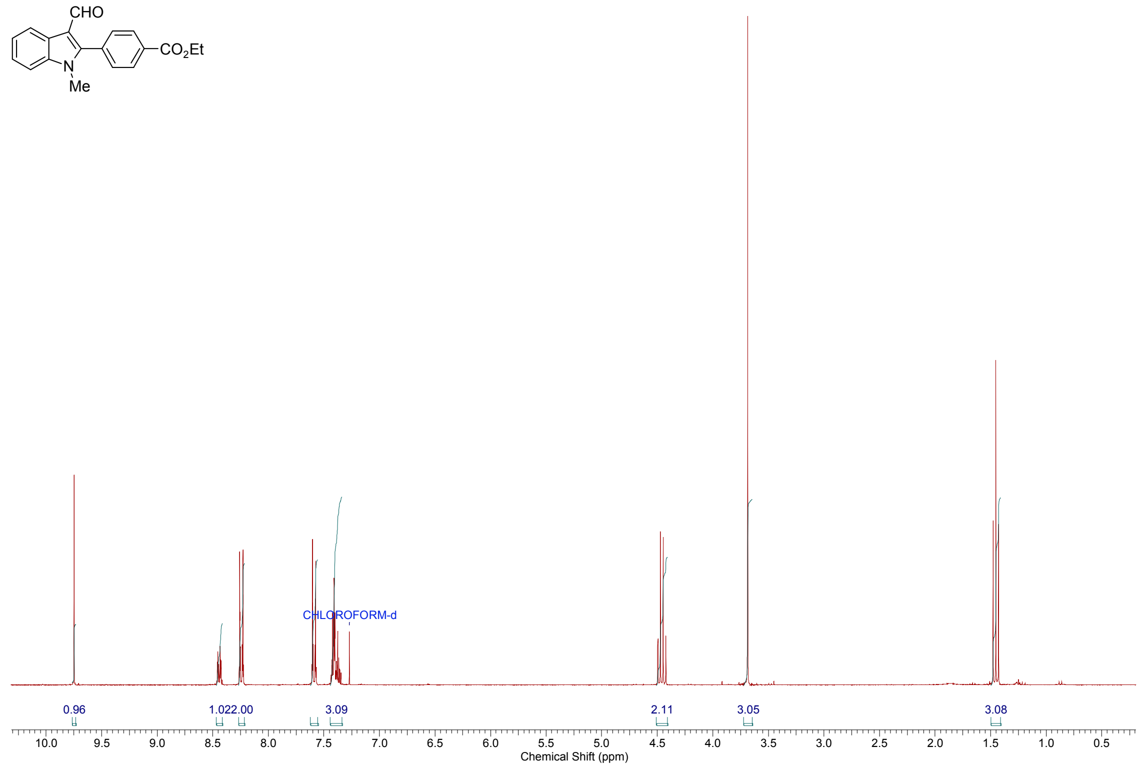
2-(2-methylallyl)-6-nitrobenzothiazole **8l**

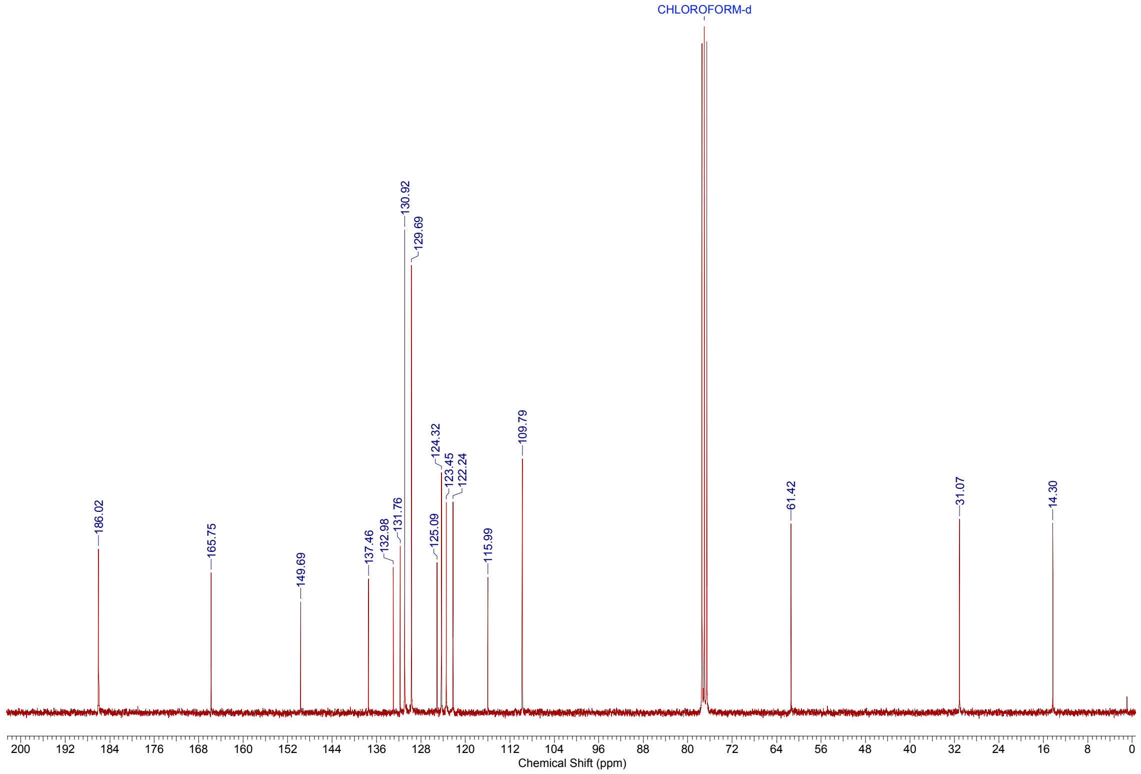




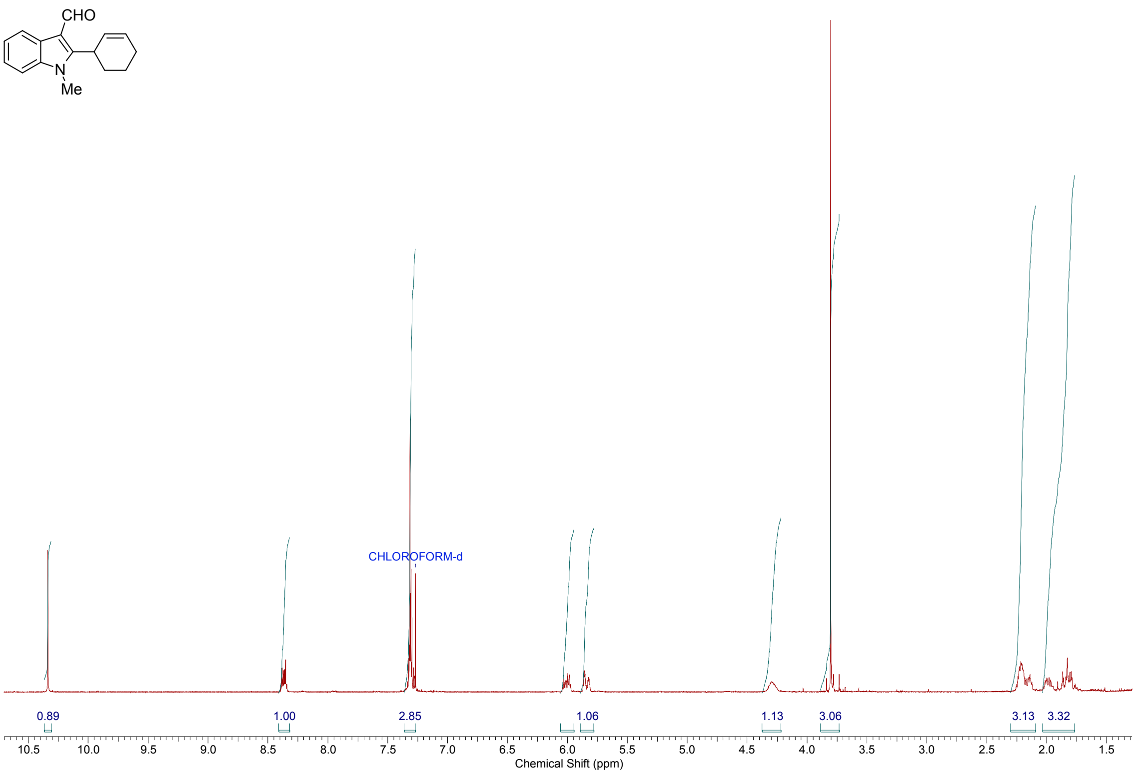


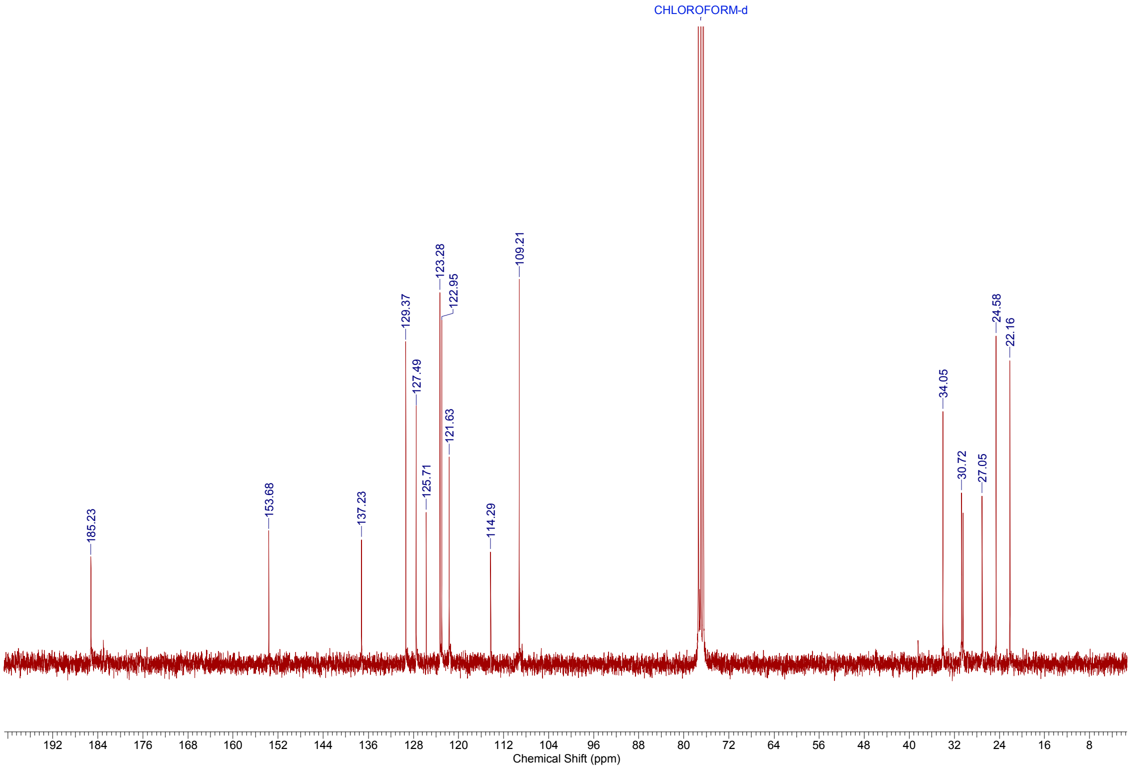
Ethyl 4-(3-formyl-1-methyl-1*H*-indol-2-yl)benzoate **8m**



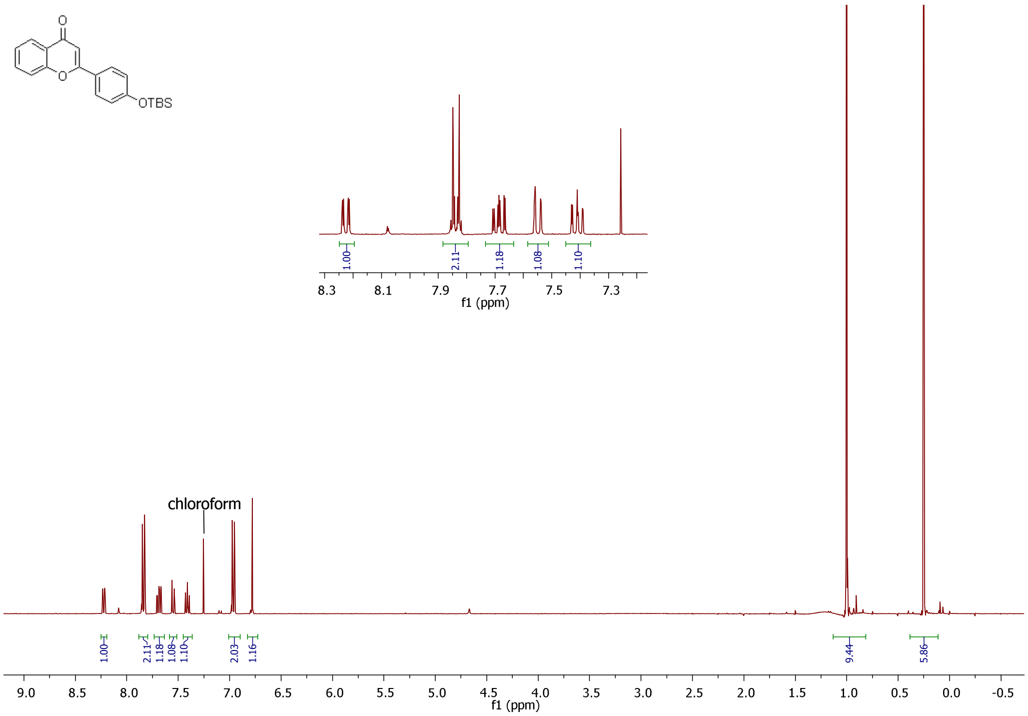


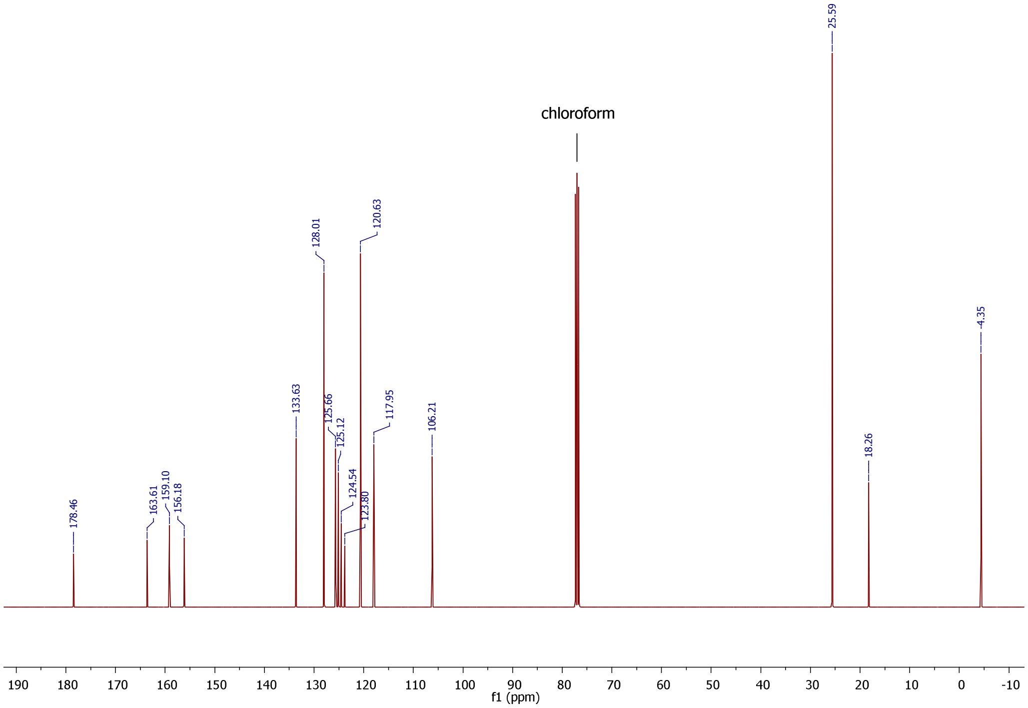
2-(Cyclohex-2-en-1-yl)-1-methyl-1*H*-indole-3-carbaldehyde **8n**



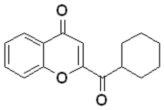


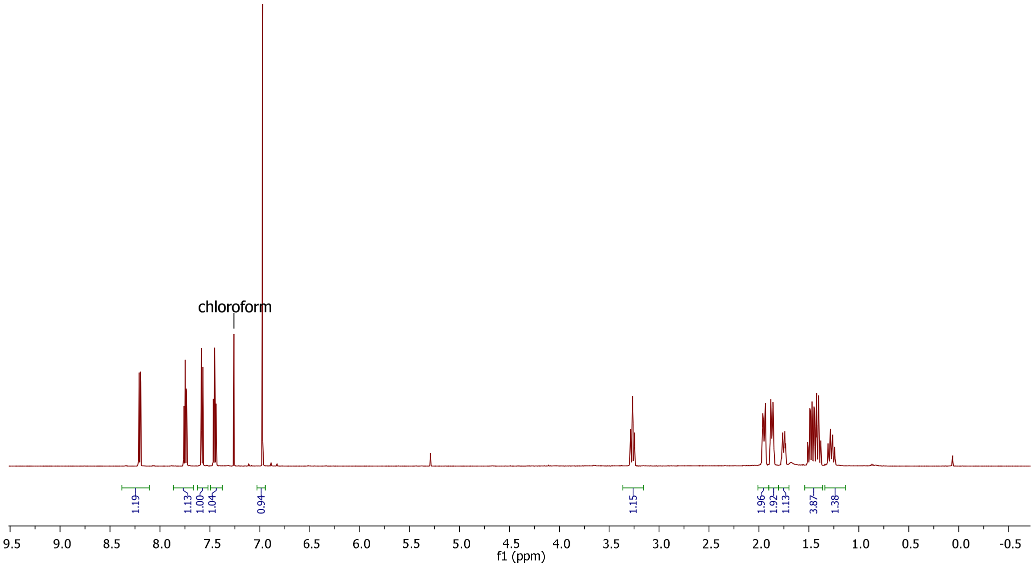
2-(4-(tert-butyldimethylsilyloxy)phenyl)-4H-chromone **8o**

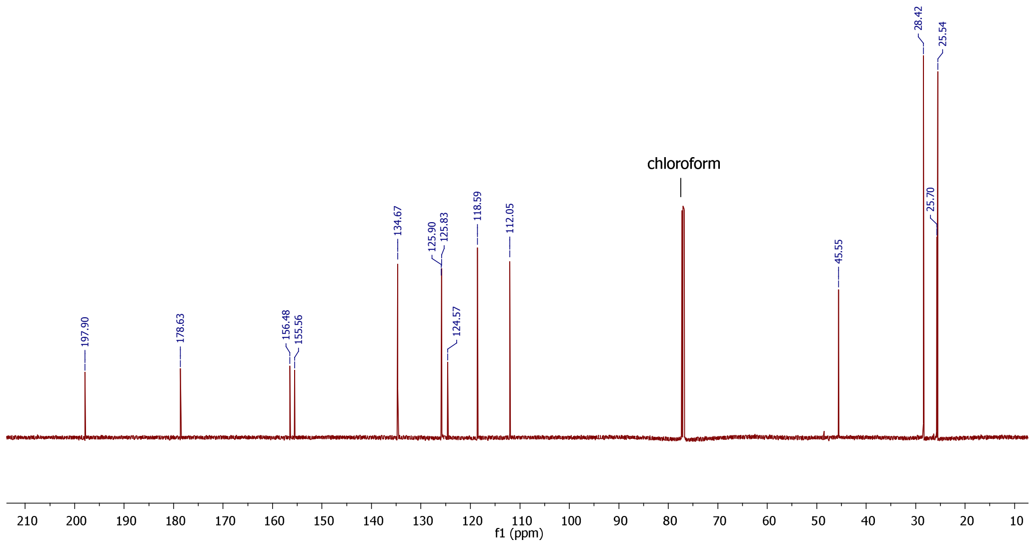




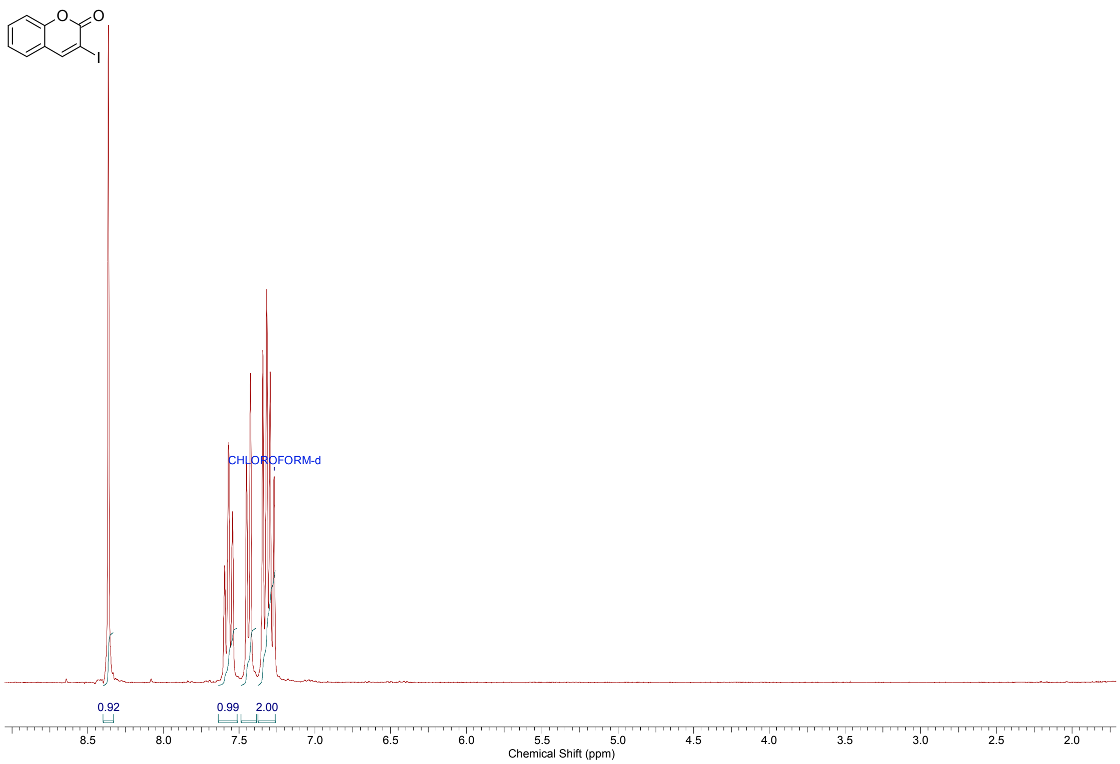
2-(cyclohexanecarbonyl)-4H-chromen-4-one **8p**

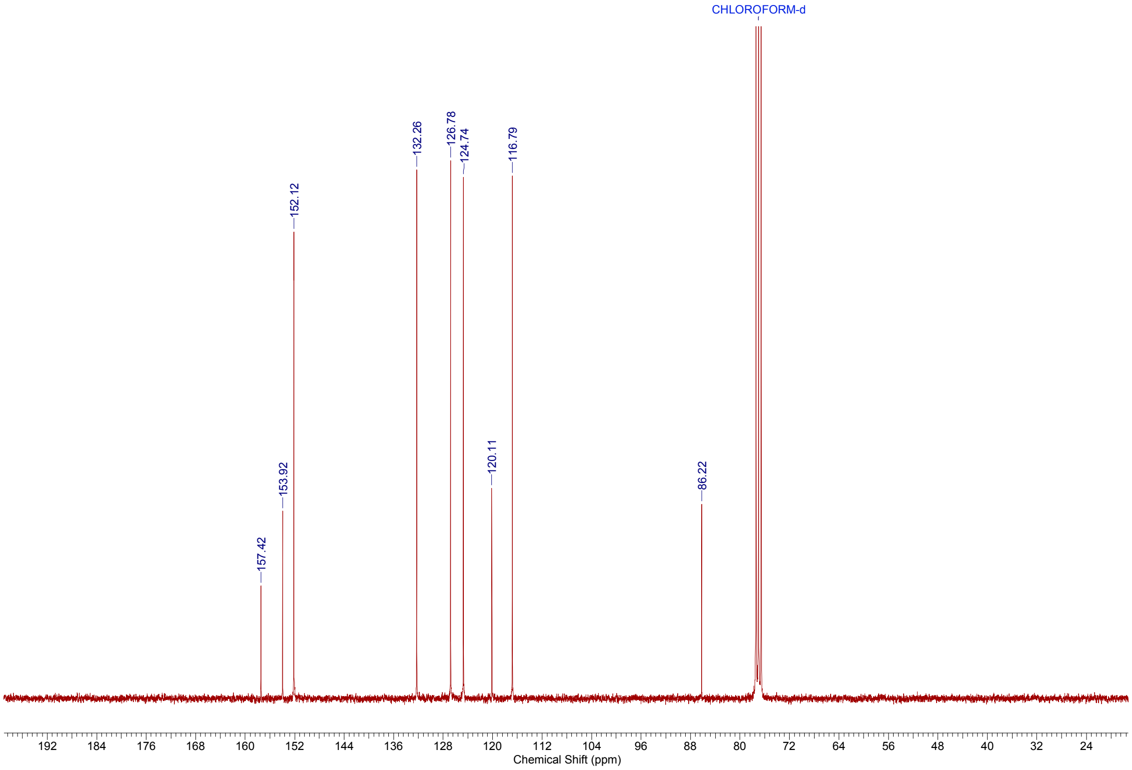




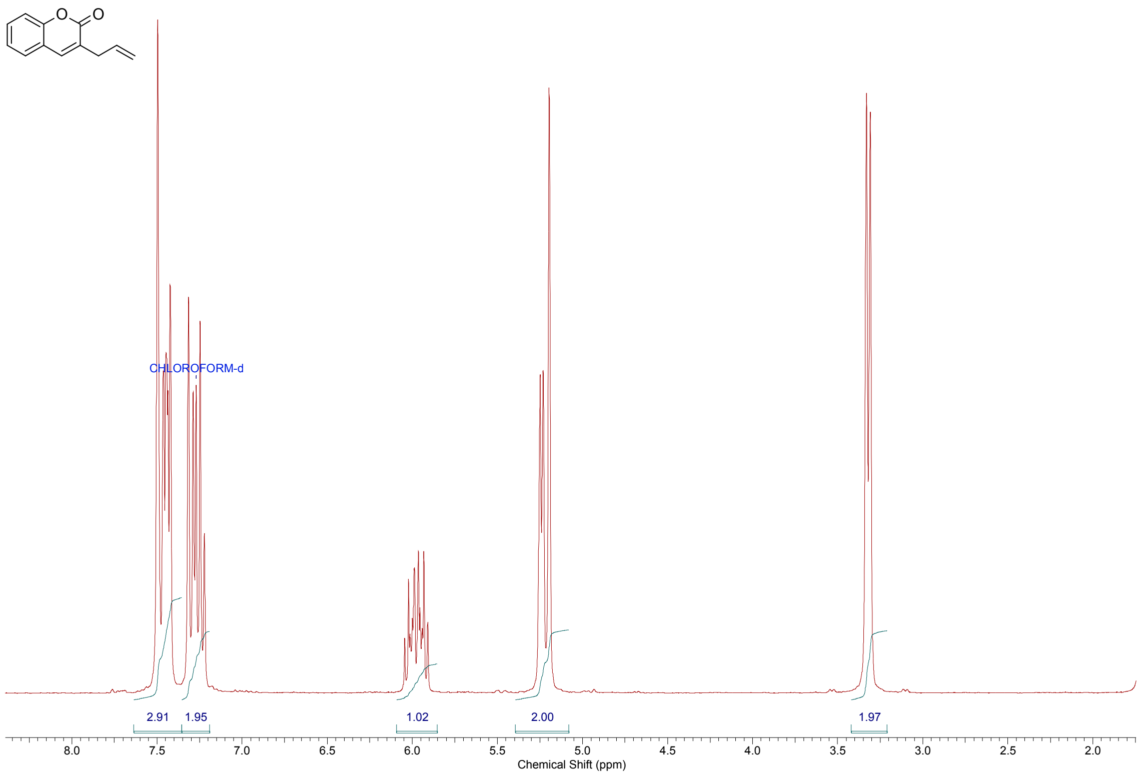


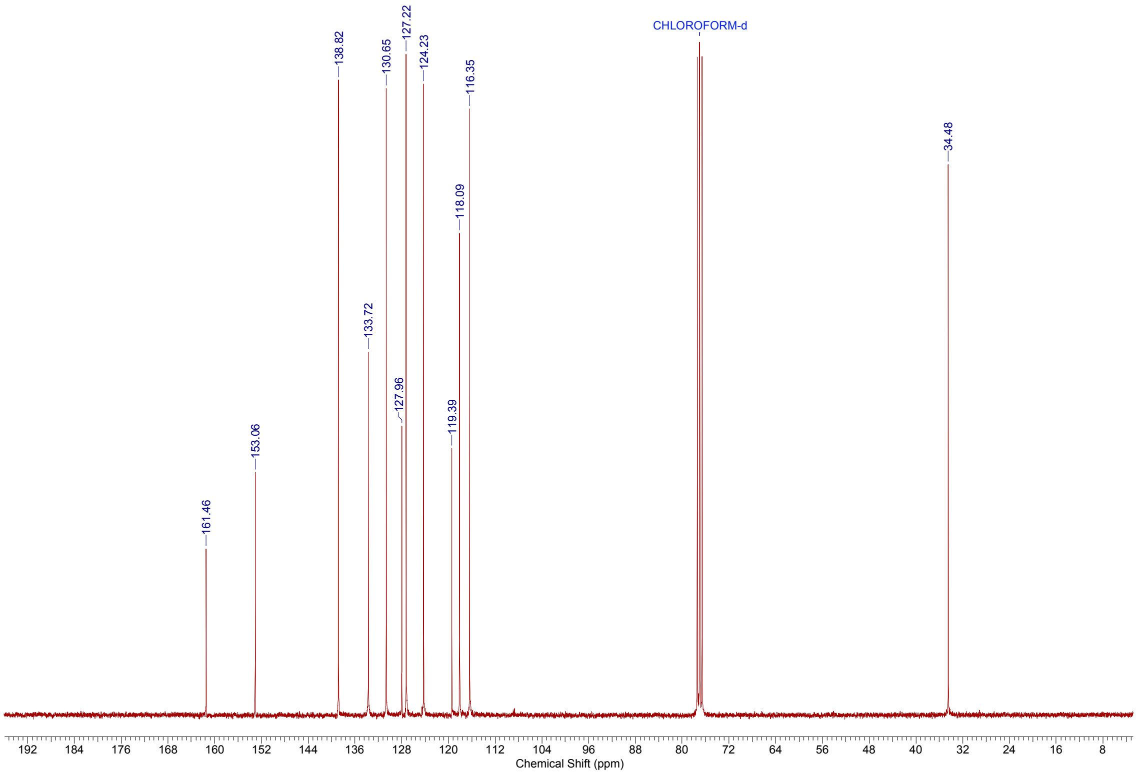
3-Iodo-2*H*-chromen-2-one **8q**



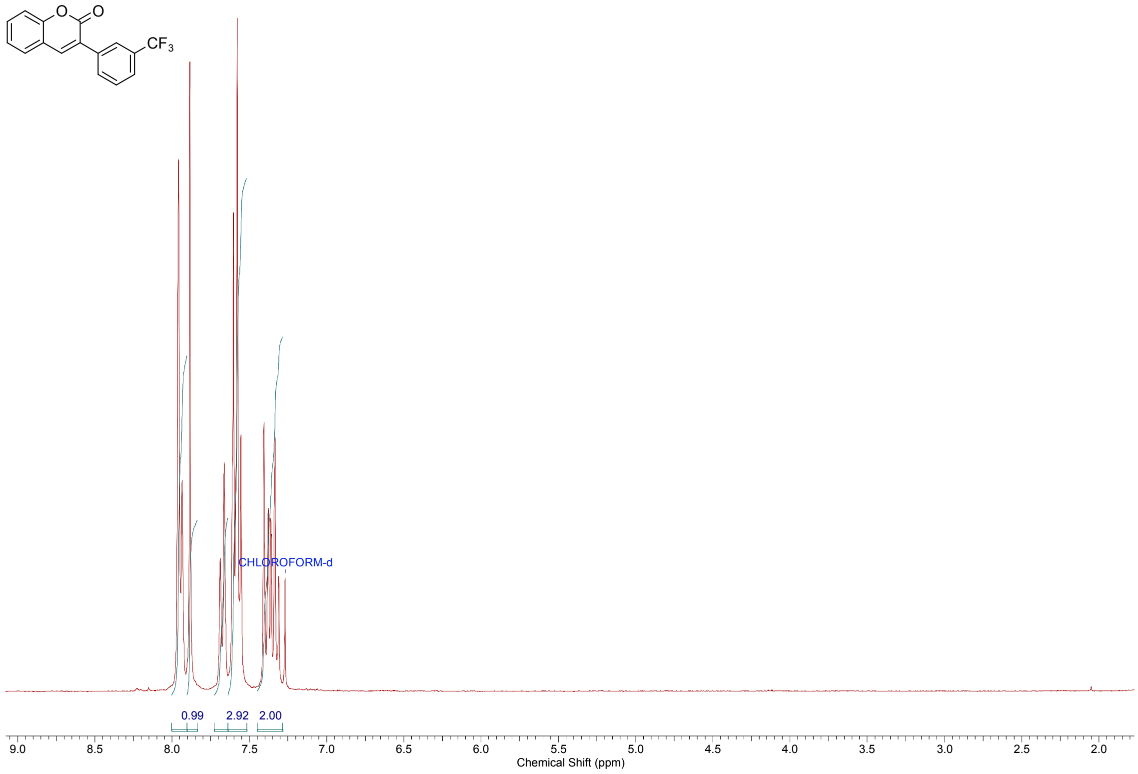


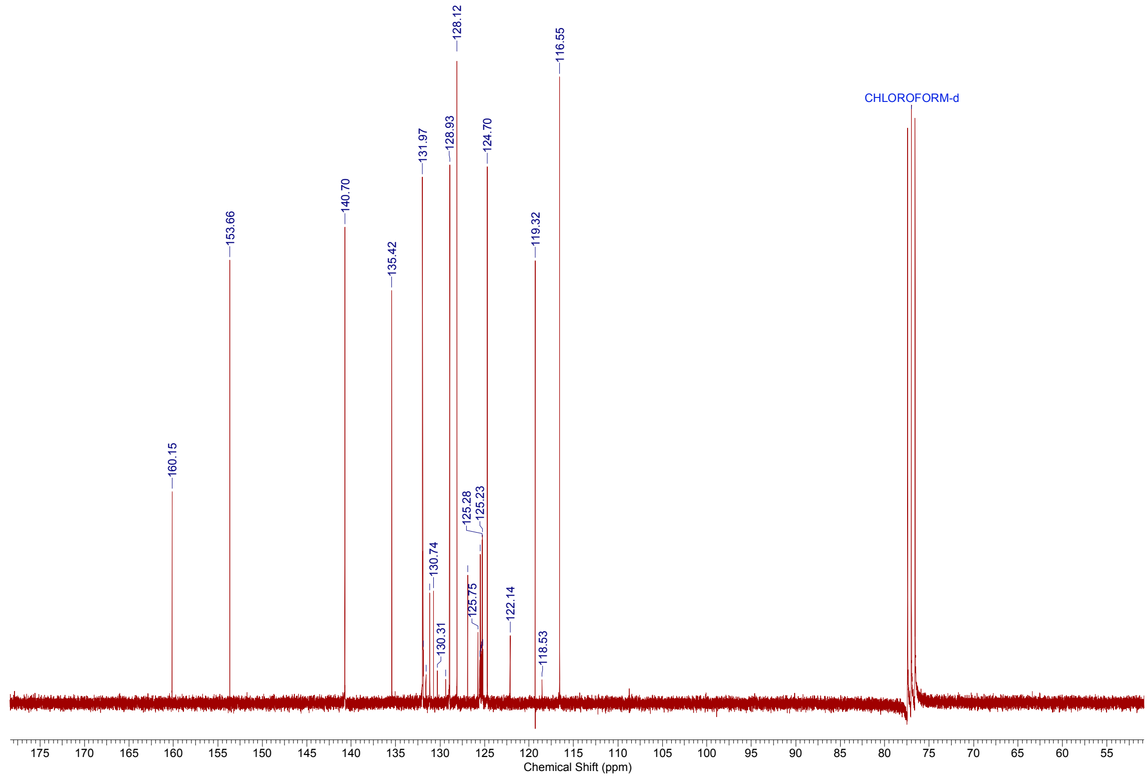
3-Allyl-2*H*-chromen-2-one **8r**



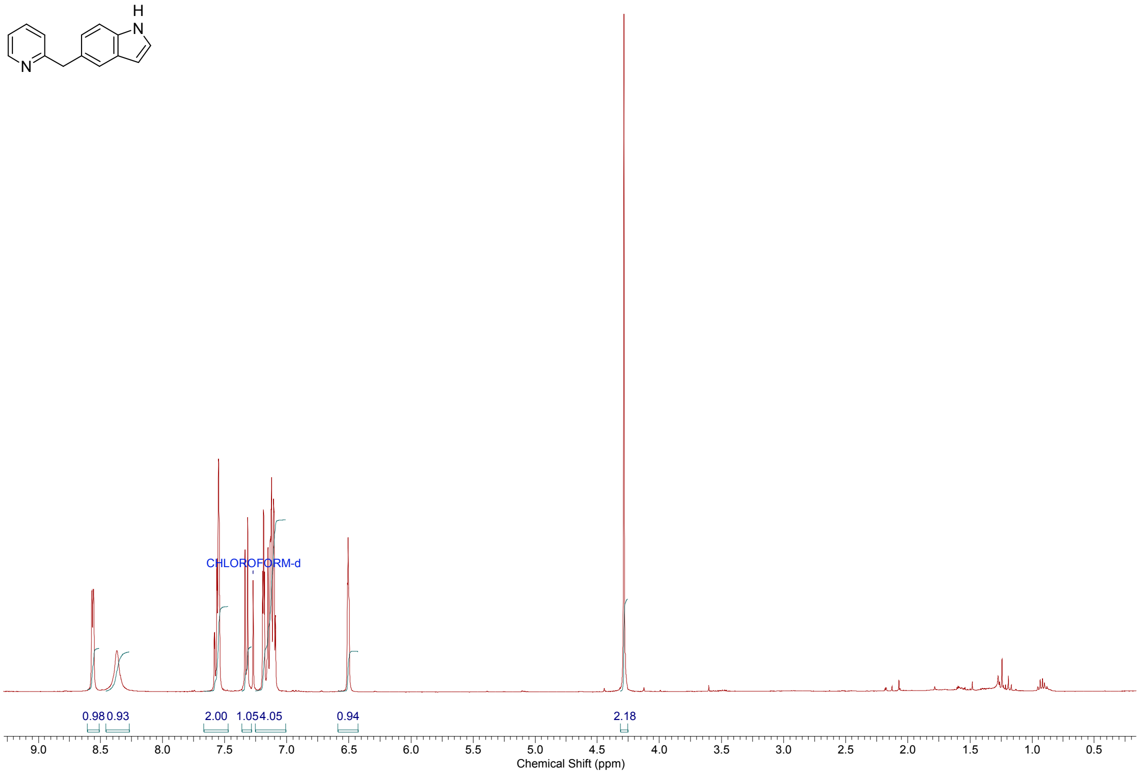


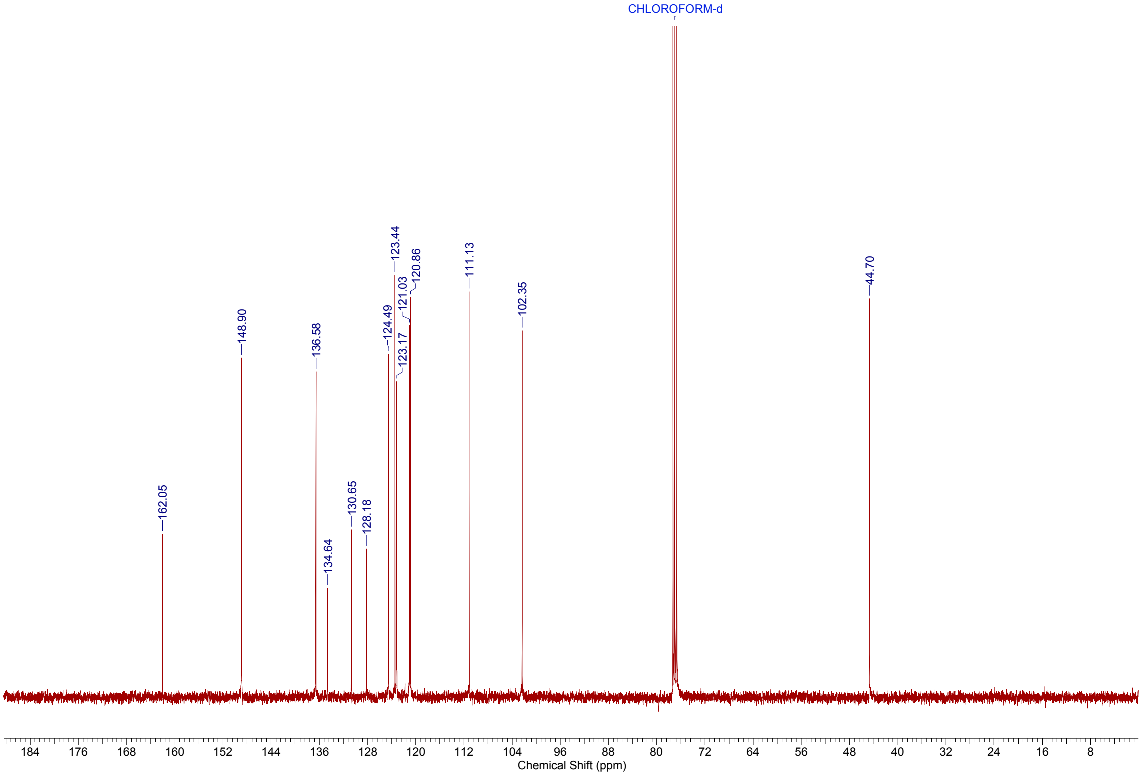
3-(3-(Trifluoromethyl)phenyl)-2*H*-chromen-2-one **8s**



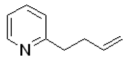


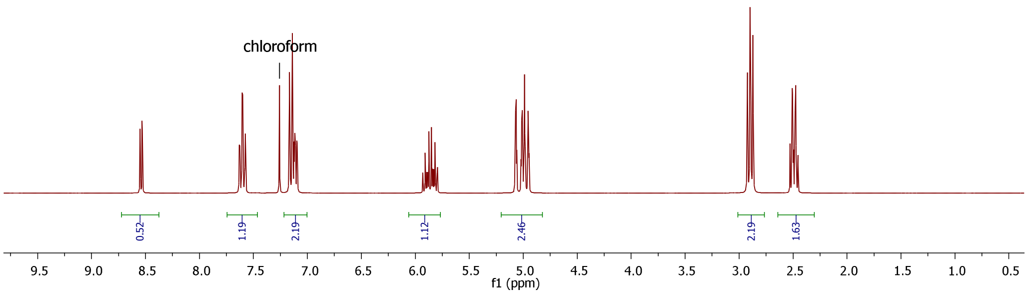
5-(Pyridin-2-ylmethyl)-1*H*-indole **8t**

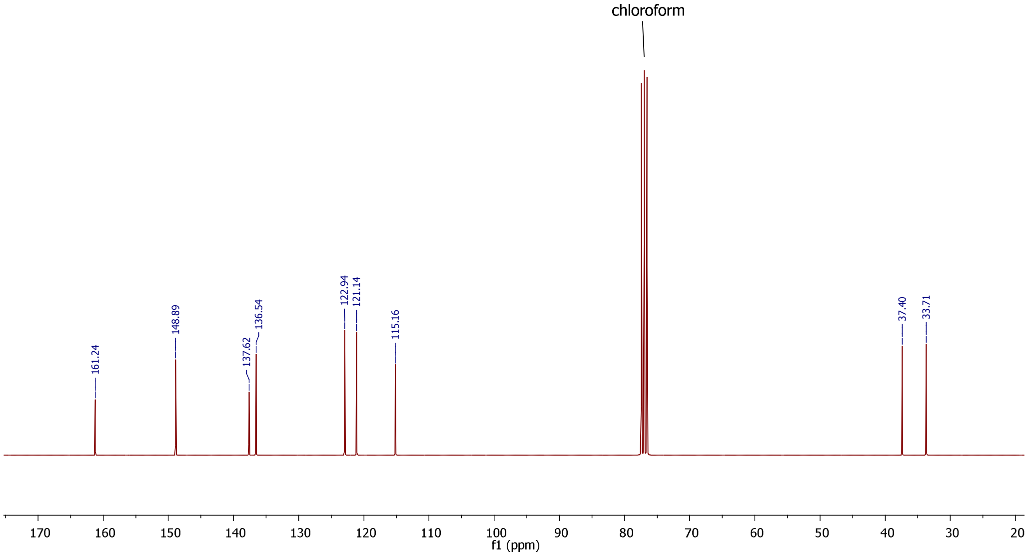




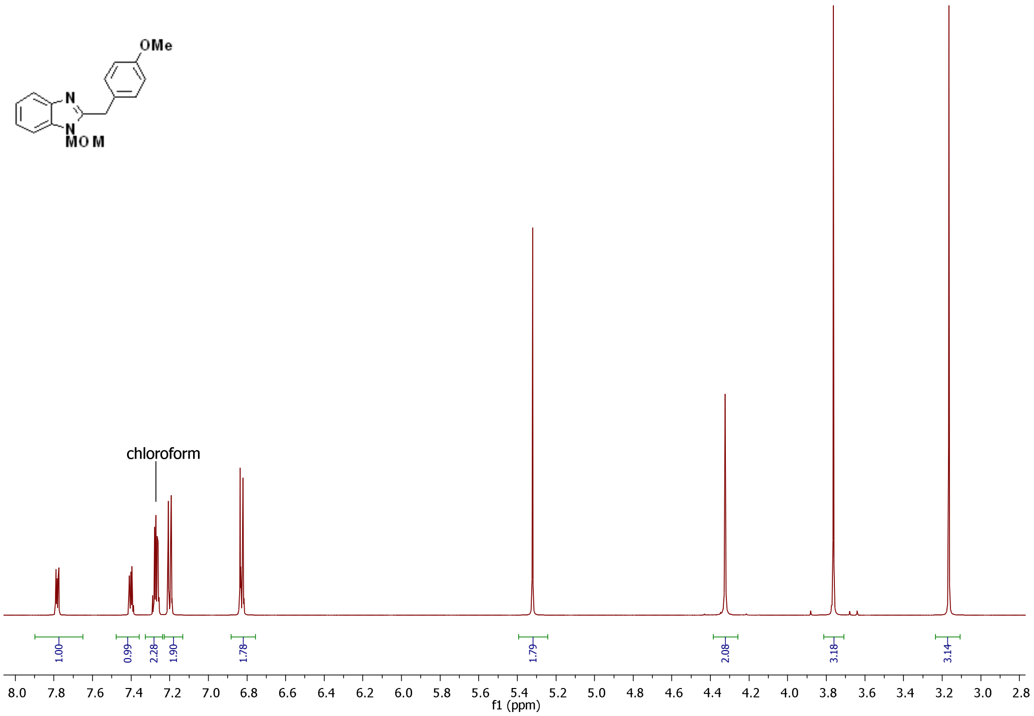
2-(but-3-enyl)pyridine **8u**

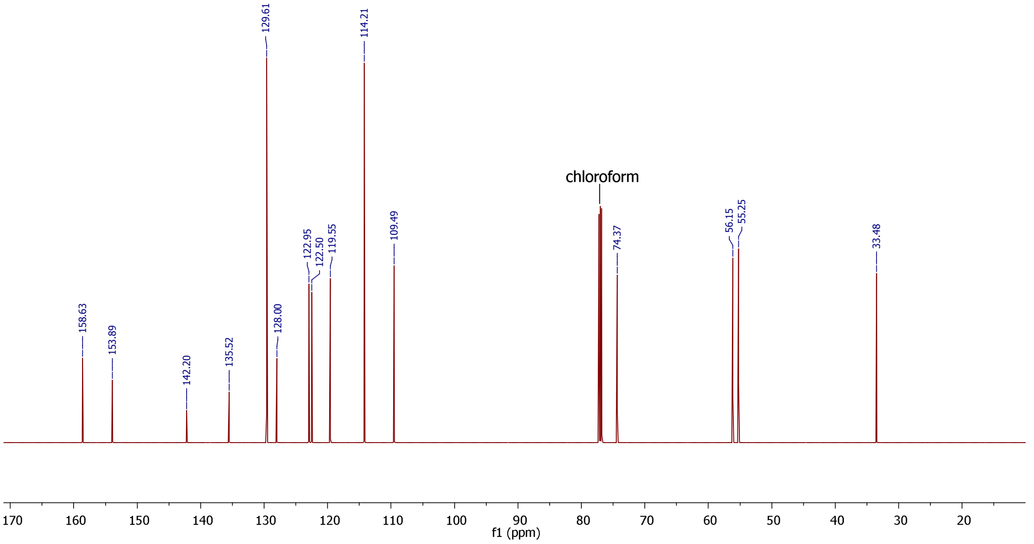






2-(4-methoxybenzyl)-1-(methoxymethyl)-1H-benzo[d]imidazole **8v**





Ethyl 4-(1-(methoxymethyl)-1H-benzo[d]imidazol-2-yl)-2-methylenebutanoate **8w**