

**Preparation of Highly Functionalized Alkylzinc Halides from  
Alkyl Bromides using Mg, ZnCl<sub>2</sub> and LiCl**

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General information: All reactions were carried out under an argon atmosphere in dried glassware. Syringes and needles were flushed with argon three times before use. THF was continuously refluxed and freshly distilled from sodium benzophenone ketyl under nitrogen and kept over 4 Å molecular sieves. Yields refer to isolated yields of compounds estimated to be of > 95 % purity as determined by <sup>1</sup>H-NMR and capillary-GC analysis. NMR spectra were recorded on solutions in deuterated chloroform (CDCl<sub>3</sub>) with residual chloroform (δ 7.25 ppm for <sup>1</sup>H NMR and δ 77.0 ppm for <sup>13</sup>C NMR) or deuterated benzene (C<sub>6</sub>D<sub>6</sub>) with residual benzene (7.15 ppm for <sup>1</sup>H NMR and δ 128.0 ppm for <sup>13</sup>C NMR). Abbreviations for signal coupling are as follows: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet. Starting Materials: Commercially available starting materials were purchased from commercial sources and used without further purification.

*General procedures for the preparation of various metal salt solutions:*

**ZnCl<sub>2</sub> 1M in THF:**

A *Schlenk*-flask was charged with ZnCl<sub>2</sub> (20.45 g, 0.15 mol) and dried for 6 h at 150 °C under high vacuum ( $5 \cdot 10^{-2}$  mbar) (dry stirring). Careful addition of THF (150 mL) (heat development!) and stirring overnight furnishes a clear colourless solution, which is kept over molecular sieves (4 Å)

**CuCN·2 LiCl 1M in THF:**

A *Schlenk*-flask was charged with LiCl (16.96 g, 0.40 mol) and CuCN·2 LiCl (17.95 g, 0.20 mol) and dried for 6 h at 150 °C under high vacuum ( $5 \cdot 10^{-2}$  mbar; dry stirring). Careful addition of THF (200 mL) (heat development!) and stirring overnight furnishes a slightly yellowish to greenish solution which is kept over molecular sieves (4 Å). A dark green to black colour indicates the presence of Cu(II), this solution should not be used.

*General procedure for the preparation of alkylzinc reagents using the Mg/ZnCl<sub>2</sub>/LiCl method:*

An argon flushed *Schlenk*-flask was charged with LiCl (1.25-2.5 equiv) and dried 5-10 min at 400 °C (heat gun) under high vacuum ( $5 \cdot 10^{-2}$  mbar). Mg-turnings or powder (2.5 equiv) were added under argon and heated additionally for 5 min at 400 °C. The flask was evacuated and backfilled with argon three times before ZnCl<sub>2</sub> solution (1M in THF, 1.1 equiv) was added with a syringe. A solution of alkyl bromide (1.0 equiv) (along with internal standard: tetradecane) in THF (2.5 mL/mmol) was added at 25 °C and the resulting solution was stirred at the appropriate temperature. The completion of the insertion reaction was checked by GC analysis of reaction aliquots quenched with a solution of saturated NH<sub>4</sub>Cl in water. After complete conversion (>95%) the remaining Mg was allowed to

settle down and the resulting alkylzinc solution was separated and canulated to a new dried and argon flushed flask. (Important note: Separation from remaining magnesium should be performed as soon as the conversion is complete, otherwise decomposition of the organometallic reagent is observed.)

*Procedures for the preparation of products 3a-1 of TABLE 1 and Scheme 3-4 using the Mg/ZnCl<sub>2</sub>/LiCl method:*

**Ethyl 7-oxo-7-p-tolyheptanoate (3a).**

The general procedure was followed using Mg-turnings (244 mg, 10 mmol), LiCl (212 mg, 5 mmol), ZnCl<sub>2</sub> (1M solution in THF, 4.4 mL, 4.4 mmol) and ethyl 6-bromohexanoate (**2a**, 893 mg, 4 mmol). The reaction was carried out at 20 °C for 2.5 h and provided the alkylzinc reagent **1a** which was transferred to an argon flushed flask.

CuCN·2 LiCl (1M solution in THF, 4.0 mL, 1.0 equiv) was added at -30 °C and the mixture stirred for 30 min. 4-Methylbenzoyl chloride (433 mg, 2.8 mmol, 0.7 equiv) was added dropwise at -30 °C under argon. The mixture was stirred for 2.5 h and allowed to warm up slowly to 20 °C before being quenched with sat. aqueous NH<sub>4</sub>Cl solution (20 mL) and conc. aqueous ammonia (20 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (diethyl ether/pentane = 1:7) to yield compound **3a** (516 mg, 70%) as white powder. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.87–7.80 (m, 2H), 7.26–7.20 (m, 2H), 4.10 (q, <sup>3</sup>J<sub>HH</sub> = 7.2 Hz, 2H), 2.96–2.89 (m, 2H), 2.39 (s, 3H), 2.30 (t, <sup>3</sup>J<sub>HH</sub> = 7.6 Hz, 2H), 1.79–1.60 (m, 4H), 1.47–1.34 (m, 2H), 1.23 (t, <sup>3</sup>J<sub>HH</sub> = 7.2 Hz, 3H); <sup>13</sup>C (75 MHz, CDCl<sub>3</sub>) δ 199.9, 173.7, 143.6, 134.5, 129.2, 128.1, 60.2, 38.2, 34.1, 28.8, 24.8, 23.9, 21.6, 14.2; MS (EI, 70 eV): m/z 262 (<1) [M<sup>+</sup>], 134 (59), 119 (100), 91 (22), 65 (5); HRMS: m/z calcd. for C<sub>16</sub>H<sub>22</sub>O<sub>3</sub> (M<sup>+</sup>) 262.1569, found 262.1567; FT-IR

(Diamond-ATR, neat)  $\tilde{\nu}$  2988 (w), 2946 (m), 2930 (m), 1728 (s), 1670 (vs), 1606 (s), 1464 (s), 1408 (m), 1344 (s), 1240 (s), 1178 (s), 1160 (s), 1122 (s), 1096 (s), 1010 (s), 972 (s), 812 (vs), 762 (s), 728 (s), 694 (m)  $\text{cm}^{-1}$ , mp ( $^{\circ}\text{C}$ ) = 56-57.

### **Ethyl 7-p-tolylheptanoate (3b).**

The general procedure was followed using Mg-turnings (122 mg, 5 mmol), LiCl (106 mg, 2.5 mmol),  $\text{ZnCl}_2$  (1M solution in THF, 2.2 mL, 2.2 mmol) and ethyl 6-bromohexanoate (**2a**, 447 mg, 2 mmol). The reaction was carried out at 20  $^{\circ}\text{C}$  for 2.5 h and provided the alkylzinc reagent **1a** which was transferred to an argon flushed flask.

A mixture of  $\text{Pd}(\text{OAc})_2$  (6 mg,  $2.8 \cdot 10^{-2}$  mmol, 1.4 mol%), Ru-Phos (26 mg,  $5.6 \cdot 10^{-2}$  mmol, 2.8 mol%) and *p*-bromotoluene (240 mg, 1.4 mmol, 0.7 equiv) in 2 mL THF was added at 20 $^{\circ}\text{C}$  and the reaction mixture stirred for 1.5 h before being quenched with sat. aqueous  $\text{NH}_4\text{Cl}$  solution (25 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over  $\text{Na}_2\text{SO}_4$  and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (diethyl ether/pentane = 1:60) to yield compound **3b** (270 mg, 82%) as colourless liquid.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.15-7.06 (m, 4H), 4.15 (q,  $^3J_{\text{HH}} = 7.2$  Hz, 2H), 2.60 (m, 2H), 2.34 (s, 3H), 2.33-2.28 (m, 2H), 1.74-1.59 (m, 4H), 1.46-1.33 (m, 2H), 1.28 (t,  $^3J_{\text{HH}} = 7.1$  Hz, 3H);  $^{13}\text{C}$  (75 MHz,  $\text{CDCl}_3$ )  $\delta$  173.8, 139.4, 135.1, 128.9, 128.3, 60.2, 35.3, 34.3, 31.2, 28.8, 24.9, 21.00, 14.2; MS (EI, 70 eV):  $m/z$  234 (15) [ $\text{M}^+$ ], 188 (18), 144 (42), 105 (100), 85 (11), 71 (14), 57 (18); HRMS:  $m/z$  calcd. for  $\text{C}_{15}\text{H}_{22}\text{O}_2$  ( $\text{M}^+$ ) 234.1620, found 234.1614; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  2980 (w), 2930 (m), 2858 (w), 1733 (vs), 1515 (w), 1463 (w), 1446 (w), 1372 (w), 1348 (w), 1177 (m), 1133 (w), 806 (w)  $\text{cm}^{-1}$ .

### **Ethyl 5-(2-chlorophenyl)-5-oxopentanoate (3c).**

The general procedure was followed using Mg-turnings (244 mg, 10 mmol), LiCl (212 mg, 5 mmol), ZnCl<sub>2</sub> (1M solution in THF, 4.4 mL, 4.4 mmol) and ethyl 4-bromobutanoate (**2b**, 893 mg, 4 mmol). The reaction was carried out at 20 °C for 1.5 h and provided the alkylzinc reagent **1b** which was transferred to an argon flushed flask.

CuCN·2 LiCl (1M solution in THF, 4.0 mL, 1.0 equiv) was added at -30 °C and the mixture stirred for 30 min. 2-Chlorobenzoyl chloride (490 mg, 2.8 mmol, 0.7 equiv) was added dropwise at -30 °C under argon. The mixture was stirred for 2.5 h and allowed to warm up slowly to 20 °C before being quenched with sat. aqueous NH<sub>4</sub>Cl solution (25 mL) and conc. aqueous ammonia (25 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (diethyl ether/pentane = 1:5) to yield compound **3c** (516 mg, 65%) as colourless liquid. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.45–7.27 (m, 4H), 4.12 (q, <sup>3</sup>J<sub>HH</sub> = 7.2 Hz, 2H), 3.00 (t, <sup>3</sup>J<sub>HH</sub> = 7.2 Hz, 2H), 2.40 (t, <sup>3</sup>J<sub>HH</sub> = 7.2 Hz, 2H), 2.09–1.98 (m, 2H), 1.24 (t, <sup>3</sup>J<sub>HH</sub> = 7.2 Hz, 3H); <sup>13</sup>C (75 MHz, CDCl<sub>3</sub>) δ 202.7, 173.1, 139.4, 131.6, 130.7, 130.5, 128.7, 126.9, 60.4, 41.8, 33.2, 19.3, 14.2; MS (EI, 70 eV): m/z 254 (6) [M<sup>+</sup>], 211 (12), 210 (11), 209 (40), 208 (23), 181 (28), 154 (16), 141 (100), 111 (39), 75 (10); HRMS: m/z calcd. for C<sub>13</sub>H<sub>15</sub>ClO<sub>3</sub> (M<sup>+</sup>) 254.0710, found 254.0701; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  2980 (w), 2940 (w), 2874 (vw), 1728 (vs), 1698 (s), 1590 (m), 1432 (m), 1374 (m), 1204 (s), 1028 (s), 754 (vs) cm<sup>-1</sup>.

#### **7-(4-Chlorophenyl)-2,2-dimethyl-7-oxoheptanenitrile (3d).**

The general procedure was followed using Mg-turnings (244 mg, 10 mmol), LiCl (212 mg, 5 mmol), ZnCl<sub>2</sub> (1M solution in THF, 4.4 mL, 4.4 mmol) and 6-bromo-2,2-dimethylhexanenitrile (**2c**, 817 mg, 4 mmol). The reaction was carried out at 0 °C for

5 h and provided the alkylzinc reagent **1c** which was transferred to an argon flushed flask.

CuCN·2 LiCl (1M solution in THF, 4.0 mL, 1.0 equiv) was added at -30 °C and the mixture stirred for 30 min. 4-Chlorobenzoyl chloride (490 mg, 2.8 mmol, 0.7 equiv) was added dropwise at -30 °C under argon. The mixture was stirred for 2.5 h and allowed to warm up slowly to 20 °C before being quenched with sat. aqueous NH<sub>4</sub>Cl solution (25 mL) and conc. aqueous ammonia (25 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (diethyl ether/pentane = 1:7) to yield compound **3d** (606 mg, 83%) as white powder. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.90–7.85 (m, 2H), 7.45–7.39 (m, 2H), 2.97 (t, <sup>3</sup>J<sub>HH</sub> = 7.2 Hz, 2H), 1.83–1.69 (m, 2H), 1.59–1.51 (m, 4H), 1.33 (s, 6H); <sup>13</sup>C (75 MHz, CDCl<sub>3</sub>) δ 198.4, 139.4, 135.2, 129.4, 128.9, 125.0, 40.9, 38.2, 32.3, 26.6, 25.0, 23.9; MS (EI, 70 eV): m/z 263 (<1) [M<sup>+</sup>], 156 (16), 154 (52), 139 (100), 111 (20); HRMS: m/z calcd. for C<sub>15</sub>H<sub>18</sub>ClNO (M<sup>+</sup>) 263.1077, found 263.1068; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  2978 (m), 2936 (m), 1680 (vs), 1584 (m), 1570 (m), 1396 (m), 1370 (m), 1322 (m), 1260 (m), 1220 (m), 1204 (m), 1094 (s), 1010 (m), 986 (s), 836 (vs), 735 (m) cm<sup>-1</sup>, mp (°C) = 78–79.

### **6-(4-Fluorophenylthio)-2,2-dimethylhexanenitrile (3e).**

The general procedure was followed using Mg-turnings (244 mg, 10 mmol), LiCl (212 mg, 5 mmol), ZnCl<sub>2</sub> (1M solution in THF, 4.4 mL, 4.4 mmol) and 6-bromo-2,2-dimethylhexanenitrile (**2c**, 817 mg, 4 mmol). The reaction was carried out at 0 °C for 5 h and provided the alkylzinc reagent **1c** which was transferred to an argon flushed flask.

CuCN·2 LiCl (1M solution in THF, 4.0 mL, 1.0 equiv) was added at -30 °C and the mixture stirred for 30 min. *S*-4-Fluorophenyl benzenesulfonothioate (751 mg, 2.8 mmol, 0.7 equiv) was added at -30 °C under argon. The mixture was stirred for 16 h and

allowed to warm up slowly to 20 °C before being quenched with sat. aqueous NH<sub>4</sub>Cl solution (20 mL) and conc. aqueous ammonia (20 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (diethyl ether/pentane = 1:7) to yield compound **3e** (610 mg, 86%) as yellow liquid. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.36–7.28 (m, 2H), 7.02–6.93 (m, 2H), 2.86 (t, <sup>3</sup>J<sub>HH</sub> = 7.1 Hz, 2H), 1.68–1.43 (m, 6H), 1.31 (s, 6H); <sup>13</sup>C (75 MHz, CDCl<sub>3</sub>) δ 161.7 (d, <sup>1</sup>J<sub>CF</sub> = 246.1 Hz), 132.3 (d, <sup>3</sup>J<sub>CF</sub> = 8.0 Hz), 131.1 (d, <sup>4</sup>J<sub>CF</sub> = 3.1 Hz), 124.9, 115.9 (d, <sup>2</sup>J<sub>CF</sub> = 21.9 Hz), 40.5, 34.7 (d, <sup>6</sup>J<sub>CF</sub> = 0.8 Hz), 32.3, 29.0, 26.5, 24.3; MS (EI, 70 eV): m/z 251 (86) [M<sup>+</sup>], 218 (10), 141 (74), 128 (100), 124 (17); HRMS: m/z calcd. for C<sub>14</sub>H<sub>18</sub>SFN (M<sup>+</sup>) 251.1144, found 251.1143; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  2938 (w), 2234 (w), 1490 (vs), 1472 (m), 1462 (m), 1220 (vs), 1156 (m), 1090 (m), 824 (vs), 734 (m), 630 (m), 622 (m) cm<sup>-1</sup>.

### **2,2-Dimethyl-6-p-tolyl-hexanenitrile (3f).**

The general procedure was followed using Mg-turnings (122 mg, 5 mmol), LiCl (106 mg, 2.5 mmol), ZnCl<sub>2</sub> (1M solution in THF, 2.2 mL, 2.2 mmol) and 6-bromo-2,2-dimethylhexanenitrile (**2c**, 407 mg, 2 mmol). The reaction was carried out at 20 °C for 2.5 h and provided the alkylzinc reagent **1c** which was transferred to an argon flushed flask.

A mixture of Pd(OAc)<sub>2</sub> (6 mg, 2.8·10<sup>-2</sup> mmol, 1.4 mol%), Ru-Phos (26 mg, 5.6·10<sup>-2</sup> mmol, 2.8 mol%) and *p*-bromotoluene (240 mg, 1.4 mmol, 0.7 equiv) in 2 mL THF was added at 20°C and the reaction mixture stirred for 1.5 h before being quenched with sat. aqueous NH<sub>4</sub>Cl solution (25 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (diethyl ether/pentane = 1:50) to yield compound **3f**

(211 mg, 70%) as colourless liquid.  $^1\text{H}$  NMR (300 MHz,  $\text{C}_6\text{D}_6$ ):  $\delta$  7.07–6.98 (m, 4H), 2.43–2.35 (m, 2H), 2.16 (s, 3H), 1.44–1.23 (m, 4H), 1.08–0.99 (m, 2H), 0.82 (s, 6H);  $^{13}\text{C}$  (75 MHz,  $\text{CDCl}_3$ )  $\delta$  139.1, 134.9, 129.0, 128.2, 124.3, 40.6, 35.2, 31.8, 31.4, 26.0, 24.7, 20.7; MS (EI, 70 eV):  $m/z$  215 (27) [ $\text{M}^+$ ], 200 (9), 144 (7), 105 (100), 91 (11), 71 (22); HRMS:  $m/z$  calcd. for  $\text{C}_{15}\text{H}_{21}\text{N}$  ( $\text{M}^+$ ) 215.1674, found 215.1661; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  3048 (w), 2977 (m), 2936 (vs), 2860 (m), 1515 (s), 1470 (m), 1458 (m), 1391 (w), 1369 (w), 1206 (w), 841 (w), 807 (m)  $\text{cm}^{-1}$ .

### 5-(2-Bromophenyl)-5-oxopentanenitrile (3g).

The general procedure was followed using Mg-turnings (244 mg, 10 mmol), LiCl (212 mg, 5 mmol),  $\text{ZnCl}_2$  (1M solution in THF, 4.4 mL, 4.4 mmol) and 4-bromobutanenitrile (**2d**, 592 mg, 4 mmol). The reaction was carried out at 20 °C for 1 h and provided the alkylzinc reagent **1d** which was transferred to an argon flushed flask.

$\text{CuCN}\cdot 2\text{LiCl}$  (1M solution in THF, 4.0 mL, 1.0 equiv) was added at -30 °C and the mixture stirred for 30 min. 2-Bromobenzoyl chloride (615 mg, 2.8 mmol, 0.7 equiv) was added dropwise at -30 °C under argon. The mixture was stirred for 2 h and allowed to warm up slowly to 20 °C before being quenched with sat. aqueous  $\text{NH}_4\text{Cl}$  solution (25 mL) and conc. aqueous ammonia (25 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over  $\text{Na}_2\text{SO}_4$  and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (diethyl ether/pentane = 1:3) to yield compound **3g** (587 mg, 70%) as yellow oil.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ): 7.63–7.59 (m, 1H), 7.42–7.28 (m, 3H), 3.11 (t,  $^3J_{\text{HH}} = 6.8$  Hz, 2H), 5.52 (t,  $^3J_{\text{HH}} = 7.1$  Hz, 2H), 2.10 (pent,  $^3J_{\text{HH}} = 6.9$  Hz, 2H);  $^{13}\text{C}$  (75 MHz,  $\text{CDCl}_3$ )  $\delta$  202.3, 141.0, 133.8, 131.9, 128.3, 127.6, 119.2, 118.6, 40.5, 19.7, 16.5; MS (EI, 70 eV):  $m/z$  251 (3) [ $\text{M}^+$ ], 185 (97), 183 (100), 157 (16), 155 (15); HRMS:  $m/z$  calcd. for  $\text{C}_{11}\text{H}_{10}\text{BrNO}$  ( $\text{M}^+$ ) 250.9946, found 250.9933; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  3675



(vw), 2977 (w), 2961 (w), 2960 (w), 2246 (w), 1697 (s), 1587 (m), 1428 (m), 755 (vs)  $\text{cm}^{-1}$ .

### **7-chloro-1-(2-chlorophenyl)heptan-1-one (3h).**

The general procedure was followed using Mg-turnings (244 mg, 10 mmol), LiCl (212 mg, 5 mmol),  $\text{ZnCl}_2$  (1M solution in THF, 4.4 mL, 4.4 mmol) and 1-bromo-6-chlorohexane (**2e**, 798 mg, 4 mmol). The reaction was carried out at 20 °C for 40 min and provided the alkylzinc reagent **1e** which was transferred to an argon flushed flask.

$\text{CuCN}\cdot 2\text{LiCl}$  (1M solution in THF, 4.0 mL, 1.0 equiv) was added at -30 °C and the mixture stirred for 30 min. 2-Chlorobenzoyl chloride (490 mg, 2.8 mmol, 0.7 equiv) was added dropwise at -30 °C under argon. The mixture was stirred for 2.5 h and allowed to warm up slowly to 20 °C before being quenched with sat. aqueous  $\text{NH}_4\text{Cl}$  solution (25 mL) and conc. aqueous ammonia (25 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over  $\text{Na}_2\text{SO}_4$  and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (diethyl ether/pentane = 1:10) to yield compound **3h** (457 mg, 63%) as colourless liquid.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.44–7.27 (m, 4H), 3.52 (t,  $^3J_{\text{HH}} = 6.6$  Hz, 2H), 2.93 (t,  $^3J_{\text{HH}} = 7.3$  Hz, 2H), 1.83–1.68 (m, 4H), 1.52–1.32 (m, 4H);  $^{13}\text{C}$  (75 MHz,  $\text{CDCl}_3$ )  $\delta$  203.6, 139.7, 131.5, 130.7, 130.5, 128.7, 126.9, 45.0, 42.8, 32.4, 28.4, 26.6, 23.9; MS (EI, 70 eV):  $m/z$  258 (<1) [ $\text{M}^+$ ], 156 (23), 154 (81), 139 (100), 111 (19) HRMS:  $m/z$  calcd. for  $\text{C}_{13}\text{H}_{16}\text{Cl}_2\text{O}$  ( $\text{M}^+$ ) 258.0578, found 258.0567; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  2936 (m), 2860 (w), 1698 (s), 1590 (m), 1466 (m), 1432 (s), 1287 (m), 1268 (m), 1208 (m), 1062 (m), 756 (vs), 730 (s), 644 (s)  $\text{cm}^{-1}$ .

### **5-Cyclohex-2-en-1-yl-N,N-diethylpentanamide (3i)**

The general procedure was followed using Mg-turnings (122 mg, 5 mmol), LiCl (212 mg, 5 mmol), ZnCl<sub>2</sub> (1M solution in THF, 2.2 mL, 2.2 mmol) and 5-bromo-*N,N*-diethylpentanamide (**2f**, 472 mg, 2 mmol) dissolved in THF (3 mL). The reaction was carried out at 25 °C for 1 h and provided the alkylzinc reagent **1f** which was transferred to an argon flushed flask.

CuCN·2 LiCl (1M solution in THF, 0.4 mL, 0.2 equiv) was added at -20 °C and the mixture stirred for 30 min. 3-Bromocyclohexene (225 mg, 1.4 mmol, 0.7 equiv) was added at -20 °C under argon. The mixture was stirred for 1 h and allowed to warm up slowly to 20 °C before being quenched with sat. aqueous NH<sub>4</sub>Cl solution (20 mL) and conc. aqueous ammonia (20 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (ethyl acetate/pentane = 1:4) to yield compound **3i** (232 mg, 70%) as colorless liquid.

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 5.64-5.51 (m, 2H), 3.37-3.23 (m, 4H), 2.28-2.23 (m, 2H) 2.03-1.09 (m, 19H); <sup>13</sup>C (75 MHz, CDCl<sub>3</sub>) δ 172.2, 132.1, 126.7, 41.9, 40.0 36.1, 35.0, 33.1, 29.0, 26.8, 25.7, 25.3, 21.5, 14.4, 13.1; MS (EI, 70 eV): m/z 237 (9) [M<sup>+</sup>], 156 (15), 115 (100), 100 (59), 58 (38); HRMS: m/z calcd. for C<sub>15</sub>H<sub>27</sub>NO (M<sup>+</sup>) 237.2093, found 237.2097; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  2967 (m), 2931 (s), 2861 (m), 1616 (vs), 1480 (m), 1448 (m), 1430 (s), 1380 (m), 1362 (m), 1264 (m), 1221 (w) cm<sup>-1</sup>.

### **{3-[3-(Benzylthio)propyl]phenyl}(phenyl)methanone (3j).**

The general procedure was followed using Mg-powder (122 mg, 5 mmol), LiCl (212 mg, 5 mmol), ZnCl<sub>2</sub> (1M solution in THF, 2.2 mL, 2.2 mmol) and [3-(3-bromopropyl)phenyl] (phenyl)-methanone (**2g**, 606 mg, 2 mmol) dissolved in THF (3 mL). The reaction was carried out at 25 °C for 1.5 h and provided the

alkylzinc reagent **1g** which was transferred to an argon flushed flask.

*S*-benzyl benzenesulfonothioate (370 mg, 1.4 mmol, 0.7 equiv) was added at -20 °C and the mixture stirred for 1 h. The solution was allowed to warm up slowly to 20 °C before being quenched with sat. aqueous NH<sub>4</sub>Cl solution (20 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (diethyl ether/pentane = 1:19) to yield compound **3j** (254 mg, 58%) as colorless liquid. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.79–7.70 (m, 4H), 7.60–7.44 (m, 3H), 7.31–7.22 (m, 7H), 3.70 (s, 2H), 2.75 (t, <sup>3</sup>J<sub>HH</sub> = 7.3 Hz, 2H), 2.44 (t, <sup>3</sup>J<sub>HH</sub> = 7.0 Hz, 2H), 1.95–1.85 (m, 2H); <sup>13</sup>C (75 MHz, CDCl<sub>3</sub>) δ 196.4, 146.7, 138.4, 137.9, 137.5, 137.5, 135.4, 132.2, 130.4, 129.9, 128.8, 128.5, 128.4, 128.2, 127.0, 36.6, 34.7, 30.6, 30.4; MS (EI, 70 eV): *m/z* 346 (52) [M<sup>+</sup>] 255 (12), 222 (21), 209 (100), 196 (18), 145 (28), 105 (55), 91 (79); HRMS: *m/z* calcd. for C<sub>23</sub>H<sub>22</sub>OS (M<sup>+</sup>) 346.1391, found 346.1394; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  3059 (w), 3027 (w), 2922 (w), 2857 (w), 1653 (vs), 1604 (s), 1578 (w), 1568 (w), 1494 (w), 1446 (m), 1412 (w), 1315 (m), 1310 (m), 1276 (vs), 1202 (w), 1176 (m), 1148 (w), 1072 (w), 1028 (w), 1020 (w), 1000 (w), 938 (m), 922 (m), 847 (w), 787 (w), 768 (w), 740 (w), 697 (vs), 680 (m) cm<sup>-1</sup>.

### **[3-(3-Cyclohex-2-en-1-ylpropyl)phenyl](phenyl)methanone (3k).**

The general procedure was followed using Mg-powder (122 mg, 5 mmol), LiCl (212 mg, 5 mmol), ZnCl<sub>2</sub> (1M solution in THF, 2.2 mL, 2.2 mmol) and [3-(3-bromopropyl)phenyl] (phenyl)-methanone (**2g**, 606 mg, 2 mmol) dissolved in THF (3 mL). The reaction was carried out at 25 °C for 1.5 h and provided the alkylzinc reagent **1g** which was transferred to an argon flushed flask.

CuCN·2 LiCl (1M solution in THF, 0.4 mL, 0.2 equiv) was added at -20 °C and the mixture stirred for 30 min. 3-Bromocyclohexene (225 mg, 1.4 mmol, 0.7 equiv) was added at -20 °C under argon. The mixture was stirred for 1 h and allowed to warm up slowly to 20 °C before being quenched with sat. aqueous NH<sub>4</sub>Cl solution (20 mL) and conc. aqueous ammonia (20 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (diethyl ether/pentane = 1:9) to yield compound **3k** (261 mg, 61%) as colorless liquid.

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.43–6.97 (m, 9H), 5.70–5.56 (m, 2H), 3.02 (s, 1H) 2.60–2.53 (m, 2H), 2.10 (brs, 1H), 1.79–1.17 (m, 9H); <sup>13</sup>C (75 MHz, CDCl<sub>3</sub>) δ 144.5, 141.5, 141.3, 132.1, 128.6, 128.4, 127.3, 127.2, 126.8, 126.8, 126.8, 126.7, 35.9, 35.6, 35.0, 29.0, 28.5, 25.4, 21.5; MS (EI, 70 eV): m/z 304 (59) [M<sup>+</sup>], 209 (100), 196 (42), 183 (22), 118 (18), 105 (92), 77 (75); HRMS: m/z calcd. For C<sub>22</sub>H<sub>24</sub>O (M<sup>+</sup>) 304.1827, found 304.1804; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  2971 (m), 2941 (s), 2859 (m), 1659 (vs), 1610 (s), 1582 (w), 1560 (w), 1493 (w), 1314 (m), 1321 (m), 1275 (vs), 1243 (w), 1153 (m), 1144 (w), 1111 (w), 1022 (w), 1020 (w), 998 (w), 846 (w), 787 (w), 768 (w), 740 (w), 690 (s), 680 (m) cm<sup>-1</sup>.

### **Ethyl 2-(1,4-dioxaspiro[4.5]dec-8-ylmethyl)acrylate (3l).**

The general procedure was followed using Mg-turnings (122 mg, 5 mmol), LiCl (212 mg, 5 mmol), ZnCl<sub>2</sub> (1M solution in THF, 2.2 mL, 2.2 mmol) and 8-bromo-1,4-dioxaspiro[4.5]decane (**2h**, 442 mg, 2 mmol) dissolved in THF (3 mL). The reaction was carried out at 25 °C for 2 h and provided the alkylzinc reagent **1h** which was transferred to an argon flushed flask.

CuCN·2 LiCl (1M solution in THF, 0.4 mL, 0.2 equiv) was added at -20 °C and the mixture stirred for 30 min. ethyl 2-

(bromomethyl)acrylate (270 mg, 1.4 mmol, 0.7 equiv) was added at -20 °C under argon. The mixture was stirred for 1 h and allowed to warm up slowly to 20 °C before being quenched with sat. aqueous NH<sub>4</sub>Cl solution (20 mL) and conc. aqueous ammonia (20 mL). The aqueous layer was extracted with diethyl ether three times. The combined organic extracts were dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel (ethyl acetate/pentane = 1:9) to yield compound **31** (245 mg, 69%) as colorless liquid. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.13 (d, <sup>3</sup>J<sub>HH</sub> = 1.7 Hz, 1H), 5.46-5.45 (m, 1H), 4.18 (q, <sup>3</sup>J<sub>HH</sub> = 7.3 Hz, 2H), 3.90 (s, 4H), 2.21 (d, <sup>3</sup>J<sub>HH</sub> = 6.8 Hz, 2H), 1.74-1.64 (m, 4H), 1.53-1.43 (m, 3H), 1.27 (t, <sup>3</sup>J<sub>HH</sub> = 7.3 Hz, 3H), 1.28-1.21 (m, 2H); <sup>13</sup>C (75 MHz, CDCl<sub>3</sub>) δ 167.3, 139.3, 125.8, 109.0, 64.2, 60.5, 38.8, 35.1, 34.3, 29.9, 14.2; MS (EI, 70 eV): m/z 254 (<1) [M<sup>+</sup>], 198 (3), 181 (5), 99 (100), 86 (13); HRMS: m/z calcd. for C<sub>14</sub>H<sub>22</sub>O<sub>4</sub> (M<sup>+</sup>) 254.1518, found 254.1494; FT-IR (Diamond-ATR, neat)  $\tilde{\nu}$  2980 (w), 2930 (m), 2879 (m), 2860 (w), 1713 (vs), 1629 (w), 1477 (vw), 1446 (w), 1410 (w), 1371 (w), 1329 (w), 1301 (m), 1284 (w), 1200 (m), 1174 (m), 1156 (m), 1133 (m), 1104 (vs), 1076 (m), 1067 (w), 1033 (m), 1001 (w), 982 (w), 929 (m), 884 (w), 857 (vw), 820 (w), 768 (vw), 661 (w) cm<sup>-1</sup>.

Preparation of Highly Functionalized Alkylzinc Halides from  
Alkyl Bromides using Mg, ZnCl<sub>2</sub> and LiCl

**<sup>1</sup>H and <sup>13</sup>C spectra**

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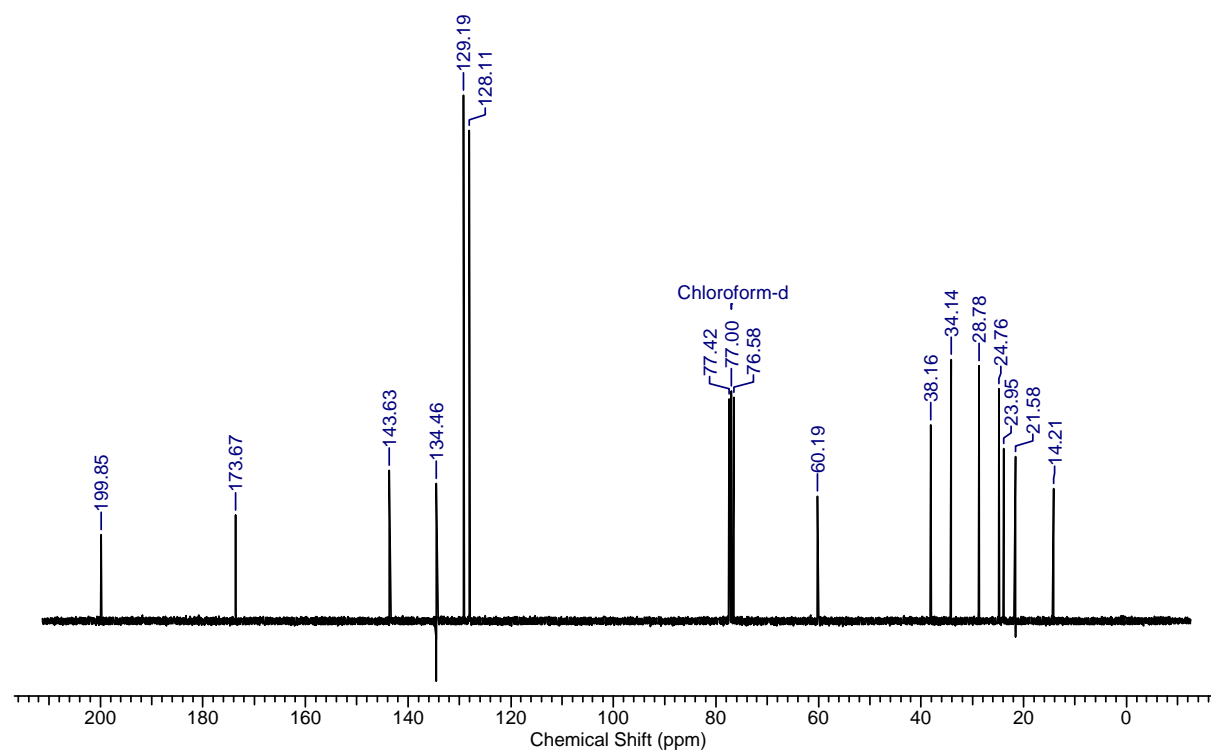
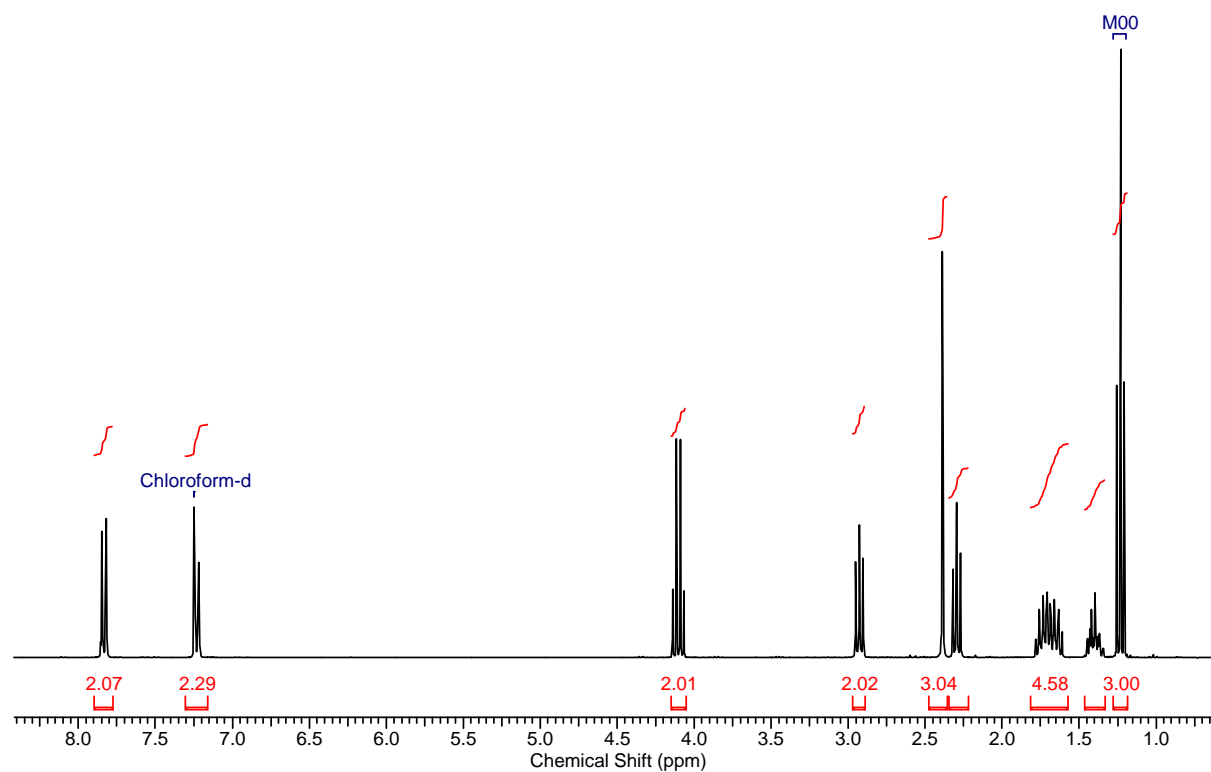
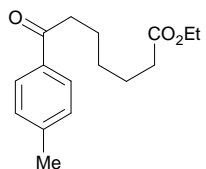
Department Chemie und Biochemie

Butenandtstrasse 5-13, Haus F, 81377 München (Germany)

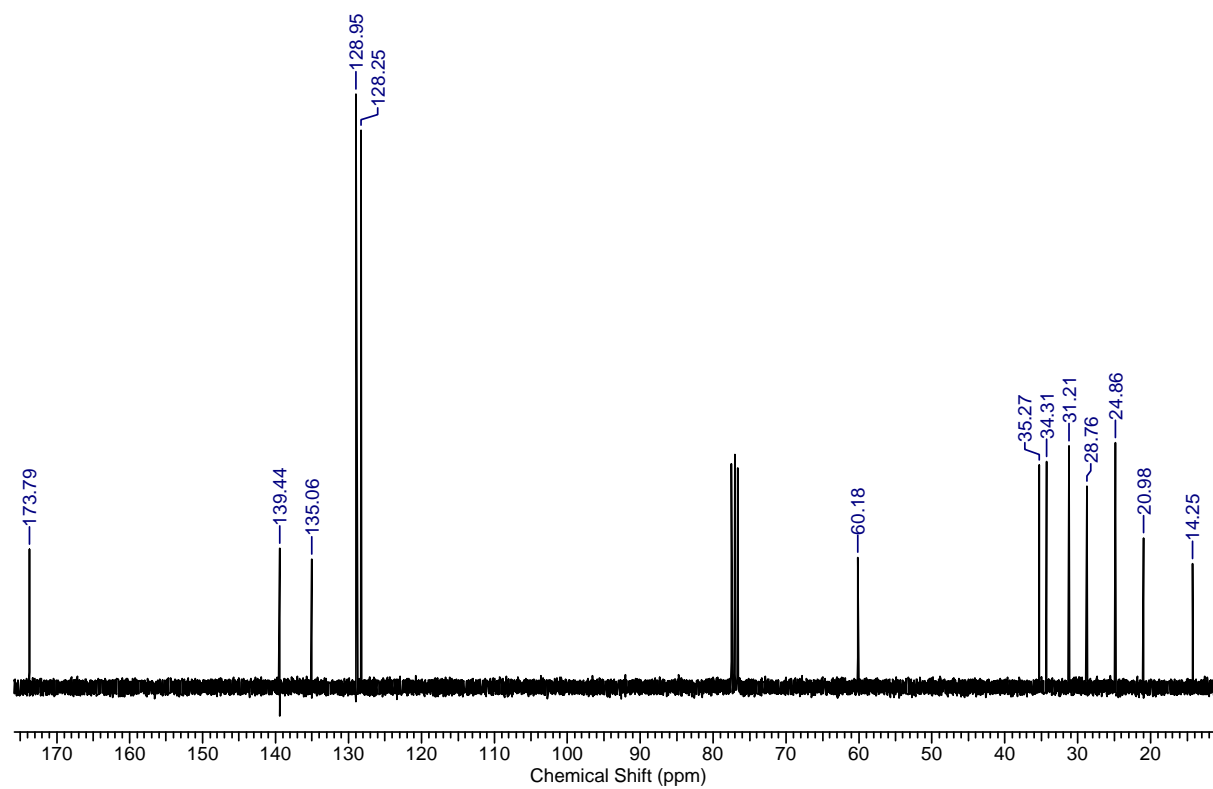
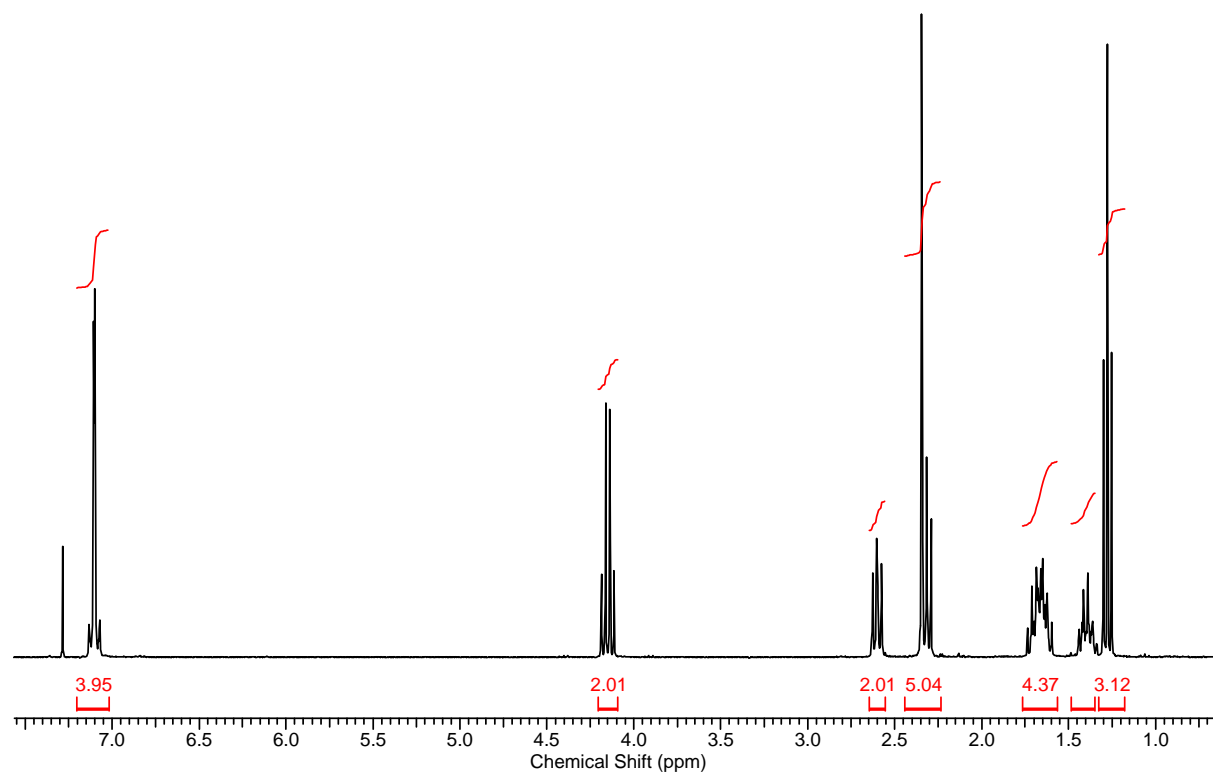
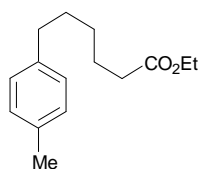
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Compound 3a

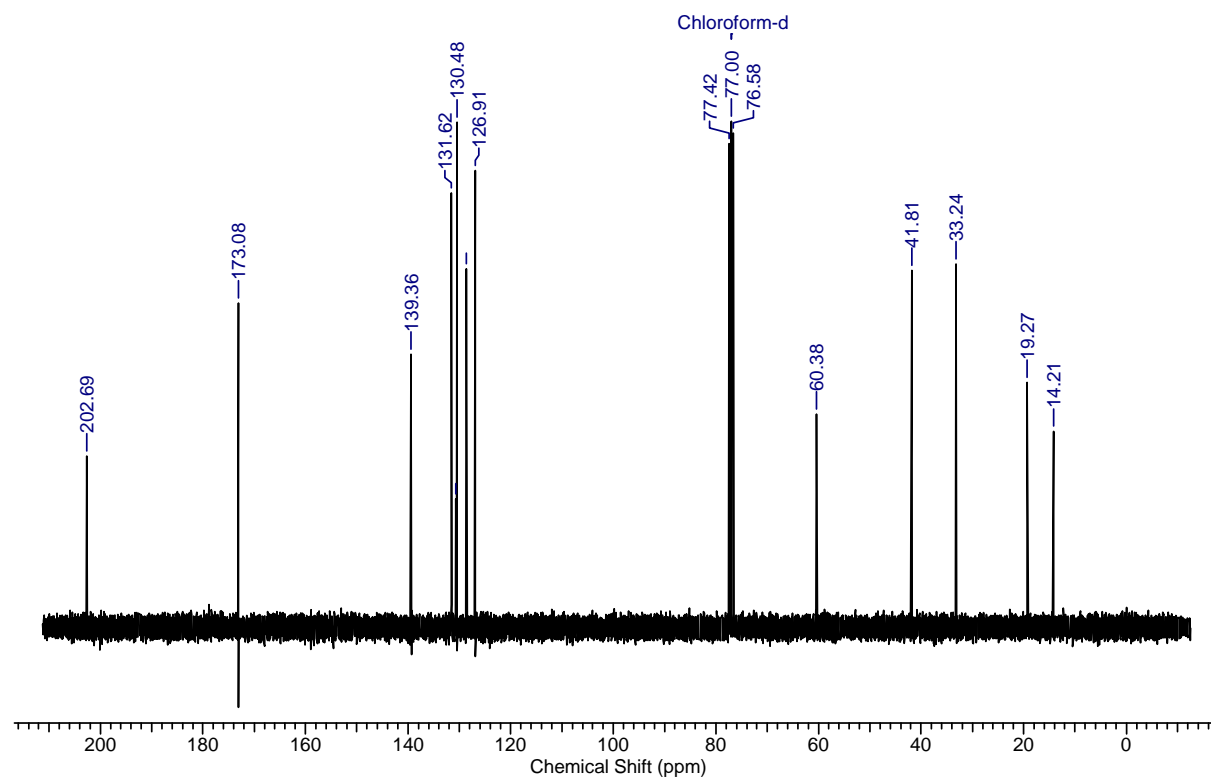
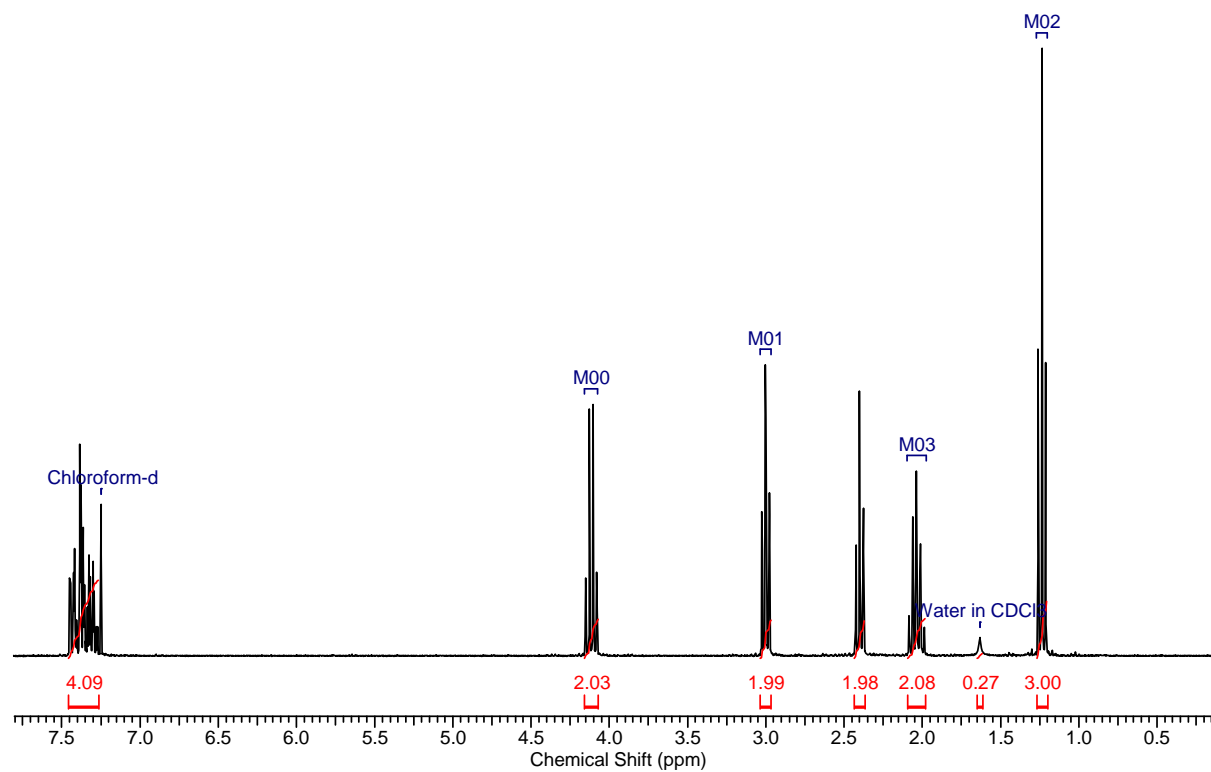
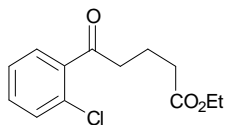


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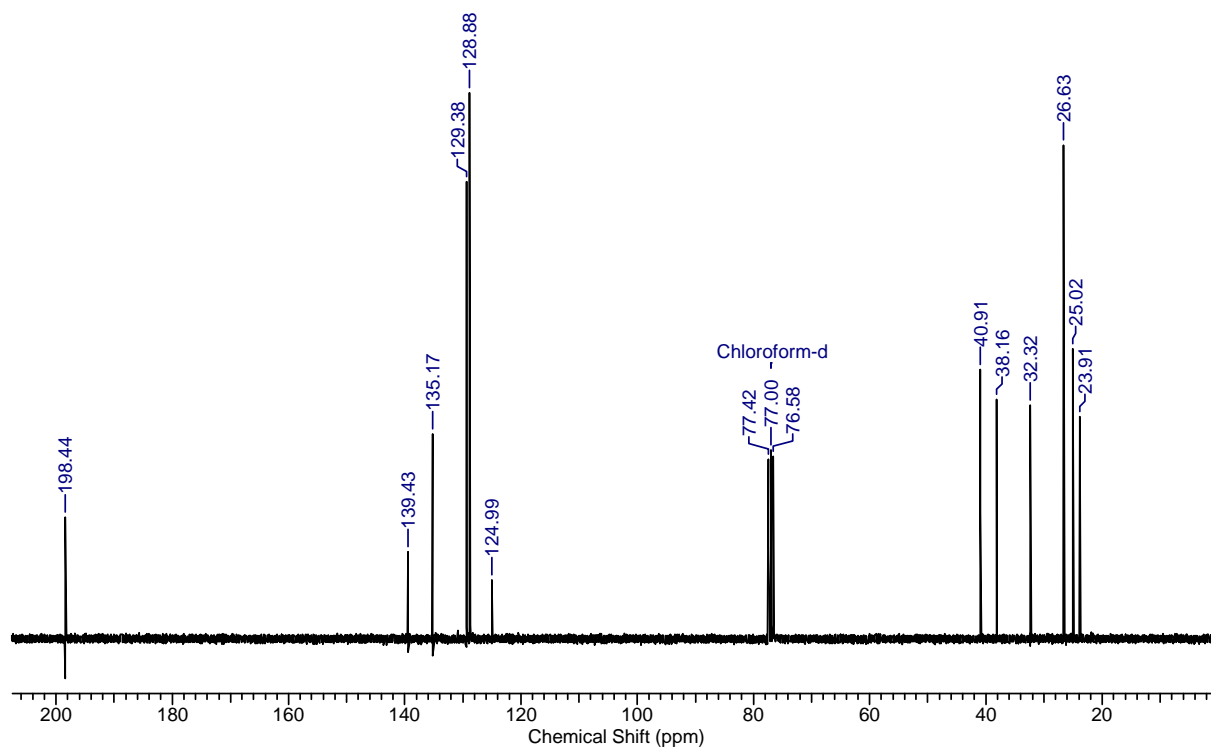
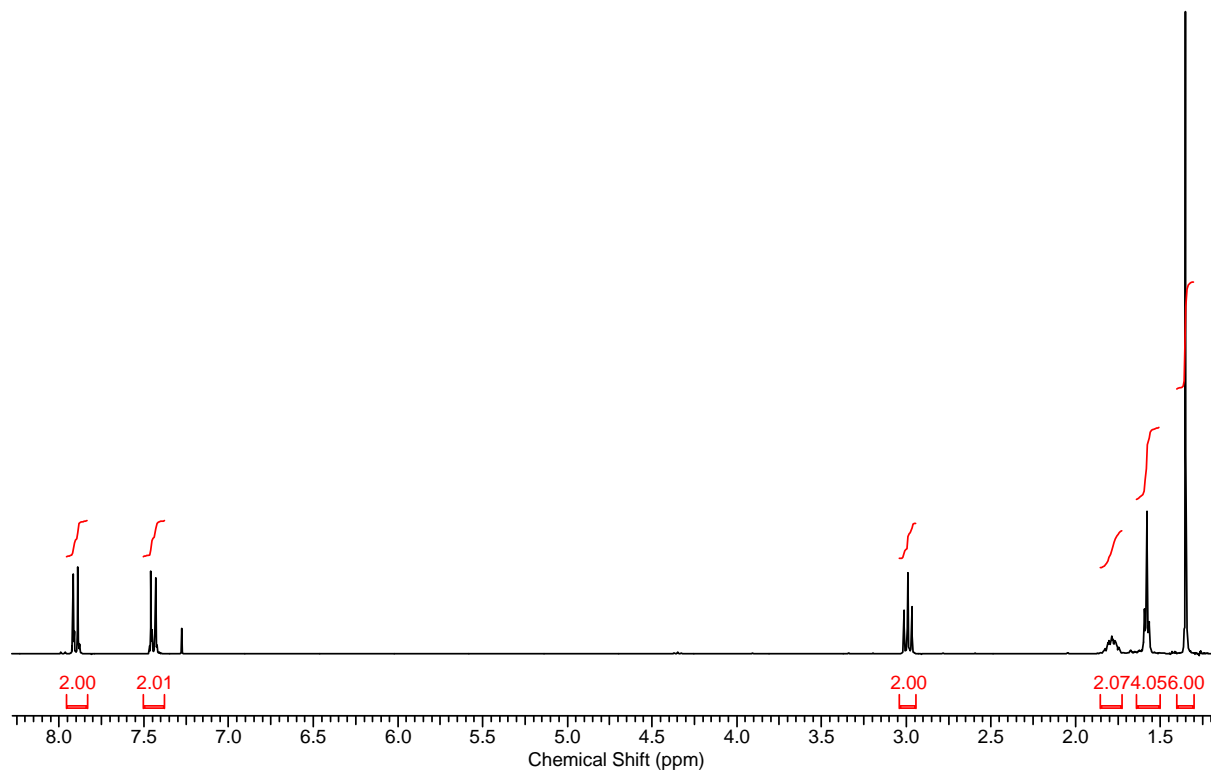
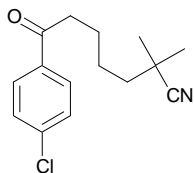




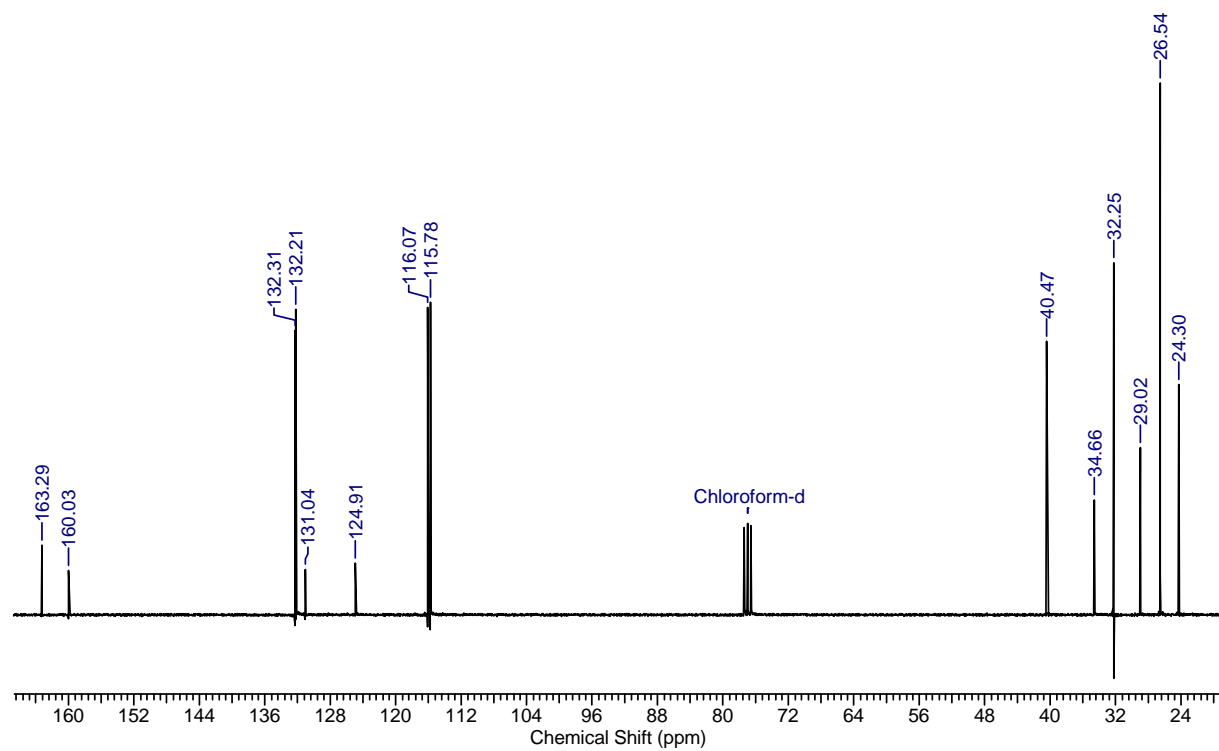
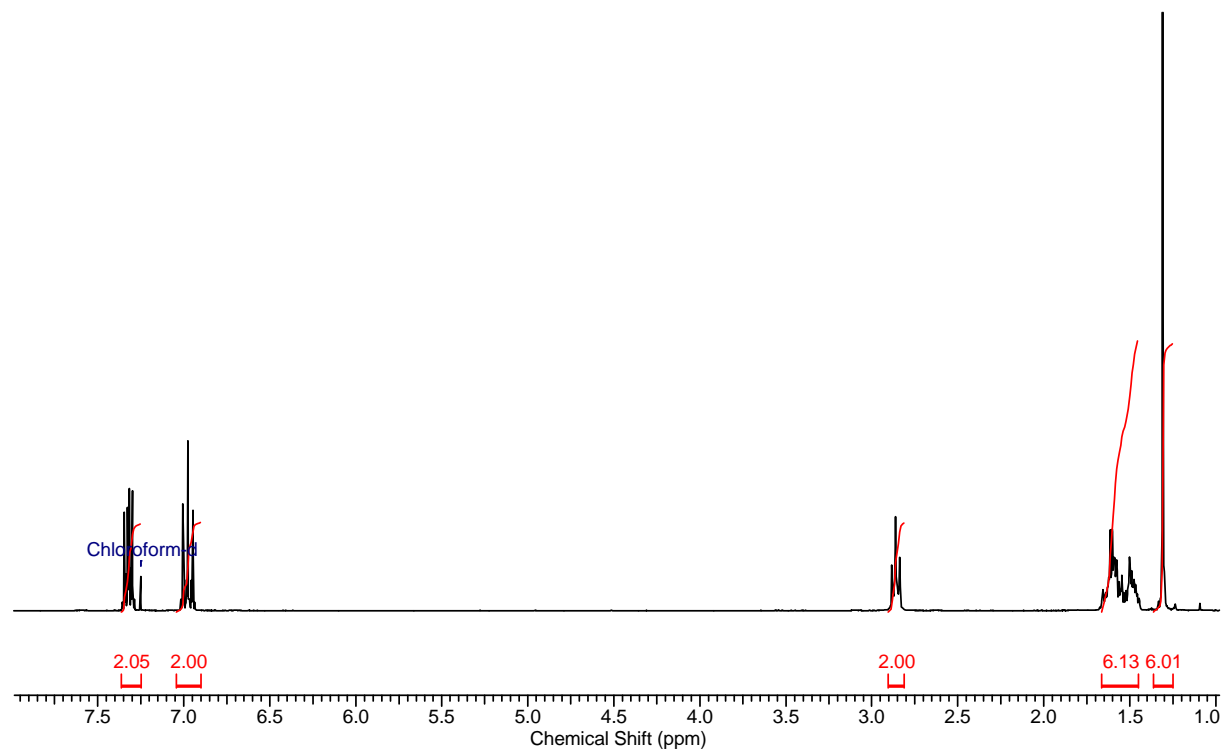
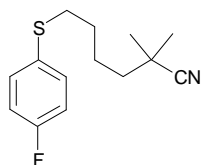
Compound 3c



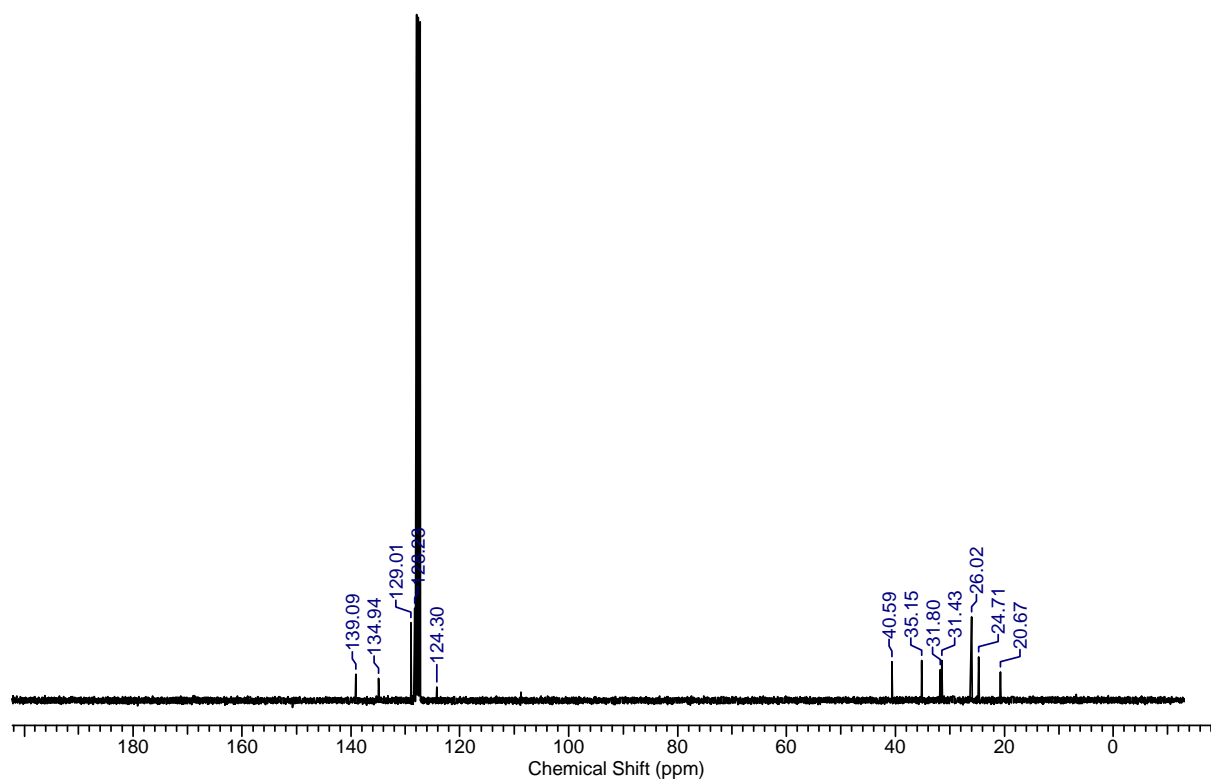
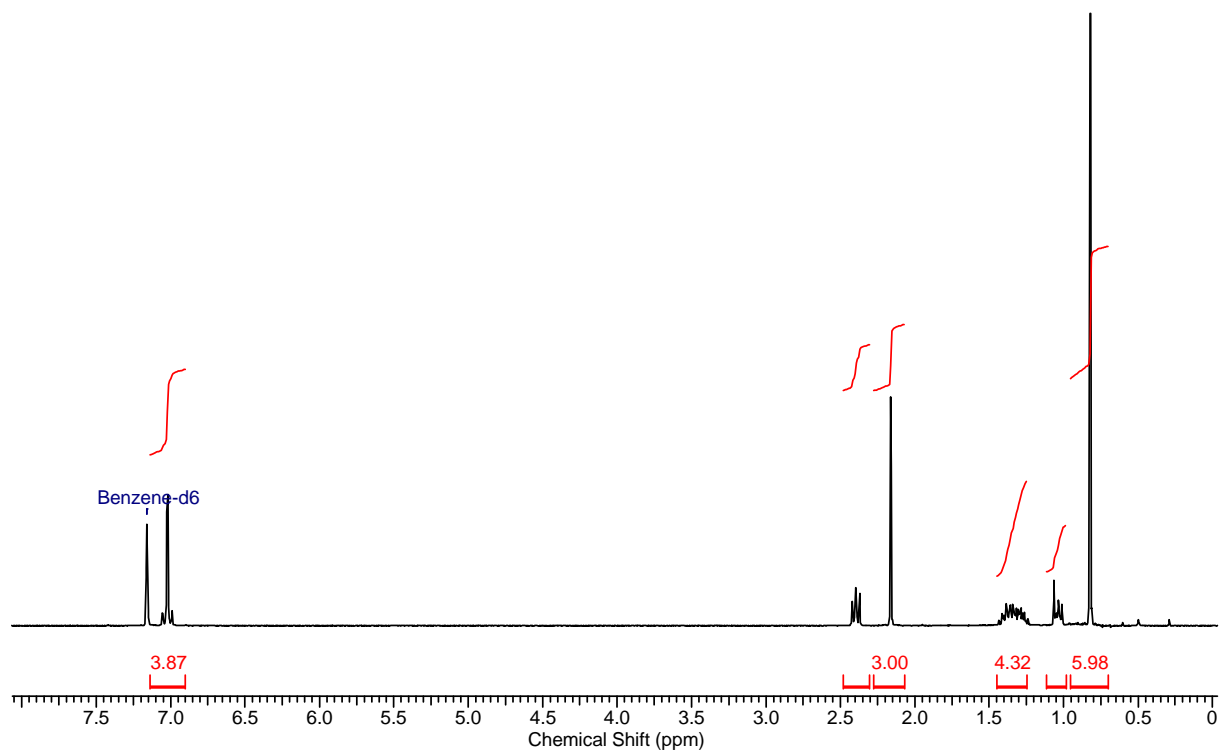
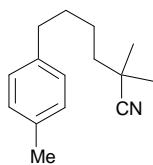
Compound 3d



Compound 3e



Compound 3f



Compound 3g

