Angewandte Chemie
Eine Zeitschrift der Gesellschaft Deutscher Chemiker

Supporting Information

69451 Weinheim, Germany

A General Method for the Direct α-Arylation of Aldehydes with Aryl Bromides and Chlorides

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General Considerations

Reagents. All reactions were set up in the air (with no use of a glovebox) and carried out under an argon atmosphere in resealable screw-cap test tubes. $Pd(OAc)_2$ was a gift from BASF. *rac*-BINAP was a gift from Rhodia. Powdered Cs_2CO_3 was a gift from Chemetall. The bulk of the base was stored under nitrogen in a Vacuum Atmospheres glovebox. Small portions (~ 5 g) were removed from the glovebox in glass vials, stored in the air in a desiccator filled with anhydrous calcium sulfate, and weighed in the air. **L8**[1] and **L10**[2] were synthesized by a known literature procedure. Anhydrous DMF and dioxane were purchased from Aldrich in Sure/Seal™ bottles. Aryl bromides and aryl chlorides were purified (if liquid) by passing through a pad of basic alumina prior to use. Commercially available aldehydes were distilled prior to use. All other reagents were purchased from commercial sources and used as received. Flash chromatography was performed with EM Science silica gel 60 (230-400 mesh).

Analytical Methods. All new compounds were characterized by ^{1}H NMR, ^{13}C NMR, IR spectroscopy and in most cases, elemental analysis. ^{1}H NMR and ^{13}C NMR spectra and melting points (where applicable) are included for all known compounds and for all new compounds not characterized by elemental analysis. ^{1}H and ^{13}C NMR spectra were recorded on a Varian XL 300 MHz. Infrared spectra were recorded on a Perkin-Elmer Model 2000 FT-

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[1] a) Kaye, S.; Fox, J. M.; Hicks, F. A.; Buchwald, S. L. *Adv. Synth. Catal.* **2001**, *343*, 789. b) Barder, T. E.; Walker, S. D.; Martinelli, J. R.; Buchwald, S. L. *J. Am. Chem. Soc.* **2005**, *127*, 4685.

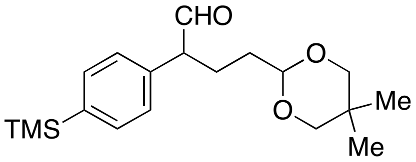
[2] T. Hamada, A. Chieffi, J. Ahman, S. L. Buchwald, *J. Am. Chem. Soc.* **2002**, *124*, 1261.

IR using NaCl plates (thin film). Elemental analyses were performed by Atlantic Microlab Inc., Norcross, GA. All ^{1}H NMR spectra are reported in parts per million (ppm) downfield of TMS and were measured relative to the signals for $CHCl_3$ (7.27 ppm). All ^{13}C NMR spectra were reported in ppm relative to residual $CHCl_3$ (77 ppm) and were obtained with ^{1}H decoupling. Melting points were obtained on a Mel-Temp capillary melting point apparatus. Gas chromatographic analyses were performed on Hewlett-Packard 6890 gas chromatography instrument with a FID detector using 25m x 0.20 mm capillary column with cross-linked methyl siloxane as the stationary phase. The yields reported in tables 2 and 3 refer to isolated yields and represent an average of at least two independent runs. The pure compounds are estimated to be ≥ 95% pure as determined by ^{1}H NMR and GC analysis and/or combustion analysis. The procedures described in this section are representative. Thus, the yields may differ slightly from those given in Tables 3-4.

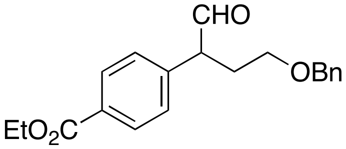
General procedure A for the Pd-catalyzed intermolecular α-arylation of linear aldehydes using aryl bromides (Table 3). An oven-dried screw-cap test tube containing a stirring bar was charged with $Pd(OAc)_2$ (4.5 mg, 2.0 mol%), *rac*-BINAP (19 mg, 3.00 mol%), Cs_2CO_3 (0.46 g, 1.20 mmol) and the aryl bromide (1 mmol), if a solid. The test tube was evacuated and back-filled with dry argon (this sequence was repeated three times). The aliphatic linear aldehyde, the aryl bromide (if liquid) and dioxane (4 mL) were then added by syringe. The mixture was then stirred in a pre-heated oil bath (80 °C) for the indicated time. The mixture was then allowed to warm to room temperature, diluted with ethyl acetate (5 mL) and filtered through a Celite® plug, eluting with additional ethyl acetate (10 mL). The filtrate was concentrated and purified by column chromatography on silica gel (eluting with hexanes/ethyl acetate mixtures).

General procedure B for the Pd-catalyzed intermolecular α-arylation of linear and α-branched aldehydes using aryl chlorides (Table 3 and 4). General procedure A was followed, but **L5** (12 mg, 3.0 mol%), aldehyde (1.50 mmol) in dioxane (8 mL) at 100 °C were used.

General procedure C for the Pd-catalyzed intermolecular α-arylation of α-branched aldehydes using aryl bromides (Table 4). General procedure A was followed, but **L2** (13 mg, 3.0 mol%) was used in liu of *rac*-BINAP as the ligand.



4-(5,5-dimethyl-1,3-dioxan-2-yl)-2-[3-(trimethylsilyl)phenyl]butanal (Table 2, entry 1). Following general procedure A, (4-bromophenyl)trimethylsilane (196 μL, 1.00 mmol) was allowed to react with 4-(5,5-dimethyl-1,3-dioxan-2-yl)butanal (200 μL, 1.20 mmol) for 7 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. White solid; yield: 281 mg (84% yield). Following general procedure B, using (4-chlorophenyl)trimethylsilane (184 μL, 1.0 mmol), for 10 h (82% yield). Mp = 61-62 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.67 (d, J = 1.8 Hz, 1H), 7.50 (d, J = 7.8 Hz, 2H), 7.16 (d, J = 7.8 Hz, 2H), 4.40 (t, J = 5.1 Hz, 1H), 3.59-3.54 (m, 3H), 3.35 (d, J = 11.1 Hz, 2H), 2.23 (m, 1H), 1.87 (m, 1H), 1.60 (m, 2H), 1.16 (s, 3H), 0.70 (s, 3H), 0.26 (s, 9H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 200.5, 139.7, 136.5, 134.0, 128.2, 101.6, 77.1, 58.8, 32.2, 30.1, 23.9, 23.0, 21.8, -1.2. IR (neat, cm^{-1}): 2954, 2847, 2716, 1725, 1599, 1471, 1393, 1248, 1178, 1137, 111, 1040, 1021, 980, 911, 840.



Ethyl 4-[3-(benzyloxy)-1-formylpropyl]benzoate (Table 2, entry 2). Following general procedure A, ethyl 4-bromobenzoate (164 μL, 1.00 mmol) was allowed to react with 4-(benzyloxy)butanal[3] (214 mg, 1.20 mmol) for 6 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. Colorless oil; yield: 234 mg (70% yield). Following general procedure B, using ethyl 4-chlorobenzoate (160 μL, 1 mmol), for 10 h (72% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.70 (d, J = 1.2 Hz, 1H), 8.01 (d, J = 8.4 Hz, 2H), 7.34-7.29 (m, 5H), 7.23 (d, J = 8.4 Hz, 2H), 4.43-4.30 (m, 4H), 3.89 (td, J = 6.7, 1.2 Hz, 1H), 3.51 (m, 1H), 3.31 (m, 1H), 2.49 (m, 1H), 1.96 (m, 1H), 1.39 (t, J = 7.2 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 199.8, 166.2, 141.0, 138.0, 130.2, 129.8, 128.9, 128.4, 127.7, 73.0, 66.8, 61.0, 55.7, 30.1, 14.3. IR (neat, cm^{-1}): 3063, 3032, 2980, 2867, 1717, 1610, 1496, 1417, 1310, 1277, 1181, 1106, 1021. Anal. Calcd. for $C_{20}H_{22}O_4$: C, 73.60; H, 6.79. Found: C, 73.69; H, 6.68 (X=Br). Found: C, 73.44, 6.91 (X=Cl).

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[3] J-Y. Lallemand, Y. Six, L. Ricard, *Eur. J. Org. Chem.* **2002**, 503.

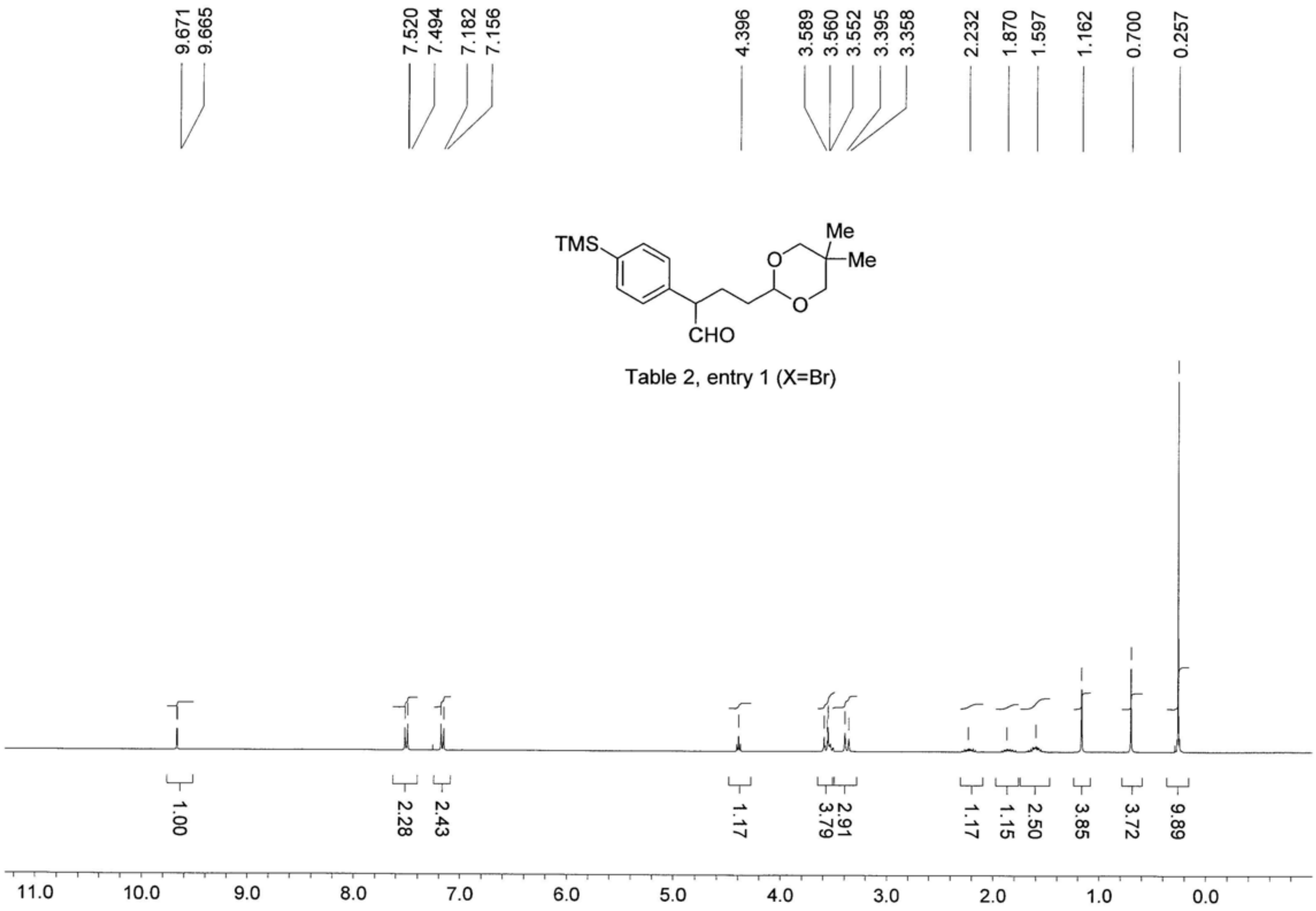


Table 2, entry 1 (X=Br)

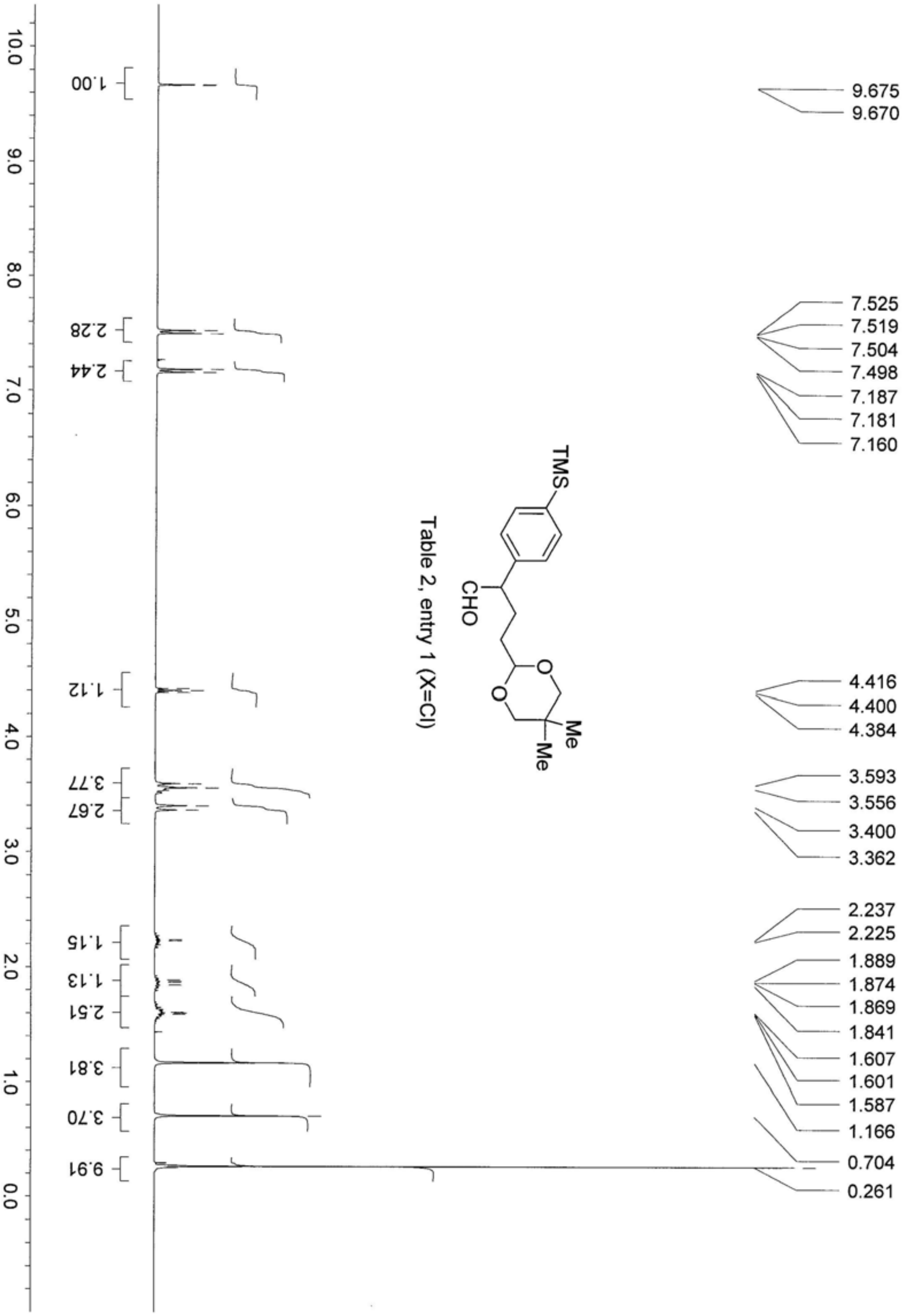


Table 2, entry 1 (X=Cl)

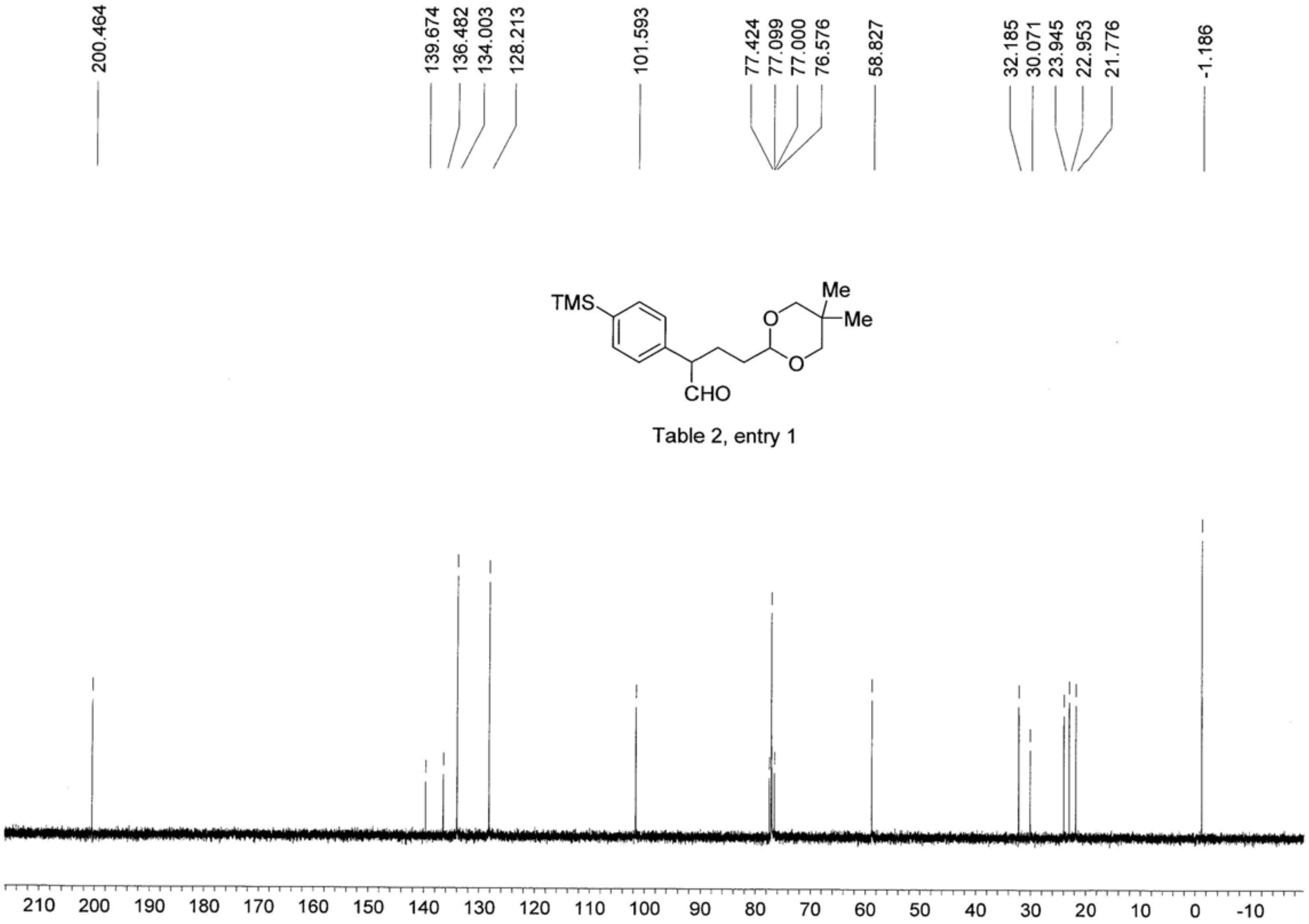
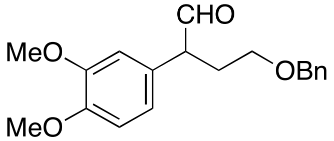
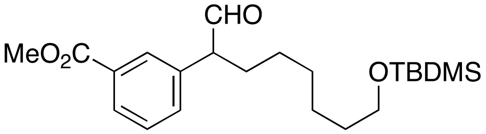


Table 2, entry 1



4-(benzyloxy)-2-(3,4-dimethoxyphenyl)butanal (Table 2, entry 3). Following general procedure A, 4-bromo-1,2-dimethoxybenzene (146 μL, 1.00 mmol) was allowed to react with 4-(benzyloxy)butanal (214 mg, 1.20 mmol) for 7 h. Column chromatography: silica gel, 2:1 hexanes/ethyl acetate. Colorless oil; yield: 242 mg (77% yield). Following general procedure B, using 4-chloro-1,2-methoxybenzene[4] (172 mg, 1.00 mmol), for 10 h (76% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.67 (d, *J* = 1.5 Hz, 1H), 7.35-7.24 (m, 5H), 6.86 (d, *J* = 8.1 Hz, 1H), 6.75 (dd, *J* = 8,1, 1.9 Hz, 1H), 6.66 (d, *J* = 1.8 Hz, 1H), 4.47 (d, *J* = 12.0 Hz, 1H), 4.42 (d, *J* = 12.0 Hz, 1H), 3.87 (s, 3H), 3.84 (s, 3H), 3.74 (td, *J* = 7.3, 1.5 Hz, 1H), 3.51 (m, 1H), 3.37 (m, 1H), 2.41 (m, 1H), 1.93 (m, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 200.3, 149.3, 148.4, 138.1, 128.3, 127.9, 127.6, 121.1, 111.6, 111.4, 72.9, 67.2, 55.8, 55.3, 29.9. IR (neat, cm^{-1}): 2978, 2935, 2718, 1720, 1591, 1516, 1453, 1419, 1261, 1143, 1098, 1027, 809. Anal. Calcd. for $C_{19}H_{22}O_4$: C, 72.59; H, 7.05. Found: C, 72.64; H, 6.99 (X=Br). Found: C, 72.77; H, 7.01 (X=Cl)



Methyl 3-(7-{*tert*-butyl(dimethyl)silyl]oxy}-1-formylheptyl)benzoate (Table 2, entry 4). Following general procedure A, methyl 3-bromobenzoate (214 mg, 1.00 mmol) was allowed to react with 8-(*tert*-butyldimethylsilyloxy)octanal[5] (310 mg, 1.20 mmol) for 6 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. Colorless oil; yield: 333 mg (85% yield). Following general procedure B, using methyl 3-chlorobenzoate (140 μL, 1 mmol), for 10 h (76% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.66 (d, *J* = 2.1 Hz, 1H), 7.95 (dt, *J* = 7.5, 1.8 Hz, 1H), 7.87 (d, *J* = 1.5 Hz, 1H), 7.44 (dd, *J* = 7.8, 7.5 Hz, 1H), 7.36 (dt, *J* = 7.5, 1.5 Hz, 1H), 3.91 (s, 3H), 3.55 (m, 3H), 2.1 (m, 1H), 1.75 (m, 1H), 1.47-1.24 (m, 8 H), 0.86 (s, 9H), 0.1 (s, 6H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 200.4, 166.7, 136.9, 133.2, 130.8, 129.7, 129.0, 128.7, 63.1, 58.9, 52.2, 32.6, 29.6, 29.1, 27.0, 25.9, 25.5, 18.4, -5.4. IR (neat, cm^{-1}): 2931, 2857, 2710, 1727, 1605, 1588, 1462, 1434, 1387, 1360, 1284, 1256, 1197, 1100, 1006, 836. Anal.

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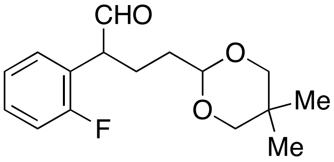
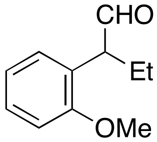
[4] J. S. Yadav, B. V. S. Reddy, P. S. R. Reddy, A. K. Basak, A. V. Narsaiah, *Adv. Synth. Catal.* **2004**, *346*, 77-82.

[5] Nishimura, T.; Onoue, T.; Ohe, K.; Uemura, S. *J. Org. Chem.* **1999**, *64*, 6750.

Calcd. for $C_{22}H_{36}O_4Si$: C, 67.30; H, 9.24. Found: C, 67.11; H, 9.47 (X=Br). Found: C, 67.52; H, 9.14 (X=Cl).



4-(5,5-dimethyl-1,3-dioxan-2-yl)-2-(2-fluorophenyl)butanal (Table 2, entry 5). Following general procedure A, 1-bromo-2-fluorobenzene (108 μL, 1.00 mmol) was allowed to react with 4-(5,5-dimethyl-1,3-dioxan-2-yl)butanal (200 μL, 1.20 mmol) for 12 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. Colorless oil; yield: 174 mg (62% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.71 (t, *J* = 1.2 Hz, 1H), 7.29-7.07 (m, 4H), 4.41 (t, *J* = 4.8 Hz, 1H), 3.84 (ddd, *J* = 9.0, 6.0, 0.9 Hz, 1H), 3.55 (d, *J* = 11.4 Hz, 2H), 3.37 (s, *J* = 11.4 Hz, 2H), 2.24 (m, 1H), 1.89-1.51 (m, 4H), 1.16 (s, 3H), 0.71 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 199.6, 162.7, 159.4, 130.2, 130.1, 129.3, 129.2, 124.6, 124.5, 123.4, 115.9, 115.6, 101.5, 77.1, 51.9, 32.1, 30.1, 23.1, 23.0, 22.9, 21.8. IR (neat, cm^{-1}): 2955, 2848, 2717, 1727, 1491, 1455, 1394, 1301, 1232, 1137, 1112, 1040. Anal. Calcd. for $C_{16}H_{21}FO_3$: C, 68.55; H, 7.55. Found: C, 68.62; H, 7.49.



2-(2-methoxyphenyl)butanal (Table 2, entry 6). Following general procedure A, 2-bromoanisole (124 μL, 1.00 mmol) was allowed to react with butanal (108 μL, 1.20 mmol) for 12 h. Column chromatography: silica gel, 20:1 hexanes/ethyl acetate. Colorless oil; yield: 139 mg (78% yield). Following general procedure B, using 2-chloroanisole (127 μL, 1 mmol), for 16 h. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.67 (s, 1H), 7.29 (dd, *J* = 8.1, 1.8 Hz, 1H), 7.08 (dd, *J* = 7.5, 1.5 Hz, 1H), 6.98 (dd, *J* = 7.5, 0.9 Hz, 1H), 6.92 (d, *J* = 8.0 Hz, 1H), 3.81 (s, 3H), 3.69 (t, *J* = 7.2 Hz, 1H), 2.11 (m, 1H), 1.72 (m, 1H), 0.89 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 201.8, 157.4, 129.9, 128.6, 125.4, 120.8, 110.7, 55.4, 54.7, 21.5, 11.8. IR (neat, cm^{-1}): 2964, 2936, 2875, 2838, 2714, 1722, 1682, 1586, 1599, 1493, 1463, 1438, 1281, 1245, 1048, 1027.

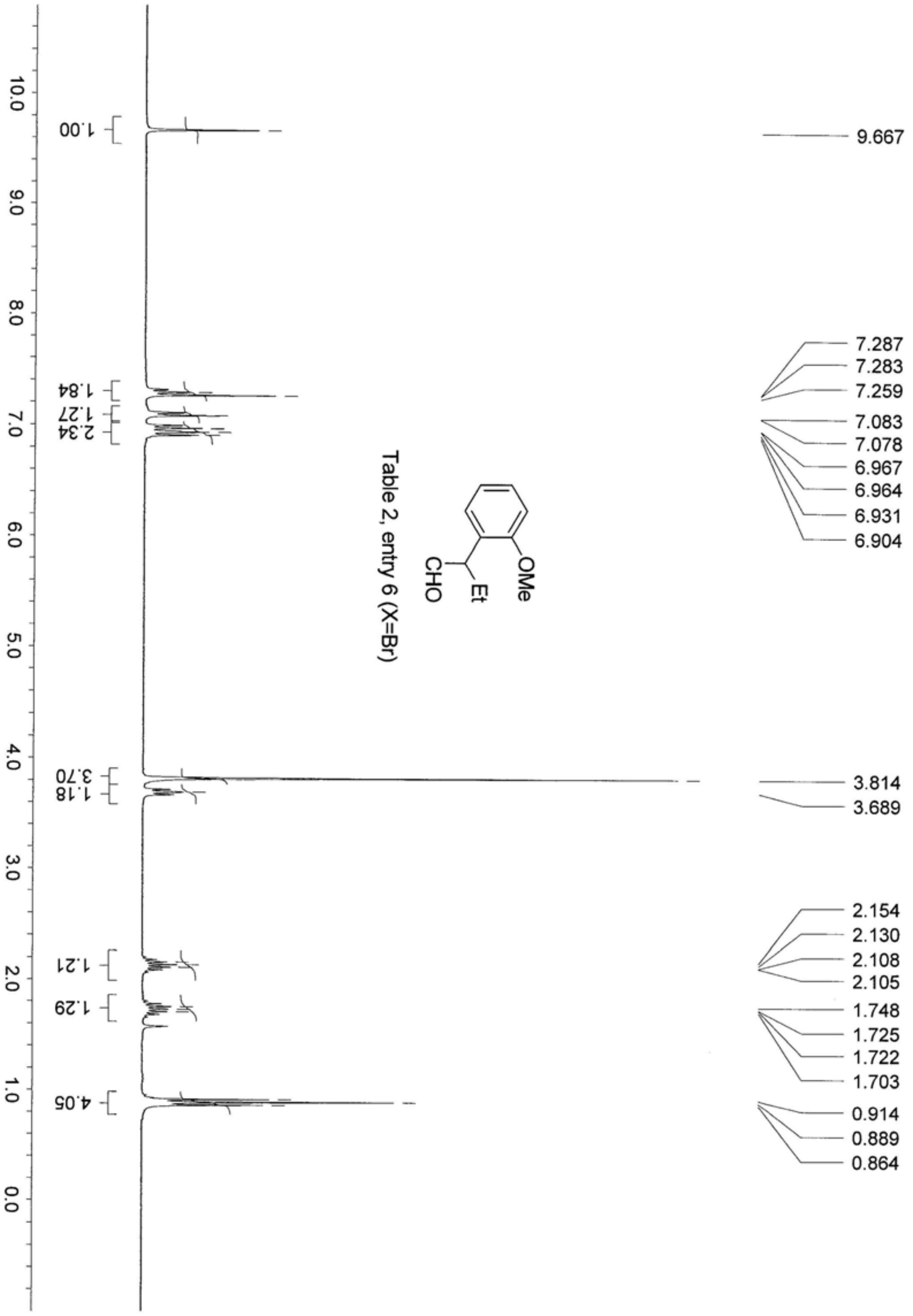


Table 2, entry 6 (X=Br)

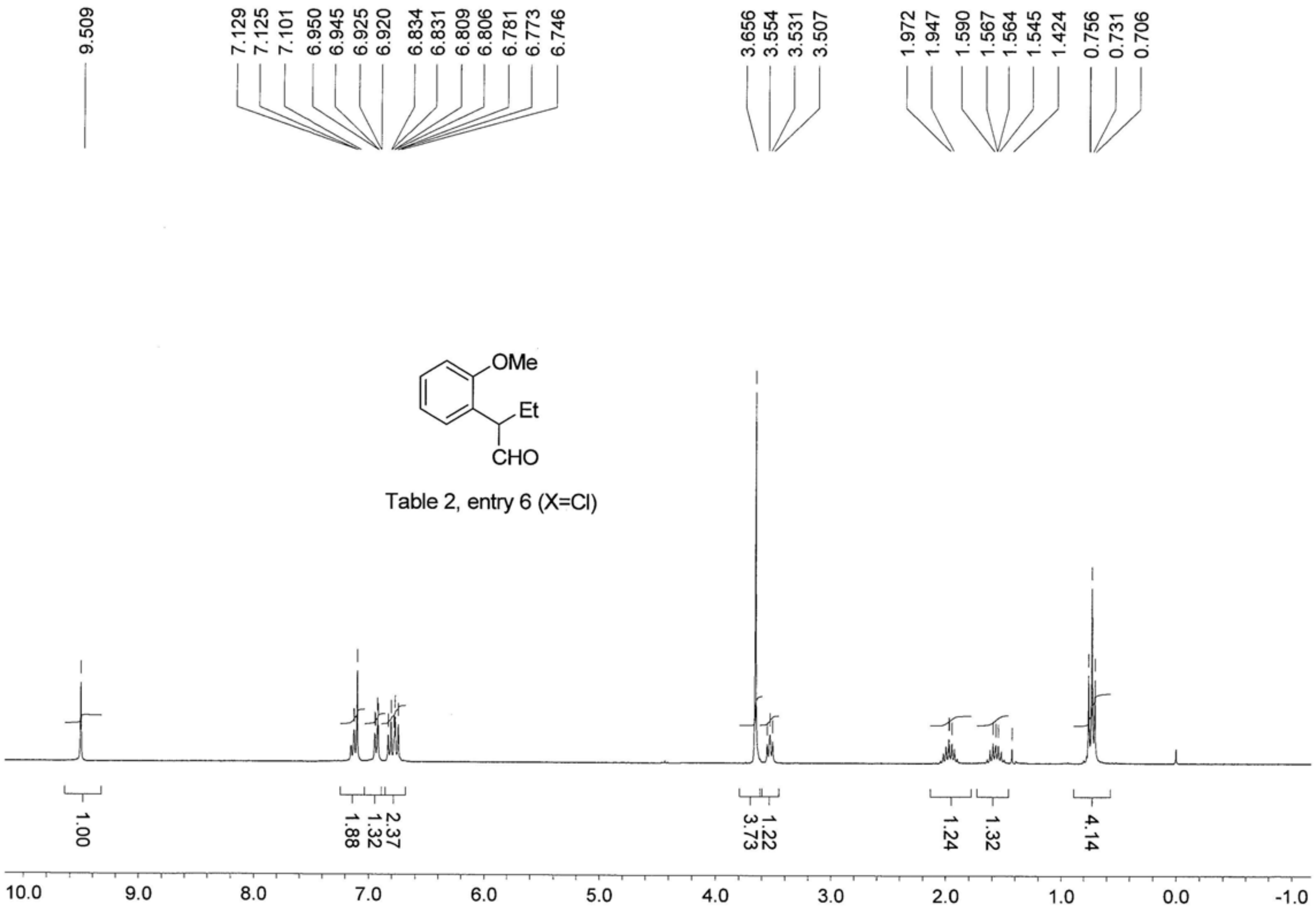


Table 2, entry 6 (X=Cl)

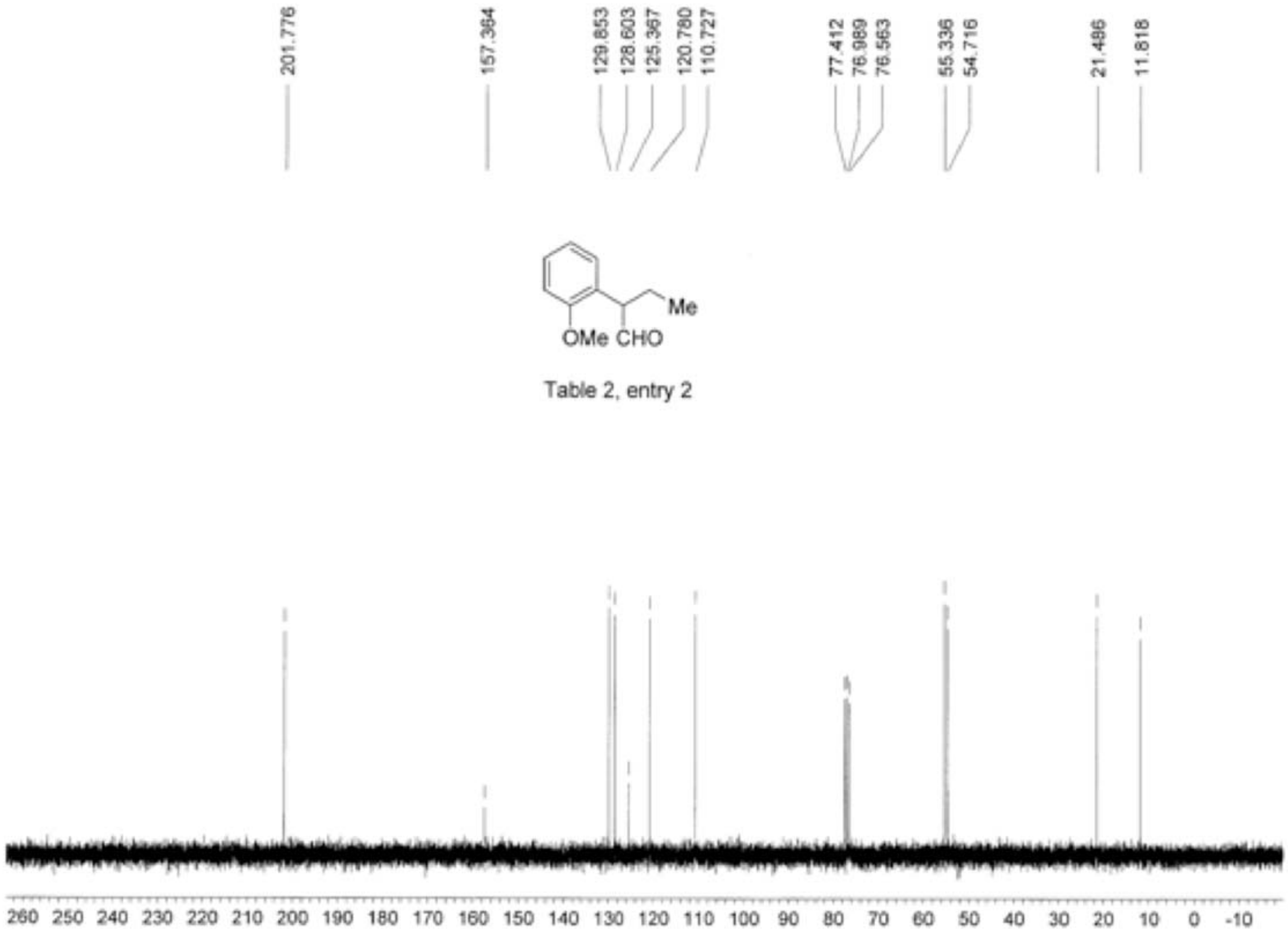
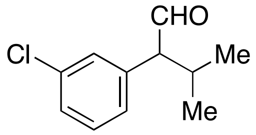
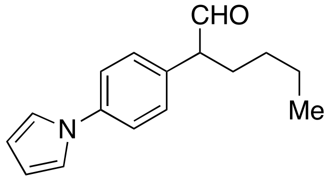


Table 2, entry 2



2-(3-chlorophenyl)-3-methylbutanal (Table 2, entry 7). Following general procedure A: 1-bromo-3-chlorobenzene (118 μL, 1.00 mmol) was allowed to react with 3-methylbutanal (130 μL, 1.20 mmol) for 12 h. Column chromatography: silica gel, 20:1 hexanes/ethyl acetate. Colorless oil; yield: 151 mg (77% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.68 (d, *J* = 3.3 Hz, 1H), 7.31-7.26 (m, 2H), 7.19 (s, 1H), 7.03 (m, 1H), 3.16 (dd, *J* = 9.6, 3.0 Hz, 1H), 2.37 (m, 1H), 1.01 (d, *J* = 6.6 Hz, 3H), 0.76 (d, *J* = 6.6 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 200.3, 137.8, 134.6, 130.0, 129.2, 127.6, 127.4, 66.3, 28.9, 21.0, 20.0. IR (neat, cm^{-1}): 2962, 2929, 2872, 2714, 1726, 1594, 1573, 1475, 1388, 1369, 1167, 1138, 1081, 1046.



2-[4-(1*H*-pyrrol-1-yl)phenyl]hexanal (Table 2, entry 8). Following general procedure A, 1-(4-bromophenyl)-1*H*-pyrrole (220 mg, 1.00 mmol) was allowed to react with hexanal (150 μL, 1.20 mmol) for 7 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. Colorless oil; yield: 205 mg (84% yield). Following general procedure B, using 1-(4-chlorophenyl)-1*H*-pyrrole (177 mg, 1 mmol), for 12 h. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.69 (d, *J* = 2.1 Hz, 1H), 7.43 (d, *J* = 8.5 Hz, 2H), 7.25 (d, *J* = 8.5 Hz, 2H), 7.10 (t, *J* = 2.1 Hz, 2H), 6.37 (t, *J* = 2.1 Hz, 2H), 3.53 (ddd, *J* = 8.4, 6.6, 2.0 Hz, 1H), 2.10 (m, 1H), 1.77 (m, 1H), 1.31 (m, 4H), 0.77 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 200.6, 140.4, 133.6, 129.8, 120.8, 119.1, 110.5, 58.4, 29.3, 29.2, 22.5, 13.8. IR (neat, cm^{-1}): 3031, 2925, 1729, 1611, 1589, 1496, 1455, 1357, 1238, 1177, 1073, 1029, 996. Anal. Calcd. for $C_{16}H_{19}NO$: C, 79.63; H, 7.94. Found: C, 79.75; H, 7.80 (X=Br).

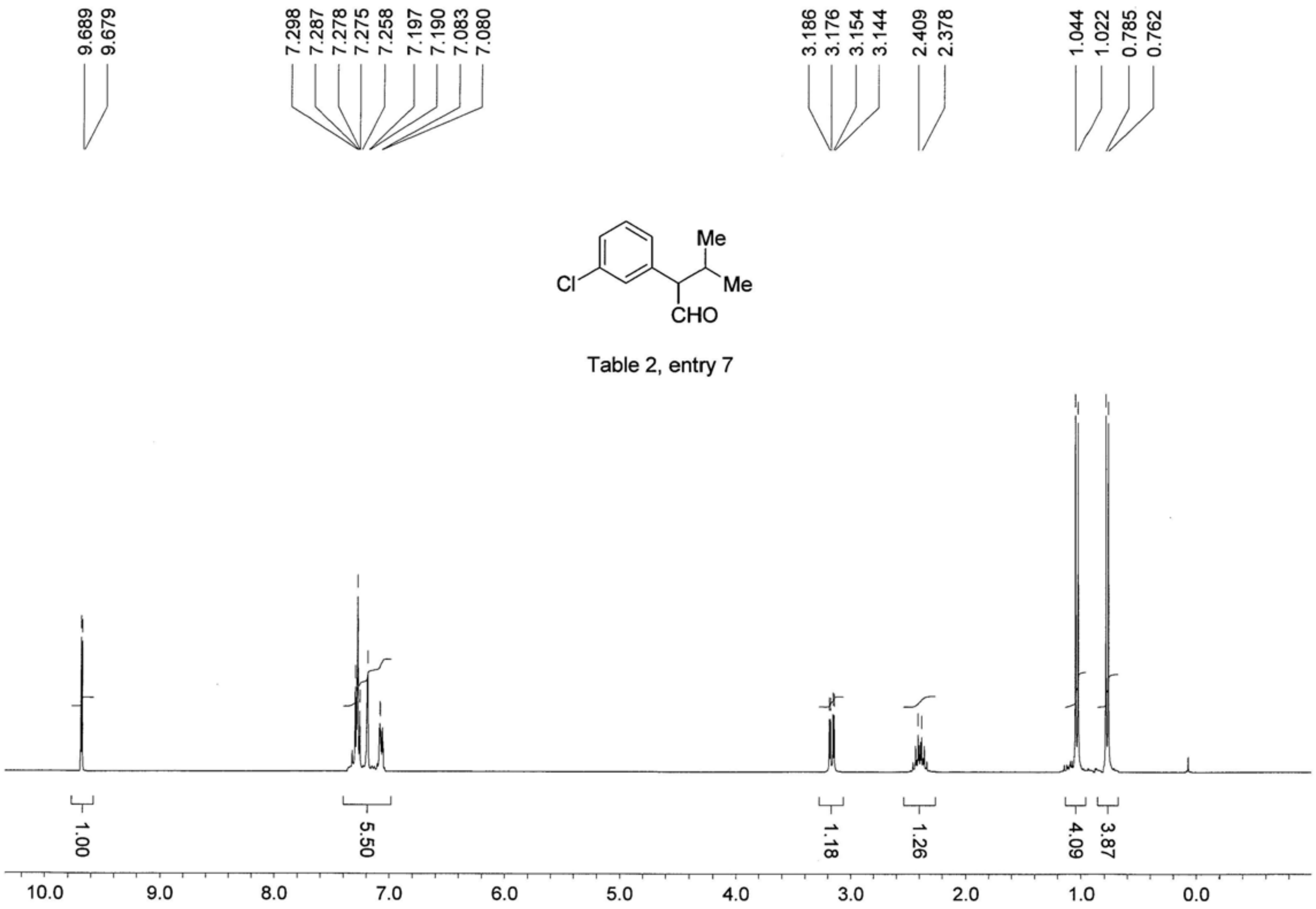


Table 2, entry 7

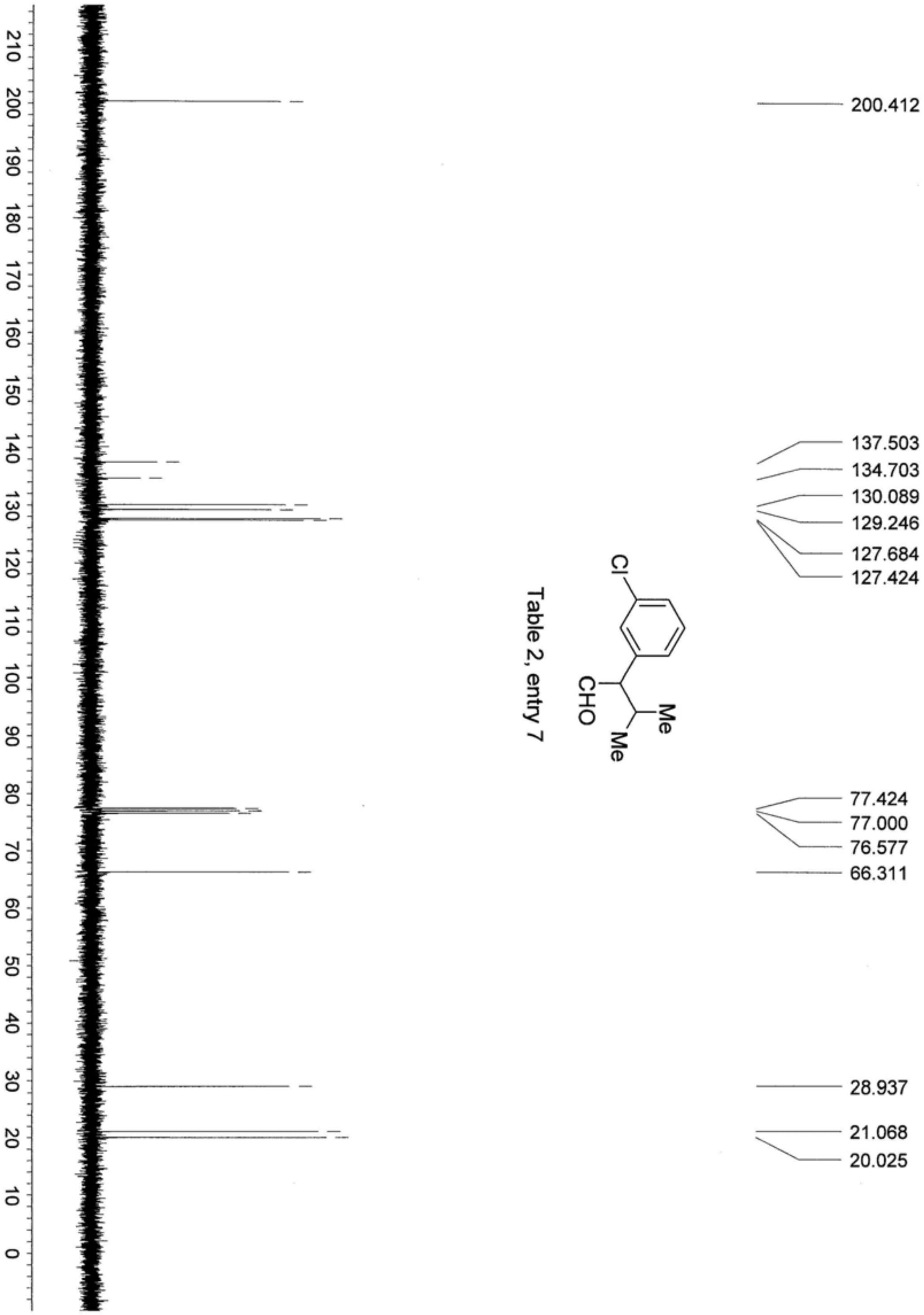


Table 2, entry 7

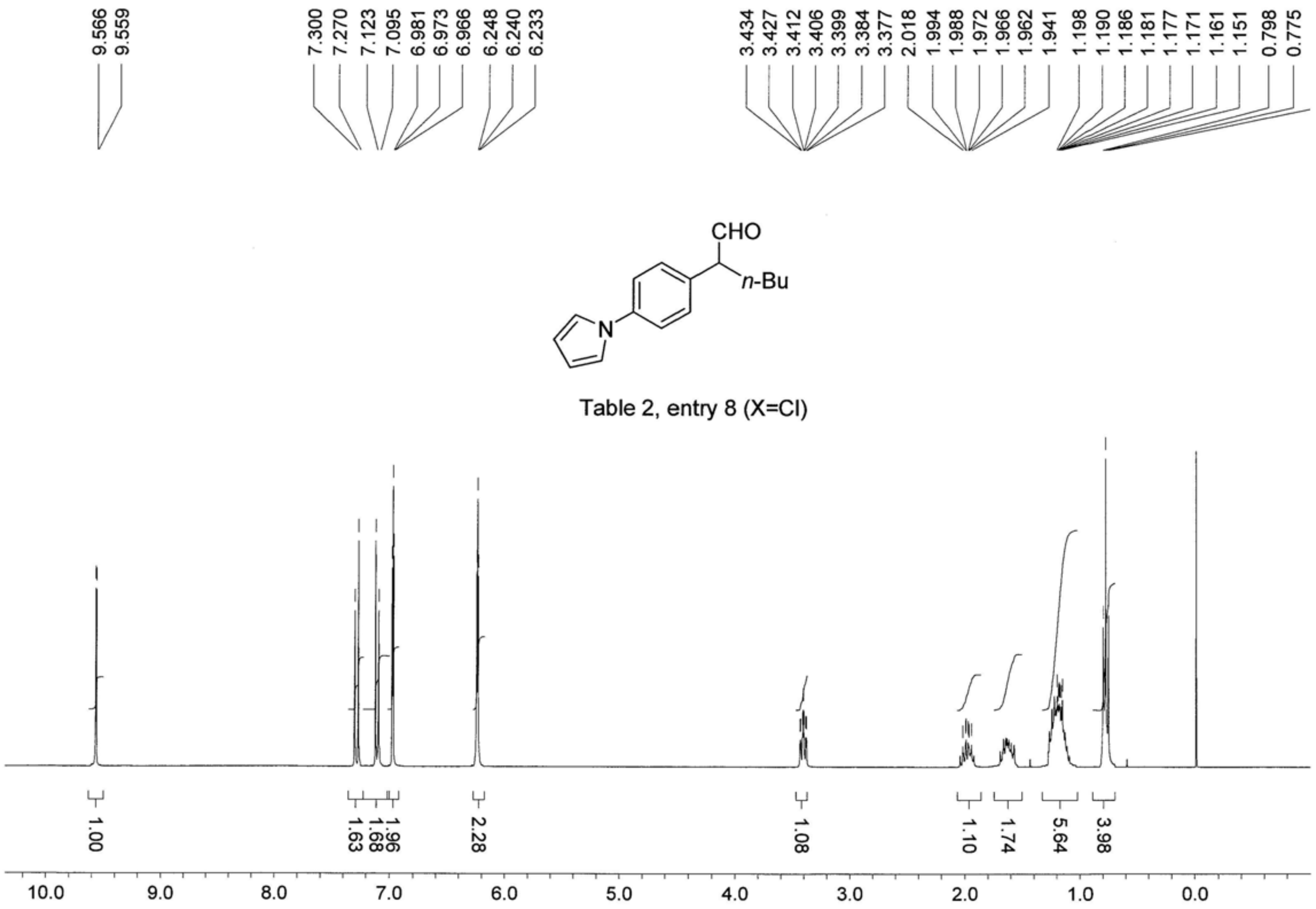


Table 2, entry 8 (X=Cl)

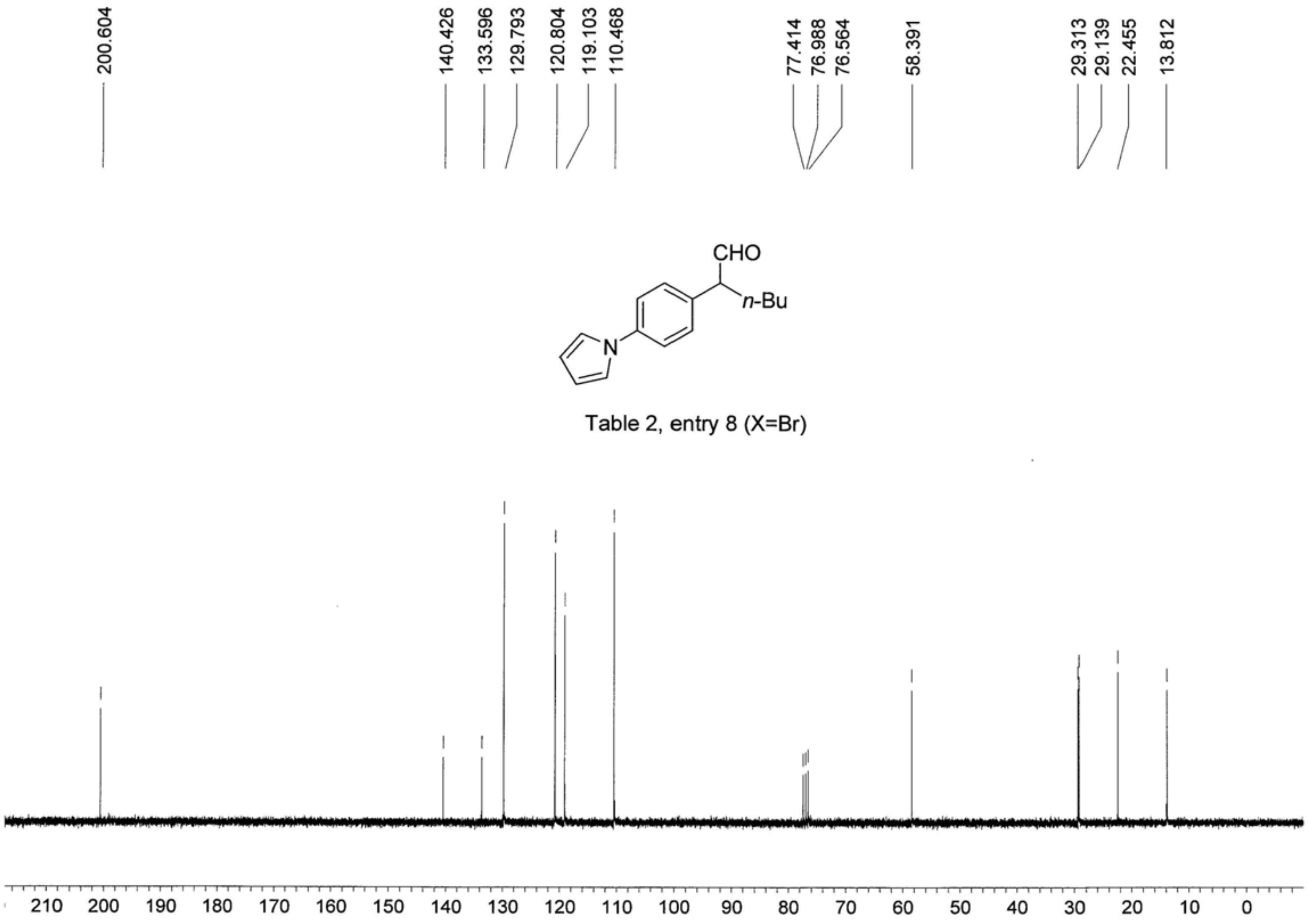
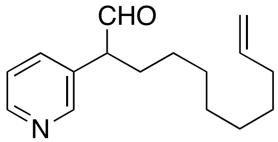
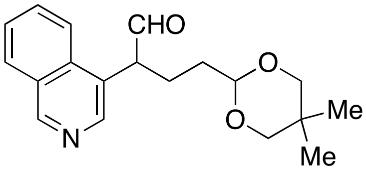


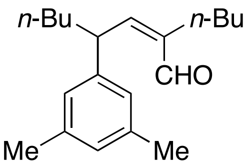
Table 2, entry 8 (X=Br)



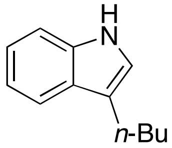
2-(3-pyridinyl)-10-undecenal (Table 2, entry 9). Following general procedure A, 3-bromopyridine (98 μL, 1.0 mmol) was allowed to react with undec-10-enal (250 μL, 1.20 mmol) for 6 h. Column chromatography: silica gel, 1:1 hexanes/ethyl acetate. Colorless oil; yield: 179 mg (73% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.68 (d, *J* = 1.8 Hz, 1H), 8.53 (dd, *J* = 4.8, 1.5 Hz, 1H), 8.45 (d, *J* = 2.1 Hz, 1H), 7.50 (dt, *J* = 7.8, 1.8 Hz, 1H), 7.30 (dd, *J* = 7.8, 4.8 Hz, 1H), 5.76 (m, 1H), 4.93 (m, 2H), 3.52 (td, *J* = 6.6, 1.8 Hz, 1H), 2.17-1.96 (m, 4H), 1.73 (m, 1H), 1.37-1.18 (m, 9H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 199.9, 150.1, 148.8, 139.0, 136.0, 132.2, 123.8, 114.1, 56.4, 33.6, 29.6, 29.2, 29.0, 28.9, 28.8, 26.9. IR (neat, cm^{-1}): 3075, 2927, 2855, 1726, 1692, 1640, 1586, 1465, 1424, 1191, 1026, 995, 910. Anal. Calcd. for $C_{16}H_{23}NO$: C, 78.32; H, 9.45. Found: C, 78.39; H, 9.28.



4-(5,5-dimethyl-1,3-dioxan-2-yl)-2-(4-isoquinolinyl)butanal (Table 2, entry 10). Following general procedure A, 4-bromoisoquinoline (208 mg, 1.00 mmol) was allowed to react with 4-(5,5-dimethyl-1,3-dioxan-2-yl)butanal (200 μL, 1.20 mmol) for 10 h. Column chromatography: silica gel, 1:2 hexanes/ethyl acetate. Colorless oil; yield: 228 mg (73% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.72 (d, *J* = 1.2 Hz, 1H), 9.17 (s, 1H), 8.35 (s, 1H), 7.98 (d, *J* = 8.7 Hz, 1H), 7.93 (d, *J* = 8.7 Hz, 1H), 7.72 (dt, *J* = 6.9, 1.5 Hz, 1H), 7.61 (m, 1H), 4.41 (t, *J* = 4.8 Hz, 1H), 4.19 (t, *J* = 7.5 Hz, 1H), 3.51 (m, 2H), 3.35 (d, *J* = 11.1 Hz, 2H), 2.47 (m, 1H), 2.01 (m, 1H), 1.63 (m, 2H), 1.16 (s, 3H), 0.67 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 199.8, 152.6, 143.0, 134.6, 131.0, 128.6, 127.2, 126.0, 122.3, 101.4, 76.9, 53.0, 32.2, 30.0, 23.5, 22.9, 21.7. IR (neat, cm^{-1}): 2954, 2849, 2718, 1723, 1622, 1582, 1503, 1471, 1393, 1312, 1237, 1136, 1021, 977, 908. Anal. Calcd. for $C_{16}H_{23}NO_3$: C, 72.82; H, 7.40. Found: C, 72.80; H, 7.47.



(2Z)-2-butyl-4-(3,5-dimethylphenyl)-2-octenal (Table 2, entry 11). Following general procedure A, 1-bromo-3,5-dimethylbenzene (136 μL, 1.00 mmol) was allowed to react with hexanal (250 μL, 2.00 mmol) in DMF (4 mL) and Cs_2CO_3 (920 mg, 2.40 mmol) for 4 h. Column chromatography: silica gel, 20:1 hexanes/ethyl acetate. Colorless oil; yield: 229 mg (80% yield). Following general procedure B, 1-chloro-3,5-dimethylbenzene (140 mg, 1 mmol) was allowed to react with hexanal (300 μL, 2.40 mmol) in DMF (4 mL) and Cs_2CO_3 (920 mg, 2.40 mmol) for 12 h (82% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.38 (s, 1H), 6.89-6.81 (m, 3H), 6.51 (d, *J* = 10.2 Hz, 1H), 3.67 (m, 1H), 2.31 (s, 6H), 2.27 (m, 2H), 1.74 (m, 2H), 1.35-1.20 (m, 8H), 0.92 (t, *J* = 7.1 Hz, 3H), 0.88 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 195.4, 157.9, 142.7, 142.4, 138.3, 128.4, 125.1, 44.9, 36.0, 30.9, 29.7, 24.1, 22.9, 22.6, 21.3, 13.9, 13.8. IR (neat, cm^{-1}): 2956, 2929, 2860, 2711, 1686, 1636, 1601, 1465, 1377, 1182, 1092, 847.



3-butyl-1*H*-indole (Table 2, entry 11).[6] Following general procedure A, 2-bromoaniline (172 mg, 1.00 mmol) was allowed to react with hexanal (300 μL, 2.40 mmol) in DMF (4 mL) and Cs_2CO_3 (920 mg, 2.40 mmol) for 12 h. Column chromatography: silica gel, 5:2 hexanes/diethyl ether. Yellow oil; yield: 138 mg (80% yield). Following general procedure B, using 2-chloroaniline (108 μL, 1 mmol) was allowed to react with hexanal (300 μL, 2.40 mmol) in DMF (4 mL) and Cs_2CO_3 (920 mg, 2.40 mmol) for 14 h. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.82 (brs, 1H), 7.77 (d, *J* = 7.5 Hz, 1H), 7.36 (d, *J* = 7.8 Hz, 1H), 7.31-7.19 (m, 2H), 6.97 (s, 1H), 2.85 (t, *J* = 7.5 Hz, 2H), 1.79 (m, 2H), 1.53 (m, 2H), 1.03 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 136.2, 127.5, 121.7, 121.0, 118.9, 116.9, 111.0, 32.3, 24.8, 22.6, 14.0. IR (neat, cm^{-1}): 3418, 3057, 2956, 2928, 2856, 1618, 1487, 1456, 1339, 1224, 1090, 1009, 740.

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[6] Baudin, J-B.; Commenil, M-G.; Julia, S. A.; Lorne, R.; Mauclaire, L. *Bull. Soc. Chim. Fr.* **1996**, *133*, 329.

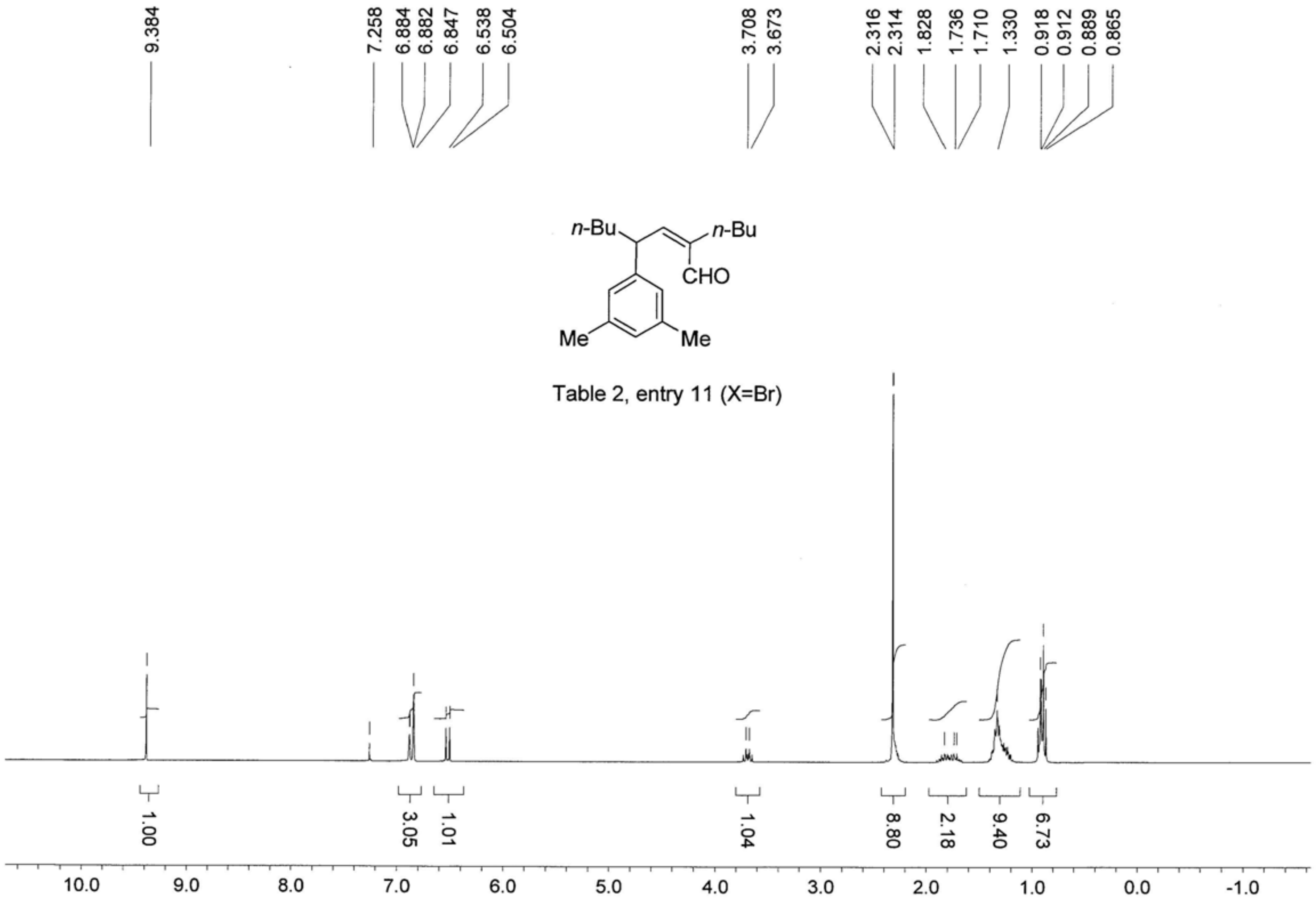


Table 2, entry 11 (X=Br)

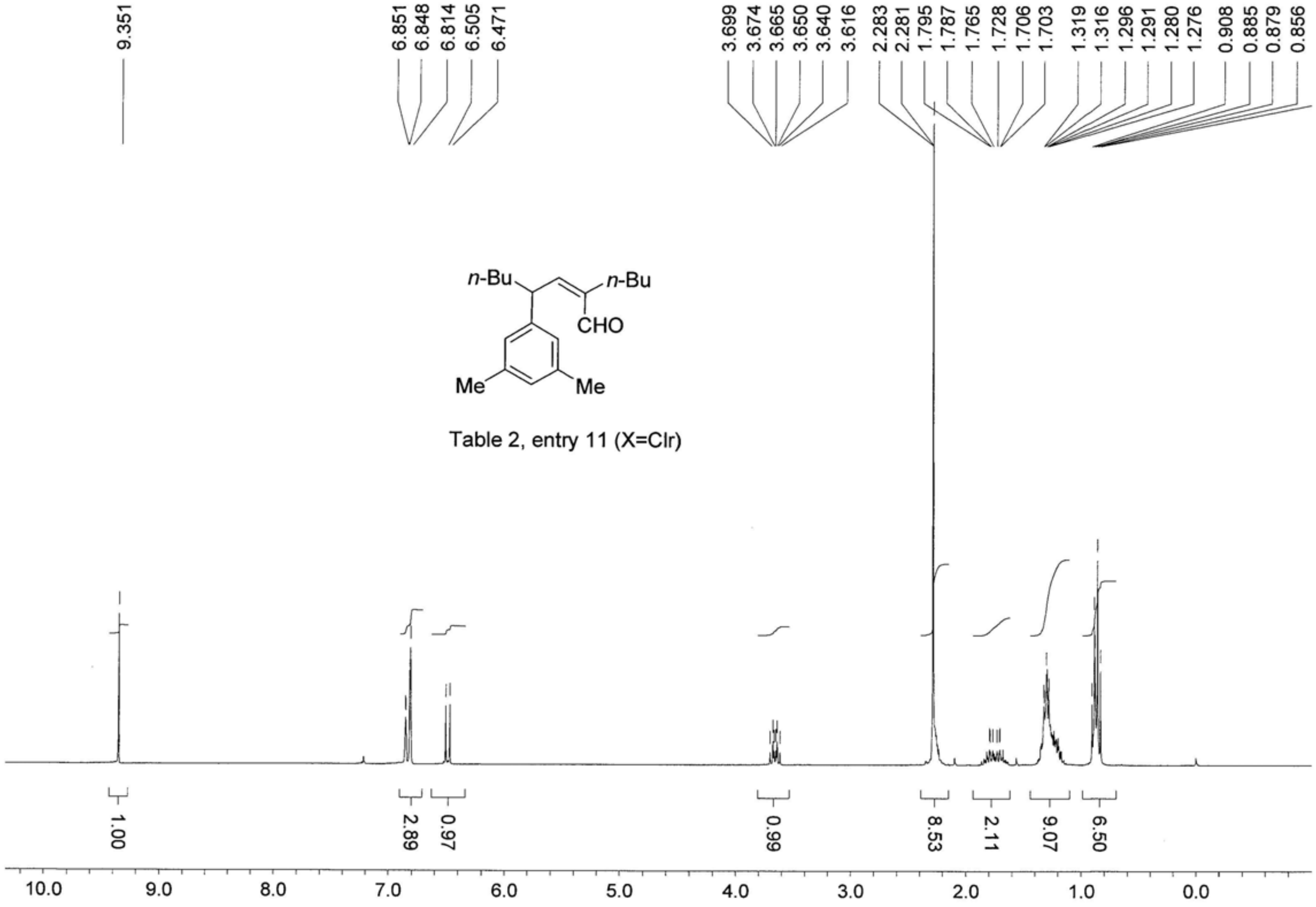


Table 2, entry 11 (X=Clr)

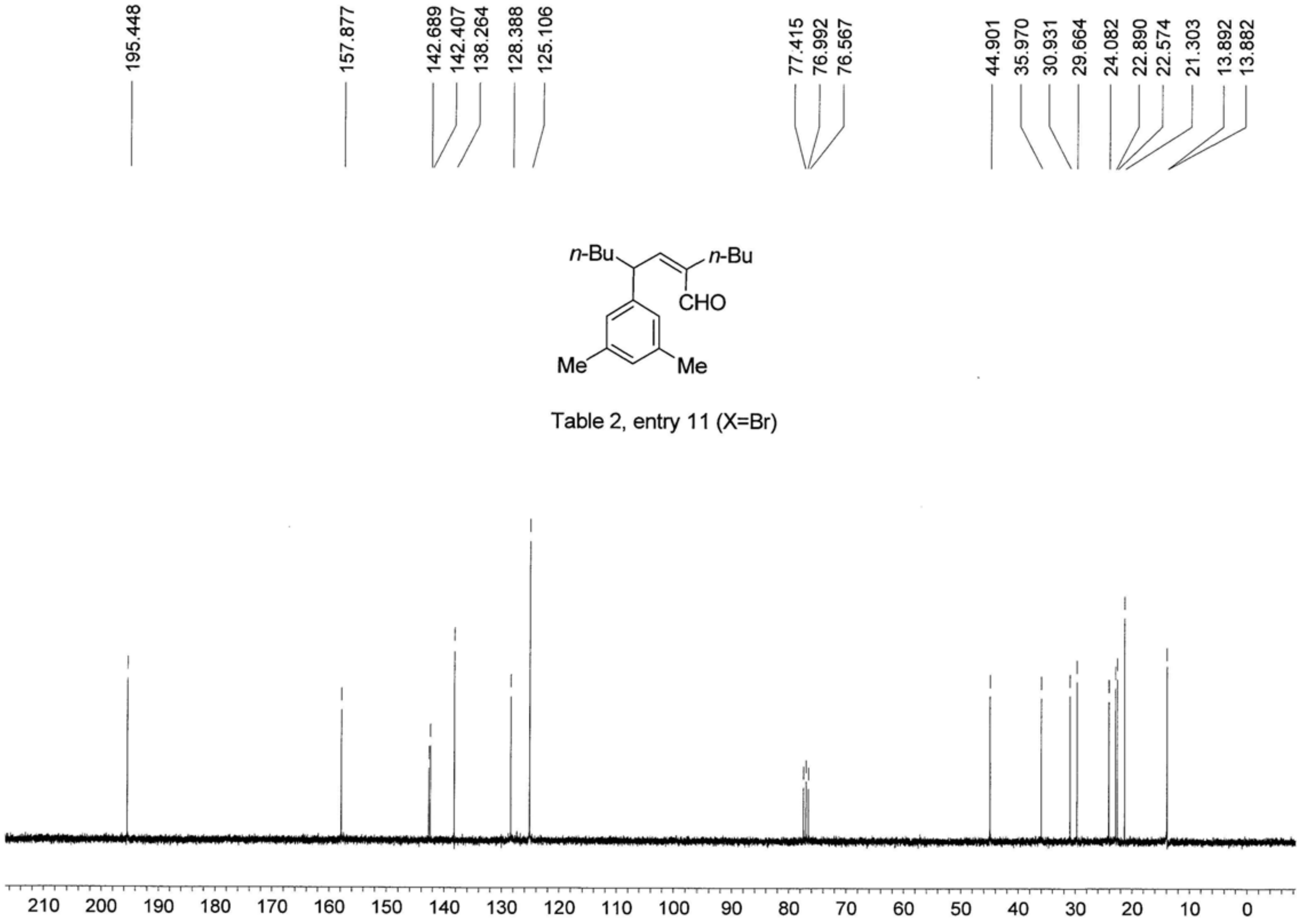


Table 2, entry 11 (X=Br)

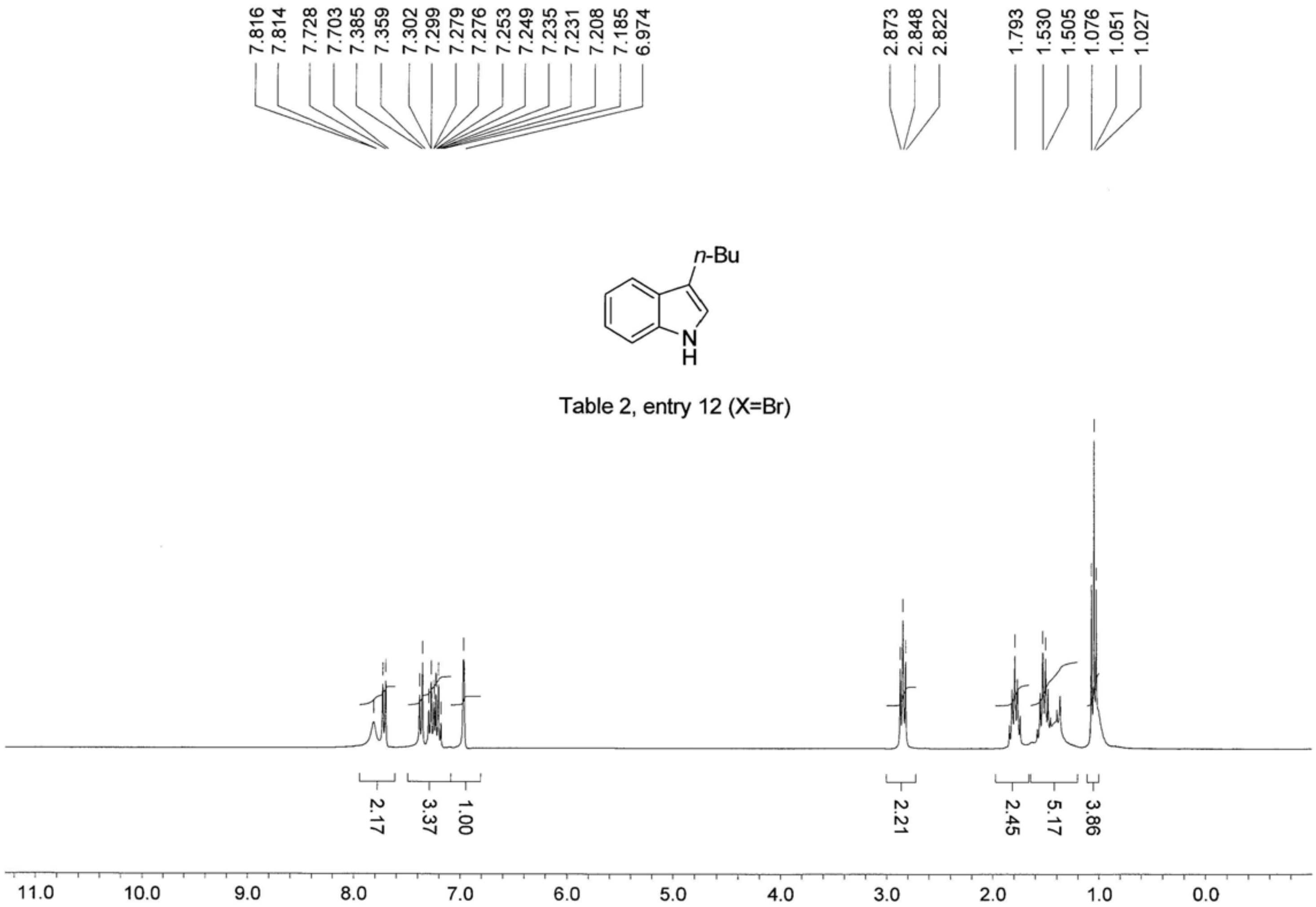


Table 2, entry 12 (X=Br)

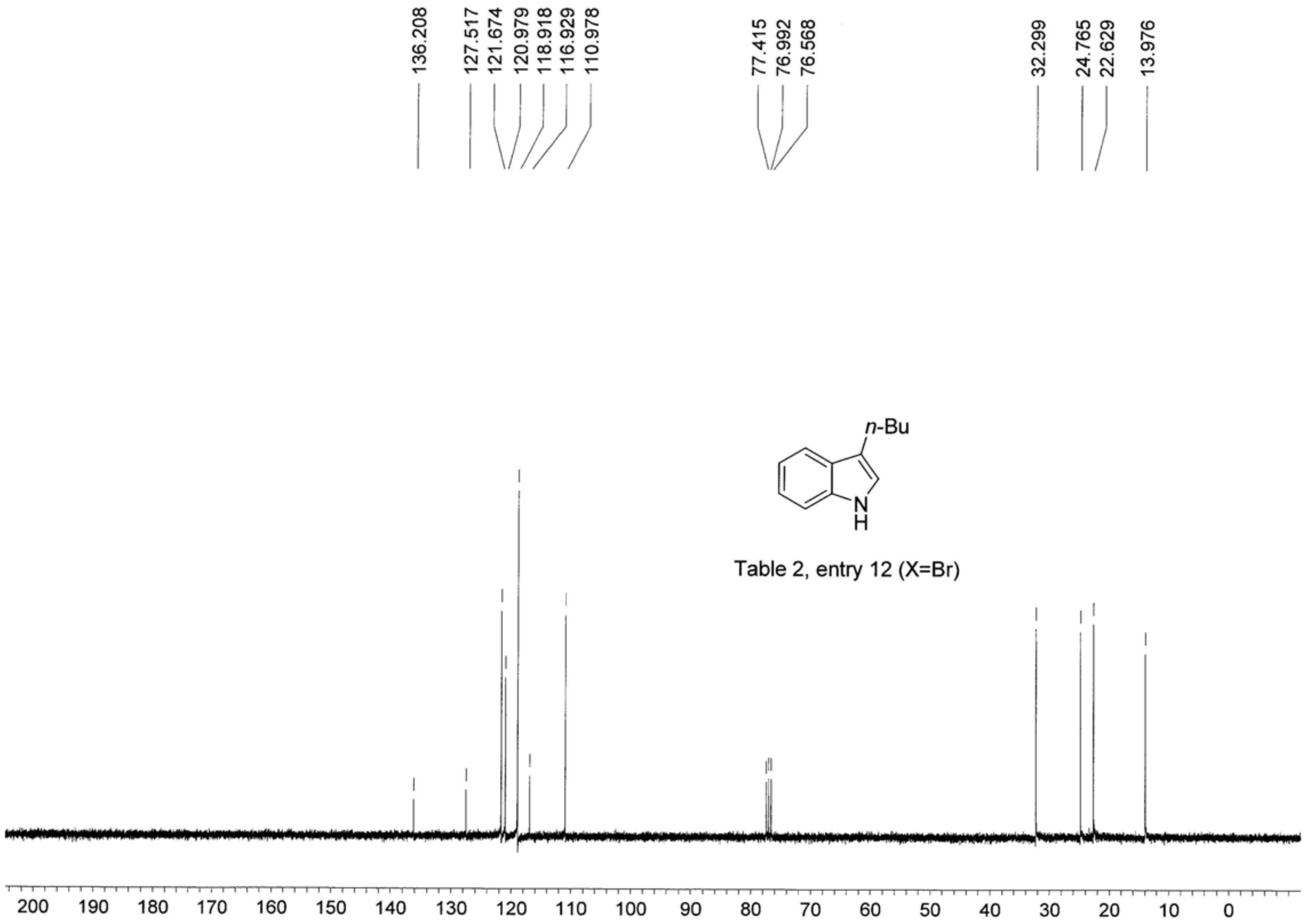
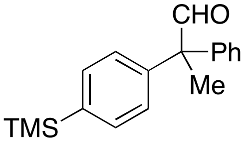
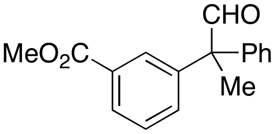


Table 2, entry 12 (X=Br)



2-phenyl-2-[4-(trimethylsilyl)phenyl]propanal (Table 3, entry 1). Following general procedure C, (4-bromophenyl)trimethylsilane (196 μL, 1.00 mmol) was allowed to react with 2-phenylpropanal (160 μL, 1.20 mmol) for 6 h. Column chromatography: silica gel, 10:1 hexanes/ethyl acetate. Colorless oil; yield: 214 mg (76% yield). Following general procedure B, using (4-chlorophenyl)trimethylsilane (184 μL, 1 mmol), for 10 h (77% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.92 (s, 1H), 7.52 (d, J = 7.8 Hz, 2H), 7.39-7.17 (m, 7H), 1.79 (s, 3H), 0.29 (s, 9H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 199.6, 142.4, 141.6, 139.3, 133.7, 128.7, 128.2, 127.5, 127.2, 59.9, 22.5, -1.2. IR (neat, cm^{-1}): 2978, 2955, 2887, 2715, 1727, 1596, 1492, 1446, 1390, 1248, 1119, 1058, 1027, 840. Anal. Calcd. for $C_{18}H_{22}OSi$: C, 76.54; H, 7.85. Found: C, 76.68; H, 7.64 (X=Br).



Methyl 3-(1-methyl-2-oxo-1-phenylethyl)benzoate (Table 3, entry 2). Following general procedure C, methyl 3-bromobenzoate (214 mg, 1.00 mmol) was allowed to react with 2-phenylpropanal (160 μL, 1.20 mmol) for 6 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. Colorless oil; yield: 201 mg (75% yield). Following general procedure B, using methyl 3-chlorobenzoate (140 μL, 1 mmol), for 10 h (72% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.91 (s, 1H), 7.99 (dt, J = 7.8, 1.2 Hz, 1H), 7.90 (t, J = 1.3 Hz, 1H), 7.47-7.24 (m, 5H), 7.14 (m, 2H), 3.89 (s, 3H), 1.81 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 199.1, 166.7, 142.3, 141.1, 132.3, 130.6, 129.1, 128.9, 128.8, 128.5, 128.1, 127.5, 59.7, 52.2, 22.6. IR (neat, cm^{-1}): 2989, 2951, 2714, 1725, 1585, 1493, 1439, 1280, 1224, 1200, 1115, 1092, 1027, 980.

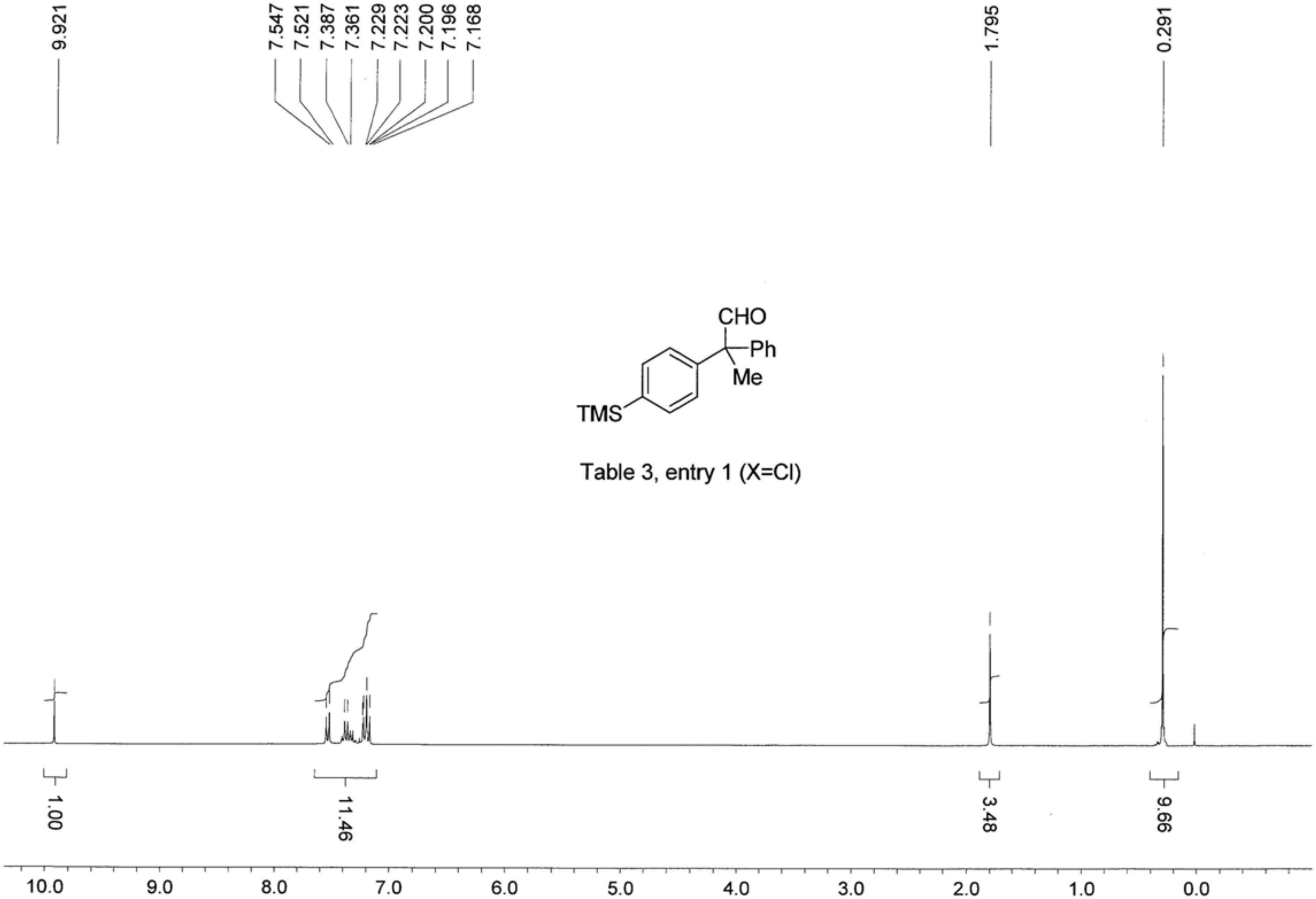


Table 3, entry 1 (X=Cl)

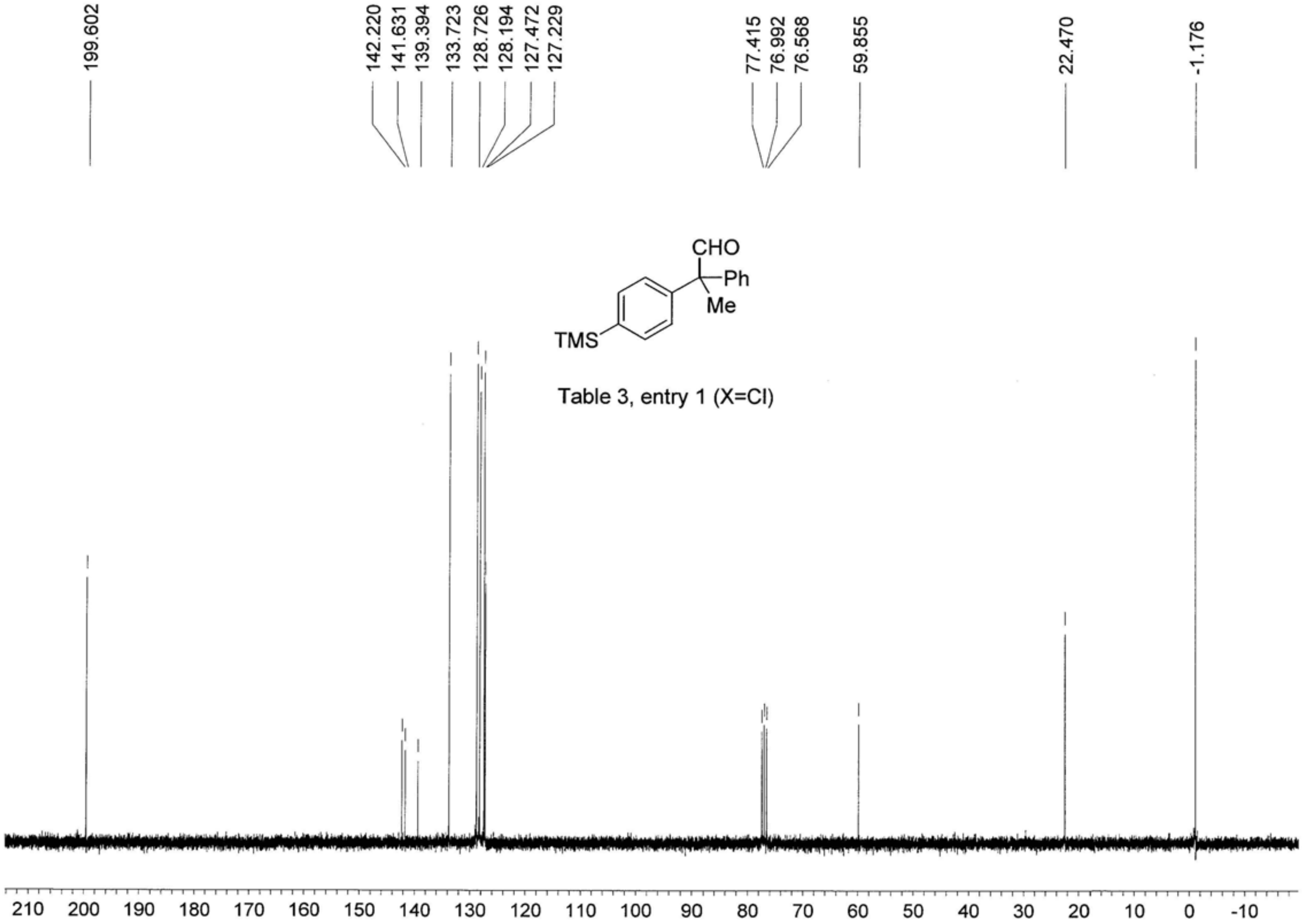


Table 3, entry 1 (X=Cl)

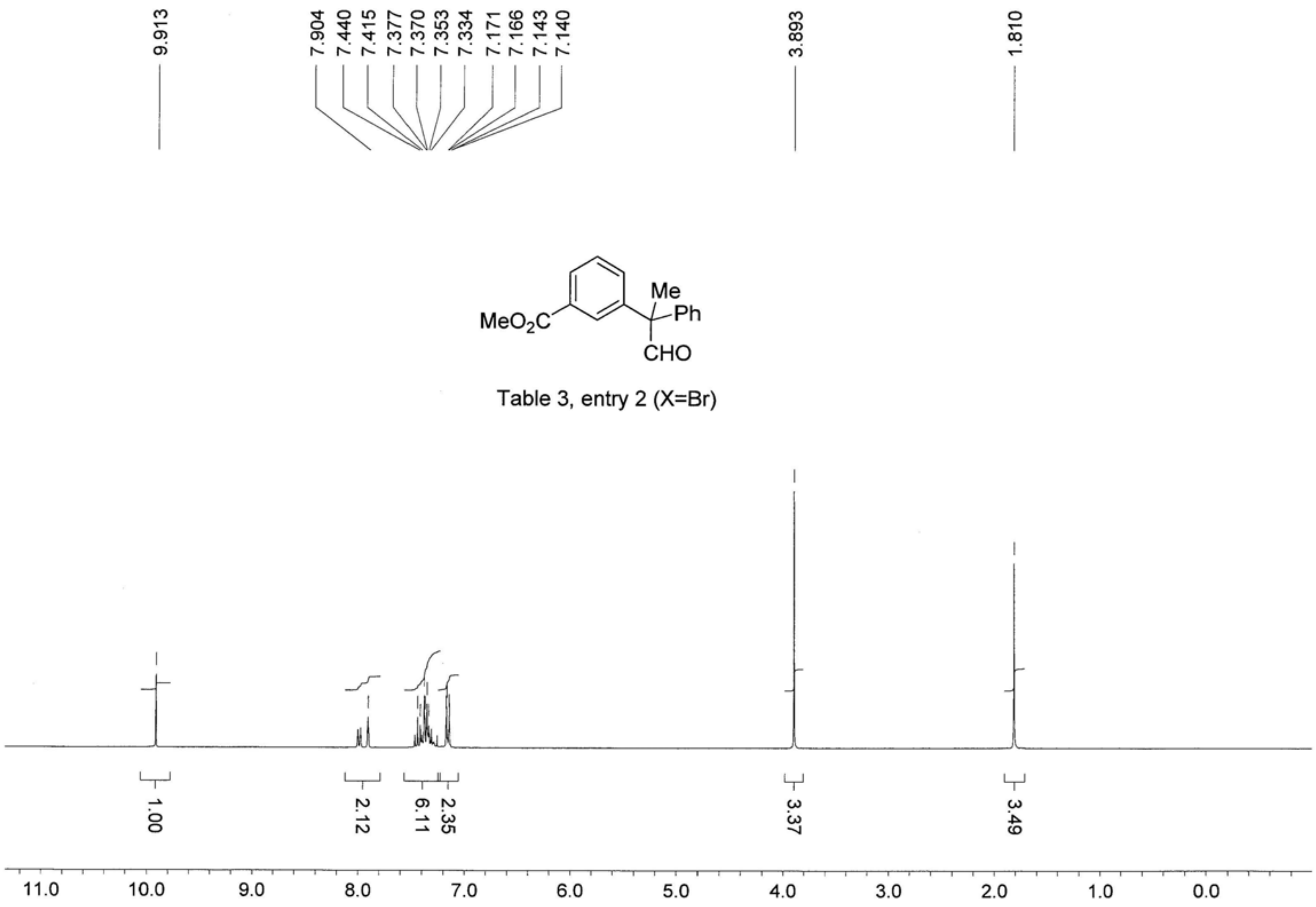


Table 3, entry 2 (X=Br)

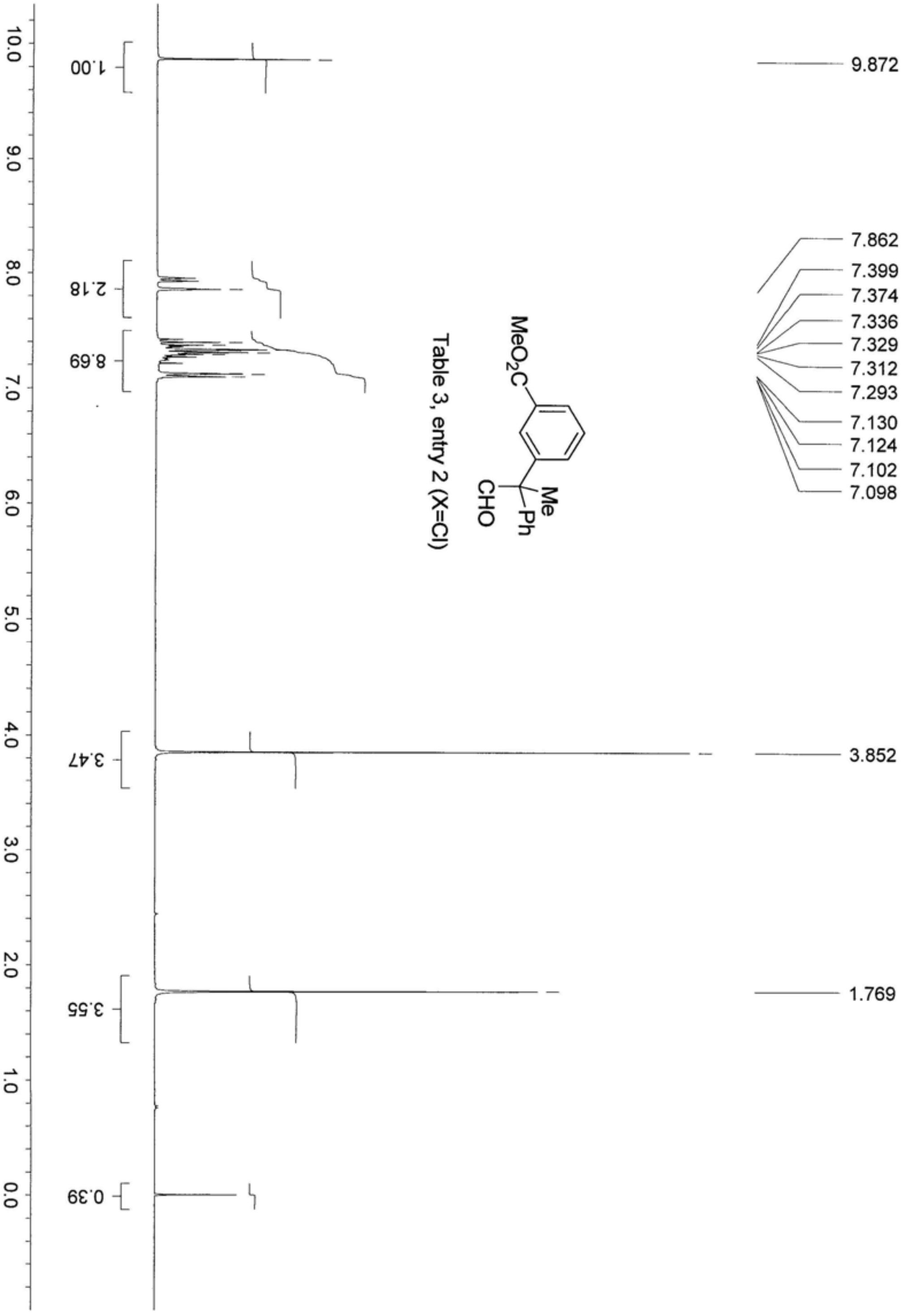


Table 3, entry 2 (X=Cl)
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Ph
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7.862
7.399
7.374
7.336
7.329
7.312
7.293
7.130
7.124
7.102
7.098
3.852
1.769
1.00
2.18
8.69
3.47
3.55
0.39
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

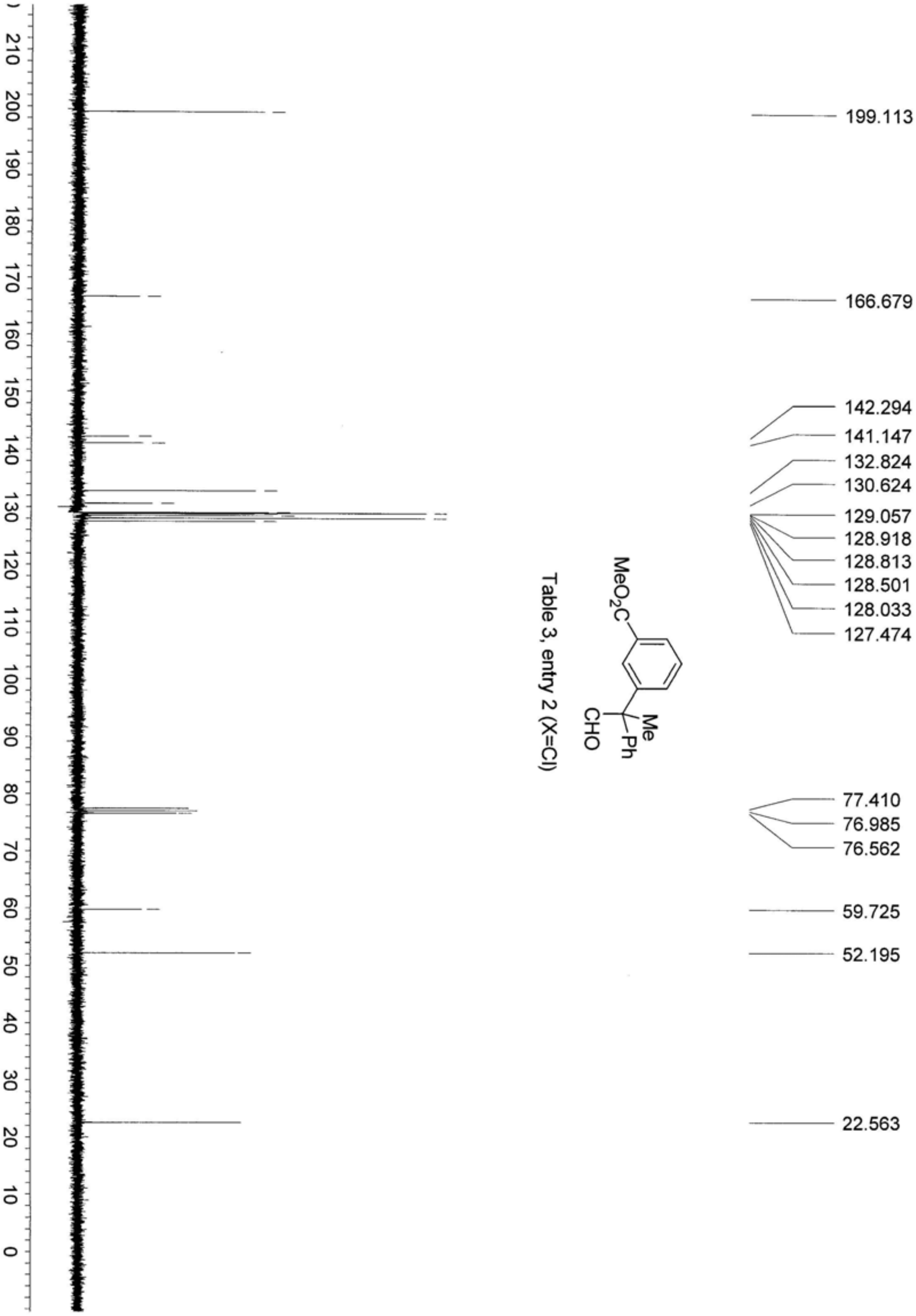
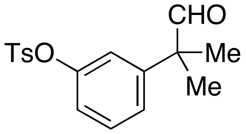
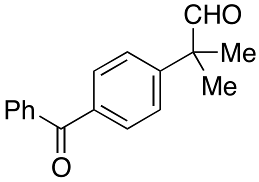


Table 3, entry 2 (X=Cl)



3-(1,1-dimethyl-2-oxoethyl)phenyl 4-methylbenzenesulfonate (Table 3, entry 3). Following general procedure C, 3-bromophenyl 4-methylbenzenesulfonate (326 mg, 1.00 mmol) was allowed to react with 2-methylpropanal (110 μL, 1.20 mmol) for 6 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. Colorless oil; yield: 267 mg (84% yield). Following general procedure B, 3-chlorophenyl 4-methylbenzenesulfonate (282 mg, 1 mmol) was allowed to react with 2-methylpropanal (183 μL, 2.00 mmol), for 12 h (53% yield). ^{1}H NMR (300 MHz, CDCl$_3$) δ: 9.34 (s, 1H), 7.69 (d, *J* = 8.4 Hz, 2H), 7.33 (m, 3H), 7.13 (ddd, *J* = 8.1, 1.8, 0.9 Hz, 1H), 6.98 (ddd, *J* = 8.1, 2.4, 0.9 Hz, 1H), 6.73 (t, *J* = 2.1 Hz, 1H), 2.45 (s, 3H), 1.33 (s, 6H). ^{13}C NMR (75 MHz, CDCl$_3$) δ: 201.1, 149.9, 145.5, 143.2, 129.9, 129.7, 128.6, 125.4, 121.4, 120.9, 50.2, 22.3, 21.7. IR (neat, cm^{-1}): 3011, 2983, 2889, 2715, 1721, 1598, 1582, 1486, 1430, 1371, 1263, 1194, 1157, 1092, 951, 908, 833, 815.



2-(4-benzoylphenyl)-2-methylpropanal (Table 3, entry 4). Following general procedure C, (4-bromophenyl)(phenyl)methanone (260 mg, 1.00 mmol) was allowed to react with 2-methylpropanal (110 μL, 1.20 mmol) for 5 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. Colorless oil; yield: 214 mg (85% yield). Following general procedure B, (4-chlorophenyl)(phenyl)methanone (216 mg, 1.00 mmol) was allowed to react with 2-methylpropanal (183 μL, 2.00 mmol), for 14 h ^{1}H NMR (300 MHz, CDCl$_3$) δ: 9.54 (s, 1H), 7.80 (m, 4H), 7.59 (m, 1H), 7.47 (m, 2H), 7.39 (d, *J* = 8.7 Hz, 2H), 1.51 (s, 6H). ^{13}C NMR (75 MHz, CDCl$_3$) δ: 201.5, 196.1, 145.8, 137.3, 132.5, 130.5, 130.0, 129.9, 128.3, 126.6, 50.7, 22.5. IR (neat, cm^{-1}): 2981, 2866, 2714, 1656, 1606, 1578, 1447, 1405, 1361, 1318, 1279, 1154, 1097, 1018, 940. Anal. Calcd. for $C_{17}H_{16}O_2$: C, 80.93; H, 6.39. Found: C, 80.77; H, 6.56 (X=Br).

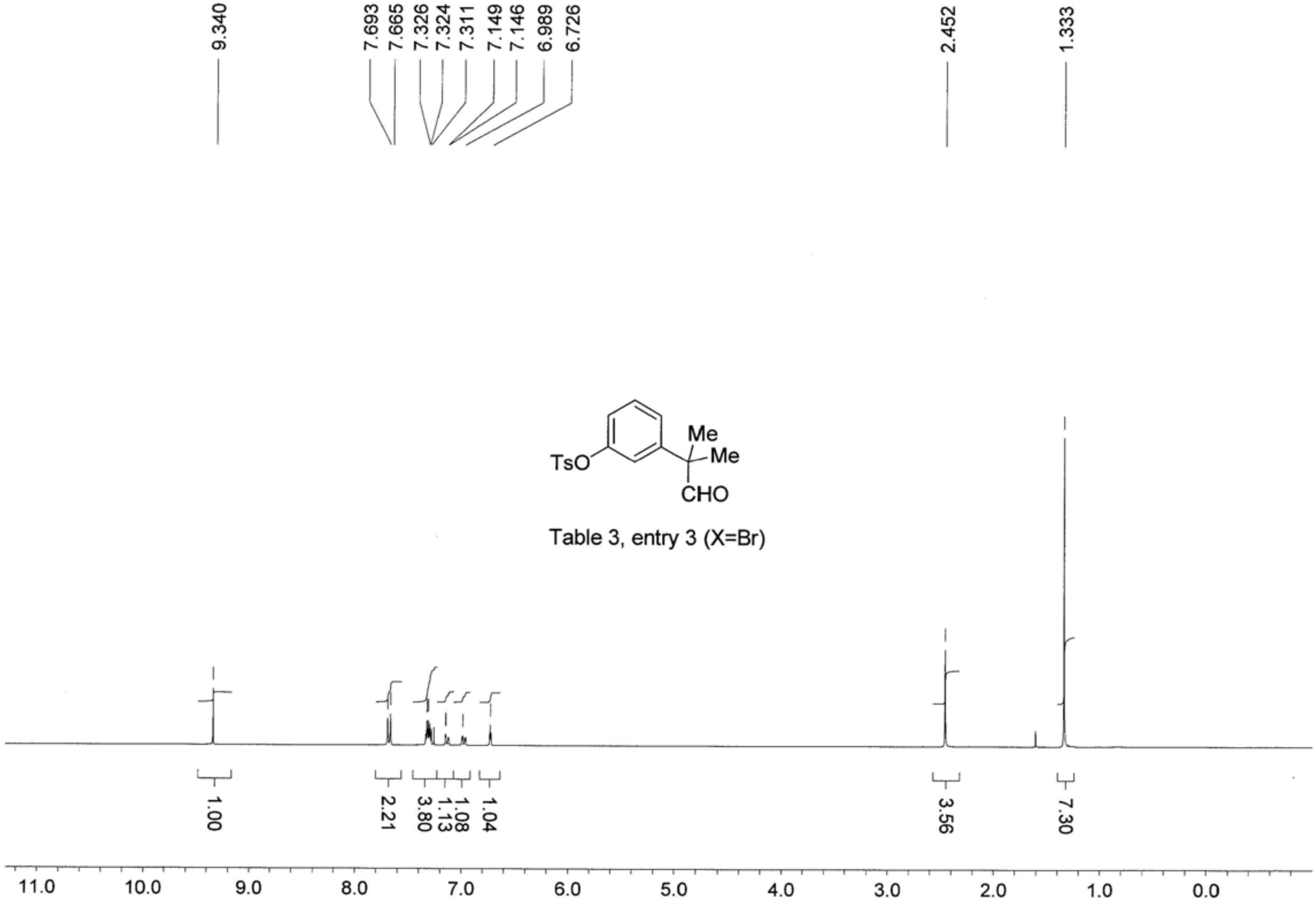


Table 3, entry 3 (X=Br)

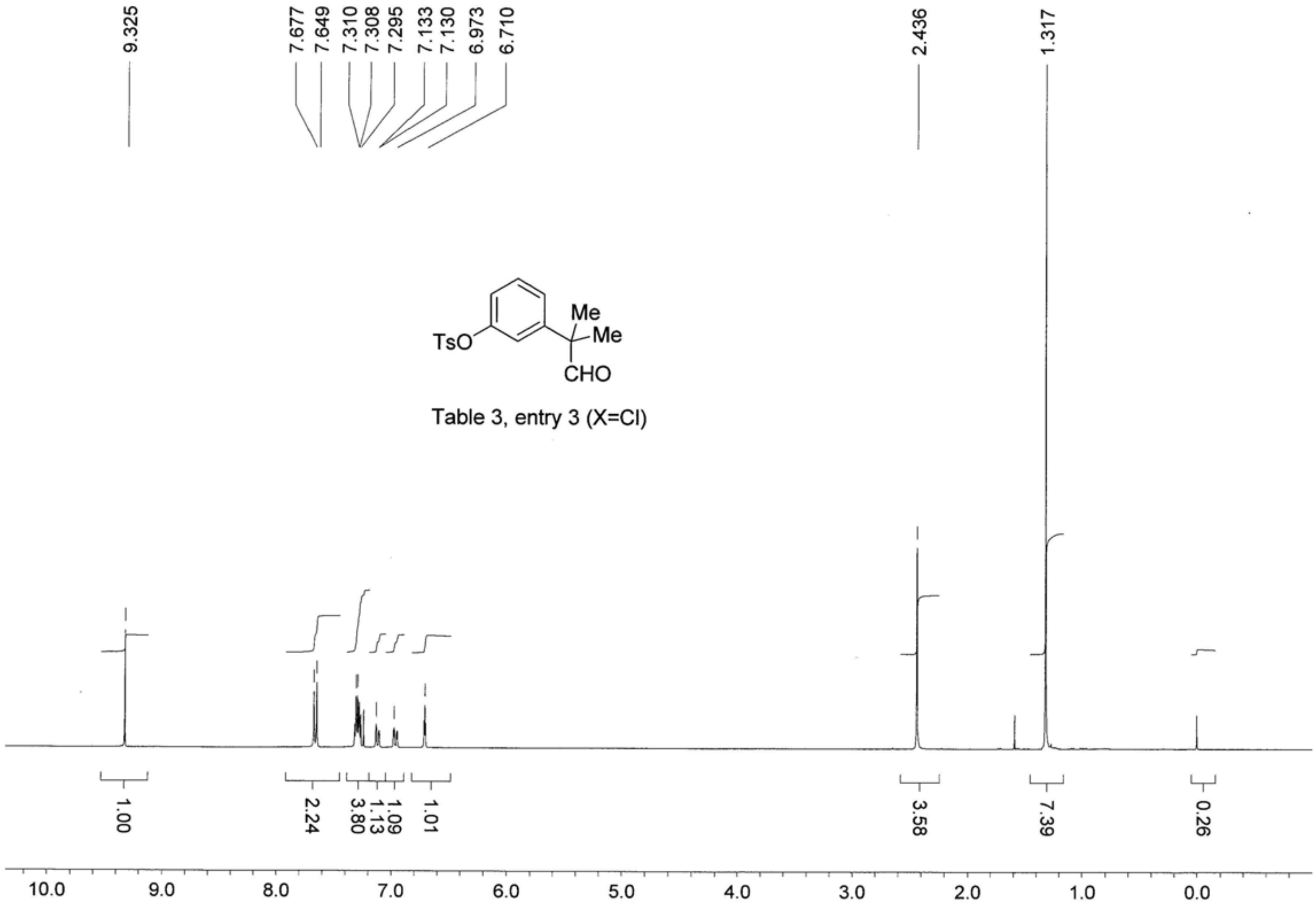


Table 3, entry 3 (X=Cl)

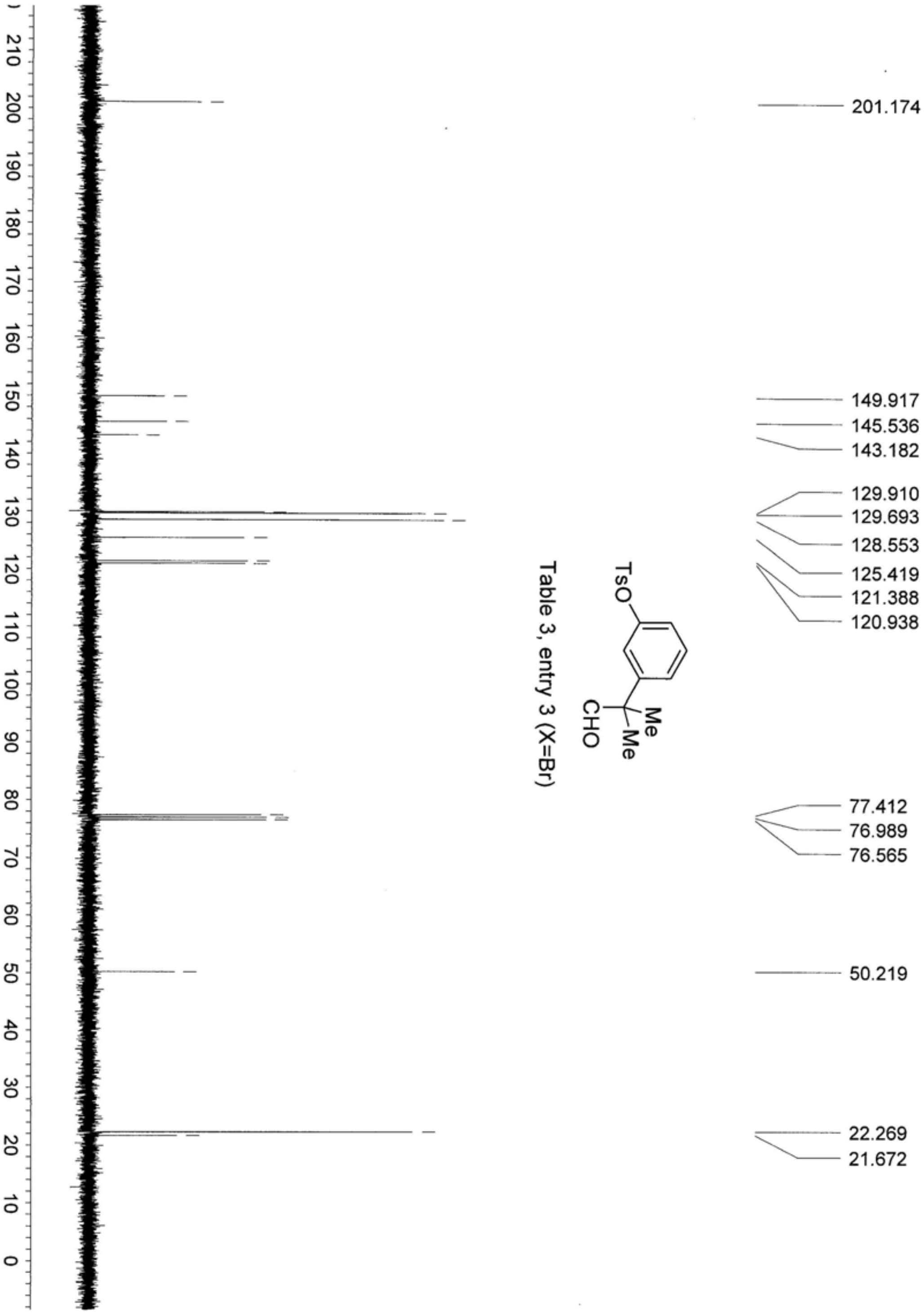


Table 3, entry 3 (X=Br)

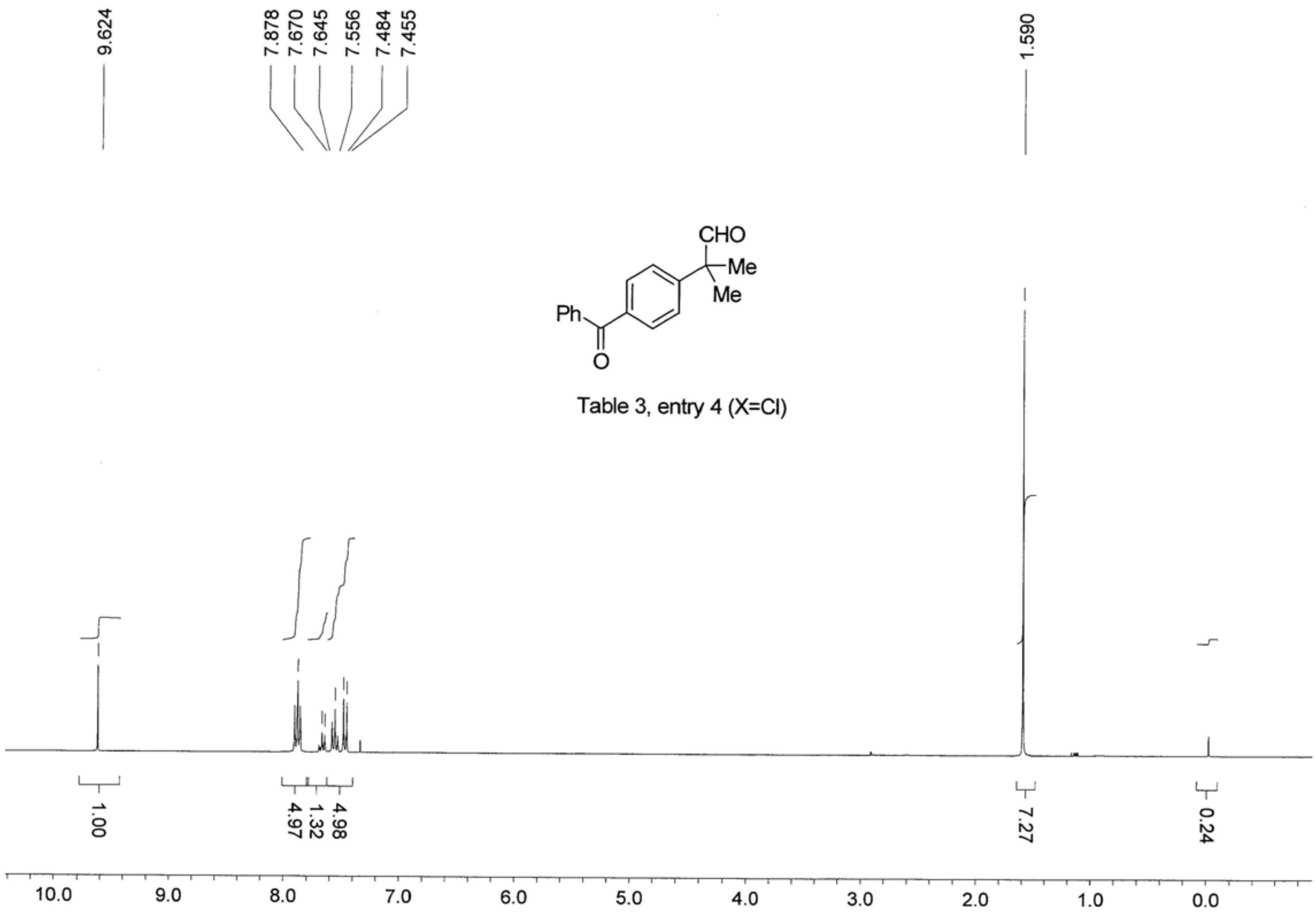


Table 3, entry 4 (X=Cl)

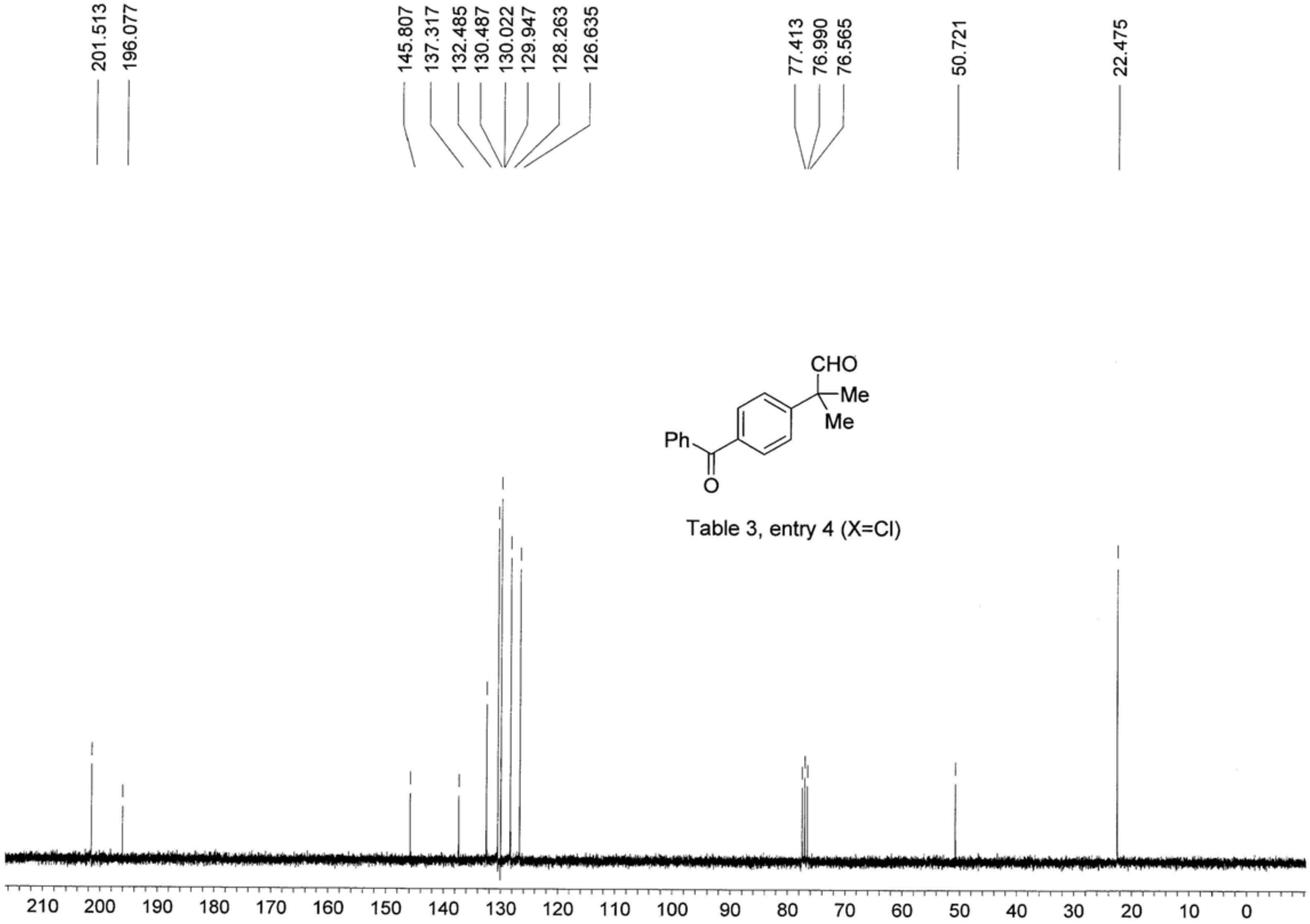
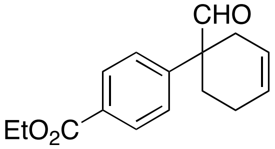
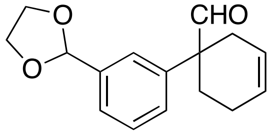


Table 3, entry 4 (X=Cl)



Ethyl 4-(1-formyl-3-cyclohexen-1-yl)benzoate (Table 3, entry 5). Following general procedure C, ethyl 4-bromobenzoate (164 μL, 1.00 mmol) was allowed to react with cyclohex-3-enecarbaldehyde (150 μL, 1.20 mmol) for 6 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. White solid; yield: 201 mg (78% yield). Following general procedure B, using ethyl 4-chlorobenzoate (160 μL, 1 mmol), for 10 h. Mp = 48-49 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.45 (s, 1H), 8.03 (d, J = 8.1 Hz, 2H), 7.34 (d, J = 8.1 Hz, 2H), 5.77 (m, 1H), 5.69 (m, 1H), 4.34 (q, J = 6.9 Hz, 2H), 2.68 (m, 1H), 2.43-2.27 (m, 2H), 2.04 (m, 3H), 1.34 (t, J = 6.9 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 200.6, 166.1, 144.3, 129.9, 129.4, 127.3, 126.9, 123.9, 60.9, 53.1, 30.0, 27.6, 22.2, 14.2. IR (neat, cm^{-1}): 3028, 2980, 2927, 2840, 2705, 1720, 1608, 1572, 1441, 1409, 1367, 1278, 1107, 1019. Anal. Calcd. for $C_{16}H_{18}O_3$: C, 74.39; H, 7.02. Found: C, 74.53; H, 6.97 (X=Br). Found: C, 74.48; H, 6.83 (X=Cl).



1-[3-(1,3-dioxolan-2-yl)phenyl]-3-cyclohexene-1-carbaldehyde (Table 3, entry 6). Following general procedure C, 2-(3-bromophenyl)-1,3-dioxolane (151 μL, 1 mmol)) was allowed to react with cyclohex-3-enecarbaldehyde (150 μL, 1.20 mmol) for 6 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. Colorless oil; yield: 209 mg (81% yield). Following general procedure B, using 2-(3-chlorophenyl)-1,3-dioxolane[7] (184 mg, 1 mmol), for 11 h (81% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.43 (s, 1H), 7.41-7.20 (m, 5H), 5.92 (m, 1H), 5.79 (s, 1H), 5.66 (m, 1H), 4.14 (m, 2H), 4.07 (m, 2H), 2.71 (m, 1H), 2.47-2.28 (m, 2H), 2.06 (m, 2H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 200.8, 139.5, 138.3, 128.8, 127.7, 127.0, 125.5, 124.8, 124.2, 103.4, 65.2, 65.1, 52.8, 30.2, 27.3, 22.3. IR (neat, cm^{-1}): 3027, 2889, 2704, 1722, 1655, 1607, 1487, 1438, 1384, 1277, 1224, 1169, 1081, 966. Anal. Calcd for $C_{16}H_{18}O_3$: C, 74.39; H, 7.02. Found: C, 74.18; H, 7.06 (X=Br). Found: C, 74.30; H, 6.89 (X=Cl).

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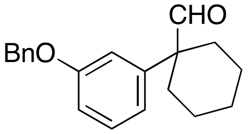
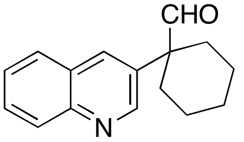
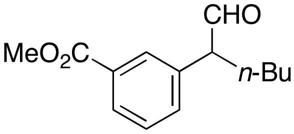
[7] M. Barbasiewicz, M. Mąkosza, *Org. Lett.* **2006**, *8*, 3745-3748.



1-[3-(benzyloxy)phenyl]cyclohexanecarbaldehyde (Table 3, entry 7). Following general procedure C, 1-(benzyloxy)-3-bromobenzene (262 mg, 1.00 mmol) was allowed to react with cyclohexanecarbaldehyde (146 μL, 1.20 mmol) for 6 h. Column chromatography: silica gel, 5:1 hexanes/ethyl acetate. White solid; yield: 259 mg (88% yield). Following general procedure B, using 1-(benzyloxy)-3-chlorobenzene (218 mg, 1.00 mmol), for 13 h. Mp = 42-43 °C. ^{1}H NMR (300 MHz, CDCl$_3$) δ: 9.37 (s, 1H), 7.47-7.26 (m, 6H), 7.07-6.87 (m, 3H), 5.06 (s, 2H), 2.26 (m, 2H), 1.84 (m, 2H), 1.69-1.28 (m, 9H). ^{13}C NMR (75 MHz, CDCl$_3$) δ: 200.1, 159.1, 141.3, 136.7, 129.7, 128.5, 127.9, 127.5, 119.6, 114.4, 112.8, 69.9, 54.3, 31.2, 25.5, 22.7. IR (neat, cm^{-1}): 3065, 3032, 2933, 2856, 2800, 2699, 1722, 1603, 1580, 1494, 1452, 1381, 1313, 1293, 1246, 1169, 1024. Anal. Calcd. for $C_{20}H_{22}O_2$: C, 81.60; H, 7.53. Found: C, 81.73; H, 7.40 (X=Br). Found: C, 81.66; H, 7.34 (X=Cl).



1-(3-quinolinyl)cyclohexanecarbaldehyde (Table 3, entry 8). Following general procedure C, 3-bromoquinoline (134 μL, 1.00 mmol) was allowed to react with cyclohexanecarbaldehyde (146 μL, 1.20 mmol) for 9 h. Column chromatography: silica gel, 2:1 hexanes/ethyl acetate. Colorless oil; yield: 194 mg (81% yield). ^{1}H NMR (300 MHz, CDCl$_3$) δ: 9.49 (s, 1H), 8.85 (d, *J* = 2.4 Hz, 1H), 8.06 (d, *J* = 8.4 Hz, 1H), 8.01 (d, *J* = 2.4 Hz, 1H), 7.75 (d, *J* = 8.4 Hz, 1H), 7.66 (ddd, *J* = 7.2, 6.9, 1.4 Hz, 1H), 7.49 (ddd, *J* = 7.2, 7.0, 1.2 Hz, 1H), 2.36 (m, 2H), 1.93 (m, 2H), 1.51-1.28 (m, 6H). ^{13}C NMR (75 MHz, CDCl$_3$) δ: 201.4, 149.5, 146.9, 134.3, 132.2, 129.5, 127.7, 127.6, 126.8, 120.9, 53.1, 30.9, 25.2, 22.4. IR (neat, cm^{-1}): 2977, 2858, 2725, 1724, 1615, 1591, 1495, 1454, 1390, 1361, 1205, 1034, 962. Anal. Calcd. for $C_{16}H_{17}NO$: C, 80.30; H, 7.16. Found: C, 80.14; H, 7.38.



Methyl 3-(1-formylpentyl)benzoate (Scheme 3). Following general procedure A: methyl 3-bromobenzoate (214 mg, 1.00 mmol) was allowed to react with hexanal (148 μL, 1.20 mmol) for 3 h. Column chromatography: silica gel, 10:1 hexanes/ethyl acetate. Colorless oil; yield: 199 mg (85% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.66 (d, *J* = 1.8 Hz, 1H), 7.92 (m, 1H), 7.88 (s, 1H), 7.46-7.36 (m, 2H), 3.91 (s, 3H), 3.54 (dt, *J* = 7.0, 1.8 Hz, 1H), 2.06 (m, 1H), 1.74 (m, 1H), 1.26 (m, 2H), 0.85 (t, *J* = 6.9 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 200.5, 166.7, 137.0, 133.3, 130.8, 129.8, 129.1, 128.7, 58.9, 52.2, 29.4, 29.2, 22.5, 13.8. IR (neat, cm^{-1}): 2955, 2932, 2860, 1725, 1605, 1588, 1487, 1445, 1434, 1286, 1197, 1106, 1085, 982. Anal. Calcd. for $C_{14}H_{18}O_3$: C, 71.77; H, 7.74. Found: C, 71.89; H, 7.68.

Following general procedure A: methyl 3-bromobenzoate (214 mg, 1 mmol) was allowed to react with 2-butyl-3-hydroxyoctanal (4:1, *anti:syn*; 130 mg, 0.65 mmol)[8] for 2.5 h. Column chromatography: silica gel, 10:1 hexanes/ethyl acetate. Colorless oil; yield: 194 mg (83% yield).

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[8] Northrup, A. B.; MacMillan, D. W. C. *J. Am. Chem. Soc.* **2002**, *124*, 6798.