

Metal-Free, Visible-Light Photoredox Catalysis: Transformation of Arylmethyl Bromides to Alcohols and Aldehydes

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SUPPORTING INFORMATION

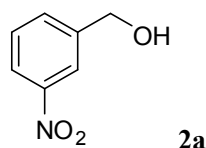
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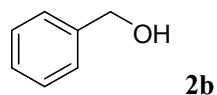
General Remarks.

All reactions were carried out under an air atmosphere condition. Various reagents were purchased from Aldrich, Acros or Alfa. Flash column chromatography was performed using silica gel (200–300 mesh). Analytical thin-layer chromatography was performed using glass plates pre-coated with 200–300 mesh silica gel impregnated with a fluorescent indicator (254 nm). The model of GC-MS is Agilent 7890A(GC)-5975(MS). NMR spectra were recorded in CDCl_3 on a Bruker NMR-400 (400MHz) and Bruker NMR-500 (500MHz) with TMS as an internal reference.

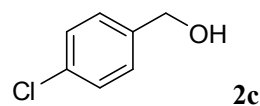
Characterization data for compounds **2**



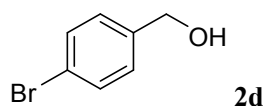
^1H NMR (CDCl_3 , 300 MHz) δ 8.22 (s, 1H), 8.12 (d, $J = 8.2$ Hz, 1H), 7.68 (d, $J = 7.6$ Hz, 1H), 7.52 (t, $J = 8.0$ Hz, 1H), 4.81 (s, 2H), 2.60 (br, 1H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 148.3, 142.9, 132.7, 129.4, 122.4, 121.4, 63.8.



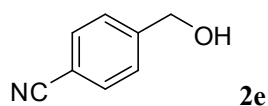
^1H NMR (CDCl_3 , 300 MHz) 7.36-7.34 (m, 4H), 7.31-7.26 (m, 1H), 4.66 (s, 2H), 1.97 (br, 1H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 140.8, 128.6, 127.7, 127.0, 65.3.



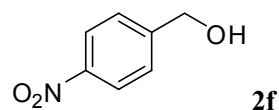
^1H NMR (CDCl_3 , 300 MHz) δ 7.36-7.28 (m, 4H), 4.69-4.67 (m, 2H), 1.88-1.84 (m, 1H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 139.2, 133.4, 128.6, 128.3, 64.5.



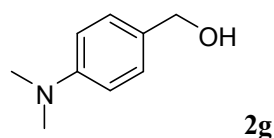
^1H NMR (CDCl_3 , 300 MHz) δ 7.47 (d, $J = 7.8$ Hz, 2H), 7.22 (d, $J = 7.8$ Hz, 2H), 4.63 (s, 2H), 1.92 (br, 1H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 139.7, 131.6, 128.6, 121.4, 64.5.



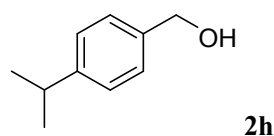
^1H NMR (CDCl_3 , 300 MHz) δ 7.64 (d, $J = 8.2$ Hz, 2H), 7.48 (d, $J = 8.4$ Hz, 2H), 4.78 (s, 2H), 2.13 (br, 1H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 146.2, 132.3, 127.0, 118.9, 111.1, 64.2.



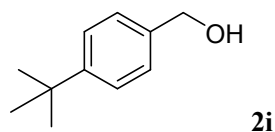
^1H NMR (CDCl_3 , 300 MHz) δ 8.23-8.20 (m, 2H), 7.55-7.52 (m, 2H), 4.83 (s, 2H), 2.00 (br, 1H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 148.1, 127.0, 123.7, 64.1.



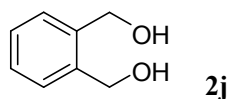
^1H NMR (CDCl_3 , 400 MHz) δ 7.28-7.25 (m, 2H), 6.77-6.74 (m, 2H), 4.58 (s, 2H), 2.97 (s, 6H), 1.77 (br, 1H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 150.4, 128.7, 112.7, 65.3, 40.7.



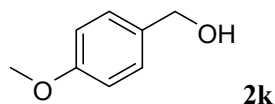
^1H NMR (CDCl_3 , 400 MHz) δ 7.31-7.28 (m, 2H), 7.24-7.21 (m, 2H), 4.65 (s, 2H), 2.93-2.82 (m, 1H), 1.67 (br, 1H), 1.26-1.23 (m, 6H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 148.5, 138.3, 127.2, 126.6, 65.3, 33.8, 24.0.



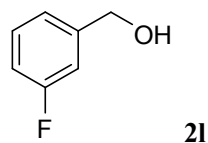
^1H NMR (CDCl_3 , 400 MHz) δ 7.38-7.35 (m, 2H), 7.27-7.24 (m, 2H), 4.58 (s, 2H), 2.29 (br, 1H), 1.30 (s, 9H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 150.6, 137.9, 126.9, 125.5, 65.0, 34.6, 31.4.



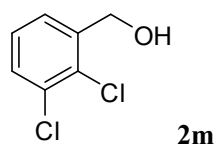
^1H NMR (CDCl_3 , 300 MHz) δ 7.32 (br, 4H), 4.68 (s, 4H), 3.98 (br, 2H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 139.4, 129.7, 128.6, 64.1.



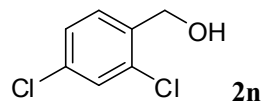
^1H NMR (CDCl_3 , 300 MHz) δ 7.28-7.25 (m, 2H), 6.89-6.86 (m, 2H), 4.58 (d, $J = 7.0$ Hz, 2H), 3.79 (s, 3H), 1.98 (t, $J = 7.4$ Hz, 1H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 159.2, 133.1, 128.7, 113.9, 64.9, 55.3.



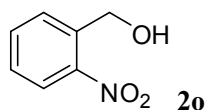
^1H NMR (CDCl_3 , 300 MHz) δ 7.33-7.25 (m, 1H), 7.10-7.04 (m, 2H), 6.99-6.94 (m, 1H), 4.65 (s, 2H), 2.30 (br, 1H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 164.6, 161.4, 143.5, 130.1, 129.9, 122.2, 122.1, 114.5, 114.3, 113.8, 64.4.



^1H NMR (CDCl_3 , 400 MHz) δ 7.41 (t, $J = 6.8$ Hz, 2H), 7.26-7.21 (m, 1H), 4.80-4.79 (m, 2H), 2.05 (t, $J = 6.2$ Hz, 1H). ^{13}C NMR (CDCl_3 , 100 MHz) δ 140.5, 133.0, 130.6, 129.4, 127.5, 126.4, 63.1.

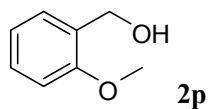


^1H NMR (CDCl_3 , 400 MHz) δ 7.44-7.42 (m, 1H), 7.37 (s, 1H), 7.28-7.26 (m, 1H), 4.75-4.74 (m, 2H), 2.02-1.99 (m, 1H). ^{13}C NMR (CDCl_3 , 100 MHz) δ 136.7, 133.8, 133.2, 129.4, 129.1, 127.3, 62.2.

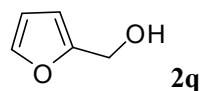


^1H NMR (CDCl_3 , 400 MHz) δ 8.12-8.09 (m, 1H), 7.75-7.65 (m, 2H), 7.51-7.45 (m, 1H), 4.97 (s,

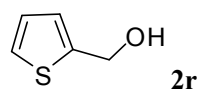
2H), 2.60 (br, 1H). ^1H NMR (CDCl_3 , 400 MHz) δ 147.7, 136.8, 134.2, 130.1, 128.5, 125.0, 62.5.



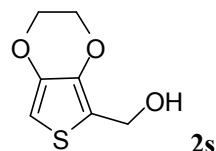
^1H NMR (CDCl_3 , 400 MHz) δ 7.29-7.25 (m, 2H), 6.93 (t, $J = 7.4$ Hz, 1H), 6.87 (d, $J = 8.4$ Hz, 1H), 4.67 (d, $J = 6.2$ Hz, 2H), 3.85 (s, 3H), 2.49 (t, $J = 6.3$ Hz, 1H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 131.6, 131.0, 130.3, 129.2, 128.4, 126.5, 125.2, 123.9, 57.4.



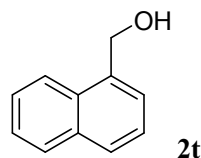
^1H NMR (CDCl_3 , 400 MHz) δ 7.40-7.38 (m, 1H), 6.35-6.33 (m, 1H), 6.29-6.28 (m, 1H), 4.61 (s, 2H), 1.96 (br, 1H). ^{13}C NMR (CDCl_3 , 100 MHz) δ 154.0, 142.6, 110.4, 107.8, 57.5.



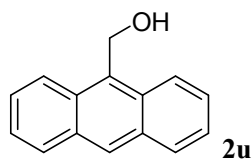
^1H NMR (CDCl_3 , 400 MHz) δ 7.29-7.27 (m, 1H), 7.01-6.98 (m, 2H), 4.82 (s, 2H), 2.04 (br, 1H). ^{13}C NMR (CDCl_3 , 100 MHz) δ 143.9, 126.8, 125.6, 59.9.



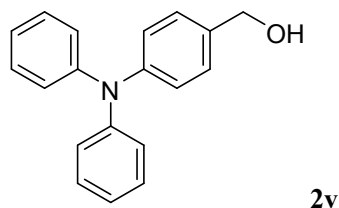
^1H NMR (CDCl_3 , 400 MHz) δ 6.28 (s, 1H), 4.66-4.65 (m, 2H), 4.24-4.18 (m, 4H), 1.86 (br, 1H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 141.5, 138.9, 116.0, 98.5, 64.7, 56.2.



^1H NMR (CDCl_3 , 300 MHz) δ 8.14 (d, $J = 7.7$ Hz, 1H), 7.92-7.83 (m, 2H), 7.60-7.45 (m, 4H), 5.16 (s, 2H), 1.88 (br, 1H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 136.3, 133.8, 131.2, 128.7, 128.6, 126.4, 125.9, 125.4, 123.6, 63.7.

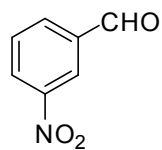


^1H NMR (CDCl_3 , 400 MHz) δ 8.44 (s, 1H), 8.37 (d, $J = 8.8$ Hz, 2H), 8.00 (d, $J = 8.4$ Hz, 2H), 7.54 (t, $J = 6.8$ Hz, 2H), 7.47 (t, $J = 7.4$ Hz, 2H), 5.61 (d, $J = 6.2$ Hz, 2H), 1.82 (t, $J = 5.2$ Hz, 1H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 131.6, 131.0, 130.3, 129.2, 128.4, 126.5, 125.2, 123.9, 57.4.

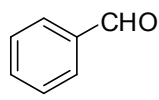


^1H NMR (CDCl_3 , 400 MHz) δ 7.26-7.21 (m, 6H), 7.08-7.06 (m, 6H), 7.02-6.98 (m, 2H), 4.63-4.62 (m, 2H), 1.68-1.64 (m, 1H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 147.7, 147.5, 134.9, 129.3, 128.3, 124.2, 124.0, 122.8, 65.1.

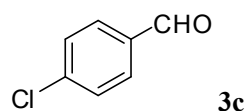
Characterization data for compounds **3**



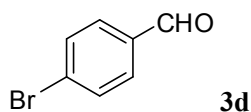
^1H NMR (CDCl_3 , 400 MHz) δ 10.13 (s, 1H), 8.72 (t, J = 1.8 Hz, 1H), 8.51-8.48 (m, 1H), 8.24 (d, J = 7.6 Hz, 1H), 7.77 (t, J = 8.0 Hz, 1H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 189.7, 137.4, 130.4, 128.6, 124.5.



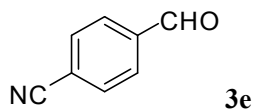
^1H NMR (CDCl_3 , 400 MHz) δ 10.03 (s, 1H), 7.89-7.88 (m, 2H), 7.63 (t, J = 7.5 Hz, 1H), 7.53 (t, J = 7.6 Hz, 2H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 192.5, 136.4, 134.5, 133.7, 130.2, 129.7, 129.0, 128.5.



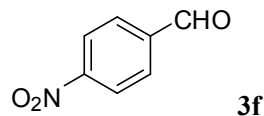
^1H NMR (CDCl_3 , 400 MHz) δ 9.99 (s, 1H), 7.84-7.82 (m, 2H), 7.53-7.51 (m, 2H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 190.8, 141.0, 134.7, 131.6, 130.9, 129.4, 128.9.



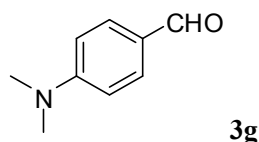
^1H NMR (CDCl_3 , 400 MHz) δ 9.98 (s, 1H), 7.76-7.74 (m, 2H), 7.70-7.68 (m, 2H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 191.1, 135.1, 132.4, 131.0, 129.8.



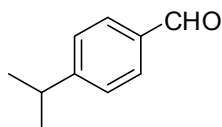
^1H NMR (CDCl_3 , 400 MHz) δ 10.10 (s, 1H), 8.01-7.99 (m, 2H), 7.86-7.84 (m, 2H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 190.5, 138.8, 132.9, 132.6, 129.9, 117.7.



^1H NMR (CDCl_3 , 400 MHz) δ 10.16 (s, 1H), 8.42-8.39 (m, 2H), 8.10-8.07 (m, 2H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 190.3, 140.0, 130.5, 124.3.

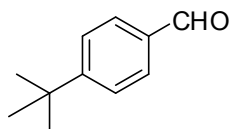


^1H NMR (CDCl_3 , 400 MHz) δ 9.74 (s, 1H), 7.75-7.73 (m, 2H), 6.71-6.69 (m, 2H), 3.09 (s, 6H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 190.3, 154.4, 131.9, 125.2, 111.0, 40.1.



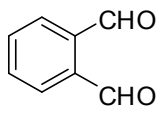
3h

^1H NMR (CDCl_3 , 400 MHz) δ 9.98 (s, 1H), 7.81 (d, J = 8.2 Hz, 2H), 7.39 (d, J = 8.2 Hz, 2H), 3.02-2.96 (m, 1H), 1.29 (s, 3H), 1.27 (s, 3H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 192.1, 156.3, 130.0, 127.2, 34.5, 23.6.



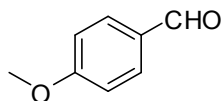
3i

^1H NMR (CDCl_3 , 400 MHz) δ 9.98 (s, 1H), 7.82 (d, J = 8.4 Hz, 2H), 7.55 (d, J = 8.4 Hz, 2H), 1.36 (s, 10H). ^{13}C NMR (125 MHz) δ 192.1, 158.5, 134.1, 130.1, 129.7, 125.9, 35.4, 31.1.



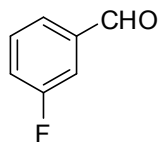
3j

^1H NMR (CDCl_3 , 400 MHz) δ 10.54 (s, 2H), 7.99-7.97 (m, 2H), 7.79-7.77 (m, 2H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 192.3, 136.4, 133.7, 131.1.



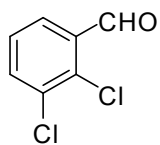
3k

^1H NMR (CDCl_3 , 400 MHz) δ 9.89 (s, 1H), 7.85 (d, J = 8.8, 2H), 7.02 (d, J = 8.7, 2H), 3.89 (s, 3H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 190.8, 164.6, 132.0, 129.9, 114.3, 55.6.



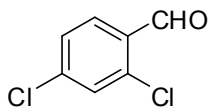
3l

^1H NMR (CDCl_3 , 400 MHz) δ 10.00 (d, J = 1.8 Hz, 1H), 7.69-7.67 (m, 1H), 7.58-7.51 (m, 2H), 7.37-7.32 (m, 1H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 190.9, 164.1, 162.1, 130.8, 130.7, 126.0, 121.6, 121.5, 115.4, 115.3.



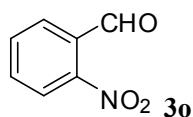
3m

^1H NMR (CDCl_3 , 400 MHz) δ 10.49 (s, 1H), 7.84 (dd, J = 6.1, 1.6 Hz, 1H), 7.35 (t, J = 7.8 Hz, 1H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 189.3, 135.6, 134.7, 134.3, 129.2, 127.7.

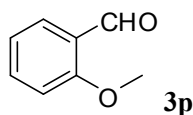


3n

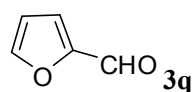
^1H NMR (CDCl_3 , 400 MHz) δ 10.41 (s, 1H), 7.87 (d, J = 8.4 Hz, 1H), 7.48 (d, J = 2.0 Hz, 1H), 7.39-7.36 (m, 1H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 188.5, 141.1, 138.6, 131.5, 130.9, 130.5, 130.3, 127.9.



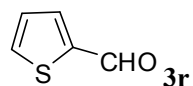
^1H NMR (CDCl_3 , 400 MHz) δ 10.44 (s, 1H), 8.14-8.11 (m, 1H), 7.97-7.95 (m, 1H), 7.82-7.74 (m, 2H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 188.1, 134.1, 133.7, 131.4, 129.6, 124.5.



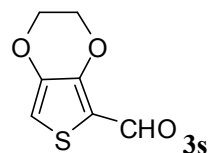
^1H NMR (CDCl_3 , 400 MHz) δ 10.47 (s, 1H), 7.83 (dd, J = 7.7, 1.8 Hz, 1H), 7.57-7.53 (m, 1H), 7.05-6.98 (m, 2H), 3.93 (s, 3H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 189.8, 161.8, 135.9, 128.6, 124.9, 120.7, 111.6, 55.6.



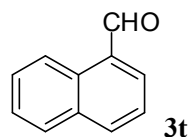
^1H NMR (CDCl_3 , 400 MHz) δ 9.72 (s, 1H), 7.70-7.69 (m, 1H), 7.26-7.25 (m, 1H), 6.60 (q, J = 1.7 Hz, 1H). ^{13}C NMR (125 MHz, 100 MHz) δ 177.9, 153.0, 148.1, 120.9, 112.6.



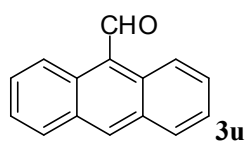
^1H NMR (CDCl_3 , 400 MHz) δ 9.96-9.95 (m, 1H), 7.79-7.76 (m, 2H), 7.23-7.21 (m, 1H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 183.0, 144.1, 136.3, 135.1, 128.3.



^1H NMR (CDCl_3 , 400 MHz) δ 9.91 (s, 1H), 6.80-6.79 (m, 1H), 4.38-4.36 (m, 2H), 4.28-4.26 (m, 2H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 180.1, 141.8, 118.6, 110.8, 65.3, 64.4.

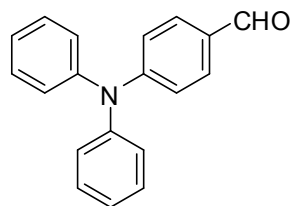


^1H NMR (CDCl_3 , 400 MHz) δ 10.42 (s, 1H), 9.26 (d, J = 8.6 Hz, 1H), 8.11 (d, J = 8.2 Hz, 1H), 8.02-8.00 (m, 1H), 7.93 (d, J = 8.2 Hz, 1H), 7.73-7.68 (m, 1H), 7.69-7.58 (m, 2H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 193.5, 136.6, 135.2, 133.6, 131.4, 130.4, 128.9, 128.4, 126.9, 124.8.



^1H NMR (CDCl_3 , 400 MHz) δ 11.54 (s, 1H), 8.99 (d, J = 9.0 Hz, 2H), 8.71 (s, 1H), 8.07 (d, J =

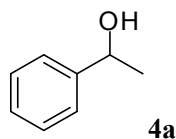
8.5 Hz, 2H), 7.72-7.67 (m, 2H), 7.58-7.56 (m, 2H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 193.0, 135.2, 132.2, 131.1, 129.3, 129.1, 128.4, 127.9, 125.7, 123.5.



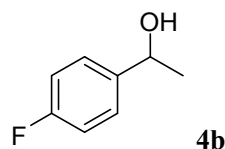
3v

^1H NMR (CDCl_3 , 400 MHz) δ 9.81 (s, 1H), 7.68 (d, $J = 8.8$ Hz, 2H), 7.36-7.32 (m, 4H), 7.18-7.15 (m, 6H), 7.01 (d, $J = 8.8$ Hz, 2H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 190.5, 153.4, 146.2, 131.3, 129.7, 126.3, 125.1, 119.4.

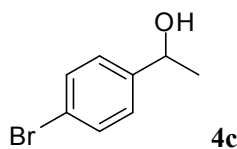
Characterization data for compounds 4



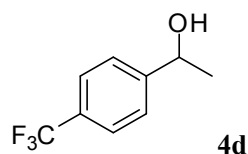
^1H NMR (CDCl_3 , 400 MHz) δ 7.34-7.28 (m, 4H), 7.27-7.23 (m, 1H), 4.87-4.84 (m, 1H), 2.19 (br, 1H), 1.46 (d, J = 6.5 Hz, 3H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 145.8, 128.5, 127.5, 125.4, 70.4, 25.2.



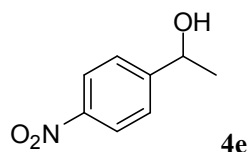
^1H NMR (CDCl_3 , 400 MHz) δ 7.34-7.29 (m, 2H), 7.04-6.98 (m, 2H), 4.88-4.84 (m, 1H), 2.15 (br, 1H), 1.45 (d, J = 6.5 Hz, 3H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 163.7, 160.5, 141.5, 127.1, 126.9, 115.4, 115.0, 69.7, 25.3.



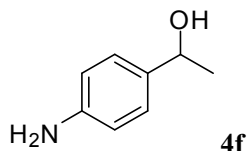
^1H NMR (CDCl_3 , 400 MHz) δ 7.45 (d, J = 7.6 Hz, 2H), 7.23 (d, J = 7.6 Hz, 2H), 4.84-4.82 (m, 1H), 2.03 (br, 1H), 1.46-1.44 (m, 3H). ^{13}C NMR (CDCl_3 , 100 MHz) δ 144.7, 131.5, 127.2, 127.1, 121.1, 69.7, 25.2.



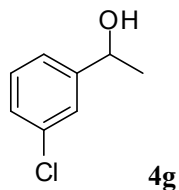
^1H NMR (CDCl_3 , 400 MHz) δ 7.60 (d, J = 7.9 Hz, 2H), 7.48 (d, J = 7.9 Hz, 2H), 4.95 (s, 1H), 2.05 (s, 1H), 1.49 (d, J = 6.5 Hz, 3H). ^{13}C NMR (CDCl_3 , 100 MHz) δ 149.7, 129.8, 129.6, 125.7, 123.2, 69.9, 25.4.



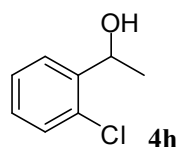
^1H NMR (CDCl_3 , 400 MHz) δ 8.19-8.16 (m, 2H), 7.54-7.51 (m, 2H), 5.02 (q, J = 6.5 Hz, 1H), 2.48 (br, 1H), 1.50 (d, J = 6.5 Hz, 3H).



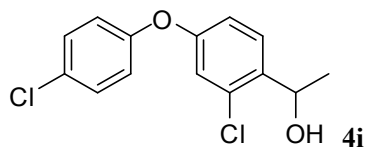
^1H NMR (CDCl_3 , 400 MHz) δ 7.18-7.15 (m, 2H), 6.67-6.65 (m, 2H), 4.78 (q, J = 6.4 Hz, 1H), 3.62 (br, 2H), 1.45 (d, J = 6.5 Hz, 3H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 145.8, 135.9, 126.7, 115.1, 70.2, 24.8.



^1H NMR (CDCl_3 , 400 MHz) δ 7.35 (s, 1H), 7.28-7.20 (m, 3H), 4.86-4.85 (m, 1H), 2.20 (br, 1H), 1.45 (d, $J = 6.4$ Hz, 3H). ^{13}C NMR (CDCl_3 , 75 MHz) δ 147.8, 134.3, 129.8, 127.5, 125.6, 123.5, 69.7, 25.2.

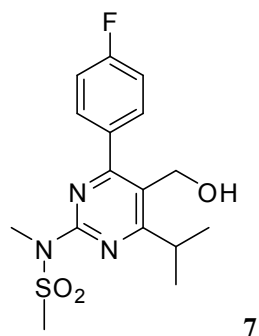


^1H NMR (CDCl_3 , 400 MHz) δ 7.57 (d, $J = 7.7$ Hz, 1H), 7.30 (t, $J = 7.9$ Hz, 2H), 7.21-7.18 (m, 1H), 5.28-5.27 (m, 1H), 2.21 (s, 1H), 1.48-1.46 (m, 3H). ^{13}C NMR (CDCl_3 , 100 MHz) δ 143.0, 131.6, 129.4, 128.3, 127.2, 126.4, 66.9, 23.5.

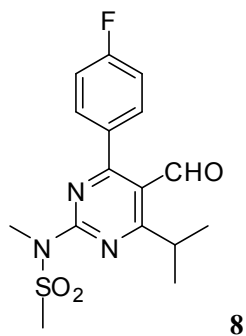


^1H NMR (CDCl_3 , 400 MHz) δ 7.48 (d, $J = 8.3$ Hz, 1H), 7.34-7.31 (m, 2H), 7.14-7.10 (m, 1H), 6.94-6.91 (m, 2H), 6.76 (d, $J = 2.0$ Hz, 1H), 5.15-5.13 (m, 1H), 2.13 (br, 1H), 1.49 (d, $J = 6.5$ Hz, 3H). ^{13}C NMR (CDCl_3 , 125 MHz) δ 134.9, 133.6, 130.1, 129.1, 127.7, 124.2, 120.1, 118.3, 65.0, 23.8.

Characterization data for other compounds



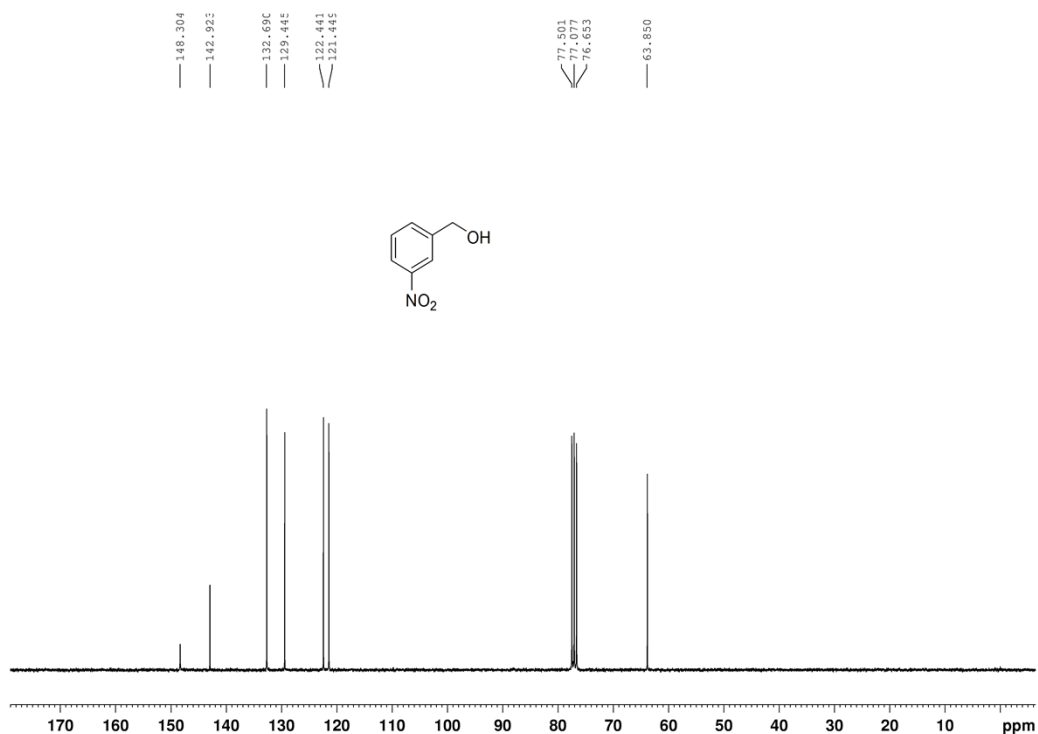
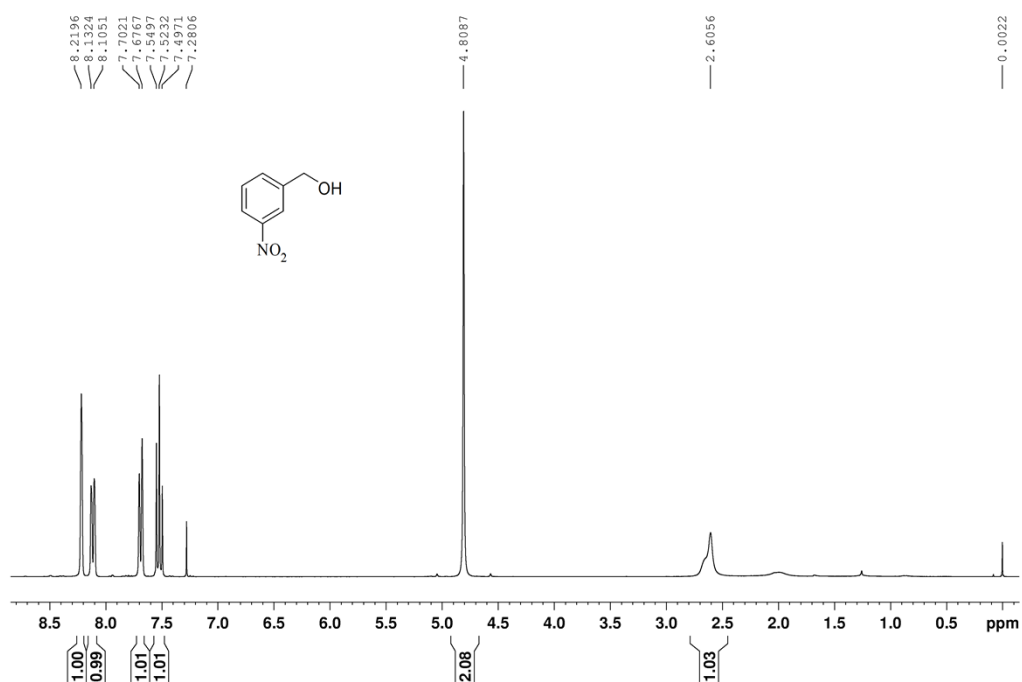
^1H NMR (CDCl_3 , 400 MHz) δ 7.82-7.79 (m, 2H), 7.16 (t, J = 8.6 Hz, 2H), 4.65 (s, 2H), 3.57 (s, 3H), 3.52 (s, 3H), 3.50-3.47 (m, 1H), 1.80 (br, 1H), 1.35 (s, 3H), 1.33 (s, 3H). ^{13}C NMR (125 MHz, 100 MHz) δ 177.7, 166.3, 164.7, 162.7, 158.0, 134.0, 131.5, 120.6, 115.5, 115.3, 57.7, 42.4, 33.1, 31.6, 22.3.



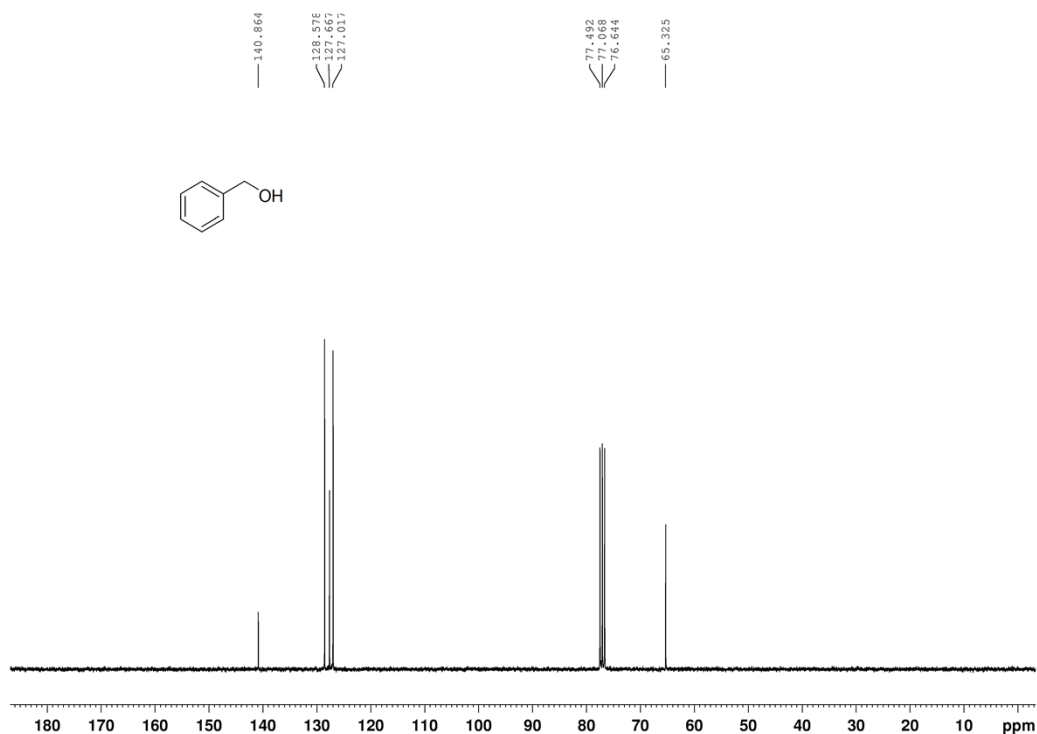
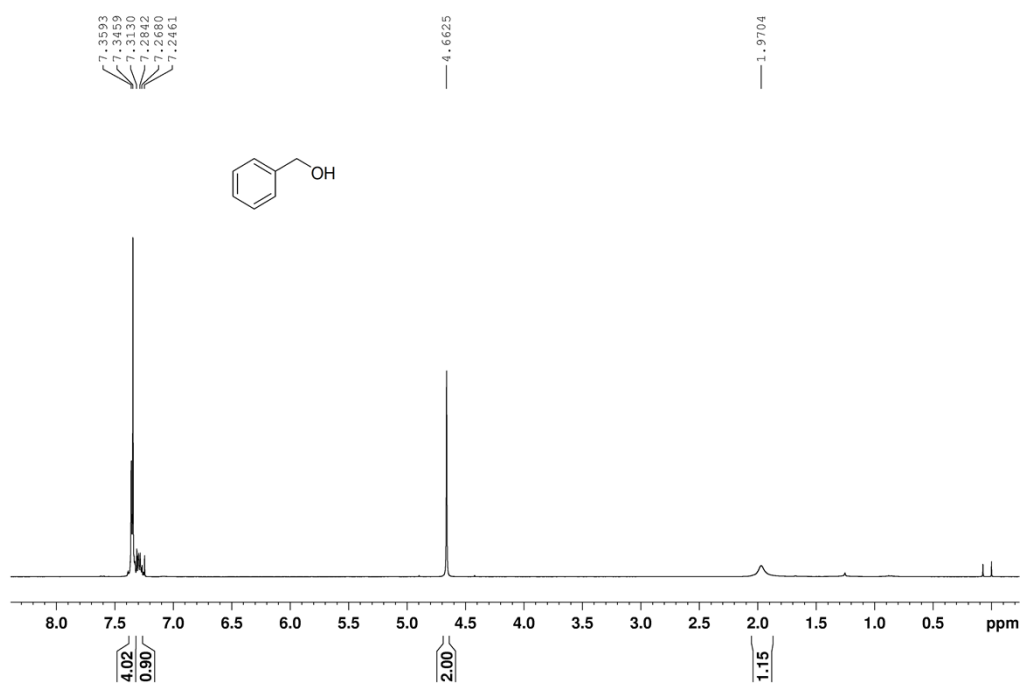
^1H NMR (CDCl_3 , 400 MHz) δ 9.97 (s, 1H), 7.64-7.61 (t, J = 6.0 Hz, 2H), 7.24-7.20 (t, J = 8.1 Hz, 2H), 4.02-3.99 (m, 1H), 3.64 (s, 3H), 3.55 (s, 3H), 1.32-1.32 (d, J = 6.6 Hz, 6H). ^{13}C NMR (125 MHz, 100 MHz) δ 190.5, 179.1, 169.8, 165.5, 163.5, 158.8, 132.7, 132.2, 119.5, 116.1, 115.9, 42.6, 33.1, 32.0, 21.7.

NMR spectra of all compounds

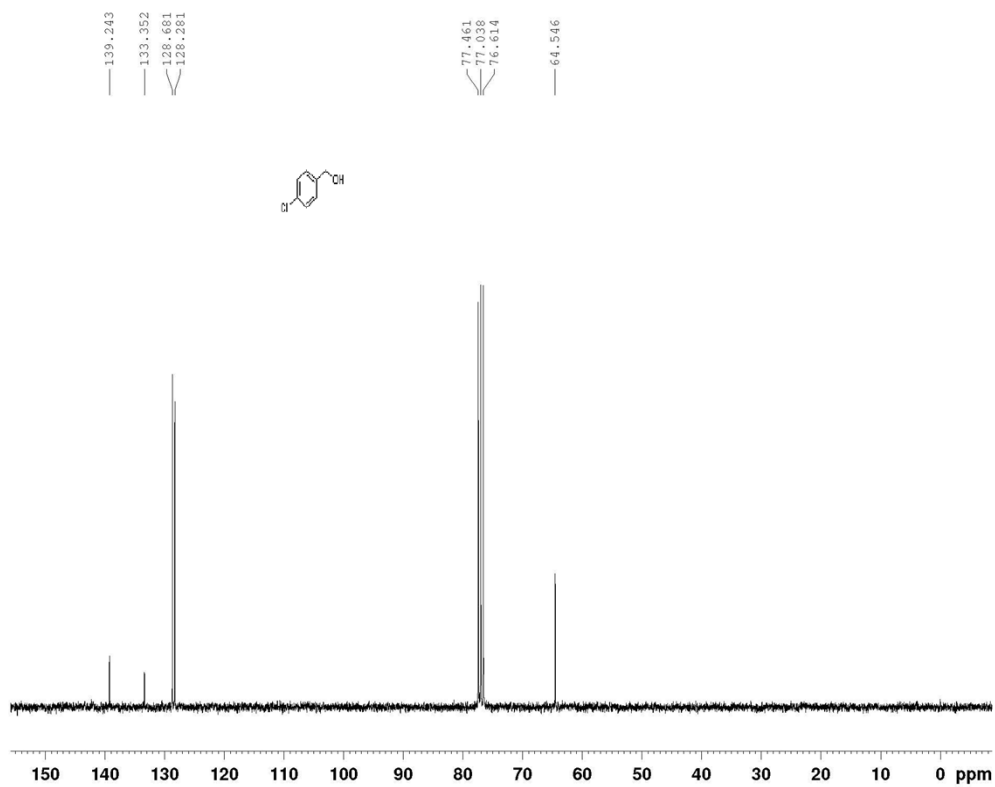
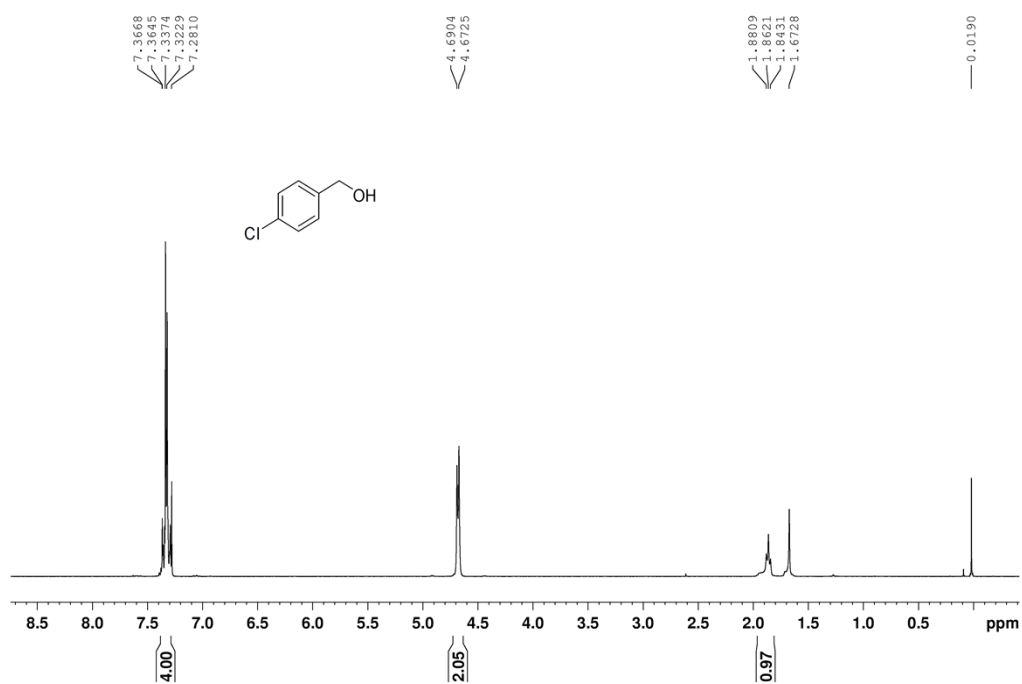
NMR spectra of 2a



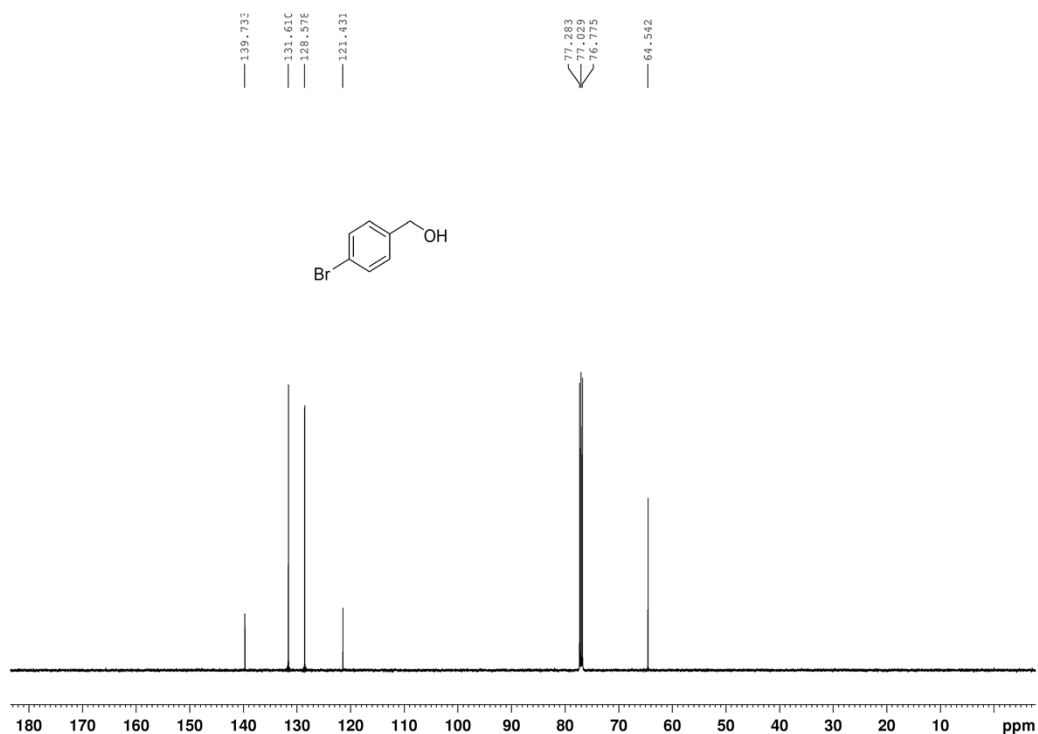
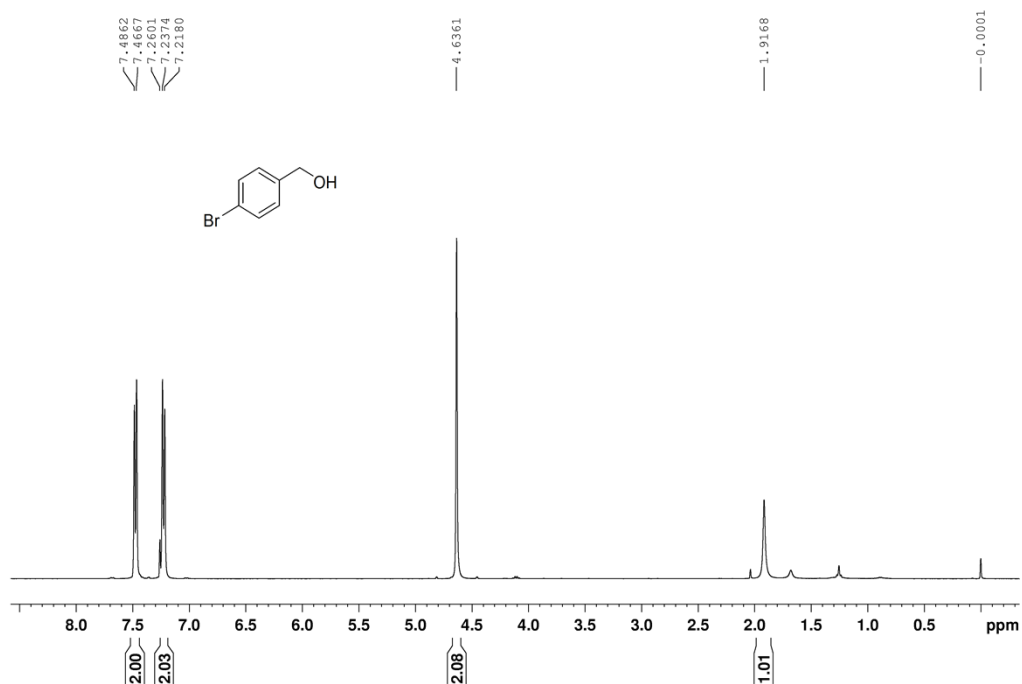
NMR spectra of 2b



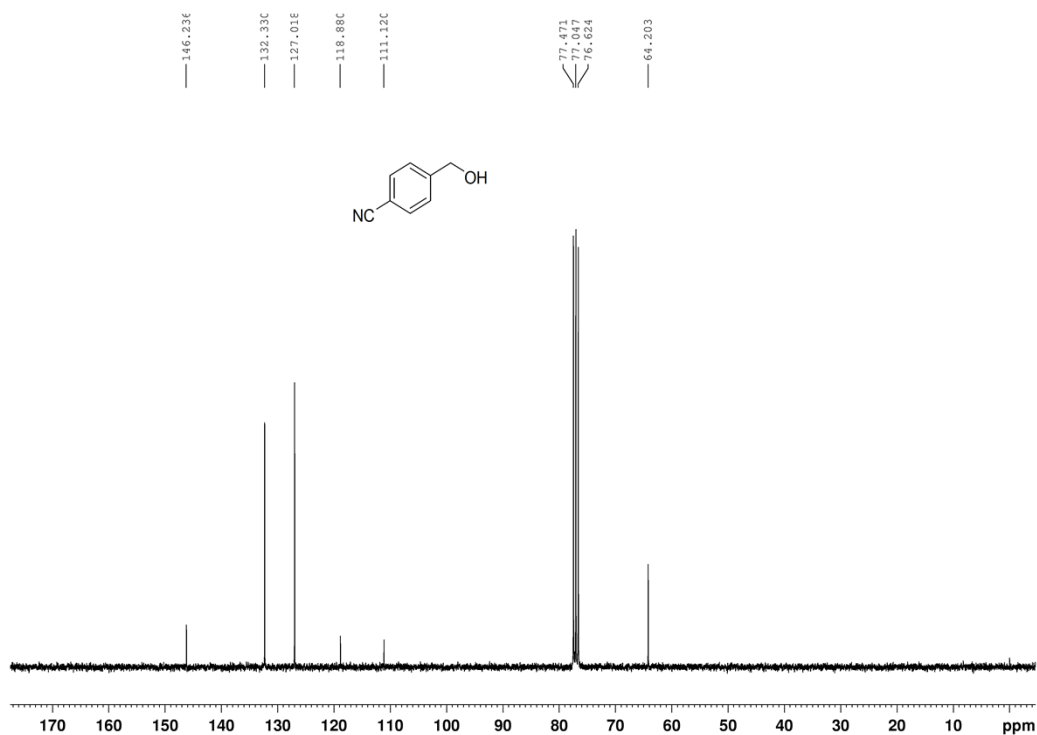
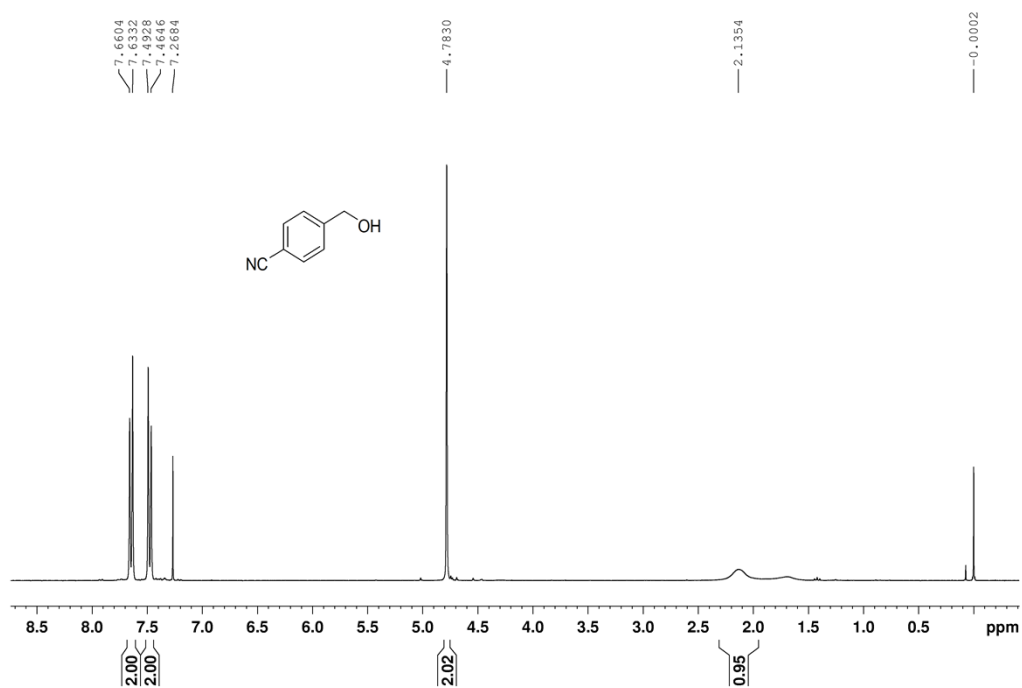
NMR spectra of 2c



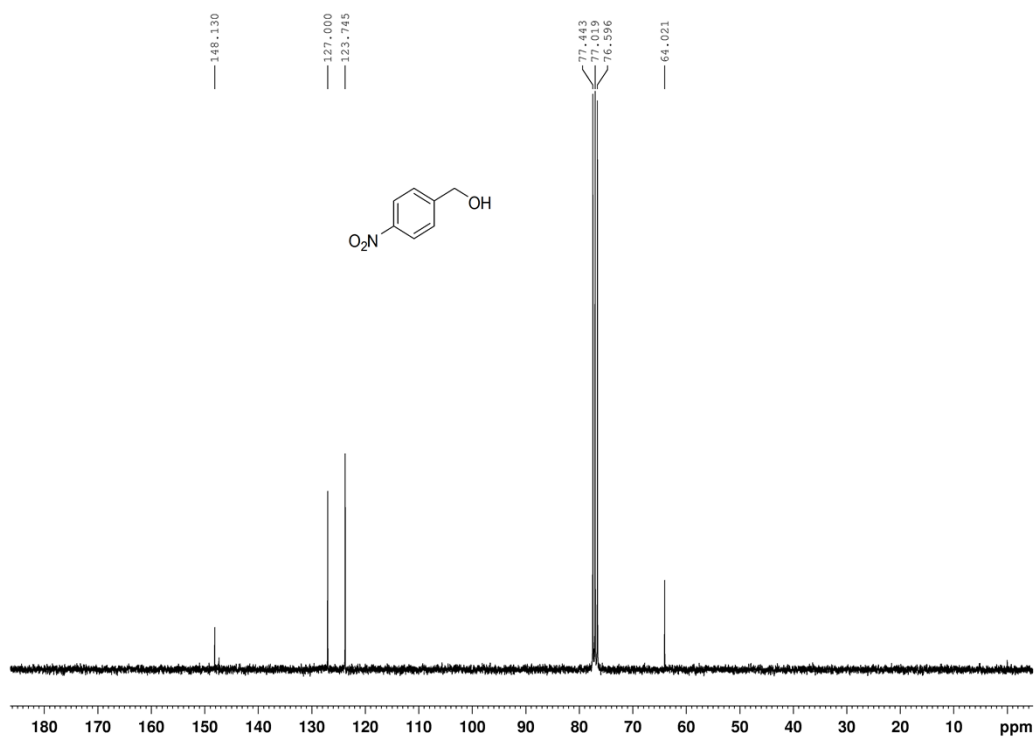
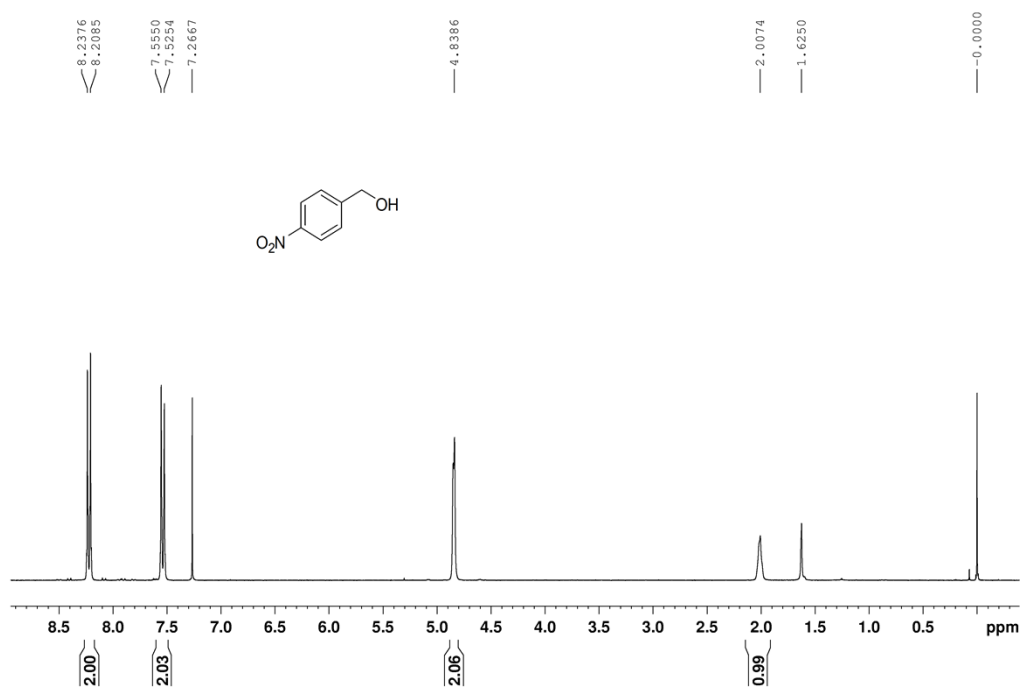
NMR spectra of 2d



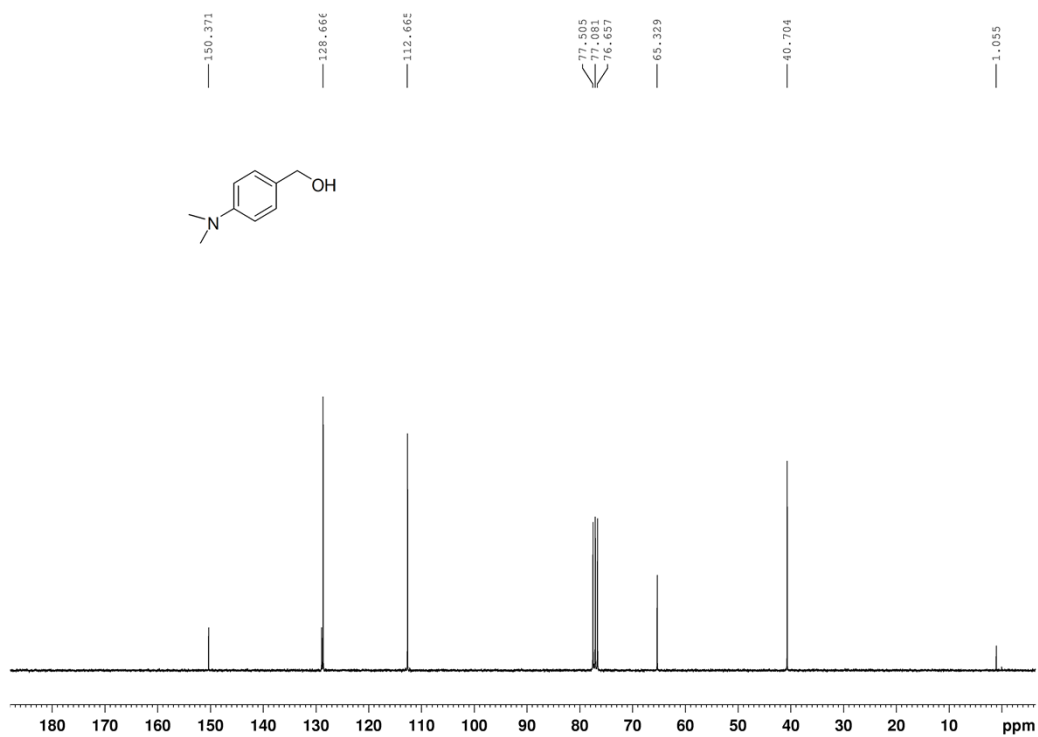
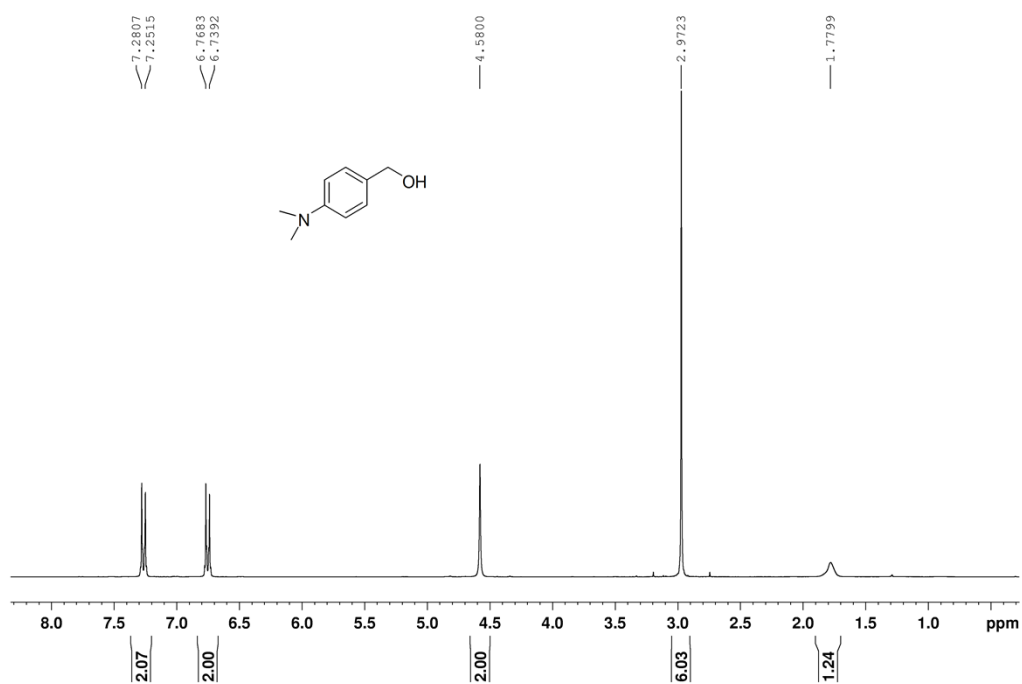
NMR spectra of 2e



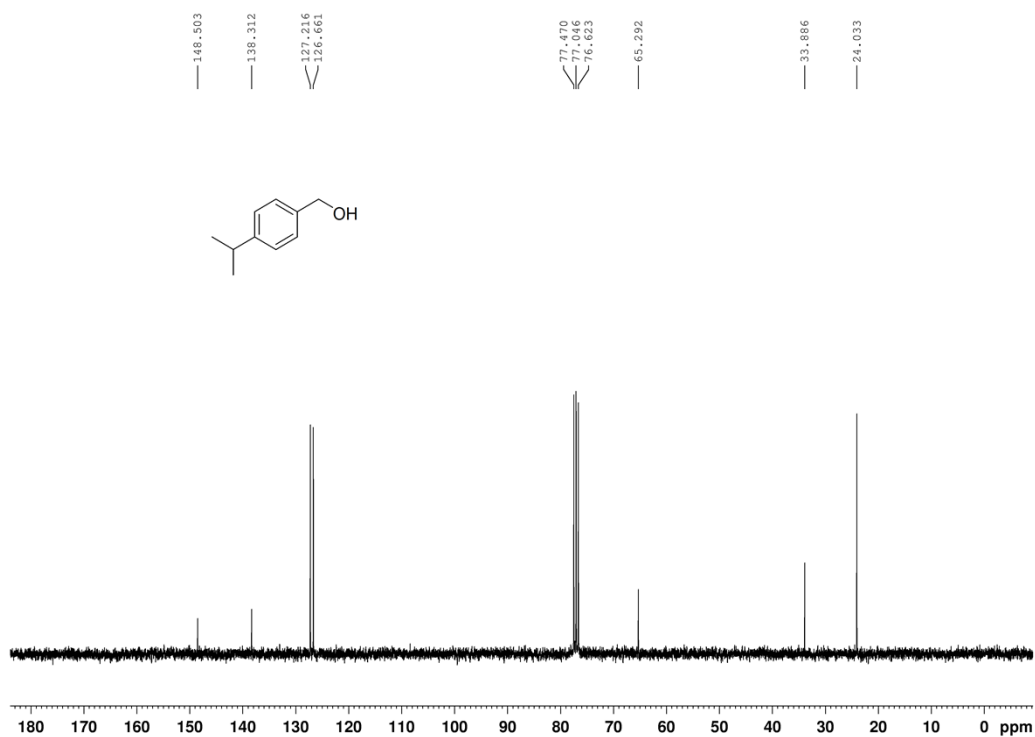
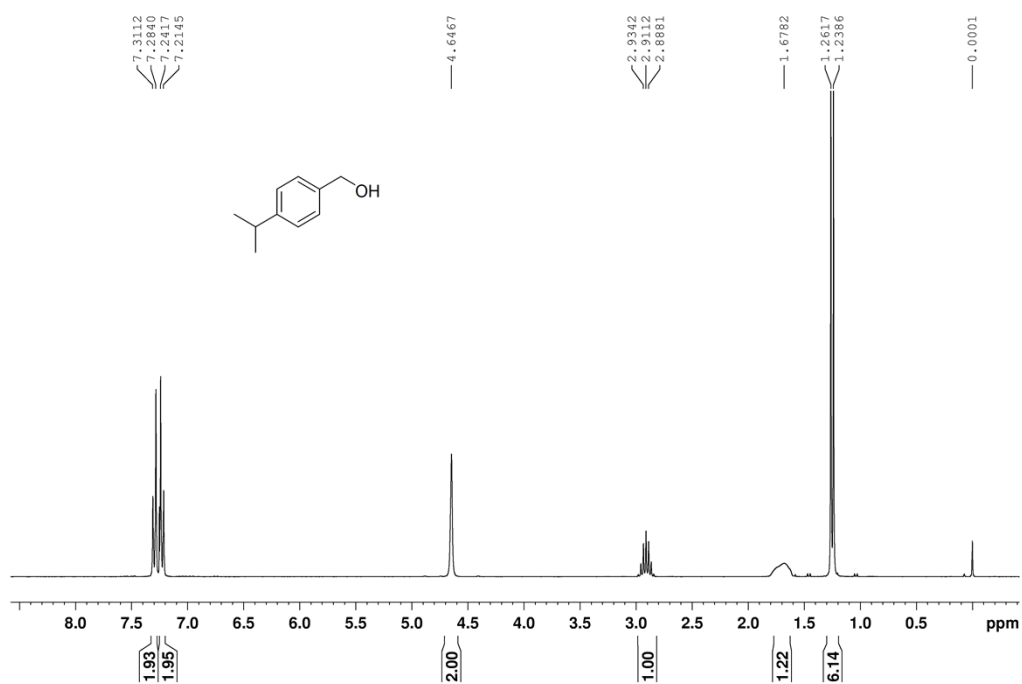
NMR spectra of 2f



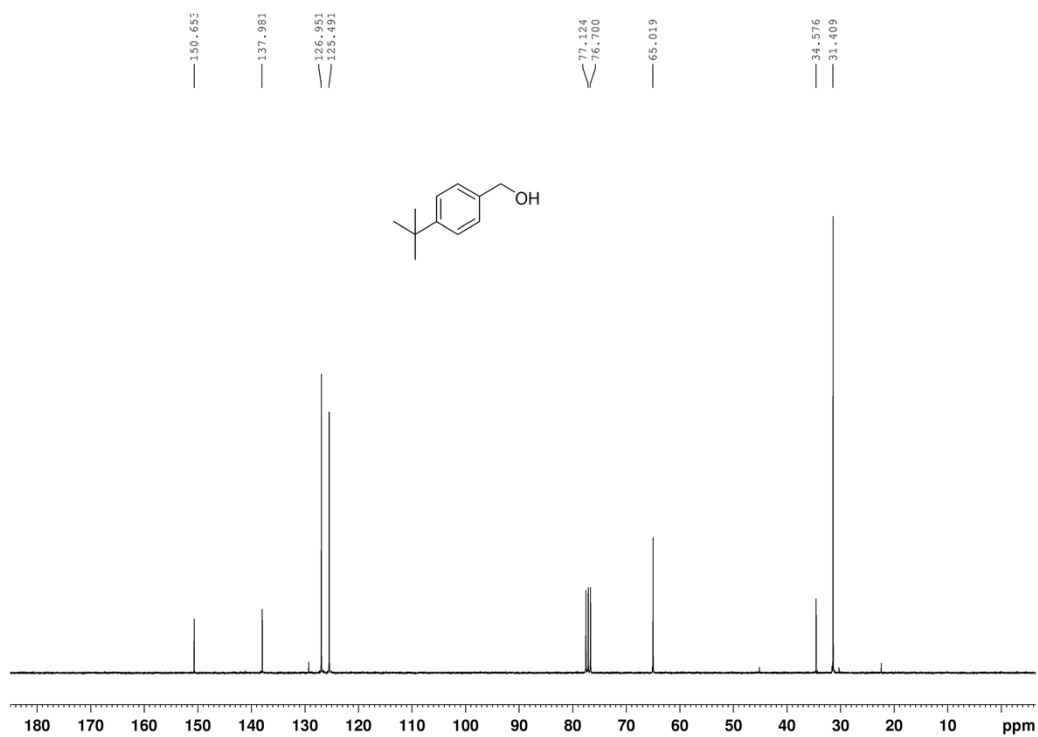
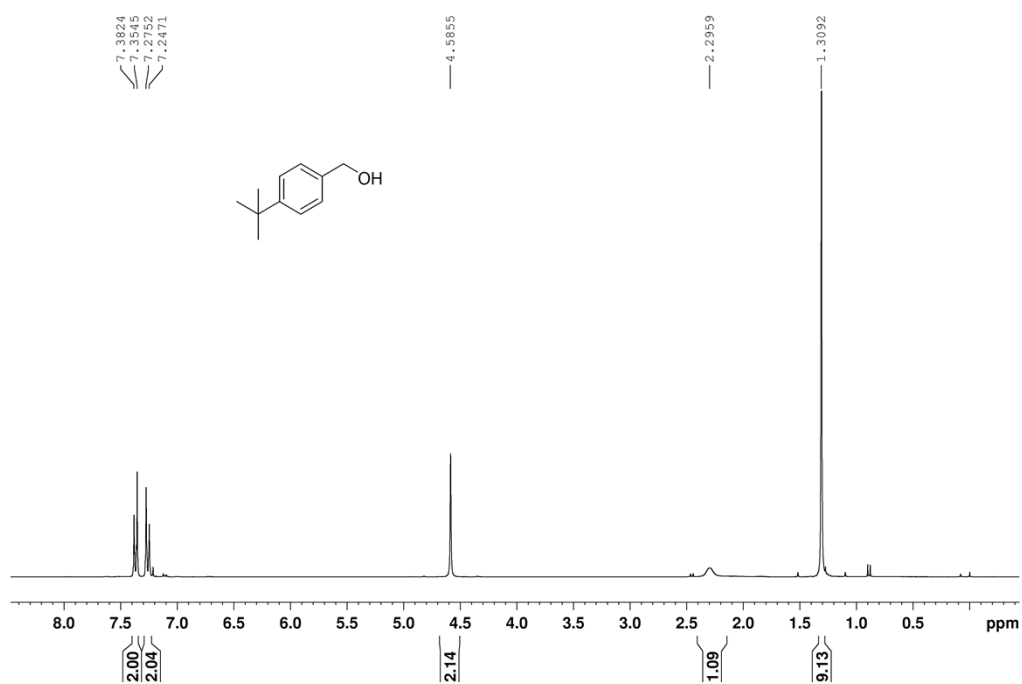
NMR spectra of 2g



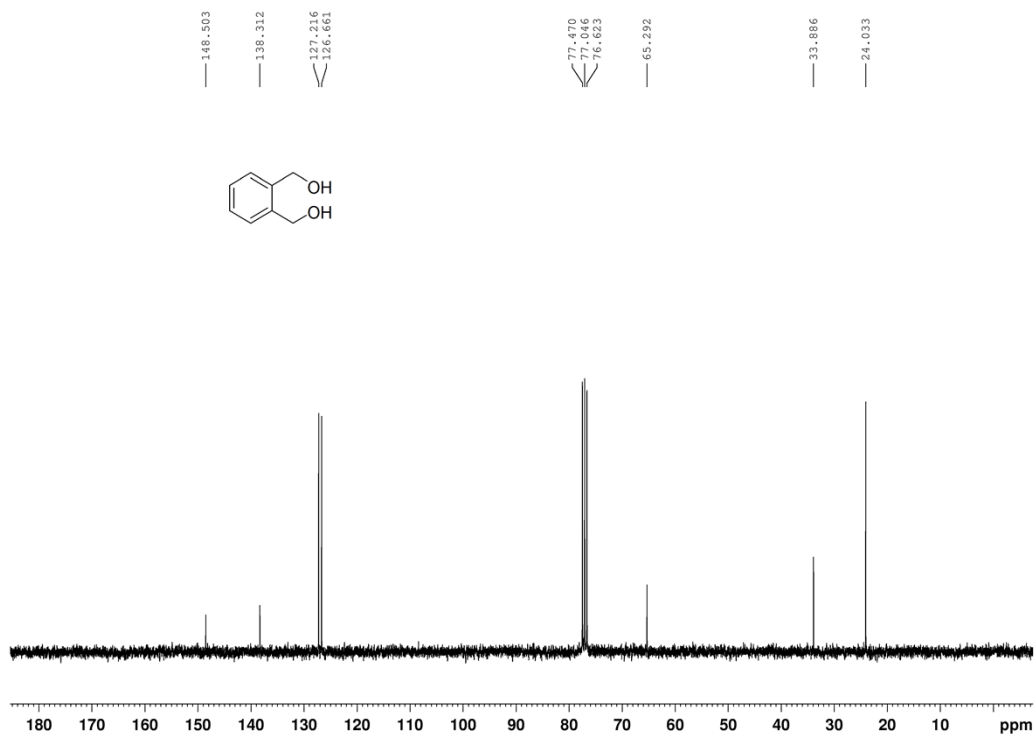
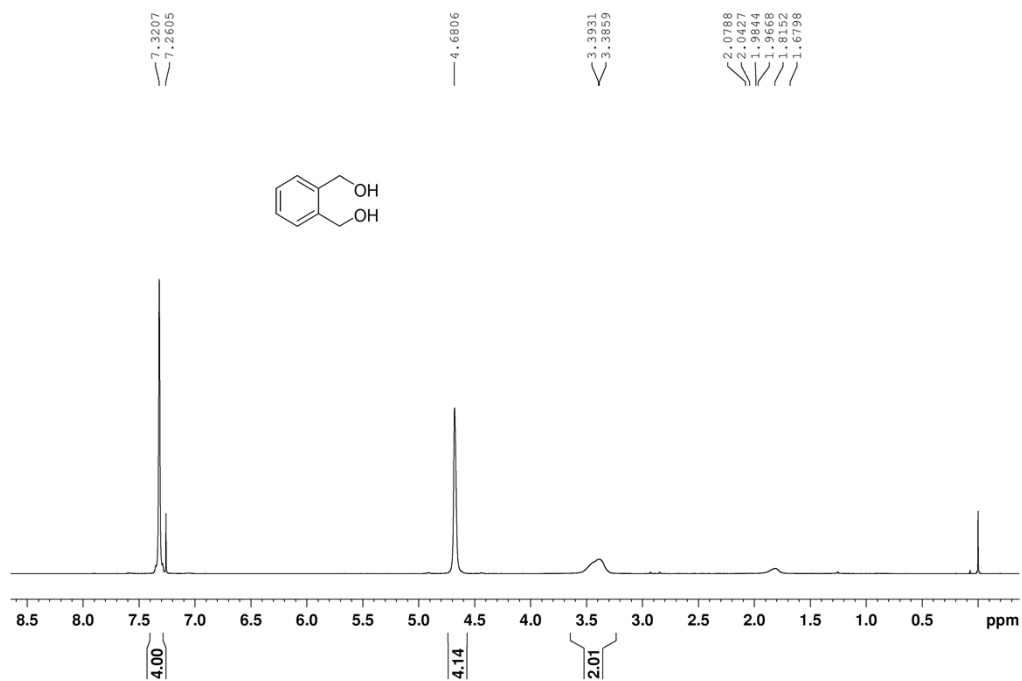
NMR spectra of 2h



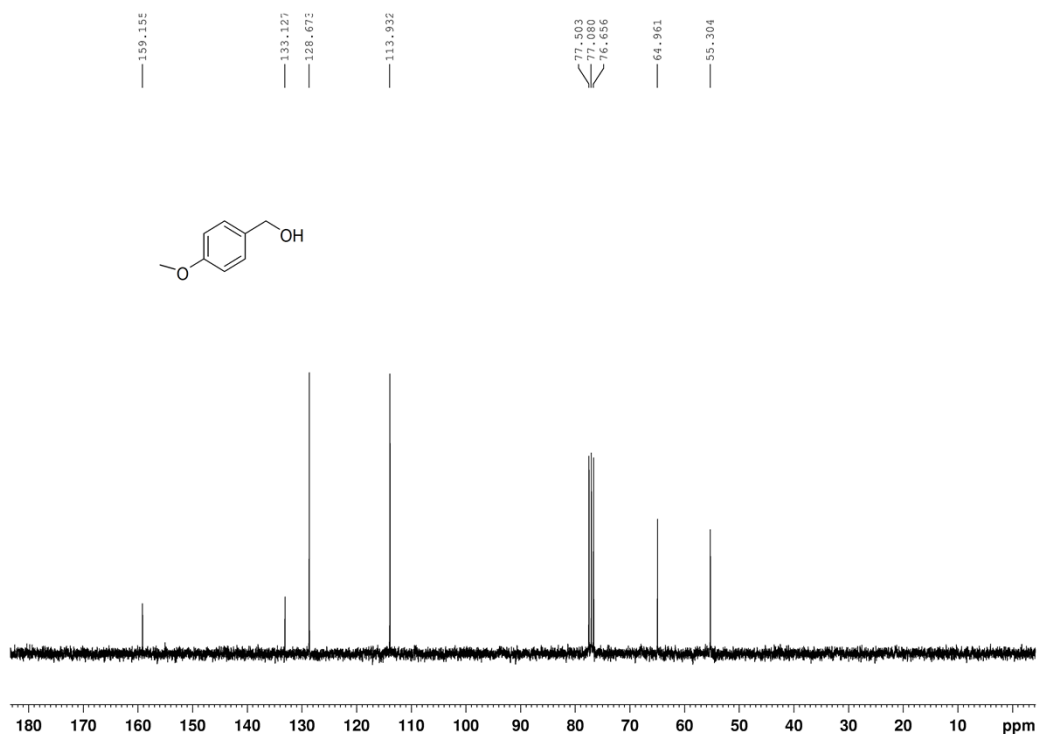
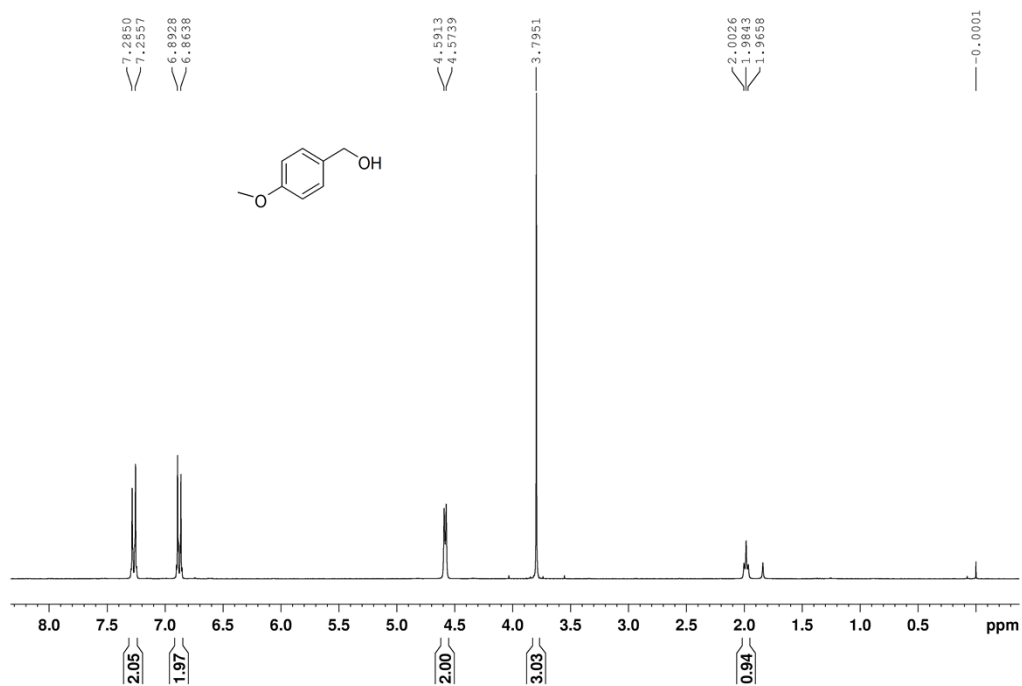
NMR spectra of 2i



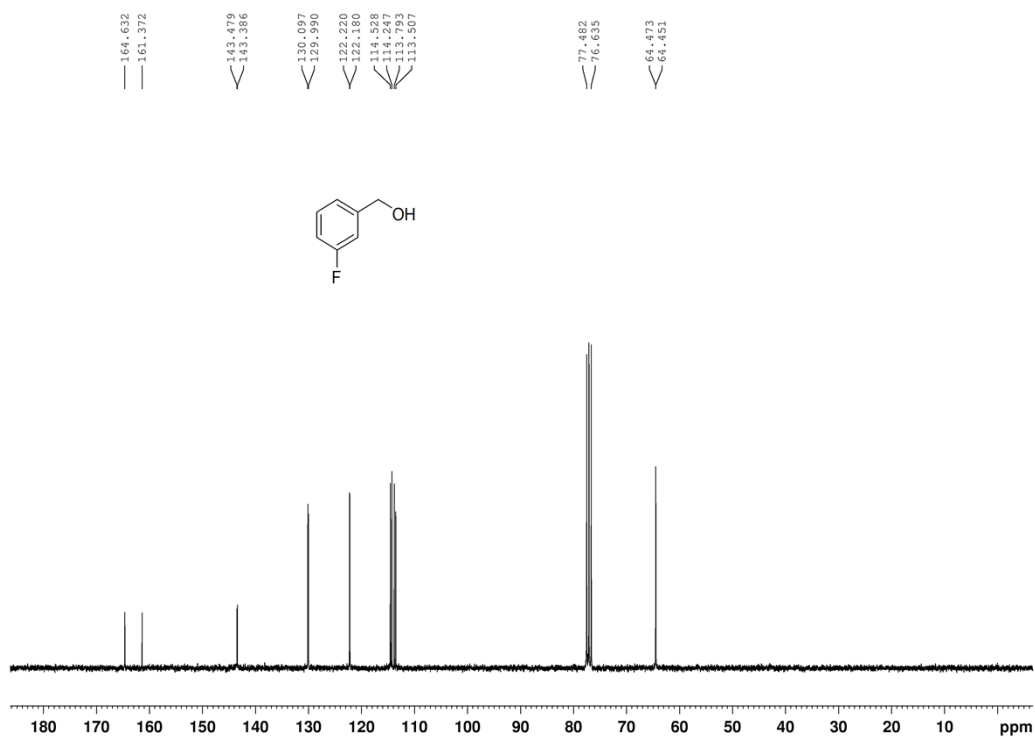
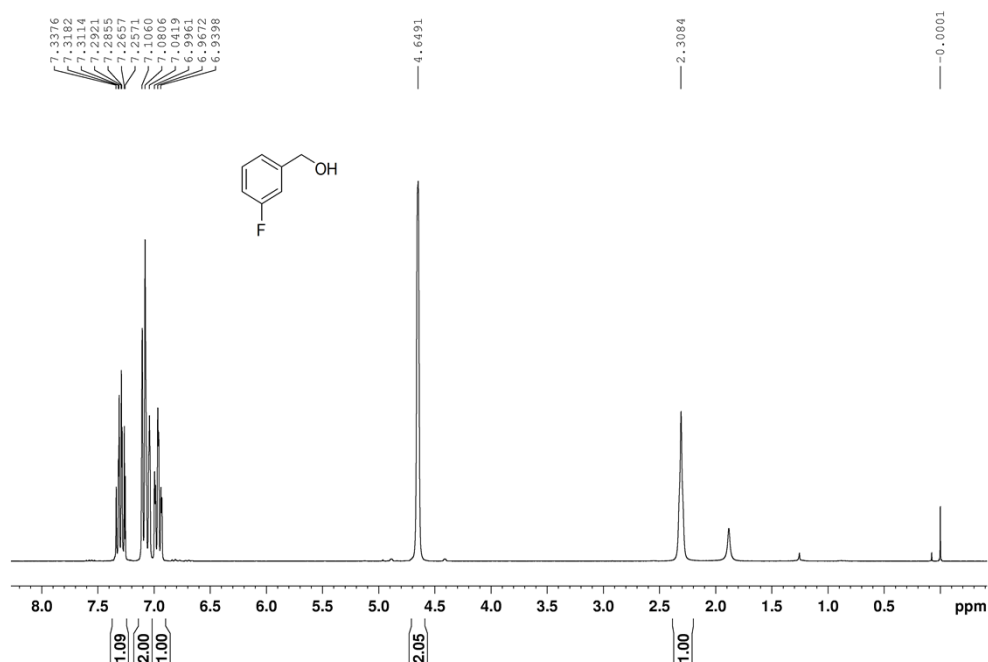
NMR spectra of 2j



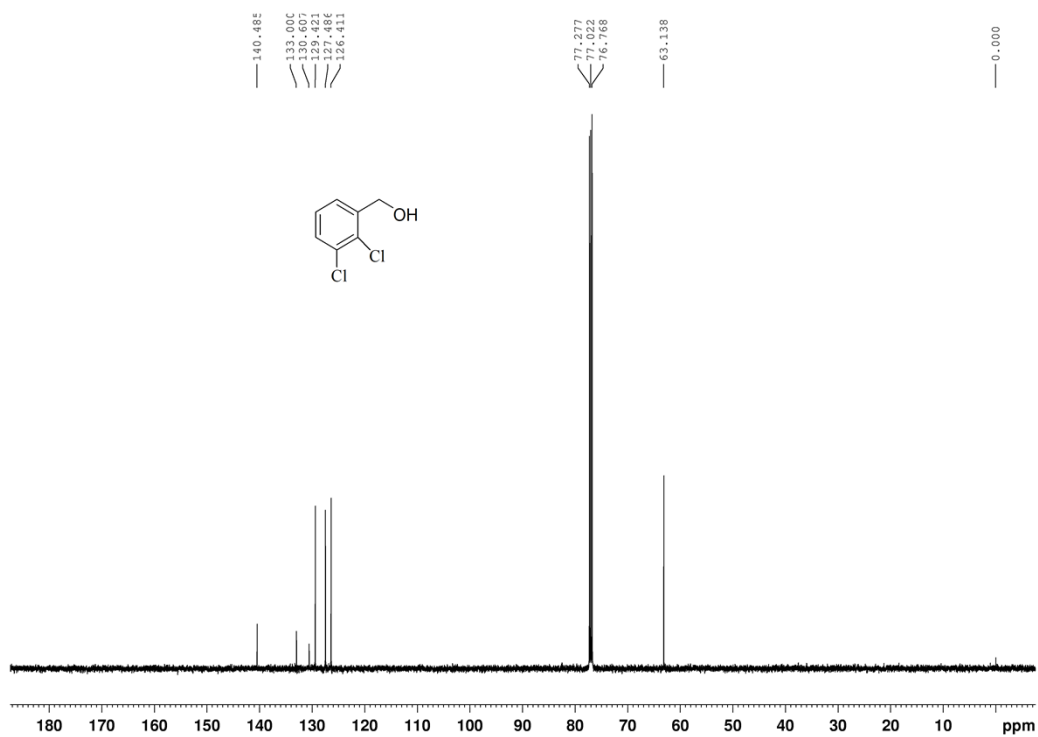
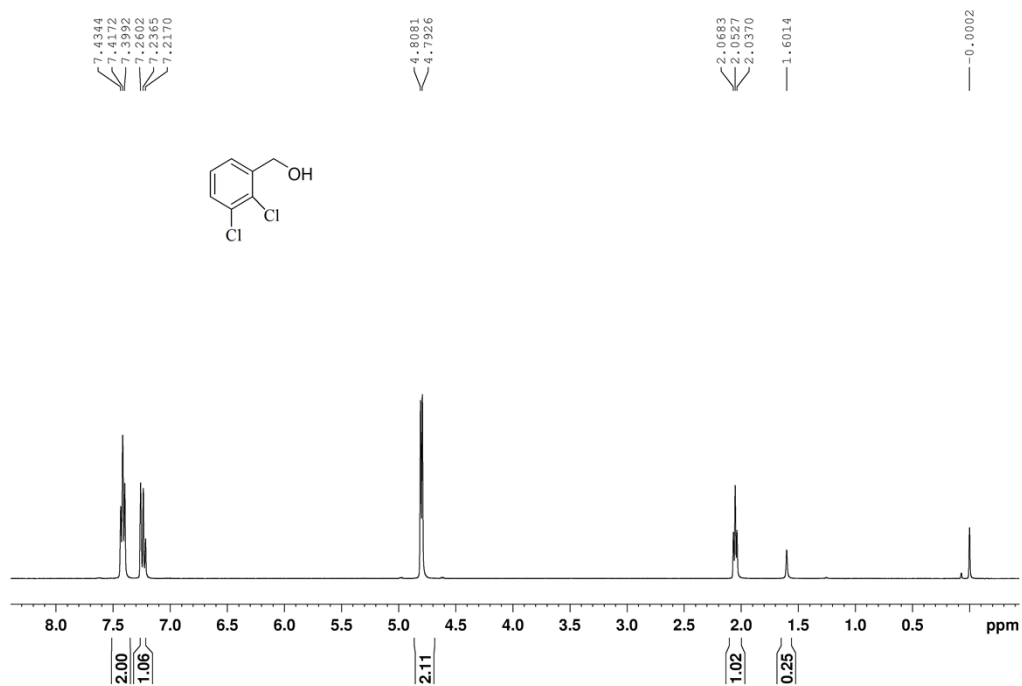
NMR spectra of 2k



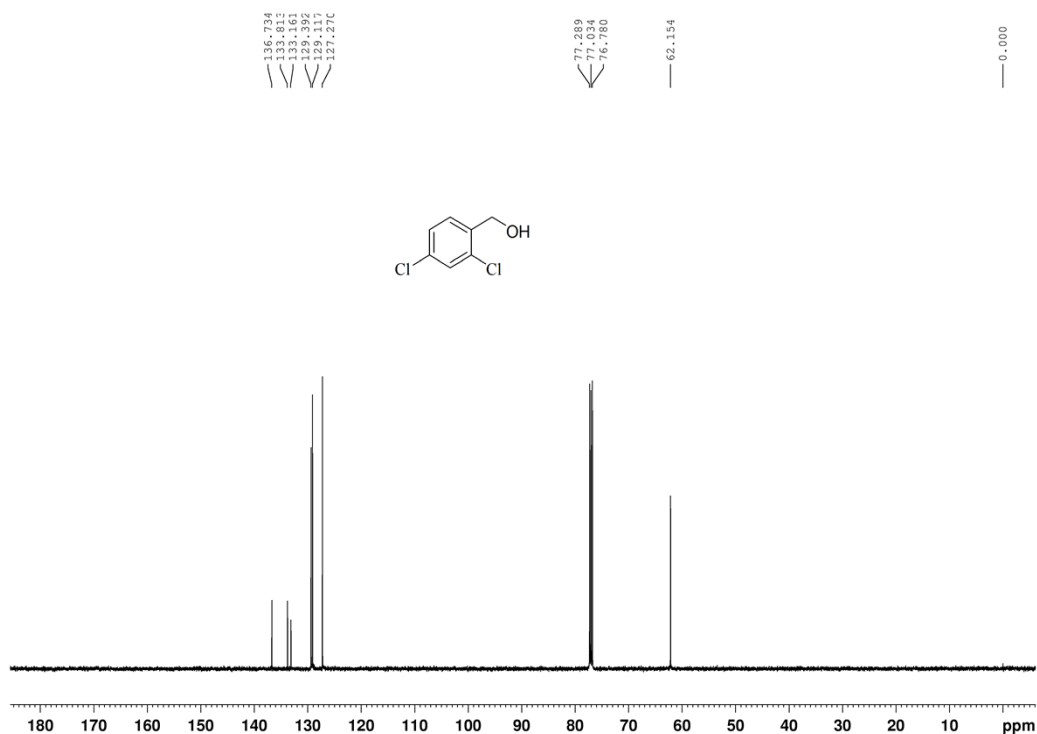
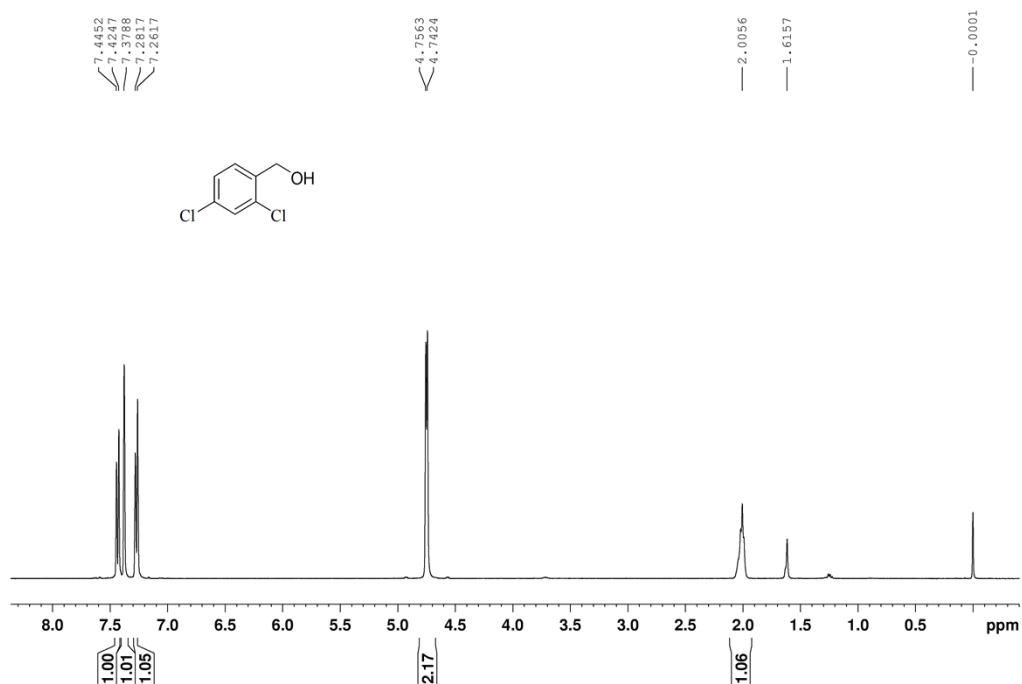
NMR spectra of 2l



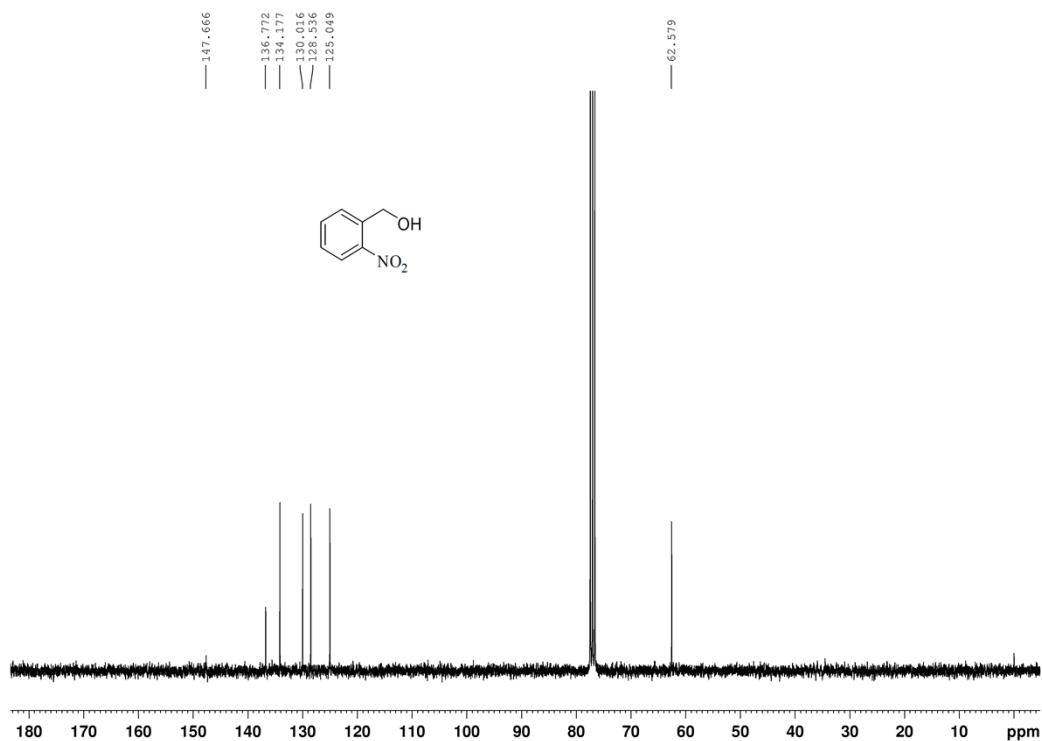
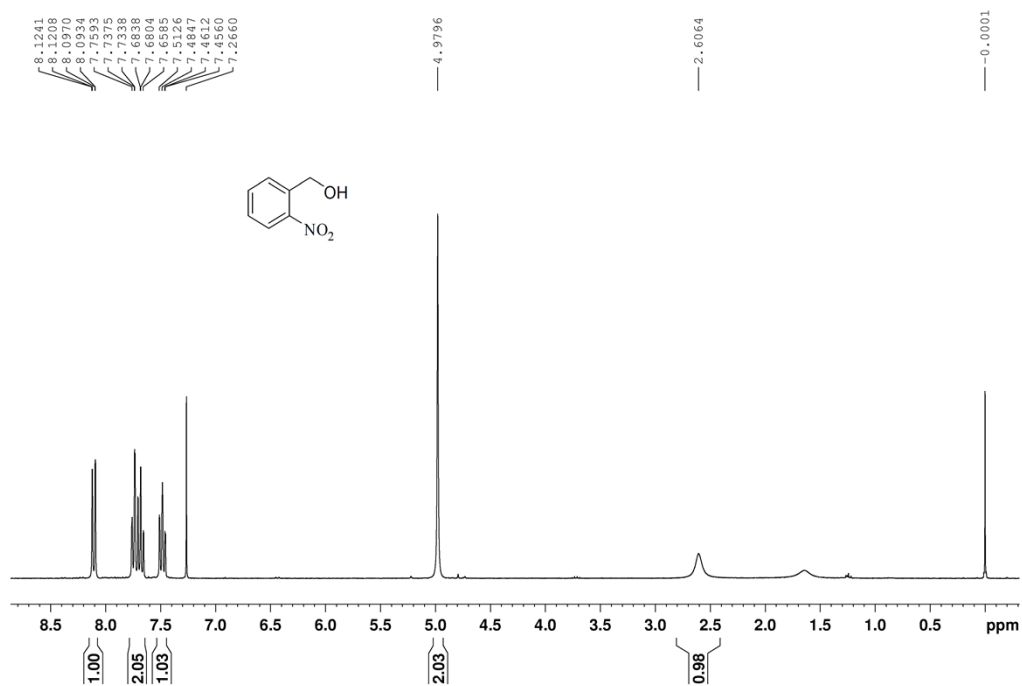
NMR spectra of 2m



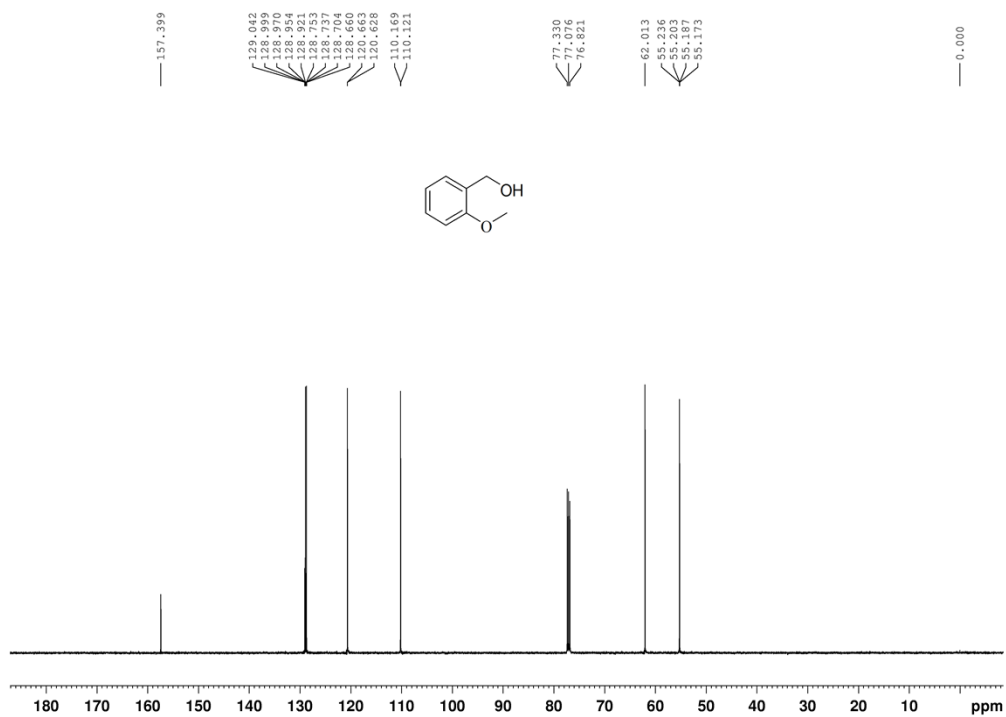
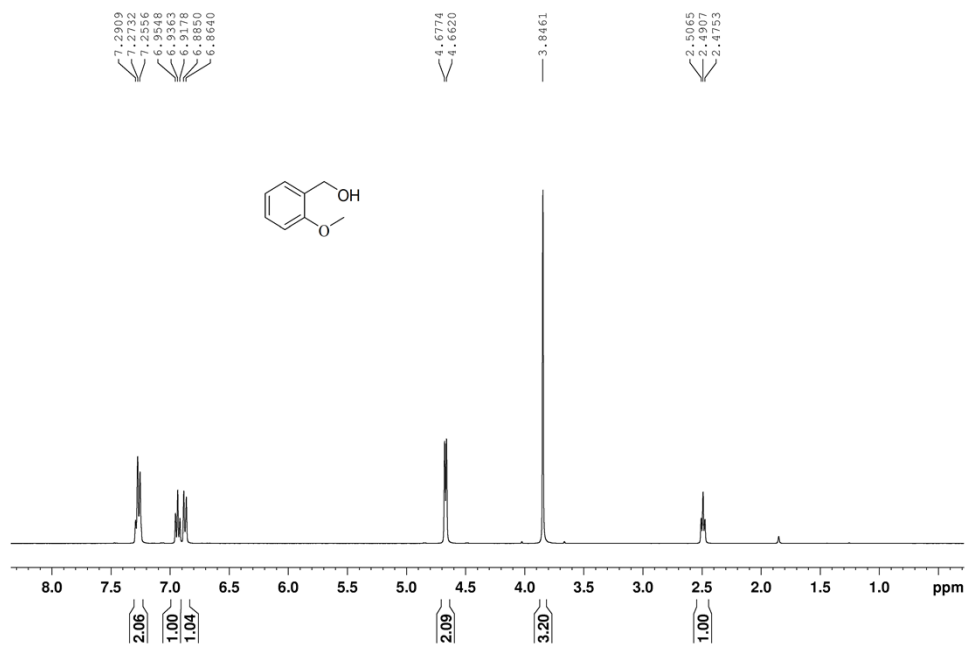
NMR spectra of 2n



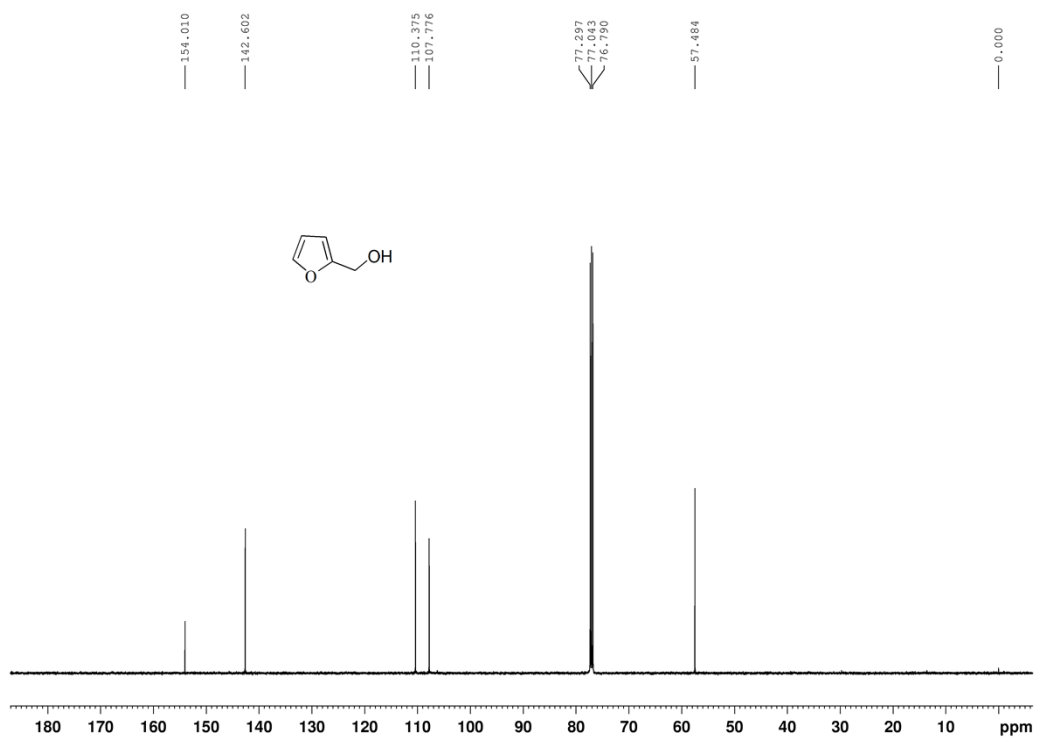
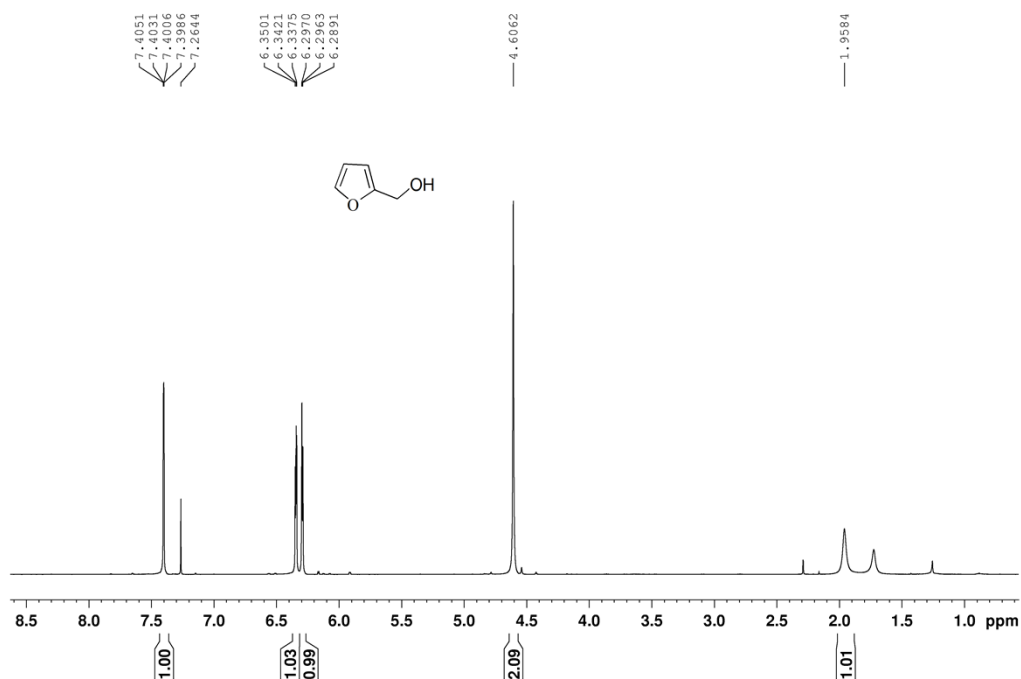
NMR spectra of 2o



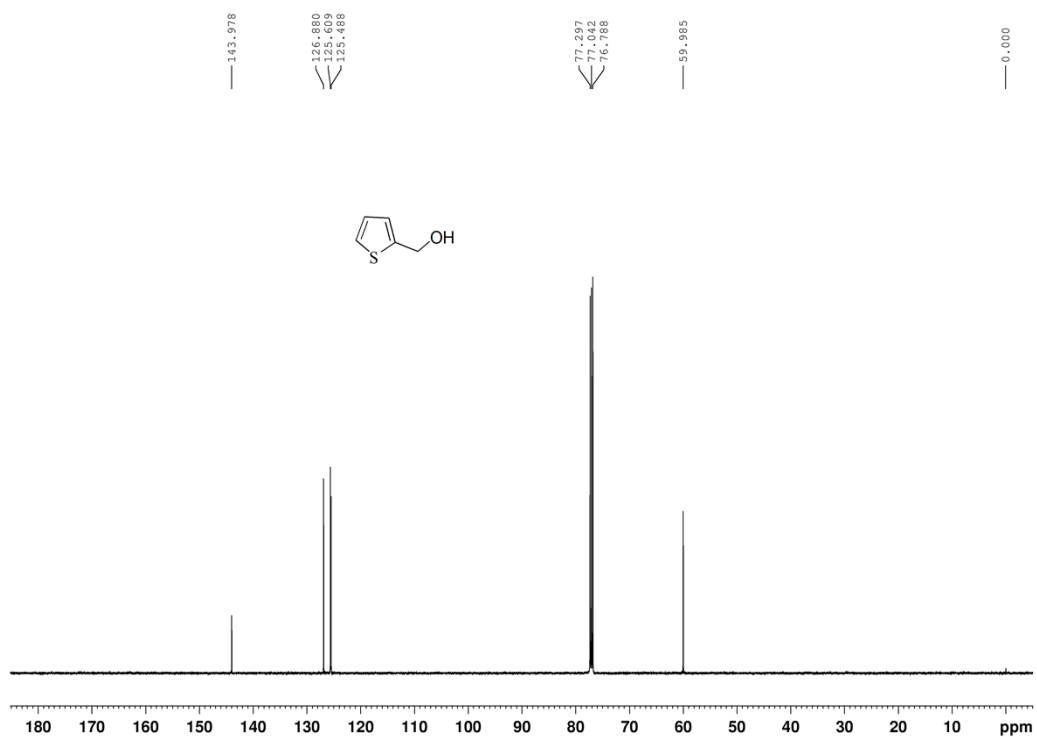
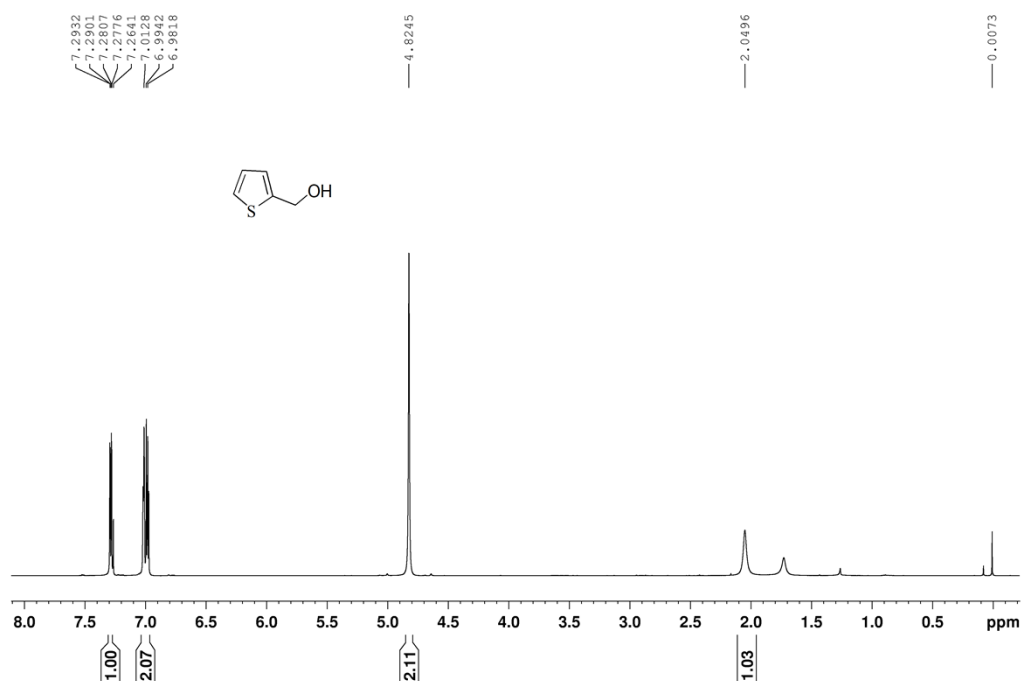
NMR spectra of 2p



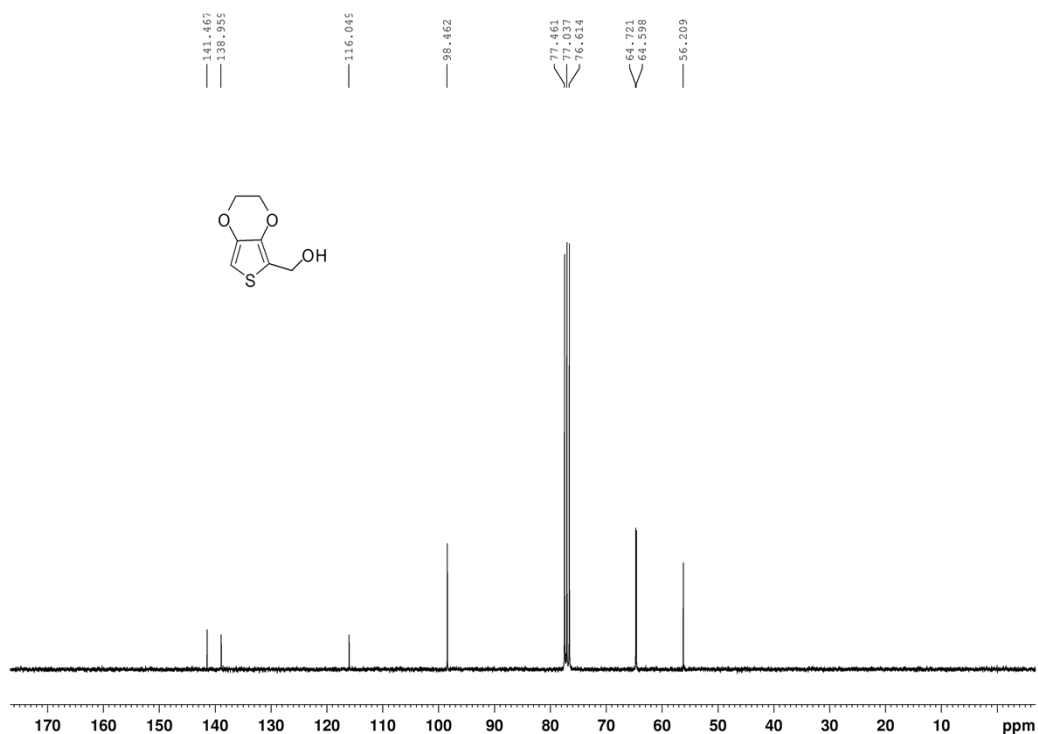
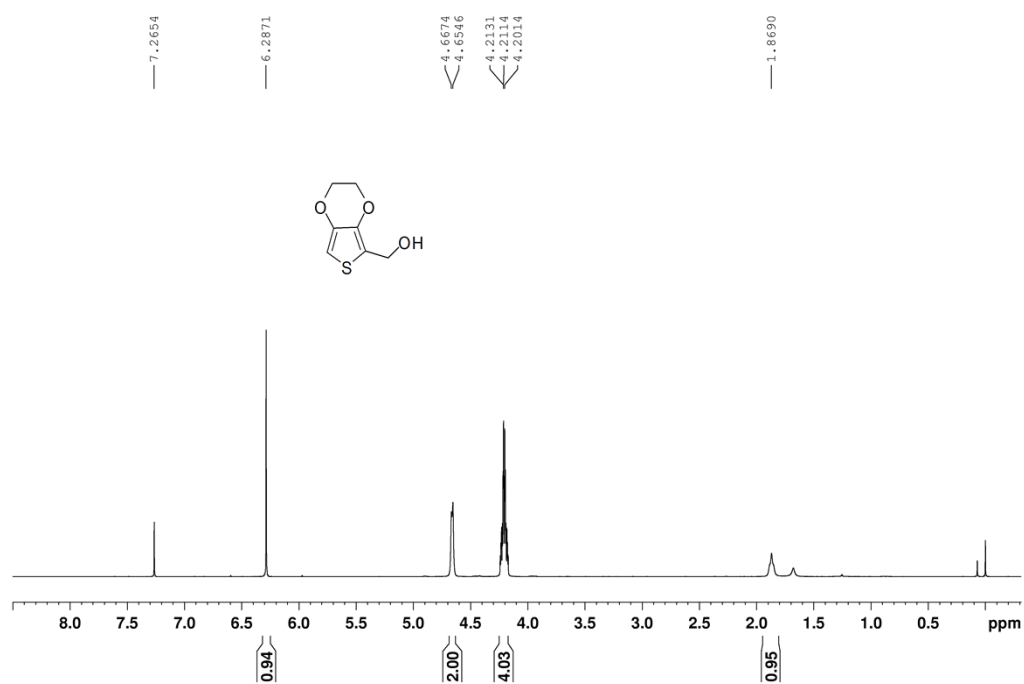
NMR spectra of 2q



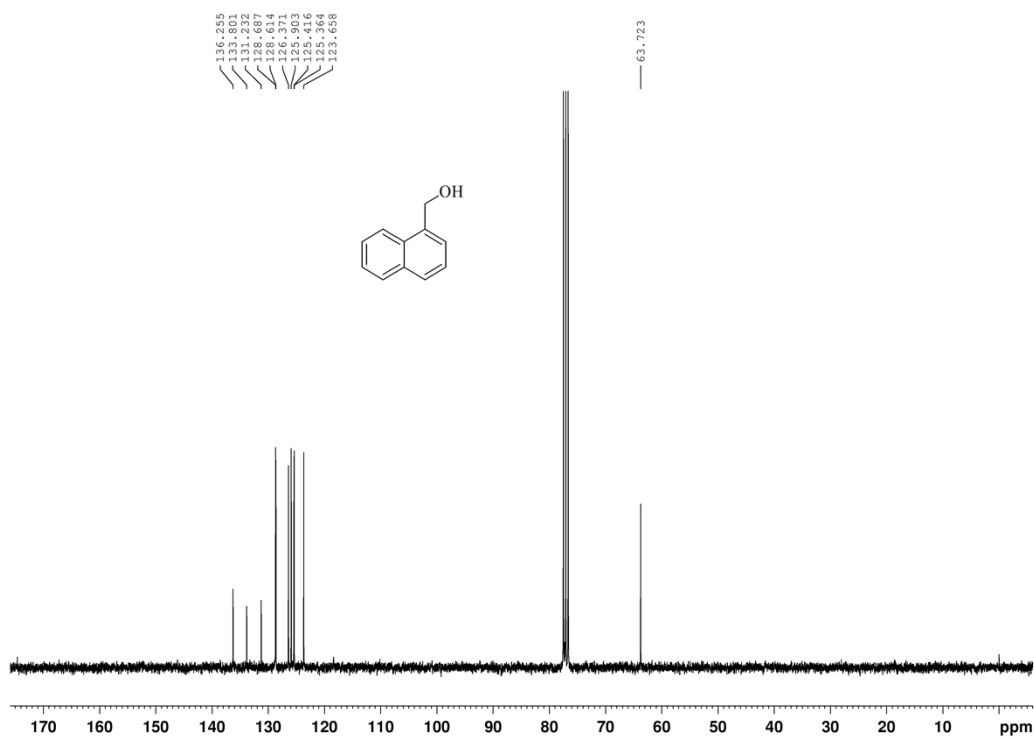
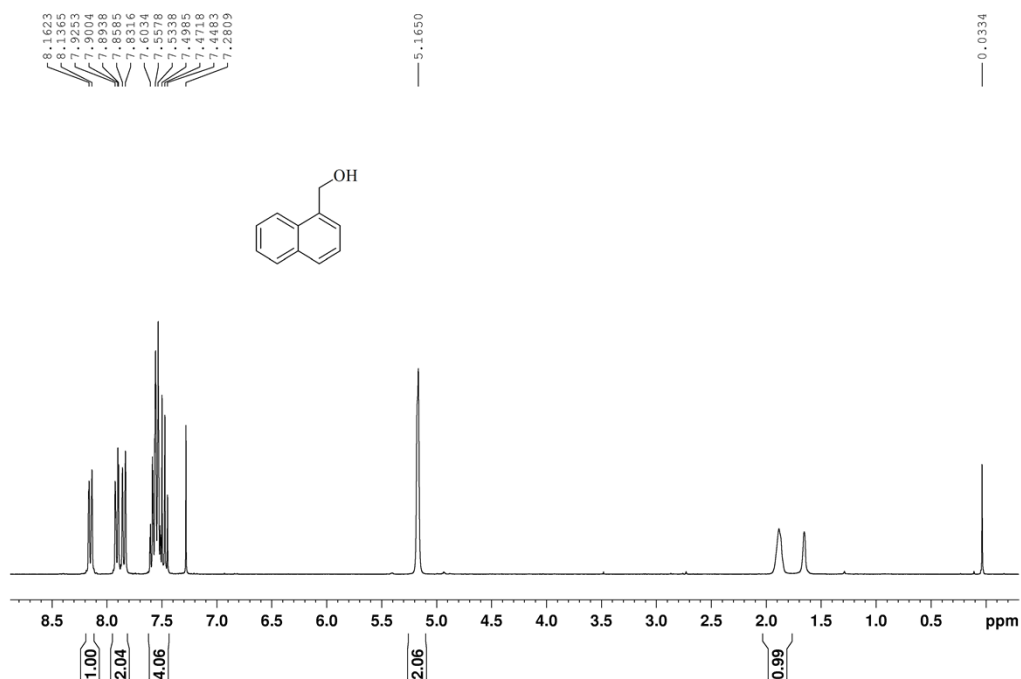
NMR spectra of 2r



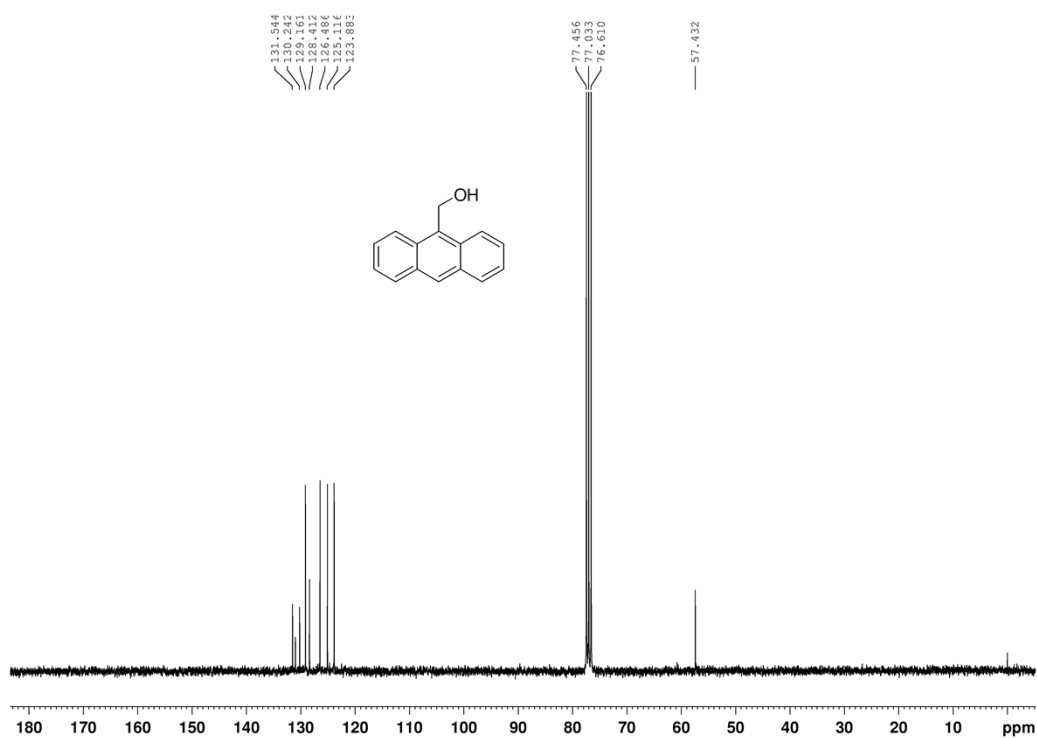
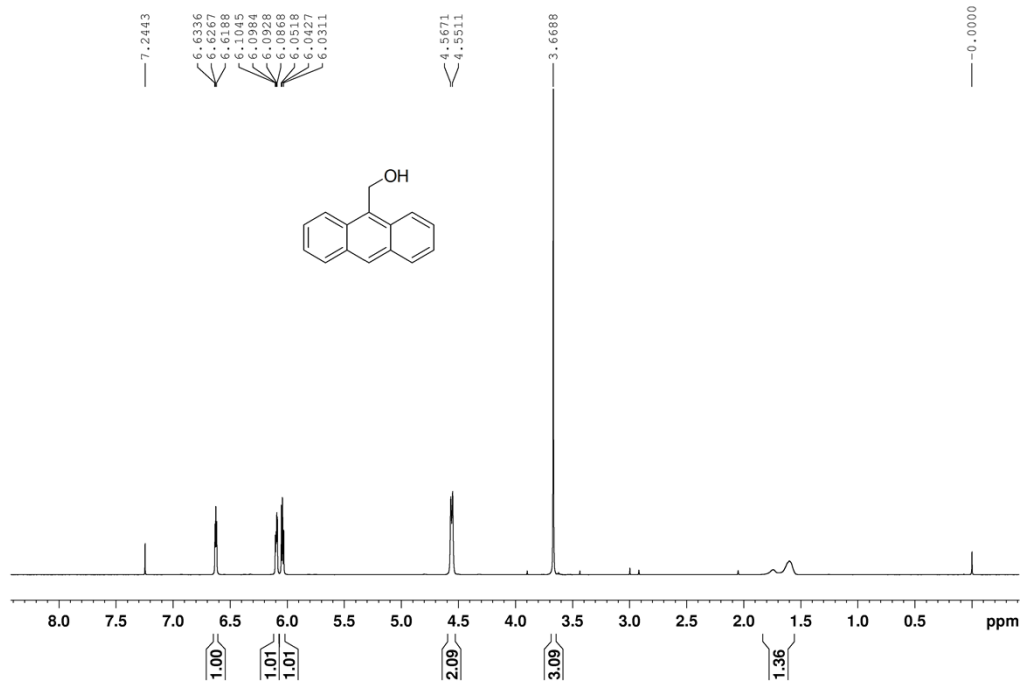
NMR spectra of 2s



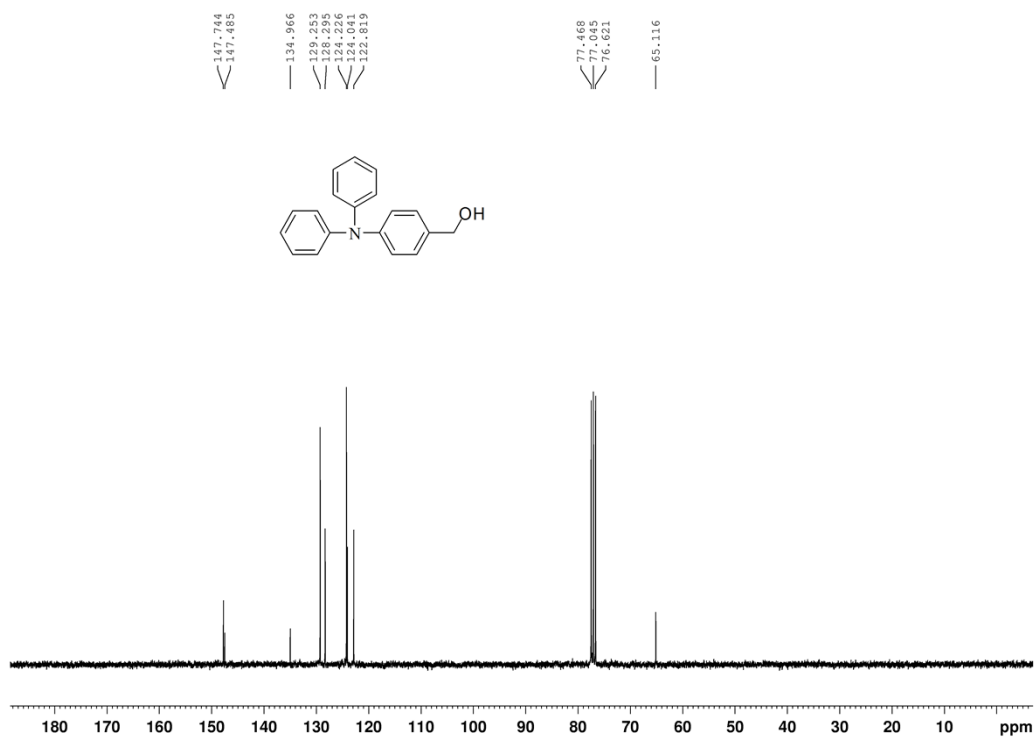
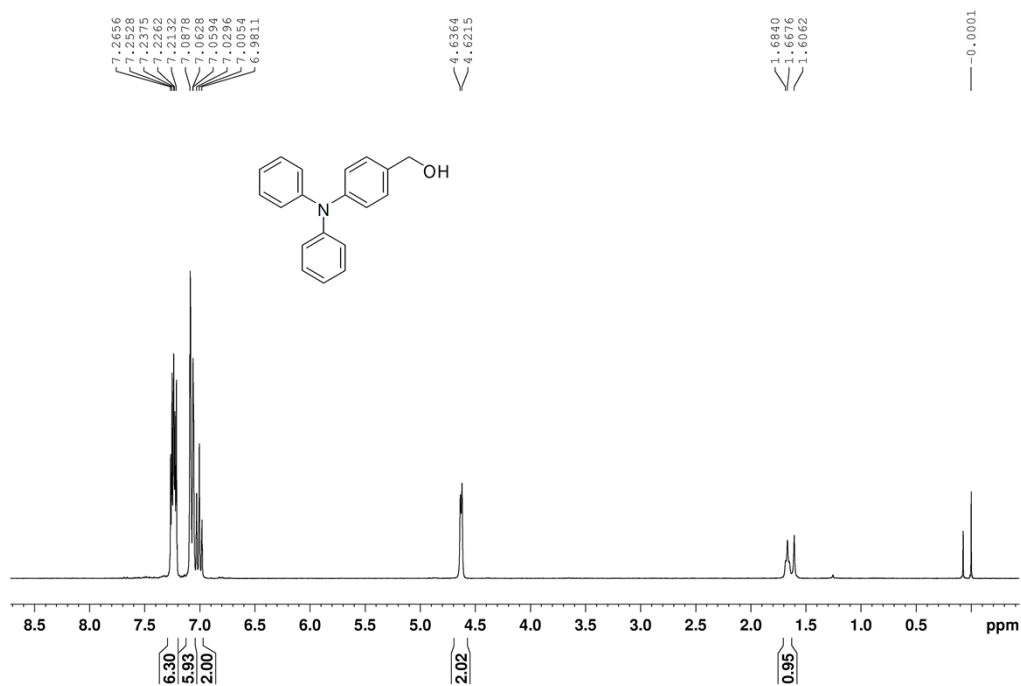
NMR spectra of 2t



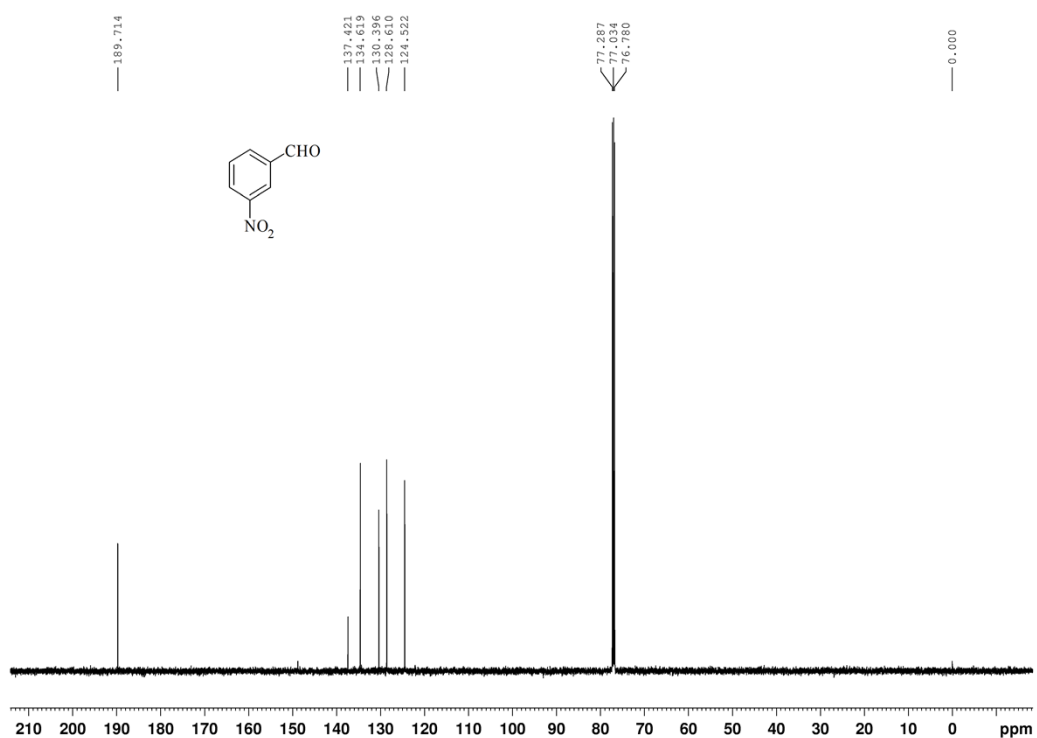
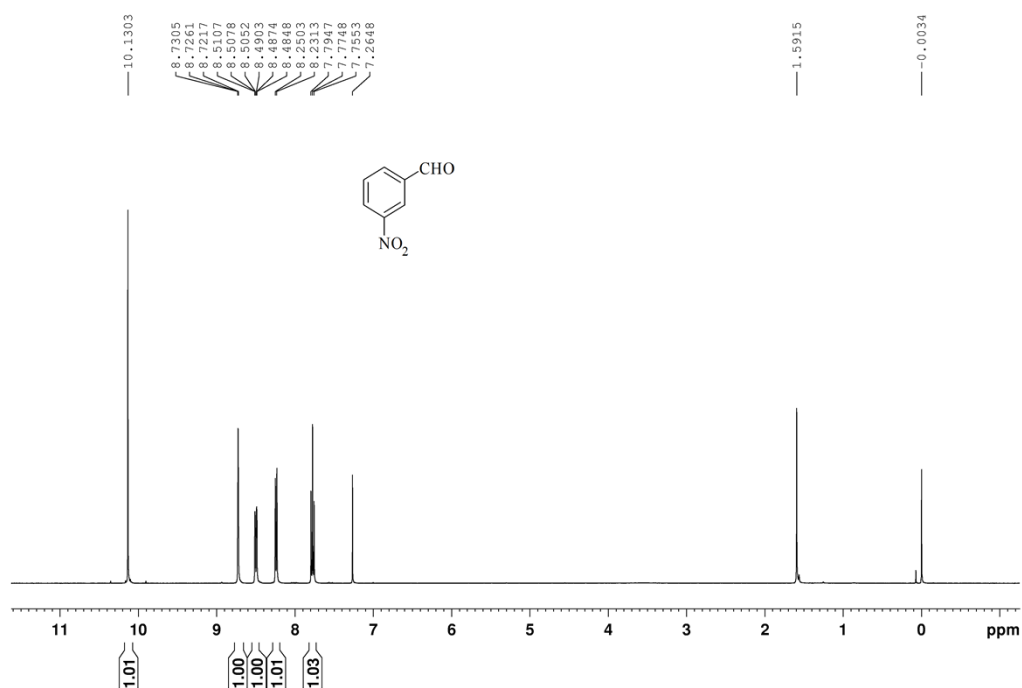
NMR spectra of 2u



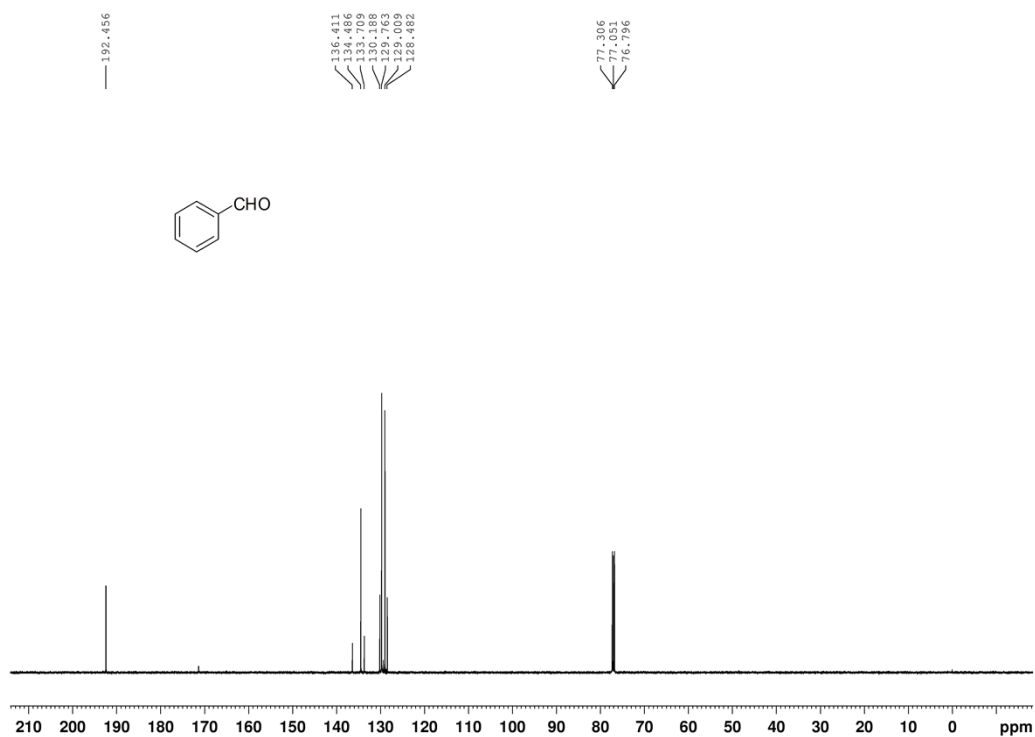
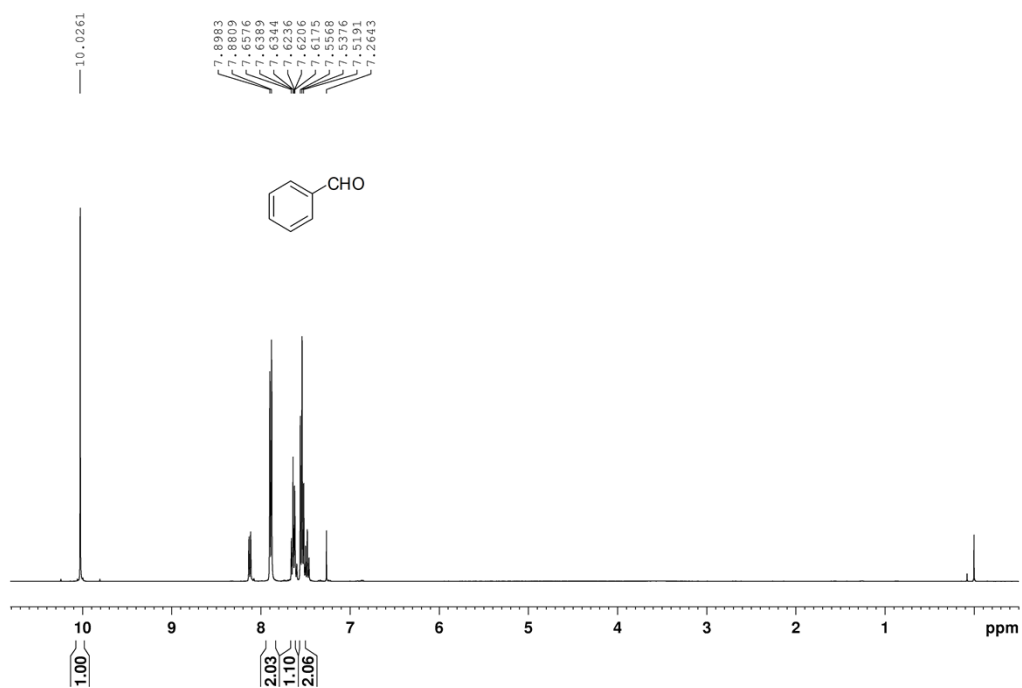
NMR spectra of 2v



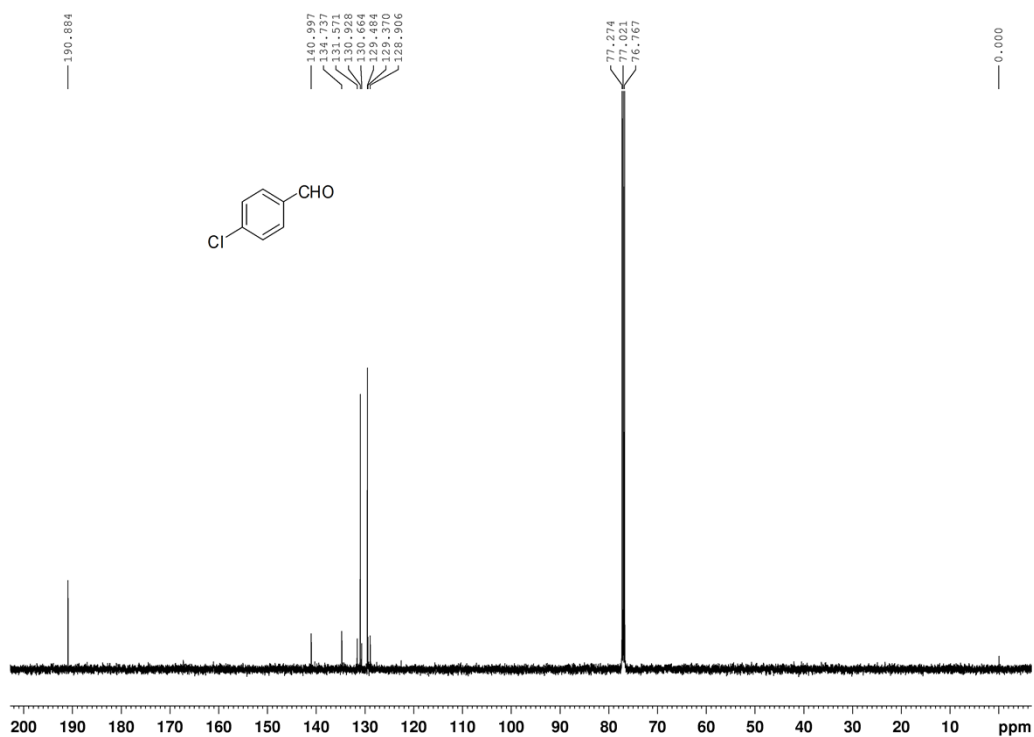
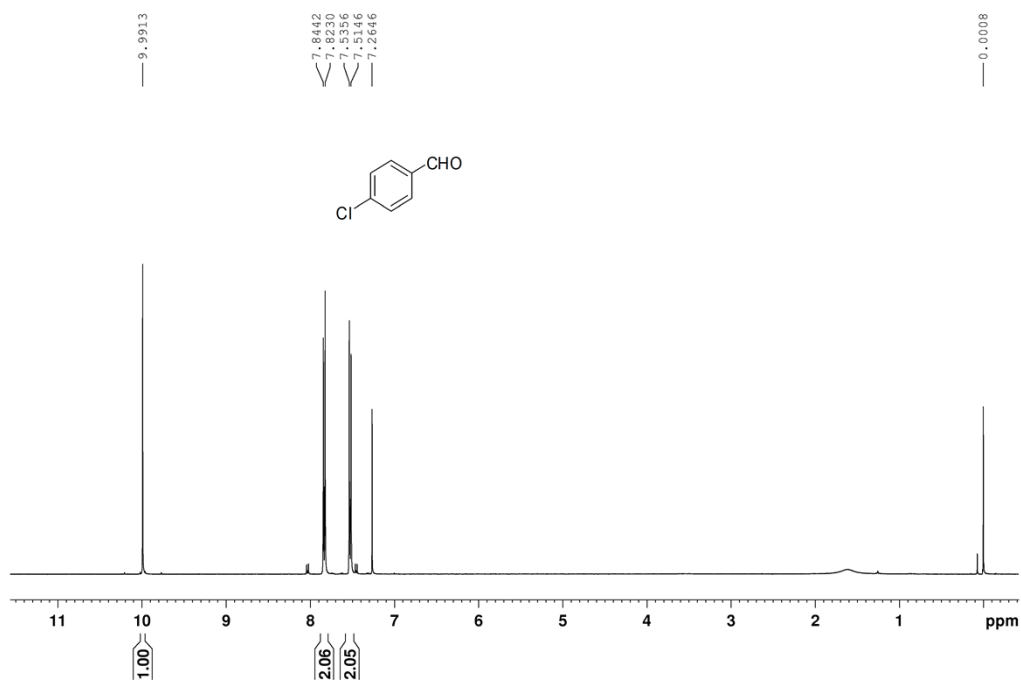
NMR spectra of 3a



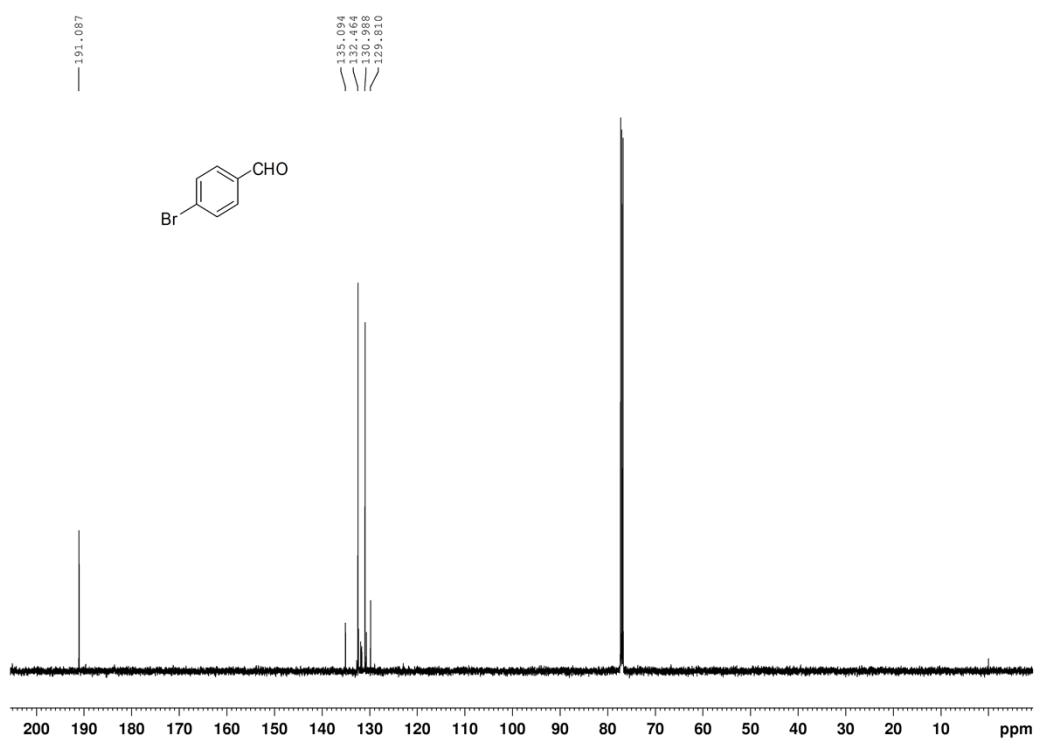
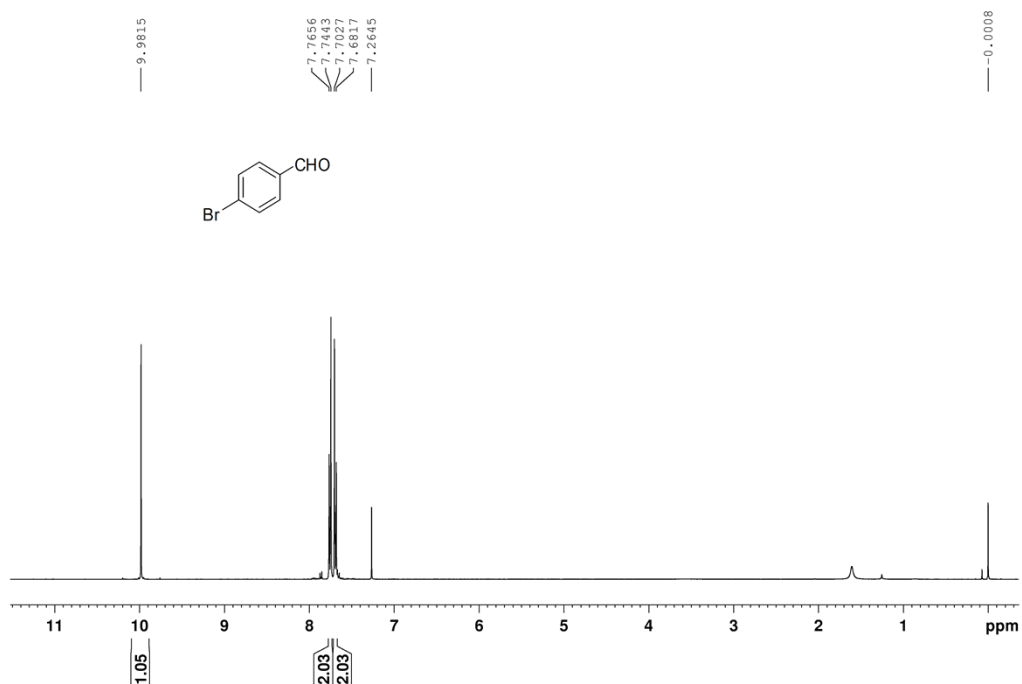
NMR spectra of 3b



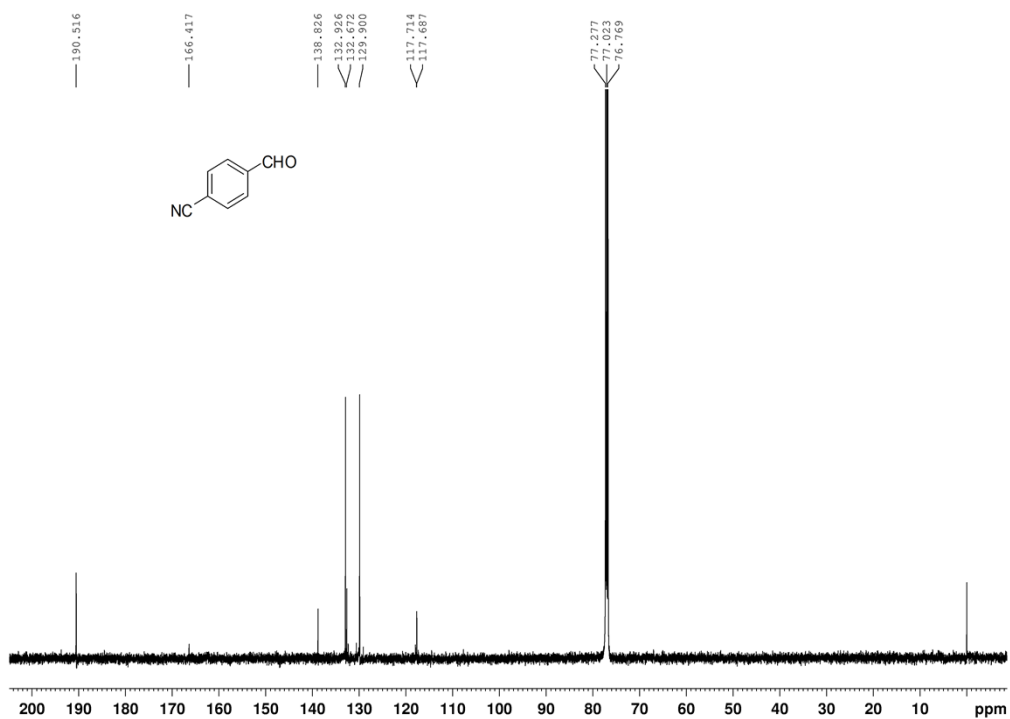
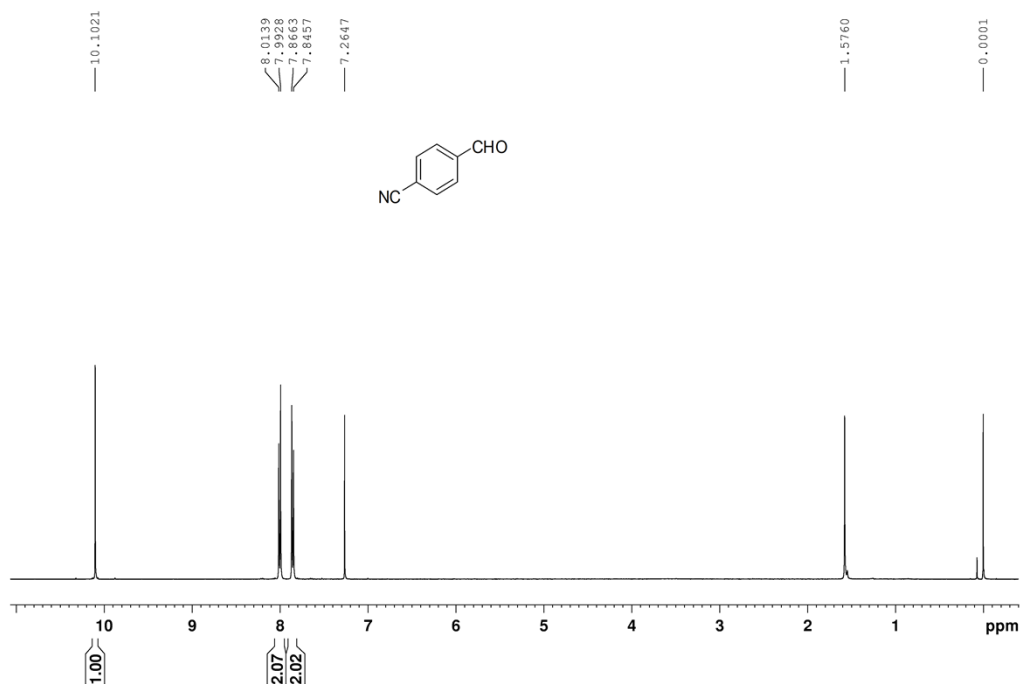
NMR spectra of 3c



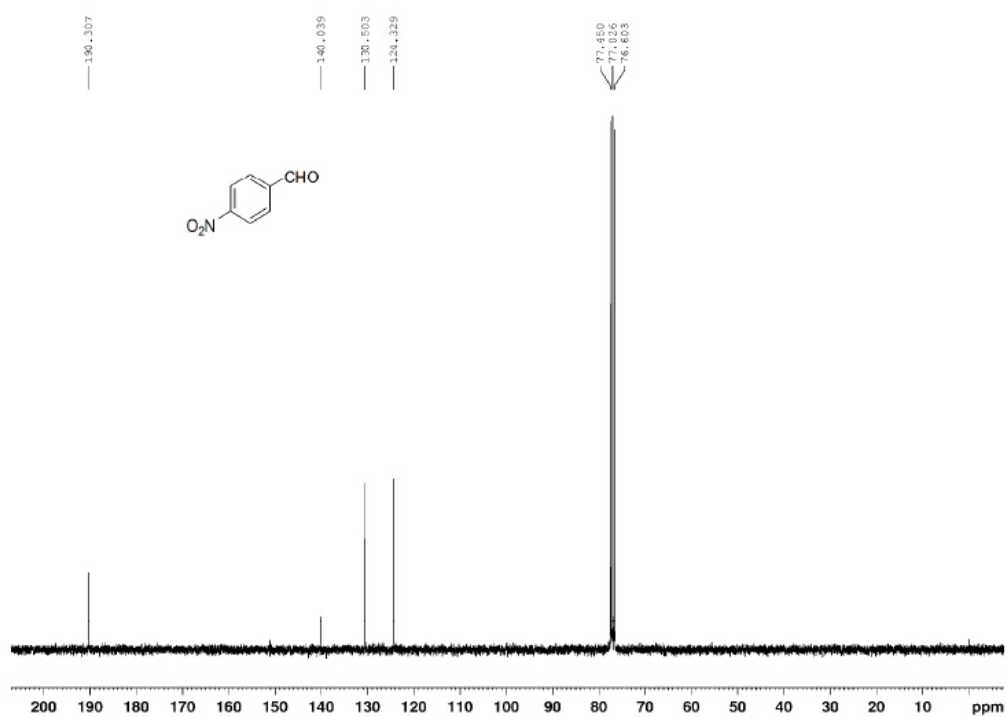
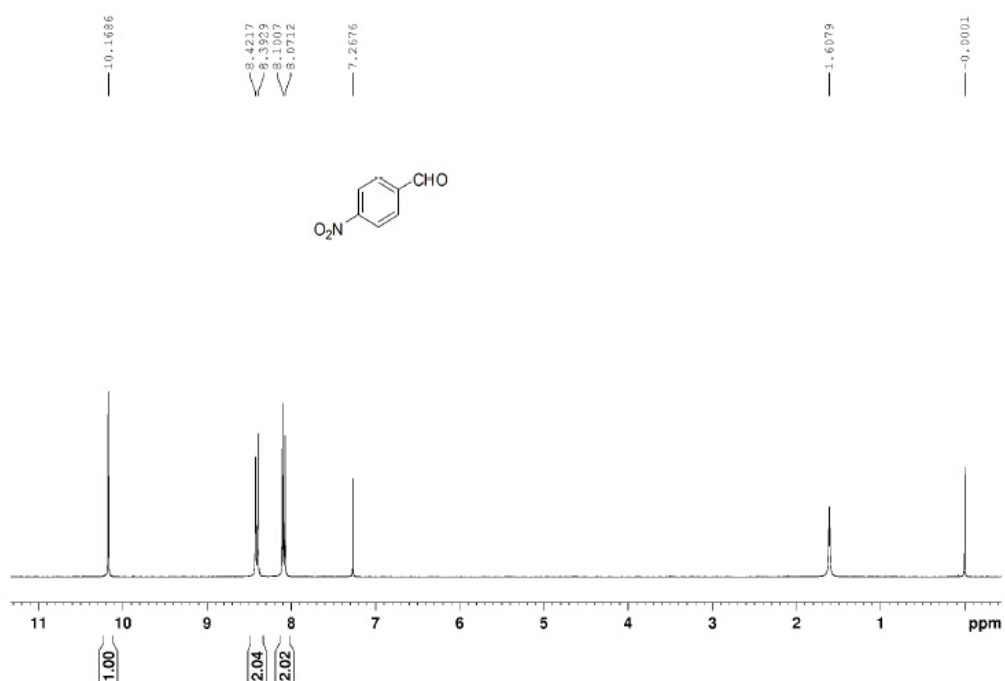
NMR spectra of 3d



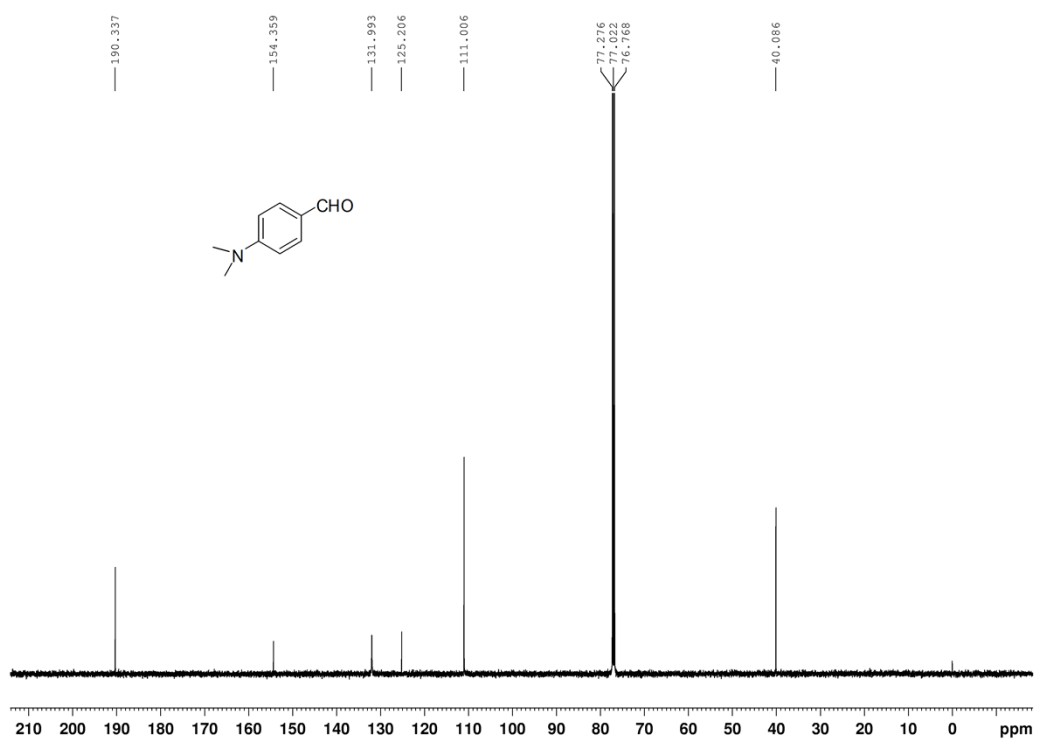
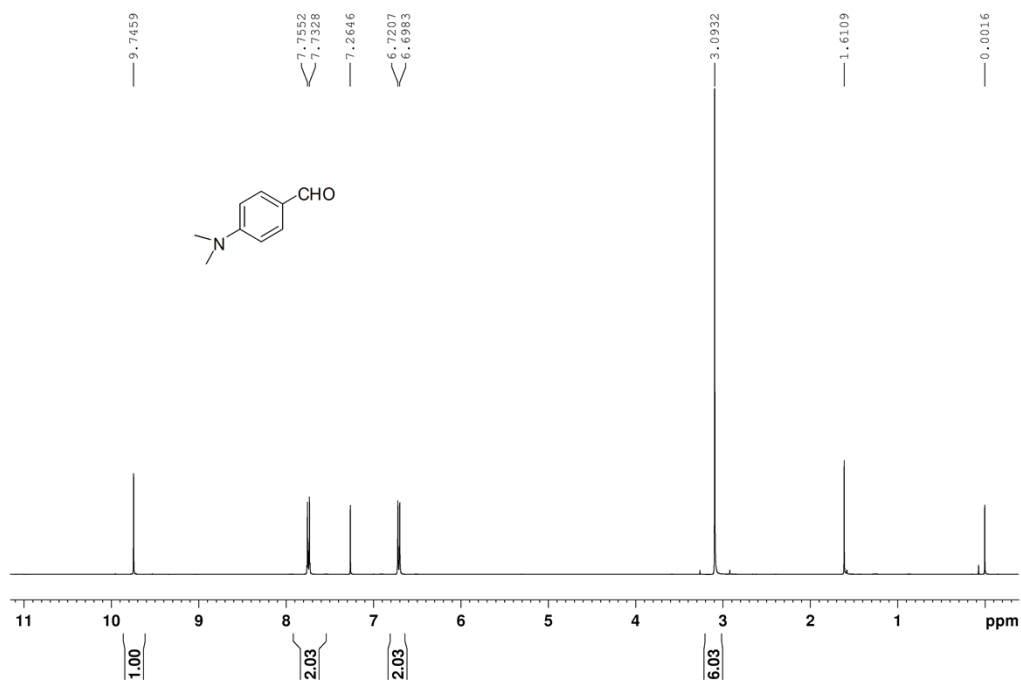
NMR spectra of 3e



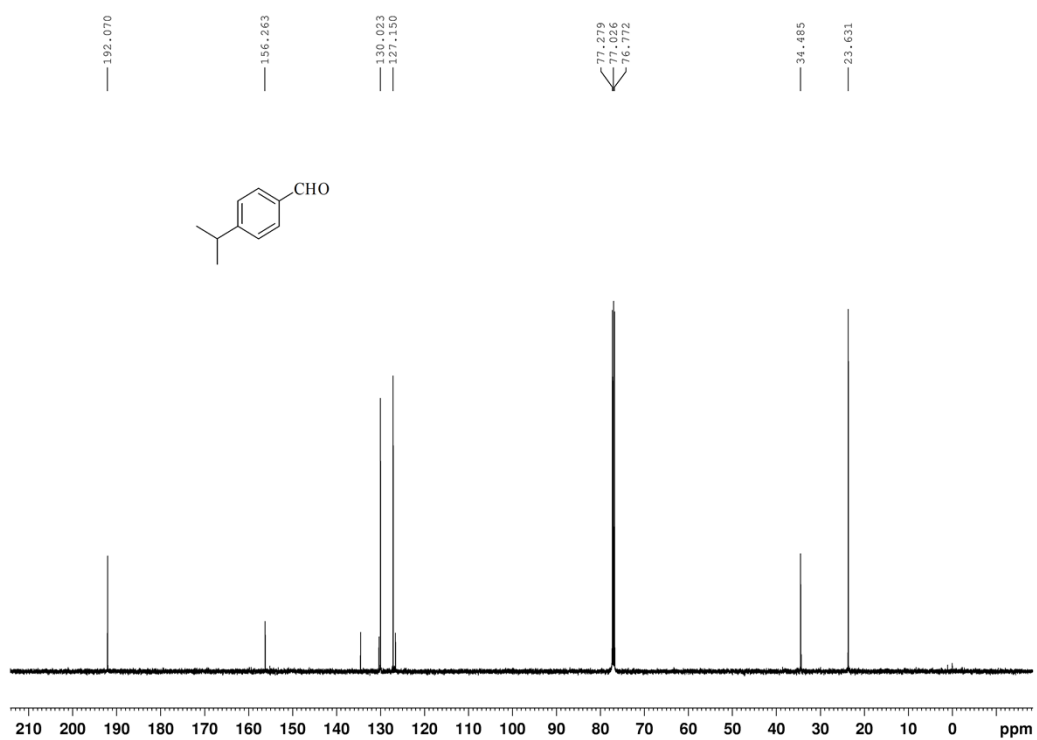
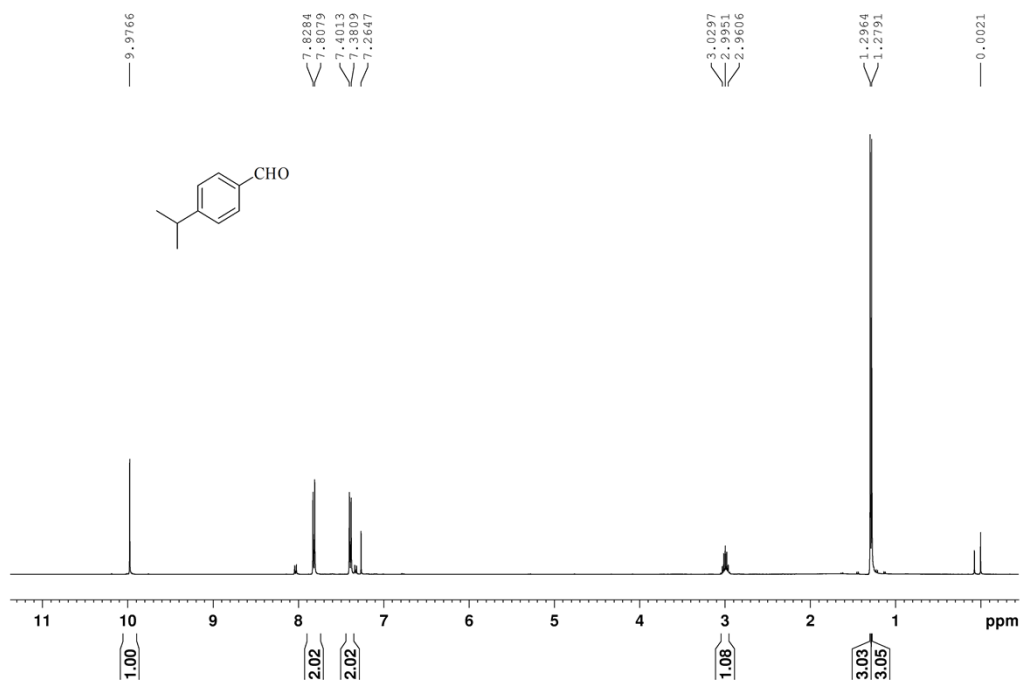
NMR spectra of 3f



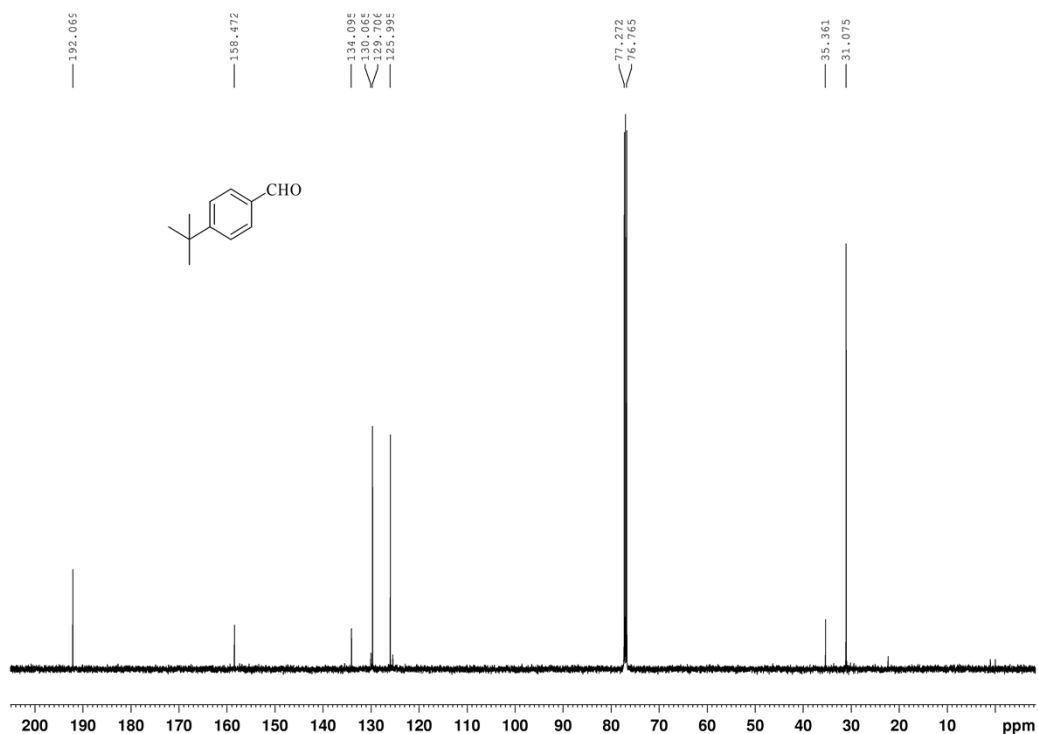
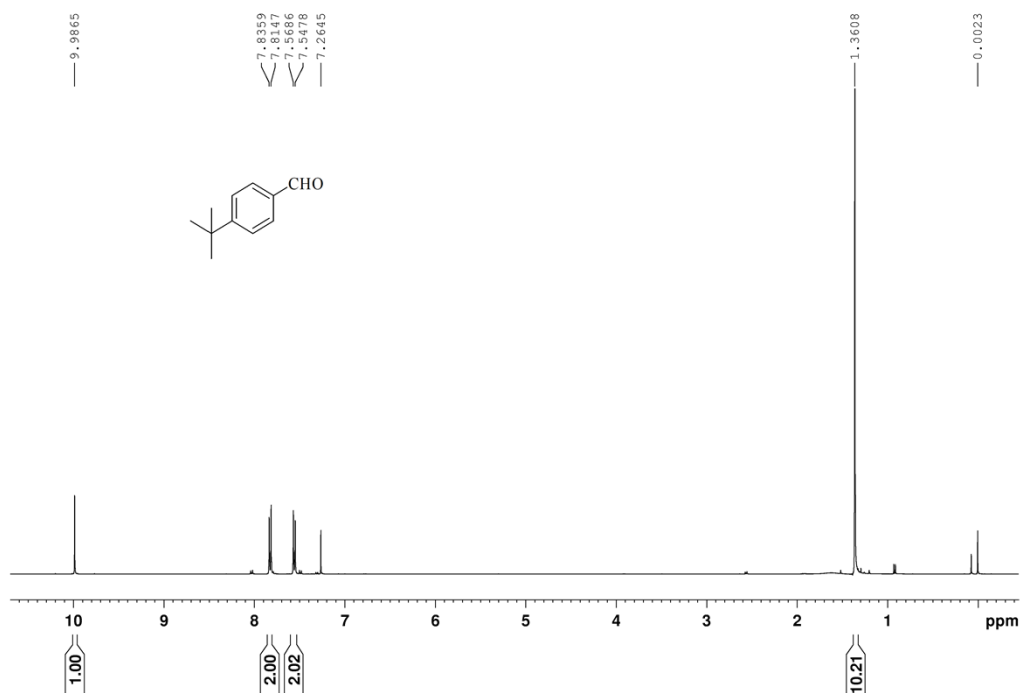
NMR spectra of 3g



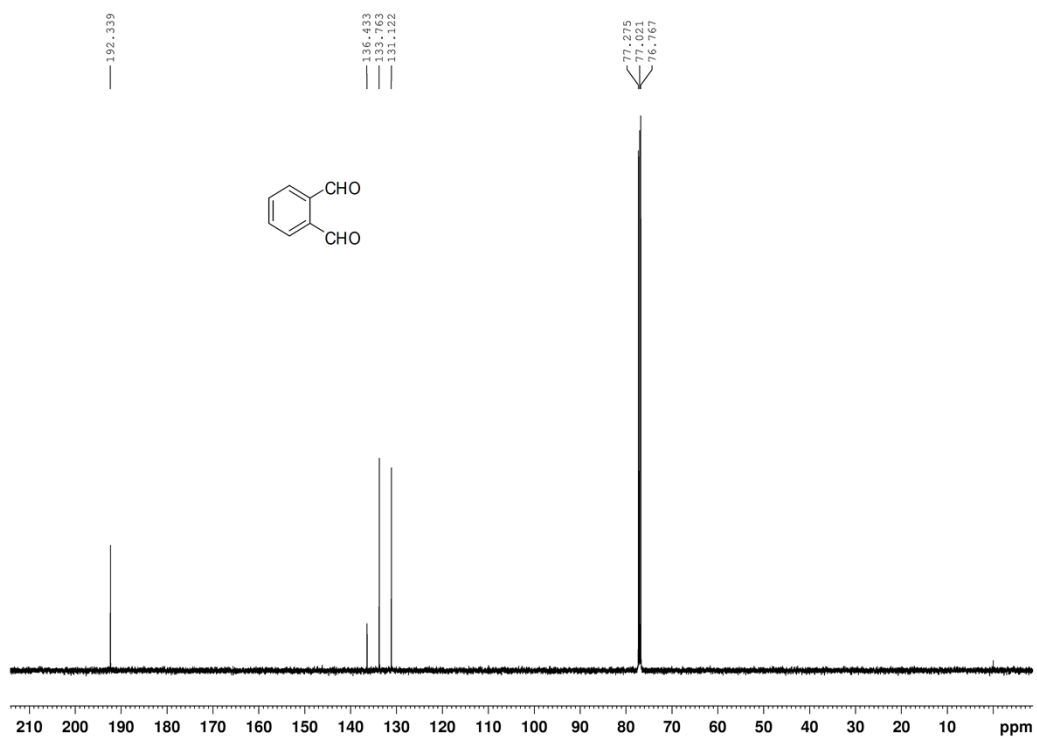
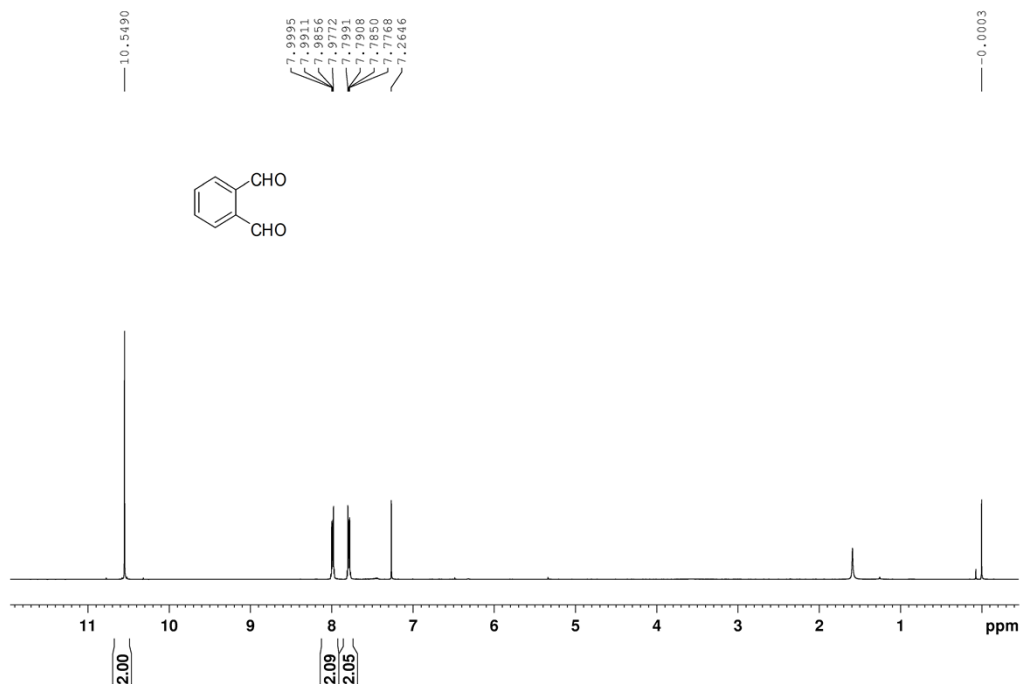
NMR spectra of 3h



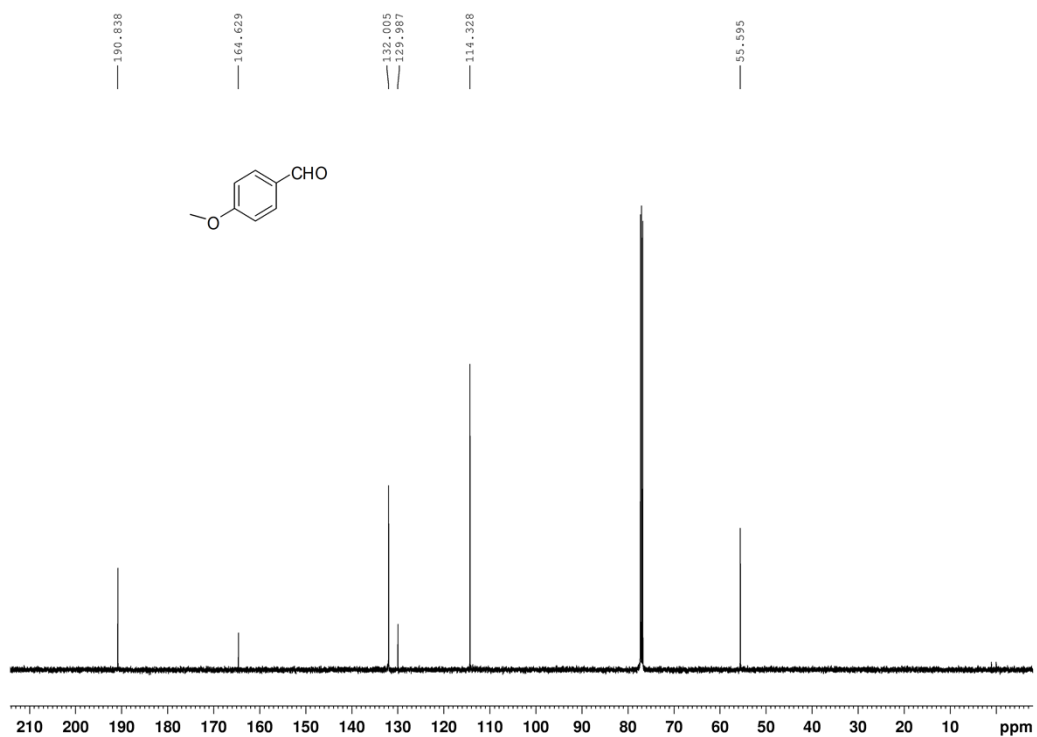
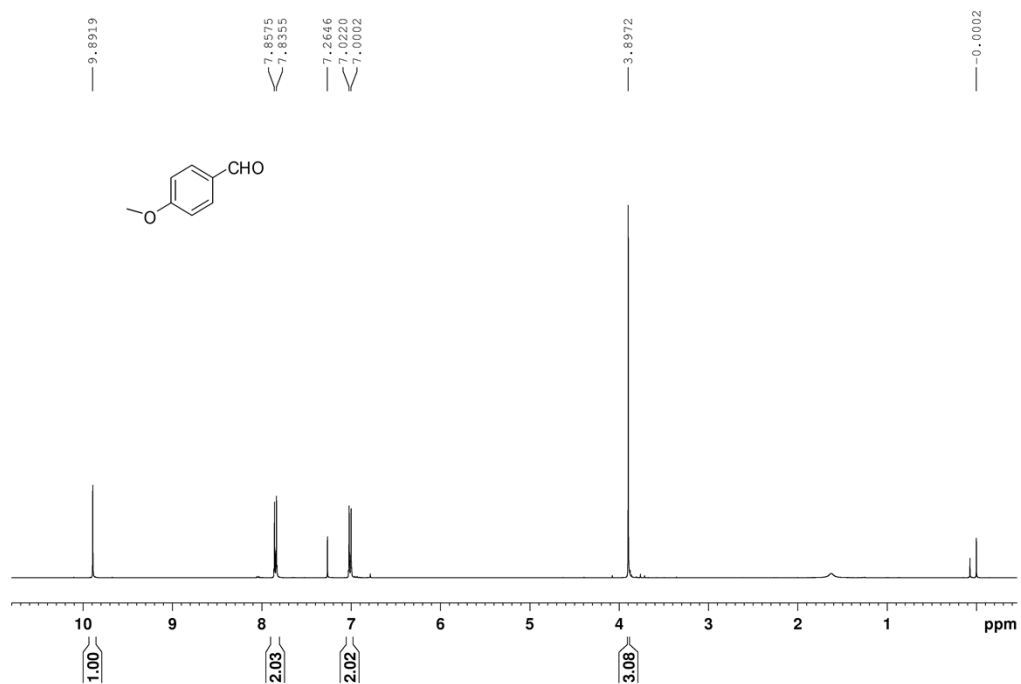
NMR spectra of 3i



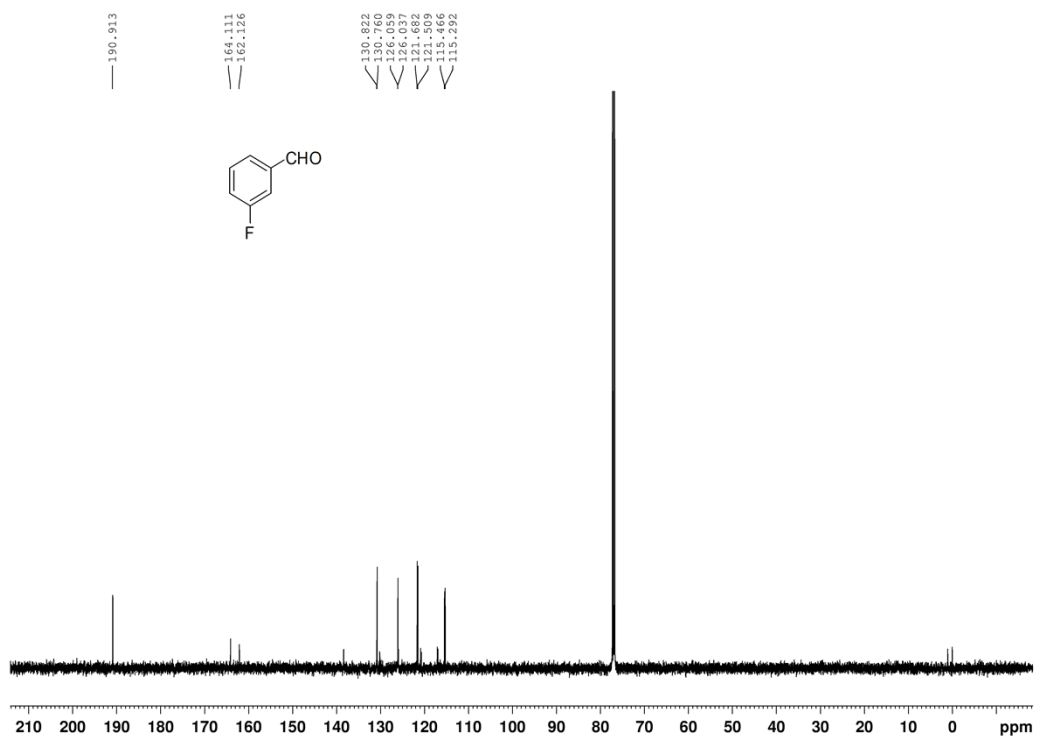
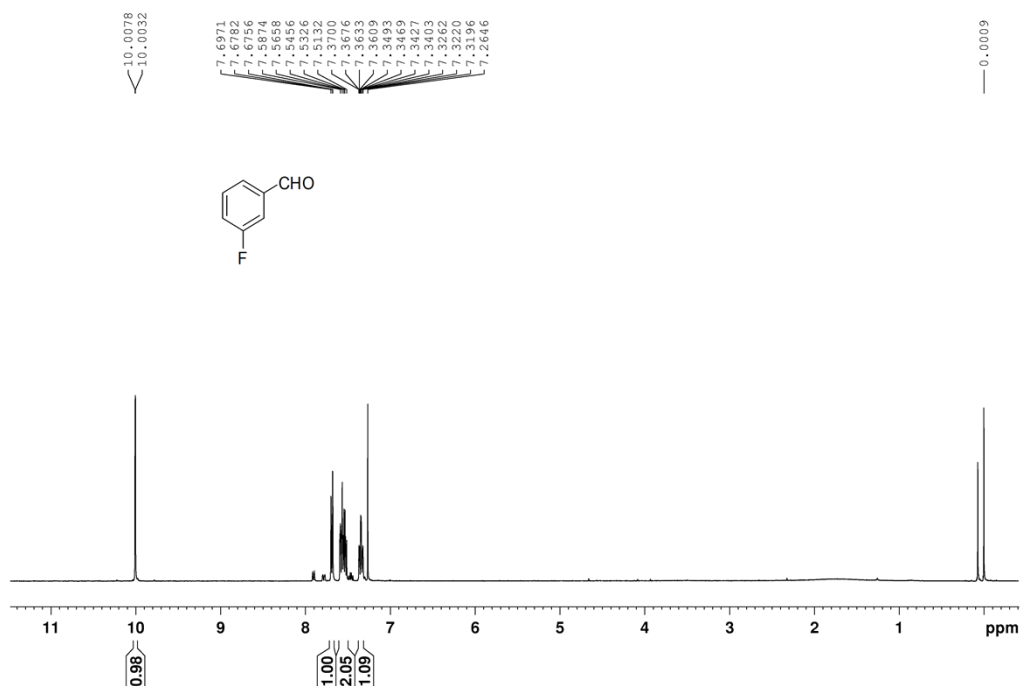
NMR spectra of 3j



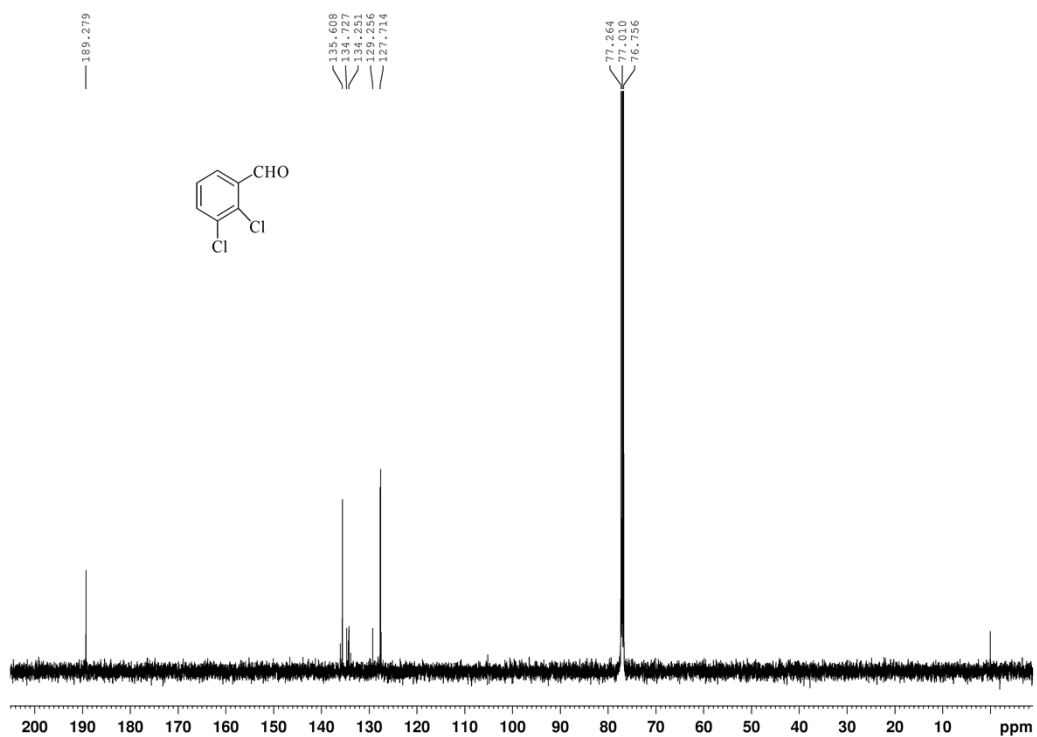
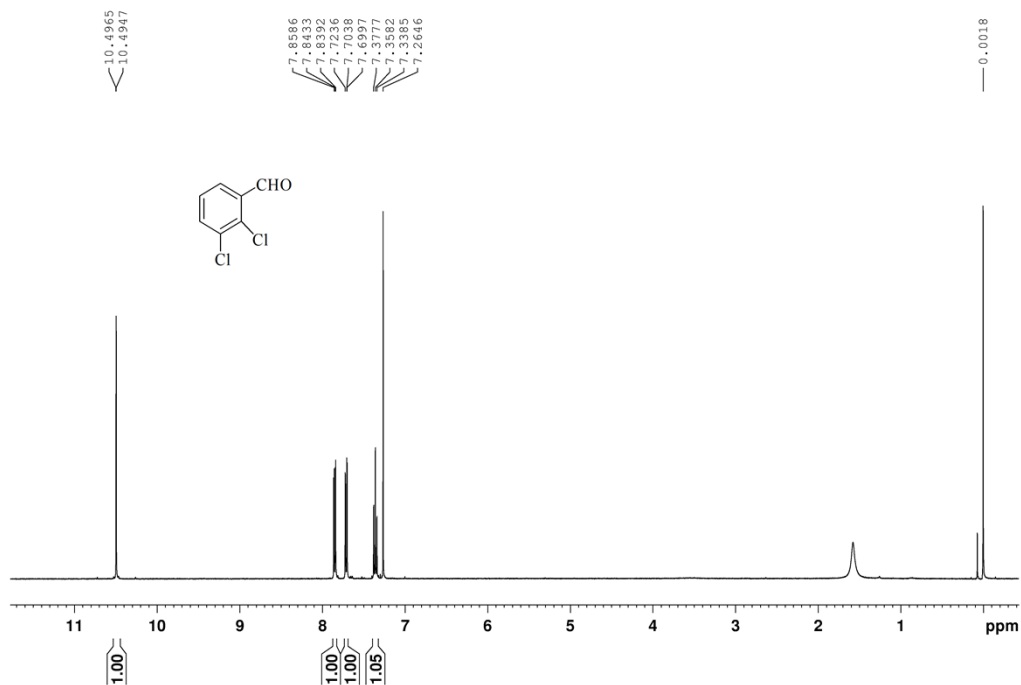
NMR spectra of 3k



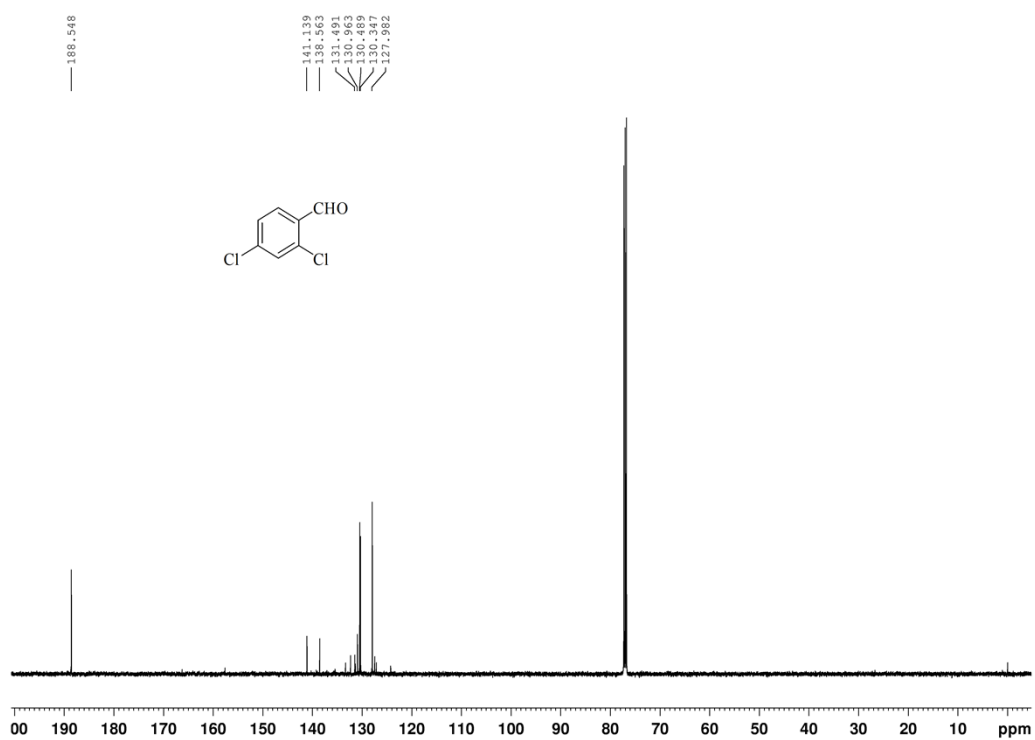
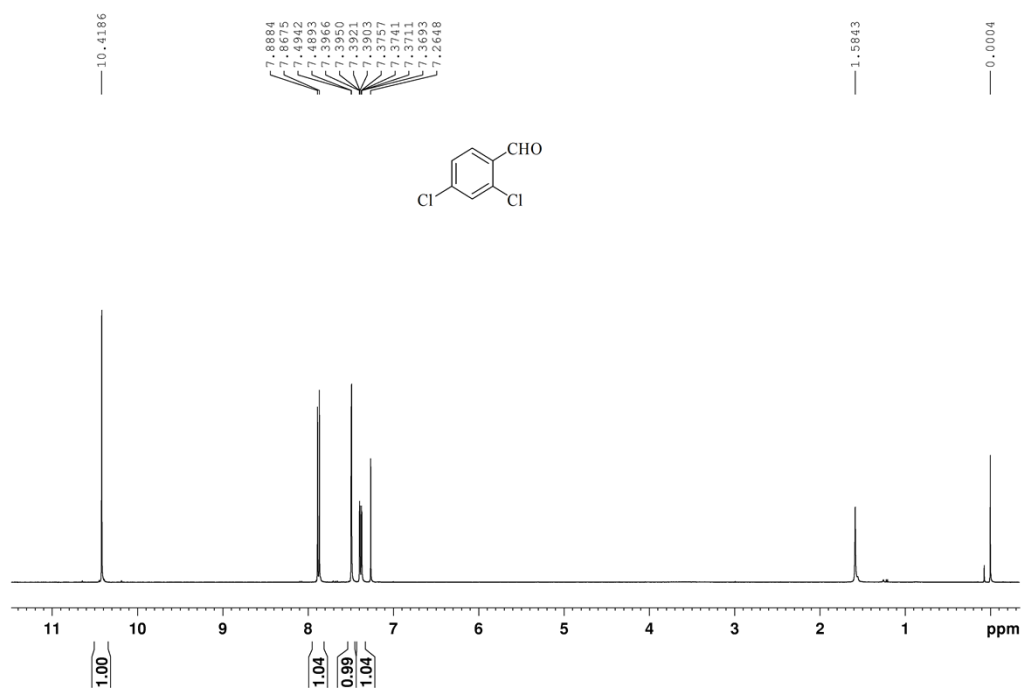
NMR spectra of 3l



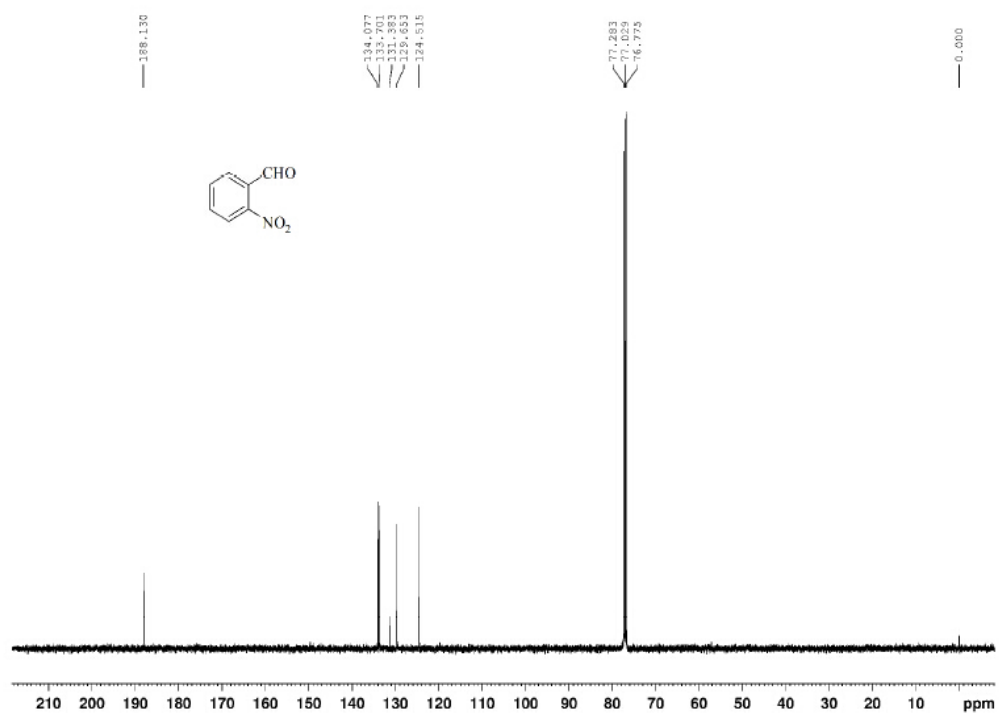
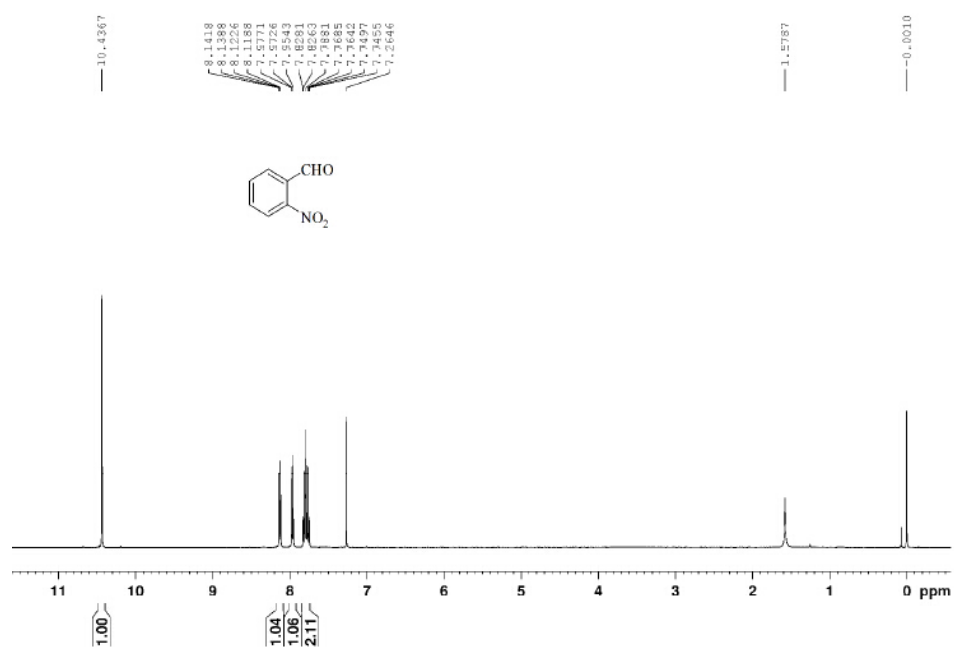
NMR spectra of 3m



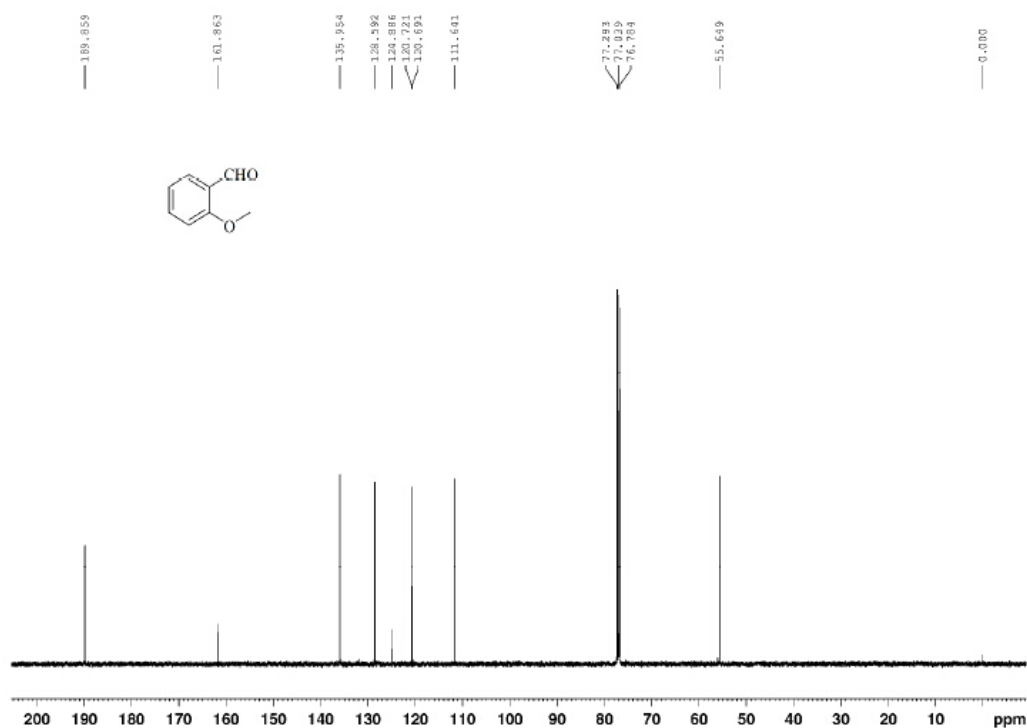
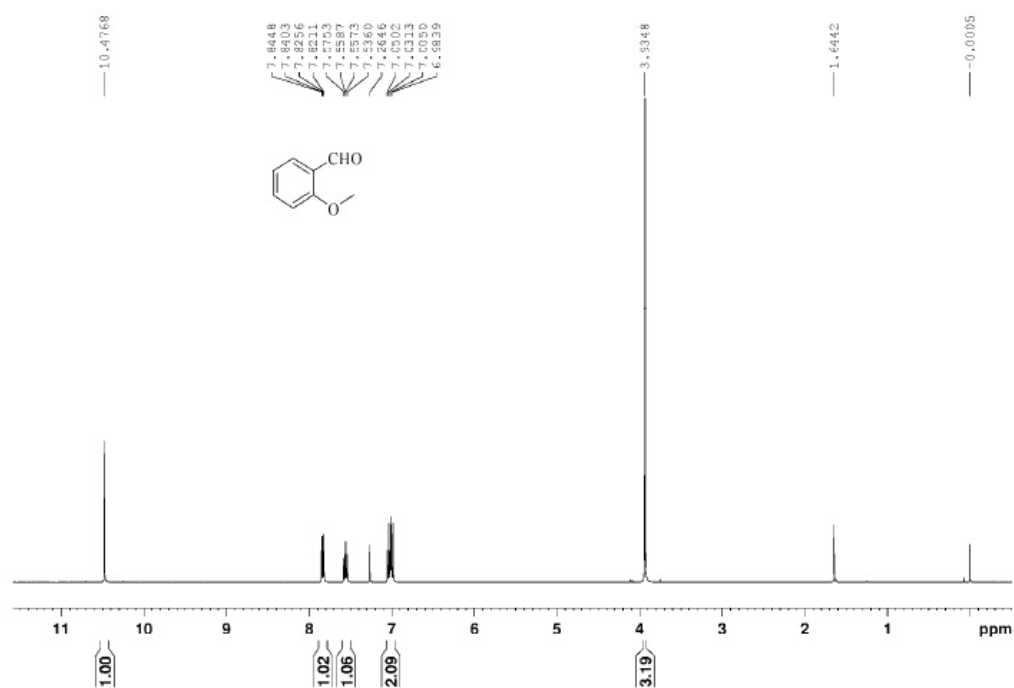
NMR spectra of 3n



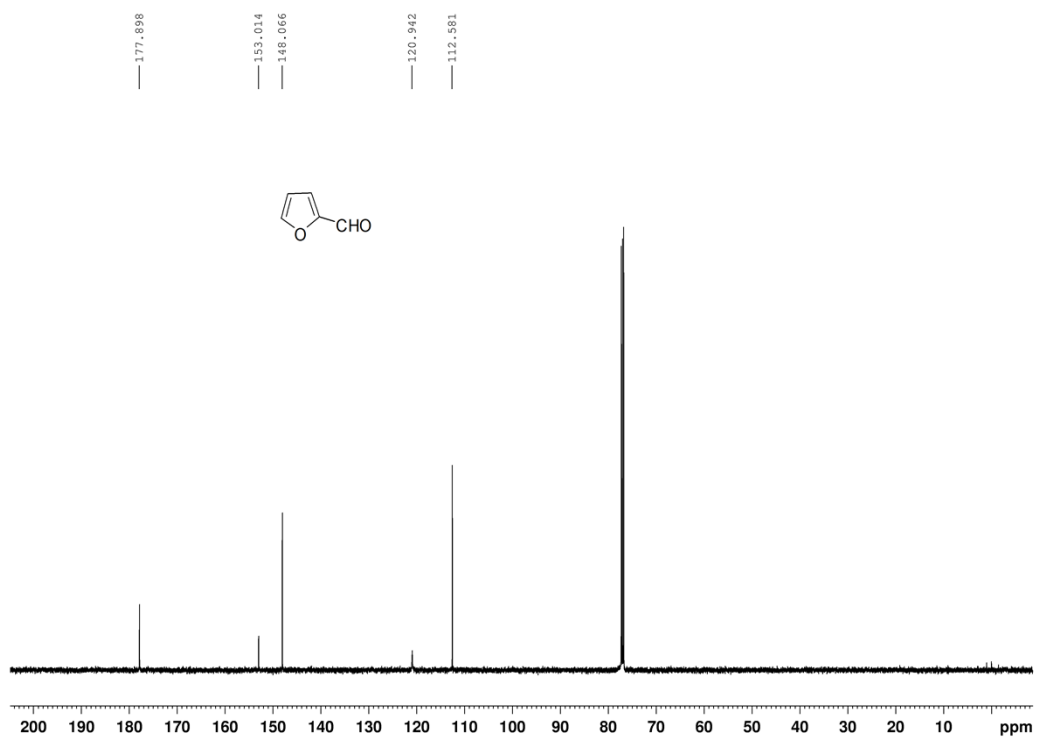
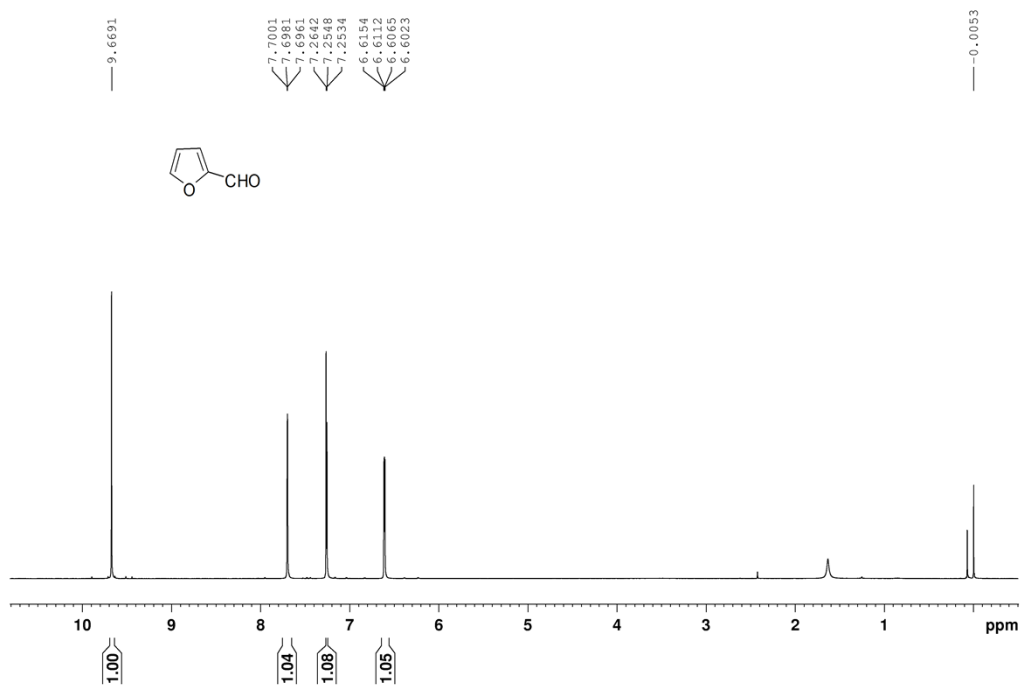
NMR spectra of 3o



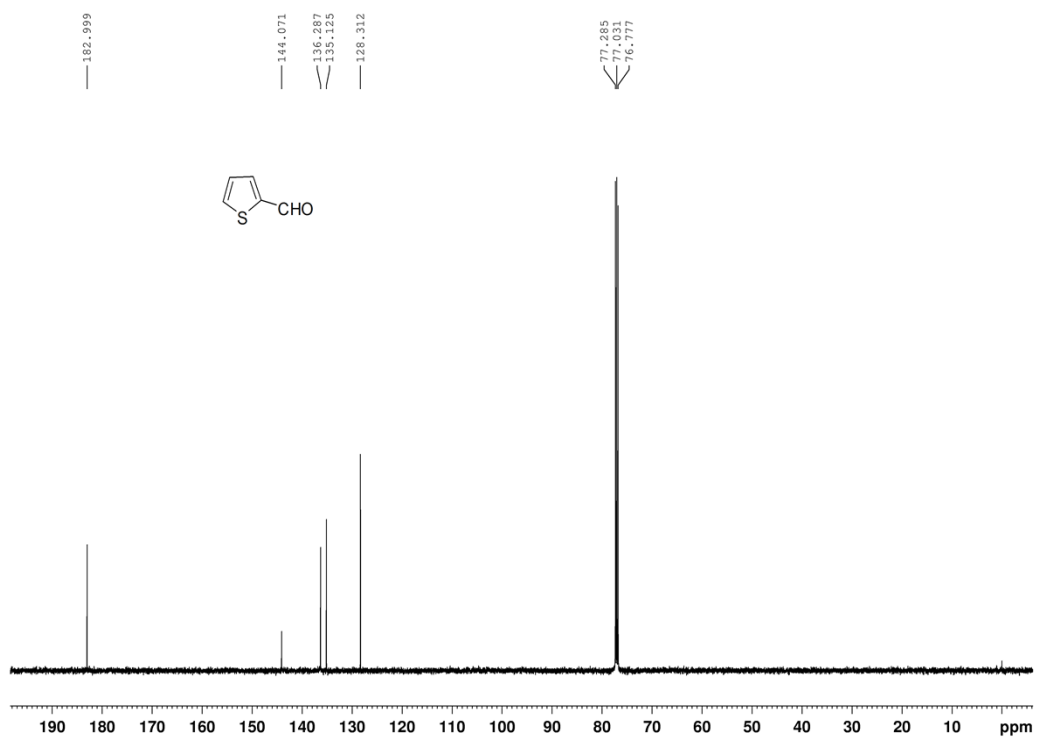
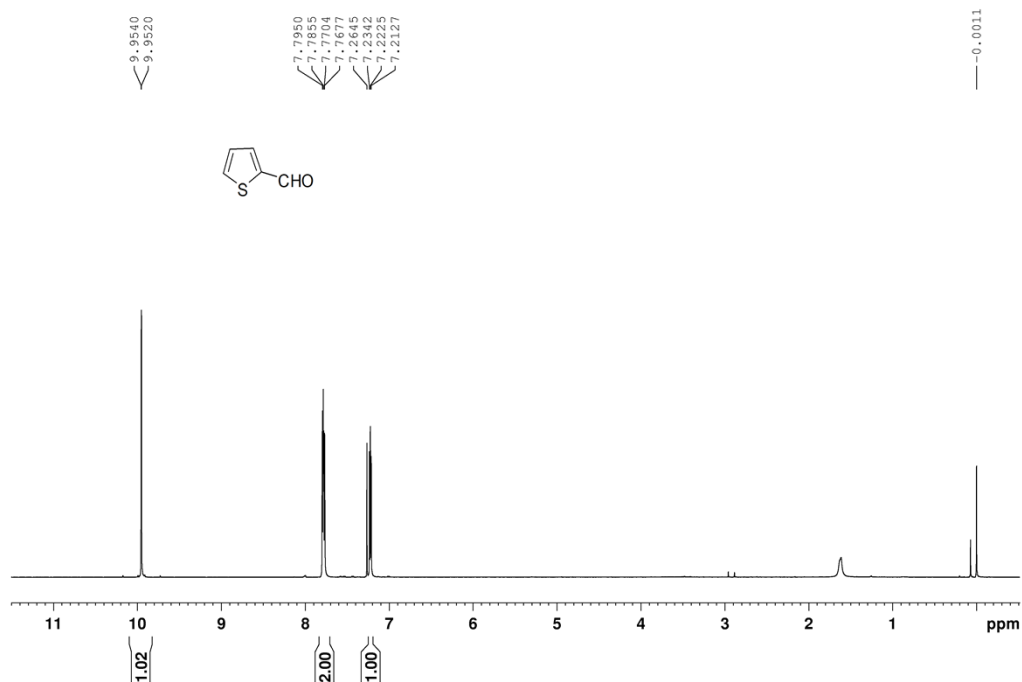
NMR spectra of 3p



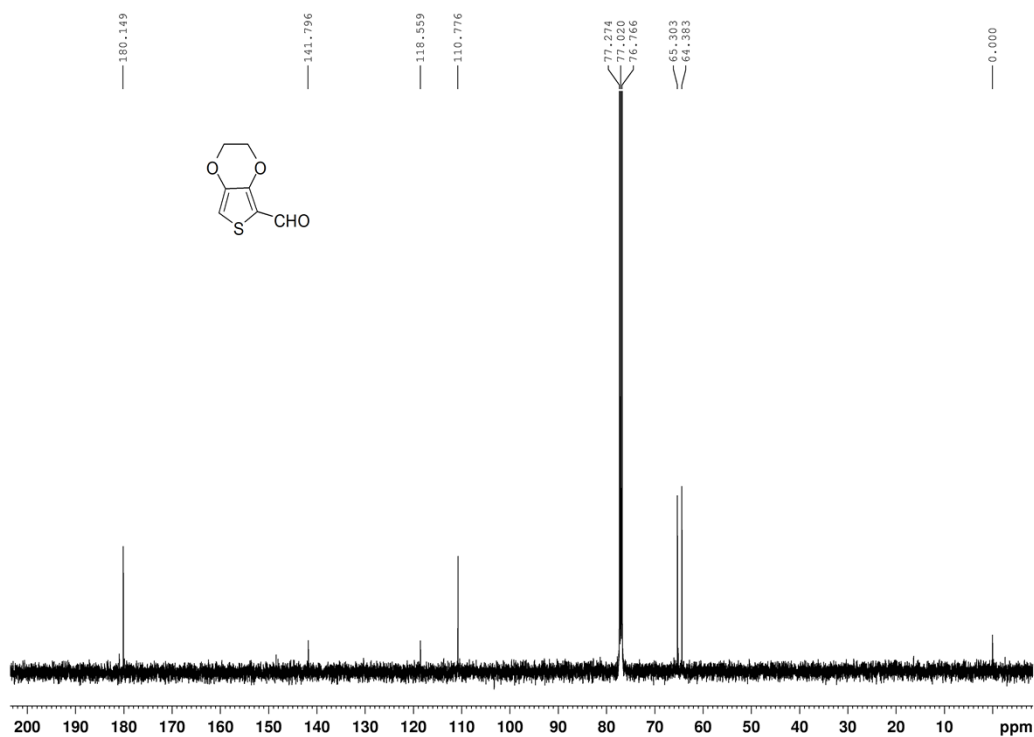
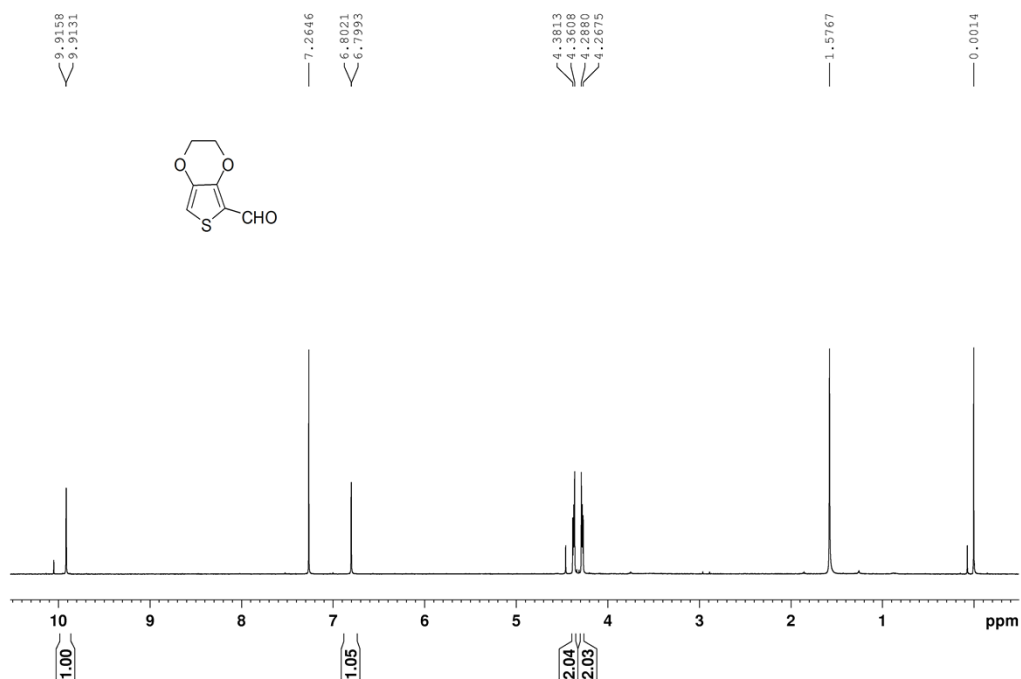
NMR spectra of 3q



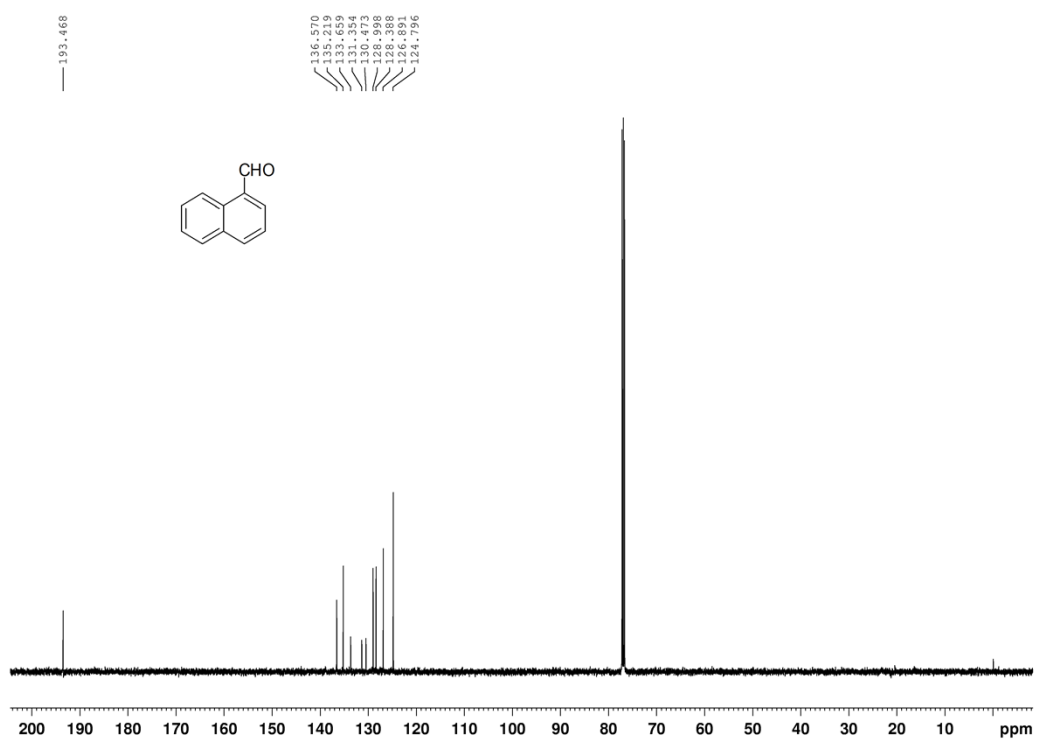
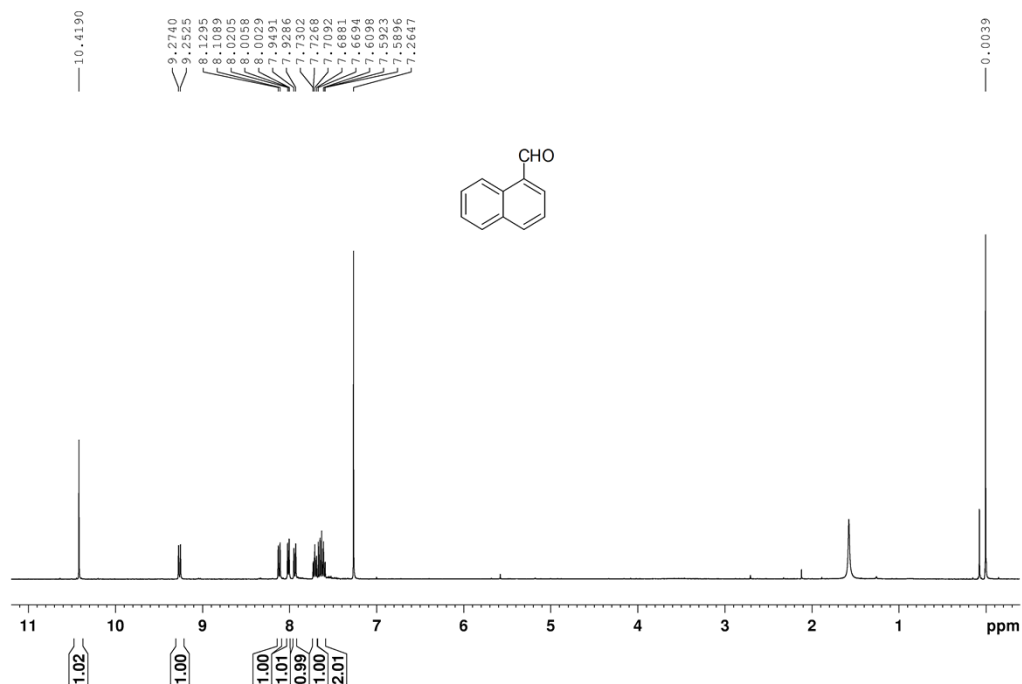
NMR spectra of 3r



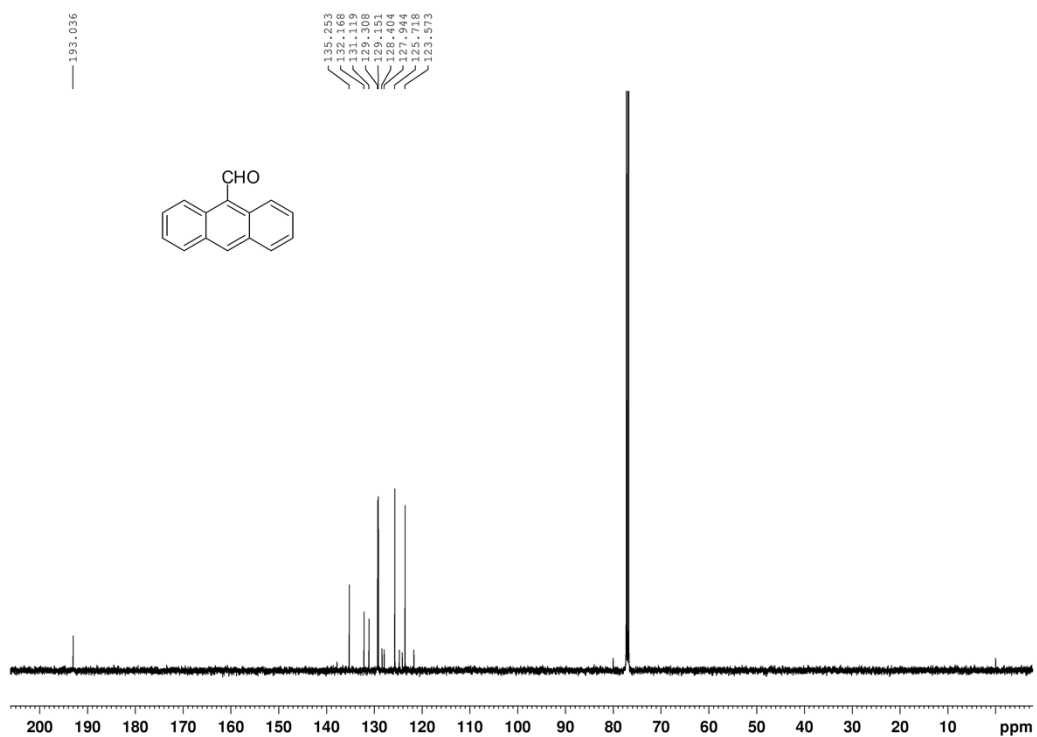
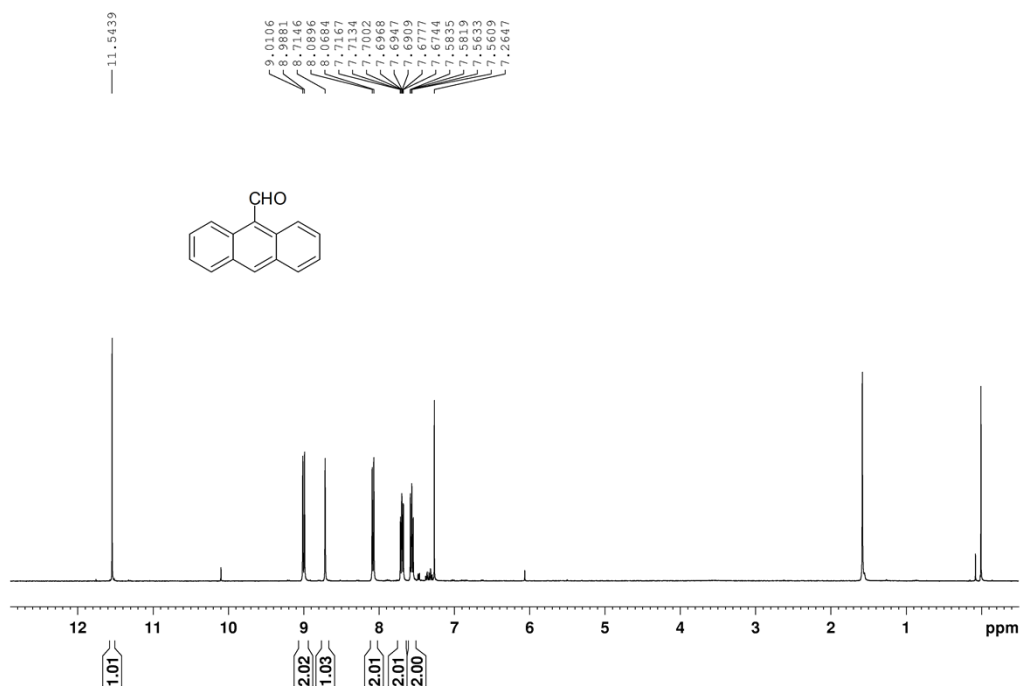
NMR spectra of 3s



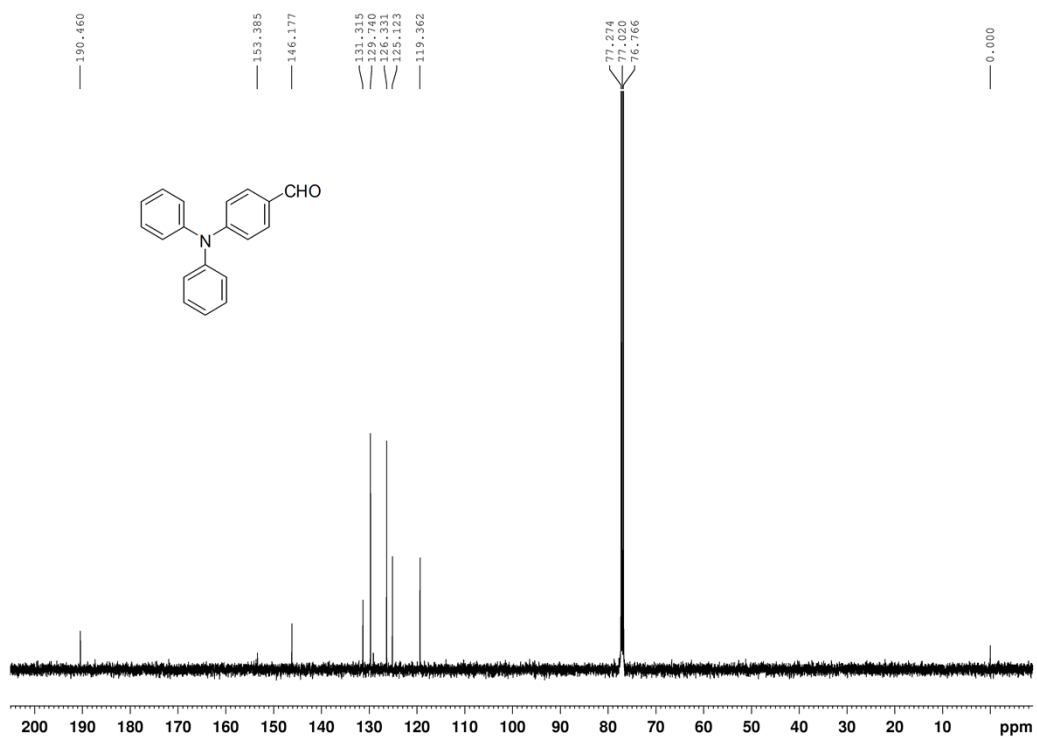
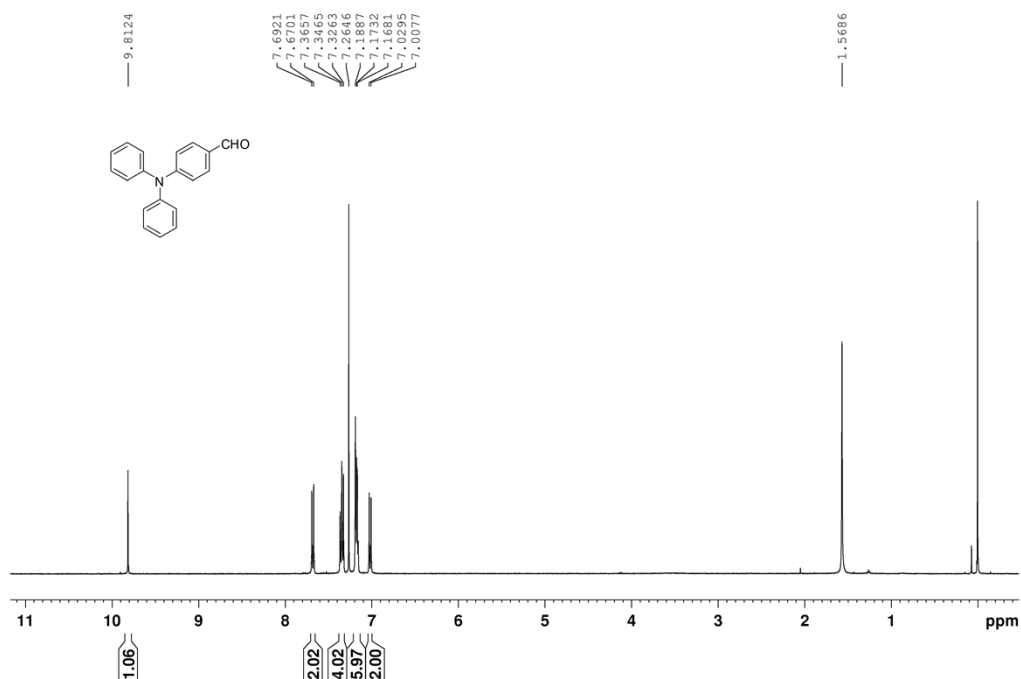
NMR spectra of 3t



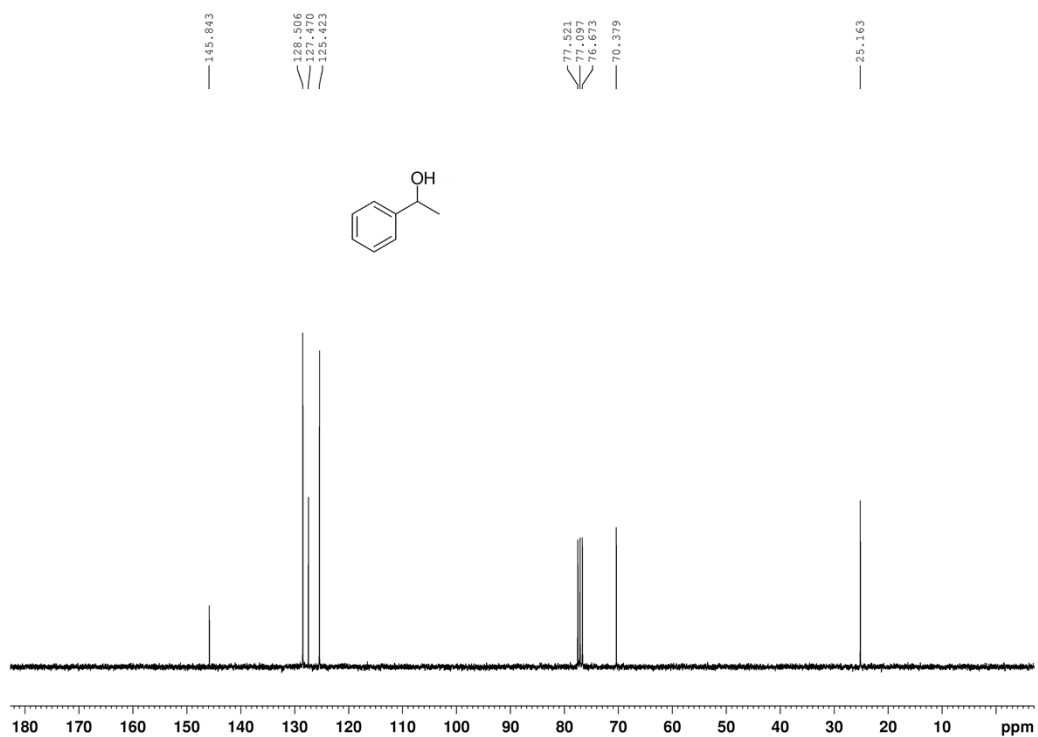
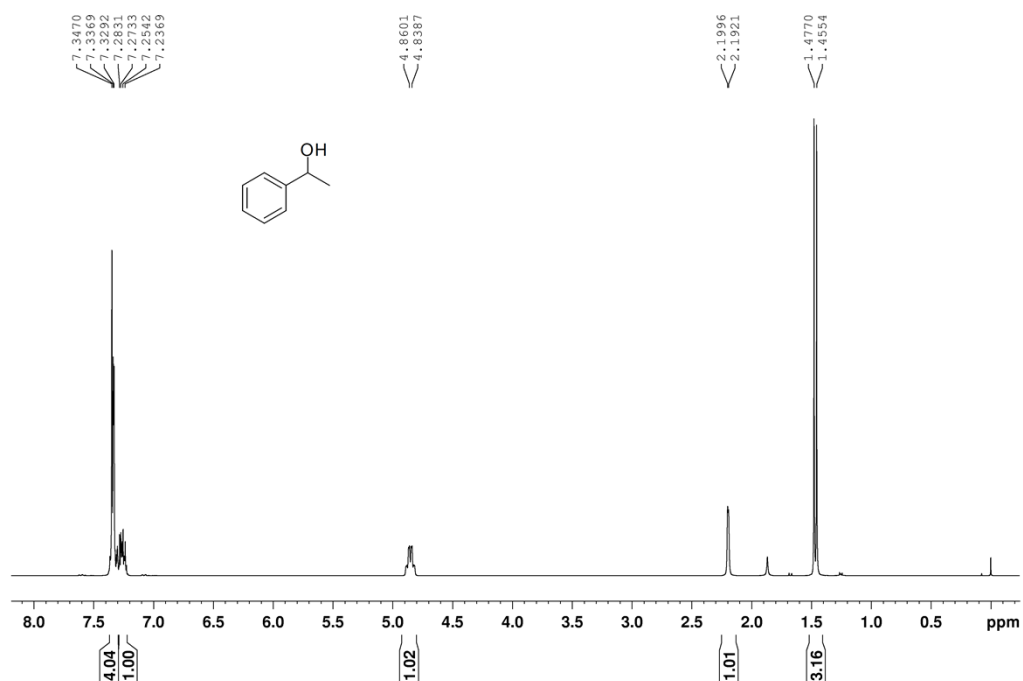
NMR spectra of 3u



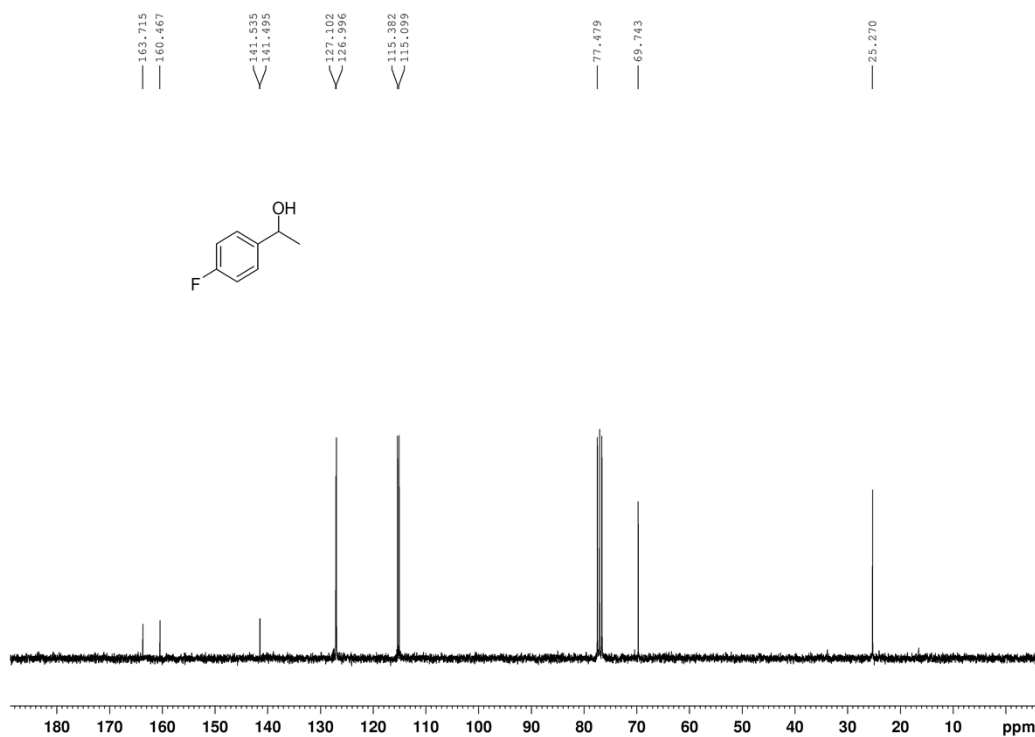
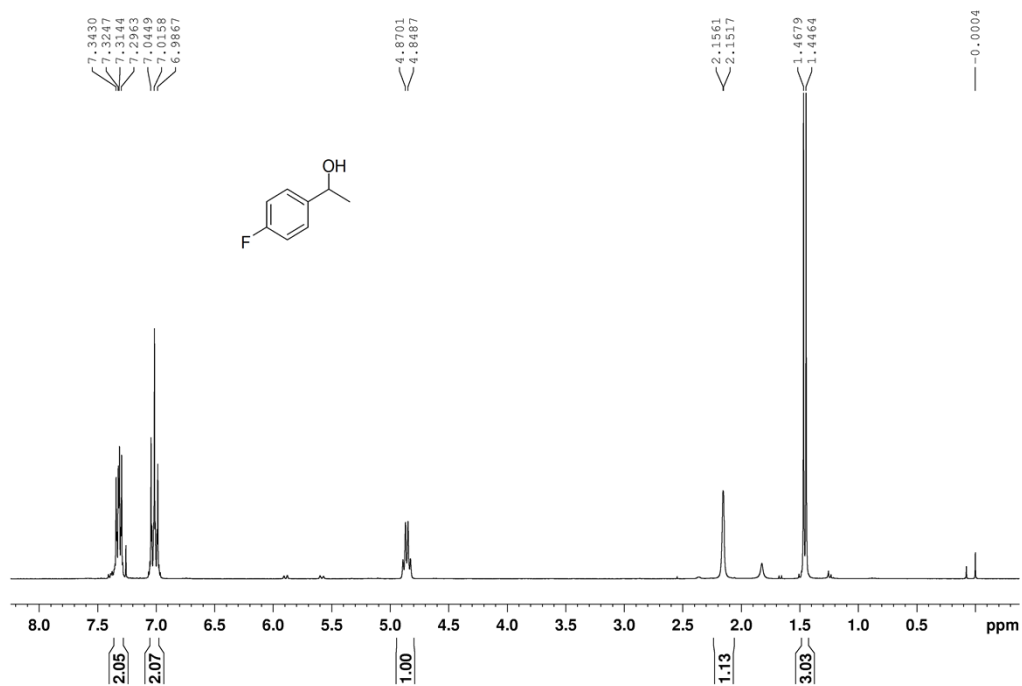
NMR spectra of 3v



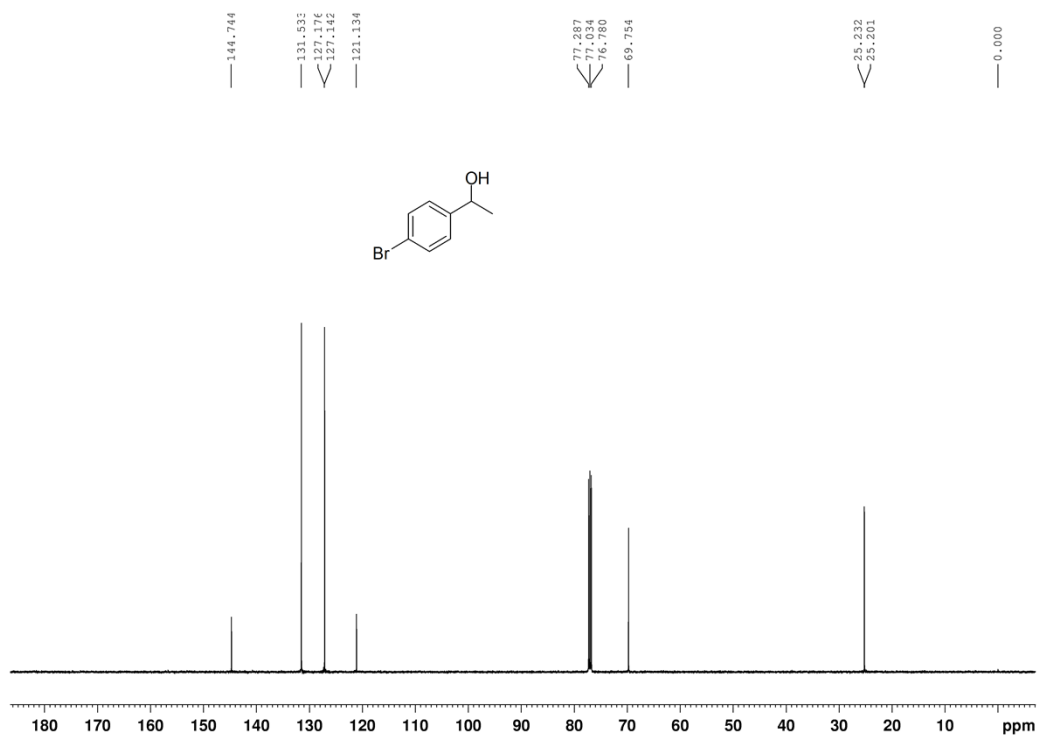
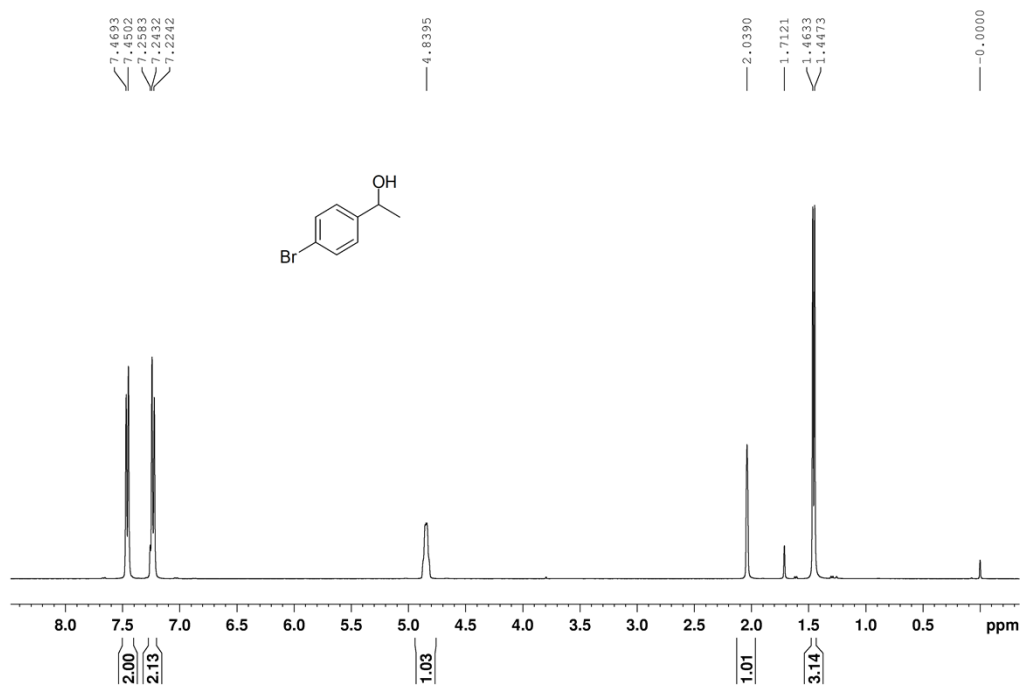
NMR spectra of 4a



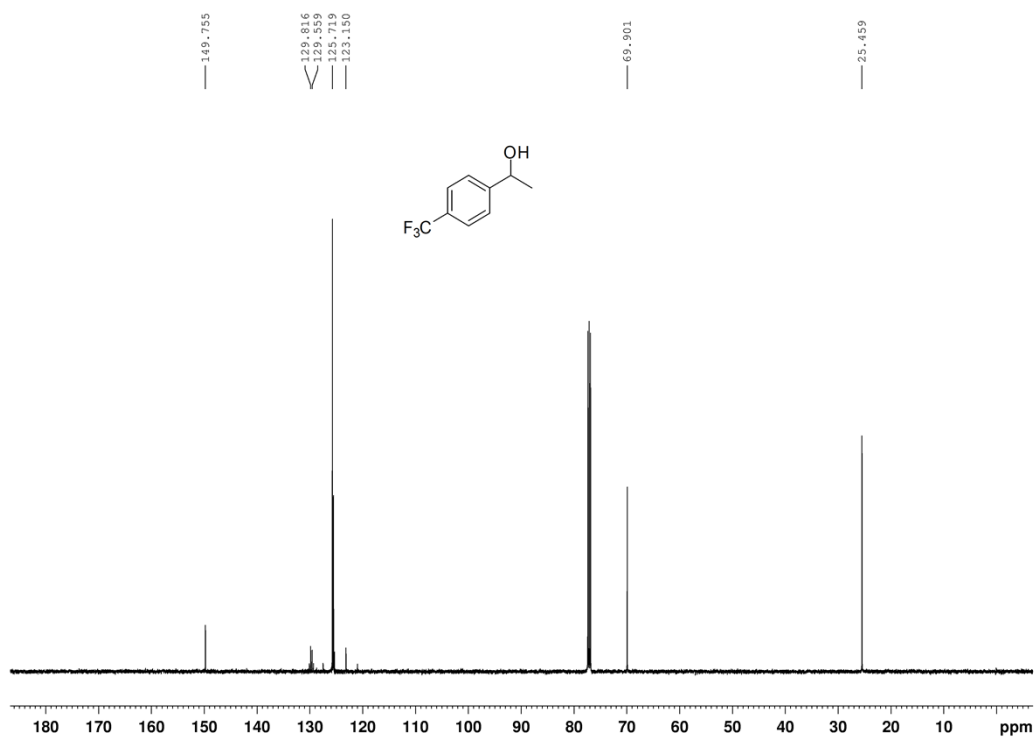
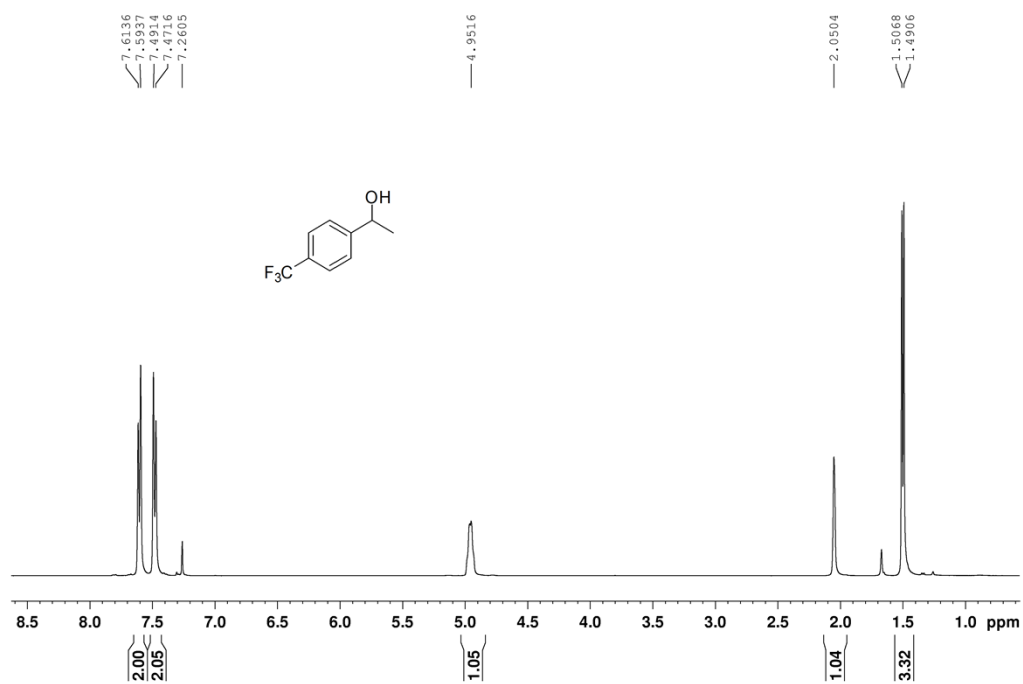
NMR spectra of 4b



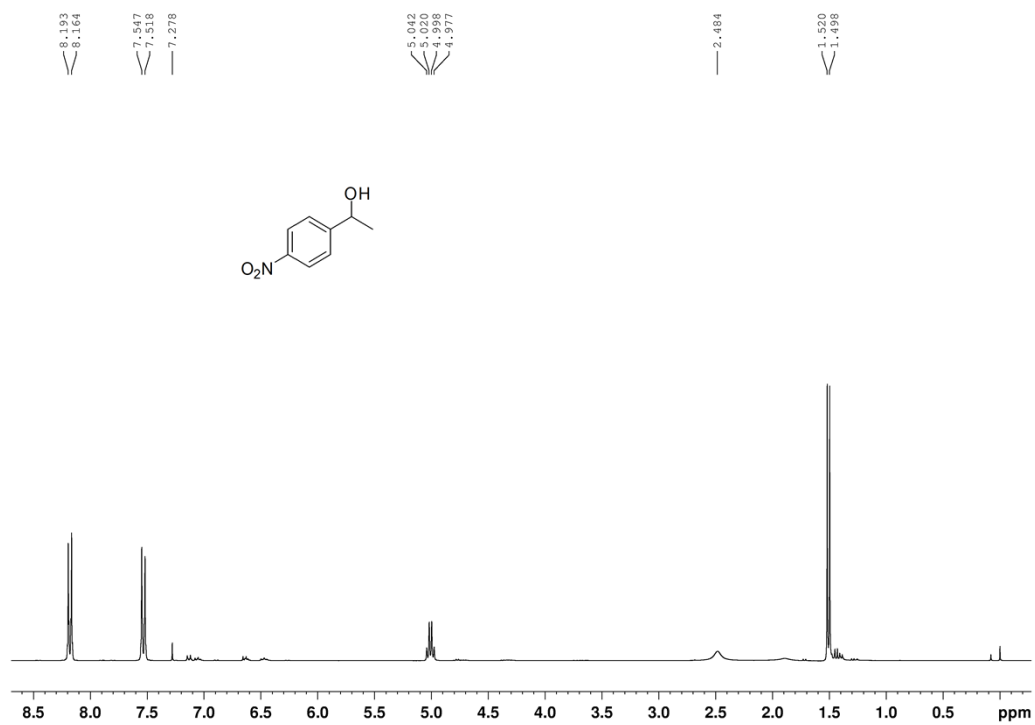
NMR spectra of 4c



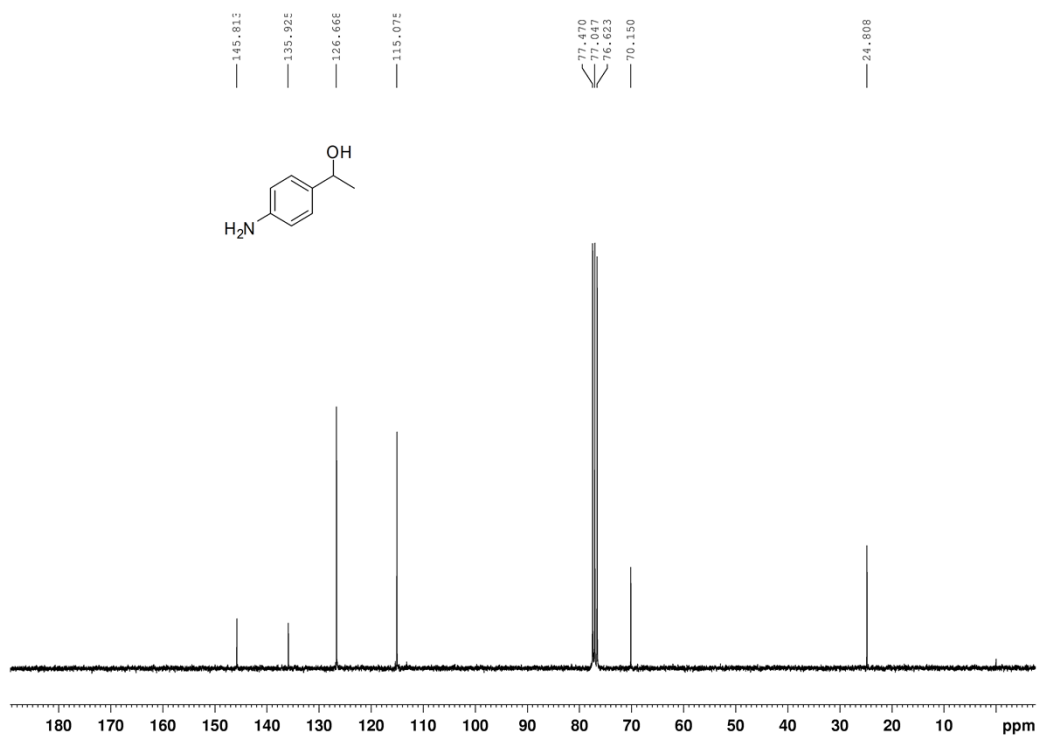
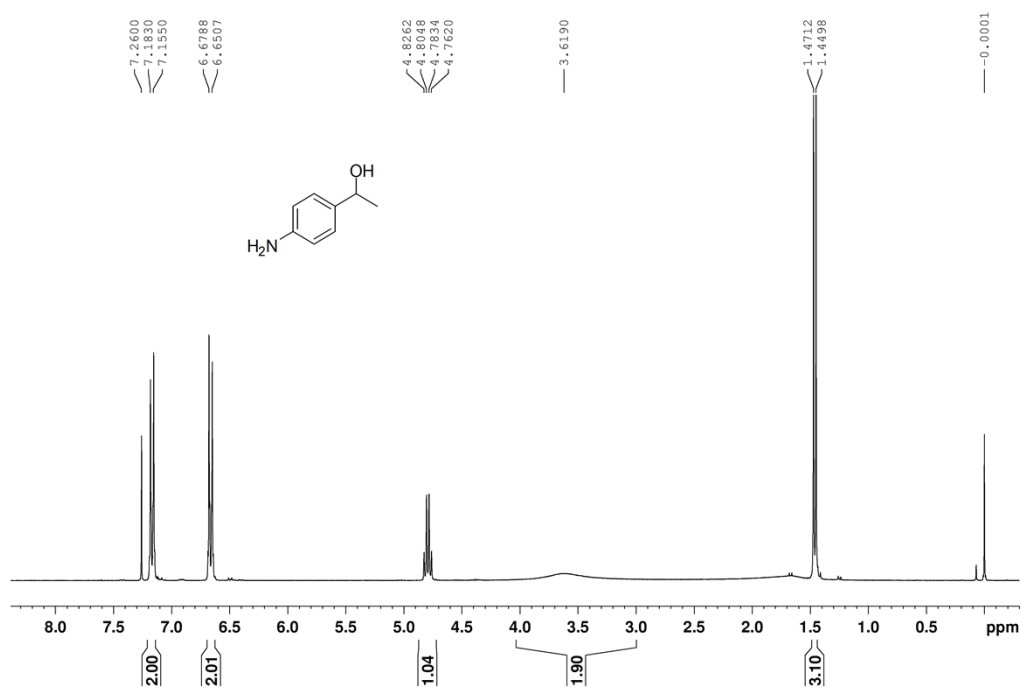
NMR spectra of 4d



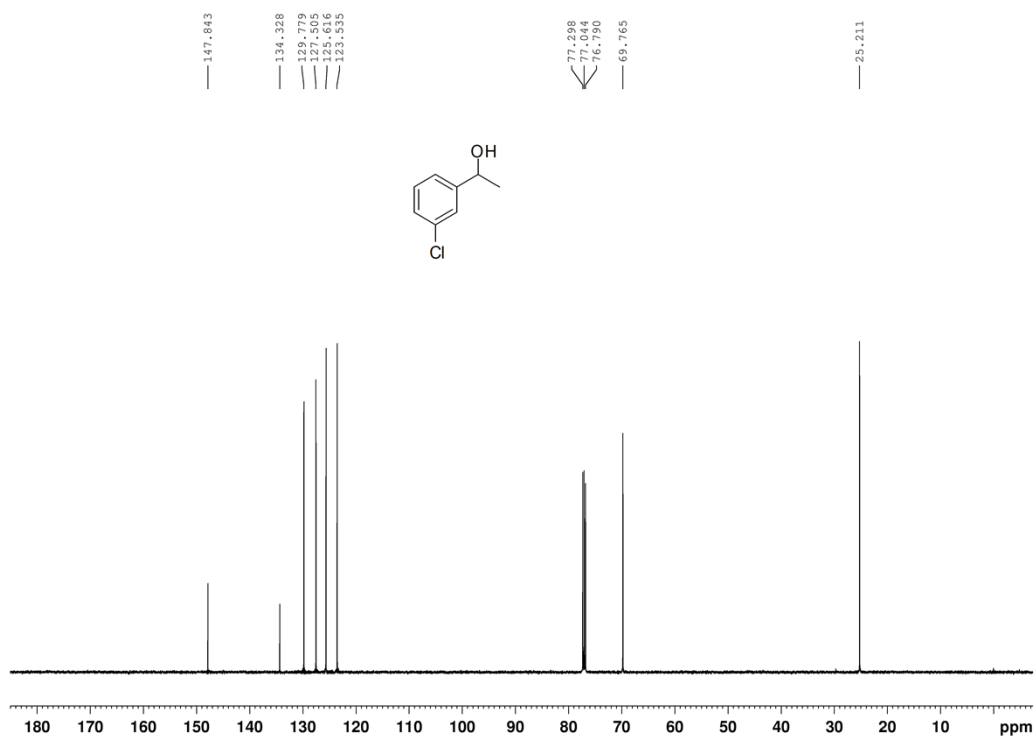
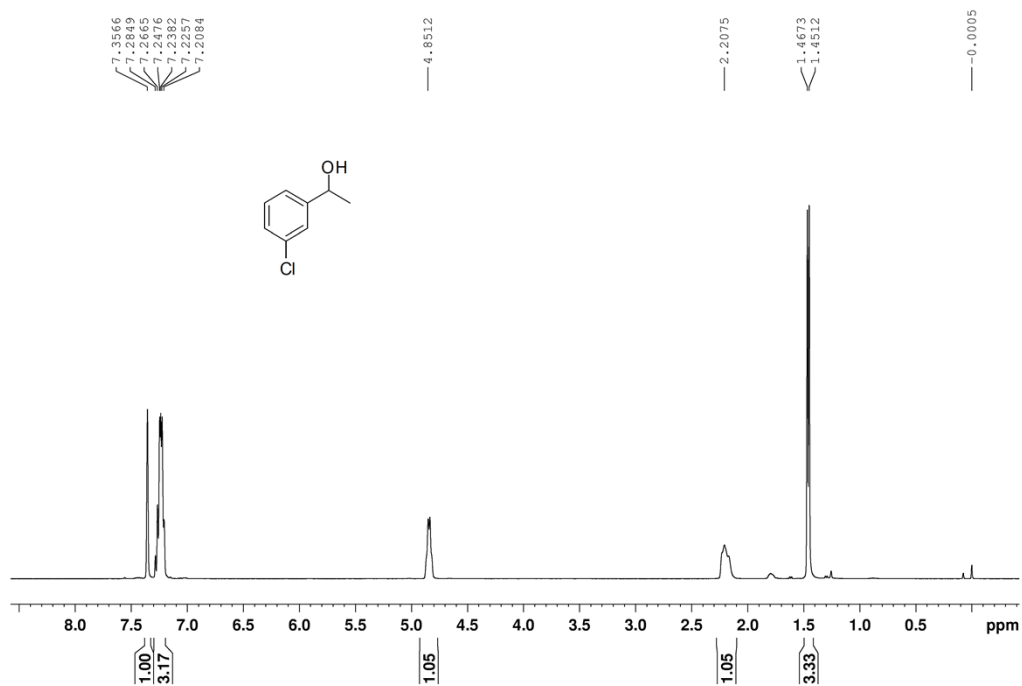
NMR spectra of 4e



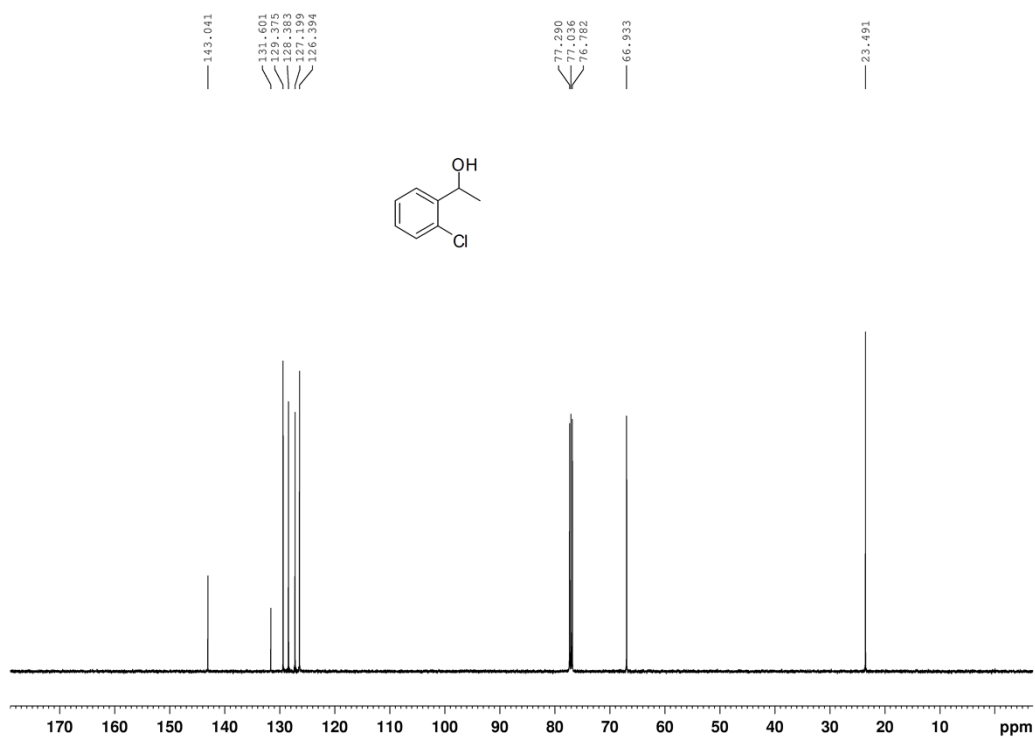
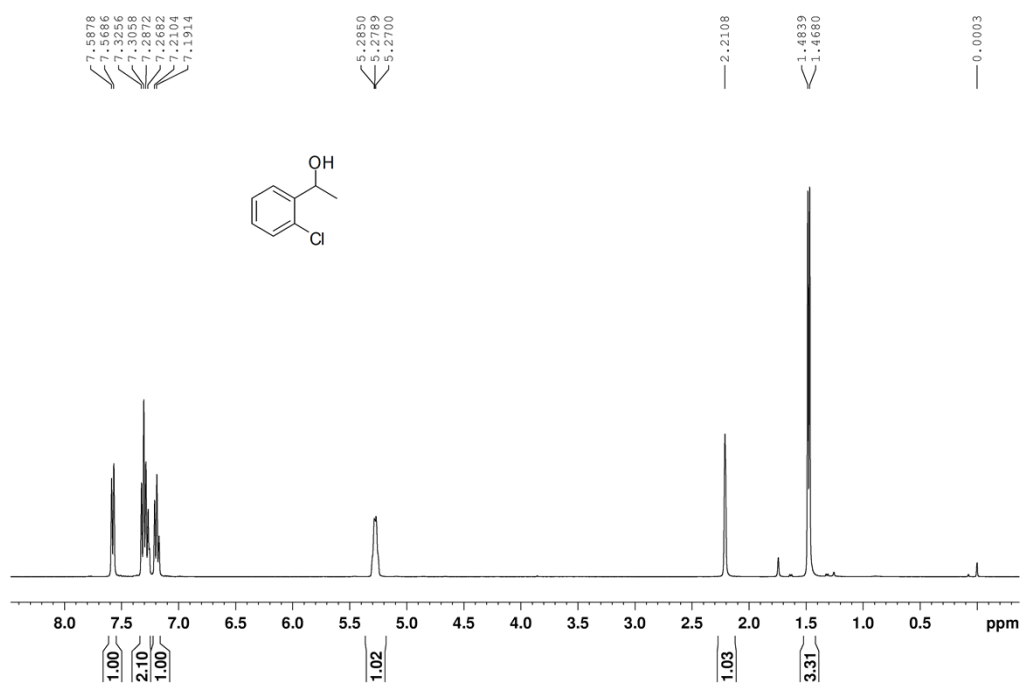
NMR spectra of 4f



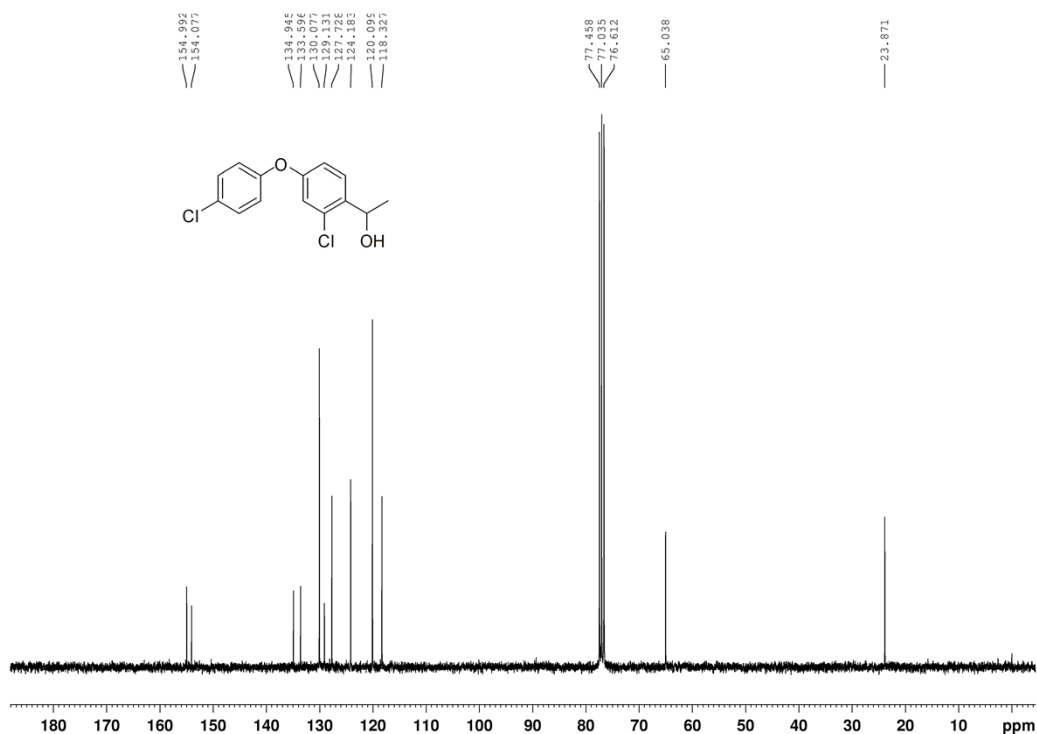
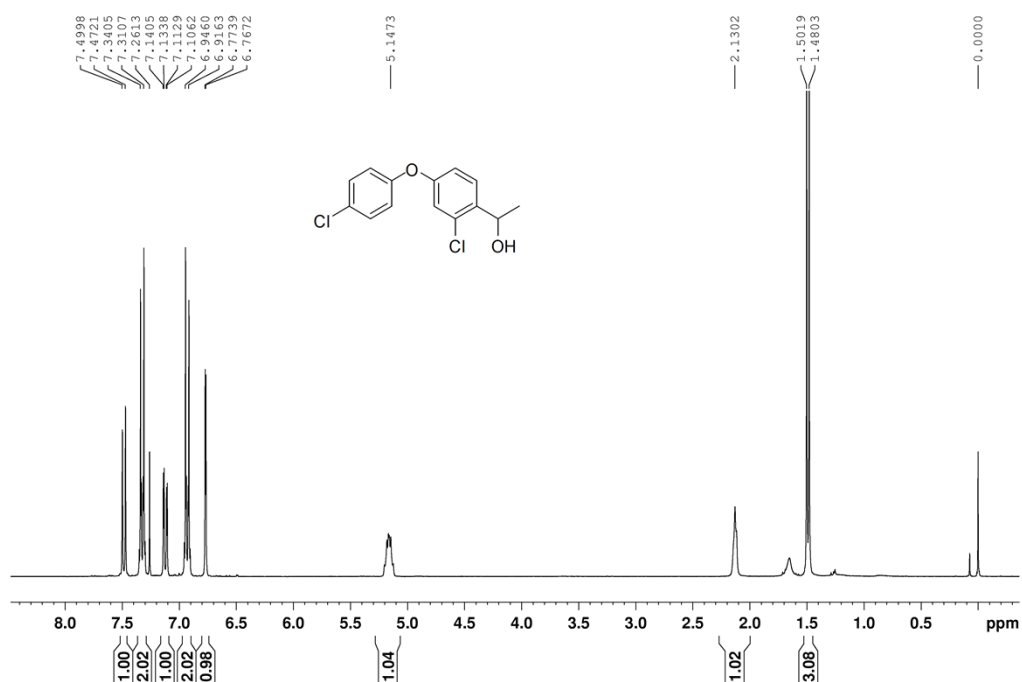
NMR spectra of 4g



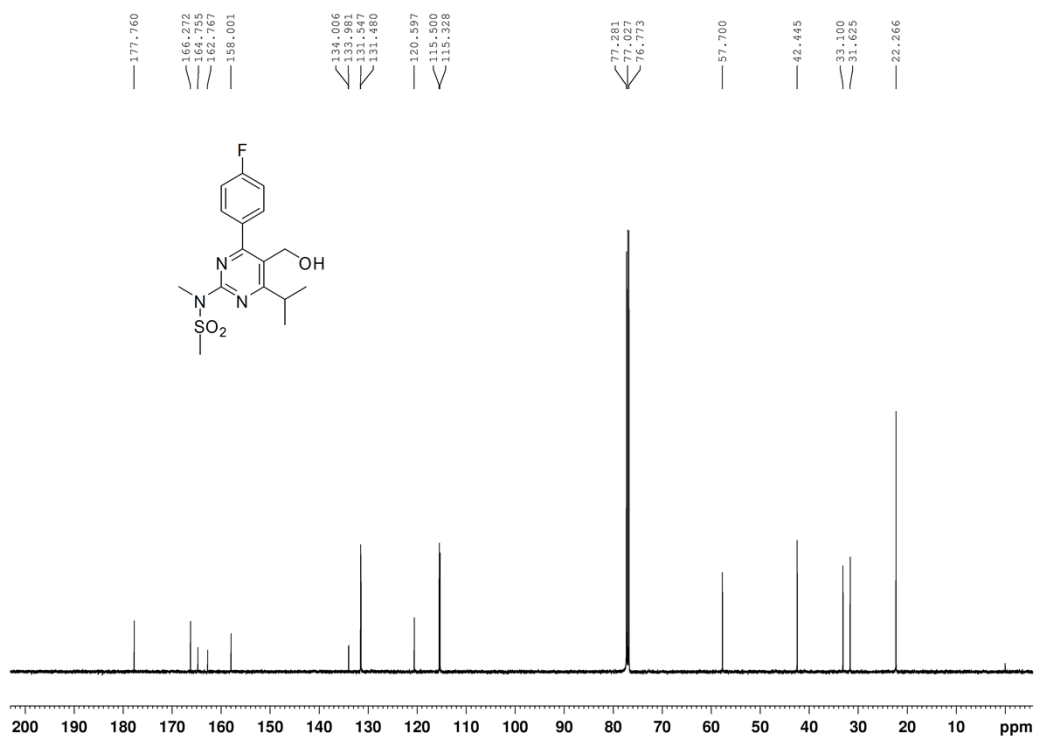
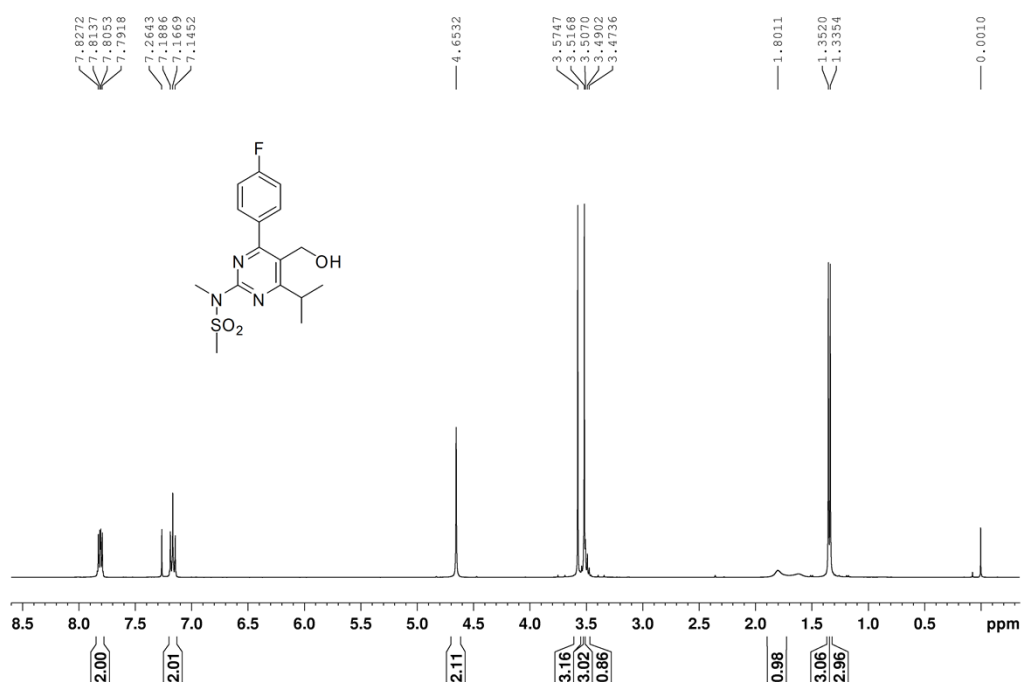
NMR spectra of 4h



NMR spectra of 4i



NMR spectra of 7



NMR spectra of 8

