Synthesis of Unsymmetrical 1,3-Substituted-1,3-dihydro-benzimidazolones via Copper-Catalyzed C–N Coupling Under Visible Light

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Supporting Information

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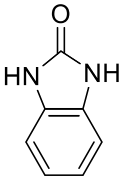
General Experimental Details

All the starting materials were purchased from commercial sources and used without further treatment. Light source was from Shanghai Liangliang Electric Inc. MT2285 with 18 W H-shaped fluorescent light. Analytical thin-layer chromatography (TLC) was performed on GF254 silica gel. ^{1}H NMR spectrum were obtained and recorded in a Bruker Avance III spectrometer at 400 MHz with tetramethylsilane as an internal standard. Multiplicities are indicated as s (singlet), d (doublet), t (triplet), q (quartet), dd (double doublet), m (multiplet), and b (broad). Coupling constants (*J*) are reported in Hertz (Hz). General NMR data were obtained at 25 ℃ (298.15 K). Infrared (IR) spectra were measured in AVATAR-370 using KBr pellets, (v [cm^{-1}]). High-resolution mass (HRMS) spectra were performed on Waters Xevo G2 Qtof spectrometer.

Synthesis of 1,3-dihydro-2*H*-benzimidazol-2-one (1)

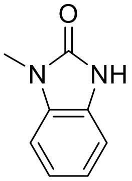


1

Urea (12 g, 0.2 mol) and *o*-phenylenediamine (21.6 g, 0.2 mol) were added to a round bottom flask. The reaction mixture was stirred and depressurized to 80 KPa by water aspirator for 10 minutes. The temperature was slowly increased to 140 ºC in 1 hour and the reaction mixture was stirred for additional 3 hours. During the reaction, solids were dissolved in the beginning, and then participated. After cooling to the room temperature, the precipitates were transferred and stirred in a beaker containing H_2O. The pH of solution was kept between 5 and 6 for 30 minutes. The precipitates were filtered and washed with H_2O (100 mL X 2) and petroleum ether (50 mL X 2). After dried in the air, 1,3-dihydro-2*H*-benzimidazol-2-one **1** (18.7 g) was obtained as yellow solids in 78%.

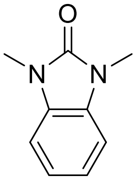
General procedure for the synthesis of substituted benzimidazolones (2a-2d and 3a-3d)

Benzicyclic urea **1** (26.8 g, 0.2 mol) and NaOH (8 g, 0.2 mol) were added to toluene (150 mL) in a round bottom flask mounting a Dean-Stark apparatus. The reaction mixture was refluxed for 6 hours and then cooled to the room temperature. During the reaction, H_2O was separated and drained through the burette and tap. Precipitates were filtered and washed with petroleum (100 mL X 2). After dried in the air, these precipitates, bromoalkane (0.1 mmol) were added into a solvothermal autoclave. The autoclave was strongly sealed by Teflon (PTFE, polytetrafluoro-ethylene) thread and by wrench. The reaction mixture was heated to 100 ºC for 6 hours while stirring inside the fume hood. After cooling to the room temperature, the organic solution was then concentrated to dryness by rotary evaporator. The crude product was loaded and purified by flash column chromatography with hexanes/ethyl acetate (60/40) as solvent. Monitored by TLC, monosubstituted benzimidazolones and disubstituted benzimidazolone were isolated, respectively.



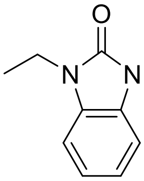
2a

Following the general procedure with methyl bromide as the bromoalkane source, compound **2a** 1-methyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a white solid (4.6 g, 31% in yield): Melting point: 189 – 191 °C. IR (KBr)/cm^{-1} v: 2927, 2857, 1704, 1620, 1381, 1234, 748, 730, 686. ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.64 (s, 1H), 7.21 – 6.95 (m, 4H), 3.46 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.12, 130.92, 128.09, 121.64, 121.27, 109.75, 107.63, 26.84. HRMS: calc for $C_8H_8N_2O$ ($[M + H]^+$) 149.0637; found 149.0620.



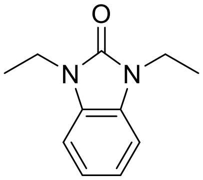
3a

Compound 1,3-dimethyl-1,3-dihydro-2*H*-benzimidazol-2-one **3a** was obtained as a yellow solid (7.5 g, 46% in yield): Melting point: 101 – 103 °C. IR (KBr)/cm^{-1} v: 3398, 3067, 2394, 1697, 1502, 1460, 1447, 1391, 1267, 1238, 1011, 912, 746, 729, 715. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.12 – 7.09 (m, 2 H), 6.99 – 6.96 (m, 2 H), 3.43 (s, 6 H). ^{13}C NMR (101 MHz, $CDCl_3$) δ: 154.66, 130.02, 121.19, 107.31, 27.14. HRMS: calc for $C_9H_{10}N_2O$ ($[M + H]^+$) 163.0793; found 163.0784.



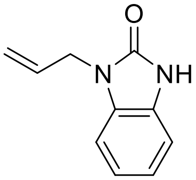
2b

Following the general procedure with ethyl bromide as the bromoalkane source, compound **2b** 1-ethyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow solid (5.8 g, 36% in yield): Melting point: 63 – 65 °C. IR (KBr)/cm^{-1} *v*: 1693, 1486, 1381, 756, 732, 687. ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.32 (s, 1H), 7.21 – 7.01 (m, 4H), 4.00 (q, *J* = 7.2 Hz, 2H), 1.40 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.63, 129.96, 128.21, 121.46, 121.20, 109.86, 107.75, 35.62, 13.68. HRMS: calc for $C_9H_{10}N_2O$ ([M+H]$^+$) 163.0871; found 163.0851.



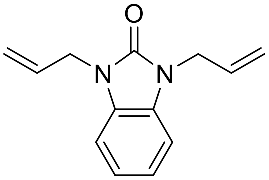
3b

Compound **3b** 1,3-diethyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow solid (7.2 g, 38% in yield): Melting point: 111 – 113 °C. IR (KBr)/cm^{-1} *v*: 2978, 2927, 1702, 1493, 741, 706. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.09 – 7.03 (m, 2H), 7.01 – 6.95 (m, 2H), 3.93 (q, *J* = 7.2 Hz, 4H), 1.32 (t, *J* = 7.2 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.66, 129.17, 120.92, 107.52, 35.81, 13.68.HRMS: calc for $C_{11}H_{14}N_2O$ ([M+H]$^+$) 191.1184; found191.1182.



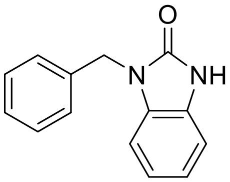
2c

Following the general procedure with allyl bromide as the bromoalkane source, compound **2c** 1-allyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow solid (7.0 g, 40% in yield): Melting point: 90 – 92 ºC. IR (KBr)/cm^{-1} *ν*: 3145, 3073, 2968, 2925, 1704, 1479, 1389, 748, 685. ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 10.98 (s, 1H), 7.19 – 6.94 (m, 4H), 5.94 (ddt, *J* = 16.9, 10.4, 5.2 Hz, 1H), 5.26 – 5.17 (m, 2H), 4.56 – 4.52 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) *δ* 155.88, 131.93, 130.16, 128.26, 121.67, 121.21, 117.45, 109.94, 108.41, 43.11. HRMS: calc for $C_{10}H_{10}N_2O$ ($[M+H]^+$) 175.0871; found 175.0877.



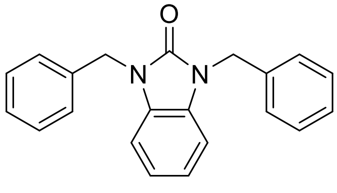
3c

Compound **3c** 1,3-diallyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow solid (7.1 g, 33% in yield): Melting point: 45 – 47 ºC. IR (KBr)/cm^{-1} *ν*: 2990, 2922, 1708, 1403, 753, 685. ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.07 – 6.94 (m, 4H), 5.96 – 5.82 (m, 2H), 5.19 (dd, *J* = 11.1, 6.1 Hz, 4H), 4.50 (d, *J* = 5.4 Hz, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) *δ* 153.75, 132.09, 129.32, 121.24, 117.52, 108.24, 43.52. HRMS: calc for $C_{13}H_{16}N_2O$ ($[M+H]^+$) 214.1184; found 214.1188.



2d

Following the general procedure with benzyl bromide as the bromoalkane source, compound **2d** 1-benzyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow solid (6.5 g, 29% in yield): Melting point: 203 – 205 ºC. IR (KBr)/cm^{-1} *ν*: 3059, 3035, 2924, 2849, 1689, 1490, 1402, 739, 692. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.99 (s, 1H), 7.39 – 7.26 (m, 5H), 7.18 – 7.12 (m, 1H), 7.10 – 7.00 (m, 2H), 6.93 – 6.86 (m, 1H), 5.13 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.76, 136.19, 130.19, 128.80, 127.98, 127.72, 127.35, 121.73, 121.40, 109.69, 108.55, 44.53. HRMS: calc for $C_{14}H_{12}N_2O$ ($[M+H]^+$) 225.0950; found 225.0933.

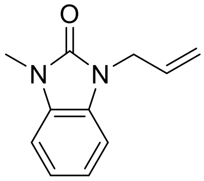


3d

Compound **3d** 1,3-dibenzyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow solid (17.9 g, 57% in yield): Melting point: 105 – 107 ºC. IR (KBr)/cm^{-1} *v*: 2929, 2867, 1693,1490, 698. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 – 7.27 (m, 10H), 7.05 – 6.98 (m, 2H), 6.95 – 6.88 (m, 2H), 5.16 (s, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.65, 136.44, 128.86, 127.78, 127.57, 121.46, 108.41, 45.05. HRMS: calc for $C_{21}H_{18}N_2O$ ($[M+H]^+$) 315.1497; found 315.1491.

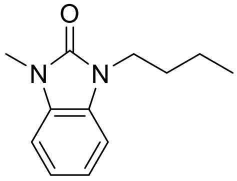
General procedure for the photoinduced C-N coupling for the synthesis of 1,3-substituted-1,3-dihydro-benzimidazolones (4a–4s).

Monosubstituted benzimidazolone **2a**–**2d** (0.1 mmol), *t*-BuOK (0.056 g, 0.05 mmol), and CuBr (0.01 mmol) was dissolved in dry acetonitrile (20 mL) in a 50 mL a conical flask under N_2 atm. After stirring for 30 minutes, add bromide (0.12 mmol) using visible light (18 W H-shaped fluorescent light, > 365 nm) response of 12 h. The solution was then concentrated to dryness by rotary evaporator. The organic phase was washed with water (5 mL X 2), brine solutions (5 mL X 2), and dried over Na_2SO_4. The organic solution was then concentrated to dryness by rotary evaporator. The crude product was loaded and purified by flash column chromatography with hexanes/ethyl acetate (80/20) as solvent. Monitored by TLC, 1,3-substituted-1,3-dihydro-benzimidazolones were isolated.



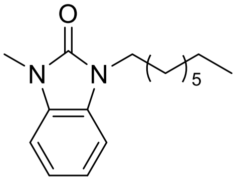
4a

Following the general procedure with **2a** as monosubstituted benzimidazolone and allyl bromide as the bromoalkane source, compound **4a** 1-allyl-3-methyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a white solid (0.016 g, 85% in yield): Melting point: 24 – 25 ºC. IR (KBr)/cm^{-1} *v*: 3066, 2927, 1702, 1493, 748, 685. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.98 – 6.89 (m, 2H), 6.85 – 6.77 (m, 2H), 5.83 – 5.69 (m, 1H), 5.11 – 5.03 (m, 2H), 4.37 – 4.32 (m, 2H), 3.25 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.93, 132.10, 129.91, 129.08, 121.09, 121.04, 117.27, 107.95, 107.27, 43.27, 26.97. HRMS: calc for $C_{11}H_{12}N_2O$ ($[M+H]^+$) 189.1028; found 189.1035.



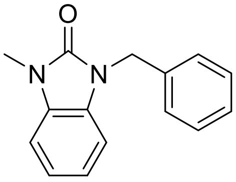
4b

Following the general procedure with **2a** as monosubstituted benzimidazolone and butyl bromide as the bromoalkane source, compound **4b** 1-butyl-3-methyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow liquid (0.017 g, 83% in yield): IR (KBr)/cm^{-1} *v*: 2931, 2874, 1708, 1618, 1500, 1326, 750, 736, 706. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.13 – 7.04 (m, 2H), 7.03 – 6.93 (m, 2H), 3.88 (t, *J* = 7.2 Hz, 2H), 3.41 (s, 3H), 1.77 – 1.67 (m, 2H), 1.45 – 1.32 (m, 2H), 0.95 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.45, 130.07, 129.45, 121.08, 120.96, 107.56, 107.36, 40.94, 30.56, 27.10, 20.10, 13.76. HRMS: calc for $C_{12}H_{16}N_2O$ ($[M+H]^+$) 205.1341; found 205.1340.



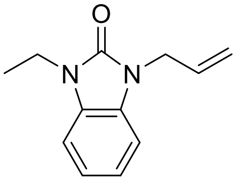
4c

Following the general procedure with **2a** as monosubstituted benzimidazolone and octyl bromide as the bromoalkane source, compound **4c** 1-octyl-3-methyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow liquid (0.022 g, 85% in yield): IR (KBr)/cm^{-1} *ν*: 2924, 2857, 1702, 1618, 1500, 1249, 1126, 748, 730, 706. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.11 – 7.04 (m, 2H), 7.01 – 6.92 (m, 2H), 3.86 (t, *J* = 7.3 Hz, 2H), 3.41 (s, 3H), 1.78 – 1.68 (m, 2H), 1.37 – 1.21 (m, 10H), 0.86 (t, *J* = 6.7 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.42, 130.07, 129.46, 121.08, 120.95, 107.55, 107.35, 41.23, 31.79, 29.28, 29.16, 28.48, 27.08, 26.87, 22.62, 14.08. HRMS: calc for $C_{16}H_{24}N_2O$ ($[M+H]^+$) 261.1967; found 261.1968.



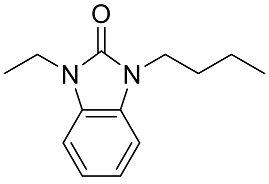
4d

Following the general procedure with **2a** as monosubstituted benzimidazolone and benzyl bromide (**4e**) as the bromoalkane source, compound **5d** 1-benzyl-3-methyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow solid (0.022 g, 92% in yield): Melting point: 74 – 76 °C. IR (KBr)/cm^{-1} *ν*: 2920, 2853, 1702, 1493, 739, 685. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.20 (m, 5H), 7.09 – 7.03 (m, 1H), 7.02 – 6.93 (m, 2H), 6.89 – 6.83 (m, 1H), 5.06 (s, 2H), 3.45 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.61, 136.42, 130.14, 129.21, 128.75, 127.69, 127.52, 121.35, 121.28, 108.22, 107.47, 44.91, 27.27. HRMS: calc for $C_{15}H_{24}N_2O$ ($[M+H]^+$) 239.1184; found 239.1186.



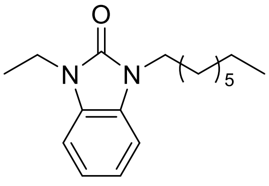
4g

Following the general procedure with **2b** as monosubstituted benzimidazolone and allyl bromide as the bromoalkane source, compound **4g** 1-allyl-3-ethyl-1,3-dihydro-2*H*-benz-imidazol-2-one was obtained as a yellow liquid (0.017 g, 84% in yield): IR (KBr)/cm^{-1} ν: 2985, 2930, 1708, 1493, 1405, 1217, 748, 736, 685. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.10 – 6.93 (m, 4H), 5.95 – 5.82 (m, 1H), 5.24 – 5.14 (m, 2H), 4.49 (dt, *J* = 5.4, 1.4 Hz, 2H), 3.94 (q, *J* = 7.2 Hz, 2H), 1.33 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.71, 132.16, 129.39, 129.11, 121.16, 121.00, 117.48, 108.25, 107.51, 43.47, 35.93, 13.67. HRMS: calc for $C_{12}H_{14}N_2O$ ($[M+H]^+$) 203.1184; found 203.1381.



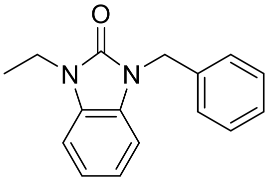
4h

Following the general procedure with **2b** as monosubstituted benzimidazolone and butyl bromide as the bromoalkane source, compound **4h** 1-butyl-3-ethyl-1,3-dihydro-2*H*-benz-imidazol-2-one was obtained as a yellow liquid (0.019 g, 87% in yield): IR (KBr)/cm^{-1} ν: 2945, 2865, 1704, 1611, 1486, 314, 755, 736. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.11 – 7.05 (m, 2H), 7.03 – 6.97 (m, 2H), 3.95 (q, *J* = 7.2 Hz, 2H), 3.88 (t, *J* = 7.3 Hz, 2H), 1.78 – 1.68 (m, 2H), 1.45 – 1.31 (m, 5H), 0.95 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.89, 129.54, 129.07, 120.86, 120.86, 107.62, 107.43, 40.81, 35.78, 30.52, 20.09, 13.73, 13.64. HRMS: calc for $C_{13}H_{18}N_2O$ ($[M+H]^+$) 219.1497; found 219.1486.



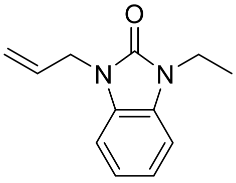
4i

Following the general procedure with **2b** as monosubstituted benzimidazolone and octyl bromide as the bromoalkane source, compound **4i** 1-octyl-3-ethyl-1,3-dihydro-2*H*-benz-imidazol-2-one was obtained as a yellow liquid (0.026 g, 95% in yield): IR (KBr)/cm^{-1} v: 2927，2853，1702，1493，1207，748，736，706. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.11 – 7.05 (m, 2H), 7.03 – 6.96 (m, 2H), 3.95 (q, J = 7.2 Hz, 2H), 3.86 (t, J = 7.4 Hz, 2H), 1.80 – 1.68 (m, 2H), 1.38 – 1.20 (m, 13H), 0.86 (t, J = 6.9 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.85, 129.54, 129.07, 120.83, 120.83, 107.59, 107.39, 41.09, 35.76, 31.77, 29.23, 29.15, 28.42, 26.85, 22.61, 14.06, 13.62. HRMS: calc for $C_{17}H_{26}N_2O$ ($[M+H]^+$) 275.2123; found 275.2164.



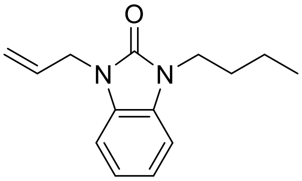
4j

Following the general procedure with **2b** as monosubstituted benzimidazolone and allyl bromide as the bromoalkane source, compound **4j** 1-butyl-3-ethyl-1,3-dihydro-2*H*-benz-imidazol-2-one was obtained as a yellow solid (0.024 g, 95% in yield): Melting point: 79 – 81 °C. IR (KBr)/cm^{-1} v: 2968, 2927, 1702, 1486, 1403, 748, 690. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18 – 6.97 (m, 5H), 6.87 – 6.64 (m, 4H), 4.85 (s, 2H), 3.76 (q, J = 7.2 Hz, 2H), 1.14 (t, J = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.09, 136.57, 129.34, 129.18, 128.76, 127.67, 127.55, 121.30, 121.10, 108.32, 107.60, 44.79, 36.00, 13.75. HRMS: calc for $C_{17}H_{26}N_2O$ ($[M+H]^+$) 253.1350; found 253.1333.



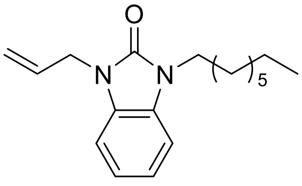
4g

Following the general procedure with **2c** as monosubstituted benzimidazolone and ethyl bromide as the bromoalkane source, compound **4g** 1-allyl-3-ethyl-1,3-dihydro-2*H*-benz-imidazol-2-one was obtained as a yellow liquid (0.015 g, 74% in yield). The structure elucidation was discussed above.



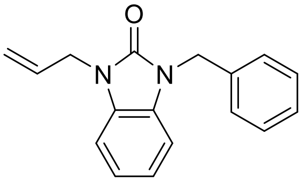
4m

Following the general procedure with **2c** as monosubstituted benzimidazolone and butyl bromide as the bromoalkane source, compound **4m** 1-allyl-3-butyl-1,3-dihydro-2*H*-benz-imidazol-2-one was obtained as a yellow liquid (0.022 g, 96% in yield): IR (KBr)/cm^{-1} *v*: 2962, 2930, 1702, 1618, 1496, 1405, 1196, 764, 736, 685. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.11 – 7.02 (m, 2H), 7.02 – 6.95 (m, 2H), 5.97 – 5.83 (m, 1H), 5.26 – 5.16 (m, 2H), 4.51 (d, *J* = 5.4 Hz, 2H), 3.89 (t, *J* = 7.2 Hz, 2H), 1.80 – 1.69 (m, 2H), 1.40 (dq, *J* = 14.7, 7.4 Hz, 2H), 0.96 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.02, 132.18, 129.53, 129.35, 121.12, 120.95, 117.46, 108.20, 107.65, 43.48, 40.97, 30.51, 20.11, 13.76. HRMS: calc for $C_{14}H_{19}N_2O$ ($[M+H]^+$) 231.1496; found 231.1473.



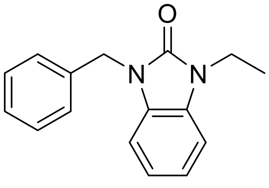
4n

Following the general procedure with **2c** as monosubstituted benzimidazolone and octyl bromide as the bromoalkane source, compound **4n** 1-allyl-3-octyl-1,3-dihydro-2*H*-benz-imidazol-2-one was obtained as a yellow liquid (0.028 g, 98% in yield): IR (KBr)/cm^{-1} *ν*: 2922, 2853, 1702, 1496, 1398, 748, 736, 683. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14 – 6.90 (m, 4H), 5.90 (ddt, *J* = 21.4, 10.6, 5.4 Hz, 1H), 5.27 – 5.15 (m, 2H), 4.53 – 4.46 (m, 2H), 3.88 (t, *J* = 7.4 Hz, 2H), 1.81 – 1.67 (m, 2H), 1.41 – 1.18 (m, 10H), 0.86 (t, *J* = 6.8 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.96, 132.18, 129.50, 129.32, 121.11, 120.93, 117.39, 108.17, 107.63, 43.44, 41.22, 31.78, 29.25, 29.16, 28.42, 26.85, 22.63, 14.09. HRMS: calc for $C_{18}H_{26}N_2O$ ([M+H]$^+$) 287.2132; found 287.2169.



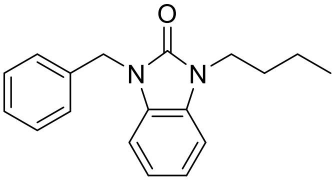
4o

Following the general procedure with **2c** as monosubstituted benzimidazolone and benzyl bromide as the bromoalkane source, compound **4o** 1-allyl-3-benzyl-1,3-dihydro-2*H*-benz-imidazol-2-one was obtained as a yellow liquid (0.025 g, 95% in yield): IR (KBr)/cm^{-1} *ν*: 2985, 2950, 1710, 741, 685. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 – 7.17 (m, 5H), 7.06 – 6.91 (m, 3H), 6.85 (M, 1H), 5.99 – 5.80 (m, 1H), 5.26 – 5.15 (m, 2H), 5.05 (s, 2H), 4.52 (d, *J* = 5.4 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.21, 136.39, 132.10, 129.40, 129.28, 128.78, 127.71, 127.51, 121.34, 121.34, 117.61, 108.32, 108.32, 44.95, 43.65. HRMS: calc for $C_{17}H_{16}N_2O$ ([M+H]$^+$) 265.1341; found 265.1338.



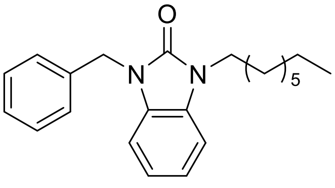
4j

Following the general procedure with **2d** as monosubstituted benzimidazolone and ethyl bromide as the bromoalkane source, compound **4j** 1-benzyl-3-ethyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow solid (0.02 g, 79% in yield). The structure elucidation was discussed above.



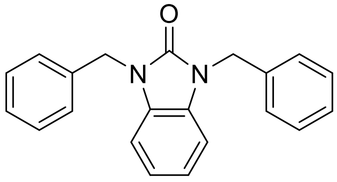
4r

Following the general procedure with **2d** as monosubstituted benzimidazolone and butyl bromide as the bromoalkane source, compound **4r** 1-benzyl-3-butyl-1,3-dihydro-2*H*-benzimidazol-2-one was obtained as a yellow liquid (0.027 g, 96% in yield): IR (KBr)/cm^{-1} *ν*: 2967, 2920, 1733, 1652, 1436, 1402, 1240, 749, 731, 683. ^{1}H NMR (400 MHz, CDCl$_3$) *δ* 7.36 – 7.15 (m, 5H), 7.08 – 6.90 (m, 3H), 6.89 – 6.81 (m, 1H), 5.06 (s, 2H), 3.91 (t, *J* = 7.2 Hz, 2H), 1.82 – 1.68 (m, 2H), 1.47 – 1.34 (m, 2H), 0.96 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, CDCl$_3$) *δ* 154.43, 136.55, 129.58, 129.29, 128.75, 127.66, 127.52, 121.25, 121.06, 108.29, 107.73, 44.83, 41.04, 30.56, 20.16, 13.83. HRMS: calc for $C_{18}H_{20}N_2O$ ([M+H]$^+$) 281.1654; found 281.1647.



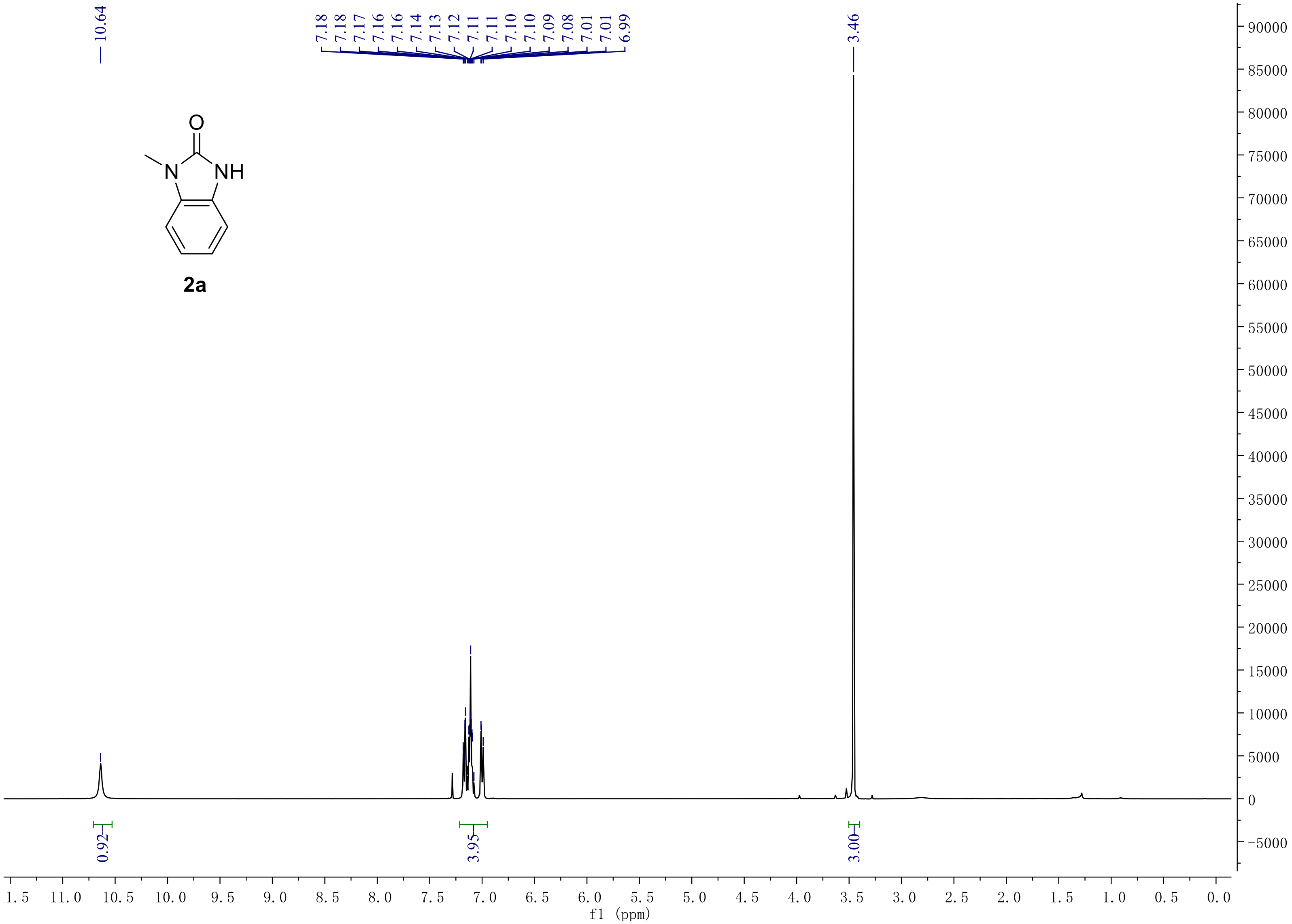
4s

Following the general procedure with **2d** as monosubstituted benzimidazolone and octyl bromide as the bromoalkane source, compound **4s** 1-benzyl-3-octyl-1,3-dihydro-2*H*-benz-imidazol-2-one was obtained as a yellow liquid (0.034 g, 99% in yield): IR (KBr)/cm^{-1} *ν*: 3053, 3032, 2957, 2926, 1709, 1612, 1492, 1402, 1240, 753, 728, 685. ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.35 – 7.20 (m, 5H), 7.11 – 6.92 (m, 3H), 6.86 (m, 1H), 5.07 (s, 2H), 3.91 (t, *J* = 7.3 Hz, 2H), 1.82 – 1.70 (m, 2H), 1.42 – 1.17 (m, 10H), 0.87 (t, *J* = 6.8 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) *δ* 154.39, 136.58, 129.57, 129.29, 128.73, 127.64, 127.52, 121.24, 121.03, 108.26, 107.70, 44.80, 41.29, 31.85, 29.31, 29.26, 28.48, 26.92, 22.72, 14.19. HRMS: calc for $C_{22}H_{29}N_2O$ ($[M+H]^+$) 337.2280; found 337.2282.



3d

Following the general procedure with **2d** as monosubstituted benzimidazolone and benzyl bromide as the bromoalkane source, compound **3d** 1,3-dibenzyl-1,3-dihydro-2*H*-benz-imidazol-2-one was obtained as a yellow solid (0.03 g, 96% in yield). The structure elucidation was discussed above.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7.09
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7.01
6.99
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NH
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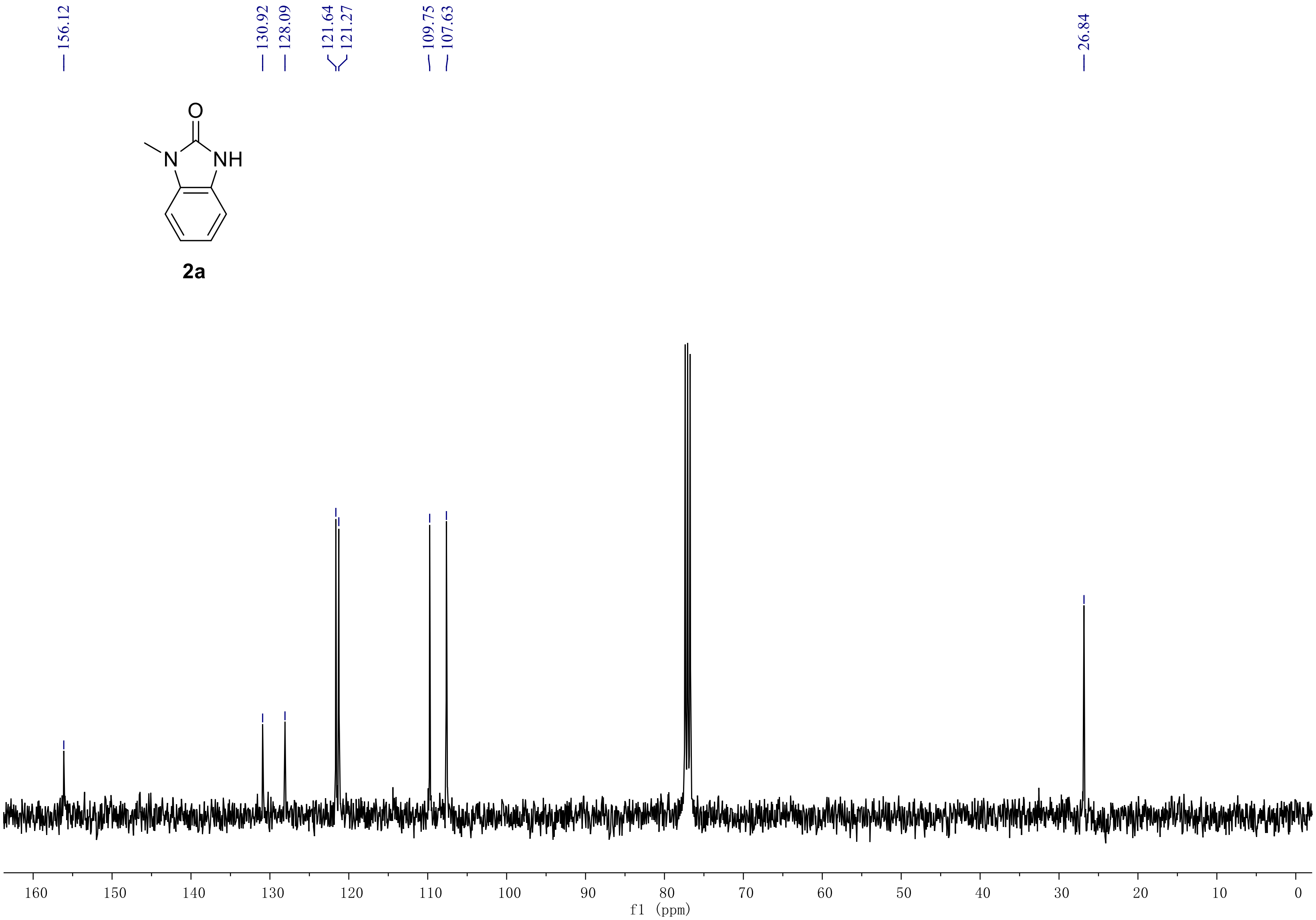

2a

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NH
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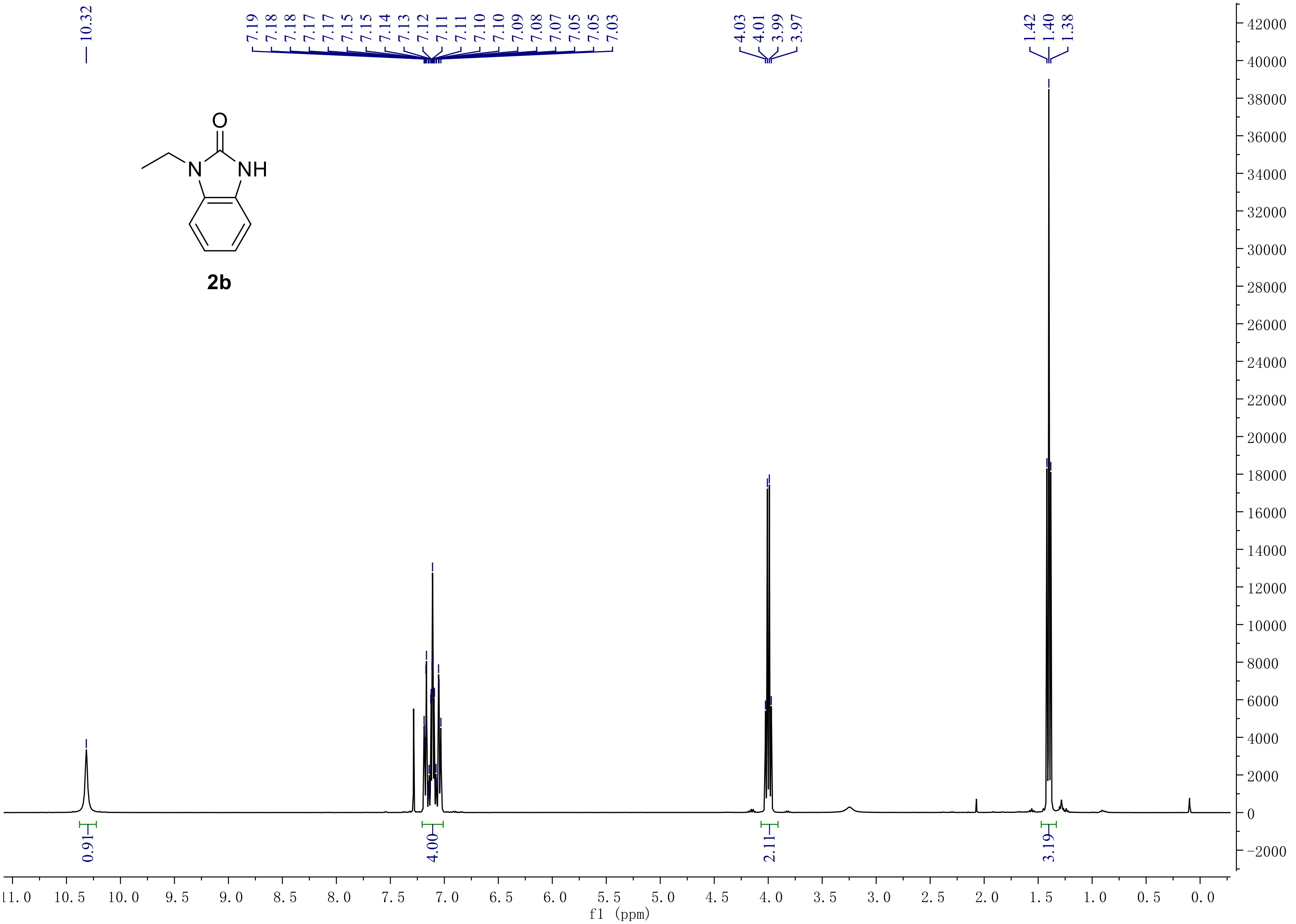
2b

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7.03
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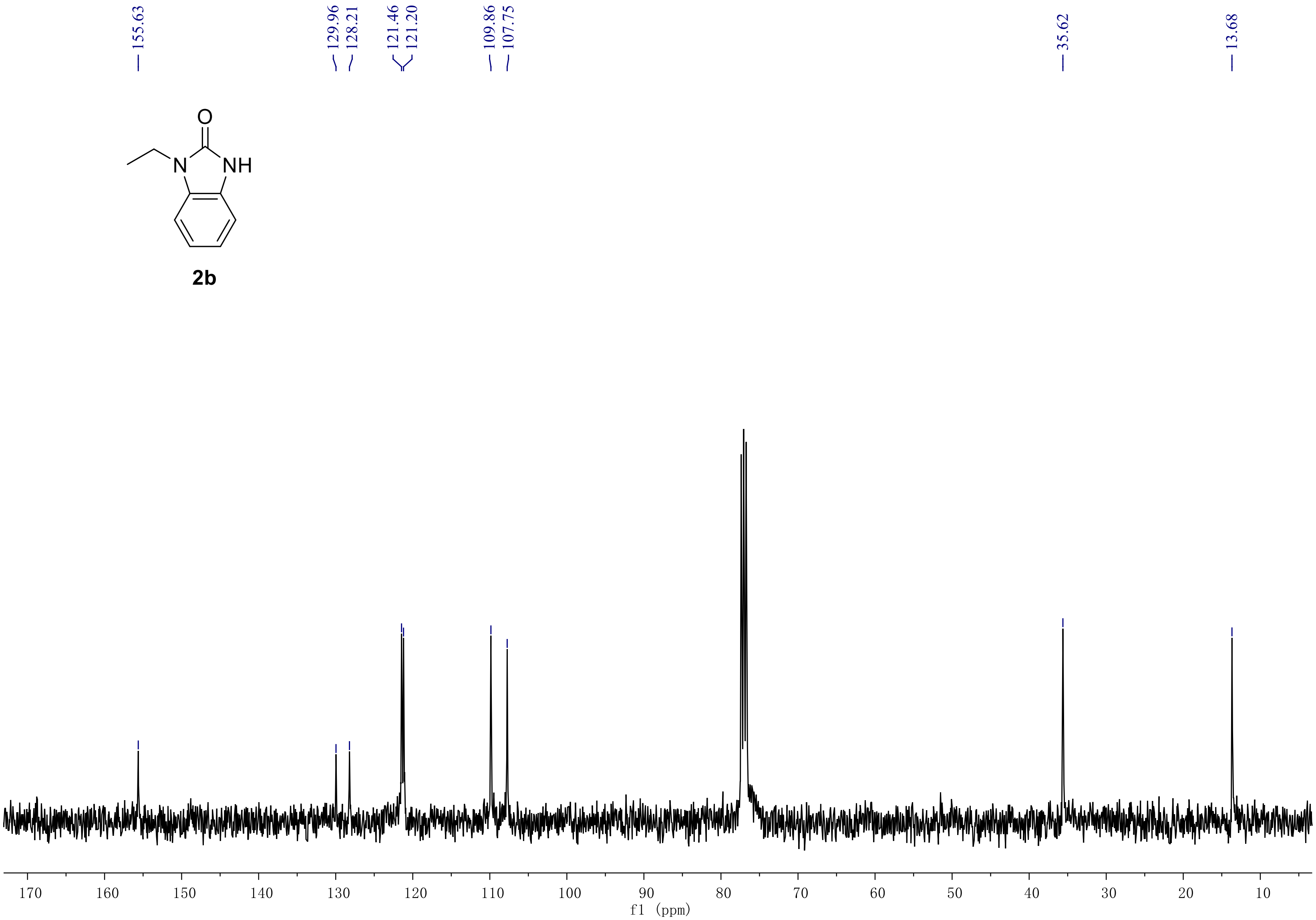
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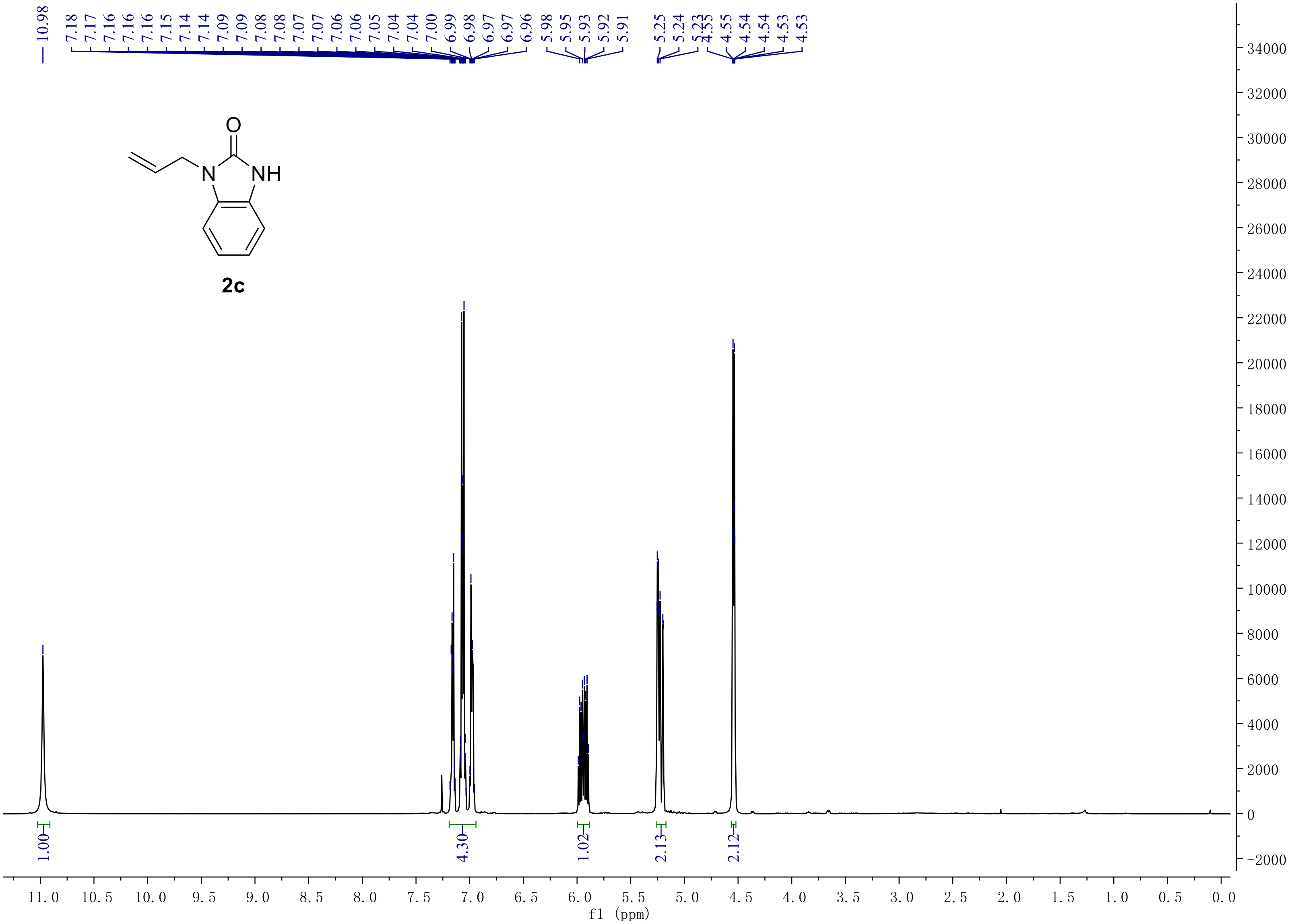
10
f1 (ppm)

2b



2c

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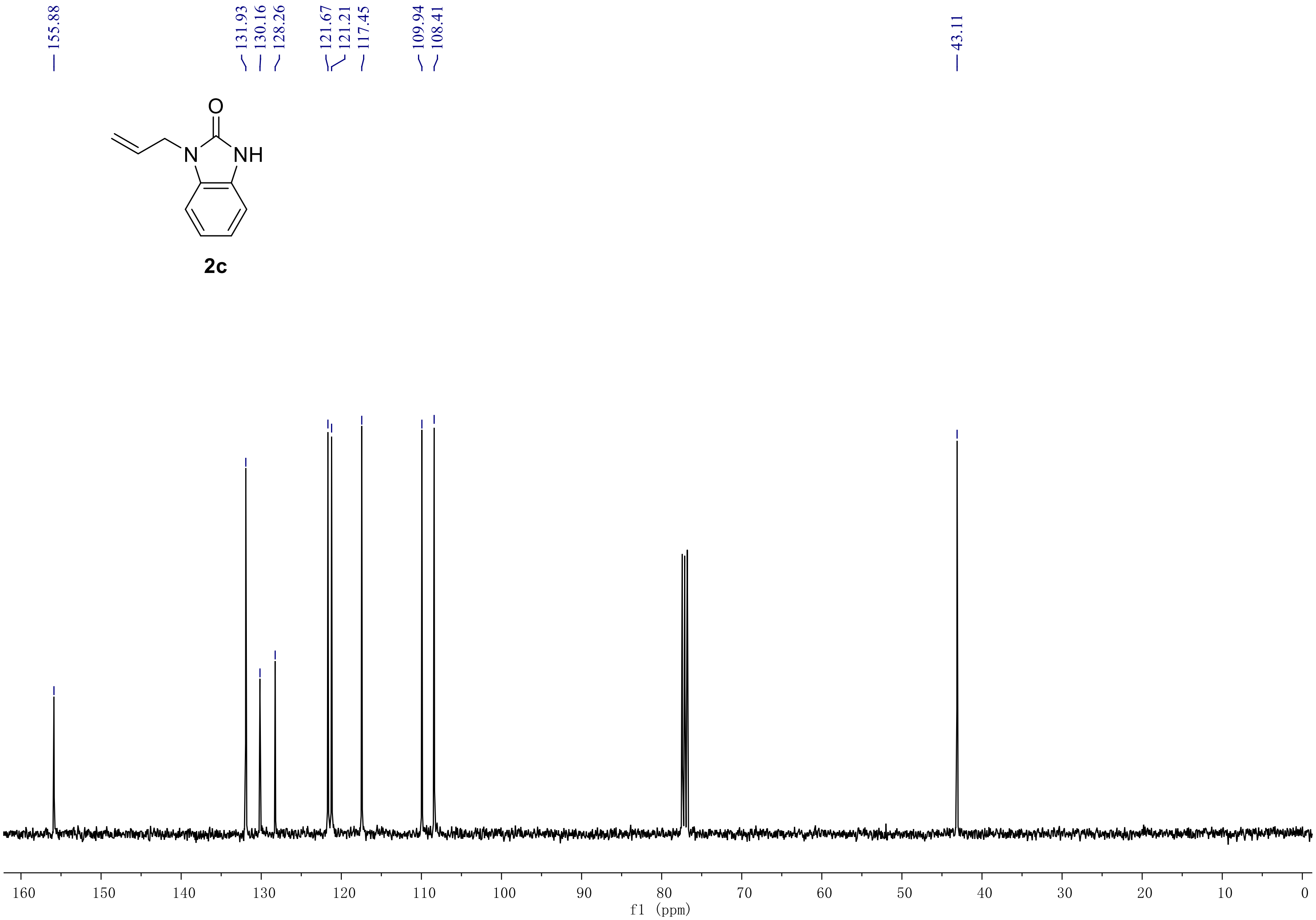
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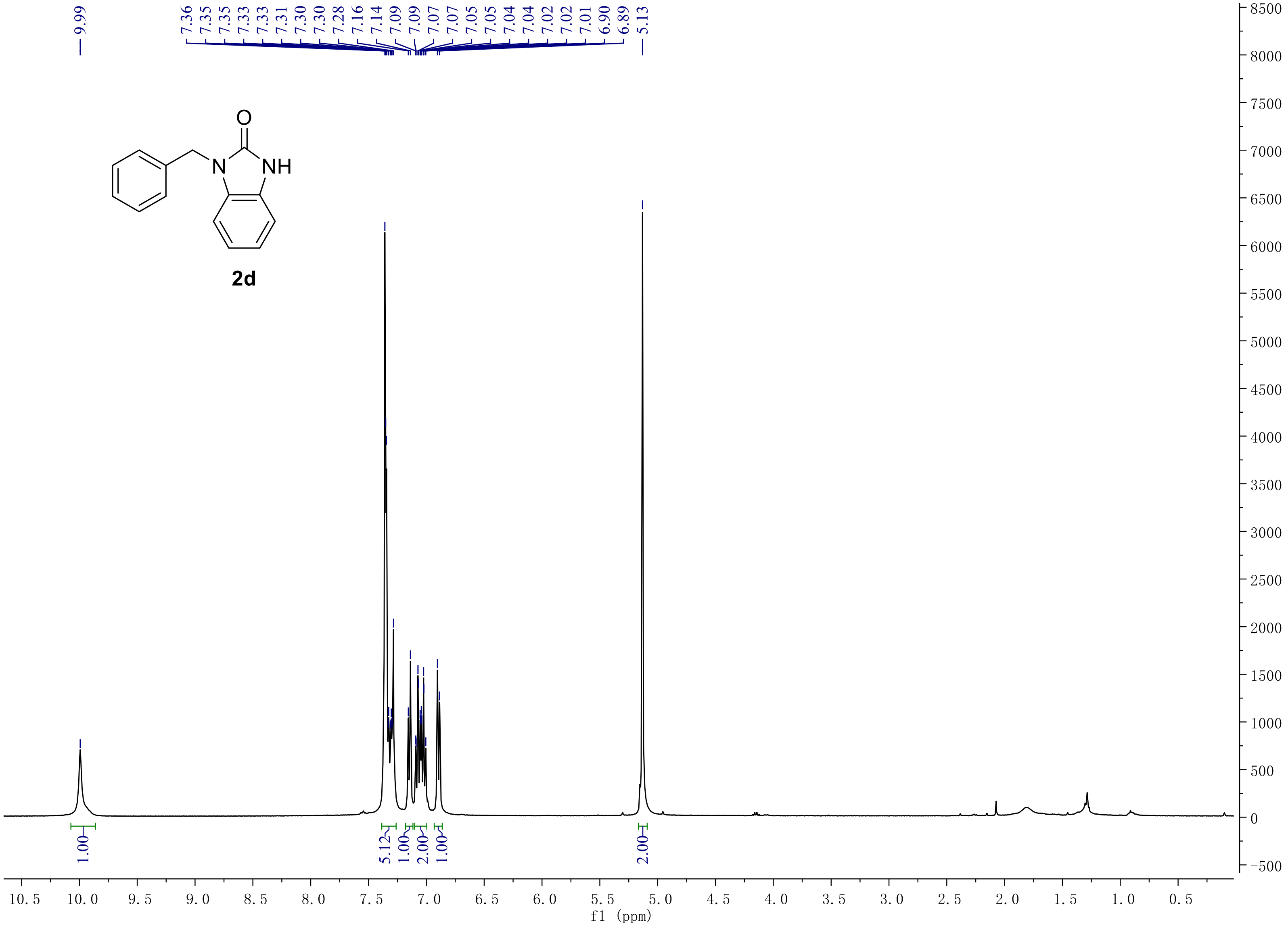
f1 (ppm)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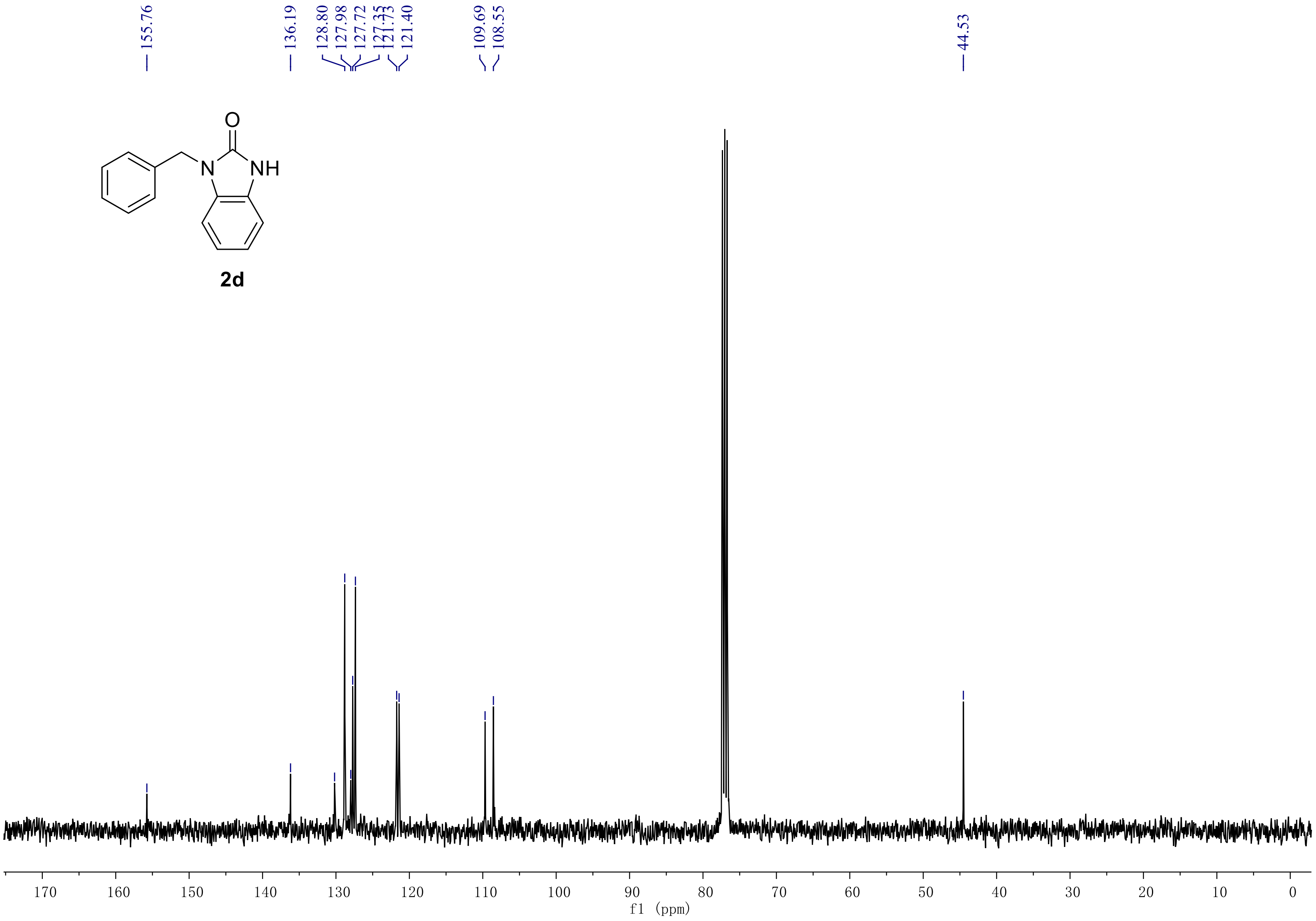
2d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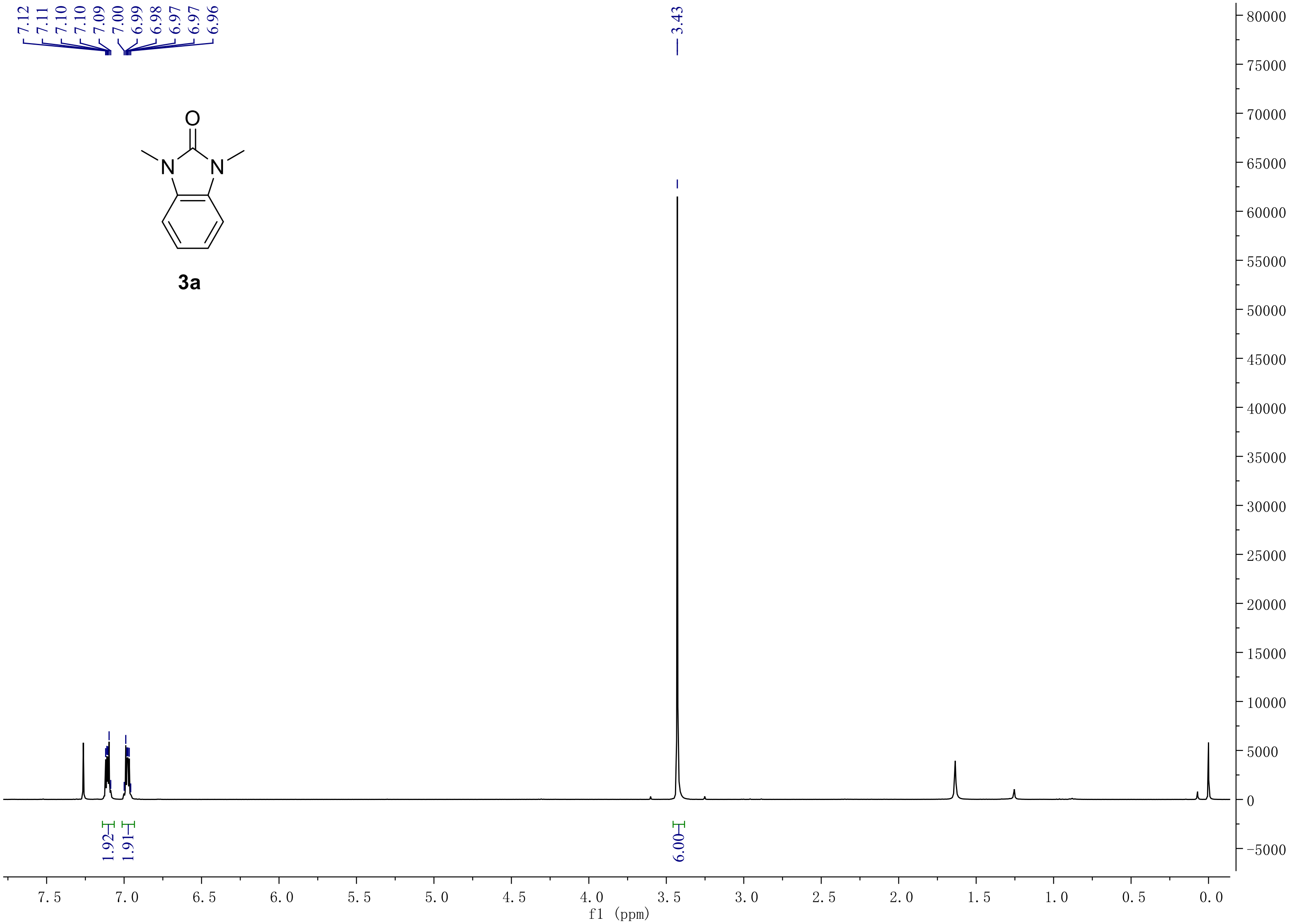
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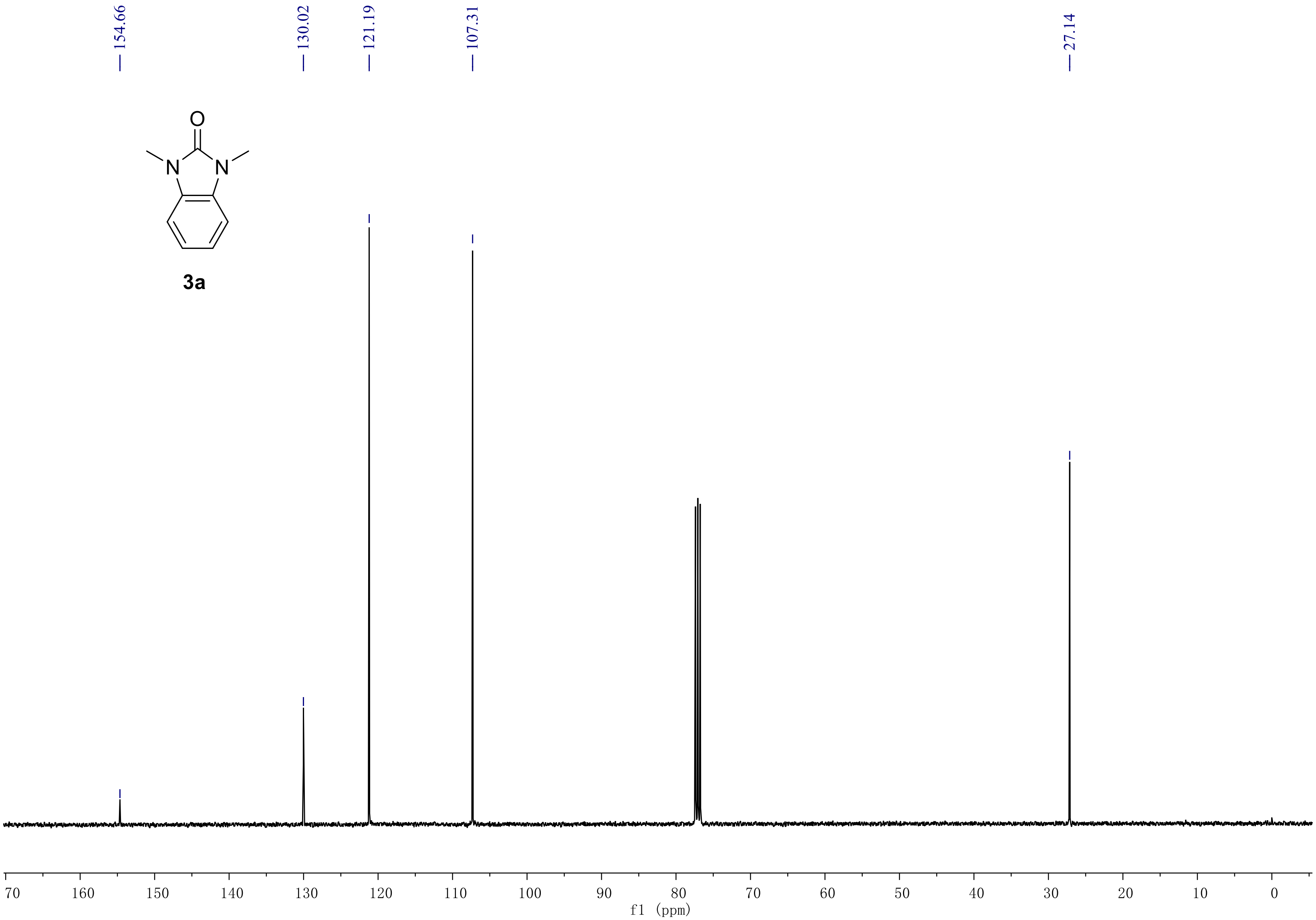
f1 (ppm)

3a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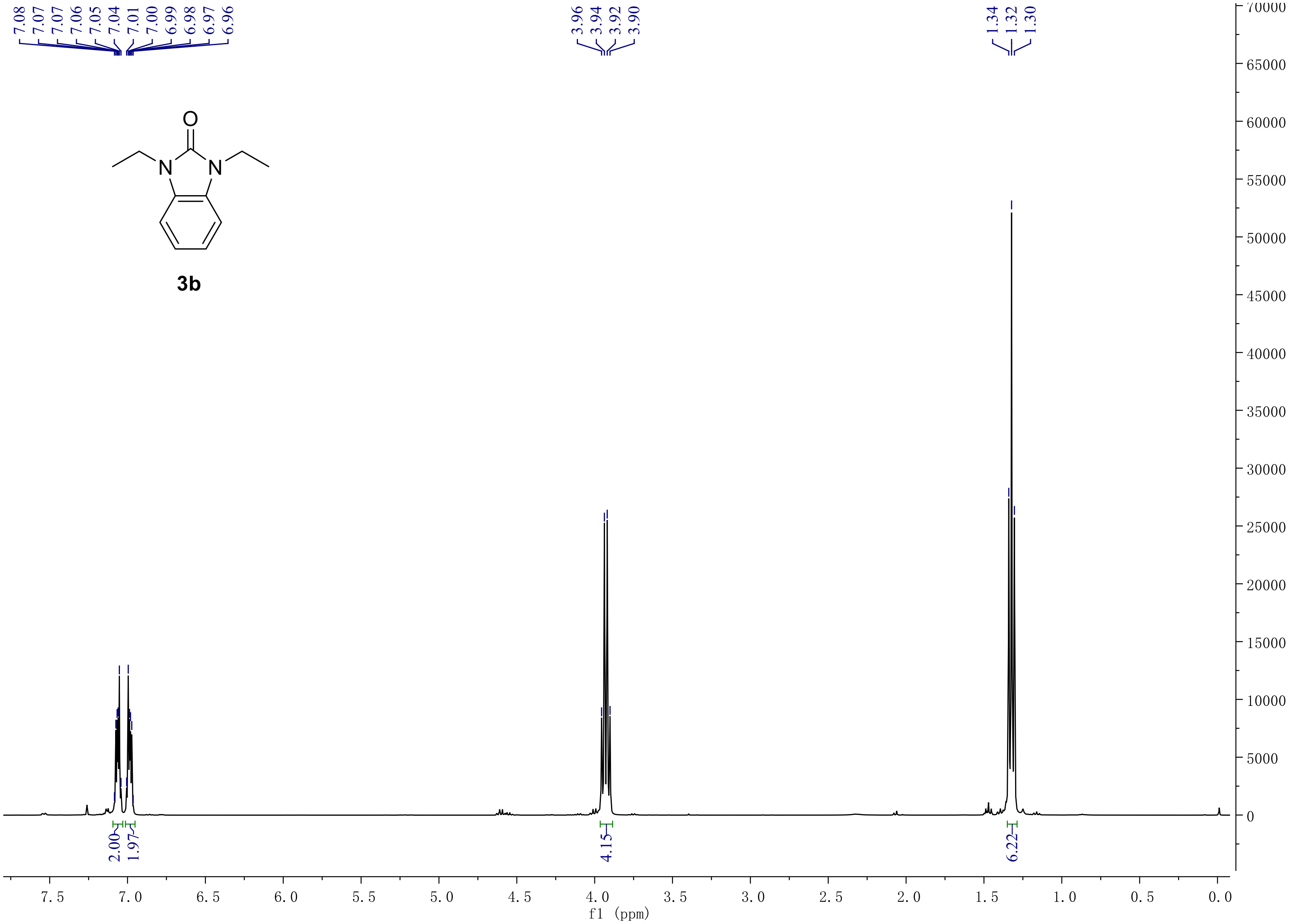
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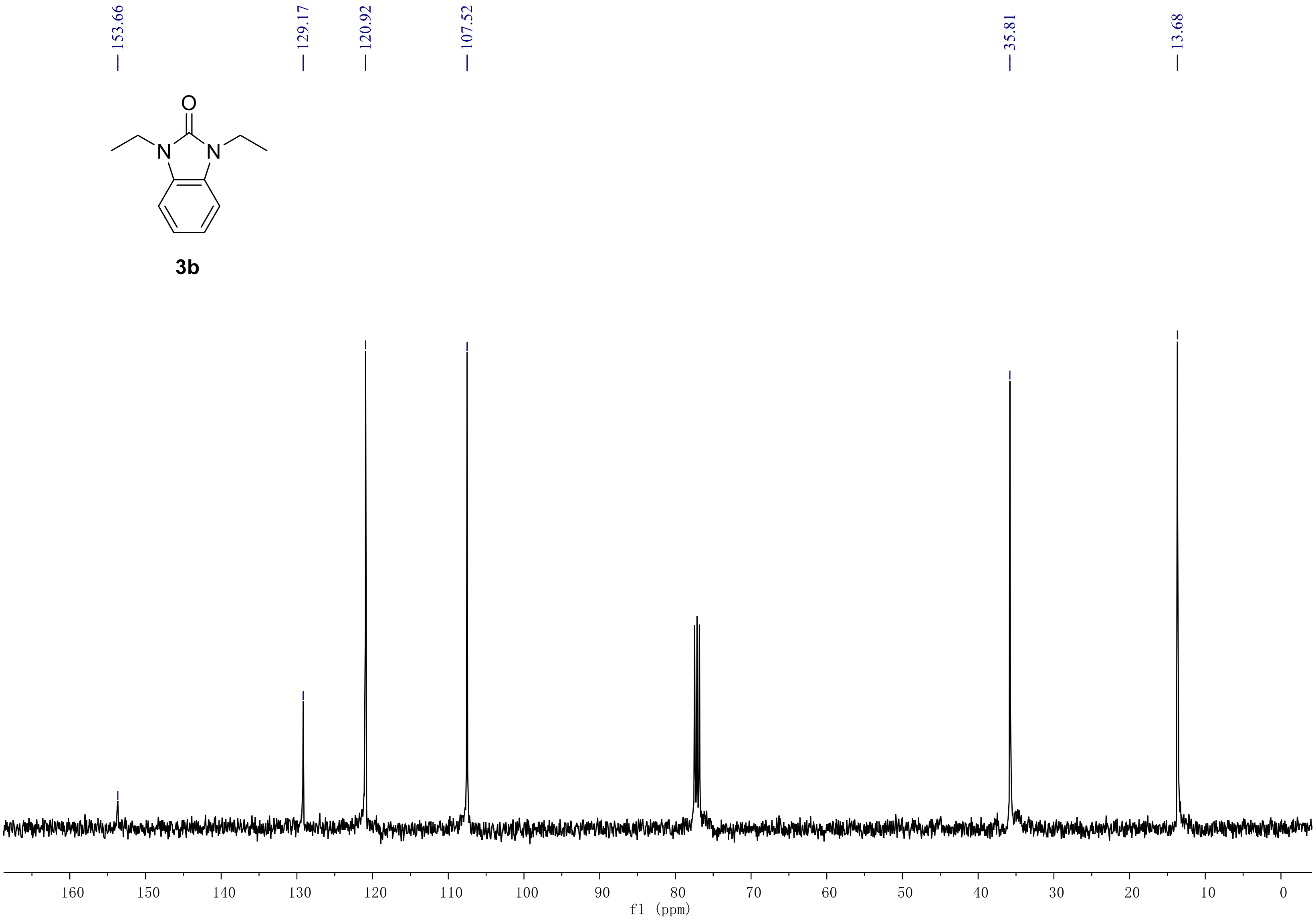
3b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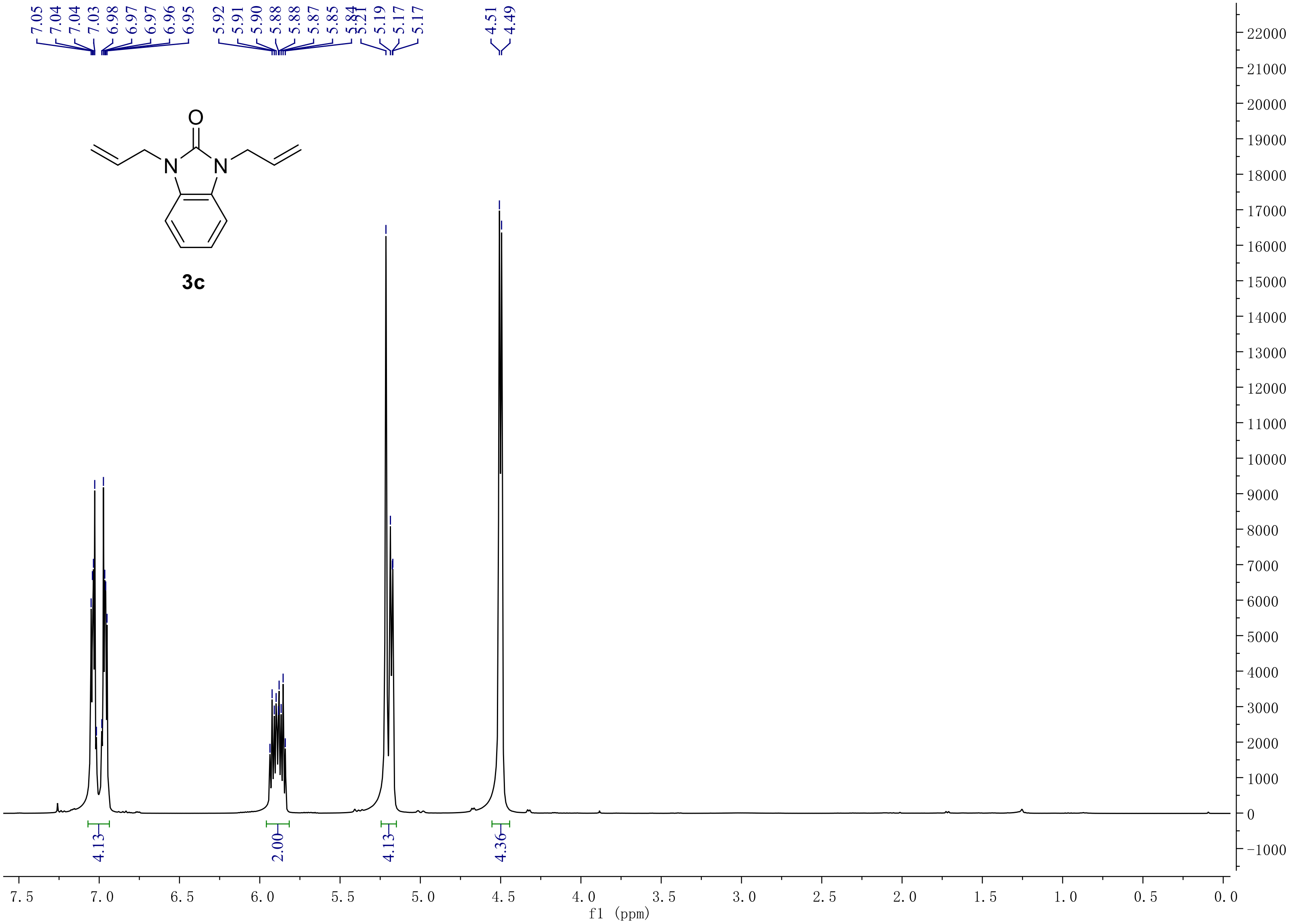
3b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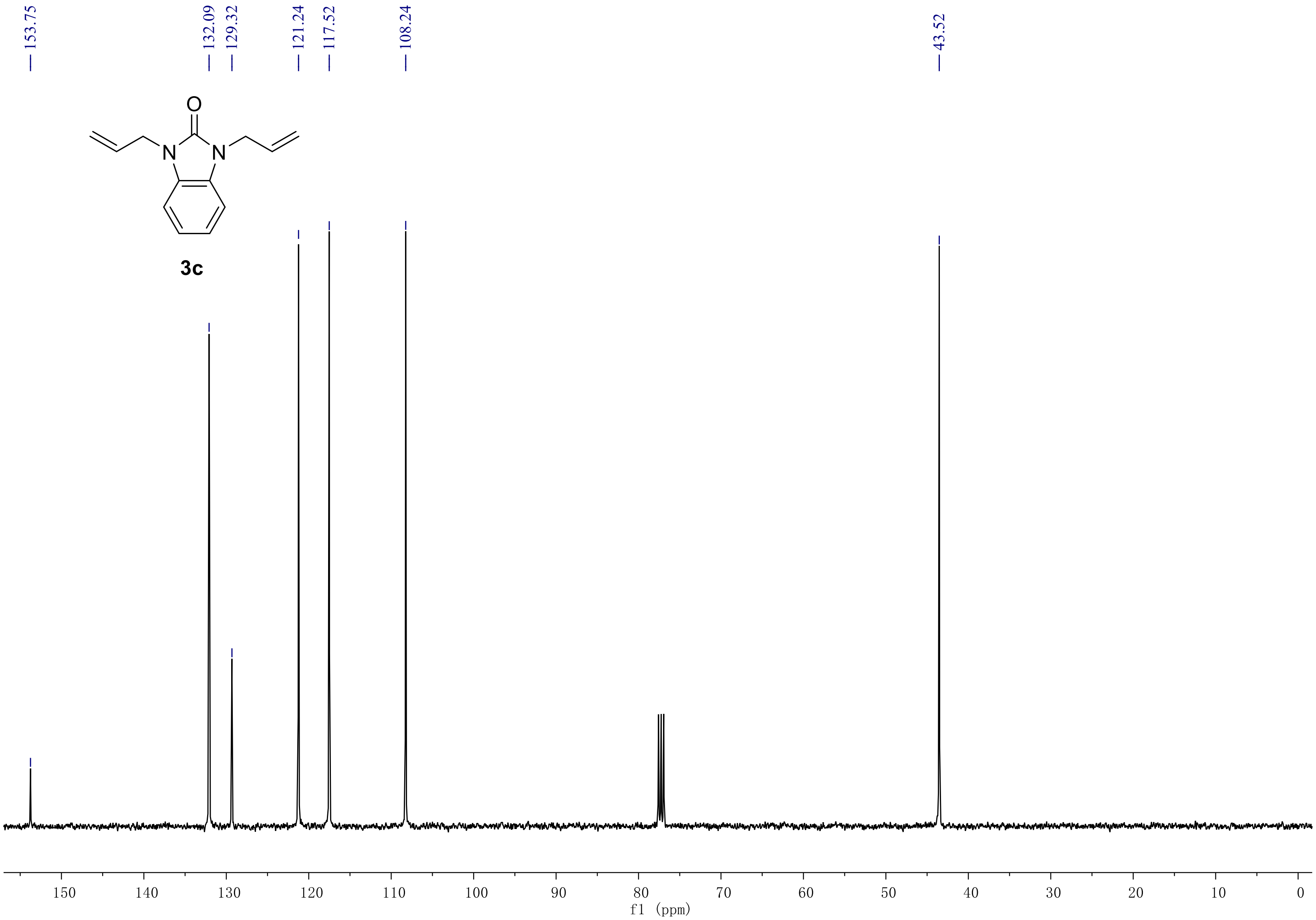

3c

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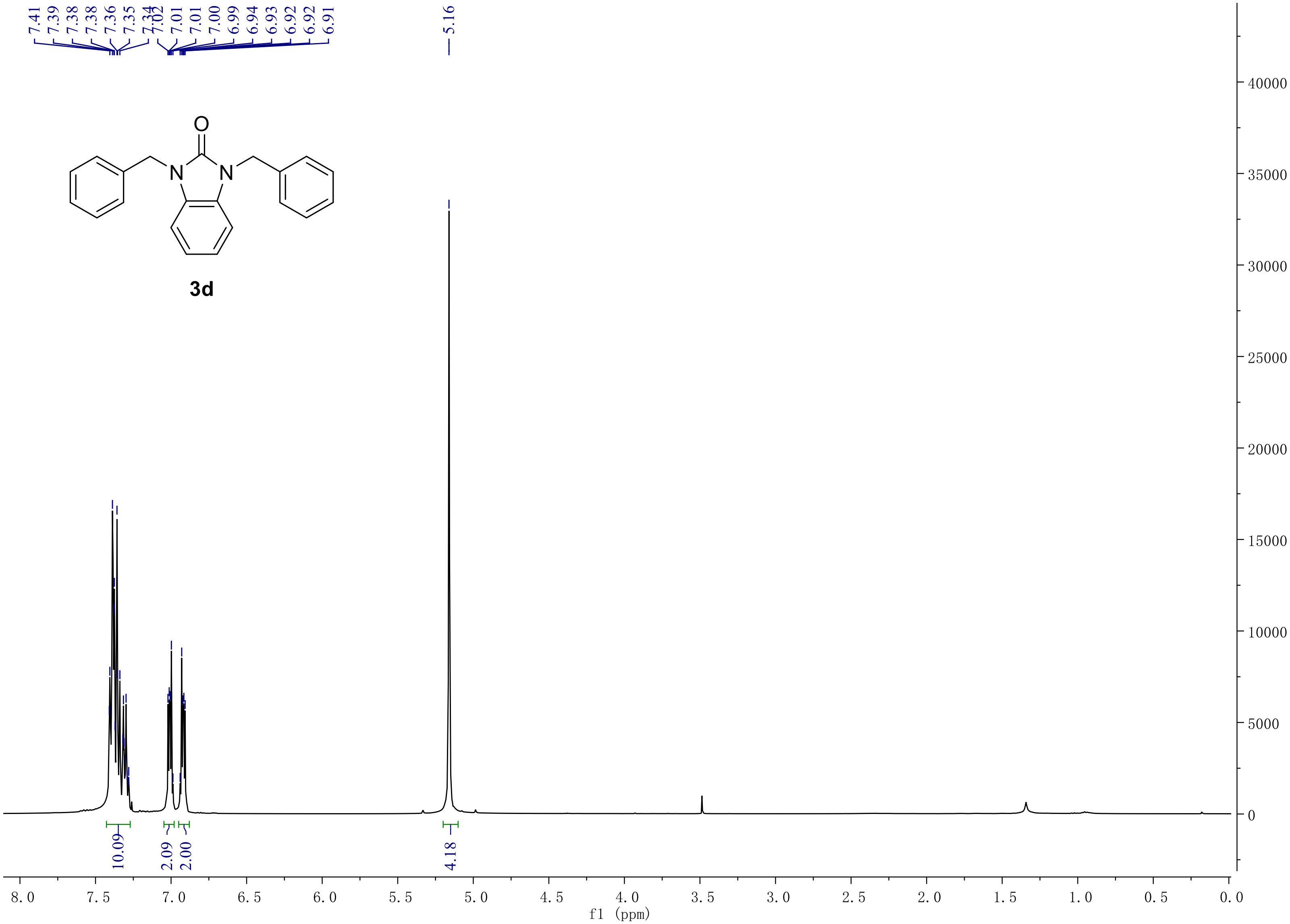
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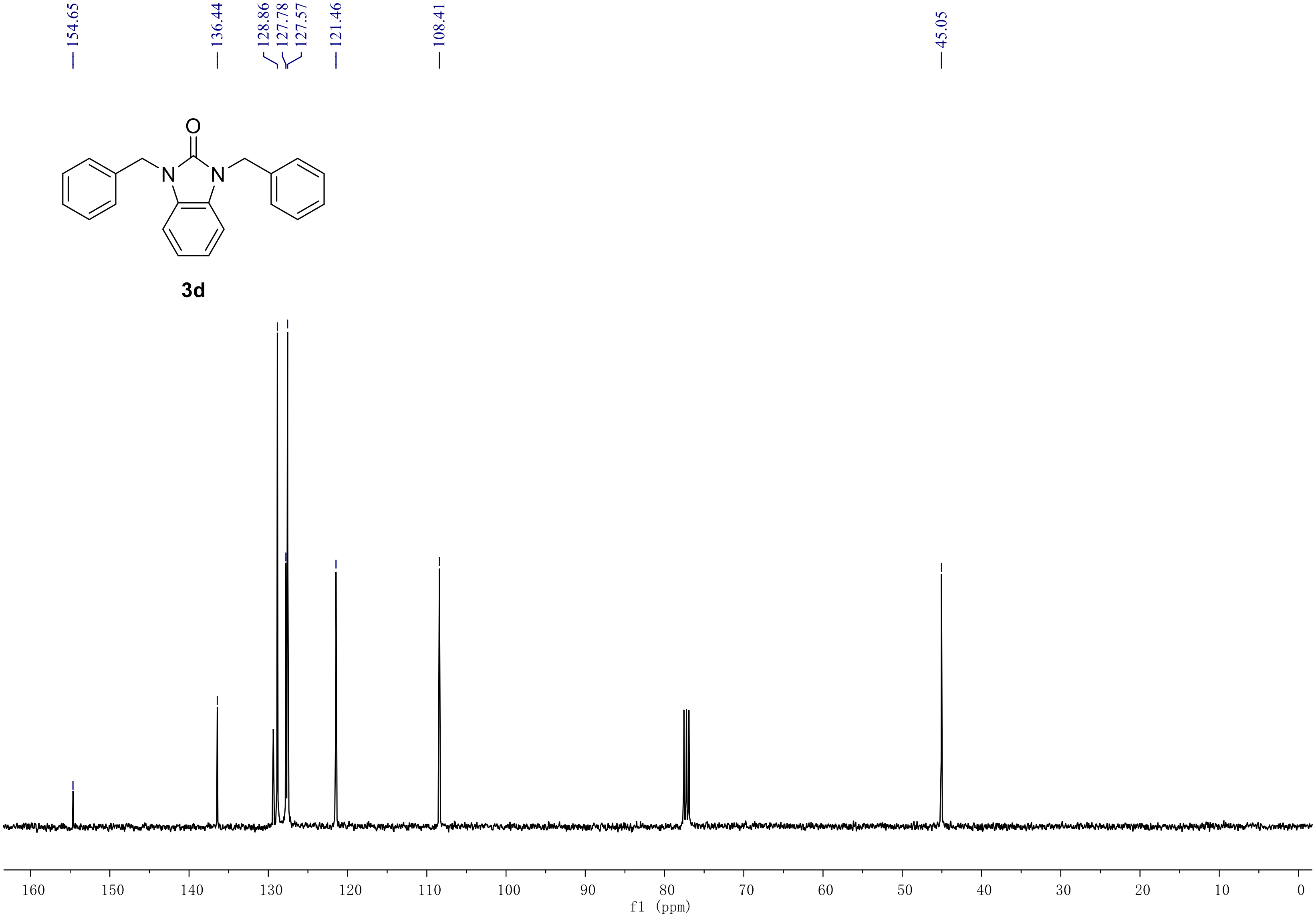
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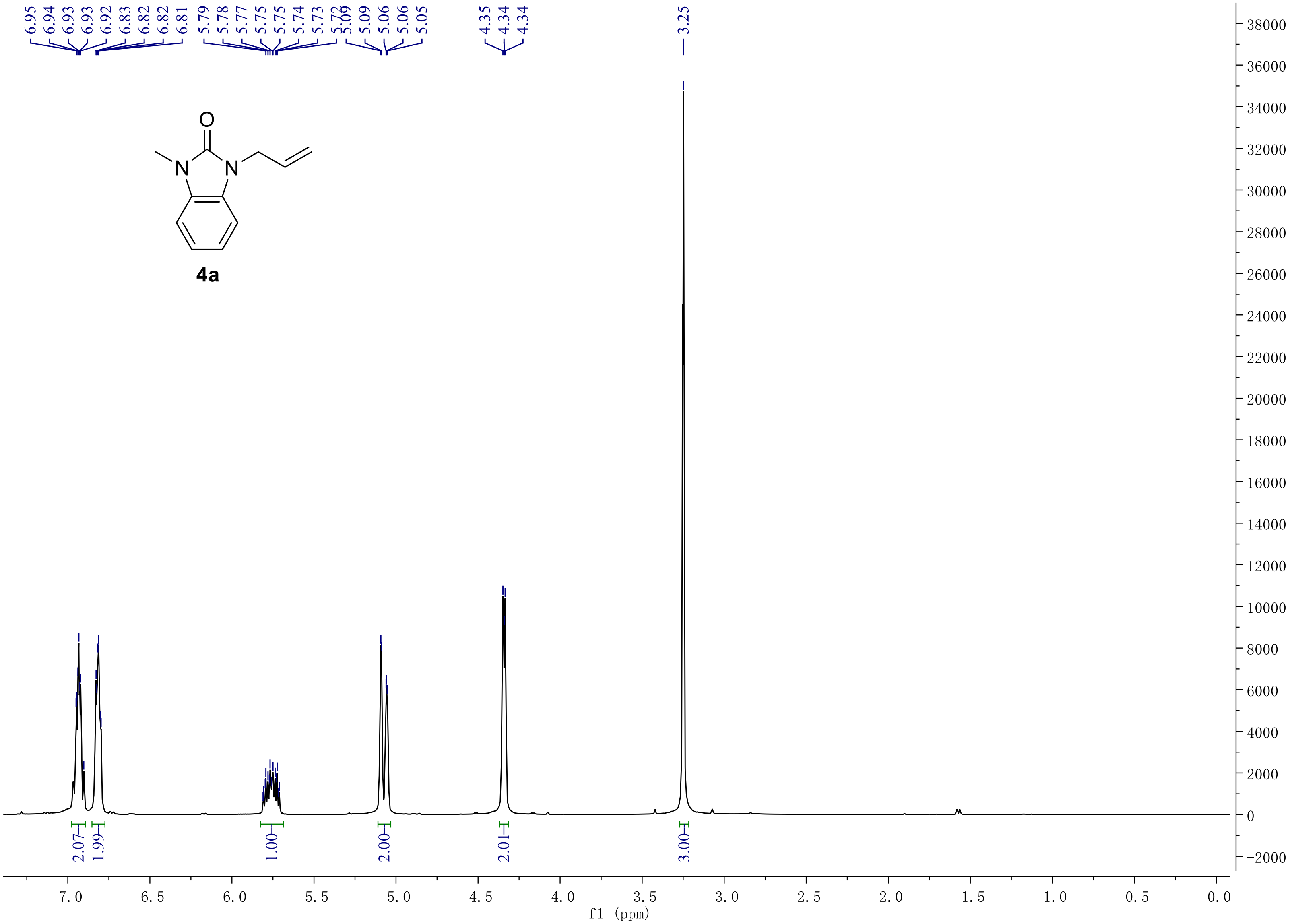
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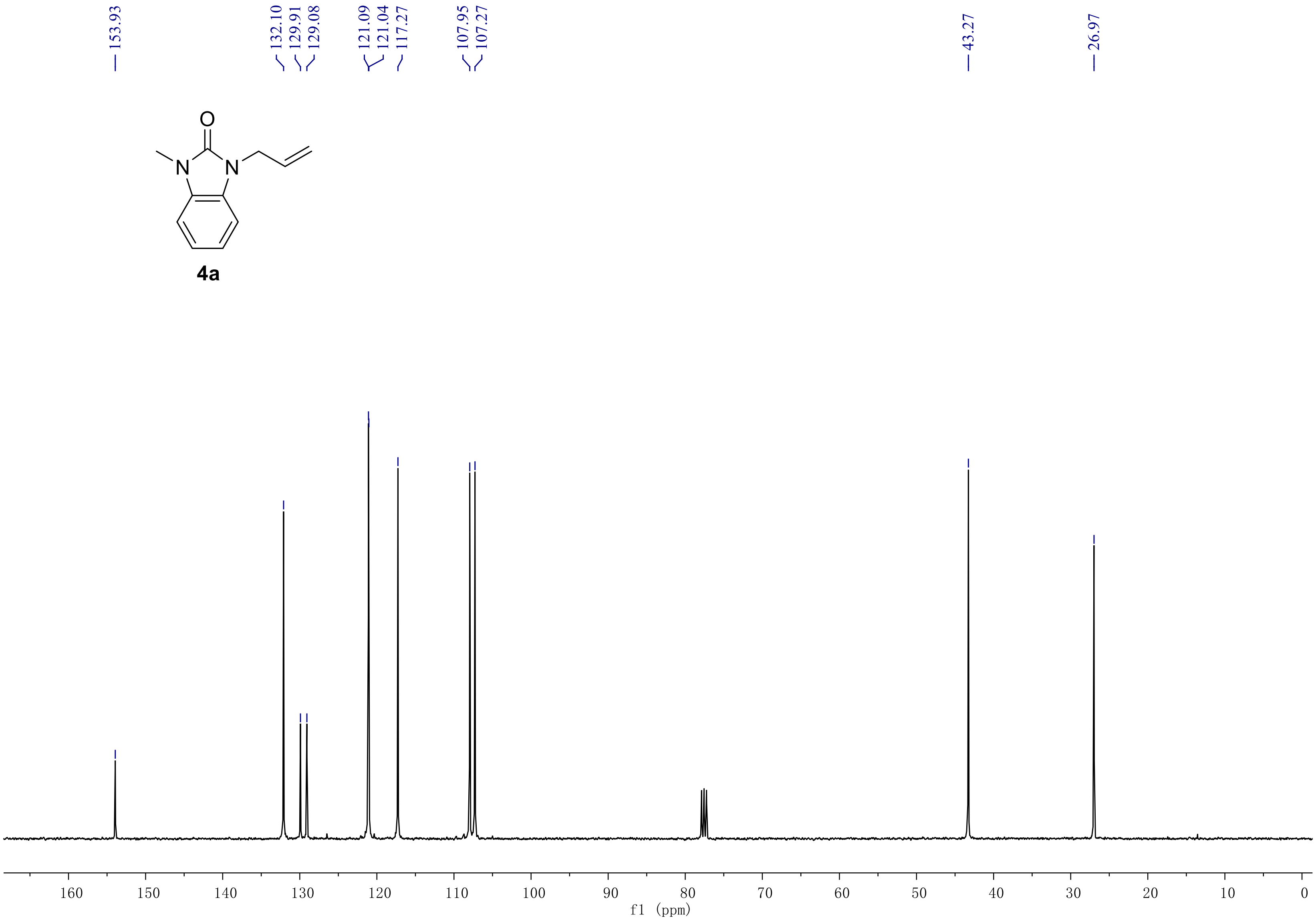
5.73
5.72
5.09
5.09
5.06
5.06
5.05
4.35
4.34
4.34
3.25
O
N
N
2.07
1.99
1.00
2.00
2.01
3.00
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
38000
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
−2000

4a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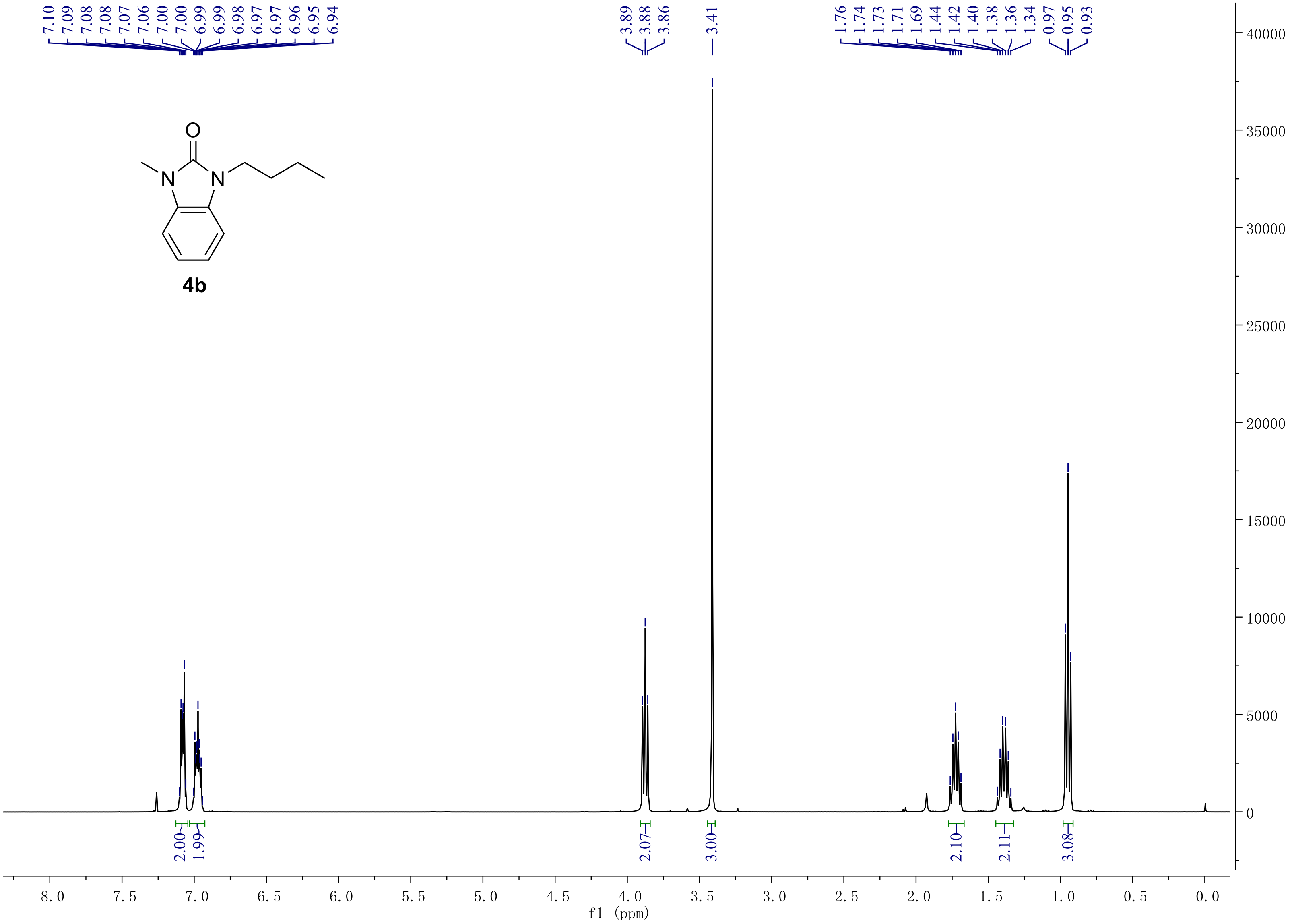
132.10
129.91
129.08
121.09
121.04
117.27
107.95
107.27
43.27
26.97
O
N
N
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4a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7.09
7.08
7.08
7.07
7.06
7.00
7.00
6.99
6.99
6.98
6.97
6.97
6.96
6.95
6.94
3.89
3.88
3.86
3.41
1.76
1.74
1.73
1.71
1.69
1.44
1.42
1.40
1.38
1.36
1.34
0.97
0.95
0.93
O
N
N
4b
2.00
1.99
2.07
3.00
2.10
2.11
3.08
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
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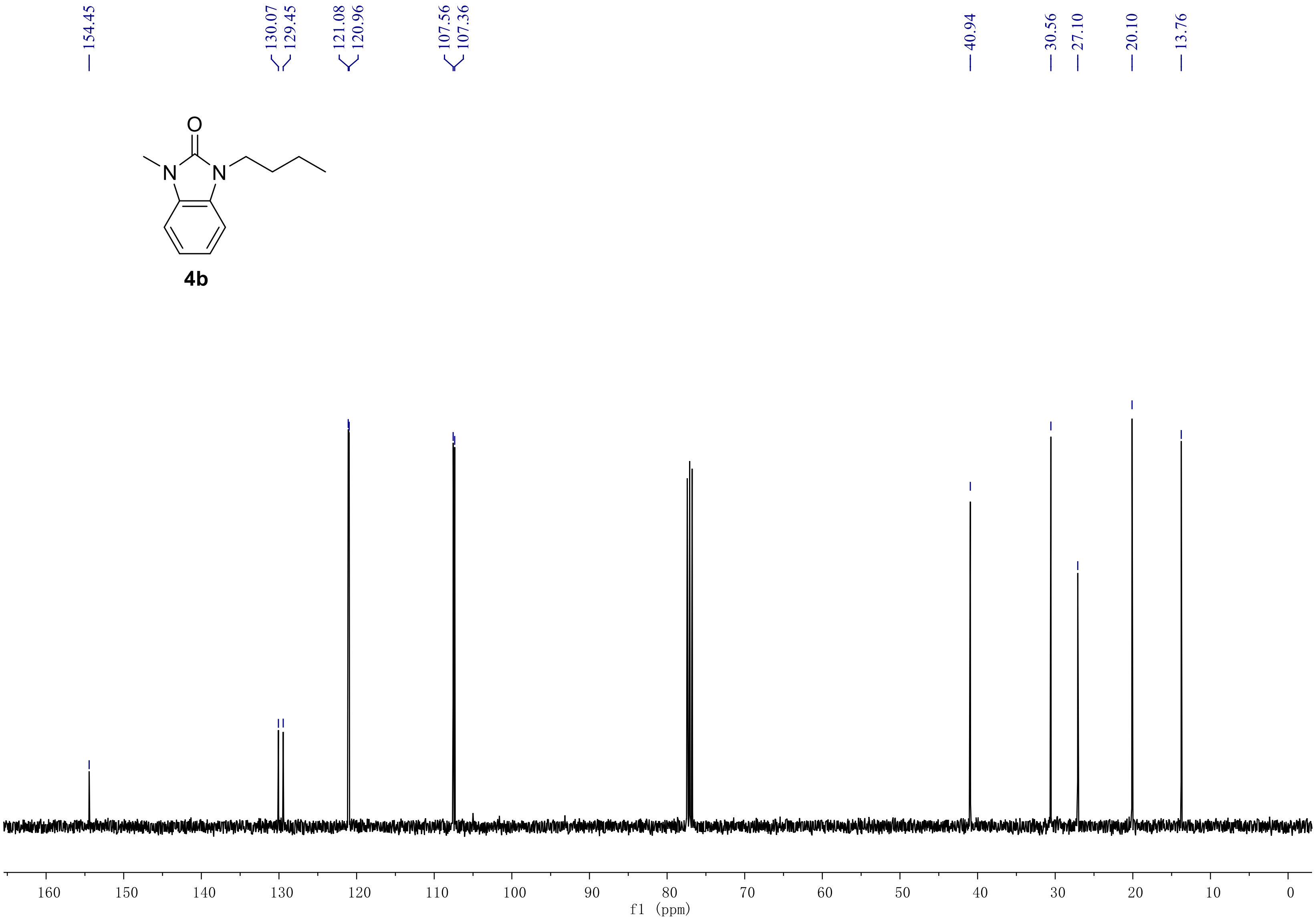
35000
30000
25000
20000
15000
10000
5000
0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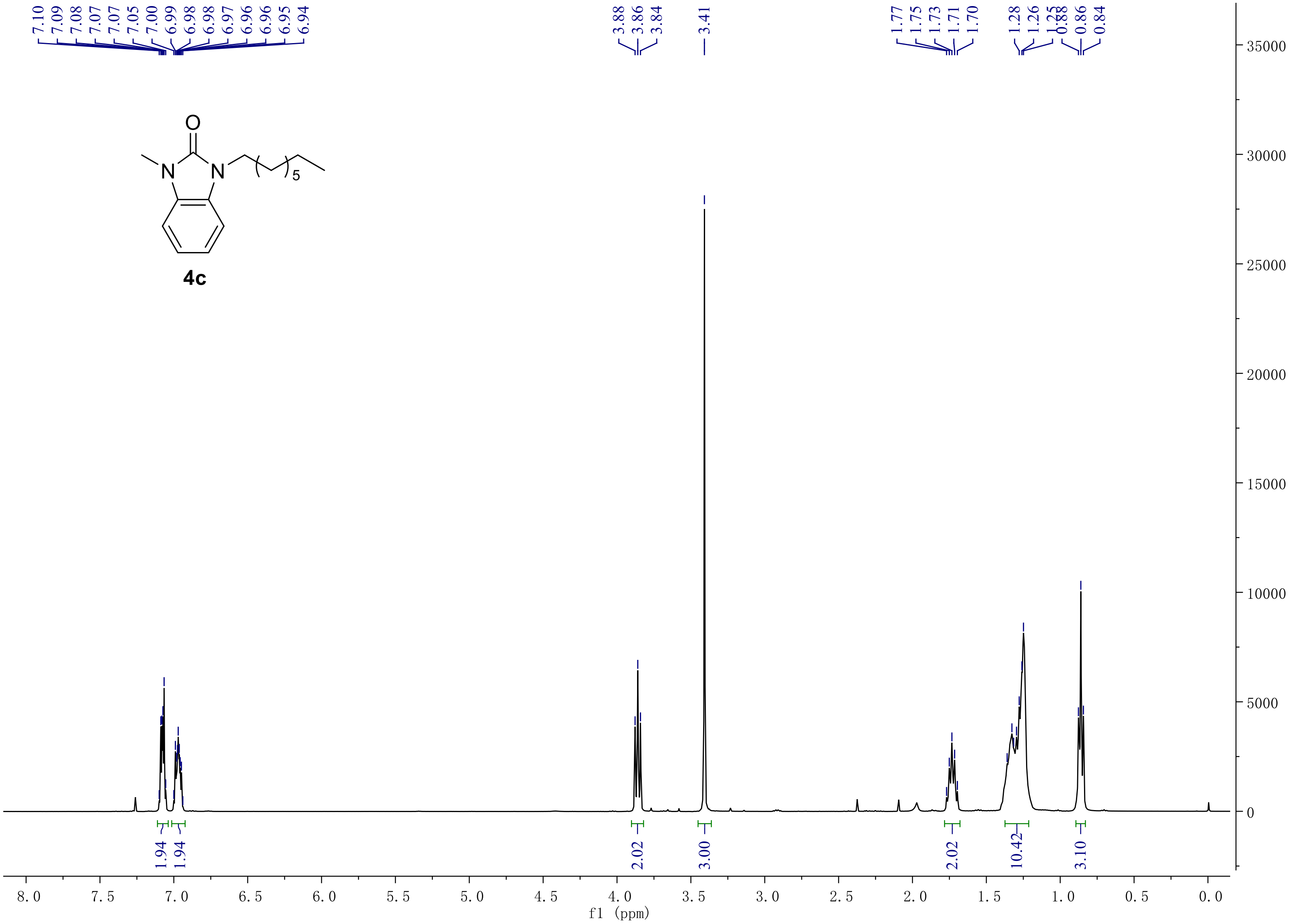
130.07
129.45
121.08
120.96
107.56
107.36
40.94
30.56
27.10
20.10
13.76
O
N
N
4b
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.09
7.08
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7.07
7.05
7.00
6.99
6.98
6.98
6.97
6.96
6.96
6.95
6.94
3.88
3.86
3.84
3.41
1.77
1.75
1.73
1.71
1.70
1.28
1.26
1.25
0.88
0.86
0.84
O
N
N
5
4c
1.94
1.94
2.02
3.00
2.02
10.42
3.10
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
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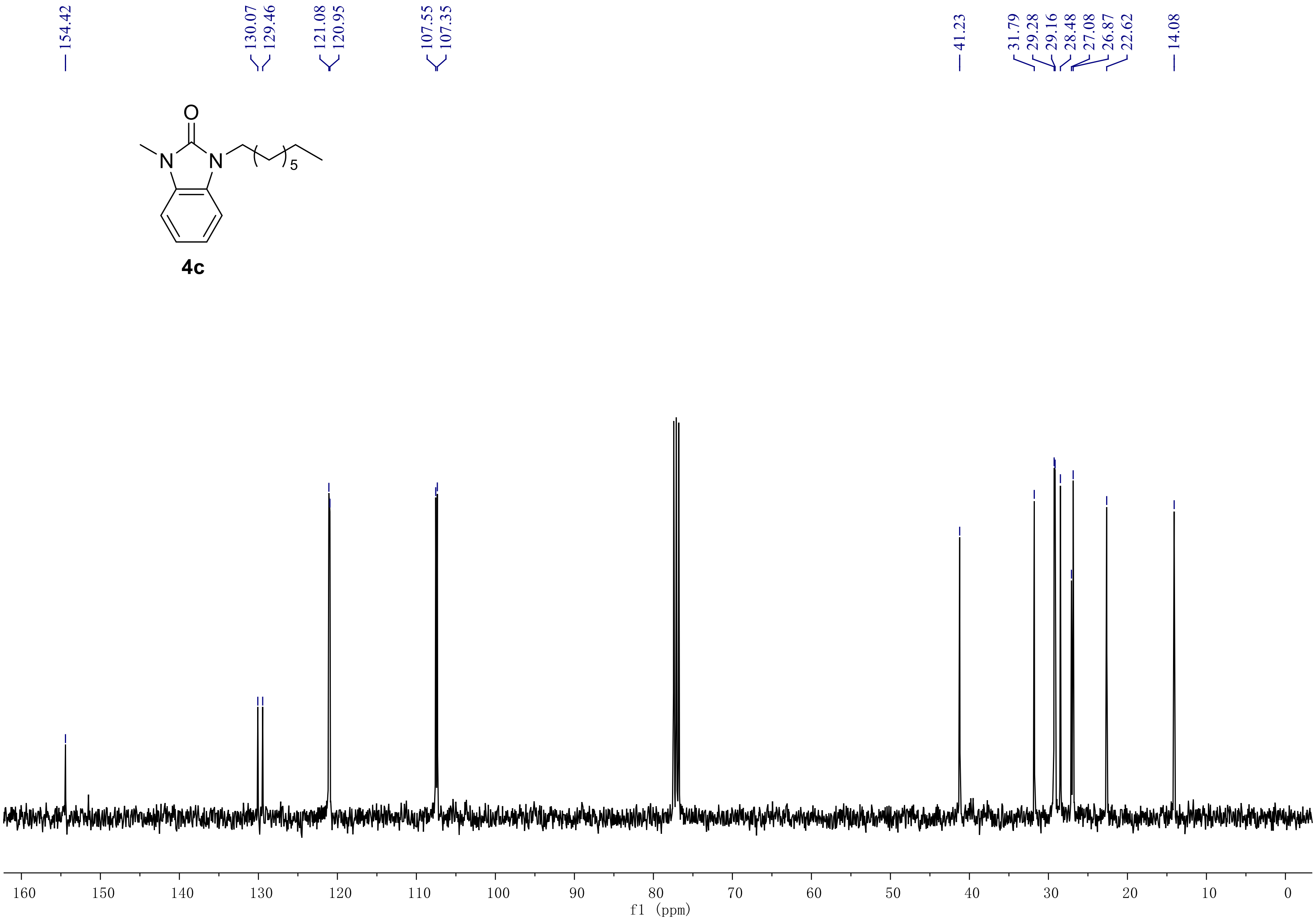
30000
25000
20000
15000
10000
5000
0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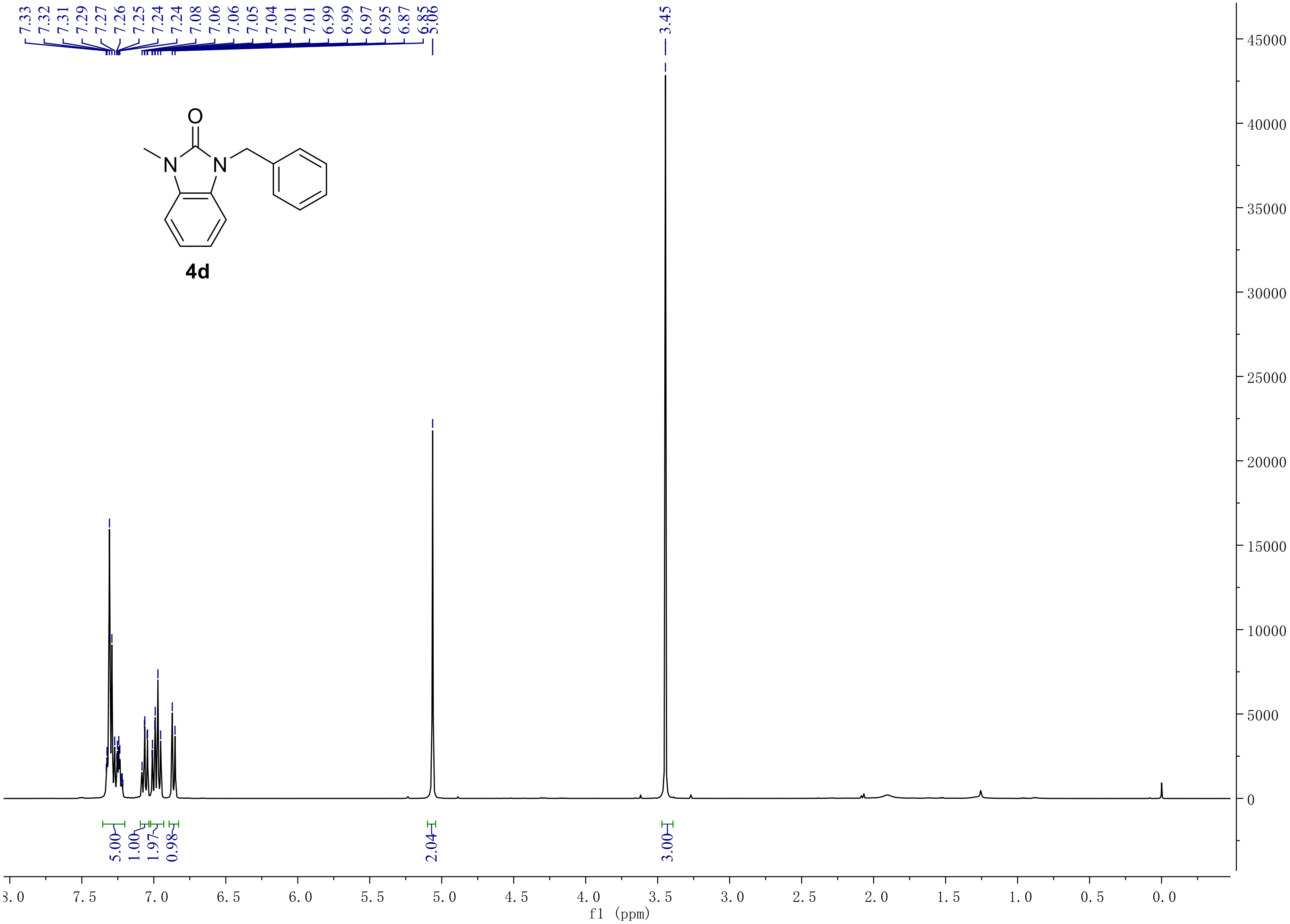
130.07
129.46
121.08
120.95
107.55
107.35
41.23
31.79
29.28
29.16
28.48
27.08
26.87
22.62
14.08
O
N
N
5
4c
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.33
7.32
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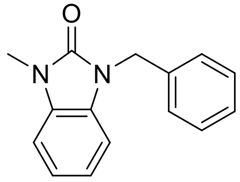
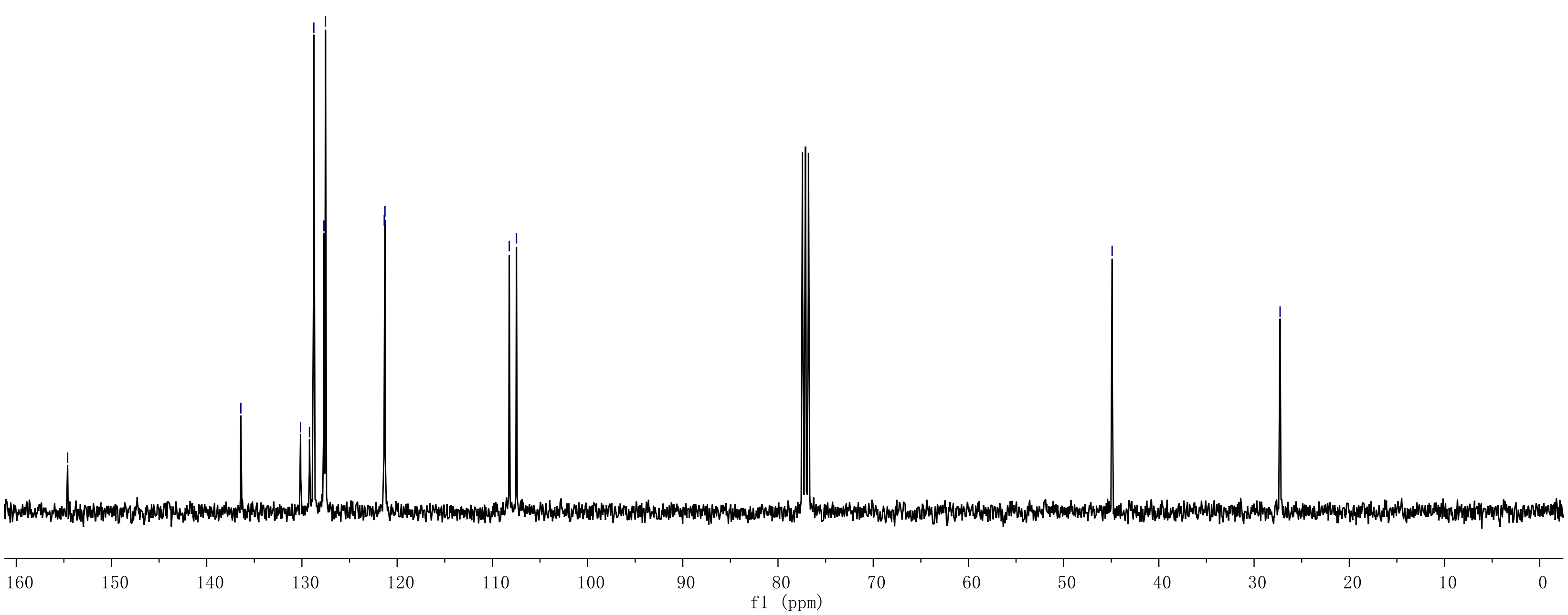
7.29
7.27
7.26
7.25
7.24
7.24
7.08
7.06
7.06
7.05
7.04
7.01
7.01
6.99
6.99
6.97
6.95
6.87
6.85
5.06
3.45
O
N
N
4d
5.00
1.00
1.97
0.98
2.04
3.00
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


O
N
N

4d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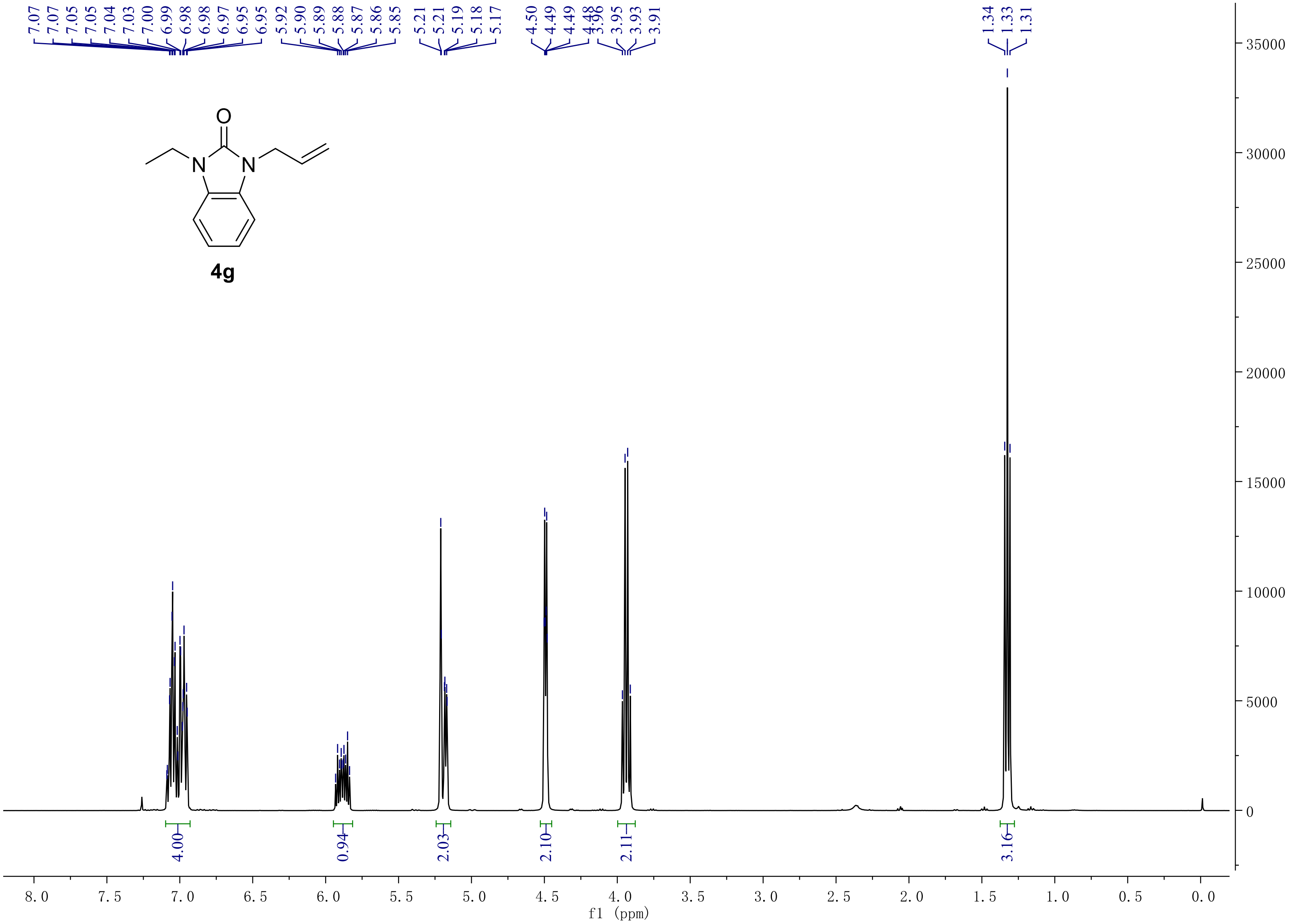
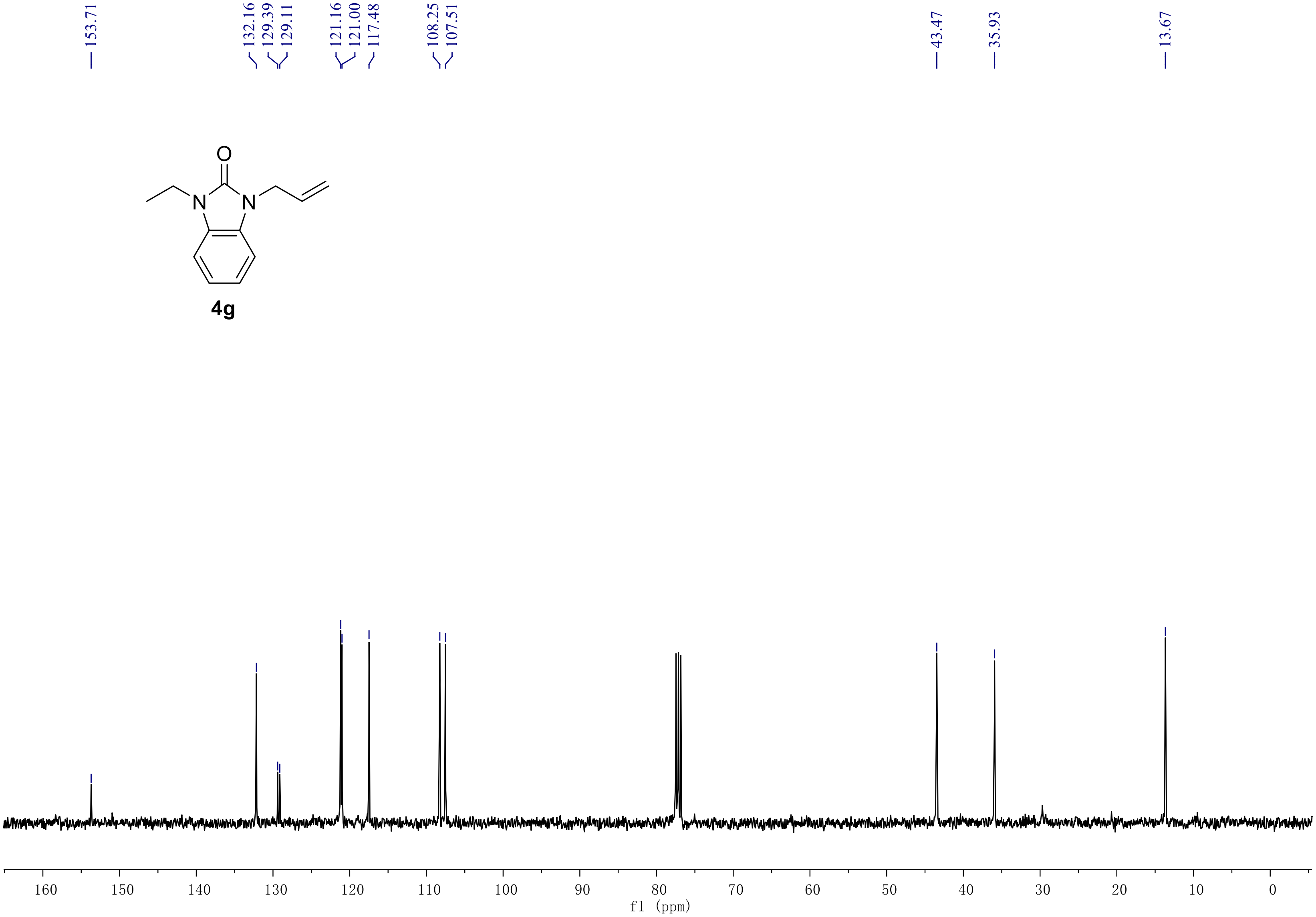
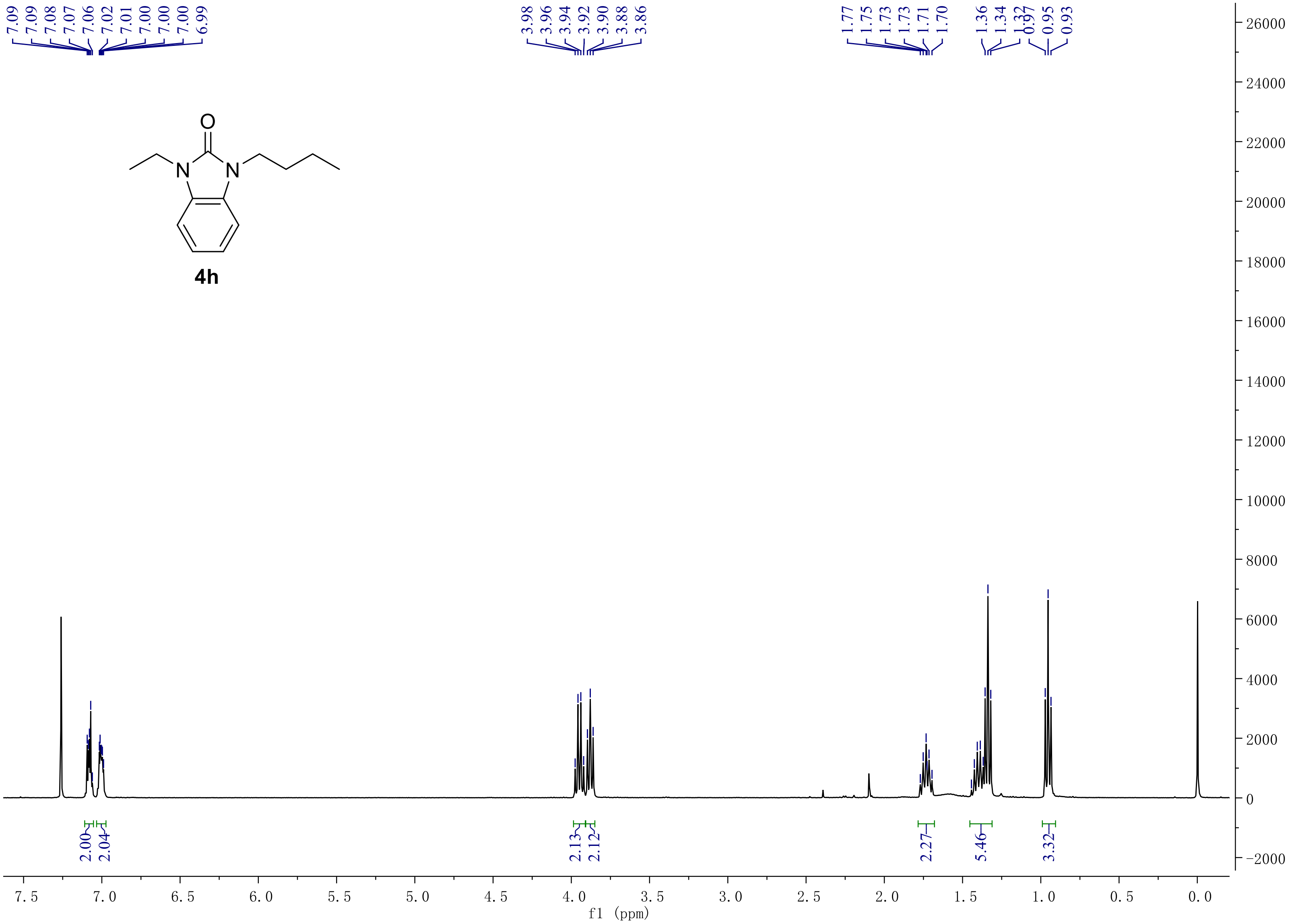
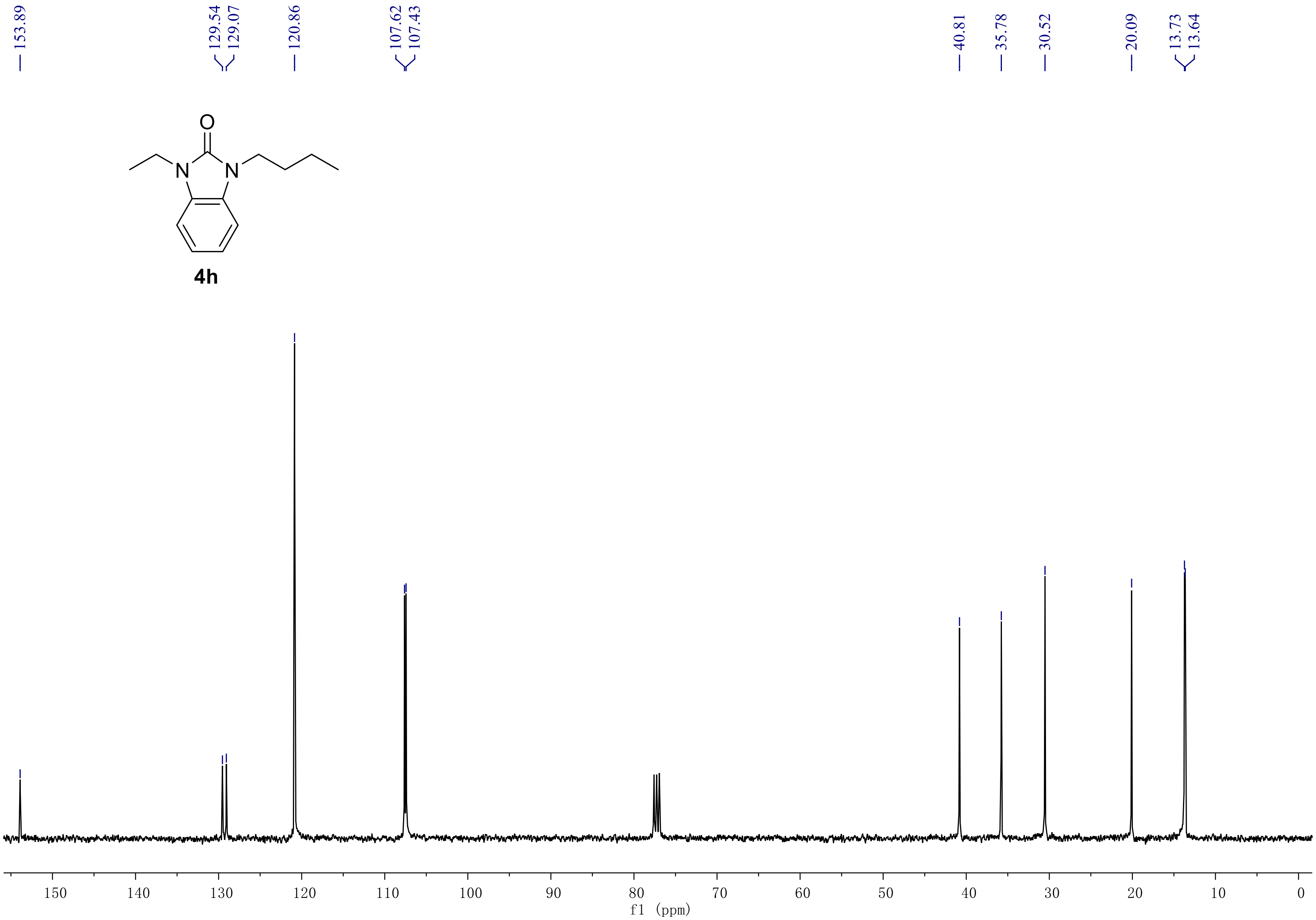
136.42
130.14
128.75
127.69
127.52
121.35
121.28
108.22
107.47
44.91
27.27
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.07
7.07
7.05
7.05
7.04
7.03
7.00
6.99
6.98
6.98
6.97
6.95
6.95
5.92
5.90
5.89
5.88
5.87
5.86
5.85
5.21
5.21
5.19
5.18
5.17
4.50
4.49
4.49
4.48
3.96
3.95
3.93
3.91
1.34
1.33
1.31
O
N
N
4g
4.00
0.94
2.03
2.10
2.11
3.16
35000
30000
25000
20000
15000
10000
5000
0
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

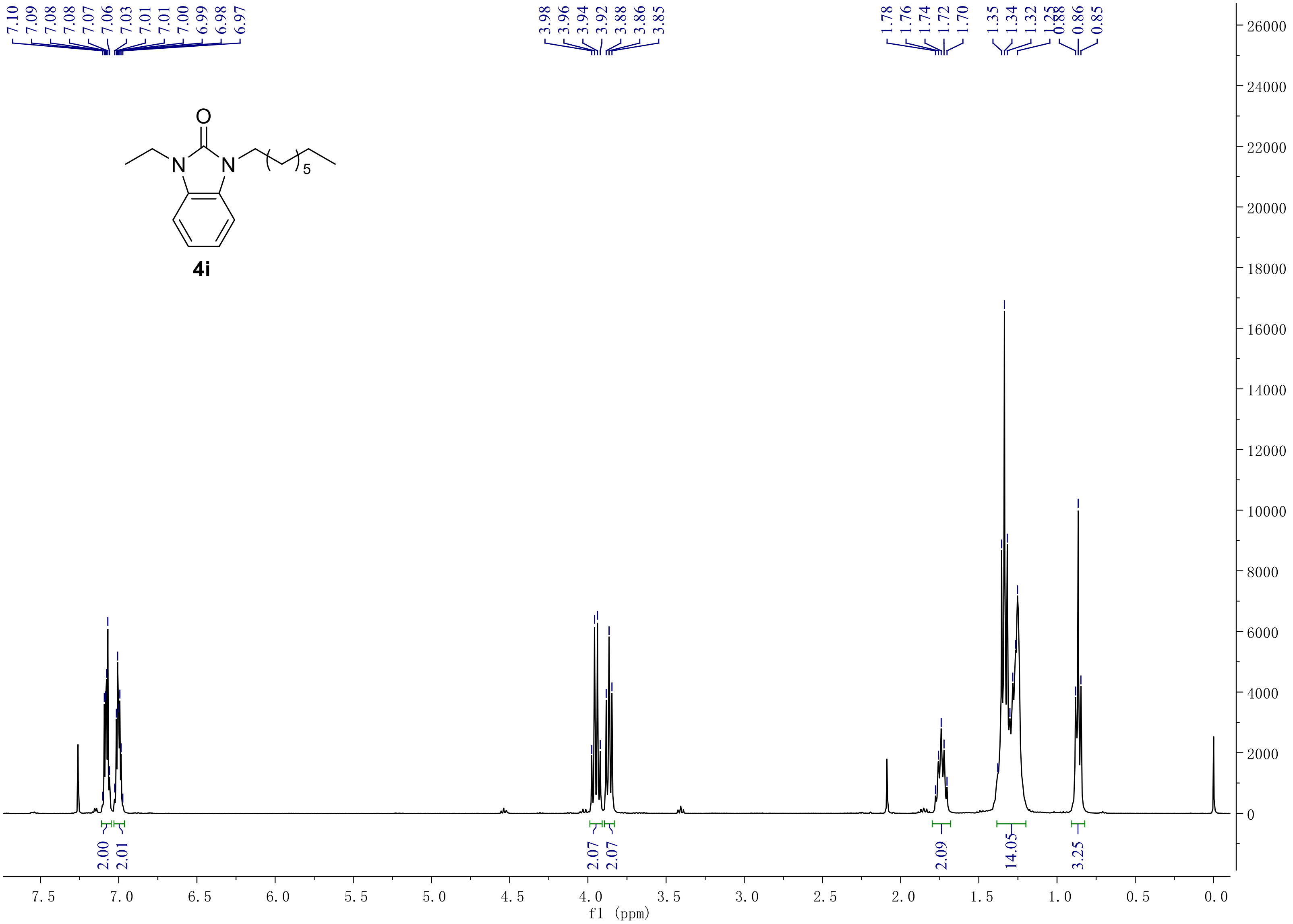

153.71
132.16
129.39
129.11
121.16
121.00
117.48
108.25
107.51
43.47
35.93
13.67
O
N
N
4g
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

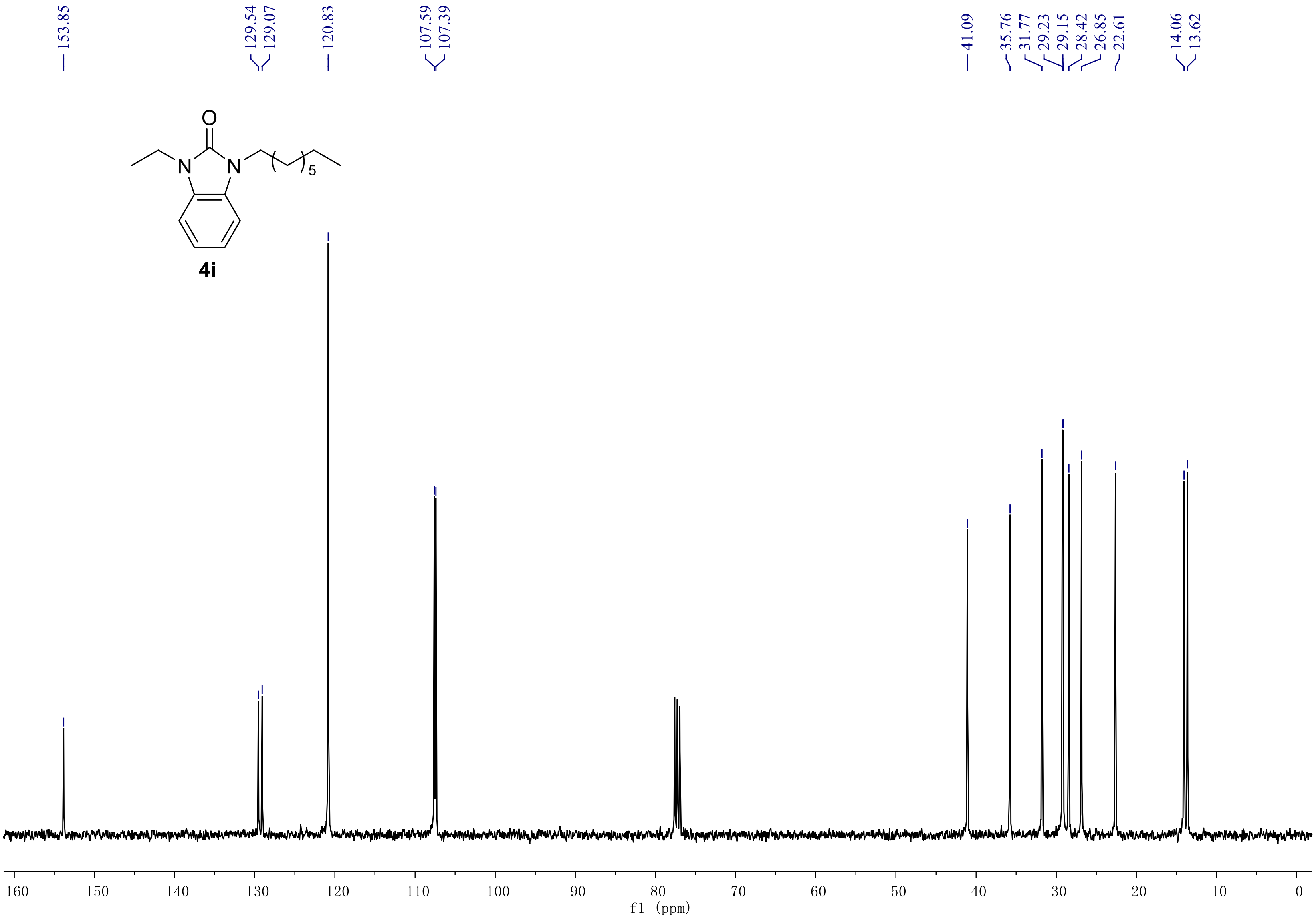


7.09
7.09
7.08
7.07
7.06
7.02
7.01
7.00
7.00
7.00
6.99
3.98
3.96
3.94
3.92
3.90
3.88
3.86
1.77
1.75
1.73
1.73
1.71
1.70
1.36
1.34
1.32
0.97
0.95
0.93
O
N
N
4h
2.00
2.04
2.13
2.12
2.27
5.46
3.32
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
−2000

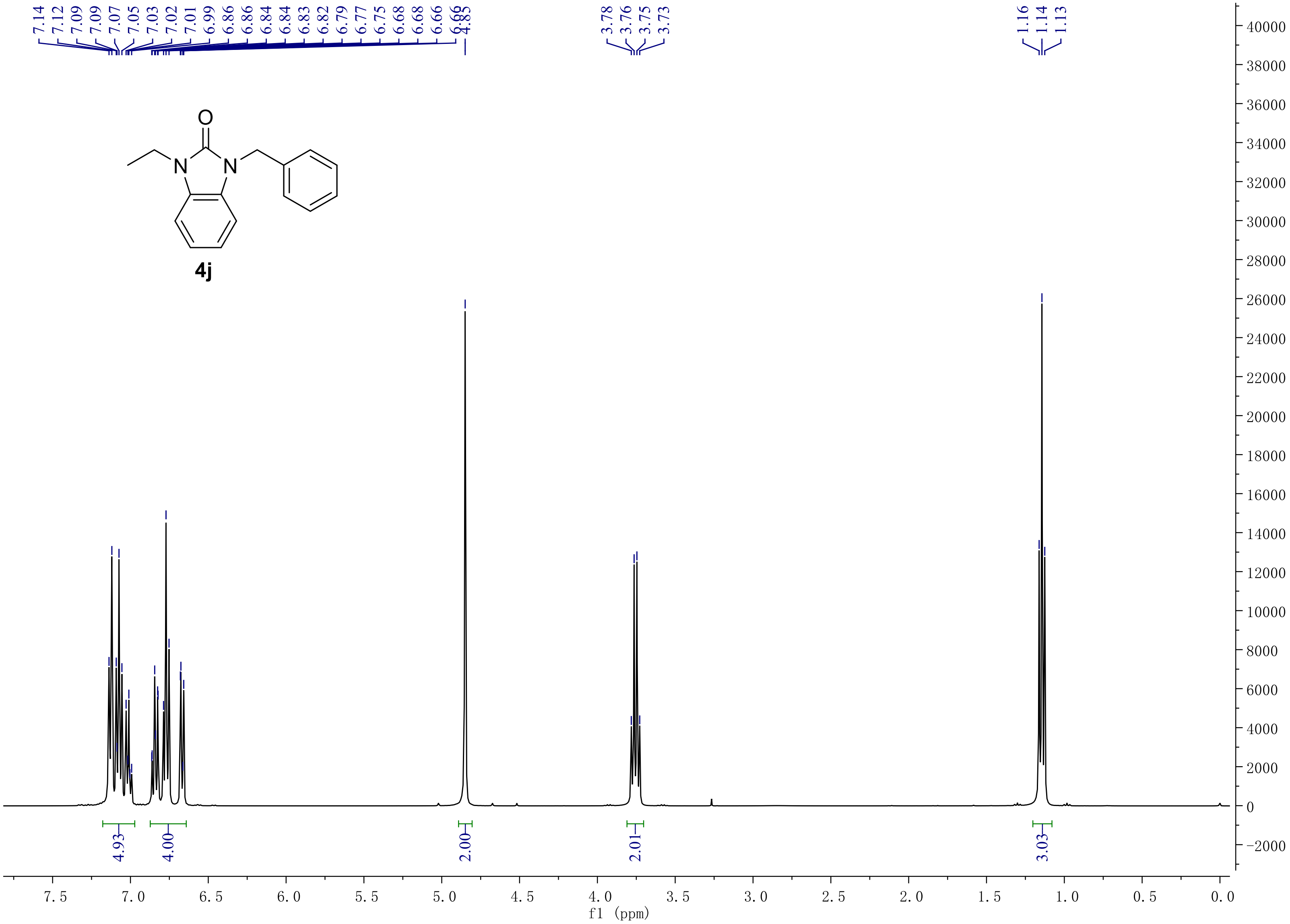

153.89
129.54
129.07
120.86
107.62
107.43
40.81
35.78
30.52
20.09
13.73
13.64
O
N
N
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4h

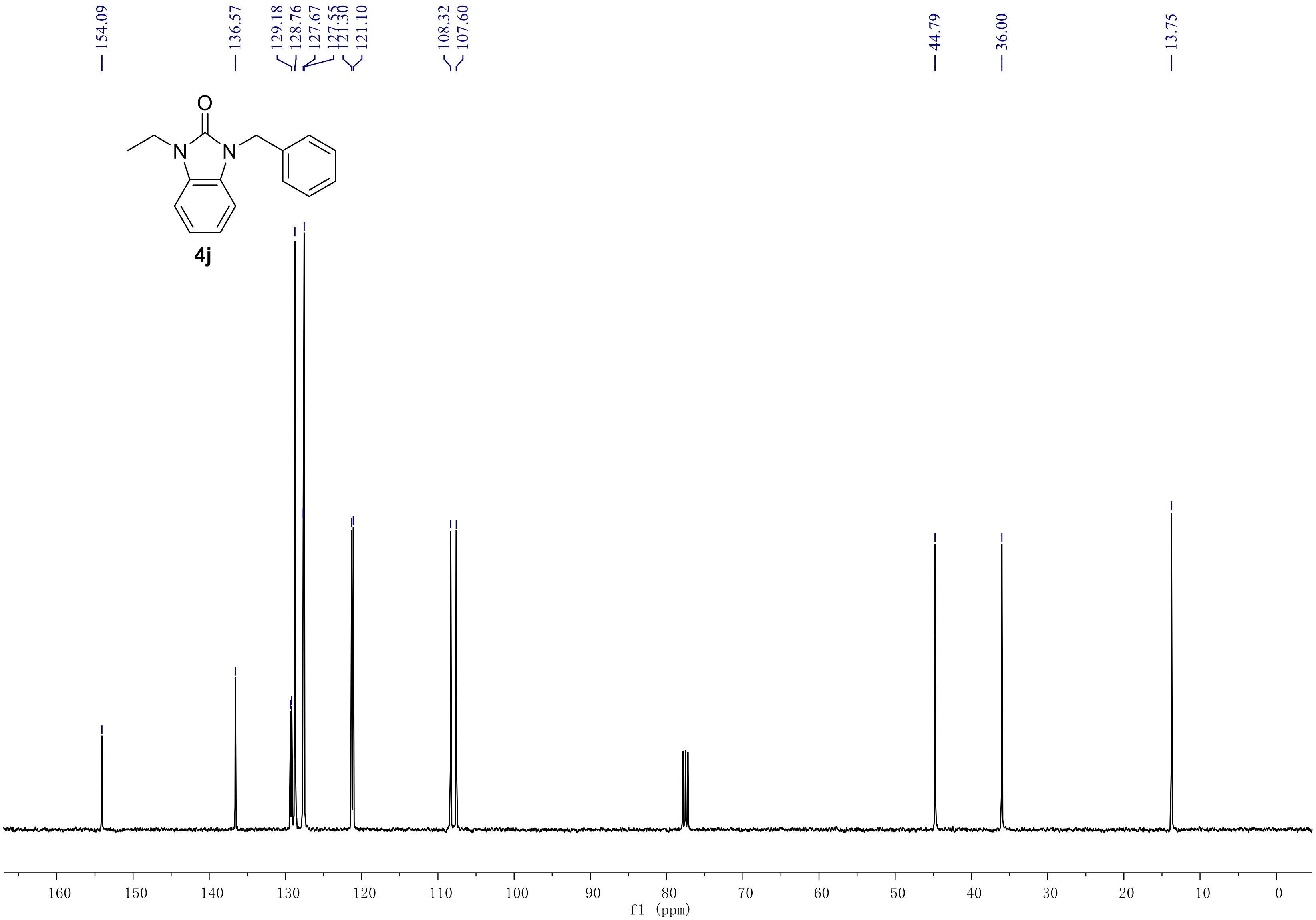

7.10
7.09
7.08
7.08
7.07
7.06
7.03
7.01
7.01
7.00
6.99
6.98
6.97
3.98
3.96
3.94
3.92
3.88
3.86
3.85
1.78
1.76
1.74
1.72
1.70
1.35
1.34
1.32
1.25
0.88
0.86
0.85
O
N
N
5
4i
2.00
2.01
2.07
2.07
2.09
14.05
3.25
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0

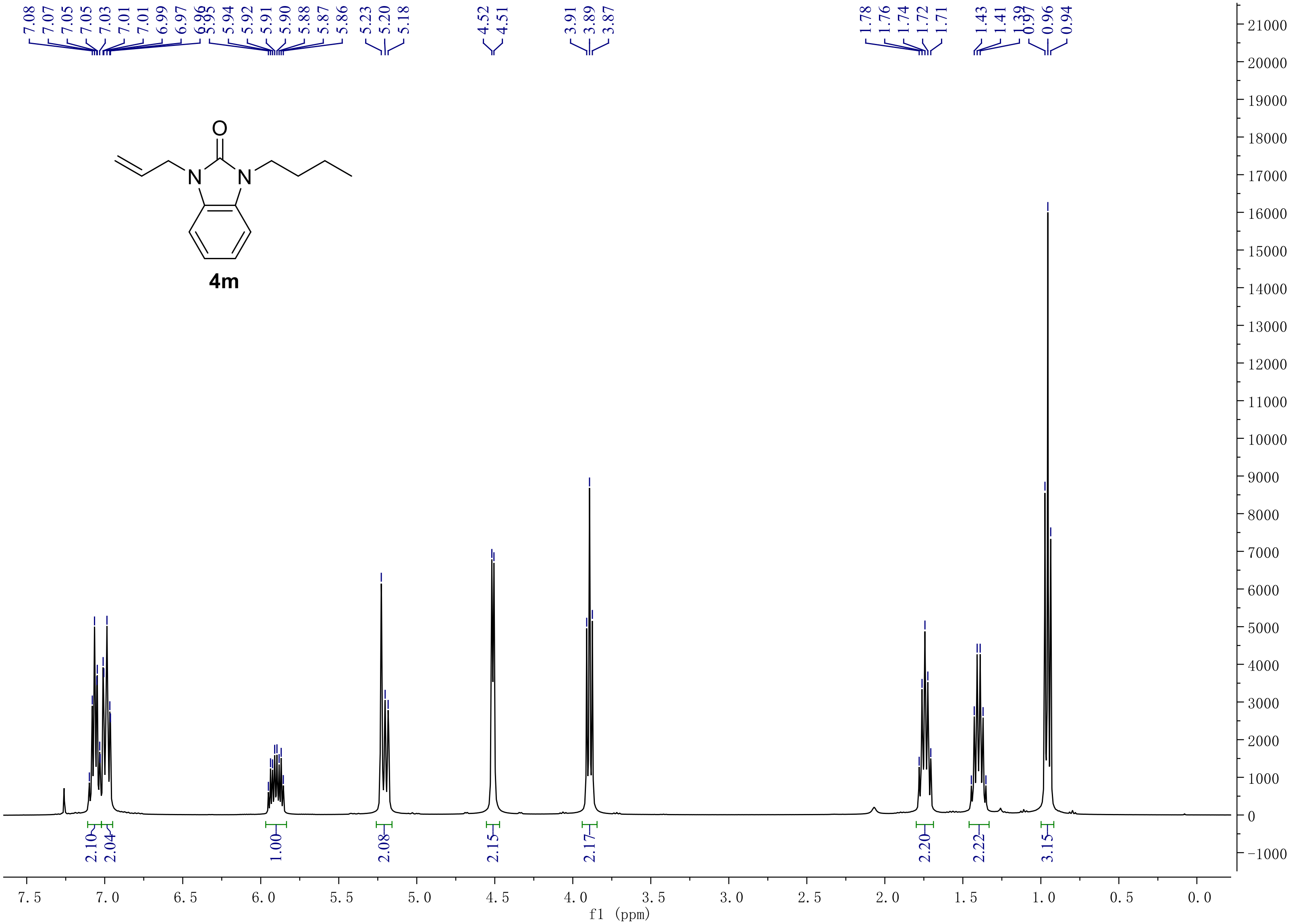

4i

153.85
129.54
129.07
120.83
107.59
107.39
41.09
35.76
31.77
29.23
29.15
28.42
26.85
22.61
14.06
13.62
O
N
N
5
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

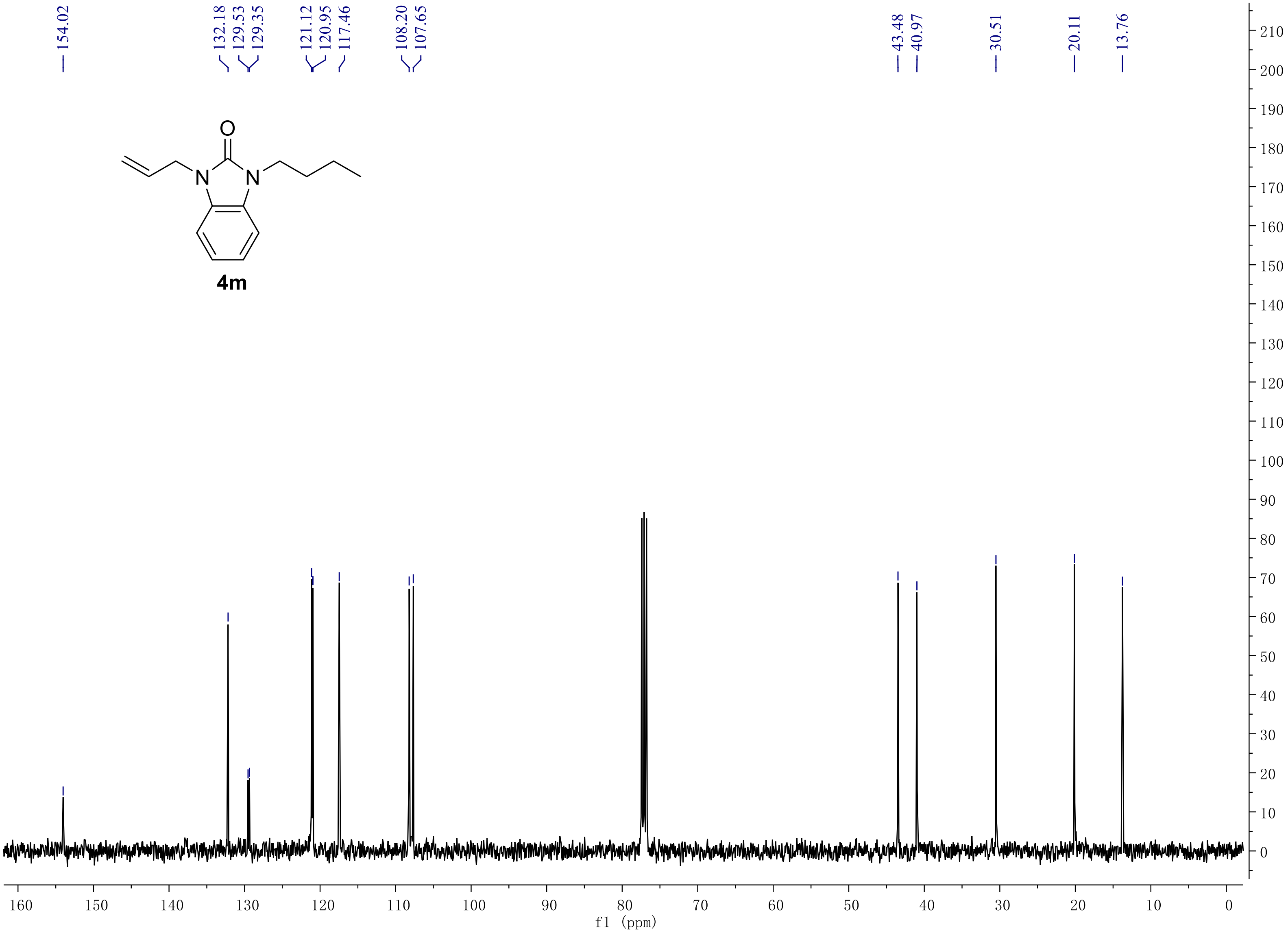

7.14
7.12
7.09
7.09
7.07
7.05
7.03
7.02
7.01
6.99
6.86
6.86
6.84
6.84
6.83
6.82
6.79
6.77
6.75
6.68
6.68
6.66
6.66
4.85
3.78
3.76
3.75
3.73
1.16
1.14
1.13
O
N
N
4.93
4.00
2.00
2.01
3.03
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
40000
38000
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
−2000

4j


4j
154.09
136.57
129.18
128.76
127.67
127.55
121.30
121.10
108.32
107.60
44.79
36.00
13.75
O
N
N
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

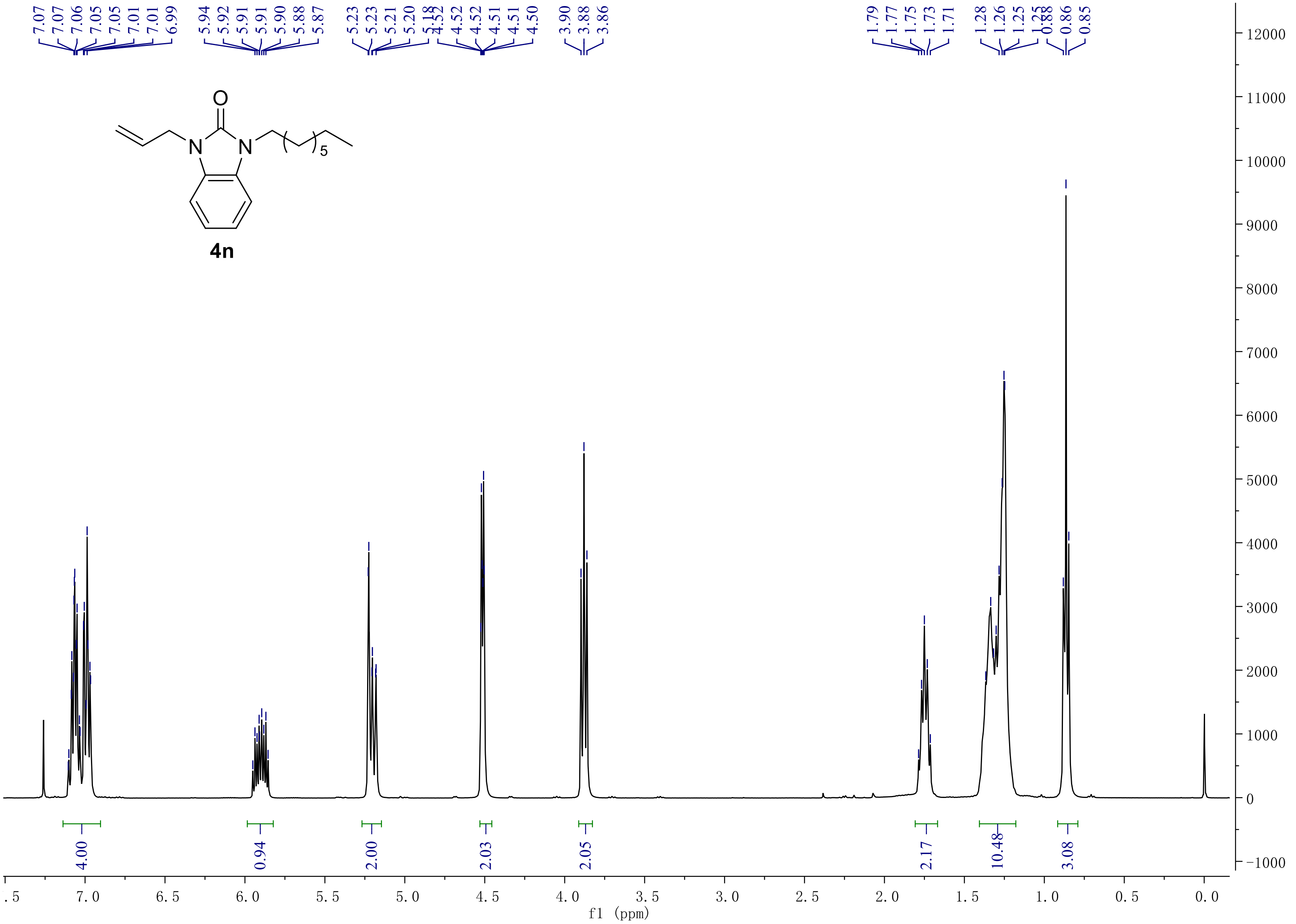


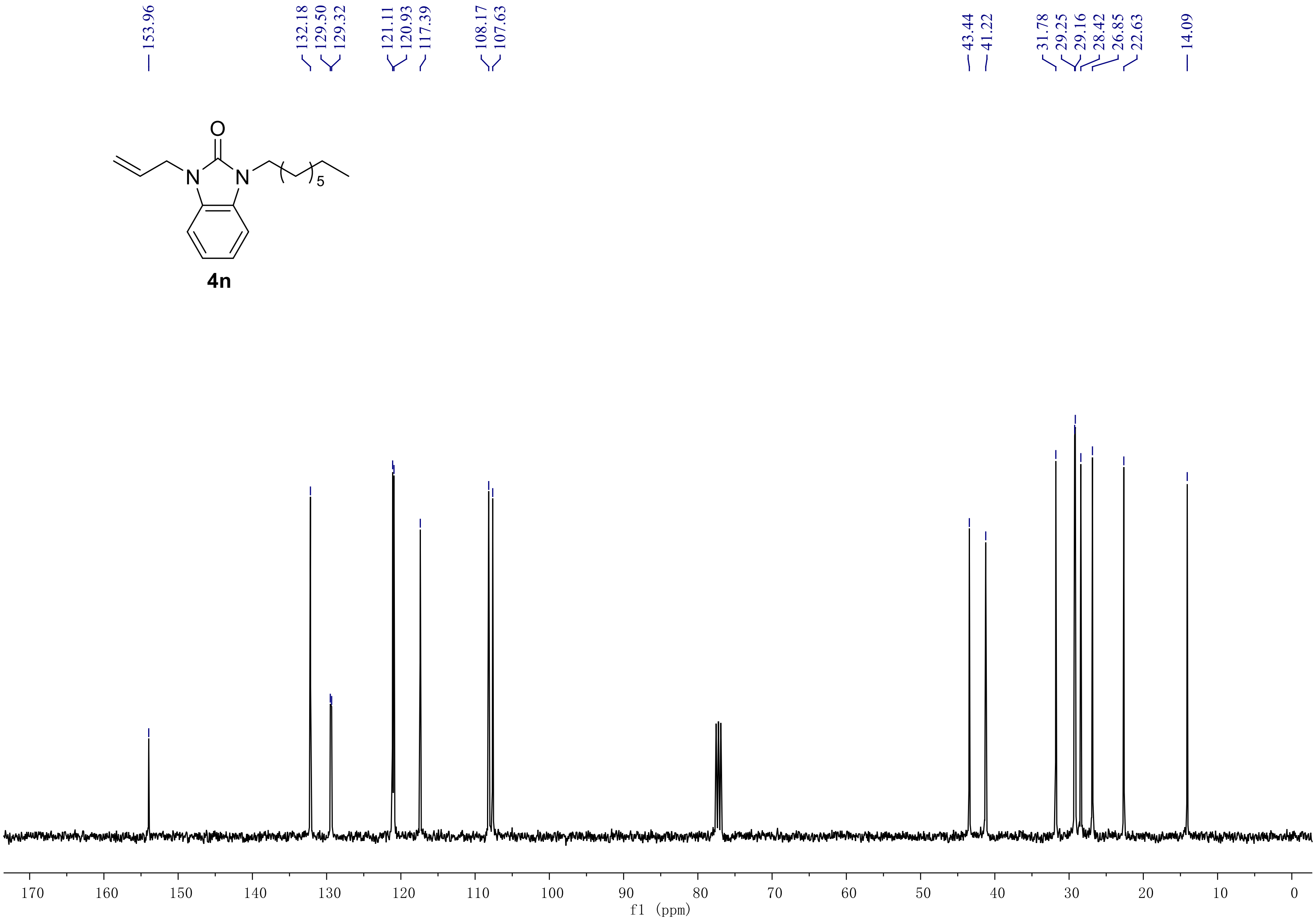
7.08
7.07
7.05
7.05
7.03
7.01
7.01
6.99
6.97
6.96
5.95
5.94
5.92
5.91
5.90
5.88
5.87
5.86
5.23
5.20
5.18
4.52
4.51
3.91
3.89
3.87
1.78
1.76
1.74
1.72
1.71
1.43
1.41
1.39
0.97
0.96
0.94
O
N
N
4m
2.10
2.04
1.00
2.08
2.15
2.17
2.20
2.22
3.15
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000



4m

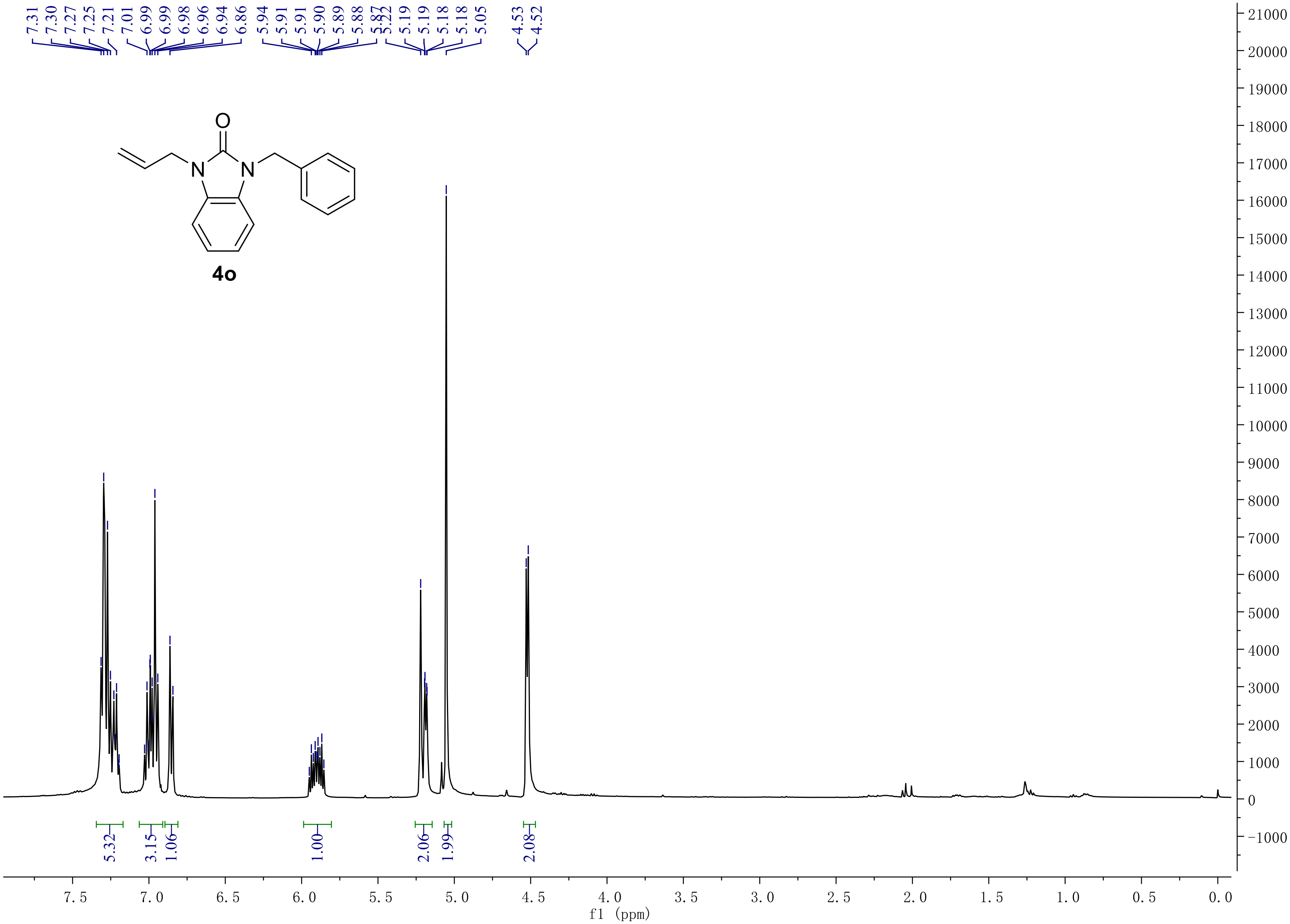
154.02
132.18
129.53
129.35
121.12
120.95
117.46
108.20
107.65
43.48
40.97
30.51
20.11
13.76
O
N
N
f1 (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


7.07
7.07
7.06
7.05
7.05
7.01
7.01
6.99
5.94
5.92
5.91
5.91
5.90
5.88
5.87
5.23
5.23
5.21
5.20
5.18
4.52
4.52
4.52
4.51
4.51
4.50
3.90
3.88
3.86
1.79
1.77
1.75
1.73
1.71
1.28
1.26
1.25
1.25
0.88
0.86
0.85
O
N
N
5
4n
4.00
0.94
2.00
2.03
2.05
2.17
10.48
3.08
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)



4n

153.96
132.18
129.50
129.32
121.11
120.93
117.39
108.17
107.63
43.44
41.22
31.78
29.25
29.16
28.42
26.85
22.63
14.09
O
N
N
5
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.31
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6.99
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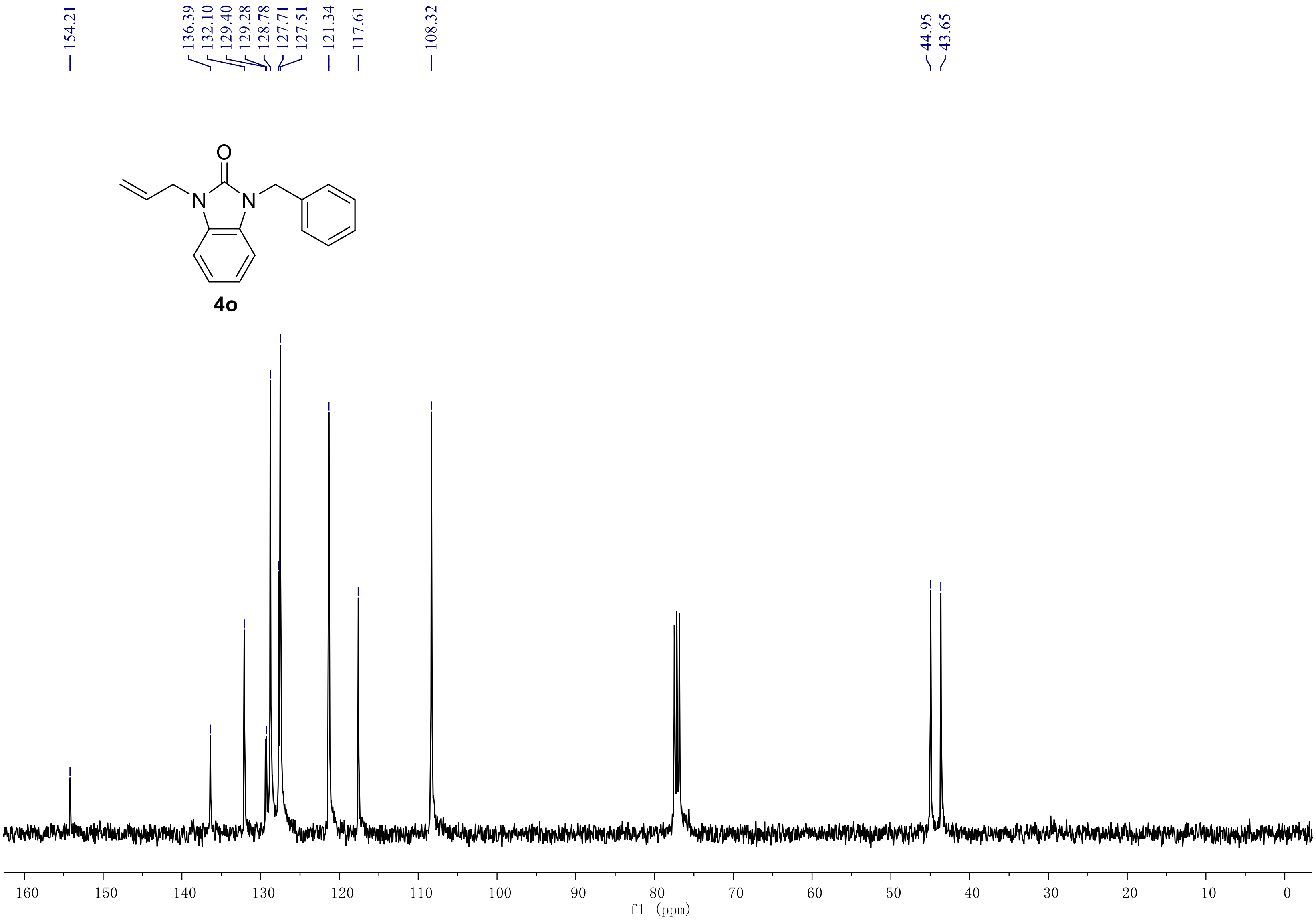
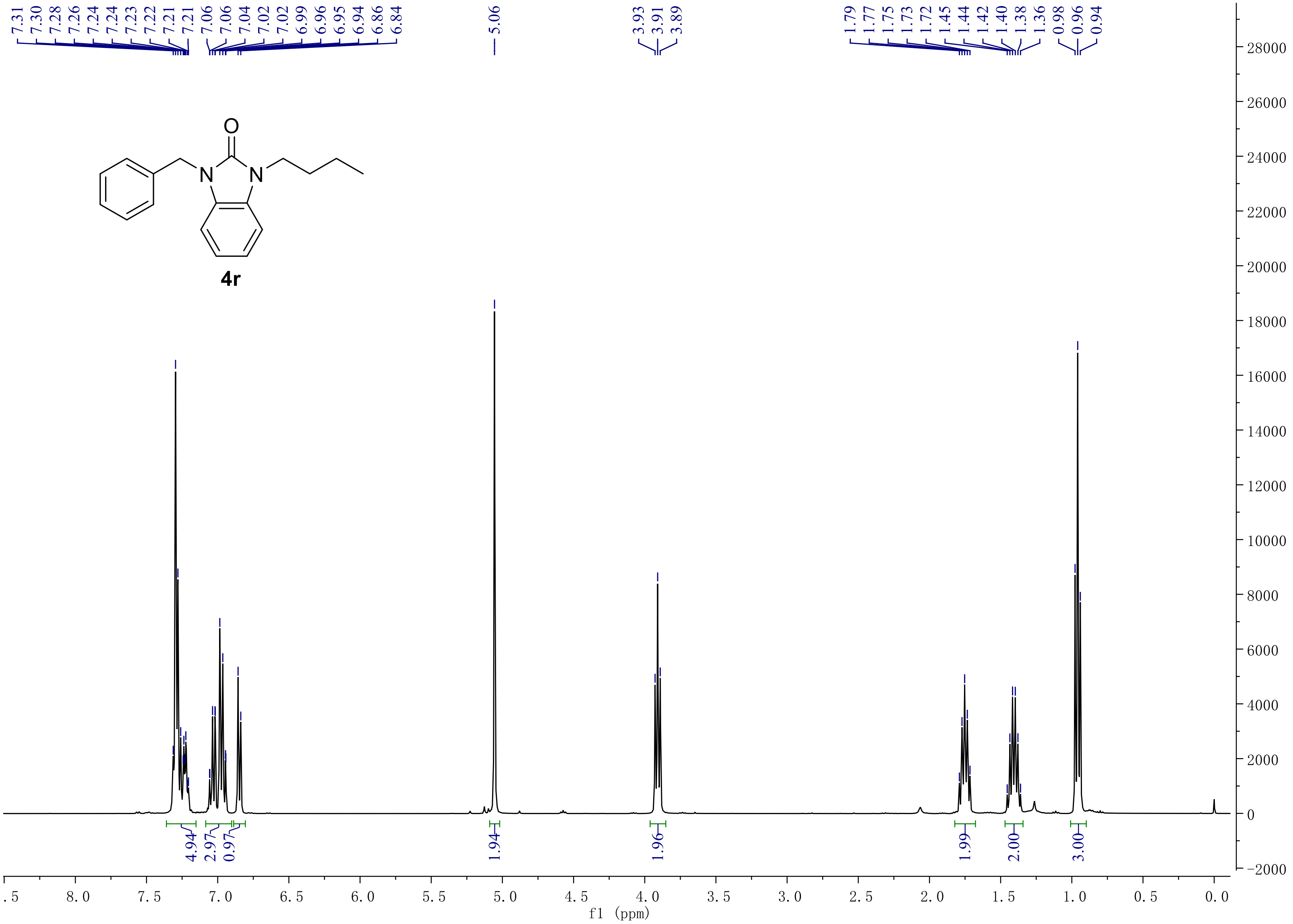
6.96
6.94
6.86
5.94
5.91
5.91
5.90
5.89
5.88
5.87
5.22
5.19
5.19
5.18
5.18
5.05
4.53
4.52
O
N
N
4o
5.32
3.15
1.06
1.00
2.06
1.99
2.08
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


154.21
136.39
132.10
129.40
129.28
128.78
127.71
127.51
121.34
117.61
108.32
44.95
43.65
O
N
N
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4o


7.31
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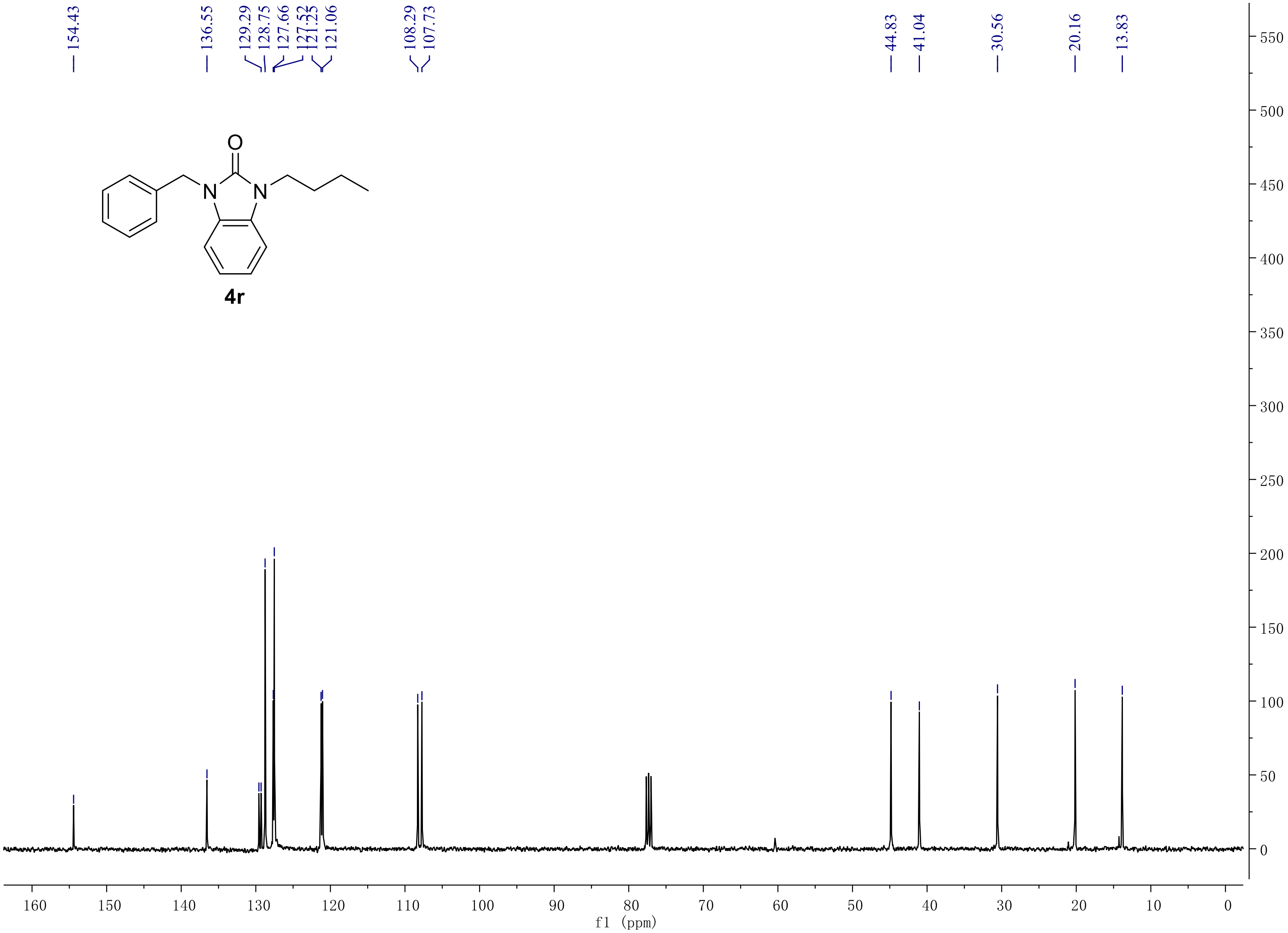
7.26
7.24
7.24
7.23
7.22
7.21
7.21
7.06
7.06
7.04
7.02
7.02
6.99
6.96
6.95
6.94
6.86
6.84
5.06
3.93
3.91
3.89
1.79
1.77
1.75
1.73
1.72
1.45
1.44
1.42
1.40
1.38
1.36
0.98
0.96
0.94
O
N
N
4r
4.94
2.97
0.97
1.94
1.96
1.99
2.00
3.00
.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
−2000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136.55
129.29
128.75
127.66
127.52
121.25
121.06
108.29
107.73
44.83
41.04
30.56
20.16
13.83
O
N
N
550
500
450
400
350
300
250
200
150
100
50
0
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110
100
90
80
70
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50
40
30
20
10
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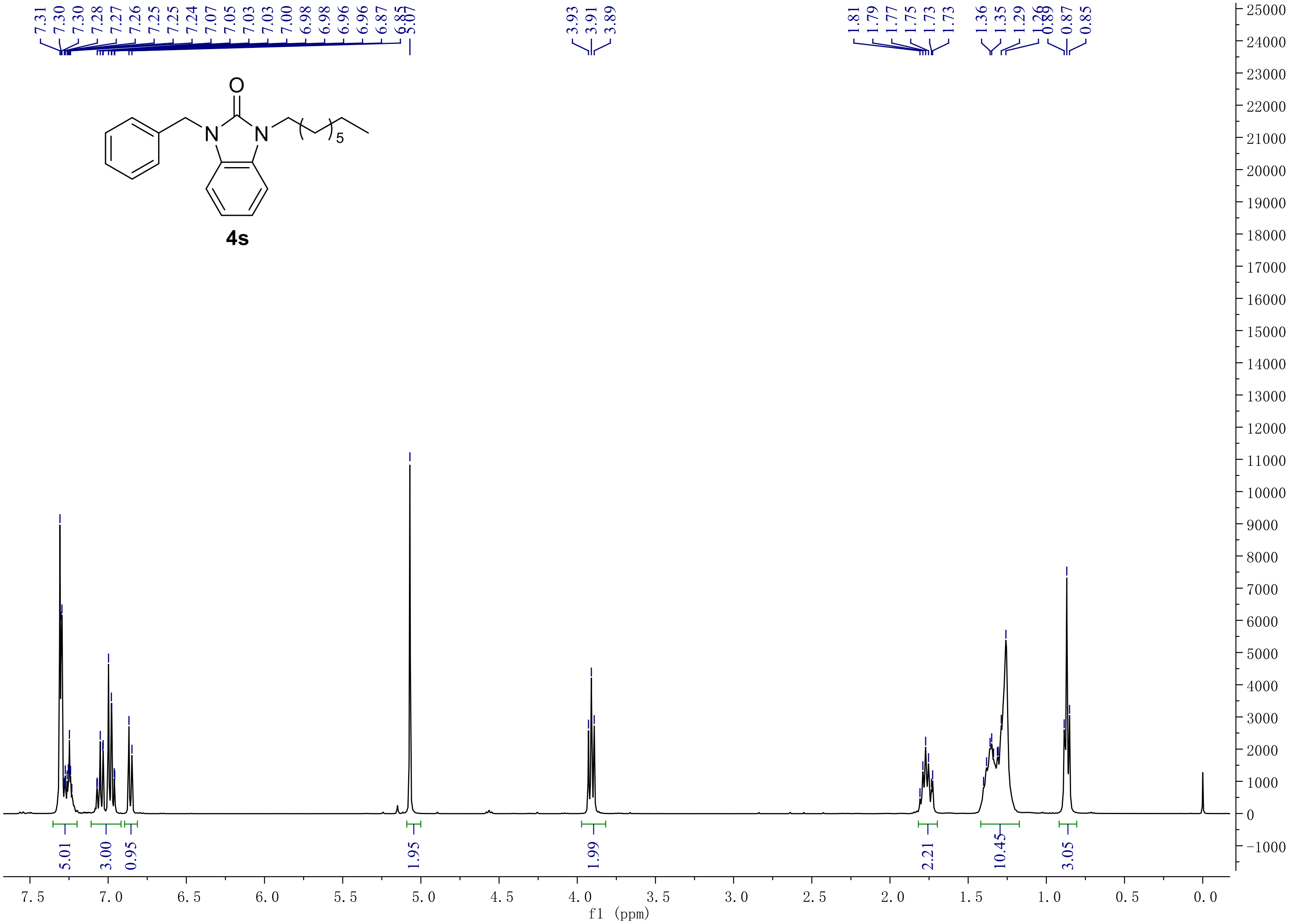
f1 (ppm)

4r


4s

7.31
7.30
7.30
7.28
7.27
7.26
7.25
7.25
7.24
7.07
7.05
7.03
7.03
7.00
6.98
6.98
6.96
6.96
6.87
6.85
5.07
3.93
3.91
3.89
1.81
1.79
1.77
1.75
1.73
1.73
1.73
1.36
1.35
1.29
1.26
0.89
0.87
0.85
O
N
N
5
5.01
3.00
0.95
1.95
1.99
2.21
10.45
3.05
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
25000
24000
23000
22000
21000
20000
19000
18000
17000
16000
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12000
11000
10000
9000
8000
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0
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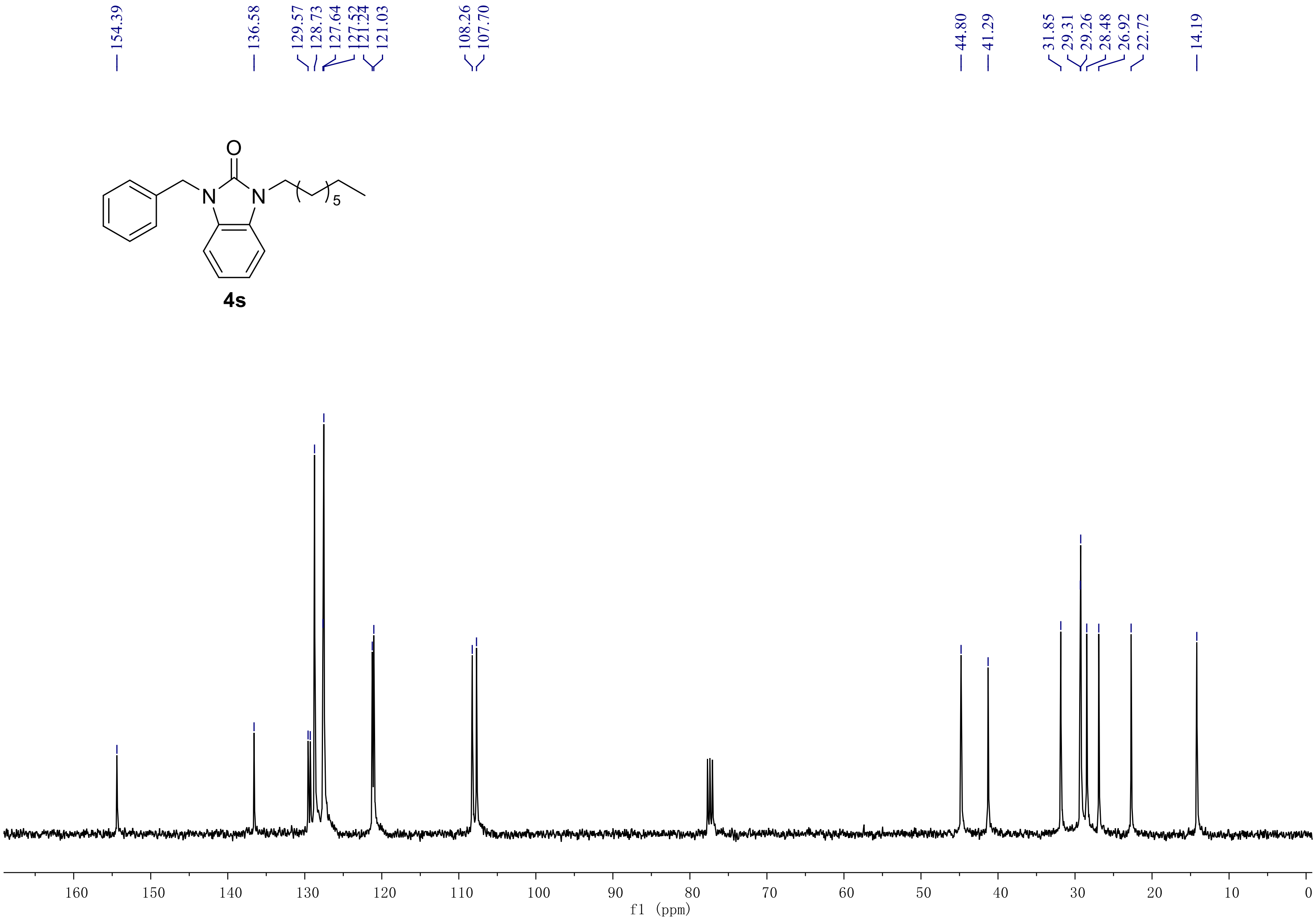
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128.73
127.64
127.52
121.24
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108.26
107.70
44.80
41.29
31.85
29.31
29.26
28.48
26.92
22.72
14.19
O
N
N
5
4s
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130
120
110
100
90
80
70
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50
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30
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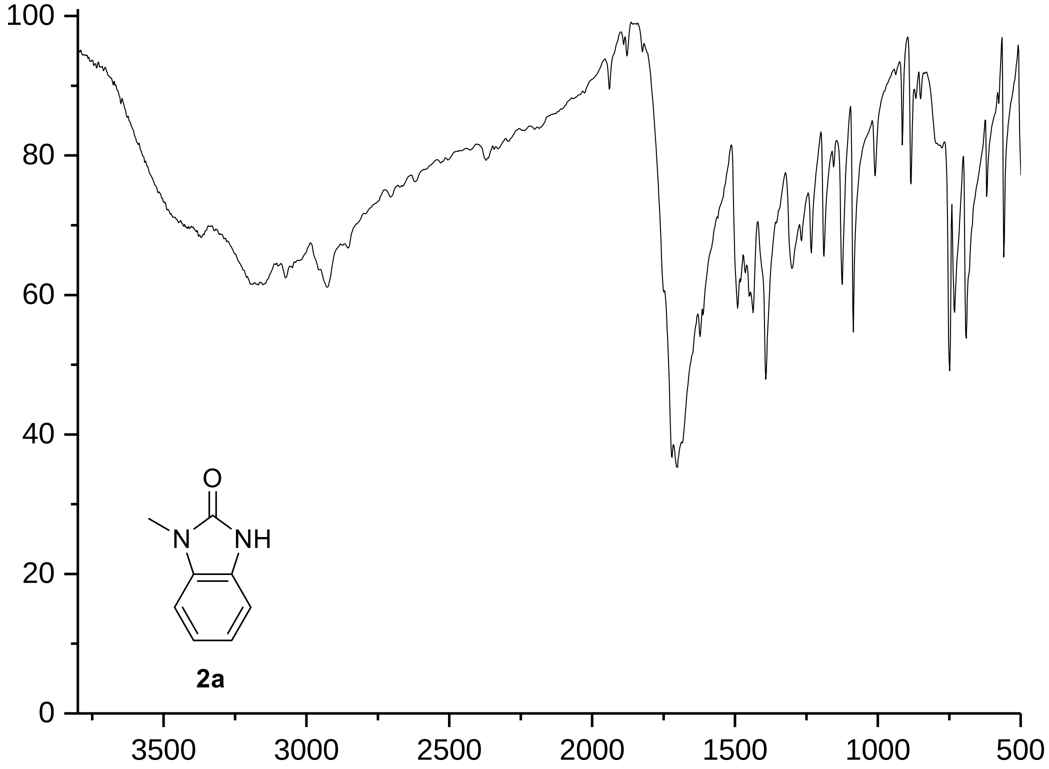
f1 (ppm)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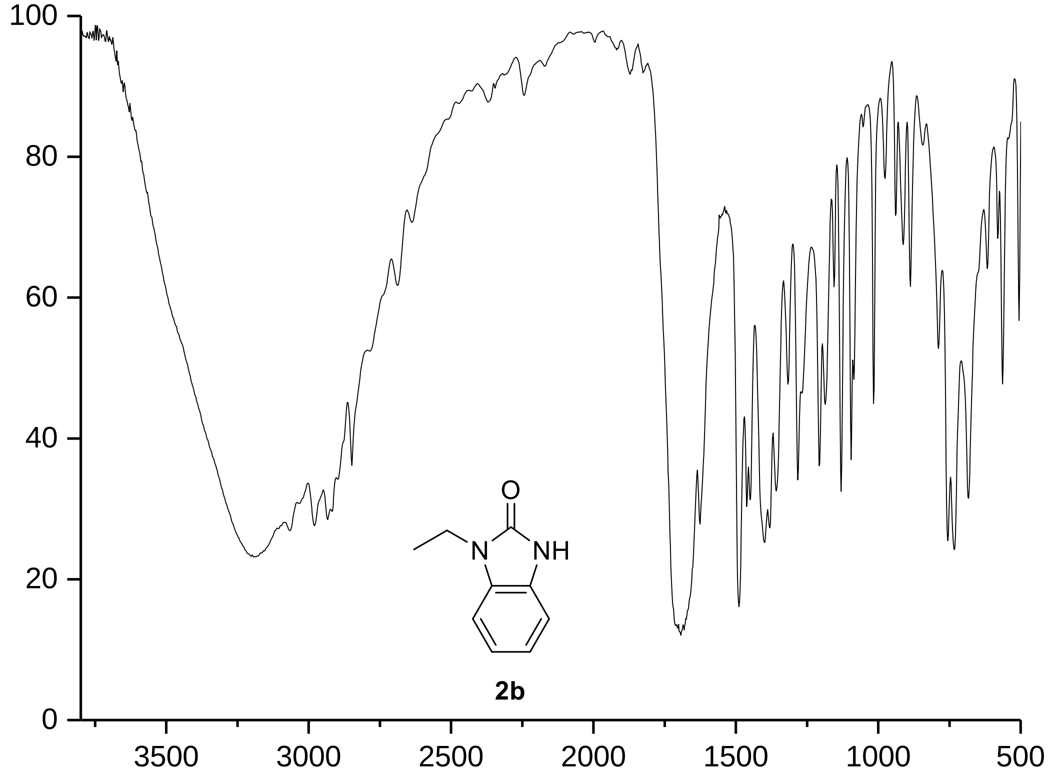
NH

2a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500
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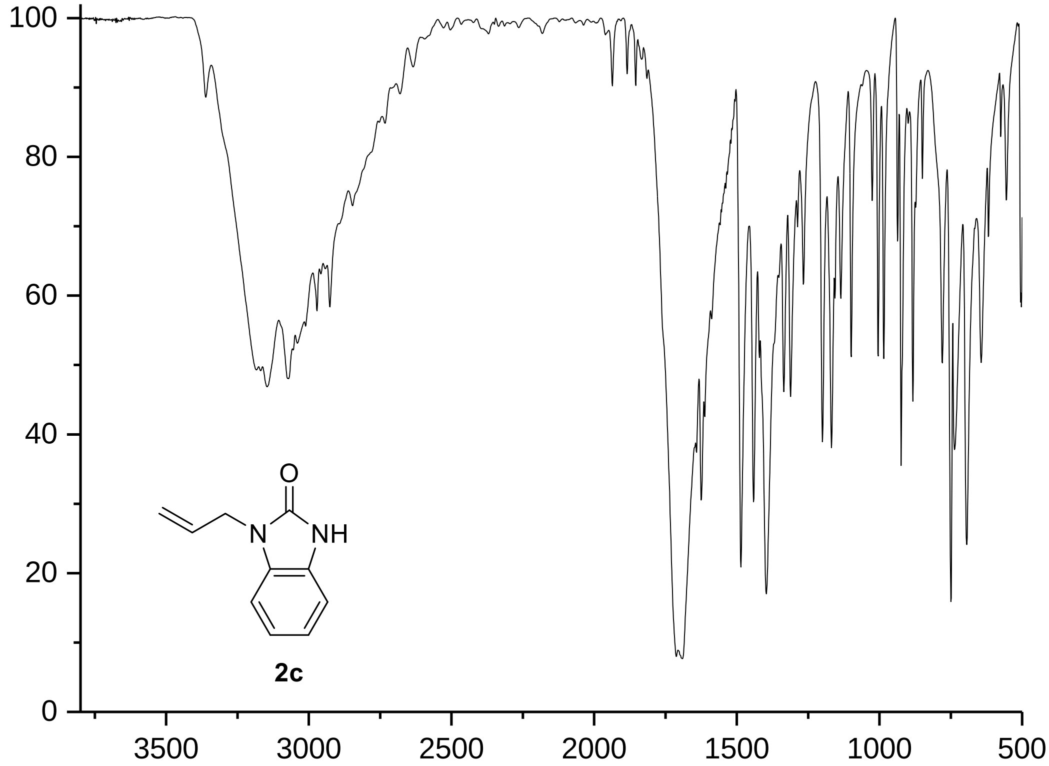
NH

2b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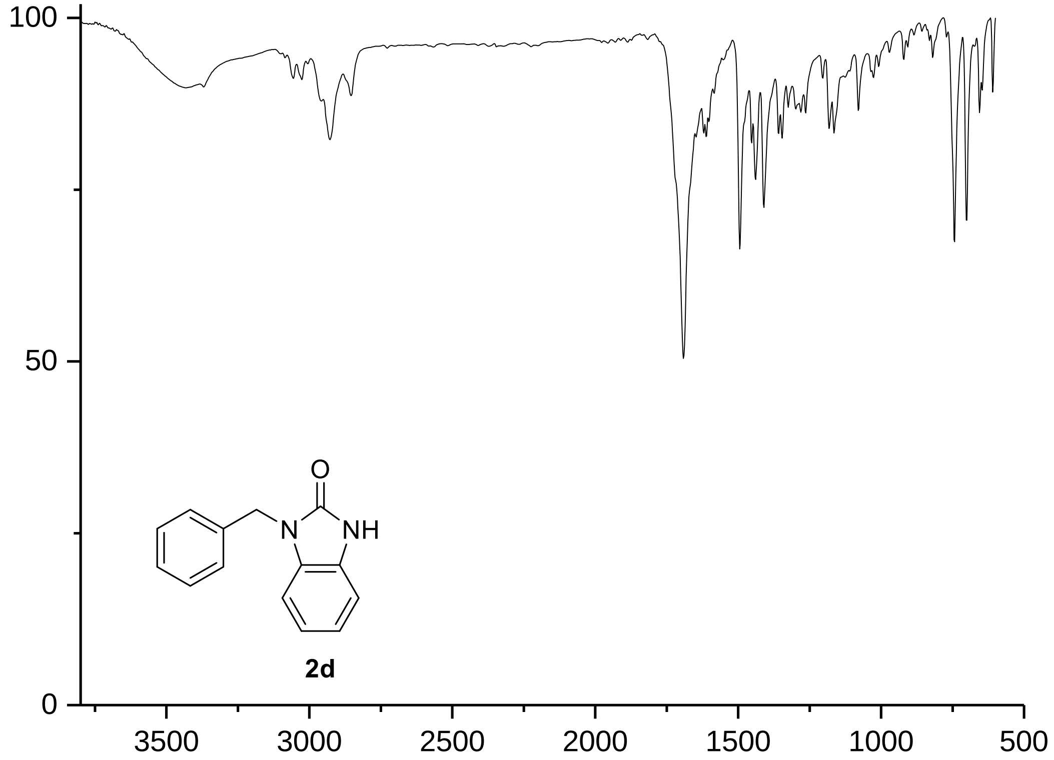
NH

2c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500
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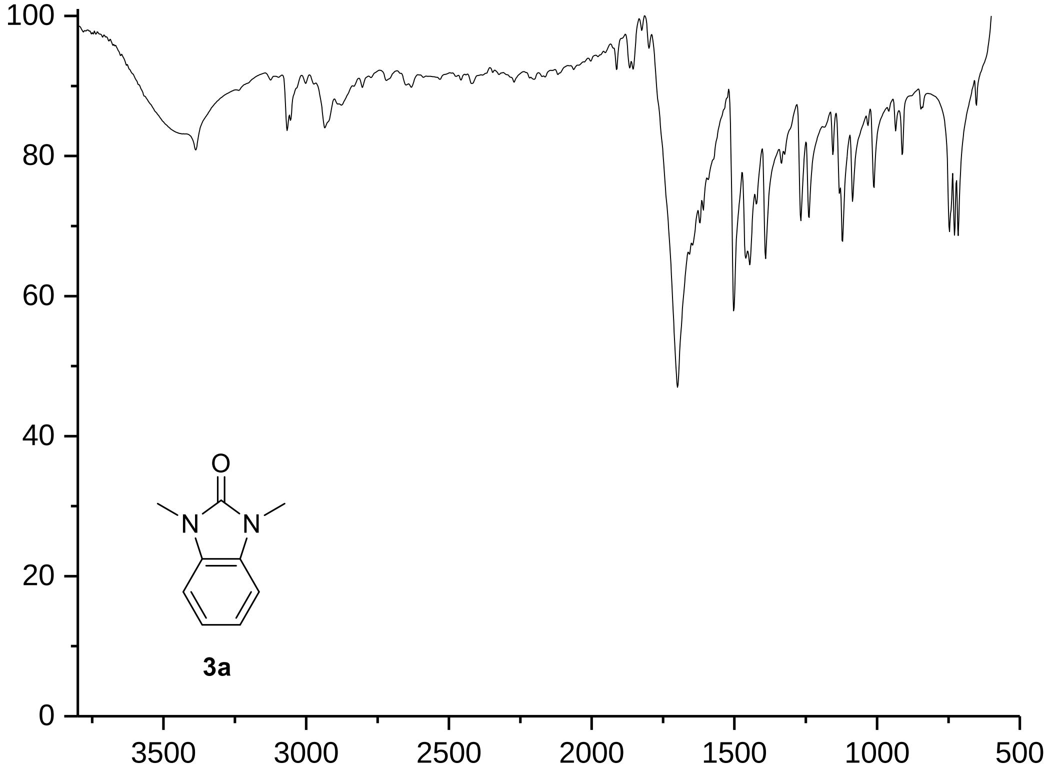
NH

2d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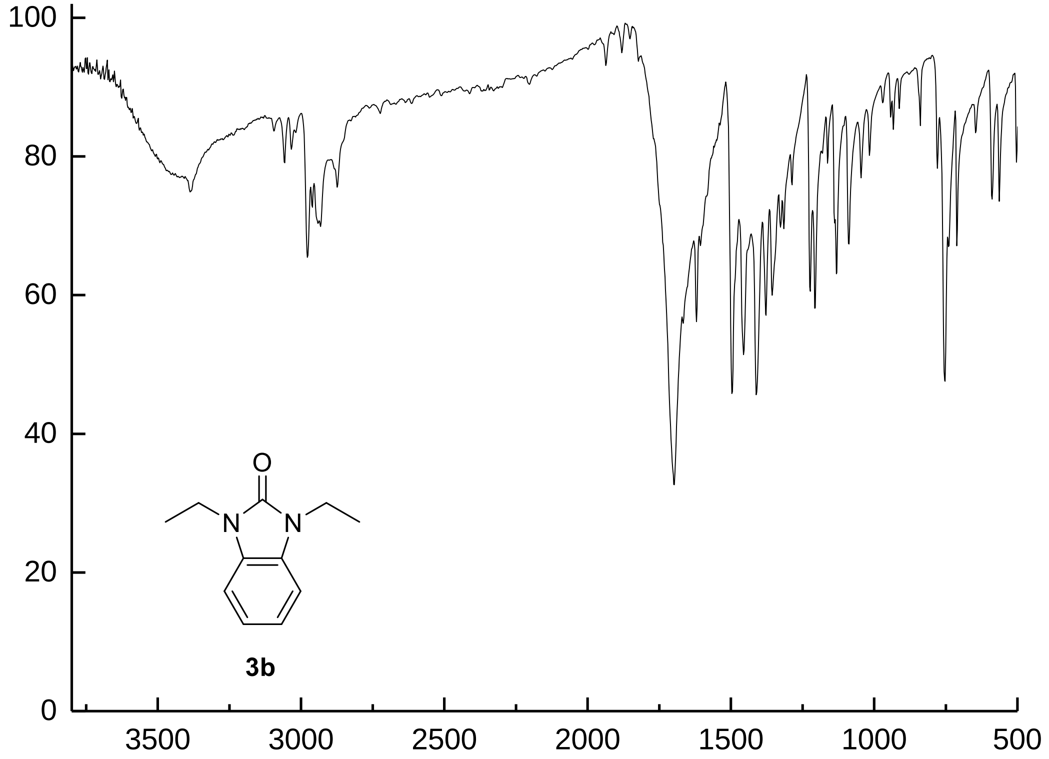
N
3a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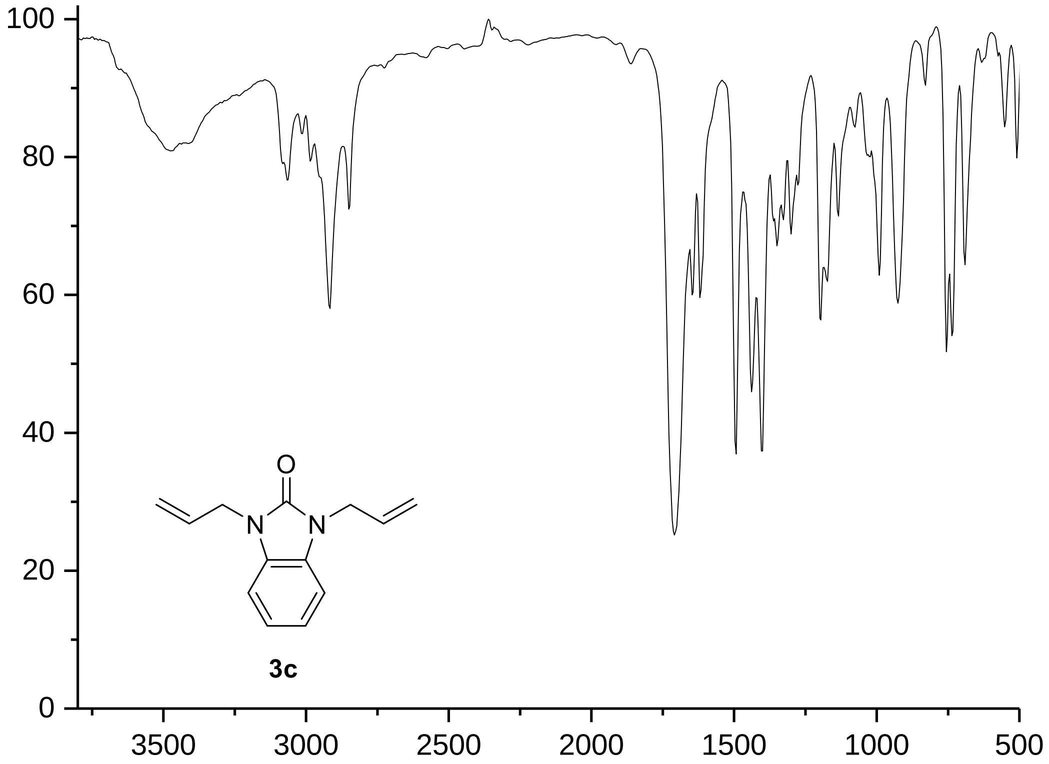
N
3b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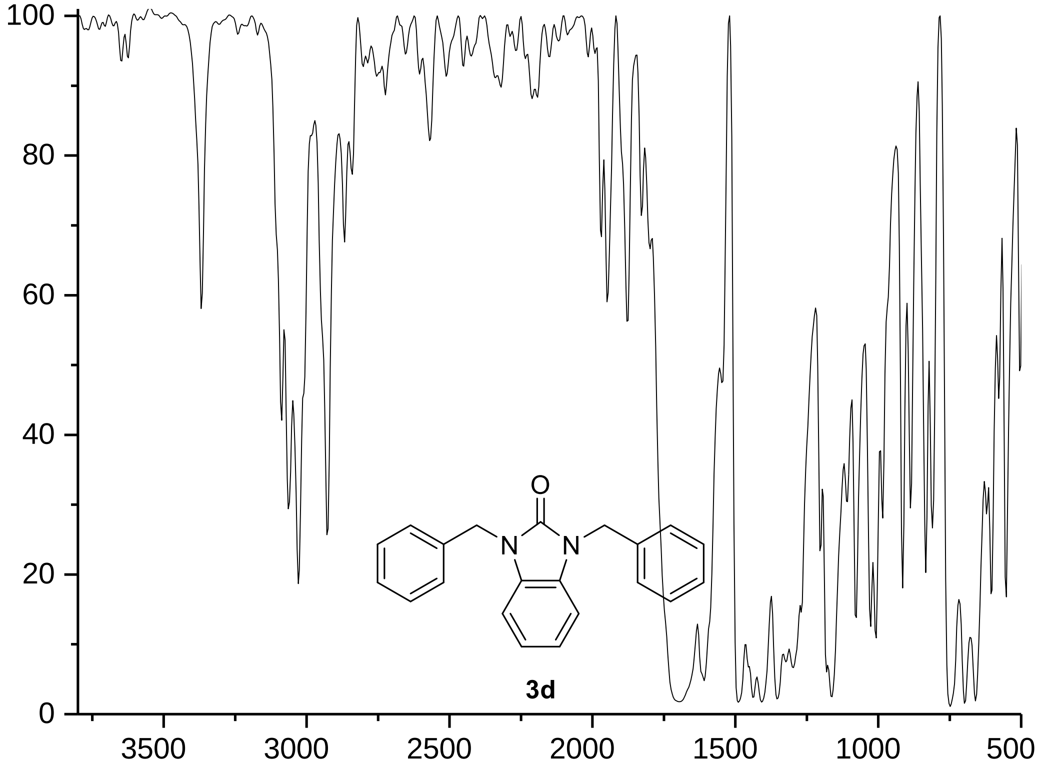
N

3c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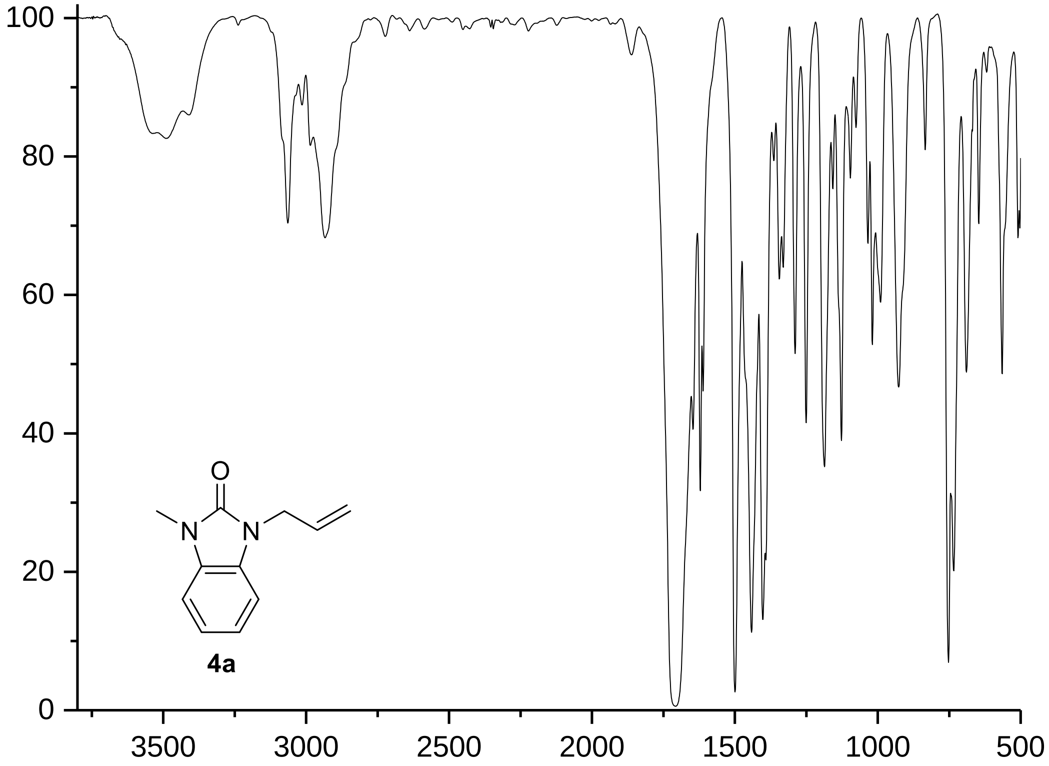
N

3d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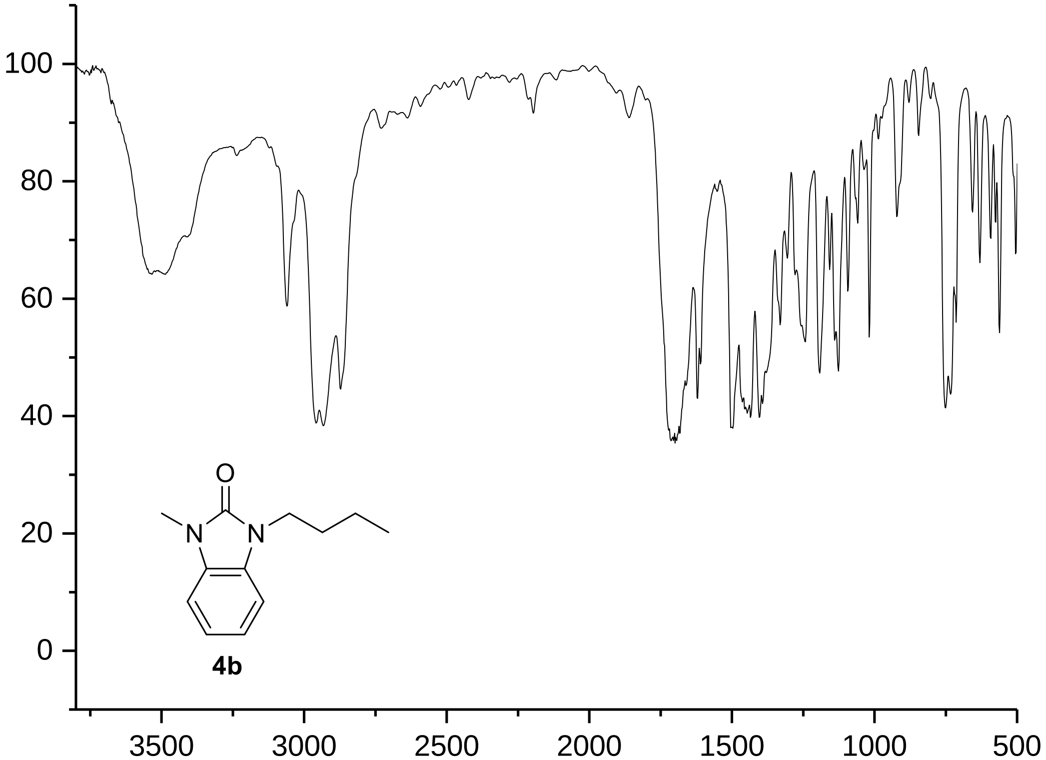
N

4a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500
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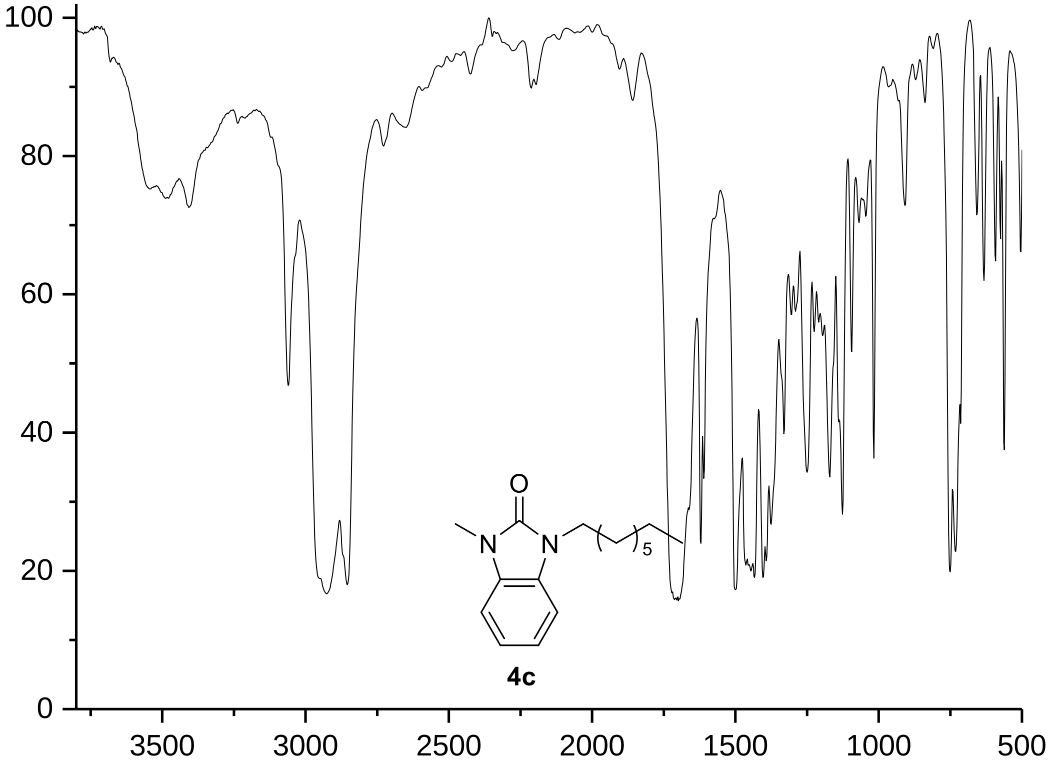
N

4b



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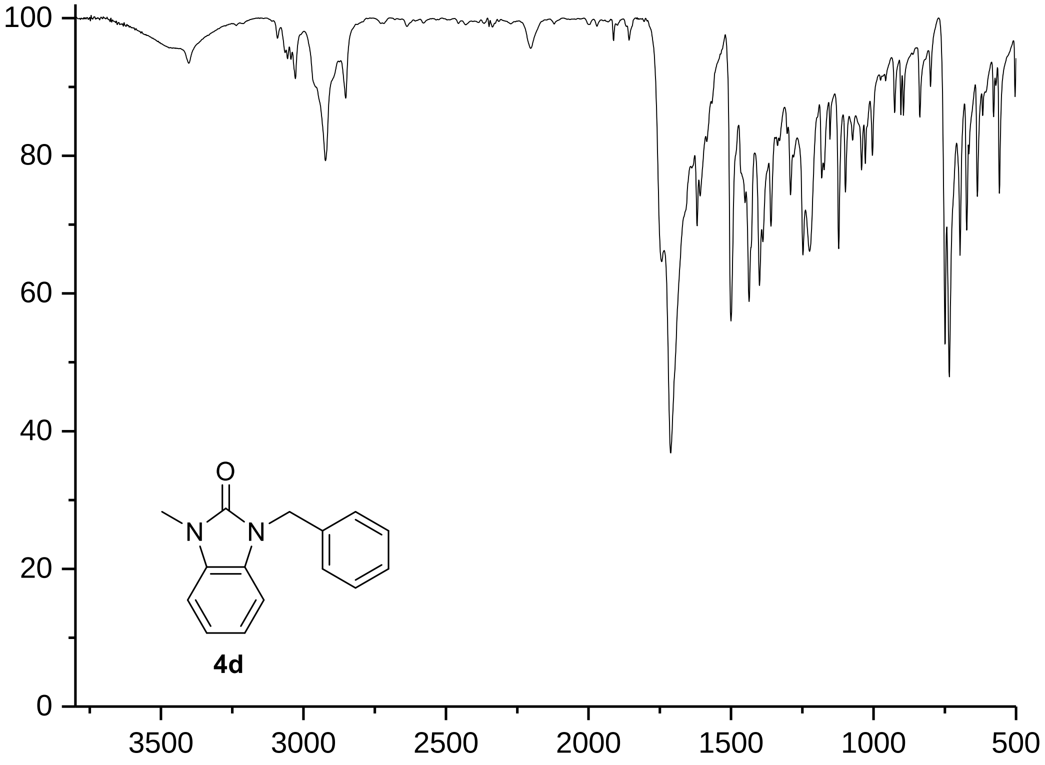
N
5

4c



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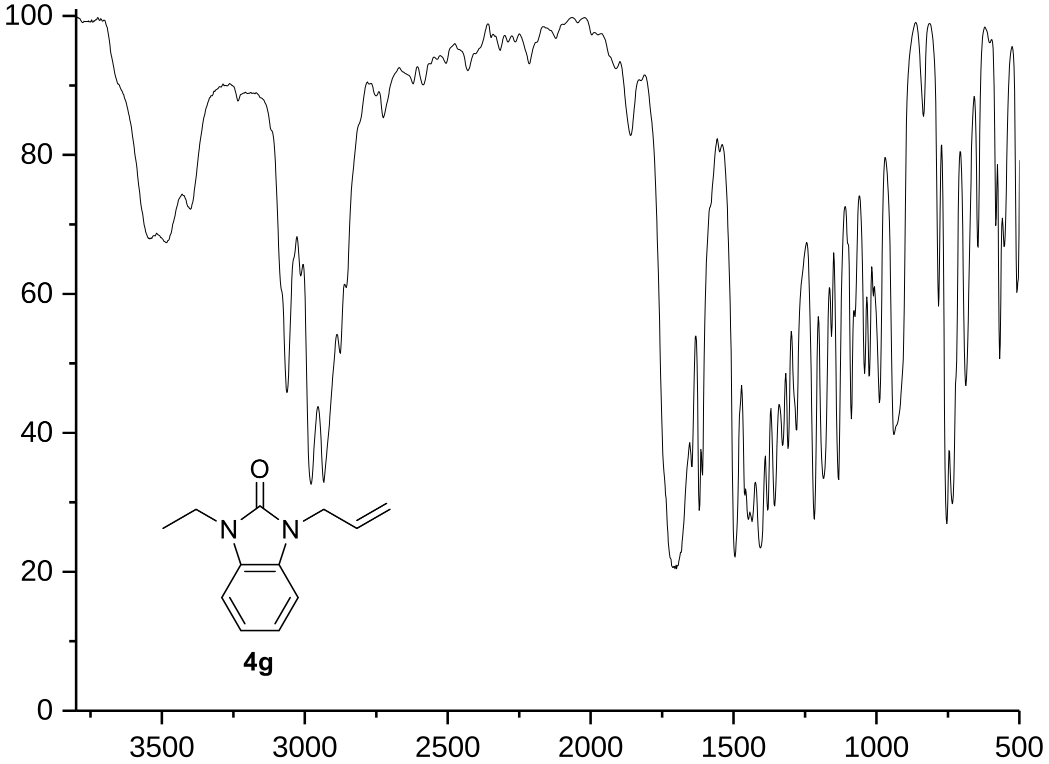
4d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N
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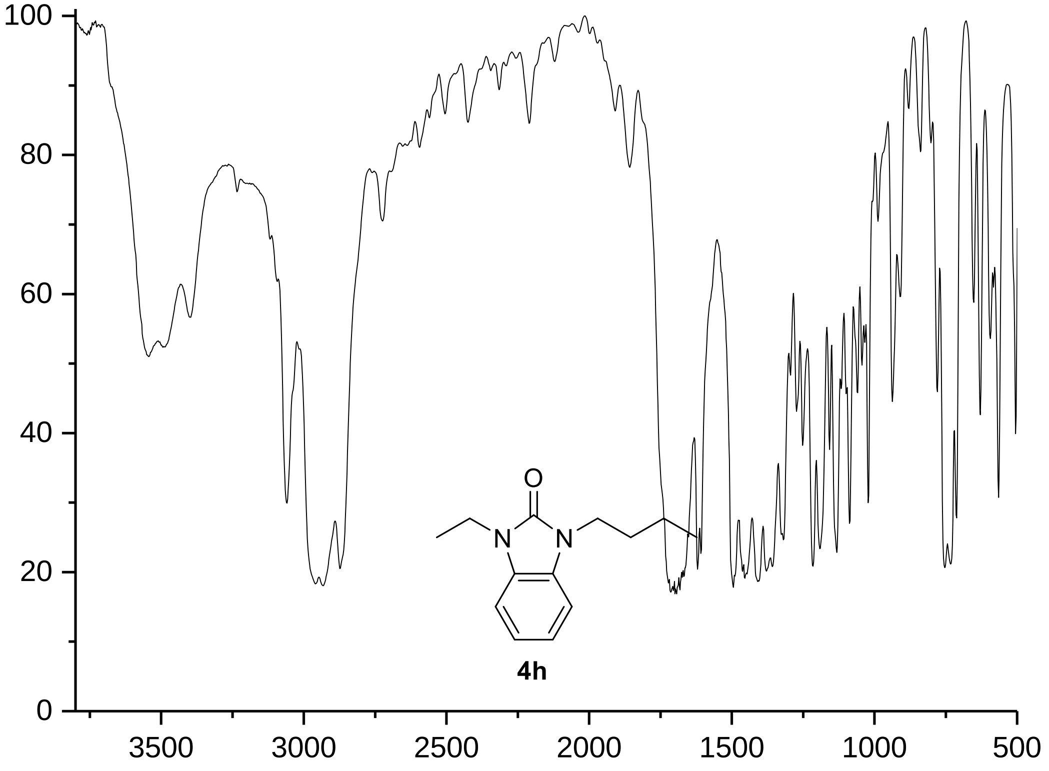
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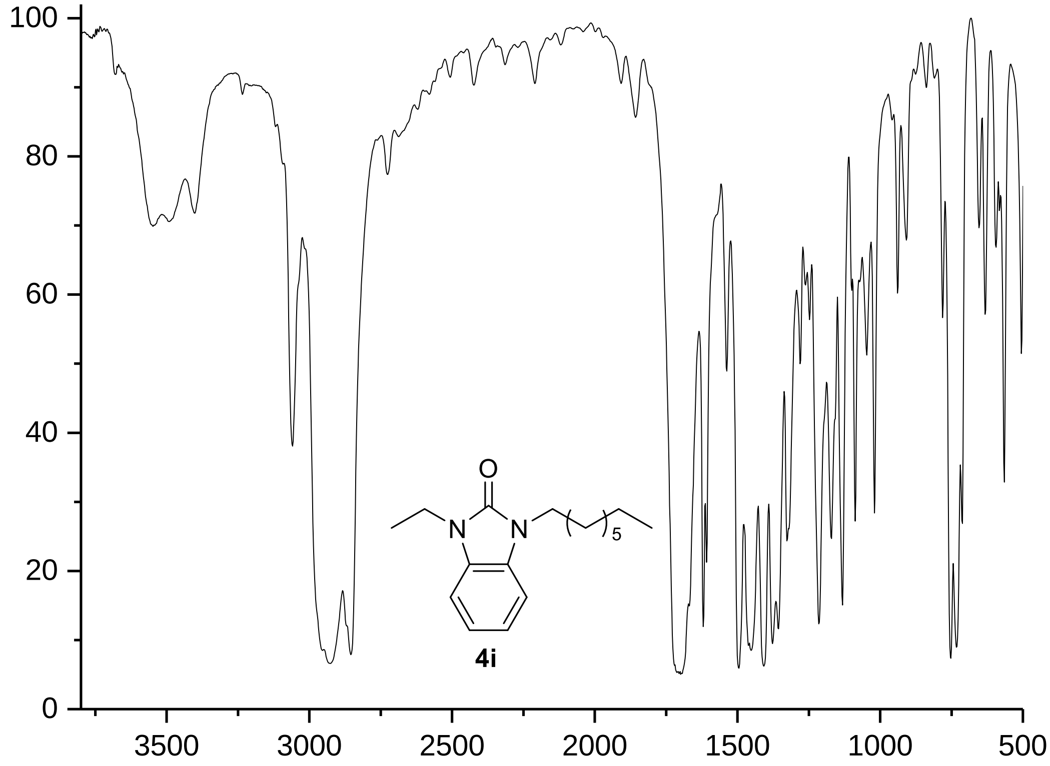
N
4h



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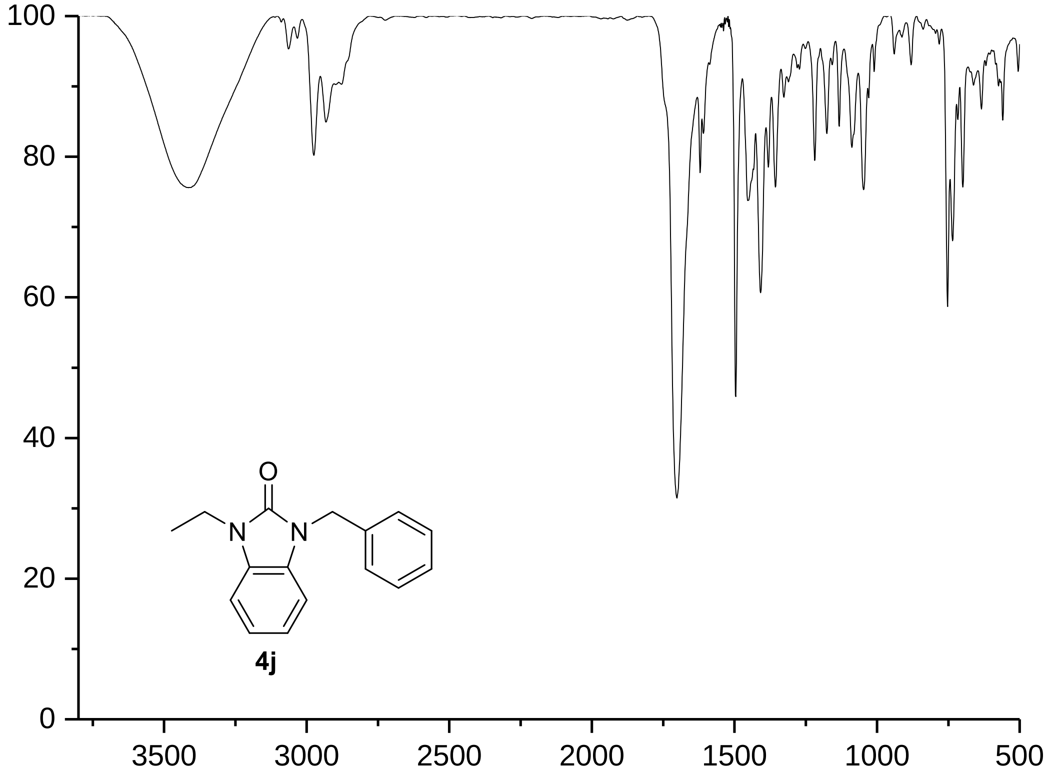
5
4i



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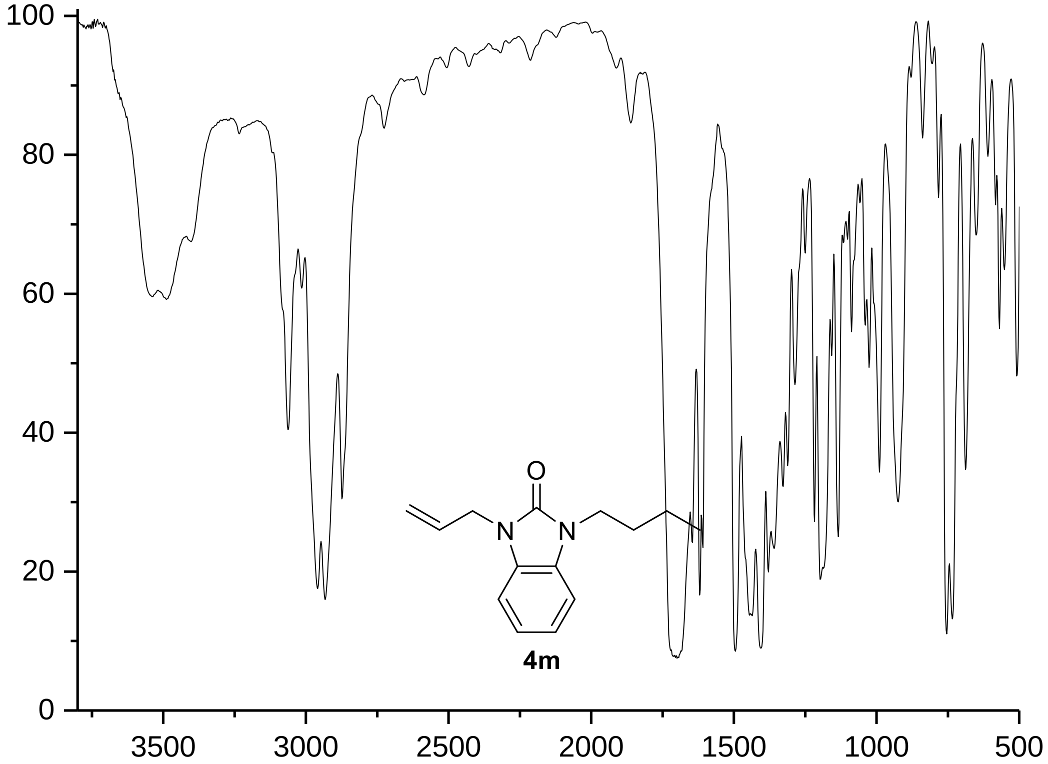
N
4j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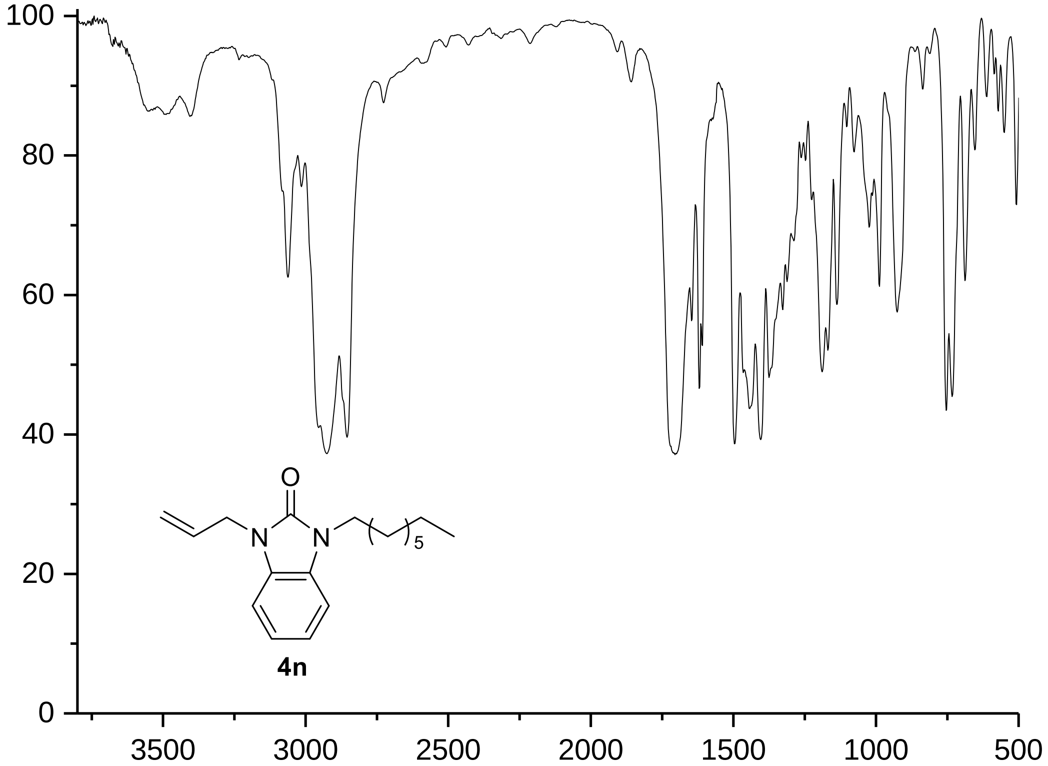
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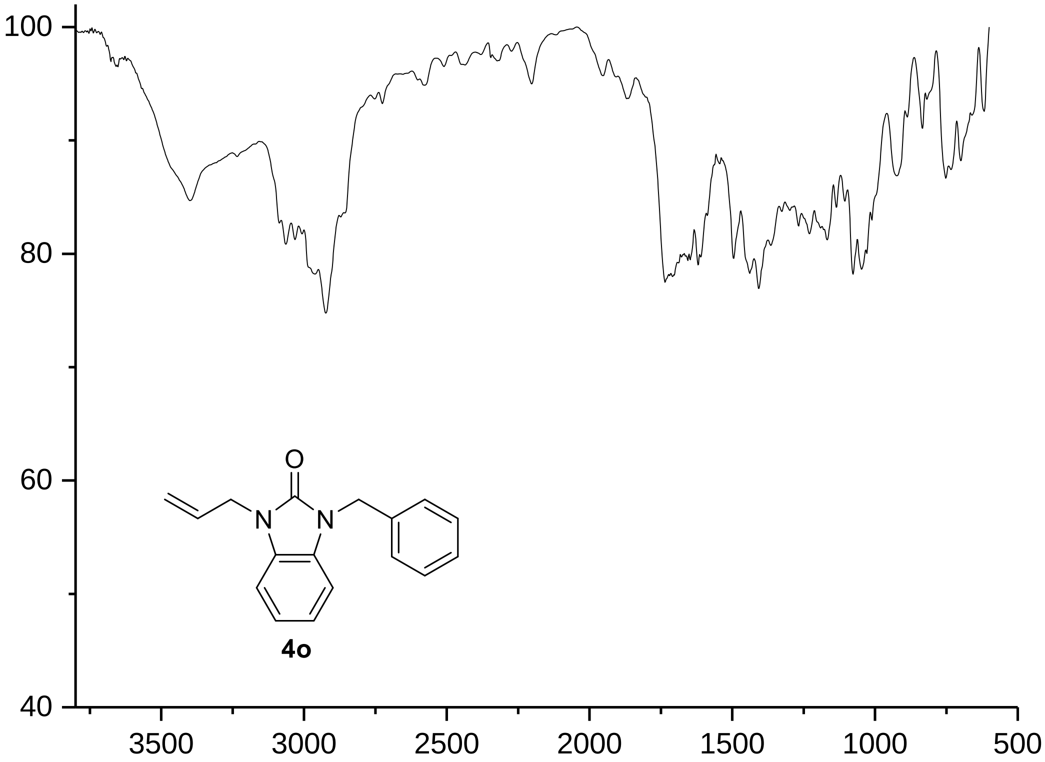
N
5
4n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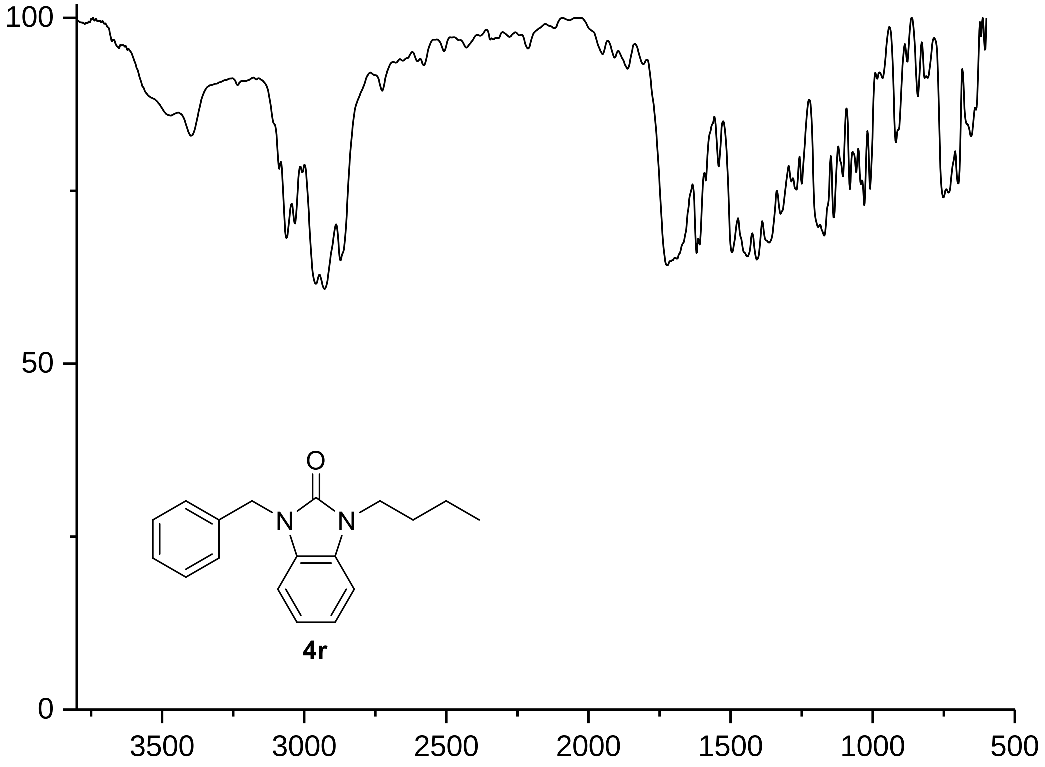
4o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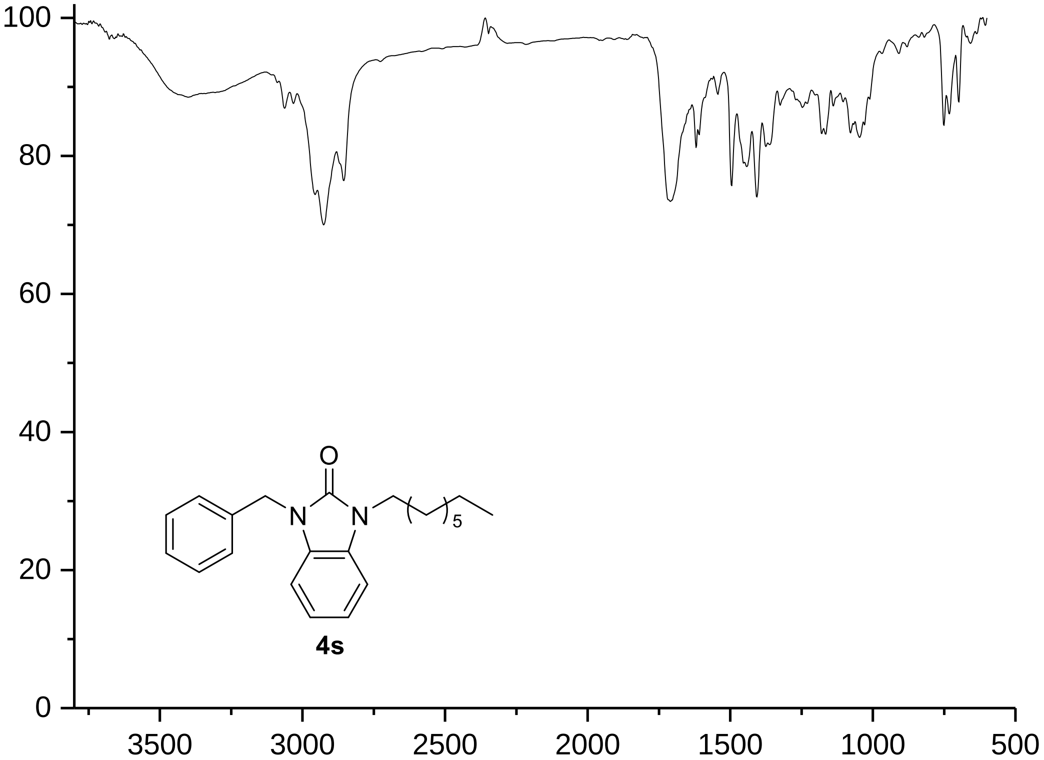
4r



100
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2000
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500
O
N
N
5
4s