A New Synthetic Approach to 6- Unsubstituted Phenanthridine and Phenanthridine-like Compounds under Mild and Metal-Free Conditions

Jumreang Tummatorn,[*,†] Suppachai Krajangsri,[†] Krissada Norseeda,[†] Charnsak Thongsornkleeb,[†,‡] and Somsak Ruchirawat,[†,‡]

†Chulabhorn Research Institute, 54 Kamphaeng Phet 6, Laksi, Bangkok 10210, Thailand. ‡Program on Chemical Biology, Chulabhorn Graduate Institute, Center of Excellence on Environmental Health and Toxicology (EHT), Ministry of Educa-tion, 54 Kamphaeng Phet 6, Laksi, Bangkok 10210, Thailand

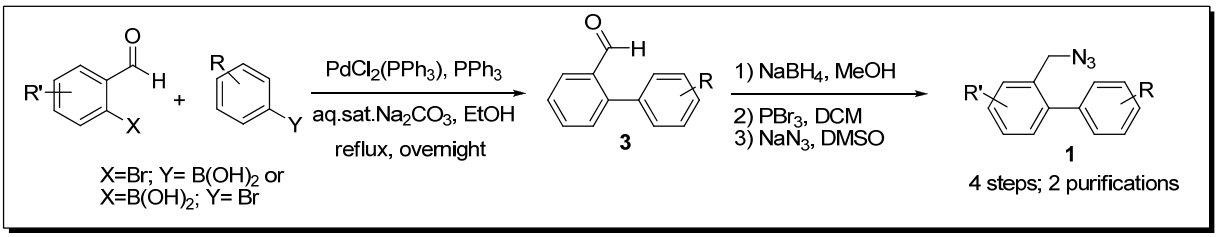
Supporting Information

Contents: **Pages**

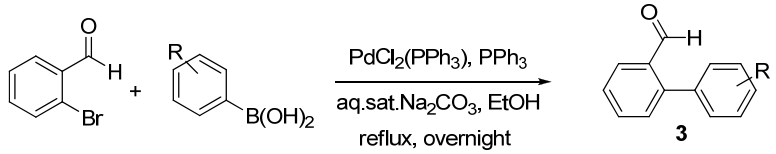
Experimental Section

1. General Information. Commercial grade reagents and solvents were used as received from the supplier except where indicated otherwise. Tetrahydrofuran (THF), dichloromethane (DCM), and toluene were purified by pressure filtration through activated alumina. All glassware was oven-dried at 110 ^{o}C for two hours or more. ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ with 300 MHz NMR spectrometers. ^{1}H NMR and ^{13}C NMR chemical shifts (δ) were reported in units of part per million (ppm), relative to tetramethylsilane (TMS) at δ equal to zero ppm. Coupling constants (*J*) were reported in Hertz (Hz). Infrared spectra measured using an FT-IR spectrometer and were reported in cm^{-1}. High resolution mass spectra (HRMS) was measured on a mass spectrometer.

2. Synthesis of 2-(azidomethyl)biaryl (1):

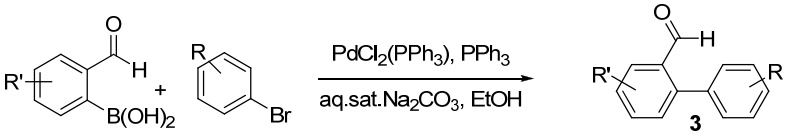


*Synthesis of compound **3b-3j, 3o-3p** and **3r**:*

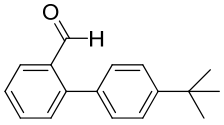


A solution of 2-bromobenxaldehyde (1.0 equiv), phenylboronic acid (1.2 eqiv), $PdCl_2(PPh_3)_2$ (5 mol%), and PPh_3 (10 mol%) in EtOH (5.0 mL/mmol) was refluxed for 30 min and then Na_2CO_3 (1.2 eqiv) in water (0.5 mL/mmol) was added into the reaction mixture. The resulting solution was stirred under refluxing conditions for overnight. The solvent was removed, and the crude material was diluted with water, extracted with EtOAc (2x 20 mL), washed with water (2x 10 mL), and dried over Na2SO4. After rotary evaporation, the crude product was purified on silica gel to yield the biphenyl-2-carbaldehyde (**3**).

*Synthesis of compound **3k-3n**:*

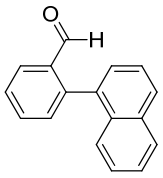


Prepared according to general procedure with a slight modification: 2-formylphenylbronic acid (1.2 equiv) and bromophenyl compound (1.0 eqiv) was used for the synthesis of compound **3k-3n.**



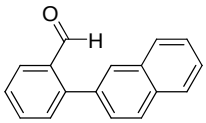
*4'-tert-butylbiphenyl-2-carbaldehyde **(3b)***: Yield 316.1 mg (82%, colorless oil); IR (neat): ν_{max}2962, 1690, 1597, 1475, 1392, 1255, 1195 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ 10.00 (s, 1H), 8.01 (d, 1H, *J* = 8.1 Hz), 7.60 (td, 1H, *J* = 7.5, 1.5 Hz), 7.49-7.42 (m, 4H), 7.33-7.28 (m, 2H), 1.37 (s, 9H); ^{13}C NMR (75 MHz,

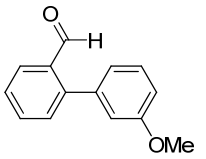
$CDCl_3$) δ 192.6, 151.1, 145.9, 134.6, 133.7, 133.4, 130.7, 129.8, 127.44, 127.40, 125.3, 34.6, 31.3. ESI-HRMS calcd for $C_{17}H_{18}NaO$ $(M+Na)^+$ 261.1250, found 261.1246.



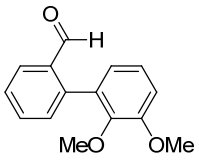
2-(naphthalen-1-yl)benzaldehyde ***(3c)***: Yield 359.9 mg (96%, white solid); 86-87 ºC. IR (neat): ν_{max}2844, 1963, 1596, 1197 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.63 (s, 1H), 8.11 (dd, 1H, *J* = 7.8, 1.5 Hz), 7.94 (app d, 2H, *J* = 8.1 Hz), 7.70 (td, 1H, *J* = 7.2, 1.5 Hz), 7.61-7.39 (m, 7H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 192.0, 144.2, 135.4, 134.8, 133.6, 133.4, 132.7, 131.7, 128.6, 128.3, 128.1, 127.0, 126.7, 126.2, 125.7, 125.0. ESI-HRMS calcd for $C_{17}H_{12}NaO$ $(M+Na)^+$ 255.0780, found 255.0787.

2-(naphthalen-2-yl)benzaldehyde ***(3d)***: Yield 309.8 mg (81%, yellow oil); IR (neat): ν_{max} 2844, 2752, 1691, 1595, 1195 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 10.03 (d, 1H, *J* = 0.6 Hz), 8.08-8.05 (m, 1H), 7.49-7.86 (m, 3H), 7.81 (s, 1H), 7.66 (td, 1H, *J* = 7.9, 1.5 Hz), 7.57-7.49 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 192.3, 145.8, 135.1, 133.8, 133.5, 132.9, 132.6, 130.9, 129.3, 128.1, 128.0, 127.8, 127.6, 126.7, 126.6. ESI-HRMS calcd for $C_{17}H_{12}NaO$ $(M+Na)^+$ 255.0780, found 255.0772.

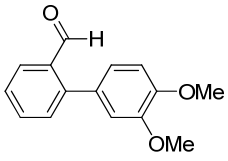




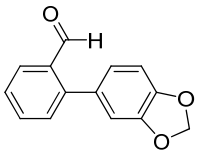
3'-methoxy-[1,1'-biphenyl]-2-carbaldehyde ***(3e)***: Yield 197.2 mg (58%, colorless oil); IR (neat): ν_{max} 2838, 1692, 1597, 1213, 763 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 10.02 (d, 1H, *J* = 0.6 Hz), 8.04 (dd, 1H, *J* = 7.8, 1.2 Hz), 7.64 (td, 1H, *J* = 7.5, 1.5 Hz), 7.53-7.45 (m, 2H), 7.39 (t, 1H, *J* = 7.8 Hz), 7.02-6.94 (m, 3H), 3.86 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 192.3, 159.4, 145.7, 139.1, 133.7, 133.4, 130.5, 129.3, 127.7, 127.4, 122.6, 115.6, 113.5, 55.2. ESI-HRMS calcd for $C_{14}H_{12}NaO_2$ $(M+Na)^+$ 235.0729, found 235.0721.



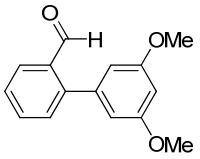
2',3'-dimethoxy-[1,1'-biphenyl]-2-carbaldehyde ***(3f)***: Yield 233.1 mg (88%, colorless oil); IR (neat): ν_{max} 2936, 2838, 1694, 1261, 1002 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.85 (d, 1H, *J* = 0.6 Hz), 8.02 (dd, 1H, *J* = 7.8, 1.2 Hz), 7.63 (td, 1H, *J* = 7.5, 1.2 Hz), 7.49 (t, 1H, *J*= 7.5 Hz), 7.40 (dd, 1H, *J* = 7.8, 0.9 Hz), 7.16 (t, 1H, *J* = 7.8 Hz), 7.01 (dd, 1H, *J* = 8.1, 1.5 Hz), 6.89 (dd, 1H, *J* = 7.8, 1.5 Hz), 3.92 (s, 3H), 3.48 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 191.8, 152.4, 146.1, 141.2, 133.5, 133.2, 131.9, 130.8, 127.6, 126.5, 124.1, 122.8, 121.5, 60.0, 55.6. ESI-HRMS calcd for $C_{15}H_{14}NaO_3$ $(M+Na)^+$ 265.0835, found 265.0837.



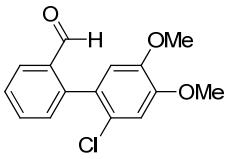
*3',4'-dimethoxy-[1,1'-biphenyl]-2-carbaldehyde****(3g)***: Yield 303.3 mg (74%, colorless oil); IR (neat):ν_{max} 2836, 1688, 1518, 1246, 1025, 760cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 10.00 (s, 1H), 7.99 (dd, 1H, *J* = 8.4, 1.8 Hz), 7.61 (td, 1H, *J* = 7.5, 1.2 Hz), 7.47 (app t, 2H, *J* = 7.8 Hz), 6.99-6.89 (m, 3H), 3.94 (s, 3H), 3.91 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 192.5, 149.0, 148.7, 145.6, 133.7, 133.3, 130.6, 130.2, 127.4, 127.3, 122.7, 113.0, 110.9, 55.9. ESI-HRMS calcd for $C_{15}H_{14}NaO_3$ $(M+Na)^+$ 265.0835, found 265.0828.



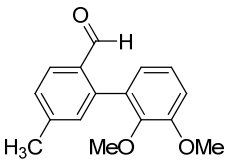
2-(benzo[d][1,3]dioxol-5-yl)benzaldehyde ***(3h)***: Yield 228.8 mg (62%, colorless oil); IR (neat): ν_{max} 2891 ,1691, 1473, 1223, 1038 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.99 (d, 1H, *J* = 0.3 Hz), 7.98 (dd, 1H, *J* = 7.5, 1.2 Hz), 7.59 (td, 1H, *J* = 7.5, 1.2 Hz), 7.45 (t, 1H, *J* = 7.5 Hz), 7.39 (dd, 1H, *J* = 7.5, 0.6 Hz), 6.90-6.86 (m, 2H), 6.78 (dd, 1H, *J* = 7.8, 1.8 Hz), 6.02 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 192.2, 147.7, 147.6, 145.3, 133.7, 133.4, 131.4, 130.5, 127.44, 127.40, 123.9, 110.1, 108.0, 101.3. ESI-HRMS calcdfor $C_{14}H_{10}NaO_3$ $(M+Na)^+$ 249.0522, found 249.0520.



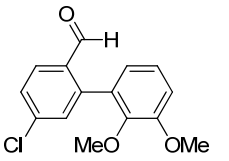
3',5'-dimethoxybiphenyl-2-carbaldehyde ***(3i)***: Yield 357.3 mg (71%, colorless oil); IR (neat): ν_{max} 2939, 2839, 1692, 1590, 1456, 1203, 1153 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 10.01 (d, 1H, *J* = 0.6 Hz), 8.01 (dd, 1H, *J* = 7.5, 0.9 Hz), 7.62 (td, 1H, *J* = 7.5, 1.5 Hz), 7.52-7.44 (m, 2H), 6.55-6.50 (m, 3H), 3.82 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 192.4, 160.6, 145.9, 139.8, 133.8, 133.5, 130.4, 127.9, 127.3, 108.4, 100.0, 55.4, . ESI-HRMS calcd for $C_{15}H_{14}NaO_3$ $(M+Na)^+$ 265.0835, found 265.0847.



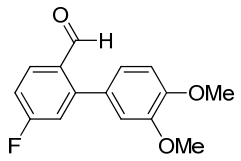
2'-chloro-4',5'-dimethoxy-[1,1'-biphenyl]-2-carbaldehyde ***(3j)***: Yield 192.7 mg (58%, white solid); mp 105-106 °C; IR (neat): ν_{max} 2842, 1694, 1508, 1210 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.83 (d, 1H, *J* = 0.6 Hz), 8.03 (dd, 1H, *J* = 7.8, 1.2 Hz), 7.66 (td, 1H, *J* = 7.5, 1.5 Hz), 7.53 (app td, 1H, *J* = 7.5, 0.9 Hz), 7.35 (dd, 1H, *J* = 7.5, 0.9 Hz), 6.98 (s, 1H), 6.80 (s, 1H), 3.94 (s, 3H), 3.87 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 191.7, 149.6, 147.8, 142.7, 134.0, 133.6, 131.1, 128.4, 128.3, 127.2, 124.8, 114.1, 112.4, 56.24, 56.20. ESI-HRMS calcd for $C_{15}H_{13}ClNaO_3$ (Cl-35) $(M+Na)^+$ 299.0455, found 299.0450.



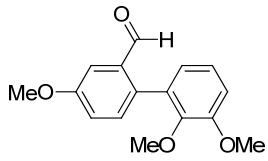
2',3'-dimethoxy-5-methyl-[1,1'-biphenyl]-2-carbaldehyde ***(3k)***: Yield 384.2 mg (99%, colorless oil); IR (neat): ν_{max} 2936, 2838, 1691, 1603, 1467, 1262 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.80 (d, 1H, *J* = 0.6 Hz), 7.93 (d, 1H, *J* = 7.8 Hz), 7.29 (d, 1H, *J* = 7.8 Hz), 7.20 (s, 1H), 7.14 (t, 1H, *J* = 7.8 Hz), 7.00 (dd, 1H, *J* = 8.1, 1.2 Hz), 6.87 (dd, 1H, *J* = 7.5, 1.5 Hz), 3.91 (s, 3H), 3.49 (s, 3H), 2.45 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 191.8, 152.6, 146.4, 144.1, 141.5, 132.2, 131.5, 131.4, 128.7, 126.9, 124.1, 123.0, 112.5, 60.3, 55.8, 21.7. ESI-HRMS calcd for $C_{16}H_{16}NaO_3$ $(M+Na)^+$ 279.0992, found 279.0994.



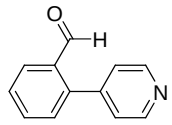
5-chloro-2',3'-dimethoxybiphenyl-2-carbaldehyde ***(3l)***: Yield 305.5 mg (81%, colorless oil); IR (neat): ν_{max} 2973, 2838, 1694, 1588, 1475, 1262 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.78 (d, 1H, *J* = 0.6 Hz), 7.96 (d, 1H, *J* = 8.4 Hz), 7.47 (ddd, 1H, *J* = 8.4, 2.1, 0.9 Hz), 7.40 (d, 1H, *J* = 2.1 Hz), 7.18 (t, 1H, *J* = 7.8 Hz), 7.03 (dd, 1H, *J* = 8.1, 1.5 Hz), 6.88 (dd, 1H, *J* = 7.5, 1.5 Hz), 3.92 (s, 3H), 3.52 (s, 3H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 190.7, 152.6, 146.2, 142.8, 139.4, 132.1, 130.8, 130.6, 128.2, 128.1, 124.3, 122.6, 113.1, 60.3, 55.8. ESI-HRMS calcd for $C_{15}H_{13}ClNaO_3$ (Cl-35) $(M+Na)^+$ 299.0445, found 299.0456.



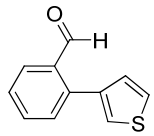
5-fluoro-3',4'-dimethoxybiphenyl-2-carbaldehyde ***(3m)***: Yield 351.9 mg (79%, white solid); mp 85-86 ºC; IR (neat): ν_{max} 2936, 2893, 1687, 1486, 1249 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.93 (d, 1H, *J* = 3.3 Hz), 7.67 (dd, 1H, *J* = 8.7, 2.7 Hz), 7.44 (dd, 1H, *J* = 8.4, 5.1 Hz), 7.32 (td, 1H, *J* = 7.8, 2.7 Hz), 6.96 (d, 1H, *J* = 9.3 Hz), 6.89 (d, 1H, *J* = 2.1 Hz), 6.86 (s, 1H), 3.95 (s, 3H), 3.91 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 191.2, 161.9 (d, J_{CF} = 247 Hz), 149.2, 148.9, 141.8 (d, J_{CF} = 12 Hz), 135.2 (d, J_{CF} = 7 Hz), 132.6 (d, J_{CF} = 8 Hz), 129.3, 122.9, 120.6 (J_{CF} = 22 Hz), 113.4 (d, J_{CF} = 26 Hz), 113.0, 111.0, 55.9. ESI-HRMS calcd for $C_{15}H_{13}FNaO_3$ $(M+Na)^+$ 283.0741, found 283.0748.



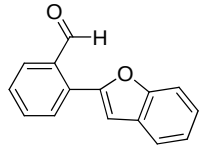
2',3',4-trimethoxy-[1,1'-biphenyl]-2-carbaldehyde ***(3n)***: Yield 375.0 mg (98%, colorless solid); mp 65-66 ºC; IR (neat): ν_{max}2935, 2838, 1687, 1468, 1018 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.81 (s, 1H), 7.52 (d, 1H, *J* = 2.7 Hz), 7.32 (d, 1H, *J* = 8.4 Hz), 7.19 (dd, 1H, *J* = 8.4, 2.7 Hz), 7.13 (t, 1H, *J* = 7.8 Hz), 6.99 (dd, 1H, *J* = 8.4 Hz), 6.87 (dd, 1H, *J* = 7.5, 1.5 Hz), 3.91 (s, 3H), 3.89 (s, 3H), 3.47 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 191.9, 159.1, 152.6, 146.4, 134.5, 134.0, 132.2, 131.8, 124.1, 123.2, 120.8, 112.4, 109.4, 60.1, 55.8, 55.4. ESI-HRMS calcd for $C_{16}H_{16}NaO_4$ $(M+Na)^+$ 295.0941, found 195.0940.



2-(pyridin-4-yl)benzaldehyde ***(3o)***: Yield 290.6 mg (89%, white solid); mp 67-68 ºC; IR (neat): ν_{max} 3030, 2848, 1693, 1593, 1408, 1258, 1195 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.98 (s, 1H), 8.72 (dd, 2H, *J* = 4.4, 1.4 Hz), 8.06 (d, 1H, *J* = 7.7 Hz), 7.71 (dd, 1H, *J* = 7.5, 1.4 Hz), 7.59 (dd, 1H, *J* = 7.6, 0.8 Hz), 7.44 (d, 1H, *J* = 7.6 Hz), 7.33 (dd, 2H, *J* = 4.4, 1.7 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 191.0, 149.7, 145.7, 142.6, 133.8, 133.3, 130.2, 128.9, 128.3, 124.6. ESI-HRMS calcd for $C_{12}H_{10}NO$ $(M+H)^+$ 184.0757, found 184.0762.

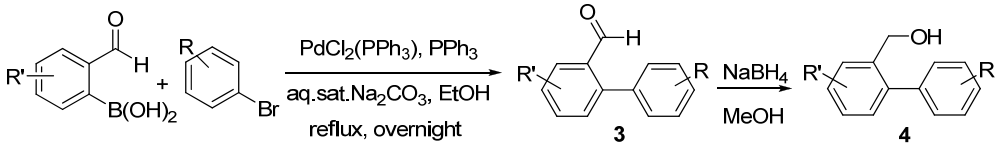


2-(thiophen-3-yl)benzaldehyde ***(3p)***: Yield 74.5 mg (73%, yellow oil); IR (neat): ν_{max}2848, 1686, 1597, 1196, 759 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 10.10 (s, 1H), 8.99 (dd, 1H, *J* = 7.8, 1.5 Hz), 7.61 (td, 1H, *J* = 7.8, 1.5 Hz), 7.49-7.43 (m, 3H), 7.29 (dd, 1H, *J* = 3.0, 1.2 Hz), 7.19 (dd, 1H, *J* = 4.8, 1.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 192.3, 140.4, 138.3, 133.9, 133.6, 130.5, 129.3, 127.7, 127.5, 126.2, 125.0. ESI-HRMS calcd for $C_{11}H_8NaOS$ $(M+Na)^+$ 211.0188, found 211.0185.

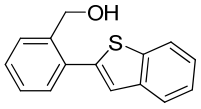


2-(benzofuran-2-yl)benzaldehyde ***(3r)***: Yield 223.4 mg (62%, colorless oil); IR (neat): ν_{max}2854, 1686, 1257, 1021, 748 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 10.46 (d, 1H, *J* = 0.6 Hz), 8.02 (dd, 1H, *J* = 7.8, 1.2 Hz), 7.81 (dd, 1H, *J* = 7.8, 0.9 Hz), 7.64 (td, 2H, *J* = 7.5, 1.2 Hz), 7.55-7.47 (m, 2H), 7.34 (td, 1H, *J* = 8.1, 1.5 Hz), 7.27 (dd, 1H, *J* = 7.5, 1.2 Hz), 6.95 (d, 1H, *J* = 0.6 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 192.0, 155.5, 152.8, 133.8, 133.5, 133.0, 129.1, 128.9, 128.5, 128.1, 125.2, 123.2, 121.3, 111.4, 107.8. ESI-HRMS calcd for $C_{15}H_{10}NaO_2$ $(M+Na)^+$ 245.0573, found 245.0576.

*General procedure for the synthesis of biphenylmethanol (**4q**):*



Biphenyl-2-carbaldehydes were prepared using the general procedure. However the products (**3e** and **3q**) were unable to isolate from the impurities. Therefore, the mixture was subjected to the reduction reaction using $NaBH_4$ (1.0 equiv) in MeOH. The reaction was quenched with water, extracted with EtOAc (2x 20 mL), washed with water (2x 10 mL), and dried over Na_2SO_4. After rotary evaporation, the crude product was purified on silica gel to yield biphenylmethanol (**4q**).

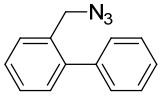


*(2-(benzo[b]thiophen-2-yl)phenyl)methanol **(4q)***: Yield 386.4 mg (65%, white solid); mp 108-109 ºC; IR (neat): ν_{max}3344, 3058, 2884, 1598, 1431, 1306, 1191, 1015cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.86-7.78 (m, 2H), 7.56 (dd, 1H, J = 7.5, 1.6 Hz), 7.52 (dd, 1H, J = 7.5, 1.6 Hz), 7.44-7.31 (m, 5H), 4.79 (s, 2H), 1.83 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 141.7, 140.2, 140.1, 138.8, 133.6, 130.9, 128.9, 128.7, 127.8, 124.5, 124.3, 123.7, 123.6, 122.0, 63.3. ESI-HRMS calcd for $C_{15}H_{12}NaOS$ $(M+Na)^+$ 263.0501, found 263.0496.

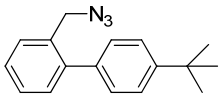
*General procedure for the synthesis of 2-(azidomethyl)biaryl (**1**):*

To a solution of biphenyl-2-carbaldehyde (1.0 equiv) in MeOH (3.8 mL/mmol) was added $NaBH_4$ (1.0 equiv) at 0 ºC and then warmed to room temperature, stirred for another 30 min. The reaction was quenched with water, extracted with EtOAc, dried with Na_2SO_4 and concentrated under reduced pressure. The crude of benzyl alcohol was dissolved in DCM (3.8 mL/mmol) and then added PBr_3 (0.34 equiv) at room temperature. The reaction mixture was stirred for 1 h and the solvent was removed under reduce pressure. The residue was used for next step without further purification. The crude product was dissolved in DMSO (3.0 mL/mmol) followed by addition of NaN_3 (2.0 equiv) at 0°C. The reaction mixture was stirred at 0°C for 0.5 h and allowed to stir at room temperature for 16 h. The mixture was diluted with water and extracted with EtOAc. The combined organic layers were washed with brine, dried (Na_2SO_4) and concentrated under reduced pressure to obtain the crude material which was purified on silica gel to yield 2-(azidomethyl)biphenyl (**1**). (**Note:** Safety precaution should be taken seriously. DCM from the first step should be removed completely when

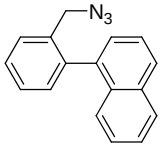
preparing the benzylic azides using NaN_3. See: R. E. Conrow, W. D. Dean, *Org. Proc. Res. Dev.* **2008**, *12*, 1285-1286.)



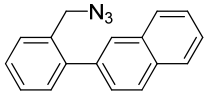
2-(azidomethyl)biphenyl ***(1a)***: Yield 529.2 mg (91%, colorless oil); IR (neat): ν_{max} 2090, 1598, 1480, 1254 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 7.48-7.30 (m, 9H), 4.28 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 142.2, 140.2, 132.8, 130.4, 129.5, 129.2, 128.3, 127.8, 127.4, 52.6. ESI-HRMS calcd for $C_{13}H_{12}N$ $(MH\text{-}N_2)^+$ 182.0964, found 182.0956.



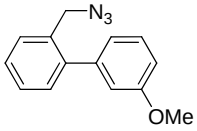
2-(azidomethyl)-4'-tert-butylbiphenyl ***(1b):*** Yield 252.3 mg (78%, colorless oil); IR (neat): ν_{max} 2963, 2094, 1483, 1268 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 7.47-7.42 (m, 3H), 7.40-7.37 (m, 2H), 7.34-7.31 (m, 1H), 7.29-7.25 (m, 2H), 4.31 (s, 2H), 1.37 (s, 9H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 150.2, 142.0, 137.2, 132.8, 130.4, 129.4, 128.8, 128.2, 127.5, 125.2, 52.5, 34.5, 31.3. ESI-HRMS calcd for $C_{17}H_{20}N$ $(MH\text{-}N_2)^+$ 238.1590, found 238.1593.



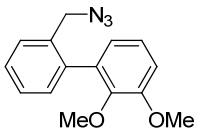
1-(2-(azidomethyl)phenyl)naphthalene ***(1c)***: Yield 242.2 mg (63%, colorless oil) IR (neat): ν_{max}2926, 2093, 1592, 1394, 1259 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 8.00-7.96 (m, 2H), 7.64-7.39 (m, 9H), 4.18 (d, 1H, *J* = 13.8 Hz), 4.10 (d, 1H, *J* = 13.8 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 139.9, 137.5, 134.3, 133.4, 132.0, 130.9, 128.7, 128.2, 128.01, 127.99, 127.0, 126.2, 125.9, 125.6, 125.2, 52.3. ESI-HRMS calcd for $C_{17}H_{14}N$ $(MH\text{-}N_2)^+$ 232.1121, found 232.1125.



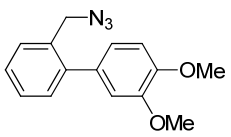
2-(2-(azidomethyl)phenyl)naphthalene ***(1d)***: Yield 110.2 mg (82%, colorless oil); IR (neat): ν_{max}2928, 2090, 1597, 1489, 1246 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 7.91-7.85 (m, 3H), 7.80 (s, 1H), 7.52-7.40 (m, 7H), 4.31 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 142.1, 137.7, 133.2, 133.0, 132.5, 130.6, 129.6, 128.4, 128.1, 128.0, 127.91, 127.88, 127.7, 127.4, 126.4, 126.2, 52.6. ESI-HRMS calcd for $C_{17}H_{14}N$ $(MH\text{-}N_2)^+$ 232.1121, found 232.1118.



(3'-methoxy-[1,1'-biphenyl]-2-yl)methanol ***(1e)***: Yield 167.5 mg (78%, colorless oil); IR (neat): ν_{max} 3749, 2938, 2836, 2093, 1598, 1475, 1213, 758 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 7.44-7.28 (m, 5H), 6.93-6.89 (m, 3H), 4.27 (s, 2H), 3.81 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.5, 142.1, 141.7, 132.8, 130.3, 129.6, 129.4, 128.4, 127.9, 121.6, 114.8, 113.2, 55.3, 52.6. ESI-HRMS calcd for $C_{14}H_{13}N_3NaO$ $(M+Na)^+$ 262.0951, found 262.0962.

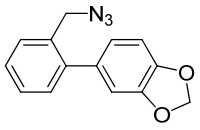


2'-(azidomethyl)-2,3-dimethoxybiphenyl ***(1f)***: Yield 316.8 mg (81%, colorless oil); IR (neat): ν_{max} 2935, 2093, 1580, 1466, 1262 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 7.53 (dd, 1H, *J* = 9.0, 3.0 Hz), 7.46-7.30 (m, 3H), 7.15 (t, 1H, *J* = 9.0 Hz), 7.00 (dd, 1H, *J* = 9.0, 3.0 Hz), 6.85 (dd, 1H, *J* = 9.0, 3.0 Hz), 4.39 (d, 1H, *J* = 13.8 Hz), 4.27 (d, 1H, *J* = 13.8 Hz), 3.92 (s, 3H), 3.53 (s, 3H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 152.5, 145.8, 137.5, 134.5, 134.0, 130.1, 128.1, 127.6, 127.5, 123.9, 122.6, 116.7, 60.2, 55.5, 52.3. ESI-HRMS calcd for $C_{15}H_{15}N_3NaO_2$ $(M+Na)^+$ 292.1057, found 292.1056.

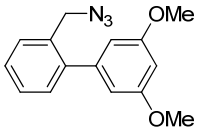


2-(azidomethyl)-3',4'-dimethoxybiphenyl ***(1g)***: Yield 229.7 mg (82%, colorless oil); IR (neat): ν_{max} 2935, 2090, 1519, 1245, 1218, 1026 cm^{-1}. ^1H NMR (300

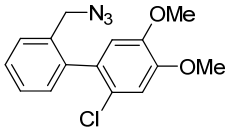
MHz, $CDCl_3$) δ 7.38-7.30 (m, 4H), 6.90 (d, 1H, *J* = 1.2 Hz), 6.88 (s, 1H), 6.87 (d, 1H, *J* = 1.5 Hz), 4.24 (s, 2H), 3.86 (s, 3H), 3.84 (s, 3H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 148.2, 148.0, 141.6, 132.4, 130.0, 129.3, 127.9, 127.1, 121.0, 112.2, 110.6, 55.3, 52.2. ESI-HRMS calcd for $C_{15}H_{15}N_3NaO_2$ $(M+Na)^+$ 292.1057, found 292.1052.



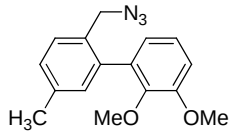
5-(2-(azidomethyl)phenyl)benzo[d][1,3]dioxole ***(1h)***: Yield 180.5 mg (87%, colorless oil); IR (neat): ν_{max} 2890, 2089, 1503, 1475, 1220, 1037 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.41-7.24 (m, 4H), 6.85-8.81 (m, 2H), 6.76 (d, 1H, *J* = 6.0 Hz), 5.94 (s, 2H), 4.26 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 147.4, 146.9, 141.7, 133.9, 132.8, 130.4, 129.5, 128.2, 127.5, 122.5, 109.6, 108.0, 101.0, 52.5. ESI-HRMS calcd for $C_{14}H_{11}N_3NaO_2$ $(M+Na)^+$ 276.0744, found 276.0736.



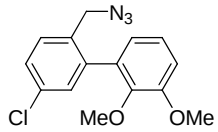
2-(azidomethyl)-3',5'-dimethoxybiphenyl ***(1i)***: Yield 138.7 mg (73%, colorless oil); IR (neat): ν_{max} 2938, 2092, 1590, 1456, 1419, 1203, 1152 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.45-7.30 (m, 4H), 6.49 (s, 3H), 4.29 (s, 2H), 3.81 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 160.5, 142.1, 132.7, 130.0, 129.5, 128.2, 127.8, 107.3, 99.5, 55.4, 52.5. ESI-HRMS calcd for $C_{15}H_{15}N_3NaO_2$ $(M+Na)^+$ 292.1056, found 292.1047.



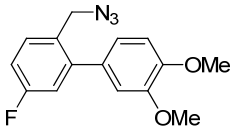
2'-(azidomethyl)-2-chloro-4,5-dimethoxy-1,1'-biphenyl ***(1j)***: Yield 146.1 mg (69%, colorless oil); IR (neat): ν_{max} 2936, 2094, 1486, 1211 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.49-7.37 (m, 3H), 7.26-7.23 (m, 1H), 6.96 (s, 1H), 6.77 (s, 1H), 4.24 (d, 1H, *J* = 13.8 Hz), 4.15 (d, 1H, *J* = 13.5 Hz), 3.92 (s, 3H), 3.85 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 149.2, 147.7, 139.1, 134.0, 130.6, 130.5, 129.0, 128.4, 128.2, 124.2, 113.82, 118.79, 112.38, 112.35, 56.16, 52.5. ESI-HRMS calcd for $C_{15}H_{14}ClN_3NaO_2$ (Cl-35) $(M+Na)^+$ 326.0667, found 326.0663.



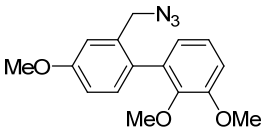
2'-(azidomethyl)-2,3-dimethoxy-5'-methylbiphenyl ***(1k)***: Yield 271.3 mg (64%, colorless oil); IR (neat): ν_{max} 2934, 2093, 1578, 1468, 1262 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.35 (d, 1H, *J* = 7.8 Hz), 7.21 (dd, 1H, *J* = 7.8, 1.2 Hz), 7.14-7.08 (m, 2H), 6.96 (dd, 1H, *J* = 8.2, 1.5Hz), 6.80 (dd, 1H, *J* = 7.6, 1.2 Hz), 4.29 (d, 1H, *J* = 13.2 Hz), 4.19 (d, 1H, *J* = 13.6 Hz), 3.91 (s, 3H), 3.50 (s, 3H), 2.38 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 152.6, 146.0, 137.6, 137.3, 134.6, 131.0, 130.9, 128.44, 128.35, 123.9, 122.9, 111.7, 60.4, 55.6, 52.3, 20.9. ESI-HRMS calcd for $C_{16}H_{17}N_3NaO_3$ $(M+Na)^+$ 306.1213, found 306.1217.



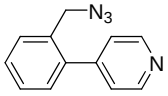
2'-(azidomethyl)-5'-chloro-2,3-dimethoxybiphenyl ***(1l)***: Yield 195.0 mg (62%, colorless oil); IR (neat): ν_{max} 2936, 2835, 2098, 1579, 1467, 1264, 1110 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.41-7.28 (m, 2H), 7.29 (d, 1H, *J* = 2.1 Hz), 7.10 (t, 1H, *J* = 8.1 Hz), 6.96 (dd, 1H, *J* = 8.1, 1.2 Hz), 6.79 (dd, 1H, *J* = 7.5, 1.5 Hz), 4.31 (d, 1H, *J* = 10.5 Hz), 4.16 (d, 1H, *J* = 13.8 Hz), 3.88 (s, 3H), 3.52 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 152.8, 146.0, 139.4, 133.3, 133.2, 133.0, 129.6, 127.9, 124.3, 122.6, 122.4, 60.7, 55.8, 52.0. ESI-HRMS calcd for $C_{15}H_{14}ClN_3NaO_2$ (Cl-35) $(M+Na)^+$ 326.0667, found 326.0682.



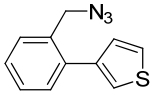
2-(azidomethyl)-4-fluoro-3',4'-dimethoxybiphenyl ***(1m)***: Yield 219.2 mg (63%, color oil); IR (neat): ν_{max} 2937, 2096, 1605, 1588, 1489, 1246 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 7.28 (dd, 1H, *J* = 8.4, 5.7 Hz), 7.16 (dd, 1H, *J* = 9.3, 2.7 Hz), 7.06 (td, 1H, *J* = 8.1, 2.7 Hz), 6.94-6.91 (m, 1H), 6.85-6.81 (m, 2H), 4.27 (s, 2H), 3.93 (s, 3H), 3.89 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.9 (d, J_{CF} = 246 Hz), 148.6, 148.5, 137.8 (d, J_{CF} = 3 Hz), 135.1 (d, J_{CF} = 7 Hz), 131.9 (d, J_{CF} = 8 Hz), 131.8, 121.4, 115.9 (d, J_{CF} = 22 Hz), 115.0 (d, *J* = 21 Hz), 112.5, 110.0, 55.8, 52.32, 52.30. ESI-HRMS calcd for $C_{15}H_{15}FNO_2$ $(M+H)^+$ 260.1018, found 260.1076.



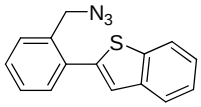
2'-(azidomethyl)-2,3,4'-trimethoxybiphenyl ***(1n)***: Yield 203.6 mg (54%, colorless oil); IR (neat): ν_{max}2936, 2097, 1609, 1467, 1262 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 7.19 (d, 1H, *J* = 4.2 Hz), 7.09 (t, 1H, *J* = 8.1 Hz), 7.02 (d, 1H, *J* = 2.7 Hz), 6.94 (dd, 1H, *J* = 8.4, 2.7 Hz), 6.90 (dd, 1H, *J* = 8.4, 2.7 Hz), 6.78 (dd, 1H, *J* = 6.8 Hz), 4.33 (d, 1H, *J* = 11.4 Hz), 4.19 (d, 1H, *J* = 12.3 Hz), 3.89 (s, 3H), 3.85 (s, 3H), 3.48 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.1, 152.6, 146.2, 135.4, 134.2, 131.3, 129.8, 124.0, 123.2, 113.3, 113.2, 111.6, 60.4, 55.7, 55.2, 52.6. ESI-HRMS calcd for $C_{16}H_{17}N_3NaO_3$ $(M+Na)^+$ 322.1162, found 322.1160.



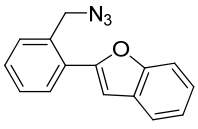
4-(2-(azidomethyl)phenyl)pyridine ***(1o):*** Yield 164.5 mg (50%, colorless oil); IR (neat): ν_{max}3029, 2095, 1594, 1479, 1408, 1251 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 8.68 (dd, 2H, *J* = 4.5, 1.5 Hz), 7.48-7.43 (m, 3H), 7.31-7.28 (m, 3H), 4.26 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 149.8, 148.0, 139.4, 132.4, 130.0, 129.9, 128.8, 128.7, 124.0, 52.3. ESI-HRMS calcd for $C_{12}H_{11}N_4$ $(M+H)^+$ 211.0978, found 211.0970.



3-(2-(azidomethyl)phenyl)thiophene ***(1p)***: Yield 203.6 mg (35%, colorless oil); IR (neat): ν_{max} 3102, 2929, 2090, 1482, 1449, 1256 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 7.42-7.36 (m, 5H), 7.32 (dd, 1H, *J* = 3.0, 1.2 Hz), 7.17 (dd, 1H, *J* = 4.8, 1.2 Hz), 4.32 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 140.2, 136.7, 132.7, 130.2, 129.8, 128.7, 128.3, 127.6, 125.5, 123.2, 52.7. ESI-HRMS calcd for $C_{11}H_{10}NS$ $(MH-N_2)^+$ 118.0528, found 188.0528.

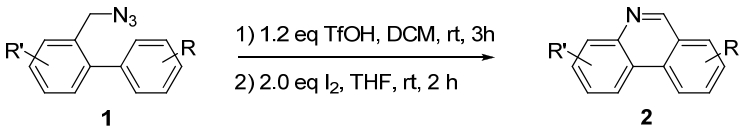


2-(2-(azidomethyl)phenyl)benzo[b]thiophene ***(1q)***: Yield 270.7 mg (71%, colorless oil); IR (neat): ν_{max}2928, 2093, 1724, 1431, 1250 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 7.92-7.87 (m, 2H), 7.64-7.61 (m, 1H), 7.55-7.41 (m, 6H), 4.52 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 141.1, 140.2, 140.0, 134.3, 133.5, 131.3, 130.0, 128.7, 128.4, 124.4, 123.8, 123.7, 122.0, 52.7. ESI-HRMS calcd for $C_{15}H_{12}NS$ $(MH-N_2)^+$ 238.0685, found 238.0686.



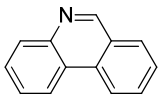
2-(2-(azidomethyl)phenyl)benzofuran ***(1r)***: Yield 350.0 mg (67%, colorless oil); IR (neat): ν_{max} 2933, 2093, 1449, 1255 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 7.95 (d, 1H, *J* = 7.2 Hz), 7.73 (d, 1H, *J* = 7.5 Hz), 7.68 (d, 1H, *J* = 7.5 Hz), 7.56-7.36 (m, 5H), 7.11 (d, 1H, *J* = 0.6 Hz), 4.68 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.7, 154.1, 132.4, 130.3, 129.9, 128.9, 128.8, 128.5, 124.5, 122.9, 121.1, 111.1, 105.5, 53.2. ESI-HRMS calcd for $C_{15}H_{11}N_3NaO$ $(M+Na)^+$ 272.0794, found 272.0796.

3. General procedure for the synthesis of phenanthridine (2):

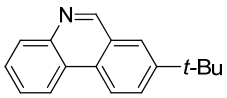


1 2

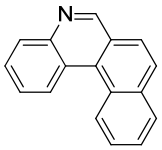
To a solution of 2-(azidomethyl)biphenyl **1** (1.0 equiv) in DCM (6.0 mL/mmol) was added TfOH (1.2 equiv) at room temperature. The reaction mixture was stirred for 3 h and then added with sat. $NaHCO_3$ to dilute the reaction. The mixture was extracted with EtOAc (2×20 mL), and the combined organic layers were washed with water (10 mL) and brine (10 mL), dried over Na_2SO_4, filtered, concentrated under reduced pressure. The residue was used in the next step without further purification. The crude product in THF (18.0 mL/mmol) was then added with I_2 (2.0 equiv) and stirred for 2 h. The reaction mixture was added aq. $Na_2S_2O_8$ (mL) and extracted with EtOAc. The combined organic layers were washed with brine, dried (Na_2SO_4) and concentrated under reduced pressure to obtain the crude material which was purified on silica gel to yield phenanthridine (**2**).



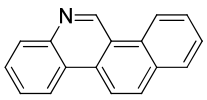
Phenanthridine (**2a**): Yield 48.3 mg (60%, white solid); mp 98-99 ºC; IR (neat): ν_{max} 2956, 1611, 1587, 1456, 1239 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.27 (S, 1H), 8.55 (d, 2H, *J* = 8.1 Hz), 8.19 (d, 1H, *J* = 8.1 Hz), 8.01 (d, 1H, *J* = 7.6 Hz), 7.82 (td, 1H, *J* = 8.1, 0.9 Hz), 7.76-7.64 (m, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 153.5, 144.4, 132.5, 130.9, 130.1, 128.7, 128.6, 127.4, 127.0, 126.3, 124.0, 122.1, 121.8. ESI-HRMS calcd for $C_{13}C_{10}N$ $(M+H)^+$ 180.0808, found 180.0809.



8-tert-butylphenanthridine ***(2b)***: Yield 44.3 mg (53%, white solid); mp 60-61 ºC; IR (neat): ν_{max} 2962, 1582, 1483, 1222, 762 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.27 (s, 1H), 8.53 (d, 1H, *J* = 6.3, 1.5 Hz), 8.52 (d, 1H, *J* = 8.7 Hz), 8.18 (dd, 1H, *J* = 8.4, 1.5 Hz), 7.98 (d, 1H, *J* = 2.1 Hz), 7.93 (dd, 1H, *J* = 6.6, 2.1 Hz), 7.74-7.62 (m, 2H), 1.46 (s, 9H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 153.7, 150.7, 144.1, 130.4, 129.9, 129.5, 128.2, 127.0, 126.4, 124.3, 124.1, 122.1, 121.7, 35.0, 31.2. ESI-HRMS calcd for $C_{17}H_{18}N$ $(M+H)^+$ 236.1434, found 236.1442.

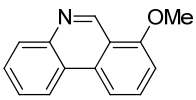


benzo[k]phenanthridine (**2c**): Yield 21.6 mg (81%, yellow light solid); mp 103-104 ºC; IR (neat): ν_{max} 3030, 2848, 1692, 1593, 1408, 1195cm^{-1}. 1H NMR (300 MHz, $CDCl_3$) δ 9.36 (s, 1H), 9.21 (dd, 1H, *J* = 7.5, 1.8 Hz), 9.11 (dd, 1H, *J* = 7.8, 0.9 Hz), 8.33 (dd, 1H, *J* = 8.4, 1.8 Hz), 8.10-8.07 (m, 1H), 8.03 (d, 1H, *J* = 8.4 Hz), 7.95 (d, 1H, *J* = 8.4 Hz), 7.85-7.72 (m, 4H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 152.6, 146.6, 135.1, 131.1, 130.2, 129.0, 128.9, 128.7, 128.2, 128.1, 127.8, 127.0, 126.9, 126.8, 125.2, 125.0, 124.6. ESI-HRMS calcd for $C_{17}H_{12}N$ $(M+H)^+$ 230.0964, found 230.0975.

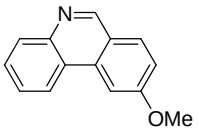


benzo[i]phenanthridine (**2d**): Yield 39.2 mg (85%, yellow light solid); mp 171-172 ºC; IR (neat): ν_{max} 2924, 1602, 1578, 1438, 1240 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 10.23 (s, 1H), 8.91 (d, 1H, *J* = 8.4 Hz), 8.65 (d, 1H, *J* = 8.1 Hz), 8.58 (d, 1H, *J* = 9.3 Hz), 8.30 (dd, 1H, *J* = 8.4, 1.2 Hz), 8.17 (d, 1H, *J* = 9.0 Hz), 8.02 (d, 1H, *J* = 7.8 Hz), 7.84-7.68 (m, 4H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 147.8, 145.2, 132.1, 132.0, 130.05, 129.97, 128.9,

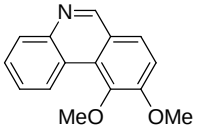
128.8, 128.0, 127.1, 127.0, 124.2, 122.6, 122.1, 121.7, 119.7. ESI-HRMS calcd for $C_{17}H_{12}N$ $(M+H)^+$ 230.0964, found 230.0959.



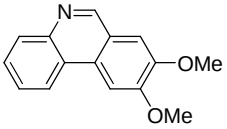
*7-methoxyphenanthridine (**2e-A**)*: Yield 6.5 mg (14%, yellow solid)); mp 116-117 °C; IR (neat): ν_{max} 2926, 1587, 1254, 1019, 751 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.74 (s, 1H), 8.55 (dd, 1H, *J* = 8.1, 1.2 Hz), 8.21-8.14 (m, 2H), 7.79-7.72 (m, 2H), 7.66 (td, 1H, *J* = 6.9,1.2 Hz), 7.05 (d, 1H, *J* = 7.8 Hz), 4.07 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 157.5, 148.3, 144.6, 133.9, 131.6, 130.0, 128.7, 126.8, 123.7, 122.7, 117.4, 113.8, 106.7, 55.8. ESI-HRMS calcd for $C_{14}H_{12}NO$ $(M+H)^+$ 210.0913, found 210.0920.



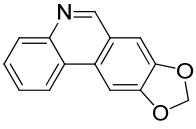
*9-methoxyphenanthridine (**2e-B**)*: Yield 31.4 mg (65%, yellow solid); mp 84-85 °C; IR (neat): ν_{max} 2835, 1617, 1232, 760 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.07 (s, 1H), 8.39 (dd, 1H, *J* = 8.1, 0.9 Hz), 8.08 (dd, 1H, *J* = 8.1, 0.9 Hz), 7.85 (d, 1H, *J* = 8.7 Hz), 7.79 (d, 1H, *J* = 2.1 Hz), 7.65 (td, 1H, *J* = 6.9, 1.2 Hz), 7.55 (td, 1H, *J* = 8.4, 1.5 Hz), 7.20 (dd, 1H, *J* = 8.7, 2.4 Hz), 3.94 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.7, 152.7, 144.6, 134.5, 130.5, 130.0, 128.7, 126.5, 123.8, 122.1, 121.4, 117.8, 102.4, 55.5. ESI-HRMS calcd for $C_{14}H_{12}NO$ $(M+H)^+$ 210.0913, found 210.0914.



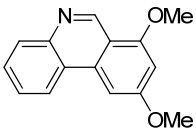
*9,10-dimethoxyphenanthridine (**2f**)*: Yield 70.7 mg (99%, white solid); mp 106-107 ºC; IR (neat): ν_{max} 2936, 1602, 1497, 1280, 1113 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.43 (dd, 1H, *J* = 8.1, 1.2 Hz), 9.12 (s, 1H), 8.15 (dd, 1H, *J* = 8.1, 1.8 Hz), 7.83 (d, 1H, *J* = 8.7 Hz), 7.74 (td, 1H, *J* = 7.2, 1.5 Hz), 7.66 (td, 1H, *J* = 6.9, 1.5 Hz), 7.42 (d, 1H, *J* = 8.7 Hz), 4.01 (s, 3H), 4.00 (s, 3H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.7, 153.2, 145.7, 144.8, 129.6, 128.5, 127.2, 126.9, 126.6, 125.9, 123.4, 122.5, 113.3, 59.8, 56.3. ESI-HRMS calcd for $C_{15}H_{14}NO_2$ $(M+H)^+$ 240.1019, found 240.1018.



8,9-dimethoxyphenanthridine (**2g**): Yield 61.6 mg (83%, white solid); mp163-164 ºC; IR (neat): ν_{max} 2998, 2832, 1609, 1504, 1264, 1160 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.13 (s, 1H), 8.42 (d, 1H, *J* = 7.8 Hz), 8.15 (d, 1H, *J* = 7.8 Hz), 7.84 (s, 1H), 7.71-7.62 (m, 2H), 7.32 (s, 1H), 4.12 (s, 3H), 4.06 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 152.8, 151.6, 149.9, 143.8, 130.0, 128.1, 127.7, 126.5, 123.7, 121.7, 121.6, 107.7, 101.7, 56.1, 56.0. ESI-HRMS calcd for $C_{15}H_{14}NO_2$ $(M+H)^+$ 240.1019, found 240.1028.

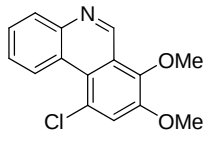


[1,3]dioxolo[4,5-j]phenanthridine (**2h**): Yield 41.8 mg (49%, white solid); mp 139-140 ºC; IR (neat): ν_{max} 2910, 1621, 1461, 1251, 1036, 939 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.07 (s, 1H), 8.34 (d, 1H, *J* = 8.1 Hz), 8.14 (d, 1H, *J* = 8.4 Hz), 7.87 (s, 1H), 7.70-7.58 (m, 2H), 7.30 (s, 1H), 6.14 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 151.7, 151.4, 148.1, 144.1, 130.1, 130.0, 127.9, 126.6, 124.2, 123.0, 121.9, 105.4, 101.8, 99.8. ESI-HRMS calcd for $C_{14}H_{10}NO_2$ $(M+H)^+$ 224.0706, found 224.0705.

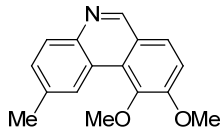


7,9-dimethoxyphenanthridine (**2i**): Yield 52.9 mg (97%, white solid); mp 138-139 ºC; IR (neat): ν_{max} 2830, 1614, 1594, 1208 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.45 (s, 1H), 8.40 (d, 1H, *J* = 8.2 Hz), 8.14 (dd, 1H, *J* = 8.2, 1.0 Hz), 7.71 (td, 1H, *J* = 7.0, 1.4 Hz), 7.59 (td, 1H, *J* = 8.2, 1.3 Hz), 7.40 (d, 1H, *J* = 1.6 Hz), 6.59 (d,

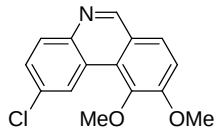
1H, *J* = 2.0 Hz), 3.99 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 162.6, 158.8, 147.6, 145.1, 135.4, 130.0, 128.7, 126.2, 123.6, 122.5, 113.2, 98.2, 94.0, 55.7, 55.5. ESI-HRMS calcd for $C_{15}H_{14}NO_2$ $(M+H)^+$ 240.1019, found 240.1023.



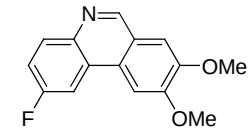
*10-chloro-7,8-dimethoxyphenanthridine (**2j-A**)*: Yield 192.7 mg (58%, white solid); mp 140-141 °C; IR (neat): ν_{max} 3749, 2946, 1586, 1306, 1076, 755 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.71 (dd, 1H, *J* = 8.7, 1.2 Hz), 9.64 (s, 1H), 8.19 (dd, 1H, *J* = 8.1, 1.5 Hz), 7.74 (td, 1H, *J* = 6.9, 1.5 Hz), 7.66 (app. td, 1H, *J* = 6.9, 1.2 Hz), 7.60 (s, 1H), 4.08 (s, 3H), 4.04 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 149.4, 148.2, 144.8, 144.6, 130.3, 128.3, 126.8, 125.9, 125.3, 123.6, 123.04, 123.01, 121.1, 62.0, 56.6. ESI-HRMS calcd for $C_{15}H_{13}ClNO_2$ (Cl-35) $(M+H)^+$ 274.0629, found 274.0637.



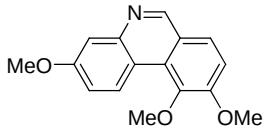
9,10-dimethoxy-2-methylphenanthridine (**2k**): Yield 97.4 mg (99%, white solid); mp 75-76 ºC; IR (neat): ν_{max} 2934, 2835, 1603, 1499, 1279, 1111 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.22 (s, 1H), 9.04 (s, 1H), 8.04 (d, 1H, *J* = 8.1 Hz), 7.76 (d, 1H, 1H, *J* = 8.7 Hz), 7.55 (dd, 1H, *J* = 8.1, 1.8 Hz), 7.35 (d, 1H, *J* = 8.7 Hz), 4.04 (s, 3H), 3.99 (s, 3H), 2.68 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.6, 152.4, 145.9, 143.2, 136.7, 130.1, 129.5, 126.9, 126.5, 125.8, 123.3, 122.9, 113.4, 59.8, 56.4, 22.2. ESI-HRMS calcd for $C_{16}H_{16}NO_2$ $(M+H)^+$ 254.1176, found 254.1181.



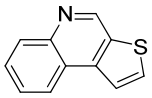
2-chloro-9,10-dimethoxyphenanthridine (**2l**): Yield 80.7 mg (86%, yellow light solid); mp 121-122 ºC; IR (neat): ν_{max} 2941, 1609, 1495, 1281, 1116 cm^{-1}. 1H NMR (300 MHz, $CDCl_3$) δ 9.43 (d, 1H, *J* = 2.1 Hz), 9.09 (s, 1H), 8.06 (d, 1H, *J* = 8.7 Hz), 7.81 (d, 1H, *J* = 6.0 Hz), 7.67 (dd, 1H, *J* = 9.0, 2.4 Hz), 7.43 (d, 1H, *J* = 8.7 Hz) 4.07 (s, 3H), 4.02 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.8, 153.5, 145.8, 143.5, 132.4, 131.0, 128.9, 126.7, 125.8, 125.6, 124.4, 122.6, 114.1, 59.8, 56.4. ESI-HRMS calcd for $C_{15}H_{13}ClNO_2$ (Cl-35) $(M+H)^+$ 247.0624, found 274.0624.



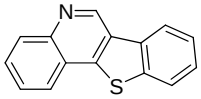
2-fluoro-8,9-dimethoxyphenanthridine (**2m**): Yield 87.1 mg (99%, yellow light solid); mp 161-162 ºC; IR (neat): ν_{max} 1618, 1503, 1467, 1265, 1158 cm^{-1}. 1H NMR (300 MHz, $CDCl_3$) δ 9.11 (s, 1H), 8.36 (dd, 1H, *J* = 9.3, 5.7 Hz), 7.77 (dd, 1H, *J* = 9.9, 2.7 Hz), 7.74 (s, 1H), 7.42-7.34 (m, 1H), 7.31 (s, 1H), 4.12 (s, 3H), 4.05 (s, 3H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 162.0 (d, J_{CF} = 246), 153.2, 152.8, 149.8, 145.1 (d, J_{CF} = 12 Hz), 128.0, 123.5 (d, J_{CF} = 9 Hz), 121.3, 120.5, 115.7 (d, J_{CF} = 24), 114.3 (d, J_{CF} = 20 Hz), 107.7, 101.5, 56.14, 56.07. ESI-HRMS calcd for $C_{15}H_{13}FNO_2$ $(M+H)^+$ 258.0925, found 258.0926.



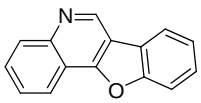
3,9,10-trimethoxyphenanthridine (**2n**): Yield 87.6 mg (76%, white solid); mp 125-126 ºC; IR (neat): ν_{max} 2932, 1603, 1467, 1281, 1106 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.31 (d, 1H, *J* = 9.3 Hz), 9.07 (s, 1H), 7.77 (d, 1H, *J* = 8.1 Hz), 7.75 (d, 1H, *J* = 2.7 Hz), 7.33 (d, 1H, *J* = 8.7 Hz), 7.28 (dd, 1H, *J* = 9.3, 3.0 Hz), 4.05 (s, 3H), 3.98 (s, 3H), 3.97 (s, 3H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.6, 154.6, 153.7, 146.9, 145.0, 128.3, 126.8, 125.8, 122.0, 117.2, 117.0, 112.5, 110.2, 59.7, 56.3, 55.3. ESI-HRMS calcd for $C_{16}H_{16}NO_3$ $(M+H)^+$ 270.1125, found 270.1128.



thieno[2,3-c]quinoline (**2p**): Yield 104.7mg (99%, white solid); mp 86-87 ºC; IR (neat): ν_{max} 1499, 1363, 1220 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.30 (s, 1H), 8.25 (app td, 2H, *J* = 7.8, 0.6 Hz), 7.95 (d, 1H, *J* = 5.1 Hz), 7.83 (dd, 1H, *J* = 4.8, 0.3 Hz), 7.71 (td, 1H, *J* = 7.2, 1.5 Hz), 7.63 (td, 1H, *J* = 8.1, 1.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.9, 144.1, 141.5, 133.0, 131.6, 129.7, 127.9, 126.8, 124.2, 123.2, 121.4. ESI-HRMS calcd for $C_{14}H_8NS$ $(M+H)^+$ 186.0372, found 186.0368.

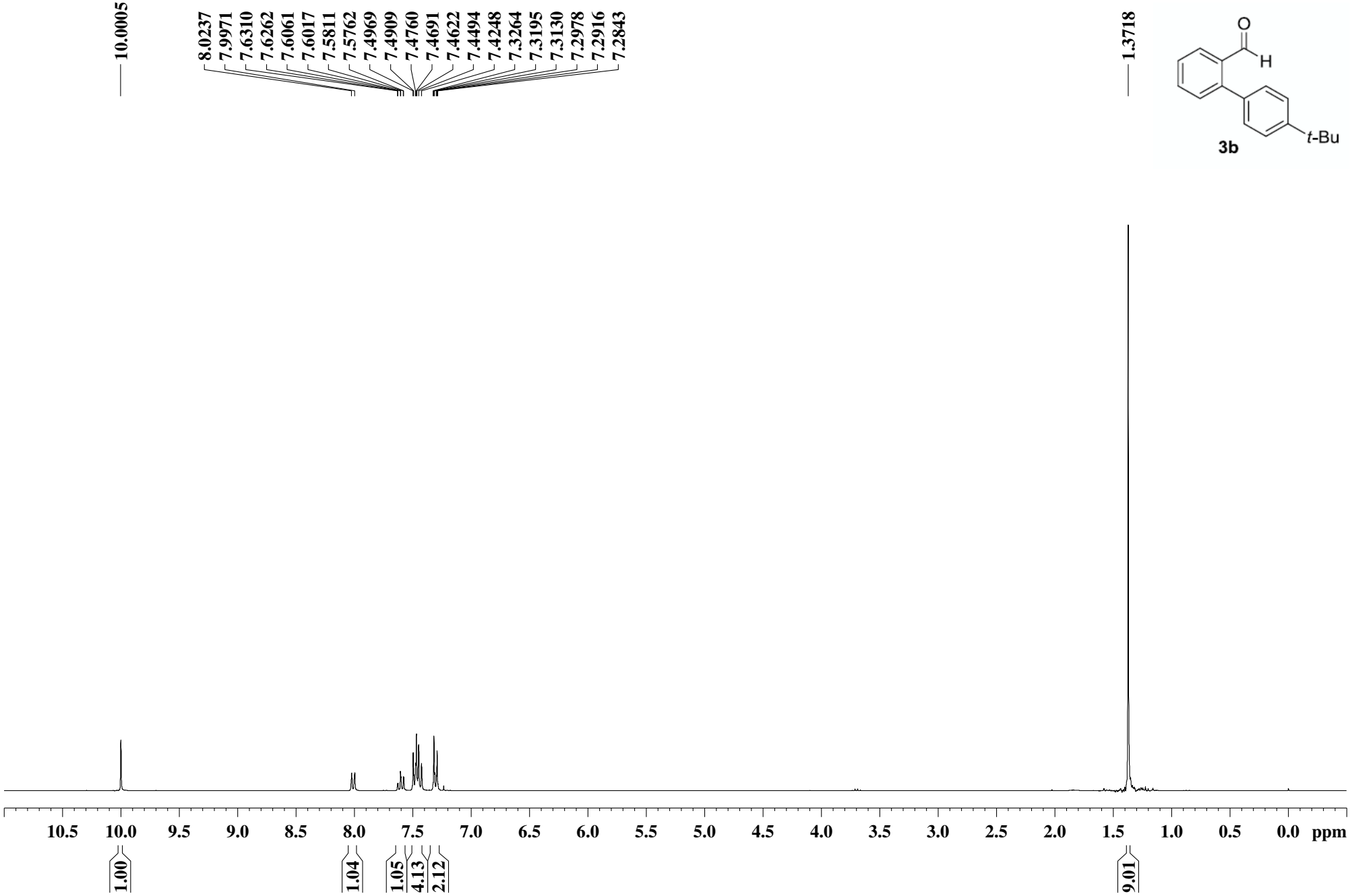


compond (**2q**): Yield 28.5 mg (62%, white solid); mp 160-161 ºC; IR (neat): ν_{max} 3052, 1560, 1499, 1359, 1243 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.55 (s, 1H), 8.31 (dd, 1H, *J* = 8.4, 1.5 Hz), 8.24 (d, 1H, *J* = 8.4 Hz), 8.08 (d, 1H, *J* = 7.8 Hz), 7.96 (dd, 1H, *J* = 7.2, 1.8 Hz), 7.75 (td, 1H, *J* = 7.8, 0.9), 7.63 (t, 1H, *J* = 7.8 Hz), 7.58-7.49 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 146.0, 145.5, 144.2, 138.9, 134.9, 130.3, 129.2, 128.6, 127.1, 126.9, 125.4, 124.2, 124.1, 123.0, 121.5. ESI-HRMS calcd for $C_{15}H_{10}NS$ $(M+H)^+$ 236.0528, found 236.0537.



benzofuro[3,2-c]quinoline (**2r**): Yield 68.6 mg (80%, white solid); mp 130-131 ºC; IR (neat): ν_{max} 2916, 2308, 2136, 1565, 1190 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ 9.41 (s, 1H), 8.32 (dd, 1H, *J* = 8.1, 1.5 Hz), 8.23 (d, 1H, *J* = 8.4), 8.00 (dd, 1H, *J* = 7.5, 1.2 Hz), 7.76-7.60 (m, 3H), 7.48 (td, 1H, *J* = 7.2, 1.2 Hz), 7.40 (td, 1H, *J* = 7.5, 1.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 157.3, 155.8, 147.2, 144.1, 129.6, 129.2, 127.1, 126.9, 123.9, 122.5, 120.7, 120.5, 117.0, 116.2, 112.0. ESI-HRMS calcd for $C_{15}H_{10}NO$ $(M+H)^+$ 220.0757, found 220.0750.

SK–1–098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7.6262
7.6061
7.6017
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7.5762
7.4969
7.4909
7.4760
7.4691
7.4622
7.4494
7.4248
7.3264
7.3195
7.3130
7.2978
7.2916
7.2843
1.3718
O
H
t-Bu
3b
10.5 10.0 9.5 9.0 8.5 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 ppm
1.00
1.04
1.05
4.13
2.12
9.01

SK–1–098

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151.1238
145.9026
134.6446
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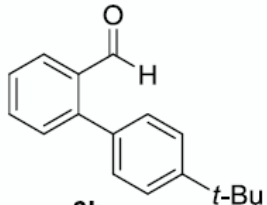
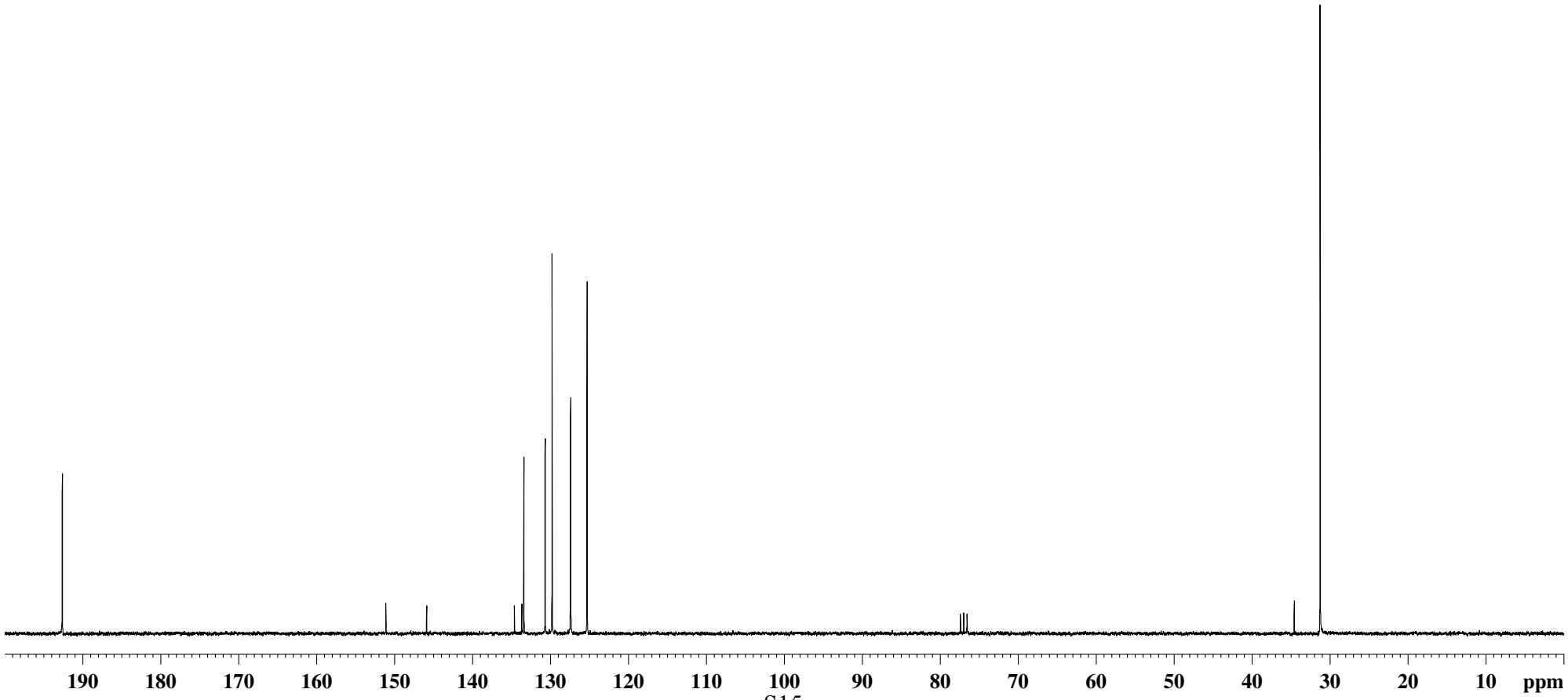
133.4250
130.6980
129.8074
127.4404
127.4008
125.3194
34.5850
31.2713



3b



SK–1–125

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7.9270
7.7313
7.7265
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7.6816
7.6766
7.6145
7.5889
7.5819
7.5585
7.5545
7.5403
7.5348
7.5309
7.5136
7.5079
7.4870
7.4836
7.4762
7.4723
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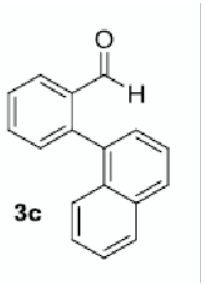
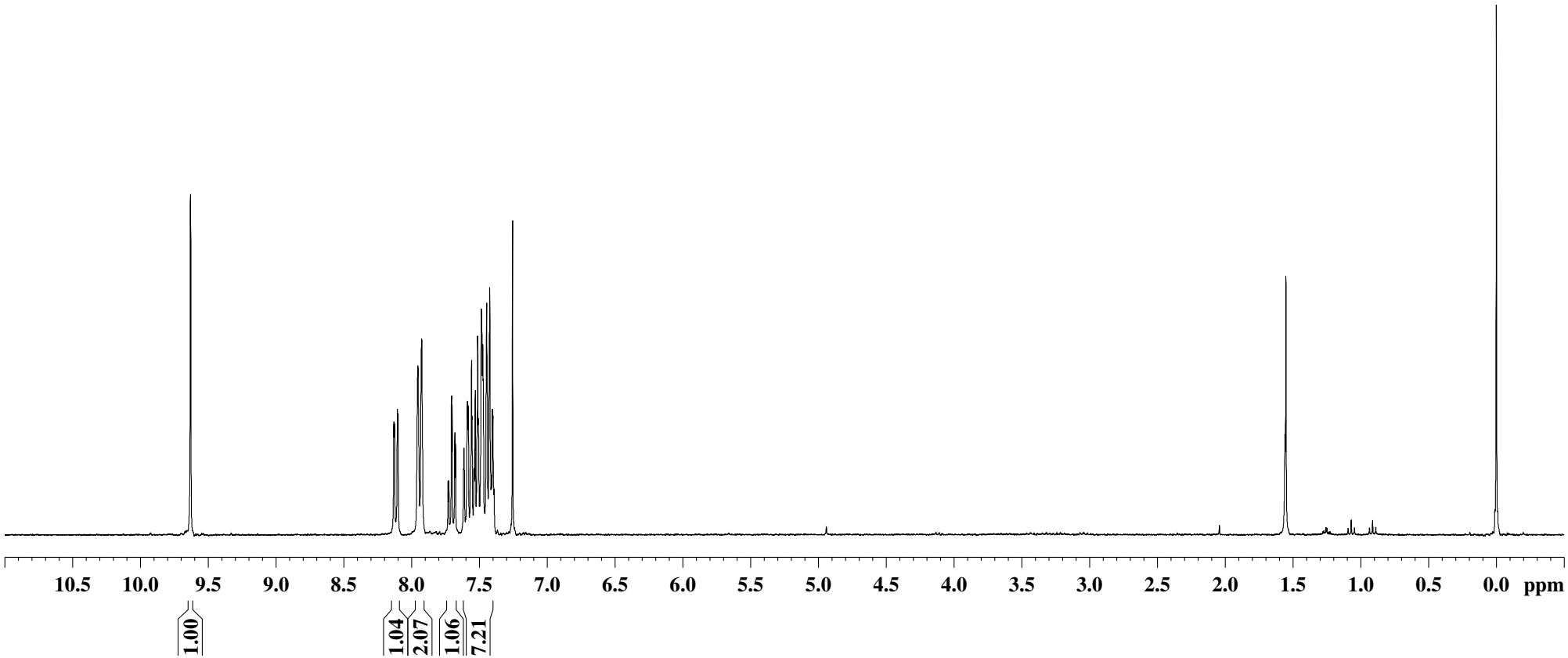
7.4428
7.4246
7.4126
7.4049
7.4011
7.3927



3c



SK–1–125

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134.8061
133.5908
133.3674
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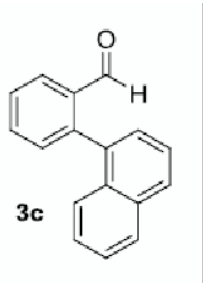
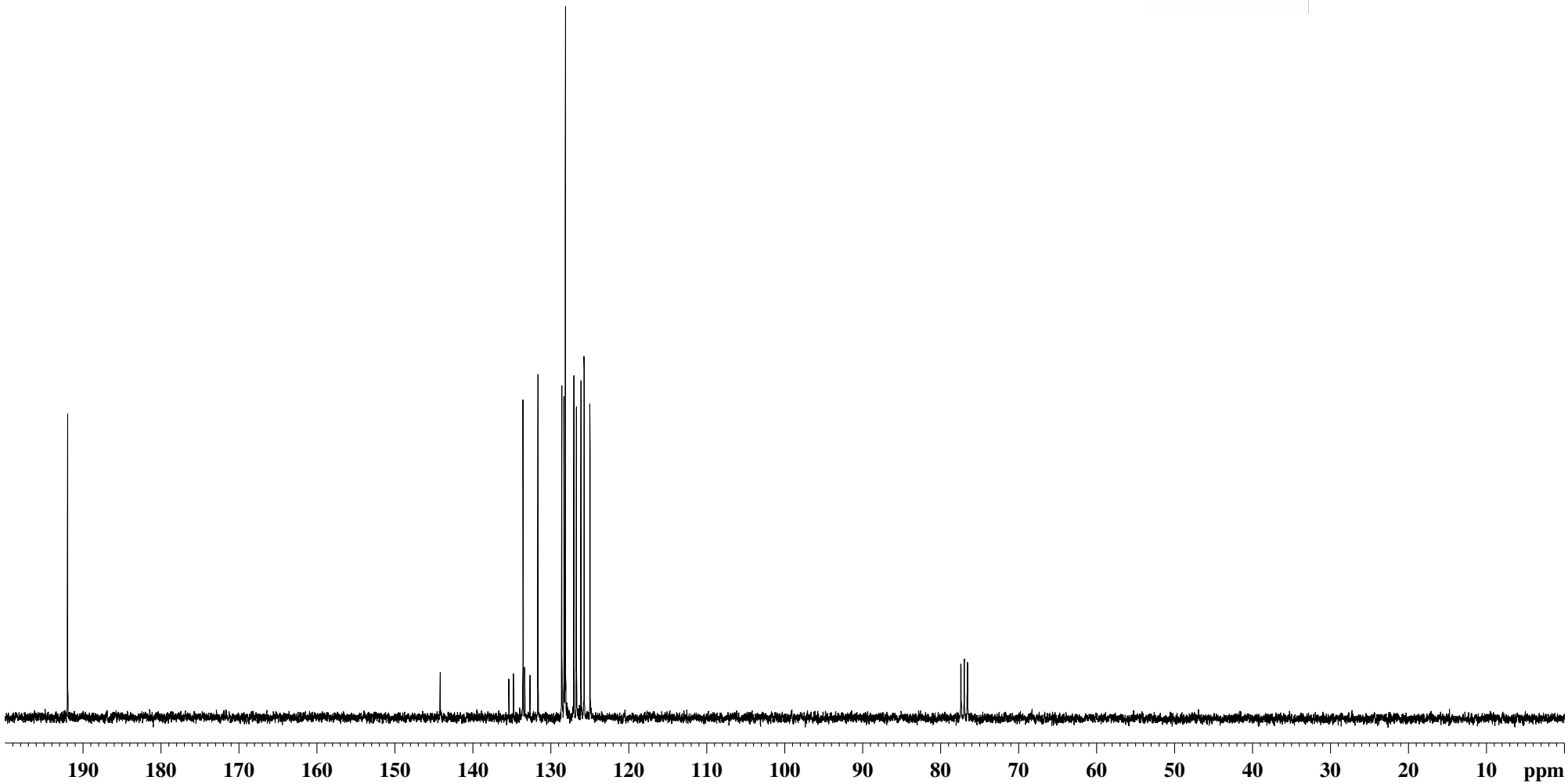
127.0606
126.7396
126.1567
125.7402
124.9914



3c



KN–1–004

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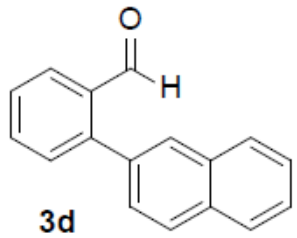
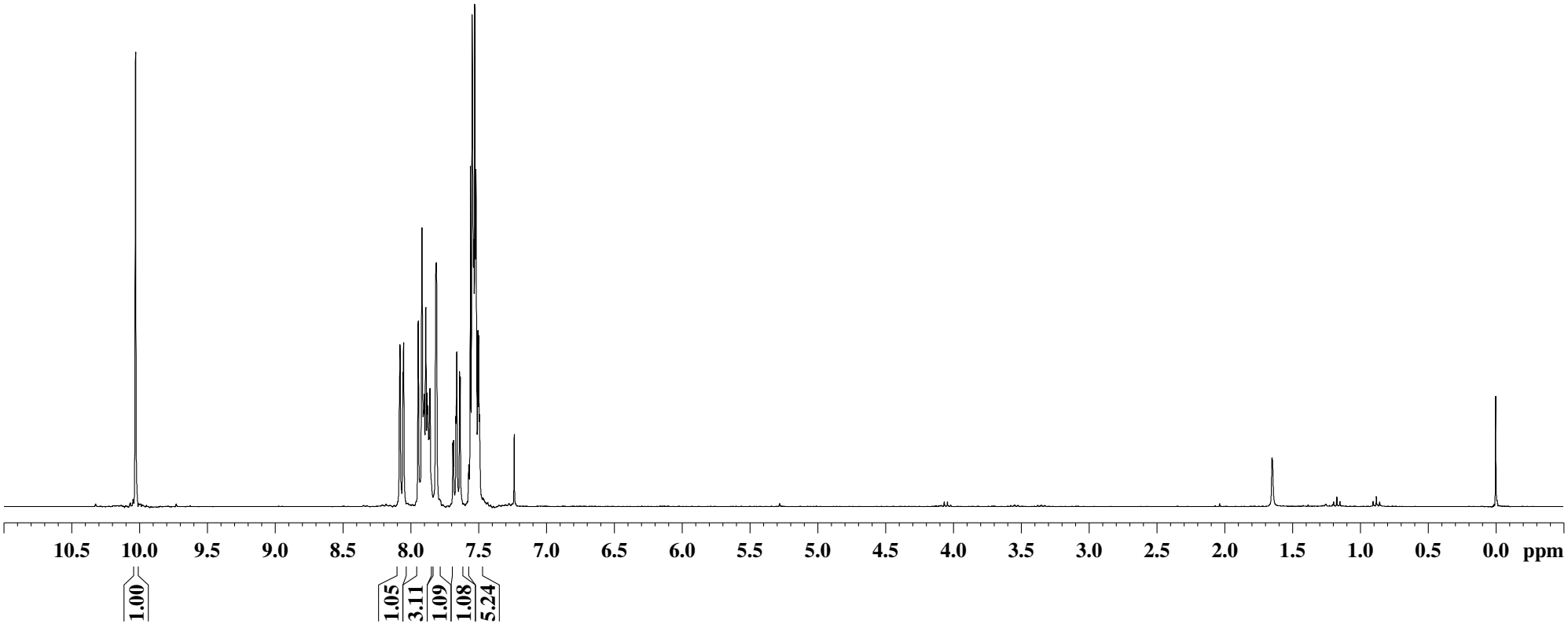


3d



KN–1–004

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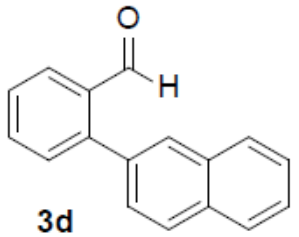
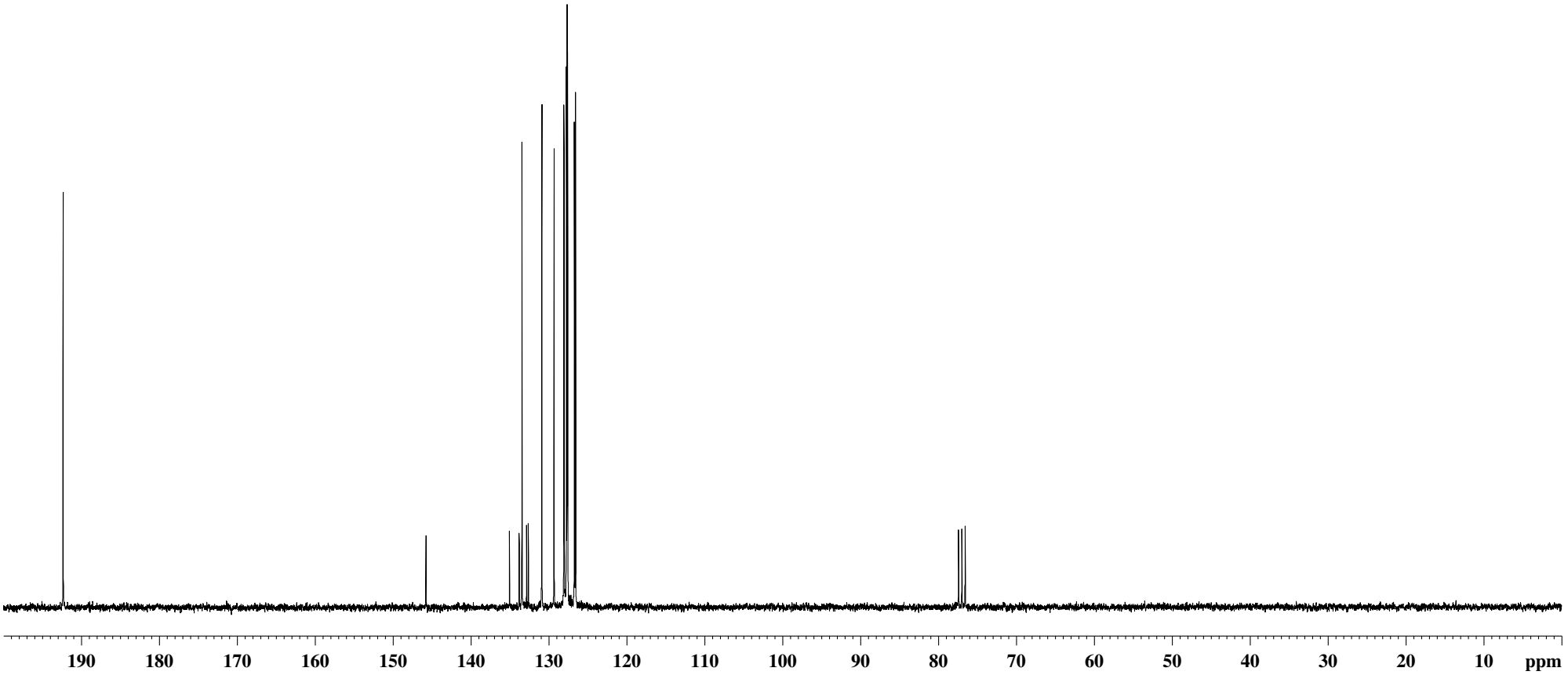
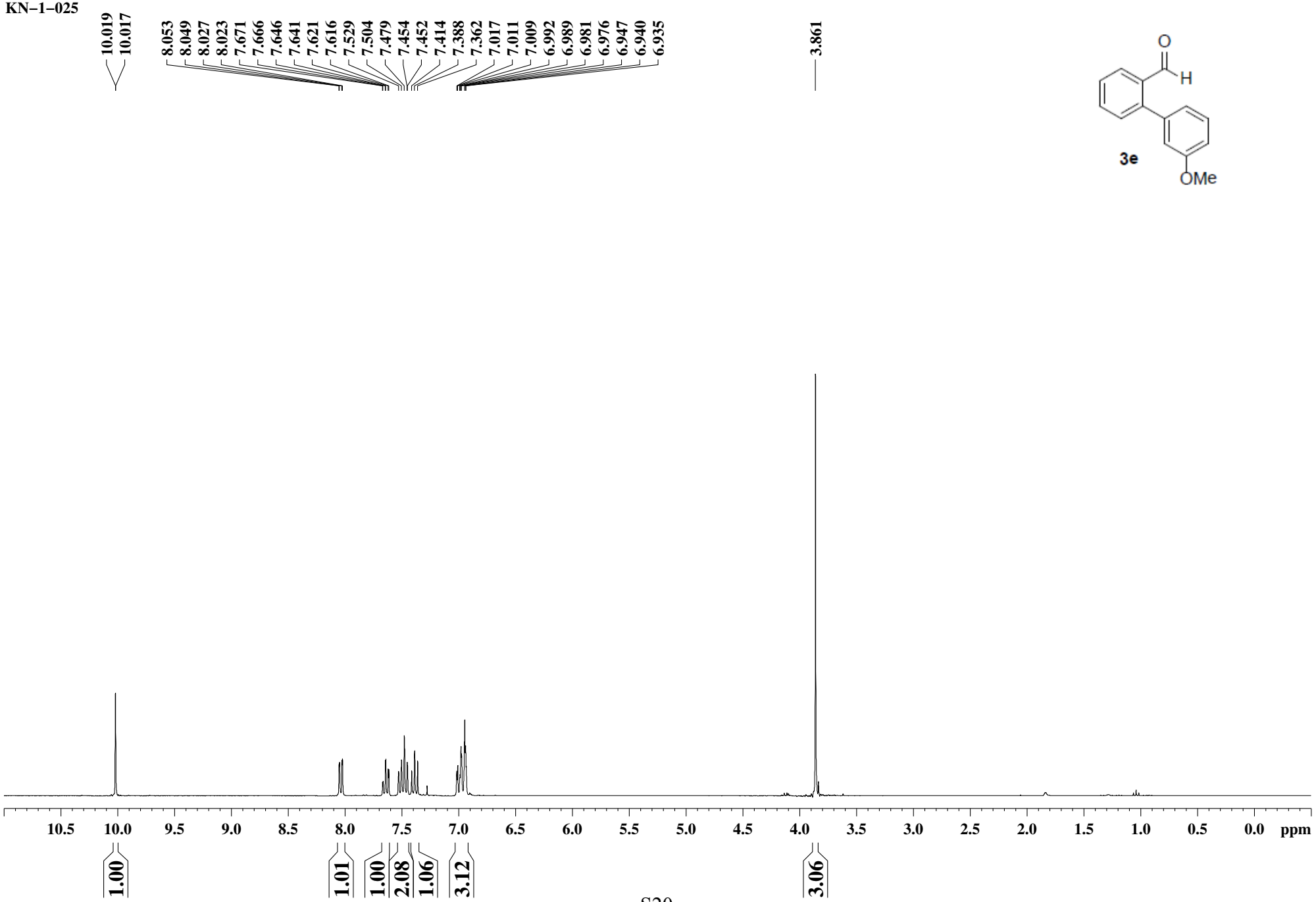
127.591
126.733
126.577



3d



KN–1–025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8.049
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7.666
7.646
7.641
7.621
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7.529
7.504
7.479
7.454
7.452
7.414
7.388
7.362
7.017
7.011
7.009
6.992
6.989
6.981
6.976
6.947
6.940
6.935
3.861
O
H
3e
OMe
10.5
10.0
9.5
9.0
8.5
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
ppm
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1.00
2.08
1.06
3.12
3.06

KN–1–025

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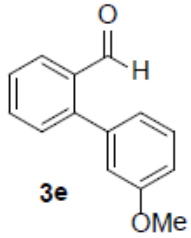
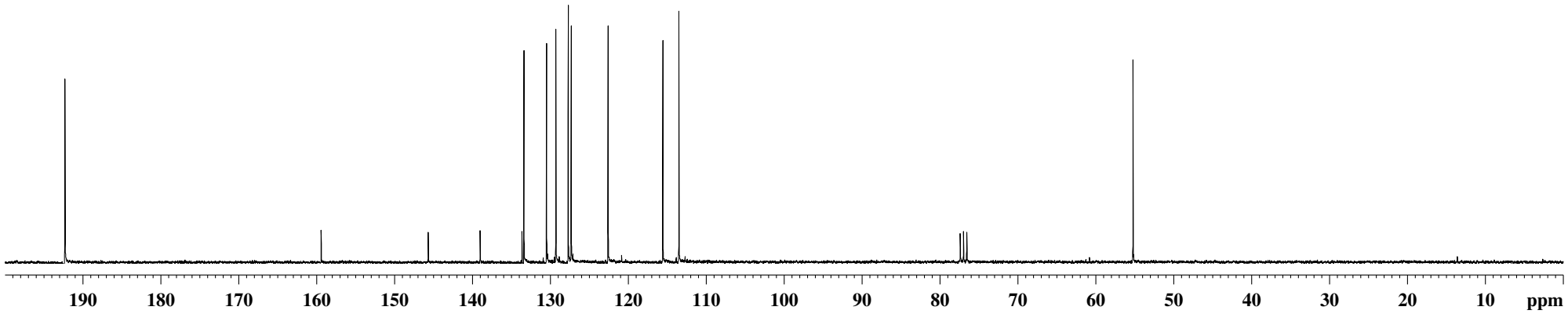
55.239



3e



SK–1–058B

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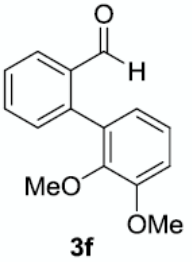
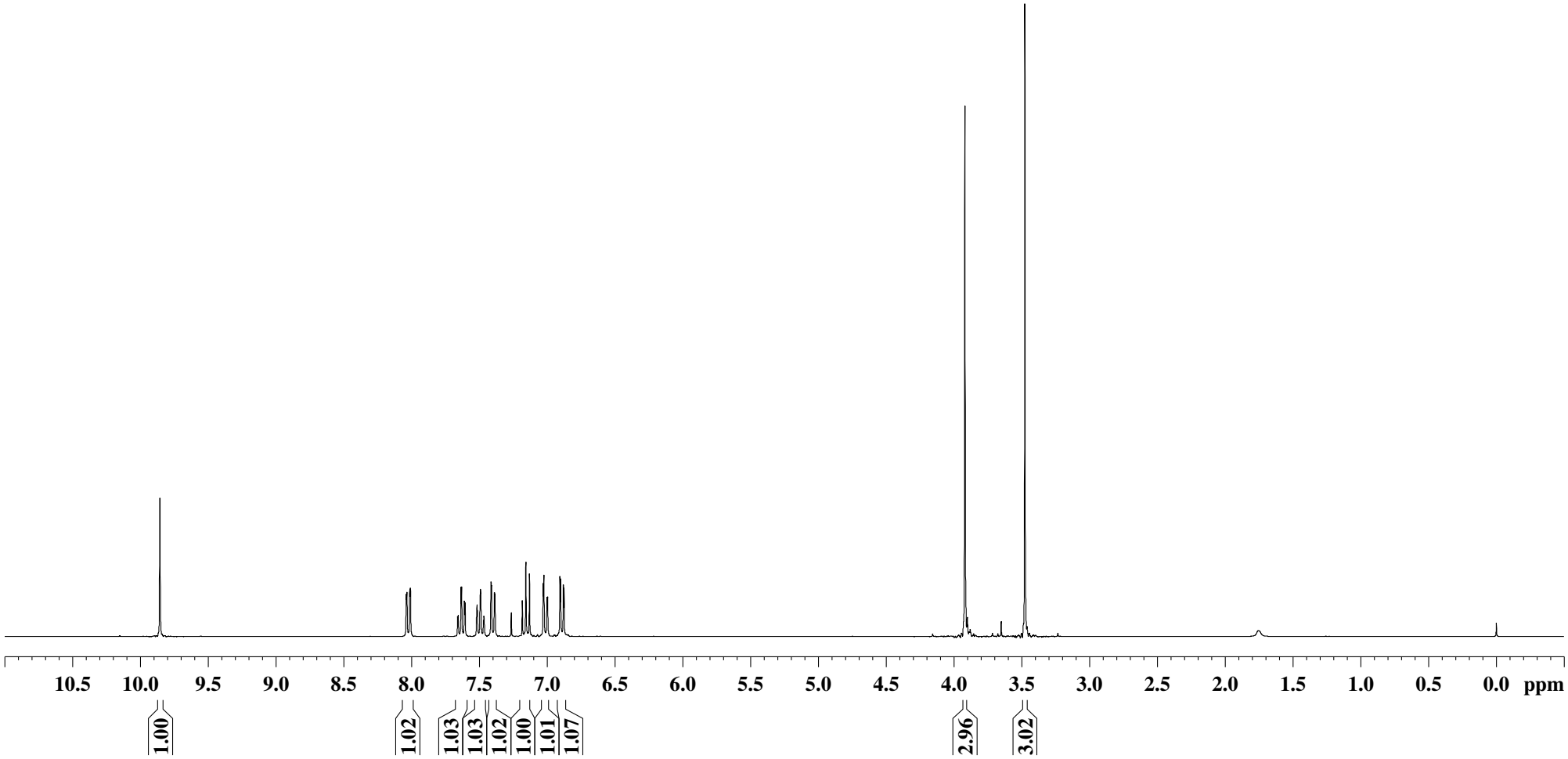


3f



SK–1–058A

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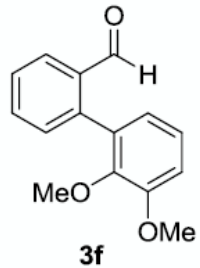
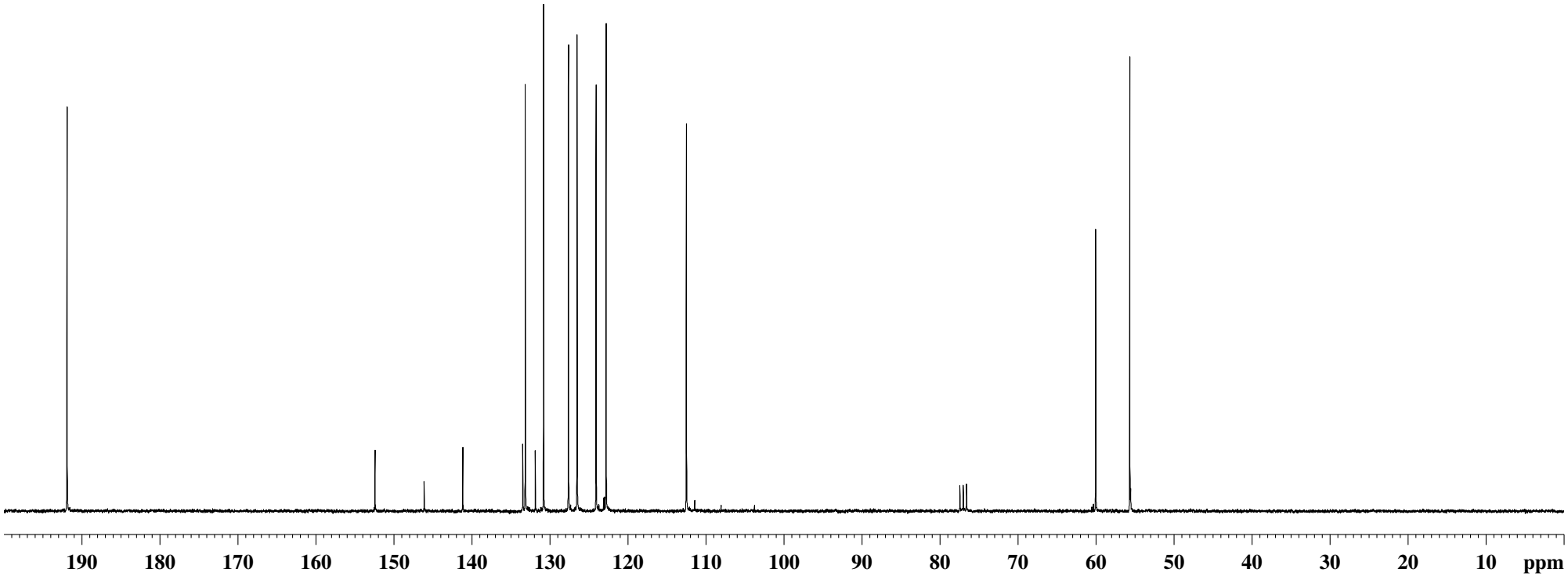
124.0769
122.7932
112.5021
60.0217
55.6469



3f



SK–1–060

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6.9846
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6.9091
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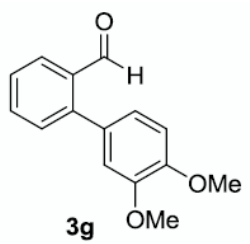
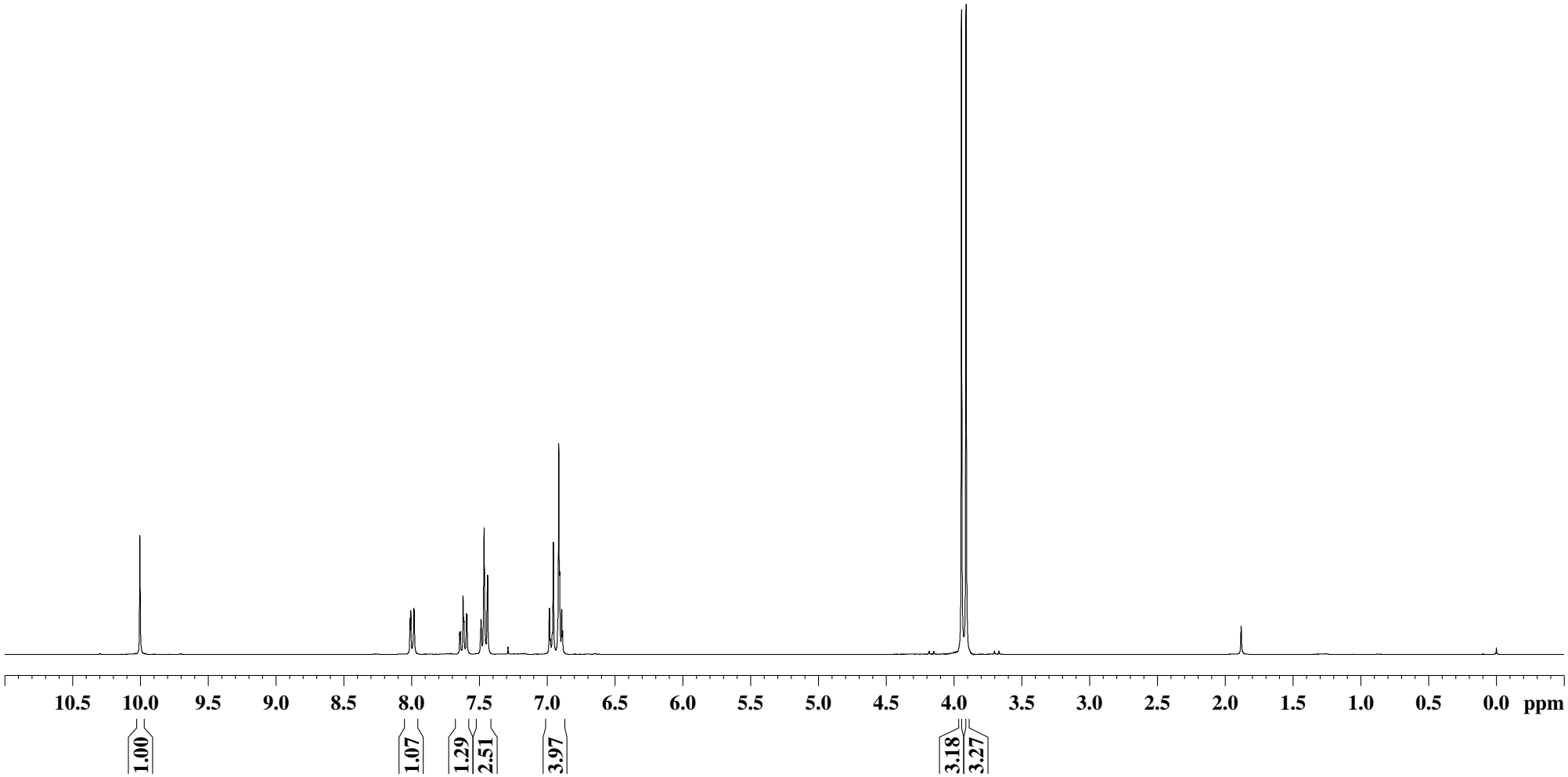
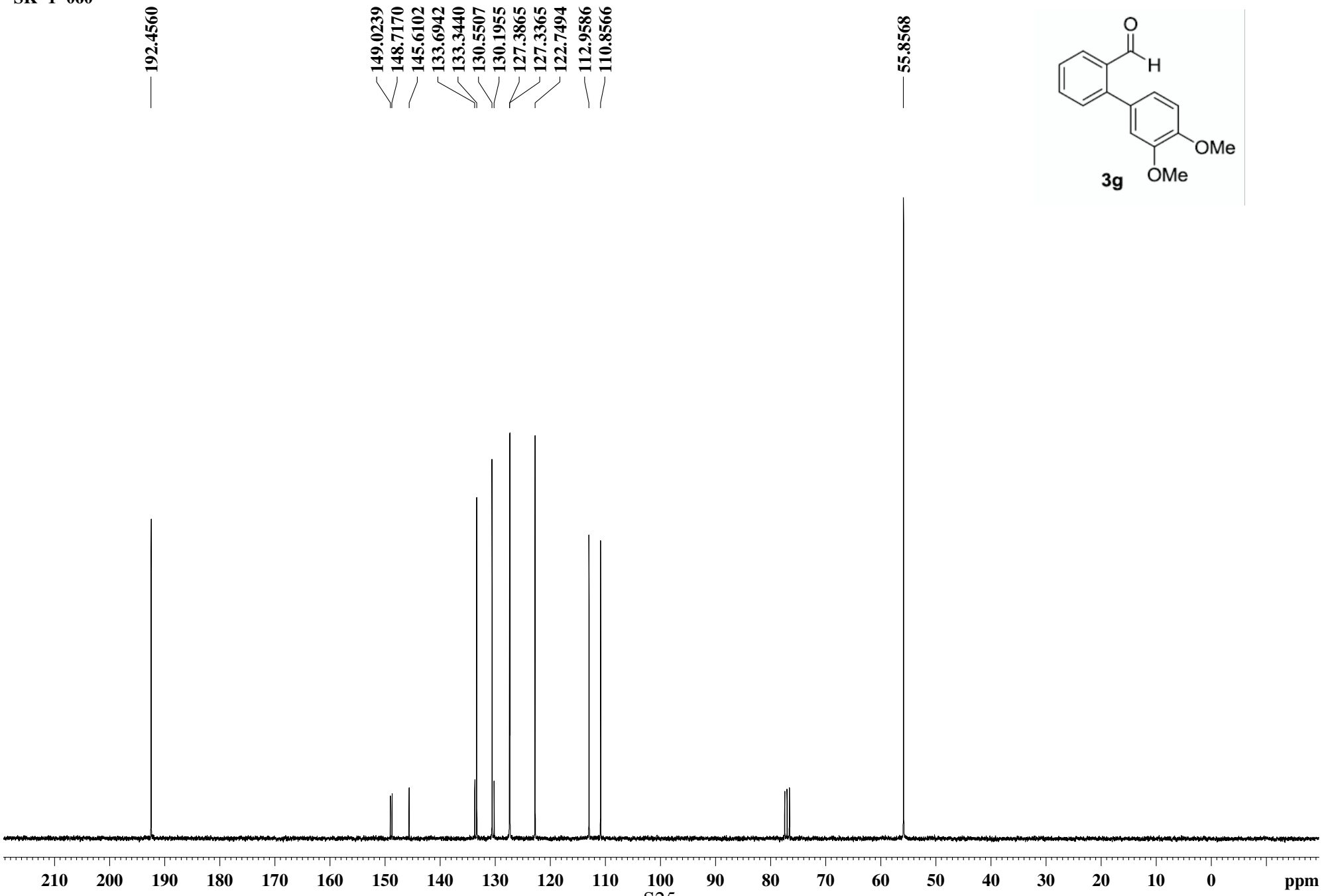
3.9449
3.9113



3g



SK–1–060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112.9586
110.8566
55.8568
O
H
OMe
OMe
3g
210
200
190
180
170
160
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140
130
120
110
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90
80
70
60
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40
30
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10
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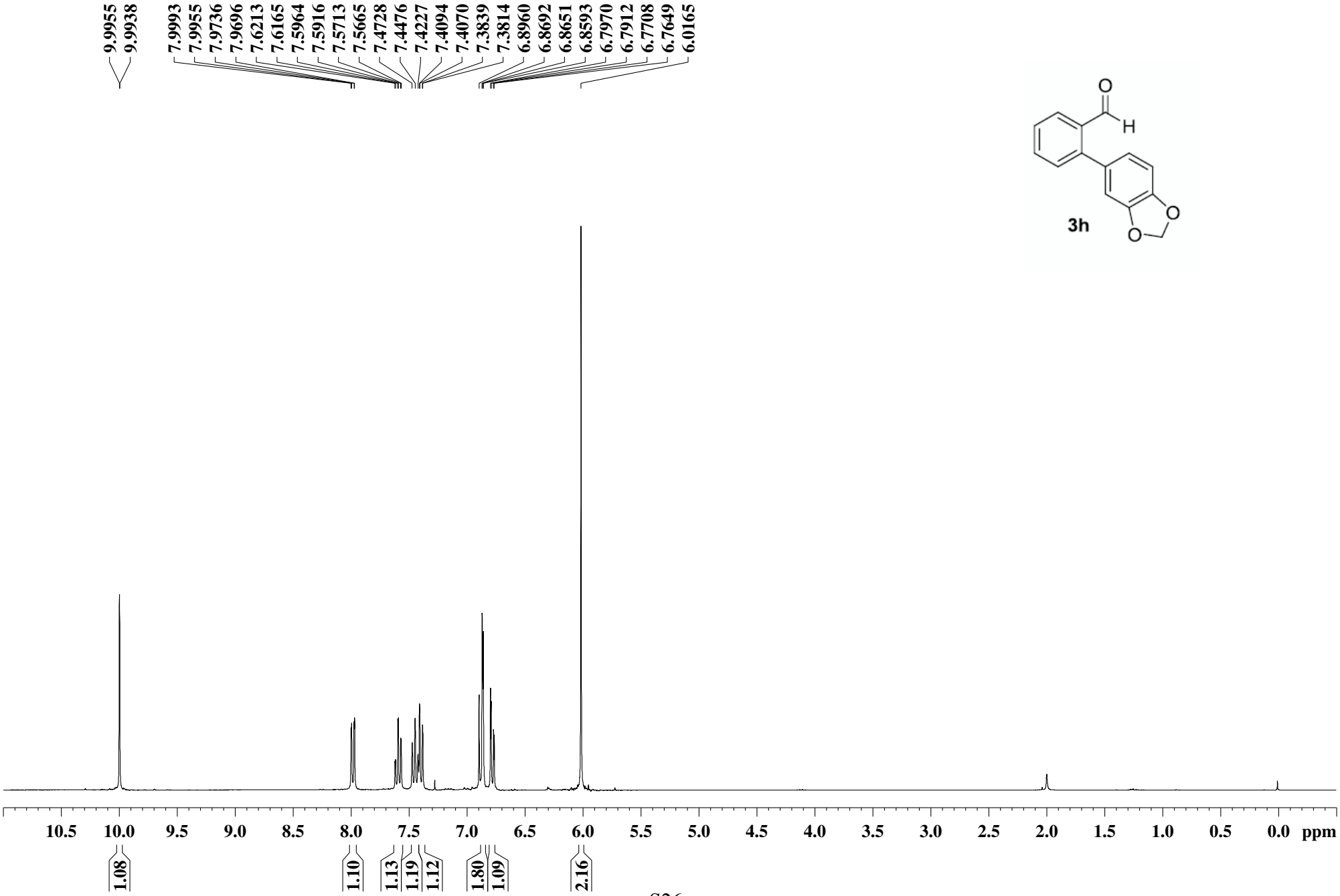
ppm

SK–1–059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7.5916
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6.7912
6.7708
6.7649
6.0165
O
H
O
O
3h
10.5
10.0
9.5
9.0
8.5
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
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0.0
ppm
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1.10
1.13
1.19
1.12
1.80
1.09
2.16

SK–1–059

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130.5328
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127.4010
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108.0365
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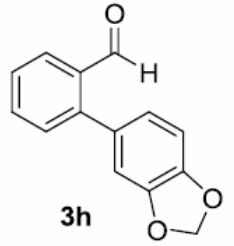
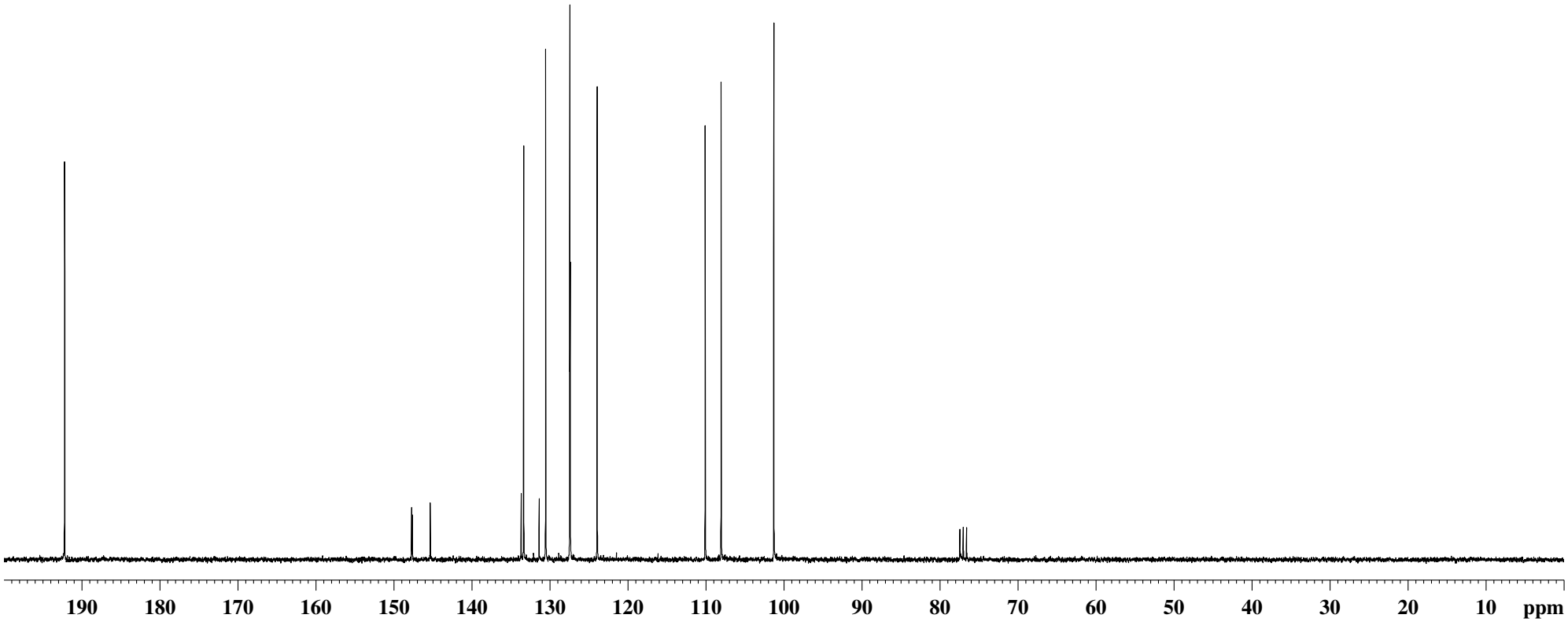
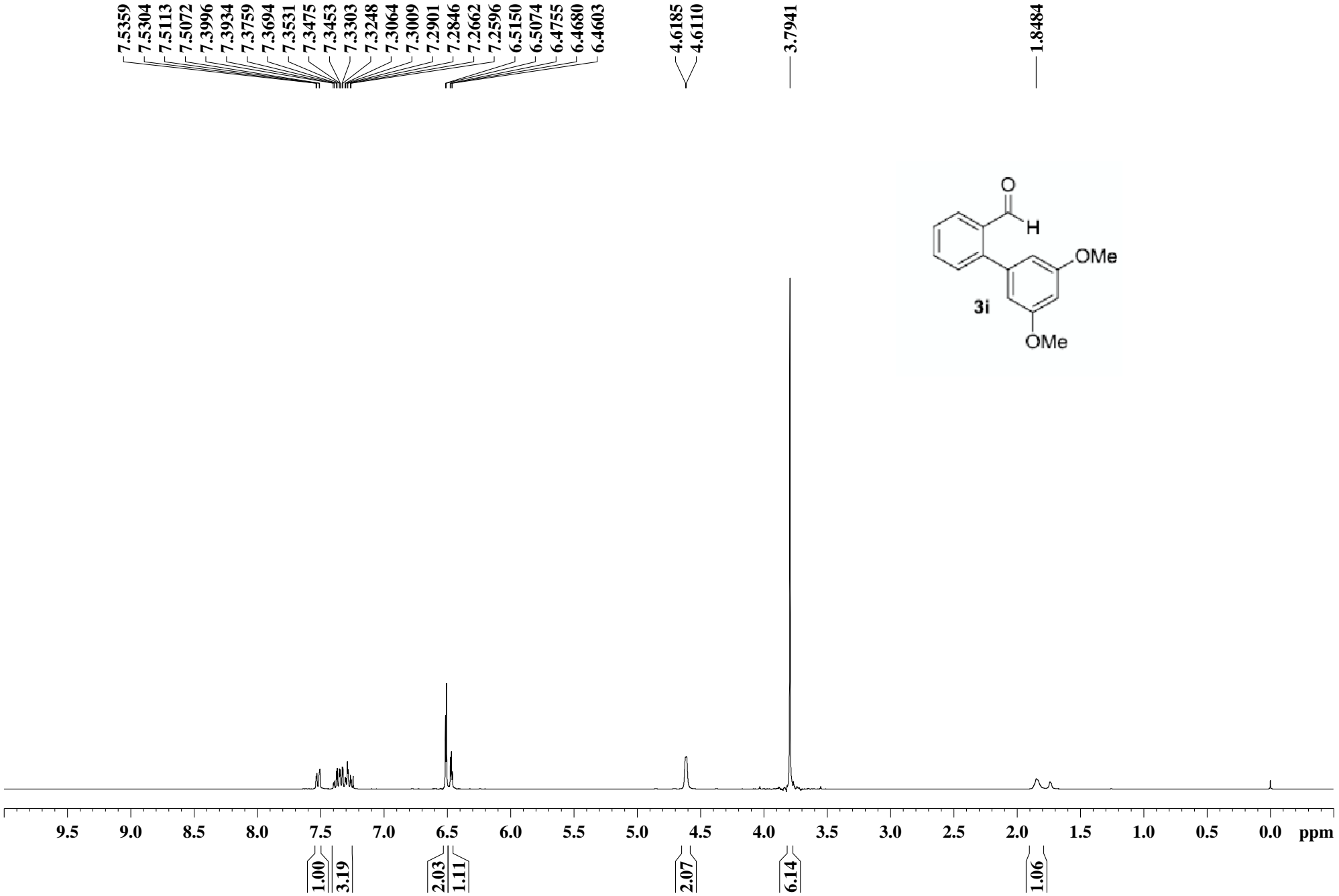


3h



SK–1–188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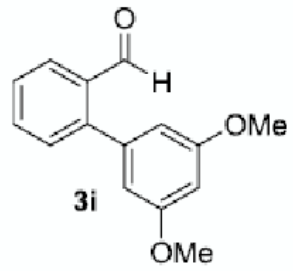
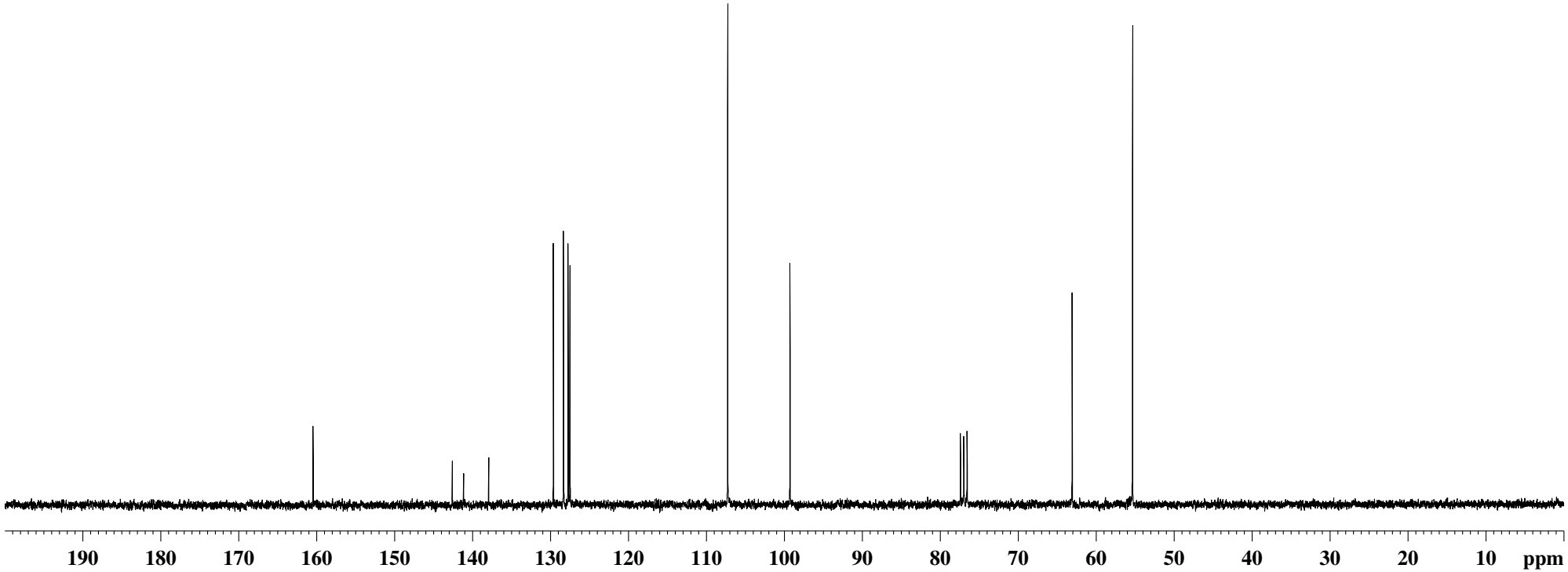
7.3531
7.3475
7.3453
7.3303
7.3248
7.3064
7.3009
7.2901
7.2846
7.2662
7.2596
6.5150
6.5074
6.4755
6.4680
6.4603
4.6185
4.6110
3.7941
1.8484
O
H
OMe
OMe
3i
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
3.19
2.03
1.11
2.07
6.14
1.06

SK–1–188

160.4742
142.6074
141.1624
137.9433
129.6454
128.3417
127.7527
127.5200
107.2730
99.2833
63.0818
55.3279

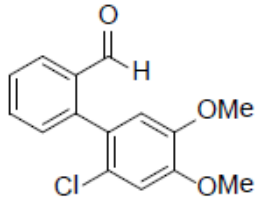


3i

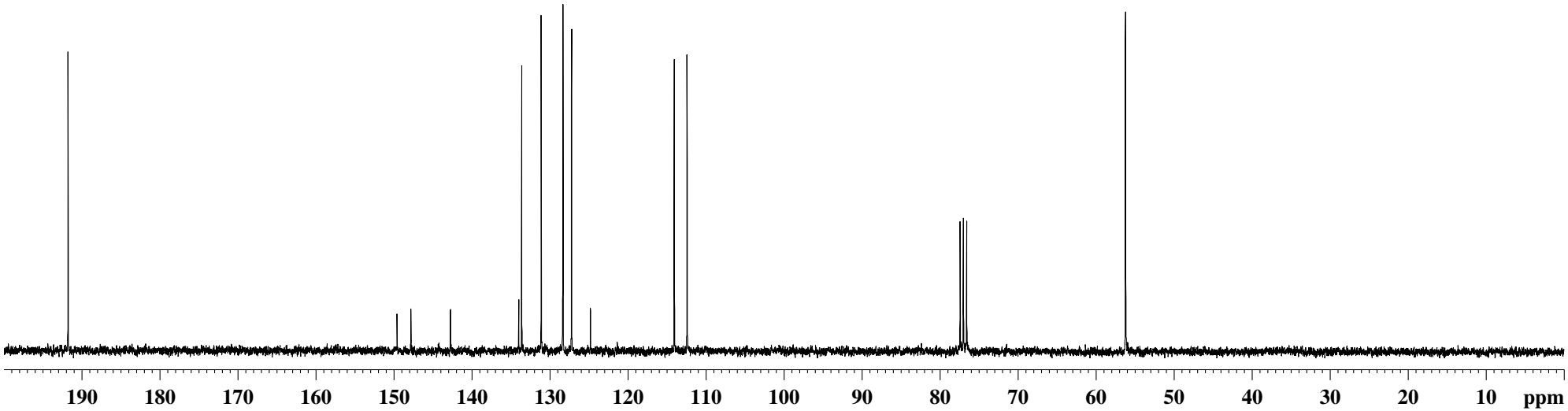


KN−1−035R

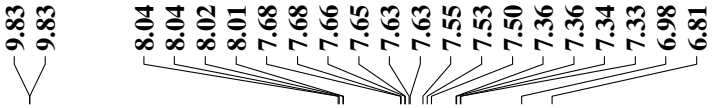
191.72
149.61
147.83
142.74
134.00
133.62
131.12
128.40
128.33
127.23
124.80
114.06
112.42
56.24
56.20



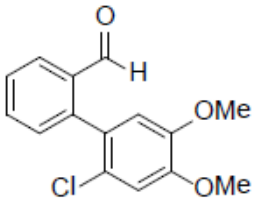
3j



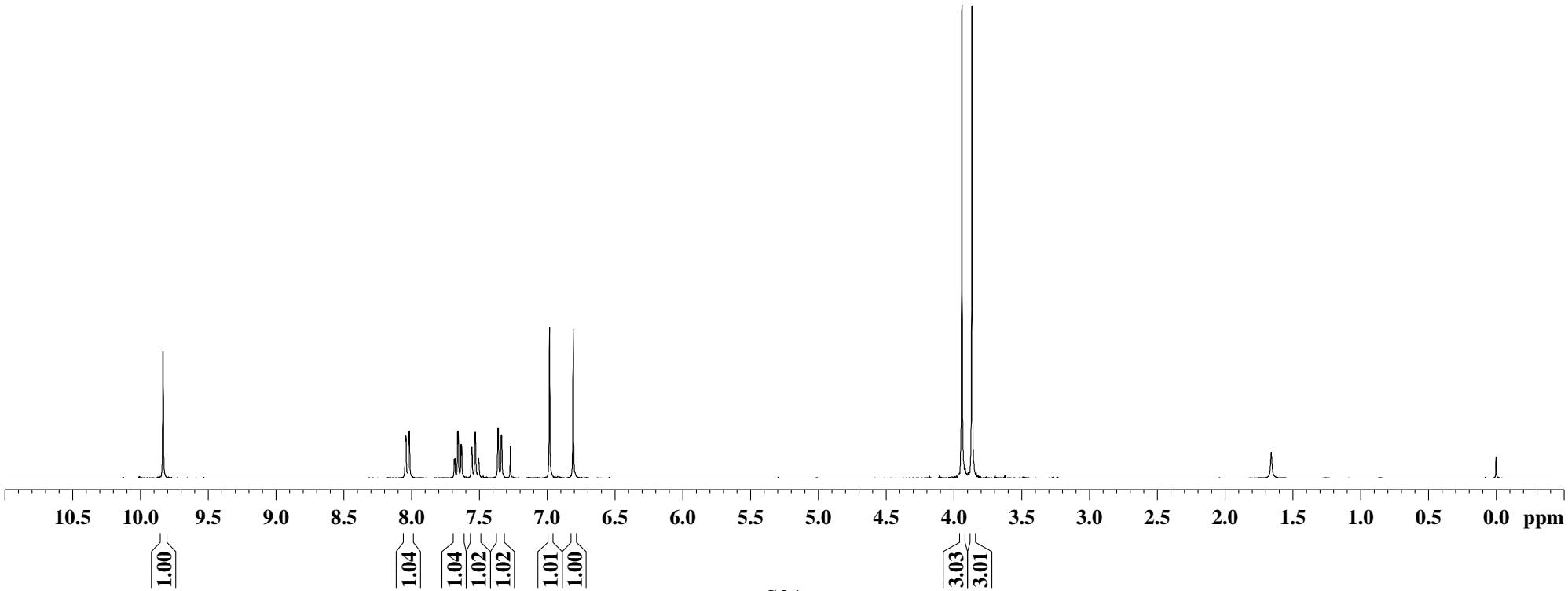
KN–1–035R


9.83
9.83
8.04
8.04
8.02
8.01
7.68
7.68
7.66
7.65
7.63
7.63
7.55
7.53
7.50
7.36
7.36
7.34
7.33
6.98
6.81


3.94
3.87

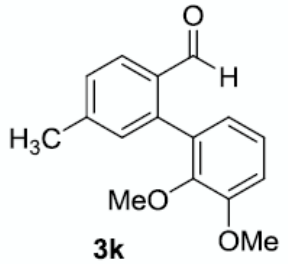

O
H
OMe
Cl
OMe

3j

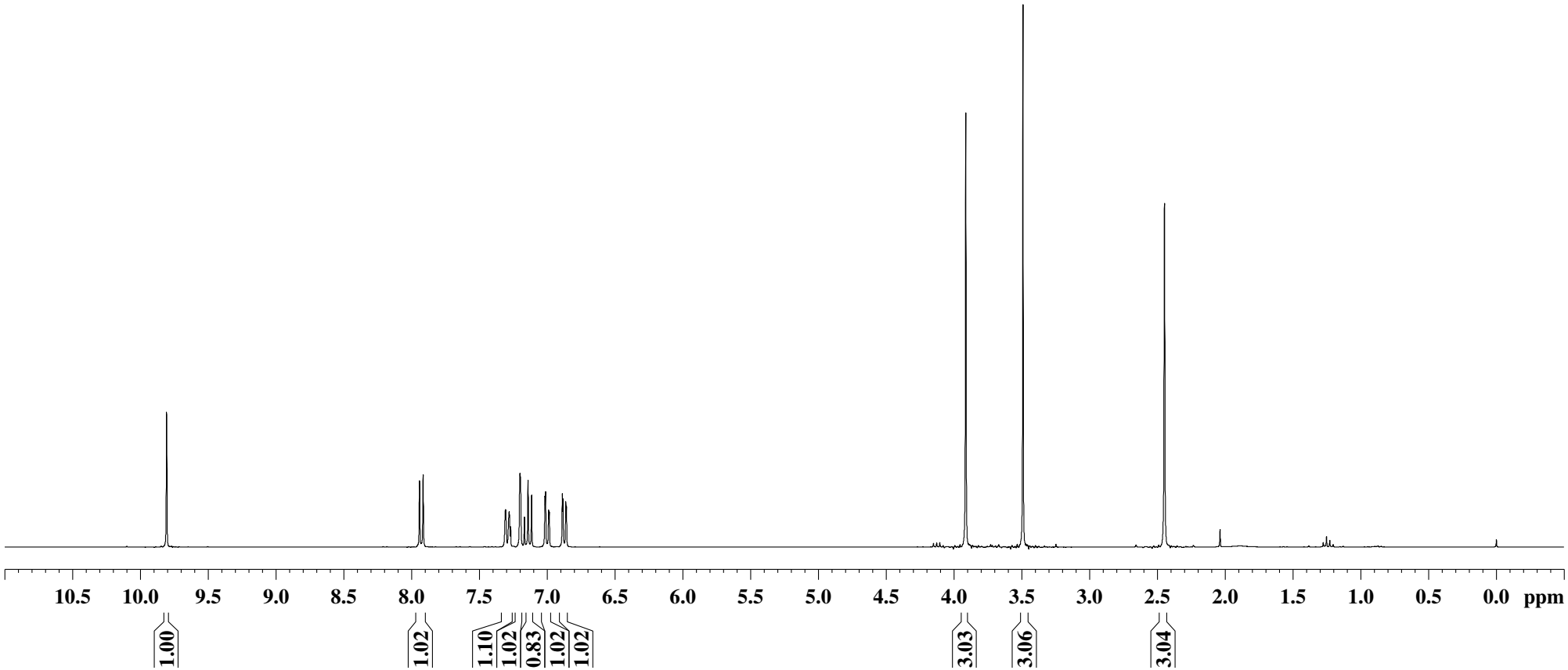

10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
1.04
1.04
1.02
1.02
1.01
1.00
3.03
3.01

SK–1–099

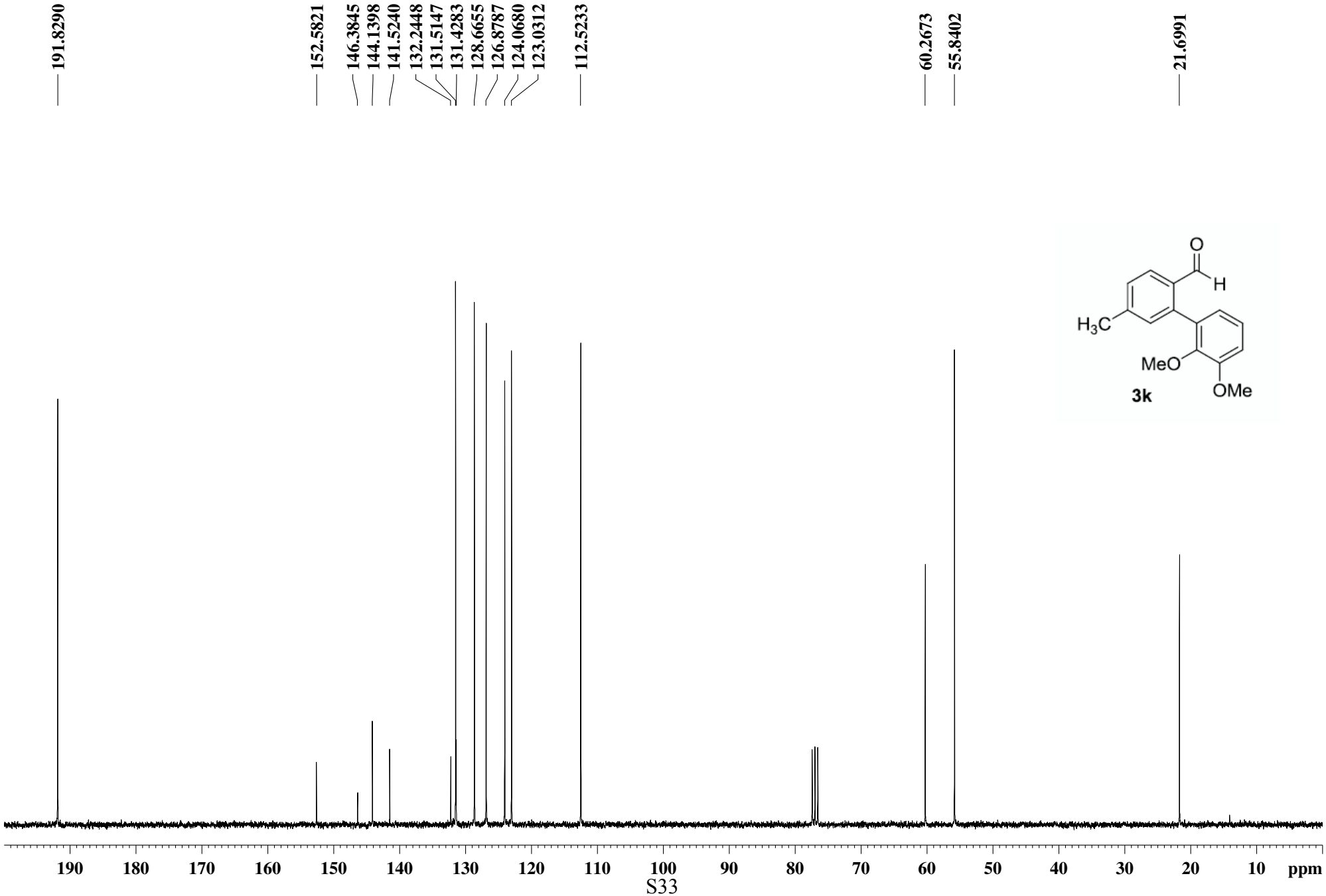
9.8053
9.8035
7.9421
7.9156
7.3074
7.2808
7.2701
7.2013
7.1680
7.1416
7.1152
7.0173
7.0125
6.9899
6.9851
6.8890
6.8840
6.8636
6.8586
3.9131
3.4915
2.4478



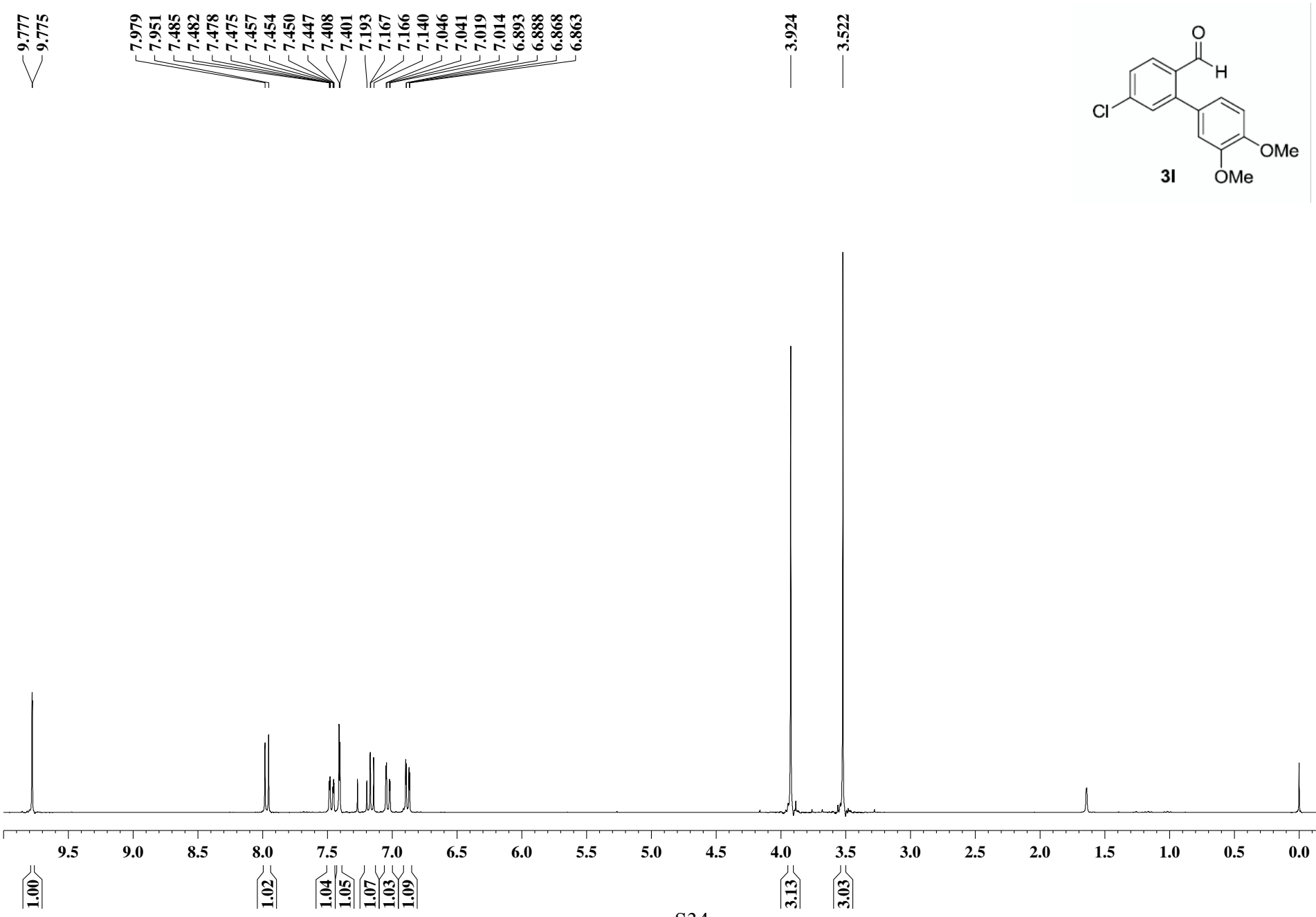
3k



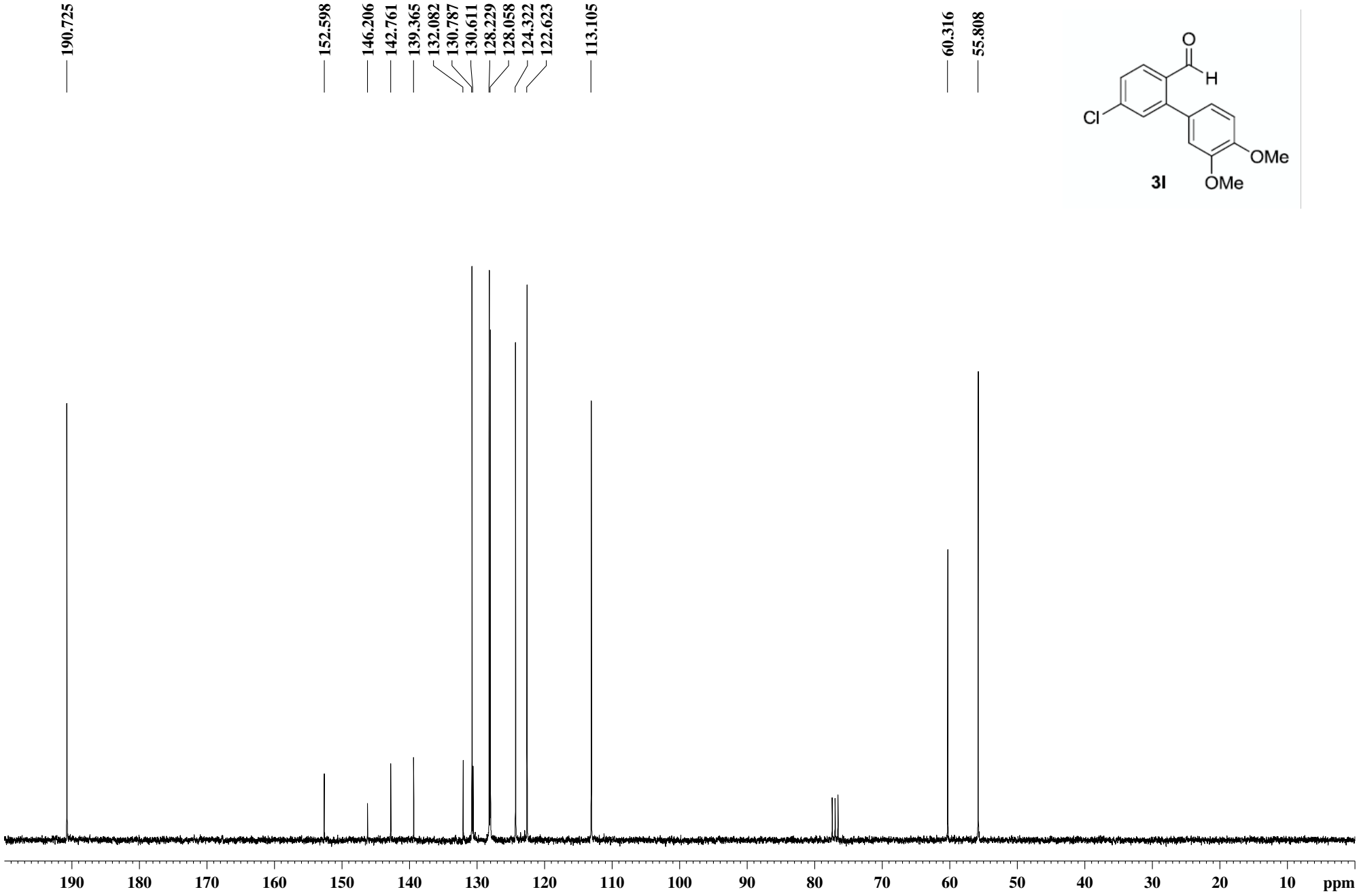
SK–1–099


191.8290
152.5821
146.3845
144.1398
141.5240
132.2448
131.5147
131.4283
128.6655
126.8787
124.0680
123.0312
112.5233
60.2673
55.8402
21.6991
O
H
H3C
MeO
OMe
3k
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

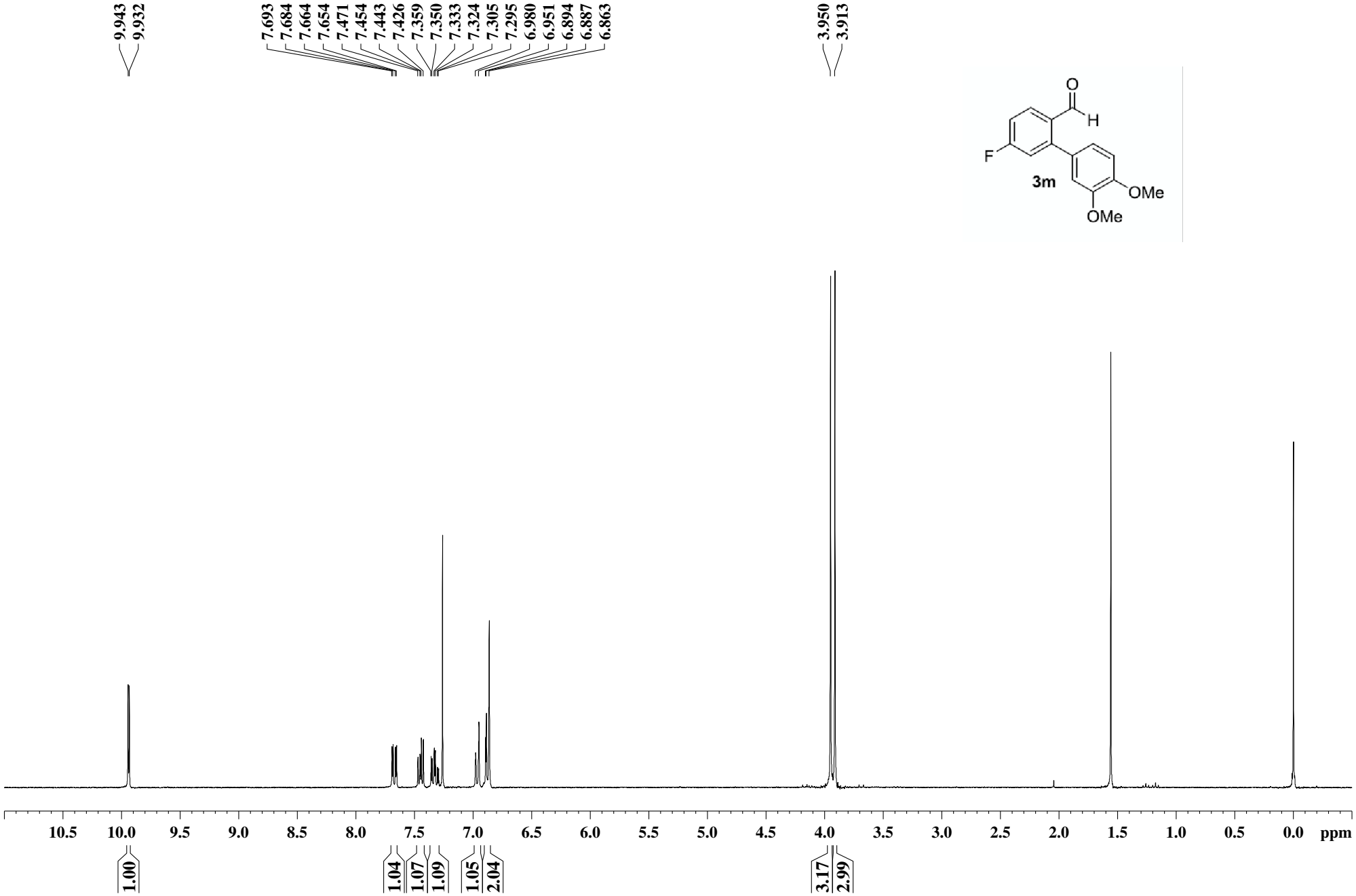
SK–1–122


9.777
9.775
7.979
7.951
7.485
7.482
7.478
7.475
7.457
7.454
7.450
7.447
7.408
7.401
7.193
7.167
7.166
7.140
7.046
7.041
7.019
7.014
6.893
6.888
6.868
6.863
3.924
3.522
O
H
Cl
OMe
OMe
3l
9.5
9.0
8.5
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
ppm
1.00
1.02
1.04
1.05
1.07
1.03
1.09
3.13
3.03

SK–1–122

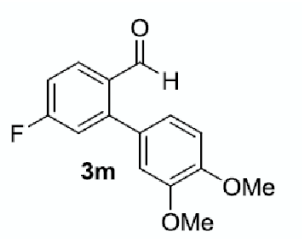

190.725
152.598
146.206
142.761
139.365
132.082
130.787
130.611
128.229
128.058
124.322
122.623
113.105
60.316
55.808
O
H
Cl
OMe
OMe
3l
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK–1–129


9.943
9.932
7.693
7.684
7.664
7.654
7.471
7.454
7.443
7.426
7.359
7.350
7.333
7.324
7.305
7.295
6.980
6.951
6.894
6.887
6.863
3.950
3.913
O
H
F
3m
OMe
OMe
10.5
10.0
9.5
9.0
8.5
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
ppm
1.00
1.04
1.07
1.09
1.05
2.04
3.17
2.99

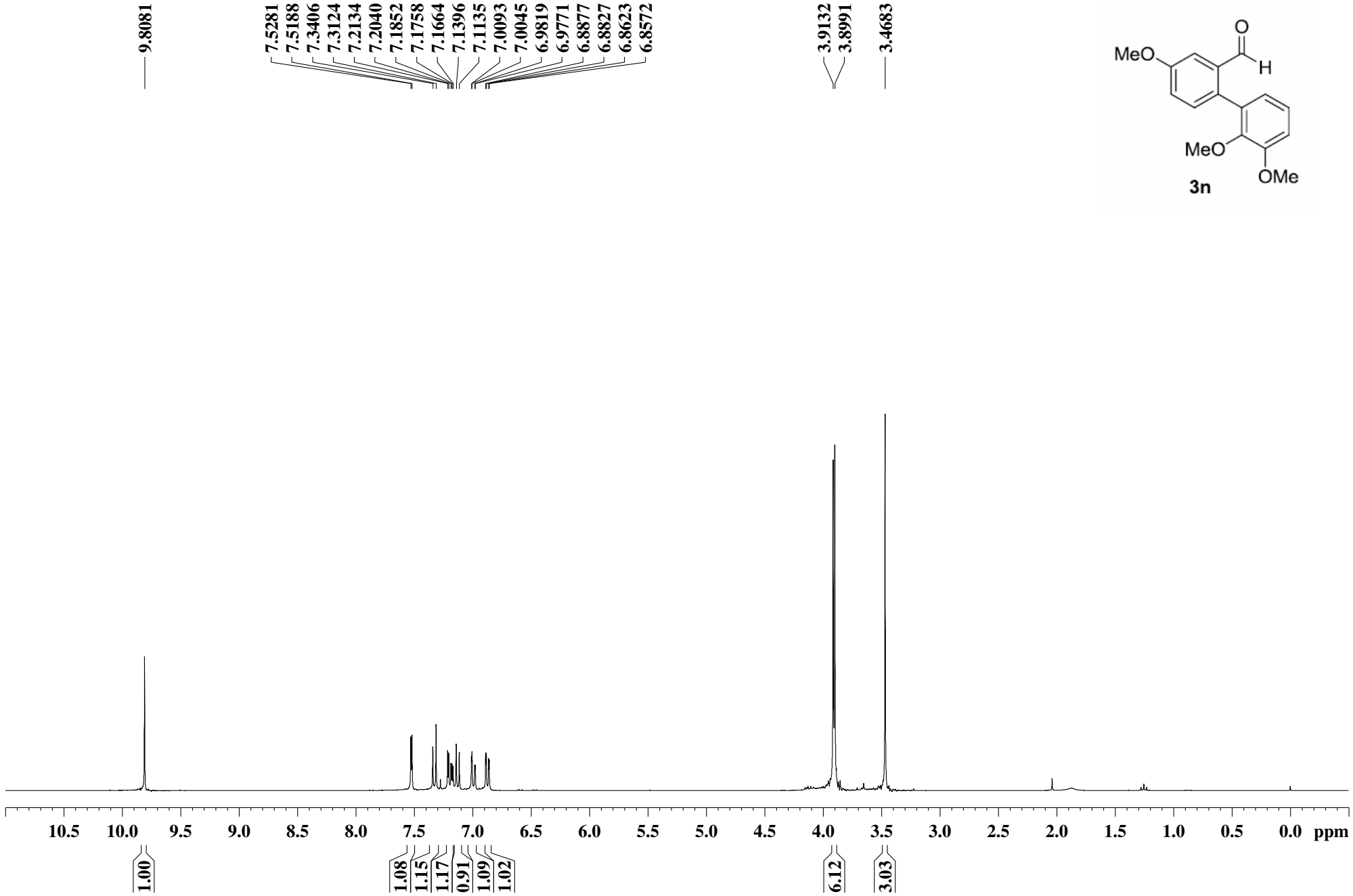
SK–1–129

191.2516
163.5718
160.2740
149.2348
148.8920
141.8376
141.7954
135.2889
135.2049
132.6264
132.5300
129.2627
122.8658
120.7680
120.4760
113.5791
113.2832
113.0307
110.9983
55.9445

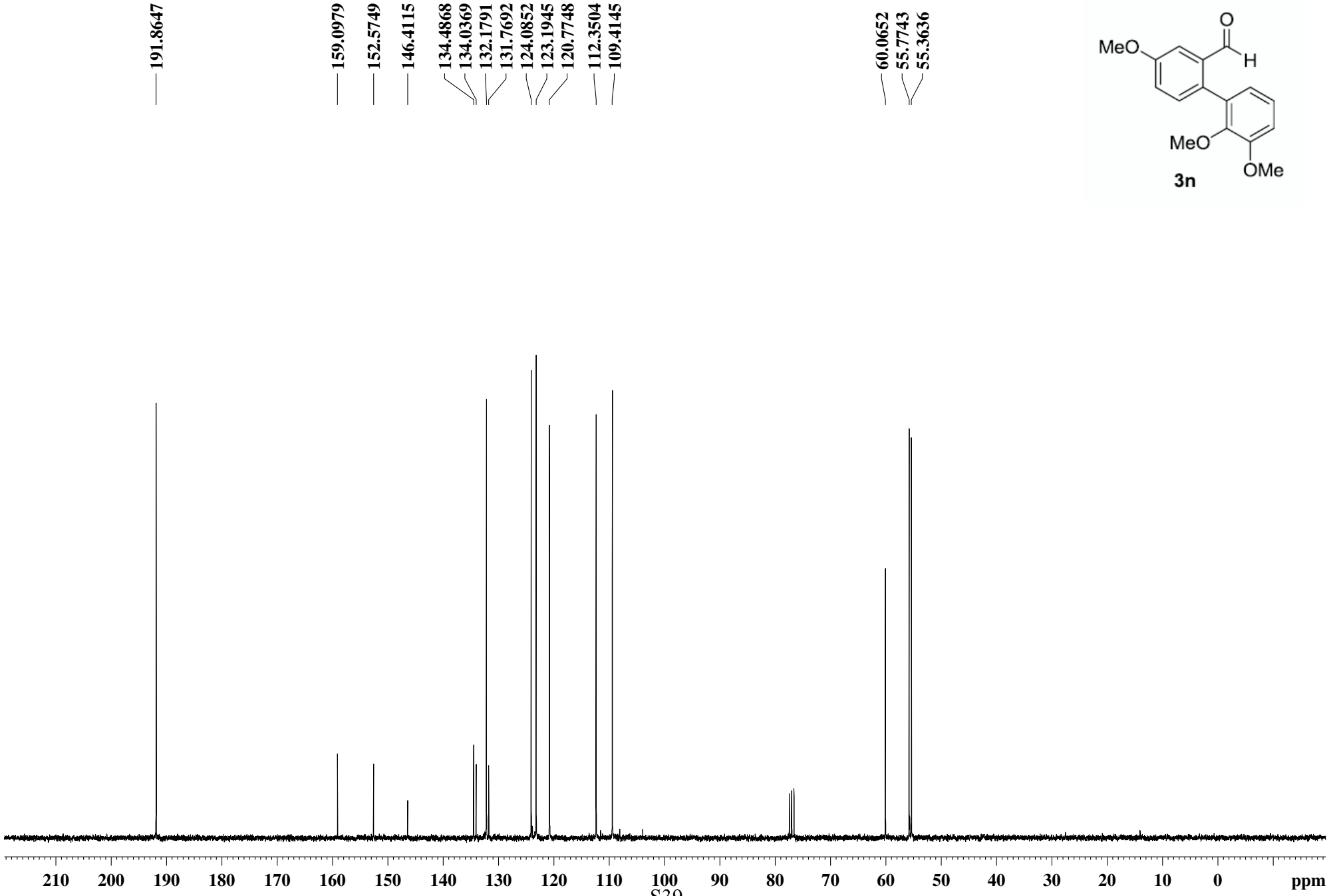


190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

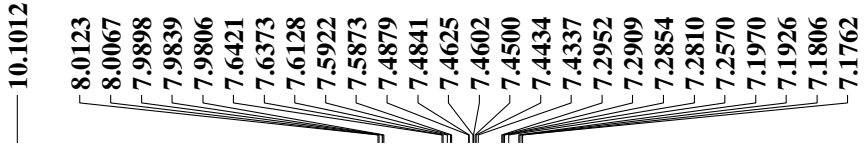
SK–1–083

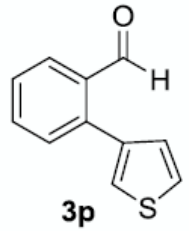

9.8081
7.5281
7.5188
7.3406
7.3124
7.2134
7.2040
7.1852
7.1758
7.1664
7.1396
7.1135
7.0093
7.0045
6.9819
6.9771
6.8877
6.8827
6.8623
6.8572
3.9132
3.8991
3.4683
MeO
O
H
MeO
OMe
3n
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
1.00
1.08
1.15
1.17
0.91
1.09
1.02
6.12
3.03

SK–1–083

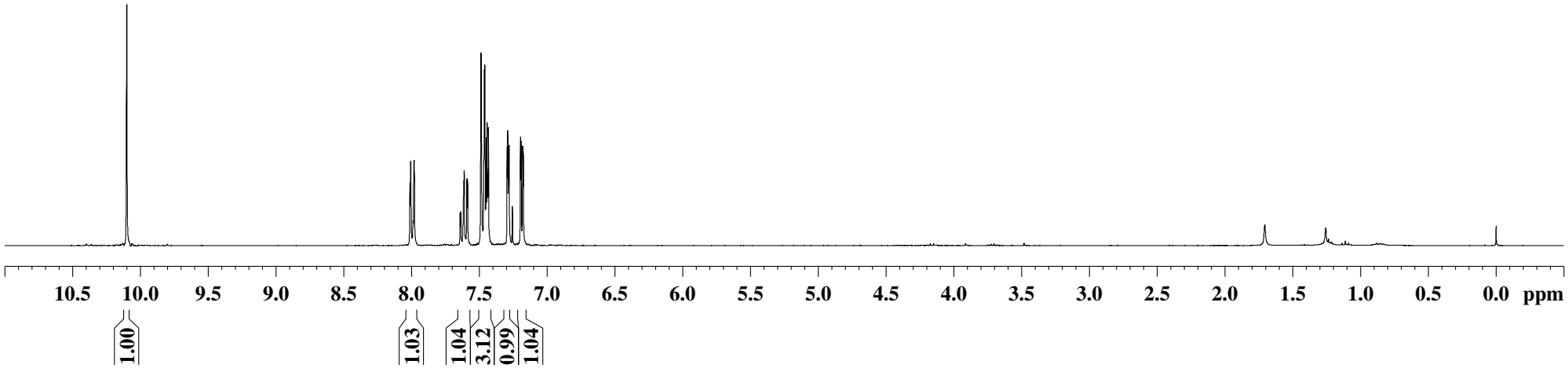

191.8647
159.0979
152.5749
146.4115
134.4868
134.0369
132.1791
131.7692
124.0852
123.1945
120.7748
112.3504
109.4145
60.0652
55.7743
55.3636
MeO
O
H
MeO
OMe
3n
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

SK–1–096


10.1012
8.0123
8.0067
7.9898
7.9839
7.9806
7.6421
7.6373
7.6128
7.5922
7.5873
7.4879
7.4841
7.4625
7.4602
7.4500
7.4434
7.4337
7.2952
7.2909
7.2854
7.2810
7.2570
7.1970
7.1926
7.1806
7.1762


O
H
S

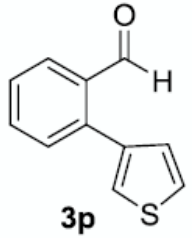
3p


10.5
10.0
9.5
9.0
8.5
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
ppm
1.00
1.03
1.04
3.12
0.99
1.04

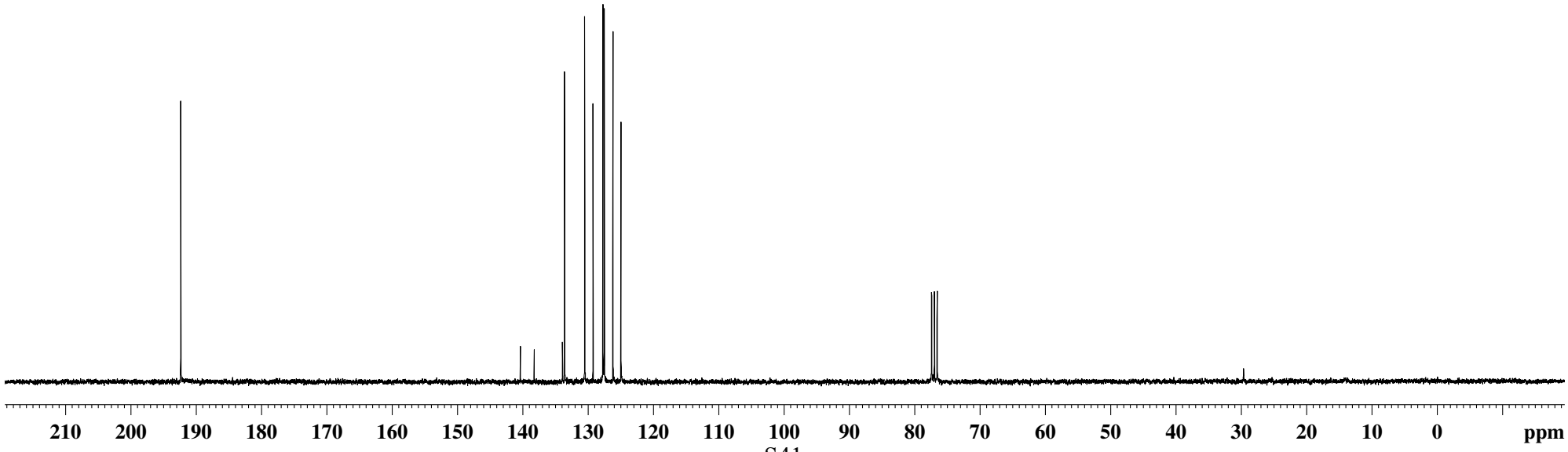
SK–1–096

192.3299

140.3807
138.2679
133.9387
133.6142
130.5350
129.2697
127.7460
127.5313
126.2181
124.9830

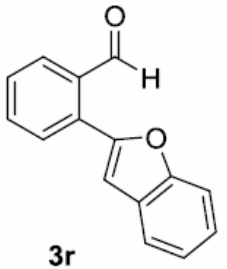


3p

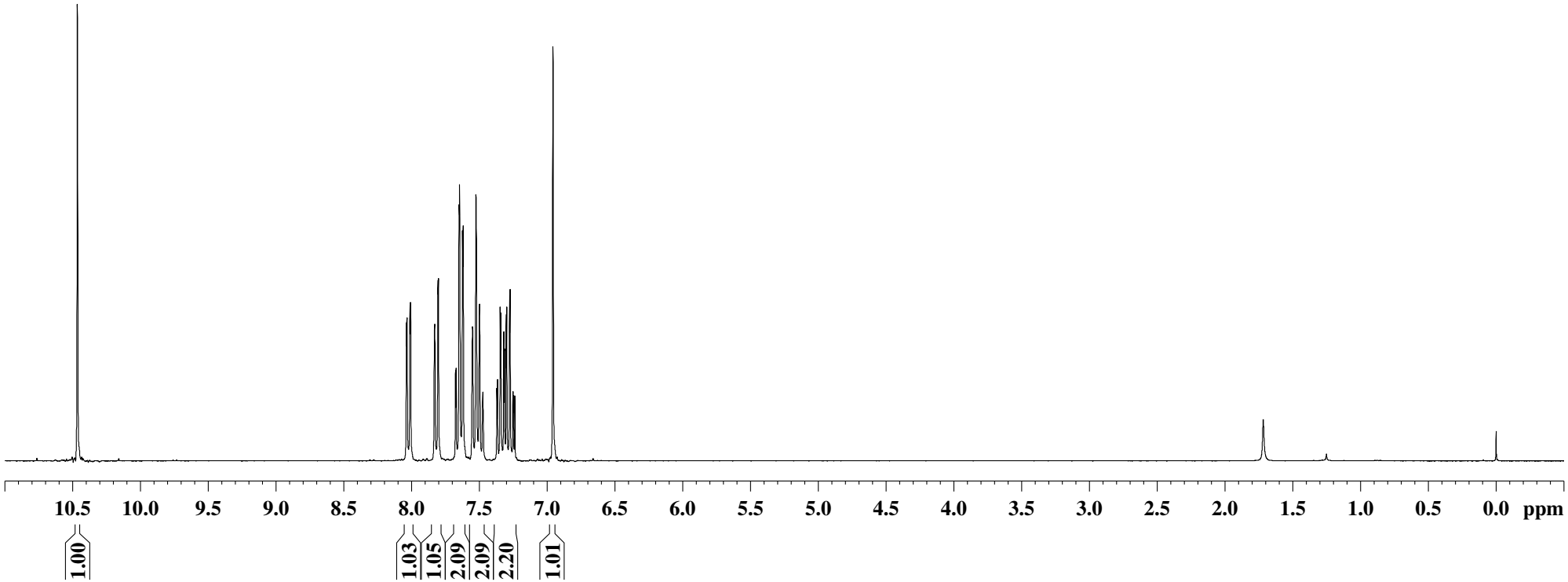


SK–1–104

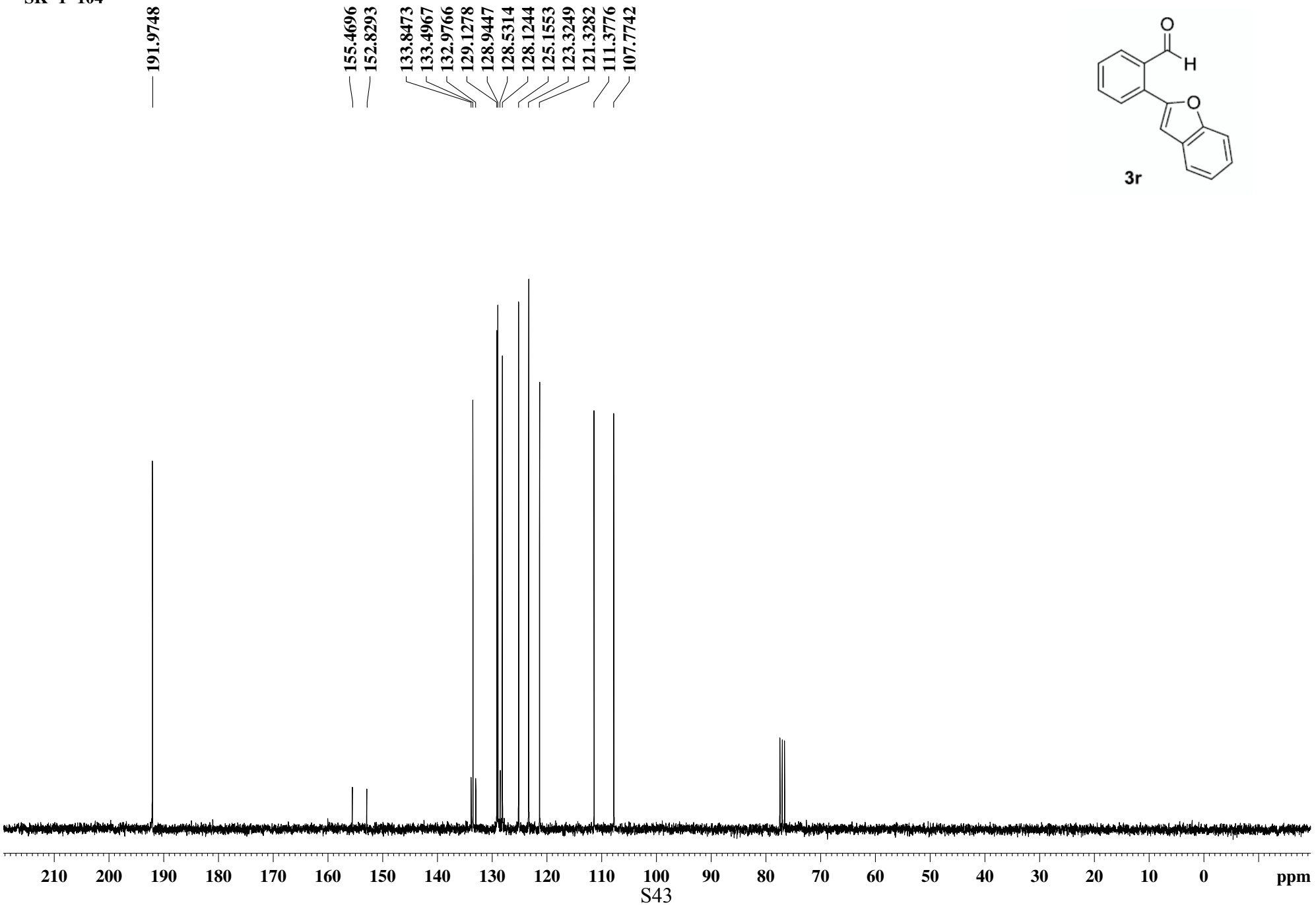
10.4634
10.4611
8.0379
8.0344
8.0119
8.0083
7.8315
7.8290
7.8055
7.8030
7.6761
7.6714
7.6507
7.6466
7.6251
7.6206
7.5503
7.5254
7.4994
7.4773
7.4745
7.3712
7.3664
7.3470
7.3423
7.3204
7.3151
7.3022
7.2980
7.2769
7.2733
7.2525
7.2489
7.2387
6.9585
6.9558



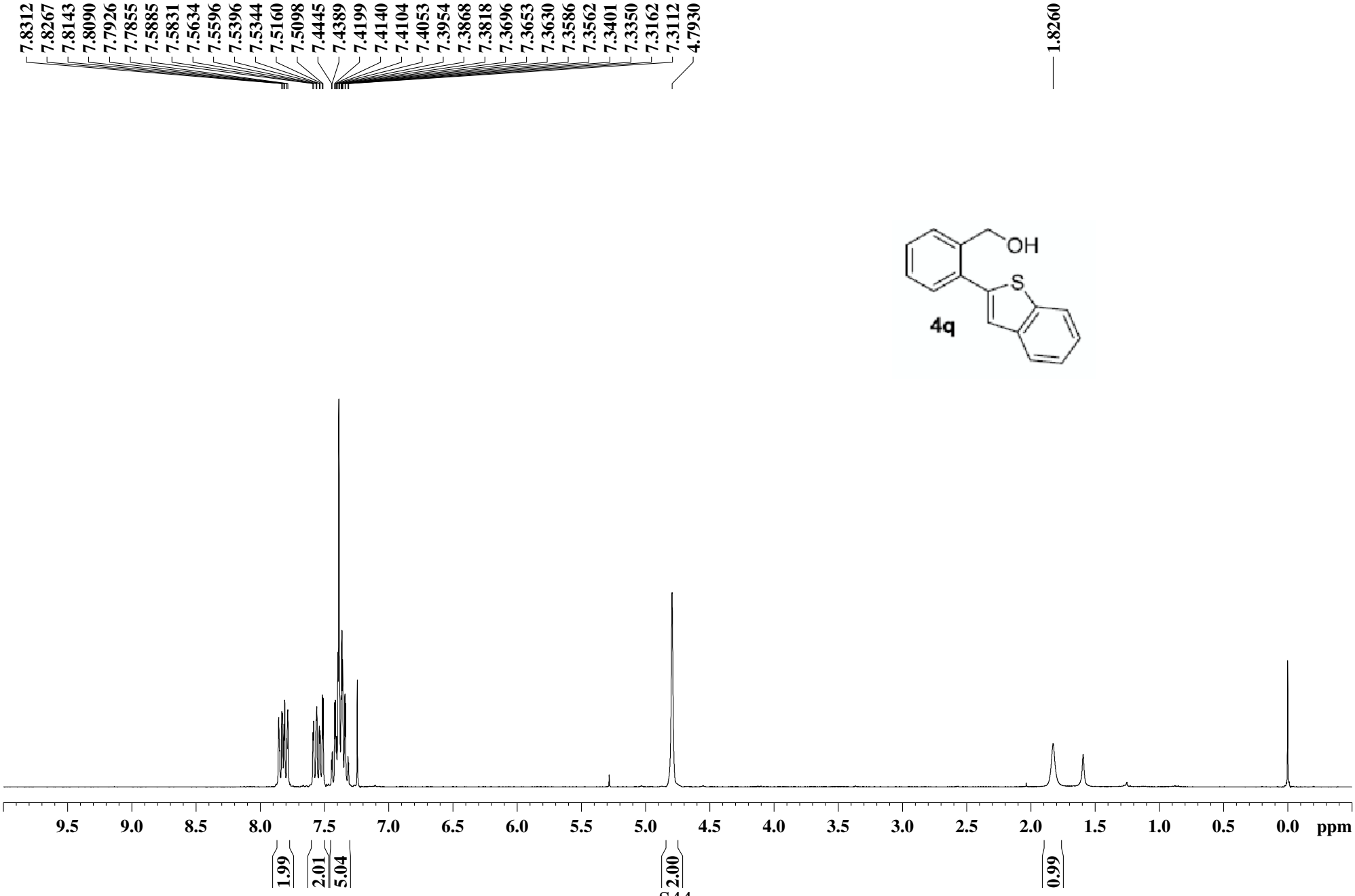
3r



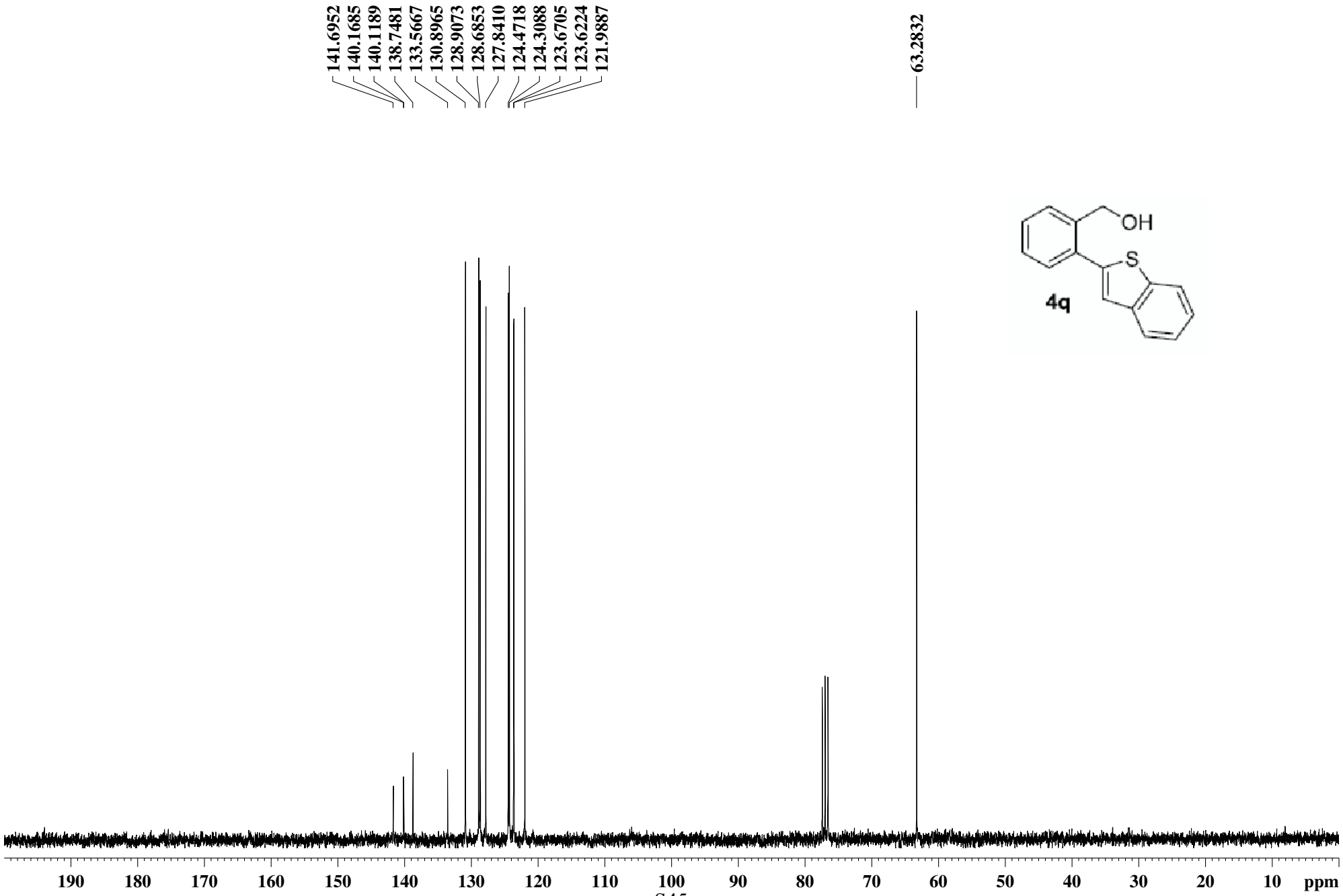
SK–1–104

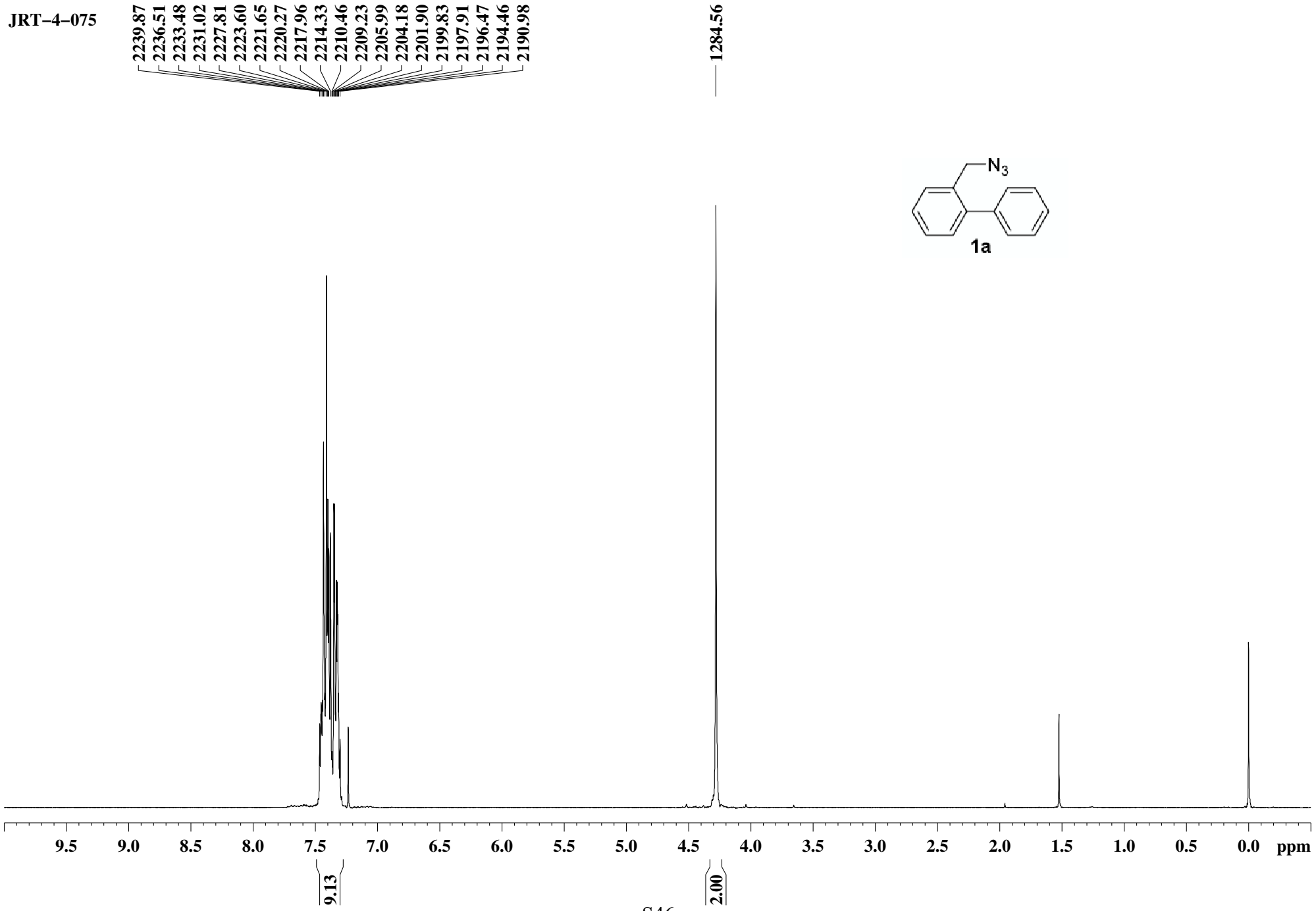

191.9748
155.4696
152.8293
133.8473
133.4967
132.9766
129.1278
128.9447
128.5314
128.1244
125.1553
123.3249
121.3282
111.3776
107.7742
O
H
O
3r
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

SK–1–161

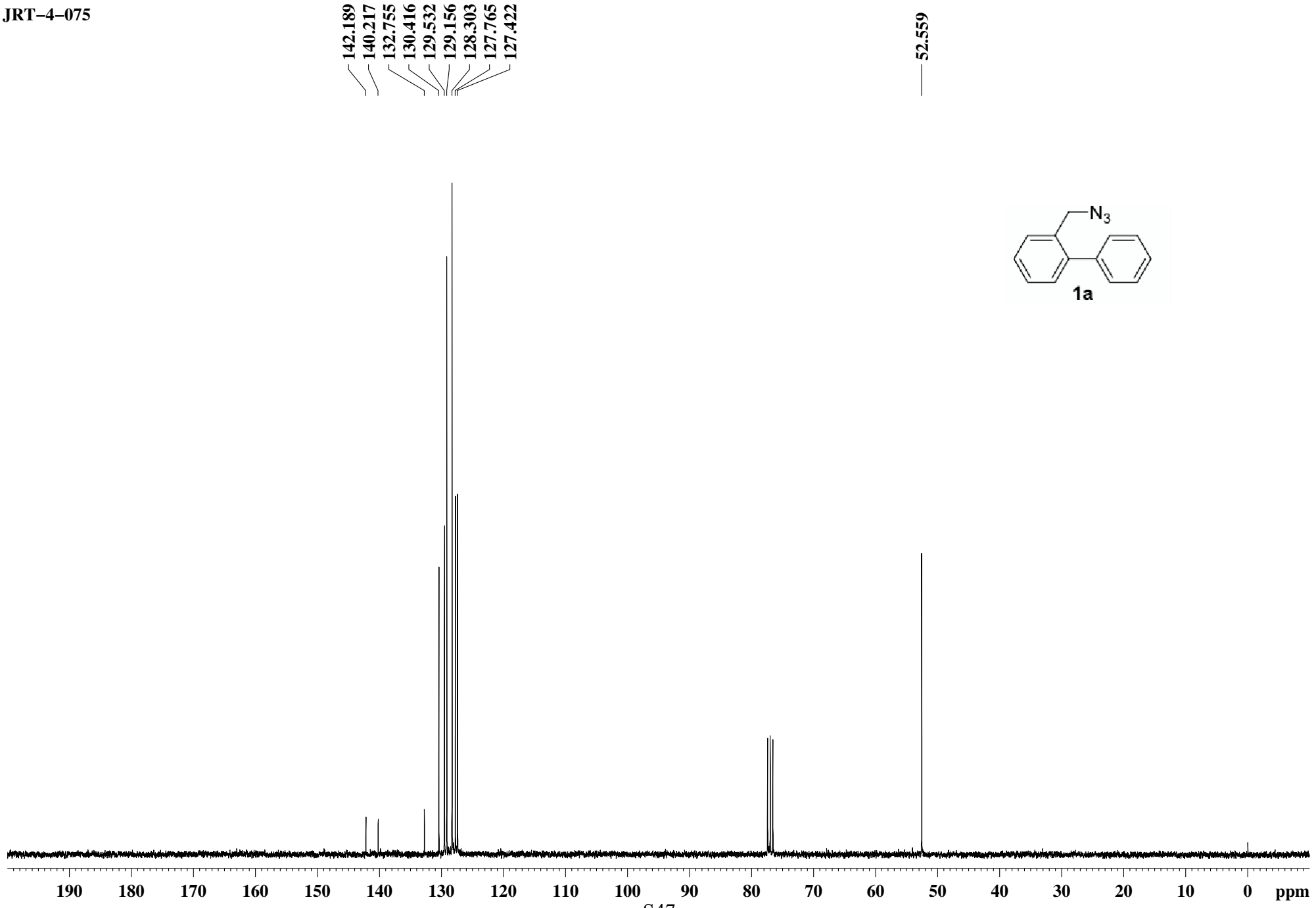

7.8312
7.8267
7.8143
7.8090
7.7926
7.7855
7.5885
7.5831
7.5634
7.5596
7.5396
7.5344
7.5160
7.5098
7.4445
7.4389
7.4199
7.4140
7.4104
7.4053
7.3954
7.3868
7.3818
7.3696
7.3653
7.3630
7.3586
7.3562
7.3401
7.3350
7.3162
7.3112
4.7930
1.8260
OH
S
4q
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.99
2.01
5.04
2.00
0.99

SK–1–161

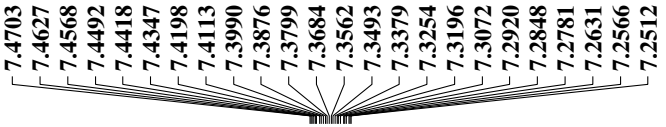

141.6952
140.1685
140.1189
138.7481
133.5667
130.8965
128.9073
128.6853
127.8410
124.4718
124.3088
123.6705
123.6224
121.9887
63.2832
OH
S
4q
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

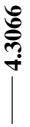

JRT−4−075
2239.87
2236.51
2233.48
2231.02
2227.81
2223.60
2221.65
2220.27
2217.96
2214.33
2210.46
2209.23
2205.99
2204.18
2201.90
2199.83
2197.91
2196.47
2194.46
2190.98
1284.56
N3
1a
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
9.13
2.00

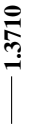
JRT–4–075

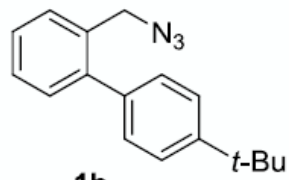

142.189
140.217
132.755
130.416
129.532
129.156
128.303
127.765
127.422
52.559
N3
1a
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

SK–1–101

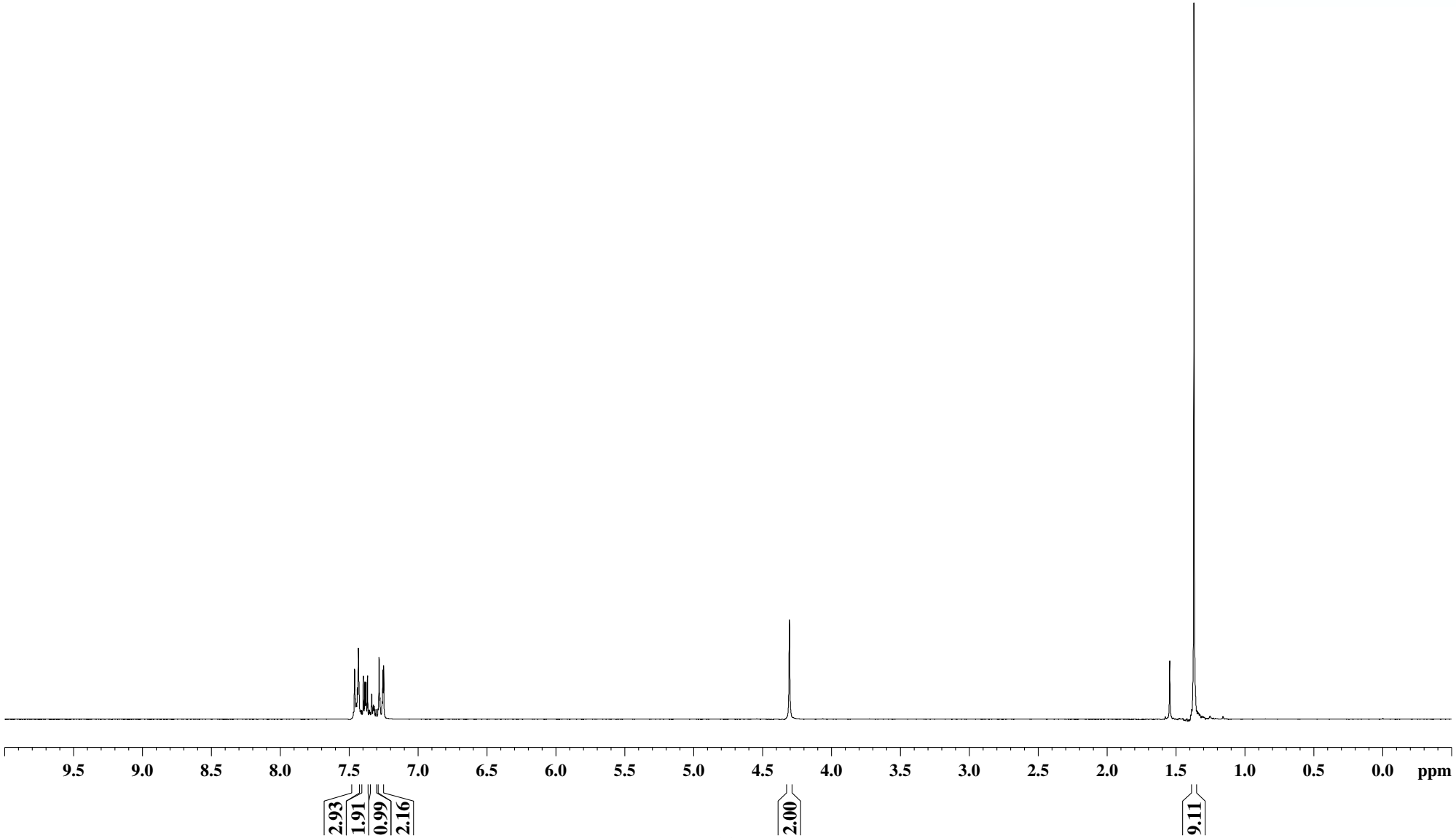

7.4703
7.4627
7.4568
7.4492
7.4418
7.4347
7.4198
7.4113
7.3990
7.3876
7.3799
7.3684
7.3562
7.3493
7.3379
7.3254
7.3196
7.3072
7.2920
7.2848
7.2781
7.2631
7.2566
7.2512


4.3066

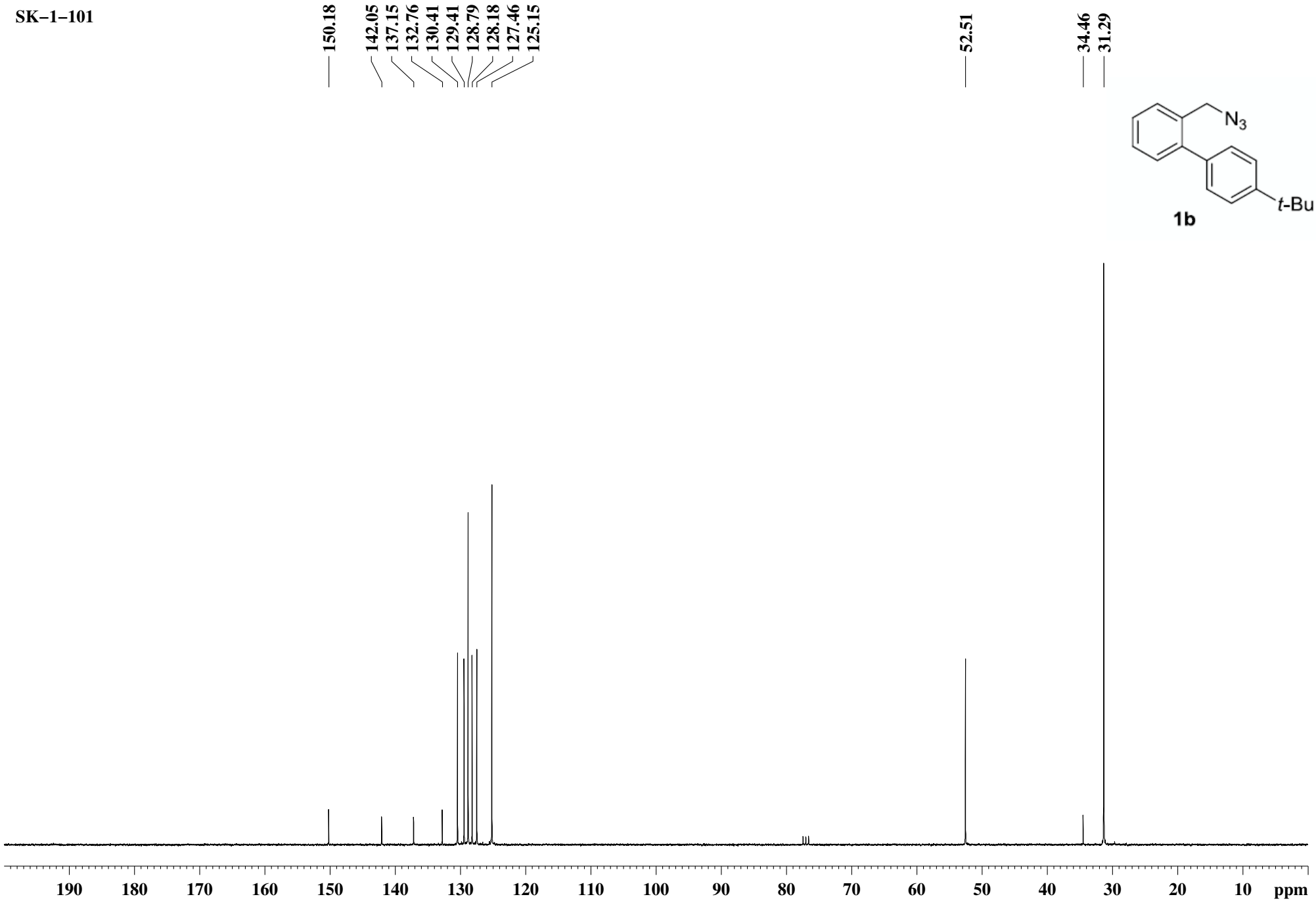

1.3710


N3
t-Bu

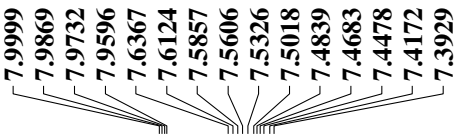
1b

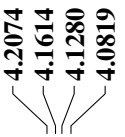

9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
2.93
1.91
0.99
2.16
2.00
9.11

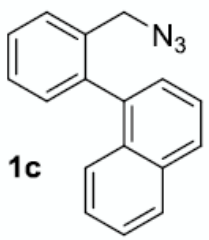
SK–1–101

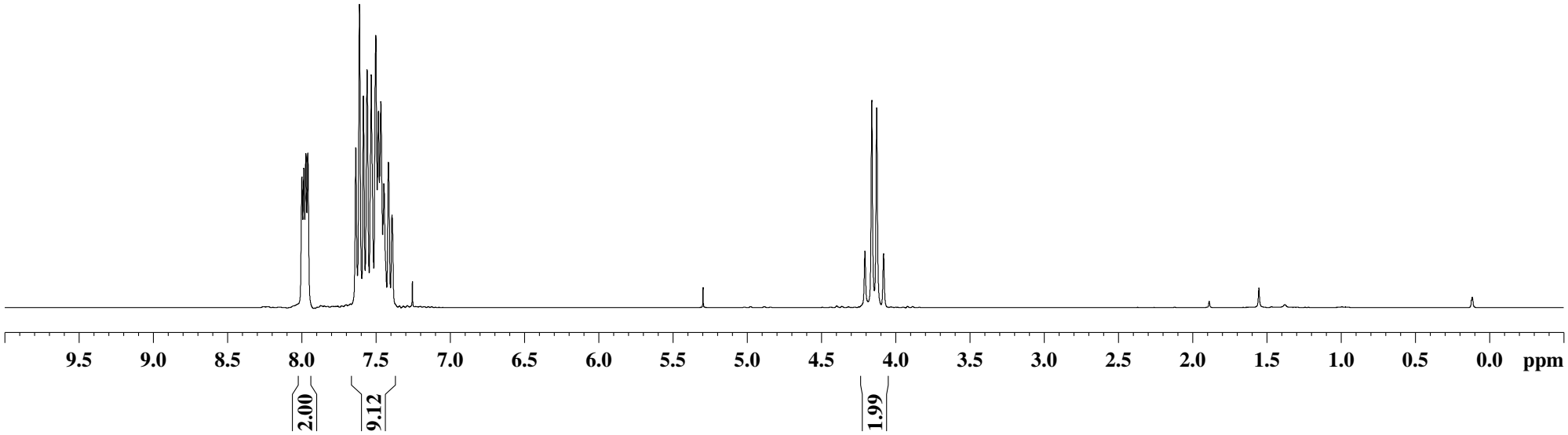

150.18
142.05
137.15
132.76
130.41
129.41
128.79
128.18
127.46
125.15
52.51
34.46
31.29
N3
t-Bu
1b
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK–1–131

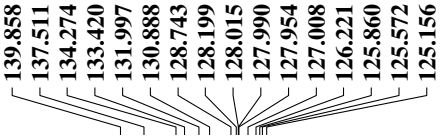

7.9999
7.9869
7.9732
7.9596
7.6367
7.6124
7.5857
7.5606
7.5326
7.5018
7.4839
7.4683
7.4478
7.4172
7.3929

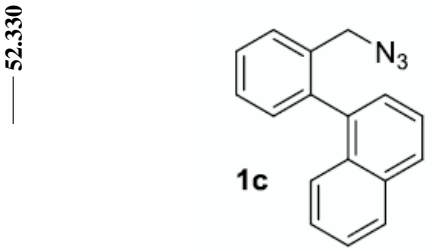

4.2074
4.1614
4.1280
4.0819


N3
1c

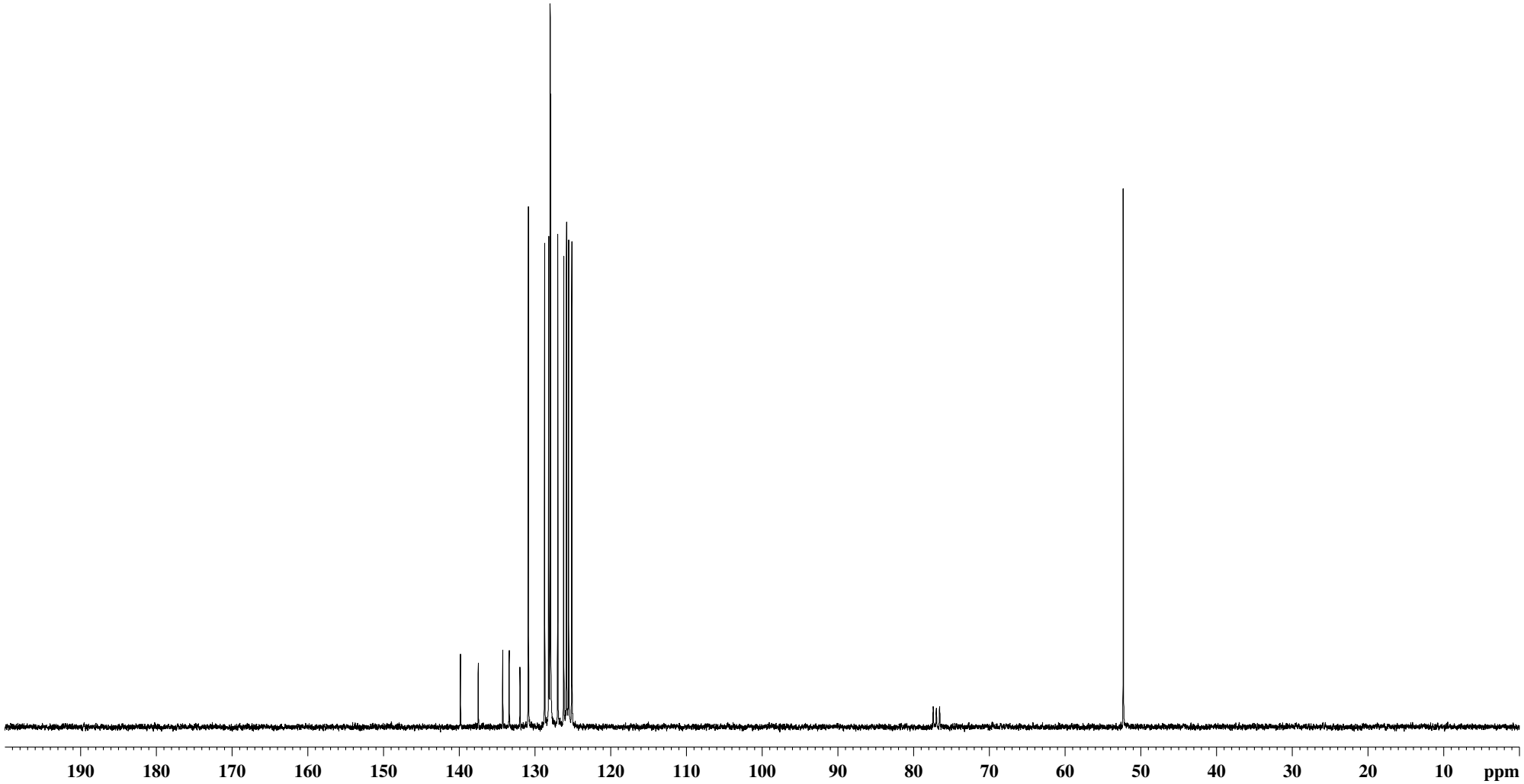

9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
2.00
9.12
1.99

SK–1–131


139.858
137.511
134.274
133.420
131.997
130.888
128.743
128.199
128.015
127.990
127.954
127.008
126.221
125.860
125.572
125.156


52.330

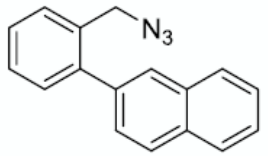
N3
1c


190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

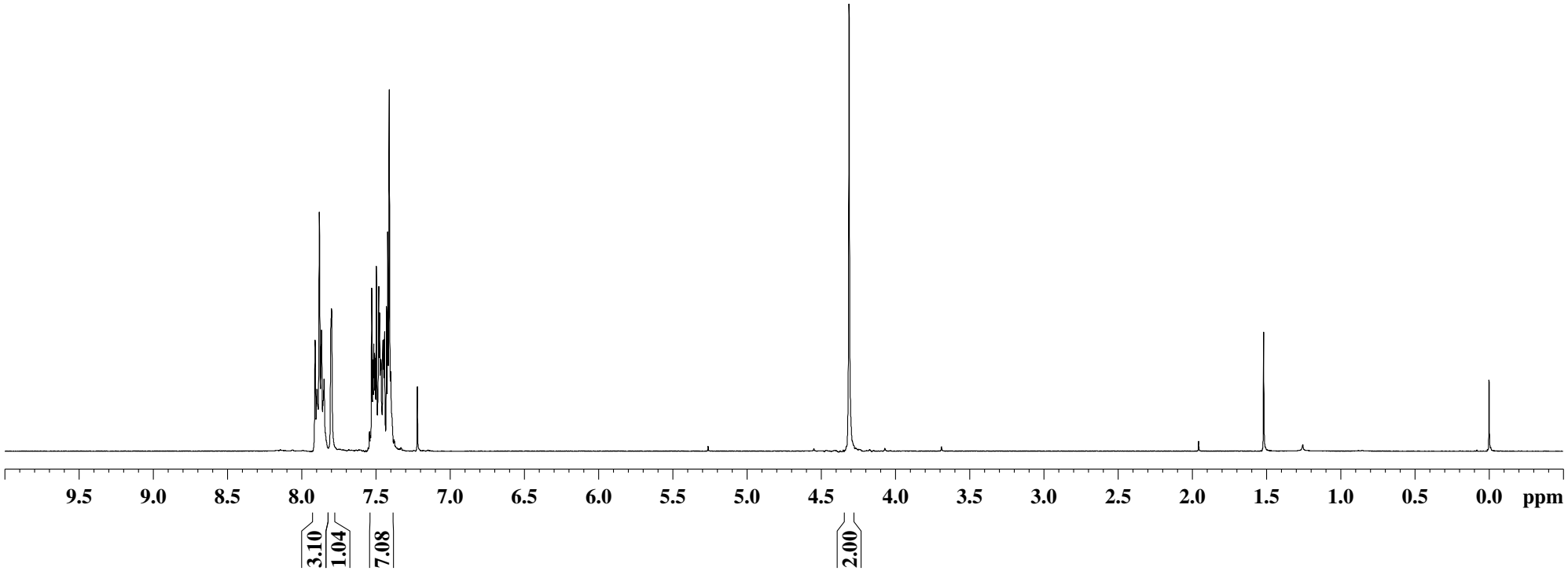
SK–1–170

7.9100
7.8983
7.8818
7.8668
7.8497
7.7994
7.5288
7.5209
7.5153
7.5108
7.5049
7.4972
7.4813
7.4752
7.4698
7.4658
7.4603
7.4530
7.4473
7.4421
7.4291
7.4212
7.4108
7.4006

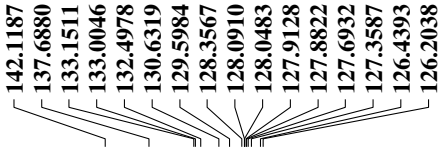
4.3123

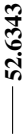


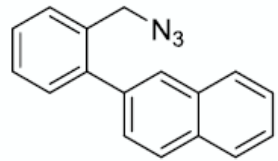
1d



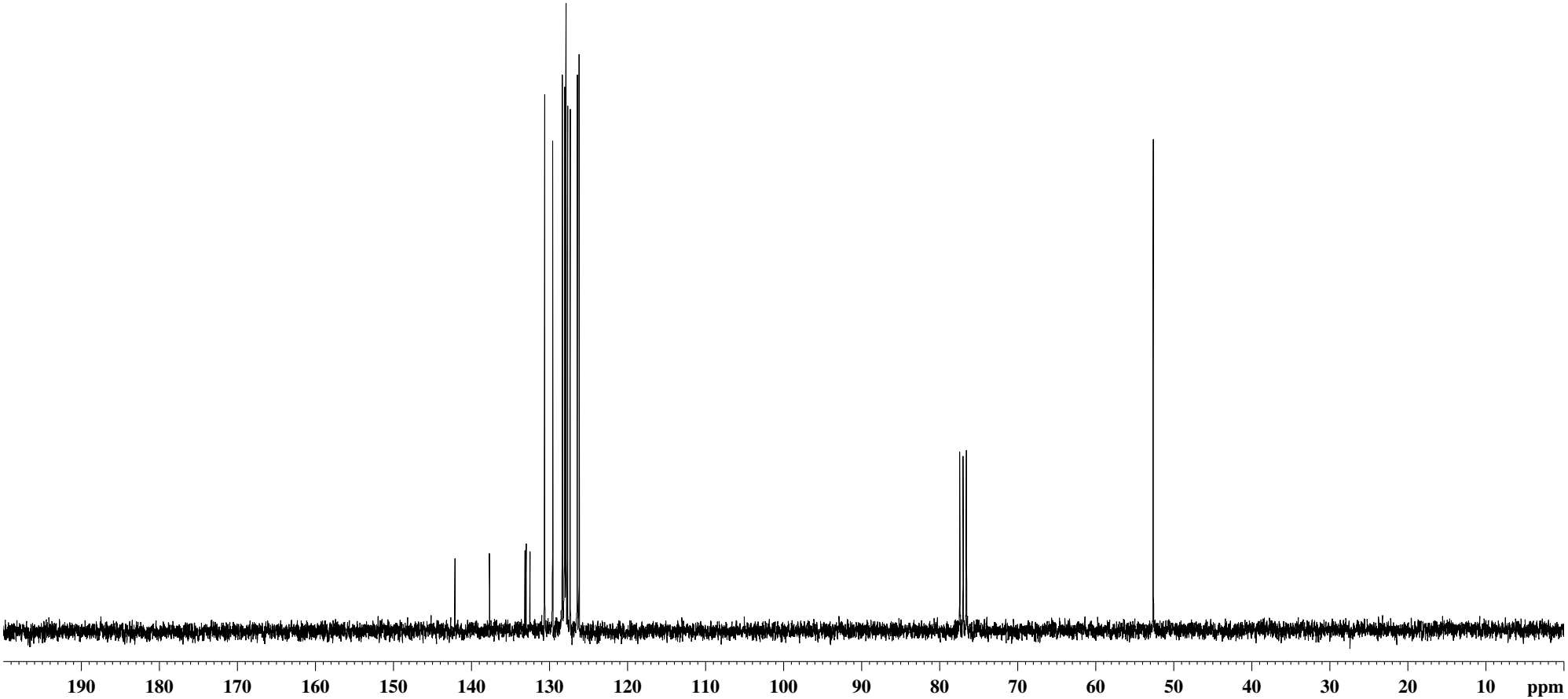
SK–1–170


142.1187
137.6880
133.1511
133.0046
132.4978
130.6319
129.5984
128.3567
128.0910
128.0483
127.9128
127.8822
127.6932
127.3587
126.4393
126.2038

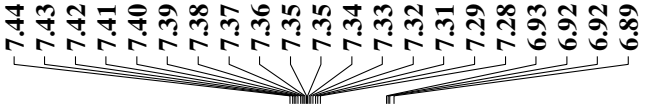

52.6343

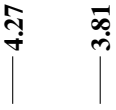

N3

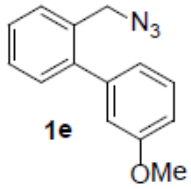
1d

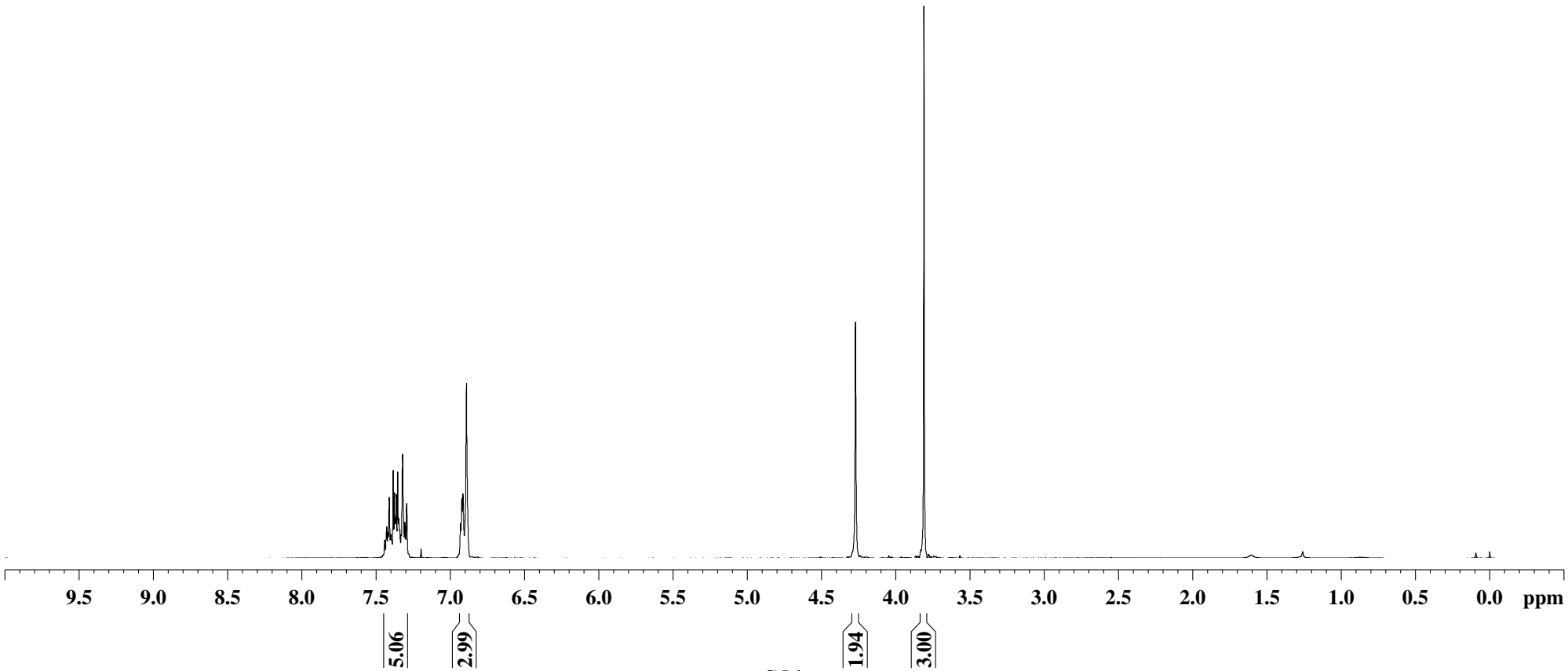

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

KN–1–029


7.44
7.43
7.42
7.41
7.40
7.39
7.38
7.37
7.36
7.35
7.35
7.34
7.33
7.32
7.31
7.29
7.28
6.93
6.92
6.92
6.89

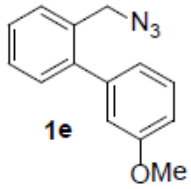

4.27
3.81


N3
1e
OMe

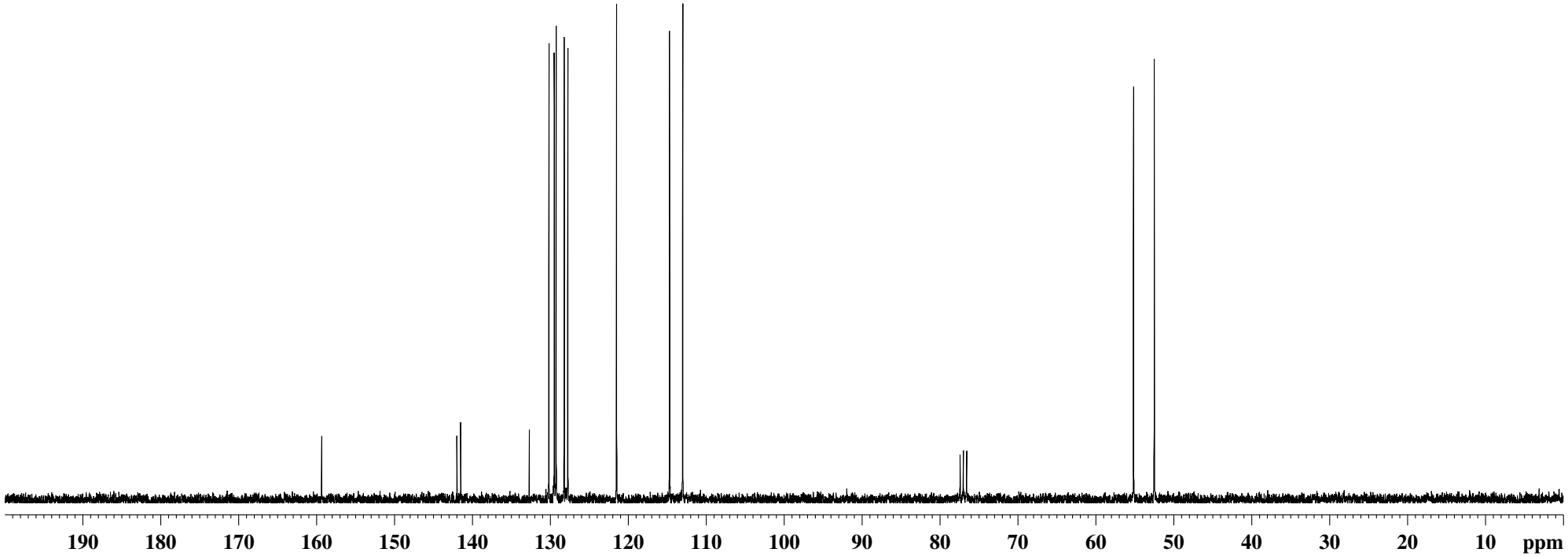

9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
5.06
2.99
1.94
3.00

KN–1–029

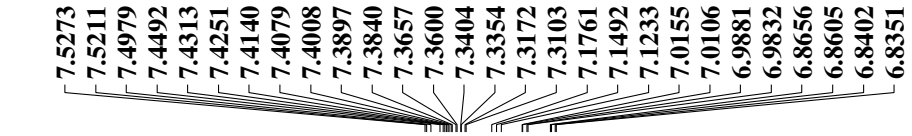
159.49
142.14
141.66
132.84
130.33
129.64
129.40
128.37
127.90
121.65
114.84
113.16
55.30
52.64

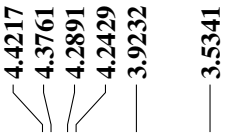


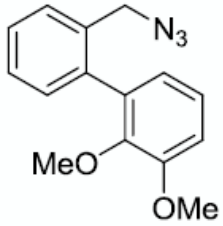
1e



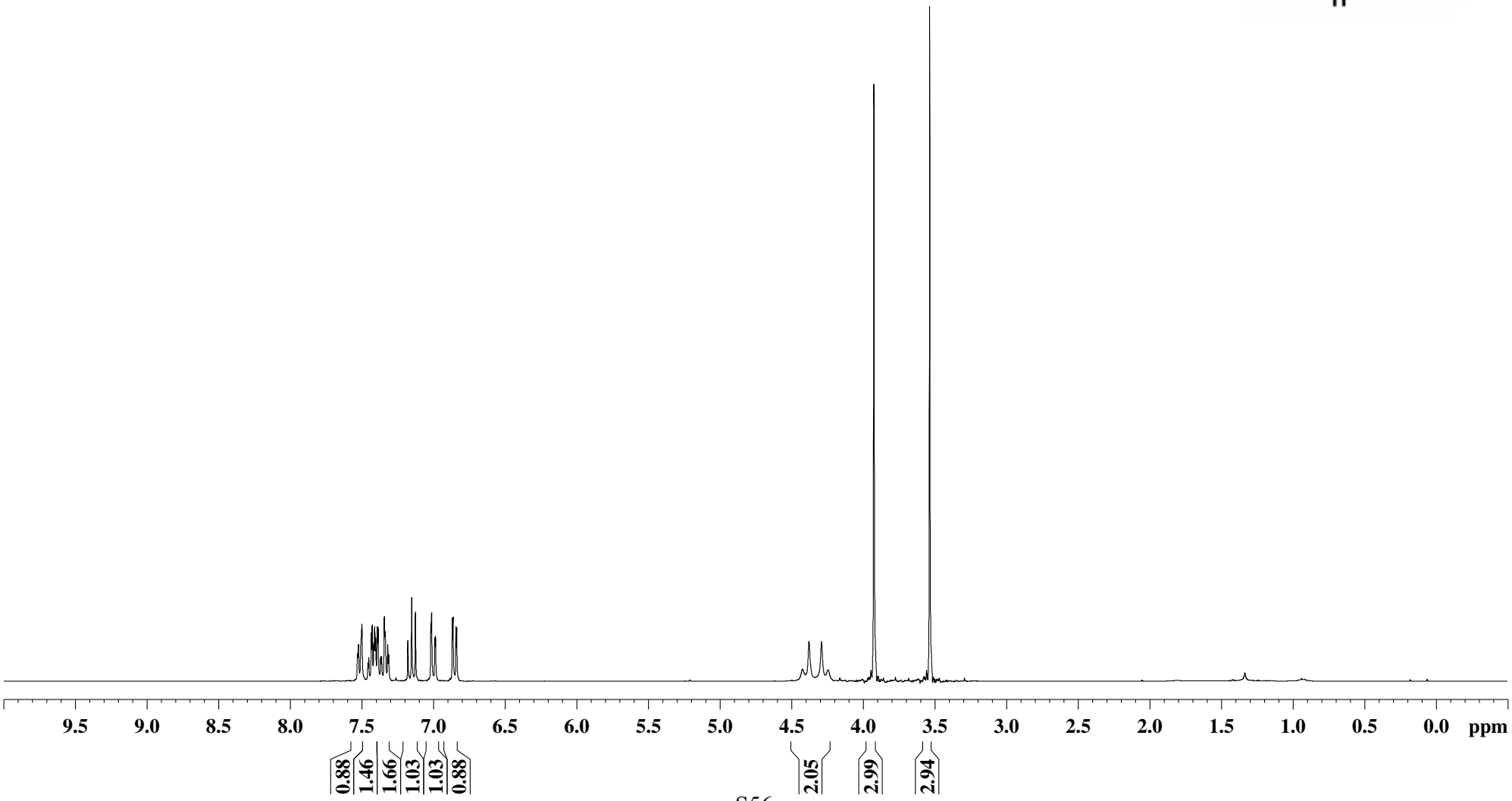
SK–1–062


7.5273
7.5211
7.4979
7.4492
7.4313
7.4251
7.4140
7.4079
7.4008
7.3897
7.3840
7.3657
7.3600
7.3404
7.3354
7.3172
7.3103
7.1761
7.1492
7.1233
7.0155
7.0106
6.9881
6.9832
6.8656
6.8605
6.8402
6.8351

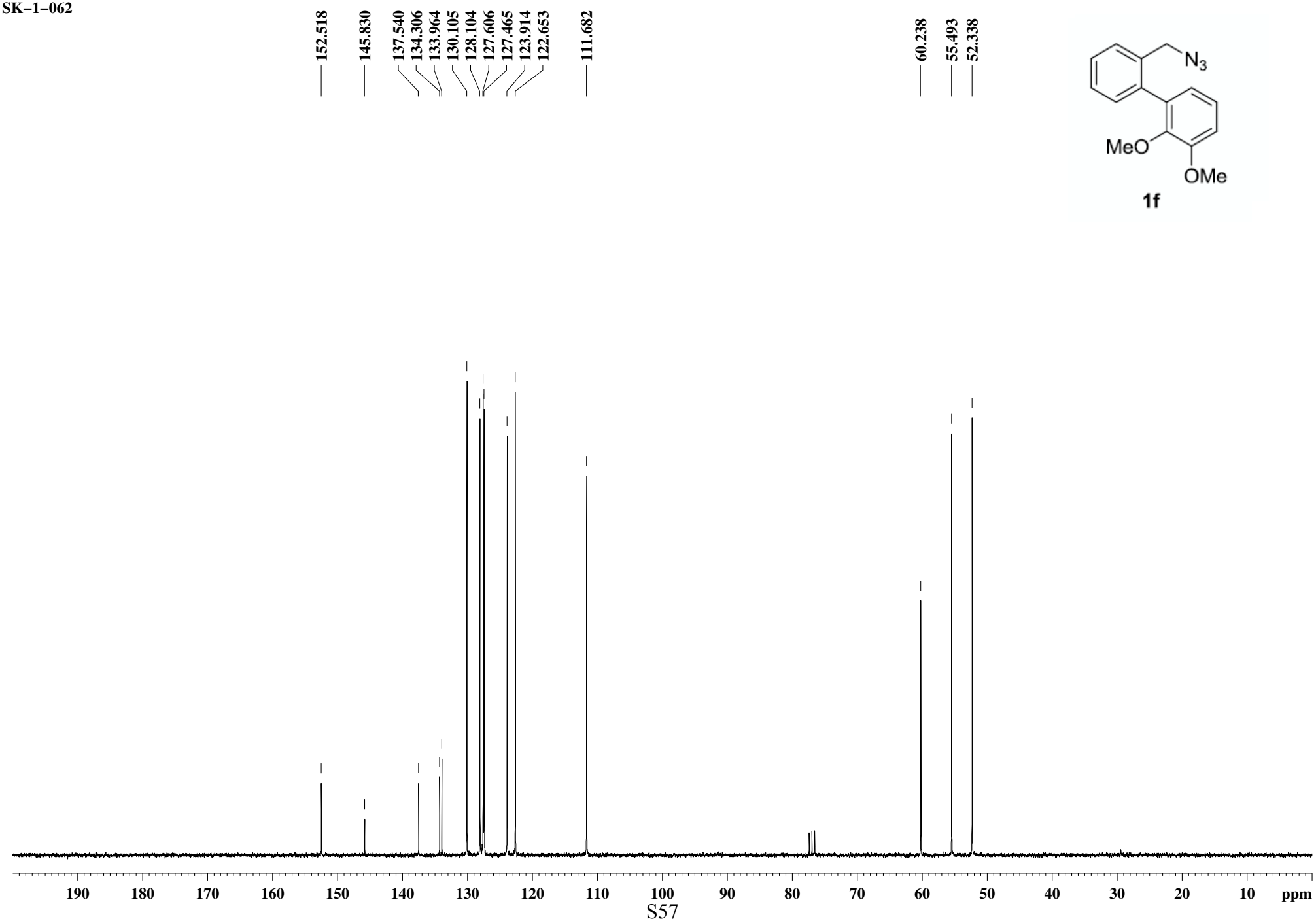

4.4217
4.3761
4.2891
4.2429
3.9232
3.5341


N3
MeO
OMe

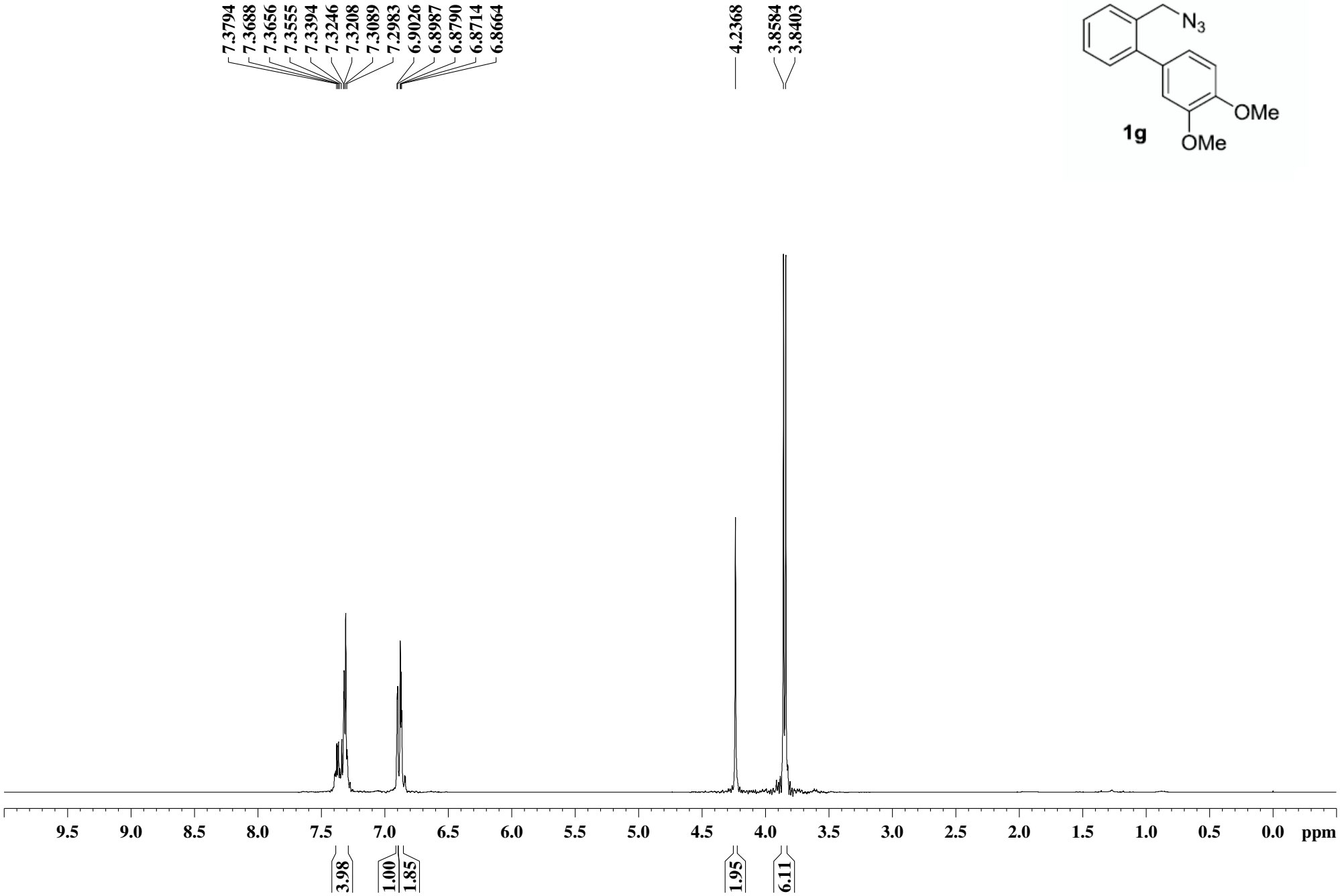
1f


9.5
9.0
8.5
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
ppm
0.88
1.46
1.66
1.03
1.03
0.88
2.05
2.99
2.94

SK−1−062

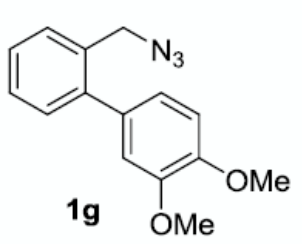

152.518
145.830
137.540
134.306
133.964
130.105
128.104
127.606
127.465
123.914
122.653
111.682
60.238
55.493
52.338
N3
MeO
OMe
1f
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK–1–070

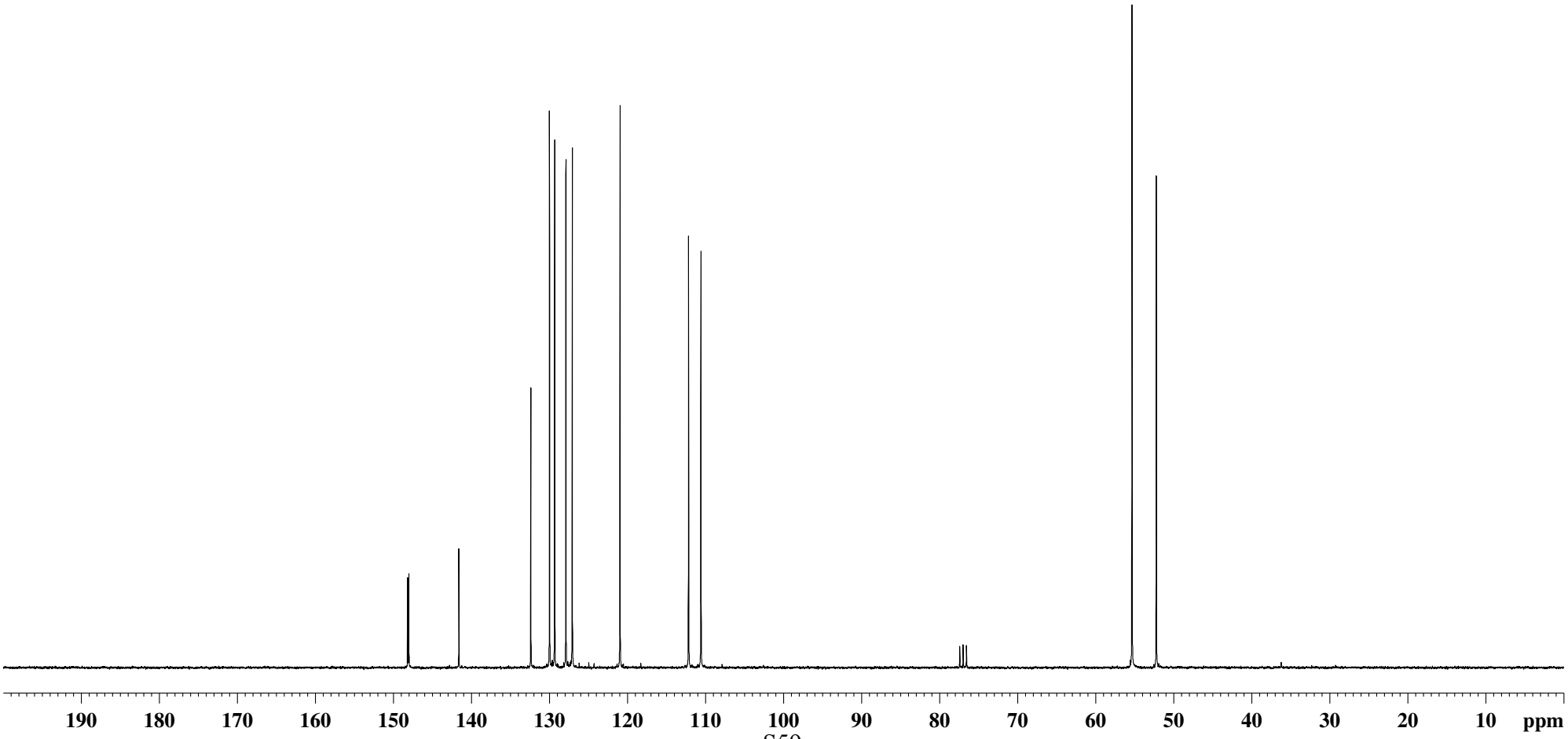

7.3794
7.3688
7.3656
7.3555
7.3394
7.3246
7.3208
7.3089
7.2983
6.9026
6.8987
6.8790
6.8714
6.8664
4.2368
3.8584
3.8403
N3
OMe
OMe
1g
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
3.98
1.00
1.85
1.95
6.11

SK–1–070

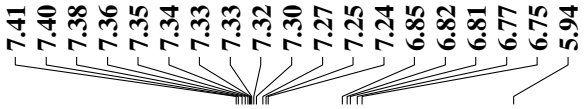
148.1945
148.0322
141.6274
132.4043
130.0020
129.3451
127.9063
127.0865
120.9702
112.1913
110.6001
55.3485
52.2387



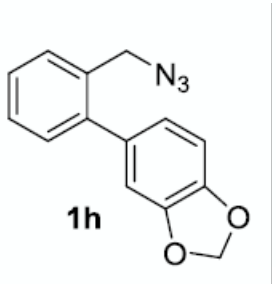
1g

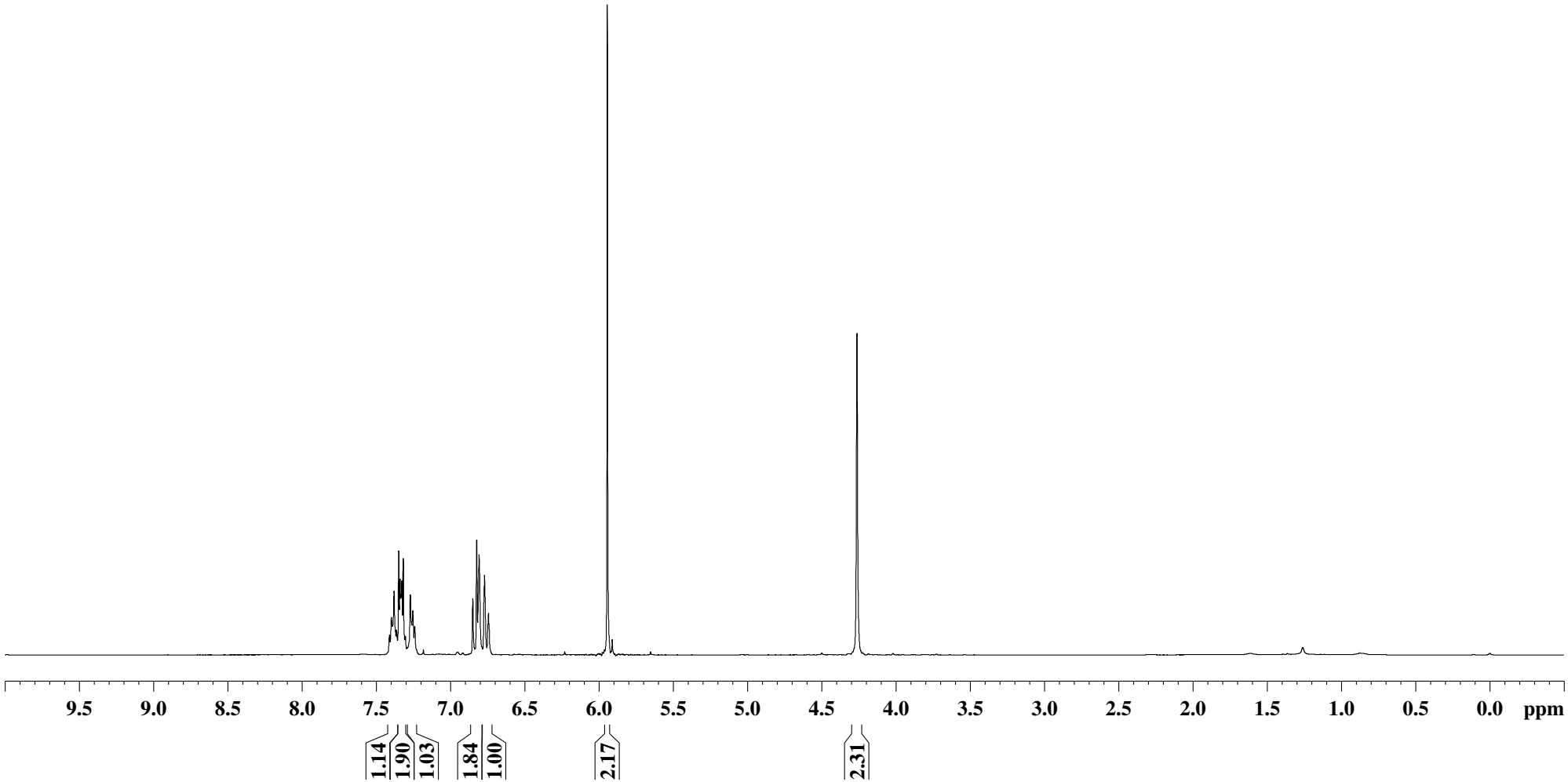


SK–1–063

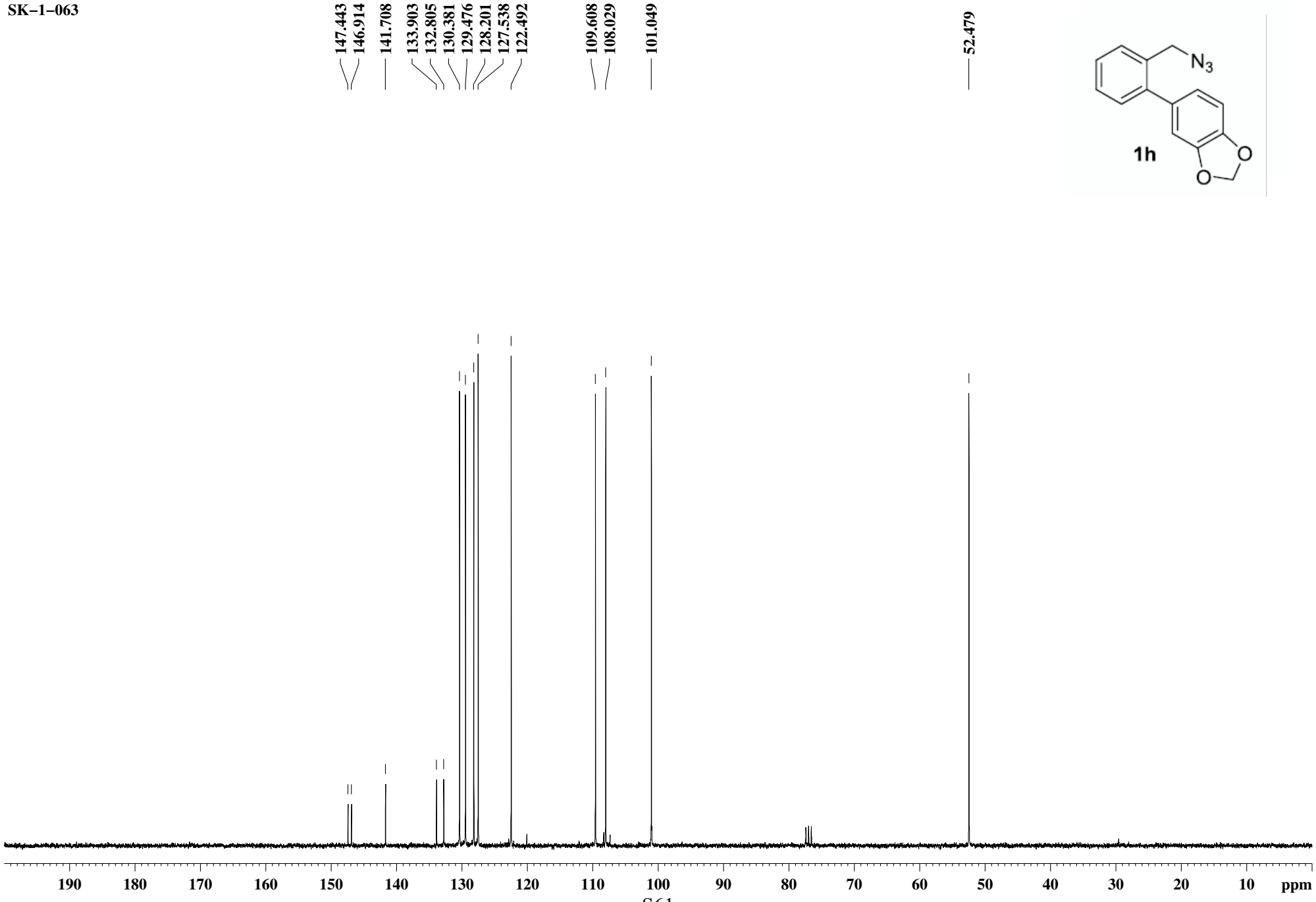

7.41
7.40
7.38
7.36
7.35
7.34
7.33
7.33
7.32
7.30
7.27
7.25
7.24
6.85
6.82
6.81
6.77
6.75
5.94

4.26

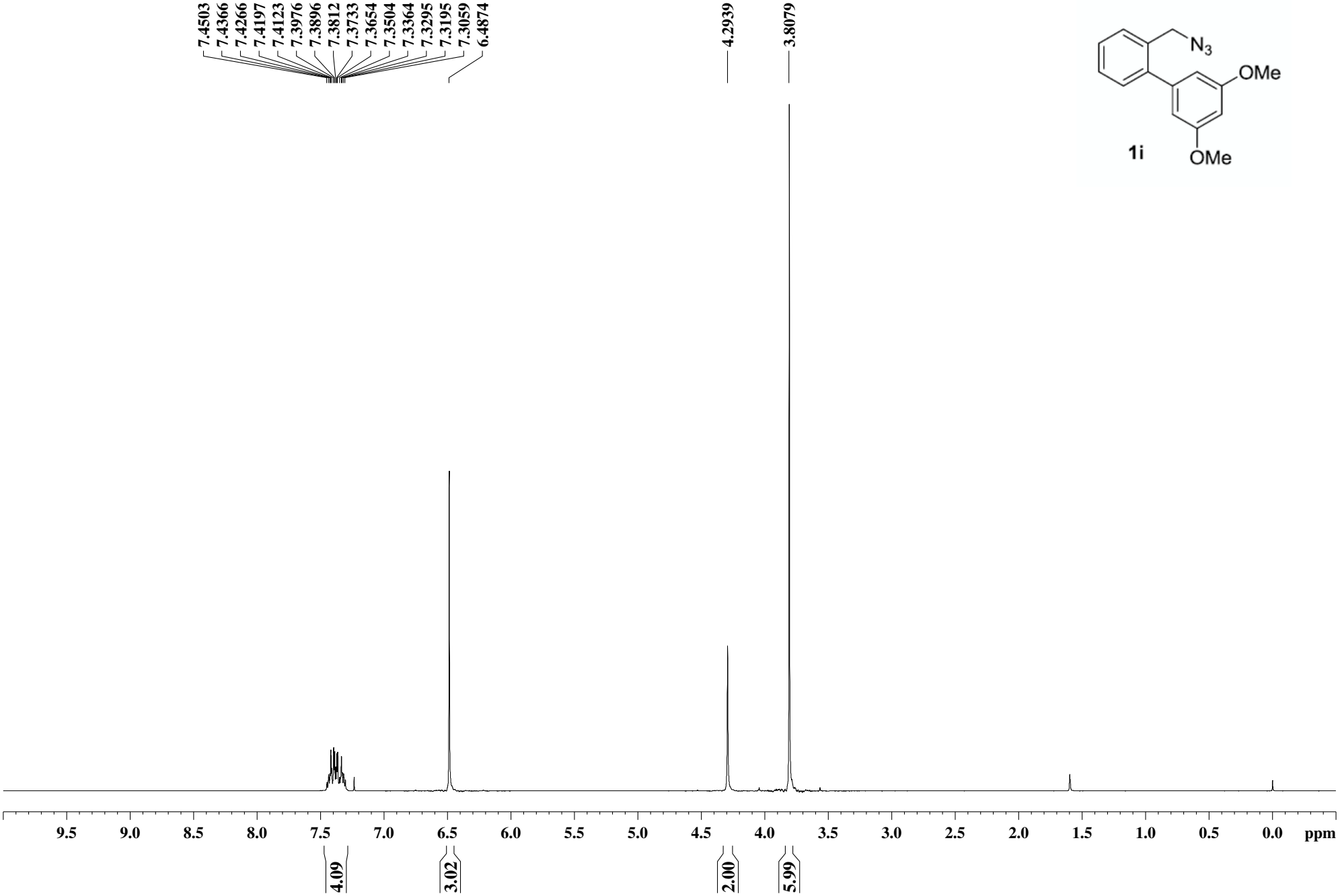

N3
O
O
1h


9.5
9.0
8.5
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
ppm
1.14
1.90
1.03
1.84
1.00
2.17
2.31

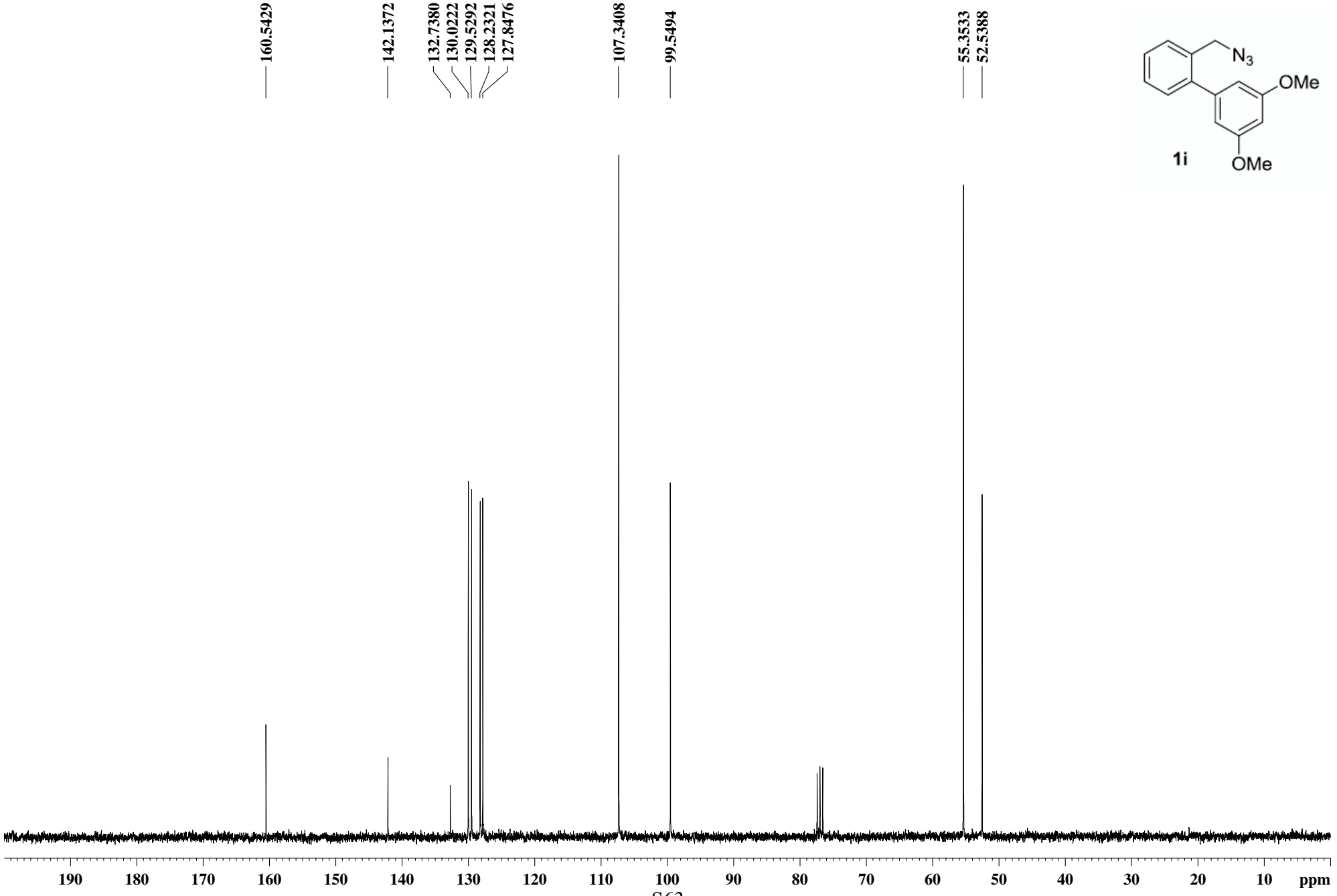
SK–1–063


147.443
146.914
141.708
133.903
132.805
130.381
129.476
128.201
127.538
122.492
109.608
108.029
101.049
52.479
N3
O
O
1h
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

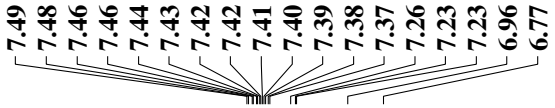
SK–1–188B

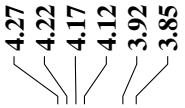

7.4503
7.4366
7.4266
7.4197
7.4123
7.3976
7.3896
7.3812
7.3733
7.3654
7.3504
7.3364
7.3295
7.3195
7.3059
6.4874
4.2939
3.8079
N3
OMe
OMe
1i
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
4.09
3.02
2.00
5.99

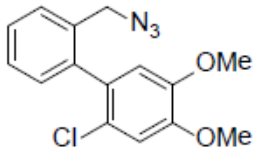
SK–1–188B


160.5429
142.1372
132.7380
130.0222
129.5292
128.2321
127.8476
107.3408
99.5494
55.3533
52.5388
N3
OMe
OMe
1i
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

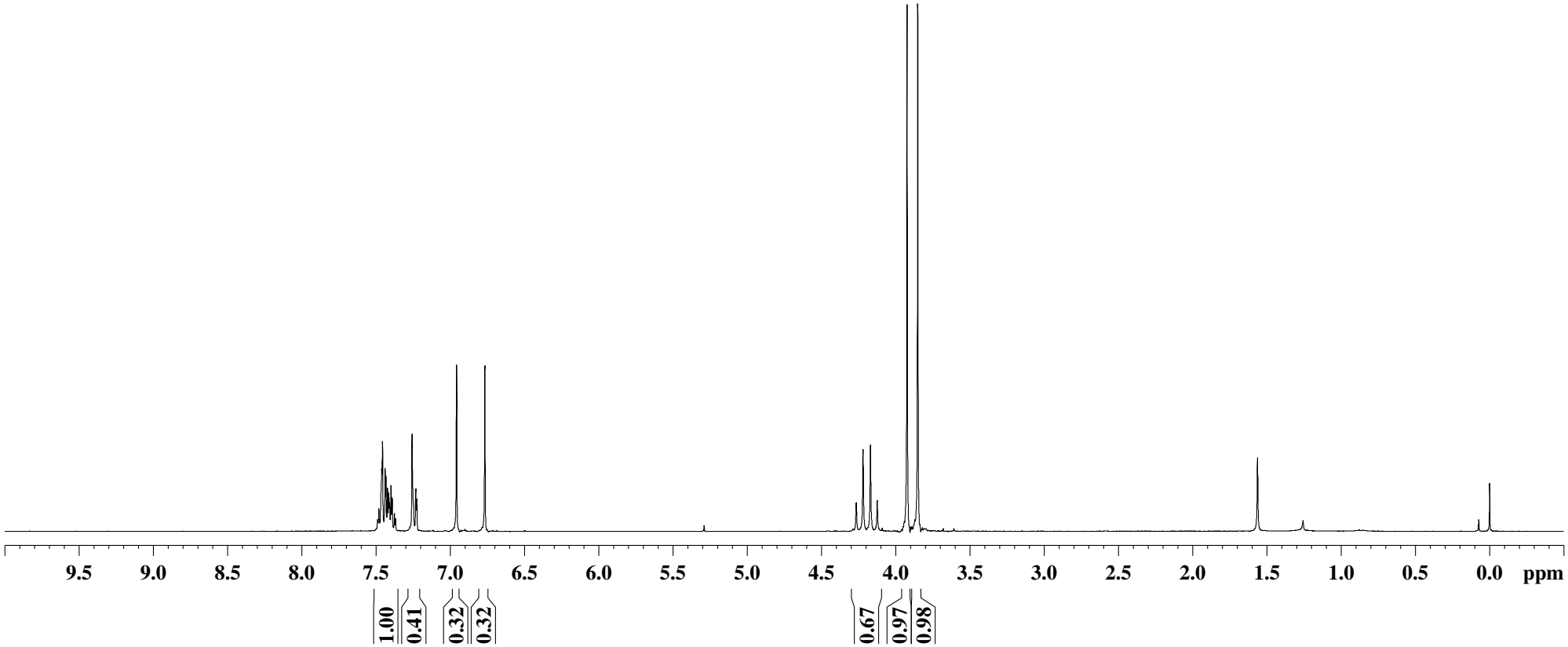
KN–1–039


7.49
7.48
7.46
7.46
7.44
7.43
7.42
7.42
7.41
7.40
7.39
7.38
7.37
7.26
7.23
7.23
6.96
6.77

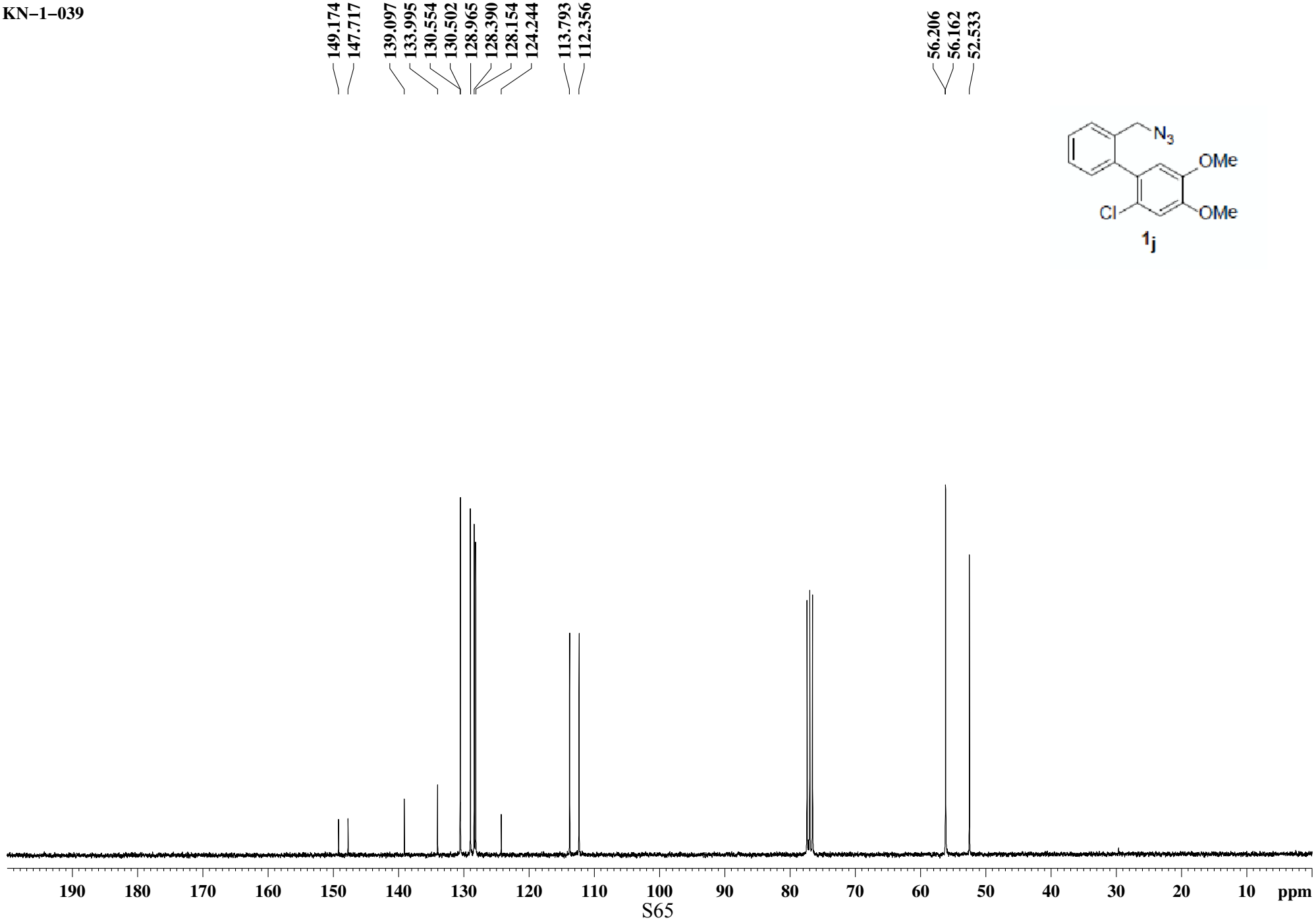

4.27
4.22
4.17
4.12
3.92
3.85


N3
OMe
Cl
OMe

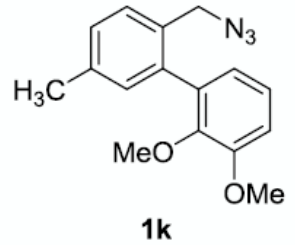
1j


9.5
9.0
8.5
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
ppm
1.00
0.41
0.32
0.32
0.67
0.97
0.98

KN–1–039

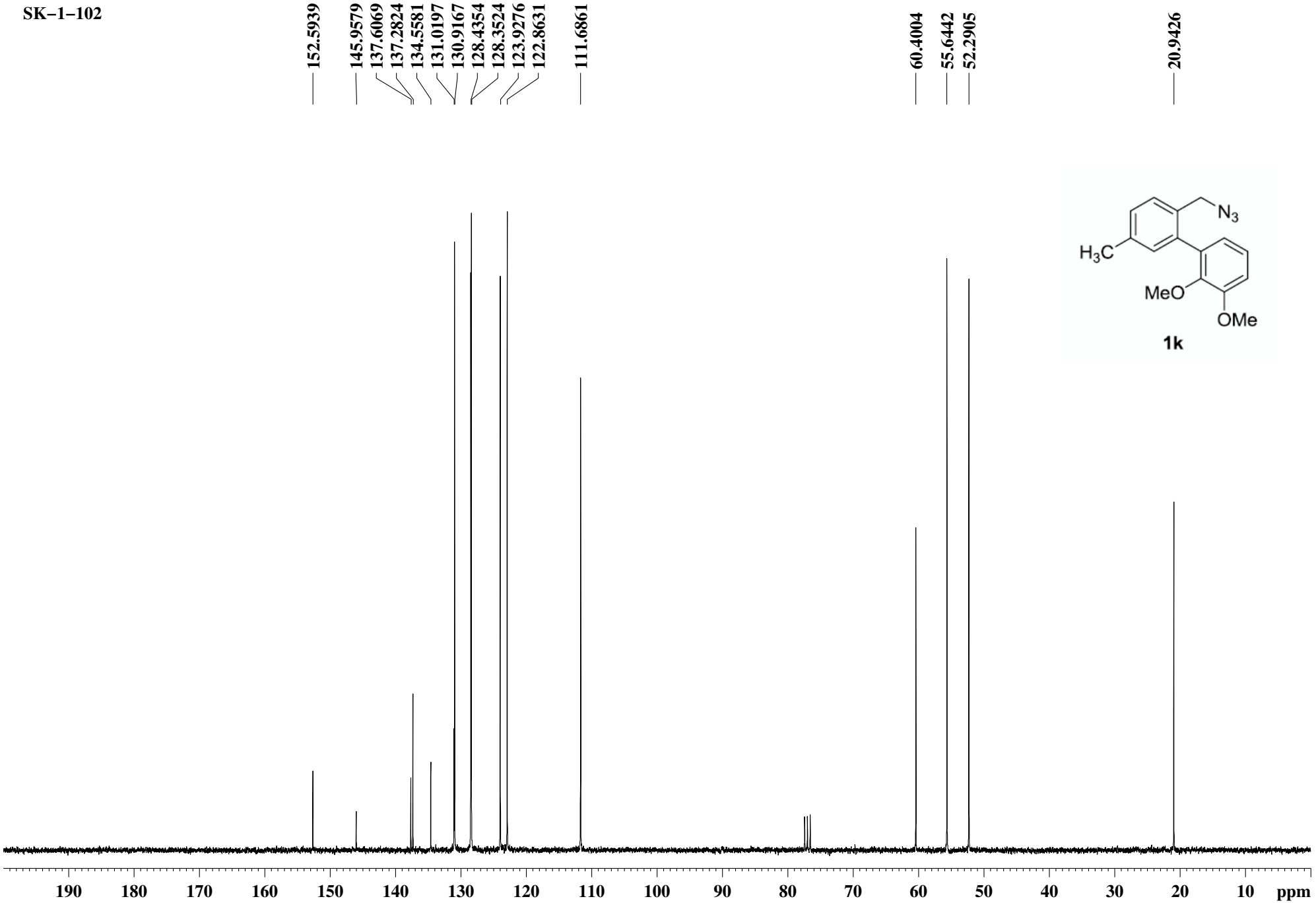

149.174
147.717
139.097
133.995
130.554
130.502
128.965
128.390
128.154
124.244
113.793
112.356
56.206
56.162
52.533
N3
OMe
OMe
Cl
1j
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK–1–102

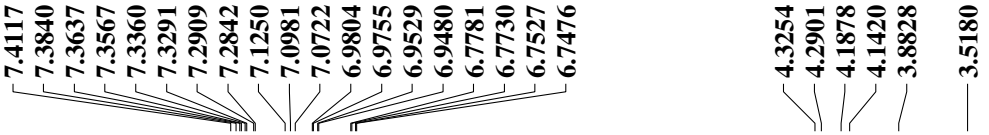


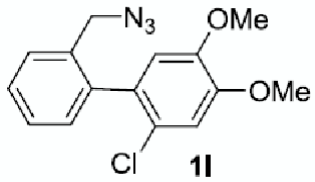
1k

SK−1−102

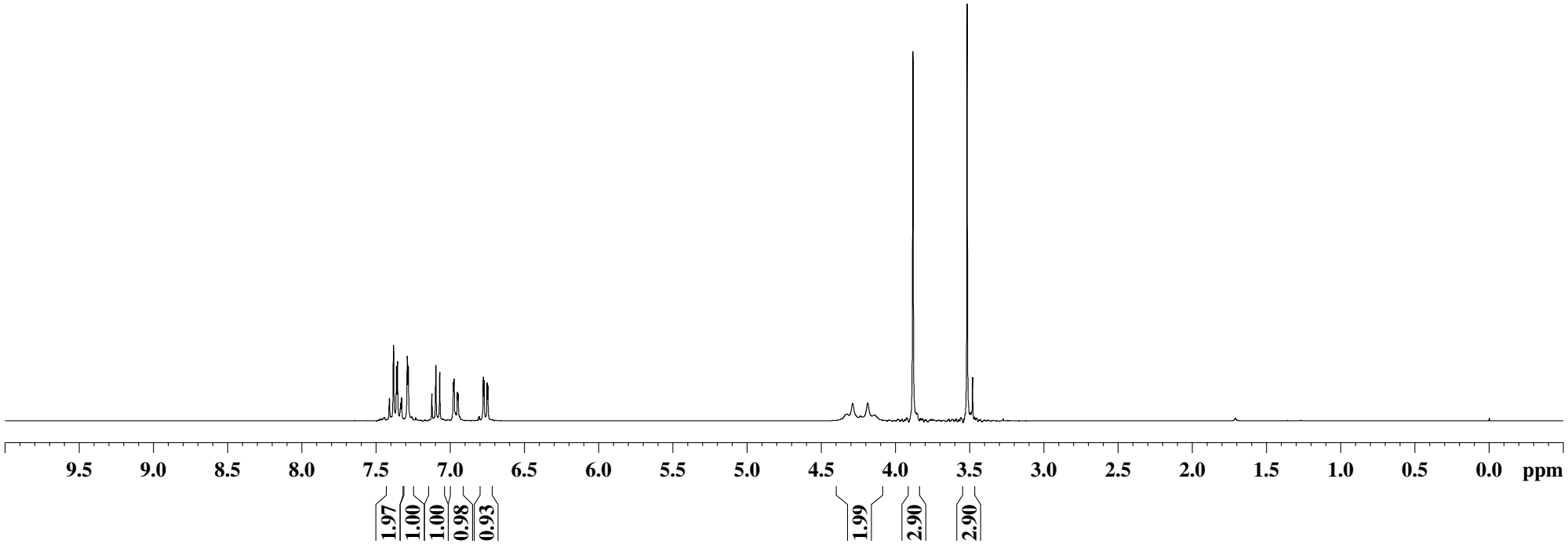

152.5939
145.9579
137.6069
137.2824
134.5581
131.0197
130.9167
128.4354
128.3524
123.9276
122.8631
111.6861
60.4004
55.6442
52.2905
20.9426
N3
H3C
MeO
OMe
1k
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK–1–130


7.4117
7.3840
7.3637
7.3567
7.3360
7.3291
7.2909
7.2842
7.1250
7.0981
7.0722
6.9804
6.9755
6.9529
6.9480
6.7781
6.7730
6.7527
6.7476
4.3254
4.2901
4.1878
4.1420
3.8828
3.5180

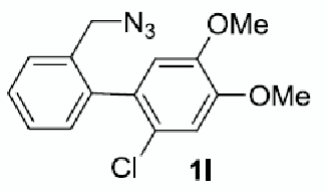

N3
OMe
OMe
Cl

1l

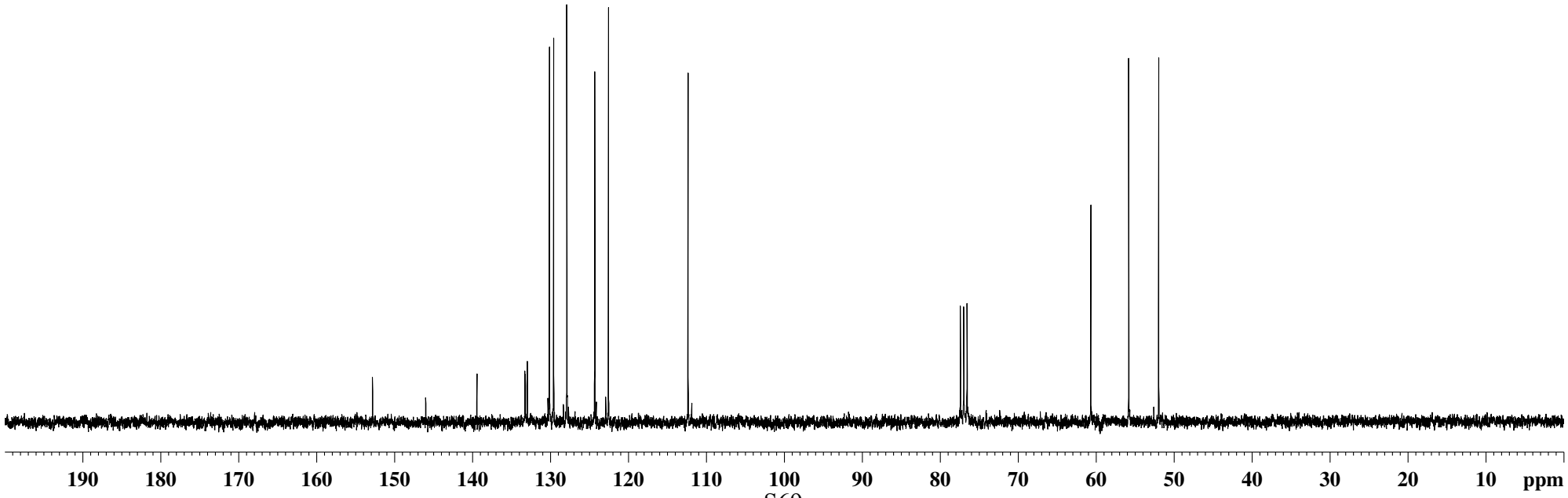

9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.97
1.00
1.00
0.98
0.93
1.99
2.90
2.90

SK–1–130

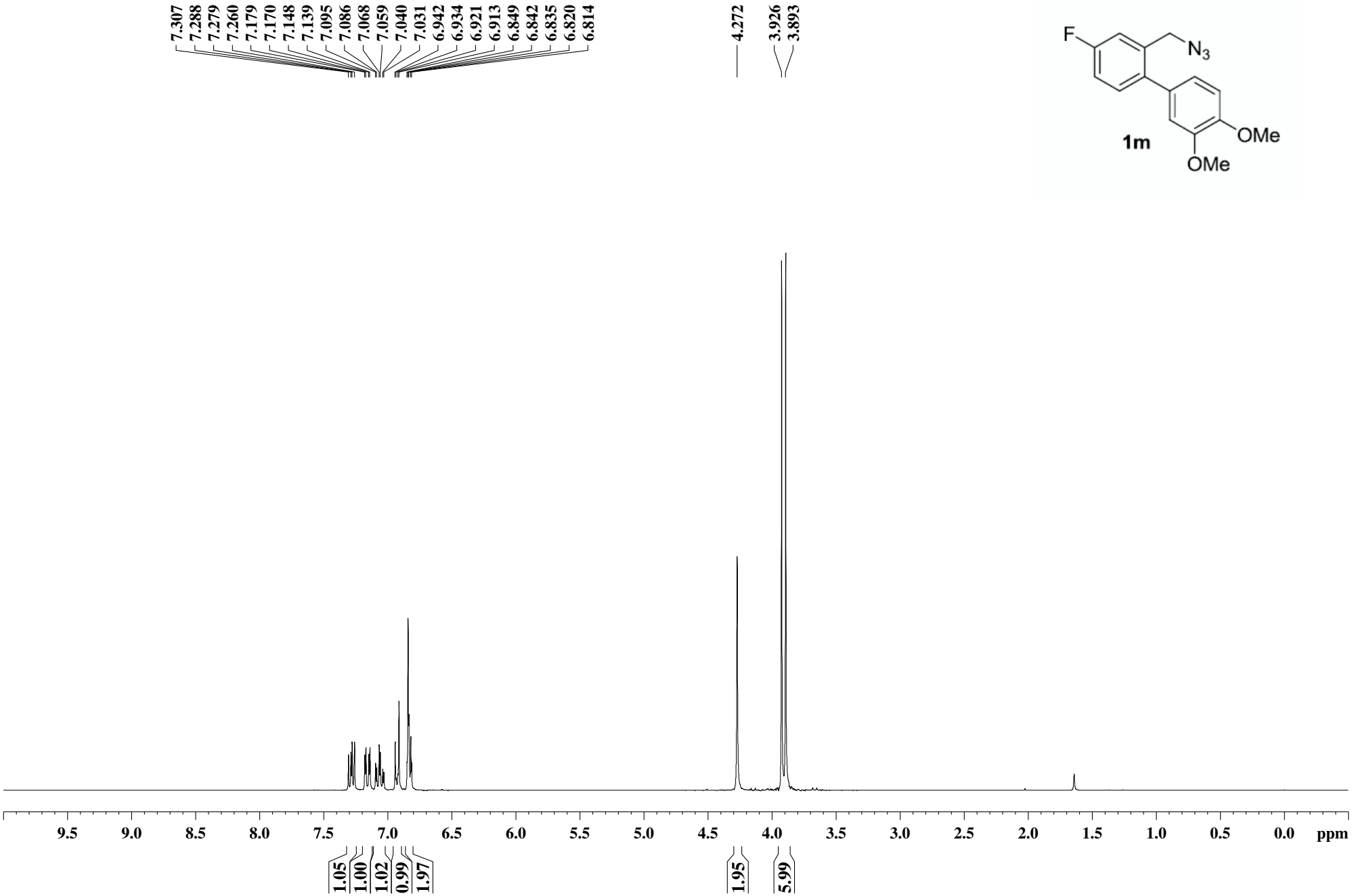
152.79
145.97
139.40
133.29
133.24
132.98
130.16
129.61
127.92
124.34
122.58
112.37
60.70
55.84
51.99



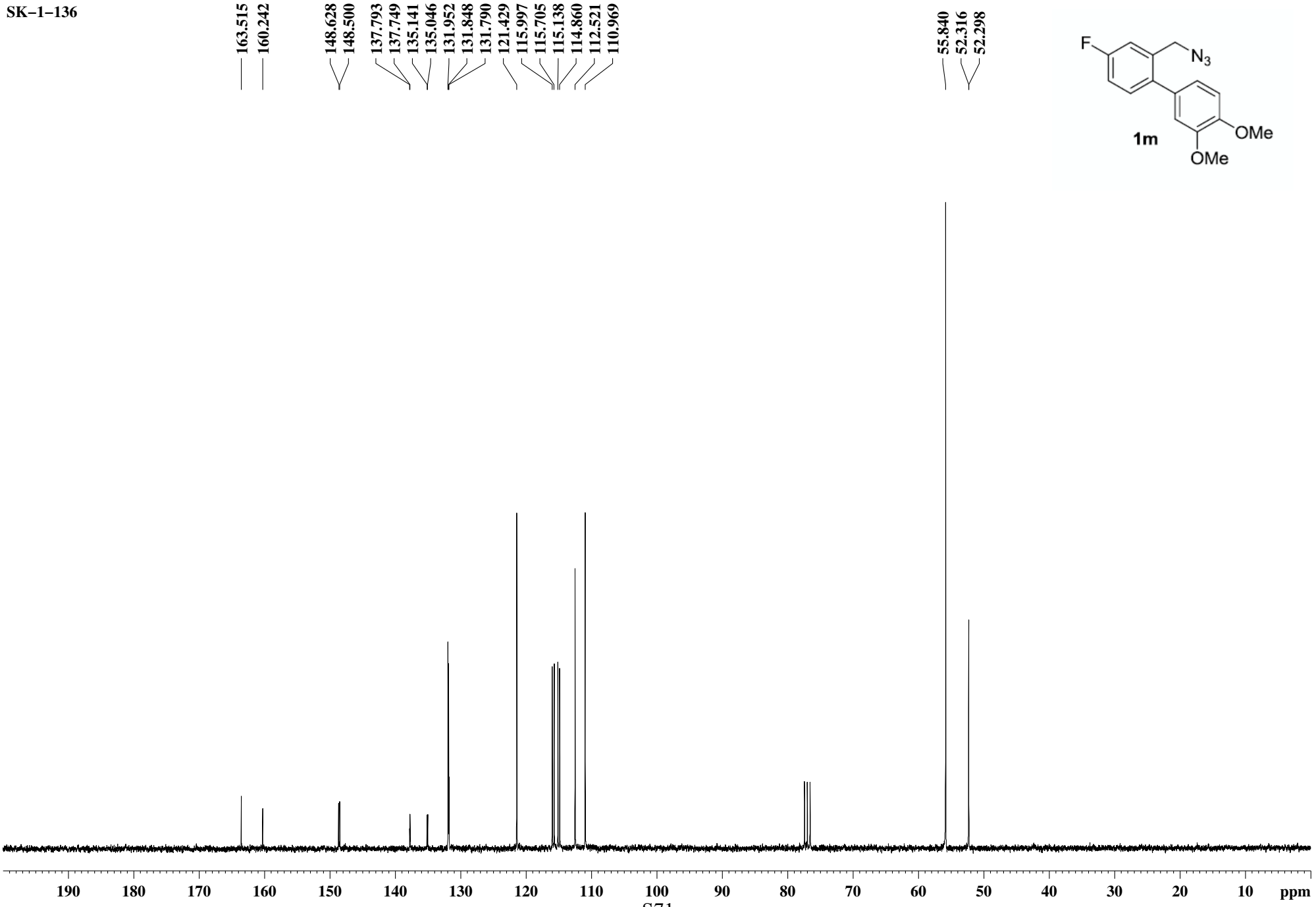
1l



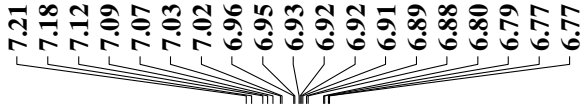
SK–1–136

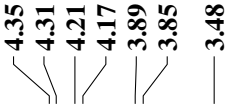

7.307
7.288
7.279
7.260
7.179
7.170
7.148
7.139
7.095
7.086
7.068
7.059
7.040
7.031
6.942
6.934
6.921
6.913
6.849
6.842
6.835
6.820
6.814
4.272
3.926
3.893
F
N3
OMe
OMe
1m
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.05
1.00
1.02
0.99
1.97
1.95
5.99

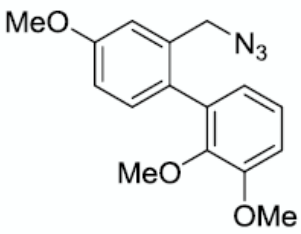
SK–1–136


163.515
160.242
148.628
148.500
137.793
137.749
135.141
135.046
131.952
131.848
131.790
121.429
115.997
115.705
115.138
114.860
112.521
110.969
55.840
52.316
52.298
F
N3
OMe
OMe
1m
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

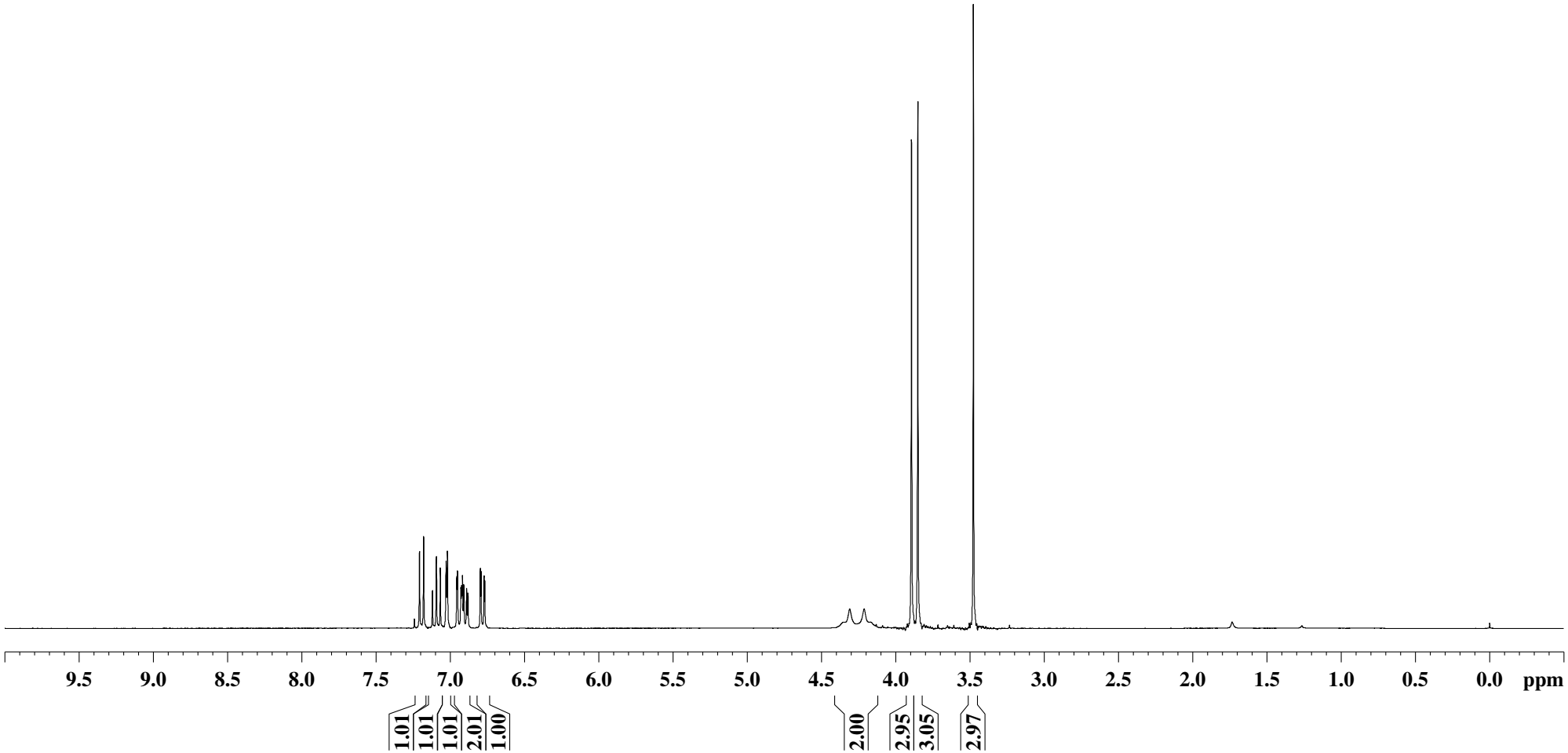
SK–1–084


7.21
7.18
7.12
7.09
7.07
7.03
7.02
6.96
6.95
6.93
6.92
6.92
6.91
6.89
6.88
6.80
6.79
6.77
6.77

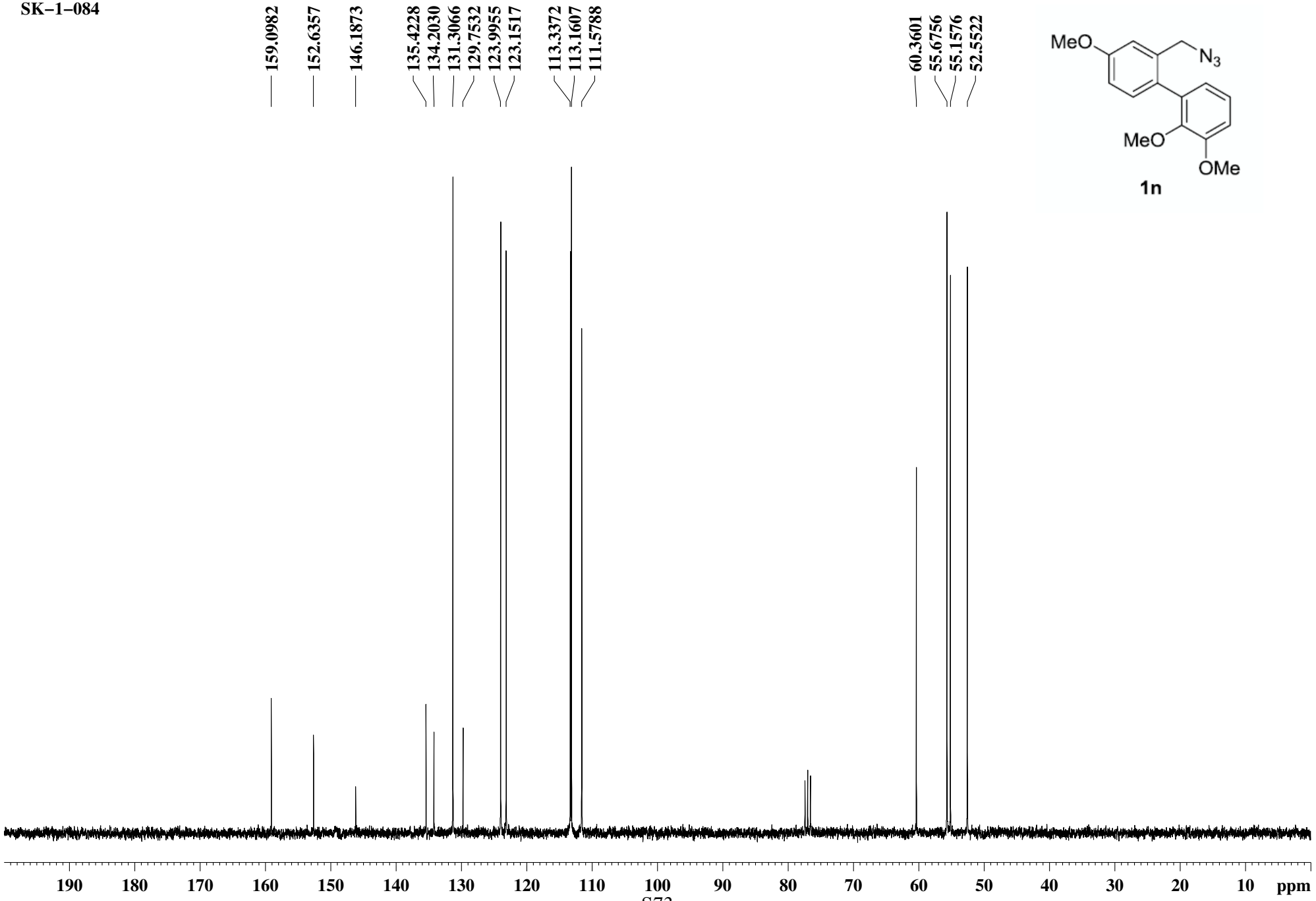

4.35
4.31
4.21
4.17
3.89
3.85
3.48


MeO
N3
MeO
OMe

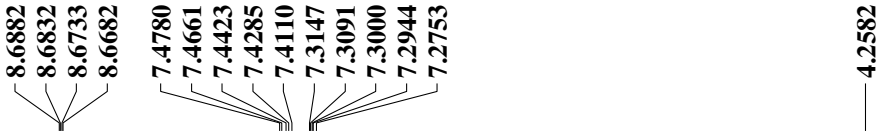
1n

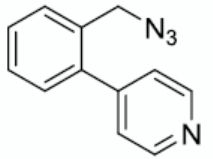

9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.01
1.01
1.01
2.01
1.00
2.00
2.95
3.05
2.97

SK–1–084

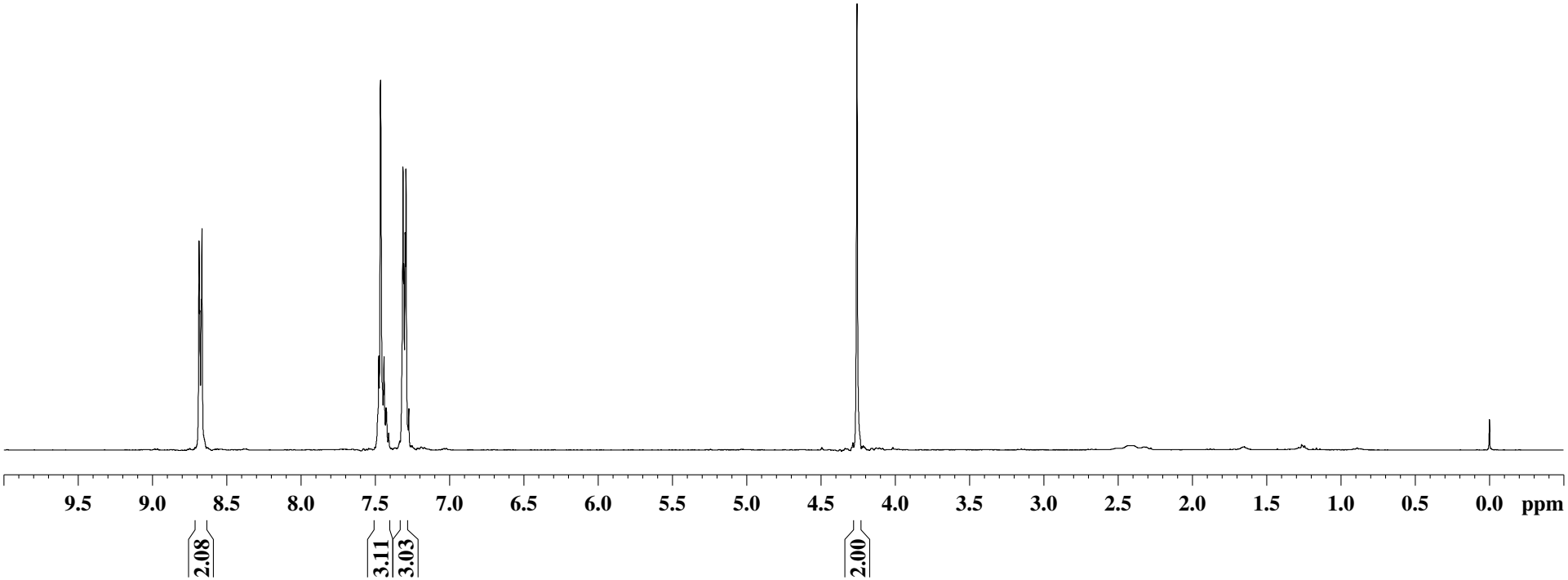

159.0982
152.6357
146.1873
135.4228
134.2030
131.3066
129.7532
123.9955
123.1517
113.3372
113.1607
111.5788
60.3601
55.6756
55.1576
52.5522
MeO
N3
MeO
OMe
1n
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK–1–159


8.6882
8.6832
8.6733
8.6682
7.4780
7.4661
7.4423
7.4285
7.4110
7.3147
7.3091
7.3000
7.2944
7.2753
4.2582

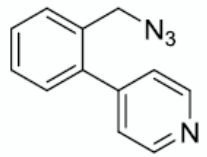

N3
N

1o

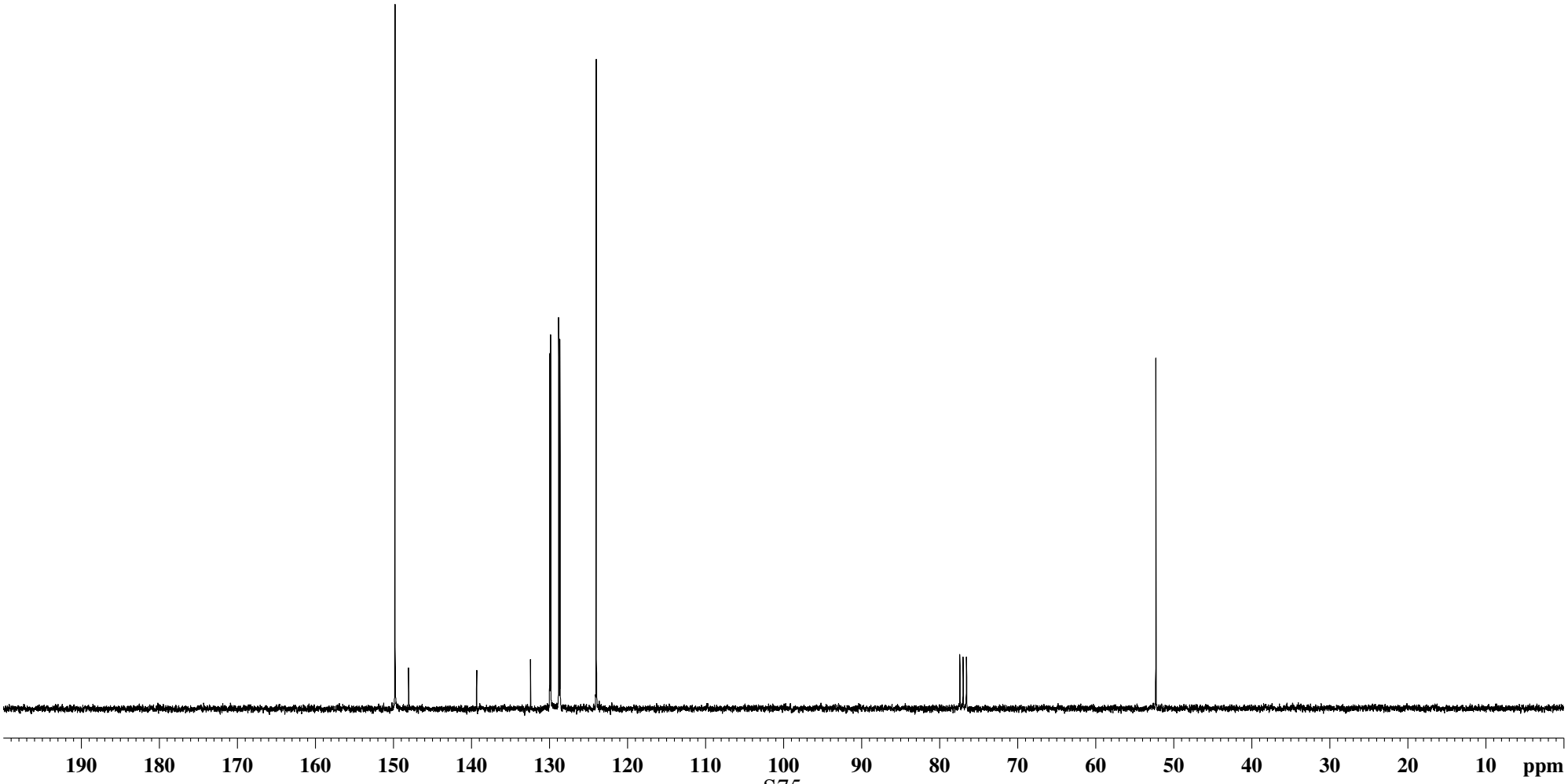

9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
2.08
3.11
3.03
2.00

SK–1–159

149.7564
148.0124
139.3517
132.4480
129.9677
129.8596
128.8228
128.6642
124.0223
52.2892



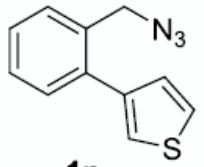
1o



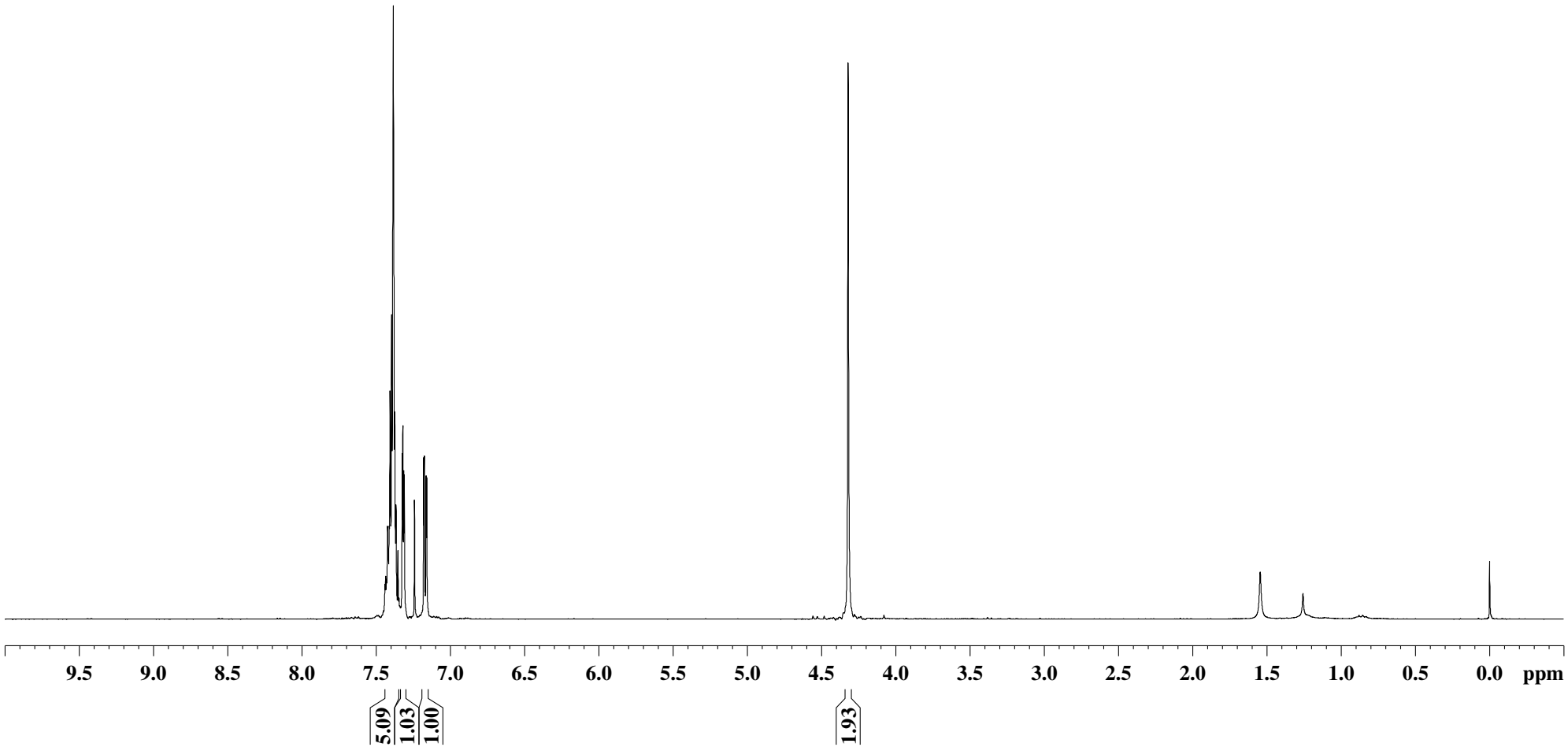
SK–1–112


7.42
7.42
7.41
7.41
7.40
7.39
7.39
7.38
7.38
7.37
7.35
7.33
7.32
7.32
7.31
7.18
7.18
7.17
7.16

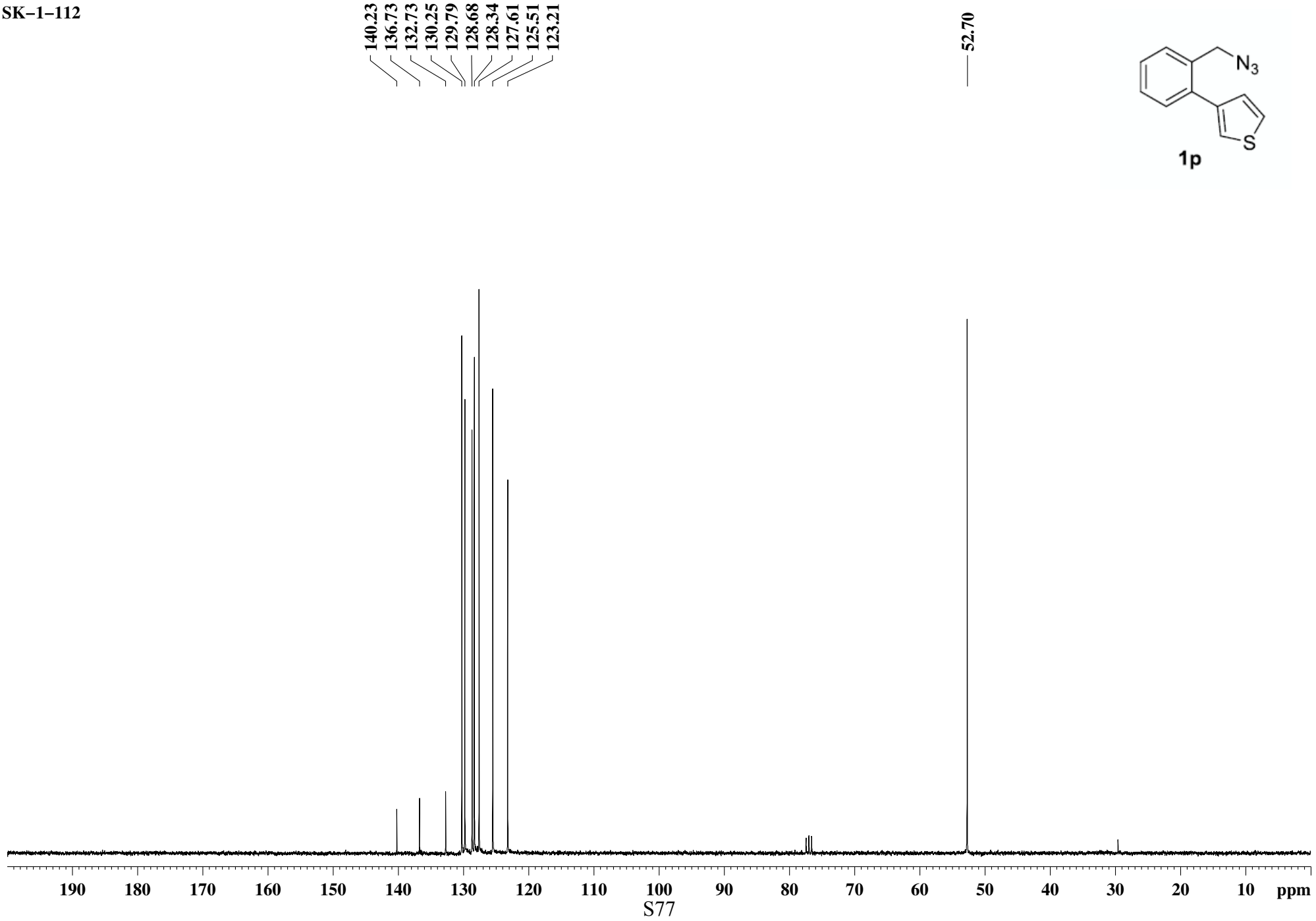

4.32


N3
S

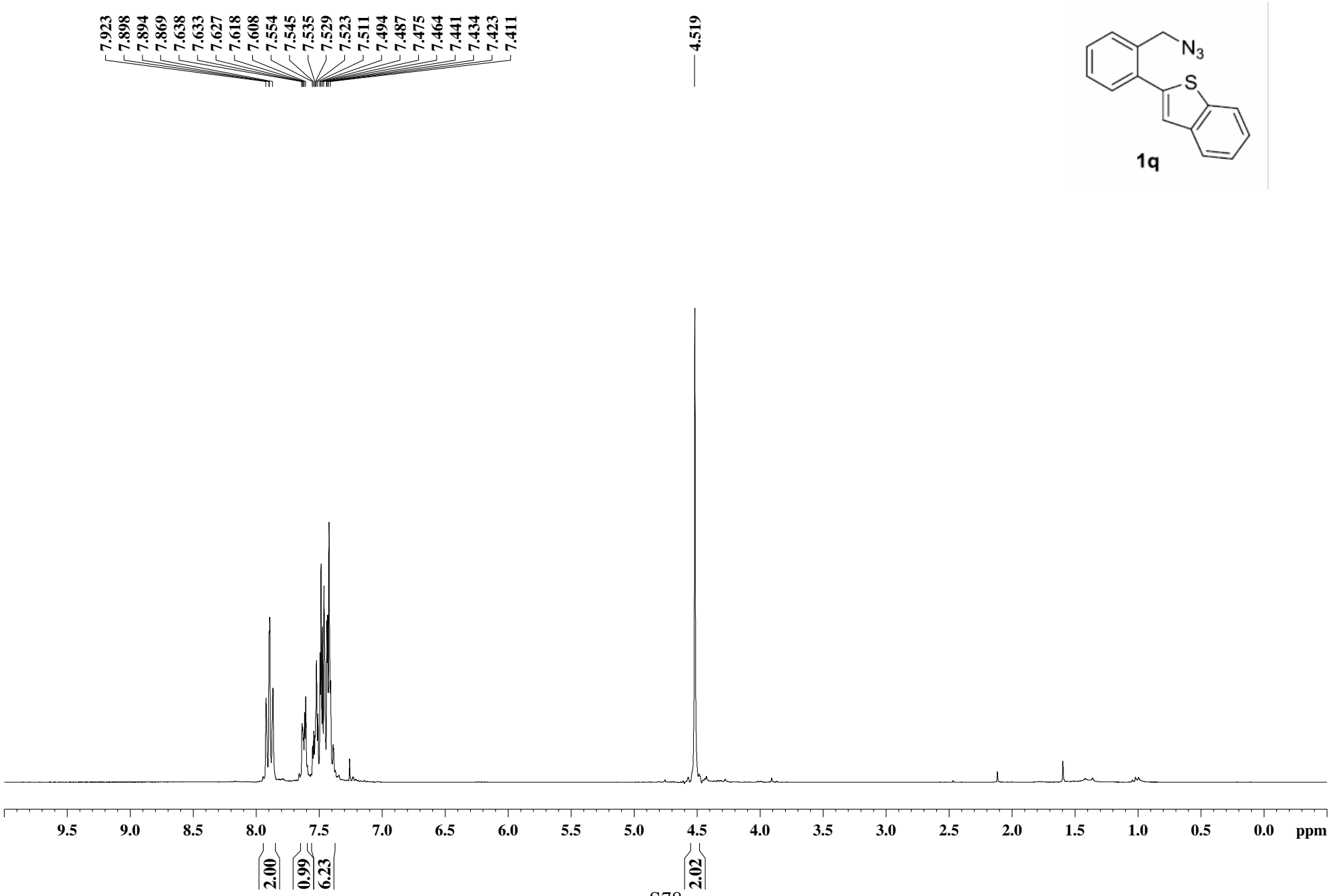
1p


9.5
9.0
8.5
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
ppm
5.09
1.03
1.00
1.93

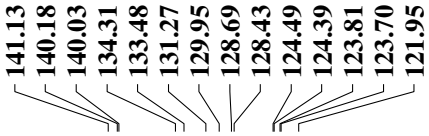
SK–1–112

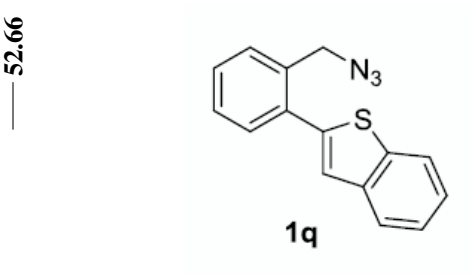

140.23
136.73
132.73
130.25
129.79
128.68
128.34
127.61
125.51
123.21
52.70
N3
S
1p
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

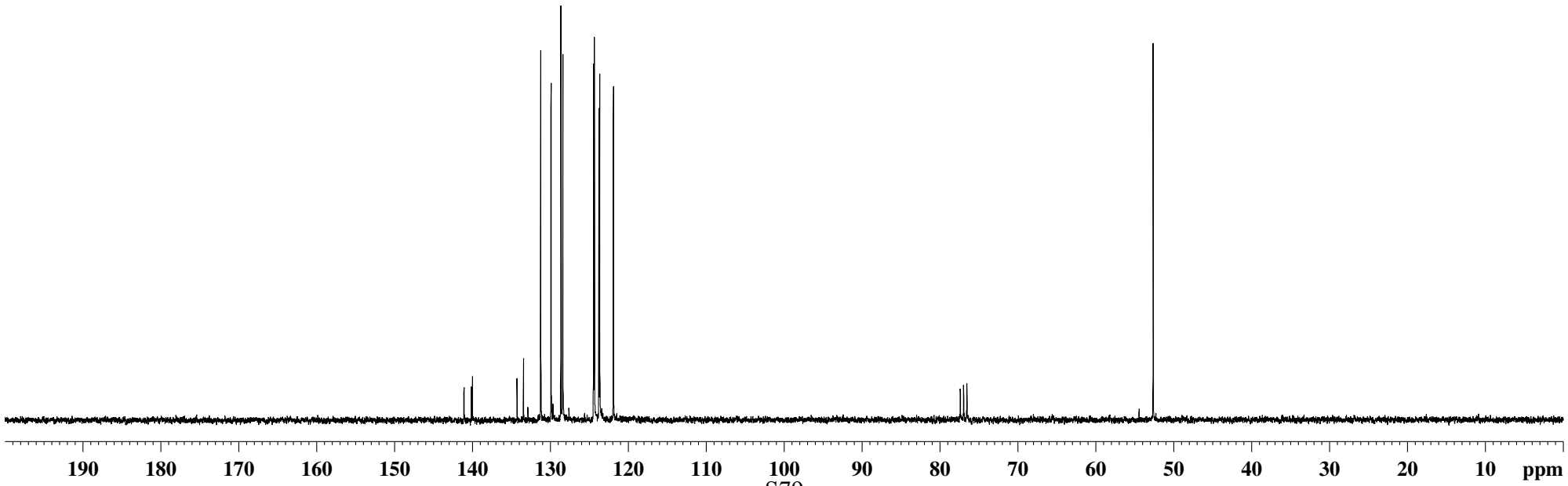
SK–1–165


7.923
7.898
7.894
7.869
7.638
7.633
7.627
7.618
7.608
7.554
7.545
7.535
7.529
7.523
7.511
7.494
7.487
7.475
7.464
7.441
7.434
7.423
7.411
4.519
N3
S
1q
9.5
9.0
8.5
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
ppm
2.00
0.99
6.23
2.02

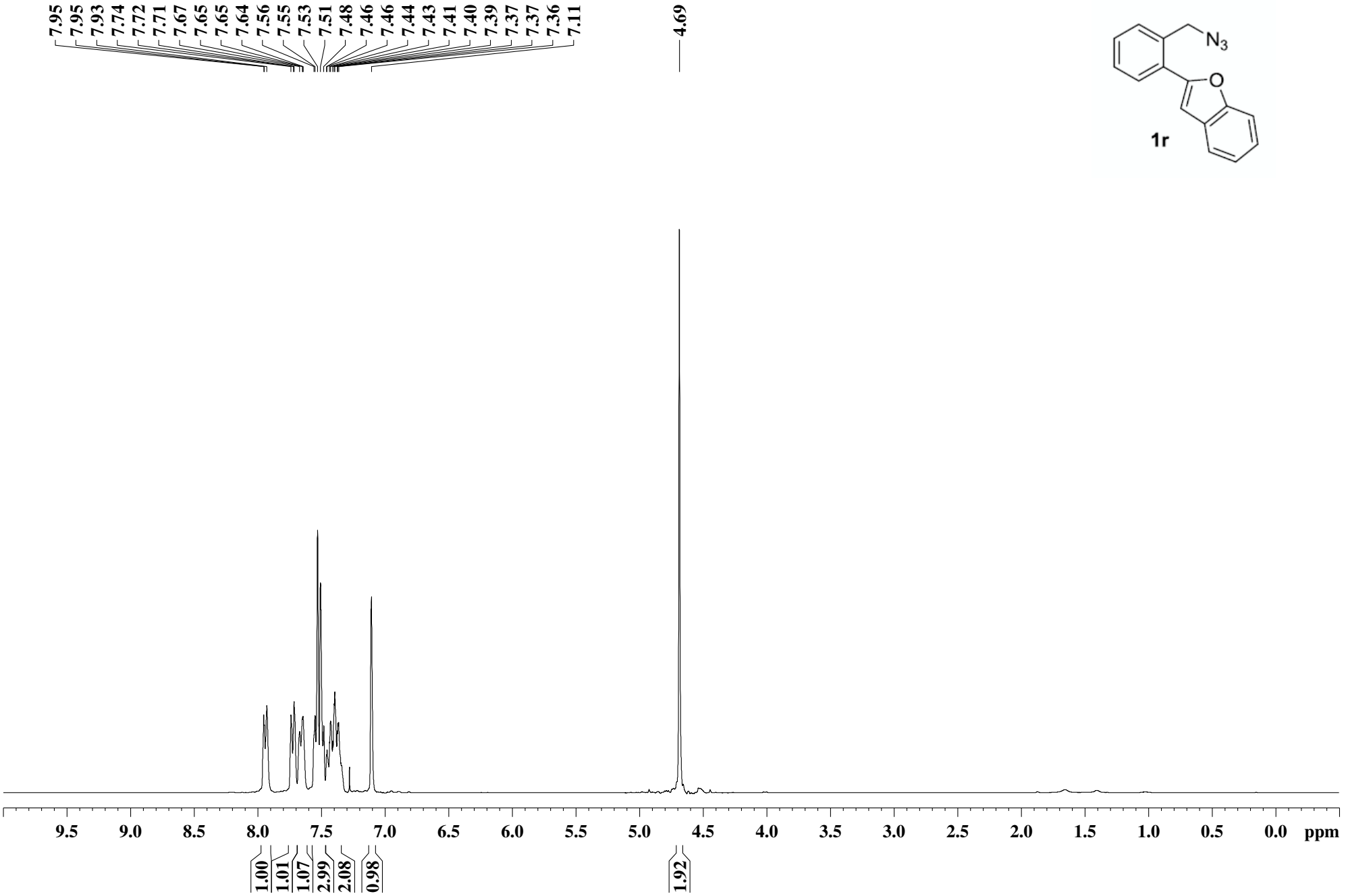
SK-1-165


141.13
140.18
140.03
134.31
133.48
131.27
129.95
128.69
128.43
124.49
124.39
123.81
123.70
121.95


52.66
N3
S
1q

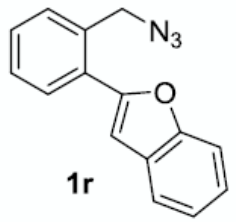

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK–1–109

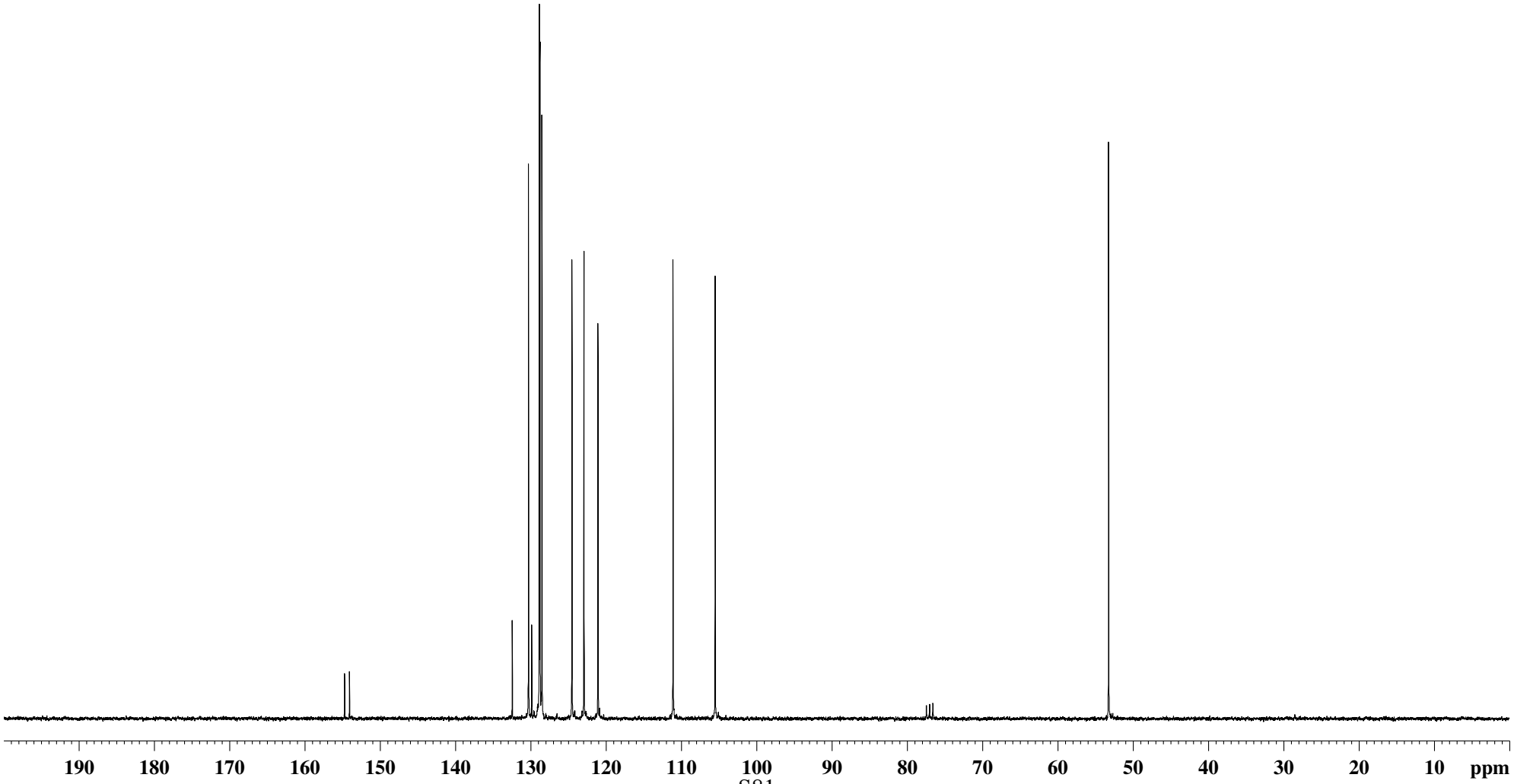

7.95
7.95
7.93
7.74
7.72
7.71
7.67
7.65
7.65
7.64
7.56
7.55
7.53
7.51
7.48
7.46
7.46
7.44
7.43
7.41
7.40
7.39
7.37
7.37
7.36
7.11
4.69
N3
O
1r
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
1.01
1.07
2.99
2.08
0.98
1.92

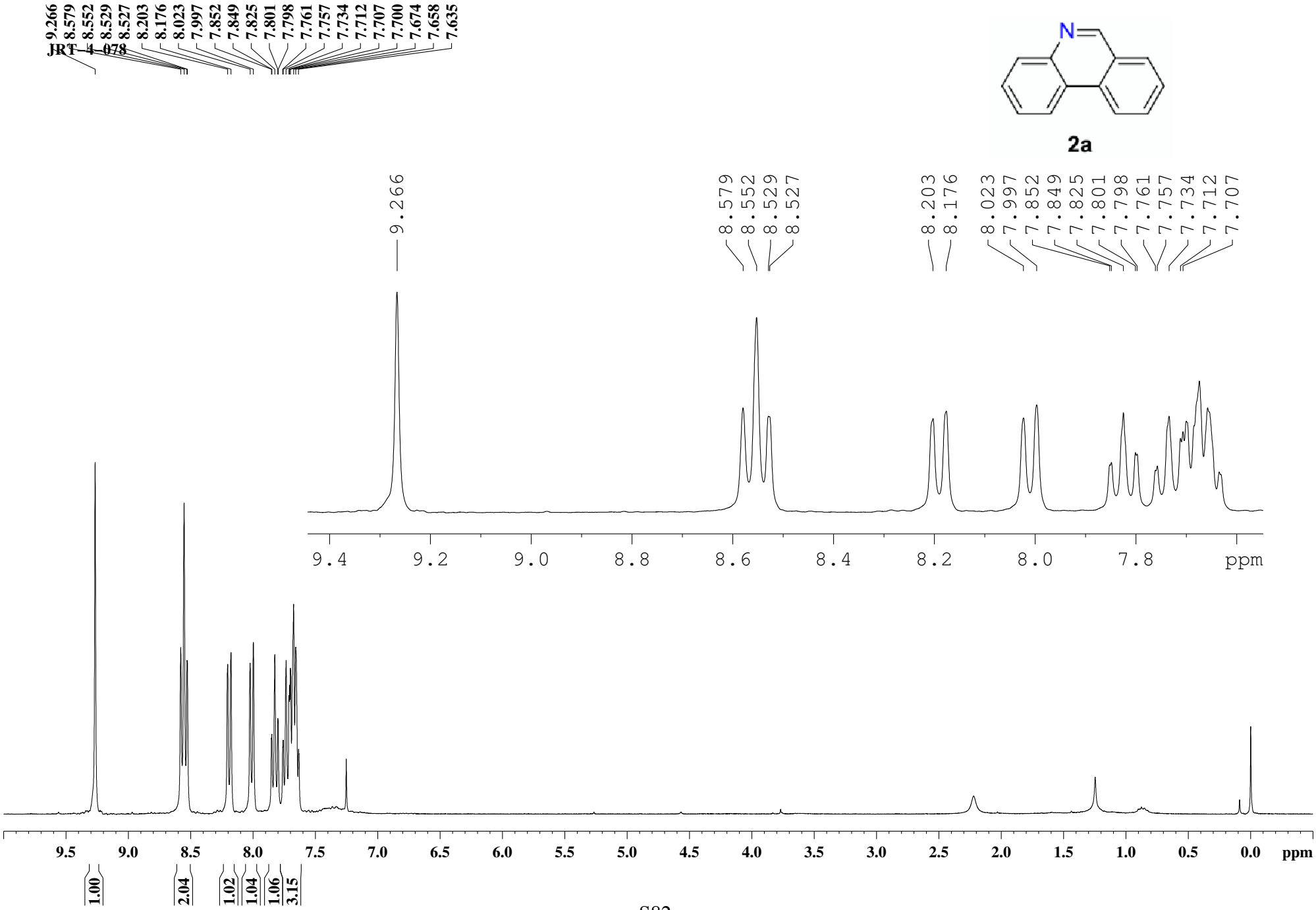
SK–1–109

154.72
154.08
132.45
130.29
129.87
128.87
128.77
128.50
124.52
122.92
121.06
111.09
105.50
53.23



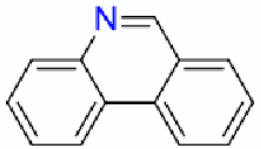
1r



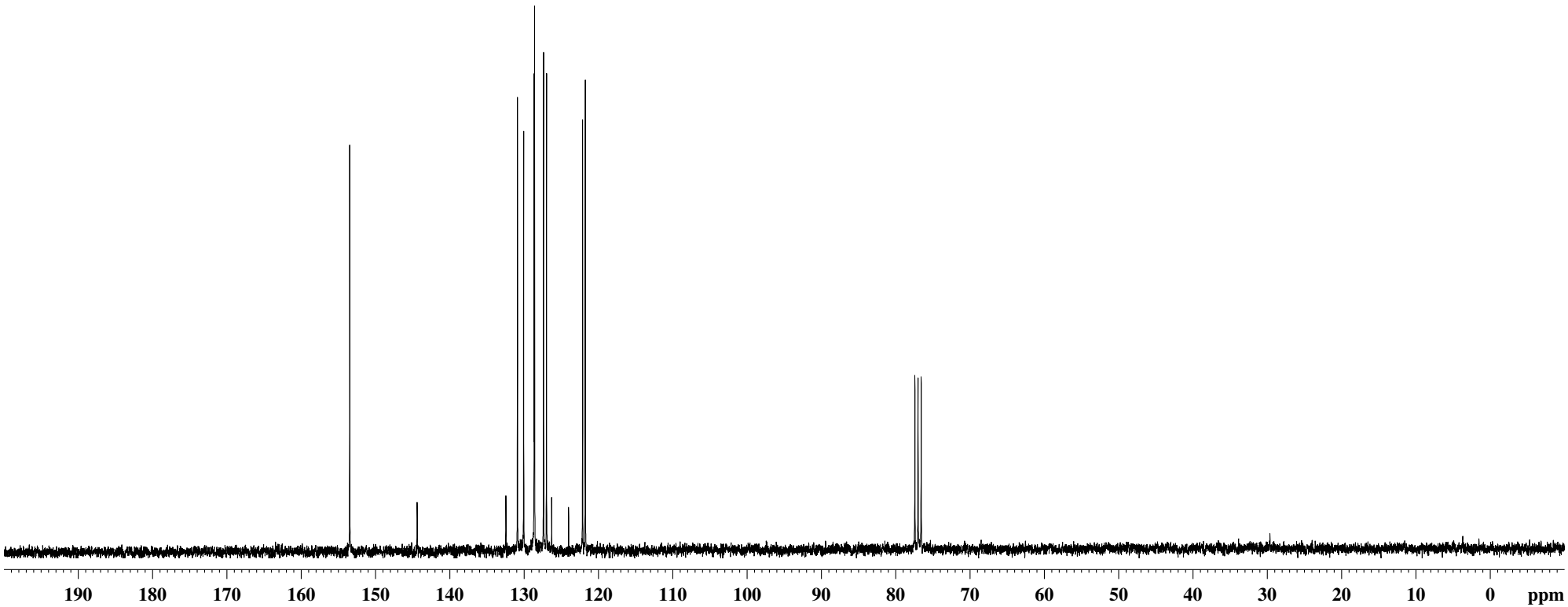

9.266
8.579
8.552
8.529
8.527
8.203
8.176
8.023
7.997
7.852
7.849
7.825
7.801
7.798
7.761
7.757
7.734
7.712
7.707
7.700
7.674
7.658
7.635
JRT-4-078
N
2a
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
7.8
ppm
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
2.04
1.02
1.04
1.06
3.15

JRT–4–078

153.486
144.397
132.464
130.911
130.070
128.669
128.607
127.399
127.001
126.304
124.023
122.141
121.778



2a

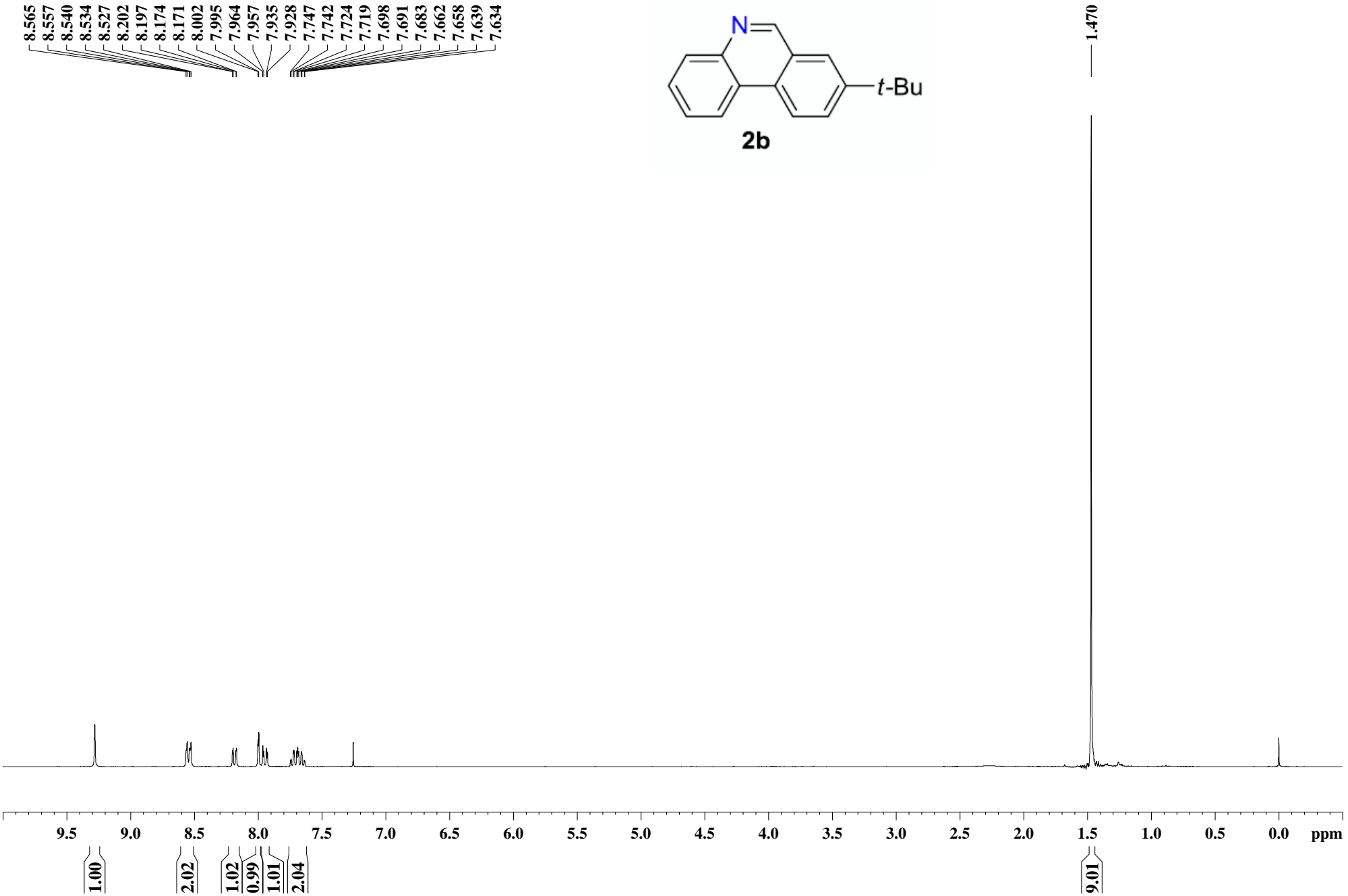


SK–1–114

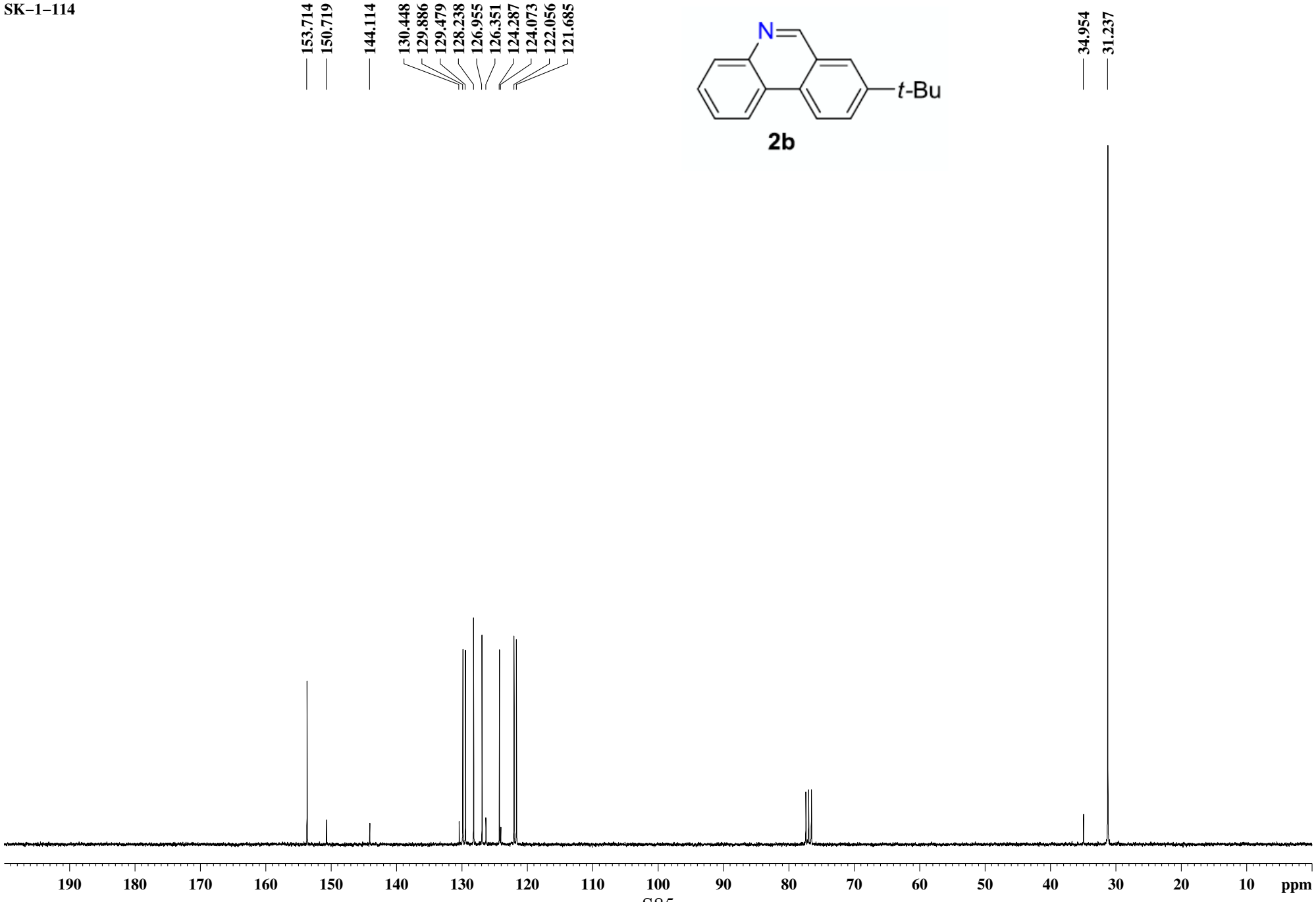
8.565
8.557
8.540
8.534
8.527
8.202
8.197
8.174
8.171
8.002
7.995
7.964
7.957
7.935
7.928
7.747
7.742
7.724
7.719
7.698
7.691
7.683
7.662
7.658
7.639
7.634

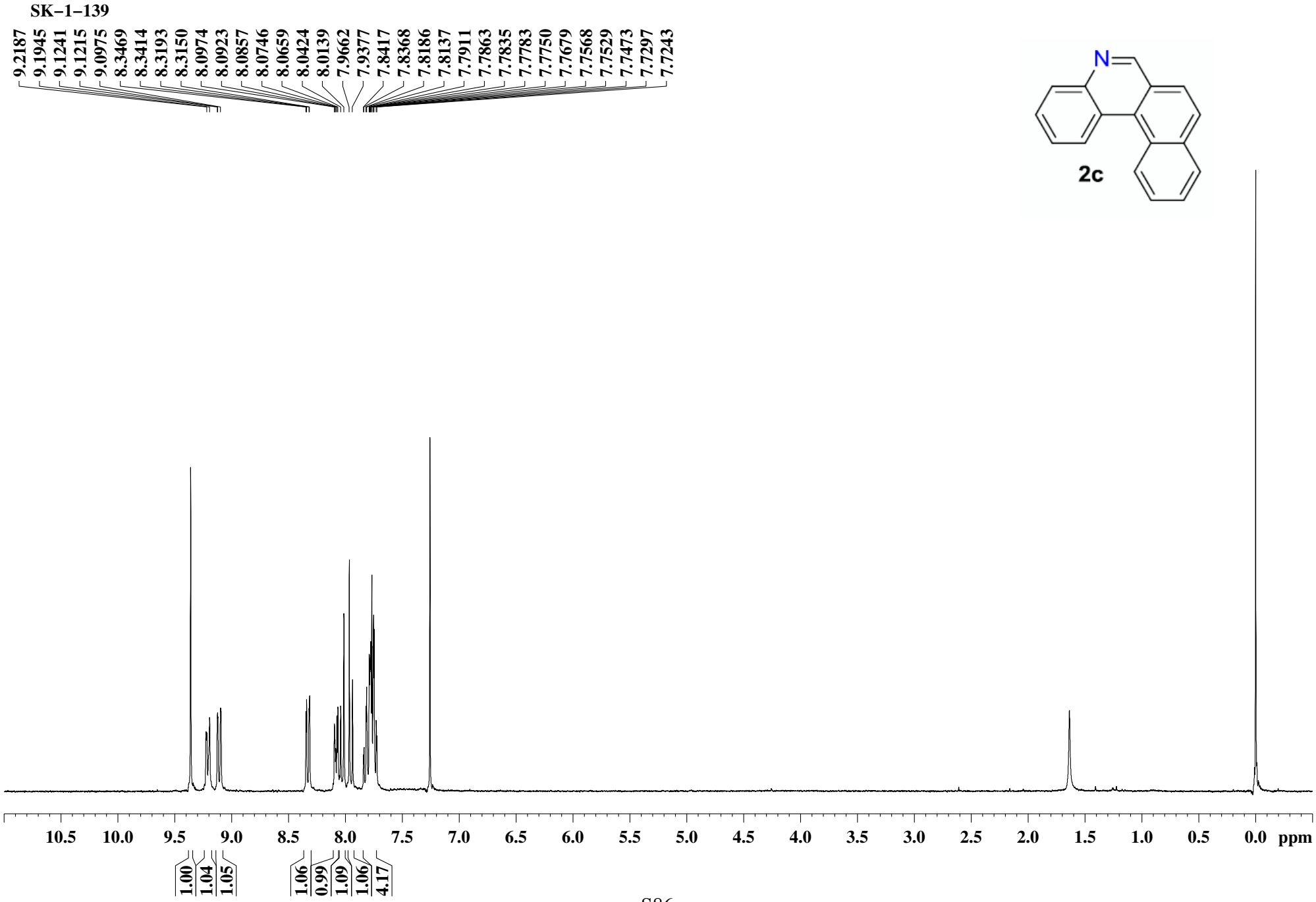
N
t-Bu

2b

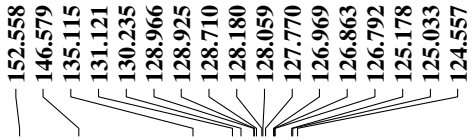

1.470
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
2.02
1.02
0.99
1.01
2.04
9.01

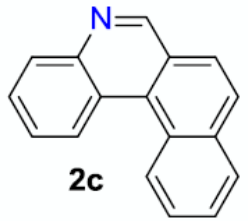
SK–1–114


153.714
150.719
144.114
130.448
129.886
129.479
128.238
126.955
126.351
124.287
124.073
122.056
121.685
34.954
31.237
N
t-Bu
2b
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

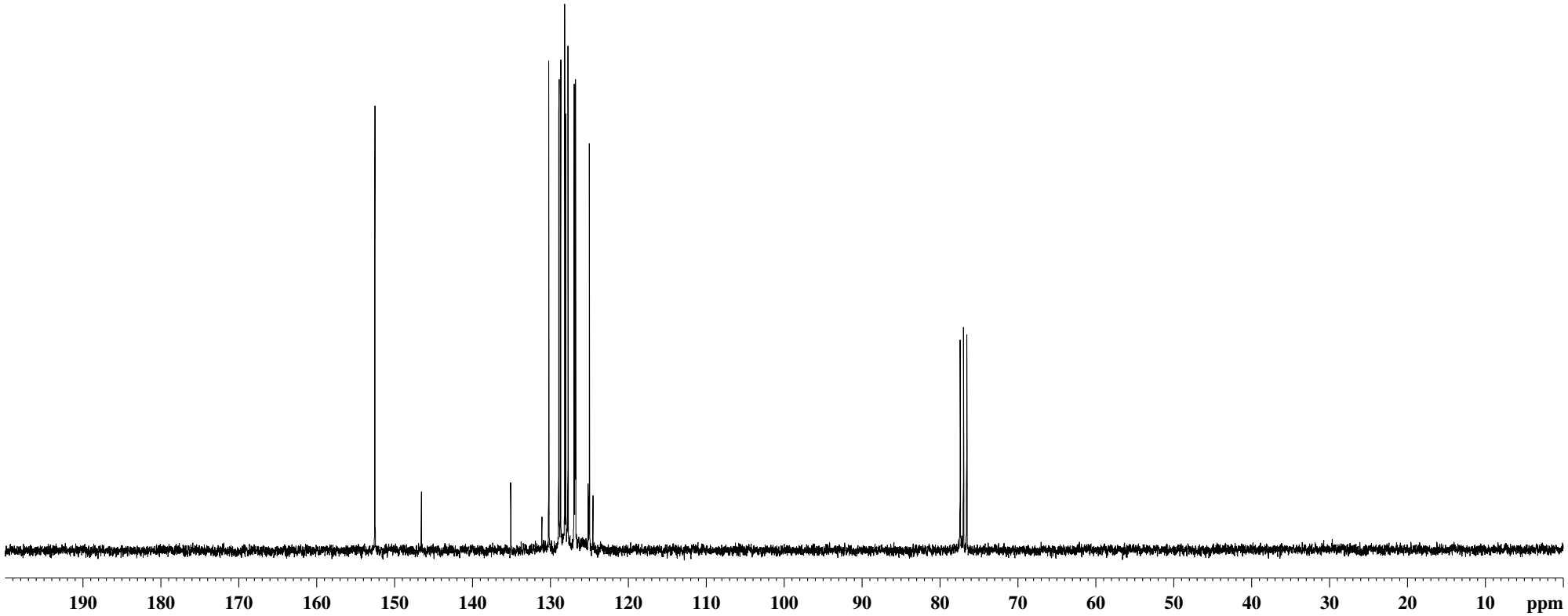

SK-1-139
9.2187
9.1945
9.1241
9.1215
9.0975
8.3469
8.3414
8.3193
8.3150
8.0974
8.0923
8.0857
8.0746
8.0659
8.0424
8.0139
7.9662
7.9377
7.8417
7.8368
7.8186
7.8137
7.7911
7.7863
7.7835
7.7783
7.7750
7.7679
7.7568
7.7529
7.7473
7.7297
7.7243
N
2c
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
1.04
1.05
1.06
0.99
1.09
1.06
4.17

SK–1–135


152.558
146.579
135.115
131.121
130.235
128.966
128.925
128.710
128.180
128.059
127.770
126.969
126.863
126.792
125.178
125.033
124.557

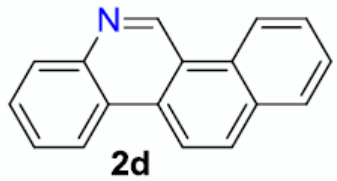

N

2c

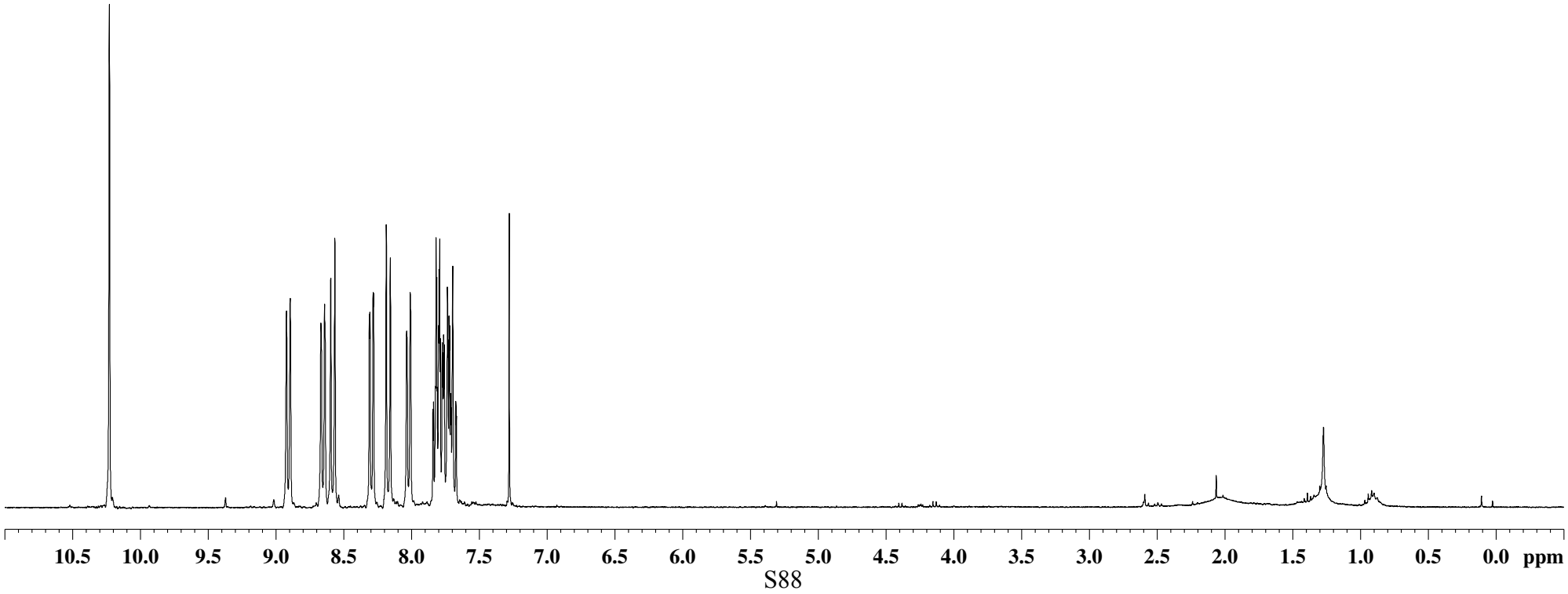

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK−1−167

8.6694
8.6422
8.5967
8.5665
8.3117
8.3076
8.2840
8.2808
8.1872
8.1571
8.0370
8.0107
7.8429
7.8382
7.8247
7.8199
7.8153
7.8110
7.8017
7.7971
7.7928
7.7878
7.7741
7.7692
7.7636
7.7587
7.7359
7.7316
7.7235
7.7198
7.7130
7.7084
7.6968
7.6736
7.6701

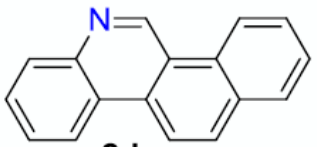


2d

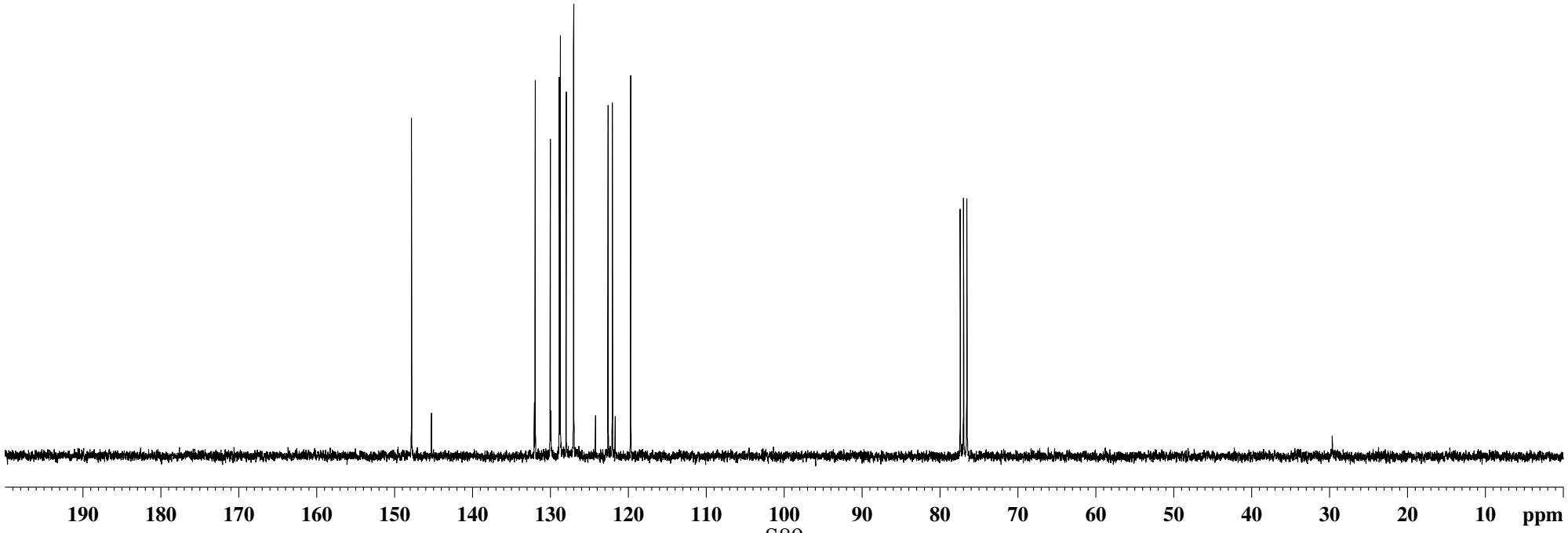


SK–1–167

147.81
145.23
132.10
131.98
130.05
129.97
128.88
128.77
128.01
127.06
127.04
124.24
122.63
122.08
121.71
119.73



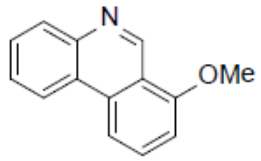
2d



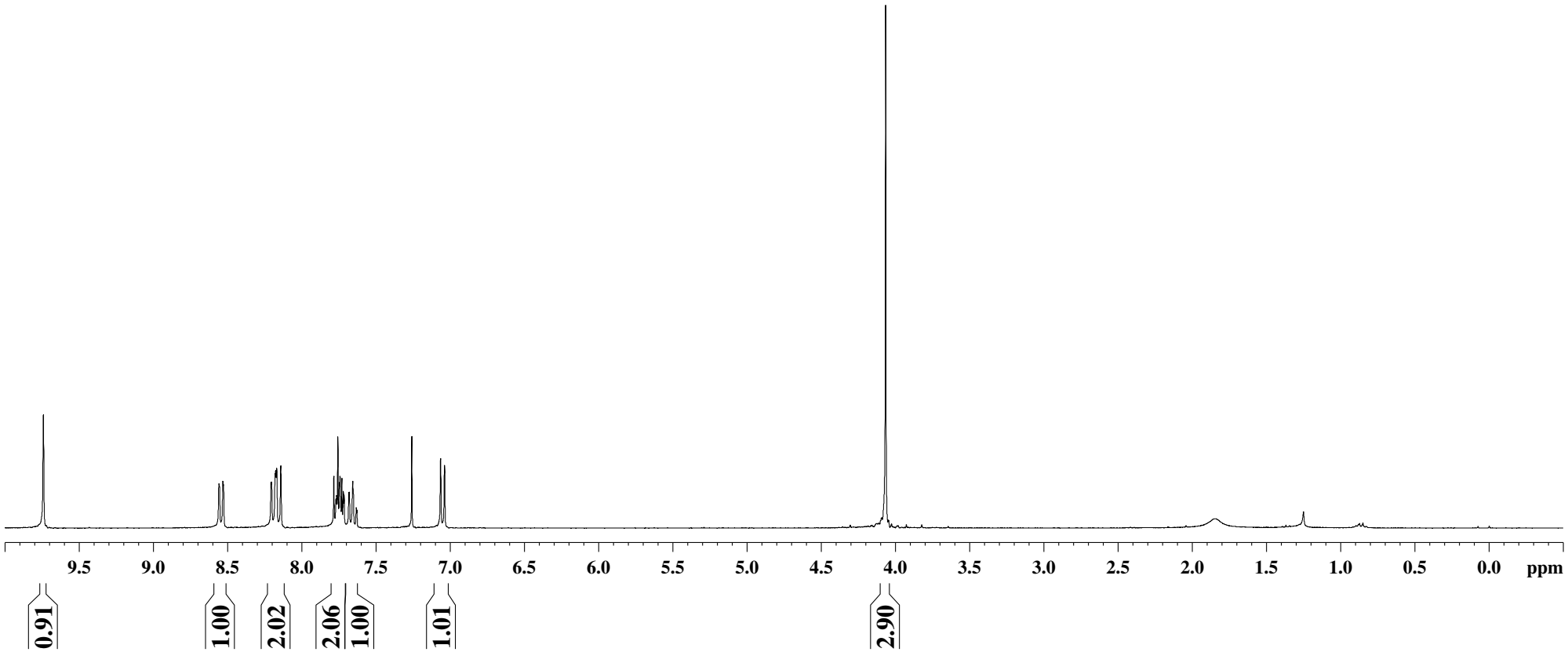
KN–1–031

9.740
8.560
8.533
8.529
8.209
8.205
8.181
8.178
8.171
8.143
7.786
7.772
7.767
7.759
7.748
7.744
7.731
7.721
7.717
7.685
7.681
7.658
7.654
7.635
7.630
7.066
7.040

4.067

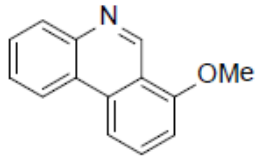


2e-A

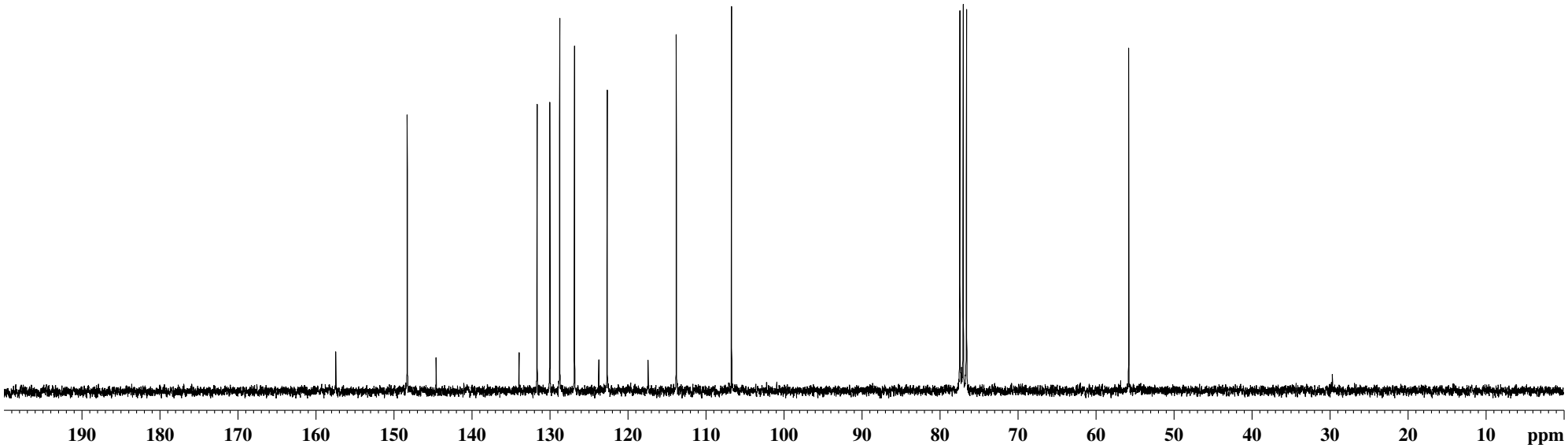


KN−1−031 (Minc

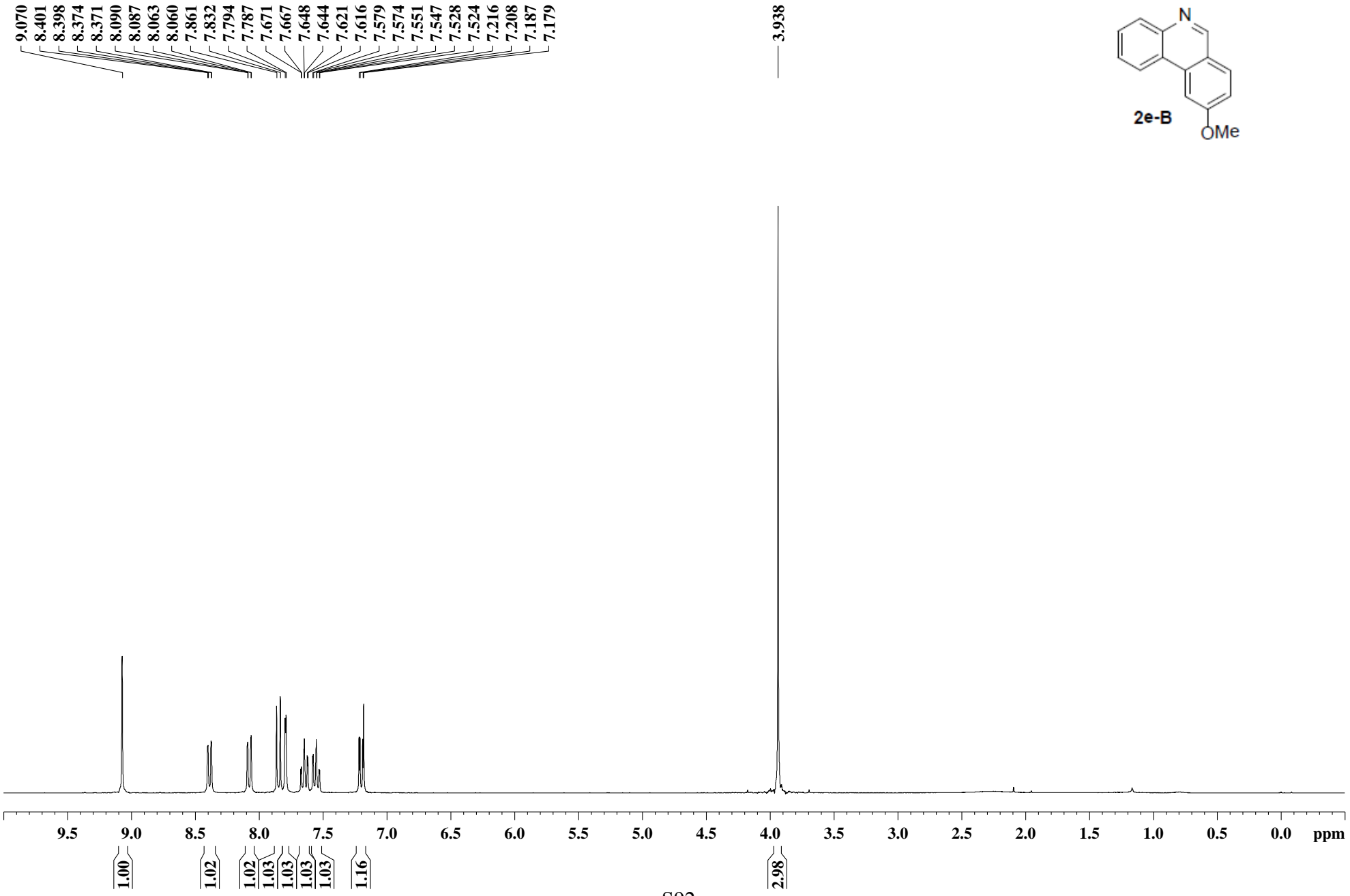
157.454
148.283
144.588
133.944
131.640
129.999
128.739
126.843
123.721
122.653
117.414
113.785
106.706
55.776



2e-A

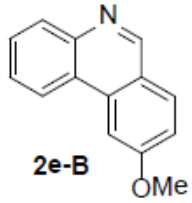


KN–1–031

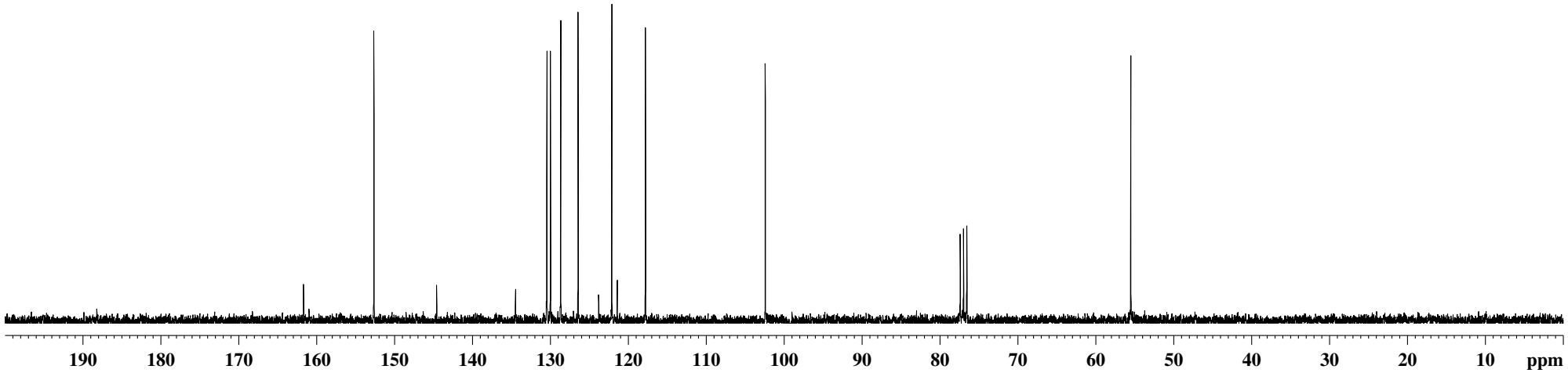

9.070
8.401
8.398
8.374
8.371
8.090
8.087
8.063
8.060
7.861
7.832
7.794
7.787
7.671
7.667
7.648
7.644
7.621
7.616
7.579
7.574
7.551
7.547
7.528
7.524
7.216
7.208
7.187
7.179
3.938
N
2e-B
OMe
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
1.02
1.02
1.03
1.03
1.03
1.03
1.16
2.98

KN–1–031

161.709
152.675
144.626
134.502
130.480
130.013
128.701
126.473
123.827
122.142
121.435
117.822
102.442
55.525



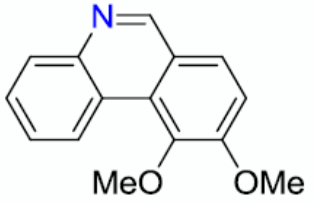
2e-B



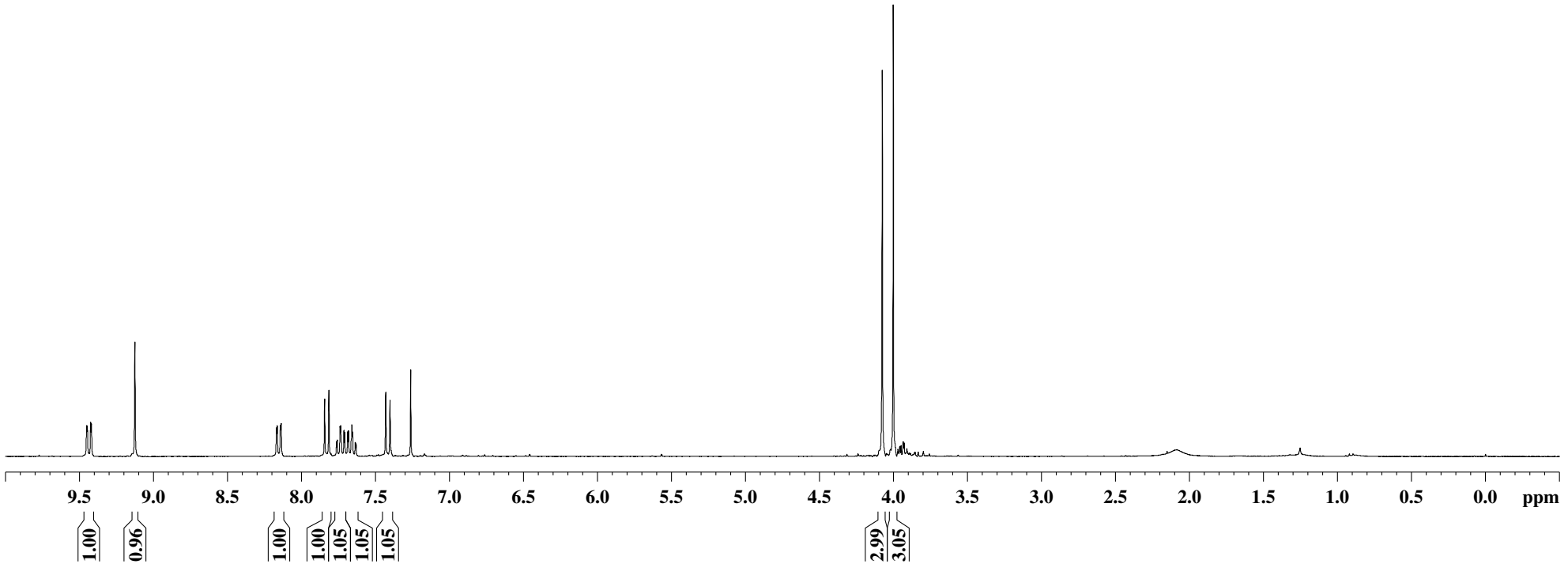
SK–1–103

9.450 9.446 9.423 9.418 9.124 8.168 8.162 8.141 8.136 7.842 7.813 7.765 7.760 7.741 7.736 7.715 7.709 7.689 7.684 7.665 7.661 7.656 7.638 7.633 7.432 7.403

4.077 4.003

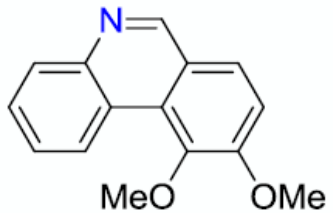


2f

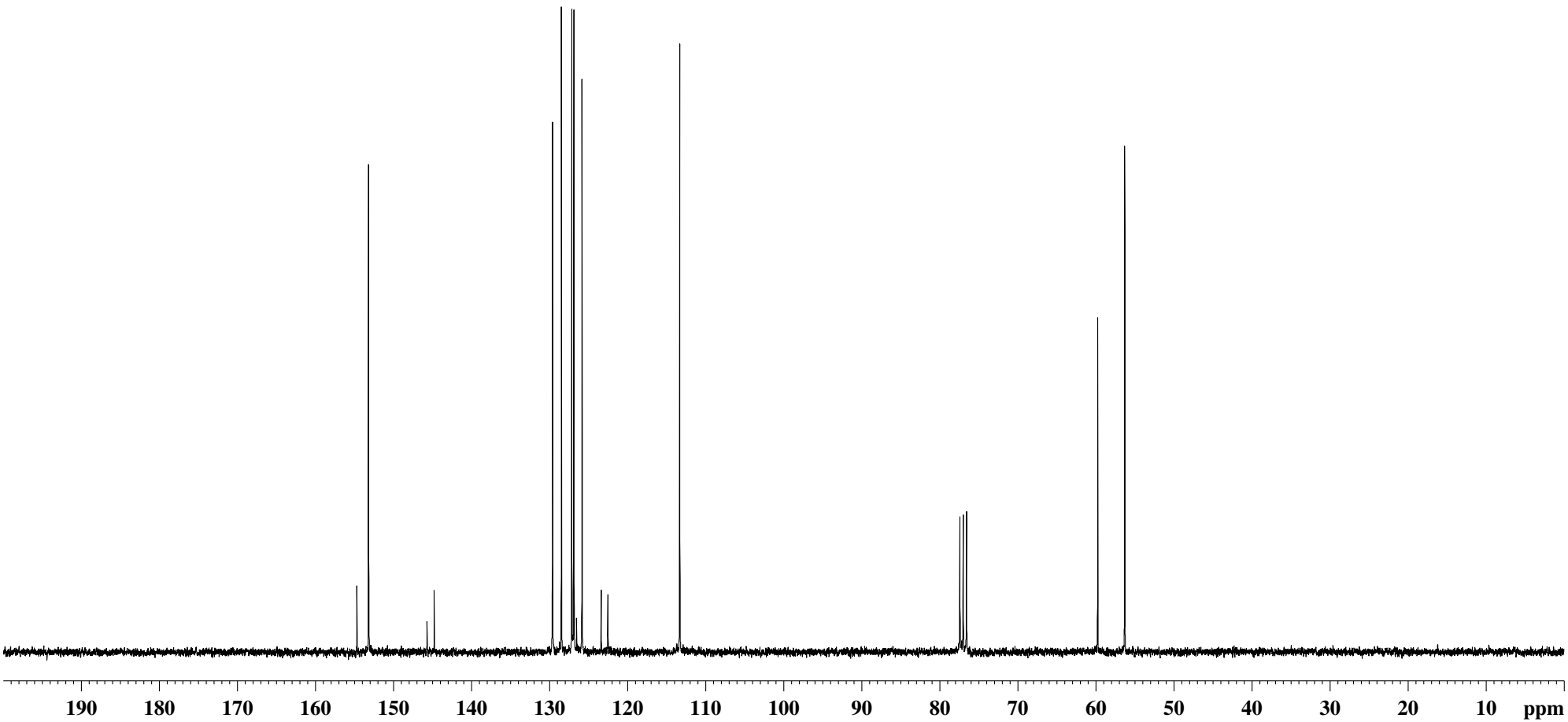


SK–1–103

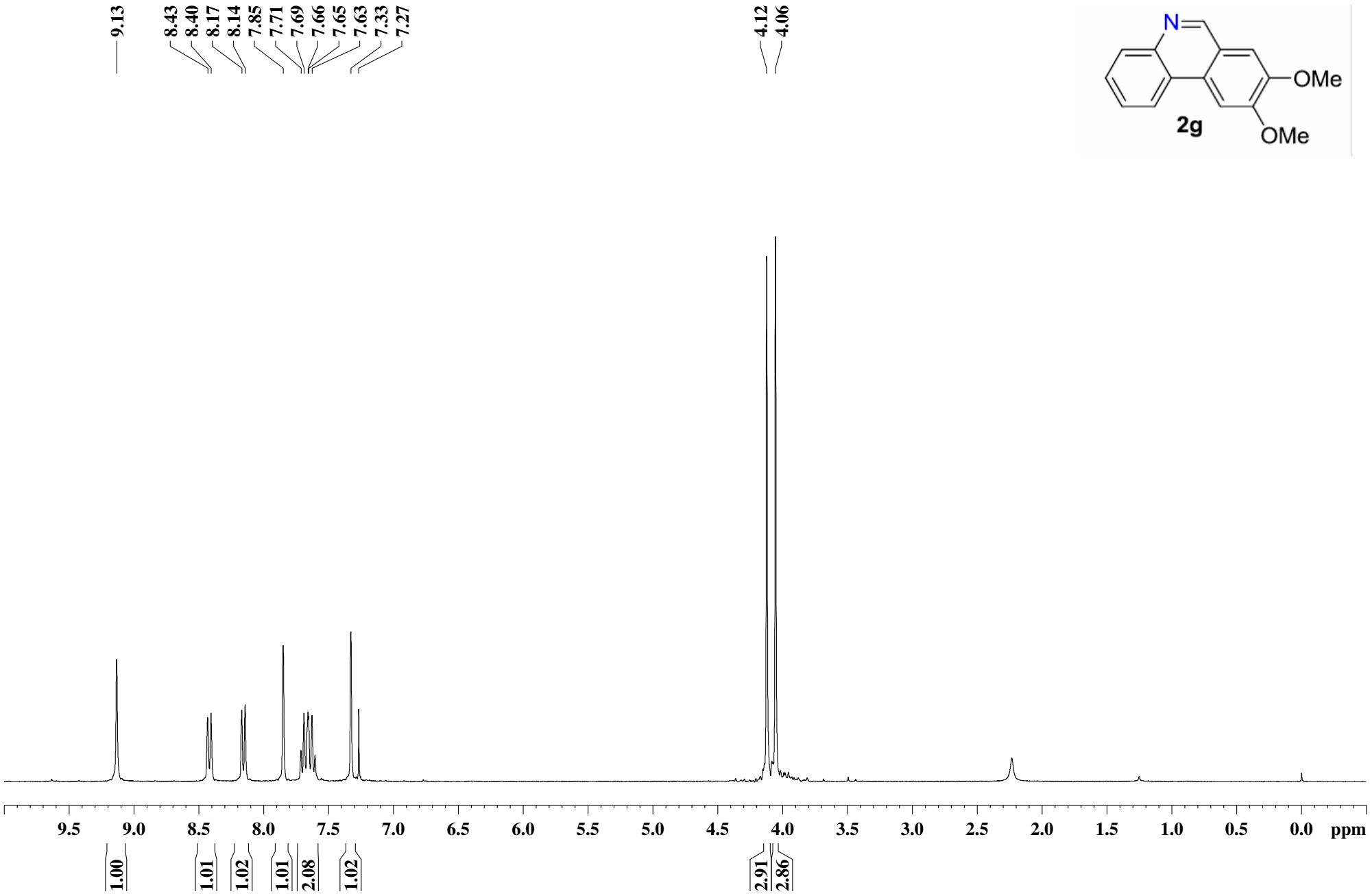
154.7018
153.2097
145.7210
144.8039
129.6314
128.4983
127.1588
126.8933
126.5640
125.8519
123.3865
122.5334
113.3314
59.7650
56.2991



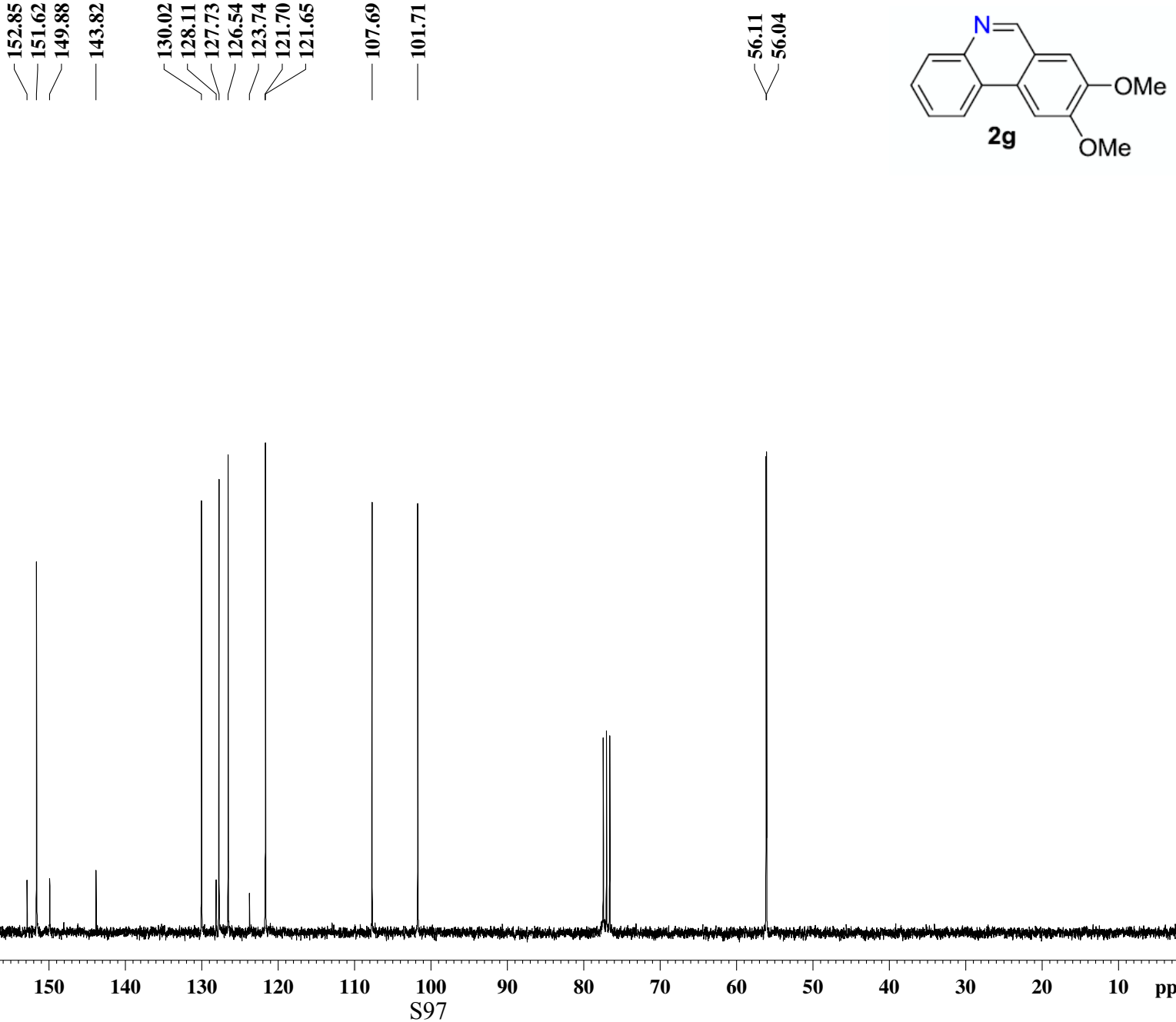
2f



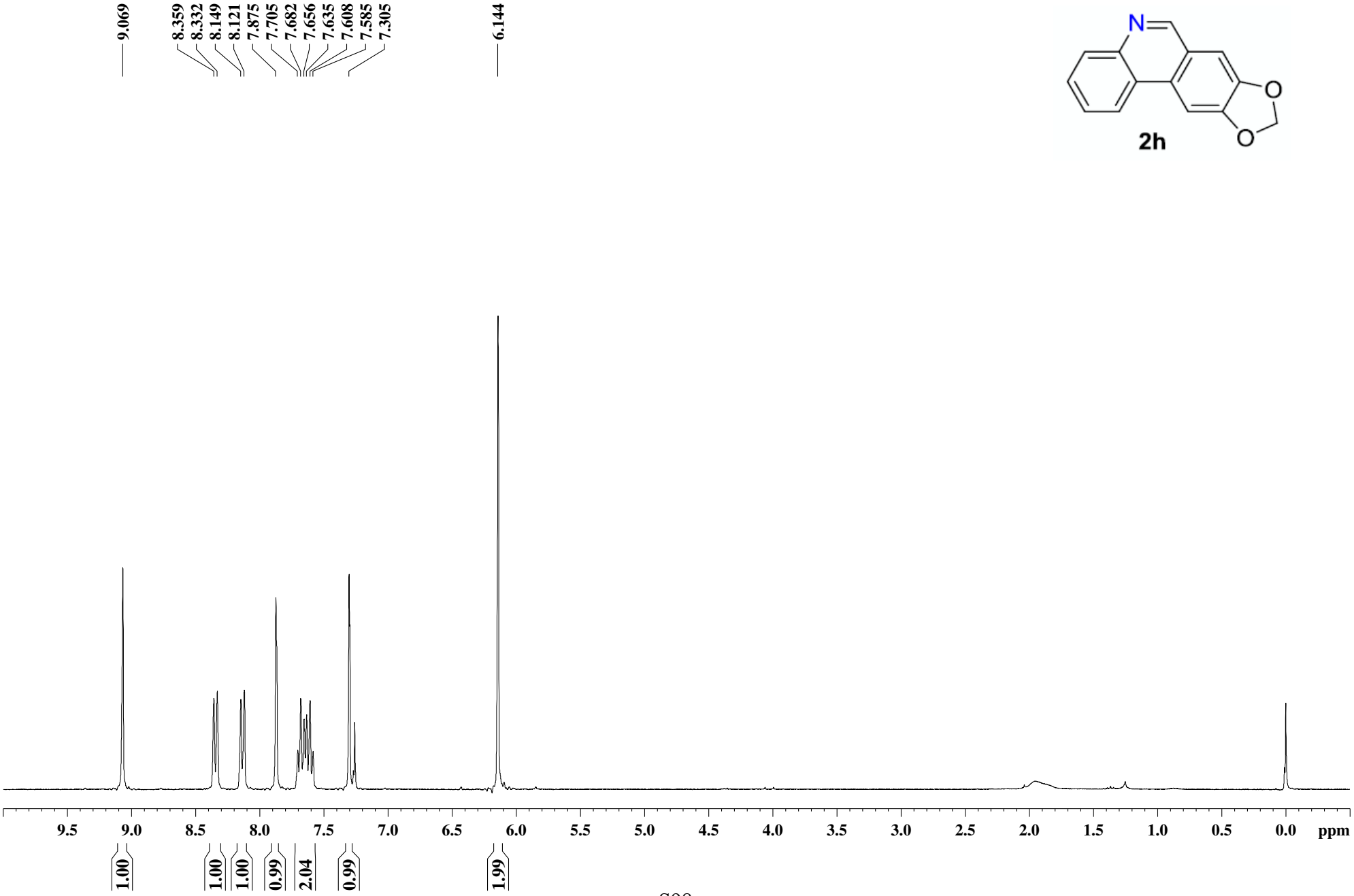
SK-1-106


9.13
8.43
8.40
8.17
8.14
7.85
7.71
7.69
7.66
7.65
7.63
7.33
7.27
4.12
4.06
N
OMe
OMe
2g
9.5
9.0
8.5
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
ppm
1.00
1.01
1.02
1.01
2.08
1.02
2.91
2.86

SK-1-106

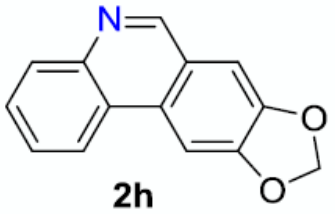

152.85
151.62
149.88
143.82
130.02
128.11
127.73
126.54
123.74
121.70
121.65
107.69
101.71
56.11
56.04
N
OMe
OMe
2g
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK–1–117

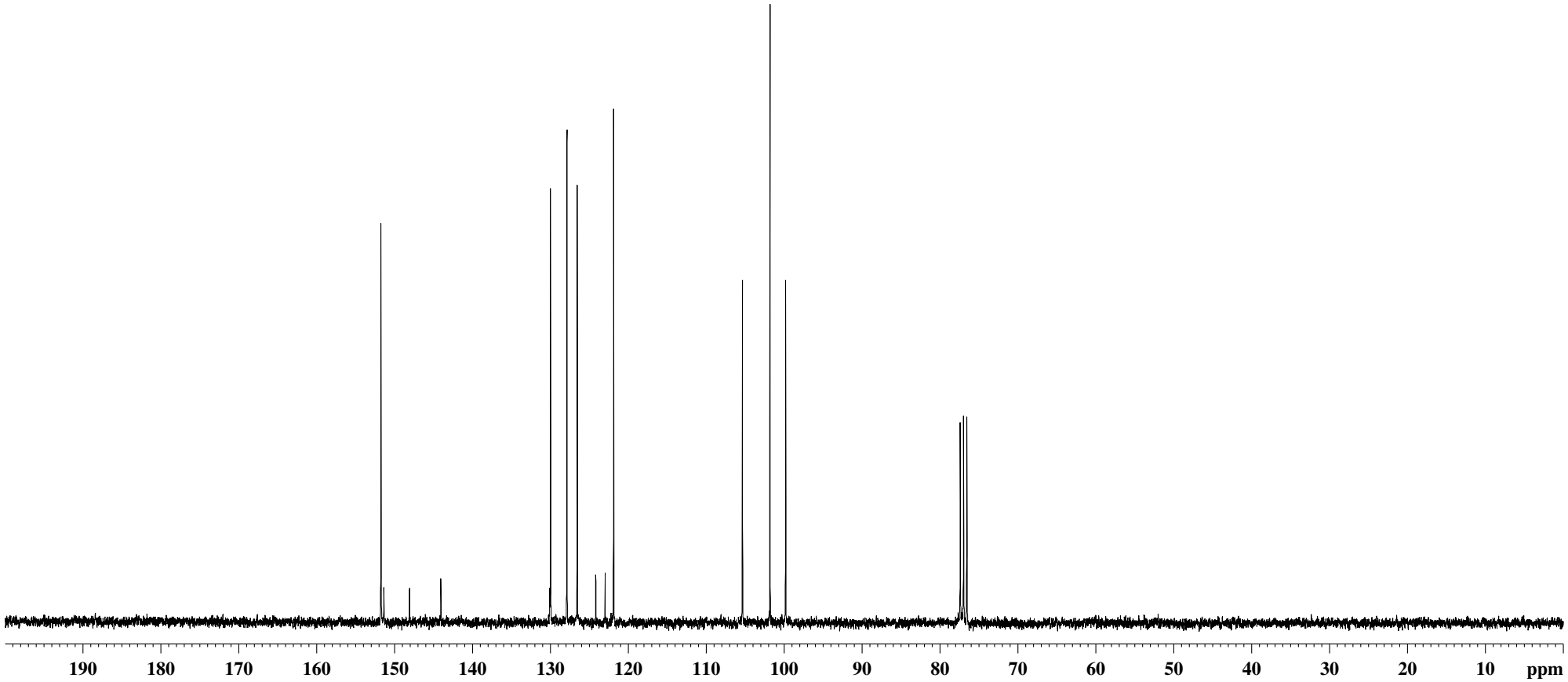

9.069
8.359
8.332
8.149
8.121
7.875
7.705
7.682
7.656
7.635
7.608
7.585
7.305
6.144
N
O
O
2h
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
1.00
1.00
0.99
2.04
0.99
1.99

SK–1–117

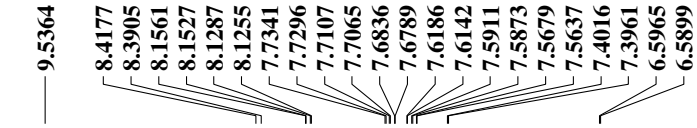
151.729
151.364
148.110
144.100
130.131
130.015
127.909
126.589
124.209
123.010
121.920
105.380
101.843
99.838

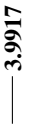


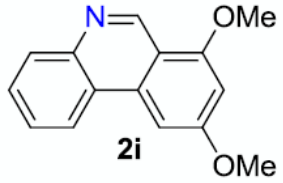
2h

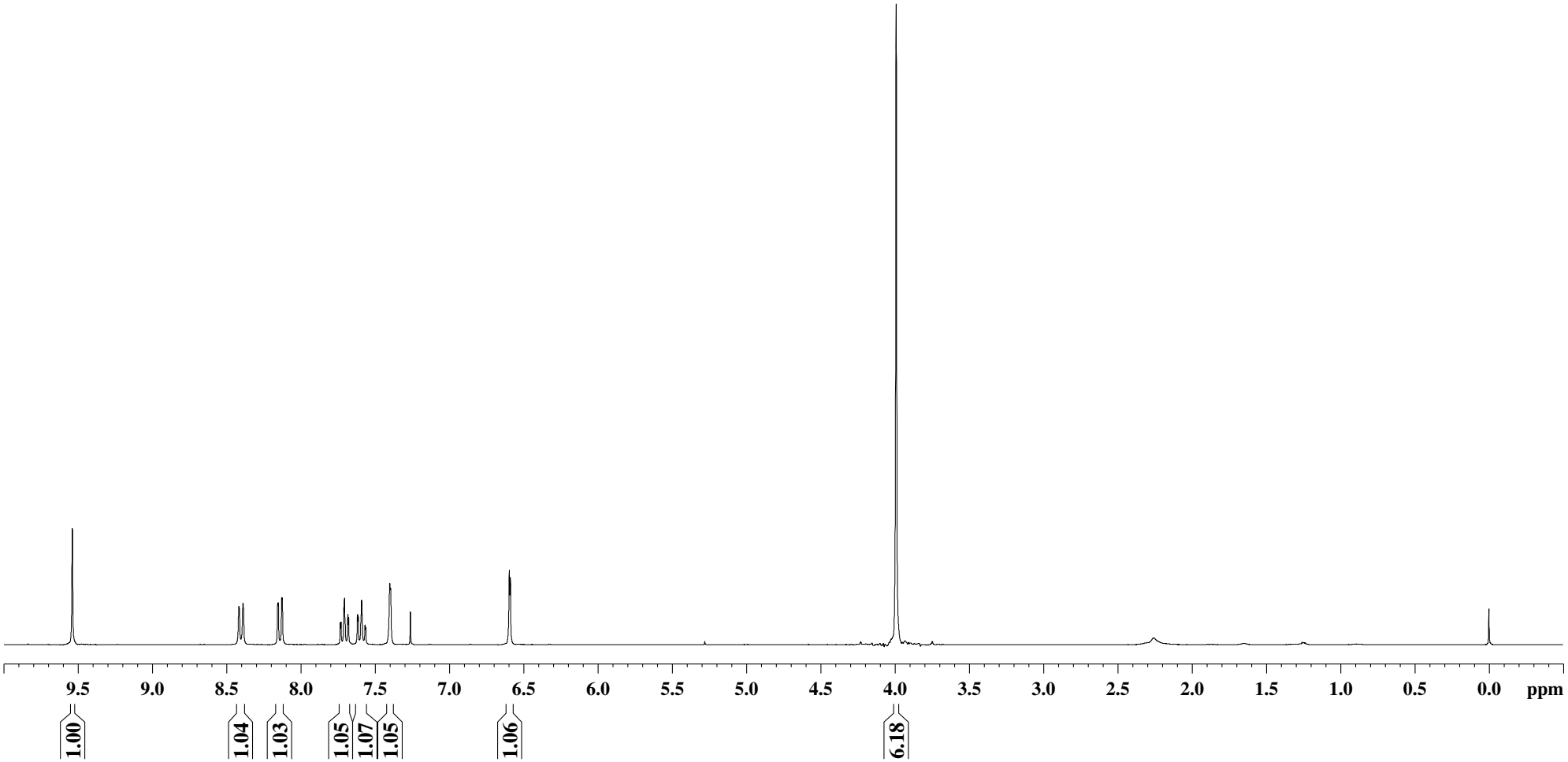


SK–1–190


9.5364
8.4177
8.3905
8.1561
8.1527
8.1287
8.1255
7.7341
7.7296
7.7107
7.7065
7.6836
7.6789
7.6186
7.6142
7.5911
7.5873
7.5679
7.5637
7.4016
7.3961
6.5965
6.5899

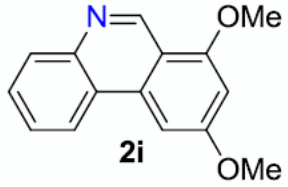

3.9917


N
OMe
OMe
2i

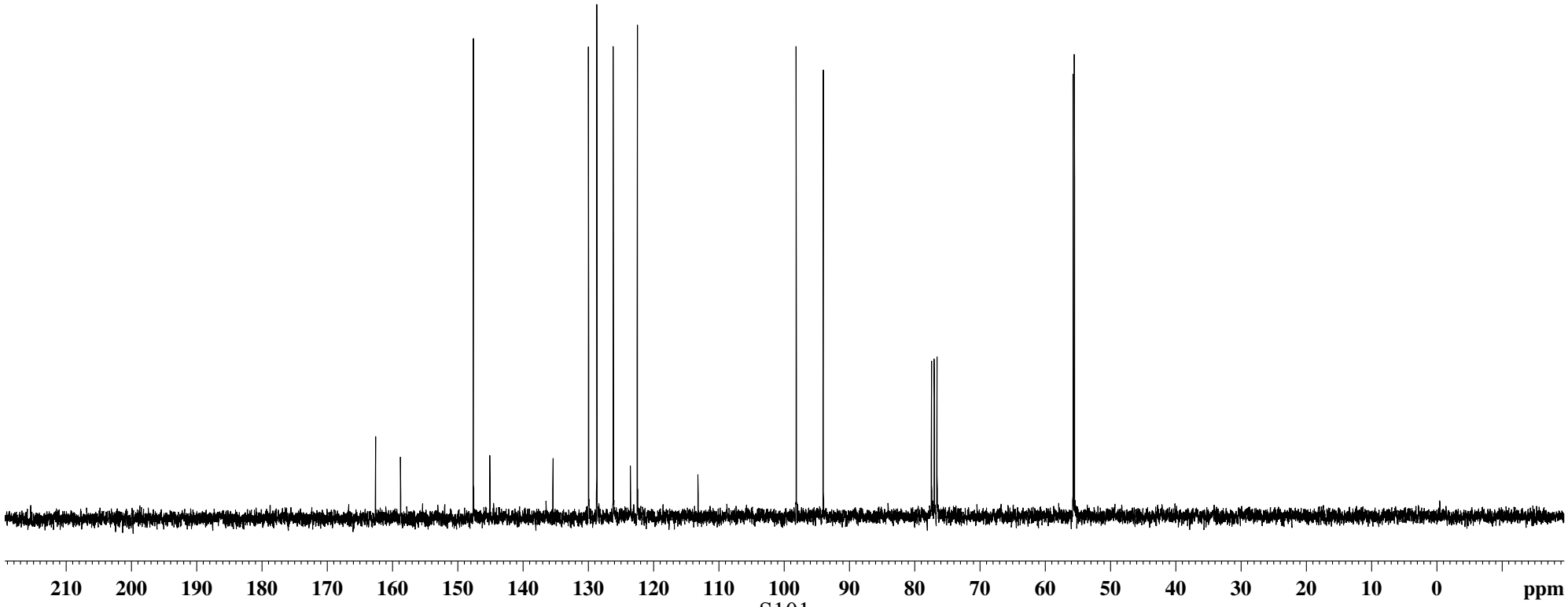

9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
1.04
1.03
1.05
1.07
1.05
1.06
6.18

SK–1–190

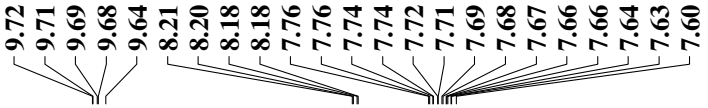
162.6117
158.7787
147.6227
145.1071
135.4245
129.9732
128.7119
126.1873
123.5508
122.4948
113.1955
98.1525
94.0157
55.7223
55.5223



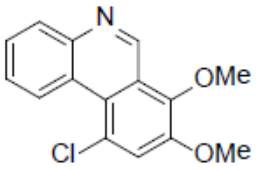
2i



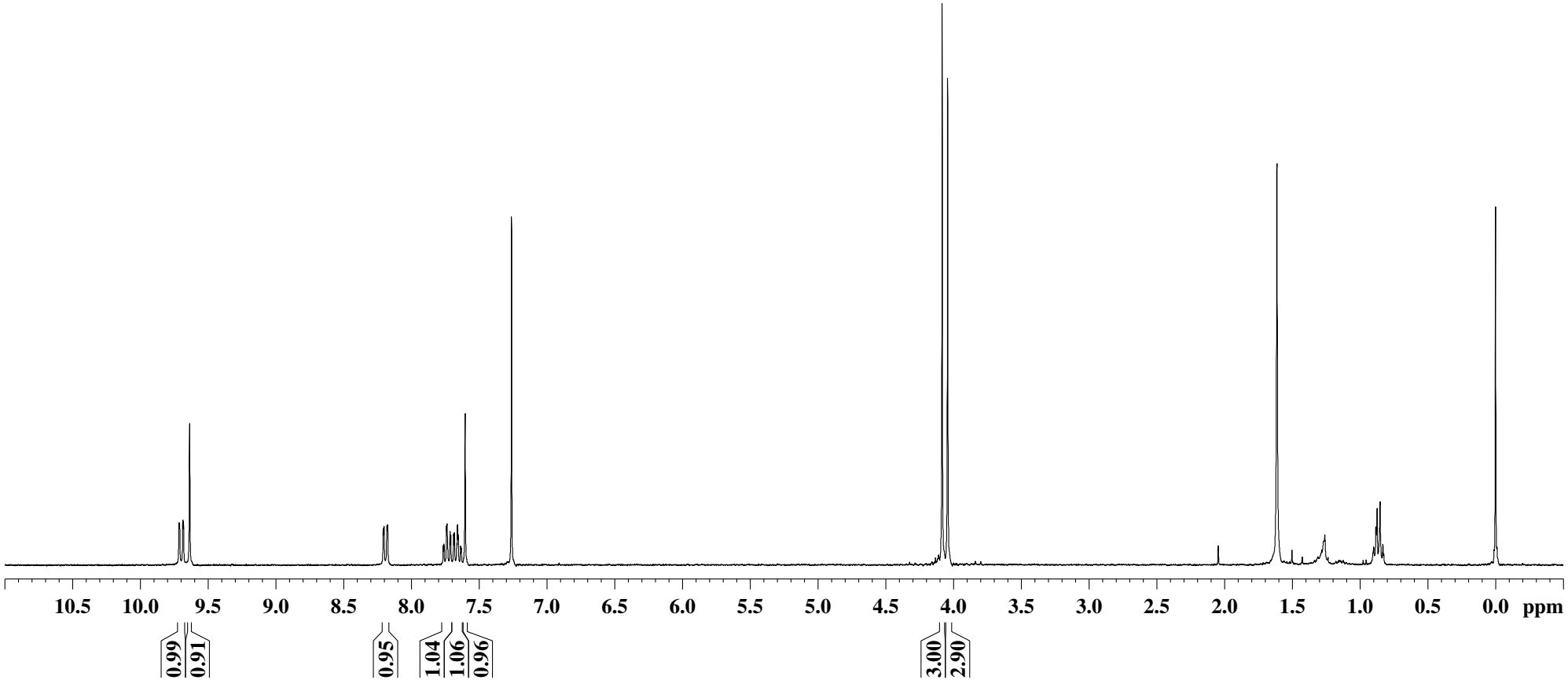
KN–1–040


9.72
9.71
9.69
9.68
9.64
8.21
8.20
8.18
8.18
7.76
7.76
7.74
7.74
7.72
7.71
7.69
7.68
7.67
7.66
7.66
7.64
7.63
7.60


4.08
4.04


N
OMe
Cl
OMe

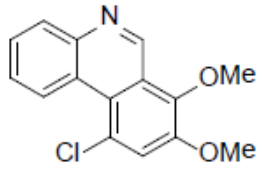
2j-A


10.5
10.0
9.5
9.0
8.5
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
ppm
0.99
0.91
0.95
1.04
1.06
0.96
3.00
2.90

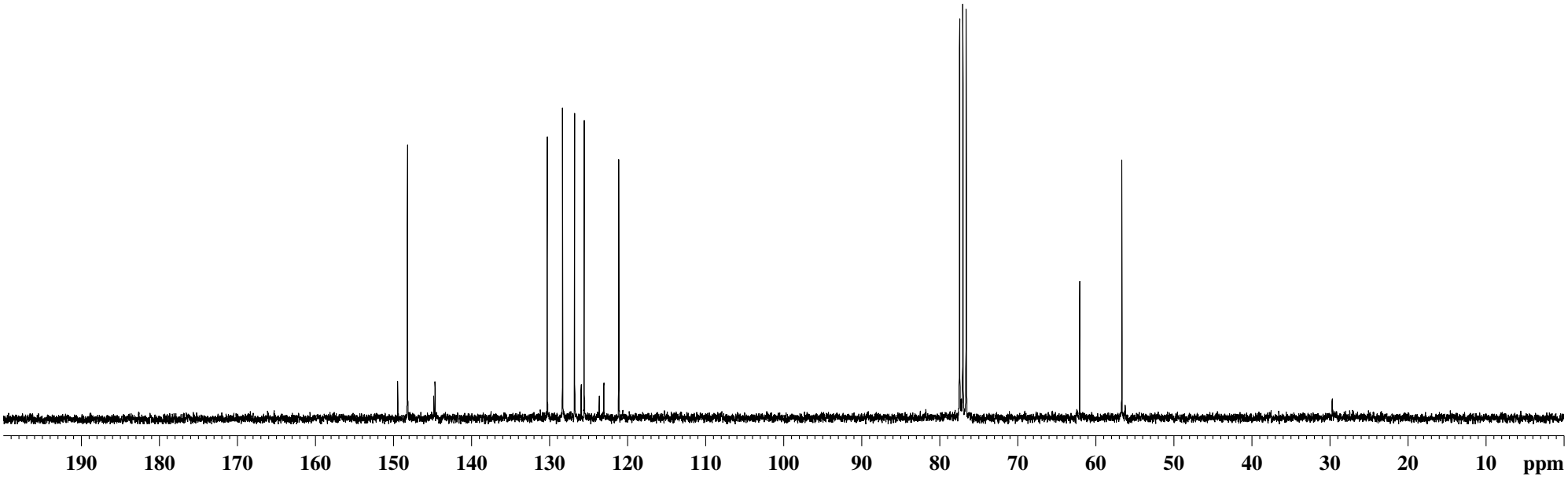
KN–1–040

149.42
148.18
144.80
144.63
130.27
128.30
126.75
125.92
125.53
123.60
123.04
123.01
121.10

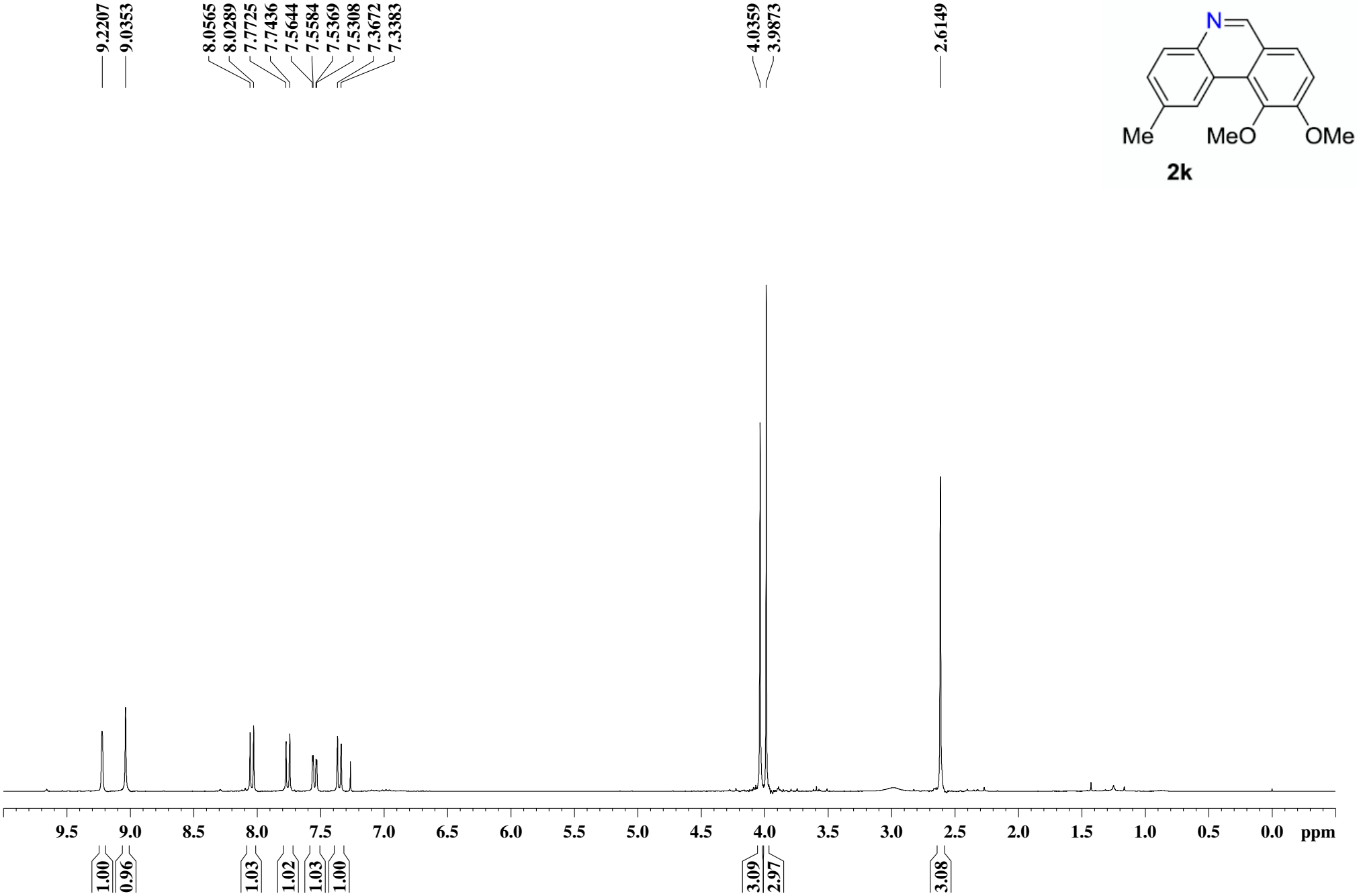
62.03
56.63



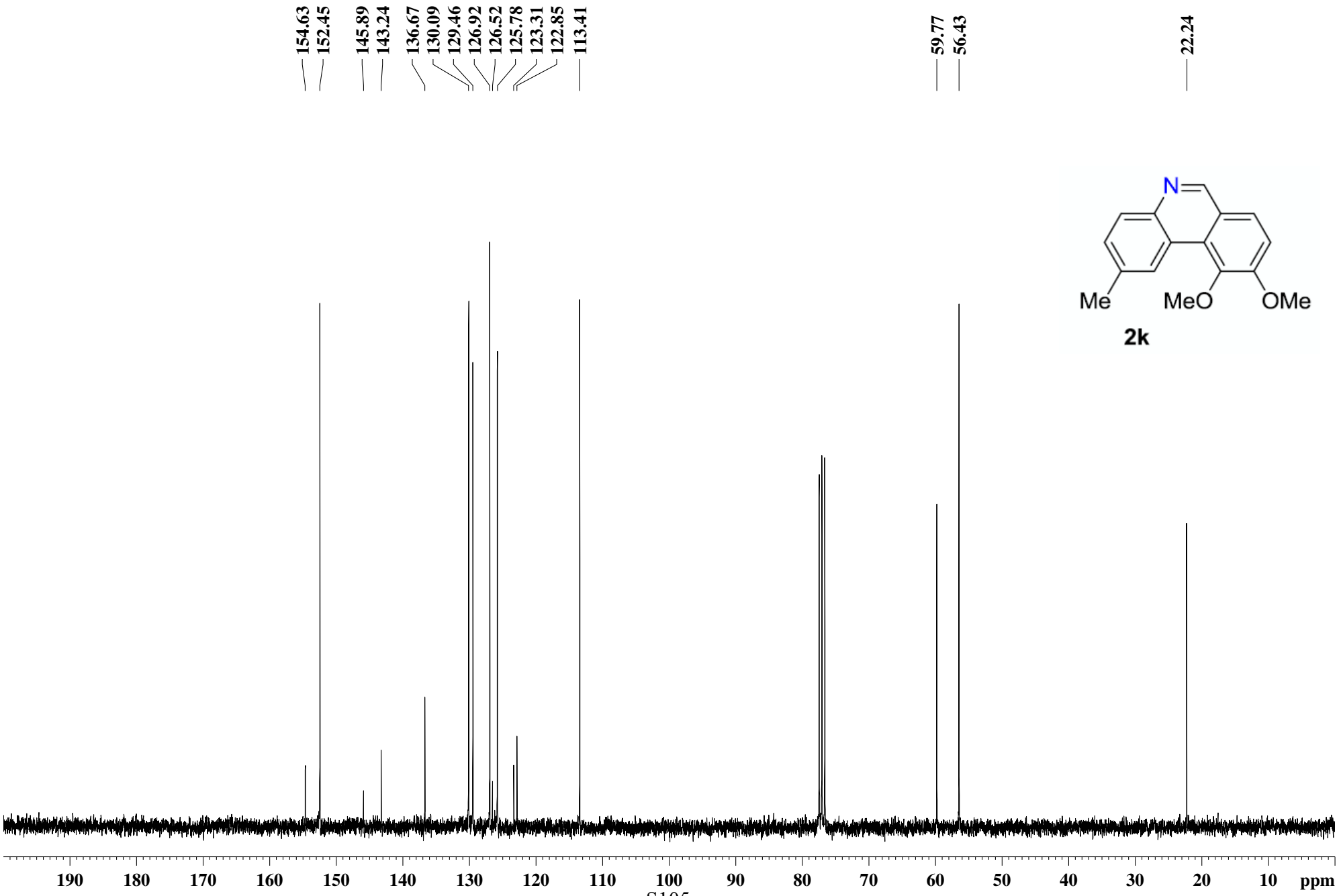
2j-A



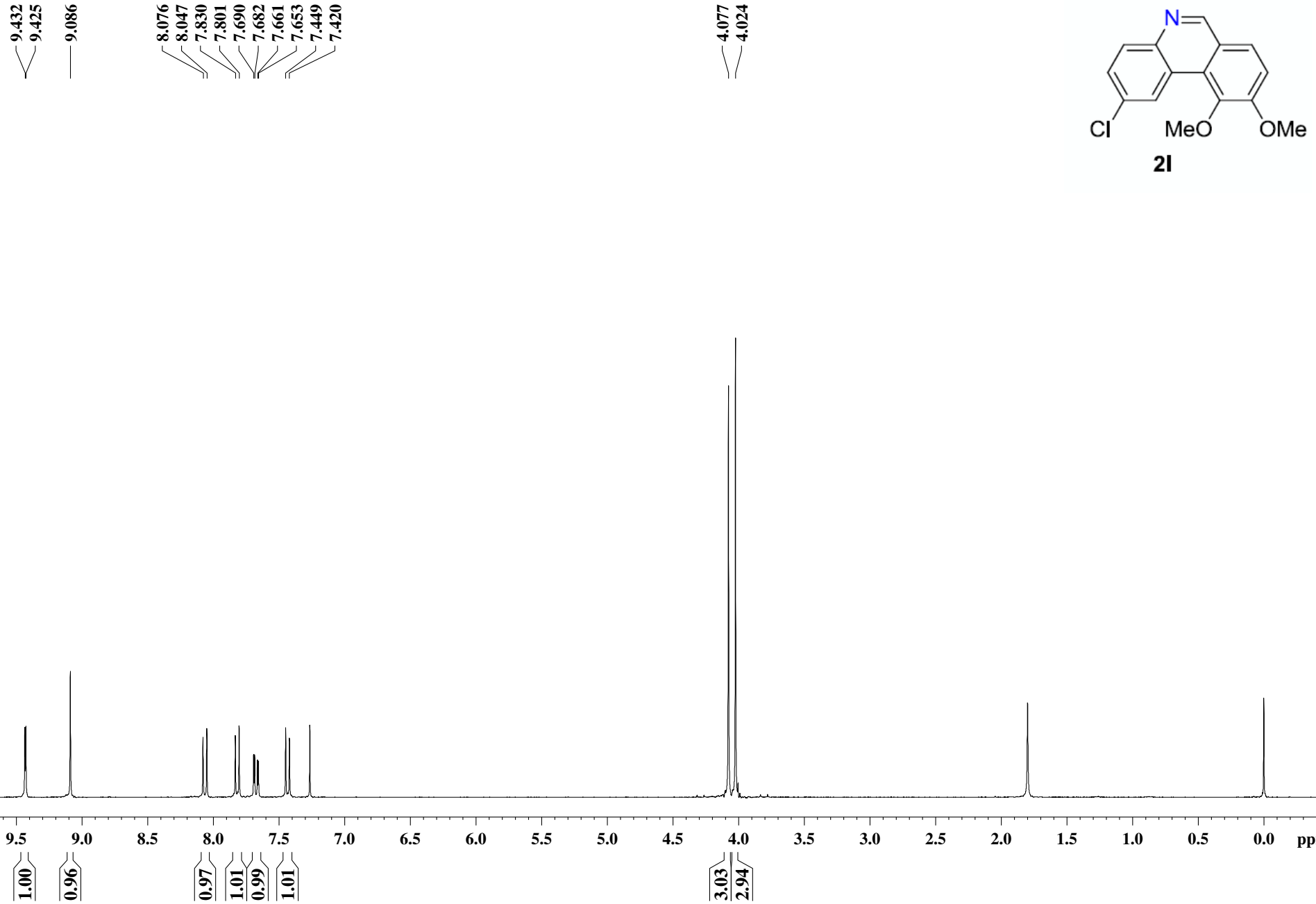
SK-1-111


9.2207
9.0353
8.0565
8.0289
7.7725
7.7436
7.5644
7.5584
7.5369
7.5308
7.3672
7.3383
4.0359
3.9873
2.6149
N
Me
MeO
OMe
2k
9.5
9.0
8.5
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
ppm
1.00
0.96
1.03
1.02
1.03
1.00
3.09
2.97
3.08

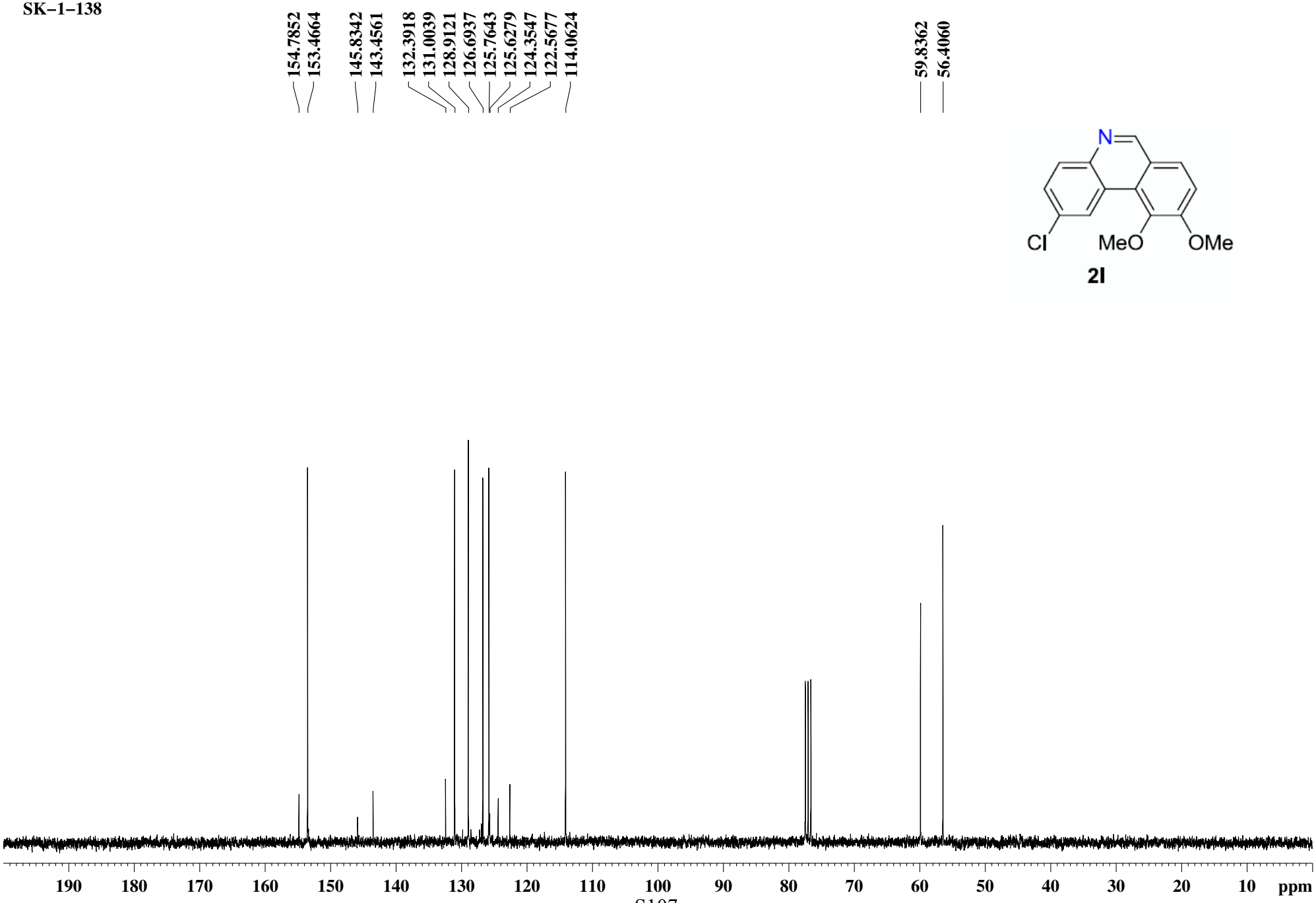
SK–1–111


154.63
152.45
145.89
143.24
136.67
130.09
129.46
126.92
126.52
125.78
123.31
122.85
113.41
59.77
56.43
22.24
N
Me
MeO
OMe
2k
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

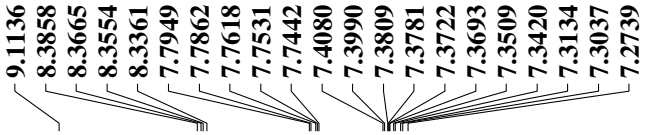
SK–1–138


9.432
9.425
9.086
8.076
8.047
7.830
7.801
7.690
7.682
7.661
7.653
7.449
7.420
4.077
4.024
N
Cl
MeO
OMe
2l
9.5
9.0
8.5
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
ppm
1.00
0.96
0.97
1.01
0.99
1.01
3.03
2.94

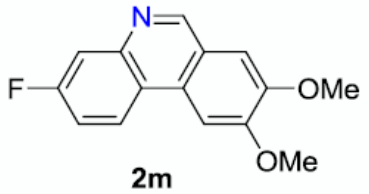
SK–1–138


154.7852
153.4664
145.8342
143.4561
132.3918
131.0039
128.9121
126.6937
125.7643
125.6279
124.3547
122.5677
114.0624
59.8362
56.4060
N
Cl
MeO
OMe
2l
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

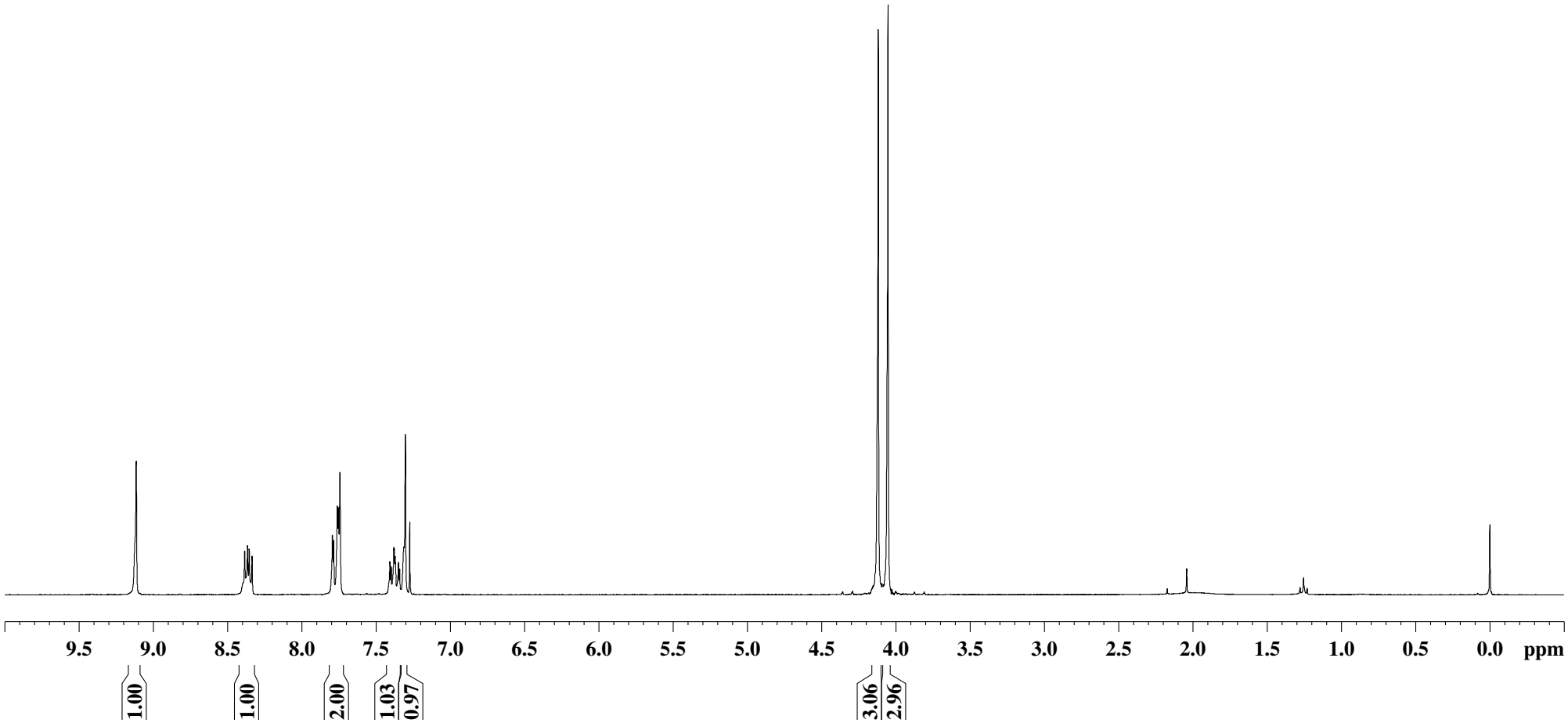
SK–1–146


9.1136
8.3858
8.3665
8.3554
8.3361
7.7949
7.7862
7.7618
7.7531
7.7442
7.4080
7.3990
7.3809
7.3781
7.3722
7.3693
7.3509
7.3420
7.3134
7.3037
7.2739

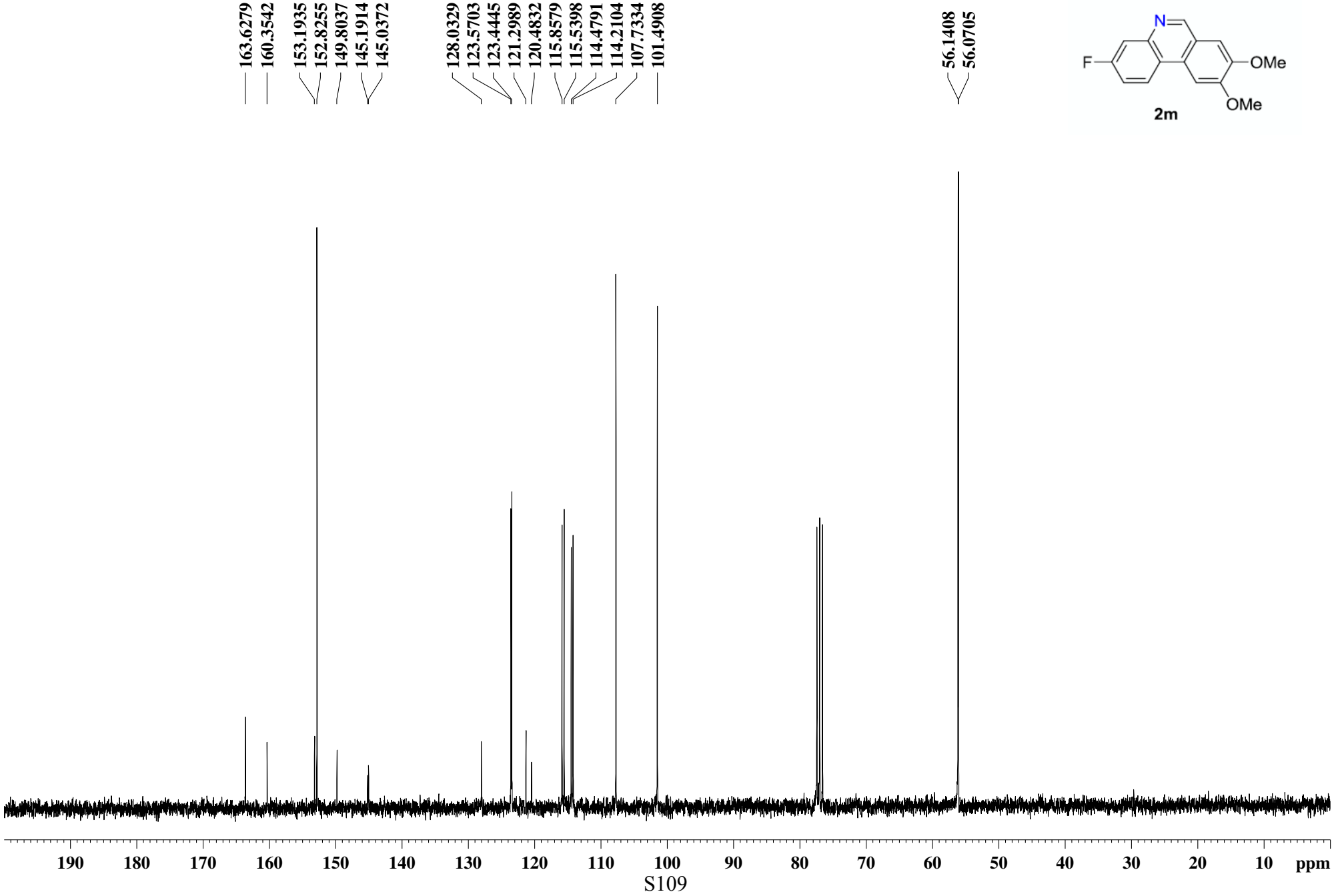

4.1190
4.0533


N
F
OMe
OMe

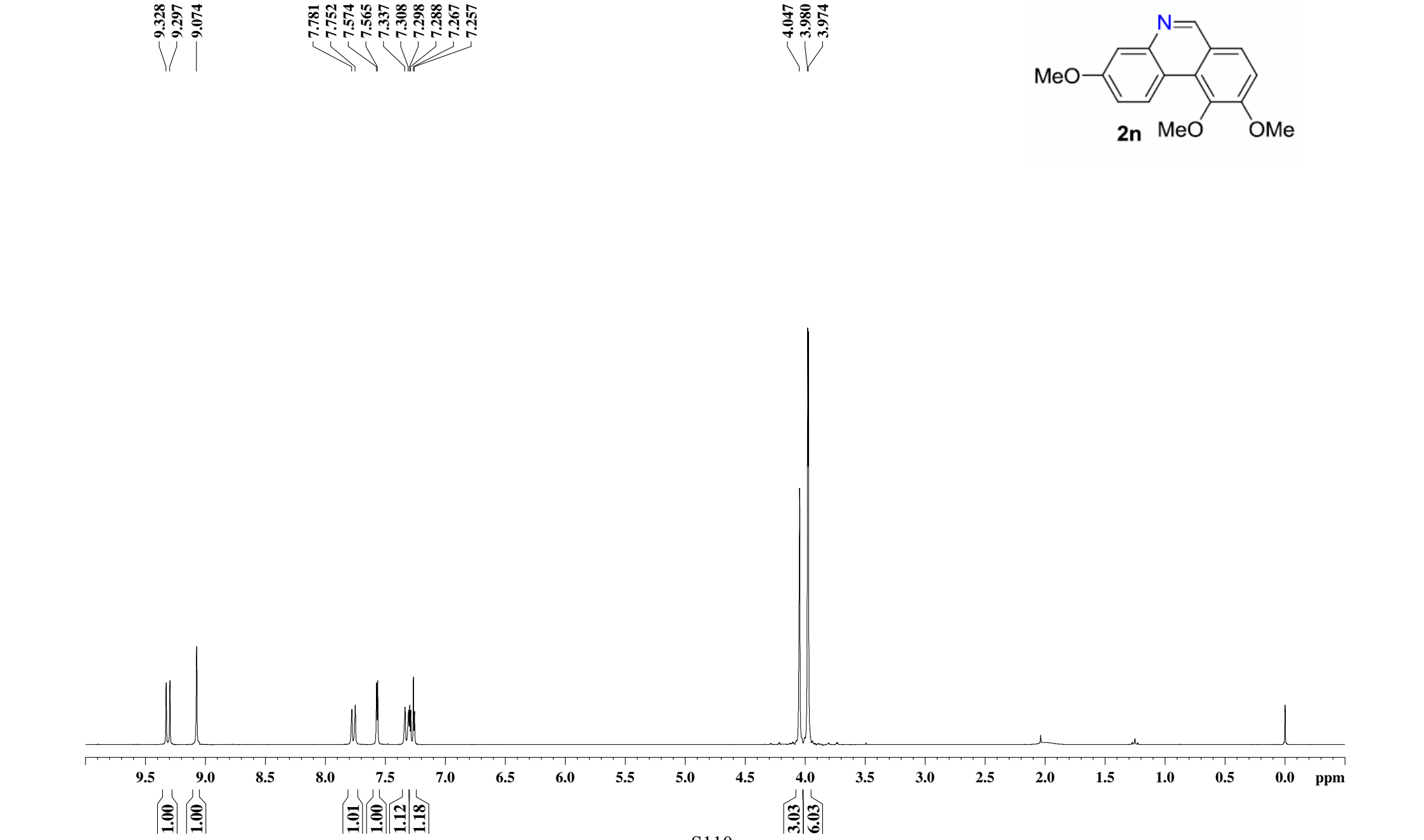
2m


9.5
9.0
8.5
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
ppm
1.00
1.00
2.00
1.03
0.97
3.06
2.96

SK–1–146

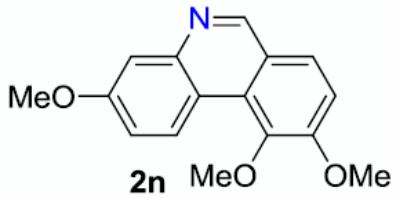

163.6279
160.3542
153.1935
152.8255
149.8037
145.1914
145.0372
128.0329
123.5703
123.4445
121.2989
120.4832
115.8579
115.5398
114.4791
114.2104
107.7334
101.4908
56.1408
56.0705
N
F
OMe
OMe
2m
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK–1–118

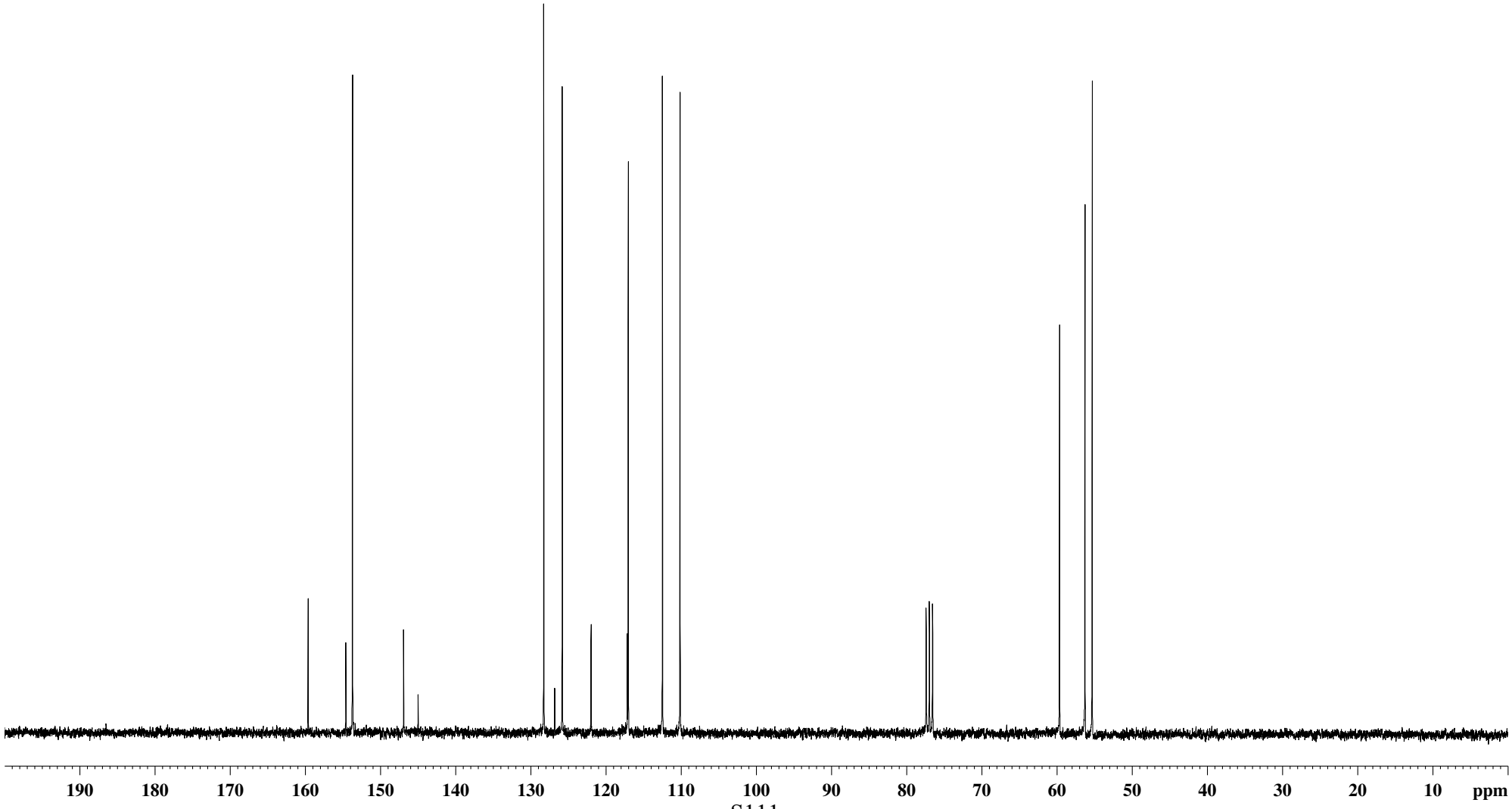

9.328
9.297
9.074
7.781
7.752
7.574
7.565
7.337
7.308
7.298
7.288
7.267
7.257
4.047
3.980
3.974
N
MeO
MeO
OMe
2n
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
1.00
1.01
1.00
1.12
1.18
3.03
6.03

SK–1–118

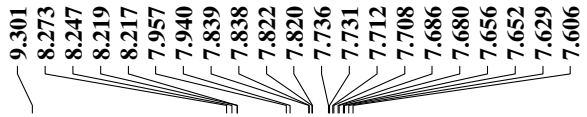
159.592
154.579
153.690
146.888
144.963
128.296
126.839
125.835
122.003
117.181
117.054
112.504
110.158
59.666
56.280
55.324

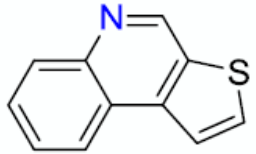


2n

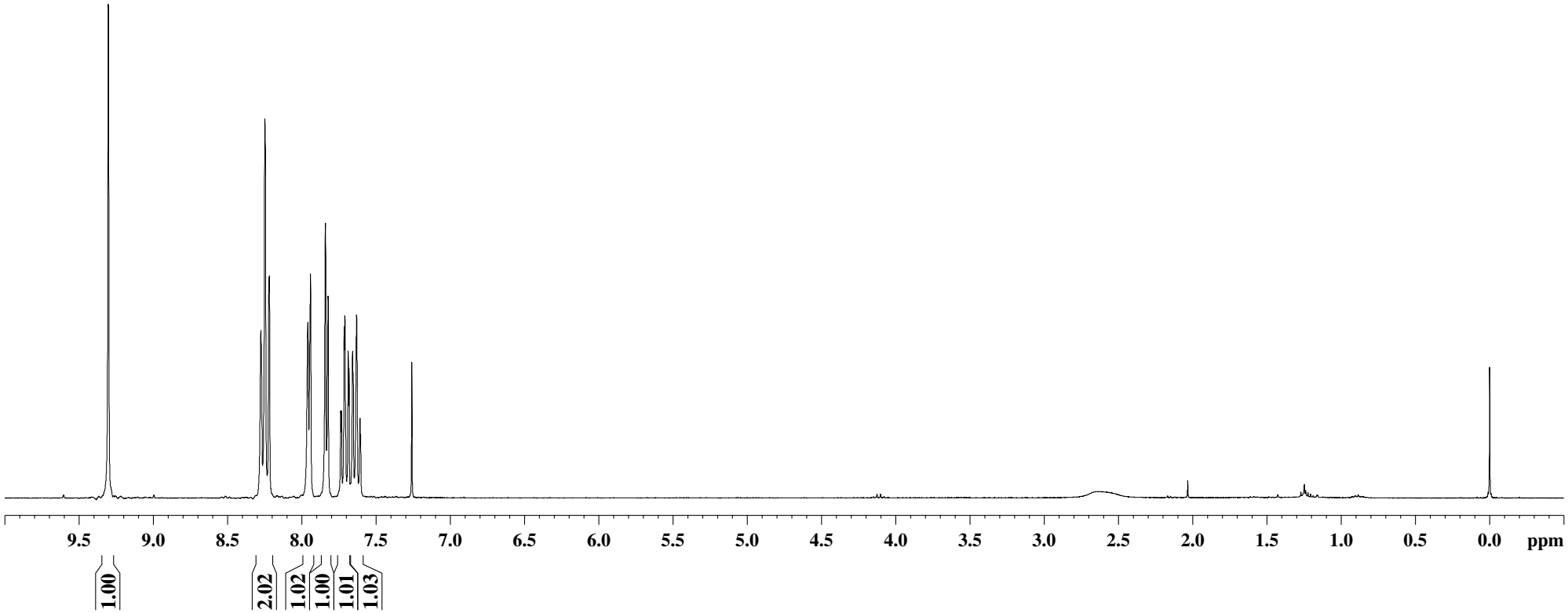


SK–1–116

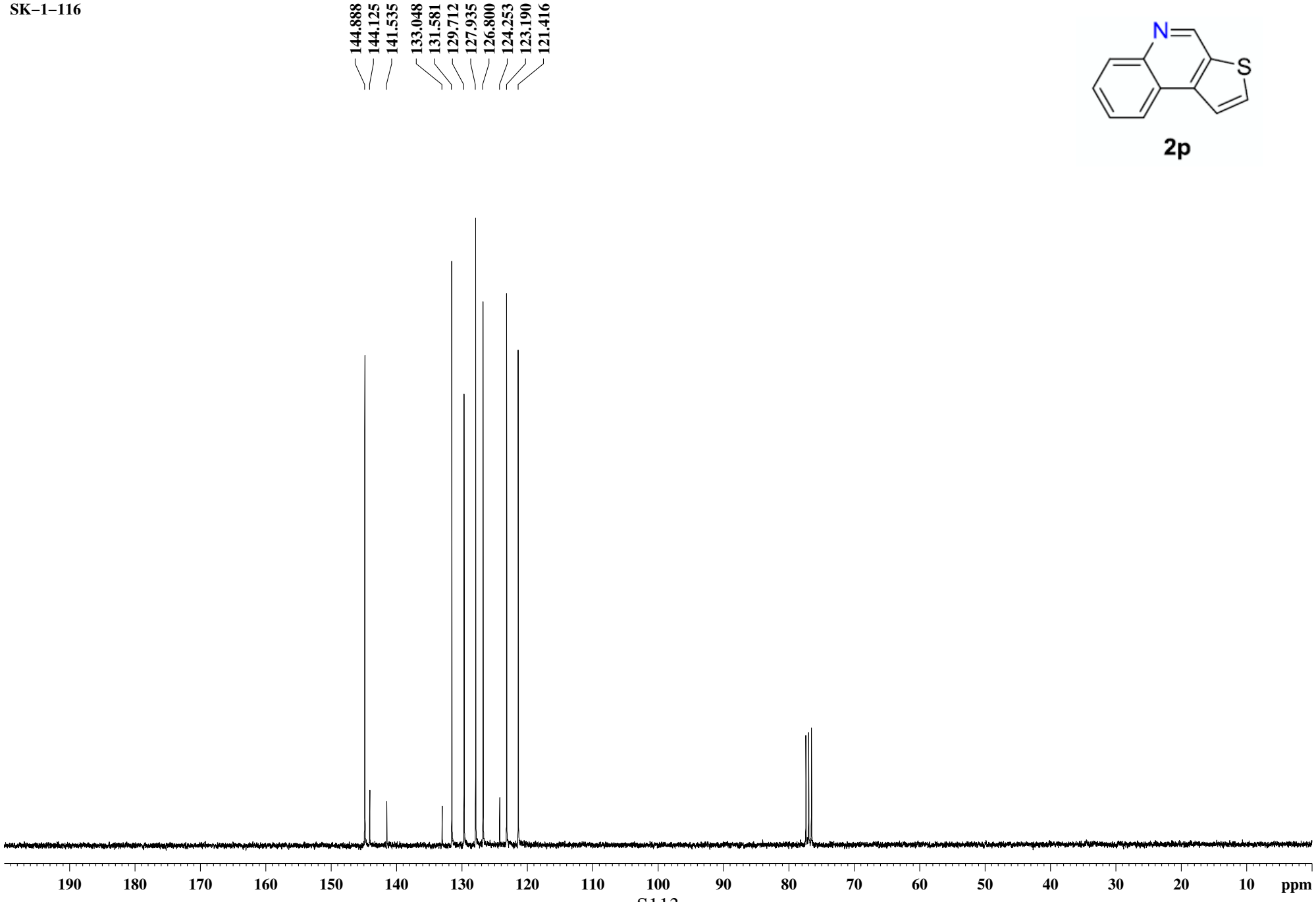

9.301
8.273
8.247
8.219
8.217
7.957
7.940
7.839
7.838
7.822
7.820
7.736
7.731
7.712
7.708
7.686
7.680
7.656
7.652
7.629
7.606


N
S

2p

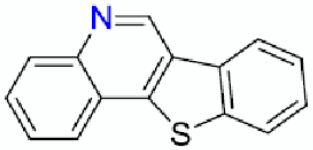

9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
2.02
1.02
1.00
1.01
1.03

SK–1–116

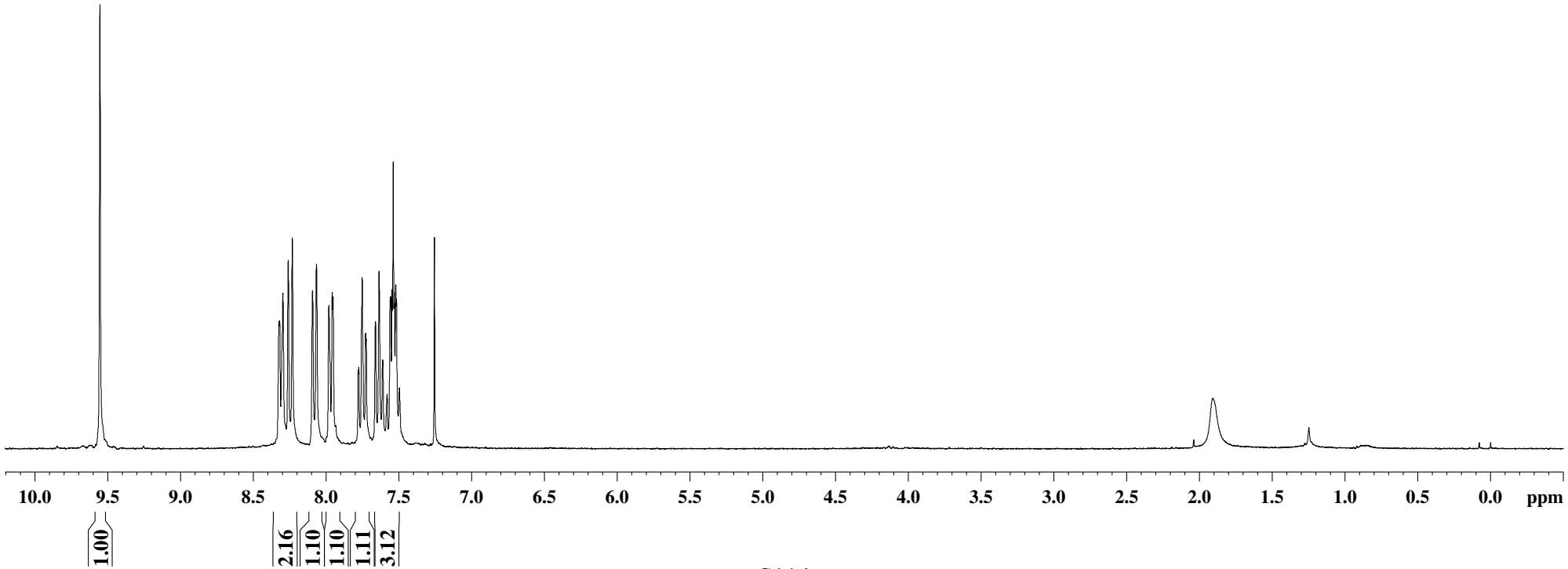

144.888
144.125
141.535
133.048
131.581
129.712
127.935
126.800
124.253
123.190
121.416
N
S
2p
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

SK–1–175

9.553
8.323
8.318
8.295
8.259
8.231
8.091
8.065
7.980
7.956
7.950
7.777
7.774
7.751
7.727
7.723
7.660
7.634
7.610
7.579
7.559
7.555
7.545
7.537
7.530
7.520
7.515
7.496

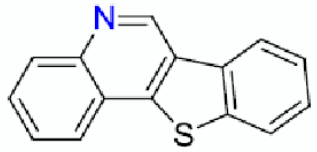


2q

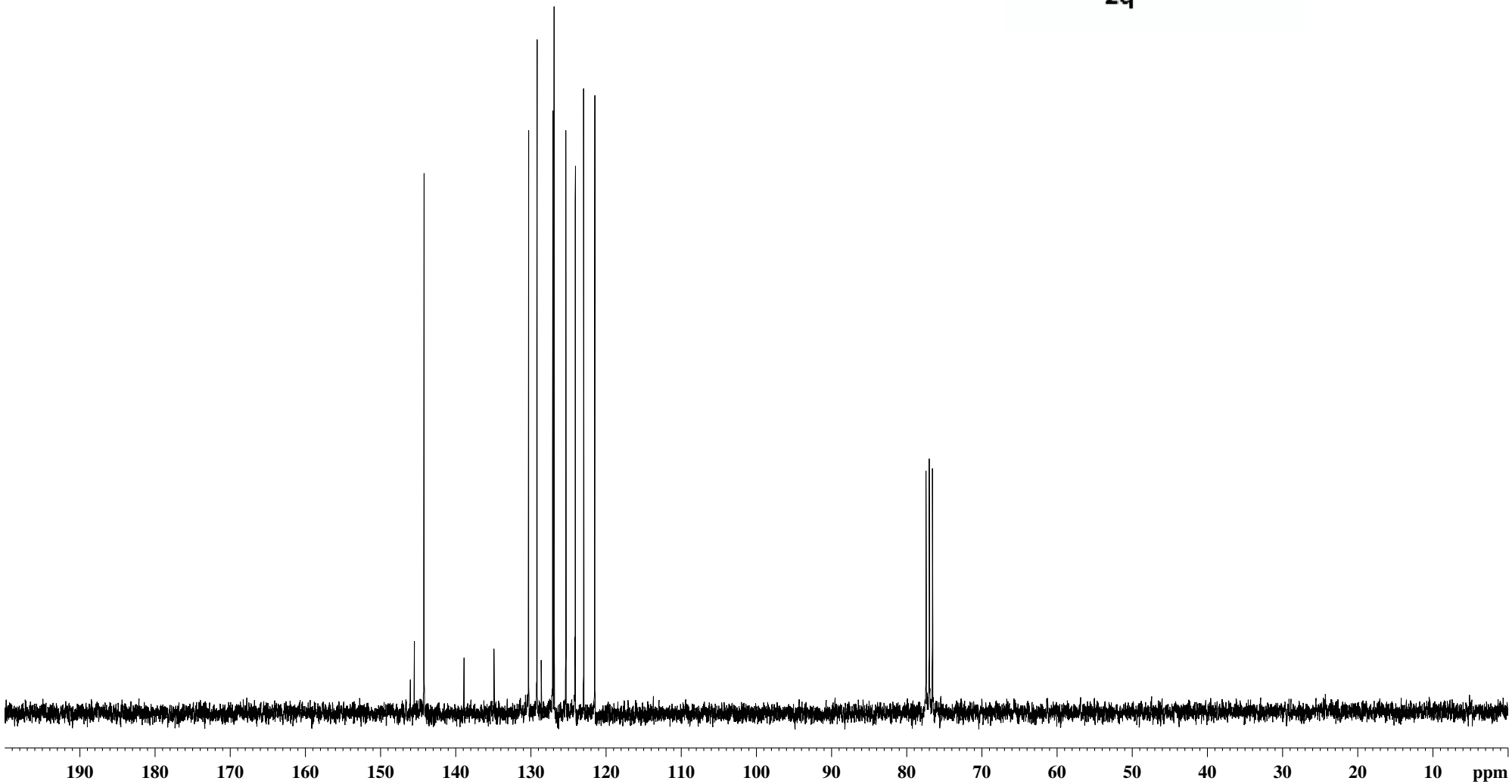


SK–1–172

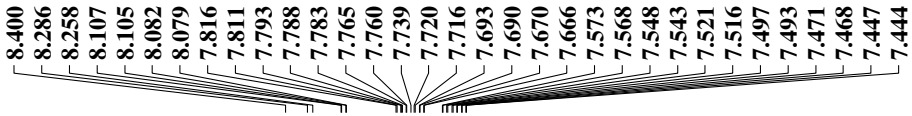
146.035
145.519
144.226
138.897
134.906
130.311
129.195
128.618
127.099
126.915
125.350
124.162
124.096
122.978
121.505

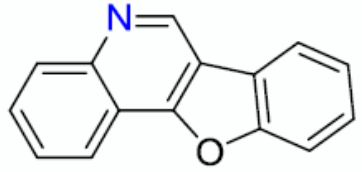


2q

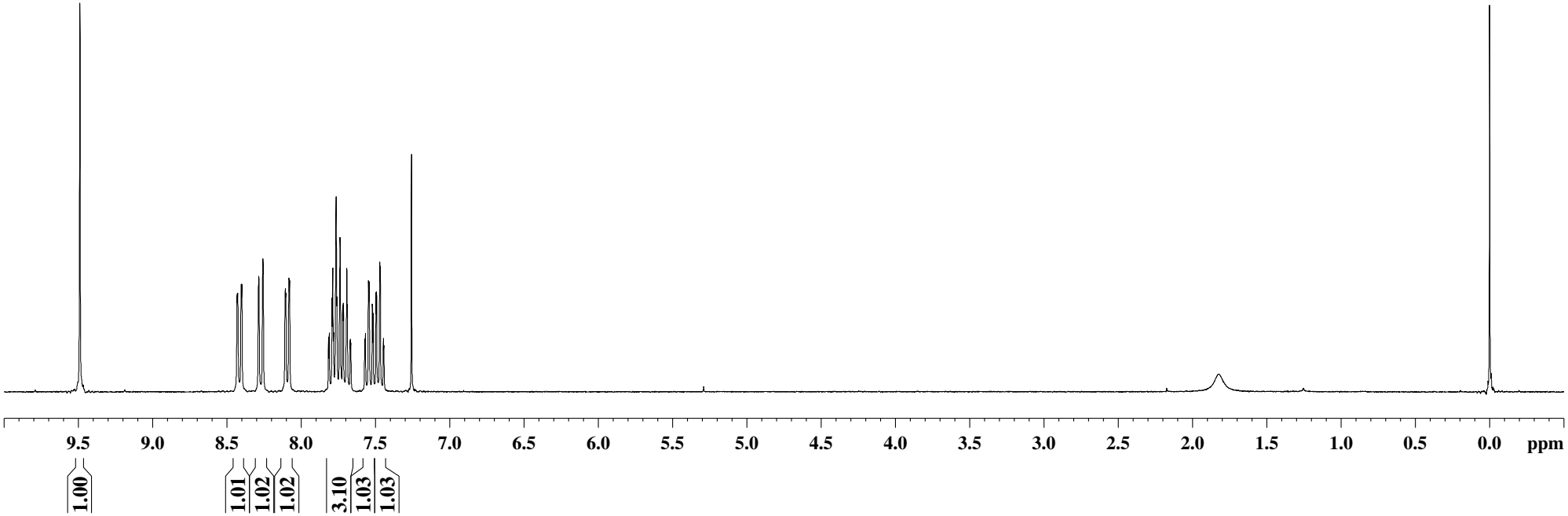


SK–1–115


8.400
8.286
8.258
8.107
8.105
8.082
8.079
7.816
7.811
7.793
7.788
7.783
7.765
7.760
7.739
7.720
7.716
7.693
7.690
7.670
7.666
7.573
7.568
7.548
7.543
7.521
7.516
7.497
7.493
7.471
7.468
7.447
7.444

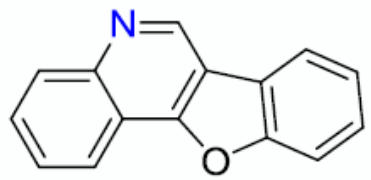

N
O

2r


9.5
9.0
8.5
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
ppm
1.00
1.01
1.02
1.02
3.10
1.03
1.03

SK–1–115

157.316
155.798
147.155
144.146
129.647
129.190
127.108
126.875
123.937
122.524
120.670
120.460
117.009
116.156
111.980



2r