Supporting Information

CuBr-Catalyzed α-Arylation and Aerobic Oxidative Dehydrogenative C-N Coupling for the Synthesis of Spiro[cyclohexane-1,12'-isoindolo[1,2-b]quinazolin]-10'-one Derivatives

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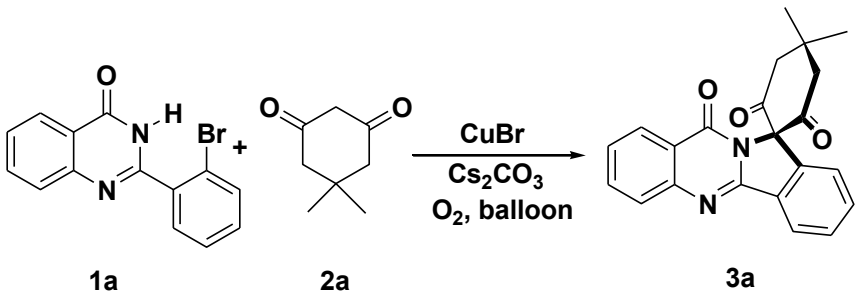
Content

General Information

^{1}H-NMR and ^{13}C-NMR spectra were recorded at 25 ºC on a BRUKER AVANCE DMX 400 MHz and 100 MHz, respectively, and TMS was used as internal standard from a solution in $CDCl_3$ or DMSO-d_6. High resolution mass spectra (HRMS) were recorded on Bruck-micro-TOF by using APCI method. Melting points were determined in open capillaries and are uncorrected. IR spectra were recorded on a TENSOR 27 spectrometer in KBr. The products were purified by column chromatography over silica gel (300-400 mesh). All reagents were purchased from commercial sources and used without treatment, unless otherwise indicated.

Substrates **1** were prepared according to the published procedure.[1]

Synthetic Procedure and Characterization Data for 3



1a **2a** **3a**

A reaction flask with high vacuum valve was charged with 2-(2-bromophenyl) quinazolin-4(3*H*)-one(**1a**, 151 mg, 0.5 mmol), dimedone (**2a**, 77 mg, 0.55 mmol), CuBr(14 mg, 0.1 mmol), and Cs_2CO_3 (195 mg, 0.6 mmol). After being degassed by three freeze-thaw pump cycles with O_2, the solvent of DMF (10.0 mL) was injected into the mixture. Subsequently, the resulting mixture was stirred at 100 °C (oil bath) under O_2 balloon. After completion of the reaction monitored by TLC, the insoluble substance was filtered off by a fast hot-filtration, and the filtrate was concentrated under reduced pressure. The resulting crude residue was purified by silica-gel column chromatography using ethyl acetate and petroleumether (1:4, v/v) as an eluent to give final products **3a**.

For the gram-scale reaction of **3a**, the experimental operation is the same as the model reaction of **3a**.

4,4-Dimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3a**): Yield: 85% (152 mg). Pale yellow solid. M.p. 264~266 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.42 (s, 3H), 1.54 (s, 3H), 2.92 (d, J = 15.6 Hz, 2H), 3.17 (d, J = 15.2 Hz, 2H), 7.49~7.53 (m, 1H), 7.64~7.72 (m, 3H), 7.79~7.86 (m, 2H), 8.21~8.24 (m, 1H), 8.33 (d, J = 8.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 27.1, 30.8, 31.7,

51.8, 86.1, 121.3, 121.4, 125.1, 127.0, 127.1, 127.7, 130.6, 132.5, 134.6, 137.0, 149.3, 154.0, 158.9, 195.5. IR (KBr): *ν*3188, 3136, 3065, 2942, 1667, 1644, 1624, 1609, 1591, 1469, 1442, 1391, 1379, 1337, 1309, 1254, 1148, 1078, 1030, 955, 884, 773 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{22}H_{19}N_2O_3$ $[M + H]^+$359.1390, found 359.1396.

2'-Chloro-4,4-dimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3b**): Yield: 78% (153 mg). Pale yellow solid. M.p. 244~246 °C; ^1H NMR ($CDCl_3$, 400 MHz): δ_H1.41 (s, 3H), 1.51 (s, 3H), 2.91 (d, *J* = 15.2 Hz, 2H), 3.16 (d, *J* = 15.2 Hz, 2H), 7.62~7.68 (m, 2H), 7.70~7.74 (m, 2H), 7.78 (d, *J* = 8.8 Hz, 1H), 8.19 (d, *J* = 8.0 Hz, 1H), 8.26 (s, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 27.0, 30.8, 31.7, 51.7, 86.2, 121.5, 122.3, 125.1, 126.5, 129.2, 130.7, 132.1, 132.66, 132.74, 134.9, 136.9, 147.7, 154.2, 157.8, 195.2. IR (KBr): *ν*3188, 3136, 3065, 2942, 1667, 1644, 1624, 1609, 1591, 1469, 1442, 1391, 1379, 1337, 1309, 1254, 1148, 1078, 1030, 955, 884, 773 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{22}H_{18}ClN_2O_3$ $[M + H]^+$393.1000, found 393.1026.

2',4,4-Trimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3c**): Yield: 81% (151 mg). Pale yellow solid. M.p. 241~243 °C; ^1H NMR ($CDCl_3$, 400 MHz): δ_H1.42 (s, 3H), 1.54 (s, 3H), 2.52 (s, 3H), 2.90 (d, *J* = 15.6 Hz, 2H), 3.17 (d, *J* = 15.2 Hz, 2H), 7.43~7.50 (m, 3H), 7.79~7.84 (m, 2H), 8.09 (d, *J* = 8.4 Hz, 1H), 8.31 (dd, *J* = 8.0 Hz, *J'* = 0.8 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 22.3, 27.1, 30.8, 31.8, 51.8, 85.9, 121.2, 121.9, 124.7, 126.7, 127.0, 127.5, 129.7, 131.6, 134.5, 137.3, 143.6, 149.3, 154.1, 158.9, 195.7. IR (KBr): *ν* 3105, 3071, 2965, 1744, 1717, 1689, 1633, 1604, 1609, 1470, 1334, 1223, 1180, 1077, 946, 835, 775 cm^{-1}.

HRMS (APCI, *m/z*): Calcd for $C_{23}H_{21}N_2O_3$ $[M + H]^+$373.1547, found 373.1553.

3'-Chloro-4,4-dimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3d**): Yield: 80% (157 mg). Pale yellow solid. M.p. 249~251 °C; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_H1.38 (s, 3H), 1.39 (s, 3H), 2.82 (d, J = 15.6 Hz, 2H), 3.48 (d, J = 15.6 Hz, 2H), 7.64~7.68 (m, 1H), 7.84 (dd, J = 8.4 Hz, J' = 2.4 Hz, 1H), 7.88 (d, J = 8.4 Hz, 1H), 7.95~7.99 (m, 1H), 8.20~8.25 (m, 2H), 8.47 (d, J = 8.4 Hz, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz): δ_C 26.9, 30.1, 30.8, 50.8, 85.4, 120.6, 123.9, 125.3, 126.6, 127.8, 128.0, 132.7, 133.5, 135.4, 135.6, 136.2, 148.4, 152.9, 157.7, 196.7. IR (KBr): ν 3072, 3034, 2955, 1742, 1722, 1690, 1634, 1608, 1591, 1469, 1334, 1219, 1074, 1021, 873, 775 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{22}H_{18}ClN_2O_3$ $[M + H]^+$393.1000, found 393.1013.

3'-Fluoro-4,4-dimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3e**): Yield: 77% (145 mg). Pale yellow solid. M.p. 261~262 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.41 (s, 3H), 1.53 (s, 3H), 2.92 (d, J = 15.6 Hz, 2H), 3.12 (d, J = 15.2 Hz, 2H), 7.32~7.37 (m, 1H), 7.50~7.54 (m, 1H), 7.68 (dd, J = 8.8 Hz, J' = 4.0 Hz, 1H), 7.82~7.86 (m, 2H), 7.90 (dd, J = 7.2 Hz, J' = 2.4 Hz, 1H), 8.32 (dd, J = 8.0 Hz, J' = 1.2 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 27.0, 30.8, 31.7, 51.8, 85.5, 112.0 (d, $J_{F\text{-}C}$ = 24.4 Hz), 119.9 (d, $J_{F\text{-}C}$ = 23.9 Hz), 121.4, 123.1 (d, $J_{F\text{-}C}$ = 8.9 Hz), 127.1, 127.3, 127.8, 132.6 (d, $J_{F\text{-}C}$ = 2.8 Hz), 134.7, 134.9 (d, $J_{F\text{-}C}$ = 9.7 Hz), 149.0, 152.9 (d, $J_{F\text{-}C}$ = 3.9 Hz), 158.7, 163.9 (d, $J_{F\text{-}C}$ = 250.8 Hz), 195.3. IR (KBr): ν 3081, 2987, 2963, 1749, 1721, 1685, 1633, 1610, 1481, 1473, 1329, 1269, 1224, 1153, 1066, 1021, 878, 775 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{22}H_{18}FN_2O_3$ $[M + H]^+$377.1296,

found 377.1309.

3'-Methoxy-4,4-dimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoli ne]-2,6,10'-trione (**3f**): Yield: 81% (157 mg). Pale yellow solid. M.p. 254~256 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.39 (s, 3H), 1.52 (s, 3H), 2.88 (d, *J* = 15.6 Hz, 2H), 3.13 (d, *J* = 15.2 Hz, 2H), 3.93 (s, 3H), 7.16 (dd, *J* = 8.8 Hz, *J'* = 2.4 Hz, 1H), 7.48~7.52 (m, 1H), 7.58 (d, *J* = 8.8 Hz, 1H), 7.66 (d, *J* = 2.4 Hz, 1H), 7.78~7.85 (m, 2H), 8.32 (dd, *J* = 8.0 Hz, *J'* = 1.6 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 27.1, 30.8, 31.7, 51.8, 56.1, 85.5, 107.6, 120.8, 121.4, 122.4, 127.0, 127.1, 127.6, 129.4, 133.9, 134.6, 149.2, 154.1, 158.8, 161.6, 195.9. IR (KBr): ν 3062, 3029, 2964, 2928, 1743, 1716, 1683, 1624, 1605, 1560, 1352, 1337, 1298, 1229, 1180, 1078, 1049, 928, 830, 772 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{23}H_{21}N_2O_4$ $[M + H]^+$389.1496, found 389.1489.

2',3'-Dimethoxy-4,4-dimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quina zoline]-2,6,10'-trione (**3g**): Yield: 75% (157 mg). Pale yellow solid. M.p. 245~246 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.42 (s, 3H), 1.54 (s, 3H), 2.93 (d, *J* = 15.6 Hz, 2H), 3.09 (d, *J* = 15.6 Hz, 2H), 3.93 (s, 3H), 4.07 (s, 3H), 7.00~7.06 (m, 1H), 7.45~7.49 (m, 1H), 7.62 (s, 1H), 7.78~7.83 (m, 2H), 8.28~8.31 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 27.0, 30.7, 32.0, 52.1, 56.6, 56.7, 85.5, 104.1, 106.1, 120.9, 125.0, 126.6, 127.1, 127.3, 130.4, 134.6, 149.4, 151.7, 153.1, 154.2, 158.8, 195.7. IR (KBr): ν 3081, 2996, 2963, 1748, 1719, 1609, 1571, 1560, 1482, 1466, 1440, 1337, 1222, 1254, 1178, 1134, 1023, 898, 769 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{24}H_{23}N_2O_5$ $[M + H]^+$419.1601, found 419.1615.

4,4,6'-Trimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10

'-trione (**3h**): Yield: 77% (143 mg). Pale yellow solid. M.p. 234~235 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.41 (s, 3H), 1.54 (s, 3H), 2.73 (s, 3H), 2.91 (d, *J* = 15.6 Hz, 2H), 3.17 (d, *J* = 15.6 Hz, 2H), 7.36~7.40 (m, 1H), 7.62~7.70 (m, 4H), 8.17 (dd, *J* = 8.0 Hz, *J'* = 0.8 Hz, 1H), 8.22~8.25 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 17.6, 27.1, 30.8, 31.7, 51.8, 86.0, 121.3, 121.4, 124.7, 125.0, 126.4, 130.5, 132.2, 132.9, 135.2, 136.4, 136.9, 147.8, 152.6, 159.3, 195.7. IR (KBr): ν 3069, 2921, 1711, 1694, 1627, 1601, 1553, 1471, 1373, 1342 1328, 1181, 1058, 971, 771 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{23}H_{21}N_2O_3$ $[M + H]^+$373.1547, found 373.1563.

7'-Chloro-4,4-dimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3i**): Yield: 78% (153 mg). Pale yellow solid. M.p. 255~256 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.43 (s, 3H), 1.52 (s, 3H), 2.92 (d, *J* = 15.6 Hz, 2H), 3.17 (d, *J* = 15.6 Hz, 2H), 7.45 (dd, *J* = 8.8 Hz, *J'* = 2.0 Hz, 1H), 7.66~7.73 (m, 3H), 7.85 (d, *J* = 2.0 Hz, 1H), 8.20~8.22 (m, 1H), 8.24 (d, *J* = 8.4 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 27.1, 30.8, 31.7, 51.7, 86.3, 119.8, 121.5, 125.3, 127.3, 127.5, 128.4, 130.7, 132.1, 132.8, 137.0, 140.8, 150.3, 155.1, 158.3, 195.3. IR (KBr): ν 3063, 2959, 1749, 1719, 1683, 1636, 1599, 1470, 1425, 1340, 1296, 1231, 1207, 1184, 1081, 957, 854, 773 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{22}H_{18}ClN_2O_3$ $[M + H]^+$393.1000, found 393.1017.

8'-Chloro-4,4-dimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3j**): Yield: 81% (159 mg). Pale yellow solid. M.p. 264~266 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.41 (s, 3H), 1.52 (s, 3H), 2.91 (d, *J* = 15.6 Hz, 2H), 3.16 (d, *J* = 15.2 Hz, 2H), 7.64~7.74 (m, 4H), 7.79 (d, *J* = 8.8 Hz, 1H), 8.19~8.21 (m, 1H),

8.29 (d, J = 2.4 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 27.0, 30.8, 31.7, 51.7, 86.3, 121.5, 122.4, 125.1, 126.5, 129.2, 130.7, 132.1, 132.7, 132.8, 134.9, 136.9, 147.8, 154.2, 157.8, 195.2. IR (KBr): ν 3070, 2992, 2941, 1744, 1713, 1671, 1630, 1604, 1468, 1344, 1242, 1132, 1095, 1073, 968, 870, 770 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{22}H_{18}ClN_2O_3$ $[M + H]^+$393.1000, found 393.1027.

8'-Chloro-3'-methoxy-4,4-dimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3k**): Yield: 76% (161 mg). Pale yellow solid. M.p. 253~254 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.40 (s, 3H), 1.50 (s, 3H), 2.89 (d, J = 15.6 Hz, 2H), 3.13 (d, J = 15.2 Hz, 2H), 3.93 (s, 3H), 7.18 (dd, J = 8.8 Hz, J' = 2.4 Hz, 1H), 7.58 (d, J = 8.8 Hz, 1H), 7.64 (d, J = 2.4 Hz, 1H), 7.73 (dd, J = 8.8 Hz, J' = 2.4 Hz, 1H), 7.78 (d, J = 8.8 Hz, 1H), 8.29 (d, J = 2.4 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 27.0, 30.8, 31.7, 51.8, 56.1, 85.6, 107.6, 120.9, 122.41, 122.43, 126.6, 129.1, 129.4, 132.8, 133.6, 134.9, 147.7, 154.4, 157.8, 161.7, 195.6. IR (KBr): ν 3092, 3075, 2969, 1744, 1713, 1687, 1626, 1614, 1603, 1464, 1274, 1225, 1151, 1070, 1025, 952, 865, 790 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{23}H_{20}ClN_2O_4$ $[M + H]^+$423.1106, found 423.1126.

4,4,8'-Trimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3l**): Yield: 78% (145 mg). Pale yellow solid. M.p. 248~249 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.42 (s, 3H), 1.54 (s, 3H), 2.49 (s, 3H), 2.91 (d, J = 15.6 Hz, 2H), 3.17 (d, J = 15.2 Hz, 2H), 7.61~7.65 (m, 3H), 7.69~7.76 (m, 2H), 8.13 (s, 1H), 8.20~8.22 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 21.3, 27.1, 30.8, 31.8, 51.8, 86.0, 121.0, 121.4, 124.9, 126.6, 127.5, 130.6, 132.2, 132.6, 136.0, 136.9, 137.3, 147.2,

153.2, 158.9, 195.6. IR (KBr): ν 2960, 1748, 1719, 1683, 1630, 1616, 1487, 1339, 1323, 1301, 1074, 913, 836, 774 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{23}H_{21}N_2O_3$ [M + H]$^+$373.1547, found 373.1560.

10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3m**): Yield: 75% (124 mg). Pale yellow solid. M.p. 284~286 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H 2.41~2.51 (m, 2H), 3.02~3.10 (m, 2H), 3.15~3.20 (m, 2H), 7.49~7.53 (m, 1H), 7.59~7.67 (m, 3H), 7.80~7.84 (m, 1H), 7.88 (d, J = 7.6 Hz, 1H), 8.22~8.27 (m, 1H), 8.28 (dd, *J* = 8.0 Hz, *J*' = 1.2 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 17.0, 39.4, 83.8, 121.1, 121.2, 125.1, 126.8, 127.0, 127.9, 130.5, 132.6, 133.0, 134.7, 138.5, 149.7, 154.2, 158.7, 197.5. IR (KBr): ν 3166, 3093, 2970, 1742, 1712, 1686, 1626, 1607, 1578, 1489, 1464, 1346, 1247, 1151, 1025, 865, 770 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{20}H_{15}N_2O_3$ [M + H]$^+$331.1077, found 331.1077.

4-Methyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trion e (**3n**): Yield: 80% (138 mg). Pale yellow solid. M.p. 271~272 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.35 (d, *J* = 5.6 Hz, 3H), 2.78~2.84 (m, 3H), 3.12 (d, *J* = 15.6 Hz, 2H), 7.49~7.53 (m, 1H), 7.58~7.67 (m, 3H), 7.80~7.83 (m, 1H), 7.88 (d, *J* = 8.0 Hz, 1H), 8.21~8.24 (m, 1H), 8.27 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 21.6, 24.8, 48.0, 82.7, 121.12, 121.13, 125.1, 126.8, 127.0, 127.9, 130.5, 132.5, 132.9, 134.7, 138.3, 149.7, 154.3, 158.6, 196.9. IR (KBr): ν 3065, 2960, 2927, 1743, 1717, 1671, 1626, 1603, 1467, 1344, 1290, 1144, 1085, 949, 790, 774 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{21}H_{17}N_2O_3$ [M + H]$^+$345.1234, found 345.1241.

4-Phenyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trion

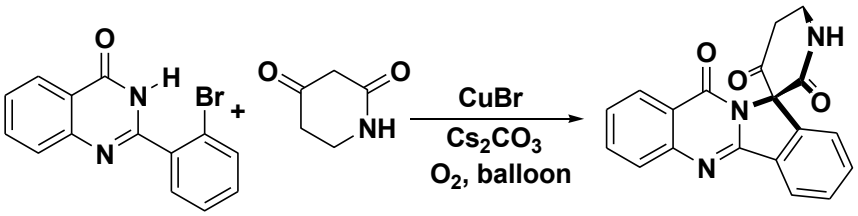
e (**3o**): Yield: 83% (169 mg). Pale yellow solid. M.p. 283~285 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): 3.27~3.37 (m, 4H), 3.87~3.96 (m, 1H), 7.35~7.39 (m, 1H), 7.43~7.49 (m, 4H), 7.52~7.56 (m, 1H), 7.66~7.73 (m, 3H), 7.82~7.86 (m, 1H), 7.91 (d, J = 7.2 Hz, 1H), 8.21~8.24 (m, 1H), 8.31 (dd, J = 8.0 Hz, J' = 1.2 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 34.6, 47.3, 82.9, 121.1, 121.2, 125.2, 126.6, 126.8, 127.1, 127.9, 128.0, 129.4, 130.7, 132.6, 133.0, 134.8, 138.2, 140.7, 149.8, 154.2, 158.8, 196.4. IR (KBr): ν 3065, 2960, 2925, 1750, 1718, 1681, 1629, 1610, 1467, 1341, 1240, 1169, 771 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{26}H_{19}N_2O_3$ $[M + H]^+$407.1390, found 407.1410.

3,3-Dimethyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3p**): Yield: 75% (134 mg). Pale yellow solid. M.p. 284~286 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.48 (s, 3H), 1.51 (s, 3H), 2.34~2.49 (m, 2H), 3.12~3.16 (m, 2H), 7.47~7.54 (m, 2H), 7.59~7.63 (m, 2H), 7.78~7.82 (m, 1H), 7.86~7.88 (m, 1H), 8.21~8.26 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 26.3, 26.8, 31.5, 35.9, 44.4, 81.1, 121.0, 121.8, 124.9, 126.7, 126.8, 127.9, 130.2, 132.7, 133.6, 134.7, 139.9, 149.8, 154.5, 158.6, 199.0, 205.7. IR (KBr): ν 3121, 3037, 2959, 1750, 1714, 1674, 1627, 1609, 1587, 1467, 1443, 1347, 1310, 1288, 1266, 1150, 1045, 967 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{22}H_{19}N_2O_3$ $[M + H]^+$359.1390, found 359.1397.

3'-Methoxy-4-methyl-10'*H*-spiro[cyclohexane-1,12'-isoindolo[1,2-*b*]quinazoline]-2,6,10'-trione (**3q**): Yield: 79% (148 mg). Pale yellow solid. M.p. 264~266 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H1.48 (d, J = 6.8 Hz, 3H), 2.76~2.85 (m, 1H), 2.92~2.97 (m, 2H), 3.24~3.29 (m, 2H), 3.94 (s, 3H), 7.16 (dd, J = 8.8 Hz, J' = 2.4 Hz, 1H), 7.48~7.54 (m, 2H), 7.68 (d, J = 2.4 Hz, 1H), 7.81~7.87 (m, 2H), 8.30 (dd, J = 8.0 Hz,

J' = 0.8 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 20.7, 24.5, 45.2, 56.1, 84.5, 107.6, 120.9, 121.3, 122.5, 126.9, 127.0, 127.7, 130.4, 134.4, 134.6, 149.4, 154.3, 158.8, 161.5, 197.5. IR (KBr): ν 3064, 3025, 2960, 1667, 1750, 1718, 1684, 1629, 1611, 1468, 1341, 1240, 1168, 1094, 927, 772 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{22}H_{19}N_2O_4$ $[M + H]^+$375.1339, found 375.1367.

Synthetic Procedure and Characterization Data for 5



1a **4** **5a**

A reaction flask with high vacuum valve was charged with2-(2-bromophenyl) quinazolin-4(3*H*)-one (**1a**, 151 mg, 0.5 mmol), piperidine-2,4-dione (**4**, 62 mg, 0.55 mmol), CuBr (14 mg, 0.1 mmol), and Cs_2CO_3 (195 mg, 0.6 mmol). After being degassed by three freeze-thaw pump cycles with O_2, the solvent of DMF (10.0 mL) was injected into the mixture. Subsequently, the resulting mixture was stirred at 100 °C (oil bath) under O_2 balloon. After completion of the reaction monitored by TLC, the insoluble substance was filtered off by a fast hot-filtration, and the filtrate was concentrated under reduced pressure. The resulting crude residue was purified by silica-gel column chromatography using ethyl acetate and petroleumether (1:3, v/v) as an eluent to give final products **5a**.

10*H*-Spiro[isoindolo[1,2-*b*]quinazoline-12,3'-piperidine]-2',4',10-trione (**5a**): Yield: 80% (133 mg). Pale yellow solid. M.p. 250~252 °C; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_H 3.01~3.07 (m, 1H), 3.43~3.8651 (m, 1H), 3.67~3.71 (m, 1H), 3.79~3.85 (m, 1H), 7.61~7.64 (m, 1H), 7.73~7.80 (m, 2H), 7.89~7.99 (m, 3H), 8.16~8.18 (m, 2H),9.04 (s, 1H).^{13}C NMR (DMSO-d_6, 100 MHz): δ_C 36.1, 38.1, 77.1, 120.7, 123.0, 124.2, 126.6, 127.8, 128.1, 131.2, 132.4, 134.1, 135.8, 141.0, 149.4, 155.1, 158.3, 165.7, 198.9. IR (KBr): ν 3442, 3081, 2951, 2917, 1745, 1716, 1684, 1653, 1489, 1469, 1338, 1222, 1190, 1154, 1074, 842, 776 cm^{-1}. HRMS (ESI, *m/z*): Calcd for $C_{19}H_{12}N_3O_3$ [M - H]$^-$

330.0879, found 330.0877.

2-Fluoro-10*H*-spiro[isoindolo[1,2-*b*]quinazoline-12,3'-piperidine]-2',4',10-trione (**5b**): Yield: 79% (138 mg). Pale yellow solid. M.p. 241~242 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H 3.20~3.24 (m, 2H), 3.79~3.86 (m, 1H), 4.01~4.08 (m, 1H), 6.78 (s, 1H), 7.25~7.28 (m, 1H),7.34~7.38 (m, 1H), 7.50~7.54 (m, 1H), 7.81~7.88 (m, 2H), 8.22 (dd, J = 8.4 Hz, J' = 4.8 Hz, 1H), 8.27 (d, J = 8.0 Hz, 1H).^{13}C NMR ($CDCl_3$, 100 MHz): δ_C 36.8, 38.4, 77.2, 109.3 (d, J_{F-C} = 25.4 Hz), 118.5 (d, J_{F-C} = 23.1 Hz), 120.7, 126.6, 126.7 (d, J_{F-C} = 9.2 Hz), 127.0, 127.2 (d, J_{F-C} = 1.5 Hz), 127.9, 129.4 (d, J_{F-C} = 2.4 Hz), 134.9, 149.7, 153.4, 159.0, 165.3 (d, J_{F-C} = 253.7 Hz), 166.4, 195.6. IR (KBr): ν 3452, 3080, 2963, 1748, 1721, 1686, 1633, 1481, 1474, 1339, 1269, 1208, 1154, 1066, 891, 825, 775 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{19}H_{11}FN_3O_3$ $[M - H]^-$ 350.0935, found 350.0940.

2-Methyl-10*H*-spiro[isoindolo[1,2-*b*]quinazoline-12,3'-piperidine]-2',4',10-trione (**5c**): Yield: 78% (135 mg). Pale yellow solid. M.p. 238~239 °C; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_H2.48 (s, 3H),2.77~3.06 (m, 1H),3.46~3.53 (m, 1H), 3.64~3.86 (m, 2H), 7.53~7.63 (m, 2H), 7.81 (s, 1H),7.86~7.88 (m, 1H), 7.92~7.96 (m, 1H), 8.03~8.08 (m, 1H), 8.15~8.17 (m, 1H), 9.00 (s, 1H).^{3}C NMR (DMSO-d_6, 100 MHz): δ_C 21.9, 36.1, 38.0, 76.9, 120.6, 123.2, 123.9, 126.6, 127.6, 128.0, 129.7, 131.9, 135.7, 141.3, 145.1, 149.5, 155.2, 158.3, 165.8, 198.9.IR (KBr): ν3450, 3065, 2960, 1748, 1720, 1683, 1629, 1487, 1339, 1301, 1221, 1073, 913, 836, 774 cm^{-1}. HRMS (ESI, *m/z*): Calcd for $C_{20}H_{14}N_3O_3$ $[M - H]^-$344.1029, found 344.1021.

3-Fluoro-10*H*-spiro[isoindolo[1,2-*b*]quinazoline-12,3'-piperidine]-2',4',10-trione

(**5d**): Yield: 77% (134 mg). Pale yellow solid. M.p. 261~262 °C; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_H 3.00~3.06 (m, 1H), 3.45~3.53 (m, 1H),3.63~3.67 (m, 1H), 3.77~3.84 (m, 1H), 7.63~7.68 (m, 2H), 7.90 (d, J = 7.6 Hz, 1H), 7.95~8.02 (m, 2H), 8.06 (dd, J = 8.8 Hz, J' = 4.4 Hz, 1H), 8.18 (dd, J = 8.0 Hz, J' = 1.2 Hz, 1H), 9.08 (s, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz): δ_C 36.1, 38.1, 76.5, 111.1 (d, J_{F-C} = 24.8 Hz), 120.7, 121.5 (d, J_{F-C} = 23.6 Hz), 125.3 (d, J_{F-C} = 9.2 Hz), 126.7, 128.17, 128.22, 134.7 (d, J_{F-C} = 9.9 Hz), 136.0, 137.0 (d, J_{F-C} = 2.3 Hz), 149.2, 154.2 (d, J_{F-C} = 4.0 Hz), 158.2, 163.7 (d, J_{F-C} = 246.8 Hz), 165.4, 198.7. IR (KBr): ν3453, 3080, 2963, 1749, 1722, 1686, 1633, 1482, 1474, 1340, 1269, 1223, 891, 825, 775 cm^{-1}. HRMS (APCI, *m/z*): Calcd for $C_{19}H_{11}FN_3O_3$ $[M - H]^-$ 350.0935, found 350.0938.

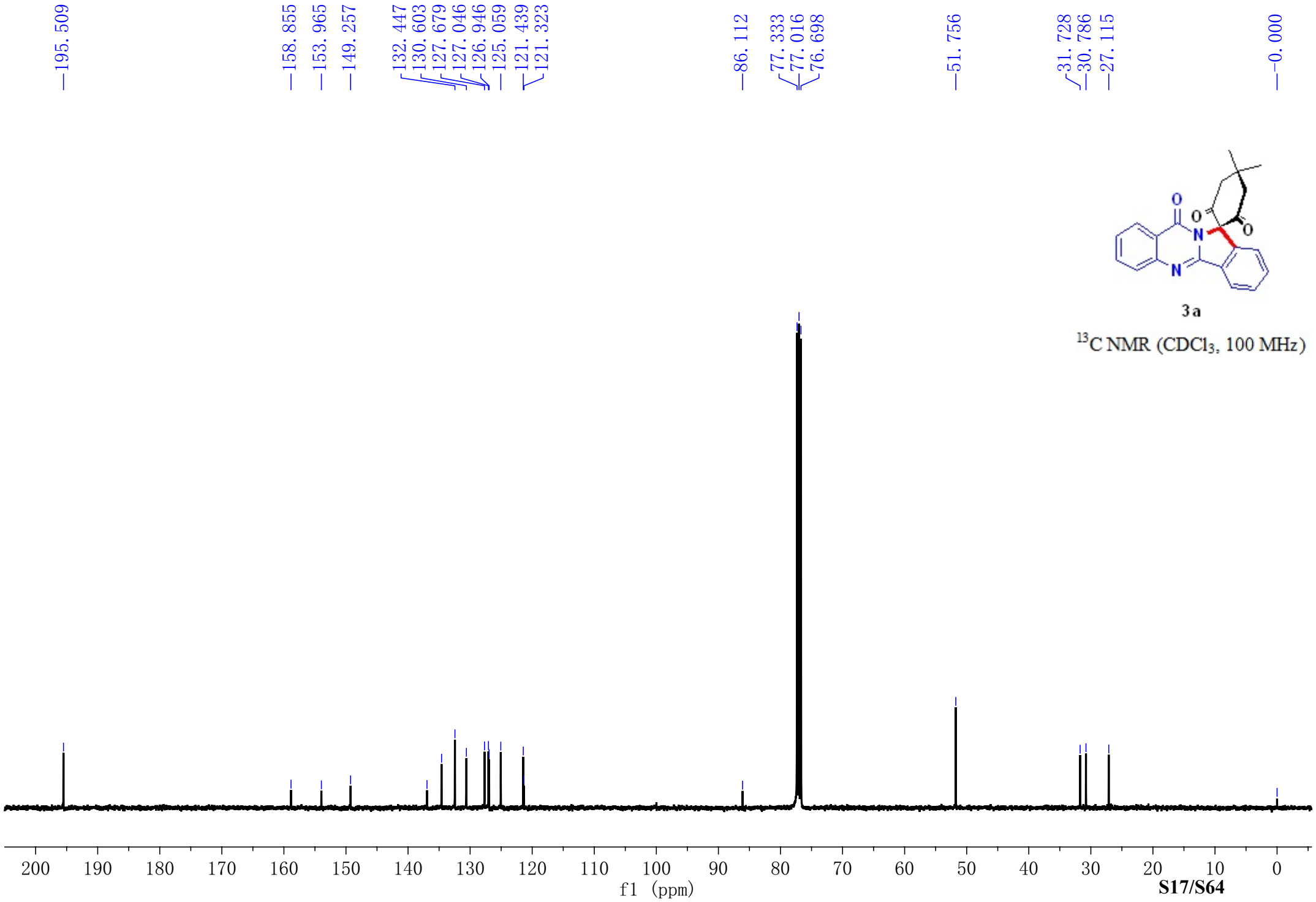
3-Methoxy-10*H*-spiro[isoindolo[1,2-*b*]quinazoline-12,3'-piperidine]-2',4',10-trion e (**5e**): Yield: 80% (145 mg). Pale yellow solid. M.p. 261~263 °C; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_H2.98~3.04 (m, 1H), 3.40~3.48 (m, 1H), 3.61~3.83 (m, 2H), 3.93 (s, 3H), 7.31 (dd, J = 8.4 Hz, J' = 2.4 Hz, 1H), 7.60~7.64 (m, 2H), 7.86~7.95 (m, 3H), 8.17 (dd, J = 8.0 Hz, J' = 1.2 Hz, 1H), 8.98 (s, 1H).^{13}C NMR (DMSO-d_6, 100 MHz): δ_C 36.1, 38.1, 56.5, 76.5, 107.3, 120.8, 121.5, 124.0, 126.6, 127.8, 128.1, 133.4, 134.0, 135.8, 149.4, 155.1, 158.2, 161.5, 165.8, 199.1. IR (KBr): ν3420, 3260, 3000, 1734, 1696, 1676, 1618, 1609, 1488, 1466, 1349, 1278, 1219, 1155, 1106, 1045, 1025, 999, 870, 769 cm^{-1}. HRMS (ESI, *m/z*): Calcd for $C_{20}H_{14}N_3O_4$ $[M - H]^-$ 360.0984, found 360.0962.

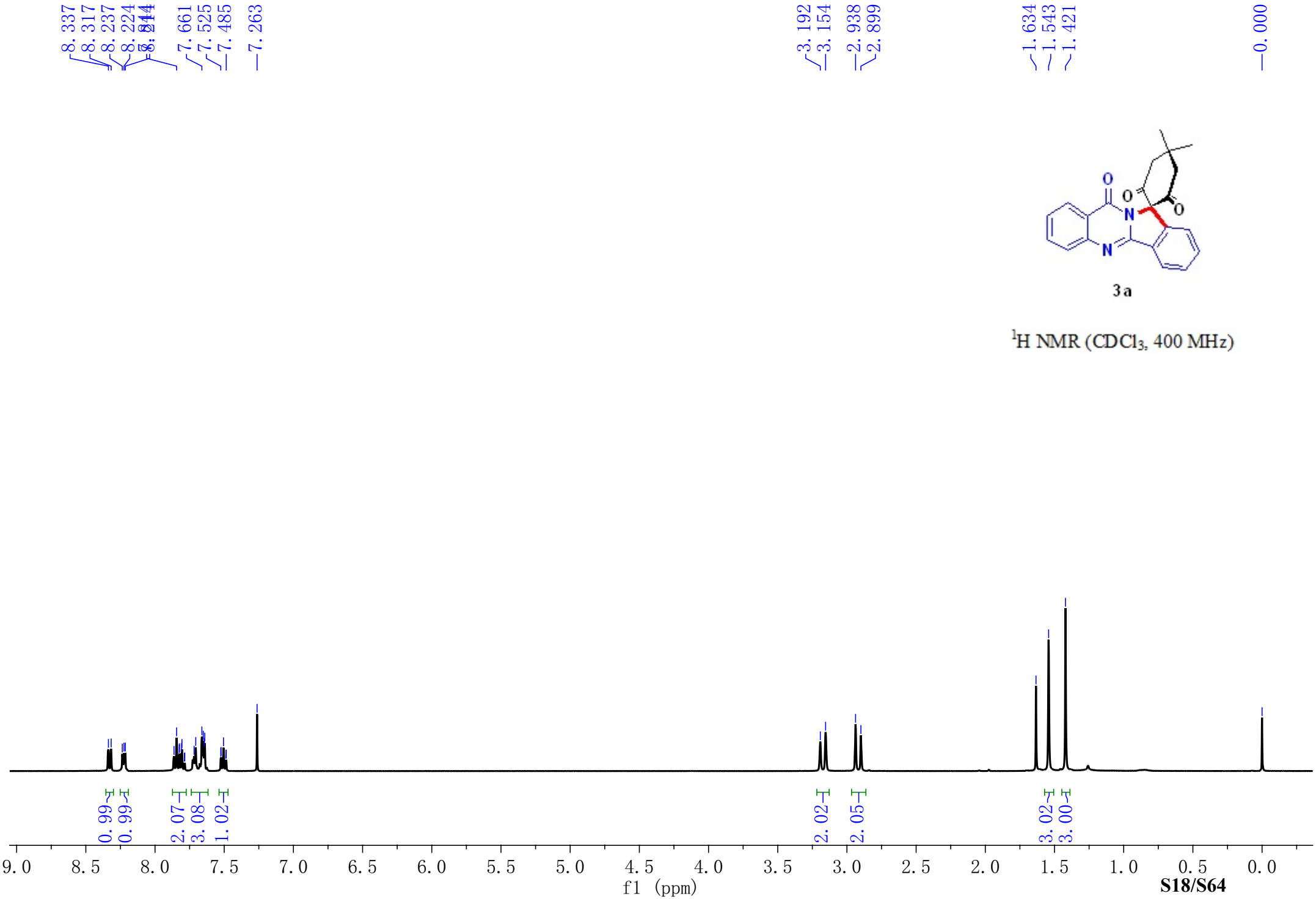
6,7-Dimethyl-10*H*-spiro[isoindolo[1,2-*b*]quinazoline-12,3'-piperidine]-2',4',10-tri one (**5f**): Yield: 75% (135 mg). Pale yellow solid. M.p. 249~250 °C; ^{1}H NMR

(DMSO-d_6, 400 MHz): δ_H 2.47 (s, 3H), 2.65 (s, 3H), 2.99~3.05 (m, 1H), 3.42~3.51 (m, 1H), 3.63~3.70 (m, 1H), 3.78~3.83 (m, 1H), 7.43 (d, J = 8.0 Hz, 1H), 7.72~7.78 (m, 2H), 7.91 (d, J = 8.0 Hz, 1H), 7.95~7.97 (m, 1H), 8.16~8.19 (m, 1H), 8.99 (s, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): 13.6, 21.1, 36.1, 38.1, 76.8, 118.7, 122.9, 123.4, 124.1, 129.3, 131.1, 132.8, 133.8, 134.5, 141.0, 144.5, 153.9, 158.6, 165.8, 199.1. IR (KBr): ν 3147, 3063, 2958, 1749, 1719, 1684, 1635, 1471, 1457, 1340, 1230, 1183, 1080, 957, 854, 772 cm^{-1}. HRMS (ESI, *m/z*): Calcd for $C_{21}H_{16}N_3O_3$ $[M - H]^-$ 358.1192, found 358.1199.

References

1. Zhan, D.; Li, T. B.; Wei, H. D.; Weng, W.; Ghandic, K. *RSC Adv*. 2013, *3*, 9325-9329.

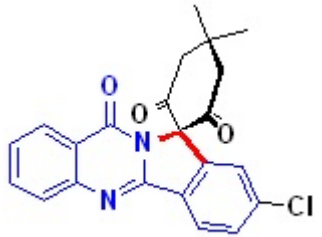

195.509
158.855
153.965
149.257
132.447
130.603
127.679
127.046
126.946
125.059
121.439
121.323
86.112
77.333
77.016
76.698
51.756
31.728
30.786
27.115
0.000
O
O
O
N
N
3a
^{13}C NMR ($CDCl_3$, 100 MHz)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



3a

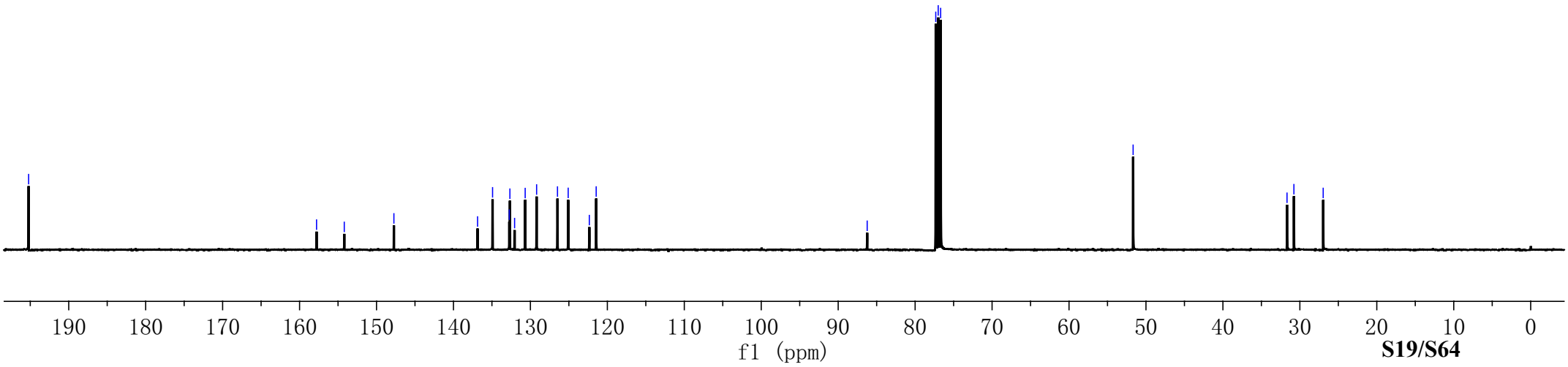
^{1}H NMR ($CDCl_3$, 400 MHz)

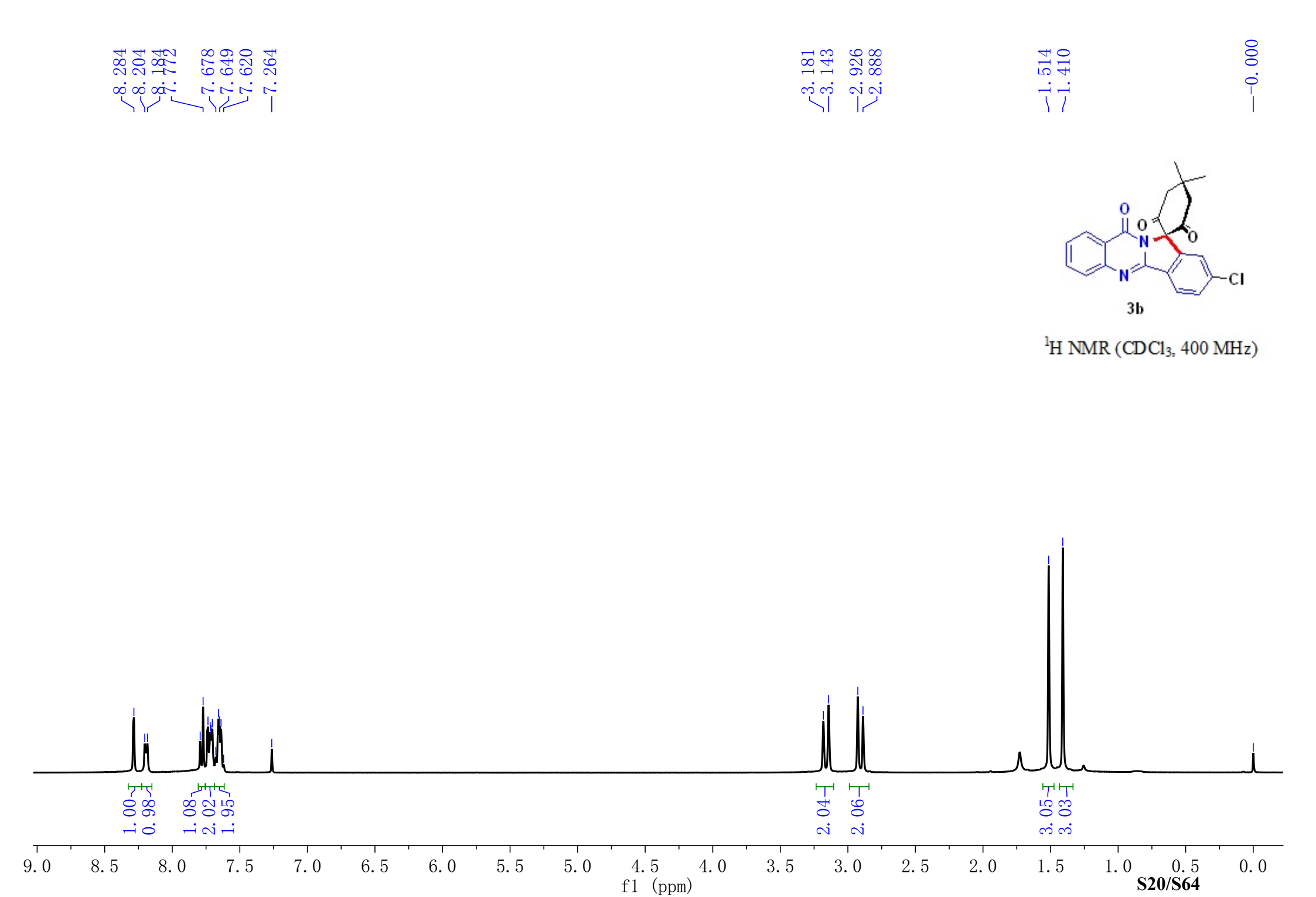
195.211
157.792
154.190
147.741
136.865
134.917
132.740
132.664
132.055
130.679
129.193
126.480
125.089
122.344
121.451
86.231
77.318
77.000
76.682
51.670
31.669
30.772
26.967



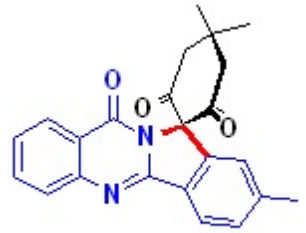
3b

^{13}C NMR ($CDCl_3$, 100 MHz)



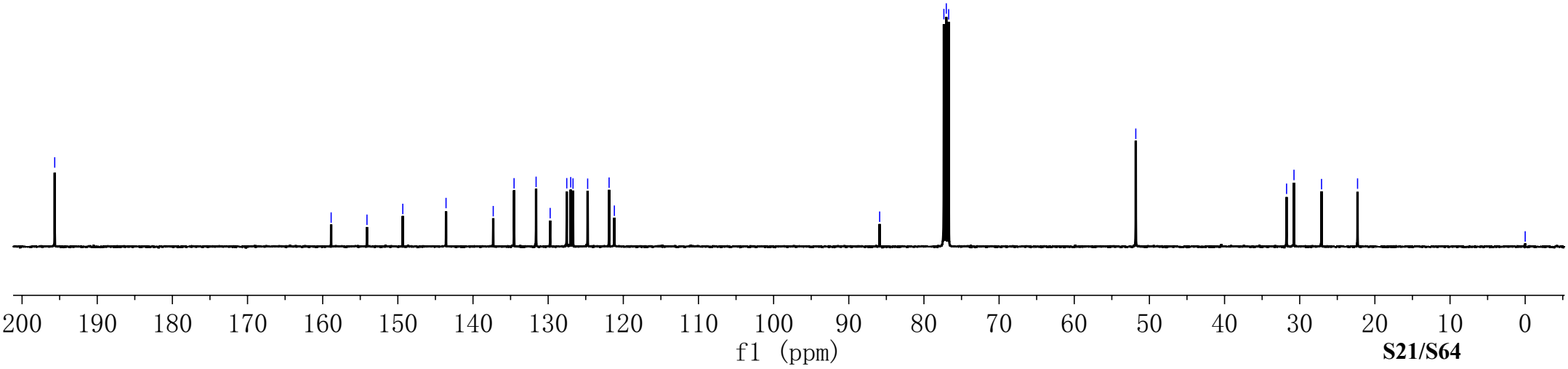

8.284
8.204
8.184
7.772
7.678
7.649
7.620
7.264
3.181
3.143
2.926
2.888
1.514
1.410
0.000
O
O
O
N
N
Cl
3b
^{1}H NMR ($CDCl_3$, 400 MHz)
1.00
0.98
1.08
2.02
1.95
2.04
2.06
3.05
3.03
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

195.654
158.875
154.109
149.342
143.588
137.308
134.535
131.604
129.735
127.523
126.999
126.694
124.743
121.893
121.193
85.891
77.345
77.027
76.710
51.811
31.749
30.762
27.097
22.305
0.000

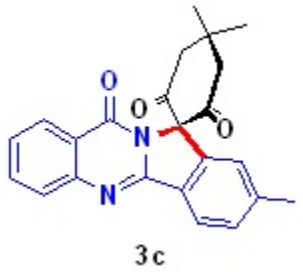


3c

^{13}C NMR ($CDCl_3$, 100 MHz)

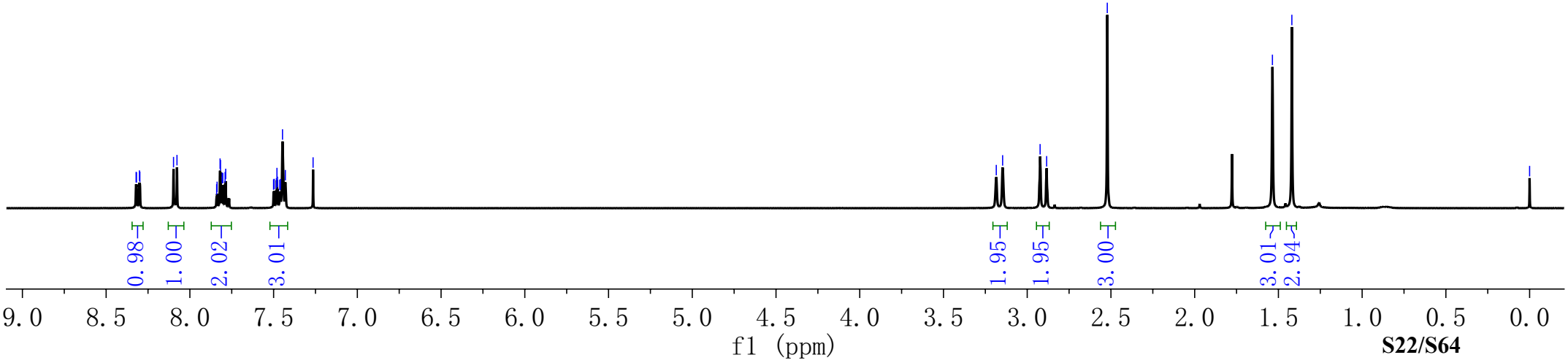


8.321
8.319
8.301
8.299
8.077
7.817
7.786
7.477
7.430
7.264
3.185
3.147
2.923
2.884
2.522
1.536
1.420
0.000

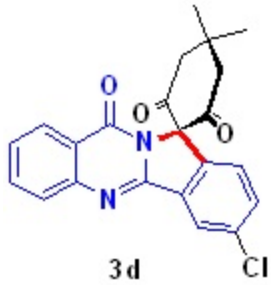


3c

^{1}H NMR ($CDCl_3$, 400 MHz)

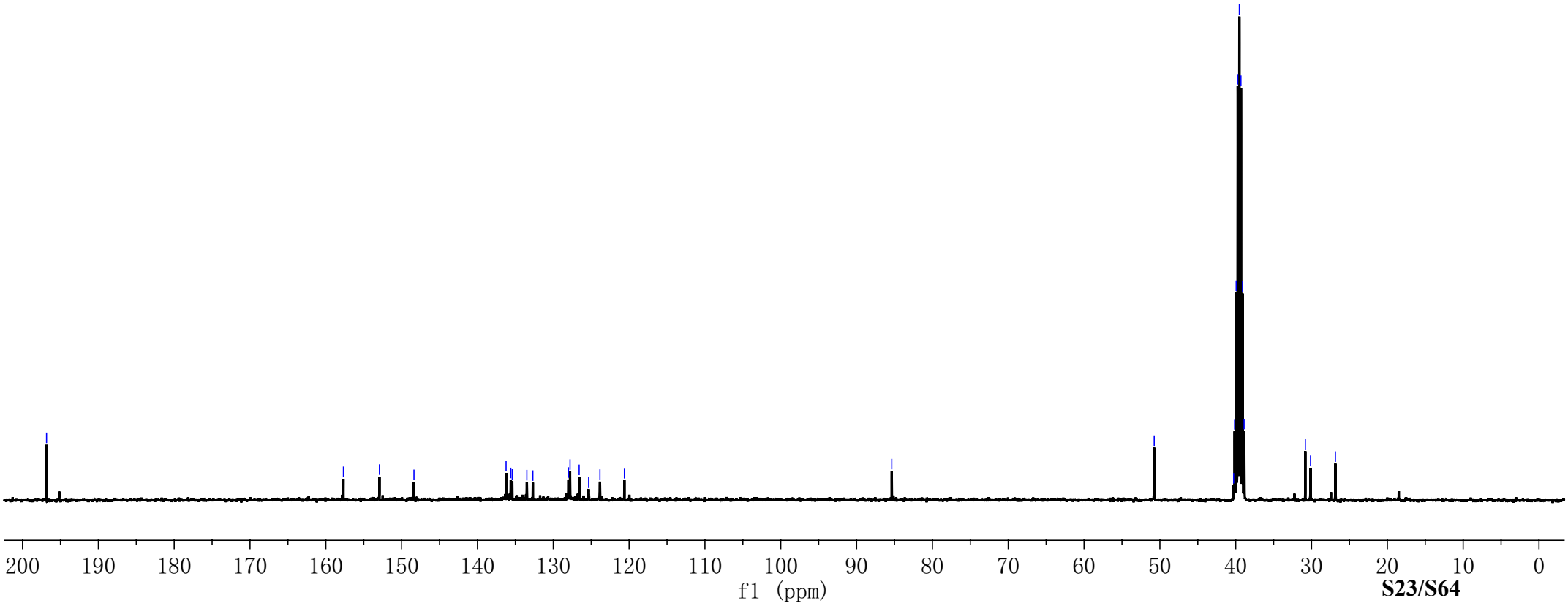


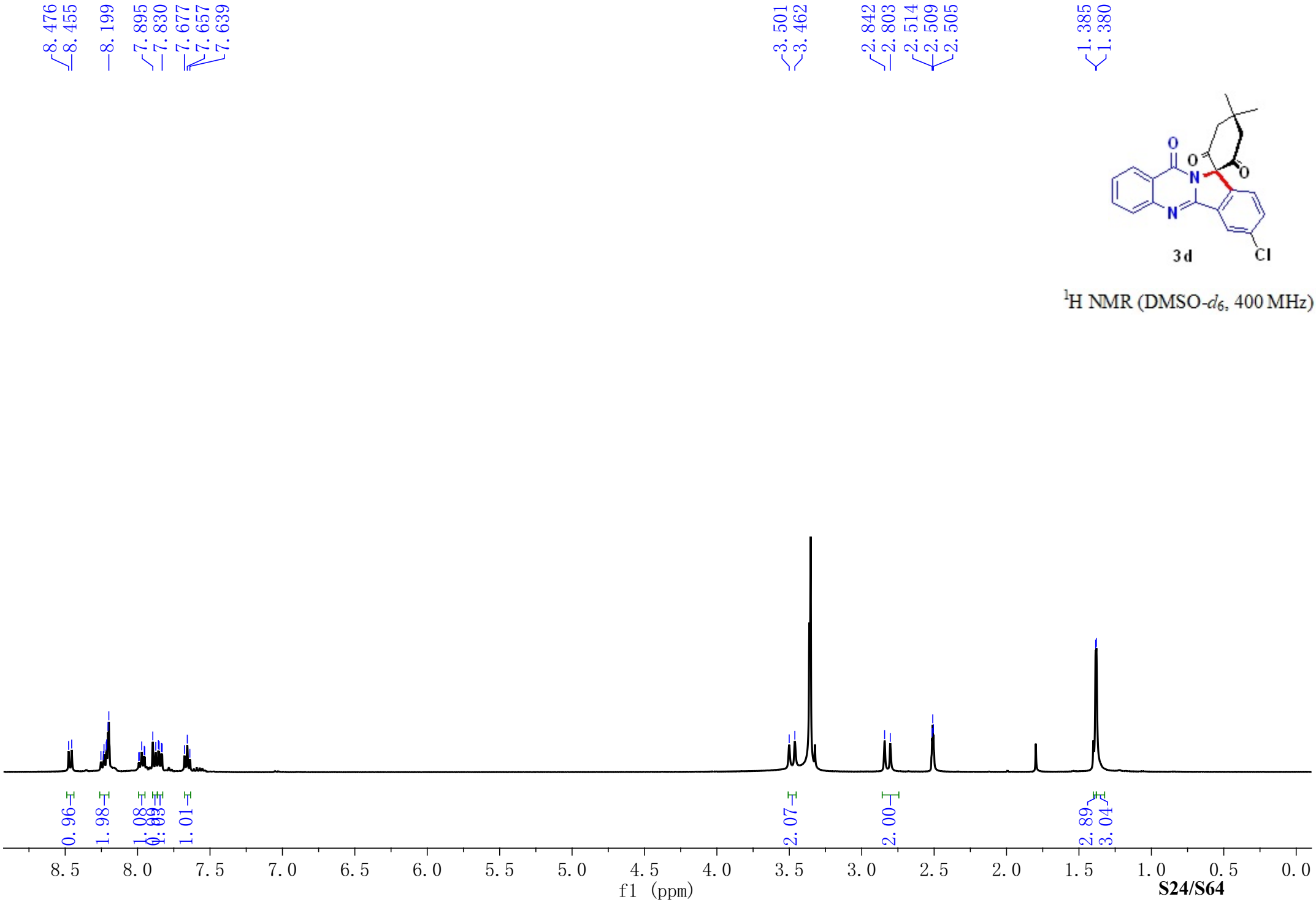
196.835
157.680
152.929
148.375
136.226
135.412
133.485
132.694
126.588
123.848
120.623
85.360
50.748
39.729
39.311
38.894
30.816
30.130
26.851



3d

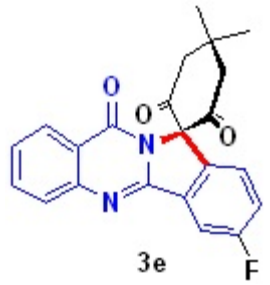
^{13}C NMR (DMSO-d_6, 100 MHz)





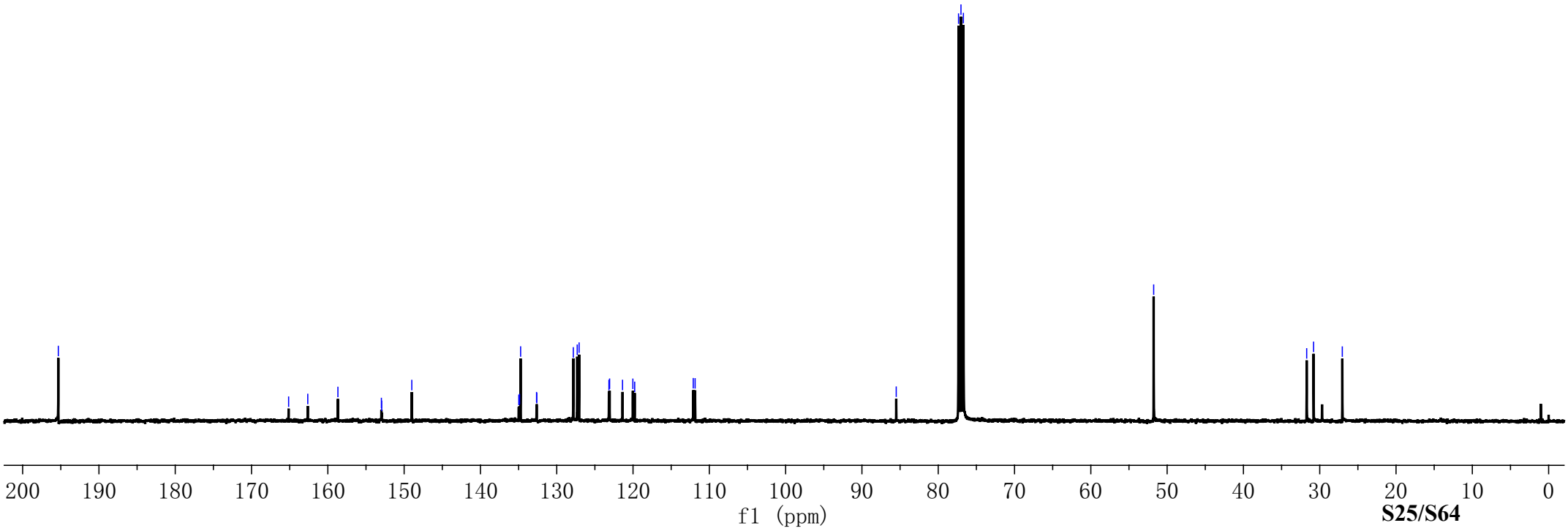
^{1}H NMR (DMSO-d_6, 400 MHz)

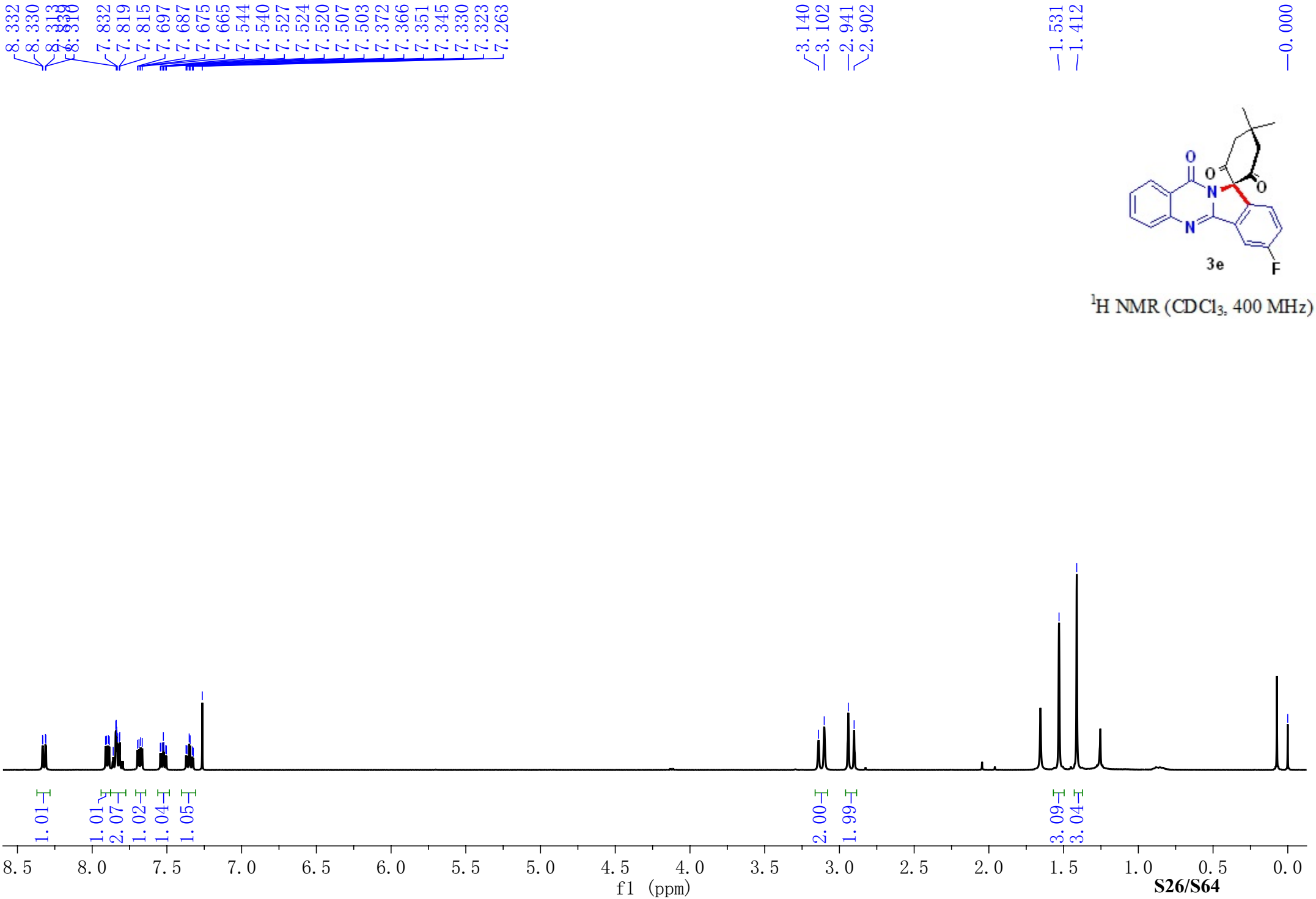
195.323
165.138
162.630
158.680
152.941
148.996
134.876
134.734
132.645
132.617
127.065
121.376
119.784
112.108
111.864
85.505
77.338
77.021
76.703
51.763
31.710
30.806
27.041



3e

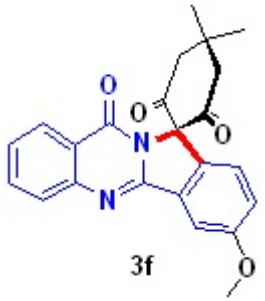
^{13}C NMR ($CDCl_3$, 100 MHz)





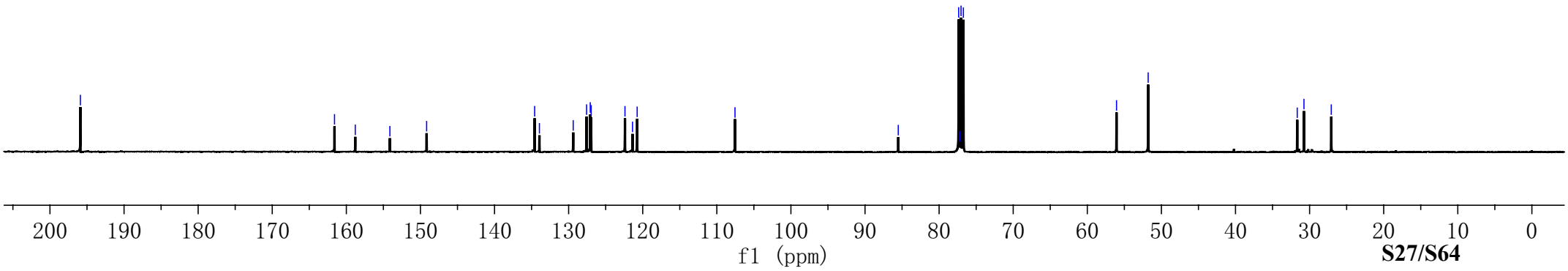
^{1}H NMR ($CDCl_3$, 400 MHz)

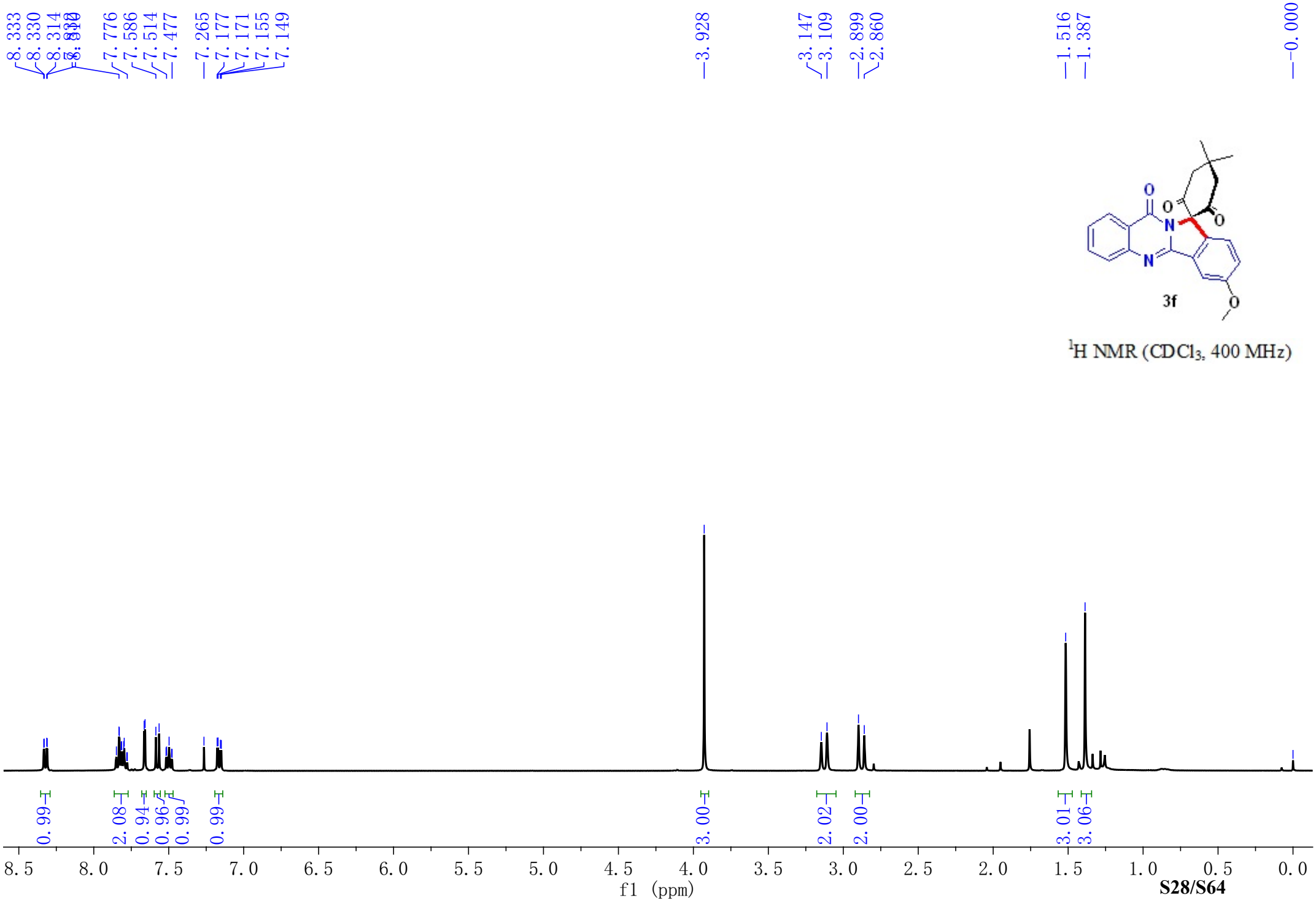
195.896
161.595
158.796
154.123
149.164
134.585
133.942
126.959
122.397
121.375
120.752
107.548
85.513
77.359
77.242
77.041
76.723
56.055
51.785
31.668
30.760
27.076



3f

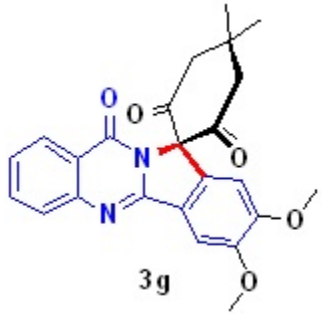
^{13}C NMR ($CDCl_3$, 100 MHz)



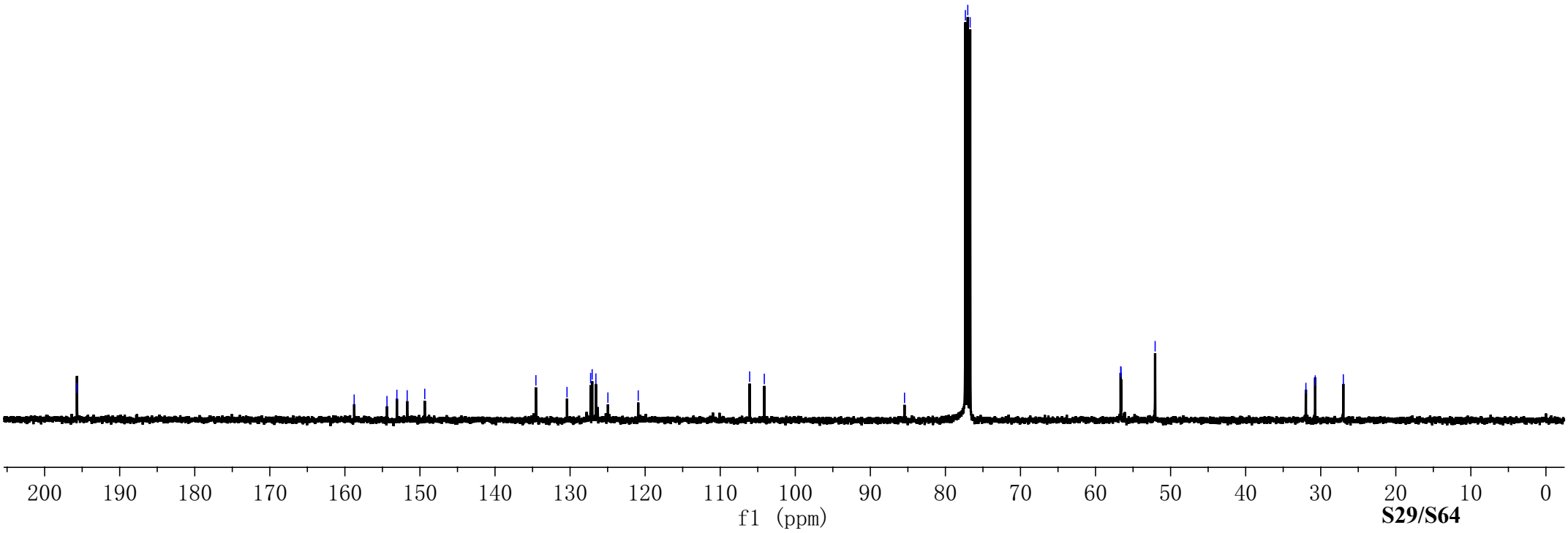


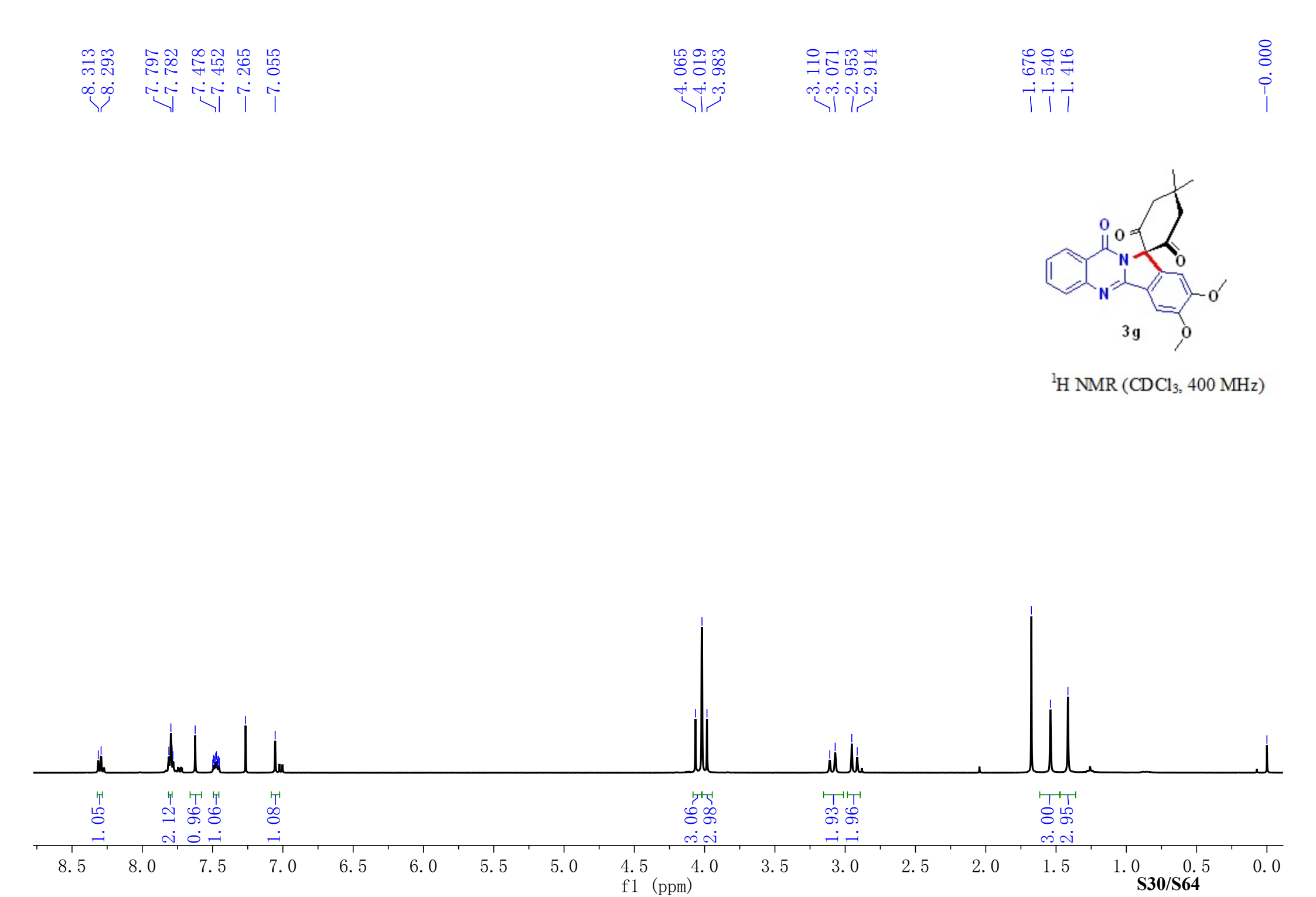
^{1}H NMR ($CDCl_3$, 400 MHz)

195.701
158.763
154.393
153.073
151.703
149.359
134.552
127.058
124.960
120.921
106.074
104.127
85.446
77.337
77.020
76.702
56.648
56.602
52.060
31.977
30.737
26.988



^{13}C NMR ($CDCl_3$, 100 MHz)



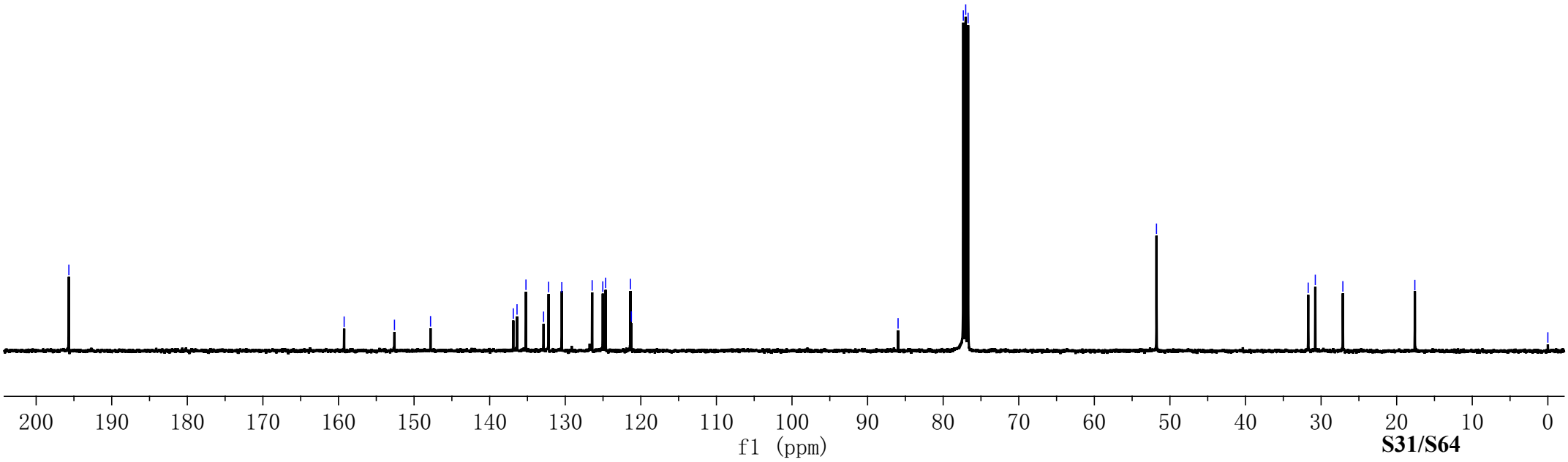


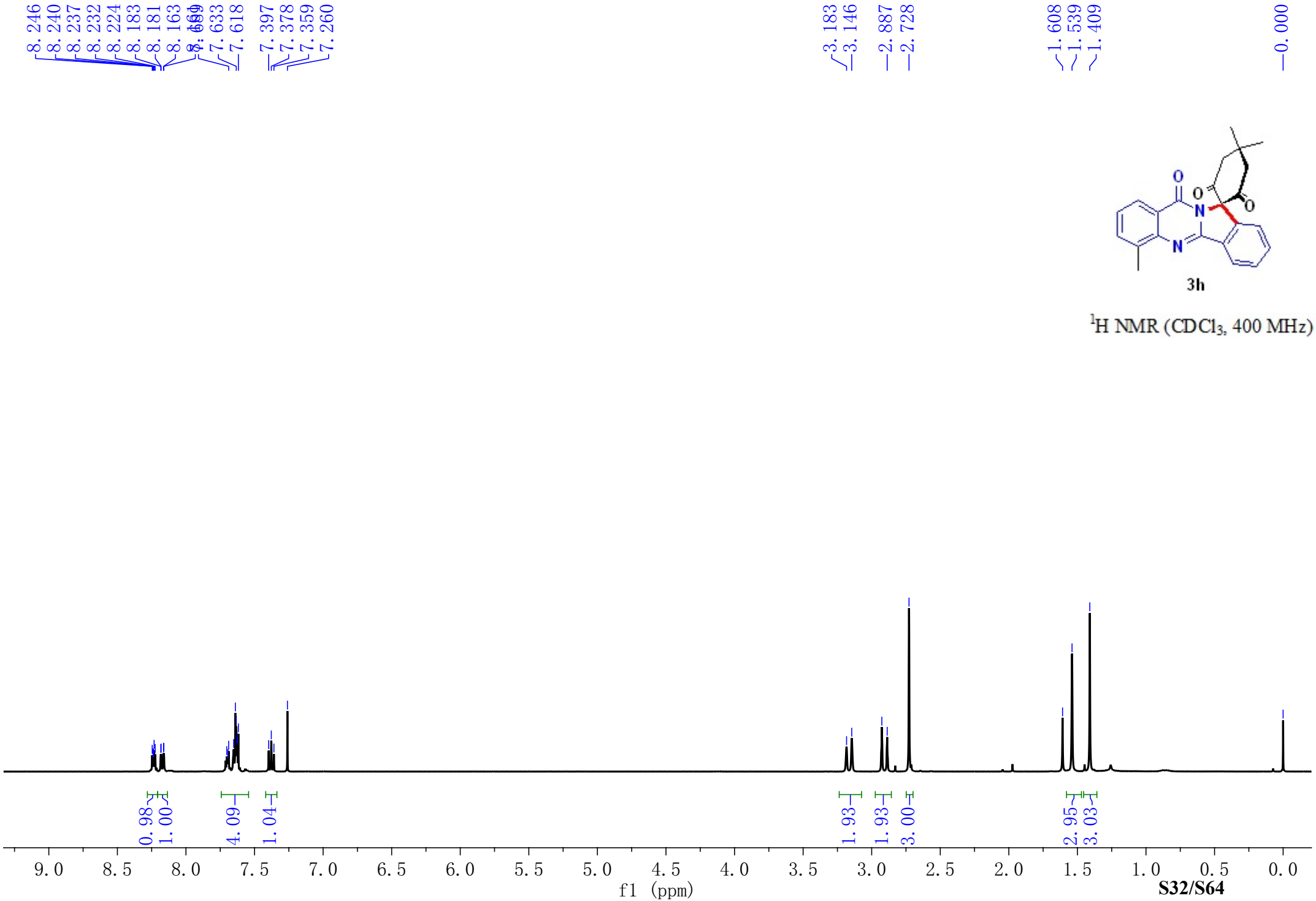
^{1}H NMR ($CDCl_3$, 400 MHz)

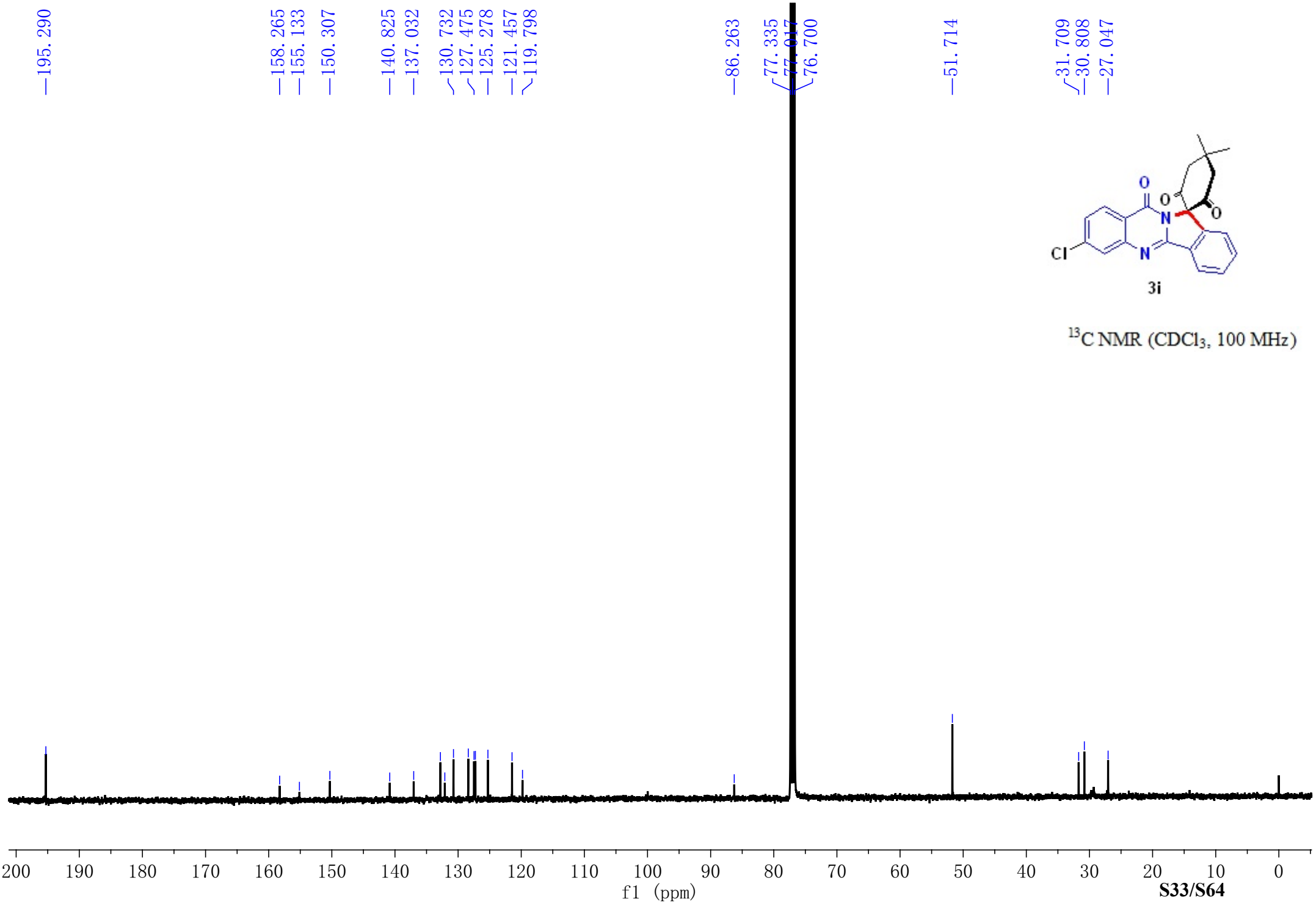
195.670
159.250
152.593
147.820
135.197
132.865
132.198
130.453
124.656
121.371
121.251
85.965
77.335
77.018
76.700
51.778
31.707
30.767
27.120
17.598
0.000

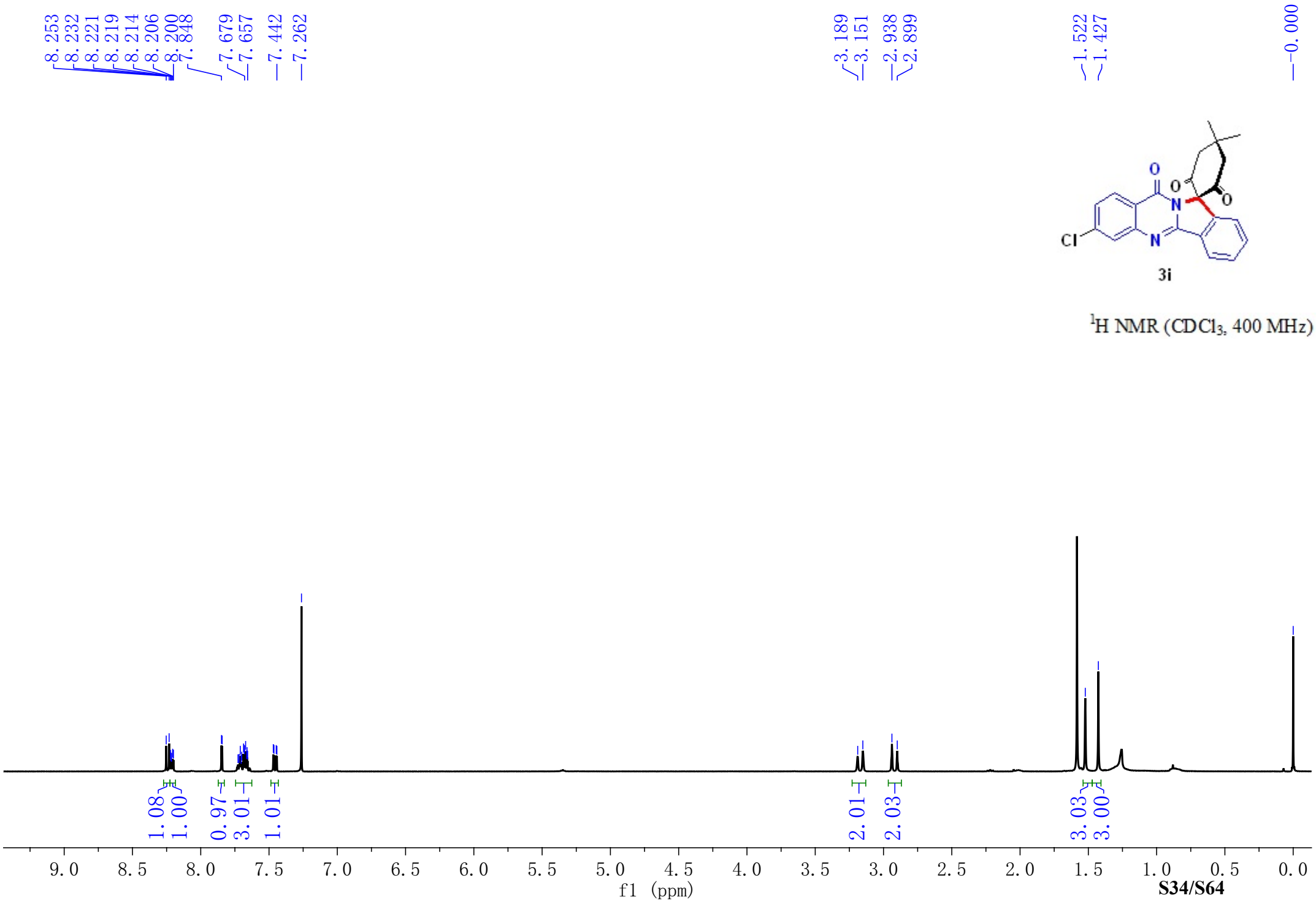
3h

^{13}C NMR ($CDCl_3$, 100 MHz)

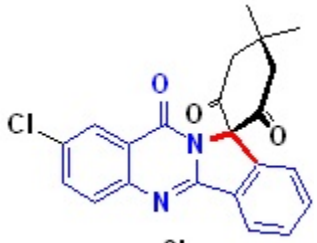



8.246
8.240
8.237
8.232
8.224
8.183
8.181
8.163
7.633
7.618
7.397
7.378
7.359
7.260
3.183
3.146
2.887
2.728
1.608
1.539
1.409
0.000
O
O
O
N
N
3h
^{1}H NMR (CDCl$_3$, 400 MHz)
0.98
1.00
4.09
1.04
1.93
1.93
3.00
2.95
3.03
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


195.290
158.265
155.133
150.307
140.825
137.032
130.732
127.475
125.278
121.457
119.798
86.263
77.335
77.017
76.700
51.714
31.709
30.808
27.047
O
O
O
N
N
Cl
3i
^{13}C NMR ($CDCl_3$, 100 MHz)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

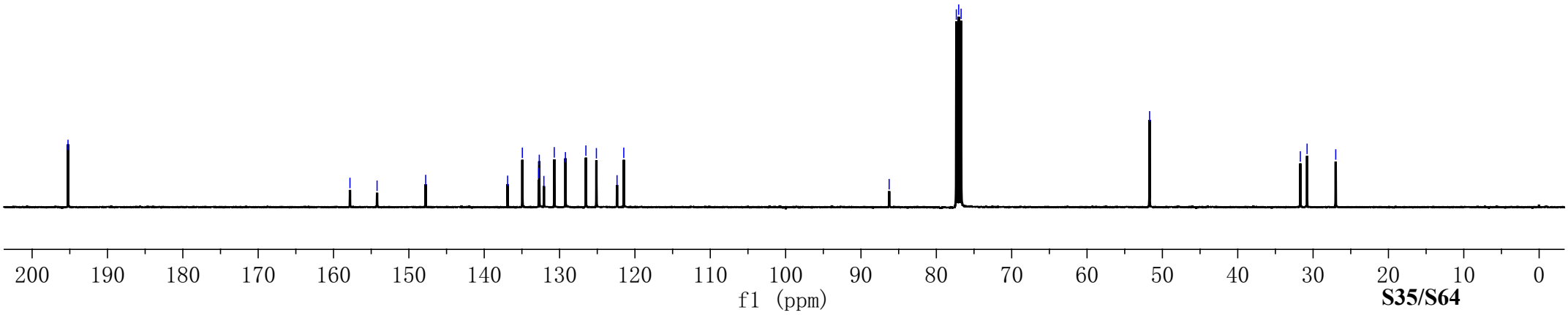

8.253
8.232
8.221
8.219
8.214
8.206
8.200
7.848
7.679
7.657
7.442
7.262
3.189
3.151
2.938
2.899
1.522
1.427
0.000
O
O
O
N
N
Cl
3i
^{1}H NMR ($CDCl_3$, 400 MHz)
1.08
1.00
0.97
3.01
1.01
2.01
2.03
3.03
3.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

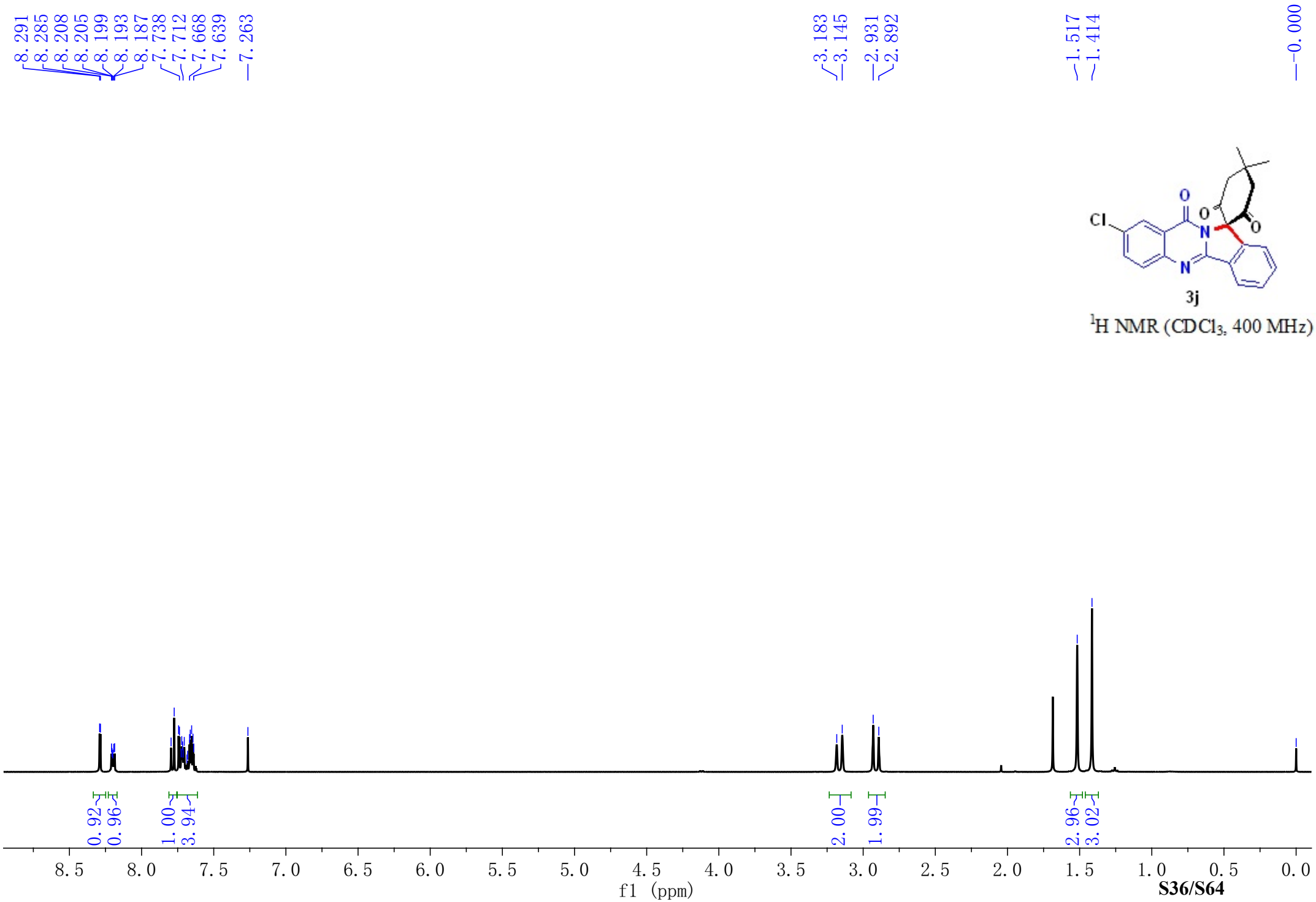
195.239
157.820
154.221
147.772
136.897
134.942
132.766
132.694
132.082
130.706
129.224
126.506
125.115
122.374
121.480
86.260
77.348
77.031
76.713
51.697
31.693
30.797
26.994

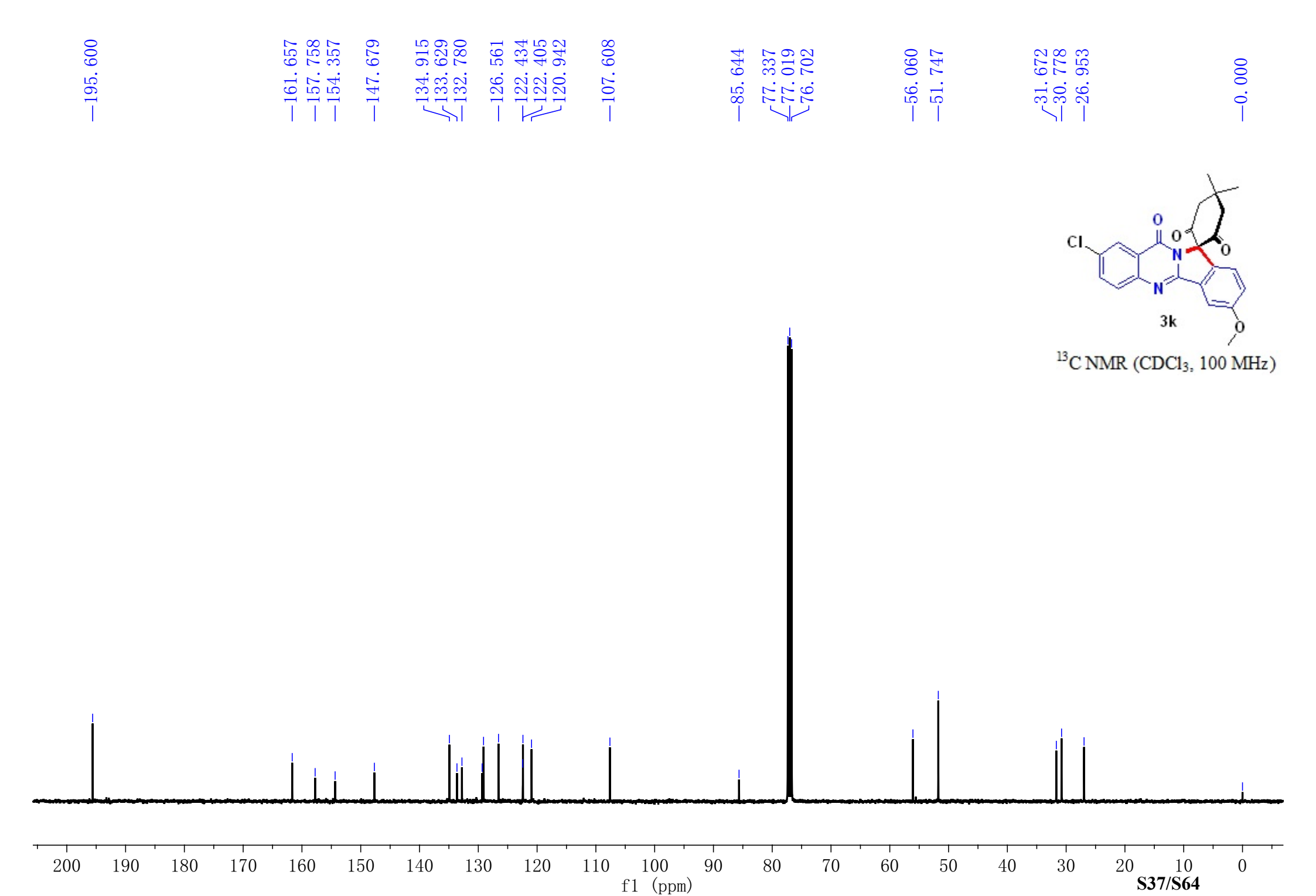


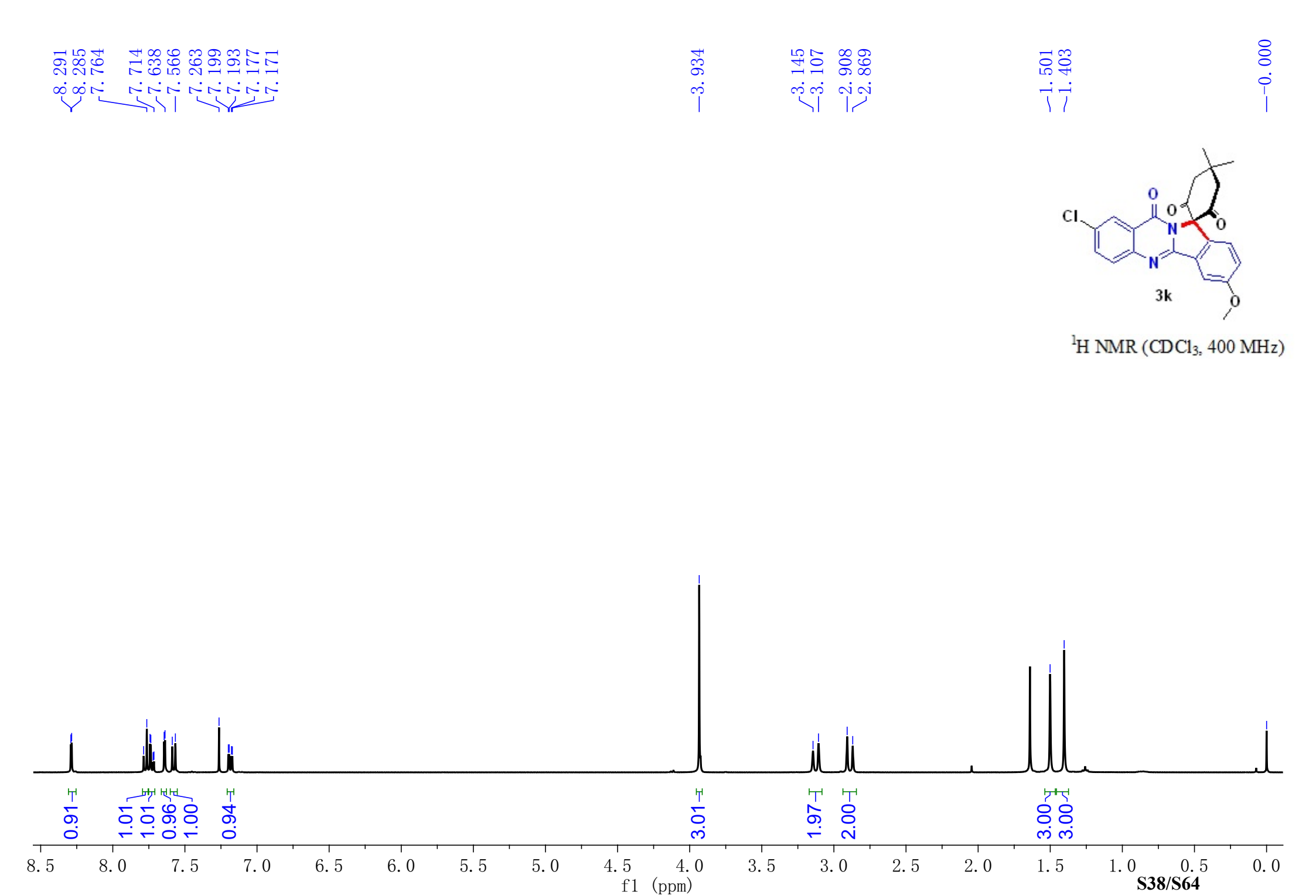
3j

^{13}C NMR ($CDCl_3$, 100 MHz)

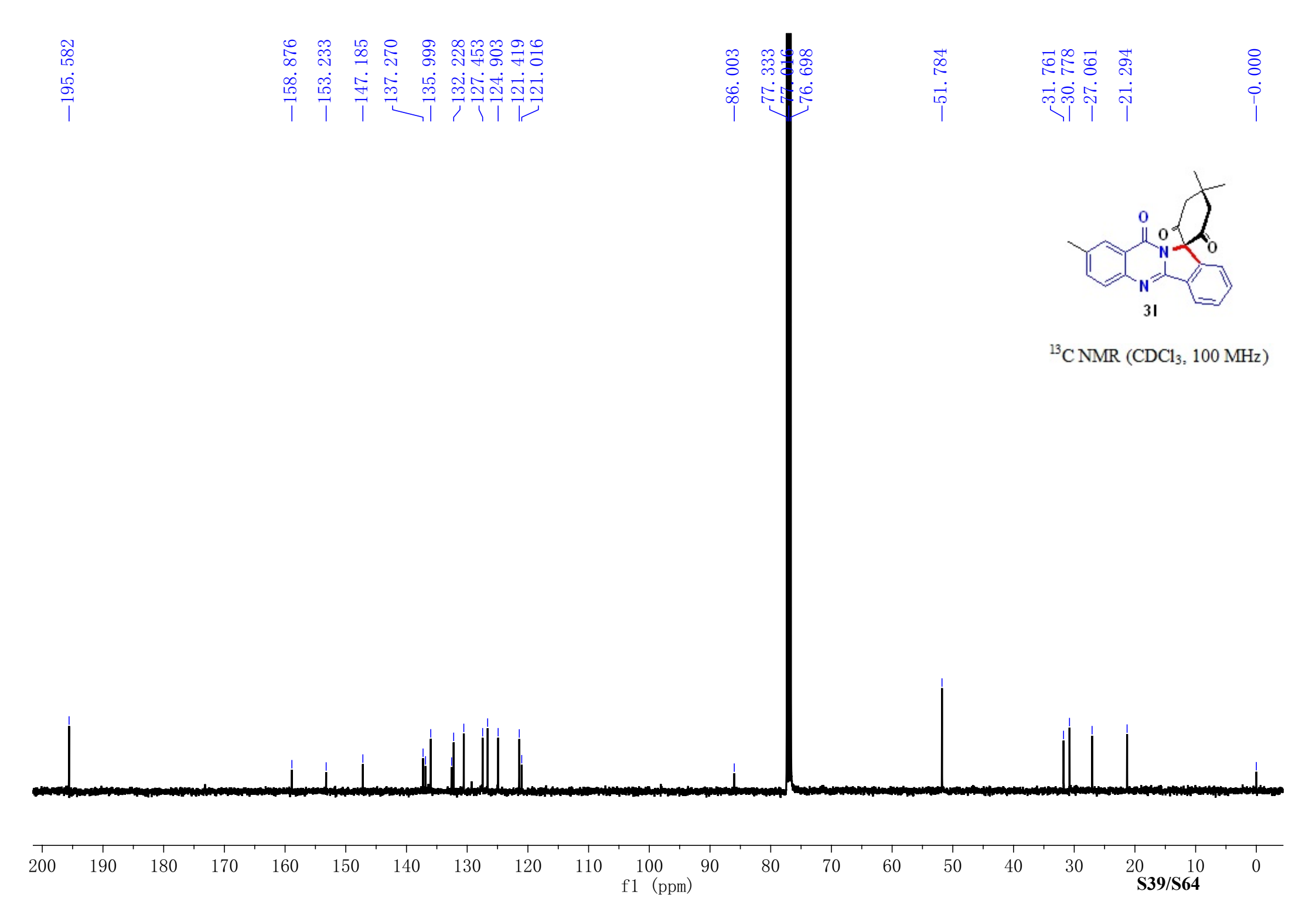


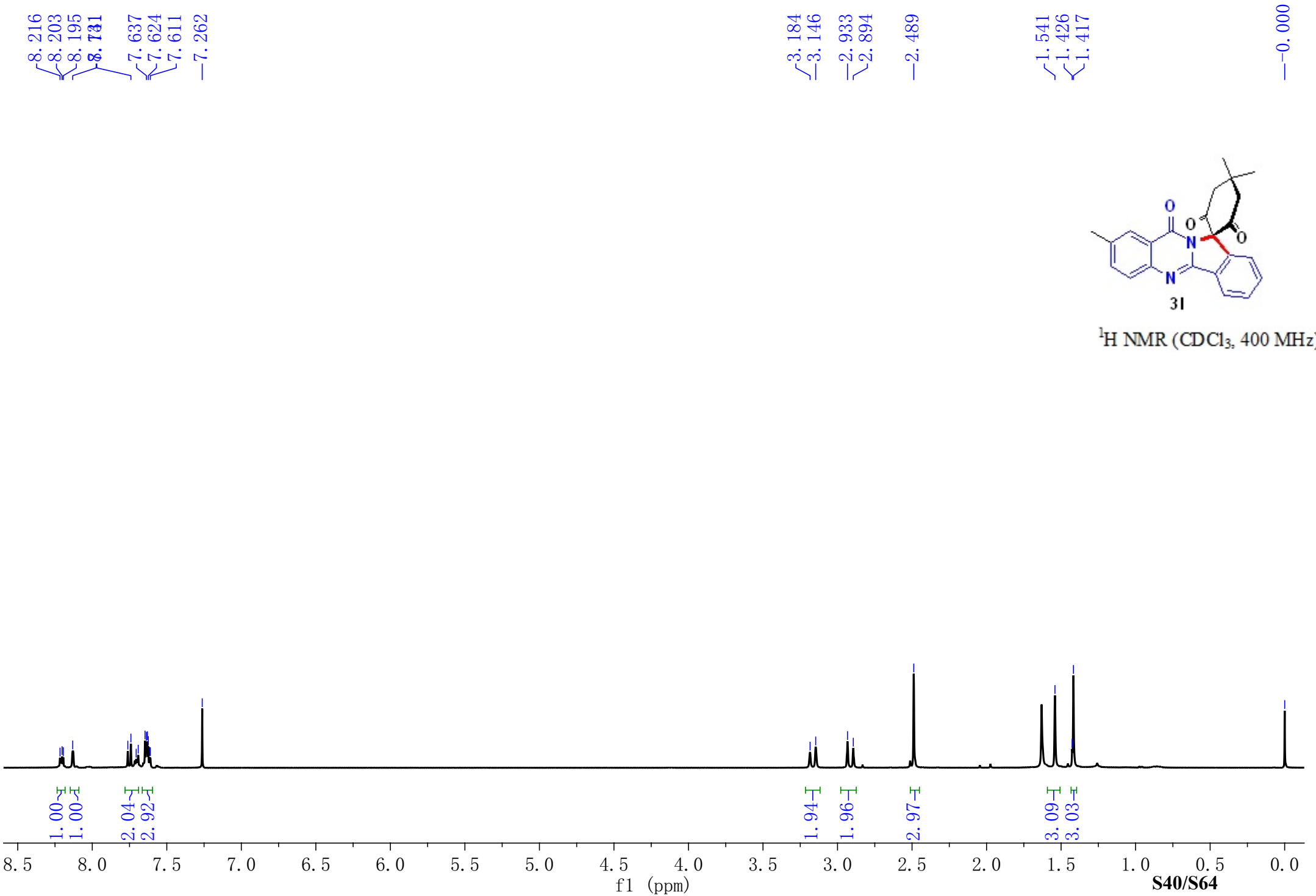

8.291
8.285
8.208
8.205
8.199
8.193
8.187
7.738
7.712
7.668
7.639
7.263
3.183
3.145
2.931
2.892
1.517
1.414
0.000
Cl
O
O
O
N
N
3j
^{1}H NMR ($CDCl_3$, 400 MHz)
0.92
0.96
1.00
3.94
2.00
1.99
2.96
3.02
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


195.600
161.657
157.758
154.357
147.679
134.915
133.629
132.780
126.561
122.434
122.405
120.942
107.608
85.644
77.337
77.019
76.702
56.060
51.747
31.672
30.778
26.953
0.000
Cl
O
O
O
N
N
O
3k
13C NMR (CDCl3, 100 MHz)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



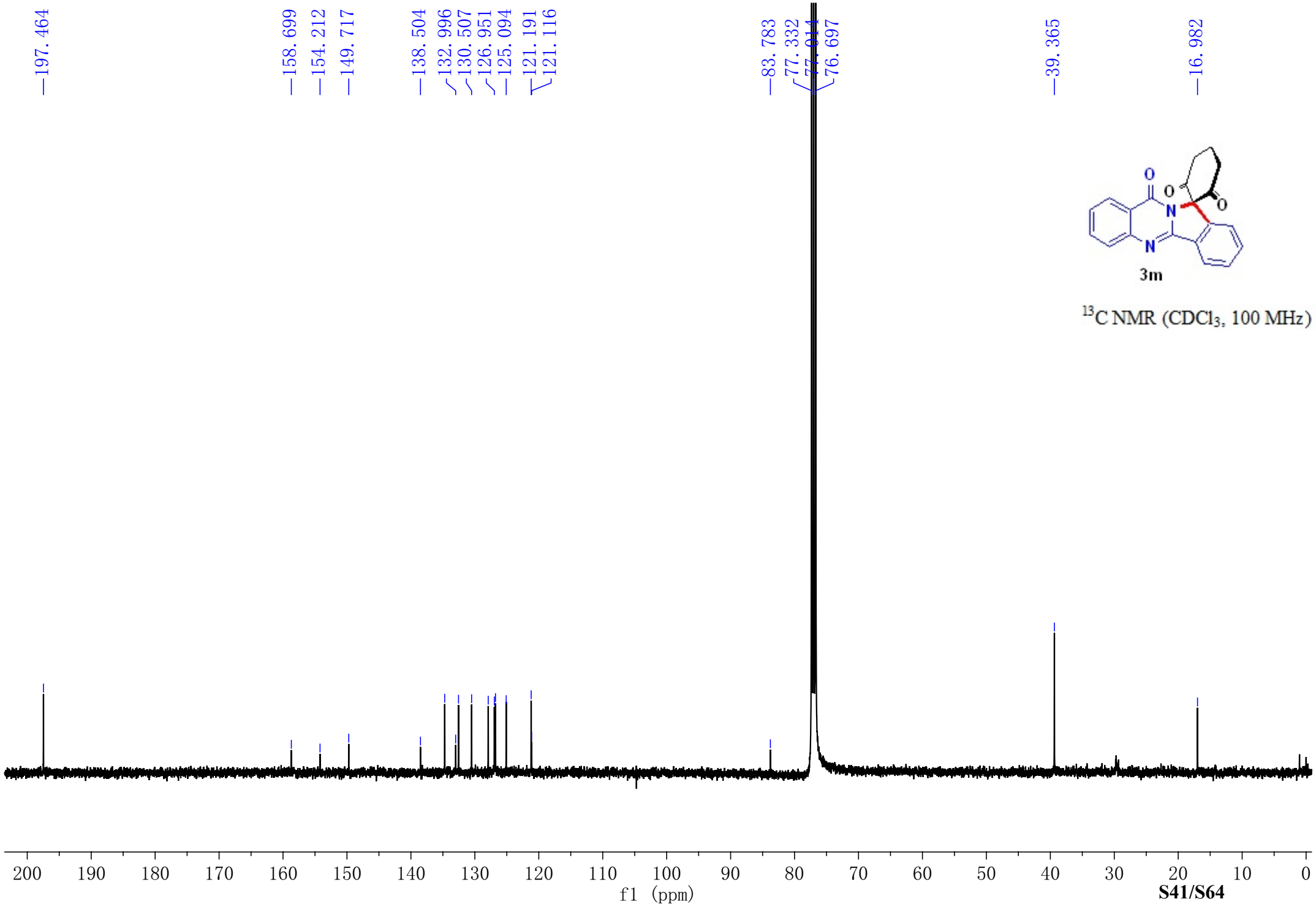
^{1}H NMR ($CDCl_3$, 400 MHz)

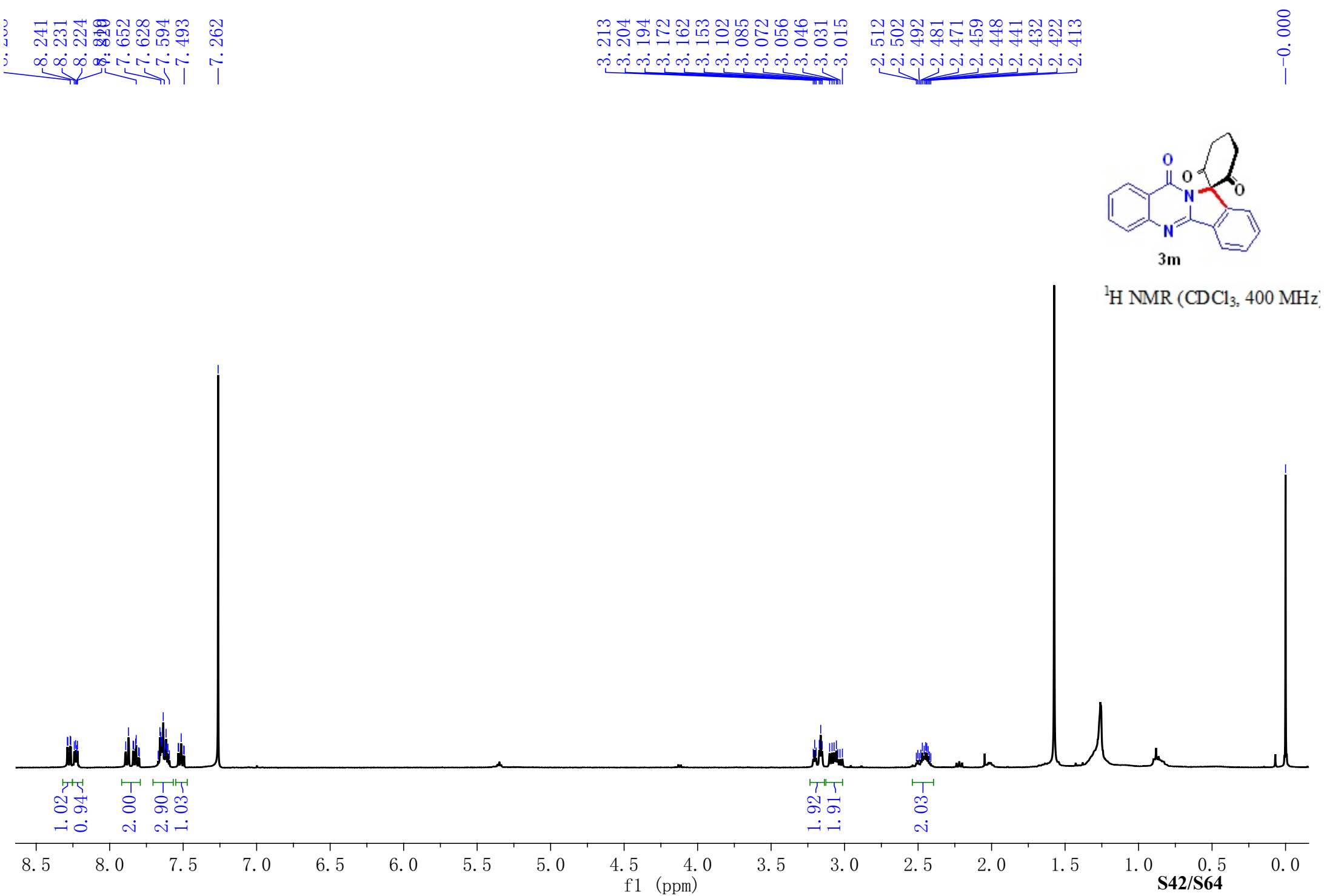

195.582
158.876
153.233
147.185
137.270
135.999
132.228
127.453
124.903
121.419
121.016
86.003
77.333
77.016
76.698
51.784
31.761
30.778
27.061
21.294
0.000
O
O
O
N
N
3l
^{13}C NMR ($CDCl_3$, 100 MHz)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

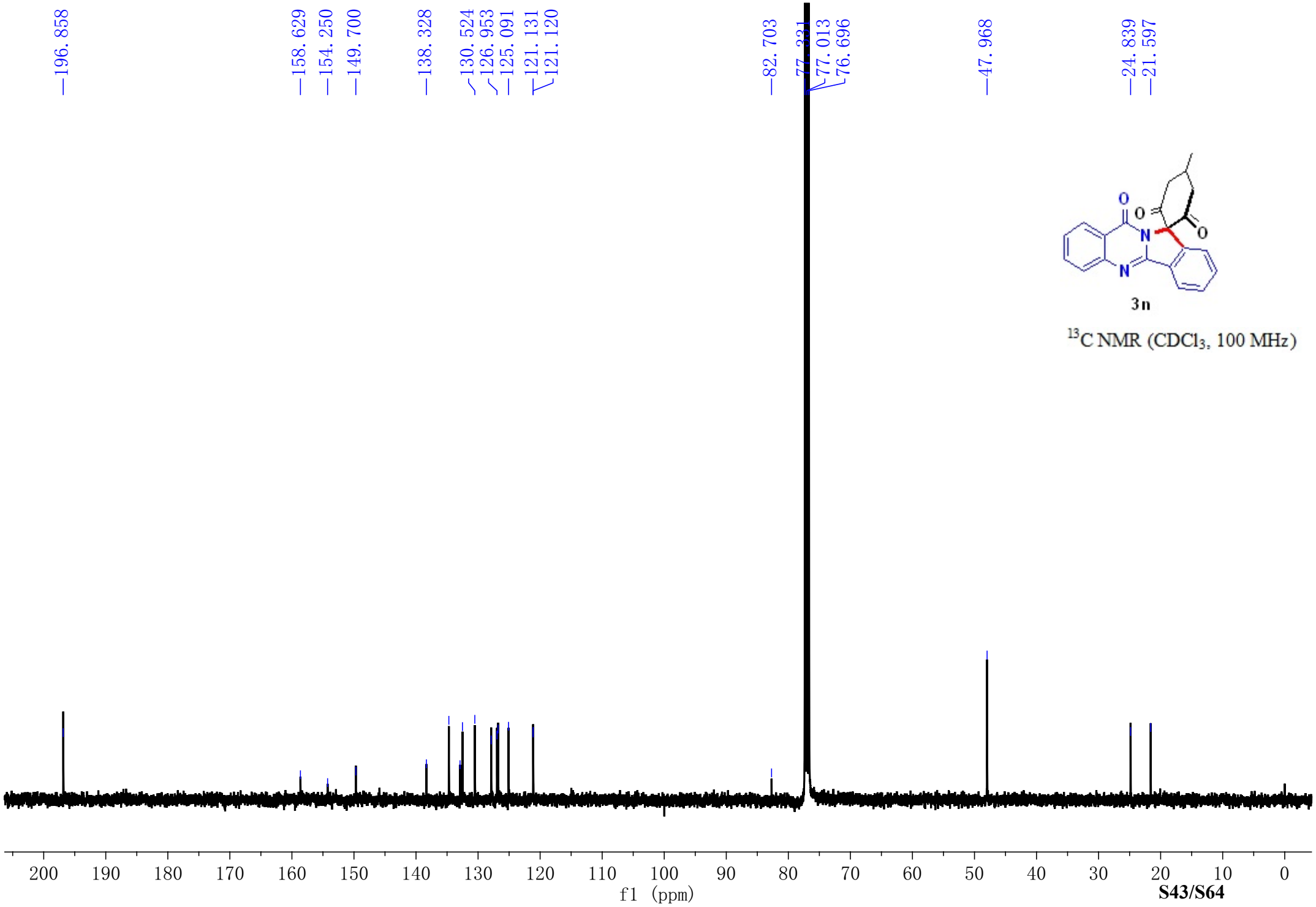


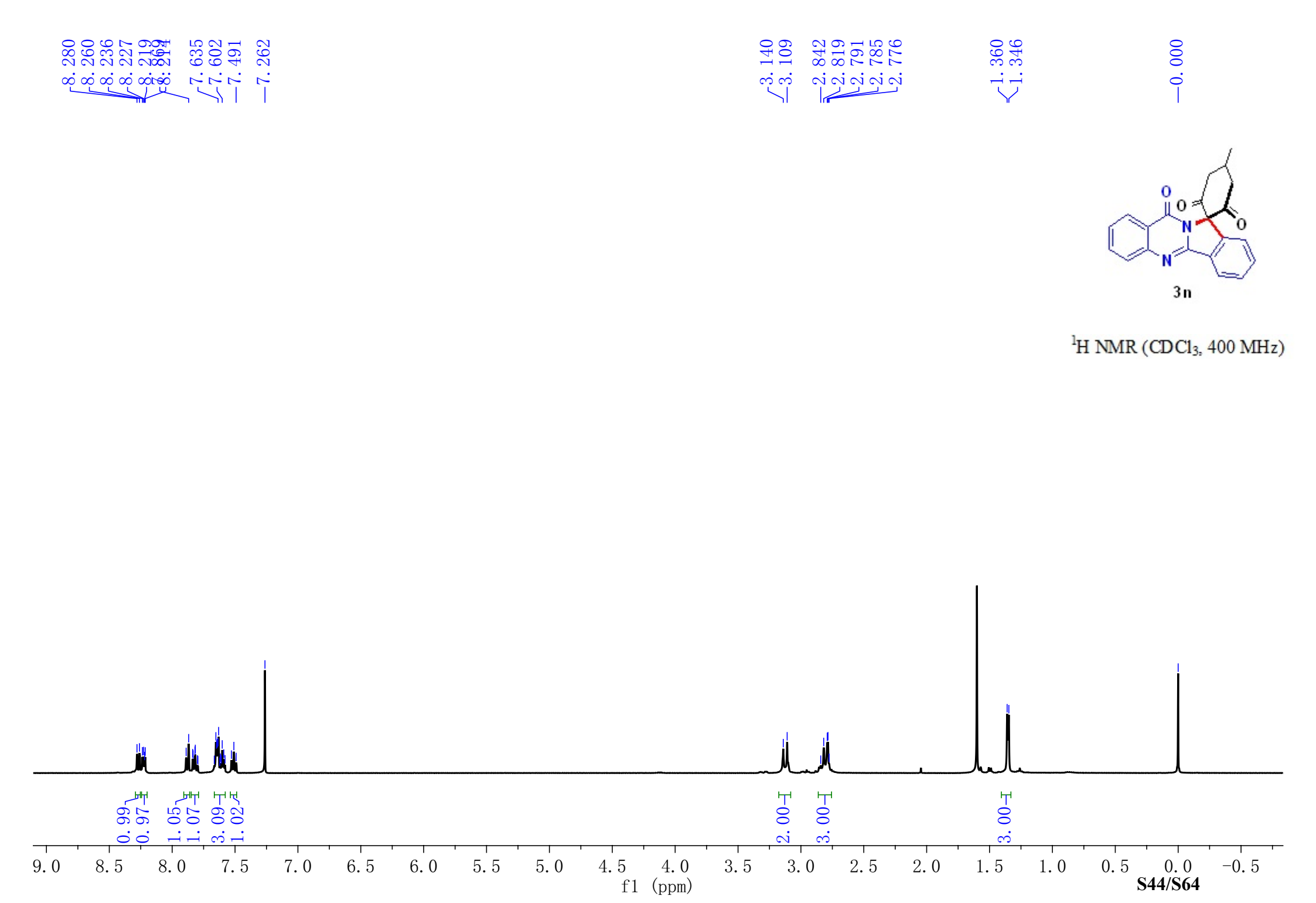
3l

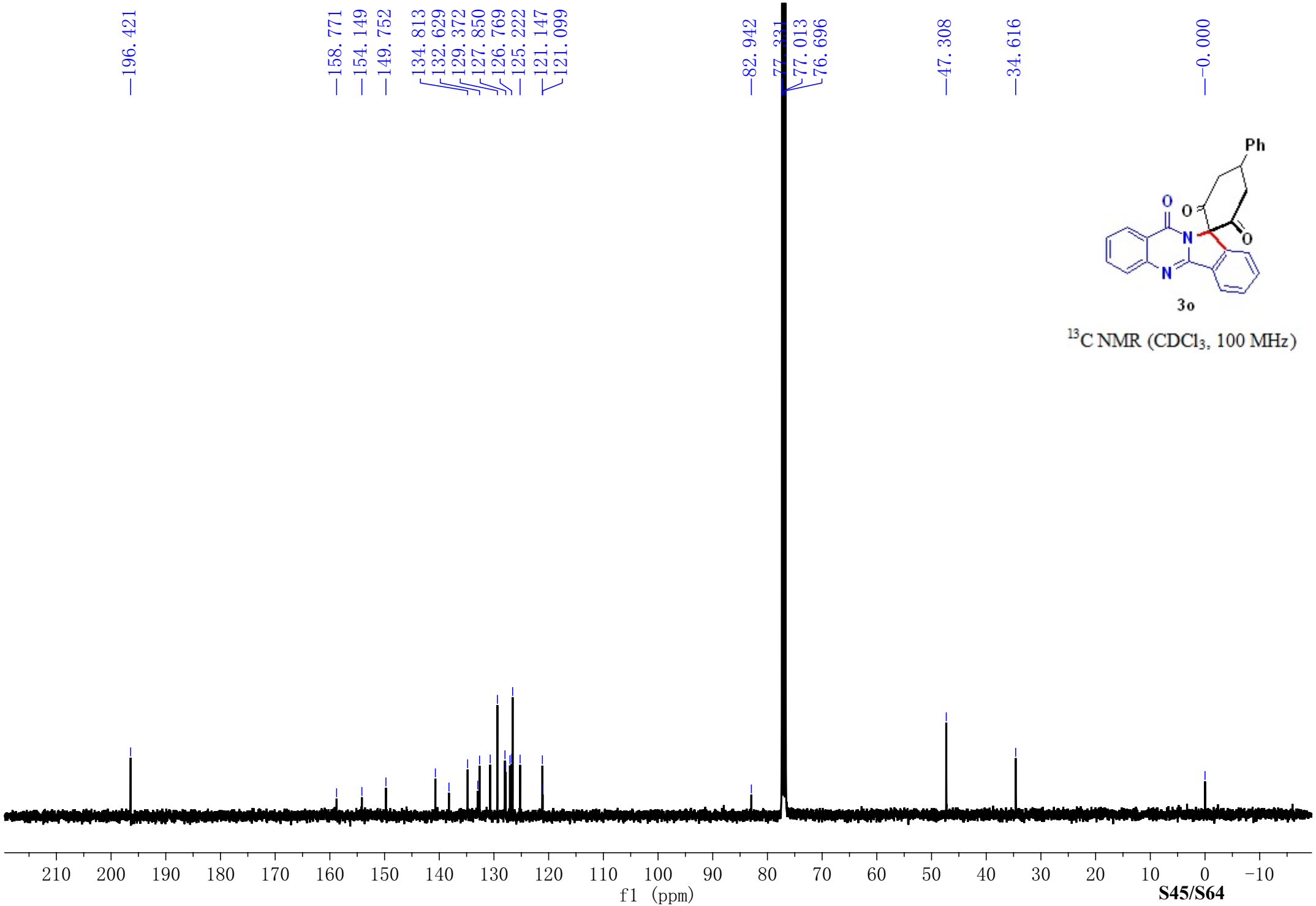
^{1}H NMR ($CDCl_3$, 400 MHz)

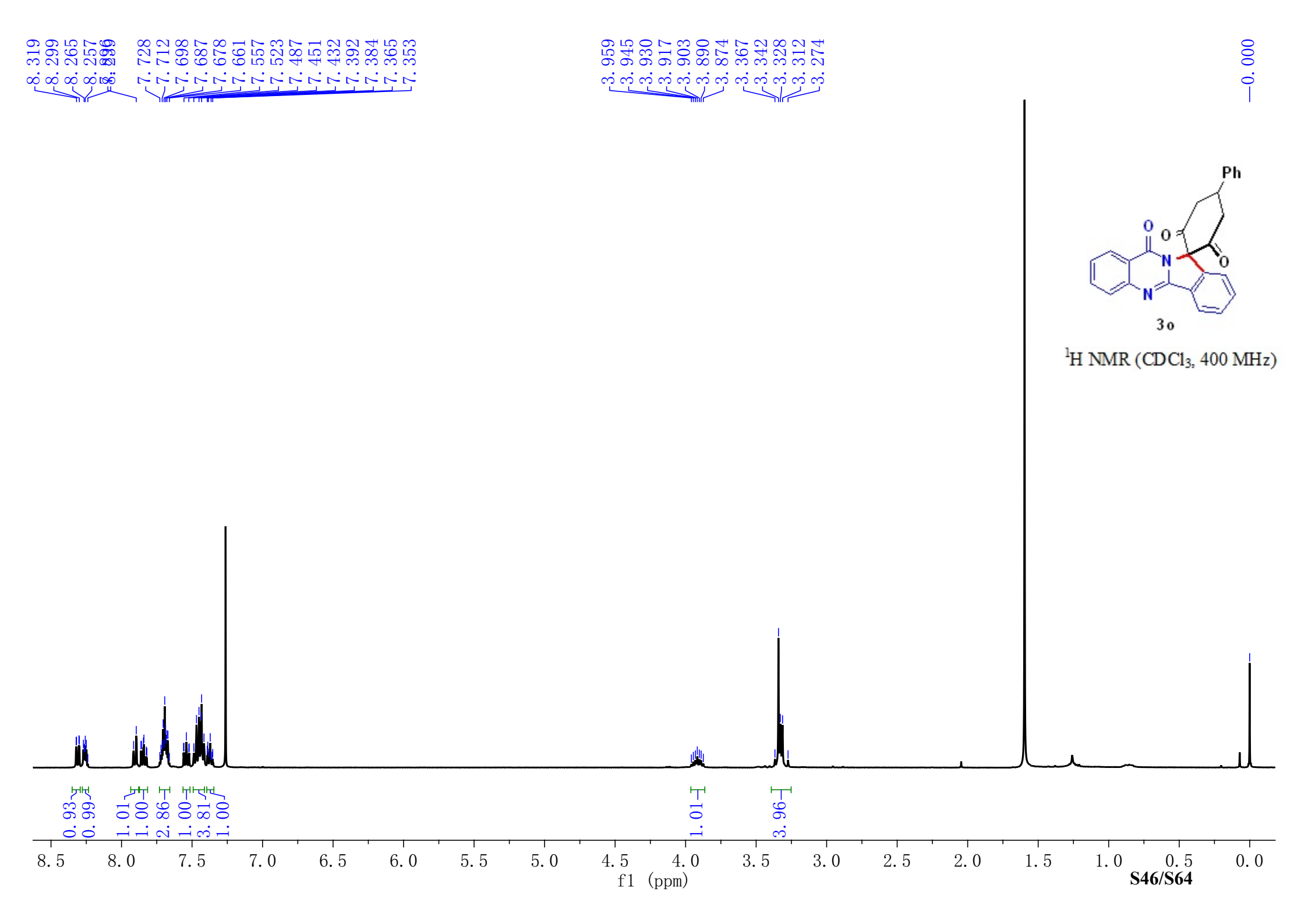

197.464
158.699
154.212
149.717
138.504
132.996
130.507
126.951
125.094
121.191
121.116
83.783
77.332
77.014
76.697
39.365
16.982
O
O
O
N
N
3m
^{13}C NMR (CDCl$_3$, 100 MHz)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

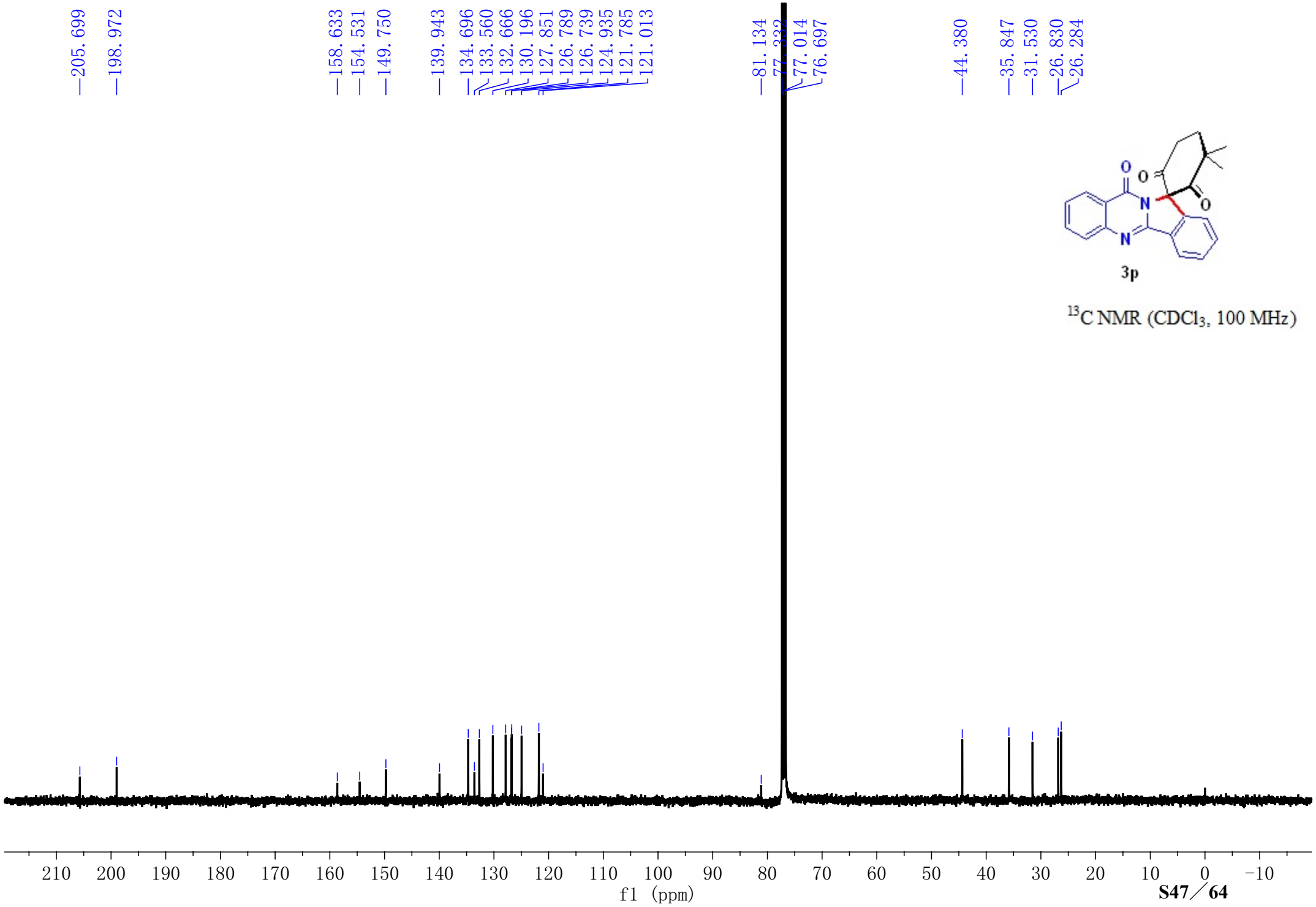

8.241
8.231
8.224
7.652
7.628
7.594
7.493
7.262
3.213
3.204
3.194
3.172
3.162
3.153
3.102
3.085
3.072
3.056
3.046
3.031
3.015
2.512
2.502
2.492
2.481
2.471
2.459
2.448
2.441
2.432
2.422
2.413
0.000
O
O
O
N
N
3m
^{1}H NMR (CDCl$_3$, 400 MHz)
1.02
0.94
2.00
2.90
1.03
1.92
1.91
2.03
8.5
8.0
7.5
7.0
6.5
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
f1 (ppm)

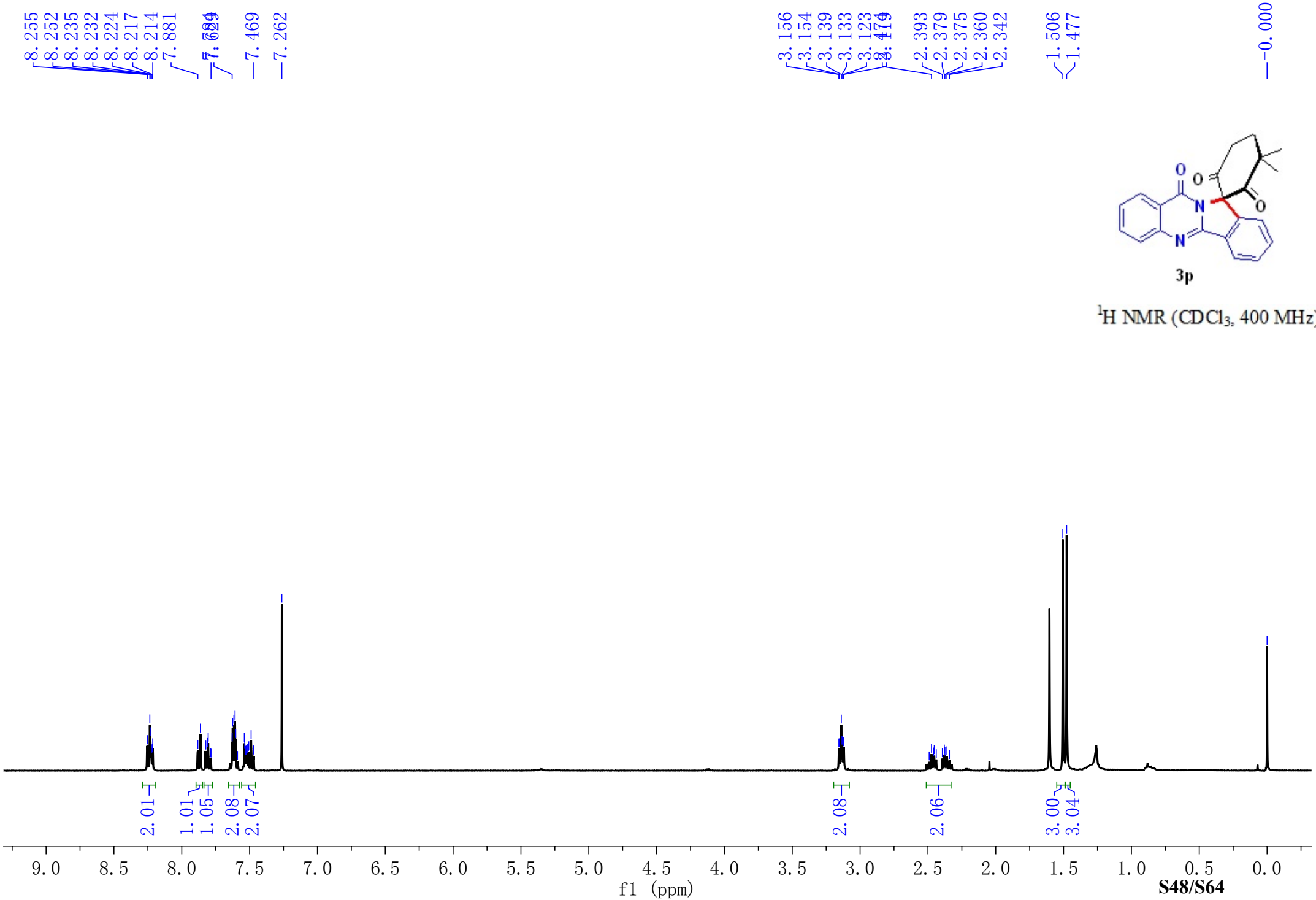

196.858
158.629
154.250
149.700
138.328
130.524
126.953
125.091
121.131
121.120
82.703
77.331
77.013
76.696
47.968
24.839
21.597
O
O
O
N
N
3n
^{13}C NMR ($CDCl_3$, 100 MHz)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

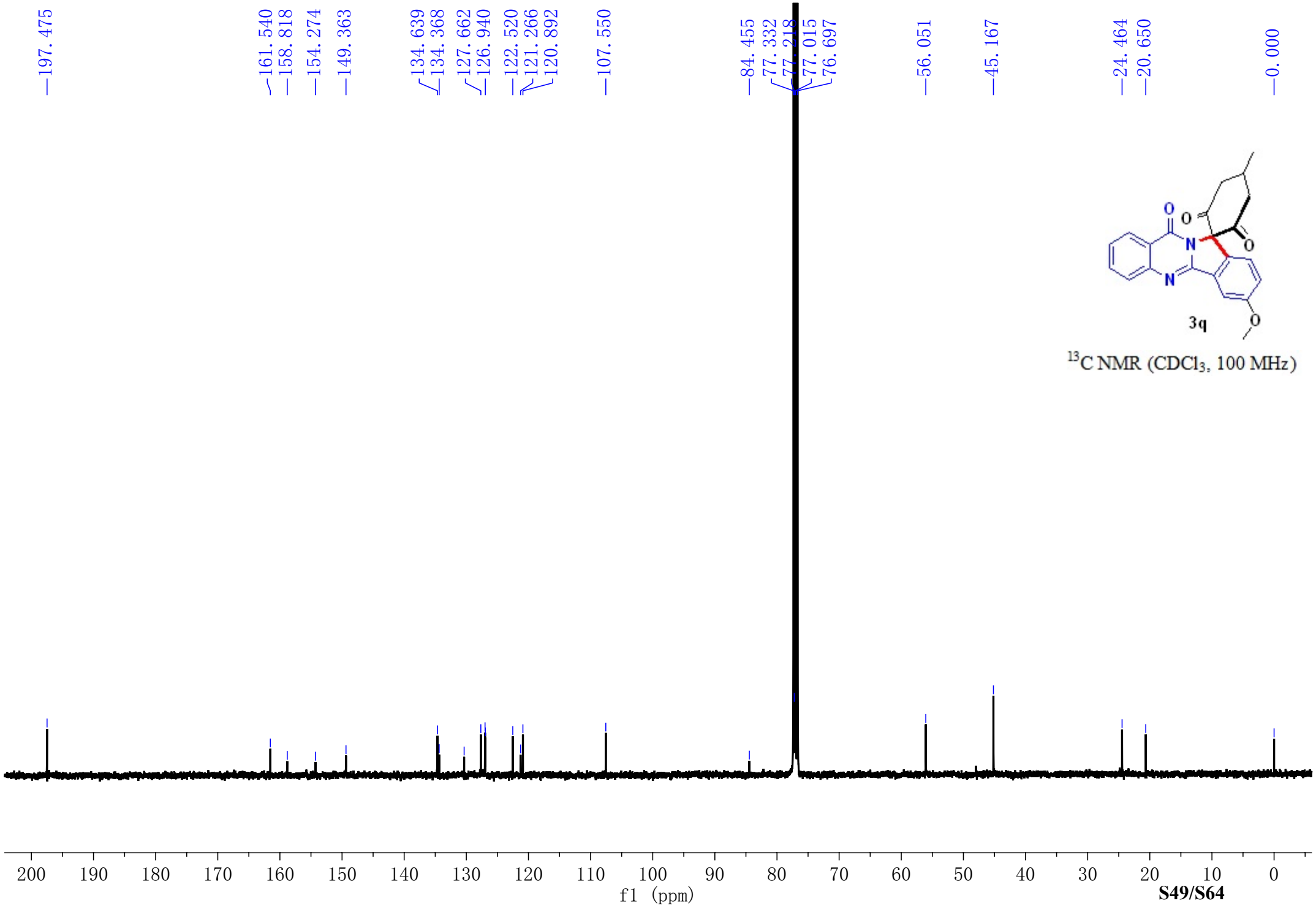

8.280
8.260
8.236
8.227
7.635
7.602
7.491
7.262
3.140
3.109
2.842
2.819
2.791
2.785
2.776
1.360
1.346
0.000
O
O
O
N
N
3n
^{1}H NMR (CDCl$_3$, 400 MHz)
0.99
0.97
1.05
1.07
3.09
1.02
2.00
3.00
3.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


196.421
158.771
154.149
149.752
134.813
132.629
129.372
127.850
126.769
125.222
121.147
121.099
82.942
77.331
77.013
76.696
47.308
34.616
0.000
Ph
O
O
O
N
N
3o
13C NMR (CDCl3, 100 MHz)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

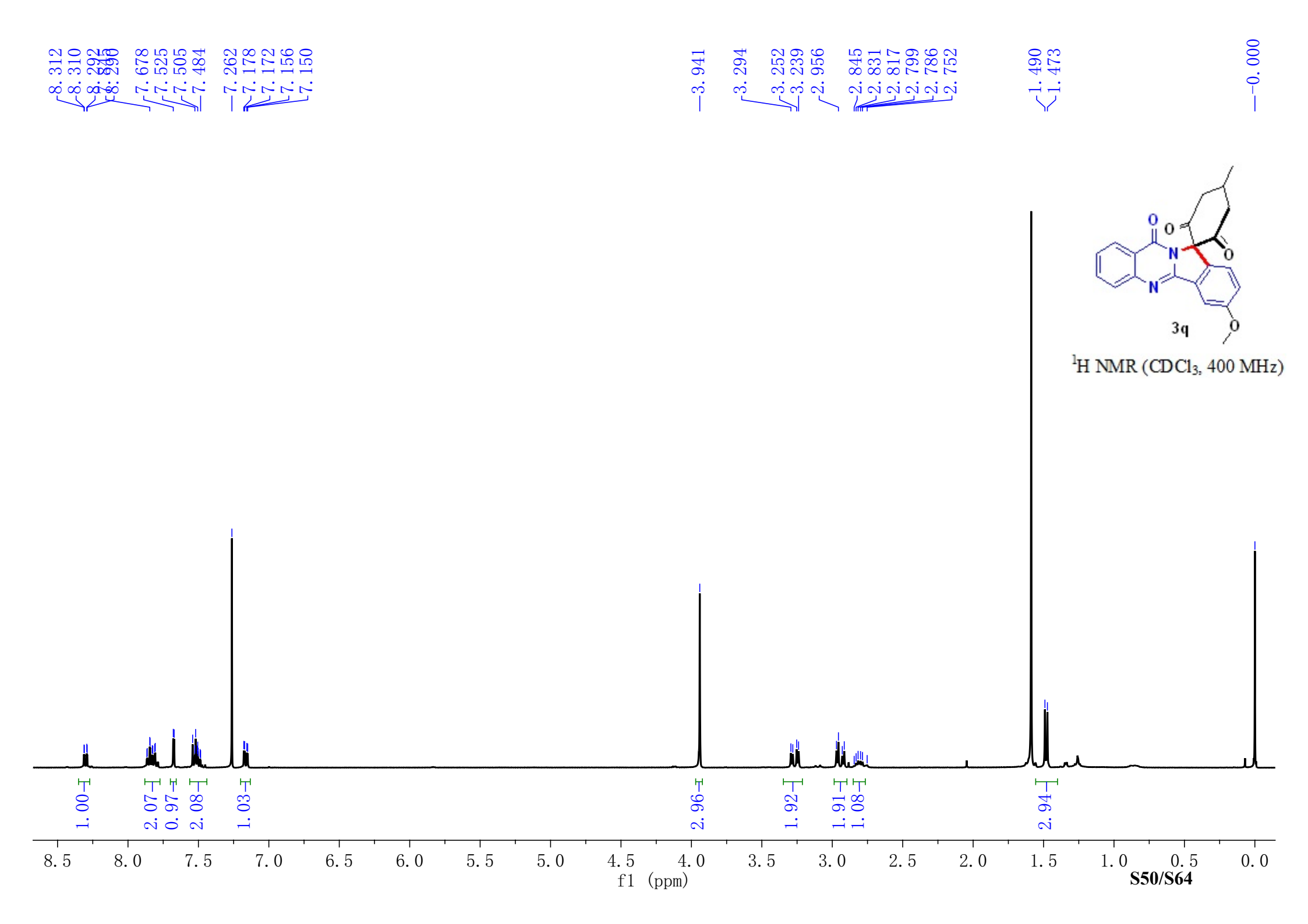

8.319
8.299
8.265
8.257
7.728
7.712
7.698
7.687
7.678
7.661
7.557
7.523
7.487
7.451
7.432
7.392
7.384
7.365
7.353
3.959
3.945
3.930
3.917
3.903
3.890
3.874
3.367
3.342
3.328
3.312
3.274
0.000
Ph
O
O
O
N
N
3o
1H NMR (CDCl3, 400 MHz)
0.93
0.99
1.01
1.00
2.86
1.00
3.81
1.00
1.01
3.96
8.5
8.0
7.5
7.0
6.5
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
f1 (ppm)

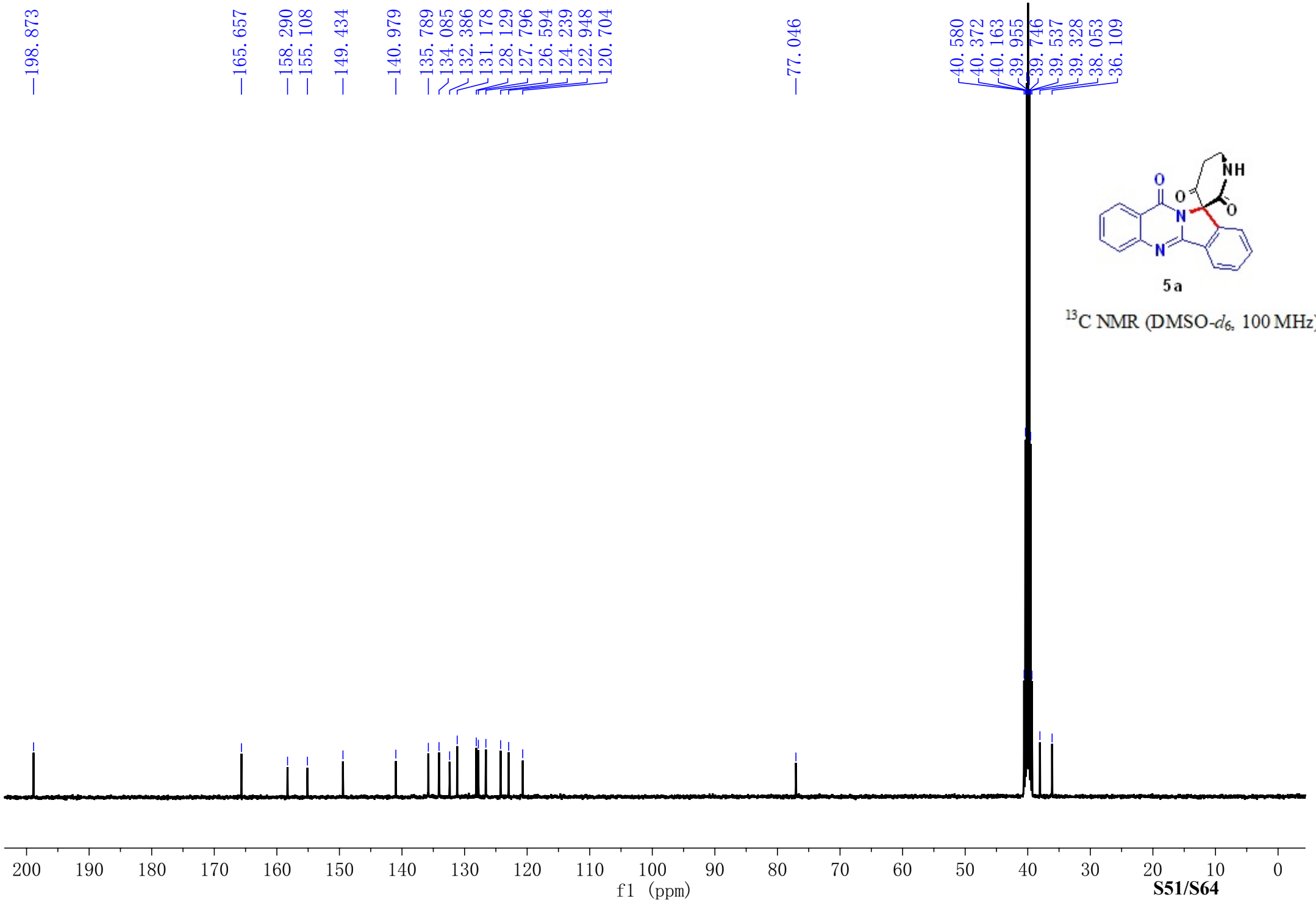

205.699
198.972
158.633
154.531
149.750
139.943
134.696
133.560
132.666
130.196
127.851
126.789
126.739
124.935
121.785
121.013
81.134
77.332
77.014
76.697
44.380
35.847
31.530
26.830
26.284
O
O
O
N
N
3p
^{13}C NMR ($CDCl_3$, 100 MHz)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

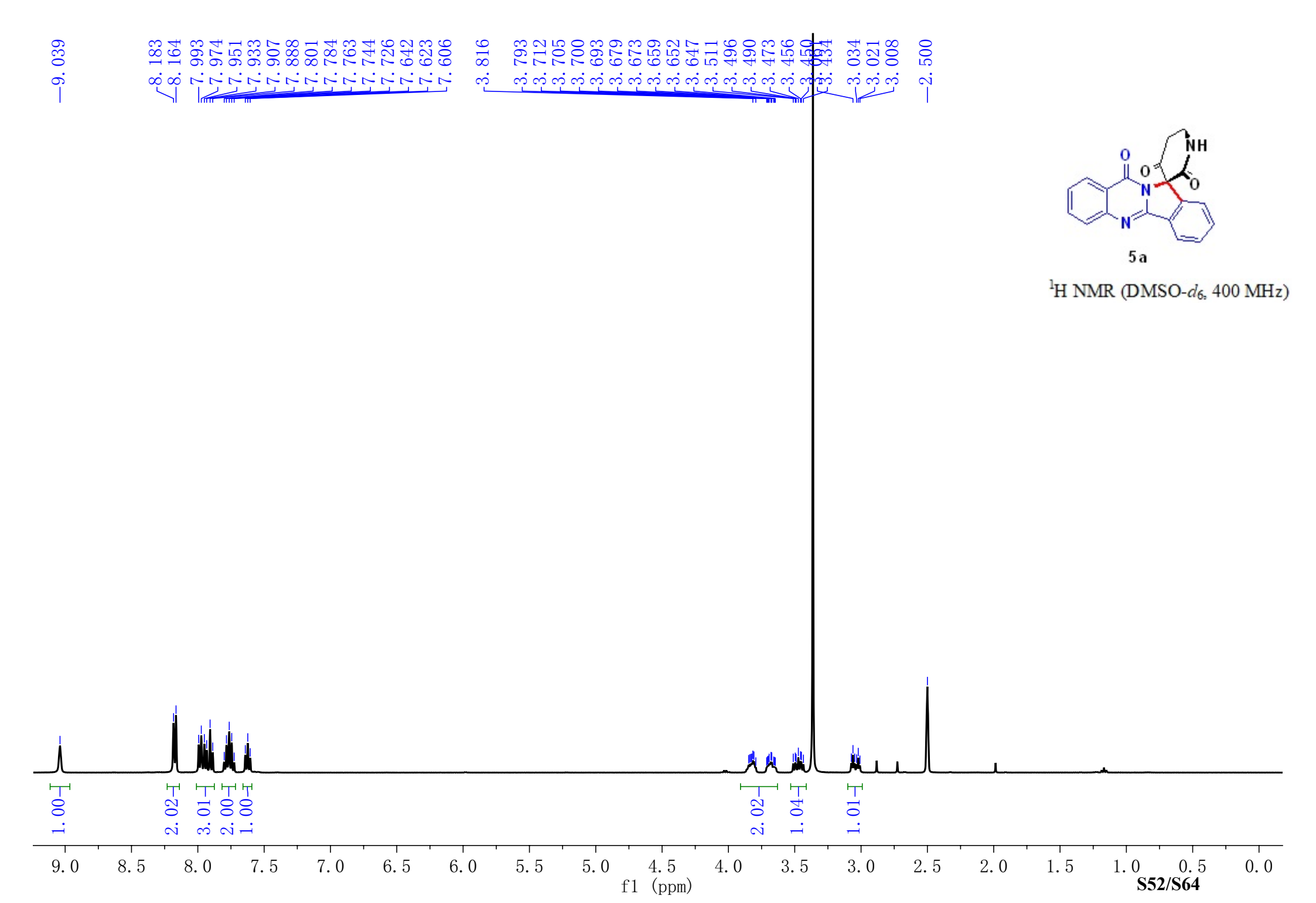

8.255
8.252
8.235
8.232
8.224
8.217
8.214
7.881
7.469
7.262
3.156
3.154
3.139
3.133
3.123
2.393
2.379
2.375
2.360
2.342
1.506
1.477
0.000
O
O
O
N
N
3p
^{1}H NMR ($CDCl_3$, 400 MHz)
2.01
1.01
1.05
2.08
2.07
2.08
2.06
3.00
3.04
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)



^{13}C NMR ($CDCl_3$, 100 MHz)

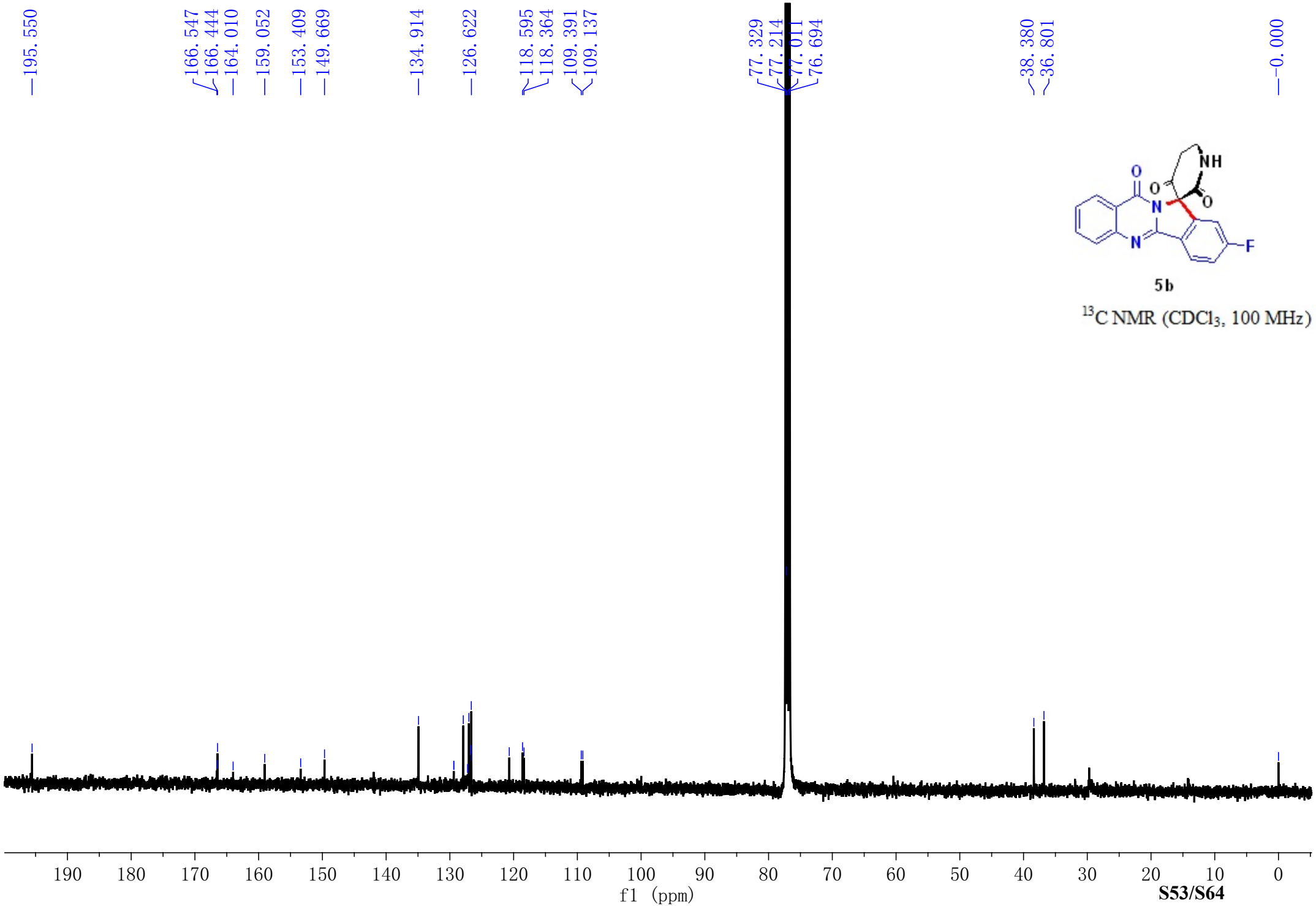

8.312
8.310
8.292
7.678
7.525
7.505
7.484
7.262
7.178
7.172
7.156
7.150
3.941
3.294
3.252
3.239
2.956
2.845
2.831
2.817
2.799
2.786
2.752
1.490
1.473
0.000
O
O
N
O
N
O
3q
1H NMR (CDCl3, 400 MHz)
1.00
2.07
0.97
2.08
1.03
2.96
1.92
1.91
1.08
2.94
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

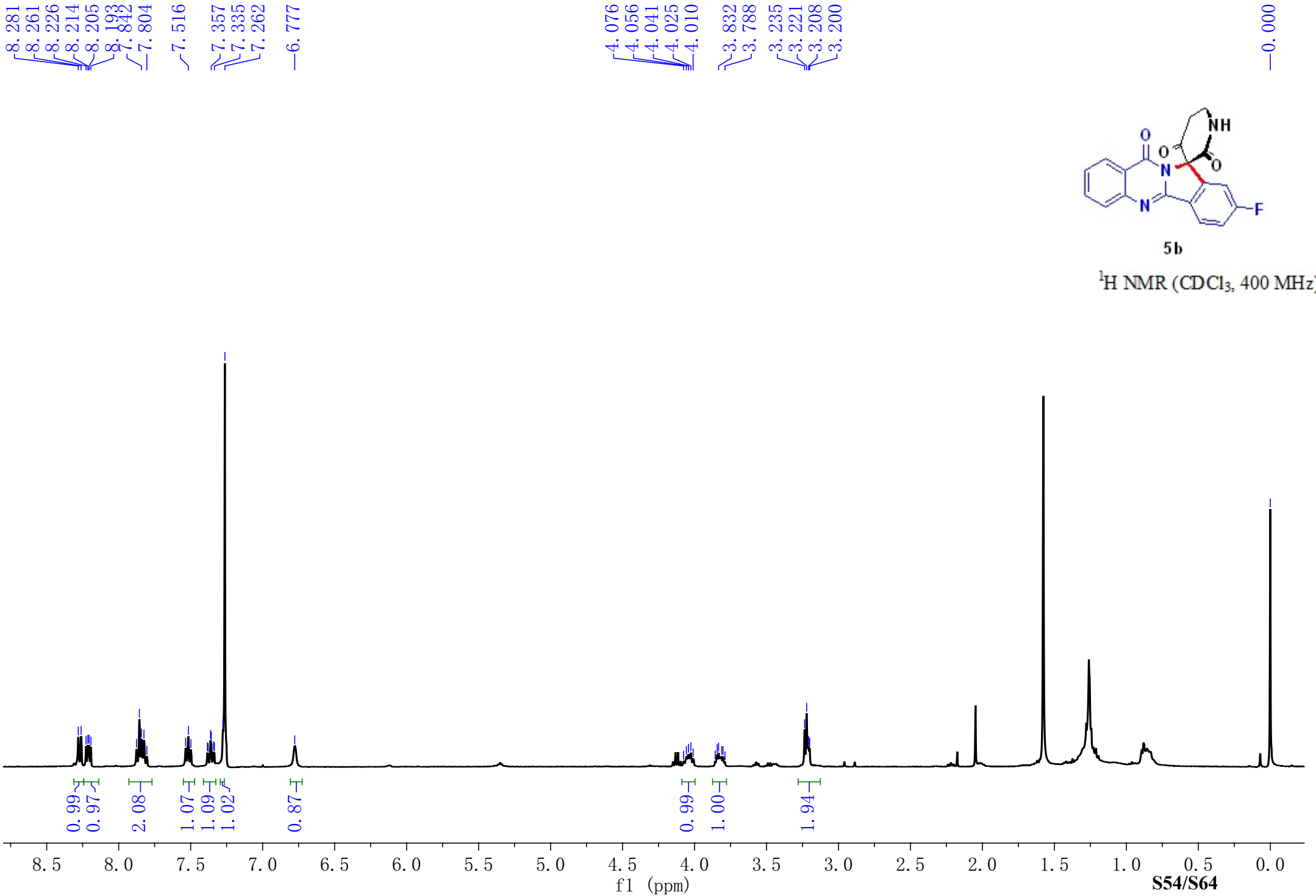

198.873
165.657
158.290
155.108
149.434
140.979
135.789
134.085
132.386
131.178
128.129
127.796
126.594
124.239
122.948
120.704
77.046
40.580
40.372
40.163
39.955
39.746
39.537
39.328
38.053
36.109
NH
O
O
O
N
N
5a
^{13}C NMR (DMSO-d_6, 100 MHz)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



5a

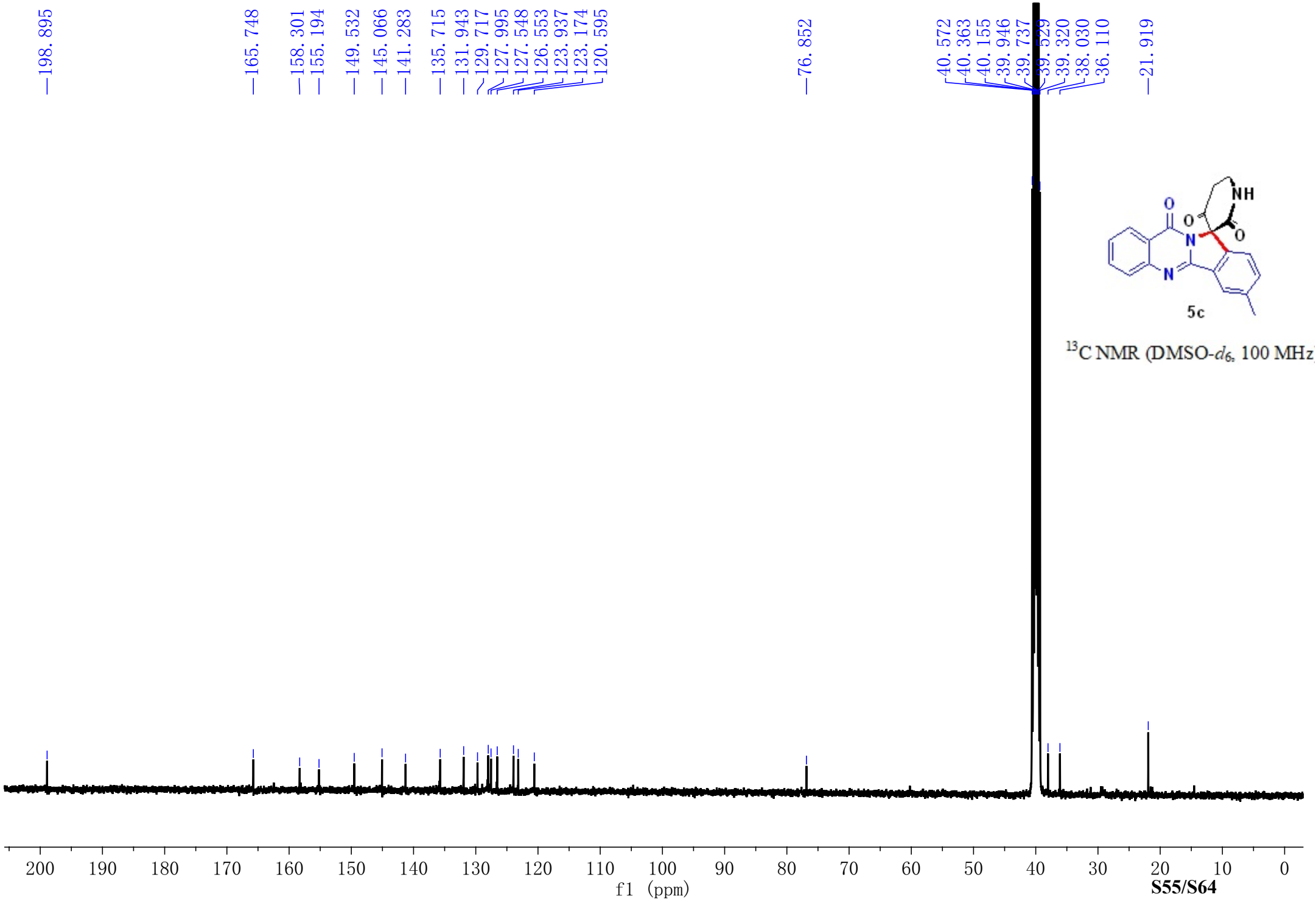
^{1}H NMR (DMSO-d_6, 400 MHz)

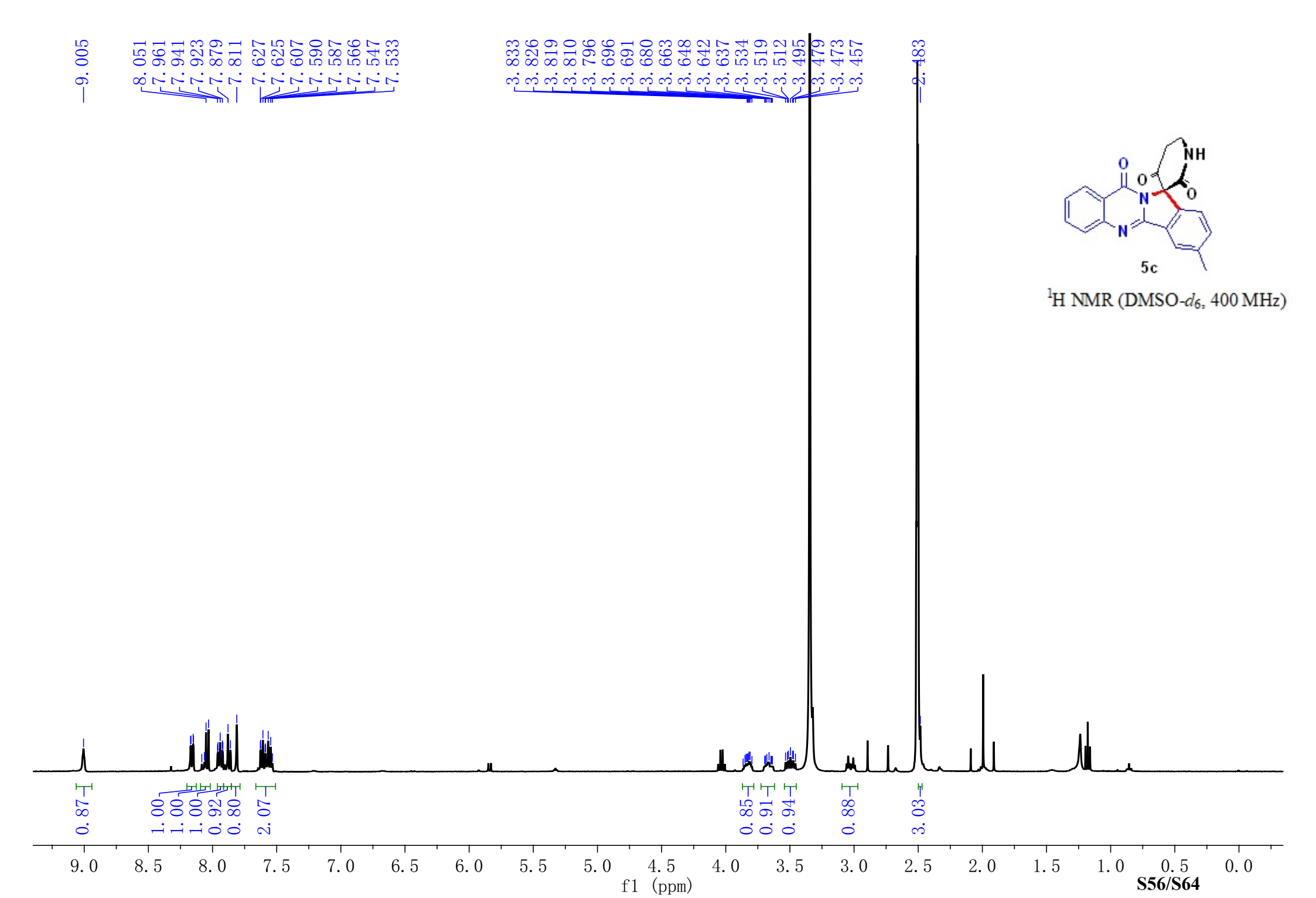

195.550
166.547
166.444
164.010
159.052
153.409
149.669
134.914
126.622
118.595
118.364
109.391
109.137
77.329
77.214
77.011
76.694
38.380
36.801
0.000
NH
O
O
O
N
N
F
5b
^{13}C NMR (CDCl$_3$, 100 MHz)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



5b

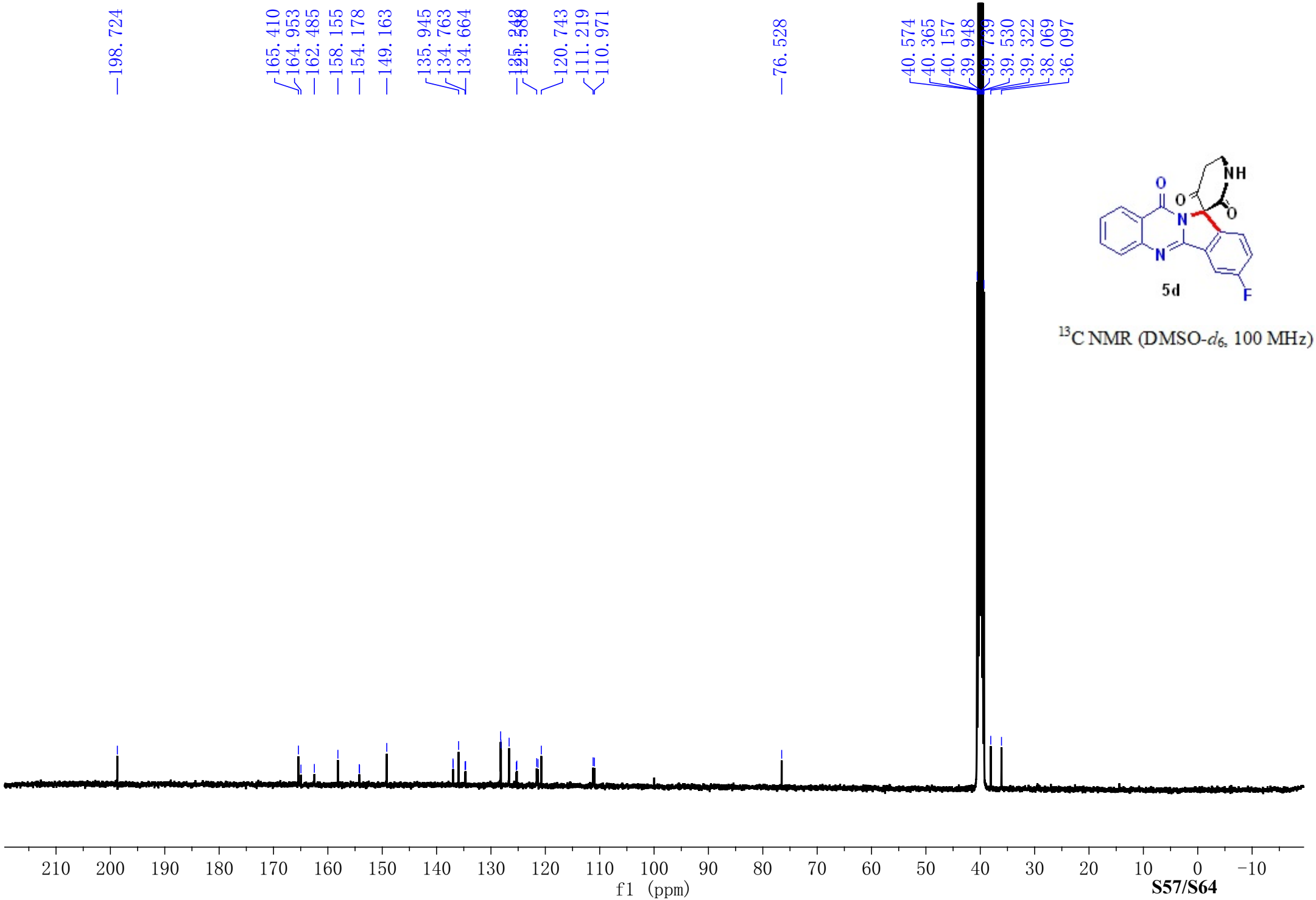
^{1}H NMR ($CDCl_3$, 400 MHz)

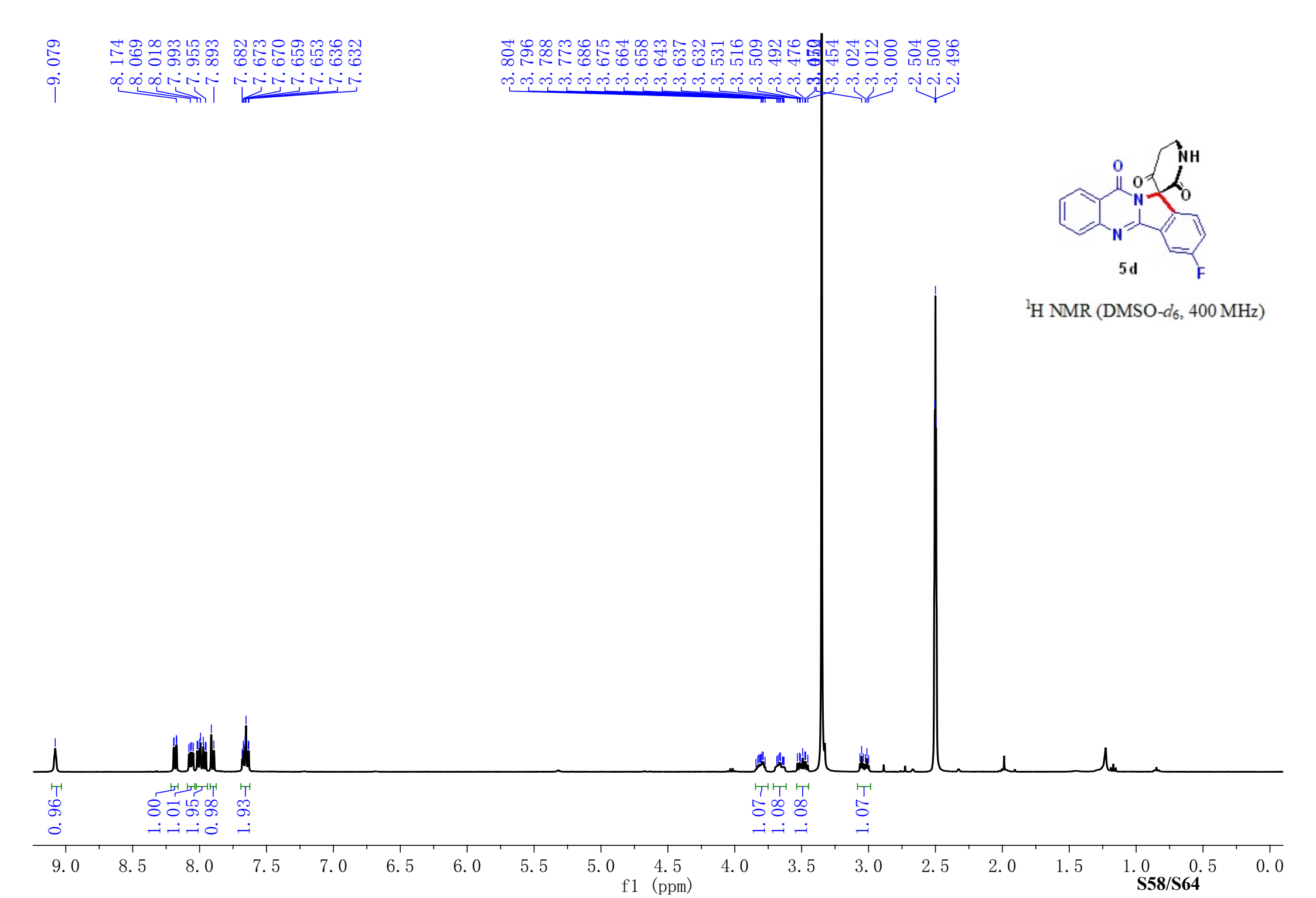

198.895
165.748
158.301
155.194
149.532
145.066
141.283
135.715
131.943
129.717
127.995
127.548
126.553
123.937
123.174
120.595
76.852
40.572
40.363
40.155
39.946
39.737
39.529
39.320
38.030
36.110
21.919
NH
O
O
O
N
N
5c
13C NMR (DMSO-d6, 100 MHz
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

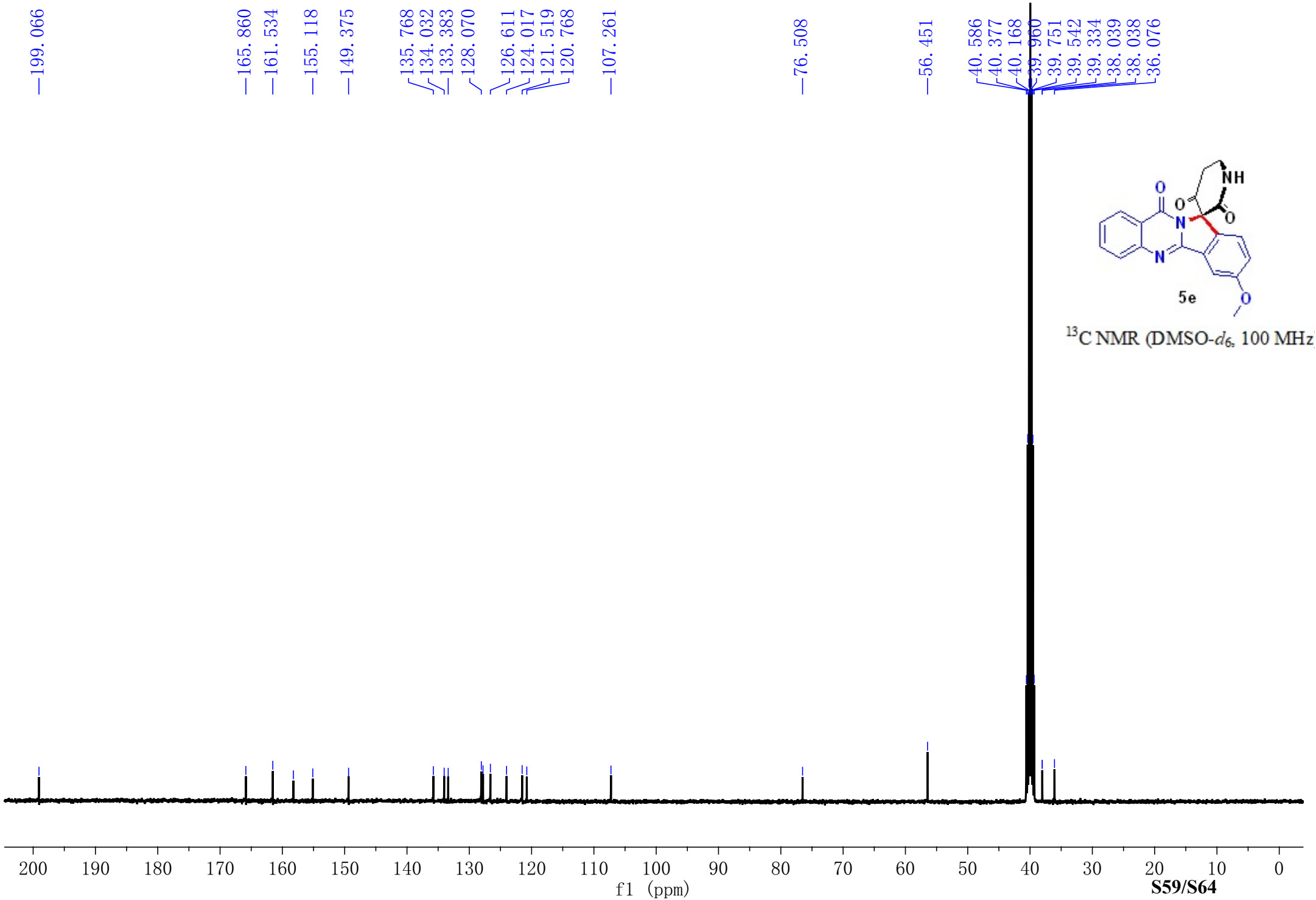


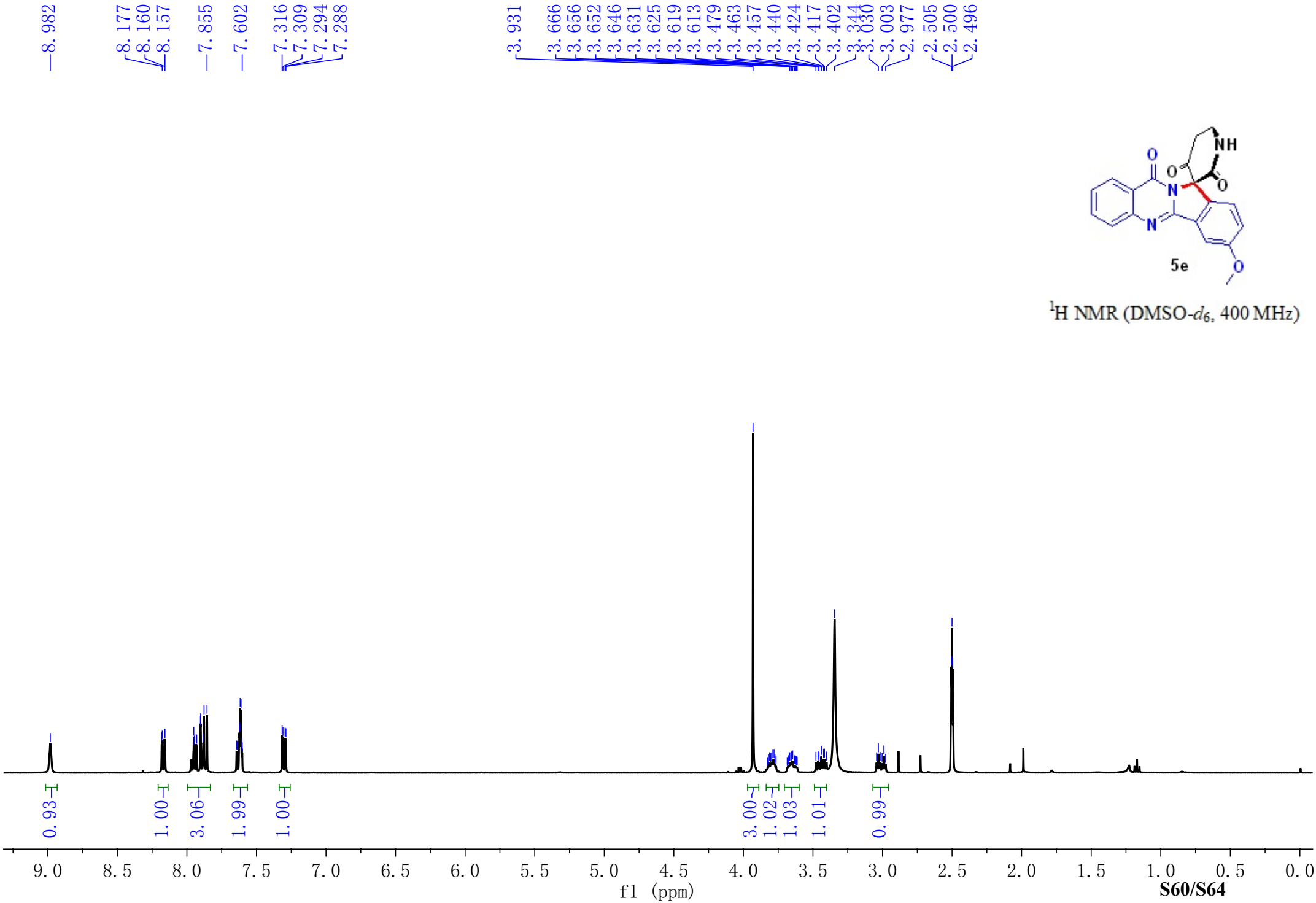
5c

^{1}H NMR (DMSO-d_6, 400 MHz)

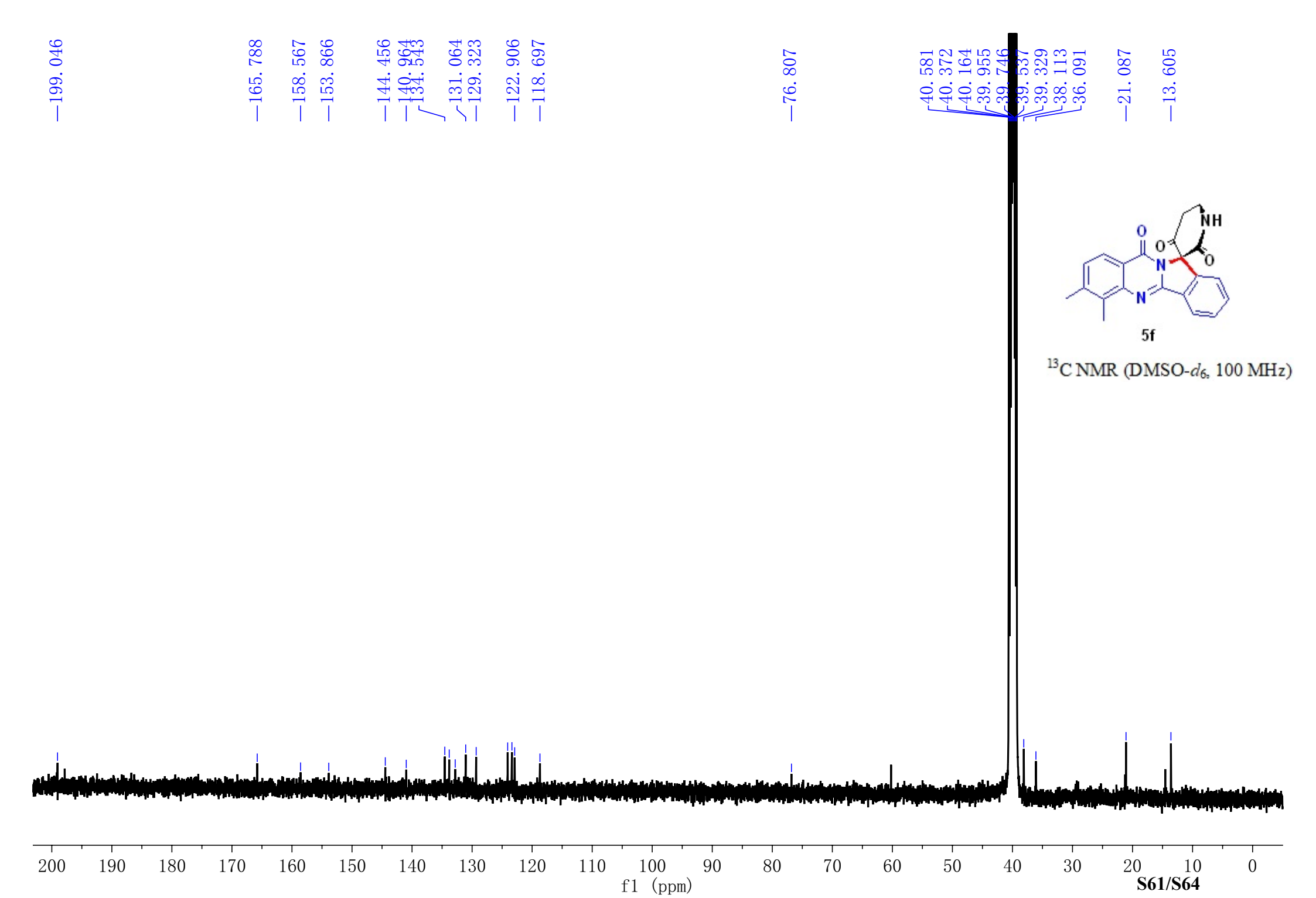

198.724
165.410
164.953
162.485
158.155
154.178
149.163
135.945
134.763
134.664
120.743
111.219
110.971
76.528
40.574
40.365
40.157
39.948
39.739
39.530
39.322
38.069
36.097
NH
O
O
O
N
N
F
5d
^{13}C NMR (DMSO-d_6, 100 MHz)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

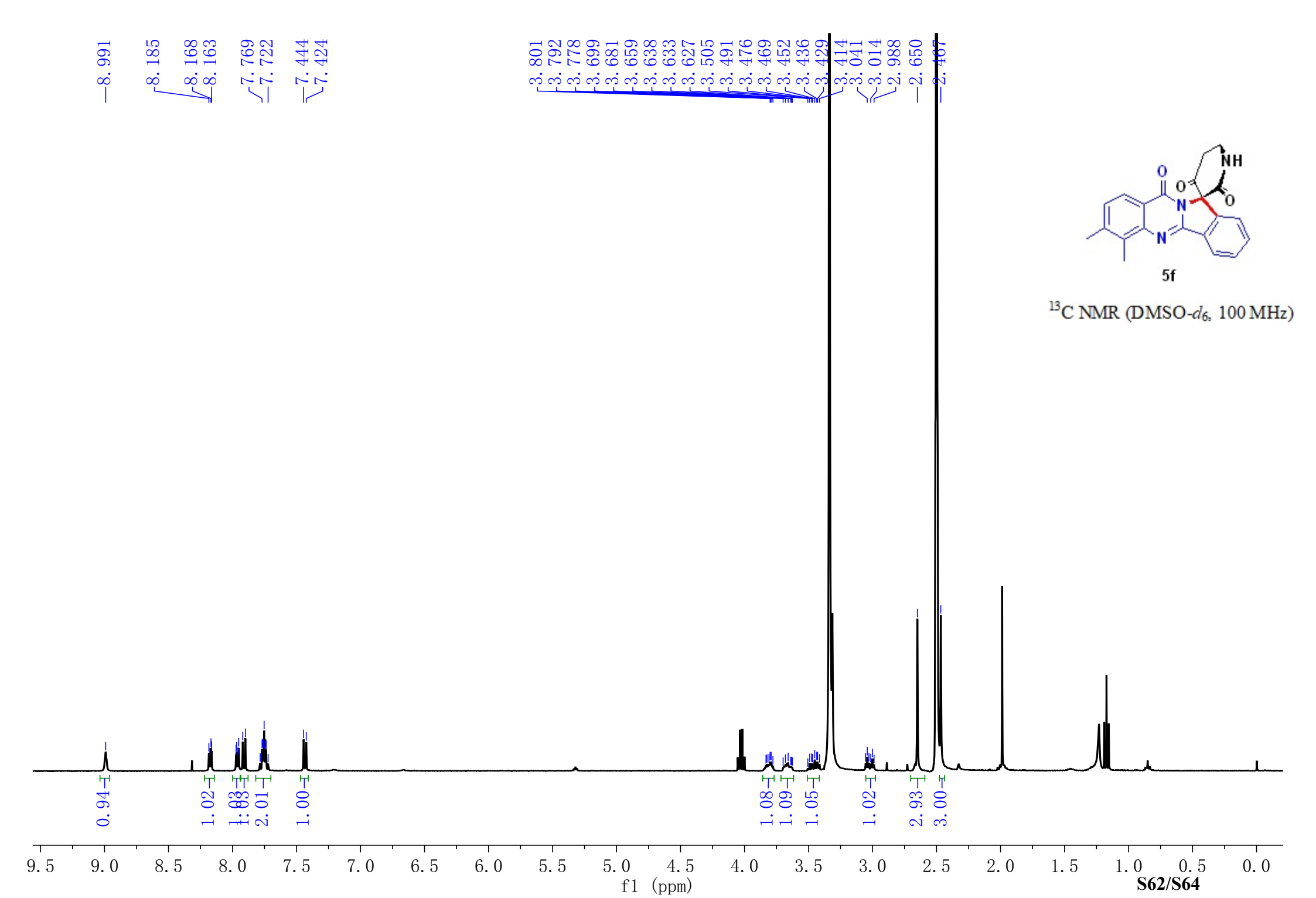

9.079
8.174
8.069
8.018
7.993
7.955
7.893
7.682
7.673
7.670
7.659
7.653
7.636
7.632
3.804
3.796
3.788
3.773
3.686
3.675
3.664
3.658
3.643
3.637
3.632
3.531
3.516
3.509
3.492
3.476
3.454
3.024
3.012
3.000
2.504
2.500
2.496
0.96
1.00
1.01
1.95
0.98
1.93
1.07
1.08
1.08
1.07
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
O
O
N
NH
O
N
F
5d
^{1}H NMR (DMSO-d_6, 400 MHz)


199.066
165.860
161.534
155.118
149.375
135.768
134.032
133.383
128.070
126.611
124.017
121.519
120.768
107.261
76.508
56.451
40.586
40.377
40.168
39.960
39.751
39.542
39.334
38.039
38.038
36.076
NH
O
O
O
N
N
O
5e
^{13}C NMR (DMSO-d_6, 100 MHz)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



^{1}H NMR (DMSO-d_6, 400 MHz)


199.046
165.788
158.567
153.866
144.456
140.964
134.543
131.064
129.323
122.906
118.697
76.807
40.581
40.372
40.164
39.955
39.746
39.537
39.329
38.113
36.091
21.087
13.605
NH
O
O
O
N
N
5f
13C NMR (DMSO-d6, 100 MHz)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



5f

^{13}C NMR (DMSO-d_6, 100 MHz)

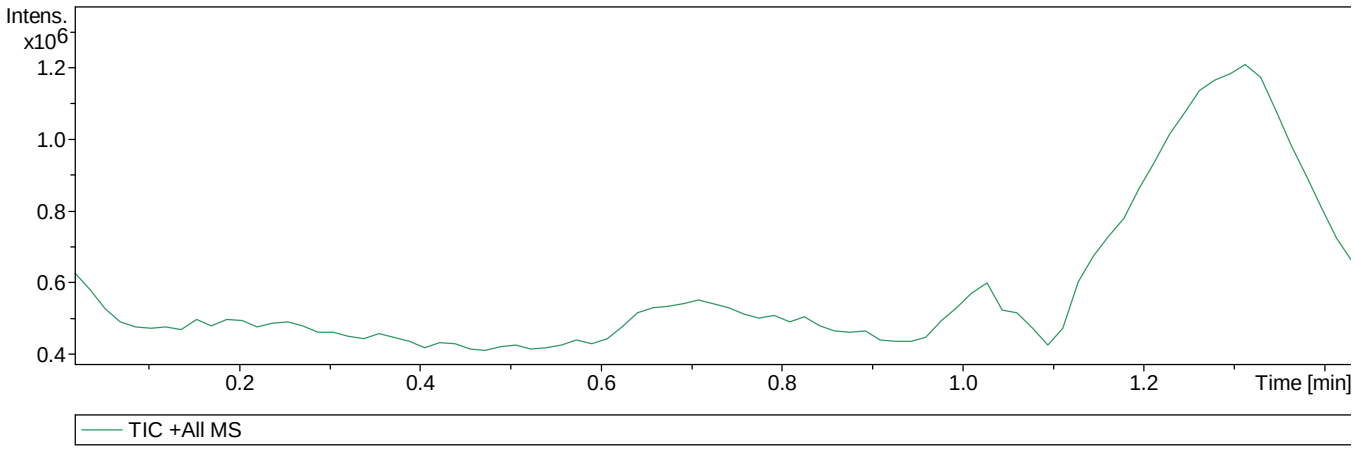
Display Report

Analysis Info

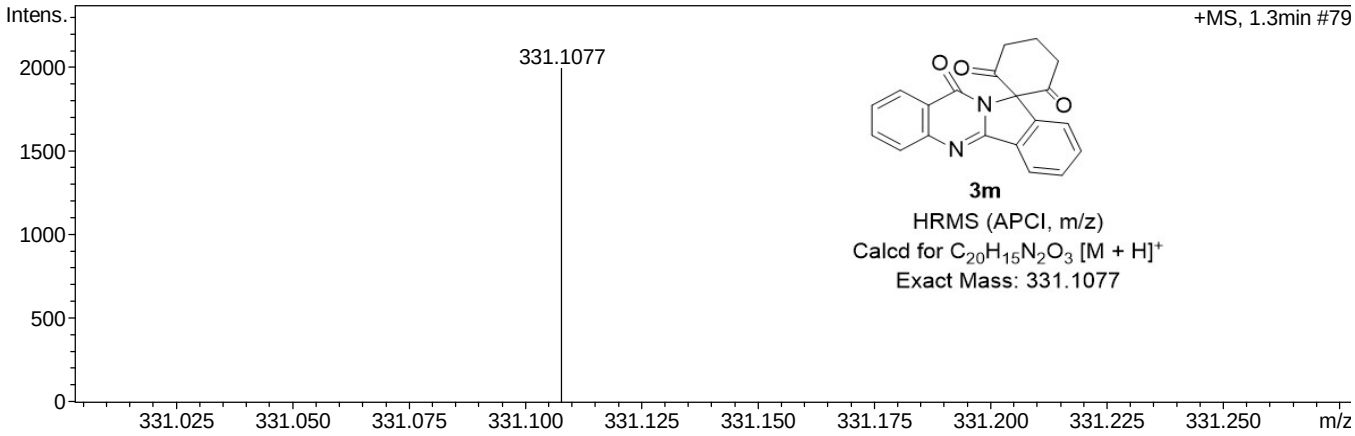
Analysis Name	D:\Data\wxs\20171025\D-8A.d	Acquisition Date	10/25/2017 10:33:19 AM
Method	tune_low.m	Operator	XZNU
Sample Name		Instrument	micrOTOF-Q 134
Comment			

Acquisition Parameter

Source Type	APCI	Ion Polarity	Positive	Set Nebulizer	2.0 Bar
Focus	Active	Set Capillary	4000 V	Set Dry Heater	200 °C
Scan Begin	50 m/z	Set End Plate Offset	-500 V	Set Dry Gas	5.0 l/min
Scan End	3000 m/z	Set Collision Cell RF	150.0 Vpp	Set Divert Valve	Source



TIC +All MS

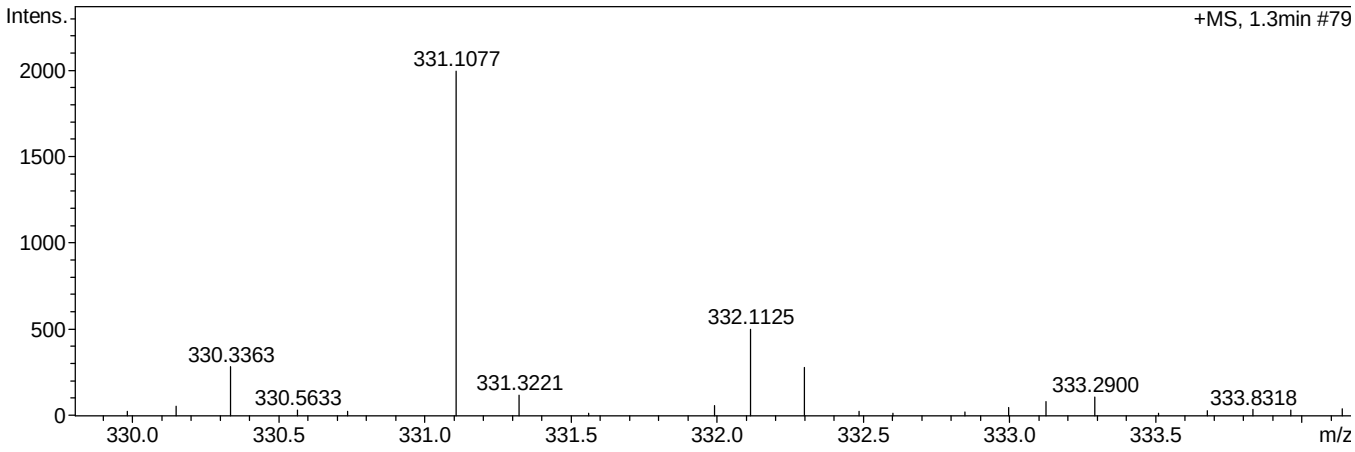


3m

HRMS (APCI, m/z)

Calcd for $C_{20}H_{15}N_2O_3$ $[M + H]^+$

Exact Mass: 331.1077



Display Report

Analysis Info

Analysis Name	D:\Data\wxs\20171025\D-1.d	Acquisition Date	10/25/2017 8:55:01 AM
Method	tune_low.m	Operator	XZNU
Sample Name		Instrument	micrOTOF-Q 134
Comment			

Acquisition Parameter

Source Type	APCI	Ion Polarity	Positive	Set Nebulizer	2.0 Bar
Focus	Active	Set Capillary	4000 V	Set Dry Heater	200 °C
Scan Begin	50 m/z	Set End Plate Offset	-500 V	Set Dry Gas	5.0 l/min
Scan End	3000 m/z	Set Collision Cell RF	150.0 Vpp	Set Divert Valve	Source