Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

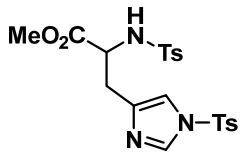
Total Synthesis of Haploscleridamine, Villagorgin A and an Approach Towards Lissoclin C

Moumita Singha Roy, Xiaofeng Meng, Karuna Koda, Andrina Shrestha, Joshua Putman, Delphine Gout, Daniel W. Armstrong and Carl J. Lovely*

Department of Chemistry and Biochemistry, University of Texas Arlington, Arlington, TX76019-0065

Contents

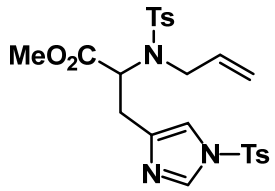
(±)-2-(Toluene-4-sulfonylamino)-3-[1-(toluene-4-sulfonyl)-1*H*-imidazol-4-ylpropionic acid methyl ester (**33**): Histidine methyl ester hydrochloride (±)-**25** (8.00 g, 28.7 mmol) was dissolved



in dichloromethane (50 mL), triethylamine (15 mL) and tosyl chloride (11.0 g, 57.5 mmol) were slowly added with vigorous stirring and cooled in an ice bath. The reaction mixture was stirred at 0 °C for 30 min and then room temperature for 2 h, additional dichloromethane (50 mL) was added to the reaction mixture and the solution was washed with water and brine (3 x 25 mL) and dried over anhydrous Na_2SO_4 The extract was concentrated under reduced pressure. The residue was purified by flash chromatography (silica gel, EtOAc/hexane = 50:50) to furnish desired compound (±)-**33** (12.0 g, 88%) as a colorless crystalline solid. m.p. = 183-185 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.82 (d, *J* = 1.3 Hz, 1H), 7.77 (d, *J* = 8.4 Hz, 2H), 7.65 (d, *J* = 8.3 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.02 (d, *J* = 1.1 Hz, 1H), 5.74 (d, *J* = 8.7 Hz, 1H), 4.19 (dt, *J* = 8.7, 5.6 Hz, 1H), 3.46 (s, 3H), 2.91 (d, *J* = 6.3 Hz, 2H), 2.41 (d, *J* = 11.0 Hz, 6H), ^{13}C NMR (125.8 MHz, Chloroform-*d*) δ 171.2, 146.5, 143.7, 139.3, 137.0, 136.4, 134.9, 130.6, 129.7, 127.4, 127.2, 115.2, 55.0, 52.6, 31.4, 21.8, 21.6. FT-IR (neat, cm^{-1}): 3478, 3011, 2584, 2310, 2180, 2071, 1920, 1796, 1747, 1632, 1594, 1458, 969, 913, 845, 813, 781, 657, 560, 477. HR-MS (*m/z*): calcd. for $[M+H]^+$ $C_{21}H_{23}N_3O_6S_2$ 478.1101, found 478.1087.

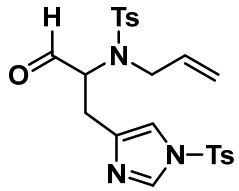
(±)-2-[Allyl-(toluene-4-sulfonyl)-amino]-3-[1-(toluene-4-sulfonyl)-1*H*-imidazol-4-yl]-propionic acid methyl ester (**34**)**:** Tosyl protected histidine (±)-**33** (13.0 g, 27.5 mmol) was dissolved in DMF (70 mL) and K_2CO_3 (5.6 g, 41 mmol) was added and stirred for 1h. Then allyl bromide (3.00 mL, 30.3 mmol) was added, and the reaction mixture was stirred at room temperature for 16h. The

reaction mixture was cooled in ice-cold water, the resulting precipitated solid was isolated by



vacuum filtration and washed thoroughly with hexanes. The crude compound was purified through flash chromatography (silica gel, EtOAc/hexane = 40:60) to afford (±)-**34** (12.7 g, 84 %) as white solid m.p. = 116-120 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.83 (t, *J* = 1.2 Hz, 1H), 7.81 – 7.74 (m, 2H), 7.61 (d, *J* = 8.0 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 7.27 – 7.21 (m, 2H), 7.06 – 7.02 (m, 1H), 5.58 (ddt, *J* = 16.6, 10.0, 6.3 Hz, 1H), 5.13 – 4.92 (m, 2H), 4.80 (dd, *J* = 9.0, 5.9 Hz, 1H), 3.93 – 3.62 (m, 2H), 3.51 (d, *J* = 0.9 Hz, 3H), 3.24 – 3.12 (m, 1H), 3.01 – 2.82 (m, 3H), 2.41 (s, 6H). ^{13}C NMR (125.8 MHz, Chloroform-*d*) δ 170.8, 146.3, 143.6, 140.4, 137.2, 136.2, 135.1, 134.5, 130.5, 129.5, 127.5, 127.3, 118.1, 115.2, 59.0, 52.2, 48.9, 29.2, 21.8, 21.6. FT-IR (neat, cm^{-1}): 3110, 3118, 2936, 1723, 1640, 1590, 1485, 1480, 1430, 1300, 1285, 1200, 1195, 1161, 1081, 990, 878, 790, 757, 730, 670, 580, 541, 450. HR-MS (*m/z*): calcd. for [M+H] $^{+}$ $C_{24}H_{27}N_3O_6S_2$ 518.1414, found 518.1406.

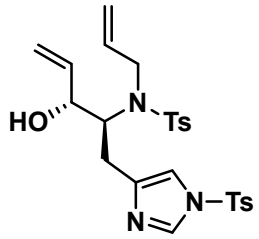
(±)-*N*-Allyl-*N*-1-formyl-2-[1-(toluene-4-sulfonyl)-1*H*-imidazol-4-yl]-ethyl-4-methyl-benzenesulfonamide (**35**): The ester (±)-**34** (5.0 g, 9.7 mmol) was dissolved in dry CH_2Cl_2 (50 mL)



and cooled to -78 °C. A precooled (-78 °C) solution of DIBAL-H (19.3 mL) was slowly added to the reaction mixture. After stirring for 2 h at this temperature the reaction was quenched while still at -78 °C with water (0.77 mL), 15% NaOH (0.77 mL) and then water (2 mL). After warming to room temperature and the resulting mixture was stirred for 30 min the residue was extracted with CH_2Cl_2 (3 x 30 mL). The combined organic solutions were washed with brine and dried over

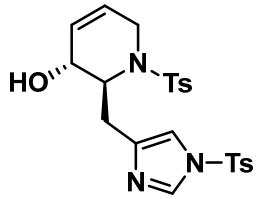
anhydrous Na_2SO_4. The concentrated residue was purified by flash chromatography (silica gel, EtOAc/hexane = 40:60) to furnish the aldehyde (±)-**35** as a colorless solid (3.0 g, 64%). m.p. = 106-110 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.65 (s, 1H), 7.75 – 7.73 (m, 2H), 7.61 – 7.58 (m, 2H), 7.35 – 7.32 (m, 2H), 7.28 – 7.23 (m, 2H), 6.69 (s, 1H), 5.71 – 5.61 (m, 1H), 5.15 (d, *J* = 1.3 Hz, 1H), 5.12 (dq, *J* = 6.9, 1.2 Hz, 1H), 4.47 (dd, *J* = 9.3, 5.1 Hz, 1H), 3.89 – 3.83 (m, 1H), 3.63 (ddt, *J* = 15.5, 6.7, 1.3 Hz, 1H), 3.19 (ddd, *J* = 15.4, 5.1, 1.1 Hz, 1H), 2.69 (dd, *J* = 15.4, 9.2 Hz, 1H), 2.43 (d, *J* = 17.5 Hz, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.8, 146.4, 144.0, 140.4, 137.5, 136.2, 135.0, 133.3, 130.5, 129.9, 127.3, 127.2, 120.5, 114.9, 65.6, 49.9, 26.0, 21.8, 21.7. FT-IR (neat, cm^{-1}): 3150, 3120, 2934, 2833, 1907, 1721, 1586, 1470, 1246, 1207, 1144, 930, 773, 615, 510. HR-MS (*m/z*): calcd. for $[M+H]^+$ $C_{23}H_{25}N_3O_5S_2$ 488.1308, found 488.1314.

(±)-*N*-Allyl-*N*-{2-hydroxy-1-[1-(toluene-4-sulfonyl)-1*H*-imidazol-4-yl-methyl]-but-3-enyl}-4-methyl-benzenesulfonamide (**32**): A solution of aldehyde (±)-**35** (6.3 g, 13 mmol) in THF (50 mL) was added to a solution of vinyl magnesium bromide (1.3 M in THF, 11 mL) at -78 °C, and the mixture was stirred for 2 h. After stirring for an additional 1 h at 25 °C, a saturated solution of NH_4Cl (30 mL) was added to the mixture which was then extracted with ethyl acetate (3 x 25 mL). The organic phase was washed with brine, dried over anhydrous Na_2SO_4, and then evaporated to give an oil. The crude product was purified by flash chromatography (silica gel, EtOAc/hexane = 50:50), to give the desired alcohol (±)-**32** (5.0 g, 76%). m.p. = 132-136 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.77 (s, 1H), 7.76 (d, *J* = 2.3 Hz, 2H), 7.56 – 7.53 (m, 2H), 7.36 – 7.33 (m, 2H), 7.22 – 7.19 (m, 2H), 6.85 (d, *J* = 1.3 Hz, 1H), 5.83 – 5.69 (m, 2H), 5.22 – 5.12 (m, 3H), 5.03 (ddt, *J* = 16.2,



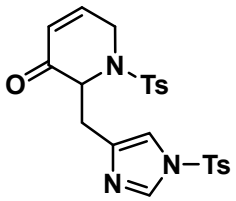
10.5, 1.5 Hz, 2H), 4.28 (tt, *J* = 5.7, 1.7 Hz, 1H), 4.04 (ddd, *J* = 8.3, 5.3, 4.1 Hz, 1H), 3.93 – 3.81 (m, 3H), 2.85 (ddd, *J* = 15.4, 5.4, 1.1 Hz, 1H), 2.77 (dd, *J* = 15.3, 8.4 Hz, 1H), 2.49 – 2.45 (m, 1H), 2.42 (d, *J* = 3.2 Hz, 6H), 2.37 (d, *J* = 12.3 Hz, 1H). ^{13}C NMR (125.8 MHz, Chloroform- *d*) δ 146.5, 143.5, 141.2, 138.2, 137.8, 136.0, 135.8, 134.9, 130.5, 129.6, 127.4, 127.2, 117.7, 116.0, 114.9, 74.8, 62.5, 48.5, 26.6, 21.8, 21.6. FT-IR (neat, cm^{-1}): 3100, 1729, 1621, 1510, 1230, 1134, 1070, 984, 915, 824, 741, 644, 582, 468, 435, 410. HR-MS (*m/z*): calcd. for [M+H] $^{+}$ $C_{25}H_{29}N_3O_5S_2$ 515.1621, found, 515.1605.

(±)-1-(Toluene-4-sulfonyl)-3-[1-(toluene-4-sulfonyl)-1H-imidazol-4-yl-methyl]-1,2,3,4-tetrahydropyridin-4-ol (**38**): The allylic alcohol (±)-**32** (3.0 g, 5.8 mmol) was taken up in dry CH_2Cl_2 (40 mL). The Grubbs' second-generation catalyst (0.246 g, 0.29 mmol, 5 mol%) was added, followed by heating the mixture at reflux for 3 h. The mixture was stirred at room temperature for 6 h, at which time TLC analysis indicated the completion of the reaction. The solvent was concentrated. The crude product was purified by chromatography EtOAc/hexanes = 75:25) to give the title compound (±)-**38** as a colorless solid (1.8 g, 65%). m.p. = 146-148 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.85 (d, *J* = 1.3 Hz, 1H), 7.80 (d, *J* = 8.4 Hz, 2H), 7.64 (d, *J* = 8.3 Hz, 2H), 7.37 – 7.33 (m, 2H), 7.24 (d, *J* = 7.9 Hz, 2H), 7.03 (d, *J* = 1.1 Hz, 1H), 5.90 (dd, *J* = 3.8, 1.4 Hz, 1H), 4.36 (t, *J* = 7.5 Hz, 1H), 4.11 (dd, *J* = 18.7, 2.8 Hz, 1H), 3.97 – 3.93 (m, 1H), 3.61 – 3.55 (m, 1H), 2.56 – 2.45 (m, 3H), 2.41 (d, *J* = 10.1 Hz, 6H). ^{13}C NMR (125.8 MHz, Chloroform-*d*) δ 146.4, 143.7, 140.9, 136.8, 136.2, 134.9, 130.6, 129.8, 127.5, 127.3, 127.1, 125.8, 114.4, 64.9, 58.6, 40.6, 27.8, 21.8,



21.6. FT-IR (neat, cm^{-1}): 3727, 3117, 1726, 1572, 1366, 1143, 1060, 910, 820, 770, 530. HR-MS (*m/z*): calcd. for $[M+H]^+$ $C_{23}H_{26}N_3O_5S_2$ 488.1308, found 488.1312.

(±)-1-Tosyl-2-[(1-tosyl-1H-imidazol-4-yl) methyl]-1,6-dihydropyridin-3(2H)-one (37): To a



stirred solution of cyclic alcohol (±)-**38** (1.8 g, 3.7 mmol) in acetone (50 mL) was added IBX (1.1 g, 4.1 mmol) at 0 °C. The resulting reaction mixture was heated to reflux for 6 h. The reaction mixture was cooled to room temperature, and resulting slurry was filtered and washed with ethyl acetate. The filtrated was concentrated under reduced pressure. The crude product was purified by column chromatography (EtOAc/Hexanes = 4:1) to afford desired compound (±)-**37** (1.4 g, 82%) as an off-white solid. m.p. = 105-108 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.86 (d, *J* = 1.3 Hz, 1H), 7.79 (d, *J* = 8.5 Hz, 2H), 7.51 (d, *J* = 8.3 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 7.21 (d, *J* = 7.9 Hz, 3H), 6.68 (ddd, *J* = 10.4, 4.9, 1.9 Hz, 1H), 5.76 (dt, *J* = 10.4, 2.3 Hz, 1H), 4.64 (t, *J* = 7.5 Hz, 1H), 4.40 (ddd, *J* = 21.0, 4.9, 1.6 Hz, 1H), 4.00 (dt, *J* = 21.1, 2.1 Hz, 1H), 2.90 (d, *J* = 7.5 Hz, 2H), 2.39 (d, *J* = 16.2 Hz, 6H). ^{13}C NMR (126 MHz, Chloroform- *d*) δ 193.4, 146.4, 144.3, 144.1, 139.4, 136.3, 136.1, 134.9, 130.5, 130.0, 127.4, 127.0, 126.7, 115.4, 61.1, 41.2, 29.2, 21.8, 21.6. FT-IR (neat, cm^{-1}): 3427, 3129, 2940, 1686, 1490, 1464, 1387, 1163, 1154, 1100, 757, 698, 550, 520. HR-MS (*m/z*): calcd. for $[M+H]^+$ $C_{23}H_{24}N_3O_5S_2$ 486.1152, found 486.1170.

(±)-1-(Toluene-4-sulfonyl)-3-[1-(toluene-4-sulfonyl)-1*H*-imidazol-4-ylmethyl]-piperidin-4-one (31): The enone (±)-**37** (1.0 g, 2.0 mmol) and 10% Pd/C (200 mg) were placed in a 1:3 mixture of

ethyl acetate and ethanol (10 mL) and under H_2 (40 psi) with stirring for # h. Then, the catalyst was filtered and rinsed with ethyl acetate and the filtrate was concentrated. The crude product was purified by flash chromatography (EtOAc/hexanes = 80:20) to provide the pure title compound (±)-**31** (0.85 g, 85%) as a yellow solid. m.p. = 125-130 °C, ^{1}H NMR (500 MHz, Chloroform- *d*) δ 7.81 (d, *J* = 1.2 Hz, 1H), 7.78 (d, *J* = 8.4 Hz, 2H), 7.56 (d, *J* = 8.3 Hz, 2H), 7.33 (d, *J* = 8.0 Hz, 2H), 7.23 (s, 2H), 7.07 (s, 1H), 4.52 (t, *J* = 7.1 Hz, 1H), 3.80 – 3.73 (m, 1H), 3.27 – 3.19 (m, 1H), 2.45 (d, *J* = 16.3 Hz, 1H), 2.39 – 2.36 (m, 1H), 2.23 (dt, *J* = 16.1, 5.4 Hz, 1H), 1.78 – 1.67 (m, 2H). ^{13}C NMR (125.8 MHz, Chloroform- *d*) δ 206.2, 146.3, 143.9, 139.4, 137.2, 136.2, 135.0, 130.5, 130.0, 127.4, 127.0, 115.5, 63.7, 40.3, 36.5, 30.1, 23.2, 21.8, 21.6. FT-IR (neat, cm^{-1}): 3422, 3119, 2930, 1738, 1620, 1510, 1360, 1260, 1210, 1100, 1010, 720, 680, 550, 530, 510. HR-MS (m/z): calcd. for $[M+H]^+$ $C_{23}H_{26}N_3O_5S_2$, 488.1308, found 488.1322

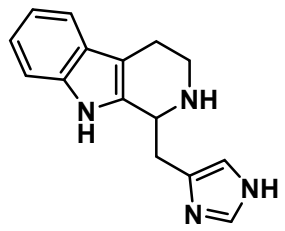
(±)-Synthesis of 1-((1H-imidazol-5-yl)methyl)-2-tosyl-2,3,4,9-tetrahydro-1H-pyrido[3,4-*b*] indole (51): A suspension of ketone (±)-**31** (67 mg, 0.14 mmol), benzophenone phenylhydrazone (25 mg, 0.09 mmol) and p-TsOH·H_2O (45 mg, 0.23 mmol) was in EtOH (3 mL) heated to reflux for 72 h. The reaction mixture was cooled to room temperature, diluted with CH_2Cl_2 (20 mL) and washed with saturated sodium bicarbonate solution (3 x 25 mL) followed by water (20 mL) and brine (20 mL). The organic part was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude was purified by column chromatography (MeOH/EtOAc = 1:49) to afford desired compound (±)-**51** (25 mg, 70%) as an off-white solid. m.p. = 136-140 °C,

^{1}H NMR (500 MHz, Chloroform- *d*) δ 10.05 (d, *J* = 9.9 Hz, 1H), 7.65 (s, 1H), 7.56 (d, *J* = 7.4 Hz, 2H), 7.33 – 7.26 (m, 2H), 7.09 (t, *J* = 7.6 Hz, 1H), 7.04 (d, *J* = 7.9 Hz, 2H), 7.03 – 6.99 (m, 1H), 6.85 (s, 1H), 5.41 (t, *J* = 6.0 Hz, 1H), 4.15 (dd, *J* = 13.8, 4.7 Hz, 1H), 3.42 – 3.33 (m, 1H), 3.23 (dd, *J* = 15.1, 5.7 Hz, 2H), 2.55 – 2.50 (m, 1H), 2.39 (dd, *J* = 10.9, 5.2 Hz, 1H), 2.24 (s, 3H). ^{13}C NMR (125.8 MHz, Chloroform- *d*) δ 143.4, 138.0, 136.1, 133.2, 129.7, 126.7, 121.8, 119.1, 118.0, 111.4, 107.3, 53.6, 40.4, 21.4, 20.2. FT-IR (neat, cm^{-1}): 3366, 3045, 2898, 2840, 1730, 1492, 1315, 1135, 1080, 900, 820. HR-MS (*m/z*): calcd. for [M+H] $^{+}$ $C_{22}H_{23}N_4O_2S$, 407.1536, found 407.1543.

Villagorgin A (±)-(7): Mg (turnings) was added (9.4 mg, 0.39 mmol) to a solution of indole (±)-**51** (20 mg, 0.049 mmol) in dry MeOH (2 mL), and the mixture was sonicated at 48 °C until all magnesium turnings were consumed. MeOH was evaporated, saturated ammonium chloride (15 mL) was added and extracted with dichloromethane (2x 30 mL). The combined extracts were dried over anhydrous Na_2SO_4, concentrated under reduced pressure. During reaction, a non-polar spot formed villagorgin A (±)-(**7**) along with haploscleridamine (±)-(**9**). The crude product was purified by column chromatography (ammoniacal MeOH: DCM = 1: 19) to provide as colorless solid villagorgin A (±)-(**7**) (3.7 mg 29%) m.p. = 145-152 °C, ^{1}H NMR (500 MHz, Methanol-d_4) δ 7.57 (s, 1H), 7.40 (d, *J* = 7.8 Hz, 1H), 7.30 (d, *J* = 8.4 Hz, 1H), 7.05 (t, *J* = 7.4 Hz, 1H), 6.97 (t, *J* = 7.4 Hz, 1H), 3.99 (d, *J* = 13.7 Hz, 1H), 3.85 (d, *J* = 14.4 Hz, 1H), 3.65 – 3.62 (m, 1H), 3.36 (d, *J* = 3.7 Hz, 1H), 3.32 (d, *J* = 1.7 Hz, 1H), 2.99 (tdd, *J* = 11.6, 4.9, 2.4 Hz, 1H), 2.88 (td, *J* = 11.3, 3.7 Hz, 1H), 2.83 – 2.77 (m, 1H), 2.75 – 2.68 (m, 1H). ^{13}C NMR (125.8 MHz, Methanol-d_4) δ 138.4, 135.6, 134.8, 129.8, 128.0, 122.3, 119.9, 118.8, 112.0, 108.4, 73.8, 58.5, 54.0, 53.3,

29.2, 22.3. FT-IR (neat, cm^{-1}): 3094, 2957, 1714, 1616, 1525, 1440, 1345, 1285, 1262, 1193, 1100, 1072, 950, 924, 822, 750, 713. HR-MS (m/z): calcd. for $[M+H]^+$ $C_{16}H_{17}N_4$ 265.1448, found 265.1422.

(±)-Synthesis of 1-((1H-imidazol-5-yl) methyl)-2,3,4,9-tetrahydro-1H-pyrido[3,4-*b*] indole (Haploscleridamine) (9): Further elution of the column (ammoniacal MeOH: DCM = 1: 9)



provide haploscleridamine (±)-**9** (7 mg, 59%) as a colorless solid. m.p. = 155-160 °C, ^{1}H NMR (500 MHz, Methanol-d_4) δ 7.70 (d, *J* = 1.0 Hz, 1H), 7.45 (s, 1H), 7.33 (d, *J* = 8.1 Hz, 1H), 7.13 – 7.10 (m, 1H), 7.04 – 7.00 (m, 1H), 6.95 (s, 1H), 4.77 (dd, *J* = 8.6, 3.5 Hz, 1H), 3.59 (dt, *J* = 12.5, 4.9 Hz, 1H), 3.45 (d, *J* = 4.3 Hz, 1H), 3.42 (d, *J* = 4.1 Hz, 1H), 3.11 (dd, *J* = 15.4, 9.2 Hz, 1H), 3.01 – 2.94 (m, 2H). ^{13}C NMR (125.8 MHz, Methanol-d_4) δ 140.2, 138.3, 137.1, 135.3, 131.6, 123.4, 120.5, 119.2, 112.4, 108.2, 55.0, 43.0, 31.5, 20.6. FT-IR (neat, cm^{-1}): 3135, 3110, 2950, 2920, 2830, 2795, 1630, 1429, 1300, 1185, 1064, 1000, 748, 600 HR-MS (*m/z*): calcd. for $[M+H]^+$ $C_{15}H_{17}N_4$ 253.1448, found 253.1441.

Table S1: Conditions for attempted reductive detosylation of 1-((1H-imidazol-5-yl)methyl)-7-bromo-2-tosyl-2,3,4,9-tetrahydro-1H-pyrido[3,4-*b*]indole:

Reagent	Solvent	Temp (°C)	Time (min)	Observation Lissoclin C: Haploscleridamine
Mg (10 equiv)	MeOH	48	20	0:1
Mg (10 equiv)	MeOH	48	40	0:1
Mg (5 equiv)	MeOH	48	40	2:1
Mg (5 equiv)	Toluene	reflux	60	0:1
Sodium Naphthalide (stock solution)	MeOH	- 60	10	0:1
Sodium bis(2-methoxyethoxy) aluminium hydride Red-Al (4 equiv)	Toluene	rt	30-120	Starting material remained

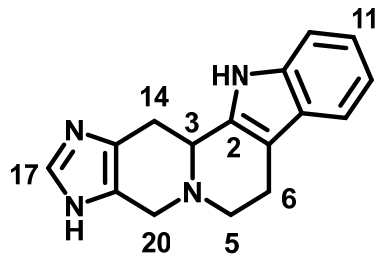


Table S2: Key ^{1}H NMR Data for Natural and Synthetic Villagorgin A

Signal	Carbon	Reported	Synthesized
1	3	3.83 (dt, *J* = 3.7 Hz, 11.0 1H)	3.84 (m, 1H)
2	5	3.33 (m, 1H)	3.34 (m, 1H)
3	5’	2.87 (ddd, *J* = 4.0, 12.0, and 22.5 Hz, 1H)	2.89 (ddd, *J* = 3.8, 8.4, 15.0 Hz, 1H)
4	6	3.00 (m, 1H)	3.05 (m, 1H)
5	6’	2.79 (dt, *J* =2.0, and 16.0 Hz, 1H)	2.79 (m, 1H)
6	14	3.36 (m, 1H)	3.37 (m, 1H),
7	14’	2.72 (m, 1H)	2.73 (m, 1H).
8	17	7.57 (s, 1H)	7.60 (d, *J* = 2.7 Hz, 1H),
9	20	3.99 (d, *J* = 13 Hz, 1H)	4.00 (dd, *J* = 3.3, 14.1 Hz, 1H)
10	20’	3.62 (dt, *J* =13 Hz, 1H)	3.62 (m, 1H)

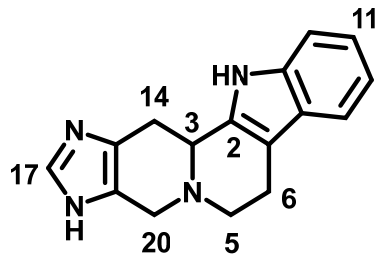
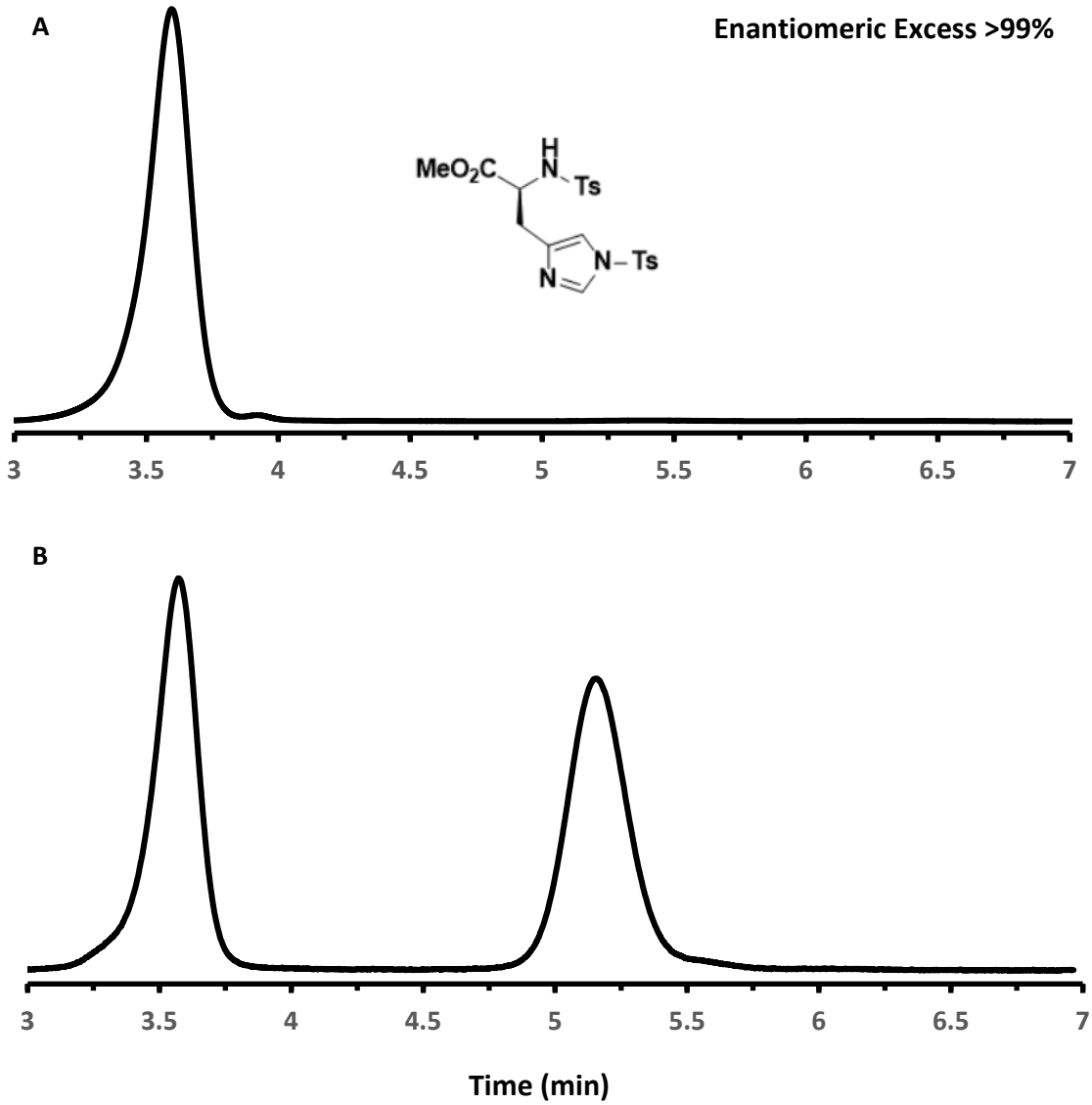


Table S3: Key ^{13}C NMR Data for natural and synthetic villagorgin

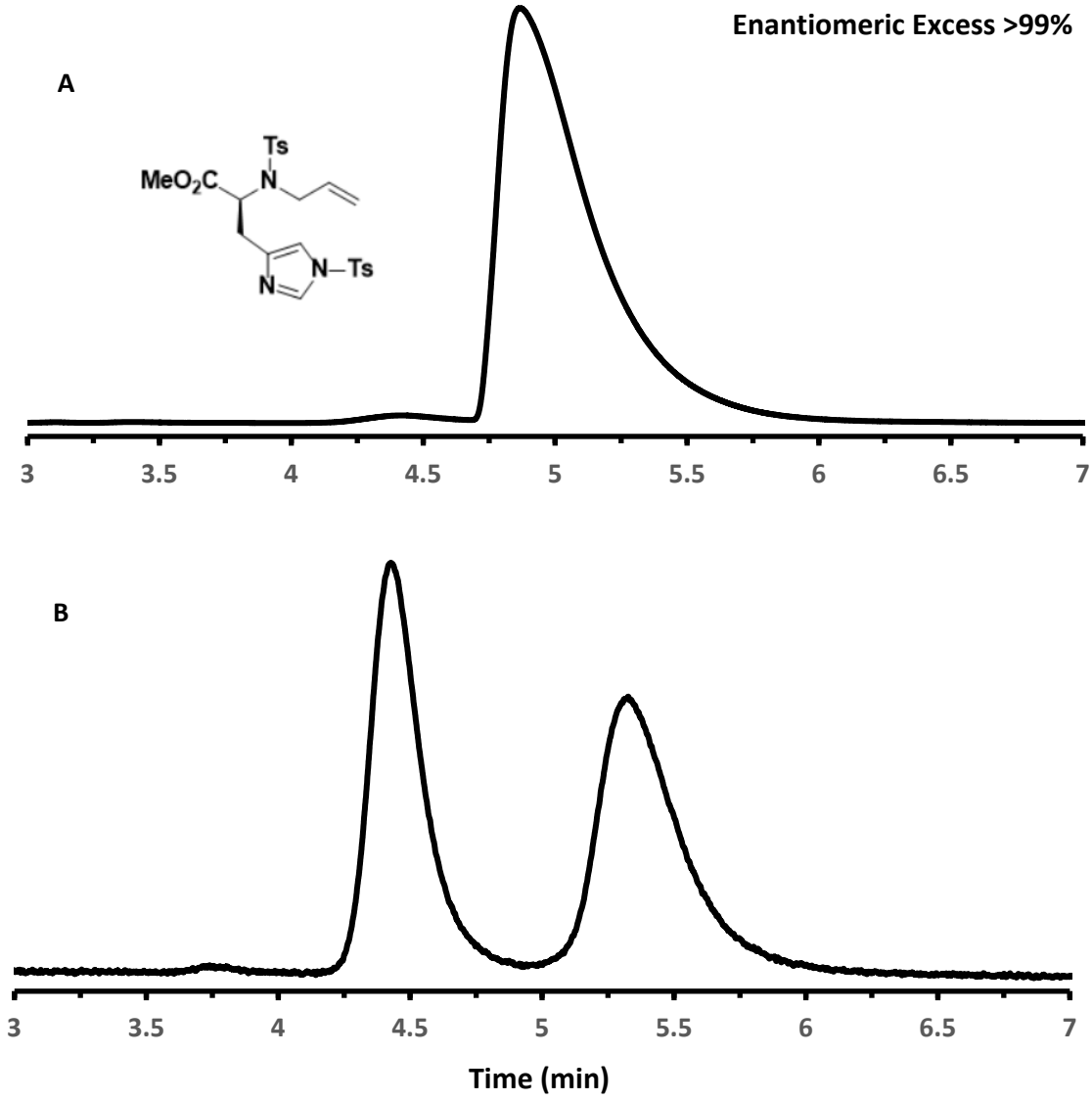
Signal	Carbon	Reported	Synthesized
1	2	135.1 s	134.8
2	3	58.4 d	58.4
3	5	54.0 t	54.0
4	6	22.3 t	22.3
5	14	29.2 t	29.2
6	15	129.7 s	129.8
7	17	135.2 d	135.6
8	19	127.3 s	128.0
9	20	53.4 t	53.3

General Experimental for the Enantiomer Analysis:

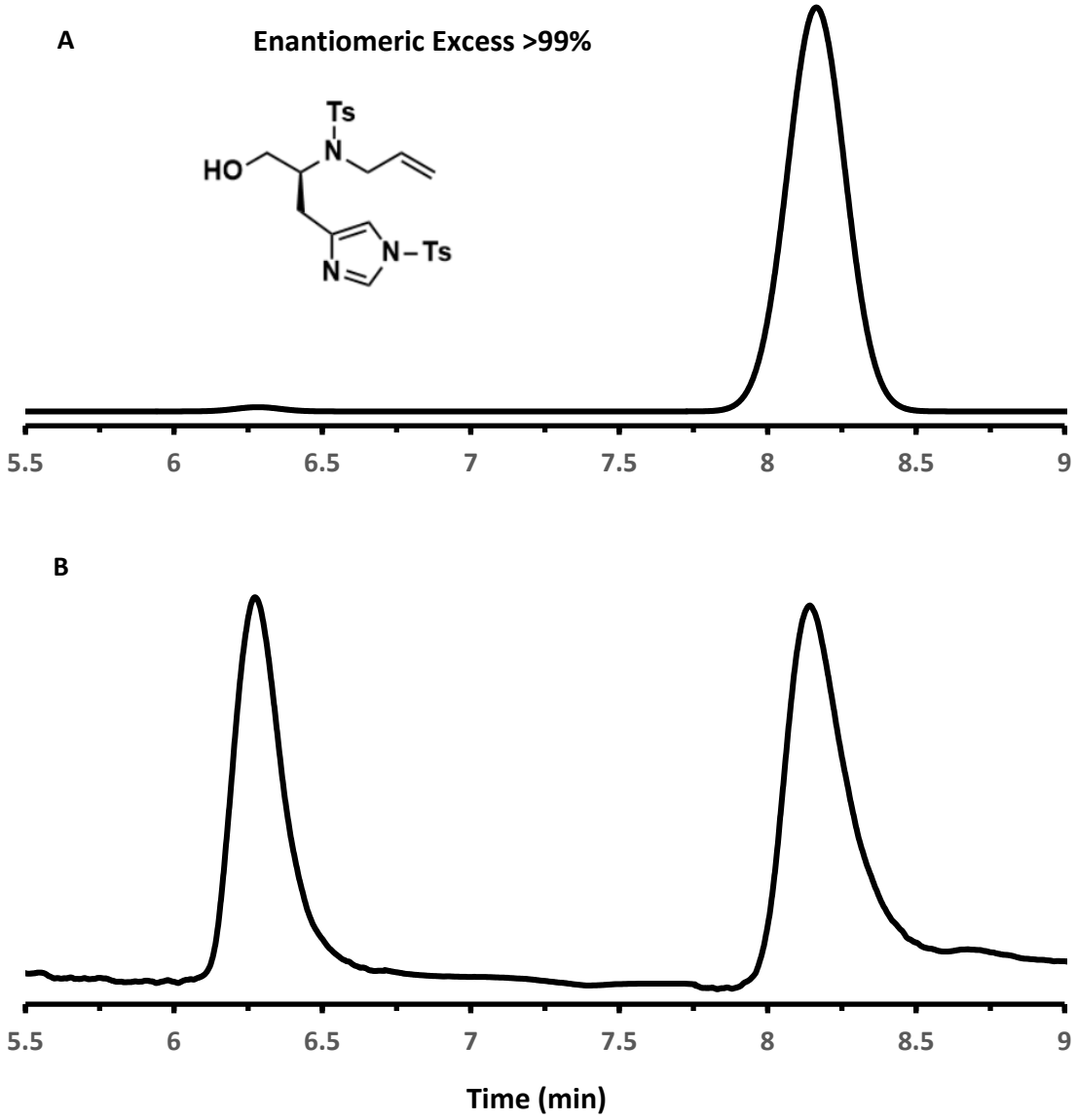
The liquid chromatography system used was the 1100 Infinity from Agilent (Santa Clara. CA. USA) which includes a quaternary pump, mobile phase degasser, 96 vial sample injector, column thermostat, and diode array UV detector. A personal computer drove the chromatographic system and handled data with the OpenLab CDS ChemStation software (Agilent). Acetonitrile solutions of all samples were made at a concentration of 2 mg/mL. One microliter of each individual solution was injected for each analysis. Both the, NicoShell column (3 x 150 mm) and MaltoShell (4.6 x 100 mm), were packed with superficially porous (SPP) 2.7 µm particles provided by AZYP, LLC (Arlington, TX, USA). The Chiralpack IC -3 column (3.0 x 150 mm) was packed with 3 µm fully porous particles (FPP) and provided by Daicel (Chiral Technologies, West Chester, PA, USA). All chromatograms are shown in the supporting information.



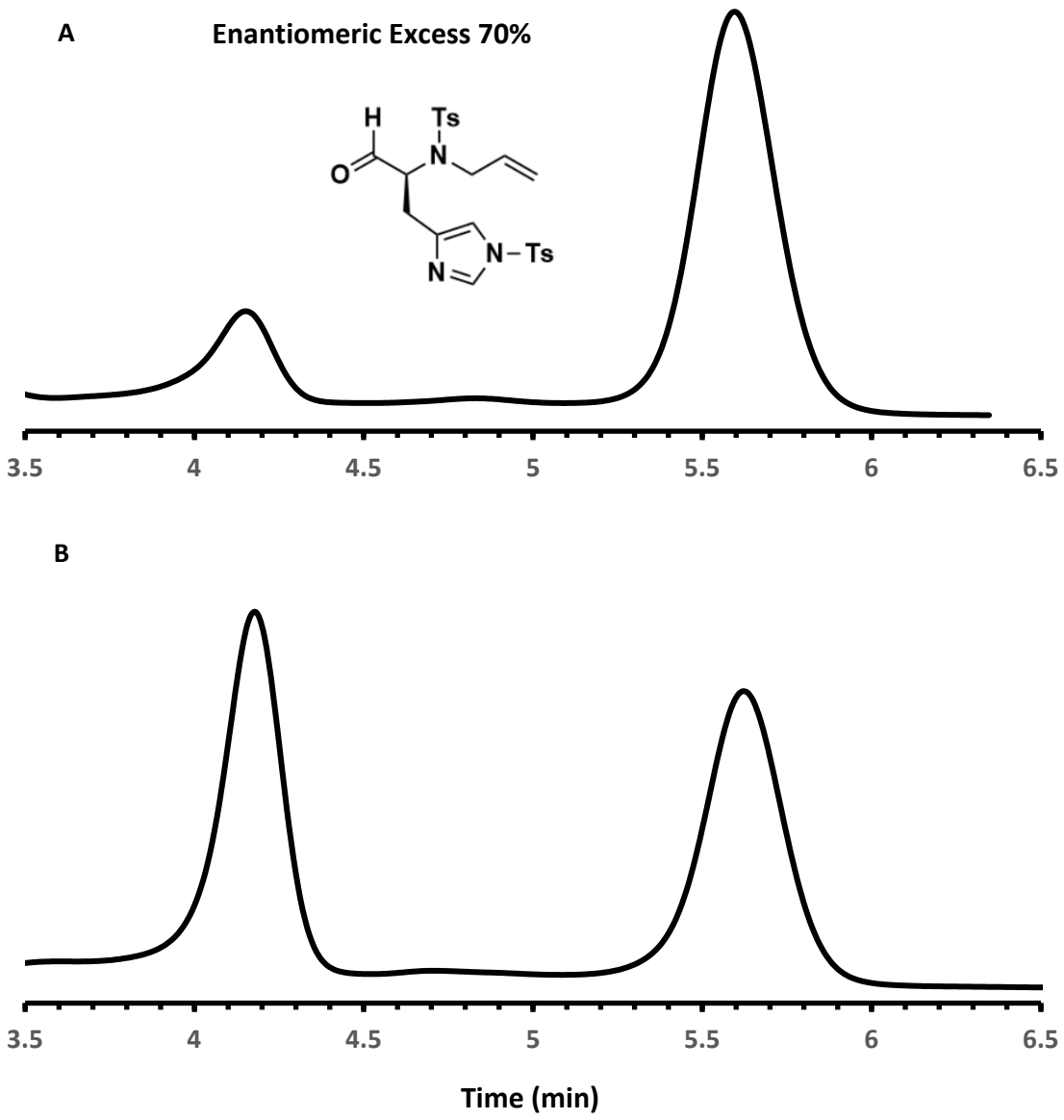
Chromatogram A is the separation of non-racemic compound **33** and B is the racemic separation of compound **33** both on ChiralPak IC 3 µm, 3 mm ID x 150 mm L, 100% Ethanol, 0.4 mL/min, Detection UV 254 nm, Temperature 25 ˚C



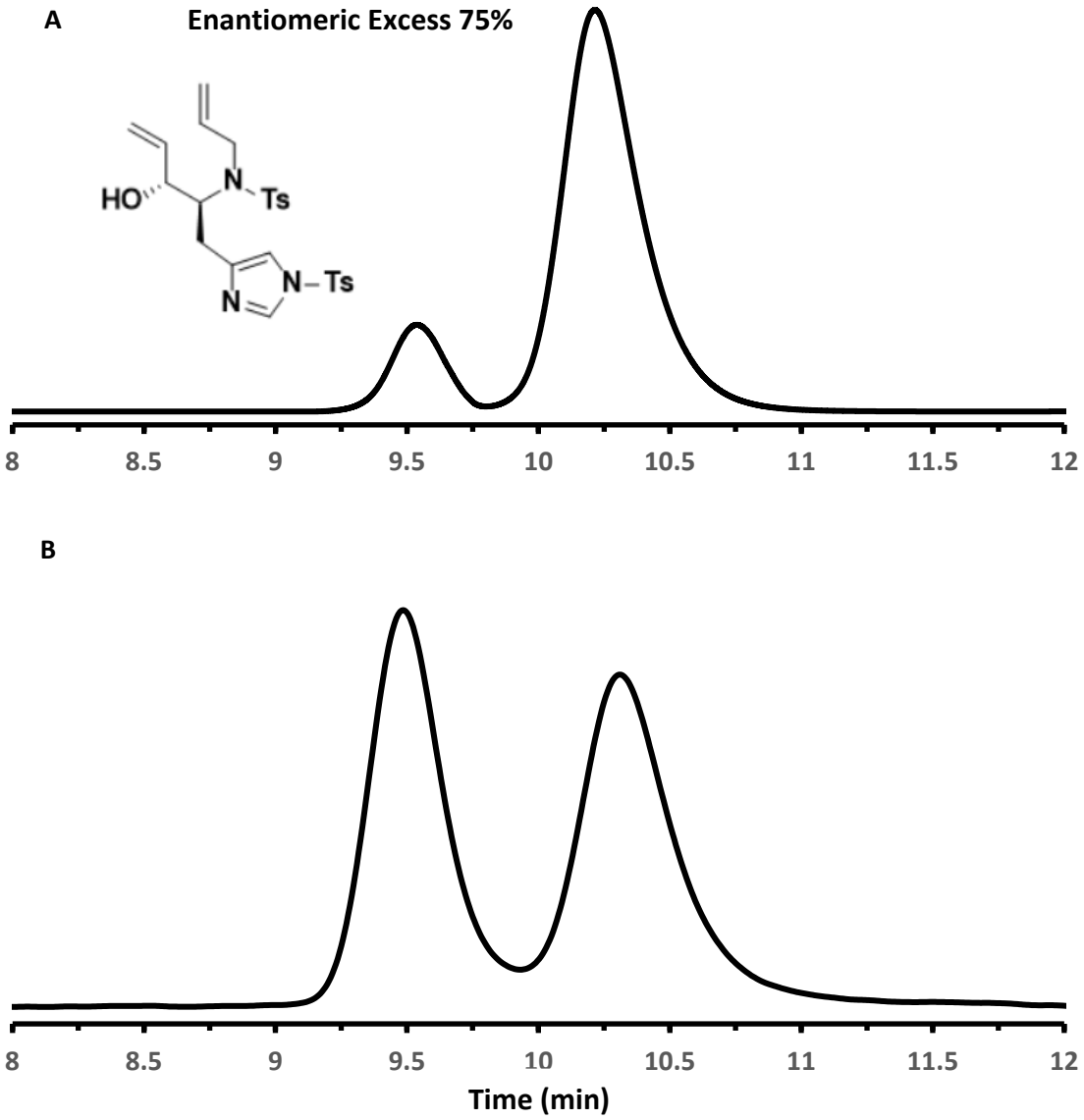
Chromatogram A is the separation of non-racemic compound **34** and B is the racemic separation of compound **34** both on MaltoShell 2.7 µm SPP, 4.6 mm ID x 100 mm L, 20%-15%-65% Ethanol-Methanol-Heptane, 1 mL/min, Detection UV 254 nm, Temperature 25 °C



Chromatogram A is the separation of non-racemic compound **55** and B is the racemic separation of compound **55** both on MaltoShell 2.7 µm SPP, 4.6 mm ID x 100 mm L, 20%-15%-65% Ethanol-Methanol-Heptane, 1 mL/min, Detection UV 254 nm, Temperature 25 °C

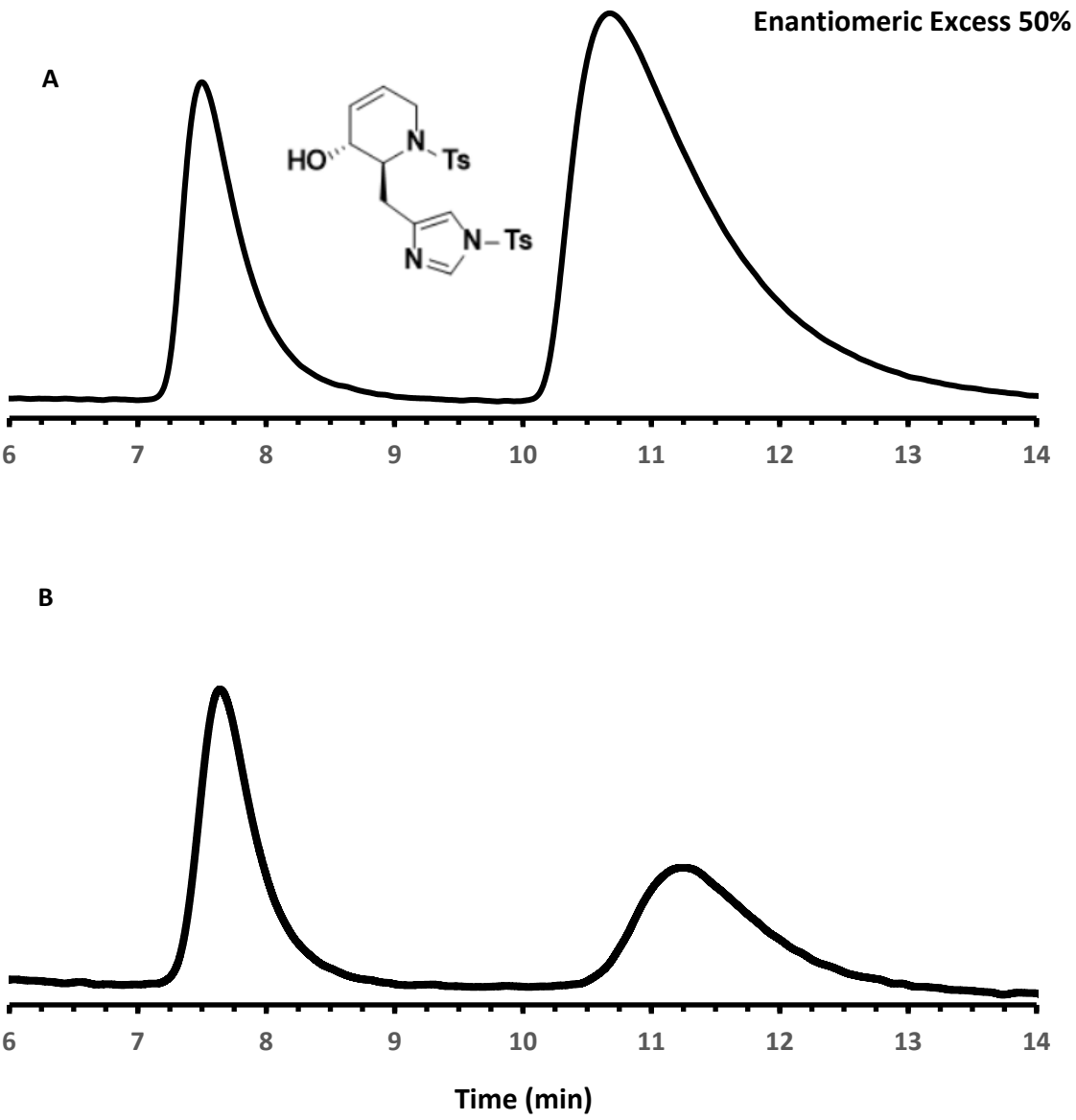


Chromatogram A is the separation of non-racemic compound **35** and B is the racemic separation of compound **35** both on ChiralPak IC 3 µm, 3 mm ID x 150 mm L, 100% Ethanol, 0.4 mL/min, Detection UV 254 nm, Temperature 25 ˚C

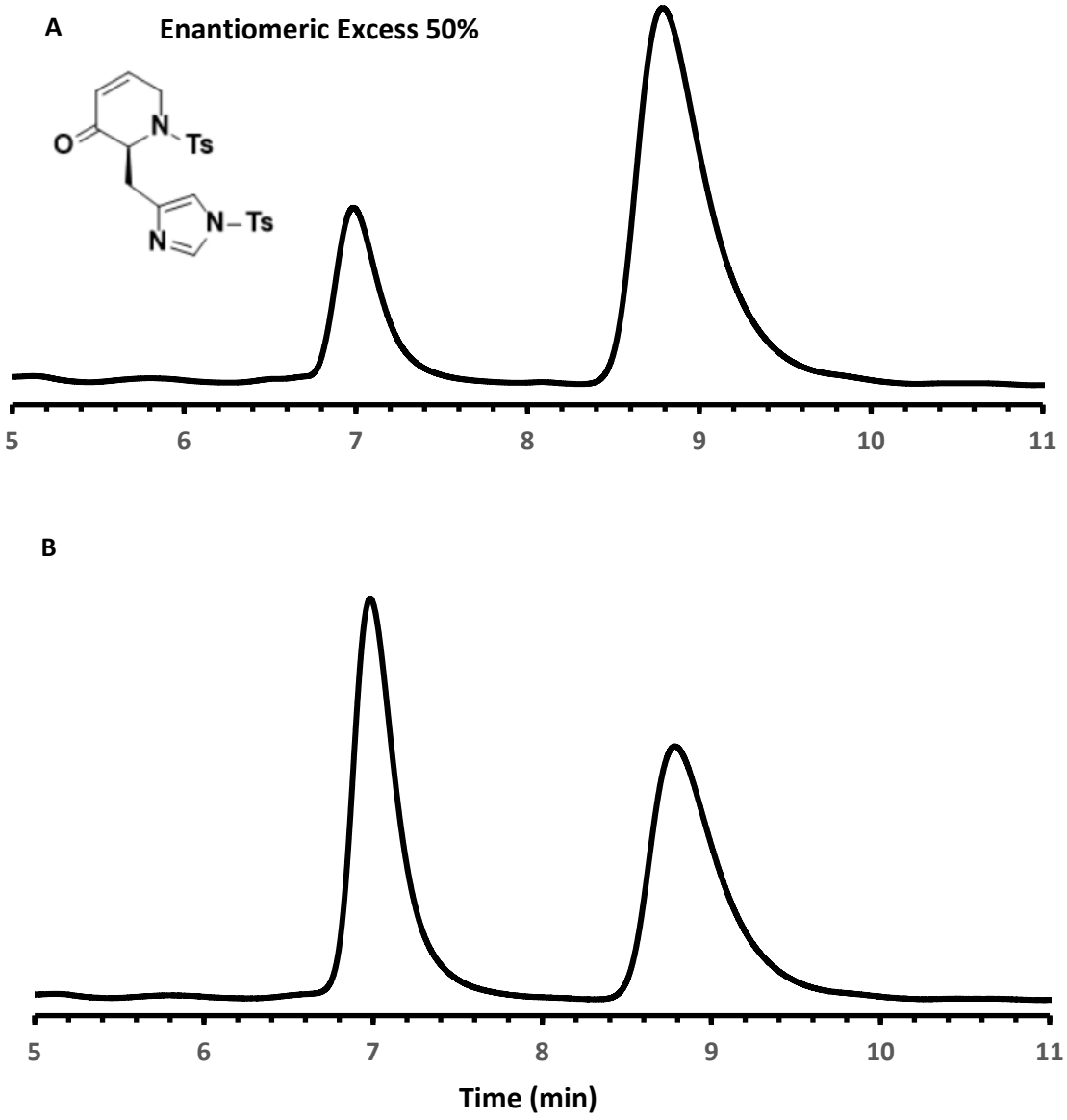


Chromatogram A is the separation of non-racemic compound **32** and B is the racemic separation of compound **32** both on MaltoShell 2.7 µm SPP, 4.6 mm ID x 100 mm L, 5%-5%-90% Ethanol-Methanol-Heptane, 1 mL/min, Detection UV 254 nm, Temperature 25 °C

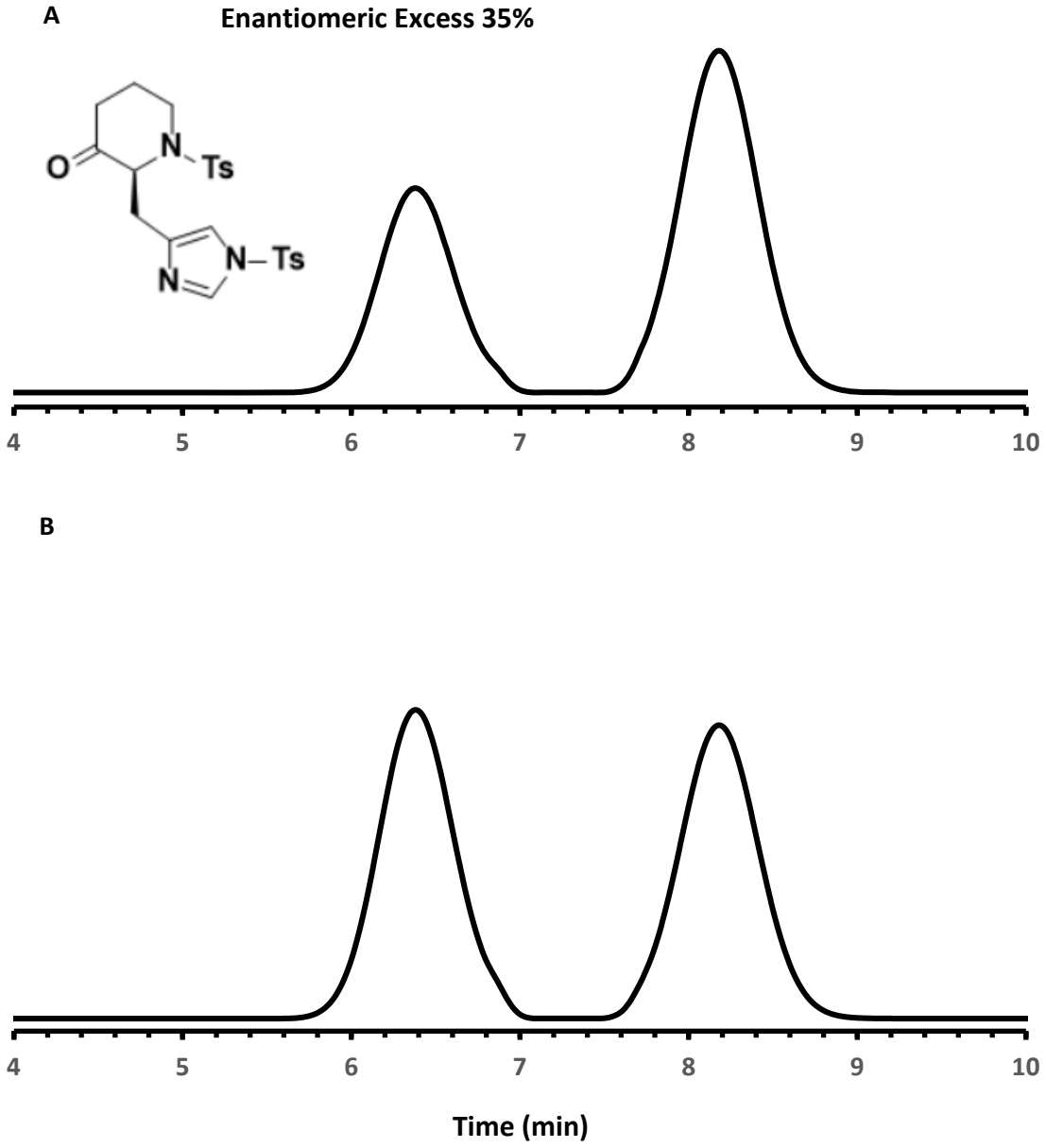
Compound 38



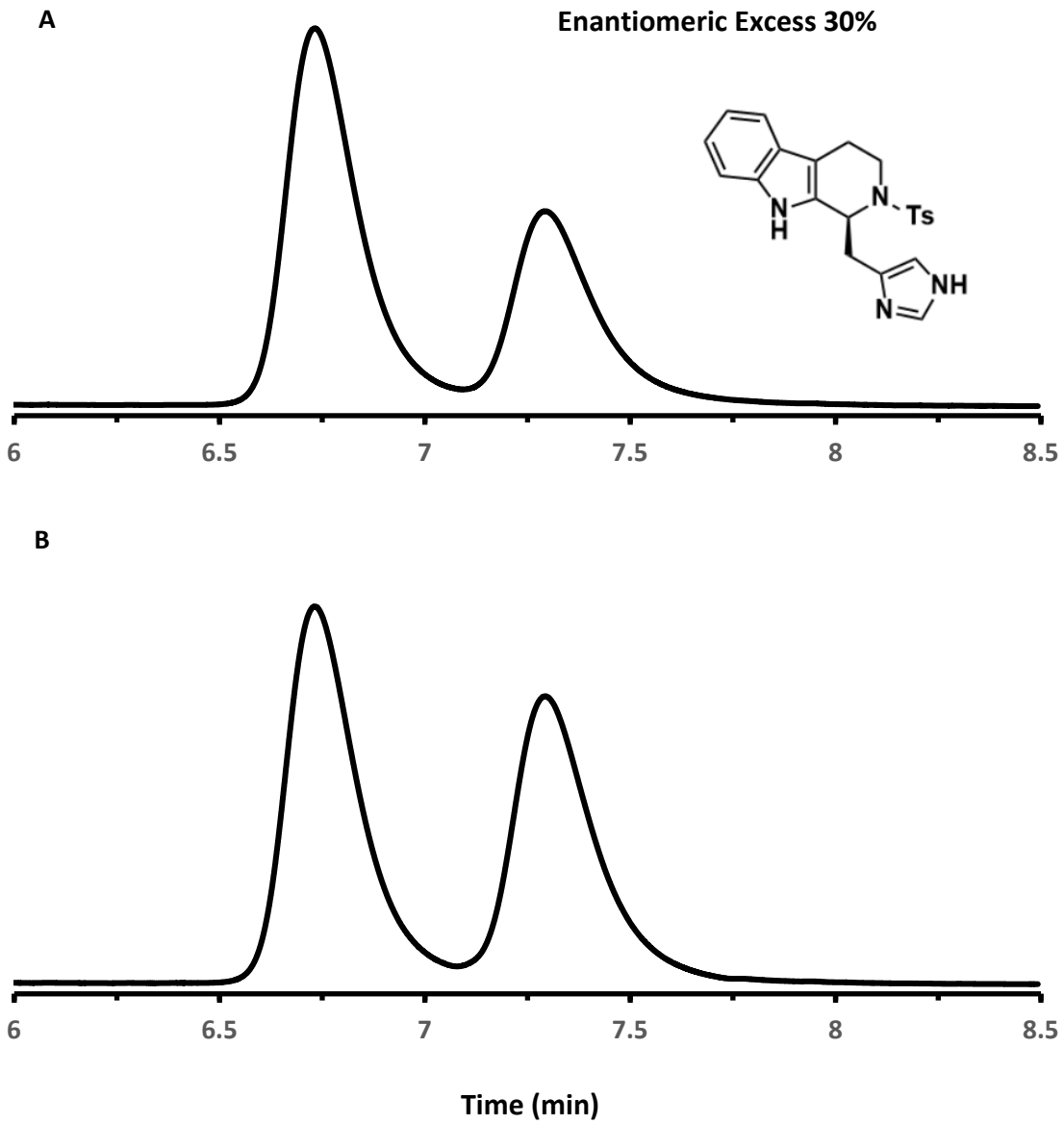
Chromatogram A is the separation of non-racemic compound **38** and B is the racemic separation of compound **38** both on MaltoShell 2.7 µm SPP, 4.6 mm ID x 100 mm L, 10%-10%-80% Ethanol Methanol Heptane, 1 mL/min, Detection UV 254 nm, Temperature 25 °C



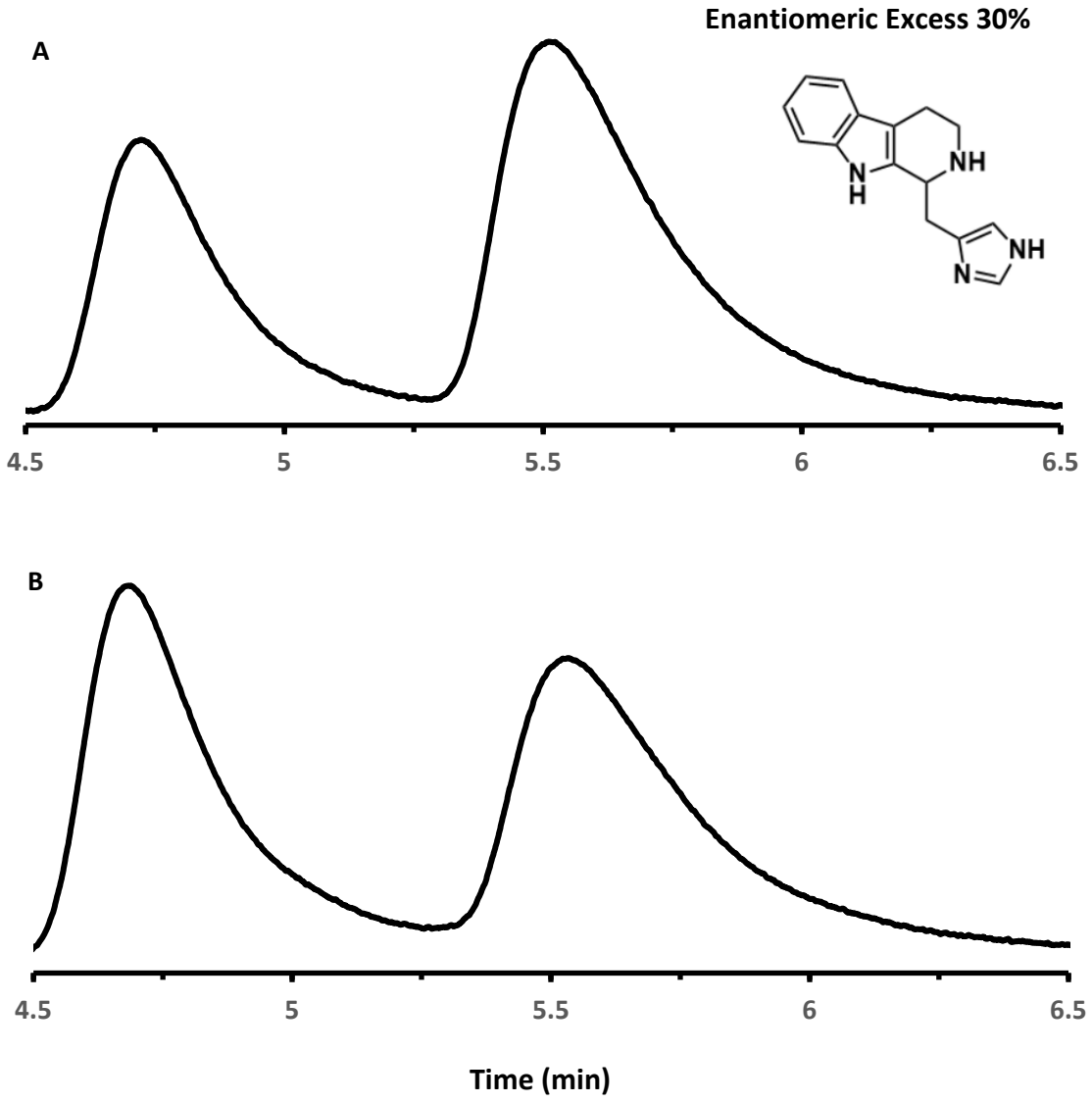
Chromatogram A is the separation of non-racemic compound **37** and B is the racemic separation of compound **37** both on MaltoShell 2.7 µm SPP, 4.6 mm ID x 100 mm L, 15%-10%-75% Ethanol Methanol Heptane, 1 mL/min, Detection UV 254 nm, Temperature 25 °C



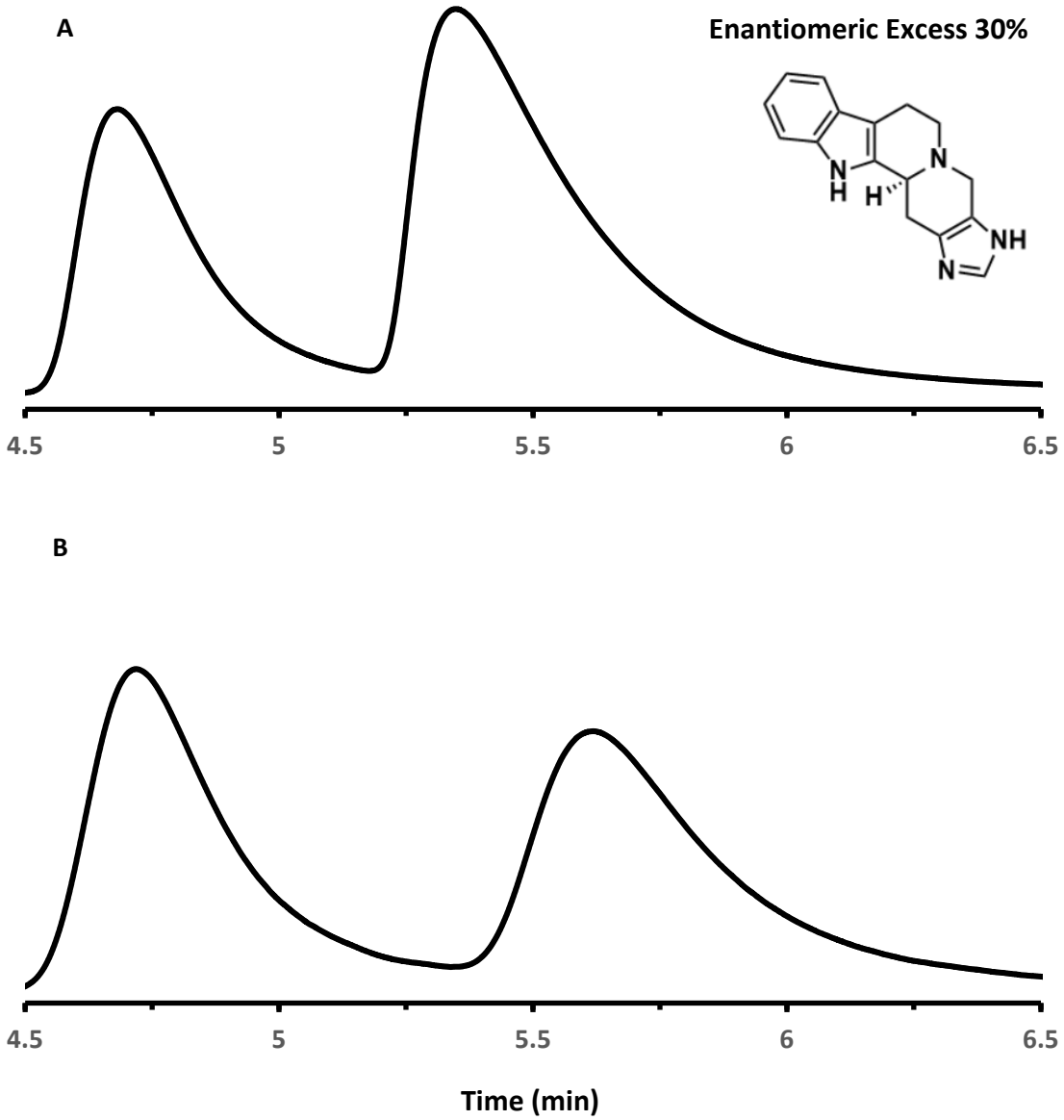
Chromatogram A is the separation of non-racemic compound **31** and B is the racemic separation of compound **31** both on MaltoShell 2.7 µm SPP, 4.6 mm ID x 100 mm L, 15%-15%-70% Ethanol-Methanol-Heptane, 1 mL/min, Detection UV 254 nm, Temperature 25 °C



Chromatogram A is the separation of non-racemic compound **51** and B is the racemic separation of compound **51** both on NicoShell 2.7 µm SPP, 3 mm ID x 150 mm L, 100% Methanol 0.1% ammonium trifluoroacetate, 0.4 mL/min, Detection UV 254 nm, Temperature 25 °C

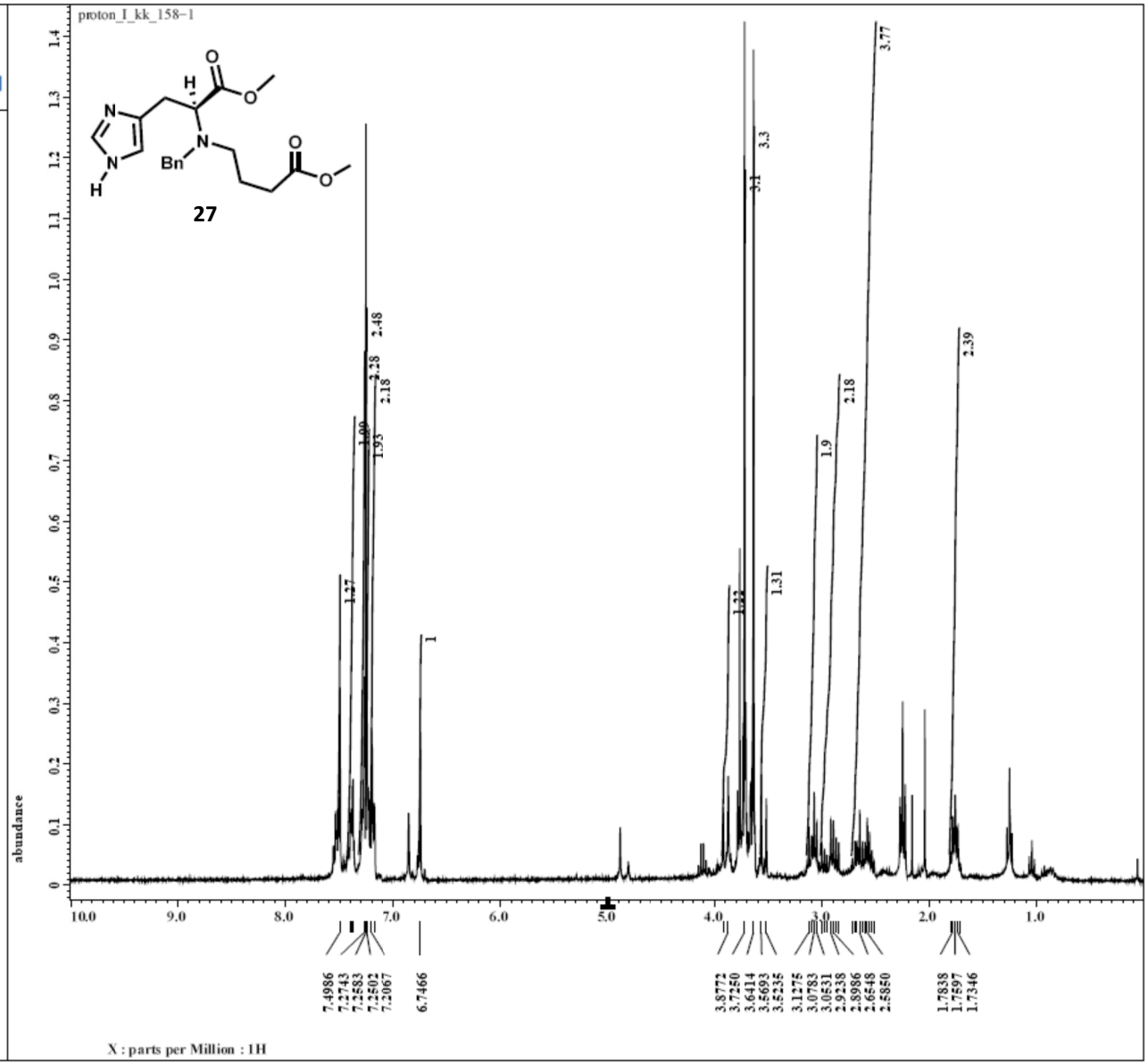


Chromatogram A is the separation of non-racemic compound **9** and B is the racemic separation of compound **9** both on NicoShell 2.7 µm SPP, 3 mm ID x 150 mm L, 100% Methanol 0.1% ammonium trifluoroacetate, 0.4 mL/min, Detection UV 254 nm, Temperature 25 °C



Chromatogram A is the separation of non-racemic compound **7** and B is the racemic separation of compound **7** both on NicoShell 2.7 µm SPP, 3 mm ID x 150 mm L, 100% Methanol 0.1% ammonium trifluoroacetate, 0.4 mL/min, Detection UV 254 nm, Temperature 25 °C

Filename	= I_158_r.a-6-7.jdf
Author	= delta
Experiment	= single_pulse.ex2
Sample_id	= lovely/karuna/proton/
Solvent	= CHLOROFORM-D
Creation_time	= 4-OCT-2006 11:51:41
Revision_time	= 5-DEC-2007 23:57:51
Current_time	= 6-DEC-2007 00:00:29
Comment	= single_pulse
Data_format	= 1D COMPLEX
Dim_size	= 13107
Dim_title	= 1H
Dim_units	= [ppm]
Dimensions	= X
Site	= ECX 300
Spectrometer	= DELTA2_NMR
Field_strength	= 7.0586013[T] (300[MHz
X_acq_duration	= 2.90717696[s]
X_domain	= 1H
X_freq	= 300.52965592[MHz]
X_offset	= 5[ppm]
X_points	= 16384
X_prescans	= 0
X_resolution	= 0.34397631[Hz]
X_sweep	= 5.63570784[kHz]
Irr_domain	= 1H
Irr_freq	= 300.52965592[MHz]
Irr_offset	= 5[ppm]
Tri_domain	= 1H
Tri_freq	= 300.52965592[MHz]
Tri_offset	= 5[ppm]
Clipped	= FALSE
Mod_return	= 1
Scans	= 24
Total_scans	= 24
X_90_width	= 13.01[us]
X_acq_time	= 2.90717696[s]
X_angle	= 45[deg]
X_atn	= 4[dB]
X_pulse	= 6.505[us]
Irr_mode	= Off
Tri_mode	= Off
Dante_presat	= FALSE
Initial_wait	= 1[s]
Recvr_gain	= 46
Relaxation_delay	= 5[s]
Repetition_time	= 7.90717696[s]
Temp_get	= 23.2[dC]



Filename	= I_kk_125_bnprotester-
Author	= delta
Experiment	= single_pulse_dec
Sample_id	= S#633482
Solvent	= CHLOROFORM-D
Creation_time	= 30-NOV-2007 02:12:51
Revision_time	= 3-DEC-2007 11:20:41
Current_time	= 3-DEC-2007 11:21:22
Comment	= single pulse decouple
Data_format	= 1D COMPLEX
Dim_size	= 65536
Dim_title	= 13C
Dim_units	= [ppm]
Dimensions	= X
Site	= Eclipse+ 500
Spectrometer	= DELTA_NMR
Field_strength	= 11.7473579[T] (500[MH
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X_domain	= 13C
X_freq	= 125.76529768[MHz]
X_offset	= 100[ppm]
X_points	= 65536
X_prescans	= 4
X_resolution	= 0.47983613[Hz]
X_sweep	= 31.44654088[kHz]
Irr_domain	= 1H
Irr_freq	= 500.15991521[MHz]
Irr_offset	= 5[ppm]
Clipped	= FALSE
Mod_return	= 1
Scans	= 2500
Total_scans	= 2500
X_90_width	= 14.2[us]
X_acq_time	= 2.0840448[s]
X_angle	= 30[deg]
X_pulse	= 4.73333333[us]
Initial_wait	= 1[s]
Noe_time	= 1[s]
Phase_preset	= 3[us]
Recvr_gain	= 29
Relaxation_delay	= 2[s]
Temp_get	= 26.8[dC]
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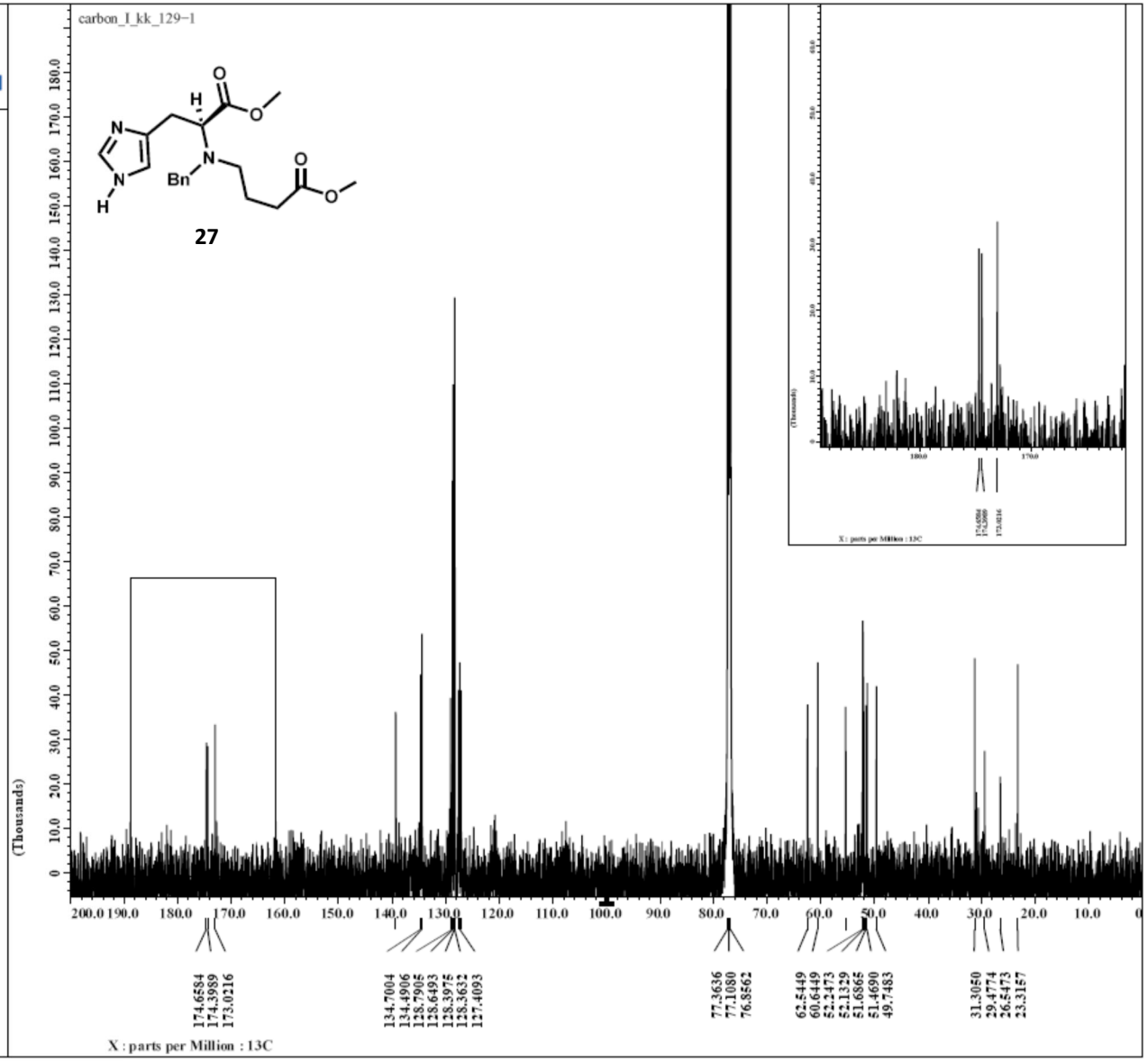

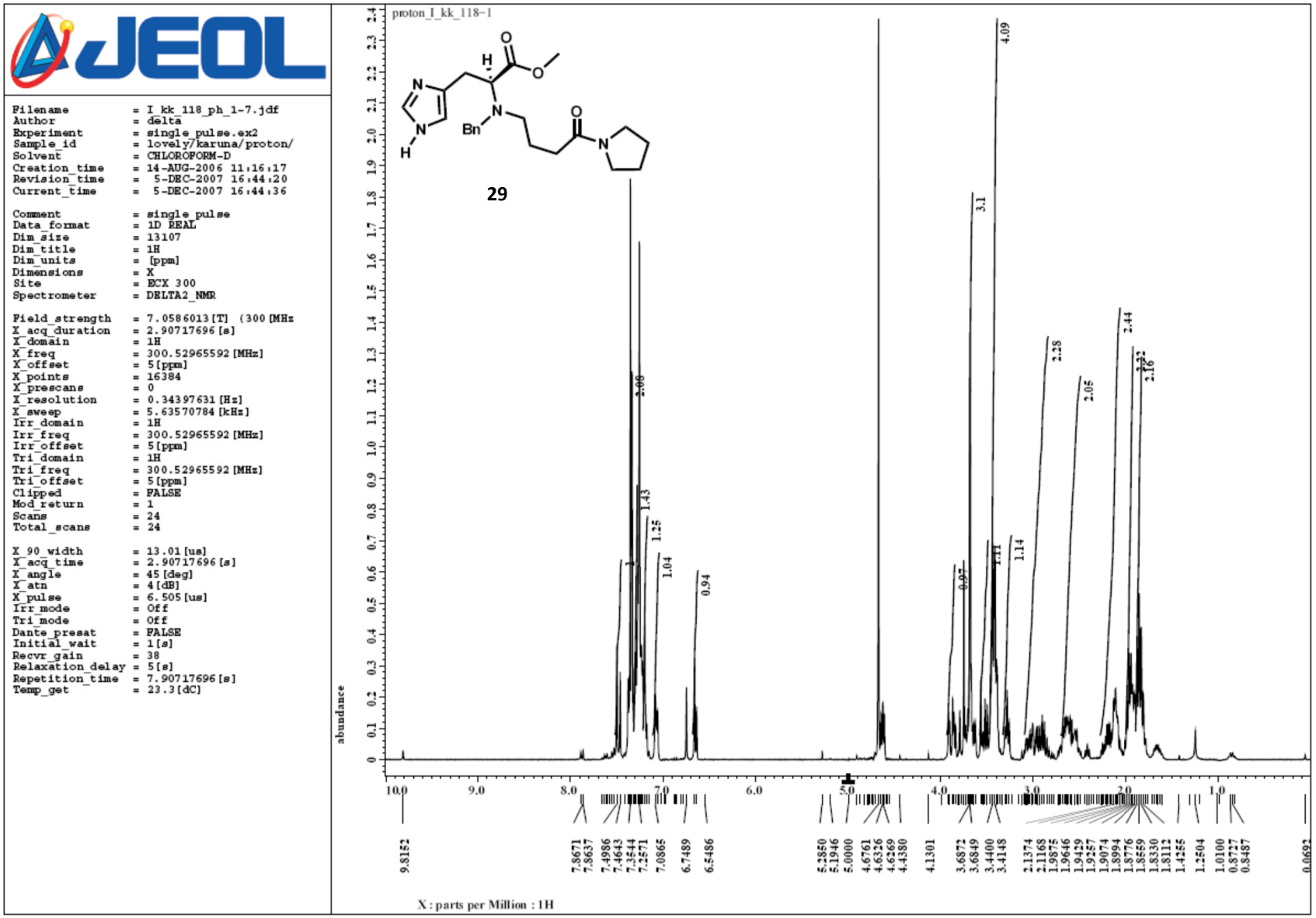
JEOL
Filename = I_kk_118_ph_1-7.jdf
Author = delta
Experiment = single_pulse.ex2
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Solvent = CHLOROFORM-D
Creation_time = 14-AUG-2006 11:16:17
Revision_time = 5-DEC-2007 16:44:20
Current_time = 5-DEC-2007 16:44:36
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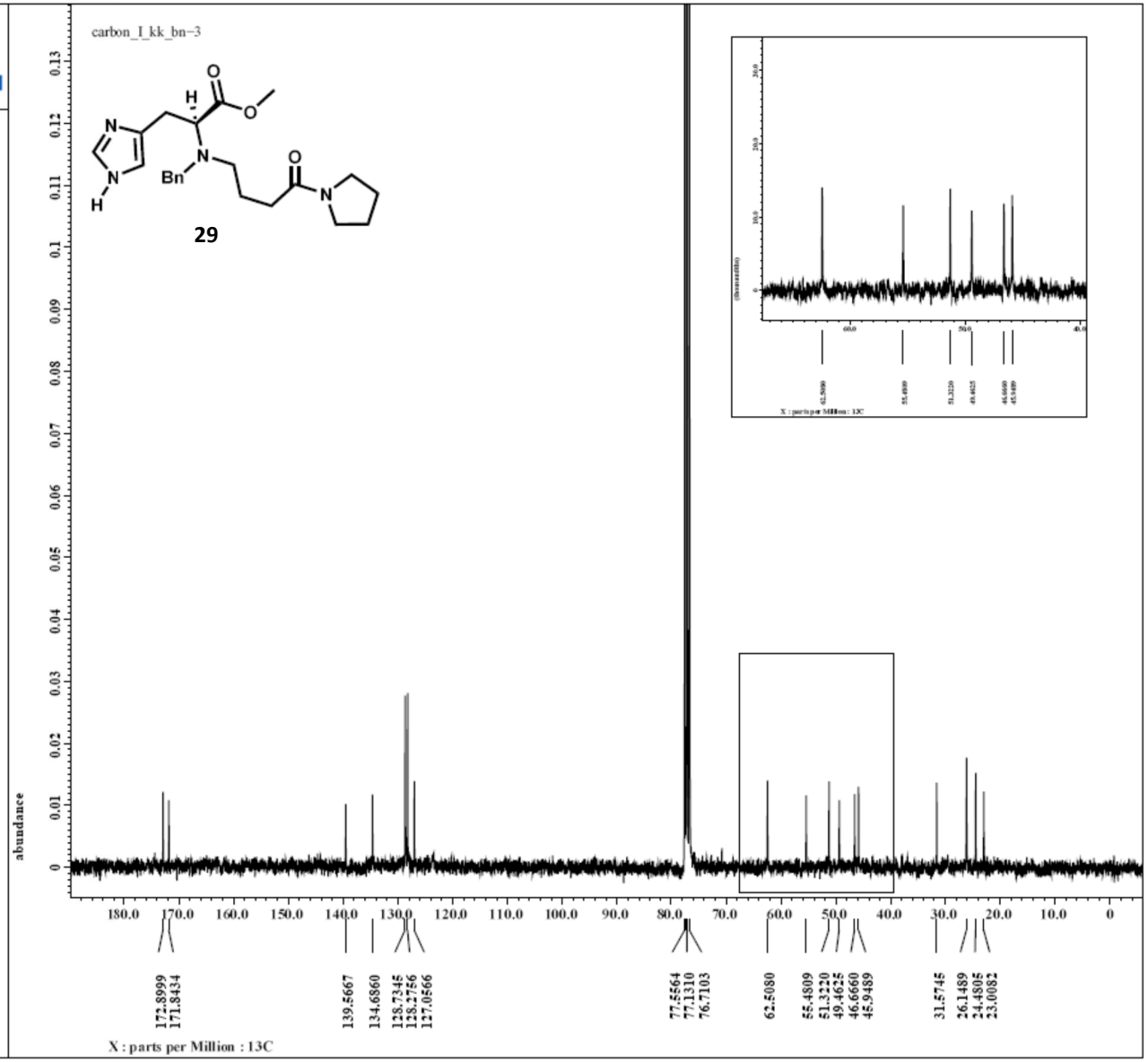
Dim_units = [ppm]
Dimensions = X
Site = ECX 300
Spectrometer = DELTA2_NMR
Field_strength = 7.0586013[T] (300[MHz
X_acq_duration = 2.90717696[s]
X_domain = 1H
X_freq = 300.52965592[MHz]
X_offset = 5[ppm]
X_points = 16384
X_prescans = 0
X_resolution = 0.34397631[Hz]
X_sweep = 5.63570784[kHz]
Irr_domain = 1H
Irr_freq = 300.52965592[MHz]
Irr_offset = 5[ppm]
Tri_domain = 1H
Tri_freq = 300.52965592[MHz]
Tri_offset = 5[ppm]
Clipped = FALSE
Mod_return = 1
Scans = 24
Total_scans = 24
X_90_width = 13.01[us]
X_acq_time = 2.90717696[s]
X_angle = 45[deg]
X_atn = 4[dB]
X_pulse = 6.505[us]
Irr_mode = Off
Tri_mode = Off
Dante_presat = FALSE
Initial_wait = 1[s]
Recvr_gain = 38
Relaxation_delay = 5[s]
Repetition_time = 7.90717696[s]
Temp_get = 23.3[dC]
proton_I_kk_118-1
29
abundance
X : parts per Million : 1H

Filename	= I_kk_139_Bn(cyc)_copy
Author	= delta
Experiment	= single_pulse_dec
Sample_id	= S#507416
Solvent	= CHLOROFORM-D
Creation_time	= 10-SEP-2006 15:43:11
Revision_time	= 1-DEC-2007 16:20:01
Current_time	= 1-DEC-2007 16:20:17
Comment	= single pulse decouple
Data_format	= 1D COMPLEX
Dim_size	= 52428
Dim_title	= 13C
Dim_units	= [ppm]
Dimensions	= X
Site	= ECX 300
Spectrometer	= DELTA2_NMR
Field_strength	= 7.0586013[T] (300[MHz
X_acq_duration	= 2.76824064[s]
X_domain	= 13C
X_freq	= 75.56823426[MHz]
X_offset	= 100[ppm]
X_points	= 65536
X_prescans	= 4
X_resolution	= 0.36124027[Hz]
X_sweep	= 23.67424242[kHz]
Irr_domain	= 1H
Irr_freq	= 300.52965592[MHz]
Irr_offset	= 5[ppm]
Clipped	= FALSE
Incomplete_copy	= TRUE
Mod_return	= 10
Scans	= 500
Total_scans	= 500
X_90_width	= 9.75[us]
X_acq_time	= 2.76824064[s]
X_angle	= 30[deg]
X_atn	= 8[dB]
X_pulse	= 3.25[us]
Irr_atn_dec	= 25[dB]
Irr_atn_noe	= 25[dB]
Irr_noise	= WALTZ
Decoupling	= TRUE
Initial_wait	= 1[s]
Noe	= TRUE
Noe_time	= 4[s]
Recvr_gain	= 50
Relaxation_delay	= 4[s]
Repetition_time	= 6.76824064[s]
Temp_get	= 23.2[dC]



Filename	= I_kk_118_r.a sod boro
Author	= delta
Experiment	= single_pulse.ex2
Sample_id	= lovely/karuna/proton/
Solvent	= CHLOROFORM-D
Creation_time	= 2-AUG-2006 00:23:56
Revision_time	= 29-NOV-2007 15:58:55
Current_time	= 29-NOV-2007 15:59:15
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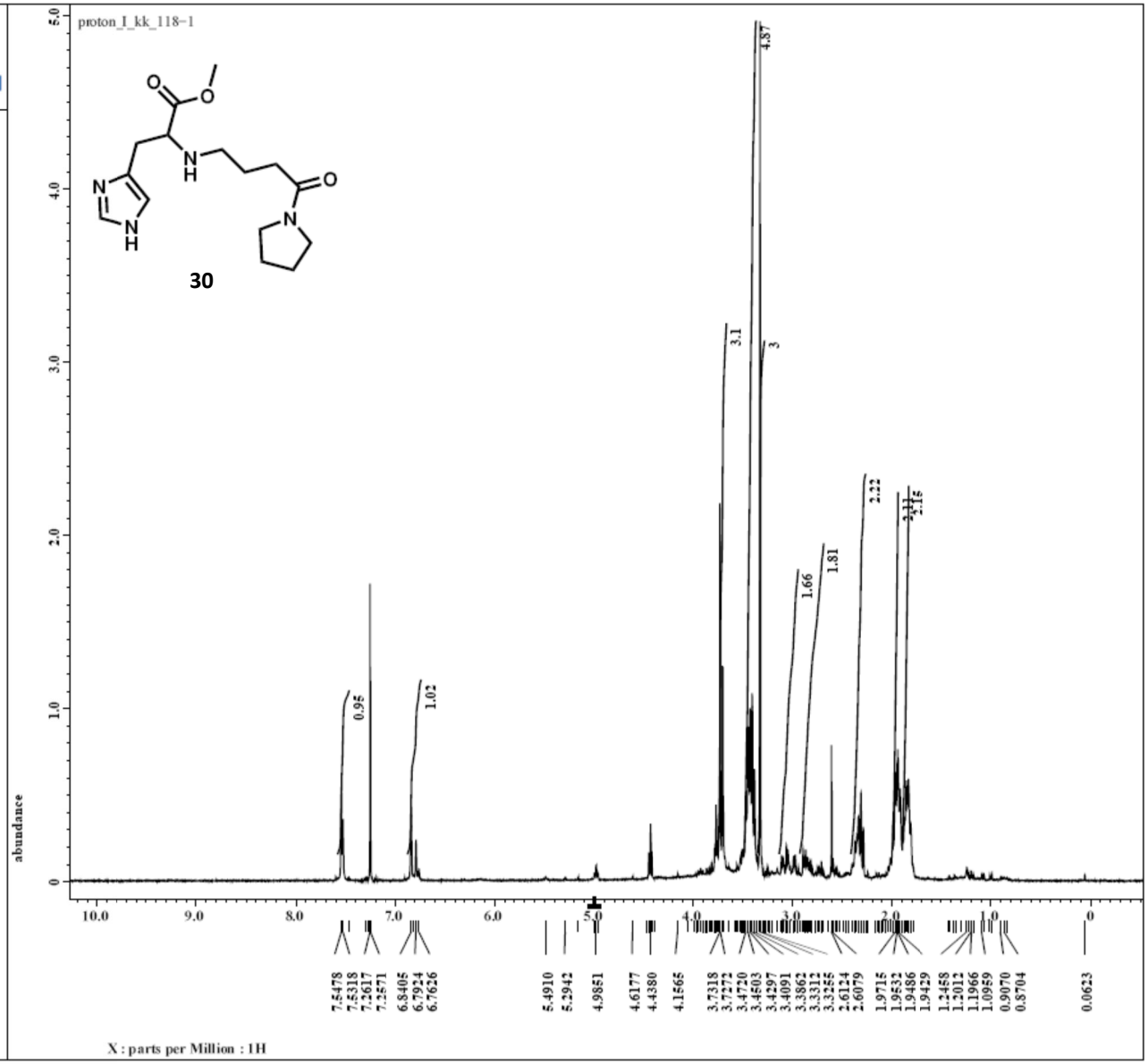
Dim_units	= [ppm]
Dimensions	= X
Site	= ECX 300
Spectrometer	= DELTA2_NMR
Field_strength	= 7.0586013[T] (300[MHz
X_acq_duration	= 2.90717696[s]
X_domain	= 1H
X_freq	= 300.52965592[MHz]
X_offset	= 5[ppm]
X_points	= 16384
X_prescans	= 0
X_resolution	= 0.34397631[Hz]
X_sweep	= 5.63570784[kHz]
Irr_domain	= 1H
Irr_freq	= 300.52965592[MHz]
Irr_offset	= 5[ppm]
Tri_domain	= 1H
Tri_freq	= 300.52965592[MHz]
Tri_offset	= 5[ppm]
Clipped	= FALSE
Mod_return	= 1
Scans	= 24
Total_scans	= 24
X_90_width	= 13.01[us]
X_acq_time	= 2.90717696[s]
X_angle	= 45[deg]
X_atn	= 4[dB]
X_pulse	= 6.505[us]
Irr_mode	= Off
Tri_mode	= Off
Dante_presat	= FALSE
Initial_wait	= 1[s]
Recvr_gain	= 50
Relaxation_delay	= 5[s]
Repetition_time	= 7.90717696[s]
Temp_get	= 23.3[dC]



Filename	= I_kk_117_NaBH4(RA)-4.
Author	= delta
Experiment	= single_pulse_dec
Sample_id	= S#804997
Solvent	= CHLOROFORM-D
Creation_time	= 8-SEP-2006 09:17:19
Revision_time	= 29-NOV-2007 10:29:25
Current_time	= 29-NOV-2007 10:31:04
Comment	= single pulse decouple
Data_format	= 1D COMPLEX
Dim_size	= 52428
Dim_title	= 13C
Dim_units	= [ppm]
Dimensions	= X
Site	= ECX 300
Spectrometer	= DELTA2_NMR
Field_strength	= 7.0586013[T] (300[MHz
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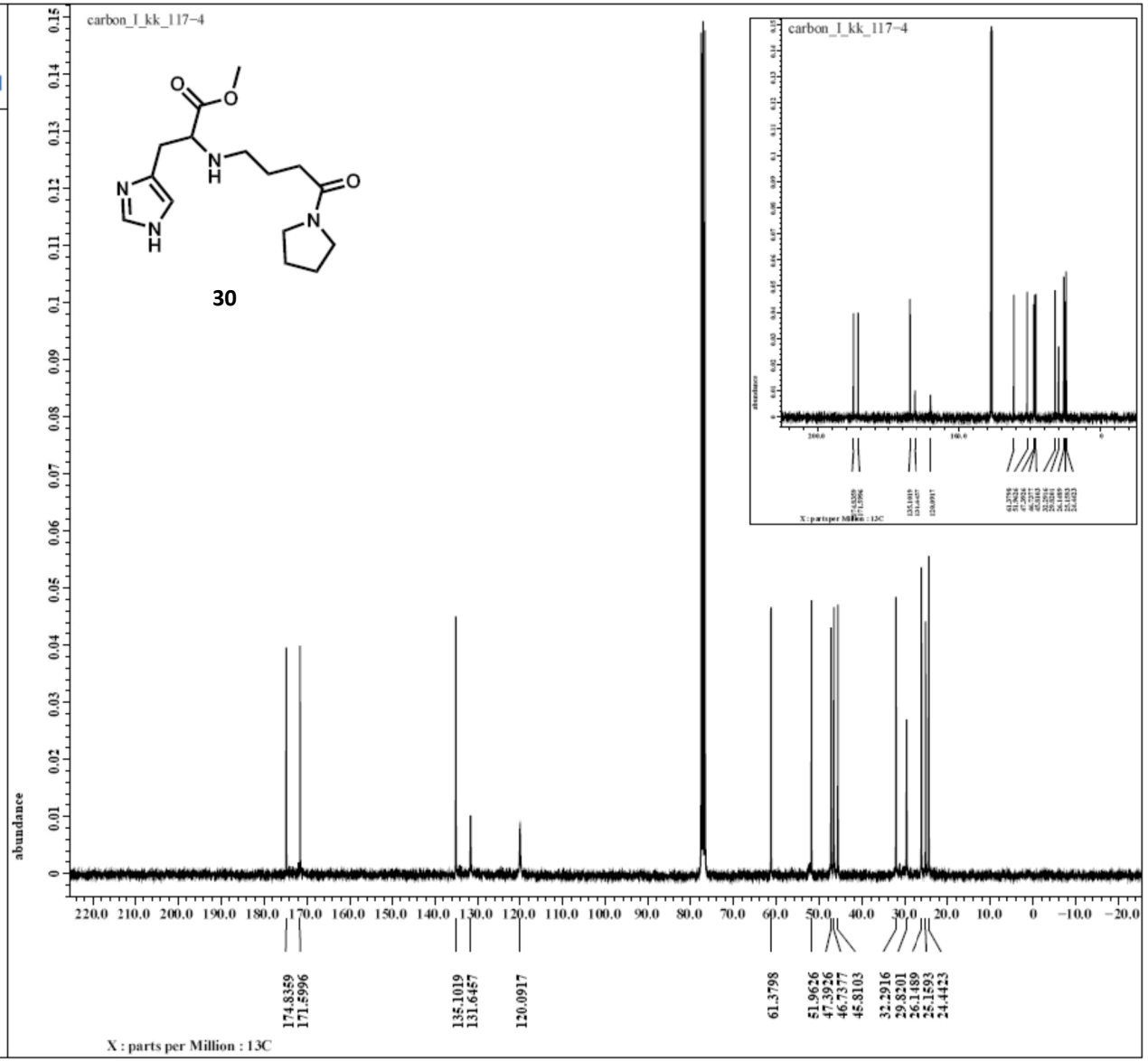
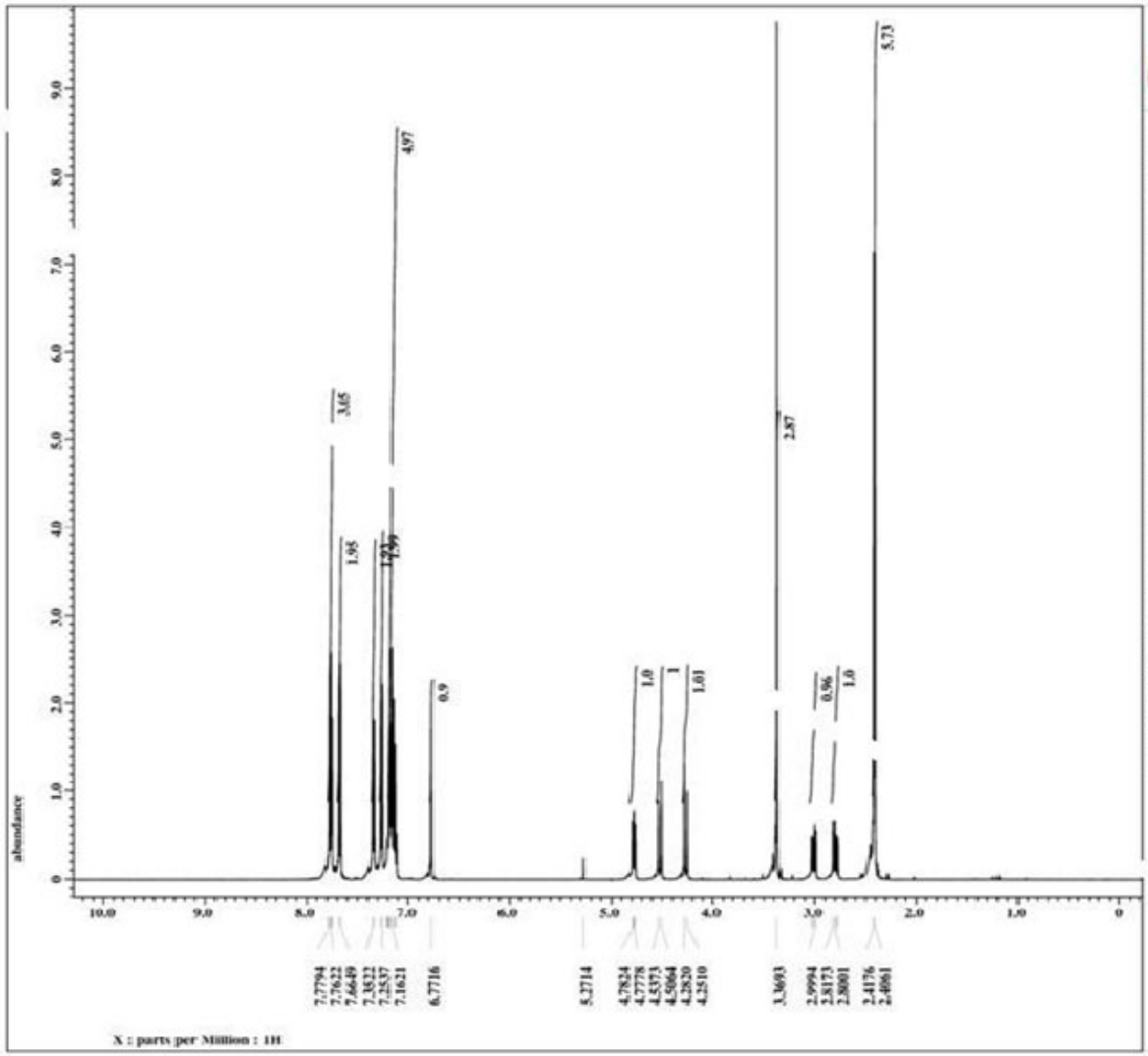
X_domain	= 13C
X_freq	= 75.56823426[MHz]
X_offset	= 100[ppm]
X_points	= 65536
X_prescans	= 4
X_resolution	= 0.36124027[Hz]
X_sweep	= 23.67424242[kHz]
Irr_domain	= 1H
Irr_freq	= 300.52965592[MHz]
Irr_offset	= 5[ppm]
Clipped	= FALSE
Mod_return	= 10
Scans	= 5440
Total_scans	= 5440
X_90_width	= 9.75[us]
X_acq_time	= 2.76824064[s]
X_angle	= 30[deg]
X_atn	= 8[dB]
X_pulse	= 3.25[us]
Irr_atn_dec	= 25[dB]
Irr_atn_noe	= 25[dB]
Irr_noise	= WALTZ
Decoupling	= TRUE
Initial_wait	= 1[s]
Noe	= TRUE
Noe_time	= 4[s]
Recvr_gain	= 50
Relaxation_delay	= 4[s]
Repetition_time	= 6.76824064[s]
Temp_get	= 23.4[dC]





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Author = delta
Experiment = single_pulse.ex2
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Solvent = CHLOROFORM-D
Creation_time = 29-MAR-2013 04:15:31
Revision_time = 16-JUL-2013 14:40:17
Current_time = 16-JUL-2013 14:40:34

Comment = single_pulse
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Dim_title = 1H
Dim_units = [ppm]
Dimensions = X
Site = ECA 500
Spectrometer = JNM-ECA500

Field_strength = 11.7473579[T] (500[MH
X_acq_duration = 1.74587904[s]
X_domain = 1H
X_freq = 500.1599152[MHz]
X_offset = 5.0[ppm]
X_points = 16384
X_prescans = 0
X_resolution = 0.57277737[Hz]
X_sweep = 9.38438438[kHz]
Irr_domain = 1H
Irr_freq = 500.1599152[MHz]
Irr_offset = 5.0[ppm]
Tri_domain = 1H
Tri_freq = 500.1599152[MHz]
Tri_offset = 5.0[ppm]
Clipped = FALSE
Mod_return = 1
Scans = 3
Total_scans = 3

X_90_width = 12.54[us]
X_acq_time = 1.74587904[s]
X_angle = 45[deg]
X_atn = 4[dB]
X_pulse = 6.27[us]
Irr_mode = Off
Tri_mode = Off
Dante_presat = FALSE
Initial_wait = 1[s]
Recvr_gain = 30
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Repetition_time = 6.74587904[s]
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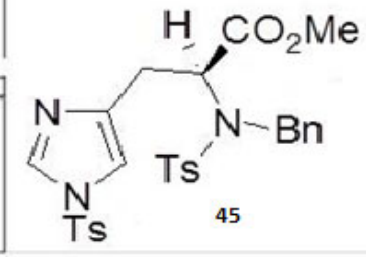
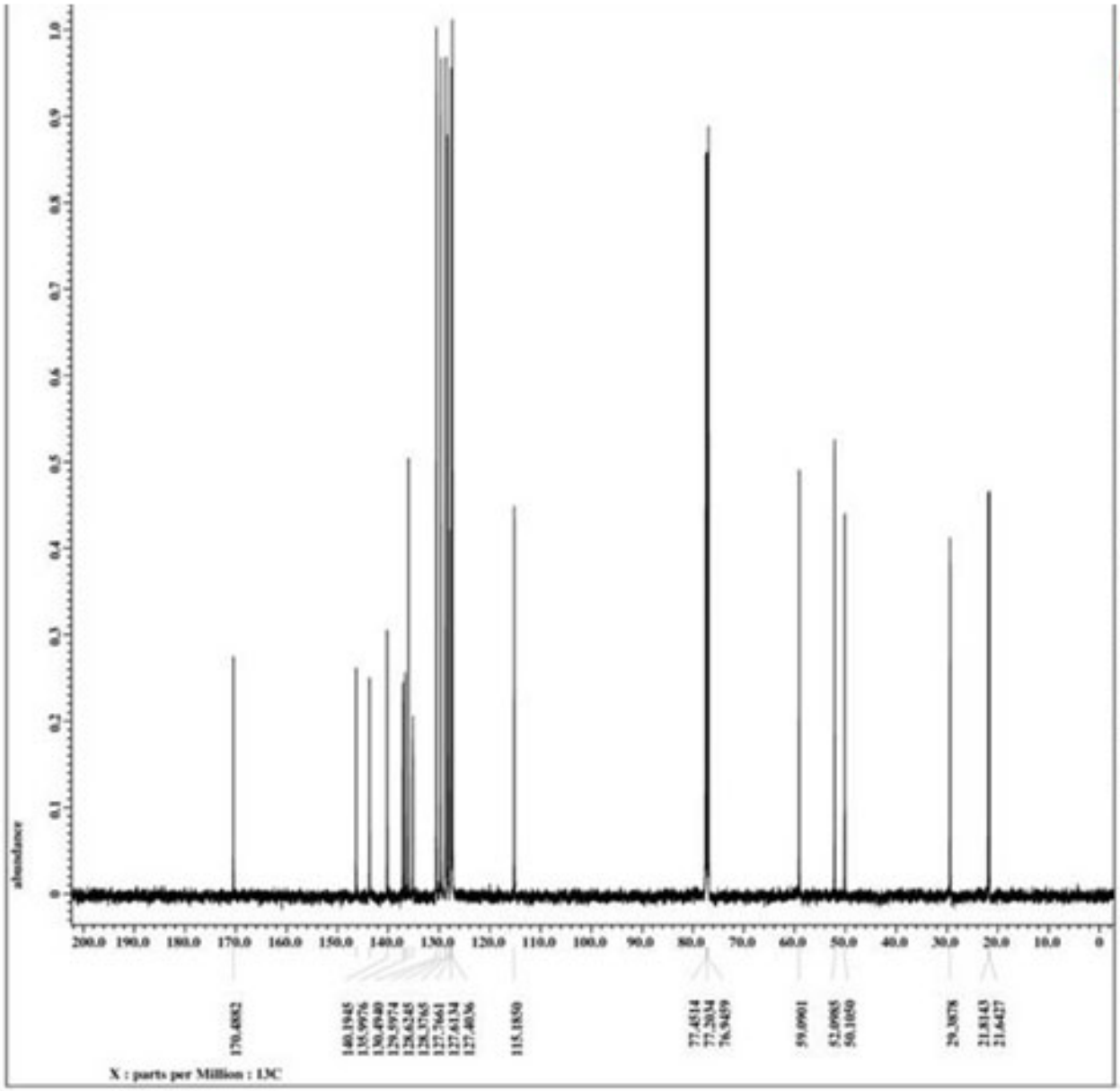
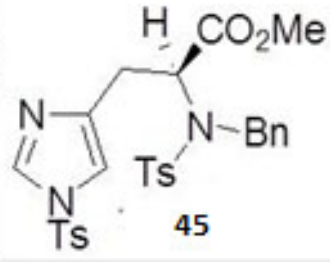


45

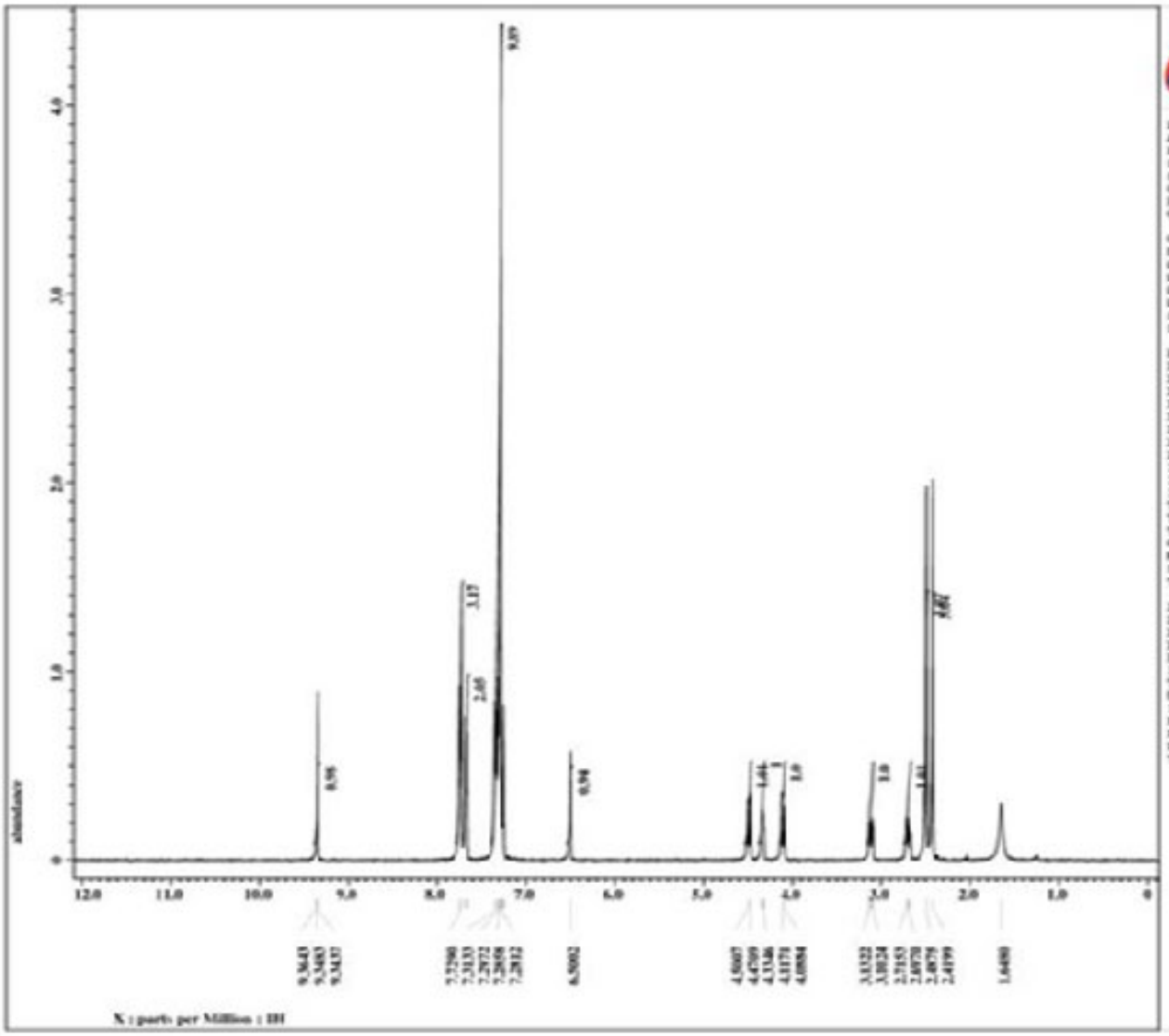


JEOL

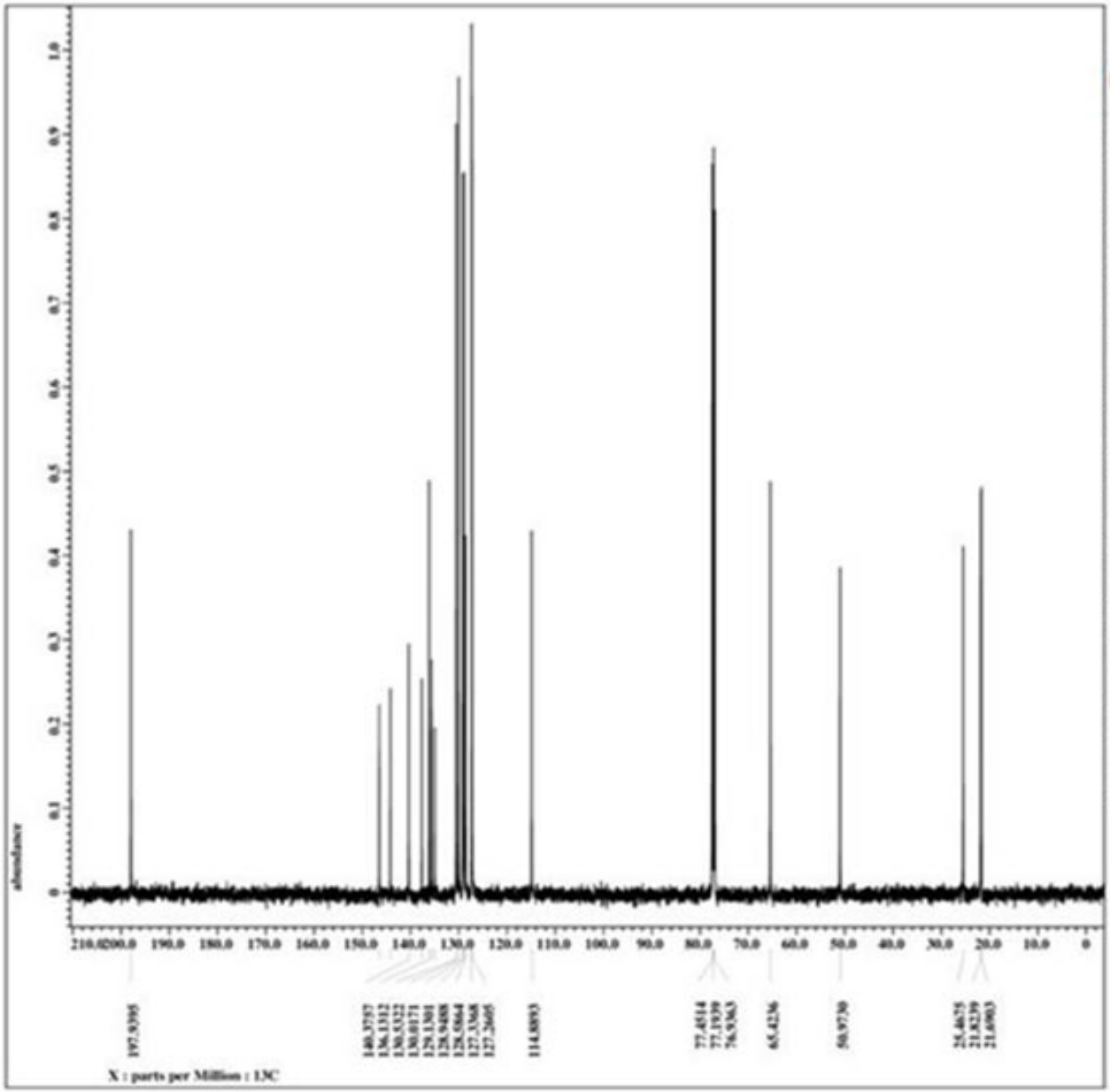
```
Filename          = IV-maf-methylester 13
Author            = delta
Experiment        = single_pulse_dec
Sample_id         = S#533659
Solvent           = CHLOROFORM-D
Creation_time     = 29-MAR-2013 04:25:58
Revision_time     = 25-JUN-2013 13:20:02
Current_time      = 25-JUN-2013 13:20:25

Comment           = single pulse decouple
Data_format       = 1D COMPLEX
Dim_size          = 26214
Dim_title         = 13C
Dim_units         = [ppm]
Dimensions        = X
Site              = RCA 500
Spectrometer      = JNM-ECA500

Field_strength    = 11.7473579[T]  (500[MH
X_acq_duration    = 0.83361792[s]
X_domain          = 13C
X_freq            = 125.76529768[MHz]
X_offset          = 100[ppm]
X_points          = 32768
X_prescans        = 4
X_resolution      = 1.19959034[Hz]
X_sweep           = 39.3081761[kHz]
Irr_domain        = 1H
Irr_freq          = 500.15991521[MHz]
Irr_offset        = 5.0[ppm]
Clipped           = FALSE
Mod_return        = 10
Scans             = 206
Total_scans       = 206

X_90_width        = 10.73[us]
X_acq_time        = 0.83361792[s]
X_angle           = 30[deg]
X_atn             = 9[dB]
X_pulse           = 3.57666667[us]
Irr_atn_dec       = 20[dB]
Irr_atn_noe       = 20[dB]
Irr_noise         = WALTZ
Decoupling        = TRUE
Initial_wait      = 1[s]
Noe               = TRUE
Noe_time          = 2[s]
Recvr_gain        = 50
Relaxation_delay  = 2[s]
Repetition_time   = 2.83361792[s]
Temp_get          = 21.5[dC]
```



45

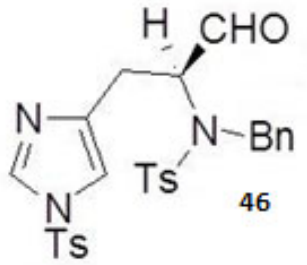

9.59
3.17
2.60
8.95
8.94
3.01
3.00
1.61
1.61
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
intensity
N : parts per Million : 1H


JEOL
Filename = 1V-maf-aldehyde-2.jdf
Author = delta
Experiment = single_pulse.exp
Sample_id = 08513585
Solvent = CHLOROFORM-D
Creation_time = 18-JUL-2013 03:39:20
Revision_time = 16-JUL-2013 23:16:19
Current_time = 16-JUL-2013 23:16:43
Comment = single_pulse
Data_format = 1D COMPLEX
Dim_size = 131072
Dim_title = 1H
Dim_units = [ppm]
Dimensions = X
Site = RCA 500
Spectrometer = JNM-ECA500
Field_strength = 11.7473179[T] (500[MH
X_acq_duration = 1.74587904[s]
X_domain = 1H
X_freq = 500.15991521[MHz]
X_offset = 5.0[ppm]
X_points = 16384
X_prescans = 0
X_resolution = 0.57277727[Hz]
X_sweep = 9.38438438[kHz]
Irr_domain = 1H
Irr_freq = 500.15991521[MHz]
Irr_offset = 5.0[ppm]
Trk_domain = 1H
Trk_freq = 500.15991521[MHz]
Trk_offset = 5.0[ppm]
Clipped = FALSE
Mod_return = 1
Scans = 8
Total_scans = 8
X_90_width = 12.54[us]
X_acq_time = 1.74587904[s]
X_angle = 45[deg]
X_atn = 4[dB]
X_pulse = 6.27[us]
Irr_mode = Off
Trk_mode = Off
Dante_preset = FALSE
Initial_wait = 1[s]
Recvr_gain = 44
Relaxation_delay = 5[s]
Repetition_time = 6.74587904[s]
Temp_get = 23.1[dC]
H
CHO
N
N
Bn
Ts
N
Ts
46

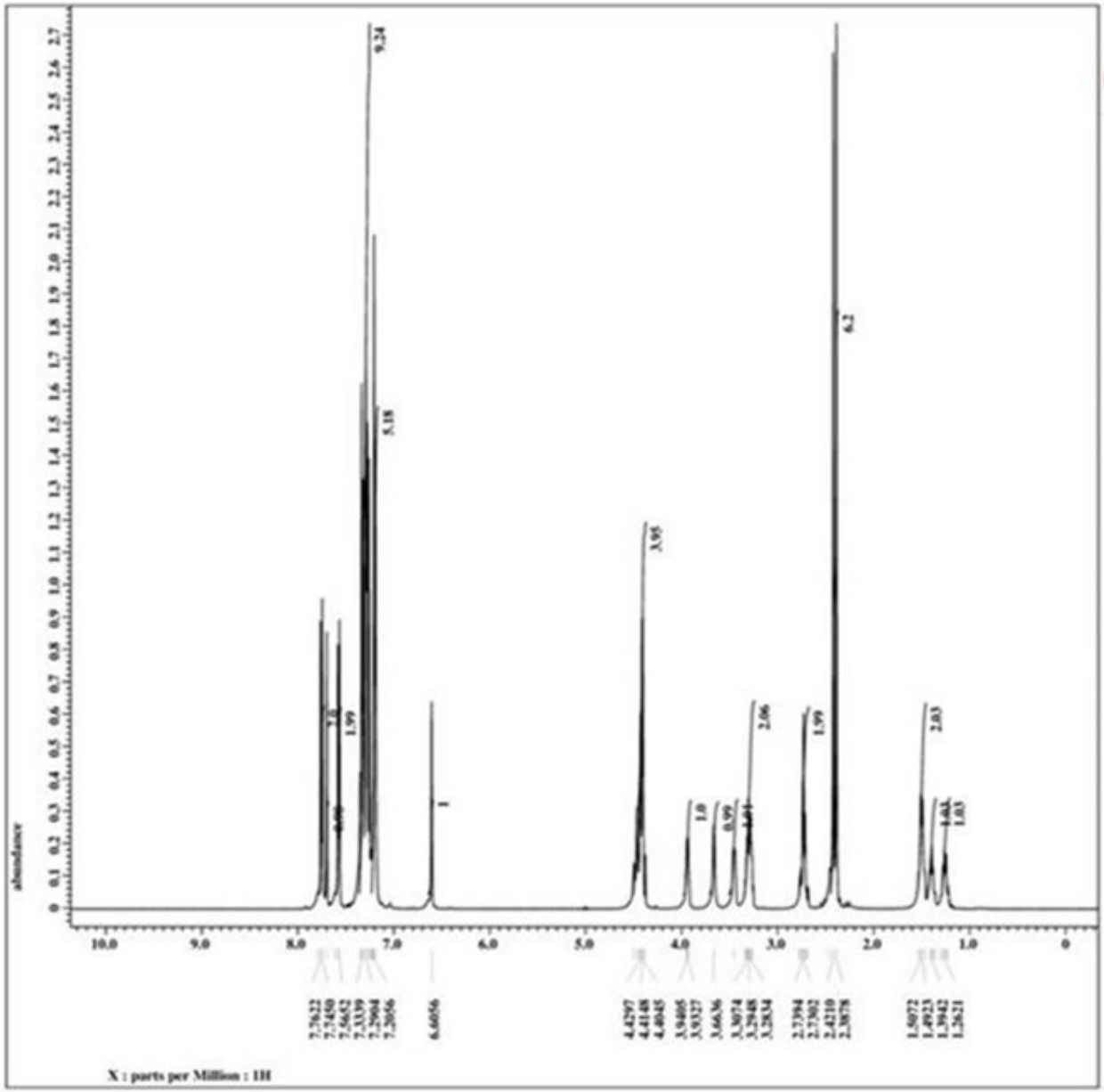


JEOL

Filename	= IV-naf-aldehyde 13CNM
Author	= delta
Experiment	= single_pulse_dec
Sample_id	= S#542548
Solvent	= CHLOROFORM-D
Creation_time	= 29-MAR-2013 04:37:09
Revision_time	= 30-JUN-2013 08:11:57
Current_time	= 30-JUN-2013 08:13:00
Comment	= single pulse decouple
Data_format	= 1D COMPLEX
Dim_size	= 26214
Dim_title	= 13C
Dim_units	= [ppm]
Dimensions	= X
Site	= ECA 500
Spectrometer	= JNM-ECA500
Field_strength	= 11.7473579[T] (500[MH
X_acq_duration	= 0.83361792[s]
X_domain	= 13C
X_freq	= 125.76529768[MHz]
X_offset	= 100[ppm]
X_points	= 32768
X_prescans	= 4
X_resolution	= 1.19959034[Hz]
X_sweep	= 39.3081761[kHz]
Irr_domain	= 1H
Irr_freq	= 500.15991521[MHz]
Irr_offset	= 5.0[ppm]
Clipped	= FALSE
Mod_return	= 10
Scans	= 130
Total_scans	= 130
X_90_width	= 10.73[us]
X_acq_time	= 0.83361792[s]
X_angle	= 30[deg]
X_atn	= 9[dB]
X_pulse	= 3.57666667[us]
Irr_atn_dec	= 20[dB]
Irr_atn_noe	= 20[dB]
Irr_noise	= WALTZ
Decoupling	= TRUE
Initial_wait	= 1[s]
Noe	= TRUE
Noe_time	= 2[s]
Recvr_gain	= 50
Relaxation_delay	= 2[s]
Repetition_time	= 2.83361792[s]
Temp_get	= 21.5[dC]

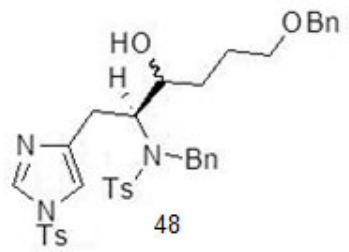


46

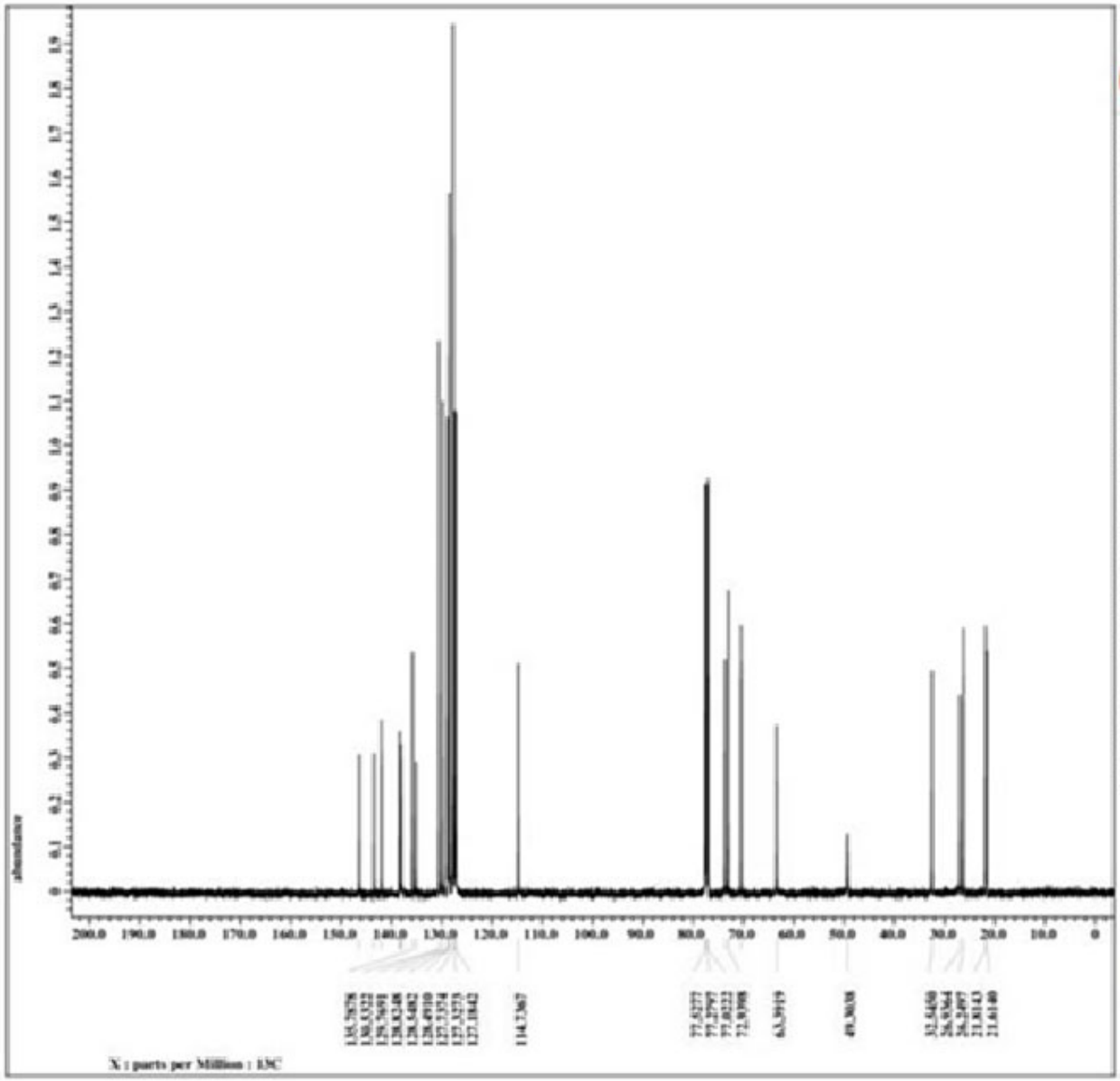


JEOL

```
Filename            = IV-maf-secondary alco
Author              = delta
Experiment          = single_pulse.ex2
Sample_id           = S8582043
Solvent             = CHLOROFORM-D
Creation_time       =  6-AUG-2013 05:23:42
Revision_time       =  6-AUG-2013 11:52:23
Current_time        =  6-AUG-2013 11:53:05

Comment             = single_pulse
Data_format         = 1D COMPLEX
Dim_size            = 13107
Dim_title           = 1H
Dim_units           = [ppm]
Dimensions          = X
Site                = ECA 500
Spectrometer        = JNM-ECA500

Field_strength      = 11.7473579[T]  (500[MH
X_acq_duration      = 1.74587904[s]
X_domain            = 1H
X_freq              = 500.15991521[MHz]
X_offset            = 5.0[ppm]
X_points            = 16384
X_prescans          = 0
X_resolution        = 0.57277737[Hz]
X_sweep             = 9.38438438[kHz]
Irr_domain          = 1H
Irr_freq            = 500.15991521[MHz]
Irr_offset          = 5.0[ppm]
Tri_domain          = 1H
Tri_freq            = 500.15991521[MHz]
Tri_offset          = 5.0[ppm]
Clipped             = FALSE
Mod_return          = 1
Scans               = 6
Total_scans         = 6

X_90_width          = 12.54[us]
X_acq_time          = 1.74587904[s]
X_angle             = 45[deg]
X_atn               = 4[dB]
X_pulse             = 6.27[us]
Irr_mode            = Off
Tri_mode            = Off
Dante_presat        = FALSE
Initial_wait        = 1[s]
Recvr_gain          = 22
Relaxation_delay    = 5[s]
Repetition_time     = 6.74587904[s]
Temp_get            = 21.8[dC]
```

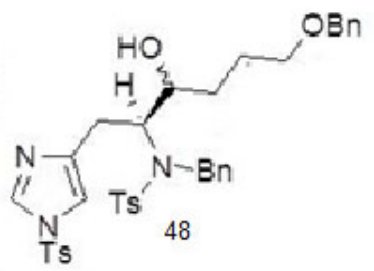


48

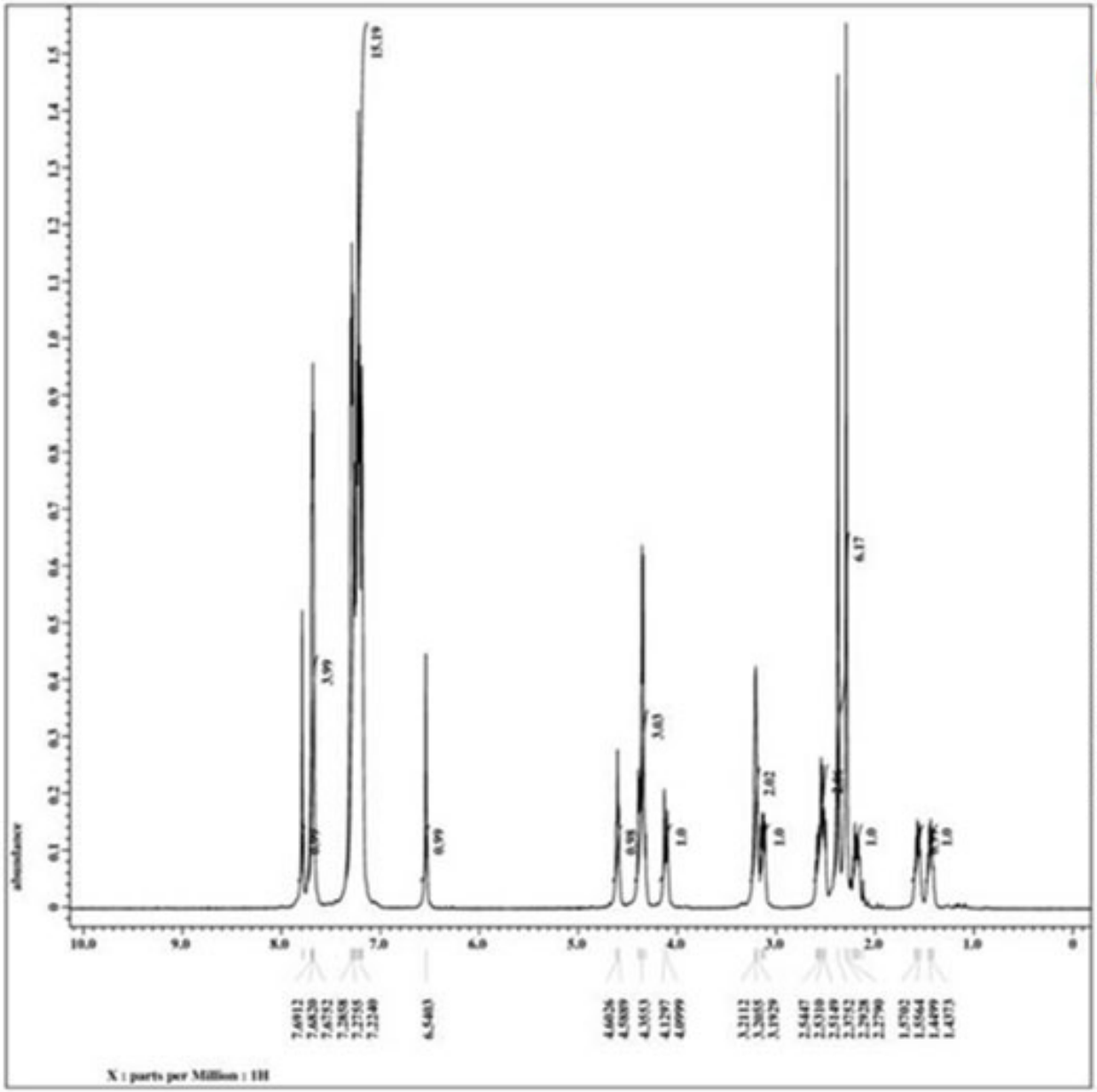


JEOL

Filename	= IV-maf-secondary alco
Author	= delta
Experiment	= single_pulse_dec
Sample_id	= 88582909
Solvent	= CHLOROFORM-D
Creation_time	= 6-AUG-2013 05:32:55
Revision_time	= 6-AUG-2013 11:54:32
Current_time	= 6-AUG-2013 11:58:45
Comment	= single pulse decouple
Data_format	= 1D COMPLEX
Dim_size	= 262114
Dim_title	= 13C
Dim_units	= [ppm]
Dimensions	= X
Site	= ECA 500
Spectrometer	= JNM-ECA500
Field_strength	= 11.7473579[T] (500[MH
X_acq_duration	= 0.83361792[s]
X_domain	= 13C
X_freq	= 125.76529768[MHz]
X_offset	= 100[ppm]
X_points	= 32768
X_prescans	= 4
X_resolution	= 1.19959034[Hz]
X_sweep	= 39.3081745[kHz]
Irr_domain	= 1H
Irr_freq	= 500.15991521[MHz]
Irr_offset	= 5.0[ppm]
Clipped	= FALSE
Mod_return	= 10
Scans	= 190
Total_scans	= 190
X_90_width	= 10.73[us]
X_acq_time	= 0.83361792[s]
X_angle	= 30[deg]
X_atn	= 9[dB]
X_pulse	= 3.57444447[us]
Irr_atn_dec	= 20[dB]
Irr_atn_noe	= 20[dB]
Irr_noise	= WALTZ
Decoupling	= TRUE
Initial_wait	= 1[s]
Noe	= TRUE
Noe_time	= 2[s]
Recvr_gain	= 50
Relaxation_delay	= 2[s]
Repetition_time	= 2.83361792[s]
Temp_get	= 22.3[dC]

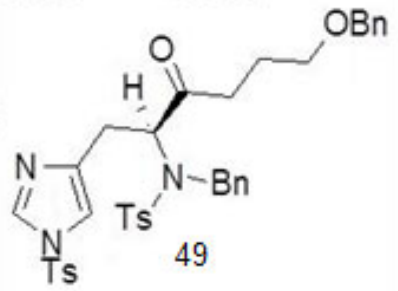


48

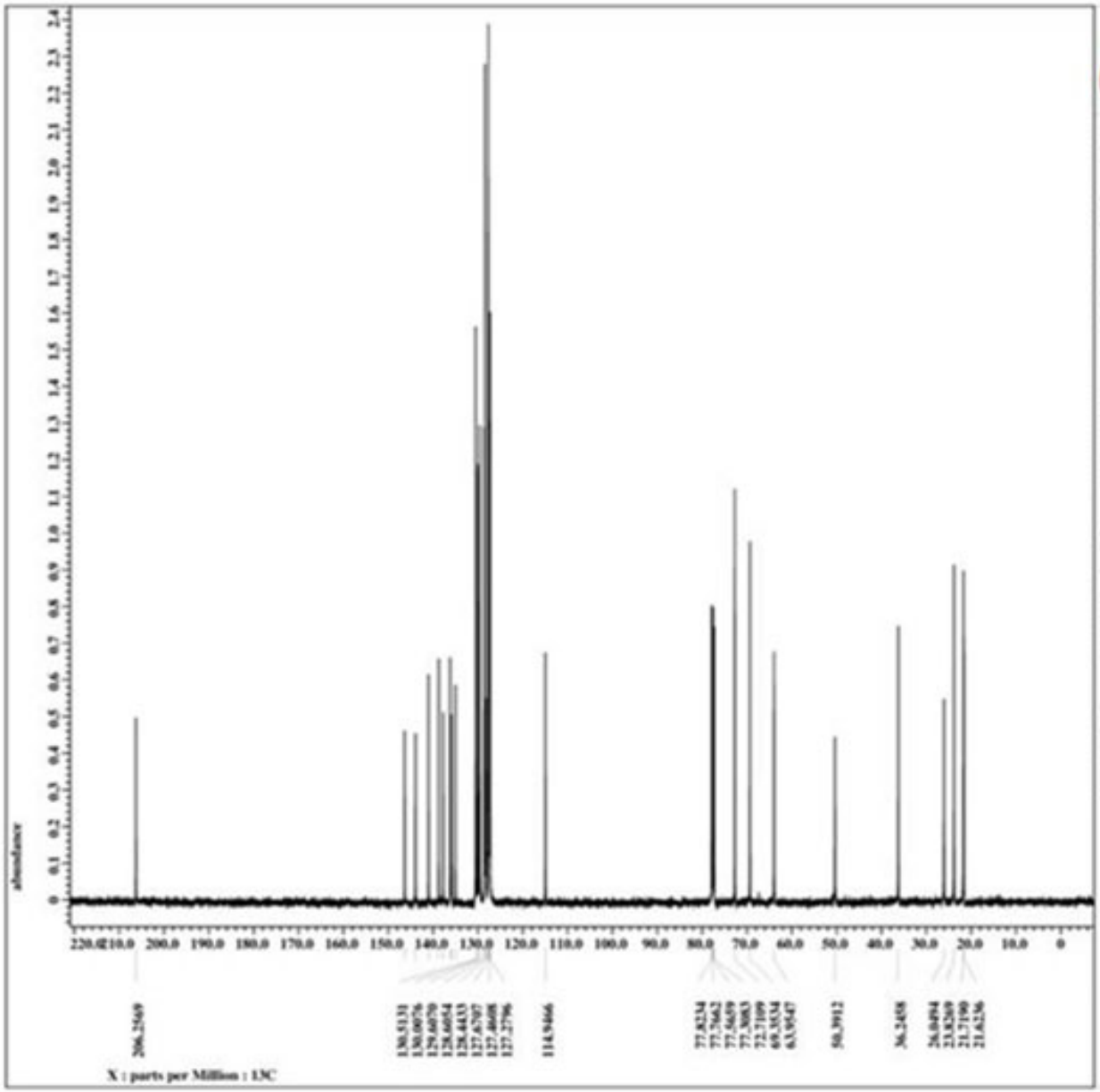


JEOL

```
Filename          = IV-maf-ketone-2.jdf
Author            = delta
Experiment        = single_pulse.exp
Sample_id         = S8397549
Solvent           = CHLOROFORM-D
Creation_time     =  8-AUG-2013 00:16:09
Revision_time     =  6-AUG-2013 12:12:08
Current_time      =  6-AUG-2013 12:12:28

Comment           = single_pulse
Data_format       = 1D COMPLEX
Dim_size          = 13107
Dim_title         = 1H
Dim_units         = [ppm]
Dimensions        = X
Site              = ECA 500
Spectrometer      = JNM-ECA500

Field_strength    = 11.7473579[T]  (500[MH
X_acq_duration    = 1.74587904[s]
X_domain          = 1H
X_freq            = 500.15991521[MHz]
X_offset          = 5.0[ppm]
X_points          = 16384
X_prescans        = 0
X_resolution      = 0.57277737[Hz]
X_sweep           = 9.38438438[kHz]
Irr_domain        = 1H
Irr_freq          = 500.15991521[MHz]
Irr_offset        = 5.0[ppm]
Tri_domain        = 1H
Tri_freq          = 500.15991521[MHz]
Tri_offset        = 5.0[ppm]
Clipped           = FALSE
Mod_return        = 1
Scans             = 5
Total_scans       = 5

X_90_width        = 12.54[us]
X_acq_time        = 1.74587904[s]
X_angle           = 45[deg]
X_atn             = 4[dB]
X_pulse           = 6.27[us]
Irr_mode          = Off
Tri_mode          = Off
Dante_presat      = FALSE
Initial_wait      = 1[s]
Recvr_gain        = 14
Relaxation_delay  = 5[s]
Repetition_time   = 6.74587904[s]
Temp_get          = 24.1[dC]
```

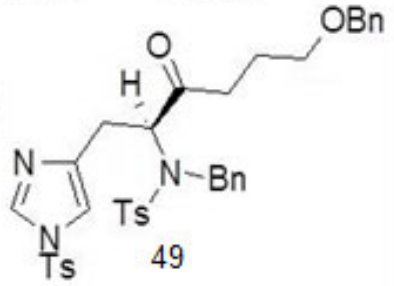


49

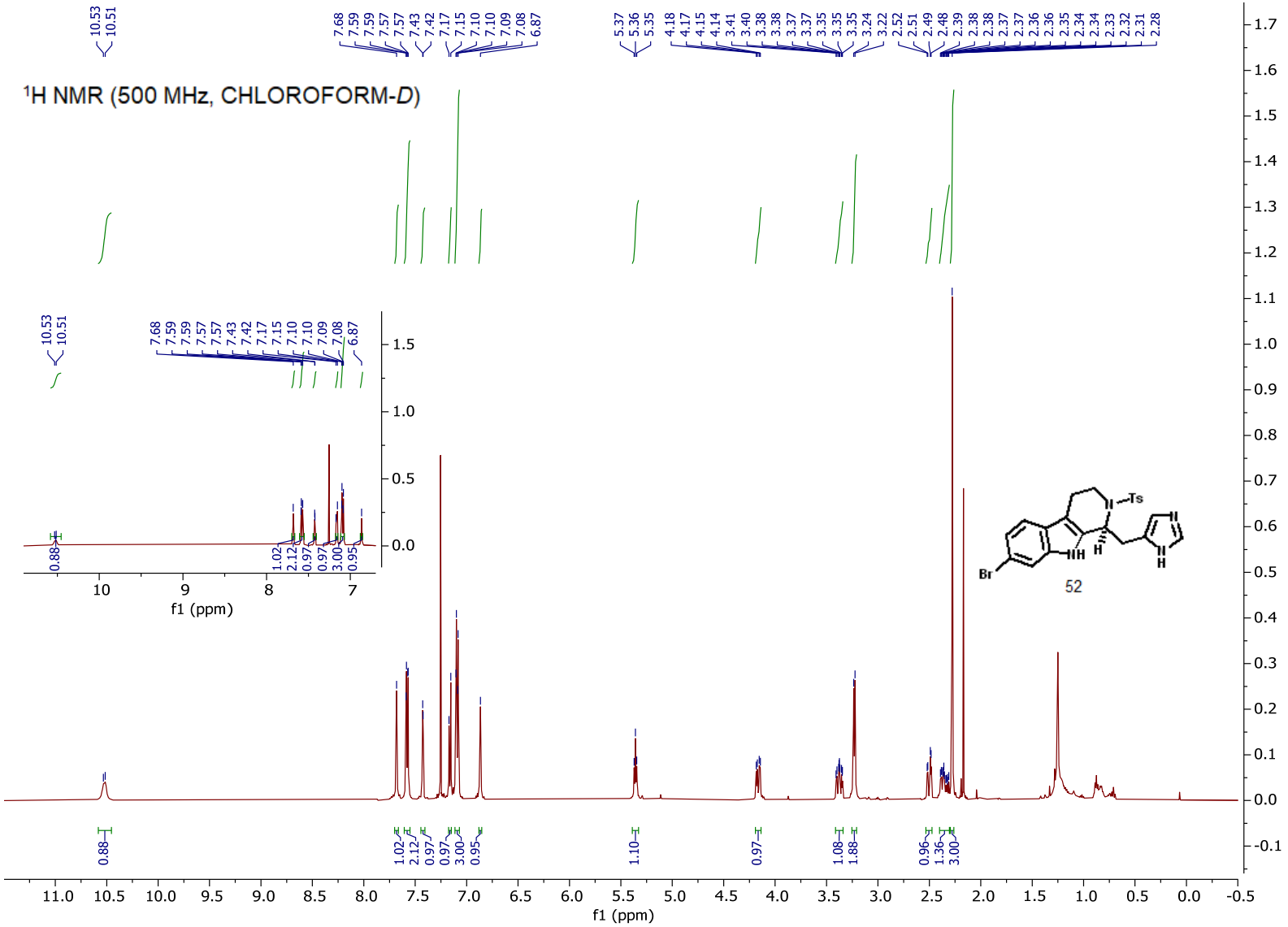


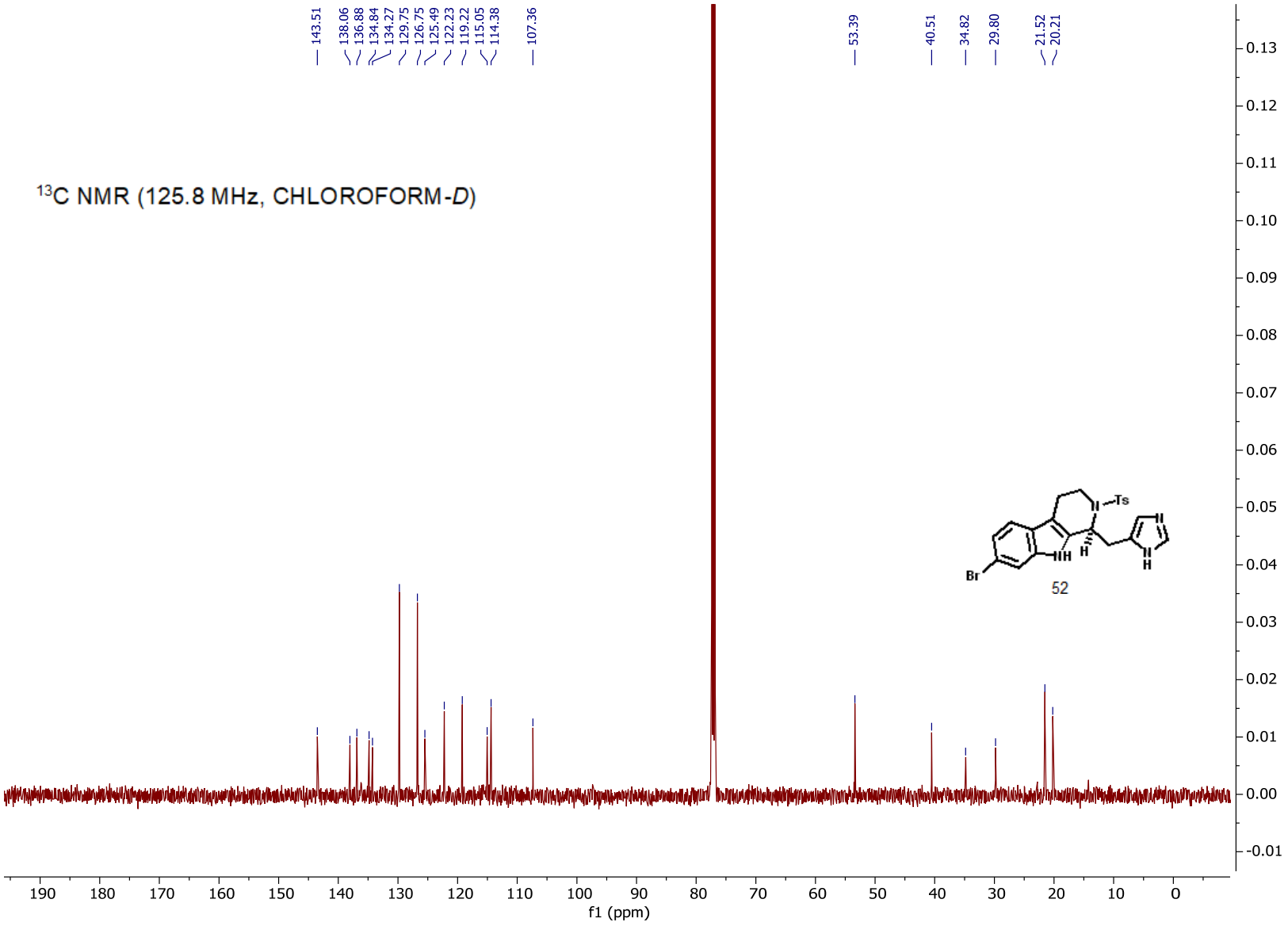
JEOL

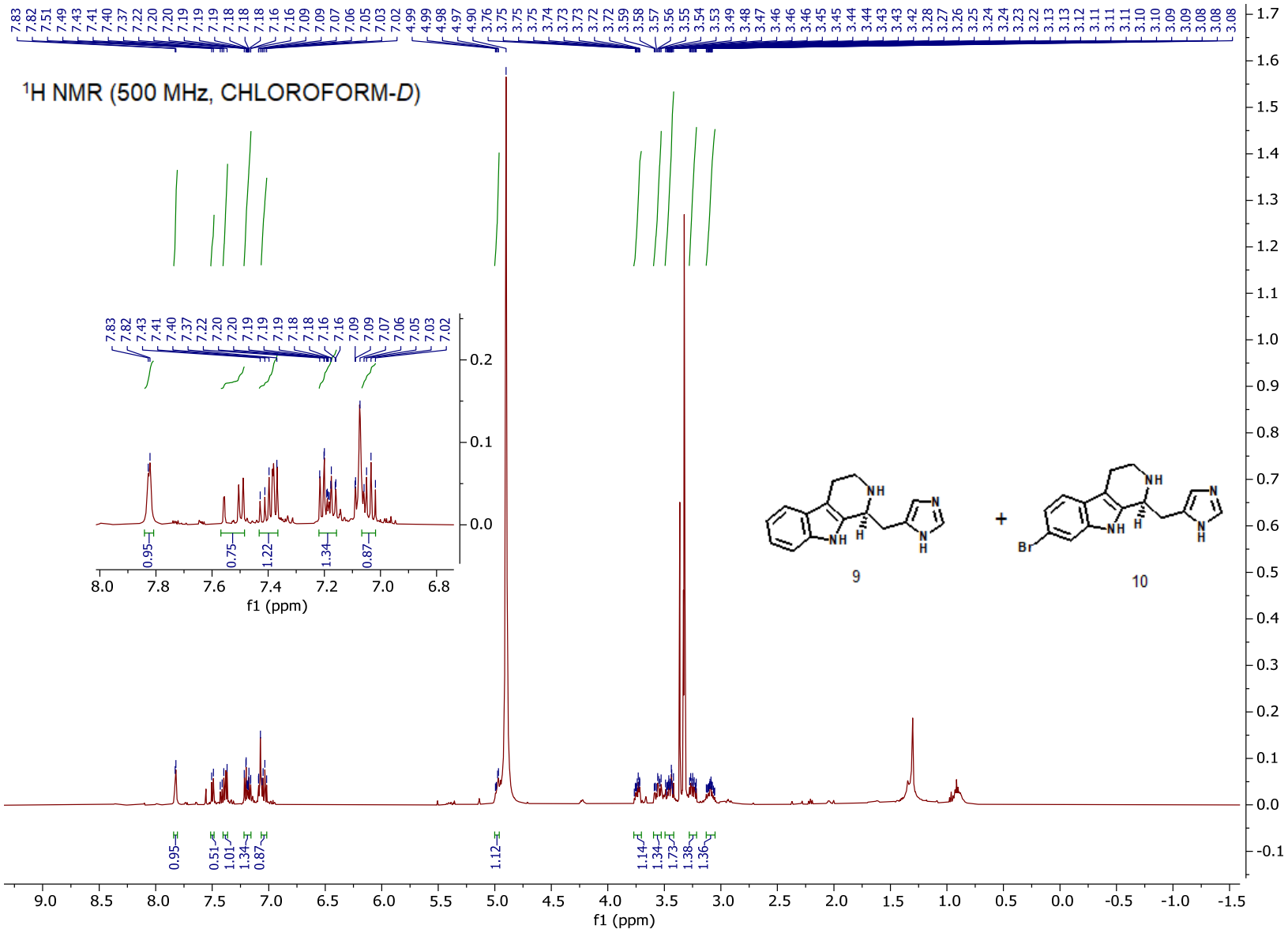
Filename	= IV-maf-ketone C13-2.j
Author	= delta
Experiment	= single_pulse_dec
Sample_id	= S#398367
Solvent	= CHLOROFORM-D
Creation_time	= 5-AUG-2013 00:23:27
Revision_time	= 6-AUG-2013 12:05:57
Current_time	= 6-AUG-2013 12:06:11
Comment	= single pulse decouple
Data_format	= 1D COMPLEX
Dim_size	= 26214
Dim_title	= 13C
Dim_units	= [ppm]
Dimensions	= X
Site	= ECA 500
Spectrometer	= JNM-ECA500
Field_strength	= 11.7473579[T] (500[MH
X_acq_duration	= 0.83361792[s]
X_domain	= 13C
X_freq	= 125.76529768[MHz]
X_offset	= 100[ppm]
X_points	= 32768
X_prescans	= 4
X_resolution	= 1.19959034[Hz]
X_sweep	= 39.3081761[kHz]
Irr_domain	= 1H
Irr_freq	= 500.15991521[MHz]
Irr_offset	= 5.0[ppm]
Clipped	= FALSE
Mod_return	= 10
Scans	= 150
Total_scans	= 150
X_90_width	= 10.73[us]
X_acq_time	= 0.83361792[s]
X_angle	= 30[deg]
X_atn	= 9[dB]
X_pulse	= 3.57666667[us]
Irr_atn_dec	= 20[dB]
Irr_atn_noe	= 20[dB]
Irr_noise	= WALTZ
Decoupling	= TRUE
Initial_wait	= 1[s]
Noe	= TRUE
Noe_time	= 2[s]
Recvr_gain	= 50
Relaxation_delay	= 2[s]
Repetition_time	= 2.83361792[s]
Temp_get	= 24.6[dC]

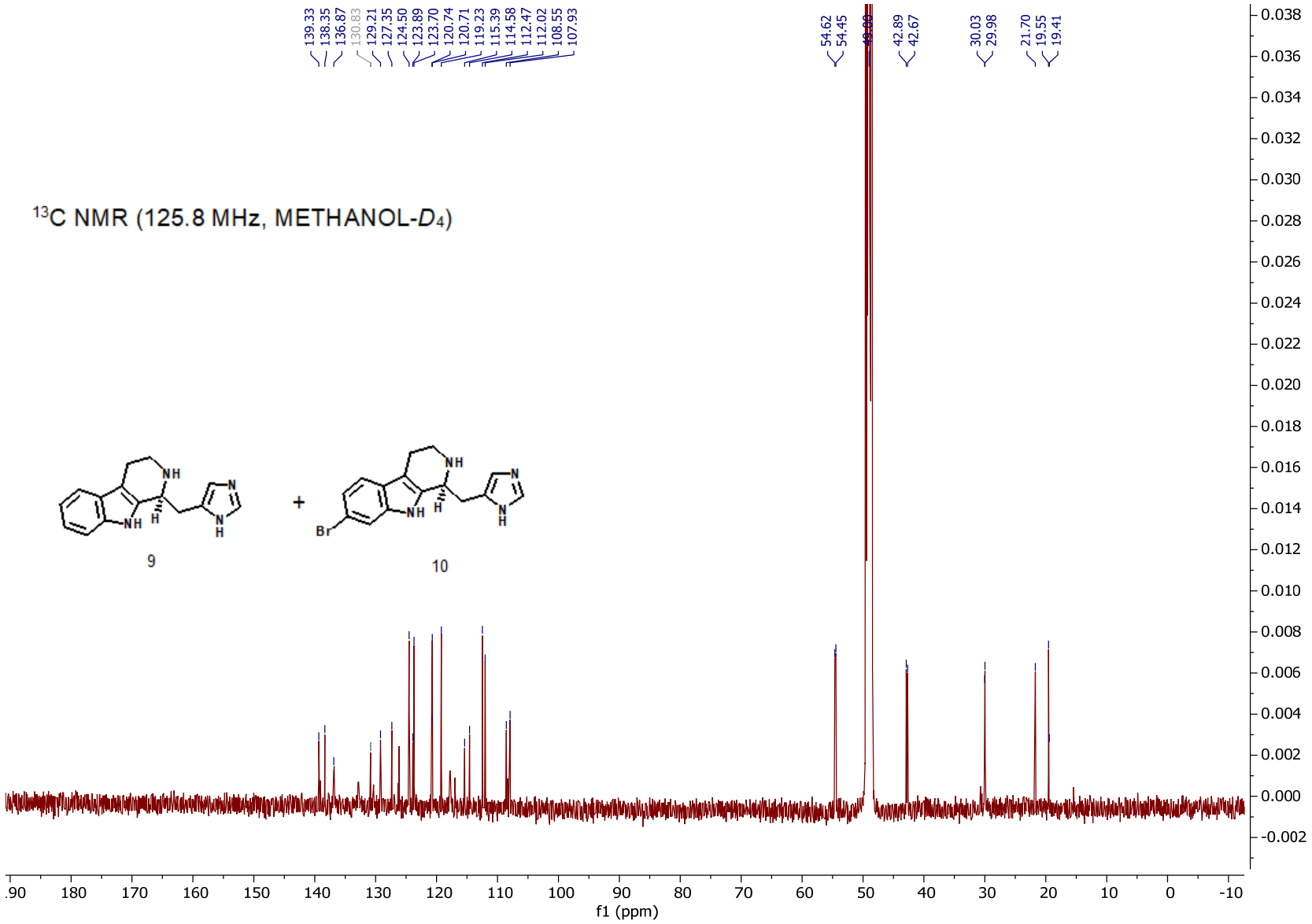


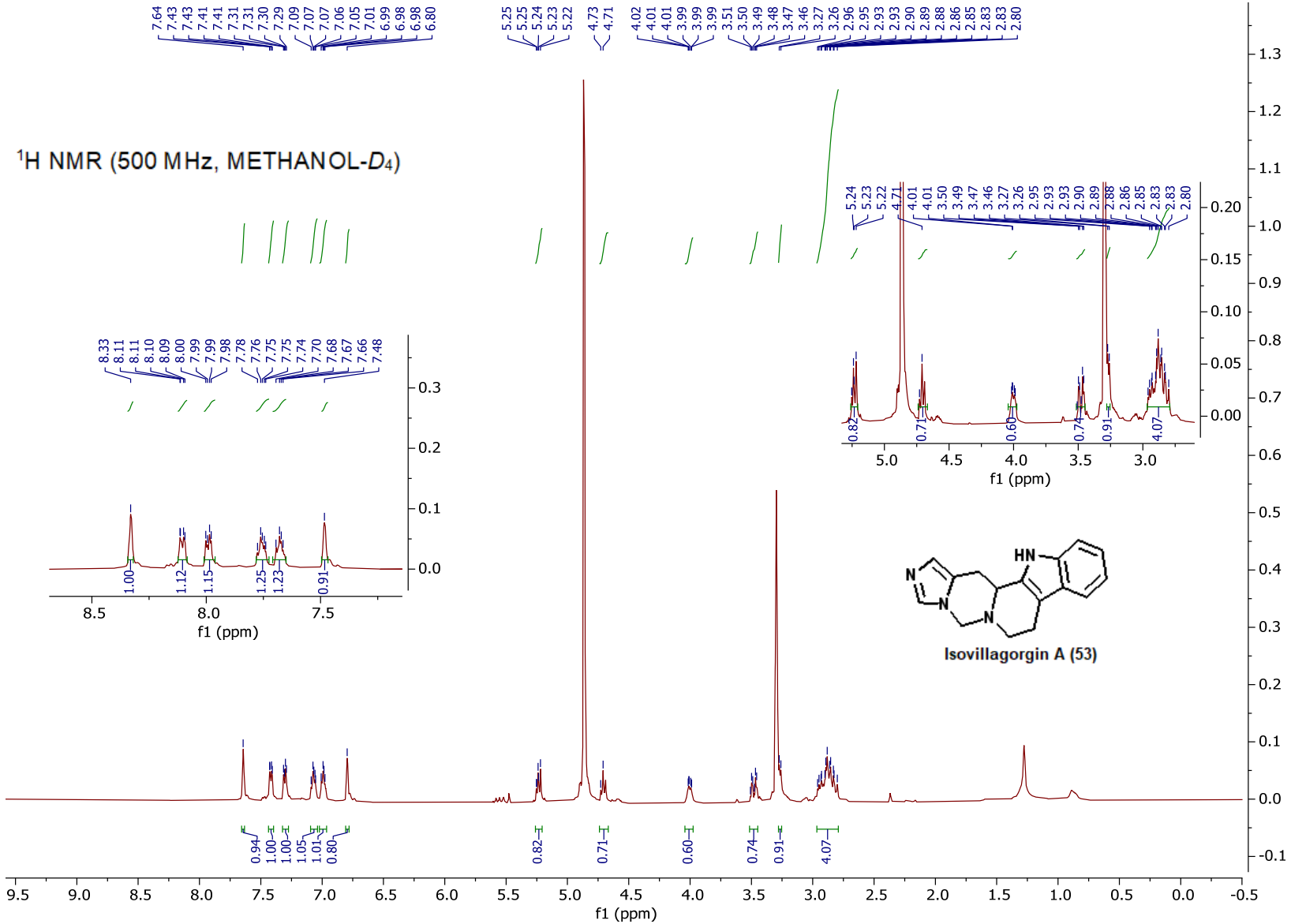
49

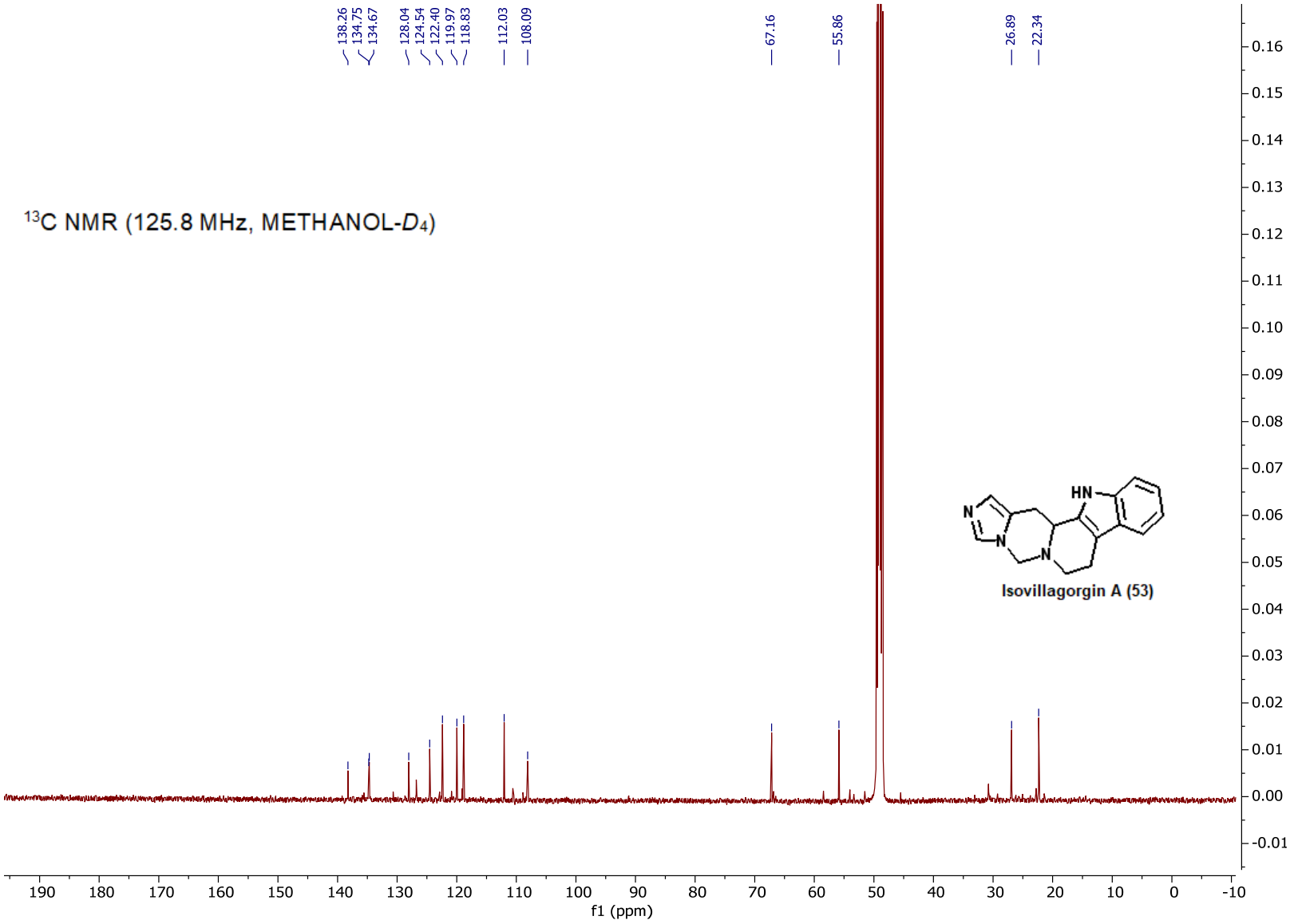

^{1}H NMR (500 MHz, CHLOROFORM-*D*)
10.53
10.51
7.68
7.59
7.59
7.57
7.57
7.43
7.42
7.17
7.15
7.10
7.10
7.09
7.08
6.87
5.37
5.36
5.35
4.18
4.17
4.15
4.14
3.41
3.40
3.38
3.38
3.37
3.37
3.35
3.35
3.35
3.24
3.22
2.52
2.51
2.49
2.48
2.39
2.38
2.38
2.37
2.37
2.36
2.36
2.35
2.34
2.34
2.33
2.32
2.31
2.28
0.88
1.02
2.12
0.97
0.97
3.00
0.95
1.10
0.97
1.08
1.88
0.96
1.36
3.00
f1 (ppm)
Ts
Br
NH
H
H
52

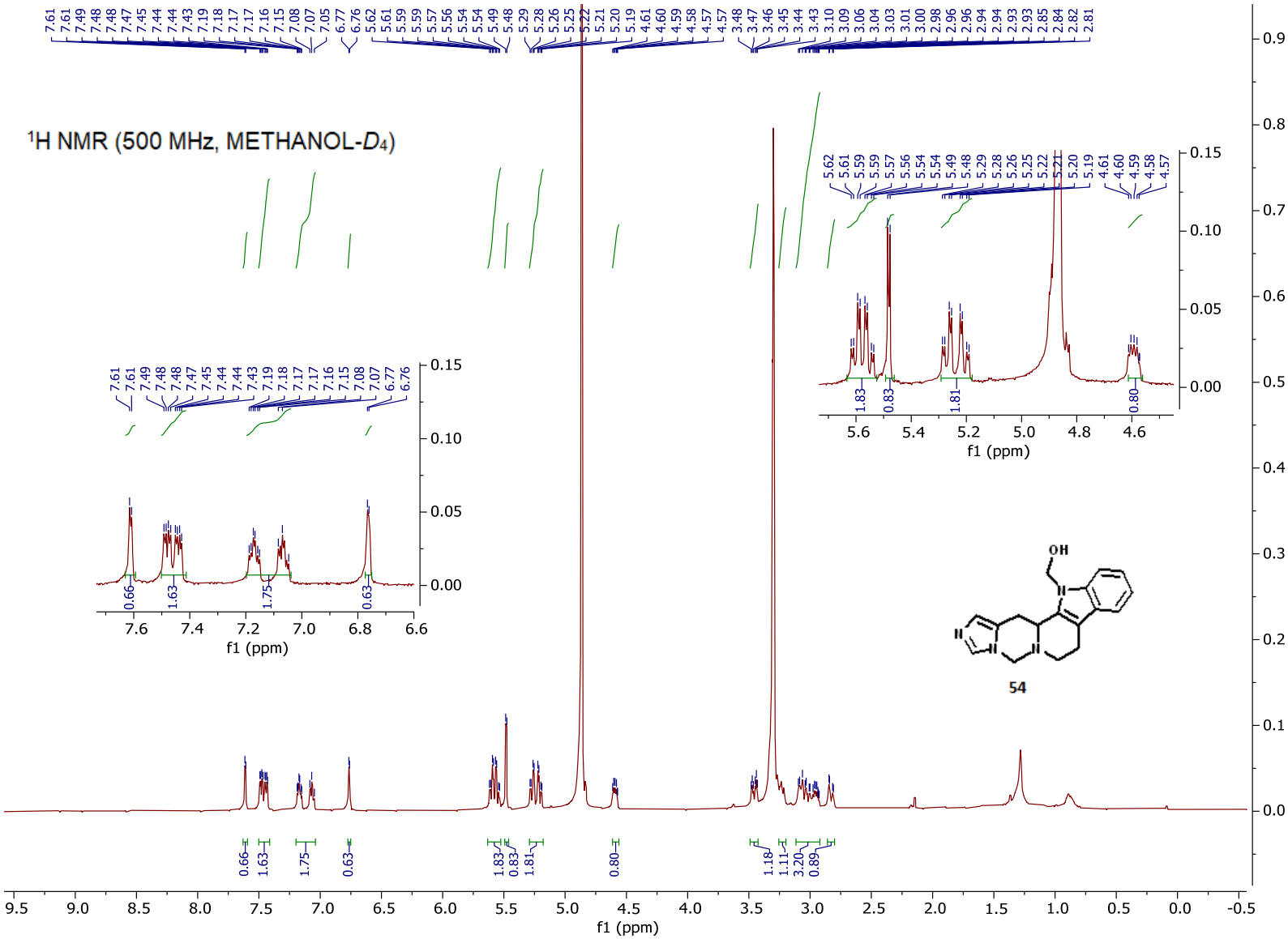

143.51
138.06
136.88
134.84
134.27
129.75
126.75
125.49
122.23
119.22
115.05
114.38
107.36
53.39
40.51
34.82
29.80
21.52
20.21
13C NMR (125.8 MHz, CHLOROFORM-D)
Ts
NH
H
H
Br
52
f1 (ppm)

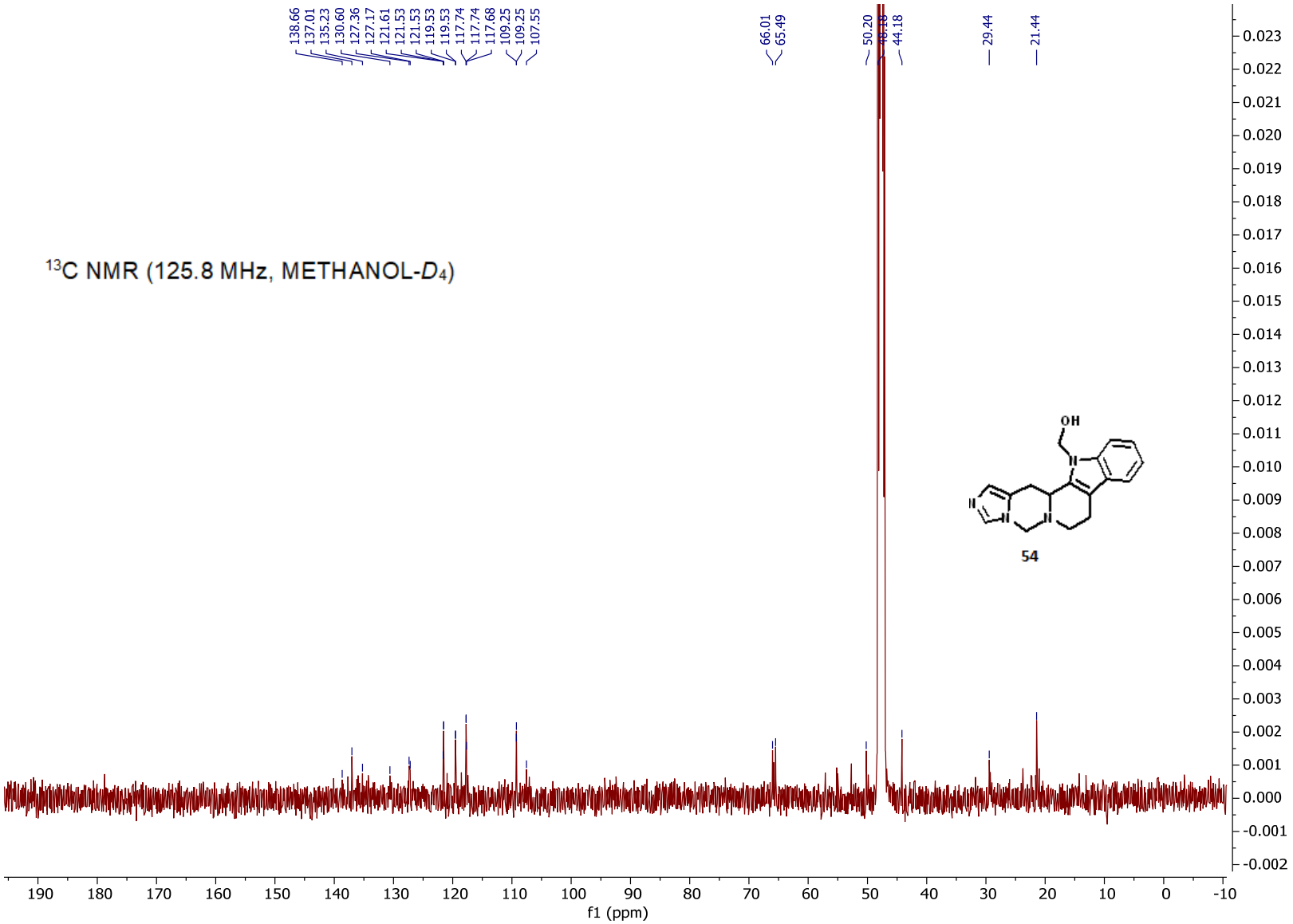

1H NMR (500 MHz, CHLOROFORM-D)
f1 (ppm)
9
10
Br

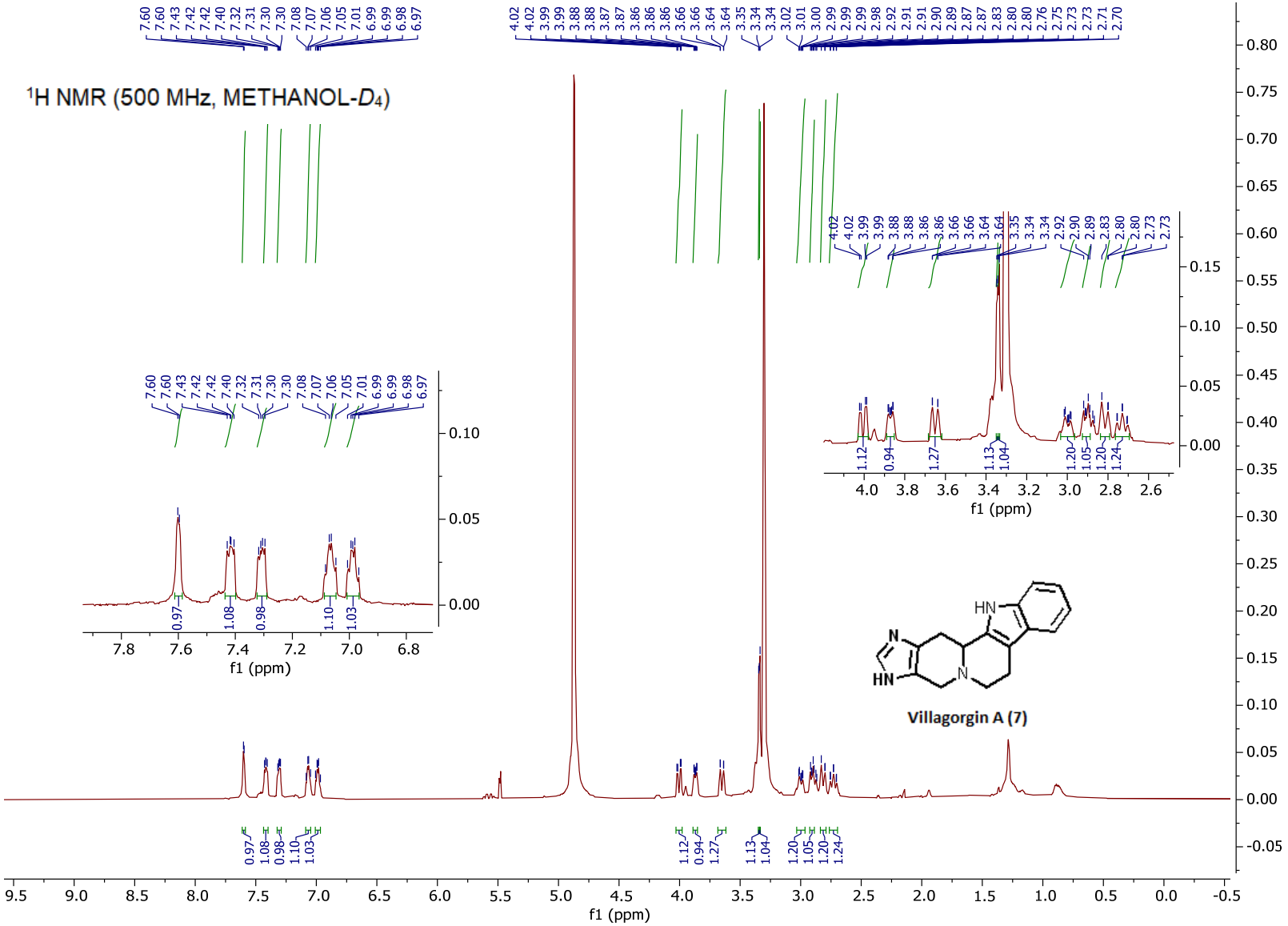

139.33
138.35
136.87
130.83
129.21
127.35
124.50
123.89
123.70
120.74
120.71
119.23
115.39
114.58
112.47
112.02
108.55
107.93
54.62
54.45
49.00
42.89
42.67
30.03
29.98
21.70
19.55
19.41
13C NMR (125.8 MHz, METHANOL-D4)
9
10
f1 (ppm)

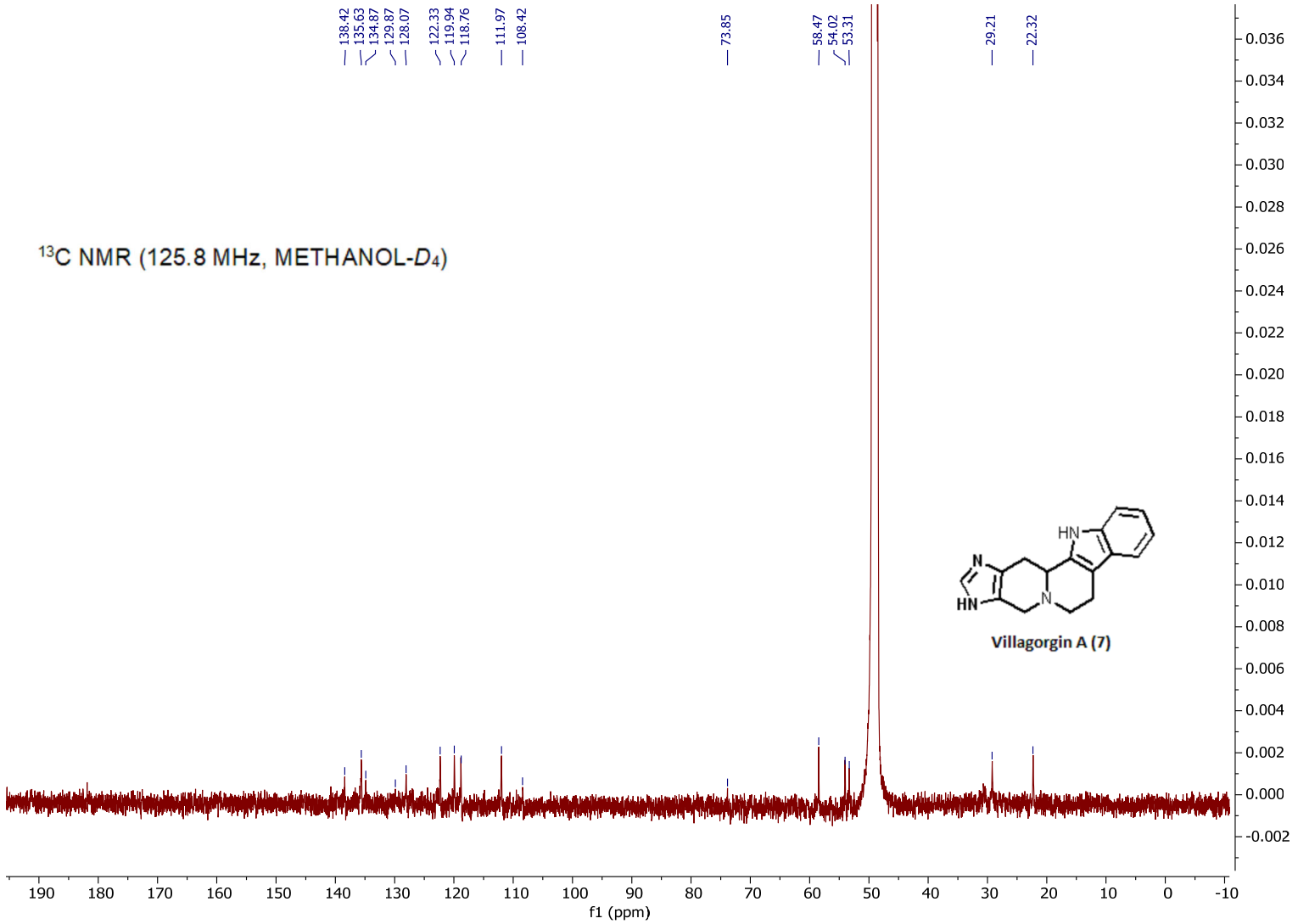

^{1}H NMR (500 MHz, METHANOL-D_4)
f1 (ppm)
Isovillagorgin A (53)

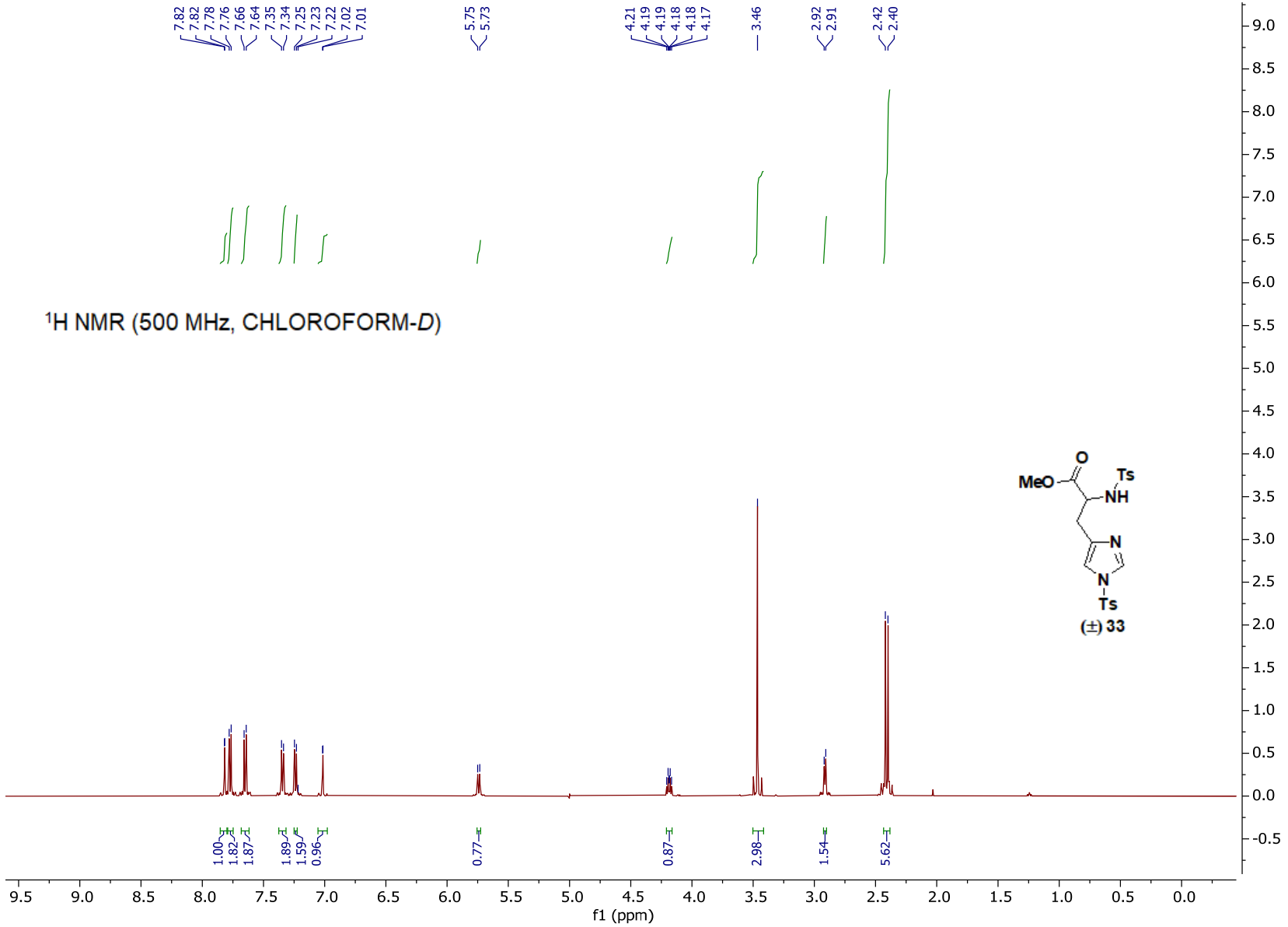

138.26
134.75
134.67
128.04
124.54
122.40
119.97
118.83
112.03
108.09
67.16
55.86
26.89
22.34
13C NMR (125.8 MHz, METHANOL-D4)
HN
N
N
N
Isovillagorgin A (53)
f1 (ppm)

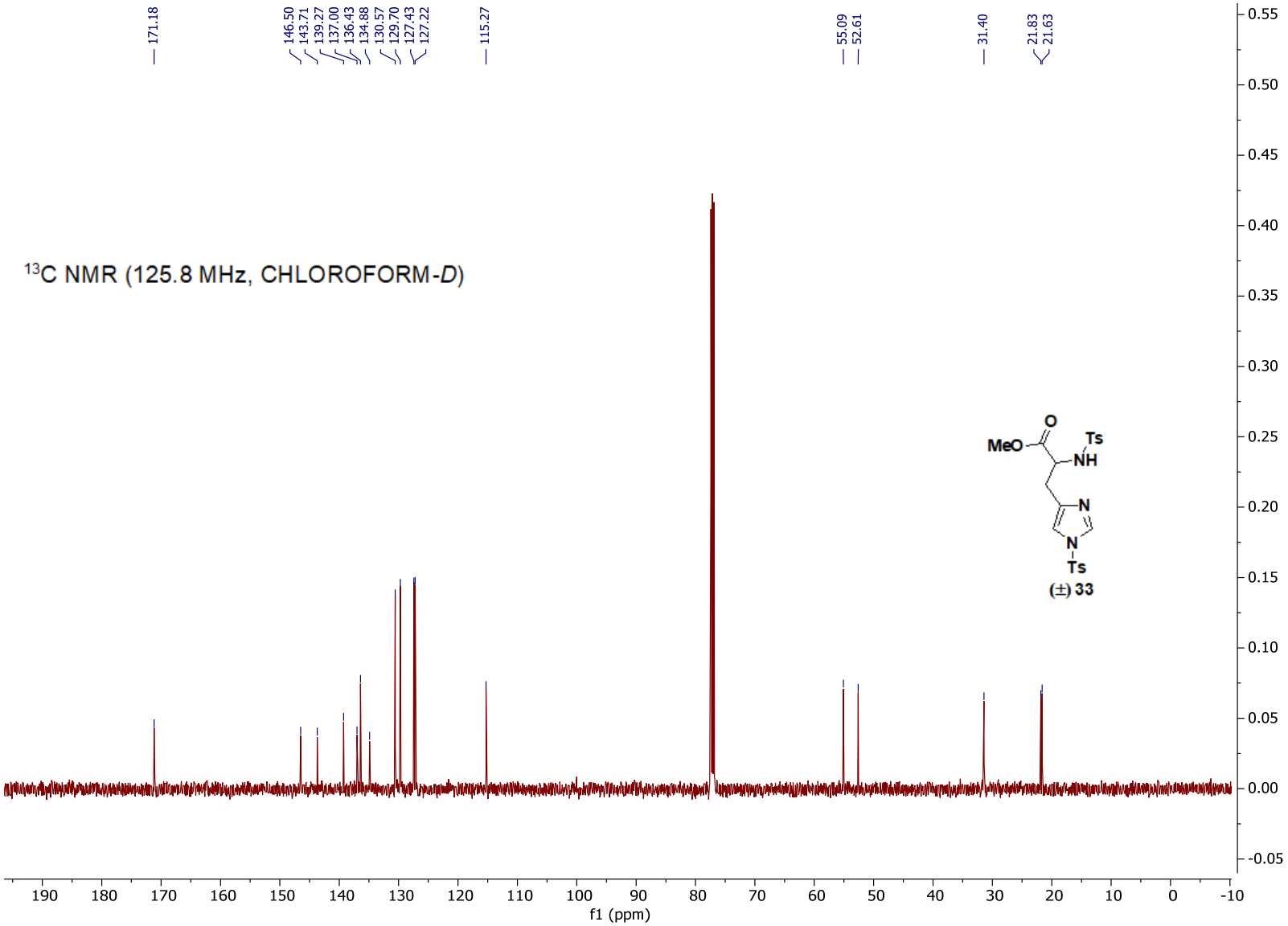

^{1}H NMR (500 MHz, METHANOL-D_4)
f1 (ppm)
54

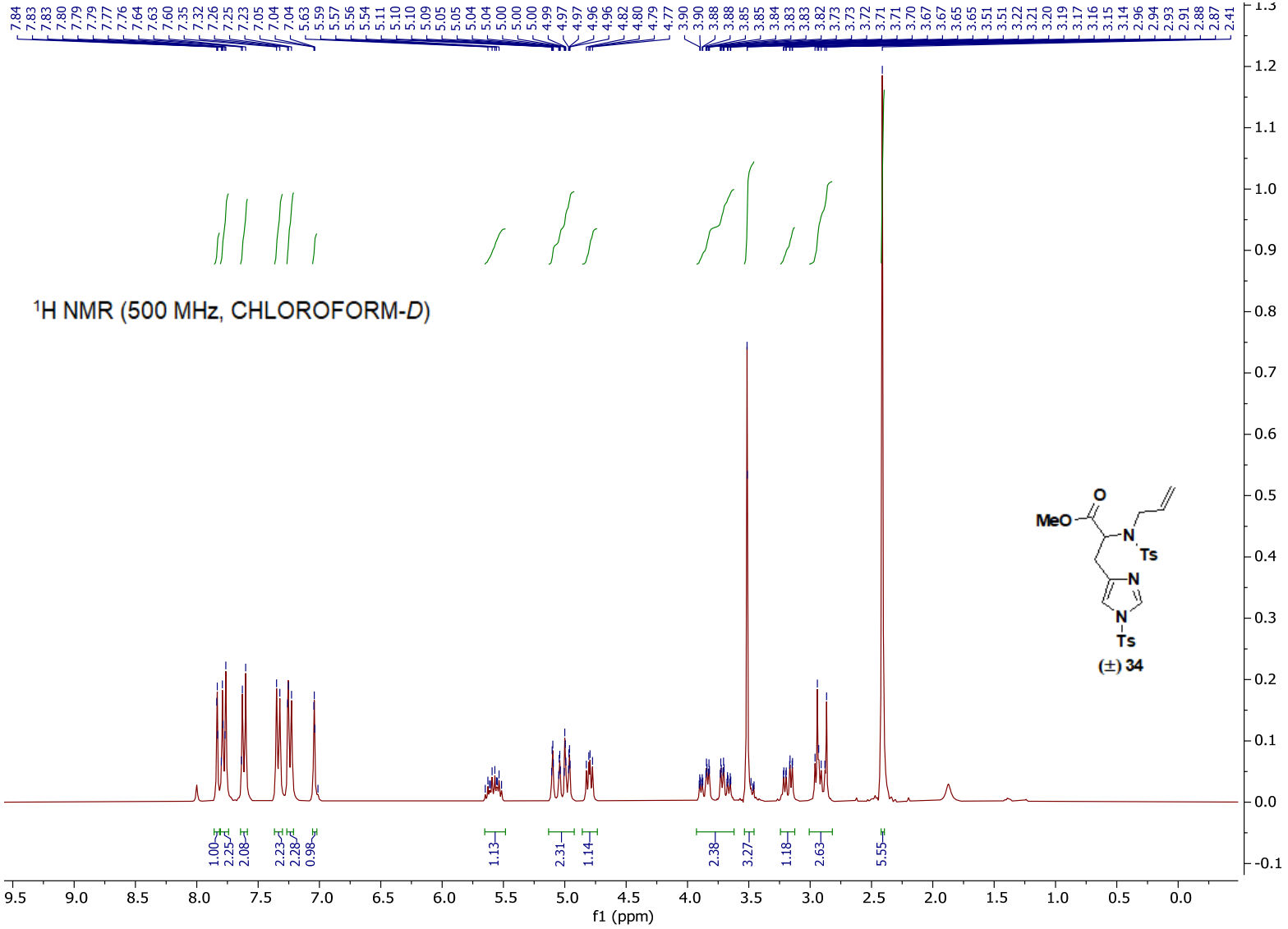

138.66
137.01
135.23
130.60
127.36
127.17
121.61
121.53
121.53
119.53
119.53
117.74
117.74
117.68
109.25
109.25
107.55
66.01
65.49
50.20
48.18
44.18
29.44
21.44
^{13}C NMR (125.8 MHz, METHANOL-D_4)
OH
54
f1 (ppm)

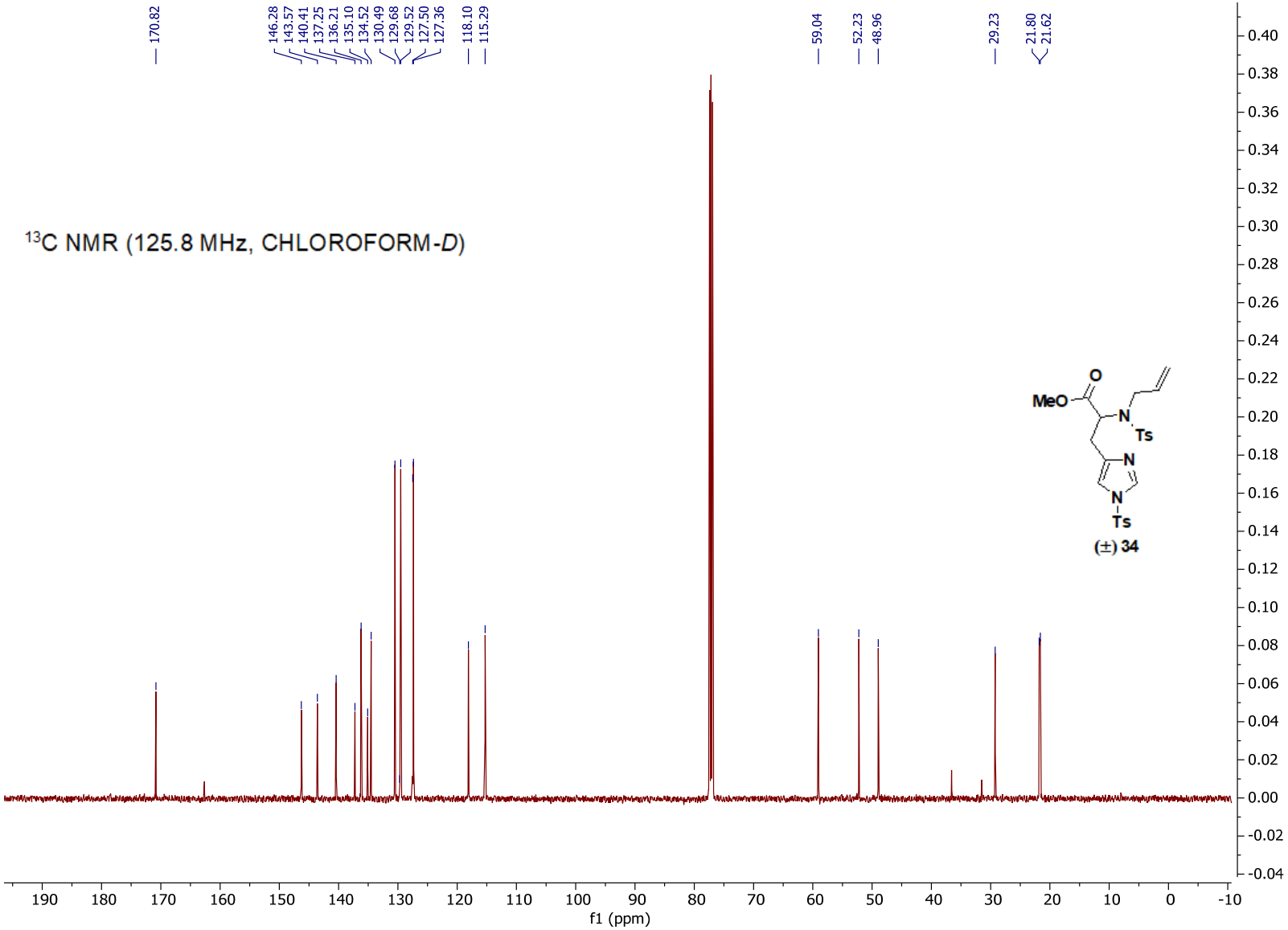

^{1}H NMR (500 MHz, METHANOL-D_4)
f1 (ppm)
Villagorgin A (7)

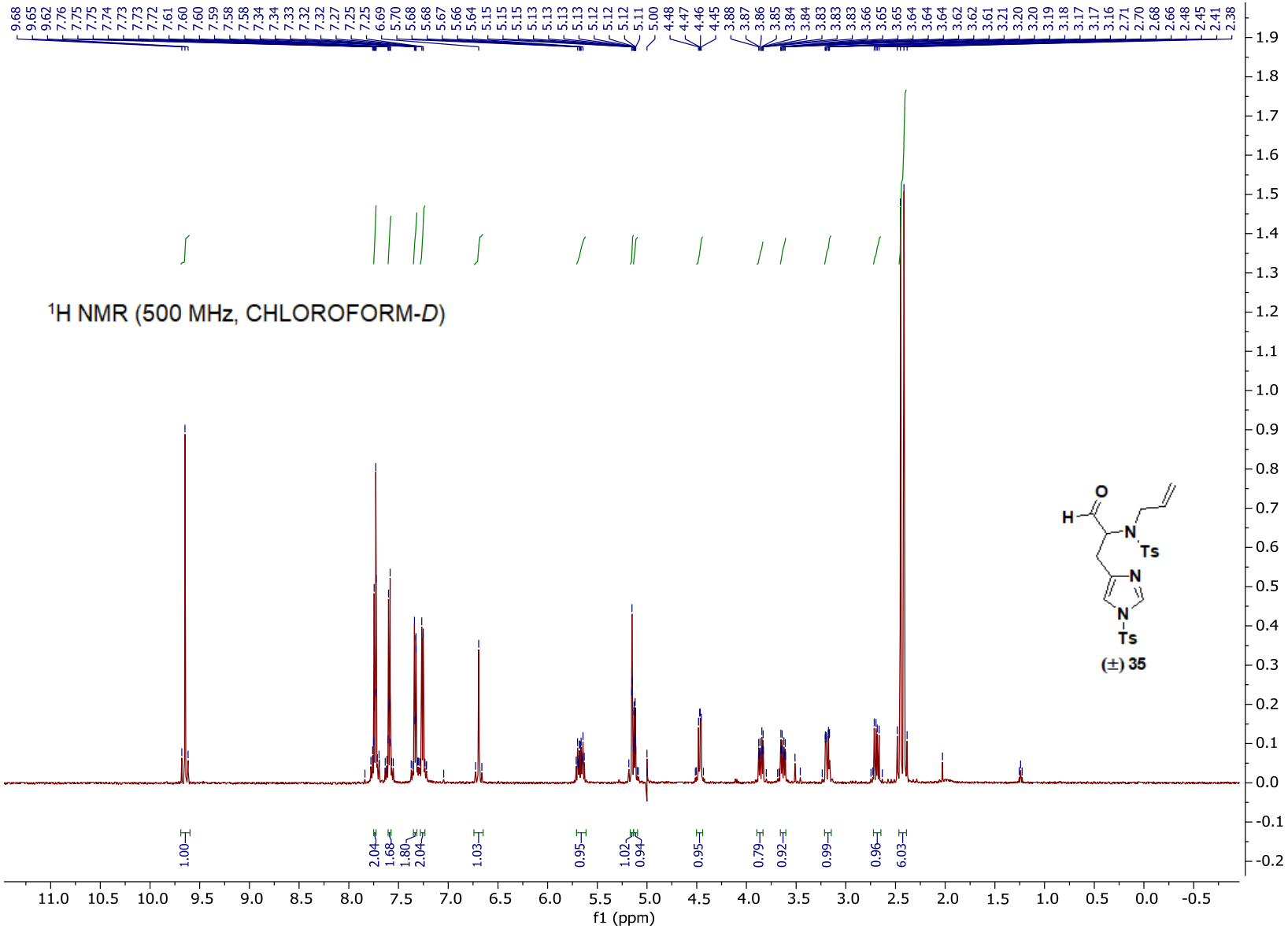

138.42
135.63
134.87
129.87
128.07
122.33
119.94
118.76
111.97
108.42
73.85
58.47
54.02
53.31
29.21
22.32
^{13}C NMR (125.8 MHz, METHANOL-D_4)
HN
N
HN
N
Villagorgin A (7)
f1 (ppm)

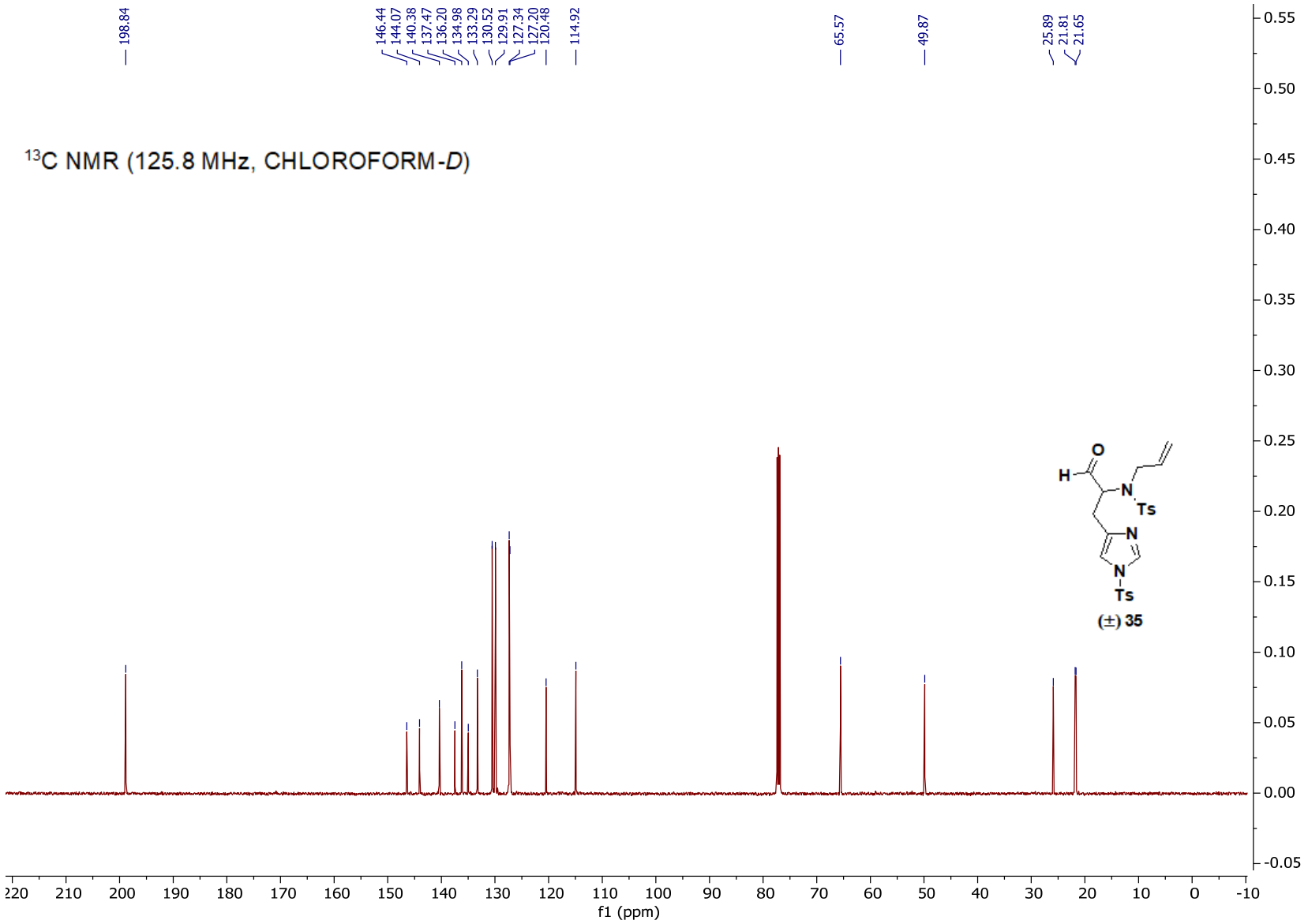

7.82
7.82
7.78
7.76
7.66
7.64
7.35
7.34
7.25
7.23
7.22
7.02
7.01
5.75
5.73
4.21
4.19
4.19
4.18
4.18
4.17
3.46
2.92
2.91
2.42
2.40
1H NMR (500 MHz, CHLOROFORM-D)
MeO
O
NH
Ts
N
N
Ts
(±) 33
1.00
1.82
1.87
1.89
1.59
0.96
0.77
0.87
2.98
1.54
5.62
f1 (ppm)

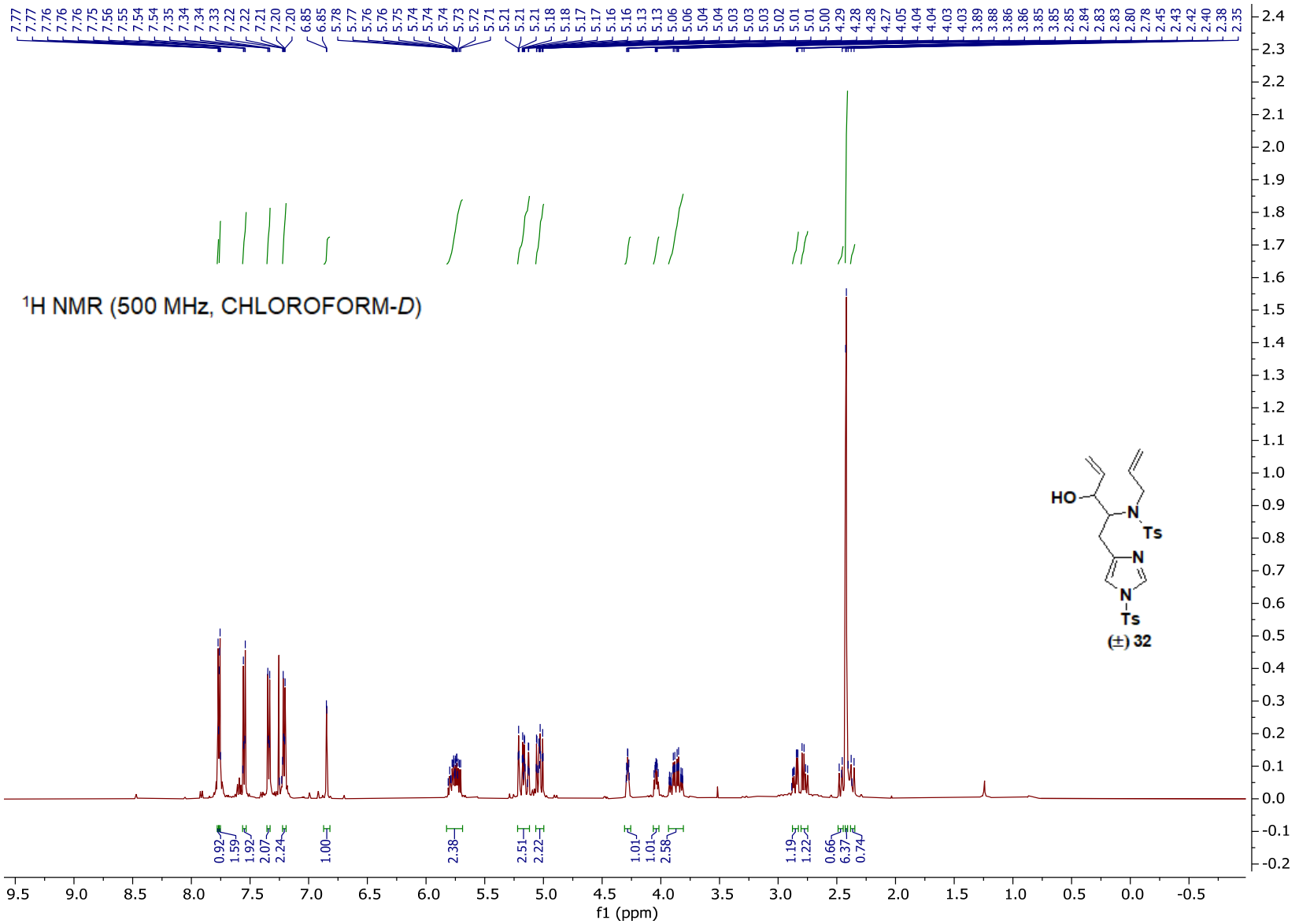

171.18
146.50
143.71
139.27
137.00
136.43
134.88
130.57
129.70
127.43
127.22
115.27
55.09
52.61
31.40
21.83
21.63
13C NMR (125.8 MHz, CHLOROFORM-D)
MeO
O
NH
Ts
N
N
Ts
(±) 33
f1 (ppm)

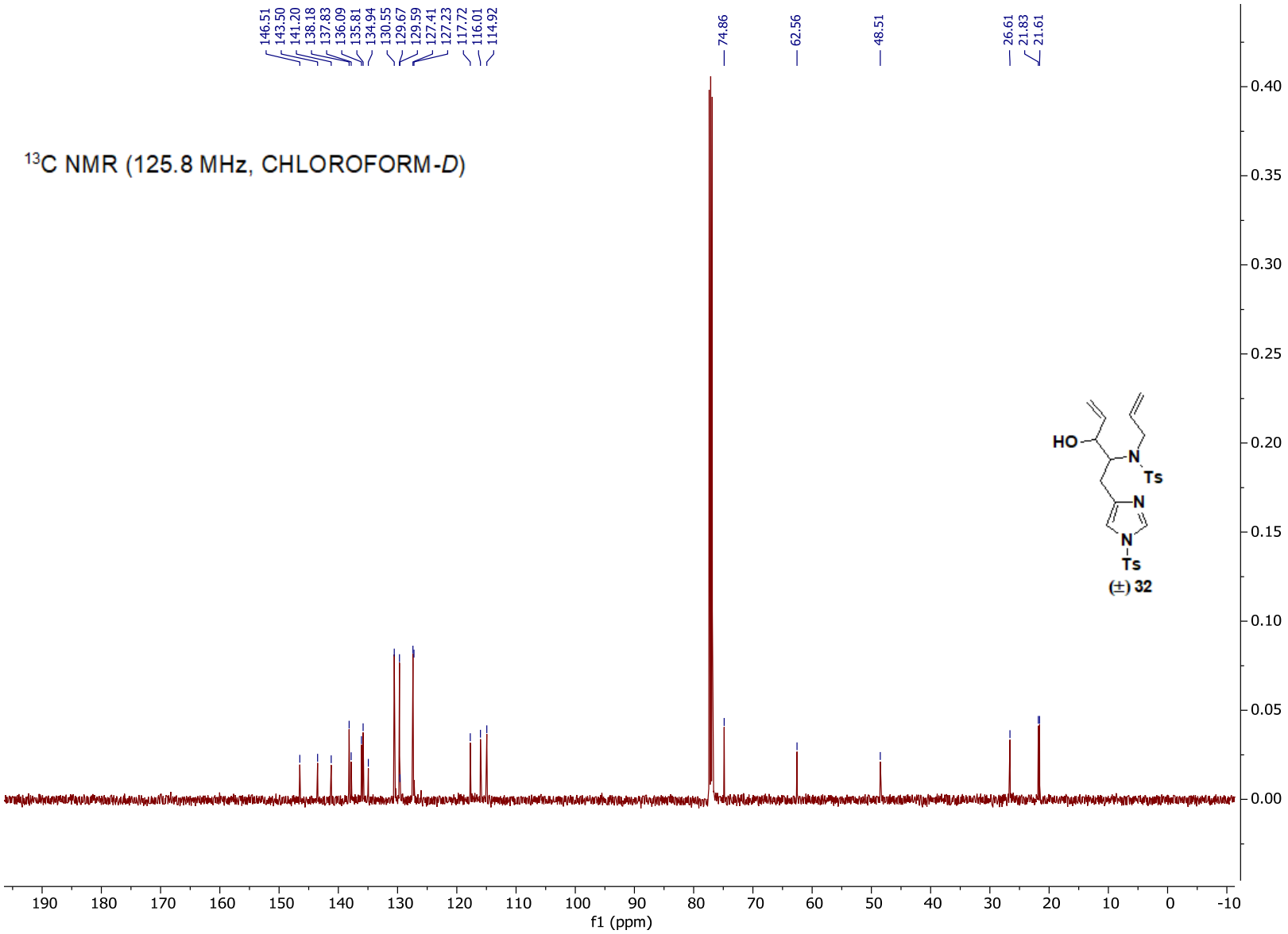

^{1}H NMR (500 MHz, CHLOROFORM-*D*)
MeO
O
N
Ts
N
N
Ts
(±) 34
f1 (ppm)

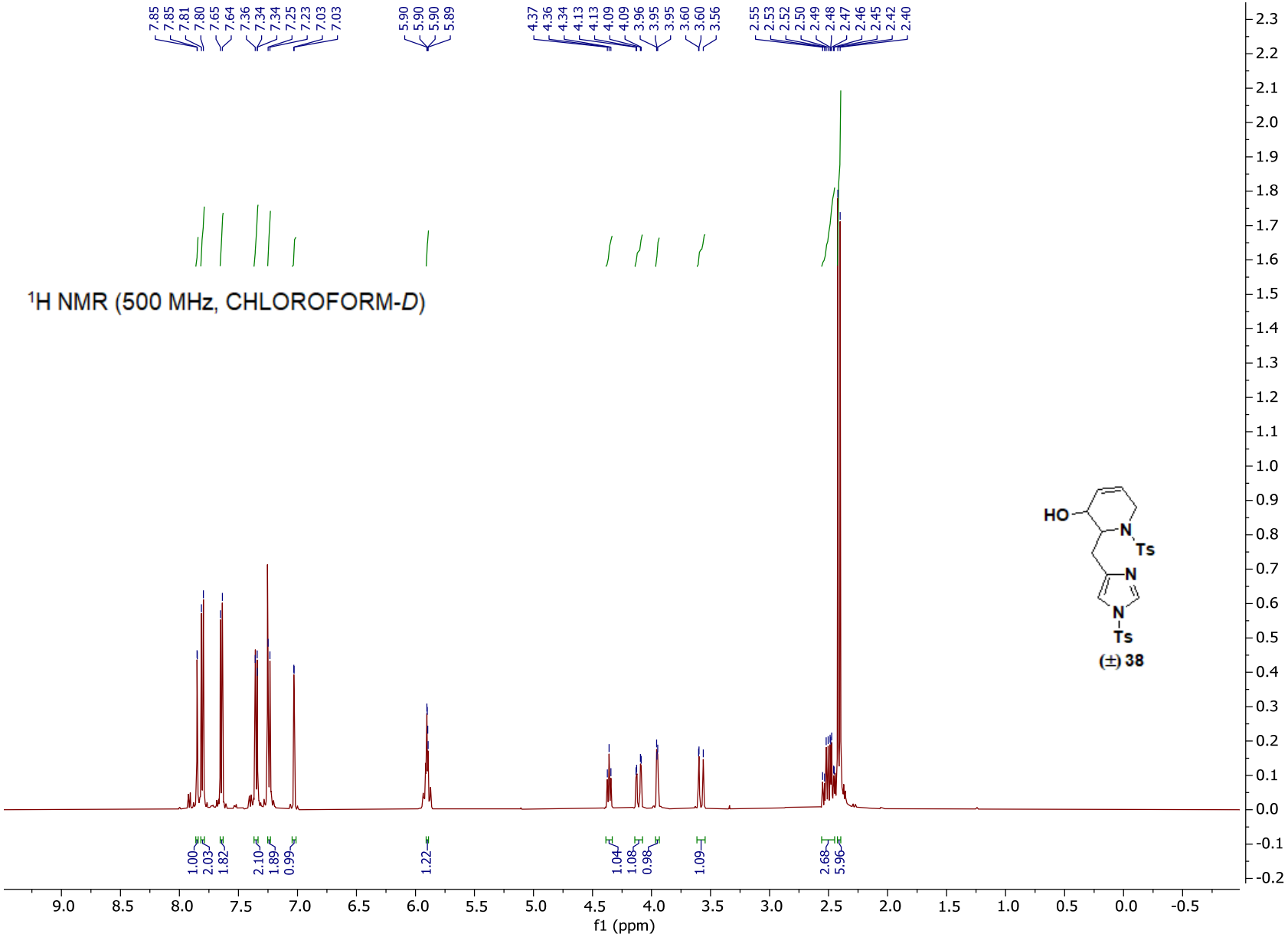

170.82
146.28
143.57
140.41
137.25
136.21
135.10
134.52
130.49
129.68
129.52
127.50
127.36
118.10
115.29
59.04
52.23
48.96
29.23
21.80
21.62
13C NMR (125.8 MHz, CHLOROFORM-D)
MeO
O
N
Ts
N
N
Ts
(±) 34
f1 (ppm)

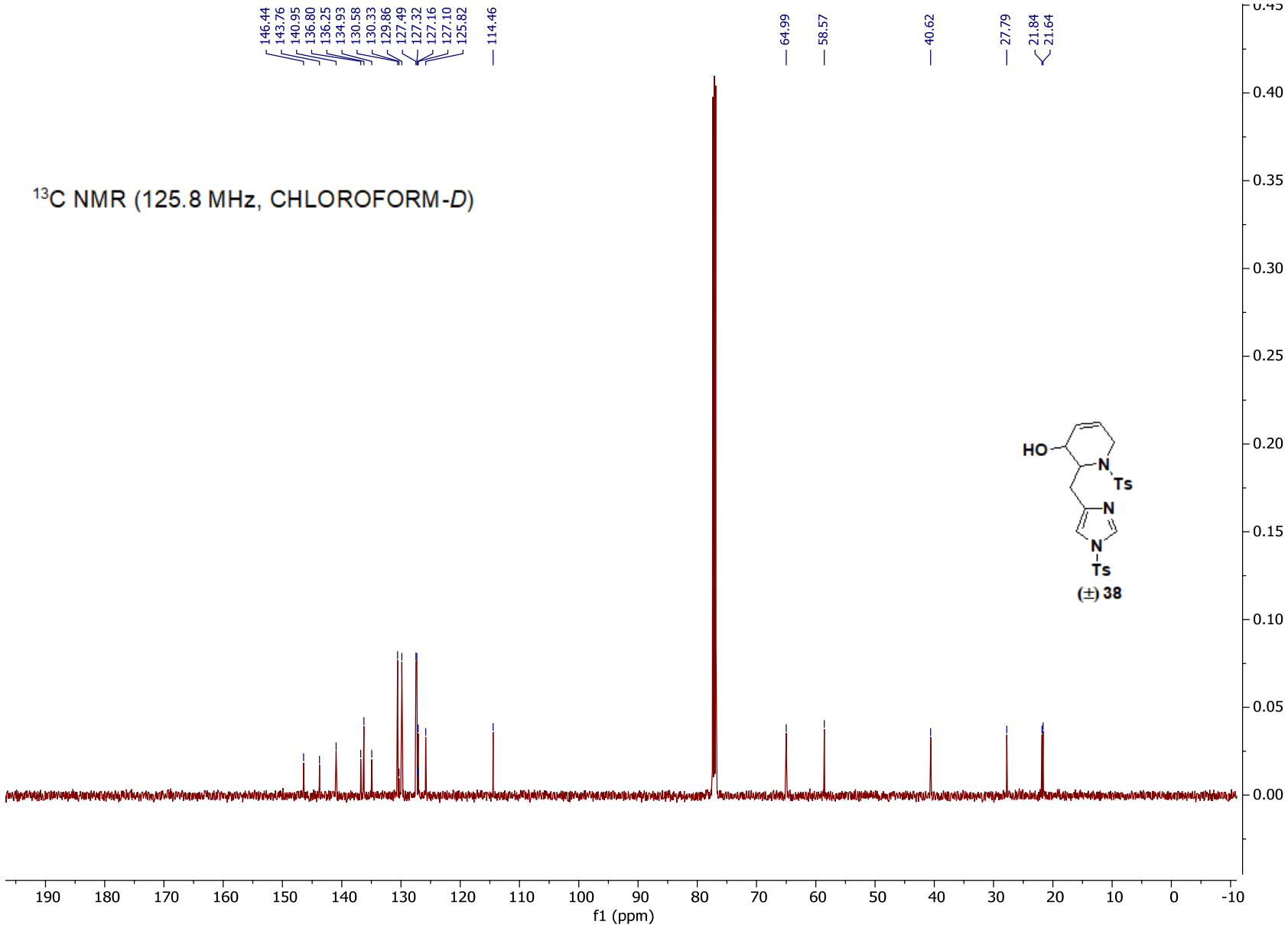

9.68 9.65 9.62 7.76 7.75 7.75 7.74 7.73 7.73 7.72 7.61 7.60 7.60 7.59 7.58 7.58 7.34 7.34 7.33 7.32 7.32 7.27 7.25 7.25 6.69 5.70 5.68 5.68 5.67 5.66 5.64 5.15 5.15 5.15 5.13 5.13 5.13 5.13 5.12 5.12 5.12 5.11 5.00 4.48 4.47 4.46 4.45 3.88 3.87 3.86 3.85 3.84 3.84 3.83 3.83 3.83 3.66 3.65 3.65 3.64 3.64 3.64 3.62 3.62 3.61 3.21 3.20 3.20 3.19 3.18 3.17 3.17 3.16 2.71 2.70 2.68 2.66 2.48 2.45 2.41 2.38
1H NMR (500 MHz, CHLOROFORM-D)
1.00 2.04 1.68 1.80 2.04 1.03 0.95 1.02 0.94 0.95 0.79 0.92 0.99 0.96 6.03
11.0 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 -0.5
f1 (ppm)
1.9 1.8 1.7 1.6 1.5 1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0 -0.1 -0.2
O
H
N
Ts
N
N
Ts
(±) 35

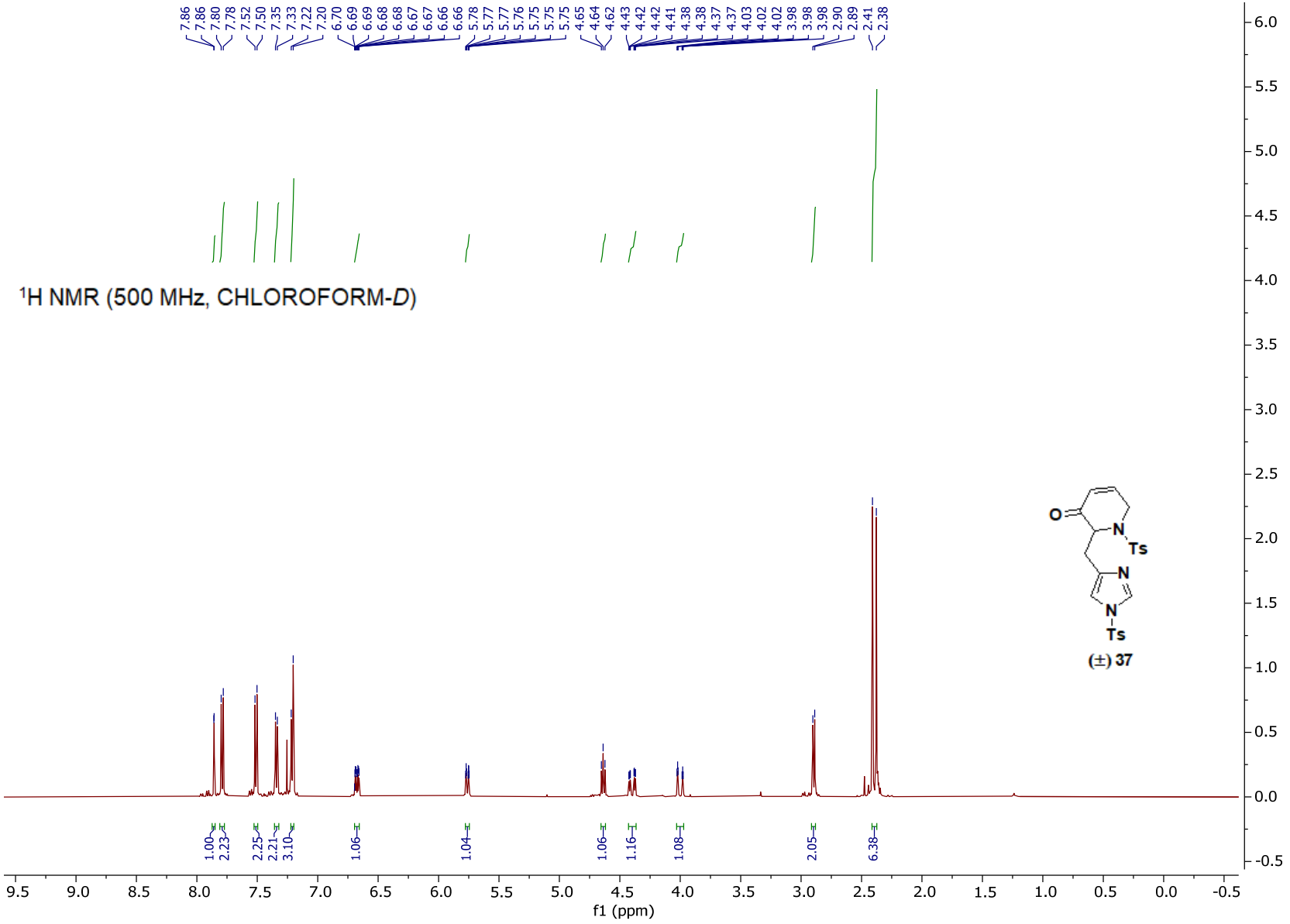

198.84
146.44
144.07
140.38
137.47
136.20
134.98
133.29
130.52
129.91
127.34
127.20
120.48
114.92
65.57
49.87
25.89
21.81
21.65
13C NMR (125.8 MHz, CHLOROFORM-D)
O
H
N
Ts
N
N
Ts
(±) 35
f1 (ppm)

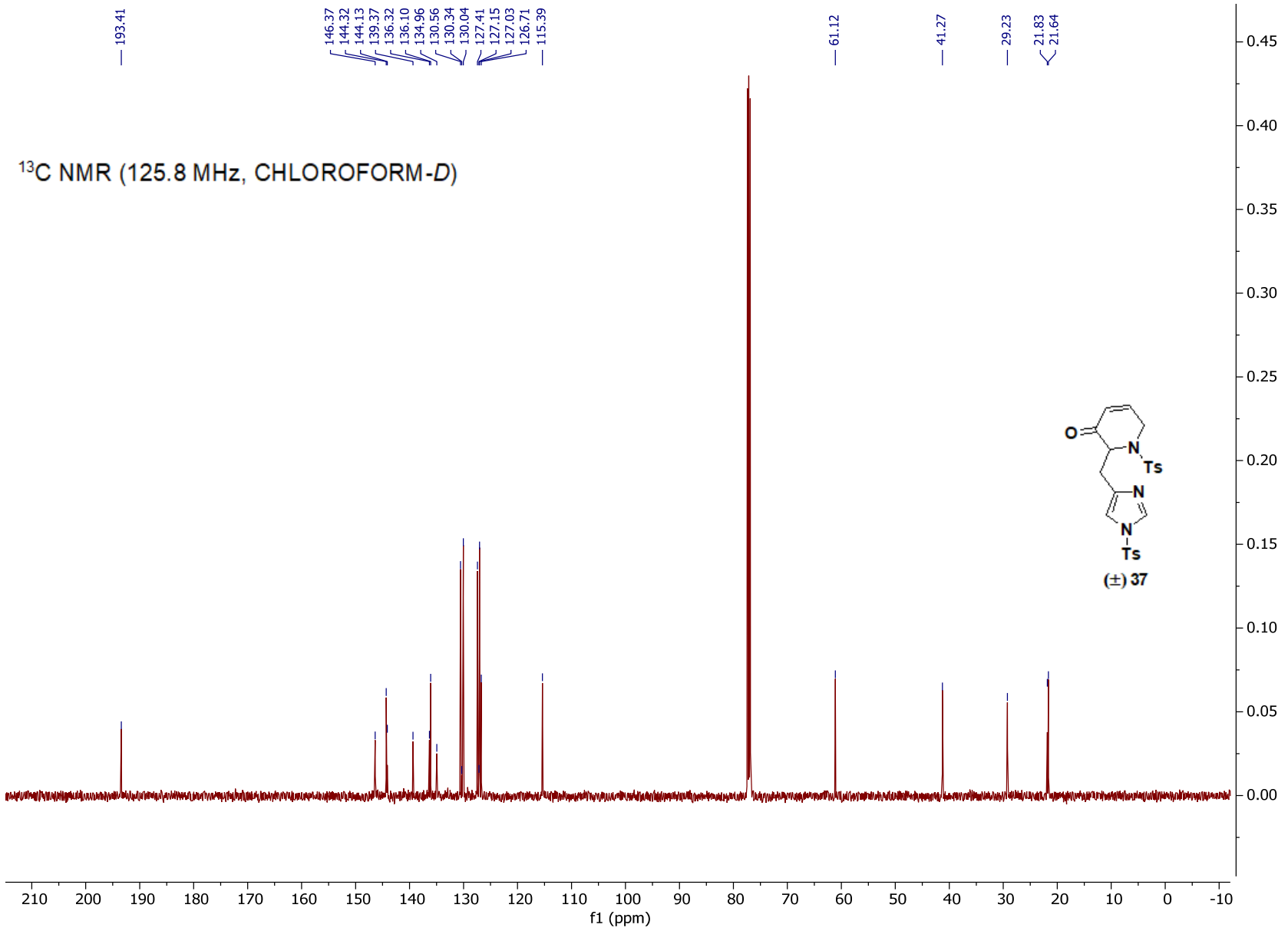

7.77 7.77 7.76 7.76 7.76 7.75 7.56 7.55 7.54 7.54 7.35 7.34 7.34 7.33 7.22 7.21 7.20 7.20 6.85 6.85 5.78 5.77 5.76 5.76 5.75 5.74 5.74 5.74 5.73 5.72 5.71 5.21 5.21 5.21 5.18 5.18 5.17 5.17 5.16 5.16 5.13 5.13 5.06 5.06 5.04 5.04 5.03 5.03 5.03 5.02 5.01 5.01 5.00 4.29 4.28 4.28 4.27 4.05 4.04 4.04 4.03 4.03 3.89 3.88 3.86 3.86 3.85 3.85 2.85 2.84 2.83 2.80 2.78 2.45 2.43 2.42 2.40 2.38 2.35
¹H NMR (500 MHz, CHLOROFORM-D)
HO
N
Ts
N
N
Ts
(±) 32
0.92 1.59 1.92 2.07 2.24 1.00 2.38 2.51 2.22 1.01 1.01 2.58 1.19 1.22 0.66 6.37 0.74
f1 (ppm)

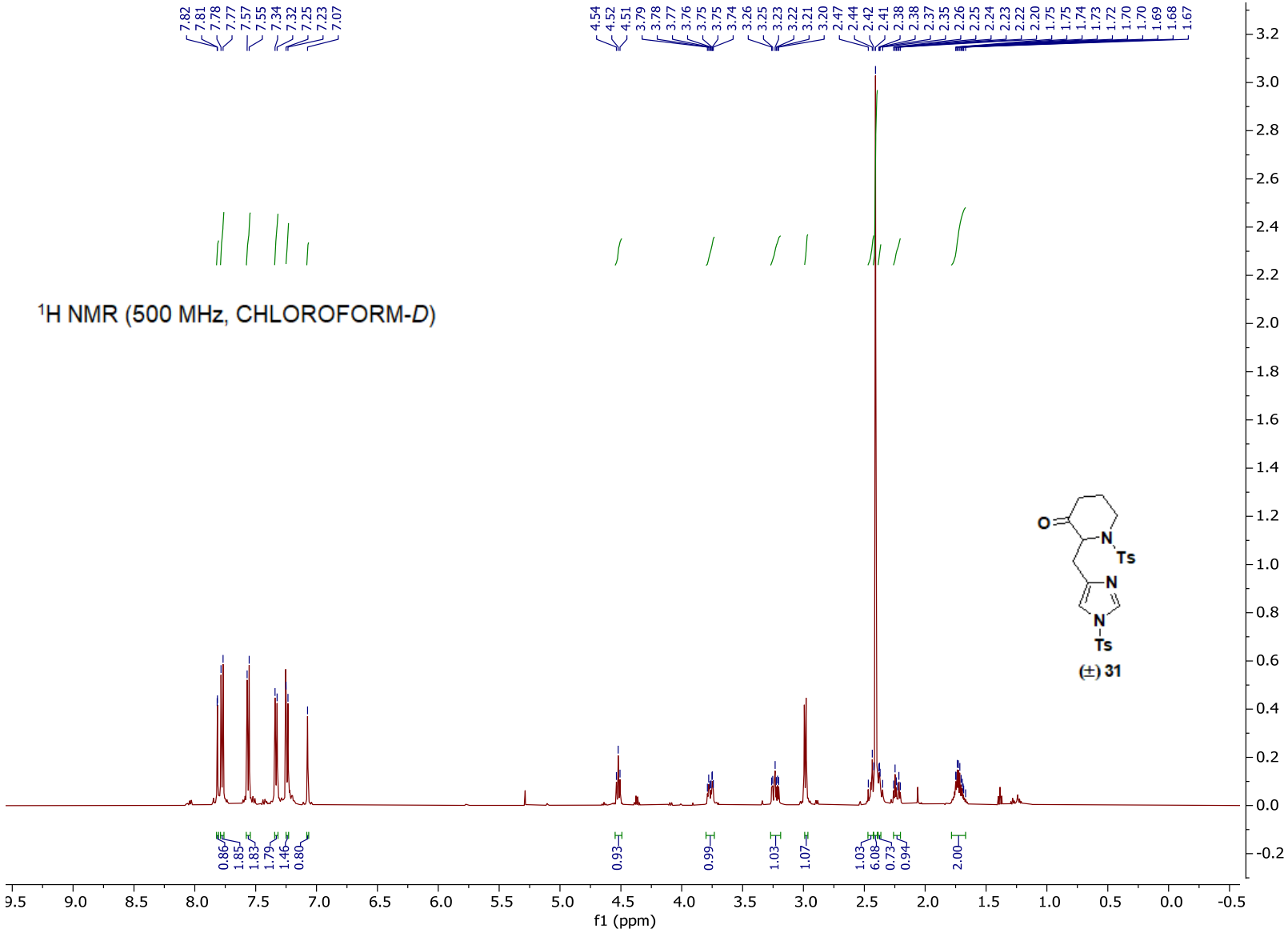

146.51
143.50
141.20
138.18
137.83
136.09
135.81
134.94
130.55
129.67
129.59
127.41
127.23
117.72
116.01
114.92
74.86
62.56
48.51
26.61
21.83
21.61
^{13}C NMR (125.8 MHz, CHLOROFORM-*D*)
HO
N
Ts
N
N
Ts
(±) 32
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

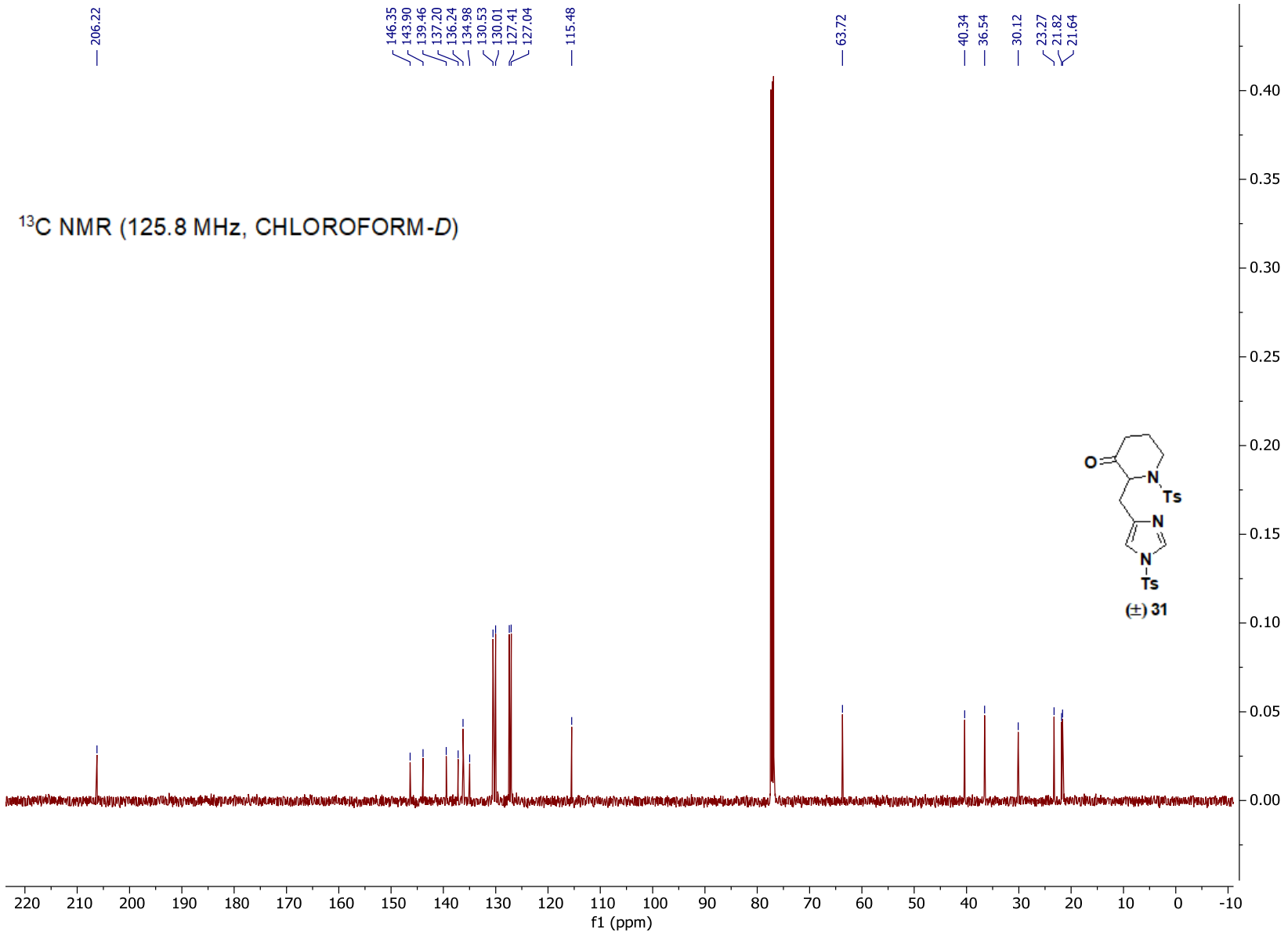

7.85
7.85
7.81
7.80
7.65
7.64
7.36
7.34
7.34
7.25
7.23
7.03
7.03
5.90
5.90
5.90
5.89
4.37
4.36
4.34
4.13
4.13
4.09
4.09
3.96
3.95
3.95
3.60
3.60
3.56
2.55
2.53
2.52
2.50
2.49
2.48
2.47
2.46
2.45
2.42
2.40
1H NMR (500 MHz, CHLOROFORM-D)
HO
N
Ts
N
N
Ts
(±) 38
1.00
2.03
1.82
2.10
1.89
0.99
1.22
1.04
1.08
0.98
1.09
2.68
5.96
f1 (ppm)

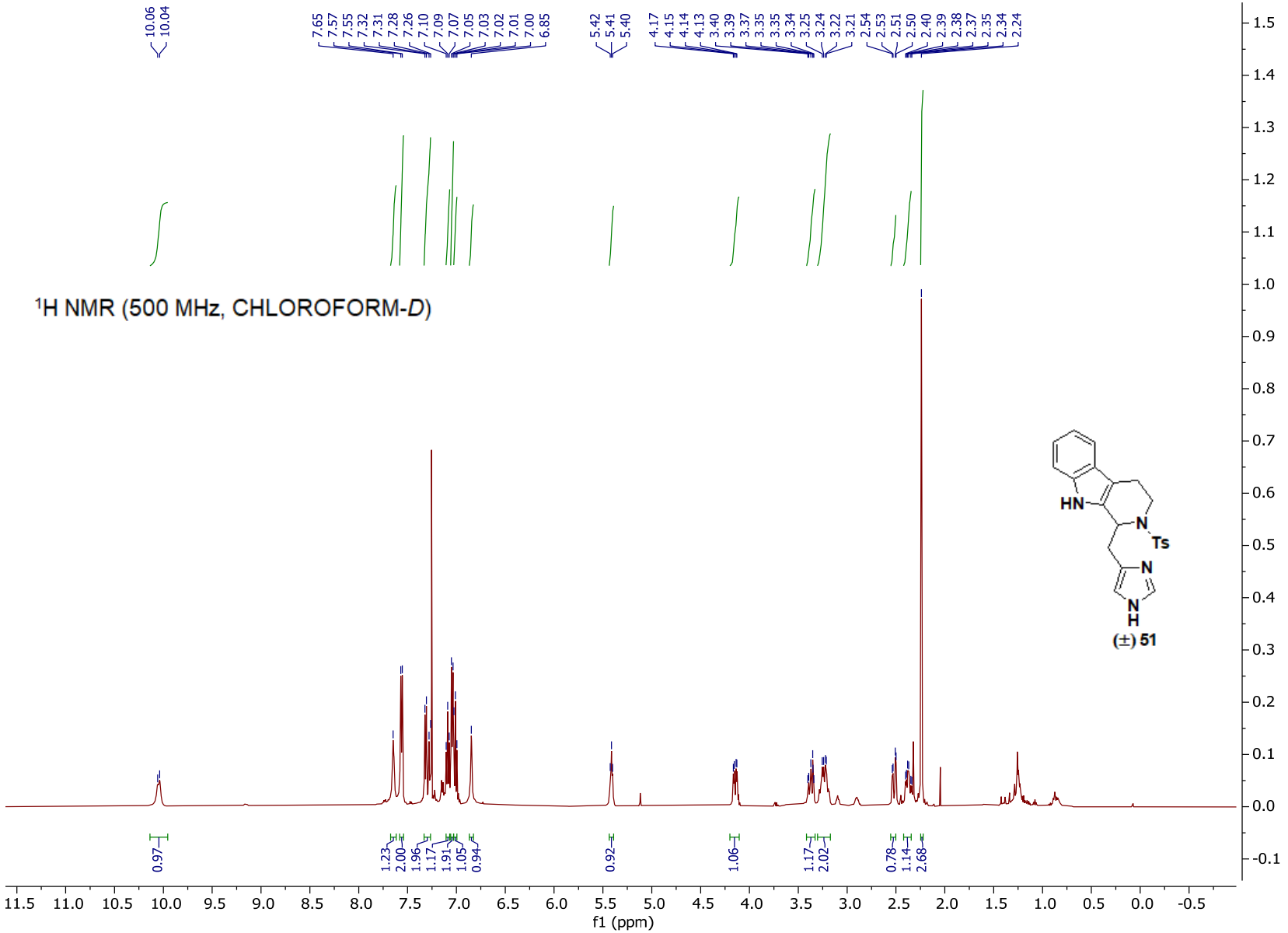

146.44
143.76
140.95
136.80
136.25
134.93
130.58
130.33
129.86
127.49
127.32
127.16
127.10
125.82
114.46
64.99
58.57
40.62
27.79
21.84
21.64
13C NMR (125.8 MHz, CHLOROFORM-D)
HO
N
Ts
N
N
Ts
(±) 38
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

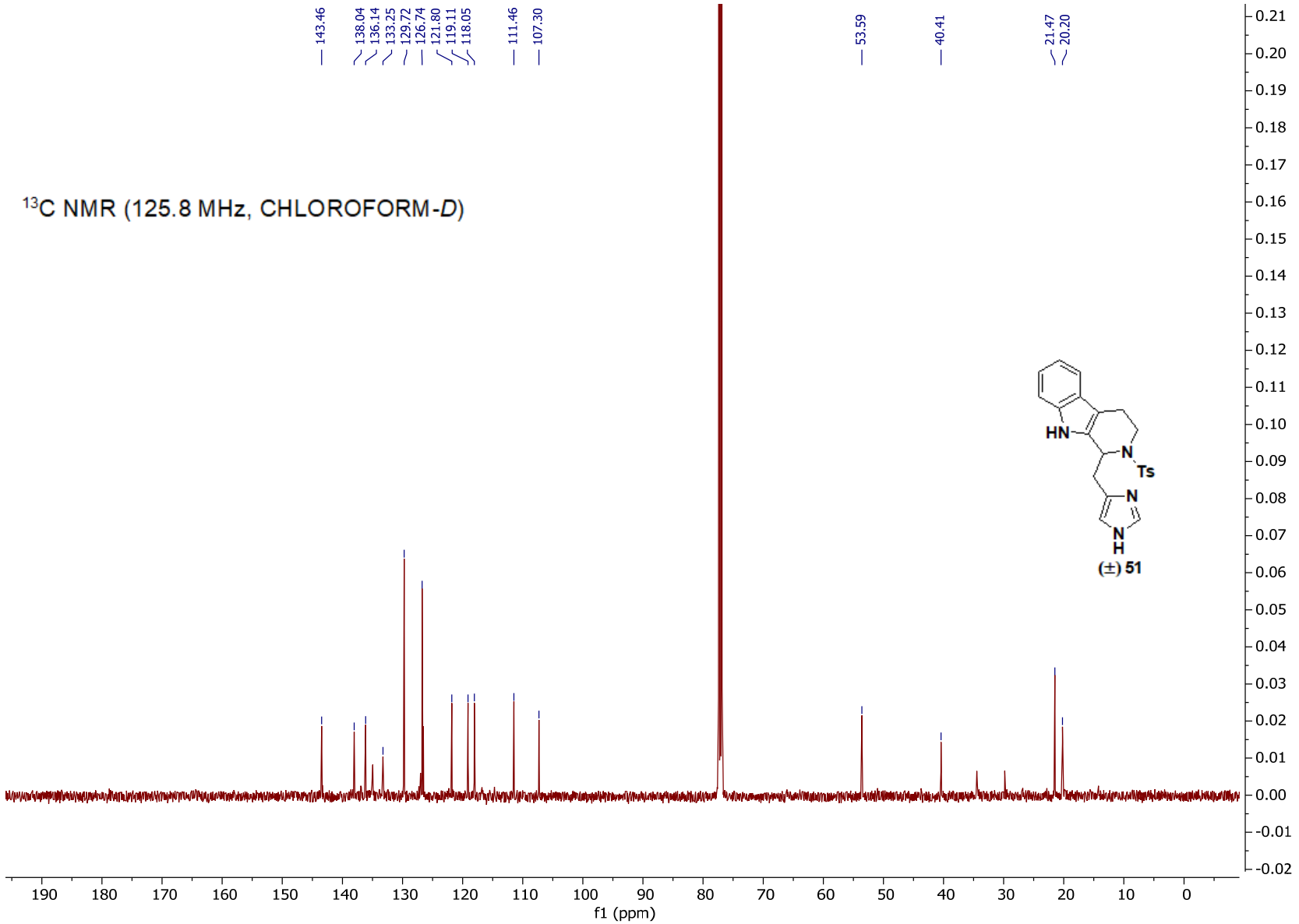

7.86
7.86
7.80
7.78
7.52
7.50
7.35
7.33
7.22
7.20
6.70
6.69
6.69
6.68
6.68
6.67
6.67
6.66
6.66
5.78
5.77
5.77
5.76
5.75
5.75
5.75
4.65
4.64
4.62
4.43
4.42
4.42
4.41
4.38
4.38
4.37
4.37
4.03
4.02
4.02
3.98
3.98
3.98
2.90
2.89
2.41
2.38
¹H NMR (500 MHz, CHLOROFORM-D)
O
N
Ts
N
N
Ts
(±) 37
1.00
2.23
2.25
2.21
3.10
1.06
1.04
1.06
1.16
1.08
2.05
6.38
f1 (ppm)

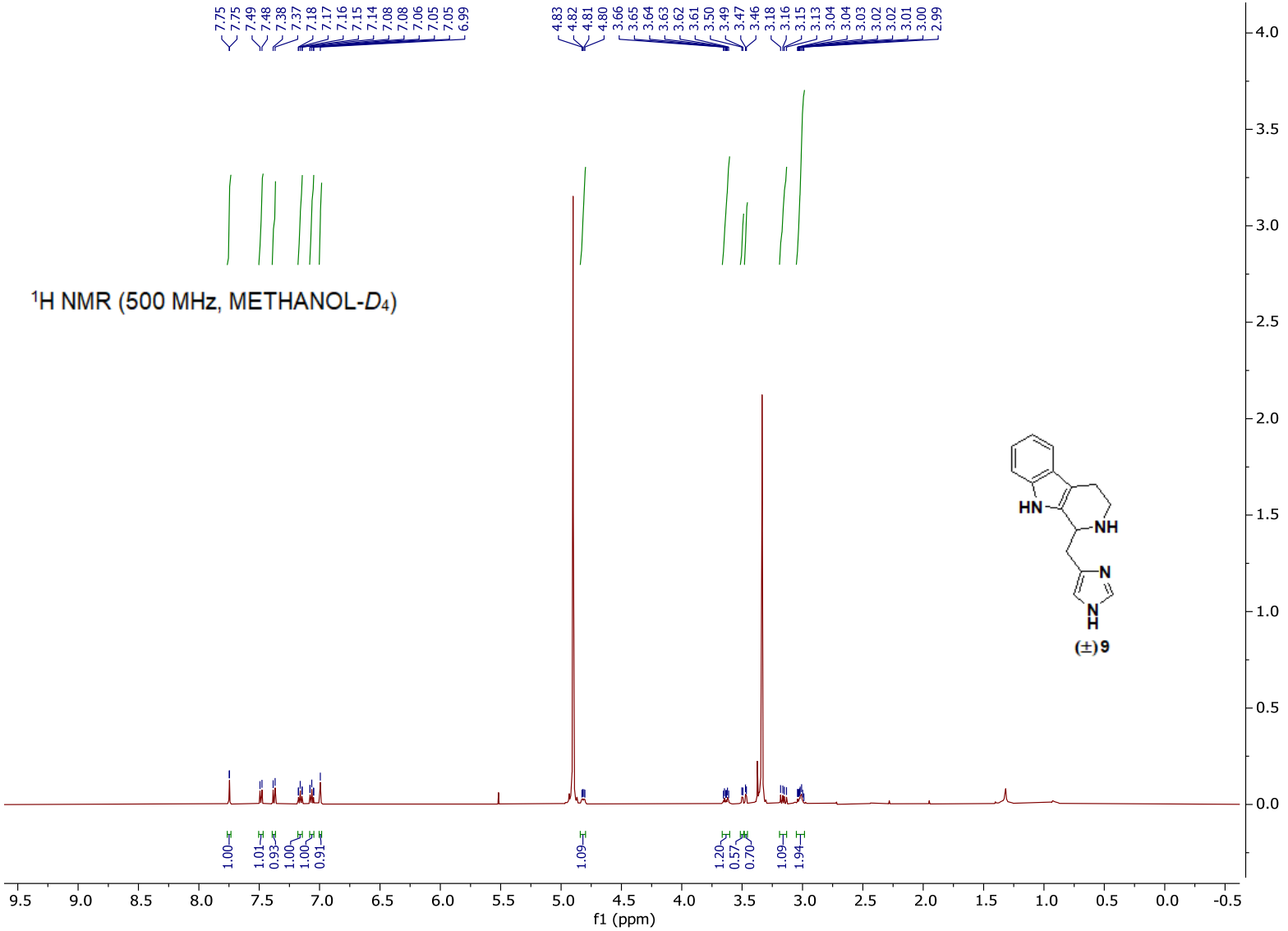

193.41
146.37
144.32
144.13
139.37
136.32
136.10
134.96
130.56
130.34
130.04
127.41
127.15
127.03
126.71
115.39
61.12
41.27
29.23
21.83
21.64
13C NMR (125.8 MHz, CHLOROFORM-D)
O
N
Ts
N
N
Ts
(±) 37
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

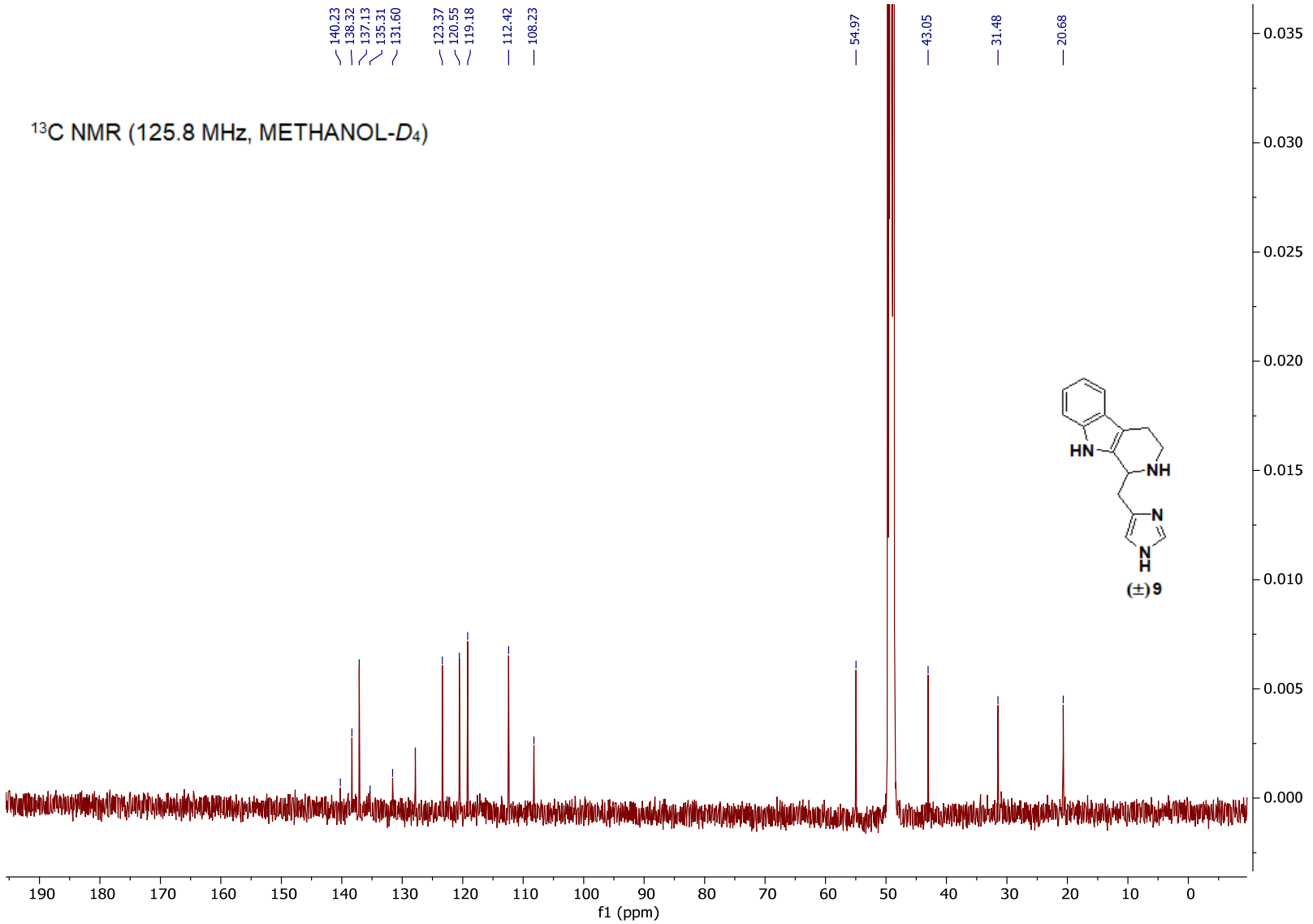

7.82
7.81
7.78
7.77
7.57
7.55
7.34
7.32
7.25
7.23
7.07
4.54
4.52
4.51
3.79
3.78
3.77
3.76
3.75
3.75
3.74
3.26
3.25
3.23
3.22
3.21
3.20
2.47
2.44
2.42
2.41
2.38
2.38
2.37
2.35
2.26
2.25
2.24
2.23
2.22
2.20
1.75
1.75
1.74
1.73
1.72
1.70
1.70
1.69
1.68
1.67
¹H NMR (500 MHz, CHLOROFORM-D)
O
N
Ts
N
N
Ts
(±) 31
0.86
1.85
1.83
1.79
1.46
0.80
0.93
0.99
1.03
1.07
1.03
6.08
0.73
0.94
2.00
f1 (ppm)

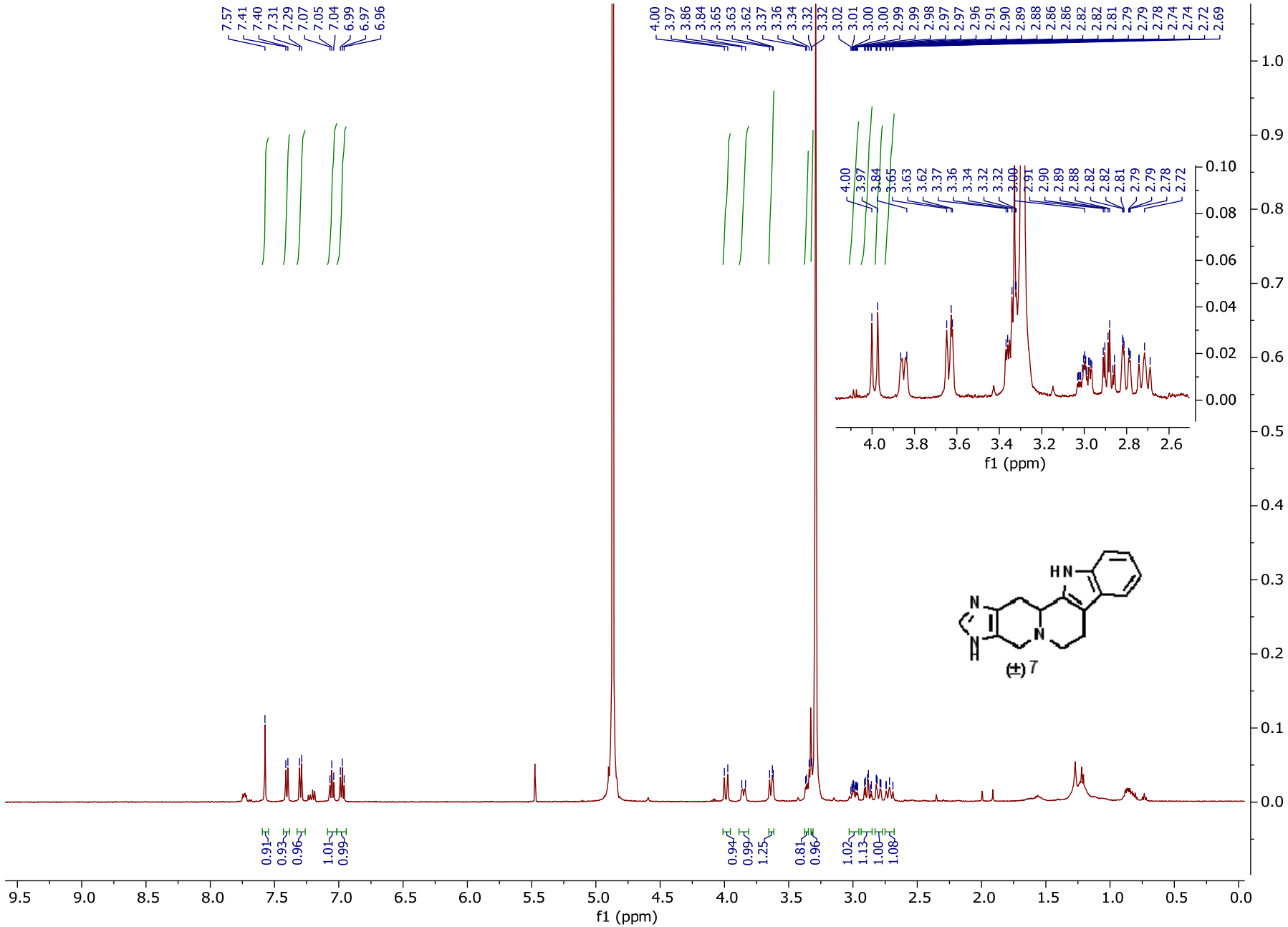

206.22
146.35
143.90
139.46
137.20
136.24
134.98
130.53
130.01
127.41
127.04
115.48
63.72
40.34
36.54
30.12
23.27
21.82
21.64
13C NMR (125.8 MHz, CHLOROFORM-D)
O
N
Ts
N
N
Ts
(±) 31
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

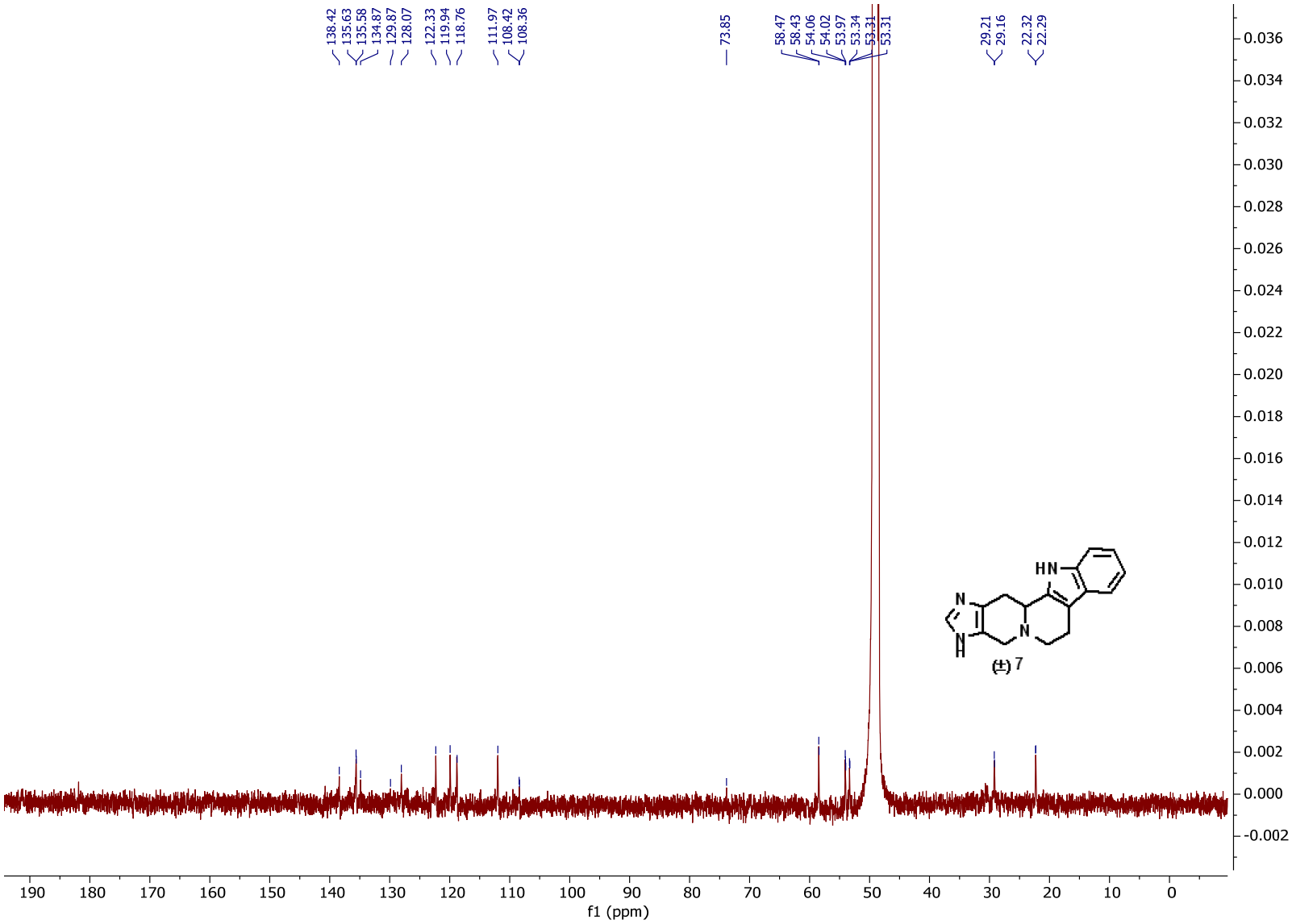

10.06
10.04
7.65
7.57
7.55
7.32
7.31
7.28
7.26
7.10
7.09
7.07
7.05
7.03
7.02
7.01
7.00
6.85
5.42
5.41
5.40
4.17
4.15
4.14
4.13
3.40
3.39
3.37
3.35
3.35
3.34
3.25
3.24
3.22
3.21
2.54
2.53
2.51
2.50
2.40
2.39
2.38
2.37
2.35
2.34
2.24
1H NMR (500 MHz, CHLOROFORM-D)
HN
N
Ts
N
N
H
(±) 51
0.97
1.23
2.00
1.96
1.17
1.91
1.05
0.94
0.92
1.06
1.17
2.02
0.78
1.14
2.68
f1 (ppm)

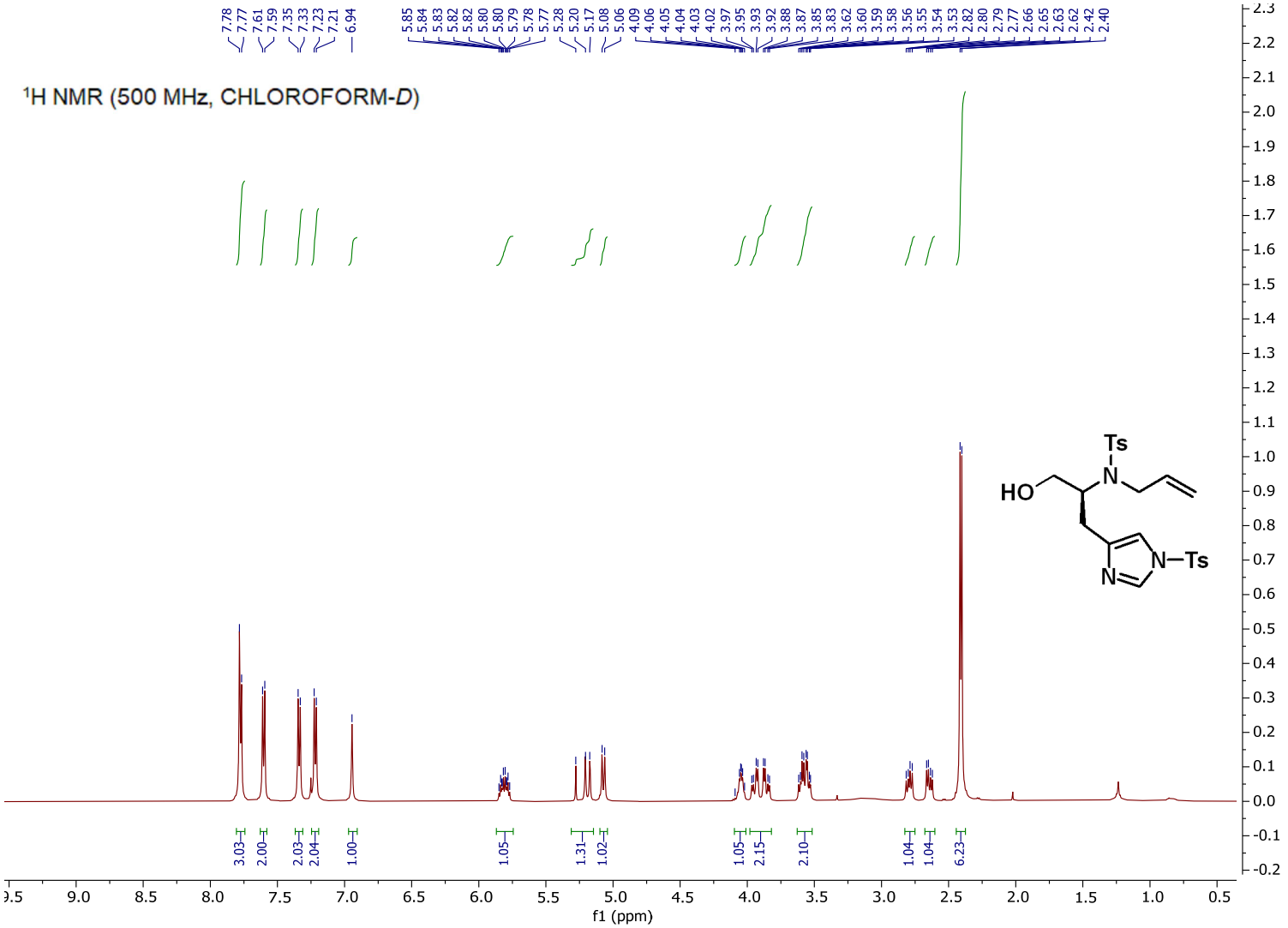

143.46
138.04
136.14
133.25
129.72
126.74
121.80
119.11
118.05
111.46
107.30
53.59
40.41
21.47
20.20
^{13}C NMR (125.8 MHz, CHLOROFORM-*D*)
HN
N
Ts
N
N
H
(±) 51
f1 (ppm)

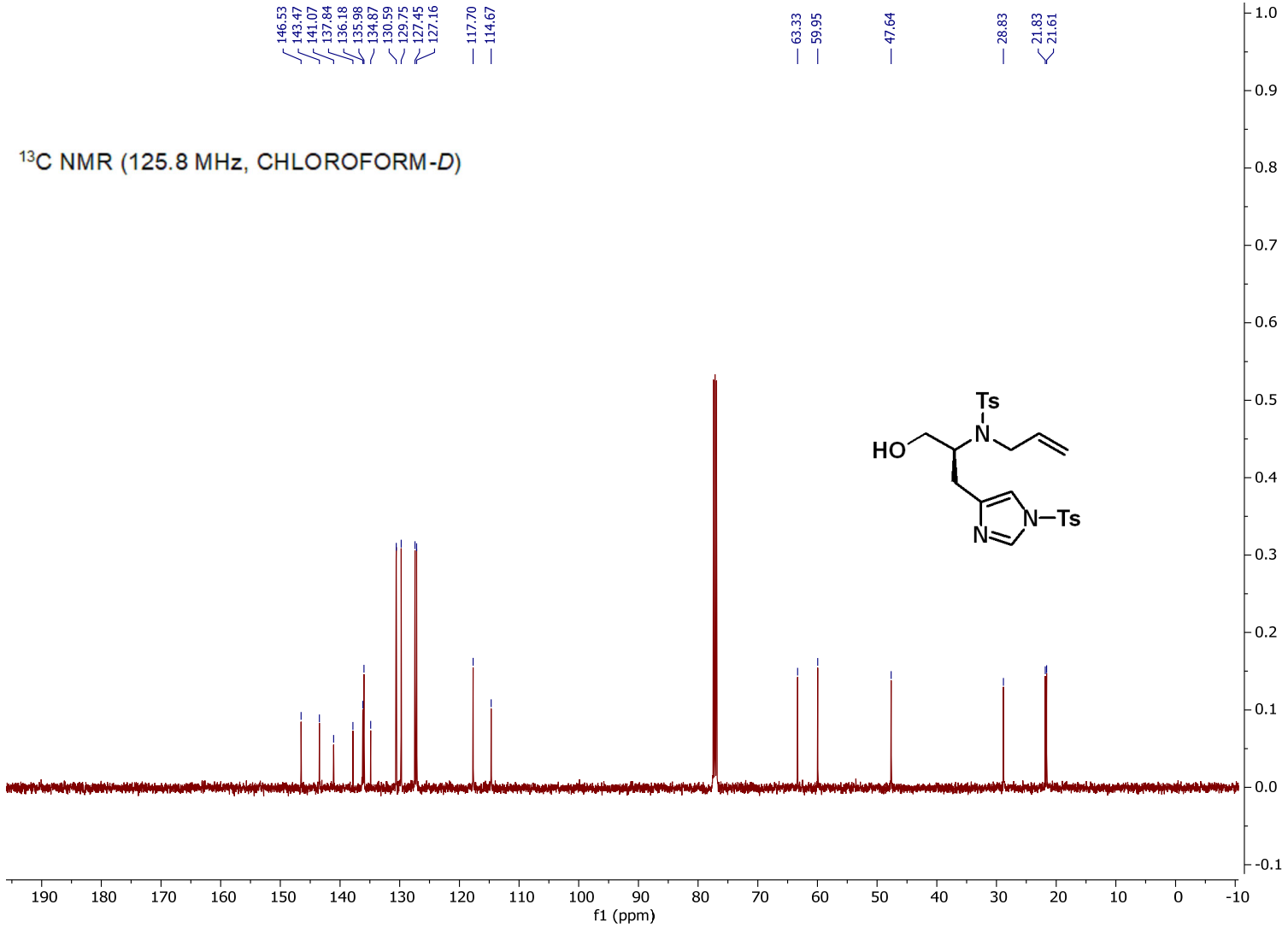

7.75
7.75
7.49
7.48
7.38
7.37
7.18
7.17
7.16
7.15
7.14
7.08
7.08
7.06
7.05
7.05
6.99
4.83
4.82
4.81
4.80
3.66
3.65
3.64
3.63
3.62
3.61
3.50
3.49
3.47
3.46
3.18
3.16
3.15
3.13
3.04
3.04
3.03
3.02
3.02
3.01
3.00
2.99
1H NMR (500 MHz, METHANOL-D4)
HN
NH
N
N
H
(±)9
1.00
1.01
0.93
1.00
1.00
0.91
1.09
1.20
0.57
0.70
1.09
1.94
f1 (ppm)


140.23
138.32
137.13
135.31
131.60
123.37
120.55
119.18
112.42
108.23
54.97
43.05
31.48
20.68
13C NMR (125.8 MHz, METHANOL-D4)
HN
NH
N
N
H
(±)9
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.57 7.41 7.40 7.31 7.29 7.07 7.05 7.04 6.99 6.97 6.96
4.00 3.97 3.86 3.84 3.65 3.63 3.62 3.37 3.36 3.34 3.32 3.32 3.02 3.01 3.00 3.00 2.99 2.99 2.98 2.97 2.97 2.96 2.91 2.90 2.89 2.88 2.86 2.86 2.82 2.82 2.81 2.79 2.79 2.78 2.74 2.74 2.72 2.69
0.91 0.93 0.96 1.01 0.99
0.94 0.99 1.25 0.81 0.96 1.02 1.13 1.00 1.08
f1 (ppm)
HN
N
N
N
H
(±) 7


138.42
135.63
135.58
134.87
129.87
128.07
122.33
119.94
118.76
111.97
108.42
108.36
73.85
58.47
58.43
54.06
54.02
53.97
53.34
53.31
53.31
29.21
29.16
22.32
22.29
0.036
0.034
0.032
0.030
0.028
0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
-0.002
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)
HN
N
N
N
H
(±) 7


7.78
7.77
7.61
7.59
7.35
7.33
7.23
7.21
6.94
5.85
5.84
5.83
5.82
5.82
5.80
5.80
5.79
5.78
5.77
5.28
5.20
5.17
5.08
5.06
4.09
4.06
4.05
4.04
4.03
4.02
3.97
3.95
3.93
3.92
3.88
3.87
3.85
3.83
3.62
3.60
3.59
3.58
3.56
3.55
3.54
3.53
2.82
2.80
2.79
2.77
2.66
2.65
2.63
2.62
2.42
2.40
¹H NMR (500 MHz, CHLOROFORM-D)
Ts
N
HO
N
N—Ts
3.03
2.00
2.03
2.04
1.00
1.05
1.31
1.02
1.05
2.15
2.10
1.04
1.04
6.23
f1 (ppm)


146.53
143.47
141.07
137.84
136.18
135.98
134.87
130.59
129.75
127.45
127.16
117.70
114.67
63.33
59.95
47.64
28.83
21.83
21.61
13C NMR (125.8 MHz, CHLOROFORM-D)
Ts
N
HO
N
N—Ts
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)