α-C–H Bond Functionalization of Unprotected Alicyclic Amines: Lewis Acid Promoted Addition of Enolates to Transient Imines

Jae Hyun Kim,[a,†] Anirudra Paul,[a,†] Ion Ghiviriga,[b] and Daniel Seidel[a,*]

[a] *Center for Heterocyclic Compounds, Department of Chemistry, University of Florida, Gainesville, Florida 32611, United States*

[b] *Center for NMR Spectroscopy, Department of Chemistry, University of Florida, Gainesville, Florida 32611, United States*

* Correspondence to: seidel@chem.ufl.edu

† These authors contributed equally to this work.

Supporting Information

Table of Contents

General Information: Starting materials and reagents were purchased from commercial sources and used as received unless stated otherwise. Anhydrous diethyl ether and tetrahydrofuran was dried using a JC Meyer solvent system. All liquid amines, liquid esters, nitriles, and trifluoroacetophenone were distilled prior to use. *n*-BuLi solution in hexanes was purchased from commercial sources and freshly titrated using *N*-pivaloyl-*o*-toluidine prior to use.[1] Purification of reaction products was carried out by flash column chromatography using Sorbent Technologies Standard Grade silica gel (60 Å, 230–400 mesh). Analytical thin layer chromatography was performed on EM Reagent 0.25 mm silica gel 60 F254 plates. Visualization was accomplished with UV light, Dragendorff-Munier or $KMnO_4$ stains, followed by heating. Proton nuclear magnetic resonance spectra (^{1}H NMR) were recorded on Bruker 400 MHz and Varian Unity Inova 500 MHz instrument and chemical shifts are reported in ppm using the solvent as an internal standard ($CDCl_3$ at 7.26 ppm). Data are reported as app = apparent, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, comp = complex, br = broad; coupling constant(s) in Hz. Proton-decoupled carbon nuclear magnetic resonance spectra (^{13}C NMR) spectra were recorded on a Bruker 400 MHz and Varian Unity Inova 500 MHz instrument and chemical shifts are reported in ppm using the solvent as an internal standard ($CDCl_3$ at 77.16 ppm). High resolution mass spectra (HRMS) were obtained from an Agilent 6230 ESI-TOF instrument. Compounds (±)-**1a**,[2] (±)-**1a'**,[2] (±)-**1e**,[3] (±)-**1l**,[4] (±)-**3a**,[5] (±)-**3b**,[5] (±)-**3f**,[6] (±)-**4a**,[7] (±)-**4a'**,[7] (±)-**4b**[8] (±)-**4c**,[9] (±)-**4c'**,[9] (±)-**4d**[10] and (±)-**6**[11] were previously reported and their published characterization data matched our own in all respects.

General Procedure A for the α-C–H Bond Functionalization of Unprotected Alicyclic Amines with Ester or Nitrile Enolates:

To a stirred solution of diisopropylamine (1 mmol, 1 equiv, 141 μL) in anhydrous THF (1.5 mL) was added dropwise *n*-BuLi in hexanes (1 mmol, 1 equiv) at −78 °C under nitrogen and the resulting solution was stirred at the same temperature for 10 min. To this was then added a solution of the corresponding ester or nitrile (1 mmol, 1 equiv) in anhydrous THF (1.0 mL). The resulting mixture was stirred at –78 °C for 30 min. To a separate dry round-bottom flask charged with the corresponding cyclic amine (2 mmol, 2 equiv) was added dry ether (1.5 mL). The solution was cooled to −78 °C and *n*-BuLi in hexanes (2 mmol, 2 equiv) was added dropwise. The mixture was stirred at the same temperature for 10 minutes, and a solution of trifluoroacetophenone (2.1 mmol, 2.1 equiv, 295 μL) in dry ether (1 mL) was then added dropwise. The mixture was stirred at −78 °C for another 10 minutes to give the corresponding cyclic imine solution in ether. The imine solution was then taken up by a syringe and added in one portion to the stirred lithium-enolate solution at −78 °C followed immediately by the addition of BF_3•OEt_2 (2.4 mmol, 2.4 equiv, 296 μL). Subsequently, the reaction vessel was taken out of the low temperature bath and stirred at room temperature for 2 h. The reaction mixture was then cooled to 0 °C and saturated $NaHCO_3$ aqueous solution (4 mL) was added. The resulting mixture was diluted with EtOAc (20 mL) and washed with saturated $NaHCO_3$ aqueous solution (20 mL). The aqueous layer was then extracted with EtOAc (3 x 20 mL) and the combined organic layers were dried over anhydrous Na_2SO_4. Solvent was then removed under reduced pressure and the residue purified by silica gel chromatography.

General Procedure B for the α-C–H Bond Functionalization of Unprotected Alicyclic Amines with Ester or Nitrile Enolates:

To a stirred solution of diisopropylamine (1 mmol, 1 equiv, 141 μL) in anhydrous THF (1.5 mL) was added dropwise *n*-BuLi in hexanes (1 mmol, 1 equiv) at −78 °C under nitrogen and the resulting solution was stirred at the same temperature for 10 min. To this was then added a solution of the corresponding ester or nitrile (1 mmol, 1 equiv) in anhydrous THF (1.0 mL). The resulting mixture was stirred at –78 °C for 15 min. Subsequently, the reaction vessel was taken out of the low temperature bath and stirred at room temperature for 15 min after which it was cooled back down to –78 °C. To a separate dry round-bottom flask charged with the corresponding cyclic amine (2 mmol, 2 equiv) was added dry ether (1.5 mL). The solution was cooled to −78 °C and *n*-BuLi in hexanes (2 mmol, 2 equiv) was added dropwise. The mixture was stirred at the same temperature for 10 minutes, and a solution of trifluoroacetophenone (2.1 mmol, 2.1 equiv, 295 μL) in dry ether (1 mL) was then added dropwise. The mixture was stirred at −78 °C for another 10 minutes to give the corresponding cyclic imine solution in ether. The imine solution was then taken up by a syringe and added in one portion to the stirred lithium-enolate solution at −78 °C followed immediately by the addition of BF_3•OEt_2 (2.4 mmol, 2.4 equiv, 296 μL). Subsequently, the reaction vessel was taken out of the low temperature bath and stirred at room temperature for 2 h. The reaction mixture was then cooled to 0 °C and saturated $NaHCO_3$ aqueous solution (4 mL) was added. The resulting mixture was diluted with EtOAc (20 mL) and washed with saturated $NaHCO_3$ aqueous solution (20 mL). The aqueous layer was then extracted with EtOAc (3 x 20 mL) and the combined organic layers were dried over anhydrous Na_2SO_4. Solvent was then removed under reduced pressure and the residue purified by silica gel chromatography.

General Procedure C for the α-C–H Bond Functionalization of Unprotected Alicyclic Amines with 1,3-Diketone Dianions:

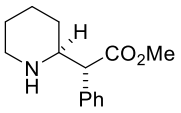
To a stirred solution of diisopropylamine (2 mmol, 2 equiv, 282 μL) in anhydrous THF (1.5 mL) was added dropwise *n*-BuLi in hexanes (2 mmol, 2 equiv) at −78 °C under nitrogen and the resulting solution was stirred at 0 °C for 10 min. To this was then added a solution of the corresponding 1,3-diketone (1 mmol, 1 equiv) in anhydrous THF (1.0 mL). The resulting mixture was stirred at 0 °C for 1 h and then cooled down to –78 °C. To a separate dry round-

bottom flask charged with the corresponding cyclic amine (2 mmol, 2 equiv) was added dry ether (1.5 mL). The solution was cooled to −78 °C and *n*-BuLi in hexanes (2 mmol, 2 equiv) was added dropwise. The mixture was stirred at the same temperature for 10 minutes, and a solution of trifluoroacetophenone (2.1 mmol, 2.1 equiv, 295 μL) in dry ether (1 mL) was then added dropwise. The mixture was stirred at −78 °C for another 10 minutes to give the corresponding cyclic imine solution in ether. The imine solution was then taken up by a syringe and added in one portion to the stirred lithium-enolate solution at −78 °C followed immediately by the addition of BF_3•OEt_2 (2.4 mmol, 2.4 equiv, 296 μL). The reaction mixture was stirred at the same temperature for 16 h after which saturated $NaHCO_3$ aqueous solution (4 mL) was added. Subsequently, the reaction vessel was taken out of the low temperature bath and stirred at room temperature for 10 h. The resulting mixture was diluted with EtOAc (20 mL) and washed with saturated $NaHCO_3$ aqueous solution (20 mL). The aqueous layer was then extracted with EtOAc (3 x 20 mL) and the combined organic layers were dried over anhydrous Na_2SO_4. Solvent was then removed under reduced pressure and the residue purified by silica gel chromatography.

General Procedure D for the α-C–H Bond Functionalization of Unprotected Alicyclic Amines with α,β-Unsaturated Ketone Enolates:

To a solution of diisopropylamine (1 mmol, 1 equiv, 141 μL) in anhydrous THF (1.5 mL) was added dropwise *n*-BuLi in hexanes (1 mmol, 1 equiv) at –78 °C under nitrogen and the resulting solution was stirred at the same temperature for 10 min. To this was then added a solution of the corresponding α,β-unsaturated ketone (1 mmol, 1 equiv) in anhydrous THF (1.0 mL). The resulting mixture was stirred at –78 °C for 30 min. To a separate dry round-bottom flask charged with the corresponding cyclic amine (2 mmol, 2 equiv) was added dry ether (1.5 mL). The solution was cooled to −78 °C and *n*-BuLi in hexanes (2 mmol, 2 equiv) was added dropwise. The mixture was stirred at the same temperature for 10 minutes, and a solution of trifluoroacetophenone (2.1 mmol, 2.1 equiv, 295 μL) in dry ether (1 mL) was then added dropwise. The mixture was stirred at −78 °C for another 10 minutes to give the corresponding cyclic imine solution in ether. The imine solution was then taken up by a syringe and added in one portion to the stirred lithium-enolate solution at −78 °C followed immediately by the addition of BF_3•OEt_2 (2.4 mmol, 2.4 equiv, 296 μL). The reaction vessel was taken out of the low temperature bath and stirred at room temperature for 2 h. The reaction mixture was then cooled to 0 °C and saturated $NaHCO_3$ aqueous solution (4 mL) was added and stirred at room temperature for 2–72 h. The resulting mixture was diluted with EtOAc (20 mL) and washed with saturated $NaHCO_3$ aqueous solution (20 mL). The aqueous layer was then extracted with EtOAc (3 x 20 mL) and the combined organic layers were dried over anhydrous Na_2SO_4. Solvent was then removed under reduced pressure and the residue purified by silica gel chromatography.

Methyl-(*R*)*-2-phenyl-2-((*S*)*-piperidin-2-yl)acetate



(±)-**1a'**

To a stirred solution of diisopropylamine (141 μL, 1 mmol, 1 equiv) in anhydrous THF (1.5 mL) was added dropwise a 2.5 M solution of *n*-BuLi in hexanes (400 μL, 1 mmol, 1 equiv) at −78 °C under nitrogen and the resulting solution was stirred at the same temperature for 10 min. To this was then added a solution of methyl phenylacetate (150 mg, 1 mmol, 1 equiv) in anhydrous THF (1.0 mL). The resulting mixture was stirred at –78 °C for 30 min. To a separate dry round-bottom flask charged with piperidine (197 μL, 2 mmol, 2 equiv) was added dry ether (1.5 mL). The solution was cooled to −78 °C and a 2.5 M solution of *n*-BuLi in hexanes (800 μL, 2 mmol, 2 equiv) was added dropwise. The mixture was stirred at the same temperature for 10 minutes, and a solution of trifluoroacetophenone (295 μL, 2.1 mmol, 2.1 equiv) in dry ether (1 mL) was then added dropwise. The mixture was stirred at −78 °C for another 10 minutes to give a solution of 1-piperideine in ether. The 1-piperideine solution was then taken up by a syringe and added in one portion to the stirred lithium-enolate solution at −78 °C followed immediately by the addition of BF_3•OEt_2 (296 μL, 2.4 mmol, 2.4 equiv). The reaction mixture was stirred at the same temperature for 30 min and then saturated $NaHCO_3$ aqueous solution (4 mL) was added. The reaction vessel was taken out of the low temperature bath and warmed up to room temperature. The resulting mixture was diluted with EtOAc (20 mL) and washed with saturated $NaHCO_3$ aqueous solution (20 mL). The aqueous layer was then extracted with EtOAc (3 x 20 mL) and the combined organic layers were dried over anhydrous Na_2SO_4. Solvent was then removed under reduced pressure and the residue purified by silica gel chromatography to yield (±)-**1a'** and (±)-**1a** in 89% combined yield (0.89 mmol, 207 mg) and 1.5:1 diastereomeric ratio. EtOAc containing methanol (1–9%) and isopropylamine (1%) was used as the eluent for silica gel chromatography. The major diastereomer was isolated as a clear oil.

Characterization data of the major diastereomer:

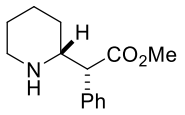
R_f = 0.40 in EtOAc/MeOH/*i*-$PrNH_2$ 90:9:1 v/v/v.

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 7.42–7.36 (comp, 2H), 7.35–7.29 (comp, 2H), 7.29–7.22 (m, 1H), 3.62 (s, 3H), 3.45 (d, *J* = 10.1 Hz, 1H), 3.09 (app td, *J* = 10.2, 2.1 Hz, 1H), 2.94–2.86 (m, 1H), 2.48 (app td, *J* = 11.5, 2.8 Hz, 1H), 1.83–1.74 (comp, 2H), 1.59–1.49 (comp, 2H), 1.48–1.30 (comp, 2H), 1.30–1.18 (m, 1H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 172.9, 135.9, 128.7, 128.5, 127.7, 58.9, 58.1, 51.7, 46.9, 30.9, 25.6, 24.3.

HRMS (ESI-TOF): Calculated for $C_{14}H_{20}NO_2$ $[M + H]^+$: 234.1489, Found: 234.1481.

Methyl-(*R*)*-2-phenyl-2-((*R*)*-piperidin-2-yl)acetate



(±)-**1a**

From the reaction shown above, the minor diastereomer was isolated as a clear oil.

Characterization data of the minor diastereomer:

$\mathbf{R_f}$ = 0.23 in EtOAc/MeOH/*i*-$PrNH_2$ 90:9:1 v/v/v.

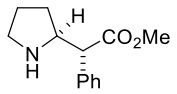
^{1}H-NMR (500 MHz, $CDCl_3$): δ = 7.34–7.22 (comp, 5H), 3.63 (s, 3H), 3.44 (d, *J* = 10.1 Hz, 1H), 3.12 (app td, *J* = 10.4, 2.6 Hz, 1H), 3.09–3.02 (m, 1H), 2.69 (td, *J* = 12.0, 2.8 Hz, 1H), 2.02 (brs, 1H), 1.72–1.62 (m, 1H), 1.61–1.52 (m, 1H), 1.43–1.31 (m, 1H), 1.29–1.14 (comp, 2H), 1.01–0.89 (m, 1H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 173.7, 136.4, 128.5, 128.4, 127.4, 58.8, 58.6, 51.8, 46.8, 29.9, 26.0, 24.3.

HRMS (ESI-TOF): Calculated for $C_{14}H_{20}NO_2$ $[M + H]^+$: 234.1489, Found: 234.1477.

(±)-**1a** was obtained as the major diastereomer using the following procedure: To a stirred solution of diisopropylamine (212 μL, 1.5 mmol, 1.5 equiv) in anhydrous THF (1.5 mL) under nitrogen was added dropwise a 2.5 M solution of *n*-BuLi in hexanes (600 μL, 1.5 mmol, 1.5 equiv) at −78 °C. The resulting solution was stirred at the same temperature for 10 min. To this was then added a solution of methyl phenylacetate (225 mg, 1.5 mmol, 1.5 equiv) in anhydrous THF (1.0 mL). The resulting mixture was stirred at –78 °C for 30 min. To a separate dry round-bottom flask charged with piperidine (99 μL, 1 mmol, 1 equiv) was added dry ether (1.5 mL). The resulting solution was cooled to −78 °C and a 2.5 M solution of *n*-BuLi in hexanes (400 μL, 1 mmol, 1 equiv) was added dropwise. The mixture was stirred at the same temperature for 10 minutes, and a solution of trifluoroacetophenone (147 μL, 1.05 mmol, 1.05 equiv) in dry ether (1 mL) was then added dropwise. The mixture was stirred at −78 °C for another 10 minutes to give a solution of 1-piperideine in ether. The lithium-enolate solution was then taken up by a syringe and added in one portion to the stirred 1-piperideine solution at −78 °C followed immediately by the addition of BF_3•OEt_2 (296 μL, 2.4 mmol, 2.4 equiv). Subsequently, the reaction vessel was taken out of the low temperature bath and stirred at room temperature for 2 h. The reaction mixture was then cooled to 0 °C and saturated aqueous $NaHCO_3$ solution (4 mL) was added. The resulting mixture was diluted with EtOAc (20 mL) and washed with saturated aqueous $NaHCO_3$ solution (20 mL). The aqueous layer was then extracted with EtOAc (3 x 20 mL) and the combined organic layers were dried over anhydrous Na_2SO_4. Solvent was then removed under reduced pressure and the residue purified by silica gel chromatography to yield (±)-**1a** and (±)-**1a'** in 66% combined yield (0.66 mmol, 154 mg) and 3.2:1 diastereomeric ratio. EtOAc containing methanol (1–9%) and isopropylamine (1%) was used as the eluent for silica gel chromatography. The major diastereomer was isolated as a clear oil.

Methyl-(*R*)*-2-phenyl-2-((*S*)*-pyrrolidin-2-yl)acetate



(±)-**1b**

Following general procedure A, compound (±)-**1b** was obtained from pyrrolidine (164 μL, 2 mmol) and methyl phenylacetate (150 mg, 1 mmol) in 46% combined yield (0.46 mmol, 101 mg) and 2.4:1 diastereomeric ratio (*erythro* : *threo*). Dichloromethane containing methanol (5–10%) followed by EtOAc containing methanol (1–20%) and isopropylamine (1%) was used as the eluent for silica gel chromatography. The major diastereomer was isolated as a clear oil.

Characterization data of the major diastereomer:

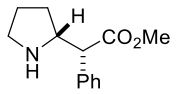
R_f = 0.37 in EtOAc/MeOH/*i*-$PrNH_2$ 90:9:1 v/v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.41–7.35 (comp, 2H), 7.35–7.22 (comp, 3H), 3.71–3.59 (comp, 4H), 3.50 (d, *J* = 9.9 Hz, 1H), 2.92 (ddd, *J* = 9.9, 7.7, 5.3 Hz, 1H), 2.76 (ddd, *J* = 9.9, 8.2, 6.8 Hz, 1H), 2.49 (s, 1H), 2.04 (dddd, *J* = 12.2, 8.9, 6.8, 5.0 Hz, 1H), 1.91–1.68 (comp, 2H), 1.48 (app ddt, *J* = 12.5, 9.5, 7.3 Hz, 1H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 173.2, 137.5, 128.8, 128.5, 127.7, 61.3, 57.5, 52.0, 45.8, 30.0, 24.5.

HRMS (ESI-TOF): Calculated for $C_{13}H_{18}NO_2$ $[M + H]^+$: 220.1332, Found: 220.1332.

Methyl-(*R*)*-2-phenyl-2-((*R*)*-pyrrolidin-2-yl)acetate



(±)-**1b'**

From the reaction shown above, the minor diastereomer was isolated as a clear oil.

Characterization data of the minor diastereomer:

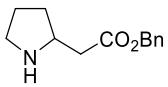
R_f = 0.11 in EtOAc/MeOH/*i*-$PrNH_2$ 90:9:1 v/v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.33–7.23 (comp, 5H), 3.79–3.68 (m, 1H), 3.65 (s, 3H), 3.42 (d, *J* = 10.3 Hz, 1H), 3.04–2.90 (comp, 2H), 2.28 (s, 1H), 1.82–1.70 (m, 1H), 1.70–1.58 (m, 1H), 1.57–1.46 (m, 1H), 1.26 (app ddt, *J* = 12.7, 9.0, 7.7 Hz, 1H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 174.2, 137.4, 128.8, 128.3, 127.6, 61.4, 59.0, 52.1, 46.7, 29.6, 25.2.

HRMS (ESI-TOF): Calculated for $C_{13}H_{18}NO_2$ $[M + H]^+$: 220.1332, Found: 220.1342.

Benzyl-2-(pyrrolidin-2-yl)acetate



(±)-**1c**

Following general procedure B, compound (±)-**1c** was obtained from pyrrolidine (164 μL, 2 mmol) and benzyl acetate (150 mg, 1 mmol) in 40% yield (0.40 mmol, 88 mg) as a colorless oil. EtOAc containing methanol (1–9%) and isopropylamine (1%) was used as the eluent for silica gel chromatography.

Characterization data:

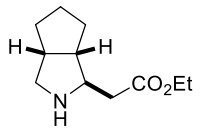
$\mathbf{R_f}$ = 0.16 in EtOAc/MeOH/*i*-$PrNH_2$ 90:9:1 v/v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.40–7.29 (comp, 5H), 5.16–5.10 (comp, 2H), 3.44 (app qd, *J* = 7.7, 5.5 Hz, 1H), 2.99 (ddd, *J* = 10.1, 7.6, 5.4 Hz, 1H), 2.88 (ddd, *J* = 10.1, 8.1, 6.7 Hz, 1H), 2.69–2.40 (comp, 2H), 2.28–2.12 (m, 1H), 1.92 (dddd, *J* = 12.1, 8.7, 7.0, 4.9 Hz, 1H), 1.84–1.59 (comp, 2H), 1.35 (app ddt, *J* = 12.3, 9.2, 7.5 Hz, 1H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 172.3, 136.0, 128.6, 128.2, 66.2, 54.9, 46.4, 41.0, 31.2, 25.0.

HRMS (ESI-TOF): Calculated for $C_{13}H_{18}NO_2$ $[M + H]^+$: 220.1332, Found: 220.1343.

Ethyl-2-((1*R,3a*R**,6a*S**)-octahydrocyclopenta[*c*]pyrrol-1-yl)acetate**



(±)-**1d**

Following general procedure A, compound (±)-**1d** was obtained from octahydrocyclopenta[*c*]pyrrole (222 mg, 2 mmol) and ethyl acetate (98 μL, 1 mmol) in 32% yield (0.32 mmol, 63 mg) as a colorless oil in >20:1 diastereomeric ratio. EtOAc containing methanol (1–9%) and isopropylamine (1%) was used as the eluent for silica gel chromatography.

Characterization data:

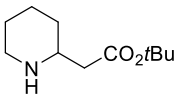
R_f = 0.26 in EtOAc/MeOH/*i*-$PrNH_2$ 90:9:1 v/v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 4.10 (q, *J* = 7.1 Hz, 2H), 3.21 (ddd, *J* = 10.1, 8.2, 0.6 Hz, 1H), 2.84 (ddd, *J* = 8.8, 7.3, 4.4 Hz, 1H), 2.66–2.48 (comp, 2H), 2.46–2.33 (comp, 2H), 2.26 (s, 1H), 2.14–2.03 (m, 1H), 1.63–1.45 (comp, 4H), 1.43–1.32 (comp, 2H), 1.22 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 172.7, 62.3, 60.4, 53.5, 49.7, 43.7, 40.1, 31.8, 30.9, 25.3, 14.3.

HRMS (ESI-TOF): Calculated for $C_{11}H_{20}NO_2$ $[M + H]^+$: 198.1489, Found: 198.1488.

***tert*-Butyl-2-(piperidin-2-yl)acetate**



(±)-**1e**

Following general procedure B, compound (±)-**1e** was obtained from piperidine (197 μL, 2 mmol) and *tert*-butyl acetate (116 mg, 1 mmol) in 30% yield (0.3 mmol, 60 mg) as a colorless oil. Dichloromethane containing methanol (1–10%) was used as the eluent for silica gel chromatography.

Characterization data:

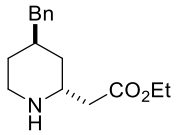
$\mathbf{R_f}$ = 0.55 in CH_2Cl_2/MeOH 90:10 v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 3.34–3.22 (m, 1H), 3.13–3.00 (m, 1H), 2.88 (dddd, *J* = 10.4, 7.7, 5.7, 2.6 Hz, 1H), 2.65 (app td, *J* = 11.8, 2.8 Hz, 1H), 2.37–2.26 (comp, 2H), 1.89–1.70 (m, 1H), 1.68–1.53 (comp, 2H), 1.48–1.28 (comp, 11H), 1.18 (app tdd, *J* = 12.5, 10.8, 3.7 Hz, 1H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 171.7, 80.7, 53.5, 46.7, 42.4 32.1, 28.2 25.7, 24.5

HRMS (ESI-TOF): Calculated for $C_{11}H_{22}NO_2$ $[M + H]^+$: 200.1645, Found: 200.1642.

Ethyl-2-((2*R,4*R**)-4-benzylpiperidin-2-yl)acetate**



(±)-**1f**

Following general procedure A, compound (±)-**1f** was obtained from 4-benzylpiperidine (351 μL, 2 mmol) and ethyl acetate (98 μL, 1 mmol) in 92% yield (0.92 mmol, 240 mg) as a colorless oil in >20:1 diastereomeric ratio. EtOAc containing methanol (1–19%) and isopropylamine (1%) was used as the eluent for silica gel chromatography.

Characterization data:

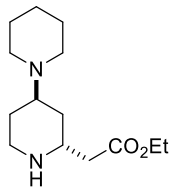
$\mathbf{R_f}$ = 0.16 in EtOAc/MeOH/*i*-$PrNH_2$ 80:19:1 v/v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.30–7.21 (comp, 2H), 7.21–7.07 (comp, 3H), 4.11 (q, *J* = 7.1 Hz, 2H), 3.43–3.33 (m, 1H), 2.96–2.85 (m, 1H), 2.85–2.75 (m, 1H), 2.65 (d, *J* = 7.8 Hz, 2H), 2.56–2.42 (m, 1H), 2.35–2.25 (m, 1H), 2.10 (brs, 1H), 2.03–1.95 (m, 1H), 1.69–1.57 (m, 1H), 1.52–1.37 (comp, 2H), 1.41–1.28 (m, 1H), 1.23 (t, *J* = 7.2 Hz, 3H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 172.2, 140.6, 128.8, 128.0, 125.6, 60.1, 48.1, 40.5, 39.9, 39.2, 35.8, 33.2, 30.5, 14.0.

HRMS (ESI-TOF): Calculated for $C_{16}H_{24}NO_2$ $[M + H]^+$: 262.1802, Found: 262.1789.

Ethyl-2-((2'*R,4'*R**)-[1,4'-bipiperidin]-2'-yl)acetate**



(±)-**1g**

Following general procedure A, compound (±)-**1g** was obtained from 1,4'-bipiperidine (336.3 mg, 2 mmol) and ethyl acetate (98 μL, 1 mmol) in 42% yield (0.42 mmol, 107 mg) as a colorless oil in >20:1 diastereomeric ratio. EtOAc containing methanol (1–9%) and isopropylamine (1%) was used as the eluent for silica gel chromatography.

Characterization data:

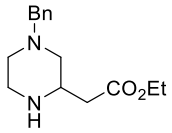
$\mathbf{R_f}$ = 0.18 in EtOAc/MeOH/*i*-$PrNH_2$ 80:19:1 v/v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 4.05 (q, *J* = 7.2 Hz, 2H), 3.47 (app dtd, *J* = 9.3, 5.6, 4.2 Hz, 1H), 2.90 (ddd, *J* = 12.2, 6.2, 4.5 Hz, 1H), 2.68 (ddd, *J* = 12.0, 7.3, 4.4 Hz, 1H), 2.51 (dd, *J* = 15.5, 9.0 Hz, 1H), 2.42–2.30 (comp, 5H), 2.26 (dd, *J* = 15.6, 5.1 Hz, 1H), 2.10–1.84 (m, 1H), 1.75 (ddd, *J* = 12.9, 8.6, 4.1 Hz, 1H), 1.63–1.53 (comp, 2H), 1.53–1.37 (comp, 5H), 1.37–1.29 (comp, 2H), 1.17 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 172.4, 60.3, 57.7, 50.5, 48.7, 40.4, 38.3, 33.6, 28.8, 26.4, 24.7, 14.2.

HRMS (ESI-TOF): Calculated for $C_{14}H_{27}N_2O_2$ $[M + H]^+$: 255.2067, Found: 255.2070.

Ethyl-2-(4-benzylpiperazin-2-yl)acetate



(±)-**1h**

Following general procedure A, compound (±)-**1h** was obtained from 1-benzylpiperazine (348 μL, 2 mmol) and ethyl acetate (98 μL, 1 mmol) in 66% yield (0.66 mmol, 172 mg) as a colorless oil. EtOAc containing methanol (1–9%) and isopropylamine (1%) was used as the eluent for silica gel chromatography.

Characterization data:

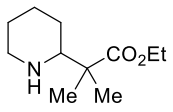
R_f = 0.15 in EtOAc/MeOH/*i*-$PrNH_2$ 90:9:1 v/v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.33–7.23 (comp, 4H), 7.26–7.16 (m, 1H), 4.09 (q, *J* = 7.1 Hz, 2H), 3.53–3.41 (comp, 2H), 3.16 (dddd, *J* = 10.1, 7.9, 5.4, 2.7 Hz, 1H), 2.97–2.84 (comp, 2H), 2.74–2.66 (comp, 2H), 2.55 (s, 1H), 2.43–2.20 (comp, 2H), 2.15–2.03 (m, 1H), 1.86–1.76 (m, 1H), 1.20 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 171.7, 137.8, 128.8, 128.0, 126.8, 63.0, 60.2, 58.6, 53.3, 51.3, 45.1, 38.5, 14.0.

HRMS (ESI-TOF): Calculated for $C_{15}H_{23}N_2O_2$ $[M + H]^+$: 263.1754, Found: 263.1746.

Ethyl-2-methyl-2-(piperidin-2-yl)propanoate



(±)-**1i**

Following general procedure B, compound (±)-**1i** was obtained from piperidine (197 μL, 2 mmol) and ethyl isobutyrate (116 mg, 1 mmol) in 30% yield (0.30 mmol, 60 mg) as a colorless oil. Dichloromethane containing methanol (1–10%) was used as the eluent for silica gel chromatography.

Characterization data:

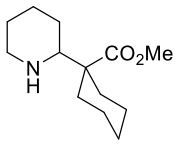
$\mathbf{R_f}$ = 0.51 in CH_2Cl_2/MeOH 90:10 v/v.

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 4.18–4.05 (comp, 2H), 3.08 (app dq, *J* = 12.3, 2.1 Hz, 1H), 2.73–2.52 (comp, 2H), 1.85–1.78 (m, 1H), 1.69 (s, 1H), 1.61–1.50 (comp, 2H), 1.41–1.27 (comp, 2H), 1.23 (t, *J* = 7.1, 3H), 1.15–1.06 (comp, 7H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 177.5, 63.4, 60.4, 47.8, 46.1, 27.2, 26.8, 25.2, 22.2, 21.1, 14.2.

HRMS (ESI-TOF): Calculated for $C_{11}H_{22}NO_2$ $[M + H]^+$: 200.1645, Found: 200.1644.

Methyl-1-(piperidin-2-yl)cyclohexane-1-carboxylate



(±)-**1j**

Following general procedure B, compound (±)-**1j** was obtained from piperidine (197 μL, 2 mmol) and methyl cyclohexanecarboxylate (142 mg, 1 mmol) in 62% yield (0.62 mmol, 140 mg) as a colorless oil. Dichloromethane containing methanol (1–10%) was used as the eluent for silica gel chromatography.

Characterization data:

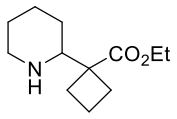
$\mathbf{R_f}$ = 0.44 in CH_2Cl_2/MeOH 90:10 v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 3.68 (s, 3H), 3.22–3.05 (m, 1H), 2.84–2.50 (comp, 2H), 2.46 (dd, *J* = 11.4, 2.3 Hz, 1H), 2.18–2.02 (comp, 2H), 1.84–1.75 (m, 1H), 1.66–1.47 (comp, 5H), 1.41–1.17 (comp, 6H), 1.17–1.00 (comp, 2H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 175.8, 64.6, 51.6, 51.4, 47.9, 31.2, 31.0, 27.5, 26.5, 25.9, 25.2, 23.6.

HRMS (ESI-TOF): Calculated for $C_{13}H_{24}NO_2$ $[M + H]^+$: 226.1802, Found: 226.1807.

Ethyl-1-(piperidin-2-yl)cyclobutane-1-carboxylate



(±)-**1k**

Following general procedure B, compound (±)-**1k** was obtained from piperidine (197 μL, 2 mmol) and ethyl cyclobutanecarboxylate (128 mg, 1 mmol) in 52% yield (0.52 mmol, 110 mg) as a colorless oil. Dichloromethane containing methanol (1–10%) was used as the eluent for silica gel chromatography.

Characterization data:

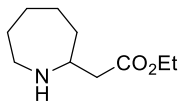
$\mathbf{R_f}$ = 0.42 in CH_2Cl_2/MeOH 90:10 v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 4.12 (q, *J* = 7.1 Hz, 2H), 3.16–3.05 (m, 1H), 2.81–2.63 (comp, 2H), 2.57 (app ddt, *J* = 12.3, 9.7, 2.9 Hz, 1H), 2.39–2.23 (comp, 2H), 2.23–2.11 (m, 1H), 2.01 (app dddt, *J* = 11.9, 9.4, 6.7, 1.2 Hz, 1H), 1.89–1.67 (comp, 3H), 1.63–1.56 (m, 1H), 1.56–1.46 (m, 1H), 1.37–1.25 (comp, 2H), 1.21 (t, *J* = 7.1 Hz, 3H), 1.07 (app tdd, *J* = 12.6, 11.3, 3.7 Hz, 1H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 176.3, 62.3, 60.5, 51.4, 47.5, 27.9, 27.4, 26.9, 26.4, 24.9, 15.8, 14.3.

HRMS (ESI-TOF): Calculated for $C_{12}H_{22}NO_2$ $[M + H]^+$: 212.1645, Found: 212.1649.

Ethyl-2-(azepan-2-yl)acetate



(±)-**1l**

Following general procedure A, compound (±)-**1l** was obtained from azepane (225 μL, 2 mmol) and ethyl acetate (98 μL, 1 mmol) in 52% yield (0.52 mmol, 96 mg) as a colorless oil. EtOAc containing methanol (1–9%) and isopropylamine (1%) was used as the eluent for silica gel chromatography.

Characterization data:

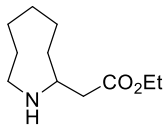
R_f = 0.16 in EtOAc/MeOH/*i*-PrNH$_2$ 90:9:1 v/v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 4.11 (q, *J* = 7.1 Hz, 2H), 3.12 (dddd, *J* = 9.6, 7.6, 5.8, 4.0 Hz, 1H), 2.99–2.89 (m, 1H), 2.77–2.64 (m, 1H), 2.44–2.29 (comp, 3H), 1.83–1.68 (m, 1H), 1.72–1.54 (comp, 4H), 1.54–1.46 (comp, 2H), 1.49–1.29 (m, 1H), 1.23 (t, *J* = 7.2 Hz, 3H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 172.4, 60.3, 55.5, 46.8, 42.3, 36.2, 31.0, 27.2, 25.5, 14.2.

HRMS (ESI-TOF): Calculated for $C_{10}H_{20}NO_2$ $[M + H]^+$: 186.1489, Found: 186.1497.

Ethyl-2-(azocan-2-yl)acetate



(±)-**1m**

Following general procedure A, compound (±)-**1m** was obtained from azocane (253 μL, 2 mmol) and ethyl acetate (98 μL, 1 mmol) in 51% yield (0.51 mmol, 102 mg) as a colorless oil. EtOAc containing methanol (1–9%) and isopropylamine (1%) was used as the eluent for silica gel chromatography.

Characterization data:

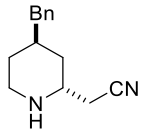
$\mathbf{R_f}$ = 0.18 in EtOAc/MeOH/*i*-$PrNH_2$ 90:9:1 v/v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 4.13 (q, *J* = 7.1 Hz, 2H), 3.24–3.12 (m, 1H), 3.02–2.91 (m, 1H), 2.77–2.66 (m, 1H), 2.43–2.28 (comp, 2H), 1.95 (brs, 1H), 1.75–1.57 (comp, 6H), 1.57–1.45 (comp, 3H), 1.44–1.32 (m, 1H), 1.25 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 172.6, 60.2, 54.1, 46.7, 42.5, 33.6, 29.3, 27.6, 25.3, 24.0, 14.2.

HRMS (ESI-TOF): Calculated for $C_{11}H_{22}NO_2$ $[M + H]^+$: 200.1645, Found: 200.1638.

2-((2*R,4*R**)-4-Benzylpiperidin-2-yl)acetonitrile**



(±)-**2a**

Following general procedure A, compound (±)-**2a** was obtained from 4-benzylpiperidine (351 μL, 2 mmol) and acetonitrile (52 μL, 1 mmol) in 43% yield (0.43 mmol, 92 mg) as a colorless oil and in >20:1 diastereomeric ratio. EtOAc containing methanol (1–9%) and isopropylamine (1%) was used as the eluent for silica gel chromatography.

Characterization data:

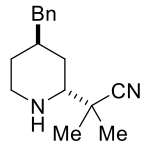
$\mathbf{R_f}$ = 0.22 in EtOAc/MeOH/*i*-$PrNH_2$ 90:10:1 v/v/v

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.37–7.27 (comp, 2H), 7.27–7.19 (m, 1H), 7.19–7.12 (comp, 2H), 3.37 (app dtd, *J* = 7.8, 6.1, 4.3 Hz, 1H), 2.97 (ddd, *J* = 12.6, 8.1, 3.6 Hz, 1H), 2.84 (ddd, *J* = 12.6, 7.0, 3.8 Hz, 1H), 2.71–2.63 (comp, 2H), 2.56 (dd, *J* = 16.7, 8.0 Hz, 1H), 2.43 (dd, *J* = 16.7, 5.8 Hz, 1H), 2.08–1.97 (comp, 2H), 1.77–1.62 (m, 1H), 1.65–1.50 (comp, 2H), 1.43–1.31 (m, 1H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 140.1, 128.9, 128.3, 126.0, 118.2, 48.6, 40.5, 40.2, 35.4, 33.0, 30.4, 23.1.

HRMS (ESI-TOF): Calculated for $C_{14}H_{19}N_2$ $[M + H]^+$: 215.1543, Found: 215.1524.

2-((2*R,4*R**)-4-Benzylpiperidin-2-yl)-2-methylpropanenitrile**



(±)-**2b**

Following general procedure B, compound (±)-**2b** was obtained from 4-benzylpiperidine (351 μL, 2 mmol) and isobutyronitrile (69 mg, 1 mmol) in 45% yield (0.45 mmol, 109 mg) and 10:1 diastereomeric ratio. EtOAc containing methanol (1–9%) and isopropylamine (1%) was used as the eluent for silica gel chromatography. The major diastereomer was obtained as a colorless oil.

Characterization data of the major diastereomer:

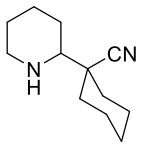
$\mathbf{R_f}$ = 0.28 in Hexanes/EtOAc 50:50 v/v/.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.33–7.26 (comp, 2H), 7.23–7.17 (m, 1H), 7.16–7.12 (comp, 2H), 3.04–2.90 (comp, 2H), 2.84–2.70 (comp, 3H), 2.32–2.22 (m, 1H), 1.81–1.39 (comp, 5H), 1.36 (s, 3H), 1.28 (s, 3H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 140.9, 129.0, 128.5, 126.1, 124.4, 57.7, 42.0, 37.7, 37.3, 33.7, 30.6, 29.5, 24.1, 23.0.

HRMS (ESI-TOF): Calculated for $C_{16}H_{23}N_2$ $[M + H]^+$: 243.1856, Found: 243.1848.

1-(Piperidin-2-yl)cyclohexane-1-carbonitrile



(±)-**2c**

Following general procedure B, compound (±)-**2c** was obtained from piperidine (197 μL, 2 mmol) and cyclohexanecarbonitrile (109 mg, 1 mmol) in 58% yield (0.58 mmol, 111 mg) as a colorless oil. Dichloromethane followed by hexanes containing EtOAc (40–90%) was used as the eluent for silica gel chromatography.

Characterization data:

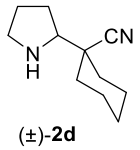
$\mathbf{R_f}$ = 0.33 in Hexanes/EtOAc 30:70 v/v/.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 3.17–3.05 (m, 1H), 2.57 (app td, *J* = 12.1, 2.8 Hz, 1H), 2.40 (dd, *J* = 10.8, 2.5 Hz, 1H), 2.09 (ddd, *J* = 13.3, 3.7, 2.1 Hz, 1H), 1.99–1.91 (m, 1H), 1.90–1.84 (m, 1H), 1.83–1.68 (comp, 4H), 1.66–1.51 (comp, 3H), 1.47–1.40 (m, 1H), 1.40–1.18 (comp, 5H), 1.18–1.03 (m, 1H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 122.8, 63.3, 47.5, 44.2, 32.6, 31.9, 27.8, 26.6, 25.5, 24.8, 23.1, 23.1.

HRMS (ESI-TOF): Calculated for $C_{12}H_{21}N_2$ $[M + H]^+$: 193.1699, Found: 193.1682.

1-(Pyrrolidin-2-yl)cyclohexane-1-carbonitrile



(±)-**2d**

Following general procedure A, compound (±)-**2d** was obtained from pyrrolidine (164 μL, 2 mmol) and cyclohexanecarbonitrile (109 mg, 1 mmol) in 54% yield (0.54 mmol, 96 mg) as a colorless oil. Dichloromethane followed by hexanes containing EtOAc (60–100%) was used as the eluent for silica gel chromatography.

Characterization data:

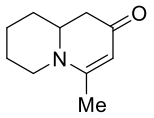
$\mathbf{R_f}$ = 0.42 in EtOAc/MeOH/*i*-$PrNH_2$ 90:9:1 v/v/v.

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 3.09–2.83 (comp, 3H), 2.19–2.08 (m, 1H), 1.98–1.79 (comp, 4H), 1.77–1.49 (comp, 7H), 1.30–1.21 (comp, 2H), 1.15 (app tdd, *J* = 12.4, 8.7, 3.7 Hz, 1H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 123.0, 65.8, 47.1, 45.2, 33.7, 33.1, 28.0, 26.1, 25.5, 23.0.

HRMS (ESI-TOF): Calculated for $C_{11}H_{19}N_2$ $[M + H]^+$: 179.1543, Found: 179.1530.

4-Methyl-1,6,7,8,9,9a-hexahydro-2*H*-quinolizin-2-one



(±)-**3a**

Following general procedure C, compound (±)-**3a** was obtained from piperidine (197 μL, 2 mmol) and acetylacetone (103 μL, 1 mmol) as a clear oil in 55% yield (0.55 mmol, 91 mg). EtOAc containing methanol (1–9%) was used as the eluent for silica gel chromatography.

Characterization data:

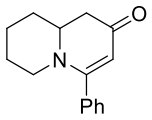
R_f = 0.14 in EtOAc.

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 4.94 (s, 1H), 3.78–3.70 (m, 1H), 3.36–3.26 (m, 1H), 2.77 (app td, *J* = 12.8, 2.9 Hz, 1H), 2.47 (dd, *J* = 16.4, 5.8 Hz, 1H), 2.25 (dd, *J* = 16.4, 10.6 Hz, 1H), 1.94 (s, 3H), 1.85–1.77 (m, 1H), 1.75–1.68 (m, 1H), 1.68–1.53 (comp, 2H), 1.53–1.34 (comp, 2H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 190.7, 162.5, 101.1, 58.0, 47.6, 42.4, 30.9, 25.2, 23.2, 20.7.

HRMS (ESI-TOF): Calculated for $C_{10}H_{16}NO$ $[M + H]^+$: 166.1226, Found: 166.1235.

4-Phenyl-1,6,7,8,9,9a-hexahydro-2*H*-quinolizin-2-one



(±)-**3b**

Following general procedure C, compound (±)-**3b** was obtained from piperidine (197 μL, 2 mmol) and 1-phenyl-1,3-butanedione (162 mg, 1 mmol) as a yellow solid in 56% yield (0.56 mmol, 127 mg). Hexanes containing EtOAc (15–50%) was used as the eluent for silica gel chromatography.

Characterization data:

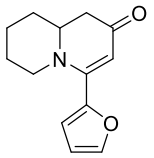
$\mathbf{R_f}$ = 0.31 in hexane/EtOAc 75:25 v/v.

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 7.38–7.29 (comp, 3H), 7.28–7.19 (comp, 2H), 5.01 (s, 1H), 3.54–3.47 (m, 1H), 3.43 (ddd, *J* = 14.2, 11.1, 6.1 Hz, 1H), 2.60–2.51 (comp, 2H), 2.39 (dd, *J* = 16.3, 11.1 Hz, 1H), 1.86–1.75 (m, 1H), 1.75–1.67 (comp, 2H), 1.56–1.47 (m, 1H), 1.47–1.33 (comp, 2H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 191.3, 165.8, 136.6, 128.8, 128.4, 126.8, 103.1, 58.4, 50.2, 42.5, 31.2, 25.8, 23.7.

HRMS (ESI-TOF): Calculated for $C_{15}H_{18}NO$ $[M + H]^+$: 228.1383, Found: 228.1374.

4-(Furan-2-yl)-1,6,7,8,9,9a-hexahydro-2*H*-quinolizin-2-one



(±)-**3c**

Following general procedure C, compound (±)-**3c** was obtained from piperidine (197 μL, 2 mmol) and 1-(furan-2-yl)butane-1,3-dione (152 mg, 1 mmol) as a light brown solid in 39% yield (0.39 mmol, 85 mg). Hexanes containing EtOAc (50–90%) was used as the eluent for silica gel chromatography.

Characterization data:

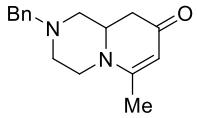
R_f = 0.34 in hexane/EtOAc 25:75 v/v.

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 7.51–7.47 (m, 1H), 6.56 (dd, J = 3.3, 1.0 Hz, 1H), 6.44 (dd, J = 3.4, 1.8 Hz, 1H), 5.29 (s, 1H), 3.87–3.79 (m, 1H), 3.50–3.40 (m, 1H), 2.78 (app td, *J* = 12.7, 2.9 Hz, 1H), 2.54 (dd, *J* = 16.4, 5.6 Hz, 1H), 2.40 (dd, *J* = 16.3, 11.5 Hz, 1H), 1.90–1.80 (m, 1H), 1.79–1.64 (comp, 3H), 1.59 (app ddt, *J* = 16.7, 12.9, 6.6 Hz, 1H), 1.53–1.41 (m, 1H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 192.1, 154.3, 148.7, 143.5, 112.2, 111.3, 103.1, 58.8, 50.4, 42.5, 31.3, 25.8, 23.6.

HRMS (ESI-TOF): Calculated for $C_{13}H_{16}NO_2$ $[M + H]^+$: 218.1176, Found: 218.1168.

2-Benzyl-6-phenyl-1,2,3,4,9,9a-hexahydro-8*H*-pyrido[1,2-*a*]pyrazin-8-one



(±)-**3d**

Following general procedure C, compound (±)-**3d** was obtained from 1-benzylpiperazine (348 μL, 2 mmol) and acetylacetone (103 μL, 1 mmol) as a brown oil in 50% yield (0.50 mmol, 128 mg). EtOAc containing methanol (5–20%) was used as the eluent for silica gel chromatography.

Characterization data:

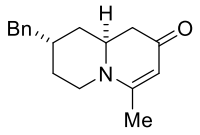
R_f = 0.37 in EtOAc/methanol 90:10 v/v.

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 7.37–7.25 (comp, 5H), 5.03 (s, 1H), 3.59 (app dt, *J* = 12.5, 2.6 Hz, 1H), 3.57–3.46 (comp, 3H), 3.03 (app td, *J* = 12.2, 3.1 Hz, 1H), 2.92–2.85 (comp, 2H), 2.37–2.26 (comp, 2H), 2.19 (app td, *J* = 11.9, 3.2 Hz, 1H), 2.14–2.03 (m, 1H), 1.97 (s, 3H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 191.2, 163.2, 137.3, 129.0, 128.4, 127.4, 102.7, 62.5, 58.4, 56.7, 52.3, 46.4, 40.3, 20.8.

HRMS (ESI-TOF): Calculated for $C_{16}H_{21}N_2O$ $[M + H]^+$: 257.1648, Found: 257.1659.

(8*S,9a*S**)-8-Benzyl-4-methyl-1,6,7,8,9,9a-hexahydro-2*H*-quinolizin-2-one**



(±)-**3e**

Following general procedure C, compound (±)-**3e** was obtained from 4-benzylpiperidine (351 µL, 2 mmol) and acetylacetone (103 µL, 1 mmol) as a yellow oil in 56% yield (0.56 mmol, 144 mg) and in >20:1 diastereomeric ratio. EtOAc containing methanol (1–10%) was used as the eluent for silica gel chromatography.

Characterization data:

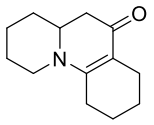
R_f = 0.26 in EtOAc.

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 7.34–7.25 (comp, 2H), 7.24–7.17 (m, 1H), 7.17–7.08 (comp, 2H), 5.02 (s, 1H), 3.64 (app tdd, *J* = 12.1, 5.3, 3.3 Hz, 1H), 3.57 (ddd, *J* = 13.2, 4.9, 2.7 Hz, 1H), 3.13 (app td, *J* = 13.2, 3.2 Hz, 1H), 2.75 (d, *J* = 8.1 Hz, 2H), 2.37 (dd, *J* = 16.4, 5.3 Hz, 1H), 2.27 (dd, *J* = 16.4, 12.3 Hz, 1H), 2.23–2.16 (m, 1H), 1.99 (s, 3H), 1.83–1.69 (comp, 2H), 1.66–1.55 (comp, 2H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 191.4, 163.3, 140.1, 128.8, 128.5, 126.2, 102.2, 52.9, 43.1, 42.2, 36.8, 34.9, 32.2, 28.4, 21.1.

HRMS (ESI-TOF): Calculated for $C_{17}H_{22}NO$ $[M + H]^+$: 256.1696, Found: 256.1680.

1,2,3,4,4a,5,7,8,9,10-Decahydro-6*H*-pyrido[1,2-*a*]quinolin-6-one



(±)-**3f**

Following general procedure C, compound (±)-**3f** was obtained from piperidine (197 μL, 2 mmol) and 2-acetylcyclohexan-1-one (130 μL, 1 mmol) as a yellow solid in 60% yield (0.60 mmol, 122 mg). Hexanes containing EtOAc (66–80%) was used as the eluent for silica gel chromatography.

Characterization data:

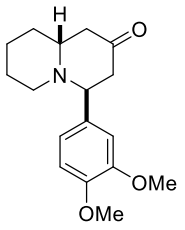
R_f = 0.34 in hexane/EtOAc 25:75 v/v.

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 3.83–3.75 (m, 1H), 3.15 (app tdd, *J* = 11.6, 5.1, 3.2 Hz, 1H), 2.57 (app td, *J* = 12.7, 2.8 Hz, 1H), 2.44 (dd, *J* = 16.3, 5.1 Hz, 1H), 2.38–2.11 (comp, 5H), 1.82–1.65 (comp, 3H), 1.65–1.56 (comp, 2H), 1.56–1.43 (comp, 3H), 1.43–1.30 (comp, 2H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 191.2, 160.6, 109.3, 58.1, 47.0, 43.0, 31.5, 27.6, 25.7, 23.6, 22.6, 21.9, 21.6.

HRMS (ESI-TOF): Calculated for $C_{13}H_{20}NO$ $[M + H]^+$: 206.1539, Found: 206.1548.

(4*S,9a*R**)-4-(3,4-Dimethoxyphenyl)octahydro-2*H*-quinolizin-2-one**



(±)-**4a**

Following general procedure D, compound (±)-**4a** was obtained from piperidine (197 μL, 2 mmol) and 3,4-dimethoxybenzylideneacetone (206 mg, 1 mmol) in 63% yield (0.63 mmol, 180 mg) and 5:1 diastereomeric ratio (*cis* : *trans*). Hexanes containing EtOAc (75–80%) was used as the eluent for silica gel chromatography. The major diastereomer was isolated as a yellow solid.

Note - After addition of saturated $NaHCO_3$ aqueous solution, the reaction mixture was stirred for 10 h.

Characterization data of the major diastereomer:

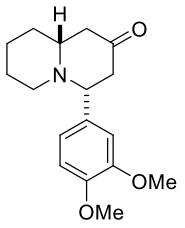
$\mathbf{R_f}$ = 0.16 in hexane/EtOAc 25:75 v/v.

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 6.80 (d, *J* = 8.5 Hz, 1H), 6.70–6.64 (comp, 2H), 4.23 (dd, *J* = 6.4, 4.0 Hz, 1H), 3.86 (s, 3H), 3.85 (s, 3H), 2.94–2.83 (comp, 3H), 2.65–2.53 (comp, 2H), 2.41–2.33 (m, 1H), 2.24–2.15 (m, 1H), 1.72–1.64 (m, 1H), 1.64–1.55 (comp, 2H), 1.54–1.47 (m, 1H), 1.46–1.35 (m, 1H), 1.27–1.13 (m, 1H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 209.7, 148.7, 148.4, 131.5, 120.9, 111.7, 110.6, 63.9, 55.9, 55.8, 54.3, 51.3, 47.6, 46.8, 31.9, 24.0, 23.4.

HRMS (ESI-TOF): Calculated for $C_{17}H_{24}NO_3$ $[M + H]^+$: 290.1751, Found: 290.1742.

(4*R,9a*R**)-4-(3,4-Dimethoxyphenyl)octahydro-2*H*-quinolizin-2-one**



(±)-**4a'**

From the reaction shown above, the minor diastereomer was isolated as a yellow solid.

Characterization data of the minor diastereomer:

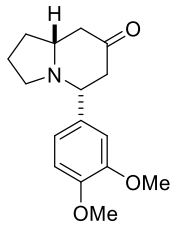
R_f = 0.40 in hexane/EtOAc 25:75 v/v

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 6.92–6.88 (m, 1H), 6.86–6.77 (comp, 2H), 3.89 (s, 3H), 3.86 (s, 3H), 3.19 (dd, *J* = 12.9, 2.4 Hz, 1H), 2.81–2.74 (m, 1H), 2.71–2.62 (m, 1H), 2.53–2.45 (m, 1H), 2.43–2.36 (m, 1H), 2.35–2.25 (comp, 2H), 1.76–1.60 (comp, 3H), 1.58–1.39 (comp, 3H), 1.32–1.20 (m, 1H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 207.9, 149.3, 148.3, 135.2, 119.5, 111.0, 109.8, 70.0, 62.4, 56.0, 55.9, 52.8, 50.9, 48.7, 34.3, 25.8, 24.2.

HRMS (ESI-TOF): Calculated for $C_{17}H_{24}NO_3$ $[M + H]^+$: 290.1751, Found: 290.1721.

(5*R,8a*R**)-5-(3,4-Dimethoxyphenyl)hexahydroindolizin-7(1*H*)-one**



(±)-**4b**

Following general procedure D, compound (±)-**4b** was obtained from pyrrolidine (164 μL, 2 mmol) and 3,4-dimethoxybenzylideneacetone (206 mg, 1 mmol) as a yellow oil in 34% yield (0.34 mmol, 93 mg) and >20:1 diastereomeric ratio. Hexanes containing EtOAc (33–66%) was used as the eluent for silica gel chromatography.

Note - After addition of saturated $NaHCO_3$ aqueous solution, the reaction mixture was stirred for 10 h.

Characterization data:

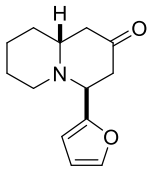
$\mathbf{R_f}$ = 0.23 in hexane/EtOAc 50:50 v/v

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 6.95 (d, *J* = 2.0 Hz, 1H), 6.89 (dd, *J* = 8.2, 2.0 Hz, 1H), 6.84 (d, *J* = 8.2 Hz, 1H), 3.92 (s, 3H), 3.89 (s, 3H), 3.27 (dd, *J* = 11.5, 3.5 Hz, 1H), 2.89–2.81 (m, 1H), 2.67–2.57 (comp, 2H), 2.52–2.37 (comp, 3H), 2.11–1.91 (comp, 2H), 1.91–1.82 (m, 1H), 1.82–1.72 (m, 1H), 1.72–1.59 (m, 1H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 208.8, 149.2, 148.5, 134.9, 119.3, 111.0, 109.8, 66.6, 64.0, 56.0, 55.9, 51.5, 49.9, 47.3, 31.1, 21.5.

HRMS (ESI-TOF): Calculated for $C_{16}H_{22}NO_3$ $[M + H]^+$: 276.1594, Found: 276.1602.

(4*S,9a*R**)-4-(Furan-2-yl)octahydro-2*H*-quinolizin-2-one**



(±)-**4c**

Following general procedure D, compound (±)-**4c** was obtained from piperidine (197 μL, 2 mmol) and (*E*)-4-(furan-2-yl)but-3-en-2-one (136 mg, 1 mmol) in 51% yield (0.51 mmol, 112 mg) and 4:1 diastereomeric ratio (*cis* : *trans*). Hexanes containing EtOAc (33–66%) was used as the eluent for silica gel chromatography. The major diastereomer was isolated as a yellow oil.

Note - After addition of saturated $NaHCO_3$ aqueous solution, the reaction mixture was stirred for 10 h.

Characterization data of the major diastereomer:

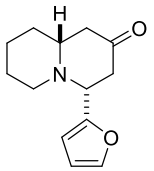
R_f = 0.27 in hexane/EtOAc 50:50 v/v

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 7.34 (d, *J* = 1.8 Hz, 1H), 6.29 (dd, *J* = 3.2, 1.8 Hz, 1H), 6.08 (d, *J* = 3.2 Hz, 1H), 4.25 (dd, *J* = 7.0, 1.9 Hz, 1H), 2.95 (dd, *J* = 14.6, 6.9 Hz, 1H), 2.92–2.85 (m, 1H), 2.55–2.42 (comp, 3H), 2.26 (dd, *J* = 15.2, 10.8 Hz, 1H), 2.18 (app td, *J* = 11.7, 3.0 Hz, 1H), 1.70–1.53 (comp, 4H), 1.34–1.22 (m, 1H), 1.15–1.02 (m, 1H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 208.0, 152.6, 142.1, 109.8, 109.0, 59.1, 54.5, 52.3, 47.8, 45.0, 34.4, 25.9, 23.2.

HRMS (ESI-TOF): Calculated for $C_{13}H_{18}NO_2$ $[M + H]^+$: 220.1332, Found: 220.1338.

(4*R,9a*R**)-4-(Furan-2-yl)octahydro-2*H*-quinolizin-2-one**



(±)-**4c'**

From the reaction shown above, the minor diastereomer was isolated as a yellow oil.

Characterization data of the minor diastereomer:

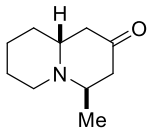
$\mathbf{R_f}$ = 0.18 in hexane/EtOAc 75:25 v/v

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 7.40 (d, *J* = 1.9 Hz, 1H), 6.31 (dd, *J* = 3.3, 1.8 Hz, 1H), 6.21 (d, *J* = 3.2 Hz, 1H), 3.42 (dd, *J* = 12.5, 3.1 Hz, 1H), 3.00 (app t, *J* = 13.4 Hz, 1H), 2.71–2.64 (m, 1H), 2.54–2.45 (m, 1H), 2.43 (app dt, *J* = 14.4, 2.9 Hz, 1H), 2.33 (app dt, *J* = 14.4, 2.9 Hz, 1H), 2.25 (app td, *J* = 11.2, 2.8 Hz, 1H), 1.83 (app td, *J* = 11.9, 3.0 Hz, 1H), 1.77–1.65 (comp, 2H), 1.65–1.45 (comp, 3H), 1.33–1.20 (m, 1H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 207.1, 153.3, 142.3, 110.0, 108.1, 62.6, 61.8, 52.6, 48.5, 46.9, 34.0, 25.6, 23.9.

HRMS (ESI-TOF): Calculated for $C_{13}H_{18}NO_2$ $[M + H]^+$: 220.1332, Found: 220.1327.

(4*R,9a*R**)-4-Methyloctahydro-2*H*-quinolizin-2-one**



(±)-myrtine (**4d**)

Following general procedure D, (±)-myrtine (**4d**) was obtained from piperidine (197 μL, 2 mmol) and (*E*)-pent-3-en-2-one (98 μL, 1 mmol) in 38% yield (0.38 mmol, 64 mg) and 10:1 diastereomeric ratio (*cis* : *trans*). Dichloromethane containing methanol (2–10%) was used as the eluent for silica gel chromatography.

Note - After addition of saturated $NaHCO_3$ aqueous solution, the reaction mixture was stirred for 2 h.

Characterization data of the major diastereomer:

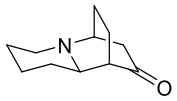
$\mathbf{R_f}$ = 0.45 in CH_2Cl_2/MeOH 90:10 v/v

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 3.34–3.22 (m, 1H), 2.78 (dd, *J* = 13.4, 5.9 Hz, 1H), 2.74–2.68 (m, 1H), 2.64–2.54 (m, 1H), 2.41 (app td, *J* = 11.6, 2.7 Hz, 1H), 2.25–2.12 (comp, 2H), 2.15–2.09 (m, 1H), 1.69–1.60 (comp, 3H), 1.60–1.49 (m, 1H), 1.30–1.09 (comp, 2H), 0.90 (d, *J* = 6.8 Hz, 3H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 209.4, 57.0, 53.3, 51.3, 48.5, 47.9, 34.1, 25.7, 23.3, 10.9.

HRMS (ESI-TOF): Calculated for $C_{10}H_{18}NO$ $[M + H]^+$: 168.1383, Found: 168.1388.

(1*S,4*S**,9a*R**)-Octahydro-2*H*-1,4-ethanoquinolizin-2-one**



(±)-**4e**

Following general procedure D, compound (±)-**4e** was obtained from piperidine (197 μL, 2 mmol) and cyclohex-2-en-1-one (97 μL, 1 mmol) as a clear oil in 34% yield (0.34 mmol, 62 mg) and 7:1 diastereomeric ratio. EtOAc containing methanol (2–5%) was used as the eluent for silica gel chromatography.

Note - After addition of saturated $NaHCO_3$ aqueous solution, the reaction mixture was stirred for 72 h.

Characterization data for (±)-4e:

R_f = 0.31 in EtOAc.

^{1}H-NMR (500 MHz, $CDCl_3$): δ = 3.00–2.94 (m, 1H), 2.72 (app dt, *J* = 10.7, 3.9 Hz, 1H), 2.58–2.50 (m, 1H), 2.47 (ddd, *J* = 17.1, 4.6, 2.4 Hz, 1H), 2.40–2.30 (m, 1H), 2.20–2.12 (comp, 2H), 2.11–2.01 (m, 1H), 1.97–1.88 (m, 1H), 1.78–1.61 (comp, 3H), 1.59–1.52 (comp, 2H), 1.52–1.44 (m, 1H), 1.34–1.20 (comp, 2H).

^{13}C-NMR (125 MHz, $CDCl_3$): δ = 215.1, 64.3, 55.4, 52.5, 49.3, 47.6, 31.5, 26.5, 24.8, 23.0, 20.2.

HRMS (ESI-TOF): Calculated for $C_{11}H_{18}NO$ $[M + H]^+$: 180.1383, Found: 180.1393.

(4a*R*,6a*S***,10a*R***)-Dodecahydro-6*H*-pyrido[1,2-*a*]quinolin-6-one**

(±)-**4f**

Following general procedure D, compound (±)-**4f** and compound (±)-**4f'** were obtained from piperidine (197 μL, 2 mmol) and 1-acetyl-1-cyclohexene (129 μL, 1 mmol) as a clear oil in 49% combined yield (0.49 mmol, 101 mg) in a 7:1 diastereomeric ratio as an inseparable mixture. Hexanes containing EtOAc (75–90%) was used as the eluent for silica gel chromatography.

Note - After addition of saturated $NaHCO_3$ aqueous solution, the reaction mixture was stirred for 72 h.

Characterization data for (±)-4f:

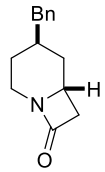
$\mathbf{R_f}$ = 0.19 in hexane/EtOAc 25:75 v/v.

^{1}H-NMR (major isomer is assigned, 500 MHz, $CDCl_3$): δ = 3.06 (ddd, *J* = 12.1, 5.5, 3.3 Hz, 1H), 2.90–2.84 (m, 1H), 2.82–2.75 (m, 1H), 2.70 (app tt, *J* = 10.0, 3.4 Hz, 1H), 2.59 (app td, *J* = 11.5, 2.8 Hz, 1H), 2.31–2.14 (comp, 3H), 1.89–1.75 (comp, 2H), 1.75–1.53 (comp, 4H), 1.50–1.34 (comp, 2H), 1.32–1.00 (comp, 5H).

^{13}C-NMR (major isomer is assigned, 125 MHz, $CDCl_3$): δ = 210.3, 65.2, 54.2, 50.7, 50.5, 48.0, 34.5, 26.1, 25.4, 24.7, 23.3, 22.0, 21.2.

HRMS (ESI-TOF): Calculated for $C_{13}H_{22}NO$ $[M + H]^+$: 208.1696, Found: 208.1686.

(4*R,6*R**)-4-Benzyl-1-azabicyclo[4.2.0]octan-8-one**



(±)-**5**

Following a modified literature procedure,[12] to a solution of *t*-BuMgCl (1.35 M in THF, 295 μL, 0.4 mmol, 2 equiv) in anhydrous THF (0.5 mL) cooled to –20 °C was slowly added a solution of (±)-**1f** (52 mg, 0.2 mmol) in anhydrous THF (0.5 mL) over 2 h via cannula under the protection of nitrogen. The reaction mixture was stirred at the same temperature for 10 min and quenched by the addition of saturated aqueous NH_4Cl solution (2 mL). Subsequently, the reaction vessel was taken out of the low temperature bath and warmed up to room temperature. The resulting mixture was diluted with EtOAc (10 mL) and washed with saturated aqueous NH_4Cl solution (10 mL). The aqueous layer was then extracted with EtOAc (2 x 10 mL) and the combined organic layers were dried over anhydrous Na_2SO_4. Solvent was then removed under reduced pressure and the residue purified by silica gel chromatography using hexanes containing EtOAc (30–60%) as the eluent to provide compound (±)-**5** (0.144 mmol, 31 mg, 72%) as a crystalline solid.

Characterization data:

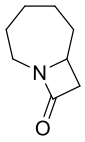
$\mathbf{R_f}$ = 0.35 in hexane/EtOAc 50:50 v/v

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.41–7.30 (comp, 2H), 7.27–7.17 (comp, 3H), 3.75 (ddd, *J* = 13.7, 6.3, 1.8 Hz, 1H), 3.65 (app dtd, *J* = 10.9, 4.5, 1.8 Hz, 1H), 3.15 (ddd, *J* = 14.5, 4.5, 1.8 Hz, 1H), 3.07–2.98 (m, 1H), 2.88–2.73 (comp, 2H), 2.58 (dd, *J* = 14.5, 1.8 Hz, 1H), 2.35–2.27 (m, 1H), 1.95 (app dt, *J* = 13.2, 4.1 Hz, 1H), 1.71–1.61 (m, 1H), 1.58–1.51 (m, 1H), 1.47 (app ddd, *J* = 13.2, 10.9, 4.1 Hz, 1H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 166.6, 140.3, 128.7, 128.6, 126.3, 45.1, 43.3, 36.2, 34.8, 33.9, 33.3, 27.6.

HRMS (ESI-TOF): Calculated for $C_{14}H_{18}NO$ $[M + H]^+$: 216.1383, Found: 216.1367.

1-Azabicyclo[5.2.0]nonan-9-one



(±)-**6**

Following a modified literature procedure,[12] to a solution of *t*-BuMgCl (1.35 M in THF, 296 μL, 0.4 mmol, 2 equiv) in anhydrous THF (0.5 mL) cooled to –20 °C was slowly added a solution of (±)-**1l** (37 mg, 0.2 mmol) in anhydrous THF (0.5 mL) over 2 h via cannula under the protection of nitrogen. The reaction mixture was stirred at the same temperature for 10 min and quenched by the addition of saturated aqueous NH_4Cl solution (2 mL). Subsequently the reaction vessel was taken out of the low temperature bath and warmed up to room temperature. The resulting mixture was diluted with EtOAc (10 mL) and washed with saturated aqueous NH_4Cl solution (10 mL). The aqueous layer was then extracted with EtOAc (2 x 10 mL) and the combined organic layers were dried over anhydrous Na_2SO_4. Solvent was then removed under reduced pressure and the residue purified by silica gel chromatography using hexanes containing EtOAc (30–60%) to provide compound (±)-**6** (0.146 mmol, 20 mg, 73%) as a clear oil.

Characterization data:

$\mathbf{R_f}$ = 0.18 in hexane/EtOAc 50:50 v/v

^{1}H-NMR (400 MHz, $CDCl_3$): δ = 3.70–3.64 (m, 1H), 3.42–3.23 (comp, 2H), 2.97 (ddd, *J* = 14.4, 4.8, 1.6 Hz, 1H), 2.46 (d, *J* = 14.5 Hz, 1H), 2.09–1.99 (m, 1H), 2.01–1.81 (comp, 3H), 1.59–1.47 (m, 1H), 1.47–1.28 (comp, 3H).

^{13}C-NMR (100 MHz, $CDCl_3$): δ = 166.9, 52.7, 43.0, 41.6, 35.8, 29.3, 28.6, 26.9.

HRMS (ESI-TOF): Calculated for $C_8H_{14}NO$ $[M + H]^+$: 140.1070, Found: 140.1072.

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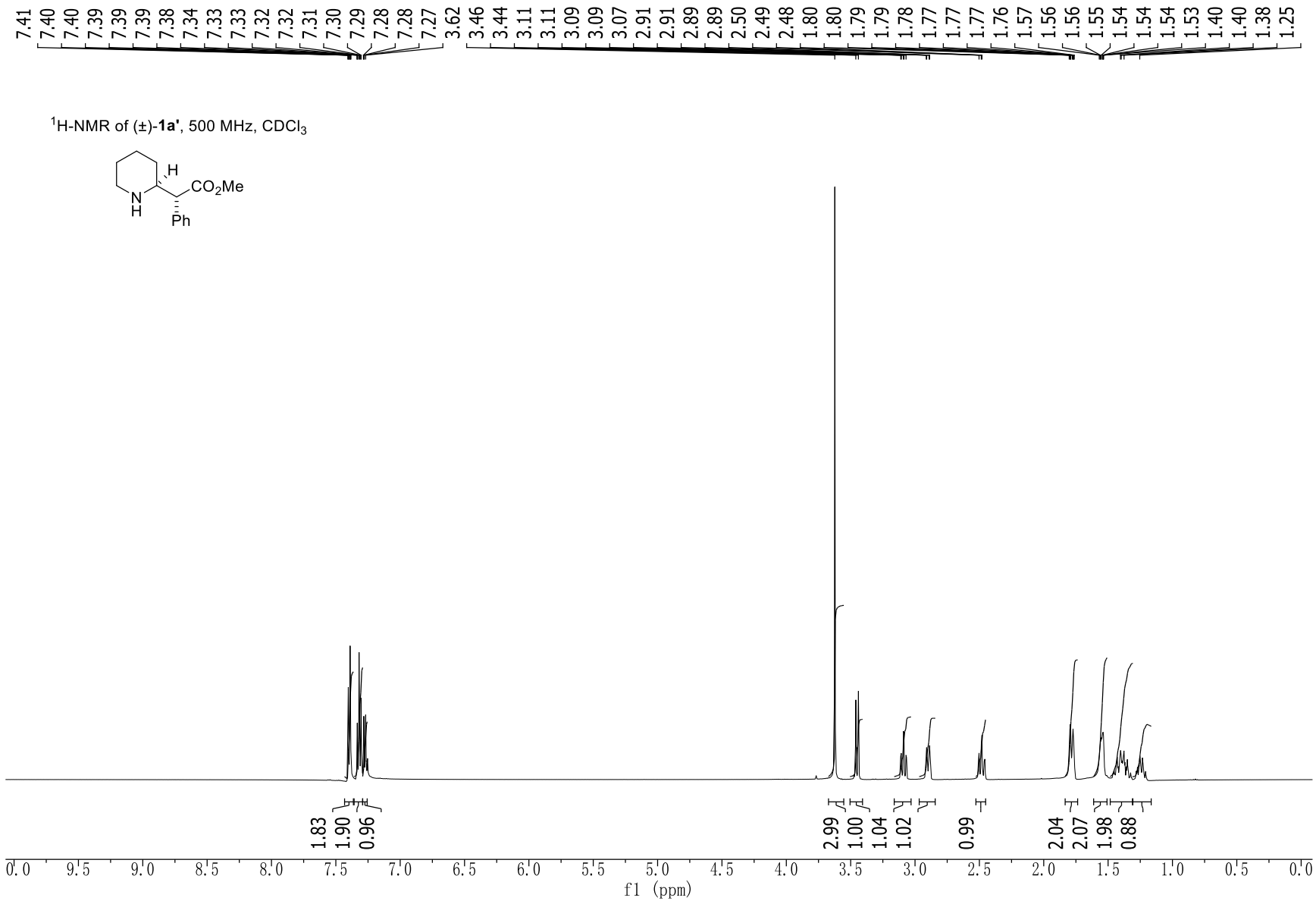
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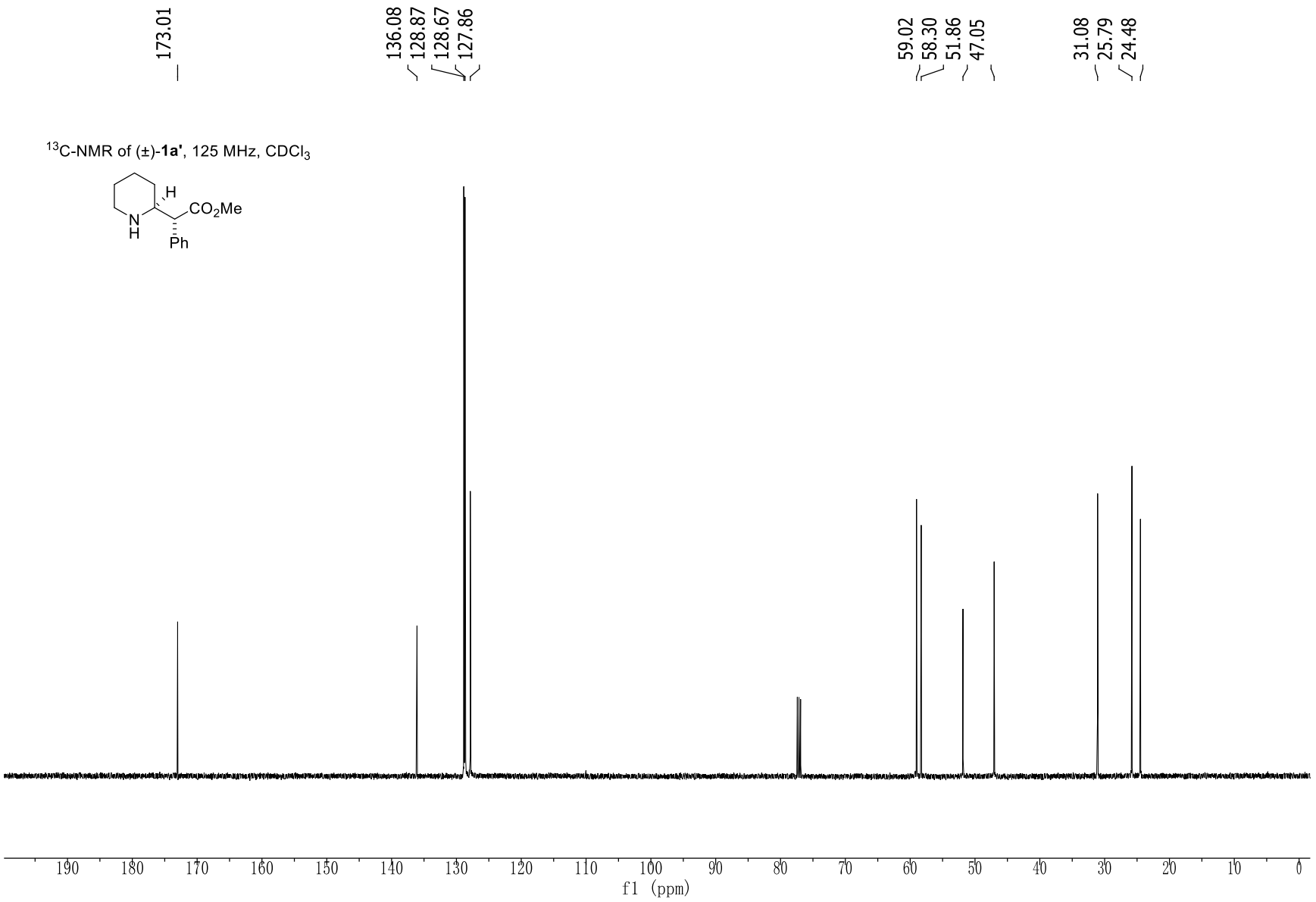
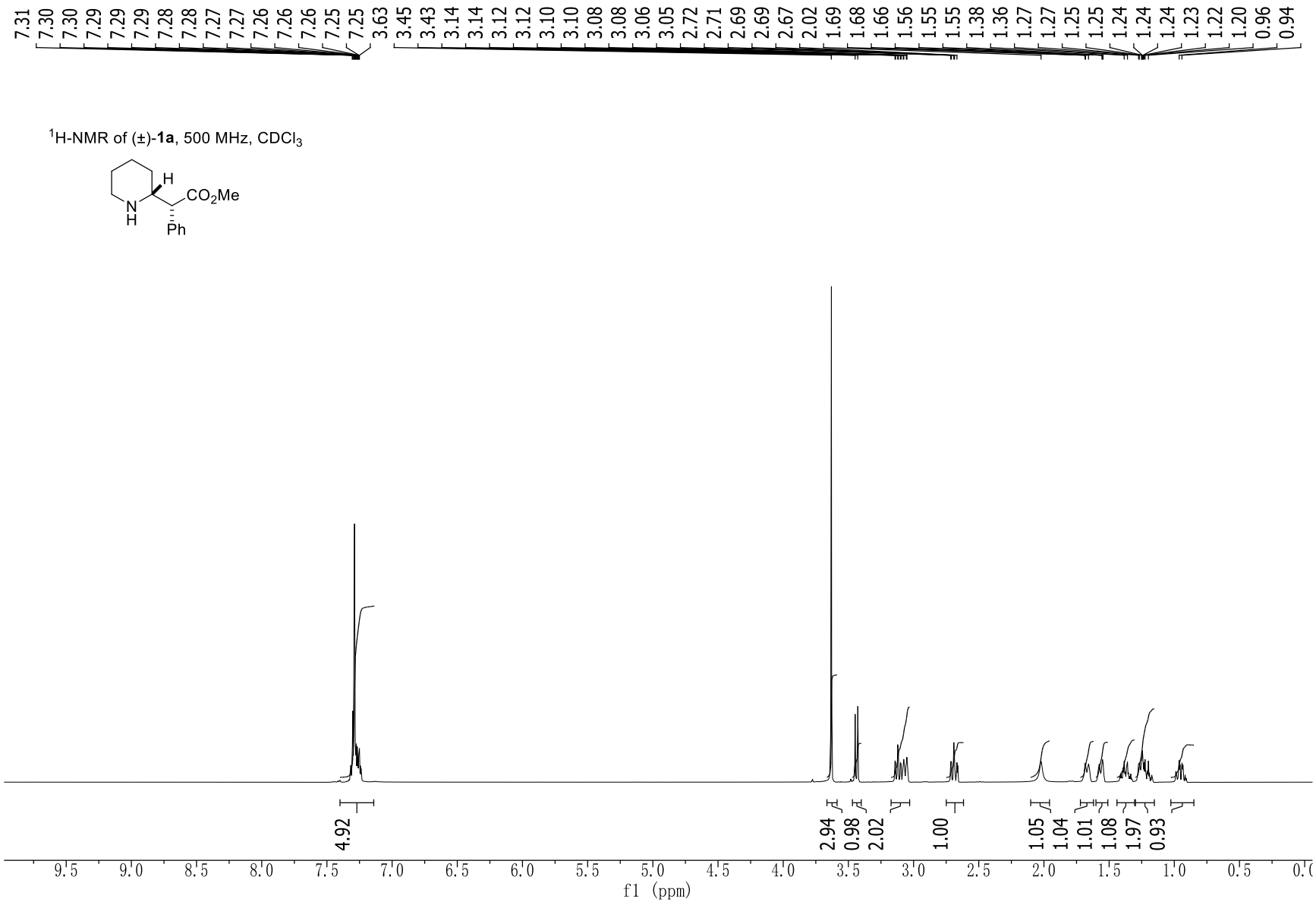
1H-NMR of (±)-1a', 500 MHz, CDCl3
H
CO2Me
N
H
Ph
1.83 1.90 0.96 2.99 1.00 1.04 1.02 0.99 2.04 2.07 1.98 0.88
f1 (ppm)


173.01
136.08
128.87
128.67
127.86
59.02
58.30
51.86
47.05
31.08
25.79
24.48
^{13}C-NMR of (±)-**1a'**, 125 MHz, $CDCl_3$
H
CO_2Me
N
H
Ph
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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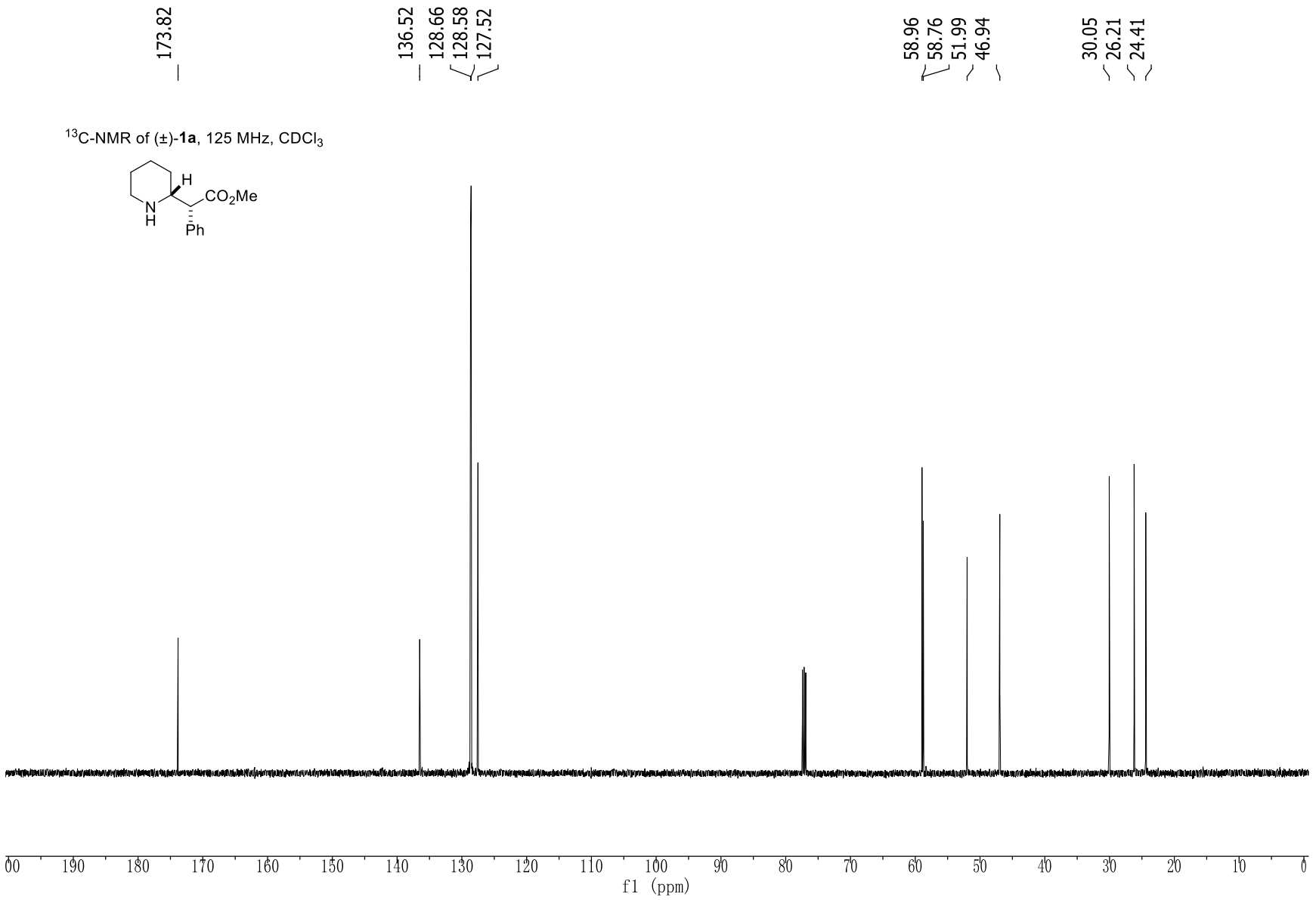
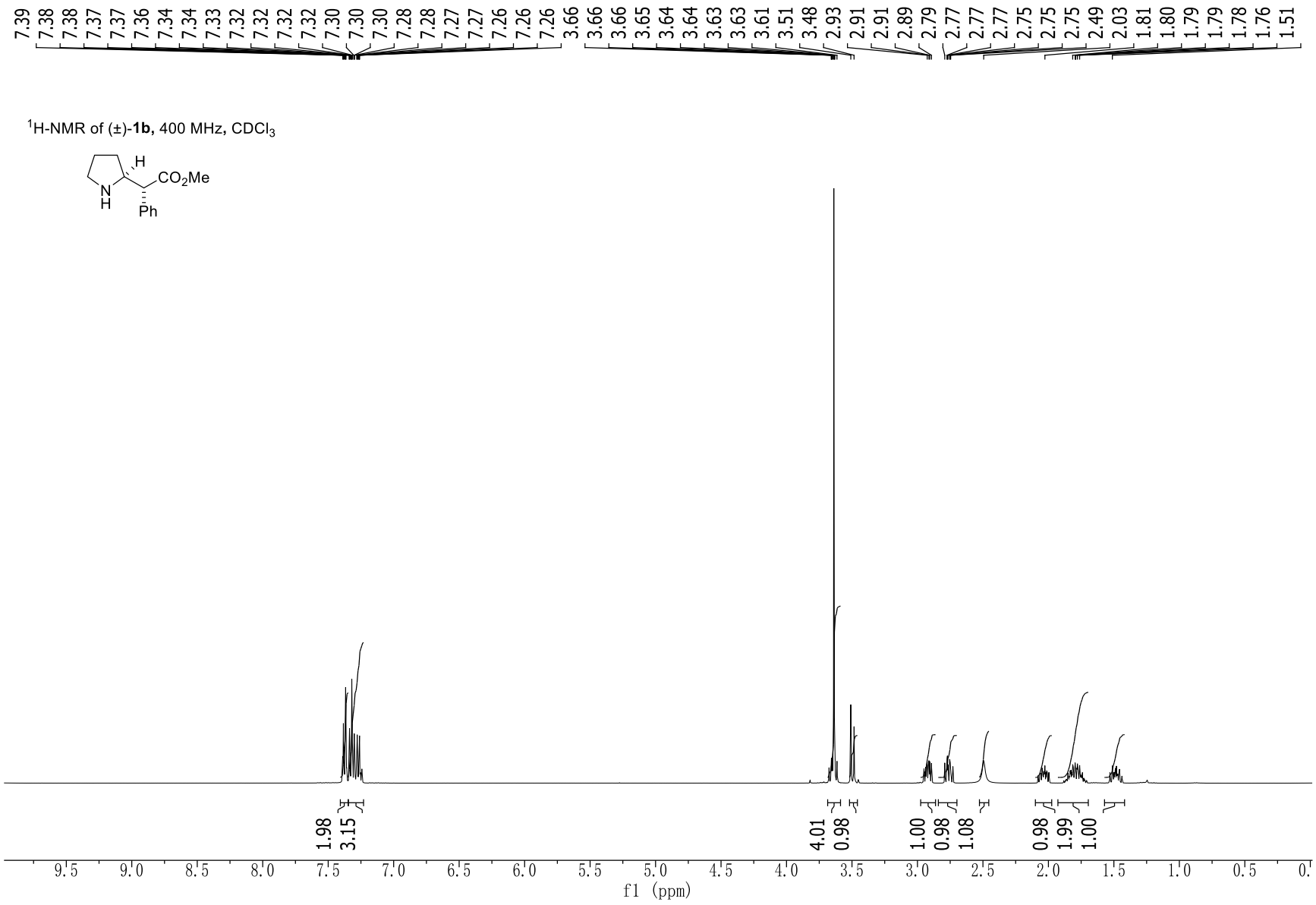
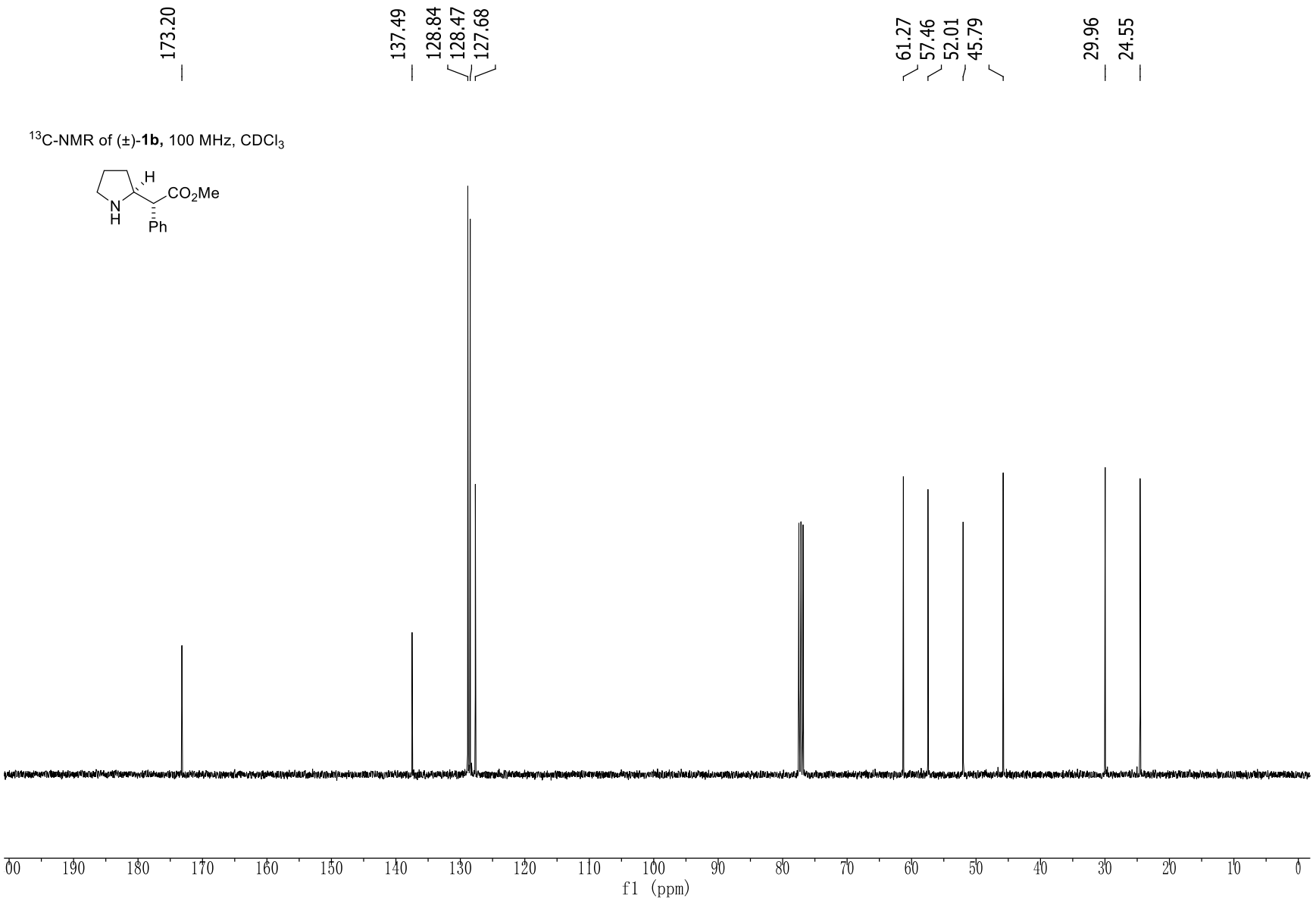
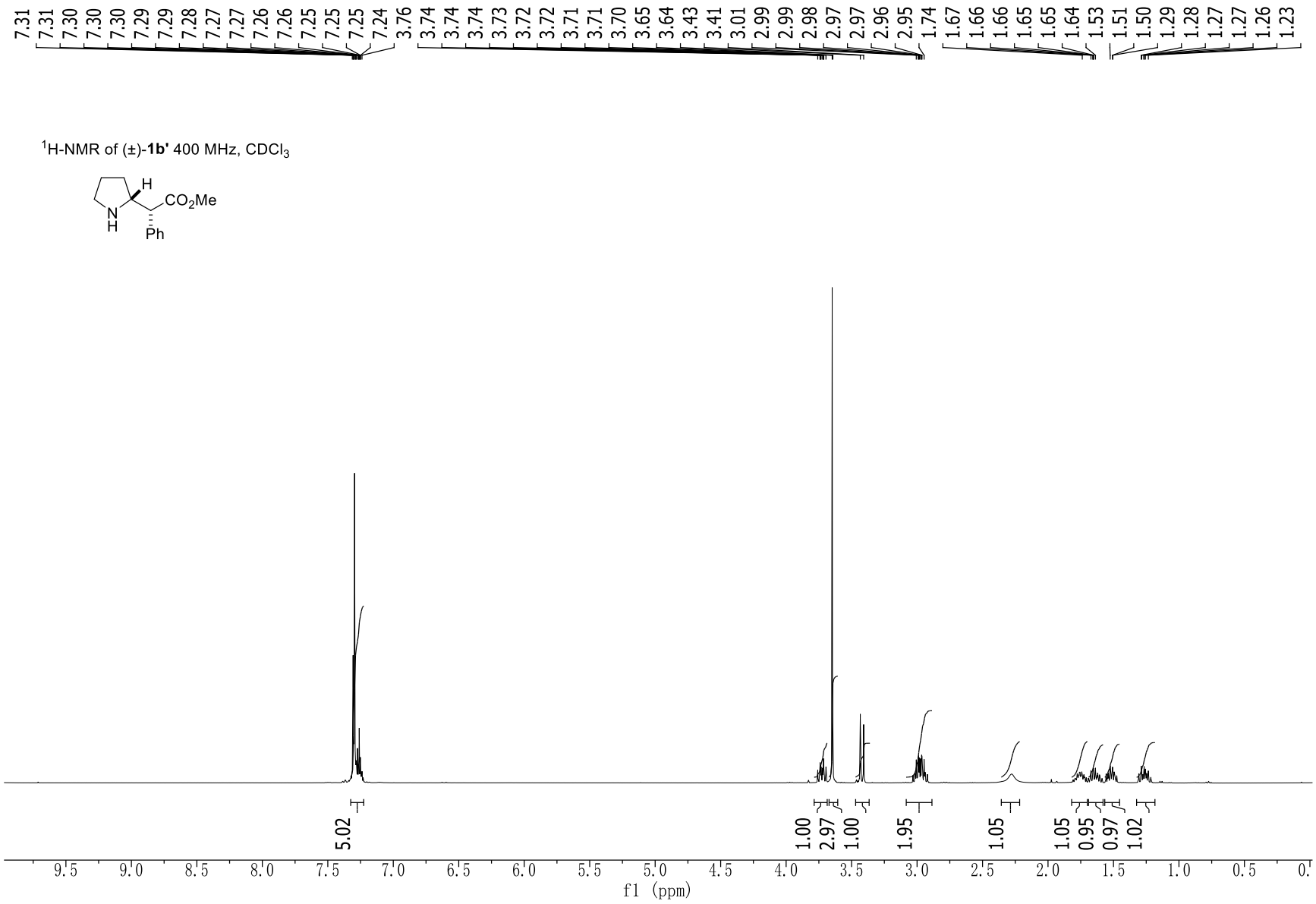
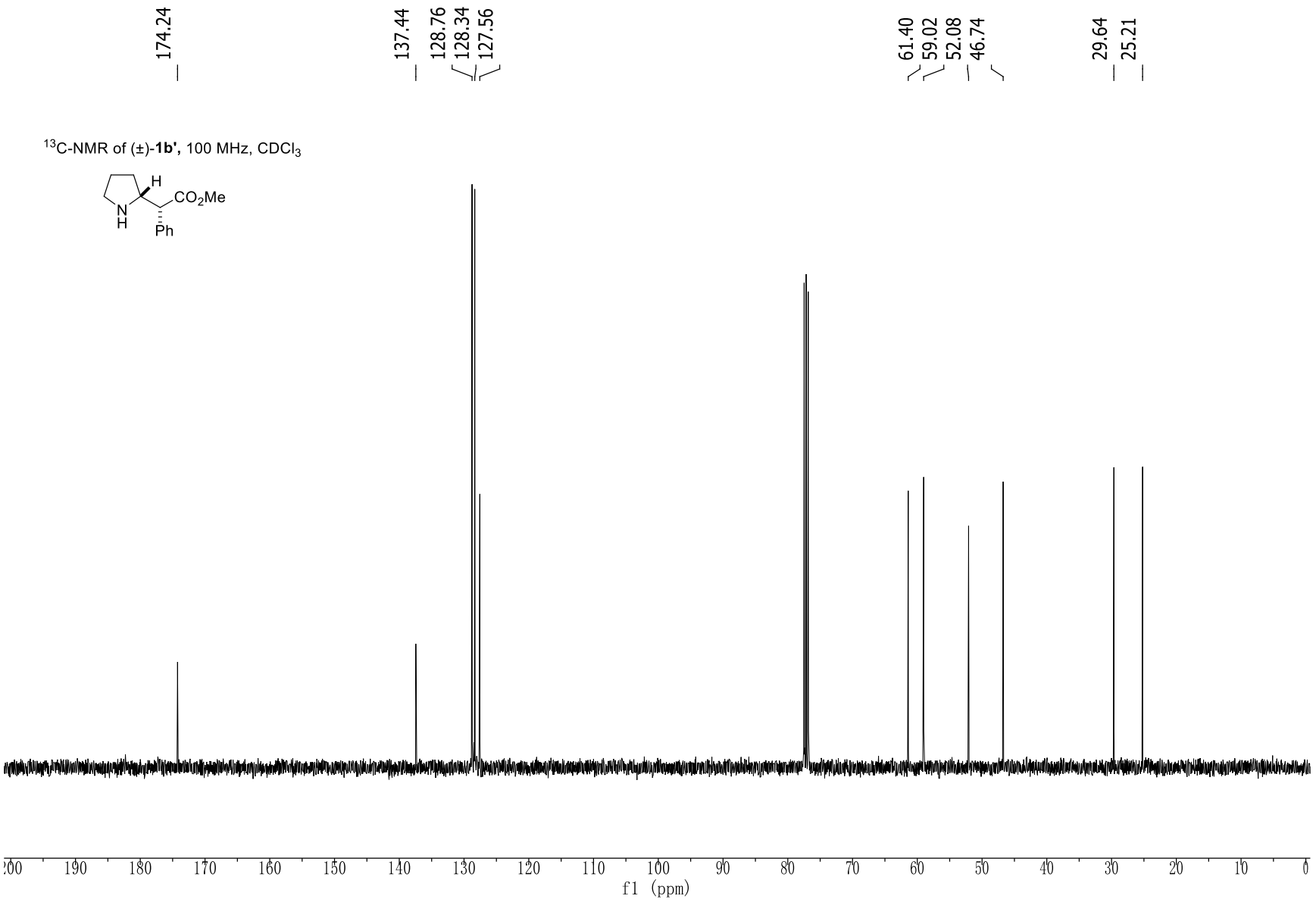
3.45 3.43 3.14 3.14 3.12 3.12 3.10 3.10 3.08 3.08 3.06 3.05 2.72 2.71 2.69 2.69 2.67 2.02 1.69 1.68 1.66 1.56 1.55 1.55 1.38 1.36 1.27 1.27 1.25 1.25 1.24 1.24 1.24 1.23 1.22 1.20 0.96 0.94
1H-NMR of (±)-1a, 500 MHz, CDCl3
H
N
H
CO2Me
Ph
4.92
2.94
0.98
2.02
1.00
1.05
1.04
1.01
1.08
1.97
0.93
f1 (ppm)

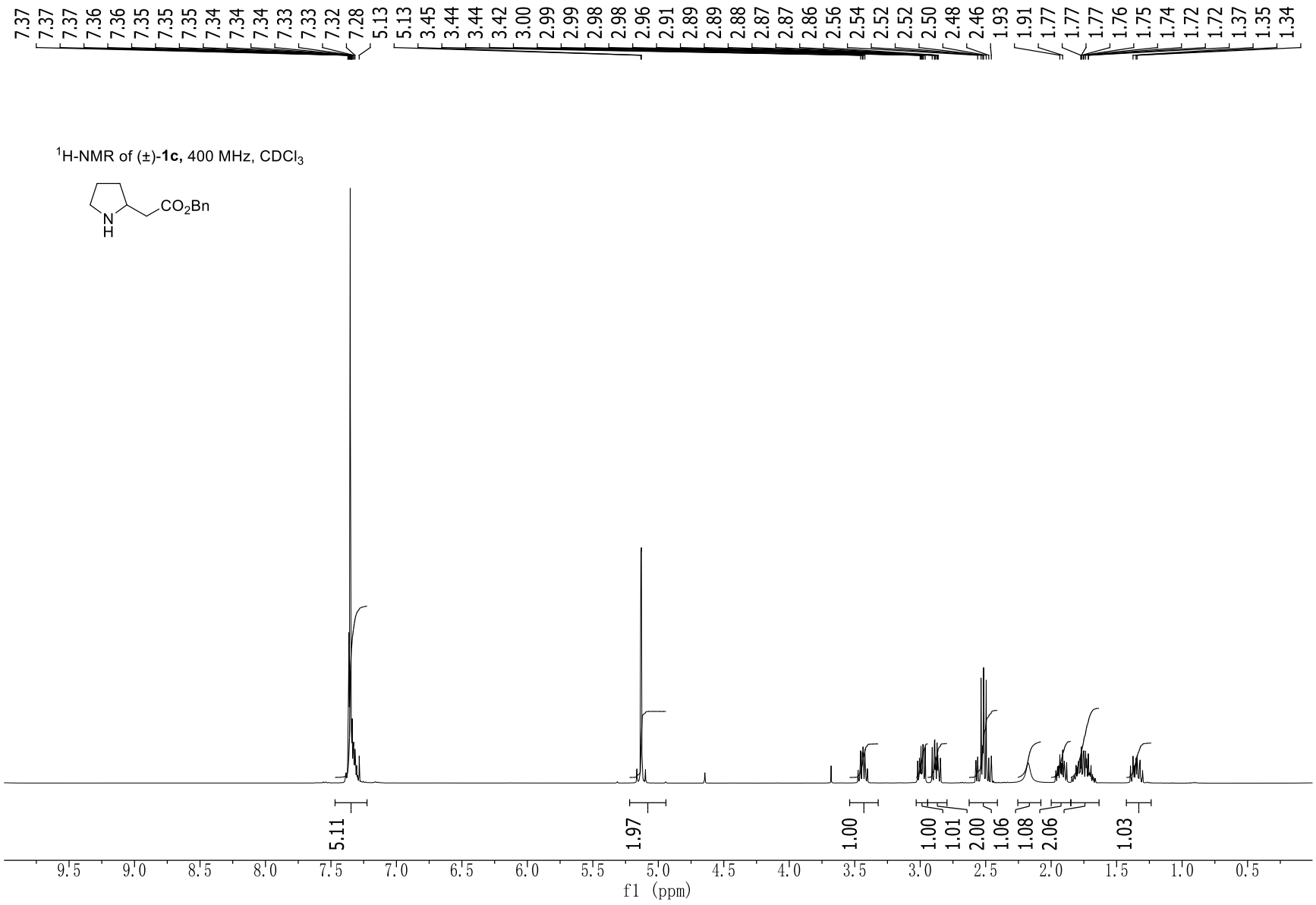

173.82
136.52
128.66
128.58
127.52
58.96
58.76
51.99
46.94
30.05
26.21
24.41
^{13}C-NMR of (±)-**1a**, 125 MHz, $CDCl_3$
H
N
H
CO_2Me
Ph
f1 (ppm)

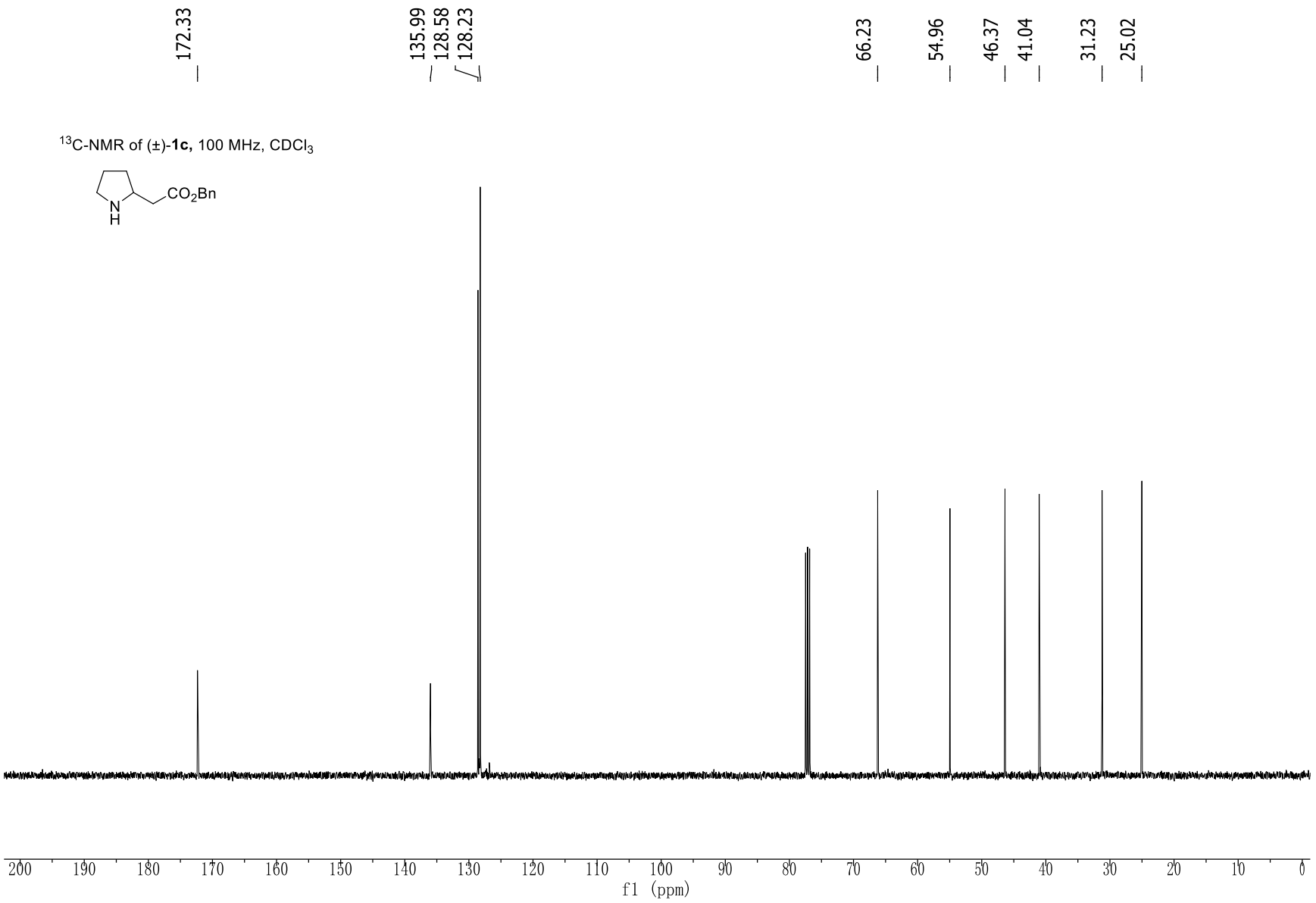

7.39 7.38 7.38 7.37 7.37 7.36 7.34 7.34 7.33 7.32 7.32 7.32 7.32 7.30 7.30 7.30 7.28 7.28 7.27 7.27 7.26 7.26 7.26 3.66
3.66 3.66 3.65 3.64 3.64 3.63 3.63 3.61 3.51 3.48 2.93 2.91 2.91 2.89 2.79 2.77 2.77 2.77 2.75 2.75 2.75 2.49 2.03 1.81 1.80 1.79 1.79 1.78 1.76 1.51
1H-NMR of (±)-1b, 400 MHz, CDCl3
H
CO2Me
N
H
Ph
1.98 3.15 4.01 0.98 1.00 0.98 1.08 0.98 1.99 1.00
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.
f1 (ppm)

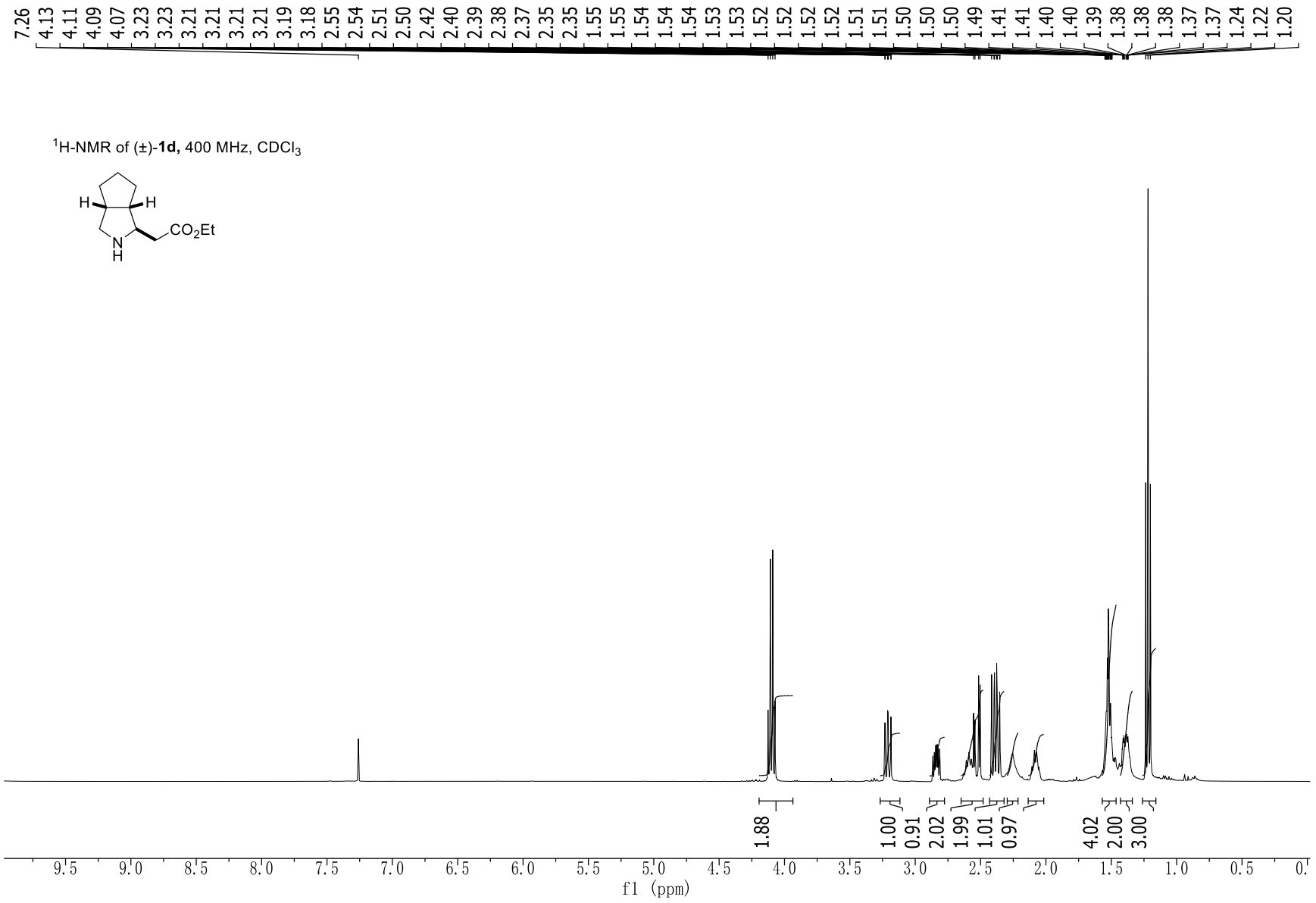

173.20
137.49
128.84
128.47
127.68
61.27
57.46
52.01
45.79
29.96
24.55
^{13}C-NMR of (±)-**1b,** 100 MHz, $CDCl_3$
H
CO_2Me
N
H
Ph
f1 (ppm)


7.31 7.31 7.30 7.30 7.30 7.29 7.29 7.28 7.27 7.27 7.26 7.26 7.25 7.25 7.25 7.24 3.76 3.74 3.74 3.74 3.73 3.72 3.72 3.71 3.71 3.70 3.65 3.64 3.43 3.41 3.01 2.99 2.99 2.98 2.97 2.97 2.96 2.95 1.74 1.67 1.66 1.66 1.65 1.65 1.64 1.53 1.51 1.50 1.29 1.28 1.27 1.27 1.26 1.23
^{1}H-NMR of (±)-**1b'** 400 MHz, $CDCl_3$
H
CO_2Me
N
H
Ph
5.02
1.00
2.97
1.00
1.95
1.05
1.05
0.95
0.97
1.02
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.
f1 (ppm)


174.24
137.44
128.76
128.34
127.56
61.40
59.02
52.08
46.74
29.64
25.21
^{13}C-NMR of (±)-**1b'**, 100 MHz, $CDCl_3$
H
CO_2Me
N
H
Ph
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.37 7.37 7.37 7.36 7.36 7.35 7.35 7.35 7.34 7.34 7.34 7.33 7.33 7.32 7.28 5.13
5.13 3.45 3.44 3.44 3.42 3.00 2.99 2.99 2.98 2.98 2.96 2.91 2.89 2.89 2.88 2.87 2.87 2.86 2.56 2.54 2.52 2.52 2.50 2.48 2.46 1.93 1.91 1.77 1.77 1.77 1.76 1.75 1.74 1.72 1.72 1.37 1.35 1.34
^{1}H-NMR of (±)-**1c,** 400 MHz, $CDCl_3$
CO_2Bn
N
H
5.11
1.97
1.00
1.00
1.01
2.00
1.06
1.08
2.06
1.03
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
f1 (ppm)


172.33
135.99
128.58
128.23
66.23
54.96
46.37
41.04
31.23
25.02
13C-NMR of (±)-1c, 100 MHz, CDCl3
CO2Bn
N
H
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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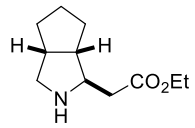
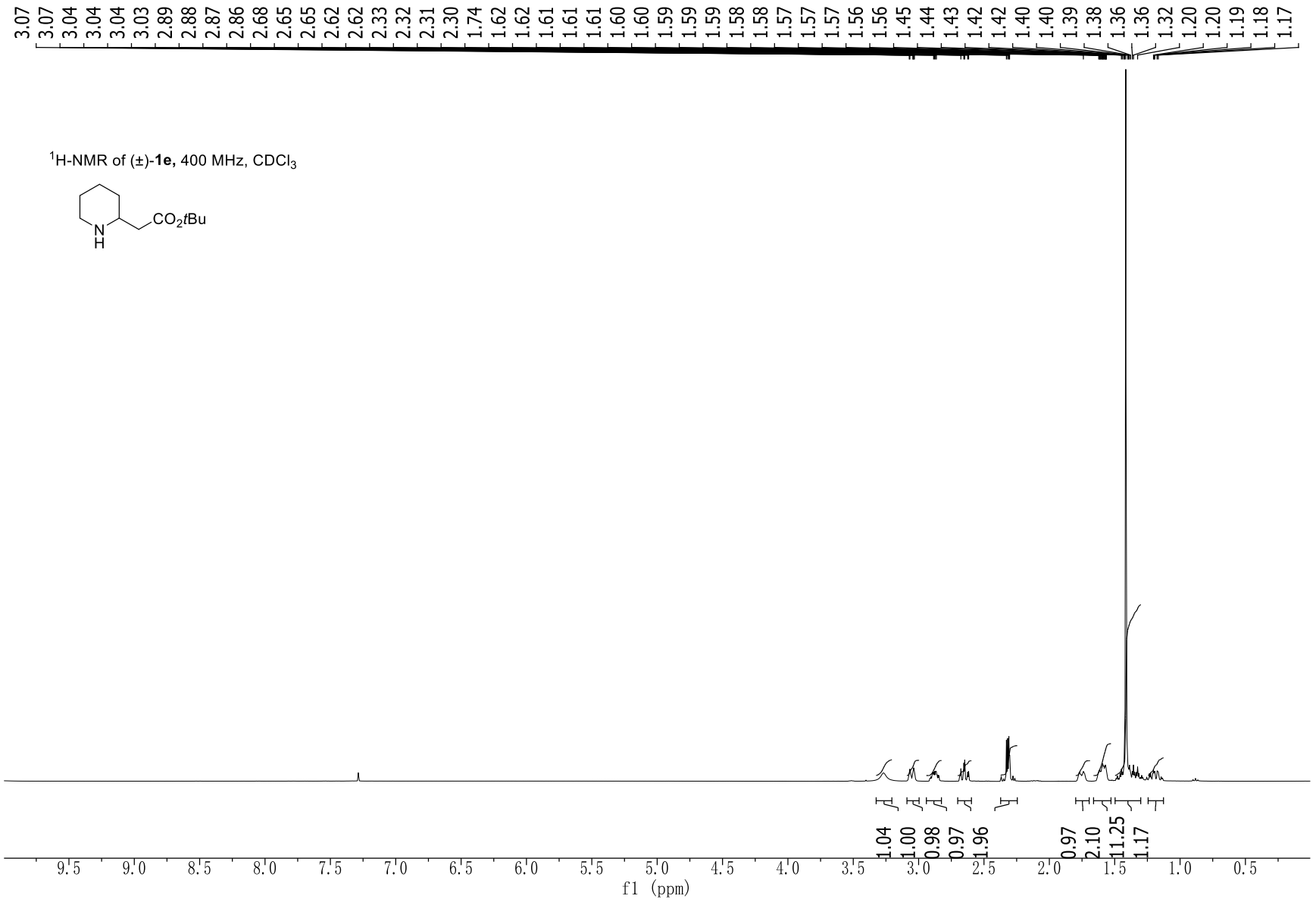
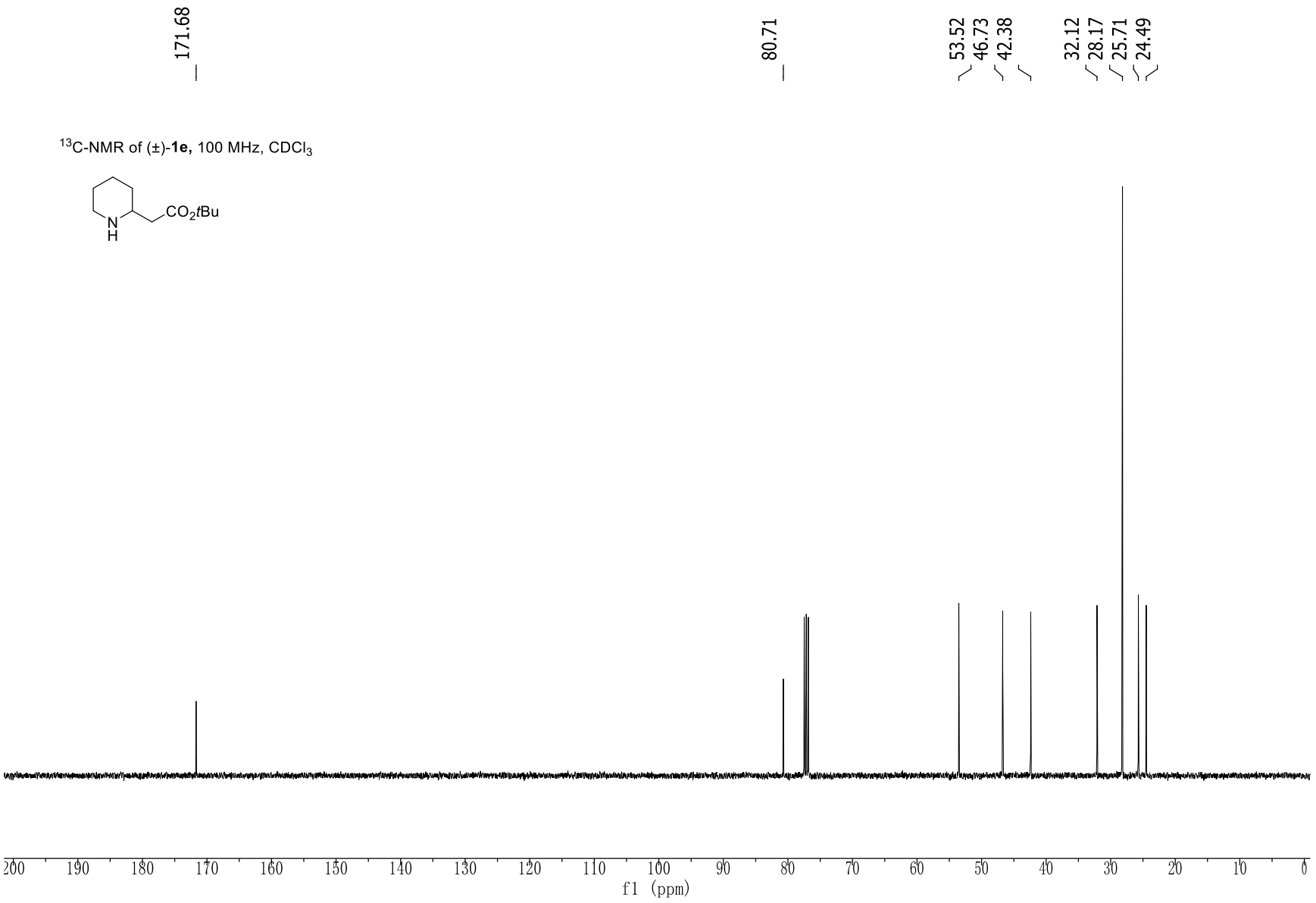
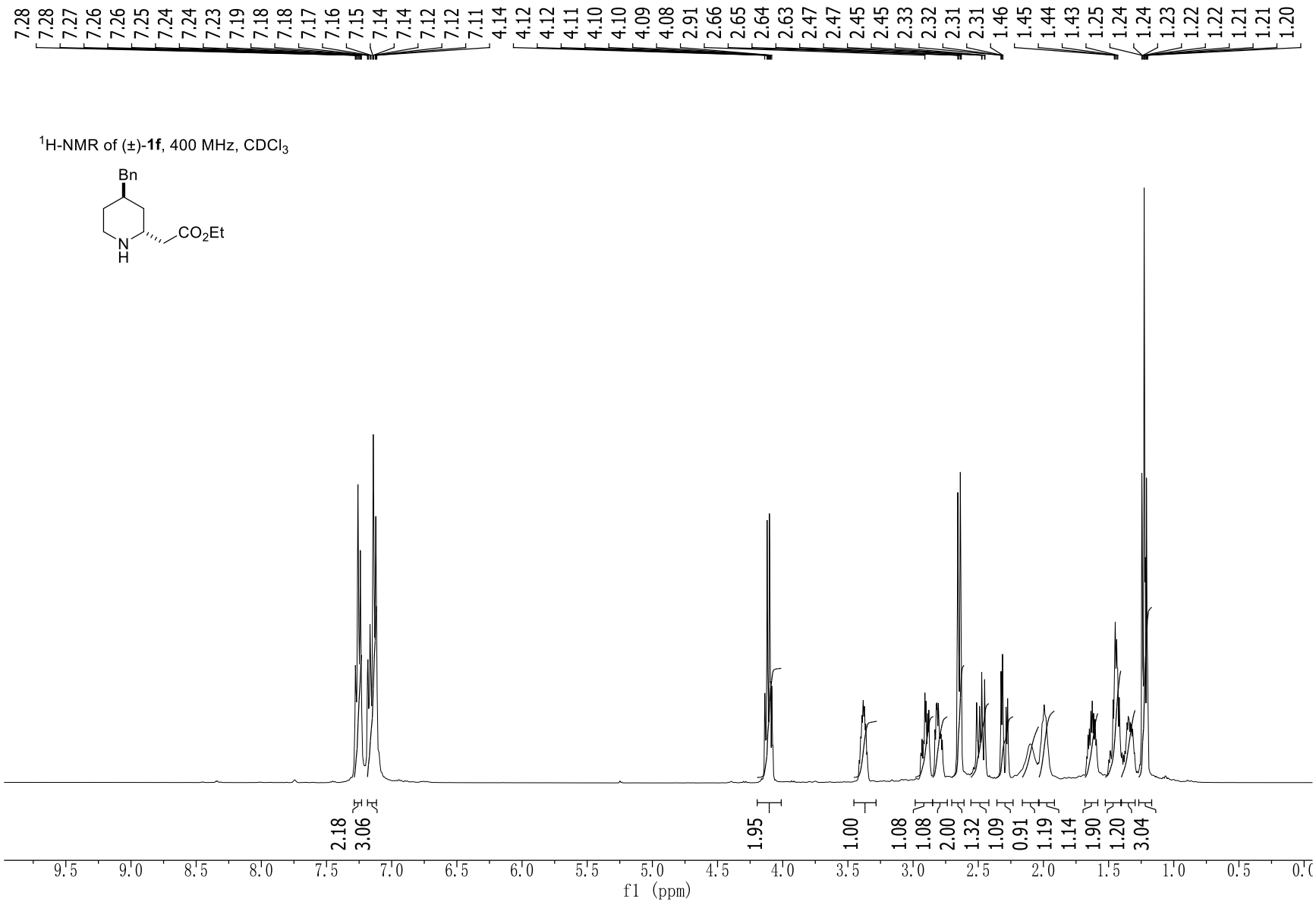
1H-NMR of (±)-1d, 400 MHz, CDCl3
H
H
CO2Et
N
H
1.88
1.00
0.91
2.02
1.99
1.01
0.97
4.02
2.00
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.
f1 (ppm)

^{13}C-NMR of (±)-**1d**, 100 MHz, $CDCl_3$

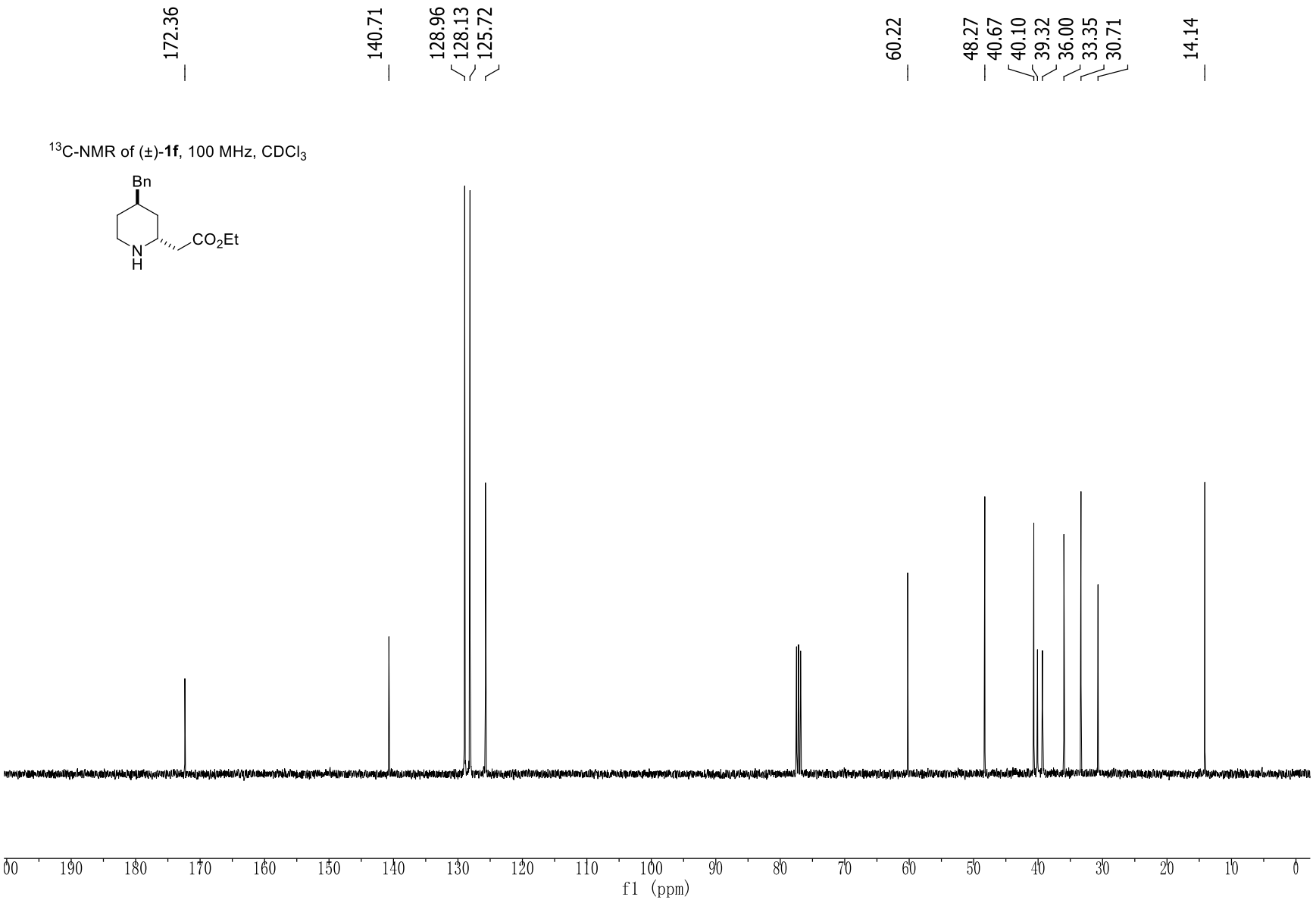


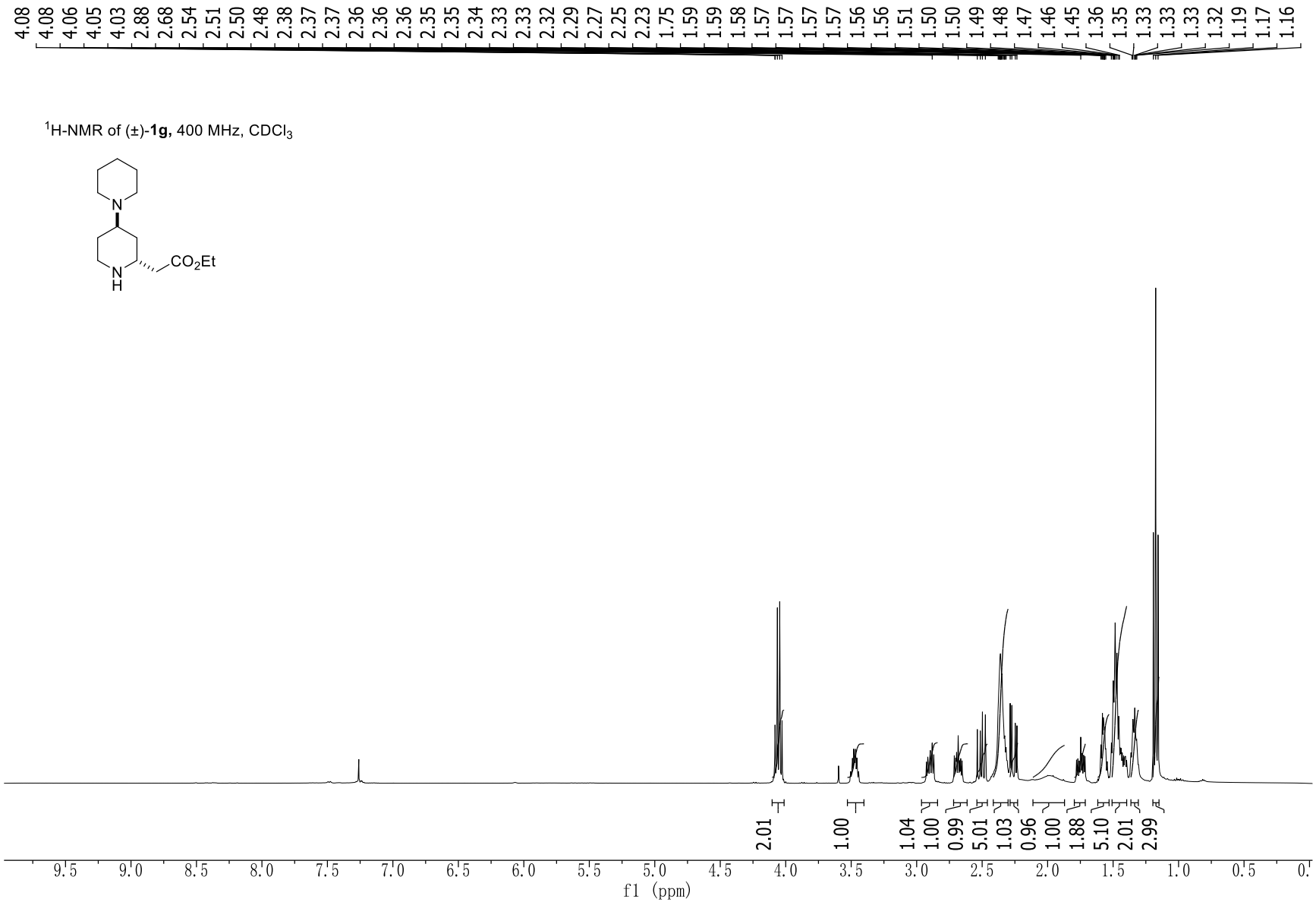

3.07 3.07 3.04 3.04 3.04 3.03 2.89 2.88 2.87 2.86 2.68 2.65 2.65 2.62 2.62 2.33 2.32 2.31 2.30 1.74 1.62 1.62 1.61 1.61 1.61 1.60 1.60 1.59 1.59 1.59 1.58 1.58 1.57 1.57 1.57 1.56 1.56 1.45 1.44 1.43 1.42 1.42 1.40 1.40 1.39 1.38 1.36 1.36 1.32 1.20 1.20 1.19 1.18 1.17
1H-NMR of (±)-1e, 400 MHz, CDCl3
CO2tBu
N
H
1.04 1.00 0.98 0.97 1.96 0.97 2.10 11.25 1.17
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
f1 (ppm)


171.68
80.71
53.52
46.73
42.38
32.12
28.17
25.71
24.49
^{13}C-NMR of (±)-**1e,** 100 MHz, $CDCl_3$
CO_2tBu
N
H
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

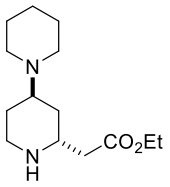


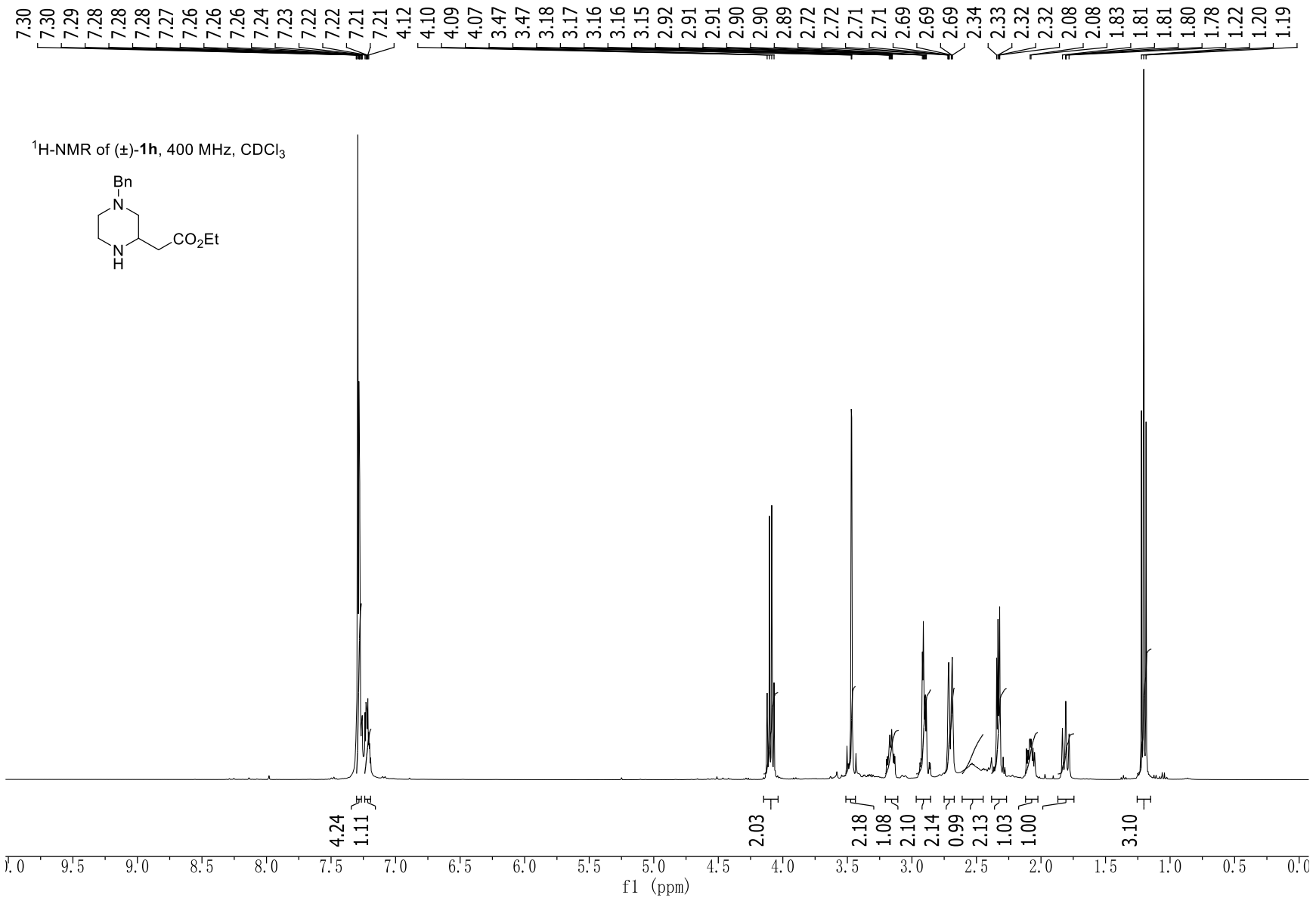
^{1}H-NMR of (±)-**1f**, 400 MHz, $CDCl_3$

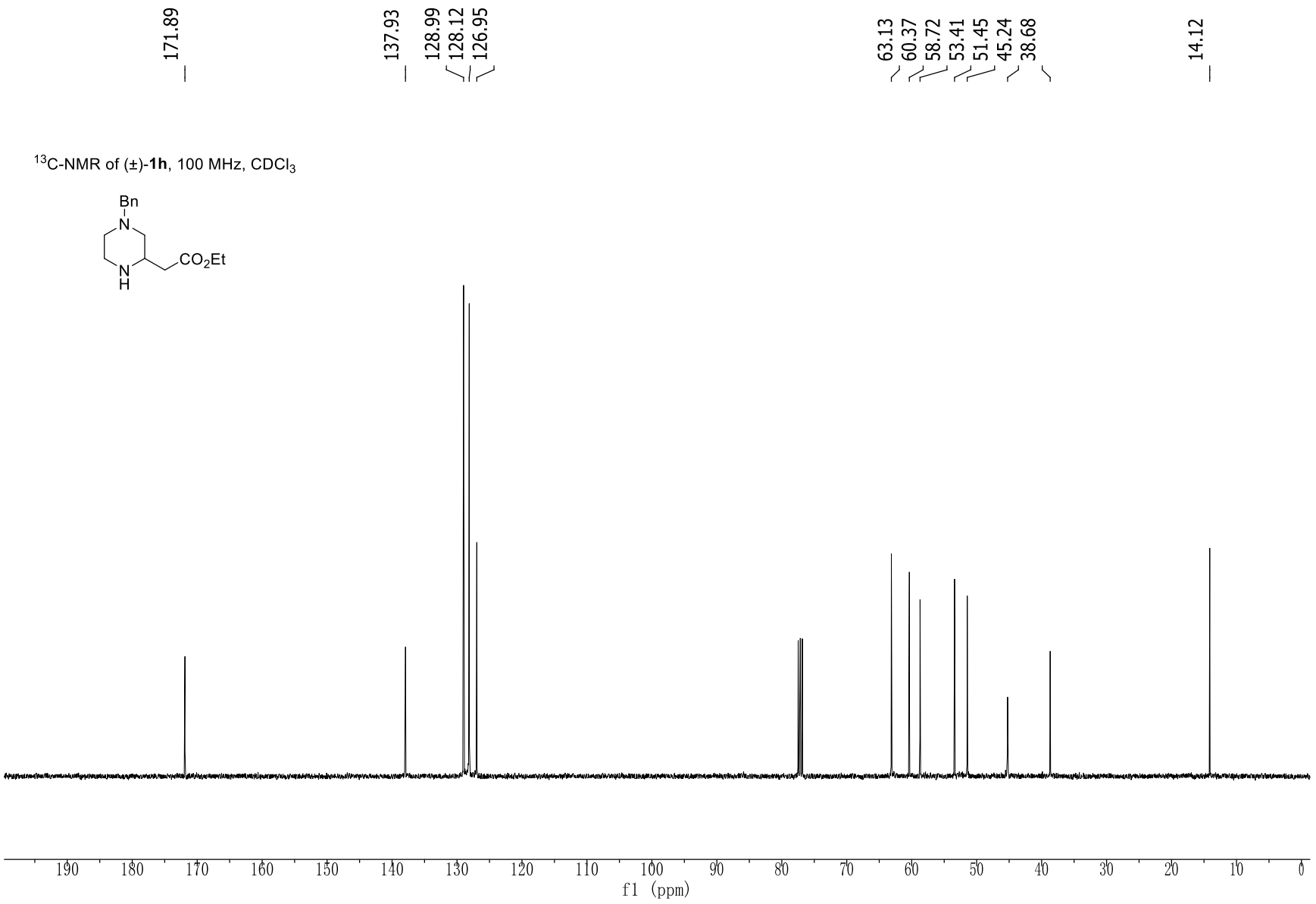

172.36
140.71
128.96
128.13
125.72
60.22
48.27
40.67
40.10
39.32
36.00
33.35
30.71
14.14
13C-NMR of (±)-1f, 100 MHz, CDCl3
Bn
CO2Et
N
H
f1 (ppm)


4.08 4.08 4.06 4.05 4.03 2.88 2.68 2.54 2.51 2.50 2.48 2.38 2.37 2.37 2.36 2.36 2.36 2.35 2.35 2.34 2.33 2.33 2.32 2.29 2.27 2.25 2.23 1.75 1.59 1.59 1.58 1.57 1.57 1.57 1.57 1.56 1.56 1.51 1.50 1.50 1.49 1.48 1.47 1.46 1.45 1.36 1.35 1.33 1.33 1.33 1.32 1.19 1.17 1.16
1H-NMR of (±)-1g, 400 MHz, CDCl3
N
N
H
CO2Et
2.01 1.00 1.04 1.00 0.99 5.01 1.03 0.96 1.00 1.88 5.10 2.01 2.99
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.
f1 (ppm)

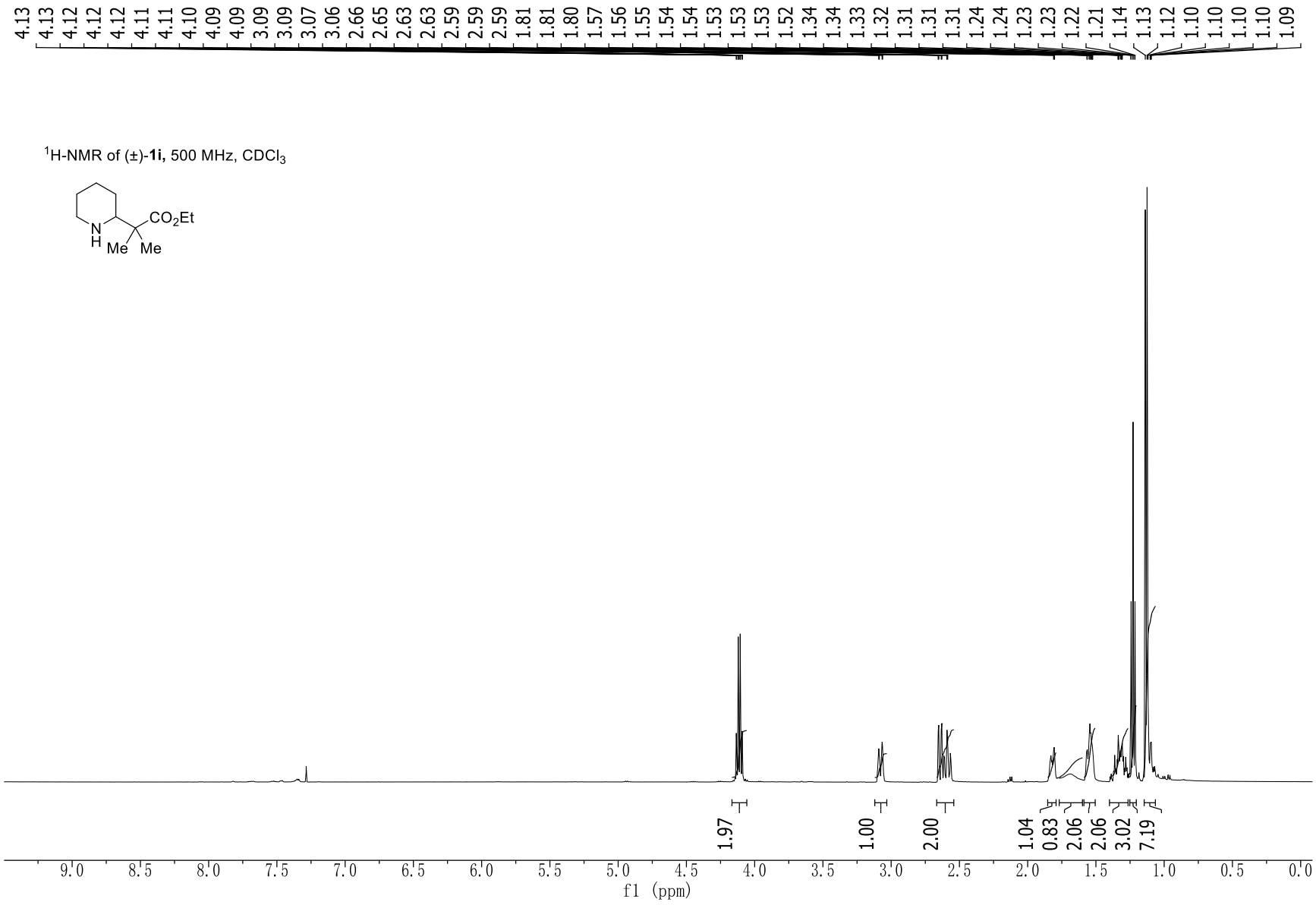
^{13}C-NMR of (±)-**1g,** 100 MHz, $CDCl_3$



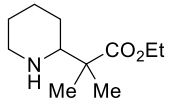

7.30 7.30 7.29 7.28 7.28 7.28 7.27 7.26 7.26 7.26 7.24 7.23 7.22 7.22 7.21 7.21 4.12 4.10 4.09 4.07 3.47 3.47 3.18 3.17 3.16 3.16 3.15 2.92 2.91 2.91 2.90 2.90 2.89 2.72 2.72 2.71 2.71 2.69 2.69 2.69 2.34 2.33 2.32 2.32 2.08 2.08 1.83 1.81 1.81 1.80 1.78 1.22 1.20 1.19
1H-NMR of (±)-1h, 400 MHz, CDCl3
Bn
N
N
H
CO2Et
4.24 1.11 2.03 2.18 1.08 2.10 2.14 0.99 2.13 1.03 1.00 3.10
f1 (ppm)

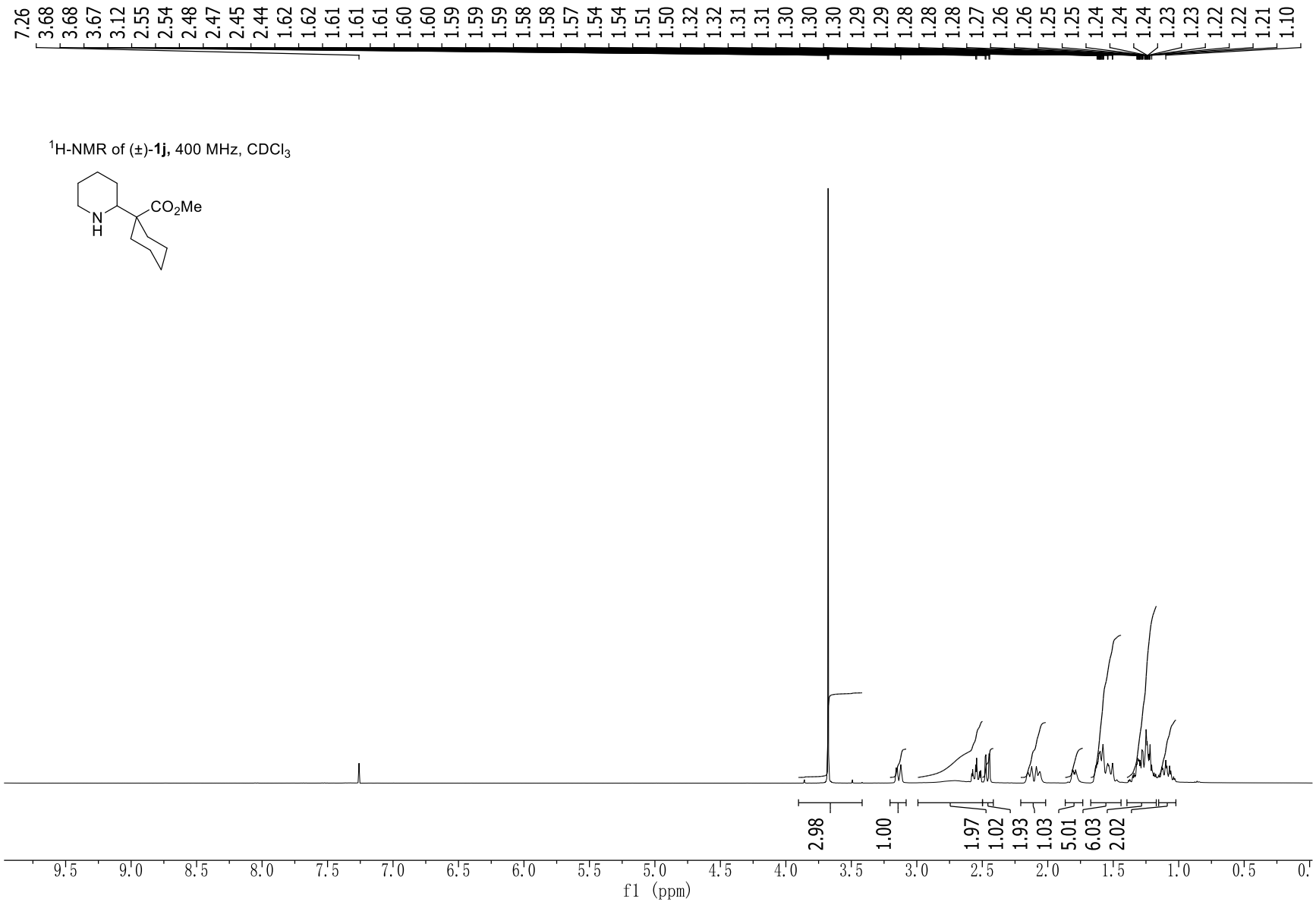


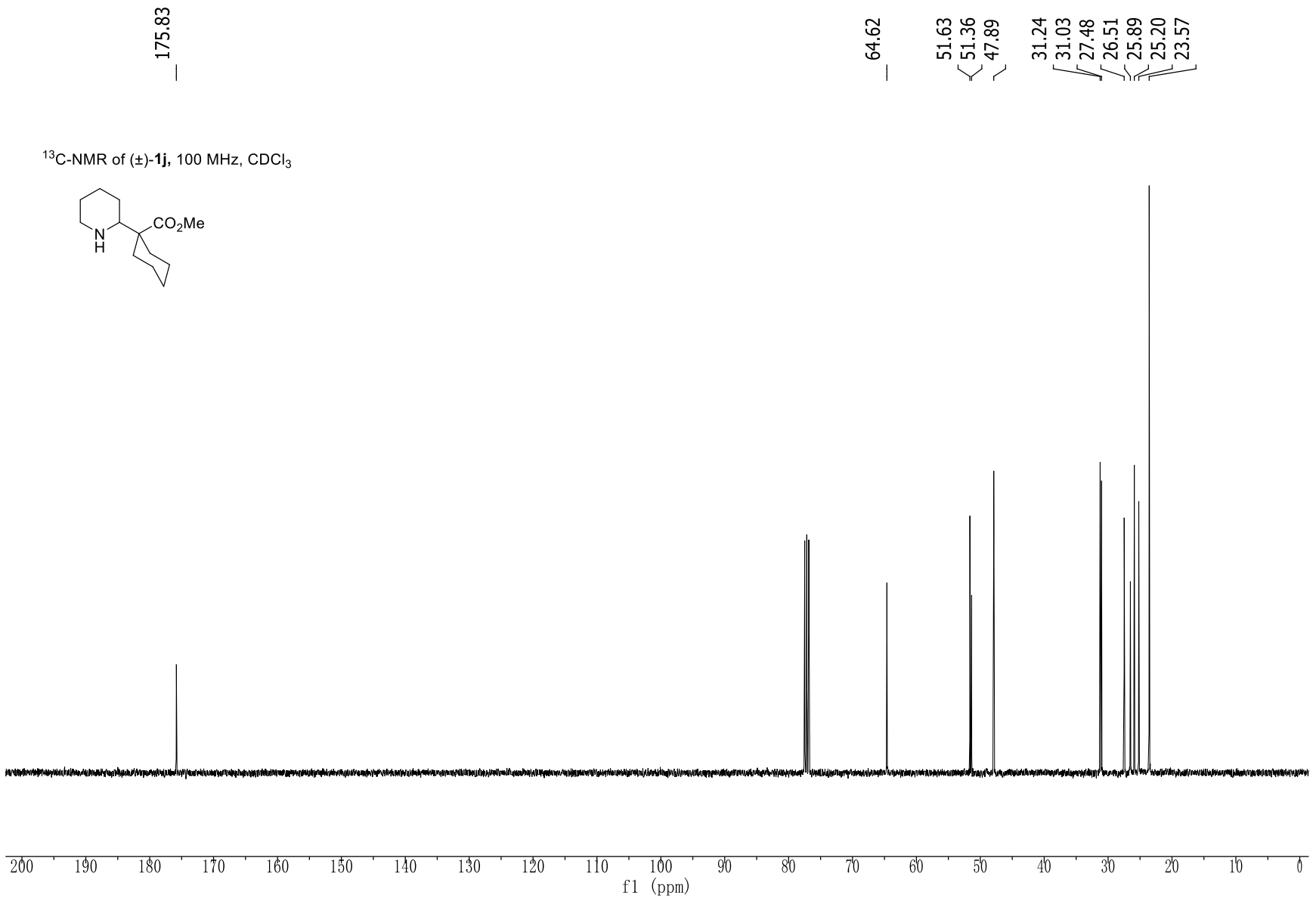
^{13}C-NMR of (±)-**1h**, 100 MHz, $CDCl_3$

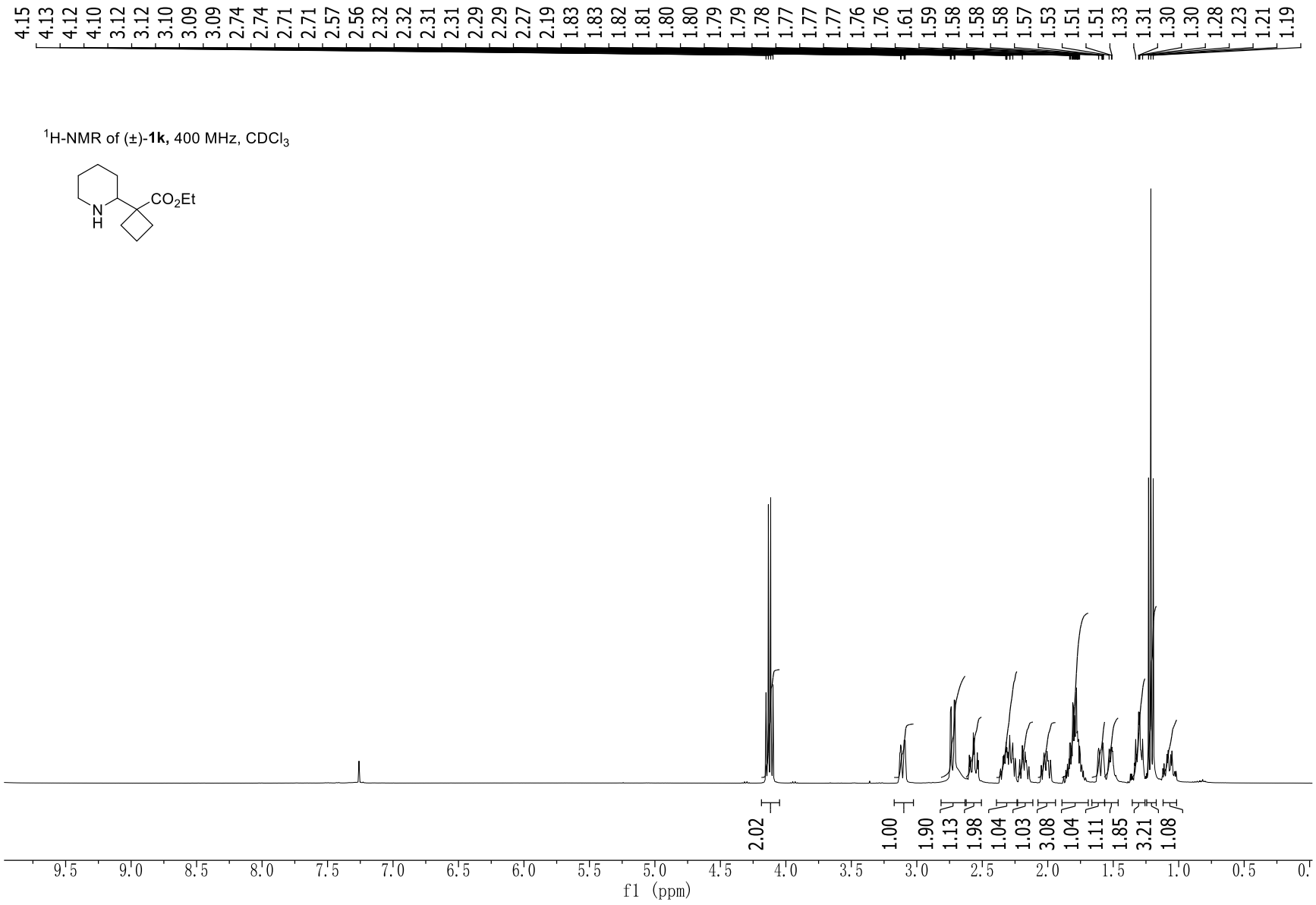

4.13 4.13 4.12 4.12 4.12 4.11 4.11 4.10 4.09 4.09 3.09 3.09 3.07 3.06 2.66 2.65 2.63 2.63 2.59 2.59 2.59 1.81 1.81 1.80 1.57 1.56 1.55 1.54 1.54 1.53 1.53 1.53 1.52 1.34 1.34 1.33 1.32 1.31 1.31 1.31 1.24 1.24 1.23 1.23 1.22 1.21 1.14 1.13 1.12 1.10 1.10 1.10 1.10 1.09
1H-NMR of (±)-1i, 500 MHz, CDCl3
CO2Et
N
H
Me Me
1.97 1.00 2.00 1.04 0.83 2.06 2.06 3.02 7.19
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 of (±)-**1i**, 125 MHz, $CDCl_3$

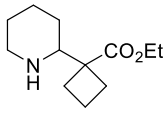


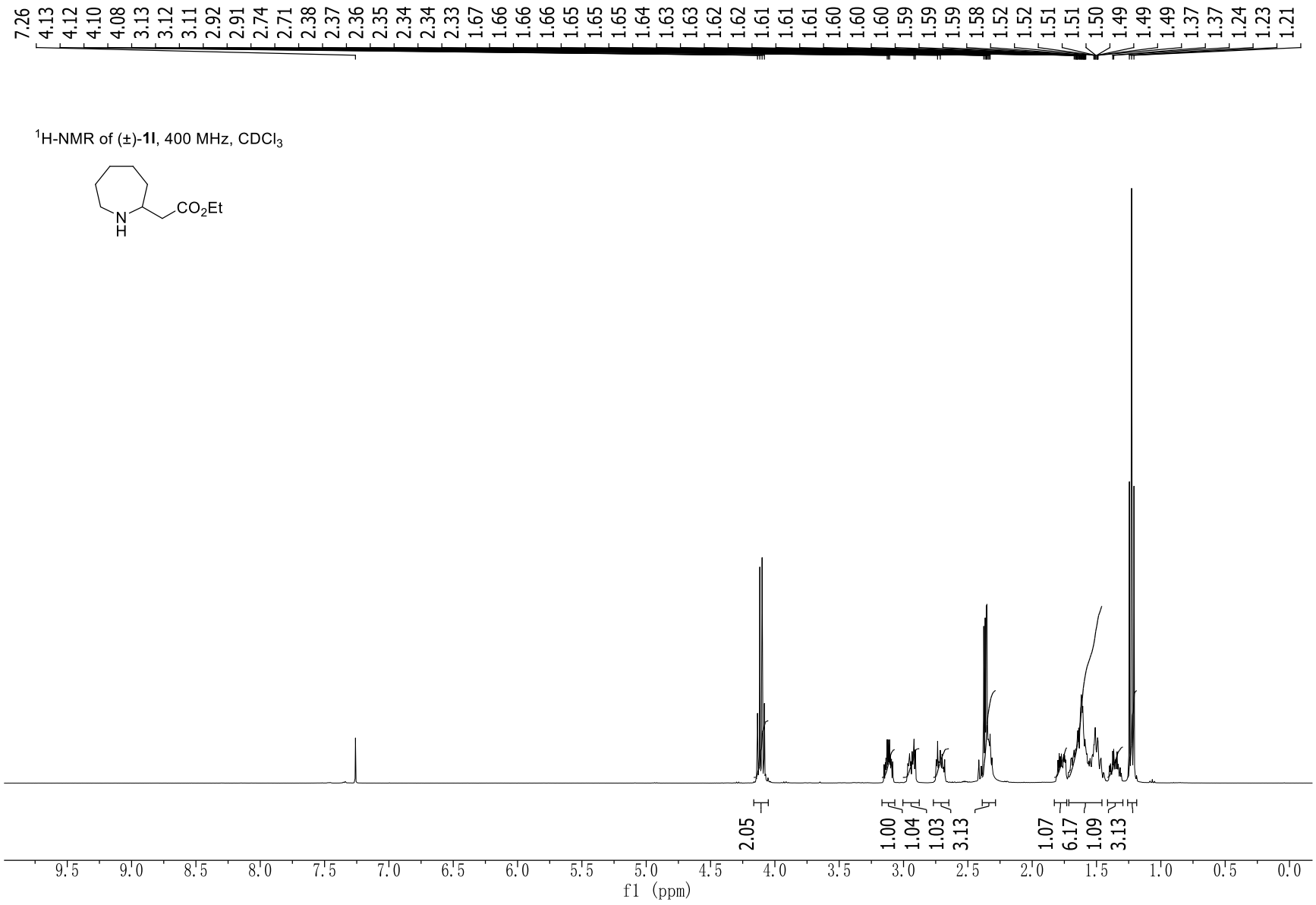

7.26
3.68
3.68
3.67
3.12
2.55
2.54
2.48
2.47
2.45
2.44
1.62
1.62
1.61
1.61
1.61
1.60
1.60
1.59
1.59
1.59
1.58
1.58
1.57
1.54
1.54
1.51
1.50
1.32
1.32
1.31
1.31
1.30
1.30
1.30
1.29
1.29
1.28
1.28
1.28
1.27
1.26
1.26
1.25
1.25
1.24
1.24
1.24
1.23
1.23
1.22
1.22
1.21
1.10
1H-NMR of (±)-1j, 400 MHz, CDCl3
CO2Me
N
H
2.98
1.00
1.97
1.02
1.93
1.03
5.01
6.03
2.02
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.
f1 (ppm)

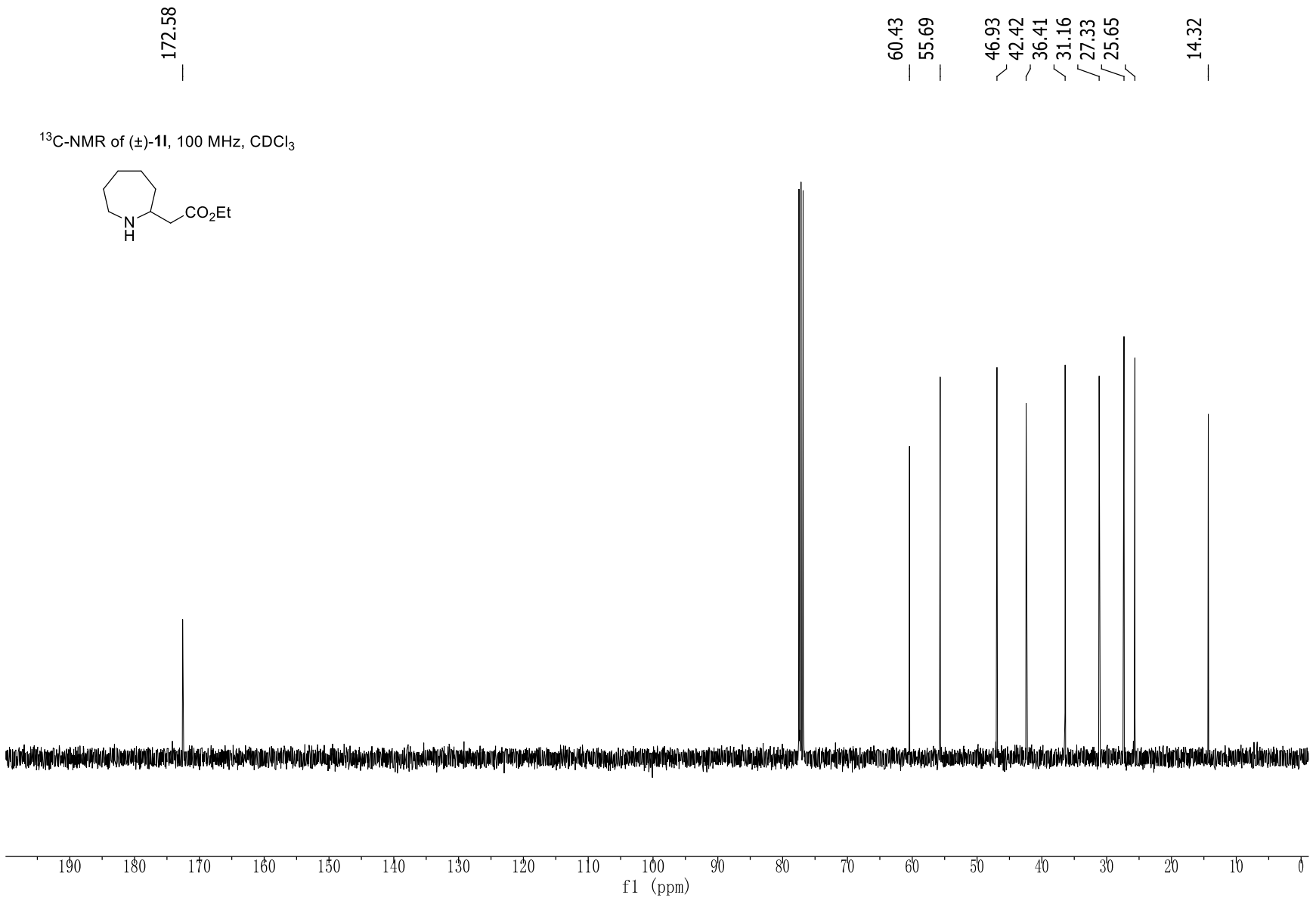

175.83
64.62
51.63
51.36
47.89
31.24
31.03
27.48
26.51
25.89
25.20
23.57
^{13}C-NMR of (±)-**1j**, 100 MHz, $CDCl_3$
CO_2Me
N
H
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

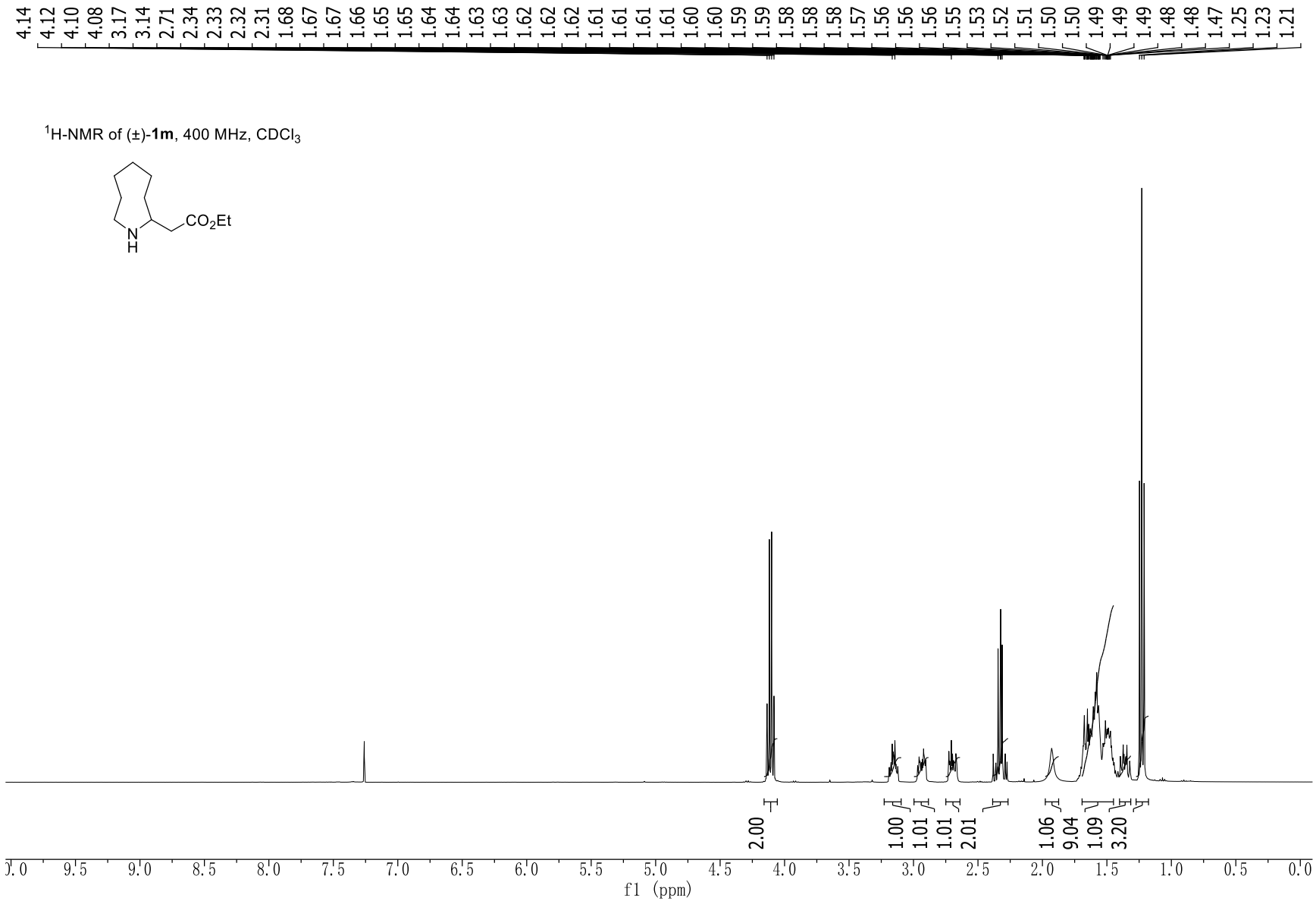

4.15 4.13 4.12 4.10 3.12 3.12 3.10 3.09 3.09 2.74 2.74 2.71 2.71 2.57 2.56 2.32 2.32 2.31 2.31 2.29 2.29 2.27 2.19 1.83 1.83 1.82 1.81 1.80 1.80 1.79 1.79 1.78 1.77 1.77 1.77 1.76 1.76 1.61 1.59 1.58 1.58 1.58 1.57 1.53 1.51 1.51 1.33 1.31 1.30 1.30 1.28 1.23 1.21 1.19
^{1}H-NMR of (±)-**1k,** 400 MHz, $CDCl_3$
CO_2Et
N
H
2.02 1.00 1.90 1.13 1.98 1.04 1.03 3.08 1.04 1.11 1.85 3.21 1.08
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.
f1 (ppm)

^{13}C-NMR of (±)-**1k**, 100 MHz, $CDCl_3$

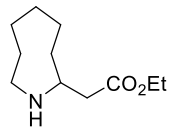


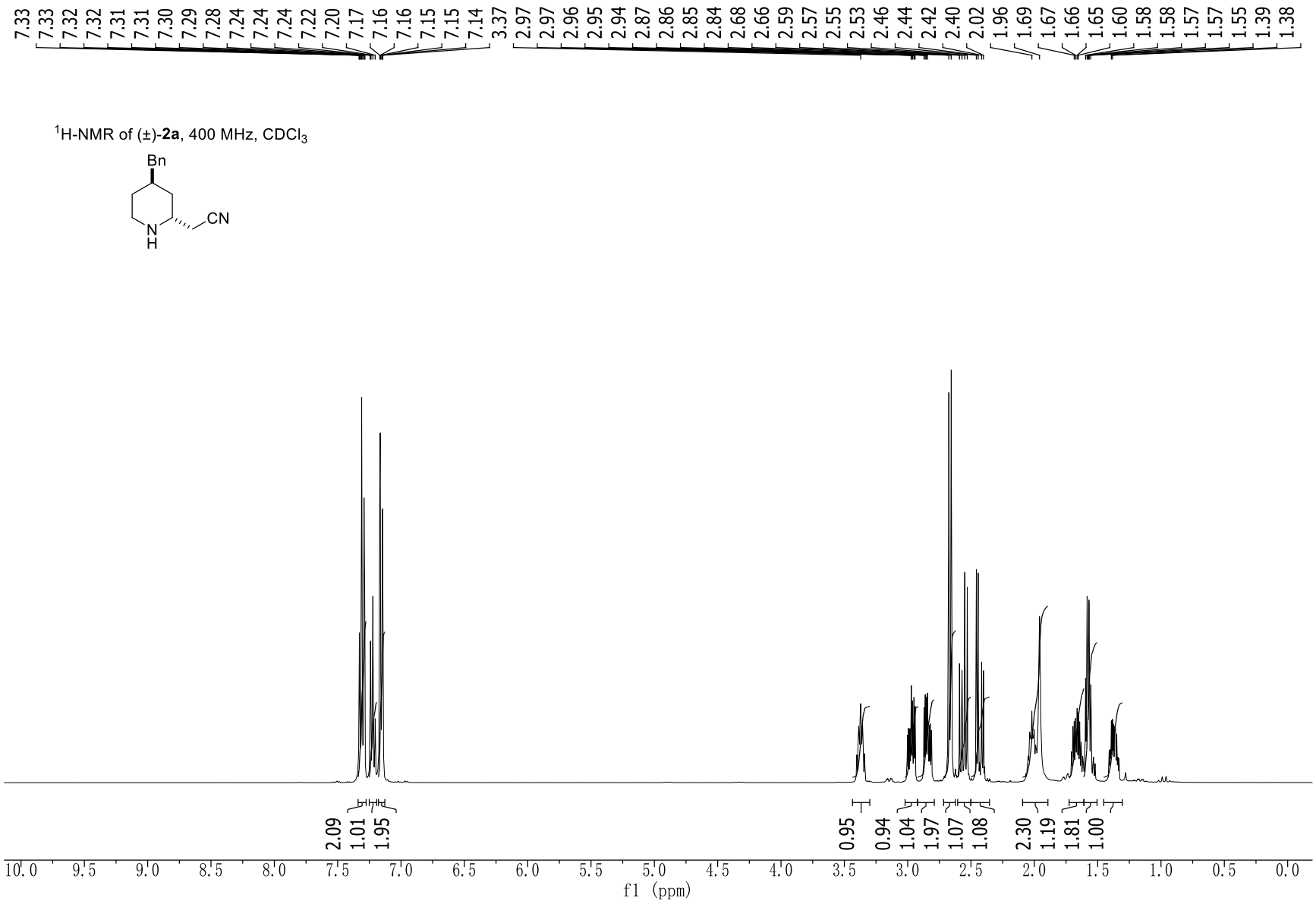

7.26 4.13 4.12 4.10 4.08 3.13 3.12 3.11 2.92 2.91 2.74 2.71 2.38 2.37 2.36 2.35 2.34 2.34 2.33 1.67 1.66 1.66 1.66 1.65 1.65 1.65 1.64 1.63 1.63 1.62 1.62 1.61 1.61 1.61 1.60 1.60 1.60 1.59 1.59 1.59 1.58 1.52 1.52 1.51 1.51 1.50 1.49 1.49 1.49 1.37 1.37 1.24 1.23 1.21
1H-NMR of (±)-1l, 400 MHz, CDCl3
CO2Et
N
H
2.05 1.00 1.04 1.03 3.13 1.07 6.17 1.09 3.13
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
f1 (ppm)


172.58
60.43
55.69
46.93
42.42
36.41
31.16
27.33
25.65
14.32
13C-NMR of (±)-1l, 100 MHz, CDCl3
CO2Et
N
H
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

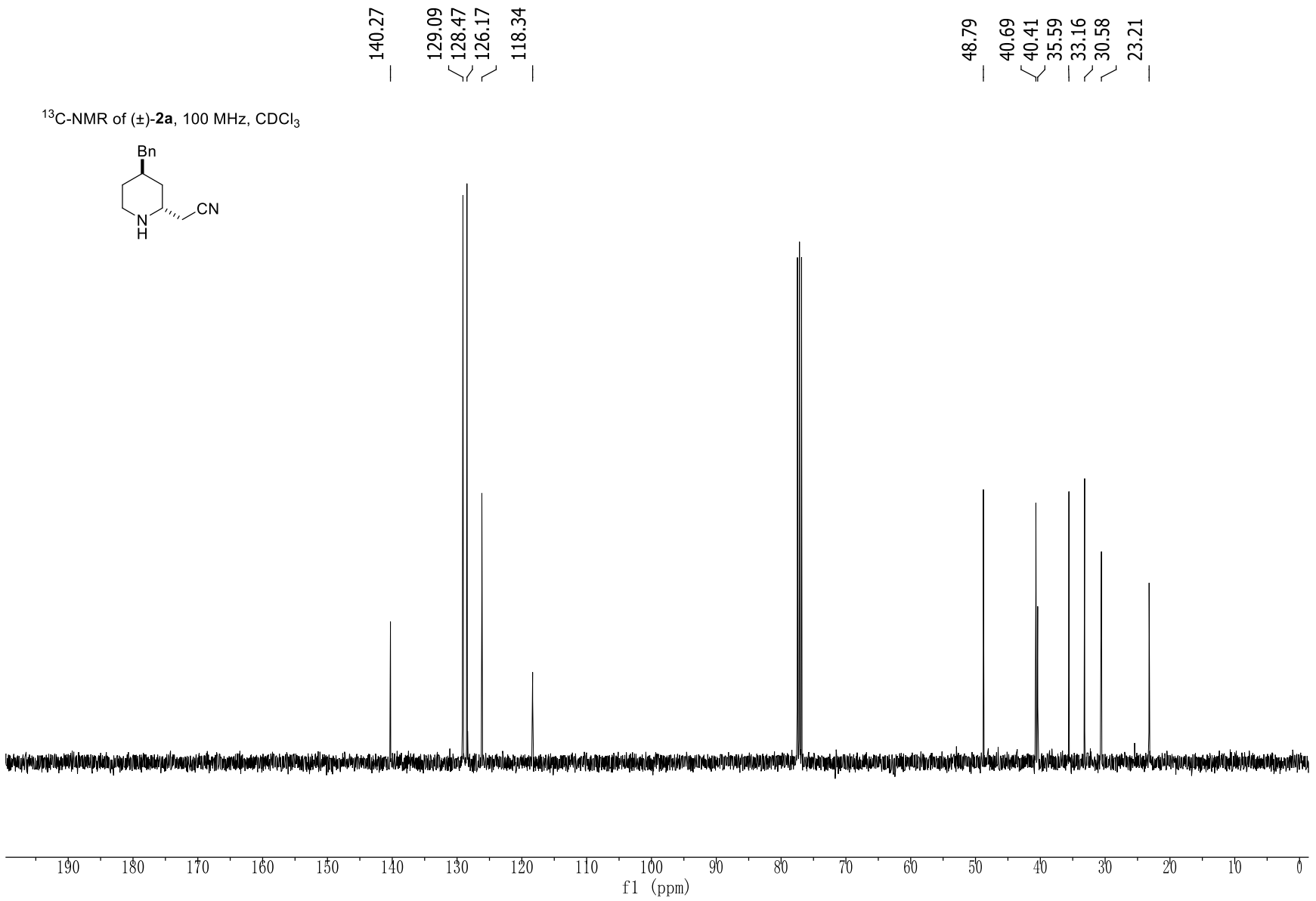

4.14 4.12 4.10 4.08 3.17 3.14 2.71 2.34 2.33 2.32 2.31 1.68 1.67 1.67 1.66 1.65 1.65 1.64 1.64 1.63 1.63 1.62 1.62 1.62 1.61 1.61 1.61 1.61 1.60 1.60 1.59 1.59 1.58 1.58 1.58 1.57 1.56 1.56 1.56 1.55 1.53 1.52 1.51 1.50 1.50 1.49 1.49 1.49 1.48 1.48 1.47 1.25 1.23 1.21
1H-NMR of (±)-1m, 400 MHz, CDCl3
CO2Et
N
H
2.00 1.00 1.01 1.01 2.01 1.06 9.04 1.09 3.20
f1 (ppm)

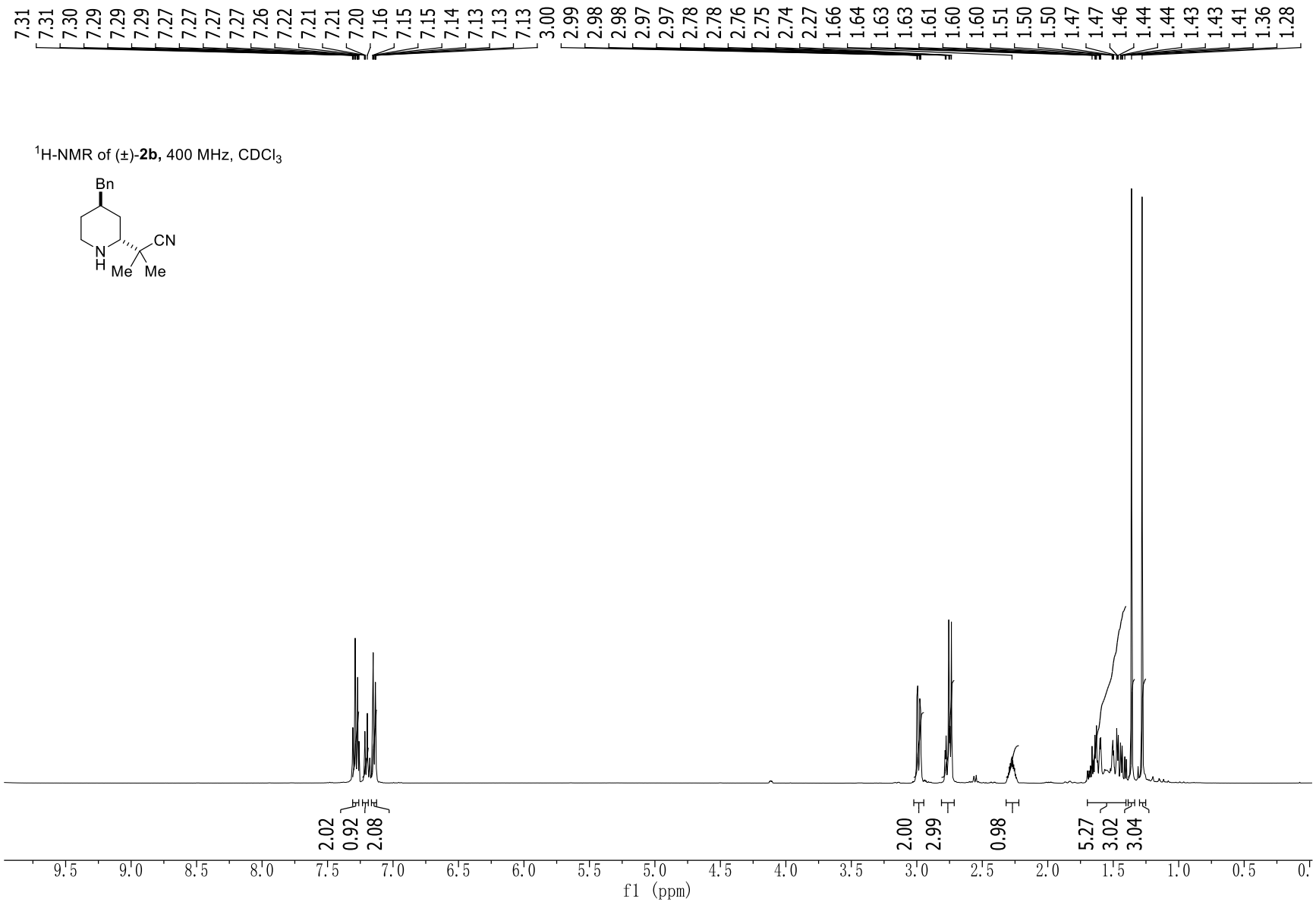
^{13}C-NMR of (±)-**1m**, 100 MHz, $CDCl_3$

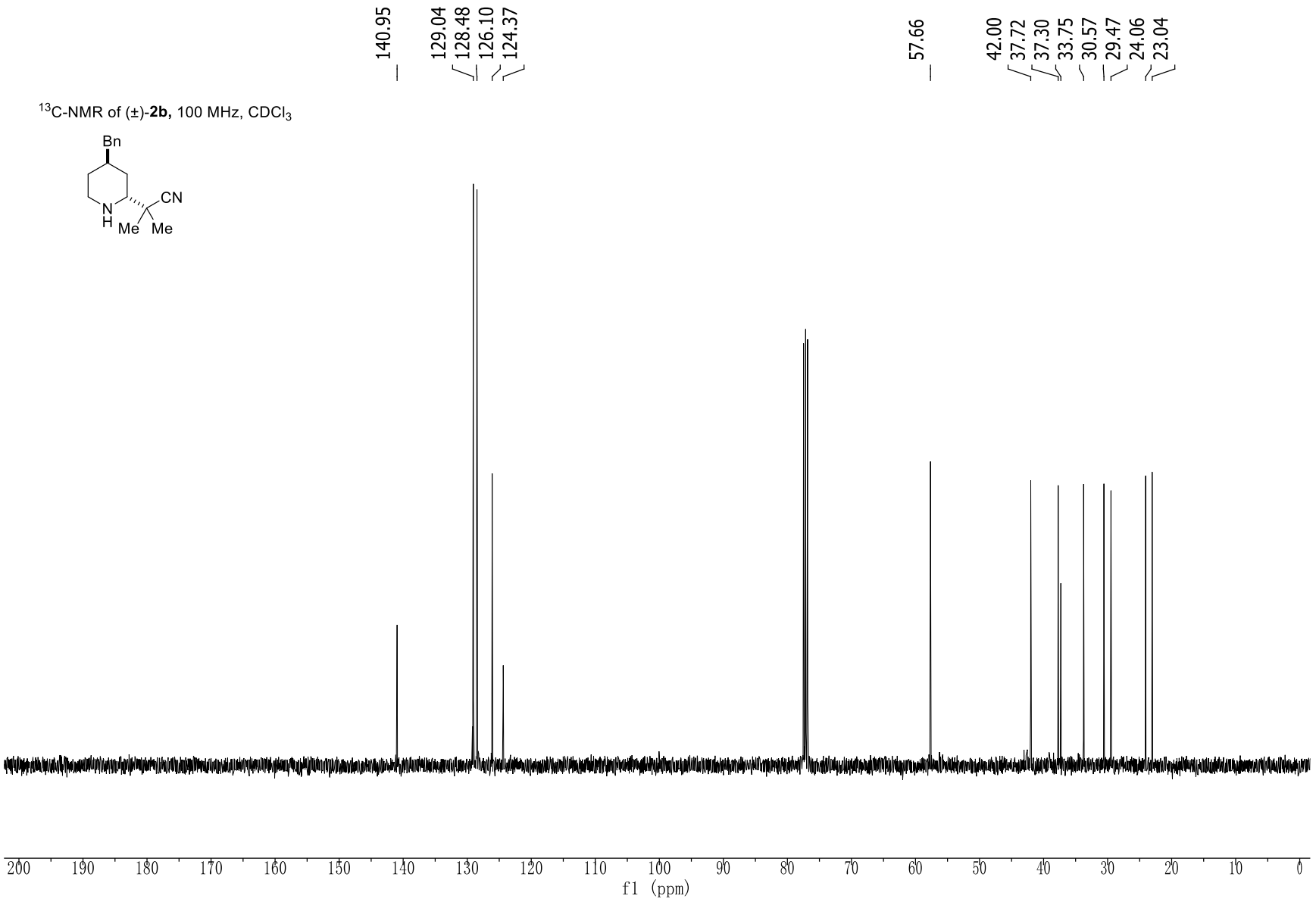


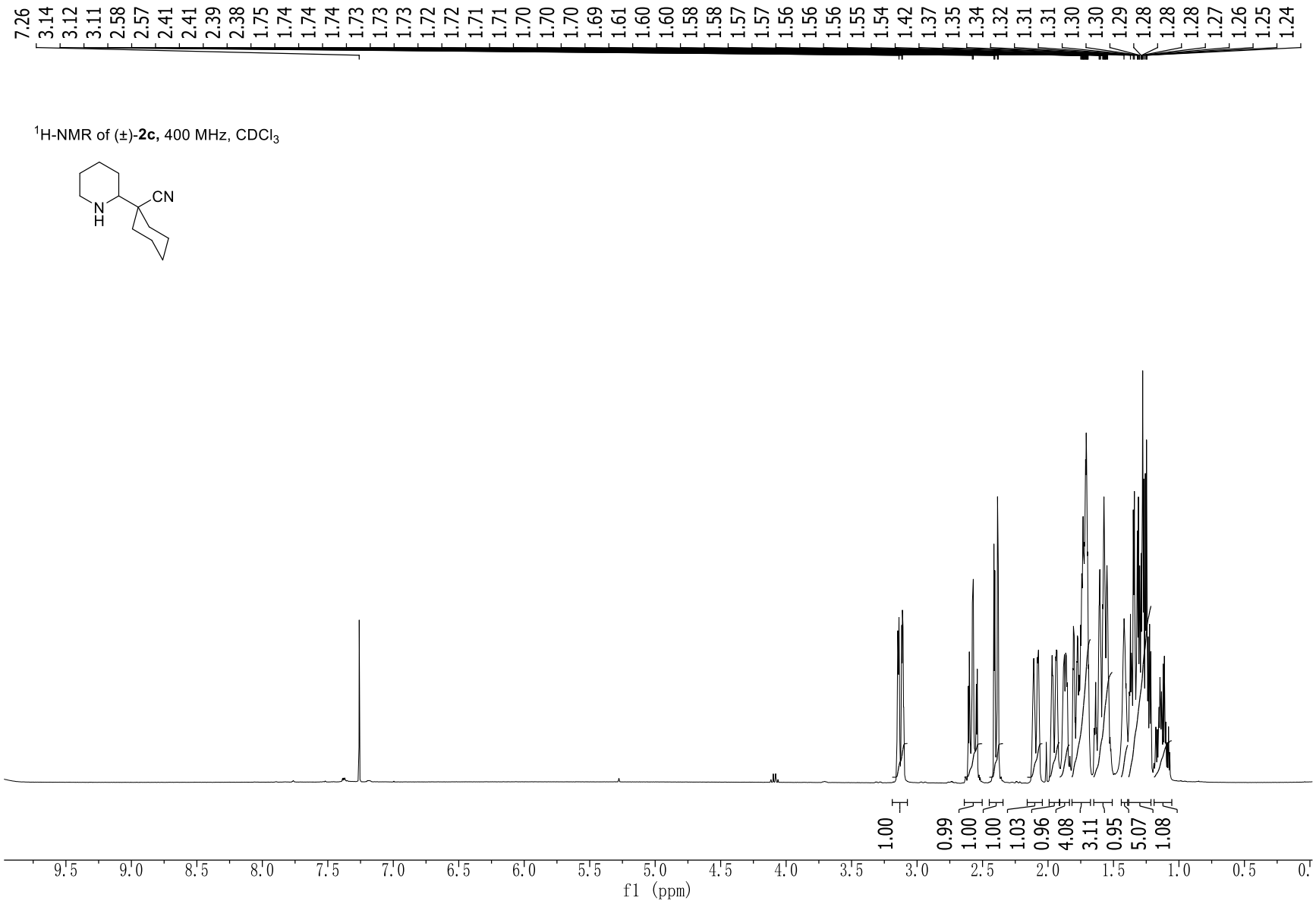


^{1}H-NMR of (±)-**2a**, 400 MHz, $CDCl_3$

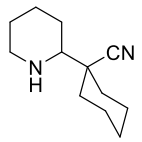

140.27
129.09
128.47
126.17
118.34
48.79
40.69
40.41
35.59
33.16
30.58
23.21
^{13}C-NMR of (±)-**2a**, 100 MHz, $CDCl_3$
Bn
CN
N
H
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

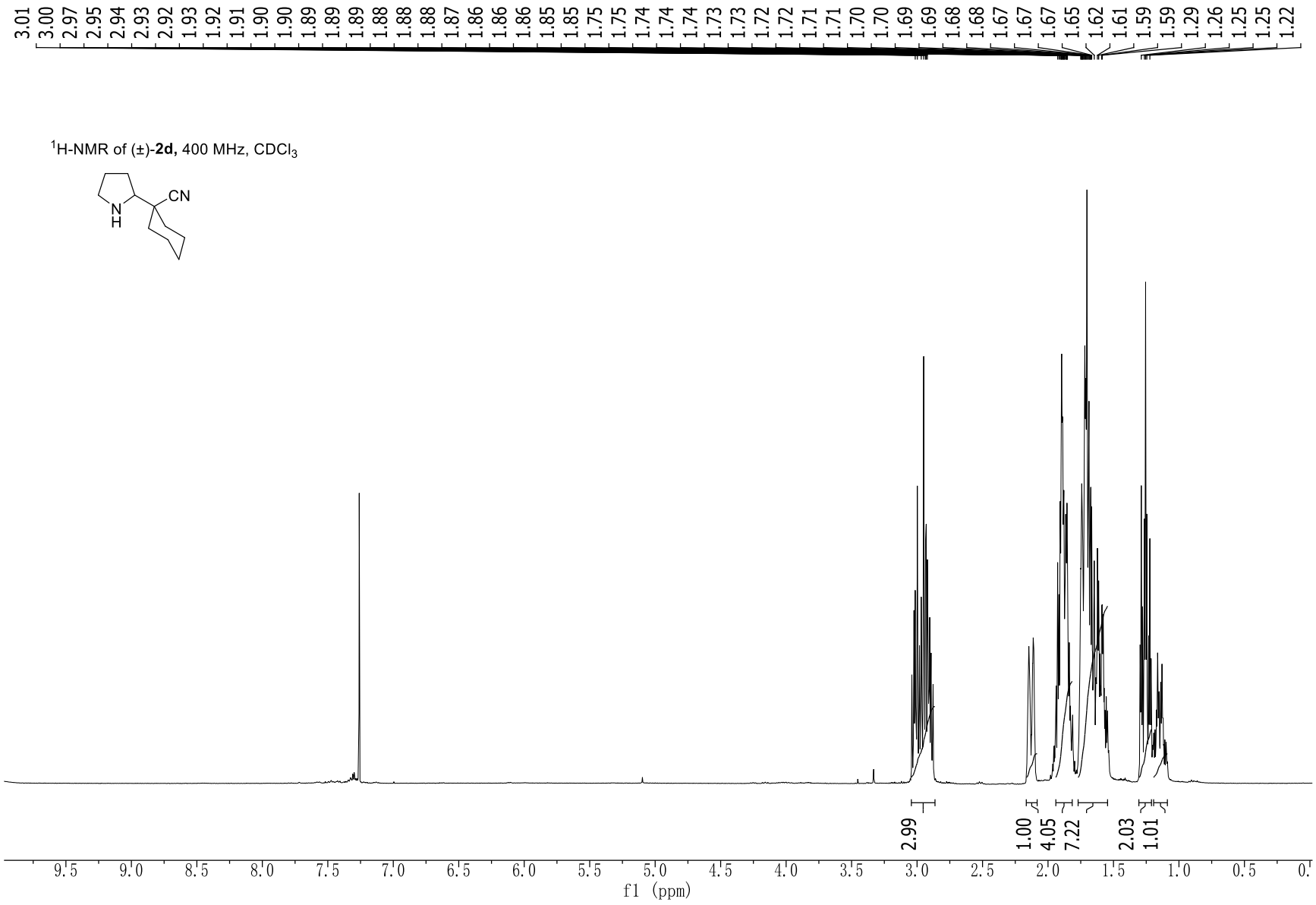

7.31 7.31 7.30 7.29 7.29 7.29 7.27 7.27 7.27 7.27 7.26 7.22 7.21 7.21 7.20 7.16 7.15 7.15 7.14 7.13 7.13 7.13 3.00
2.99 2.98 2.98 2.97 2.97 2.78 2.78 2.76 2.75 2.74 2.27 1.66 1.64 1.63 1.63 1.61 1.60 1.60 1.51 1.50 1.50 1.47 1.47 1.46 1.44 1.44 1.43 1.43 1.41 1.36 1.28
1H-NMR of (±)-2b, 400 MHz, CDCl3
Bn
CN
N
H
Me
Me
2.02
0.92
2.08
2.00
2.99
0.98
5.27
3.02
3.04
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.
f1 (ppm)

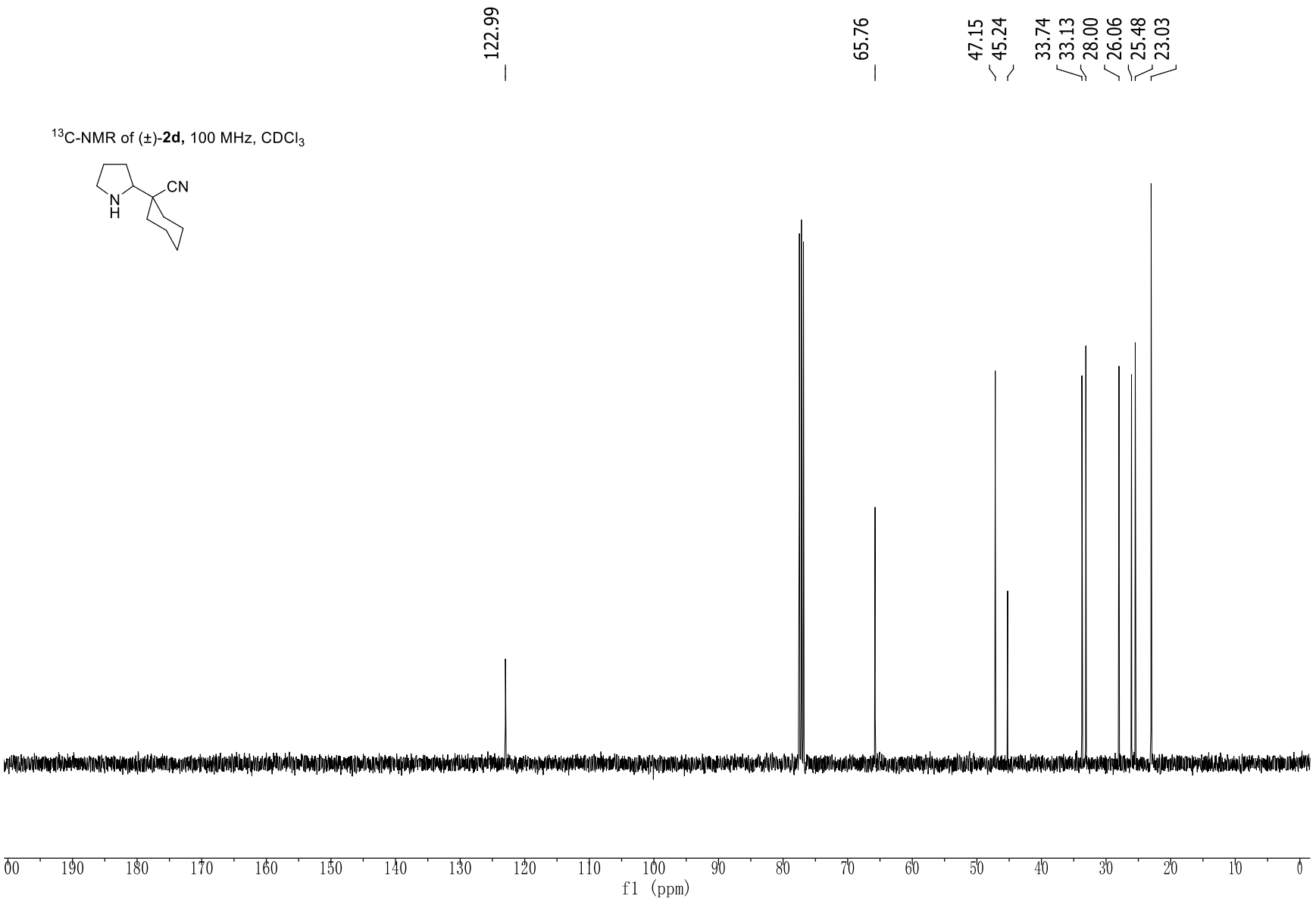

140.95
129.04
128.48
126.10
124.37
57.66
42.00
37.72
37.30
33.75
30.57
29.47
24.06
23.04
^{13}C-NMR of (±)-**2b,** 100 MHz, $CDCl_3$
Bn
N
H
CN
Me
Me
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

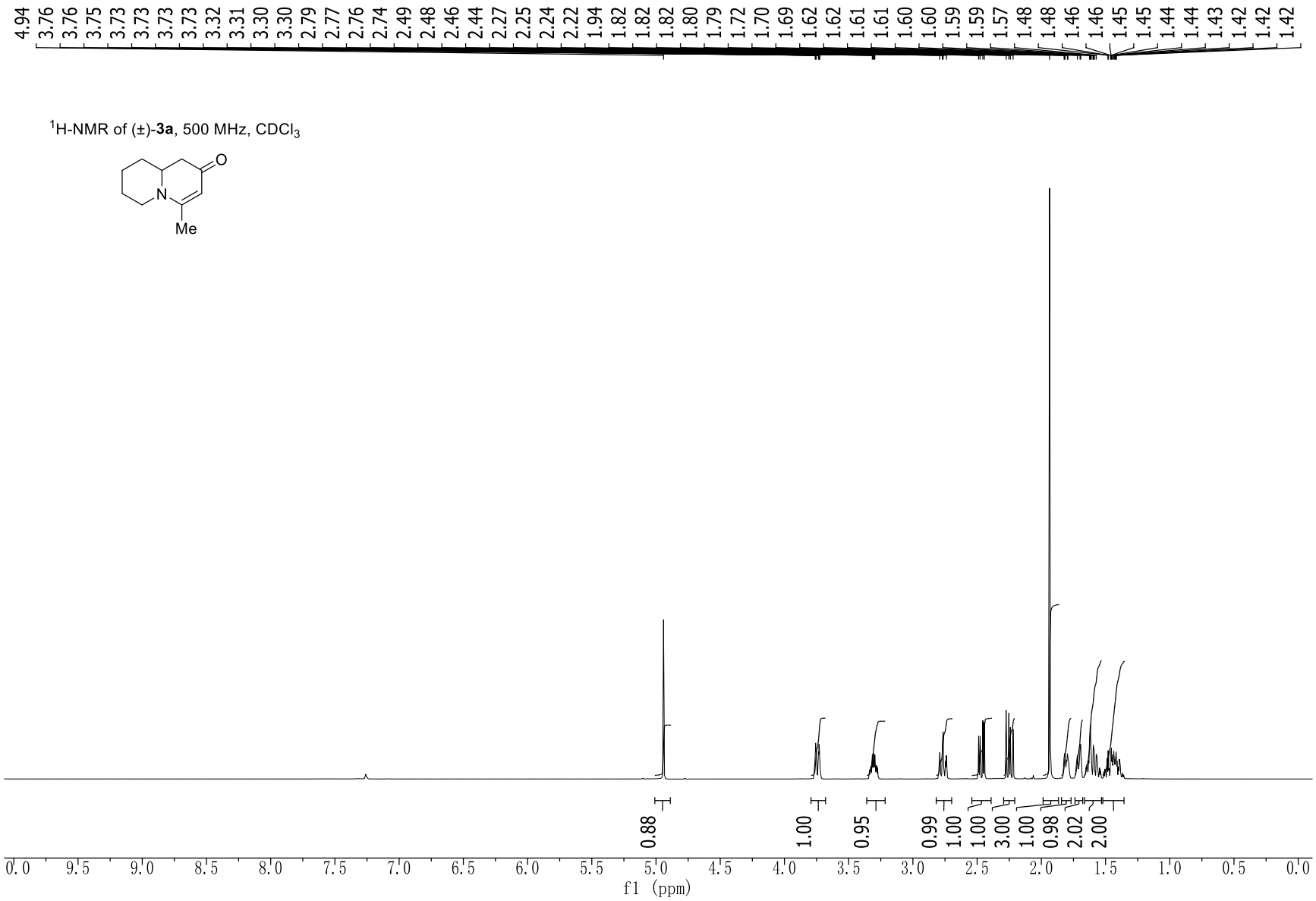

7.26 3.14 3.12 3.11 2.58 2.57 2.41 2.41 2.39 2.38 1.75 1.74 1.74 1.74 1.73 1.73 1.73 1.72 1.72 1.71 1.71 1.70 1.70 1.70 1.69 1.61 1.60 1.60 1.58 1.58 1.57 1.57 1.56 1.56 1.56 1.55 1.54 1.42 1.37 1.35 1.34 1.32 1.31 1.31 1.30 1.30 1.29 1.28 1.28 1.28 1.27 1.26 1.25 1.24
1H-NMR of (±)-2c, 400 MHz, CDCl3
CN
N
H
1.00 0.99 1.00 1.00 1.03 0.96 4.08 3.11 0.95 5.07 1.08
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.
f1 (ppm)

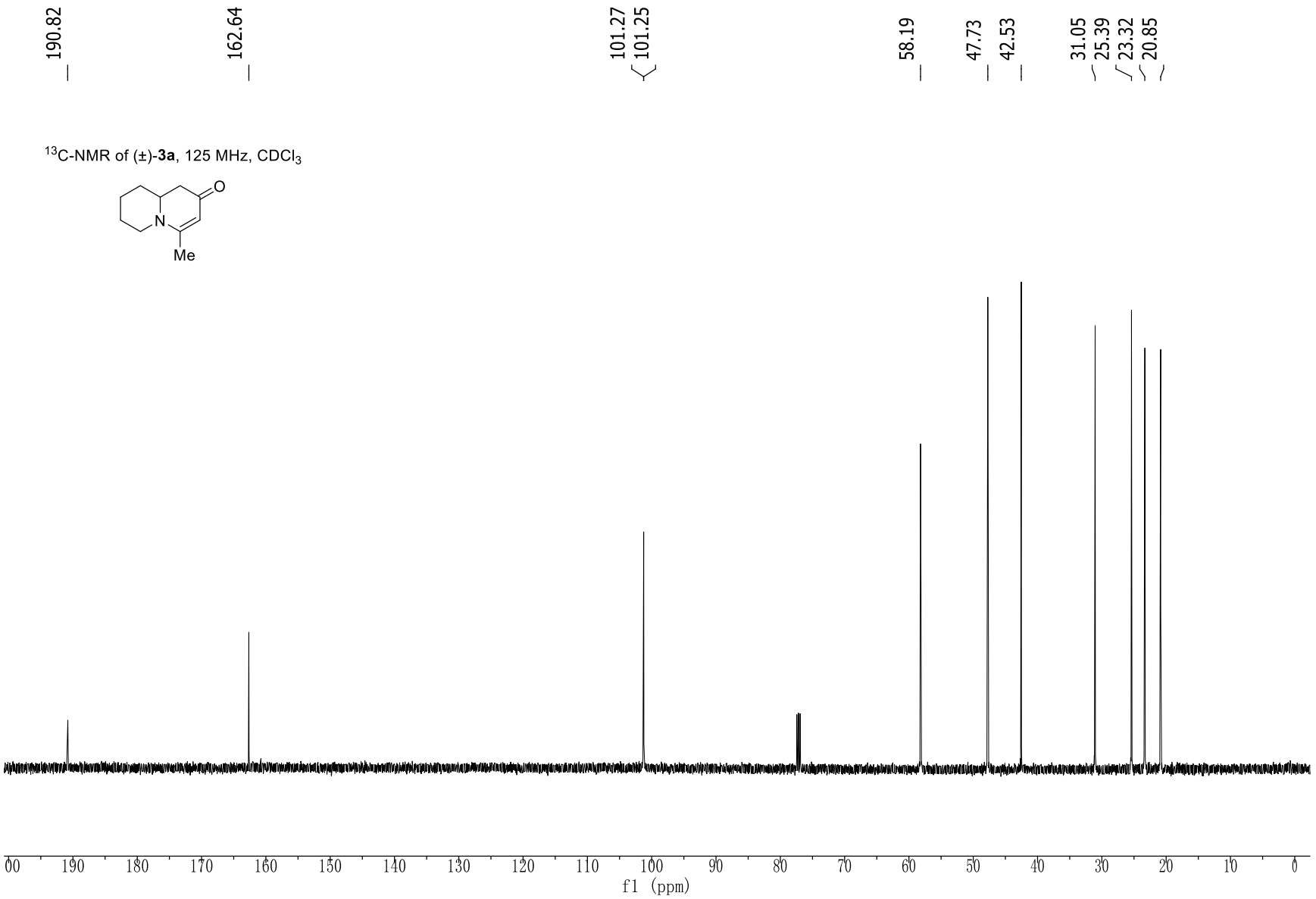
^{13}C-NMR of (±)-**2c,** 100 MHz, $CDCl_3$



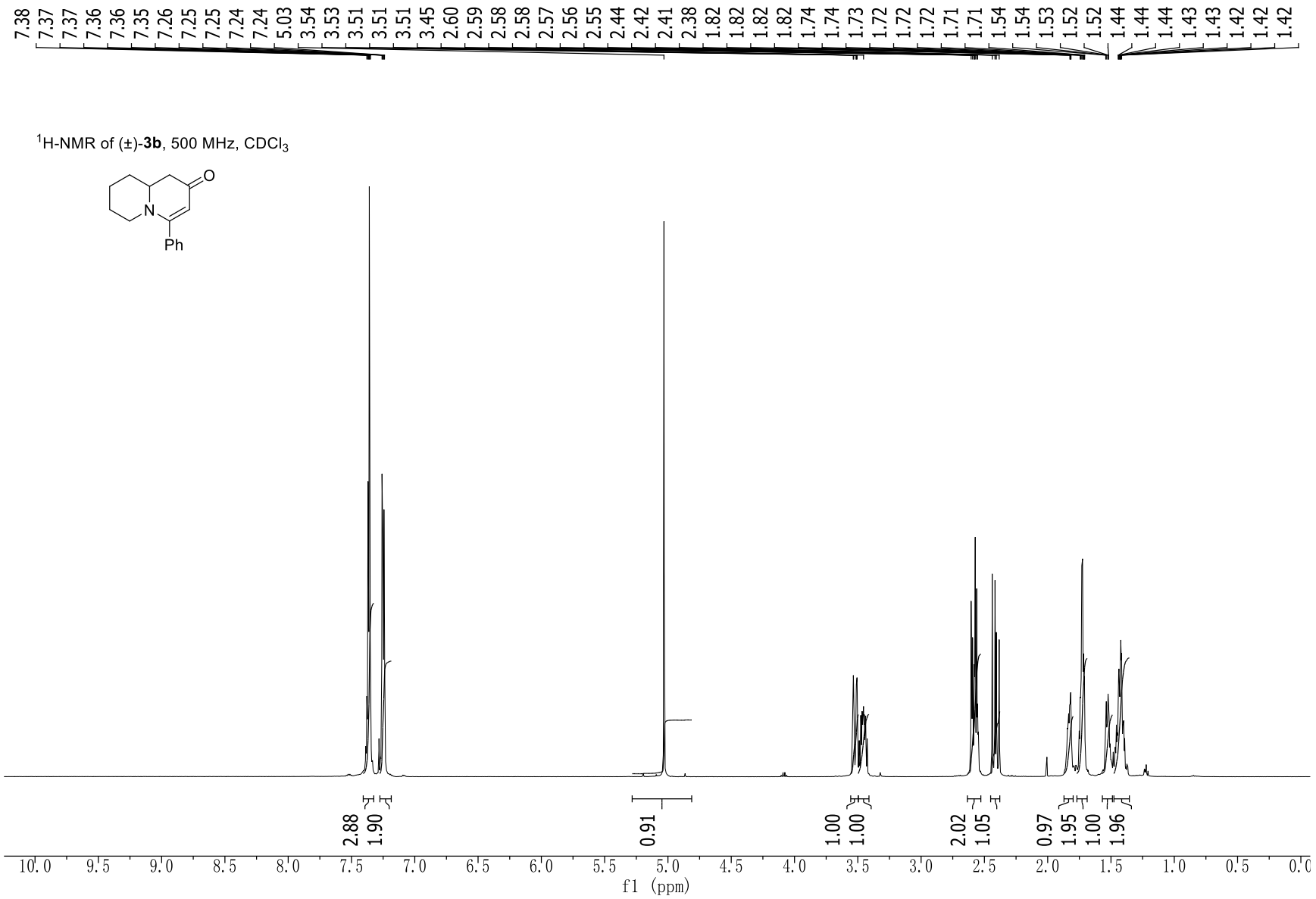

3.01 3.00 2.97 2.95 2.94 2.93 2.92 1.93 1.92 1.91 1.90 1.90 1.89 1.89 1.89 1.88 1.88 1.88 1.87 1.86 1.86 1.86 1.85 1.85 1.75 1.75 1.74 1.74 1.74 1.73 1.73 1.72 1.72 1.71 1.71 1.70 1.70 1.69 1.69 1.68 1.68 1.67 1.67 1.67 1.65 1.62 1.61 1.59 1.59 1.29 1.26 1.25 1.25 1.22
1H-NMR of (±)-2d, 400 MHz, CDCl3
CN
N
H
2.99
1.00
4.05
7.22
2.03
1.01
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.
f1 (ppm)

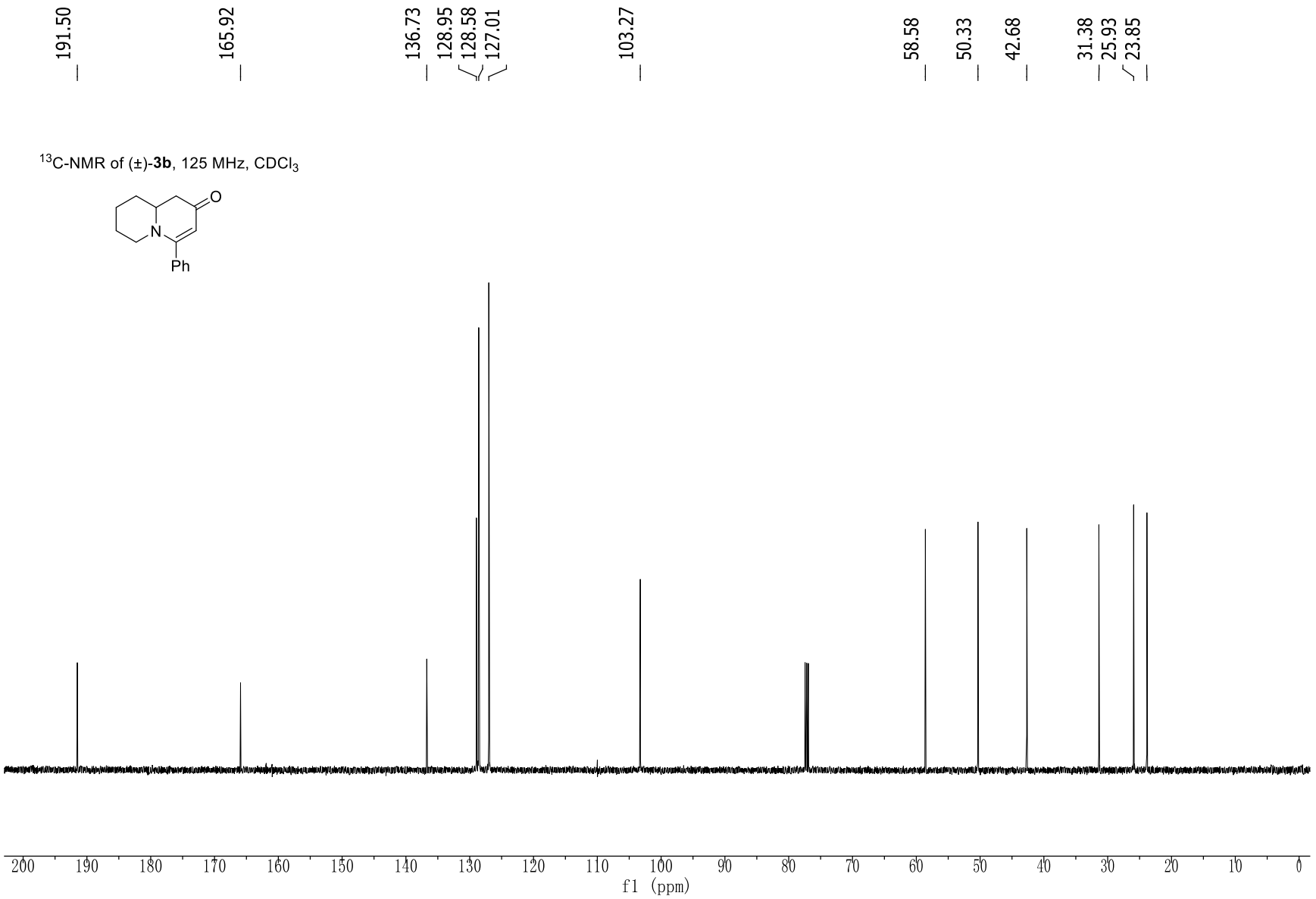

122.99
65.76
47.15
45.24
33.74
33.13
28.00
26.06
25.48
23.03
^{13}C-NMR of (±)-**2d**, 100 MHz, $CDCl_3$
CN
N
H
f1 (ppm)


4.94 3.76 3.76 3.75 3.73 3.73 3.73 3.73 3.32 3.31 3.30 3.30 2.79 2.77 2.76 2.74 2.49 2.48 2.46 2.44 2.27 2.25 2.24 2.22 1.94 1.82 1.82 1.82 1.80 1.79 1.72 1.70 1.69 1.62 1.62 1.61 1.61 1.60 1.60 1.59 1.59 1.57 1.48 1.48 1.46 1.46 1.45 1.45 1.44 1.44 1.43 1.42 1.42 1.42
1H-NMR of (±)-3a, 500 MHz, CDCl3
O
N
Me
0.88 1.00 0.95 0.99 1.00 1.00 3.00 1.00 0.98 2.02 2.00
f1 (ppm)

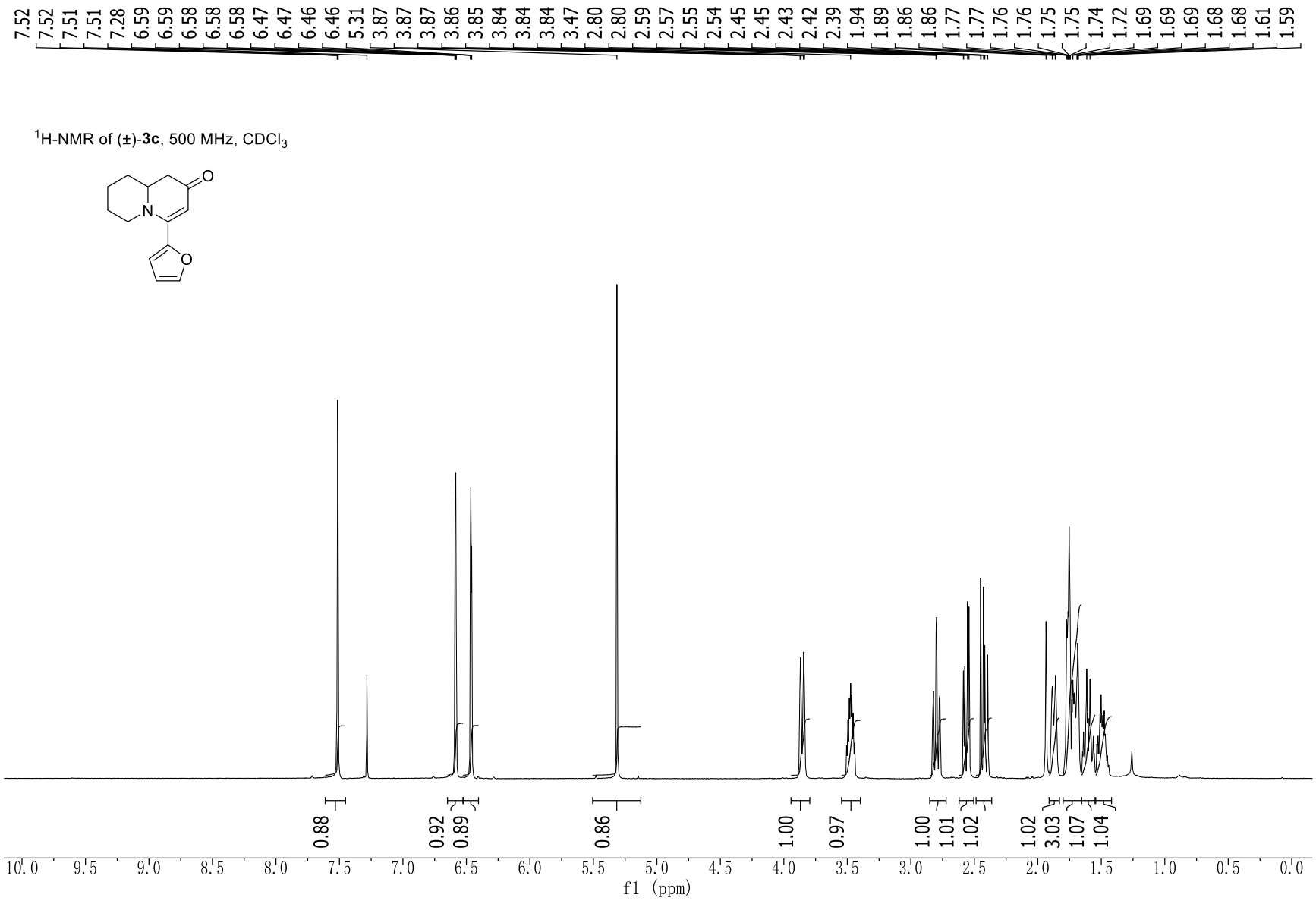


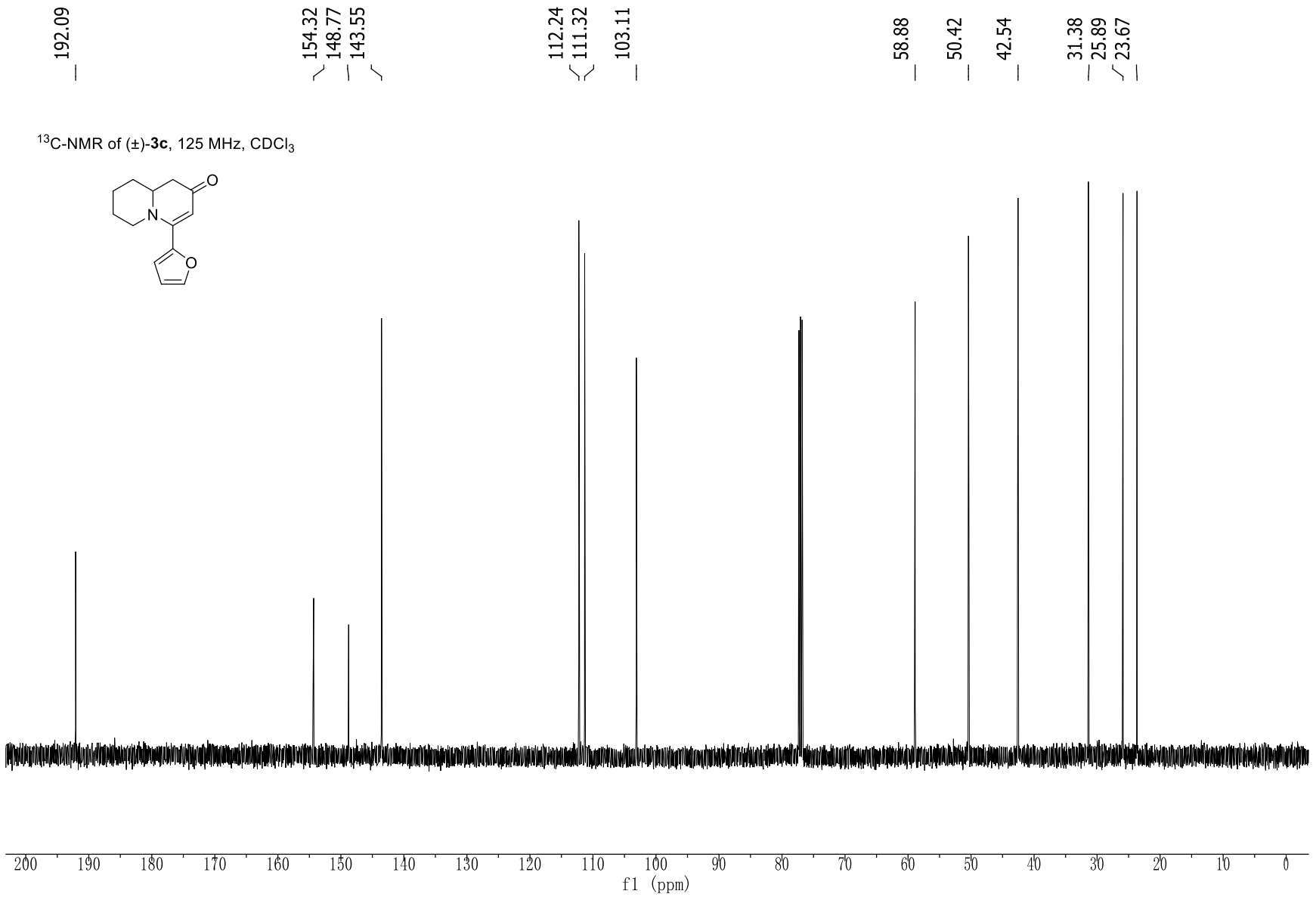
^{13}C-NMR of (±)-**3a**, 125 MHz, $CDCl_3$


7.38 7.37 7.37 7.36 7.36 7.35 7.26 7.25 7.25 7.24 7.24 5.03 3.54 3.53 3.51 3.51 3.51 3.45 2.60 2.59 2.58 2.58 2.57 2.56 2.55 2.44 2.42 2.41 2.38 1.82 1.82 1.82 1.74 1.74 1.73 1.72 1.72 1.72 1.71 1.71 1.54 1.54 1.53 1.52 1.52 1.44 1.44 1.44 1.43 1.43 1.42 1.42 1.42
1H-NMR of (±)-3b, 500 MHz, CDCl3
O
N
Ph
2.88 1.90 0.91 1.00 1.00 2.02 1.05 0.97 1.95 1.00 1.96
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
f1 (ppm)

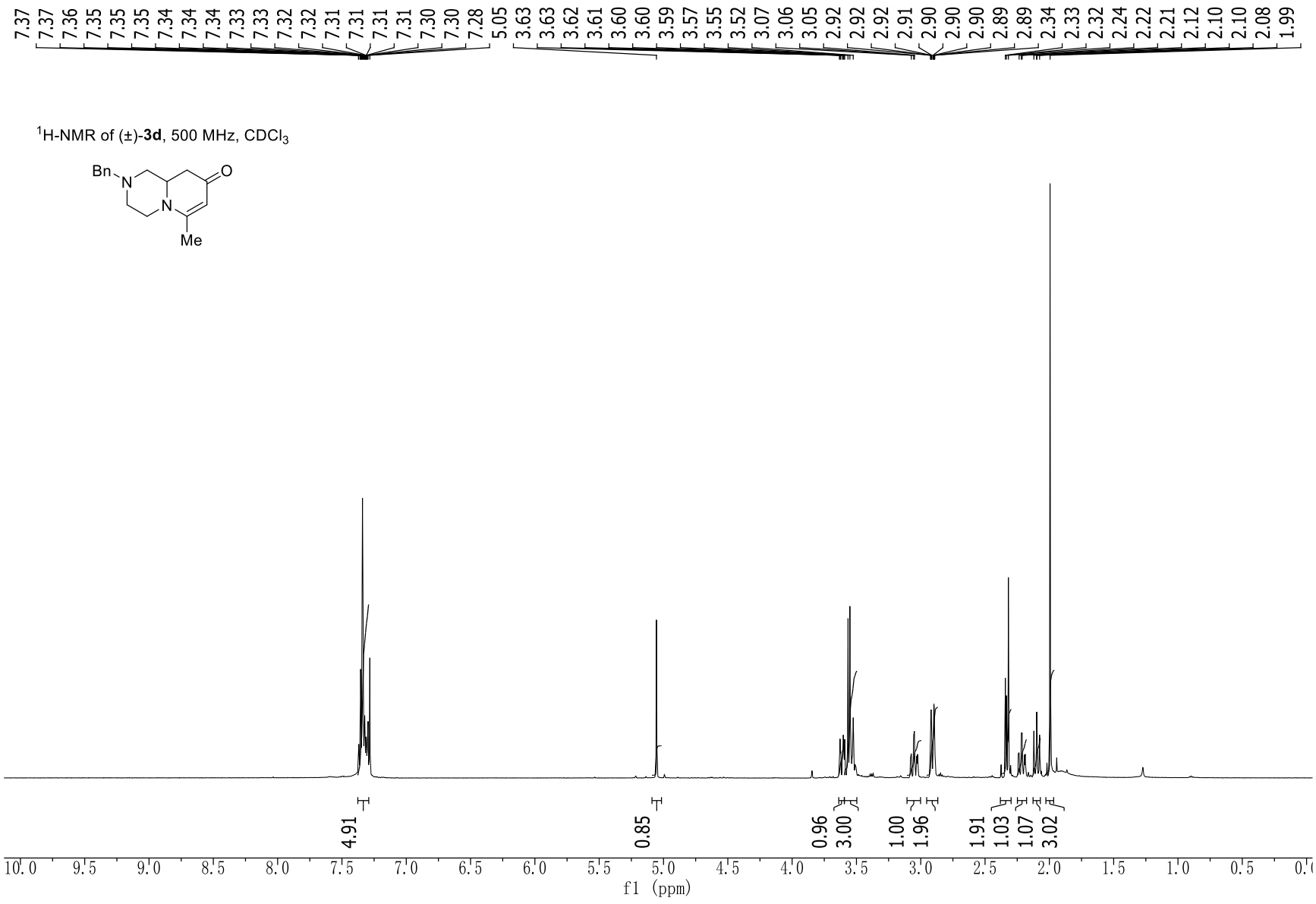


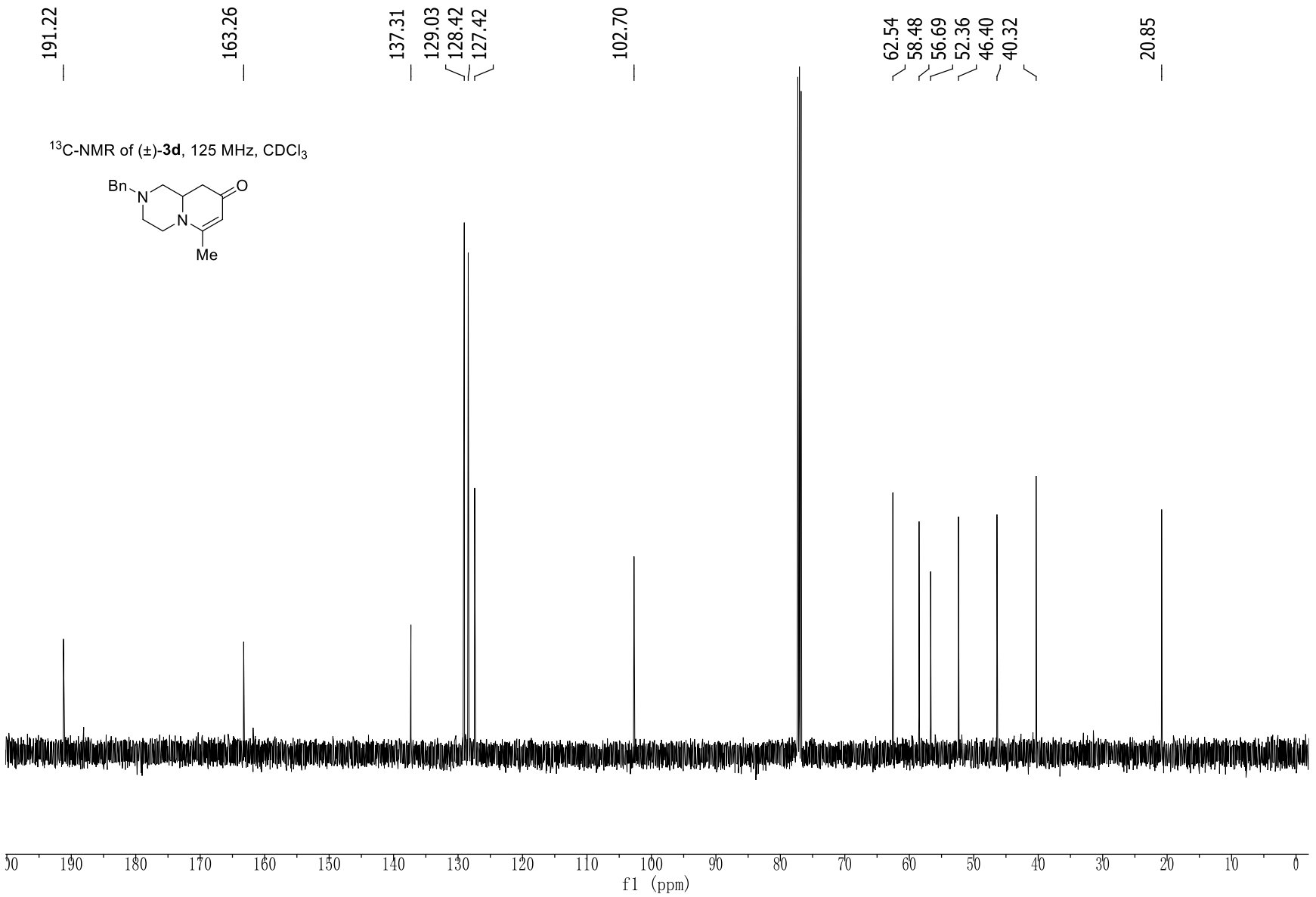
^{13}C-NMR of (±)-**3b**, 125 MHz, $CDCl_3$

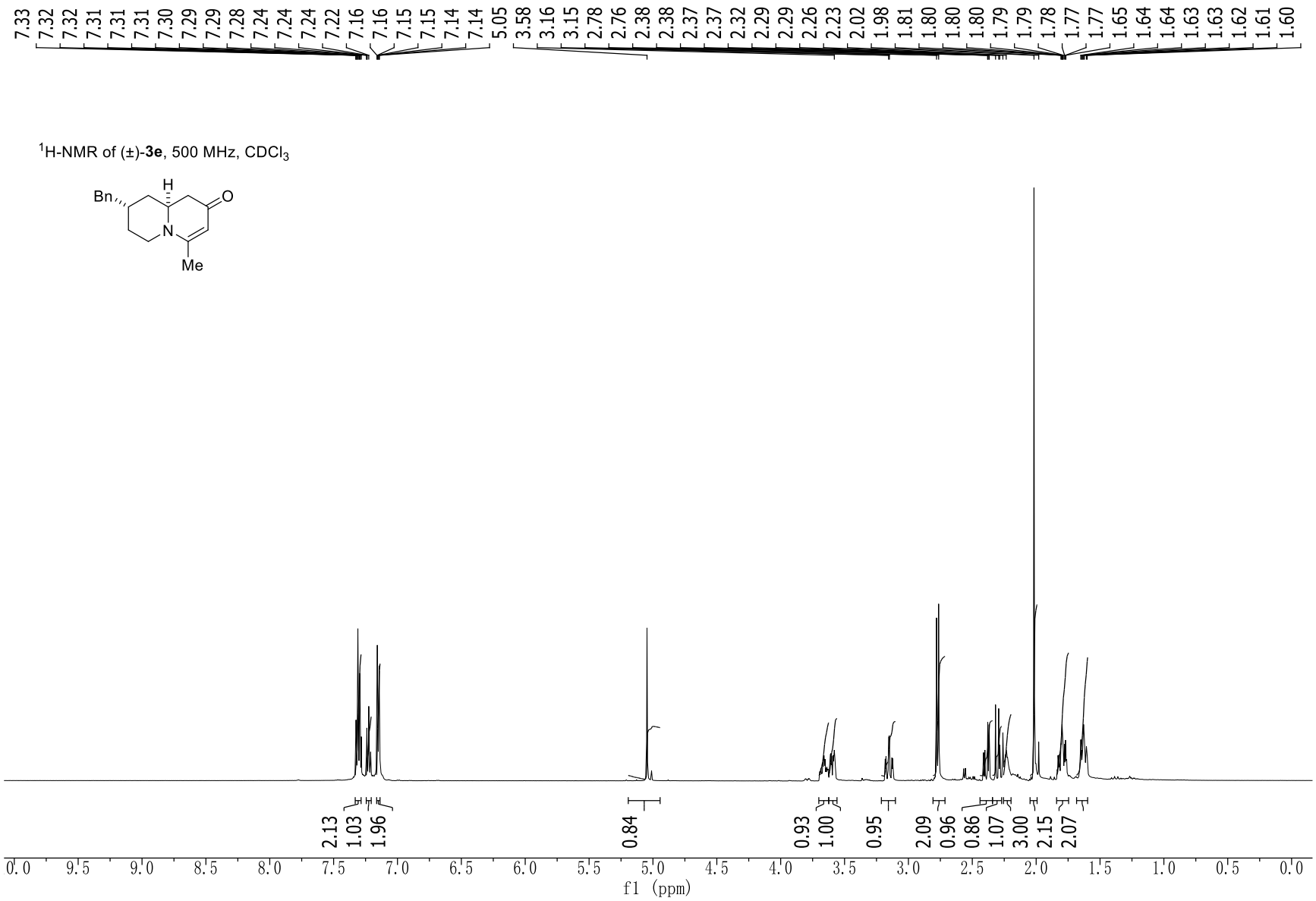

7.52 7.52 7.51 7.51 7.28 6.59 6.59 6.58 6.58 6.58 6.47 6.47 6.46 6.46 5.31 3.87 3.87 3.87 3.86 3.85 3.84 3.84 3.84 3.47 2.80 2.80 2.59 2.57 2.55 2.54 2.45 2.45 2.43 2.42 2.39 1.94 1.89 1.86 1.86 1.77 1.77 1.76 1.76 1.75 1.75 1.74 1.72 1.69 1.69 1.69 1.68 1.68 1.61 1.59
1H-NMR of (±)-3c, 500 MHz, CDCl3
O
N
O
0.88 0.92 0.89 0.86 1.00 0.97 1.00 1.01 1.02 1.02 3.03 1.07 1.04
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
f1 (ppm)

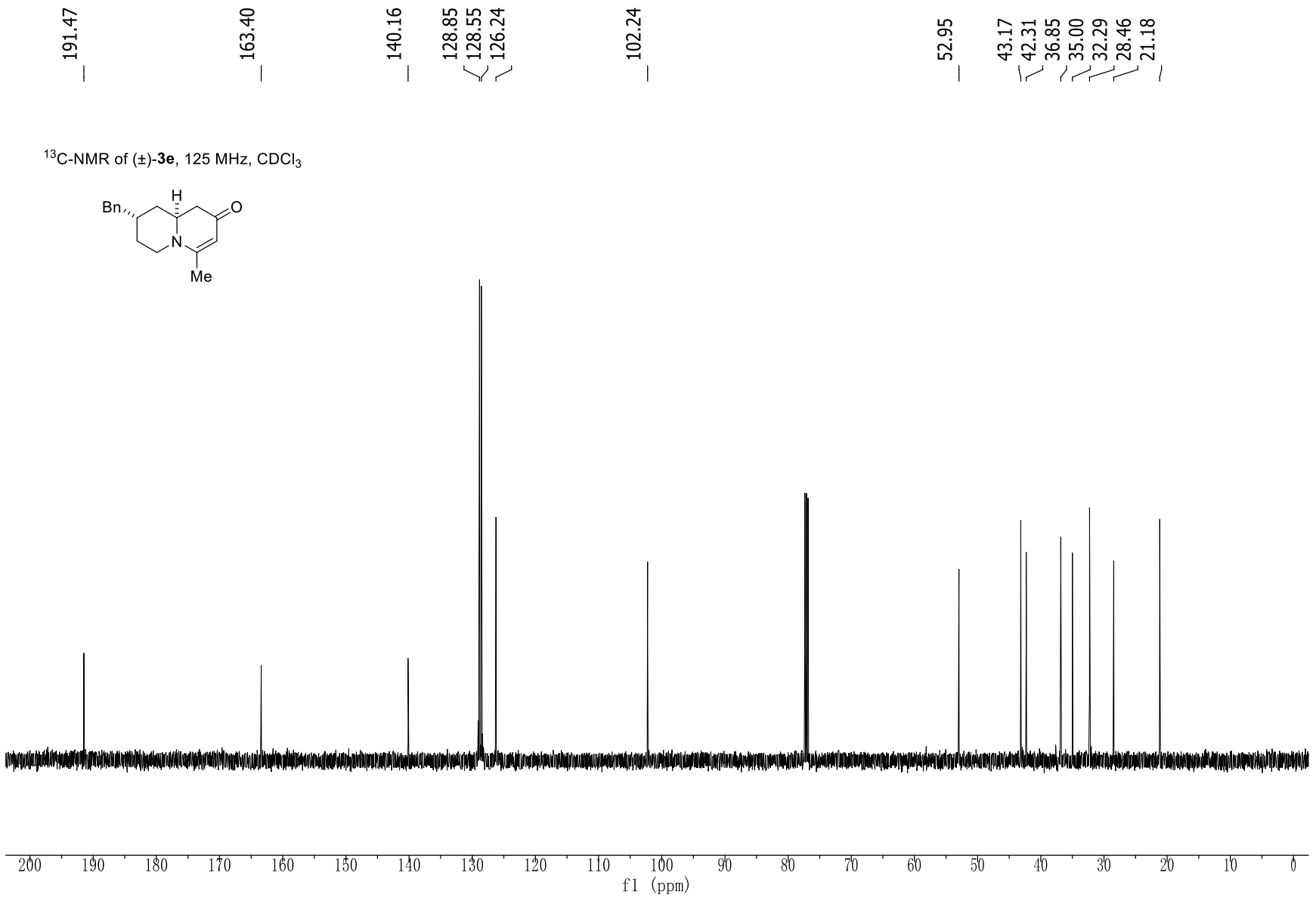


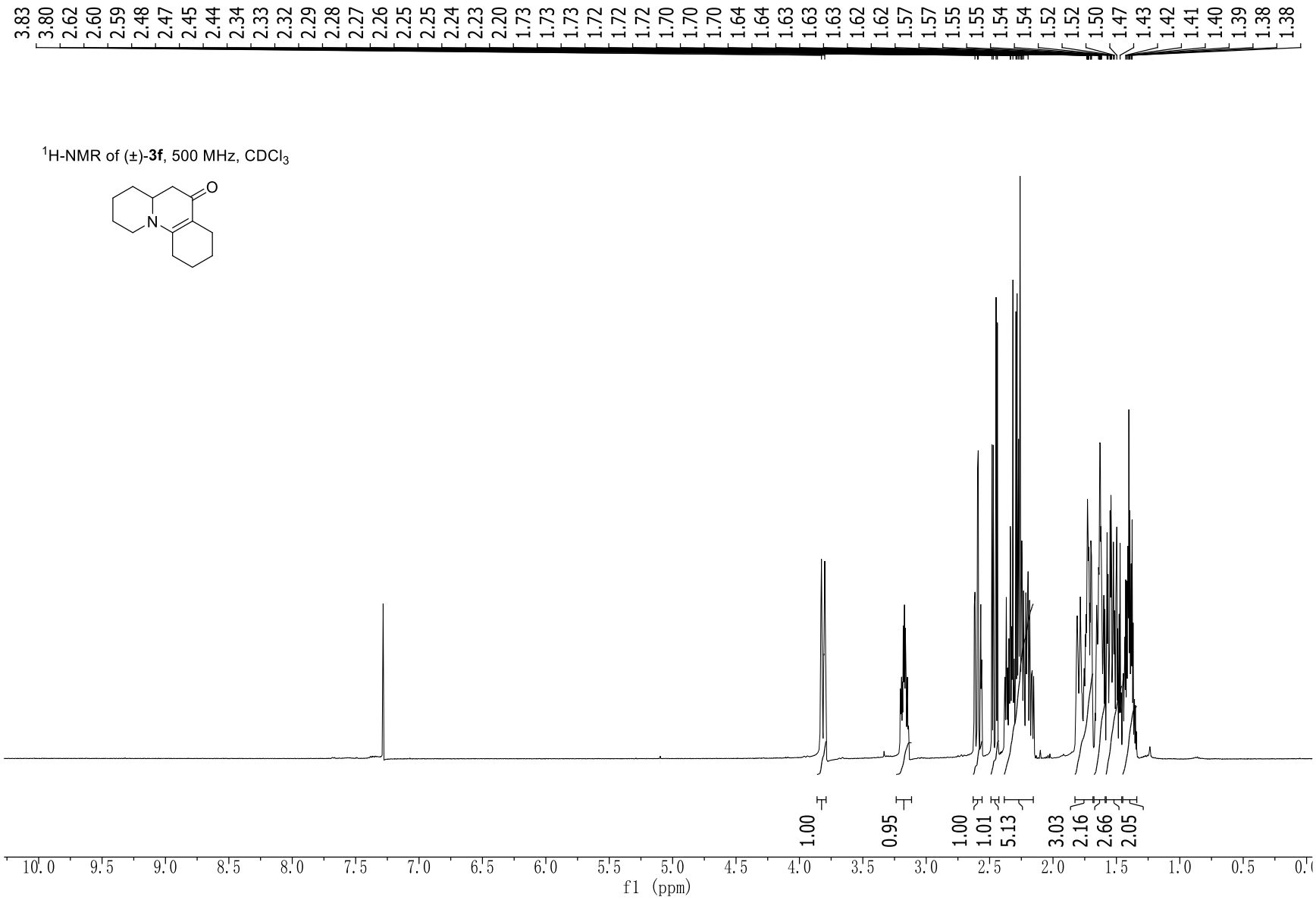
^{13}C-NMR of (±)-**3c**, 125 MHz, $CDCl_3$

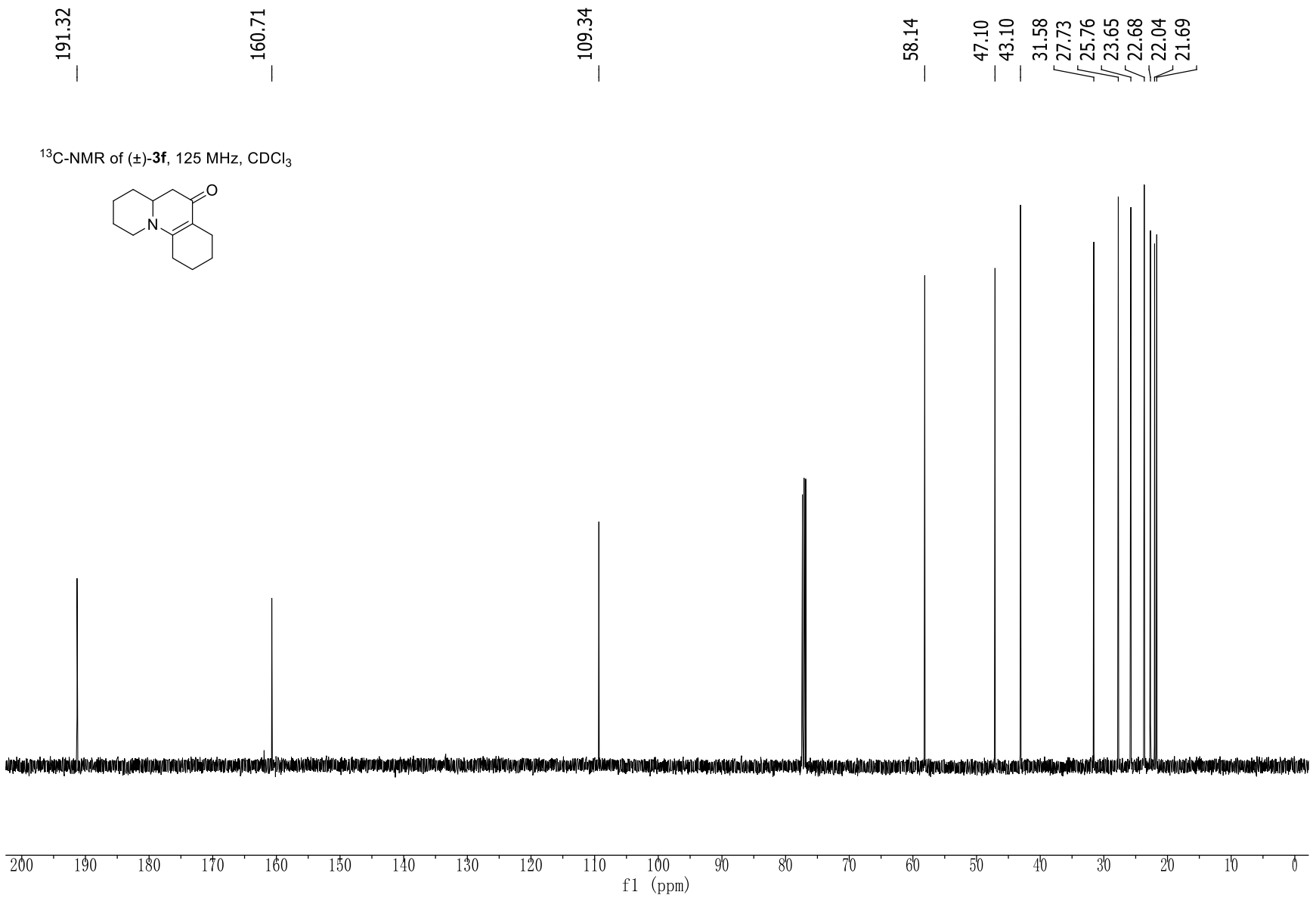

7.37 7.37 7.36 7.35 7.35 7.35 7.34 7.34 7.34 7.33 7.33 7.32 7.32 7.31 7.31 7.31 7.31 7.30 7.30 7.28 5.05
3.63 3.63 3.62 3.61 3.60 3.60 3.59 3.57 3.55 3.52 3.07 3.06 3.05 2.92 2.92 2.92 2.91 2.90 2.90 2.90 2.89 2.89 2.34 2.33 2.32 2.24 2.22 2.21 2.12 2.10 2.10 2.08 1.99
1H-NMR of (±)-3d, 500 MHz, CDCl3
Bn
N
N
O
Me
4.91
0.85
0.96
3.00
1.00
1.96
1.91
1.03
1.07
3.02
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
f1 (ppm)


191.22
163.26
137.31
129.03
128.42
127.42
102.70
62.54
58.48
56.69
52.36
46.40
40.32
20.85
13C-NMR of (±)-3d, 125 MHz, CDCl3
Bn
N
N
O
Me
f1 (ppm)

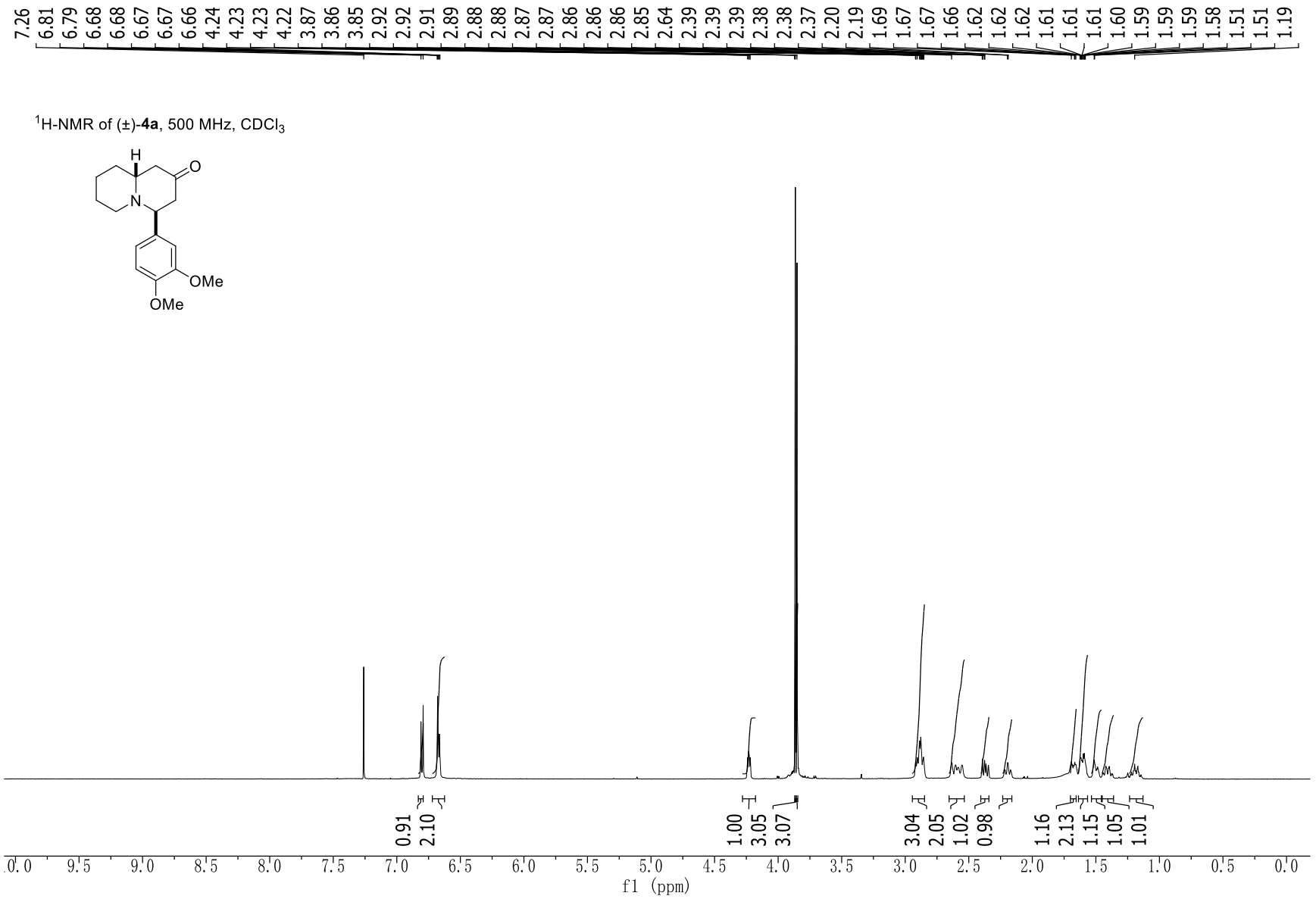

7.33 7.32 7.32 7.31 7.31 7.31 7.30 7.29 7.29 7.28 7.24 7.24 7.24 7.22 7.16 7.16 7.15 7.15 7.14 7.14 5.05 3.58 3.16 3.15 2.78 2.76 2.38 2.38 2.37 2.37 2.32 2.29 2.29 2.26 2.23 2.02 1.98 1.81 1.80 1.80 1.80 1.79 1.79 1.78 1.77 1.77 1.65 1.64 1.64 1.63 1.63 1.62 1.61 1.60
^{1}H-NMR of (±)-**3e**, 500 MHz, $CDCl_3$
H
Bn
O
N
Me
2.13 1.03 1.96 0.84 0.93 1.00 0.95 2.09 0.96 0.86 1.07 3.00 2.15 2.07
f1 (ppm)


191.47
163.40
140.16
128.85
128.55
126.24
102.24
52.95
43.17
42.31
36.85
35.00
32.29
28.46
21.18
^{13}C-NMR of (±)-**3e**, 125 MHz, $CDCl_3$
Bn
H
O
N
Me
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

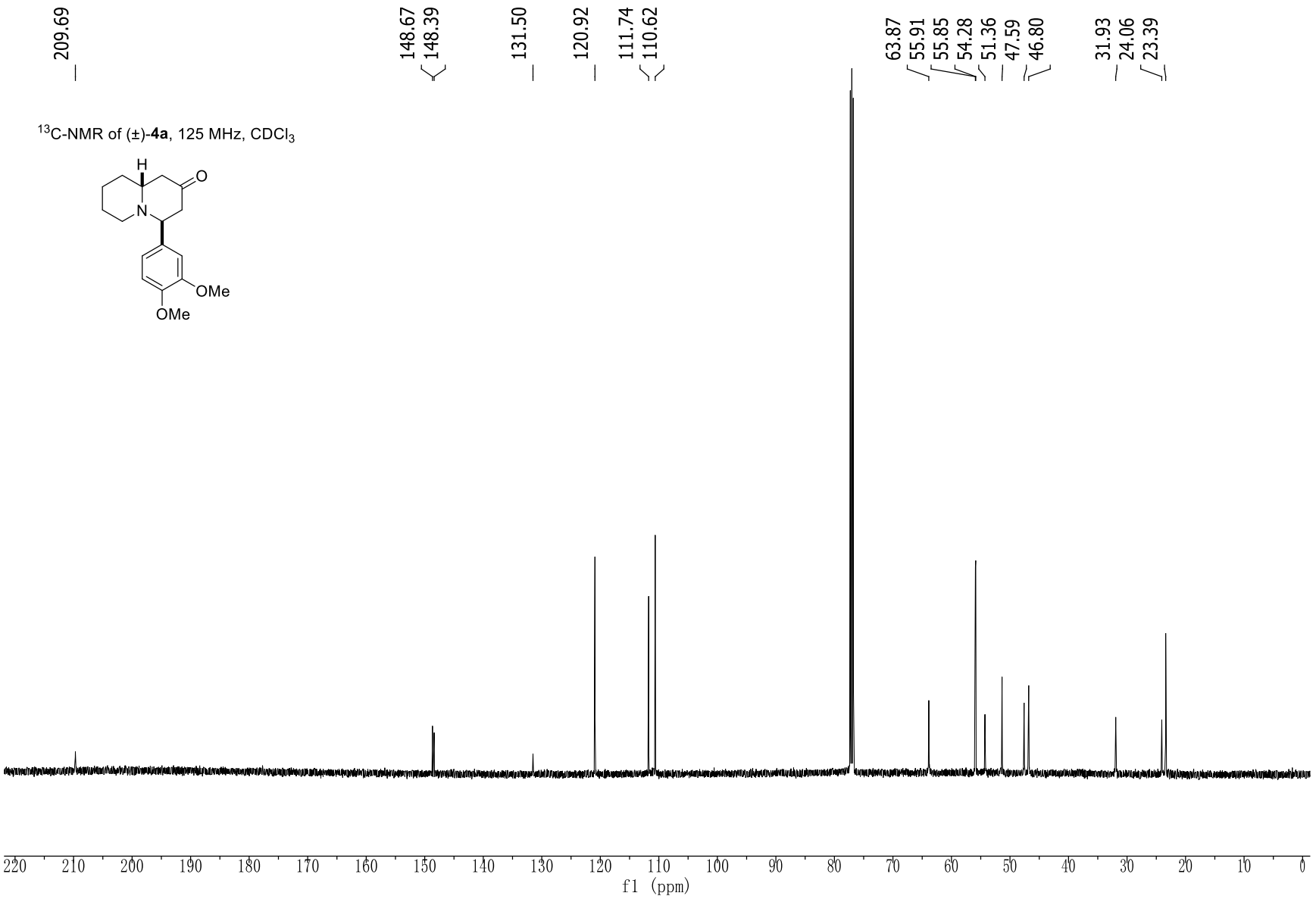

3.83 3.80 2.62 2.60 2.59 2.48 2.47 2.45 2.44 2.34 2.33 2.32 2.29 2.28 2.27 2.26 2.25 2.25 2.24 2.23 2.20 1.73 1.73 1.73 1.72 1.72 1.72 1.70 1.70 1.70 1.64 1.64 1.63 1.63 1.63 1.62 1.62 1.57 1.57 1.55 1.55 1.54 1.54 1.52 1.52 1.50 1.47 1.43 1.42 1.41 1.40 1.39 1.38 1.38
1H-NMR of (±)-3f, 500 MHz, CDCl3
O
N
1.00 0.95 1.00 1.01 5.13 3.03 2.16 2.66 2.05
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
f1 (ppm)

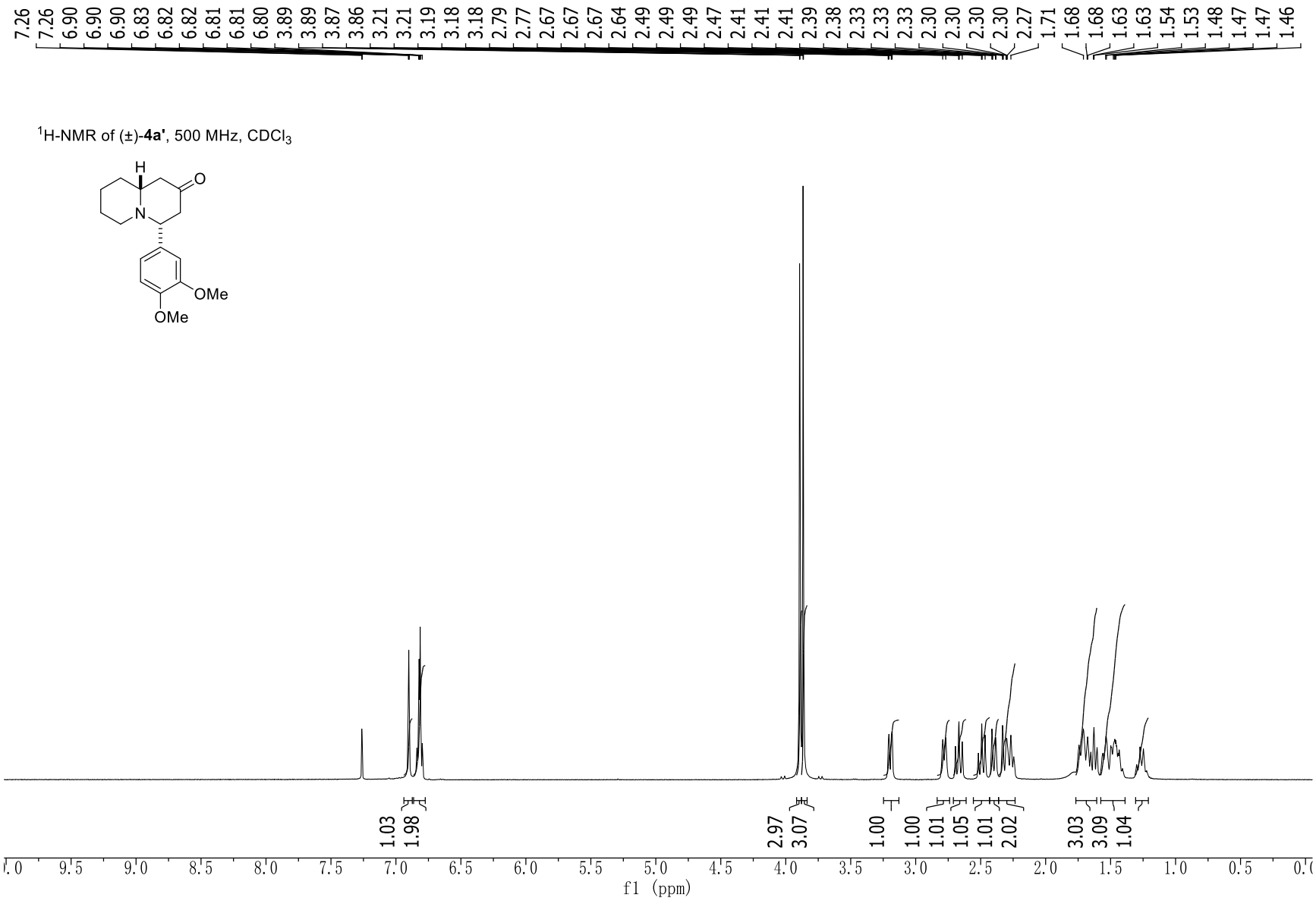


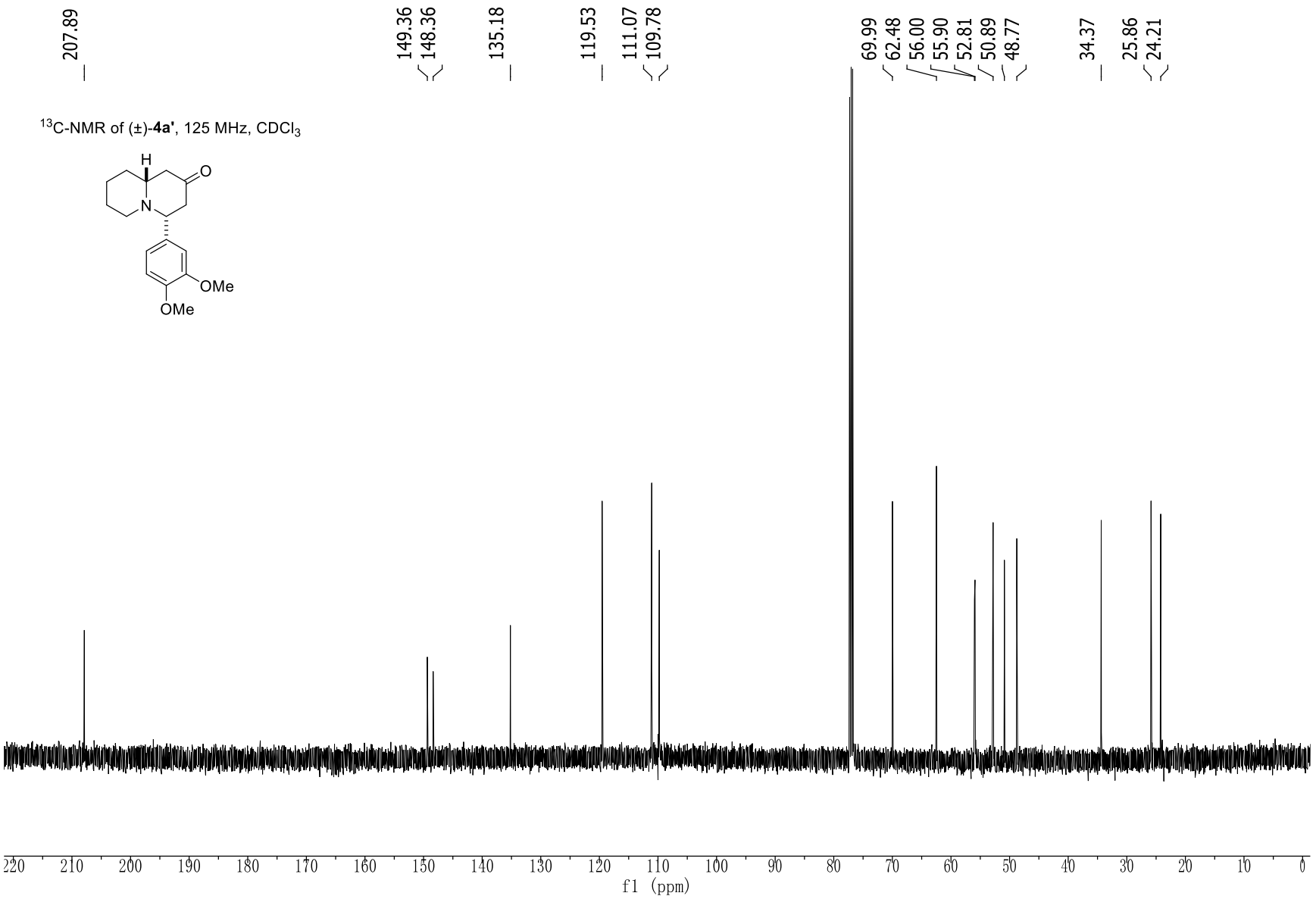
^{13}C-NMR of (±)-**3f**, 125 MHz, $CDCl_3$

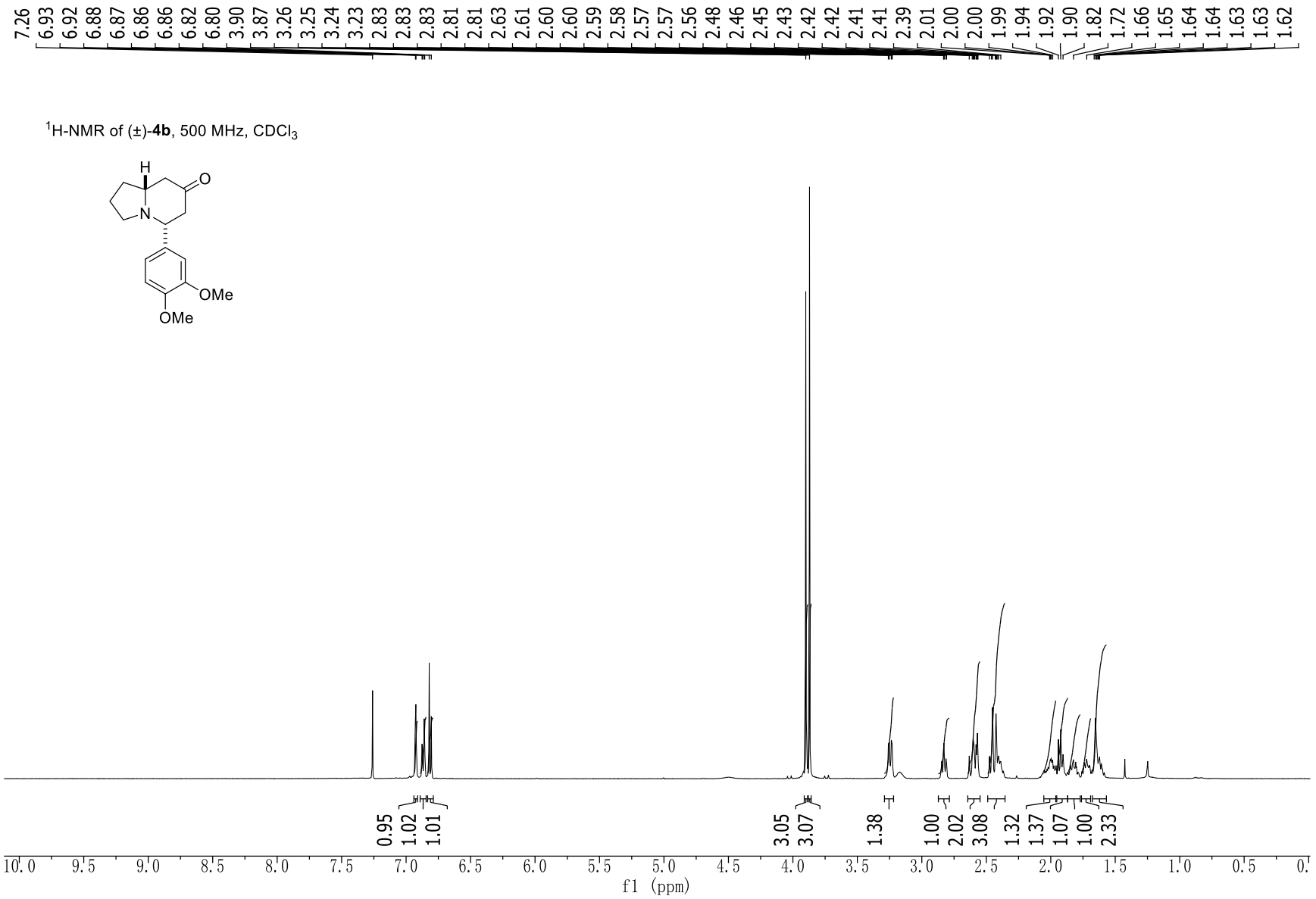


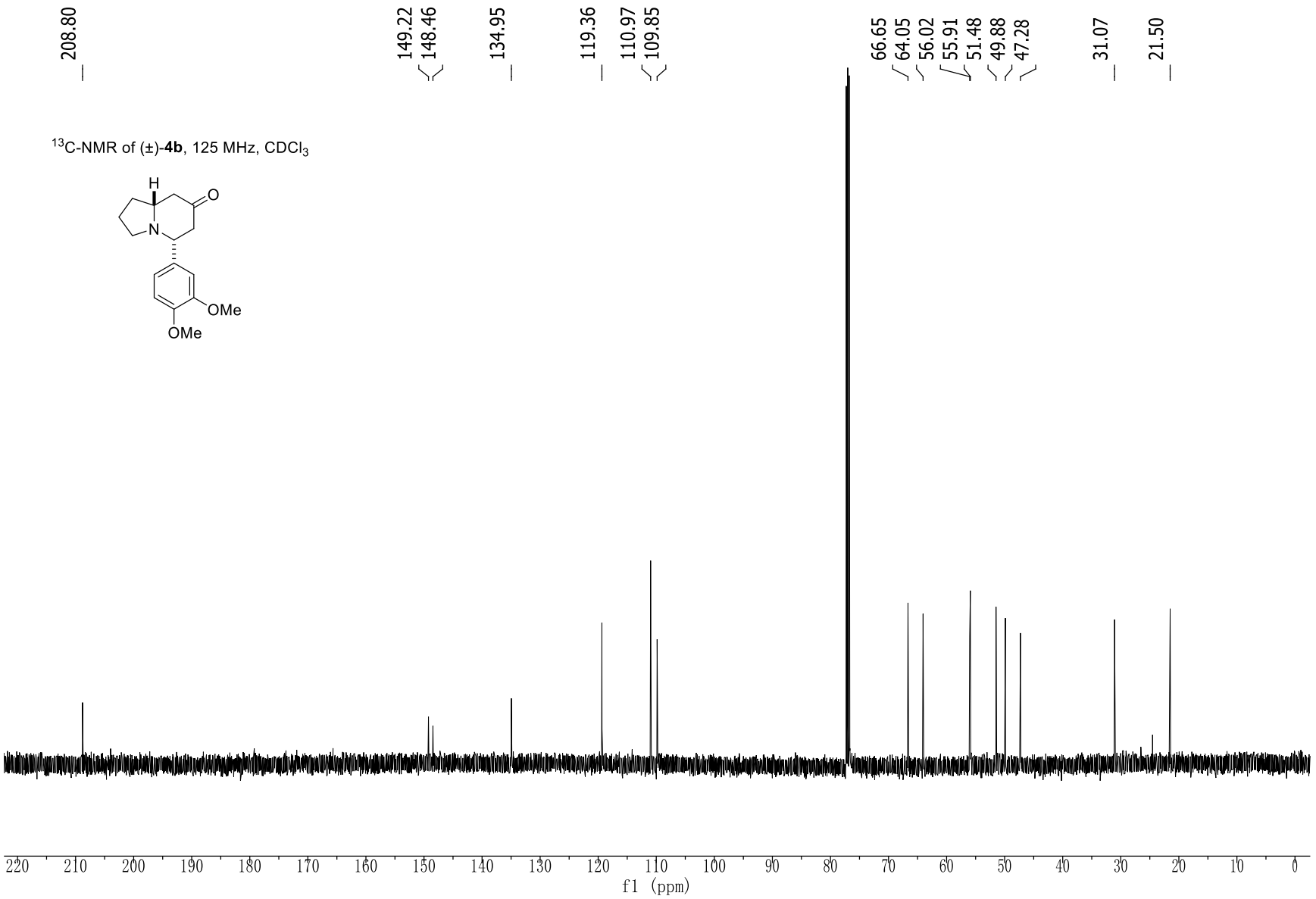
^{1}H-NMR of (±)-**4a**, 500 MHz, $CDCl_3$

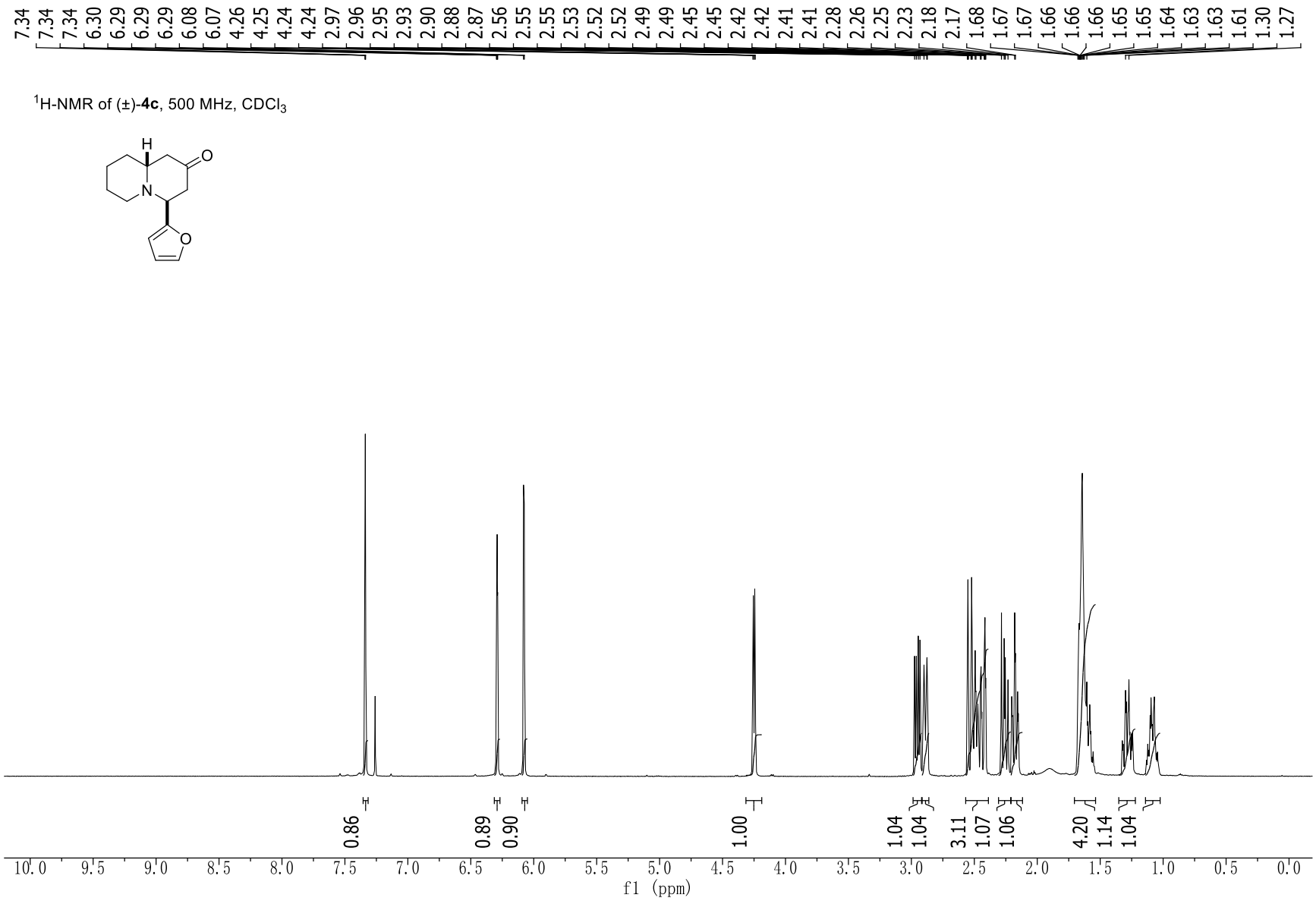

209.69
148.67
148.39
131.50
120.92
111.74
110.62
63.87
55.91
55.85
54.28
51.36
47.59
46.80
31.93
24.06
23.39
13C-NMR of (±)-4a, 125 MHz, CDCl3
H
O
N
OMe
OMe
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.26 7.26 6.90 6.90 6.90 6.83 6.82 6.82 6.81 6.81 6.80 3.89 3.89 3.87 3.86 3.21 3.21 3.19 3.18 3.18 2.79 2.77 2.67 2.67 2.67 2.64 2.49 2.49 2.49 2.47 2.41 2.41 2.41 2.39 2.38 2.33 2.33 2.33 2.30 2.30 2.30 2.30 2.27 1.71 1.68 1.68 1.63 1.63 1.54 1.53 1.48 1.47 1.47 1.46
1H-NMR of (±)-4a', 500 MHz, CDCl3
H
O
N
OMe
OMe
1.03 1.98 2.97 3.07 1.00 1.00 1.01 1.05 1.01 2.02 3.03 3.09 1.04
f1 (ppm)

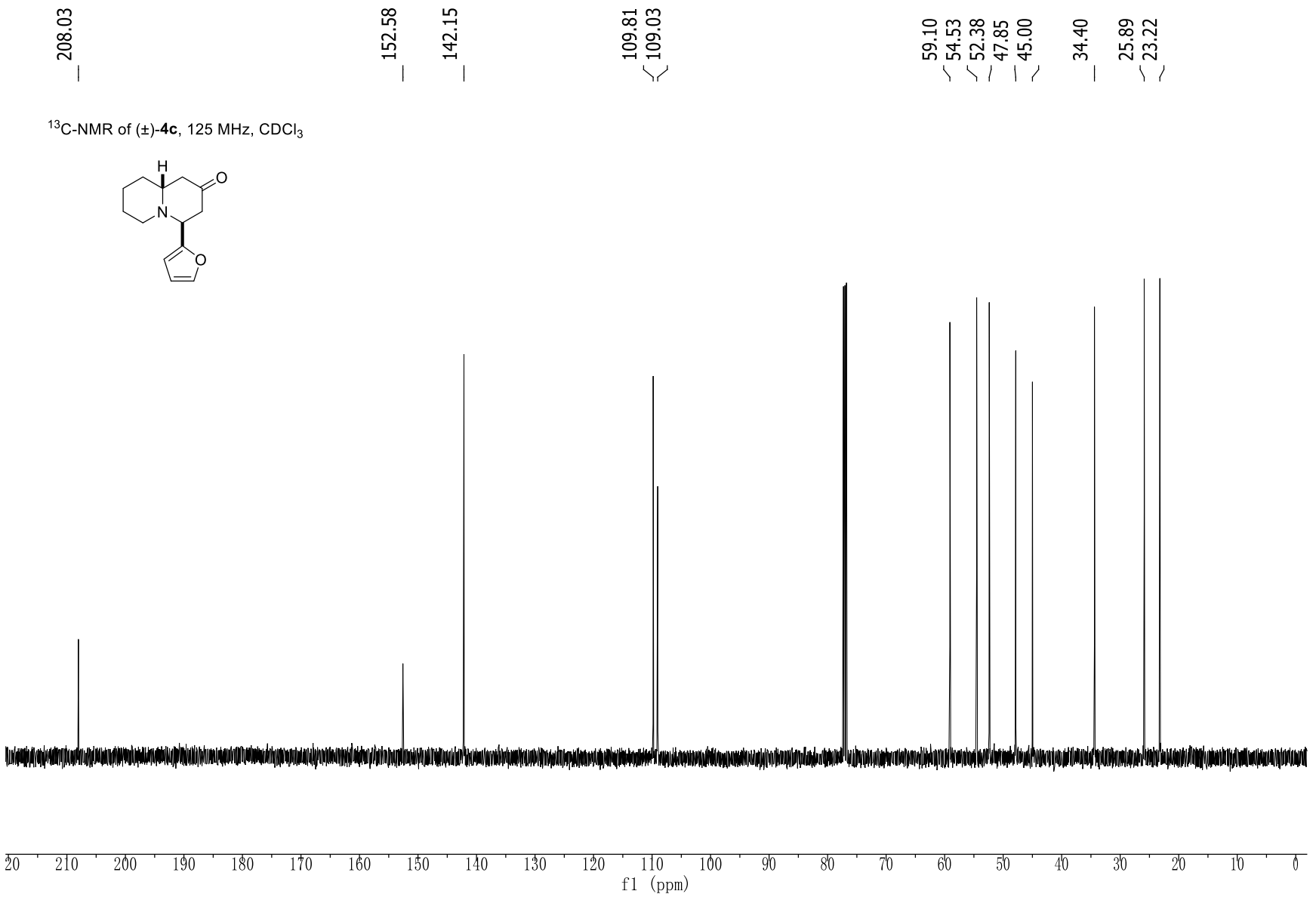

207.89
149.36
148.36
135.18
119.53
111.07
109.78
69.99
62.48
56.00
55.90
52.81
50.89
48.77
34.37
25.86
24.21
13C-NMR of (±)-4a', 125 MHz, CDCl3
H
O
N
OMe
OMe
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.26 6.93 6.92 6.88 6.87 6.86 6.86 6.82 6.80 3.90 3.87 3.26 3.25 3.24 3.23 2.83 2.83 2.83 2.81 2.81 2.63 2.61 2.60 2.60 2.59 2.58 2.57 2.57 2.56 2.48 2.46 2.45 2.43 2.42 2.42 2.41 2.41 2.39 2.01 2.00 2.00 1.99 1.94 1.92 1.90 1.82 1.72 1.66 1.65 1.64 1.64 1.63 1.63 1.62
^{1}H-NMR of (±)-**4b**, 500 MHz, $CDCl_3$
H
O
N
OMe
OMe
0.95 1.02 1.01 3.05 3.07 1.38 1.00 2.02 3.08 1.32 1.37 1.07 1.00 2.33
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.
f1 (ppm)

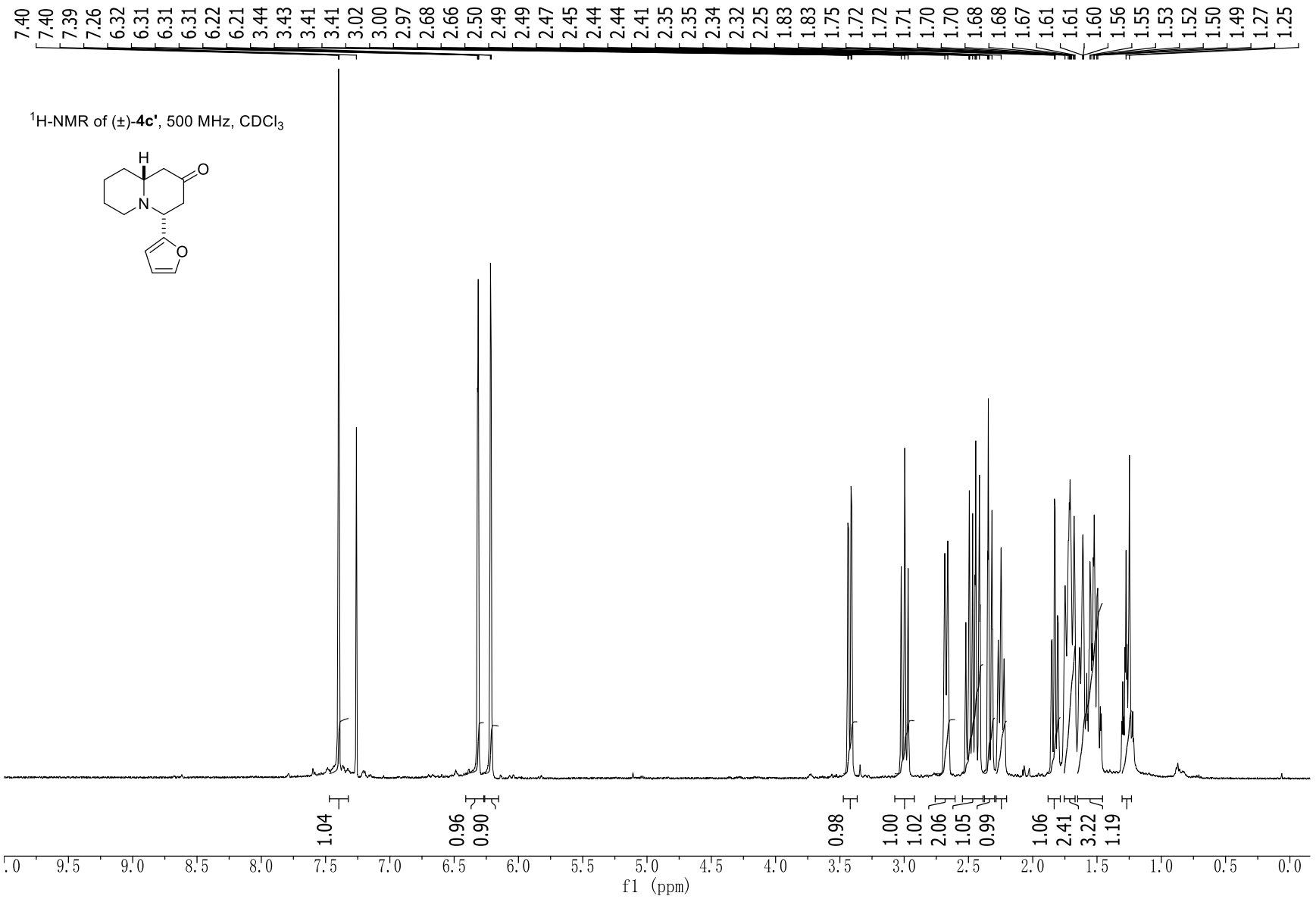

208.80
149.22
148.46
134.95
119.36
110.97
109.85
66.65
64.05
56.02
55.91
51.48
49.88
47.28
31.07
21.50
13C-NMR of (±)-4b, 125 MHz, CDCl3
H
O
N
OMe
OMe
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

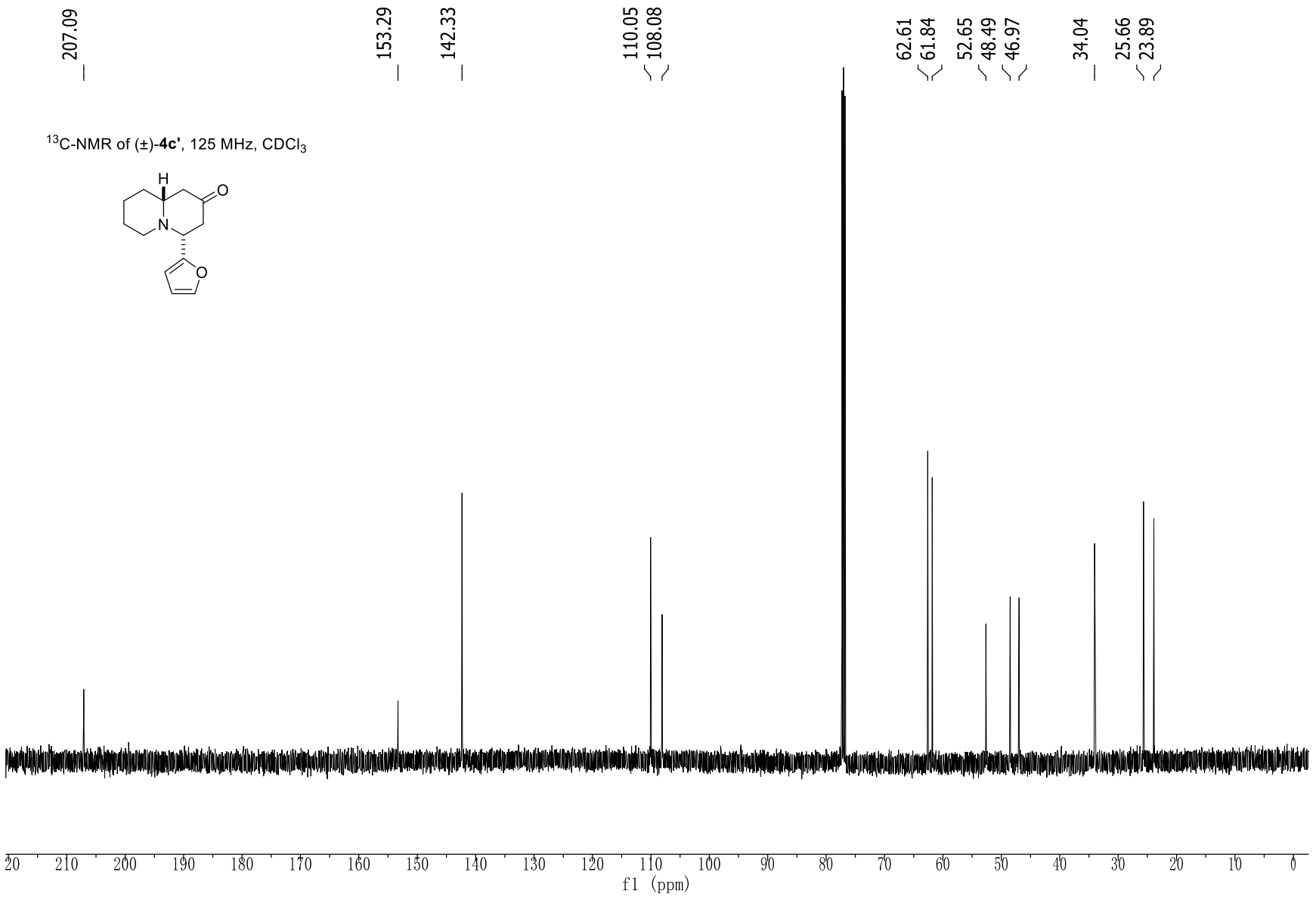


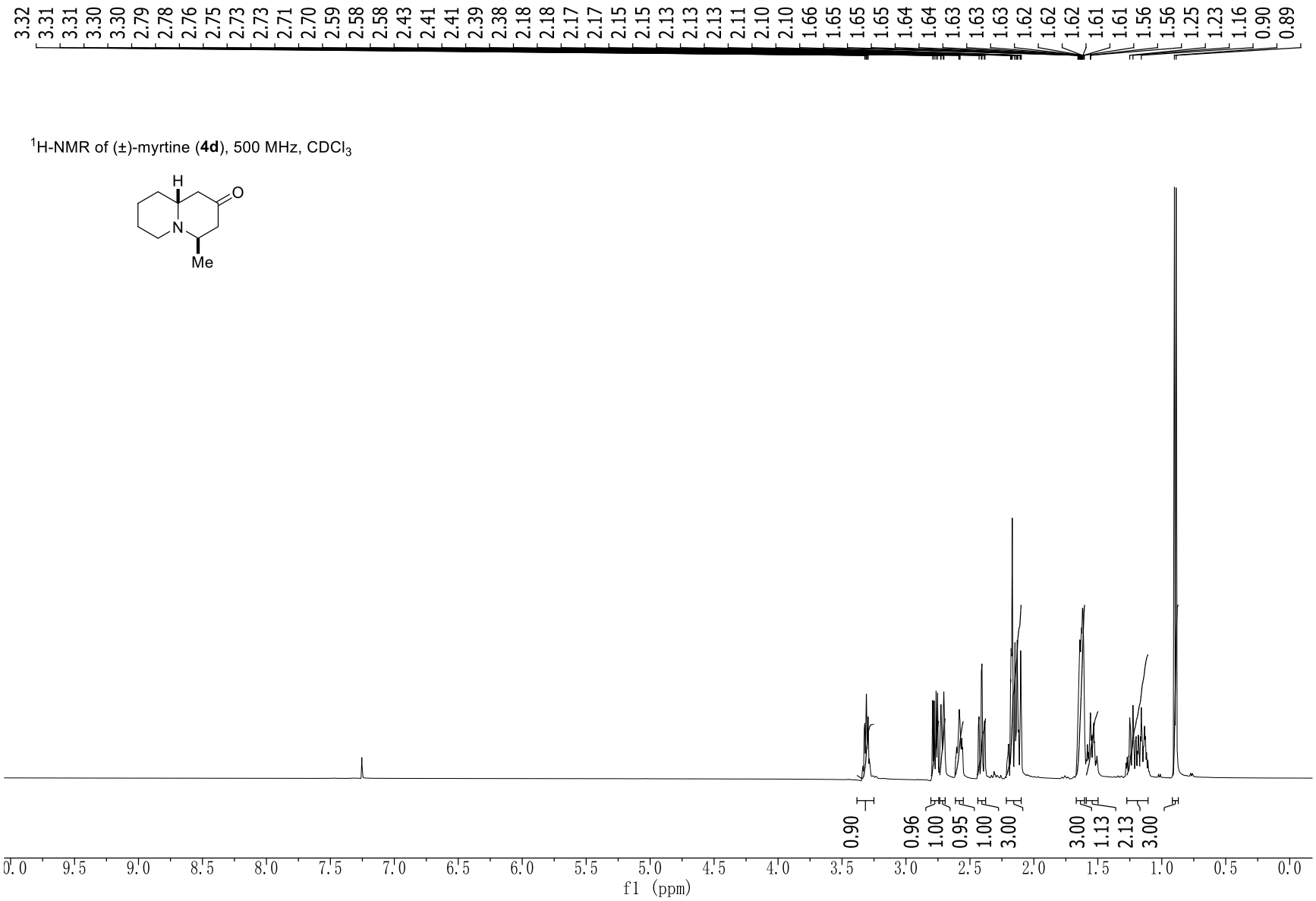
^{1}H-NMR of (±)-**4c**, 500 MHz, $CDCl_3$



^{13}C-NMR of (±)-**4c**, 125 MHz, $CDCl_3$

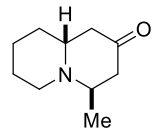

7.40 7.40 7.39 7.26 6.32 6.31 6.31 6.31 6.22 6.21 3.44 3.43 3.41 3.41 3.02 3.00 2.97 2.68 2.66 2.50 2.49 2.49 2.47 2.45 2.44 2.44 2.41 2.35 2.35 2.34 2.32 2.25 1.83 1.83 1.75 1.72 1.72 1.71 1.70 1.70 1.68 1.68 1.67 1.61 1.61 1.60 1.56 1.55 1.53 1.52 1.50 1.49 1.27 1.25
1H-NMR of (±)-4c', 500 MHz, CDCl3
H
O
N
O
1.04 0.96 0.90 0.98 1.00 1.02 2.06 1.05 0.99 1.06 2.41 3.22 1.19
f1 (ppm)

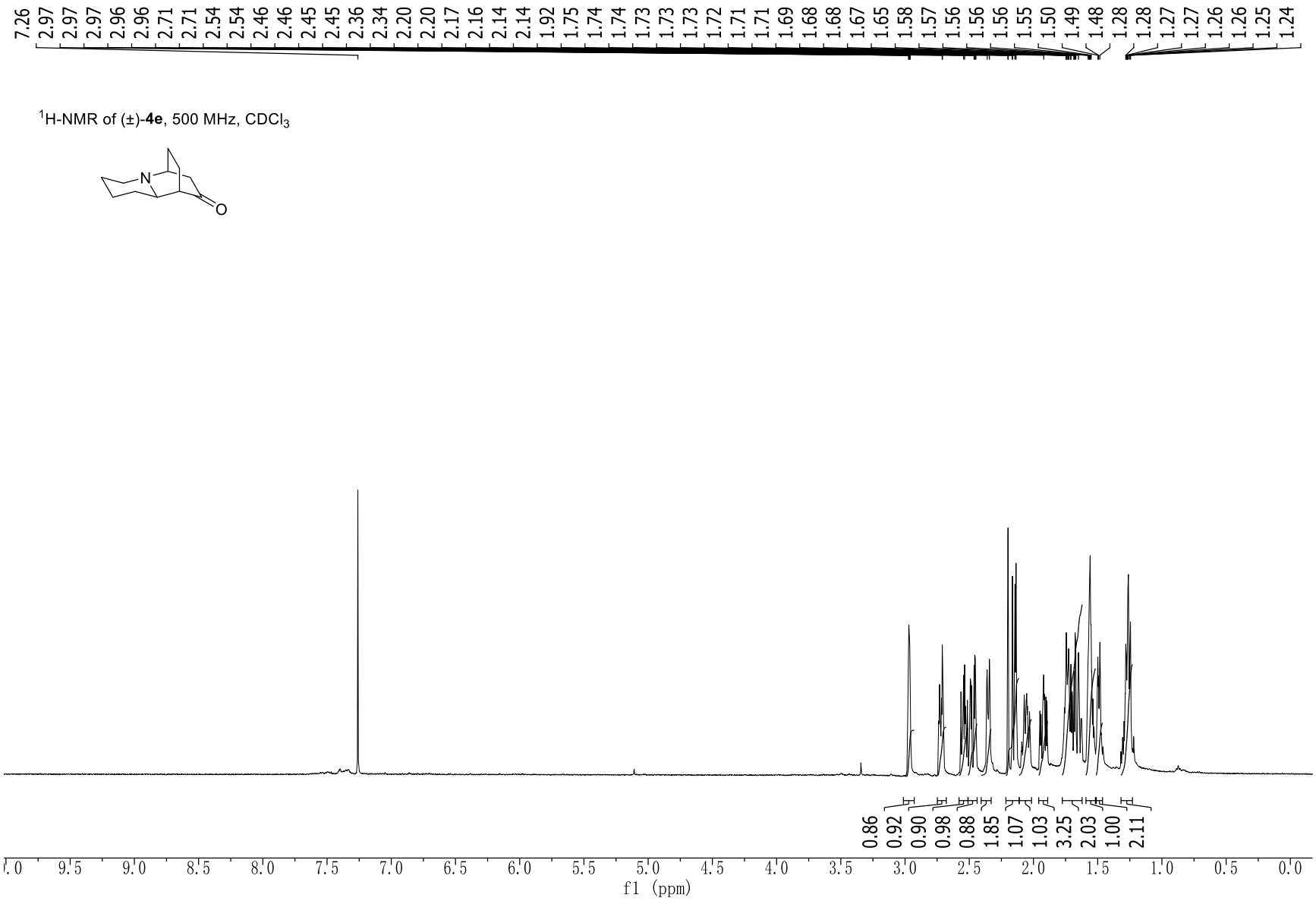

207.09
153.29
142.33
110.05
108.08
62.61
61.84
52.65
48.49
46.97
34.04
25.66
23.89
13C-NMR of (±)-4c', 125 MHz, CDCl3
H
O
N
O
f1 (ppm)



^{1}H-NMR of (±)-myrtine (**4d**), 500 MHz, $CDCl_3$

^{13}C-NMR of (±)-myrtine (**4d**), 125 MHz, $CDCl_3$





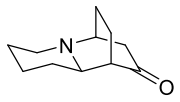
^{1}H-NMR of (±)-**4e**, 500 MHz, $CDCl_3$

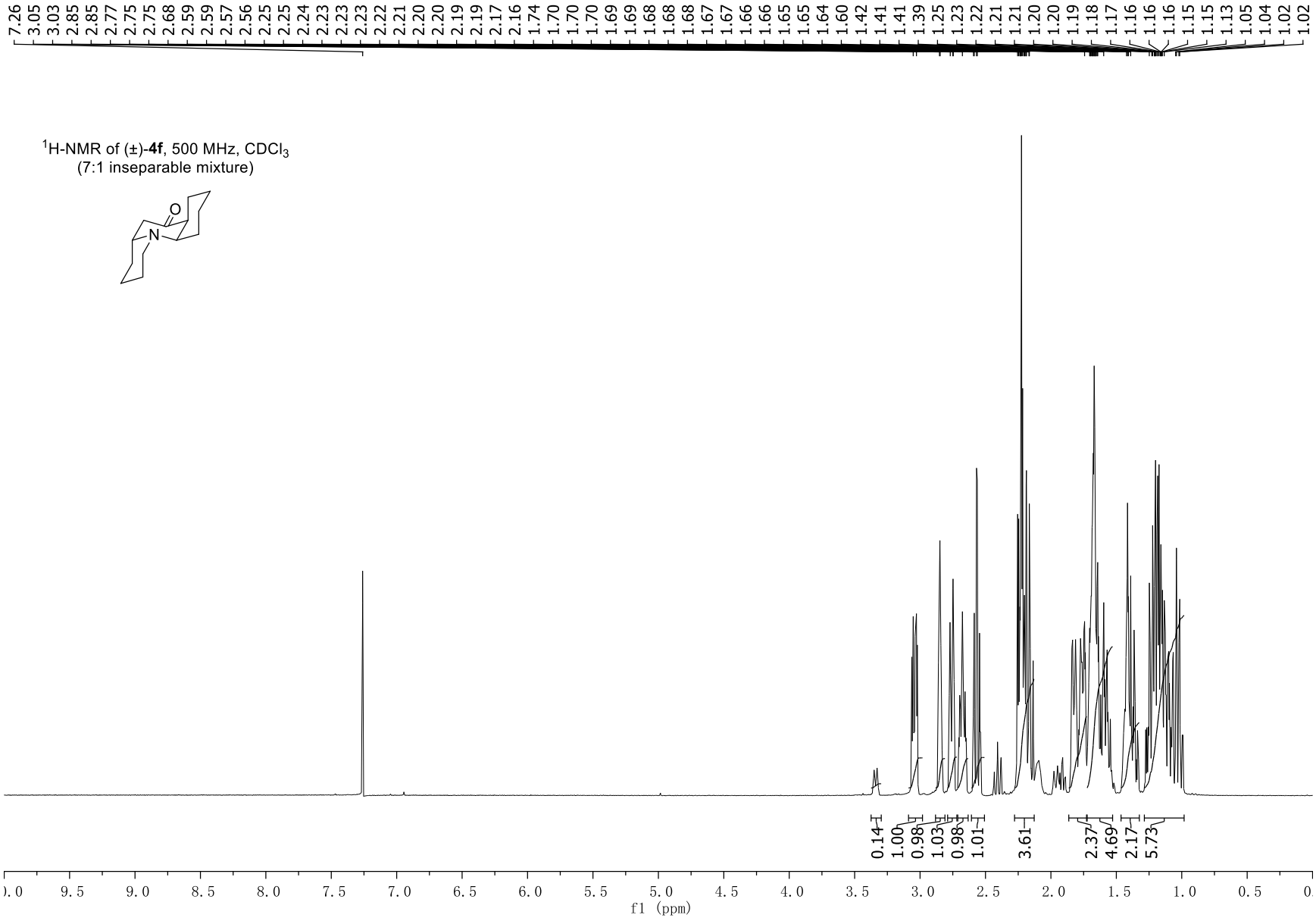
215.08

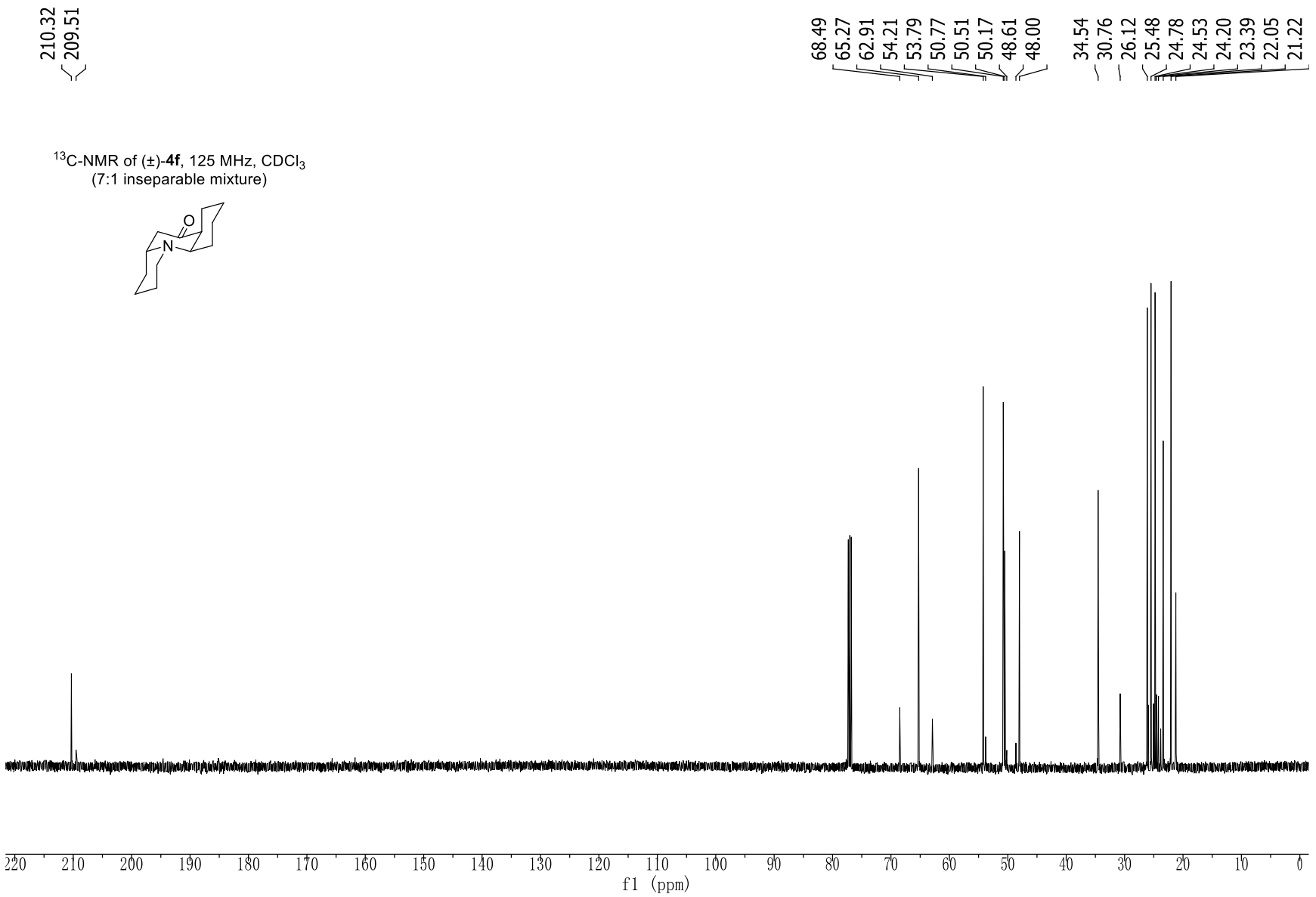
64.32
55.37
52.56
49.32
47.66

31.49
26.53
24.84
23.03
20.27

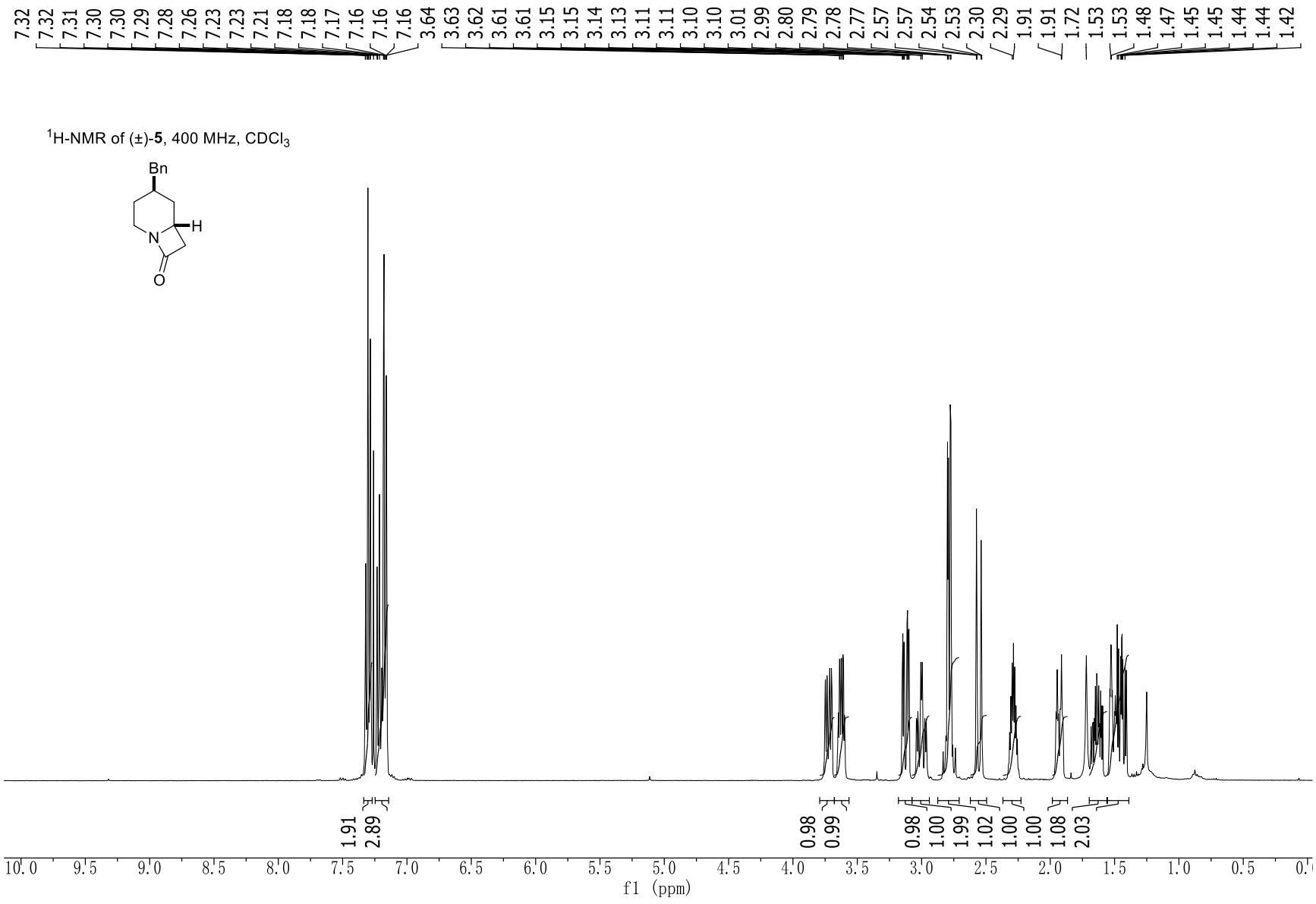
^{13}C-NMR of (±)-**4e**, 125 MHz, $CDCl_3$

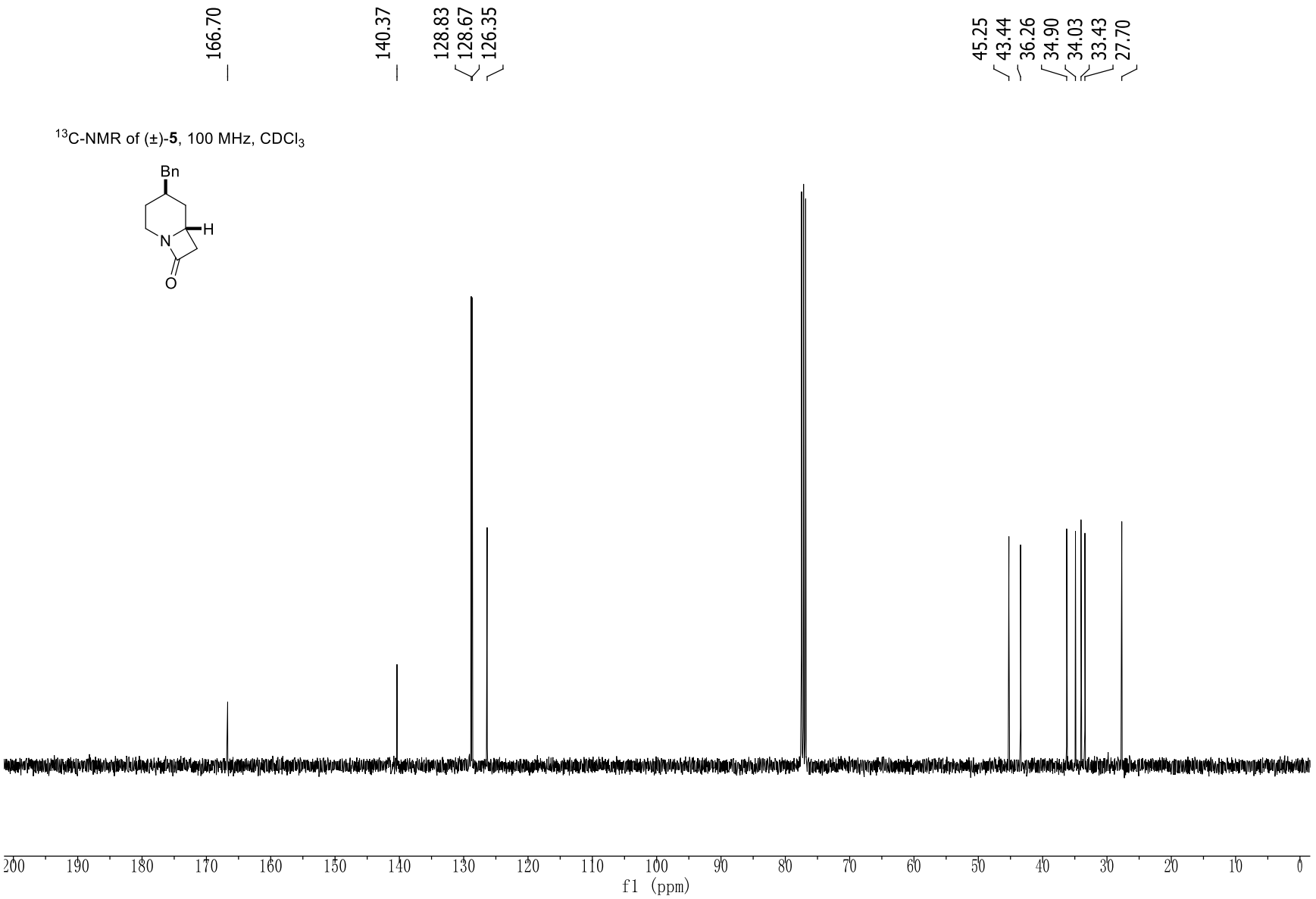


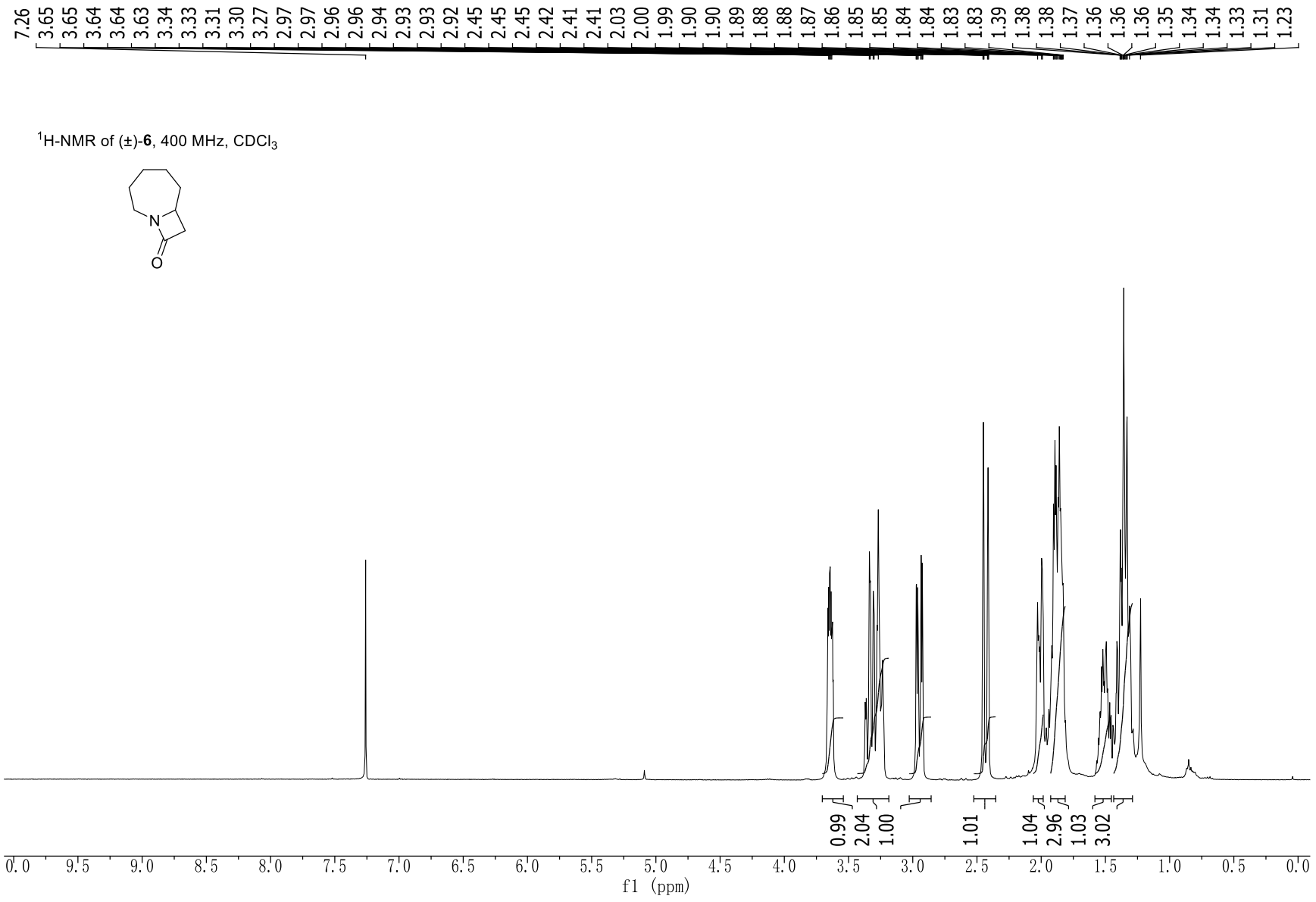

7.26 3.05 3.03 2.85 2.85 2.77 2.75 2.75 2.68 2.59 2.59 2.57 2.56 2.25 2.25 2.24 2.23 2.23 2.23 2.22 2.21 2.20 2.20 2.19 2.19 2.17 2.16 1.74 1.70 1.70 1.70 1.69 1.69 1.68 1.68 1.68 1.67 1.67 1.66 1.66 1.65 1.65 1.64 1.60 1.42 1.41 1.41 1.39 1.25 1.23 1.22 1.21 1.21 1.20 1.20 1.19 1.18 1.17 1.16 1.16 1.16 1.15 1.15 1.13 1.05 1.04 1.02 1.02
1H-NMR of (±)-4f, 500 MHz, CDCl3
(7:1 inseparable mixture)
O
N
0.14 1.00 0.98 1.03 0.98 1.01 3.61 2.37 4.69 2.17 5.73
f1 (ppm)



^{13}C-NMR of (±)-**4f**, 125 MHz, $CDCl_3$
(7:1 inseparable mixture)


7.32 7.32 7.31 7.30 7.30 7.29 7.28 7.26 7.23 7.23 7.21 7.18 7.18 7.17 7.16 7.16 7.16 3.64
3.63 3.62 3.61 3.61 3.15 3.15 3.14 3.13 3.11 3.11 3.10 3.10 3.01 2.99 2.80 2.79 2.78 2.77 2.57 2.57 2.54 2.53 2.30 2.29 1.91 1.91 1.72 1.53 1.53 1.48 1.47 1.45 1.45 1.44 1.44 1.42
1H-NMR of (±)-5, 400 MHz, CDCl3
Bn
N
H
O
1.91 2.89
0.98 0.99 0.98 1.00 1.99 1.02 1.00 1.00 1.08 2.03
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.
f1 (ppm)


166.70
140.37
128.83
128.67
126.35
45.25
43.44
36.26
34.90
34.03
33.43
27.70
13C-NMR of (±)-5, 100 MHz, CDCl3
Bn
H
N
O
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 of (±)-**6**, 400 MHz, $CDCl_3$

^{13}C-NMR of (±)-**6**, 100 MHz, $CDCl_3$